# APS-XSD Detector Workshop

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TWG Meeting, June 15, 2006

# APS-XSD Detector Workshop

This one-day workshop is being organized upon request of the APS X-ray Science Division (APS-XSD) management.

**Objectives:**

a. Develop a coherent plan for detector activities at the APS that can be incorporated into the APS Renewal upgrade proposal to DOE.
b. Provide XSD management with a comprehensive list of current and future (3-5 years) detector needs at APS beam lines and possible ways to address these needs.

**Logistics:**

The all-day workshop will be held on Friday, July 21, 2006, in Building 401, Room A5000 – Time and agenda TBD

# APS-XSD Detector Workshop

- In preparation for the workshop, the organizing committee solicited information on current and future detector needs from ~ 80 beam line scientists representing all APS sectors.
- We received 17 responses, representing 15 sectors.
- We will use this information and your contributions today to finalize the workshop agenda.
- Most of the speakers will be internal.  Where appropriate, we will ask the speakers to present the needs of the community that they represent.
- We will have a few non-APS speakers to discuss strategies for detector development, particularly related to collaborations with other institutions.

# Summary – E dispersive (1)

| Application | Current characteristics | Development direction | Submitter |
|---|---|---|---|
| Microprobe; fluorescence imaging; dilute XAFS | 7-, 13-element Ge from Canberra (OK for BM, saturates for ID), long shaping time to get $\Delta E/E$=2%. | 50-100 element SDD: higher count rates (hexagonal SDD from Ketek). | Steve Heald |
| Micro fluorescence | Multi element solid state detector (Ge?). | Larger area multi-element detector, minimize sample-detector distance for each element. | Qun Shen |
| Nanoprobe - fluorescence | SDD array: 50 kHz, $\Delta E$ = 180 eV at 5.9 keV; but small area 170 $mm^2$; only 350 µm Si, ~ 10% absorption at 30 keV. | Increase solid angle; thicker for better efficiency at higher energies. | Jörg Maser |
| Micro-XRF, micro-XANES | Canberra LEGe, Vortex SDD, good E resolution but small solid angle. | Fluorescence detector, >2π sr coverage; compact; no LN2; < 20 elements. To be developed by industry (SDD). | Barry Lai |

# Summary – E dispersive (2)

| Application | Current characteristics | Development direction | Submitter |
|---|---|---|---|
| XSW measurements (fluorescence) | Canberra LEGe; Vortex SDD. | Better E resolution. Higher efficiency for E > 17 keV. Higher count rate. | Paul Fenter |
| XSW protein crystallography | | XRF detector array, large solid angle, high count rate → SDD. Collaborate w/ industry; Hasylab/ESRF collaboration. | Mike Bedzyk |
| High resolution inelastic x-ray scattering | CdTe Amptek, single and 4-element array; $\Delta E$ = 290 eV at 5.9 keV (typ.). | Compact design to pack detectors closer together (9, then 21). Work w/ supplier. | Ercan Alp |
| Resonant inelastic x-ray scattering (5-12 keV) | Si diode (Amptek); $\Delta E$ < 200 eV at 5.9 keV. | PAD (Pilatus?): low noise, good efficiency at 5-10 keV, packaging. Siddons 1-dimensional array. | Ercan Alp |
| Energy dispersive diffraction, high energy ~ 80 keV | | STJ or similar; $\Delta E$ = 10 eV at 80 keV; pixellated detector. | Dean Haeffner |

# Summary – λ dispersive

| Application | Current characteristics | Development direction | Submitter |
|---|---|---|---|
| Microprobe; dilute XAFS | Bent Laue ($\Delta E/E=0.005$, poor background rejection, large solid angle) and WDX (low background, $\Delta E/E<0.002$, tiny solid angle). | Combine $\Delta E/E$ and low background of WDX with solid angle of bent Laue detector (Attenkofer & Adams). Multilayer analyzers for low energies. | Steve Heald |
| High resolution inelastic x-ray scattering | Curved, diced analyzers produced at APS. Difficult to make, expensive. | Continue work w/ XSD-OFM group. | Ercan Alp |
| 1 eV resolution IXS x-ray Raman scattering | LERIX at 20-ID: 19-element bent SI analyzers, 1% of 4π sr. | LERIX-2: collect 25% of 4π sr. | Jerry Seidler |

# Summary – Timing

| Application | Current characteristics | Development direction | Submitter |
|---|---|---|---|
| Time-resolved XAFS, need to tag individual bunches in 24 bunch mode (153 ns) | APD (I0) and large area plastic scintillator (fluorescence); max rate 150 kHz (linearity issues, has to attenuate the beam). | Near future: multi-element APD to increase count rate by 50x, combined w/ WDX → fluorescence detection w/ ΔE and Δt resolution. | Steve Heald |
| Nuclear resonant scattering | APDs: 9 orders of magnitude dynamic range; 1 ns time resolution; low noise ~ 0.01Hz; 100 μm thick Si. | Stacked for better efficiency; 0.1 ns time resolution; packaging; electronics; large quantities needed. | Ercan Alp |
| Nuclear resonant inelastic scattering | APDs: 9 orders of magnitude dynamic range; 1 ns time resolution; low noise ~ 0.01Hz; 2x2 arrays; 100 μm thick Si. | Need 2x2 or 3x3 APD arrays; can also use linear arrays w/ 30-50 elements. | Ercan Alp |
| Materials science - time resolved diffraction | APDs, fast scintillators, InGaAs diodes, SDD. | Need to gate pulses in 24 bunch mode. Streak camera w/ < 1 ps resolution (commercial?). APD arrays. SDD arrays. | Eric Dufresne |
| Materials science - time resolved diffraction | | Advanced x-ray chopper, capable of hybrid mode (1.59 μs) or 24-bunch mode (153 ns) selection. | Eric Dufresne |

# Summary – Area (1)

| Application | Current characteristics | Development direction | Submitter |
|---|---|---|---|
| Surface scattering measurements | CCD Roper 1" square, 20 μm pixels, w/ 1:1 FO, 1-2 sec readout, dynamic range $10^5$-$10^6$, fast x-ray shutter. | Perhaps faster readout. Real time data (electronic gate): Pilatus w/ smaller pixels, more compact. | Paul Fenter |
| Interfacial x-ray microscopy | Use CCD w/ optical lenses looking at phosphor. | Flux limited. Need small pixels. | Paul Fenter |
| Microdiffraction | Bruker CCD. | Use detector for dark field imaging, need ~ 1-10 fr/sec → commercially available? | Steve Heald |
| Microscropy; coherent imaging | | Pixel size < 20 μm; dynamic range > $10^6$; DQE > 30%; 2Kx2K pixels minimum; radiation resistant → Pilatus w/ smaller pixels. Will need 4-5 detectors. | Qun Shen |
| Protein powder diffraction | mar345, 300 μm PSF. | CCD w/ 30-50 μm res, 75x75 $mm^2$, can be tiled, uses Kodak chip, 2Kx2K 25 μm pixels. | Robert Von Dreele |

# Summary – Area (2)

| Application | Current characteristics | Development direction | Submitter |
|---|---|---|---|
| Nanoprobe - scanning probe phase contrast imaging | | Configured Si detector. | Jörg Maser |
| High energy (> 50 keV) | | 1 µm resolution; area > 2x2 $mm^2$; good efficiency for E > 50 keV; stackable. | Dean Haeffner |
| SAXS and high q-resolution mapping at high energies (> 50 keV) | | PSF < 40 µm; 2Kx4K pixels; readout > 1 fr/s; leaded glass FO to suppress direct x-rays. | Ulrich Lienert |
| Materials science (x-ray scattering techniques) | mar345, mar165, GE a-Si. | Higher frame rates; large area; efficient at 16 keV. | Doug Robinson |
| PDF measurements (~ 120 keV); SAXS/WAXS | GE a-Si. | Large area; < 100 µm resolution; 10-100 fr/s; external gate; hole in center for SAXS/WAXS. | Dean Haeffner |

# Summary – Area (3)

| Application | Current characteristics | Development direction | Submitter |
|---|---|---|---|
| 3-D diffraction maps | Roper 2Kx2K, 1:1 FO, 2 pixel PSF, 8 sec full readout, but collect data in <0.1 sec. | Faster readout CCD, e.g. LBNL/APS collaboration on 100-200 fr/s, 16 bit CCD; data analysis software. Also, a-Si detector 20x more sensitive than GE at lower energies (< 40 keV). | Gene Ice |
| Materials science - time resolved diffraction | | Gated area detector (Pilatus): Mpixel, 25-100 µm pixel, 12-16 bits, 10 ns gate. | Eric Dufresne |
| XPCS | SMD CCD camera. | Direct detection CCD; fast readout 1-10 kHz, w/ ROI; Peltier cooling; inexpensive chip. | Michael Sprung |
| SAXS/TRSAXS | TRSAXS detector, $\Delta t$ = 300 ns, can also be used as static SAXS detector w/ good SNR. | Use TRSAXS detector technology for transmission SAXS detector to cover large reciprocal space ($10^3$), w/ time resolution < 100 ps. | Jan Hessler |
| SAXS/TRSAXS on biological samples - muscle diffraction | Custom 160x80 $mm^2$, high sensitivity CCD. | Larger area CCD (300x300 $mm^2$); high sensitivity; 1 kHz frame rate. Collaborate w/ industry (EMCCD). Make larger TRSAXS detector (Hessler et al.). | Tom Irving |

# Wish list: Energy/wavelength dispersive detectors

For diverse applications :

- Fluorescence arrays: modular multi-element SDD arrays, large solid angle coverage. Thicker sensor for higher energies (~ 20 keV).

For custom applications:

- Custom array for high energy resolution backscattering geometry.
- Very high resolution at high energies, $\Delta E \sim 10$ eV at 80 keV: STJ detector or similar.
- Adaptive-optic x-ray fluorescence analyzer.
- Curved, diced analyzers for high resolution IXS.
- LERIX-2 (Seidler et al.).

# Wish list: Timing detectors

For diverse applications :

- Single APD: custom packaging and electronics; improved time resolution; stacked for better efficiency above 10 keV.
- APD arrays – electronics: can be reused for specific applications.

For custom applications:

- APD arrays - sensors: 2D or linear; custom geometry.
- Streak camera: less than 1 ps resolution.
- x-ray chopper for hybrid or 24 bunch mode.

# Wish list: Area detectors

For diverse applications:

- Pilatus PAD: smaller pixels.
- a-Si flat panel detector: for E ~ 20 keV and E ~ 100 keV; frame rate ~ 30 Hz; large area; < 100 μm pixels; electronic gate.
- CCD: fast (10-100 Hz) and faster (1-10 kHz) readout; small pixels < 20 μm; 2Kx2K pixels; direct detection or FO/lens coupling; possibly tiled for larger area.

For custom applications:

- Time-resolved SAXS detector (Hessler et al.): optimum design for specific application; very large area; time resolution < 100 ps.
- Configured Si detector: custom segmentation for specific application.
- High spatial resolution detector for E > 50 keV: 1 μm resolution; stackable.

# Next Steps

- Workshop agenda based on the information received. Please continue to send us your requests.
- Speakers will be asked to present the specific desired detector characteristics and the science driving these requirements.
- The workshop committee will generate a report to be submitted to APS management. The report will be circulated for comments among the workshop participants.