Probe of Extreme Multi-Messenger Astrophysics (POEMMA) Probe Mission

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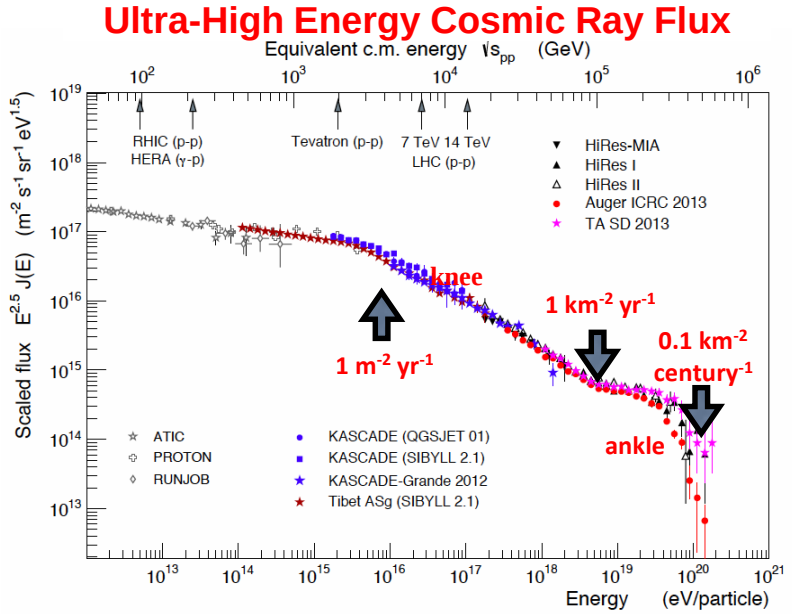
NASA Probe Studies for 2020 Decadal Survey

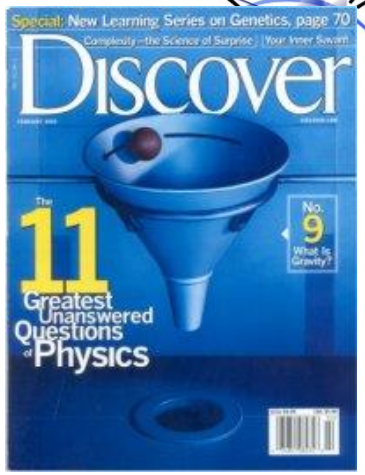
- NASA funding 10 Probe Class (below 1B$) Mission (18 mos) Studies in Preparation for the 2020 Decadal Survey - POEMMA: Probe of Extreme Multi-Messenger Astrophysics
- PI responsible for the final report (due NLT Dec 2018)
- NASA will submit these studies to the Decadal Survey
- Decadal Survey Committee will have the option to prioritize any of these mission concepts, or recommend a competed line of Probes (similar to Explorers)
- Selection based on Science Merit (cost, schedule)

PI	Affiliation	Short title	Design Lab/Prog Office
Camp, J.	NASA's GSFC	Transient Astrophysics Probe	IDC/PCOS-COR
Cooray, A.	Univ. California, Irvine	Cosmic Dawn Intensity Mapper	TeamX/ExEP
Danchi, W.	GSFC	Cosmic Evolution through UV spectroscopy	IDC/PCOS-COR
Glenn, J.	Univ. of Colorado	Galaxy Evolution Probe	TeamX/ExEP
Hanany, S.	Univ. of Minnesota	Inflation Probe Mission Concept Study	TeamX/ExEP
Mushotzky, R.	Univ. of Maryland	High Spatial Resolution X-ray Probe	IDC/PCOS-COR
Olinto, A.	Univ. of Chicago	Multi-Messenger Astrophysics	IDC/PCOS-COR
Plavchan, P.	Missouri State Univ.	Precise Radial Velocity Observatory	No design lab funded/HQ grant
Ray, P.	Naval Research Lab	X-ray Timing and Spectroscopy	IDC/PCOS-COR
Seager, S.	MIT	Starshade Rendezvous	TeamX/ExEP

Extensive Air Showers (EASs)

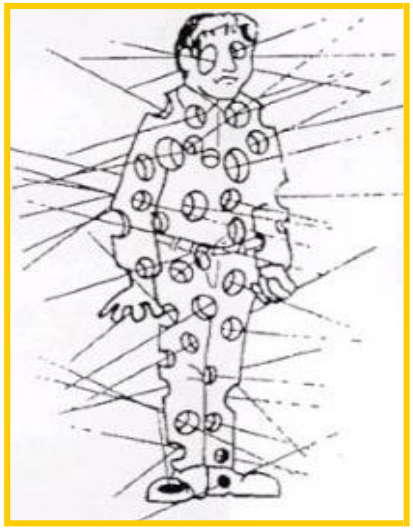


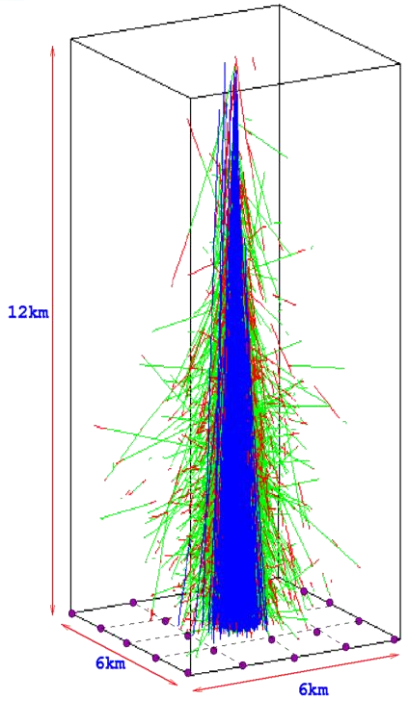
3x10^{20} eV = 50 joules = 1 Tyson = UHECRs traveling at 99.999999999999999999% of the speed of light



1 of 11 unanswered questions in Physics - still unanswered

- Cosmic rays are charged particles such as protons, electrons and nuclei of atoms
- They are NOT electromagnetic radiation (aka light)
- They interact with nitrogen in the atmosphere to produces EASs
- More than a hundred secondary particles of swarm through our body every second!
- Cosmic rays are of great importance in biology as they are responsible for many genetic mutations and to spacecraft as they cause single event upsets (SEUs) in computers
- The air fluorescence will be a luminous disc (equal to 100W light bulb) a few meters thick, 1 km across moving at nearly the speed of light. The wavelengths of interest are in the 300 – 400 nm region.





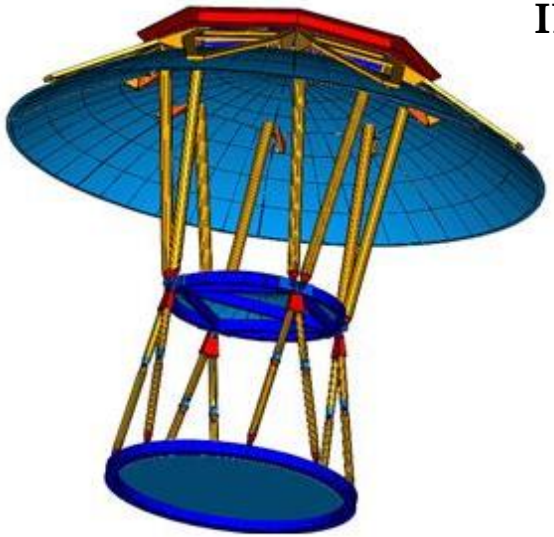
100 billion particles at sea level
photons, electrons (99%), muons (1%)
• Ground Array stations

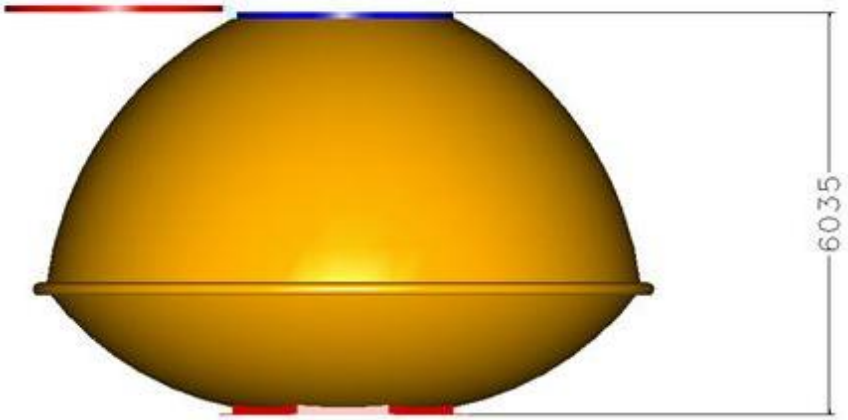
Starting Point Design

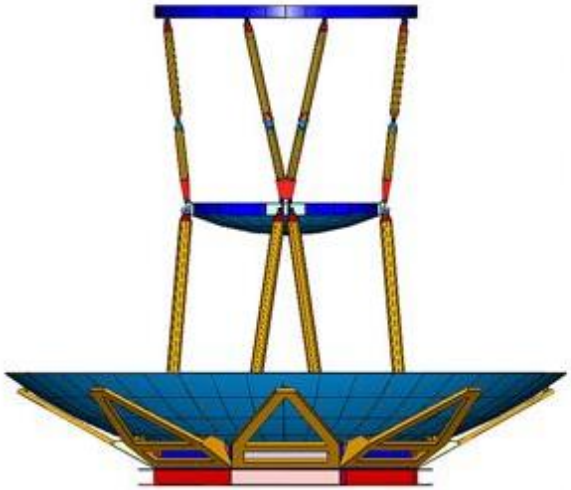
- 2 formation-flying spacecraft (OWL concept)
- f/1 Schmidt camera, 45° FoV,
- Detailed design being defined – OWL scaling:
- 10 m diam. primary mirror deployable (OWL: 7m)
- 4.3 m diam. corrector lens
- 8 m^2 focal plane with ~500,000 pixels
- (~ 0.06^O pixel ~1 km^2 projected on the ground at 1,000km altitude)
- 14 m^2 effective aperture (OWL: 7.07 m^2)
- weight TBD ~2400 kg;
- power consumption TBD ~600 W

CAD Views of OWL

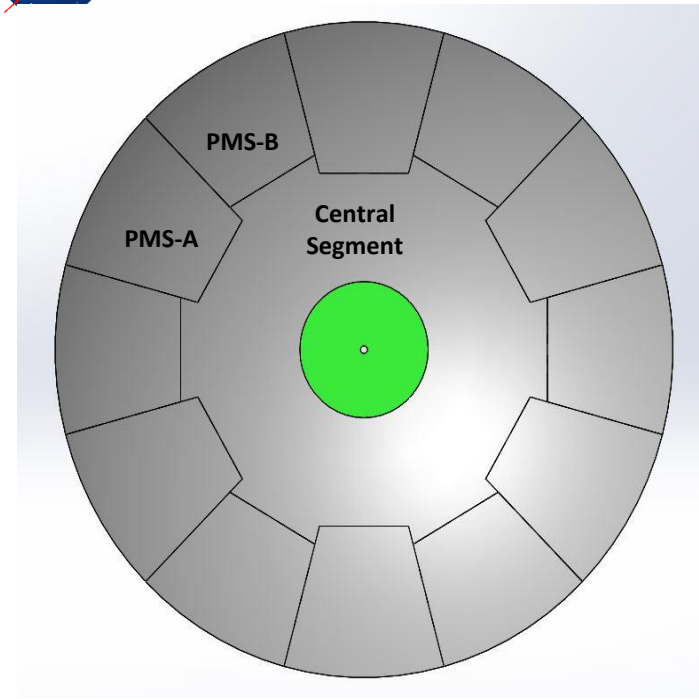
OWL – Orbiting Wide-Angle Light Collectors
IDL Study - 2001

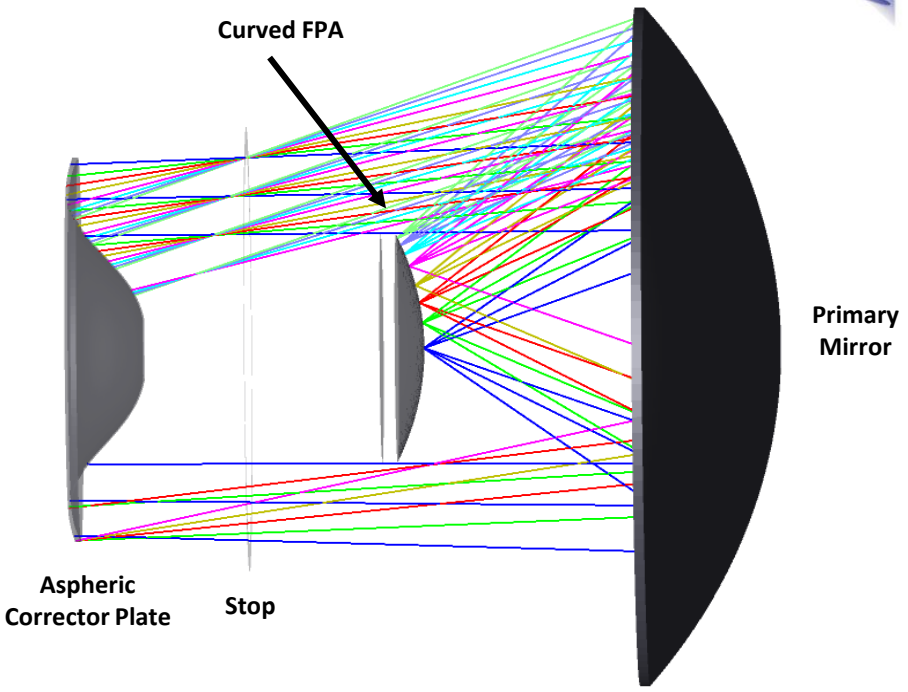


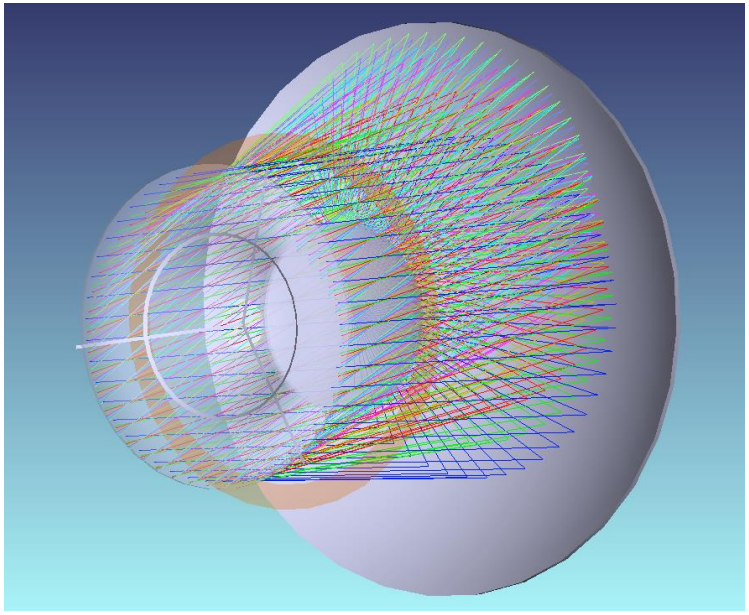




POEMMA Optical Layout

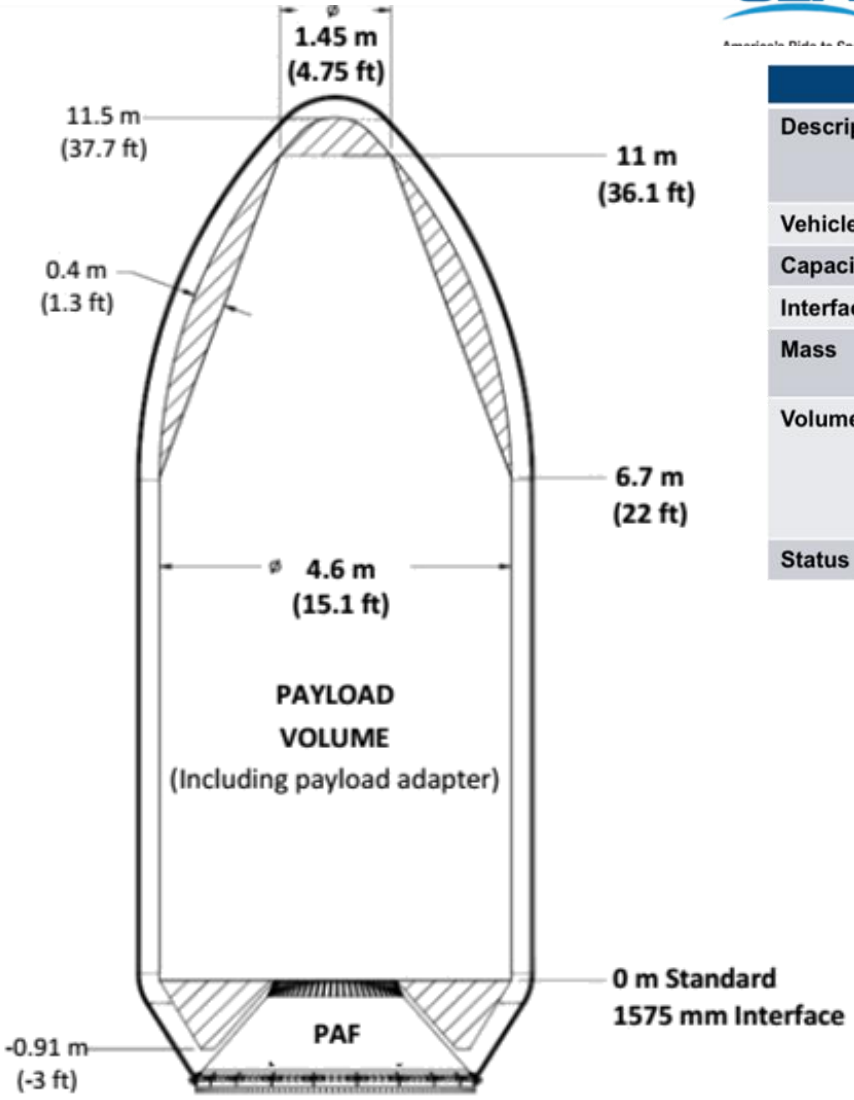






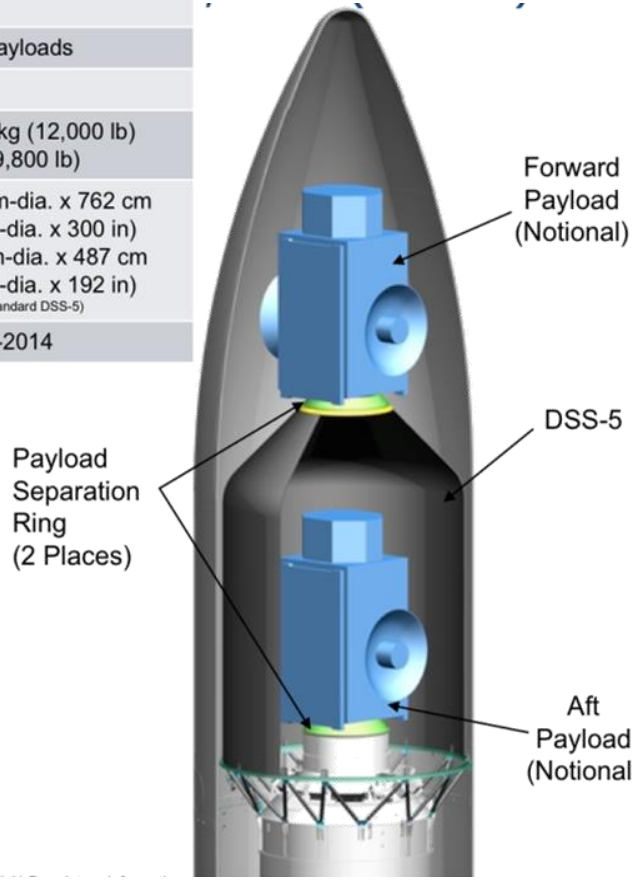
Launch Configuration

SpaceX Fairing

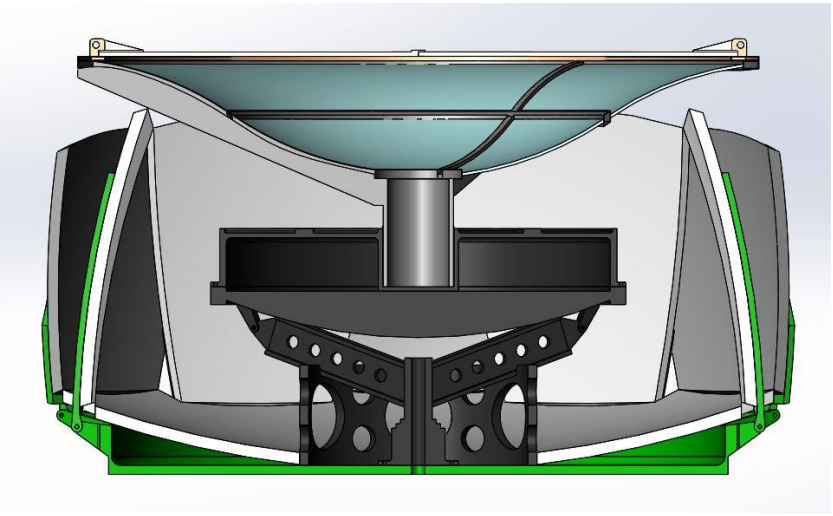


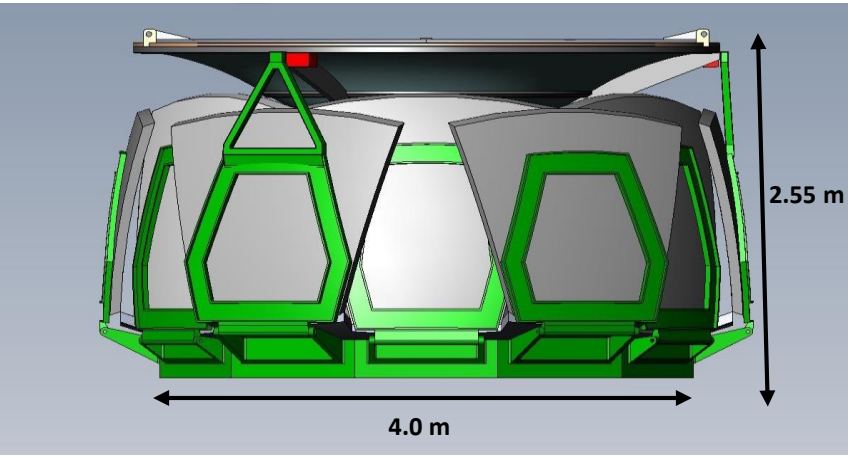
Dual Spacecraft System, 5-m (DSS-5)

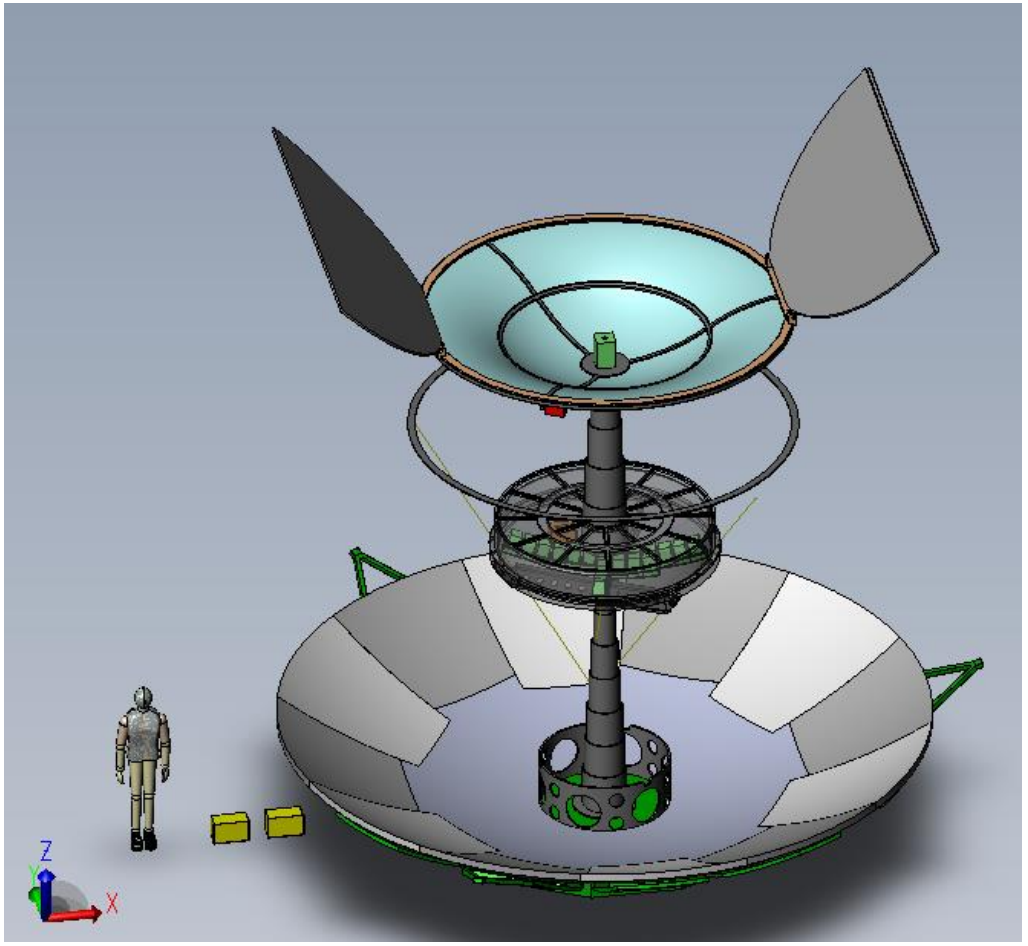
DSS-5	
Description	A Dual-manifest Launch Capability for 5-m Fairings, Using Newly Designed Composite Structure
Vehicle	Atlas V, Delta IV, Vulcan
Capacity	1 DSS-5 per Launch, 2 Payloads
Interface	62-in Bolted
Mass	Forward Payload: 5,440 kg (12,000 lb) Aft Payload: 9,000 kg (19,800 lb)
Volume	Forward Payload: 457-cm-dia. x 762 cm (180-in-dia. x 300 in) Aft Payload: 375-cm-dia. x 487 cm (148-in-dia. x 192 in) (Standard DSS-5)
Status	In Development; CDR 12-2014



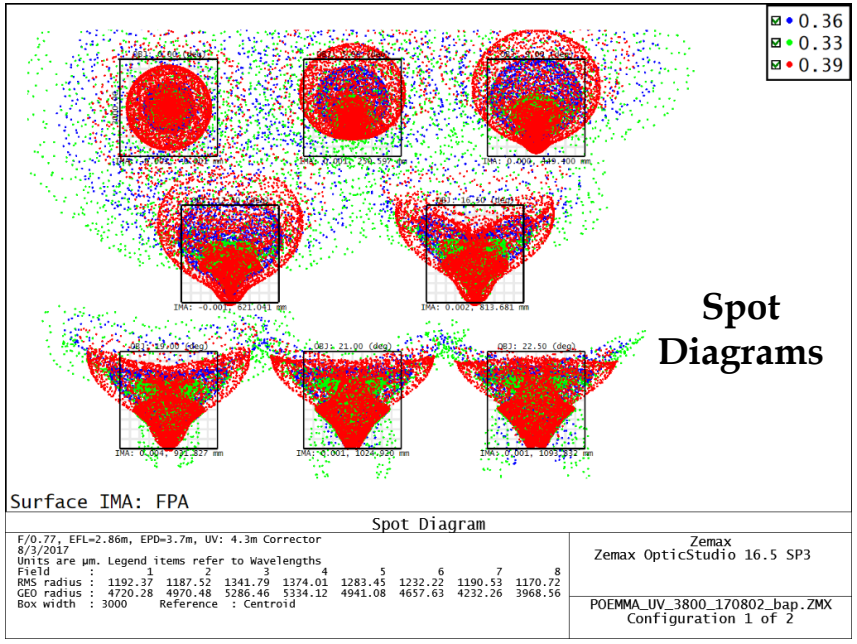
IDL Mechanical Design

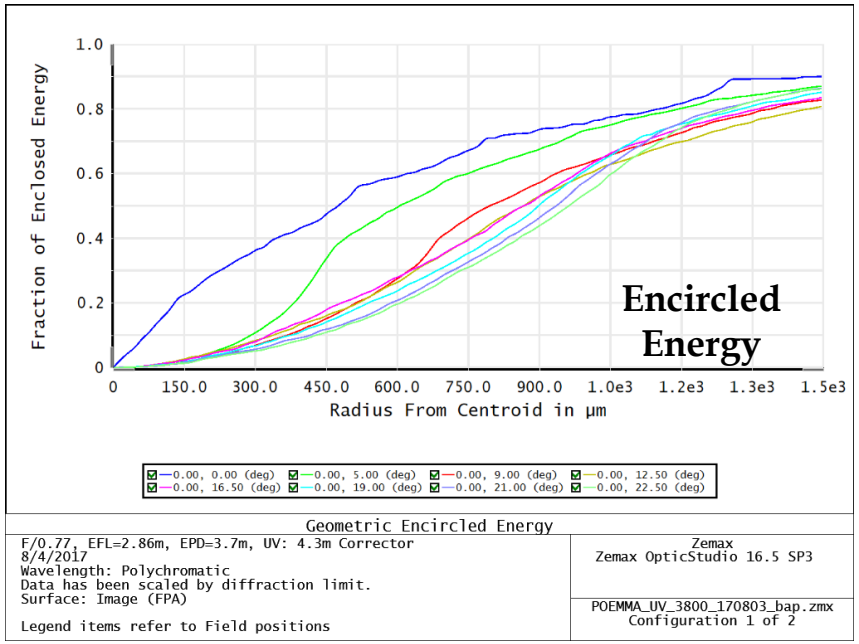




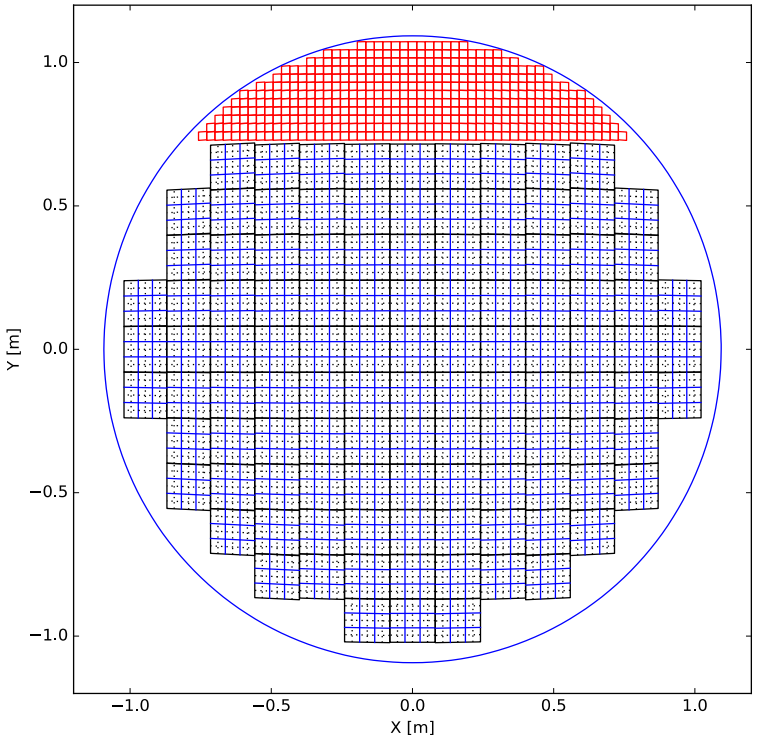


Optical Performance



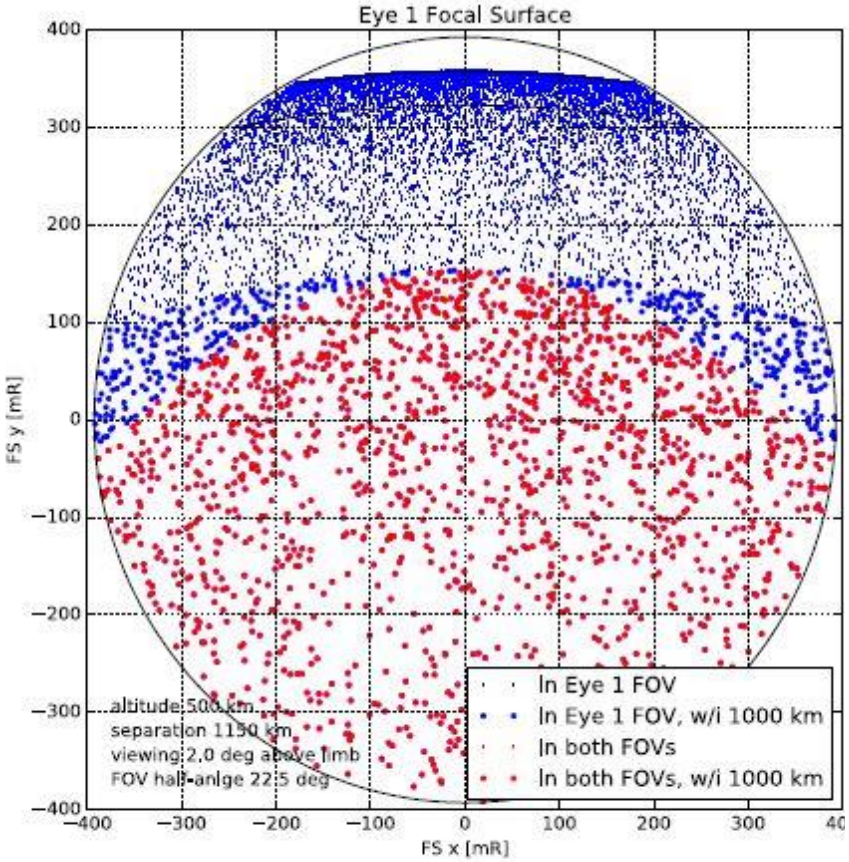


Cherenkov (SiPM)

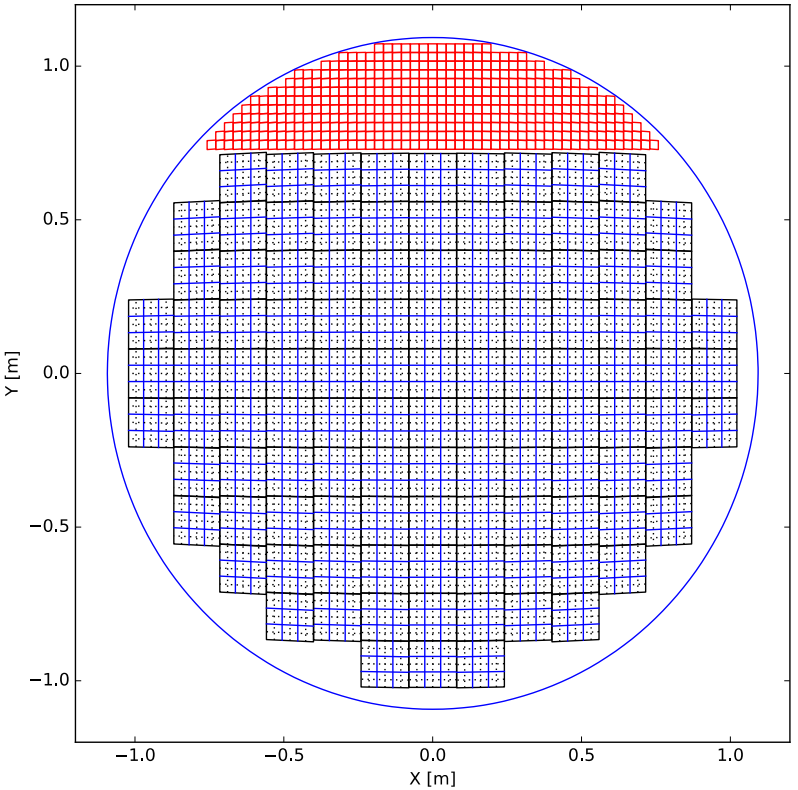


Fluorescence (PDM)

500 km, 1150 km, 2

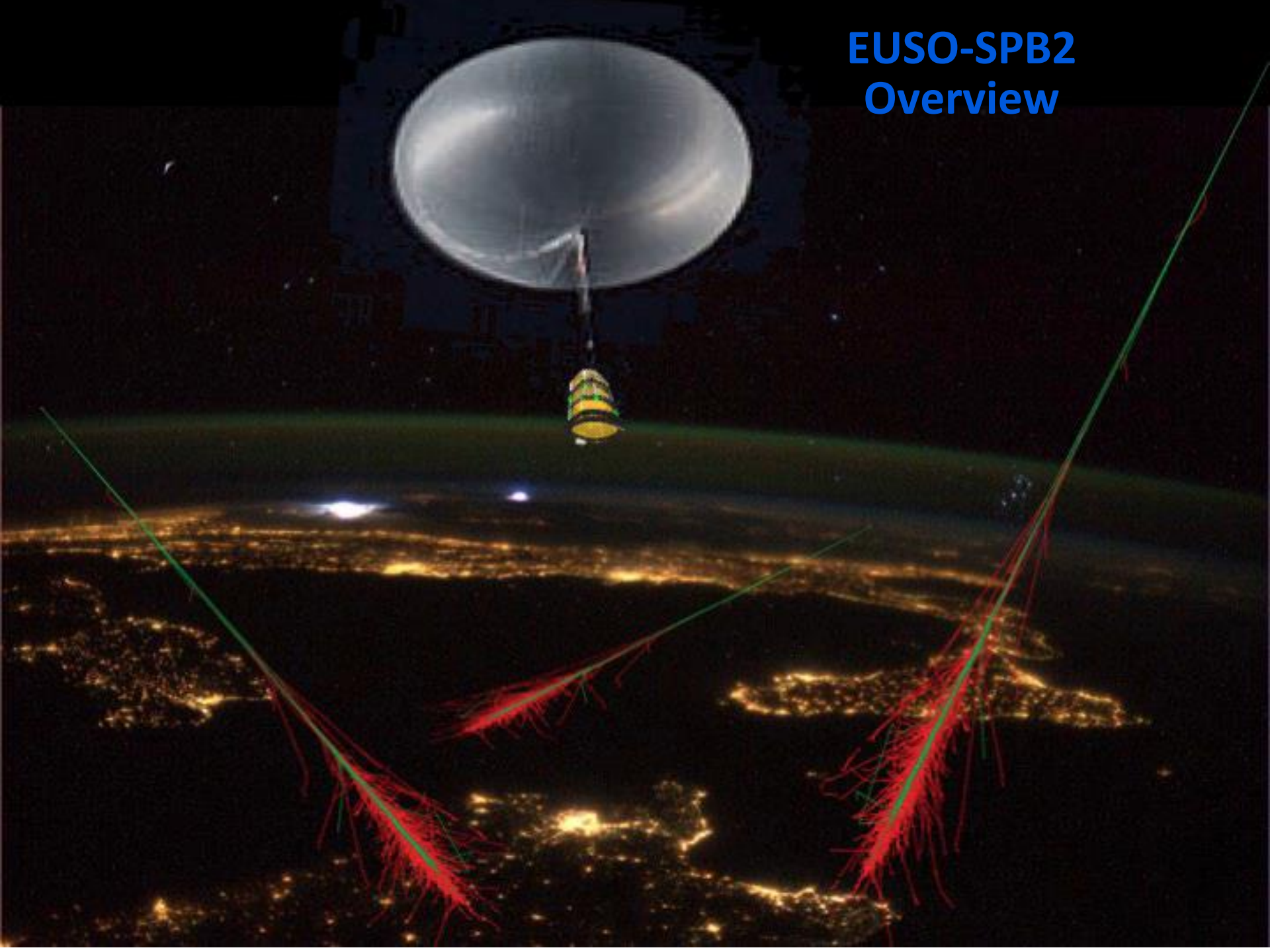


Cherenkov (SiPM)

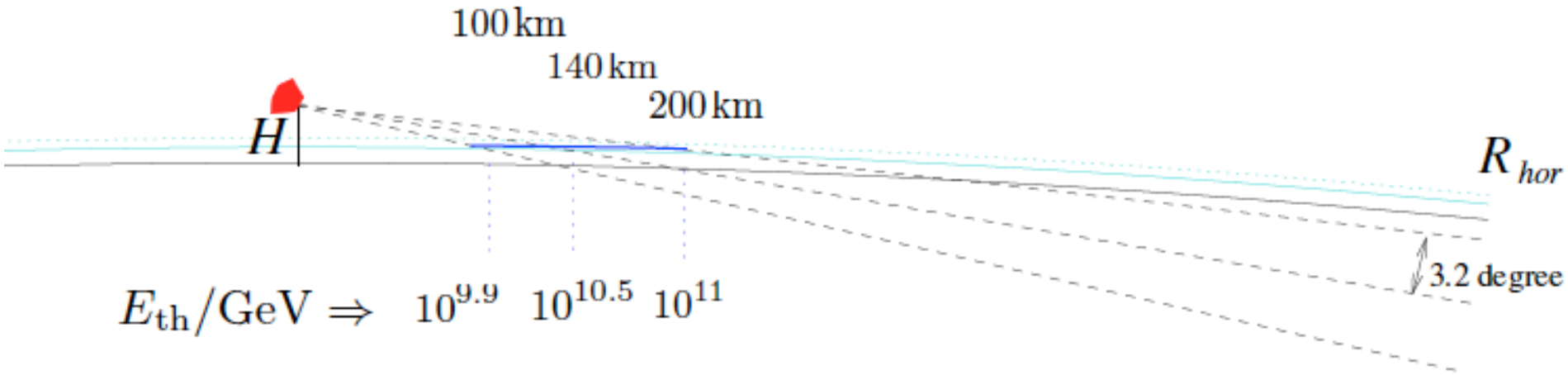


Fluorescence (PDM)

EUSO-SPB2 Overview



EUSO-SPB2 Observation Approach



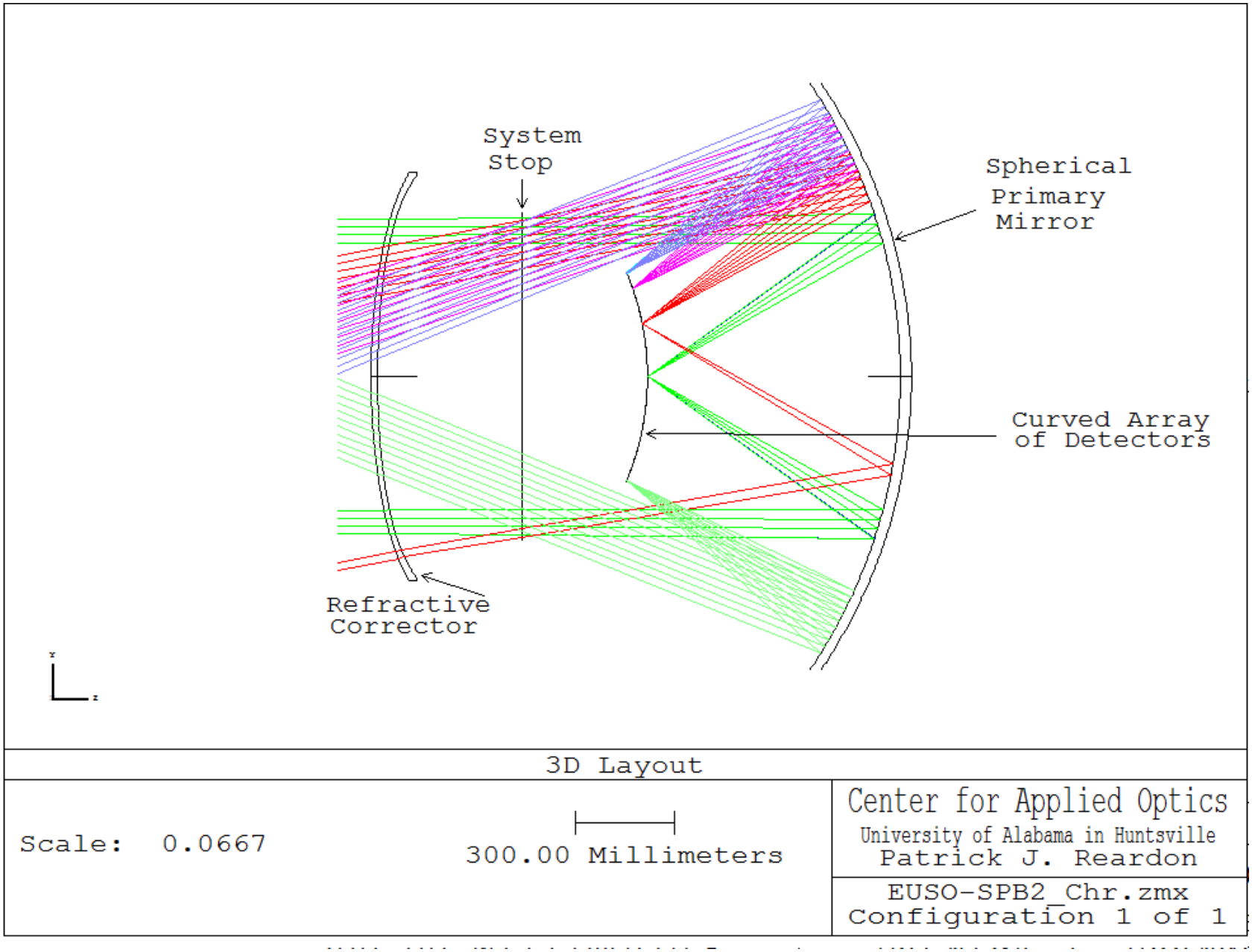
- Detect high altitude UHECR and UHEv through Cherenkov signal
- Pathfinder for POEMMA Instrumentation
  - Schmidt camera: corrector, stop, mirror, coatings
  - Detector technology (MAPMT, SiPM, others), filters
  - Corrector material: PMMA vs glass
  - Charged particle rejection: Veto, Coincidence, Bi-focal
  - Limb field of view
- Background measurement for upward going EAS shower
- Detect EAS showers through fluorescence

EUSO-SPB2 Instrument (as proposed)

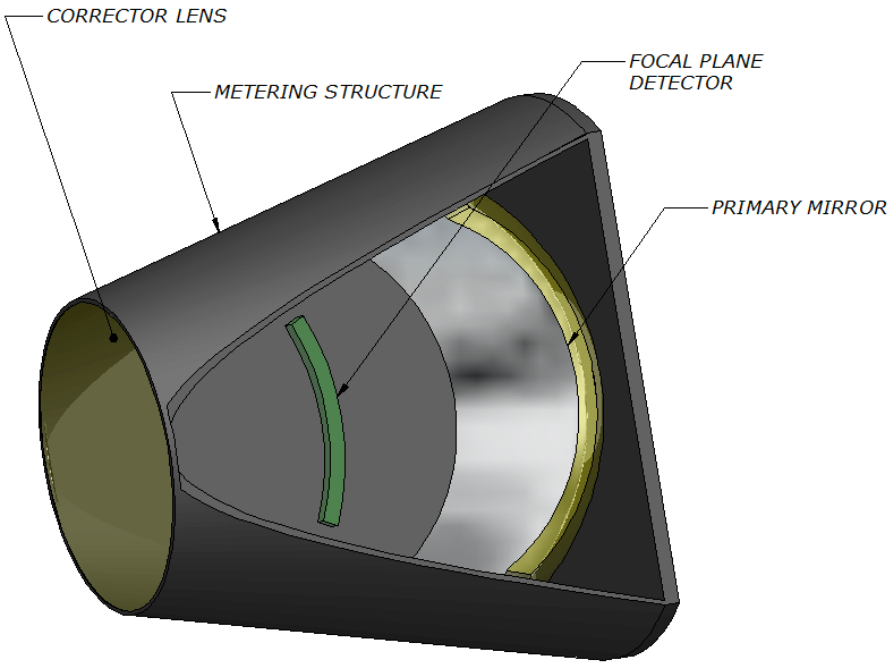
- **Optics FoV: 29°x3.2°**
  - Corrector Plate: PMMA ~1m^2
  - Image resolution: 1mm
  - Pixel size: 3mm square
  - Mirror: 1.8(H) x 1.1(V) split

- **Detectors**
  - Cherenkov
    - response range: 400 – 700 nm
    - 1st level trigger threshold discriminator (realtime),
    - 2nd level trigger simple logic in FPGA (serial, near realtime)
    - 100 ns signal sampling for 1 us, continuous digitization with 16 channel fifo buffer
  - Fluorescence
    - response range: 330 – 400nm
    - 0th level trigger threshold discriminator (realtime),
    - 1st & 2nd level trigger logic in FPGA (serial, near realtime)
    - 1us signal sampling for 256 us

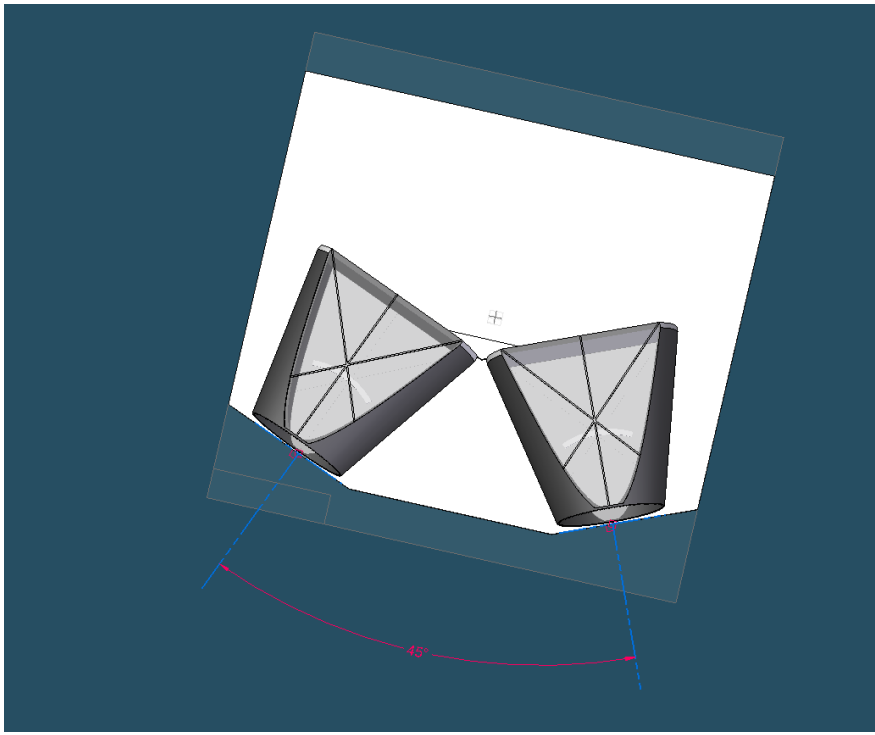
Optics

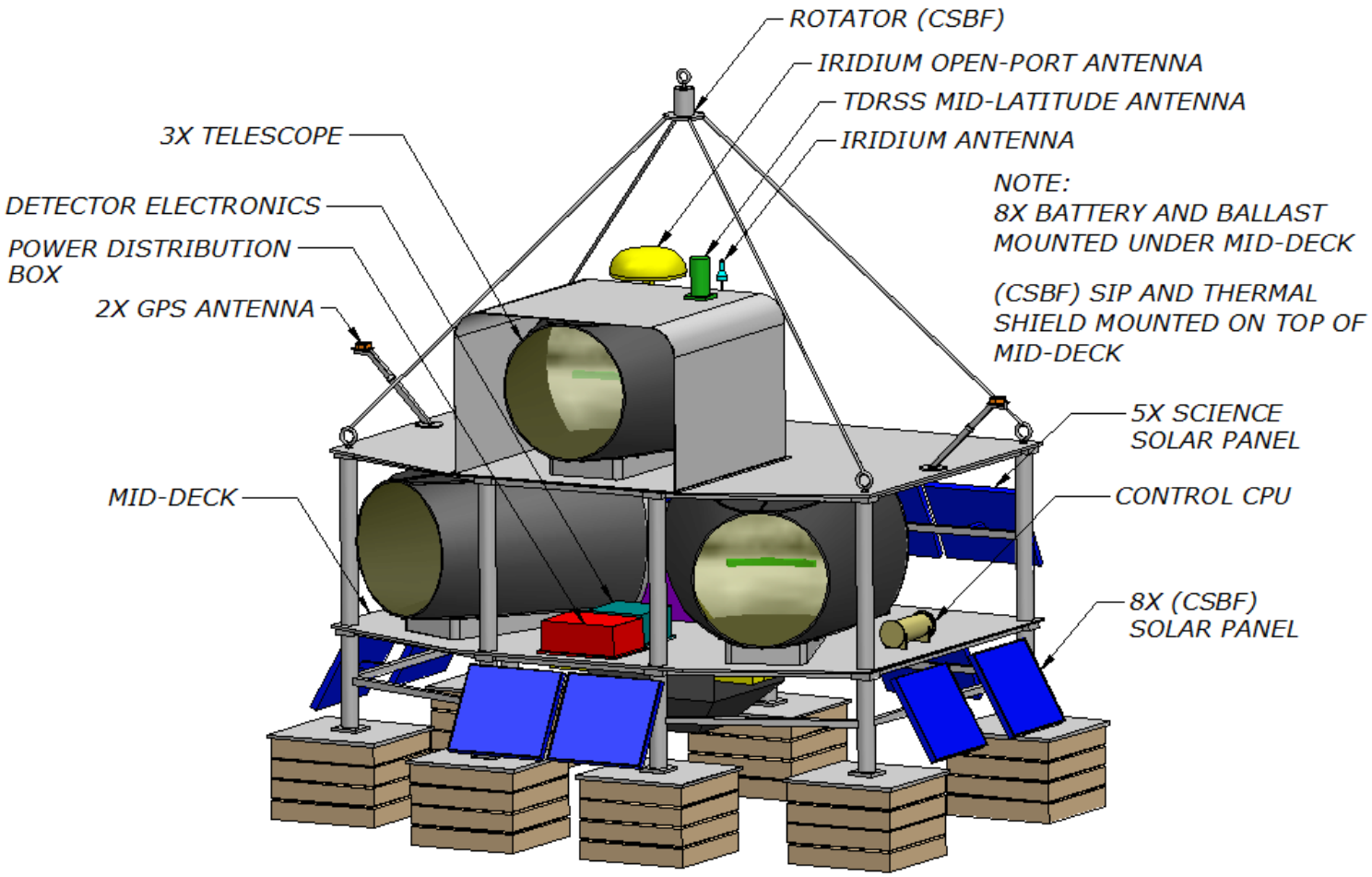

System
Stop
Spherical
Primary
Mirror
Curved Array
of Detectors
Refractive
Corrector
3D Layout
Scale: 0.0667
300.00 Millimeters
Center for Applied Optics
University of Alabama in Huntsville
Patrick J. Reardon
EUSO-SPB2_Chr.zmx
Configuration 1 of 1

SP2 Telescope



TELESCOPE SECTION VIEW





GONDOLA ASSEMBLY