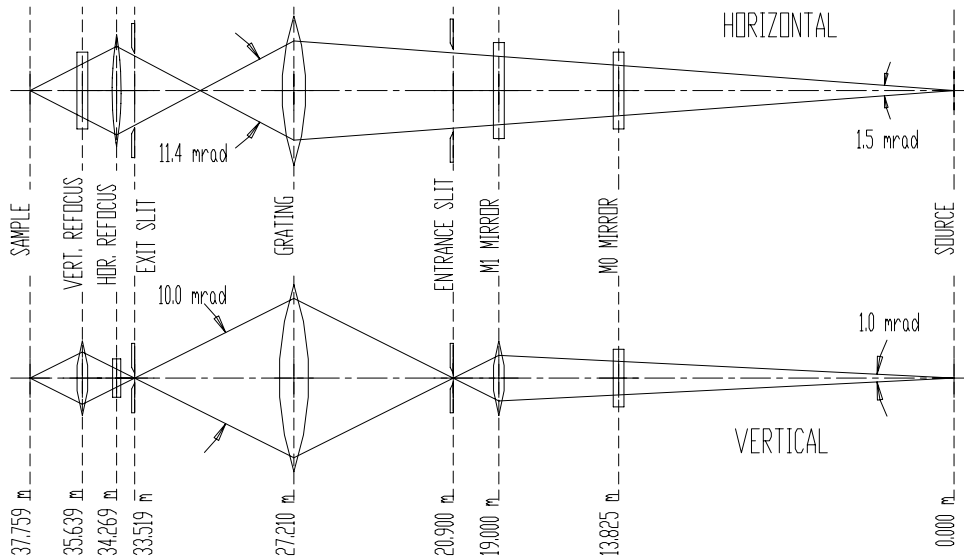


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## Beam Line 5-4 NIM, Optical Layout and Alignment Data

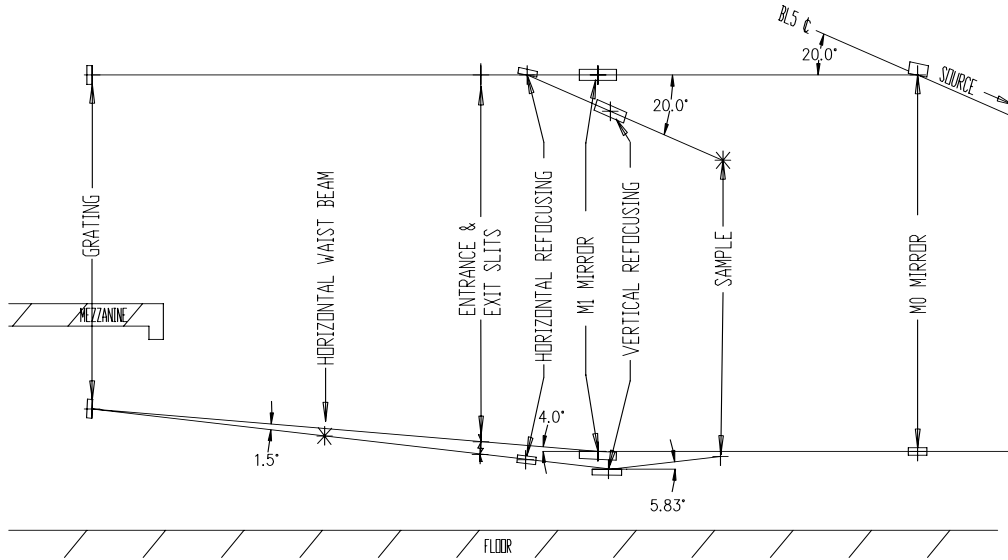
Purpose: This document specifies the optical layout for the beam line 5-4 Normal Incidence Monochromator (NIM) and the position of all optical elements and brass plugs for use in alignment.

The 5-4 NIM is optimized for high flux with resolution to match that of a 200 mm SCIENTA electron spectrometer. The energy range is 10 to 40 eV with a resolution of better than 0.3 meV at a slit setting of 100 microns. The basic optical design of the beam line is astigmatic, the horizontal and vertical focii are not at the same positions except at the source and the sample. This was done to achieve a reasonable horizontal demagnification at the sample (see figure 1).



### 1) Schematic of the optical function of the elements.

The M0, a flat mirror, can be inserted just upstream of the existing BL5 monochromator (the Locust). It is primarily a power filter, absorbing all the high energy photons, and it is side cooled. It deflects all the beam horizontally through  $20^\circ$ . The M1 mirror vertically focusing and deflects the beam up through  $4^\circ$ . The normal incidence grating deflects the beam down through  $1.5^\circ$ . The grating has a maximum scan angle of  $10^\circ$  and is translated towards the slits along the line that bisects the angle input and output beams, i.e.  $4.75^\circ$  from the horizontal. The grating is also the first horizontal focusing element in the beam line with the horizontal waste between the grating and the exit slit. Imaging the beam on the sample is done with Kirkpatrick-Baez pair of cylindrical mirrors for independent horizontal and vertical focusing. The first, M3, deflects the beam horizontally through  $20^\circ$  and the second through  $11^\circ$  vertically. (See figure 2.)



2) Layout showing relative position of optical elements.

Below is a summary of pertinent information on the optical layout including: type of element, position, figure for mirrors, material, size coating and for the beam: size, foot print, solid angle and direction.

Source:	10 period undulator	K of 4.5 to 9
	Maximum Power (100 mA)	289 W
	Peak Power Density (100 mA)	1.07 W/mm <sup>2</sup> (at K=6.6)
	Size (FWHM, width x height):	4.66 x 0.12 mm
	Solid Angle Collected (horizontal x vertical):	1.5 x 1.0 mrad

M0 Mirror:	This mirror is a power filter and deflects the beam horizontally. It is side cooled to copper blocks.
	Distance from Source: (along optical axis) 13.825 m
	Height center of Element (from plane of ring) 0.0 mm
	Distance to Next Optical Element: 5.175 m
	Grazing Angle: 10°
	Figure: Flat
	Material: Silicon, Single Crystal
	Coating: None
	Beam Cross Section: (horizontal x vertical) 22 x 14 mm
	Beam Footprint (width x length): 14 x 124 mm
	Size Optical Surface: 20 x 200 mm
	Dimensions Blank (width x length x depth): 20 x 200 x 38 mm

Beam:	M0 to M1
	Maximum Divergence (horizontal x vertical): 1.5 x 1.0 mrad
	Angle of beam from horizontal: 0.0°

M1 Mirror:	This mirror focuses the beam vertically on the entrance slit. The beam continues to diverge in the horizontal plane. It is profiled mirror, bent with independent moments at each end in to an elliptical cylinder.
	Distance from Source: (along optical axis) 19.000 m
	Height center of Element (from plane of ring) 0.0 mm
	Distance from M0 (projected to M0-M1 axis) 5.1750 m

Distance to Next Optical Element: 1.900 m  
 Distance to Optical Source: 19.000 m  
 Distance to Vertical Image: 1.9000 m  
 Grazing Angle: 2°  
 Figure: Elliptical Cylinder  
 Material: Glass  
 Coating: Pt  
 Beam Cross Section (horizontal x vertical): 29 x 19 mm  
 Beam Footprint (width x length): 29mm x 545mm  
 Size Optical Surface (width x length): 50 x 650 mm  
 Dimensions Blank (width x length x depth): 50-100 x 650 x 4.7 mm

Beam: M1 to Entrance Slit  
 Maximum Divergence (horizontal x vertical): 1.5 x 10.0 mrad  
 Angle of beam from horizontal: +4.0°

Entrance Slit:  
 Distance from Source: (along optical axis) 20.900 m  
 Height center of Element (from plane of ring) 0.1325 m  
 Distance from M0 (projected to M0-M1 axis) 7.0704 m  
 Distance to Next Optical Element: 6.3096 m  
 Beam Cross Section (horizontal x vertical): 32 x 0.02 mm  
 Maximum Aperture (width x height): 36.5 x 2.46 mm

Beam: Entrance Slit to Grating  
 Maximum Divergence (horizontal x vertical): 1.5 x 10.0 mrad  
 Angle of beam from horizontal: +4.0°

Gratings The line densities and blaze angles for the three gratings are:

	Grating 1	Grating 2	Grating 3
Rule density (l/mm)	1700	2800	3600
Blaze angle (deg.)	5	5	4
Coating (Angstroms)	700 Pt	700 Pt	700 Ir

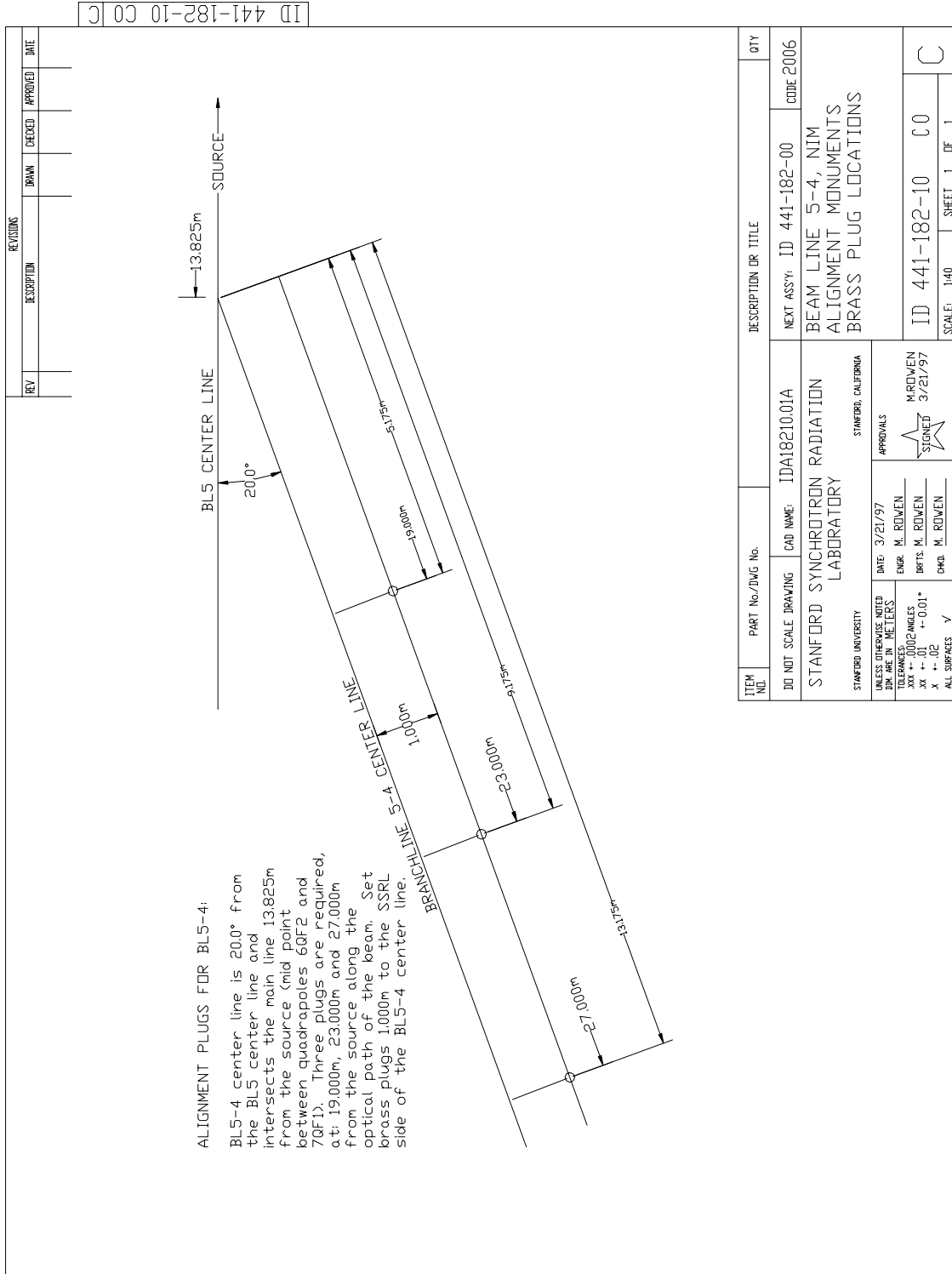
The grating translates along the line that bisects the input and out put beams. The granite base on which the grating system is mounted is 4.75° from horizontal. At a 10° scan angle the grating is translated 100 mm toward the slits.

Distance from Source at Zero Order Position:  
 (along optical axis) 27.210 m  
 Height center of Element (from plane of ring) 0.5727 m  
 Distance from M0 (projected to M0-M1 axis) 13.3646 m  
 Distance to Next Optical Element: 6.309 m  
 Distance to Vertical Source: 6.309 m  
 Distance to Horizontal Source: 27.209 m  
 Distance to Vertical Image: 6.309 m  
 Distance to Horizontal Image: 3.568 m  
 Grazing Angle: (Zero Order) 89.25°  
 Figure: Spherical, Radius = 6.3096 m  
 Material: Silicon, Single Crystal  
 Beam Cross Section (horizontal x vertical): 41 x 63 mm  
 Beam Footprint (width x length): 41 x 63 mm  
 Size Optical Surface: 50 x 80 mm  
 Dimensions Blank (width x length x depth): 60 x 90 x 25 mm

Beam:	Grating to Exit Slit	
	Maximum Divergence (horizontal x vertical):	11.4 x 10.0 mrad
	Angle of beam from horizontal:	-5.5°
Horizontal Focus:		
	Distance from Source: (along optical axis)	30.78 m
	Distance from M0 (projected to M0-M1 axis)	9.8130 m
	Distance to Next Optical Element:	2.742 m
	Beam Cross Section (width x height):	0.64 x 27 mm
Exit Slit:		
	Distance from Source: (along optical axis)	33.519 m
	Height center of Element (from plane of ring)	-0.0321 m
	Distance from M0 (projected to M0-M1 axis)	7.0840 m
	Distance to Next Optical Element:	0.750 m
	Beam Cross Section (horizontal x vertical):	32 x 0.02 mm
	Maximum Aperture (width x height):	36.5 x 2.46 mm
Beam:	Exit Slit to M3	
	Maximum Divergence (horizontal x vertical):	11.4 x 10.0 mrad
	Angle of beam from horizontal:	-5.5°
M3 Mirror:	This is the horizontal refocusing mirror. It images, 1:1, the horizontal waste in the monochromator on to the sample.	
	Distance from Source: (along optical axis)	34.269 m
	Height center of Element (from plane of ring)	0.1040 m
	Distance from M0 (projected to M0-M1 axis)	6.3375 m
	Distance to Next Optical Element:	1.370 m
	Distance to Optical Source:	3.492 m
	Distance to Optical Image:	3.490m
	Grazing Angle:	10°
	Figure:	Cylinder, Radius = 20.10 m
	Material:	Silicon, Single Crystal
	Coating:	None
	Beam Cross Section (horizontal x vertical):	40 x 8 mm
	Beam Footprint (width x length):	8 x 229mm
	Size Optical Surface:	15 x 203mm
	Dimensions Blank (width x length x depth):	25.4 x 241 x 5 mm
Beam:	M3 to M4	
	Maximum Divergence (Horizontal x Vertical):	11.4 x 10.0 mrad
	Angle of beam from horizontal:	-5.17°
	Angle of beam from M0-M1 axis	20.09°
M4 Mirror:	This is the vertical refocusing mirror. It images, 1:1, the exit slit on to the sample.	
	Distance from Source: (along optical axis)	35.639 m
	Height center of Element (from plane of ring)	-0.2274 m
	Distance from M0 (projected to M0-M1 axis)	5.0561 m
	Distance from M0-M1 axis (horizontal)	0.4687 m
	Distance to Optical Source:	2.120 m
	Distance to Optical Image:	2.120 m
	Grazing Angle:	5.5°
	Figure:	Cylinder, Radius = 22.12 m
	Material:	Glass

Coating:	Pt
Beam Cross Section (horizontal x vertical):	24 x 21 mm
Beam Footprint (width x length):	24 x 220 mm
Size Optical Surface:	30 x 203 mm
Dimensions Blank (width x length x depth):	40 x 240 x 4.7 mm
Beam:	M4 to Sample
Maximum Divergence (Horizontal x Vertical):	11.4 x 10.0 mrad
Angle of beam from horizontal:	+5.83°
Sample:	
Distance from Source: (along optical axis)	37.759 m
Height center of Element (from plane of ring)	-0.0121 m
Distance from M0 (projected to M0-M1 axis)	3.0754 m
Distance from M0-M1 axis (horizontal)	1.1931 m
Beam Cross Section (horizontal x vertical):	0.64 x 0.02 mm (Nominal FWHM)

To align the BL 5-4 components there will be three brass plugs installed parallel to the new branch line. See drawing number ID 441-182-10 C0 (figure 3) for the locations.



3) ID 441-182-10 C0, Alignment monument locations