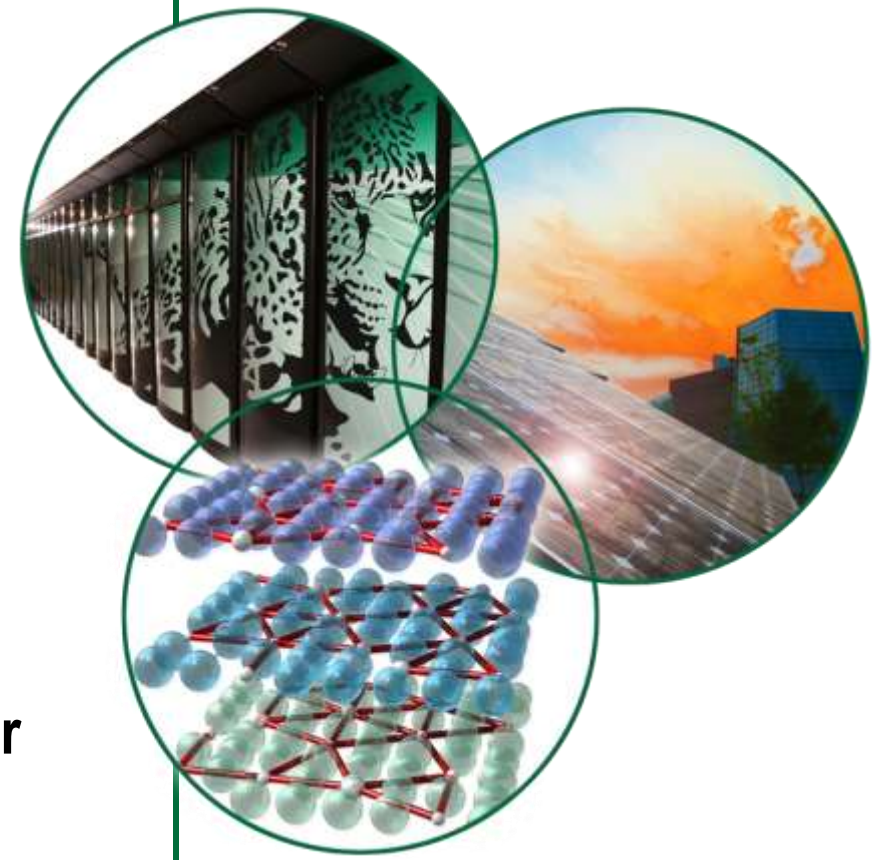
Beam Instrumentation Performance and Plans



Alexander Aleksandrov

Beam Instrumentation Group Leader

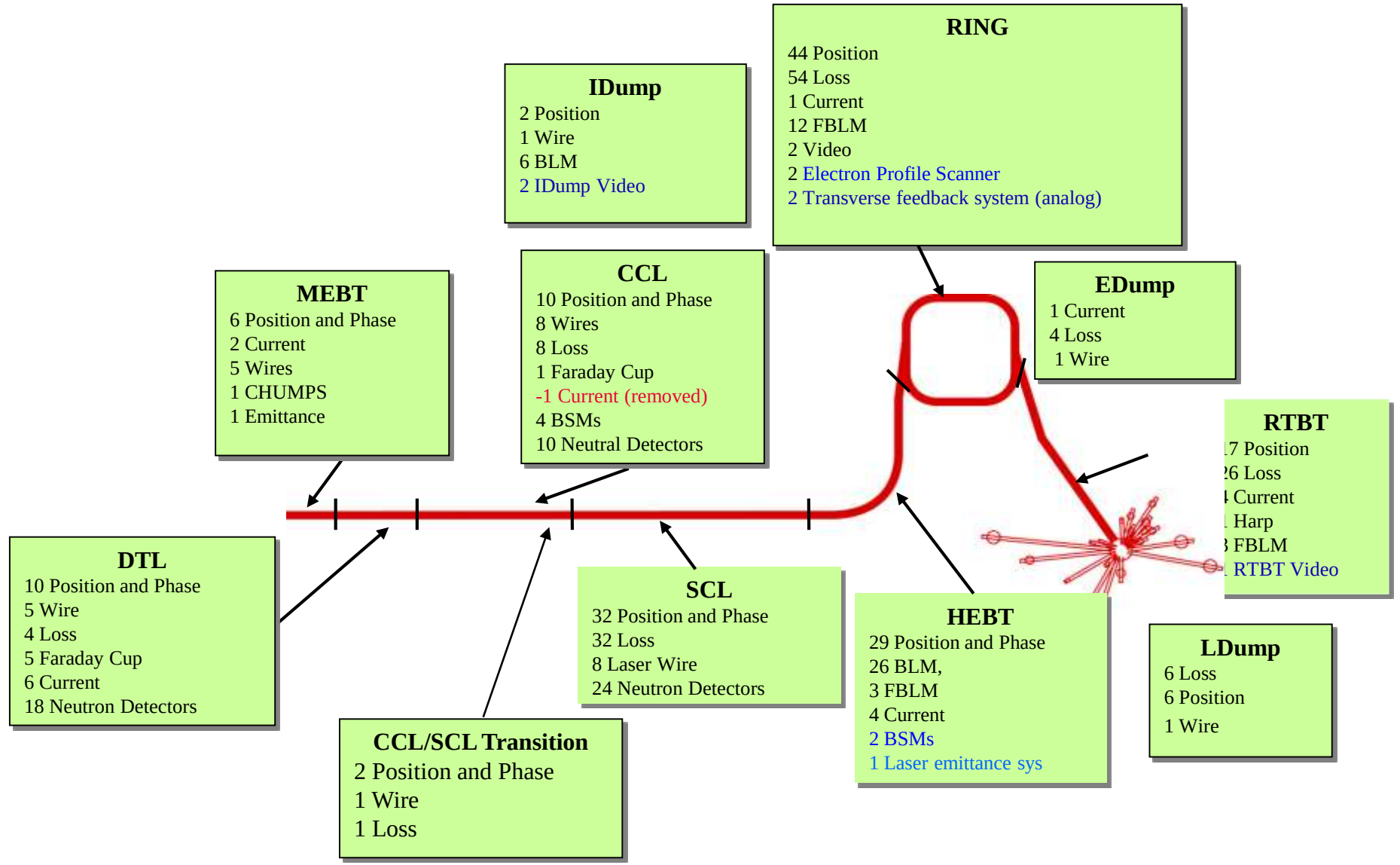
February 3, 2010

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

SNS Beam Instrumentation Systems are Numerous and Diverse

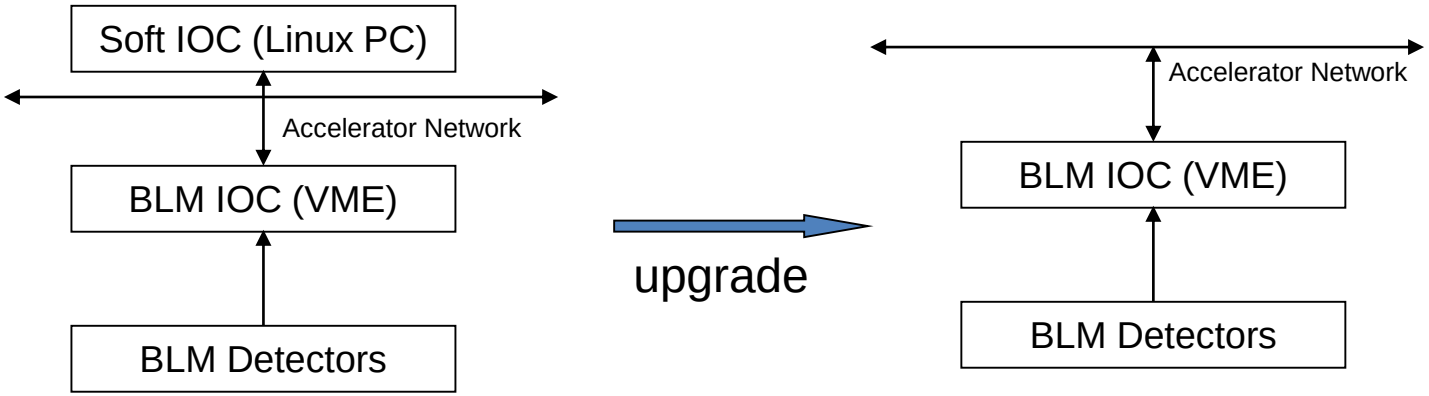


Outline

- Diagnostics downtime
- New Systems
- Overview of performance improvements upgrades and development progress
  - SCL Laser Wire
  - Wire Scanners
  - Ring Transverse Feedback system
  - Laser Stripping Experiment

Beam instrumentation-related downtime

- 12 hours for last year
- Mainly related to BLM software upgrade



The old VME BLM IOC processing power was insufficient to perform all desired BLM functionality. This necessitated partial functionality being distributed to a separate Soft IOC (IOC without instrumentation hardware).

BLM IOC CPU hardware upgrades have since made this unnecessary.

The Soft IOC functionality has now been rolled back into the VME IOC in order to reduce system complexity and increase both maintainability and reliability.

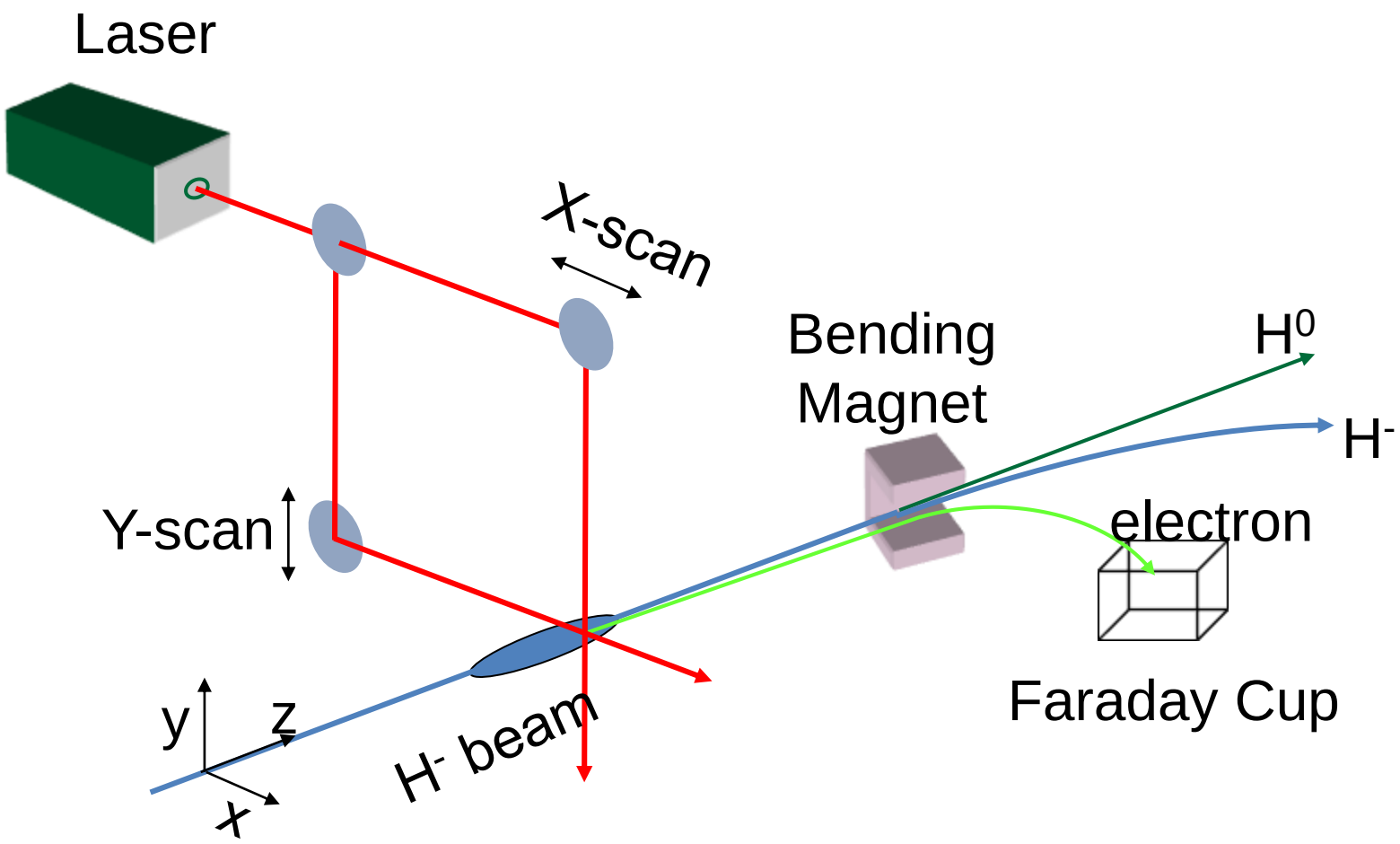
New Systems

- 8 HEBT BPMs — in operation
- 4 HEBT scrapers read-outs — in operation
- 2 MEBT scrapers — in operation
- 1 MEBT chopper — in operation
- 5 Ring Electron Detector read-outs — commissioning
- Momentum Dump Diagnostics
  - 2 scraper read out — commissioning
  - 4 Beam Loss Monitors (BLMs) — installing
  - 1 Wire Scanner (WS) — installing
  - 1 NanoCurrent Detector (NCD) — manufacturing
  - 1 Beam Current Transformer (BCM) — designing
- Ring Injection Dump Line Upgrade
  - 3 BPMs — designing

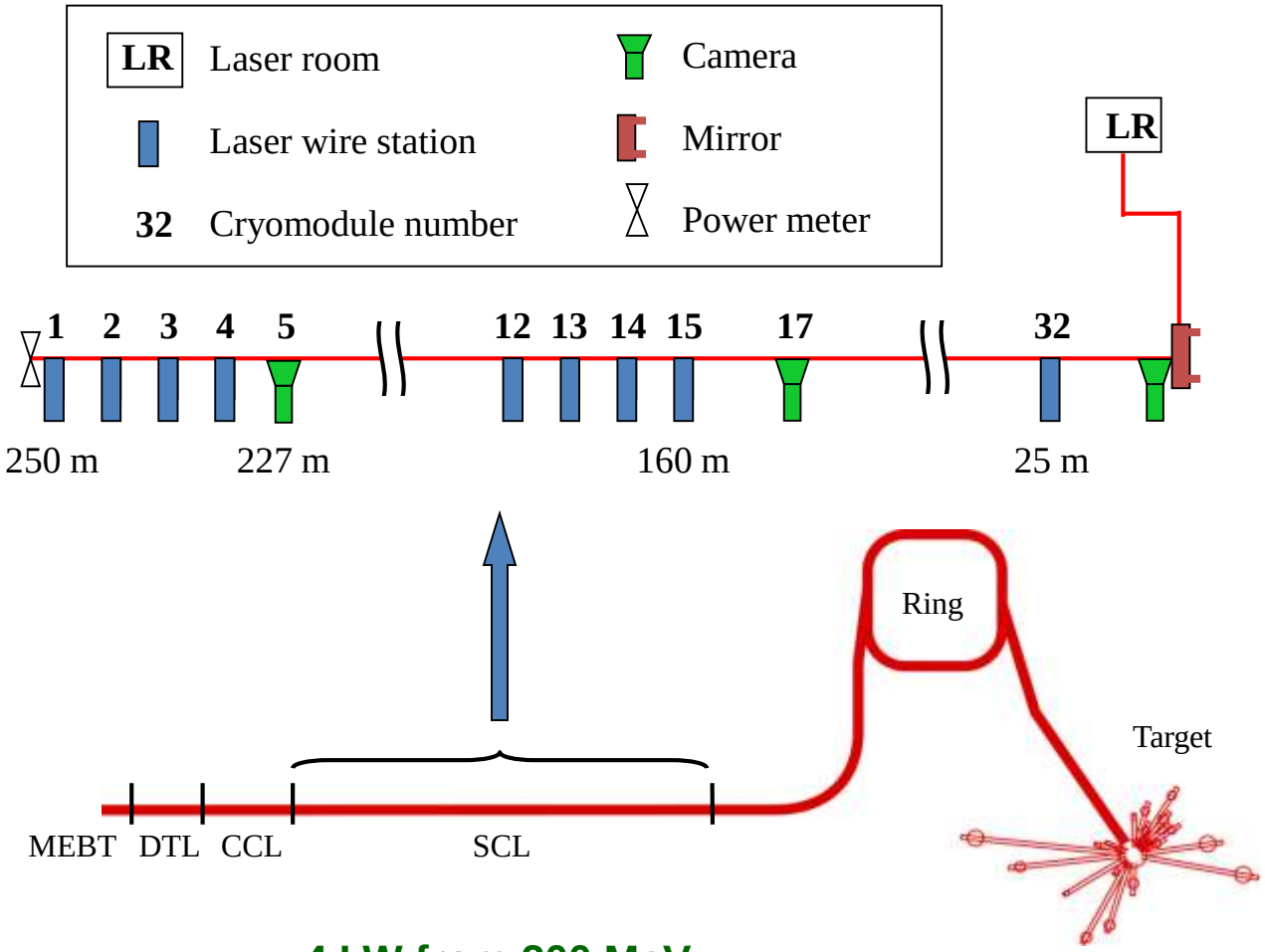
AAC'09 Recommendation on Laser Wire

"In the transverse phase plane, the Laser Wire Scanners are remarkable instruments capable of monitoring transverse beam evolution along the linac and during the pulse. It is regrettable that they cannot presently be used to their full potential, mostly because of stability problems. The committee urges the implementation of the improvements proposed by the beam instrumentation specialists. "

Laser wire profile scanner

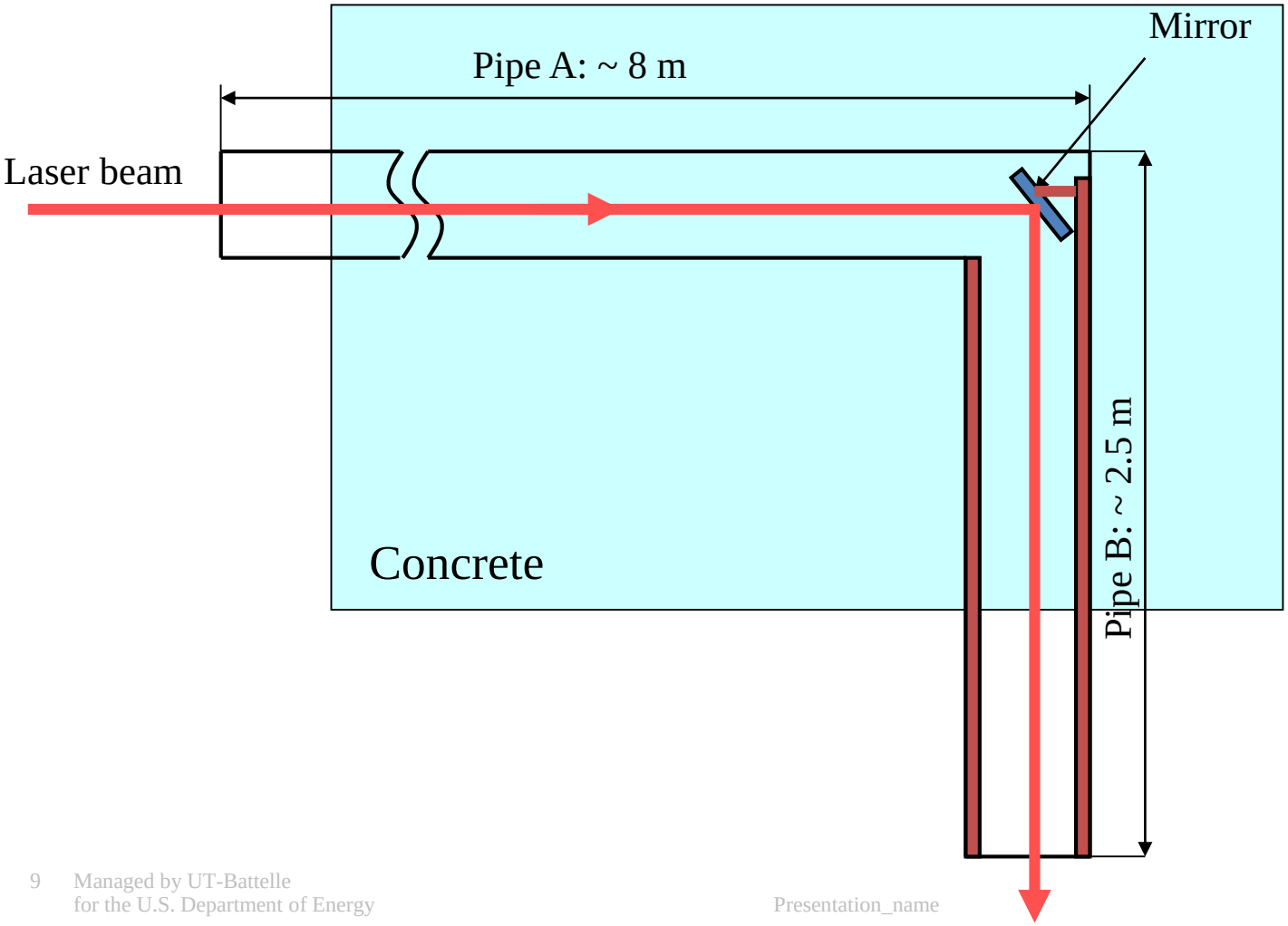


Layout of the SCL Laser Wire System

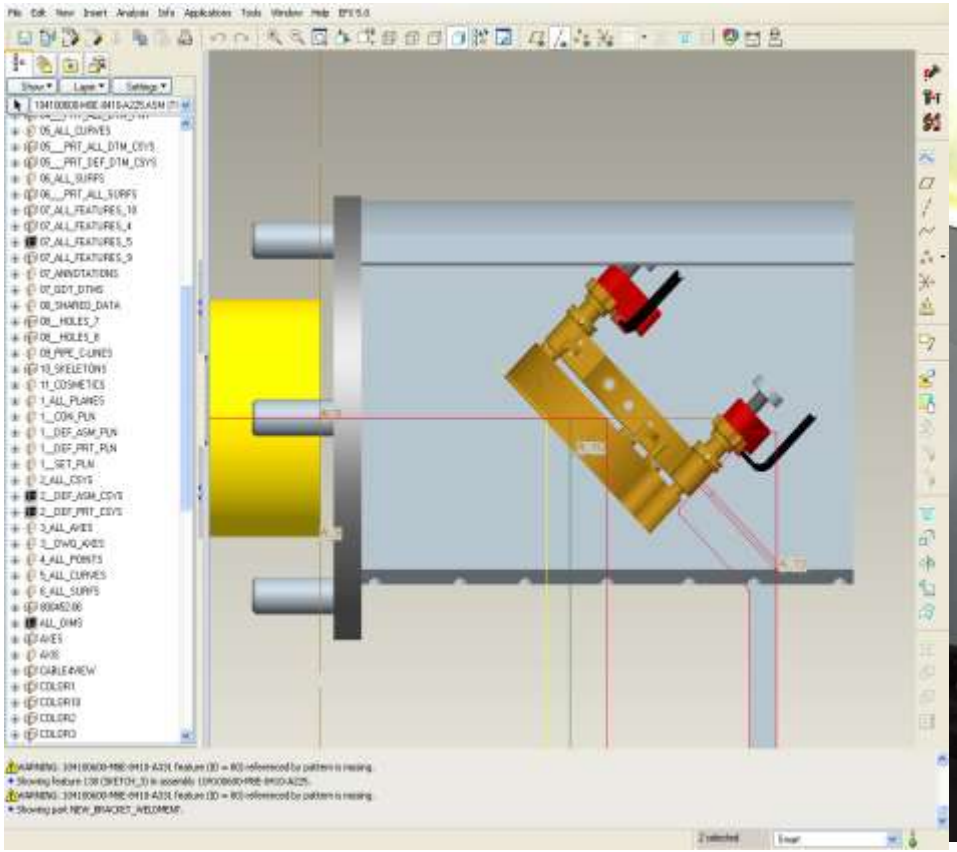


- **4 LW from 200 MeV**
- **4 LW from 450 MeV**
- **1 LW at 1 GeV**

Periscope box upper mirror – hidden corner – identified as a major source of the laser beam vibration



Installed New Mirror Holder

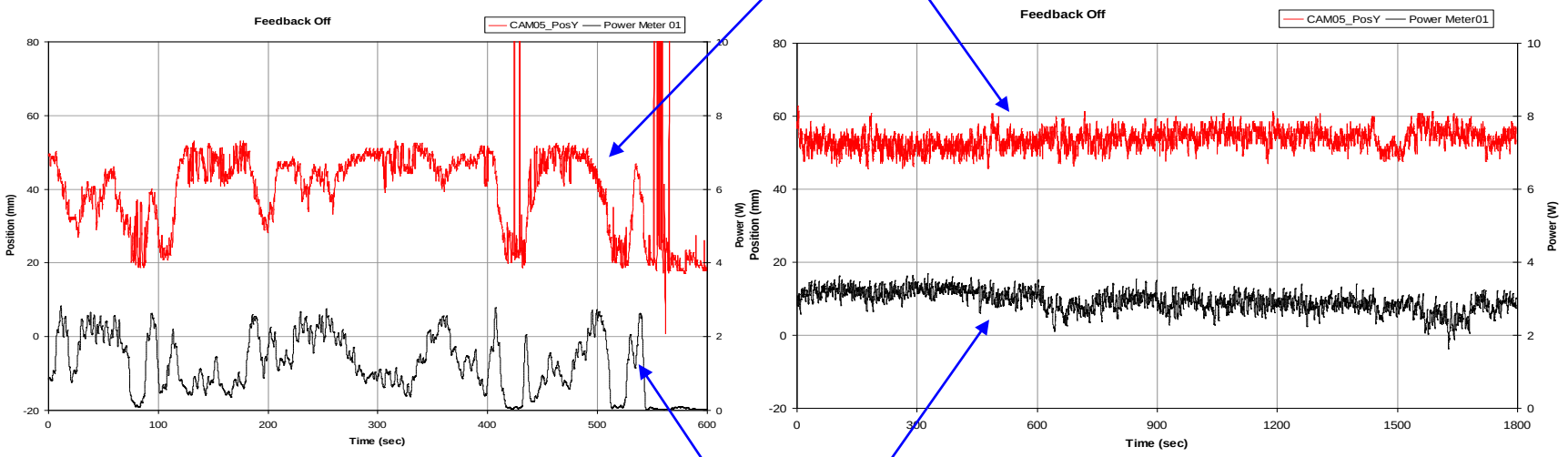


Improvement of laser beam stability

Beam position Y on Cam5

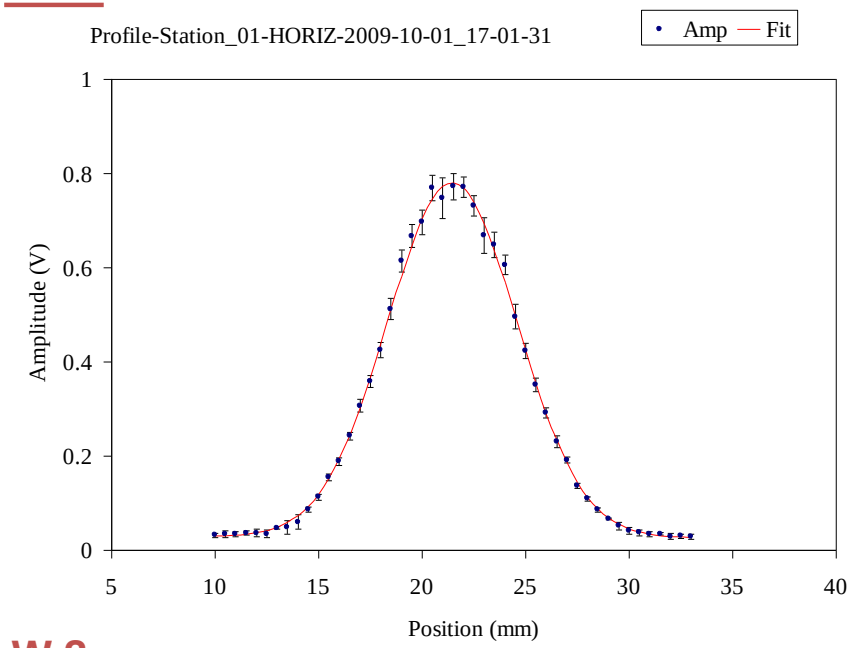
May 29, 2009

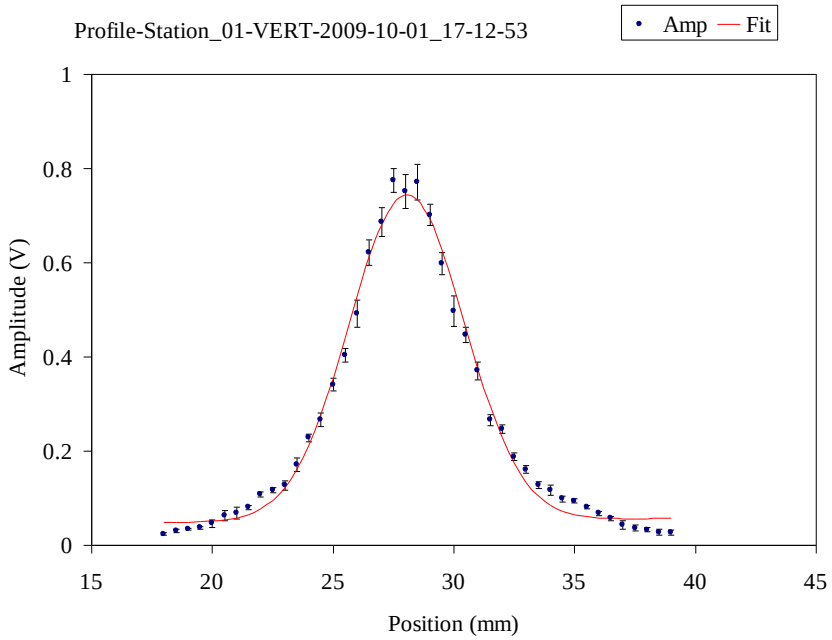
Aug. 12, 2009



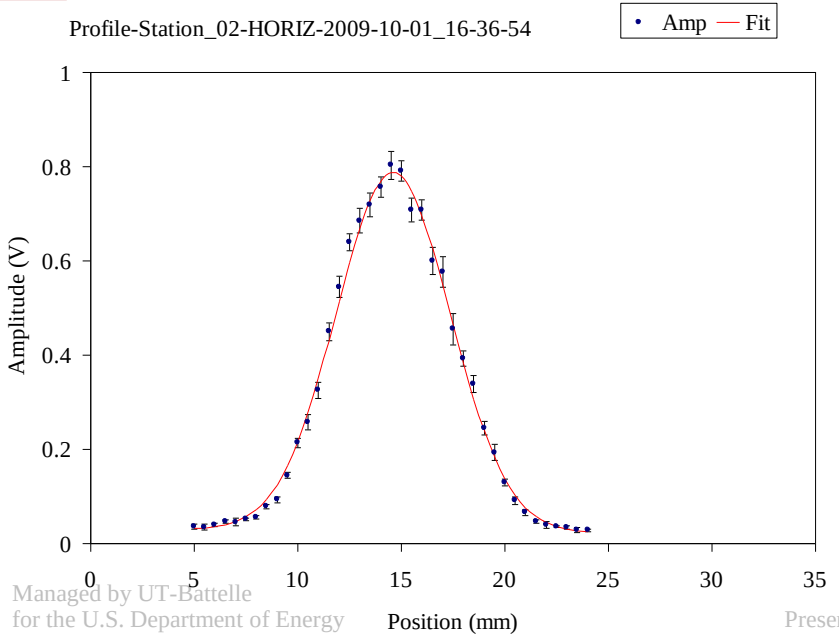
Laser power measured at LW1

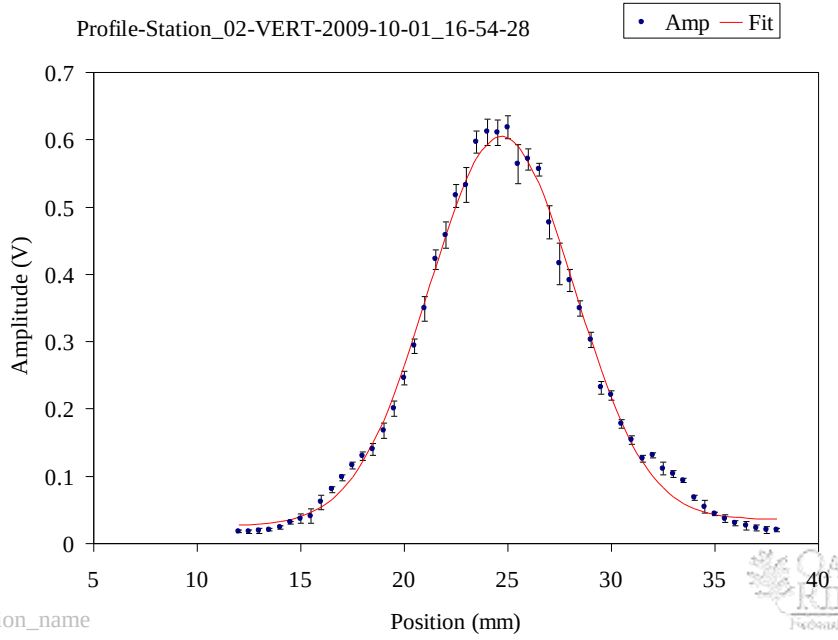
LW 1


Profile-Station_01-HORIZ-2009-10-01_17-01-31
Amp
Fit
Amplitude (V)
Position (mm)


Profile-Station_01-VERT-2009-10-01_17-12-53
Amp
Fit
Amplitude (V)
Position (mm)

LW 2


Profile-Station_02-HORIZ-2009-10-01_16-36-54
Amp
Fit
Amplitude (V)
Position (mm)


Profile-Station_02-VERT-2009-10-01_16-54-28
Amp
Fit
Amplitude (V)
Position (mm)

Improvement of profile measurement
(noise reduced by 30-60%)

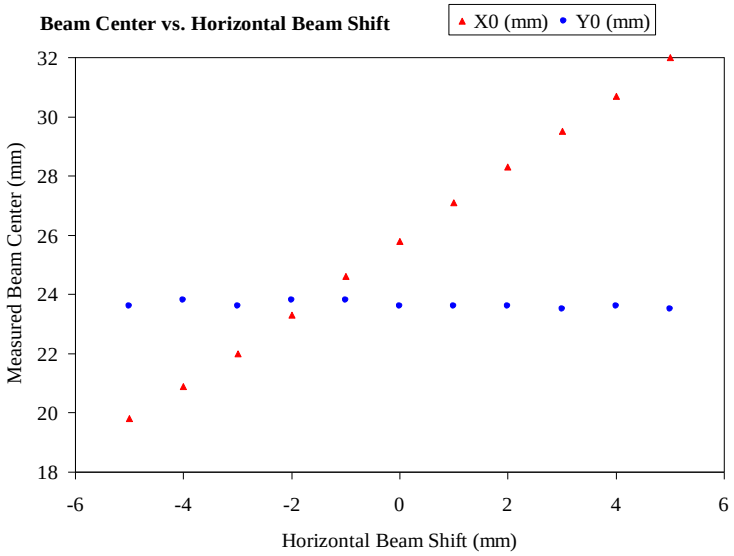
Y. Liu

STD Measurement Noise

LW Station #	1	2	3	4	12	13	14	15	32
Previous run	13.5% (H) 11.0% (V)	12.1 11.8	8.8 10.7	10.0 7.4	7.6 6.8	7.6 6.8	7.3 8.1	6.7 6.8	4.5 4.8
This run	4.2% (H) 5.0% (V)	5.0 4.7	5.4 6.2	6.6 6.6	3.7 3.3	4.3 4.5	3.5 3.5	4.1 4.4	4.1 4.0

Verification of LW data self-consistency

LW 12V	Cam17 Pos: (81,88)			
Focus Lens Pos (mm)	σ_V (mm)	Amp_V (V)	C_V (mm)	E_V (%)
0	3.12	0.94	22.98	5.47
2	3.14	0.89	22.88	3.93
4	3.14	0.79	22.96	4
6	3.18	0.66	23.01	3.98
8	3.17	0.59	23.06	3.49
10	3.14	0.65	22.97	3.28



LW12	Oct.15, 2009							
Ion beam power: 800 KW								
Laser pulse energy (mJ)	σ_H (mm)	σ_V (mm)	Amp_H (V)	Amp_V (V)	E_H (%)	E_V (%)	C_H (mm)	C_V (mm)
75	2.45	3.07	0.35	0.37	4.9	4.2	19.8	22.95
150	2.46	3.11	0.67	0.64	4.1	4.8	19.76	23.13
225	2.37	3.16	0.9	0.96	4.4	4.1	19.78	23.16
300	2.42	3.13	1.06	1.22	4.3	3.9	19.79	23.02

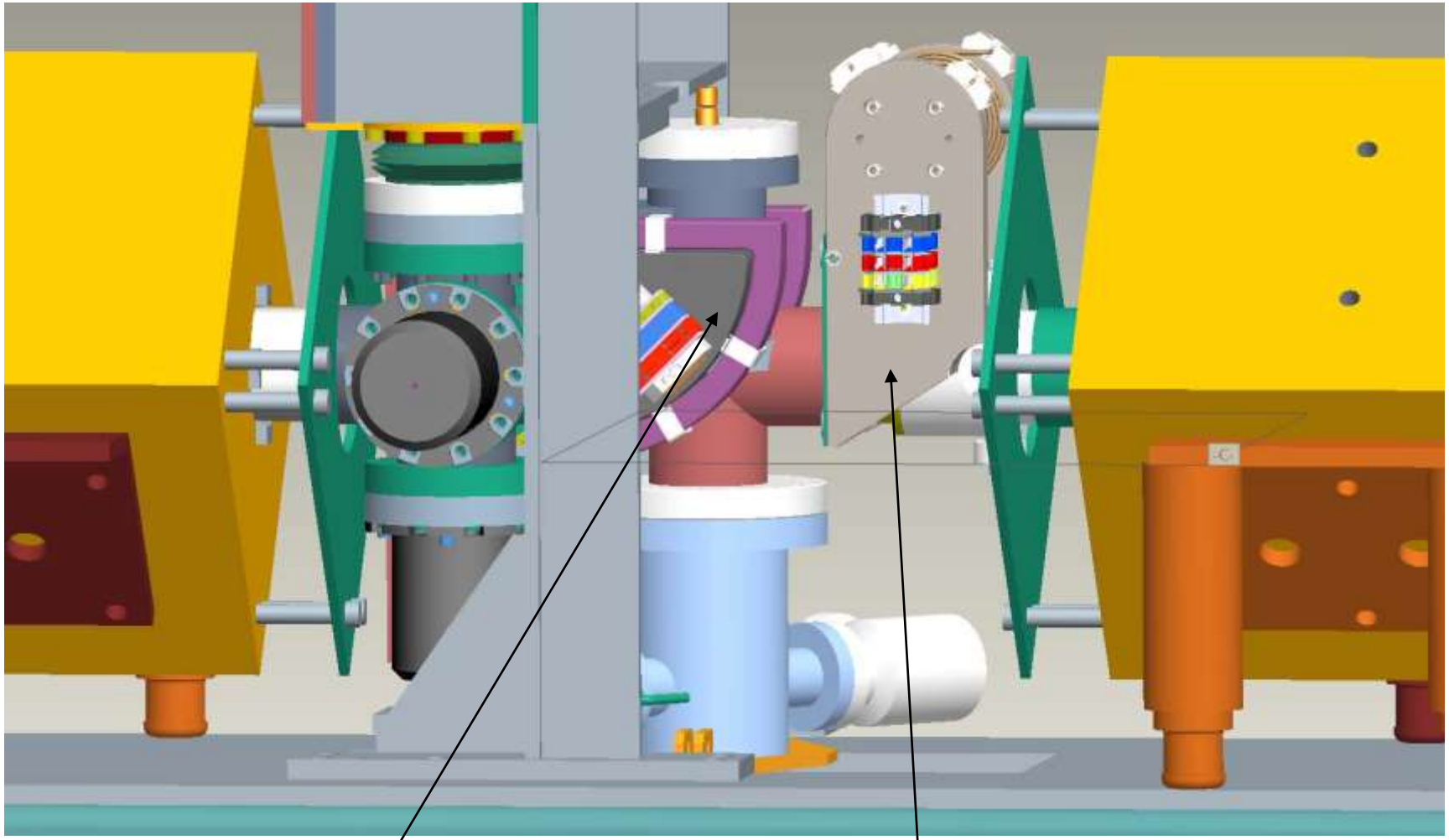
Summary of laser wire system status

- Laser Wire system has been improved and verified to give reliable profile measurement.
- Measurement noise has been reduced by 30-60%.
- System is available to AP with help from BIG experts.
- Trained Operation's Accelerator Specialist in operating the Laser Wire.
- Laser Wire is used often during neutron production
- First Laser Wire journal paper - *Laser wire beam profile monitor in the SNS Superconducting linac* – published in NIMA.

On-going efforts

- Laser wire bump compensation magnet (design has been finished, sent out for quotation request).
- Feedback bandwidth improvement (from 1 Hz to 15-30 Hz).
- Laser energy pulse-to-pulse measurement at laser wire station.
- Simultaneous profile measurement at multiple laser wire stations (currently two-station measurement was made available on hardware).

Laser wire station with the compensation magnet

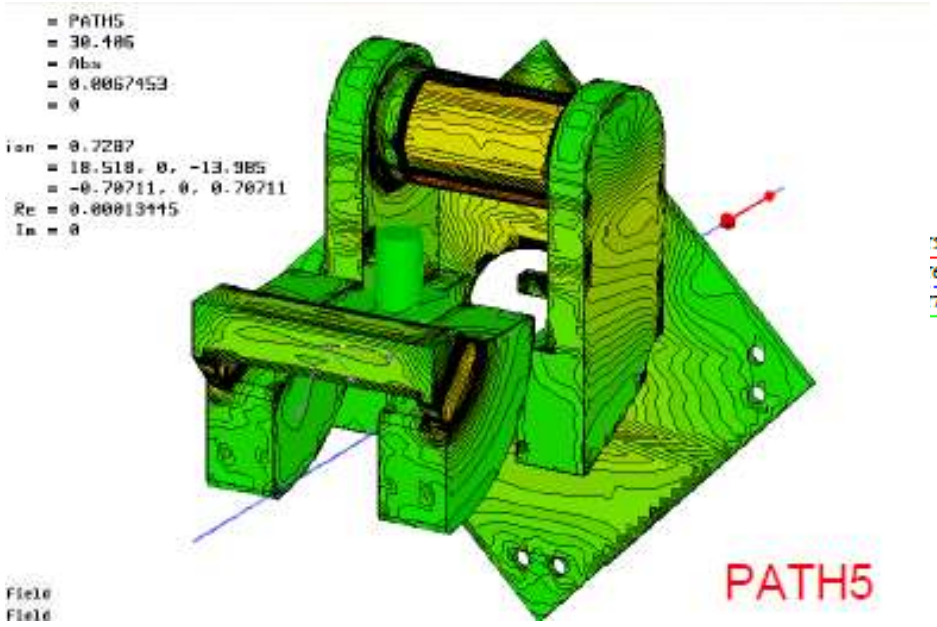


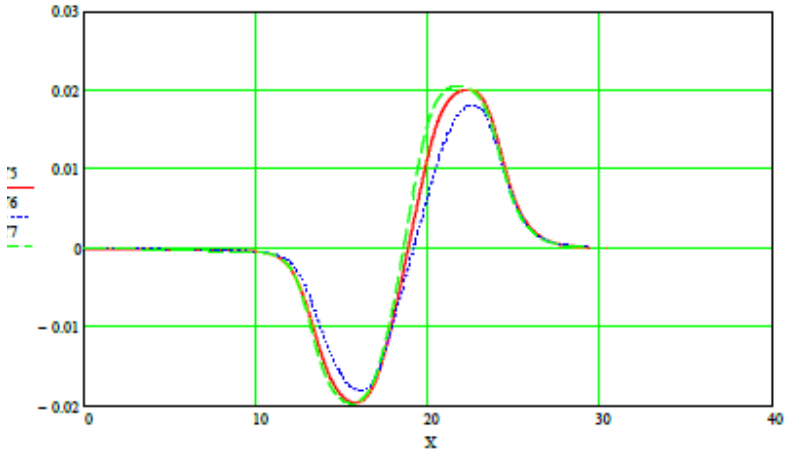
Magnet for collecting electrons

Compensating magnet

Compensating magnet is designed to be connected to power supply in series with the main magnet

A. Menshov





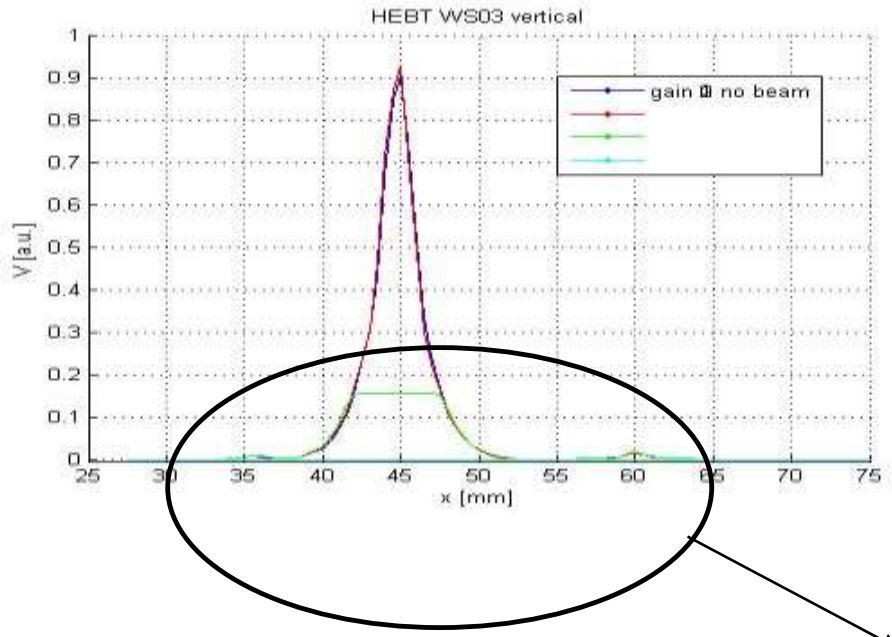
Sent for manufacturing

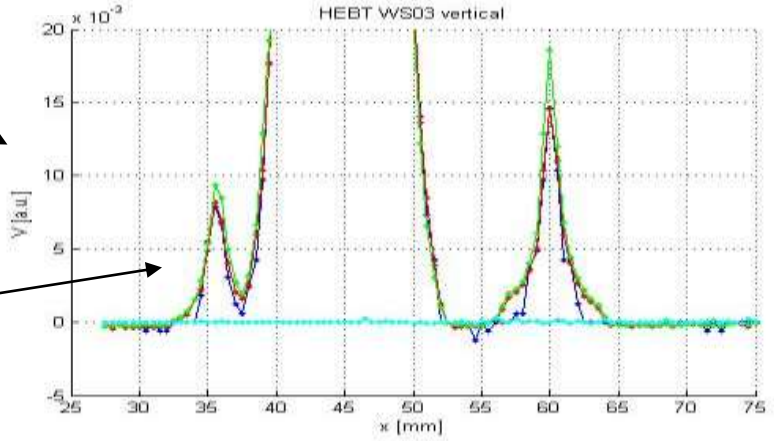
Plan to install during summer 2010 outage

AAC09 Recommendation on large dynamic range profile measurements

- "…The only possibility to measure transverse beam halo down to the 10^{-5} level is with the HEBT beam scraper. Transforming this scraper into a fully functional halo monitor is essential to help understand the process of halo formation and minimization…."
  - We equipped the HEBT scraper with large dynamic range charge sensitive electronics. AP started to use it (J. Galambos's talk)
  - We are looking into possibility of increasing measurement dynamic range of all SNS wire scanners

Limitations in Large Dynamic Range Measurements with SNS Wire Scanners

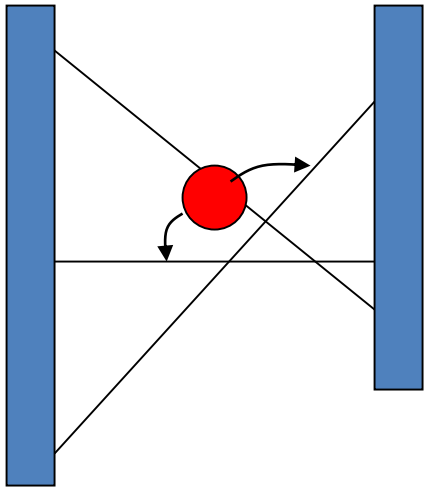




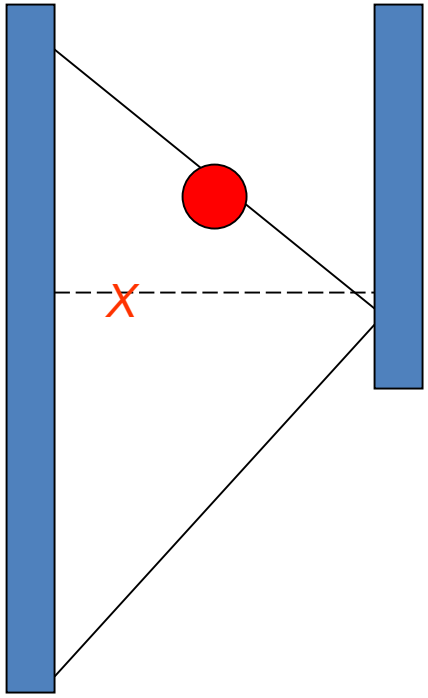
#1

Signal in the beam tail is dominated by the cross-talk between the wires

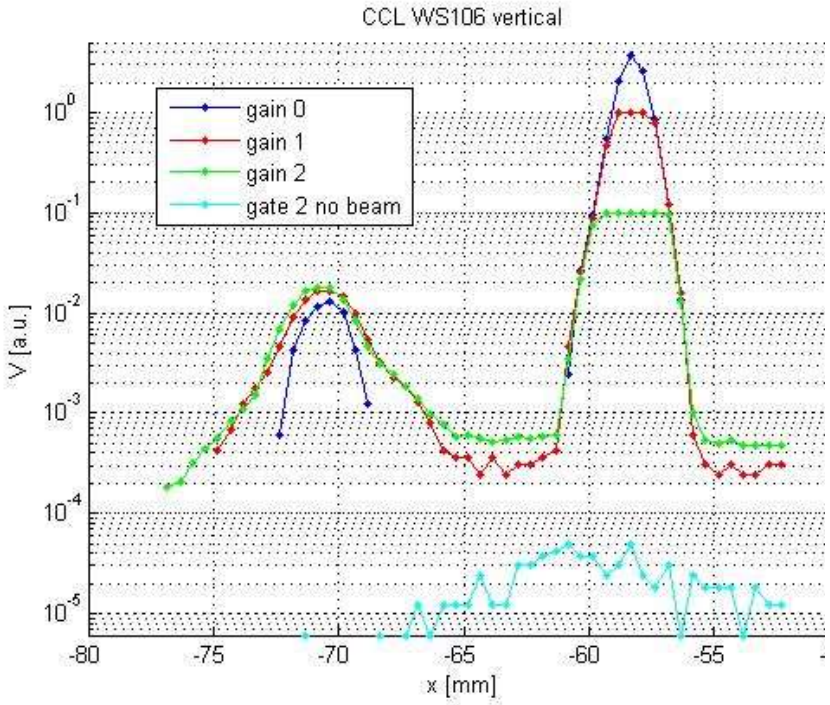
Cross-talk between the wires

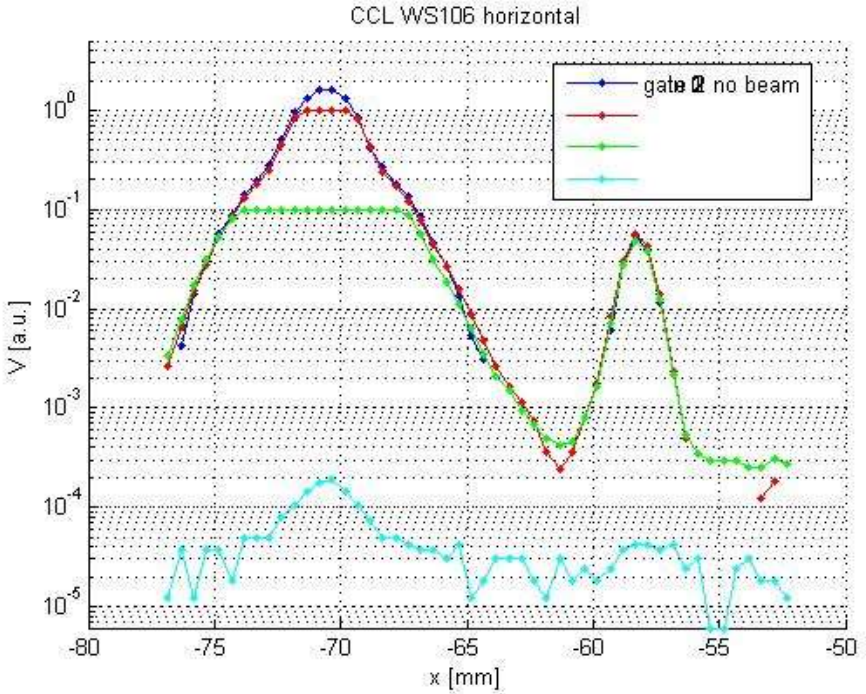


Large separation between the wires helps to reduce the cross talk



Performance of the CCL WS with diagonal wire removed



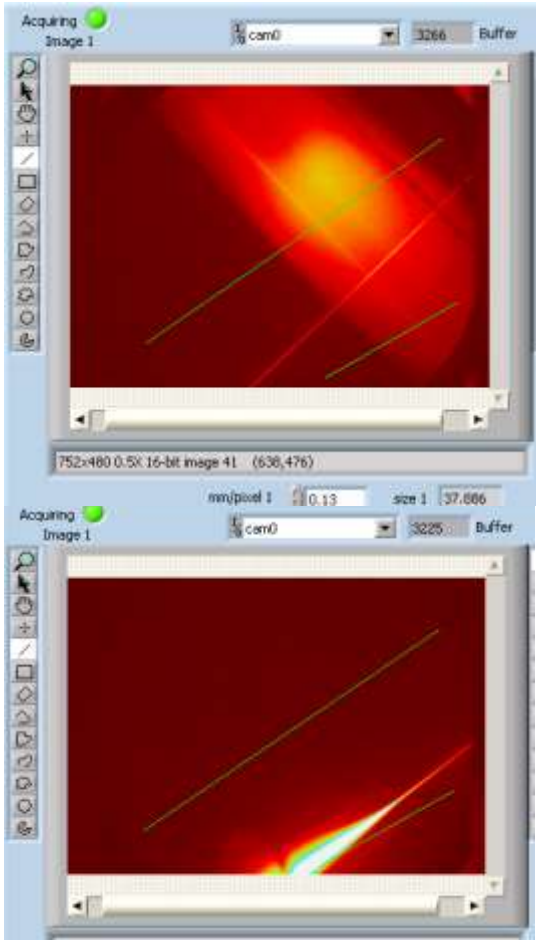


Modified all DTL and HEBT wire scanners during January outage

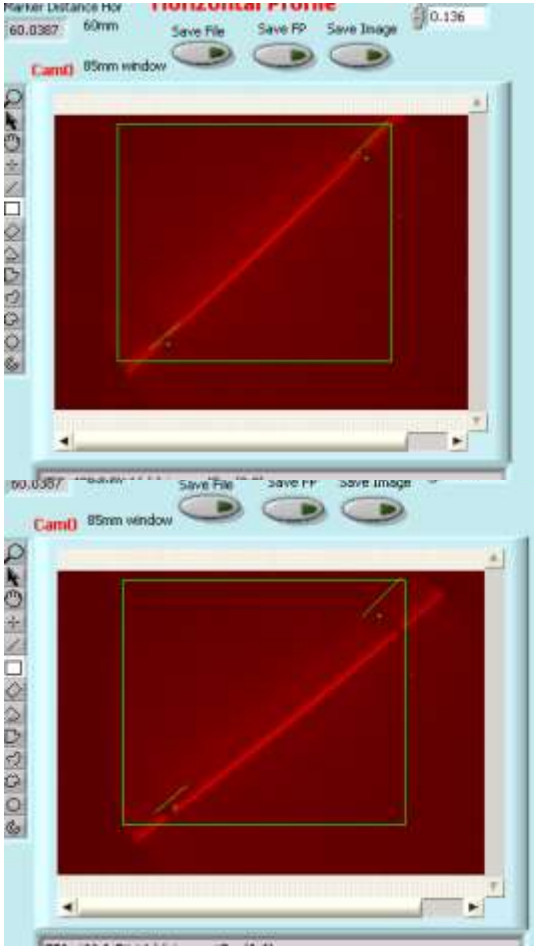
AAC09 Recommendation on ring profile measurements using electron beam

- "... In the accumulator ring, the committee is favorably impressed by the preliminary results obtained with the electron scanner and encourages its further development …."
  - Installed magnetic shielding, which improved stability of measurements greatly
  - Electron beam energy of 60kV is significant limitation. Initiated collaboration with Budker Institute of Nuclear Physics for increasing operating energy to 100kV

Effect of Magnetic Shields on electron beam trace

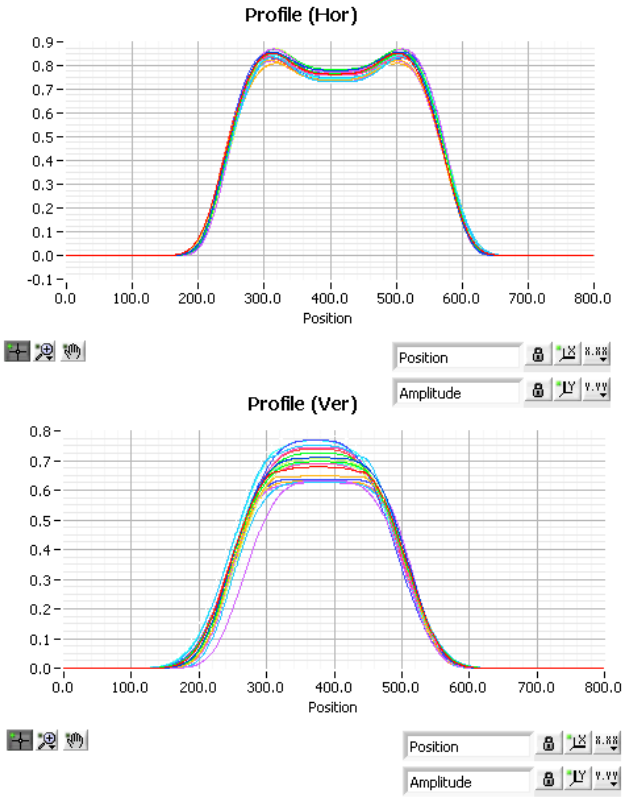


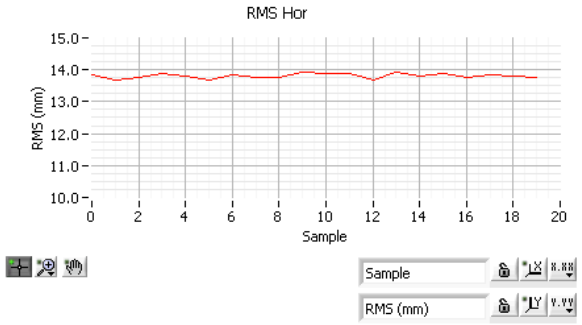
Before shielding: Dipole current at 0 amps (top) and 4000 amps (bottom)

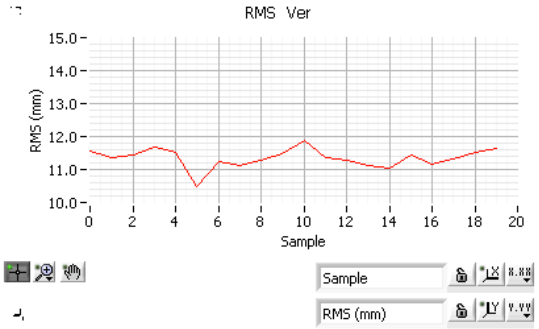


After shielding: Dipole current at 0 amps (top) and 4000 amps (bottom)

Profile measurement repeatability





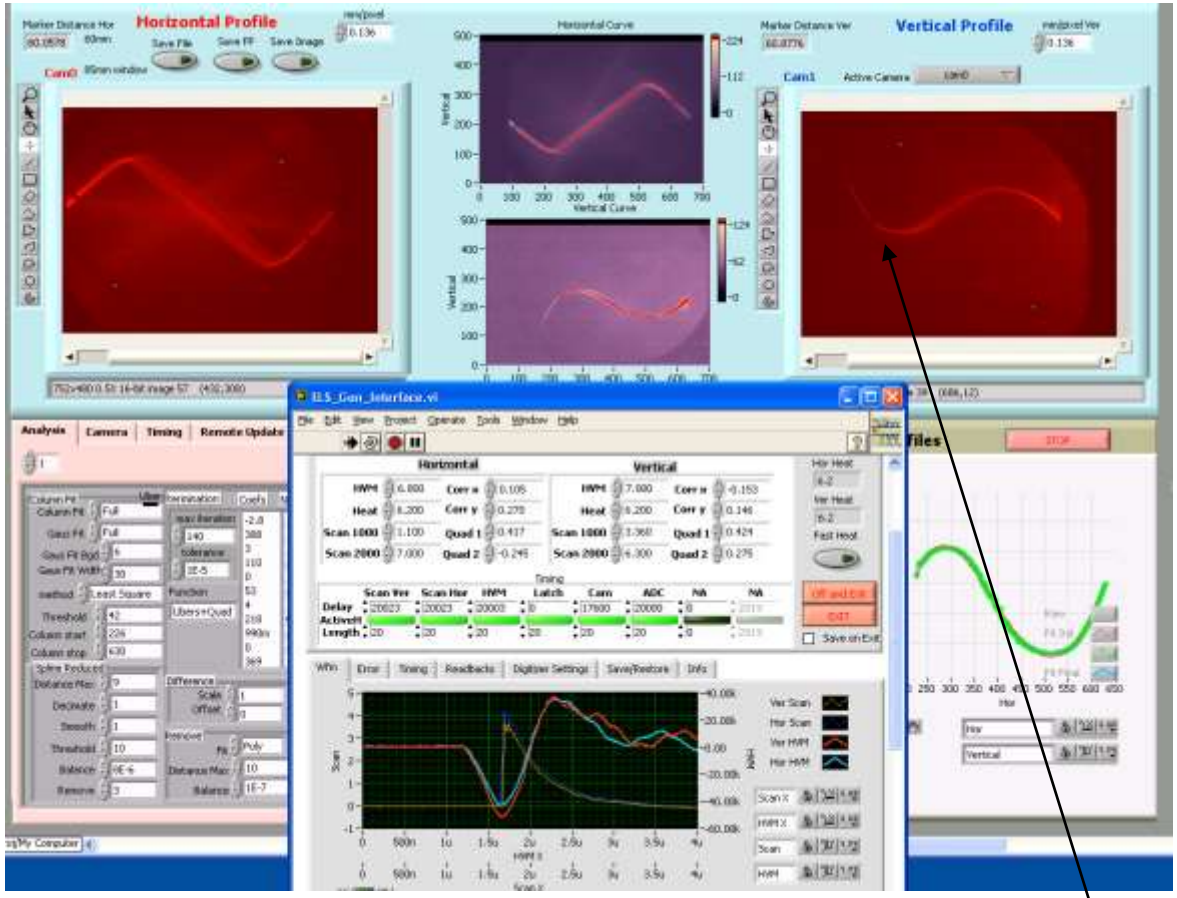


W. Blokland

Twenty profiles taken without changing settings:

- **Nice horizontal repeatability**
- **Still not so great vertical repeatability**

Electron beam energy is too low



Curvature becomes too strong

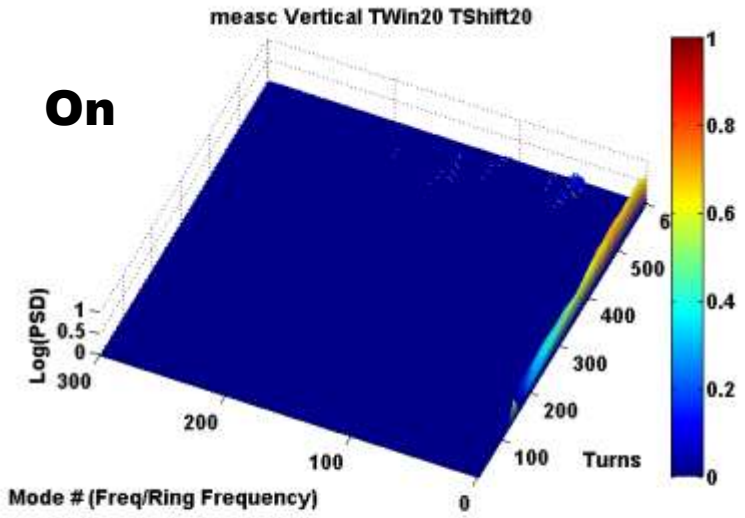
- **Status of Large Bandwidth Feedback System for the SNS Ring:**
  - **Tested analog system with beam**
  - **Have demonstrated e-p instability suppression**
  - **Need more study time for better understanding of the system**
  - **Digital controller is on the way**

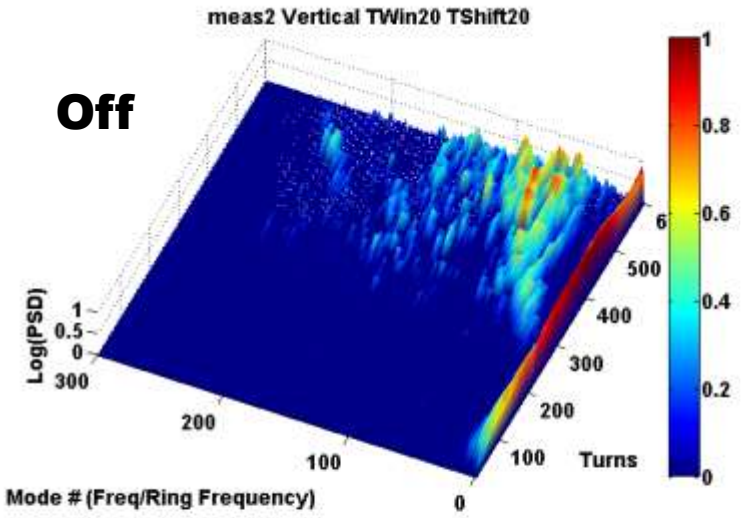
Damper system components in the ring service building

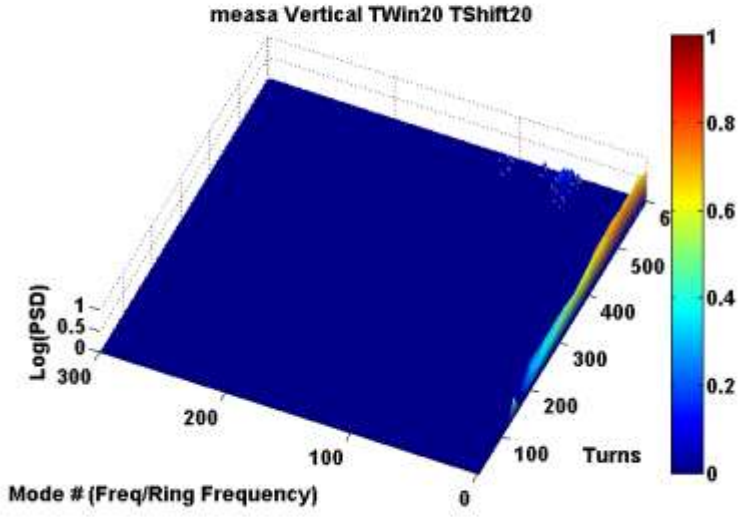
C. Deibele

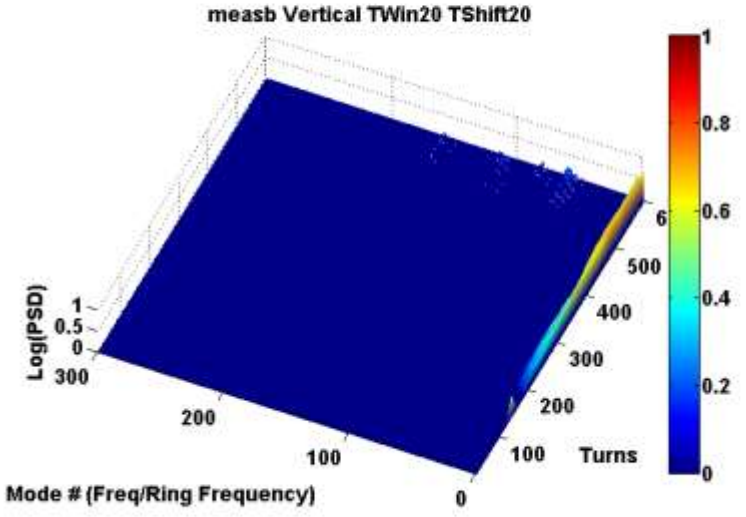
Vertical Damper Test Results

R. Hardin

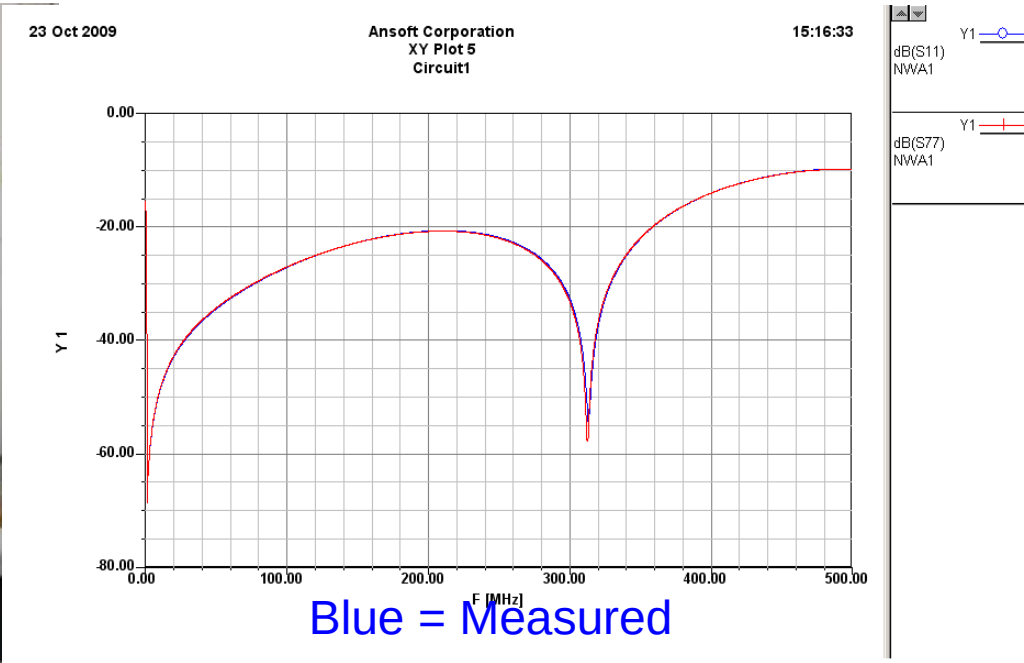








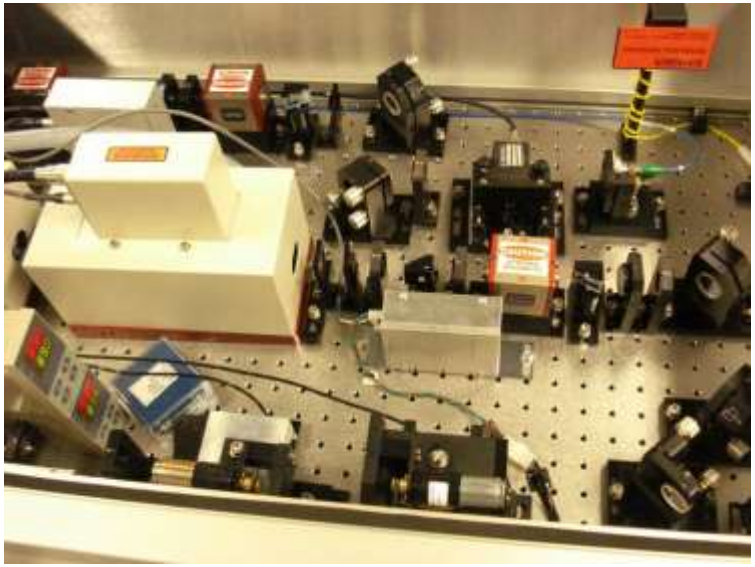
New pick up and kicker hardware

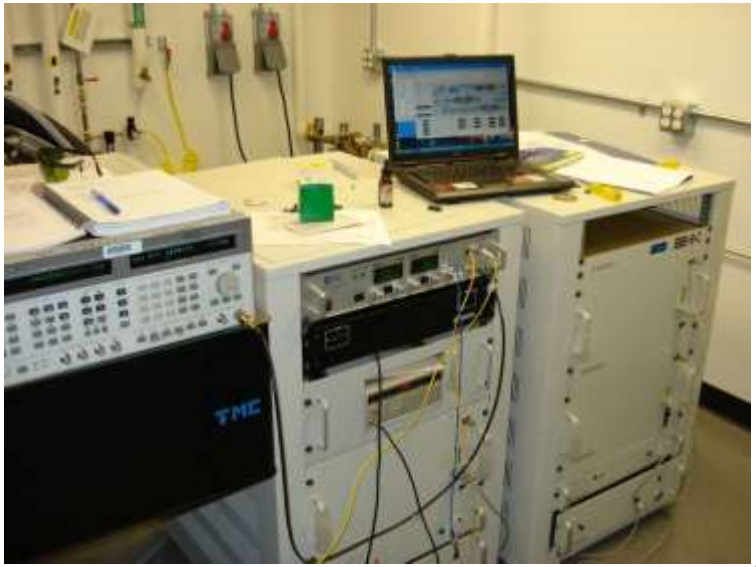


Blue = Measured

Red = Simulated

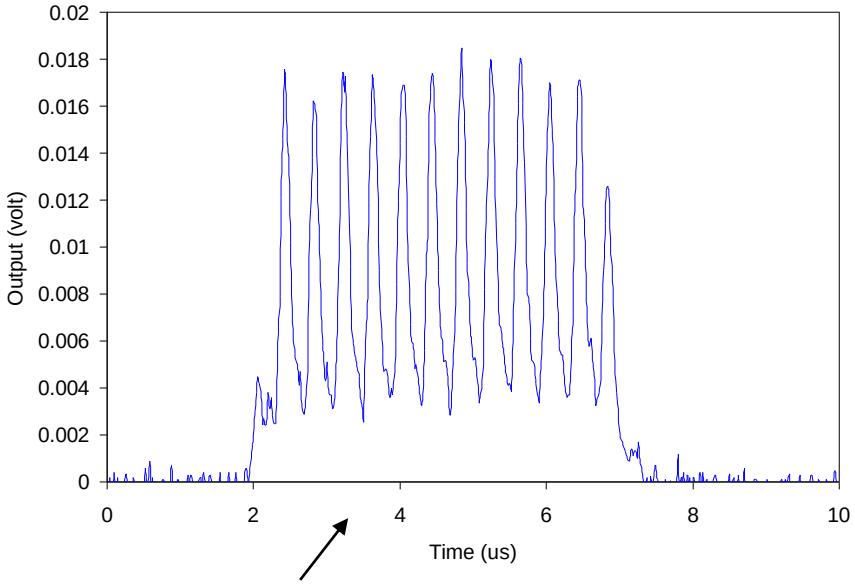
High power mode-locked laser for laser stripping is installed in the new laser room

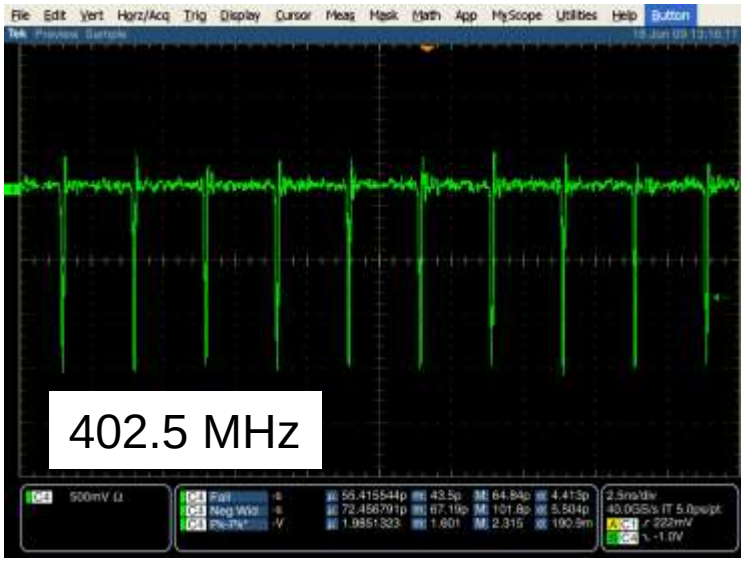




Laser beam parameters are sufficient for the next laser stripping experiment

Y. Liu





UV power: 2.5 W/macro-pulse
120 uJ/micro-pulse (2.2 MW peak power @ 55 ps)

Measured full pulse width: 69 ps (green light).
Estimated UV light pulse width: ~ 55 ps.

Summary

- Existing Beam Instrumentation is capable to support machine tuning and production runs
- Downtime associated with beam diagnostics is low. Goal is to not exceed 10 hours next year
- Laser wire is brought to routine operation status. Have several improvements in works
- Removing the diagonal wire allowed to demonstrate 10^4 dynamic range on CCL wire scanner. Expanding modification to DTL and HEBT wires.
- Reduction of AP beam time requires Improvement of BI user interface and speed up of measurement
  - bringing BSM and MEBT emittance devices to “user friendly” status is main goal for this year