Temporary FEL Diagnostics

Josef Frisch – for the LCLS Commissioning Group
June 09, 2009

Compact FEL Diagnostic

- Provide beam diagnostics until FEE is ready
  - Primary source of FEL information to date
- Provide beam diagnostics when PPS stoppers are closed
  - Allows machine tuning while FEE and experimental hutches are in access
- First generation diagnostics located in unused ST0 chamber
- Second generation diagnostics under construction

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Temporary Diagnostics

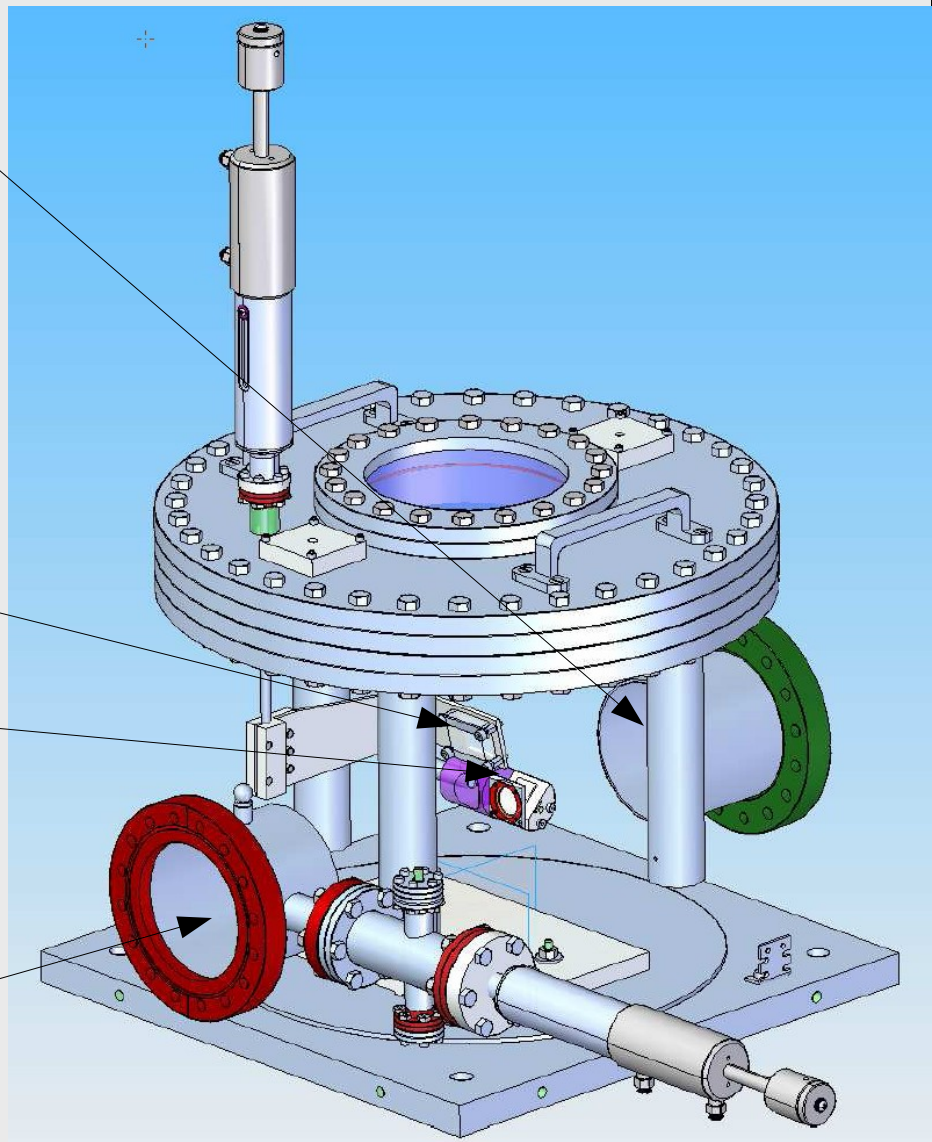
B4C stopper permanently installed downstream

Cameras to monitor YAG and B4C continuously

Ni, B4C, Or C

YAG screen

Be Coherent visible radiation blocking foil



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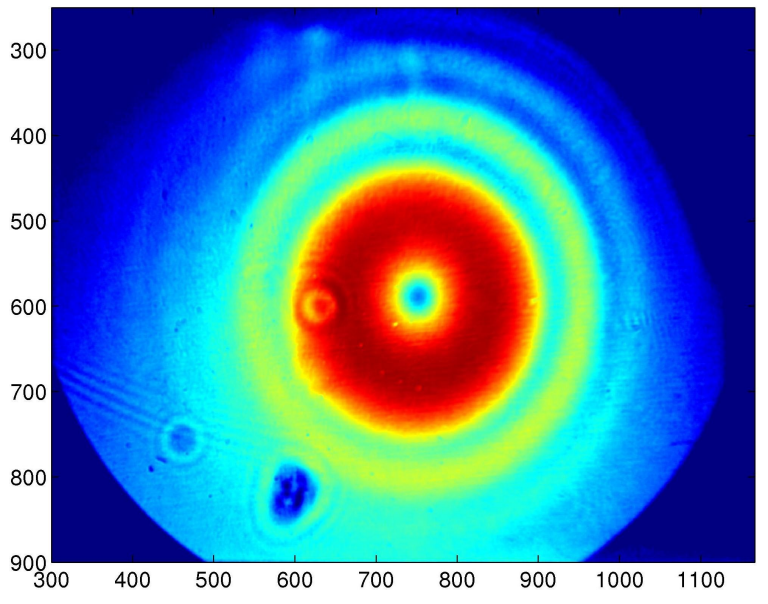
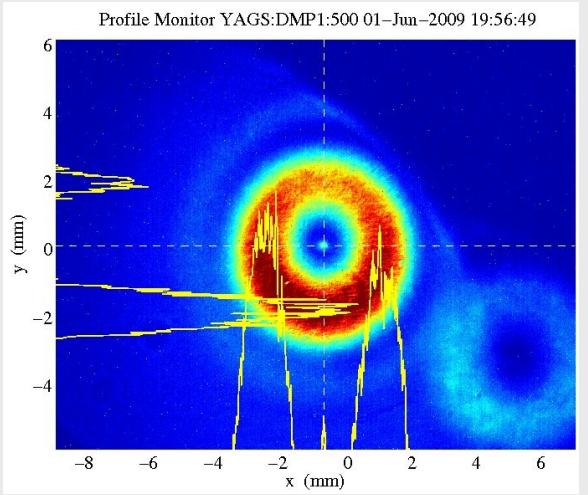
Be Coherent Radiation Block



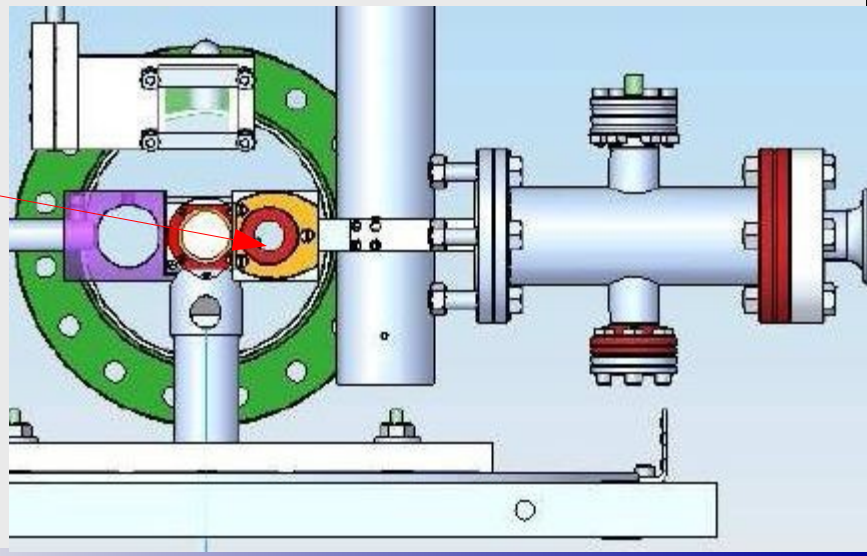
Coherent light has blue-white color



FEL spot visible in center of coherent light ring

Coherent Visible light from dump bend
Will blind YAG screen

Be foil, 1um thick
1cm diameter



No evidence of damage to Be yet.

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B4C / Ni / Carbon Insert

- Only have an in/out pneumatic actuator
  - Need to vent to change insert materials
- Materials choices:
  - B4C: Damage tests, Stopper for 800 eV
  - Ni: K-edge at 8.33 KeV for wavelength calibration.
  - Carbon / Ni: Attenuator to allow operation with the the YAG unsaturated. K edge from Ni for wavelength calibration
- When FEE is ready, B4C will be used as a MPS photon stop to protect PPS stoppers.

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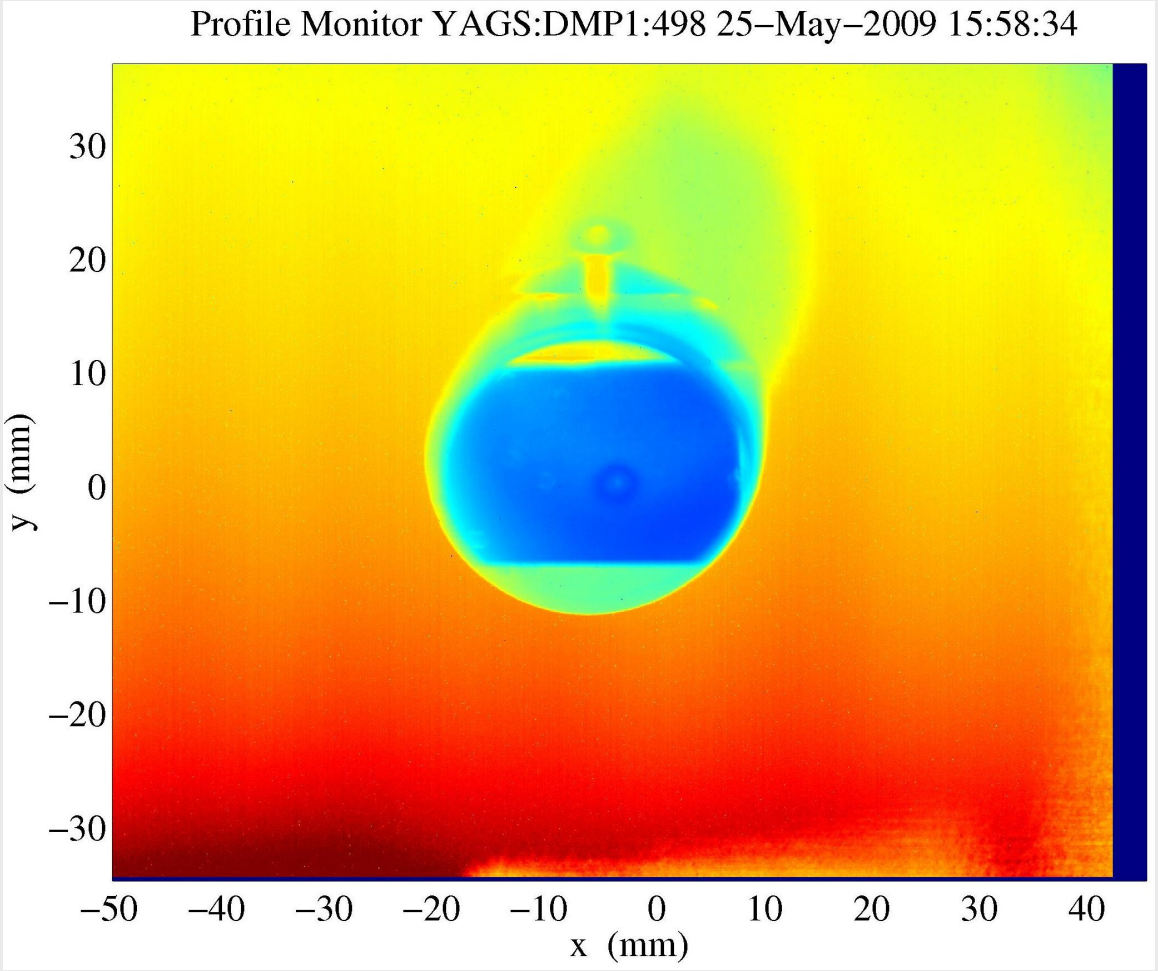
B4C Damage Testing



B4C after 4M shots at 820eV.
Dark area may be deposited Carbon, sample is being analyzed now

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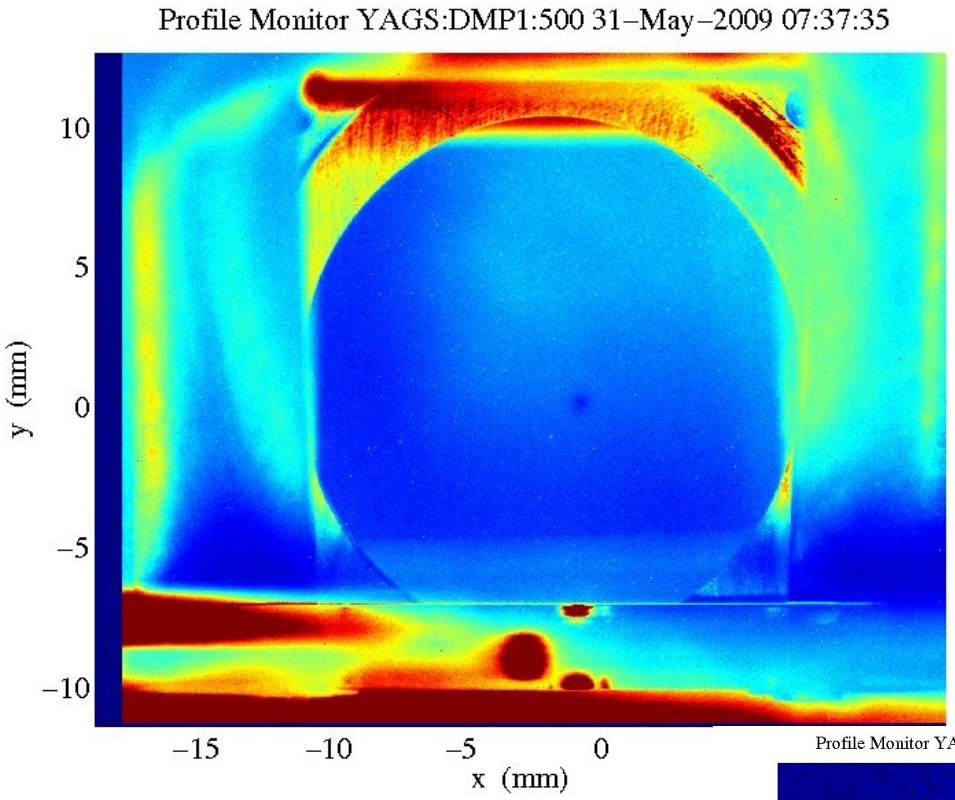
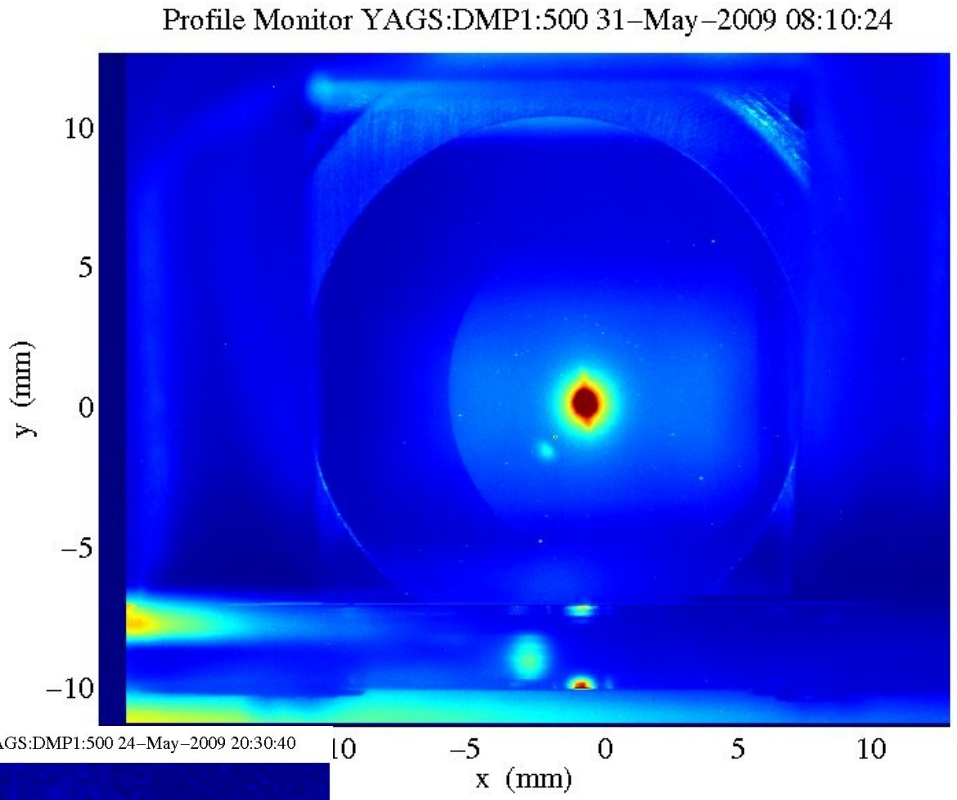
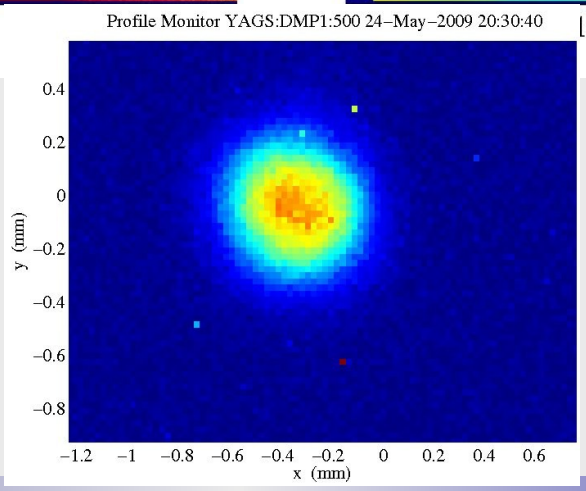
YAG Images





No Beam

Zoom Image



With 8.33 KeV FEL

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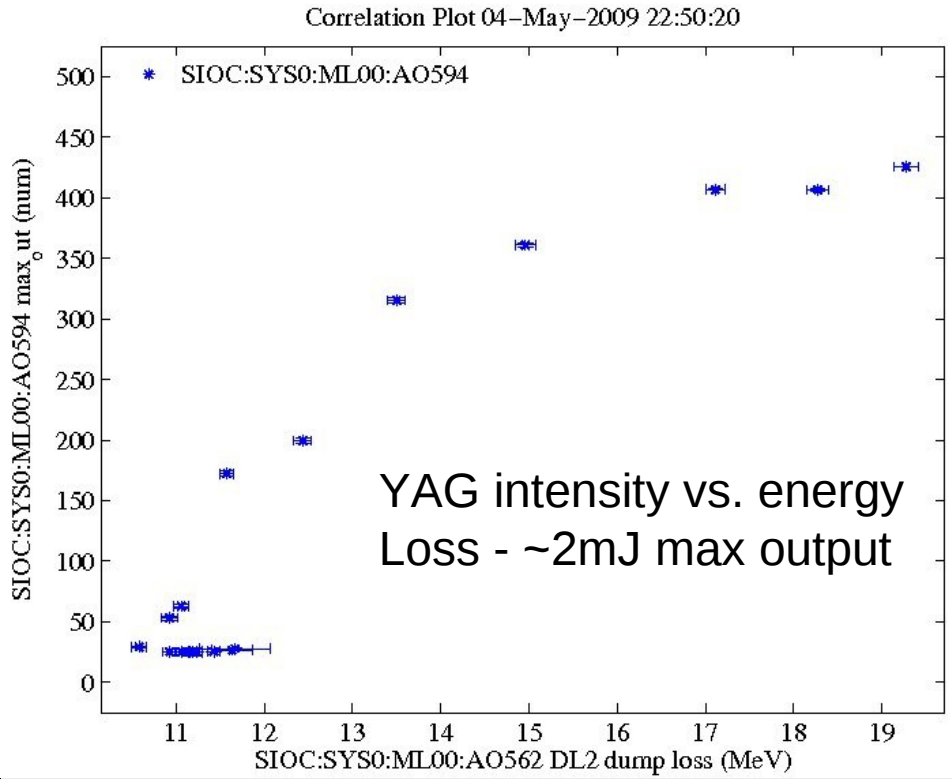
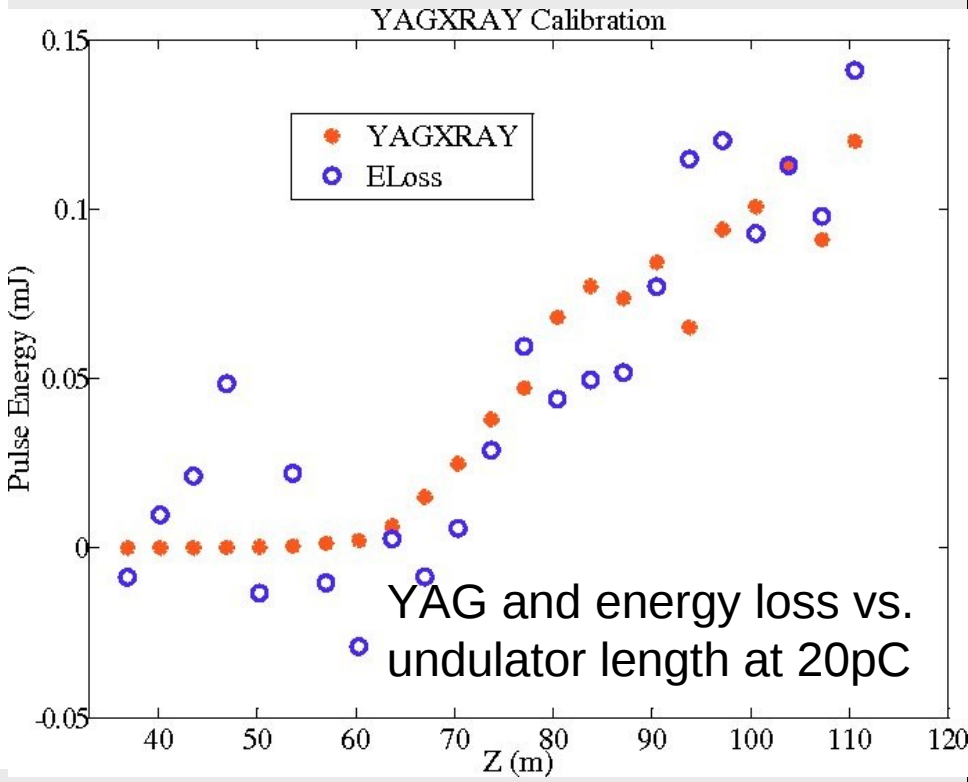
YAG Screen Saturation





YAG screen is 100 micron thick Ce:YAG, same as used in injector profile monitors

At normal FEL powers, 8.33 KeV saturation is significant

Cannot use at low energy – possibility of damage

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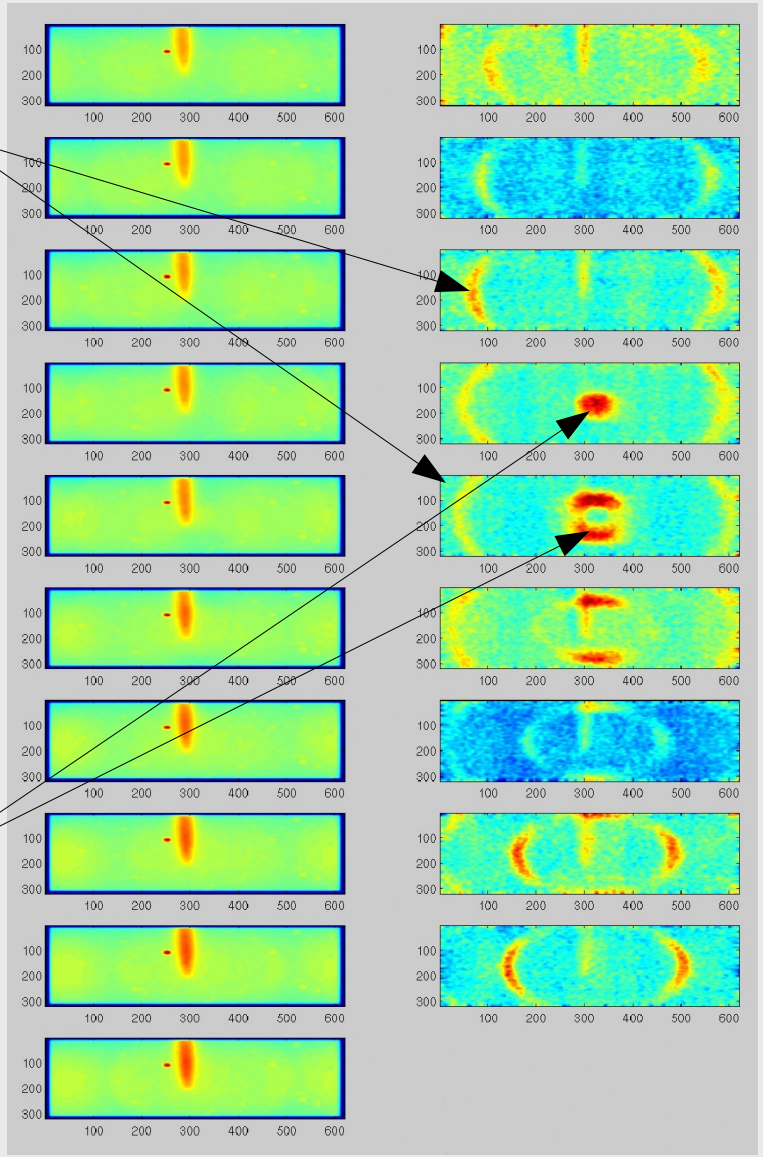
Use Yttrium K-edge in YAG

Use Yttrium K-edge 17.08 KeV to measure energy of spontaneous radiation 3rd harmonic

Sequence of images starting at 10.8 GeV, 200MeV steps, raw images on left, difference images on right.

Similar technique can be used to measure FEL 3rd harmonic (not tried yet).



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Next Generation Diagnostic

- Existing ST0 can not designed for this job
  - Very difficult to modify
  - Stopper in front of YAG
  - Need to remove YAG permanently when FEE is read
- Need a diagnostic for FEL tuning when FEE is in access and PPS stoppers are closed
- New vacuum chamber to fit in existing ST0 location
- Designed for easy installation of new diagnostics

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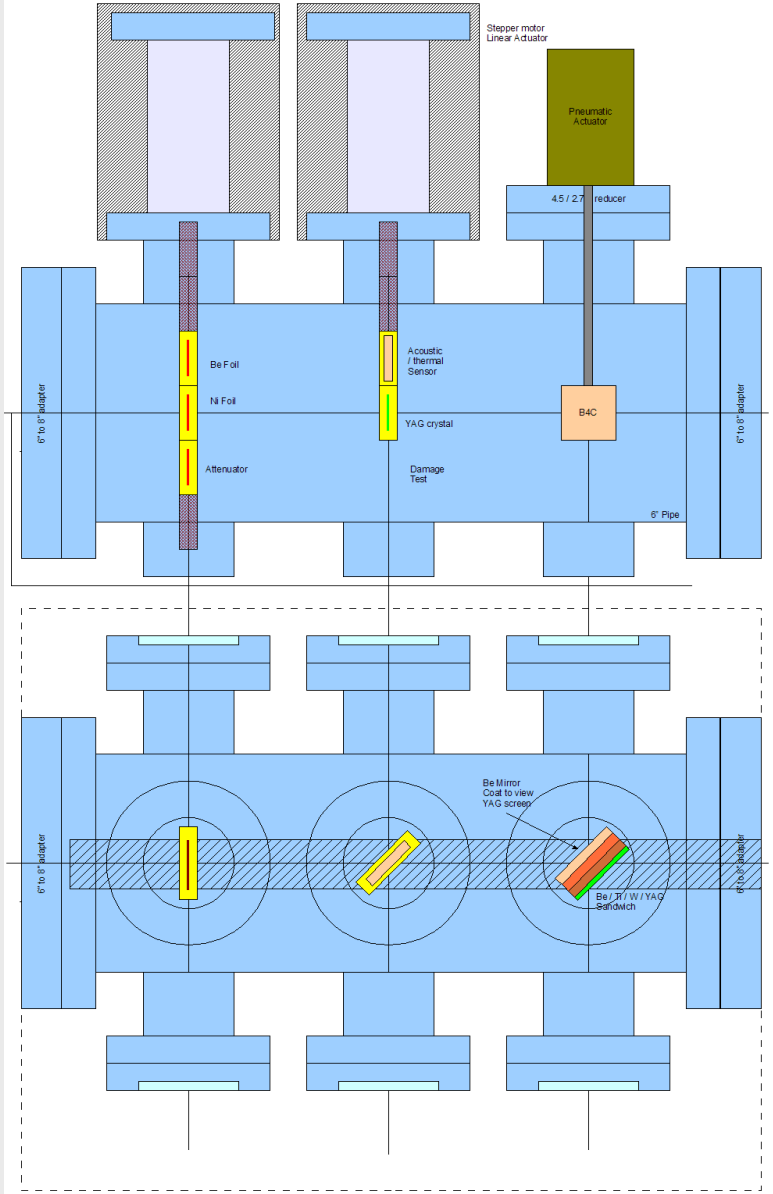
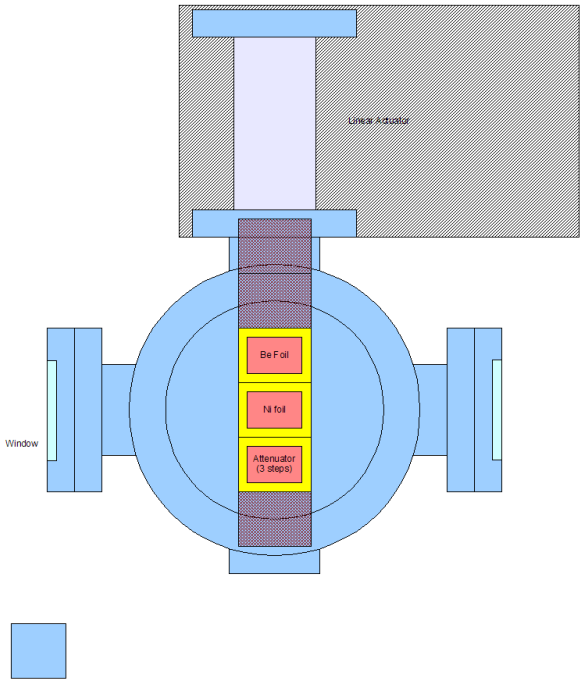
New Diagnostics Chamber - Schematic





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New Diagnostic Chamber - Functions

- Test Position #1
  - Motorized Position
  - Series of X-ray attenuators and filters
- Test Position #2
  - Motorized Position (Initially pneumatic)
  - YAG screen (same as on existing chamber)
  - Acoustic / thermal X-ray power sensor
- Test Position #3
  - Pneumatic Position
  - B4C X-ray shutter, MPS interlocked to downstream PPS shutters.

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Attenuators / Filters

- Want to attenuate X-rays before YAG screen to prevent saturation
  - Be for low energy, C or B4C for high energy
- Different thickness required for different energies
  - With large attenuation 3rd harmonic transmission becomes relatively large – unsolved problem
- Filters – Use K edge for wavelength calibration
  - Range from Mg = 1.305 KeV to Cu at 8.98 KeV

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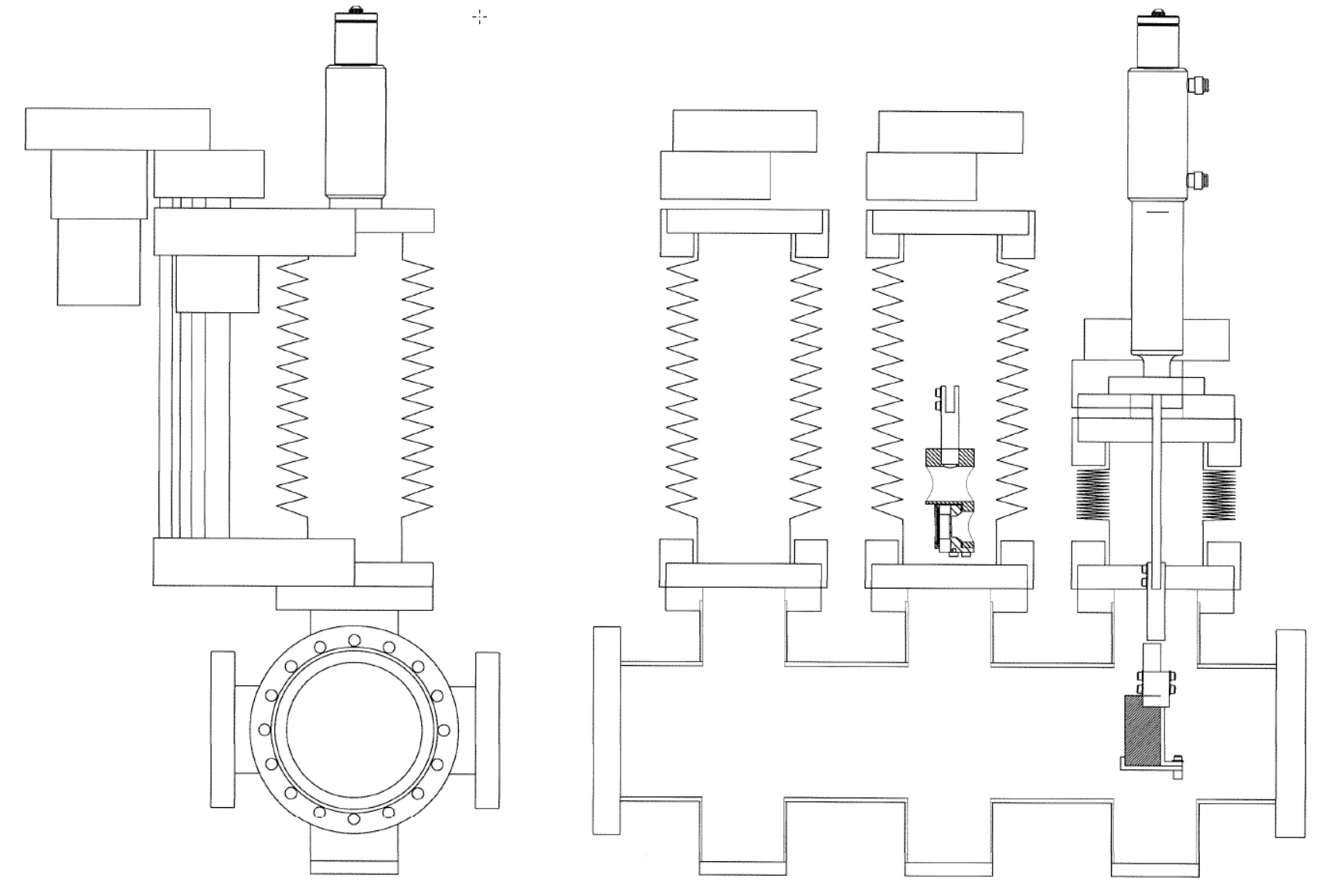
New Diagnostic Chamber



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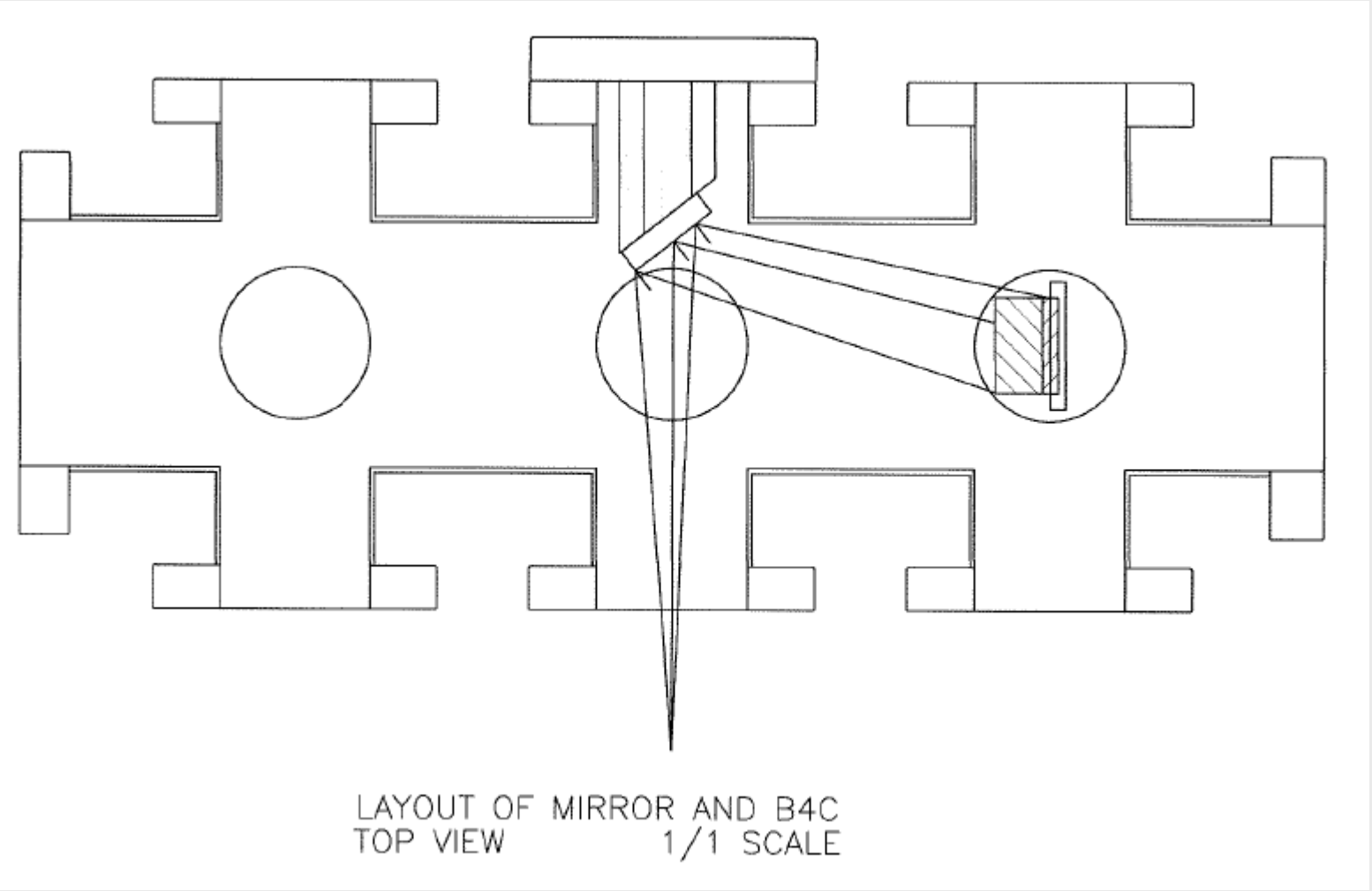
New Diagnostic Chamber



Mirror to observe front surface of B4C stopper

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Acoustic / Thermal Sensor

- X-ray beam heats target
  - ~ 1cm cube of B4C, or Be
- Thermal expansion → acoustic wave
  - Detect with ultrasonic piezo-electric sensors
- Provides shot to shot measurement of X-ray pulse energy
- In low frequency limit, signal should be nearly independent of X-ray wavelength.
- Average temperature rise of block used for calibration.

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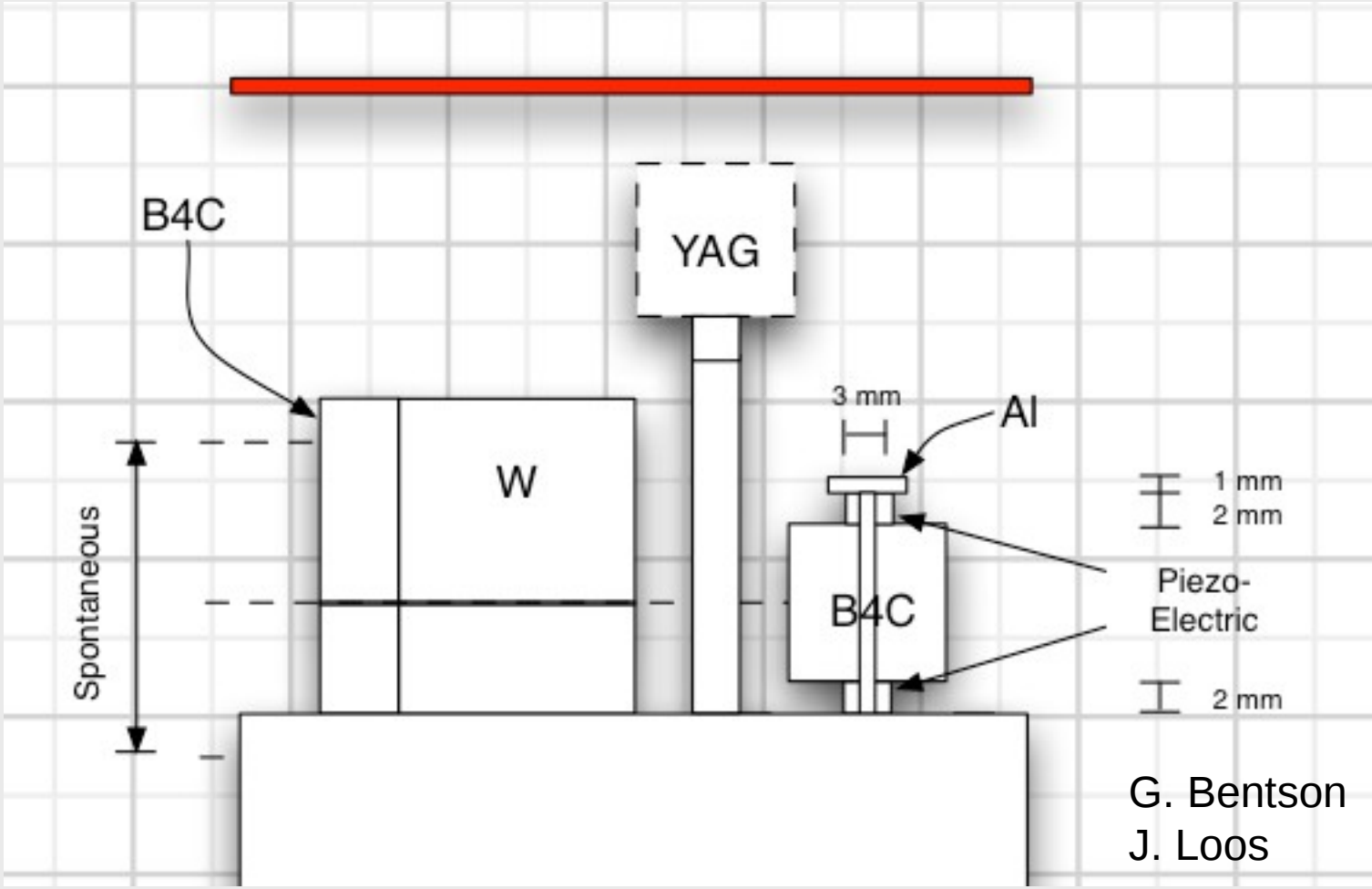
Acoustic Thermal Sensor



B4C / W collimator to block spontaneous radiation
B4C block to absorb X-rays.
Piezo sensors for acoustic wave. RTD and heater for calibration

Acoustic / Thermal Sensor - Status

- Conceptual design done
- Sensor test with conventional laser in July
  - Test acoustic and thermal sensors
- Details of sensor attachment still undecided
  - Need good thermal and acoustic contact
  - Difficult in UHV
- Mechanical and electronic parts probably ready for install in August.
- Test and install schedule depends on manpower – presumably after FEE.

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New Chamber Status

- Vacuum chamber fabrication finished
- Vacuum parts, movers expect delivery in June
- B4C shutter, YAG screen parts in shop
- Filter holder donated by PSI (Thanks Rasmus!!!)
- Hope to install chamber before FEE ready
  - B4C shutter, YAG screen.
- Install additional components over next several months.

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