

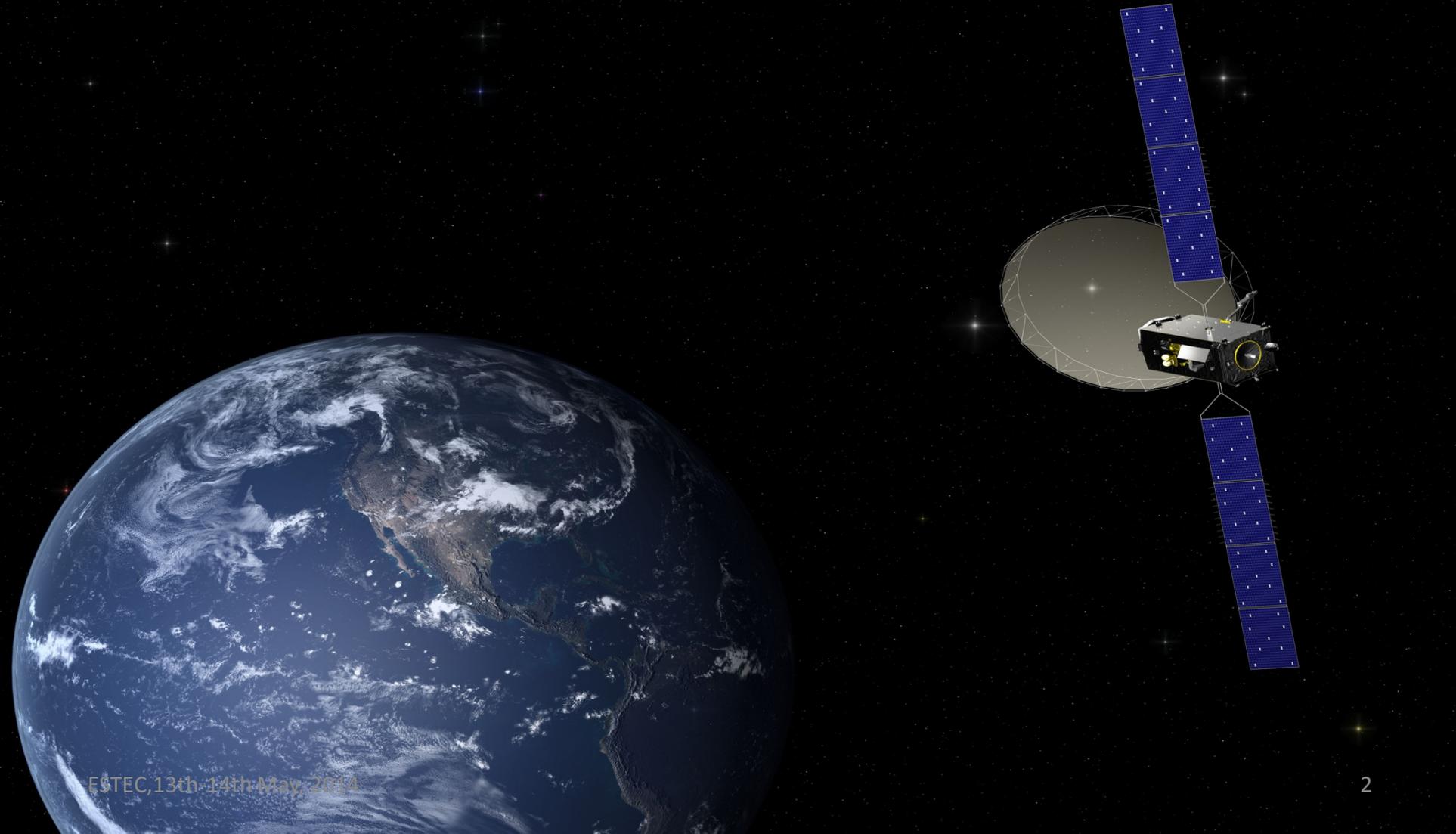
Alphasat TDP-8 MFS Particle Spectrometer Data Analysis: Towards a MFS Geant4 Simulation of the Flight Model and Flight data analysis

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LIP

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Experimental de Partículas)

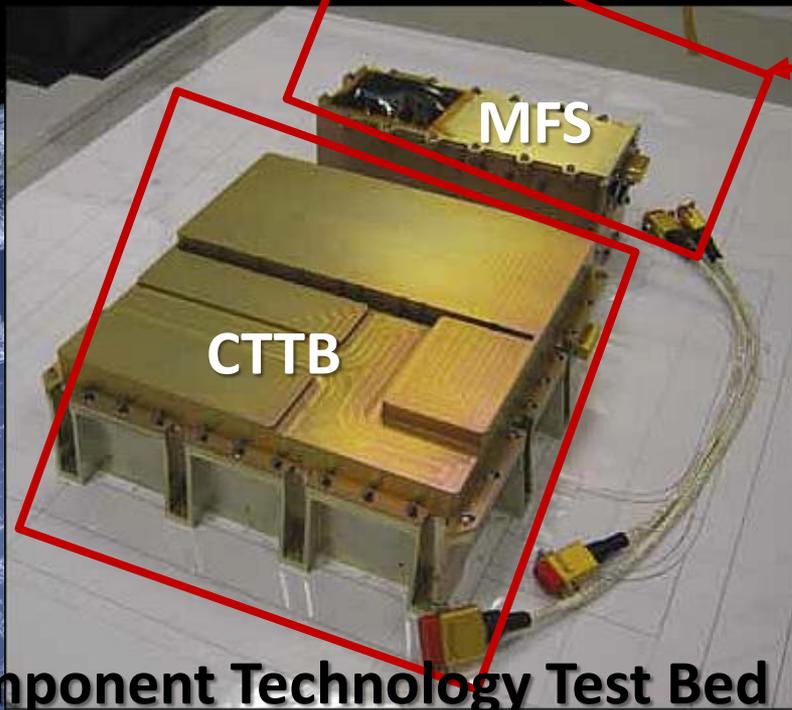
The AEEF: AlphaSat Environment and Effects Facility

- ✓ The AlphaSat was launched to GEO in 25th July 2013 carrying the AEEF (TDP8).

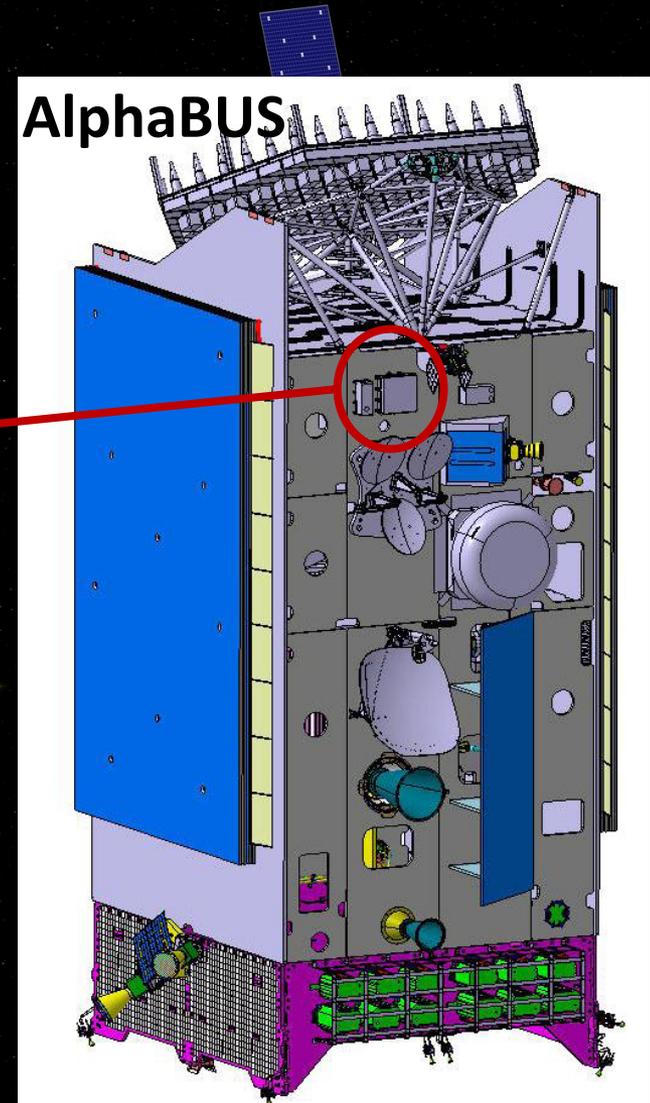


The AEEF: AlphaSat Environment and Effects Facility

- ✓ The AlphaSat was launched to GEO in 25th July 2013 carrying the AEEF (TDP8).
- ✓ MFS + CTTB make AEEF-TDP8.
- ✓ The two units are installed on X-panel of the AlphaSat

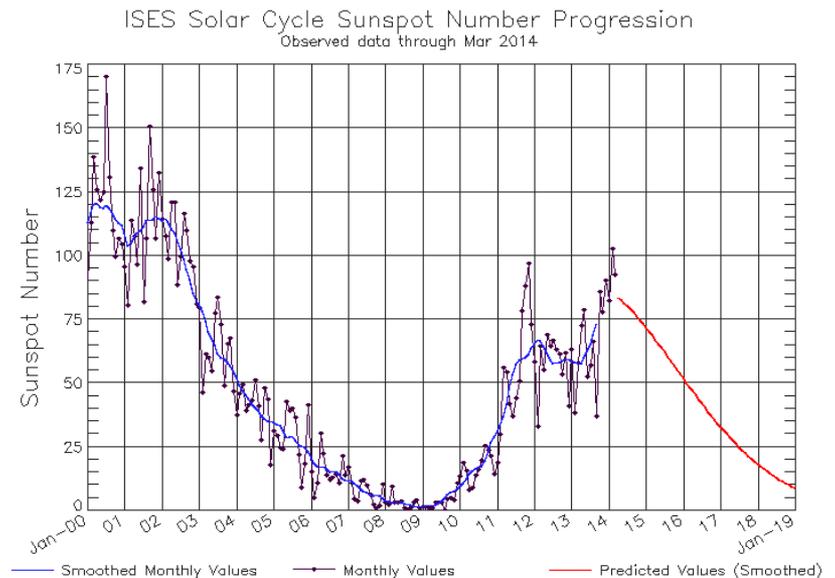
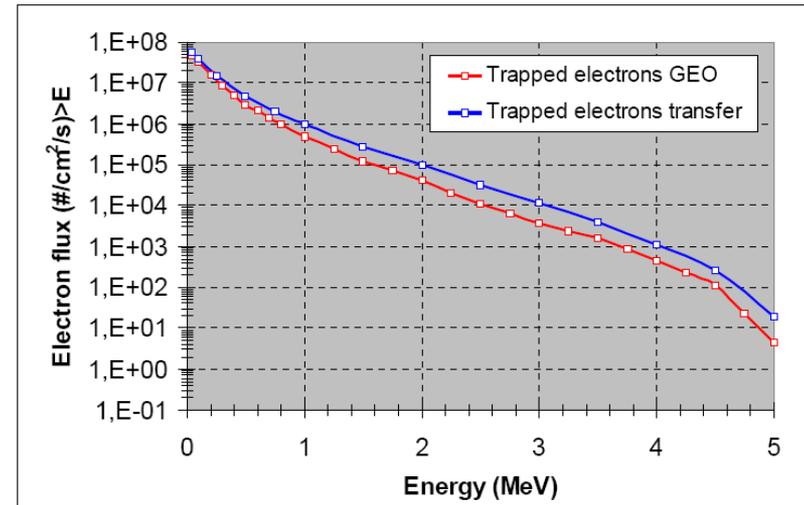


CTTB: Component Technology Test Bed

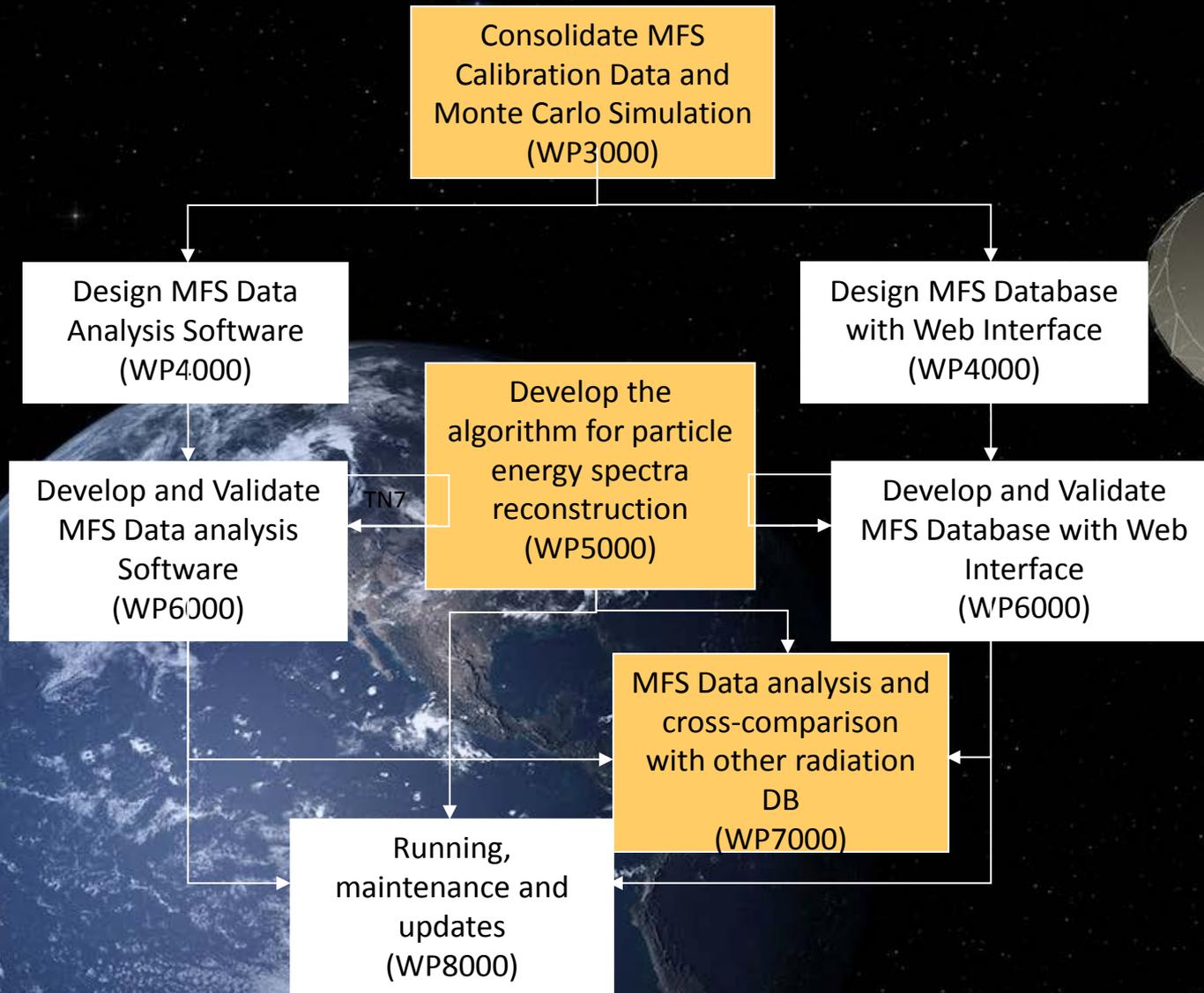


Scientific Motivation

- Telecommunication missions in GEO encounter a severe radiation environment:
 - *Trapped electron radiation*
 - *Solar Particle Events (SPE)*
- Pursuit for highly miniaturised electronics, low power and high speed implies **higher sensitivity to radiation effects**.
- A radiation monitor is a key piece in keeping a mission safe but it can also provide **valuable scientific data**.



MFS data analysis



MFS data analysis – current status

04-04-2014

Reaccess the MFS PFM Geant4 simulation



Consolidation of PFM Ground Test Data Analysis



Inclusion of Alphasat description in Geant4 simulation



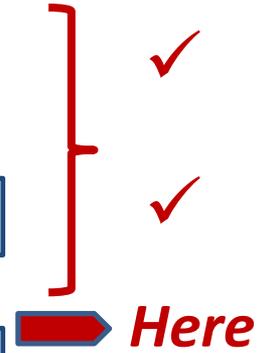
MFS in-flight data analysis



Cross-check with the output from PFM Geant4 simulation



Particle energy spectra reconstruction



MFS: MultiFunctional Spectrometer

MFS requirements:

Electron detector

*Spectral range 450 (goal 300 KeV) – 7 MeV
 $\Delta E/E < 20\%$*

Proton detector

*Spectral range 1 MeV – 200 MeV
 $\Delta E/E < 10\%$*

Alphas detector

*Spectral range 5 MeV – 200 MeV
 $\Delta E/E < 20\%$*

Heavy ions detector

*Spectral range 5 MeV/nuc – 50 MeV/nuc
Particle Separation: 1 amu up to Z=8*

Count rate

$10^7/\text{cm}^2/\text{s}$ for e⁻ and p E>1MeV (integral mode)

Field of View

40°

Accumulation time

60s to 600s in 60s steps

Power consumption

5W

Mission Lifetime

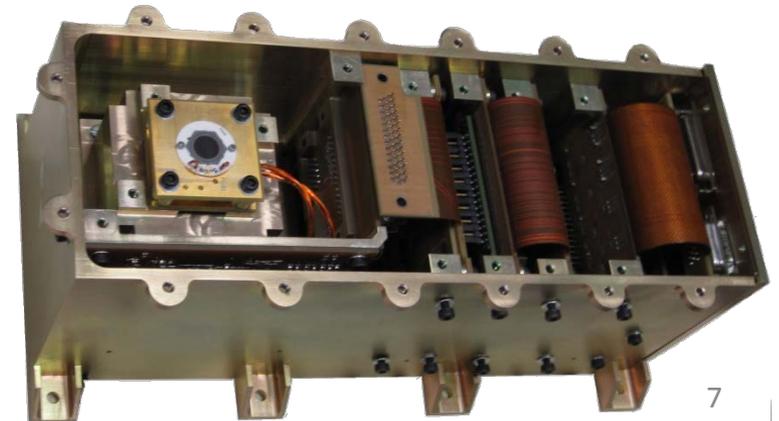
3 years

Weight

2.914 kg

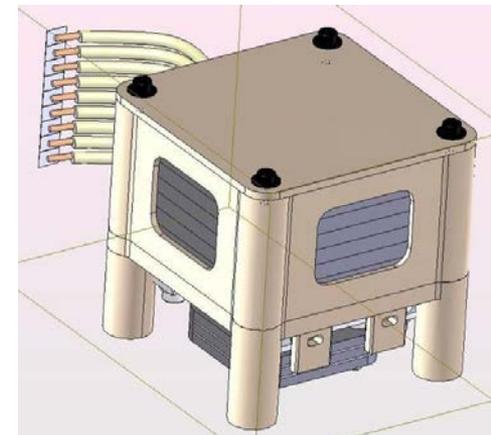
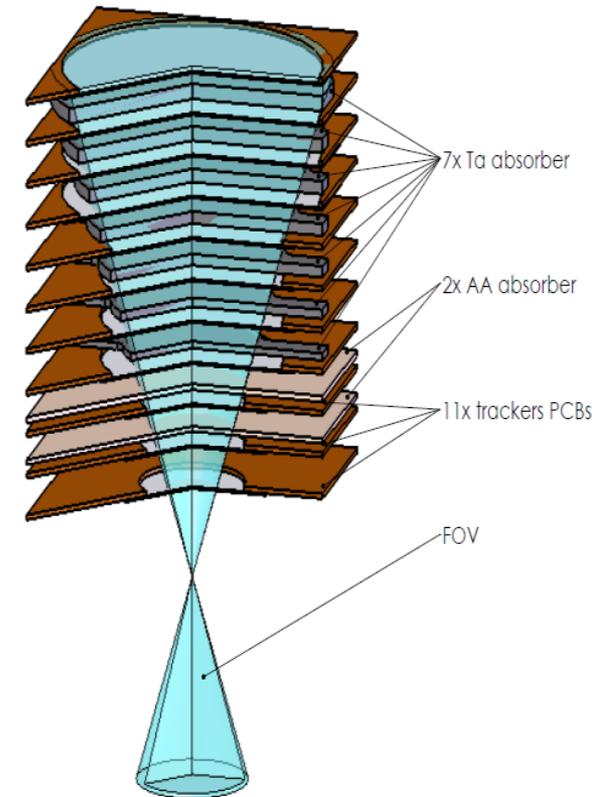
Dimensions

257 x 120 x 117mm³



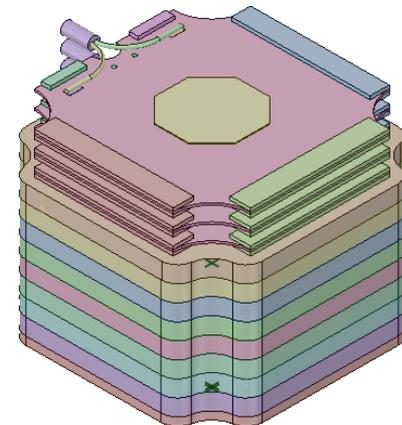
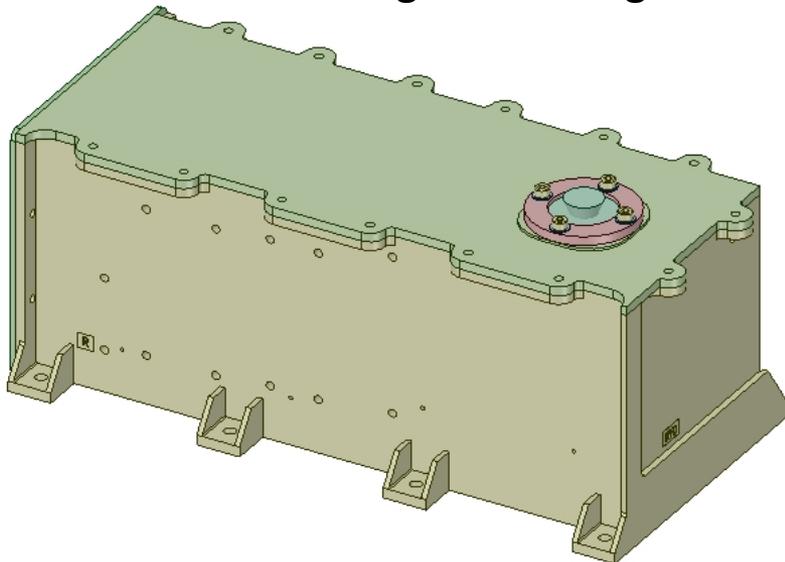
MFS: MultiFunctional Spectrometer

- Particle detection principle: dE/dx measurement in a stack of **11 silicon** detectors interleaved by layers of absorber material (**aluminium** and **tantalum**)
- Stack is surrounded by tantalum structure to shield events out from FOV.



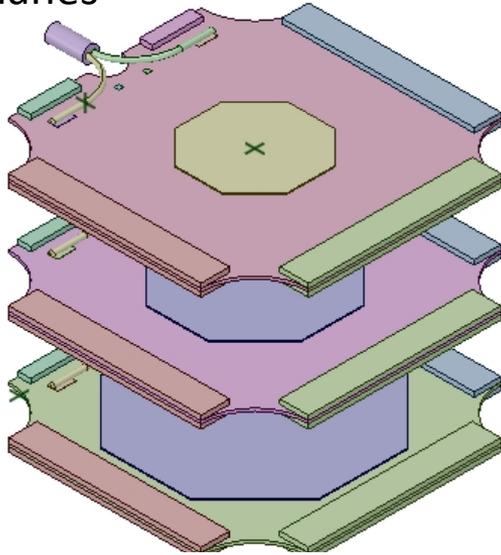
MFS Geant4 simulation

- A detailed MC simulation of MFS is being implemented using the Geant4 version 4.9.4.p02 with the description for :
 - Detector's geometry
 - Materials
 - Calibrations and front-end electronics response
 - ✓ Stack detector: Currently implemented in Geant4
 - ✓ A simplified description of Alphasat spacecraft will be included to take into account shieldings and background sources.

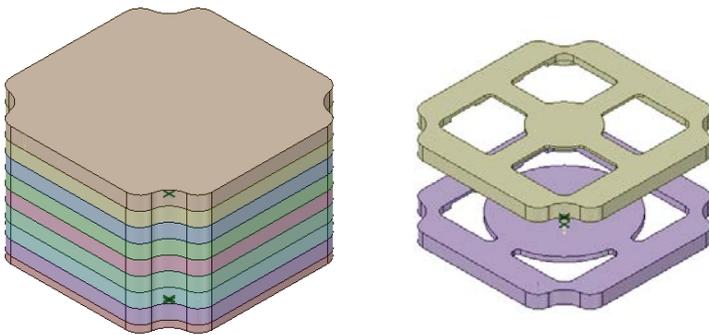


MFS Geant4 simulation: stack detector

PCB+Si Planes

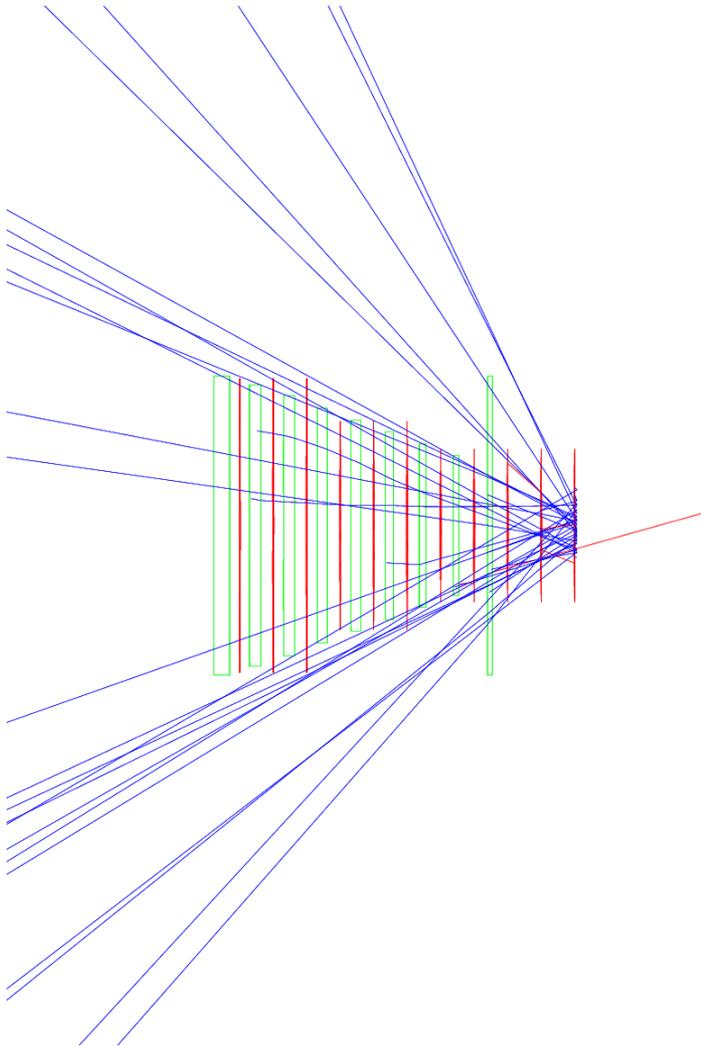


Absorbers



- ✓ 11 cylinders of silicon
 - thickness: 0.2 mm
 - diameter: 8.2428 mm, 11.2666 mm and 15.9058 mm
 - distance btw planes: 3.6mm
- ✓ PCBs
 - made of FR-4: composite material (99.986% SiO₂ + 0.014%Cu)
- ✓ Absorbers
 - made of aluminium (1st two) and tantalum
 - thickness: 0.6, 0.7, 0.8, 0.9, 1.1, 1.2, 1.3, 1.4, 1.5 2.0 mm
 - central radius: 9.125, 10.65, 12.25, 13.75, 15.3, 17, 18.35 mm

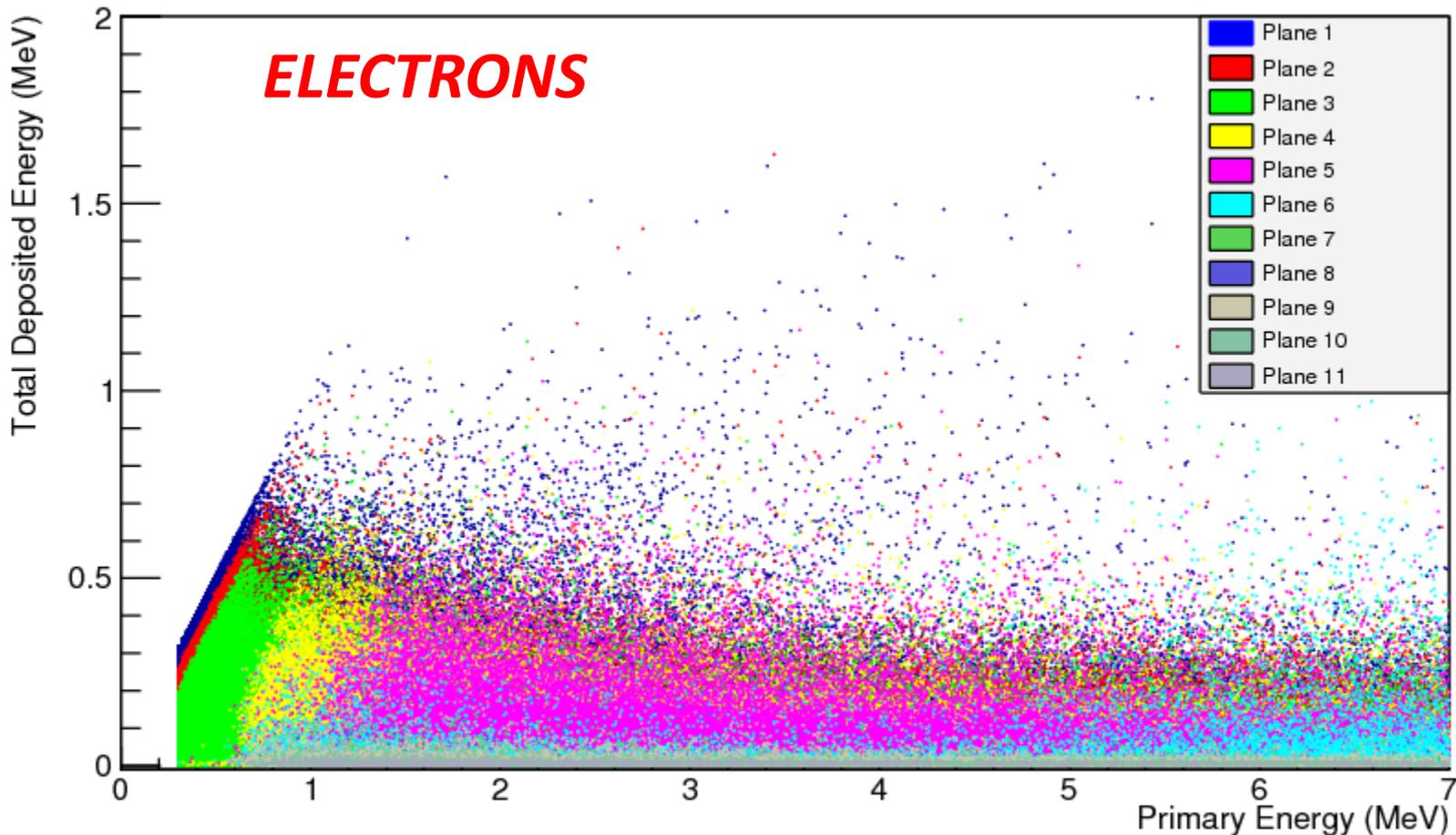
MFS Geant4 simulation



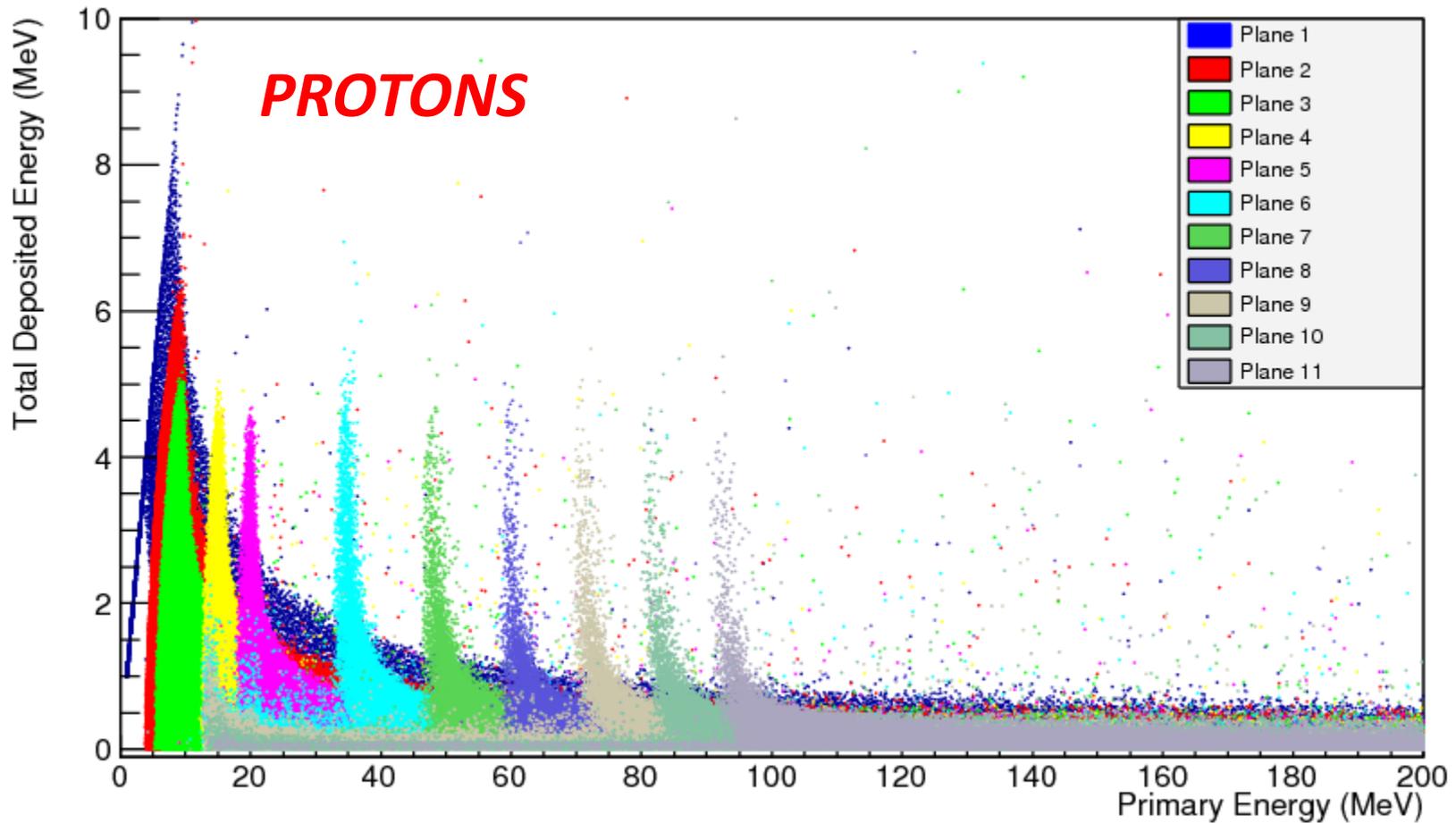
- Simulated particles:
 - Protons, Electrons, Alpha particles
- Particle direction:
 - isotropic
- Particle spectrum:
 - $1/E$ and corrected for CR on-orbit spectrum
- Hadronic Physics list used is QGSP_BIC_HP (Binary Cascade)
- Deposited energy in detectors computed as ADC channel output to include electronics response:
 - Pedestals and gains simulated

MFS Geant4 simulation analysis

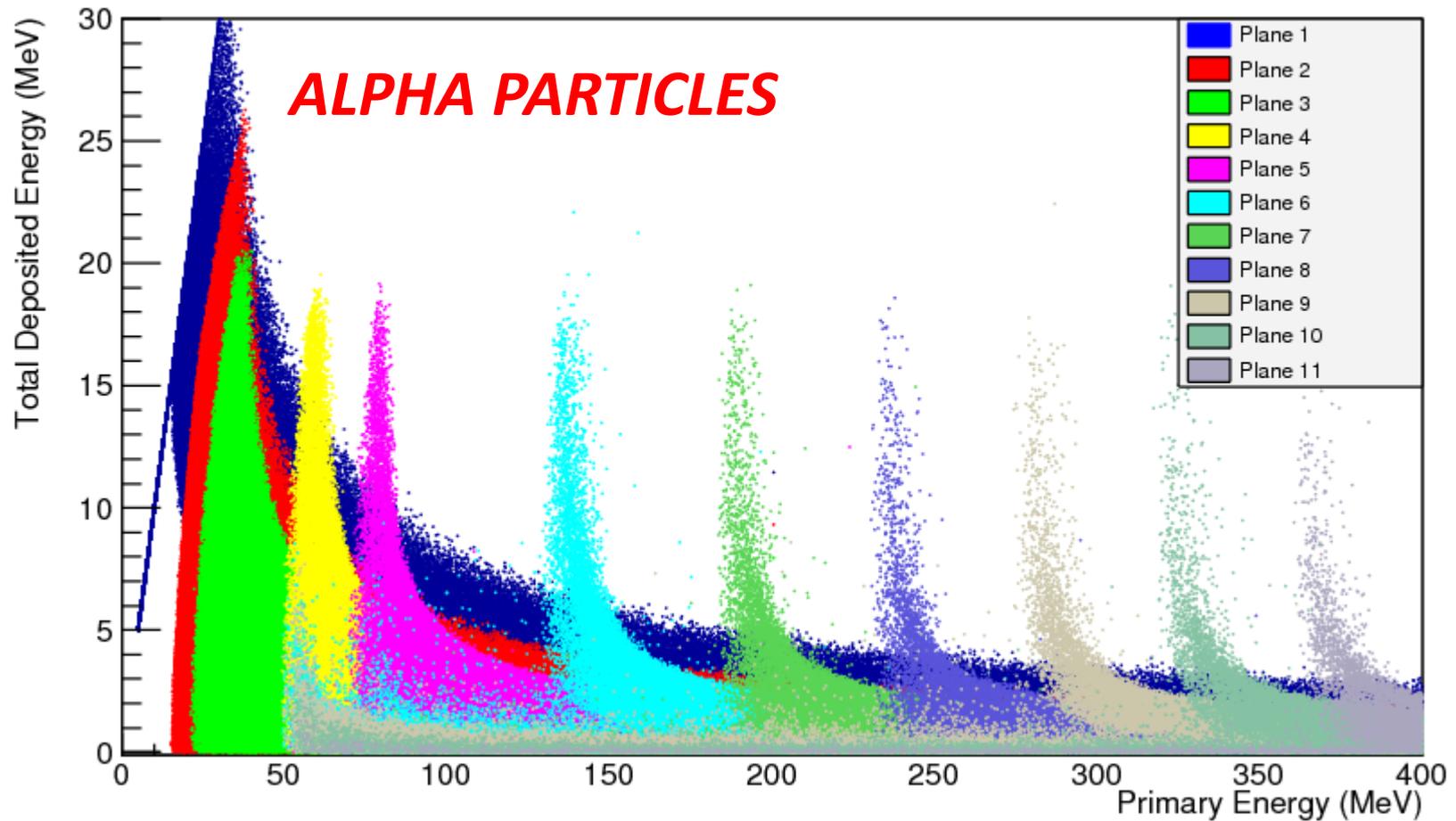
- The analysis framework of the simulation output was developed in ROOT (object oriented)



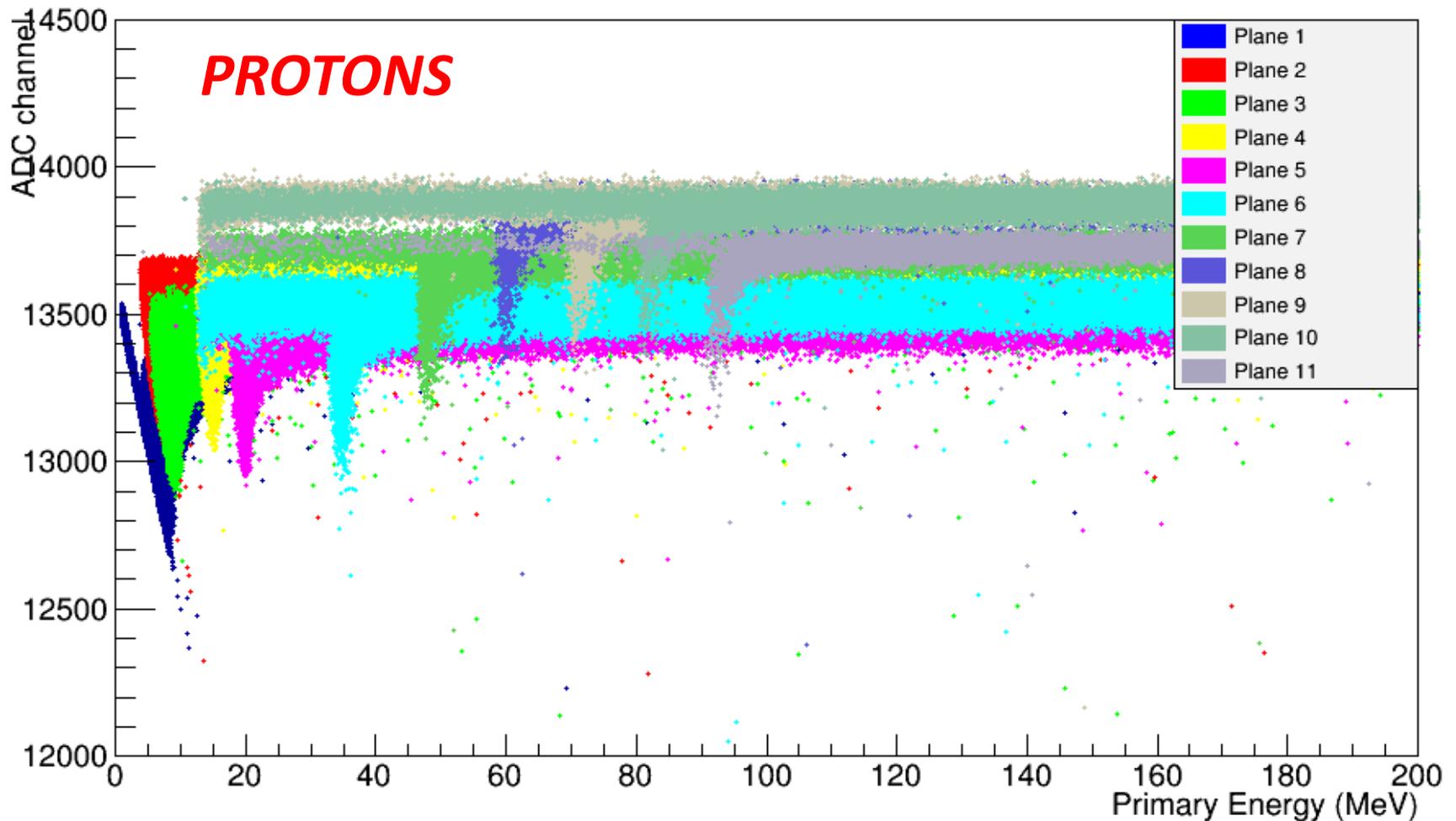
MFS Geant4 simulation analysis



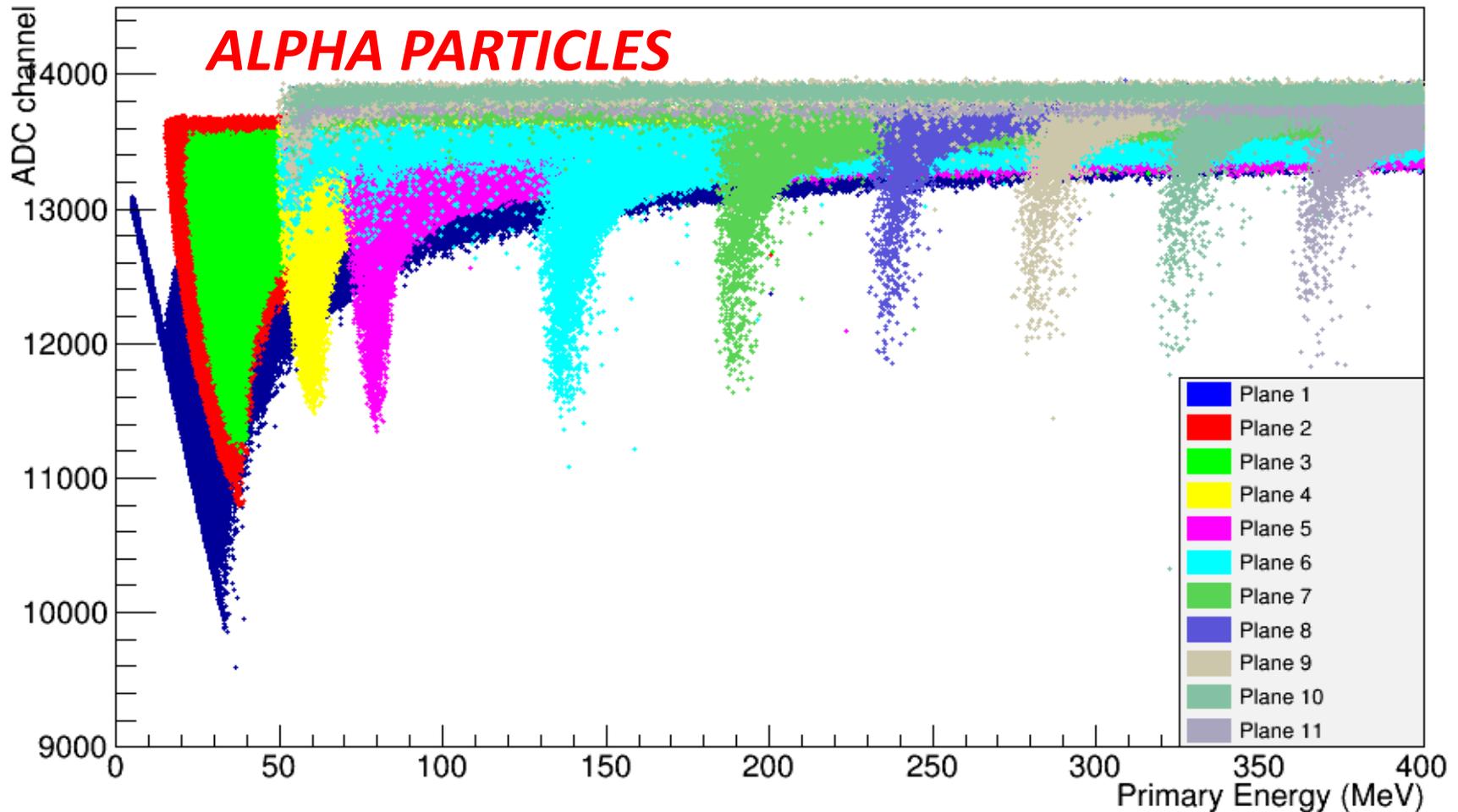
MFS Geant4 simulation analysis



MFS Geant4 simulation analysis

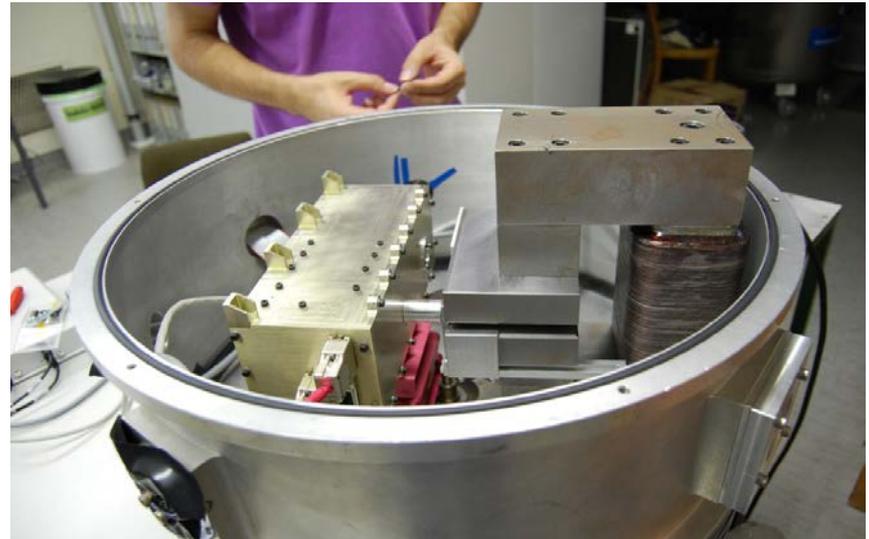
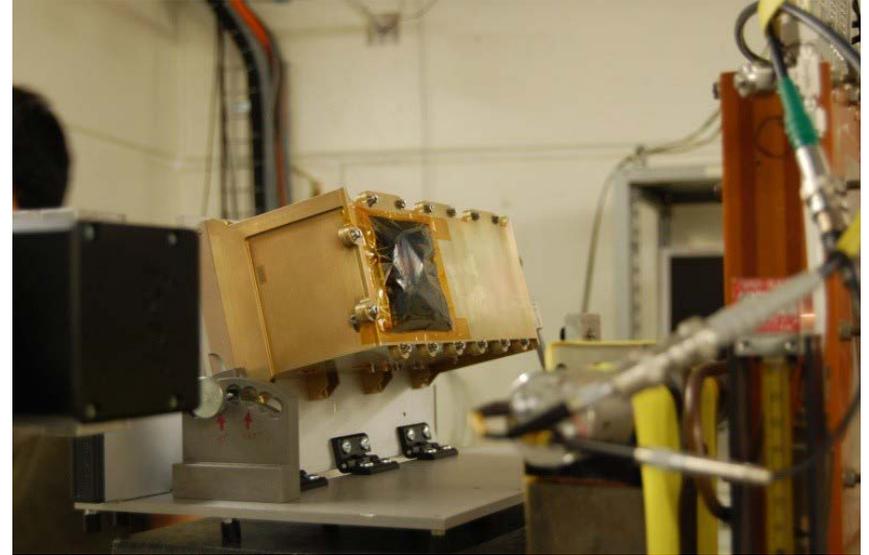


MFS Geant4 simulation analysis

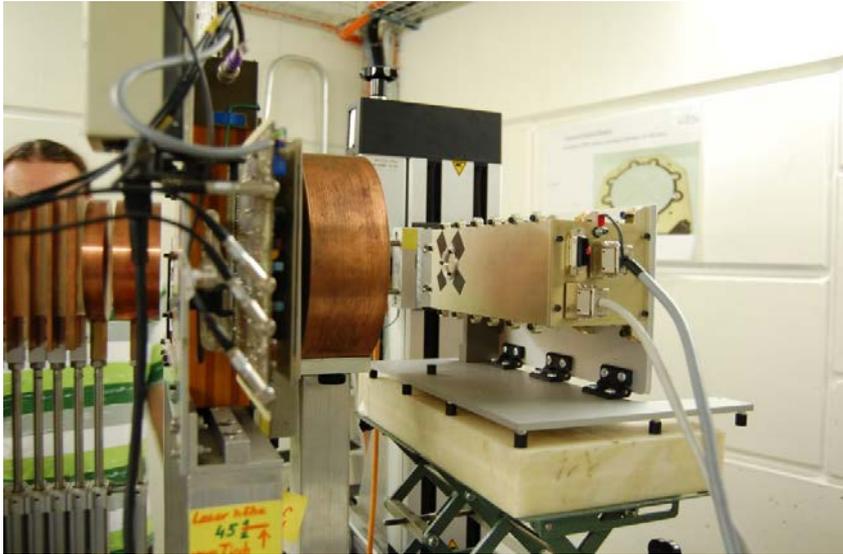


PFM test beam

- MFS PFM was submitted to test beam at PSI (Switzerland) at end 2010.
- Proton beam energies (Proton Irradiation facility)
 - from 10 MeV to 150 MeV using collimators
- Electron monochromator energies
 - from 250 keV to 2.2 MeV
- Different configurations studied: detector perpendicular to beam line and tilted (FOV study)
- Objectives:
 - Study PFM detection capabilities of beam particles
 - Calibration studies
 - Electronics behaviour analysis subject to radiation



TB conditions simulation



- Simulated particles:
 - Protons, Electrons
- Particle spectrum:
 - Protons: 9.6 MeV, 18.95 MeV, 31.2 MeV, 61.9 MeV, 76.1 MeV, 91.0 MeV, 106.3 MeV, 120.2 MeV, 134.84 MeV, 150 MeV
 - Energy straggling from the initial beam energy of 74.3 MeV simulated.
 - FWHM=2.4 MeV at 42 MeV, FWHM=5.6 MeV at 13.3 MeV
- Particle direction:
 - Focused beam (no angular dispersion assumed)
- Beam profile of Gaussian form with FWHM=10cm
- Pedestals and gains measured in the campaign assumed
- PFM geometry assumed + Lexan filter at entry covered with MLI material

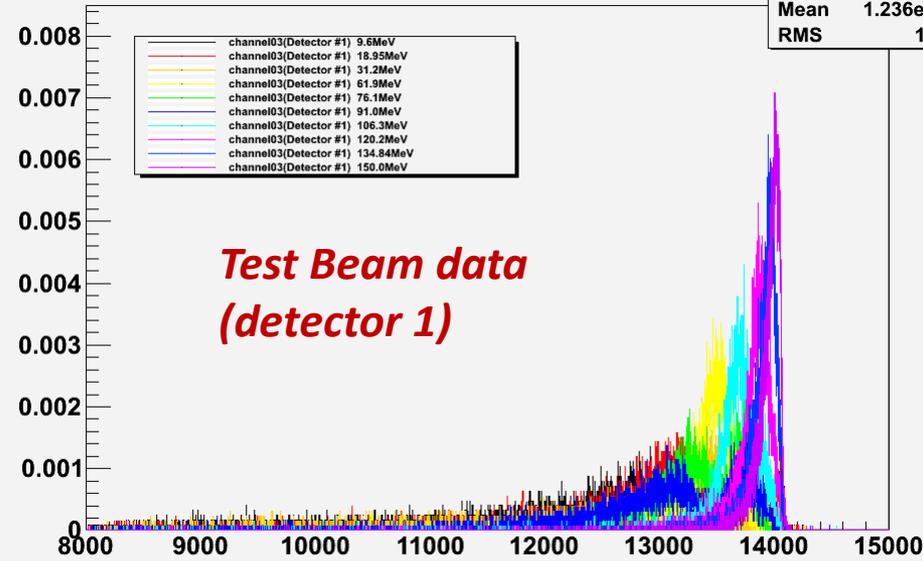


TB data analysis comparion with MC

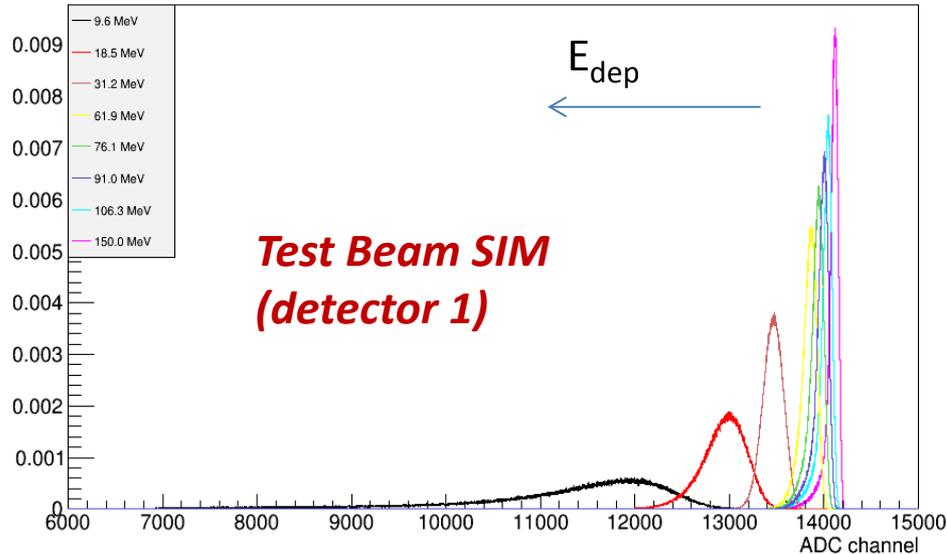
Channel03 (Detector #1) Protons PFM 1st day

channel03(Detector #1) 9.6MeV

Entries	12488
Mean	1.236e+04
RMS	1228



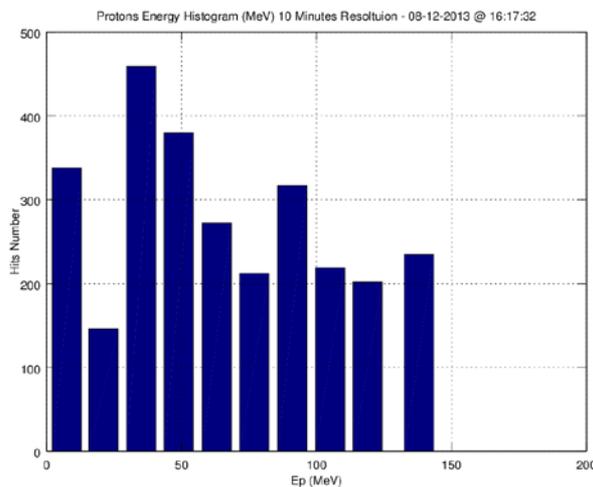
✓ Current Geant4 simulation shows good agreement with Test Beam results with PFM of MFS



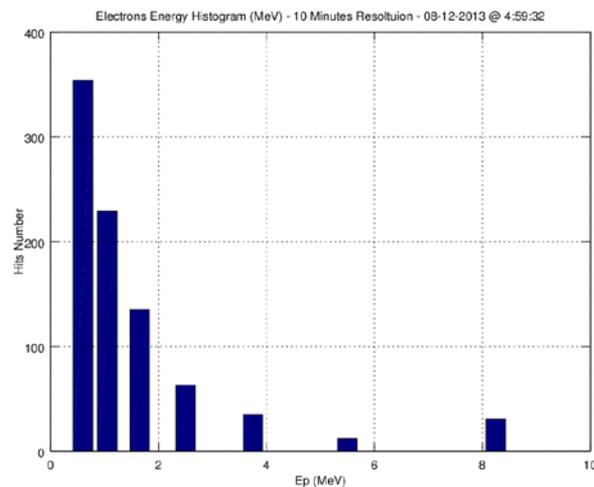
Work in progress and next steps

- Comparison with electron results from TB
- Look at MFS flight data to identify particles and reconstruct their energy spectra.

Protons



Electrons



Alphas

