TARGET IMAGING SYSTEM (TIS) STATUS

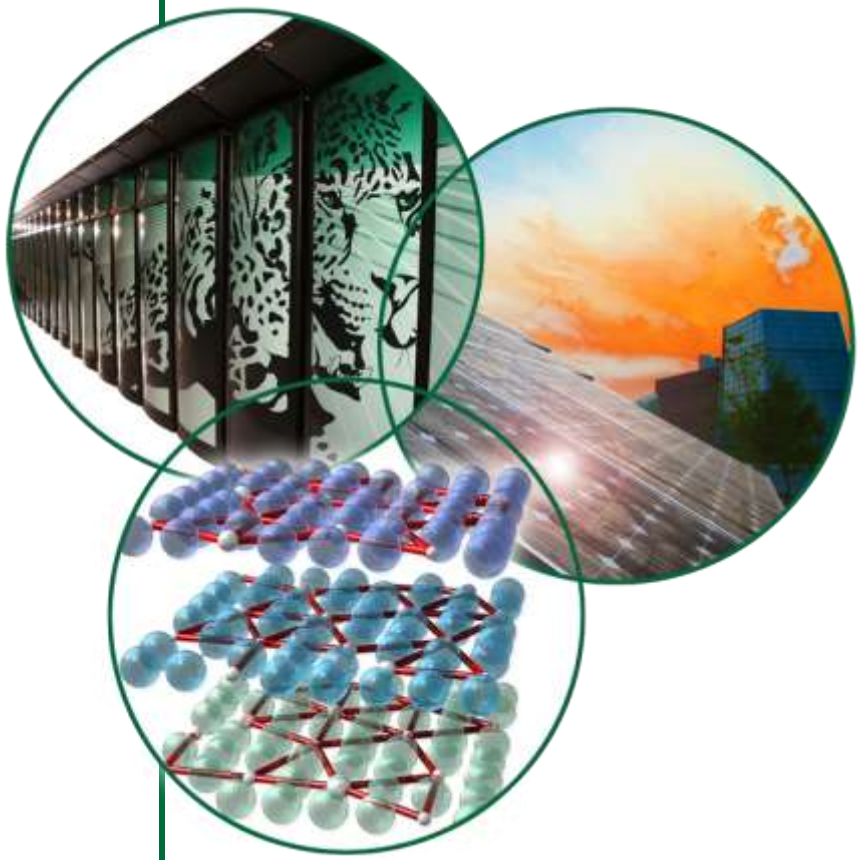
Shea, McManamy, Maxey, Goetz, Brunson, Wagner, Blokland, Lance, Kenik, Montgomery, Murray, McTeer (ORNL: RAD, NFDD, Mat. Sci., Bldg. Tech)

Sampath, Bancke, et. al. (SUNY-SB)

Fiorito, Shkvarunets, et. al. (U of Maryland)

White (TN Metalizing)

AAC Meeting February 2 -4, 2010



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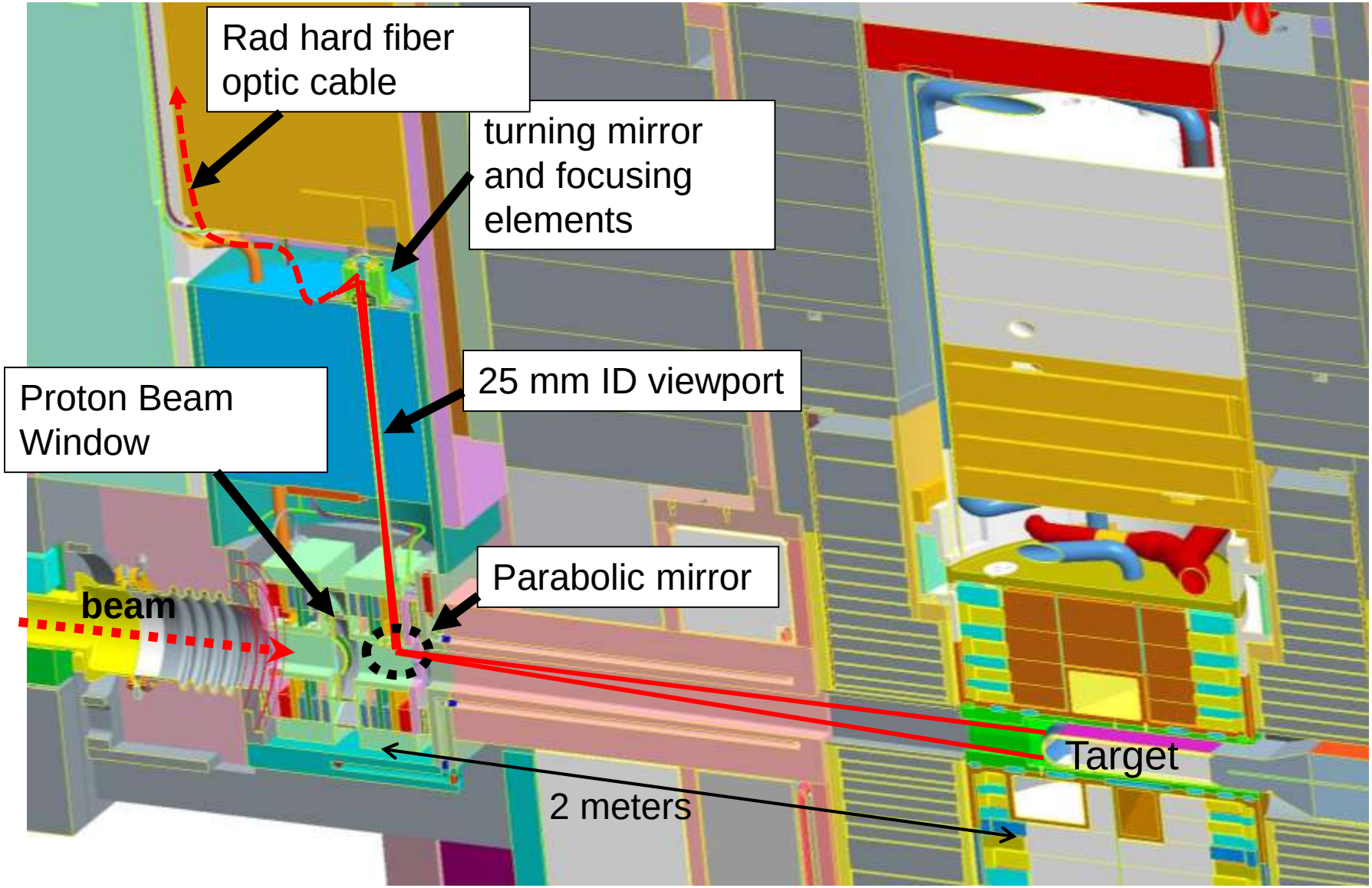
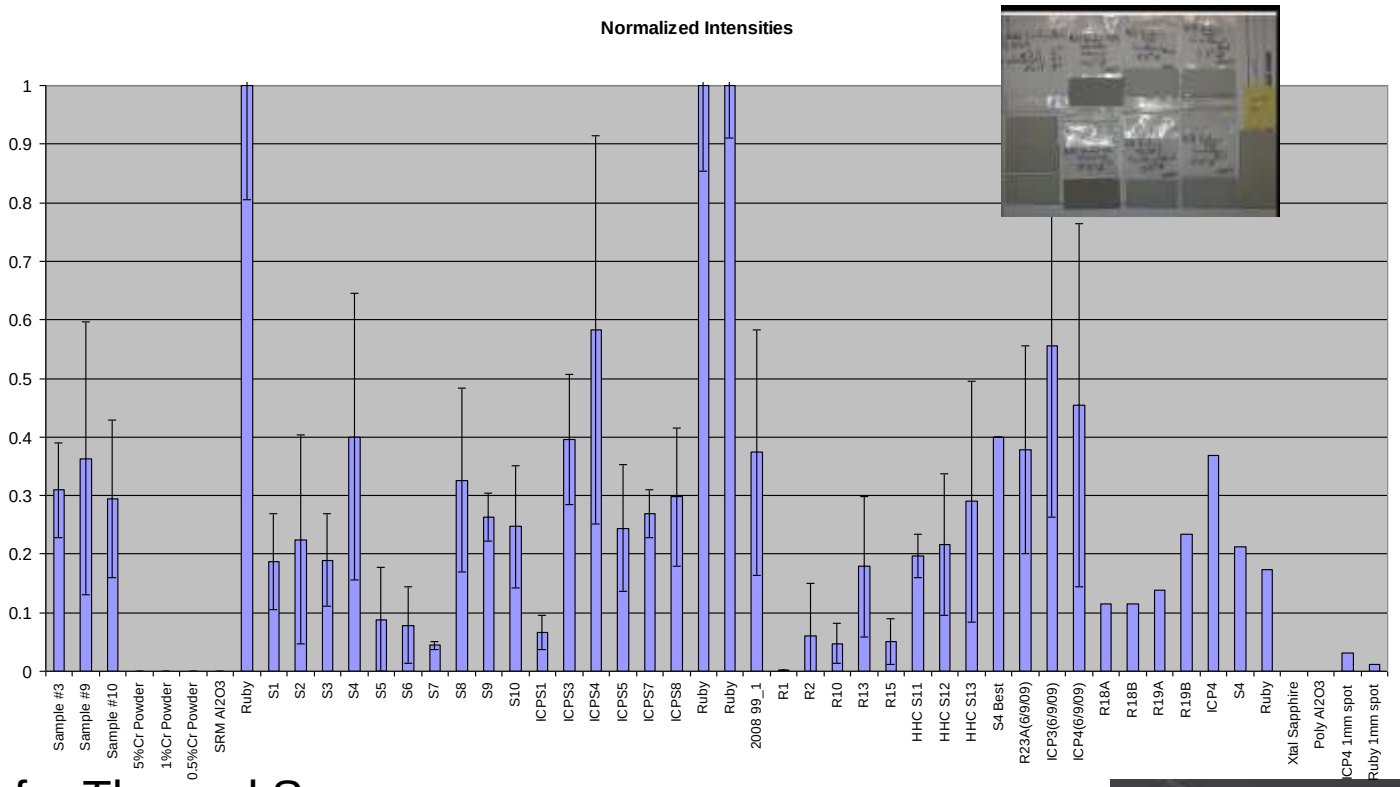
Optical Path



Flame Spray Process Development



- Center for Thermal Spray Research at State University of New York, Stony Brook fabricated multiple samples to evaluate process
- ORNL measured emission intensity at ~ 690 nm after excitation by green laser

- Relative intensity of ~ 60% compared to chromox plate achieved
- Particle size, % Chromia and pre-reacting mix important

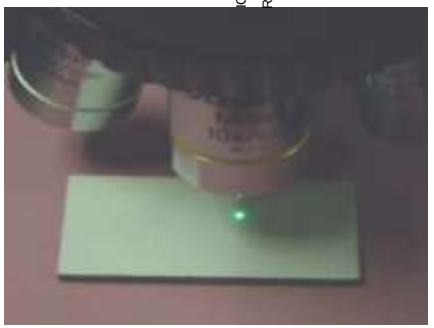
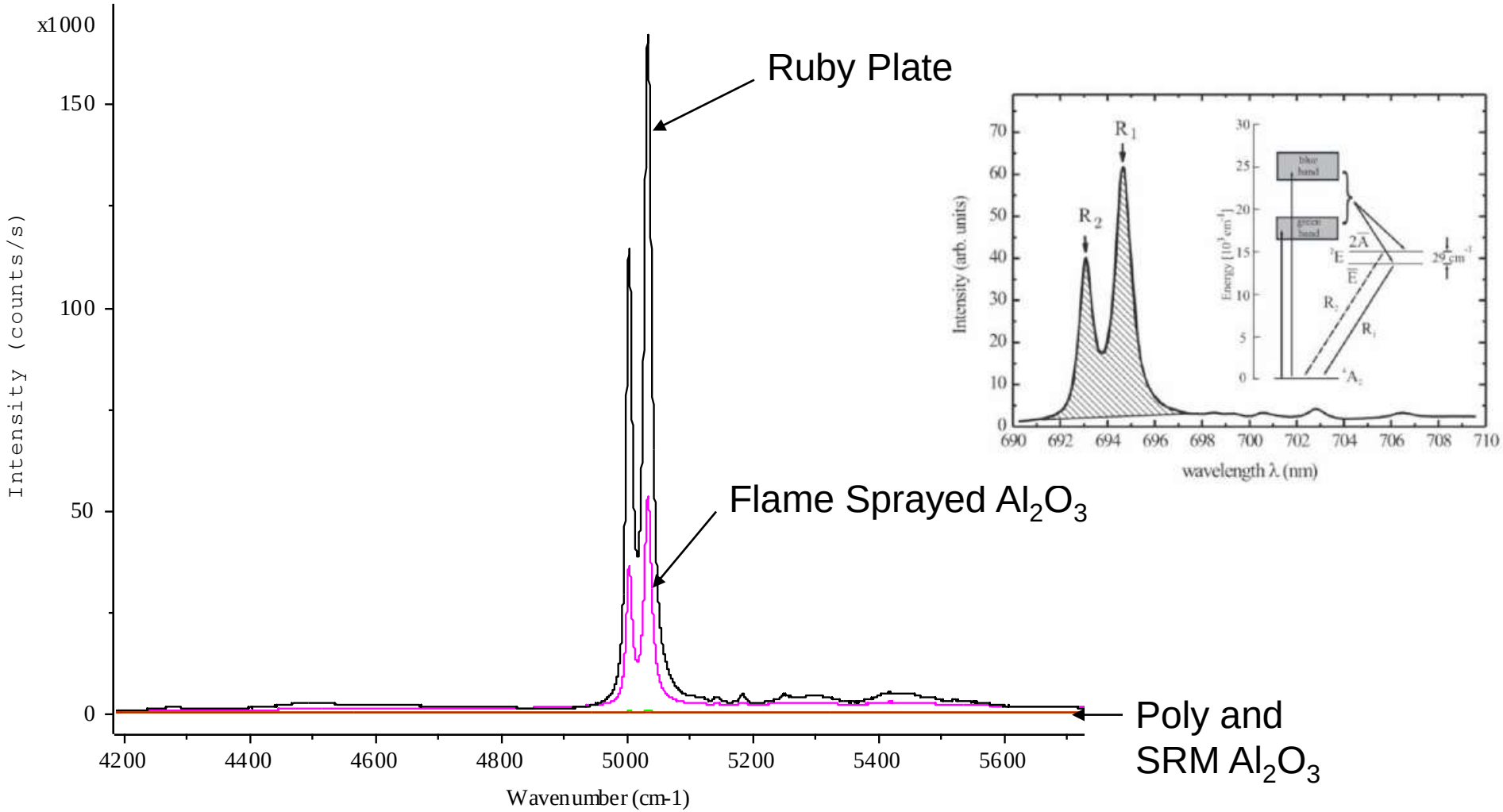


Photo Stimulated Luminescence

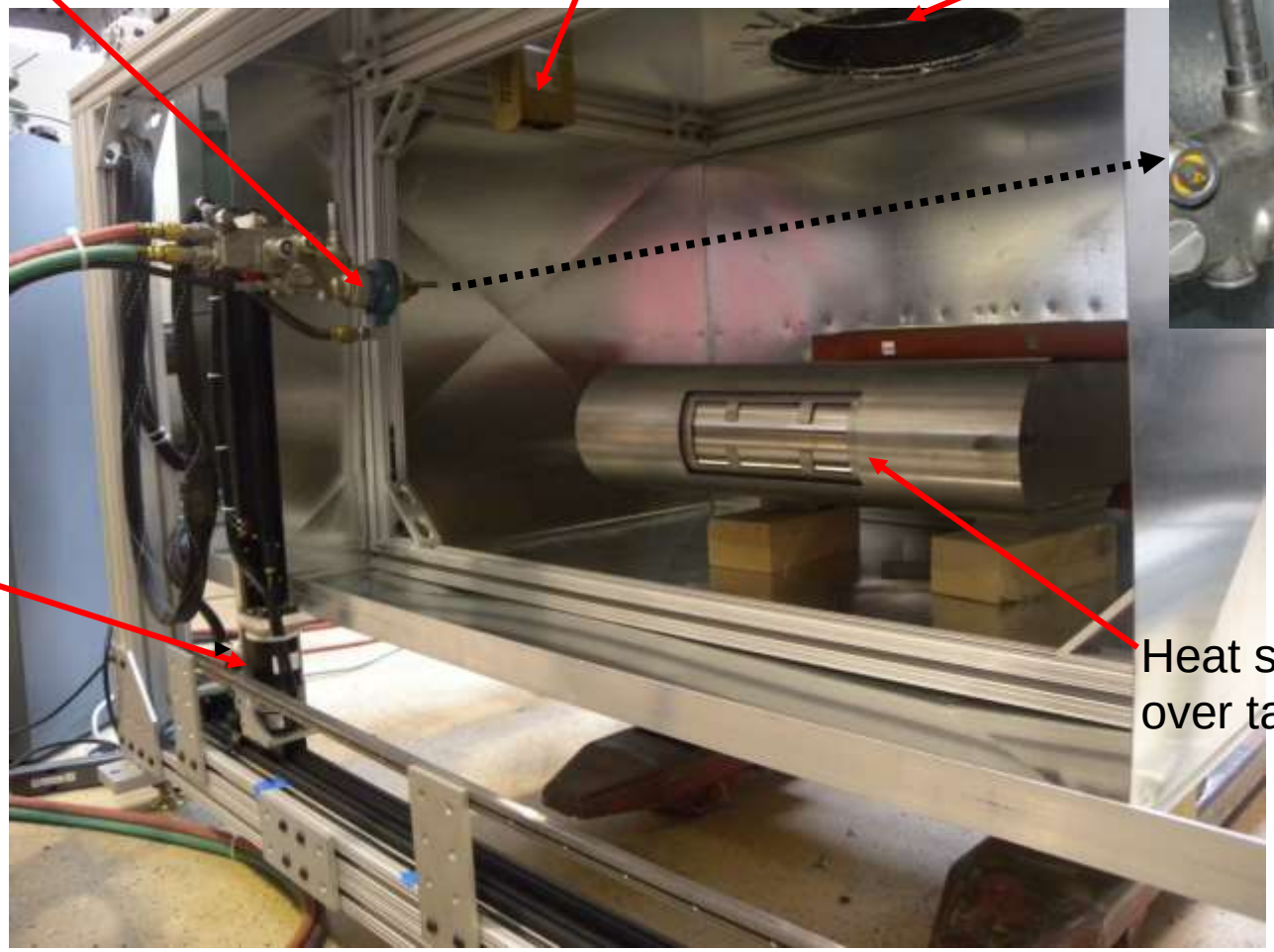


- Early sample shown; efficiency improved throughout spray development program
- The x-axis are in terms of Raman cm^{-1}; subtract the values from 19435 cm^{-1}

Mockup testing was done to validate process

- Automated spray system developed
- Mockup targets with thermocouples used to measure substrate temperature
- Peak substrate temperatures < 120 C achieved
- Application temperature is close to operating temperature which reduces stresses in the coating

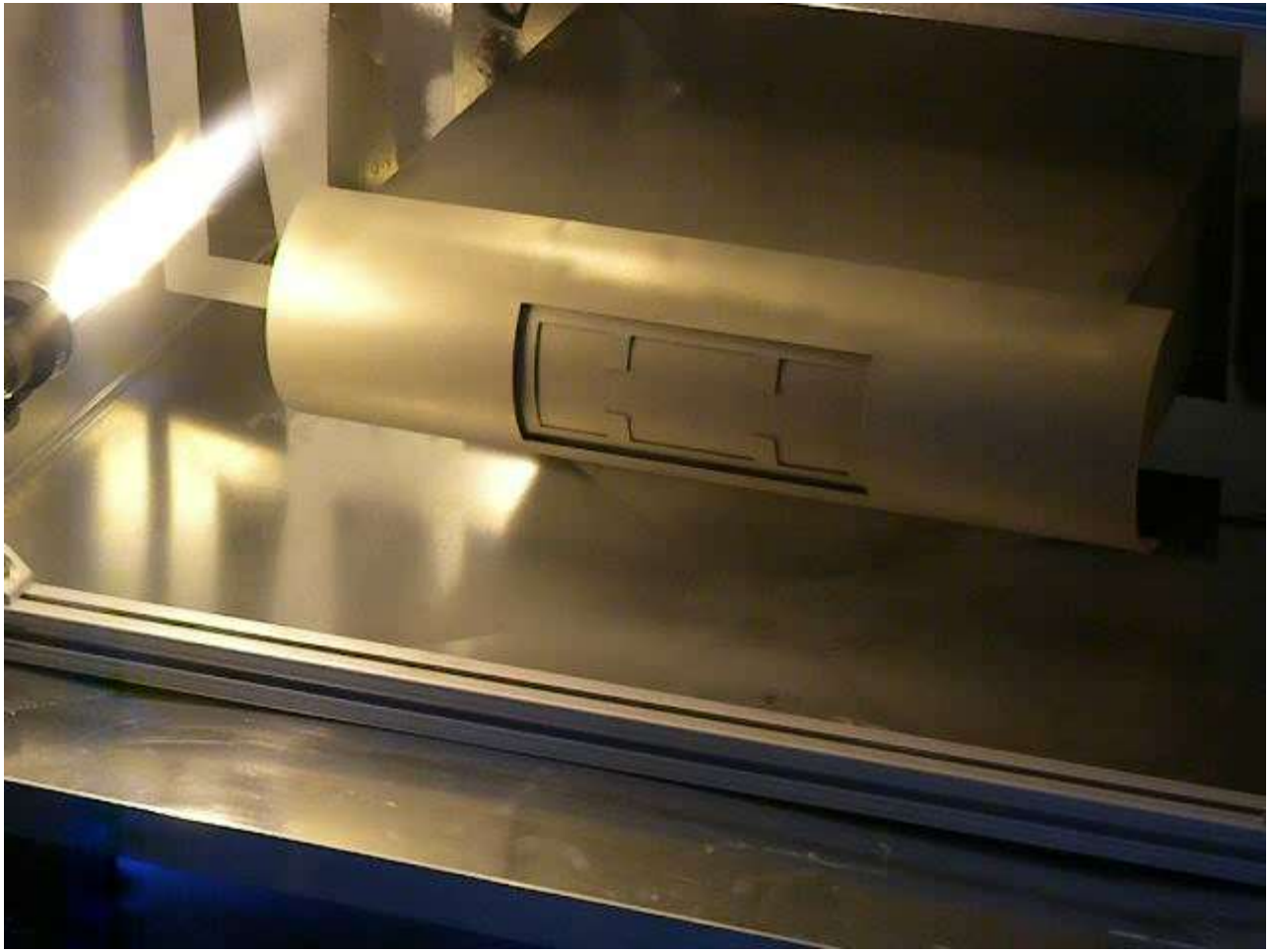
Flame Spray (Al_2O_3+ 1.5% Cr_2O_3) development



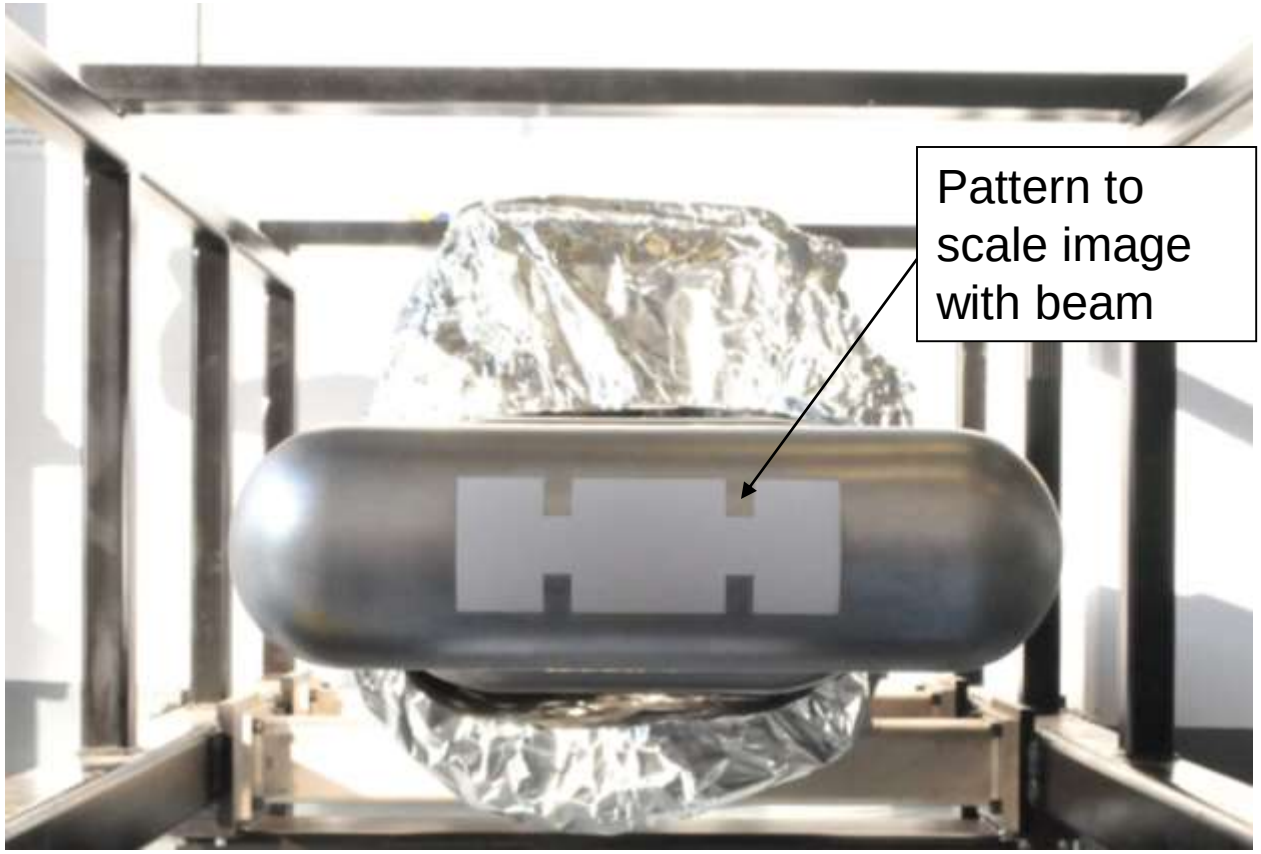
Portable Flame Spray Coating and Ventilation System Developed by the Center for Thermal Spray Research (SUNY at Stony Brook)

Late June: Target Coating

~ 1 yr luminescent materials and process development
Automated spray process: Concept to completion in 8 weeks, 2 targets sprayed just in time for change-out.



Completed Target Coating



Nominal Thickness 0.25 mm, 200mm x 70 mm pattern

Mockup testing established parameters and showed substrate temperatures were < 120 C with air cooling

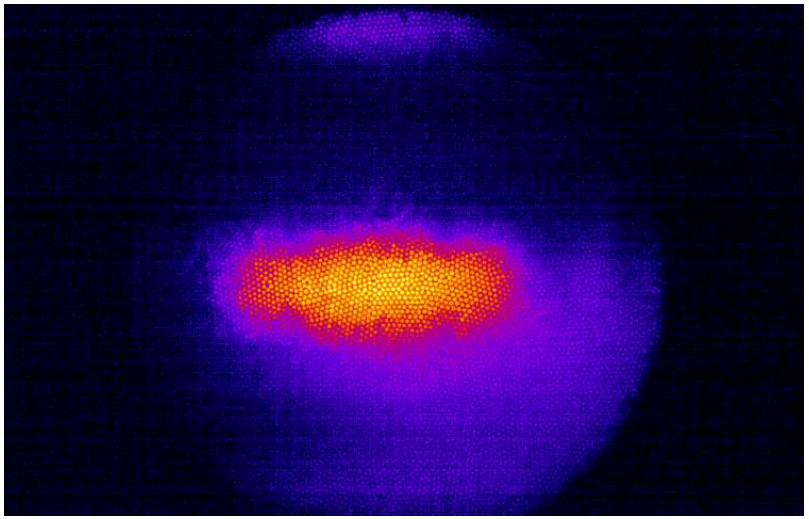
July/Aug: Optical Installation and Testing

Image of simulated target prior to PBW/optics installation:

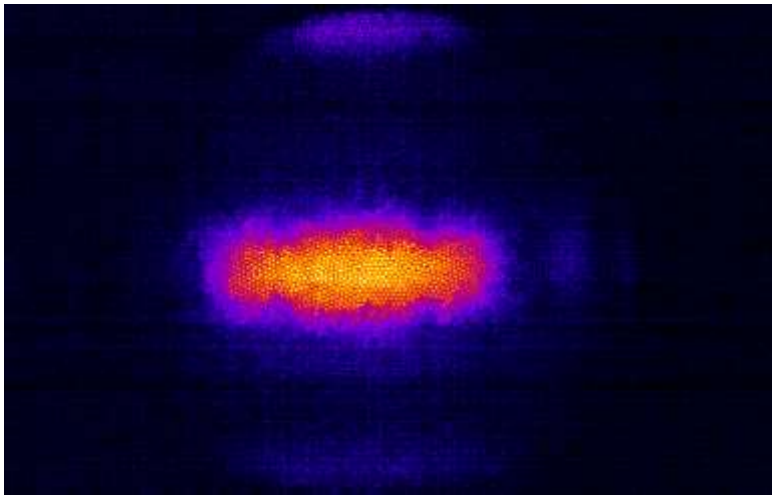
Image of actual retracted target after PBW/optics installation:

- Resolution was poorer then would be expected from the fiber spacing
  - On-line calibration from fiducial pattern difficult
  - Spherical aberrations in the focusing lens assembly seem to be the cause

Images after initial operation

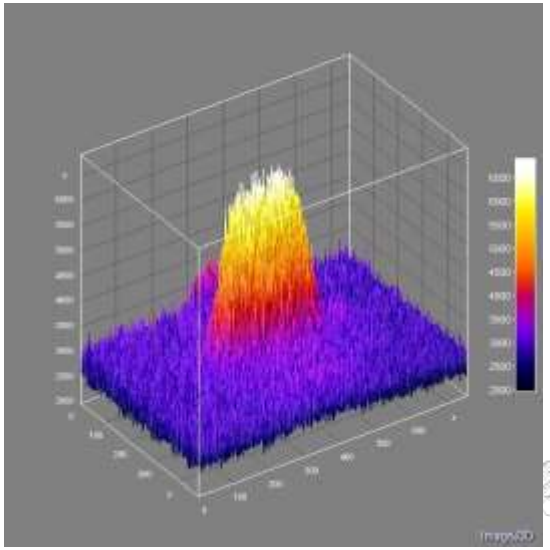


Case 1: image with potential gas scintillation

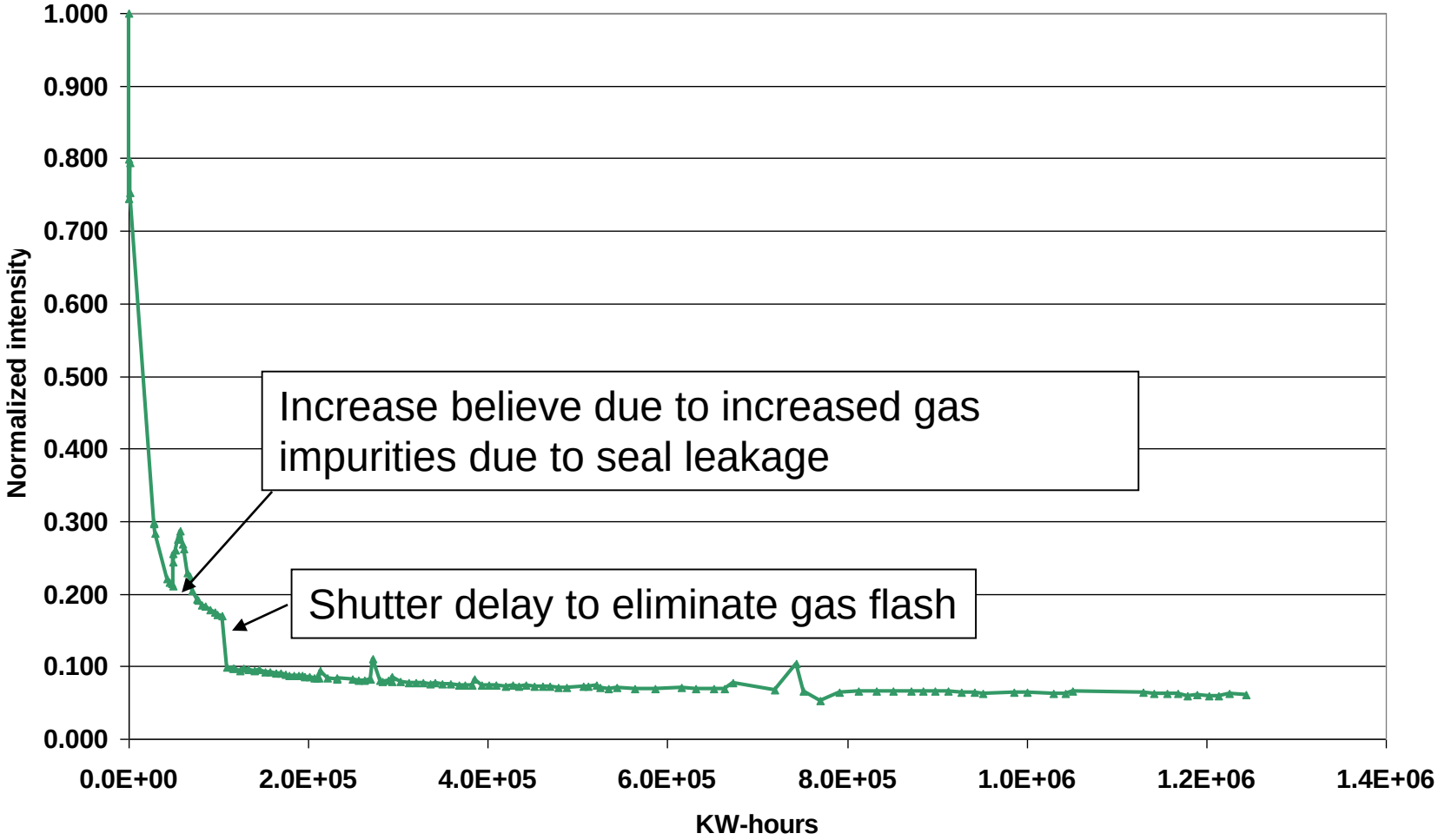


Case 2: image with shutter delayed by 4 microseconds to gate out suspected gas

- No beam tilt observed
- Initial comparison of TIS with RTBT Wizard gave peak densities ~ 10% higher from TIS
- On line TIS show lower peak density then projections from harp
- Detailed comparison study of the two methods is needed for single pulse and at power and is planned for the next startup



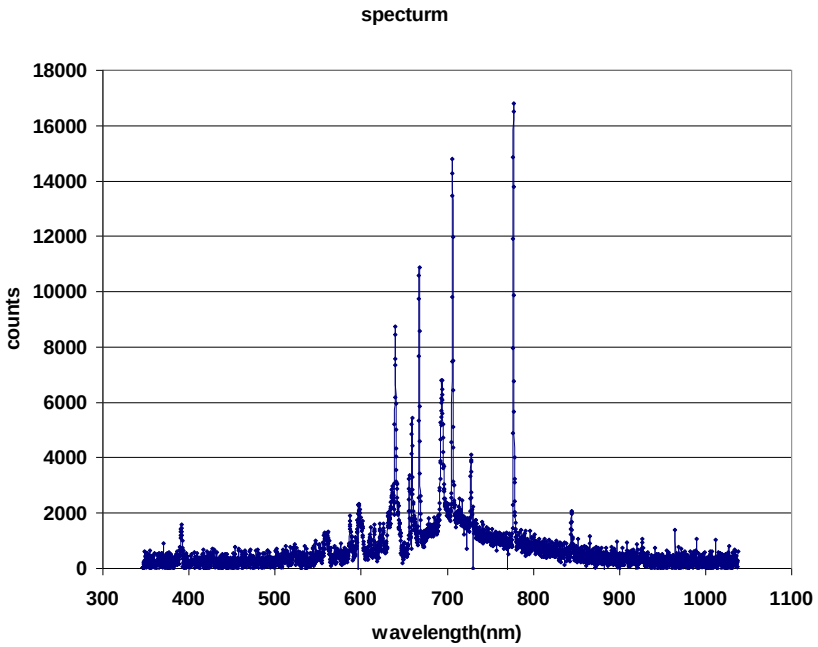
Observed intensity vs. kW-hrs on target



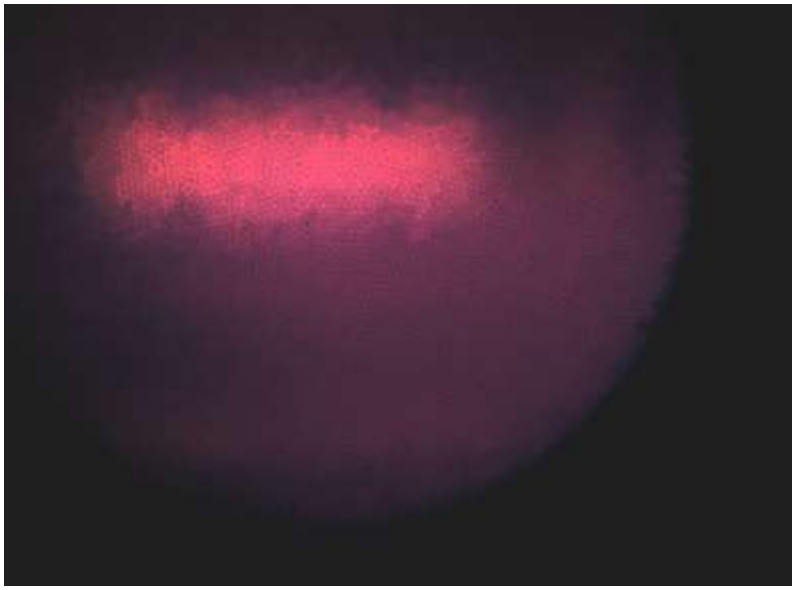
An initial drop in intensity was observed, but degradation has slowed dramatically – should last for life of target

Loss of intensity believed to be from production of oxygen dislocations-F centers which saturate at ~ 0.1 dpa

Typical spectrum and color image

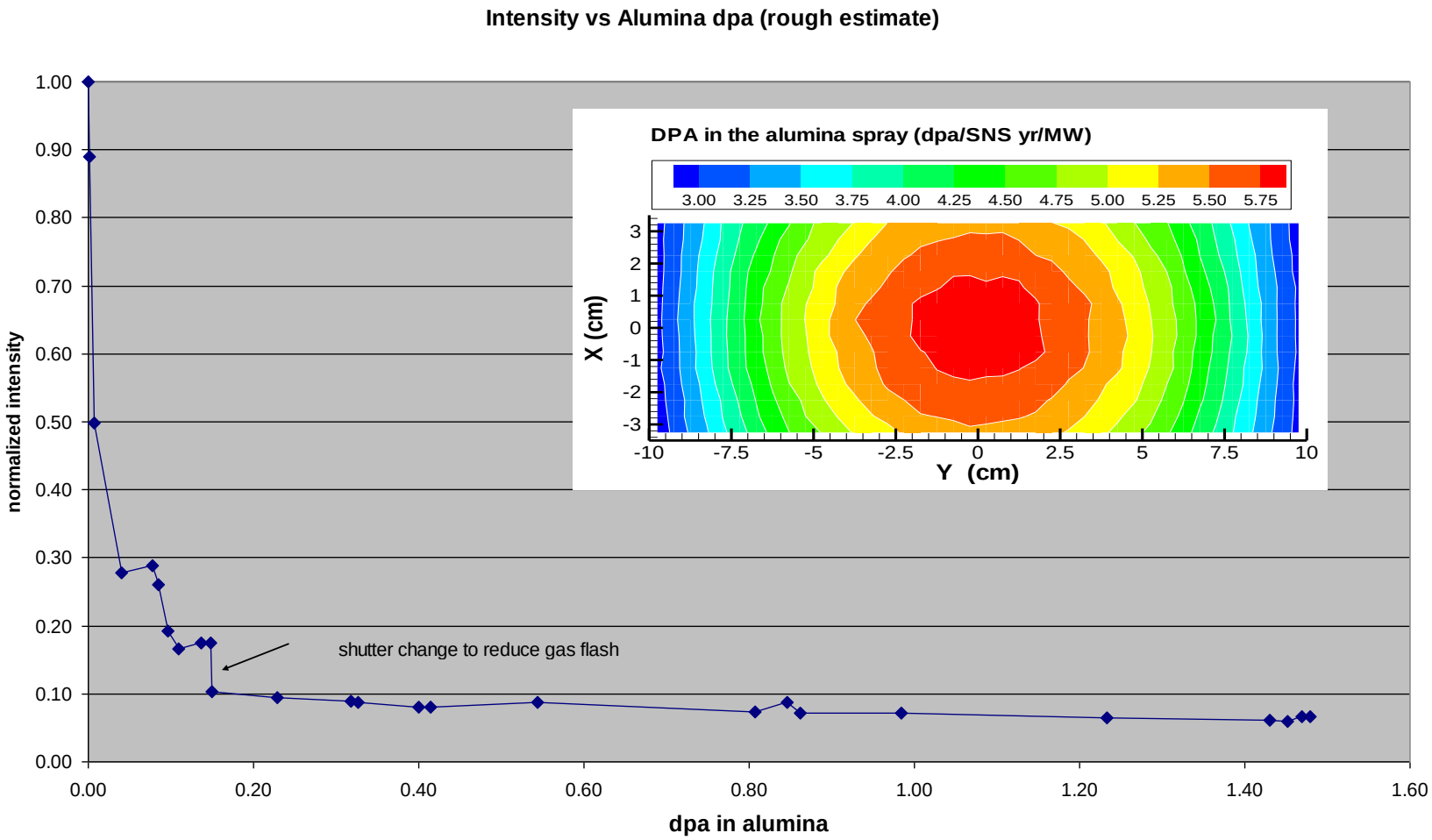


Typical spectrum showing ~ 690 nm ruby line and also many Helium, Oxygen and other lines

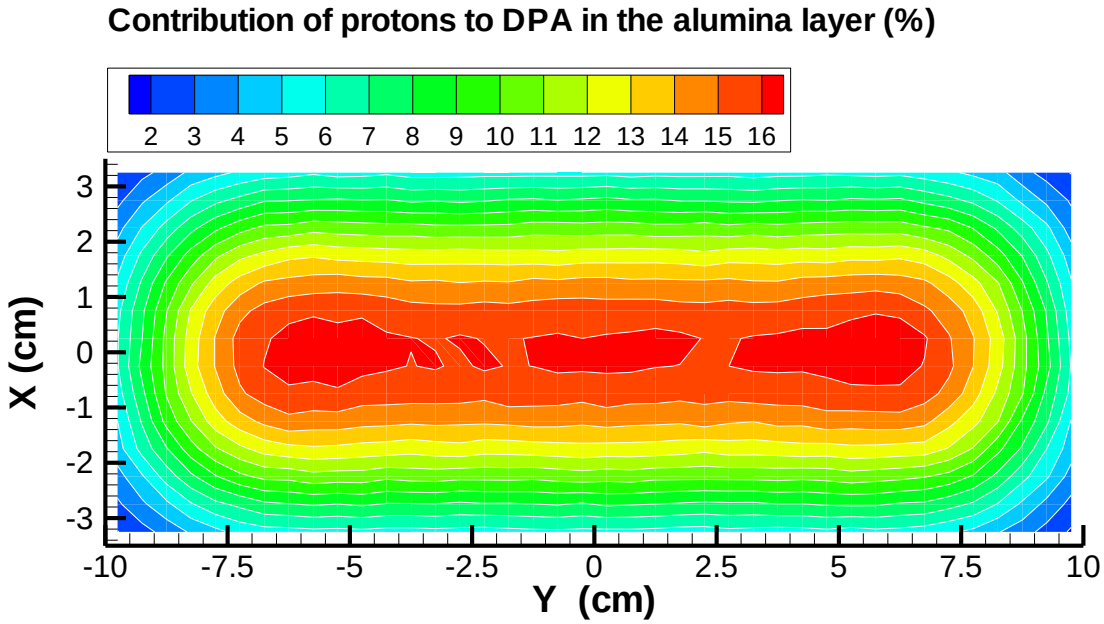


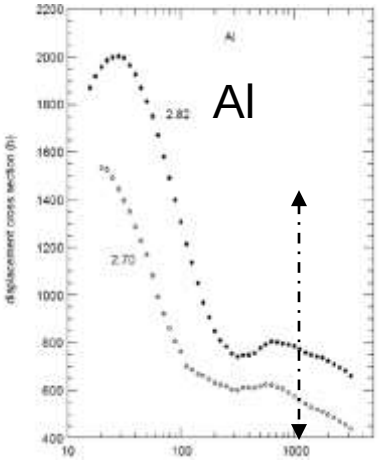
Color image showing more blue in the lower right region from helium

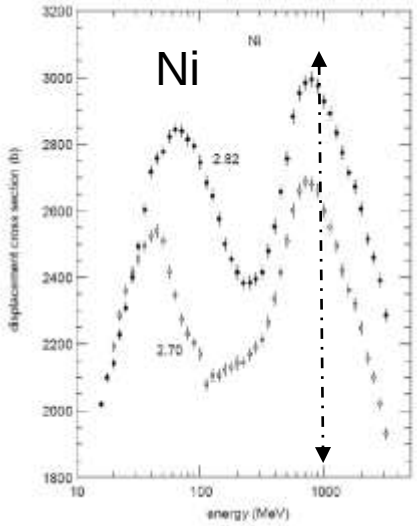
Normalized Intensity vs dpa



Small Proton Contribution to DPA in Alumina

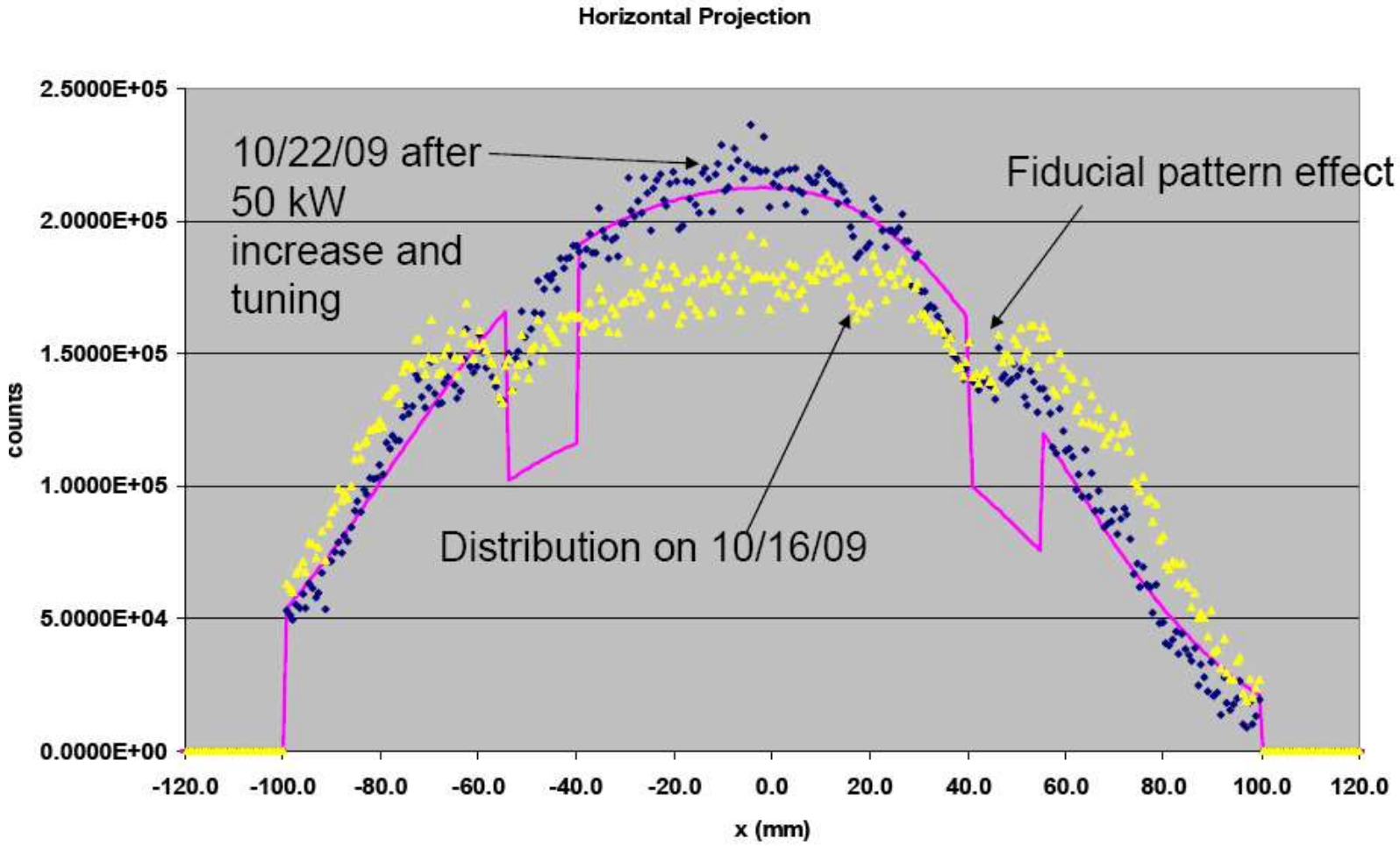






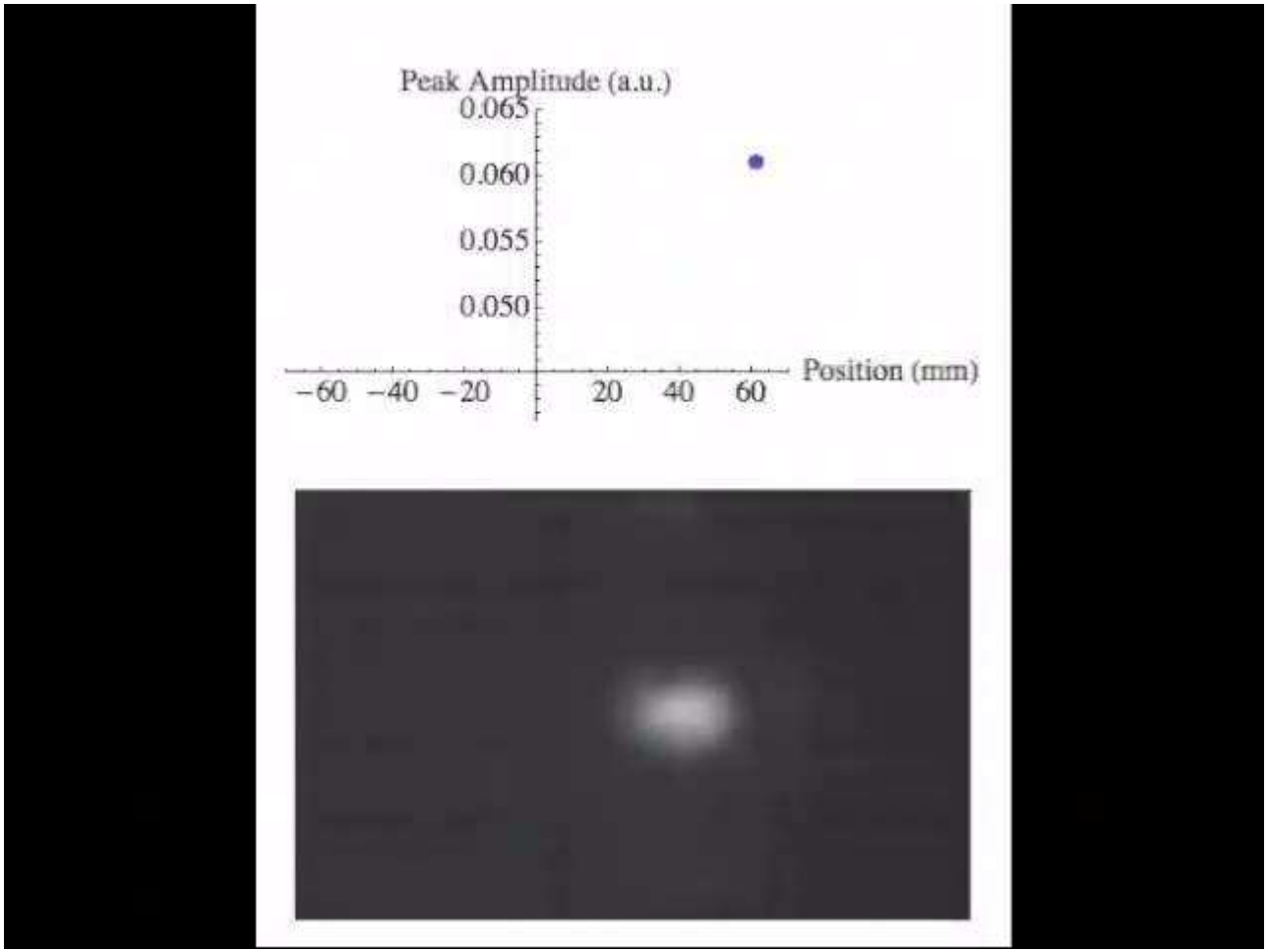
Contribution is low because the cross section for damage in Al is low at 1 GeV and the neutron flux is approximately 3 times the proton flux

Operational Example

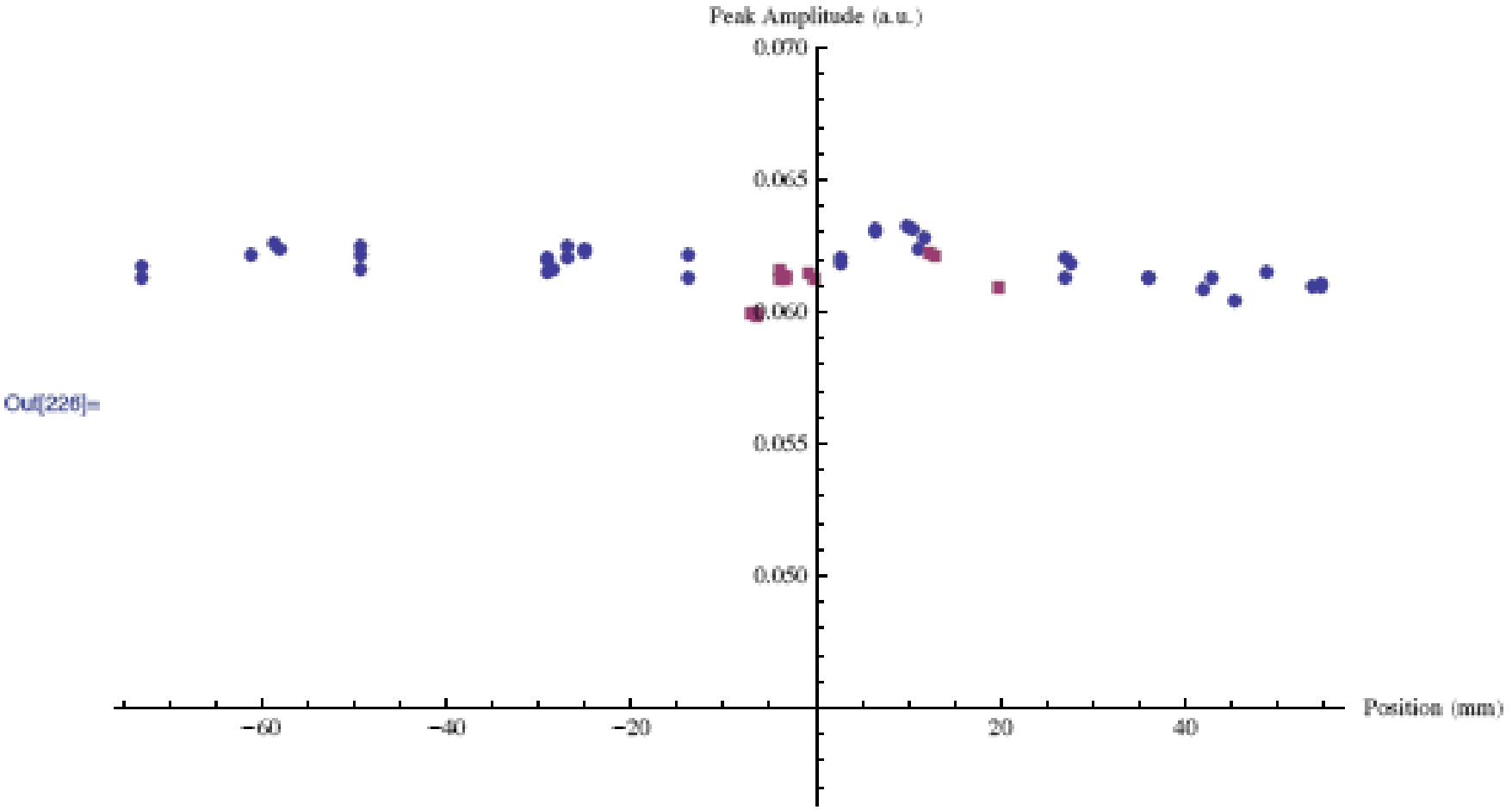


20% increase in peaking easily detected on TIS but operators were not aware because harp was not updating - corrected later

Uniformity Scan with Small Beam



Uniformity scan results

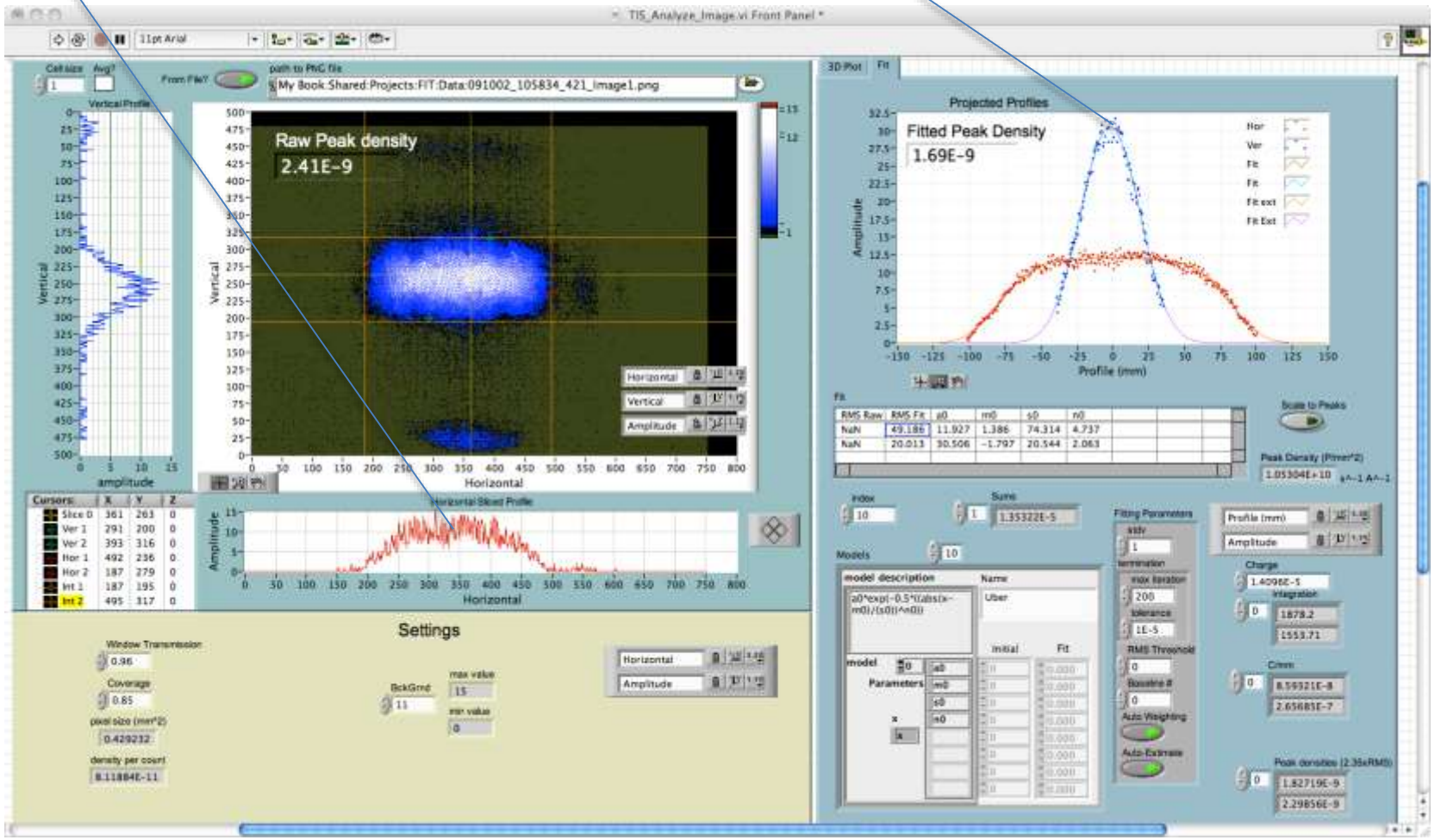


- A small beam spot was moved across the approximate horizontal and vertical center lines and the relative peak intensity measured
- Horizontal variations were ~ +/-5% and the vertical ~ +/- 8%

Comparison of profiles: Possible correction for optical fiber pattern - W. Blokland

Note up and down from optical fiber

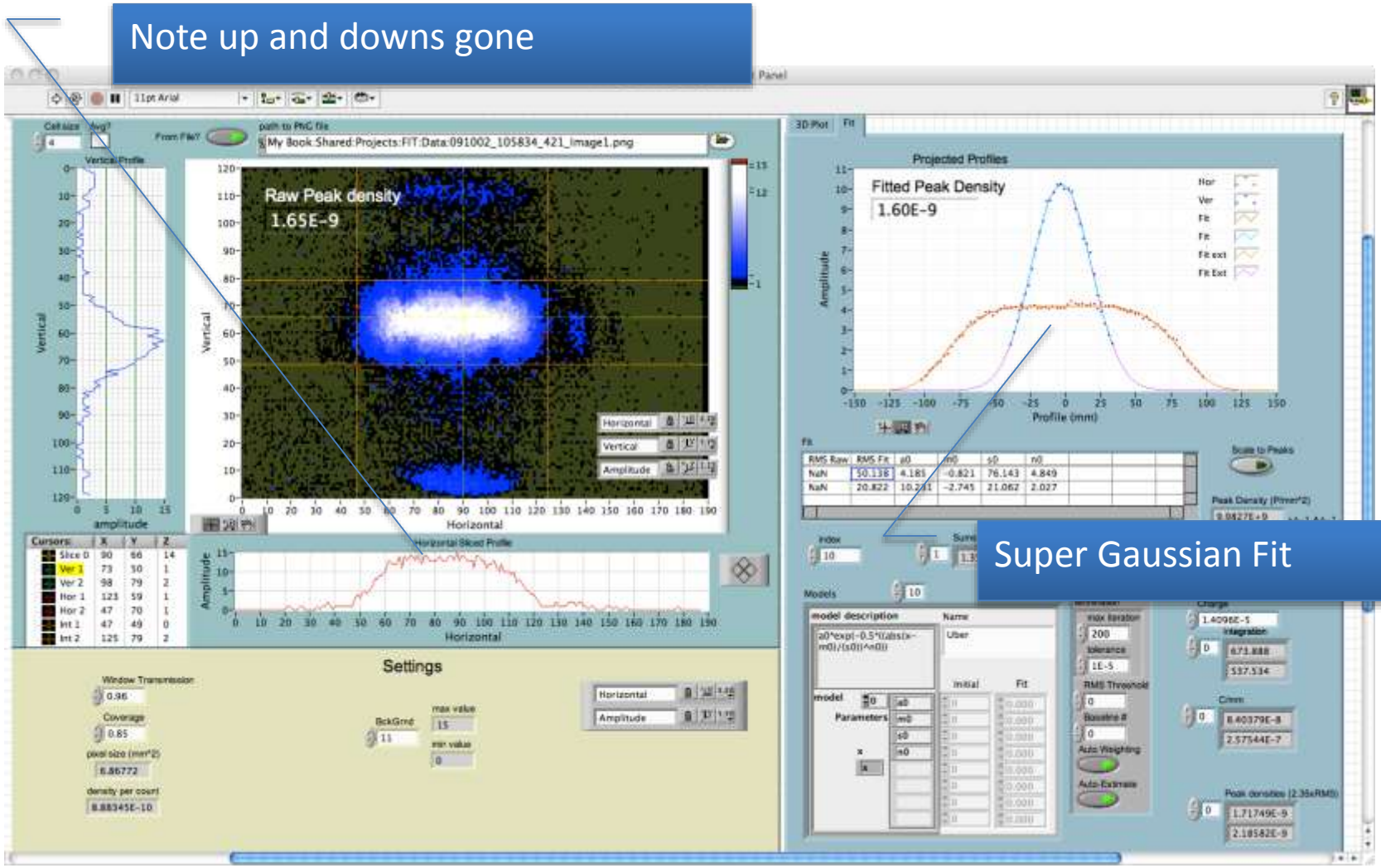
Even the projections show this



Original Data

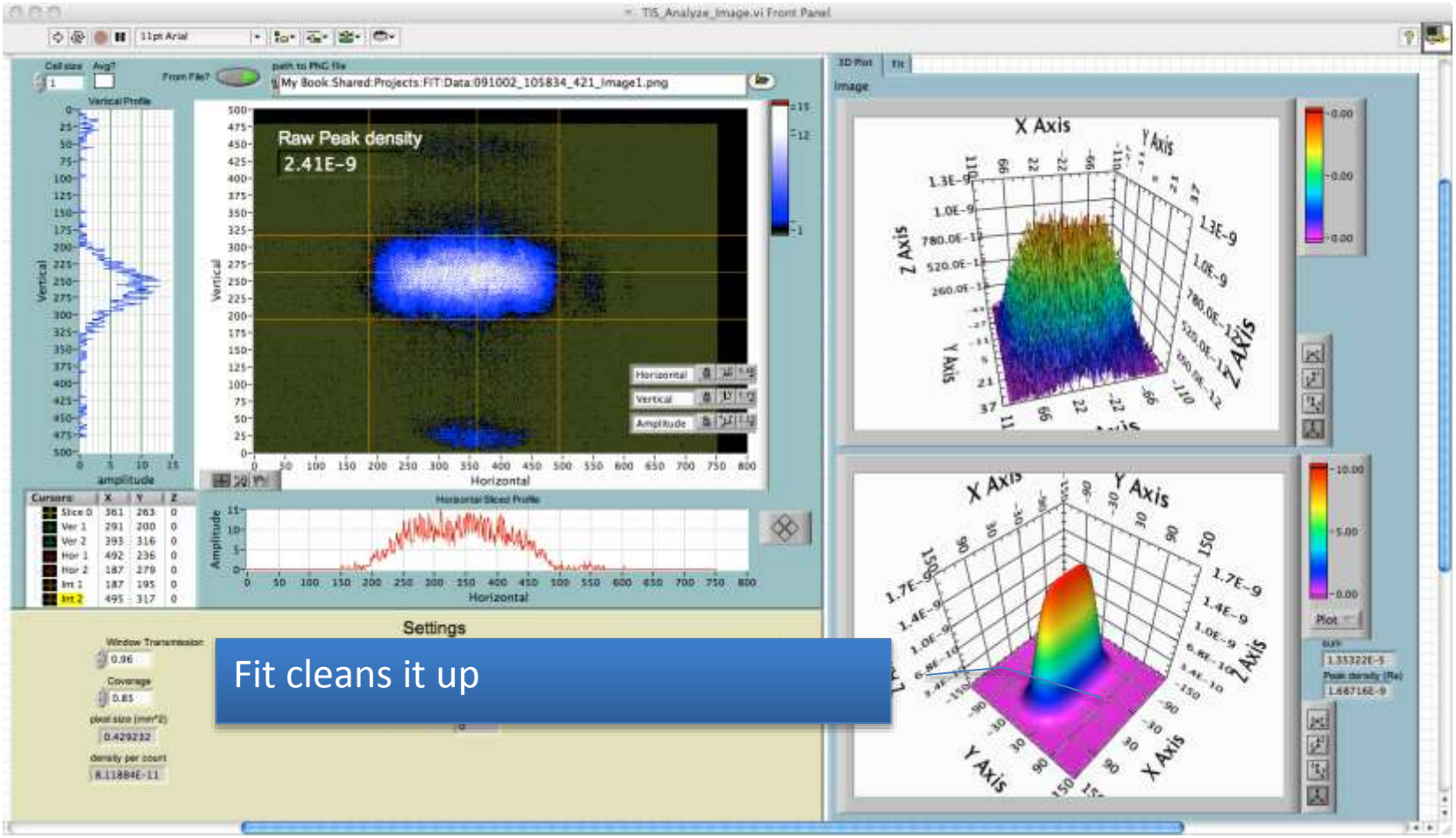
Fiber pattern reduces total light -> higher peak density

Processed with 4x4 cell



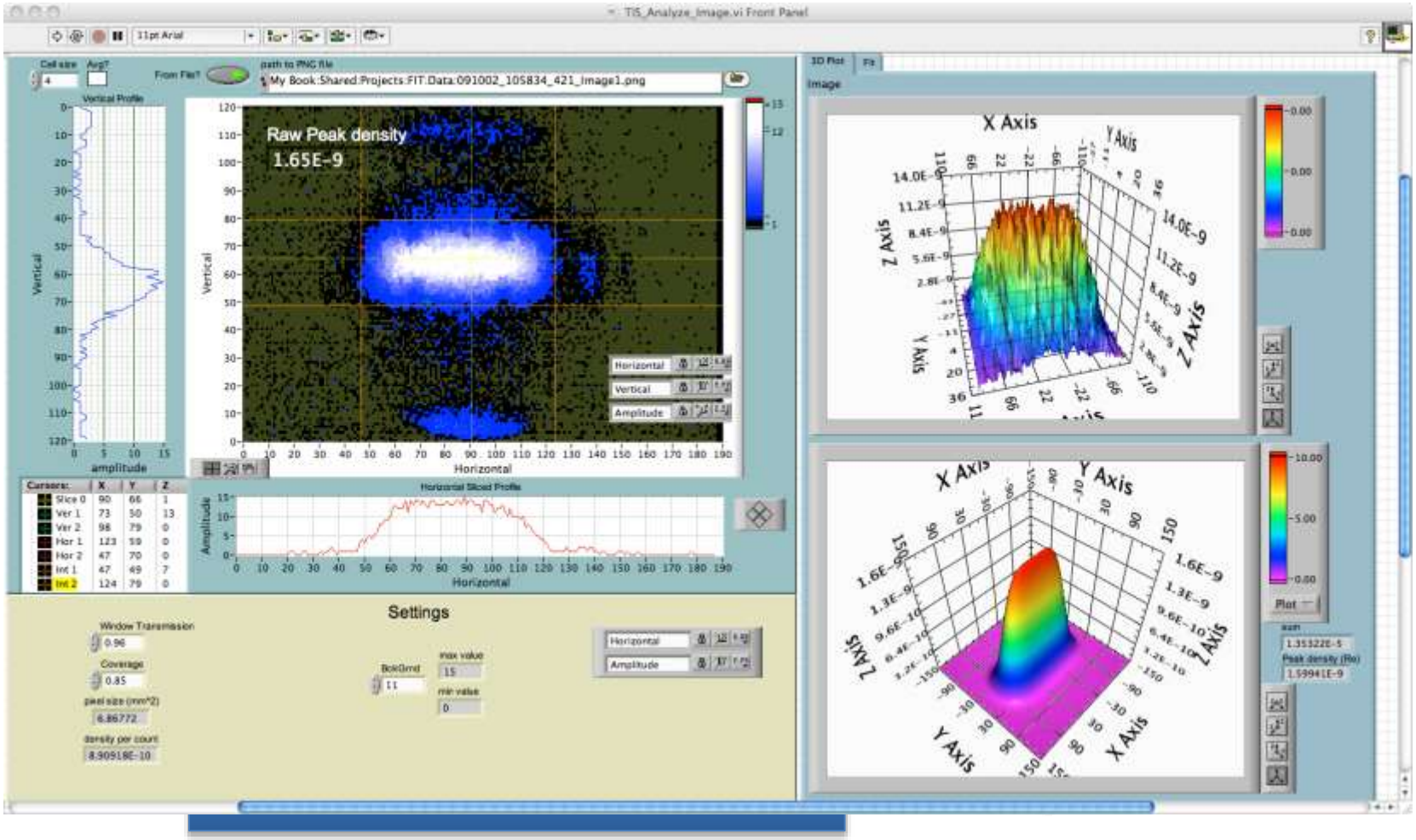
Reduce the image by using a 4x4 cell : Raw Peak density correct and fit peak density went down slightly

3D image before cell processing



Correction for increased background: important as the fit assumes zero background

3D image after cell processing



- Cell processing cleans up raw image but 3D reconstruction cleaner (of course)
- **The fitted results don't change much depending on the cell processing**
- **Cell Processing gives a quick and dirty Peak density without requiring fiber pattern calibration (calibration can be more accurate)**

Next Proton Beam Window and Targets

- Coating
  - SUNY to improve coating process
  - Same luminescent material
- Optics
  - Incremental improvements to resolution and contrast
    - 1.4 mm, 20,000 fiber vs. 1.0 mm 10,000
    - Aspherical optics in lens assembly to reduce 3rd and 5th order spherical aberration in first design
    - Narrower field of view since pointing accuracy is good
  - Minor mechanical revisions
  - Additional tube for material irradiation tests and dose monitoring
- Second PBW shield plug 25 mm diameter penetration in opposite corner
  - Potential use with a mercury diagnostic target R&D
  - Potential TIS use for a light and on-line spectrometer

R&D

- Time-gated imaging spectroscopy
  - DLP for spatial modulation
- Analyze time-resolved images
  - Large reduction in decay time observed (~ 2ms to 26 μs)
  - Attempt to correlate decay time constant with temperature and sensitivity(?)
- High resolution spectroscopy to investigate changes in material along with temperature and stress
- Investigate alternate luminescent materials
- Further improvements to fiber and optics
- Radiation damage studies
  - Investigate HFIR irradiation testing
- Coating process and investigation of surface annealing
- Complete the deferred beam studies (LANL or elsewhere)
- Other applications (RID, PBW?)

Summary

- Target Imaging System is performing well despite an initial loss of intensity
- Further calibration and comparison with the RTBT Wizard projections are needed as part of the process of turning it over to Operations
- Upgrades for the next generation are being incorporated
- R&D activities to understand radiation damage and develop improvements have been identified