國家同步輻射研究中心
National Synchrotron Radiation Research Center

Status and Future of Taiwan Light Source

by

Keng S. Liang, G.H. Luo, C.C. Kuo, J.R. Chen,

D.J. Wang and Y.W. Yang

APAC 2007

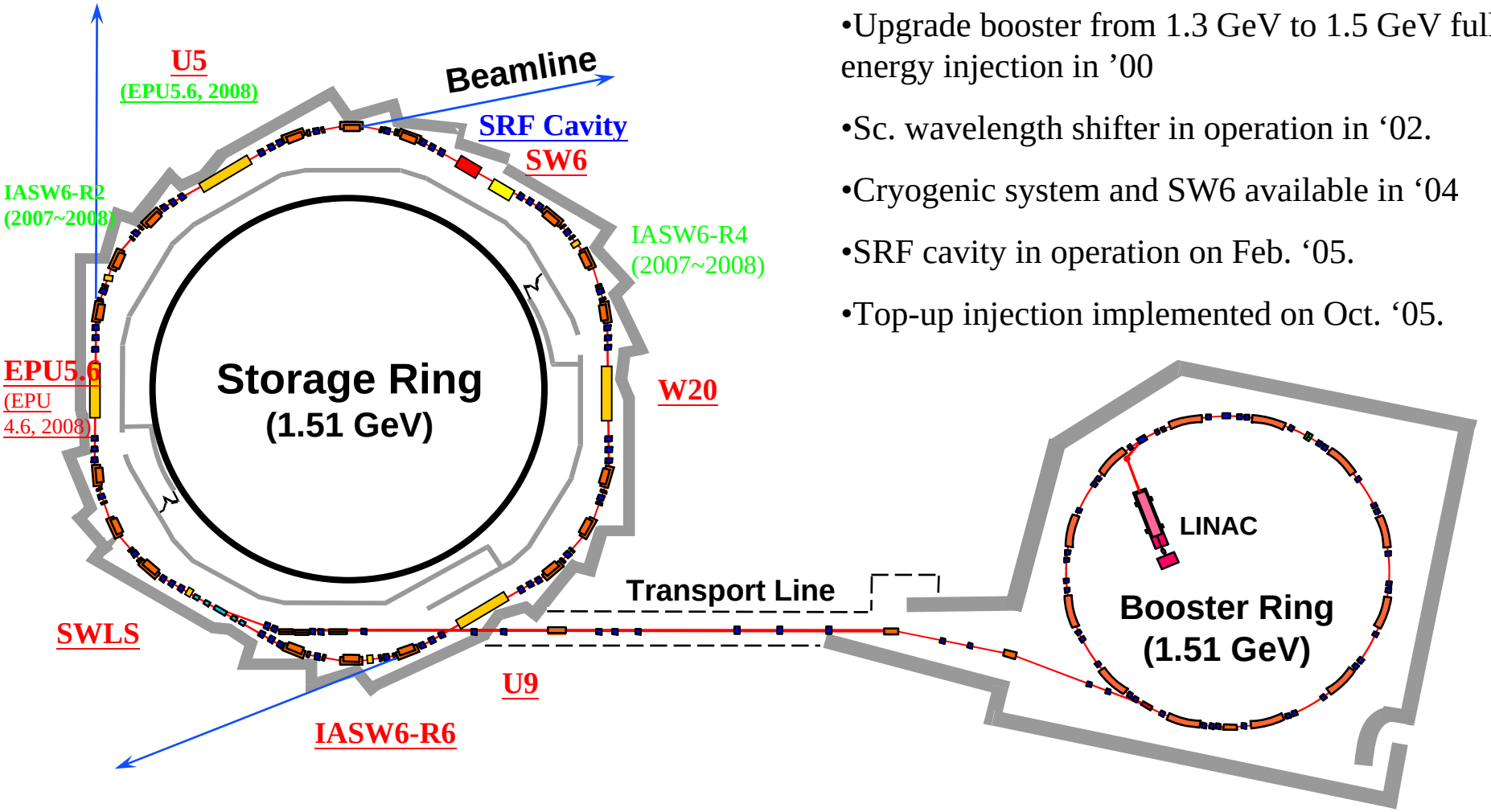
Indore, India

Outline

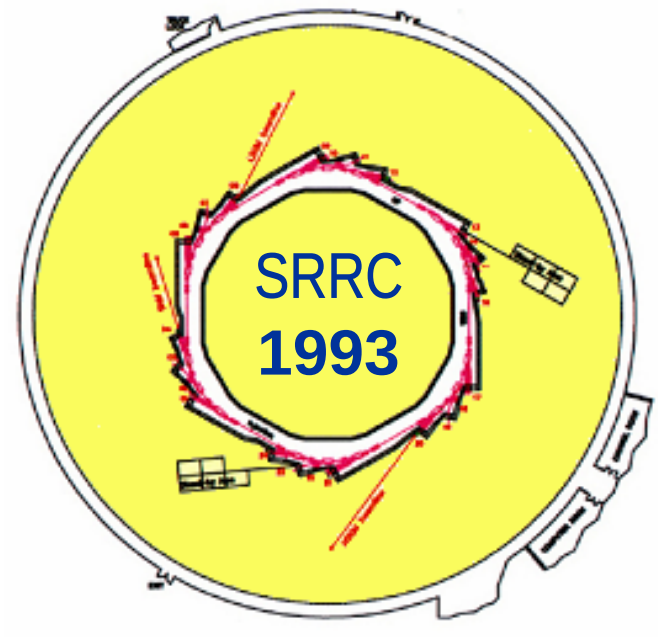
- *Overview of Taiwan Light Source*
- *Performance and Upgrade*
  - *Superconducting RF cavity and cryogenic system*
  - *Superconducting wigglers*
  - *Top-up injection*
- *Statistics of TLS Operation*
- *Taiwan Photon Source*

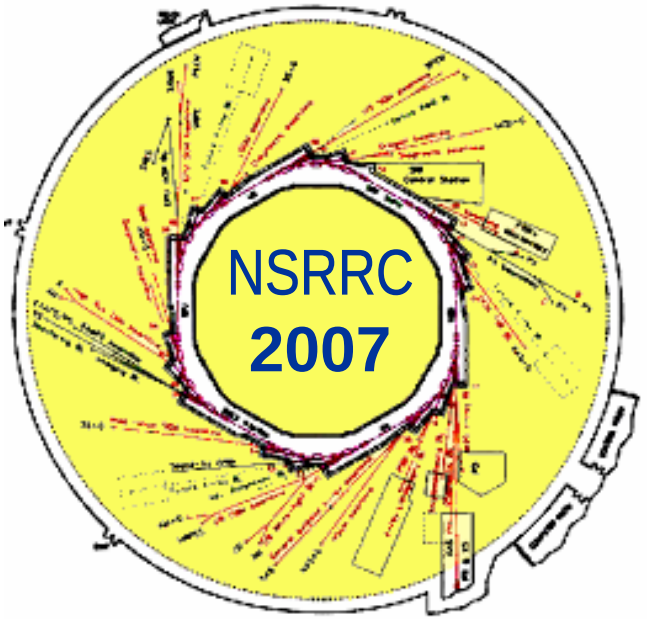
Schematic Layout and Timeline of TLS

- Commission on Apr. open to users on Oct. '93
- 1.3 to 1.5 GeV ramping in operation in '96
- 240 mA operation beam current in '96
- Upgrade booster from 1.3 GeV to 1.5 GeV full energy injection in '00
- Sc. wavelength shifter in operation in '02.
- Cryogenic system and SW6 available in '04
- SRF cavity in operation on Feb. '05.
- Top-up injection implemented on Oct. '05.



Facility Development





+

- Light Source: 1.3 → 1.5 GeV
- Insertion Device: 0 → 8
- Beamline: 3 → 27
- End Station: 3 → 55

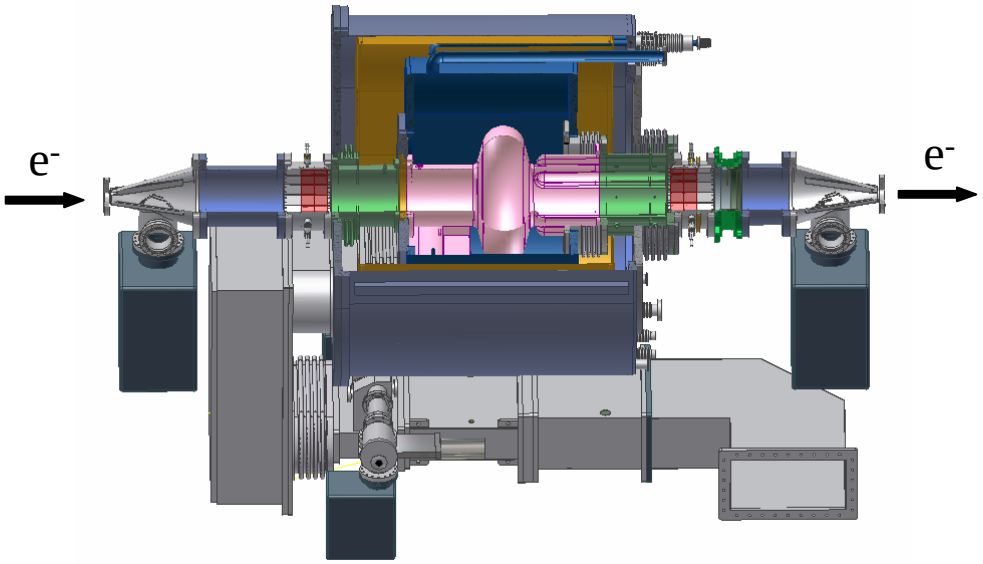
Taiwan Contract Beamlines at SPring-8

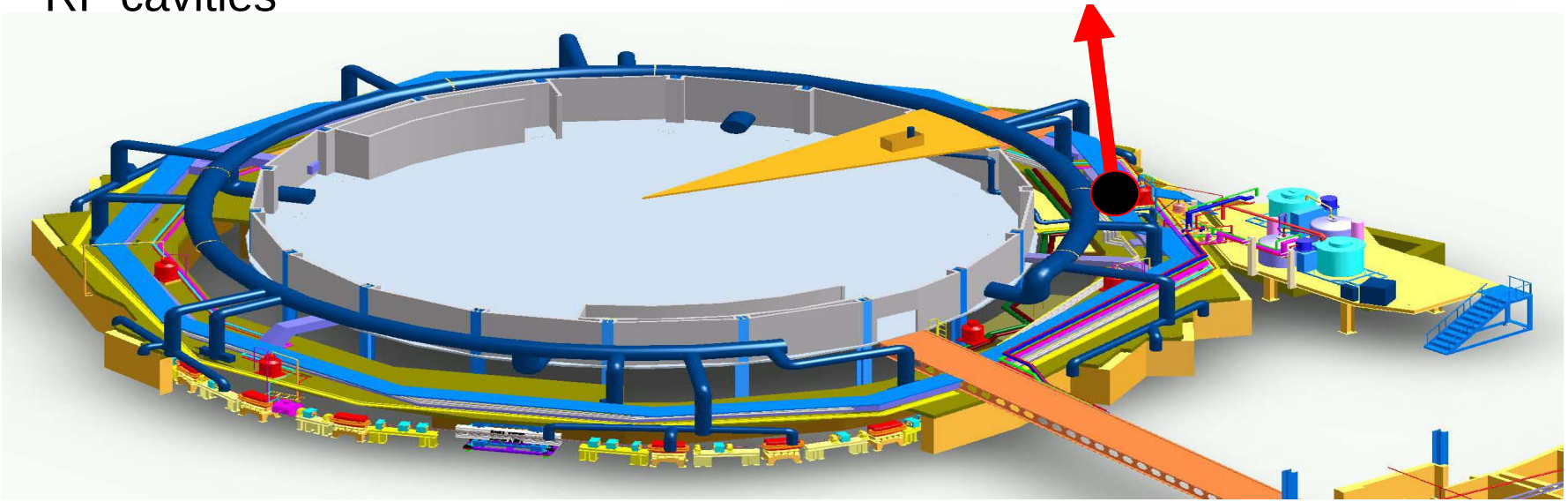
Superconducting RF (SRF) project

Goals :

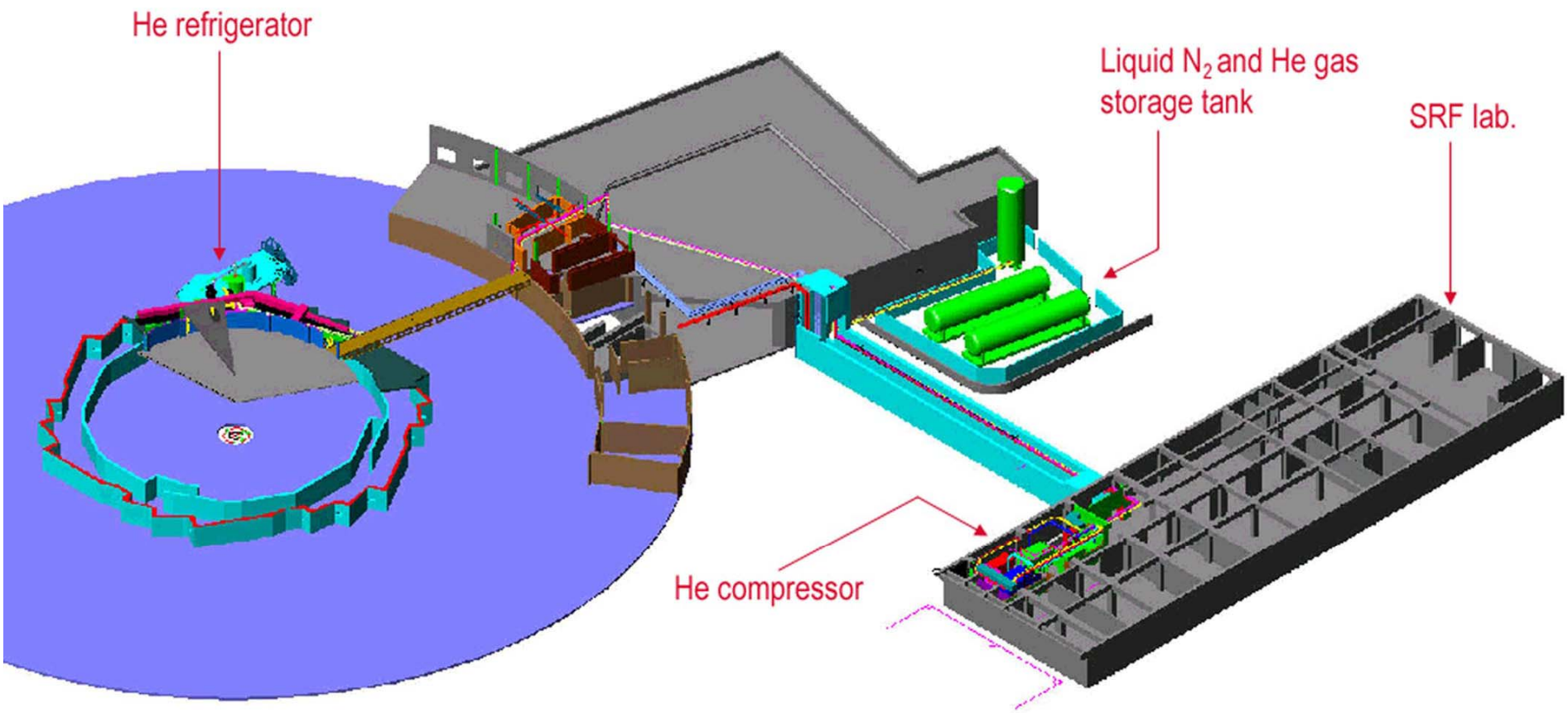
- To double the maximum stored beam current of the storage ring

- To eliminate beam instabilities caused by the strong higher-order-modes (HOMs) of Doris RF cavities



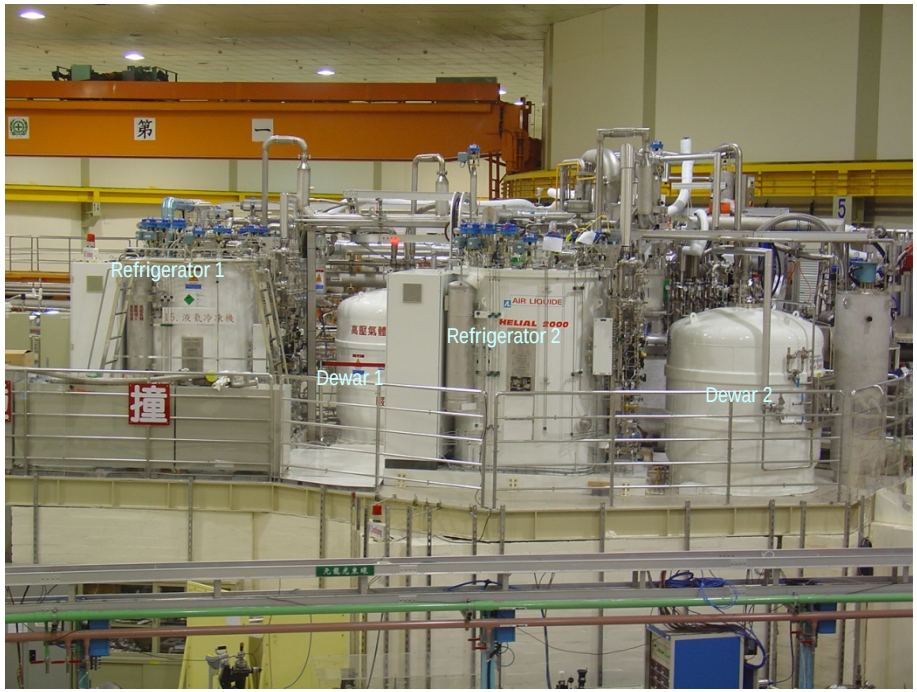


Layout of Cryogenic System

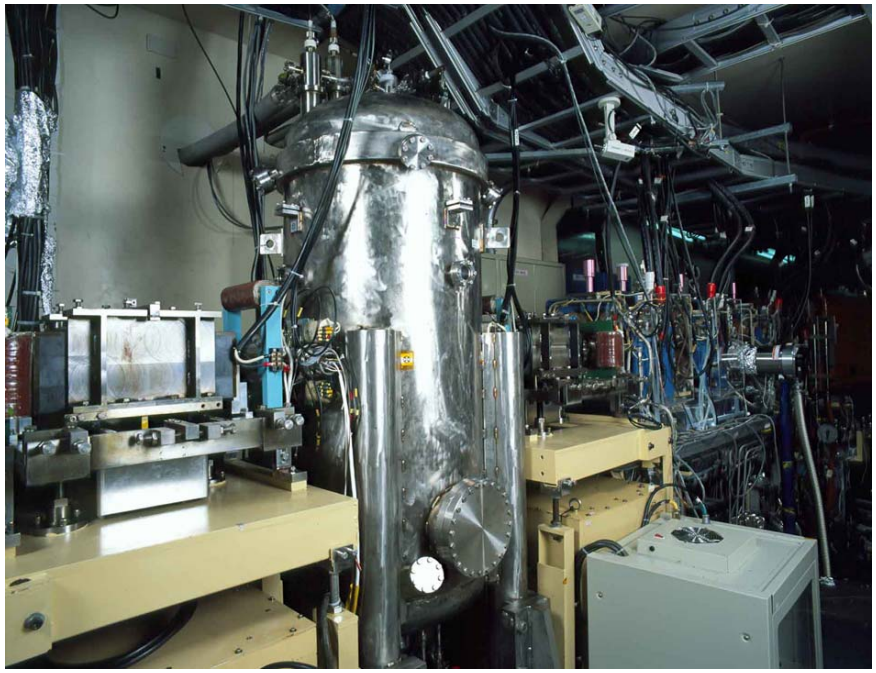



主壓縮機一
回收壓縮機一
成分分析儀
主油氣過濾器

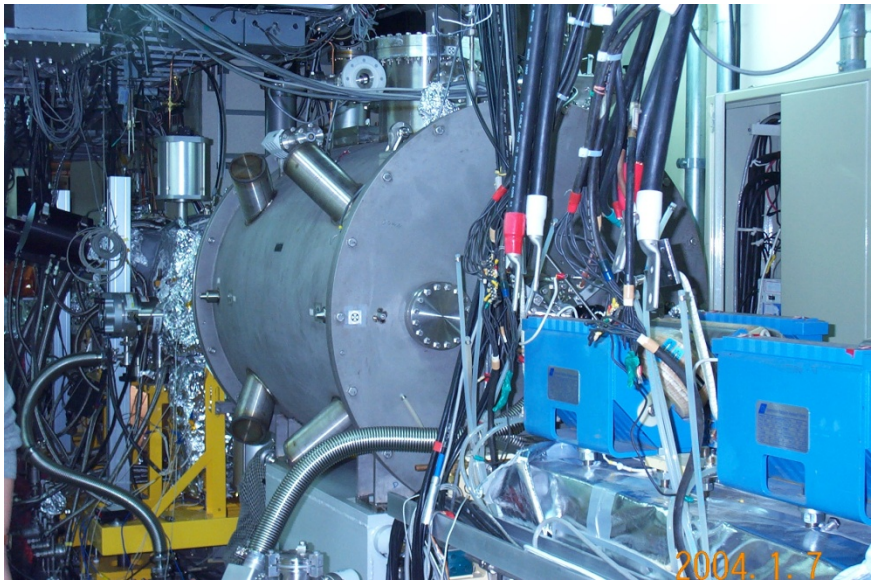

液態氮儲槽
氦氣儲槽


Refrigerator 1
Refrigerator 2
Dewar 1
Dewar 2

Superconducting Insertion Devices

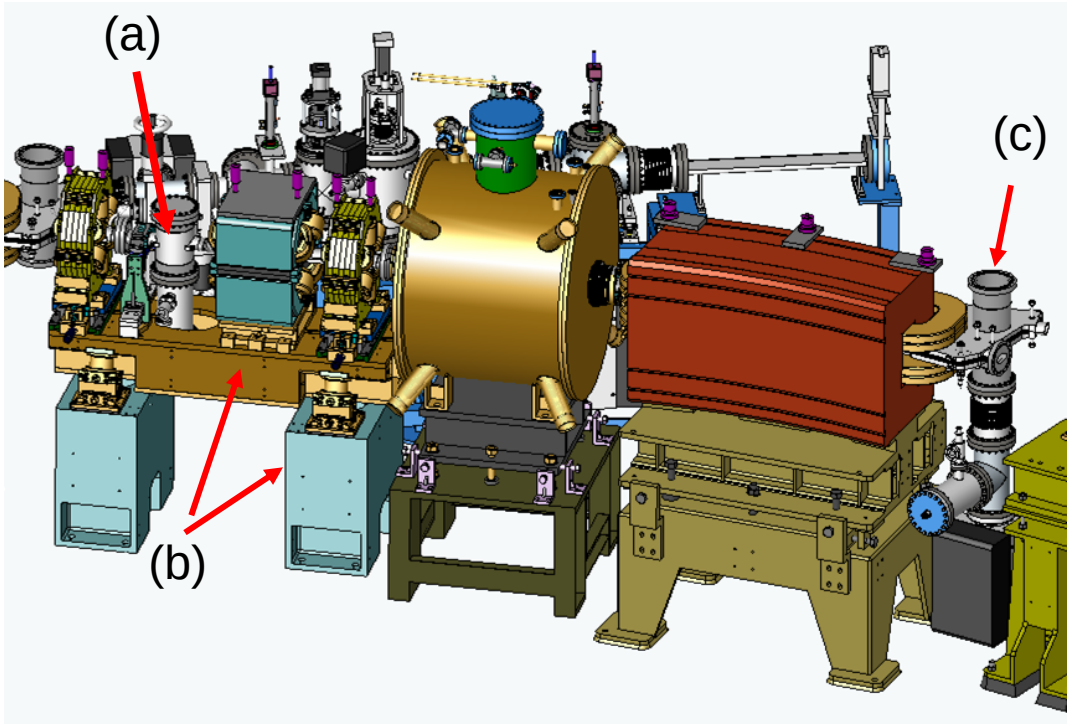


Superconducting Wavelength Shifter (6 T, SWLS)

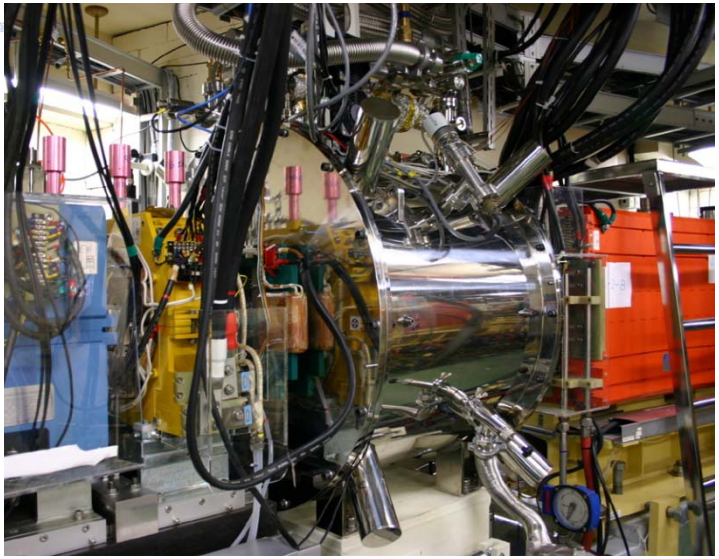


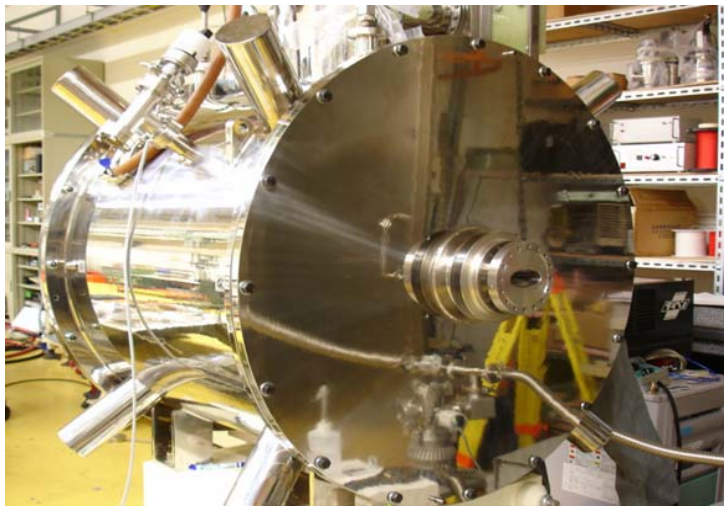
Superconducting Wiggler (3.2T, SW6)

IASW Construction Project



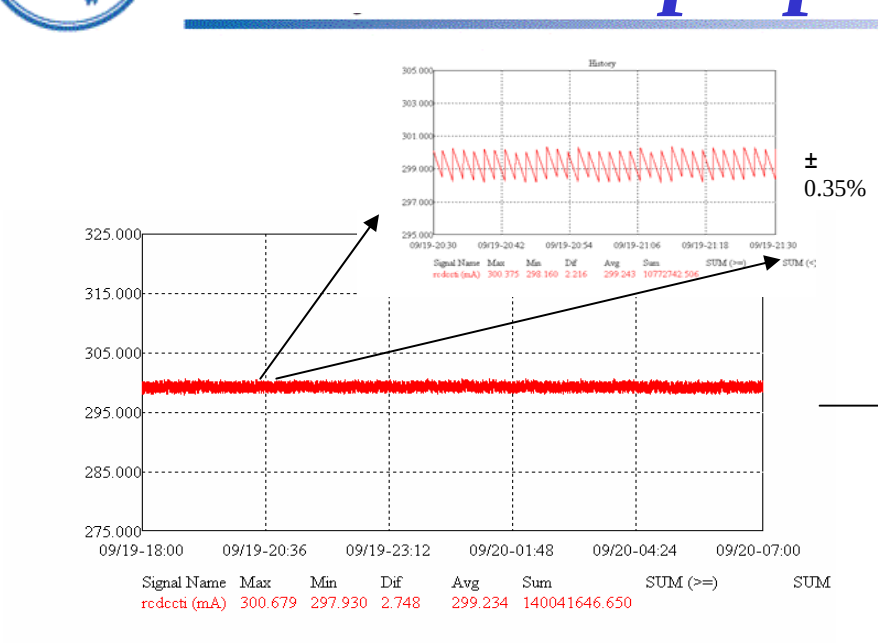
(a) vacuum chamber for straight section
(b) girder
(c) vacuum chamber for arc section

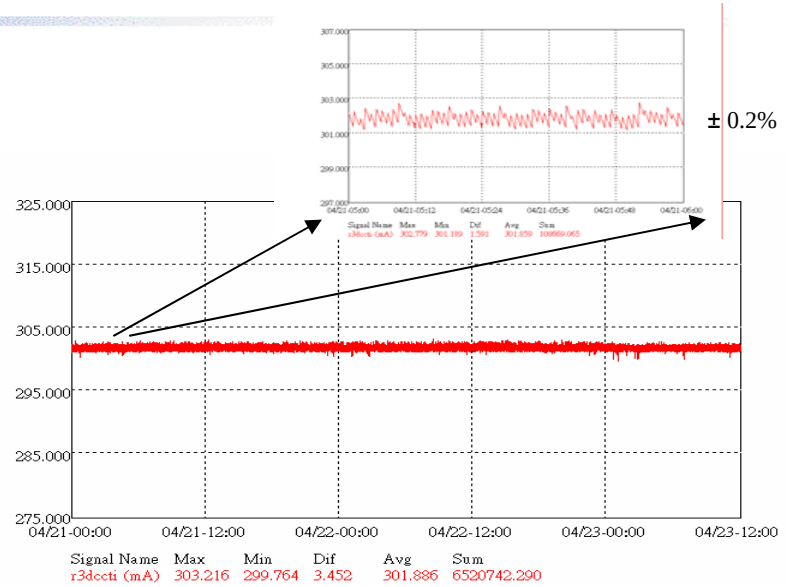


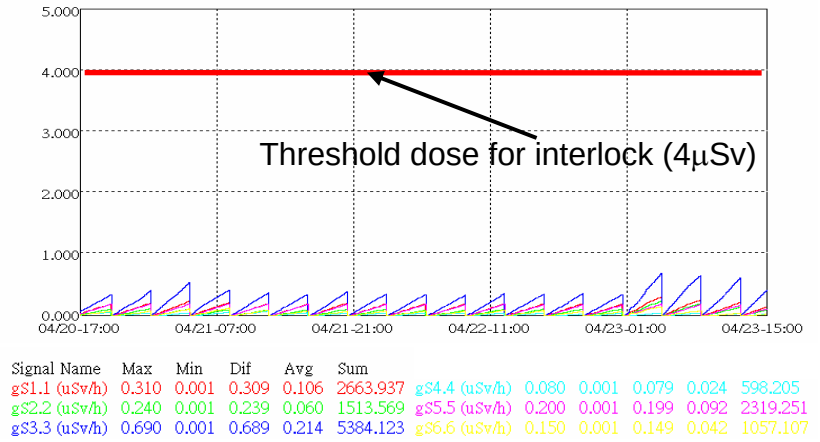


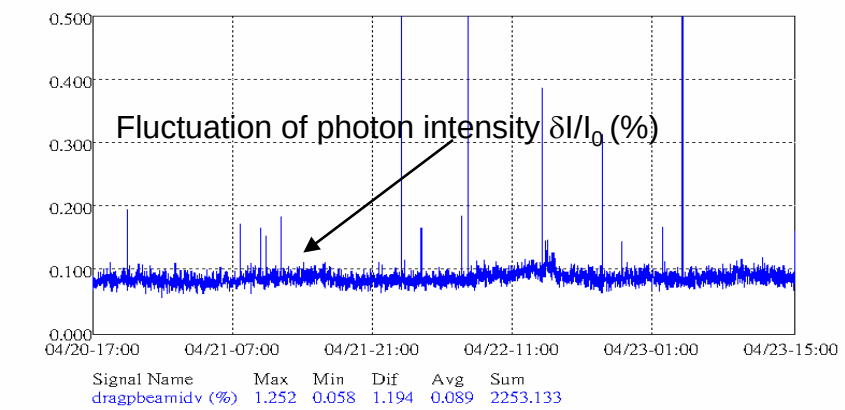
IASW under construction

Top up injection

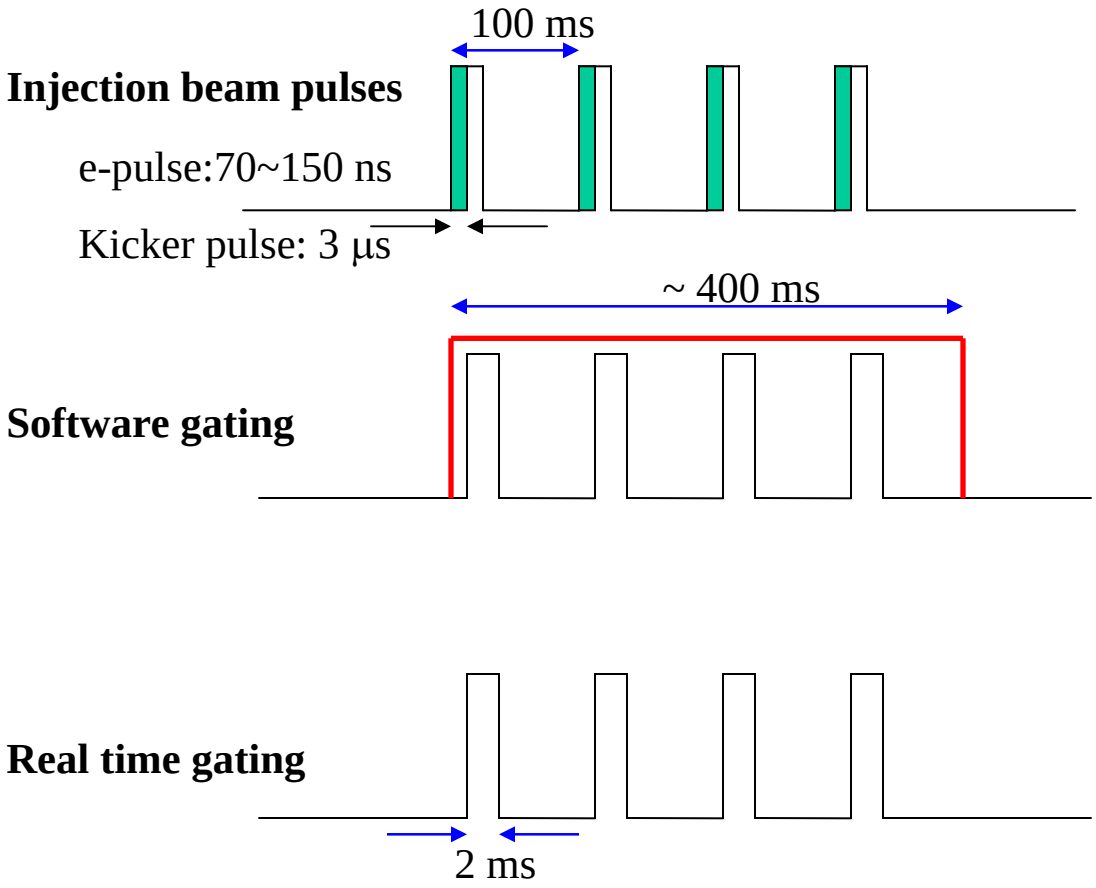




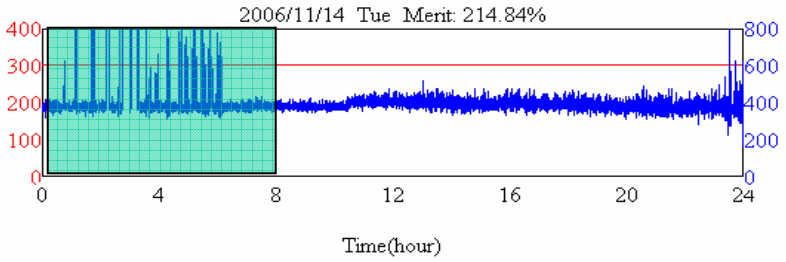


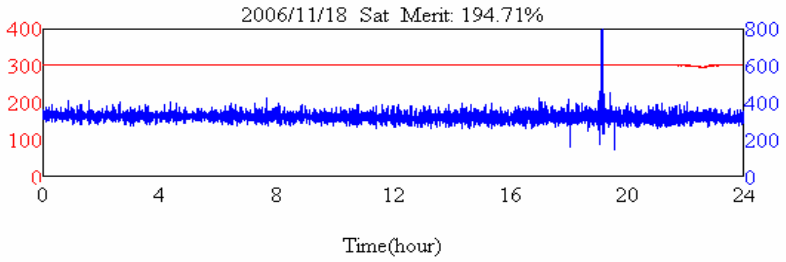


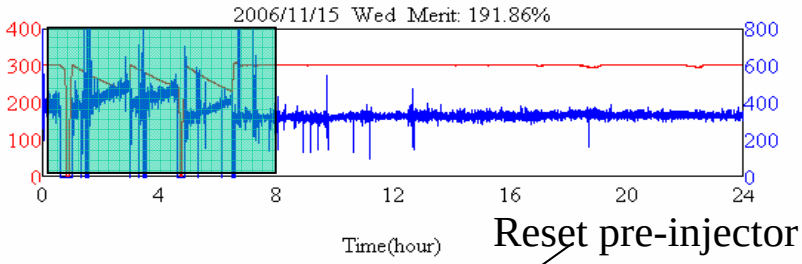
- Software gating
  - BL01 B IMAGE
  - BL03 Absorption
  - BL05 XAS,PEEM
  - BL09A XAS
  - BL20 XAS
  - BL21B Absorption
  - BL24 XAS
- Real time gating
  - BL11 MCD
  - BL15 XAS
- Non-gating
  - BL01 C EXAFS
  - BL09A SPEM
  - BL14 FTIR
  - BL17 B,C Scattering, EXAFS

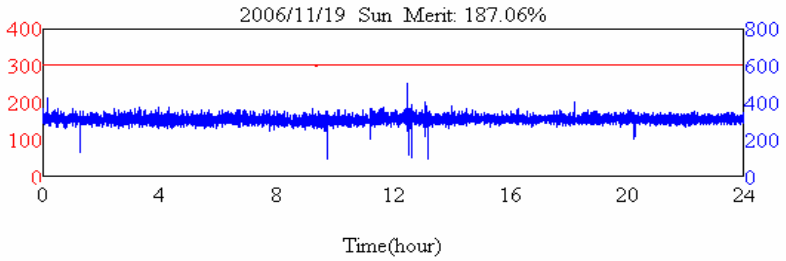


Weekly Operation Report (Nov. 14~20, 2006)

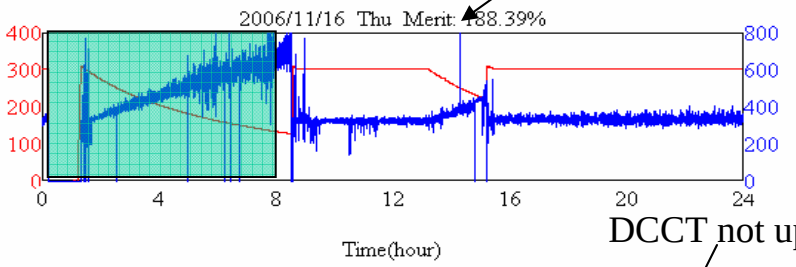


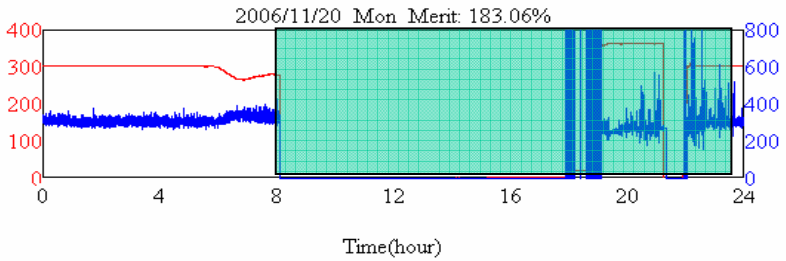




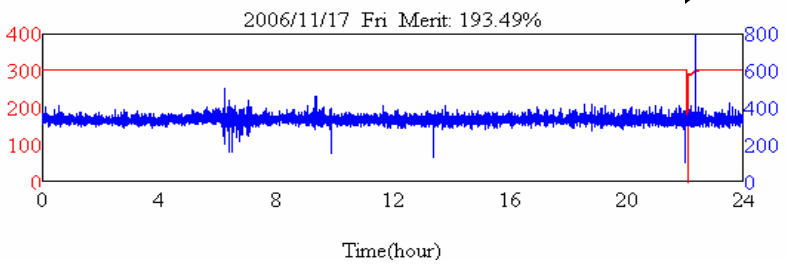


Reset pre-injector



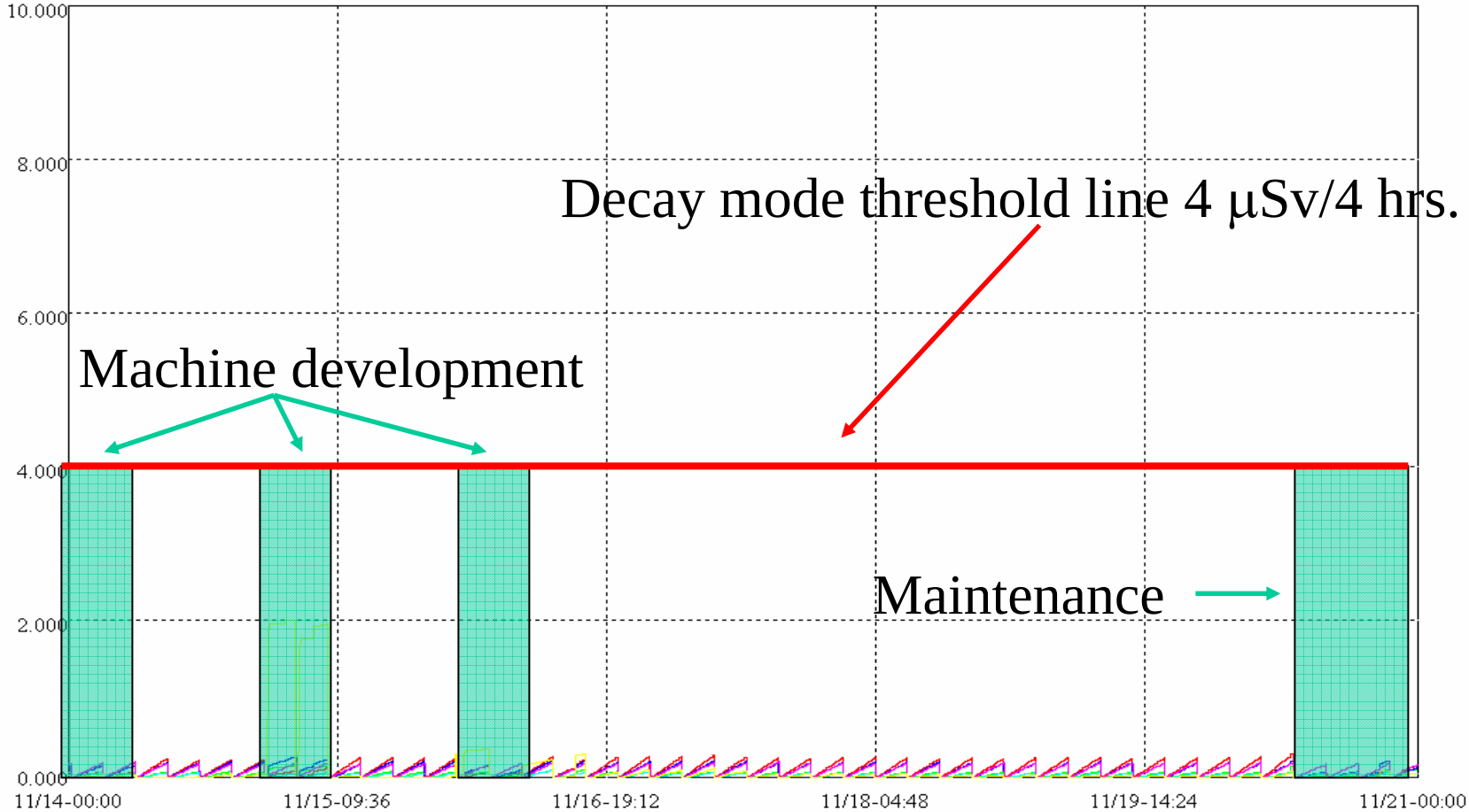


DCCT not updating



Beam Current(mA)
Life Time(min)

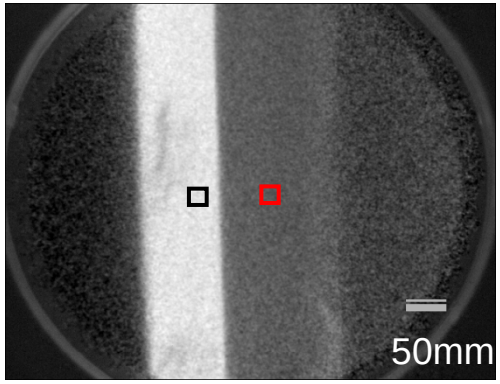
Accumulated dosage per 4 hours (Nov. 14~20)

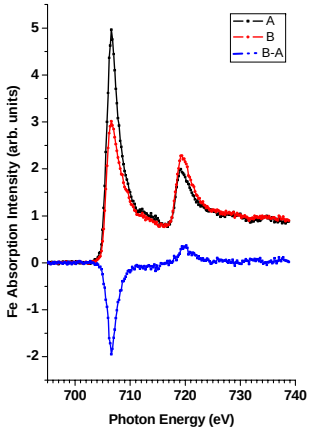


Signal Name	Max	Min	Dif	Avg	Sum
gS1.1 (uSv/h)	0.310	0.001	0.309	0.109	6597.339
gS2.2 (uSv/h)	0.170	0.001	0.169	0.042	2570.360
gS3.3 (uSv/h)	0.270	0.001	0.269	0.097	5889.946
gS4.4 (uSv/h)	0.100	0.001	0.099	0.031	1862.947
gS5.5 (uSv/h)	0.210	0.001	0.209	0.096	5780.251
gS6.6 (uSv/h)	2.050	0.001	2.049	0.114	6924.762

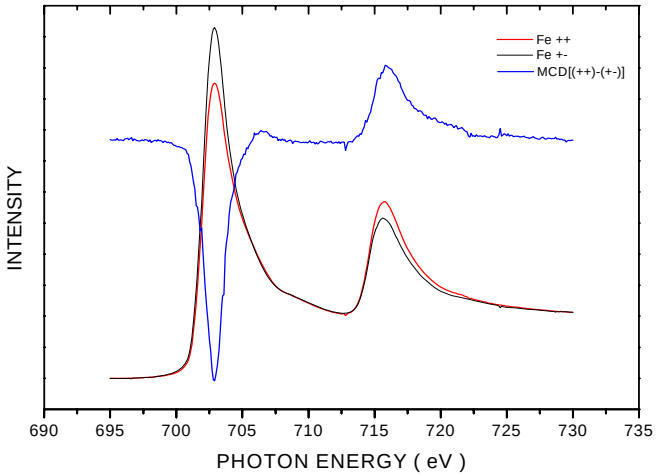
Top-up Injection

BL05B (EPU)

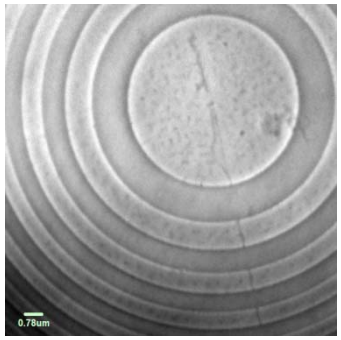




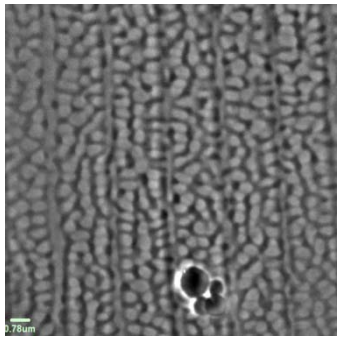
BL11A (Dragon)



BL01B (X-ray Microscopy)



15μm

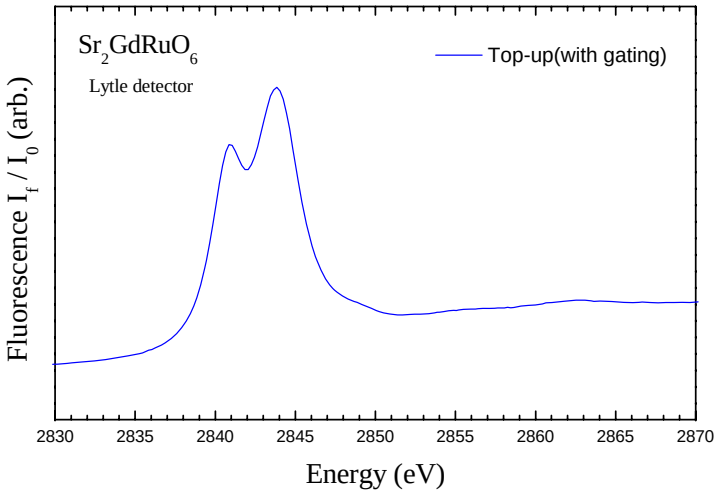


15μm

Plastic zone plate

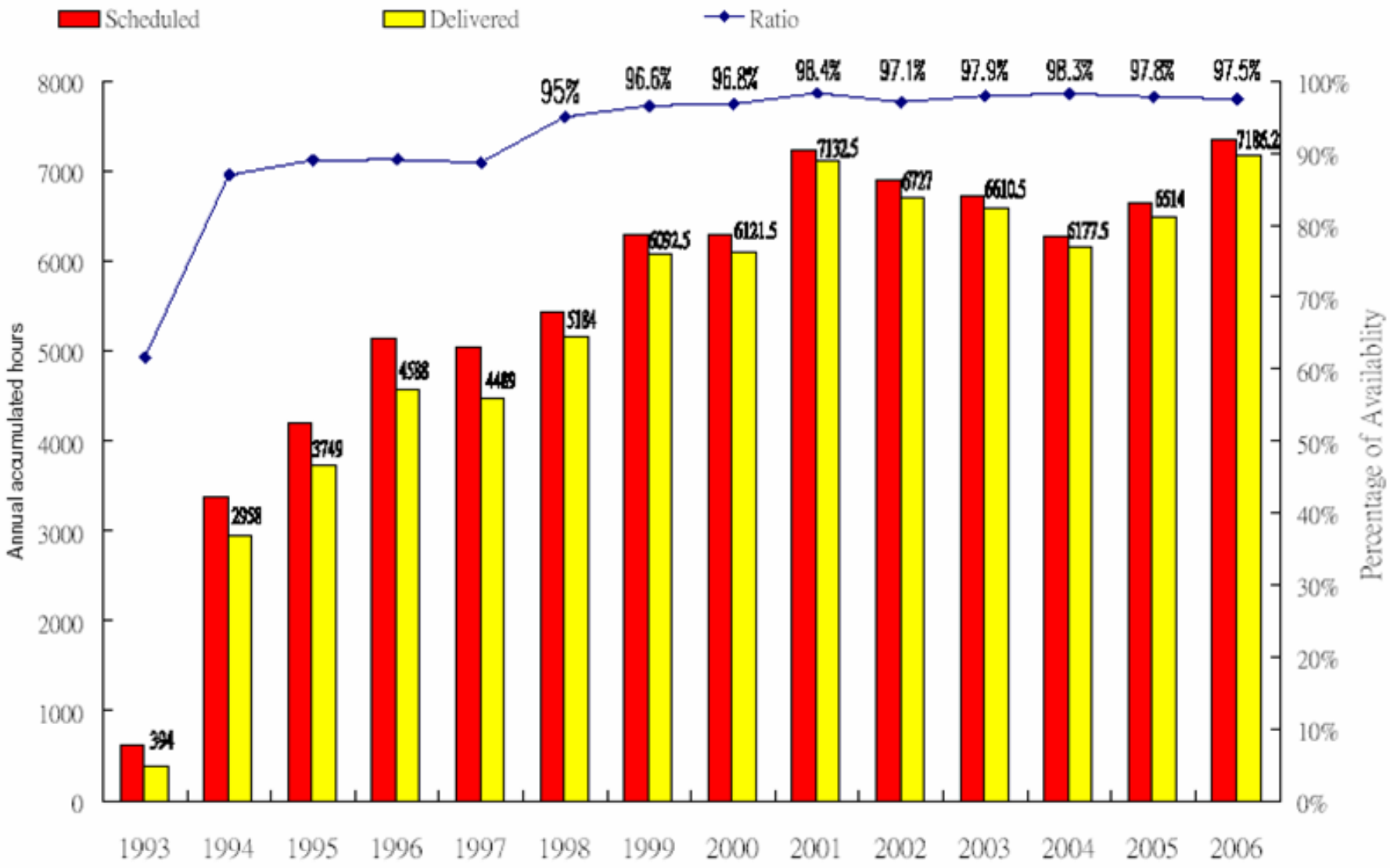
Butterfly, 2D phase contrast.

BL15B

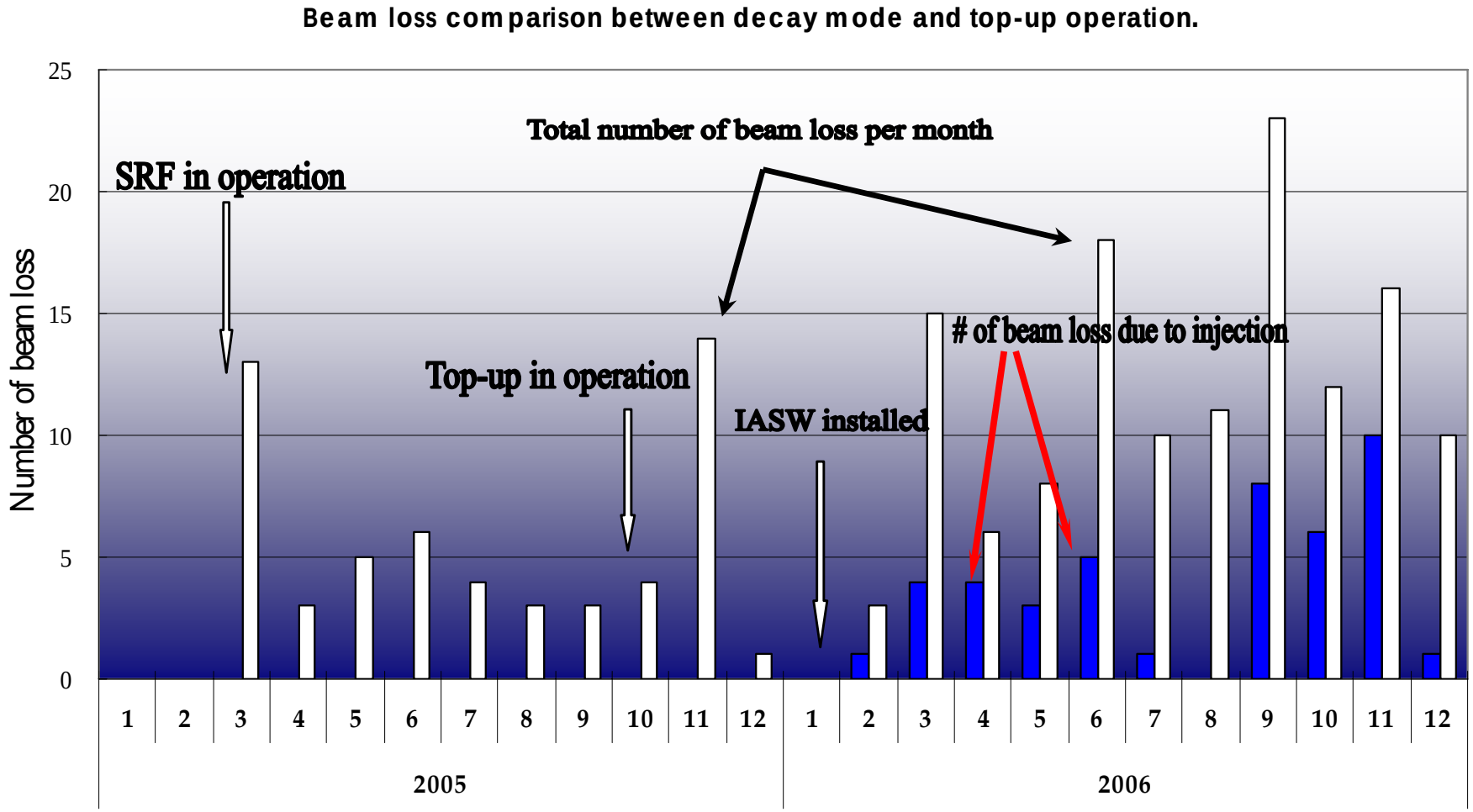


Top-up mode injection has no negative effect on the data quality.

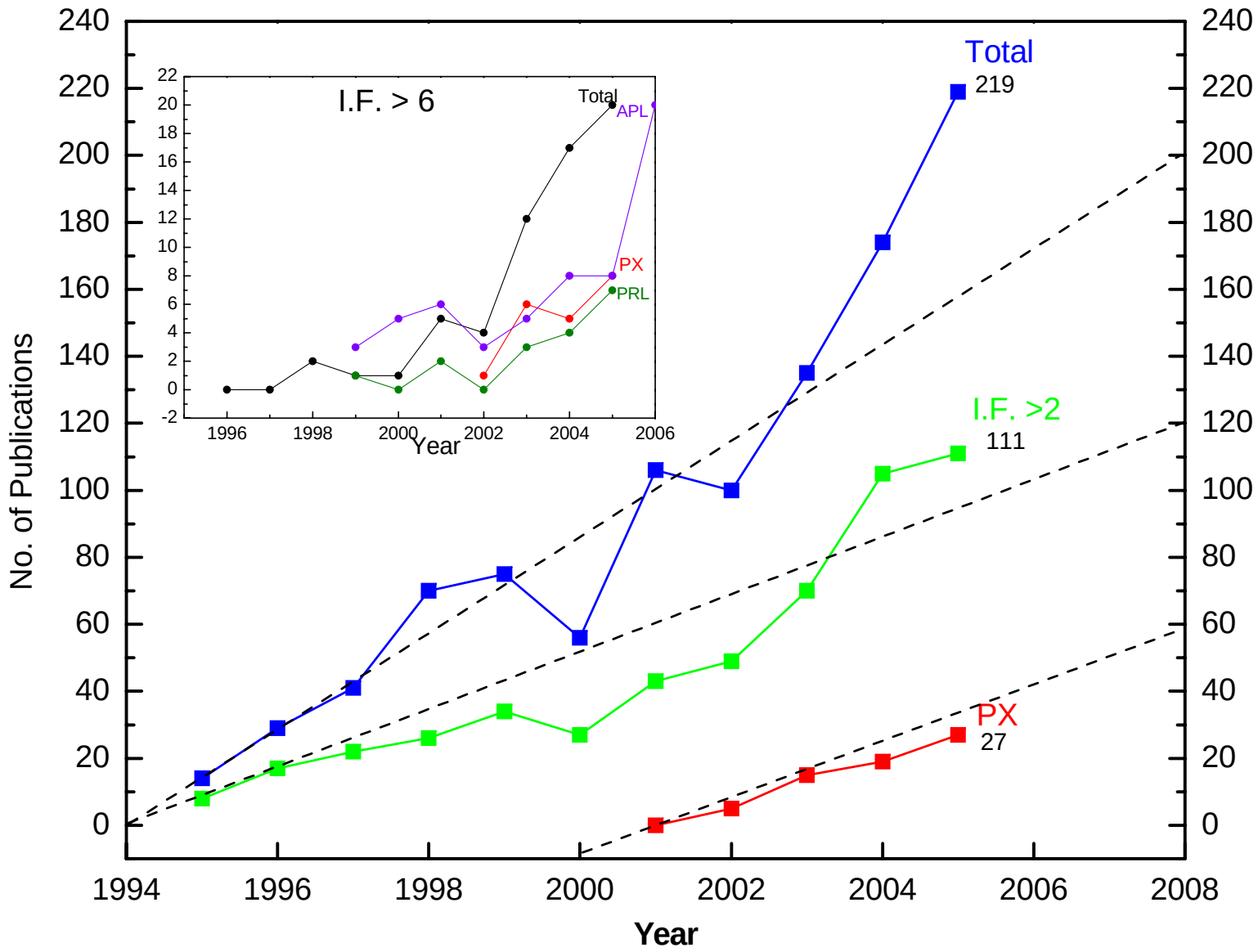
Annual scheduled and delivered machine time



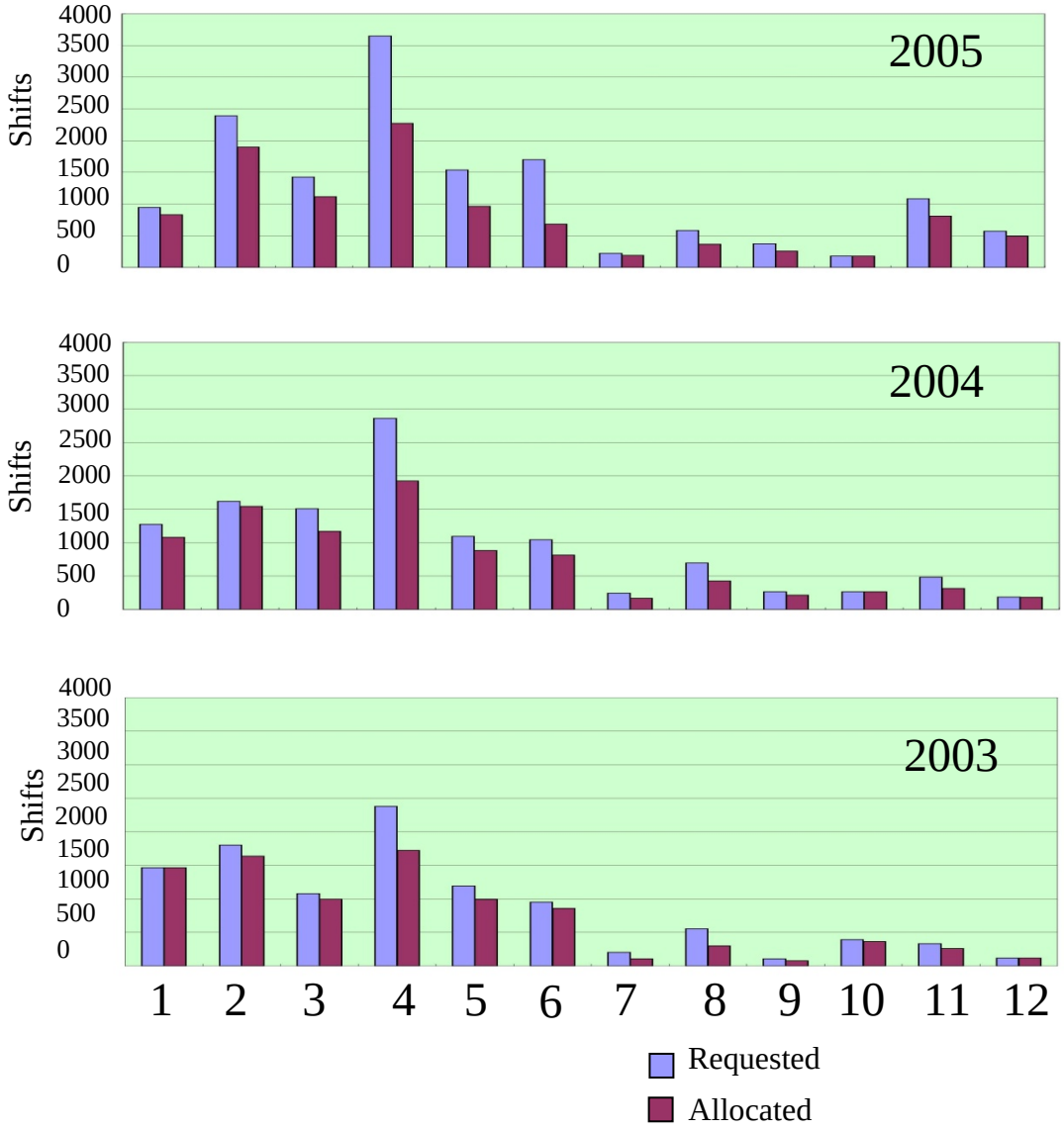
Statistics of unexpected beam loss



Statistics of SCI Publication



Distribution and Growth of Users Research Area



1. Atomic and Molecular Science
2. Surface, Interface and Thin Films
3. Condensed Matter Physics
4. Materials Science
5. Chemistry
6. Nanofabrication
7. Soft Matter
8. Protein Crystallography
9. Environmental and Earth Science
10. Applied and Industrial Research
11. Methodology and Instrumentation
12. Others

The Feature of TPS

- Taiwan Photon Source
  - Beam energy: 3 ~ 3.3 GeV
  - Circumference: ~ 486 m to accommodate in current site
  - Beam current: 400 ~ 300 mA
  - Beam emittance: ~ 2 nm-rad.
  - Number of straight sections: 24
  - Top-up operation by single bunch injection
  - Adopting superconducting technology in IDs and cavities

Taiwan Photon Source (TPS)

- The estimated hardware budget and time for constructing accelerator are NTD 6.88 billions and 7 years, respectively.
- The lattice design has reached an emittance of 1.7 nm·rad and a dynamical aperture of ± 25 mm
- Conceptual design of sub-systems has begun.
- TPS will reach 10^{21} photons/s/0.1%BW/mm^2/mr^2 brilliance and become one of the brightest synchrotron X-ray sources in the world.

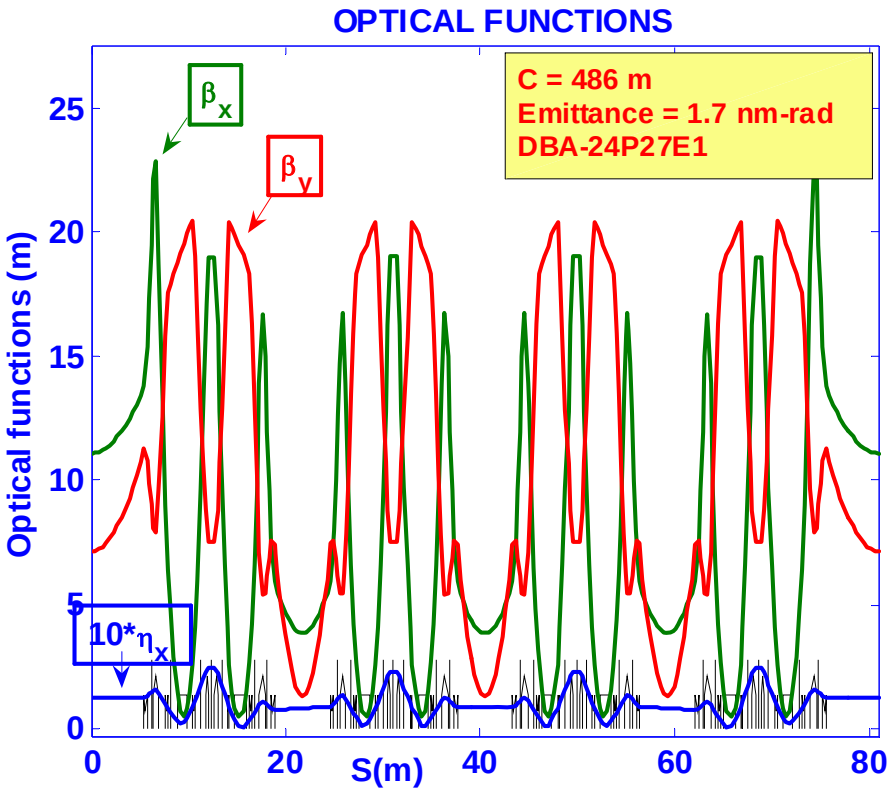
Basic Parameters of DBA, QBA Lattices

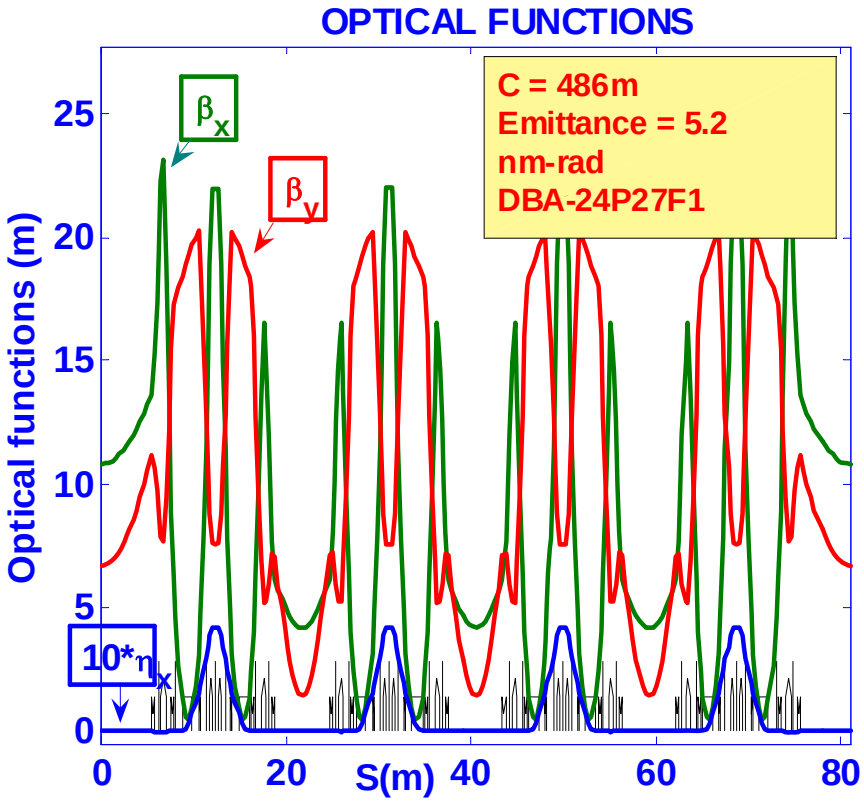
	DBA_27E1 Non-achromat	DBA_27F1 Achromat	QBA_27Q1 Hybrid	QBA_27R2 Hybrid
Energy (GeV)	3.0			
Beam current (mA)	400			
Circumference (m)	486			
Nat. emittance ε_x(nm-rad)	1.7	5.2	2.7	2.7
Cell / symmetry / structure	24 / 6 / DBA		24 / 6 / QBA	
Straights	10.9m*6+5.7m*18		10.9m*6+5.3m*18	10m*6+6m*12+4.8m*6
β_x / β_y / η_x (m) LS middle	11.1 / 7.14 / 0.15	11.3 / 7.1 / 0.0	11.2 / 8.6 / 0.018	10.8 / 7.4 / 0.016
β_x / β_y / η_x (m) MS middle	3.8 / 1.3 / 0.12	4.2 / 1.4 / 0.0	2.5 / 1.2 / 0.1 4.2 / 1.4 / 0.012	2.7 / 1.5 / 0.1
β_x / β_y / η_x (m) SS middle	-	-	-	4.1 / 1.4 / 0.01
Betatron tune ν_x /ν_y	26.22 / 12.30	26.22 / 12.30	26.28 / 12.25	26.28 / 12.25
Mom. comp. (α_1, α_2)	2.4×10^{-4}, 2.4×10^{-3}	3.1×10^{-4}, 2.0×10^{-3}	2.6×10^{-4}, 2.2×10^{-3}	2.6×10^{-4}, 2.1×10^{-3}
Nat. energy spread σ_E	8.86×10^{-4}		8.31×10^{-4}	
Damping time (ms) (τ_x / τ_y /τ_s)	11.4 /11.4 / 5.7		13.0 / 13.0 / 6.5	
Dipole B/L (Tesla)/(m)	1.1908 / 1.1		1.0479 / 1.0 and 1.5	
Critical energy dipole (keV)	7.12		6.26	
Nat. chromaticity ξ_x / ξ_y	-68 / -30	-73 / -29	-63 / - 31	-62 / - 29

Effective Emittance of ID Effects (3GeV)

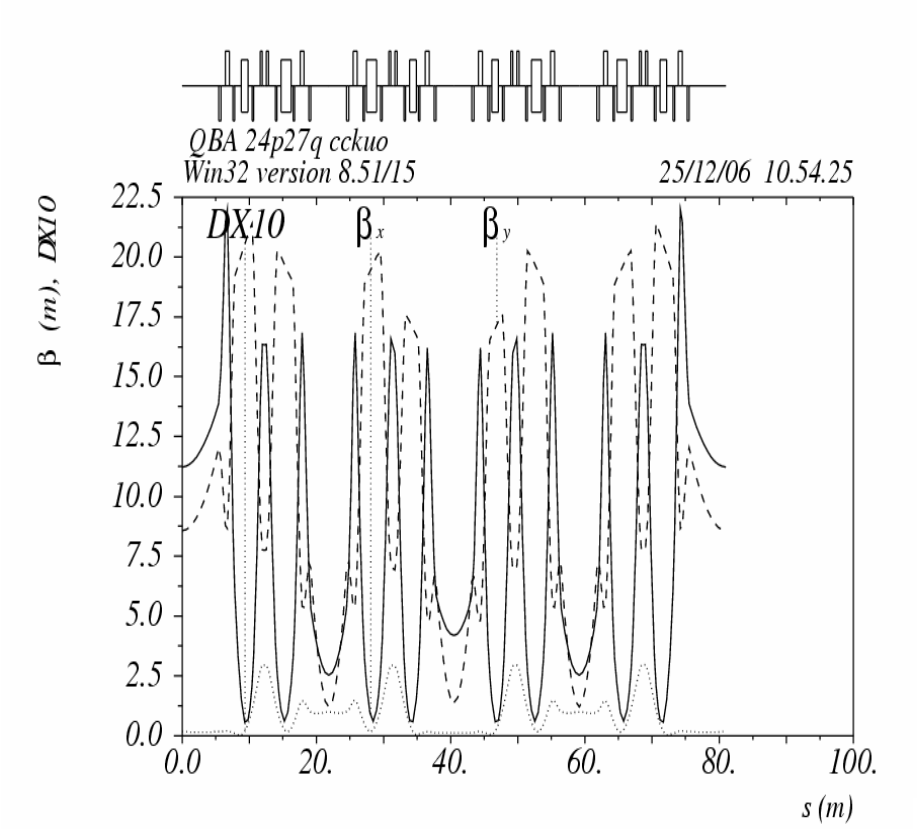
	# of SW6	Configuration	U0 (MeV)	sigE/E	Natural emittance (nm-rad)	2D effective emittance (nm-rad)		
						Long Straight	Short Straight 1	Short Straight 2
24P27E (DBA, Non-Achromat)	bare	x 000 x 000 x 000 x 000 x 000 x 000	0.85269	8.8598E-04	1.6748	2.1731	2.2638	2.2982
	1	x fef C fef H adf H bdf H bff H gff	1.4383	9.1251E-04	2.1518	2.6914	2.7914	2.8294
24P27F (DBA, Achromat)	bare	x 000 x 000 x 000 x 000 x 000 x 000	0.85269	8.8584E-04	5.2681			
	1	x fef C fef H adf H bdf H bff H gff	1.4383	9.1243E-04	3.1306			
	3	x fef C fef H adf H bdf B cff G cff	1.6388	1.0107E-03	2.7497			
24P27Q (QBA, dipole length: 1.5/1)	bare	x 000 x 000 x 000 x 000 x 000 x 000	0.75037	8.3115E-04	2.6973	2.7068	3.8302	2.7100
	1	x fcf A fhf B fhf B fhf D fhf D ege	1.3360	8.8512E-04	2.1097	2.1204	3.3182	2.1240
	3	x fcf A fcf B fcf B fhf D fhf D ege	1.5365	9.9574E-04	1.8638	1.8774	3.2875	1.8819
24P27R (QBA, dipole length: 1.5/1 3 kinds of straights)	bare	x 000 x 000 x 000 x 000 x 000 x 000	0.75037	8.3115E-04	2.7275	2.7361	3.8717	2.7357
	1	x fkf A fqf B fqf B fqf D fqf D epe	1.3360	8.8512E-04	2.1243	2.1340	3.3439	2.1336
	3	x fkf A fkf B fkf B fqf D fqf D epe	1.5365	9.9573E-04	1.8682	1.8805	3.3035	1.8799

Linear Optics Functions of DBA Lattices

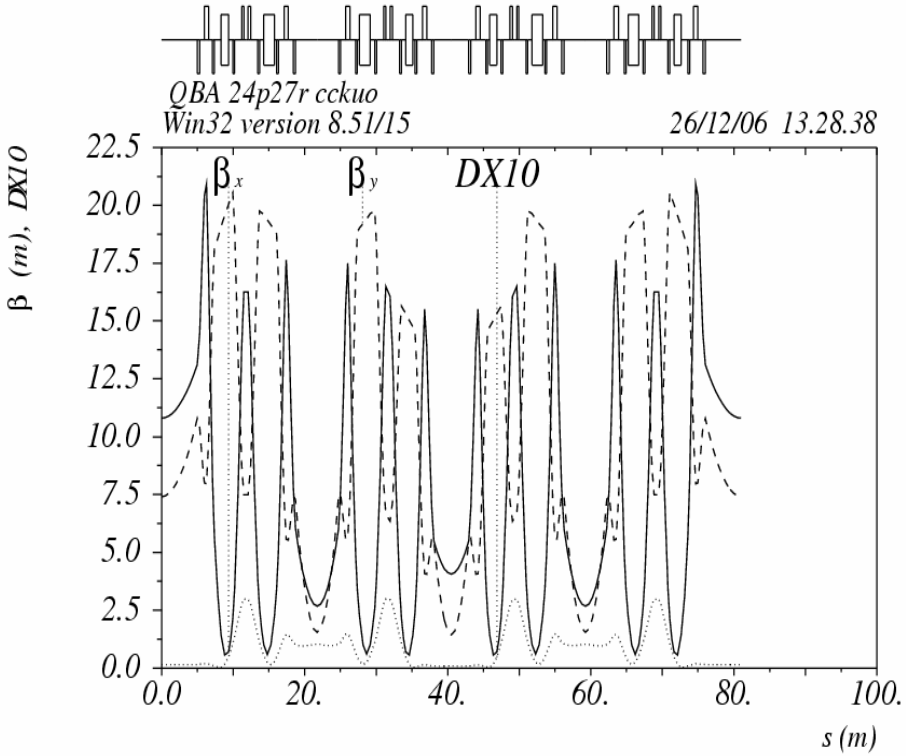




Linear Optics Functions of QBA Lattices

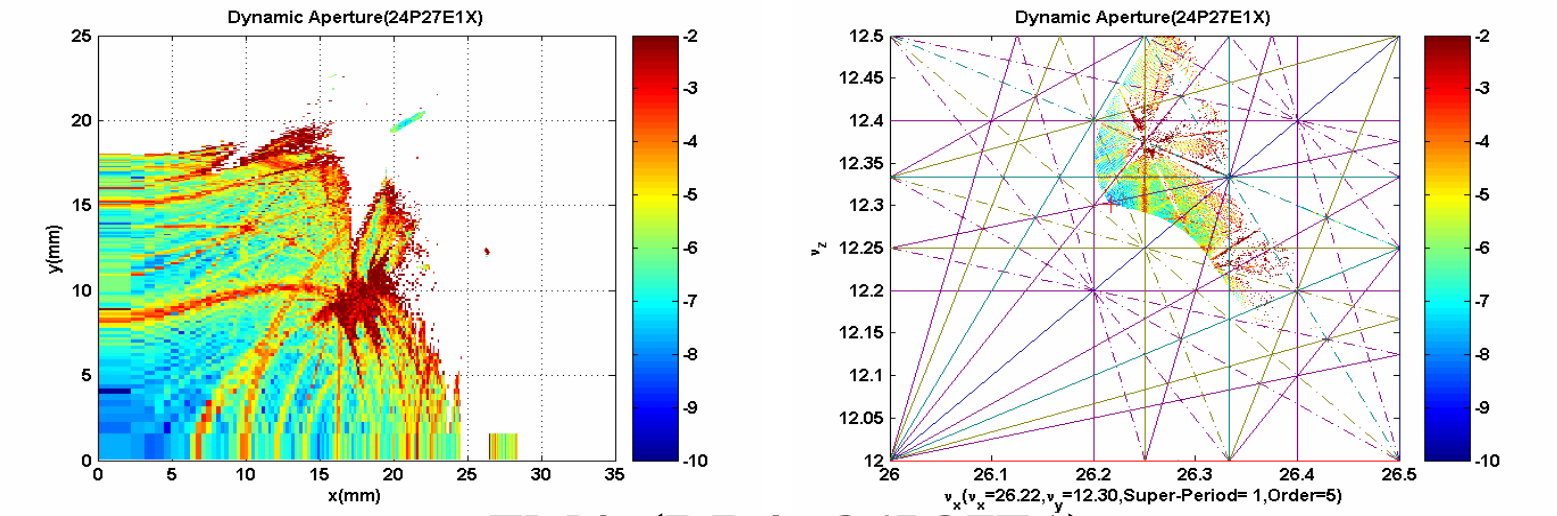


QBA_24P27Q1

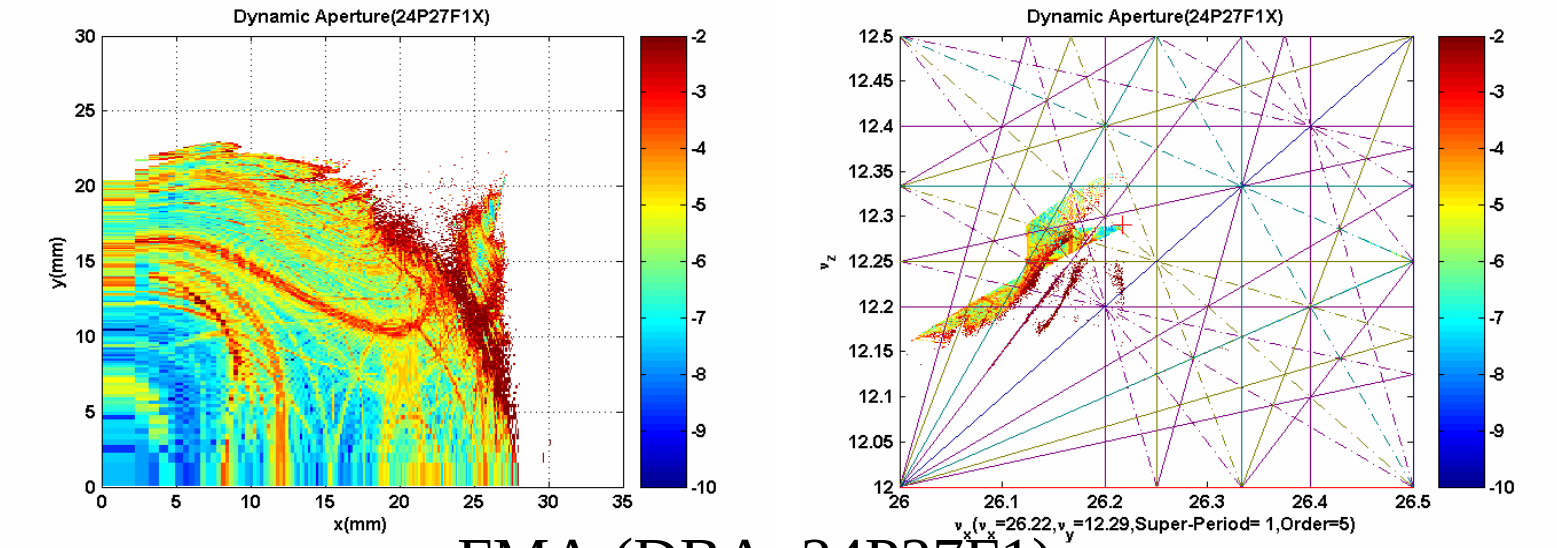


QBA_24P27R2

Nonlinear Tracking-Frequency Map Analysis

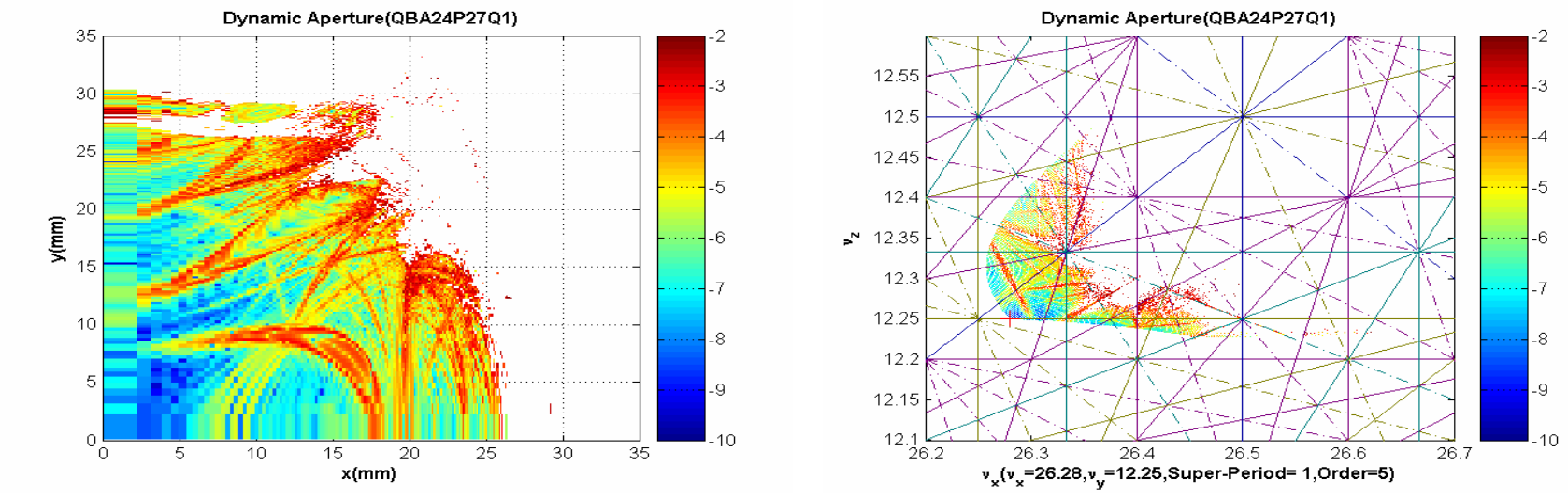


FMA (DBA_24P27E1)

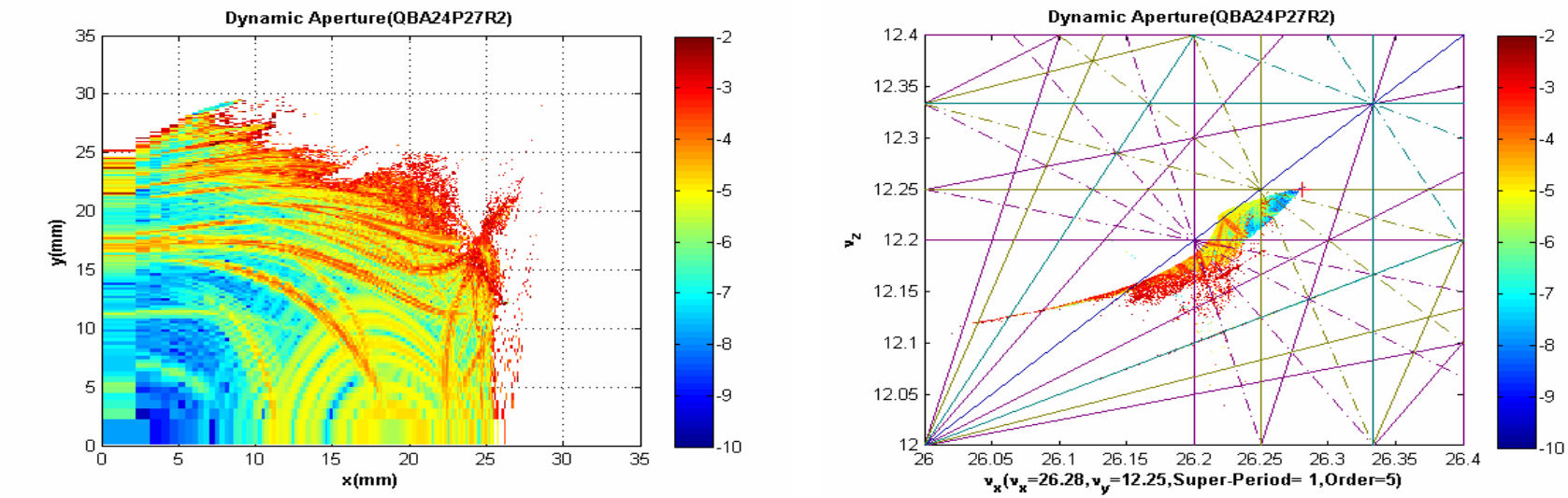


FMA (DBA_24P27F1)

Nonlinear Tracking-Frequency Map Analysis

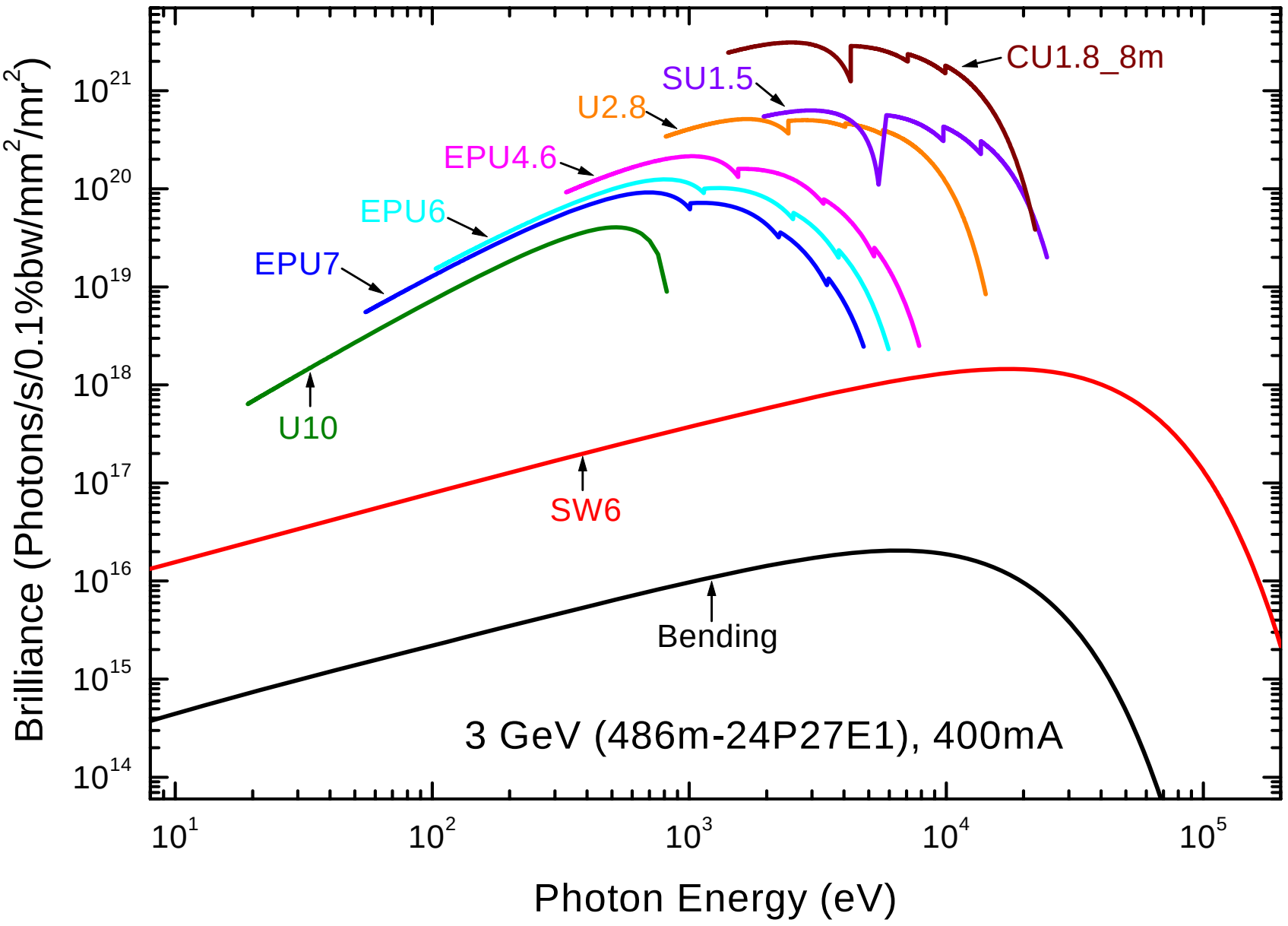


FMA QBA_24P27Q1

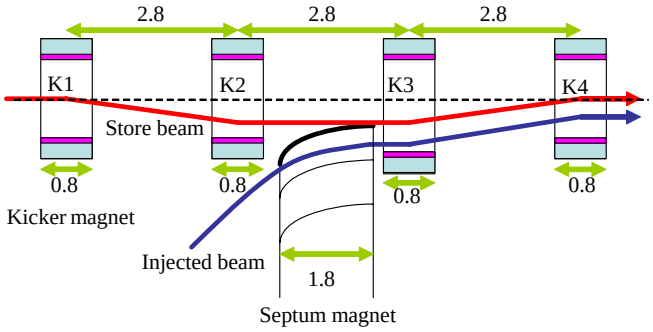


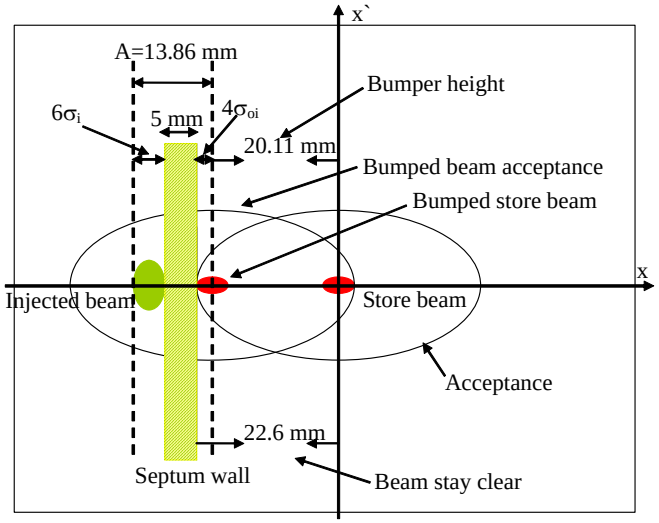
FMA QBA_ 24P27R2

Brilliance of 486 m (486m-24P27E1)



Injection scheme





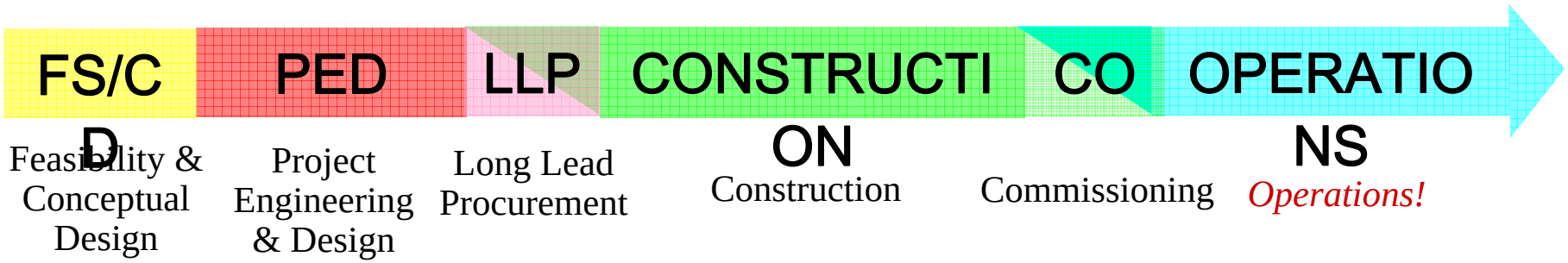
In a long straight K-t-K: 9.2m

Another option: Thick and Thin septa scheme

TPS septum and kicker parameters

	septum	kicker
Length (m)	1.8	0.80
Field (T)	0.97	0.0898
Bend Angle (mrad)	174.5	7.18

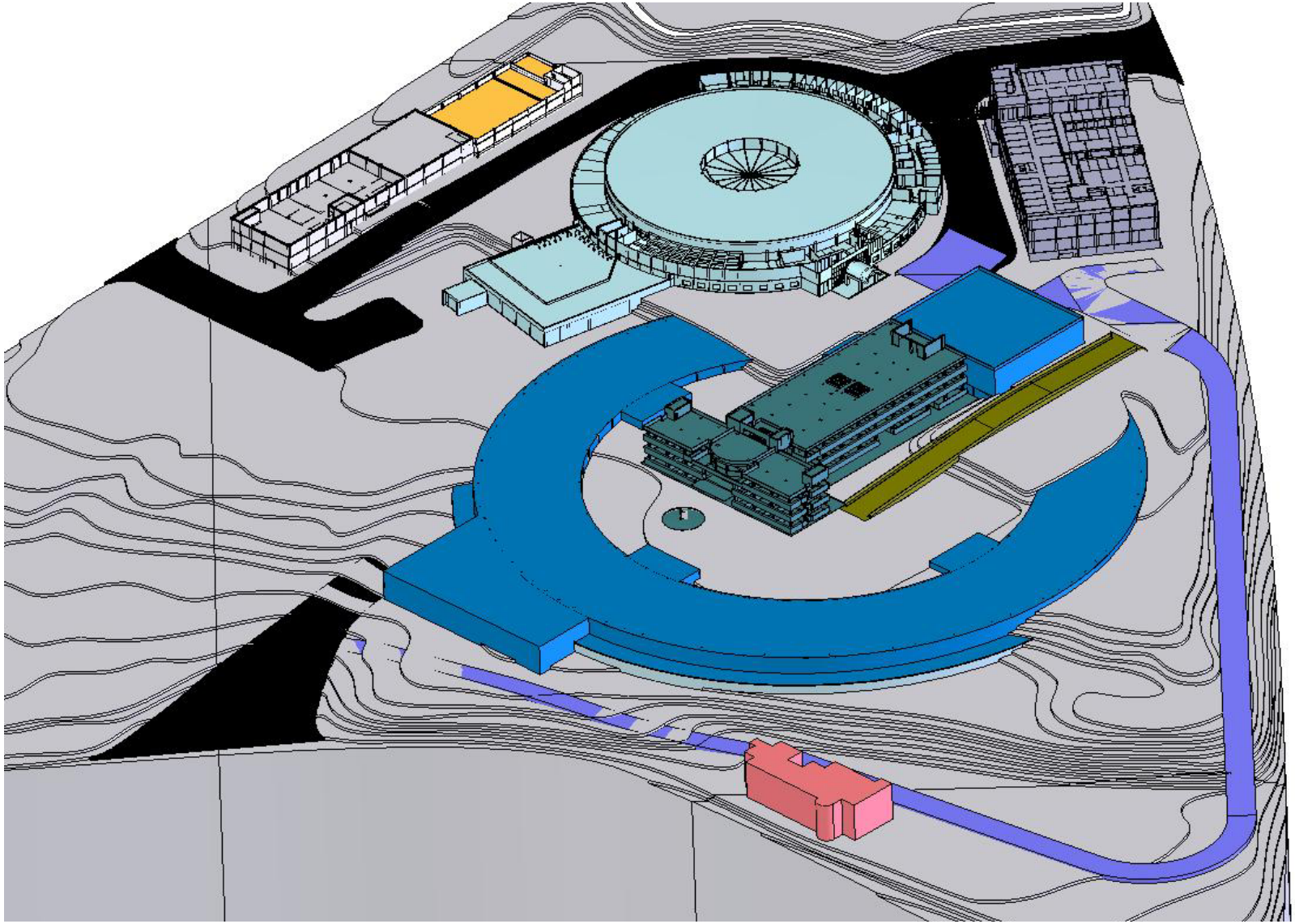
Budget and schedule of proposed TPS



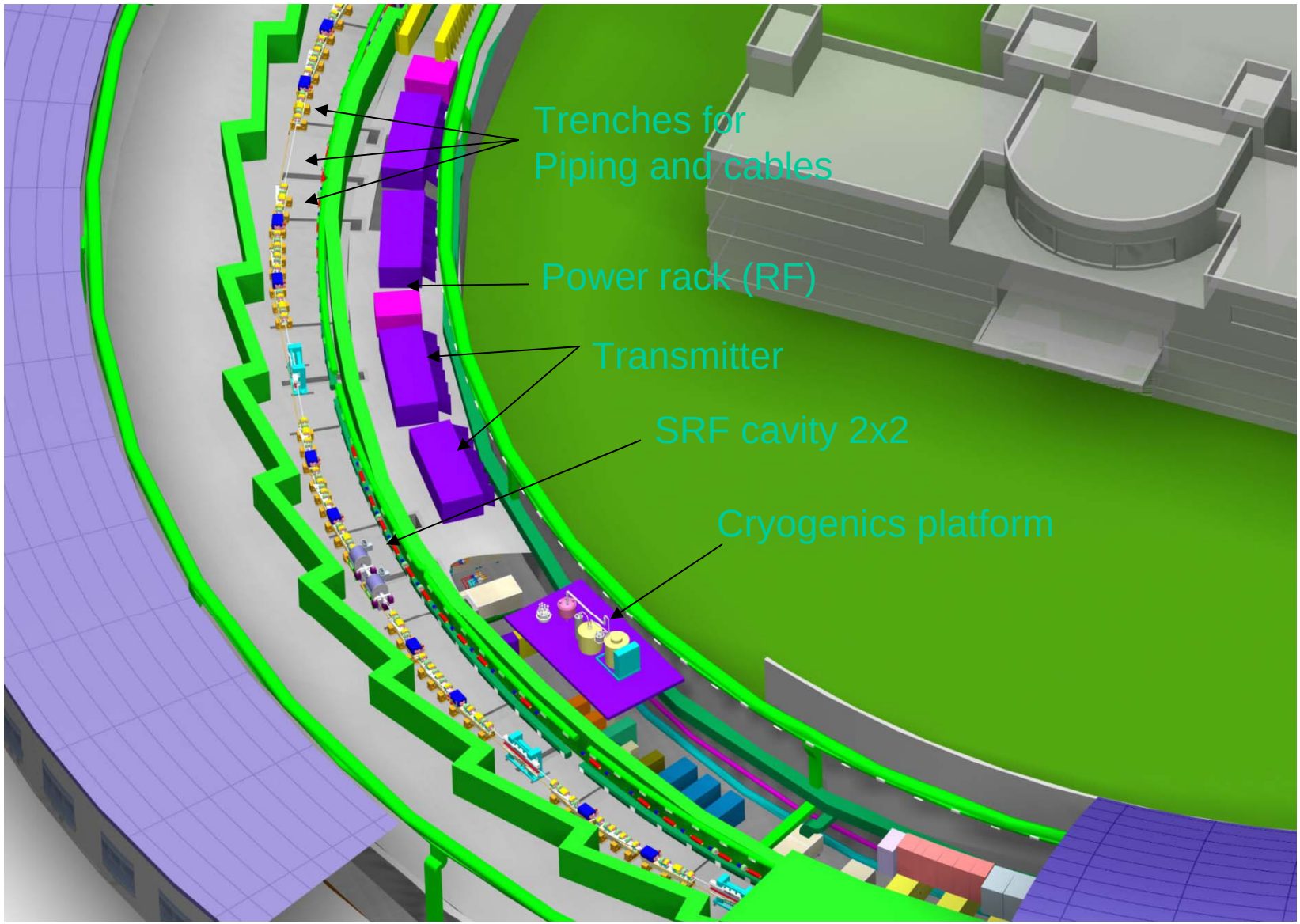
Funding source of the TPS construction (total 6.88 BNT or ~ 200 MUS):

	2006	2007	2008	2009	2010	2011	2012	2013	
NSC funding	**0.1**	**0.35**	**0.7**	**0.7**	**0.7**	**1.05**	**1.08**	**0.45**	**(5.13 BNT)**
EPC funding		**-**	**0.5**	**0.6**	**0.5**	**0.15**	**-**	**-**	**(1.75 BNT)**

NSRRC Site



RF Straight Section and Liquid Helium Supply System



Prospects

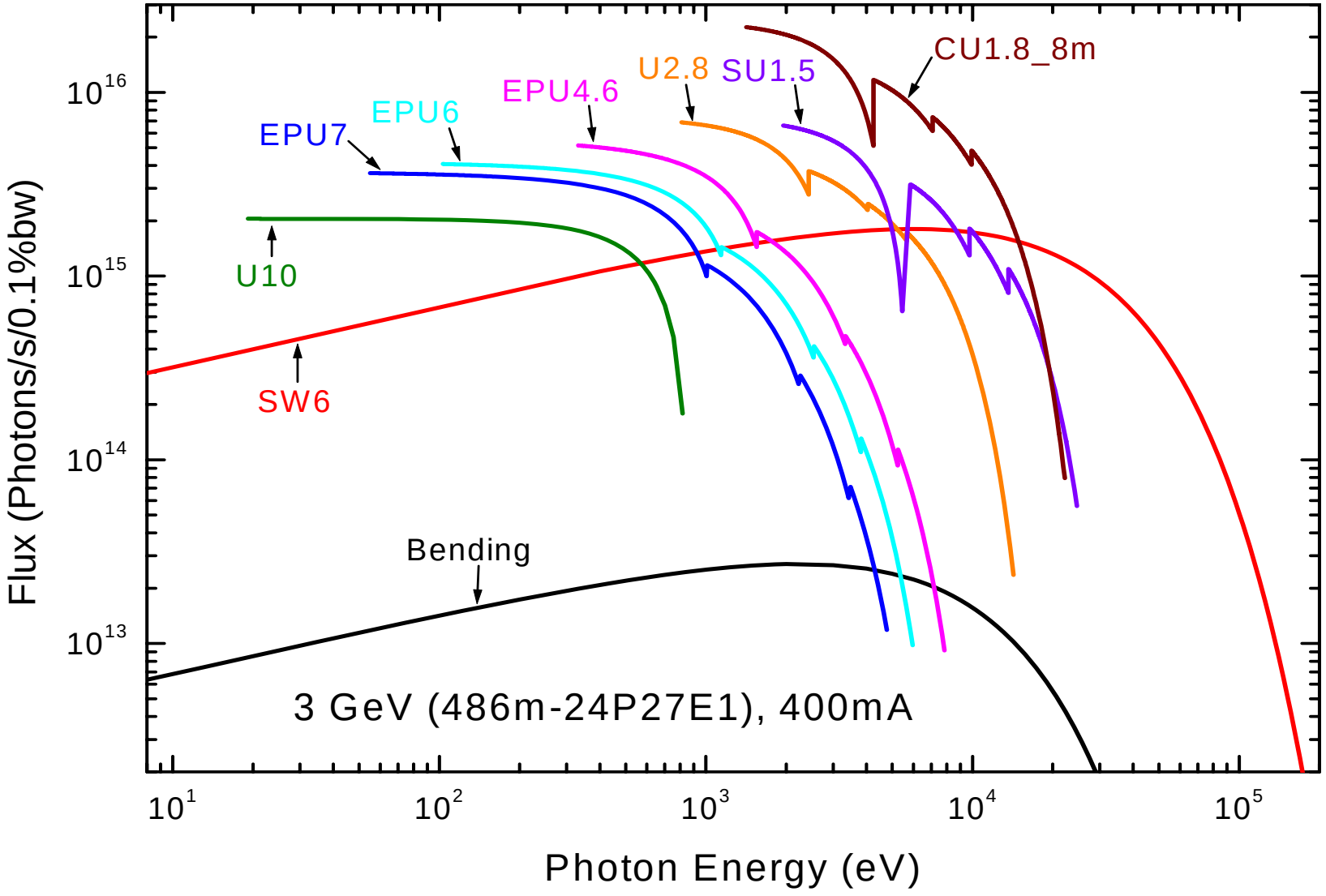
- *To become one of the world's brightest synchrotron X-ray sources*
- *To develop cutting-edge experimental facility and new areas of scientific research*
- *To help high-tech industry conduct product R&D and process optimization*
- *To attract more international scientists to perform experiments or build dedicated beamlines at NSRRC*
- *To recruit worldwide outstanding scientists to establish long-term leading-edge research in Taiwan*
- *To attract young generation to advanced scientific research and plant the seeds great future scientific discoveries*

Summary

- *7 insertion devices installed in a 6-fold symmetric TLS*
- *300 mA top-up injection mode operated with SCRF cavity and three SCIDs successfully at TLS*
- *DBA- and QBA-type lattices are studied for the proposed 3 GeV storage ring with its circumference 486 m.*
- *Nonlinear beam dynamics are studied. Both QBA and DBA deliver promising working lattices*
- *ID effects on the emittance are compared.*
- *Further studies on the nonlinear effects and error analysis are in progress.*

Thank you for your attention

Flux of 486 m (486m-24P27E1)



The Planning of TLS

- Taiwan Light Source
  - Increasing the top-up of store beam current to 360 mA
  - Installation of two more In-Archromat Sc. Wigglers
  - Implement fast orbit feedback system in vertical plan
  - Putting the second set cryogenic system into operation
  - Testing hybrid filling pattern
  - Research on low-emittance and high peak current electron gun
  - Strengthen the communication with users -Weekly Users and Operation Meeting http://srrcidd01.nsrrc.org.tw/iddA/operation.htm
  - Web site of Operation Group http://elog.nsrrc.org.tw/webblog/index.aspx