IXS CAT
Conceptual Design Report

Presented to CCRP

M. Ramanathan

October 31, 2002

Overview

- Milestones
- Management structure
- Scientific agenda
- Funding
- Required innovations
- Choice of undulators
- IXS priorities
- Beamline layout
- Time table
- Work breakdown structure

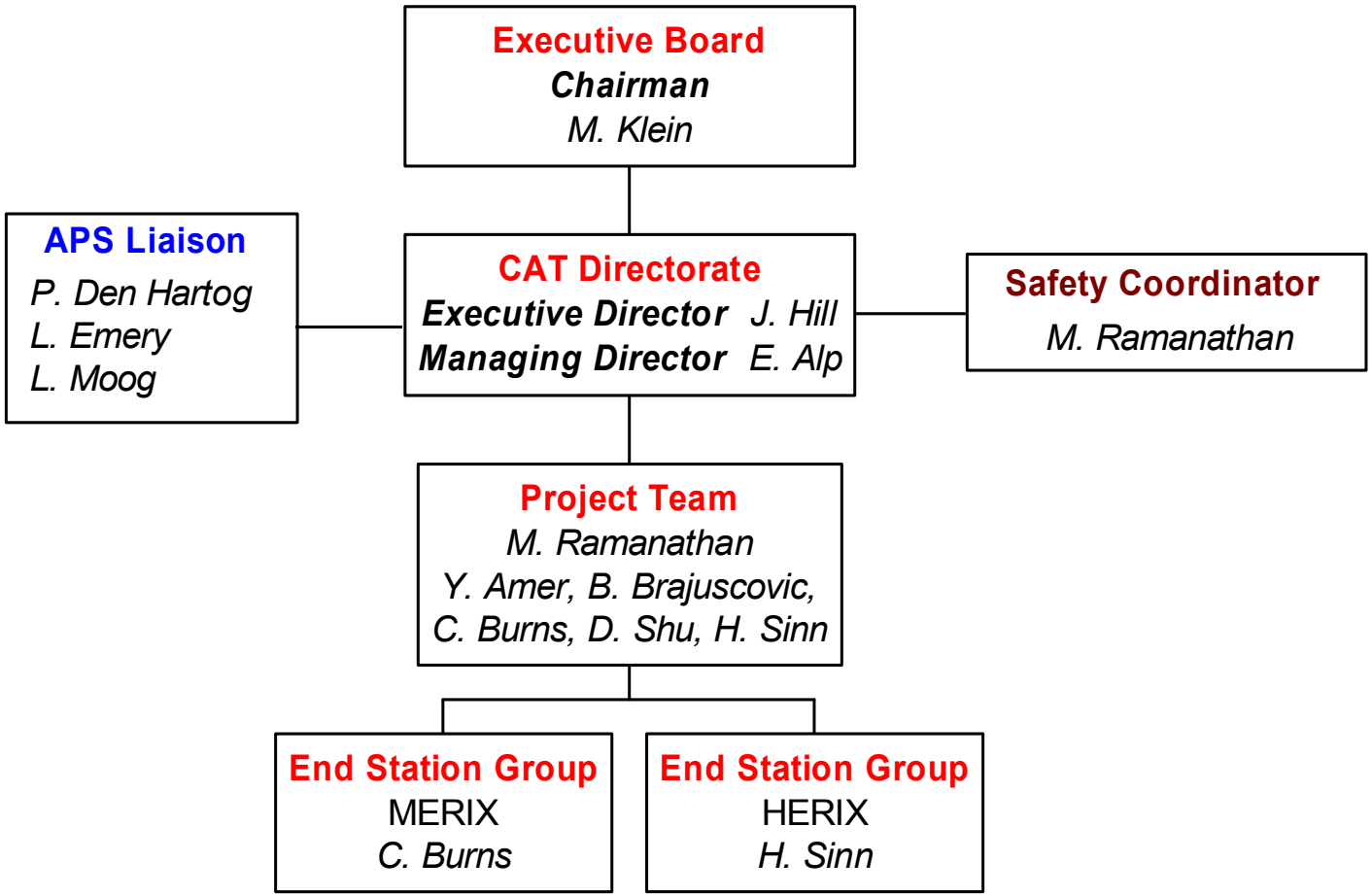
Milestones

- Technical review on April 3, 2000
- CDR submitted to APS on September 6, 2002
- Management plan submitted to APS on October 1, 2002
- CCRP(Construction /Commissioning Review Panel) meeting on October 31, 2002 to review the CDR.
- MOU in November 2002 upon acceptance of Management Plan by APS.
- Plan to submit the preliminary design report (PDR) in January 2003

Technical Review

- IXS had a technical review on April 3, 2000
  - » Participants:
    - E. Alp, A. Baron, C. Burns, J. Hill, C. Kao, M. Schwoerer-Böhning, F. Sette, G. Shenoy, D. Shu, S. Sinha, H. Sinn
  - » Topics Discussed:
    - Undulators
    - High heat load monochromator
    - Medium and High resolution monochromator
    - Medium and High resolution spectrometers

Management Structure



Scientific Agenda

- Medium resolution inelastic x-ray scattering for electronic structure studies in e.g. correlated electron systems:
  - » **MERIX (20-1000 meV @ 5-12 keV)**

- High resolution inelastic x-ray scattering for collective excitations in solids and liquids
  - » **HERIX (1 meV@ 25.7 keV)**

Funding

- DOE BES 5 M (1 M/year) 2002-2006
- NSF .9 M (0.3 M/year) 2002-2004
- Matching funds .58 M

- **TOTAL 6.48 M**

- **Budgeted Cost 6.19 M**
  - » (Does not include Contingency, Effort, Front End, Insertion Devices, Straight Section Modification)

Required Innovations

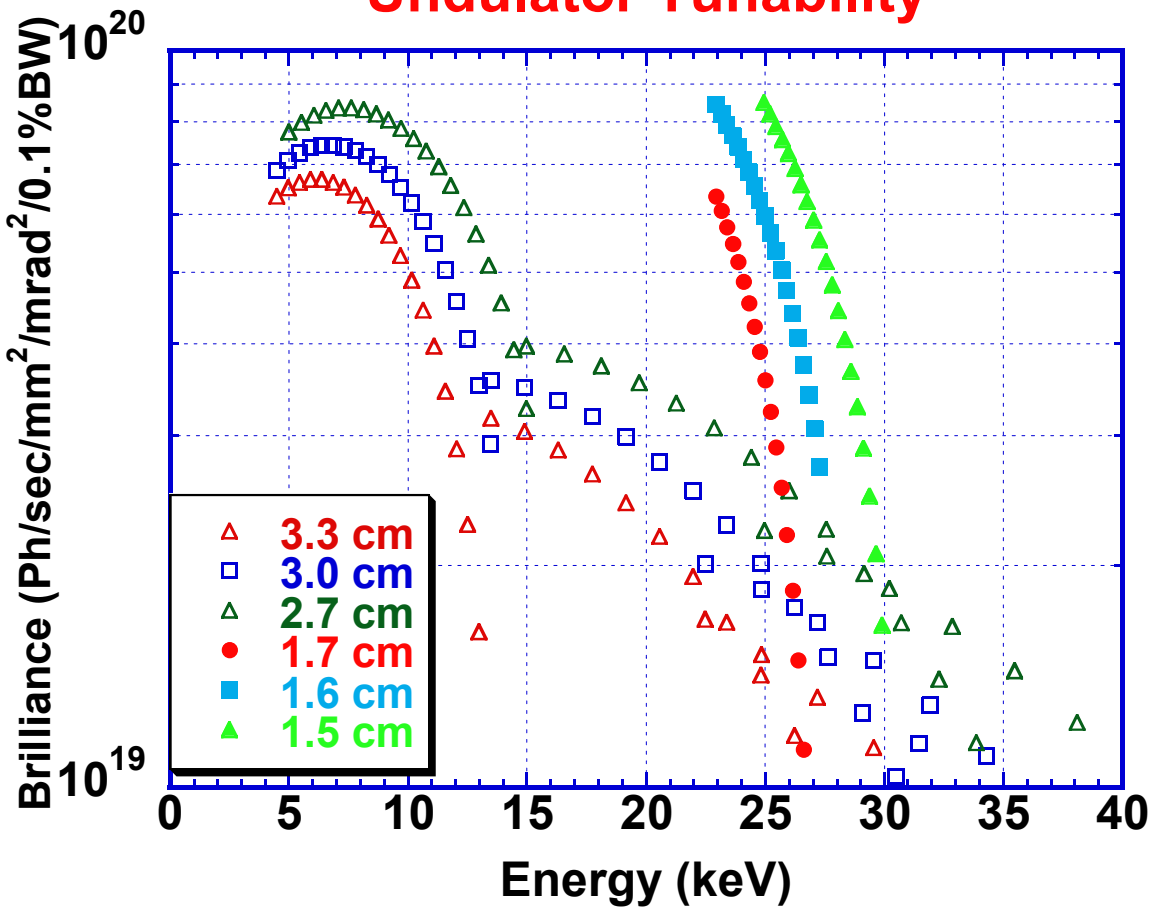
- A longer straight section (~10 m)
- A narrower minimum magnet gap (7.5 mm)
- Specialized undulators
  - » Superconducting undulator
  - » Short period planar undulator (1.5 cm)
- New Front End for higher heat loads.
- Cryogenically cooled high resolution monochromator
- Dynamically bent analyzer for HERIX and MERIX

Choice of Undulators

Period (mm)	B(T) 5 mm	B(T) 6.5 mm	B(T) 8.5 mm	B(T) 10.5mm	K 5 mm	K 6.5 mm	K 8.5 mm	K 10.5mm	E1(keV) 5 mm	E1(keV) 6.5 mm	E1(keV) 8.5 mm	E1(keV) 10.5mm
13	0.58167	0.37877	0.22787	0.14745	0.7060	0.45977	0.27659	0.17898	28.663	32.385	34.488	35.243
14	0.64812	0.43066	0.26384	0.17212	0.8472	0.56297	0.34489	0.22499	24.468	28.702	31.384	32.429
15	**0.71316**	**0.48288**	**0.30120**	**0.19845**	**0.9988**	**0.67632**	**0.42186**	**0.27794**	**20.705**	**25.257**	**28.498**	**29.879**
16	0.77652	0.53504	0.33961	0.22620	1.1601	0.79933	0.50737	0.33793	17.391	22.050	25.776	27.522
17	0.83801	0.58682	0.37877	0.25513	1.3302	0.93147	0.60123	0.40498	14.529	19.097	23.191	25.307
18	0.89753	0.63798	0.41841	0.28504	1.5085	1.0723	0.70322	0.47906	12.097	16.421	20.734	23.199
19	0.95503	0.68833	0.45830	0.31573	1.6943	1.2212	0.81305	0.56012	10.060	14.035	18.414	21.178
20	1.0105	0.73774	0.49825	0.34702	1.8870	1.3777	0.93045	0.64805	8.3711	11.942	16.244	19.236
21	1.0639	0.78611	0.53810	0.37877	2.0861	1.5414	1.0551	0.74270	6.9795	10.131	14.240	17.375
22	1.1154	0.83335	0.57772	0.41083	2.2912	1.7119	1.1867	0.84392	5.8375	8.5830	12.416	15.603
23	1.1649	0.87943	0.61700	0.44308	2.5016	1.8886	1.3250	0.95155	4.9016	7.2712	10.778	13.932
24	1.2125	0.92432	0.65585	0.47542	2.7171	2.0713	1.4697	1.0654	4.1343	6.1668	9.3248	12.374
25	1.2583	0.96801	0.69420	0.50775	2.9373	2.2596	1.6205	1.1852	3.5040	5.2407	8.0503	10.938
26	1.3024	1.0105	0.73198	0.53999	3.1618	2.4531	1.7770	1.3109	2.9847	4.4660	6.9425	9.6295
27	1.3448	1.0518	0.76916	0.57208	3.3903	2.6515	1.9391	1.4422	2.5553	3.8183	5.9863	8.4512
28	1.3856	1.0919	0.80570	0.60395	3.6226	2.8546	2.1064	1.5790	2.1986	3.2763	5.1654	7.4001
29	1.4249	1.1308	0.84157	0.63556	3.8583	3.0620	2.2788	1.7210	1.9011	2.8221	4.4632	6.4702
30	1.4627	1.1686	0.87676	0.66686	4.0973	3.2734	2.4559	1.8680	1.6518	2.4406	3.8639	5.6533
31	1.4991	1.2053	0.91124	0.69782	4.3393	3.4888	2.6376	2.0199	1.4418	2.1192	3.3529	4.9396
32	1.5342	1.2409	0.94503	0.72841	4.5841	3.7077	2.8237	2.1764	1.2642	1.8476	2.9172	4.3186
33	**1.5681**	**1.2755**	**0.97811**	**0.75860**	**4.8316**	**3.9301**	**3.0138**	**2.3375**	**1.1132**	**1.6171**	**2.5455**	**3.7799**
34	1.6007	1.3090	1.0105	0.78838	5.0816	4.1557	3.2079	2.5028	0.98418	1.4210	2.2279	3.3134
35	1.6321	1.3416	1.0422	0.81773	5.3339	4.3844	3.4058	2.6724	0.87356	1.2534	1.9560	2.9098

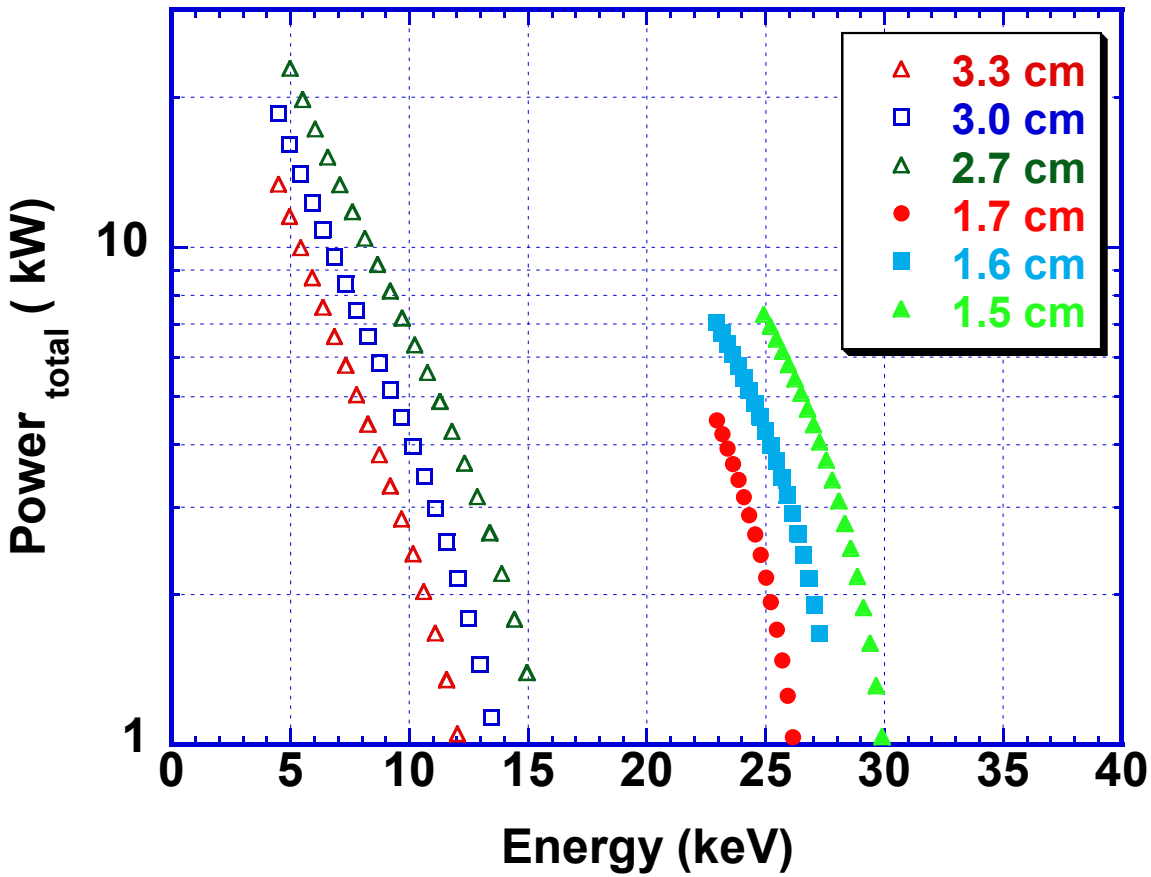
Choice of Undulators

Undulator Tunability

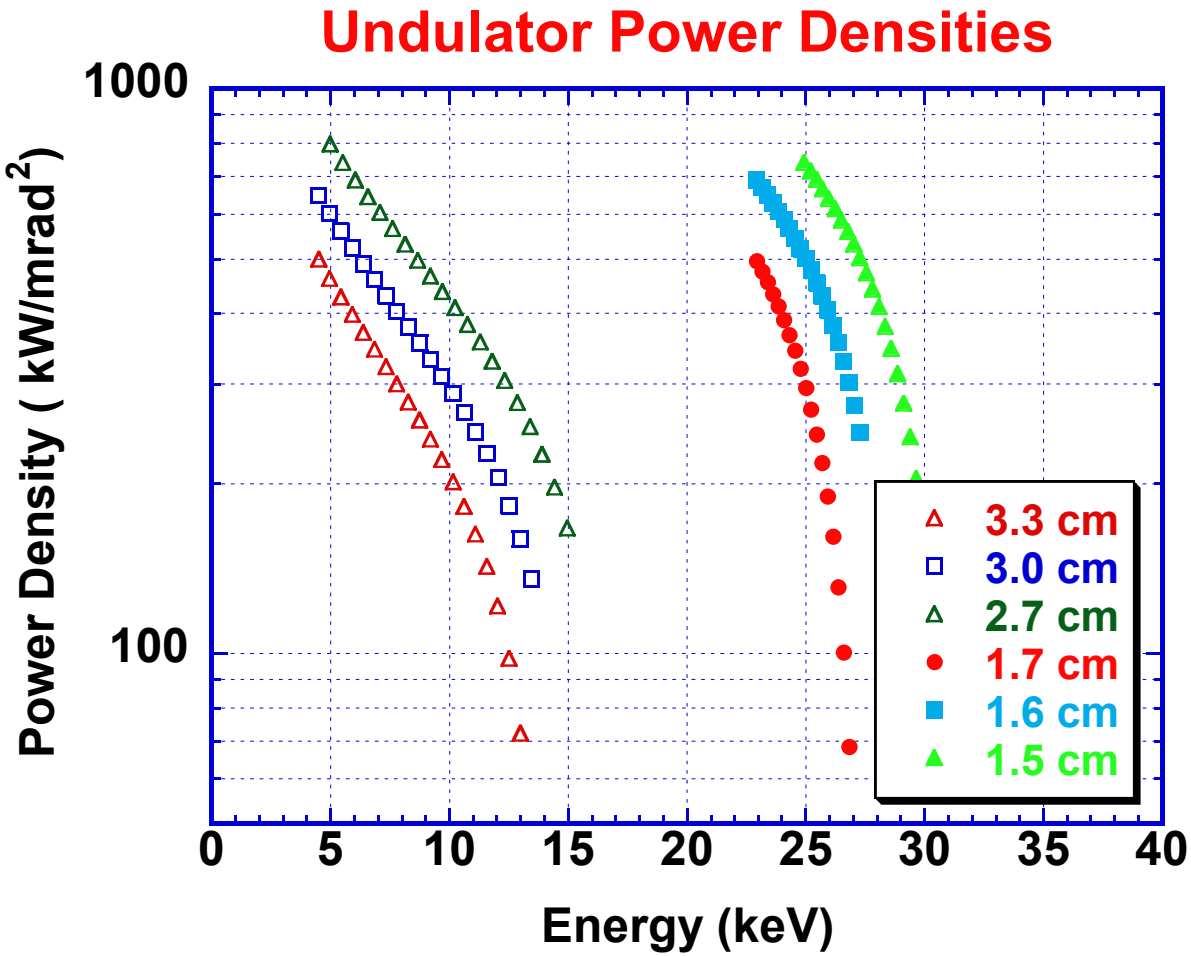


Choice of Undulators

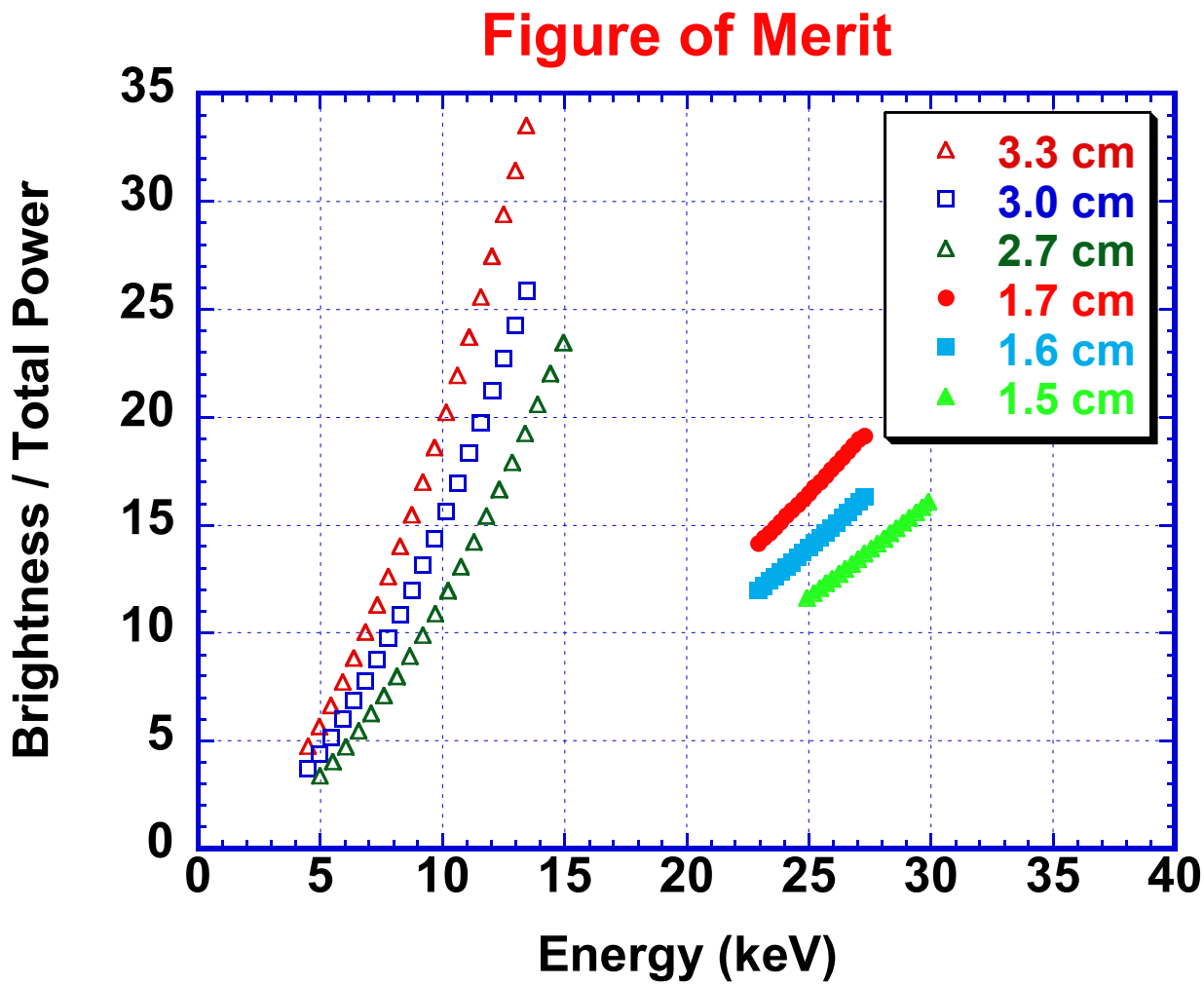
Undulator Total Power



Choice of Undulators



Choice of Undulators



Choice of Undulators

- For MERIX: 3.3 cm period 9.6 m long Undulator
- For HERIX: 1.5 cm period 9.6 m long Undulator

- However if the Superconducting Undulator is available it is the preferred choice for the HERIX

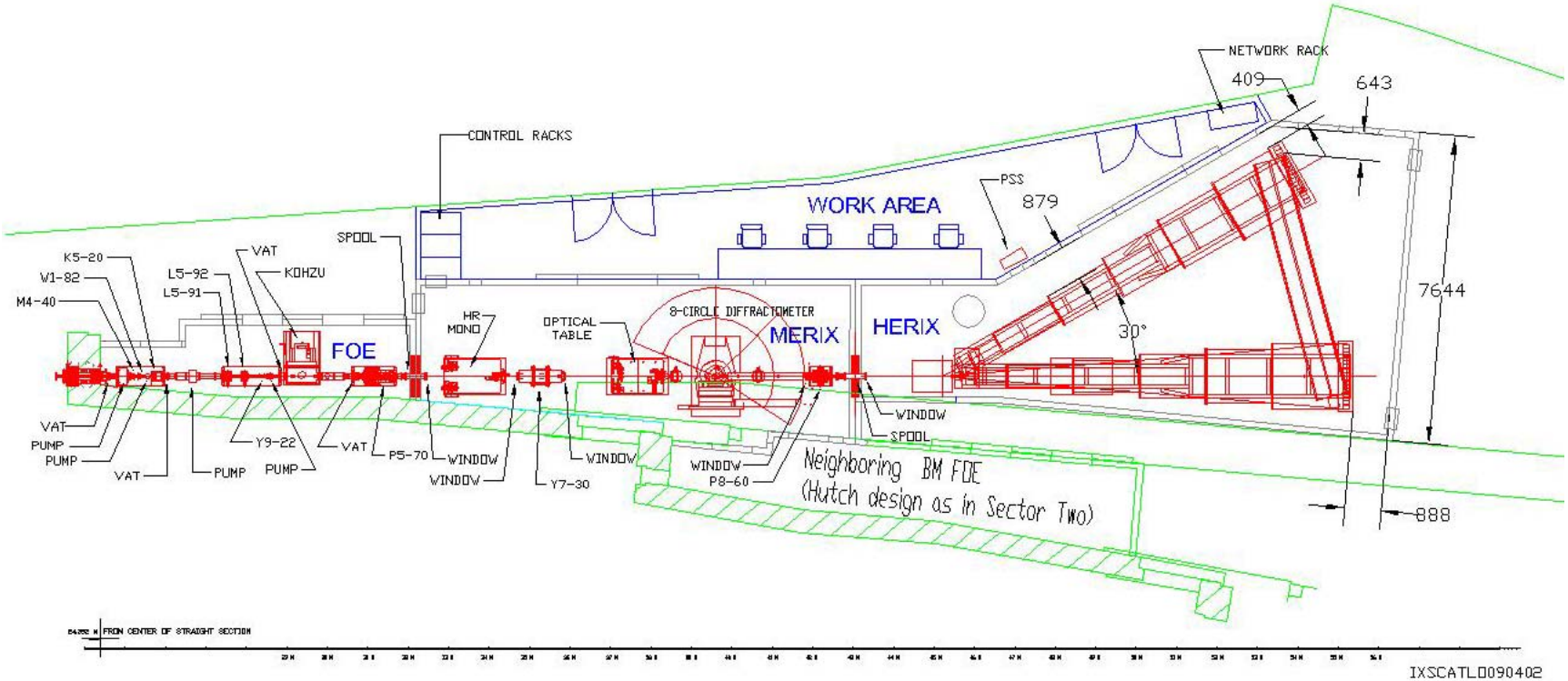
CAT Priorities

- For shielding verification one/two undulators with 3.3 cm period is adequate.
- For commissioning the FOE optics we require two undulators of 3.3 cm period.
- With two 3.3 cm period undulators the MERIX instrument can be commissioned.
- For HERIX even though not optimized the two 3.3 cm period undulators will be adequate for initial commissioning and debugging of the instruments.
- About 6 months from start of commissioning we expect either the 1.5 cm device or the superconducting device to be available for HERIX instrument.
- About 18 months from start of commissioning we expect the 10 m long straight section.
- Finally additional 3.3 cm period device and 1.5 cm period device will be needed to fill the rest of the straight section.

Beamline Layout

- Plan and elevation views.
- Bremsstrahlung ray tracings based on existing front end design.
- Synchrotron radiation ray tracings based on existing front end design.

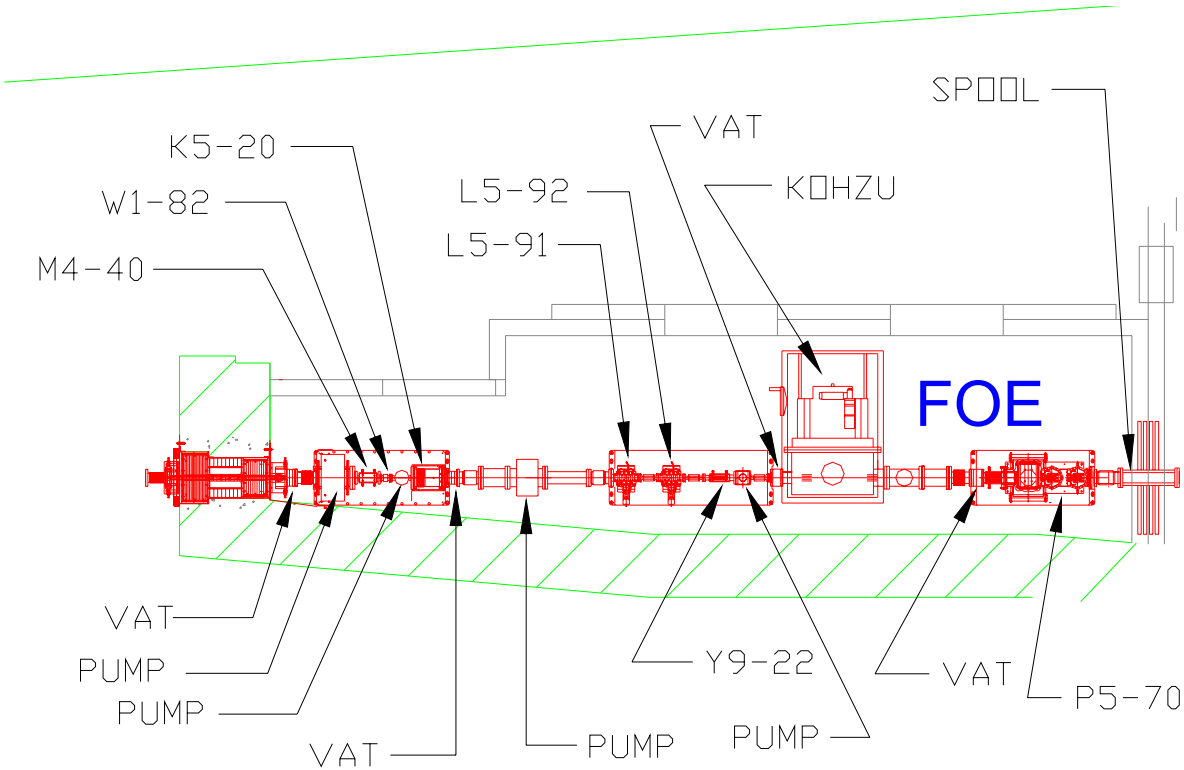
Beamline Layout Plan View



Beamline Layout -FOE

- White beam enclosure
- Beam defining apertures – L5-91 and L5-92 slits
- Be Compound Refractive Lens Y9-22
  - » Collimates the white beam
- High heat load Monochromator
  - » Kohzu double crystal monochromator
  - » Beam offset variable from 22 – 35 mm
  - » Diamond water cooled crystals
- Integral shutter P5-70
  - » White beam stop (Bremsstrahlung and photon beams)
  - » Monochromatic shutters

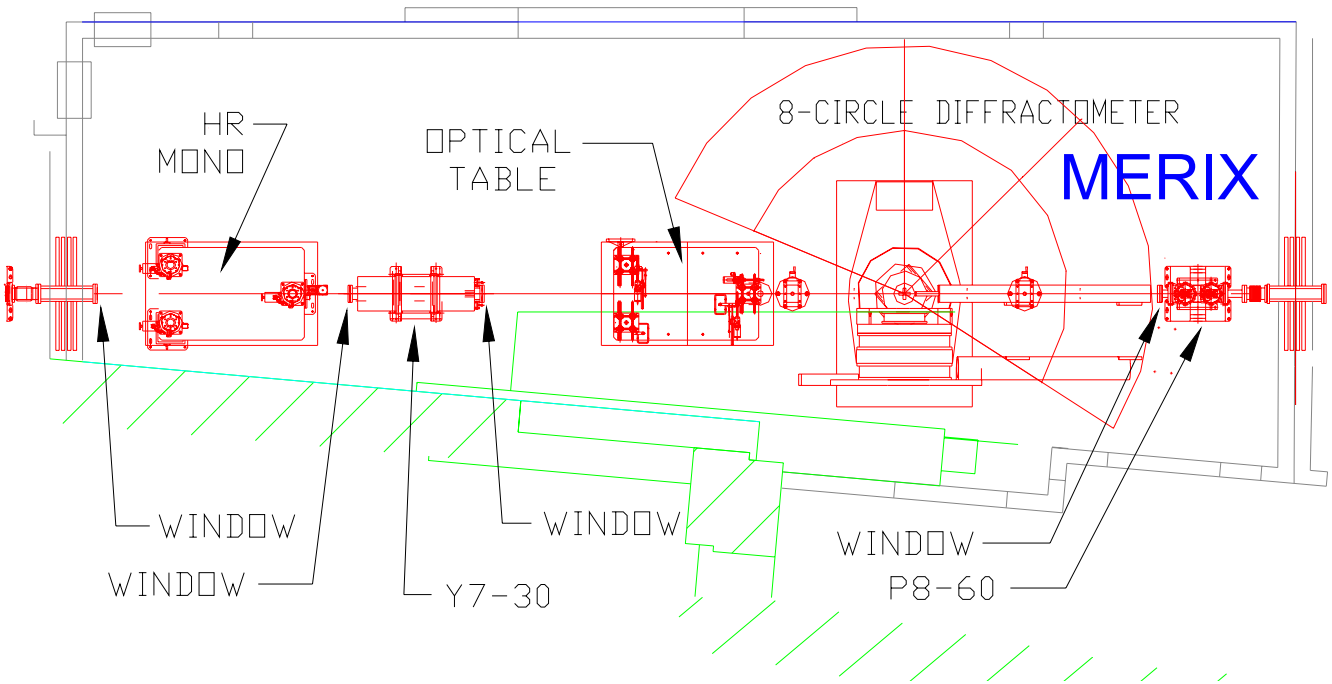
Beamline Layout -FOE



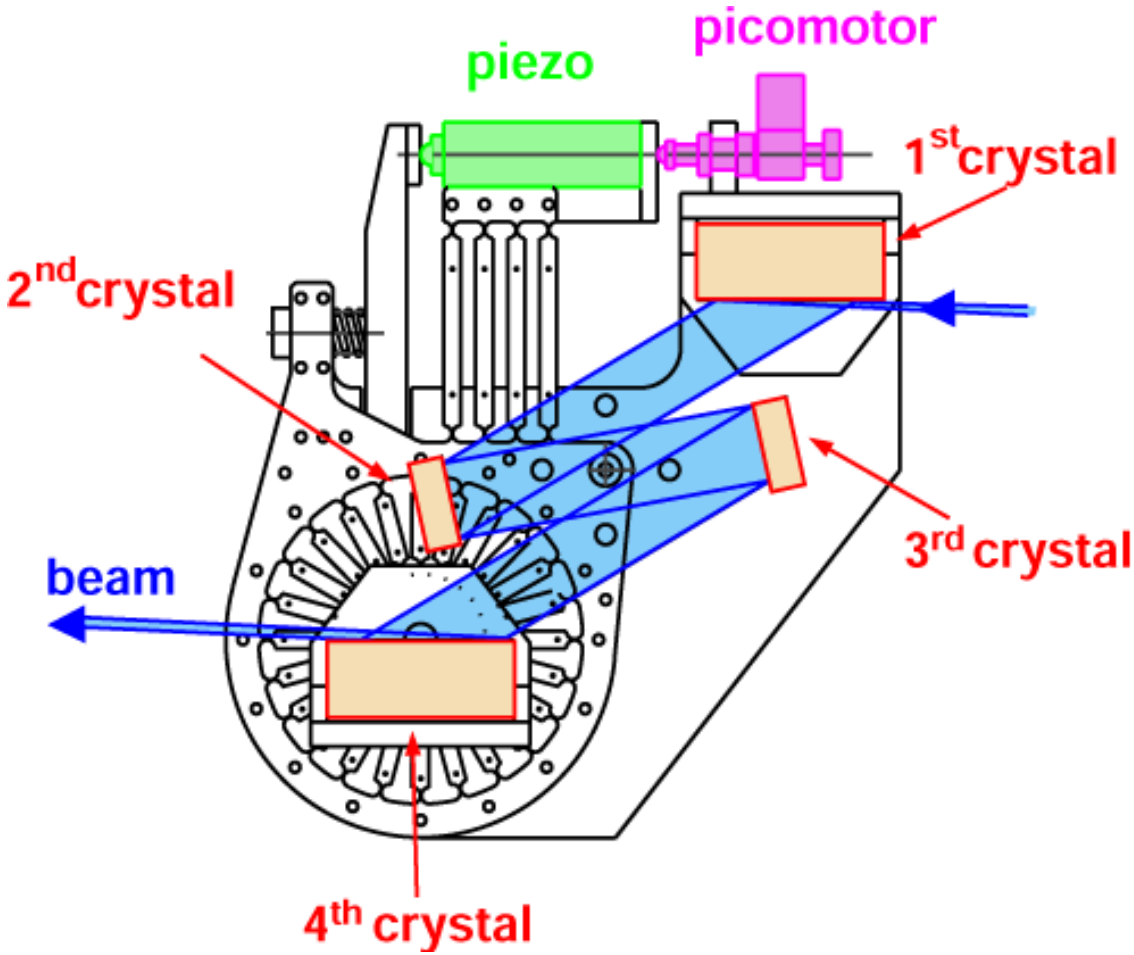
Beamline Layout -MERIX

- Monochromatic station
- Medium / High resolution monochromator
- Torroidal focusing mirror for MERIX
- MERIX instrument – 8 circle diffractometer
- Monochromatic shutter P8-60

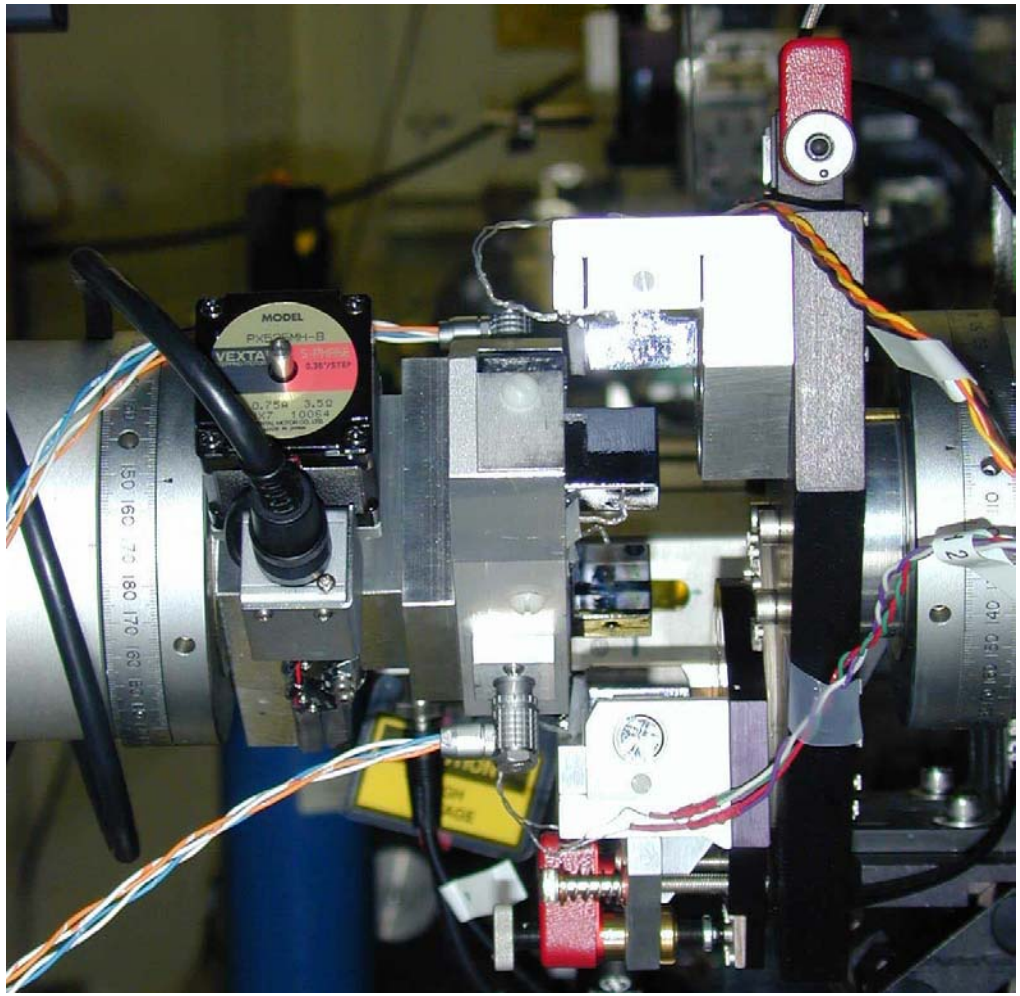
Beamline Layout -MERIX



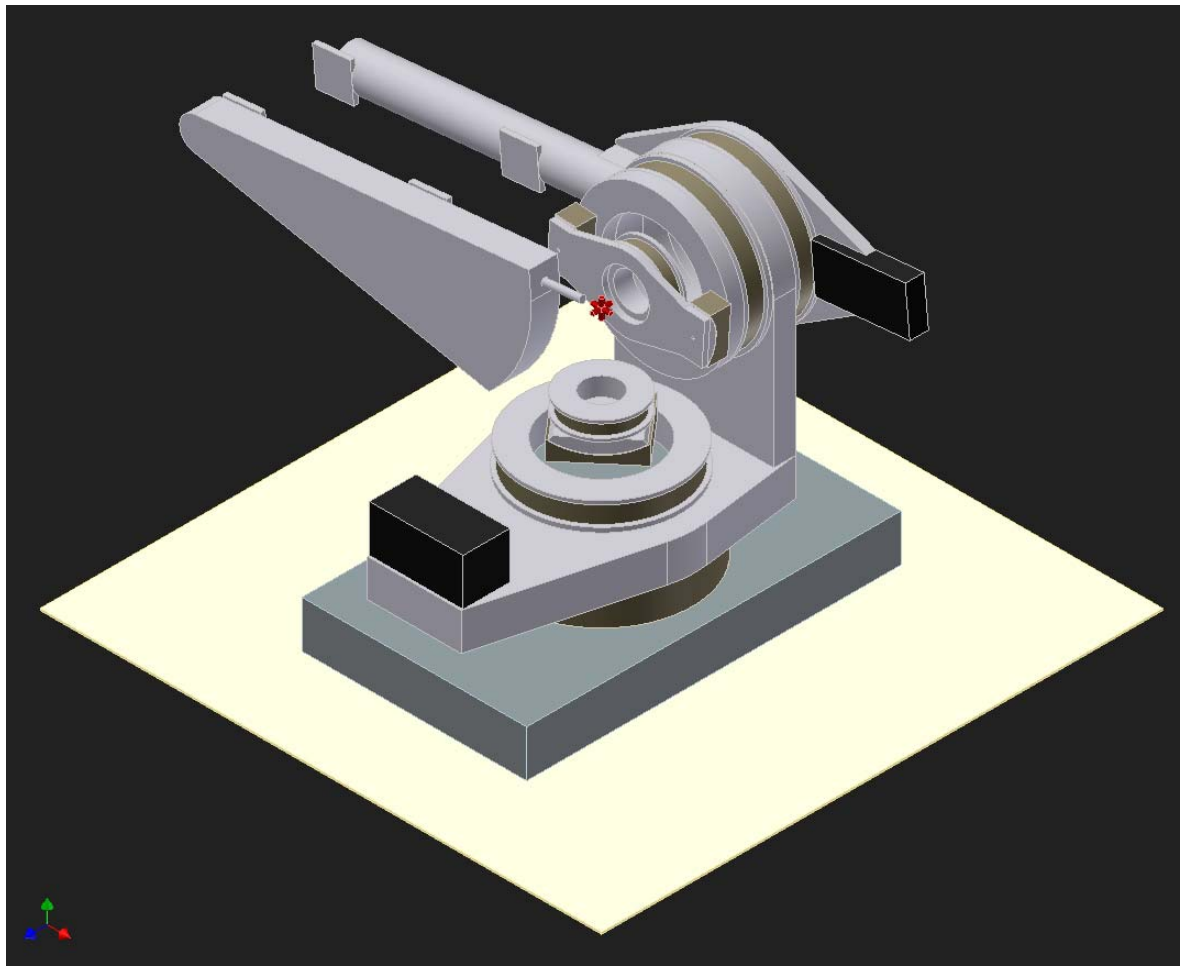
High Resolution Monochromator



High Resolution Monochromator



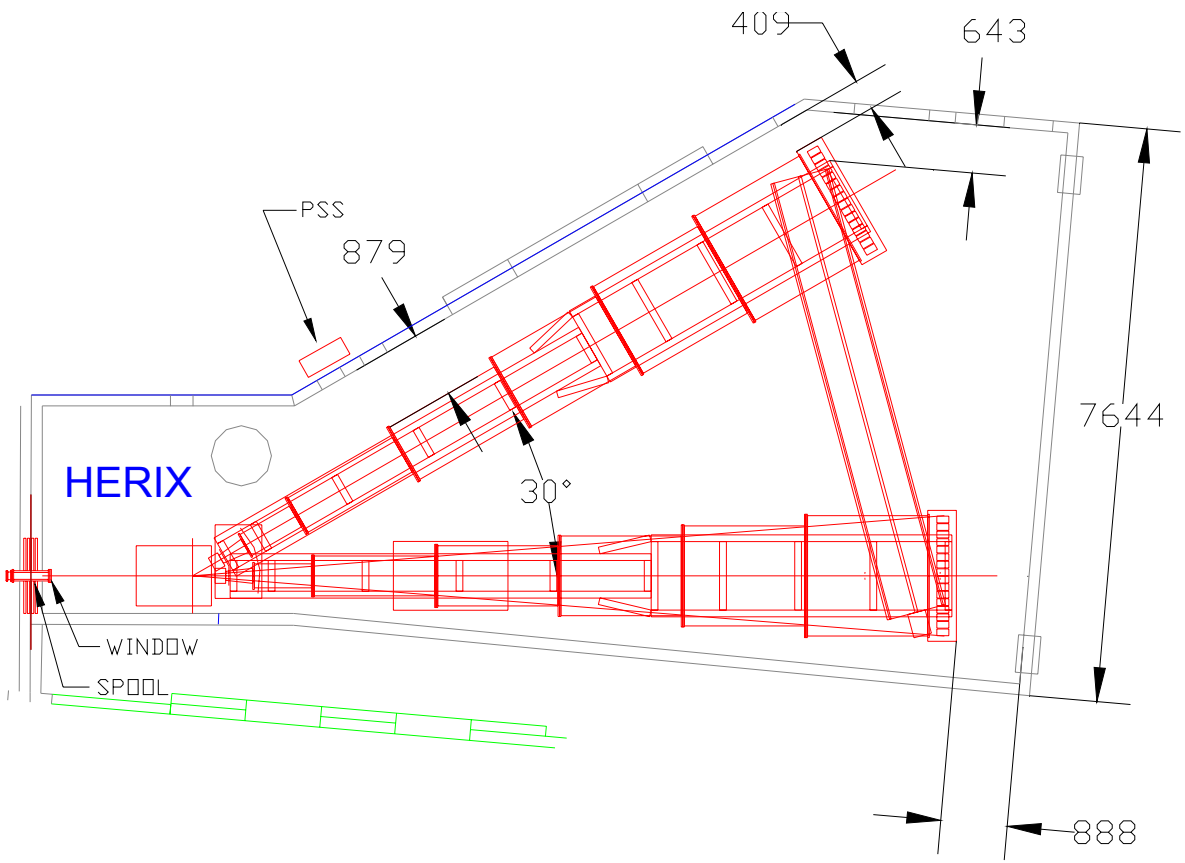
MERIX Instrument



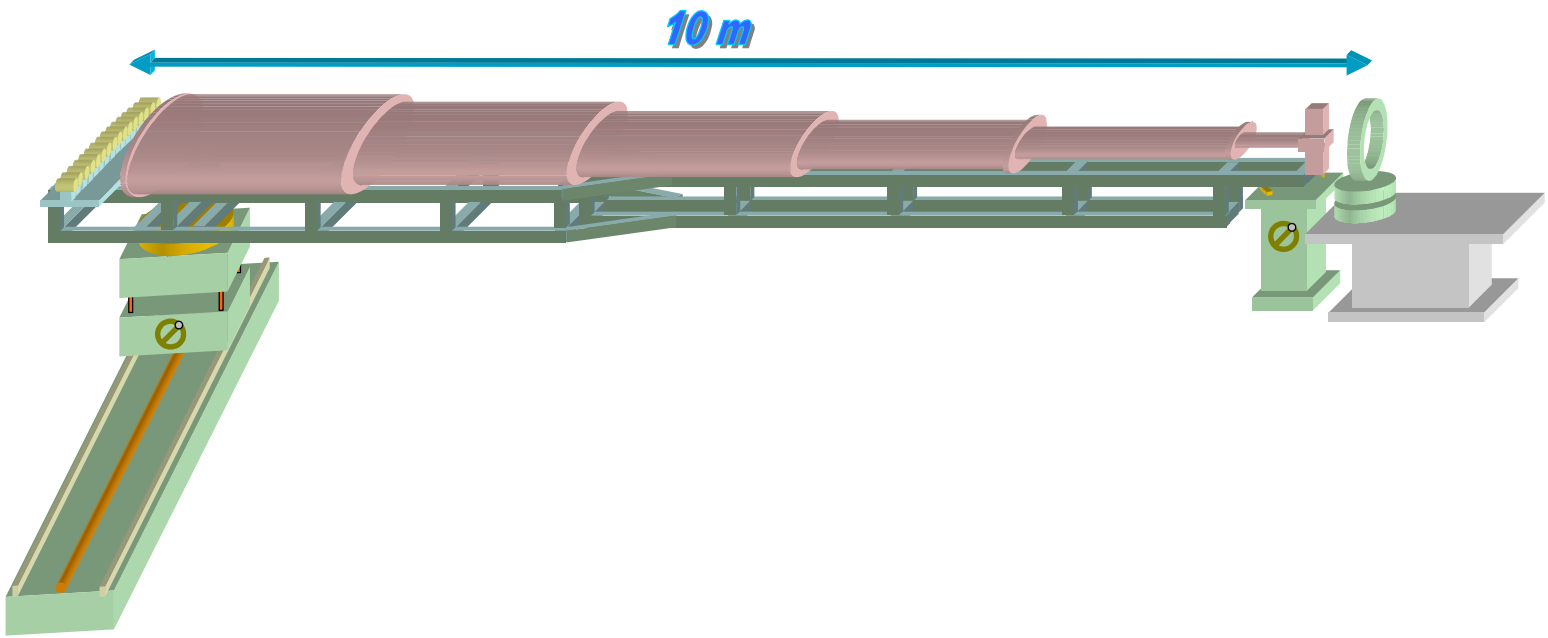
Beamline Layout - HERIX

- Monochromatic station
- Dedicated for HERIX experiments.
- KB mirrors for HERIX
- HERIX spectrometer

Beamline Layout - HERIX



HERIX Instrument

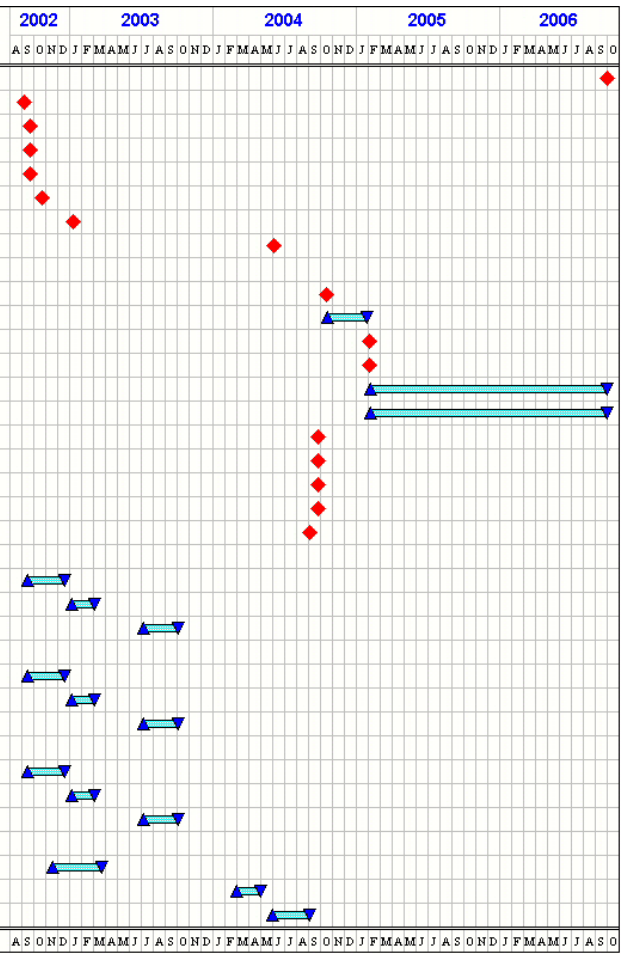


Time Table

- Start of the project : 2002
- Start of construction: 2003
- Start of commissioning: 2004
- Operational: 2006

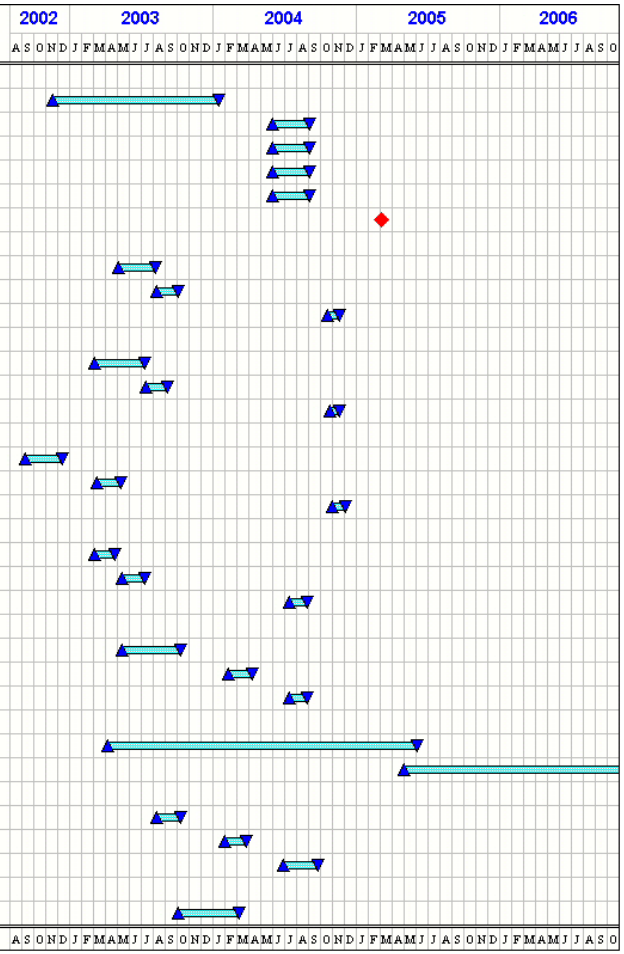
Work Breakdown Structure

WBS	Activity Name	Start Date	Finish Date	Responsibility
1.1	**Project Planning**		9/29/06	**E. Alp**
1.1.1	CDR		9/6/02	
1.1.2	Management Plan		9/20/02	
1.1.3	Safety Plan		9/20/02	
1.1.4	Cost & Schedule Plan		9/20/02	
1.1.5	MOU		10/21/02	
1.1.6	PDR		1/10/03	
1.1.7	FDR		6/4/04	
1.1.8	Commissioning			
1.1.8.1	Shielding Verification Station A		10/15/04	
1.1.8.2	Commissioning Station A Optics	10/18/04	1/28/05	
1.1.8.3	Shielding Verification Station B		2/4/05	
1.1.8.4	Shielding Verification Station C		2/4/05	
1.1.8.5	Commissioning Station B	2/7/05	9/29/06	
1.1.8.6	Commissioning Station C	2/7/05	9/29/06	
1.2	**SR Modifications**		9/24/04	**L. Emery**
1.3	**Straight Section Vacuum Chamber**		9/24/04	**P. Den Hartog**
1.4	**Insertion Devices**		9/24/04	**L. Moog**
1.5	**Front End**		9/24/04	**P. Den Hartog**
1.6	**Beamline Stations & Infrastructure**		9/3/04	**M. Ramanathan**
1.6.1	Station A			
1.6.1.1	Design	9/16/02	12/20/02	
1.6.1.2	Procurement	1/6/03	3/3/03	
1.6.1.3	Installation	7/7/03	10/3/03	
1.6.2	Station B			
1.6.2.1	Design	9/16/02	12/20/02	
1.6.2.2	Procurement	1/6/03	3/3/03	
1.6.2.3	Installation	7/7/03	10/3/03	
1.6.3	Station C			
1.6.3.1	Design	9/16/02	12/20/02	
1.6.3.2	Procurement	1/6/03	3/3/03	
1.6.3.3	Installation	7/7/03	10/3/03	
1.6.4	Beamline Utilities			
1.6.4.1	Design	11/18/02	3/21/03	
1.6.4.2	Procurement	3/1/04	4/30/04	
1.6.4.3	Installation	6/1/04	9/3/04	



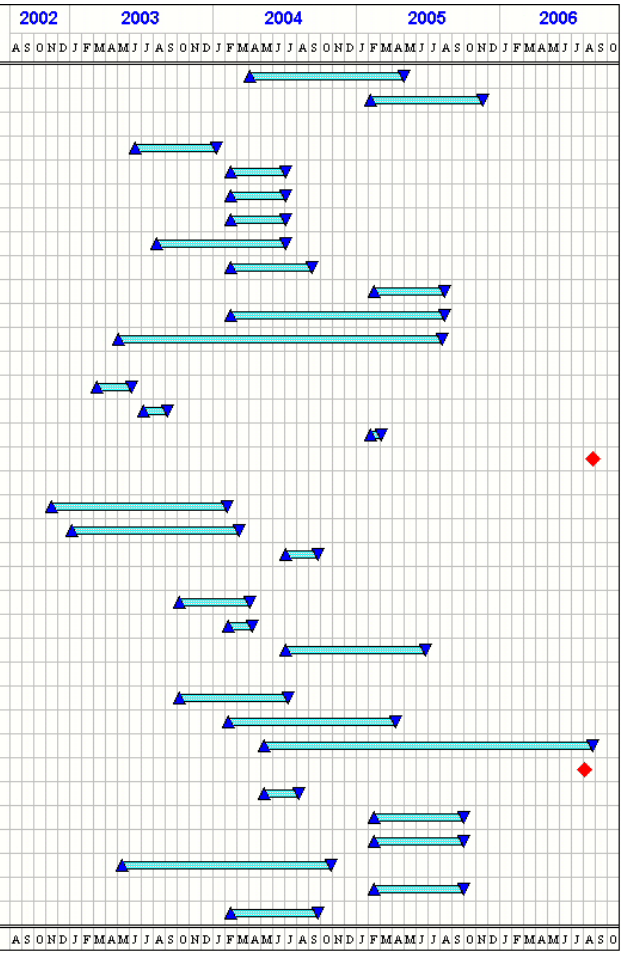
Work Breakdown Structure

WBS	Activity Name	Start Date	Finish Date	Responsibility
1.6.5	Work Area Enclosure			
1.6.5.1	Enclosure...	11/18/02	1/15/04	
1.6.5.2	Furniture	6/1/04	9/3/04	
1.6.5.3	Computers	6/1/04	9/3/04	
1.6.5.4	Printers	6/1/04	9/3/04	
1.6.5.5	TV Monitors	6/1/04	9/3/04	
1.7	**Beamline Optics**		3/4/05	**M. Ramanathan**
1.7.1	White Beam Slits			
1.7.1.1	Design	5/5/03	8/8/03	
1.7.1.2	Procurement	8/11/03	10/3/03	
1.7.1.3	Installation	10/18/04	11/19/04	
1.7.2	Focusing Lens			
1.7.2.1	Design	3/3/03	7/11/03	
1.7.2.2	Procurement	7/14/03	9/5/03	
1.7.2.3	Installation	10/25/04	11/19/04	
1.7.3	Primary Monochromator			
1.7.3.1	Design	9/9/02	12/13/02	
1.7.3.2	Procurement	3/10/03	5/9/03	
1.7.3.3	Installation	11/1/04	12/3/04	
1.7.4	Integral Shutter			
1.7.4.1	Design	3/3/03	4/25/03	
1.7.4.2	Procurement	5/12/03	7/11/03	
1.7.4.3	Installation	7/12/04	8/27/04	
1.7.5	Monochromatic Shutter			
1.7.5.1	Design	5/12/03	10/10/03	
1.7.5.2	Procurement	2/9/04	4/9/04	
1.7.5.3	Installation	7/12/04	8/27/04	
1.7.6	Monochromatic Mirrors			
1.7.6.1	MERIX Mirror...	4/7/03	6/3/05	
1.7.6.2	HERIX Mirror...	5/2/05	8/31/07	
1.7.7	Support Tables			
1.7.7.1	Design	8/11/03	10/10/03	
1.7.7.2	Procurement	2/2/04	3/26/04	
1.7.7.3	Installtion	6/28/04	9/24/04	
1.7.8	Optical Tables			
1.7.8.1	Design	10/3/03	3/5/04	



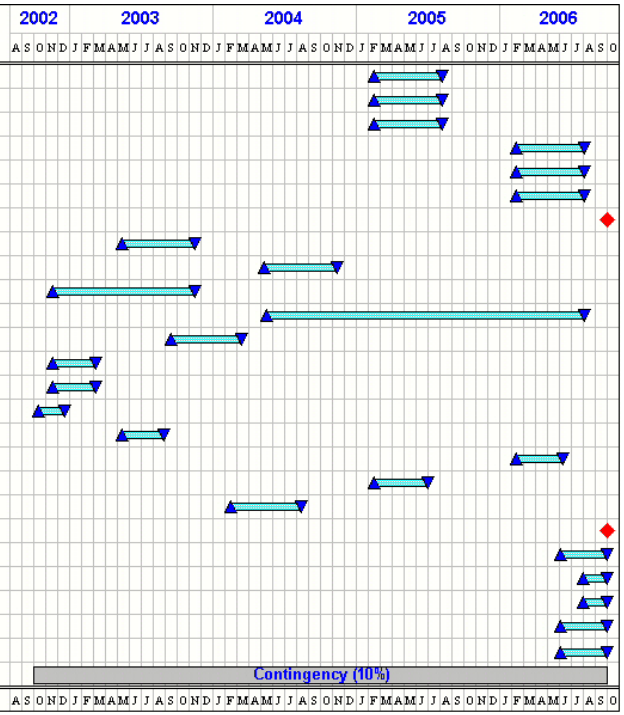
Work Breakdown Structure

WBS	Activity Name	Start Date	Finish Date	Responsibility
1.7.8.2	Procurement	4/5/04	4/29/05	
1.7.8.3	Installation	2/7/05	11/18/05	
1.7.9	Vacuum Hardware			
1.7.9.1	Ion pumps & controllers	6/16/03	1/9/04	
1.7.9.2	Ion gauges & controllers	2/16/04	7/2/04	
1.7.9.3	Inline valves	2/16/04	7/2/04	
1.7.9.4	Roughing valves	2/16/04	7/2/04	
1.7.9.5	Bellows	8/11/03	7/2/04	
1.7.9.6	Shielded spool transports	2/16/04	9/10/04	
1.7.9.7	Pumping station	2/14/05	8/12/05	
1.7.9.8	Miscellanous vacuum hardware	2/16/04	8/12/05	
1.7.9.9	Beamline rough vacuum system...	5/5/03	8/5/05	
1.7.10	Be Windows			
1.7.10.1	Design	3/10/03	6/6/03	
1.7.10.2	Procurement	7/7/03	9/5/03	
1.7.10.3	Installation	2/7/05	3/4/05	
1.8	**General Instrumentation**		8/25/06	**M. Ramanathan**
1.8.1	PSS			
1.8.1.1	Design	11/15/02	2/6/04	
1.8.1.2	Procurement	1/6/03	3/5/04	
1.8.1.3	Installation	7/5/04	9/24/04	
1.8.2	EPS			
1.8.2.1	Design	10/6/03	4/2/04	
1.8.2.2	Procurement	2/9/04	4/9/04	
1.8.2.3	Installation	7/5/04	6/24/05	
1.8.3	Controls			
1.8.3.1	Design	10/6/03	7/9/04	
1.8.3.2	Procurement	2/9/04	4/8/05	
1.8.3.3	Installation	5/10/04	8/25/06	
1.9	**MERIX Instrumentation**		8/4/06	**C. Burns**
1.9.1	Spectrometer	5/10/04	8/6/04	
1.9.2	Optical table	2/14/05	9/30/05	
1.9.3	Detectors	2/14/05	9/30/05	
1.9.4	Monochromator	5/12/03	10/29/04	
1.9.5	Analysers	2/14/05	9/30/05	
1.9.6	Monochromator crystals	2/16/04	9/24/04	



Work Breakdown Structure

WBS	Activity Name	Start Date	Finish Date	Responsibility
1.9.7	Sample cell & translation	2/14/05	8/5/05	
1.9.8	Beam transport	2/14/05	8/5/05	
1.9.9	Riso slits	2/14/05	8/5/05	
1.9.10	Displex cryostat	2/13/06	8/4/06	
1.9.11	Turbo pump	2/13/06	8/4/06	
1.9.12	Small pumps	2/13/06	8/4/06	
1.10	**HERIX Instrumentation**		9/29/06	**H. Sinn**
1.10.1	Main Structure of Spectrometer	5/12/03	11/14/03	
1.10.2	CZT detector	5/10/04	11/12/04	
1.10.3	Monochromator	11/18/02	11/14/03	
1.10.4	Analyzers	5/17/04	8/4/06	
1.10.5	Vacuum chamber	9/15/03	3/12/04	
1.10.6	Sample motion goniometers	11/18/02	3/7/03	
1.10.7	Sample slit motion delector	11/18/02	3/7/03	
1.10.8	Keithley multimeter	10/14/02	12/20/02	
1.10.9	Motor cables	5/12/03	8/29/03	
1.10.10	Vacuum pumps	2/13/06	6/9/06	
1.10.11	Sample table	2/14/05	7/1/05	
1.10.12	VME crate for analyzer motors	2/16/04	8/13/04	
1.11	**Lab Office Module (LOM)**		9/29/06	
1.11.1	Office build out	6/5/06	9/29/06	
1.11.2	Office furniture	8/1/06	9/29/06	
1.11.3	Office equipment	8/1/06	9/29/06	
1.11.4	Wet lab	6/5/06	9/29/06	
1.11.5	Dry lab	6/5/06	9/29/06	
1.12	**Contingency (10%)**	10/1/02	9/29/06	



Work Breakdown Structure

WBS	Activity Name	Start Date	Finish Date	BUDGET K$	DOE 02 K$	NSF 02 K$	DOE 03 K$	NSF 03 K$	MF 03 K$	DOE 04 K$	NSF 04 K$	MF 04 K$	DOE 05 K$	DOE 06 K$
1.1	**Project Planning**		9/29/06	**0.0**										
1.1.1	CDR		9/6/02	**0.0**										
1.1.2	Management Plan		9/20/02	**0.0**										
1.1.3	Safety Plan		9/20/02	**0.0**										
1.1.4	Cost & Schedule Plan		9/20/02	**0.0**										
1.1.5	MOU		10/21/02	**0.0**										
1.1.6	PDR		1/10/03	**0.0**										
1.1.7	FDR		6/4/04	**0.0**										
1.1.8	Commissioning													
1.1.8.1	Shielding Verification Station A		10/15/04	**0.0**										
1.1.8.2	Commissioning Station A Optics	10/18/04	1/28/05	**0.0**										
1.1.8.3	Shielding Verification Station B		2/4/05	**0.0**										
1.1.8.4	Shielding Verification Station C		2/4/05	**0.0**										
1.1.8.5	Commissioning Station B	2/7/05	9/29/06	**0.0**										
1.1.8.6	Commissioning Station C	2/7/05	9/29/06	**0.0**										
1.2	**SR Modifications**		9/24/04	**0.0**										
1.3	**Straight Section Vacuum Chamber**		9/24/04	**0.0**										
1.4	**Insertion Devices**		9/24/04	**0.0**										
1.5	**Front End**		9/24/04	**0.0**										
1.6	**Beamline Stations & Infrastructure**		9/3/04	**0.0**										
1.6.1	Station A													
1.6.1.1	Design	9/16/02	12/20/02	**0.0**										
1.6.1.2	Procurement	1/6/03	3/3/03	**198.0**	198.0									
1.6.1.3	Installation	7/7/03	10/3/03	**0.0**										
1.6.2	Station B													
1.6.2.1	Design	9/16/02	12/20/02	**0.0**										
1.6.2.2	Procurement	1/6/03	3/3/03	**396.0**	396.0									
1.6.2.3	Installation	7/7/03	10/3/03	**0.0**										
1.6.3	Station C													
1.6.3.1	Design	9/16/02	12/20/02	**0.0**										
1.6.3.2	Procurement	1/6/03	3/3/03	**770.0**	406.0		364.0							
1.6.3.3	Installation	7/7/03	10/3/03	**0.0**										
1.6.4	Beamline Utilities													
1.6.4.1	Design	11/18/02	3/21/03	**0.0**										
1.6.4.2	Procurement	3/1/04	4/30/04	**150.0**						150.0				
1.6.4.3	Installation	6/1/04	9/3/04	**0.0**										
				6186.0	1000.0	221.5	1003.0	337.5	284.0	1001.0	339.8	250.0	1006.0	743.2

Work Breakdown Structure

WBS	Activity Name	Start Date	Finish Date	BUDGET K$	DOE 02 K$	NSF 02 K$	DOE 03 K$	NSF 03 K$	MF 03 K$	DOE 04 K$	NSF 04 K$	MF 04 K$	DOE 05 K$	DOE 06 K$
1.6.5	Work Area Enclosure													
1.6.5.1	Enclosure...	11/18/02	1/15/04	**140.0**					140.0					
1.6.5.2	Furniture	6/1/04	9/3/04	**50.0**						50.0				
1.6.5.3	Computers	6/1/04	9/3/04	**20.0**						20.0				
1.6.5.4	Printers	6/1/04	9/3/04	**10.0**						10.0				
1.6.5.5	TV Monitors	6/1/04	9/3/04	**5.0**						5.0				
1.7	**Beamline Optics**		3/4/05	**0.0**										
1.7.1	White Beam Slits													
1.7.1.1	Design	5/5/03	8/8/03	**0.0**										
1.7.1.2	Procurement	8/11/03	10/3/03	**44.0**			44.0							
1.7.1.3	Installation	10/18/04	11/19/04	**0.0**										
1.7.2	Focusing Lens													
1.7.2.1	Design	3/3/03	7/11/03	**0.0**										
1.7.2.2	Procurement	7/14/03	9/5/03	**44.0**					44.0					
1.7.2.3	Installation	10/25/04	11/19/04	**0.0**										
1.7.3	Primary Monochromator													
1.7.3.1	Design	9/9/02	12/13/02	**0.0**										
1.7.3.2	Procurement	3/10/03	5/9/03	**400.0**			400.0							
1.7.3.3	Installation	11/1/04	12/3/04	**0.0**										
1.7.4	Integral Shutter													
1.7.4.1	Design	3/3/03	4/25/03	**0.0**										
1.7.4.2	Procurement	5/12/03	7/11/03	**50.0**				50.0						
1.7.4.3	Installation	7/12/04	8/27/04	**0.0**										
1.7.5	Monochromatic Shutter													
1.7.5.1	Design	5/12/03	10/10/03	**0.0**										
1.7.5.2	Procurement	2/9/04	4/9/04	**50.0**						50.0				
1.7.5.3	Installation	7/12/04	8/27/04	**0.0**										
1.7.6	Monochromatic Mirrors													
1.7.6.1	MERIX Mirror...	4/7/03	6/3/05	**275.0**			175.0		30.0	70.0				
1.7.6.2	HERIX Mirror...	5/2/05	8/31/07	**300.0**										300.0
1.7.7	Support Tables													
1.7.7.1	Design	8/11/03	10/10/03	**0.0**										
1.7.7.2	Procurement	2/2/04	3/26/04	**50.0**						50.0				
1.7.7.3	Installtion	6/28/04	9/24/04	**0.0**										
1.7.8	Optical Tables													
1.7.8.1	Design	10/3/03	3/5/04	**0.0**										
				6186.0	1000.0	221.5	1003.0	337.5	284.0	1001.0	339.8	250.0	1006.0	743.2

Work Breakdown Structure

WBS	Activity Name	Start Date	Finish Date	BUDGET K$	DOE 02 K$	NSF 02 K$	DOE 03 K$	NSF 03 K$	MF 03 K$	DOE 04 K$	NSF 04 K$	MF 04 K$	DOE 05 K$	DOE 06 K$
1.7.8.2	Procurement	4/5/04	4/29/05	**180.0**						90.0			90.0	
1.7.8.3	Installation	2/7/05	11/18/05	**0.0**										
1.7.9	Vacuum Hardware													
1.7.9.1	Ion pumps & controllers	6/16/03	1/9/04	**45.0**					45.0					
1.7.9.2	Ion gauges & controllers	2/16/04	7/2/04	**10.0**						10.0				
1.7.9.3	Inline valves	2/16/04	7/2/04	**10.0**						10.0				
1.7.9.4	Roughing valves	2/16/04	7/2/04	**5.0**						5.0				
1.7.9.5	Bellows	8/11/03	7/2/04	**10.0**					5.0	5.0				
1.7.9.6	Shielded spool transports	2/16/04	9/10/04	**10.0**						10.0				
1.7.9.7	Pumping station	2/14/05	8/12/05	**20.0**									20.0	
1.7.9.8	Miscellanous vacuum hardware	2/16/04	8/12/05	**15.0**						10.0			5.0	
1.7.9.9	Beamline rough vacuum system...	5/5/03	8/5/05	**25.0**									25.0	
1.7.10	Be Windows													
1.7.10.1	Design	3/10/03	6/6/03	**0.0**										
1.7.10.2	Procurement	7/7/03	9/5/03	**20.0**					20.0					
1.7.10.3	Installation	2/7/05	3/4/05	**0.0**										
1.8	**General Instrumentation**		8/25/06	**0.0**										
1.8.1	PSS													
1.8.1.1	Design	11/15/02	2/6/04	**0.0**										
1.8.1.2	Procurement	1/6/03	3/5/04	**110.0**						110.0				
1.8.1.3	Installation	7/5/04	9/24/04	**0.0**										
1.8.2	EPS													
1.8.2.1	Design	10/6/03	4/2/04	**0.0**										
1.8.2.2	Procurement	2/9/04	4/9/04	**33.0**						33.0				
1.8.2.3	Installation	7/5/04	6/24/05	**0.0**										
1.8.3	Controls													
1.8.3.1	Design	10/6/03	7/9/04	**0.0**										
1.8.3.2	Procurement	2/9/04	4/8/05	**320.0**						100.0			220.0	
1.8.3.3	Installation	5/10/04	8/25/06	**0.0**										
1.9	**MERIX Instrumentation**		8/4/06	**0.0**										
1.9.1	Spectrometer	5/10/04	8/6/04	**495.0**						80.0			415.0	
1.9.2	Optical table	2/14/05	9/30/05	**66.0**									66.0	
1.9.3	Detectors	2/14/05	9/30/05	**22.0**									22.0	
1.9.4	Monochromator	5/12/03	10/29/04	**220.0**			20.0			100.0		100.0		
1.9.5	Analysers	2/14/05	9/30/05	**33.0**									33.0	
1.9.6	Monochromator crystals	2/16/04	9/24/04	**33.0**						33.0				
				6186.0	1000.0	221.5	1003.0	337.5	284.0	1001.0	339.8	250.0	1006.0	743.2

Work Breakdown Structure

WBS	Activity Name	Start Date	Finish Date	BUDGET K$	DOE 02 K$	NSF 02 K$	DOE 03 K$	NSF 03 K$	MF 03 K$	DOE 04 K$	NSF 04 K$	MF 04 K$	DOE 05 K$	DOE 06 K$
1.9.7	Sample cell & translation	2/14/05	8/5/05	**11.0**									11.0	
1.9.8	Beam transport	2/14/05	8/5/05	**22.0**									22.0	
1.9.9	Riso slits	2/14/05	8/5/05	**22.0**									22.0	
1.9.10	Displex cryostat	2/13/06	8/4/06	**33.0**										33.0
1.9.11	Turbo pump	2/13/06	8/4/06	**16.5**										16.5
1.9.12	Small pumps	2/13/06	8/4/06	**2.2**										2.2
1.10	**HERIX Instrumentation**		9/29/06	**0.0**										
1.10.1	Main Structure of Spectrometer	5/12/03	11/14/03	**77.0**				77.0						
1.10.2	CZT detector	5/10/04	11/12/04	**193.6**							193.6			
1.10.3	Monochromator	11/18/02	11/14/03	**300.0**		150.0		150.0						
1.10.4	Analyzers	5/17/04	8/4/06	**387.2**							137.2	150.0		100.0
1.10.5	Vacuum chamber	9/15/03	3/12/04	**44.0**				44.0						
1.10.6	Sample motion goniometers	11/18/02	3/7/03	**44.0**		44.0								
1.10.7	Sample slit motion delector	11/18/02	3/7/03	**16.5**		16.5								
1.10.8	Keithley multimeter	10/14/02	12/20/02	**11.0**		11.0								
1.10.9	Motor cables	5/12/03	8/29/03	**16.5**				16.5						
1.10.10	Vacuum pumps	2/13/06	6/9/06	**33.0**										33.0
1.10.11	Sample table	2/14/05	7/1/05	**55.0**									55.0	
1.10.12	VME crate for analyzer motors	2/16/04	8/13/04	**9.0**							9.0			
1.11	**Lab Office Module (LOM)**		9/29/06	**0.0**										
1.11.1	Office build out	6/5/06	9/29/06	**77.0**										77.0
1.11.2	Office furniture	8/1/06	9/29/06	**33.0**										33.0
1.11.3	Office equipment	8/1/06	9/29/06	**33.0**										33.0
1.11.4	Wet lab	6/5/06	9/29/06	**60.5**										60.5
1.11.5	Dry lab	6/5/06	9/29/06	**55.0**										55.0
1.12	**Contingency (10%)**	10/1/02	9/29/06	**0.0**										
				6186.0	1000.0	221.5	1003.0	337.5	284.0	1001.0	339.8	250.0	1006.0	743.2