CAD SHIELDING ANALYSIS OF THE INTERNATIONAL SPACE STATION

N. Stoffle[1], A. Welton[1], J. Barzilla[1], R. Gaza[1],
K. Lee [2], N. Zapp [2]

[1] Lockheed Martin, Houston, TX
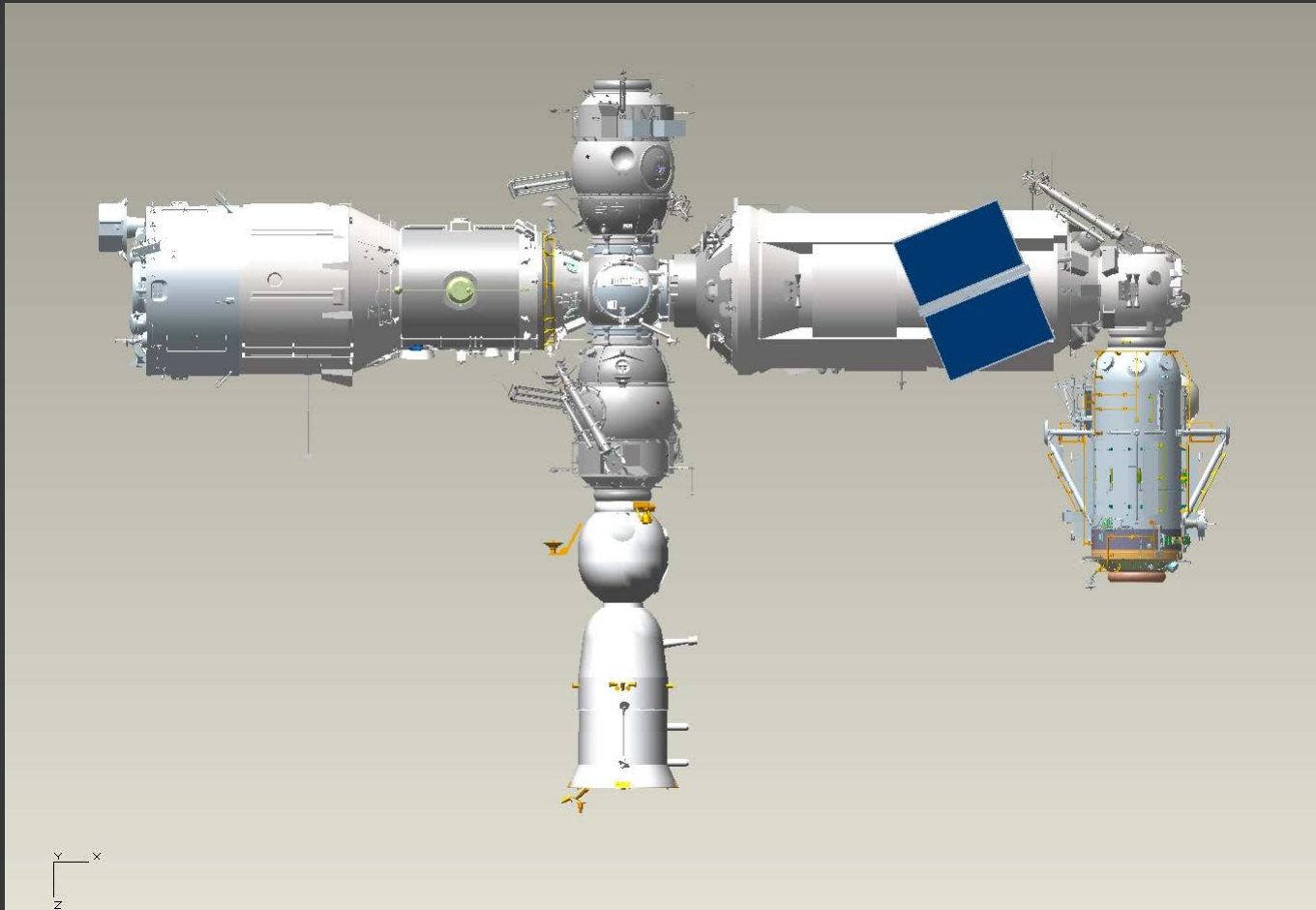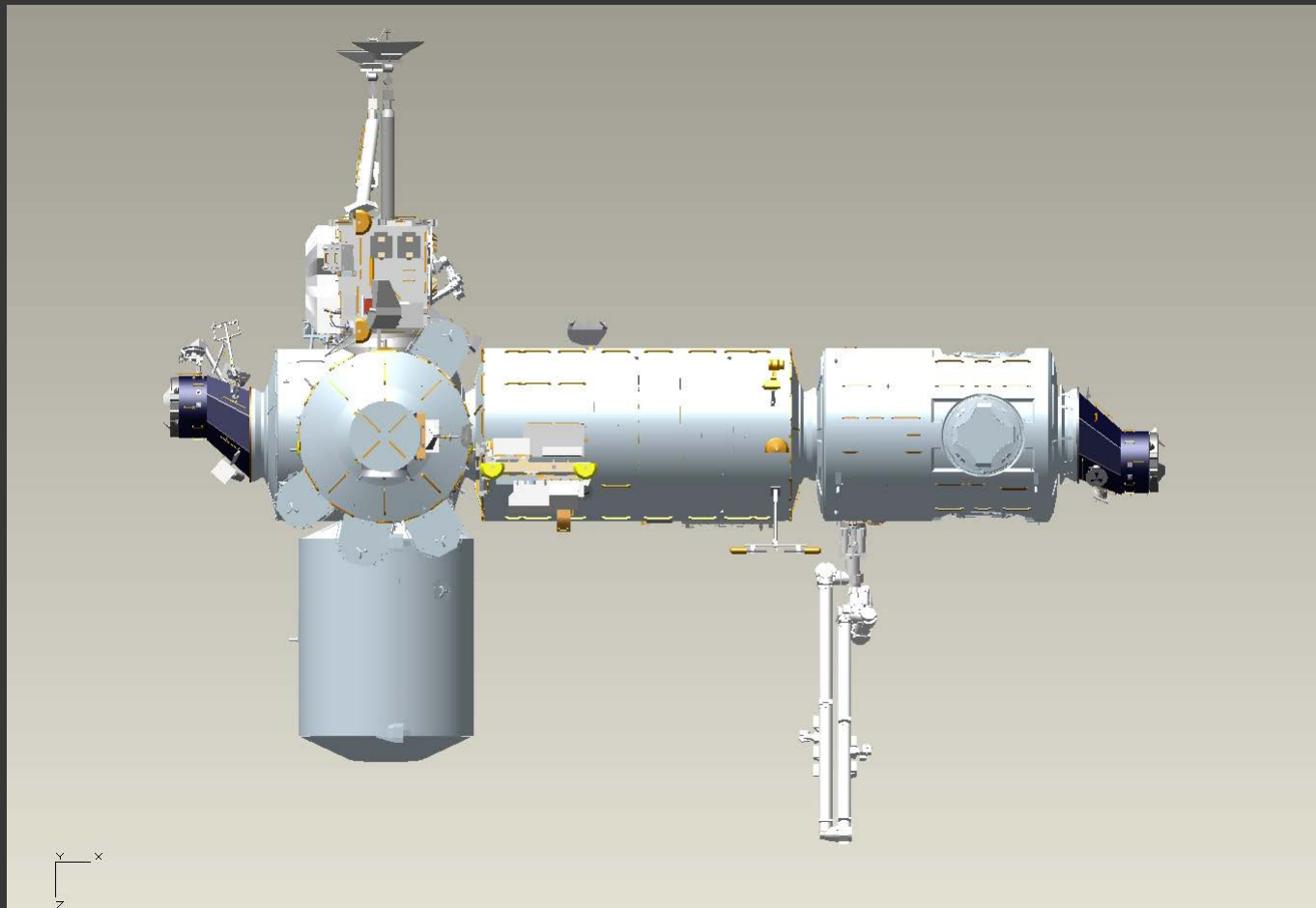[2] NASA Johnson Space Center, Houston, TX

Motivation

- Analysis of shielding strategies
- Develop capability to assess vehicle designs
- Ultimate goal is to provide near real-time assessment of space weather impact to vehicle crew
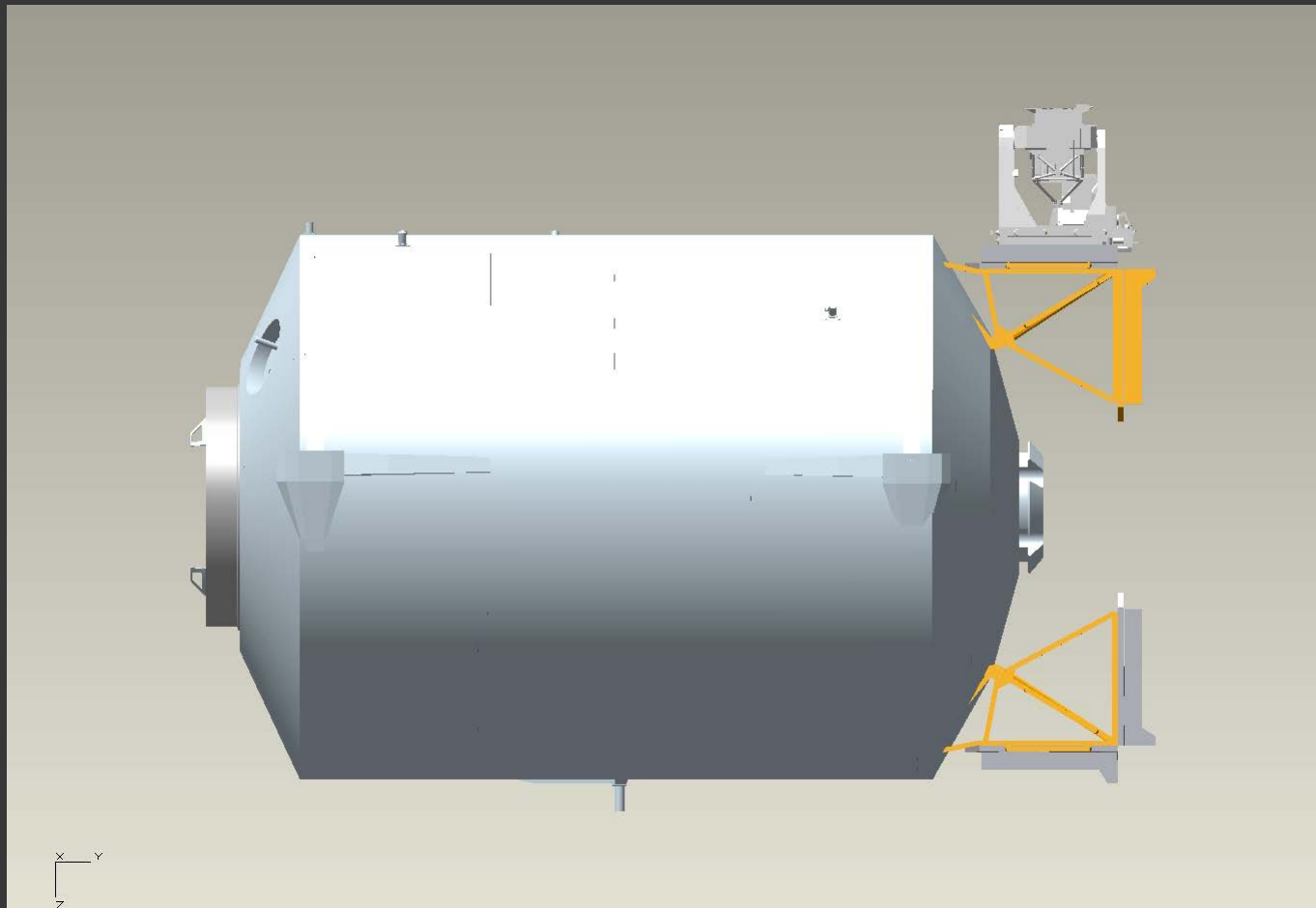
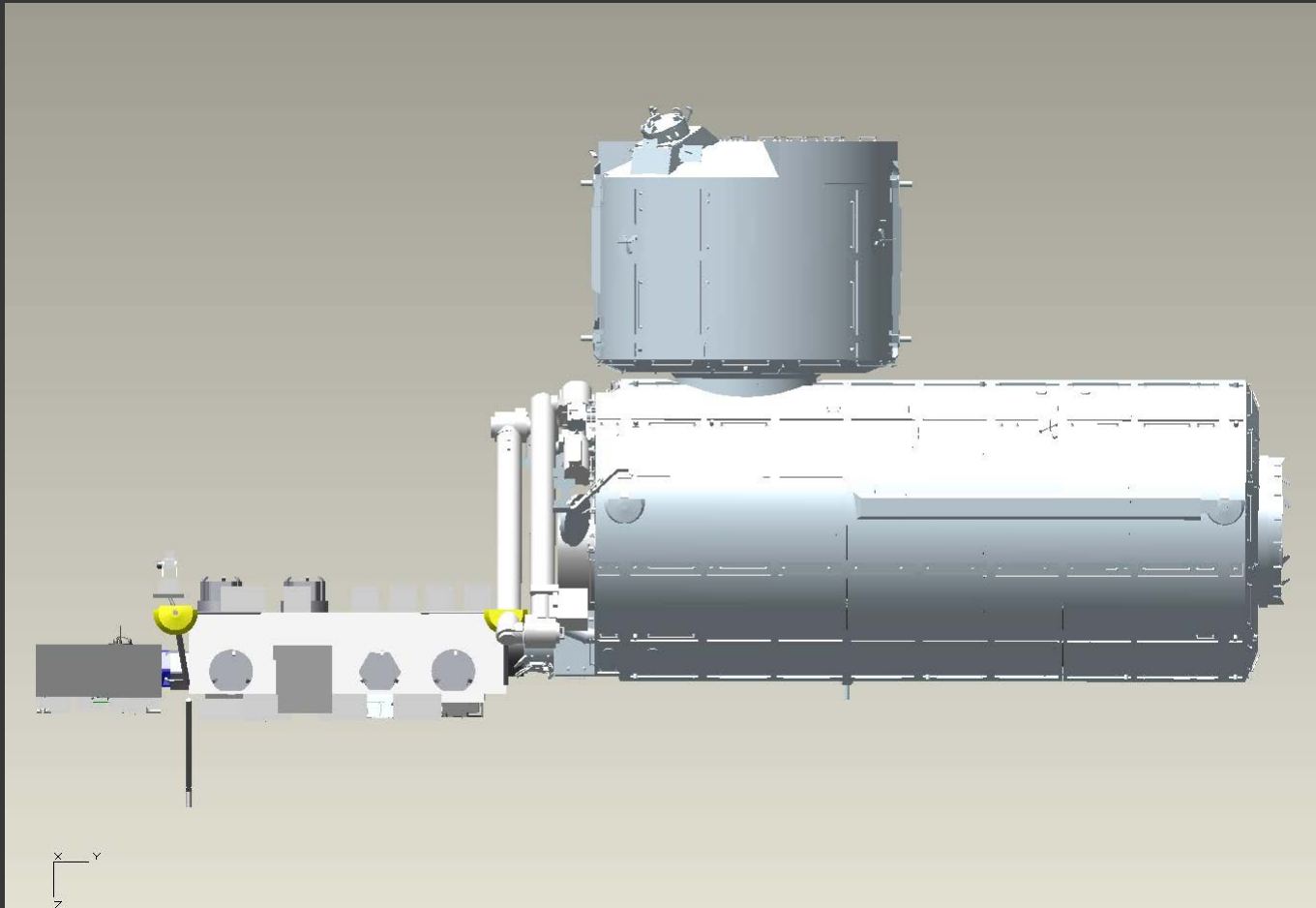# CAD Model Assembly
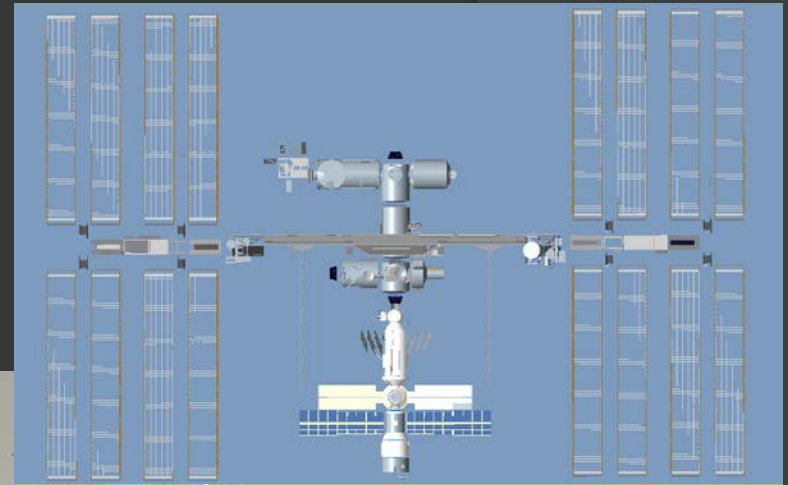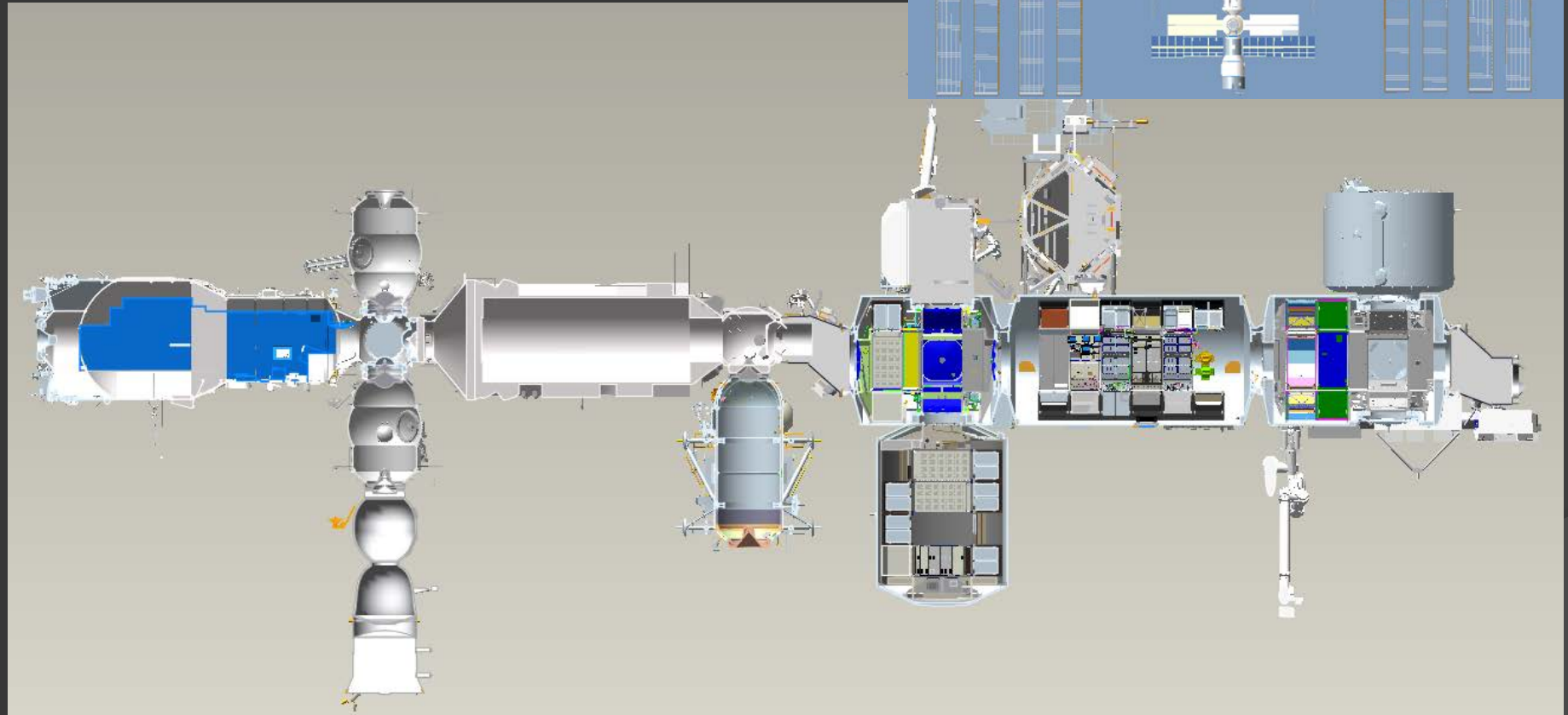
Russian Segment

US Segment

Columbus

JEM

ISS Configuration
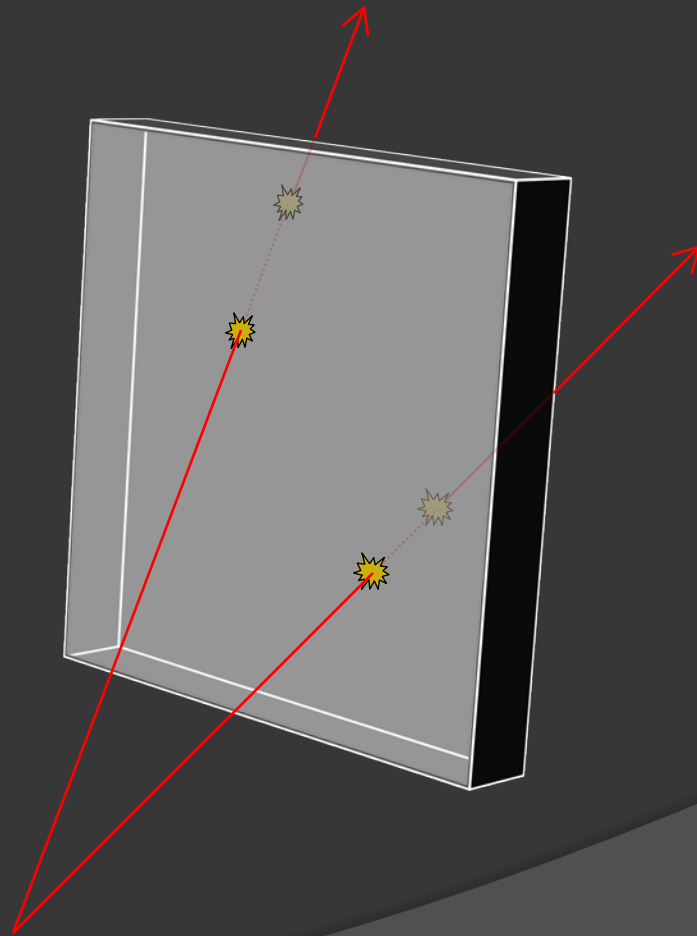
Shielding Analysis Process

Model Ray Trace

Ray Direction

Intersected Part Name

Entry and Exit points

Association of Material Info

$$T_{eq} = T_m * \rho_m * R_{Al}/R_m$$

Density

50MeV proton Range

Output


```
1   Shield file for full model
2   The following are the order of the output data in each row.
3   Theta, Phi, Placeholder, Aluminum Equivalent Thickness (g/cm2)
4   Number of Rays: 10000
5   x: -1103.38   y: -0.839281   z: 163.19
6   ==> Aluminum <==
7
8
9   0.997335     -0.130021    0    42.236
10  2.15112 0.746835     0    24.2212
11  1.87498 -0.856157    0    59.3308
12  1.14271 0.173715     0    13.8905
13  2.44096 0.0321553    0    22.8057
14  2.0117  -1.05334     0    41.6385
15  0.645341     -0.538259    0    2.68607
16  0.623566     0.103448     0    96.0866
17  2.78039 1.48189 0    19.6081
18  1.10677 -1.23662     0    11.5822
19  1.00225 -0.26687     0    7.8391
20  2.87835 -0.610345    0    29.3227
21  1.98701 -0.341752    0    26.4583
22  1.99895 1.36891 0    11.1834
23  2.52488 1.07079 0    11.6579
24  2.17302 -1.00015     0    12.8424
25  2.16155 -0.65529     0    22.0723
26  1.41798 -0.0457424   0    41.0452
27  0.62105 -0.435377    0    7.12241
28  1.43084 1.16349 0    11.6848
29  2.64203 -1.01026     0    11.3638
30  3.11351 1.38211 0    18.8595
```

```
1   Shield file for full model
2   The following are the order of the output data in each row.
3   Theta, Phi, Placeholder, Polyethylene Equivalent Thickness (g/cm2)
4   Number of Rays: 10000
5   x: -1103.38   y: -0.839281   z: 163.19
6   ==> Poly <==
7
8
9   0.997335     -0.130021    0    0
10  2.15112 0.746835     0    0
11  1.87498 -0.856157    0    0
12  1.14271 0.173715     0    0
13  2.44096 0.0321553    0    0
14  2.0117  -1.05334     0    0
15  0.645341     -0.538259    0    0
16  0.623566     0.103448     0    0
17  2.78039 1.48189 0    0
18  1.10677 -1.23662     0    0
19  1.00225 -0.26687     0    0
20  2.87835 -0.610345    0    0
21  1.98701 -0.341752    0    0
22  1.99895 1.36891 0    0
23  2.52488 1.07079 0    0
24  2.17302 -1.00015     0    0
25  2.16155 -0.65529     0    0
26  1.41798 -0.0457424   0    0
27  0.62105 -0.435377    0    0
28  1.43084 1.16349 0    0
29  2.64203 -1.01026     0    0
30  3.11351 1.38211 0    0
31  0.646131     0.906018     0    0
```
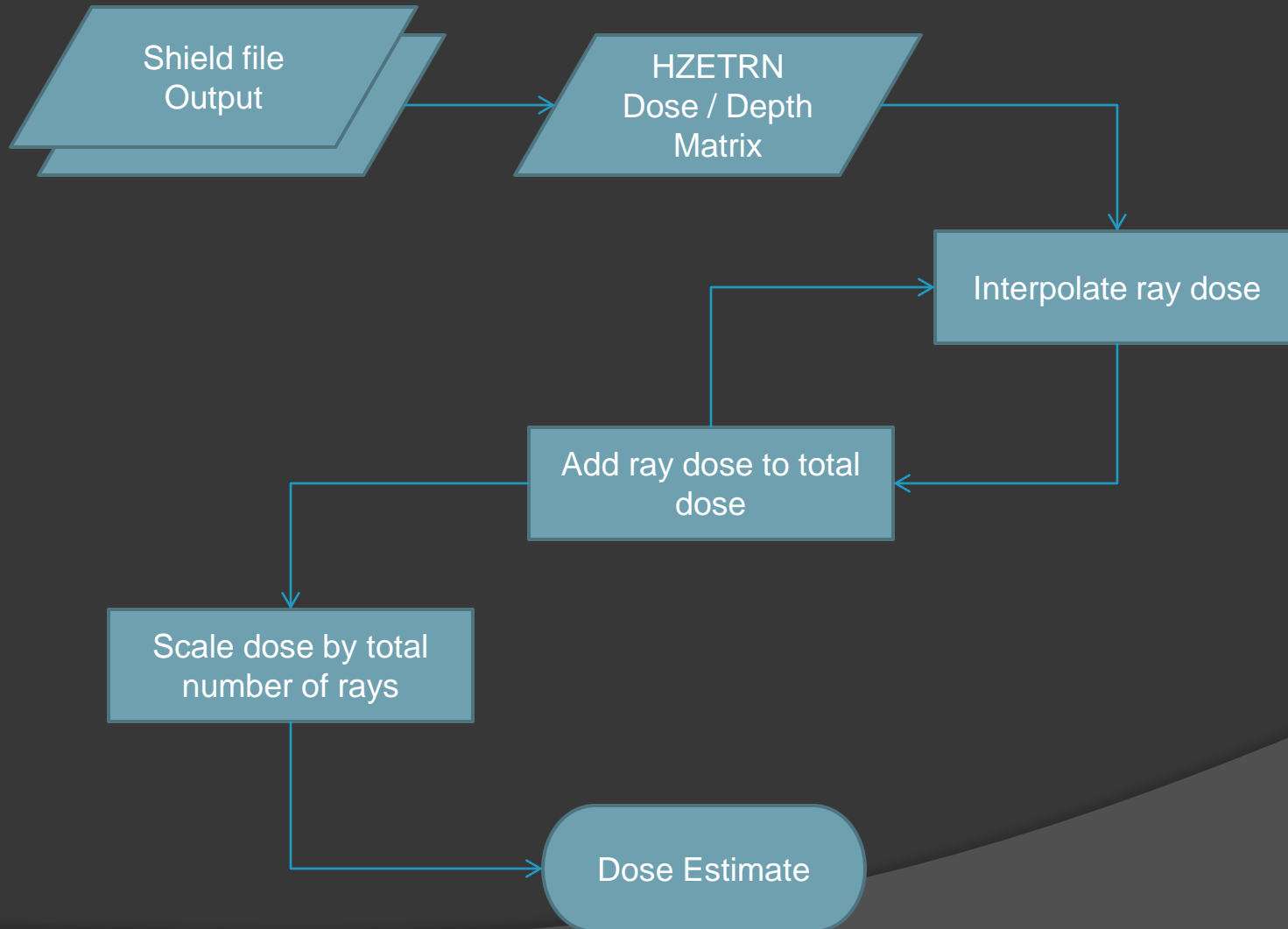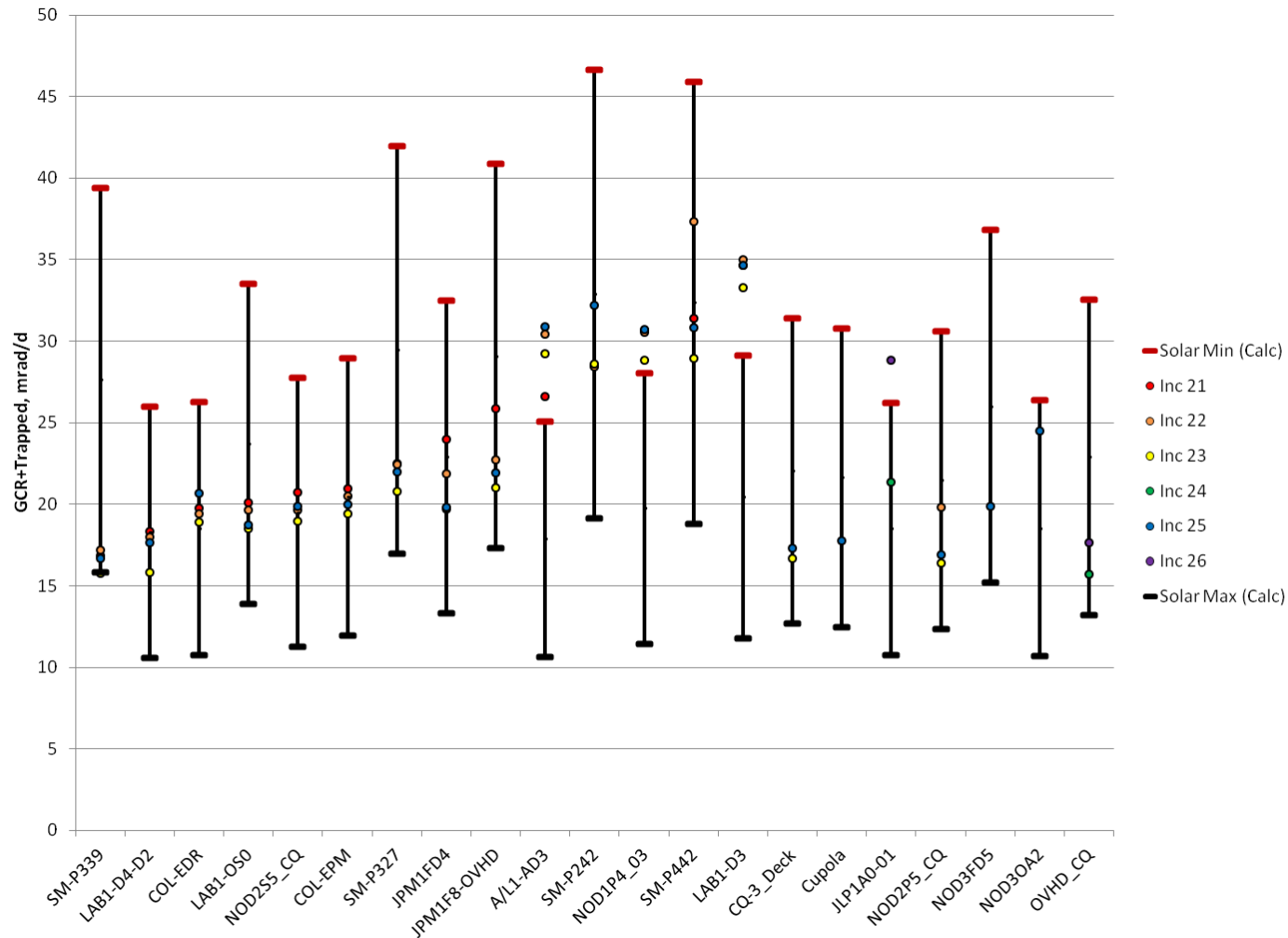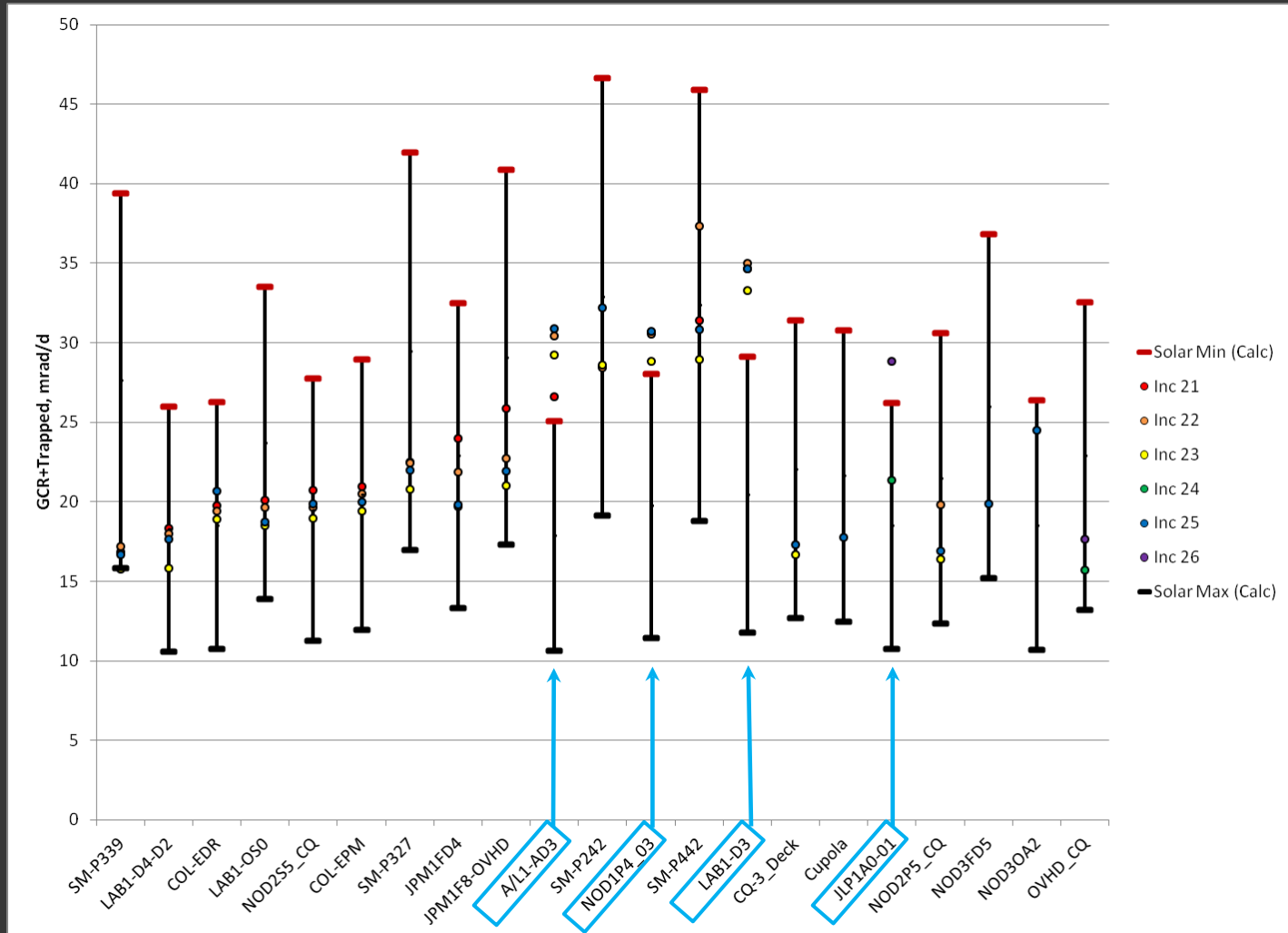
Visualizations
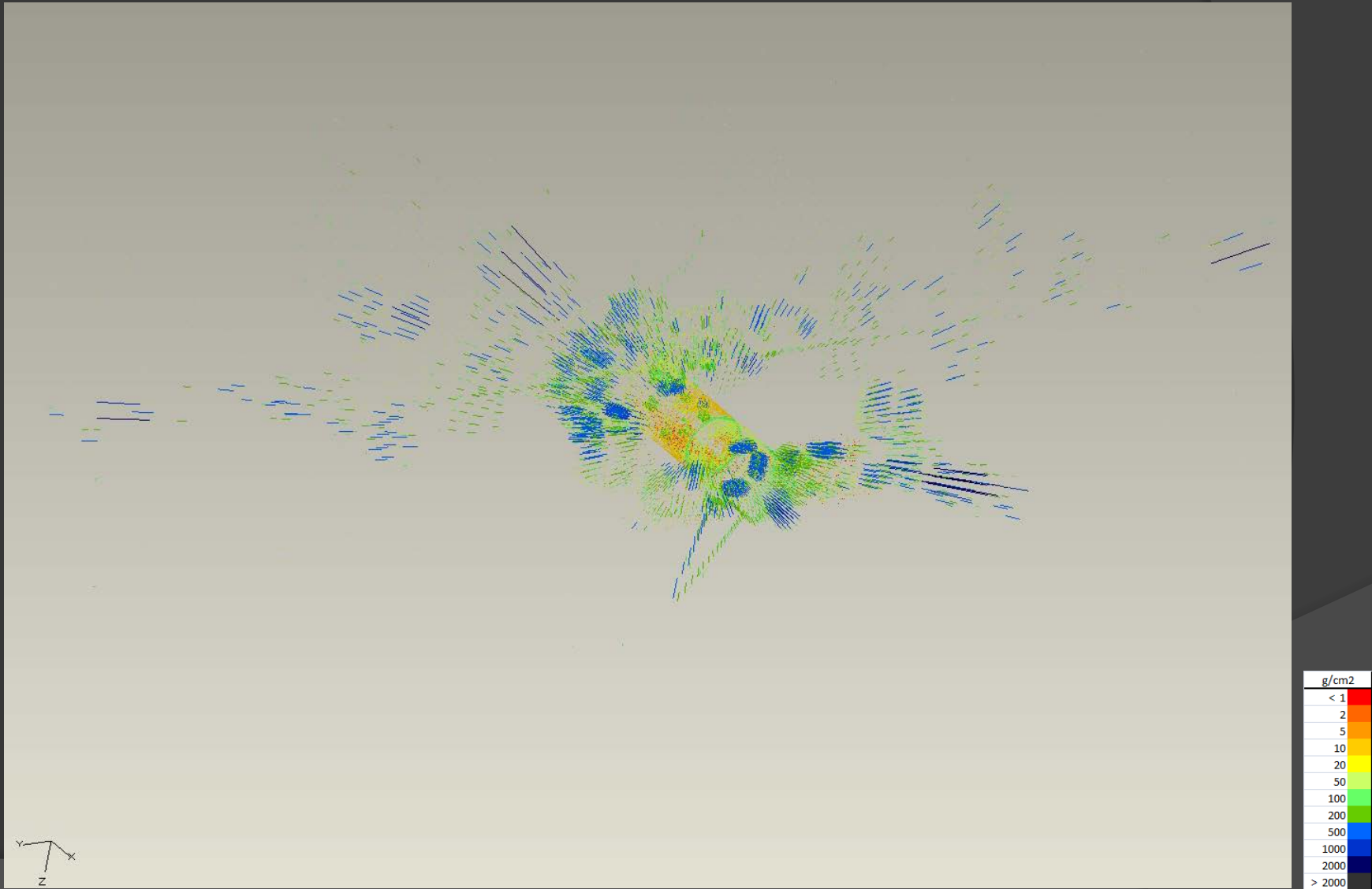
Visualizations
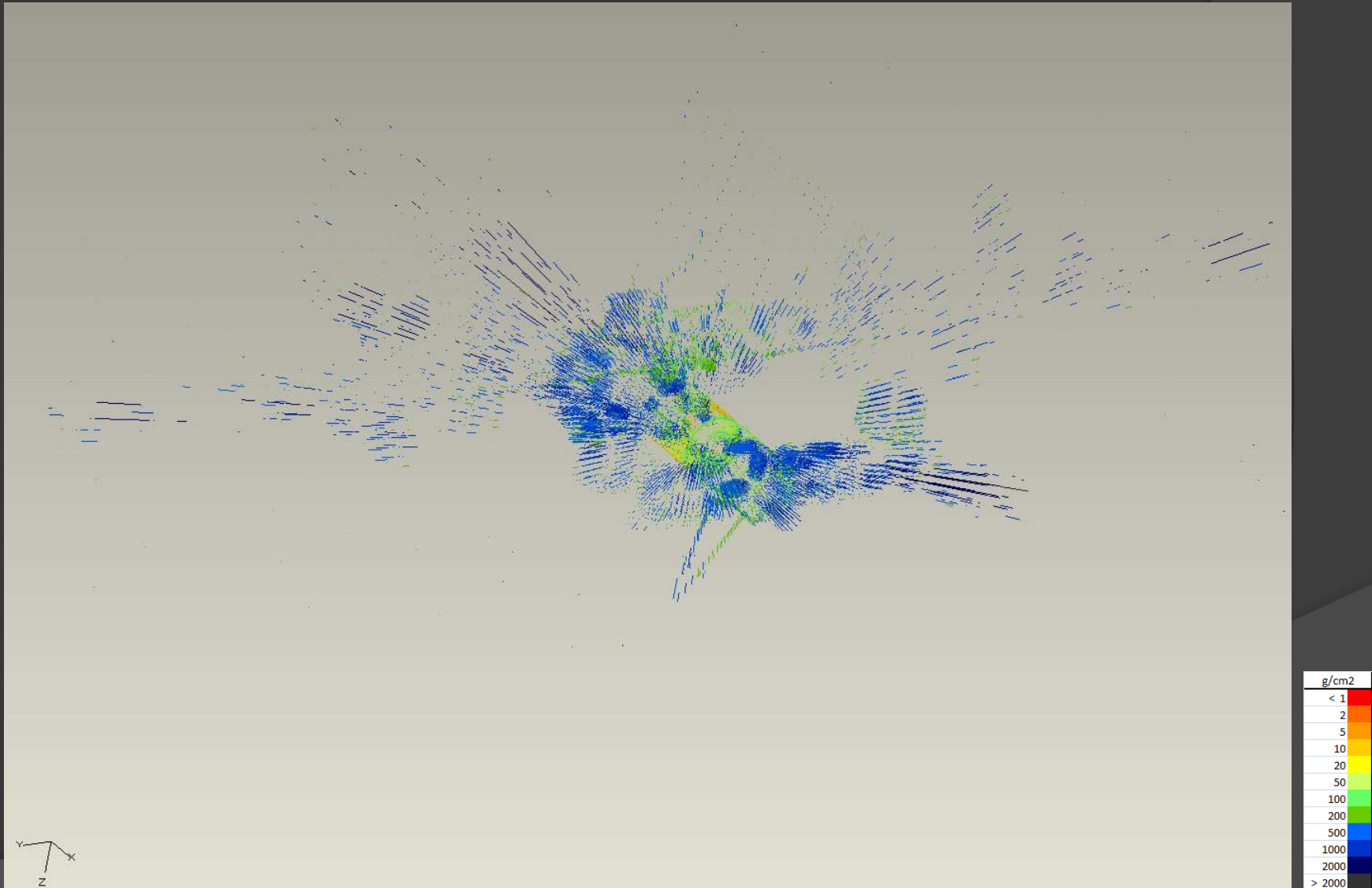
Single Point Dose Estimation
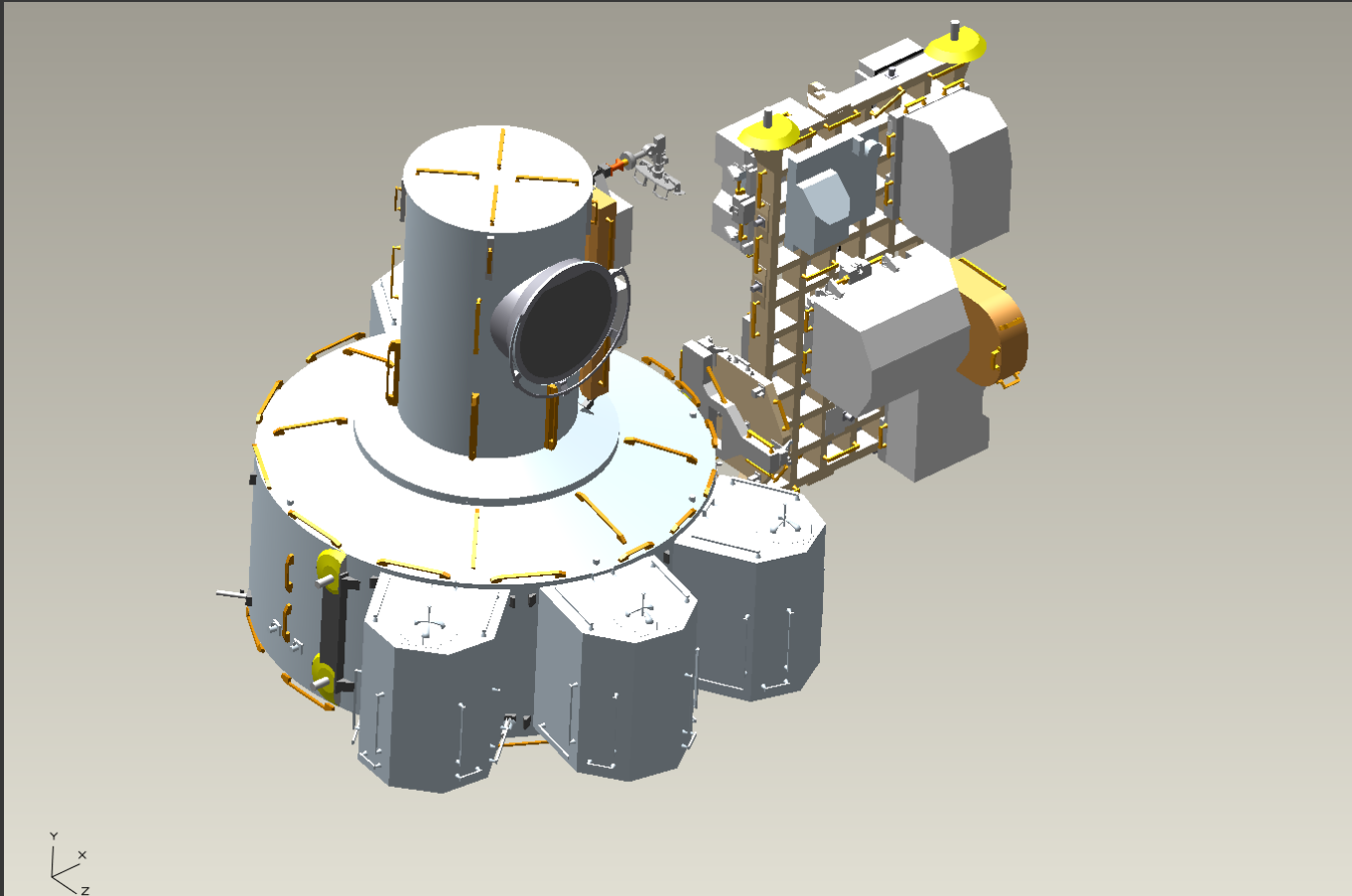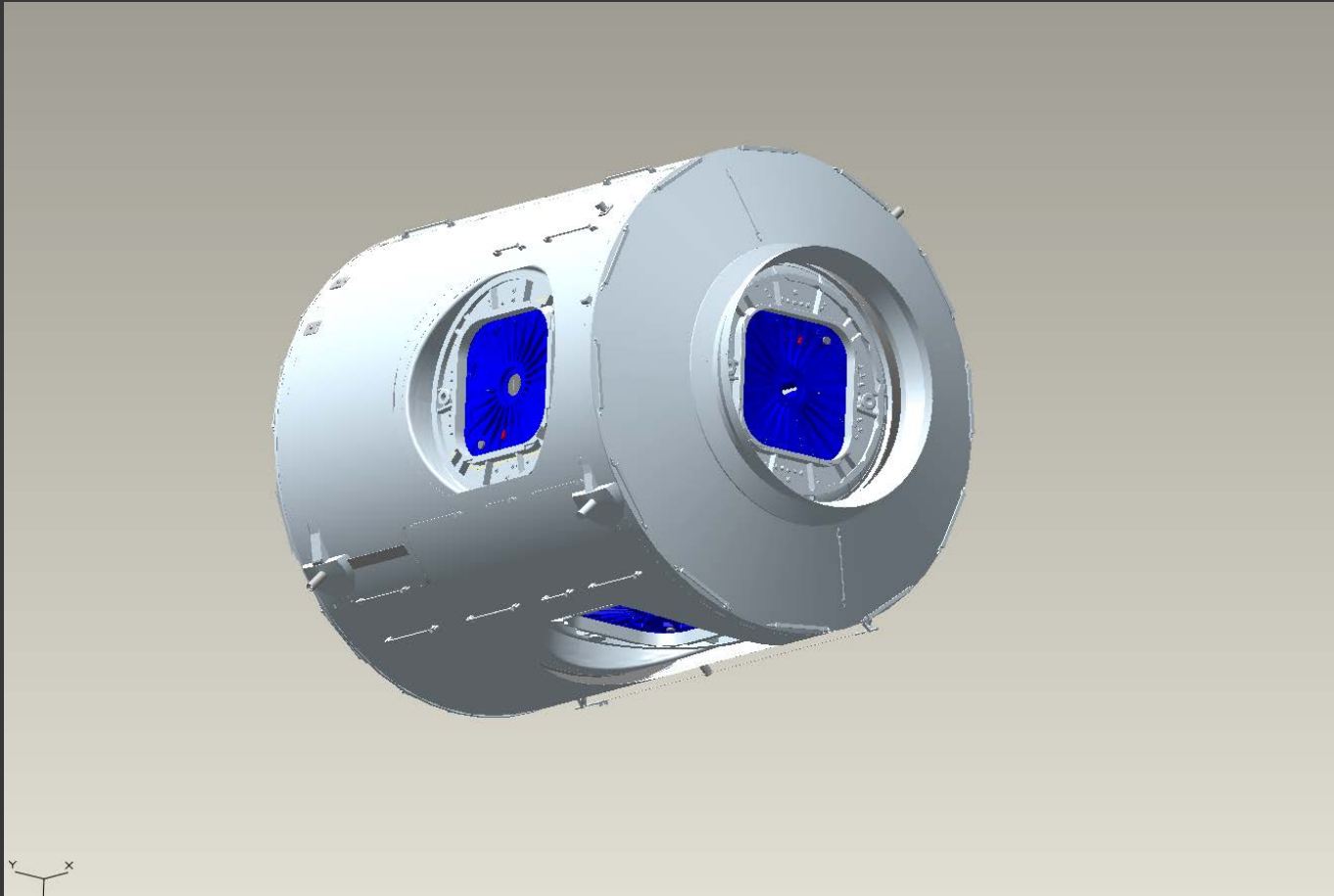
Comparison to RAM Data
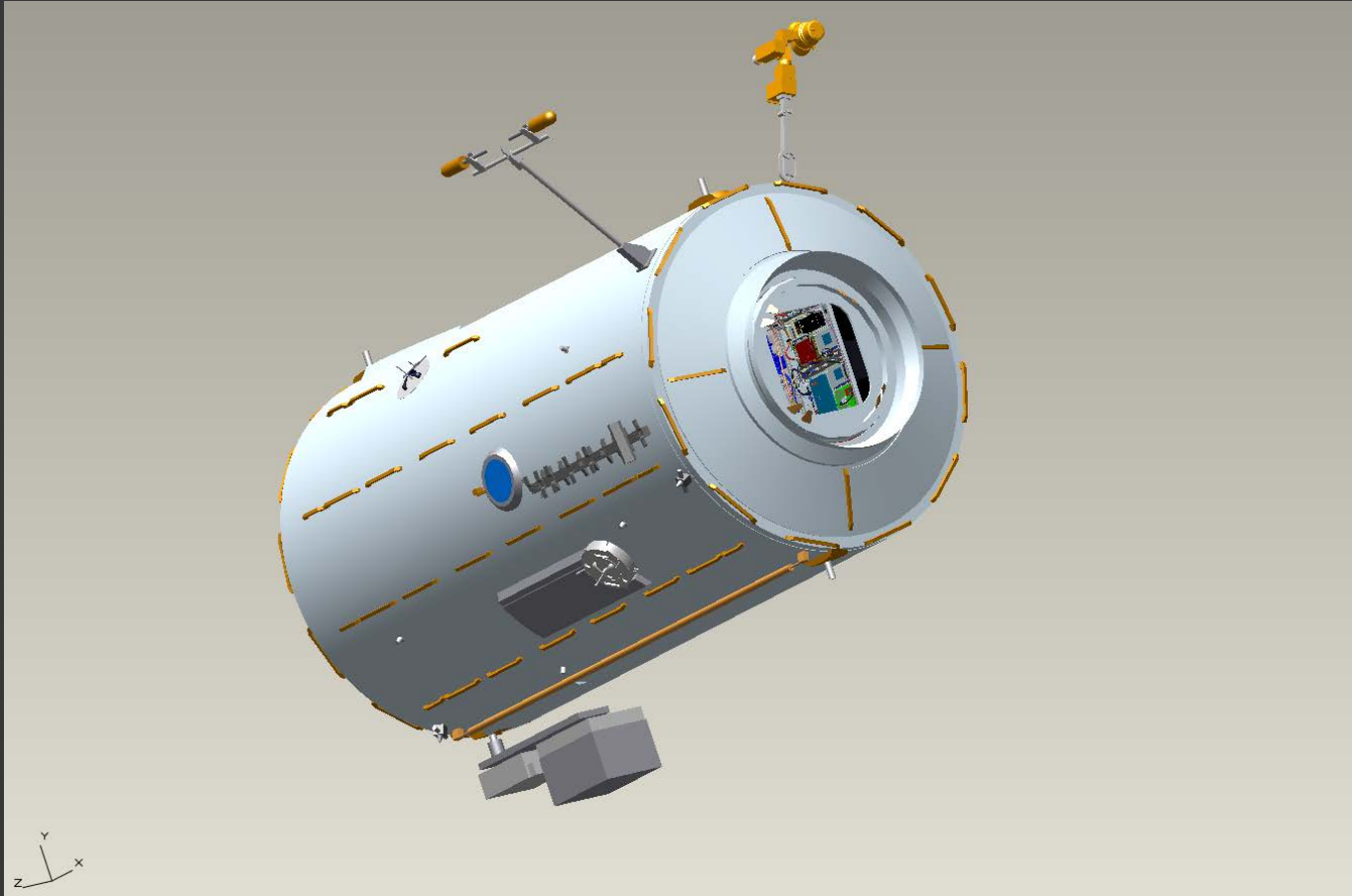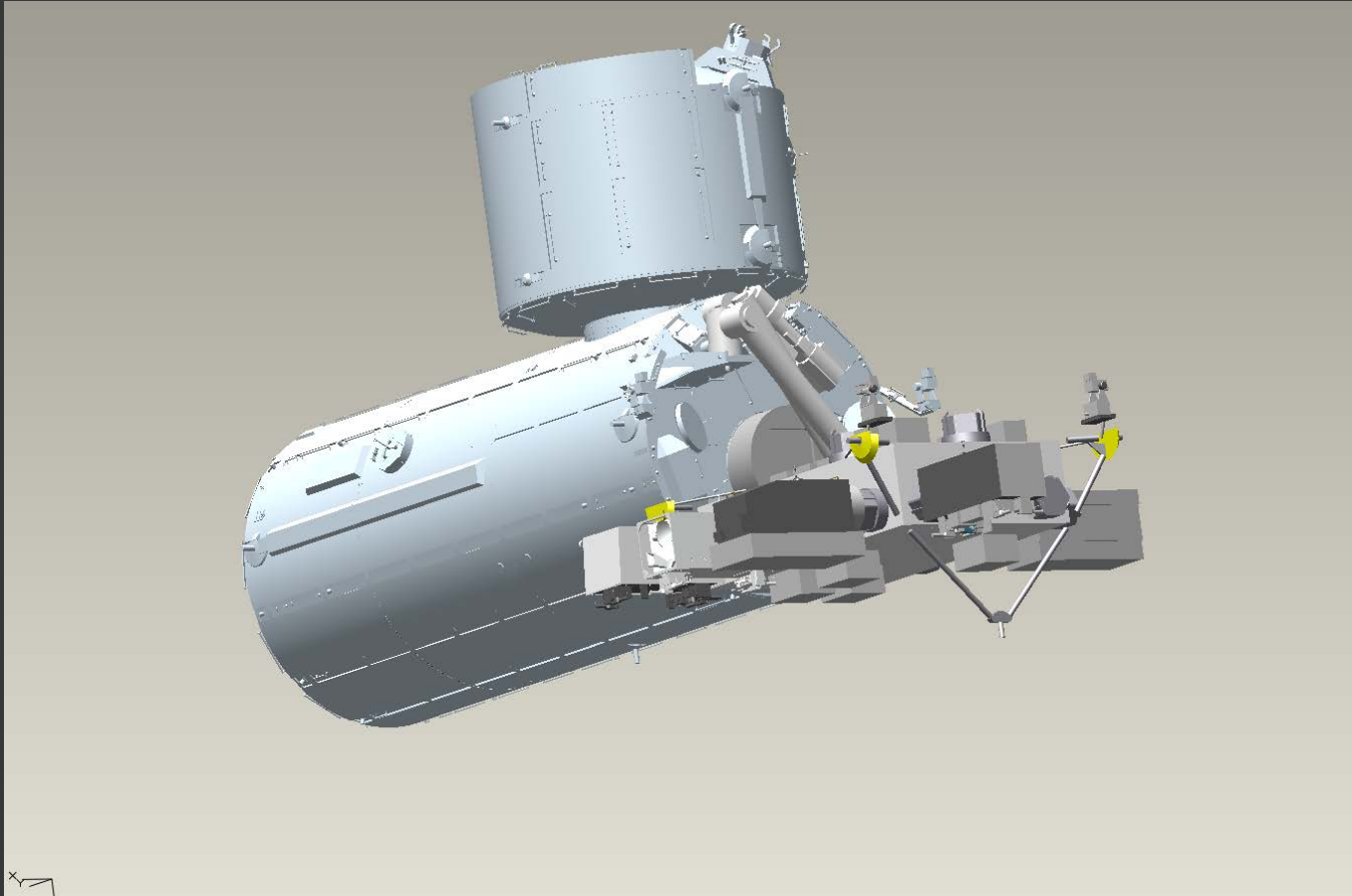
Comparison to RAM Data
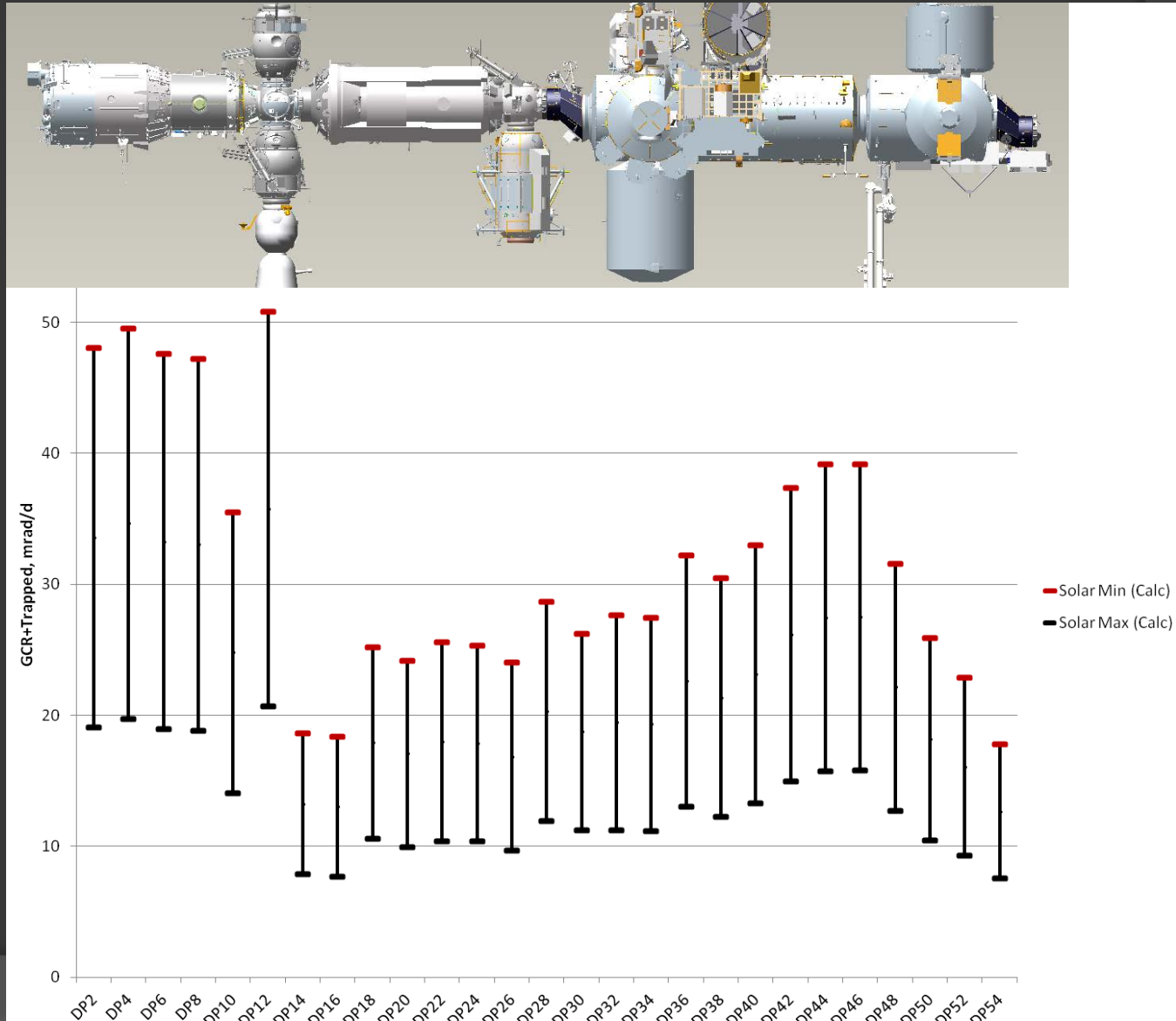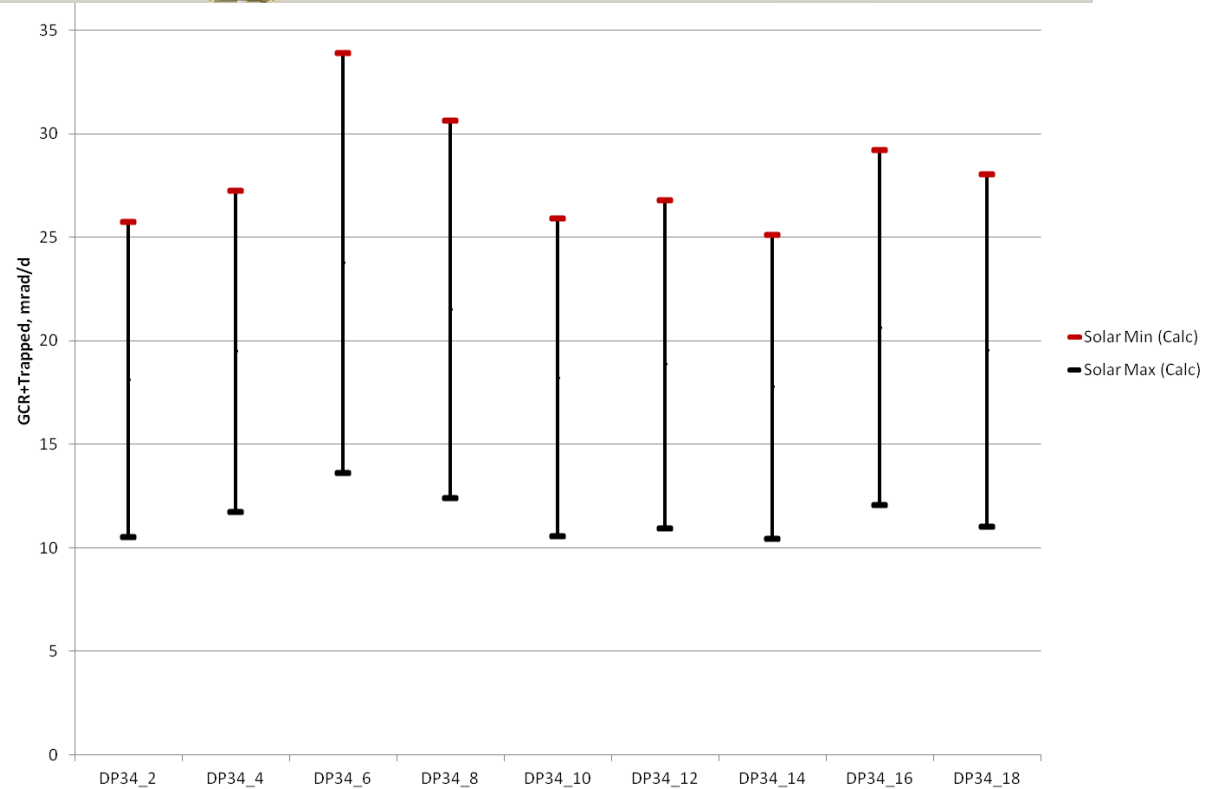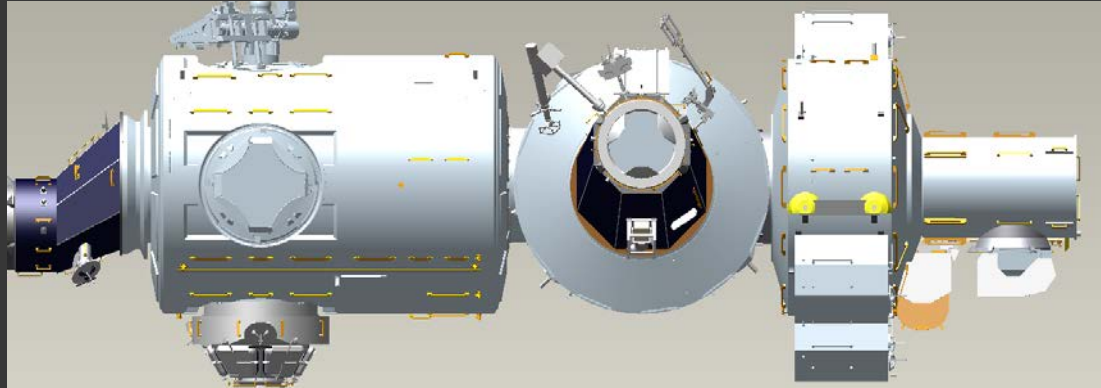
A/L1-AD3

NOD1P4_03

LAB1-D3
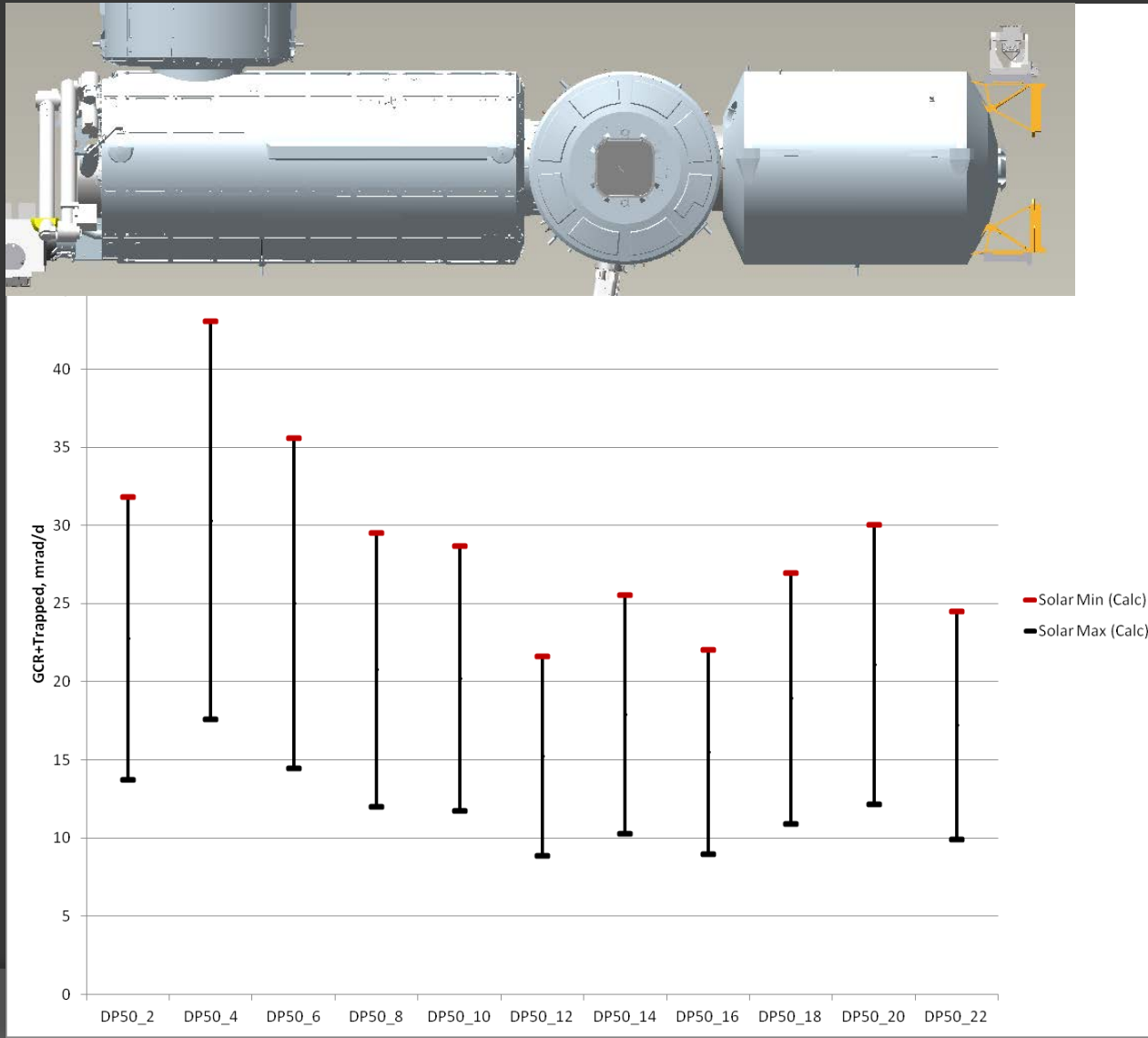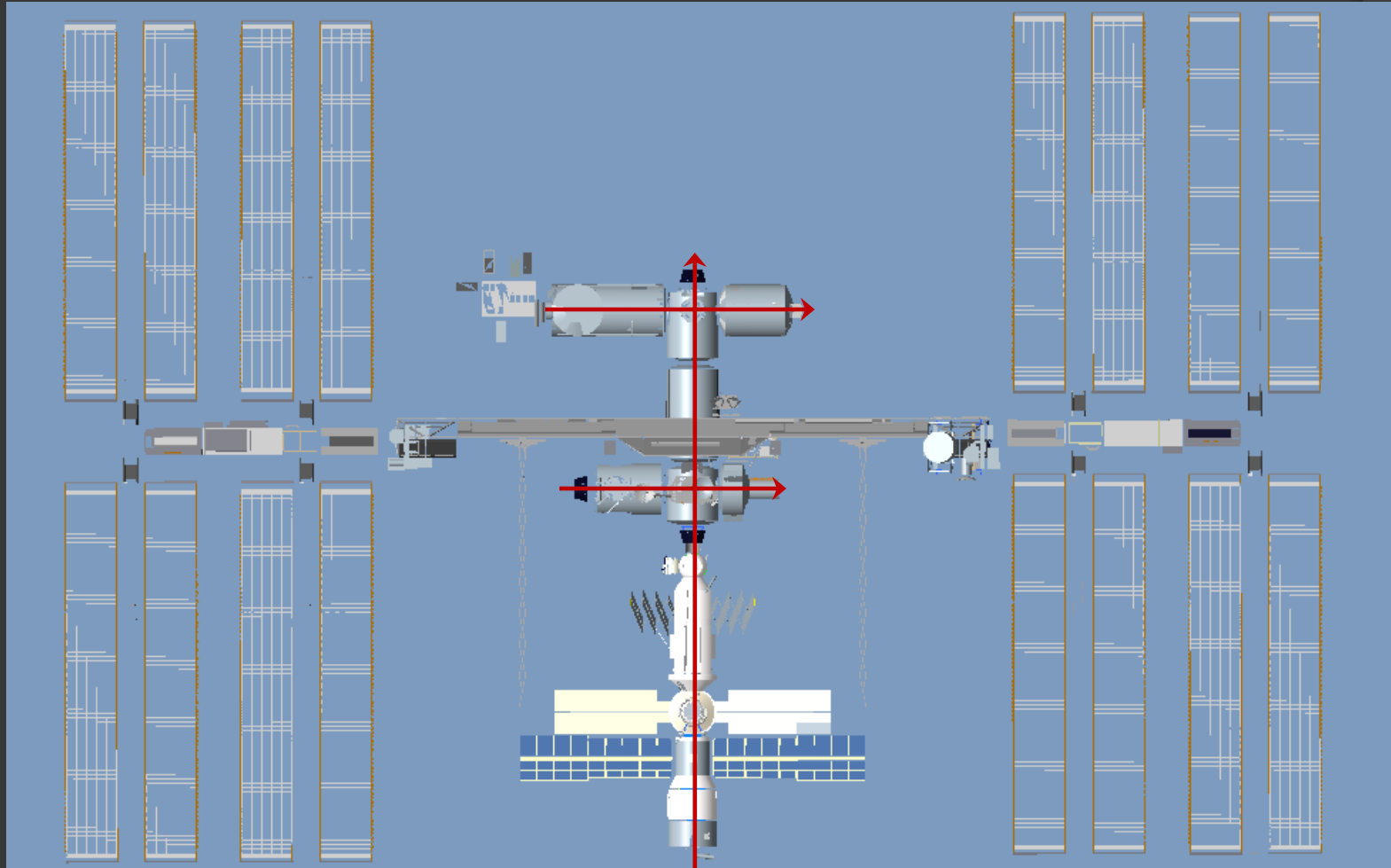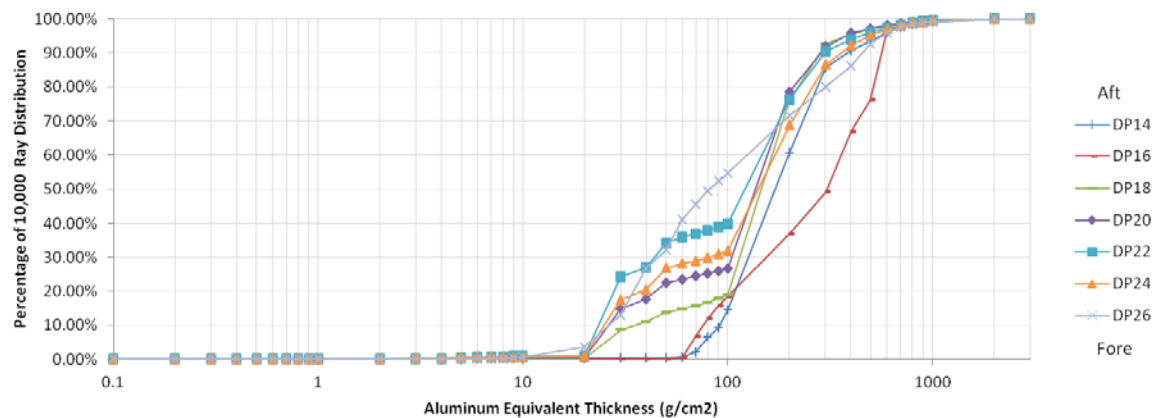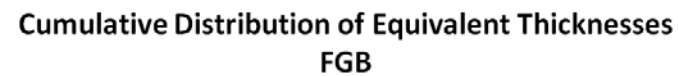
JLP1AO-01

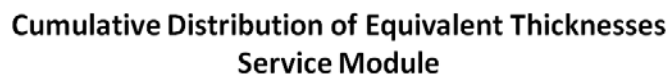# ISS CAD Shielding Survey

Primary Axis

Node1 Axis

Node2 Axis

Mass Distributions

ISS Survey

Cumulative Distribution of Equivalent Thicknesses
Service Module

Cumulative Distribution of Equivalent Thicknesses
FGB

Cumulative Distribution of Equivalent Thicknesses
Node1

Cumulative Distribution of Equivalent Thicknesses
Node2

Cumulative Distribution of Equivalent Thicknesses
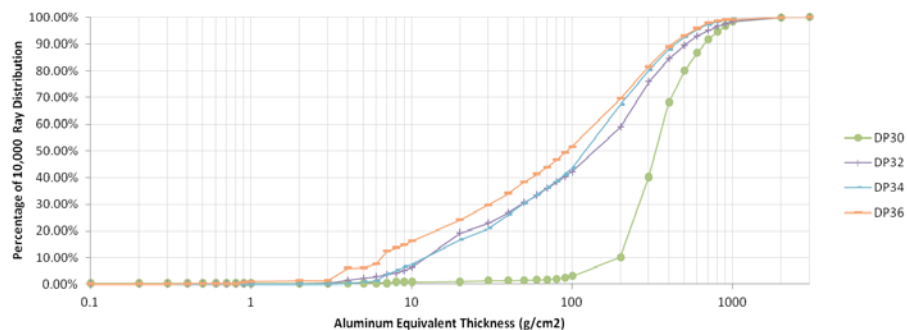US Lab

Cumulative Distribution of Equivalent Thicknesses
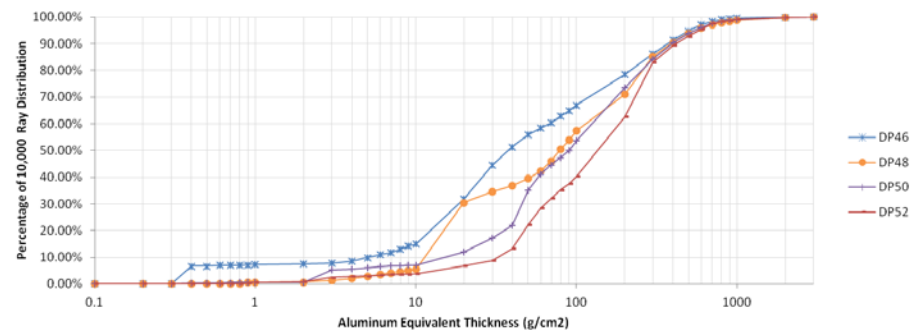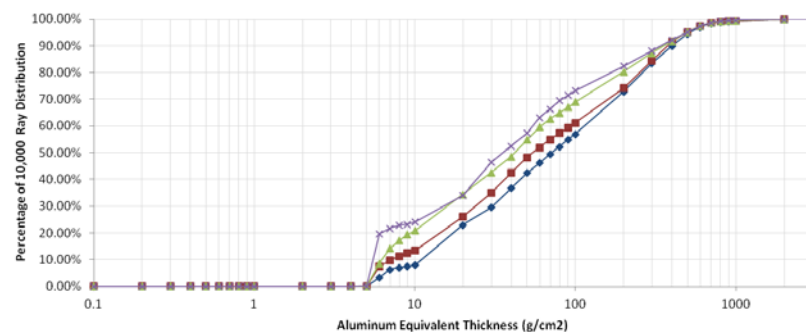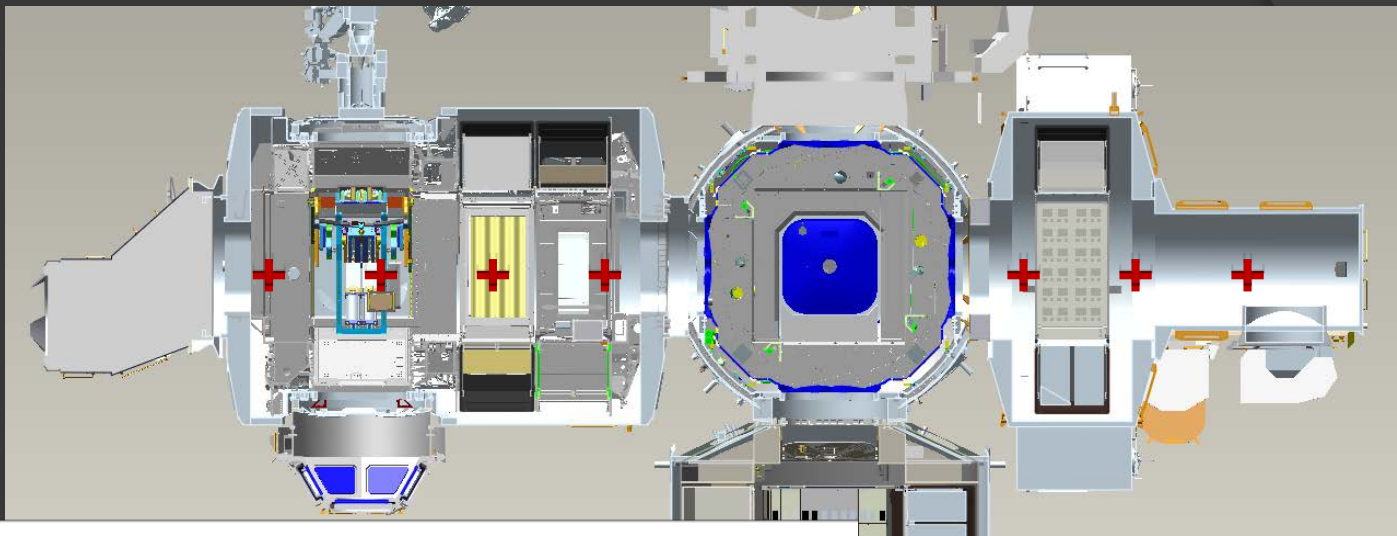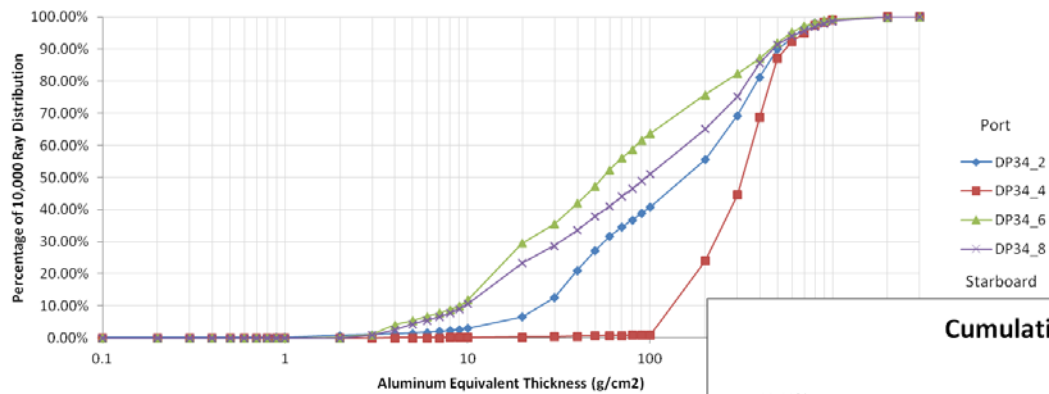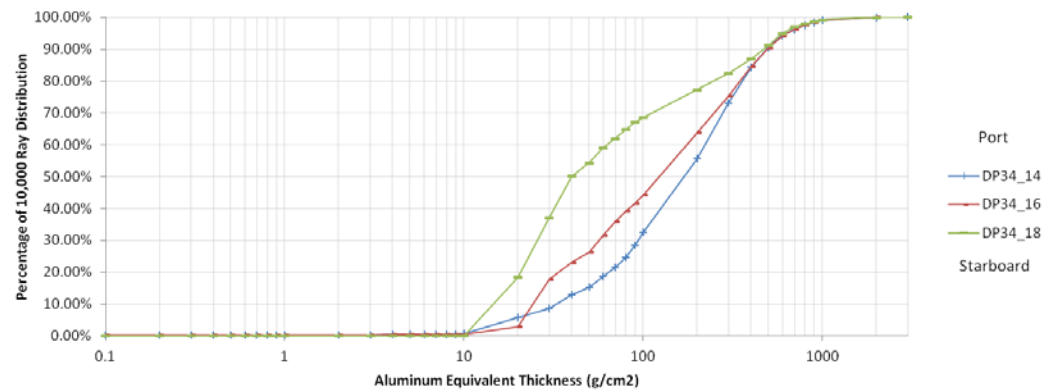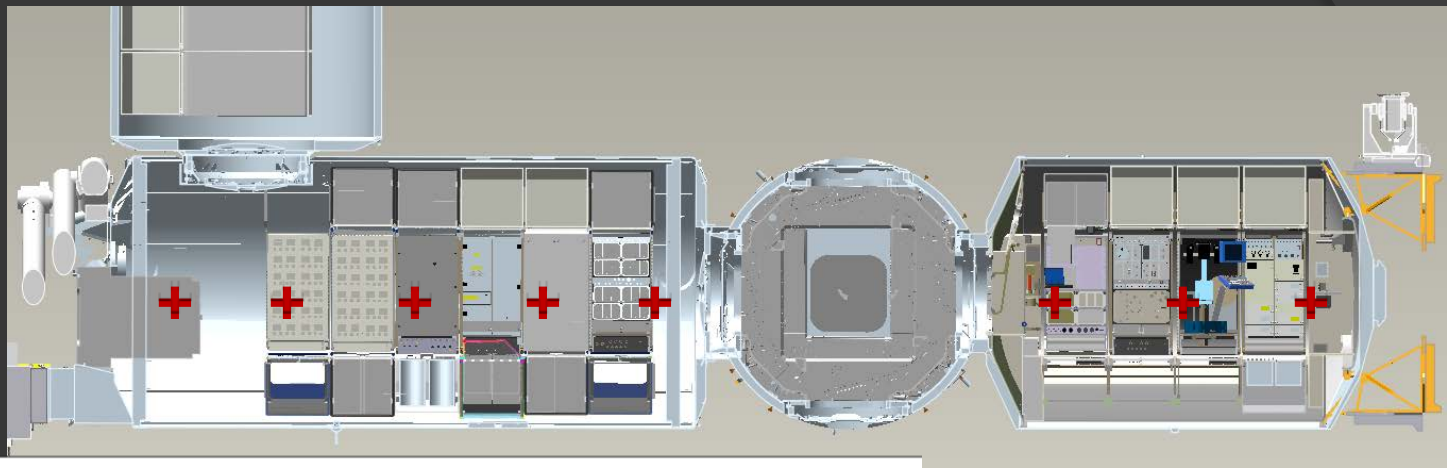Node3

Cumulative Distribution of Equivalent Thicknesses
US Airlock

Cumulative Distribution of Equivalent Thicknesses — JPM
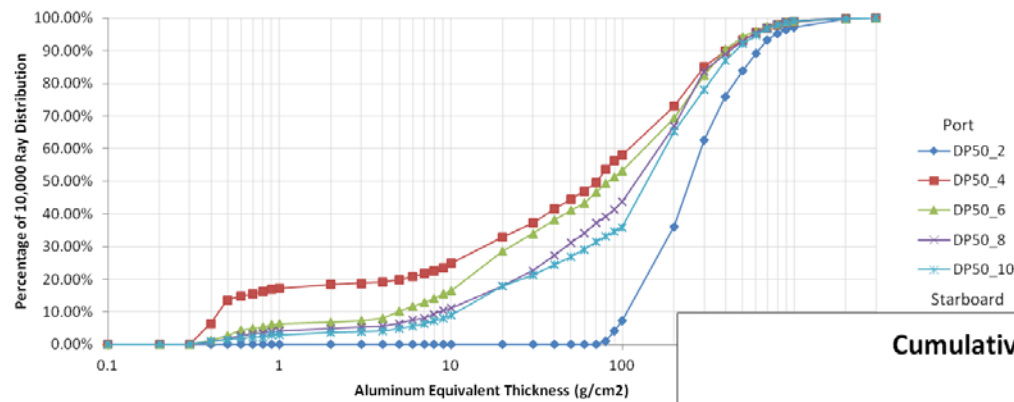
Cumulative Distribution of Equivalent Thicknesses — Columbus
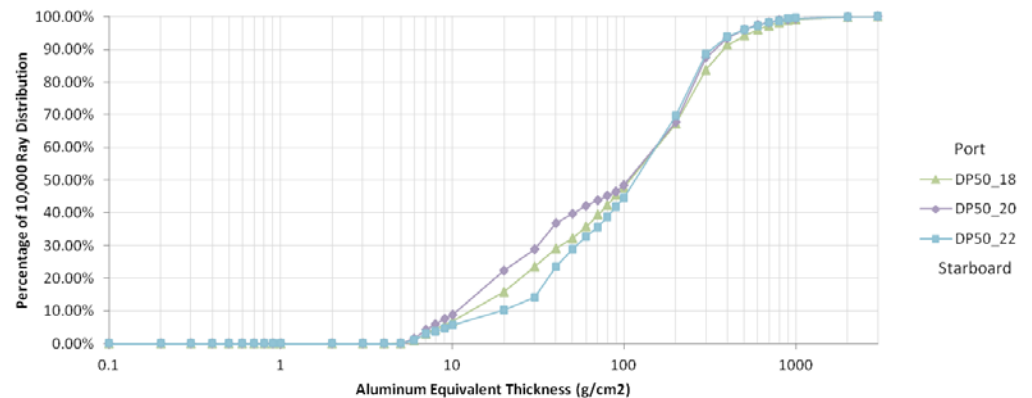
Current Limitations and Forward Work

Material Assignment Limitations

- Material assignment from parts database
  - Issues with model name associations
  - Comprehensive database yet to be found

- HZETRN limitations on Dose Calculation
  - Currently used HZETRN limited in matrix dimension for interpolation

Updates to US Module Model Fidelity

- Refine Pressure shell thicknesses
  - Currently using crude estimates
  - High Fidelity external model archives are available
- Resolve issues with rack hardware represented as surfaces (no volume)

IP Module and Visiting Vehicle Model Fidelity

- Included models are a "best guess" based on information derived from on-orbit imagery and stripped down models
- Availability of ProE, IGES, STP format models for internal structure, rack, and equipment would help refine these segments of the model