Status of XAL in CSNS

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Outline

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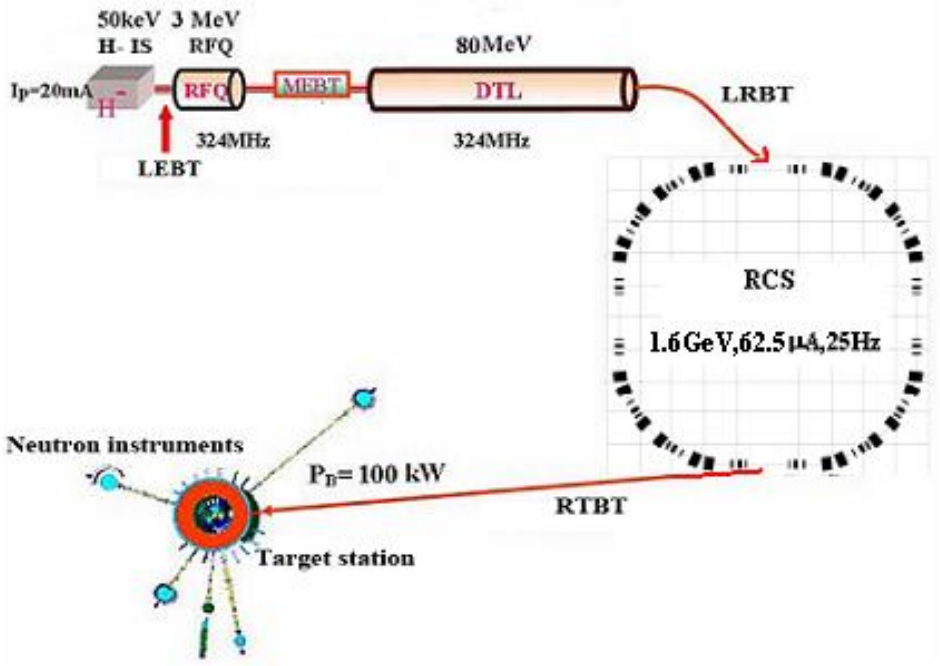
- Preliminary physics needs
- The progress of application software
- Summary

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 – LEBT&MEBT&LRBT&RTBT
  - 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)

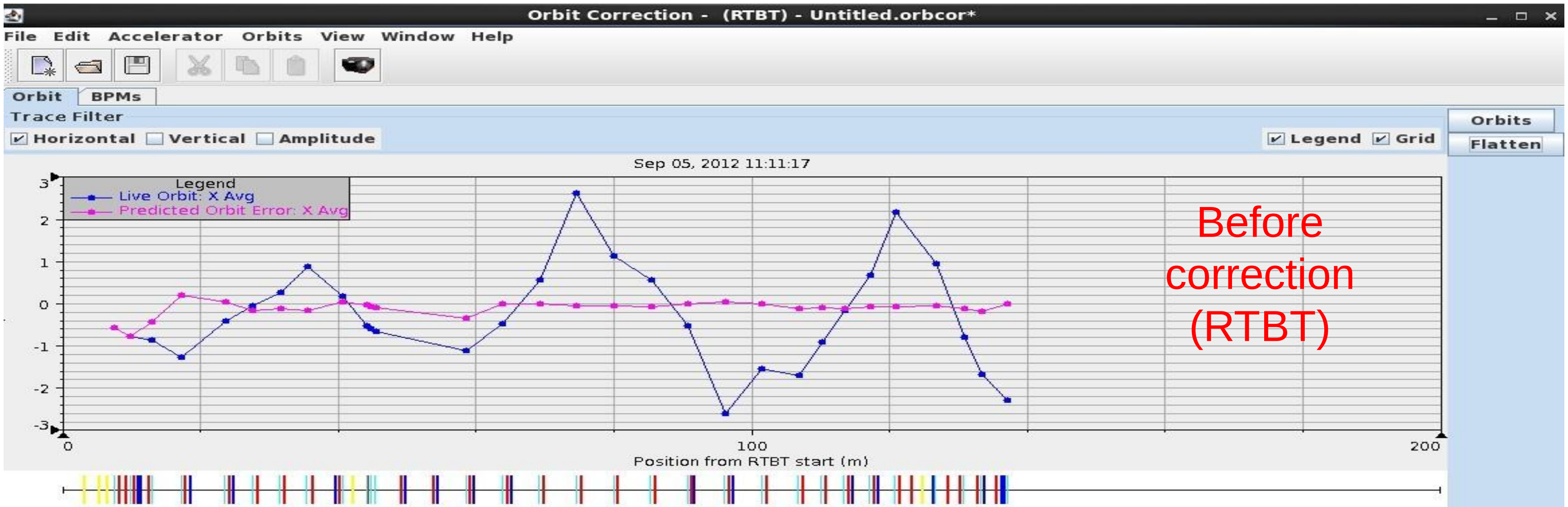
Plan for application software development

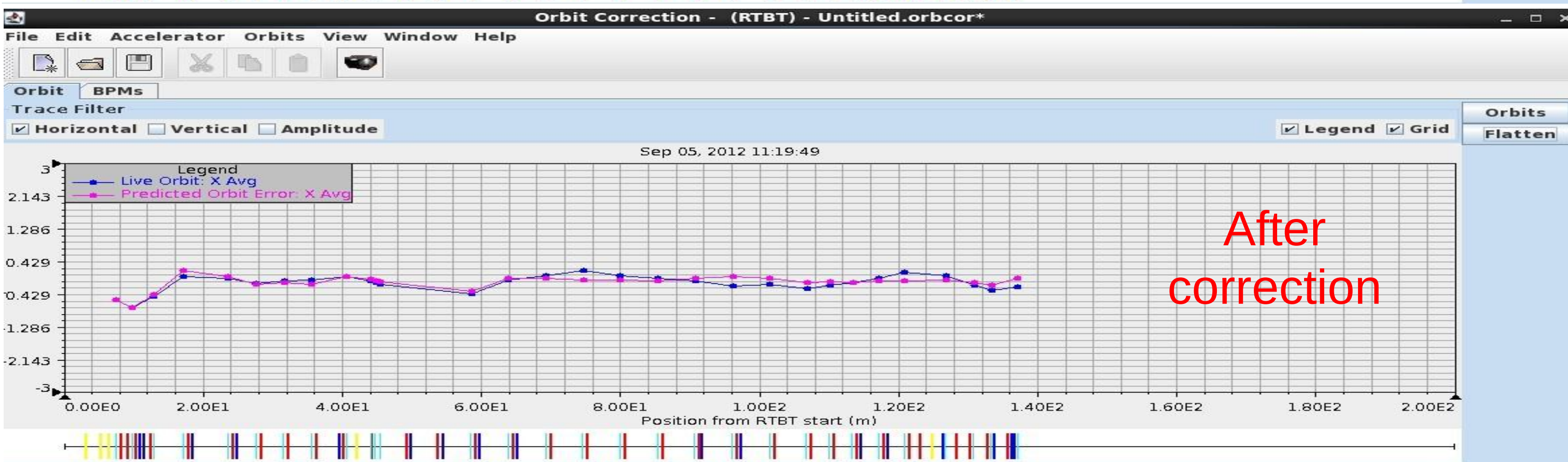
- The development of application software for commissioning has been started.
- SNS/SLAC version XAL have been used as the base of development.
- Developing XAL to meet the requirement of CSNS

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

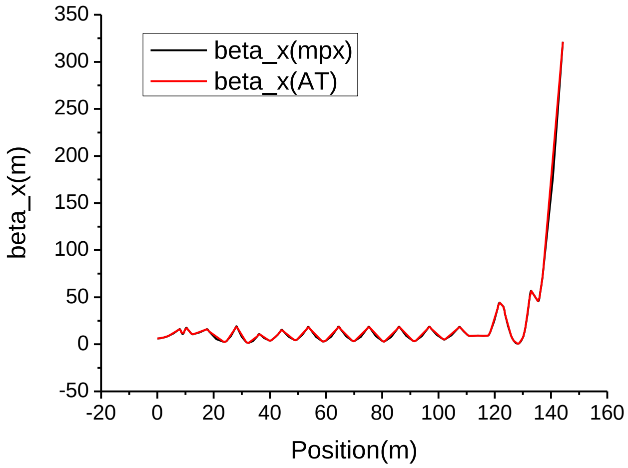


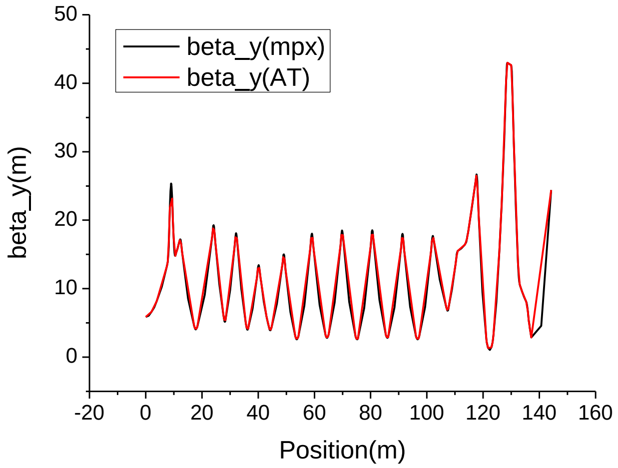


After correction, the measured orbit agrees well with the predicted one.

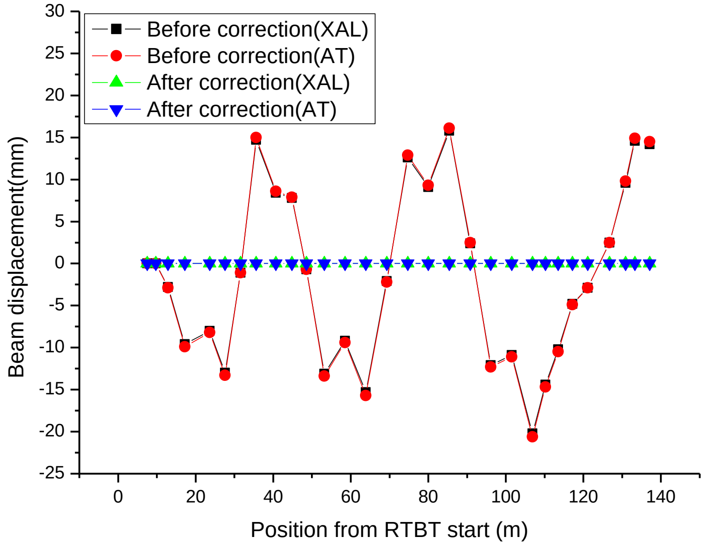
• Comparison of XAL results with AT

Beta functions:

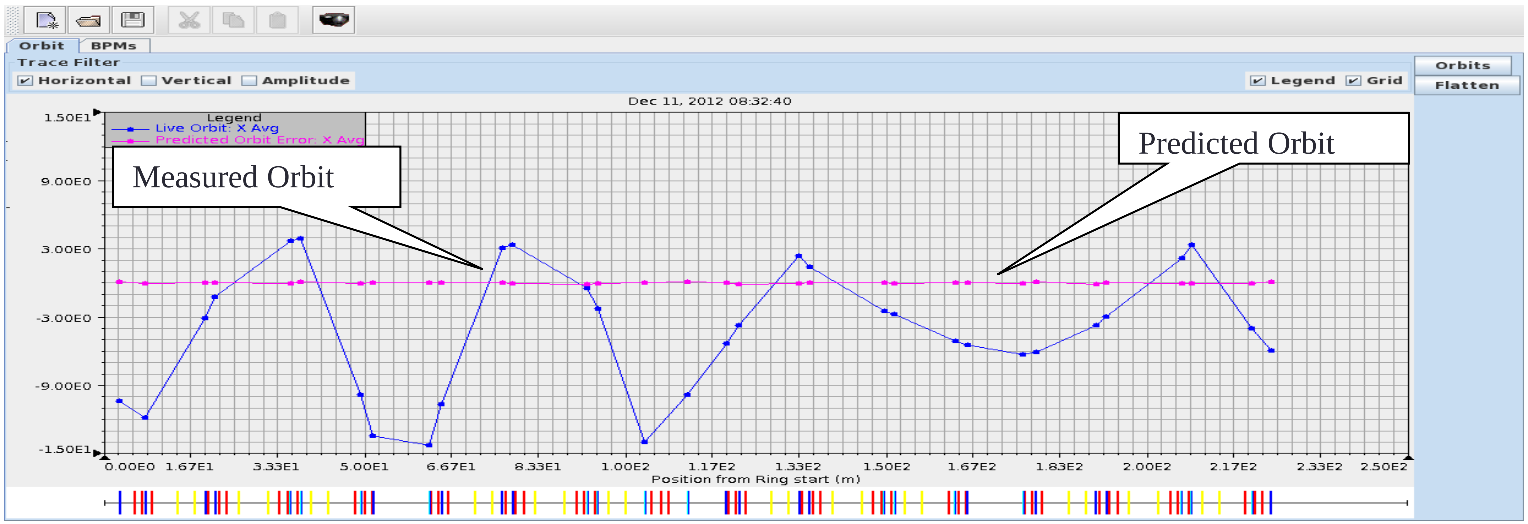


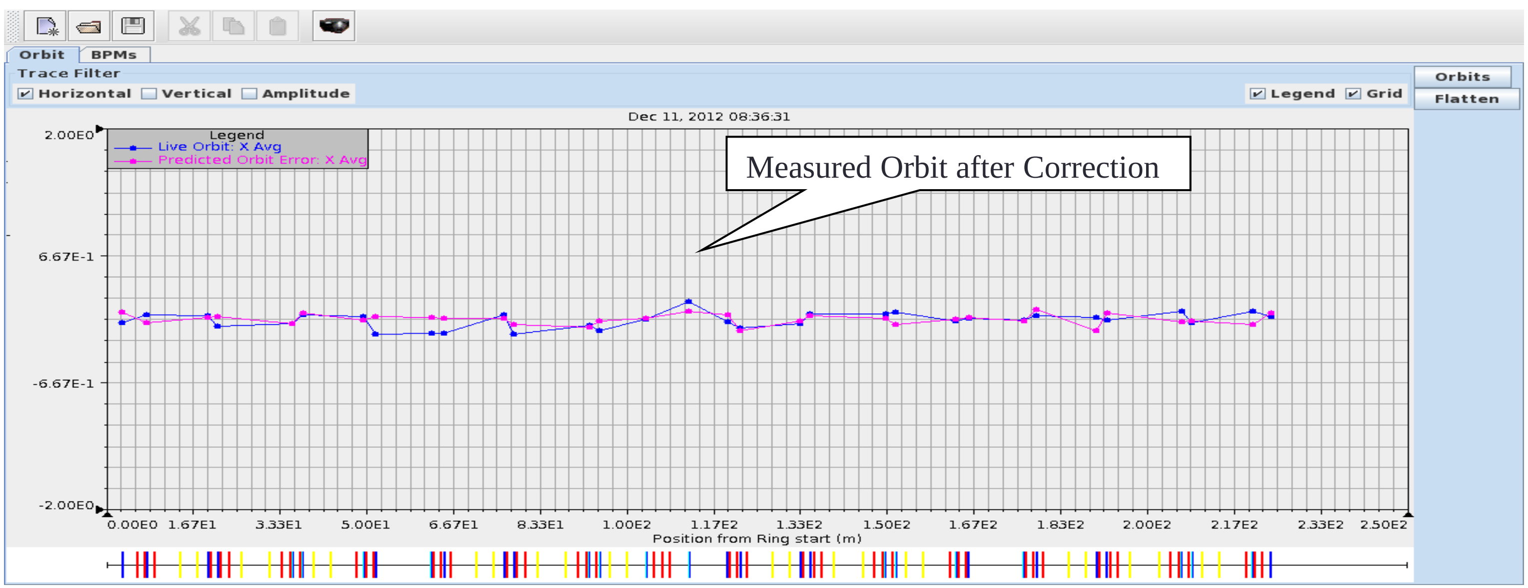


Orbit correction:



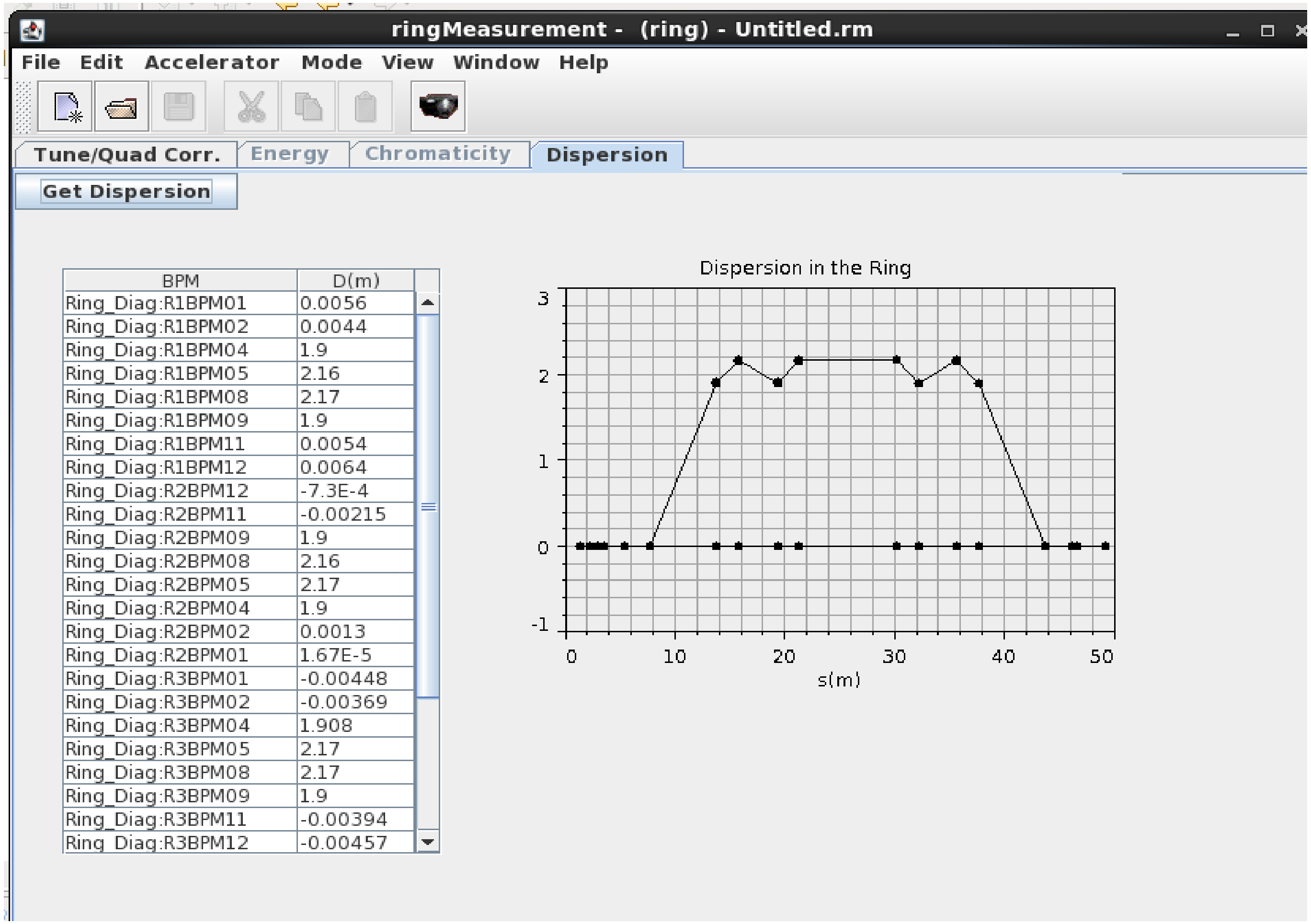
RCS Closed Orbit Correction





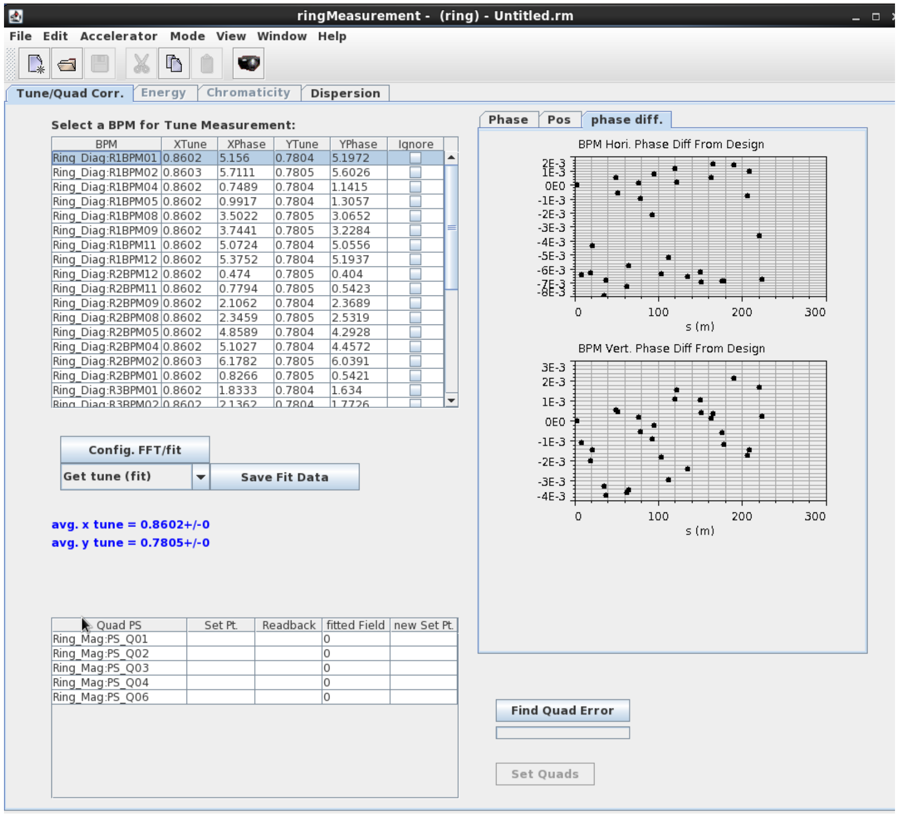
RCS Optics Measurement

- Dispersion Measurement

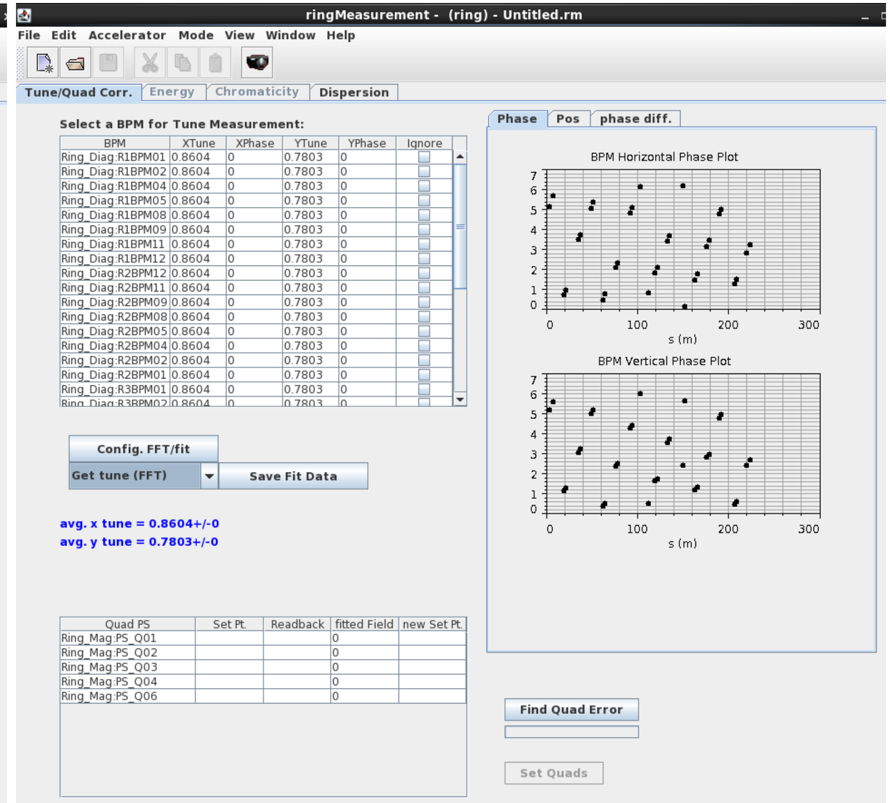


BPM	D(m)
Ring_Diag:R1BPM01	0.0056
Ring_Diag:R1BPM02	0.0044
Ring_Diag:R1BPM04	1.9
Ring_Diag:R1BPM05	2.16
Ring_Diag:R1BPM08	2.17
Ring_Diag:R1BPM09	1.9
Ring_Diag:R1BPM11	0.0054
Ring_Diag:R1BPM12	0.0064
Ring_Diag:R2BPM12	-7.3E-4
Ring_Diag:R2BPM11	-0.00215
Ring_Diag:R2BPM09	1.9
Ring_Diag:R2BPM08	2.16
Ring_Diag:R2BPM05	2.17
Ring_Diag:R2BPM04	1.9
Ring_Diag:R2BPM02	0.0013
Ring_Diag:R2BPM01	1.67E-5
Ring_Diag:R3BPM01	-0.00448
Ring_Diag:R3BPM02	-0.00369
Ring_Diag:R3BPM04	1.908
Ring_Diag:R3BPM05	2.17
Ring_Diag:R3BPM08	2.17
Ring_Diag:R3BPM09	1.9
Ring_Diag:R3BPM11	-0.00394
Ring_Diag:R3BPM12	-0.00457

Tunes and phase advances Measurement

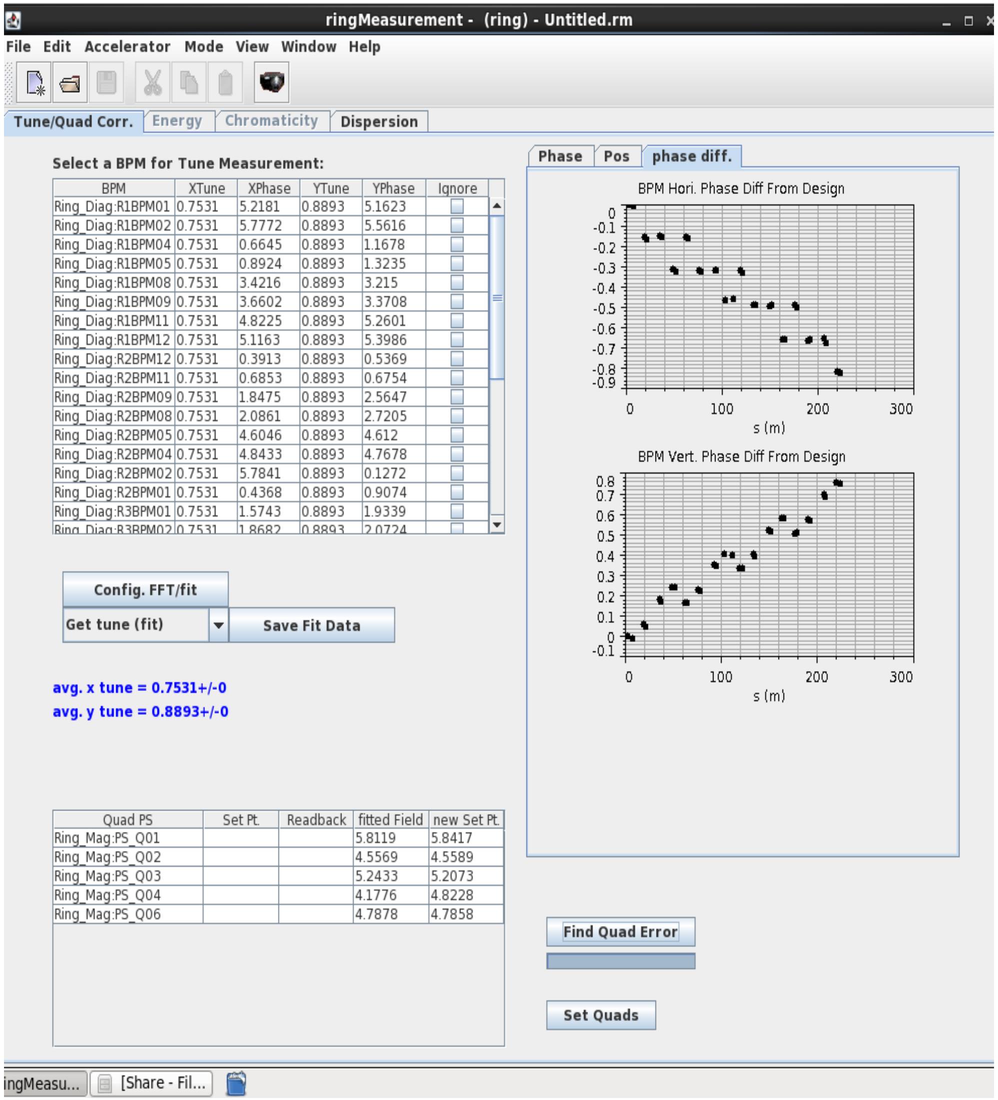


Getting tunes and phase advances by cosine fitting



Getting tunes by FFT

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

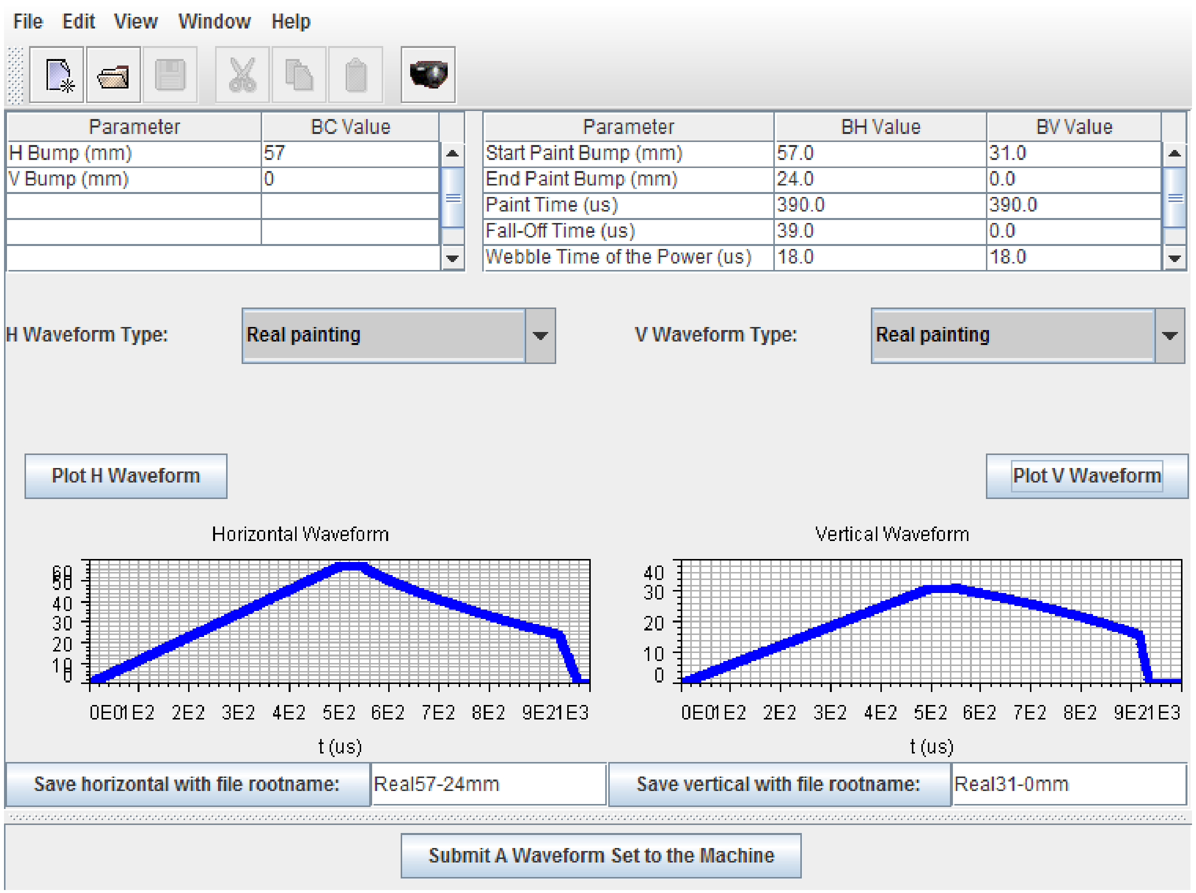


Finding quad errors

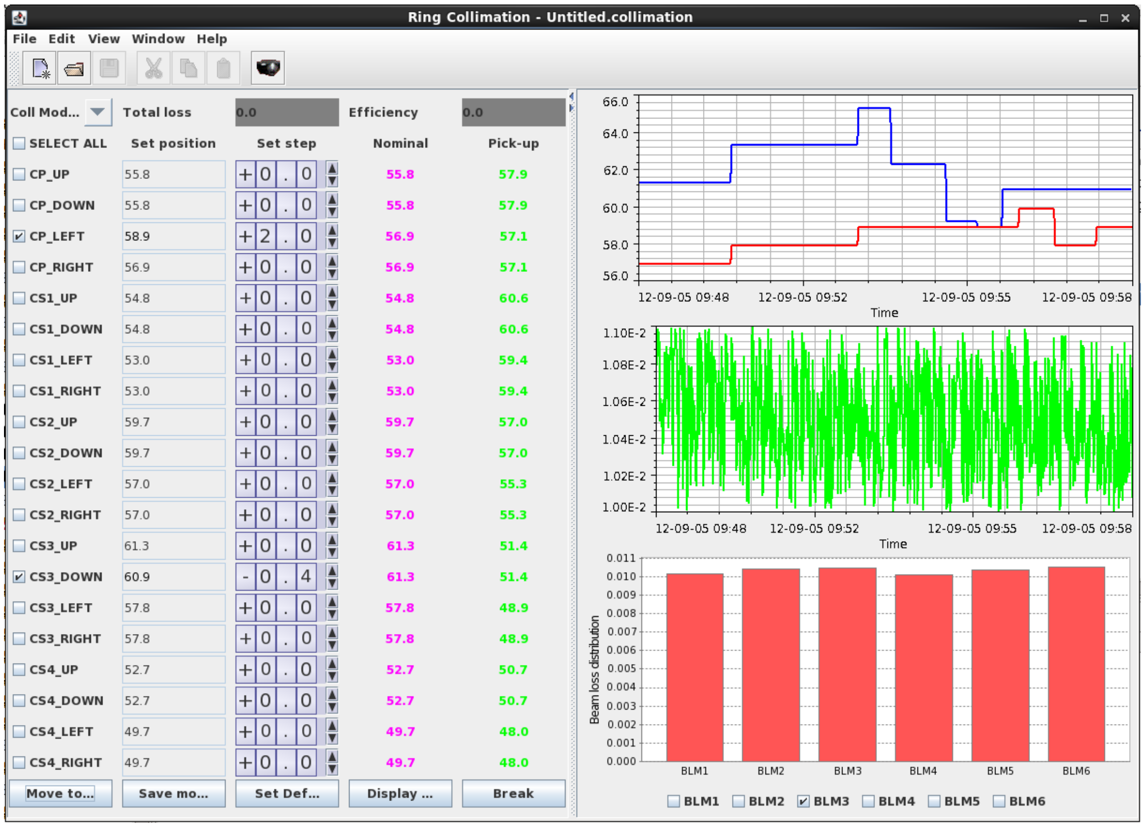
- The CSNS RCS has 5 families of quadrupoles
  - 4 for focusing quadrupoles, with 8 quadrupoles in each
  - 1 for defocusing quadrupole with 16 quadrupoles
- 5 independent power supplies
- Finding the 5 quadruple errors by minimizing the difference between the measured phase advances and the model's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

RCS Injection Painting Bump

- Saving and calling of different injection painting curves.



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.

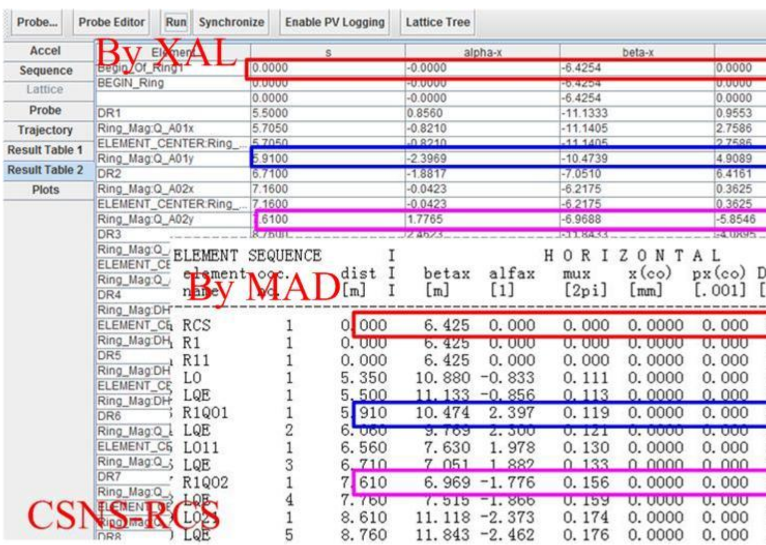
RF Curve Setting And Readback

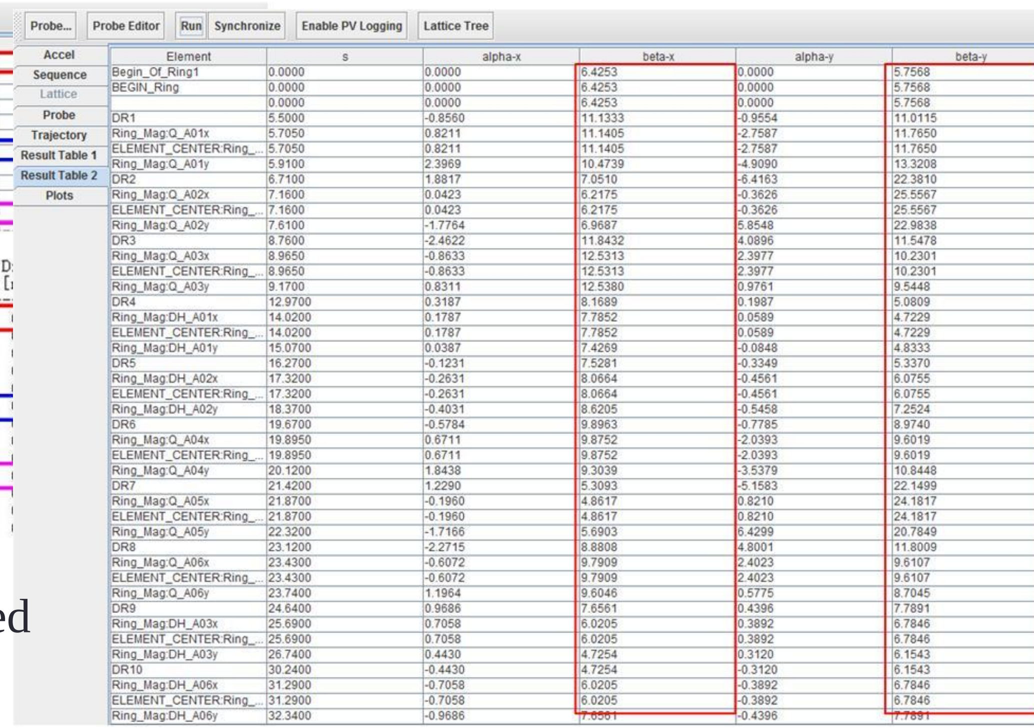
t, ms	Vrf, kV	Phis, rad	frf, MHz
-0.3	21.0	0.0	1.024
.0	21.0	0.0	1.022
.2	40.0	5.2	1.023
.5	52.5	10.1	1.029
.7	59.0	12.6	1.035
1.0	70.0	15.2	1.048
2.0	100.0	21.2	1.125
3.0	123.1	25.5	1.241
4.0	136.0	30.4	1.389
5.0	146.0	34.6	1.548
6.0	155.0	37.7	1.707
7.0	163.0	39.9	1.853
8.0	165.0	42.5	1.981
9.0	165.0	44.6	2.088
10.0	165.0	45.3	2.174
11.0	163.0	45.3	2.243
12.0	161.0	43.8	2.297
13.0	156.0	42.0	2.339
14.0	147.0	40.2	2.371
15.0	135.0	37.9	2.396
16.0	120.0	35.1	2.415
17.0	105.0	30.5	2.428
18.0	91.0	23.5	2.437
19.0	78.0	13.6	2.443
20.0	59.0	0.0	2.444

- 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





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!