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Monte Carlo Verification and Modeling of Lead-Bismuth Spallation Targets

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D-10

Nuclear Systems and Design

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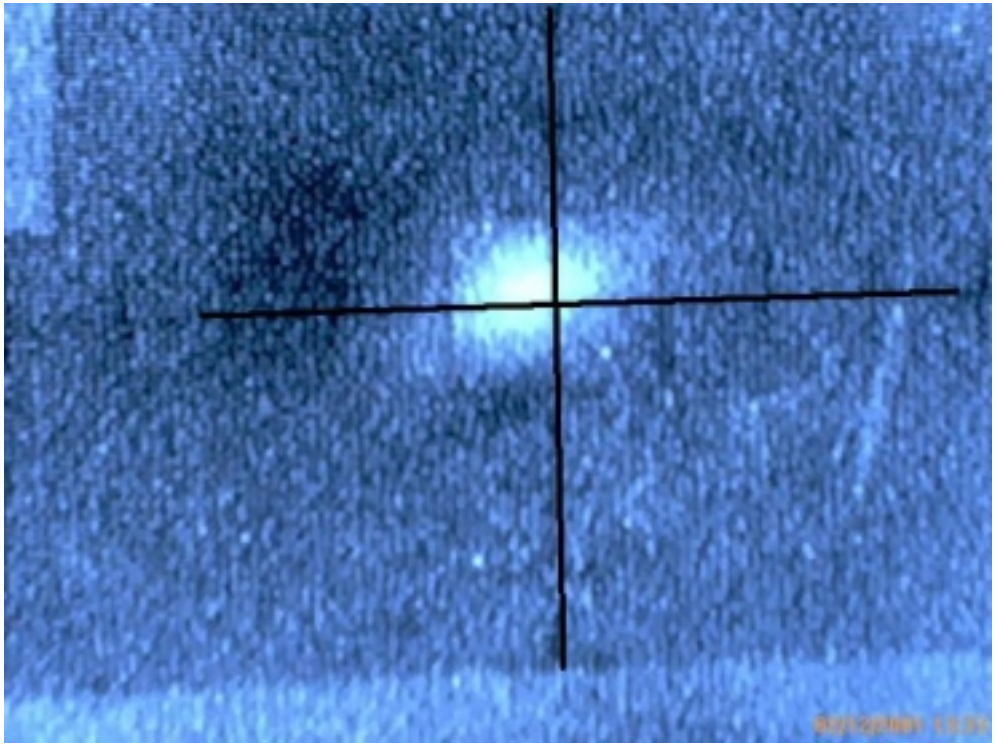
Modeling Data from 20 cm Target

- **Determine how much the beam was offset with the analyzed data from the December run.**

Beam Profile on 20 cm Target



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Total Neutron Flux Asymmetries Due to Beam Offset (Top and Bottom)

	Upper Max	Upper Min	Lower Max	Lower Min	Min % Difference	Max % Difference	Ave % Difference
Raw Data							**7.30%**
1 cm beam at origin	1.58296	1.57224	1.68371	1.67229	-5.40%	-6.80%	**-6.10%**
1 cm beam 2.0 mm up	8.20805	8.12313	7.83167	7.73515	3.70%	5.90%	**4.80%**
1 cm beam 2.5 mm up	8.21477	8.16058	7.68879	7.62897	5.95%	7.39%	**6.67%**
Guassian Beam 2.5 mm							
1 cm beam 3.0 mm up	8.33702	8.15812	7.57553	7.41959	7.40%	11.60%	**9.50%**
1 cm beam 3.5 mm up	8.37163	8.2635	7.60869	7.50441	8.25%	10.90%	**9.60%**

Total Neutron Flux Asymmetries Due to Beam Offset (Left and Right)

	Left Max	Left Min	Right Max	Right Min	Min % Difference	Max % Difference	Ave % Difference
Raw Data							**3.94%**
1 cm beam at origin	1.62059	1.60961	1.62059	1.60961	-0.67%	0.67%	**0%**
1 cm beam 1 mm left	8.09064	7.98614	7.89557	7.78891	1.10%	3.80%	**2.45%**
1 cm beam 1.5 mm left	8.14051	8.06113	7.83113	7.74081	2.50%	5.03%	**3.80%**
Gaussian beam 1.5 mm							
1 cm beam 2 mm left	8.25226	8.10825	7.73612	7.60724	4.70%	8.10%	**6.40%**

MCNPX Results on Beam Offset

- **Models with cylindrical beam profile show that the beam was approximately 2.5 mm high and 1.5 mm to the left. This looks consistent with the beam pictures.**

- **Models with Gaussian beam profile have yet to be run. Effects should be small though.**

Modeling Data from 20 cm Target

- **Models of other effects including**
  - **Humidity**
  - **Beam Shape**
  - **Table Parts and Materials**
  - **Proximity of room objects**
  - **Room Effects (dealing with the thermal reflection)**

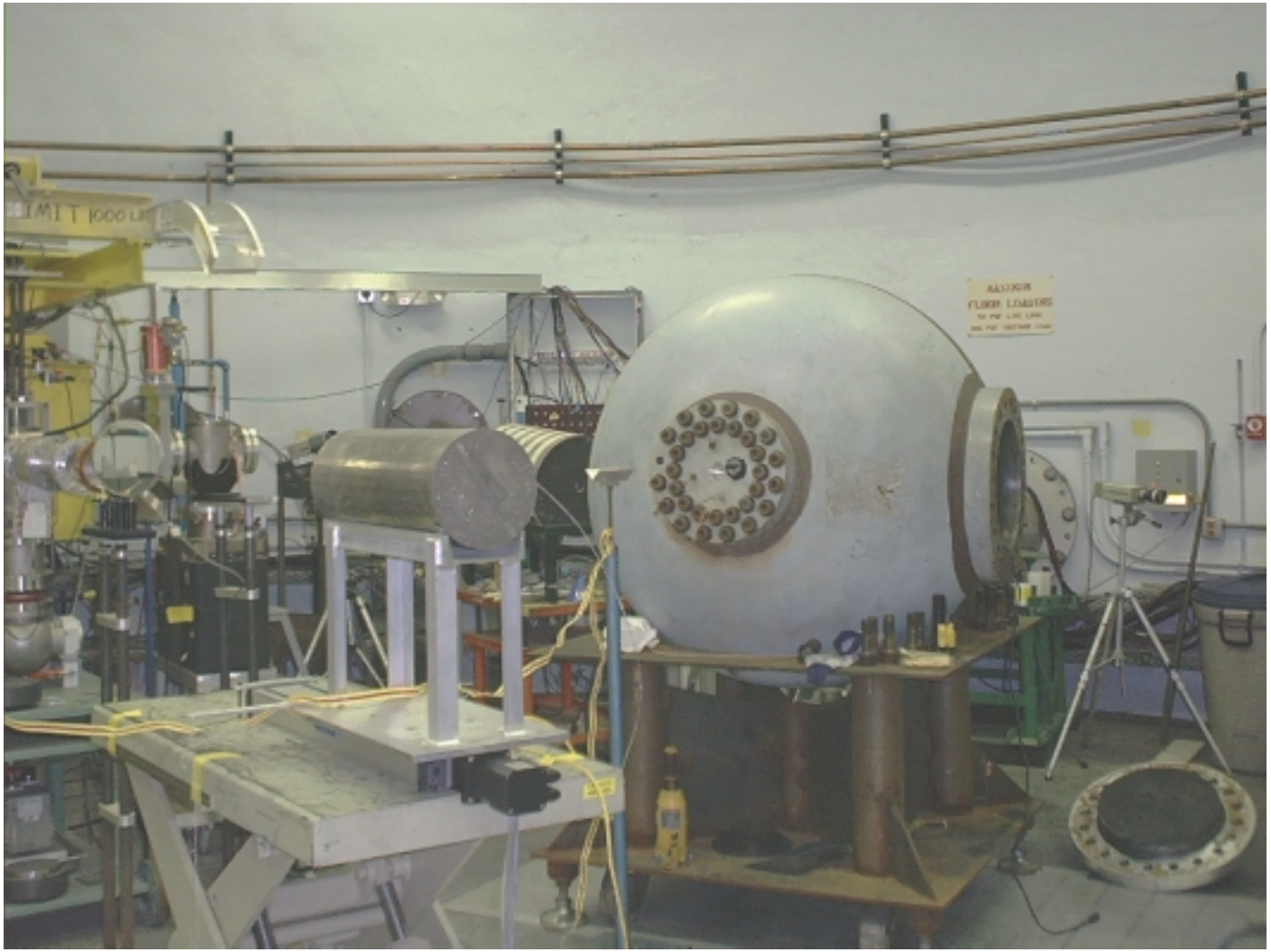
Results from MCNPX Analysis

- **Humidity**
  - **Little to no effect can be seen even when 100 percent relative humidity is modeled.**
  - **Effects are less than .1%**
  - **Actual relative humidity in Blue Room ~ 30 to 50 %**
- **Beam Shape**
  - **Cylindrical beam shapes were used for initial runs. Gaussian beam shapes are now being looked at.**
  - **Initial run indicates less than 1 percent difference between two beam shapes when beam is in the middle.**
  - **Effects of an offset gaussian beam still needs to be looked at.**

Results from MCNPX Analysis

- **Table Parts/Materials**
  - **Aluminum a better choice over steel.**
  - **Proximity of metals a larger factor than material itself. When plates of metal approach 5 cm of the target, noticeable effects can be seen.**
  - **New target stand (for 40 cm target) is better adapted to handle these concerns.**
- **Room Objects**
  - **Ceiling and walls provide for thermal neutron reflection, hence thermal capture.**
  - **Explosion sphere provides a 0.03% difference in asymmetries in neutron flux on the target.**

Explosion Chamber



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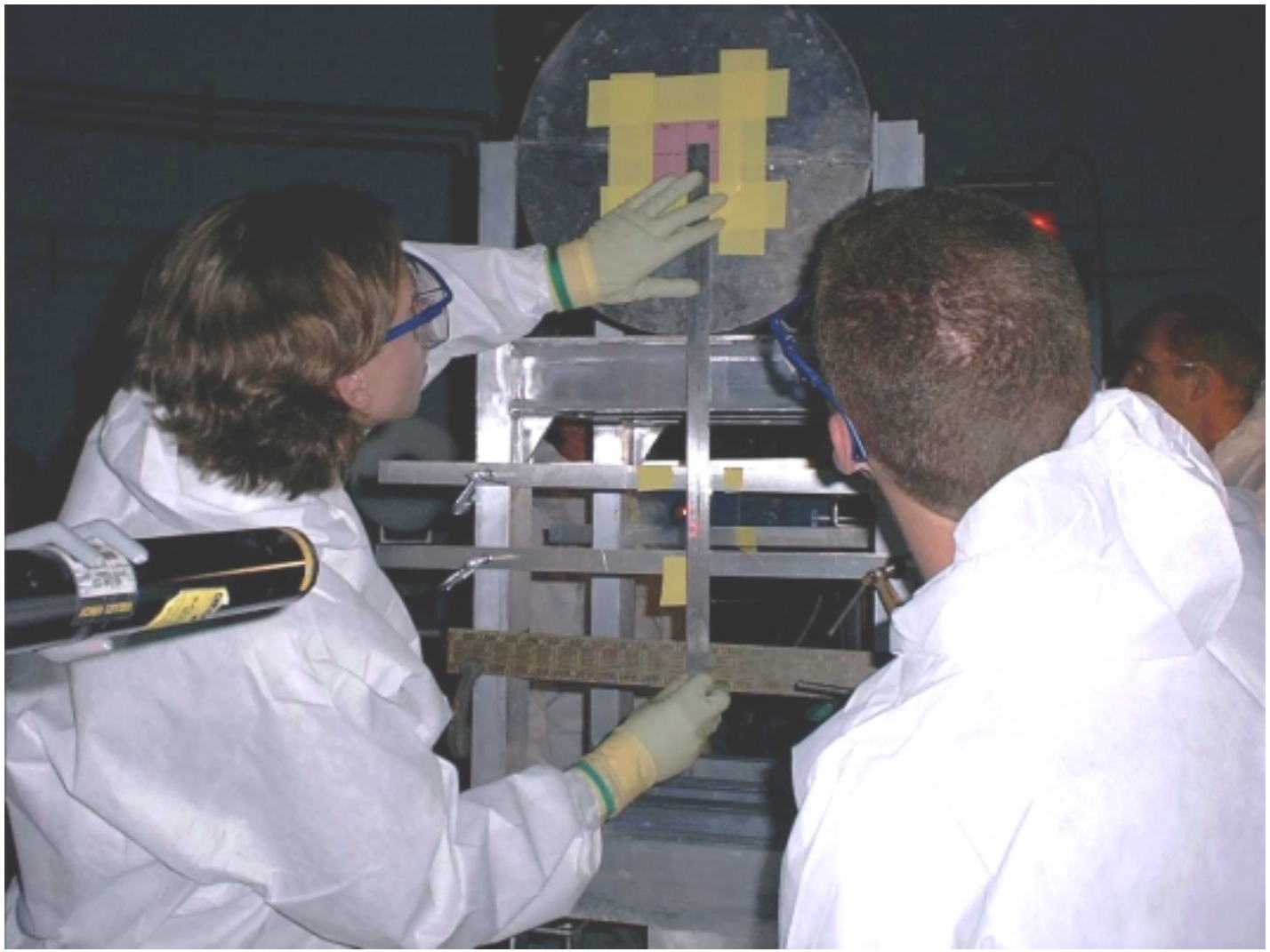
New Procedures for Beam Alignment

- **With the results from the July experiment showing that beam offset contributes the most to target asymmetries, we devised a better plan for beam alignment.**

  1. **Place 3 pieces radio-chromic film in the beam line. One at the beam tube, one in the front of the target, and one in the back of the target.**
  2. **Irradiate the film for 30 seconds at 20-30 nA.**
  3. **Place double ended laser on film spot on beam tube and front face of target, and single laser on the back end**
  4. **Lower/Raise the target into position according to the laser placement.**

Radio-Chromic Film Placement



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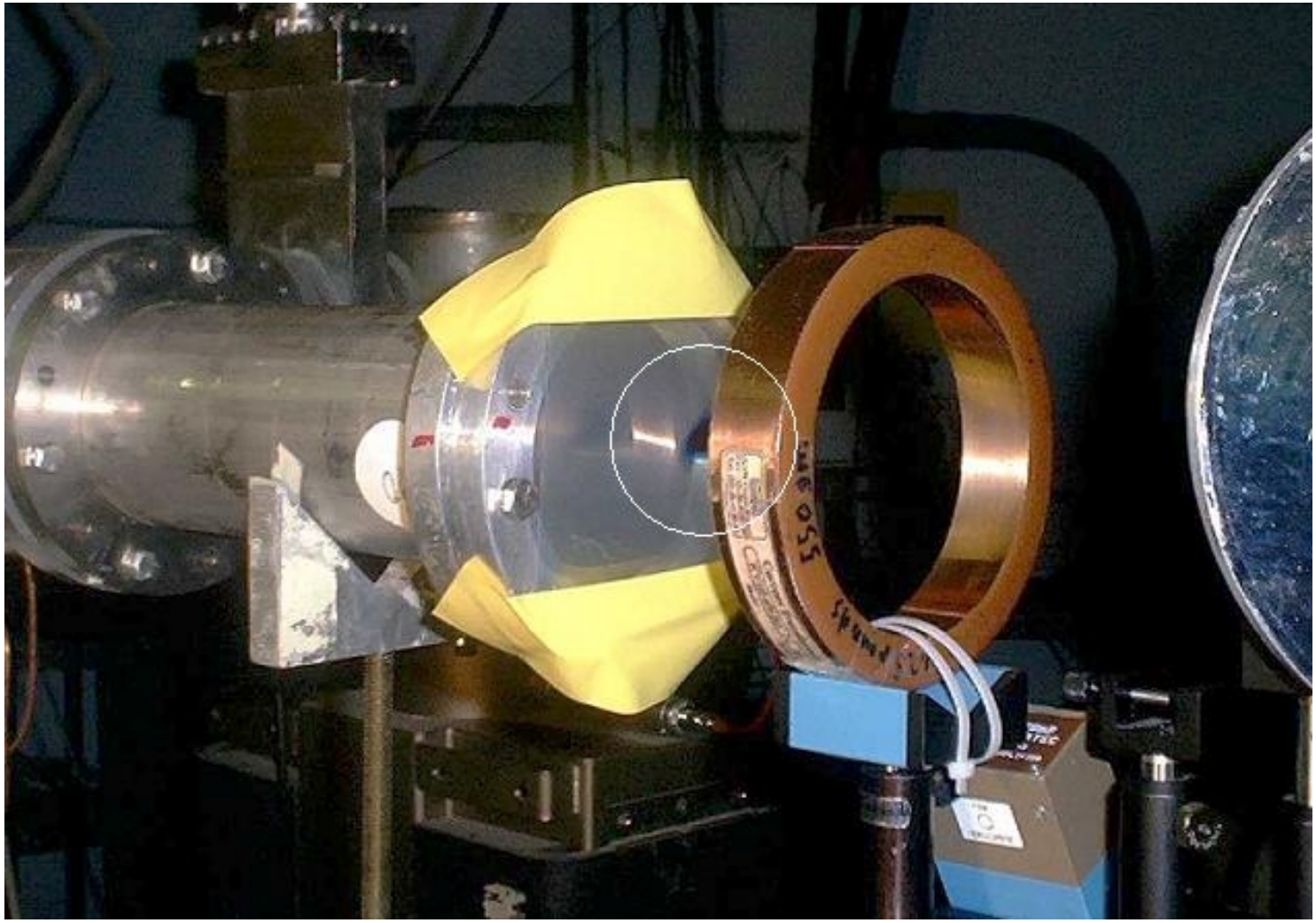
Post Irradiation Radio-Chromic Film



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Target Placement by Laser Guidance

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Picture of 20 cm Target Alignment

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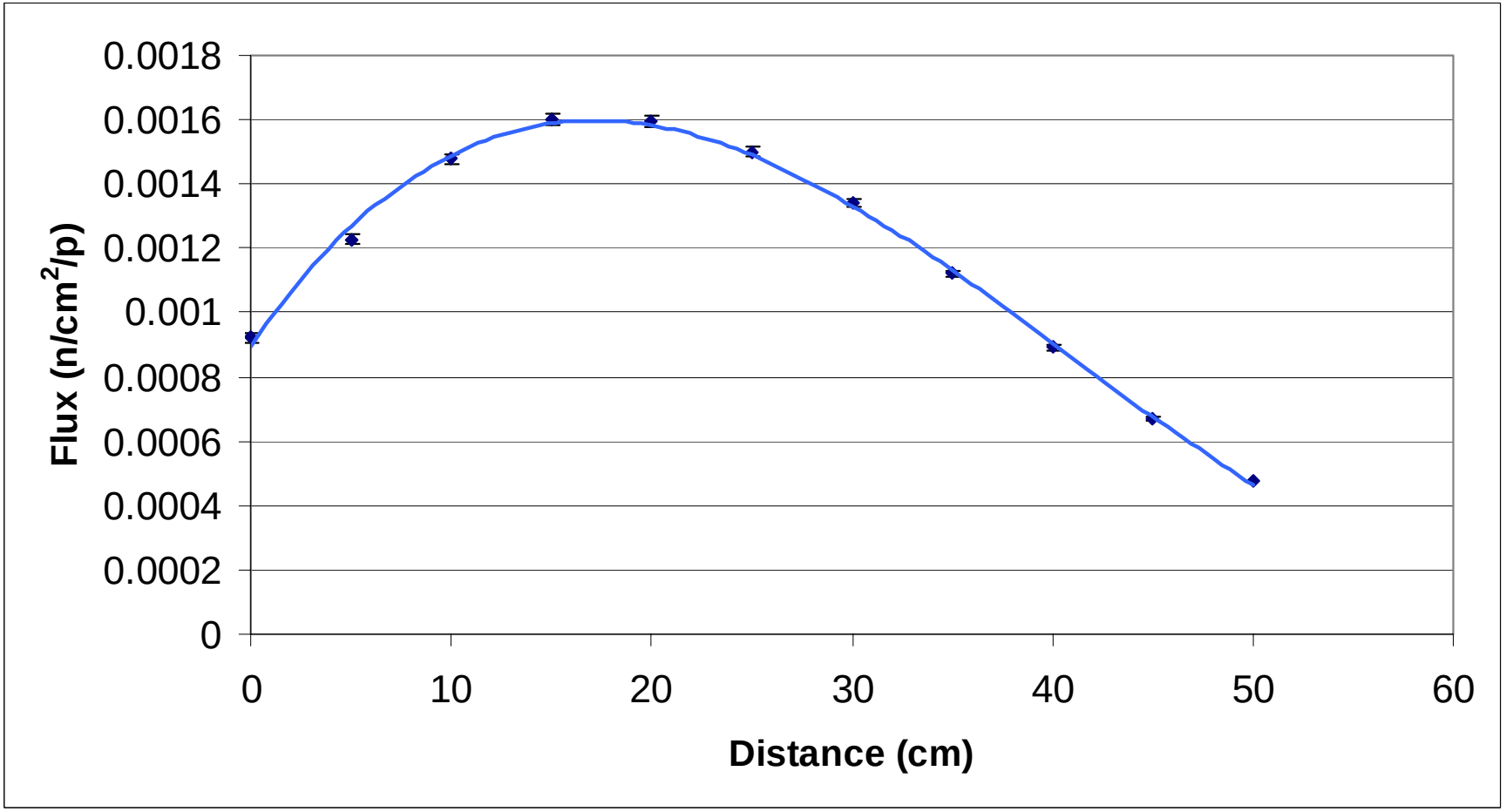
40 cm Target Goals with MCNPX

- **Determine the location of the maximum total flux as a function of axial position**

Total Neutron Flux vs. Axial Distance



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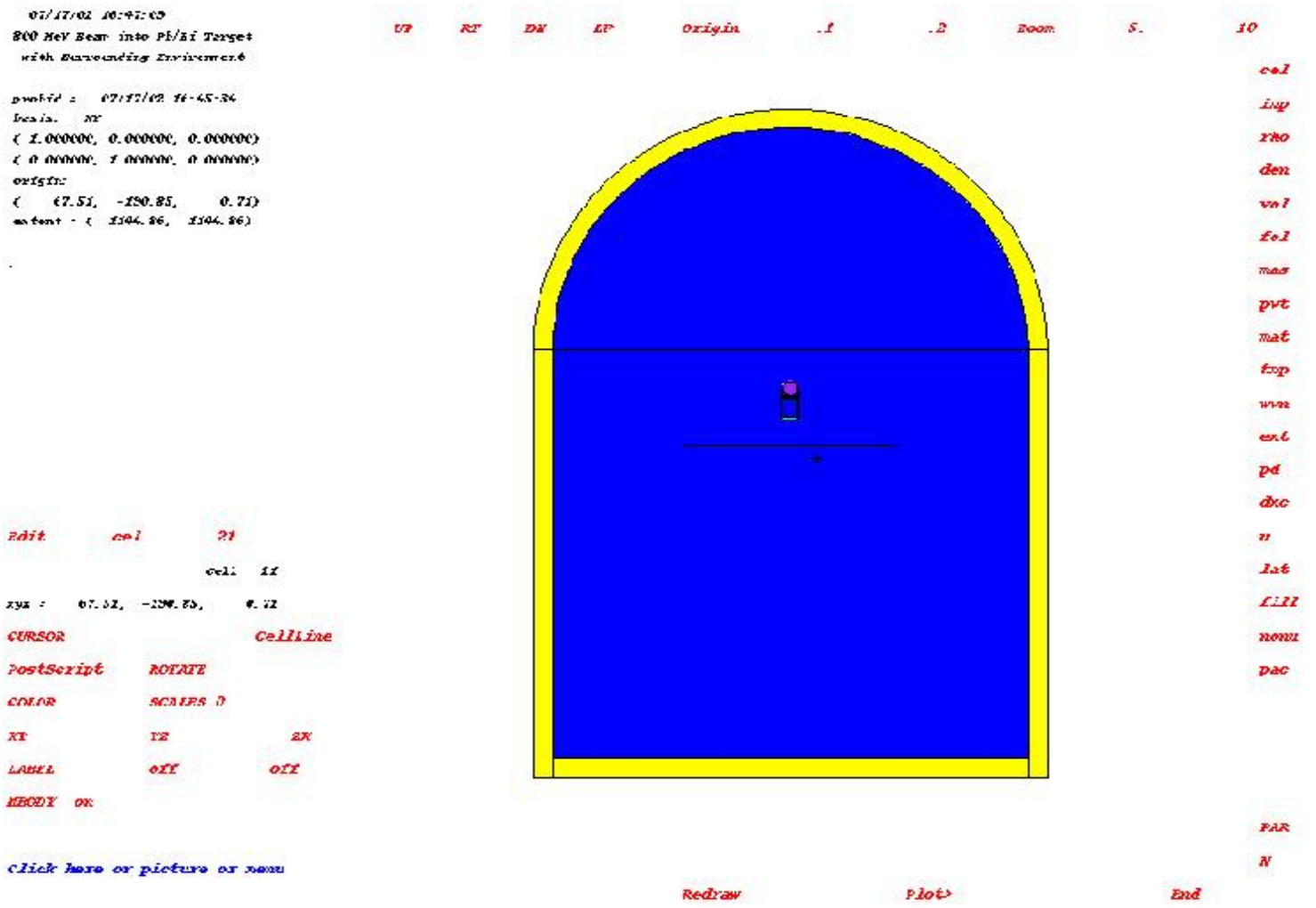
40 cm Target Goals with MCNPX

- **Model Blue Room as close as possible in order to have benchmarking capabilities in the future.**

Blue Room Model



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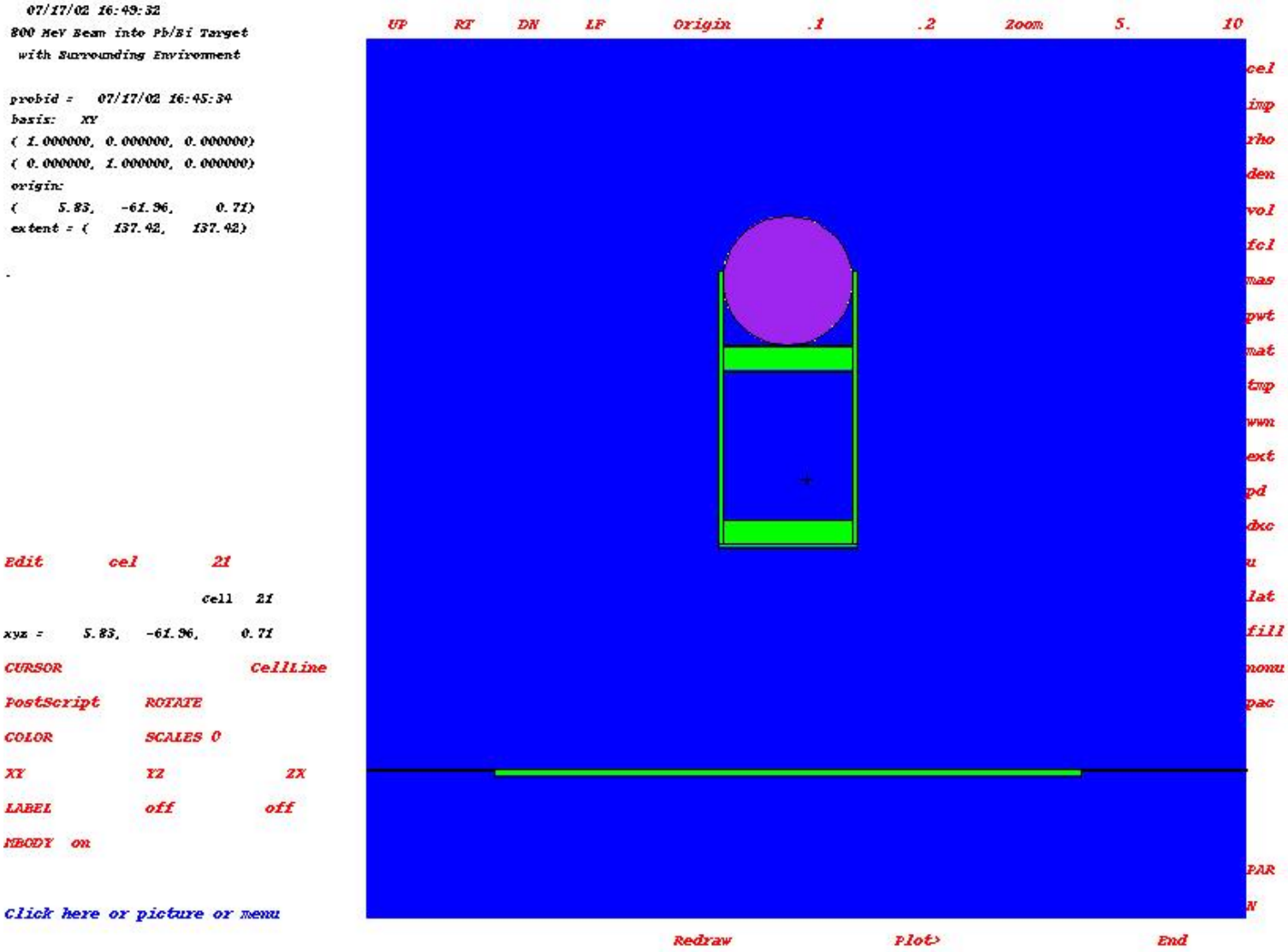
Target Stand



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Useful Picture

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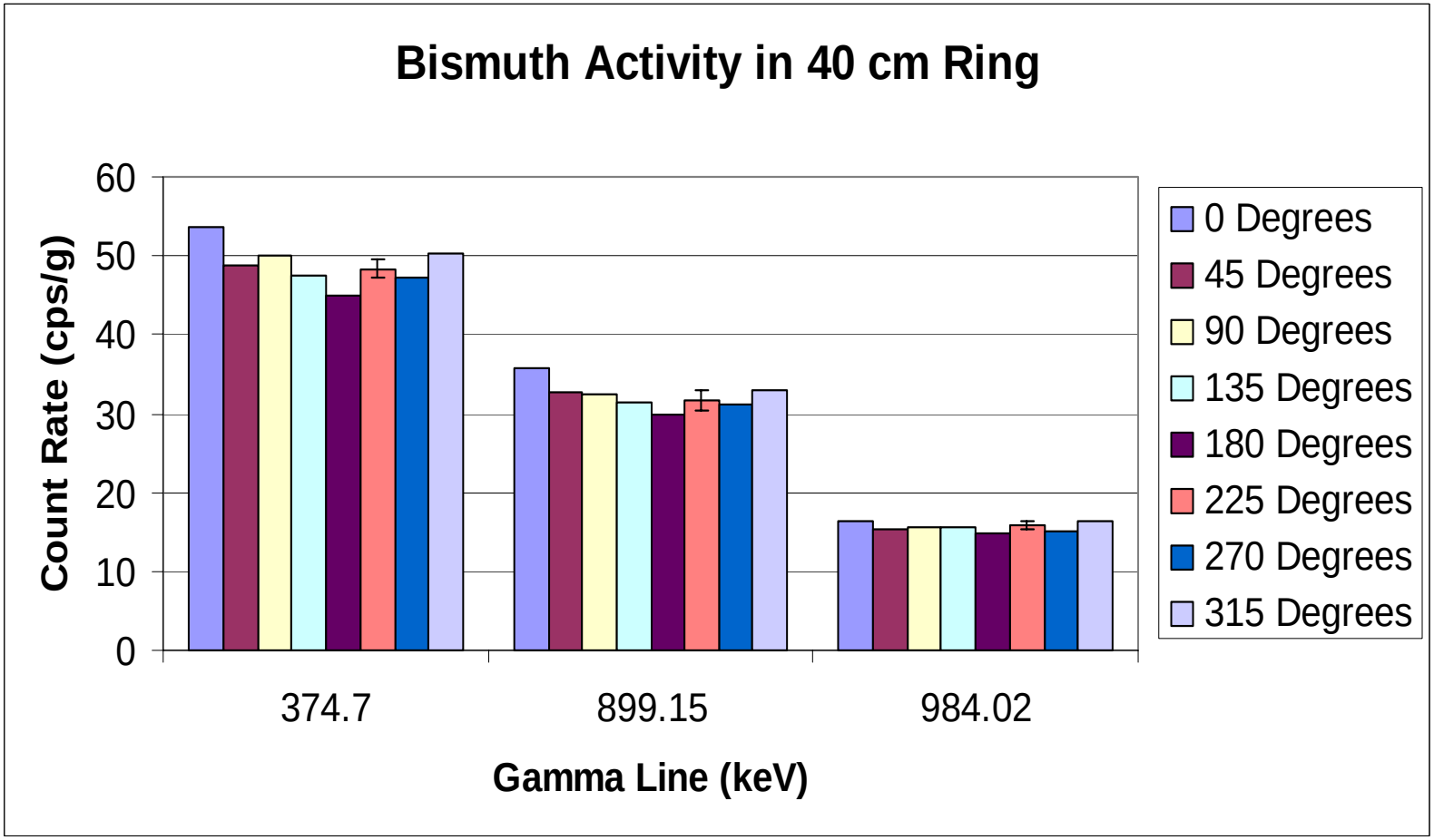
Bismuth Foil Activation at 40 cm Ring



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Future Goals/Objectives

- **3D Modeling of Blue room with a well known CAD product such as Pro-Engineer or Solid-Works. (Benchmarking uses)**
- **Analyze foil data (from 40 cm target) with MCNPX predictions. If there are discrepancies, why?**
- **Start models on 10 cm diameter target.**
- **If alignment process was not adequate, devise a new alignment technique**
- **Determine localized neutron spectrum for a foil pack from MCNPX**