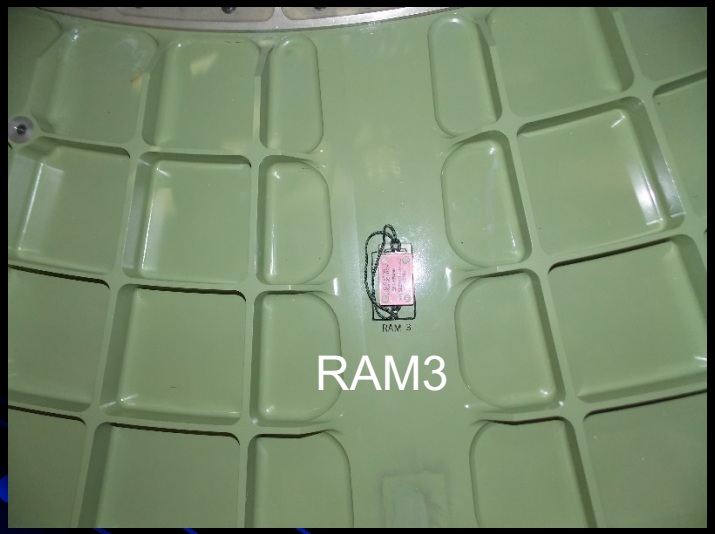
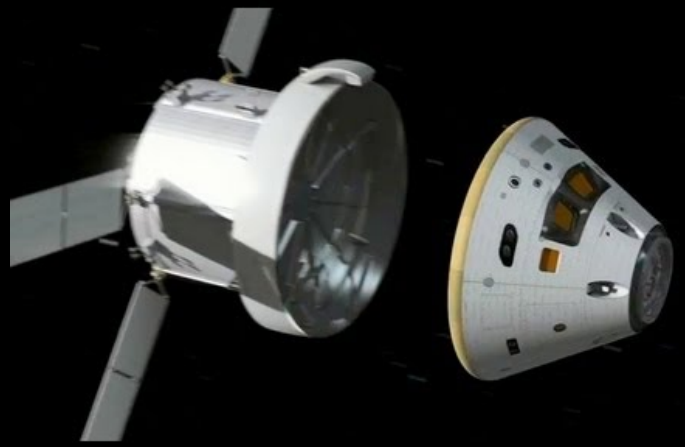
MPCV NASA Space Exploration Active Measurements and Future Operations





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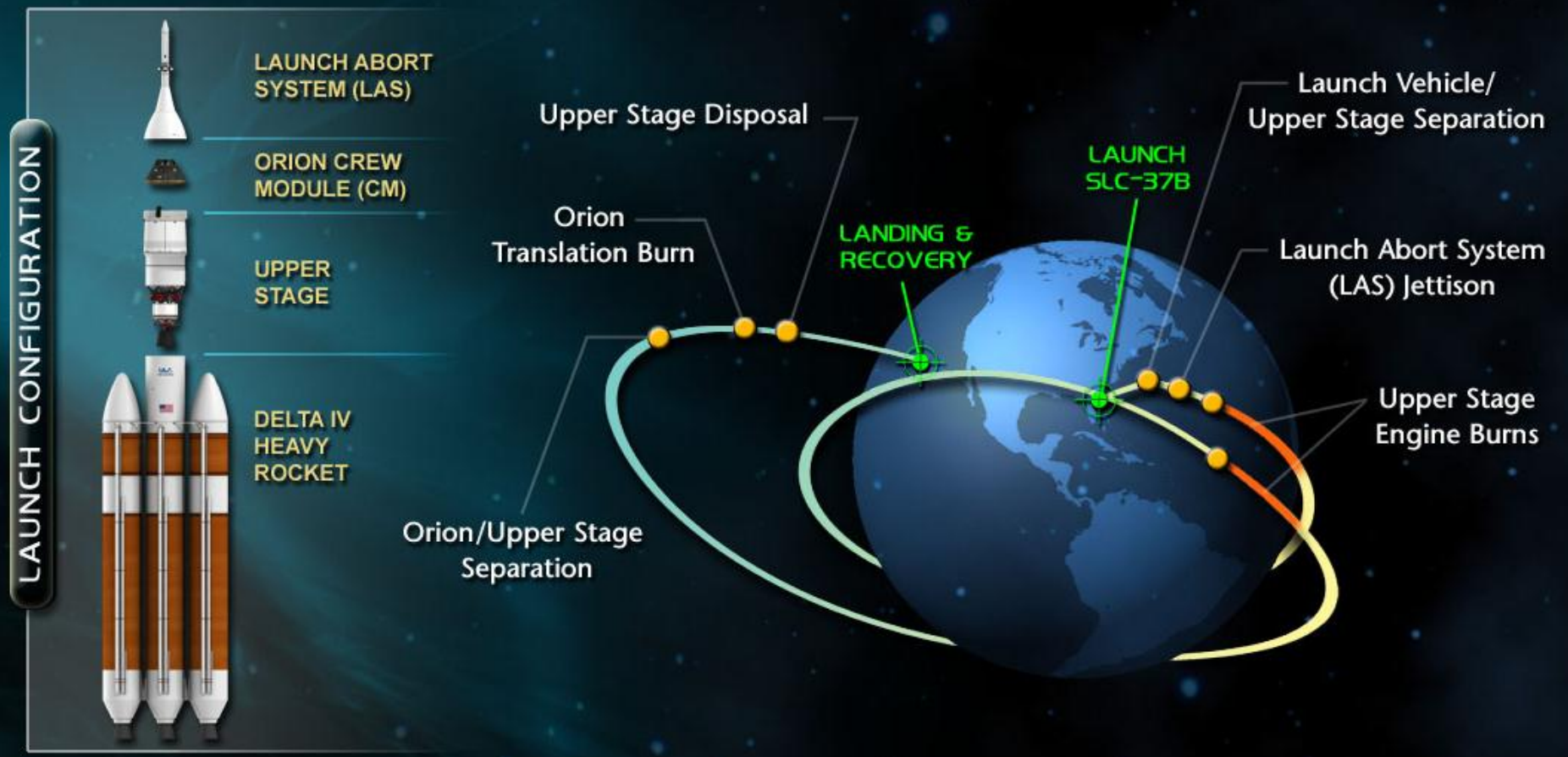
Outline

- EFT-1 BIRD Results
- HERA Integration into MPCV
- Contingency Operations for MPCV during an SPE

Exploration Flight Test 1 – Dec 5, 2014



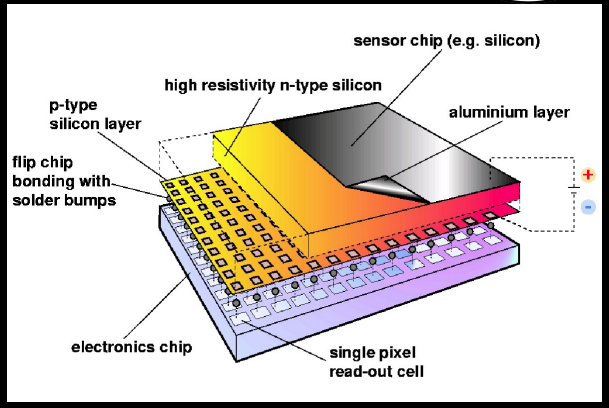
Credit: NASA

BIRD Summary

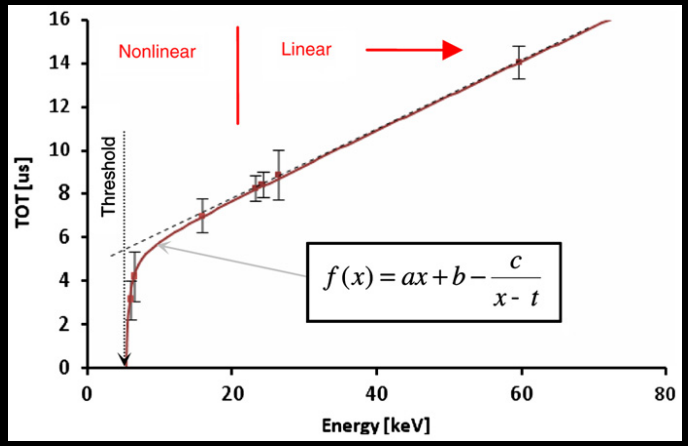
- EFT-1 presented a unique opportunity
  - First measurements in Orion MPCV
  - Information about EM-2
- Detector operation
  - Met all expectations
  - No apparent data corruption
- Data
  - Two peaks caused by spectral changes
  - Max absorbed dose rate about 1 mGy/min
  - Absorbed dose 1000x ISS TEPC

Introduction

- Timepix chip
  - Single energy threshold
  - 55 μm pixels
  - 256 x 256 pixels
  - Active area ~2 cm^2
  - Silicon detection element



L. Pinsky and J. Chancellor *IEEE* (2007)

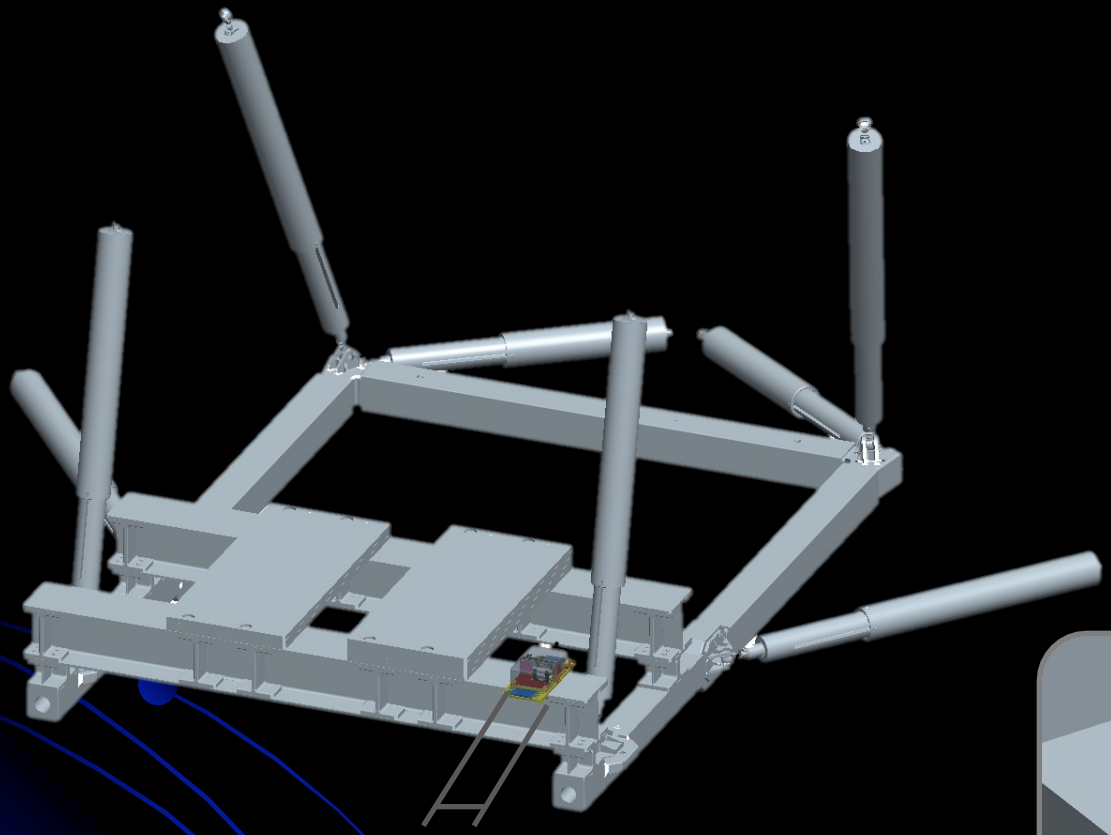


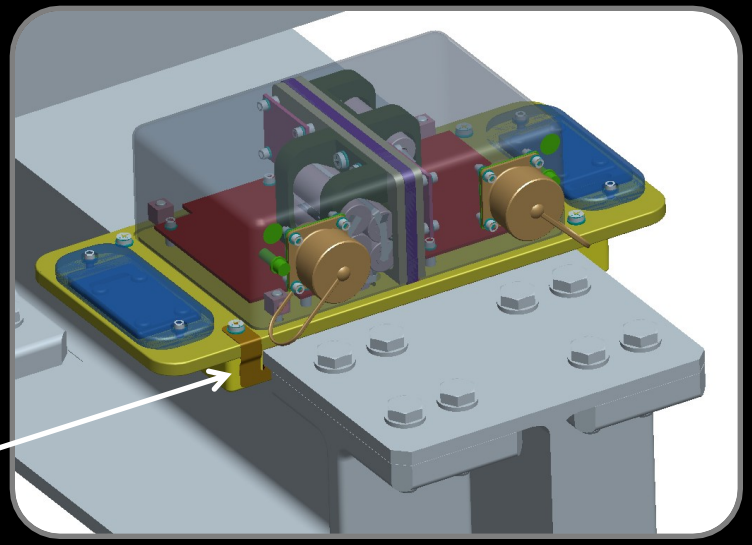
J. Jakubek *Nucl. Inst. Meth. A* **633** (2011)

Introduction

- Timepix detection at NASA
  - ISS Radiation Environment Monitor (REM)
    - Technical demonstration
    - USB communication with laptop
  - BIRD
    - Flew on Orion MPCV in December 2014
    - Independent of vehicle systems
  - Hybrid Electronic Radiation Assessor (HERA)
    - Integrated system
    - Distributed monitoring

Vehicle Attachment

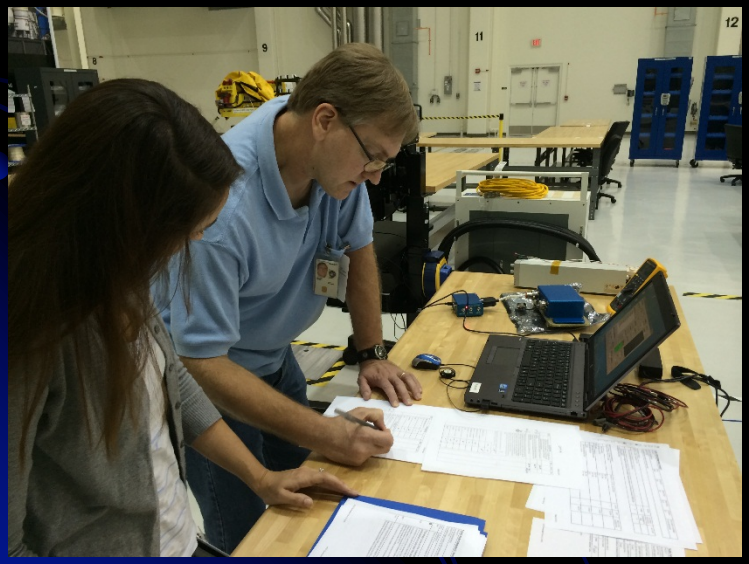




Copper bonding strip positioned to contact an alodined surface

BIRD Overview

- Oct. 2014: Flight hardware shipped to KSC
- Nov. 2014: Installed into EFT-1 vehicle
- 5 Dec. 2014: EFT-1 Launch
- 9 Dec. 2014: Recovered from vehicle
- Feb. 2015: Data report delivered to HQ



BIRD Preflight checkout at KSC

Hardware post flight

Concept of Operations

Pre-flight

- Functional check
- Enter sleep mode
- Install in Orion MPCV

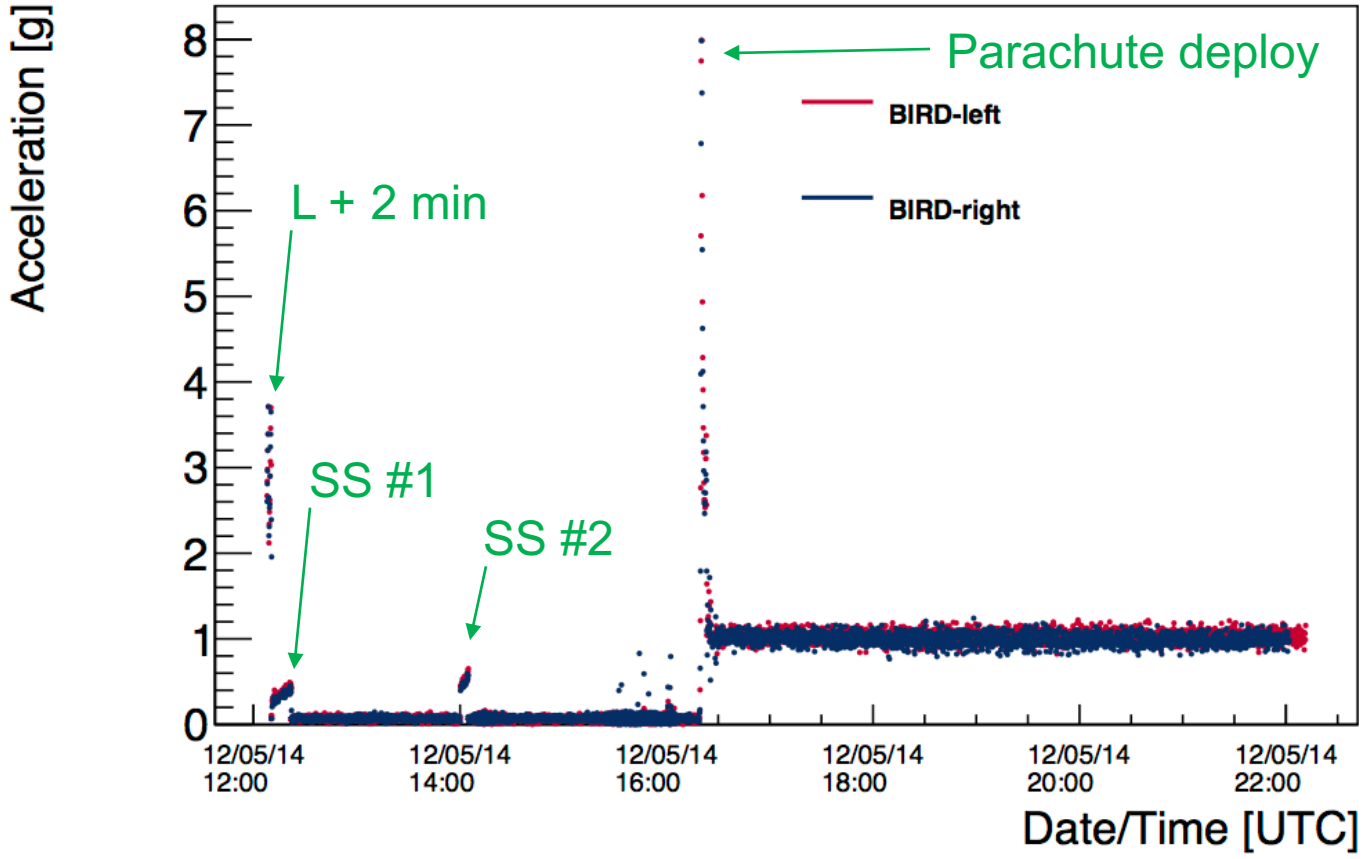
Flight

- Begin data acquisition upon launch
- Terminate once voltage drops below threshold
- Graceful shutdown

Post-flight

- De-install from Orion MPCV
- Transfer data from BIRD
- Analyze and distribute data

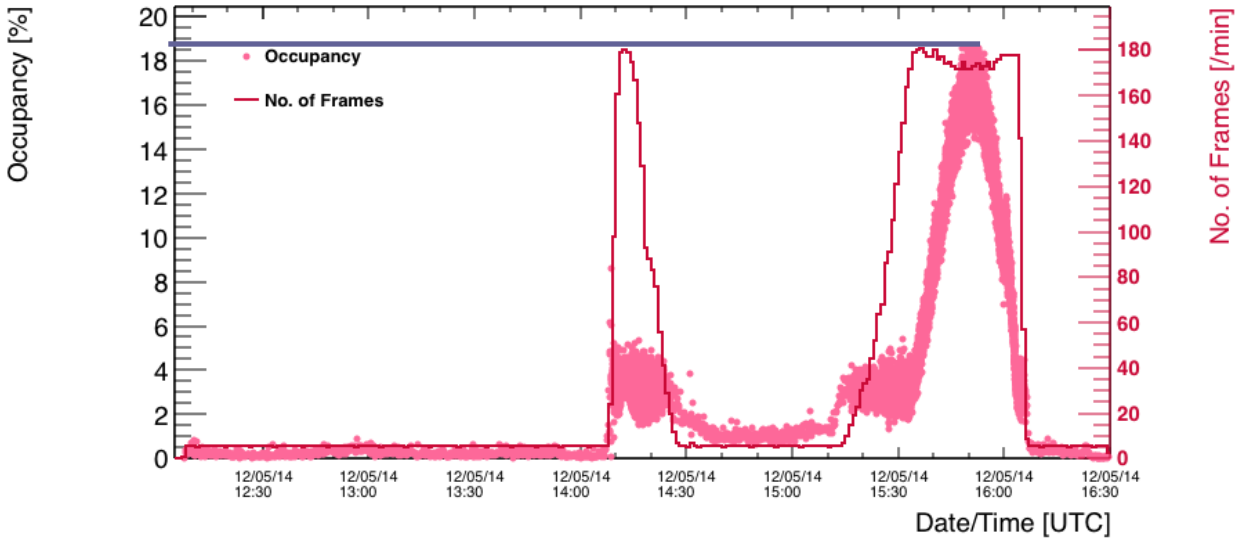
Acceleration

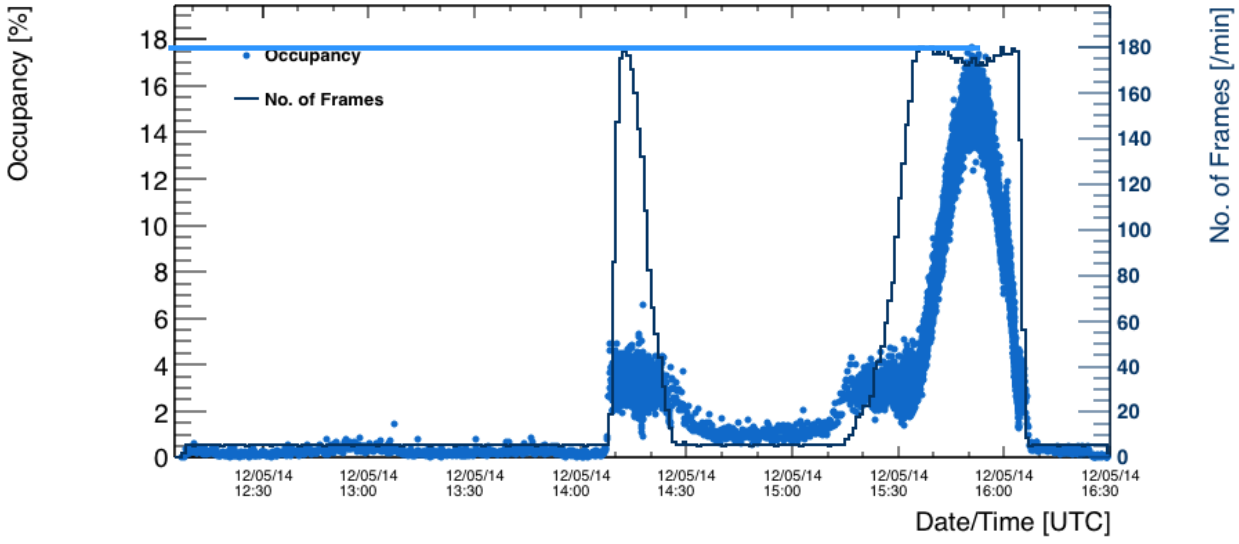


Frame Occupancy and Rate

Left Detector

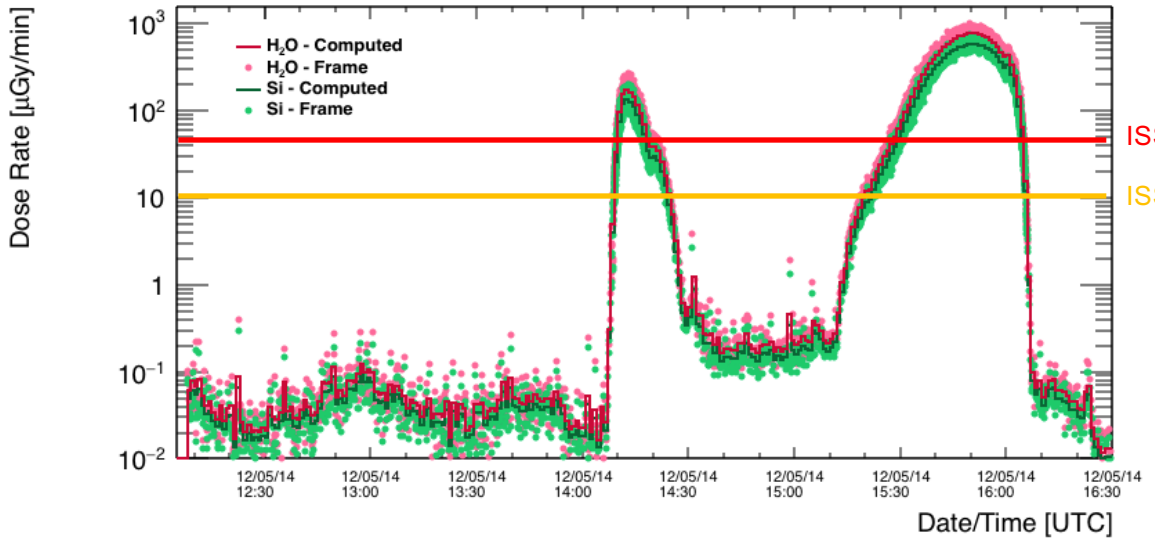
Right Detector



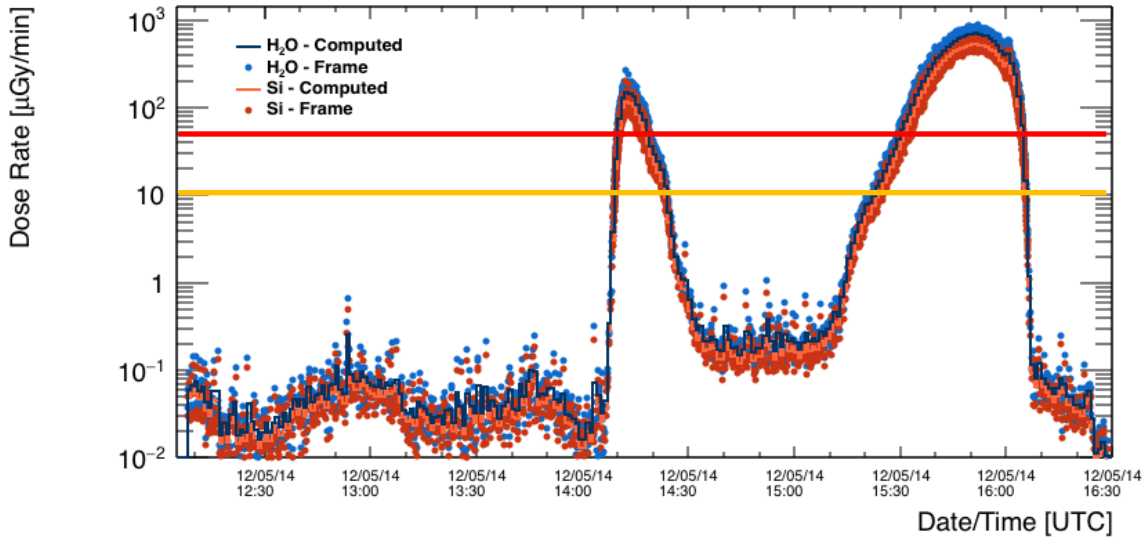


Absorbed Dose Rates

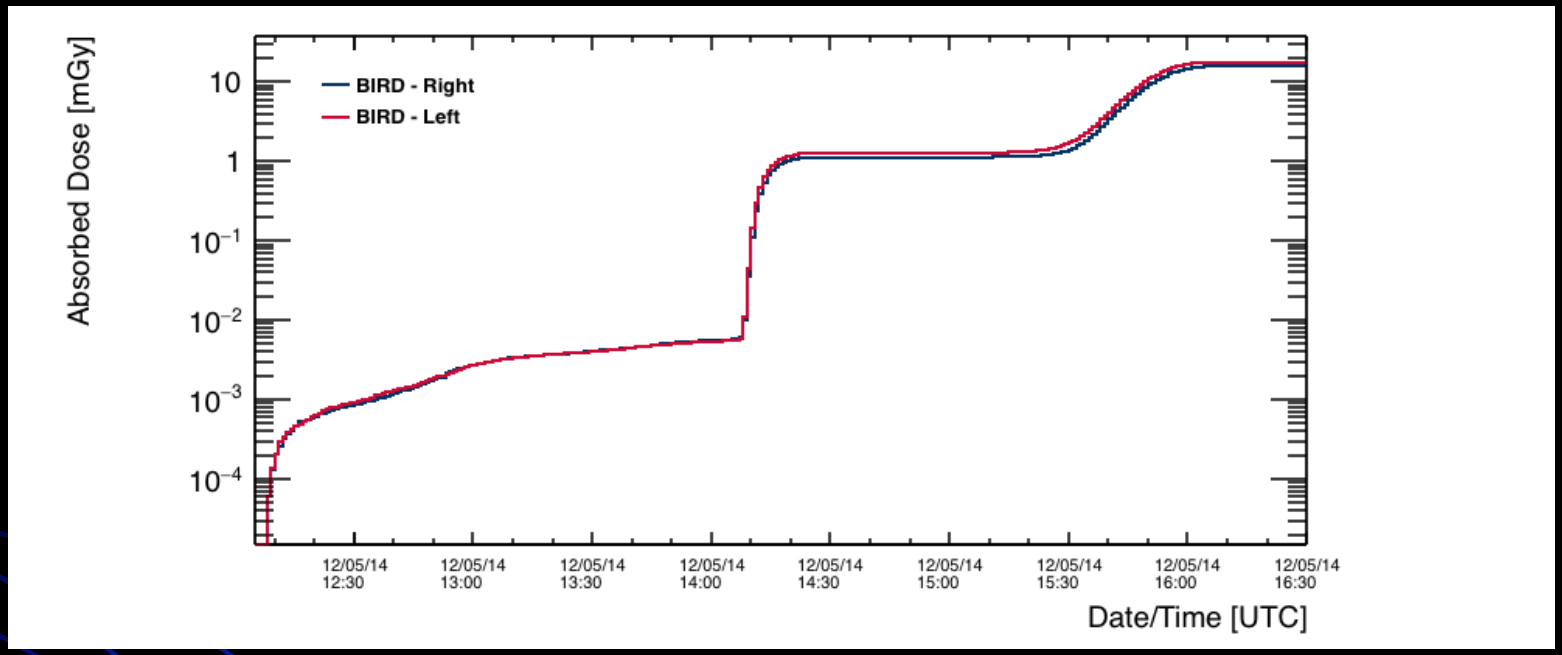
Left Detector



Right Detector



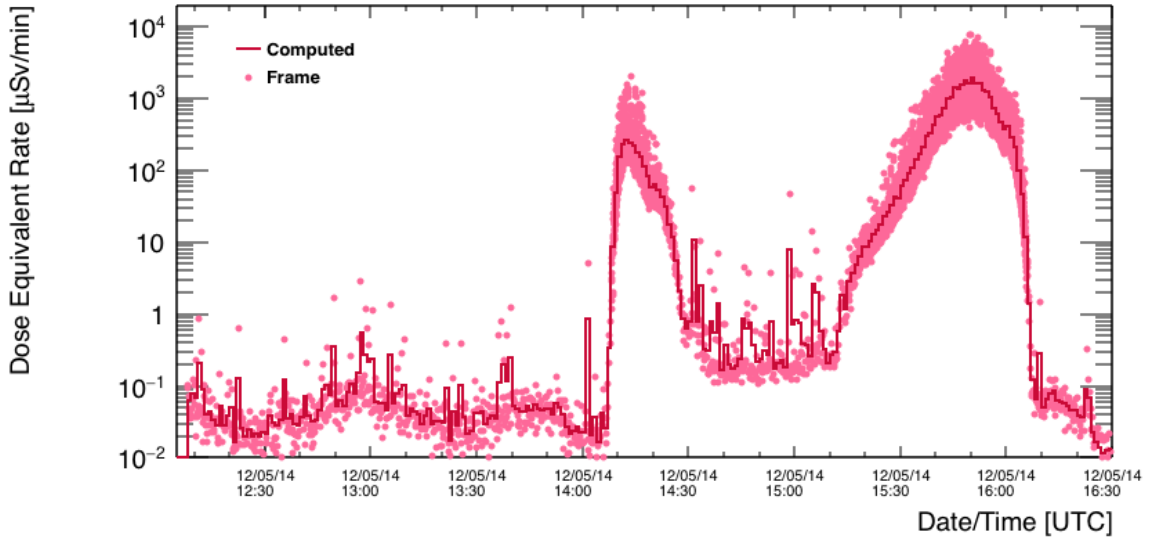
Cumulative Absorbed Dose



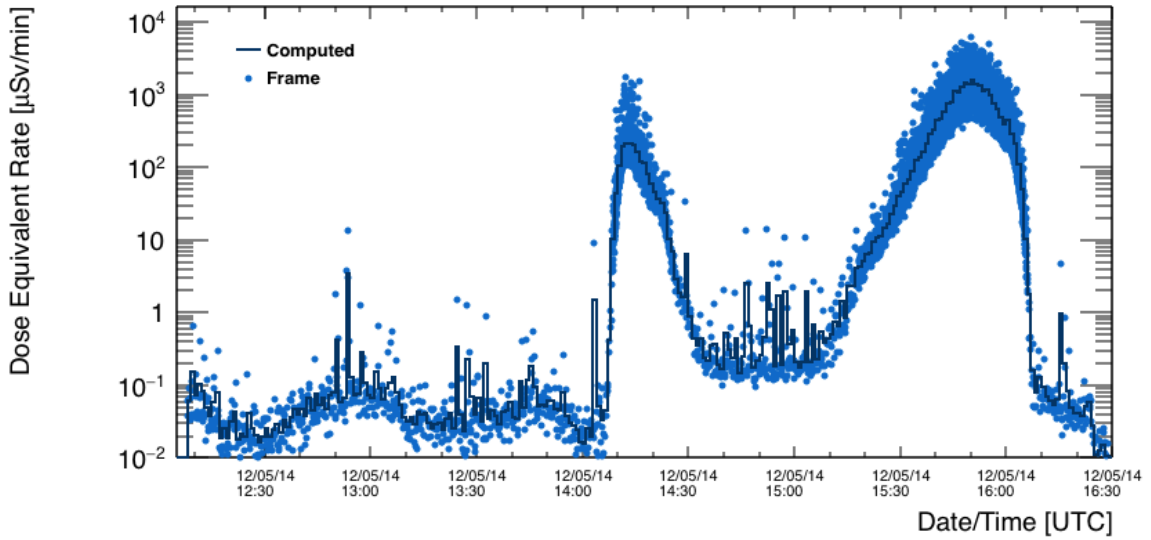
	BIRD [mGy]	RAM [mGy]	ISS-TEPC [mGy]
Left	17.9	15.1 ± 0.3	0.015
Right	15.7	13.5 ± 0.2	

Dose Equivalent Rates

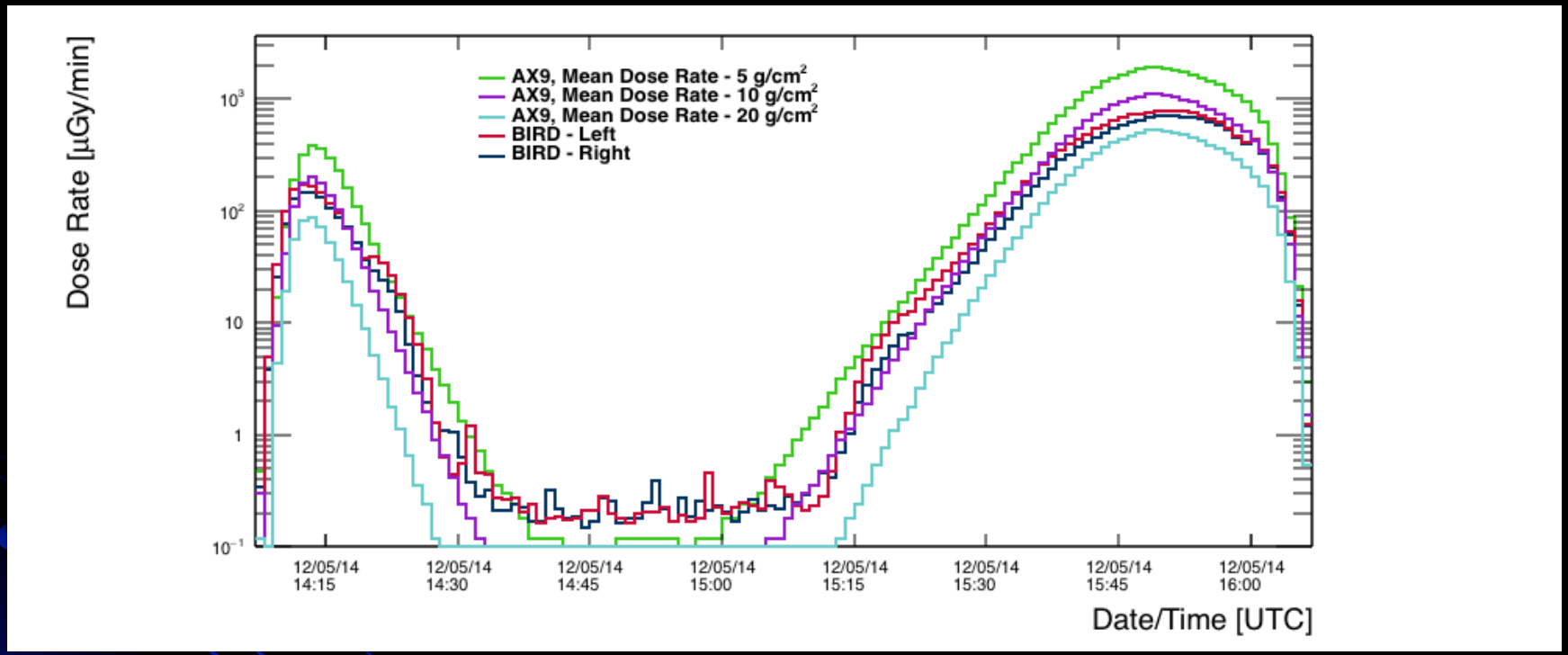
Left Detector



Right Detector

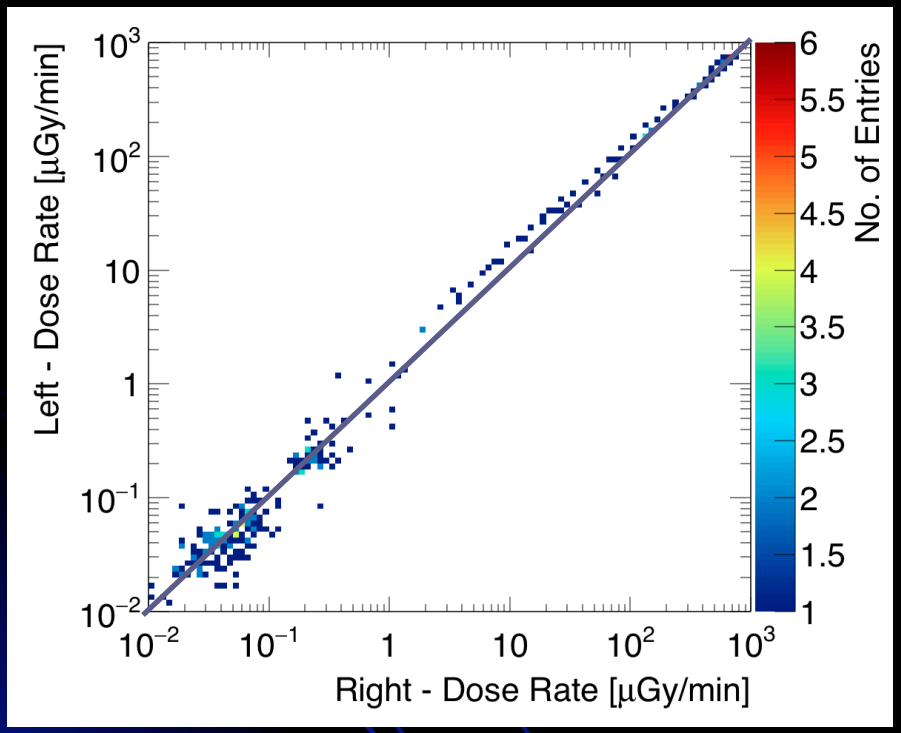


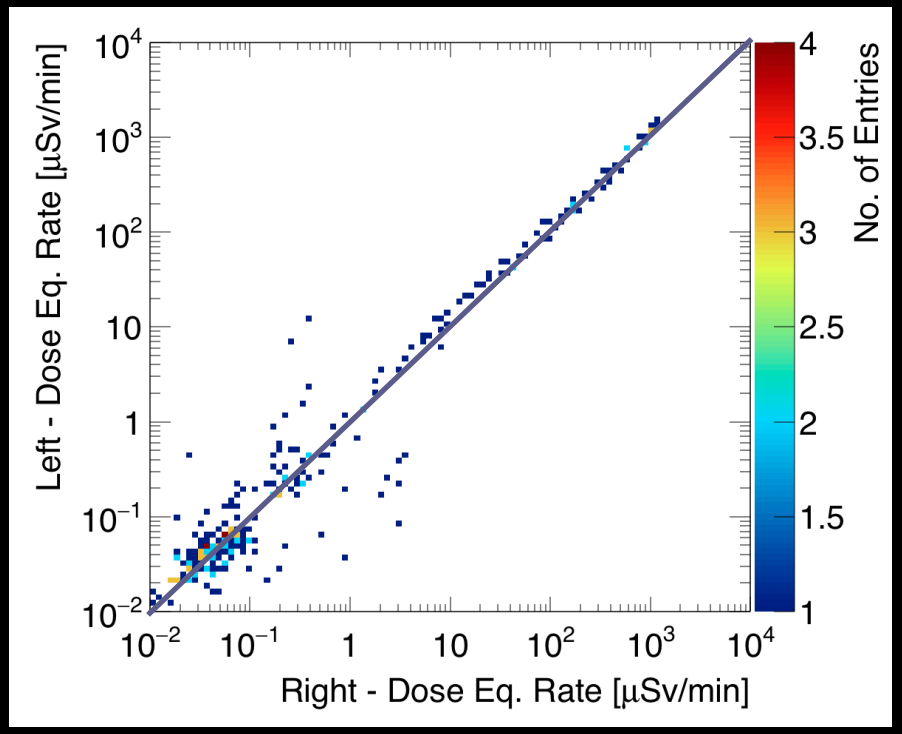
AP9/AE9 Comparison



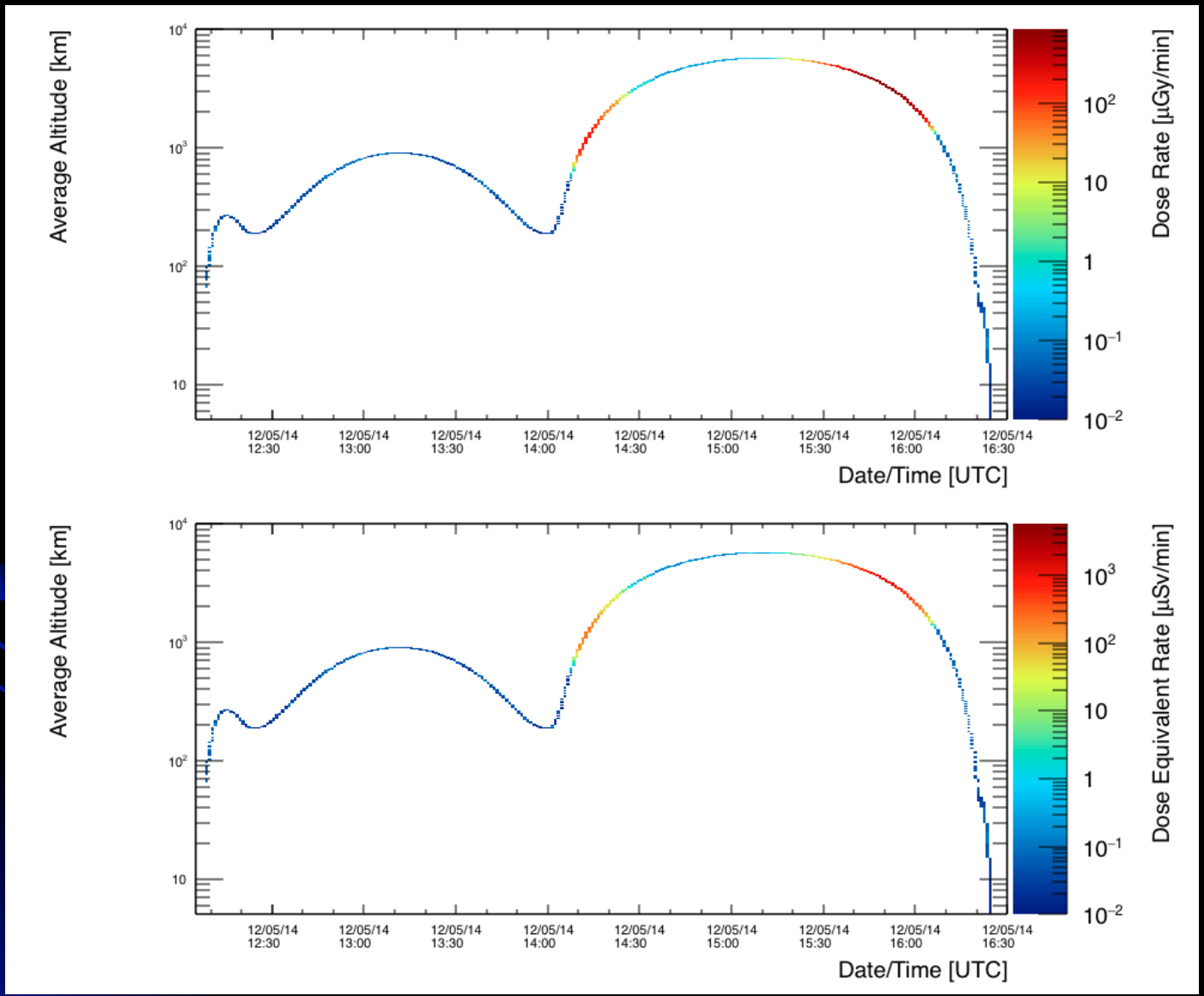
Spherical shell
No solar modulation
AP9/AE9 transport

Detector Comparison

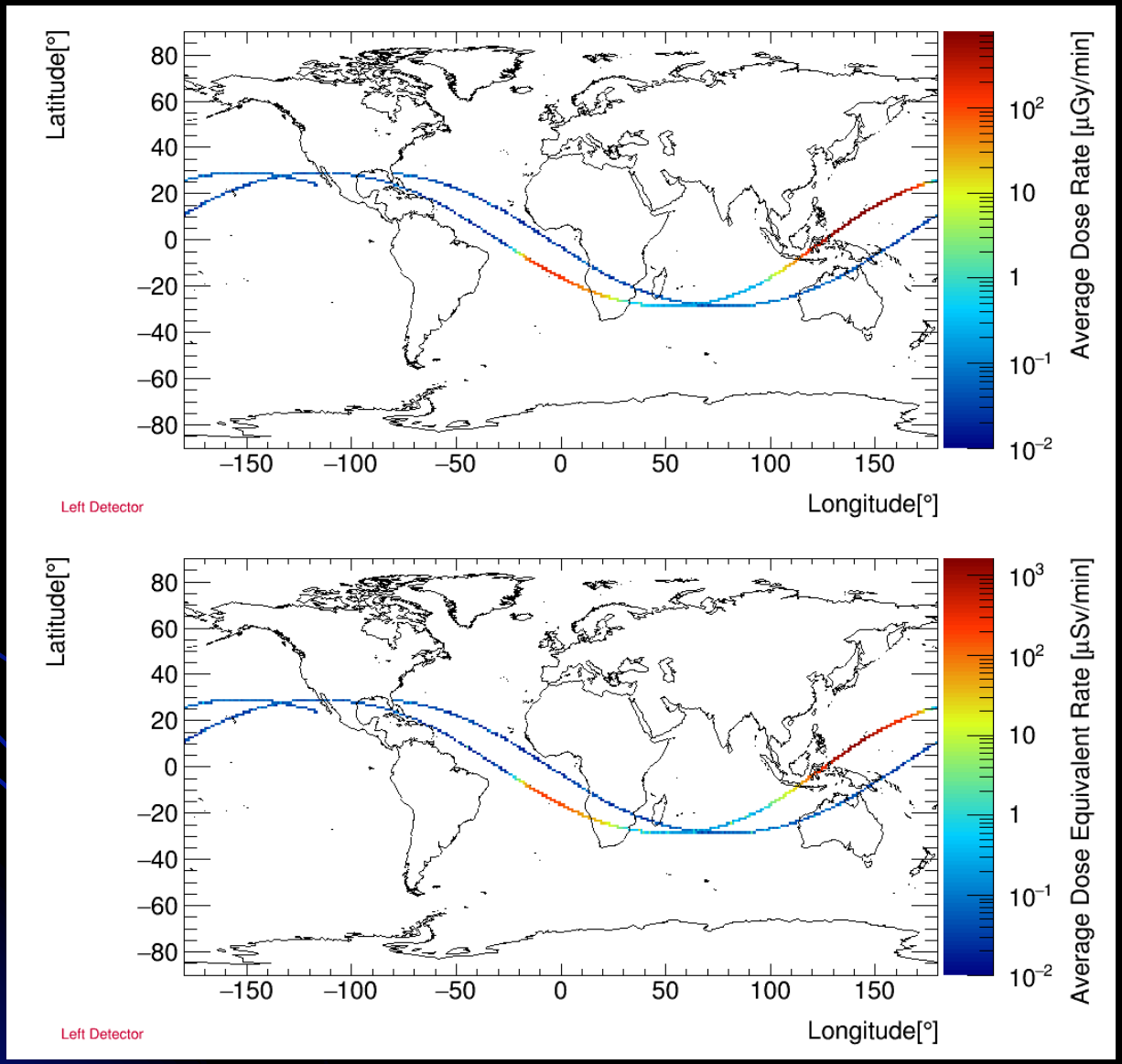




Rates vs. Altitude and Time



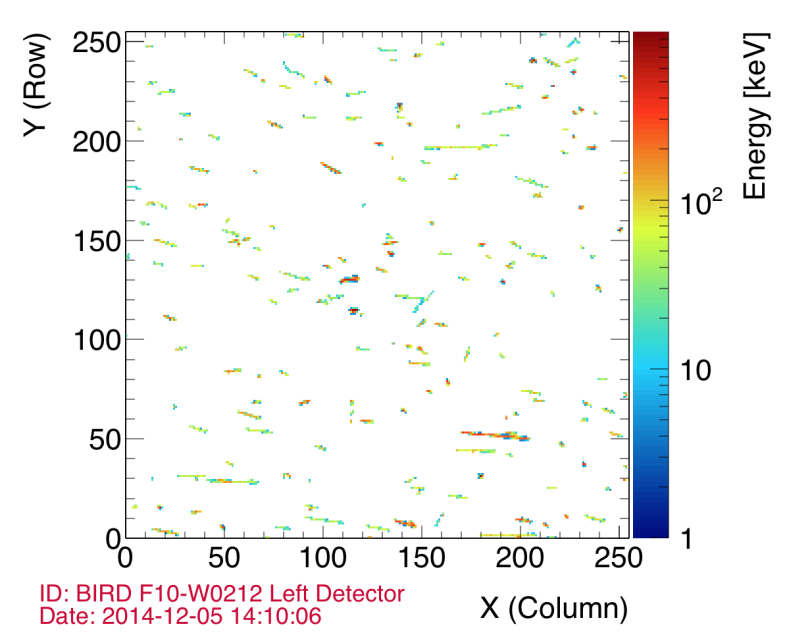
Rates vs. Latitude/Longitude

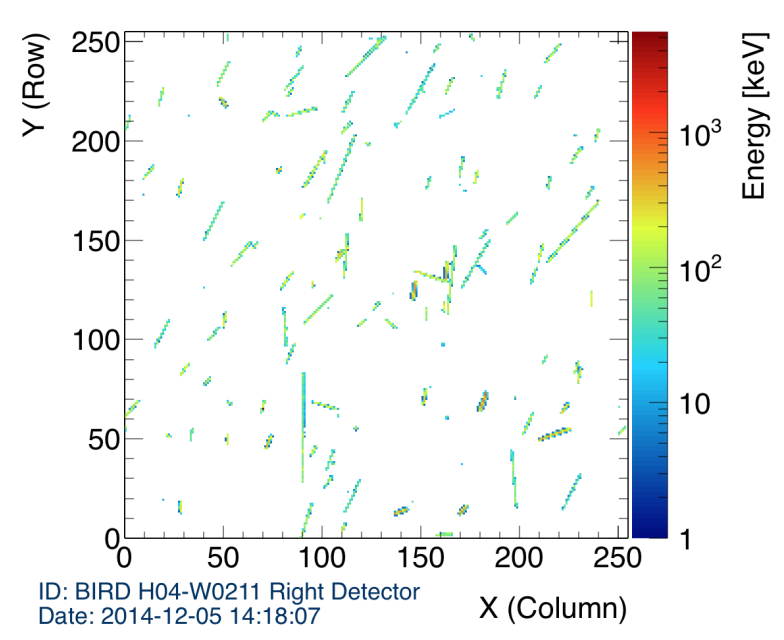


Google Earth Video

Anisotropy

- Trapped proton environment below about 2000 km is known to be anisotropic





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  - First measurements in Orion MPCV
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- Data
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  - Max absorbed dose rate about 1 mGy/min
  - Absorbed dose 1000x ISS TEPC

MPCV simplified representations mass (lbm)

Simplified Reps	CAD Mass (lbm)
RAD_SM	10925.05
RAD_CM_INT	5553.85
RAD_CM_EXT	4427.75
RAD_TPS	5825.42
RAD_Stowage/crew	1472.52

Total mass ~ 28k lbm

- Due to the complexity and size of the MPCV CAD model, it was broken down into 5 simplified representations
- Each simplified representation includes parts and assemblies that have common purpose
- The total of the simplified reps. Equal to the entire MPCV CAD model

Scenario 0: (Crew Seated)

Crew Position	Crew #1	Crew #2	Crew #3	Crew #4
Effective Dose E (mSv)	260	244	273	254

- Crew members' effective doses for August 1972 King SPE environment
- Human-Systems Integration Requirements (HSIR) not-to-exceed exposure limit is *E=150 mSv*

SPE Contingency Plan: Scenario 2 (Ideal stowage configuration)

Scenario 1:

Scenario 2:

Crew Position	Crew #1	Crew #2	Crew #3	Crew #4
SRAG Bench mark (mSv) Contingency	114	117	119	113
SRAG Optimized (mSv) Contingency	85	102	100	98

SPE Contingency Plan Scenarios: (Effective Dose due to King '72 SPE)

Scenario 1:
D&E stowage on top

Crew1: 114 mSv
Crew2: 117 mSv
Crew3: 119 mSv
Crew4: 113 mSv

Scenario 3:
D&E stowage in 8 boxes on top

Crew1: 109 mSv
Crew2: 122 mSv
Crew3: 111 mSv
Crew4: 106 mSv

Scenario 4:
D&E stowage in 16 boxes on top

Crew1: 105 mSv
Crew2: 117 mSv
Crew3: 106 mSv
Crew4: 98 mSv

Scenario 5:
18 boxes on top and 20 canisters in WMS

Crew1: 95 mSv
Crew2: 110 mSv
Crew3: 106 mSv
Crew4: 98 mSv

Scenario 2:
Ideal stowage configuration

Crew1: 85 mSv
Crew2: 102 mSv
Crew3: 100 mSv
Crew4: 98 mSv

SPE Contingency Plan Aspects

- Aspects of the Orion SPE contingency plan.
  1. Use of umbilical from pressurized suits for air flow in bays
  2. Mass risk for stowage restraints
  3. HITL (Human in the Loop) testing

It fits