2012 BIW Review

- **2012 Beam Instrumentation Workshop (BIW12)**
  April 15-19, 2012 - Newport News, VA
- Hosted by Jefferson Lab
- Last BIW → now IBIC (International Beams Instrumentation Conference)
- Attended by myself, Nathan and Alex

Focus on diagnostics for PXIE/Project X

1. Non-Invasive Detectors for Hadron Beams
2. 1 ps Longitudinal Bunch Shape Monitor
3. Water-cooled Allison Scanner
4. Lasers for diagnostics

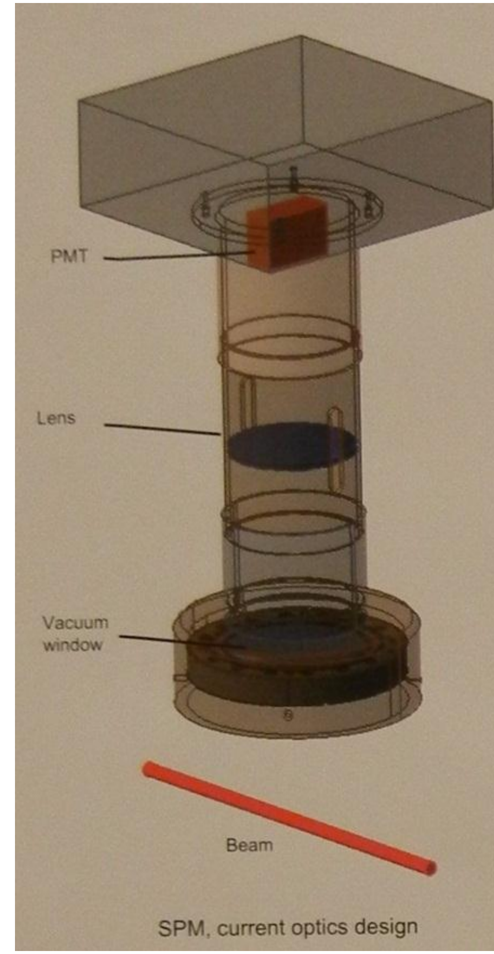
Papers, talks & posters on BIW Website

  – http://www.jlab.org/conferences/biw12/

Non-Destructive Beam Profile Monitors at COSY
V. Kamerdzhiev (Seva), FZ-Julich (also ESS)

IPM – ionization Profile Monitor

- High Sensitivity
- Fast Measurements (high rate of ionization)
- High Resolution (defined by readout)
- High Cost
- Aging components in vacuum
- Radiation damage (cameras)



SPM, current optics design

SPM – Scintillation Profile Monitor

- Low sensitivity
- Longer integration time
- Gas injection necessary
- Low resolution
- Low cost
- No components in vacuum
- Installed on any vacuum window

IPM, current design

NON-INTERCEPTIVE TOMOGRAPHIC RECONSTRUCTION OF THE TRANSVERSE SPATIAL DISTRIBUTION OF SILHI ION SOURCE BEAM

C.M. Mateo, G. Adroit, J. Egberts, R. Gobin, Y. Sauce, F. Senée, O. Tuske, CEA, Saclay

- Tomography is incorporated with non-destructive and non-interceptive beam-induced fluorescence profiler, to produce a 2D reconstruction of the transverse spatial distribution of the beam
- Six cameras, positioned at six different directions around the beam, were aligned with respect to the beam axis and were installed to obtain the image of the emitted light due to the beam-residual gas interaction

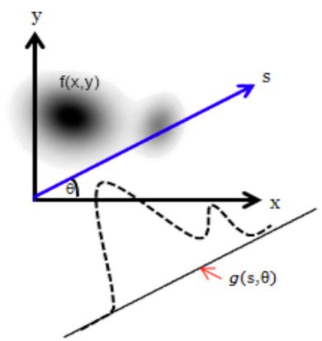


Figure 1: The geometry of the tomographic projections.

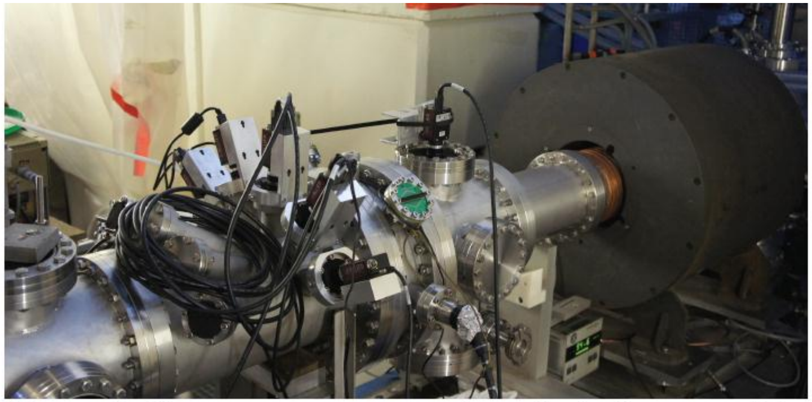


Figure 4: Six cameras were used to obtain images of the beam at six different directions. Each image corresponds to transverse beam profiles along each direction.

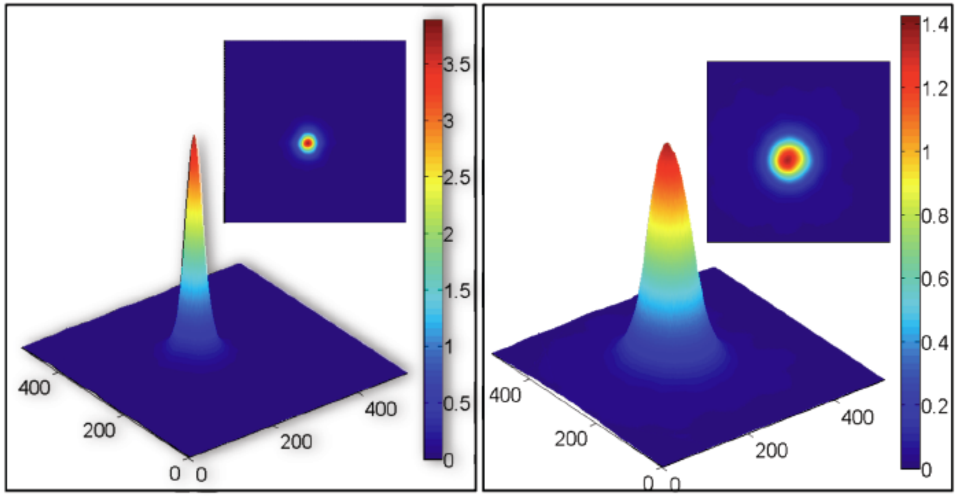


Figure 5: (Left) 3D and 2D representations of the transverse spatial distribution of the SILHI beam. (Right) 3D and 2D representations of the transverse spatial distribution of the SILHI beam at a distance of approximately 27cm from downstream.

A QUEST FOR MEASURING ION BUNCH LONGITUDINAL PROFILES WITH ONE PICOSECOND ACCURACY IN THE SNS LINAC

A. Aleksandrov, R. Dickson, SNS

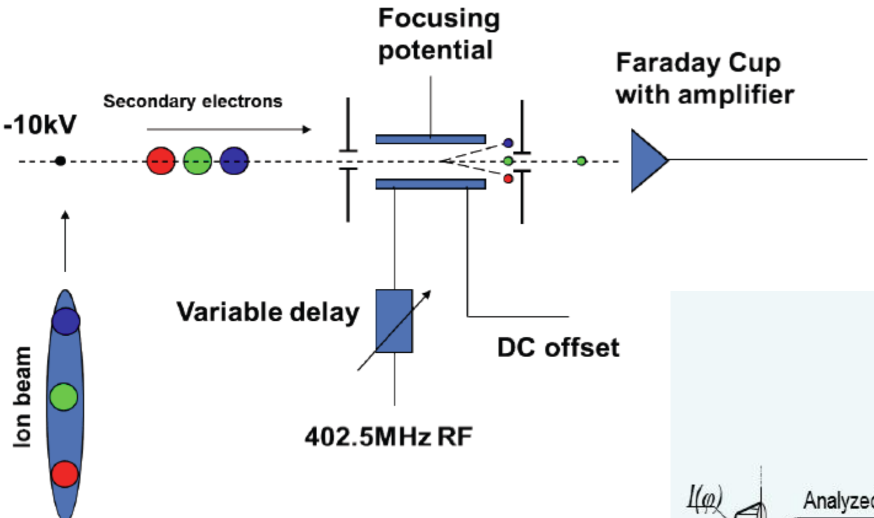
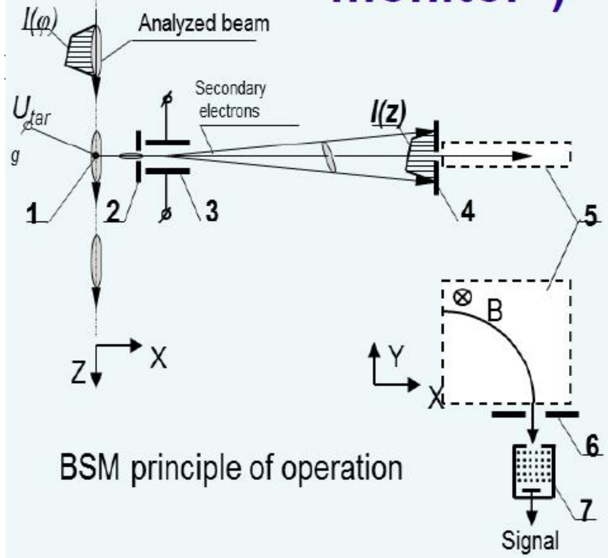


Figure 2: Schematic diagram of the SNS
Monitor operational principle.

Beam Shape Monitor (aka "Feschenko monitor")



BSM principle of operation

Factors determining resolution and accuracy

1. Secondary emission temporal response

- Expect to be less than 1ps, no reliable experimental data

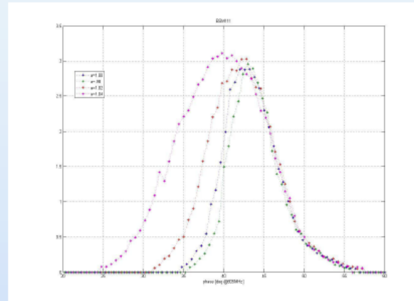
2. Space charge effect in the beam pipe

- Can be a major factor, subject of current study

3. Resolution of the deflector/analyzer

- Main focus of improvement program

limiting factor #1: secondary emission temporal response

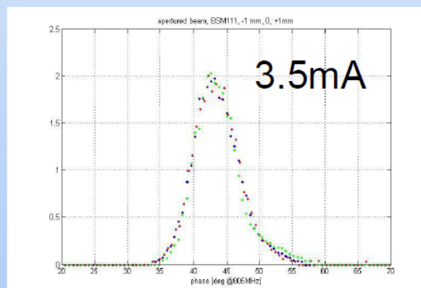


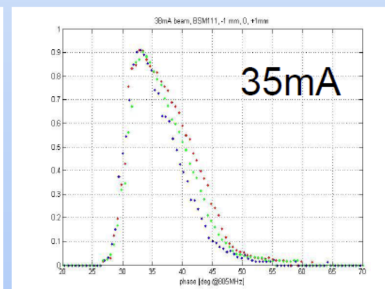
Demonstrating shortest possible beam with "zero" current

$$\sigma_{\varphi} = [5.8^{\circ} \quad 4.1^{\circ} \quad 3.3^{\circ} \quad 2.9^{\circ}]$$

~ .4° resolution is achievable

limiting factor #2: space charge





The effect is measurable

Study and mitigation strategy development is ongoing

limiting factor #3: deflector/analyzer optics

- Reduce analyzing slit size
- Optimize deflecting RF voltage
- Improve electron optics tuning

$$x = a_{max} \cdot \sin\varphi$$

$$\frac{dx}{d\varphi} = a_{max} \cdot \cos\varphi$$

$$\delta\varphi = \left.\frac{d\varphi}{dx}\right|_{x=0} \cdot \delta x = \frac{\delta x}{a_{max}} \approx \frac{\sqrt{d^2 + \sigma_x^{\,2}}}{a_{max}} = \frac{\sqrt{d^2 + \sigma_x^{\,2}}}{g \cdot V_{RF}}$$

beamlet size

slit width

deflecting voltage

SNS BSM Improvement

	BSM107	BSM109	BSM111
σ_V [V]	2.28 old slit, ~1mm	1.94 old slit, ~1mm	1.43 new slit,~0.3mm
$d\varphi/dV$ [°/V]	0.36	0.47	0.38
δ_φ [°]	0.83	0.85	0.54

- Can expect σ_V of ~ 1.5V, $d\varphi/dV$ of ~ .4 °/V
- δ_φ [°] of ~ .6° should be achievable

TRIUMF

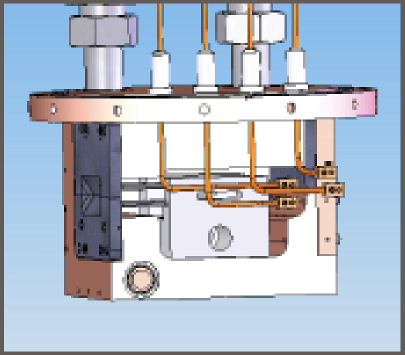
Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

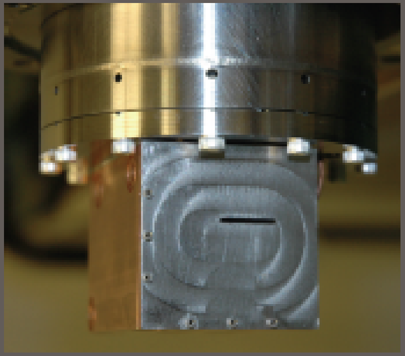
High Power Allison Scanner for Electrons

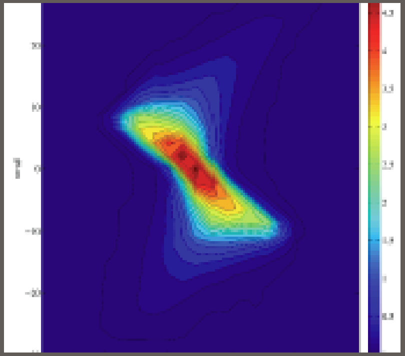
BIW12

April 17, 2012

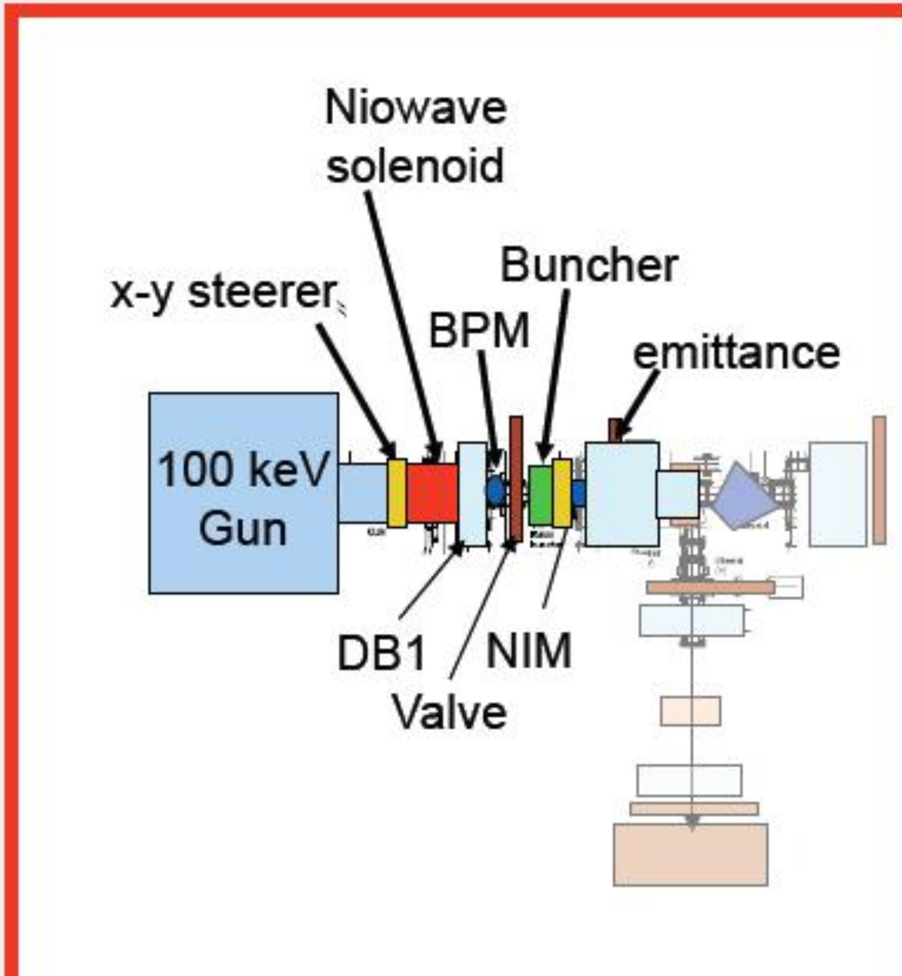
Aurelia Laxdal TRIUMF



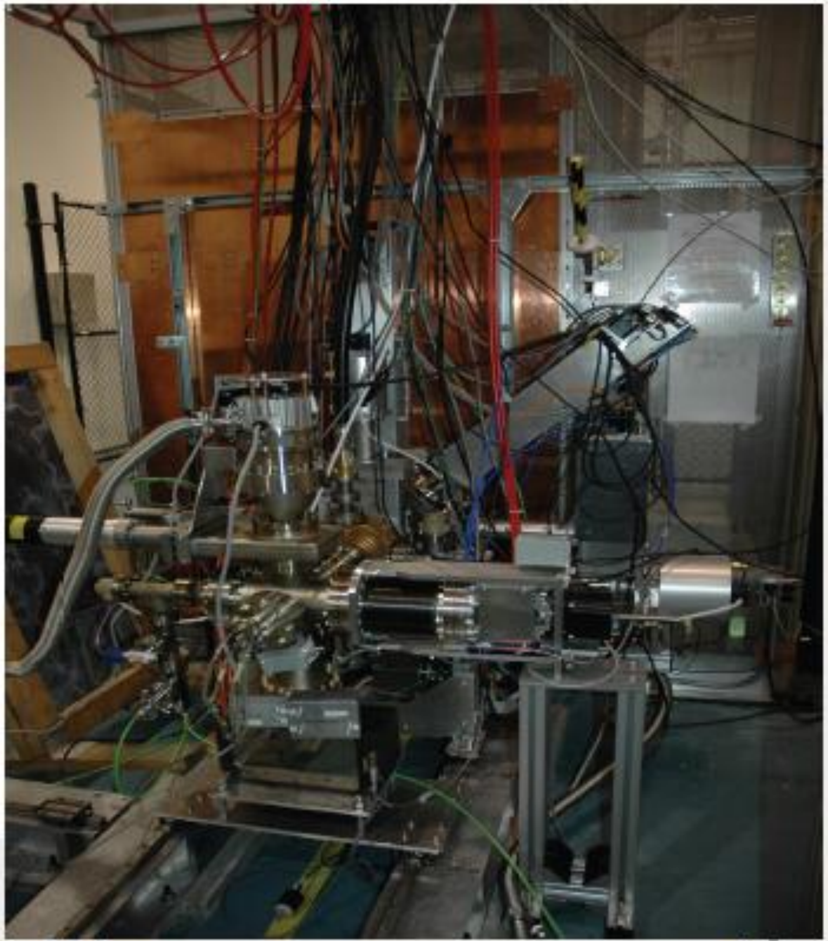




E-GUN Test Station



- 100 keV e-gun test area



Overview of the Allison type emittance scanner

- At each step the beamlet selected by the front is slit swept across the rear slit with the deflecting plates and the transmitted current measured by the Faraday cup.

- The necessary voltage for an electron of energy E entering with an angle x' through the Entrance slit and exiting through the second slit is:

$$V = 4gx' E/(D - 2\delta)$$

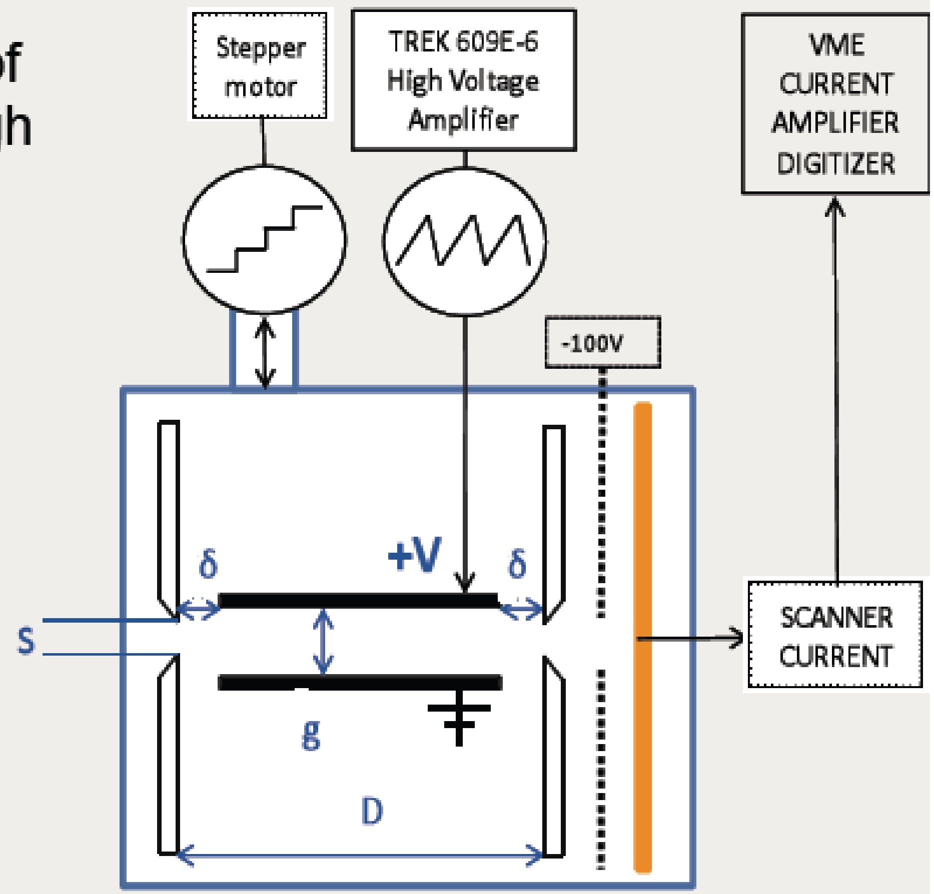
- The maximum voltage for a maximum analyzable x' angle is:

$$V_m = \pm 8Eg^2/(D^2 - 4\delta^2)$$

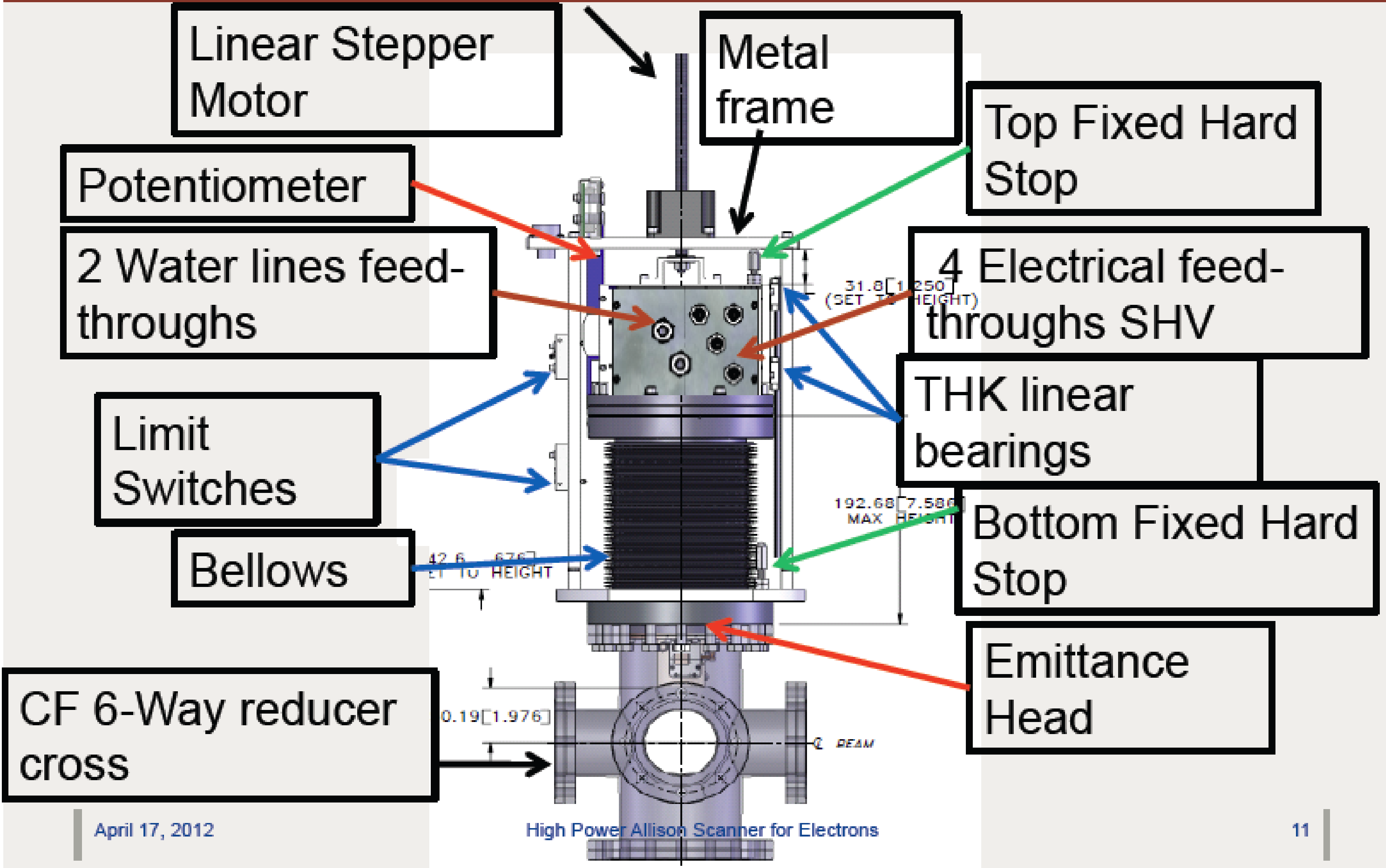
$$x' = \pm 2g/(D + 2\delta)$$

- For relativistic particles the voltage is smaller by a factor *k*

$V_{m-rel} = V_m / k$ and $k = 2/(1 + 1/\gamma)$



Overview of the Emittance Scanner Assembly



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Thermal considerations and ANSYS simulations

• Thermal calculations were done for the water-copper thermal convection; calculated heat transfer coefficient.

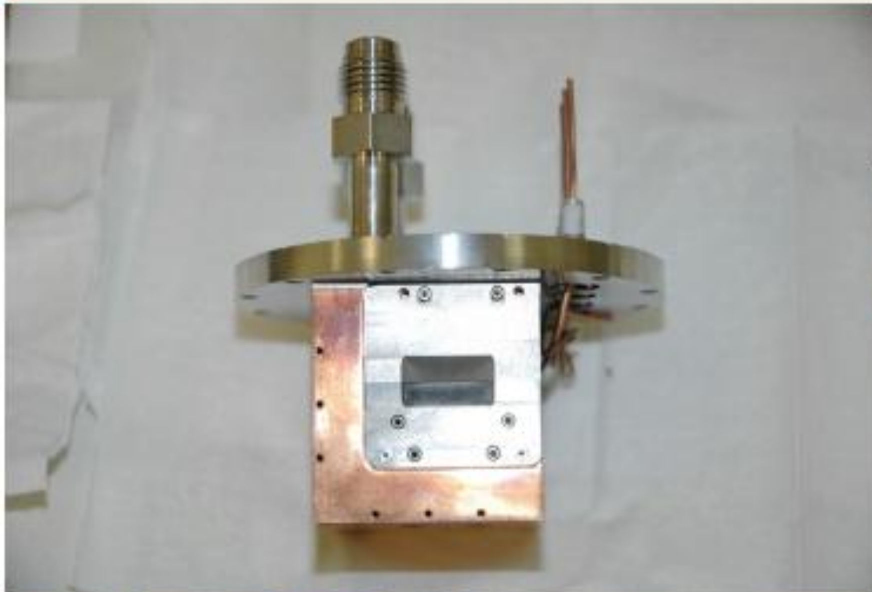
• Results were used to do thermal simplified 3D models at different homogenous beam intensities and sizes, with ANSYS, of the thermal conduction.

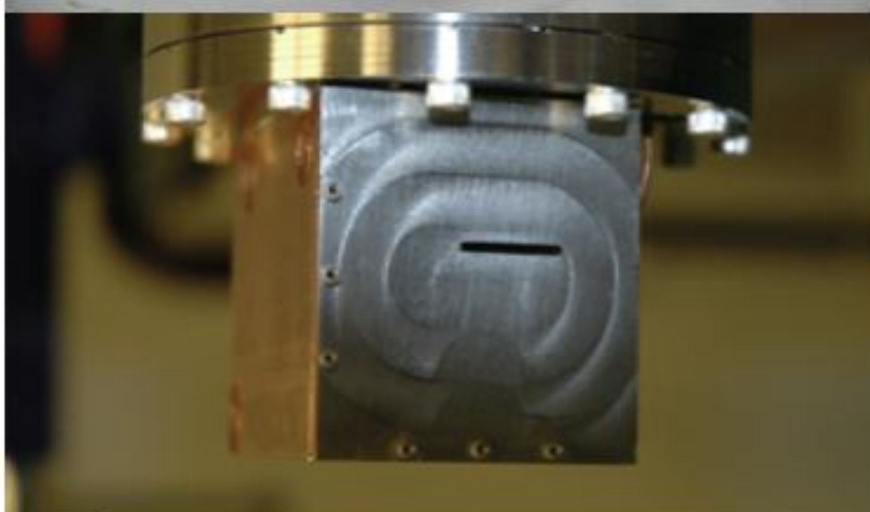
• The main constrain is introduced by the **power density** on the front slit: densities in excess of 115 W/mm^2 will close the slit (of 1.5 thou) through **thermal expansion**.

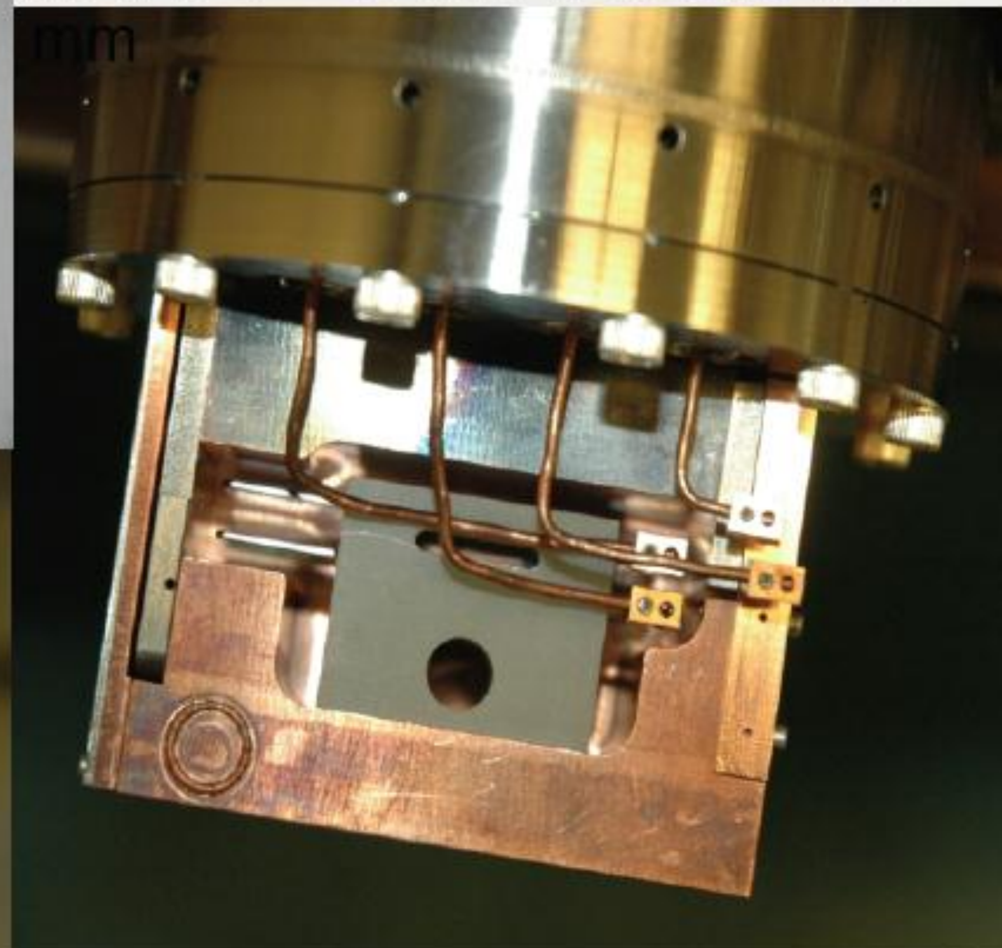
Beam energy [keV]	60	100
Beam diameter [mm]	2	10
Beam intensity [mA]	6	10
Power density [W/mm]	115	10
Slit Temp [deg C]	1650	300
Front plate Temp [deg C]	445	560
Thermal expansion [μm]	33	<< 10

Assembly

Dimensions:
l x w x h = 60 mm x 44 mm x 45 mm



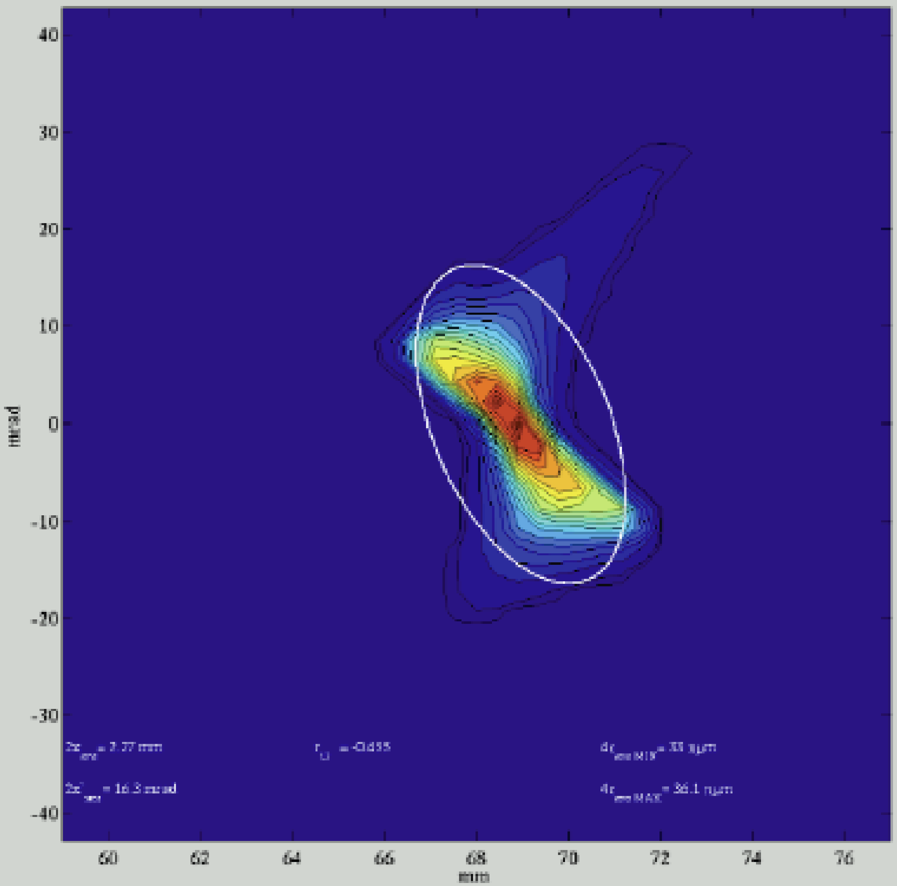


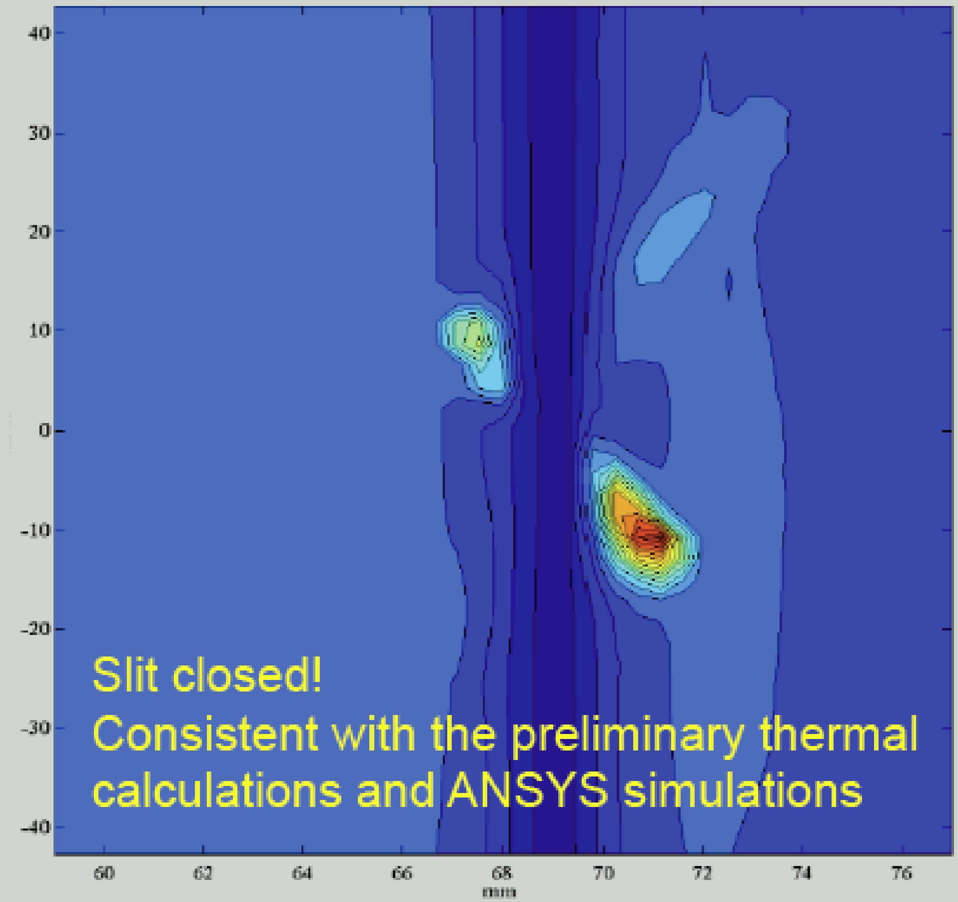


Emittance scans: 60keV 11mA at WAIST

1% D.F.
rms beam size 1.14 mm
Power Density 1.6 W/mm^2

99% D.F.
1.14 mm
160 W/mm^2 → 2,300 deg C (ANSYS)





Overview Of New Laser Technologies For Applications In Beam Instrumentation

Shukui Zhang
Thomas Jefferson National Accelerator Facility

BIW'2012, April 16, 2012, Newport News, Virginia, USA

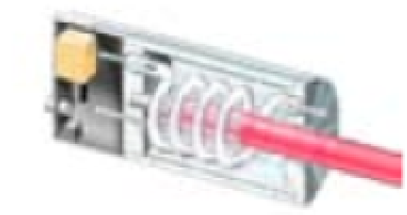
Where We Are Today

The rapid growing ***Diode Laser/Fiber*** technology brought in revolutionary advancement to other lasers,

- High Peak power, PW
- High Average power, PW/10s kW
- High Energy, MJ
- Ultrashort pulse, fs/sub-fs
- IR ~ UV/UVU/Soft-X ray (Hard X-ray FEL)
- High stability/turn-key, 24/7 operation
- High beam quality, ~DL
- Compact, suitcase-size/100W
- Commercially available

May 16, 1960

Ted Maiman demonstrates the first ruby laser.



Hughes Research Laboratory

Real Big Laser for Great Science

Mar.15, 2012, LIVERMORE, Calif. -- NIF, the world's most energetic laser, surpassed a critical milestone in its efforts to meet one of modern science's greatest challenges: achieving fusion ignition and energy gain in a laboratory setting. NIF's 192 lasers fired in perfect unison, delivering a record 1.875 MJ of ultraviolet laser light to the facility's target chamber center.

What Lasers Do for Beam/Accelerators

- Generation of High-power High Intensity High Brightness short-pulse e-beam
  - Short pulse e-bunch, Special e-beam requirements.
- Diagnostics
  - Non destructive E-bunch temporal and spatial measurement (EO)
  - Laser mapping, Laser stripping, Laser wires/scanner,
  - Compton scattering devices (external cavity)
- High precision synchronization
- Application in SC cavity
  - Laser heating,
  - SRF Cavity inspection
  - Surface repair/treatment
- Seed Lasers for future light sources

LASER APPLICATIONS: H- BEAM PHOTO-DETACHMENT AND "PUSH BUTTON" DIAGNOSTICS

Y. Liu on behalf of SNS Beam Instrumentation Team

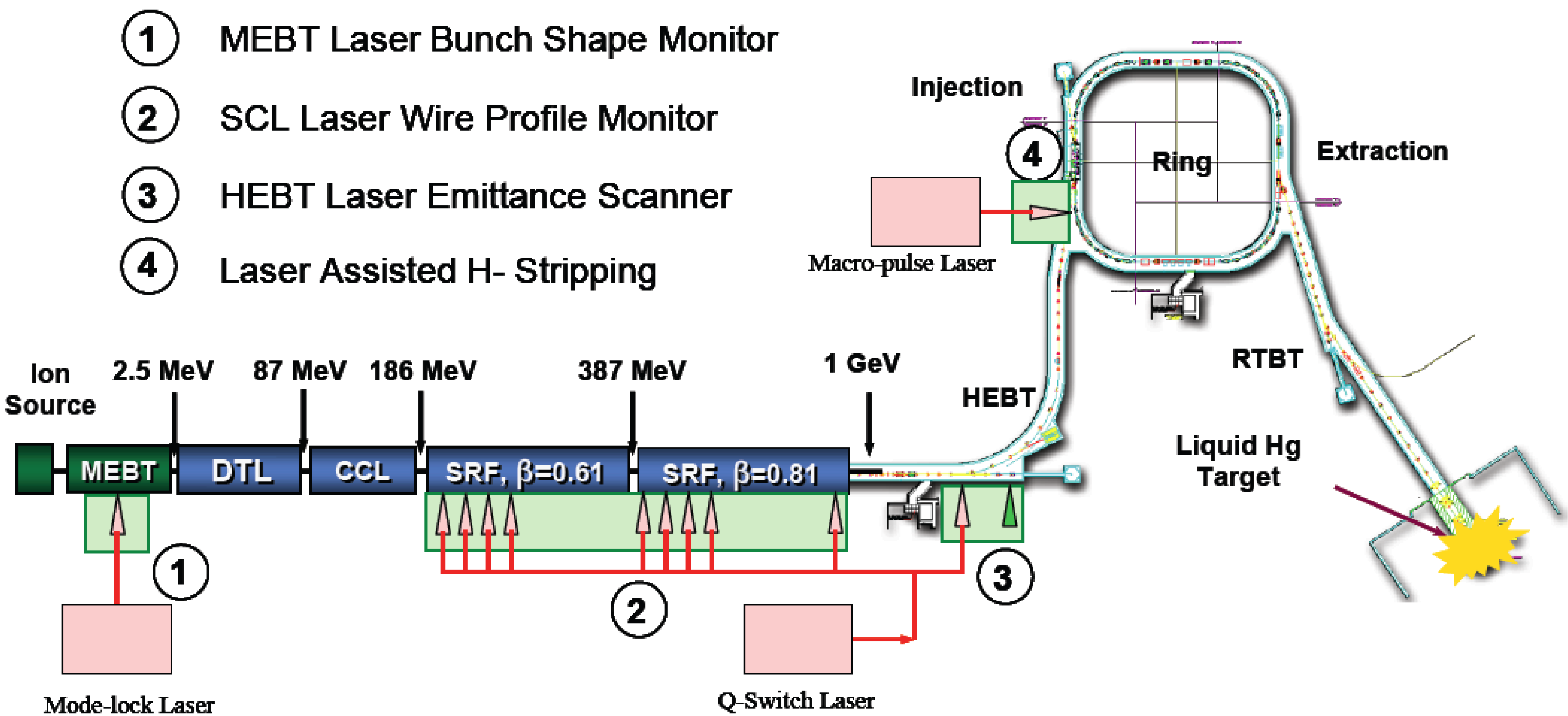


Figure 1: Layout of laser based beam instrumentation systems at the Spallation Neutron Source.

Laser Transverse Profile Monitors in Linac

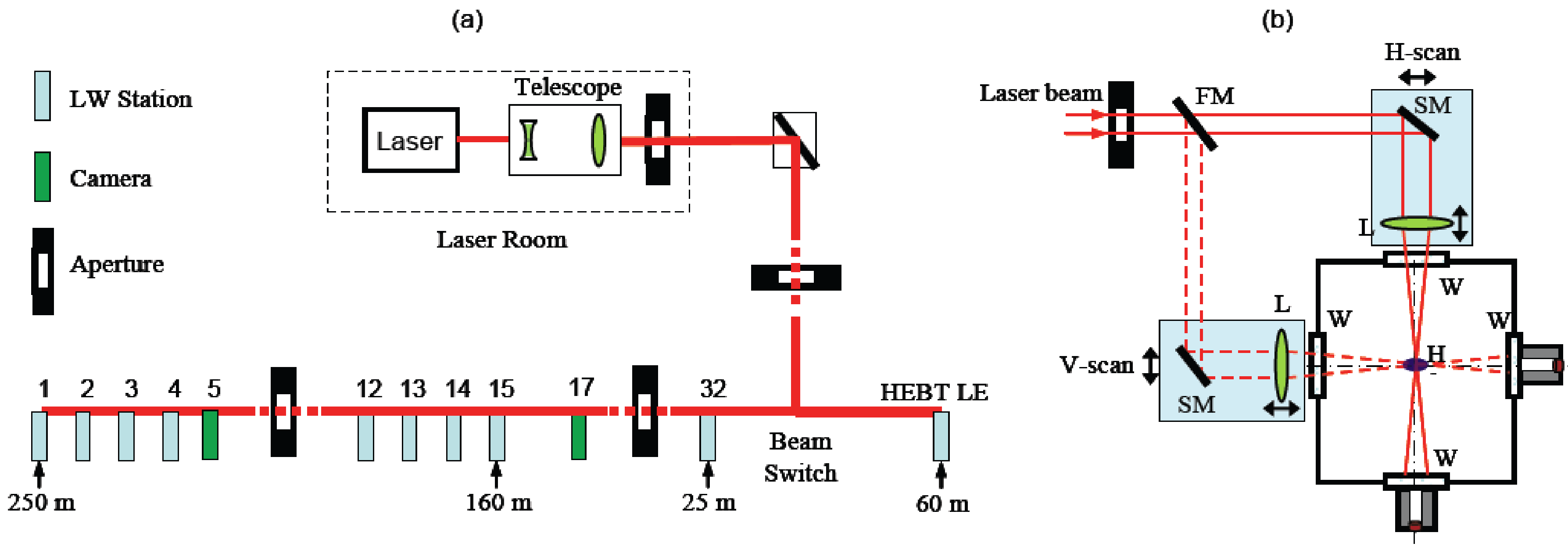


Figure 2: (a) Layout of SCL laser wire and HEBT laser emittance measurement systems. (b) Optics setup of individual laser wire scan station. Numbers indicate cryomodules and distances are from the laser room. LE: laser emittance; FM: flipper mirror; M: mirror; SM: scan mirror; L: lens; W: vacuum window.

HEBT Laser Emittance Monitor

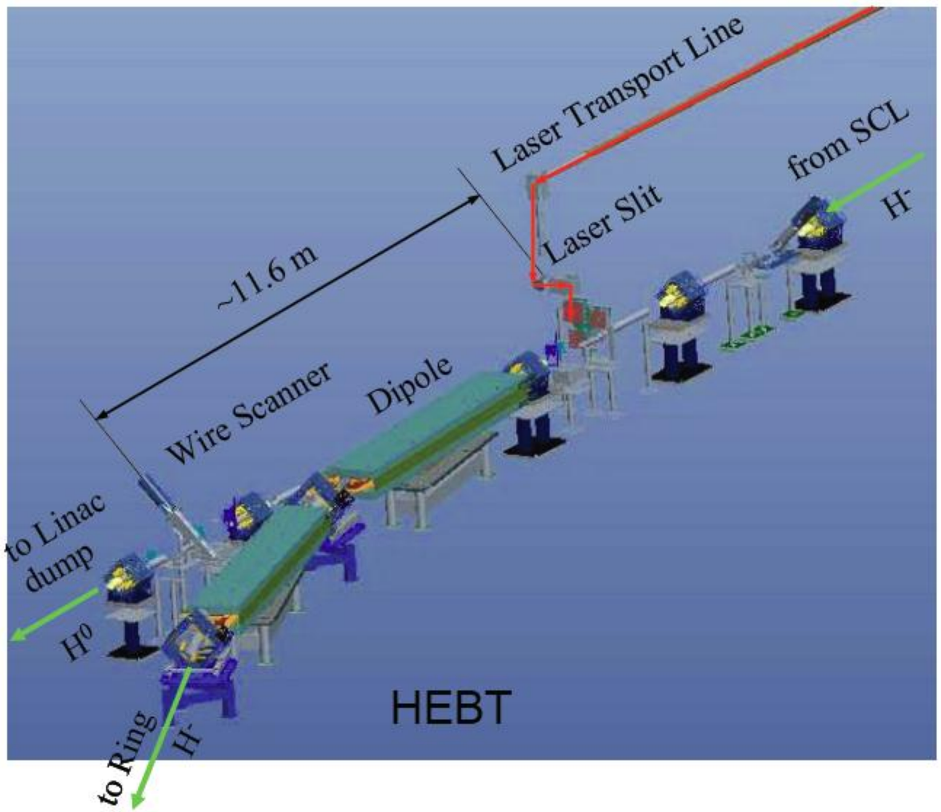


Figure 3: HEBT laser emittance monitor system.

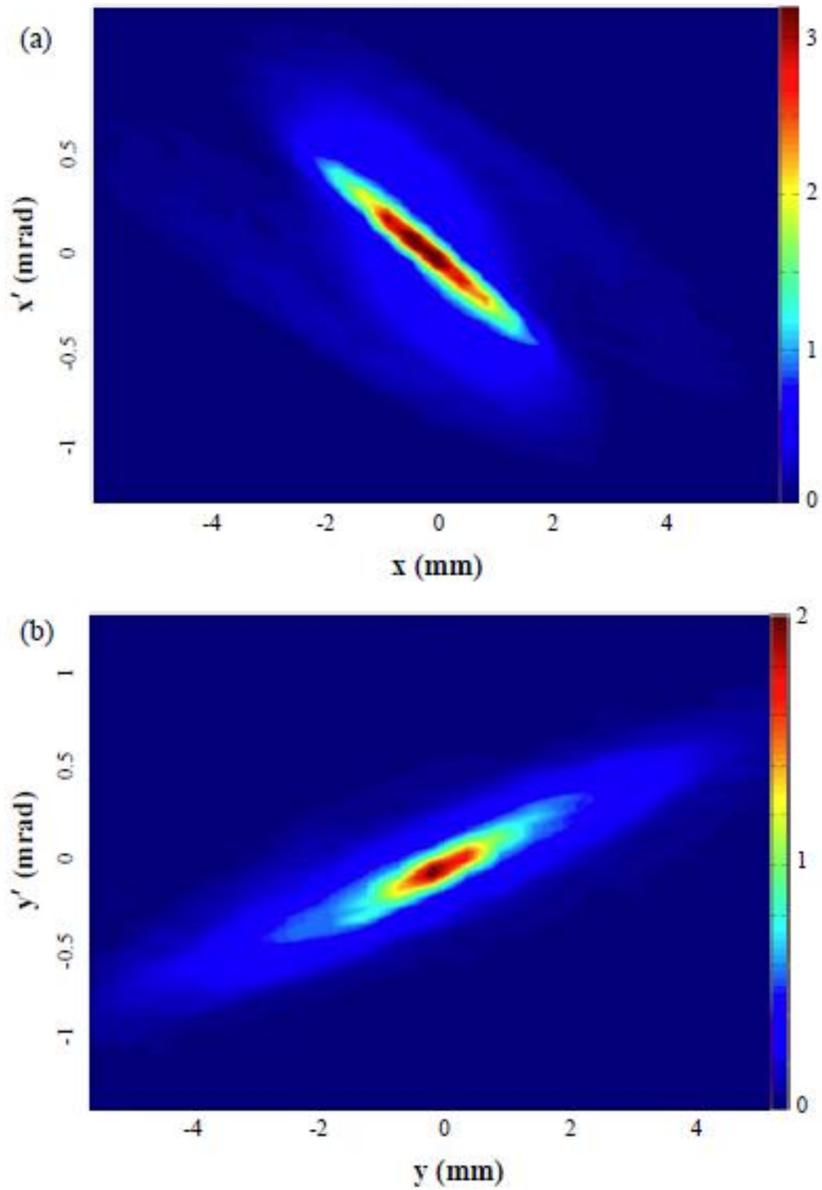


Figure 6: An example of emittance measurement.

Laser R&D

Experimental investigations on transmission of picosecond laser pulses through a large mode area (LMA) polarization maintaining fiber

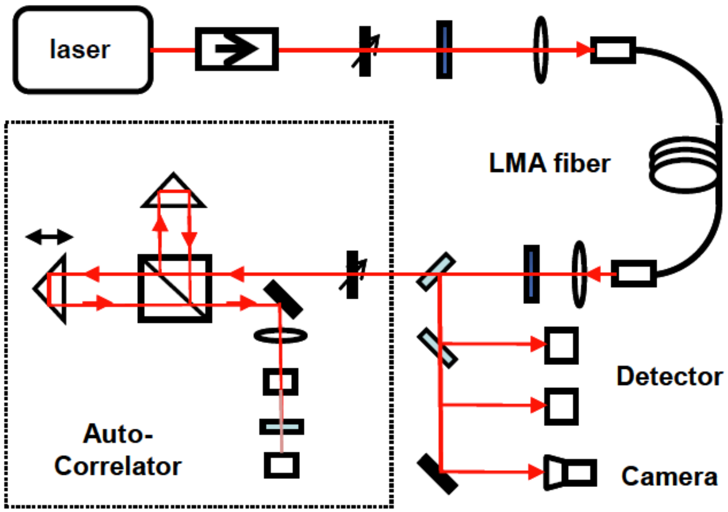


Figure 7: Experiemntal setup and pulse width broadening measurement results of the pulse tranmission through a LMA opticla fiber.

Power Enhancement Optical Cavity for stripping

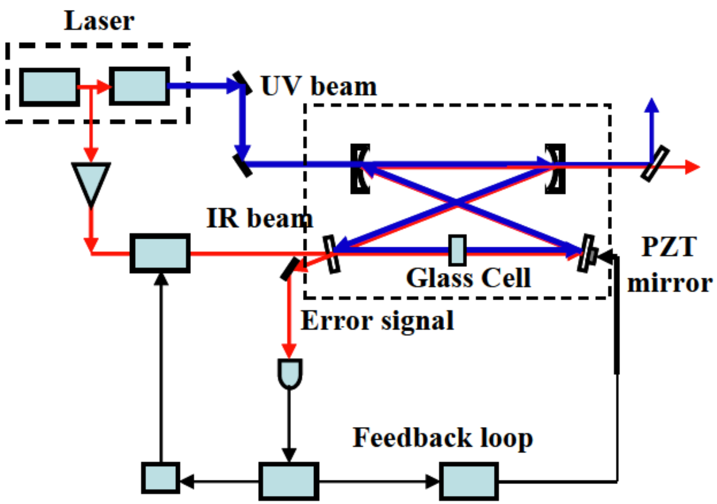


Figure 8: Schematic of the dual wavelength power recycling optical cavity.