

Status of XAL in CSNS

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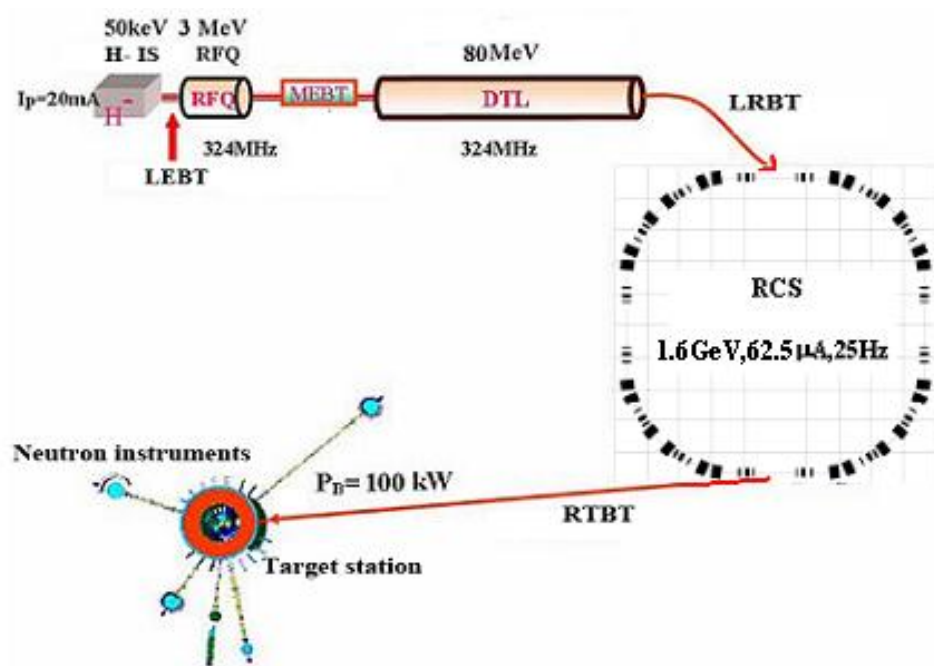
Institute of High Energy Physics

Outline

- Overview
- Preliminary physics needs
- The progress of application software
- Summary

Overview

- The phase-I CSNS facility consists of an 80-MeV H- linac, a 1.6-GeV RCS, 2 beam transport lines, a target station, and 3 instruments.
- Upgradable to 500kW at repetition rate of 25Hz and 20 instruments.
- The design is almost fixed with the officially start of the project.



	CSNS-I	CSNS-II
Beam power (kW)	100	500
Repetition rate (Hz)	25	25
Target number	1	1
Average current (μA)	62.5	312
Proton energy (GeV)	1.6	1.6
Linac energy (MeV)	80	250

Preliminary physics needs

- RFQ
 - Measurement of the transmission efficiency vs. RF voltage.
- DTL
 - Operation mode saving and calling
 - Parameter setting (RF parameters & Lattice)
 - Measurements (Orbit & Transmission efficiency)
- Beam Transport Lines – LE_{BT}&ME_{BT}&LR_{BT}&RT_{BT}
 - Lattice on line matching, Mode saving and calling
 - Measurements (Twiss parameters & Emittance & Orbit)
 - Orbit correction
 - Buncher parameter tuning

- RCS

- DC Mode

- Measurements (Circumference, Twiss parameters & tune, COD, Fudge factor, Dispersion, Chromaticity)
 - Parameter correction (COD, Twiss parameters, Dispersion, Chromaticity)

- AC Mode

- Mode saving and calling, online matching
 - Measurements (COD, Twiss parameters & tune, Timing jitter, Chromaticity, Dispersion, Response matrix, ICA, Fudge factor)
 - Parameter correction (COD, Timing jitter, Chromaticity, Dispersion)
 - Injection (Injection bump measurement, Orbit correction & adjustment, Painting mode saving & calling, fixed bump correction)
 - Extraction (Extraction orbit display & tuning, kicker online matching)
 - Collimation system tuning
 - RF system tuning (RF curve setting and readback)

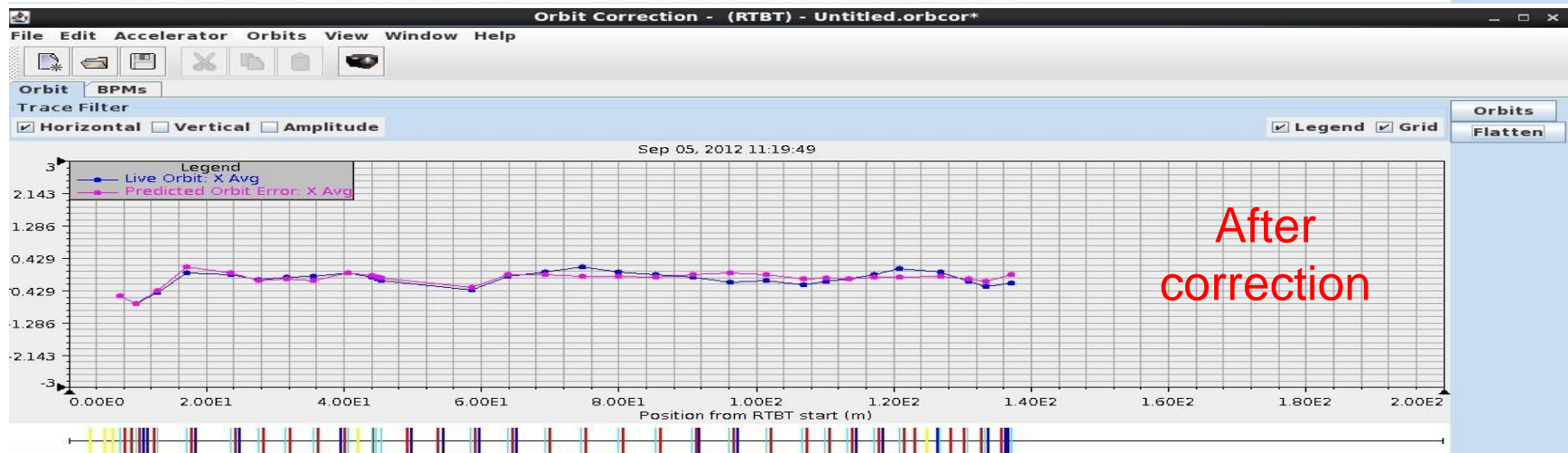
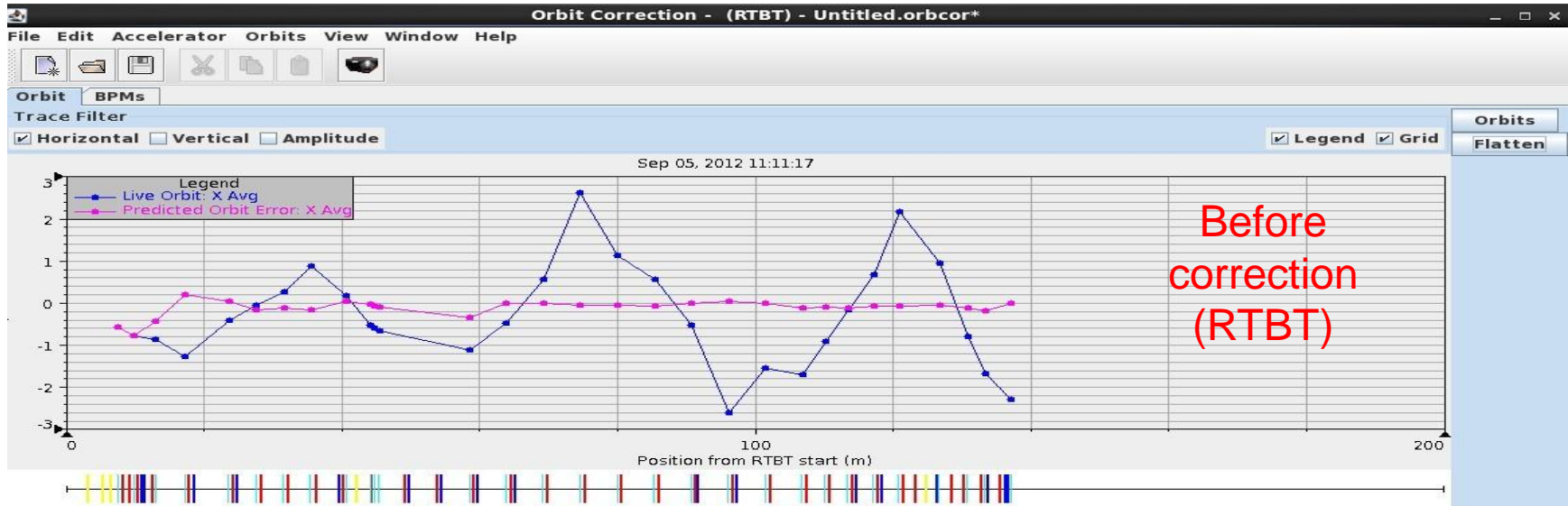
Plan for application software development

- The development of application software for commissioning has been started.
- SNS/SLAC version XAL have been used as the base of development.
- Developing XAL to meet the requirement of CSNS

The progress of application software

- With the application of virtual accelerator, many functions have been performed by transplanting XAL or developing.
 - RTBT/LRBT Orbit Correction
 - RCS Closed Orbit Correction
 - RCS Optics Measurement
 - Injection Painting Bump Control
 - Collimator Control
 - RF Curve Setting And Readback

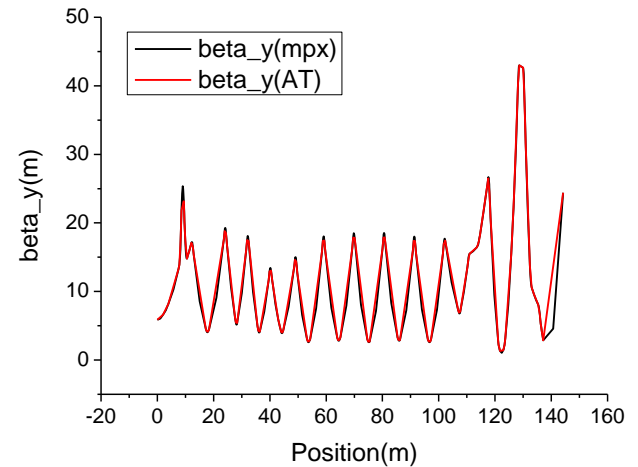
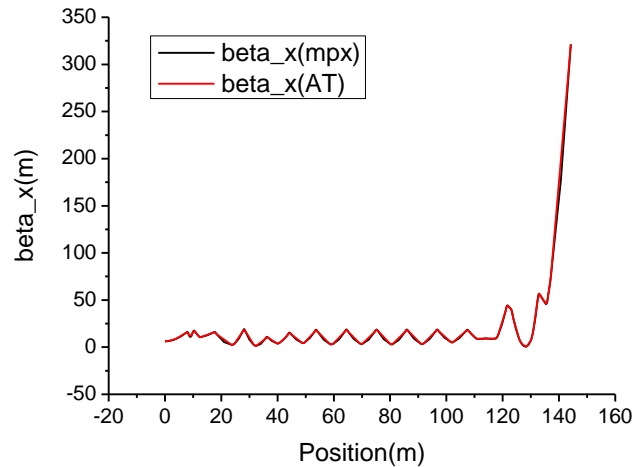
RTBT/LRBT Orbit Correction



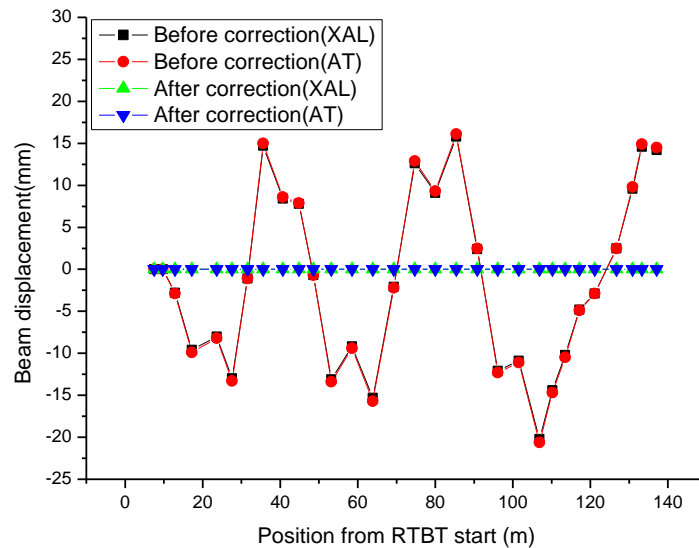
After correction, the measured orbit agrees well with the predicted one.

• Comparison of XAL results with AT

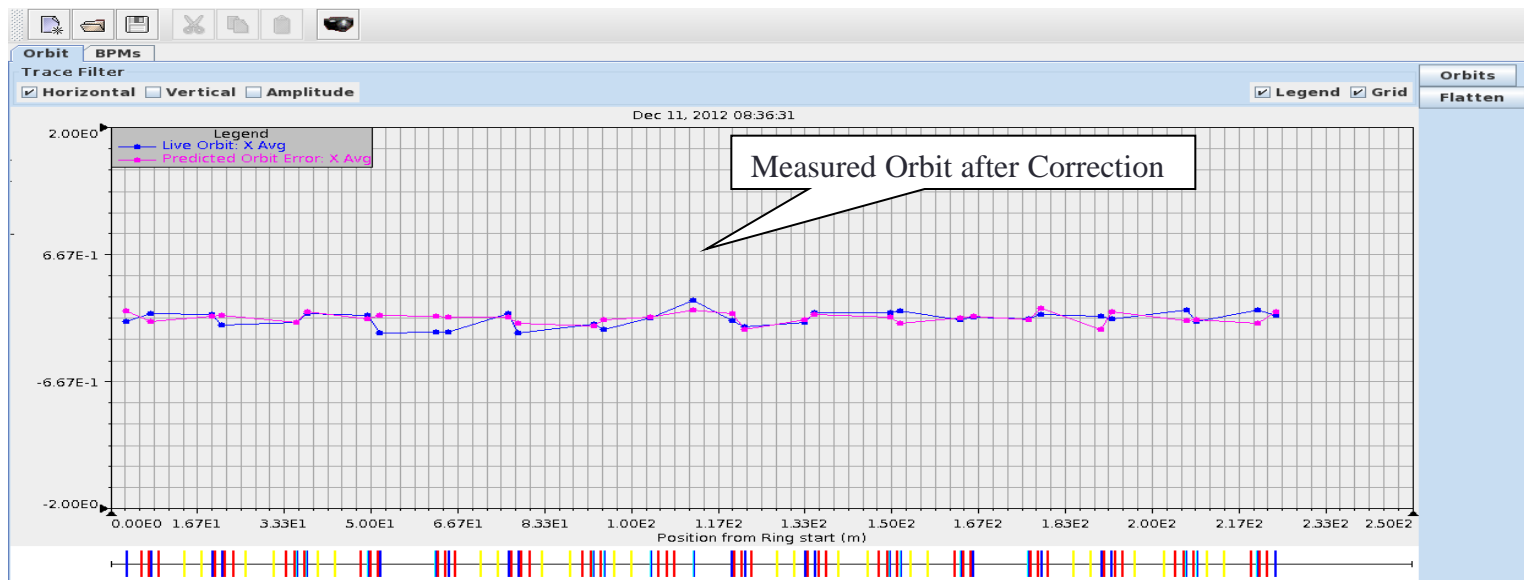
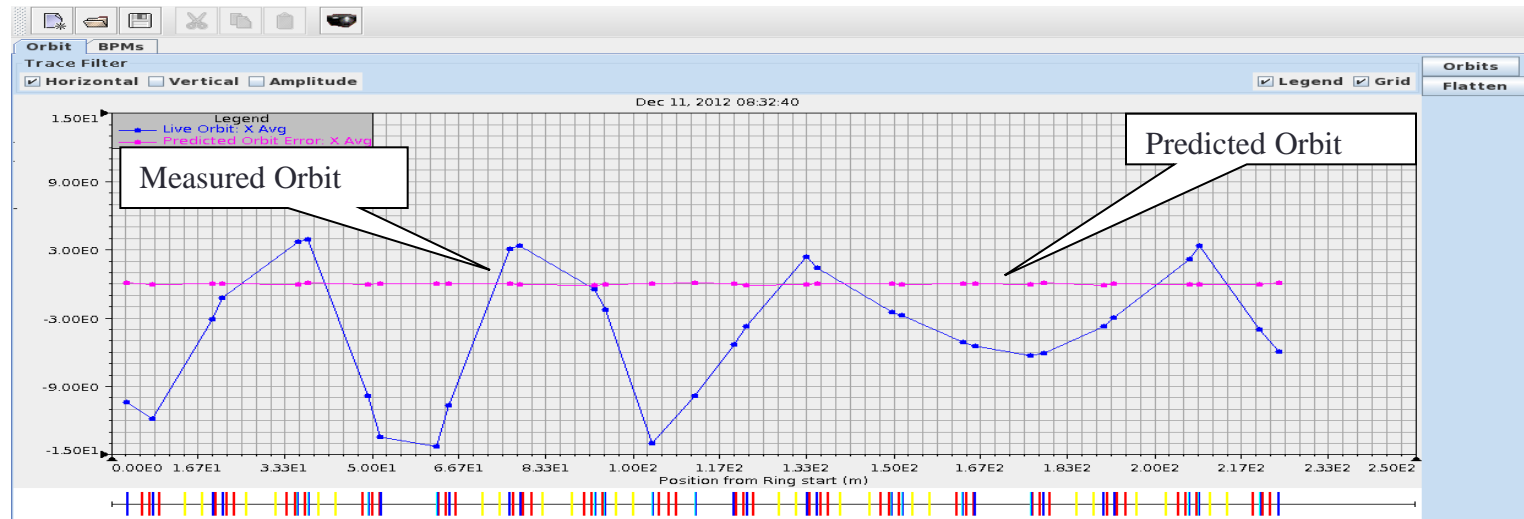
Beta functions:



Orbit correction:

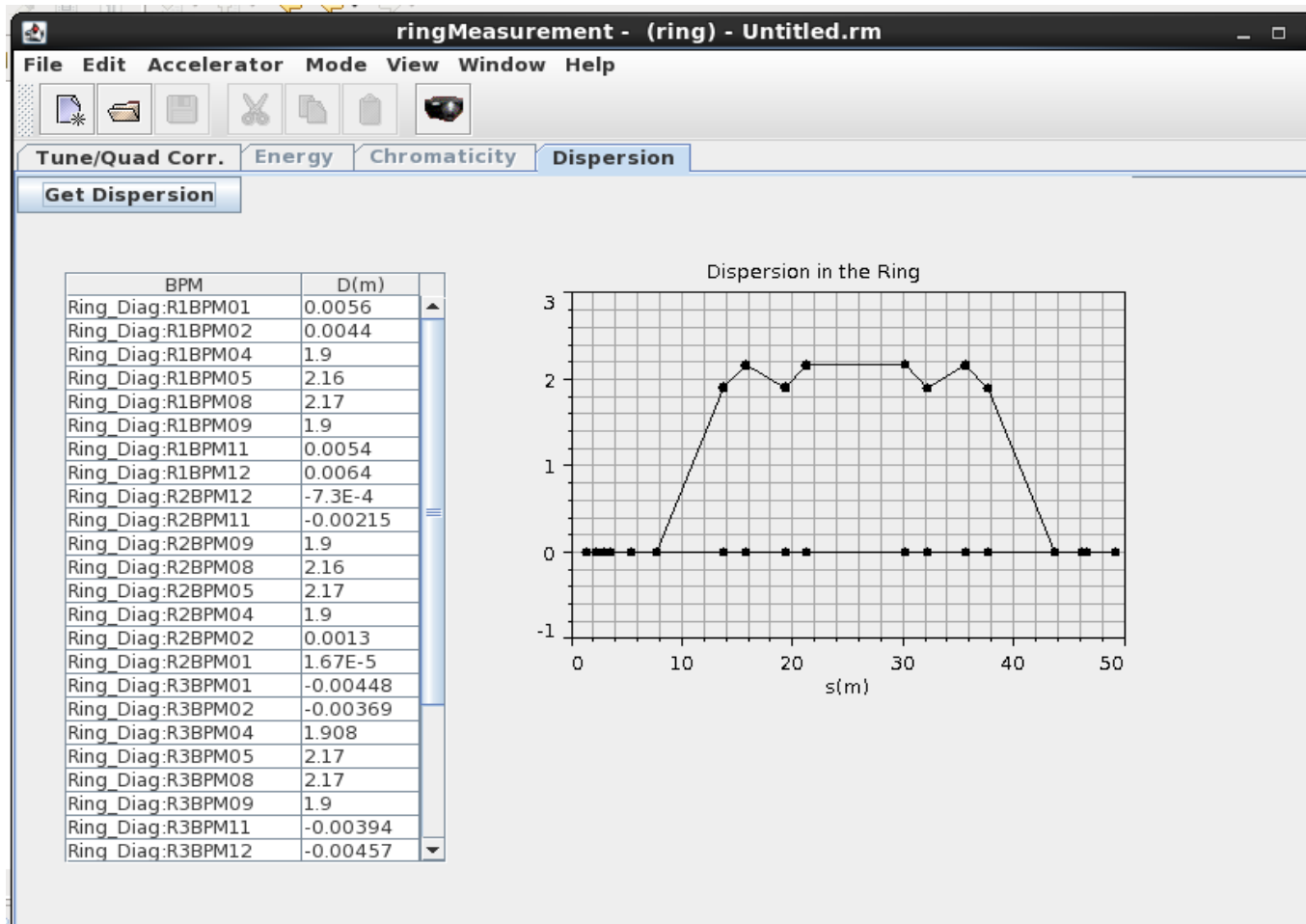


RCS Closed Orbit Correction

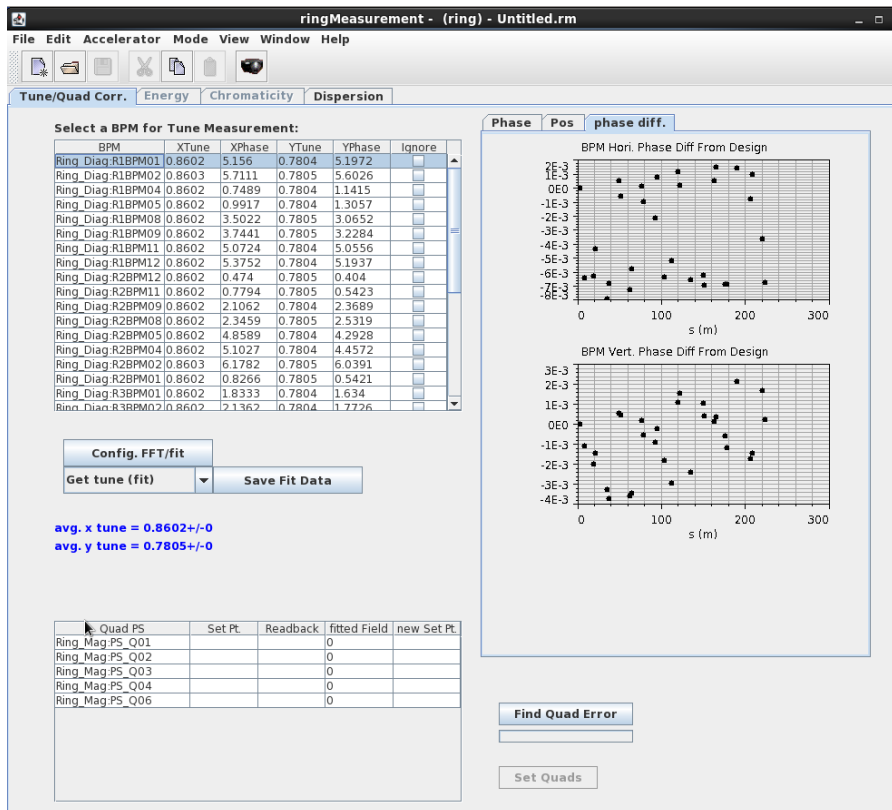


RCS Optics Measurement

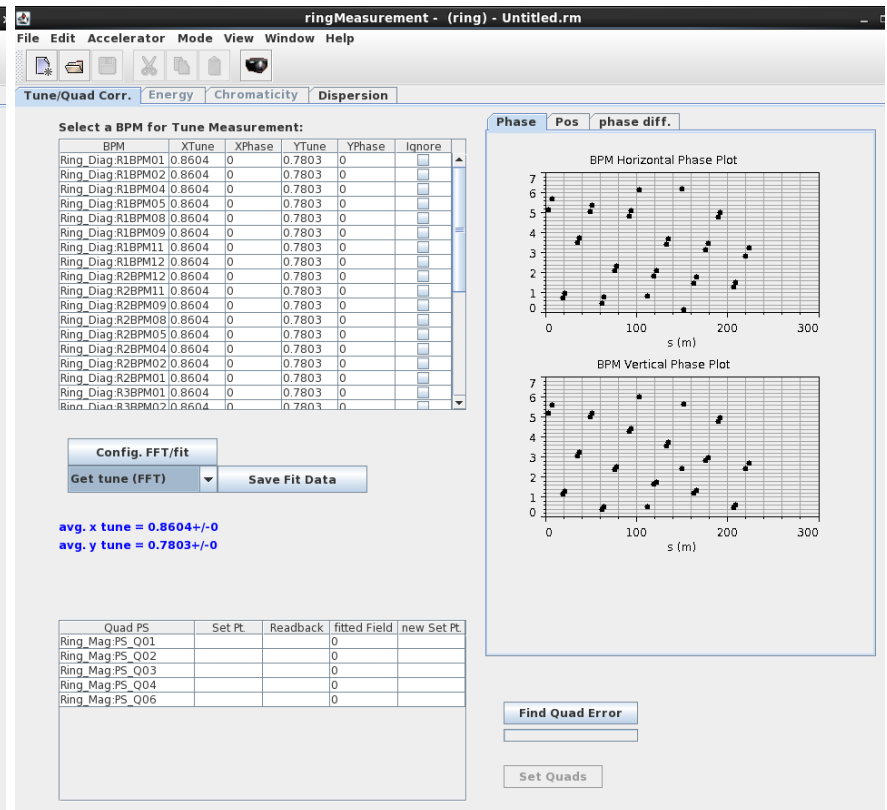
- Dispersion Measurement



Tunes and phase advances Measurement

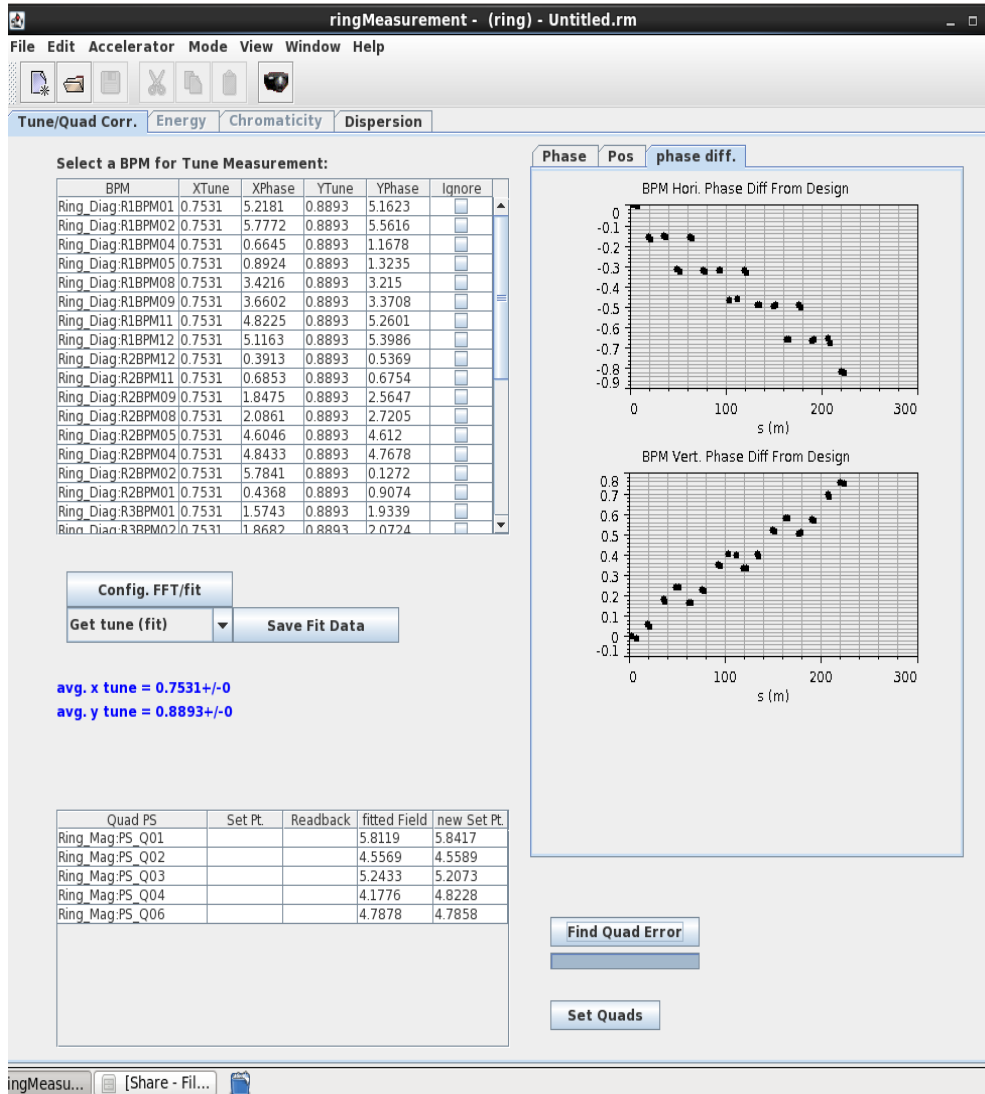


Getting tunes and phase advances by cosine fitting



Getting tunes by FFT

- BPM TBT data is from AT simulation
- The results are consistent with the AT simulations



- The CSNS RCS has 5 families of quadrupoles
 - 4 for focusing quadrupoles, with 8 quadrupoles in each
 - 1 for defocusing quadrupole with 16 quadrupoles
- 5 independent power supplies
- Finding the 5 quadrupole errors by minimizing the difference between the measured phase advances and the model's
- Simplex method is adopted

Finding quad errors

RCS Injection Painting Bump

- Saving and calling of different injection painting curves.

File Edit View Window Help

Icons: New, Open, Save, Cut, Copy, Paste, Print

Parameter	BC Value	Parameter	BH Value	BV Value
H Bump (mm)	57	Start Paint Bump (mm)	57.0	31.0
V Bump (mm)	0	End Paint Bump (mm)	24.0	0.0
		Paint Time (us)	390.0	390.0
		Fall-Off Time (us)	39.0	0.0
		Webble Time of the Power (us)	18.0	18.0

H Waveform Type: **Real painting** V Waveform Type: **Real painting**

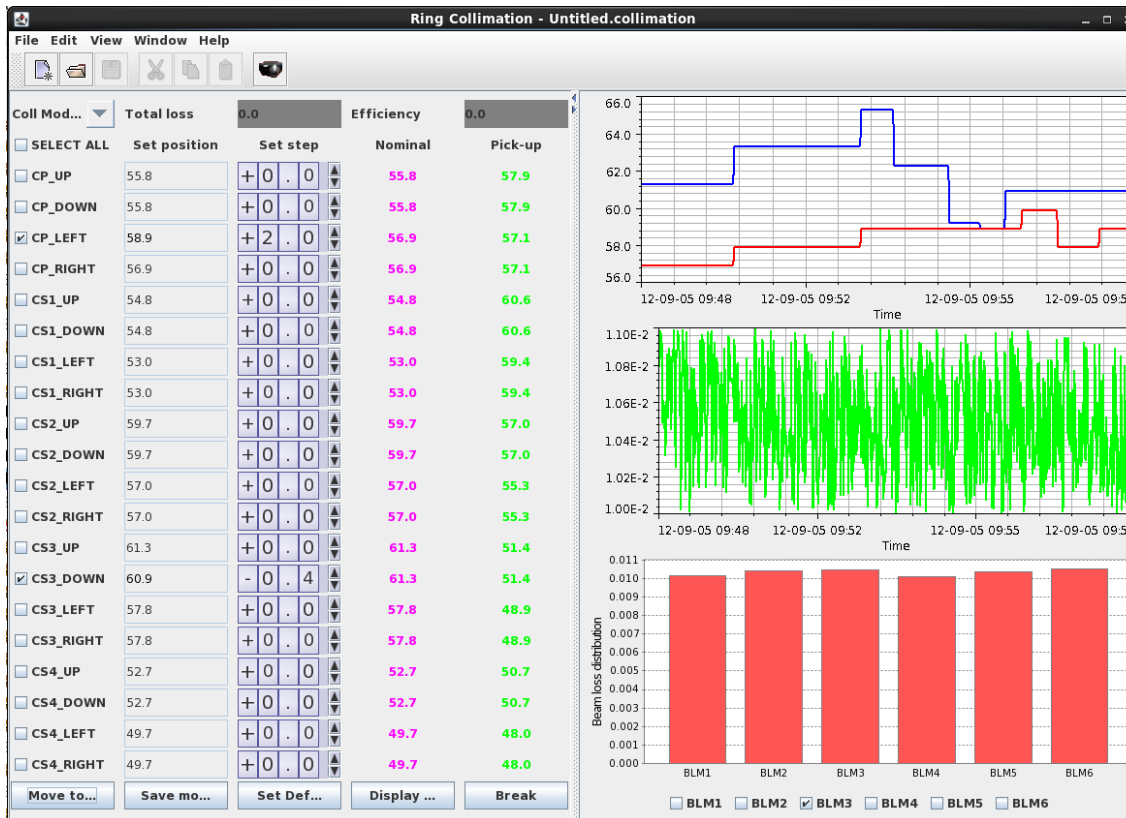
Plot H Waveform Plot V Waveform

Horizontal Waveform Vertical Waveform

Save horizontal with file rootname: Real57-24mm Save vertical with file rootname: Real31-0mm

Submit A Waveform Set to the Machine

Collimator Control



- Two stage collimation system
 - 1 primary collimator
 - 4 secondary collimators
- Each collimator consists of four jaws. Each one can be moved independently.
- The collimator jaws need to be adjusted to obtain a high collimation efficiency.

RF Curve Setting And Readback



- The RF system consists of 8 RF cavities.
- The RF setting varies with the beam energy.
- The RF curve setting includes voltage, phase and frequency.
- Readbacks of the RF curves for each cavity are required.

Errors

- During the transplanting, we have found some errors as we have started with a considerably old version of XAL.
 - Twiss parameters calculation with decimal tune above 0.5

The image shows two side-by-side screenshots of the XAL software interface, comparing Twiss parameters calculated by XAL (left) and MAD (right). The left screenshot is labeled "By XAL" and the right is labeled "By MAD". Both screenshots show a table of parameters for various elements in a particle accelerator. The parameters include s, alpha-x, beta-x, alpha-y, and beta-y. The MAD results show significant differences in the alpha-x and beta-x parameters for several elements, particularly those with decimal tunes above 0.5, which are highlighted in red in the MAD column. The XAL results for these elements are consistently zero or near zero, indicating a discrepancy in the calculation of these parameters.

Element	s	alpha-x	beta-x	alpha-y	beta-y
BEGIN_Ring1	0.0000	-0.0000	-6.4254	0.0000	5.7568
BEGIN_Ring	0.0000	-0.0000	-6.4254	0.0000	5.7568
DR1	5.5000	0.8560	-11.1333	0.9553	11.0115
Ring_Mag_Q_A01x	5.7050	-0.8210	-11.1405	2.7585	11.7650
ELEMENT_CENTER_Ring...	5.7050	0.8211	-11.1405	2.7587	11.7650
Ring_Mag_Q_A01y	5.9100	-2.3969	-10.4739	4.9089	13.3208
DR2	6.7100	1.8817	-7.0510	6.4181	22.3810
Ring_Mag_Q_A02x	7.1600	-0.0423	-6.2175	0.3625	25.5567
ELEMENT_CENTER_Ring...	7.1600	-0.0423	-6.2175	0.3625	25.5567
Ring_Mag_Q_A02y	7.1600	1.7765	-6.9688	-5.8546	22.9838
DR3	8.7600	2.4622	-11.8432	4.0896	11.5478
Ring_Mag_Q_A03x	8.9650	-0.8633	-12.5313	2.3977	10.2301
ELEMENT_CENTER_Ring...	8.9650	-0.8633	-12.5313	2.3977	10.2301
Ring_Mag_Q_A03y	9.1700	0.8311	-12.5380	0.9761	9.5448
DR4	12.9700	0.3187	8.1689	0.1987	5.0809
Ring_Mag_DH_A01x	14.0200	0.1787	7.7852	0.0589	4.7229
ELEMENT_CENTER_Ring...	14.0200	0.1787	7.7852	0.0589	4.7229
Ring_Mag_DH_A01y	15.0700	0.0387	7.4269	-0.0848	4.8333
DR5	16.2700	-0.1231	7.5281	-0.3349	5.3370
Ring_Mag_DH_A02x	17.3200	-0.2631	8.0684	-0.4561	6.0755
ELEMENT_CENTER_Ring...	17.3200	-0.2631	8.0684	-0.4561	6.0755
Ring_Mag_DH_A02y	18.3700	-0.4031	8.6205	-0.5458	7.2524
DR6	19.6700	-0.5784	9.3953	-0.7785	8.9740
Ring_Mag_Q_A04x	19.8950	0.6711	9.8752	-2.0393	9.8019
ELEMENT_CENTER_Ring...	19.8950	0.6711	9.8752	-2.0393	9.8019
Ring_Mag_Q_A04y	20.1200	1.8438	9.3039	-3.5379	10.8448
DR7	21.4200	1.2290	5.3093	-5.1583	22.1499
Ring_Mag_Q_A05x	21.8700	-0.1960	4.8617	0.8210	24.1817
ELEMENT_CENTER_Ring...	21.8700	-0.1960	4.8617	0.8210	24.1817
Ring_Mag_Q_A05y	22.3200	-1.7166	5.6903	6.4299	20.7849
DR8	23.1200	-2.2715	8.8808	4.8001	11.8009
Ring_Mag_Q_A06x	23.4300	-0.6072	9.7909	2.4023	9.6107
ELEMENT_CENTER_Ring...	23.4300	-0.6072	9.7909	2.4023	9.6107
Ring_Mag_Q_A06y	23.7400	1.1964	9.6046	0.5775	8.7045
DR9	24.6400	0.9686	7.6561	0.4396	7.7891
Ring_Mag_DH_A03x	25.6900	0.7058	6.0205	0.3892	6.7846
ELEMENT_CENTER_Ring...	25.6900	0.7058	6.0205	0.3892	6.7846
Ring_Mag_DH_A03y	26.7400	0.4430	4.7254	0.3120	6.1543
DR10	30.2400	-0.4430	4.7254	-0.3120	6.1543
Ring_Mag_DH_A06x	31.2900	-0.7058	6.0205	-0.3892	6.7846
ELEMENT_CENTER_Ring...	31.2900	-0.7058	6.0205	-0.3892	6.7846
Ring_Mag_DH_A06y	32.3400	-0.9686	7.6561	-0.4396	7.7891

Comparison of Twiss function obtained by MAD and XAL @ (4.86, 4.78)

Summary

- The preliminary physics needs has been identified.
- The work of high level application software has started. Part of XAL has been transplanted to CSNS, and some new apps have also been developed.
- The application software work will be continued, and the fundamental software package is expected to be available for day 1 commissioning within one year.

Thank you for your attention!
