

Beam Instrumentation Performance and Plans

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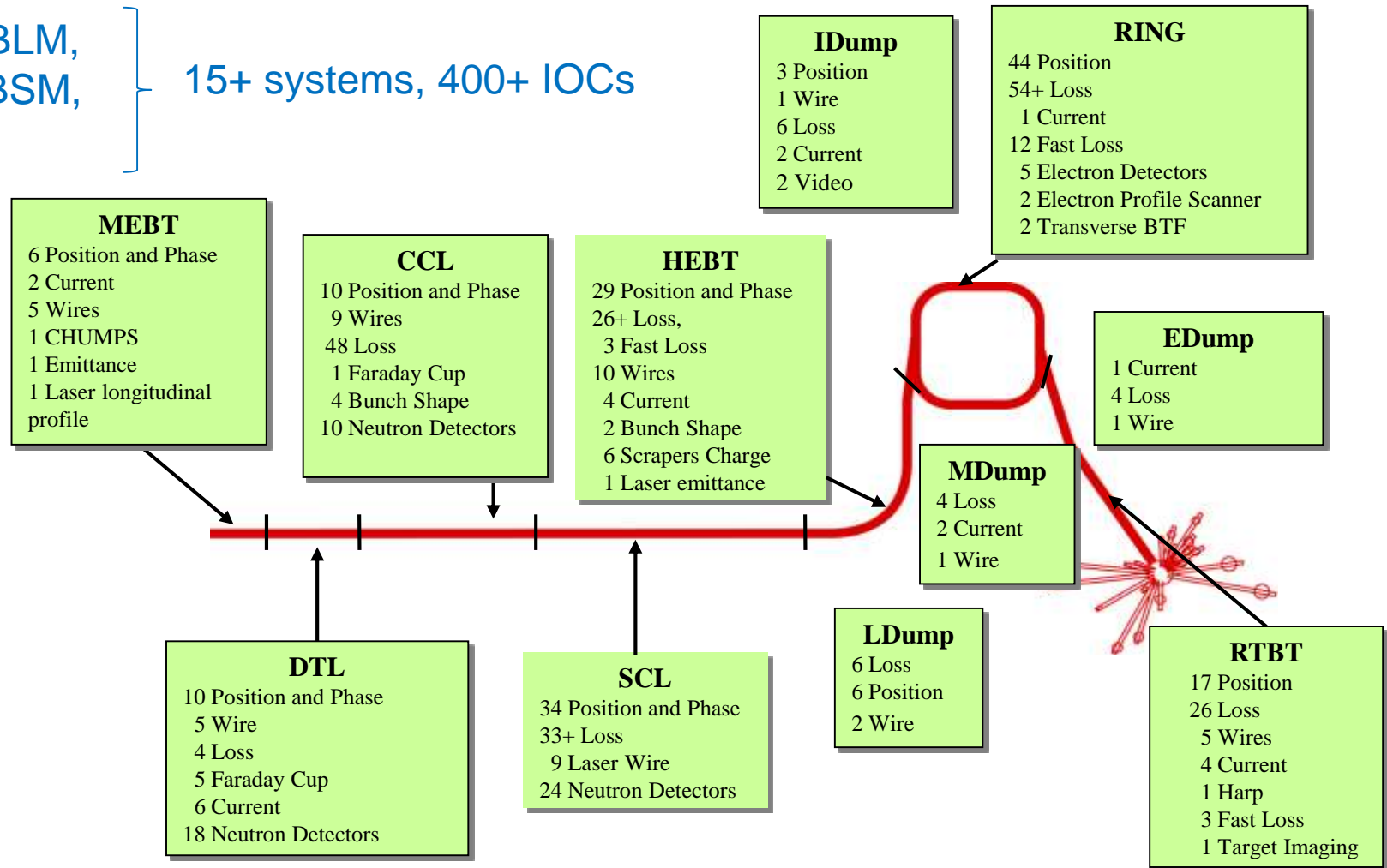
May 07, 2013



SNS Beam Instrumentation Systems are Numerous, Diverse and Growing in Number

BCM, BLM,
BPM, BSM,
WS....

15+ systems, 400+ IOCs



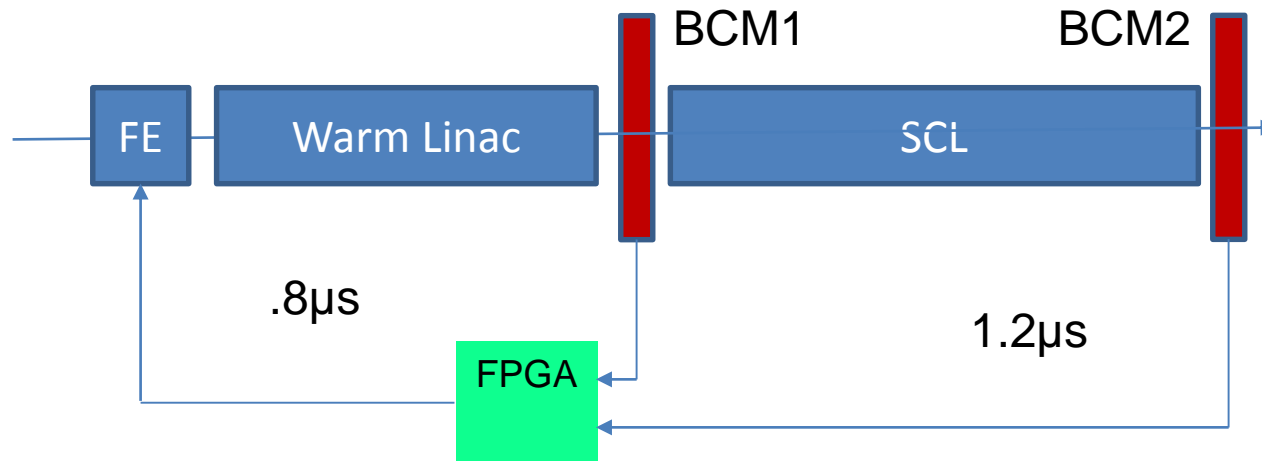
< 5 hours of beam downtime in FY12-13
due to Beam Instrumentation systems

New systems (operational and in development)

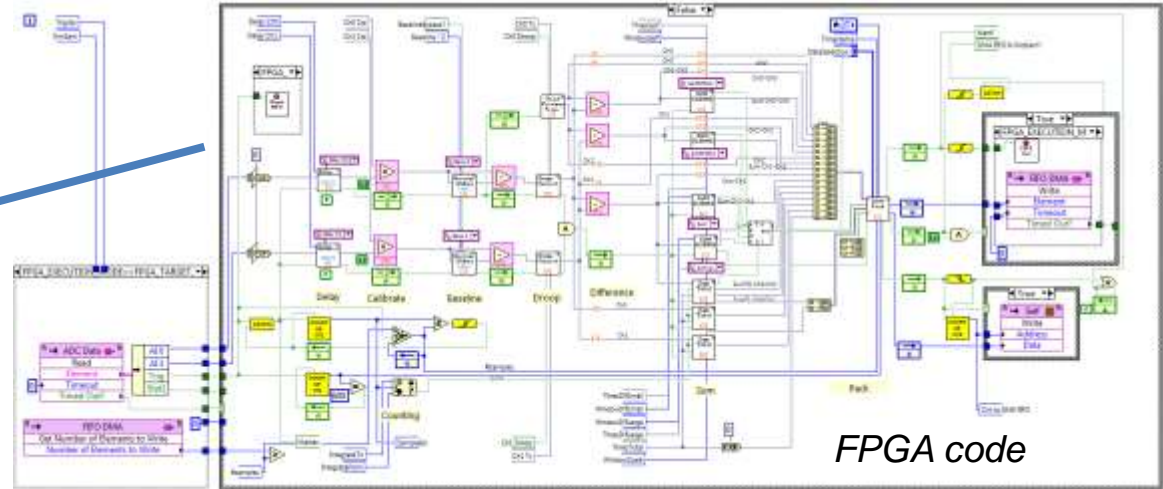
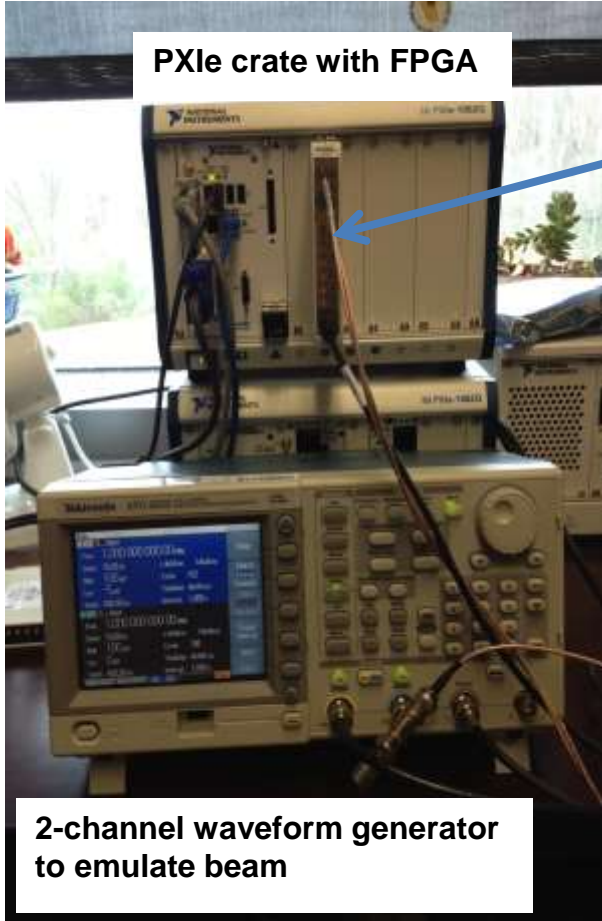
- To address day-to-day operational issues
 - Errant beam detection (in Charles Peter's talk)
 - Fast Differential Beam Current Monitor
 - MEBT vertical scrapers
- To address obsolescence problems new electronics for
 - Beam Position and Phase Monitors
 - Beam Loss Monitors
- For machine study
 - MEBT longitudinal profiles
 - High resolution transverse emittance
- In preparation for 1.4MW beam power
 - Foil image and temperature (no progress since AAC 2012)
 - Ring transverse feedback and beam transfer function measurement
- Accelerator technology development
 - Laser stripping experiment (Mike Plum's talk)
 - Diagnostics for Integrated Test Stand Facility

We are developing Fast Differential Beam Current Monitor for SCL (F-DBCM)

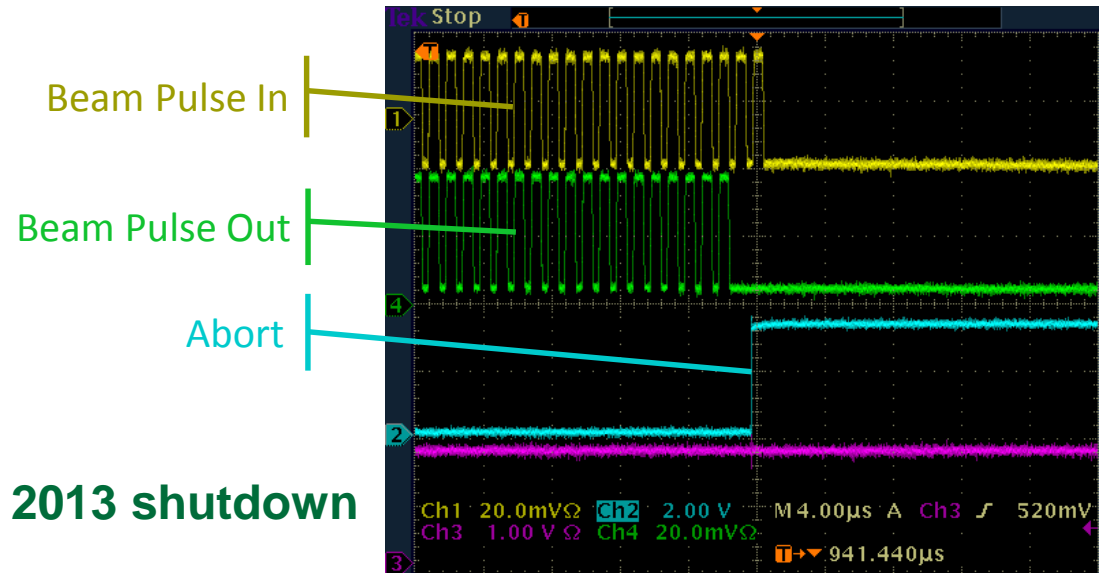
- Goal is to reduce shut off time for errant beam from $\sim 25\mu\text{s}$ to $5\text{-}6\mu\text{s}$
 - $25\text{-}30\mu\text{s}$ beam pulse lost in superconducting cavity can degrade its performance
 - Time for abort signal propagation through MPS tree structure is $15\text{-}20\mu\text{s}$
 - Dedicated protection system, bypassing MPS tree, allows to switch beam off faster
 - MEBT chopper can be used as fast switch off device



New F-DBCM shows good results in laboratory tests



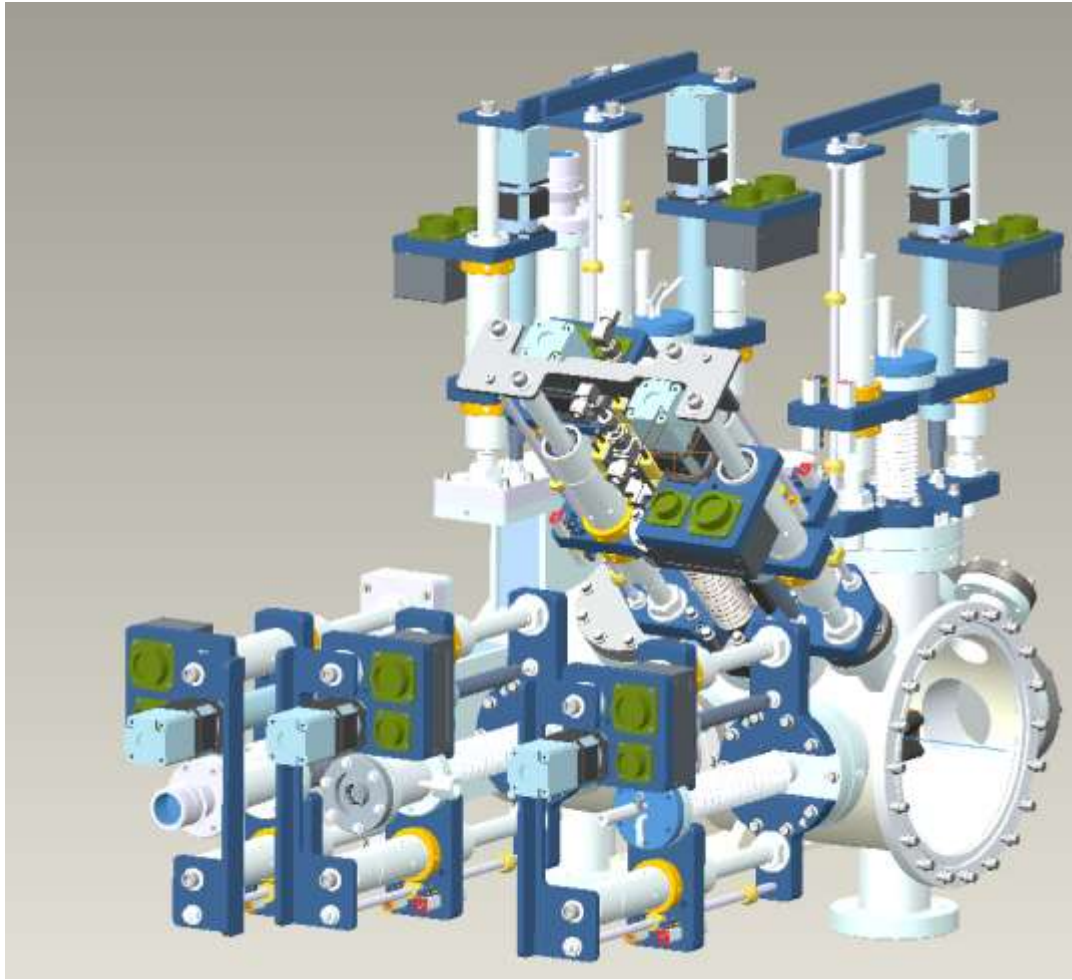
RT Host Display



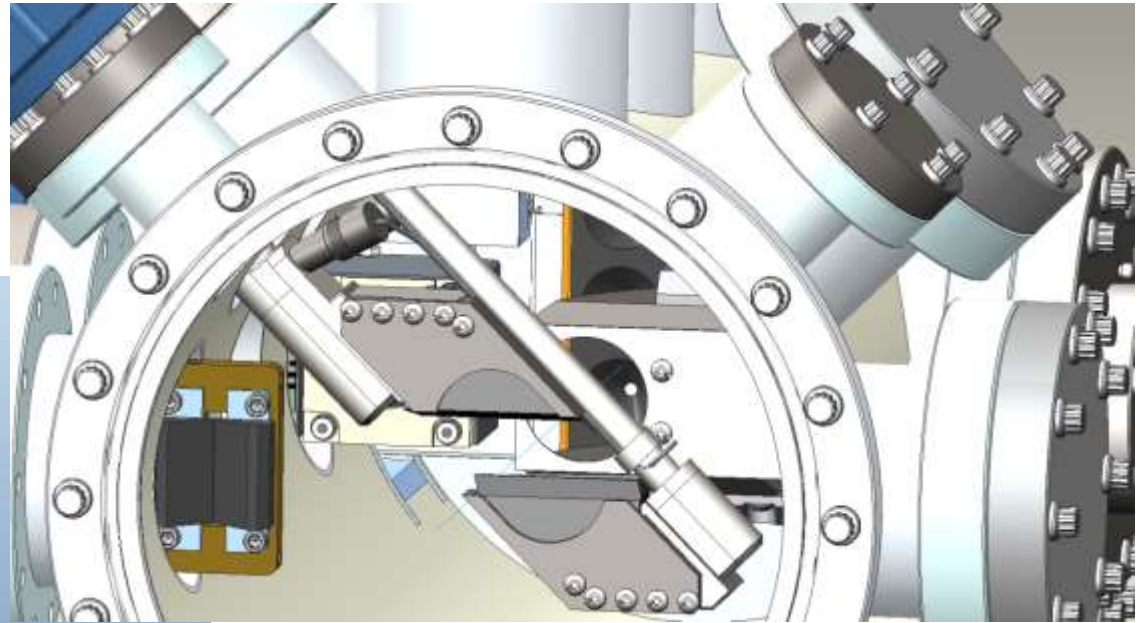
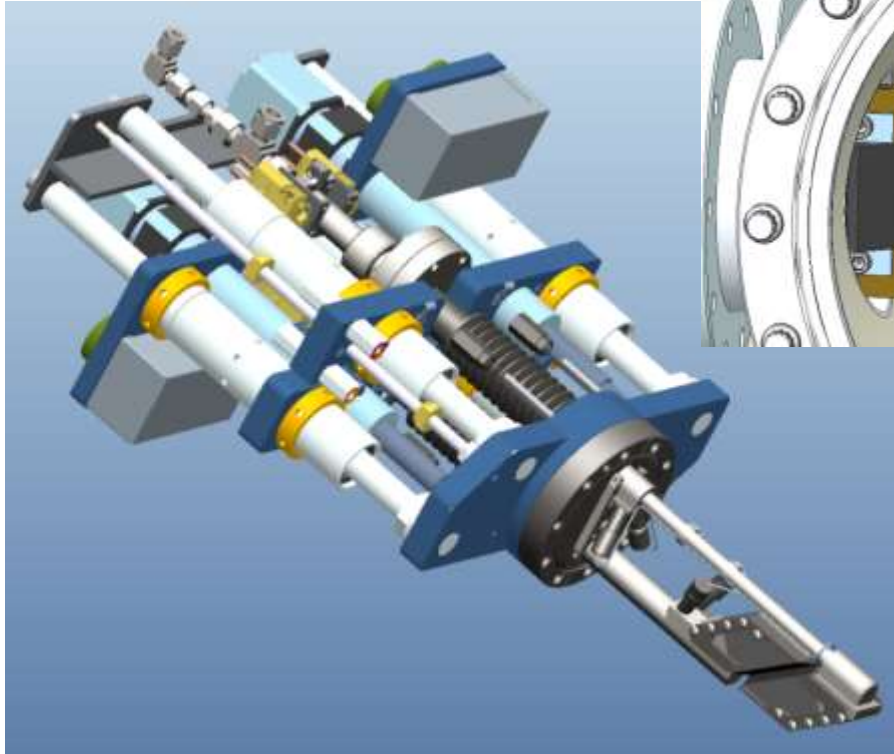
Plan for field test after summer 2013 shutdown

Courtesy of W. Blokland

We are adding vertical scrapers in MEBT to cut halo and reduce beam loss



New MEBT vertical scrapers design



Courtesy of A. Menshov

New MEBT scraper being prepared for installation during summer 2013 shutdown



We are developing new Beam Loss Monitor and Beam Position Monitor electronics to mitigate obsolescence problem

- BLMs and BPMs are major tool for machine protection and tune up
- Distributed multichannel systems (380 BLMs, 160 BPMs)
- VME platform with VxWorks OS for BLMs; PC for BPMs
- BLM system is very reliable , <5 hours/year downtime
- **Hardware obsolescence is becoming a problem**
- **Short term solution: stock up on spares**
- **Long term solution: new electronics**

Design approach for new systems:

- Compatibility with existing infrastructure (EPICS, RF, MPS)
- Less custom designs, more off-the-shelf components
- No major changes in functionality or specs
 - Increase BPM trigger rate from 1Hz to 60Hz
- National Instruments platform with LabView software is first choice



SNS BPM electronics



SNS BLM electronics

Status of new BPM electronics

- Had a prototype system ready for lab testing in Oct. 2012
 - Very good test results in the lab
- Deployed prototype system in the field in Dec. 2012
 - Observed unacceptably large phase drift with real beam signals
- Troubleshooting the digital processor in collaboration with NI experts
- Plan to return to field testing in summer 2013



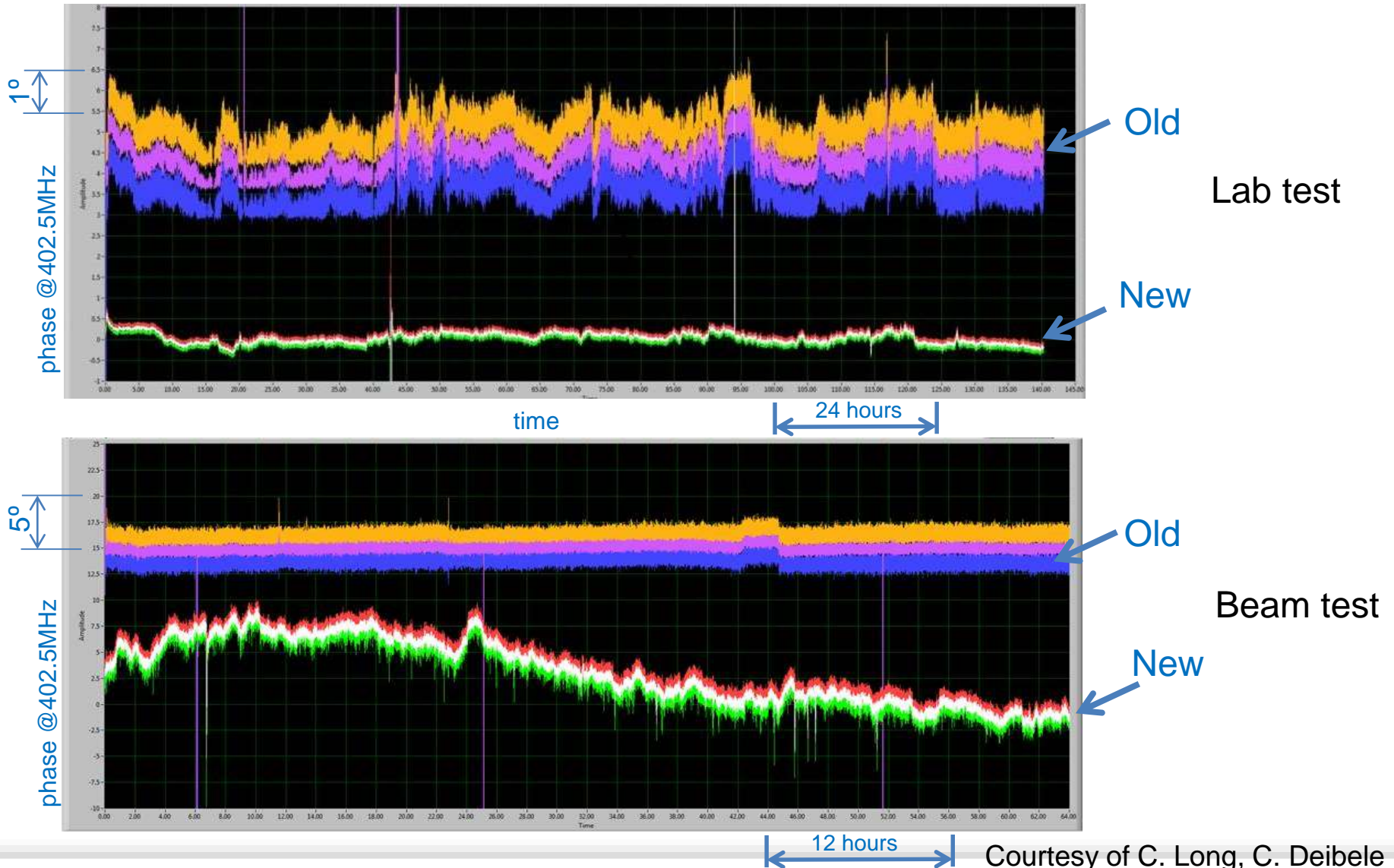
New BPM AFE board

Courtesy of M. Crofford, C. Deibele, C. Long

Test of new digital processor



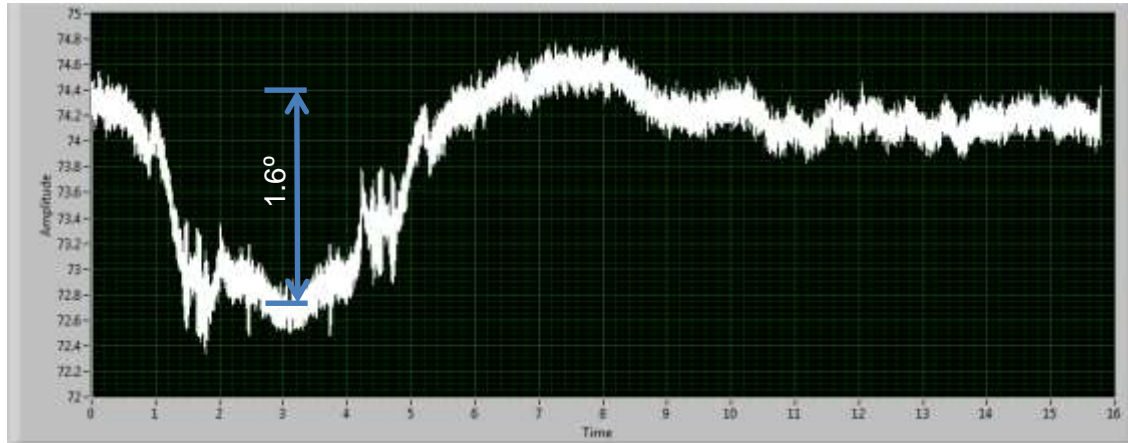
Test results for phase stability



Courtesy of C. Long, C. Deibele

Latest measurement of temperature dependence show good results

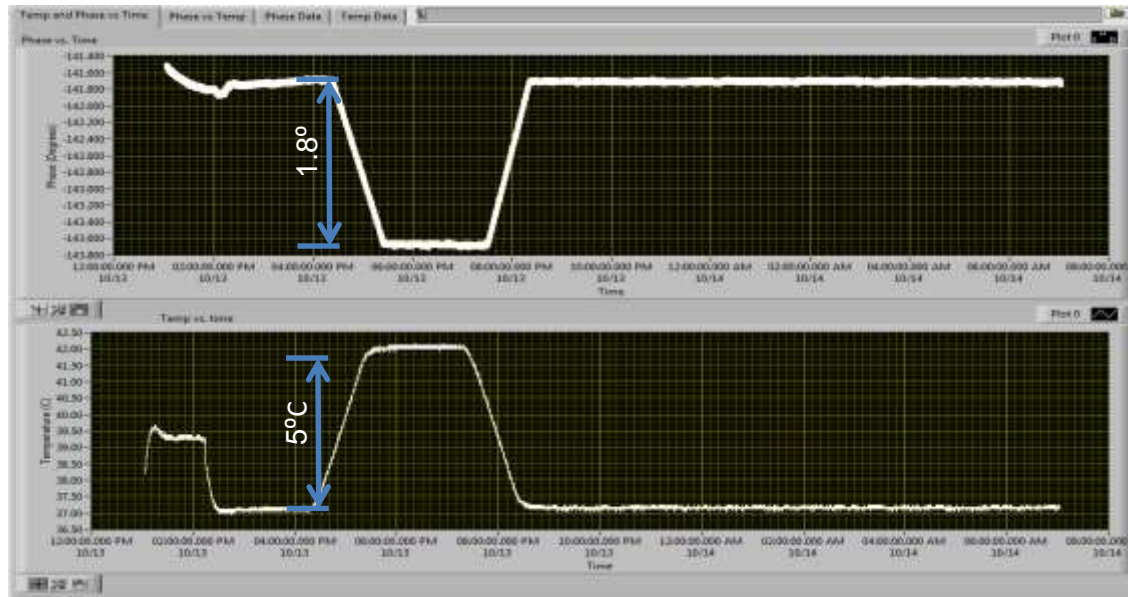
phase @402.5MHz



Time (hours)

Old electronics

phase @402.5MHz



Temperature °C

New electronics

Courtesy of C. Long, C. Deibele

Status of new BLM electronics

- Had prototype system ready for lab testing in Nov. 2012
 - Discovered few errors in the AFE board layout
 - EE & RF will help with redesign
- Have cRIO digital processor working in the field for >1 year
- Plan to deploy full prototype for testing with beam in summer/fall 2013



New BLM AFE board

Assembled
8-channels
chassis



NI BLM CRIO crate

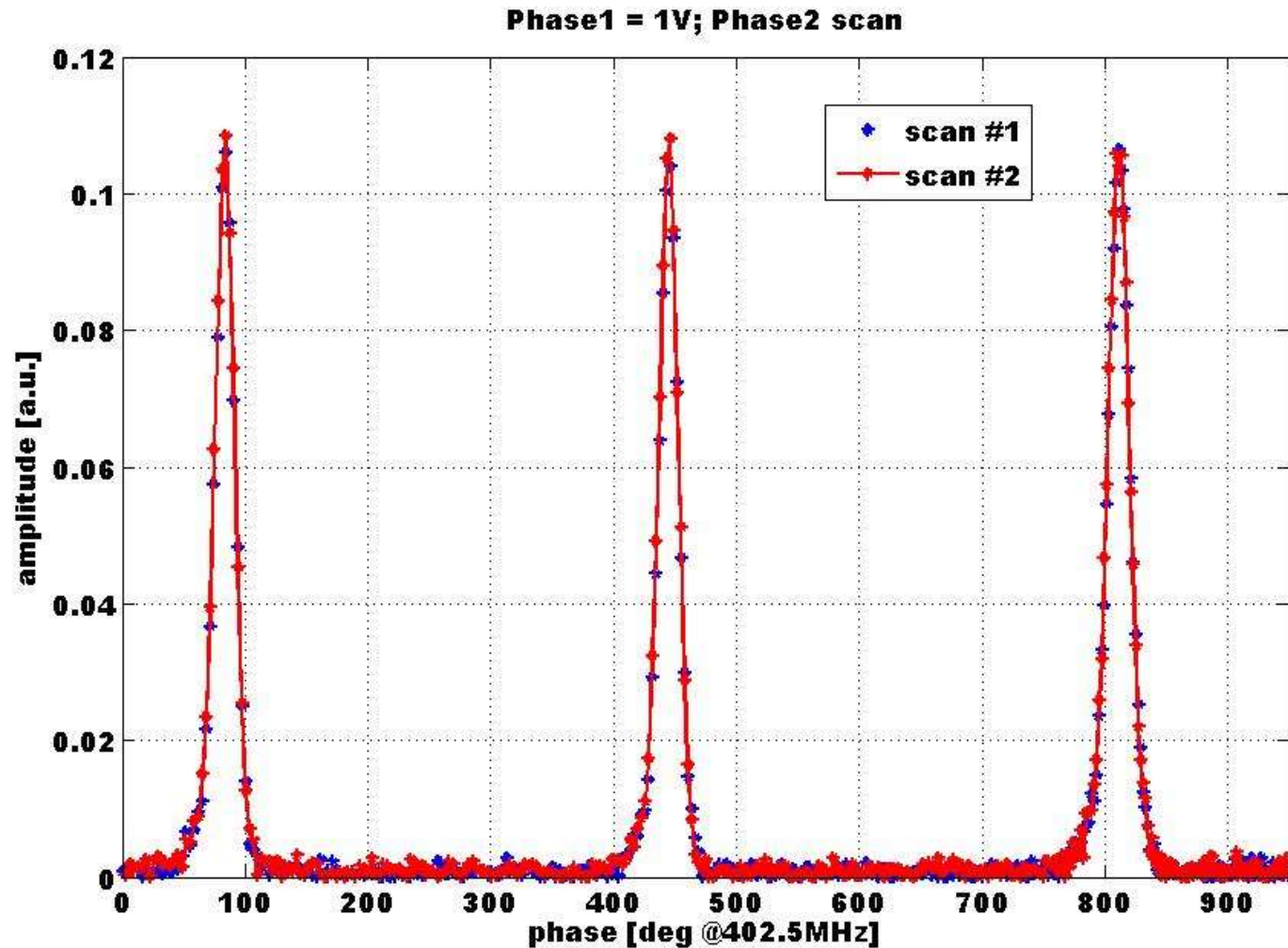
Courtesy of A. Zhukov

We resurrected MEBT laser longitudinal bunch profile scanner

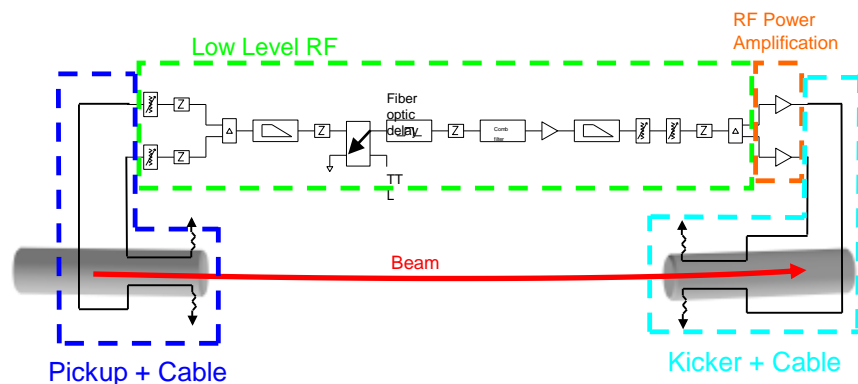
- Had laser system put together in 2003 to verify beam parameters after RFQ retuning
- Decommissioned later due to significant maintenance cost
 - Vibrations in the laser light transmission line was major problem
 - Small aperture detector required precise ion beam centering
- Discovery of larger than expected longitudinal emittance in SCL prompted resurrection efforts
- Developed new 30m long fiber transmission line and large aperture detector
 - New system provides stable and repeatable signals



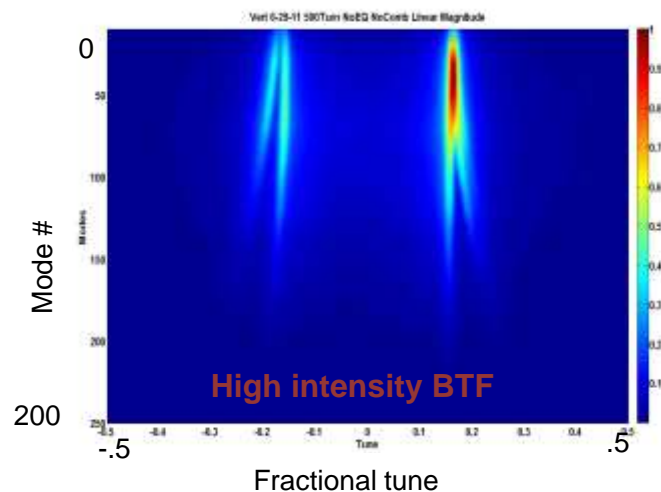
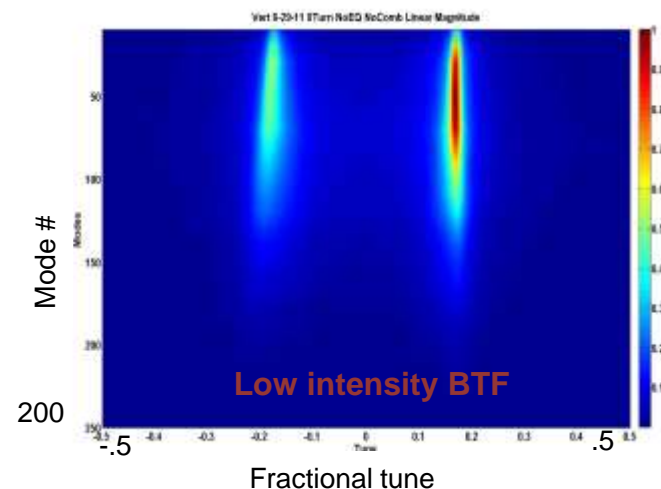
Measured bunch RMS length of 8.5° is smaller than design value of 15°



We are developing transverse feedback system for suppressing e-p instability in accumulator ring



- Wide bandwidth and high power are required
 - 1-300MHz bandwidth
 - 400 W/channel peak power
- Have demonstrated e-p instability suppression with analog processor, but results were not repeatable and consistent
- Commissioned FPGA digital processor recently
- Both, analog and digital systems showed same unexpected, and so far unexplained beam response
 - Can be a key to successful e-p damping
- Development efforts are resources limited



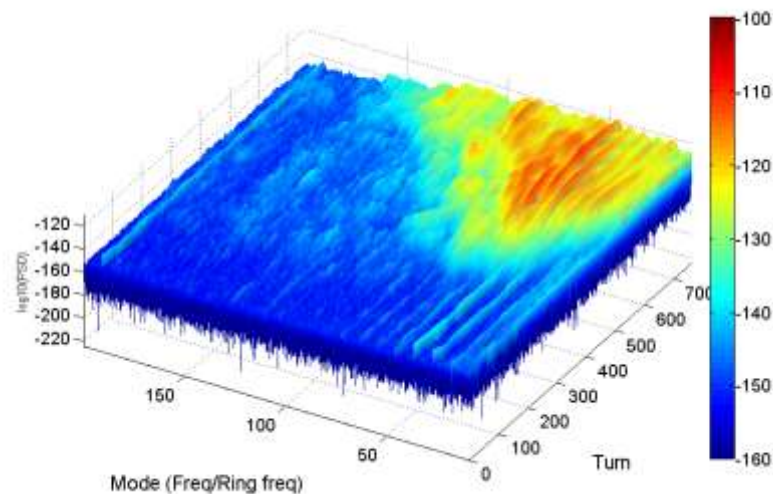
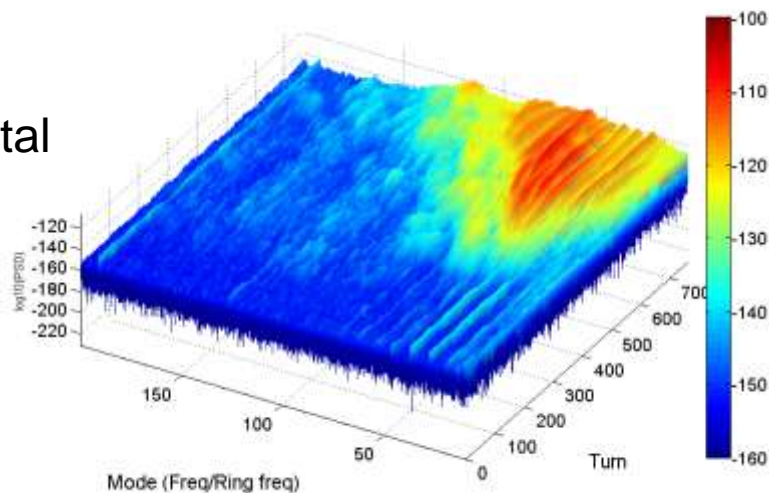
Courtesy of C. Deibele and Z. Xie

First results of damping attempt on April 28th

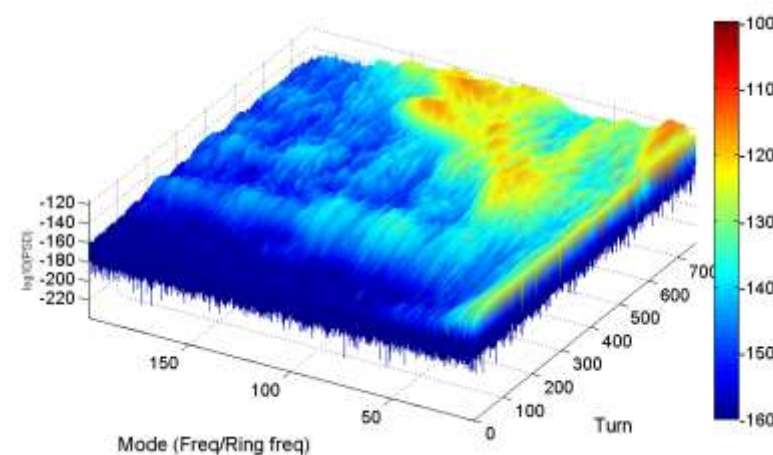
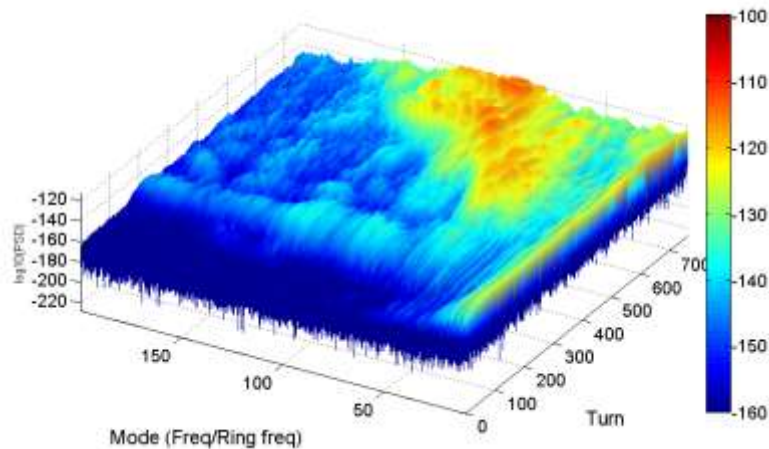
Feedback OFF

Feedback ON

horizontal
plane



vertical
plane

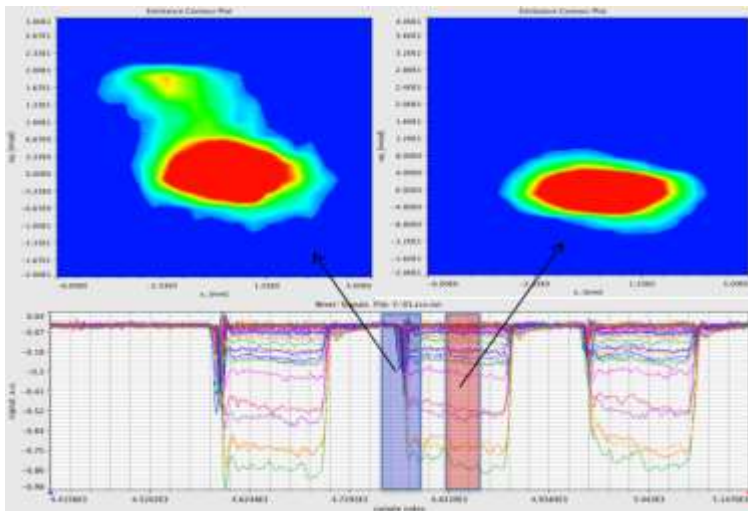
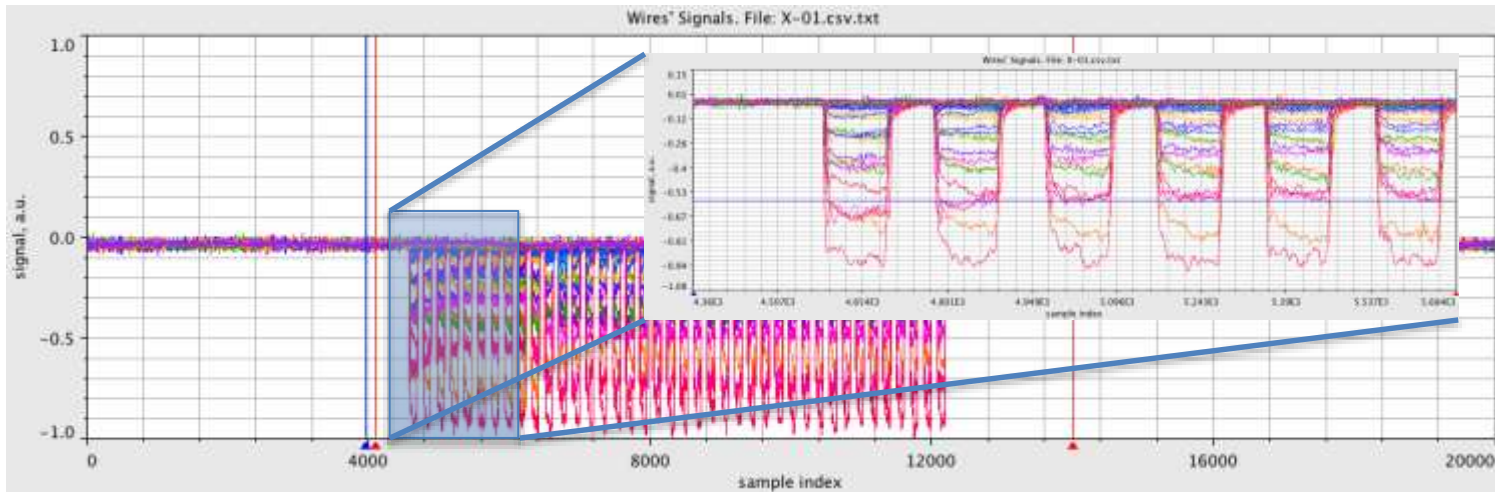


Courtesy of C. Deibele and Z. Xie

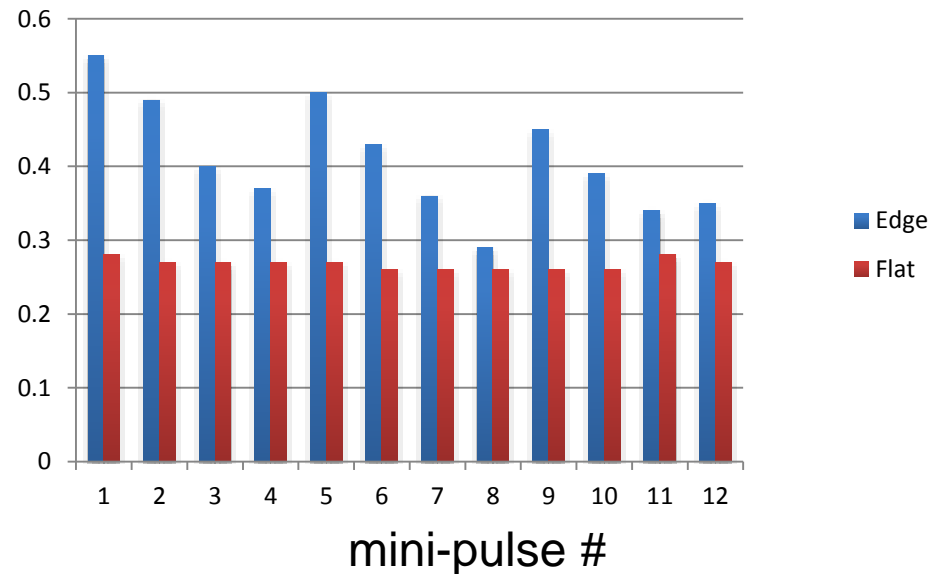
We are also improving performance of existing diagnostics

- **Increase temporal resolution**
- **Increase dynamic range**
- **Speed up measurement process**
- **Improve user interface**

We can measure transverse emittance in MEBT with high resolution



Courtesy of A. Zhukov



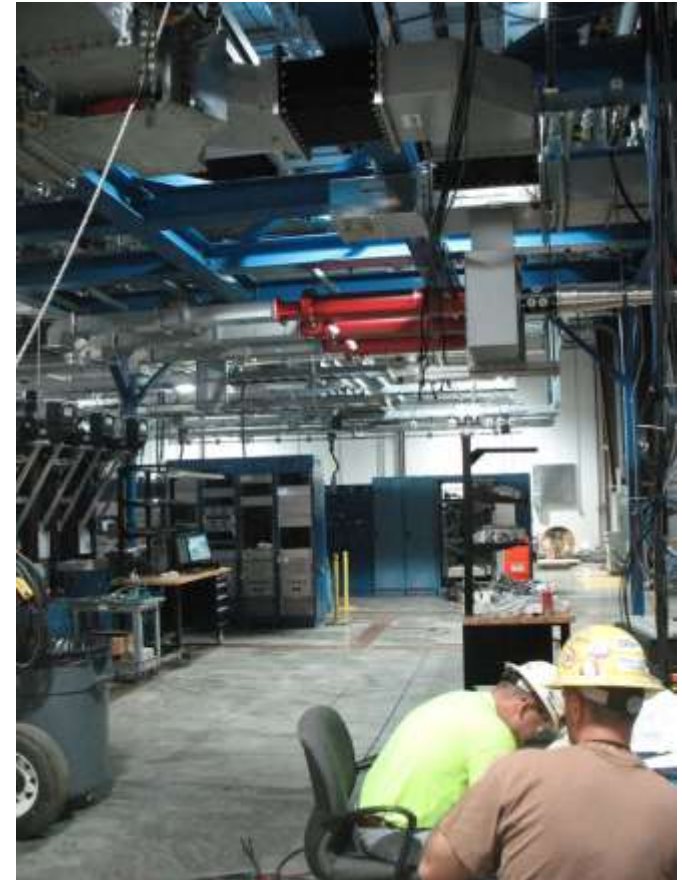
We can measure beam profiles with Laser Wire at 9 locations in SCL simultaneously with one click through EPICS



Courtesy of Y. Liu, C. Long, C. Peters, D. Brown

New Integrated Test Stand Facility (ITSF) is being constructed

- Includes
 - Ion Source, 65keV LEPT, 2.5MeV RFQ, 2.5MeV MEPT
 - Infrastructure: High Power RF, AC, water, controls
- Goals
 - Spare RFQ acceptance test with beam:
 - beam parameters measurements
 - full power beam test (5kW)
 - Future Front End Systems development
 - Magnetic LEPT
 - Diagnostics
 - MEPT systems (re-bunchers, choppers, etc.)
 - High intensity beam dynamics study
- Timeline
 - Spare RFQ acceptance test, RF only
 - Beam through RFQ



- summer/fall 2013
- winter 2014

We have many parts and systems for ITSF available



402.5 MHz RF system



Electrostatic LEBT



2 MHz RF system



Ion Source



2 solenoid LEBT

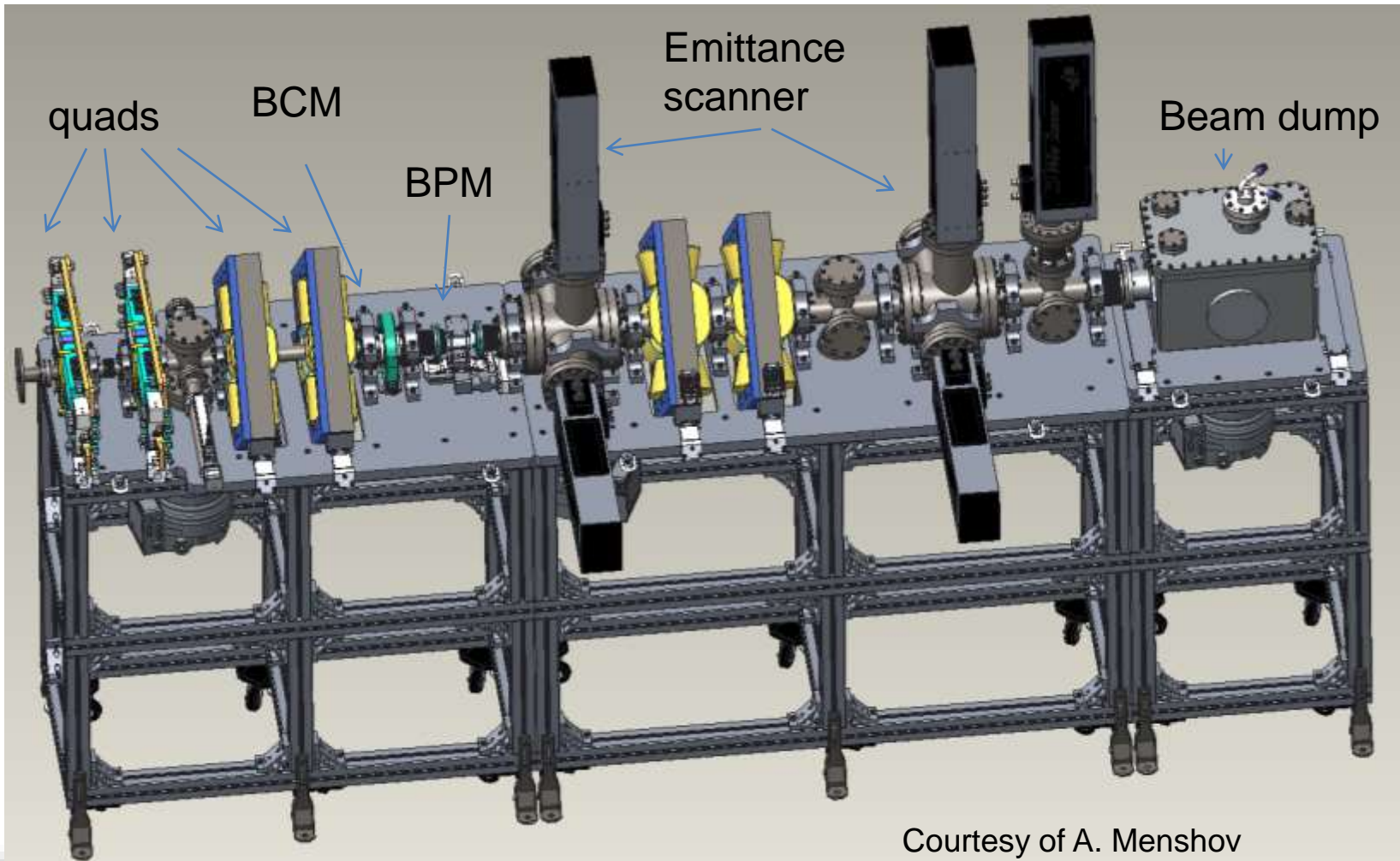
We are designing 2.5MeV diagnostics beam line for Integrated Test Stand Facility

- Set of diagnostics for spare RFQ acceptance test
 - Beam current
 - transformer
 - Beam energy
 - TOF using Movable Beam Position and Phase monitor
 - Transverse beam emittance
 - 2 slit system
 - Longitudinal bunch size
 - Fast Faraday Cup
- Future expansion capability
 - 180° turn + 5m beam line
- Plan to have beam line ready for beam by end of 2013
 - Design efforts are funded from operations budget
 - Procurement funding is not certain

Existing SNS BI technology

ITSF diagnostics beam line layout

- Mechanical design is 85% complete
- Expect to have procurement packages by June 2013



Courtesy of A. Menshov

Answers to AAC2012 action items. #1

“ The committee was presented with a wish list of mostly unfunded diagnostic development projects. SNS is encouraged to indicate which accelerator performance goal is associated with each diagnostic in order to help prioritize these projects.”

A near-term wish list

- **MEBT vertical scrapers** ————— Current operation improvement – loss reduction.
– Not funded in FY12 Project will finish in FY13. Operations budget.
- **Ring Ionization Profile Monitor (IPM)** ————— Power increase. Project deferred in favor of electron beam scanner aperture increase. No activity or plans.
– Design 90% complete
– Not funded in FY12
- **Ring electron scanner aperture increase** ————— Power increase. Priority #3. No activity in FY13.
– Not funded in FY12
- **Laser stripping experiment set-up** ————— Long term accelerator technology development.
– Not funded in FY12 Project is funded by DOE grant. Priority #2.
- **Laser based BSM** ————— Beam diagnostics technology development.
– Not funded in FY12 Project is deferred. No activity or plans.
- **New Ring pinger electrode** ————— Beam diagnostics technology development. Project is deferred.
– Not funded in FY12 No activity or plans.
- **RFQ test stand diagnostics** ————— Current operation improvement – spare RFQ test. Power increase.
– Not funded in FY12 Long term accelerator technology development. Priority #1.

Answers to AAC2012 action items. #2

“The ring transverse feedback system work should be pursued, particularly at intensities corresponding to 1.4MW operation. If this cannot be done due to limited resources, a cost projection should be made so that it can be planned in the context of other priorities.

Post Doc position. ~150k\$ year x 3years

Summary

- We are supporting neutron production with good reliability
- We are addressing new day-to-day operation needs
- We are mitigating obsolescence problems
 - Added FPGA programming to BI team skill set
- We are developing new, state-of-the art beam instrumentation
- We are designing ITSF diagnostics beam line
- We are providing support to other groups
 - Target instrumentation
 - Sample environment