



中国科学院上海应用物理研究所
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Machine Operation and Progresses in SSRF

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- Operation statistics of SSRF
- Progresses in recent two years
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Location

Shanghai Synchrotron Radiation Facility





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Bird's eye view of SSRF

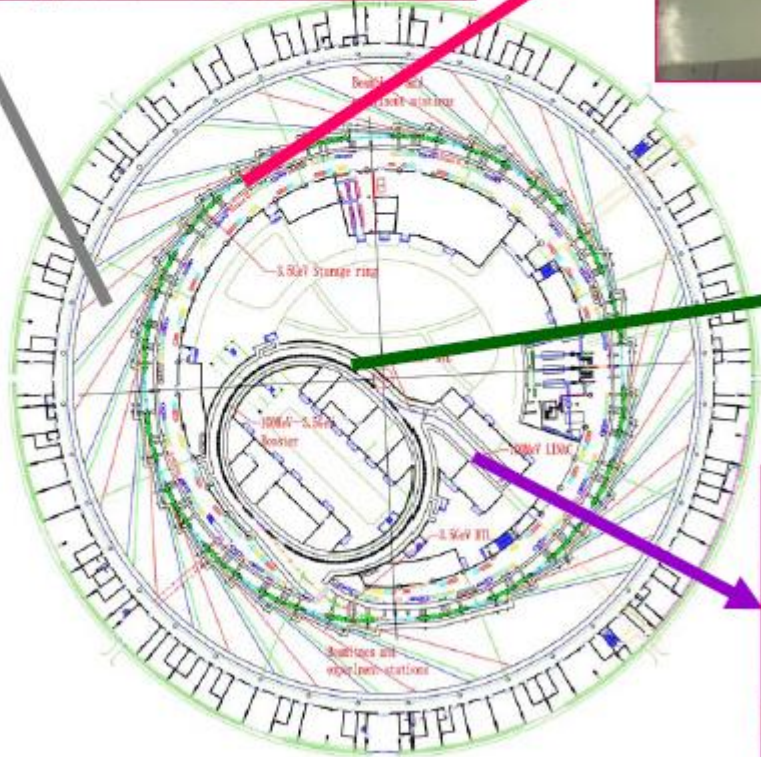




Overview of SSRF



Storage Ring
3.5GeV, C=432m



Booster
3.5GeV, C=180m



Electron Linac
150MeV

Introduction -- History

- Dec. 25, 2004 -- Groundbreaking;**
- Oct. 2007 --- Commissioning**
- May, 2009 ---- Open to users**
 - 7 Beamlines -- in the first phase**
 - 2 bending magnets; 2 wiggler ; 3 in-vacuum undulators**
 - 5 Beamlines are under construction**
 - 24 Beamlines are planed to build in next 3 years**

Beam Parameters (Operation mode)

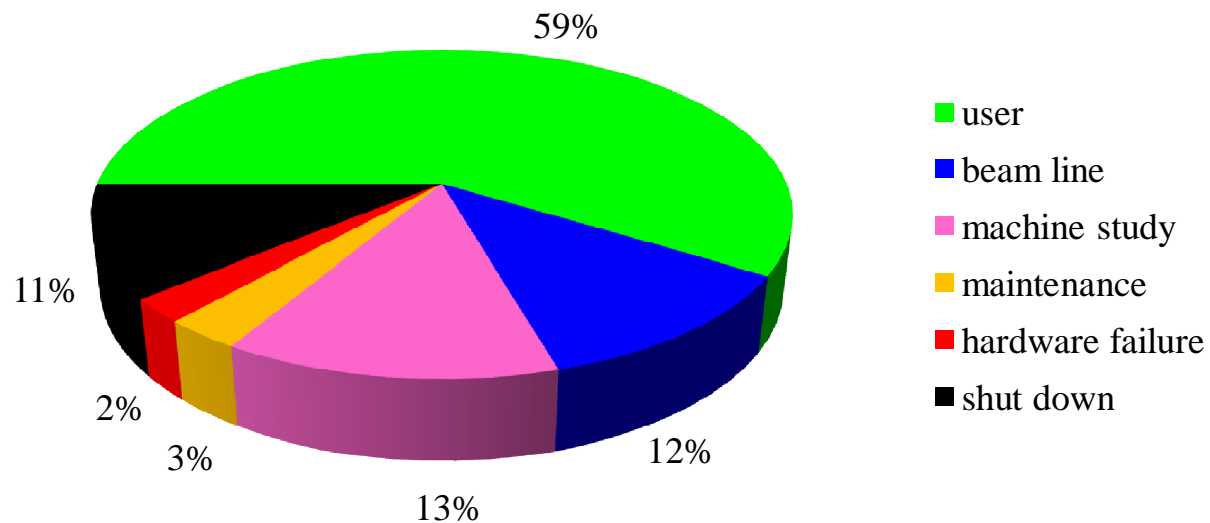
Parameter / unit	Design value	Measured value
Beam energy / GeV	3.50	3.50 ± 0.02
Beam current / mA	200~300	210 (operation current) 300 (achievable)
Tune (H, V)	22.22, 11.29	$22.220, 11.290 (\pm 0.002)$
Natural emittance / nm.rad	3.89	3.8 ± 0.2
Coupling	1%	0.3%
Natural chromaticity (H, V)	-55.7, -17.9	-55.8, -17.9 (LOCO model) -50, -15 (direct measurement)
Corrected chromaticity (H, V)	-----	1.5, 0.5
RMS energy spread	9.845×10^{-4}	0.001
Energy loss per turn / MeV	1.435	~1.45 (without ID, from RF power)
Momentum compaction factor	4.27×10^{-4}	$(4.2 \pm 0.2) \times 10^{-4}$
RF voltage / MV	4.0	1.51, 1.55, 1.54 (Three cavities)
RF frequency / MHz	499.654	499.654 (depend on machine conditions)
Synchrotron frequency	0.0072 ($V_{RF}=4.0MV$)	0.0075 ± 0.0002
Natural bunch length / ps	13	14 ± 2
Injection efficiency	-----	>95% (from BS DCCT to SR DCCT)
Beam lifetime / hrs	>10	~17 (0.3% coupling, 210 mA)

Machine Operation Status

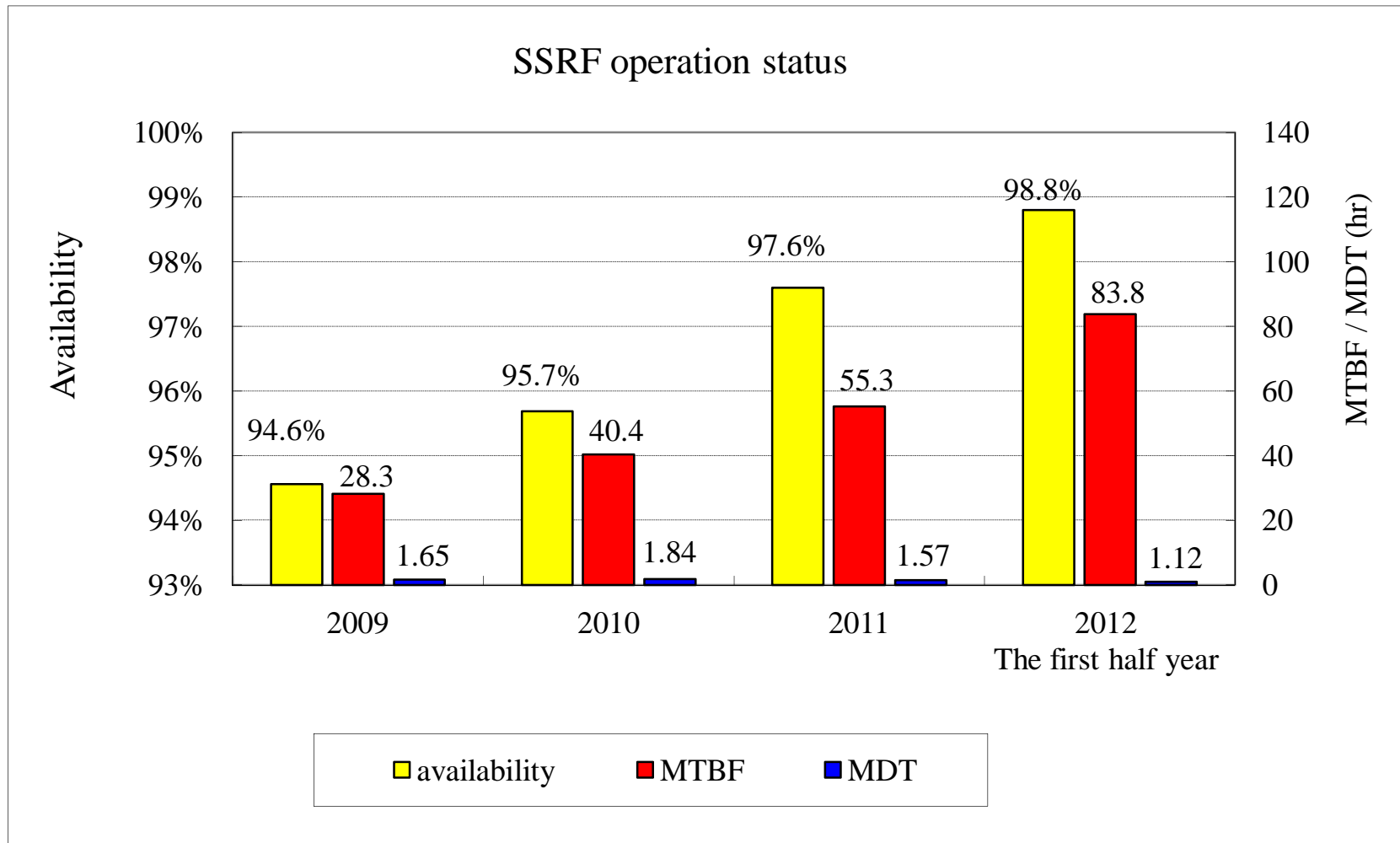
Operation Schedule

Year	User time (hours)
2009(May-Dec.)	2094
2010	3829
2011	4370
2012	4600

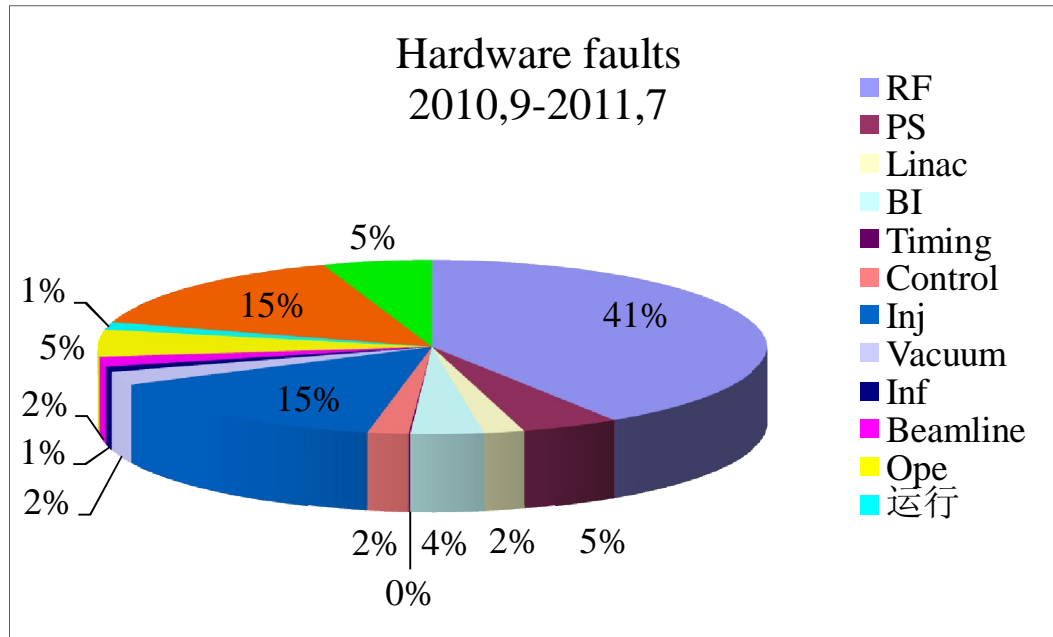
2011.9-2012.7



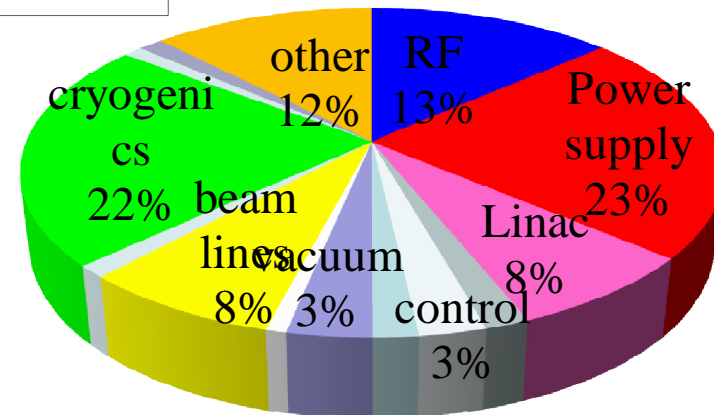
Availability & MTBF during scheduled user time



Hardware faults

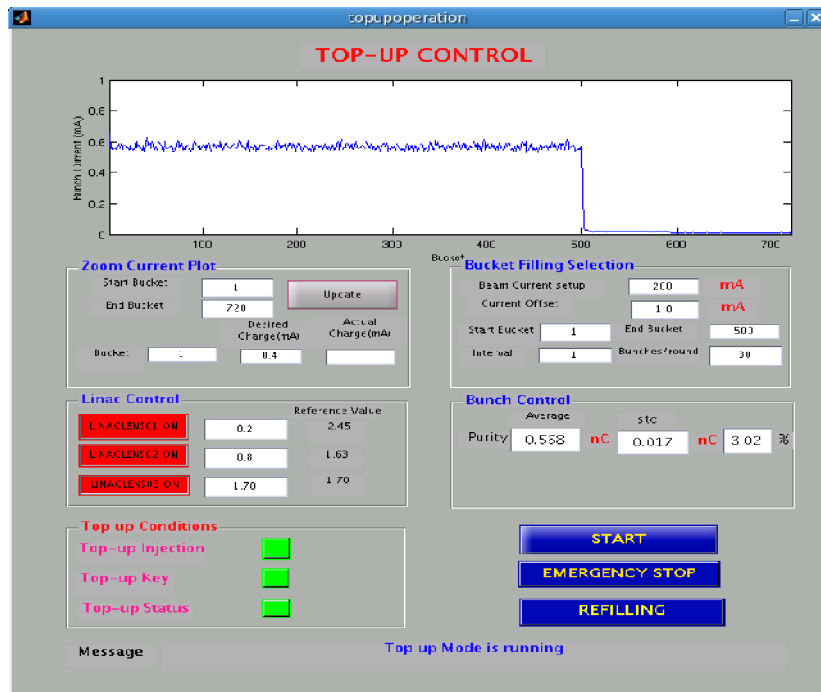


Hardware faults 2011.9-2012.7

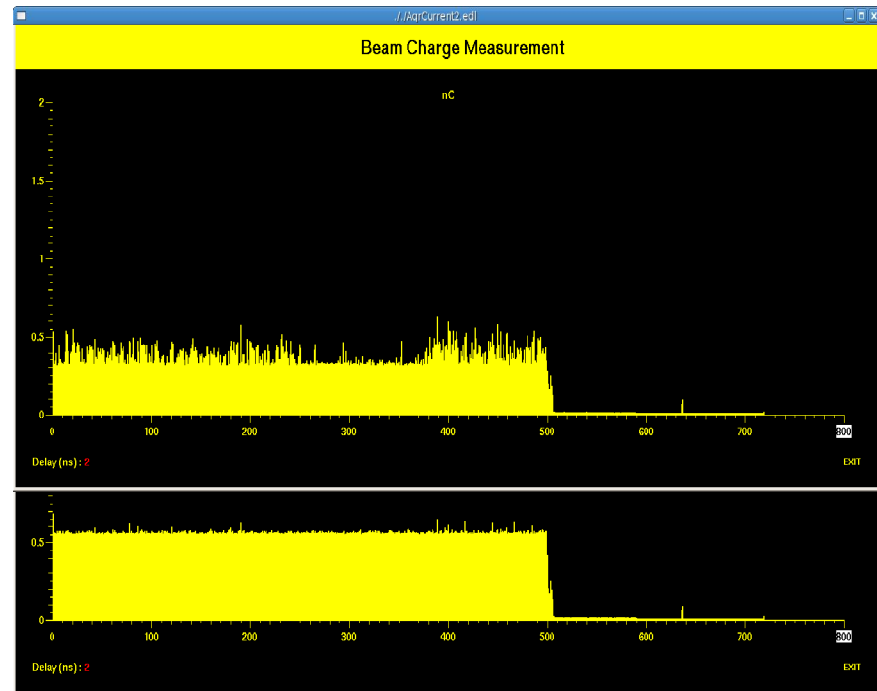


Progresses

Top up preparation

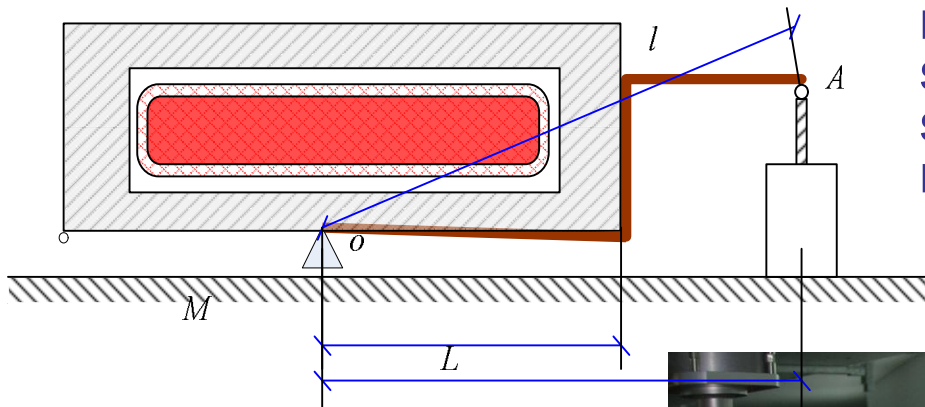


Control software panel

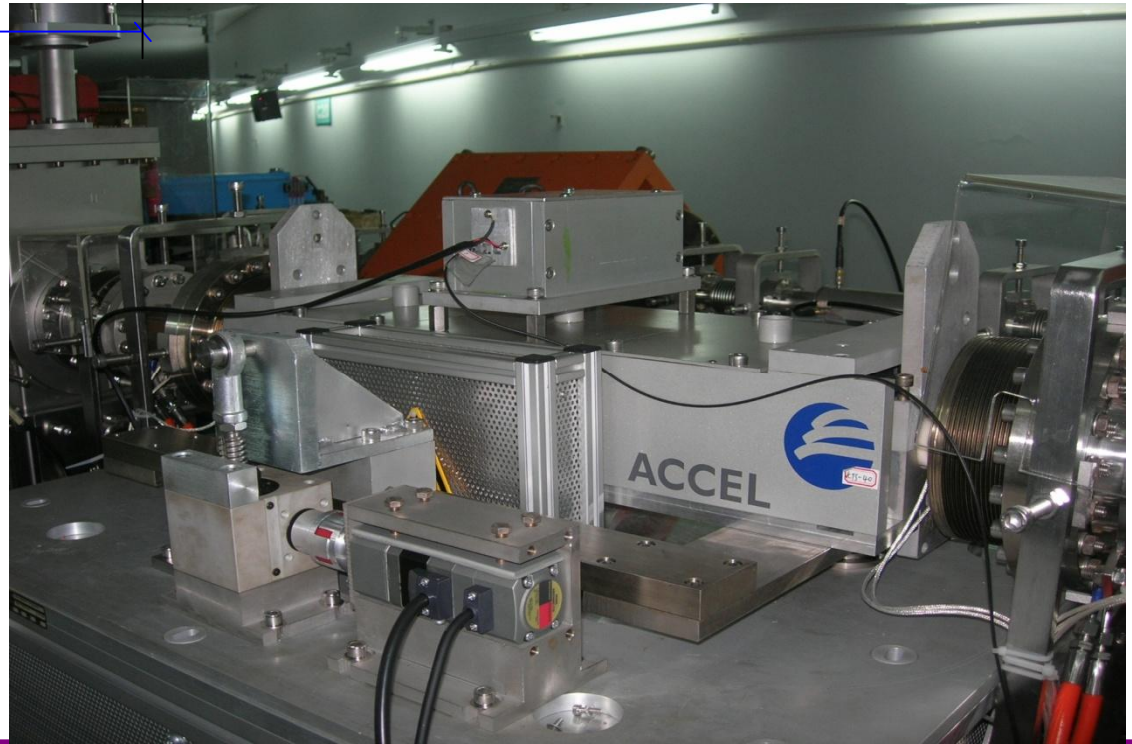


Filling pattern control (up: initial,
below: 3hours top-up operation)

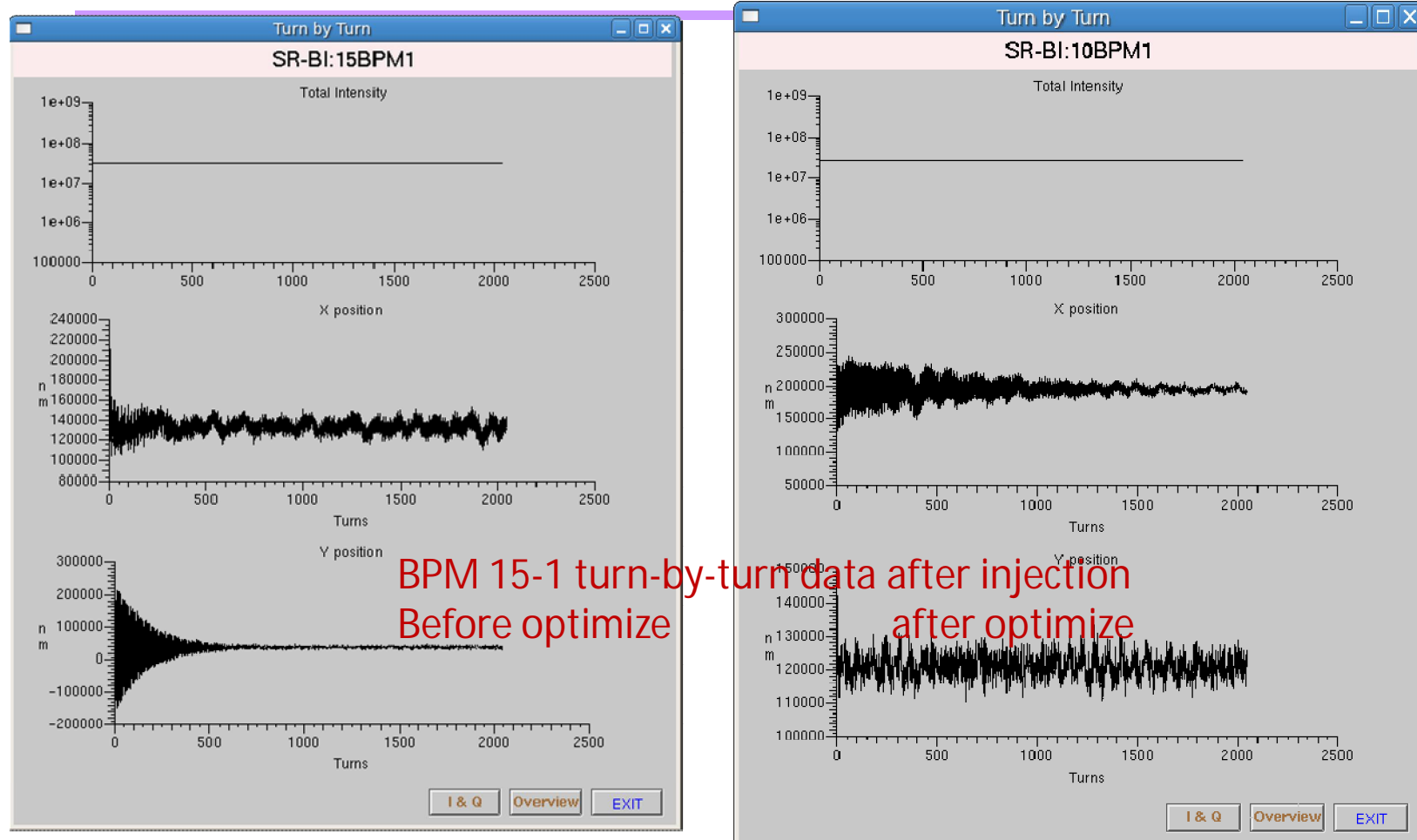
Topup injection



range: $-5\sim 5$ mrad (± 2 mm) ;
step: $< 10\mu$ rad;
speed: $= 18\mu$ rad/sec;
resolution: 10μ rad;



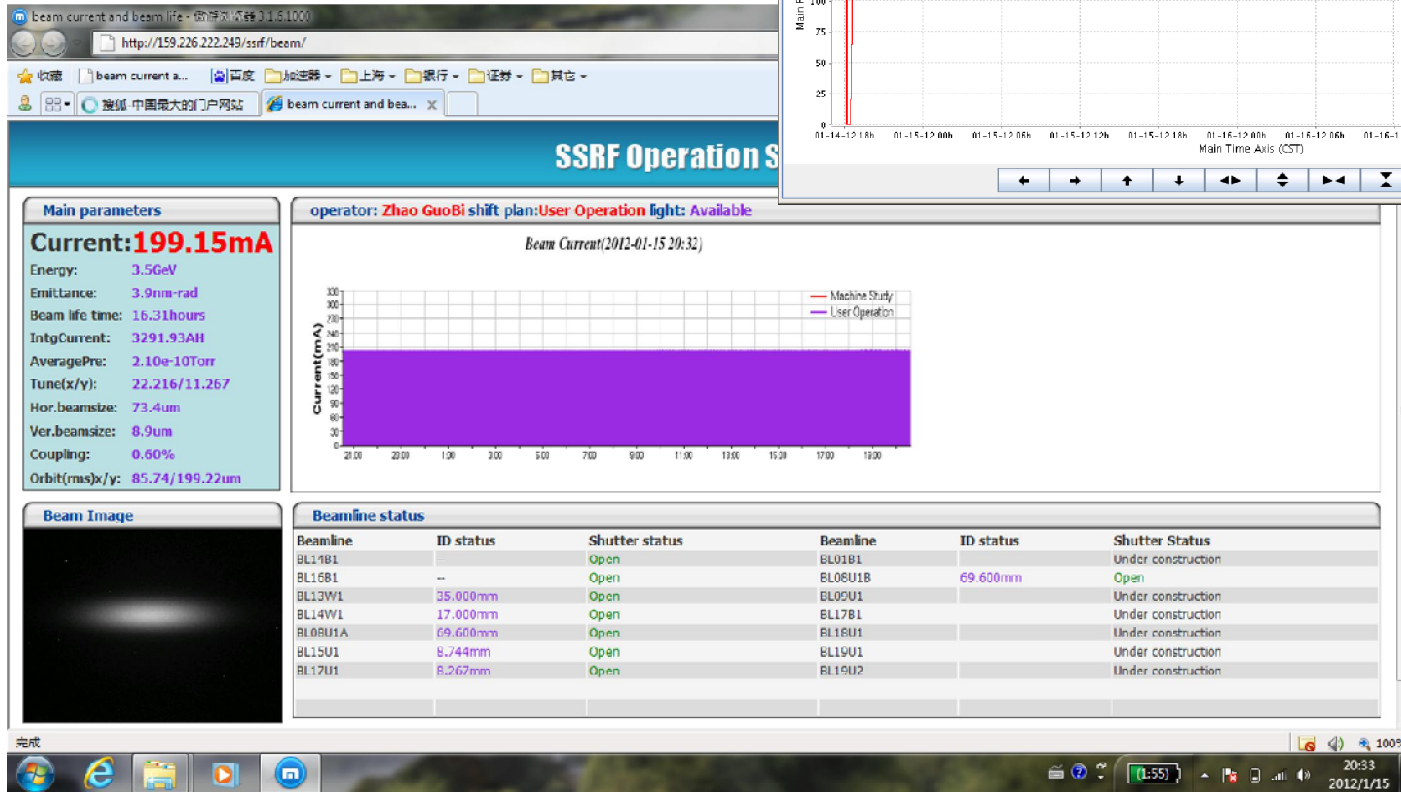
Top up commissioning



During machine shutdown, 4 stepper motors are added to the 4 injection kickers to adjust tilt. After online optimizing, the injection perturbation in vertical plane reduced from 150micron to 10 micron , and +/- 50 micron in horizontal

Jan. 14, 2012

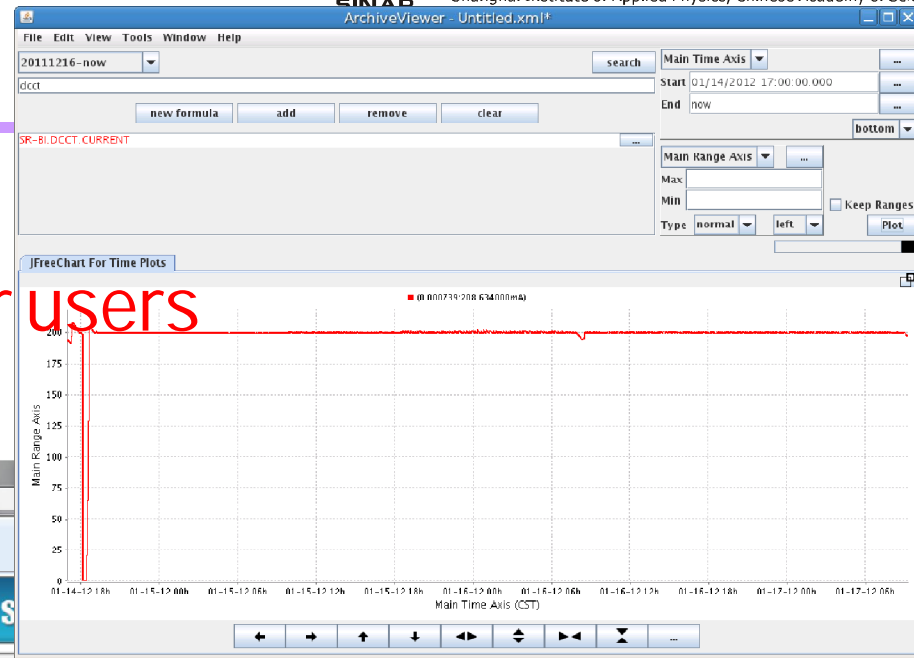
4 days top up operation for users



The screenshot displays the SSRF Operation System interface. At the top, a browser window shows the URL <http://159.226.222.249/ssrf/beam/>. The main interface is divided into several sections:

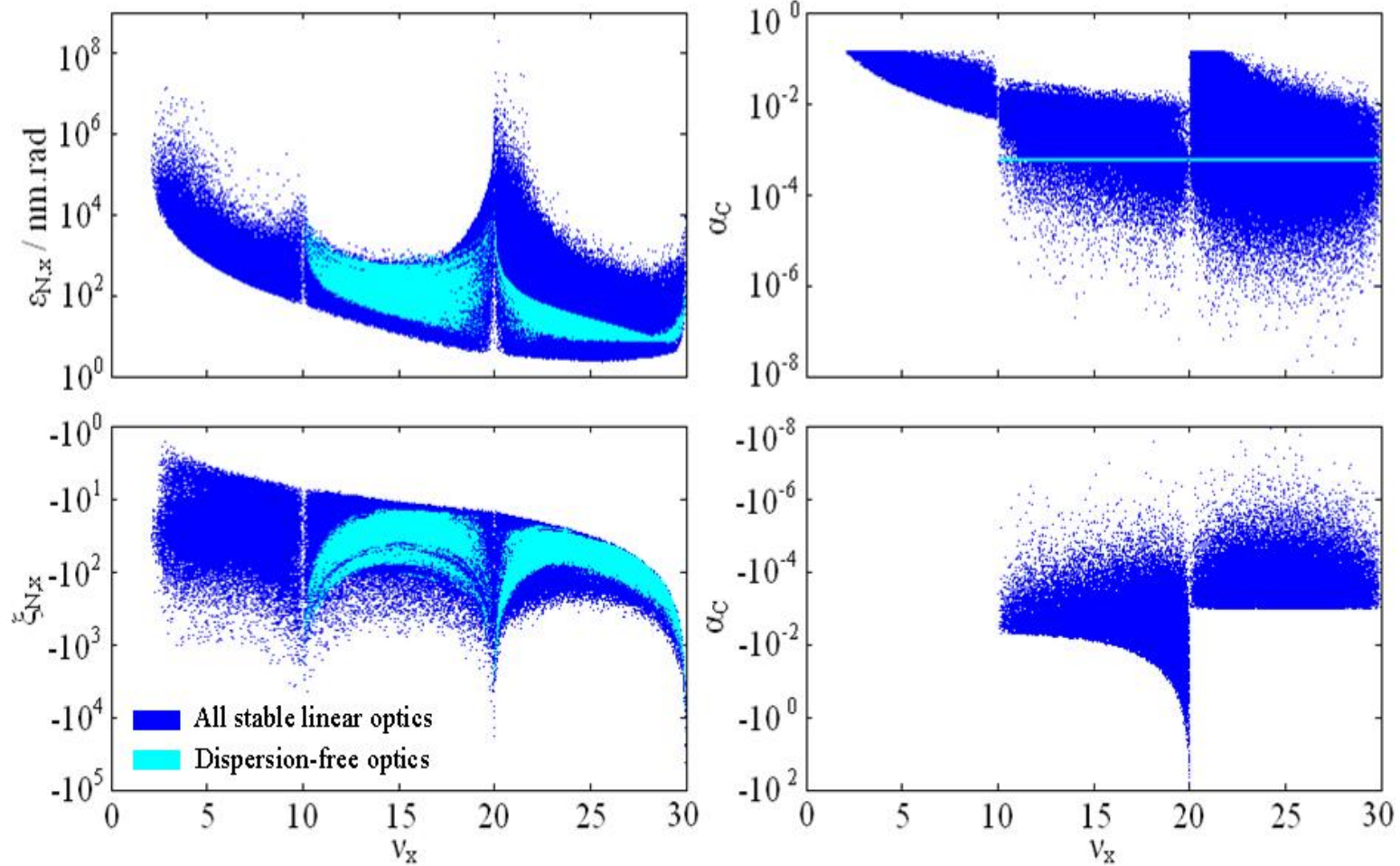
- Main parameters:**
 - Current: **199.15mA**
 - Energy: 3.5GeV
 - Emittance: 3.9nm-rad
 - Beam life time: 16.31hours
 - IntgCurrent: 3291.93AH
 - AveragePre: 2.10e-10Torr
 - Tune(x/y): 22.216/11.267
 - Hor.beamsize: 73.4um
 - Ver.beamsize: 8.9um
 - Coupling: 0.60%
 - Orbit(rms)x/y: 85.74/199.22um
- operator:** Zhao GuoBi shift plan: User Operation light: Available
- Beam Current(2012-01-15 20:32):** A bar chart showing current (mA) over time. The chart is divided into 'Machine Study' (red) and 'User Operation' (purple) periods. The 'User Operation' period shows a steady current of approximately 199 mA.
- Beamline status:** A table listing beamline IDs, their status, and shutter status.

Beamline	ID status	Shutter status	Beamline	ID status	Shutter Status
BL11B1		Open	EL01B1		Under construction
BL16B1	--	Open	EL08U1B	69.600mm	Open
BL13W1	35.000mm	Open	EL09U1		Under construction
BL14W1	17.000mm	Open	EL17B1		Under construction
BL08U1A	69.600mm	Open	EL18U1		Under construction
BL15U1	8.744mm	Open	EL19U1		Under construction
BL17U1	8.267mm	Open	EL19U2		Under construction



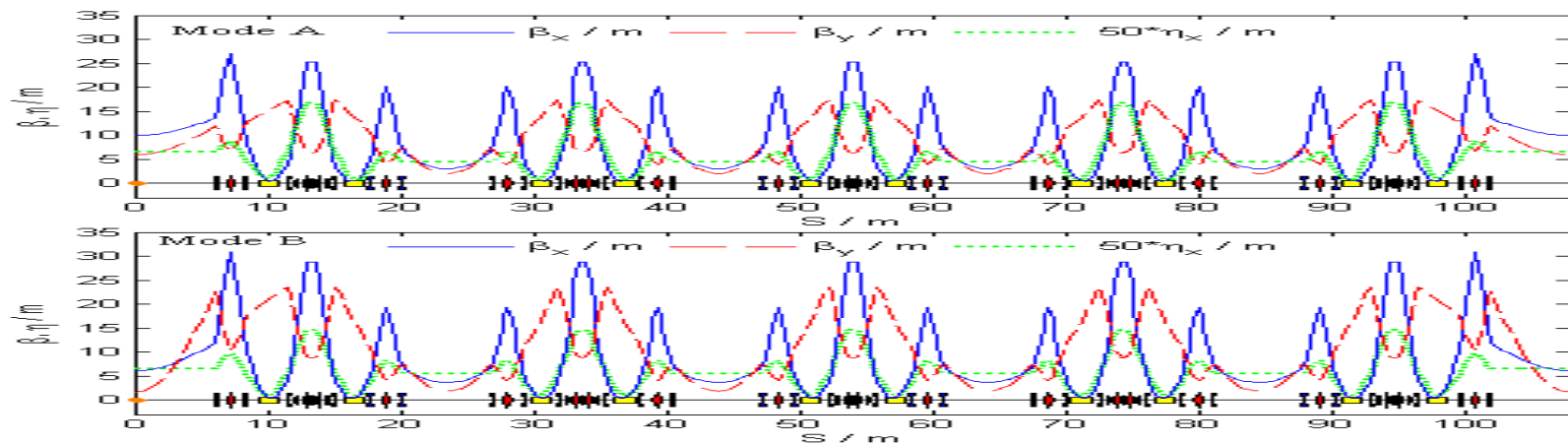
Lower Emittance Lattice mode

➤ **MOGA (Multi-Objective Genetic Algorithm)**: Is used to find
Low ϵ lattice



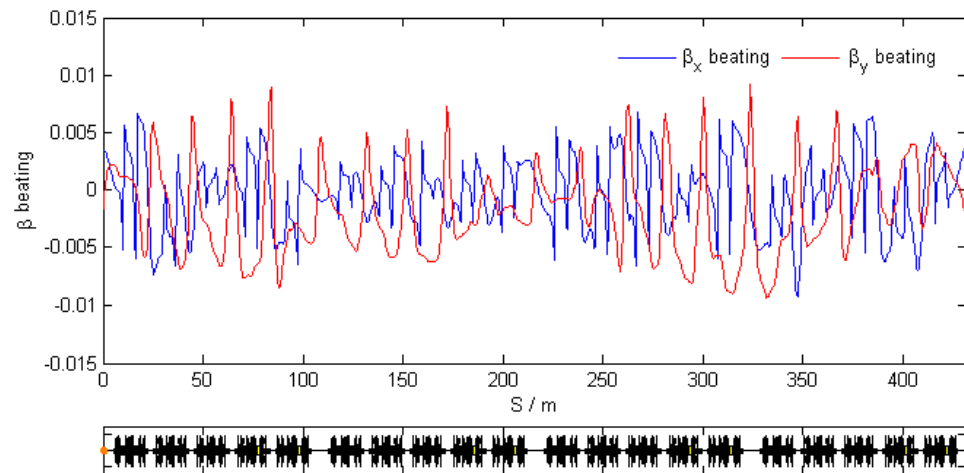
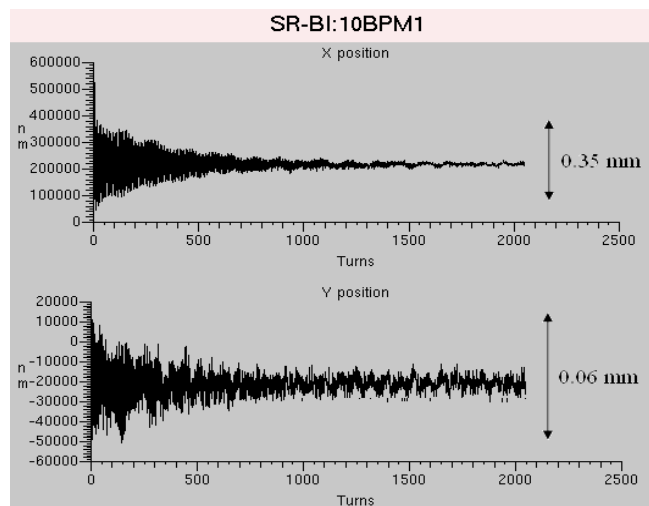
Lower emittance optimization

Parameter / unit	Oper. Mode	Mode A	Mode B
Tune (H, V)	22.22, 11.29	23.31, 11.23	23.31, 11.23
Natural emittance / nm.rad	3.89	3.51	2.88
Eff. Emitt. in LSS / nm.rad	4.86	4.25	4.00
Eff. Emitt. in SSS / nm.rad	5.17	4.58	4.15
Natural chromaticity (H, V)	-55.7, -17.9	-69.9, -20.5	-74.5, -26.7
Momentum compaction factor	4.27×10^{-4}	4.03×10^{-4}	4.13×10^{-4}
β_x, β_y, η_x at the center of LSS / m	10.00, 6.00, 0.15	10.00, 6.00, 0.13	6.15, 1.71, 0.13
β_x, β_y, η_x at the center of SSS / m	3.60, 2.50, 0.11	3.00, 2.00, 0.087	3.71, 1.90, 0.11



Lower-emittance mode commissioning and calibration

- ◆ LOCO calibration, beta beating $\sim 0.40\%/0.45\%$
- ◆ Injection efficiency $\sim 60\%$
- ◆ Coupling $\sim 0.3\%$, Beam life time 17 hours @210mA



Main parameters measurement for low emittance

	design	First measure	Second measure
Tune	23.31, 11.23	23.309, 11.238	23.316, 11.235
Beam Emittance	2.88	2.9 ± 0.2	3.0 ± 0.2
Natural Chromaticity	-74.5, -26.7	-67, -23	-----
Corrected Chromaticity	-----	2.0, 3.0	-----
Injection Efficiency	-----	~50%	60%~70%
Beam Current	-----	210	210
Coupling	-----	0.5%	0.3%
Beam Lifetime	-----	15	17
Alpha 1	4.13e-4	$(4.2 \pm 0.2)e-4$	-----
Synchrotron tune	0.0075	0.0074 ± 0.0002	-----
RMS Beta Beating	-----	0.70%, 0.80%	0.40%, 0.45%

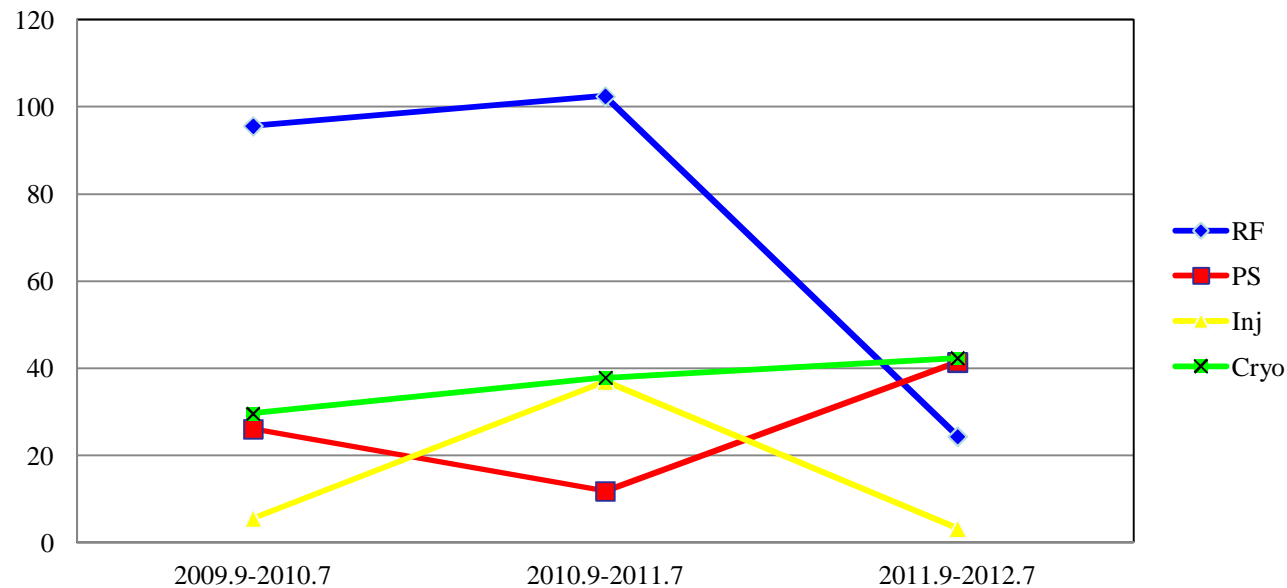
Beamlines commissioning results

Beam lines	Brightness	Other merit
BL08U	+20%	
BL13W	-	Beam size decreased
BL14W	+50%	Ionization chamber I0 decreased
BL14B	+8%	Much stable
BL16B	+7%	Scattering background -10%
BL15U	+30%	Energy resolution
BL17U	-	

Maintenance

- **Routine maintenance every two weeks**
 - check hardware according to plan
 - RF commissioning 5~6 hours
- **Summer shutdown**

Main faults in recent years

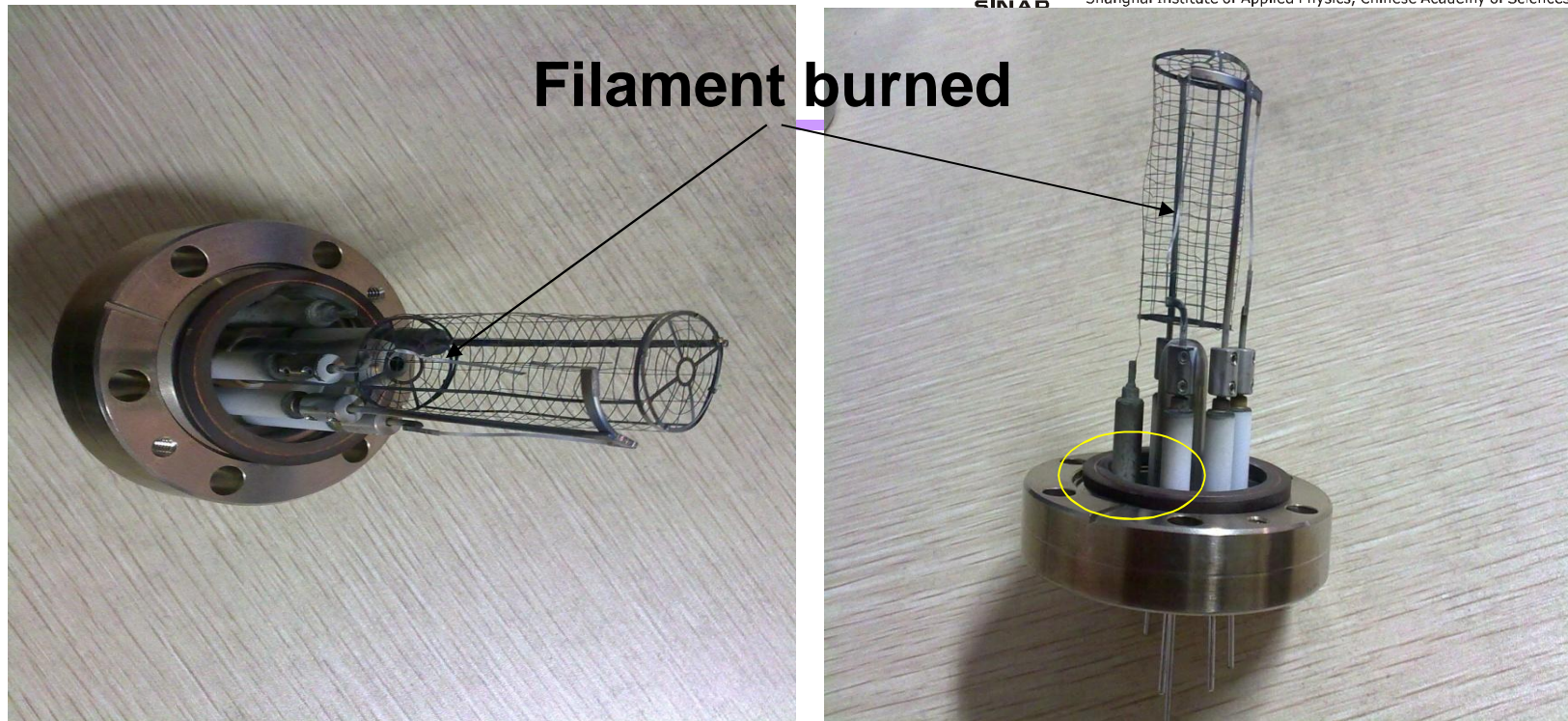


Other problem we meet

VARIAN vacuum gauge



In 2006, some problems had been found with cathode shortcutting



- 2007--2010 , there are 48 filaments which have burned (total 170) at storage ring
- 2010-- 2012 , same case for LINAC and Booster
- The average life time is about 3 years.
- We can not get enough support from VARIAN.



Thank you for your attention