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## Monte Carlo Verification and Modeling of Lead-Bismuth Spallation Targets

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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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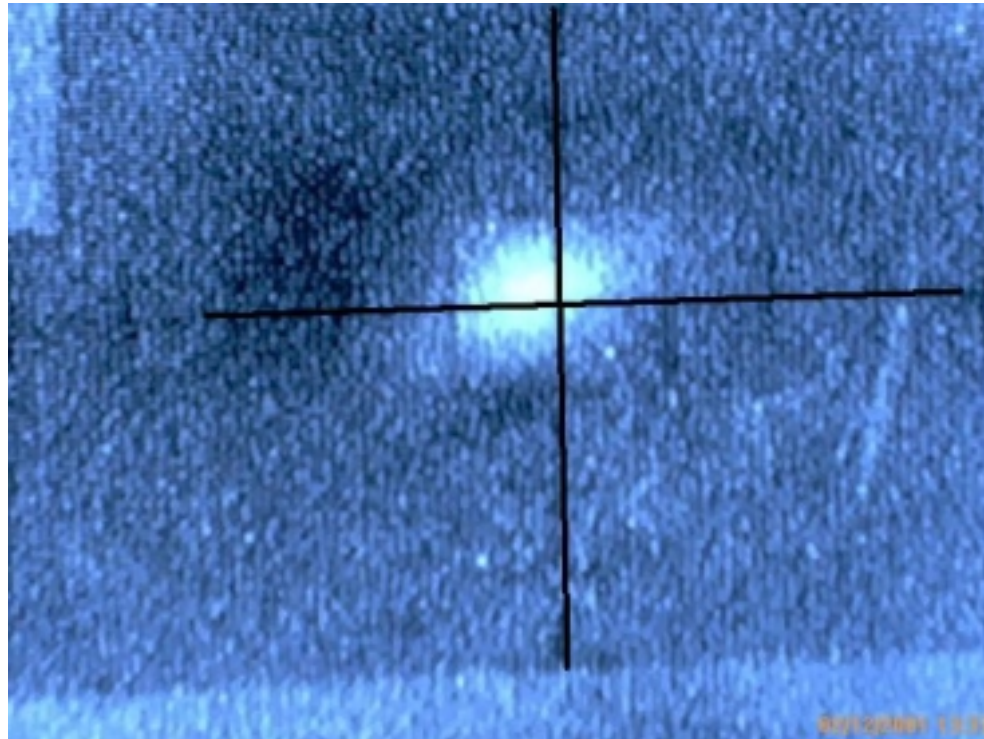
## Modeling Data from 20 cm Target

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- 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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<b>Total Neutron Flux Asymmetries Due to Beam Offset (Top and Bottom)</b>							
	Upper Max	Upper Min	Lower Max	Lower Min	Min % Difference	Max % Difference	<b>Ave % Difference</b>
Raw Data							<b>7.30%</b>
1 cm beam at origin	1.58296	1.57224	1.68371	1.67229	-5.40%	-6.80%	<b>-6.10%</b>
1 cm beam 2.0 mm up	8.20805	8.12313	7.83167	7.73515	3.70%	5.90%	<b>4.80%</b>
1 cm beam 2.5 mm up	8.21477	8.16058	7.68879	7.62897	5.95%	7.39%	<b>6.67%</b>
Guassian Beam 2.5 mm							
1 cm beam 3.0 mm up	8.33702	8.15812	7.57553	7.41959	7.40%	11.60%	<b>9.50%</b>
1 cm beam 3.5 mm up	8.37163	8.2635	7.60869	7.50441	8.25%	10.90%	<b>9.60%</b>
<b>Total Neutron Flux Asymmetries Due to Beam Offset (Left and Right)</b>							
	Left Max	Left Min	Right Max	Right Min	Min % Difference	Max % Difference	<b>Ave % Difference</b>
Raw Data							<b>3.94%</b>
1 cm beam at origin	1.62059	1.60961	1.62059	1.60961	-0.67%	0.67%	<b>0%</b>
1 cm beam 1 mm left	8.09064	7.98614	7.89557	7.78891	1.10%	3.80%	<b>2.45%</b>
1 cm beam 1.5 mm left	8.14051	8.06113	7.83113	7.74081	2.50%	5.03%	<b>3.80%</b>
Gaussian beam 1.5 mm							
1 cm beam 2 mm left	8.25226	8.10825	7.73612	7.60724	4.70%	8.10%	<b>6.40%</b>

## MCNPX Results on Beam Offset

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- **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

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- **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

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- **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

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- **Table Parts/Materials**

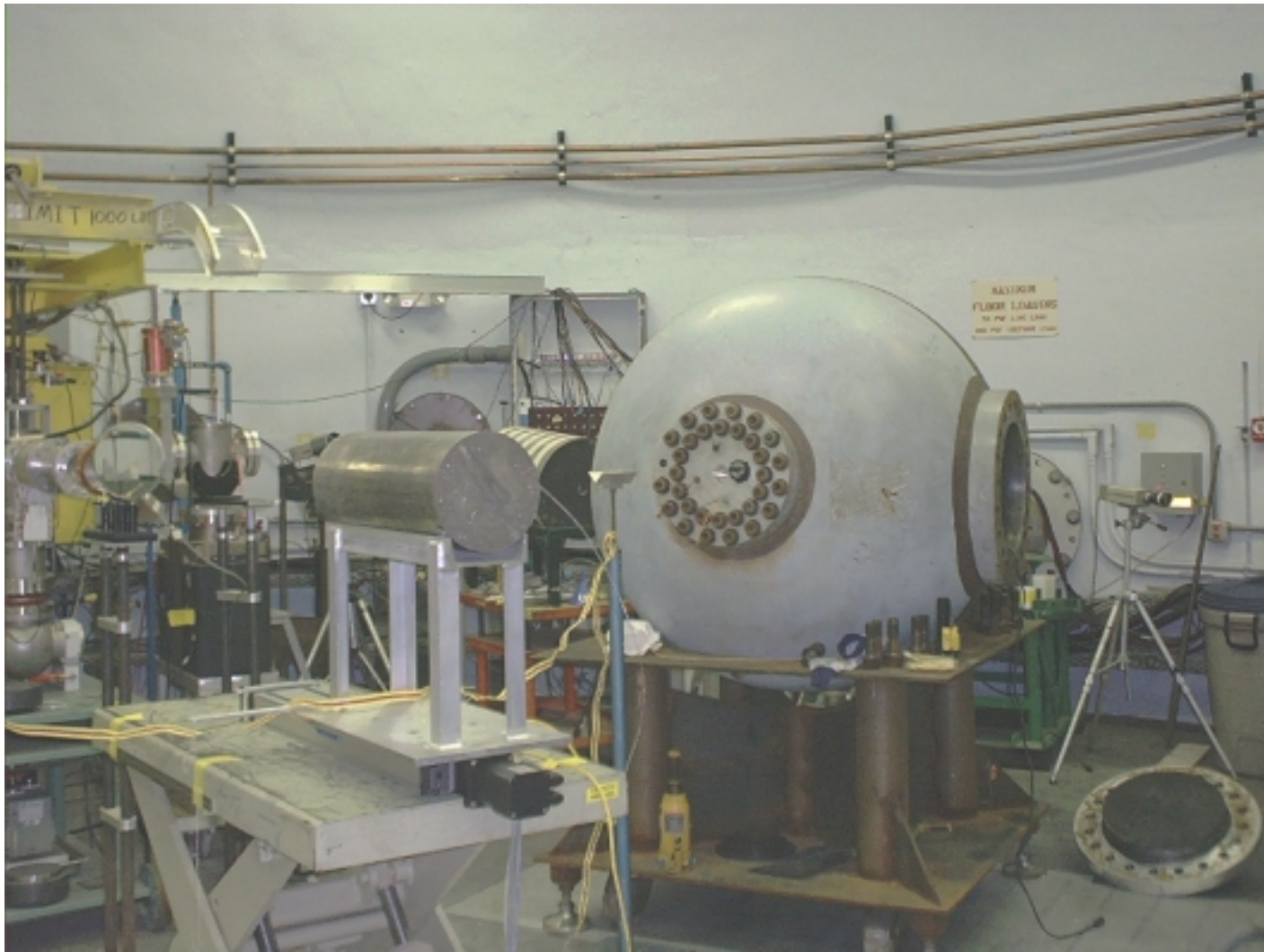
- Aluminum a better choice over steel.
- Proximity of metals a larger factor than material itself. When plates of metal approach 5 cm of the target, noticeable effects can be seen.
- New target stand (for 40 cm target) is better adapted to handle these concerns.

- **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

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- **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

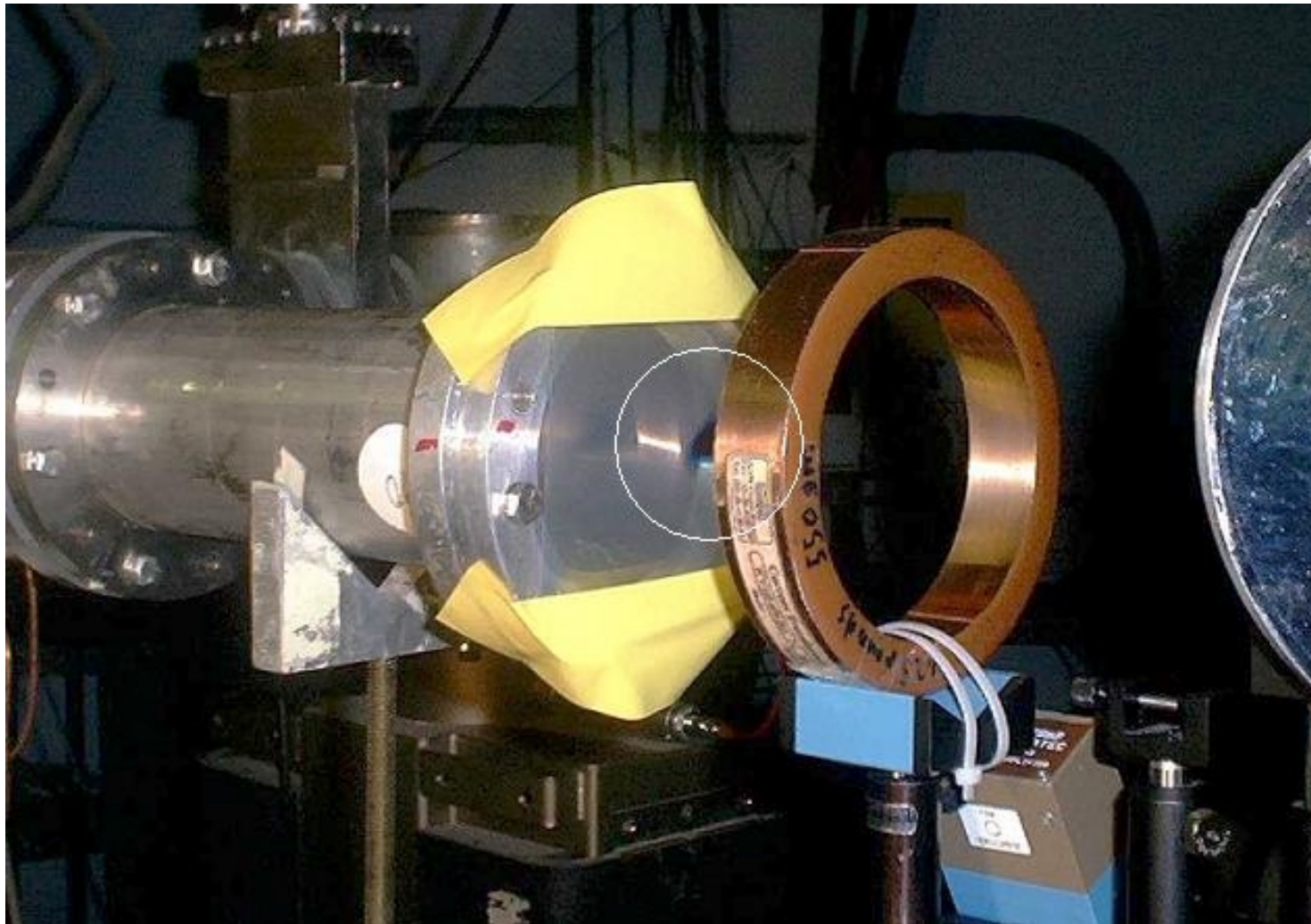
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## Post Irradiation Radio-Chromic Film

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## Target Placement by Laser Guidance





## Picture of 20 cm Target Alignment

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## 40 cm Target Goals with MCNPX

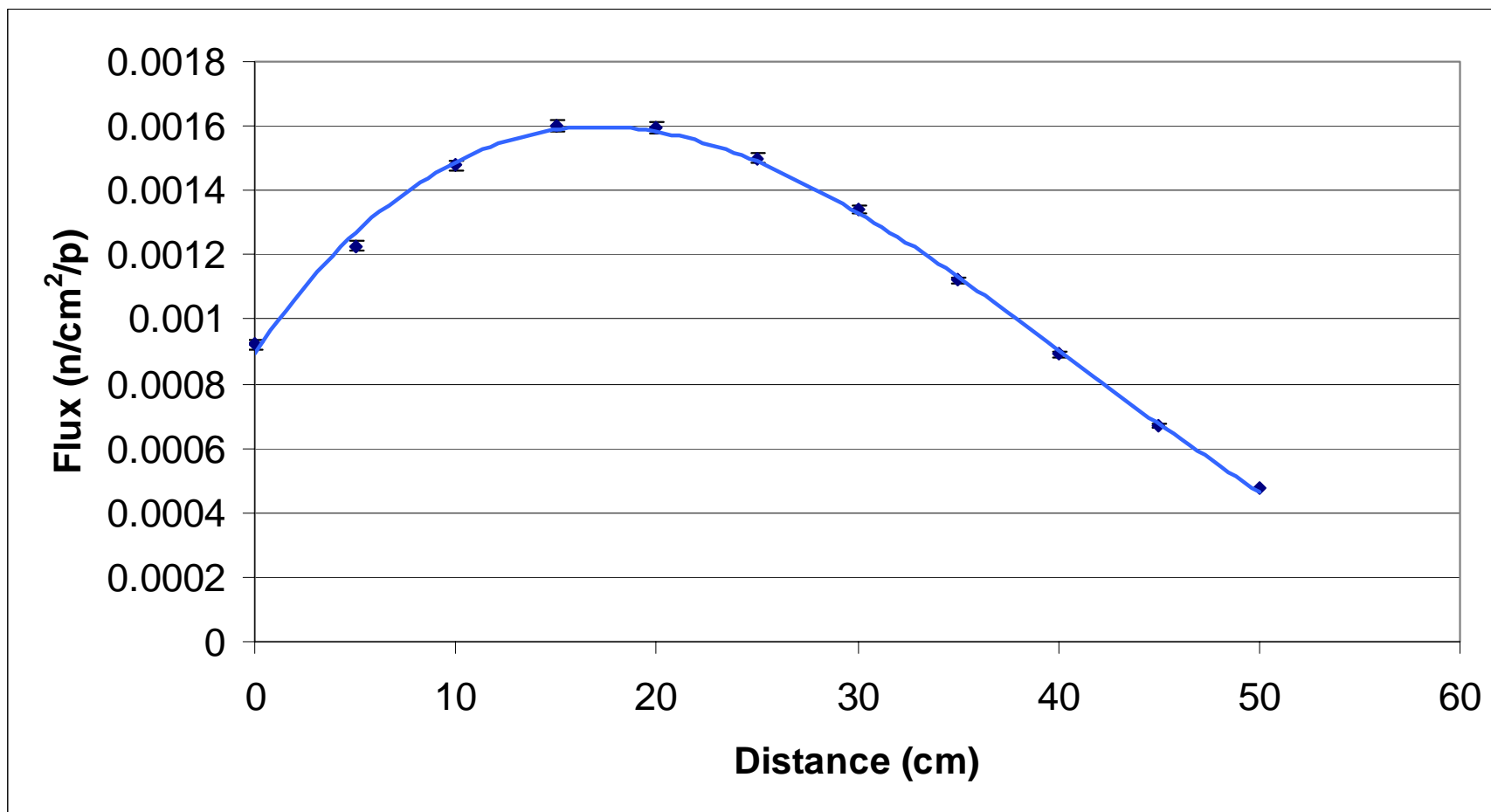
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- Determine the location of the maximum total flux as a function of axial position



## Total Neutron Flux vs. Axial Distance

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## 40 cm Target Goals with MCNPX

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

# Blue Room Model

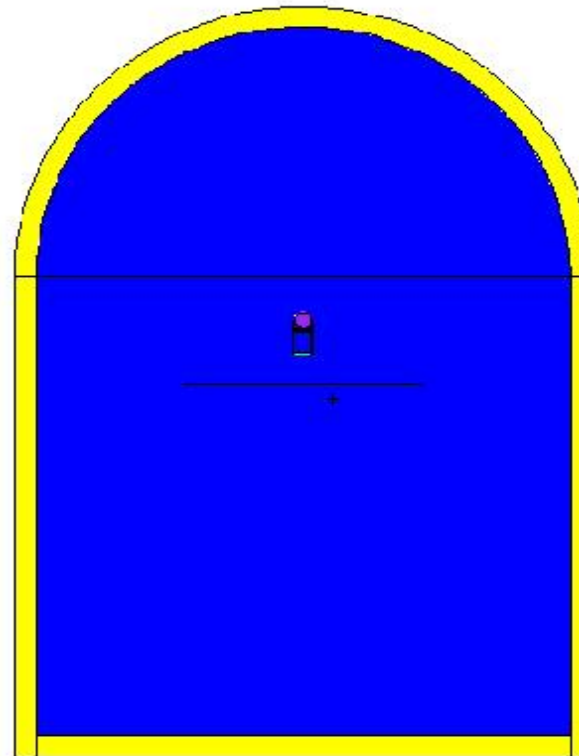
07/17/02 10:41:03  
800 MeV Beam into Pb/Pb Target  
with Surrounding Environment

probId = 07/17/02 16-45-34  
beam: 800  
( 1.000000, 0.000000, 0.000000)  
( 0.000000, 1.000000, 0.000000)  
origin:  
( 47.51, -150.85, 0.71)  
extent = ( 1104.86, 1104.86)

Edit: cel 21  
cell: 11  
xyz: 07.51, -150.85, 0.71  
CURSOR CellLine  
PostScript ROTATE  
COLOR SCALERS 0  
XT YZ 2X  
LABEL OFF OFF  
RECORD ON

[Click here](#) or picture or menu

UT RT DN LP Origin .1 .2 Room S. 10



cel  
lay  
rho  
den  
vol  
foi  
mas  
pvt  
mat  
tsp  
wms  
ent  
pd  
dnc  
u  
lst  
lill  
nomu  
pac

FAR  
N

Redraw

Plot

End

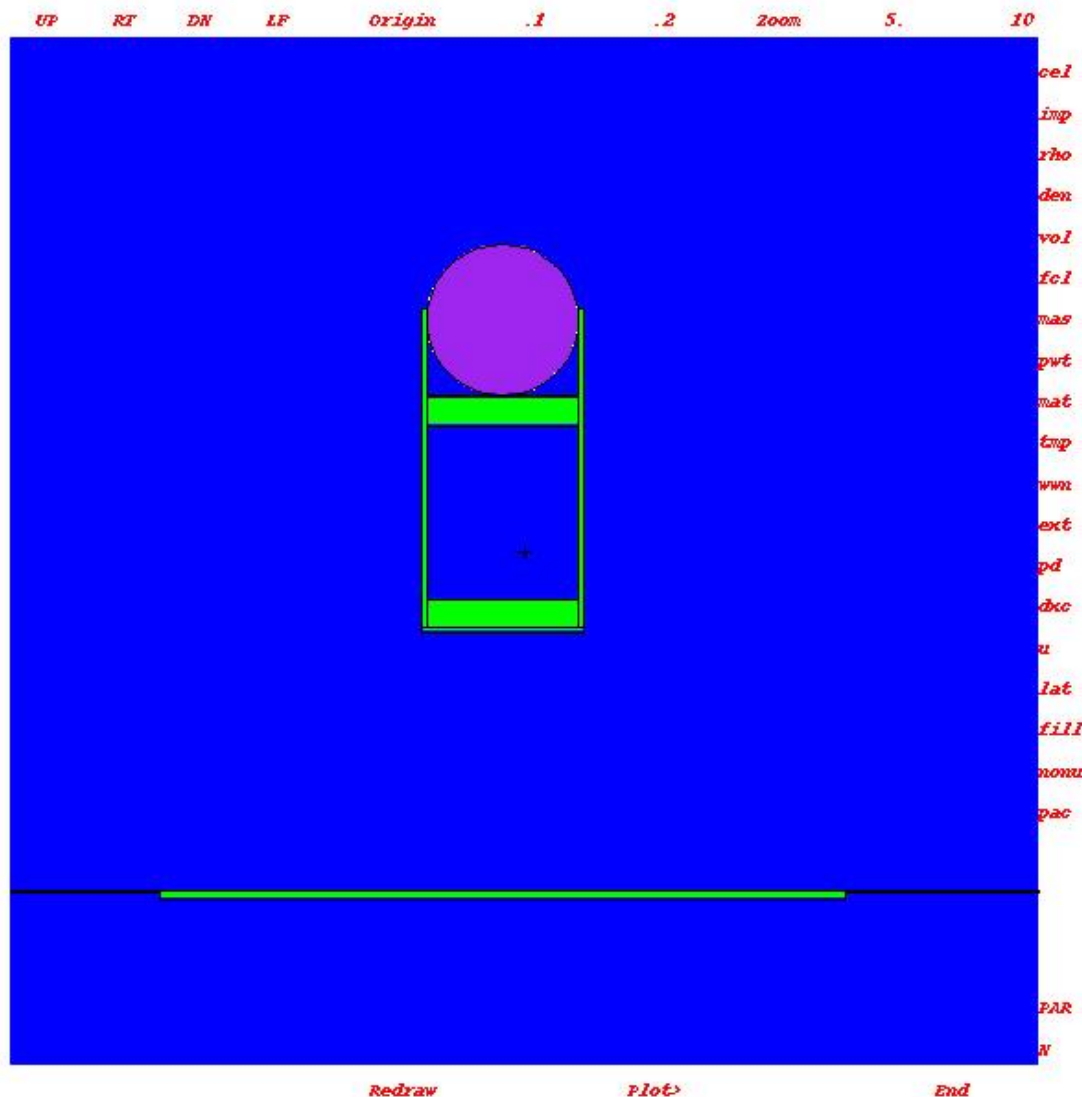
# Target Stand

07/17/02 16:49:32  
800 MeV Beam into Pb/Bi Target  
with Surrounding Environment

probid = 07/17/02 16:45:34  
basis: XY  
( 1.000000, 0.000000, 0.000000)  
( 0.000000, 1.000000, 0.000000)  
origin:  
( 5.83, -61.96, 0.71)  
extent = ( 137.42, 137.42)

Edit cel 21  
cell 21  
xyz = 5.83, -61.96, 0.71  
CURSOR CellLine  
PostScript ROTATE  
COLOR SCALES 0  
XY YZ ZX  
LABEL off off  
MBODY on

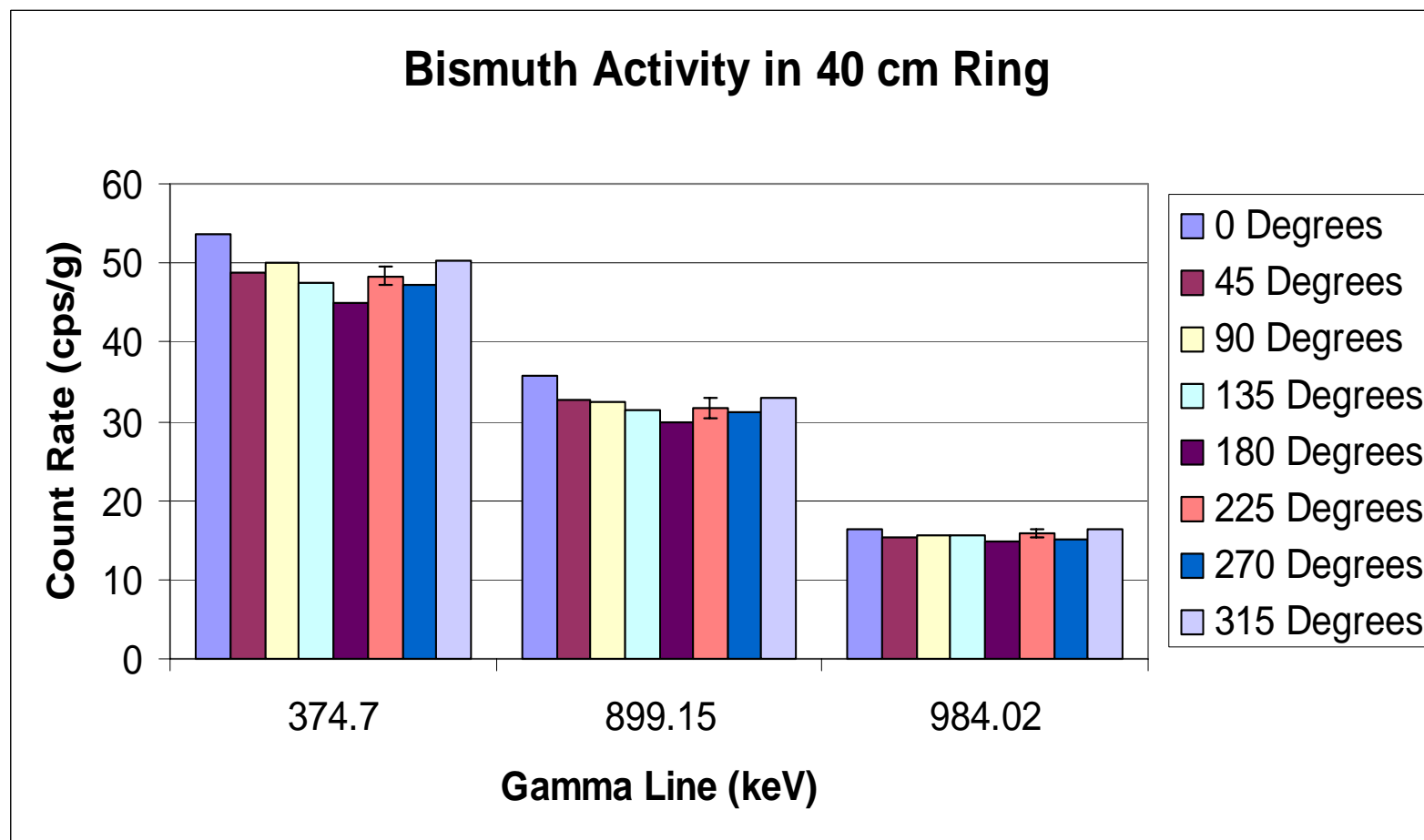
[Click here](#) or picture or menu



## Useful Picture



## Bismuth Foil Activation at 40 cm Ring



## Future Goals/Objectives

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- **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**