SAND2011-6880P

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Saturn Beam Deconvolution using MATLAB Image Processing and ADEPT Code Package

An Overview

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Intern

Sandia National Laboratories is a multi program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
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Project Overview

- **Goal: Determine energy of electrons in radiation field produced by Saturn**
- **Two main techniques**
  - –**Experimental**
    - *Experiments in Saturn*
    - *MATLAB Image Processing for analysis*
  - –**Computational**
    - *ADEPT Code Package*

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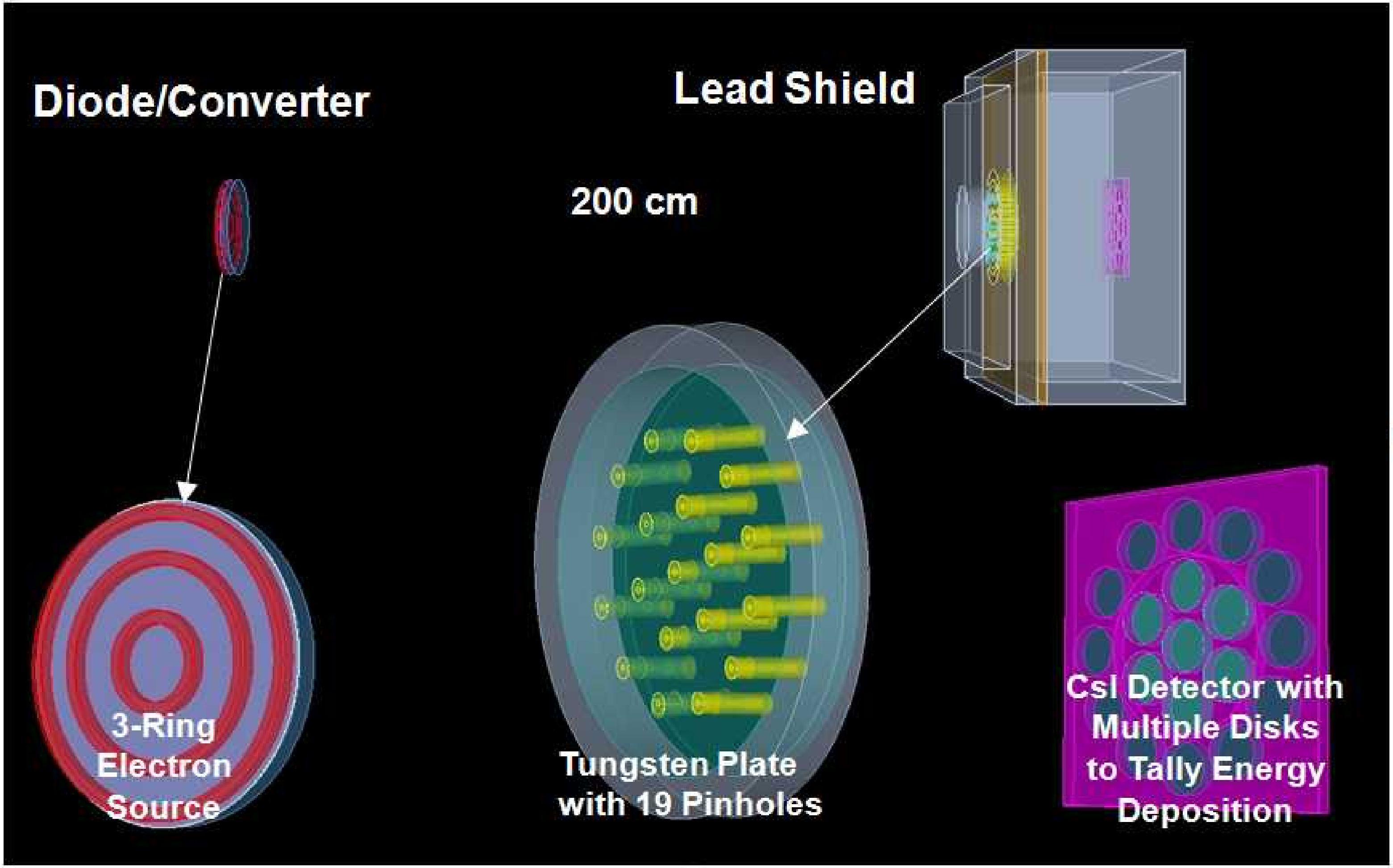
Saturn Experiments: Setup

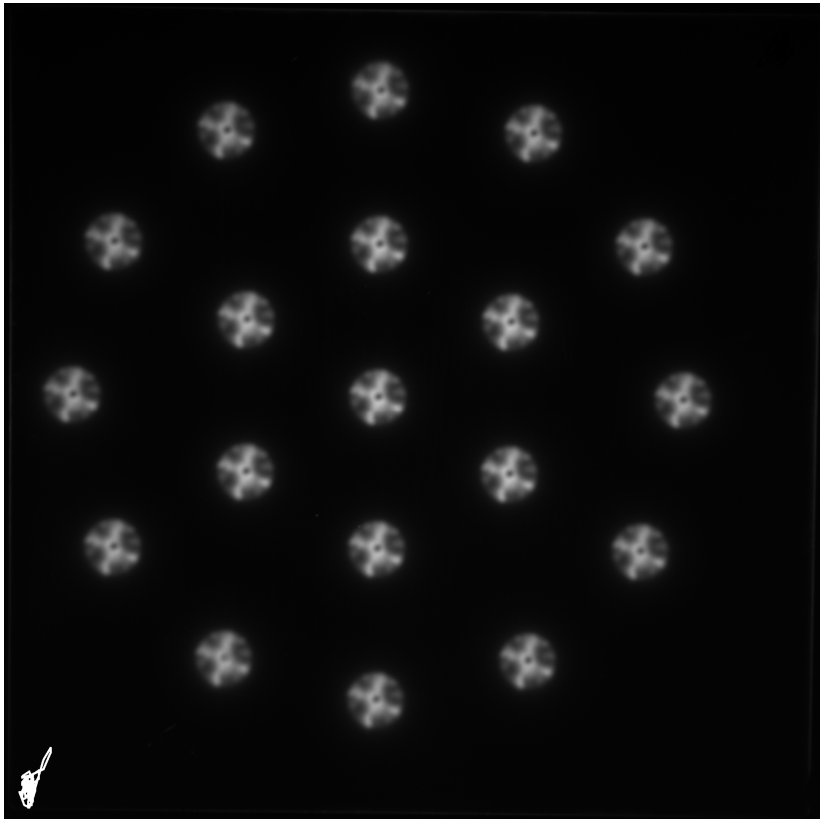


Experimental Analysis

- **Method: Image Processing in MATLAB**
- **Pre-processed image with ImageJ software**
  - –Removed outliers
  - –Converted image into MATLAB preferred data type
    - *from tiff to bitmap—to preserve color scaling*
- **Utilized a series of graphical user interfaces (GUIs) developed by a previous intern**
  - –Alignment
  - –Factors
  - –Intensity

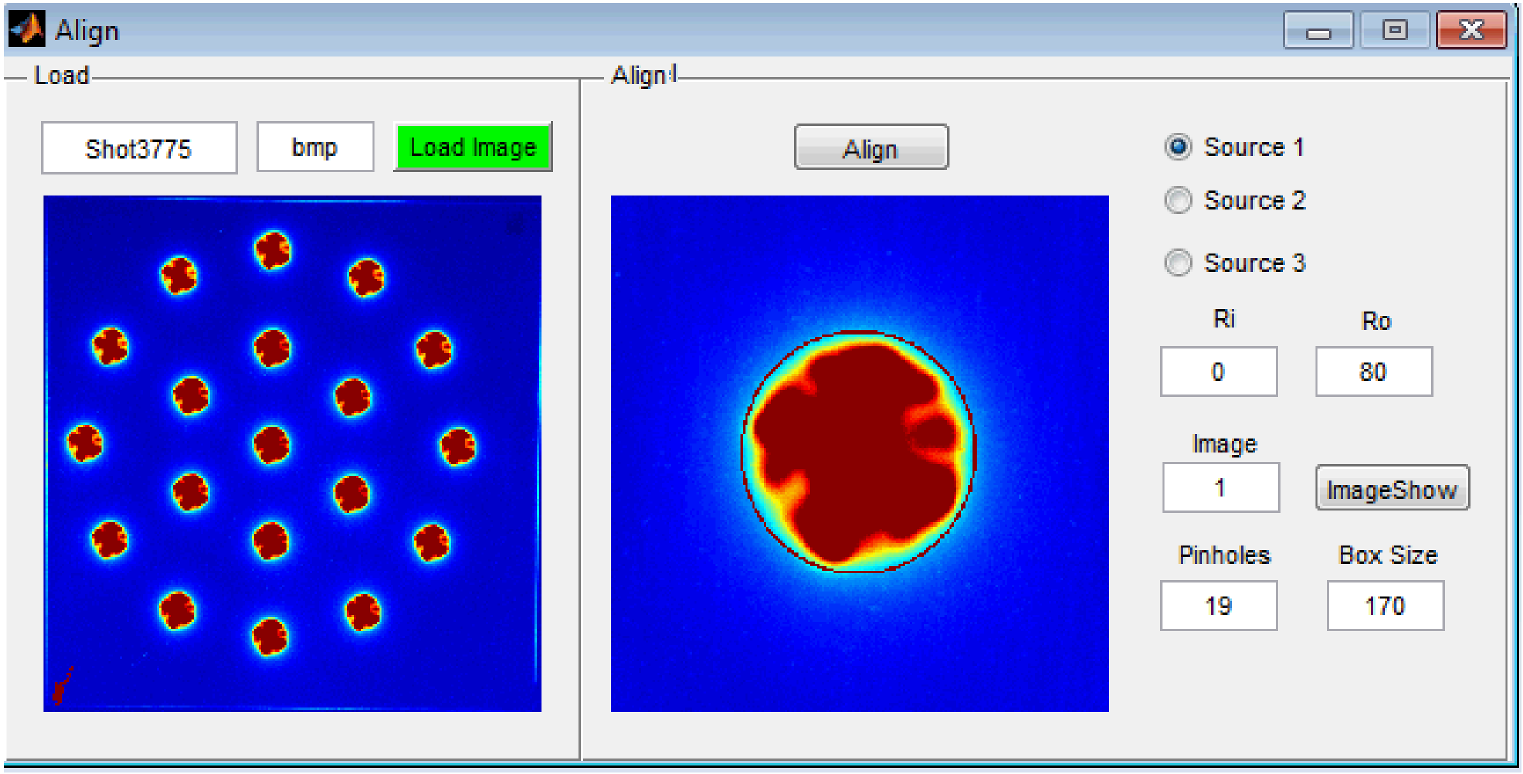
Alignment GUI

- Most important analysis GUI, fundamentally
- Breaks up a single total shot image into individual pinhole images



- Uses initial guesses for image centers and aligns them by maximizing the light within a user-designated disc region

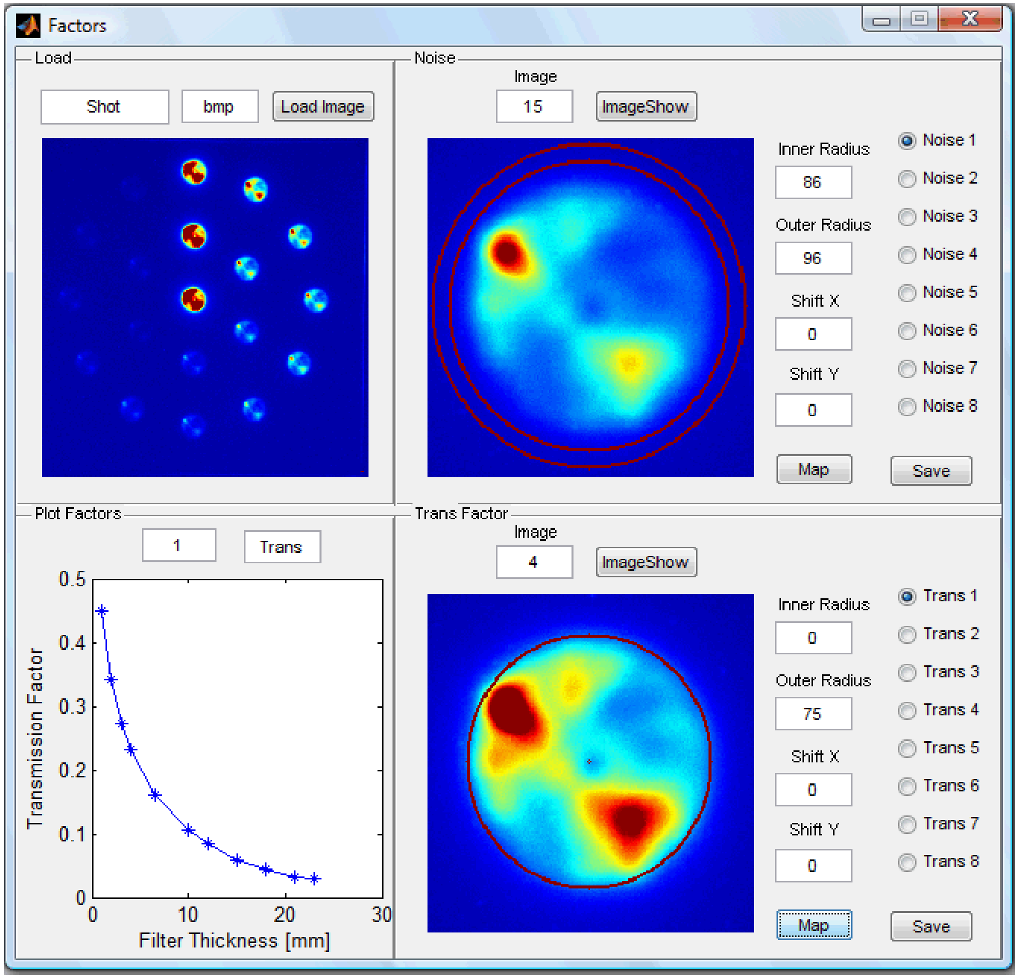
Alignnment GUI



Factors GUI

- **Measure background noise and/or transmission factors**
  - **Background Noise: unwanted or unintentional signal that disrupts or masks true signal**
  - **Transmission Factors: normalize individual pinhole images in a shot with respect to brightest image**
    - *Because different pinhole locations may cause brighter images inherently*
      - for example, we expect pinhole in the center to receive more radiation than the pinholes on the edges of the disc

Factors GUI

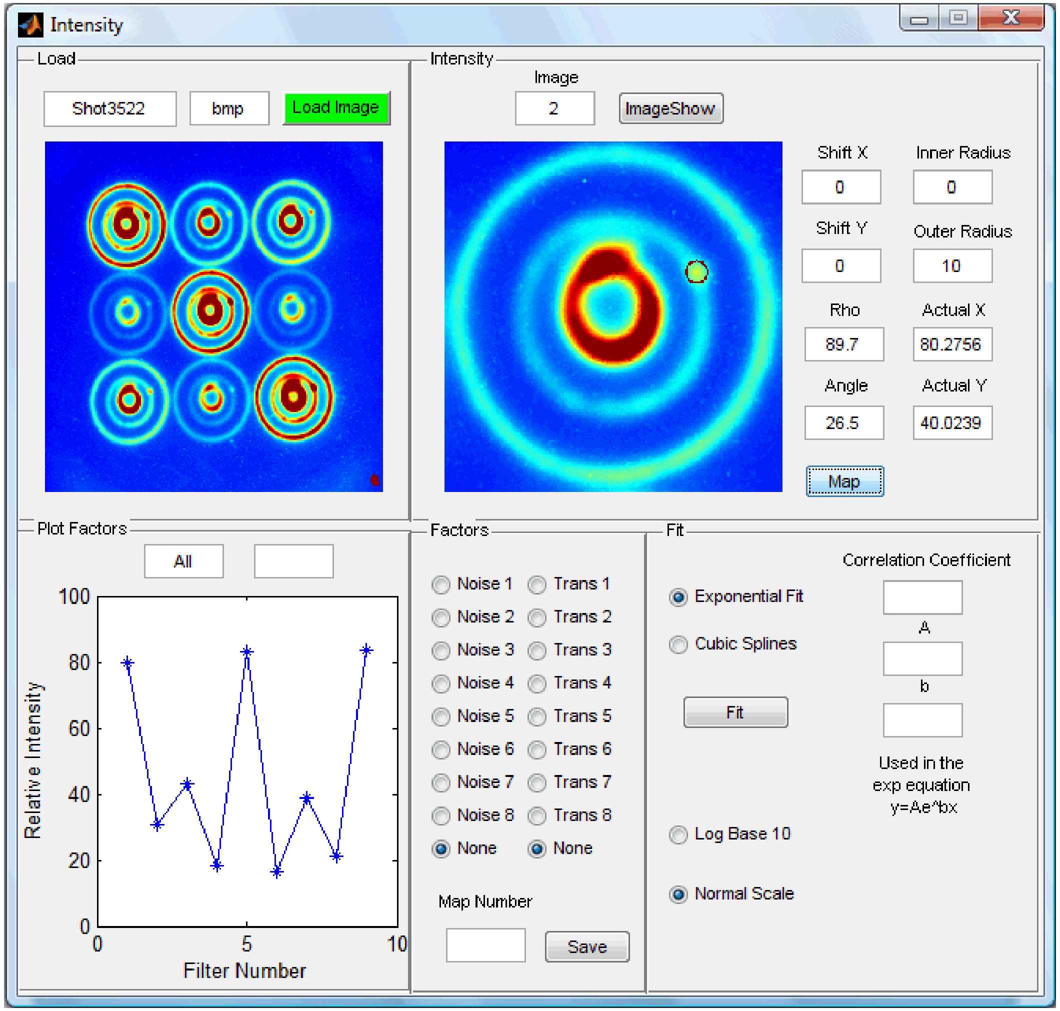


Factors
Load
Shot
bmp
Load Image
Noise
Image
15
ImageShow
Inner Radius
86
Outer Radius
96
Shift X
0
Shift Y
0
Noise 1
Noise 2
Noise 3
Noise 4
Noise 5
Noise 6
Noise 7
Noise 8
Map
Save
Plot Factors
1
Trans
Transmission Factor
Filter Thickness [mm]
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
Trans Factor
Image
4
ImageShow
Inner Radius
0
Outer Radius
75
Shift X
0
Shift Y
0
Trans 1
Trans 2
Trans 3
Trans 4
Trans 5
Trans 6
Trans 7
Trans 8
Map
Save

Intensity GUI

- **Need to obtain image integral to determine intensity**
  - This will be compared to computational results to determine the radiation spectrum from Saturn
- **To obtain image data, an average light intensity is used minus the background noise and multiplied by the transmission factor**

Intensity GUI



Computational Method

- **Goal: Dose-depth profile for a variety of electron source energies and filter materials**
  - Allows comparison between experimental results and computational results, to determine incident energy in each Saturn shot

Computational Tools Overview

- **ADEPT Code Package: One-Dimensional Electron-Photon Transport by Discrete Ordinates**
  - Developed at SNL
  - Includes:
    - *CEPXS: multigroup electron-photon cross section generating code*
    - *ONELD discrete ordinates code (developed at LANL)*
    - *PRE1D and POST1D: preprocessor and postprocessor codes for use with ONELD code*
- **MATLAB: Matrix Laboratory**
  - Used for analyzing ADEPT Output
  - Formatted with Perl script before using MATLAB module

ADEPT Overview: Input Parameters

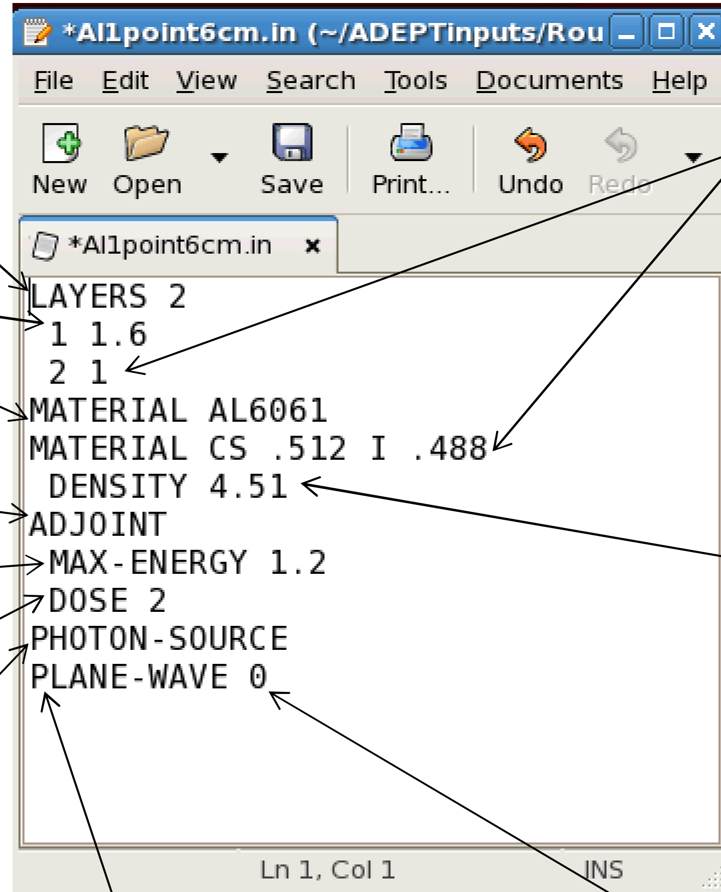
The radiation will be incident on two layers of material.

The first layer on which the radiation is incident is 1.6 cm of Aluminum 6061. (Filter Layer)

Adjoint Transport

Maximum energy of the adjoint response function: 1.2 MeV

The response function is the dose in layer 2 (the CsI layer).



The second layer is 1 cm of CsI with a 0.512 weight fraction of Cs, and a 0.488 weight fraction of I. (Scintillator Layer)

The density of CsI is 4.51 g/cm^3.

Source particles are photons.

The source is a plane wave.

The angle of incidence relative to the surface normal of the plane wave is 0°

ADEPT Overview: Output

Energy (MeV)	Dose (MeV-cm^2/g-photon)
1.2000	3.1772E-02
8.8876E-01	2.8234E-02
6.5824E-01	2.6087E-02
4.8752E-01	2.5525E-02
3.6107E-01	2.6385E-02
2.6742E-01	2.7902E-02
1.9806E-01	2.7946E-02
1.0864E-01	1.7192E-02
8.0465E-02	1.0959E-02
5.9595E-02	5.7333E-03
2.8845E-02	3.0559E-05
1.8845E-02	1.4752E-10
3.6725E-03	-7.3383E-39

Negative dose numbers were discarded.

Table 1: ADEPT Output—Response Function

Computational Method

- **Start with cumulative photon spectrum that corresponds to each source electron energy (obtained from Integrated Tiger Series software)**

Energy (MeV)	Cumulative Distribution Function
0.01	0
0.0292	0.1375
0.0418	0.2505
0.0547	0.3493
0.0654	0.5245
0.1338	0.7483
0.3912	0.9544
0.8	1

Table 2: Cumulative Photon Spectrum for 0.8 MeV Source Electrons

Computational Method

- **To find energy deposition on each filter by photons:**
  - **# of photons in particular energy bin X dose corresponding to that energy**
    - *Issue 1: photon energy bins in cumulative photon spectrum are different from the photon energy bins in the response function in the ADEPT output—must interpolate cumulative photon spectrum on energy bins from ADEPT output*
      - MATLAB linear interpolation code
      - Linear interpolation was a good (but not perfect) approximation
    - *Issue 2: given photon spectrum is cumulative—must break down the cumulative photon spectrum to obtain the photon number distribution in each energy bin after interpolating*
      - Simply subtract the number of photons in all of the previous energy bins
      - This was also done using MATLAB

Computational Method

- This process gives the energy deposition on each filter by photons in each energy bin—to calculate the total dose, simply sum the energy depositions from each bin
- Doing this for each thickness of a particular type of filter will give a dose-depth profile for a given electron source energy
- This is done for each of the electron source energies considered
- This is also done for each filter material considered

Computational Method: Results

- **Dose-depth profiles for different incident electron energies for each material considered:**
  - **Tungsten**
  - **Copper**
  - **Aluminum**

Computational Method: Results

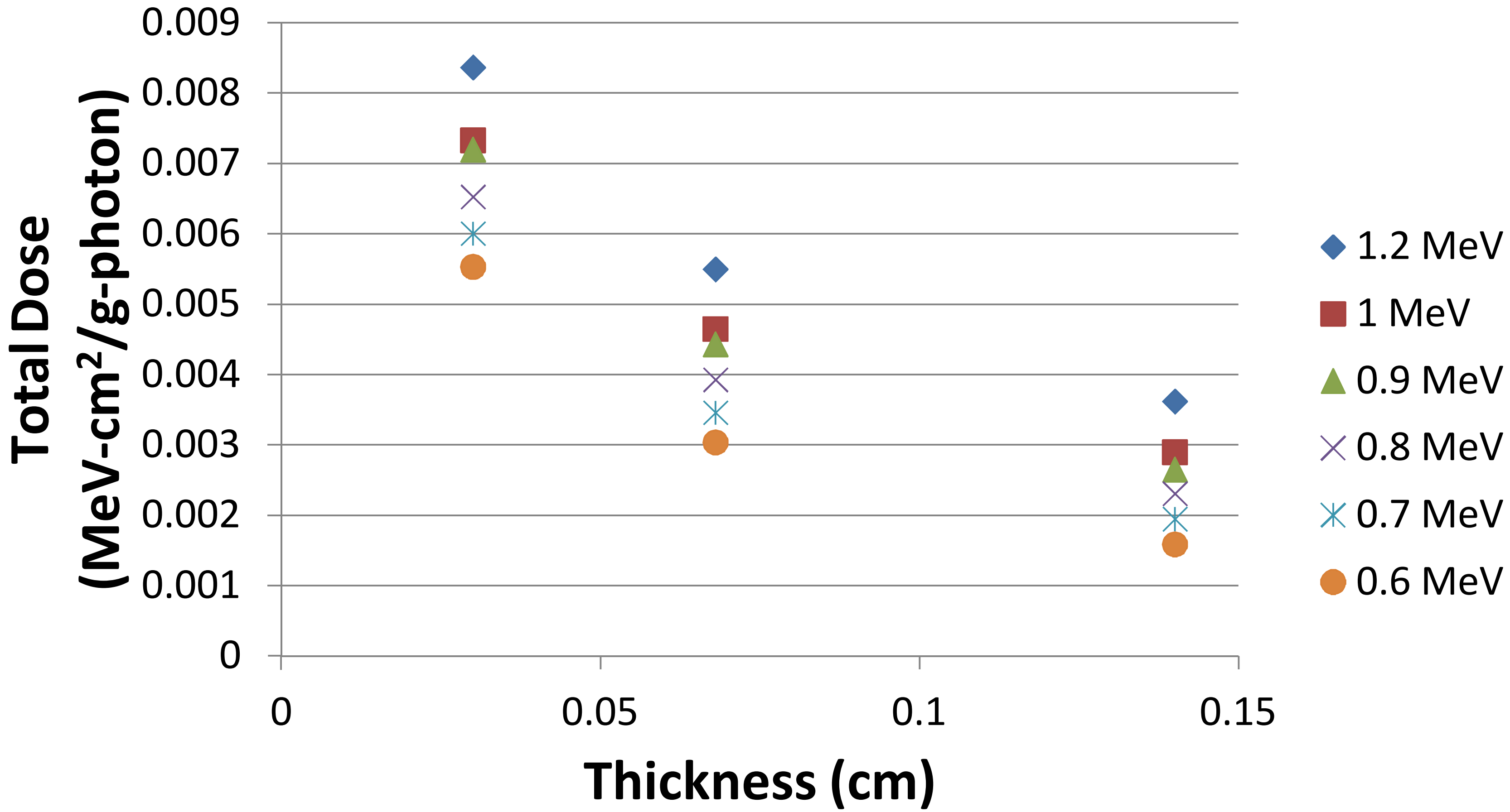


Chart 1: Tungsten Dose-Depth Profiles for Indicated Electron Source Energies

Computational Method: Results

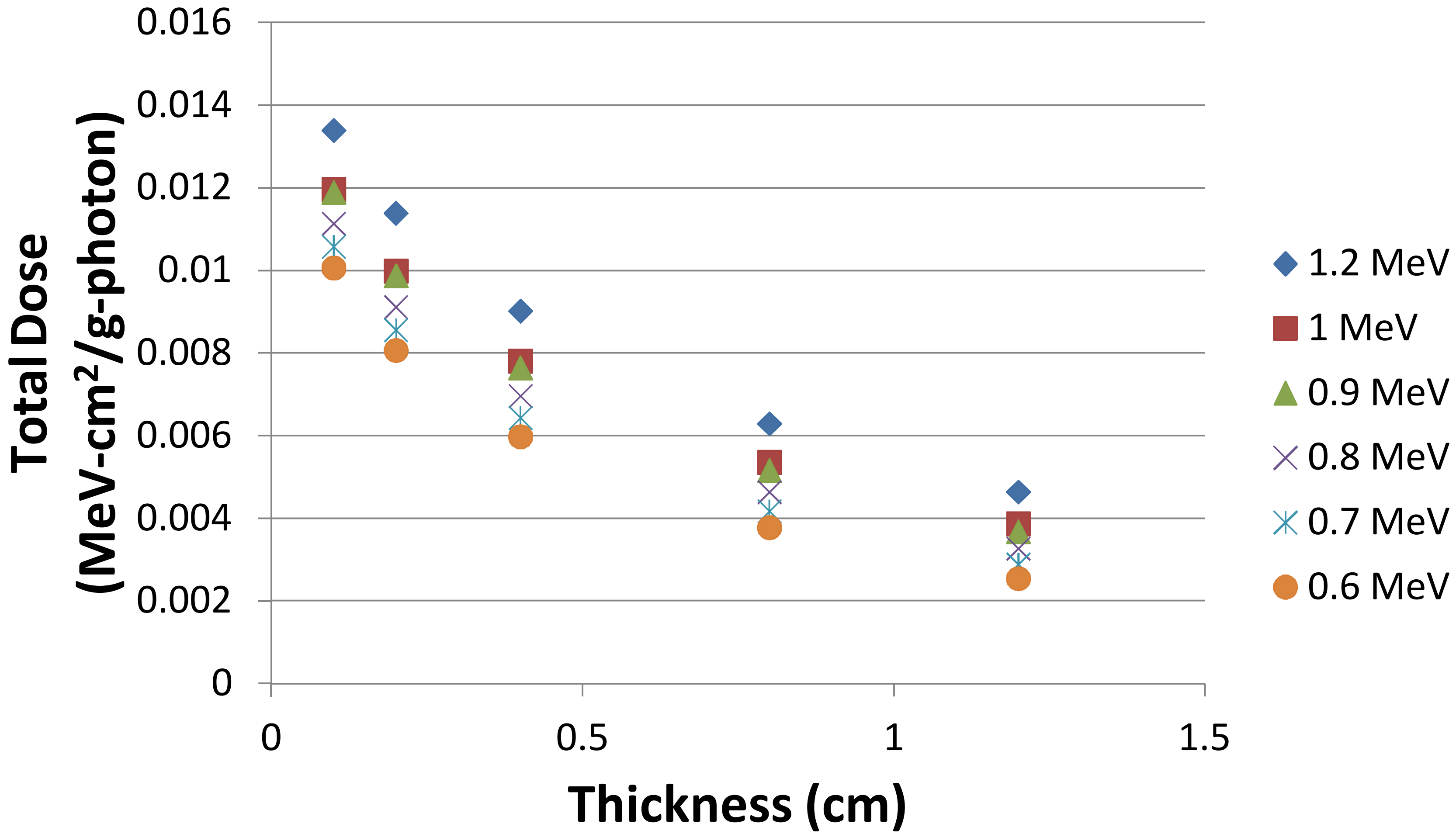


Chart 2: Copper Dose-Depth Profiles for Indicated Electron Source Energies

Computational Method: Results

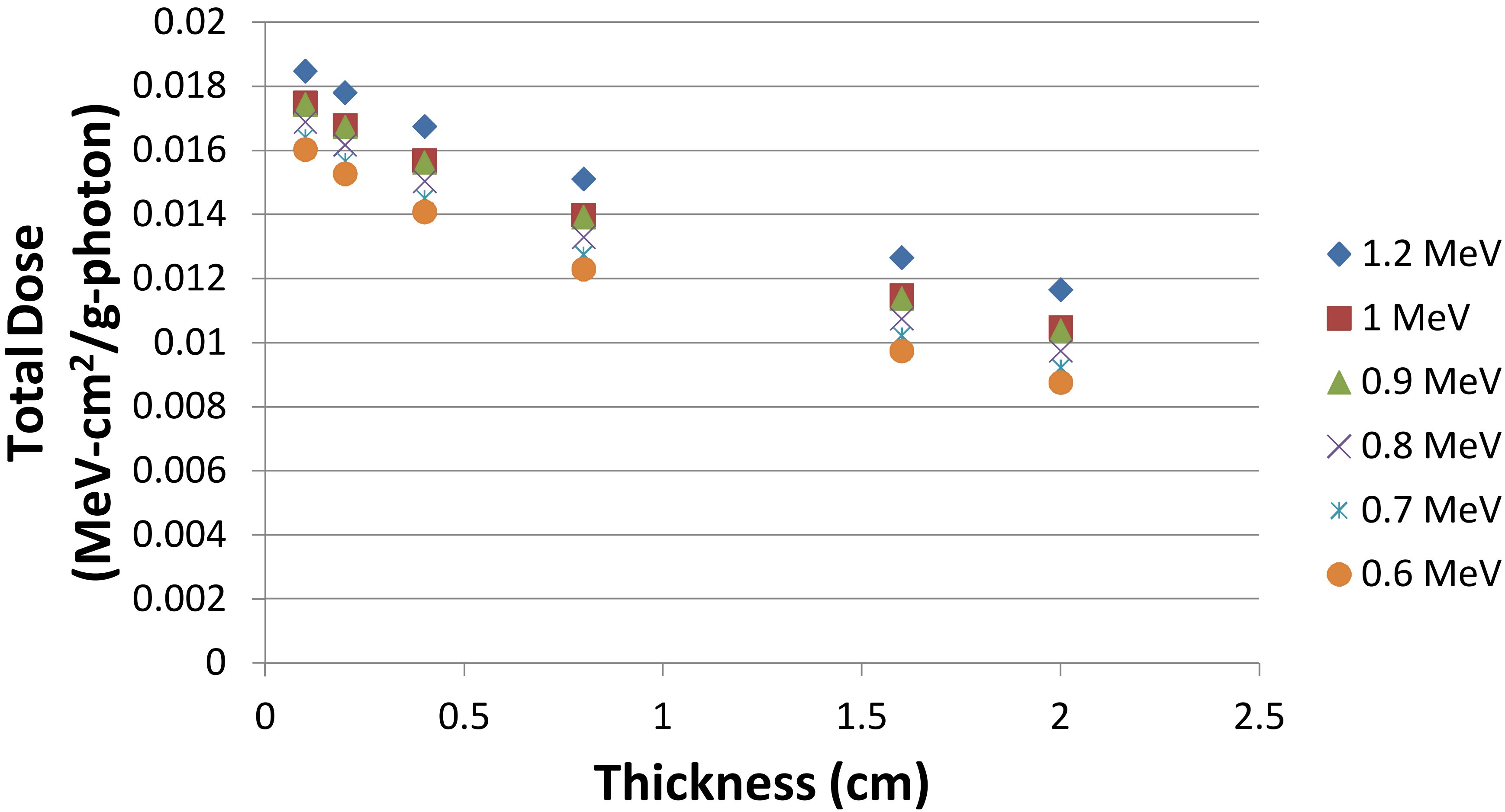


Chart 3: Aluminum Dose-Depth Profiles for Indicated Electron Source Energies

Next Steps

- **Continue to process Saturn shot images**
- **Compare image processing results with computational results**