Space Radiation and Plasma Environment Monitoring Workshop
13 and 14 May 2014 - ESTEC

Efacec Space Radiation Monitors MFS & BERM

Technology that moves the world

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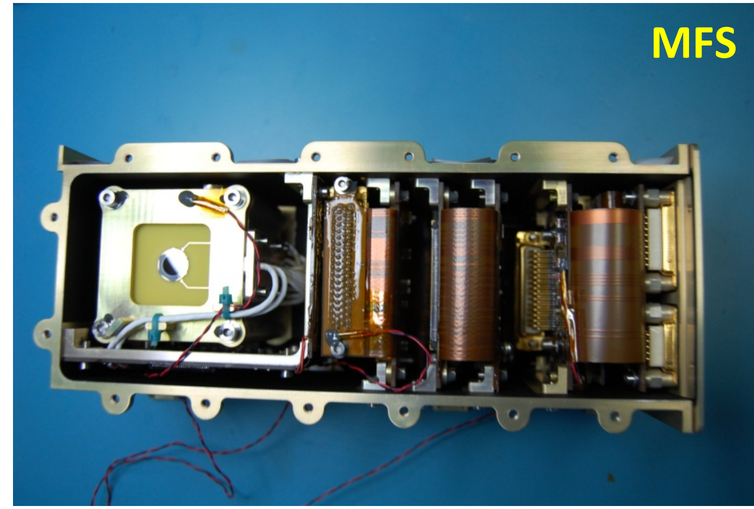
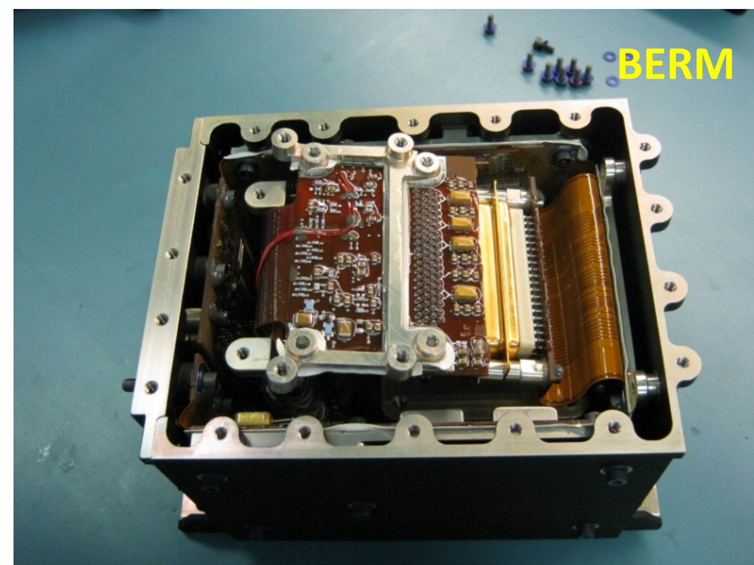
Contents

MFS & BERM Architecture

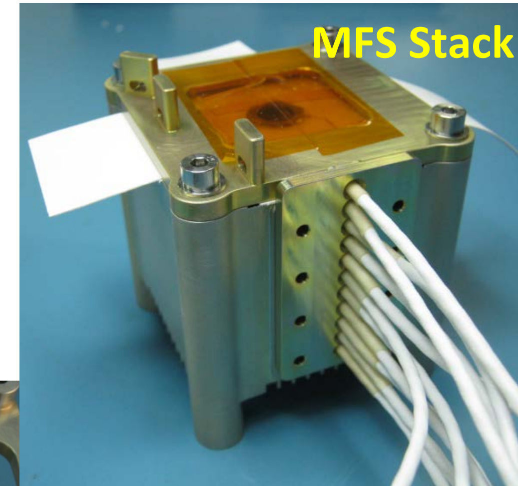
- Efacec Radiation Monitors are based in:
  - Physical Concept – stack of Silicon Detectors;
  - Electronics – Ideas ASIC (FE) and FPGA with memories (BE);
    - FE – CSA with slow shaper for integration and fast shaper for trigger system;
      - Integration time 2.125µs and discharge time 10us (both configurable);
    - BE – FPGA and memories running:
      - Particle recognition process;
      - Communications;
      - Health/housekeeping process;
      - Memories scrubbing (configurable);
  - LUT – All functional parameters are TM/TC configurable by ground;
  - Default values stored in EEPROM;

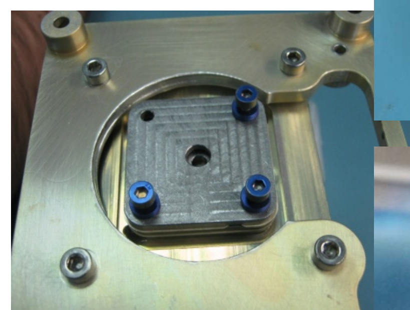


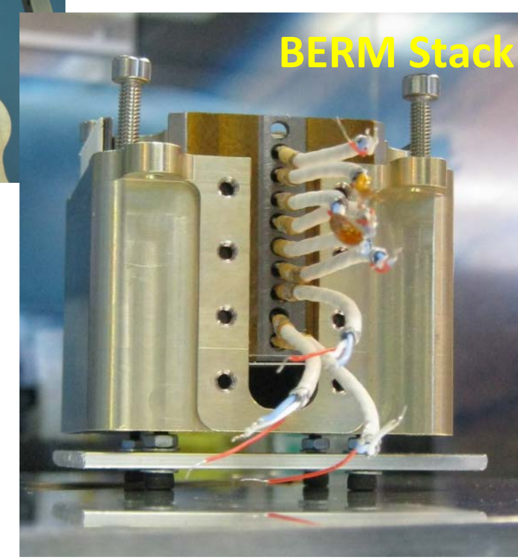


MFS & BERM Detectors

- Stack of Detectors:
  - Both Spectrometers are composed by a single stack of 11 Si detectors;
  - No anti-coincidence HW, Ta side shield in BERM;
  - MFS has a field of view of 40º limited by its Ta collimator;
  - BERM has the same field of view, but it is defines either by the Ta collimator and top detector;
  - All detectors are 300um thickness with an entrance window of less than 50nm;
    - Exception is the top detector in BERM which is 200um – remaining parameters identical;
  - MFS collimator shielded by Lexan/Kapton;
  - BERM collimator shielded by Nickel;







MFS & BERM Stack

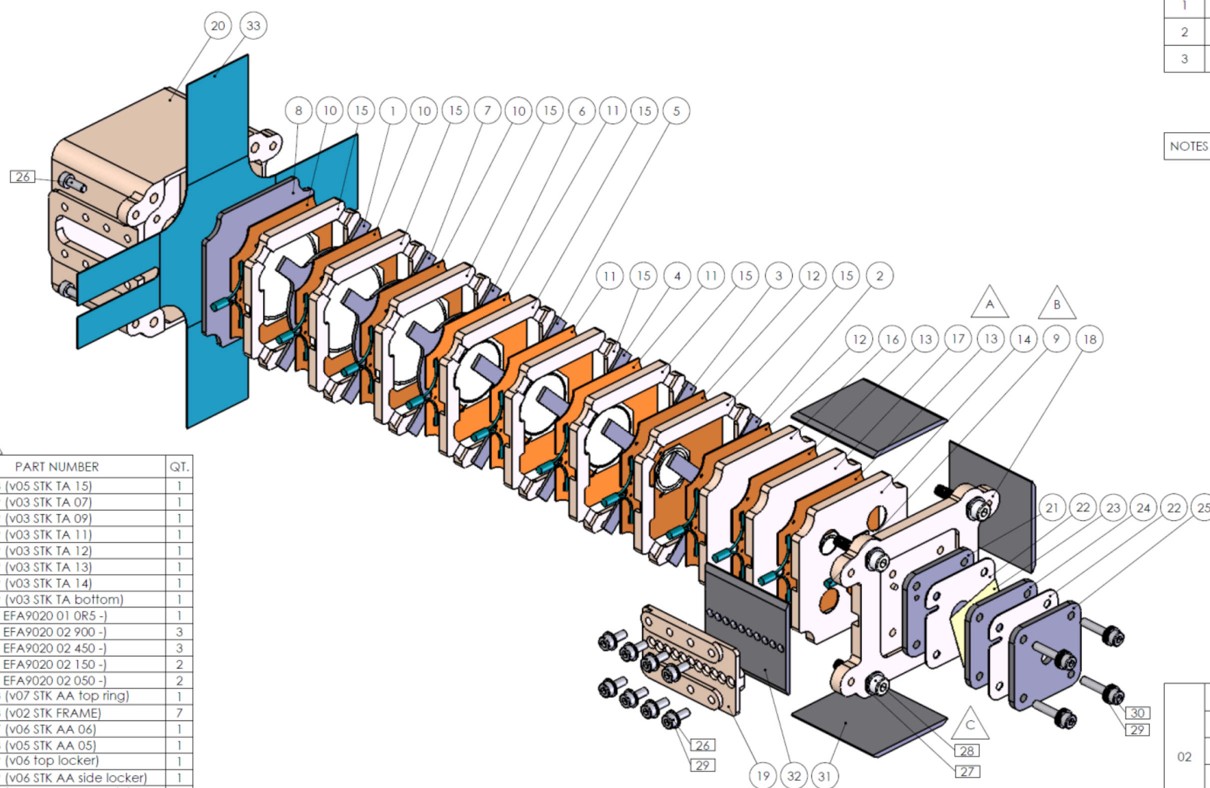


Table of Contents

Page	Description
1	DA exploded view
2	DA main features' dimensions
3	Mass properties

NOTES

ITEM NO.	PART NUMBER	QT.
1	3908.073 (v05 STK TA 15)	1
2	3908.009 (v03 STK TA 07)	1
3	3908.019 (v03 STK TA 09)	1
4	3908.029 (v03 STK TA 11)	1
5	3908.039 (v03 STK TA 12)	1
6	3908.059 (v03 STK TA 13)	1
7	3908.069 (v03 STK TA 14)	1
8	3908.099 (v03 STK TA bottom)	1
9	TBD (v02 EFA9020 01 0R5 -)	1
10	TBD (v02 EFA9020 02 900 -)	3
11	TBD (v01 EFA9020 02 450 -)	3
12	TBD (v01 EFA9020 02 150 -)	2
13	TBD (v02 EFA9020 02 050 -)	2
14	3908.093 (v07 STK AA top ring)	1
15	3908.013 (v02 STK FRAME)	7
16	3908.107 (v06 STK AA 06)	1
17	3908.103 (v05 STK AA 05)	1
18	3908.129 (v06 top locker)	1
19	3908.089 (v06 STK AA side locker)	1
20	3908.079 (v02 STK AA capsule)	1
21	3908.119 (v03 -Z dsk)	1
22	3908.125 (v03 DISK SPACER VH)	2
23	4509.006 (v01 BE FOIL 25 25 .025)	1
24	3908.113 (v02 mid dsk)	1
25	3908.109 (v02 +Z dsk)	1
26	DIN 912 M3 x 8 --- 8N	12
27	Washer DIN 125 - A 4.3	4
28	NA (v02 TI M4 BOLTS)	4
29	Washer DIN 125 - A 3.2	24
30	DIN 912 M3 x 16 --- 16N	4
31	3908.133 (v01 STK TA SW)	3
32	3908.135 (v01 STK TA SW HOLES)	1
33	NA (v01 STK CHOT CROSS)	1

Doc Issue	Zone	Description
02	D	BOM updated as result f the changes A, B and C
	C	Items #28 and 29 added
	B	Item identified in the exploded view
	A	Former item replaced by a item #13
	Assy Internal Code	v03 replaced by v04
01	All	First Issue

Revision Table (Only revision detailled in this sheet)

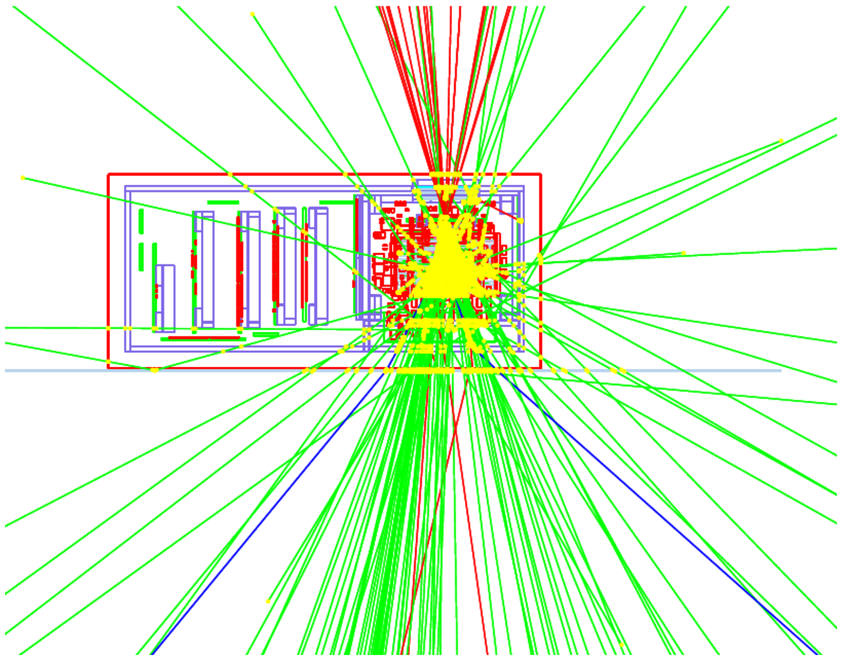
SHEET SIZE A2	UNITS mm	DRAWING Pedro Marinho 2012-10-03	efacec	DOC CODE EFA-MEC-0057
SCALE 1:1	TOLERANCE ISO2768fH	VERIFICATION Arlindo Marques 2012-10-03		DOC ISSUE 02 / DOC DATE 2012-10-03
CAD SOLIDWORKS	SURF. FINISH Ra 3.2	APPROVAL -- 2012-10-03		DOC TITLE BERM DA LIGHT
ISO SYSTEM	DISTRIBUTION --	PA APPROVAL -- 2012-10-03	MACHINING REQUIREMENTS DOC --	PROJECT BERM - QM
	CLIENT --	CONTACTS (+351) 229403451 pedro.borges.marinho@efacec.pt	PART/ ASSEMBLY INTERNAL CODE NA (v04 BERM DA LIGHT)	PAGE 1 / 3

MFS & BERM Reconstruction

- Particle identification by dE/dx;
- Compensation of electronic noise;
- Configurable trigger scheme;
- Embedded veto algorithm;
- Adjustable gain by channel (use of weight factors in reconstruction);
- Built in test modes to check:
  - ASIC and analogue chain;
  - Digital algorithmic;
- Failure detectors can be skipped in the reconstruction algorithm;
- Default LUT stored into internal EEPROM;
- Values can be overloaded by TC;

MFS & BERM Simulations

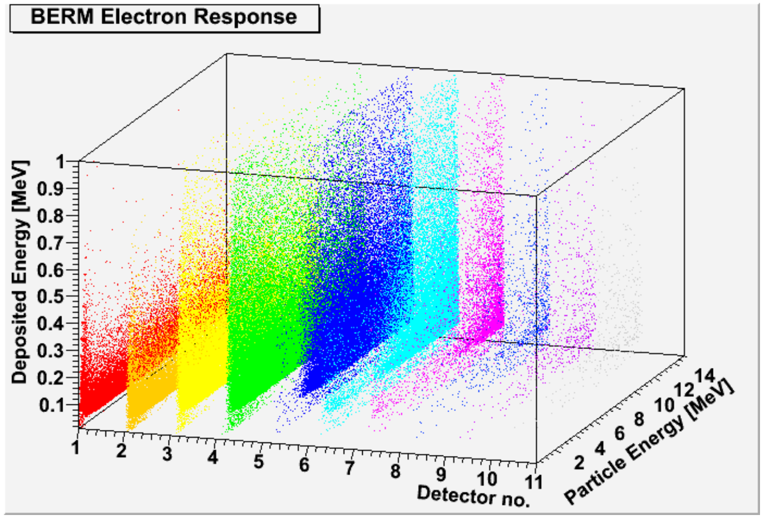
- GEANT4 simulation has been performed using GEANT4 version 9.4.p01
- Full GEANT4 model including small components has been analyzed;
- Simulation for test beam campaign has been performed for instrument calibration;
- After irradiation correlation analysis using GEANT4 has been extensively studied to understand instrument results at beam facilities;

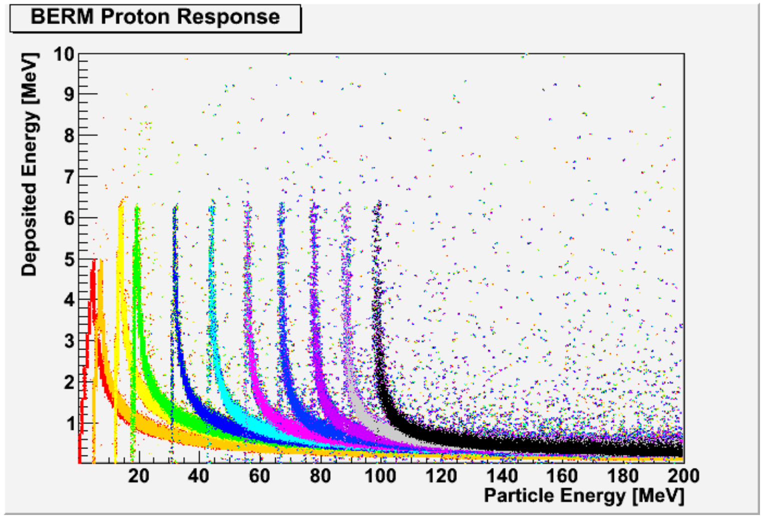


MFS & BERM Simulations

efacec

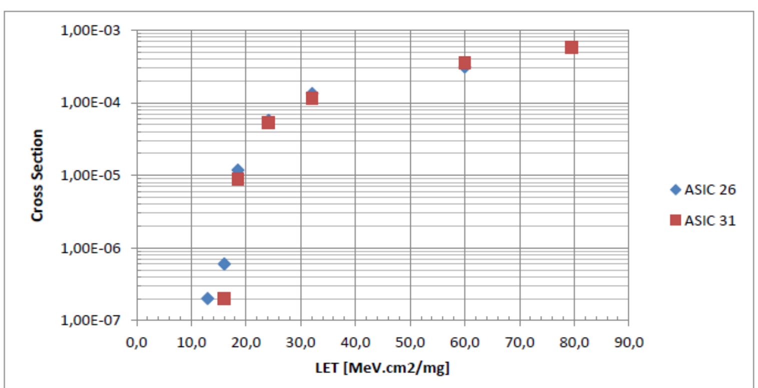
- Full 4Pi simulation performed
- Isotropic or fixed particle distribution
- Cosine-law particle momentum (biased or unbiased)
- Particle generation following on-orbit spectrum
- Simulation/(Realistic distribution) scaling factor correction
- Hadronic Process list used in the model QGSP_BERT_HP (Bertini Cascade)
- Particles simulated
  - Electrons
  - Protons
  - Heavy Ions
- Deposited energy in detectors computed as ADC channel output for test campaign comparison
- Also output converted in Matlab format for post processing outside GEANT4





MFS & BERM Qualifications

- ASIC Qualification (Ideas VA32TA2.2):
  - Under BERM program ASIC has been subjected to an up-screening program of equivalent quality Level 1;
  - A LET threshold of 13MeV.cm^2/mg was measured;
  - An active SEL protection to power re-cycle ASIC had been implemented into BERM with a reaction time < 1us
  - On MFS SEL protection is performed by a higher tier current consumption monitorisation;
  - During tests ASIC could recover from SEL even when reaction takes some seconds;
- Detectors Qualification:
  - Under BERM program ASIC has been subjected to an up-screening program of equivalent quality Level 1;
  - Leakage below <50nA on all flight detectors @ room temperature;
  - Displacement damage test shows excellent linearity for Bepicolombo levels and all recovers their nominal leakage after annealing;



PFM #1#2#3	Fluence = 7,07e11 Flux = 99,7MeV	I_{lkg} #1 S.N.:2.71 [nA] EFA9020 01 0R5	I_{lkg} #2 S.N.:2.65 [nA] EFA9020 01 0R5	I_{lkg} #3 S.N.:3.13 [nA] EFA9020 02 150
0%	0,00E+00	0,12	0,20	5,74
25%	1,80E+11	9,1	8,5	2405,4
50%	3,60E+11	17,6	16,8	4591,7
75%	5,40E+11	25,9	25,1	6675,5
100%	7,20E+11	34,5	33,7	8673,4

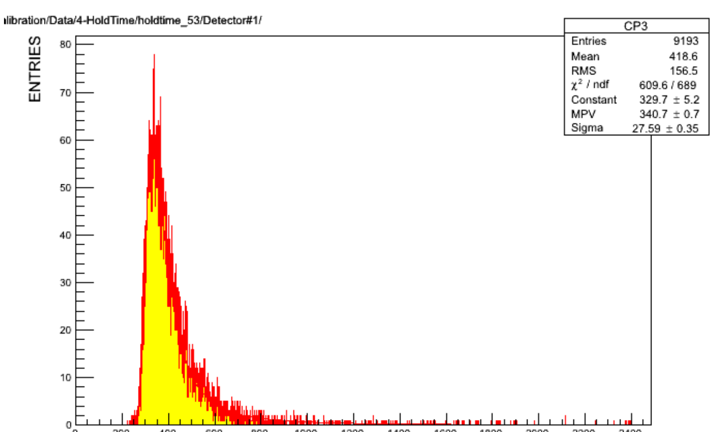
Table 2-8 – Displacement Damage Leakage Automatically Acquired during Irradiation

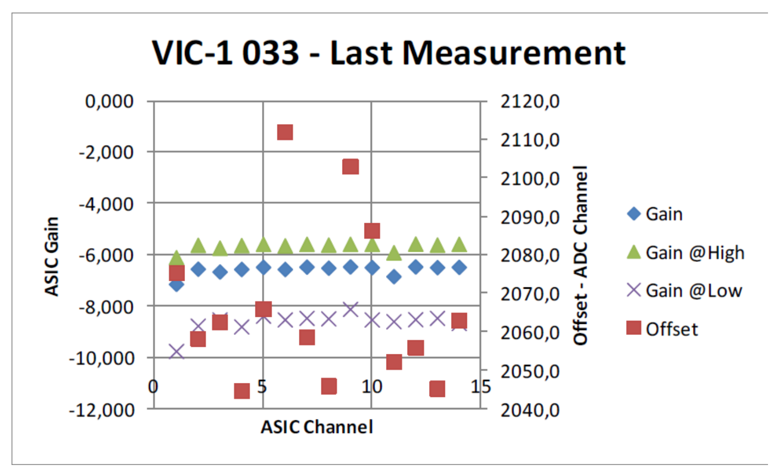
MFS & BERM Performances

	MFS	BERM	Units
Power Consumption	4 (average)	5 (average)	W
Weight	2,914	2,143	kg
Envelope	257,3x120,0x108,0	174,8x120,0x107,0	mm^3
Electrons	0,45 to 7 (7 bins)	0,3 to 10 (5 bins)	MeV
Protons	1 to 120 (10 bins)	1 to 200 (8 bins)	MeV
Alphas	5 to 400 (10 bins)	n.a.	MeV
Heavy Ions	1 to 50 (10 bins)	1 to 50 (5 bins)	$MeV/(mg.cm^2)$
Measurements Rate	1e7	1e7	$\#/(cm^2.s)$
TID (Radfet Dosimetry)	Up to 30	Up to 30	krad
Field of View	40	40	º
Temporal Resolution	1 to 30 step 1	0,5	min.
Communications Protocol	I2C Slave (TPD8) RS485	1553	-
Link Budget	<45	<55	bps
Operating Temperature	-20 to +50	-20 to +50	ºC
Life Time	3 (expansible to 5)	7,6 (expansible to 8,6)	Years

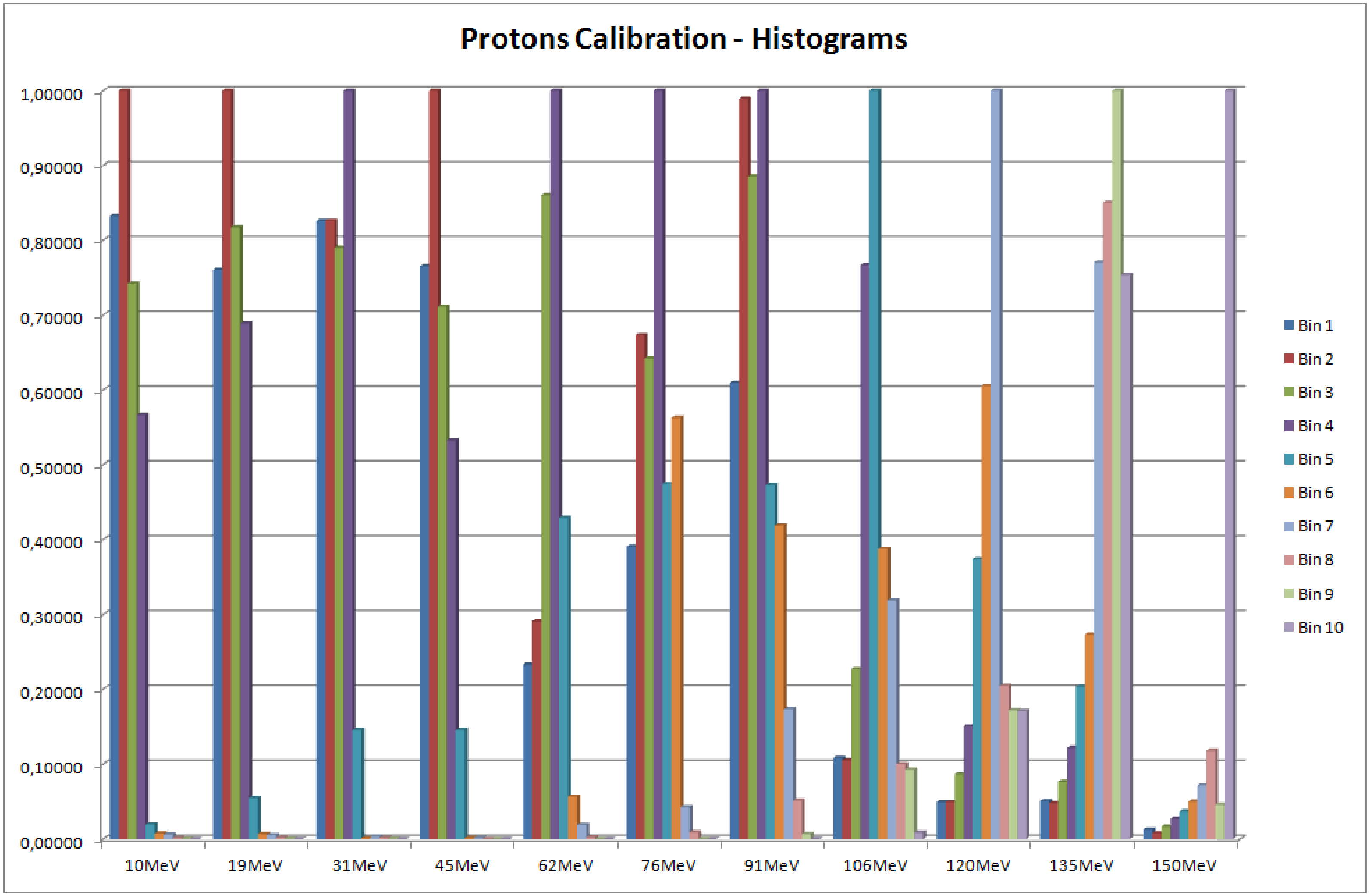
MFS Calibration Data

- MFS was full characterized in ground operations:
  - ASIC /analogue chain gain characterized at room, low and high temperatures;
  - Radiation tests performed to characterize:
    - Integration time (hold time delay) and gain;
    - Count Rate – Flux;
    - Energy Scan;
    - Background Noise;
    - Field-of-view (tilt);
  - Particle recognition process fully implemented in Octave/Matlab for LUT optimization
  - LUT optimization with data smooth by moving average with window of 5 and Landau fit

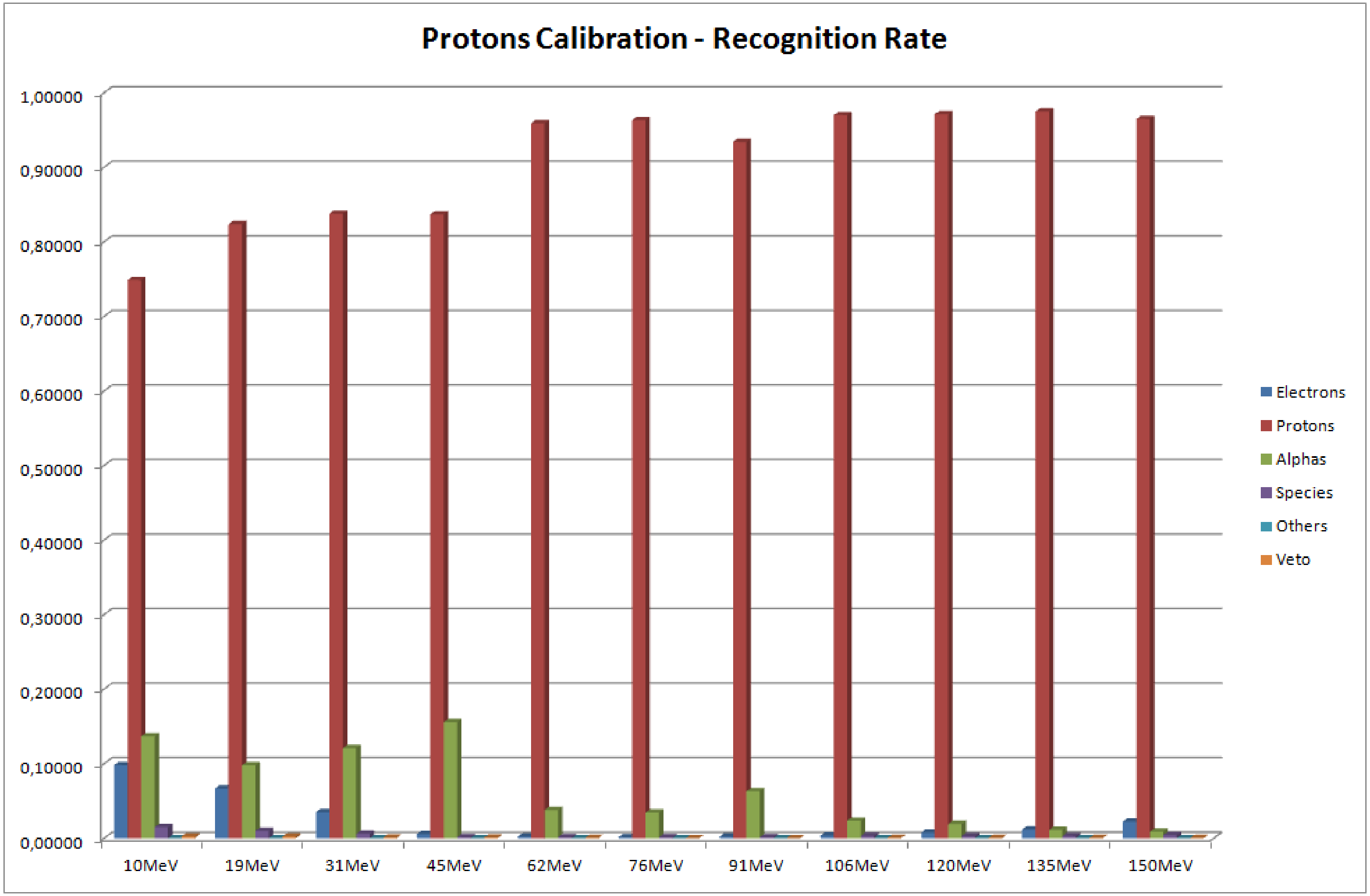




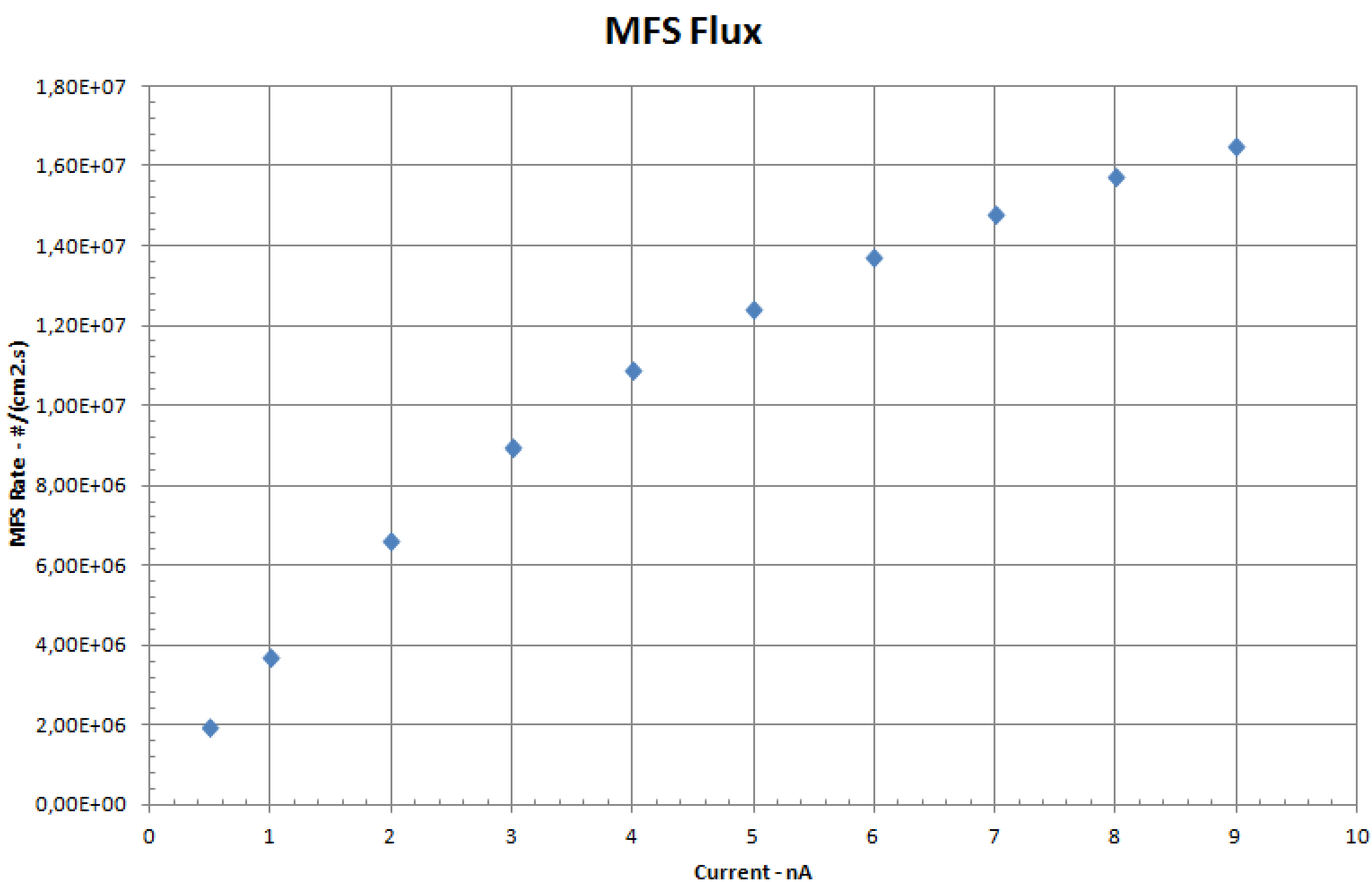
MFS Calibration Data



MFS Calibration Data



MFS Calibration Data

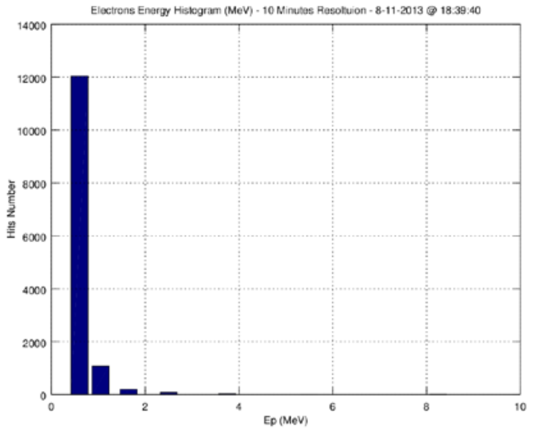


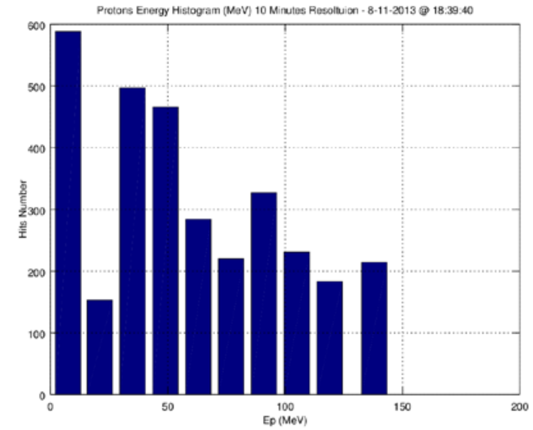
MFS Exploitation

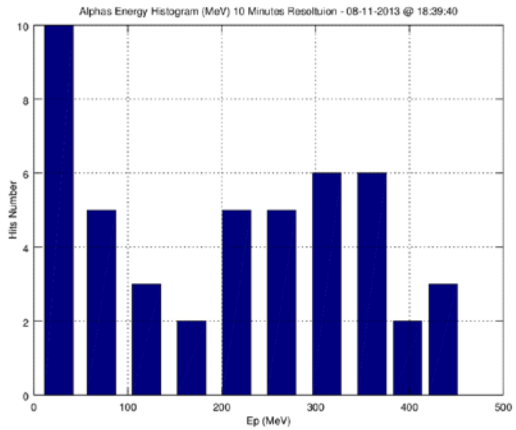
- MFS onboard of Alphasat was launched in 25 of July of 2013;
- MFS IOT performed in 28 of August of 2013;
- MFS switched on after a shedding period on 08 of November of 2013;
- MFS is operating triggering only by its top detector;

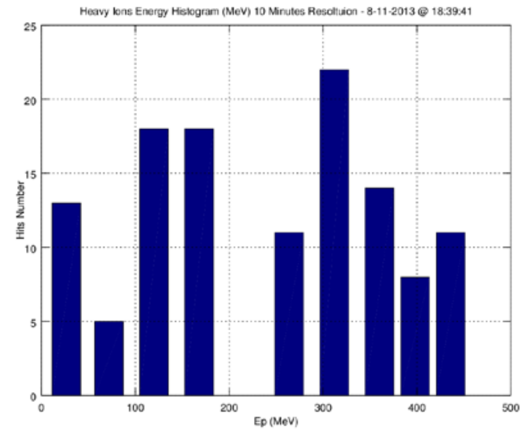
- Next activities:
  - Perform a noise level measurement;
  - Perform a full test frontend check to analyze drifts;
  - Update LUT if required;

MFS Exploitation - November

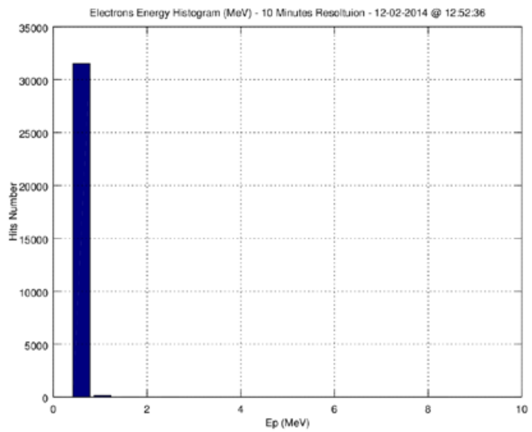


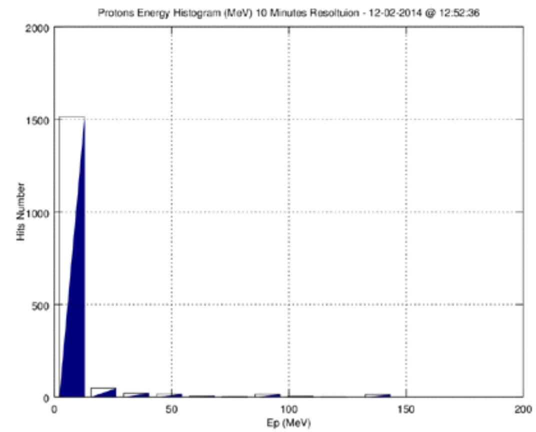


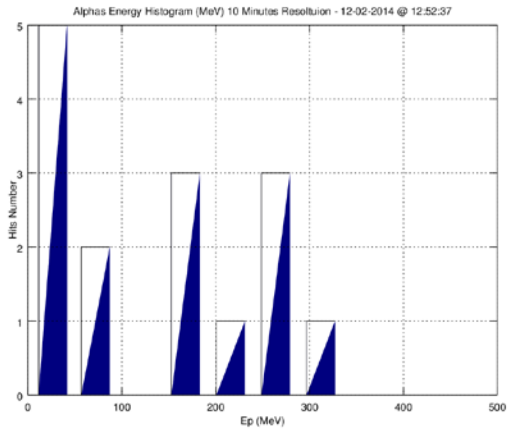


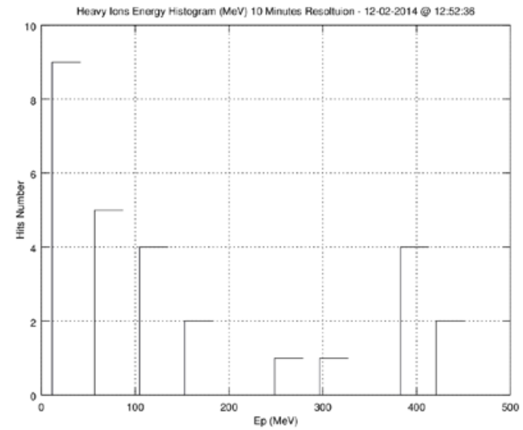


MFS Exploitation - February

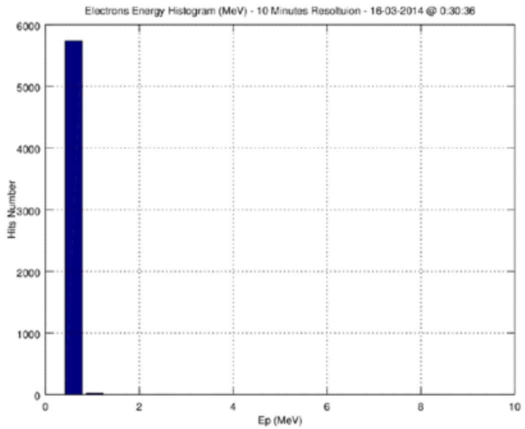


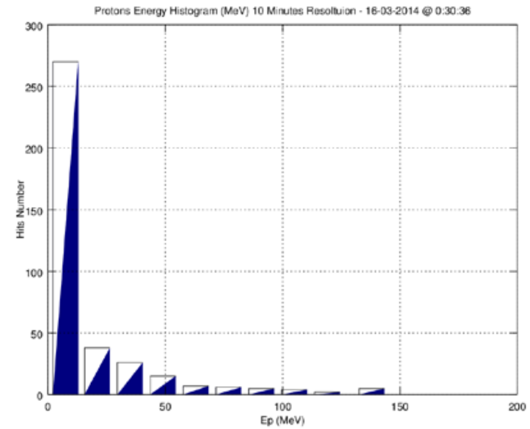


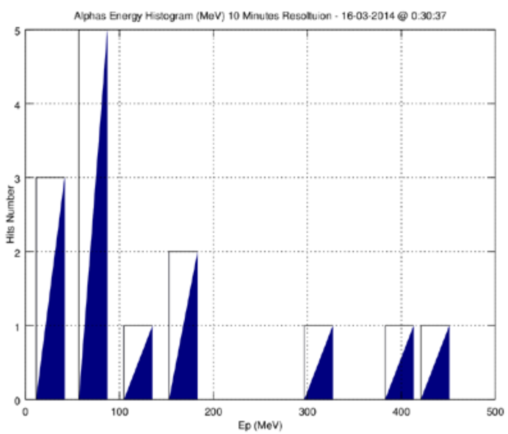


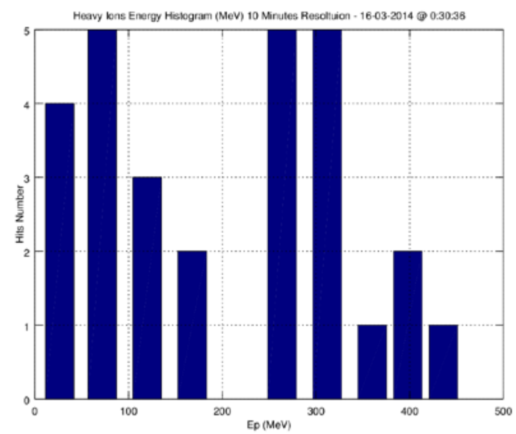


MFS Exploitation - March



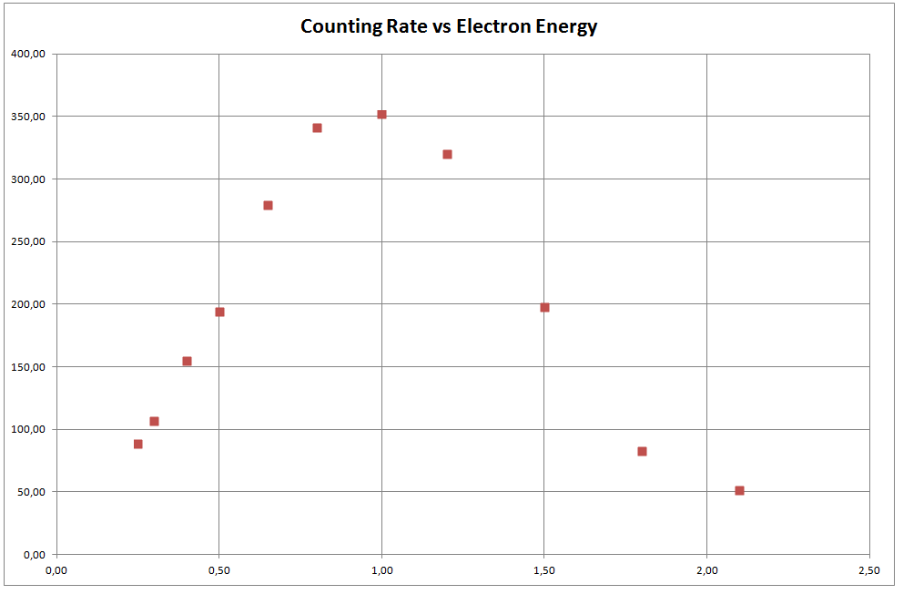


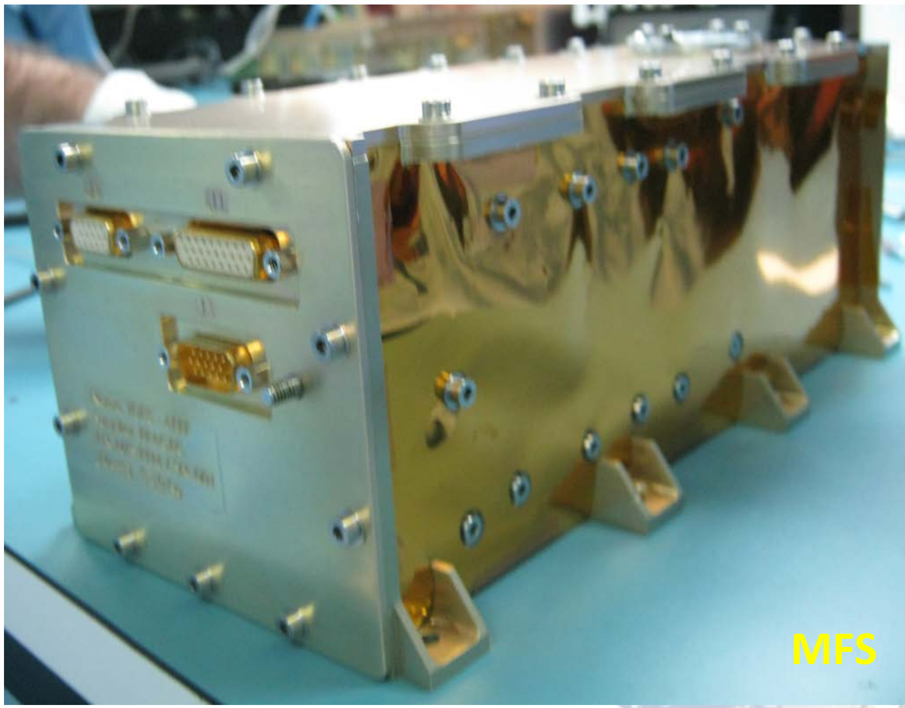


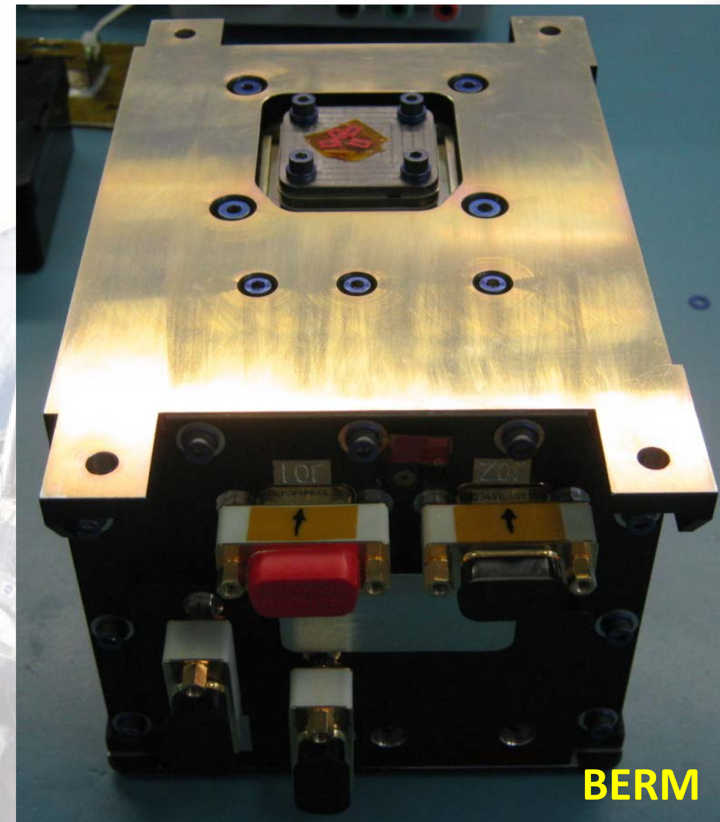


BERM

- BERM is being closed;
- BERM Bepicolombo MPO integration foreseen for June 2014;
- A preliminary radiation campaign has to be carried out;
- First radiation tests shows improved performance compared to MFS;
  - Lower Electrons threshold measured around 200-250keV;
- BERM on-ground database calibration composed by the same MFS parameters;
  - BERM LUT needs final validation;







Thank You