Recent Changes and Results in Insertion Device Design

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NSLS-II

NSLS-II Accelerator Systems Advisory Committee
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Outline

1) Various Review Recommendations and New ID Table
2) Permanent Magnet Damping / User Wiggler (ACD report)
3) Elliptically Polarized Undulator (EPU)
4) 3 Pole Wiggler (ACD report)
5) Magnetic Measurement Laboratory
6) Schedule and Budgetary Issues

Recommendations by Various Reviews

- *Insertion Device Technical Review (Aug.20-21, 2007)*
  - The construction of a dedicated ID laboratory seems essential.
  - The calculation of spectral flux in a finite aperture (primary slits for example) placed at some distance from the source must be performed for optimization
  - Separation (0.47m) between DWs with canting magnet might be too tight
  - It is probably important to investigate a “backup” solution in parallel to the CPMU R&D.
  - SCUs needs substantial R&D to become attractive.
- *NSLS-II Comprehensive Design Review (Sep. 11-13,2007)*
  - The review committee supports the principle of variable (→movable) gap for damping wigglers.
  - Implement an ID lab as soon as possible to start the R&D program.
  - Clarify with the Experimental Facilities Division the ID specifications (period, gap, flux, energy range,..) taking into account the technical specifications of the beamlines (defining slits, power load,..).

NSLS-II IDs Planned as of 10/2007

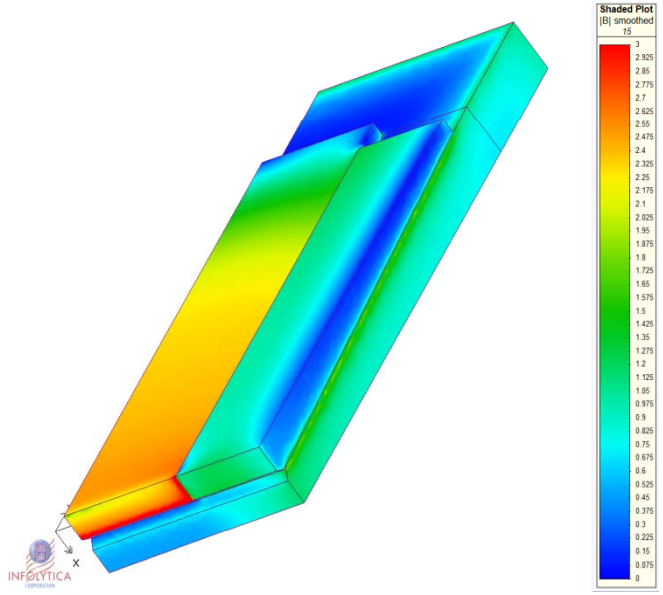
New

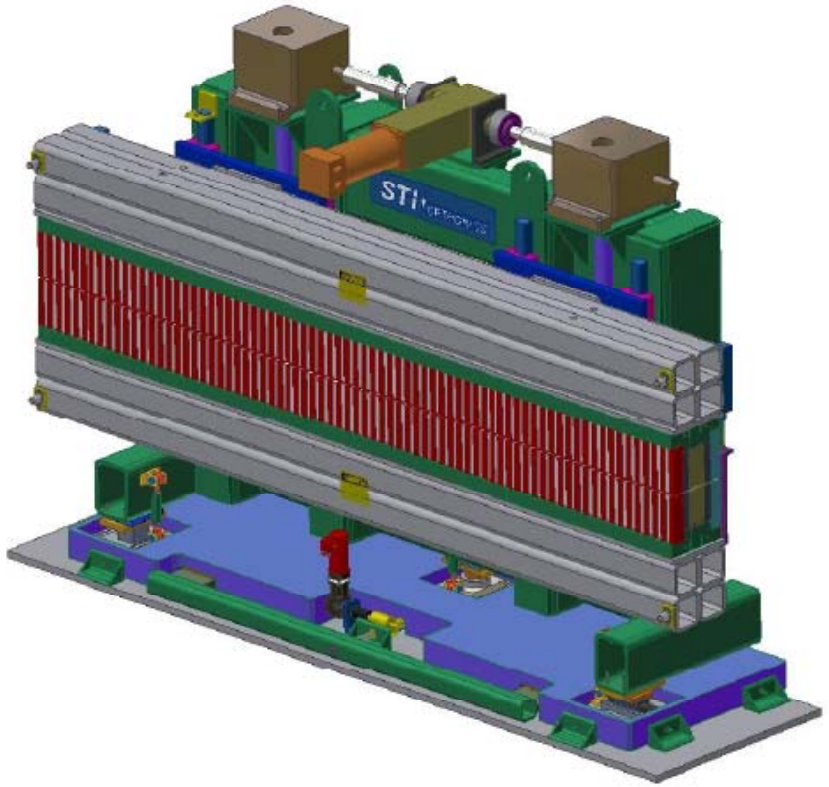
Name	**U20**	U19	**U45**	U100	**DW-1.8T**	SCW	**3PW**
Type	IVU	CPMU	EPU	EPU	PMW	SCW	PMW
Photon energy range	Hard x-ray (1.9-20keV)	Hard x-ray (1.5-20keV)	Soft x-ray (180eV-7keV)	VUV (8eV-4keV)	Broad band (<10eV-100keV)	Very hard x-ray (<10eV-200keV)	Broad band (<10eV-100keV)
Type of straight section	5m	5m	8m	8m	8m	5m	near 2nd Dipole
Period length (mm)	20	19	45	100	90	60	-
Total undulator length (m)	**3.0**	3.0	**4.0**	4.0	**7.0**	1.0	0.25
Number of periods	148	158	89	40	75	17	0.5
Magnetic gap (mm)	**5**	5	**10**	10	**12.5**	15	35 (32)
Peak magnetic field strength B (T)	1.03	1.21	0.68(Heli) 1.03 (Lin)	1.50	1.80	3.50	1.14
K	1.81 (eff)	2.03 (eff)	2.87 (eff) 4.67 (eff)	14.01	16.70(eff)	19.61	-
hν fundamental, eV	1832.8	1469.7	183.1	8.6			
hν critical, keV				11.8	21.0	2.4	6.8
Total power (kW)	8.02	11.18	12.09	25.64	64.40	34.89	0.34
G(K)	0.97785	0.9818	0.9959	0.9996	0.9997	0.9998	-
On-axis power density (kW/mrad^2)	62.33	77.86	40.03	26.33	55.30	25.60	0.28

DW-ACD by STI Optronics, Inc.

Note: ACD was carried out with 3.0m long, 80mm period length and 12.0mm magnetic gap, and cost estimate was done with the order of 7 devices.

- Wedged Pole + Side Magnet Design → Straight Pole could be used for 90mm Device
  - Br=*1.28T*, Bpeak=1.867T
  - Integral of B2=0.150 T2.m (103% of ideal 1.8T sinusoidal field=0.146 T2.m)





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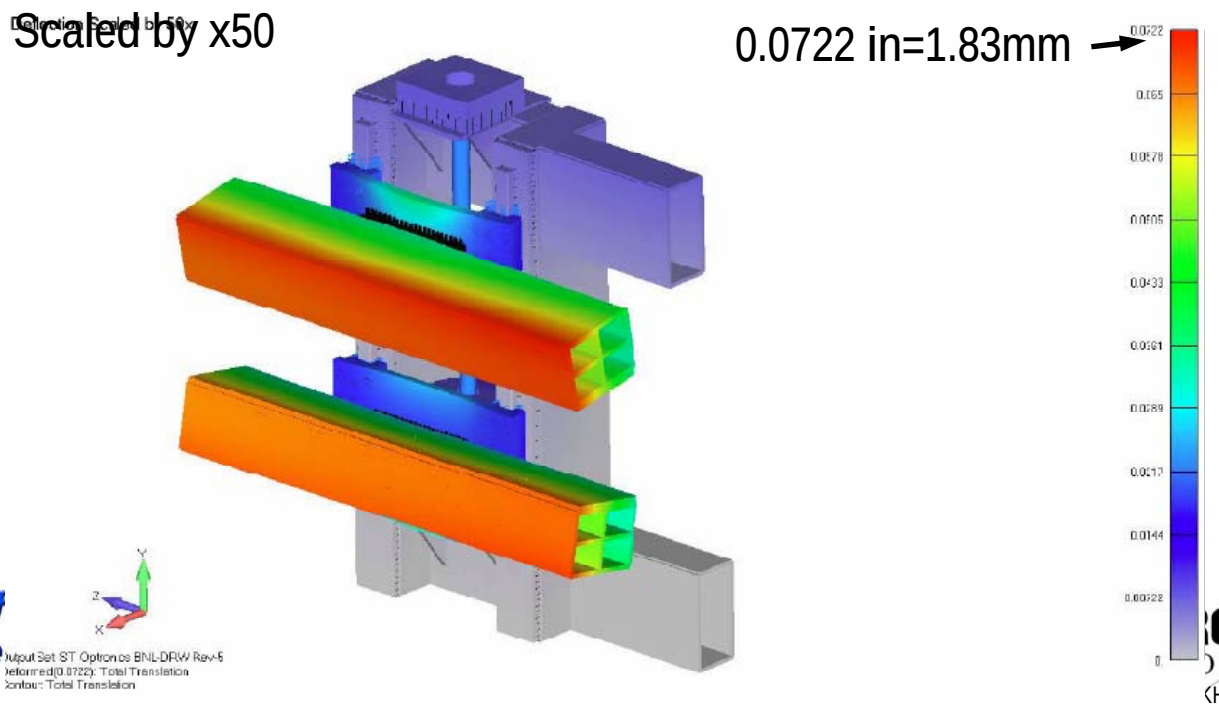
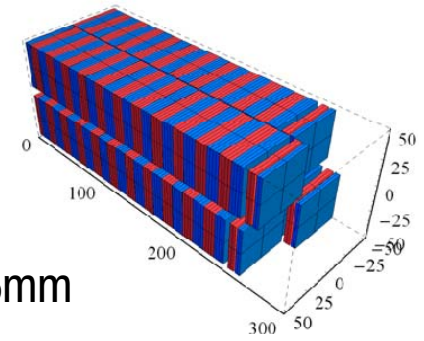
ACD Findings

- Most of permendur poles are highly saturated even with wedged pole design
- Specified Hcj=20 kOe may be low → More expensive material such as NEOMAX 42AH (Br=1.28 [min], Hcj=24kOe [min]) maybe needed.
- Estimated attractive force is approximately 6.3 tons/m
- Deformation could be adjusted for the operating gap, but then care is needed for open position.
- With 7 device order, estimate cost of a device is $0.67M (Magnetic Portion 65%)



EPU Design Choice

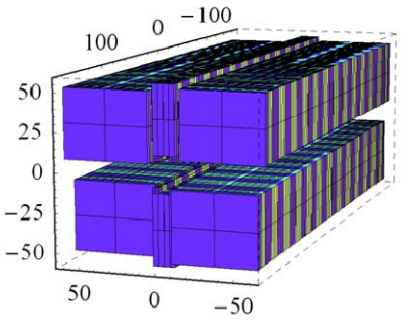
- Apple-II



Period length=45mm

Bx=By=0.64T

v.s. HiSOR EPU



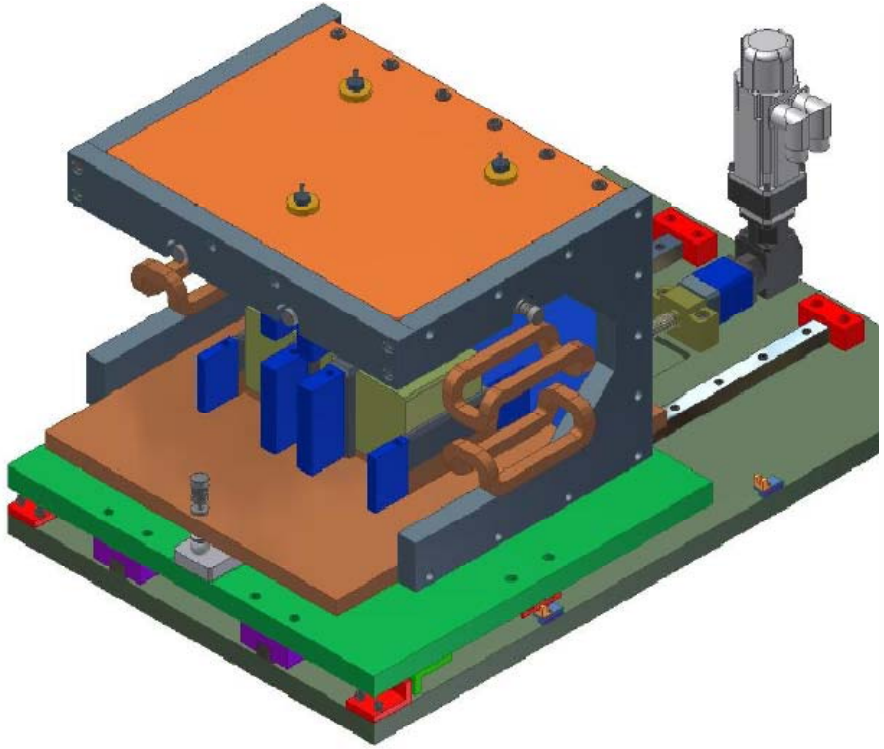
Period length=52mm

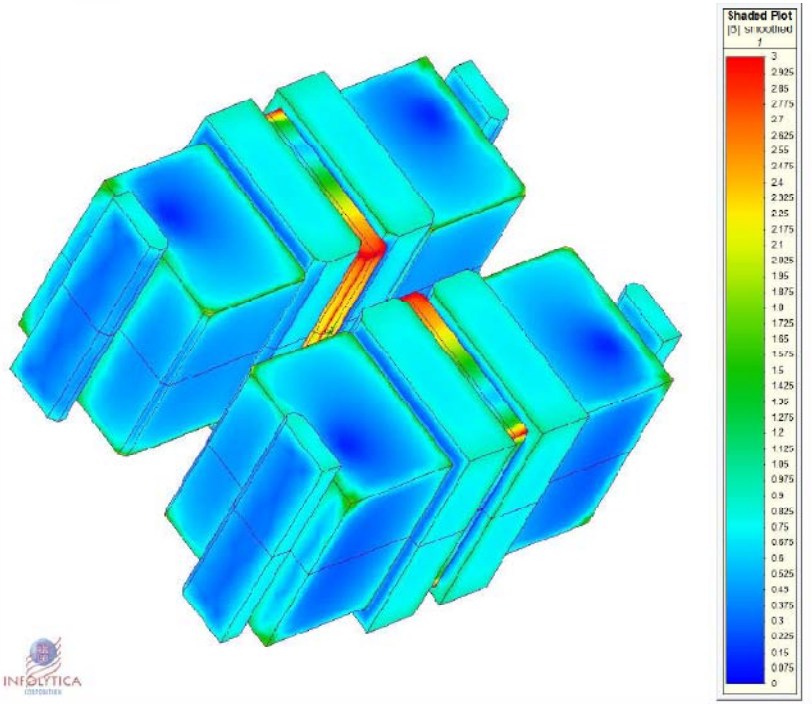
Bx=By=0.58T

- After tracking study by J. Bengtsson, there appear to be only marginal improvement on DA for HiSOR design
  → Apple-II will be working assumption

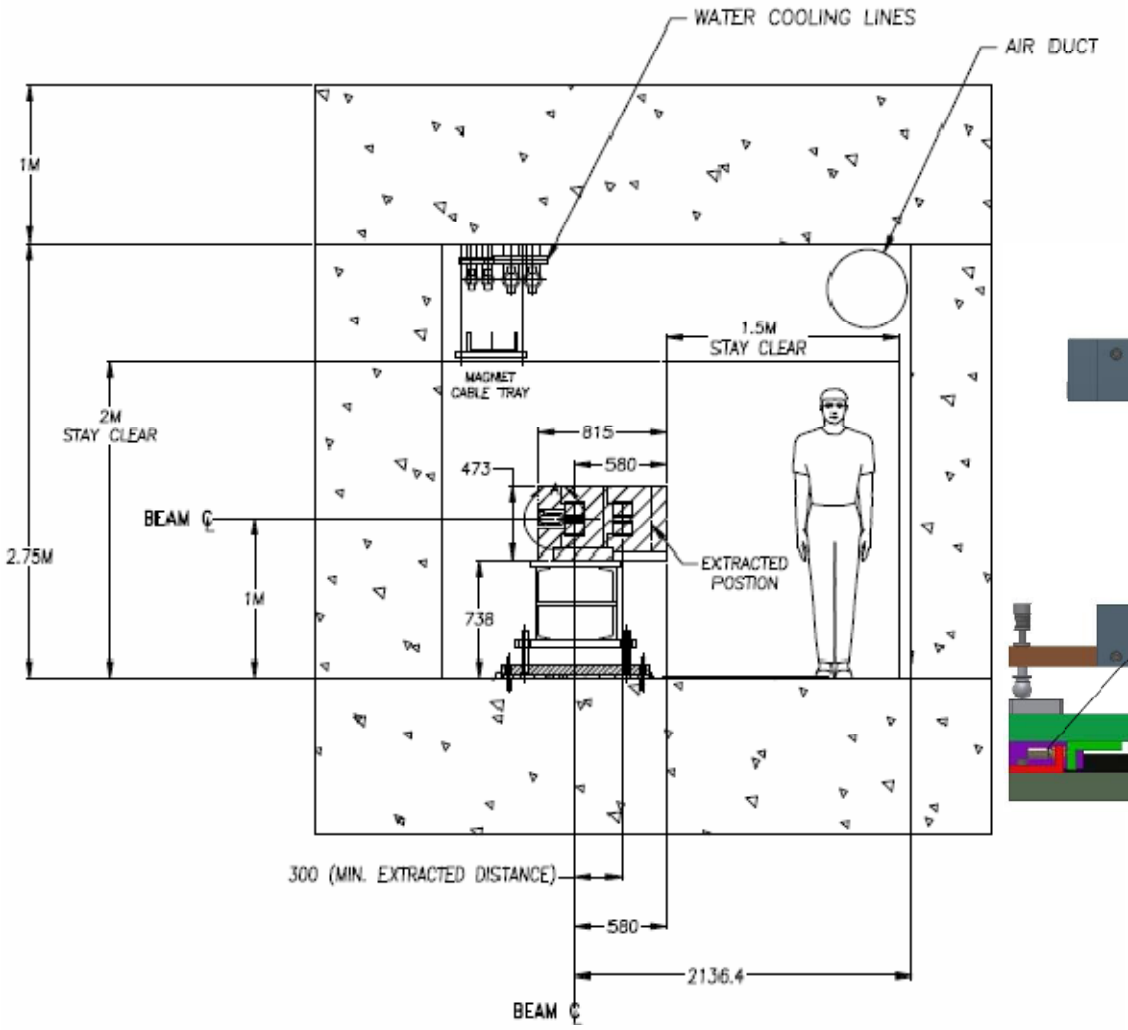
3PW (Gap=28mm) ACD by STI

- Findings:
  - Attractive force ~ 200 kg → C frame suffices
  - Specified Hcj=20 kOe should be increased with Br=1.28T magnet
  - Permendur is needed for center pole to achieve required performance
  - $140K per device with an order of 15 devices

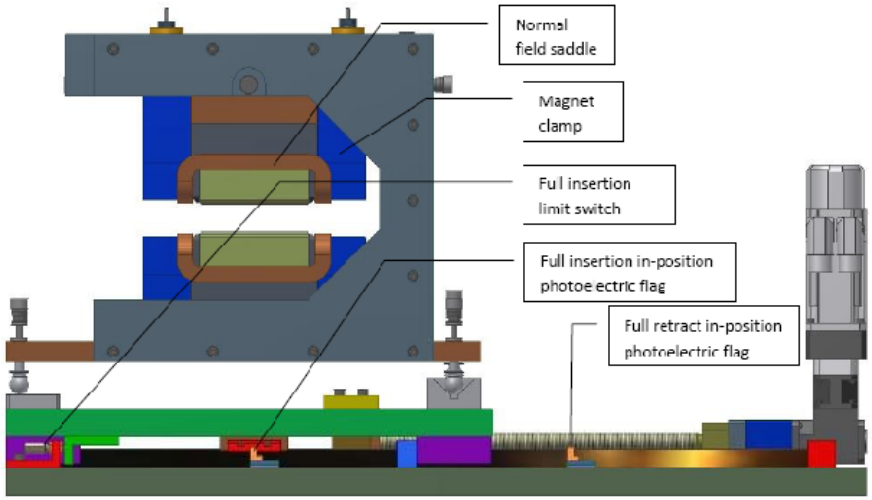




Elevation View



3-POLE WIGGLER ELEVATION VIEW
SR-MG-3PW-1001-A

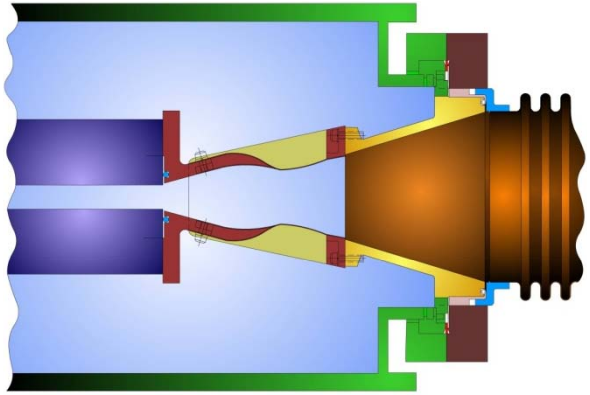


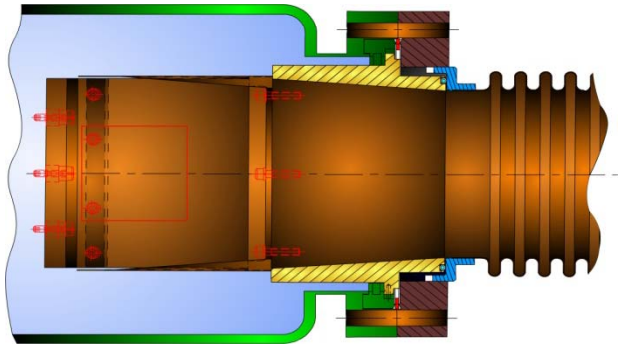
Room Temperature IVU

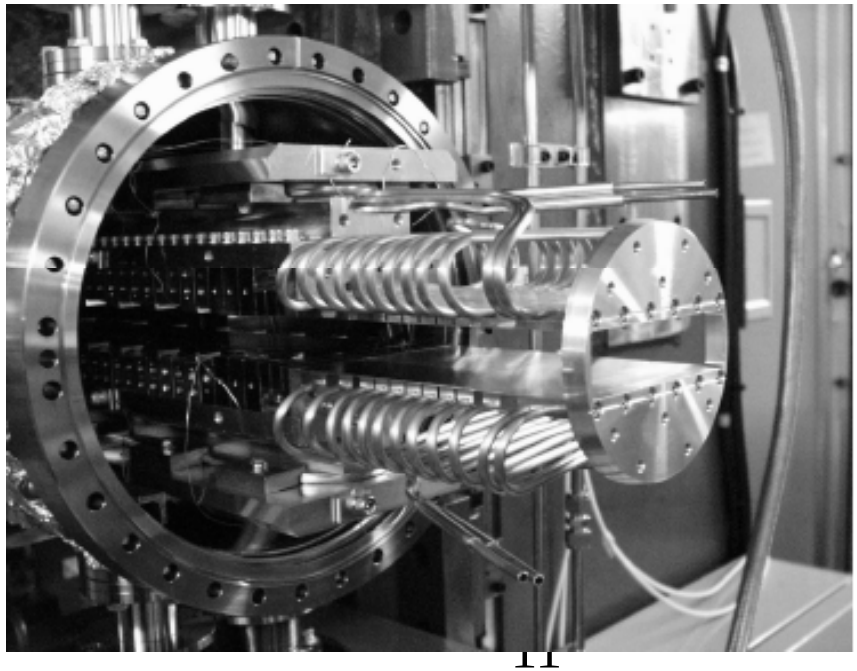
- Vacuum chamber selection
  - Cylinderical
    - Used by most of IVUs in the world
    - Magnetic arrays have to be inserted from the end
    - Measurement is done without chamber →
  - Square
    - 1m version works for MGU-X25 at NSLS
    - 4m version must be tested
    - Installation and measurement can be carried out without detaching main vacuum vessel.
- Transition area design
  - Taper angle and cooling capacity to be determined

Transition Area Design

- X25 Design → short & no cooling





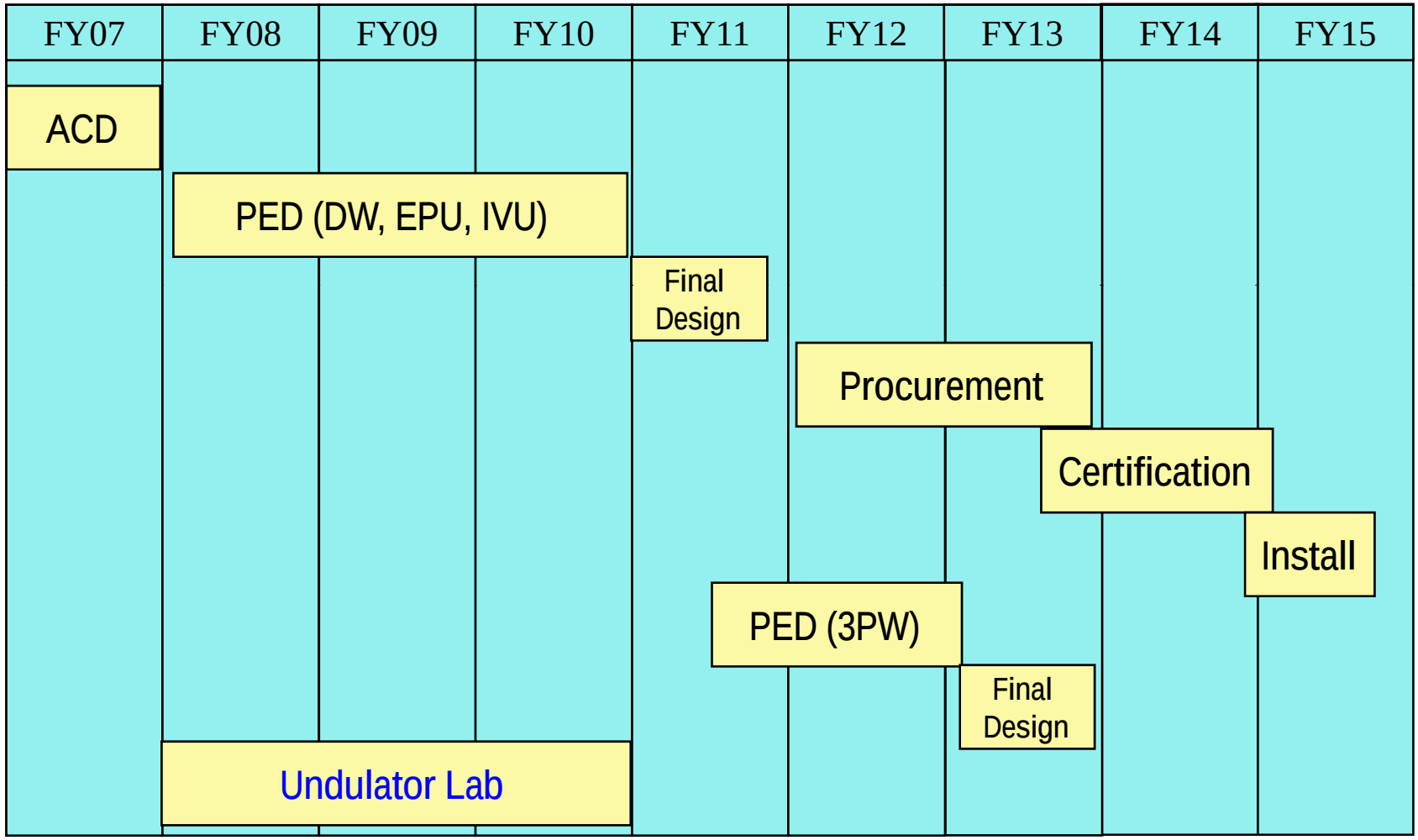


- SLS Design

Insertion Device Laboratory

- Class 10000 Temperature Controlled Semi-Clean Room for IVU Measurement
  - Metalic dust is very hard to remove after assembly.
  - Prevent bugs from entering hard-to-reach area.
  - 22 °C± 0.2 °C or tighter
  - Low vibration required by pulsed wire measurement
  - Cleanliness is also required for air-bearing stage in Hall probe bench
- Standard ID measurement setups
  - 6-7 m Hall probe bench
  - Stretched / pulsed wire system (3-4m)
  - Magnet characterization equipment (Helmholtz coil / small moving coil)
  - Hall probe calibration equipment

Schedule as of Oct.4, 2007



WBS and Scope of Work

WBS	Scope	$(Unburdened)
1.02.01.03	Magnet Development Laboratory (preparation for insertion device magnet measurement facility)	$3.3M
1.03.07.01 (DW)	PM wiggler mainly for the reduction of emittance, but also used as broadband user sources (2x 3.5m x3)	$6.7M
1.03.07.02 (IVU)	In-Vacuum Undulators (3m x3) for hard X-rays.	$6.2M
1.03.07.03 (EPU)	Elliptically Polarized Undulator (2x2m) for Soft X-ray polarization control.	$3.7M
1.03.07.04 (3PW)	Three Pole Wiggler (15 devices) for NSLS-BM user needs.	$0.2M (design only)
1.03.07.05	Certification of device performance (measurement and corrections)	$0.37M
1.03.07.06	Installation	$0.18M
1.03.07.07	Integrated Test without electron beam	$0.08M
1.03.08.02	Insertion Device Magnet Measurement Facility	$0.7M

ID-Group FTE Profiles

Category	*2007*	*2008*	*2009*	*2010*	*2011*
Scientist	1.3	2	3	4	4
Post Doc	0	1	2	1	0
Mechanical Engineer	0.5	1	2	2	2
Electrical Engineer	0.25	1	2	2	2
Mechanical Technician	0.25	1	1	1	2
Total	2.3	6	10	10	10

Summary

- Advanced Conceptual Design of User / Damping Wiggler has been accomplished.
  - Small available cross section may be a risk factor
  - Movable gap design has been chosen for various reasons
- Apple-II type EPU with the latest field correction schemes is being designed as another ACD.
- Optimum IVU design requires more studies such as impedance optimization for vacuum chamber and transitions
- ACD for 3PW has been completed. However, production/installation will be paid for by the fund to move NSLS beamlines
- ID magnetic measurement laboratory with temperature controlled semi-clean room will be established
- Hiring competent staff is the most challenging task.