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Title: MCNP IMAGE DETECTOR PACKAGE TESTING

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## MCNP Image Detector Package Testing

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The Tower Experiments were modeled using the MCNP5 image detector (radiography) package. The tower experiments utilized either a 6 or 15 MeV bremsstrahlung source. Experimental data was gathered for eight configurations. Calculational results are presented for Experiment 3, small collimator (illuminates about a 4.6 cm diameter beam at the object), high scatter geometry (lead plates between the object and the detector), and with a 6 MeV bremsstrahlung source. Calculations were performed to observe the differences in the calculated results for, 1) particle flux averaged over a surface, 2) particle flux at a point detector, and 3) the radiography tally (point detectors with direct and scatter). The calculated differences were observed with coherent scatter and without coherent scatter. Calculations were also performed to observe the model sensitivity to the lead and tungsten part material properties and dimensions.

Most of the differences between the calculated results for the tallies were small. Small differences were observed between the flux averaged over a surface and the other tallies. This is due to the fact that the other tallies were point detectors, which are independent of area.

Little difference was observed between the calculations with and without coherent scatter. The differences that were observed were predominantly due to statistical variations in the calculation. Some differences were observed for the radiography tally that tallied only the scattered contributions to the grid of point detectors. The total, direct and scatter, was the same for both with and without coherent scatter. Coherent scatter is significant when low energy (0.01-1.0 MeV) photons and high-z materials are involved. Since only scattered contributions were tallied, the photon energy was lower than the energy originating from the source. In addition the experimental configuration analyzed involved predominantly high-z materials. Coherent scatter was found to be significant only for the scatter calculations.

Most of the calculations were insensitive to expected variations in material properties and dimensions. The scatter only calculational results demonstrated a high sensitivity to expected variations in density and dimensions. For example a 1% variation in tungsten part densities resulted in about a 15% change in the calculated results.

The MCNP5 radiography tally was shown to provide a simulated radiographic image that is consistent with the experimental data and other tallies previously in MCNP. This tally should help with image enhancement and extraction of the image from the background. These calculational tests showed that the radiography tally performed satisfactorily for this experiment.

# **MCNP Image Detector Package Testing**

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And  
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# Outline

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- Experimental Description
- Results
  - Experimental
  - Particle flux averaged over surface
  - Particle flux at point detector
  - Radiography point detectors
  - Projected image size
- Conclusion
- Future Work



# Objectives of the Experiments

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- Study Small Angle Compton Scattering
- Feasibility of Future Backscatter Experiments
- Investigate the Ability of MCNP to Calculate this Type of Experiment
- Investigate MCNP Version 5 Radiography Tally Feature



# Experimental Description

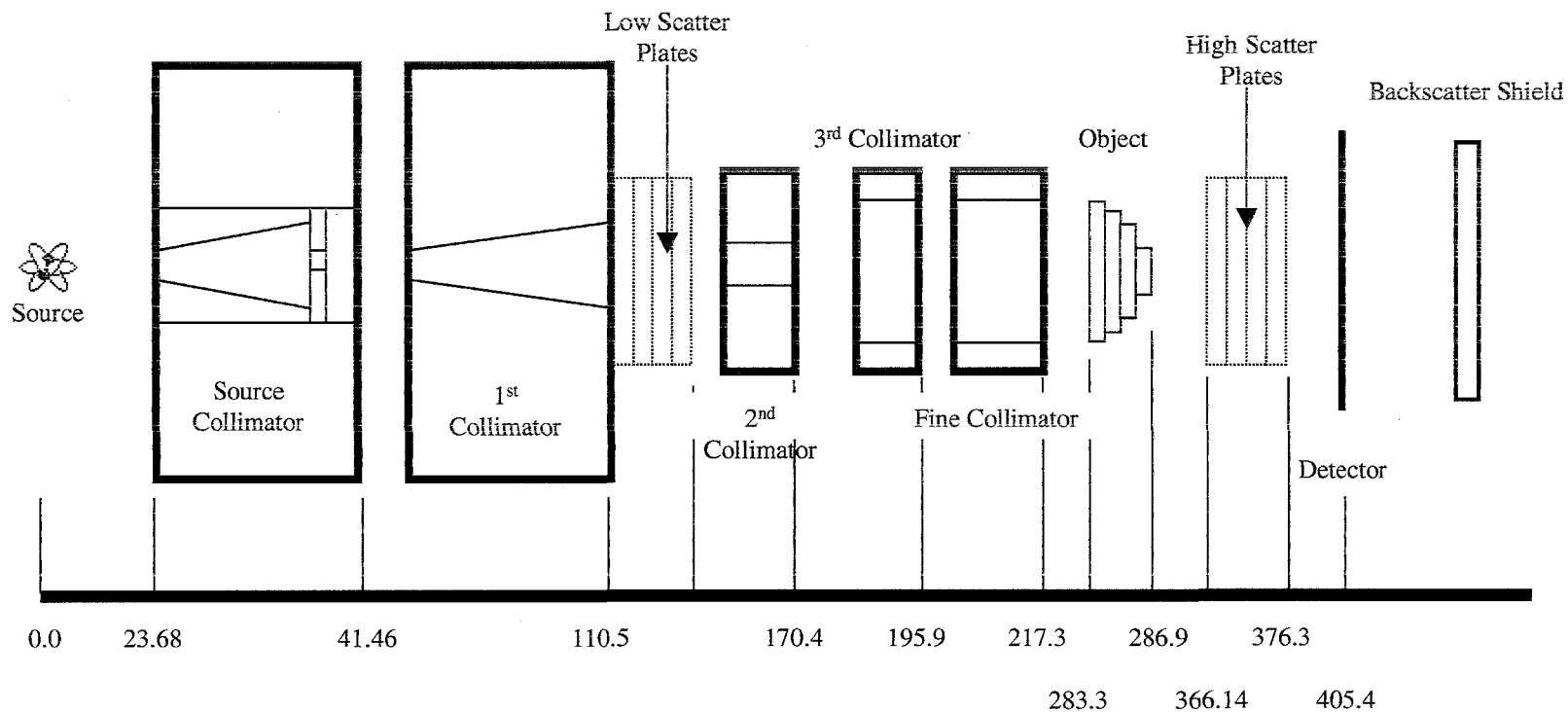
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- 8 Experimental Configurations (only analyzed experiment 3)
- 6 or 15 MeV Bremsstrahlung Source
- Collimator
  - Small – 4.6 cm beam at object
  - Large – 7.2 cm beam at object
- Scatter
  - High scatter – Pb plates between object and detector
  - Low scatter – Pb plates between source and object

# Experimental Configurations

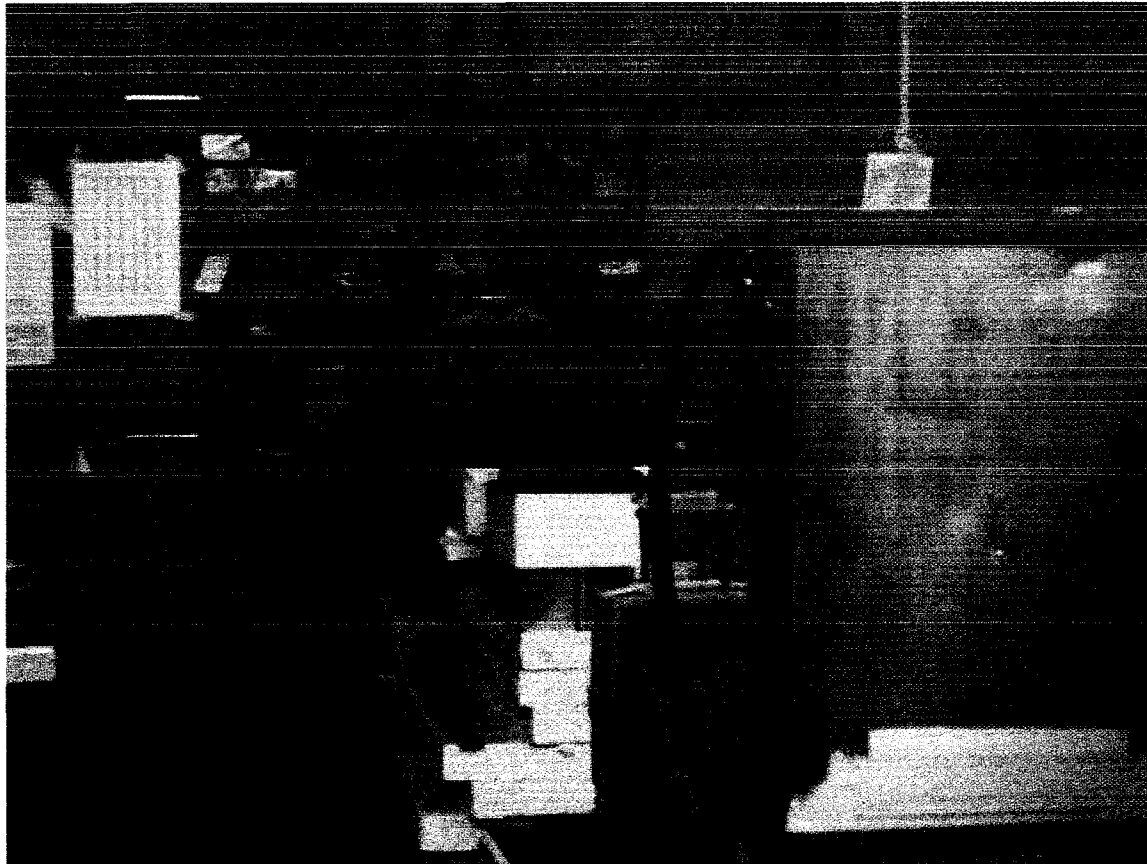
Experiment	Collimation System	Geometry	Energy (MeV)
1	Small	Low scatter	6
2	Small	Low scatter	15
3	Small	High scatter	6
4	Small	High scatter	15
5	Large	Low scatter	6
6	Large	Low scatter	15
7	Large	High scatter	6
8	Large	High scatter	15

# Experimental Schematic





# Photograph of the Experimental Assembly



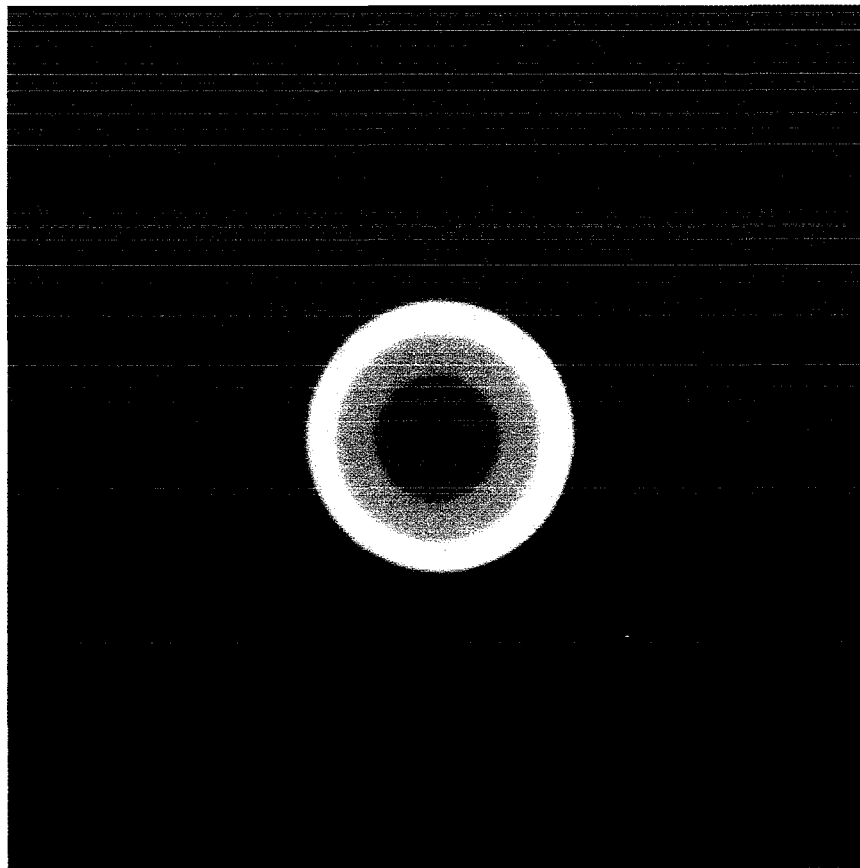


# Results

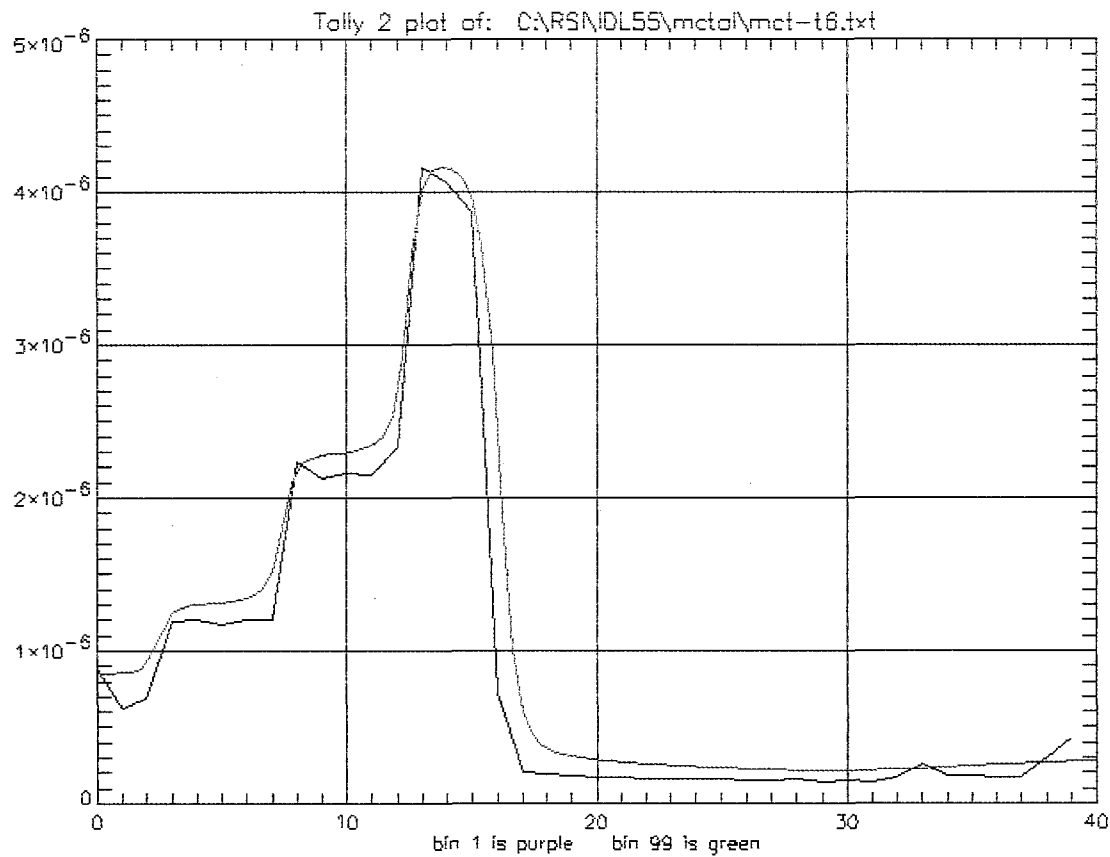
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- Minor Differences Observed
  - Calculations vs other calculations
  - Experiment vs calculations
  - With vs without coherent scatter
- Differences Predominantly Statistical
- Nonstatistical Differences Observed for Scatter – Only Calculations

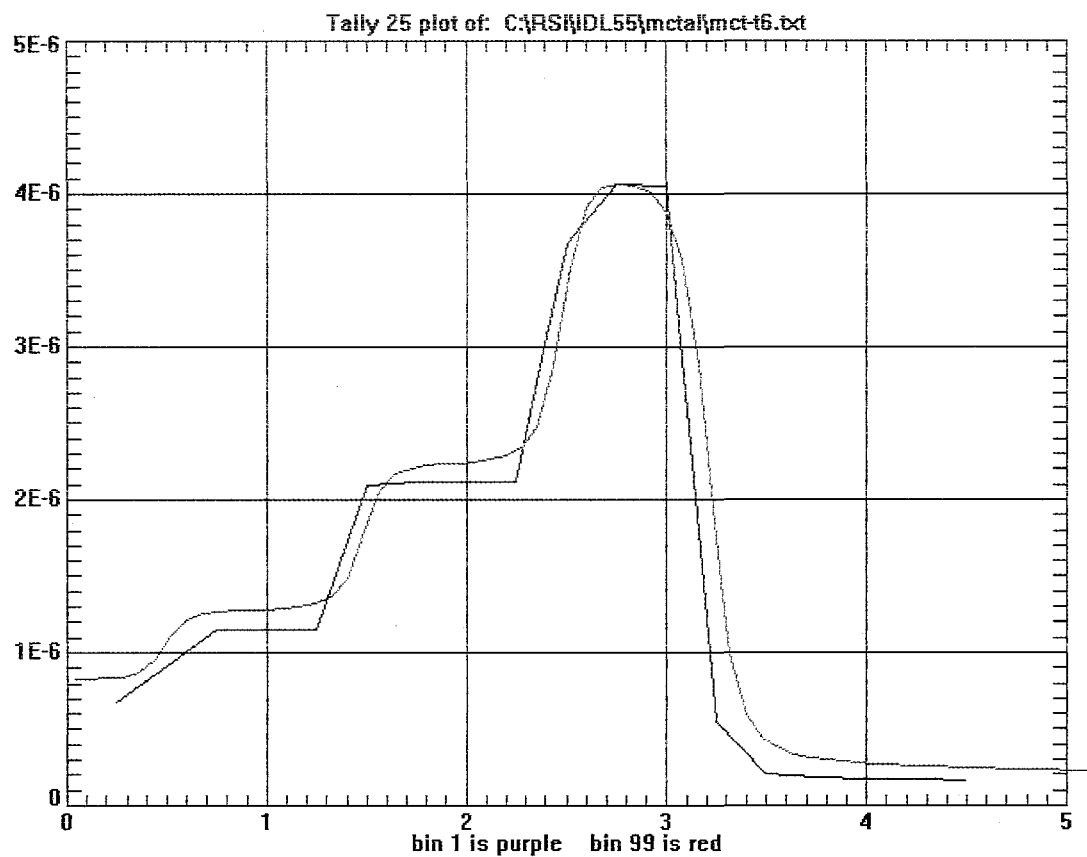
# Object Radiograph



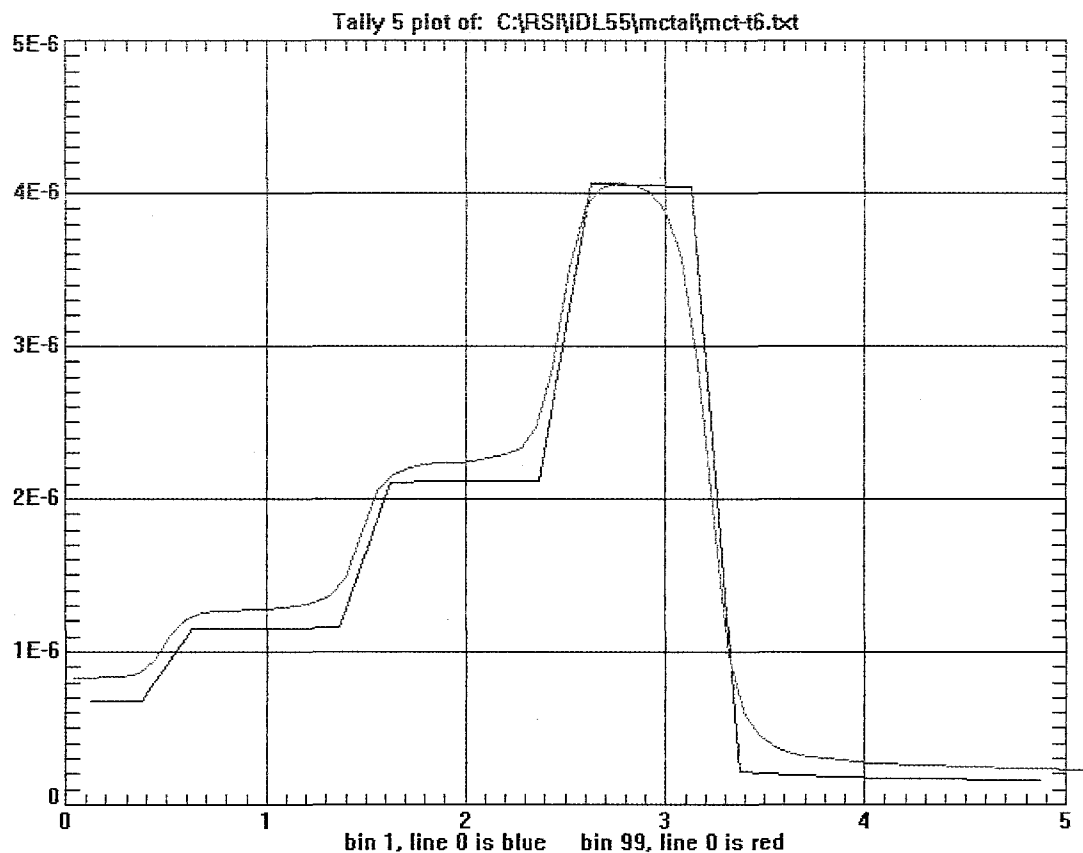
# Experimental Results vs Tally 2, Particle Flux Averaged Over a Surface



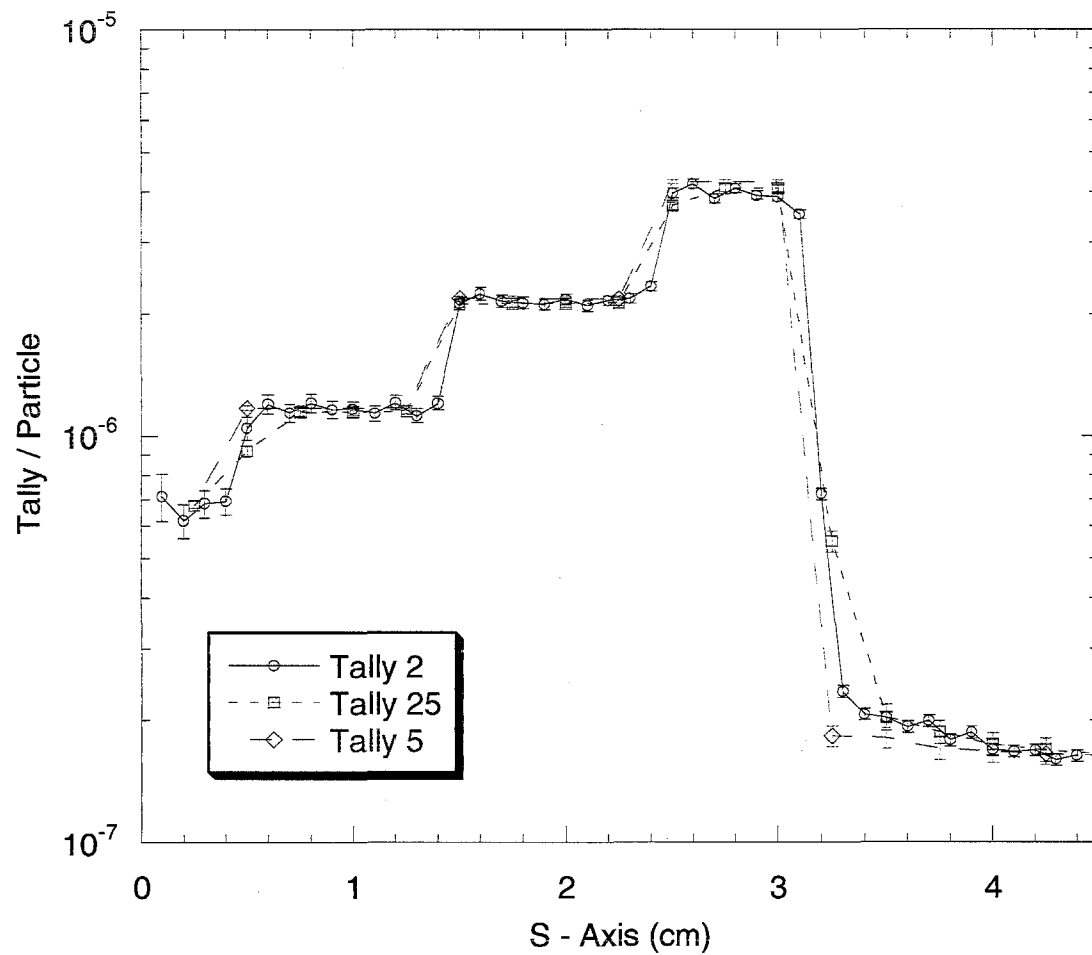
# Experimental Results vs Tally 25, Particle Flux at a Point Detector



# Experimental Results vs Tally 5, Particle Flux at a Point Detector, Radiography Tally



# Comparison of Tallies 2, 5 and 25

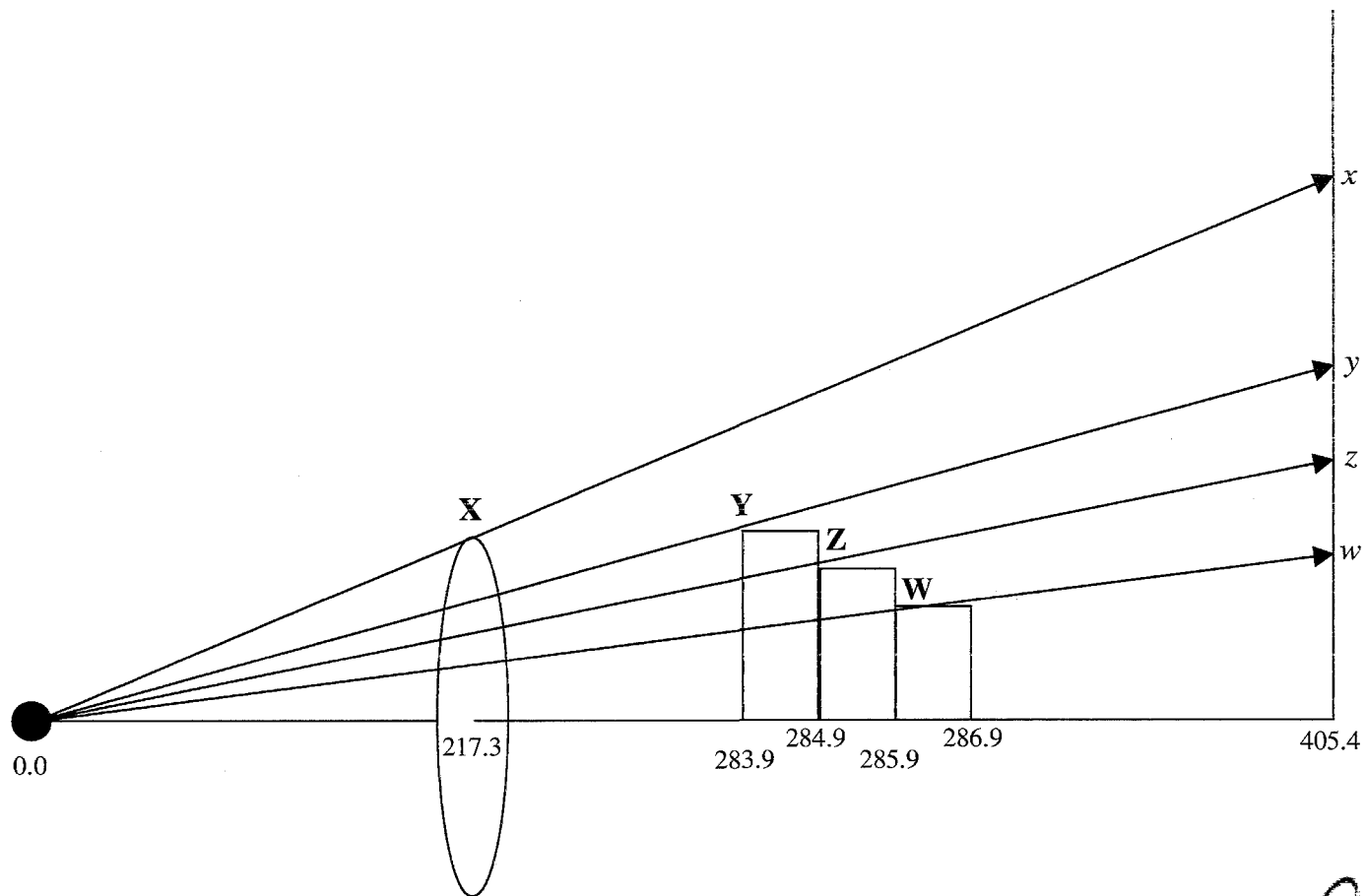


# Comparison of the Relative Height of the Steps

Tally 2	Tally 5	Tally 25
1.90E-06 (5.76E-08)	1.94E-06 (2.68E-08)	1.82E-06 (2.37E-08)
1.02E-06 (6.94E-08)	9.66E-07 (3.97E-08)	1.02E-06 (3.86E-08)
4.93E-07 (1.04E-07)	4.73E-07 (6.76E-08)	4.15E-07 (8.06E-08)



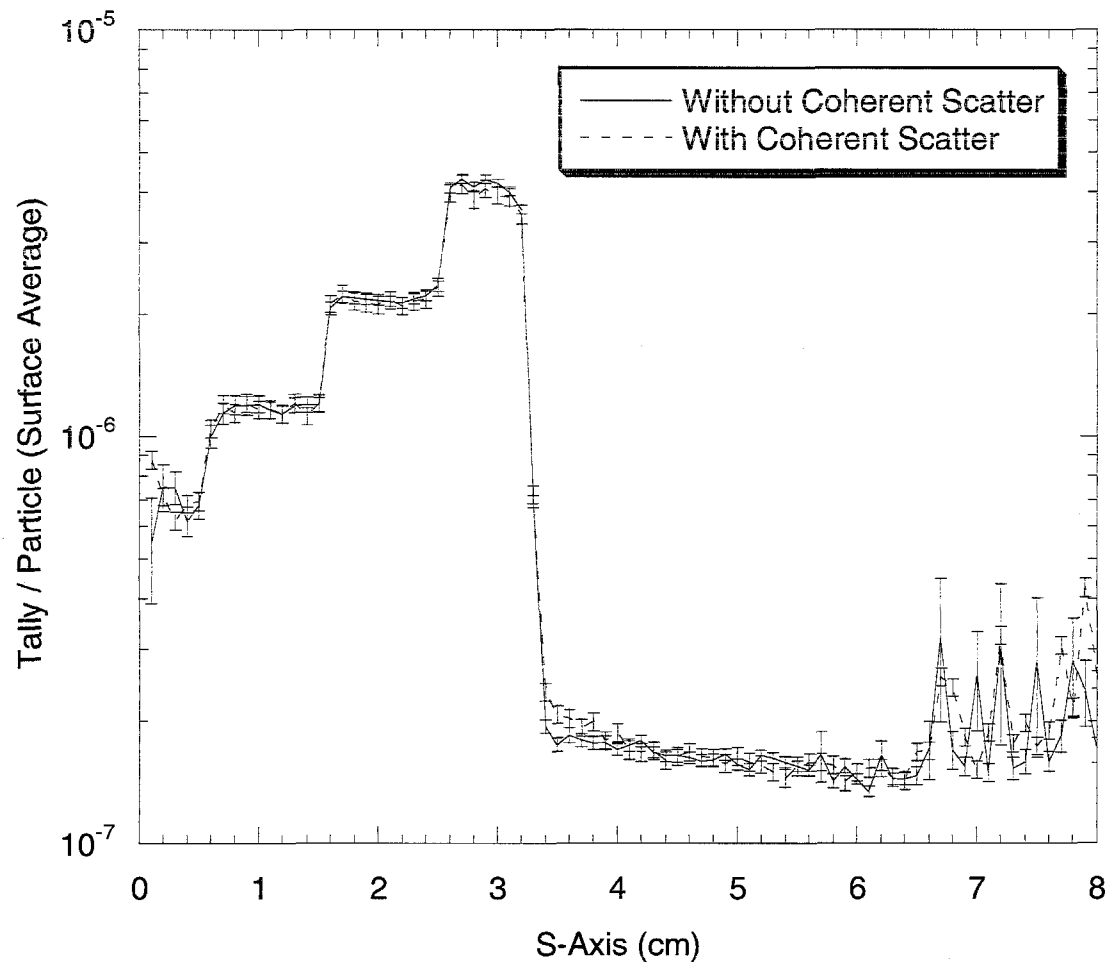
# Projected Image Size



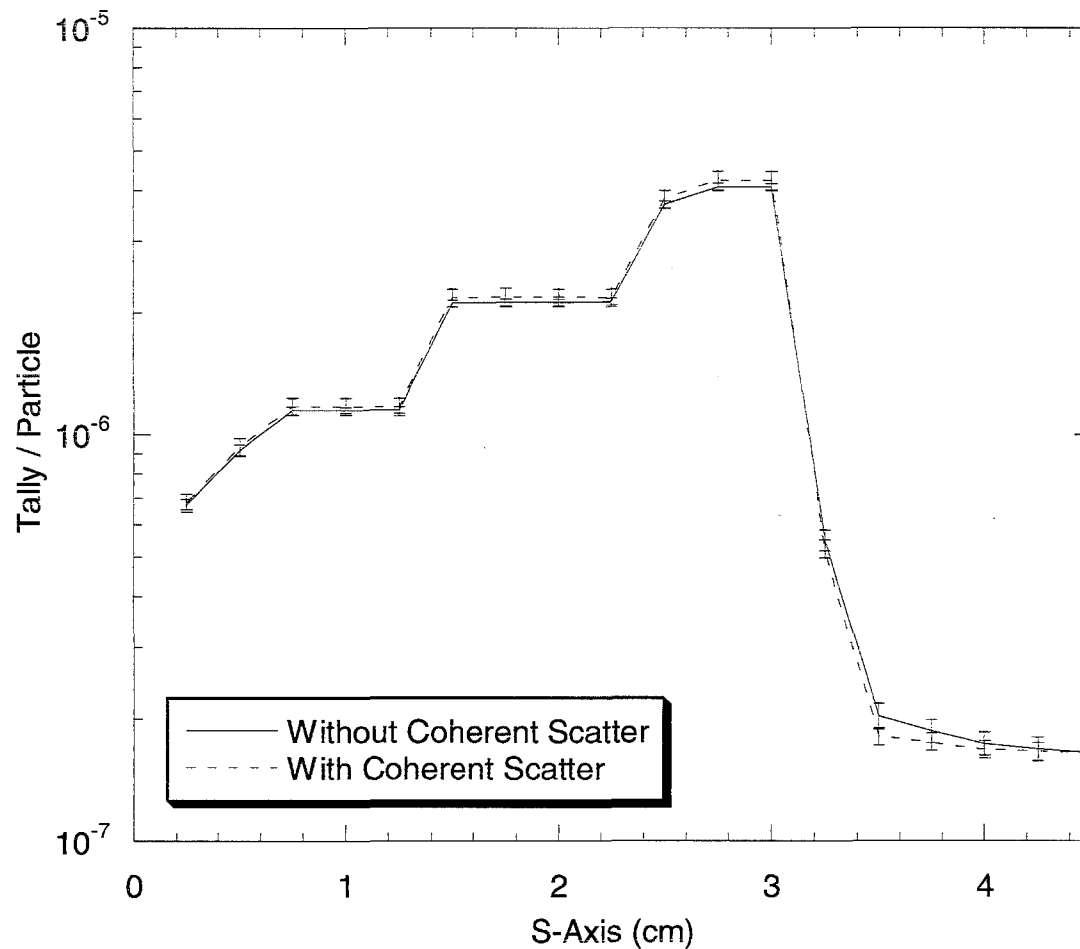
# Projected Image Size

	x (cm)	y (cm)	z (cm)	w (cm)
Calculated	3.1716	2.4931	1.4865	0.4997
Tally 2	3.2	2.5	1.6	0.6
Tally 25	3.0	2.5	1.5	0.25
Tally 5	3.1	2.5	1.5	0.5

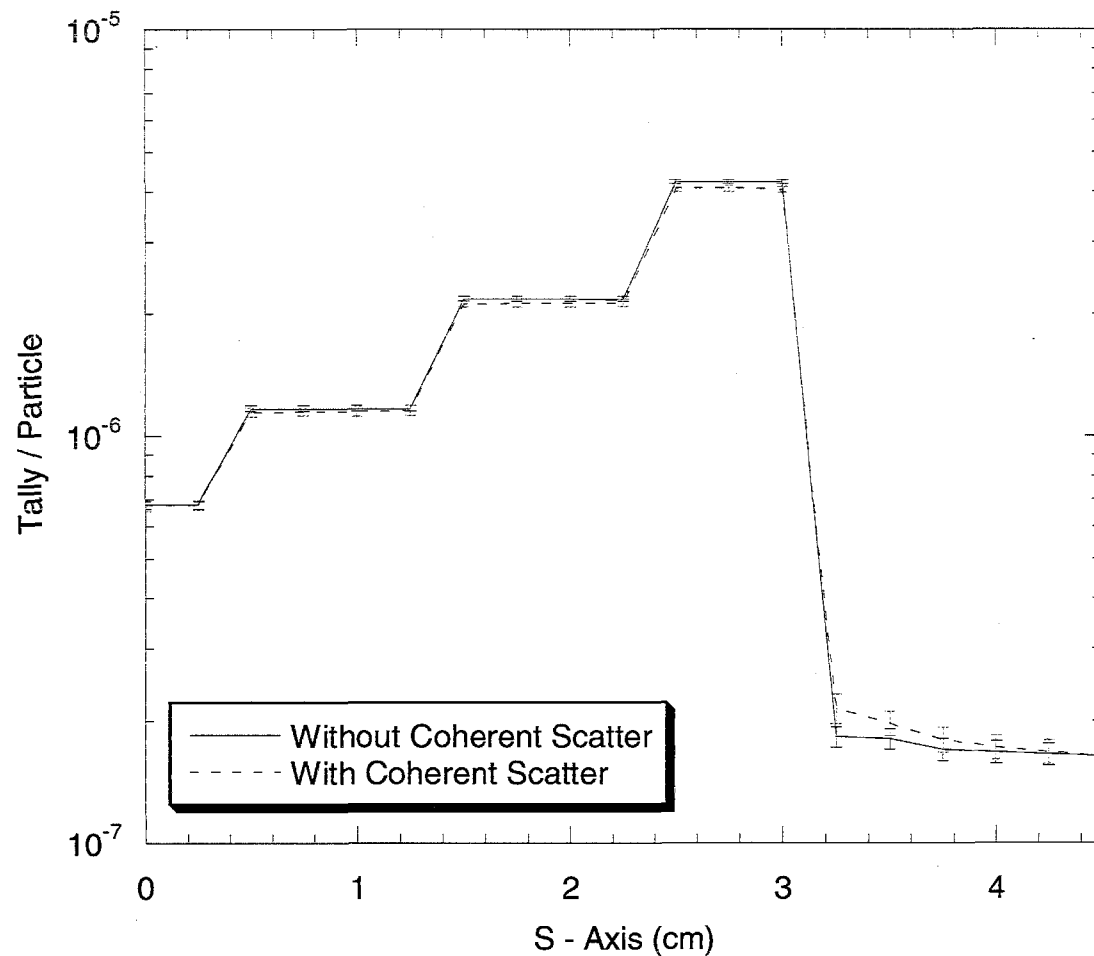
# With vs Without Coherent Scatter, Tally 2, Particle Flux Averaged Over a Surface



# With vs Without Coherent Scatter, Tally 25, Particle Flux at a Point Detector



# With vs Without Coherent Scatter, Tally 5, Particle Flux at a Point Detector, Radiography Tally





# Conclusion

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- Good Agreement Observed
  - Experimental vs Calculated
  - Calculated vs Calculated
  - With vs Without Coherent Scatter
  - Image Size



# Future Work

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- Analyze Other Experimental Configurations
- Investigate Scatter-Only Calculation
- Investigate Differential Coherent Scatter
- Model Sensitivities