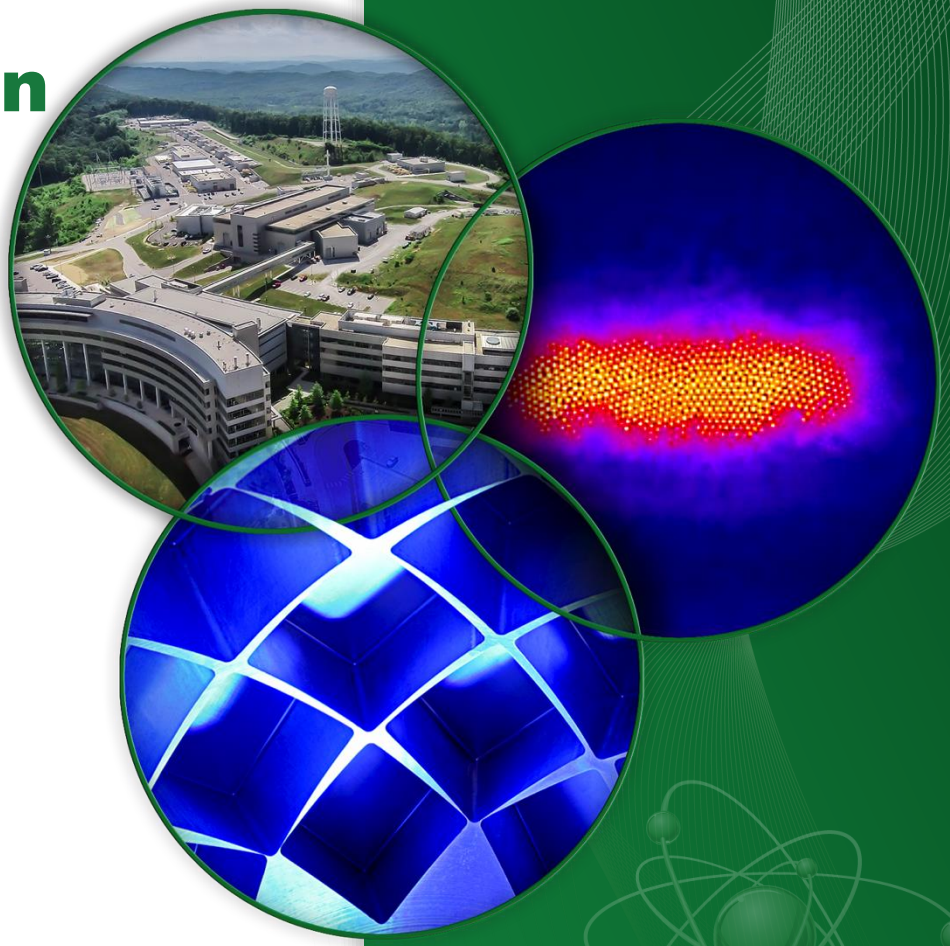
Integrated Test Stand and Beam Instrumentation

A. Aleksandrov

Integrated Test Stand manager

Beam Instrumentation Team Leader



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Integrated Test Stand Facility (ITSF) Outline

- Goals
- Organization, scope and schedule
- Status
- Near and long term plans

Recommendations from last AAC:

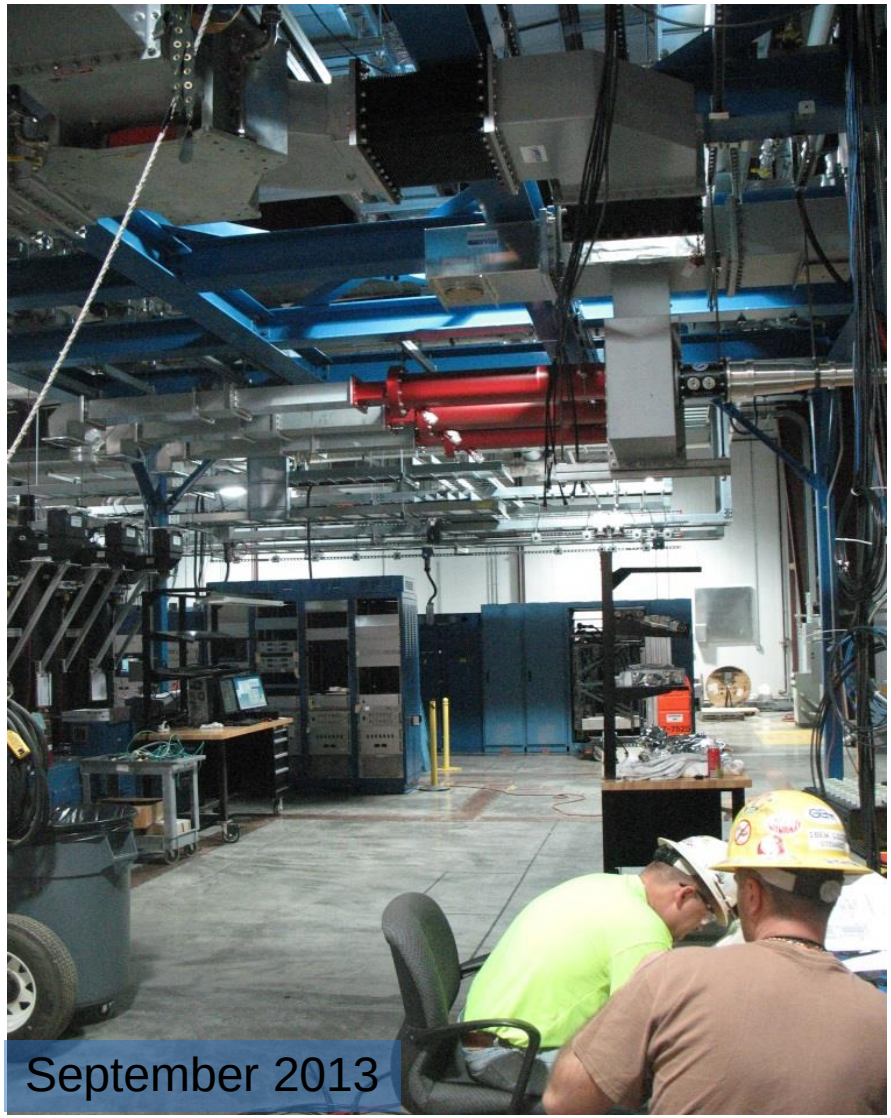
Give a high priority to completion of the Integrated Test Stand so that RFQ testing is not delayed

Make an up-to-date ITS schedule to allow tracking of progress at least through the point of the start of RFQ tests with beam.

ITSF Goals

- Spare RFQ acceptance test with beam:
  - beam parameters measurements
    - Transmission
    - Energy
    - Emittance
  - full power beam test (5kW)
- Future SNS Front End Systems development
  - Magnetic LEBT
  - Diagnostics
  - MEBT systems (re-bunchers, choppers, etc.)
- 2.5MeV proton beam source
  - Moderator Demonstration Facility
  - High intensity beam dynamics study

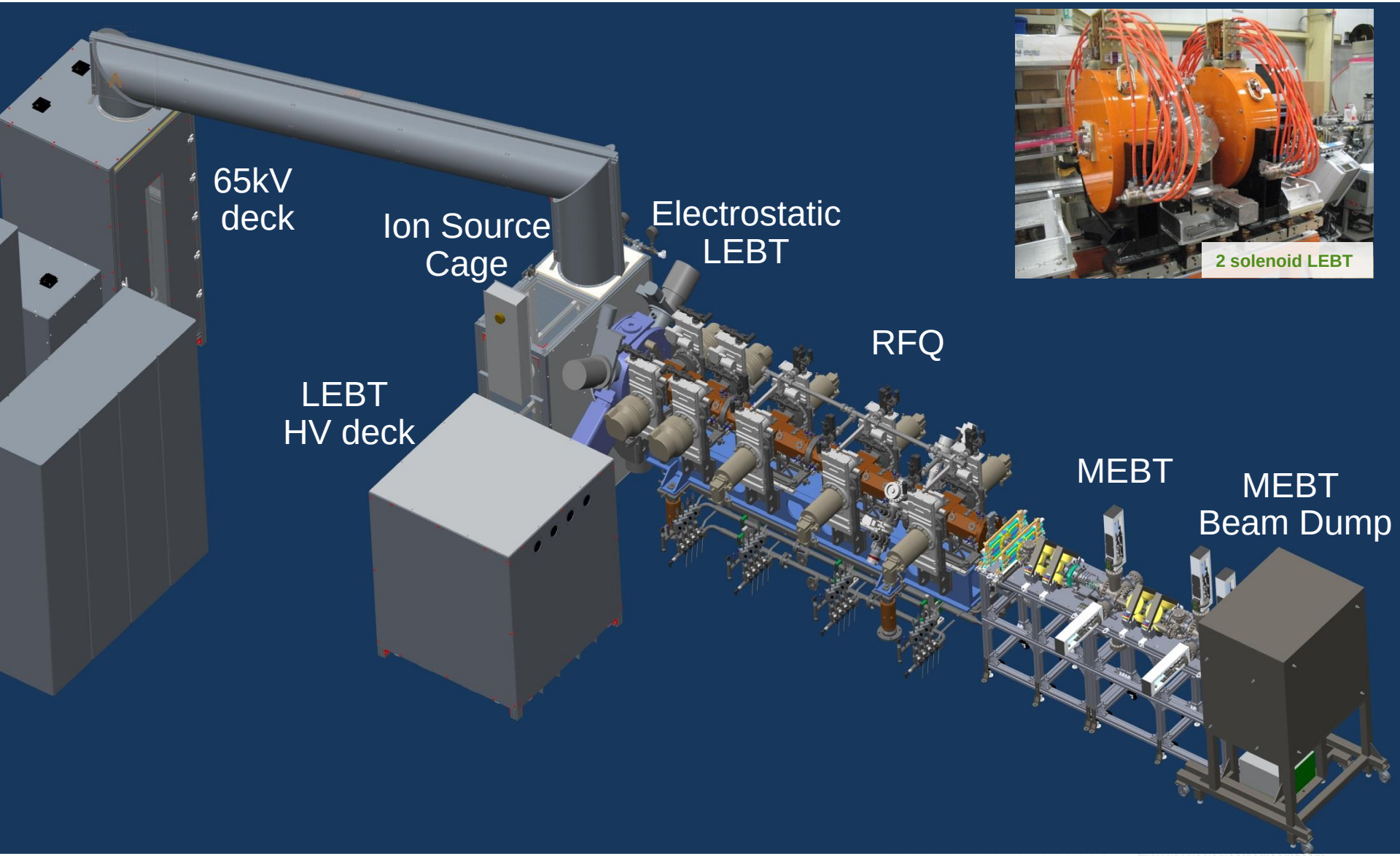
Integrated Test Stand Facility Progress



September 2013

December 2014

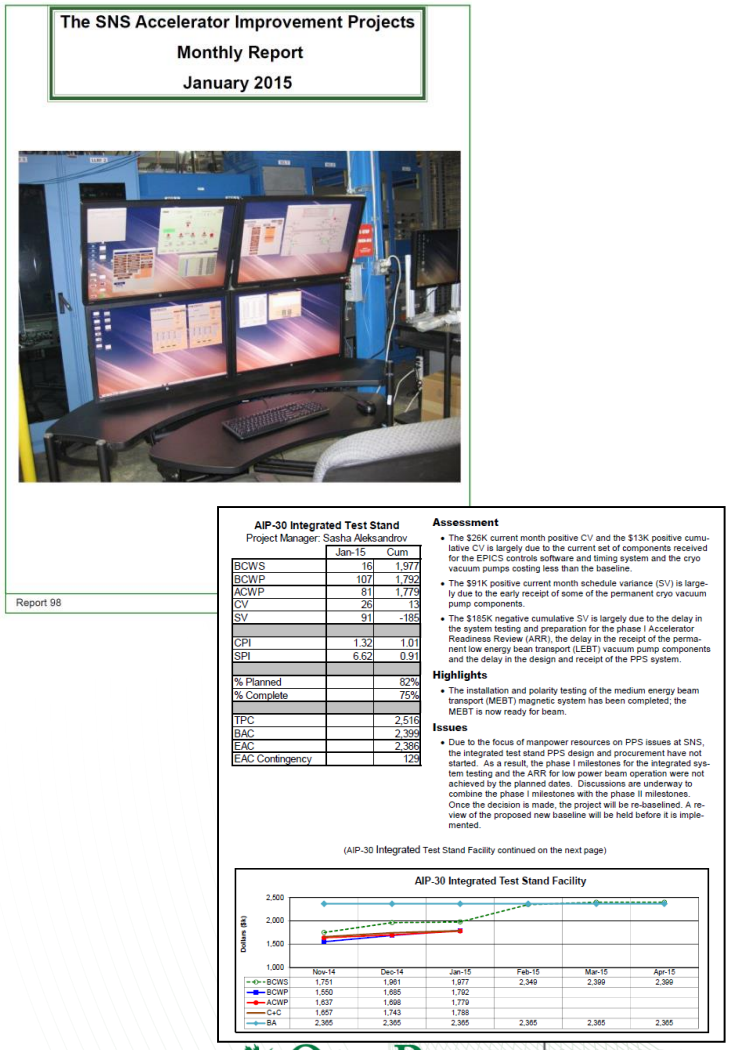
Current ITSF layout



Courtesy of T. Roseberry

ITSF organization and scope

- ITSF construction is funded through Accelerator Improvement Project
  - 2,516 k$ TPC
  - 14-Jun-13 to 18-Nov-14 duration
- Scope
  - Phase I (low power beam operation)
    - 65kV ion source
    - 65kV LEBT
    - 2.5 MeV MEBT
    - Low power beam dump
    - Local controls
  - Phase II (high power beam operation)
    - RFQ cryogenic pump system
    - High power beam dump
    - Personnel Protection System (PPS)
    - Remote EPICS controls



The SNS Accelerator Improvement Projects

Monthly Report

January 2015

Report 98

AIP-30 Integrated Test Stand

Project Manager: Sasha Aleksandrov

	Jan-15	Cum
BCWS	16	1,977
BCWP	107	1,792
ACWP	81	1,779
CV	26	13
SV	91	-185
CPI	1.32	1.01
SPI	6.62	0.91
% Planned		82%
% Complete		75%
TPC		2,516
BAC		2,399
EAC		2,386
EAC Contingency		129

Assessment

- The $26K current month positive CV and the $13K positive cumulative CV is largely due to the current set of components received for the EPICS controls software and timing system and the cryo vacuum pumps costing less than the baseline.
- The $91K positive current month schedule variance (SV) is largely due to the early receipt of some of the permanent cryo vacuum pump components.
- The $185K negative cumulative SV is largely due to the delay in the system testing and preparation for the phase I Accelerator Readiness Review (ARR), the delay in the receipt of the permanent low energy bean transport (LEBT) vacuum pump components and the delay in the design and receipt of the PPS system.

Highlights

- The installation and polarity testing of the medium energy beam transport (MEBT) magnetic system has been completed; the MEBT is now ready for beam.

Issues

- Due to the focus of manpower resources on PPS issues at SNS, the integrated test stand PPS design and procurement have not started. As a result, the phase I milestones for the integrated system testing and the ARR for low power beam operation were not achieved by the planned dates. Discussions are underway to combine the phase I milestones with the phase II milestones. Once the decision is made, the project will be re-baselined. A review of the proposed new baseline will be held before it is implemented.

(AIP-30 Integrated Test Stand Facility continued on the next page)

AIP-30 Integrated Test Stand Facility

Schedule delay drivers

- RFQ late delivery ~ 6 months
- Unscheduled maintenance periods ~ 3 months
- Change in safety requirements
  - Active PPS is needed even for low power operation
  - Phase I beam operation impossible
- PPS team availability
  - started in February 2015
- New project schedule is being built
  - No expected change in TPC
  - End date is TBD

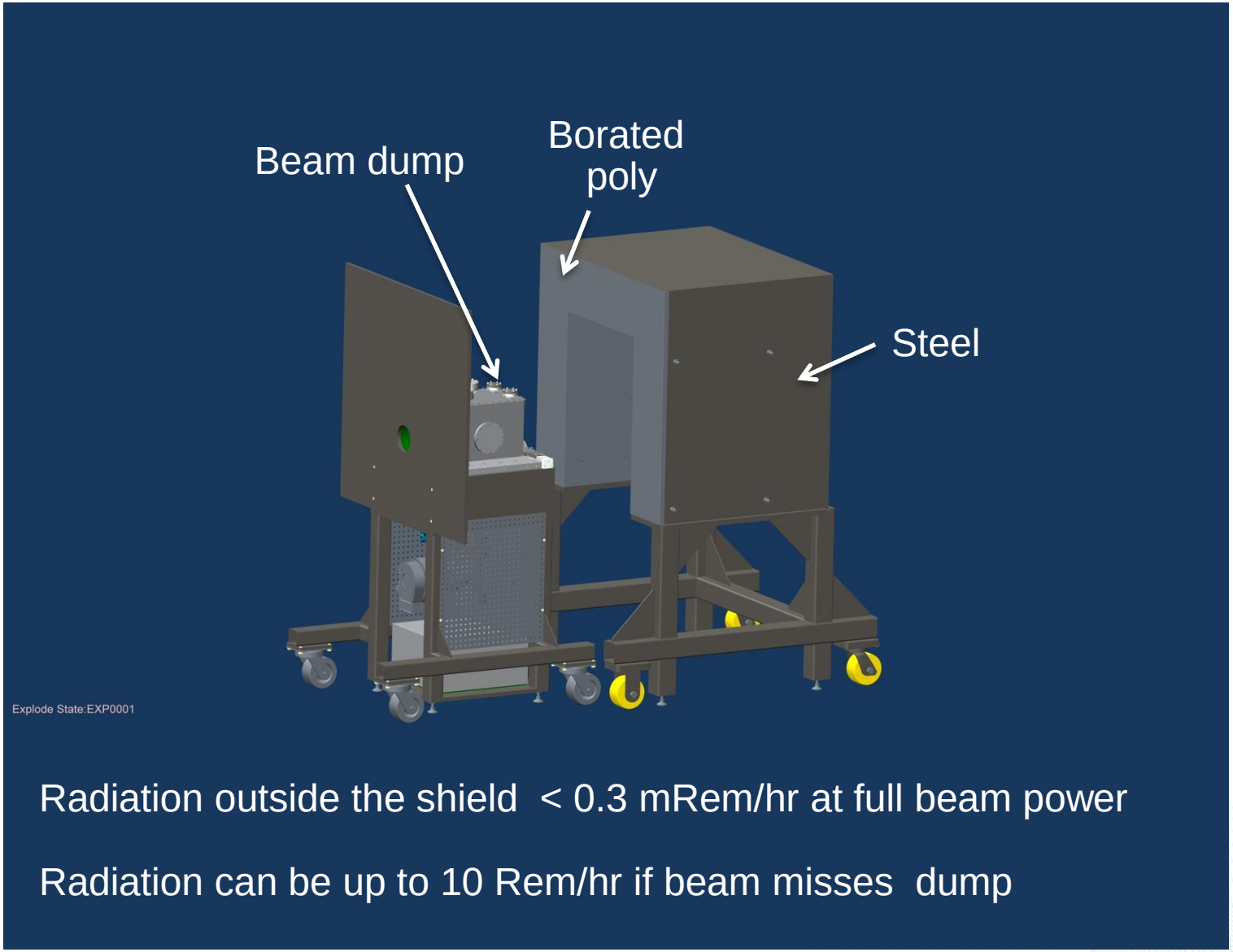
Status of major systems

	Design	Installation	Testing
Ion Source RF	done	done	done
IS/LEBT HV	done	done	not started
IS/LEBT controls	done	done	in progress
RFQ	done	done	done
MEBT magnets	done	done	done
MEBT diagnostics	done	done	done
MEBT controls	done	done	in progress
Beam dump	done	not started	not started
PPS	in progress	not started	not started

Remaining work schedule

- Ion Source and LEBT HV conditioning — April 2015
  - 2MHz RF and RFQ RF locked out
- Ion Source RF conditioning — April 2015
  - 65kV and RFQ RF locked out
- RAD internal IS readiness review — May 2015
- 65kV beam production — May 2015
- Beam dump shielding installation — June 2015
- PPS readiness — TBD
- Accelerator Readiness Review — TBD
- 2.5MeV beam production — TBD

Beam dump radiation shielding



Radiation outside the shield < 0.3 mRem/hr at full beam power

Radiation can be up to 10 Rem/hr if beam misses dump

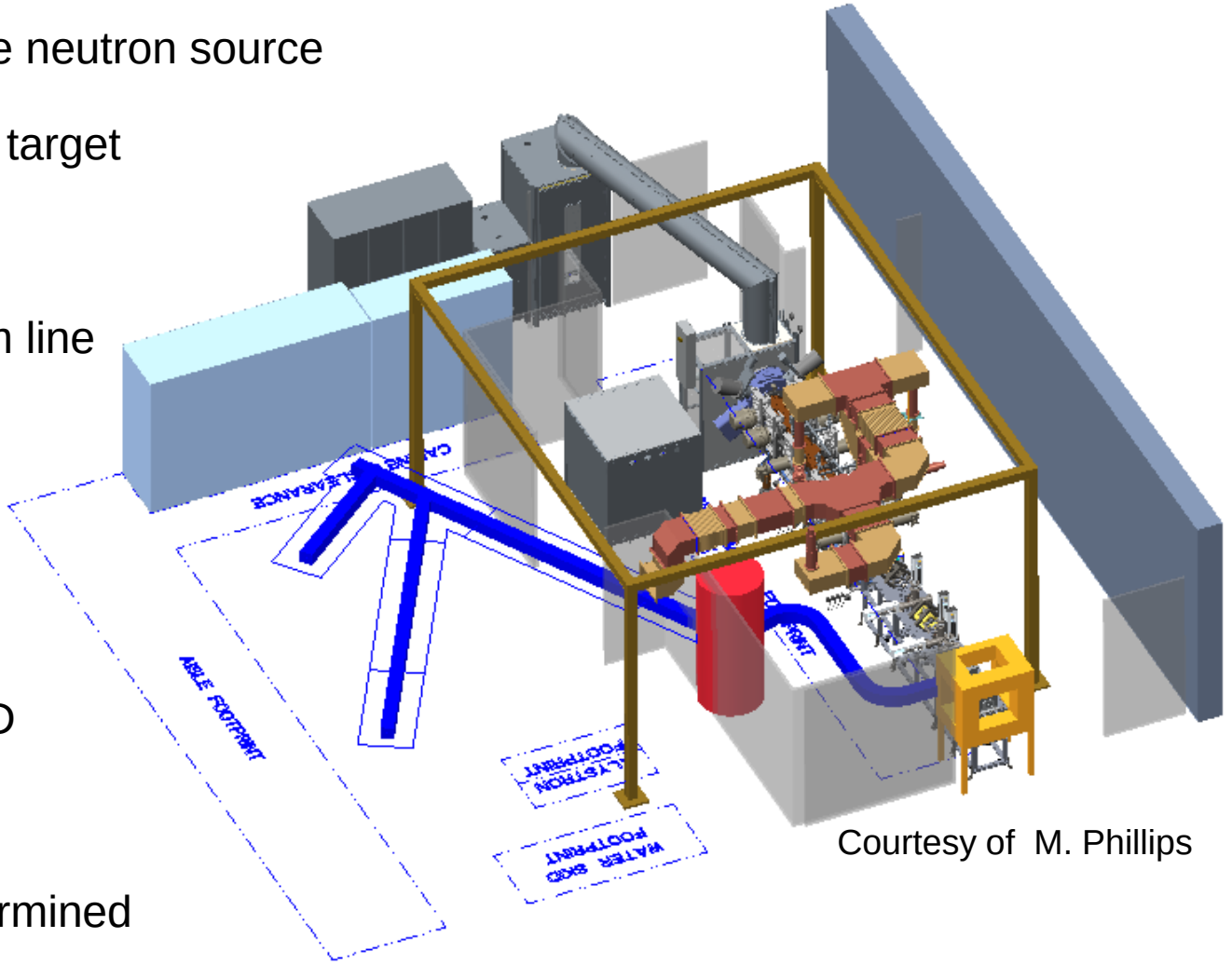
Courtesy of I. Popova and K. Ewald

Proposed PPS configuration

- Radiation detectors (“chipmunks”)
  - Shut off Ion Source 65kV and RFQ HV modulator
- ITSF enclosure
  - Is not interlocked
  - Administrative control when 2.5MeV beam is running
    - Is accessible by qualified personnel with dosimeter
    - RWP is required for entry
- PPS configuration is identical to SNS Front End

Moderator Demonstration Facility

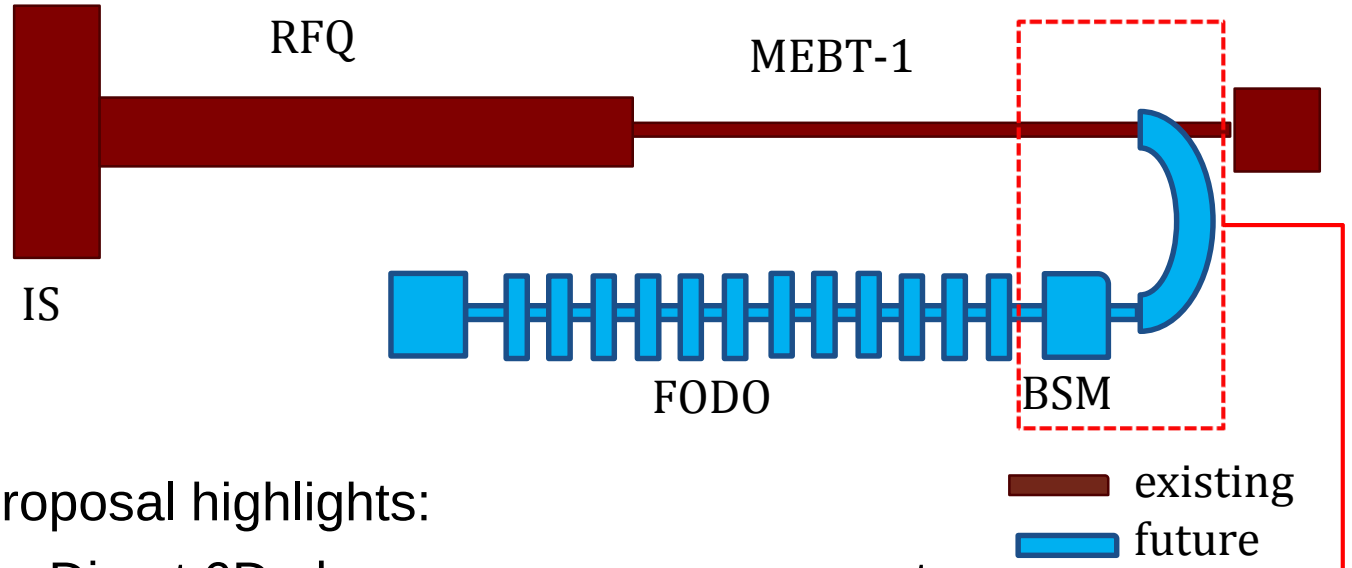
- Low power short pulse neutron source
- Up to 100 Watts on Li target
- 1-10 us pulse @60Hz
- 6m long neutron beam line



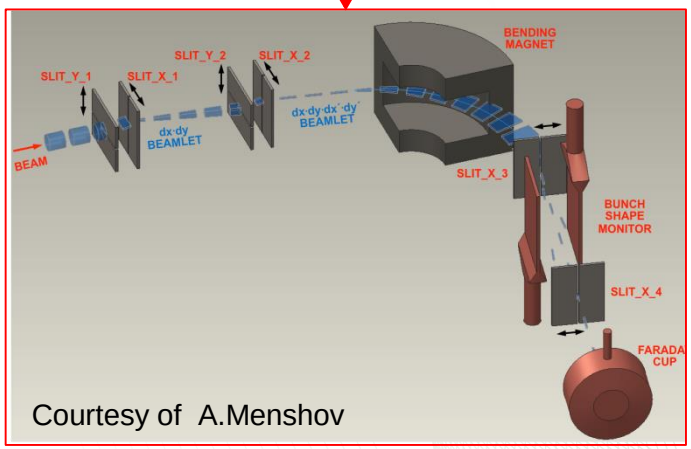
Courtesy of M. Phillips

- Funded through LDRD
- FY15-FY16
- Layout has been determined
- Components design and procurement is in progress

U. of Tennessee NSF Proposal to Extend ITSF for Beam Dynamics Studies (Sarah Cousineau is PI)



- Proposal highlights:
  - Direct 6D phase space measurement after RFQ; includes cross-plane correlations.
  - Study halo formation.
  - Benchmark codes (community resource), evaluate diagnostics.
  - Funding for 1 postdoc, 1 graduate student, 3 undergraduates.

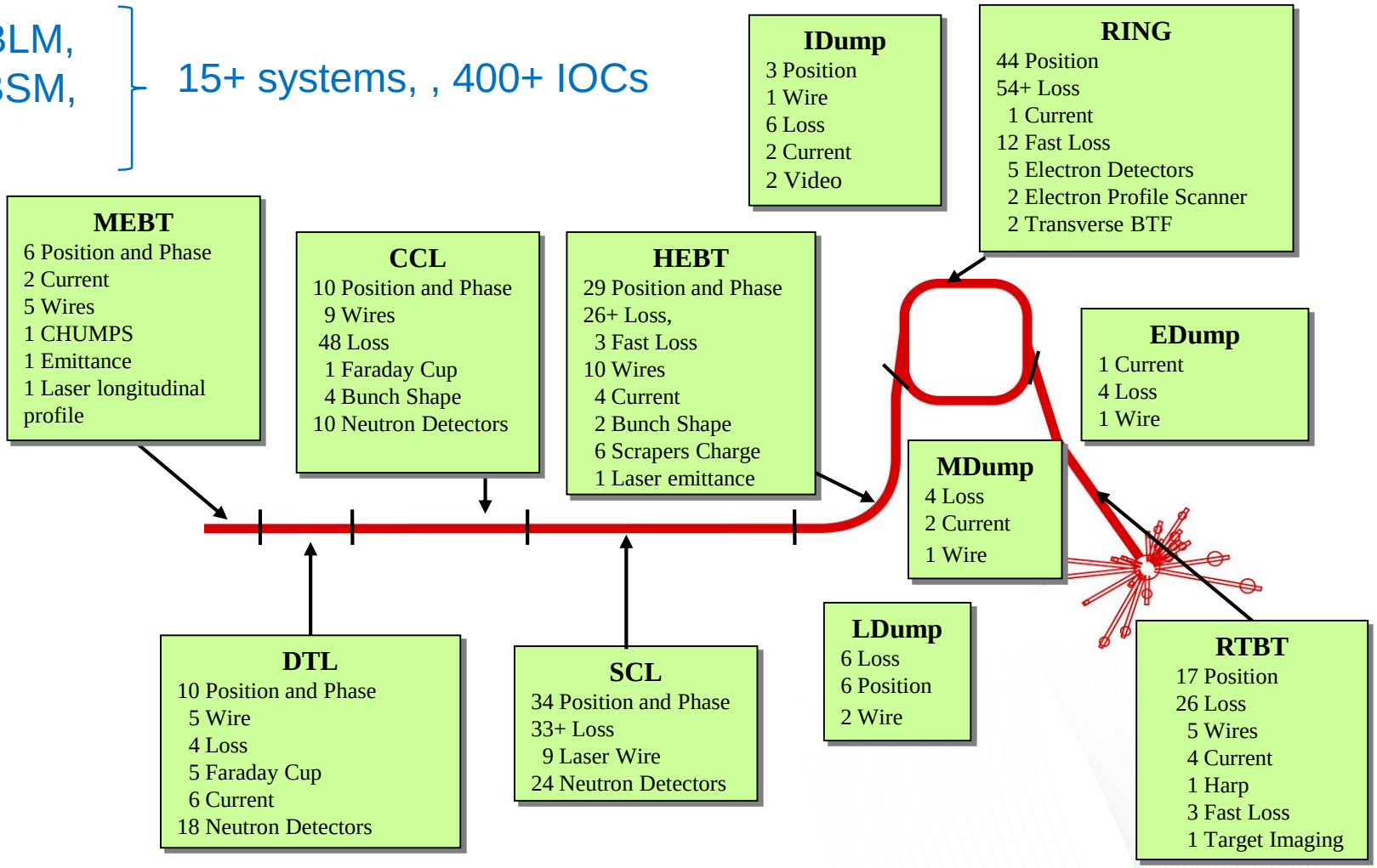


Courtesy of A.Menshov

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

BCM, BLM, BPM, BSM, WS….

15+ systems, , 400+ IOCs



Beam Instrumentation Progress Outline

- Electronics obsolescence mitigation
  - Linac BPMs
  - Ring BPMs
  - BLMs
- Ring feedback development
- Fast Differential Beam Current Monitor (FDBCM)
  - Fast beam abort for SCL protection from large instantaneous beam loss

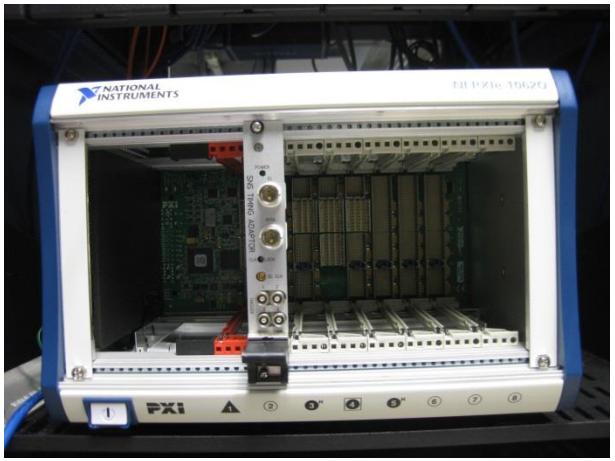
Recommendations from last AAC:

- **Continue to develop and test active damping system for e-p instability**
- **Proceed with the MPS upgrade to 5 μsec response time**

Our approach to all new electronics designs is to minimize custom design efforts

SNS design

Commercial Off-the-Shelf



Custom built
Analog Front-End

COTS
Analog-To-Digital
Conversion

COTS
General Purpose FPGA

COTS
Crate and controller

High Level Language Programming

SNS Beam Position and Phase Monitor (BPM) systems

- 96 linac style BPMs measure beam position and phase
  - 16 BPMs at 805MHz
  - 80 BPMs at 402.5MHz
- 64 ring style BPMs measure beam position
- 160 individual PC IOCs

New Linac BPM electronics development

AFE and digital

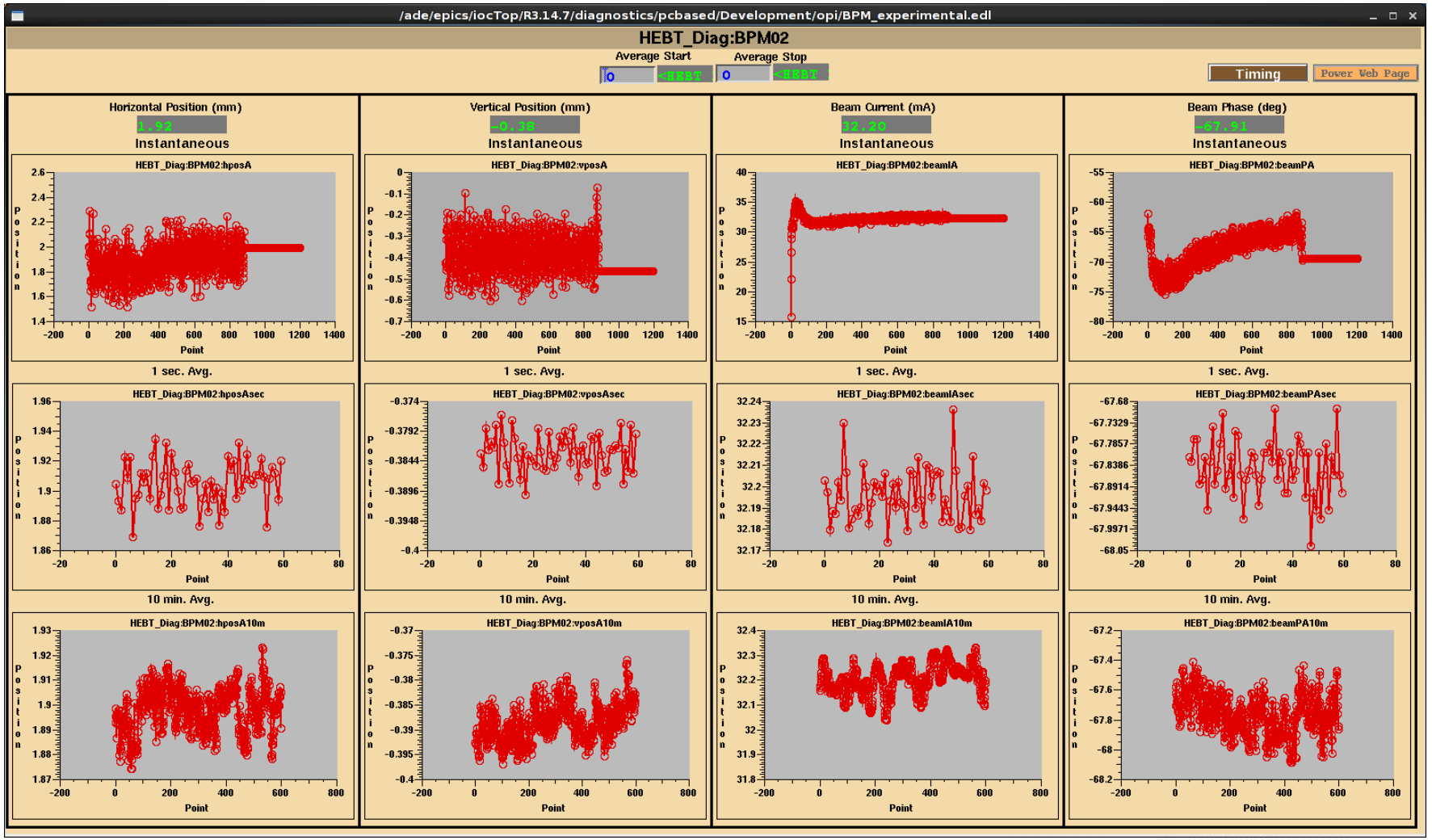
Old BPM electronics

1 BPM per chassis

New BPM electronics

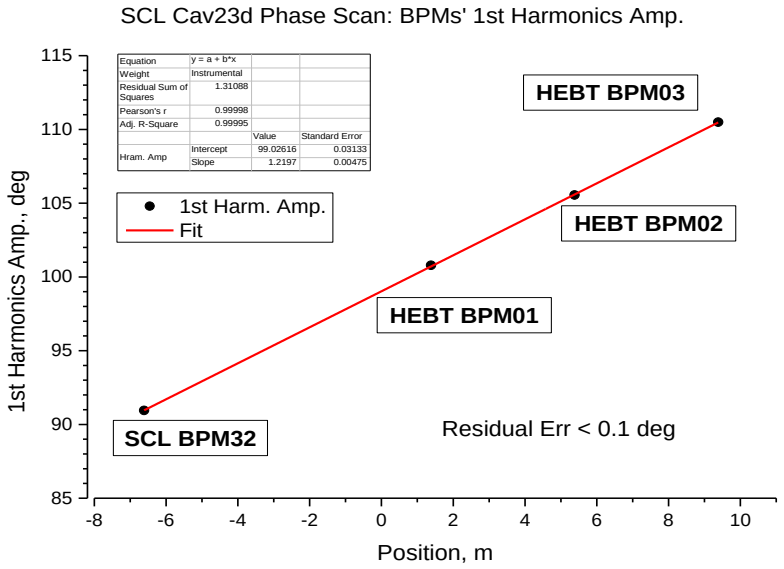
6 BPMs per crate

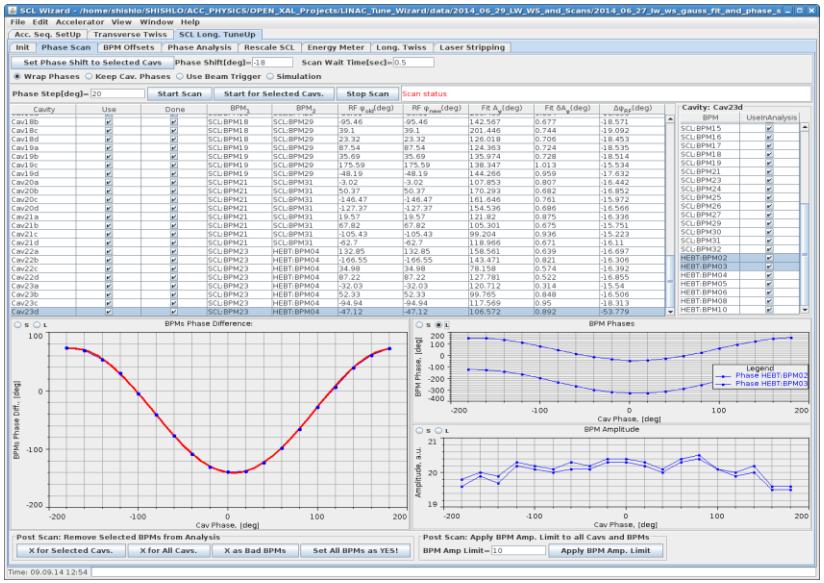
New EPICS GUI utilizes 60Hz capability

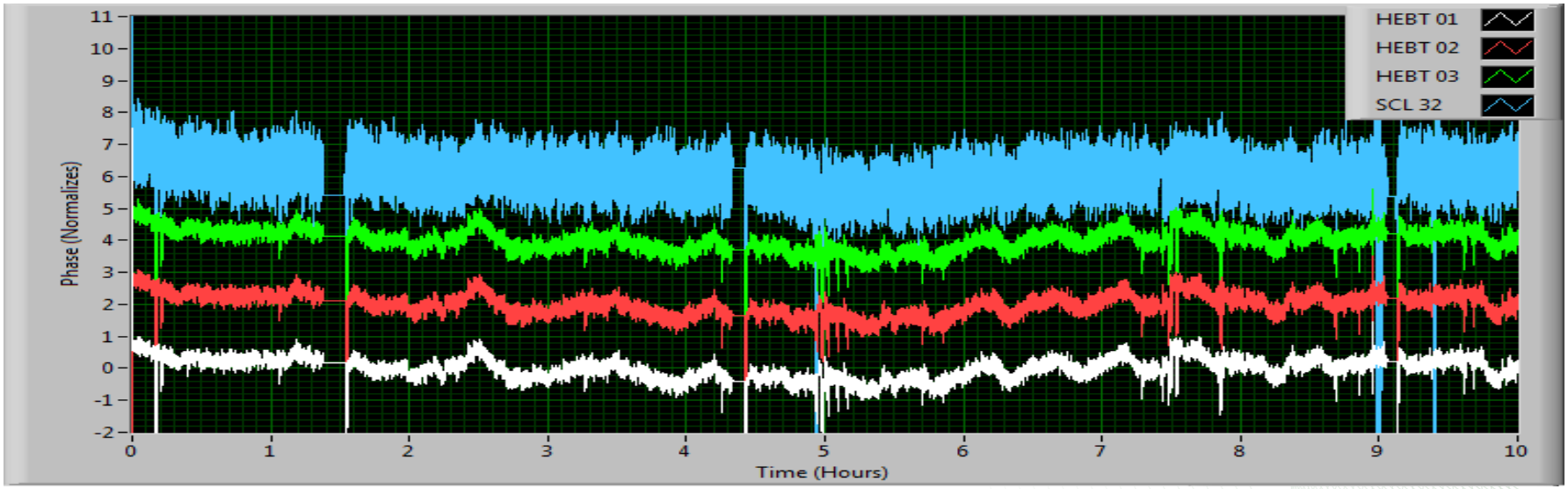


Screen by:
Dave Brown

4 BPM prototypes tested with beam

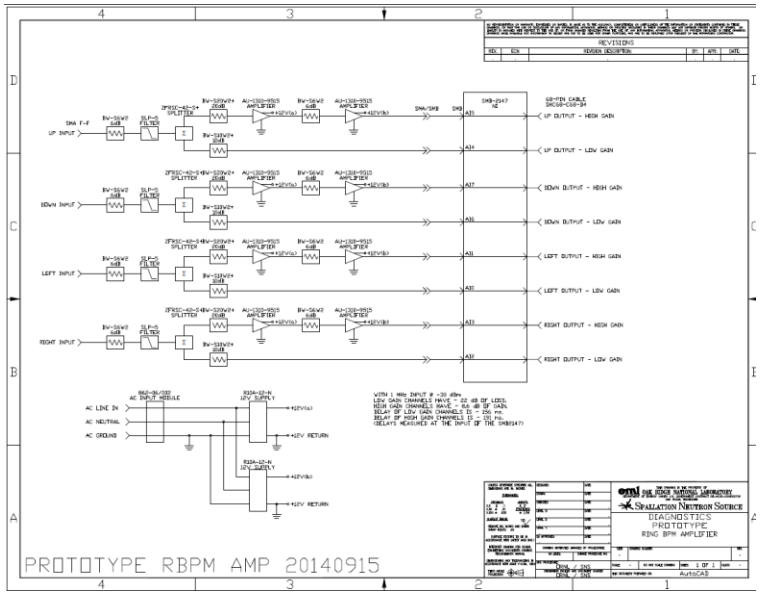


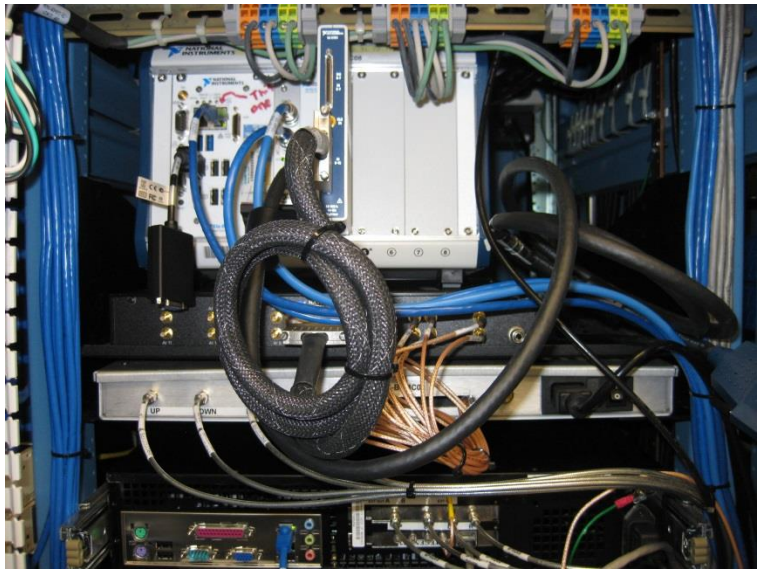




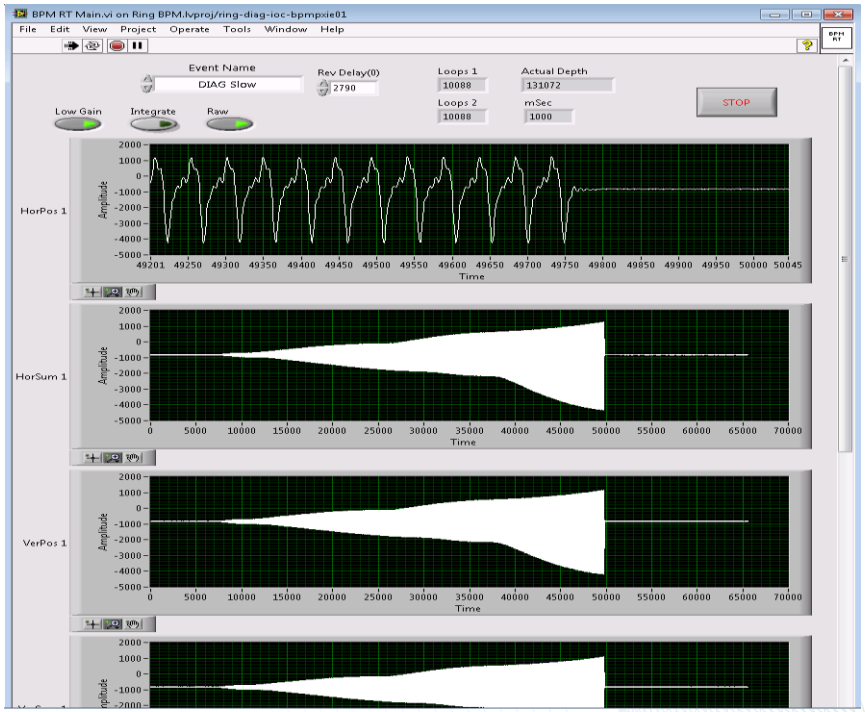
Courtesy of C.Long and A.Shishlo

Ring BPM prototype electronics





- AFE prototype developed
- One BPM set tested with beam
- Specifications for AFE PCB are being developed
- EPICS GUI is being developed



Courtesy of R. Dickson

New BPM electronics acquisition strategy

- Assemble 6 BPMs 805MHz system in FY15
  - Complete set to replace MEBT BPM electronics
  - Develop calibration procedures and software
  - Develop installation drawings and documentation
  - Cost estimate: hardware plus labor for assembling, testing and installation

~1.5 M$

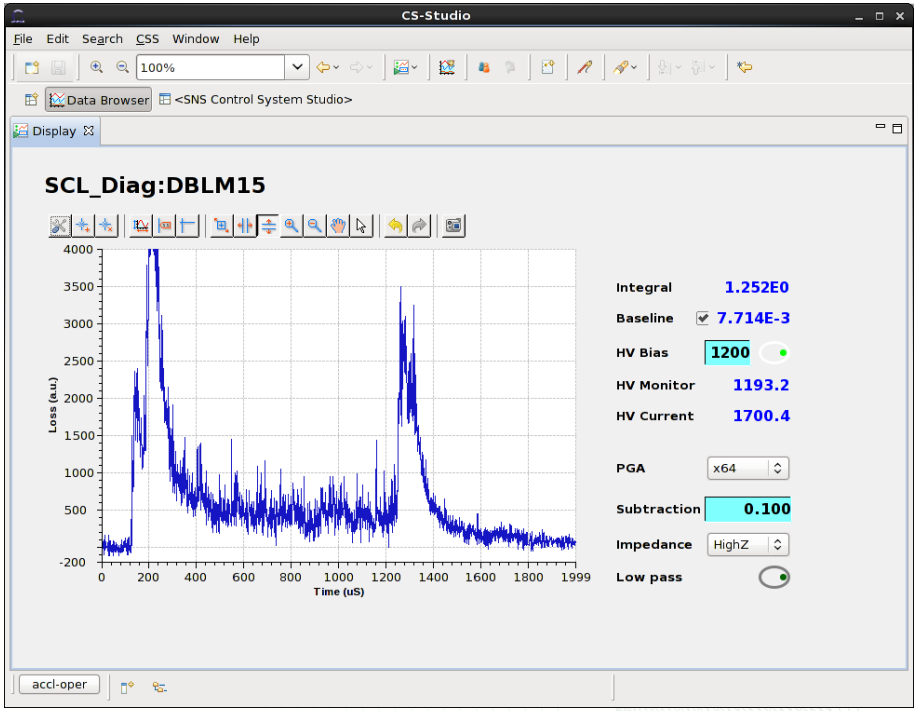
- Acquisition Option #1
  - Purchase all linac BPM electronics at once through AIP
  - Can be less expensive overall but requires significant initial investment
- Acquisition Option #2
  - Purchase 2-3 sets per FY using operational budget
  - Cost is distributed over longer period
  - Have to live with mixed system for some time

SNS Beam Loss Monitor (BLM) systems

- 370 radiation detectors in linac, ring, beam lines
  - 307 Ionization Chambers (IC)
  - 43 Neutron Detectors (ND)
  - 20 Photo Multiplier Tubes (PMT)
- 12 VME based IOCs
- Part of Machine Protection System

New BLM electronics development

- SCL dual BLM tested with beam for ~ 1year
- Formulated BLM electronics specifications based on experience with prototype



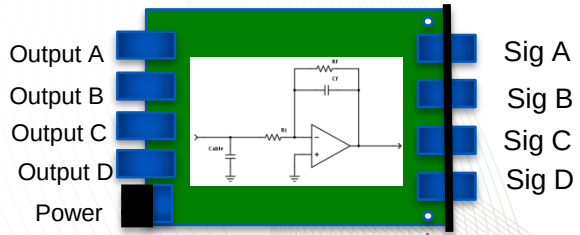
Courtesy of A.Zhukov

Current “Next BLM” system concept

- Detectors and cabling shell stay the same
- Analog electronics should be as simple as possible
  - There will be different flavors of amplifiers/chassis
  - Custom 4 channel front end with ability to be replaced within minutes
  - All three flavors have the same PCB
- Unification of the chassis, boards, power supplies

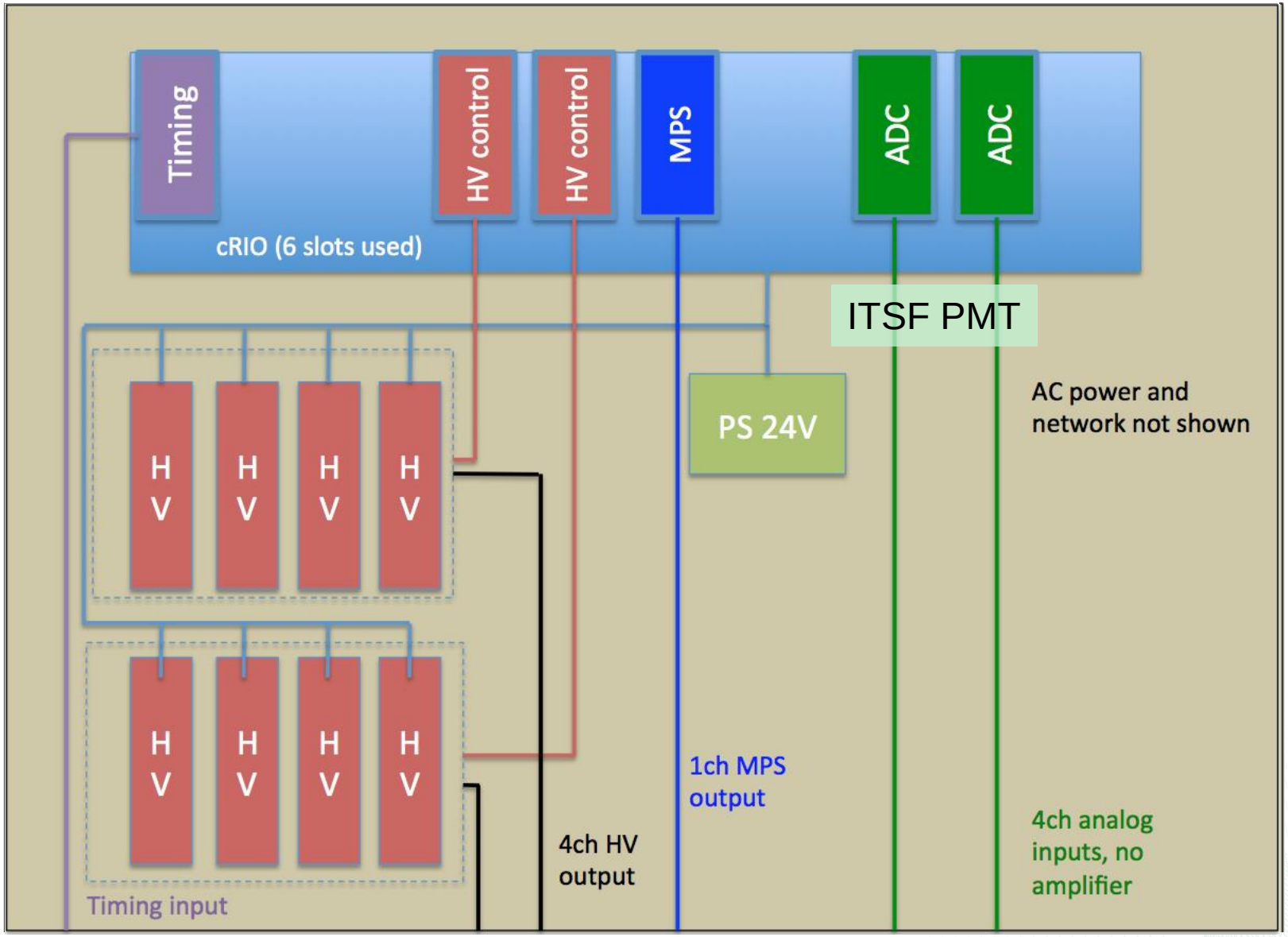
Flavor	Purpose	# Signals	# HV	# MPS	Amplifier	Comment
ISTS	PMTs in ISTS	8	8	1	None	Will have just one MPS channel
Ion Chamber	Normal BLM	16	4	16	IC Amp	Standard IC in accelerator
Target BLM	Target Facility	8	8	0	Target Amp	Sensitive DC amplifier for target people
Neutron Detector	NDs	8	8	8	IC Amp	Standard ND in accelerator
Ion Chamber Slow	Normal BLM	16	4	16	Slow IC Amp	Standard IC in accelerator where high sampling rate isn’t needed e.g. RTBT

Amplifier	Gain (Ohm)	Min Current (nA)	BW (Hz)	Sampling (kS/s)
IC Amp	600k	2	200k	1000
Target Amp	100M	0.01	1	100
Slow IC Amp	600k	2	30k	100



Courtesy of A. Zhukov

4U Chassis layout for ITSF



Courtesy of A. Zhukov

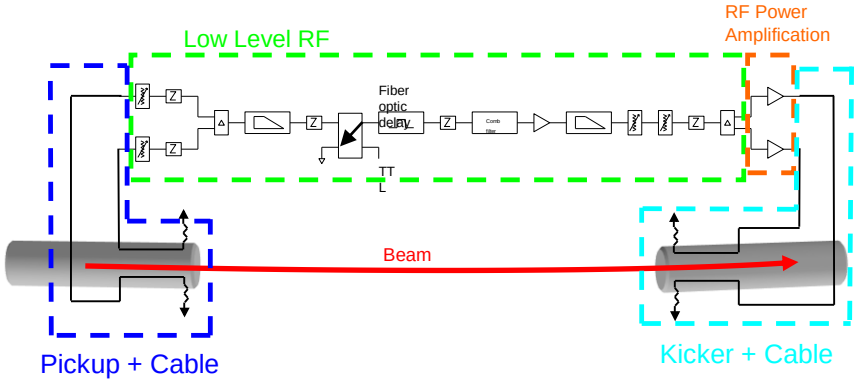
New BLM electronics acquisition strategy

- Assemble 8 PMT channels system for ITSF in FY15
  - Develop calibration procedures and software
  - Develop installation drawings and documentation
  - Cost estimate: hardware plus labor for assembling, testing and installation

~500 k$

- Acquisition Option #1
  - Purchase all BLM electronics at once through AIP
  - Can be less expensive overall but requires larger initial investment
- Acquisition Option #2
  - Purchase 2-3 sets per FY using operational budget
  - Cost is distributed over longer period
  - Have to live with mixed system for some time
    - Two systems are identical from user perspective

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



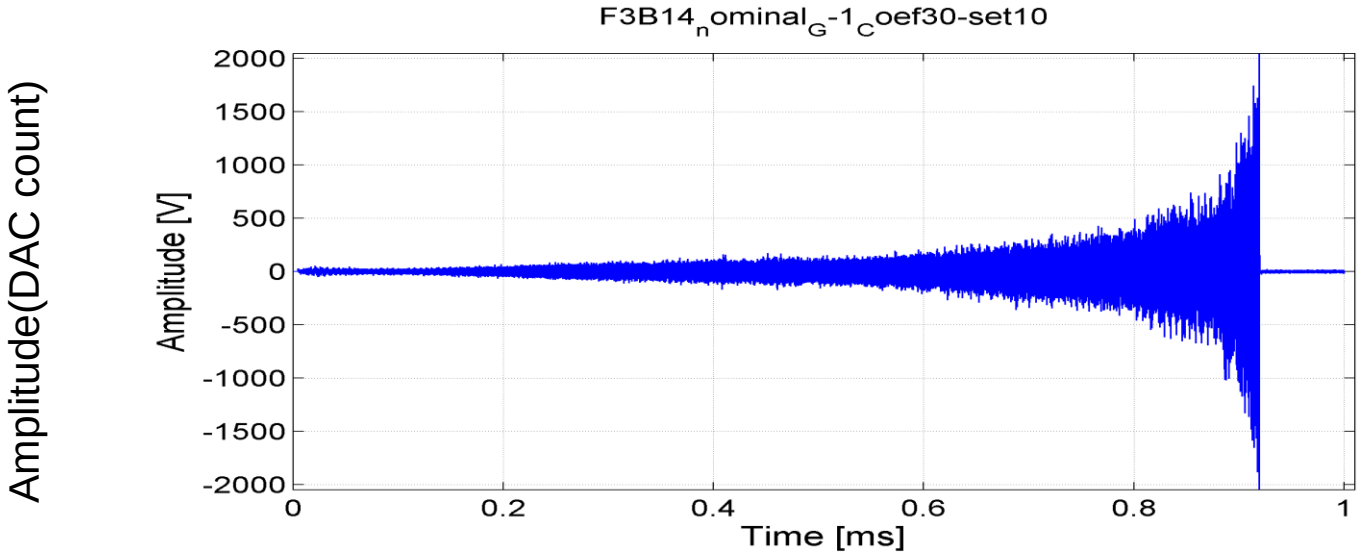
- Wide bandwidth and high power are required for e-p damping
  - 1-300MHz bandwidth
  - 400 W/channel peak power
  - Digital processor recently commissioned
- Beam Transfer Function measurements
  - Useful tool for beam dynamics study
  - Preferable mode when there is no e-p present

Ring feedback electronics

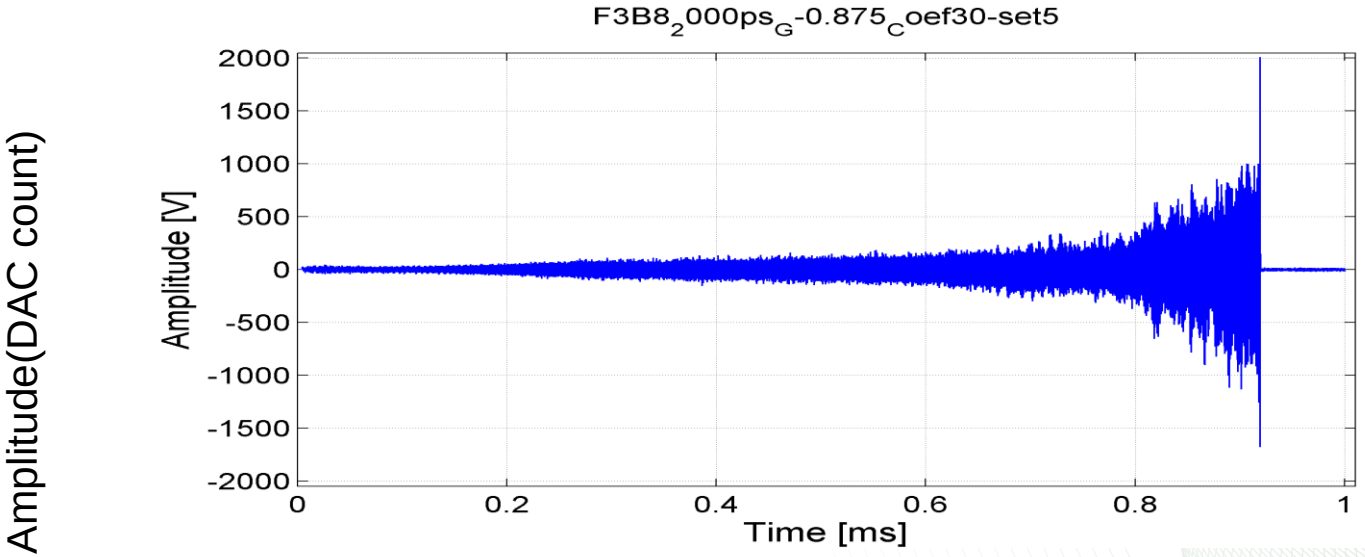
Courtesy of C. Deibele and Z. Xie

December 21st, 950us accumulation, long pulse beam

Damper off

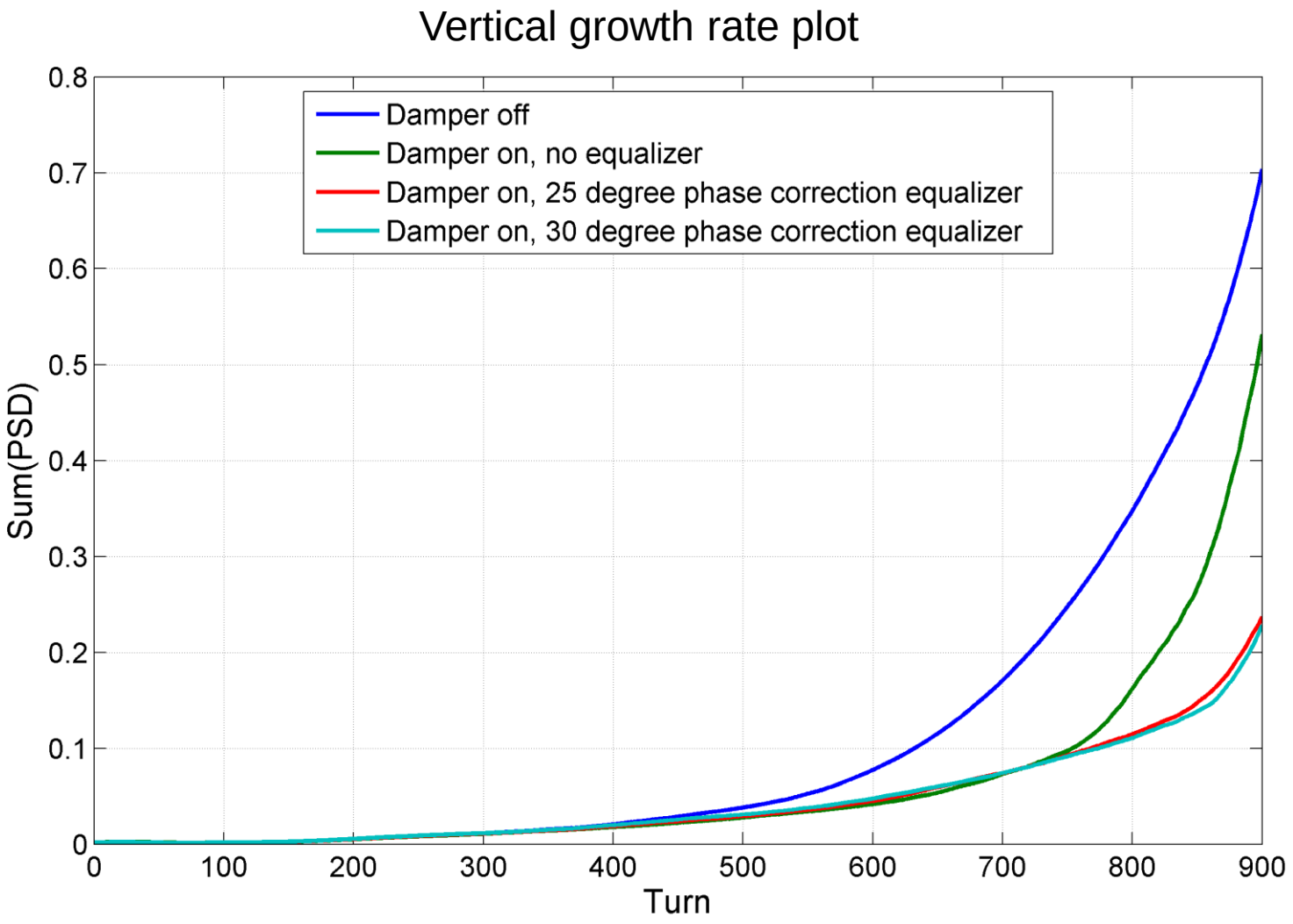


Damper on with best gain and delay



Courtesy of Z. Xie

Feb 5th, 950us accumulation, long pulse beam – Equalizer used



Courtesy of Z. Xie

Ring feedback system status and plans

- Hardware configuration is optimized
- System appears to function as expected during dedicated beam study
- Need to convert from experiment to operational user friendly tool
- Personnel change
  - System RF engineer (Craig Deibele) left SNS
  - Digital processor designer (Zaipeng Xie) will leave soon
  - Hired a postdoc (Nick Evans)
    - Take over system knowledge from Craig and Zaipeng
    - Develop control room tools
      - BTF measurements
      - Feedback set up and control
    - Future feedback system development

Results of fast beam abort test for SCL protection

- Temporary change to the Machine Protect System
  - Direct connection to chopper
- ~8.5µs abort time

→ 2 to 3x improvement

→ ~6µs best possible

- Permanent connection to MPS is being worked on