P2-103

ERG衛星搭載MEP-i/MEP-eの開発

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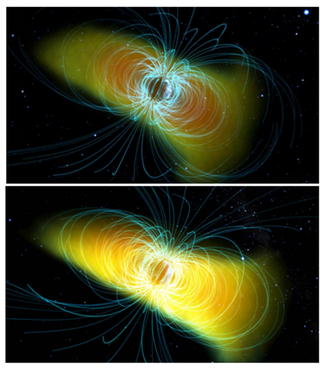
Science goals of ERG

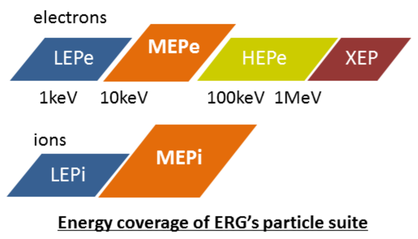
- Why the radiation belt electrons dynamically increase and decrease during space storms?

– Transport/acceleration of relativistic electrons:
  - External source or internal acceleration?
– Acceleration via waves:
  - MHD waves, magnetosonic waves, or whistler chorus?
  - How are these waves generated?
– Loss mechanisms:
  - Loss to the interplanetary space or into the ionosphere?
  - How are the background magnetic field, which controls electron trajectories, modified?
  - Which waves cause electron precipitation? How are the waves generated?



ERG satellite

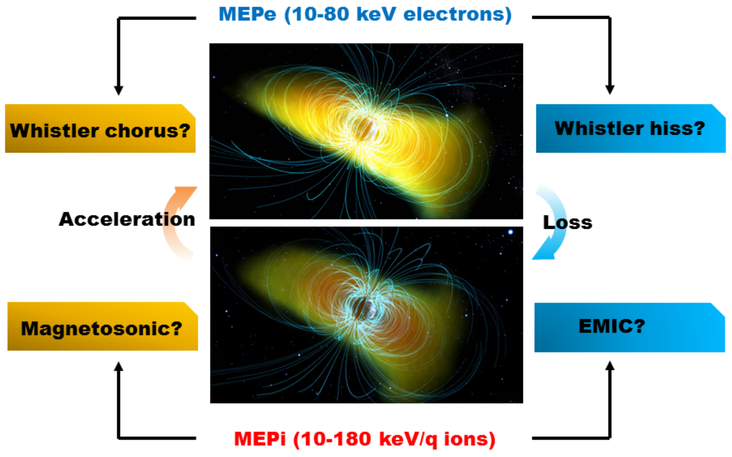
- Orbit: Elliptical orbit, apogee~4.5Re, inclination~31degree
- Launch : scheduled at December, 2015
- Mission life : 1 year



Energy coverage of ERG's particle suite

Possible roles of medium-energy particles

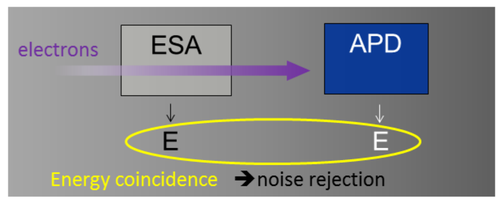
Velocity distribution functions (pitch angle distribution, energy density, etc.) are the key to understand radiation belt dynamics

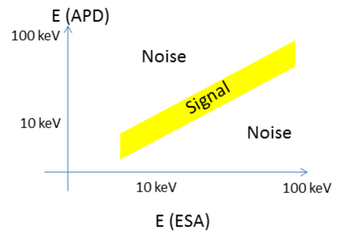


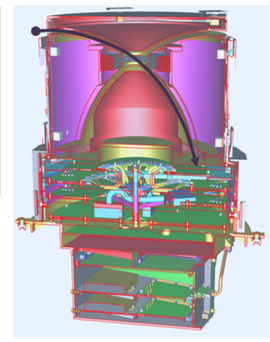
Specification of MEPi and MEPe

	MEPi	MEPe
Energy range	< 10–180 keV/q	< 10–80 keV
FOV	~360deg×5deg	~360deg×5deg
Mass range	1–32 AMU	--
Mass discrimination	H+, He++, He+, O+	--
Energy resolution	~15%	~10%
Angular resolution	10deg×22deg	5deg×5deg (per APD)
G-factor	5×10⁻³ cm² sr keV/keV (3×10⁻⁴ cm² sr keV/keV/sector)	3×10⁻³ cm² sr keV/keV (1×10⁻⁴ cm² sr keV/keV/apd)
Time resolution	4sec per 3D VDF (for 8-sec spin period)	4sec per 3D VDF (for 8-sec spin period)
Mass	~10.5 kg	~8.5 kg
Power	~21 W	~25. W
Dimension	~310 mmφ×400 mm	320 mmφ×400 mm
Data rate (max, before compression)	65.5kbit/(spin/16) =16(K)×16(Az)×16(spc)×16bit	(ordinary data) 8.19 kbit/(spin/32) =16(K)×32(Az)×16bit (S-WPIA) 1.68 Mbps

MEPe

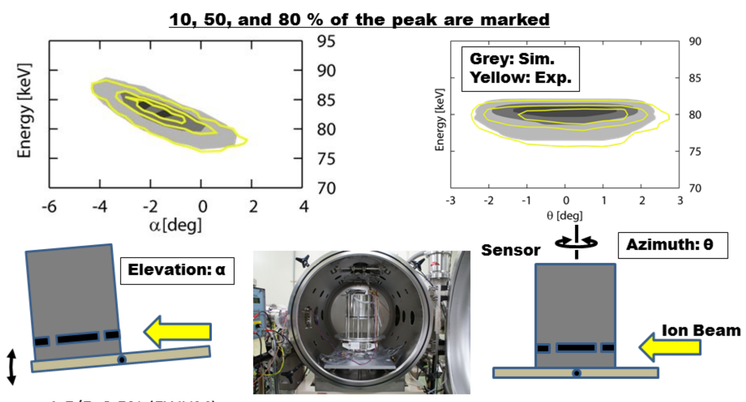






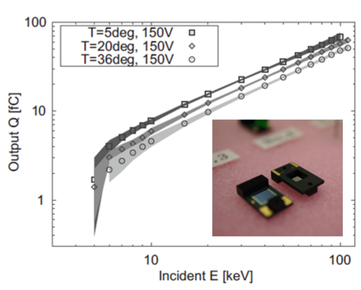
- The energy coincidence technique is applied to reduce the radiation background

MEPe electrostatic analyser

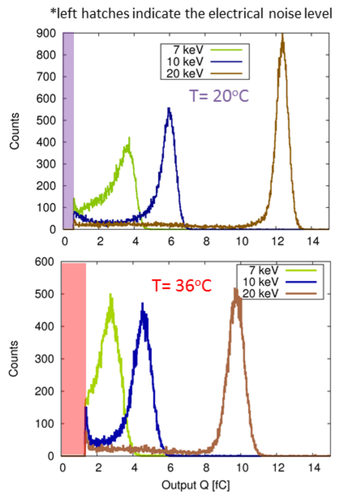


- Δ E/E~8.5% (FWHM)
- Δα~3.5° (FWHM)
- Focusing of parallel beam~ 0.5° (FWHM)

MEPe APDs

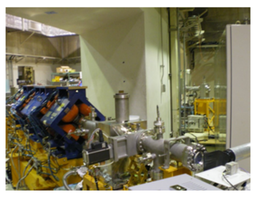


*left hatches indicate the electrical noise level

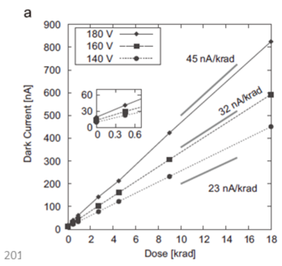


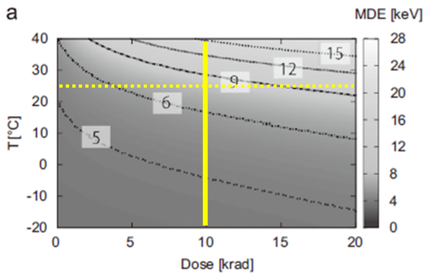
- We use reach-through type APD
- Active area: ~5 x 5 mm²
- Depletion layer thickness: 50um
- Dead-layer thickness: ~0.2um
  - measured with the BBM test
- Energy resolution
  - < 20% (>20 keV)
  - < 30% (10-20 keV)

APD degradation test: protons

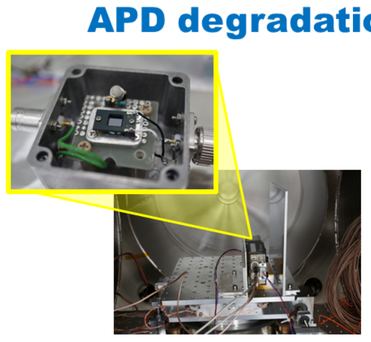


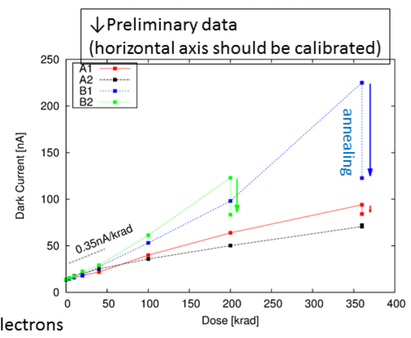
- APDs were irradiated with 230-MeV protons
- Leakage current increases with the proton dose, resulting in the degradation of noise level
- We keep the temperature below 25°C to achieve the minimum detectable energy (MDE) of 10 keV at the end of the mission life (1 year)
  - cf. for the ERG's orbit, proton dose is ~10 krad/year for the 4-mm aluminium shielding





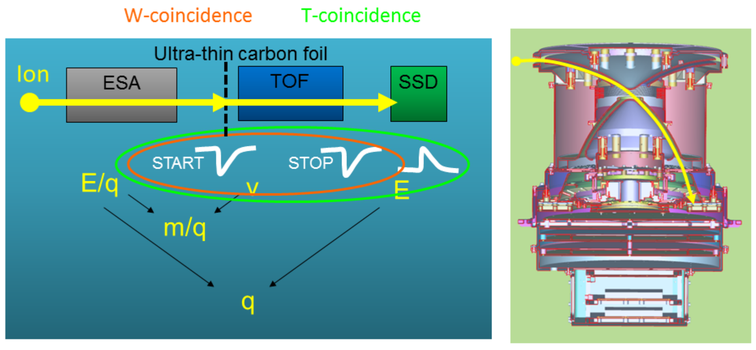
APD degradation test: electrons





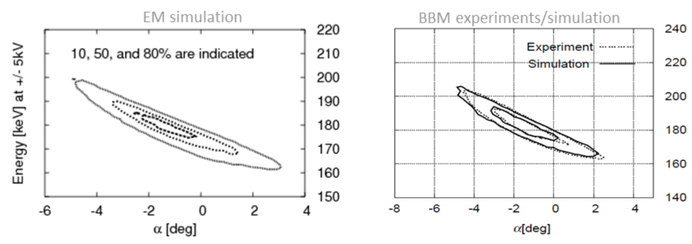
- APDs were irradiated with 1.5-MeV electrons
  - Dark current increases with the electron dose, resulting in the degradation of noise level
- Electron dose rate is expected to be ~100 krad/year for 4-mm Aluminium shielding
  - Dark current is ~50nA after the irradiation with 1.5 MeV electrons of 100 krad
  - Considering the uncertainty of the beam area (50%) and the difference in displacement damage between 1.5 MeV and ~5 MeV (a factor of ~3), the dark current may increase up to ~230 nA
  - Not dominant compared to that by the proton dose (~300 nA), although it's not negligible
- Electron dose rate is expected to be ~10 krad/year for 6-mm Aluminium shielding ➔the electron dose effect is negligible

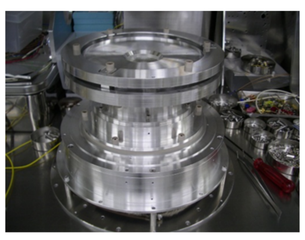
MEPi



- Energy(E), Mass(m), and charge state(q) are measured (10-180 keV/q)
- W-coincidence: START+STOP signals ➔ m/q
- T-coincidence: START+STOP+SSD signals ➔ m, q

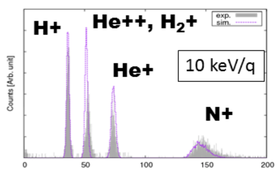
MEPi Electrostatic analyser

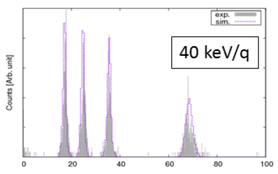


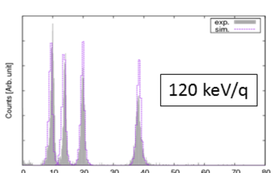


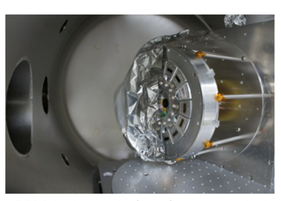
- dE/E ~15% (FWHM)
- Angular resolution (elevation Δα): ~5° (FWHM)
- Parallel beam focus (azimuth): ~5° (FWHM)
- BBM tests results agreed with the simulation

MEPi TOF unit



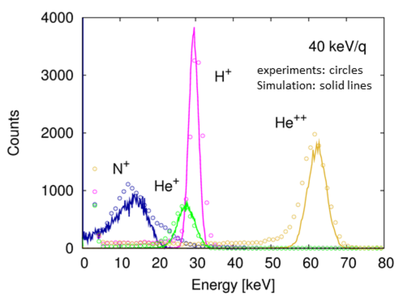


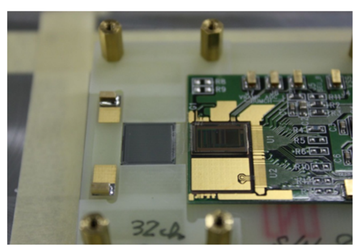




- BBM test results (grey) agrees with the simulation (purple)
  - Peak positions
  - distribution widths

MEPi SSD and ASIC





- We use single-sided strip SSDs
- Active area: 12.6 x 12.6 mm²
- Dead layer: ~100nm (measured with BBM)
  - Discrimination between H+ and He++ is possible for E>30 keV/q
  - Depletion layer: 150 um (modified from the BBM thickness of 350 um)

MEPe and MEPi EM verification plan

- System MTM test: July/2013 ➔DONE
- Sounding shock test (only for MEPi): August/2013 ➔DONE
- System TTM test: August-September/2013 ➔DONE
- Electrical I/F test: October/2013 ➔DONE
- Sensor performance test: January/2014
- Function test: January-February/2014
- Shock/vibration test: February/2014
- EMC test: February/2014
- Thermal tests: February/2014