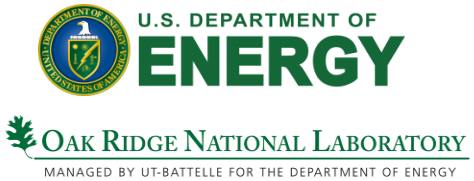
Accelerator to Target Diagnostics



Tom Shea

SNS/ORNL → ESS

2012.03.27

T. J. Shea, T. McManamy, G. Bancke, W. Blokland, A. Brunson, M. Dayton, R. Fiorito, K. C. Goetz, J. Janney, M. Lance, C. Maxey, F. Montgomery, P. Rosenblad, S. Sampath, M. Simpson, T. Ally, Garcia, K. Hasse, Mitchell

Multiple ORNL divisions, Stony Brook University, University of Maryland…

New! Now with ESS colleagues

Outline

- Goals and requirements
- Some SNS examples
  - Prediction of beam on target parameters
  - Some measurement examples
  - Quite a lot about the SNS target imaging system
- Considerations for ESS

Goals

- Support commissioning/studies of beam expansion section
- Support rapid production setup (maximize neutron production)
- Assure operations within approved envelope
- Minimize beam-induced damage to target system components
- Support neutronics studies

Development of Requirements

- Measurement functionality
- Quantified performance
- Availability
- Interfaces (between systems, to alarm system, machine protection, target protection)
- Data logging (total energy delivered, fluence, beam properties during studies and faults, etc).

SNS Operating Envelope – Summary for Production Beam on Target

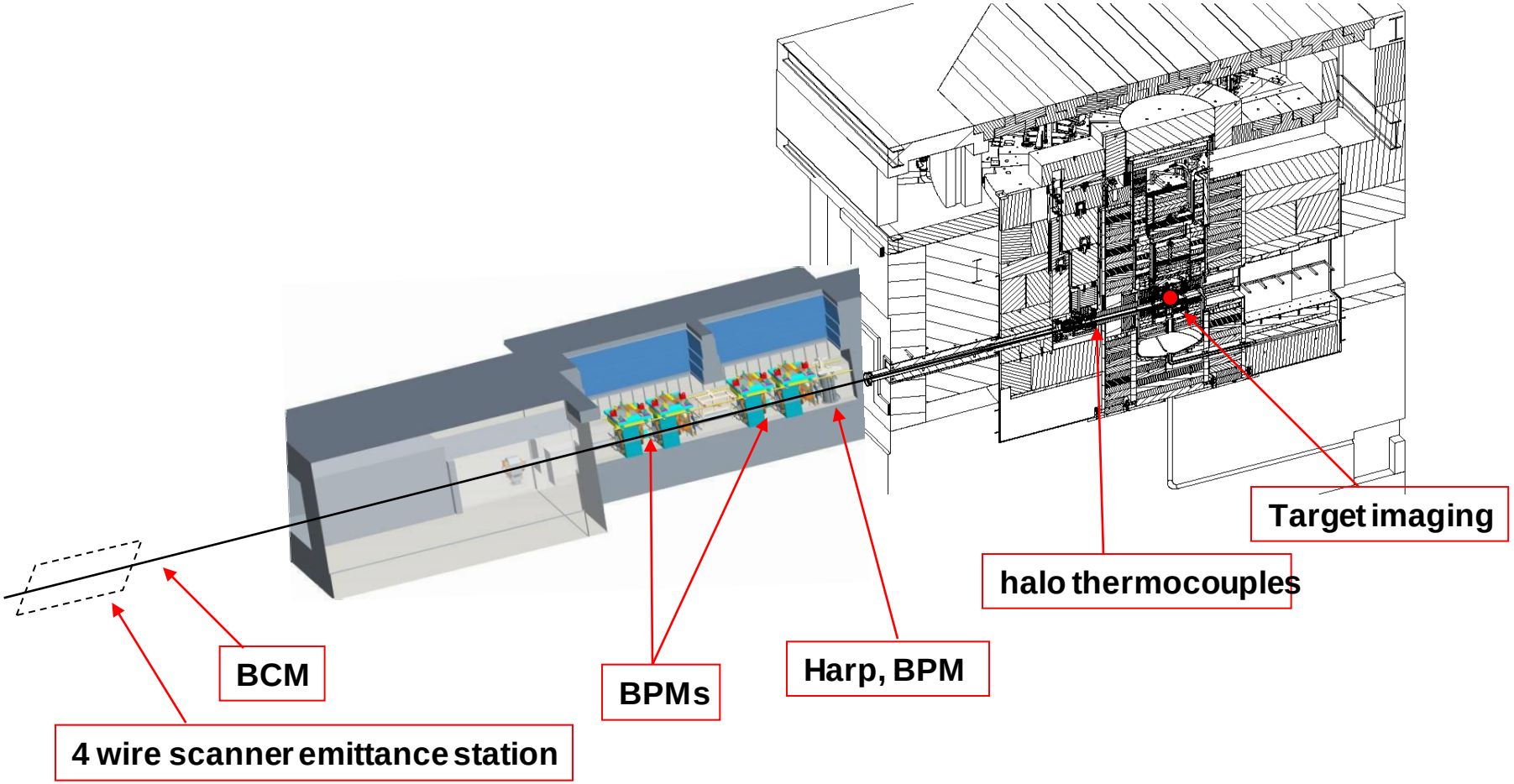
	Normal Condition	Off-normal	Action
Beam spot width height	200 mm 70 mm		
Beam power within nominal beam spot	>90 %	> 50% power outside spot	Immediate Shutdown – 2 pulses or less
Peak time-average beam current density	≤0.165 A/m^2	>0.165 and ≤0.181A/m^2	Correct within 30 min. or shutdown
		>0.181 A/m^2	Correct within 10 sec or shutdown
Peak single pulse density	≤1.72 x 10^16 protons/m^2	>2.15 x 10^16 prot/m^2	Immediate Shutdown – 2 pulses or less
Tolerance on beam horizontal centroid	±6 mm	> +/- 6 mm	Correct within 10 minutes or shutdown
Tolerance on beam vertical centroid	±4 mm	> +/- 4 mm	Correct within 10 minutes or shutdown

Operating Envelope - Beam Position at Various Power Levels

Beam Power	Position Tolerance (Maximum) OE limit
Less than 100 Watts *	**No limitation**
100 Watts to 1000 Watts	**+/- 20 mm (averaged over any 10 minute period)**
1000 Watts to 100 kW	**+/- 10 mm**
> 100 kW Vertical tolerance	**+/- 4 mm**
> 100 kW Horizontal tolerance	**+/- 6 mm**

*** or < 5 kW with > 90 % of the beam on target within a 70 mm vertical by 200 mm horizontal footprint**

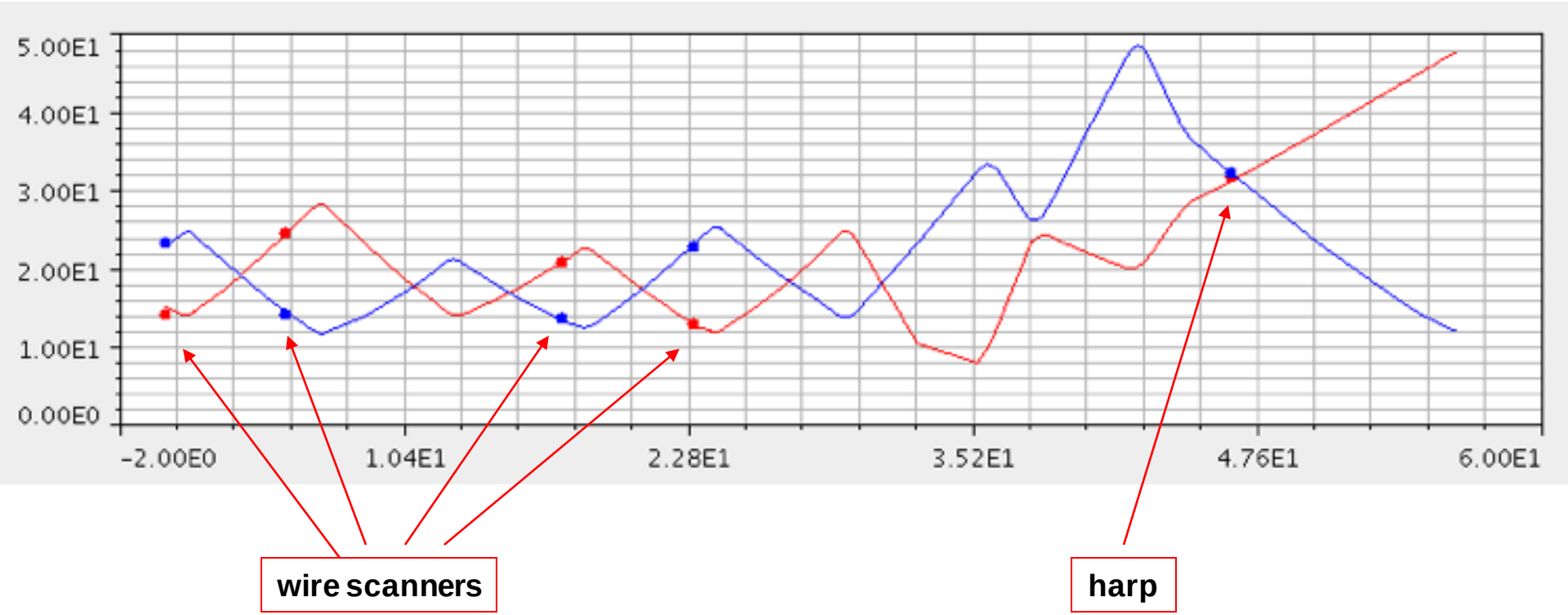
Predicting Beam-on-Target Parameters at SNS



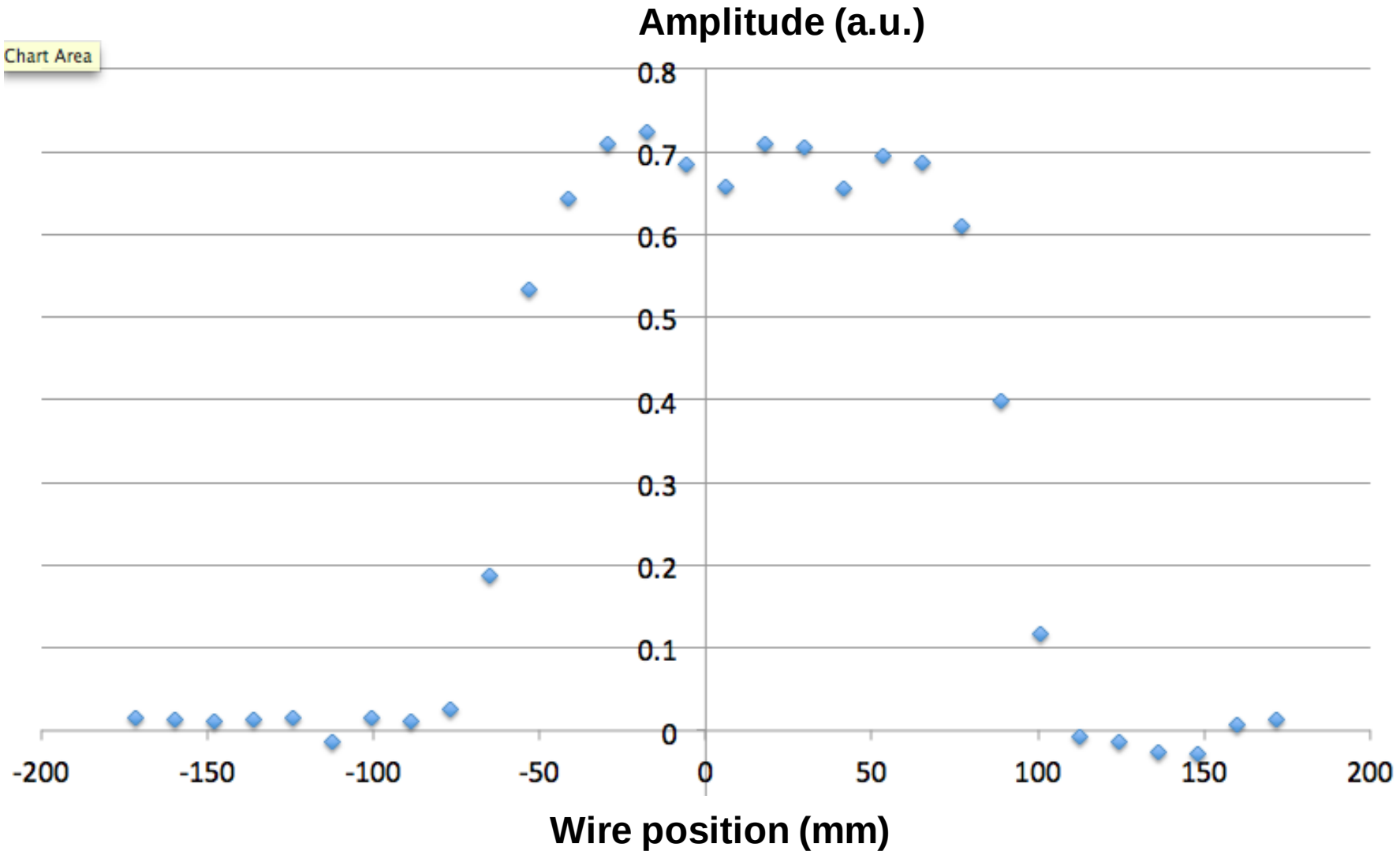
- Fitting normally only done at the start of a neutron production run of several weeks
- Harp only projections monitored during production run

M. Plum, S. Cousineau

Prediction of RMS Beam Size on SNS Window and Target

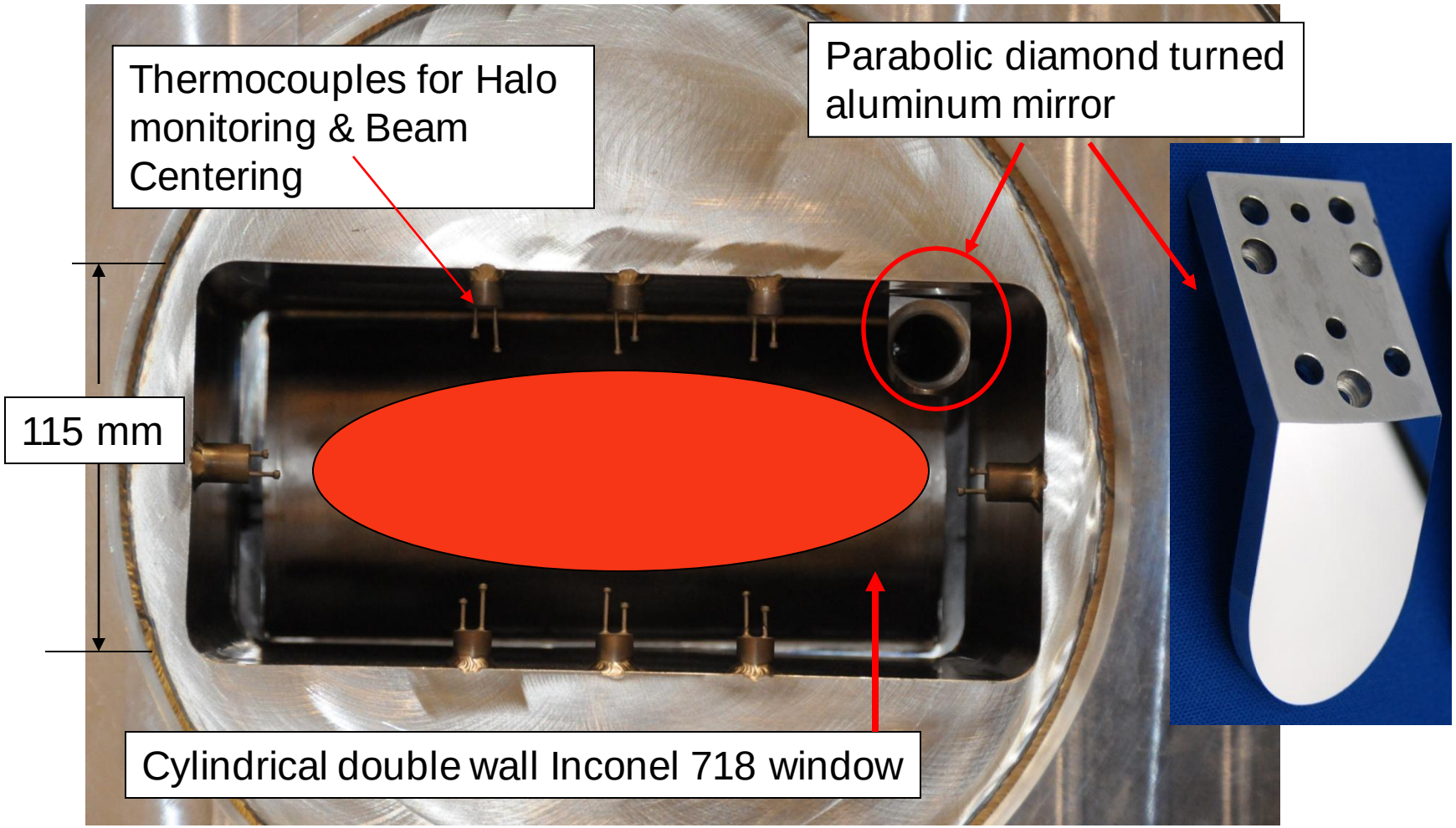


Raw Harp Signals

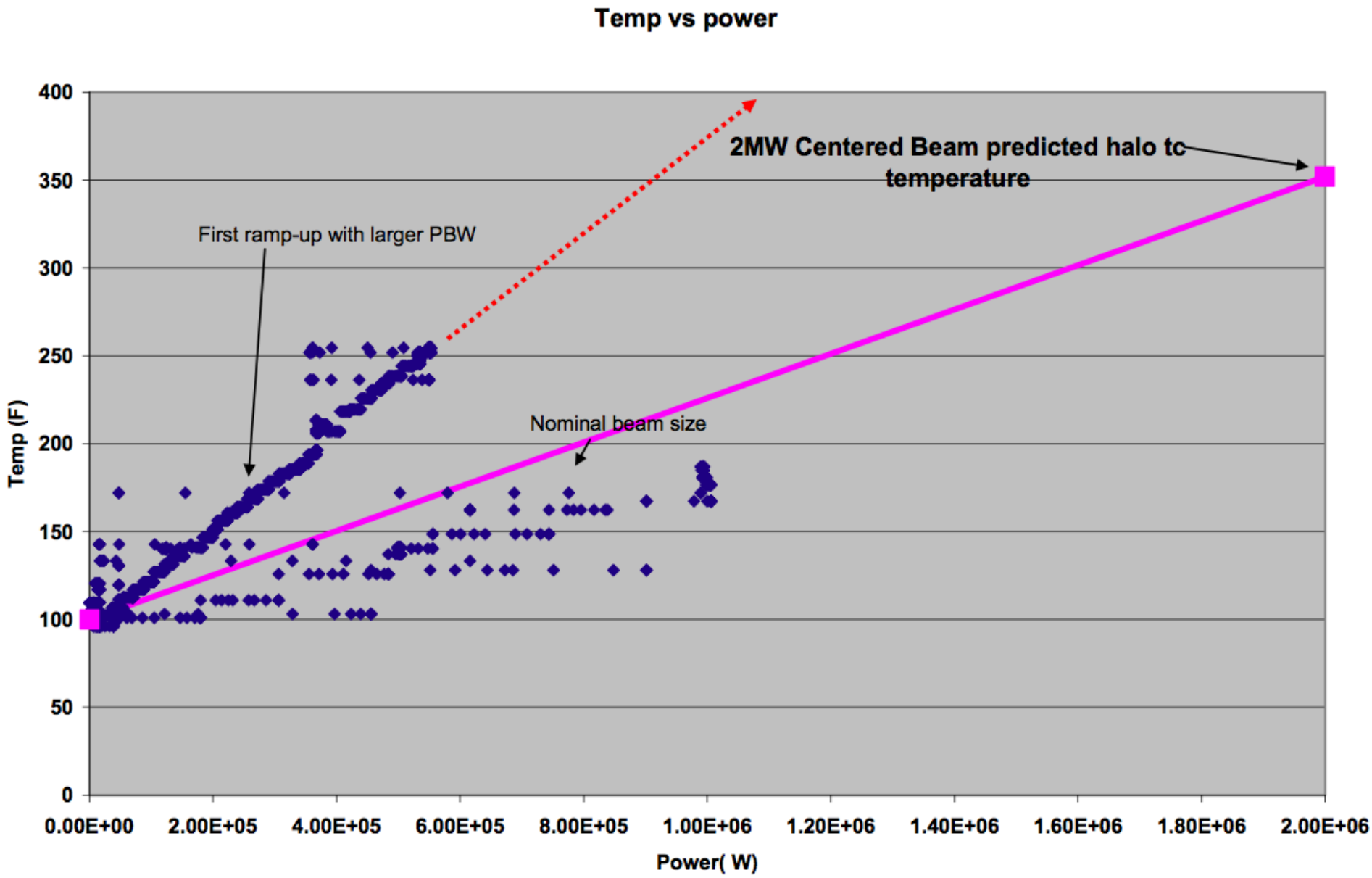


Fit profiles in transport line and near target with super-Gaussian function

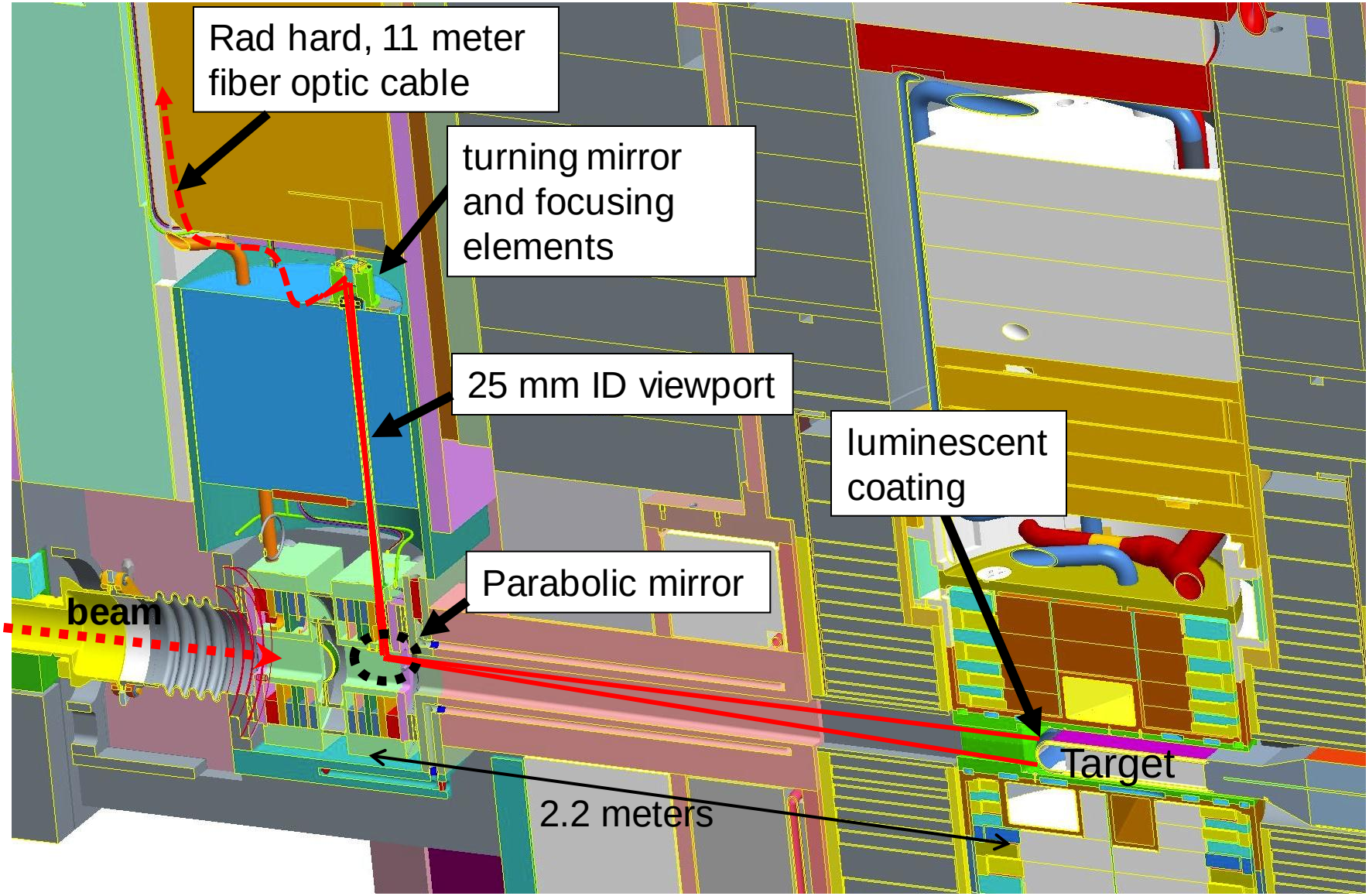
Proton Beam Window, view looking upstream



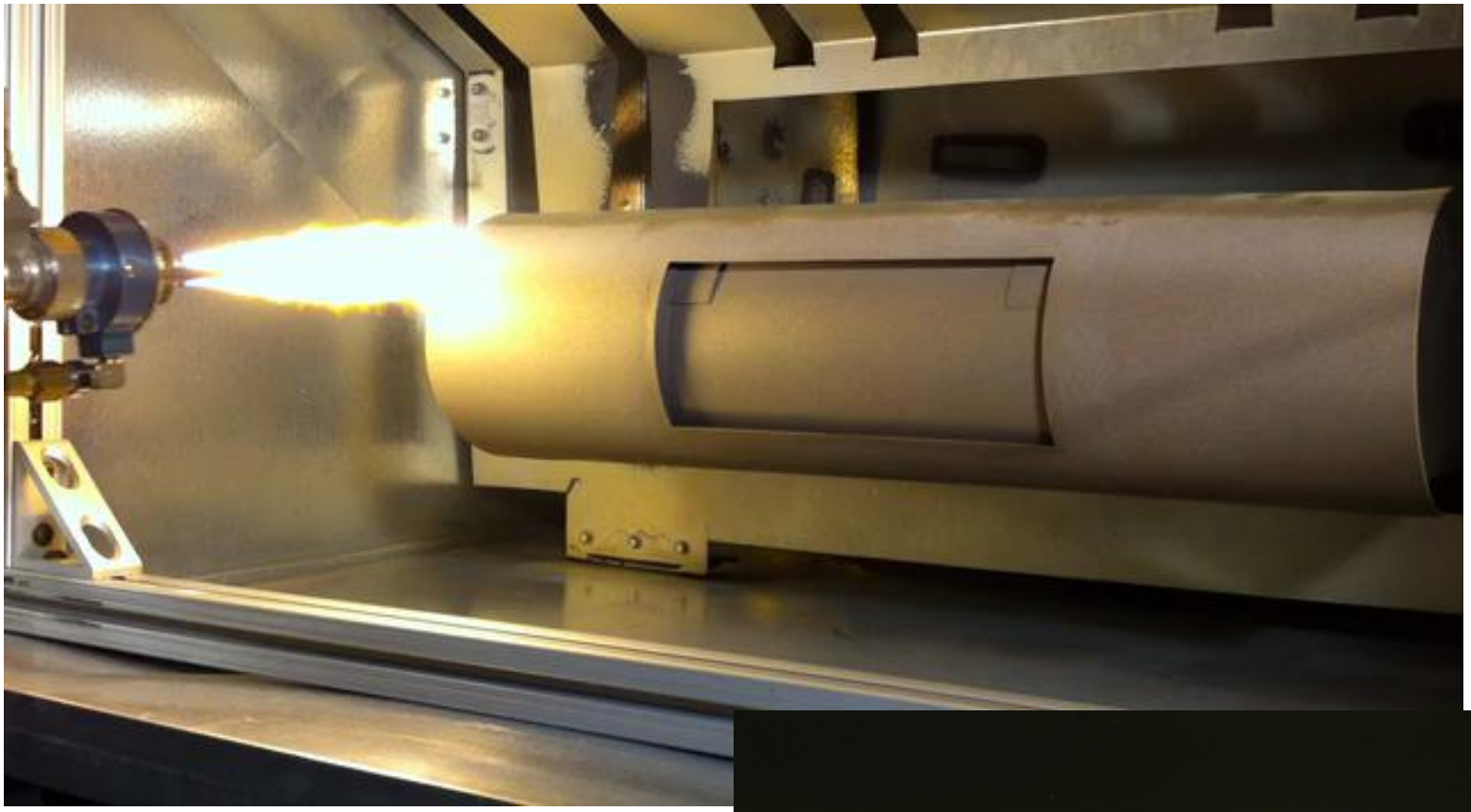
Thermocouple T vs. beam power

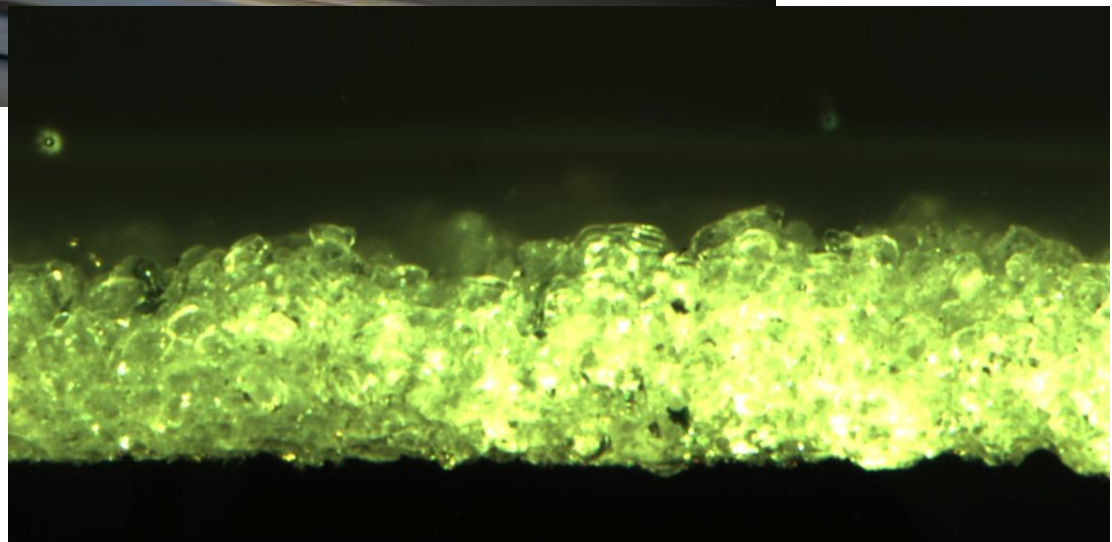


Target Imaging System (TIS)



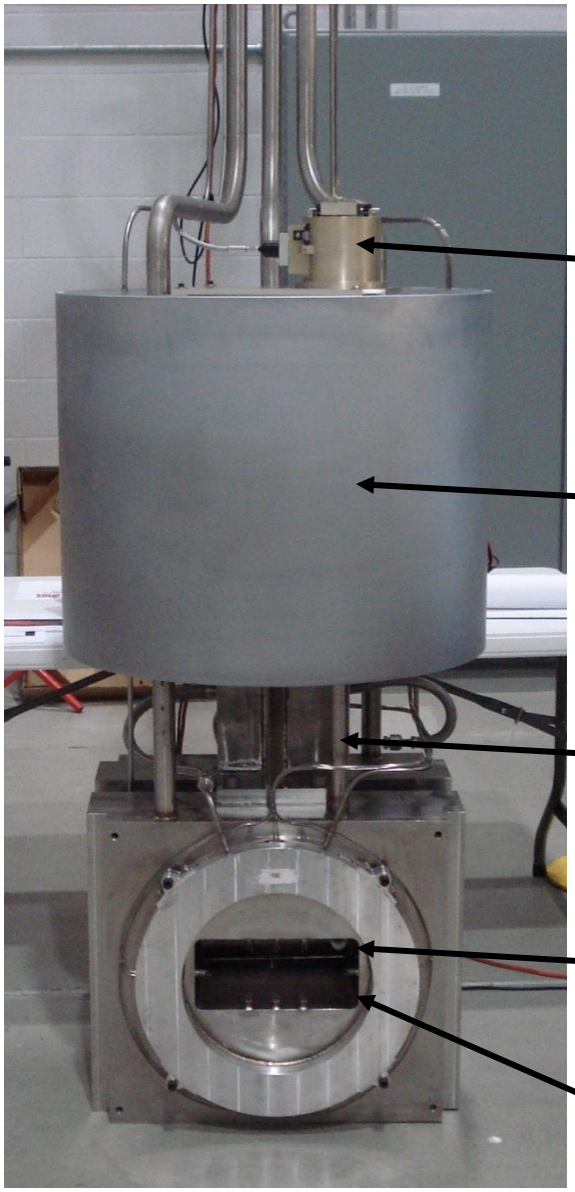
Automated Target Coating





Stony Brook University

Optics on Proton Beam Window



Turning mirror, Diffractive/refractive hybrid lens, beginning of fiber bundle

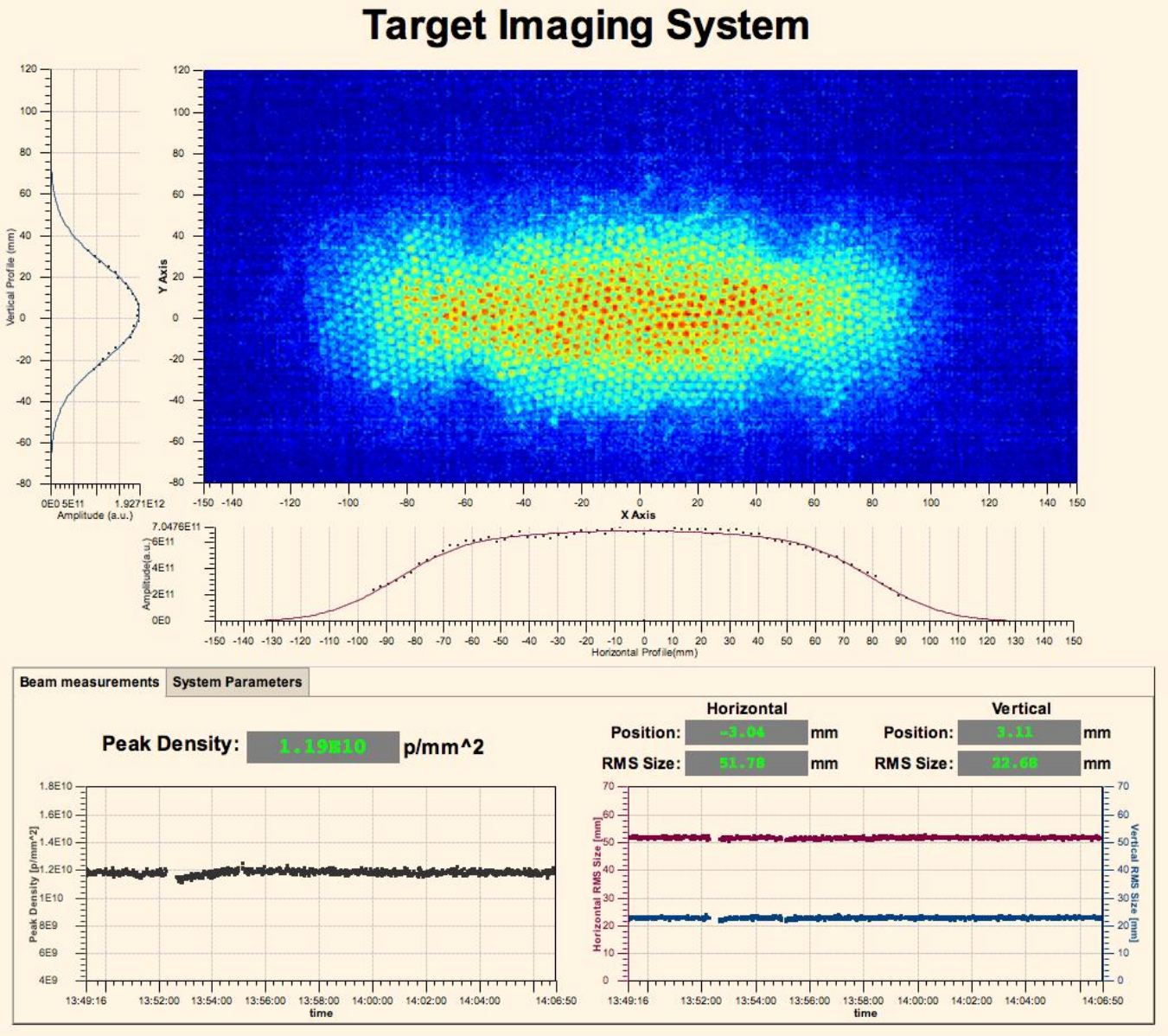
Shielding

25 mm view tube

Off-axis parabolic mirror

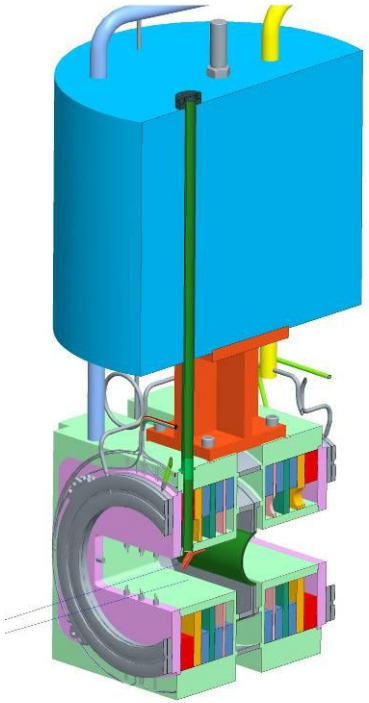
proton beam flight tube

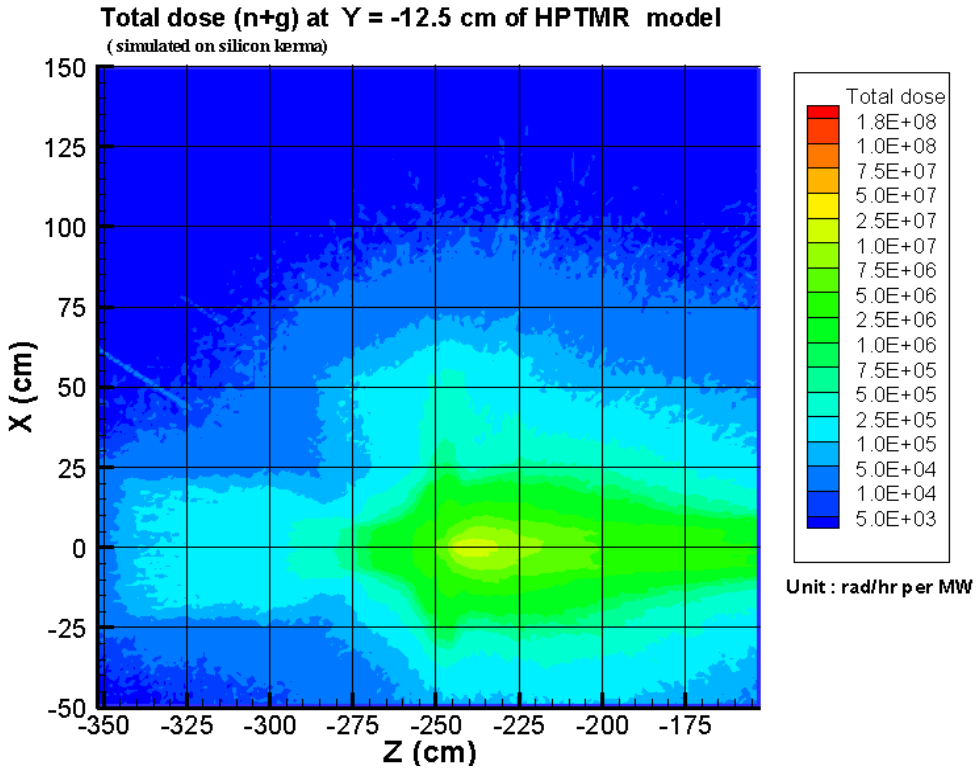
Display in Control Room



Radiation Environment near Window

Requirement: optics survive life of window assembly
Achieved





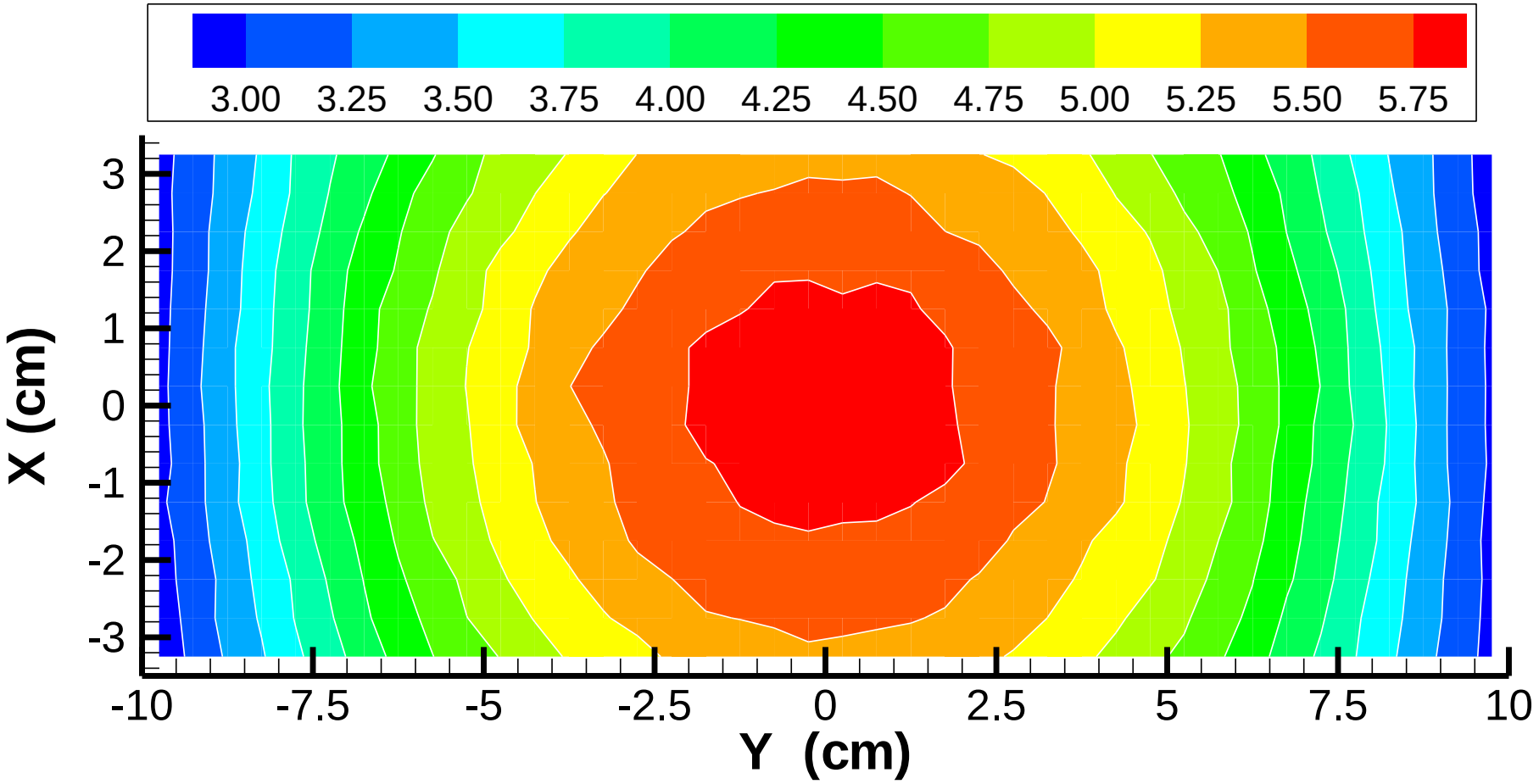
- **After 1.5 MW year window life, the dose in Si at 1 m above beam (viewport location and transition to fiber) is about 100 MRad**
- **An optical element must also be located at the in He near the hottest point**

Dose calculations: Ferguson, et. al.

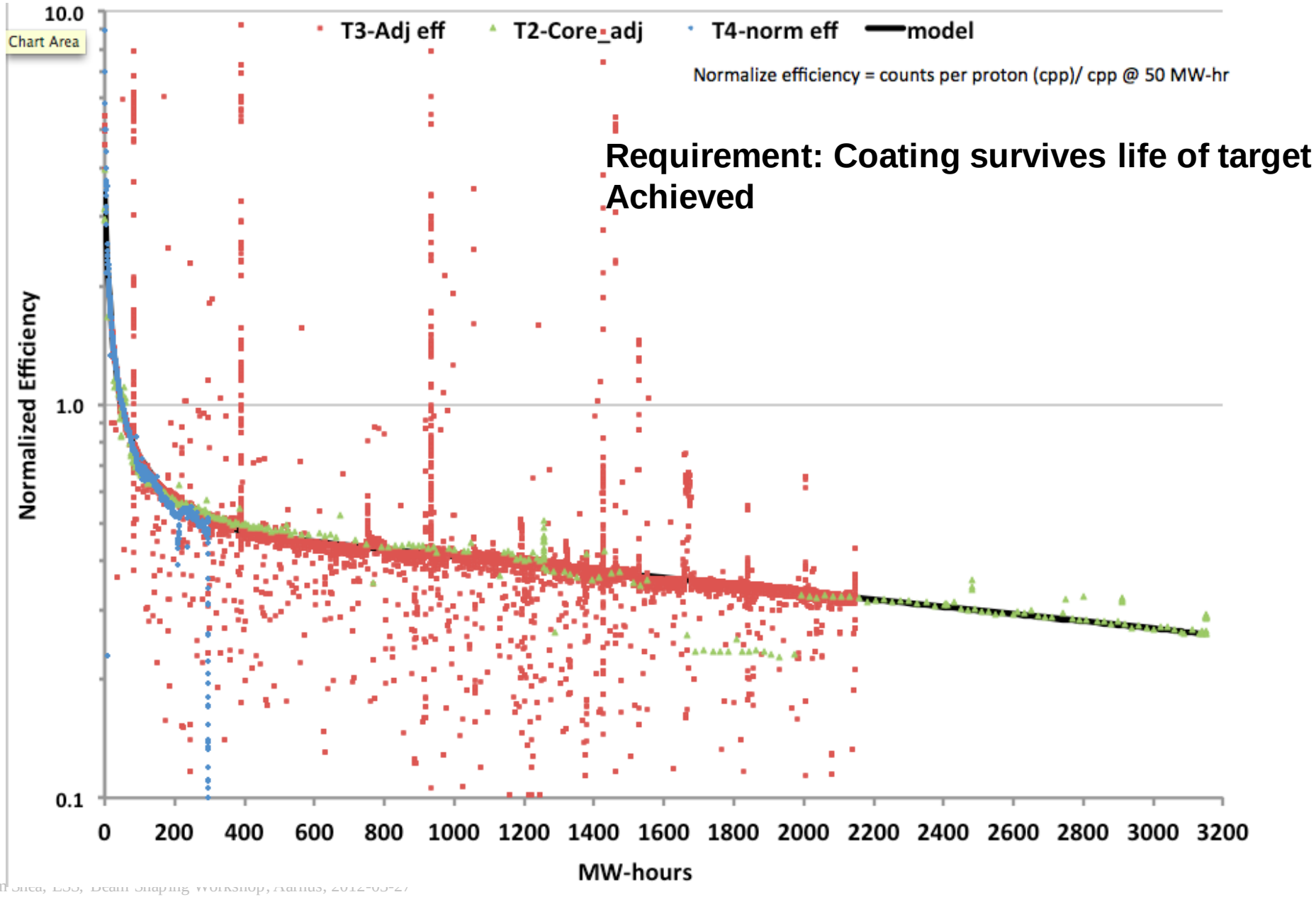
Calculated Radiation Damage to Coating

>85% due to neutrons

DPA in the alumina spray (dpa/SNS yr/MW)

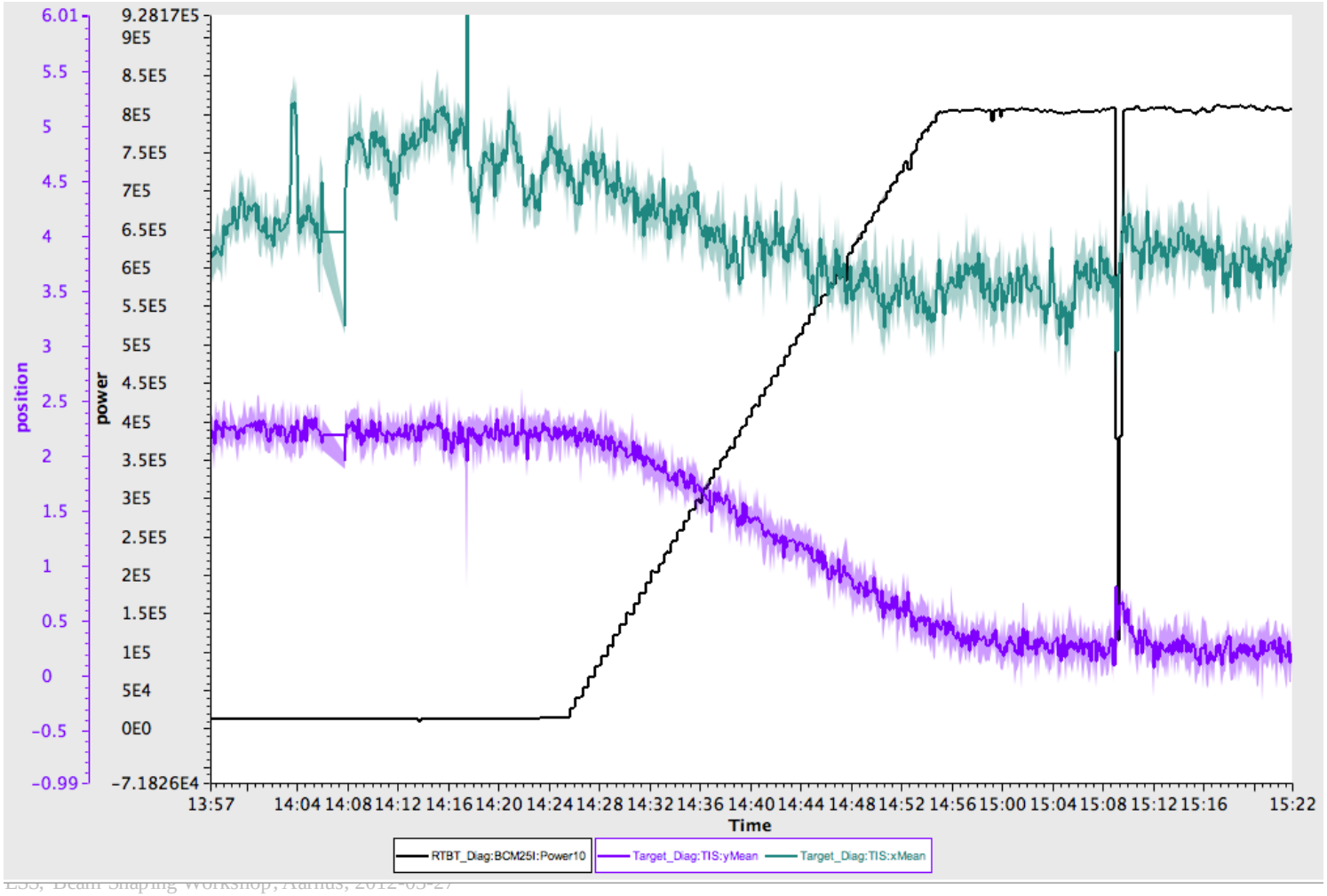


Efficiency trends

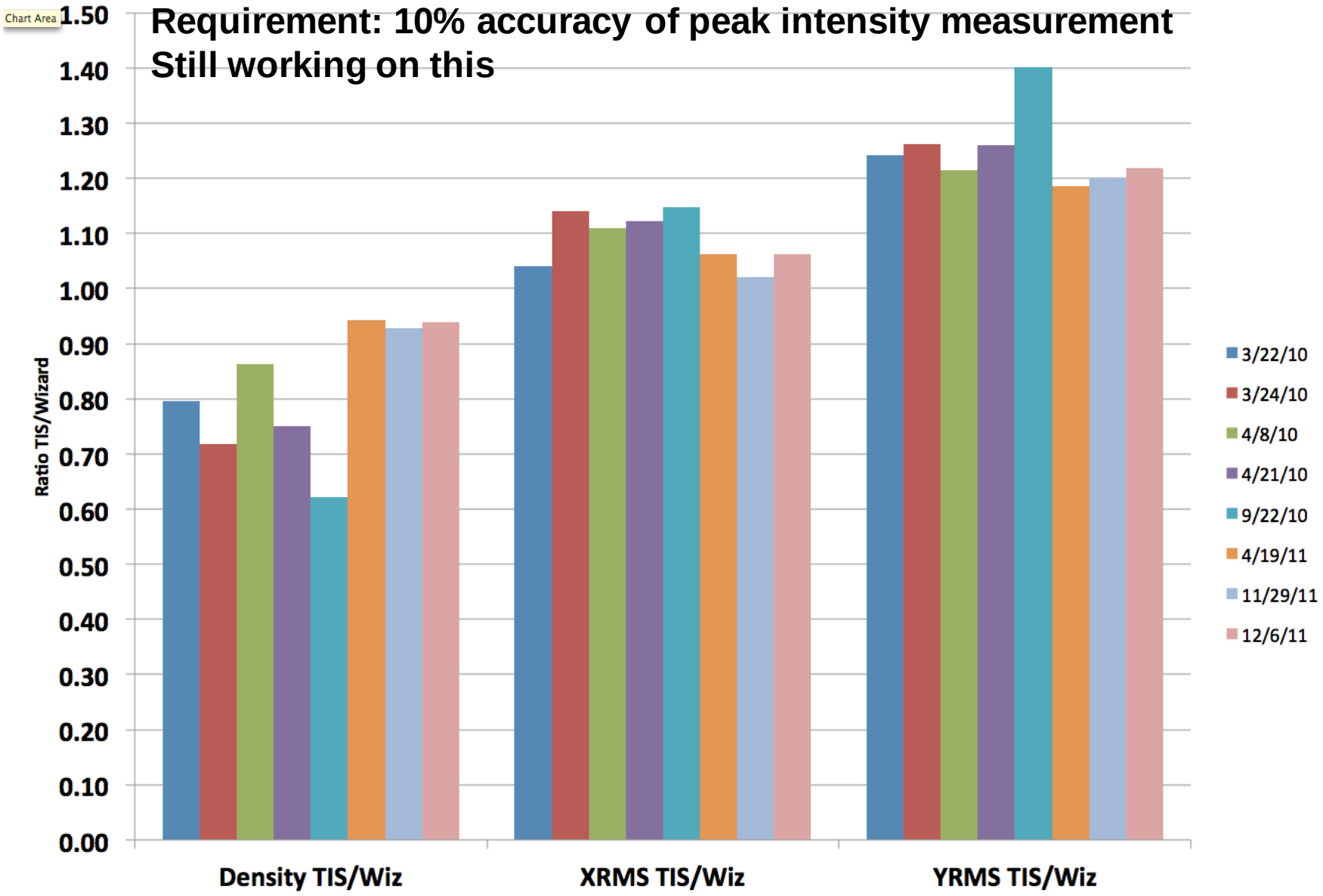


Power dependence of position measurement

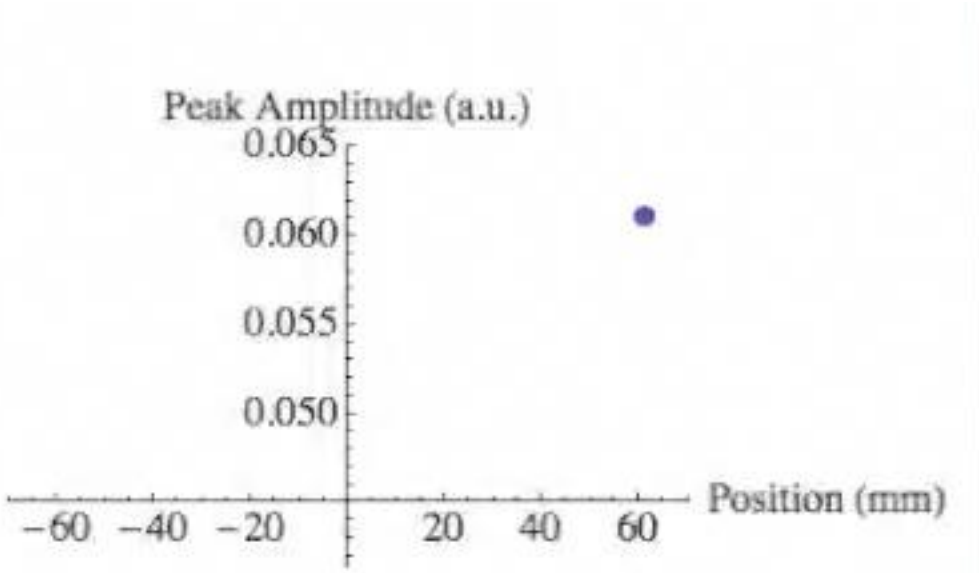
Requirement: 3 mm accuracy (~1/2 of budget) on measured beam position
Achieved by correction based on thermocouple located near mirror
Data logging was critical for debugging this effect

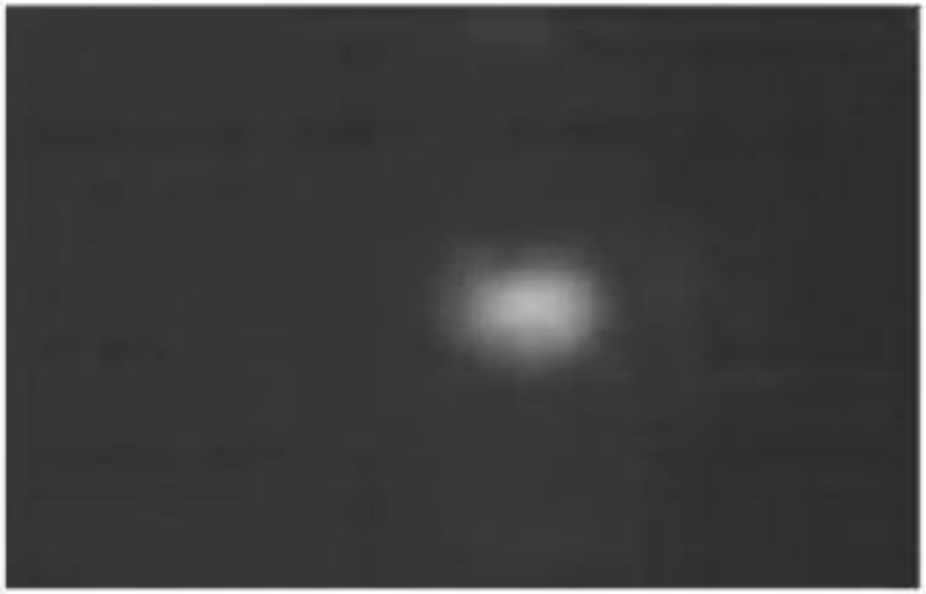


Profile Predictions vs. Measurements



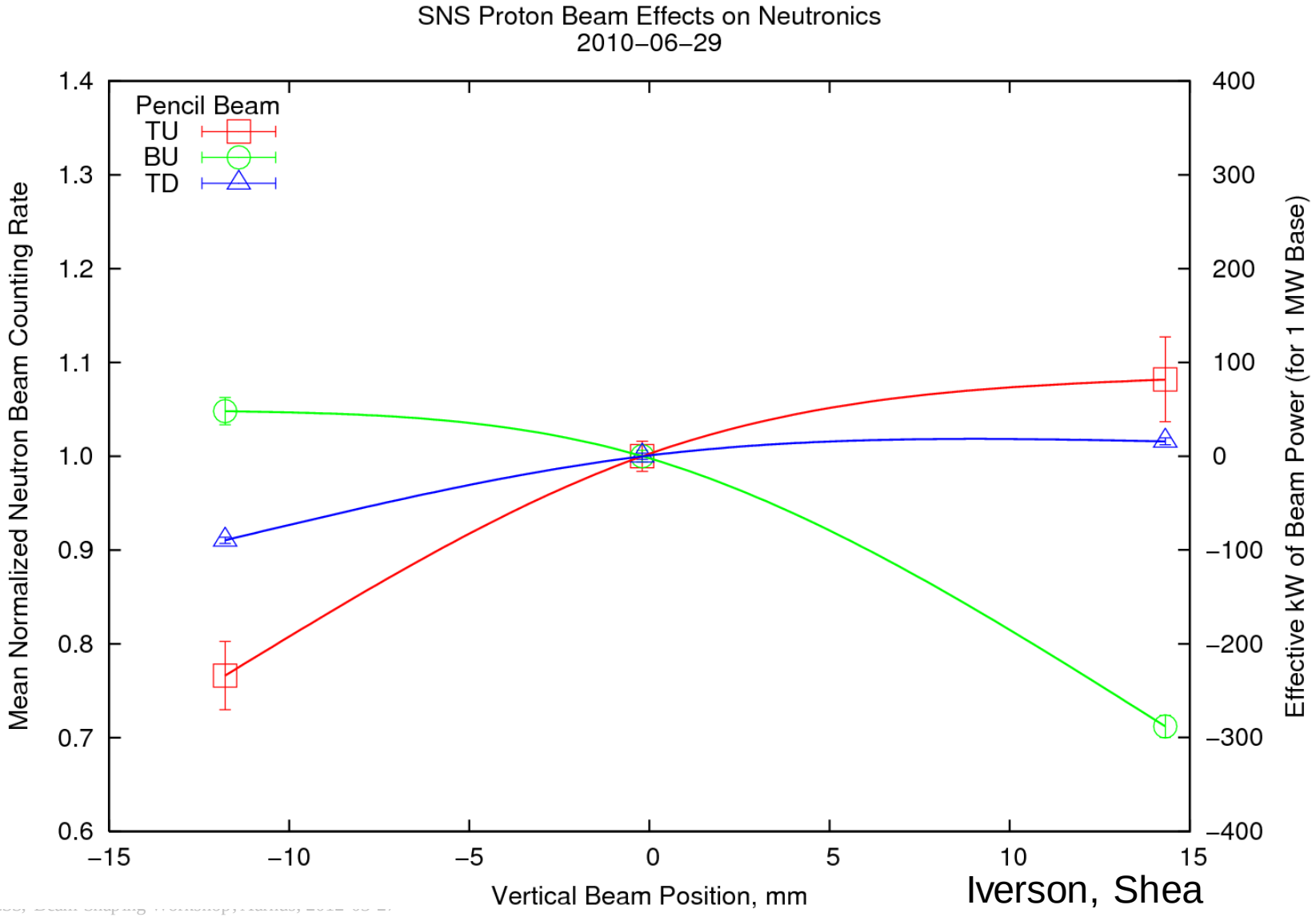
Uniformity Scan



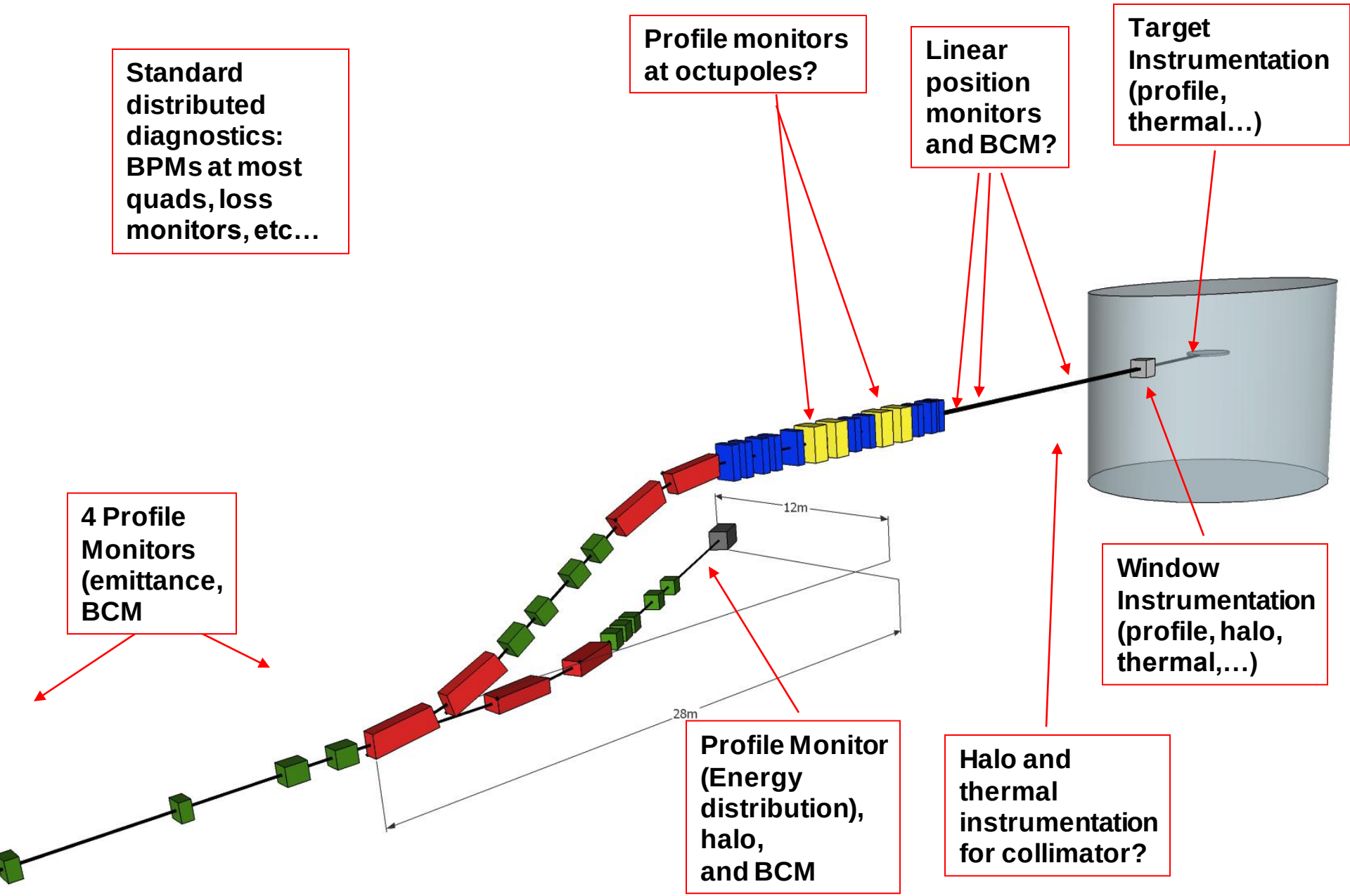


Effect of Beam Position on Neutron Production – pencil beam

Goal: support neutronics studies

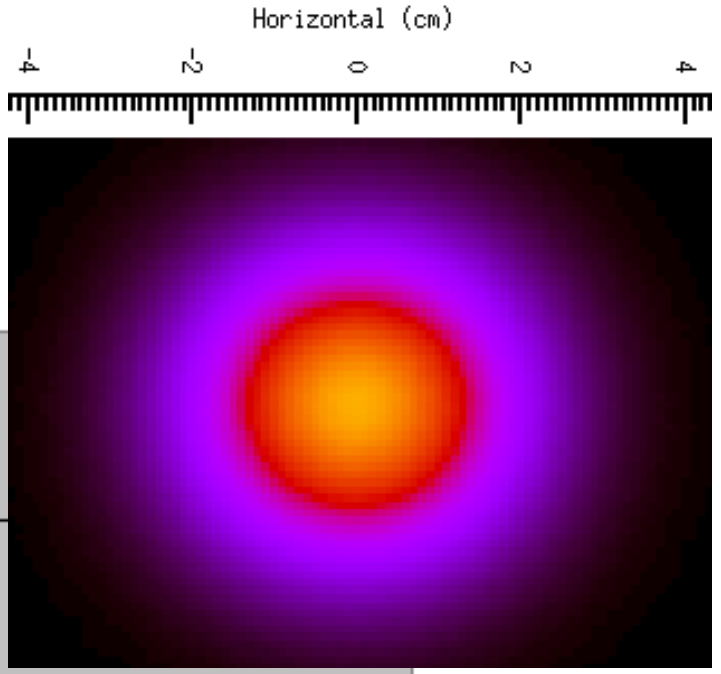


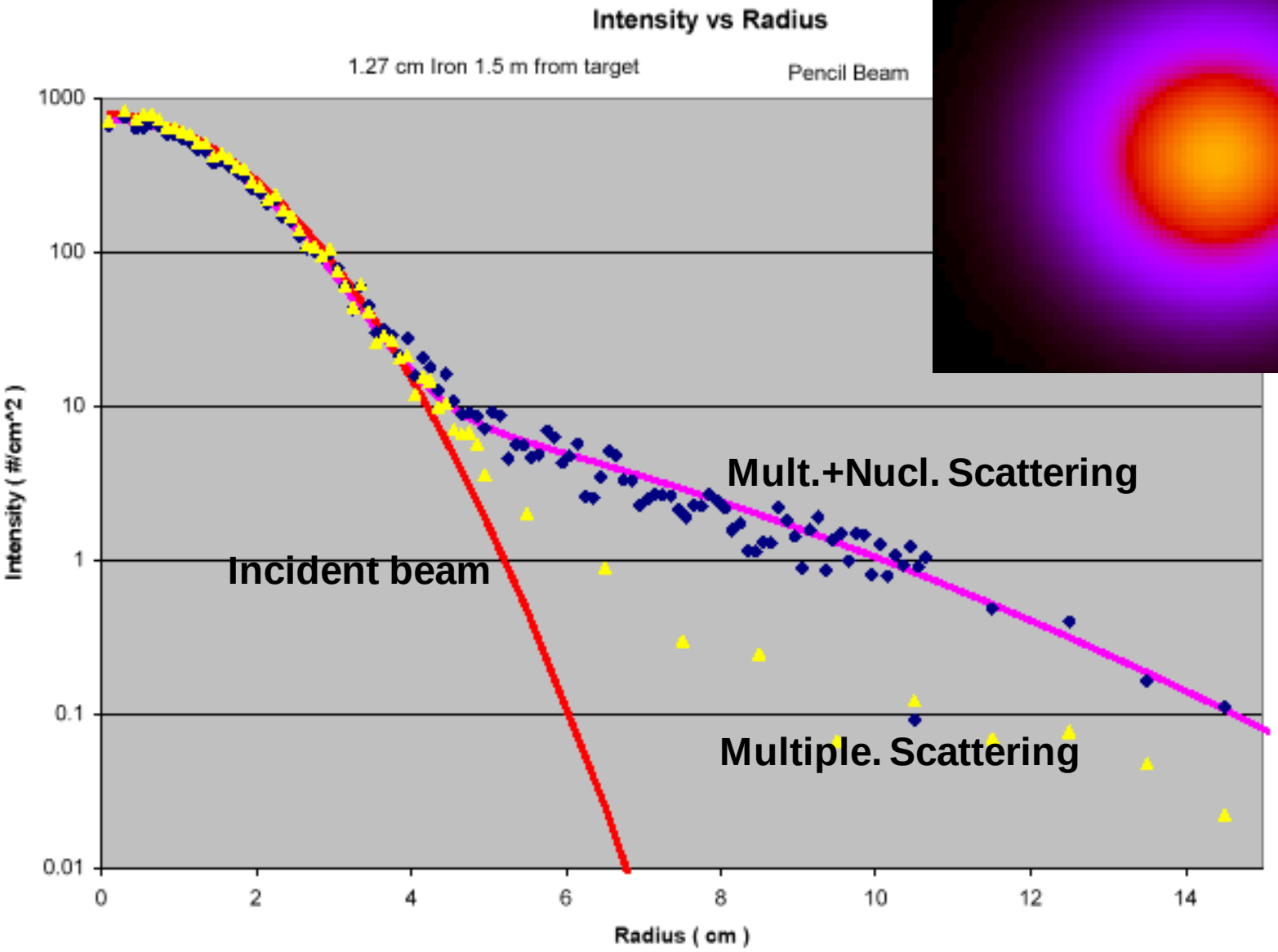
ESS Diagnostics Layout – a few ideas



Window Scattering

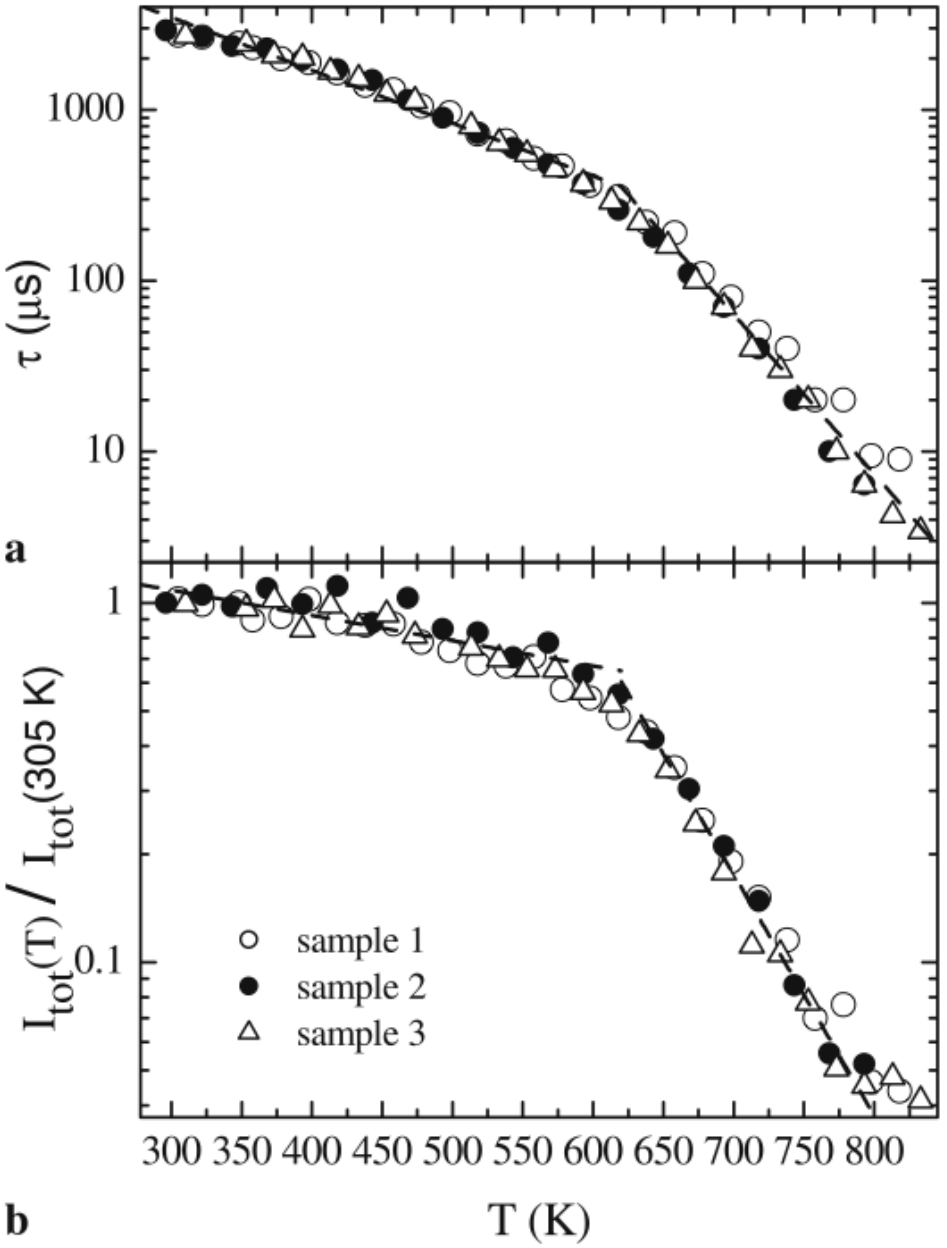
Distance between ESS window and target?





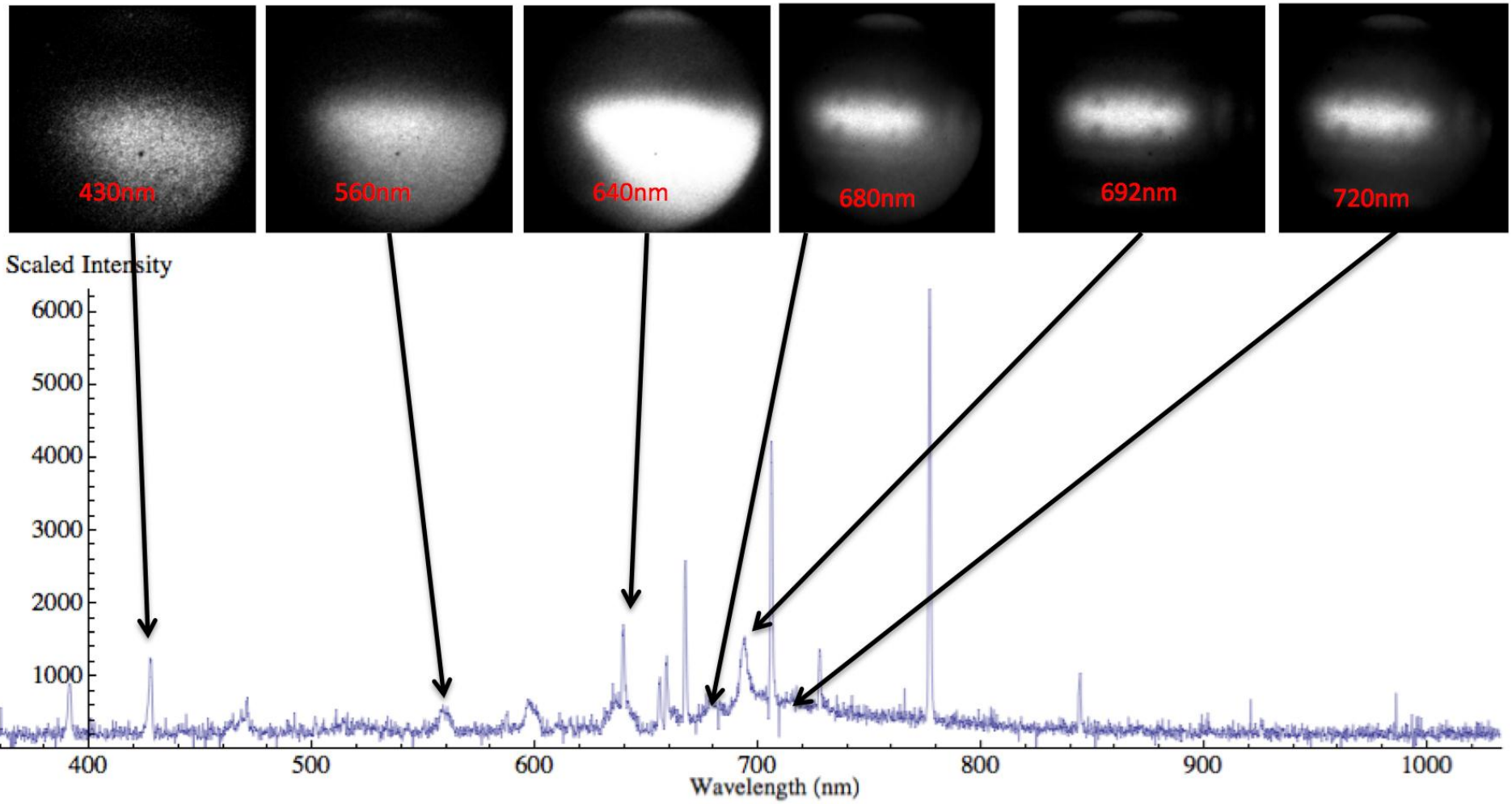
Temperature dependence

Gas cooling of ESS target and window leads to higher temperatures

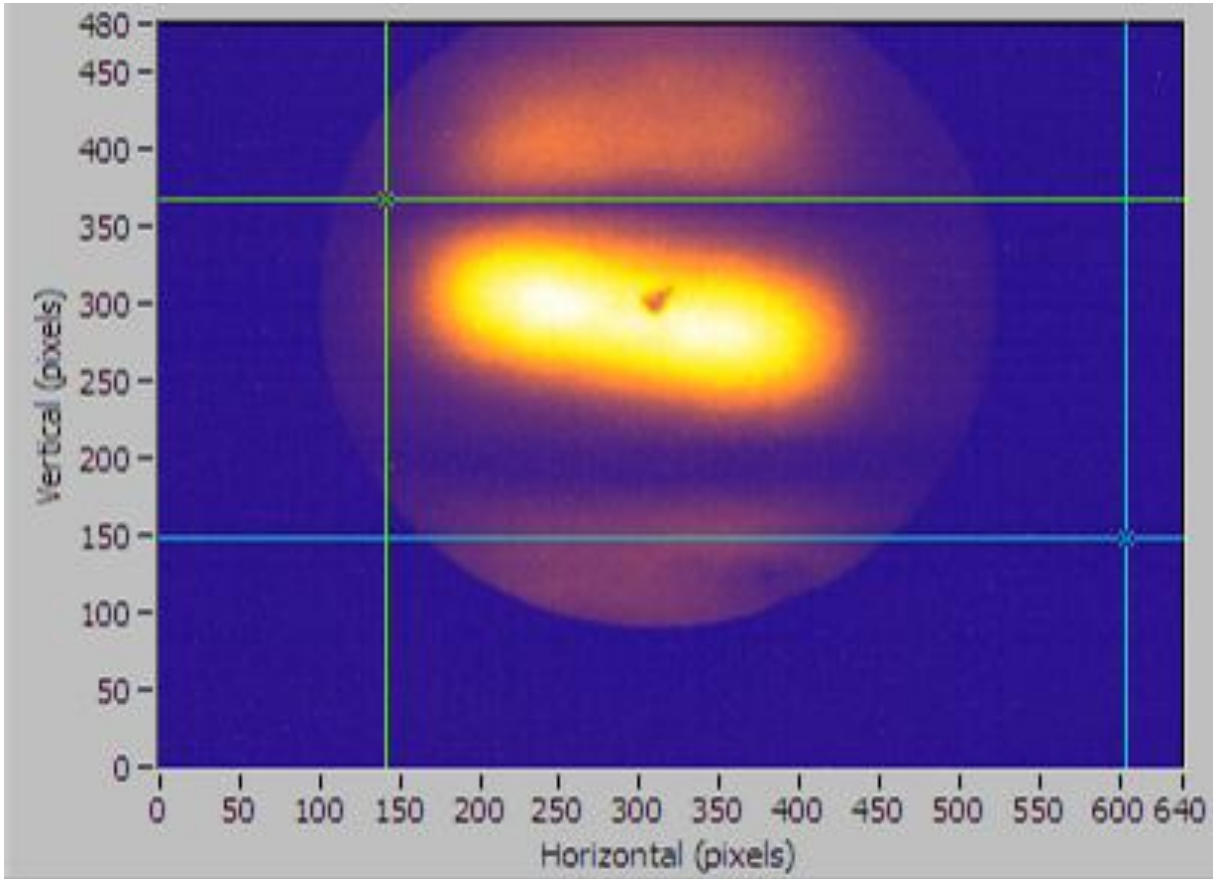


Images vs. Wavelength

Gas fluorescence signal is gated out in SNS imaging system
Consider option of using it for ESS imaging



Managing Expectations



Thank you