Machine Operation and Progresses in SSRF

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- Introduction
- Operation statistics of SSRF
- Progresses in recent two years
- Maintenance

Location

Shanghai Synchrotron Radiation Facility

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)

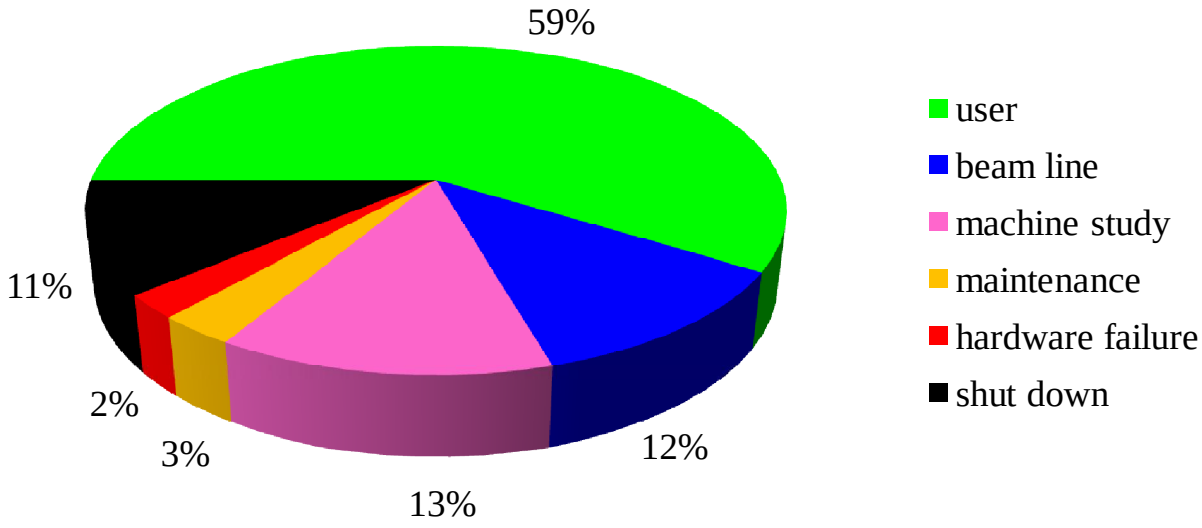
Parameter / unit	Design value	Measured value
Beam energy / GeV	3.50	3.50 ± 0.02
Beam current / mA	200~300	210 (operation current) 300 (achievable)
Tune (H, V)	22.22, 11.29	22.220, 11.290 (± 0.002)
Natural emittance / nm.rad	**3.89**	**3.8 ± 0.2**
Coupling	1%	0.3%
Natural chromaticity (H, V)	-55.7, -17.9	-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

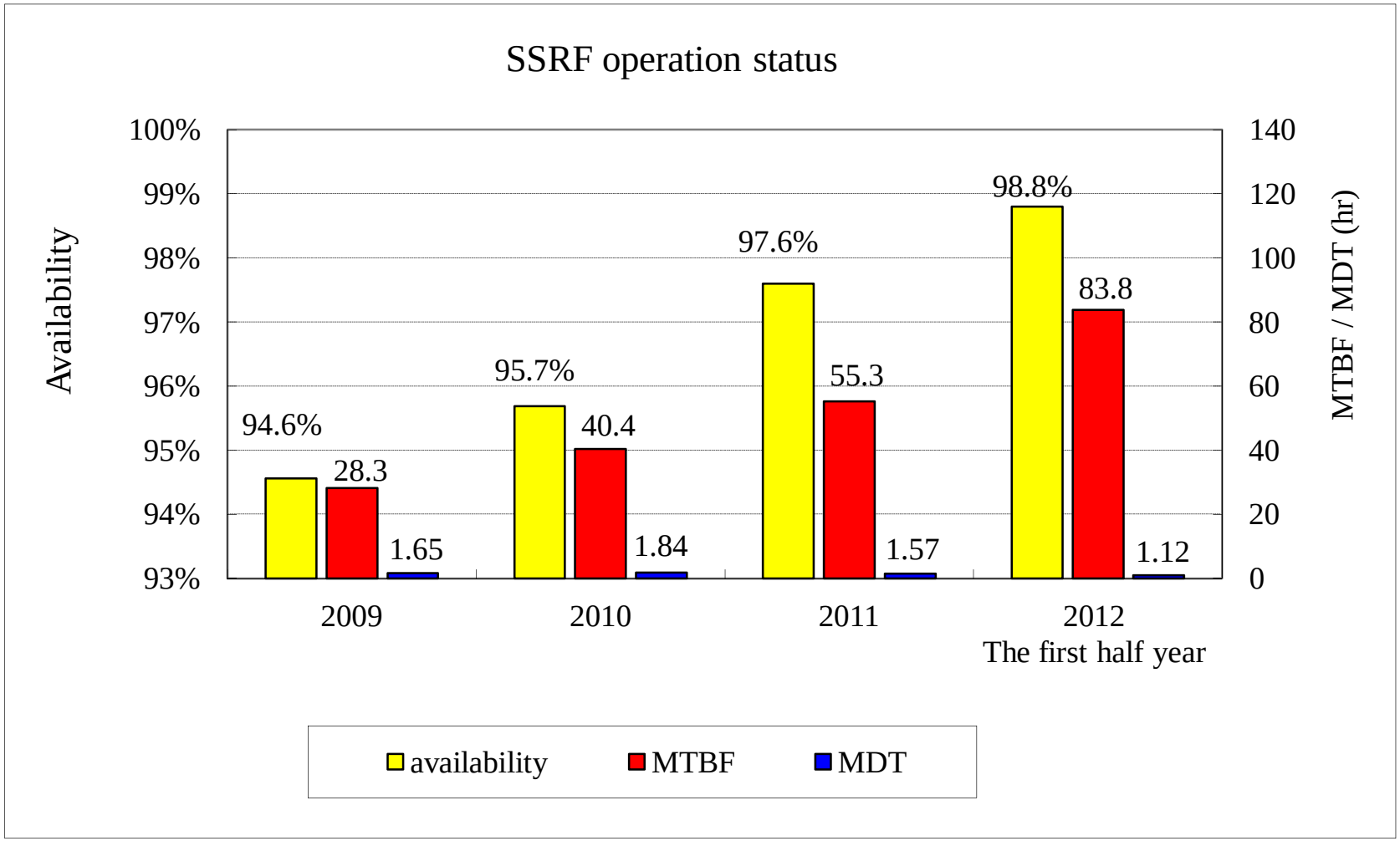
Operation Schedule

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

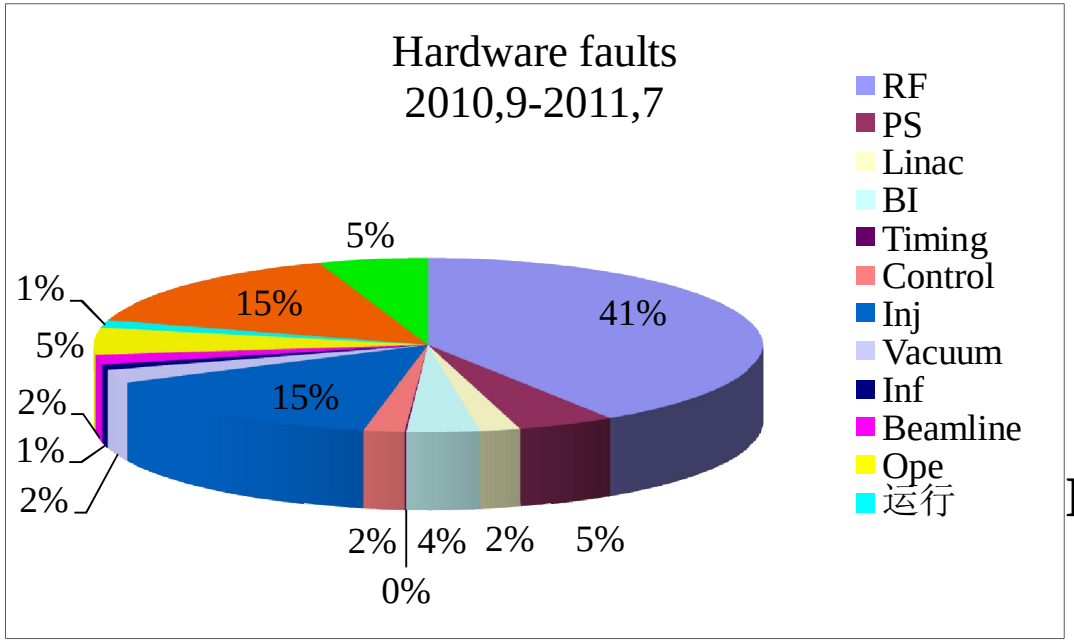
2011.9-2012.7



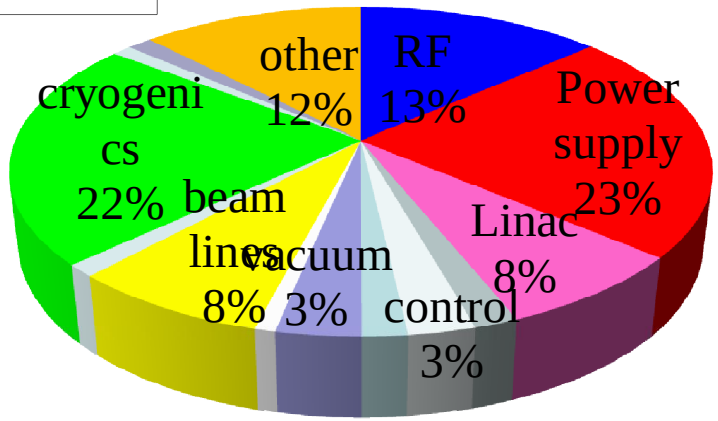
Availability & MTBF during scheduled user time



Hardware faults

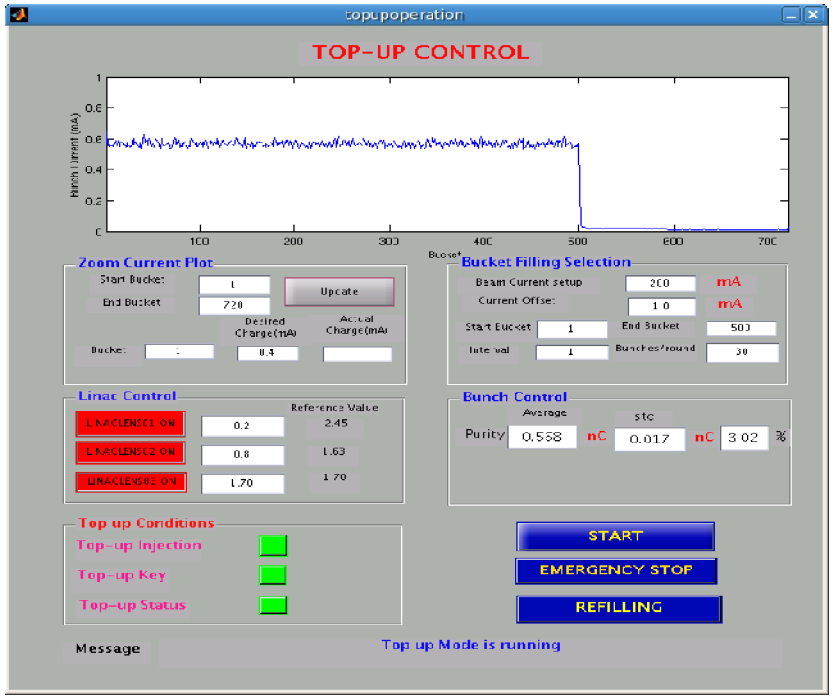


Hardware faults
2011.9-2012.7

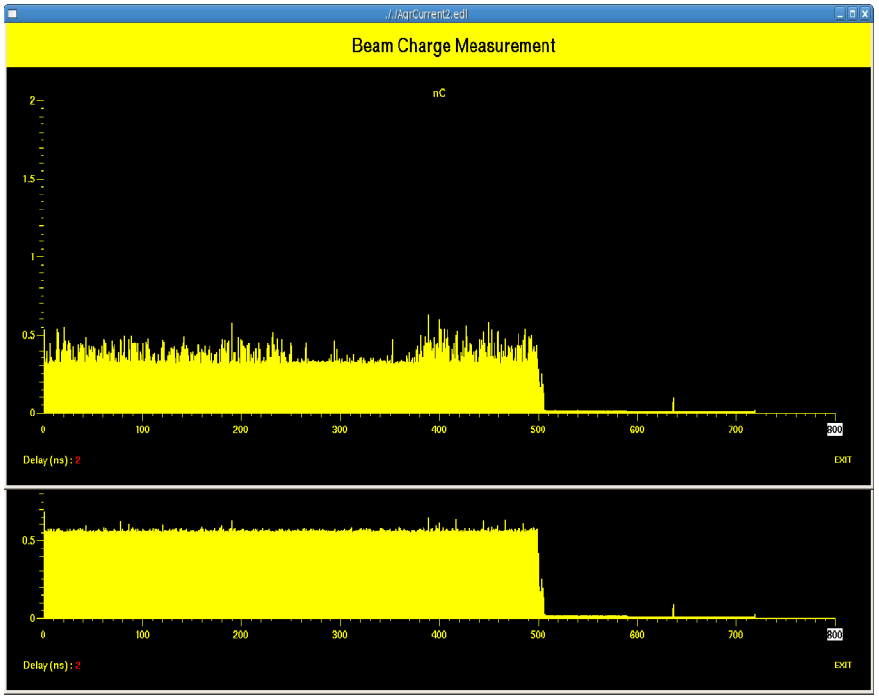


Progresses

Top up preparation

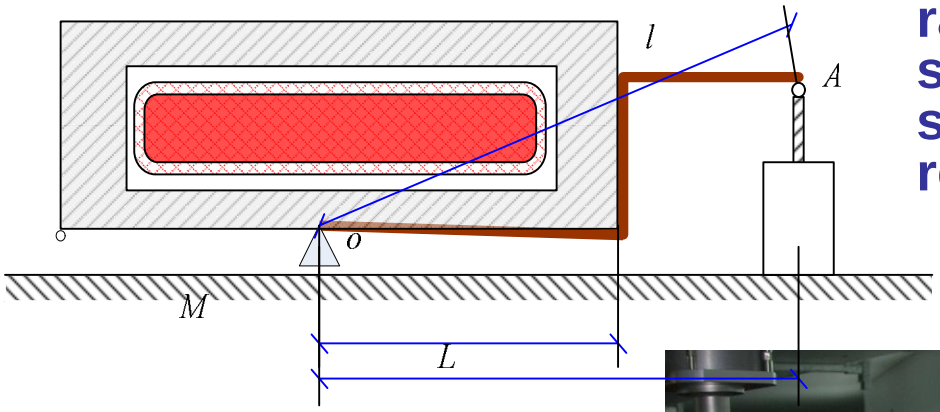


Control software panel



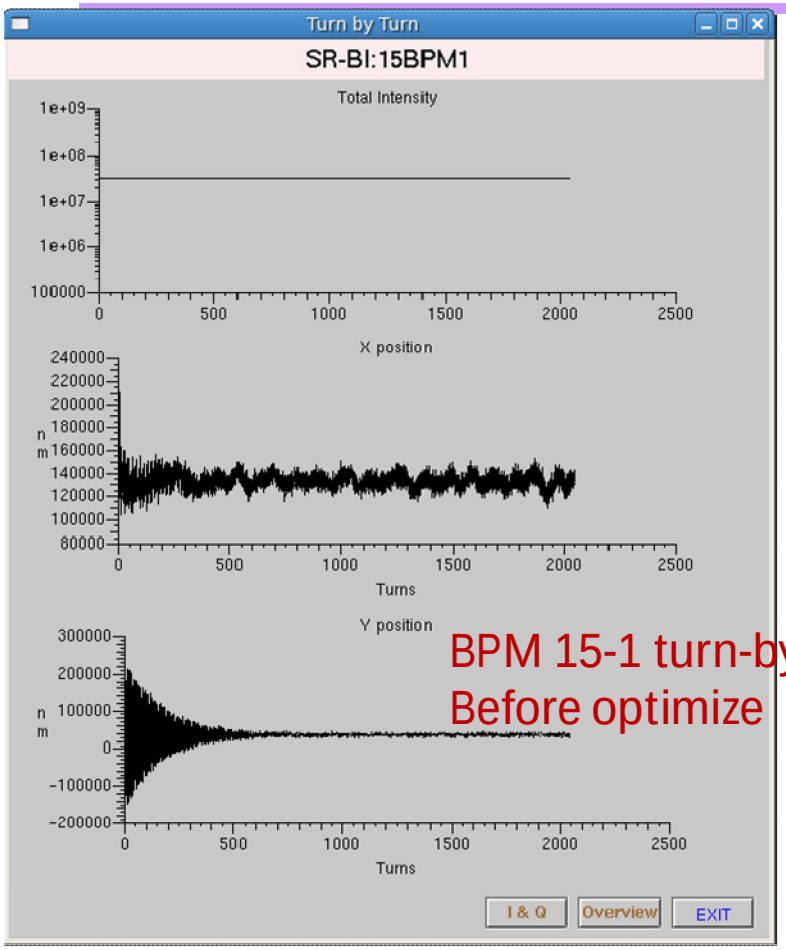
Filling pattern control (up: initial, below: 3hours top-up operation

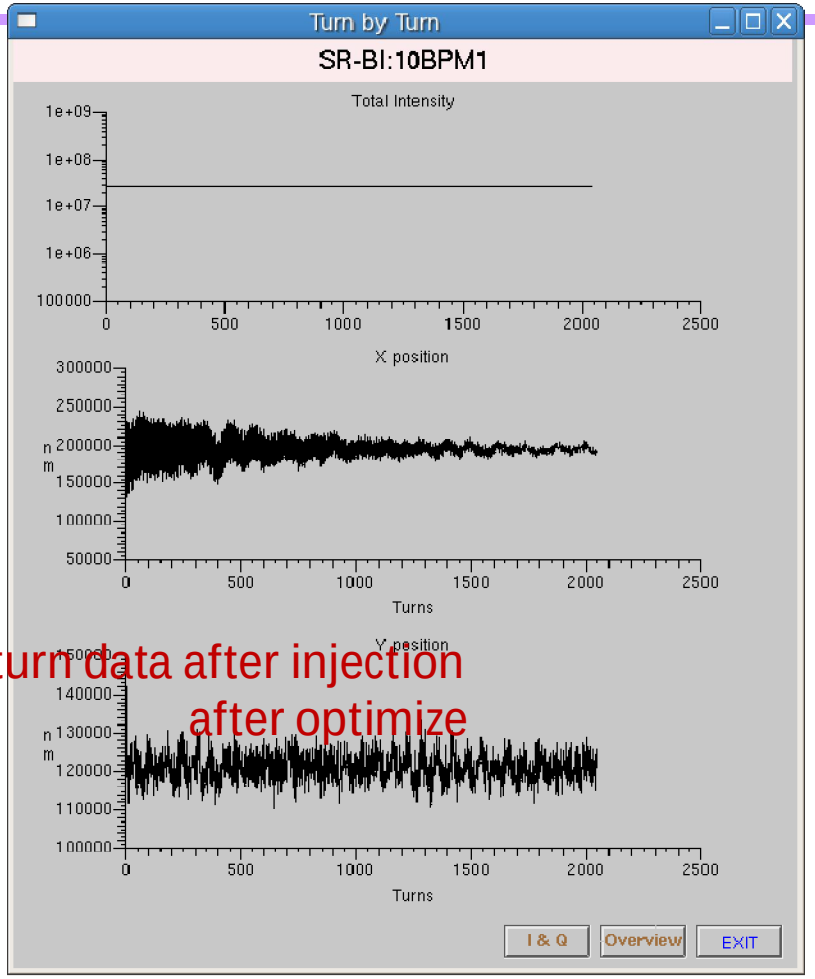
Topup injection



range：-5~5 mrad（±2mm）；
step： < 10μrad；
speed： = 18μrad/sec；
resolution： 10μrad；

Top up commissioning



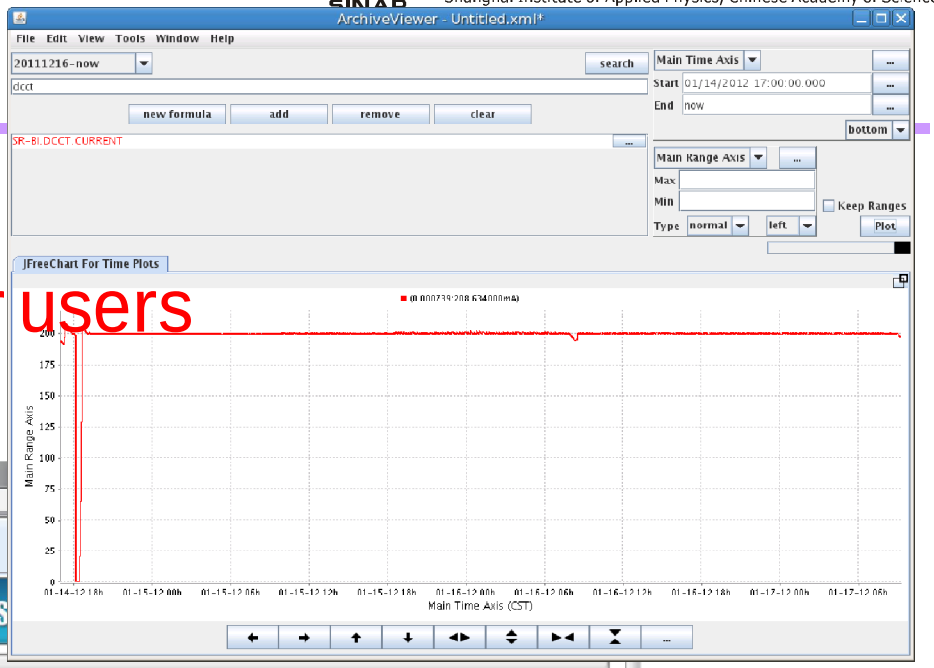


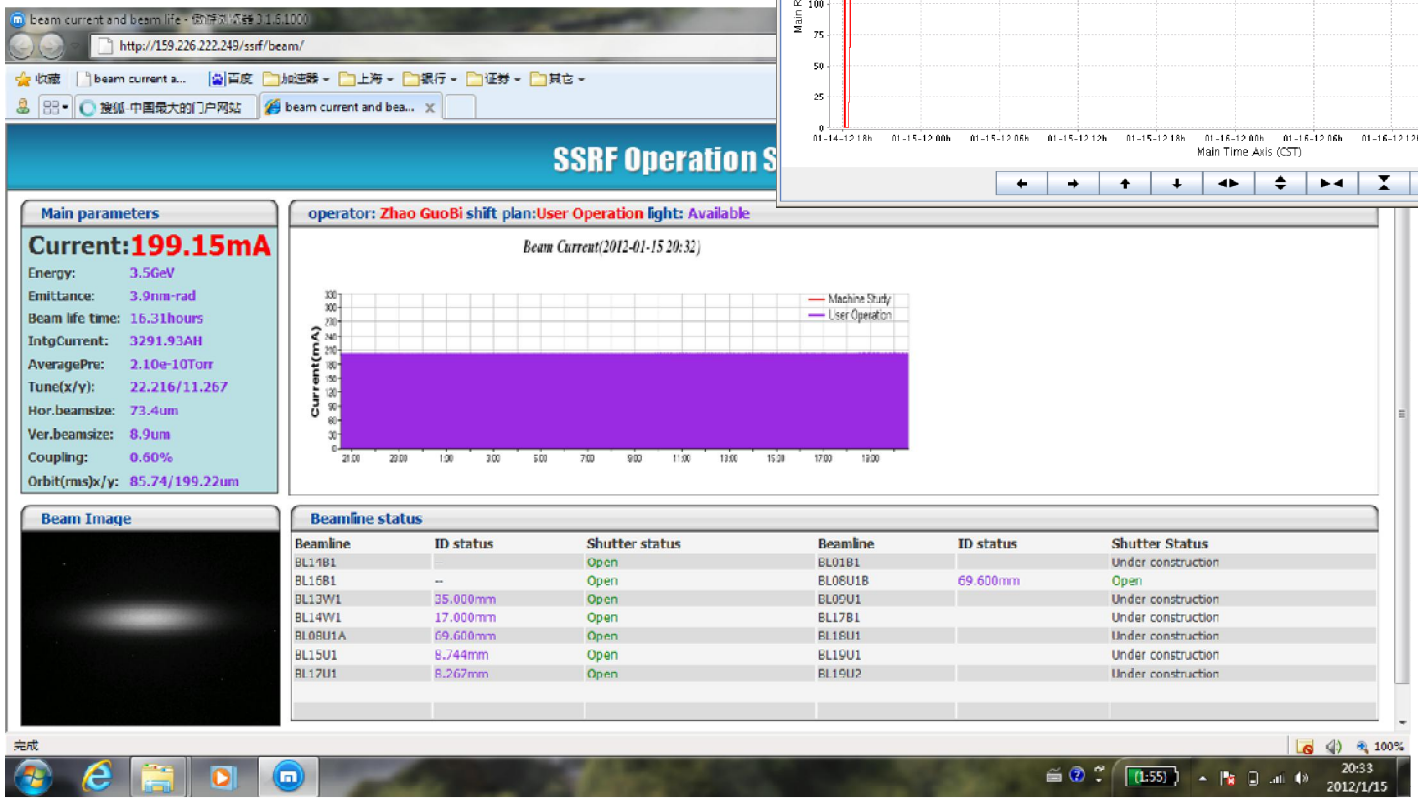
BPM 15-1 turn-by-turn data after injection
Before optimize
after optimize

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

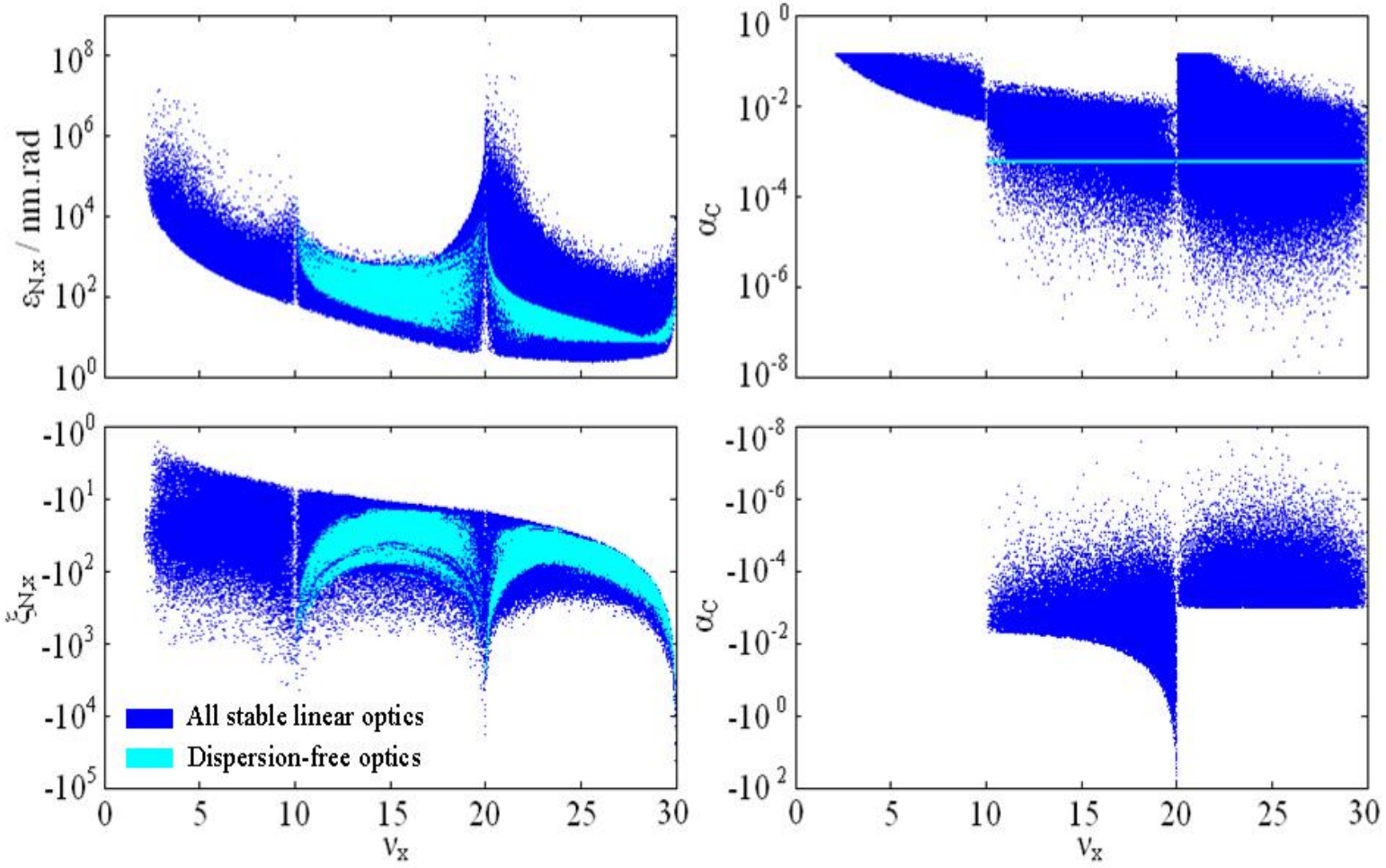
4 days top up operation for users





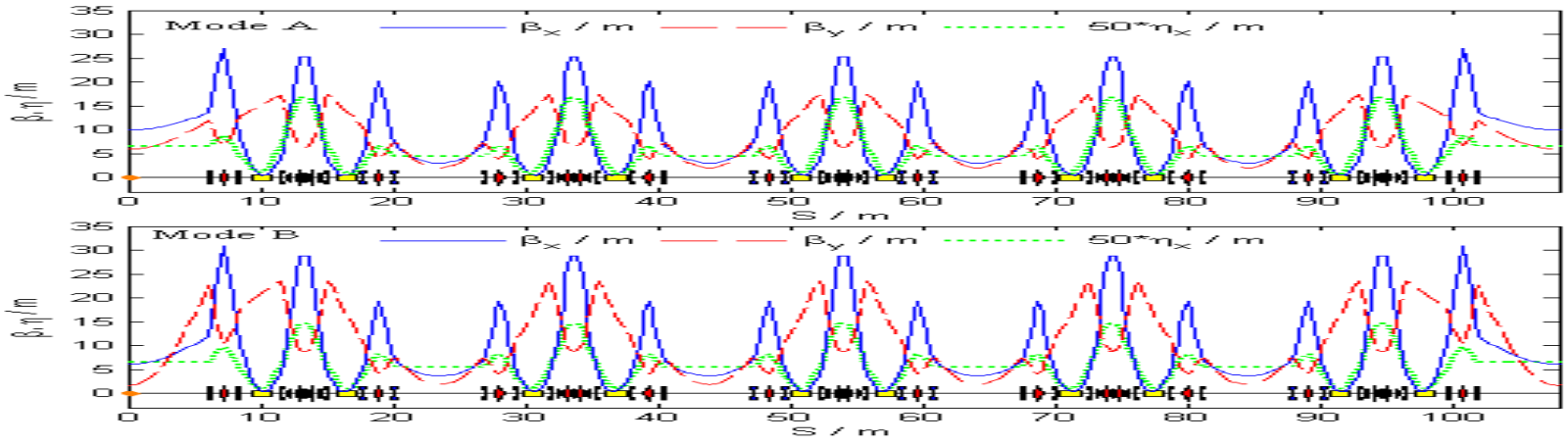
Lower Emittance Lattice mode

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



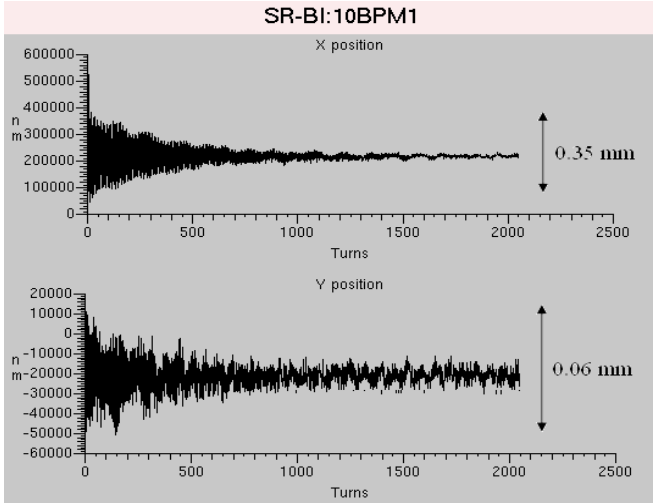
Lower emittance optimization

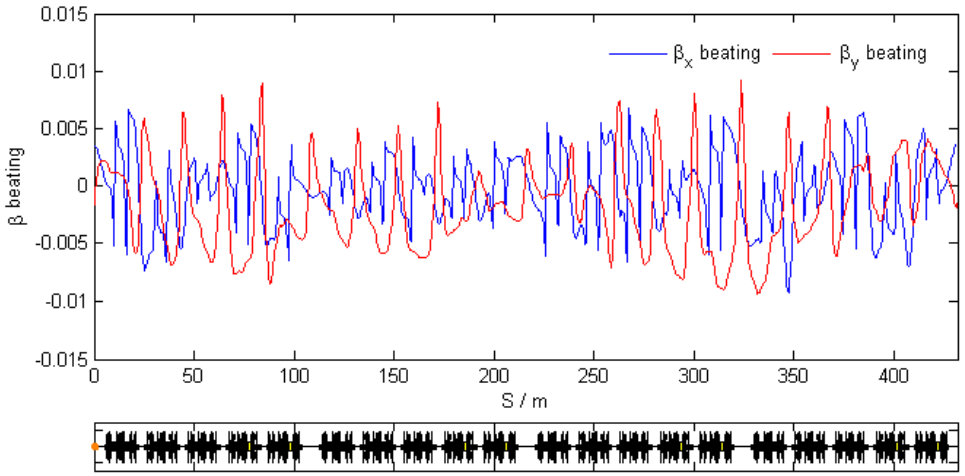
Parameter / unit	Ope. Mode	Mode A	Mode B
Tune (H, V)	22.22, 11.29	23.31, 11.23	23.31, 11.23
Natural emittance / nm.rad	**3.89**	**3.51**	**2.88**
Eff. Emitt. in LSS / nm.rad	4.86	4.25	4.00
Eff. Emitt. in SSS / nm.rad	5.17	4.58	4.15
Natural chromaticity (H, V)	-55.7, -17.9	-69.9, -20.5	-74.5, -26.7
Momentum 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~0.40%/0.45%
- Injection efficiency ~60%
- Coupling~0.3%，Beam life time 17 hours@210mA





Main parameters measurement for low emittance

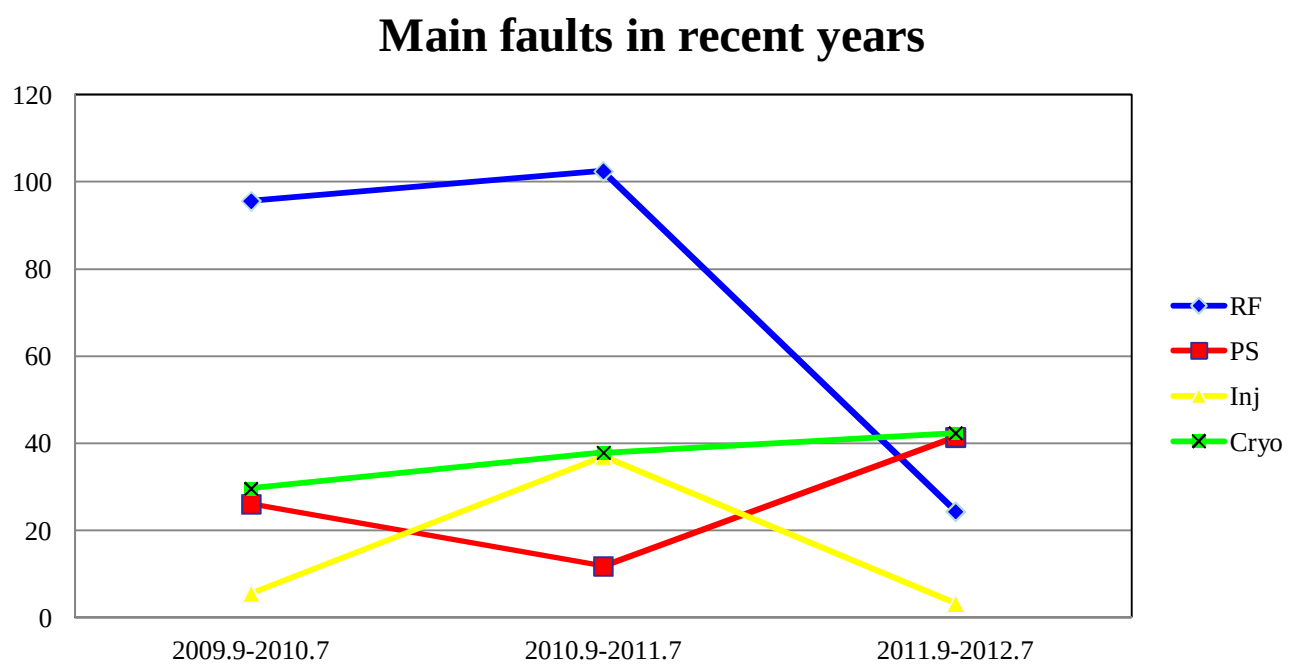
	design	First measure	Second measure
Tune	23.31, 11.23	23.309, 11.238	23.316, 11.235
Beam Emittance	**2.88**	**2.9 ± 0.2**	**3.0 ± 0.2**
Natural Chromaticity	-74.5, -26.7	-67, -23	------
Corrected Chromaticity	------	2.0, 3.0	------
Injection Efficiency	------	~50%	60%~70%
Beam Current	------	210	210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

Beablines 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

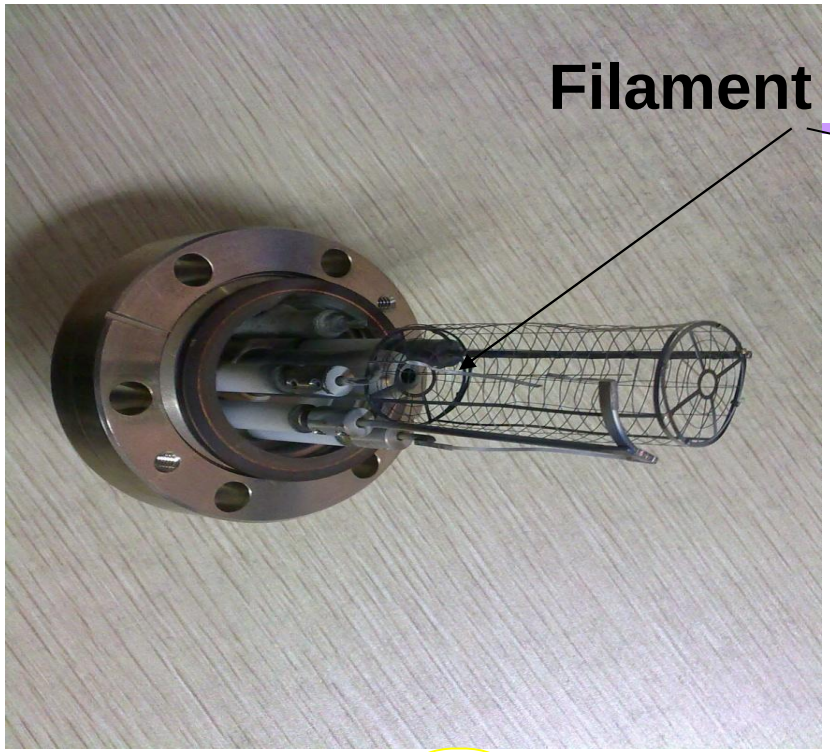
- **Routine maintenance every two weeks**
  - **check hardware according to plan**
  - **RF commissioning 5~6 hours**
- **Summer shutdown**

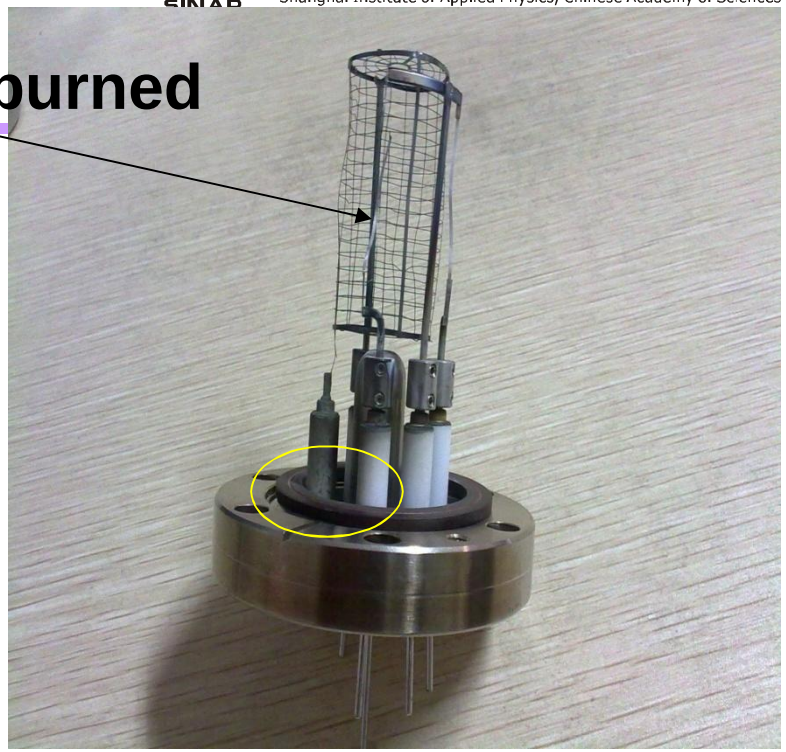


Other problem we meet

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
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