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XOR Beamline Upgrades: Updates and Future Plans

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X-ray Operations and Research

APS/UCO Monthly Operations Meeting

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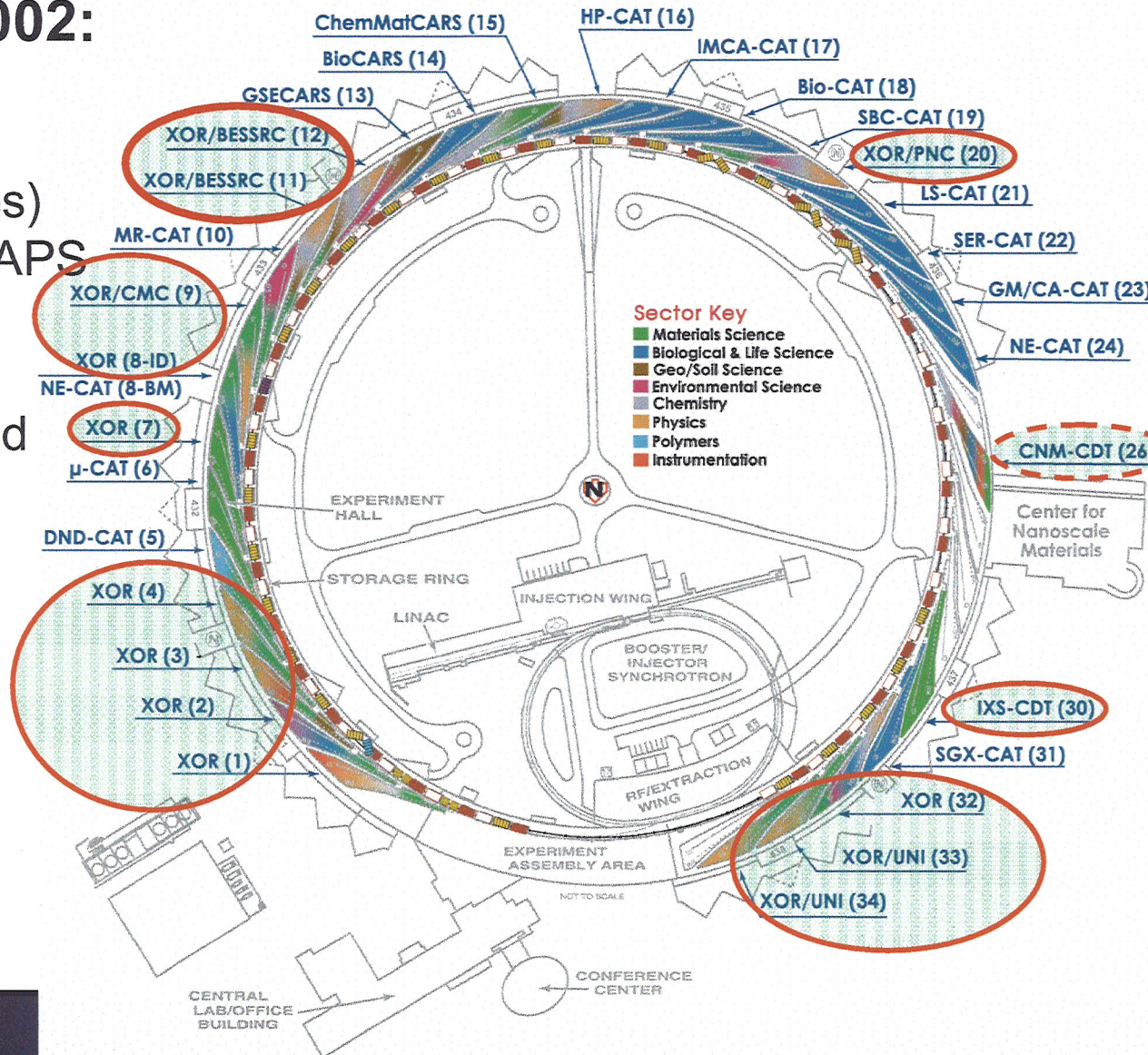
THE ADVANCED PHOTON SOURCE

Sector Allocations & Disciplines

(Present)
After FY2002:

15 Sectors
(27 beamlines)
operated by APS

X-ray
Operation and
Research



joint operation
with CNM

XOR Challenges

- XOR inherited beamlines with inadequate staffing
- XOR inherited beamlines that need upgrades
- **XOR inherited multipurpose beamlines**

Goals:

- **Develop more dedicated beamlines**
- **Accommodate users needs**

List of Beamlines

- **Beamline 1-ID**
- **Beamline 7-ID**
- **Beamline 8-ID**
- **Sector 9**
- **Beamline 11-ID**
- **Beamline 12-ID**
- **Beamline 20-ID**
- **Beamline 32-ID**
- **Beamline 33-ID**
- **Beamline 34-ID**

Beamline 1-ID

Upgrades Plans

Phase I (completed in 2006): dedicated HE beamline (\$109K)

Phase IIa (Dec.07-Jan.08) : installation of the 2.3 cm undulator

Phase IIb (pending) : replacement of the mono station and beam transport with two white beam stations

Phase III: addition of a fixed energy side station

Also, R&D on a superconducting undulator in progress

1-ID Upgrade Cost, For Now

Capital: **\$110K**

Effort:

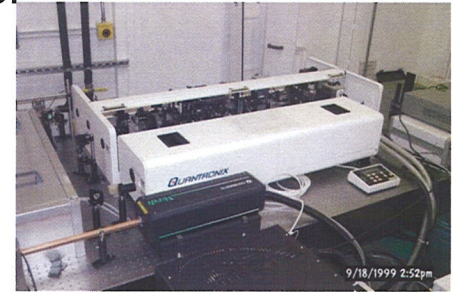
Phase I: **9 months FTE engineer time**
6 months designer time

Phase II: **3 months FTE engineer time**
3 months designer time

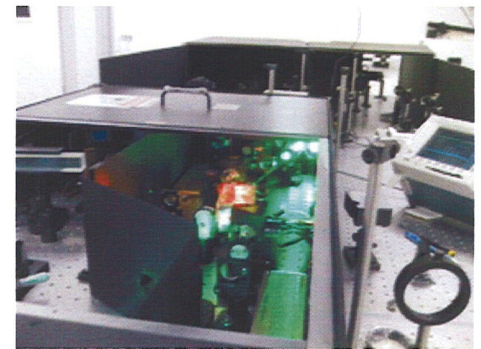
7-ID Improvements: Laser and Enclosure

- APS capital investment greatly improved the operation of fs-laser
 - State-of-art laser (procured with partner users)
 - Hours of operation from 400/yr to 4000/yr
- Dedicated laser enclosure: 7-ID-E
 - Improved experiment environment and laser maintainability
 - Allowing laser-only experiments
 - **Safer user operation**

From this old laser!

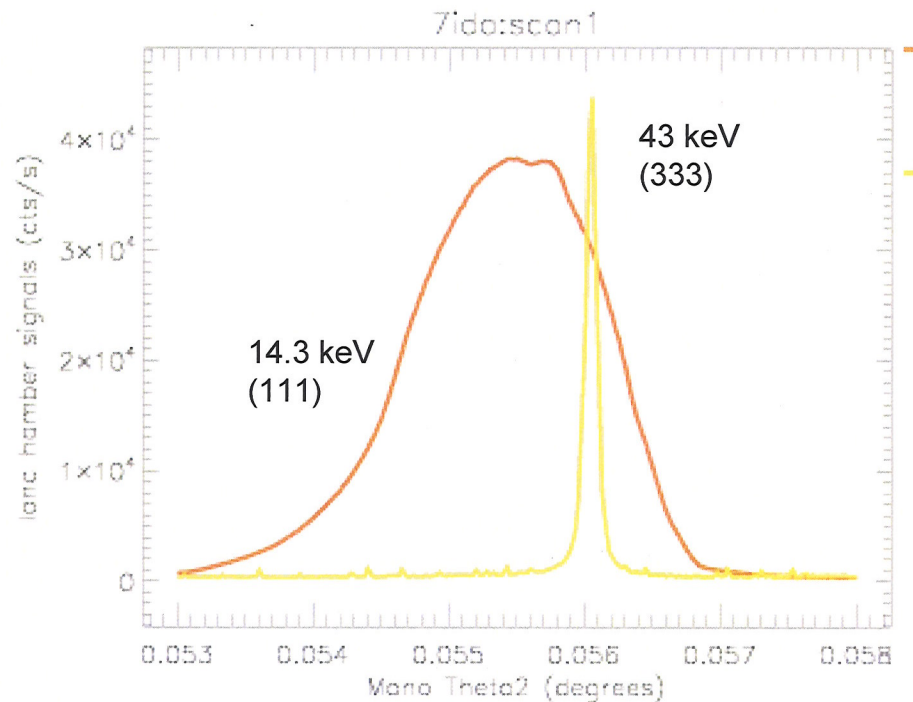
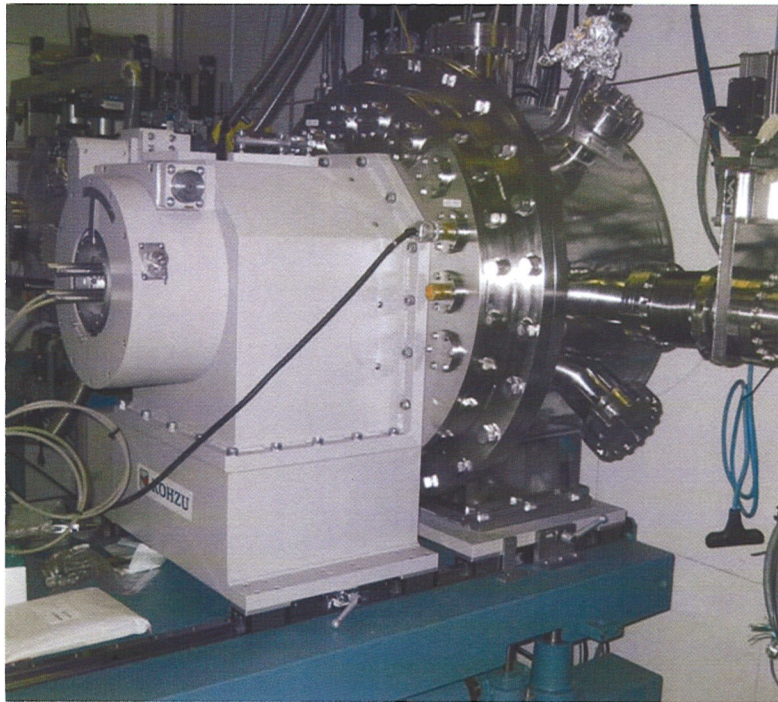


To a new Coherent system!



7-ID Improvements - Continued

- Replaced an outdated mono with a diamond double-crystal mono from sector 32 (2006)
 - Stable beam location (for spatially overlapping x-ray and laser beams)
 - Accurate energy scan (for spectroscopy experiments) and better E-resolution



Summary of 7-ID Improvements

- Laser enclosure: \$150K (2005)
- Laser: \$150K (2004)
- Controls: \$70K (2004-5)
- Monochromator: \$65K (2006)
- Computer network: \$100K

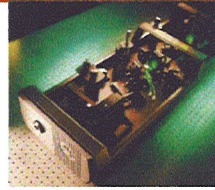
Total: \$535K

- Effort: 2 FTE a year from 2004-2005
1 FTE in 2006.

Future 7-ID Upgrade: Short Pulse

Phase I

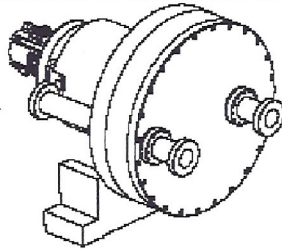
1. Low-jitter laser oscillator



CY 2007 →

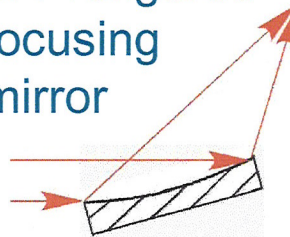
Sub-ps rf-laser jitter

2. Heat-load Chopper



enables

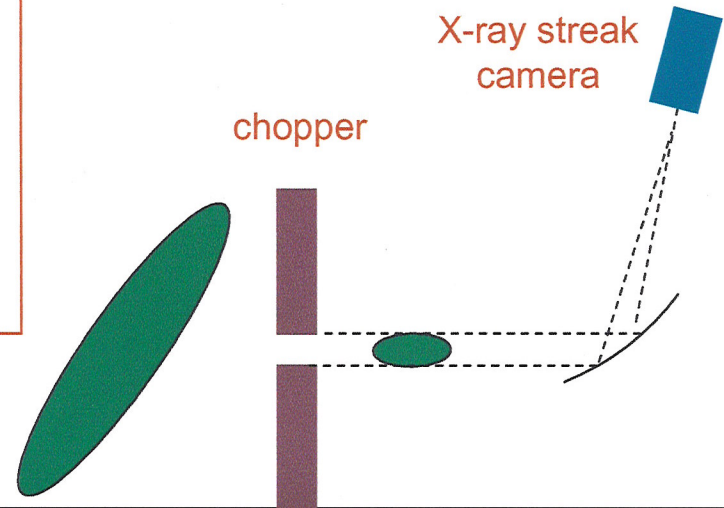
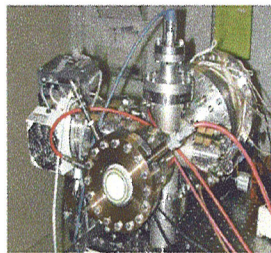
3. Prefigured focusing mirror



Single-shot x-ray/laser timing diagnostics

enables

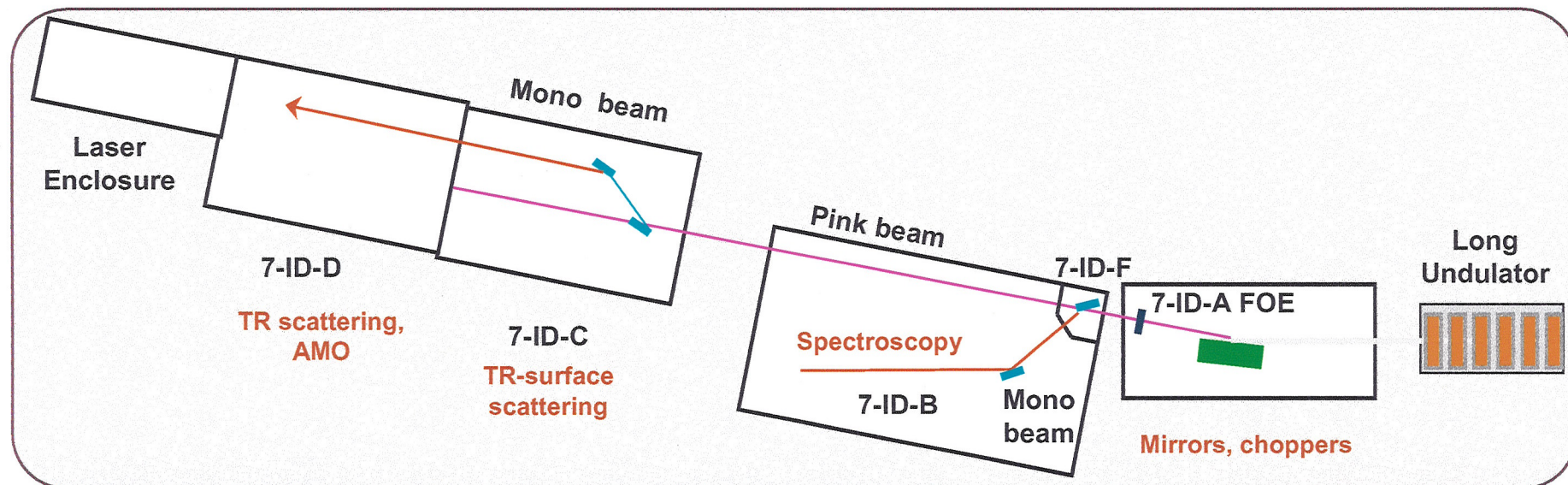
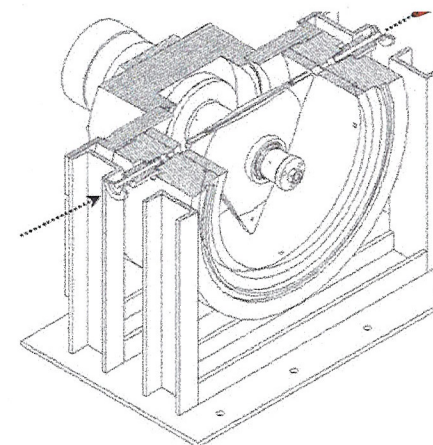
4. Dedicated Streak camera



Future 7-ID Upgrade: Short Pulse

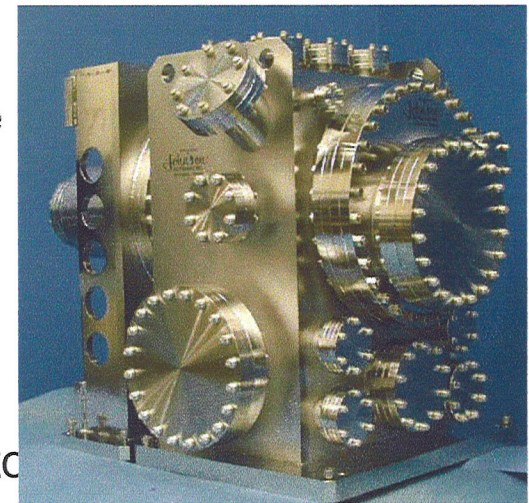
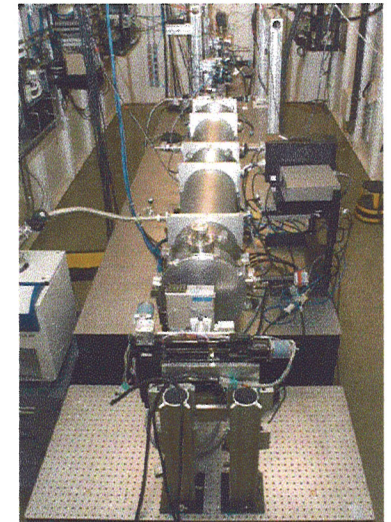
Phase II

- Long undulator
- Advanced beamline optics
- Microfocusing
- Dynamic bending mirrors
- 24-bunch singlet-mode chopper
- Troika scheme: simultaneous B and C/D instruments and stations
- 2 experiments at same time with pink/mono or mono/mono beams



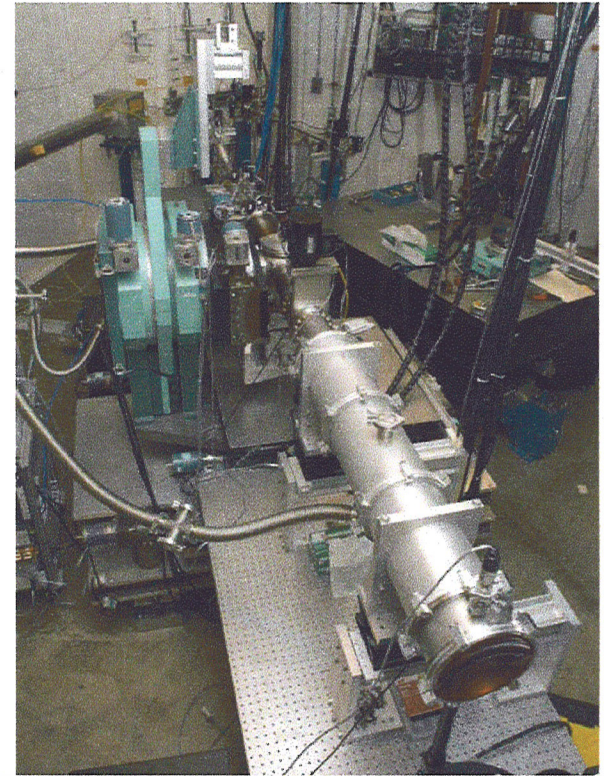
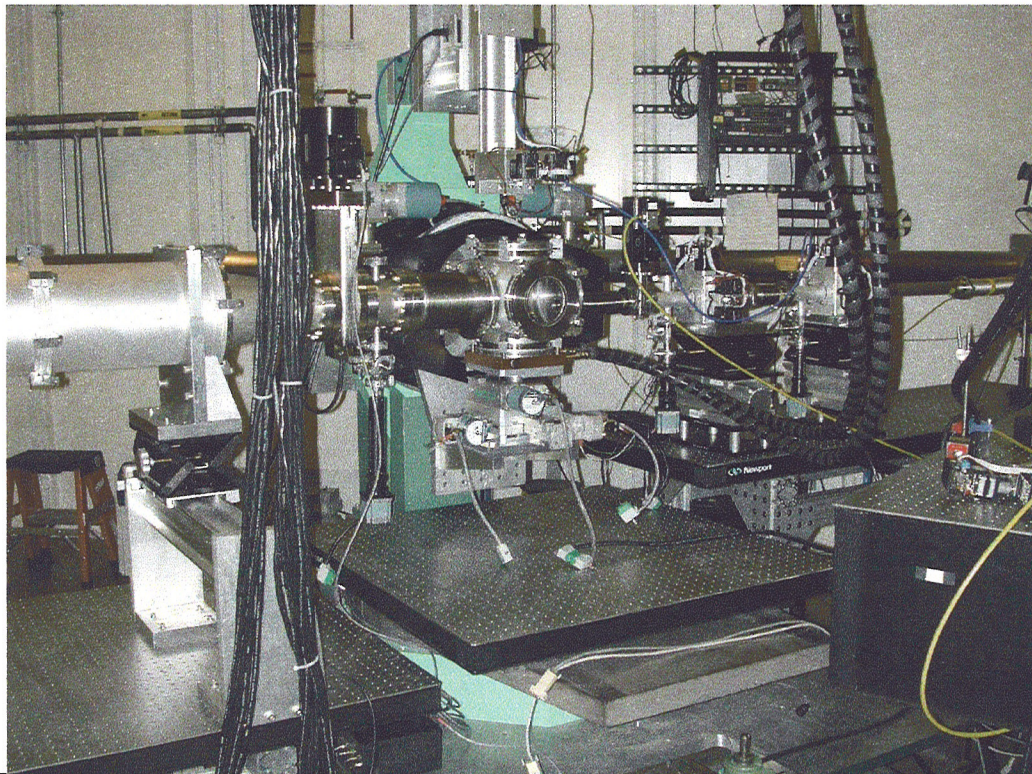
Beamline 8-ID Improvements

- Beamline specialization: XPCS
 - Beamline protection system, control, network and computing were completely updated
 - *From self-supported, outdated PC-based system to APS supported hardware and software*
- APS capital investment at work!
 - State-of-art x-ray optics to preserve beam coherence
 - *New mirror*
 - *New monochromator*
- Beamline readiness
 - XPCS setup time decreases dramatically from days to (2-3 most of time) hours between user runs



New GISAXS Beamline in Sector 8-ID-E

- Dedicated GISAXS beamline developed and commissioned
 - Built within 6 months with no beamline downtime
 - Highest q-resolution extended to probe 20 μm in real space
 - Dedicated for studying real-time kinetics in nanocomposites
 - Embraced by the “nanoscience” community



Summary of 8-ID Improvements

| | |
|------------------------|---------------|
| Mirror: | \$100K |
| I-station mono: | \$150K |
| E-station mono: | \$50K |
| Controls: | \$100K |
| Network and computers: | \$70K |
| GISAXS instrument: | \$120K |
| Total: | \$590K |

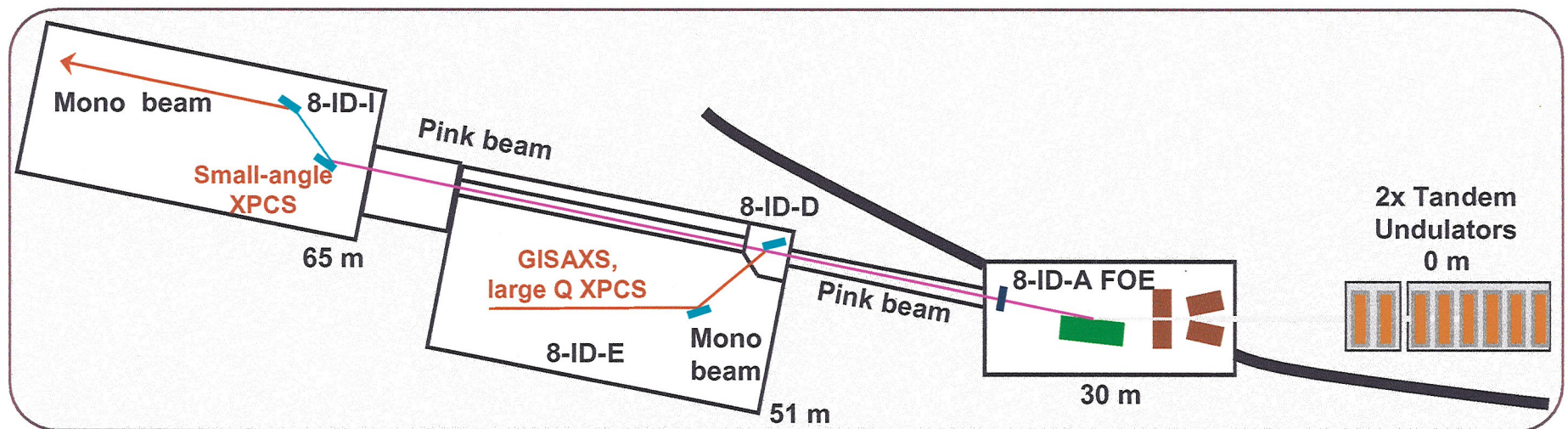
Effort: roughly 2 FTE a year from 2004-2007

Future Upgrade: Vertically Focusing for XPCS

- Today, in order to remain in the diffraction limit, only 10% of the coherent flux delivered by the undulator is used for XPCS experiments
 - The vertical coherence length is too large
- Vertical focusing (via a mirror) allows the vertical coherence length to be tailored so that the entire coherent flux can be used
 - XPCS signal-to-noise ratio considerations show that 100× faster dynamics or 10× weaker scatterers can be studied

Future 8-ID Upgrade: Two Undulators

- Tandem undulators in 8-ID straight section (5 m) : Tailored for XPCS & GISAXS
 - Long, small period undulator : Maximizes brilliance for XPCS
 - Shorter length, longer period undulator : Energy tunability for GISAXS
- +
- Large Horizontal-Offset Double Bounce Monochromator for 8-ID-E : Continuous Energy Tunability
- ⇒ Simultaneous and independent operation of 8-ID-I and 8-ID-E



Detectors

Sector 7 and 8 detector needs

- Ultrafast science: Analog pixel array detectors, x-ray streak camera
- XPCS: Pixel array detector with built-in correlators, fast CCD (10 kHz framing rate)
- GISAXS: Large area pixel array detector
- **Need to develop a vision on detector development**

Sector 9 Improvements and Upgrades

Major upgrade to computing system and network completed (\$50K)

9-ID:

- Addition of second undulator A to double incident intensity for IXS
- Conversion of high-heat load mono to diamond(111)
- Instrument improvements:
 - IXS: new detector (strip detector)
 - New secondary monochromator
 - New spherical analyzers
 - LSS: new detector (area detector, CCD)
 - New motion stages to improve precision for high-energy operation
 - Upgrades to control system, VME crates
- Addition of a secondary ID line \Rightarrow would enable simultaneous IXS and LSS

9-BM: Catalysis facility

Beamline 11-ID

11-ID source serves **three simultaneously operated** (end-)stations:

11-ID-B: *structural characterization of disordered and amorphous materials utilizing (high energy) PDF (energy range: 60-115KeV)*

11-ID-C: *structural characterization of correlated electron systems (energy: 115KeV)*

11-ID-D: *electronic and structural response of molecular systems to photo excitation utilizing time dependent XAFS and WAXS (energy range: 4.5keV-36keV)*

Until 2007-1: Elliptical Multiple Wiggler (EMW) was a source

Improvement: Replaced EMW with two in-line undulators

Source Replacement in 11-ID

A three phase upgrade plan reducing the required down-time:

Phase 1: Install undulator A, upgrade all essential optical components and test optics under high heat-load condition (2007-2)

DONE!

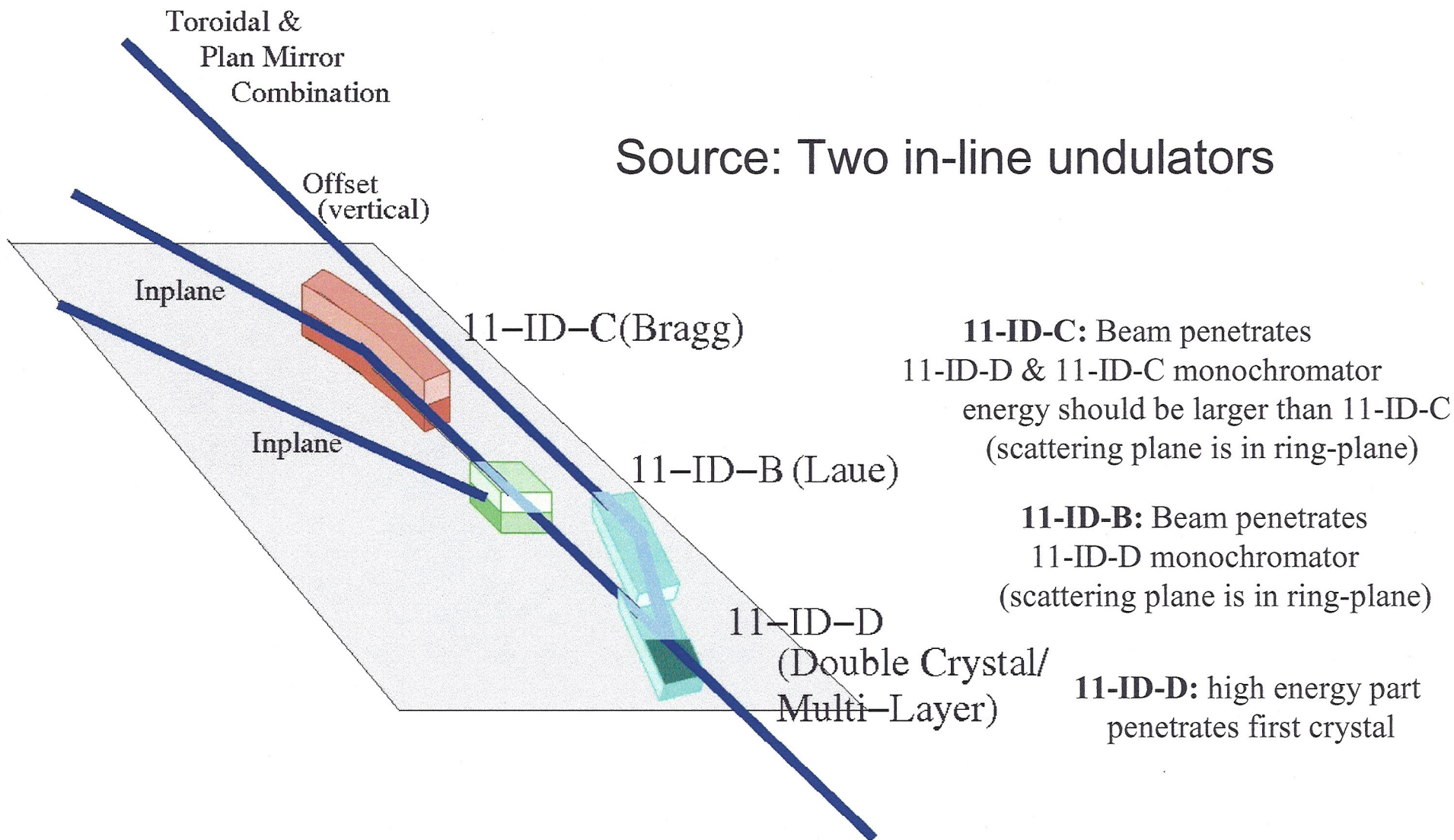
Phase 2: Install undulator 2.3 (high-energy undulator) (2007-3)

Phase 3: Optimize optics, detectors and infrastructure (2008-3)

Cost estimate for phase 1 and phase 2: \$479K

Beamline 11-ID Layout

Source: Two in-line undulators

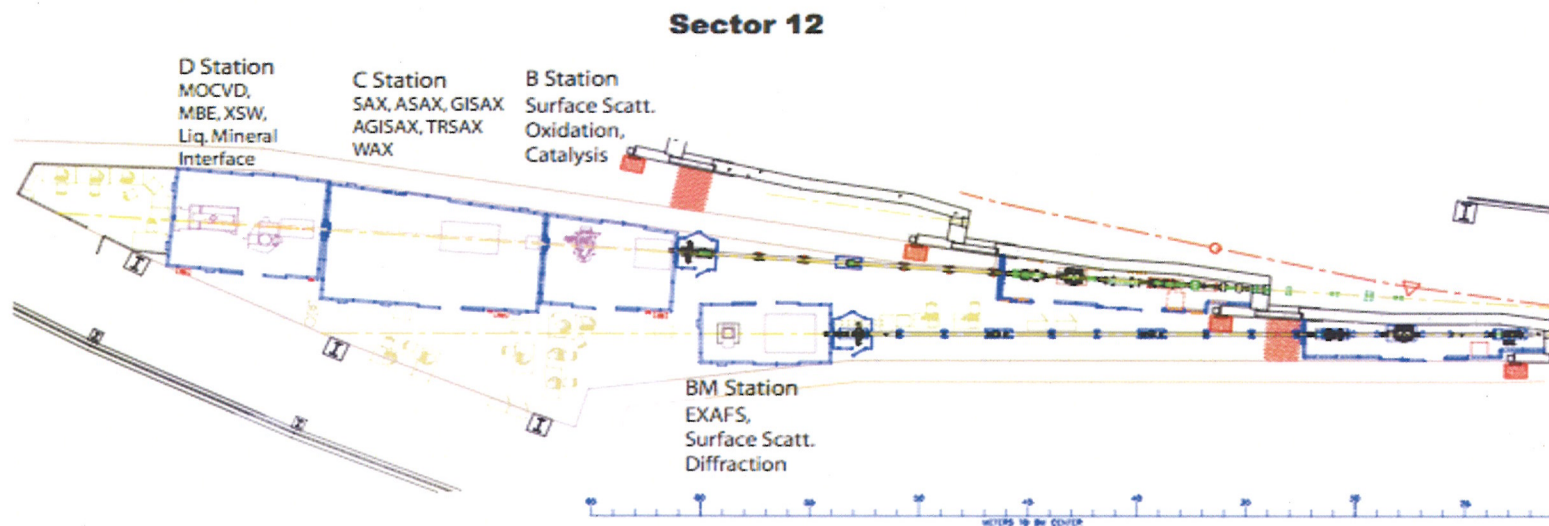


11-ID-C: Beam penetrates 11-ID-D & 11-ID-C monochromator energy should be larger than 11-ID-C (scattering plane is in ring-plane)

11-ID-B: Beam penetrates 11-ID-D monochromator (scattering plane is in ring-plane)

11-ID-D: high energy part penetrates first crystal

Layout of 12-ID Today



X-Ray Standing Waves and Mineral Interface Programs (Fenter and Bedzyk)

Plans are underway to relocate these programs to 33-ID

- Funds (\$160K) and effort (0.5 person-year) allocated
- Completion expected in September 2007
- Commissioning expected to start in October 2007

This will alleviate some of the pressure on 12-ID-D

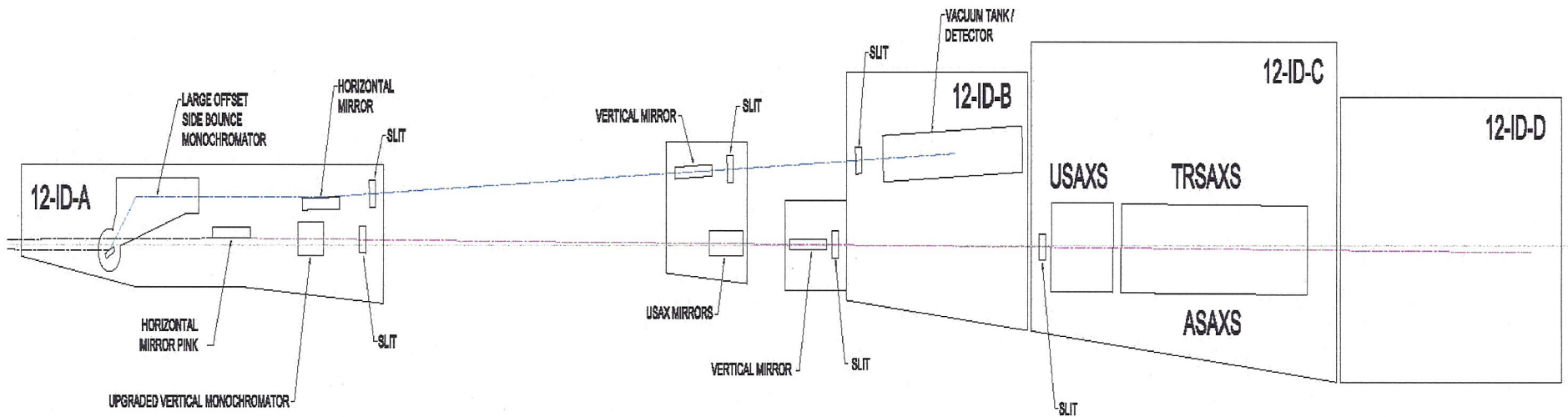
12-ID Upgrade Plans

Canted undulators

One side-bounce monochromator (7-13 keV; Si 220):

- One of the undulators beam feeds the *B-station*
 - Independent operation: dedicated SAXS
- Second undulator feeds C and D stations
 - C and D share time

12-ID Upgrade Plans



- **Cost to complete: \$1.2M (mini hutch, FE components, side-bounce mono, mirrors, vacuum chamber, support)**

Sector 20 Recent Upgrades

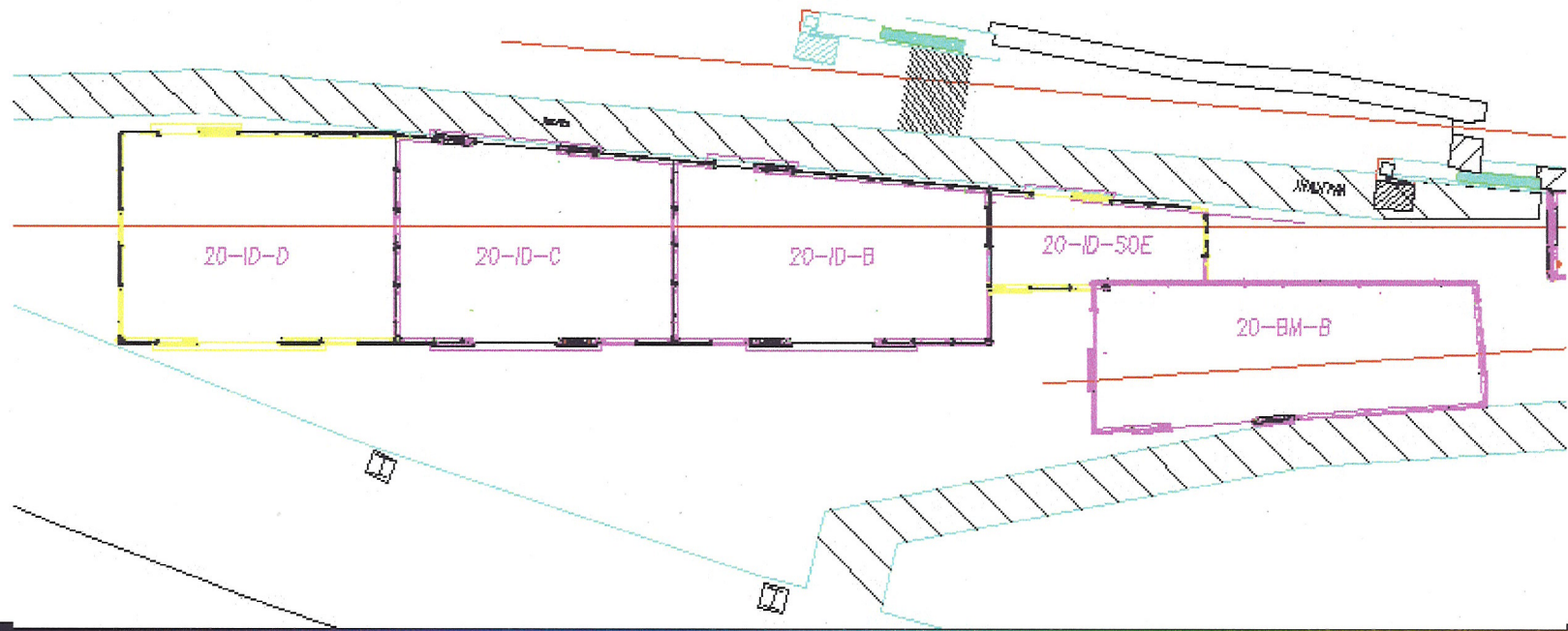
- X-ray Raman spectrometer (LERIX) brought to full operation – now accepting GU's
- 20-ID monochromator improvements for better stability
- New 13-element detector for 20-BM
- EXAFS sample prep lab established

Sector 20 Upgrades in Progress

- **BM line focusing mirror (\$250K)**
 - **Collect ~1 mrad up to 30 keV**
 - **Less than 0.5mm focal spot**
 - **5x flux over unfocused beam (1x10 mm)**
 - **Replace KB mirrors for spot sizes greater than 20 μm**
- **APD arrays for time resolved detectors**
- **Implement quick scanning for fluorescence detection (save readout overhead time)**
- **Upgrade microprobe mirrors and detectors (preparation for canted undulator project)**

Proposed Sector 20 Future Layout

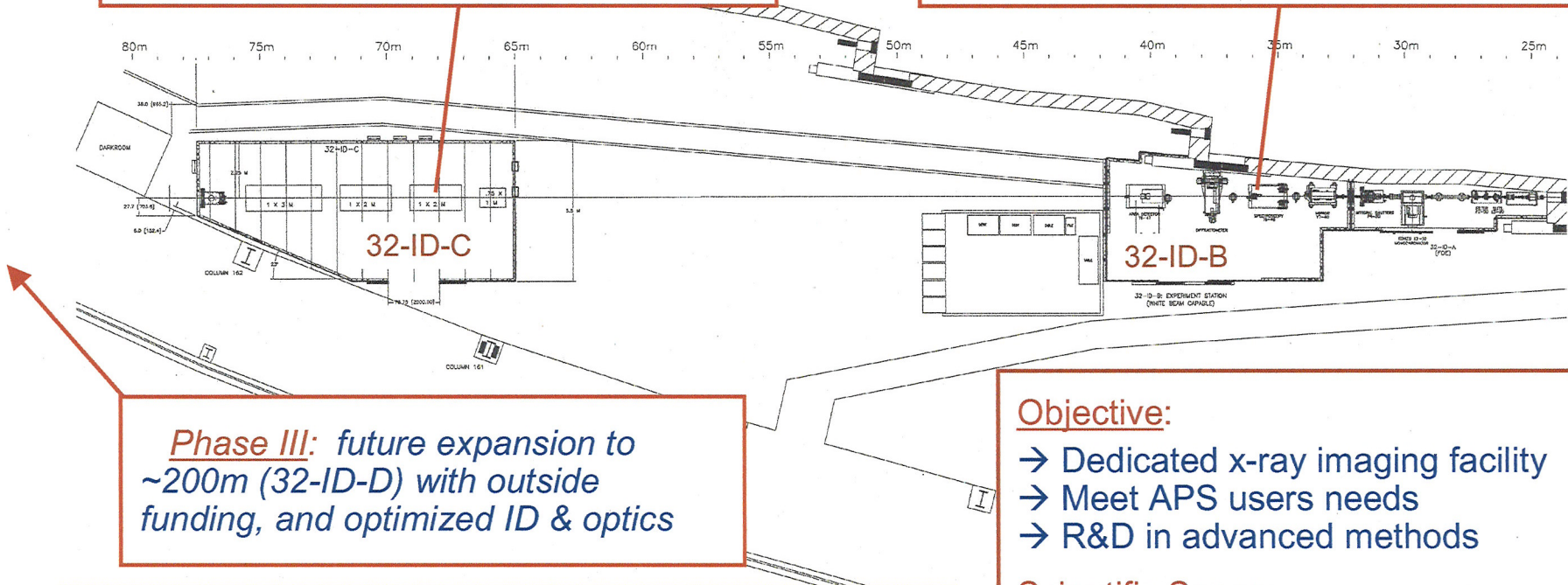
- Canted undulators
- Two new hutches (yellow)
- Beam separation 13 mrad by mirrors (similar to GMCA)
- 3 year project submitted to APS
- **Approx. \$4 million total**



Upgrade of 32-ID

Phase II: expansion to ~77m by building a new white-beam capable hutch at 77m and beam transport

Phase I: use of existing hutch and equipment, with upgrades to Si mono, Be windows, and pink-beam capability



Phase III: future expansion to ~200m (32-ID-D) with outside funding, and optimized ID & optics

Objective:

- Dedicated x-ray imaging facility
- Meet APS users needs
- R&D in advanced methods

Scientific Scope:

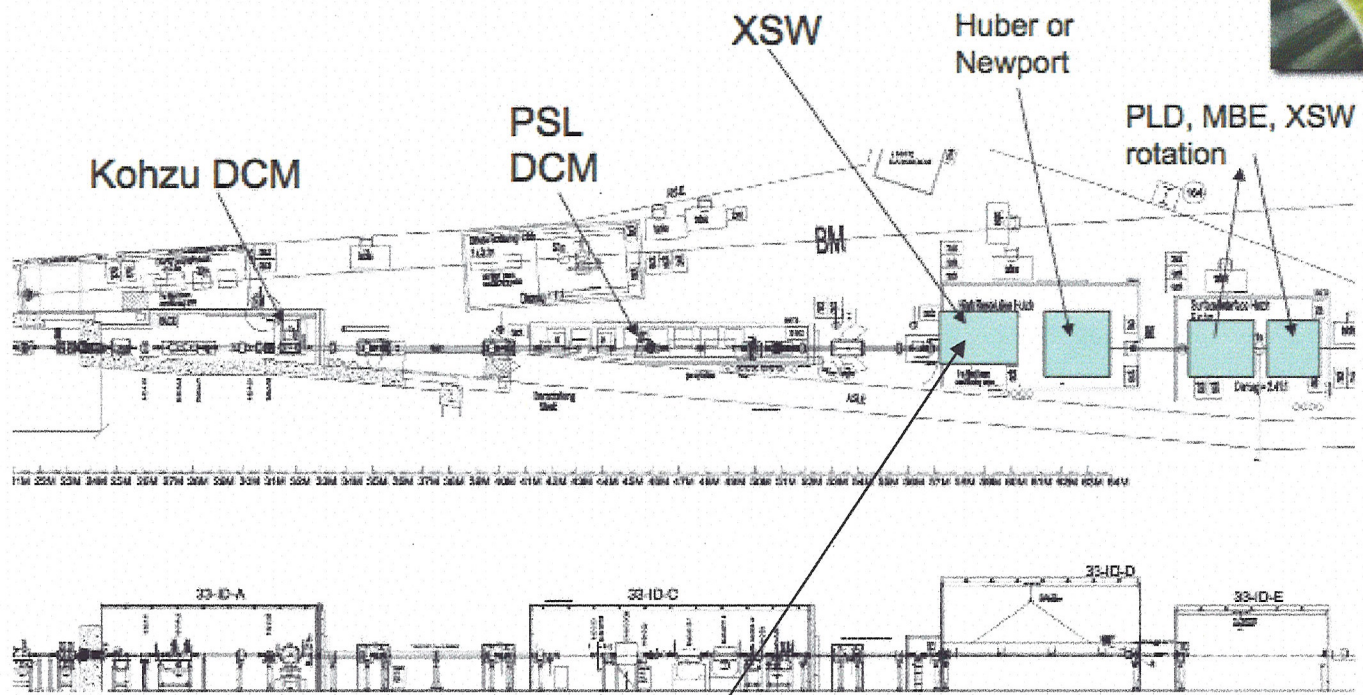
- Phase contrast imaging
- DEI and USAXS imaging
- High-speed imaging
- Transmission x-ray microscope

APS Project 460 (covers only Phase I & II):

- FY'05: \$760K approved → project started Aug.'05
- FY'06: requested ~~\$645K~~ rec'd \$160K
- FY'07: requested ~~\$671K~~ rec'd \$350K

33ID 2007

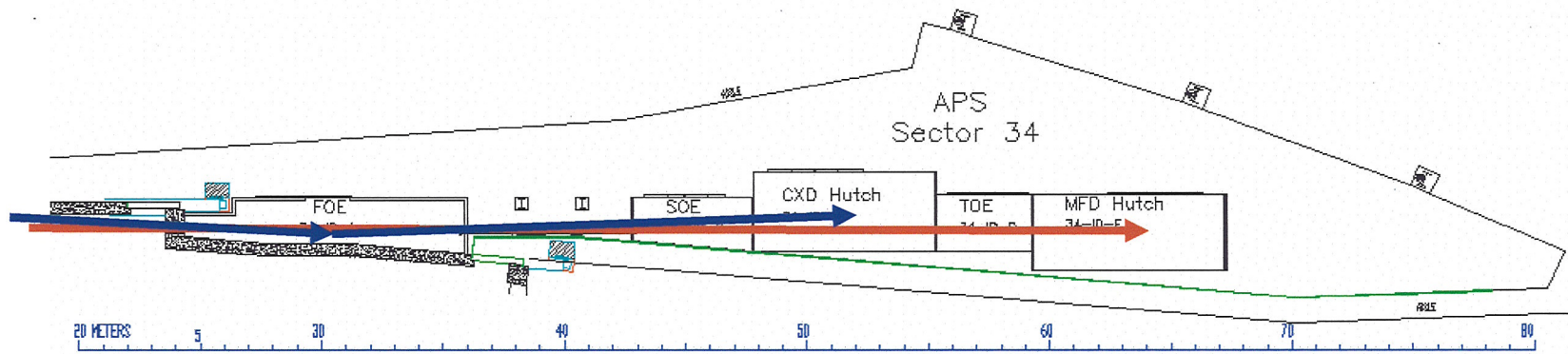
Bedzyk XSW chamber



Fenter XSW table

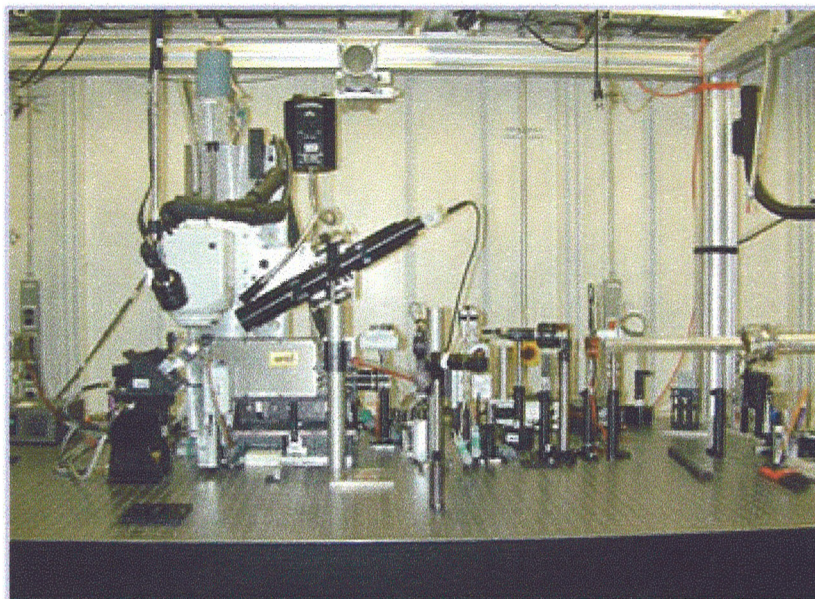
Sector 34

- Currently, 34ID-C & 34ID-E share undulator A spectrum for 3D microbeam diffraction & coherent diffraction experiments
- Beam line designed to allow dual-canted undulator front-end
- Canted ID source will immediately double GUP time available to eac
- **Canted undulators costs: \$1.5M**



Sector 34-Development of 3D Nanodiffraction

- 34ID-E has pioneered 3D Diffraction Microscopy
- Demonstrated 75 nm spot size for 3D nano-scale diffraction
- New platform required to make both micro-beam and nano-beam diffraction available to General Users
- **Project Proposal pending – costs approx: \$775K**



New platform for nano-scale diffraction

XOR Engineering Priorities - August 2007

- | | |
|---|------------------------|
| 1. ID Replacement for sector 11 | Proposal 425-07 |
| 2. Relocation of XSW techniques to sector 33 | Proposal 670-07 |
| 3. Development of dedicated SAXS in sector 12 | Proposal 428-07 |
| 4. Upgrade 1-ID (Phase II) | Proposal 650-07 |
| 5. Install short period undulator in 1-ID | Proposal 462-07 |
| 6. Design of IEX Beamline and APPLE-II | NSF/DOE |
| 7. Fuel spray beamline at 7-BM | Proposal 396-06 |
| 8. Dedicated beamline for (8-BM?) High Thro. Trace Elem. | Proposal 676-07 |
| 9. Developing picosecond capabilities at 7-ID | Proposal 814-07 |