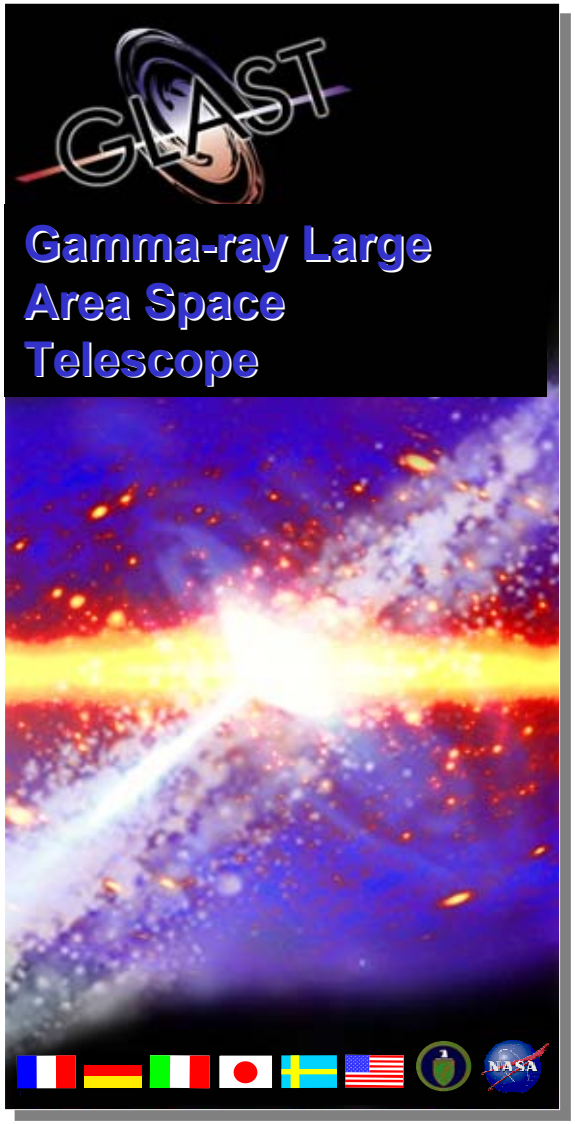

CAL material audit.

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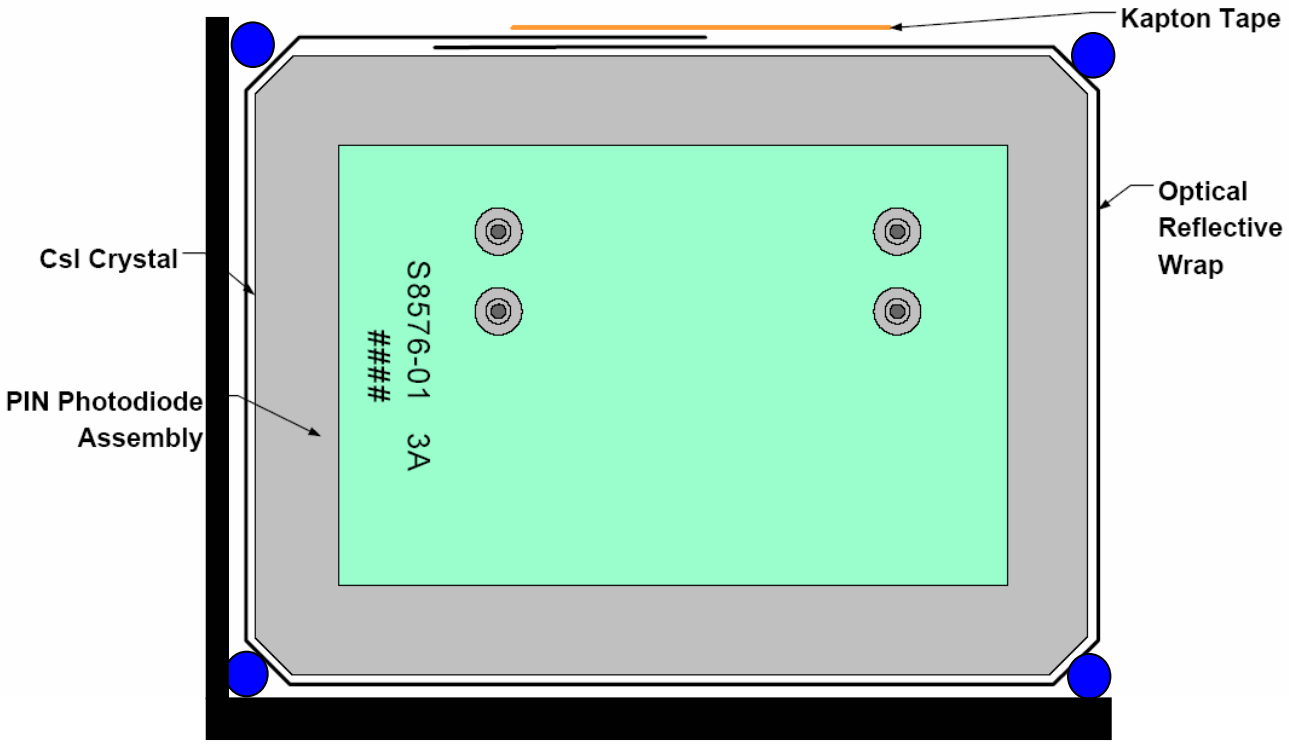
Goals and sources of information

- Main goal:
  - try to find discrepancies between simulated geometry model and real geometry
  - Identify elements missing in the simulation
  - possible contributions to the difference in shower development between simulation and beam test data
- I focus on the "regular" (central) part of CAL module
- Sources of information:
  - Specifications
    - http://heseweb.nrl.navy.mil/glast/CM/spec/CALCsICrystalSpec-LAT-DS-00095-04.pdf
    - http://heseweb.nrl.navy.mil/glast/CDE_MRR/CDEflightSpec-LAT-SS-01133-03B.pdf
  - Drawings
    - http://heseweb.nrl.navy.mil/glast/CALHardware/CM/LAT-DS-00918-03-GLT-LLR-00-02-C-CompositeStruc.pdf
  - Measurement reports
    - GLAST-LLR-RP-042-A (EM Metrology Report).doc
    - http://heseweb.nrl.navy.mil/glast/CAL_ATDP/FM109/SummaryData/CAL%20FM109%20Mass%20Properties.pdf
    - http://heseweb.nrl.navy.mil/glast/CAL_ATDP/FM101/SummaryData/CAL%20FM%20101%20Mass%20Properties.pdf
  - CAL geometry review written by Mark Strickman in 2004:
    - LAT-TD-04479-01 Calorimeter flight monte carlo geometry c.doc
  - My own measurements of the spare CAL structure which is available now at NRL

Elements of regular calorimeter cell

- CsI crystal
- VM2000 reflective wrap + adhesive kapton tape
- Carbon fiber cell walls (vertical and horizontal)
- Silicon elastomer cords in each of 4 corners



CsI crystal

- MC Model parameters
  - Dimensions: 326 mm x 26.7 mm x 19.9 mm
  - No chamfers
  - Density: 4.51 g/cm^3
  - Mass = 781.2 g
- Real geometry parameters
  - Nominal dimensions: 326 mm x 26.7 mm x 19.9 mm
    - Tolerances:
      - Length: +0, -0.6 mm; width, height: +0, -0.4 mm
  - Chamfers:
    - Distance between opposite chamfers at 45 degrees = 31.68+-0.05 mm
      - Chamfer width = 1.27 mm (for nominal dimensions)
  - Density (PDG): 4.53 g/cm^3
  - Calculated Mass:
    - Nominal dimensions without chamfers = 784.7 g
    - Nominal dimensions with chamfers = 782.3 g
    - Dimensions decreased by 0.5 of tolerance, with chamfers = 768.8 g

- Measured mean CDE mass of modules FM101 and FM109:
  - M_{CDE} =781 g
- Mass of other CDE elements

Photo diodes	3.2 g
Bonds	0.4 g
Wires	0.8 g
Solder & staking	1.6 g
Optical wrap	3.3 g
End caps	1.2 g
Kapton tape	0.5 g

- Measured average mass of CsI crystal:
  - 781 g – 11 g = 770 g
- It is less than calculated for nominal dimensions,
- but it's **consistent with dimensions decreased by 0.2 mm and PDG density**

Structure cell walls

- MC model
  - Carbon fiber density = 1.6 g/cm^3
  - Vertical wall
    - Dimensions: 326mm x 20.5 mm x 0.45 mm
    - Mass = 4.8 g
  - Horizontal wall
    - Dimensions: 326 mm x 27.84 mm x 0.85 mm
    - Mass = 12.3 g
  - Horizontal cell pitch = 27.84 mm
    - Horizontal Gap between crystals = 27.84 – 26.7 = 1.14 mm

- Real geometry
  - Carbon fiber density = 1.63 g/cm^3
    - calculated by Mark Strickman from the measured weight of real structure and calculated carbon fiber volume
  - Vertical wall
    - Dimensions: 326mm x 20.5 mm x 0.36 mm
    - Mass = 3.9 g
  - Horizontal wall
    - Dimensions: 326 mm x 27.71 mm x 0.84 mm
    - Mass = 12.3 g
  - Horizontal cell pitch = 27.71 mm
    - Horizontal gap between crystals = 27.71 – 26.5 = 1.21 mm

Elements, absent in MC model

- VM2000 reflective wrap
  - it is implemented in MC model, but with thickness 10 times smaller than real
  - Real parameters:
    - dimensions = 324.2 mm x 100 mm x 0.065 mm
    - Mass = 3.3 g
    - There is overlap region on the top surface, having double layer of wrapping
- Kapton adhesive tape
  - Dimensions 312mm x 12.7 mm x 0.064 mm
  - On the top surface of a crystal.
  - Mass = 0.3 g
- Silicone elastomer cords
  - Dimensions 326 mm x diam. 0.8 mm
  - Mass: 4 cords x 0.2 g each, total=0.8 g
- EMI shield on the top of the CAL structure:
  - Thickness = 0.1 mm Aluminum
  - Mass = 2.4 g/cell (for top layer cells only)

Material mass per CAL cell: summary table

Element	Mass in MC model, g	Real mass, g
CsI crystal	781.2	770
Cell vertical wall	4.8	3.9
cell horizontal wall	12.3	12.3
VM2000 wrap		3.3
Kapton tape		0.3
Silicone elastomer cords		0.8
EMI shield (top cells only)		2.4

Conclusion

- CAL MC geometry model parameters should be corrected:
  - Horizontal cell pitch: 27.84 -> 27.71 mm
  - Horizontal wall thickness 0.45 -> 0.36 mm
  - CsI crystal height: 19.9 -> 19.7 mm
  - CsI crystal width: 26.7 -> 26.5 mm
  - CsI crystal density: 4.51 -> 4.53 g/cm^3
  - VM2000 wrap thickness: 0.0065 -> 0.065 mm
- I suggest to add
  - 1 mm chamfers in all corners of CsI crystals
  - fill the empty space between chamfer and structure corner with silicon rubber cord (density and composition – to be defined)