DESIGN REVIEW REPORT	Report No. TR-391-003-27-0

The Design Review Report Shall include at a minimum:

- The title of the item or system;
- A description of the item;
- Design Review Report Number;
- The type of design review;
- The date of the review;
- The names of the presenters
- The names, institutions and department of the reviewers
- The names of all the attendees (attach sign-in sheet)
- Completed Design Checklist.
- Findings/List of Action Items – these are items that require formal action and closure in writing for the review to be approved. See SLAC Document AP-391-000-59 for LUSI Design Review Guidelines.
- Concerns – these are comments that require action by the design/engineering team, but a response is not required to approve the review
- Observations – these are general comments and require no response

TYPE OF REVIEW: Preliminary Design Review

WBS: 1.3 Coherent X-ray Imaging

Title of the Review	Detector Stage and 1 micron Precision Instrument Stand Preliminary Design Review	
Presented By:	Pegasus Design (Steve Calderon), William Olson, Paul Montanez, Sébastien Boutet	
Report Prepared By:	S. DeBarger	**Date:15 May 2009**
Reviewers/Lab :	S. DeBarger – SLAC M. Holmes – SLAC D. Van Campen - SLAC	
Distribution:		
Attachments:	☐Review Slides ☐Design Checklist ☐Calculations ☐Other	

Purpose/Goal of the Review:

- Assess the completeness of the physics and engineering requirements for the CXI Detector Stage and 1 micron Precision Instrument Stand
- Review the preliminary design of the CXI Detector Stage and 1 micron Precision Instrument Stand and evaluate how well it meets the requirements
- Review the interfaces that have been identified and how well they have been communicated to the relevant parties (includes controls and software interfaces, safety review committees)
- Assess plans for fabrication, assembly, testing and inspection, and maintenance
- Review the cost estimate and schedule.
- Identify high-risk elements and evaluate plans to mitigate the risk.
- Identify safety issues

Comment on whether the component design is ready to proceed to final design

Introduction and outcome summary of the review:

The 1 micron Precision Instrument Stand and Detector Stage position the 1 micron Sample Chamber and the Detector for the CXI instrument. These devices must be precisely aligned with respect to one another and also with respect to the LCLS FEL photon beam. The system must accommodate different configurations of the CXI instrument that support forward scattering and time-delay holography experiments using focused and unfocused photons.

The Preliminary Design Review confirmed that the physics requirements for the 1 micron Precision Instrument Stand and Detector Stage are documented and understood by the design team. The design of the 1 micron Precision Instrument Stand is well advanced and appears to meet the documented requirements. Some minor issues remain to be investigated, but the reviewers do not anticipate that this will lead to any substantial changes to the presented design. Although the engineers working on the design of the Detector Stage appear to have made good progress in the time that they have been involved with the project, it is not clear that the requirements for the stability of the detector position have been met. The reviewers encourage the design team to continue to pursue the presented design while looking to quantify anticipated detector motions. The CXI detector was identified as a high value item; the presented systems look to protect this item from damage as the instrument is configured for specific experiments. The CXI team has incorporated manufacturing, assembly, and servicing considerations into the presented designs.

Findings/Action Items:

None

Concerns:

The presented design shows the beamline valve as a manual valve. The decision process to determine whether this valve should be manually or pneumatically actuated was not described. The two actuation options should be evaluated. This evaluation should consider what interlocks will be needed (the detector must be protected from a closing valve and also from motion of the detector into a closed valve). The effect of a power interruption to the control system should be considered.

1 micron Precision Instrument Stand

The ESD for the 1 micron Precision Instrument Stand should be updated to reflect the fact that 45 degree mounting of the mirrors is no longer being considered.

There was some uncertainty in the understanding of vendor statements concerning the accuracy of the slide/ball screw assemblies; the engineering staff should confirm their interpretation of theses statements with the vendor.

The effects of lateral seismic loads applied to the rod ends supporting the 1 micron Precision Instrument Stand may lead to failure of the rod ends. This does not appear to present a hazard to personnel safety; the effect of this failure mode on critical hardware (particularly the detector) should be explored.

The ball screws in the slide stages in the micron Precision Instrument Stand may be able to be back-driven (particularly under seismic loads). This possibility should be evaluated and, if found to be a problem, the use of right-angle driven screws to resist this should be explored.

The roll of the 1 micron Precision Instrument Stand during X and Y positioning will be controlled in software. Excessive roll could damage bellows, so the software will need to be robust and well tested.

A procedure to reposition hard stops when the 1 micron Precision Instrument Stand is relocated needs to be developed. It may be possible to design spacers or alternate stops that could be easily and reliably installed and removed when the stand is relocated.

The stage support plates holding the main support struts may bow under loading. If this becomes an issue, the plate could be mechanically stiffened.

The positioning of the feet for the 1 Micron Position Stand was not discussed directly. These supports could be bolted nominally centered on the focused K-B beamline, or the unfocused straight-thru beamline, or somewhere in the angle between the two. It appears that the stages in the X direction were shown nominally centered. The CXI team should check the travel/offset of the X-stages of the main stand and confirm that the selected positioning is consistent with the physics requirements and that appropriate travel exists for all desired operating conditions.

Details of the anchorage of the 1 micron Precision Instrument Stand to the floor should be completed.

Detector Stage

The current ESD requires the ability to adjust the position of the Detector Stage with respect to the 1 micron Precision Instrument Stand while placing demanding limits on the amount of vibrational motion of the detector. These requirements tend to work in opposition to one another. The CXI team should reconsider the need for separate adjustment of the Detector Stage. Each rail for these secondary adjustments makes the system less stiff. The reviewers are of the opinion that alignment of the three sets of rails in the presented systems could probably be achieved with sufficient accuracy.

The envelope of possible detector motions can interfere with the valve aperture. The present plan

is to prevent this through software controls. These controls must be robust to ensure protection of this critical device. As an option, the design team could explore a collar fitted with limit switches that could sense interfering motions without damage to the detector or valve.
Modal analysis of the Detector Stage reveals a first mode at 35 Hz. As no information on the forcing function for this system exists, the design team cannot evaluate whether the present design will meet the specified vibrational stability. It may be possible to collect data on the vibrational environment from the Near Experimental Hall and apply it with some confidence to the model. A likely more accurate determination could be made by mocking up the system and measuring the actual vibration, however this will require the procurement and fabrication of parts for the mock up. Current funding regulations do not appear to allow for a mock-up.
No mention was made of fiducializing the detector to the exterior to the detector chamber. Plans for detector fiducialization should be incorporated into the Detector Stage design.

Observations:
The K-B mirrors are fixed in position, so focus cannot be adjusted. Changing from unfocussed to 1 um focus beam requires vacuum chamber translation requires rearrangement of vacuum chambers. To probe the focus beam width requires moving the the vacuum chambers along the beam path.

The 1 micron Precision Instrument Stand system weighs ~ 8000 lbs. The frame is primarily a structural steel tubing weldment with post-weld machining to bring the detector rail attachment points into proper alignment with beam axis.

The application of limit switches and hard stops to limit extreme motion of the 1 micron Precision Instrument Stand appears to be a well chosen solution.

The UHV version of the in-vacuum Micos slide will be selected.

The reentrant bellows will need to be restrained during handling/leakcheck of the main chamber prior to final assembly of the Detector Stage system.

Cost and schedule information appears to be reasonable at this time. The recent experience of the AMO group in preparing similar items at SLAC may be of interest to the CXI team.

Both the Precision Instrument Stand and Detector Stage look much stiffer in design than the original concept drawings.

LUSI	LUSI Design Review Attendance Record	
System: Coherent X-ray Imaging	Review Title: Detector Stage and 1 micron Precision Instrument Stand Preliminary Design Review	Date: 05-15-09

Name	Affiliation	Job Title
PAUL MONTANEZ	LCLS / LUSI	MECH. ENG.
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Don Schafer	LCLS/LUSI	Mechanical Engineer
Eliazar Ortiz	LCLS / LUSI	Mech. Engr.
Douglas Van Campen	SSRL/SNAL	Eng. Physicist.
SCOTT DEBARGER	LCLS	MECH ENGINEER
Armin Busse	LCLS/LUSI	Mech. Engineer
Michael Holmes	LCLS	MECH ENG
Marc Campell	LUSI	MECH ENGR
TOM FORNEK	LUSI	PROJ. MGR.
Damon Genetti	Pegasus Design	Mech. Engr.
STEVE CALDERON	PEGASUS DESIGN	OWNER
SEBASTIEN BOUTET	LUSI	Physicist

CXI 1 micron Stand and Detector Stage Preliminary Design Review WBS 1.3.5.1.1

Sébastien Boutet - CXI Instrument Scientist

May 15, 2009

Outline

- CXI Overview
- Experimental Configurations
- Detector Stage Physics Requirements
- 1 micron Precision Instrument Stand Physics Requirements
- Summary

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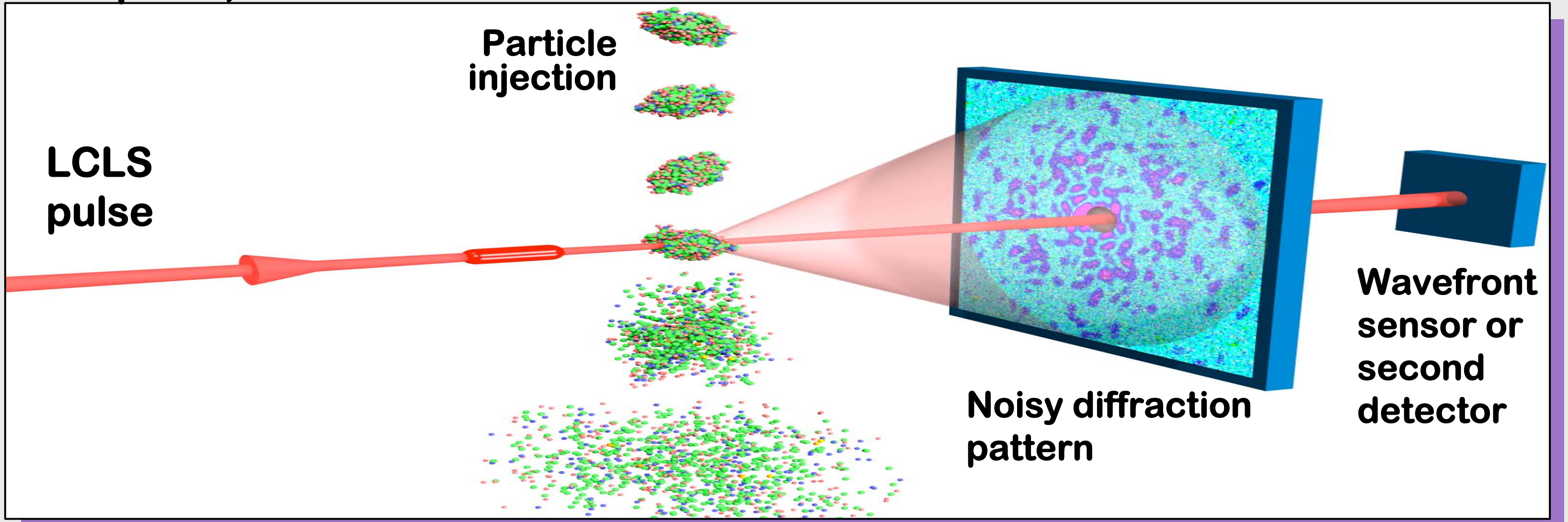
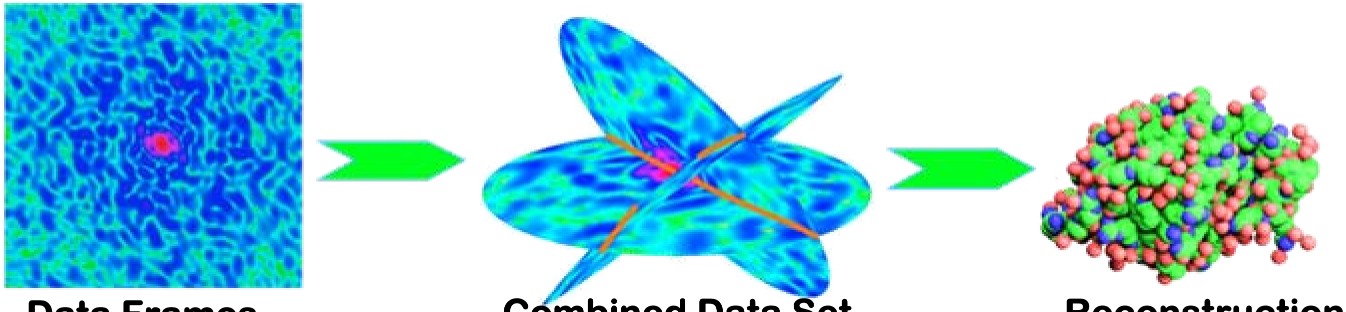
Coherent Diffractive Imaging of Biomolecules

One pulse, one measurement



Combine many measurements into 3D dataset



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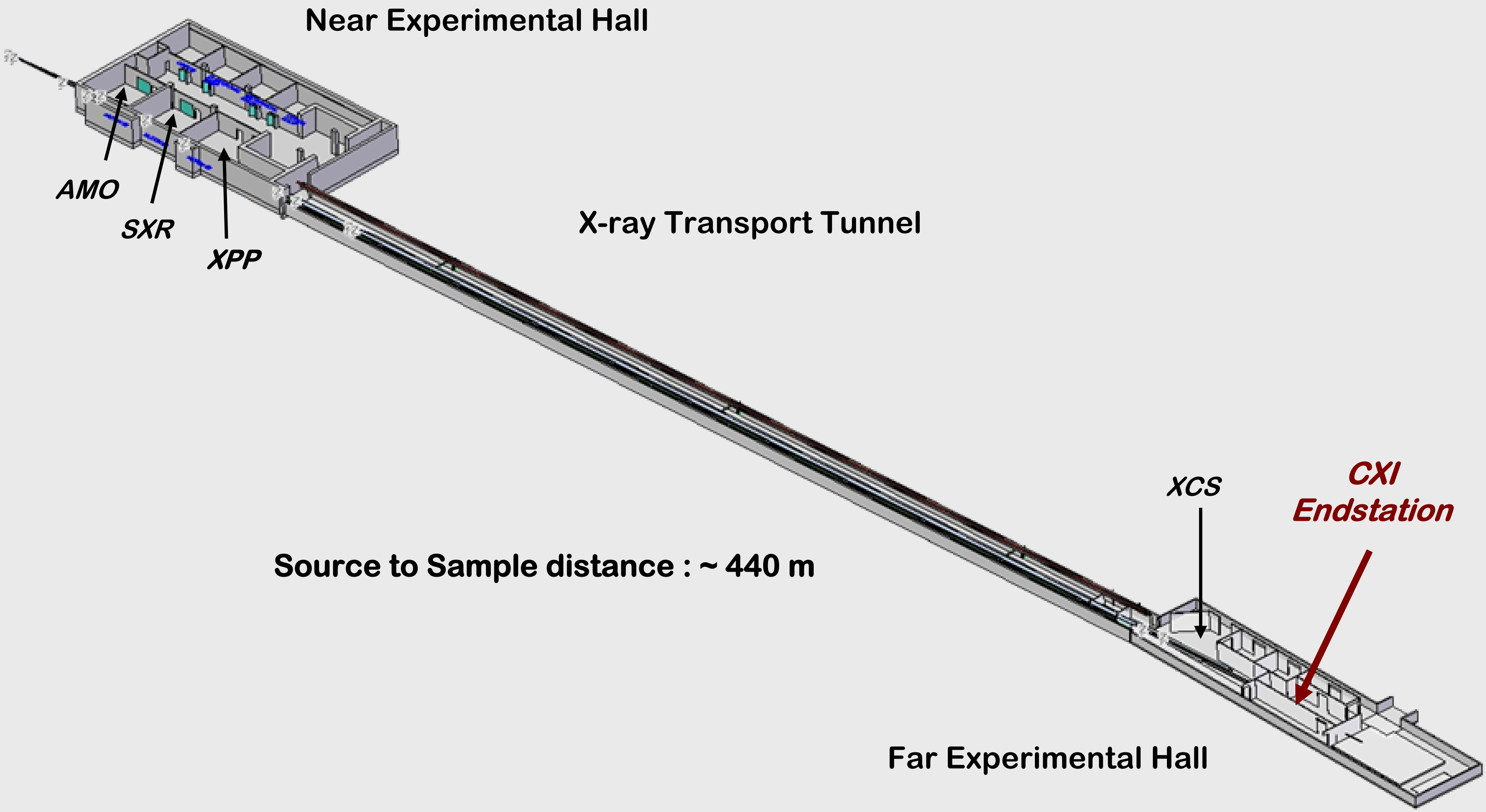
CXI Instrument Location



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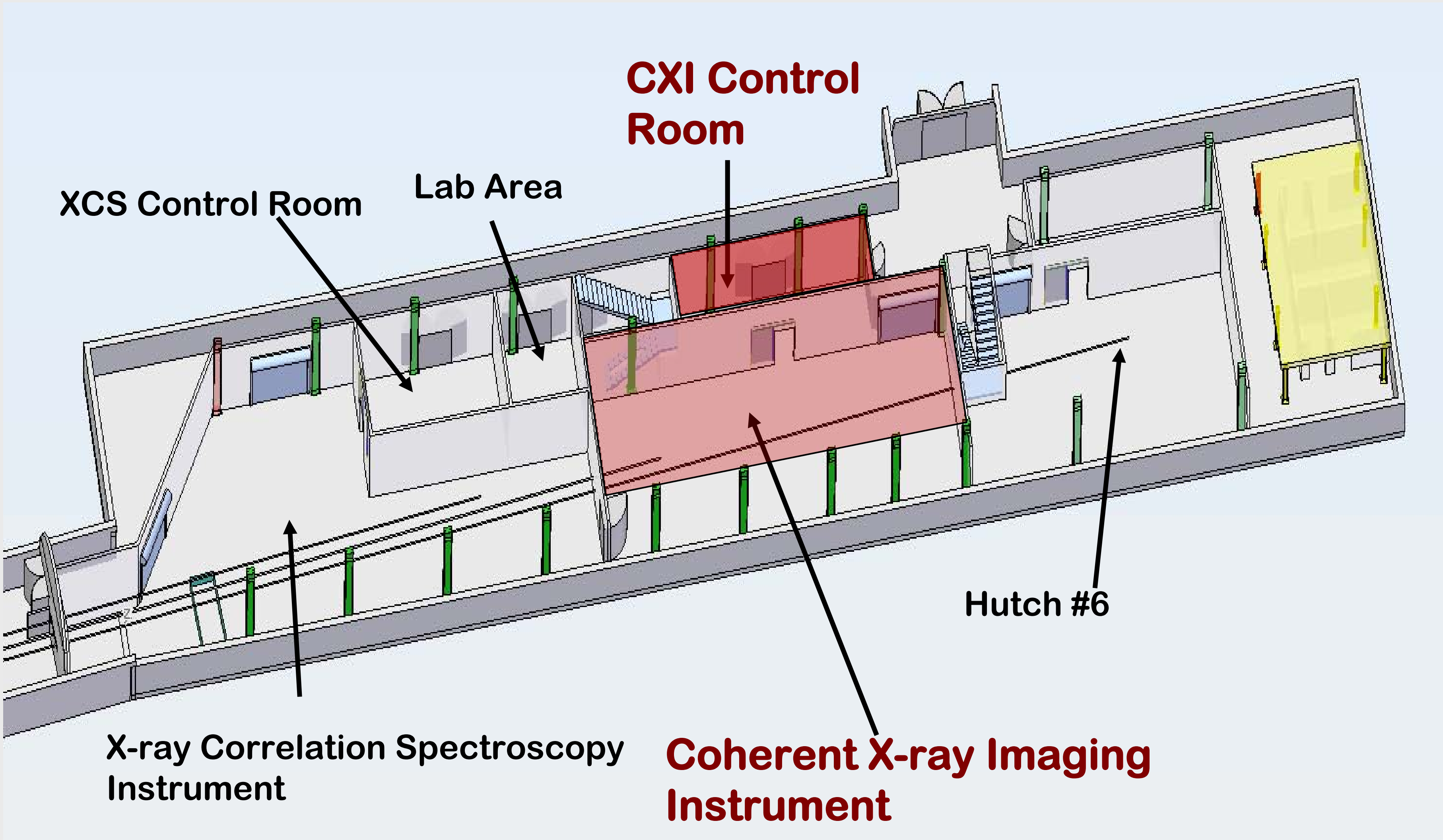
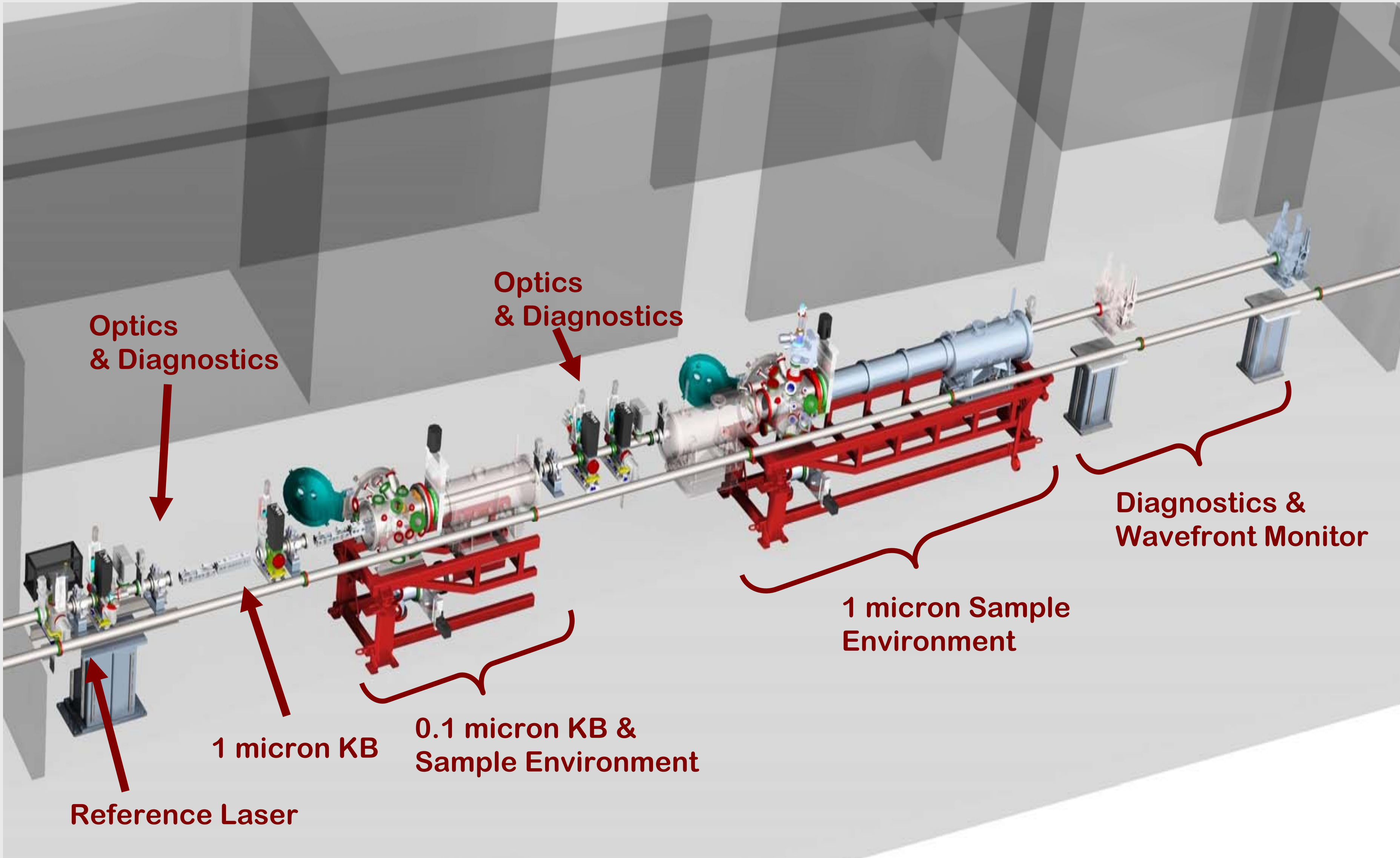
Far Experimental Hall



CXI Instrument



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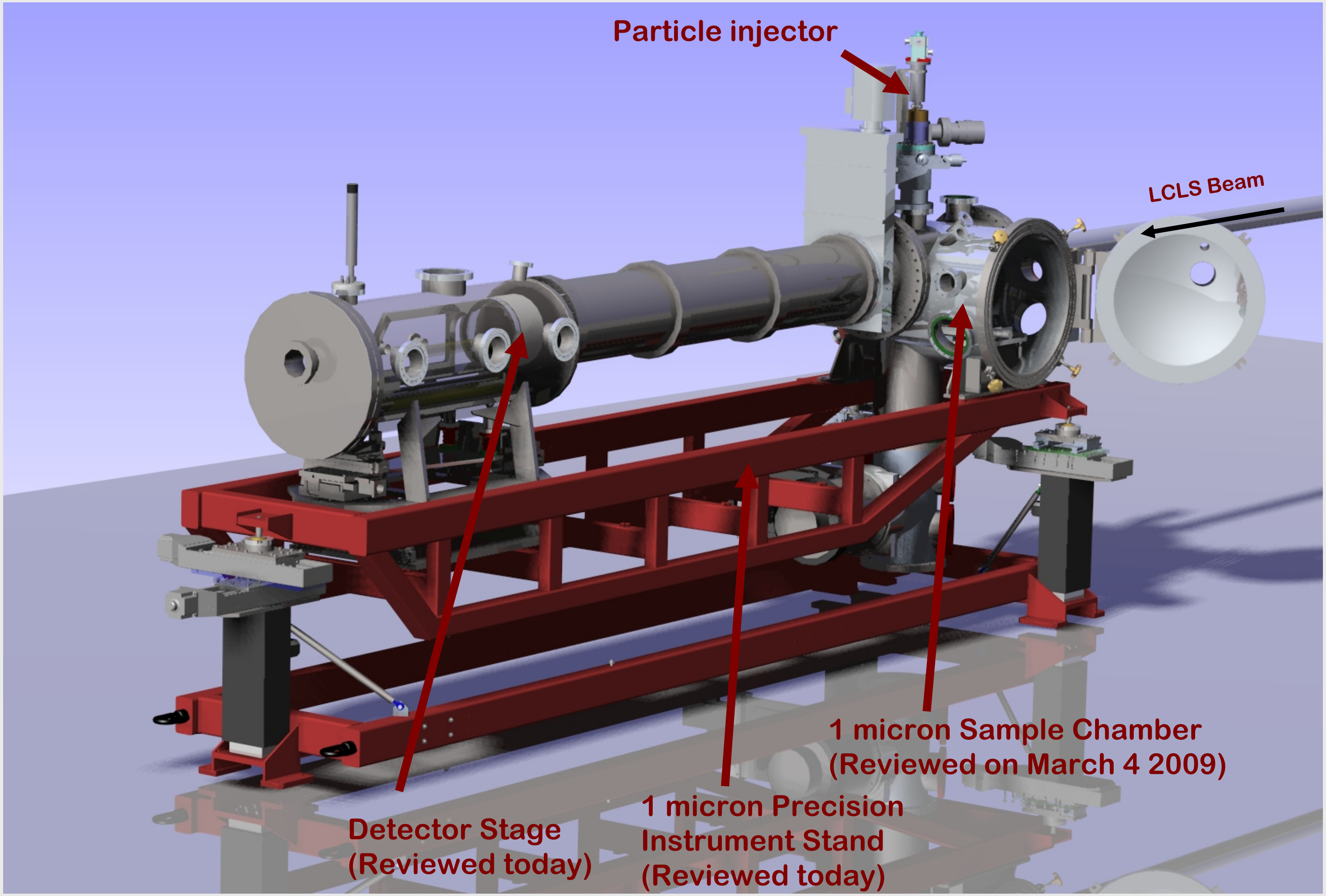
CXI Instrument Overview



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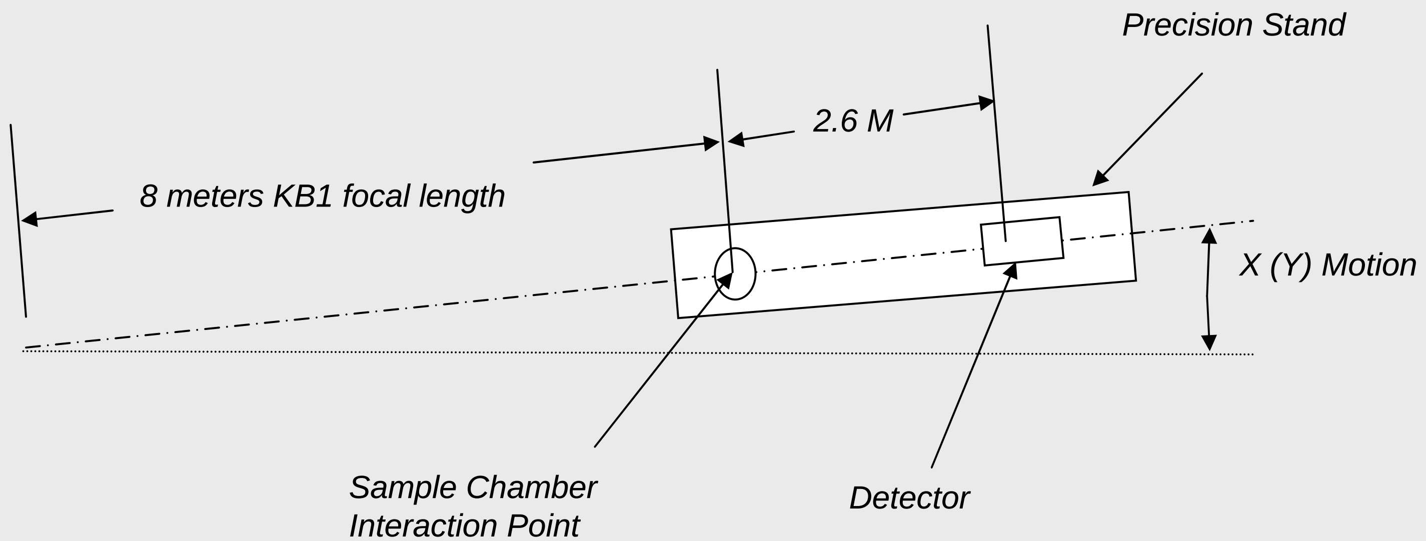
Unfocused and 1 micron Focus Positions



- Two beam directions
  - Unfocused
  - 1 micron KB
    - Beam deflected by 6.8 mrad in x and y
- 1 micron Sample Chamber and Detector Stage must align with the beam for both cases
  - The 1 micron Precision Instrument Stand is used to accomplish this task

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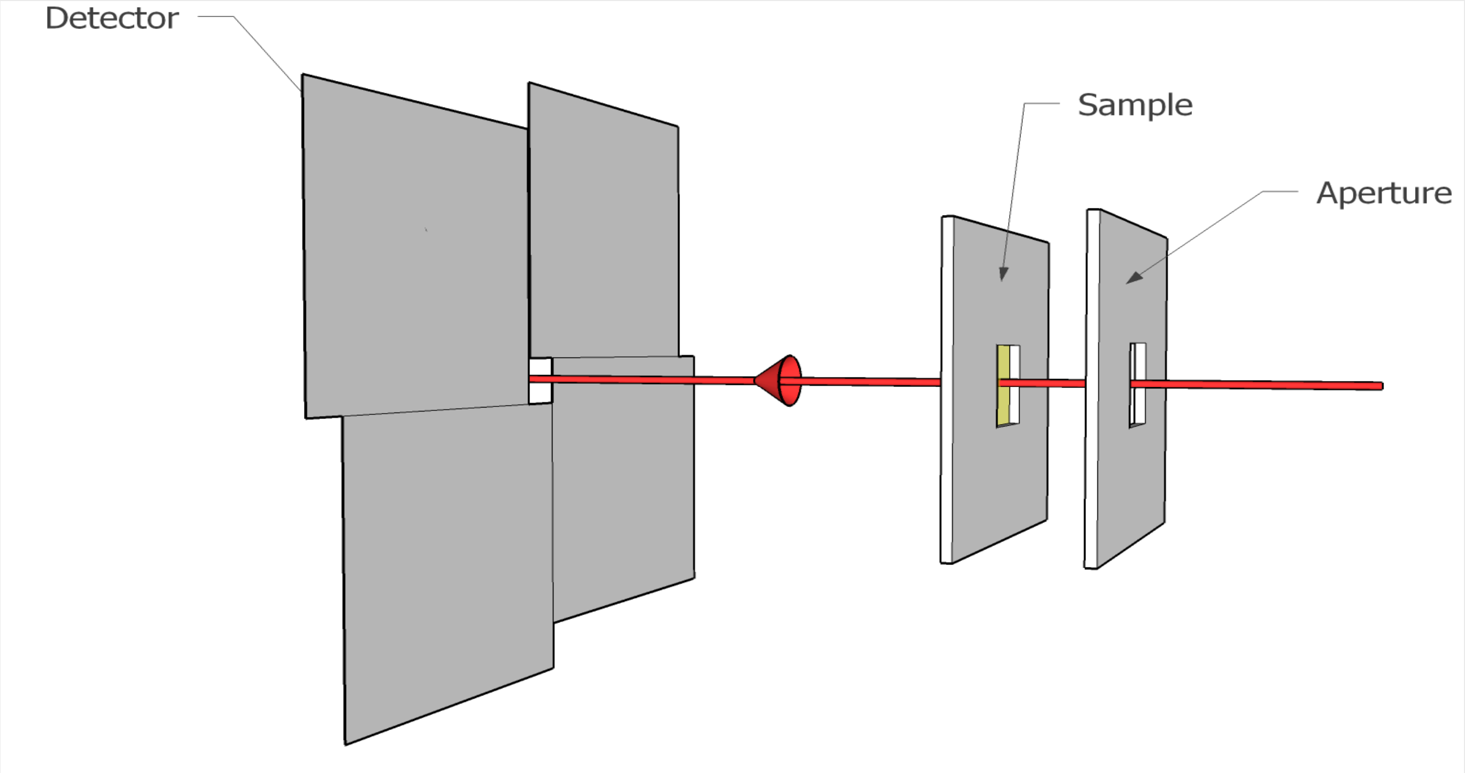
Configuration 1: Forward Scattering



- Direct beam passes through hole in the detector
- Detector mounted downstream of sample chamber
- Configuration used with direct beam and beam deflected by 1 micron KB System

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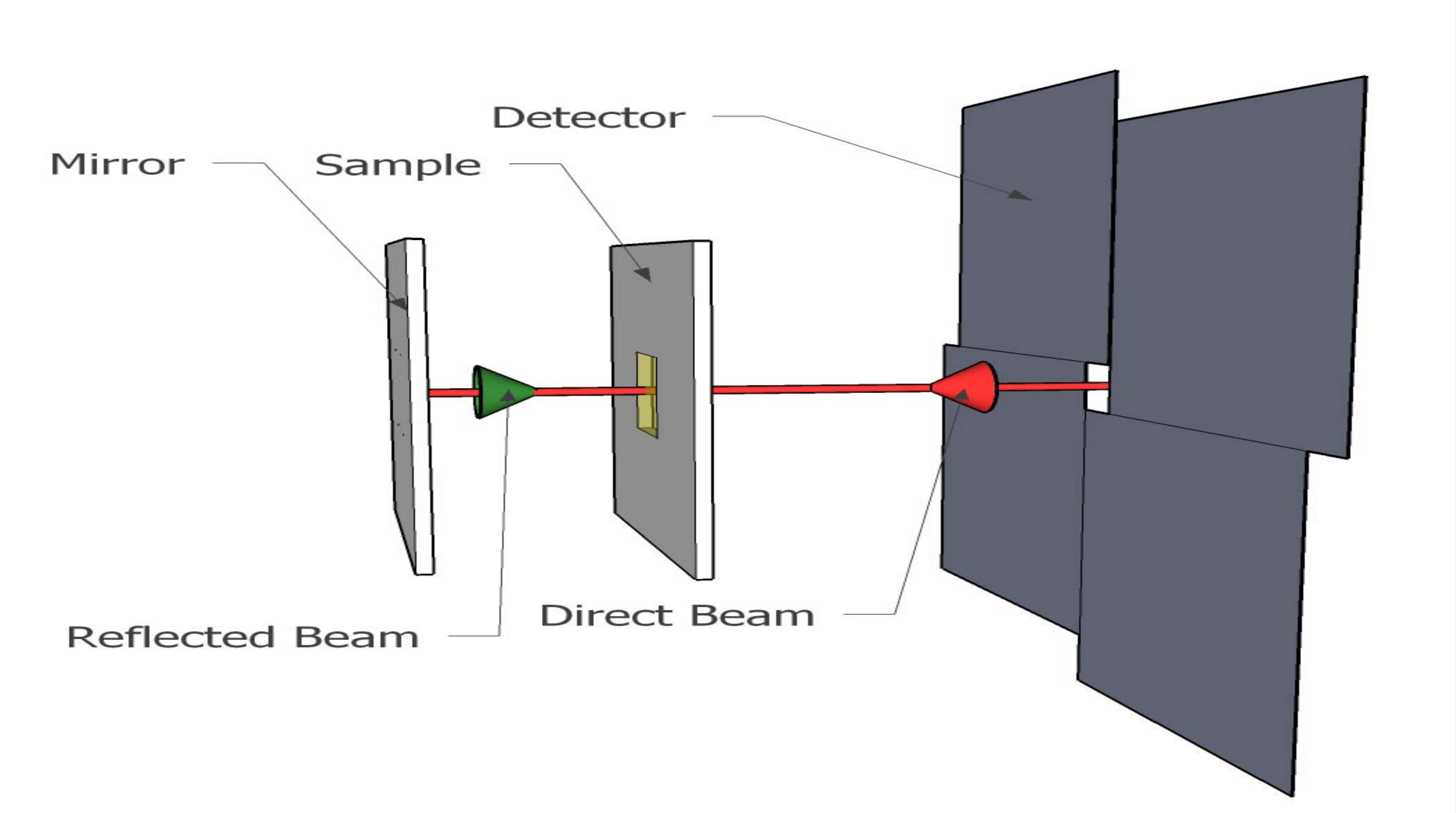
Configuration 2: Time-delay Holography



- Detector placed upstream of the sample
  - Turned 180 degrees to face the downstream end of the beamline
- Beam passes through the hole in the detector, then hits the sample
- Configuration used with direct beam and beam deflected by 1 micron KB System

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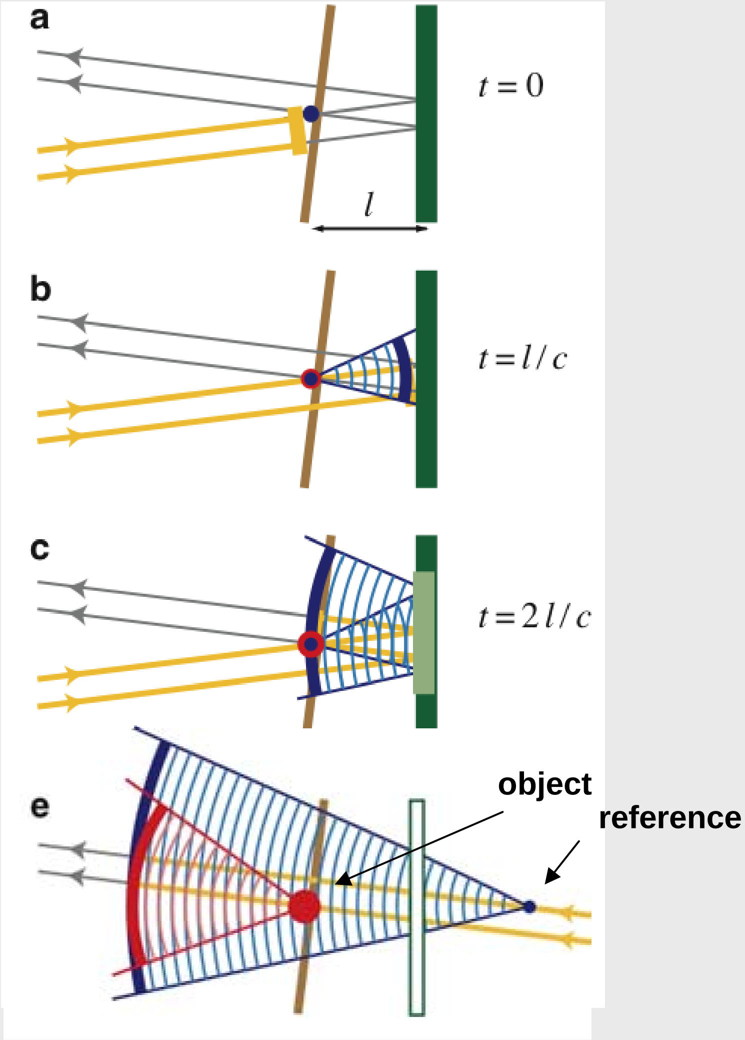
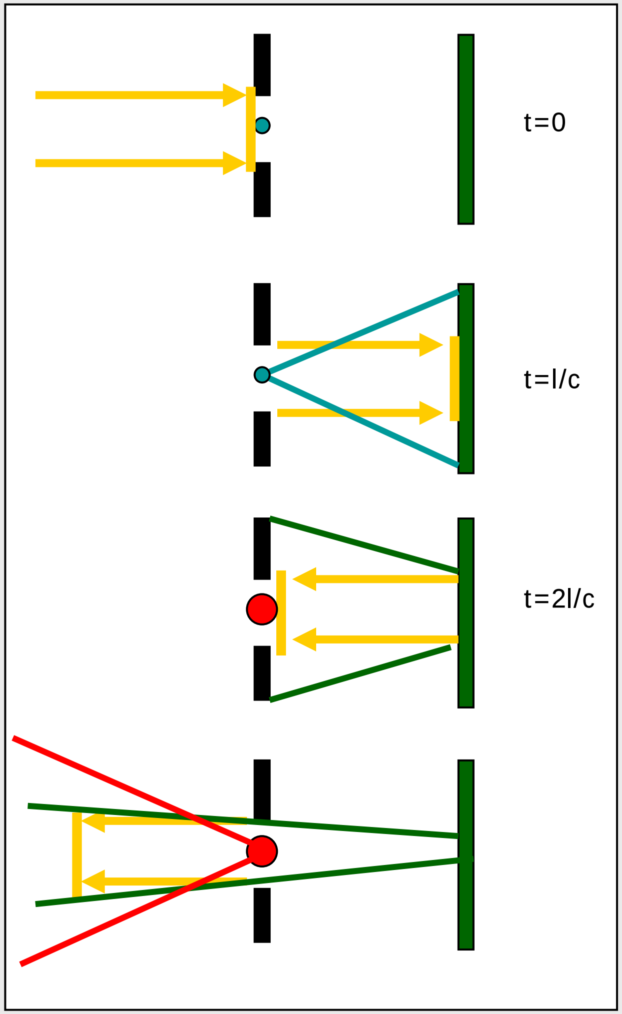
Time-Delay Holography with Hard X-rays



Soft X-rays



Hard X-rays

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CXI Detector Stage Requirements

- Purpose
  - Center the detector hole on the direct beam
  - Position the detector at the appropriate distance from the interaction region
- Performance Requirements
  - Range along the beam : 50-2600 mm
    - Non-continuous
      - Minimum continuous range sufficient to retract the detector past the gate valve
  - Possible to mount the detector stage upstream of the Sample Chamber
  - Include a photodiode and screen behind detector for alignment using a visible laser
- Size Requirements
  - Allows detector to be reentrant into the Sample Chamber
- Positioning Requirements
  - Detector face perpendicular to beam within 2 degrees

Motion	Nominal Position	Range	Resolution	Repeatability	Vibrational Stability	Thermal Stability
Out of vacuum y1	0	-5 mm < y < 5 mm	10 µm	10 µm	1 µm	10 µm
Out of vacuum x1	0	-5 mm < x < 5 mm	10 µm	10 µm	1 µm	10 µm
Out of vacuum y1	0	-5 mm < y < 5 mm	10 µm	10 µm	1 µm	10 µm
In-vacuum z	50 mm	50 < z < 2600 mm in steps of 600mm	50 µm	50 µm	1 µm	10 µm
Yaw (x combination)	0°	±20 mrad	100 µrad	100 µrad	10 µrad	10 µrad
Pitch (Y combination)	0°	±20 mrad	100 µrad	100 µrad	10 µrad	10 µrad

Table 1: Motion requirements for the Detector Stage. The vibrational stability represents stability over a period of a few seconds. The thermal stability represents the stability over a period of a few hours.

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CXI Detector Stage Requirements

- Vacuum Requirements
  - Vacuum better than 10^{-7} torr
  - Can vent Sample Chamber with Detector Stage under vacuum
    - Large gate valve
- Controls Requirements
  - Everything remote controlled
    - Follow SLAC and LCLS standards to the extent possible
- Safety Requirements
  - Interlock to prevent gate valve from closing on the detector
  - Diagnostics behind the detector for alignment
- Interfaces
  - Gate valve and Sample Chamber
  - 1 micron Precision Instrument Stand
    - At 2 locations
  - Vacuum line downstream
    - 6 inch flange

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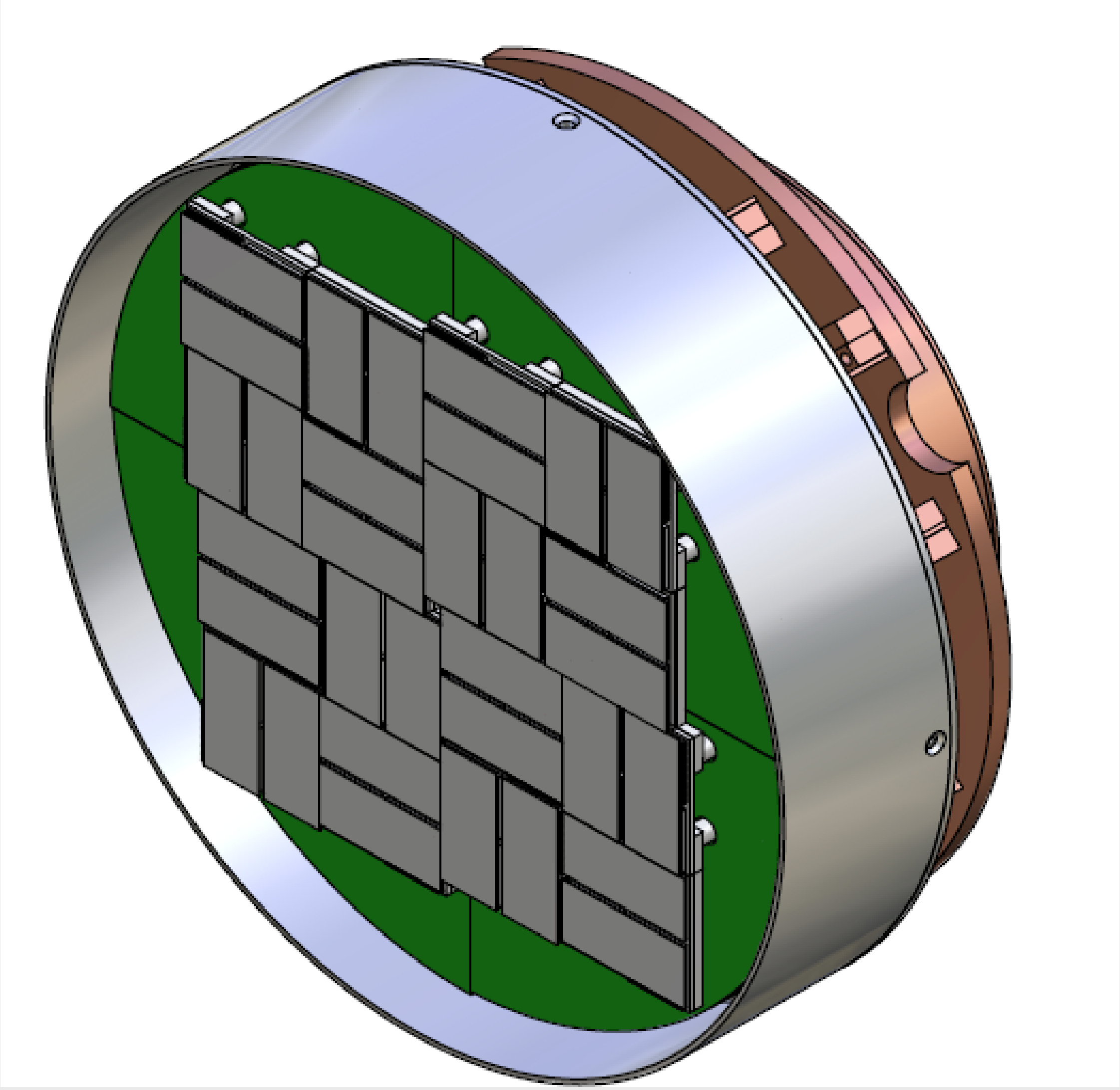
CXI Detector



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CXI 1 micron Precision Instrument Stand Requirements

- Purpose
  - Position the 1 micron Sample Chamber and Detector Stage along the unfocused or 1 micron focus beam
- Size Requirements
  - Large enough for the Sample Chamber, Detector Stage, all spacer spools and Detector Stage on upstream side
- Positioning Requirements
  - Places the 1 micron Sample Chamber 8 m downstream of mid-point of the KB mirrors
- Interface Requirements
  - 1 micron Sample Chamber
  - Detector Stage
  - Sample viewer microscope
- Controls Requirements
  - All motions remotely controlled
- Motion Requirements
  - Changing between unfocused and 1 micron beam can be achieved with a vacuum break

Motion	Range	Nominal Position	Resolution	Repeatability	Vibrational Stability	Thermal Stability
x position	-10 mm < x < 70 mm	0 mm	50 µm	50 µm	0.1 µm	20 µm
y position	-10 mm < y < 70 mm	0 mm	50 µm	50 µm	0.1 µm	20 µm
z position	-10 mm < z < 70 mm	0 mm	50 µm	50 µm	0.1 µm	20 µm
Yaw	-0.1° < yaw > 0.5°	0°	30 µrad	30 µrad	5 µrad	5 µrad
Pitch	-0.1° < pitch < 0.5°	0°	30 µrad	30 µrad	5 µrad	5 µm

Table 1: Motion requirements for the 0.1 micron Precision Instrument Stand. Translations refer to the motion of the interaction point and rotations are around the interaction point.

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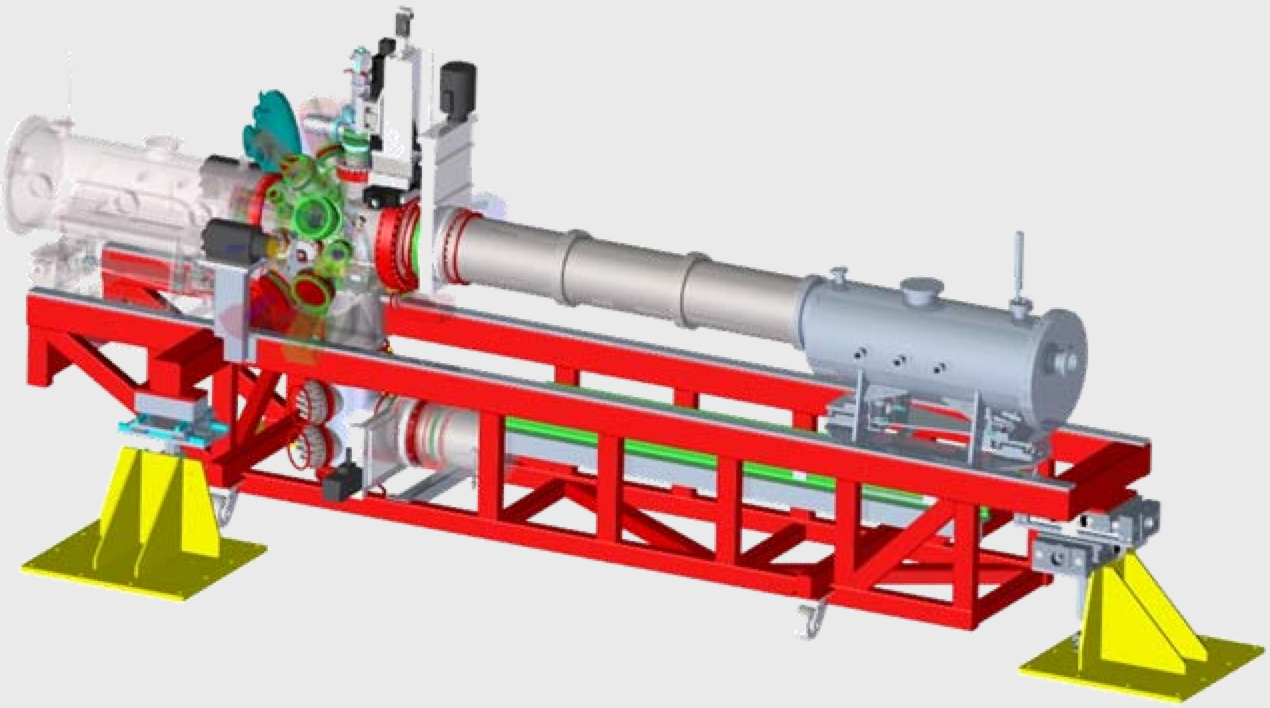
1 micron Sample Environment



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CXI 1micron Precision Instrument Stand

Bill Olson, Mechanical Engineer

Nat Stewart, Mechanical Designer

May 15, 2009

Outline

- Key documents
- Requirements
- Design Interfaces
- Preliminary Design
- Component Hardware
- System Loading
- Controls
- Safety
- Summary

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Key Applicable Documents

PRD# SP-391-000-28	Physics requirements for the CXI Detector Stage
PRD# SP-391-001-41	Physics requirements for the 1 micron CXI Sample Chamber
PRD# SP-391-001-42	Physics requirements for the 1 micron CXI Precision Stand
ESD# SP-391-000-70	CXI Detector Stage
ESD# SP-391-001-43	CXI Sample Chamber
ESD# SP-391-001-44	CXI 1 micron Precision Instrument Stand
SLAC-I-720-0A24E-001	Seismic Design Specification for Buildings, Structures, Equipment, and Systems
Et al	

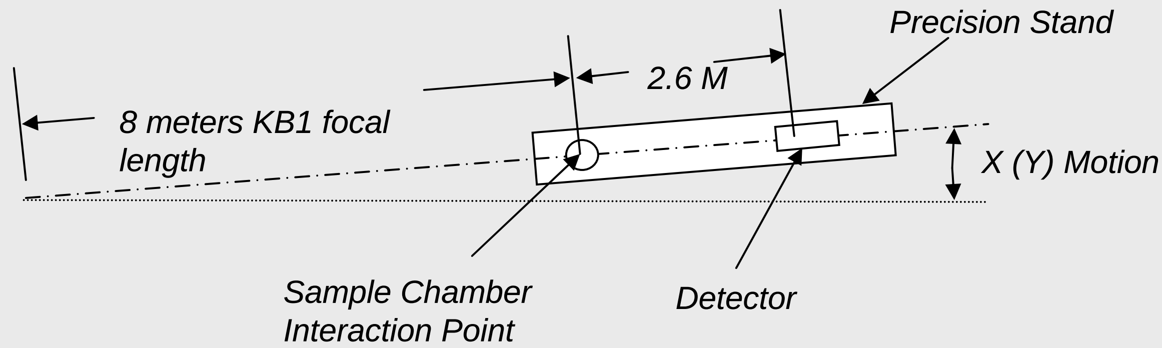
Requirements

- Requirements for the 1um Precision Instrument Stand are from SP-391-001-42 RO and SP-391-001-44 RO, with the goal of providing a stable precision positioning stand for the devices.

Motion	Range	Nominal Position	Resolution	Repeatability	Vibrational Stability	Thermal Stability
X position	-10 mm < X < 70 mm	0 mm	50 μm	50 μm	0.1 μm	20 μm
Y position	-10 mm < Y < 70 mm	0 mm	50 μm	50 μm	0.1 μm	20 μm
Z position	-10 mm < Z < 70 mm	0 mm	50 μm	50 μm	0.1 μm	20 μm
Yaw	-0.1° < Yaw < 0.5°	0°	30 μrad	30 μrad	5 μrad	5 μrad
Pitch	-0.1°< Pitch < 0.5°	0°	30 μrad	30 μrad	5 μrad	5 μrad

Requirements (2)

Design of the Precision Instrument Stand must provide a range of travel that allows for 6.8 mrad in both X and Y directions from the reflecting mirror point 8 M up-beam. The table below gives the resulting displacements for the key points of interest.



Required plus motions for 6.8 mrad in each X & Y

		Distance From Mirror		Range of Motion				Nominal
Motion	**Location**	**Inches**	**Millimeter**	**Inches**		**Millimeters**		**Position**
X	Upstream Slide	295.491	7505.5	-1 <X <	2.009	-10 <X <	51.04	0
	Sample Chamber	314.961	8000.0	-1 <X <	2.142	-10 <X <	54.40	0
	Detector Chamber	417.323	10600.0	-1 <X <	2.838	-10 <X <	72.08	0
	Downstream Slides	465.051	11812.3	-1 <X <	3.162	-10 <X <	80.32	0
Y	Upstream Slide	295.491	7505.5	-1 <Y <	2.009	-10 <Y <	51.04	0
	Sample Chamber	314.961	8000.0	-1 <Y <	2.142	-10 <Y <	54.40	0
	Detector Chamber	417.323	10600.0	-1 <Y <	2.838	-10 <Y <	72.08	0
	Downstream Slides	465.051	11812.3	-1 <Y <	3.162	-10 <Y <	80.32	0
Z	All	465.051	11812.3	-1 <Z <	2.756	-10 <Z <	70.00	0

Design Interfaces

- Sample Chamber and its auxiliaries
- Detector Stage and its auxiliaries
  - Primary location downstream of the Sample Chamber
  - Secondary location immediately upstream of the Sample Chamber
- Interconnecting Spool/Pipe supports
- Anchoring System to the Building

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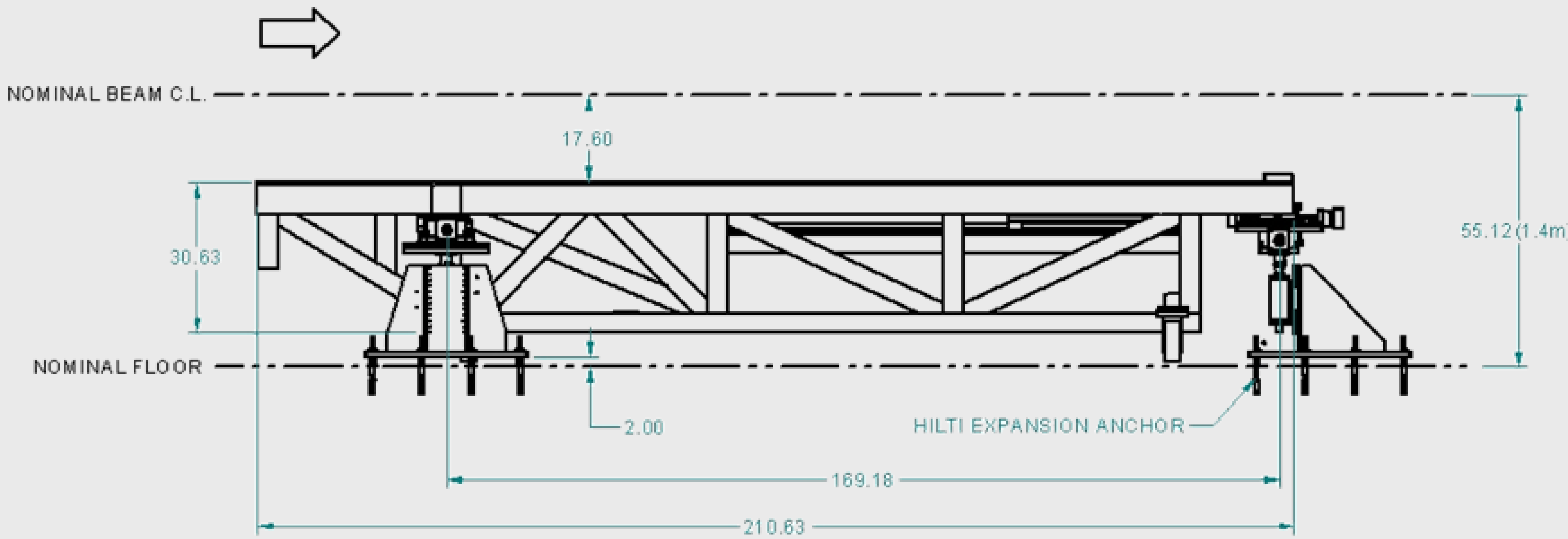
Key Dimensions

The Sample Chamber mounting surface distance from the beamline establishes the top surface of the Precision Instrument Stand.



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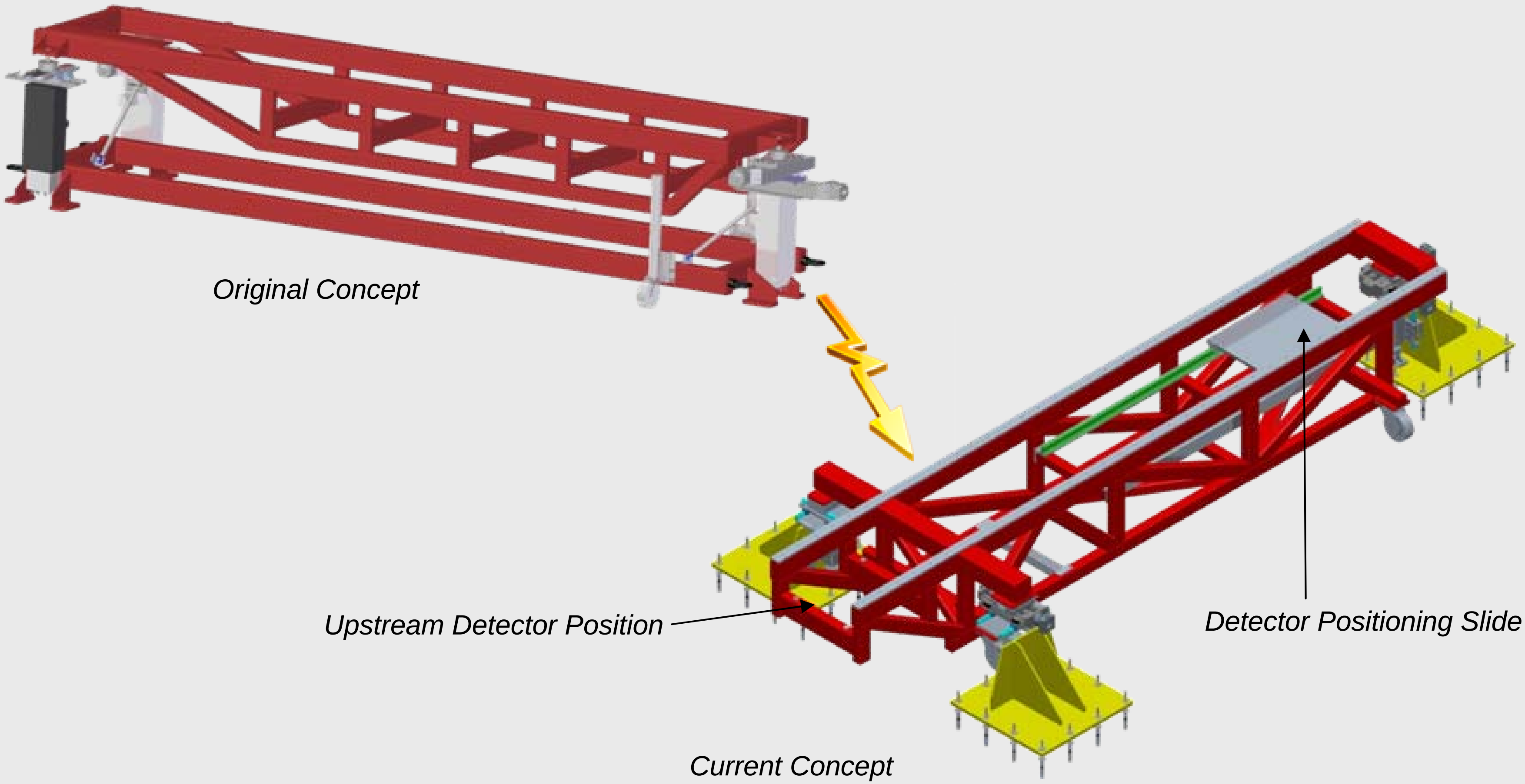
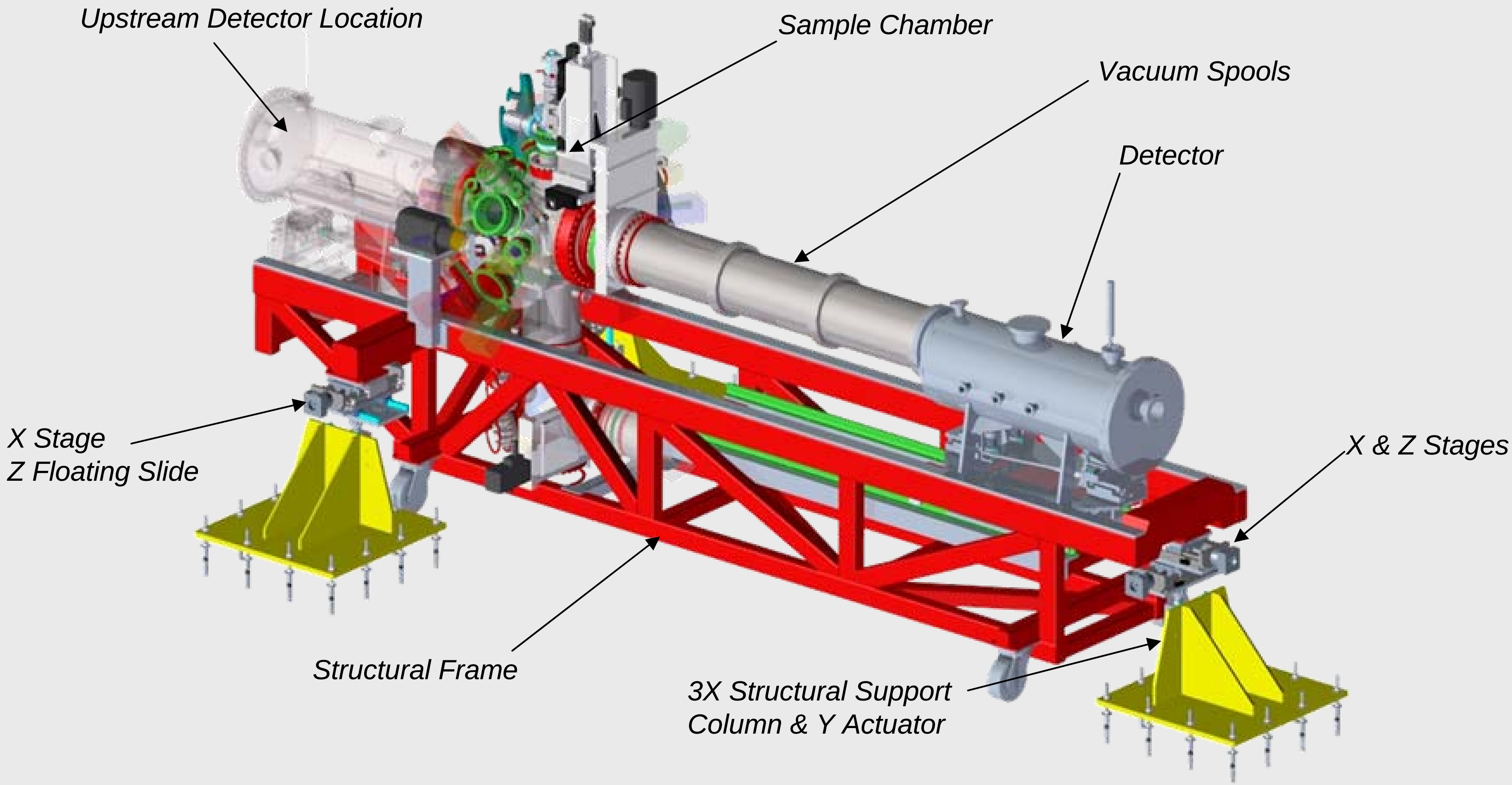
Preliminary Design

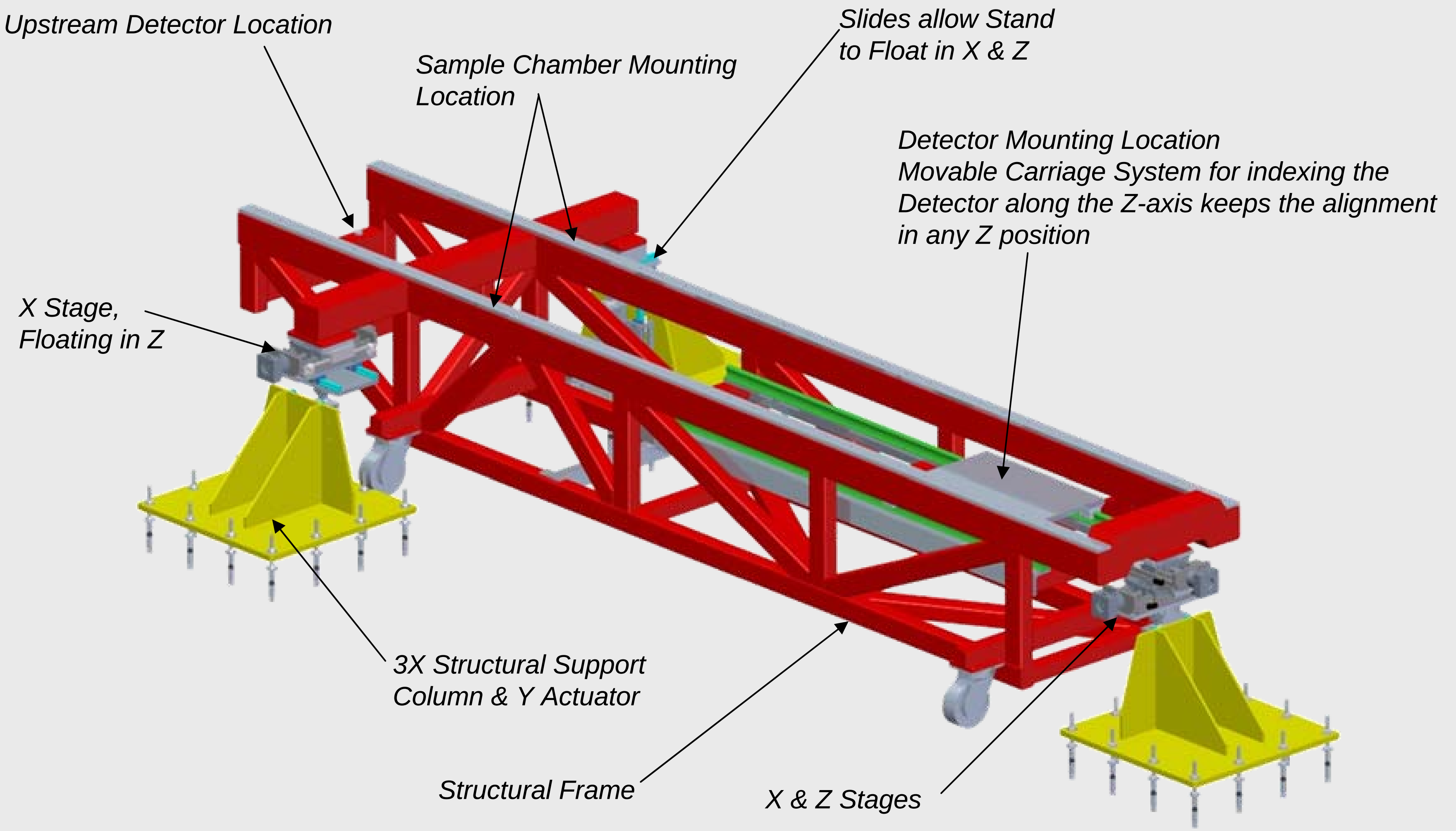
Evolution from the original concept to the current concept was necessary to accommodate increased loads, which require a more robust structural frame and higher load capacity actuators and support components. Also added to the structural frame is extended structure to support an upstream Detector position and a slide rail system to make moving the Detector in Z easier.



Precision Stand With Instruments

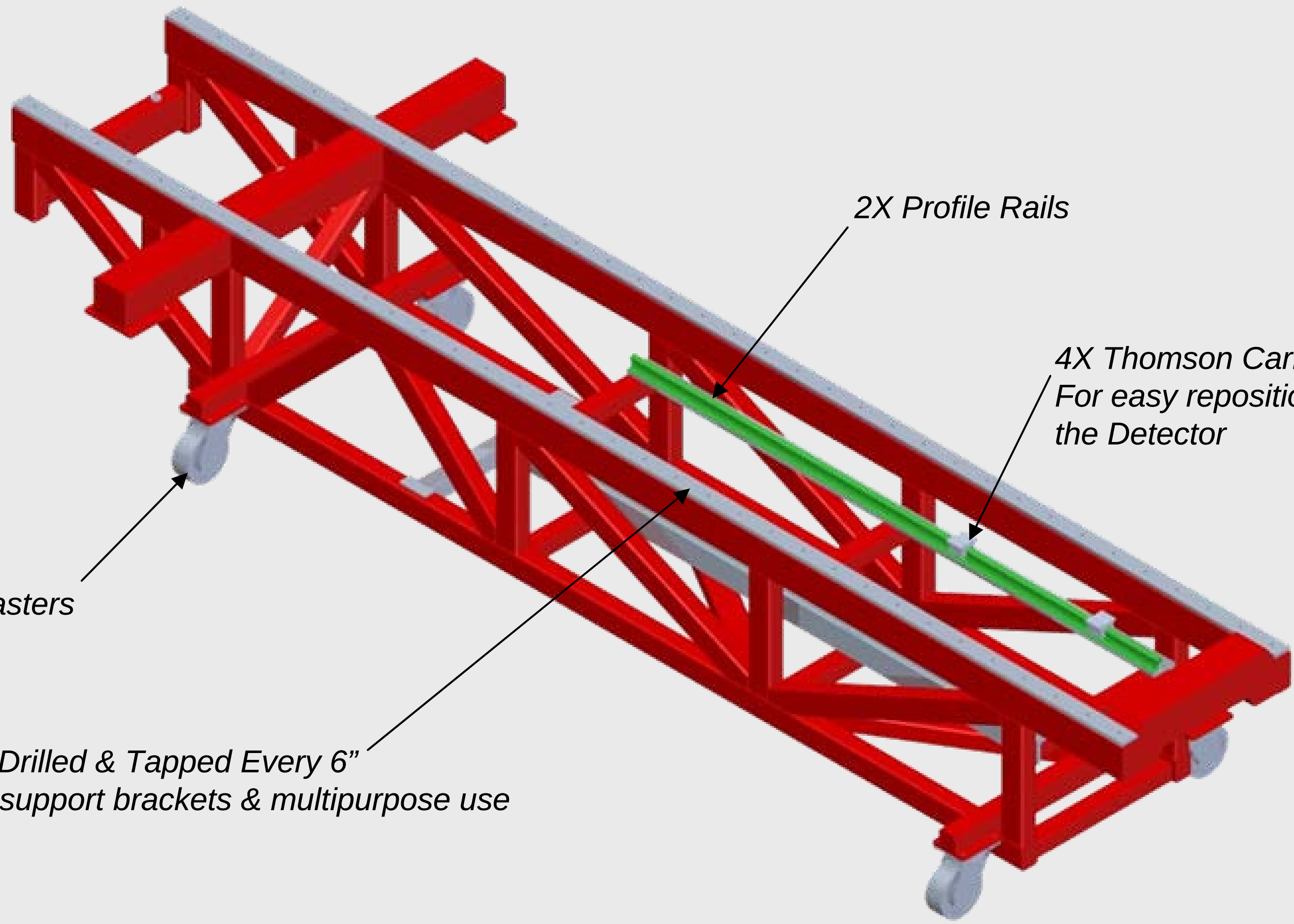


1 micron Precision Instrument Stand

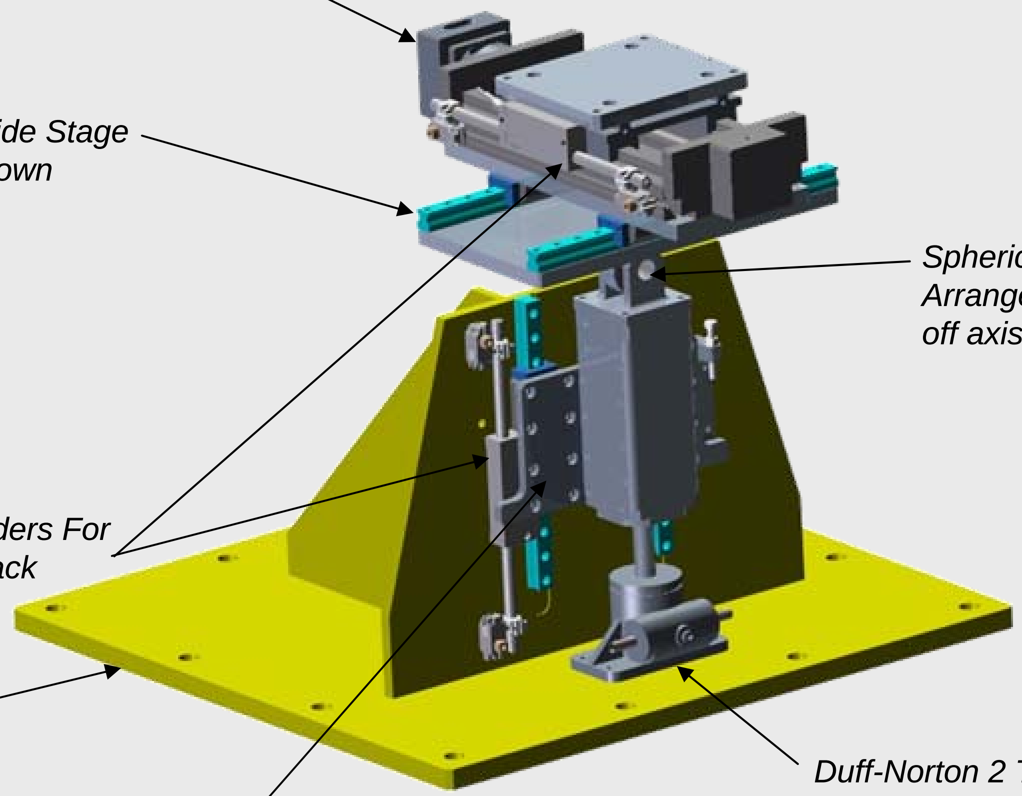


All Horizontal Stages & Slides are hard mounted to the Frame, which means Z movements can be made without moving instruments off beamline.

Precision Instrument Stand Frame



Typical Y-Support Column



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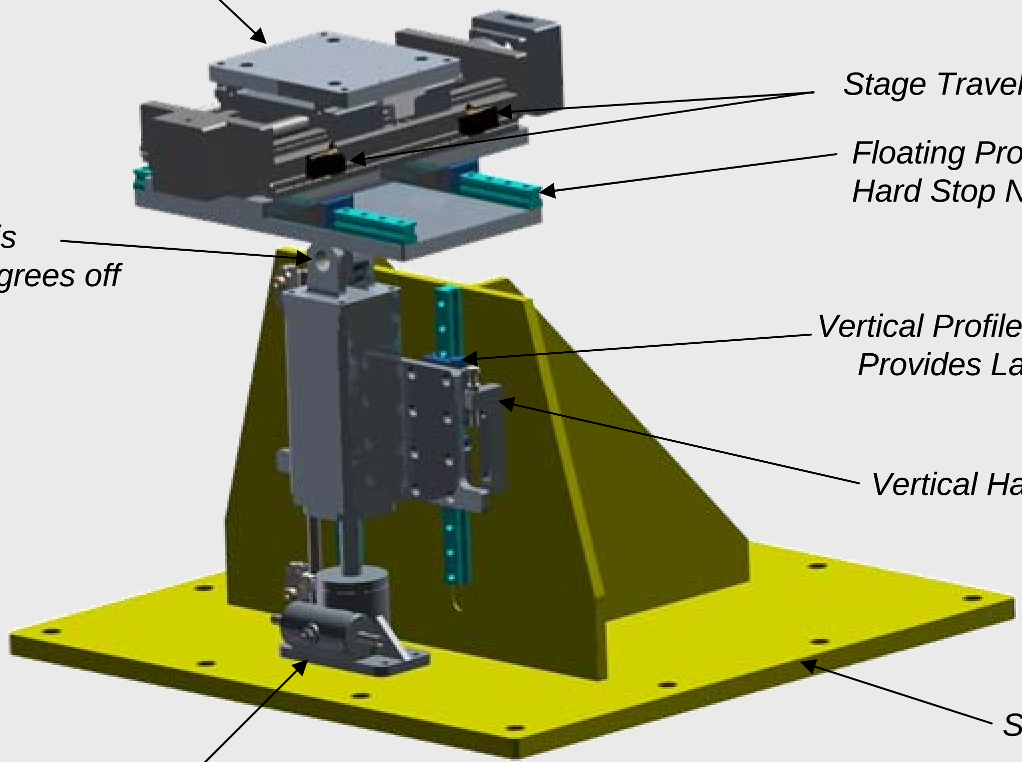
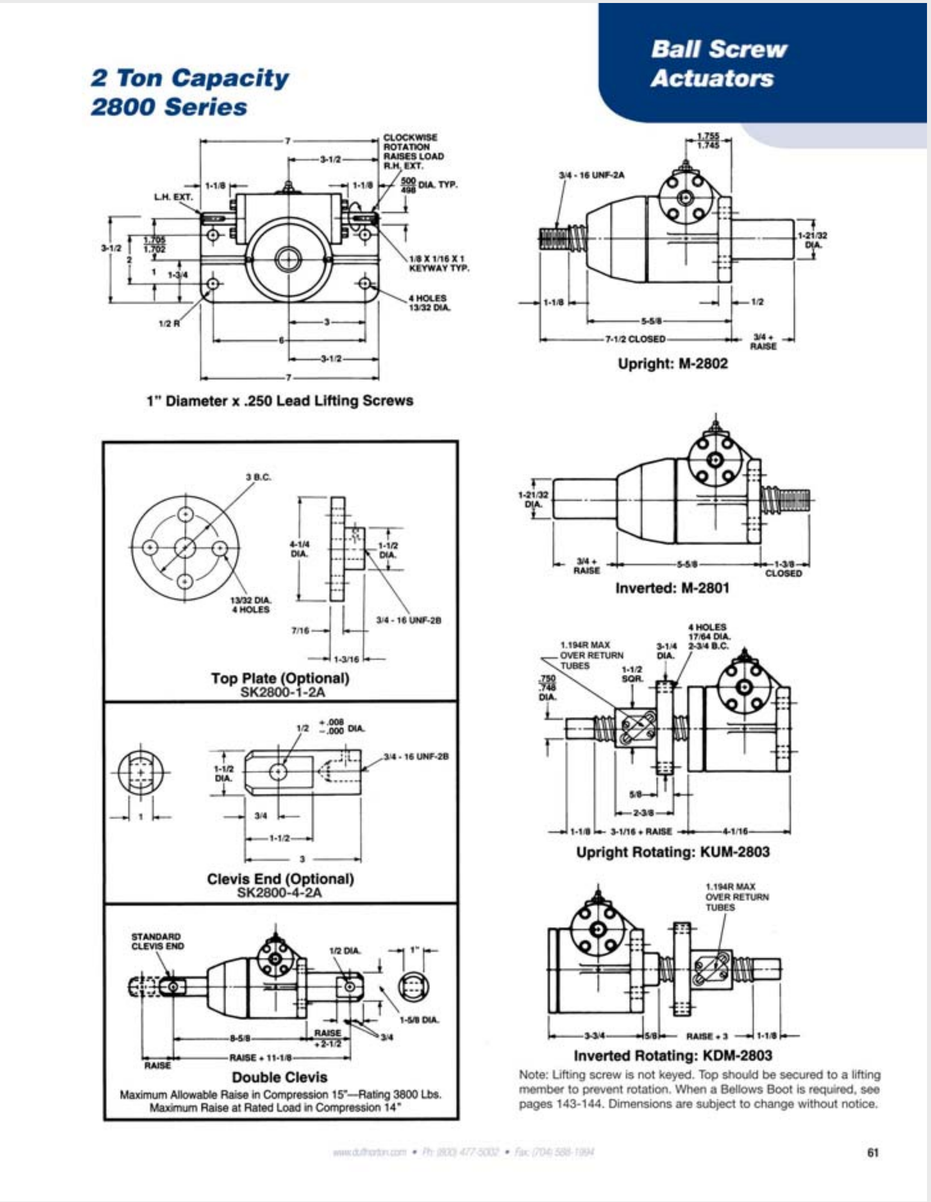
Typical Y-Support Column (2)



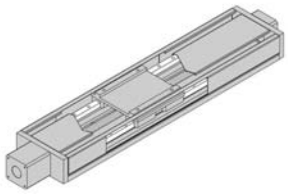
- Duff-Norton Actuator
  - Upright Rotating
  - 2 Ton Capacity
  - 0.25” Pitch Ball Screw
  - 24:1 Worm Gear Ratio
  - Full Load Torque
    - Starting: 25 in-lbs
    - Running: 20 in-lbs



Component Hardware (2)

AccuSlide* 2HB

Phone: 1-800-554-8466
Website: www.linearactuators.com



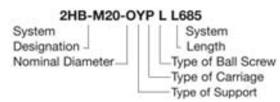
AccuSlide* 2HB
Continuously Supported ProfileRail*System,
with Carriage and Integral Ball Screw Assembly
Metric

Features
- Used in continuously supported applications that require **high** stiffness and rigidity
- Single part number is all that is required
- Equipped with high load and moment capacity AccuGlide* ProfileRail* System
- Protective shroud available with no reduction of stroke length

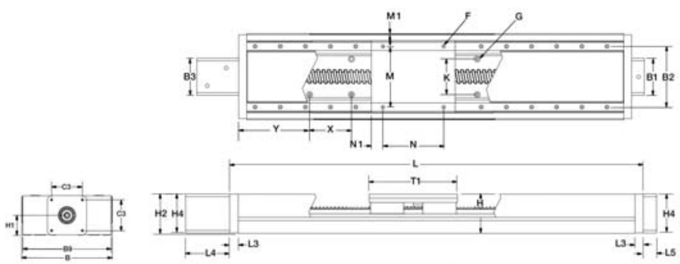
Components
- 1 double ProfileRail Assembly with T-Slots for mounting ease
- 1 carriage with 4 mounting holes
- 1 Integral Ball Screw Assembly

Specifying this Thomson System:
1. Determine the proper system for your load and life requirements.
2. Select the part number.
3. Add the letter "L" followed by the overall length in millimeters, as a suffix to the part number (choosing a standard length will reduce costs and speed delivery).
4. Place your order with your local authorized Danaher Motion distributor.

Part Numbering System

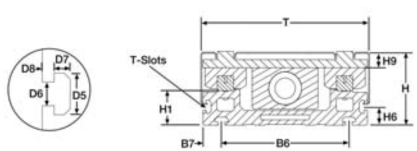


Dimensions (Metric)



Maximum Stroke Length is determined by subtracting the carriage length **(T1)** and 2 times the end block length **(L3)** from the total system length **(L)**.

Image depicts **optional** shroud cover.



Phone: 1-800-554-8466
Website: www.linearactuators.com

AccuSlide* 2HB

Metric AccuSlide 2HB ProfileRail System with Integral Ball Screw Assembly and Carriage (Dimensions in mm)

Part Number	Ball Screw (Dia. x Lead)	Accuracy mm/300mm	Repeatability	B	B1	B2	B3	B9	C3	F	G	H	H1
2HBM10OYPG	16 x 5 P	0,025	± 0,005	100	60	70	60	105	47,15	M5	M5	60	31
2HBM10OYPH	16 x 10 P	0,025	± 0,005	100	60	70	60	105	47,15	M5	M5	60	31
2HBM20OYPL	25 x 5 P	0,025	± 0,005	200	88	145	88	205	69,6	M10	M8	90	45
2HBM20OYPM	25x10 P	0,025	± 0,005	200	88	145	88	205	69,6	M10	M8	90	45
2HBM20OYPN	25x25 P	0,025	± 0,005	200	88	145	88	205	69,6	M10	M8	90	45

Metric AccuSlide 2HB ProfileRail System with Integral Ball Screw Assembly and Carriage (Dimensions in mm)

Part NumberDiameter	Nominal	D5	D6	D7	D8	B6	B7	H	H1	H6	H9	T
2HB-M10	10	10,5	6	3	2,5	70	15	60	31	15	13	100
2HB-M20	20	16,5	8,1	6	4	155	22,5	90	45	22,5	20	200

Appropriate mounting holes can be added for mounting the base of one system to the carriage of another for x–y configurations.

Metric AccuSlide 2HB ProfileRail System with Integral Ball Screw Assembly and Carriage (Dimensions in mm)

Part Number	H2	H4	K Central	M	M1	N	N1	L3	L4	L5	T1	X	Y	Max. Stroke Length Without Bellows
2HB-M10	61	60	35	70	15	70	15	12,5	70	26,5	100	75	37,5	L-125
2HB-M20	89	88	85	145	27,5	145	27,5	20	105	40	200	120	42,5	L-240

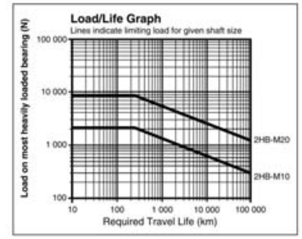
Metric System 2HB Standard Lengths (Lengths in mm)

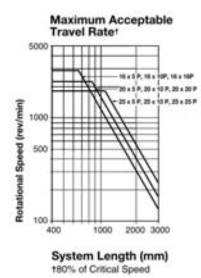
System	300	325	375	450	445	525	565	600	675	685	750	825	805	900	925	975	1045	1165	1285	1405	X	MAX
2HB-M10	■		■	■		■		■	■		■	■		■		■					75	1500
2HB-M20		■			■		■			■			■		■		■	■	■	■	120	3000

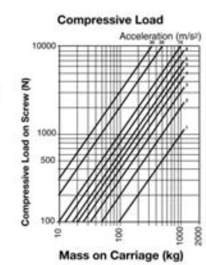
For Motion Control Options refer to the Motion Control Section on page B-66.
For Motor Coupling specifications, see page B-56.
For Bellows Way Covers, see page B-52.
For Limit Switch Packages, see pages B-63.
For Radial Mount Ball Screw Shaft Extenders, see page B-58.
For Spring Set electric brakes, see page B-62.
For TNUT mounting hardware, see page B-59.

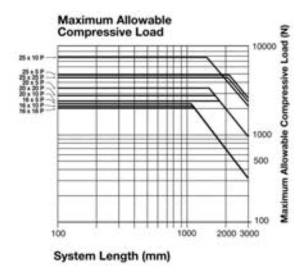
Custom Lengths

Custom length systems are available. Lengths exceeding MAX length will require butt joints. For special requirements, please contact the Danaher Motion Systems application engineering department.







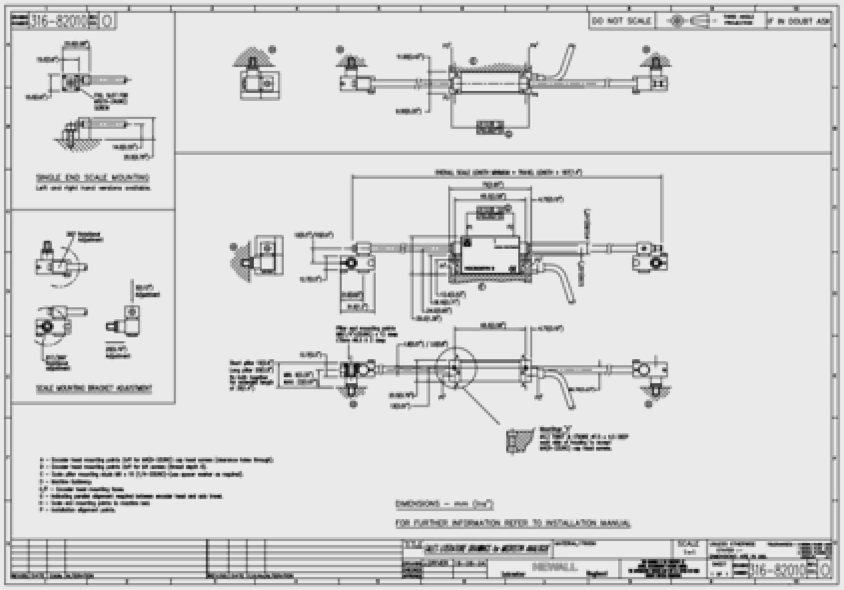


The AccuSlide has a pre-designed **Maximum Acceptable Travel Rate**. Calculate maximum rotational speed (rpm) by dividing your required maximum linear speed (m/s) by the corresponding system ball screw lead (m/rev). Enter the chart with the required system length and your maximum rotational speed. Select the system with a maximum acceptable travel rate curve above the plotted line.
Compressive load on the ball screw is a key factor in selecting the proper System. Using maximum load and acceleration requirements, plot compressive load on the left side of the chart. Using System length and compressive load, plot the maximum allowable compressive force on the right chart. Select the System with a rated maximum compressive force above your plotted point. If you have questions concerning your system requirements, contact the Thomson **Systems** application engineering department.

Note: Ball screw should never exceed recommended critical speed.

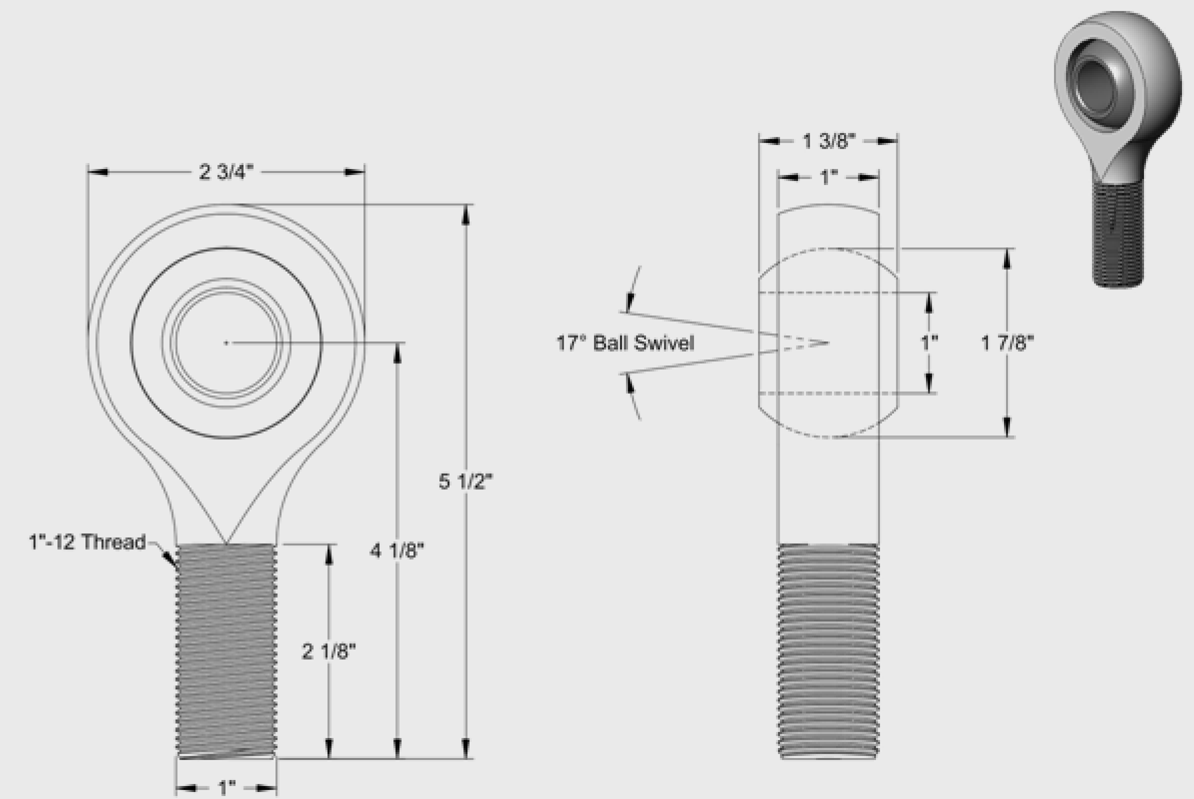
Component Hardware (3)

Newall Absolute SHG-A2 Linear Encoder



Specifications	
Output Signal	RS232
Accuracy/Meter	±0.0004", ±0.0002", ±0.0001"(±10µm, ±5µm, ±3µm)
Resolutions	10µm, 5µm, 1µm or 0.5µm
Scale Travels	4" to 137.8" (102mm to 3.5m)
Scale Diameter	0.601" (15.25mm)
Reader Head Dimensions	2.05"H x 5.16"L x 1.10"D (52mm x 131mm x 28mm)
Reference Marker	n/a
Maximum Traverse Rate	n/a
Power Supply	5VDC ±5%, <350mA
Shock (11ms)	100g (IEC 69-2-6)
Vibration (55-2000Hz)	30g (IEC 68-2-27)
Sample Period	50µs
Environmental Rating	**IP67, fully submersible (IEC 529) - Exceeds NEMA 6**
Operating Temperature	32° to 131°F (0° to 55°C)
Coefficient of Expansion	12 x 10^{-6}K
Scale Material	316 stainless steel
Overall Scale Length	Scale travel length + 10.2" (258mm)
Standard Cable	15 core, 11.5' (3.5m) armored
Maximum Cable Length	65.6' (20m)
Standard Connector	15 pin "D" type
EMC Compliance	BS EN 61000-6-2 and BS EN 61000-6-4
Options	
Resolutions	Custom resolutions available
Non-Armored Cable	PUR (polyurethane)
Connectors	• Honda PCR-E20FS (Fanuc)
	• IP67 (NEMA 6)
	• None (flying lead)
Cable Lengths	22' (7m) or 19.68" (0.5m)

Rod End



Notes:
Zinc-Plated Steel Housing
Chrome-Plated Steel Ball with Heat-Treated Stainless Steel Race

McMASTER-CARR CAD
PART NUMBER 60645K621
http://www.mcmaster.com
© 2005 McMaster-Carr Supply Company
Right-Hand Thread
Ball Joint Rod End
Unless otherwise specified, dimensions are in inches. Information in this drawing is provided for reference only.

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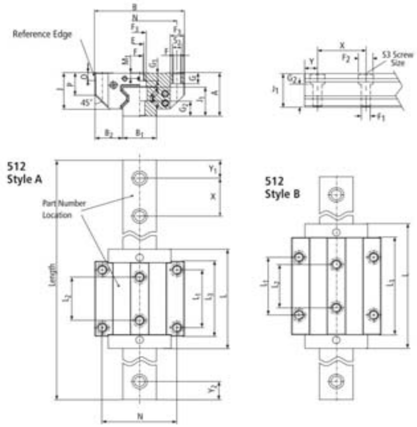
Thomson 512 Slides

500 Series Roller

512 Style A and B



512 Style A – Standard Roller

Size	Dimensions (mm) A	B	B_1* ±0.05	B_2	J	J_1	L	L_1	L_2	L_3	X	N	S	S_3	F	F_1	F_2	F_3	Roller Ø	G	G_1	G_2	M_1	O	P
25	36	70	23	23.5	29.5	24.5	81	45	40	60	30	57	M8	M6	6.8	7	11	11	3.2	9	6.5	13	5.5	7.5	17.5
35	48	100	34	33	40	32	109	62	52	80	40	82	M10	M8	8.5	9	15	15	4.5	12	10	15	7	8	23
45	60	120	45	37.5	50	40	137.5	80	60	104	52.5	100	M12	M12	10.5	14	20	18	5	15	11	21	8	10	30.5
55	70	140	53	43.5	57	48	163.5	95	70	120	60	116	M14	M14	12.5	16	24	20	6	18	13.5	26	9	12	34.5

512 Style B – Standard Long Roller

Size	Dimensions (mm) A	B	B_1* ±0.05	B_2	J	J_1	L	L_1	L_2	L_3	X	N	S_2	S_3	F	F_1	F_2	F_3	Roller Ø	G	G_1	G_2	M_1	O	P
25	36	70	23	23.5	29.5	24.5	103.4	45	40	79.4	30	57	M8	M6	6.8	7	11	11	3.2	9	6.5	13	5.5	7.5	17.5
35	48	100	34	33	40	32	136	62	52	103	40	82	M10	M8	8.5	9	15	15	4.5	12	10	15	7	8	23
45	60	120	45	37.5	50	40	172.5	80	60	135	52.5	100	M12	M12	10.5	14	20	18	5	15	11	21	8	10	30.5
55	70	140	53	43.5	57	48	205.5	95	70	162	60	116	M14	M14	12.5	16	24	20	6	18	13.5	26	9	12	34.5
65	90	170	63	53.5	76	58	251	110	82	201	75	142	M16	M16	14.5	18	26	23	7	23	19	32	13	15	51

* Standard tolerance shown, special lower tolerances are available upon request. Please consult application engineering for additional information.

** When using additional modular seals or lubrication plates, the total length L will increase. Consult page 61-62 for additional information.

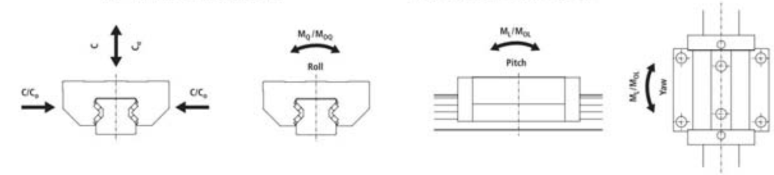
Length of rail to be specified at time of order, $Y_1 = Y_2$ unless specified otherwise at time of order.

500 Series Roller

512 Style A and B

Dynamic Load and Moment Ratings
C = Dynamic load rating
M_L = Dynamic pitch and yaw moment rating
M_Q = Dynamic roll moment rating

Static Load and Moment Capacities
C_0 = Static load capacity
M_{0L} = Static pitch and yaw moment capacity
M_Q = Static roll moment capacity



Size & Style	Loading Capabilities Co (N)	C (N)	Moments M_{0Q} (Nm)	M_Q (Nm)	M_{0L} (Nm)	M_L (Nm)	Weights Carriage (kg)	Rail (kg/m)
25A	49800	27700	733	408	476	265	0.7	
25B	70300	39100	1035	576	936	521	0.9	3.4
35A	93400	52000	2008	1118	1189	662	1.6	
35B	128500	71500	2762	1537	2214	1232	2.2	6.5
45A	167500	93400	4621	2577	2790	1556	3.2	
45B	229500	127800	6333	3527	5161	2874	4.3	10.7
55A	237000	131900	7771	4325	4738	2637	5.0	
55B	324000	180500	10624	5919	8745	4872	6.8	15.2
65B	530000	295000	20912	11640	17930	9980	13.5	22.5

1. The dynamic load and moment ratings are based upon 100 km travel life. When comparing these load ratings with other bearings take into consideration that some manufacturers dynamic and moment ratings are based on 50 km travel life. In order to compare with bearing dynamic and moment ratings based on 50 km travel life, divide the dynamic capacity of the bearing rated for 50 km by 1.23 to get an accurate comparison.

2. The static load and moment rating are the maximum radial load and moment load that should be applied to the bearing while there is no relative motion between the carriage and rail.

Bearing Travel Life Comparison

$L = (C/F)^3 \times 100km$
where:
L = travel life, km
C = dynamic load rating, N
F = applied dynamic load, N

$C_{min} = F\left(\frac{L}{100}\right)^{1/3}$
where:
C_{min} = minimum required dynamic load rating, N
F = applied dynamic load, N
L = required travel life, km

Operating Parameters:
Maximum Velocity: 3 m/s
Maximum Acceleration: 50 m/s²
Temperature:
Min: – 40° C
Max: 80° C
Max peak: 120° C short time*
*without bellows

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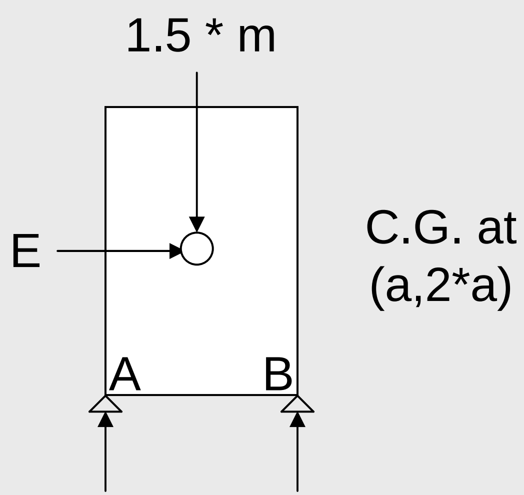
System Loading

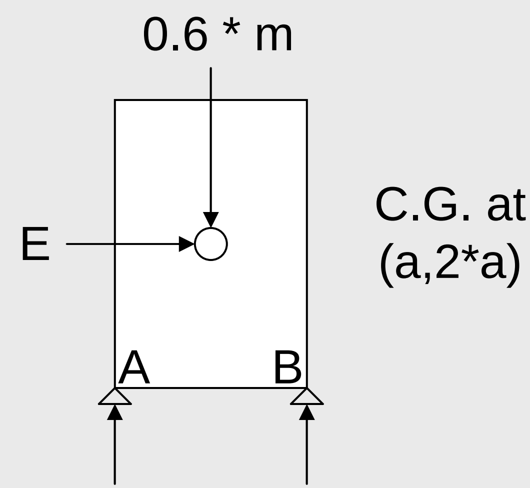
System loading is determined by calculating the center of gravity (cg) of the Frame with instruments for loads on the horizontal actuators/slides and then calculating the cg for the whole Precision Stand system for the loads on the vertical actuators at floor level. Seismic loads were then calculated per SLAC-I-720-0S24E-001 and SLAC Seismic Design Standard-26Sep08 by S. DeBarger. Results are tabularized below with the basic seismic formulae from the SLAC Seismic Standard shown on the next page. The actual calculations required modifications to the formulae shown for the uniqueness of the Precision Stand. The modifications to the formulae were made to transfer the torsional moment at the downstream support to the upstream supports.

	Detector Downstream Configuration				**Front (upstream) Detector Configuration**			
		Seismic				**Seismic**		
Location	**Static Pounds**	**Vertical 1.5m**		**Horizontal 0.7*Ws**	**Static Pounds**	**Vertical 1.5m**		**Horizontal 0.7*Ws**
Downstream Horizontal Slides	2,223	3,335		4,281	1,119	1,678		3,990
Downstream Vertical Actuator	3,150	4,725		5,443	2,044	3,065		5,152
		1.5m+E	**0.6m+E**	**0.7m**		**1.5m+E**	**0.6m+E**	
Upstream Horizontal Slides								
Right	1,860	1,913	239	0	2,185	4,021	568	0
Left	2,032	3,925	342	2,724	2,396	4,337	695	3,207
Upstream Vertical Actuators								
Right	2,410	6,003	-942	0	2,742	6,452	-694	0
Left	2,575	6,251	-843	3,490	2,935	6,741	-579	3,974

All values in pounds

When is 0.6 * Dead Load More Demanding than 1.5 * Dead Load?





Consider an element of mass m, length 2*a and height 4*a

$$E = 0.7 * m$$
$$\Sigma M \quad E*2*a+1.5*m*a-F_{by}*2*a=0$$
$$0.7*m*2*a+1.5*m*a-F_{by}*2*a=0$$
$$1.4*m*a+1.5*m*a=2*F_{by}*a$$
$$2.9*m=2*F_{by}$$
$$1.45*m=F_{by}$$
$$\Sigma F \quad 1.5*m - F_{by}-F_{ay}=0$$
$$1.5*m - 1.45*m=F_{ay} \quad 0.05*m=F_{ay}$$

Consider an element of mass m, length 2*a and height 4*a

$$E = 0.7 * m$$
$$\Sigma M \quad E*2*a+0.6*m*a-F_{by}*2*a=0$$
$$0.7*m*2*a+0.6*m*a-F_{by}*2*a=0$$
$$1.4*m*a+0.6*m*a=2*F_{by}*a$$
$$2.0*m=2*F_{by}$$
$$m=F_{by}$$
$$\Sigma F \quad 0.6*m - F_{by}-F_{ay}=0$$
$$0.6*m - m=F_{ay} \quad -0.4*m=F_{ay}$$

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Structural Frame Safety Factors

Calculations were made on a conservative basis.

•Loads were rounded up to the next 100 pounds

•Simply supported ends instead of fixed ends were used for the cross beam at the downstream vertical support

•The reaction load at the upstream actuators was used at both the Sample Chamber and Detector locations, but averaged to be equidistant from Frame supports

Item	Tensile Yield Psi	Stress Psi	Safety Factor On Yield	Deflection	
				Inch	Millimeter
Frame Bending	46,000	711	64.7	0.0043	0.110
Outriggers, Upstream Support	46,000	2,946	15.6	0.0030	0.076
Cantilever, Downstream Support	46,000	3,112	14.8	0.0030	0.077
Cross Beam, Downstream Support	36,000	1,004	35.9	0.0006	0.016

Controls

- Controls issues are being addressed in partnership with the Controls Group
- IMS stepper motors will be used to drive slides/actuators
  - To ensure commonality within LUSI
- Encoder feedback to remote control system
- Limit switches on driven components

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Safety

- Corners and sharp edges will be radiused or chamfered where possible
- Safety covers will be used on moving elements to prevent “pinch-hazards”
- Limit switches will be provided on all driven hardware, as well as hard stops on driven and non-driven components
- To comply with OSHA/DOE regulations, all electronics will have certification either through a National Recognized Testing Laboratory (NRTL) or the Authority Having Jurisdiction (AHJ) as per the SLAC Electrical Equipment Inspection Program

Summary

- Precision Stand preliminary design is well advanced
- Controls issues are being addressed in partnership with the Controls Group
- Interfaces are closely coordinated with respective design teams
- To Do list
  - Finalize the structural support and floor anchor design
  - Final interface adjustments/modifications
  - Develop an alignment plan
  - Detail the control system in partnership with the Controls Group
  - Seismic peer review
  - Seismic committee approval
- Design ready to advance to final design

Preliminary Design Review of the CXI Detector Stage

15 MAY 2009

Pegasus Design, Inc.
608-D Main St.
Pleasanton, CA 94566
925/426-2386
www.pegasus-design.com

Pegasus Design, Inc.

The Starting Point

INITIAL CONCEPTUAL DESIGN: (developed at SLAC)

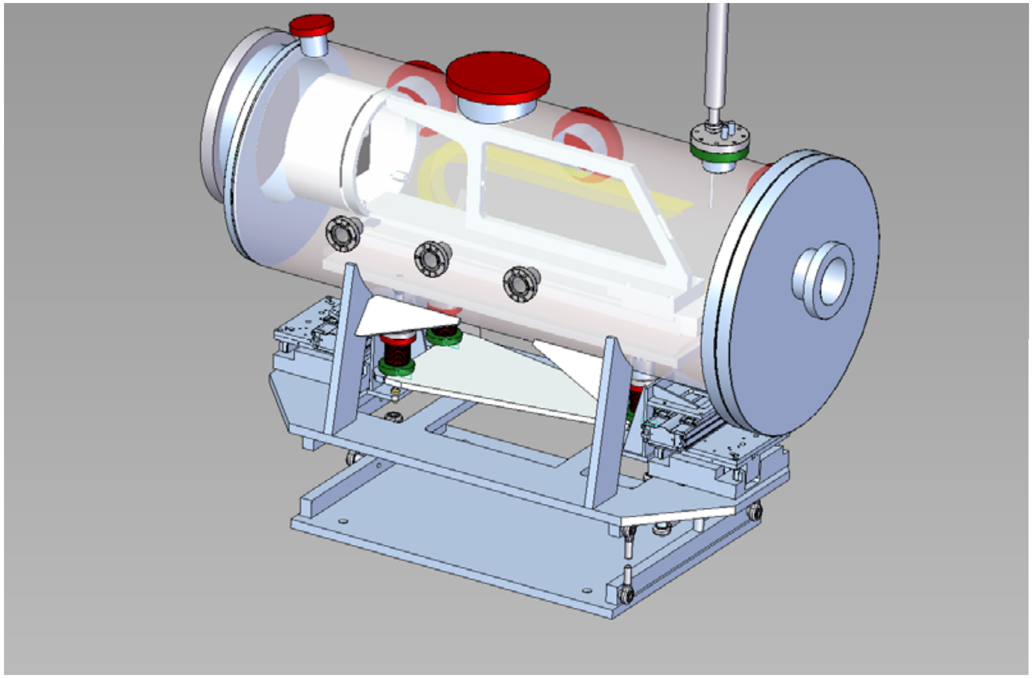


FIGURE-1

Here we see the initial conceptual design developed at SLAC. It uses paired lift-table/translation stage sub-assemblies to provide X,Y, pitch & yaw motions for fine adjustment. Coarse adjustment of the vacuum chamber is by the familiar six-strut rod-end adjustment system. The detector assembly moves in the Z-axis by means of a long-travel stage in the chamber.

INITIAL CONCEPTUAL DESIGN: (continued)

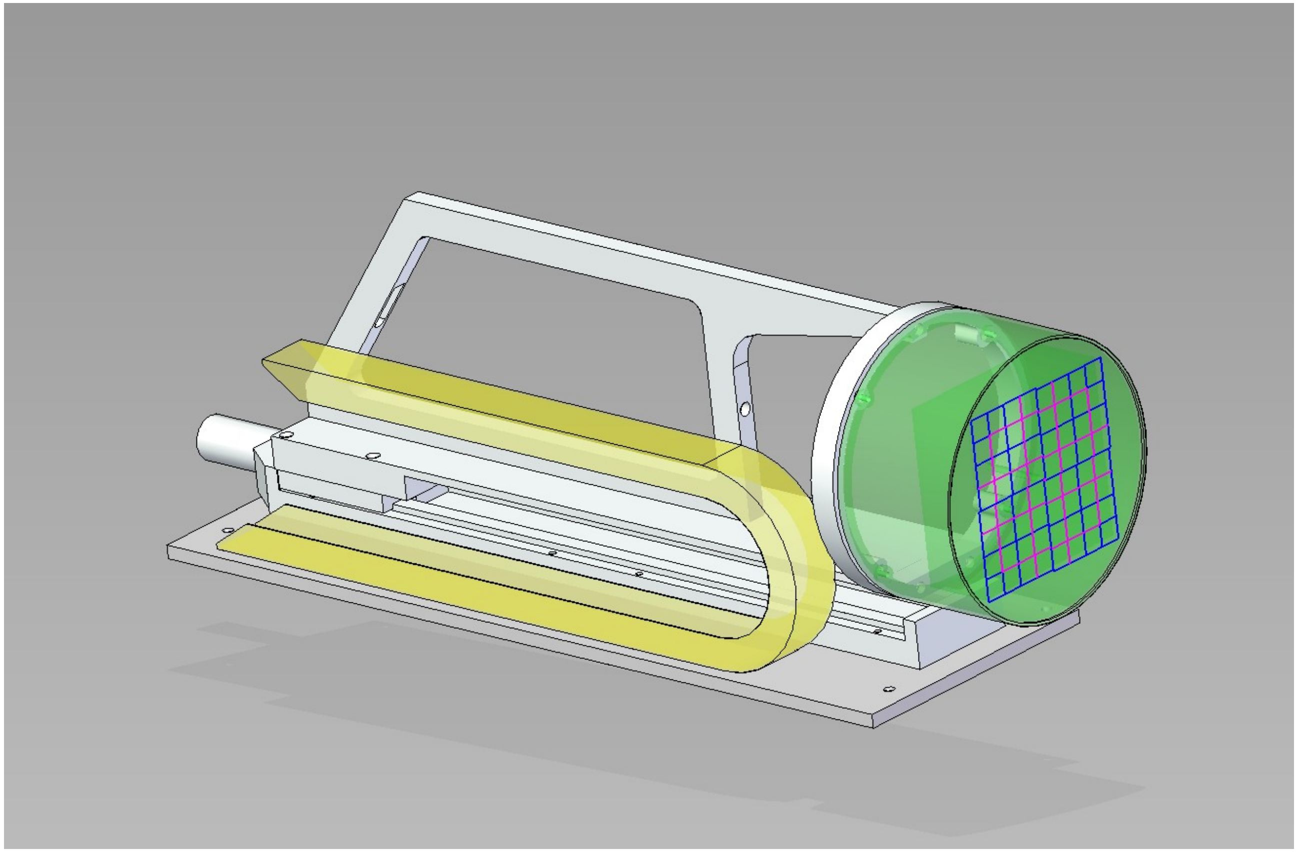


FIGURE-2

This early-stage conceptual design helped define the problem of moving the 25-pound detector assembly by pointing the way to the use of a MICOS Long Travel stage.

INITIAL CONCEPTUAL DESIGN: (continued)

From our study of the initial concept, we learned the major problem to solve is the stability of the ‘optical bench’. As you can see in this illustration, the legs look long and spindly. Couple that with the 25-pound detector and its’ 2-foot cantilever, and you can imagine how the weight of the detector will be trying to lift the single leg out of its’ kinematic mounting socket.

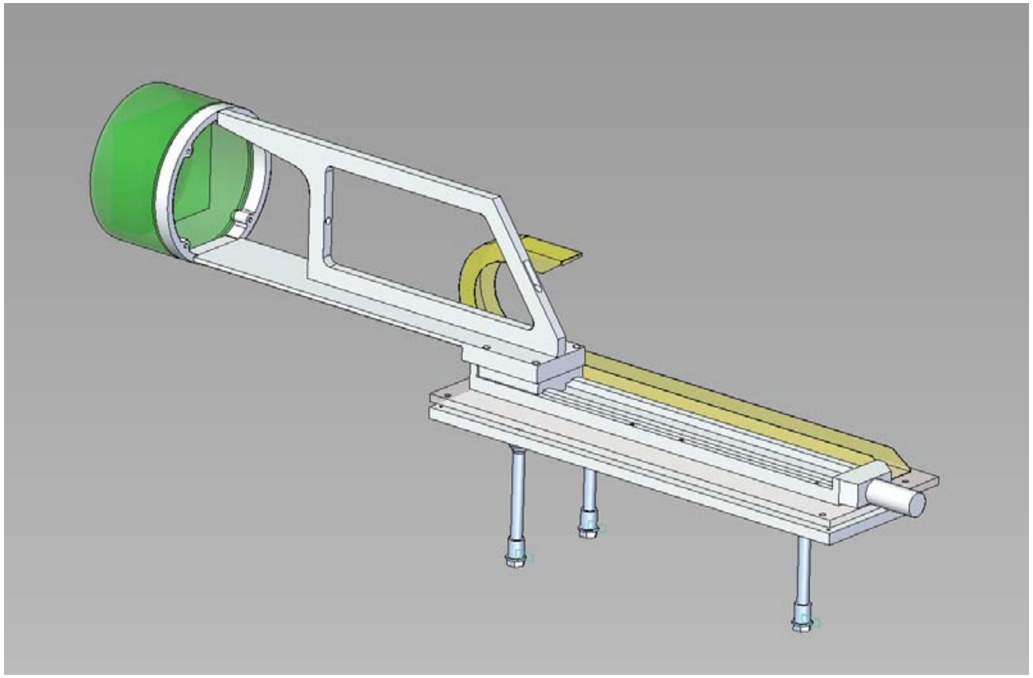


FIGURE-3

Pegasus Design, Inc.

INITIAL CONCEPTUAL DESIGN: (continued)

This simplified representation shows how the structure might react to lateral loads. It’s resonant frequency is about 28-hertz*

*Double click the illustration to see the flexural response:

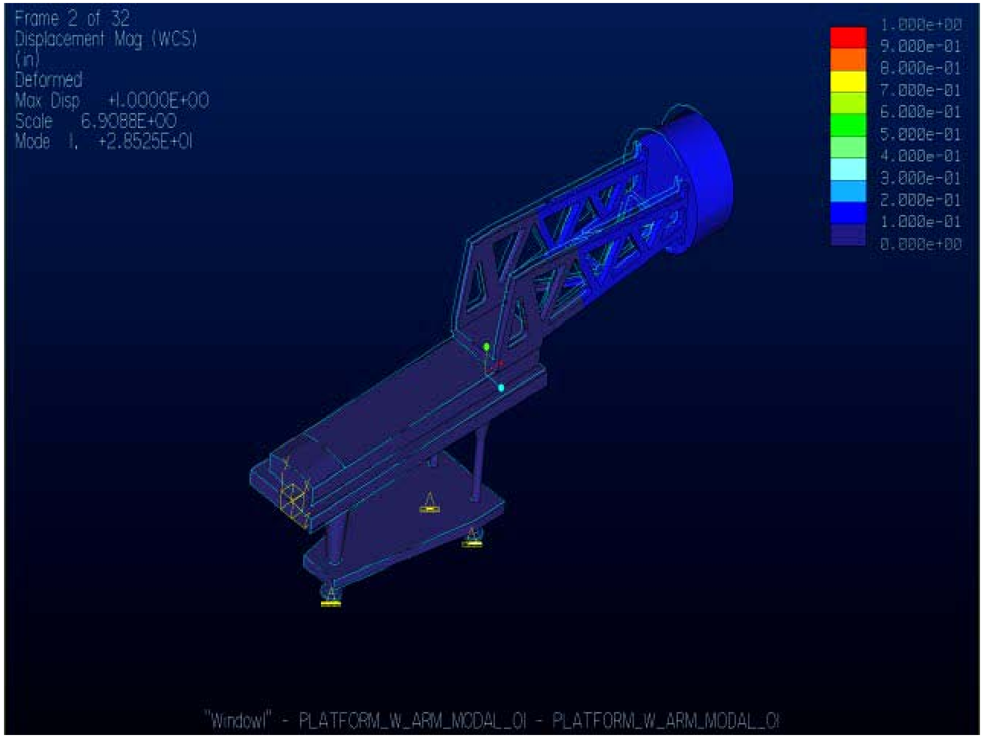


FIGURE-4

Pegasus Design, Inc.

INITIAL CONCEPTUAL DESIGN: (continued)

The kinematic mounts as shown in the initial concept appear to be overloaded with regard to the Hertz contact stresses. The detector assembly with translation stage and all it's accoutrements could weigh at least 100-pounds. A seismic restraining system is needed as well.

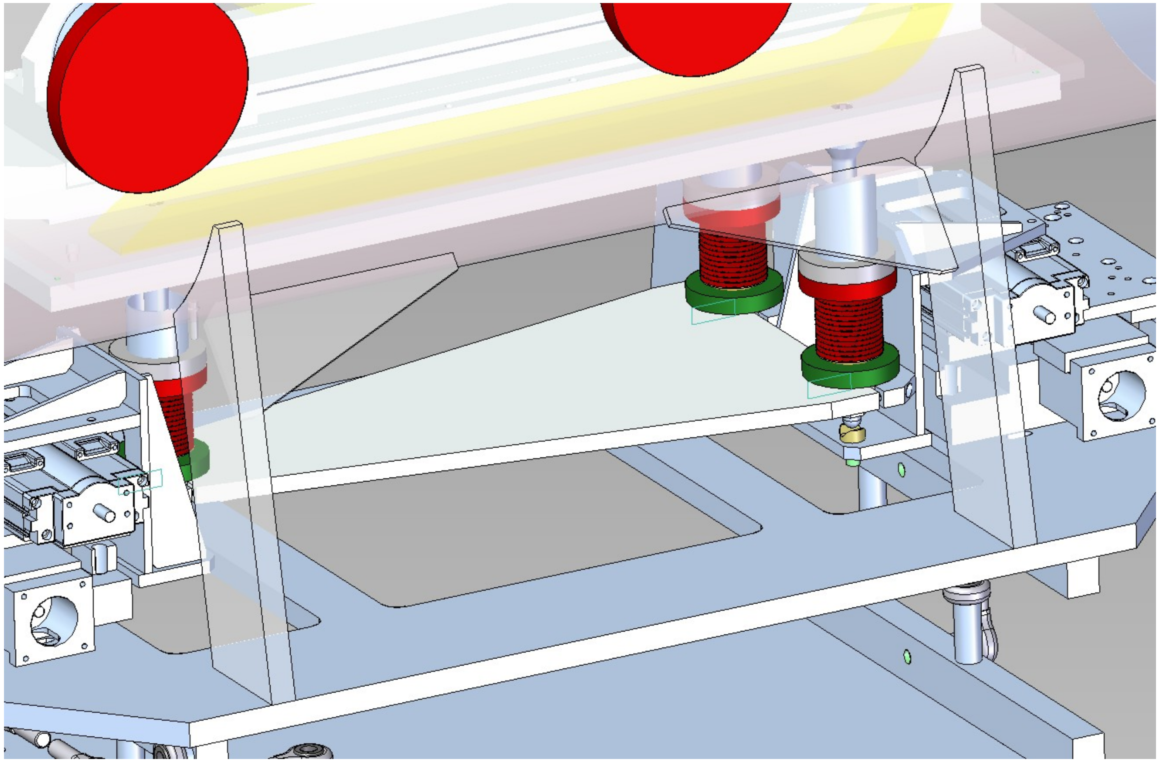
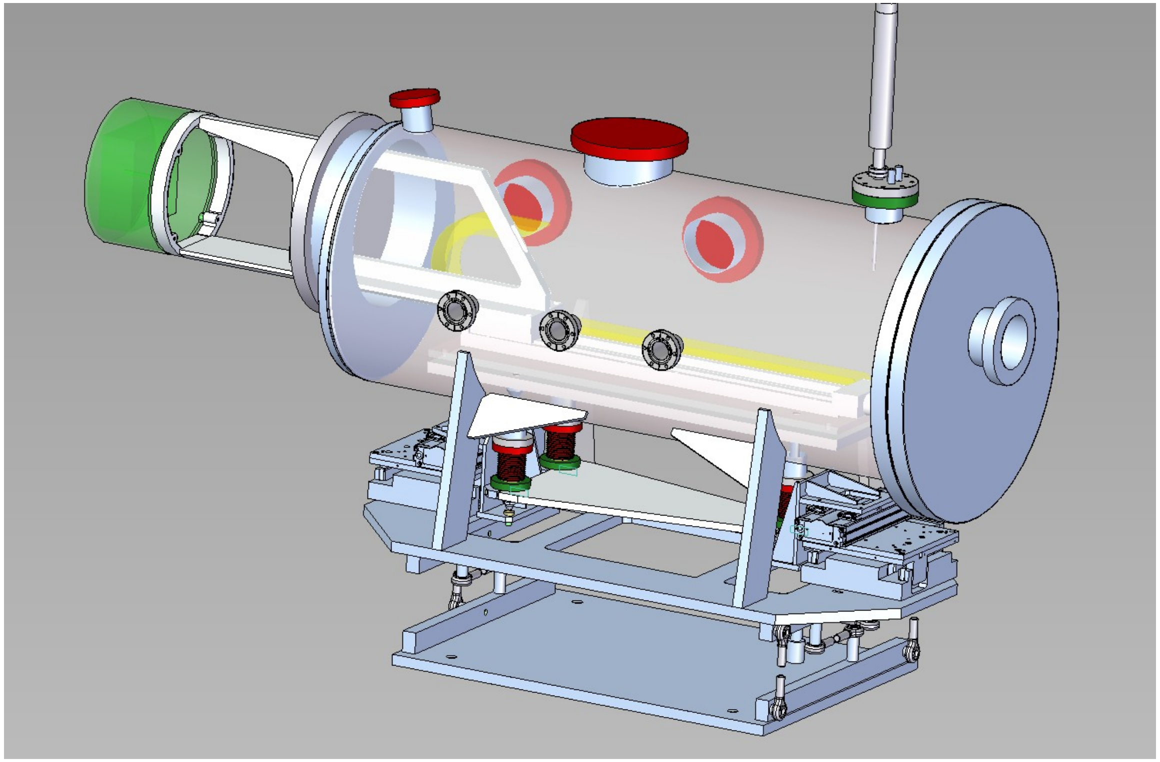


FIGURE-5

INITIAL CONCEPTUAL DESIGN: (continued)

Another significant problem comes from having the center-of-gravity of the detector above the two lift-tables. When you consider the 45-arc-sec pitch/roll tolerance of the lift-tables, the detector can roll to either side by about +/- 80 microns.

FIGURE-6



INITIAL CONCEPTUAL DESIGN: (continued)

The performance specification calls for a travel range in Pitch/Yaw of +/- 20 mrad (approximately +/- 1-degree). The bellows manufacturers warn users not to put twist in the bellows, but when pressed for data, they admit to allowing about +/- 0.5-degrees.

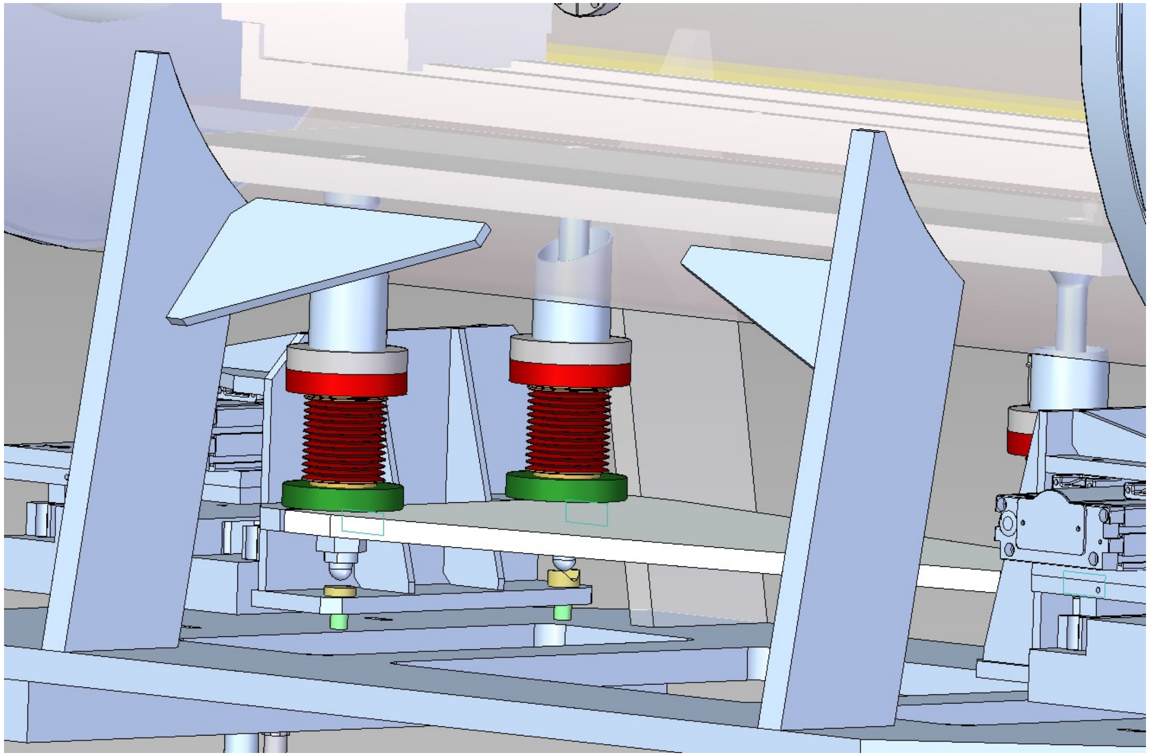


FIGURE-7

INITIAL CONCEPTUAL DESIGN: (continued)

Another design requirement is to route the water cooling lines in a water-containment system. The concept shown below had two .25-inch lines running through a 1.50-inch ID hose with 2.75-inch conflat flanges on each end. The 1.91-inch OD and dynamic bend radius of 11.81-inches meant that the bellows hose would not fit in the 18-inch diameter chamber.

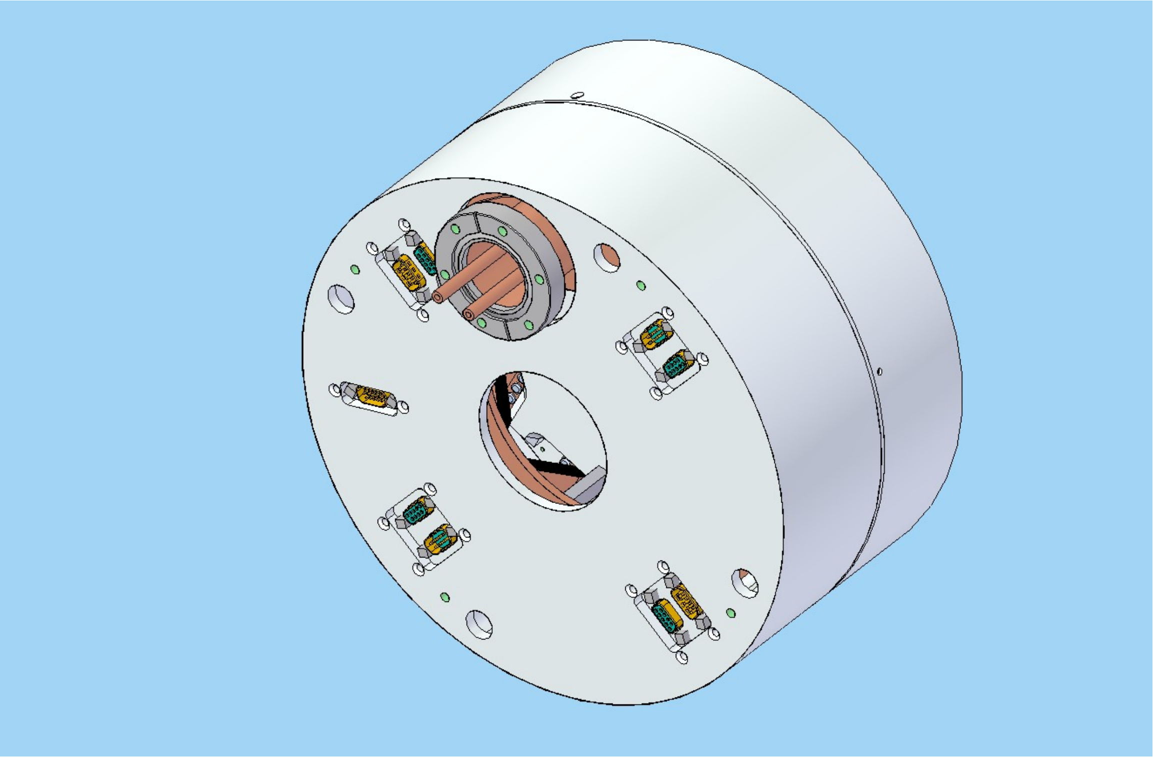


FIGURE-8

DESIGN ISSUES TO RESOLVE:

The initial detector design was 10-inches in diameter. It is now 11.25-inches in diameter. There now exists only .25-inch radial clearance around the detector. The 12-inch gate valve (with 11.75-inch bore) is the limiting factor.

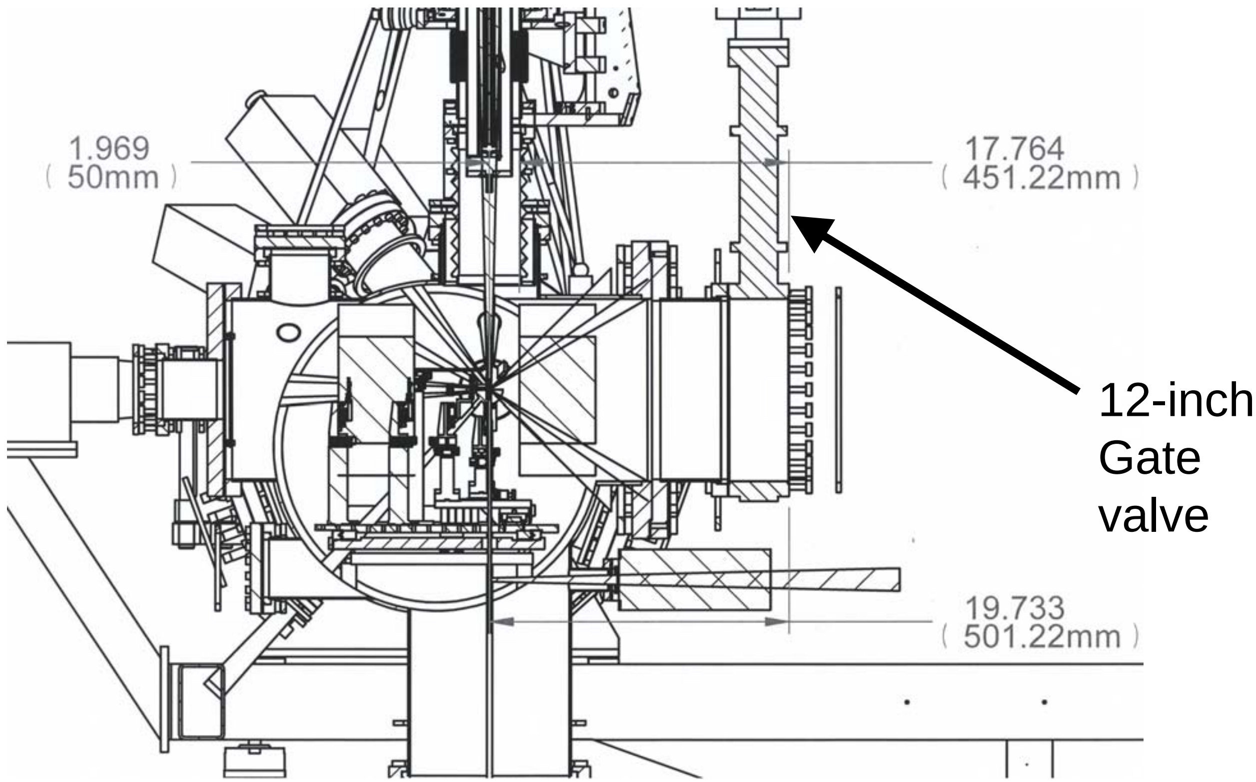


FIGURE-9

Pegasus Design, Inc.

DESIGN ISSUES TO RESOLVE:

The range of motion specifications and request for mechanical hard-stops were also evaluated. The +/- 20mrad for Pitch/Yaw motions means that with the stage fully extended, the detector could nearly hit the inner bore of the gate valve:

STROKE = 300mm
ANGULAR MOTION = 20mrad = 1.146-degrees

300mm x sin(1.146-degrees) = 6mm [.2362”]

If you superimpose the lateral adjustment requirement of +/-5mm, you will have a collision between the detector and the valve bore.

Mechanical hard stops would do nothing to prevent this collision.

Pegasus Design, Inc.

DESIGN REQUIREMENTS:

Physics Requirements
SP-391-000-28-R0

Engineering Specifications
SP-391-000-70-R0

5.1. The CXI Precision Instrument Stand (PRD SP-391-000-63) shall be used to support the CXI Detector Stage.

5.2. The rough alignment of the pitch and yaw angle of the detector stage to the LCLS beam direction which depend on the focusing optics used shall be accomplished using the CXI Precision Instrument Stand (PRD SP-391-000-69).

5.3. The detector stage shall translate in the x and y directions to allow centering of the LCLS beam to within 50 μm of the center of the hole in the detector for any of the focusing optics (KB0.1, KB1 and unfocused beam).

5.4. The detector stage shall move the detector in the z direction within the range described in requirements 3.1 and 3.2 with a repeatability of 50 μm.

5.5. The detector stage shall allow fine alignment of the pitch and yaw angle of the z stage to the LCLS to within a repeatability of 0.5 mrad.

5.6. The detector stage shall have the motorized motions listed in Table 5-1. The stability requirement listed means over a period of a few days.

5.7. The in-vacuum translation range along the z-axis shall not be required to be continuous. A minimum continuous range shall be at least 600 mm.

5.8. Spacer vacuum spools shall be used to span the space between the sample chamber and the detector stage when the detector stage is not attached directly to the sample chamber.

5.9. The surface normal of the detector sensing area shall be parallel with direction of travel of the z stage to within ±2°.

Motion	Nominal Position	Range	Resolution	Repeatability	Stability
x	0	-5 mm < x < 5 mm	10 μm	10 μm	1 μm
y	0	-5 mm < y < 5 mm	10 μm	10 μm	1 μm
z	50 mm	50 < z < 2600 mm	50 μm	50 μm	1 μm
Pitch	0 mrad	-20 mrad < z < 20 mrad	100 μrad	100 μrad	10 μrad
Yaw	0 mrad	-20 mrad < z < 20 mrad	100 μrad	100 μrad	10 μrad

Table 5-1: Motion requirements for the detector stage.

20 mr = 1.1460° = 1° 08' 46"

100 μr = .0057° = 0° 0' 21"

$\frac{180°}{\pi}$ = 57.2958° = 1-radian
= 57° 17' 45" =

10 μr = .000573°
= 0° 2' 06"

PRD SP-391-000-28
4 of 5

CXI Detector Stage

1 mr = .0573°
= 0° 3' 26"

1 μr = .000057°
= 0° 0' 21"

Our proposed solution.

NEW DEVELOPMENTS:

Based on what we learned from the SLAC early-stage concept, we developed this new concept from an idea proposed by Don Schafer, but first, let us discuss the detector slide assembly.

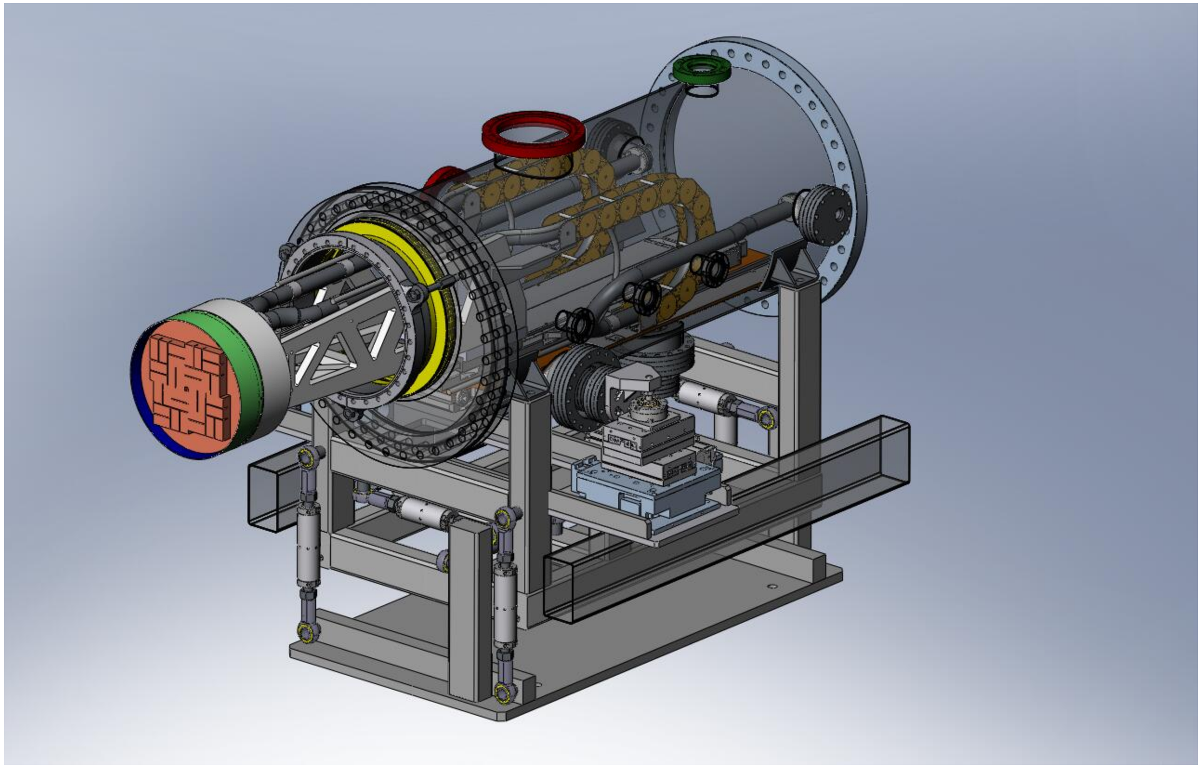


FIGURE-10

NEW DEVELOPMENTS: (continued)

The Detector Slide Assembly

NEW DEVELOPMENTS: (continued)

This first thing we did was to look for a beefier translation stage. The MICOS LS-180 looked to be a likely candidate, but had only 508mm [20”] travel. Upon discussion with SLAC engineers, the travel range was deemed acceptable.

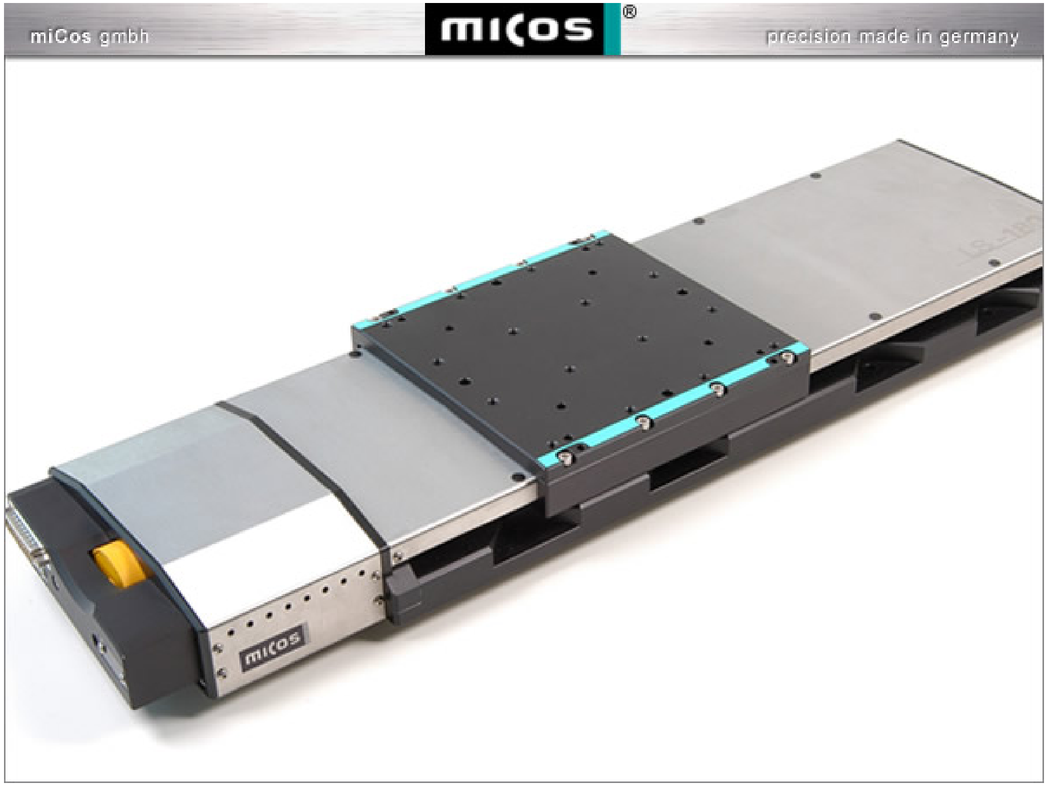


FIGURE-11

NEW DEVELOPMENTS: (continued)

The specifications for the MICOS LS-180 are:

•LOAD CAPACITY: 100kg [220-lbs]
•PITCH-AXIS MOMENT: 132-Nm [97-foot-pounds]
•YAW-AXIS MOMENT: 125-Nm [92-foot-pounds]
•BI-DIRECTIONAL REPEATABILITY: +/- 0.2 microns

•INTEGRAL LIMIT SWITCHES
•RECIRCULATING BALL DRIVE SCREW

NEW DEVELOPMENTS: (continued)

The vacuum specifications from the MICOS website are:

“Vacuum Stepper Motors For most of our IN-VACUUM stages , PHYTRON offers two different grades, a High vacuum to 10-6 torr and Ultra-High vacuum to 10-9 torr. For each grade; bearings, lubricants, adhesives, coatings, insulation and material cleaning, handling and packaging is used. Due to its simple design, PHYTRON stepping motor is used as the drive for all our IN-VACUUM stages”.

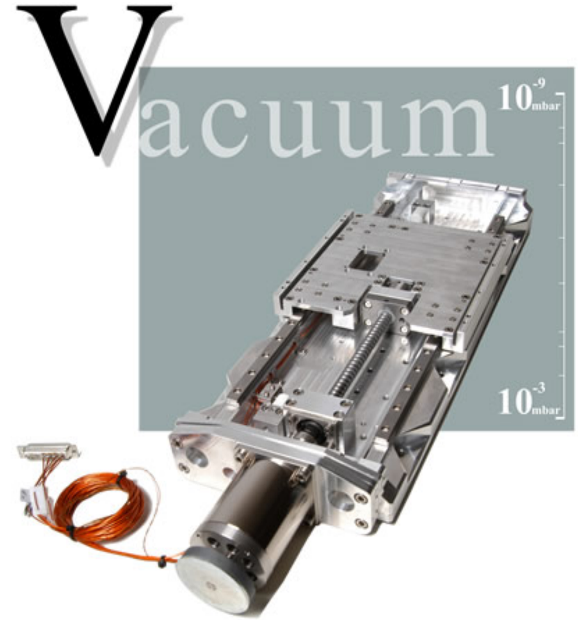


FIGURE-12

NEW DEVELOPMENTS: (continued)

The obvious question is, “Will it fit in the chamber?”. Yes, it appears to fit quite nicely. We have modified the original chamber substantially, but it’s nominally the same size. You can see the D-connector at the back will be easy to access.

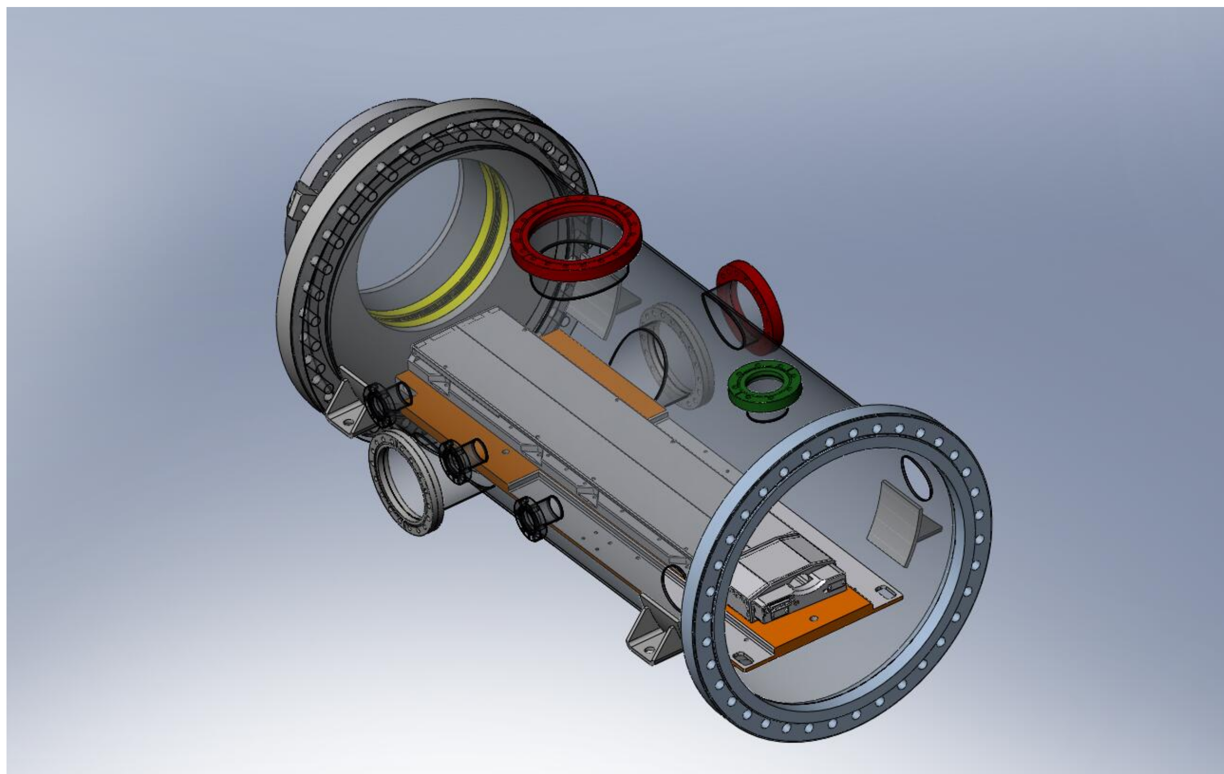


FIGURE-13

NEW DEVELOPMENTS: (continued)

This illustration shows the general arrangement of the slide assembly in the retracted position:

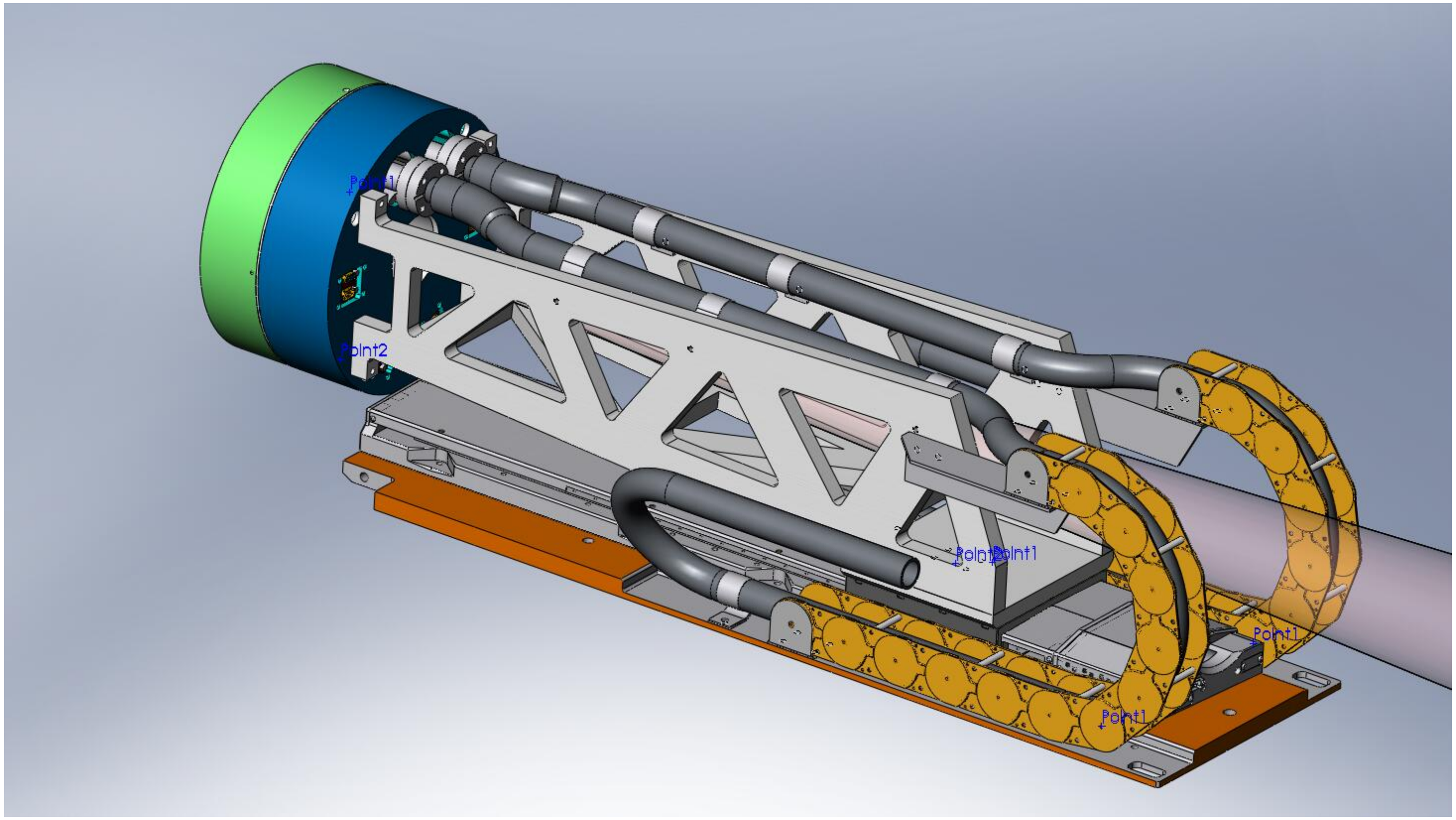


FIGURE-14

Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

The GORTRAC cable guide shown in our design concept can meet the bend radius requirement for the bellows hose. Any doubt about the viability of their use in vacuum was dispelled when a similar system was seen in use on the NIF-laser at the Lawrence Livermore National Laboratory.

The NIF-diagnostic instruments (which we are also working on for LLNL) extend from the chamber wall to almost the center of the 40-foot diameter target chamber. Cable guides are used in vacuum to connect the diagnostic instrument to the outside electronics.

Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

This illustration shows the slide assembly in the fully extended position, 508mm stroke [20”]. Shown in lavender is the 6-inch conical clear aperture zone.

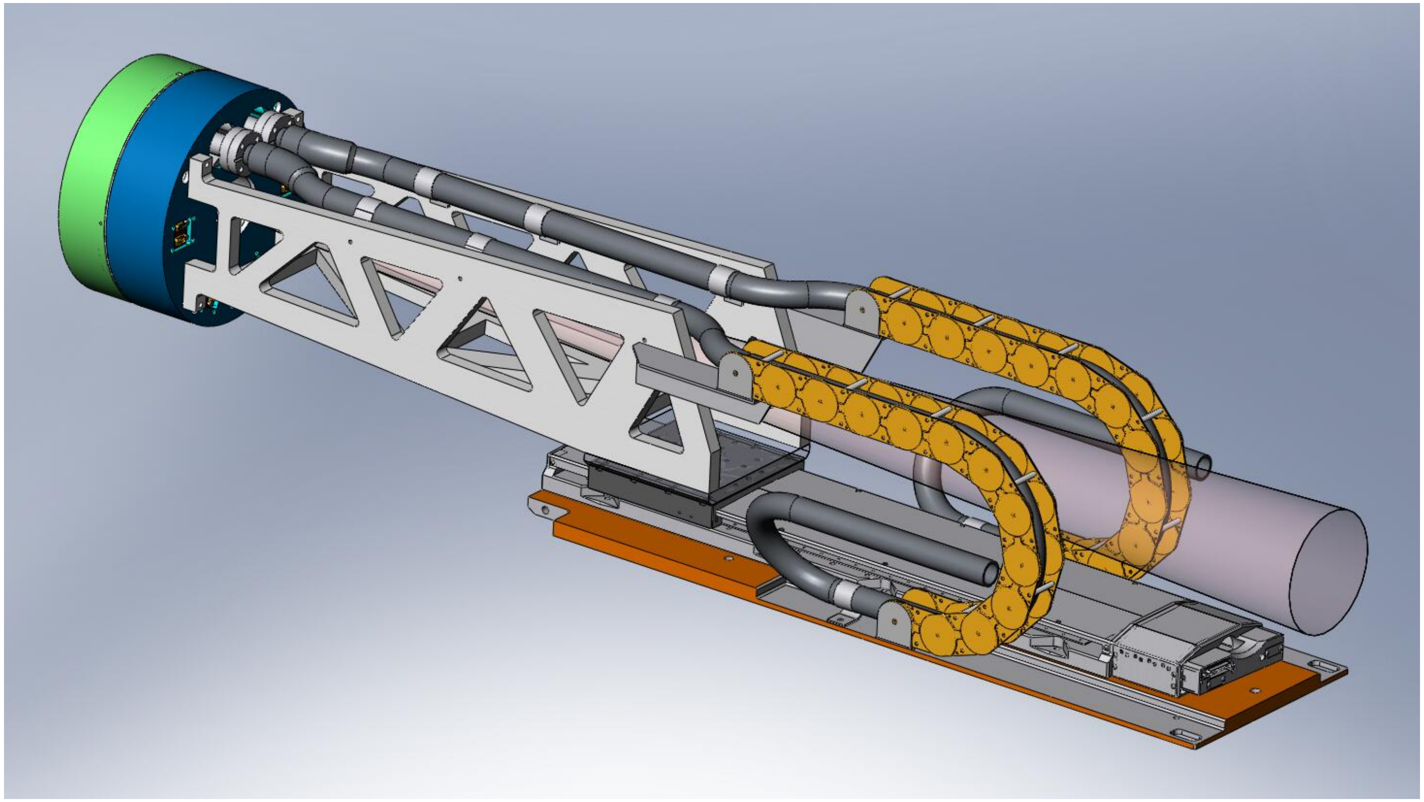


FIGURE-15

NEW DEVELOPMENTS: (continued)

The most challenging aspect of the slide assembly is routing the water-containment bellows hoses. We propose using welded-leaf bellows near the end of the convoluted bellows to allow access to the .25” VCR fittings.

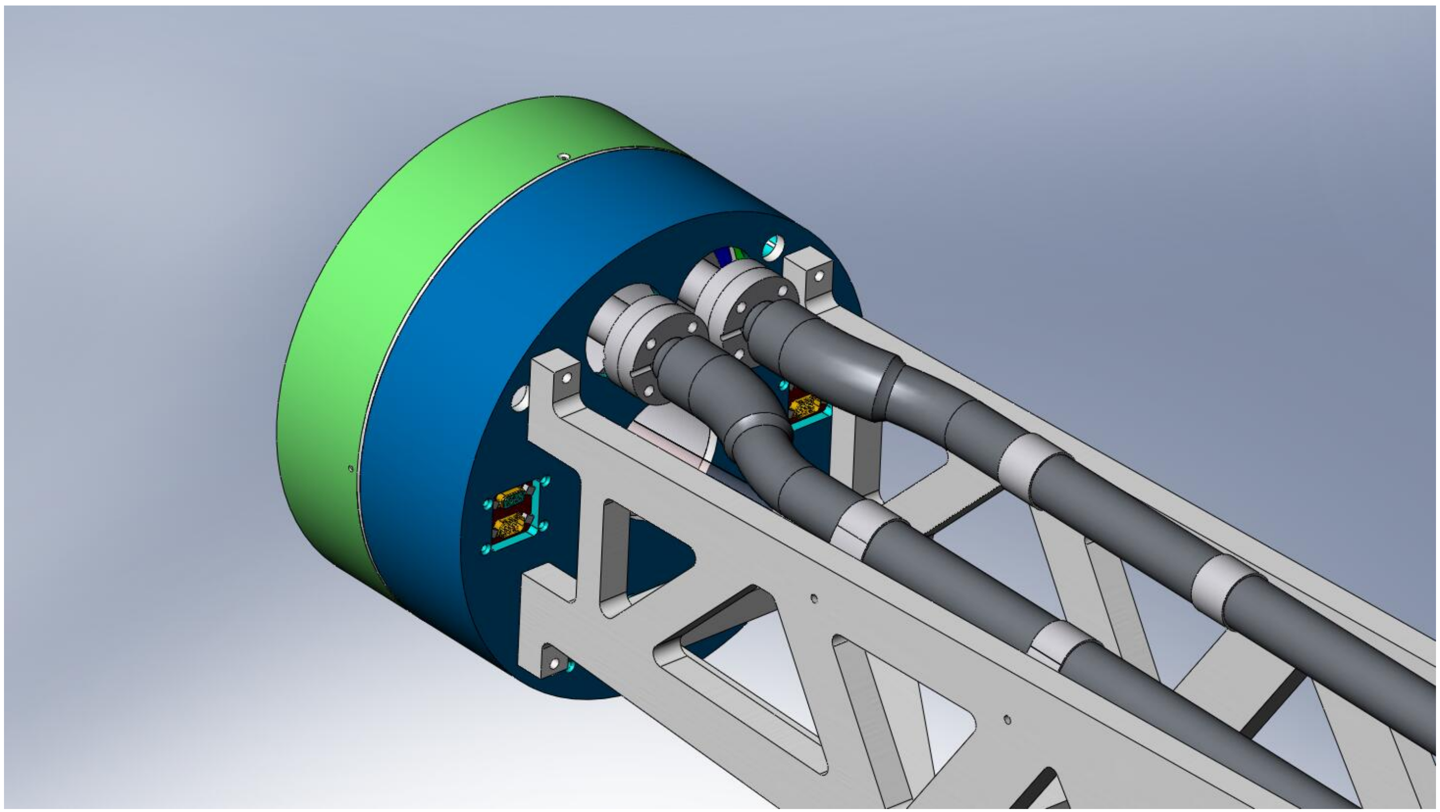


FIGURE-16

NEW DEVELOPMENTS: (continued)

The back-shell of the detector will need to be modified as shown to accommodate our design. The data cables will be bundled separately from the motor power cables and routed alongside the water containment bellows hoses. Note VCR-fittings.

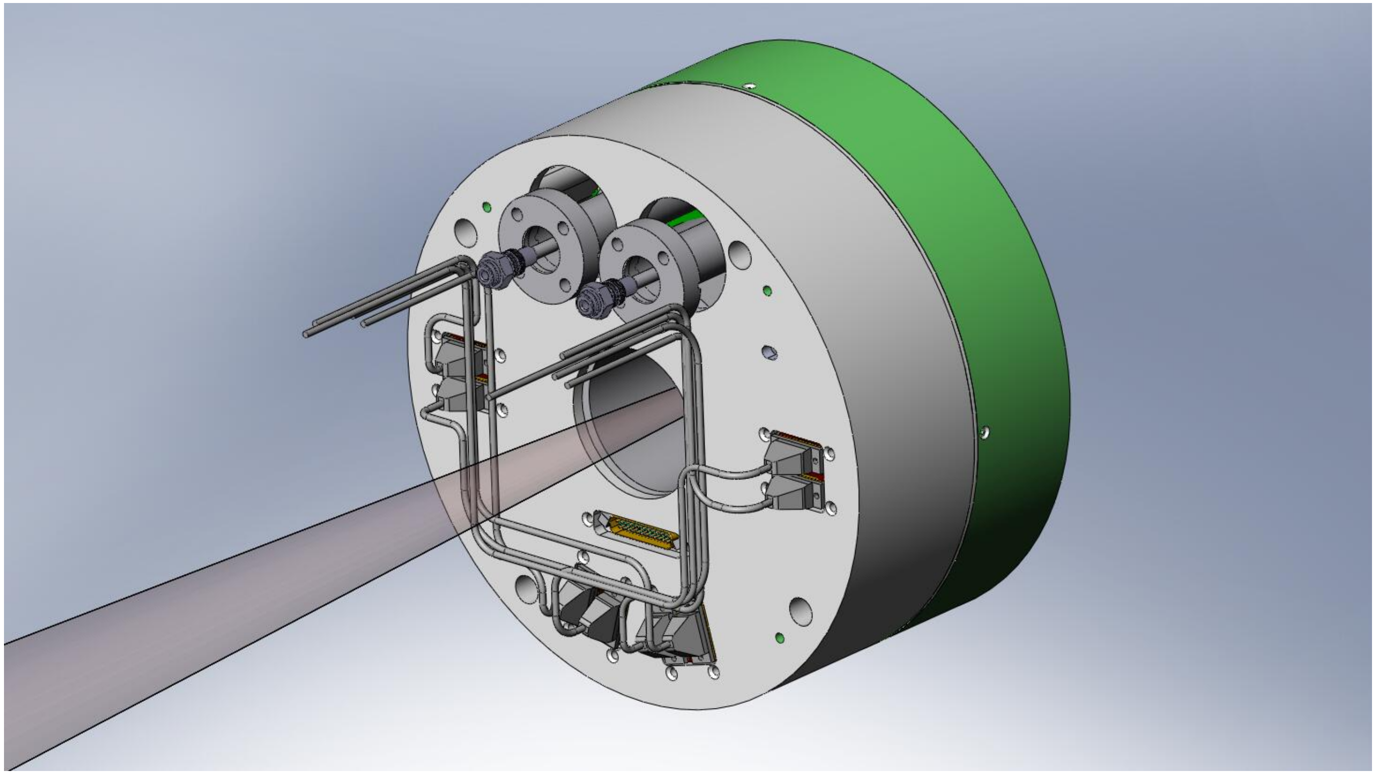


FIGURE-17

NEW DEVELOPMENTS: (continued)

The Optical Bench

NEW DEVELOPMENTS: (continued)

The optical bench is supported by Hephaist Seiko precision swivel joints on translation stages. Re-entrant bellows to reduce the overall width are shown. In medium blue is the Parker ZP200 Lift Table.

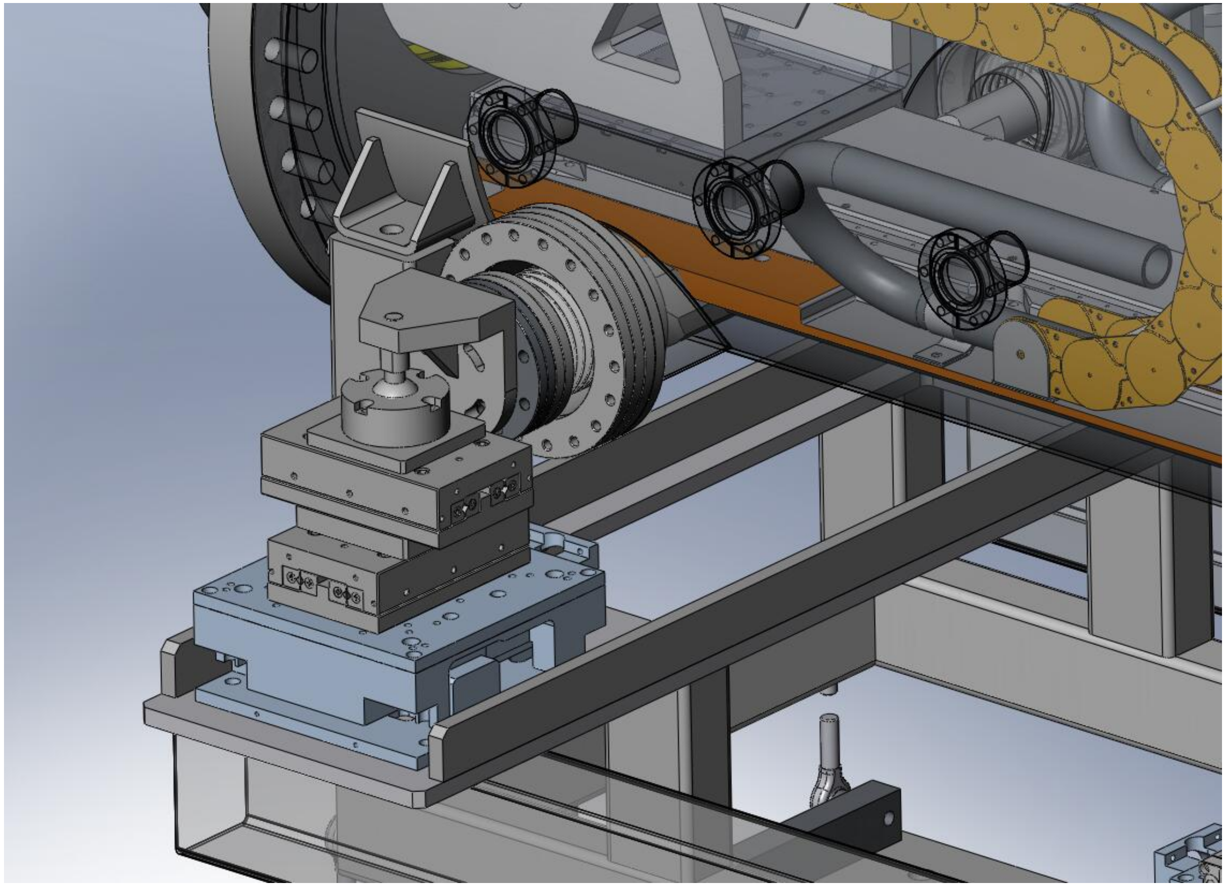


FIGURE-18

NEW DEVELOPMENTS: (continued)

Pegasus Design, Inc.

Lift table specifications:

ZP200 Specifications

	Precision	Standard
Travel (Z-axis)	25 mm (limit to limit)	25 mm (limit to limit)
Positional Accuracy		
with no encoder[1,2,7]	8 µm	20 µm
with linear encoder[3,6,7]	8 µm	—
Positional Repeatability		
with no encoder[1,7]	± 3 µm	± 10 µm
with 1.0 µm linear encoder[6,7]	± 5 µm	—
with 0.5 µm linear encoder[6,7]	± 4 µm	—
with 0.1 µm linear encoder[6,7]	± 3 µm	—
Lift Lead Ratio[4]		
5 mm lead ballscrew drive	1.8199 mm/rev	
10 mm lead ballscrew drive	3.6397 mm/rev	
20 mm lead ballscrew drive	7.2794 mm/rev	
Lift Velocity		
5 mm lead ballscrew drive	110 mm/sec	
10 mm lead ballscrew drive	220 mm/sec	
20 mm lead ballscrew drive	440 mm/sec	
Load Capacity (normal)	15 kg (33 lb)	75 kg (165 lb)
Duty Cycle	100%	
Max Acceleration	7.2 m/sec^2	
Efficiency	90%	
Max Breakaway Torque[5]	0.15 Nm	
Max Running Torque[5]	0.13 Nm	
Linear Bearing – Coefficient Of Friction	0.01	
Ballscrew Diameter	16 mm	
Unit Weight	5.82 kg	
Top Plate Weight	2.25 kg	
Pitch[7]	± 15 Arc-sec	± 45 Arc-sec
Roll[7]	± 15 Arc-sec	± 25 Arc-sec
Input Inertia		
5 mm lead ballscrew drive	2.32 x 10^{-5} Kg-m^2	
10 mm lead ballscrew drive	2.51 x 10^{-5} Kg-m^2	
20 mm lead ballscrew drive	3.12 x 10^{-5} Kg-m^2	

1) Measured 38 mm directly above the true center of the top mounting surface.
2) Measured using calibrated lead value (provided).
3) Slope correction value provided
4) Lift per 1 motor shaft revolution. Lift lead listed is nominal. All units are provided with calibrated lead value.
5) Torque ratings are measured with unit unloaded, traveling upward.
6) Measured directly over encoder on outer edge.
7) Pitch and Roll Specifications are measured with <1kg load. Addition of load increases pitch and roll error by 10 arc-sec per 5 kg of load assuming the load center of gravity is located at the center of the stage platform. Cantilevered loading increases these errors more.

FIGURE-19

NEW DEVELOPMENTS: (continued)

Pegasus Design, Inc.

Parker 404XR translation stage specifications:

Common Characteristics	404XR Precision	404XR Standard	406XR Precision	406XR Standard
Performance				
Bidirectial Repeatability (μm)	+/-1.3	+/-3.0	+/-1.3	+/-3.0
Duty Cycle	100%	100%	100%	100%
Max Acceleration – m/sec² (in/sec²)	20 (773)	20 (773)	20 (773)	20 (773)
Rated Capacity				
Normal load – kgf (lbs)	170 (375)	170 (375)	630 (1390)	630 (1390)
Axial load – kgf (lbs) Ballscrew	90 (198)	90 (198)	90 (198)	90 (198)
Leadscrew	n/a	25 (55)		
Motor Sizing				
Drive Screw Efficiency Ballscrew	90%	90%	90%	80%
Leadscrew	30%	30%		
Max Break-Away Torque – Nm (in-oz)				
0 to 600 mm Travel	0.13 (18)	0.18 (26)	0.13 (18)	0.18 (26)
600 to 2000 mm Travel	na	na	na	0.39 (55)
Max Running Torque – Nm (in-oz)				
0 to 600 mm Travel	0.11 (16)	0.17 (24)	0.11 (16)	0.17 (24)
600 to 2000 mm Travel	na	na	na	0.34 (48)
Linear Bearing – Coefficient of Friction	0.01	0.01	0.01	0.01
Ballscrew Diameter (mm)	16	16	Refer to chart on page 13	
Carriage Weight – kg (lbs)	0.70 (1.55)	0.70 (1.55)	2.7 (5.94)	2.7 (5.94)

404XR Travel (mm)	Positional [(2)] Accuracy (μm) Prec.	Std.	Straightness & Flatness Accuracy (μm) Prec./Std.	Input Inertia 10^{-5} kg-m² 5 mm	10 mm	20 mm	Max Screw Speed (Revs Per Second) Prec./Std.	Total Table Weight (kg) Prec./Std.
50	8	12	6	1.68	1.81	2.34	60	2.8
100	8	12	6	1.93	2.07	2.60	60	3.0
150	10	14	9	2.19	2.32	2.85	60	3.3
200	12	20	10	2.44	2.57	3.11	60	3.6
250	12	22	12	2.69	2.83	3.36	60	3.9
300	14	24	13	2.95	3.08	3.61	60	4.2
350	14	26	15	3.20	3.33	3.87	60	4.5
400	16	26	16	3.46	3.59	4.12	60	4.8
450	19	28	18	3.71	3.84	4.37	60	5.1
500	21	34	19	3.96	4.10	4.63	60	5.4
550	23	36	21	4.22	4.35	4.88	60	5.7
600	25	40	22	4.47	4.60	5.14	54	6.0

406XR Travel (mm)	Positional [(2)] Accuracy (μm) Prec.	Std.	Straightness & Flatness Accuracy (μm) Prec./Std.	Input Inertia 10^{-5} kg-m² 5 mm	10 mm	20 mm	25 mm	Max Screw Speed (Revs Per Second) Prec./Std.	Total Table Weight (kg) Prec./Std.
100	8	12	6	3.34	3.85	5.90	-	60	8.7
200	12	20	10	3.92	4.43	6.48	-	60	10.0
300	14	24	13	4.50	5.01	7.06	-	60	11.3
400	16	26	16	5.08	5.59	7.64	-	60	12.6
500	21	34	19	5.65	6.17	8.22	-	55	13.9
600	25	40	22	6.23	6.75	8.80	-	44	15.2
700	-	92	25	36.51	37.02	-	40.61	47	19.2
800	-	94	29	39.96	40.47	-	44.07	47	20.7
900	-	103	32	43.41	43.93	-	47.52	47	22.2
1000	-	105	35	46.87	47.38	-	50.97	47	23.7
1250	-	118	42	55.50	56.01	-	59.61	35	27.6
1500	-	134	50	64.14	64.65	-	68.24	26	31.4
1750	-	154	57	72.77	73.28	-	76.88	20	35.2
2000	-	159	65	81.40	81.92	-	85.51	16	39.1

[(2)] Positional accuracy applies to in-line motor configurations only. Contact factory for parallel motor specifications.

Parker

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www.parkermotion.com

Parker Hannifin Corporation
1140 Sandy Hill Road
Irwin, PA 15642

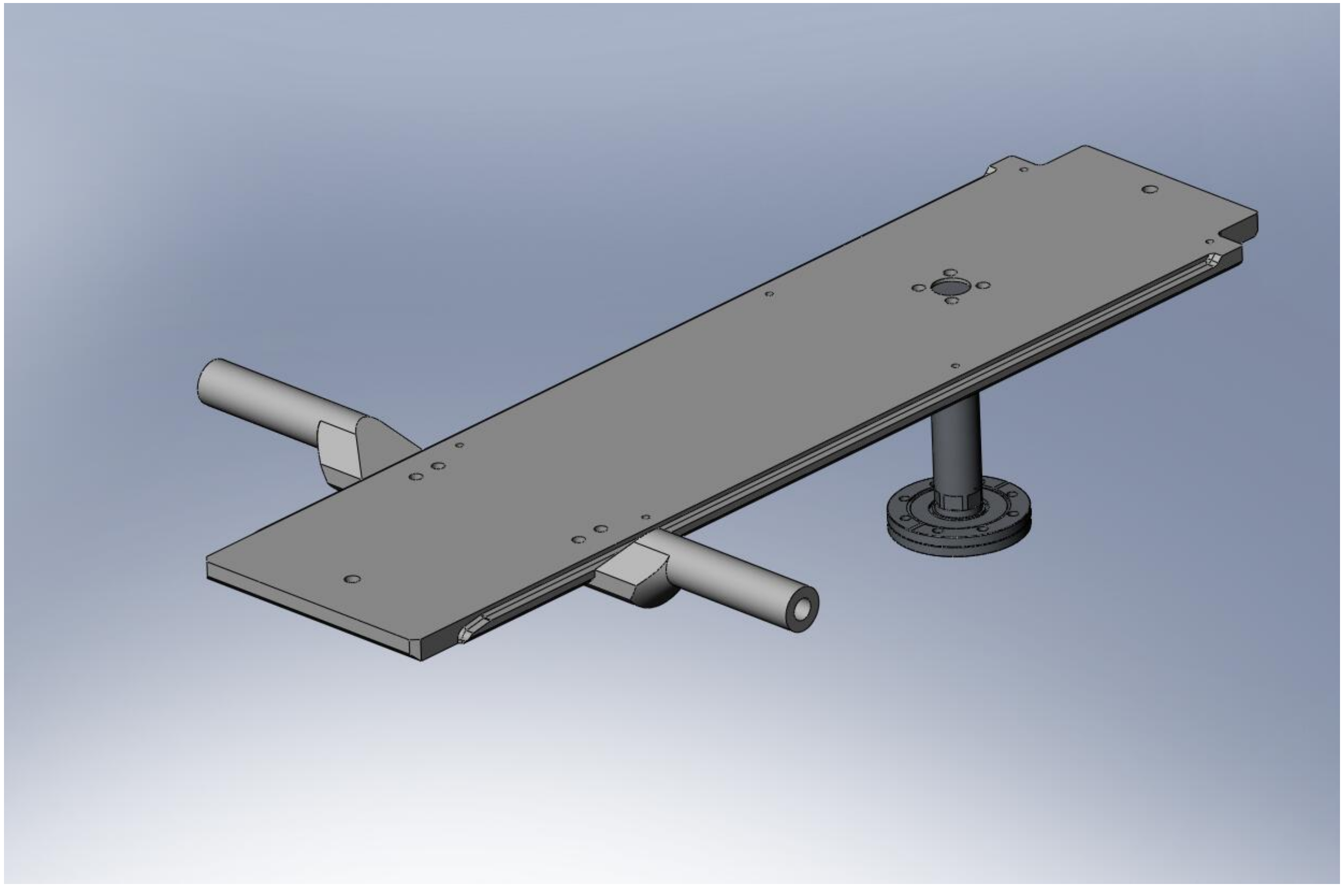
FIGURE-20

Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

Our Optical Bench concept uses a ‘dropped axle’ with a single post at the back.

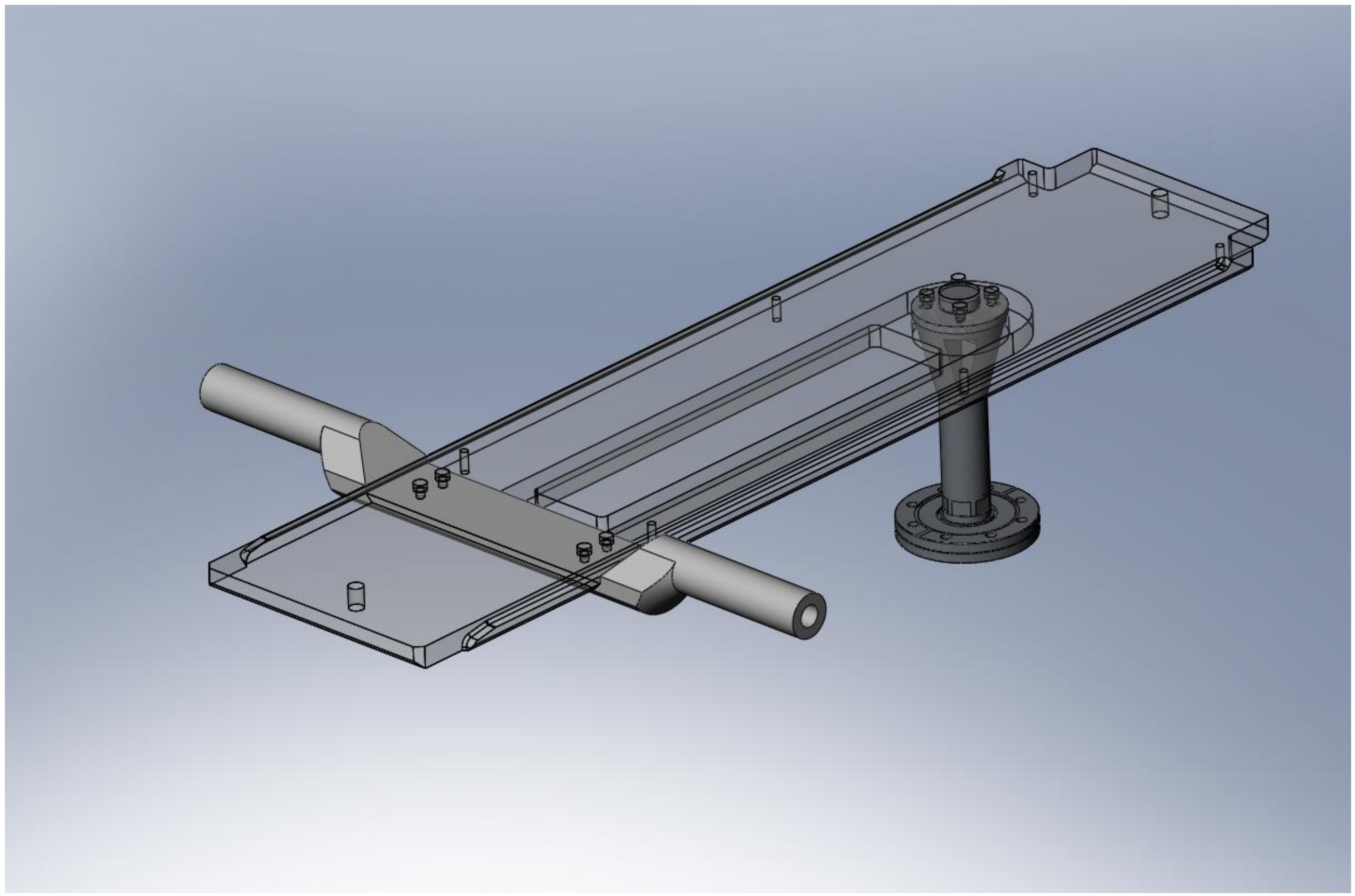
FIGURE-21



NEW DEVELOPMENTS: (continued)

This transparent view shows the back leg with a large diameter mounting flange. All three legs are threaded to allow conflat flanges to 'spun on' and tightened.

FIGURE-22

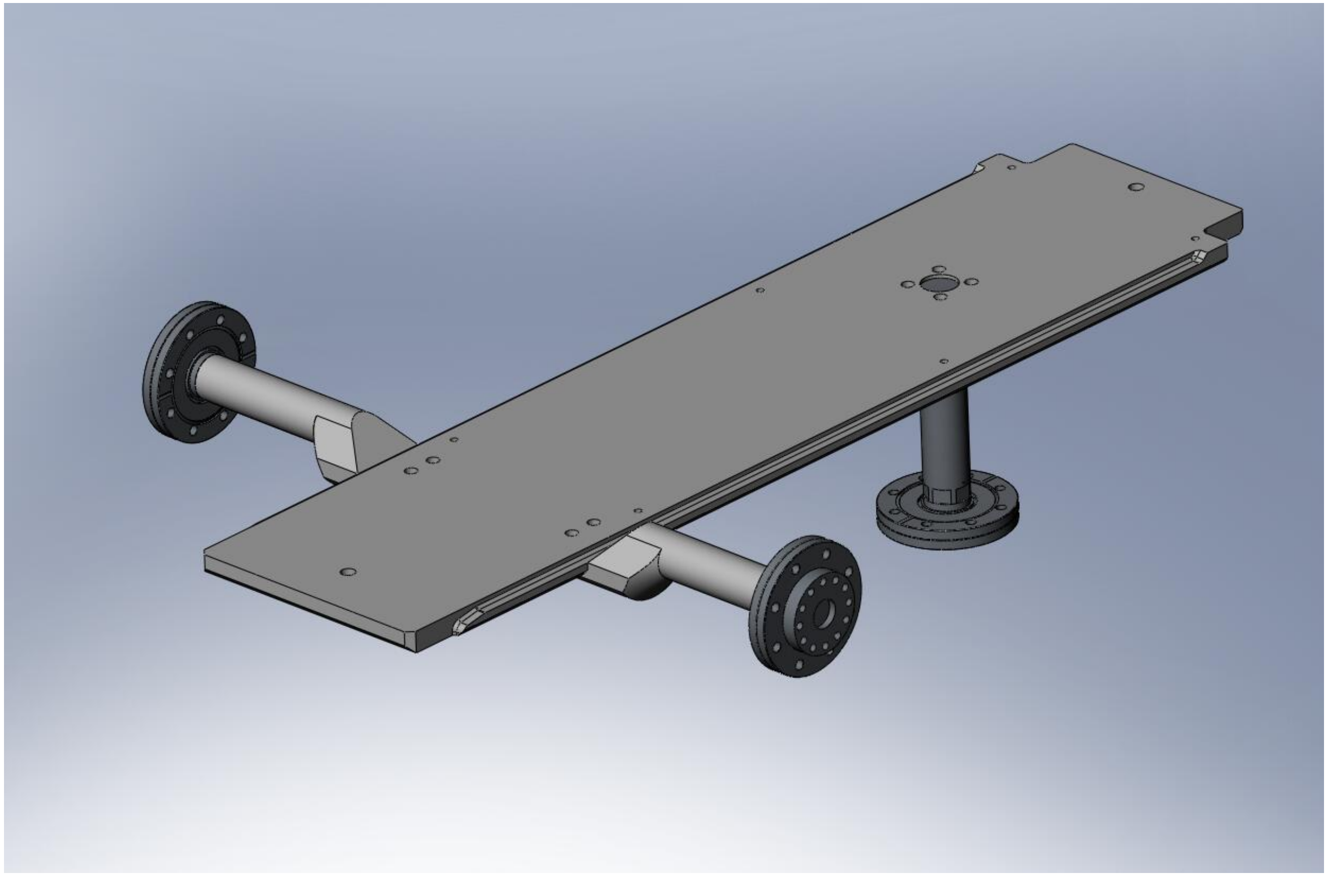


Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

The stability of the optical bench is due to the wide stance of the dropped axle.

FIGURE-23



Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

The dropped axle and center leg are fed through the chamber ports. The optical bench is put in position and bolted in place.

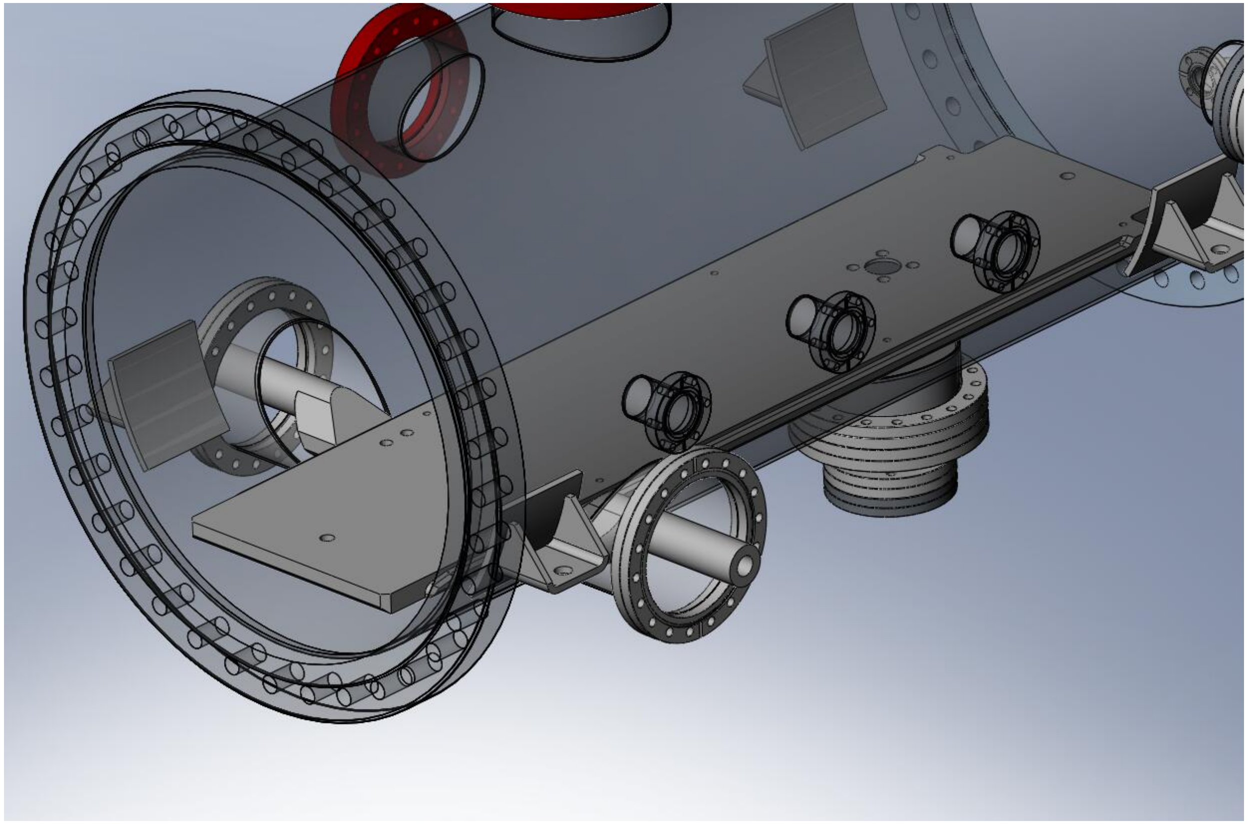


FIGURE-24

NEW DEVELOPMENTS: (continued)

This underside view shows the bench before installing the re-entrant bellows and conflat flanges.

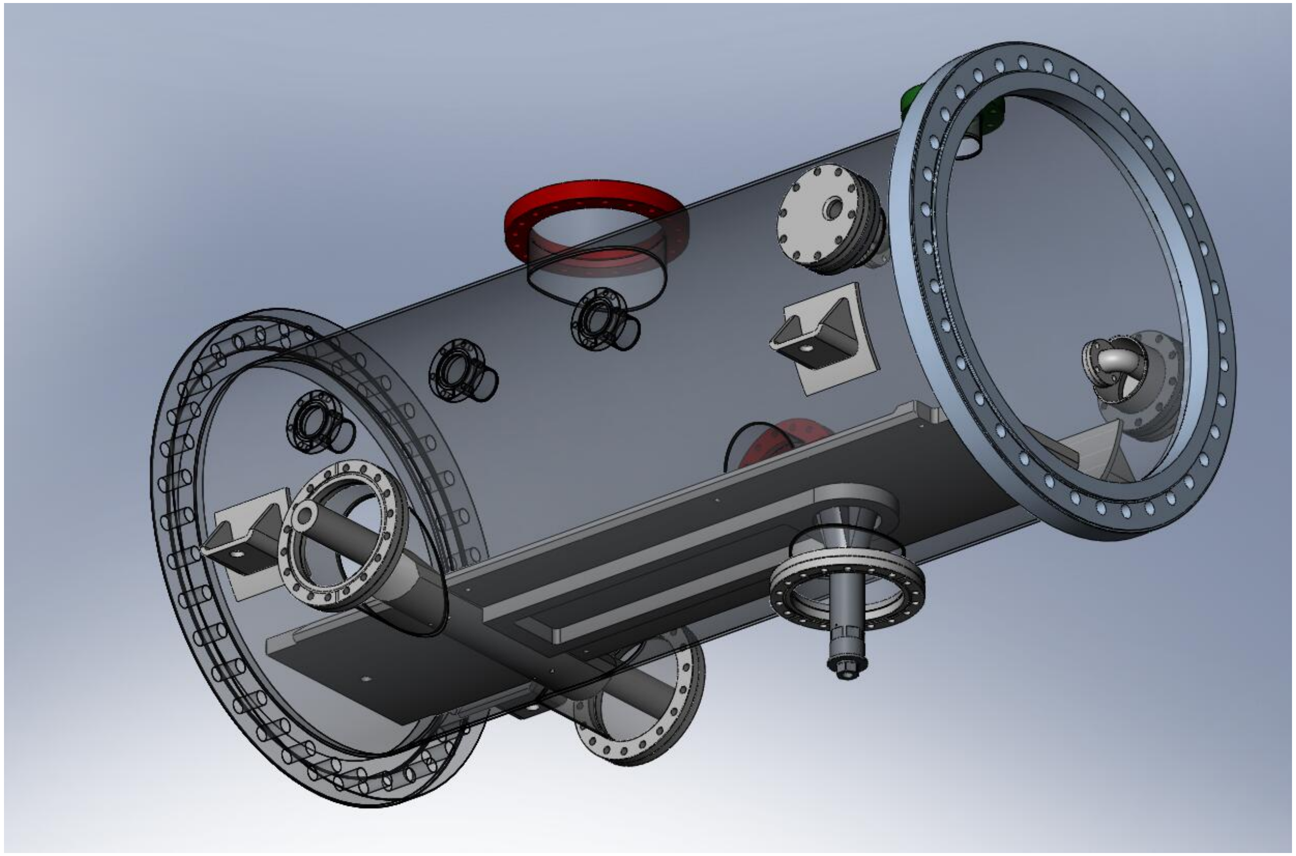


FIGURE-25

Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

Slotted right-angle brackets are then added to provide the attachment points for the precision swivel joints.

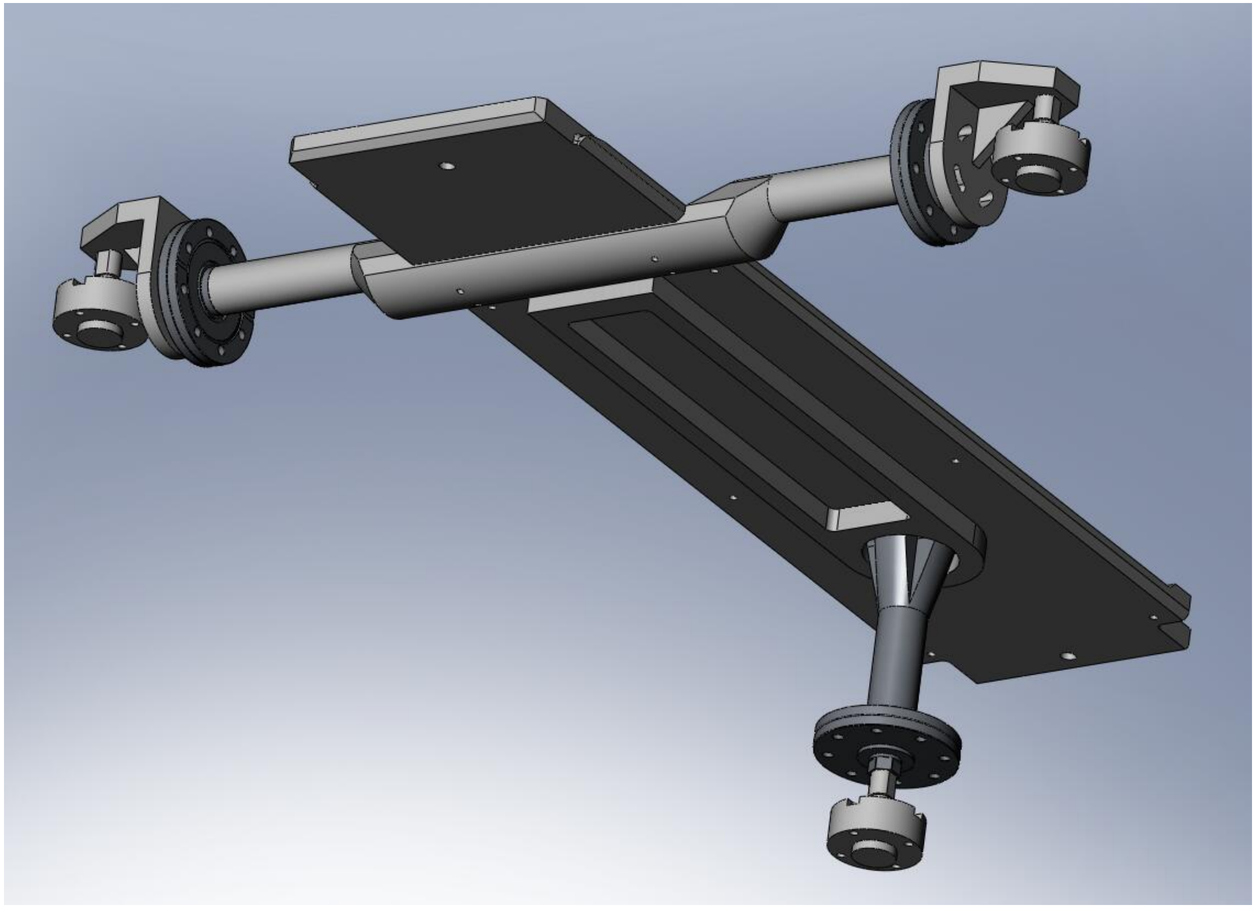


FIGURE-26

Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

Here is a side-by-side comparison of the old and the new:

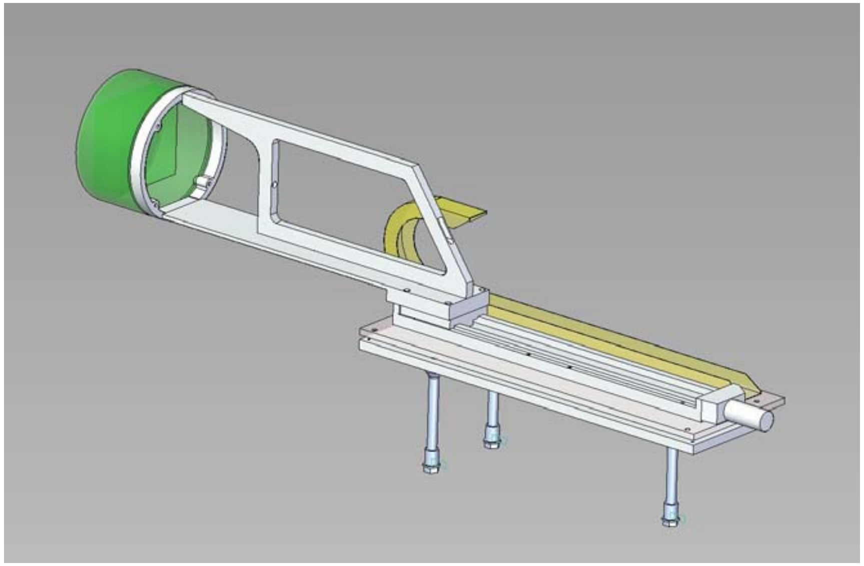


FIGURE-27

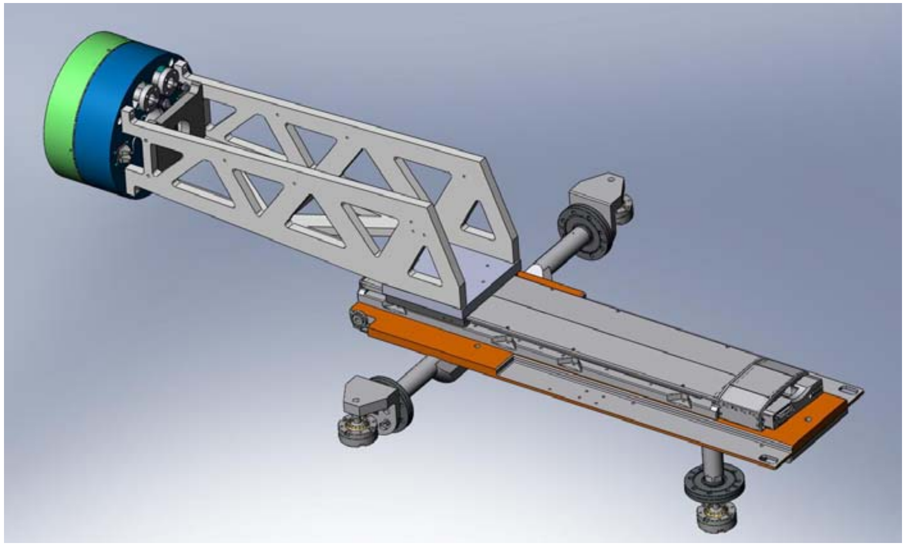


FIGURE-28

INITIAL CONCEPTUAL DESIGN: (continued)

With the detector at full extension, the fundamental Mode-1 response is about 35-hertz*

*Double click the illustration to see the flexural response:

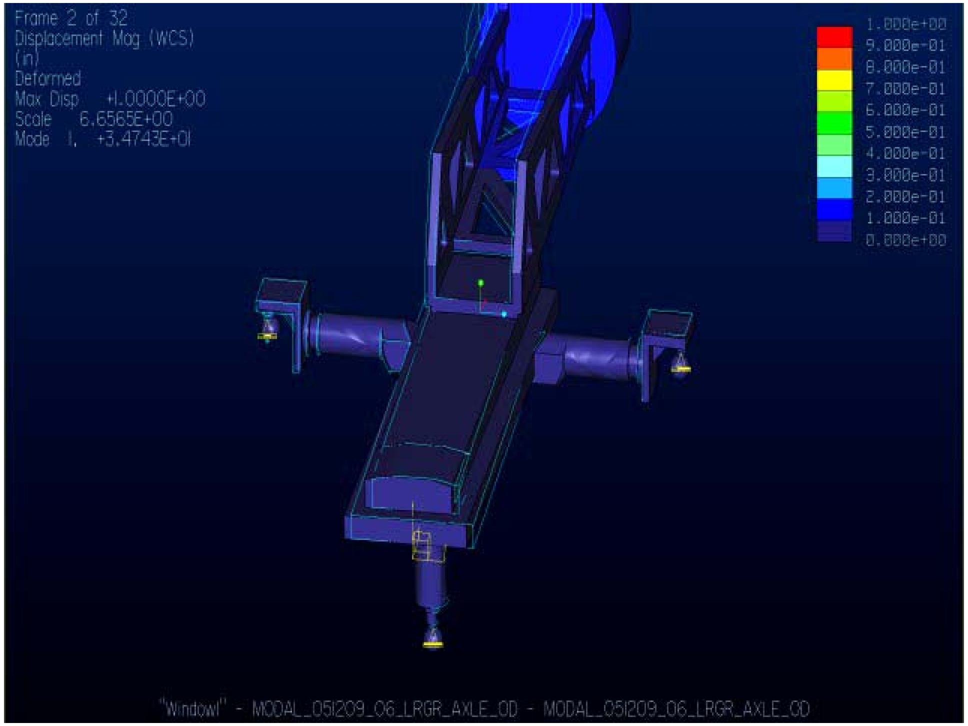


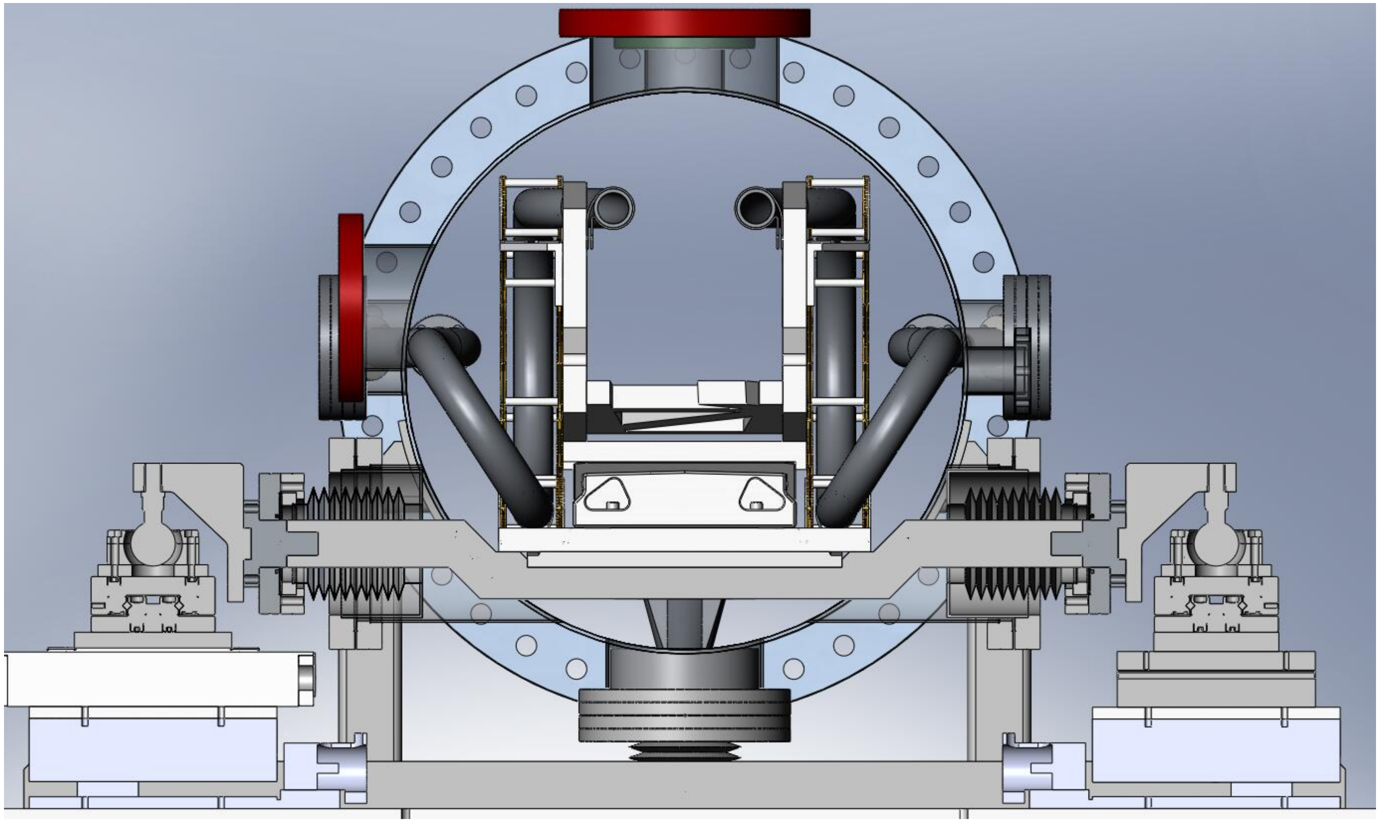
FIGURE-29

Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

This cut-away view shows the general arrangement of our 'dropped axle' concept.

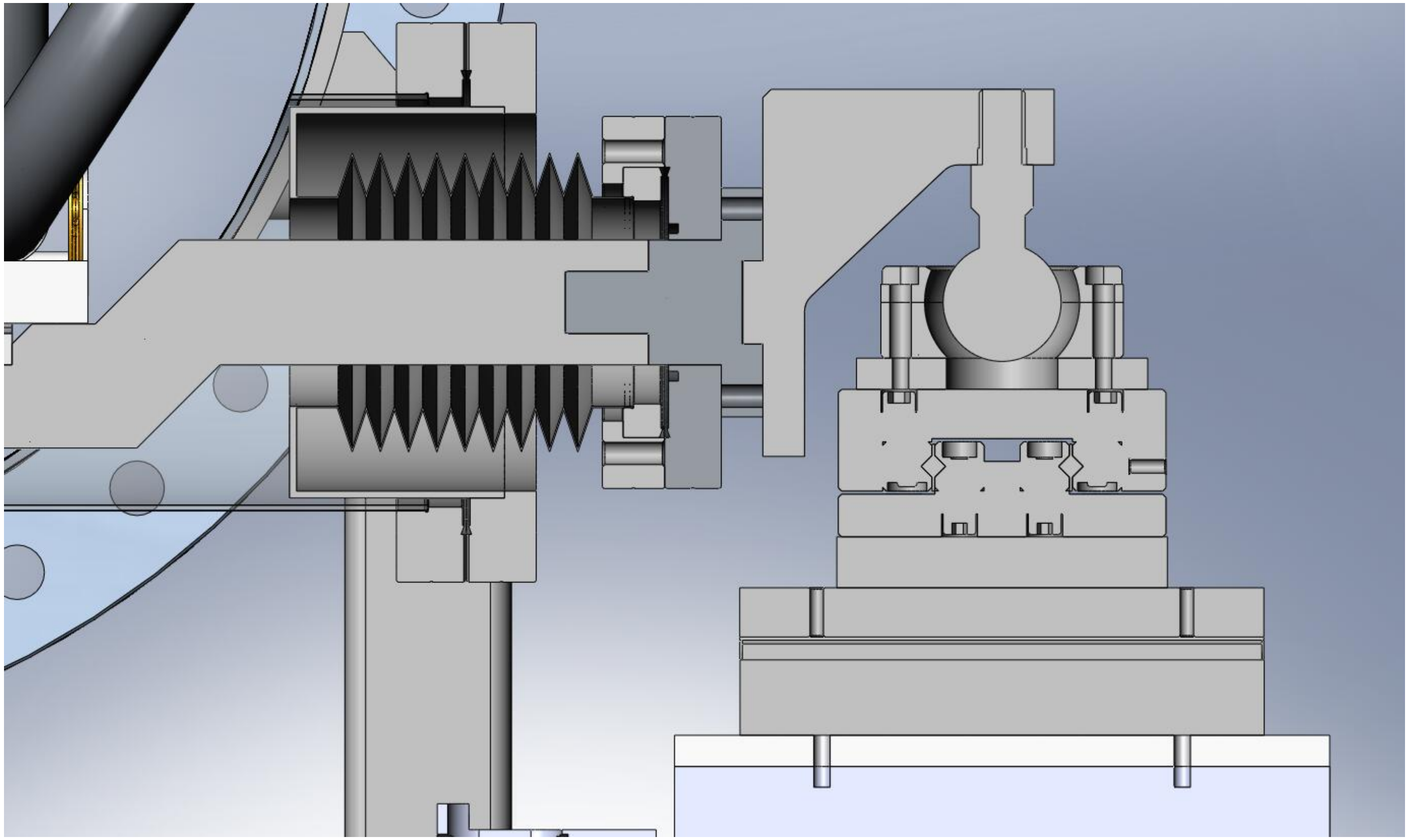
FIGURE-30



NEW DEVELOPMENTS: (continued)

This cross-section through the re-entrant bellows shows the spun-on Conflat flange (in medium grey), the universal mounting bracket and the Hephaist Seiko precision swivel joint sitting on translation stages.

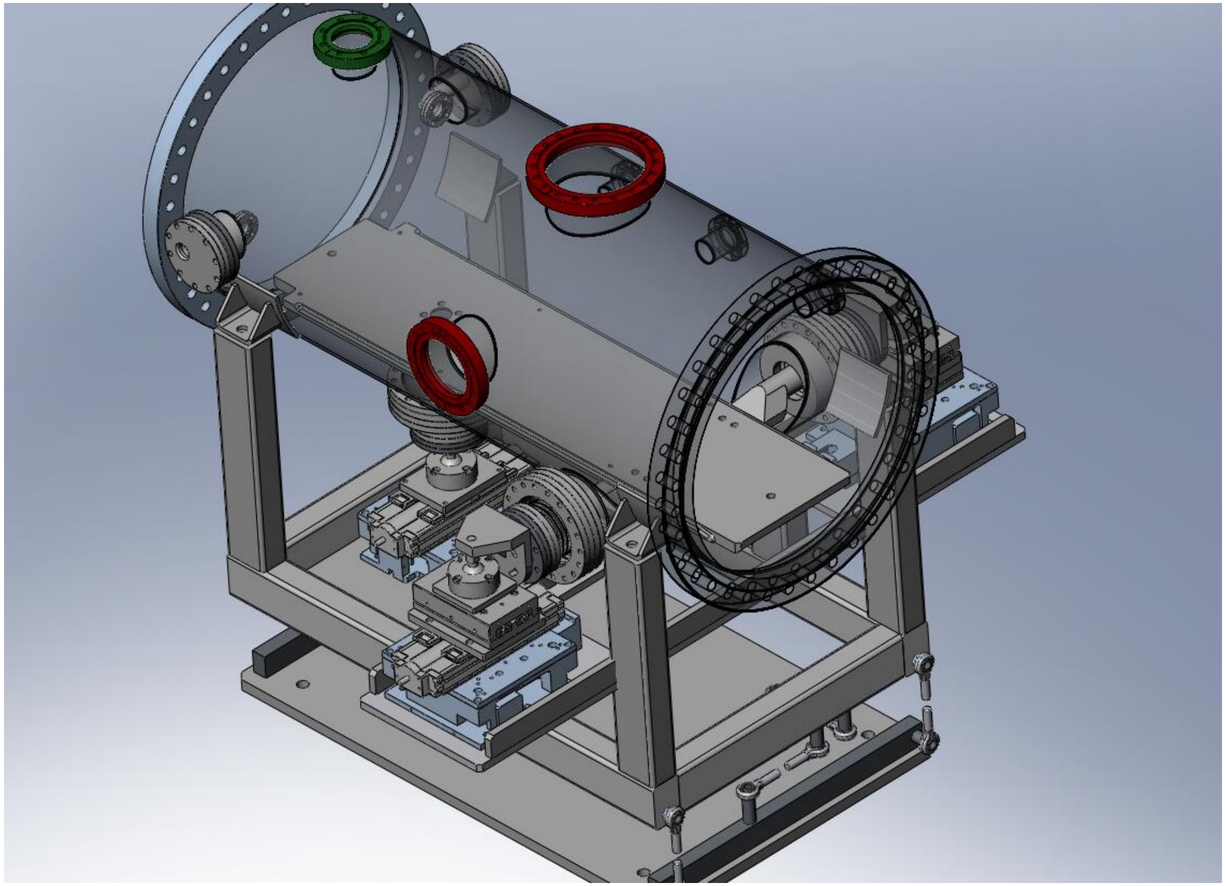
FIGURE-31



NEW DEVELOPMENTS: (continued)

Here we see the optical bench and re-entrant bellows assembled and ready to receive the detector slide assembly.

FIGURE-32



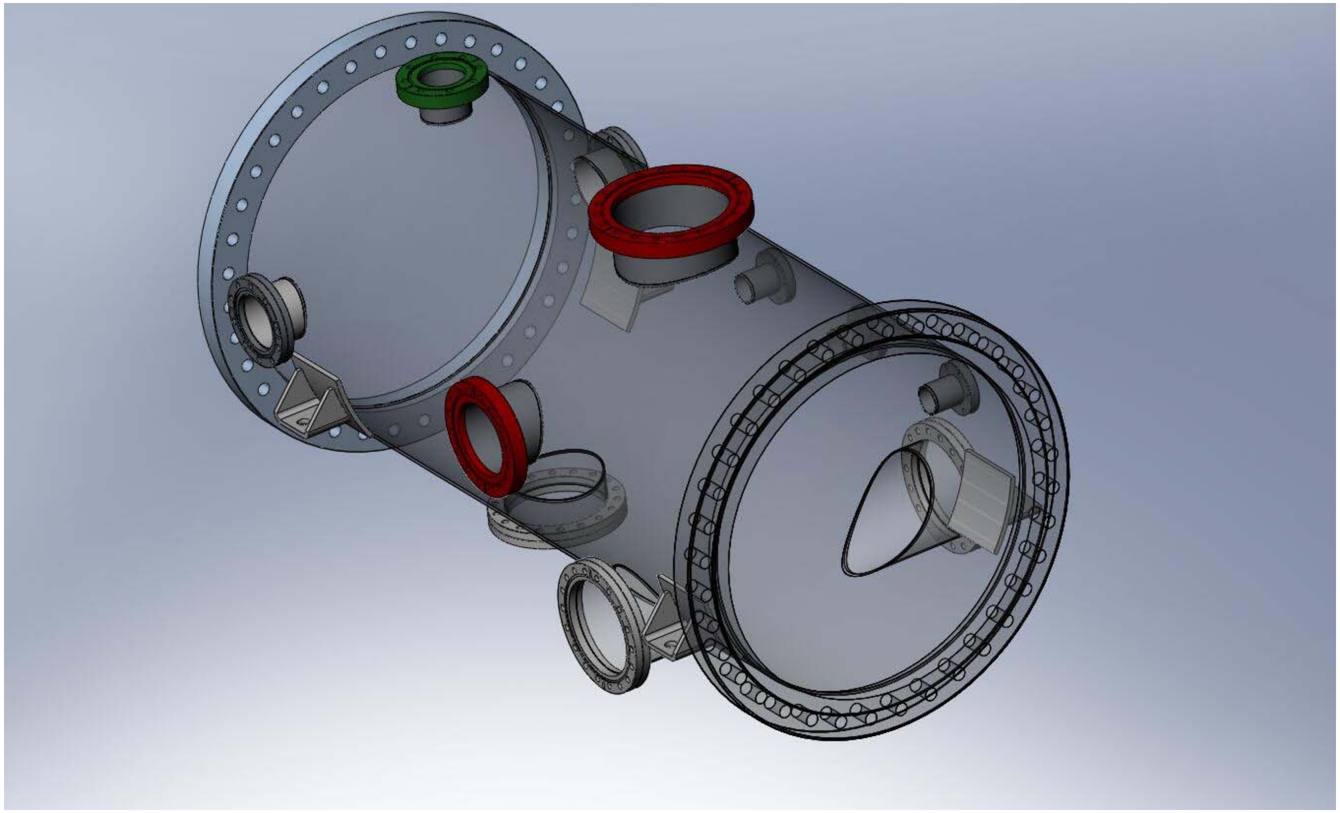
NEW DEVELOPMENTS: (continued)

The Vacuum Chamber.

NEW DEVELOPMENTS: (continued)

Shown here is the stainless steel vacuum chamber weldment. Wire-seal end flanges are shown at both ends. The chamber is approximately 43-inches long and 18-inches in diameter. The wall thickness is .125-inch.

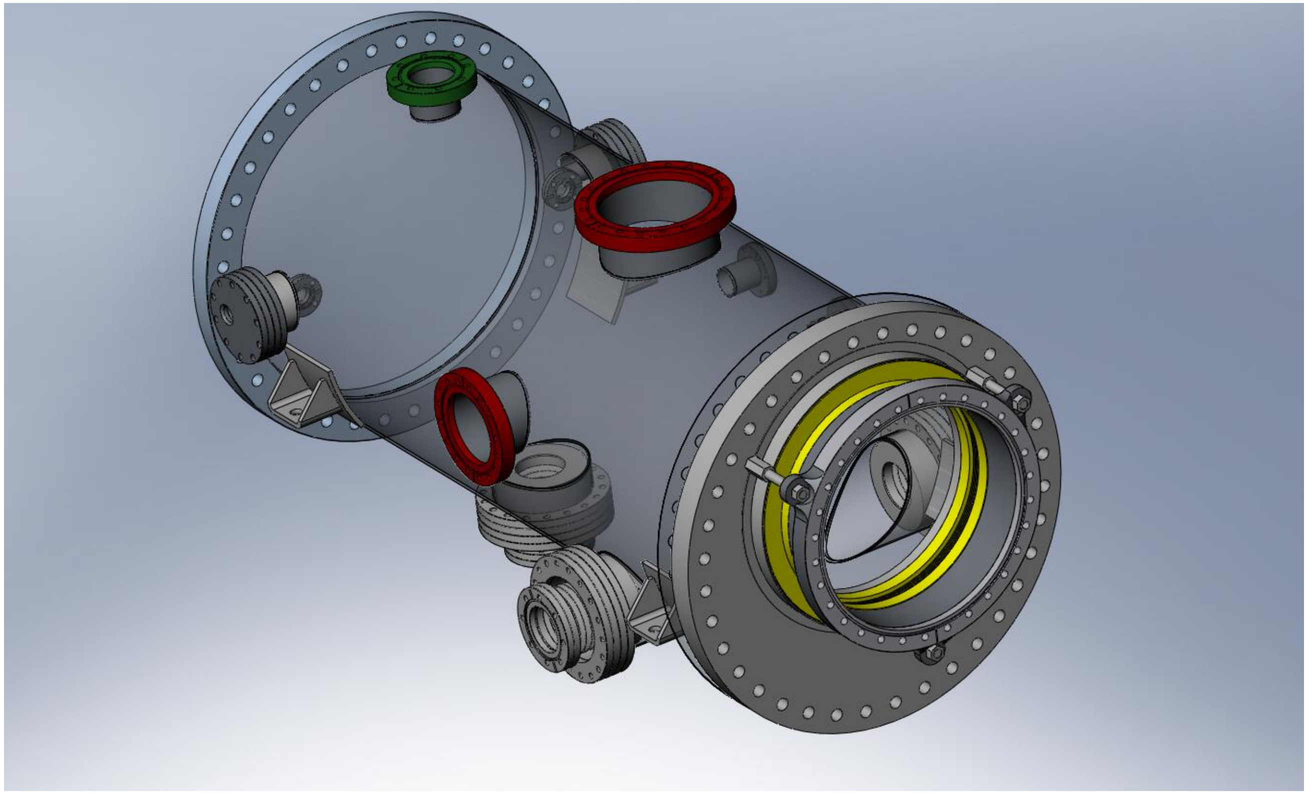
FIGURE-33



NEW DEVELOPMENTS: (continued)

This illustration shows the chamber with all bellows assemblies installed. The front bellows has threaded fittings to support the bellows during servicing, and to transfer the ~1600-pound axial load when under vacuum.

FIGURE-34

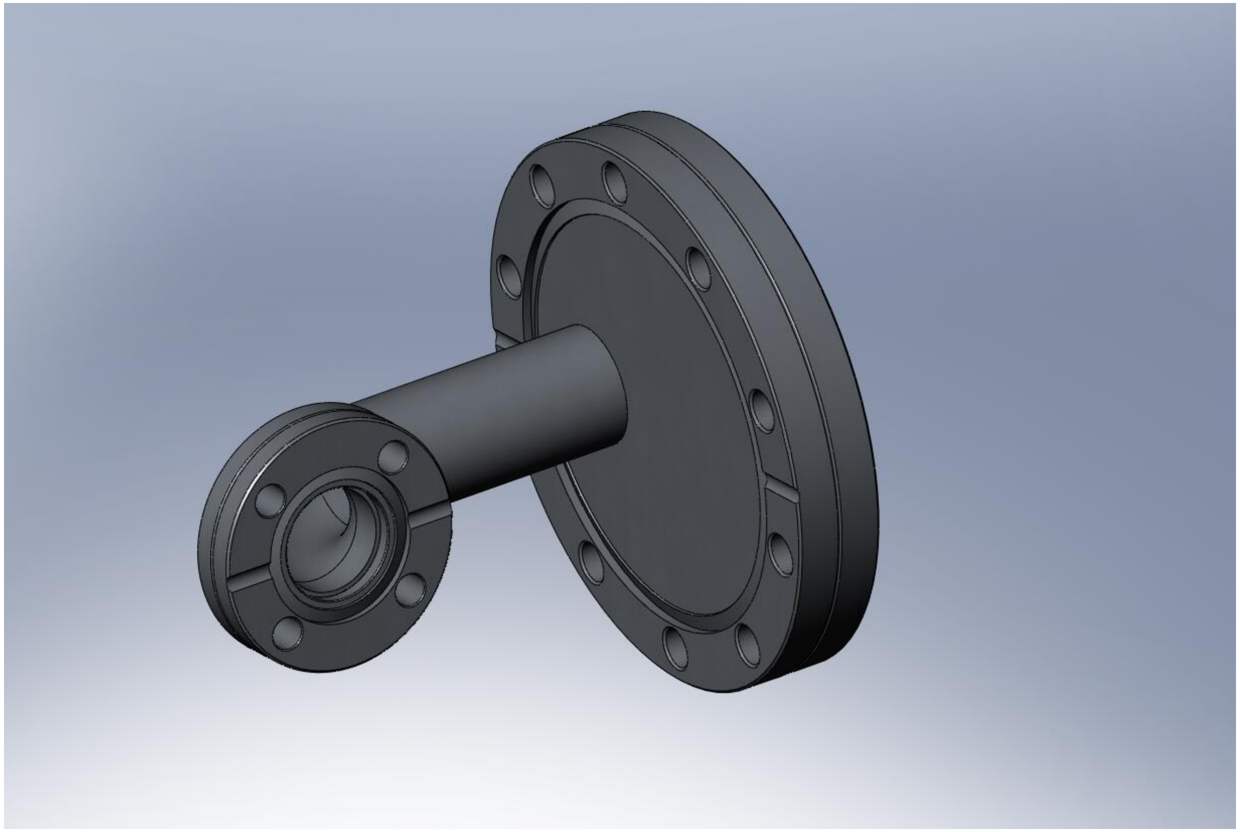


Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

This illustration shows the coolant feed-thru flange to allow the water-containment lines to exit out the side of the chamber.

FIGURE-35



Pegasus Design, Inc.

NEW DEVELOPMENTS: (continued)

This concept has the following features:

1) MICOS LS-180 with 508mm (20”) travel
2) Kinematic mounting features with wide stance
3) Cantilever load has been removed from lift table
4) Cantilever load has been removed from translation stage
5) Detector assembly can be installed from one end
6) Dual hoses for water containment of detector cooling lines
7) Dual cable guides for bellows and electrical cables

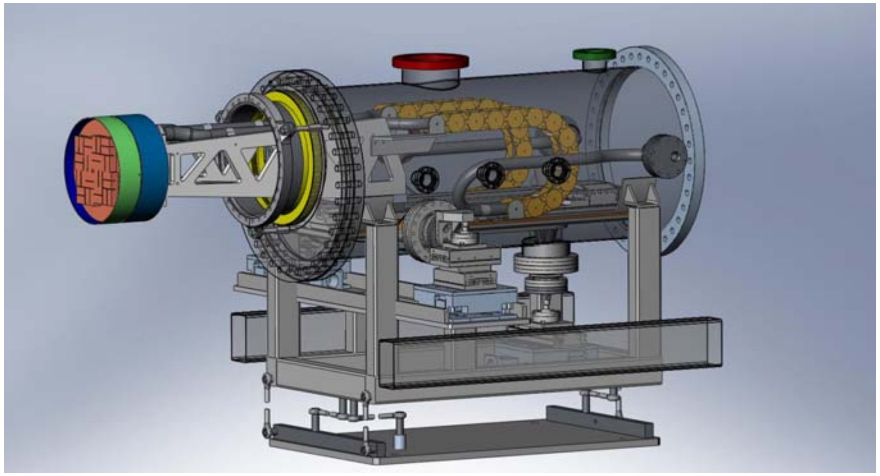


FIGURE-36

Can we proceed with this concept?

The end.

Cost & Schedule: CXI 1 micron Precision Instrument Stand and Detector Stage

Paul Montanez

CXI Lead Engineer/CAM

May 15, 2009

Outline

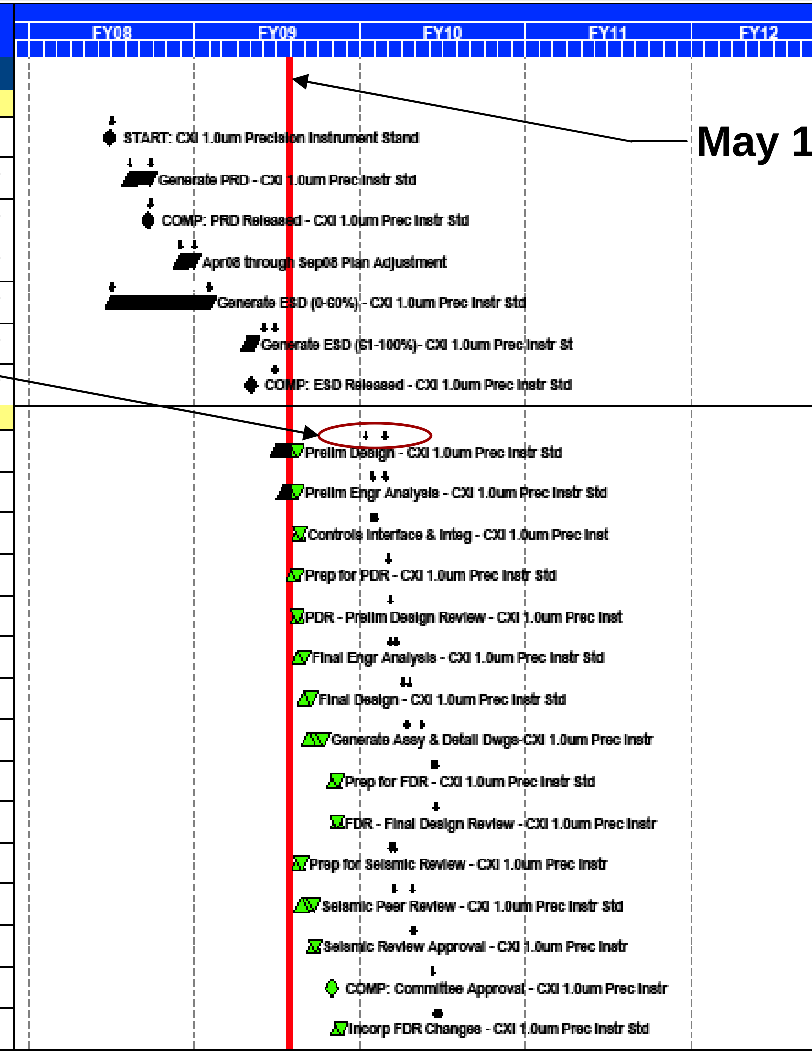
- Schedule
  - Through month end April
    - WBS 1.3.05.01.02: CXI 1 micron Precision Instrument Stand
    - WBS 1.3.05.01.03: CXI Detector Stage
- Cost
  - Through month end March
- Variances
- Summary

Schedule Status

CXI 1 micron Precision Instrument Stand

Arrows indicate OCT '08 baseline dates

Activity Description	Orig Dur	Total Float	Early Start	Early Finish
1.3.05.01.02 CXI Precision Instrument Stands				
9110355 Design & Engr - CXI Precision Instrument Stand				
START: CXI 1.0um Precision Instrument Stand	0		04/01/08A	
Generate PRD - CXI 1.0um Prec Instr Std	15		05/12/08A	06/23/08A
COMP: PRD Released - CXI 1.0um Prec Instr Std	0			06/23/08A
Apr08 through Sep08 Plan Adjustment	21		09/01/08A	09/30/08A
Generate ESD (0-60%) - CXI 1.0um Prec Instr Std	202		04/01/08A	10/31/08A
Generate ESD (61-100%)- CXI 1.0um Prec Instr St	9		01/26/09A	02/06/09A
COMP: ESD Released - CXI 1.0um Prec Instr Std	0			02/06/09A
9120355 Design & Engr - CXI Precision Instrument Stand				
Prelim Design - CXI 1.0um Prec Instr Std	30	18	04/01/09A	05/15/09
Prelim Engr Analysis - CXI 1.0um Prec Instr Std	20	18	04/15/09A	05/15/09
Controls Interface & Integ - CXI 1.0um Prec Inst	4	773	05/18/09	05/21/09
Prep for PDR - CXI 1.0um Prec Instr Std	7	18	05/06/09	05/14/09
PDR - Prelim Design Review - CXI 1.0um Prec Inst	1	18	05/15/09	05/15/09
Final Engr Analysis - CXI 1.0um Prec Instr Std	9	244	05/18/09	05/28/09
Final Design - CXI 1.0um Prec Instr Std	12	244	05/29/09	06/15/09
Generate Assy & Detail Dwgs-CXI 1.0um Prec Instr	25	244	06/08/09	07/10/09
Prep for FDR - CXI 1.0um Prec Instr Std	5	228	08/04/09	08/10/09
FDR - Final Design Review - CXI 1.0um Prec Instr	1	228	08/11/09	08/11/09
Prep for Seismic Review - CXI 1.0um Prec Instr	5	228	05/18/09	05/22/09
Seismic Peer Review - CXI 1.0um Prec Instr Std	20	228	05/25/09	06/19/09
Seismic Review Approval - CXI 1.0um Prec Instr	1	228	06/22/09	06/22/09
COMP: Committee Approval - CXI 1.0um Prec Instr	0	228		08/03/09
Incorp FDR Changes - CXI 1.0um Prec Instr Std	6	228	08/12/09	08/19/09

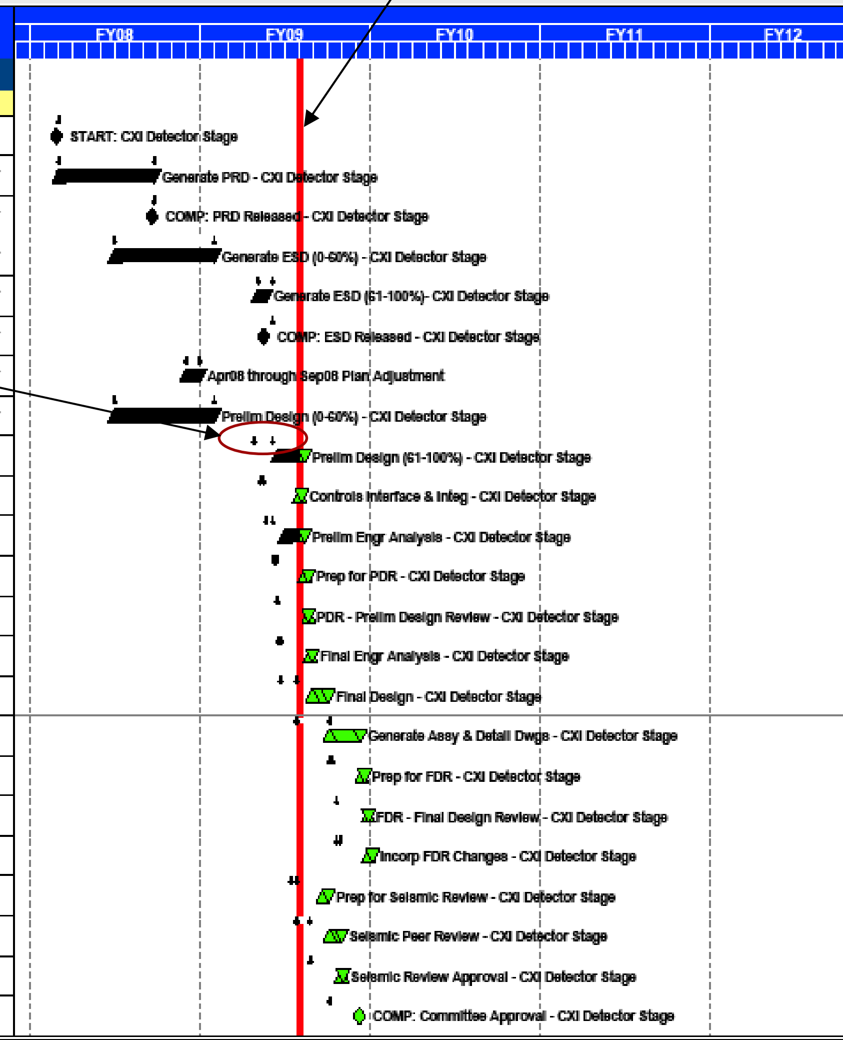


CXI Detector Stage

Arrows indicate OCT '08 baseline dates

May 1

Activity Description	Orig Dur	Total Float	Early Start	Early Finish
1.3.05.01.03 CXI Detector Stage				
9110359 Design & Engr - CXI Detector Stage				
START: CXI Detector Stage	0		12/03/07A	
Generate PRD - CXI Detector Stage	122		12/03/07A	06/23/08A
COMP: PRD Released - CXI Detector Stage	0			06/23/08A
Generate ESD (0-60%) - CXI Detector Stage	132		04/01/08A	10/31/08A
Generate ESD (61-100%)- CXI Detector Stage	25		02/02/09A	02/18/09A
COMP: ESD Released - CXI Detector Stage	0			02/18/09A
Apr08 through Sep08 Plan Adjustment	21		09/01/08A	09/30/08A
Prelim Design (0-60%) - CXI Detector Stage	120		04/01/08A	10/31/08A
Prelim Design (61-100%) - CXI Detector Stage	30	13	03/18/09A	05/14/09
Controls Interface & Integ - CXI Detector Stage	4	19	05/01/09	05/06/09
Prelim Engr Analysis - CXI Detector Stage	12	13	04/01/09A	05/14/09
Prep for PDR - CXI Detector Stage	5	13	05/15/09	05/21/09
PDR - Prelim Design Review - CXI Detector Stage	1	13	05/22/09	05/22/09
Final Engr Analysis - CXI Detector Stage	5	151	05/25/09	05/29/09
Final Design - CXI Detector Stage	25	151	06/01/09	07/03/09
Generate Assy & Detail Dwgs - CXI Detector Stage	50	156	07/06/09	09/11/09
Prep for FDR - CXI Detector Stage	5	156	09/14/09	09/18/09
FDR - Final Design Review - CXI Detector Stage	1	151	09/28/09	09/28/09
Incorp FDR Changes - CXI Detector Stage	5	151	09/29/09	10/05/09
Prep for Seismic Review - CXI Detector Stage	10	151	06/22/09	07/03/09
Seismic Peer Review - CXI Detector Stage	20	151	07/06/09	07/31/09
Seismic Review Approval - CXI Detector Stage	1	151	08/03/09	08/03/09
COMP: Committee Approval - CXI Detector Stage	0	151		09/14/09



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CXI 1 micron Precision Instrument Stand

Control Account	Work Package		FY2008	FY2009	FY2010	FY2011	FY2012	Cumulative
1.3.05.01 CXI Room Temperature Environment								
	9110355 Design & Engr - CXI Precision Instrument Stand	BCWS	$ 168	$ 5,516	$ 113,467	$ -	$ -	$ 119,151
		BCWP	$ 171	$ 10,048	$ -	$ -	$ -	$ 10,218
		ACWP	$ 168	$ 6,497	$ -	$ -	$ -	$ 6,664
	9110356 Procurement - CXI Precision Instrument Stand	BCWS	$ -	$ -	$ 40,747	$ -	$ -	$ 40,747
		BCWP	$ -	$ -	$ -	$ -	$ -	$ -
		ACWP	$ -	$ -	$ -	$ -	$ -	$ -
	9110357 Fab & Assembly - CXI Precision Instrument Stand	BCWS	$ -	$ -	$ 77,687	$ -	$ -	$ 77,687
		BCWP	$ -	$ -	$ -	$ -	$ -	$ -
		ACWP	$ -	$ -	$ -	$ -	$ -	$ -
	9110358 Testing - CXI Precision Instrument Stand	BCWS	$ -	$ -	$ 2,998	$ -	$ -	$ 2,998
		BCWP	$ -	$ -	$ -	$ -	$ -	$ -
		ACWP	$ -	$ -	$ -	$ -	$ -	$ -
Control Account Totals:		BCWS	$ 168	$ 5,516	$ 234,900	$ -	$ -	$ 240,584
		BCWP	$ 171	$ 10,048	$ -	$ -	$ -	$ 10,218
		ACWP	$ 168	$ 6,497	$ -	$ -	$ -	$ 6,664

Control Account Work Package	CUMULATIVE TO DATE					AT COMPLETION		
	BUDGETED COST		ACTUAL COST	VARIANCE				
	WORK SCHEDULED	WORK PERFORMED	WORK PERFORMED	SCHEDULE	COST	BUDGETED	ESTIMATED	VARIANCE
1.3.05.01 CXI Room Temperature Environment								
9110355 Design & Engr - CXI Precision Instrument Stand	$ 5,683	$ 10,218	$ 6,664	$ 4,535	$ 3,554	$ 119,151	$ 118,837	$ 314
9110356 Procurement - CXI Precision Instrument Stand	$ -	$ -	$ -	$ -	$ -	$ 40,747	$ 40,902	$ (155)
9110357 Fab & Assembly - CXI Precision Instrument Stand	$ -	$ -	$ -	$ -	$ -	$ 77,687	$ 77,687	$ 0
9110358 Testing - CXI Precision Instrument Stand	$ -	$ -	$ -	$ -	$ -	$ 2,998	$ 2,998	$ -
Control AccountTotals:	$ 5,683	$ 10,218	$ 6,664	$ 4,535	$ 3,554	$ 240,584	$ 240,425	$ 159

Cost Status (2)

CXI Detector Stage

Control Account	Work Package		FY2008	FY2009	FY2010	FY2011	FY2012	Cumulative
1.3.05.01 CXI Room Temperature Environment								
	9110359 Design & Engr - CXI Detector Stage	BCWS	$ 1,699	$ 133,713	$ -	$ -	$ -	$ 135,411
		BCWP	$ 1,699	$ 12,121	$ -	$ -	$ -	$ 13,821
		ACWP	$ 1,699	$ 2,530	$ -	$ -	$ -	$ 4,229
	9110360 Procurement - CXI Detector Stage	BCWS	$ -	$ -	$ 107,703	$ -	$ -	$ 107,703
		BCWP	$ -	$ -	$ -	$ -	$ -	$ -
		ACWP	$ -	$ -	$ -	$ -	$ -	$ -
	9110361 Fab & Assembly - CXI Detector Stage	BCWS	$ -	$ 8,908	$ 69,305	$ 6,892	$ -	$ 85,104
		BCWP	$ -	$ -	$ -	$ -	$ -	$ -
		ACWP	$ -	$ -	$ -	$ -	$ -	$ -
	9110362 Testing - CXI Detector Stage	BCWS	$ -	$ -	$ -	$ 1,871	$ -	$ 1,871
		BCWP	$ -	$ -	$ -	$ -	$ -	$ -
		ACWP	$ -	$ -	$ -	$ -	$ -	$ -
Control Account Totals:		BCWS	$ 1,699	$ 142,620	$ 177,007	$ 8,763	$ -	$ 330,090
		BCWP	$ 1,699	$ 12,121	$ -	$ -	$ -	$ 13,821
		ACWP	$ 1,699	$ 2,530	$ -	$ -	$ -	$ 4,229

Control Account / **Work Package**	**CUMULATIVE TO DATE**					**AT COMPLETION**		
	BUDGETED COST		**ACTUAL COST**	**VARIANCE**				
	WORK SCHEDULED	**WORK PERFORMED**	**WORK PERFORMED**	**SCHEDULE**	**COST**	**BUDGETED**	**ESTIMATED**	**VARIANCE**
1.3.05.01 CXI Room Temperature Environment								
9110359 Design & Engr - CXI Detector Stage	$ 54,277	$ 13,821	$ 4,229	$ (40,456)	$ 9,592	$ 135,411	$ 133,562	$ 1,849
9110360 Procurement - CXI Detector Stage	$ -	$ -	$ -	$ -	$ -	$ 107,703	$ 108,113	$ (410)
9110361 Fab & Assembly - CXI Detector Stage	$ -	$ -	$ -	$ -	$ -	$ 85,104	$ 84,322	$ 782
9110362 Testing - CXI Detector Stage	$ -	$ -	$ -	$ -	$ -	$ 1,871	$ 1,799	$ 72
Control Account Totals:	$ 54,277	$ 13,821	$ 4,229	$ (40,456)	$ 9,592	$ 330,090	$ 327,795	$ 2,294

Variances

- Performance Indices
  - Schedule Performance Index (SPI) = BCWP/BCWS
    - BCWP: Budgeted Cost of Work Performed
    - BCWS: Budgeted Cost of Work Scheduled
  - Cost Performance Index (CPI) = BCWP/ACWP
    - ACWP: Actual Cost of Work Performed
- CXI 1 micron Precision Instrument Stand – cumulative data through March
  - SPI=1.80
    - Engineering & Design effort was scheduled to start in FY10 (Oct 09) but W. Olson joined the CXI team mid-March and started work immediately on the Precision Instrument Stand, i.e. work was performed sooner than scheduled
  - CPI=1.53
    - Documentation efforts performed as LOE activities
- CXI Detector Stage – cumulative data through March
  - SPI=0.26
    - Engineering/Design was scheduled to start Jan '09 but we didn't have resources available until Pegasus was on-board in mid-March → behind schedule
  - CPI=3.27
    - Abnormally high since we weren't spending money on design effort but rather only on documentation (ESD & SOW) and much of that effort was accomplished as LOE

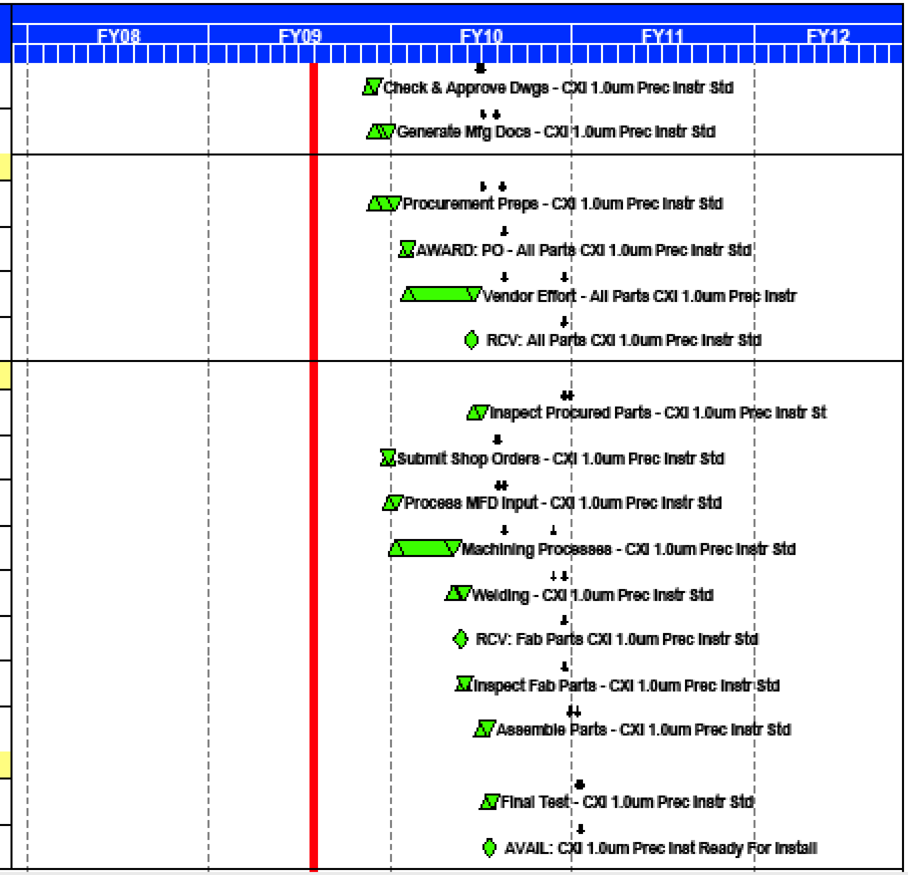
Summary

- Performance indices should be much improved for the next reporting period
  - April actuals will be folded-in
- Preliminary designs are advanced beyond what has typically been considered "PDR ready", this puts in good position as far as schedule is concerned
  - PDRs are a prerequisite for FIDR (to be held June 3rd)
  - Significant "float" remaining
- Cost & schedule in good shape for both the CXI 1 micron Precision Instrument Stand and Detector Stage

End of Presentation

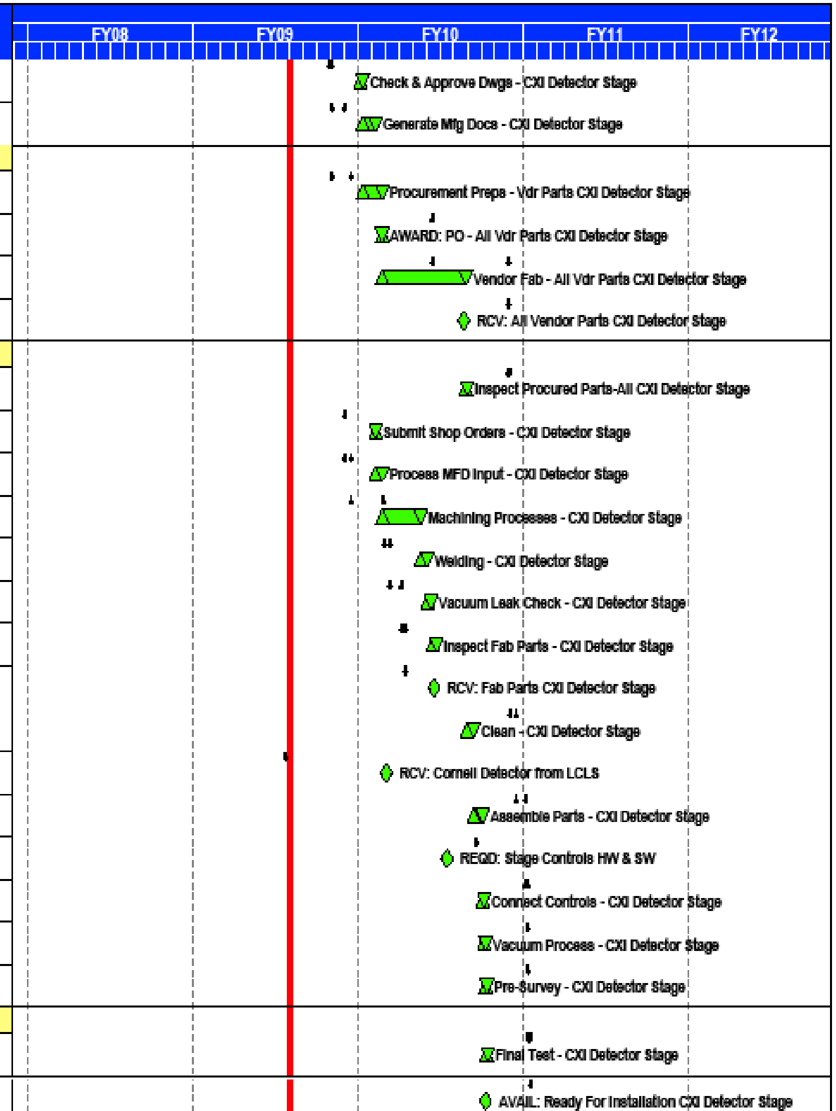
Backup Material: Schedule

Activity Description	Orig Dur	Total Float	Early Start	Early Finish
Check & Approve Dwgs - CXI 1.0um Prec Instr Std	6	228	08/20/09	08/27/09
Generate Mfg Docs - CXI 1.0um Prec Instr Std	20	235	08/28/09	09/24/09
9120356 Procurement - CXI Precision Instrument Stand				
Procurement Preps - CXI 1.0um Prec Instr Std	30	226	08/28/09	10/08/09
AWARD: PO - All Parts CXI 1.0um Prec Instr Std	1	212	11/02/09	11/02/09
Vendor Effort - All Parts CXI 1.0um Prec Instr	85	212	11/03/09	03/17/10
RCV: All Parts CXI 1.0um Prec Instr Std	0	212		03/17/10
9120357 Fab & Assembly - CXI Precision Instrument Stand				
Inspect Procured Parts - CXI 1.0um Prec Instr St	10	212	03/18/10	03/31/10
Submit Shop Orders - CXI 1.0um Prec Instr Std	1	235	09/25/09	09/25/09
Process MFD Input - CXI 1.0um Prec Instr Std	10	235	09/28/09	10/09/09
Machining Processes - CXI 1.0um Prec Instr Std	70	235	10/12/09	02/02/10
Welding - CXI 1.0um Prec Instr Std	15	235	02/03/10	02/23/10
RCV: Fab Parts CXI 1.0um Prec Instr Std	0	235		02/23/10
Inspect Fab Parts - CXI 1.0um Prec Instr Std	3	235	02/24/10	02/26/10
Assemble Parts - CXI 1.0um Prec Instr Std	10	212	04/01/10	04/14/10
9120358 Testing - CXI Precision Instrument Stand				
Final Test - CXI 1.0um Prec Instr Std	5	212	04/15/10	04/21/10
AVAIL: CXI 1.0um Prec Inst Ready For Install	0	212		04/21/10



Backup Material: Schedule (2)

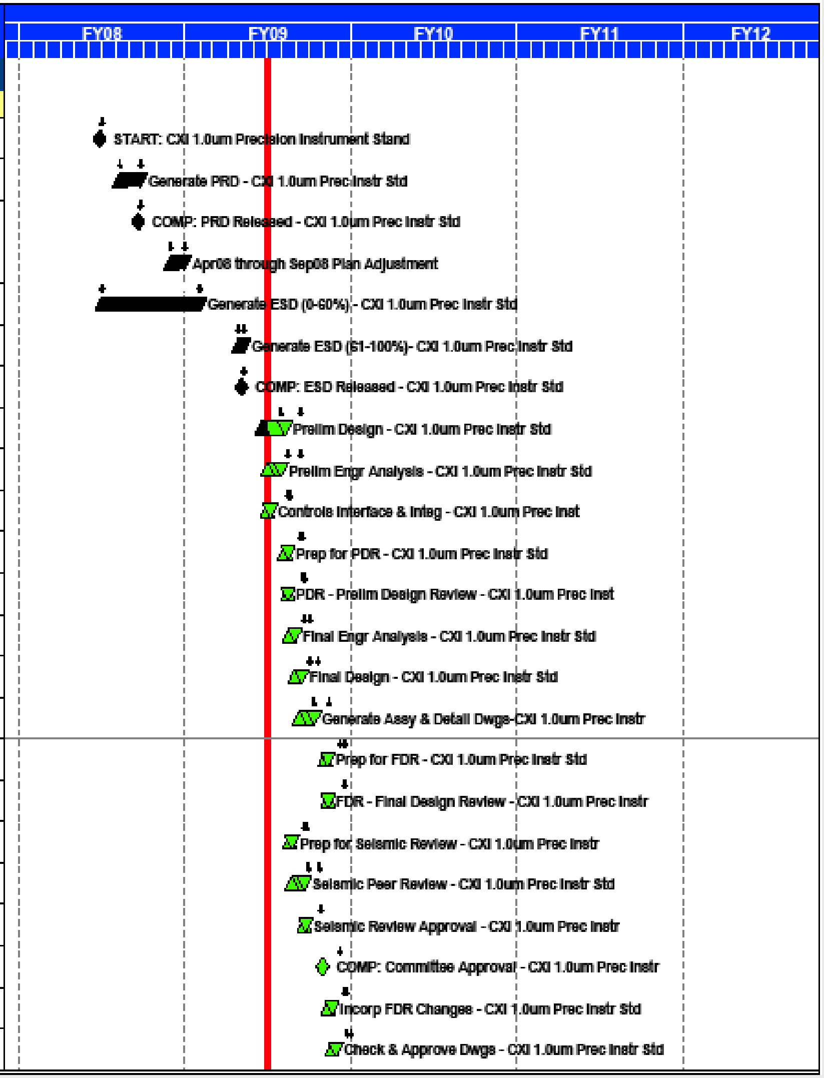
Activity Description	Orig Dur	Total Float	Early Start	Early Finish
Check & Approve Dwgs - CXI Detector Stage	5	151	10/06/09	10/12/09
Generate Mfg Docs - CXI Detector Stage	20	200	10/13/09	11/09/09
9120360 Procurement - CXI Detector Stage				
Procurement Preps - Vdr Parts CXI Detector Stage	30	151	10/13/09	11/23/09
AWARD: PO - All Vdr Parts CXI Detector Stage	1	151	11/24/09	11/24/09
Vendor Fab - All Vdr Parts CXI Detector Stage	120	151	11/25/09	05/27/10
RCV: All Vendor Parts CXI Detector Stage	0	151		05/27/10
9120361 Fab & Assembly - CXI Detector Stage				
Inspect Procured Parts-All CXI Detector Stage	2	151	05/28/10	05/31/10
Submit Shop Orders - CXI Detector Stage	1	200	11/10/09	11/10/09
Process MFD Input - CXI Detector Stage	10	200	11/11/09	11/24/09
Machining Processes - CXI Detector Stage	50	200	11/25/09	02/18/10
Welding - CXI Detector Stage	8	200	02/19/10	03/02/10
Vacuum Leak Check - CXI Detector Stage	8	200	03/03/10	03/12/10
Inspect Fab Parts - CXI Detector Stage	7	200	03/15/10	03/23/10
RCV: Fab Parts CXI Detector Stage	0	200		03/23/10
Clean - CXI Detector Stage	10	151	06/01/10	06/14/10
RCV: Cornell Detector from LCLS	0	275		12/08/09*
Assemble Parts - CXI Detector Stage	15	151	06/15/10	07/05/10
REQD: Stage Controls HW & SW	0	204		04/21/10
Connect Controls - CXI Detector Stage	3	151	07/06/10	07/08/10
Vacuum Process - CXI Detector Stage	1	151	07/09/10	07/09/10
Pre-Survey - CXI Detector Stage	1	151	07/12/10	07/12/10
9120362 Testing - CXI Detector Stage				
Final Test - CXI Detector Stage	3	151	07/13/10	07/15/10
AVAIL: Ready For Installation CXI Detector Stage	0	151		07/15/10



Backup Material: Schedule (3)

- Month end March schedule: Precision Stand

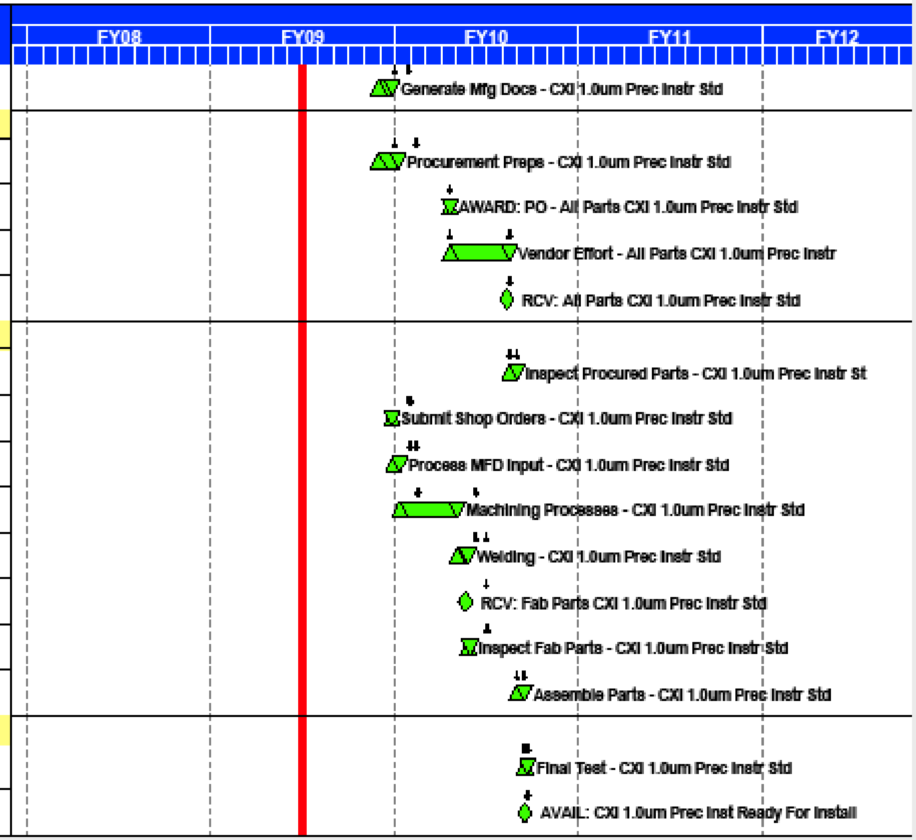
Activity Description	Orig Dur	Total Float	Early Start	Early Finish
1.3.05.01.02 CXI Precision Instrument Stands				
9110355 Design & Engr - CXI Precision Instrument Stand				
START: CXI 1.0um Precision Instrument Stand	0		04/01/08A	
Generate PRD - CXI 1.0um Prec Instr Std	15		05/12/08A	06/23/08A
COMP: PRD Released - CXI 1.0um Prec Instr Std	0			06/23/08A
Apr08 through Sep08 Plan Adjustment	21		09/01/08A	09/30/08A
Generate ESD (0-60%) - CXI 1.0um Prec Instr Std	202		04/01/08A	10/31/08A
Generate ESD (61-100%)- CXI 1.0um Prec Instr Std	9		01/26/09A	02/06/09A
COMP: ESD Released - CXI 1.0um Prec Instr Std	0			02/06/09A
Prelim Design - CXI 1.0um Prec Instr Std	30	61	03/16/09A	05/07/09
Prelim Engr Analysis - CXI 1.0um Prec Instr Std	20	68	04/01/09	04/28/09
Controls Interface & Integ - CXI 1.0um Prec Inst	4	84	04/01/09	04/06/09
Prep for PDR - CXI 1.0um Prec Instr Std	5	61	05/08/09	05/14/09
PDR - Prelim Design Review - CXI 1.0um Prec Inst	1	61	05/15/09	05/15/09
Final Engr Analysis - CXI 1.0um Prec Instr Std	9	244	05/18/09	05/28/09
Final Design - CXI 1.0um Prec Instr Std	12	244	05/29/09	06/15/09
Generate Assy & Detail Dwgs-CXI 1.0um Prec Instr	25	244	06/08/09	07/10/09
Prep for FDR - CXI 1.0um Prec Instr Std	5	226	08/04/09	08/10/09
FDR - Final Design Review - CXI 1.0um Prec Instr	1	226	08/11/09	08/11/09
Prep for Seismic Review - CXI 1.0um Prec Instr	5	228	05/18/09	05/22/09
Seismic Peer Review - CXI 1.0um Prec Instr Std	20	228	05/25/09	06/19/09
Seismic Review Approval - CXI 1.0um Prec Instr	1	228	06/22/09	06/22/09
COMP: Committee Approval - CXI 1.0um Prec Instr	0	226		08/03/09
Incorp FDR Changes - CXI 1.0um Prec Instr Std	6	226	08/12/09	08/19/09
Check & Approve Dwgs - CXI 1.0um Prec Instr Std	6	226	08/20/09	08/27/09



Backup Material: Schedule (4)

- Month end March schedule: Precision Stand

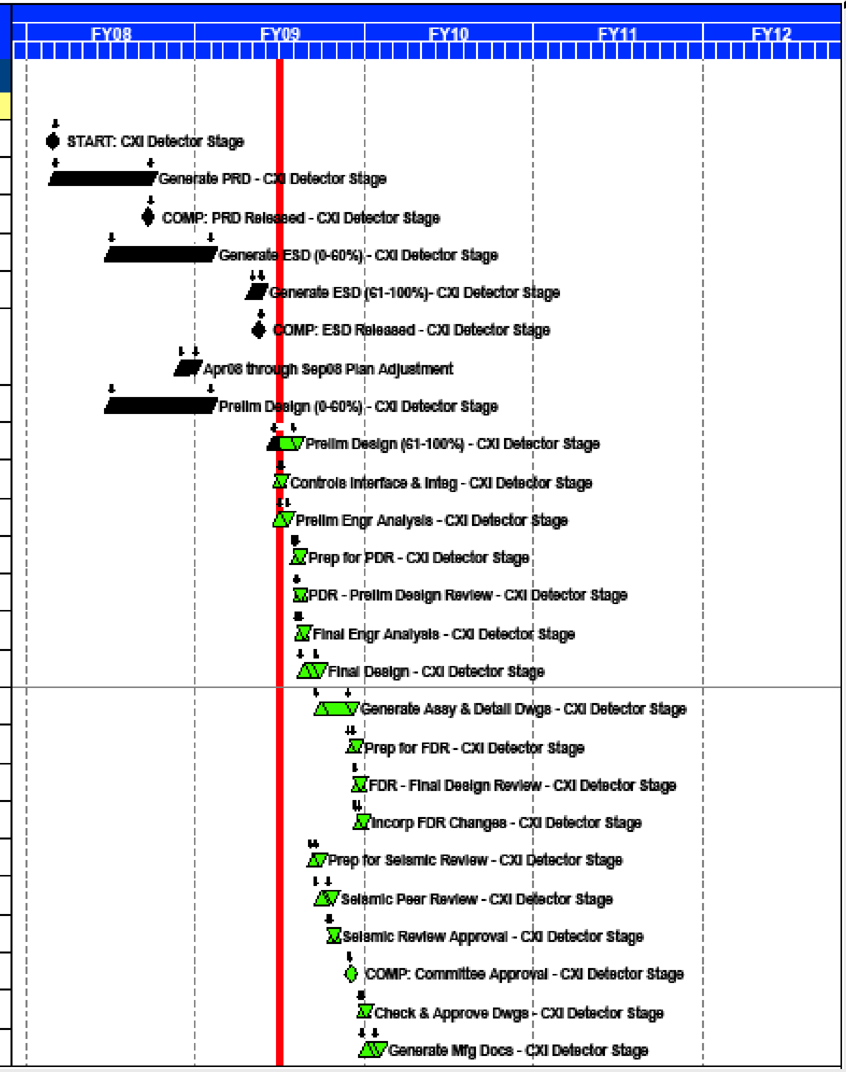
Activity Description	Orig Dur	Total Float	Early Start	Early Finish
Generate Mfg Docs - CXI 1.0um Prec Instr Std	20	235	08/28/09	09/24/09
9110356 Procurement - CXI Precision Instrument Stand				
Procurement Preps - CXI 1.0um Prec Instr Std	30	228	08/28/09	10/08/09
AWARD: PO - All Parts CXI 1.0um Prec Instr Std	1	169	01/18/10	01/18/10
Vendor Effort - All Parts CXI 1.0um Prec Instr	85	169	01/19/10	05/17/10
RCV: All Parts CXI 1.0um Prec Instr Std	0	169		05/17/10
9110357 Fab & Assembly - CXI Precision Instrument Stand				
Inspect Procured Parts - CXI 1.0um Prec Instr St	10	169	05/18/10	05/31/10
Submit Shop Orders - CXI 1.0um Prec Instr Std	1	235	09/25/09	09/25/09
Process MFD Input - CXI 1.0um Prec Instr Std	10	235	09/28/09	10/09/09
Machining Processes - CXI 1.0um Prec Instr Std	70	235	10/12/09	02/02/10
Welding - CXI 1.0um Prec Instr Std	15	235	02/03/10	02/23/10
RCV: Fab Parts CXI 1.0um Prec Instr Std	0	235		02/23/10
Inspect Fab Parts - CXI 1.0um Prec Instr Std	3	235	02/24/10	02/26/10
Assemble Parts - CXI 1.0um Prec Instr Std	10	169	06/01/10	06/14/10
9110358 Testing - CXI Precision Instrument Stand				
Final Test - CXI 1.0um Prec Instr Std	5	169	06/15/10	06/21/10
AVAIL: CXI 1.0um Prec Inst Ready For Install	0	169		06/21/10



Backup Material: Schedule (5)

- Month end March schedule: Detector Stage

Activity Description	Orig Dur	Total Float	Early Start	Early Finish
1.3.05.01.03 CXI Detector Stage				
9110359 Design & Engr - CXI Detector Stage				
START: CXI Detector Stage	0		12/03/07A	
Generate PRD - CXI Detector Stage	122		12/03/07A	05/23/08A
COMP: PRD Released - CXI Detector Stage	0			05/23/08A
Generate ESD (0-60%) - CXI Detector Stage	132		04/01/08A	10/31/08A
Generate ESD (61-100%)- CXI Detector Stage	25		02/02/09A	02/18/09A
COMP: ESD Released - CXI Detector Stage	0			02/18/09A
Apr08 through Sep08 Plan Adjustment	21		09/01/08A	09/30/08A
Prelim Design (0-60%) - CXI Detector Stage	120		04/01/08A	10/31/08A
Prelim Design (61-100%) - CXI Detector Stage	30	61	03/18/09A	05/07/09
Controls Interface & Integ - CXI Detector Stage	4	84	04/01/09	04/06/09
Prelim Engr Analysis - CXI Detector Stage	12	76	04/01/09	04/16/09
Prep for PDR - CXI Detector Stage	5	61	05/08/09	05/14/09
PDR - Prelim Design Review - CXI Detector Stage	1	61	05/15/09	05/15/09
Final Engr Analysis - CXI Detector Stage	5	156	05/18/09	05/22/09
Final Design - CXI Detector Stage	25	156	05/25/09	06/26/09
Generate Assy & Detail Dwgs - CXI Detector Stage	50	161	06/29/09	09/04/09
Prep for FDR - CXI Detector Stage	5	161	09/07/09	09/11/09
FDR - Final Design Review - CXI Detector Stage	1	156	09/21/09	09/21/09
Incorp FDR Changes - CXI Detector Stage	5	156	09/22/09	09/28/09
Prep for Seismic Review - CXI Detector Stage	10	156	06/15/09	06/26/09
Seismic Peer Review - CXI Detector Stage	20	156	06/29/09	07/24/09
Seismic Review Approval - CXI Detector Stage	1	156	07/27/09	07/27/09
COMP: Committee Approval - CXI Detector Stage	0	156		09/07/09
Check & Approve Dwgs - CXI Detector Stage	5	156	09/29/09	10/05/09
Generate Mfg Docs - CXI Detector Stage	20	205	10/06/09	11/02/09



Month end March schedule: Detector Stage

Activity Description	Orig Dur	Total Float	Early Start	Early Finish
9110360 Procurement - CXI Detector Stage				
Procurement Preps - Vdr Parts CXI Detector Stage	30	156	10/06/09	11/16/09
AWARD: PO - All Vdr Parts CXI Detector Stage	1	124	01/18/10	01/18/10
Vendor Fab - All Vdr Parts CXI Detector Stage	120	124	01/19/10	07/05/10
RCV: All Vendor Parts CXI Detector Stage	0	124		07/05/10
9110361 Fab & Assembly - CXI Detector Stage				
Inspect Procured Parts-All CXI Detector Stage	2	124	07/06/10	07/07/10
Submit Shop Orders - CXI Detector Stage	1	205	11/03/09	11/03/09
Process MFD Input - CXI Detector Stage	10	205	11/04/09	11/17/09
Machining Processes - CXI Detector Stage	50	205	11/18/09	02/11/10
Welding - CXI Detector Stage	8	205	02/12/10	02/23/10
Vacuum Leak Check - CXI Detector Stage	8	205	02/24/10	03/05/10
Inspect Fab Parts - CXI Detector Stage	7	205	03/08/10	03/16/10
RCV: Fab Parts CXI Detector Stage	0	205		03/16/10
Clean - CXI Detector Stage	10	124	07/08/10	07/21/10
RCV: Cornell Detector from LCLS	0	435		04/24/09*
Assemble Parts - CXI Detector Stage	15	124	07/22/10	08/11/10
REQD: Stage Controls HW & SW	0	201		04/26/10
Connect Controls - CXI Detector Stage	3	124	08/12/10	08/16/10
Vacuum Process - CXI Detector Stage	1	124	08/17/10	08/17/10
Pre-Survey - CXI Detector Stage	1	124	08/18/10	08/18/10
9110362 Testing - CXI Detector Stage				
Final Test - CXI Detector Stage	3	124	08/19/10	08/23/10
AVAIL: Ready For Installation CXI Detector Stage	0	124		08/23/10