



Mirror Characterization

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 **Jefferson Lab**

What we measure

- Dimensions
- Optical Properties
 - D0
 - Reflectivity
 - (Wavefront aberration with Shack-Hartmann)
- Material properties
 - Roughness
 - ..

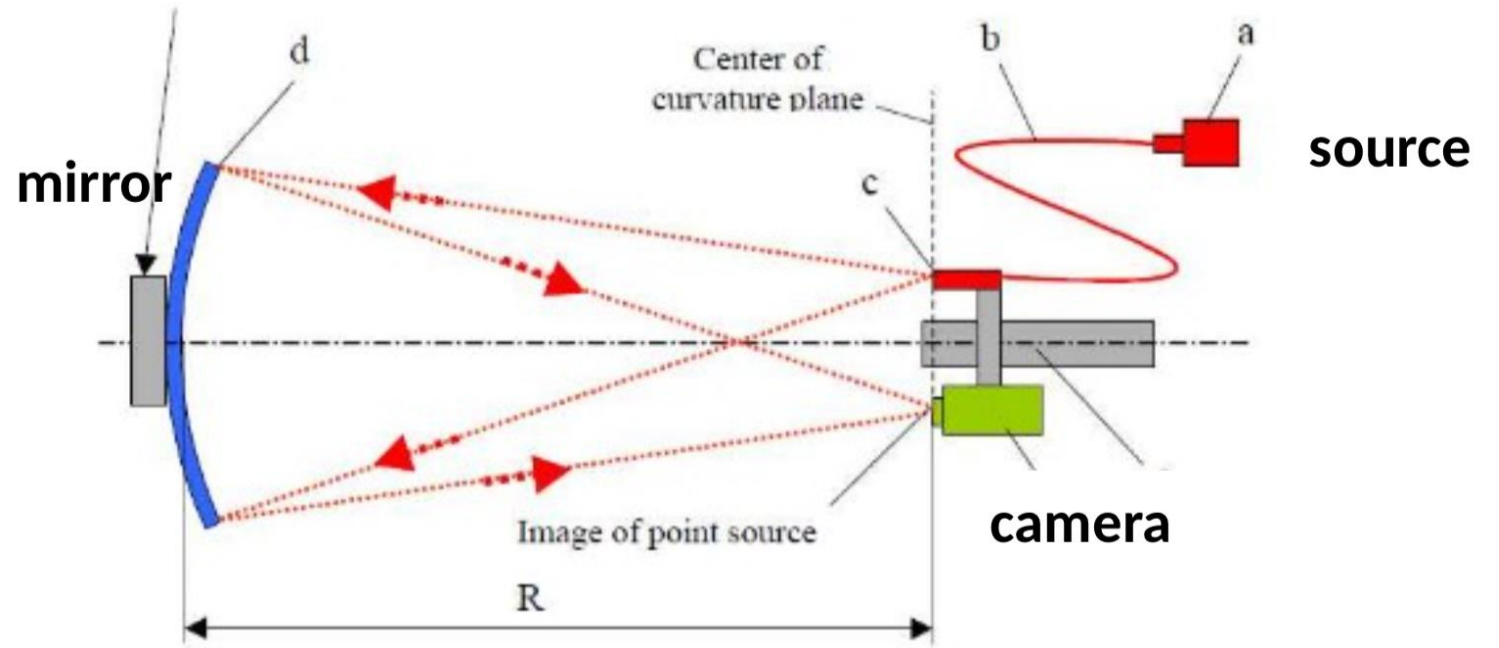
Facilities/Procedures

- JLab
 - Cleanroom with optical tables, 'clean storage'
 - INFN owned D0 and Shack-Hartmann test (not used yet)
 - Custom Reflectivity test → still needs work
- Duke
 - 'regular' lab space (collaborate with SoLID effort)
 - Off the shelf reflectivity test
 - SMIF materials facility with a variety of instruments (Cleanroom, Electron Microscopes, MicroCTs, X-Ray Characterization, optical spectroscopy, AFM, MassSpec...)
 - Trained on
 - Atomic Force Microscope for surface characterization
 - UV-Vis Spectrophotometer with integrating sphere
 - Potential interest in
 - VK-X3050 3D Optical/Laser Confocal Profiler
 - Nanometrics 210 Film Thickness Measurement
- Tentative plans to transfer D0 and Shack—Hartmann test for training
- Open question: Actually transfer mirrors to Duke (questions about safe storage, transfer etc..) or just training
- Workforce at Duke: 2 1st year/1 senior grad student, undergraduate students (summer)

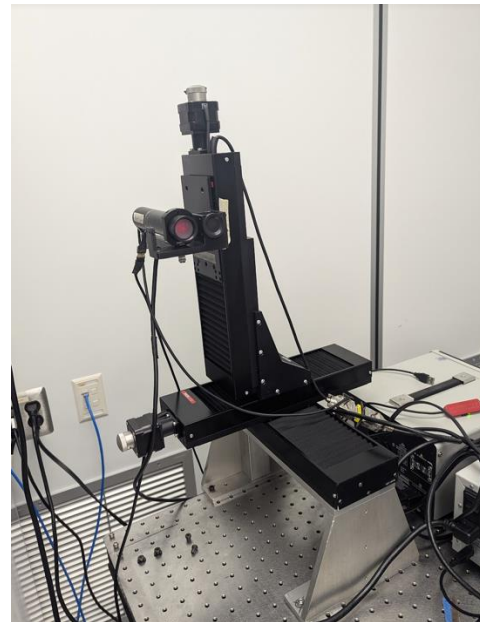


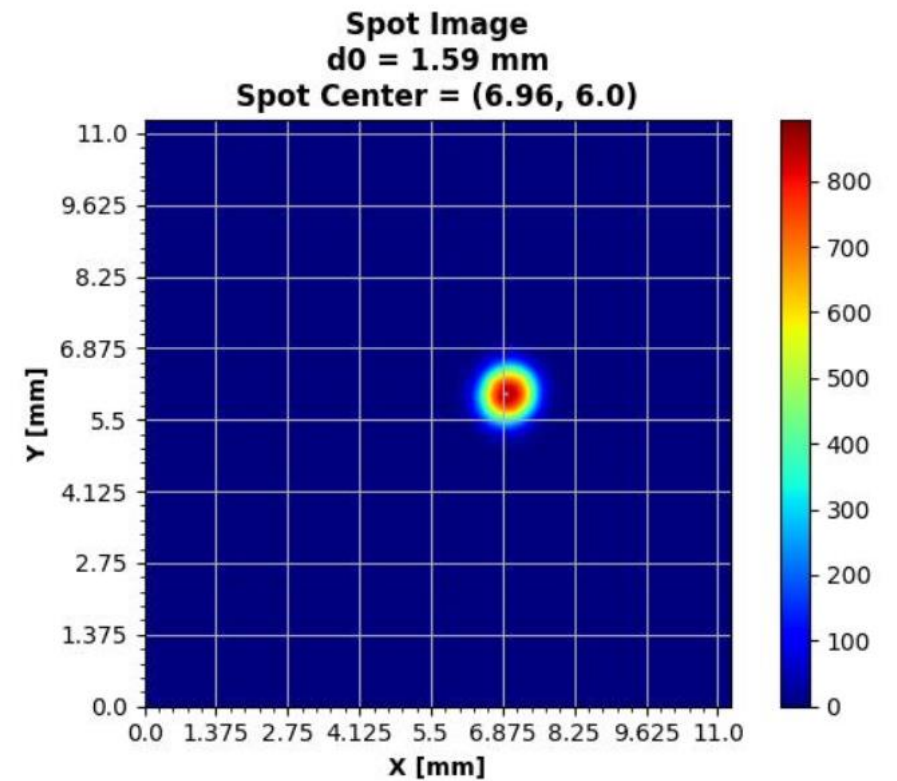
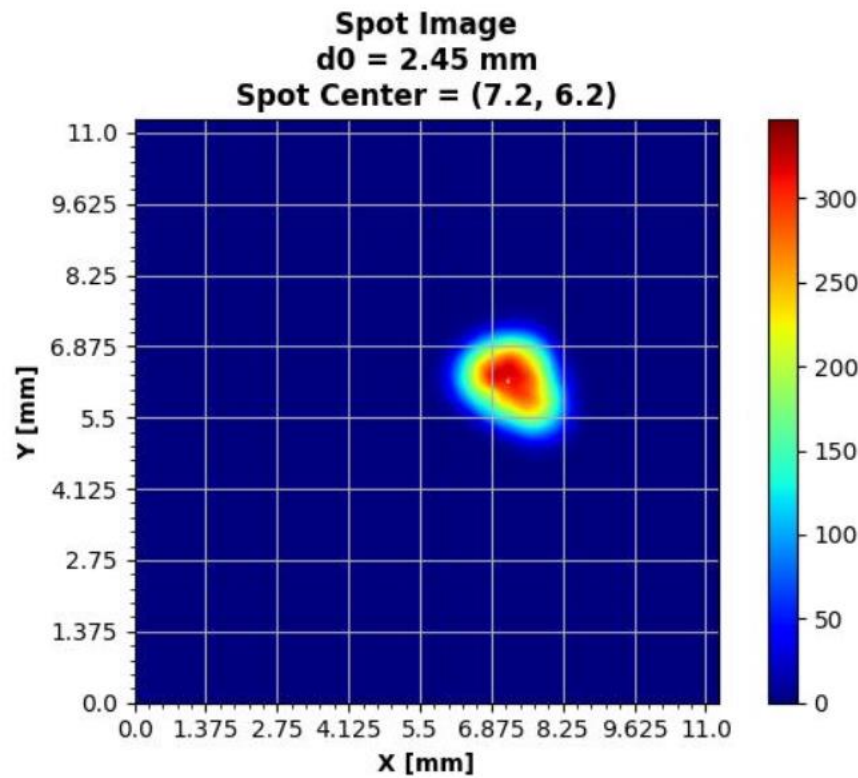
D0 Test

- INFN Setup used for the CLAS mirrors
- $D_0 < 2.5\text{mm}$
→ typically $< 1.5\text{ mm}$

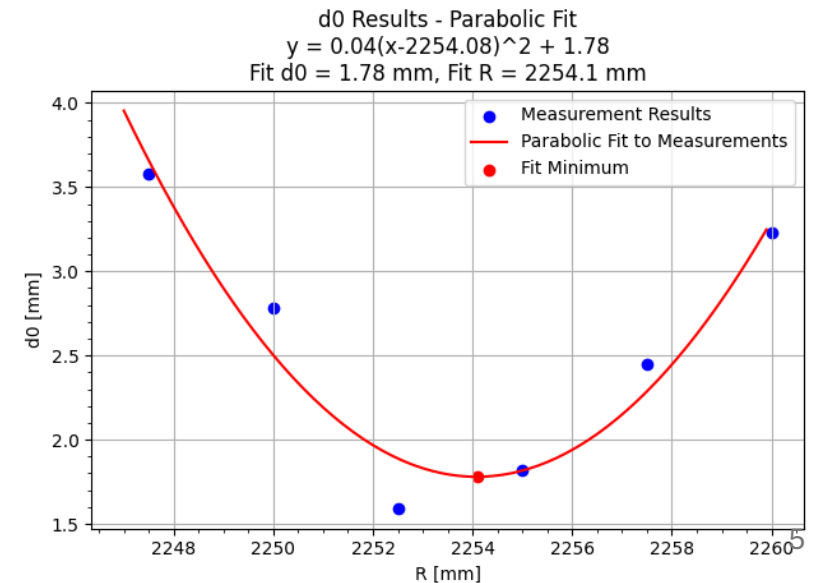


Will need adaption for final mirrors
(currently temporary contraption)





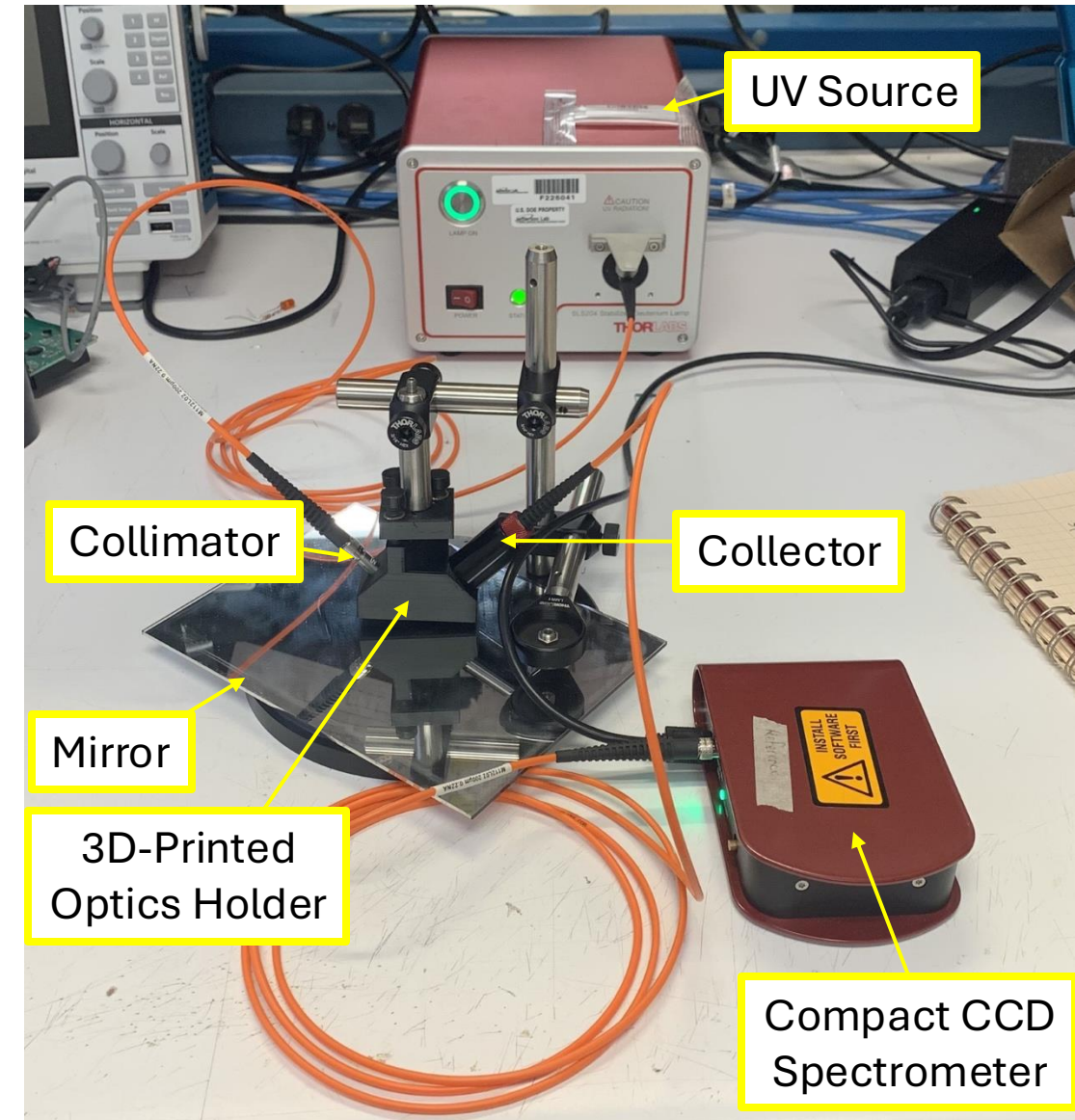
- Spot in Center looks circular
 - No obvious deformations
 - D0 within specifications, consistent with what was achieved at CLAS (1.5mm)
 - Radius according to specs: 2200 mm
 $\rightarrow \text{outside } \frac{R}{\Delta R} = 1\%$



Reflectivity Setup at JLab

- Response not yet understood
→ needs further investigation

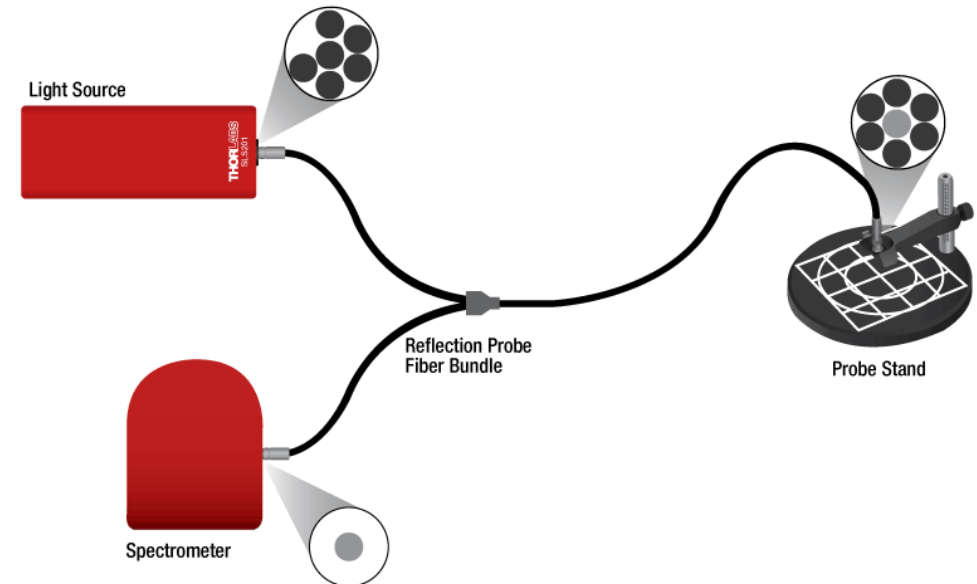
Currently very preliminary, not usable for final mirrors



Tyler Lemon

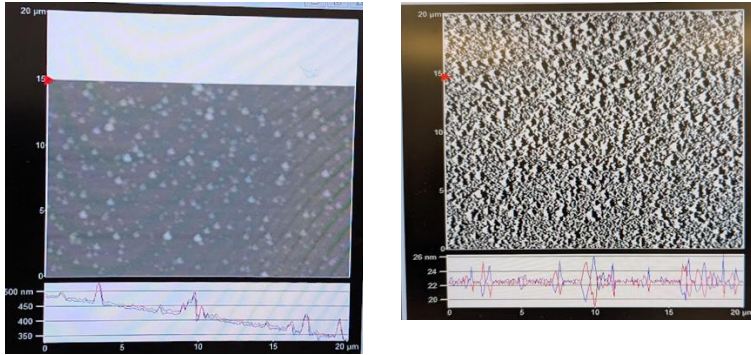
Reflectivity test at Duke

- Same lamp (deuterium) and spectrometer as JLab
- Off-the shelf reflectivity probe with reference leg (not shown here)
 - Rated to 250nm
→ solarized custom probe available but expensive
- Would need setup for final curved mirror



AMF at SMIF

- Sub nm resolution possible



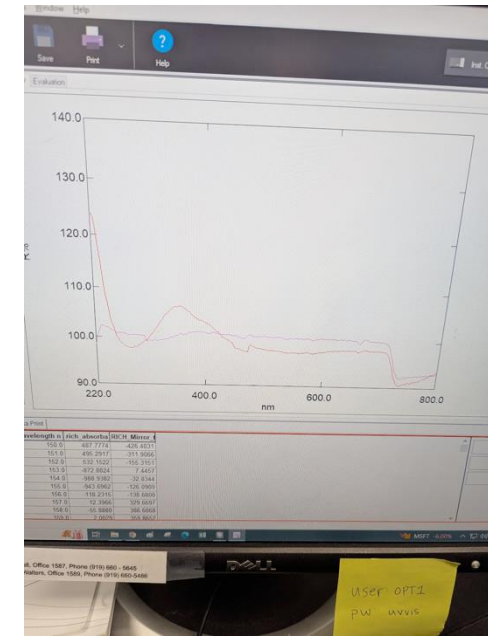
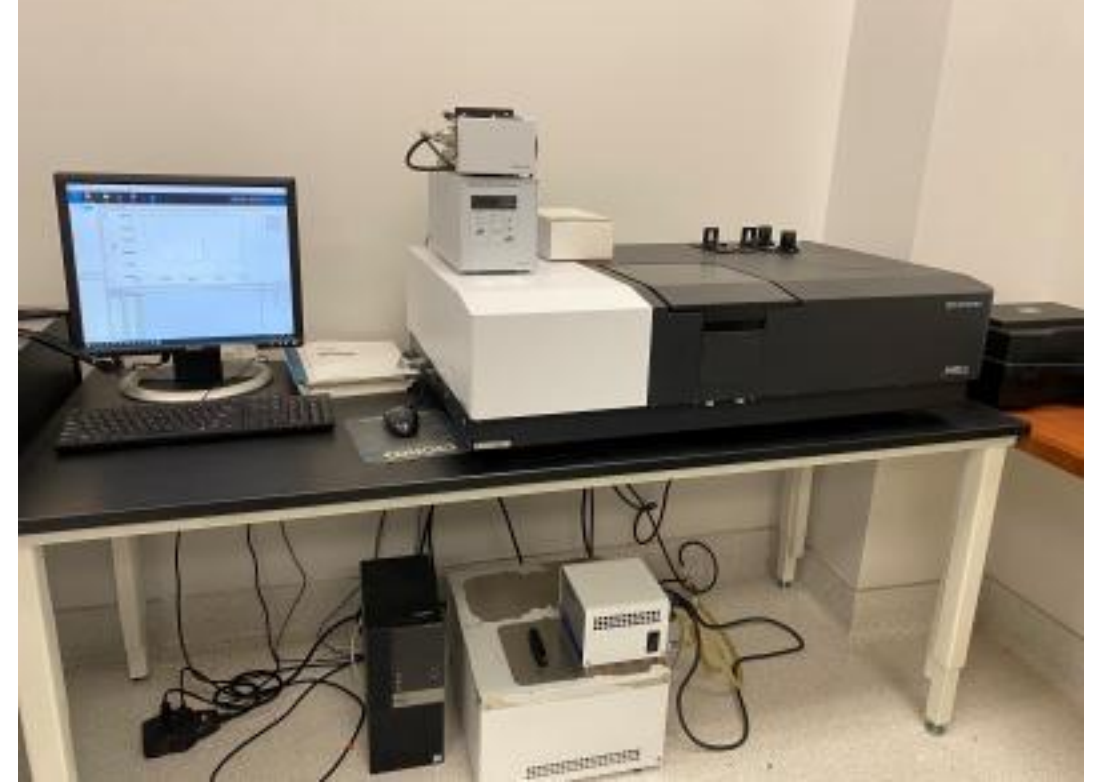
Screenshot of Atomic Force Microscope images of reflective surface coated at SBU showing roughness of $< 100 \text{ nm}$



Asylum Research Jupiter XR AFM

Spectrophotometer at SMIF

- Shimadzu UV-3600i with Integrating Sphere
- Can go down to ~ 200 nm
- Baseline flatness
 - 8% for $200\text{nm} < \lambda < 300\text{nm}$
 - 3% for $\lambda > 300\text{nm}$
- Need better reference mirror
- Could do transmission tests
- Integrating sphere uses BaSO₄, barium sulfate as reference (have not tried that yet)
nominally $> 98\%$ reflectivity for $\lambda > 250\text{nm}$



Next steps

- Survey of test mirror at JLab
 - Actually set up reflectivity test at Duke
 - Get experience...
 - Develop mirror QA procedures and ready setup for routine use
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- Transfer D0 and Shack Hartmann to train students?