ABSTRACT

Generation of energetic electrons (up to > MeV) in planetary magnetospheres is a long-standing mystery, since their seed energy is of the order of 100 eV (solar wind) or much less (ionosphere). Furthermore, such high-energy electrons have significant influences for ionospheric dynamics as well as the long-term development of planets’/moons’ surface and atmosphere. Since velocity distributions of electrons are not omnidirectional in many cases, observed velocity distribution function is the important information which provides specific restriction on the generation mechanisms and effects on planets and moons. In most cases, however, spacecraft for planetary explorations are 3-axis stabilised, and therefore it is difficult for traditional telescope-type electron detectors to obtain broad field-of-view (FOV). Toward future planetary explorations, here we design and fabricate a novel electron detector (20 - 100 keV) which can cover almost 2-pi steradian without the spacecraft spin. We develop this instrument in a step manner. First we will test the performance of this detector in a sounding rocket experiment on pulsating aurora, and then plan to downsize by using ASIC, and also extend the measurement energy up to ~ MeV by stacking detectors.
Test model of energetic electron detector with 2-pi steradian field-of-view

S. Kasahara (The University of Tokyo)
Points

• Spacecraft for planetary explorations are mostly 3-axis stabilised
• Wide field-of-view under the non-spin platform is thus required for particle instruments
  – Note that such instruments are also important for high-time resolution observations even in the case of spin-stabilised spacecraft
• We develop the energetic particle instrument with 2-pi str field-of-view
Motivation

- Previous particle instruments cover only a small part of full solid angle if the platform does not spin.
- Since spacecraft do not spin in most planetary missions, wide field-of-view is essential for particle sensors.
**Strategy**

Heritage

**ERG**

MEP-e

10-80 keV

$\Phi 300 \times 400 \text{ mm}^3$

Sounding rocket

for

Pulsating aurora

MED

20-100 keV

100x100x200 mm$^3$

Planetary exploration

/High-time resolution obs.

Widening FOV

Removing ESA

MED+

20-1000 keV

100x100x100 mm$^3$

Downsizing by using ASIC

Stacking Detectors for

the broader energy coverage

We are hear
Schematic view of MED
(medium-energy electron detector)
Sensor structure
Block diagram

APD board
- APD
- Temp. sensor

Analog board
- CSA
- Shaper
- Lower discri.
- P/H

FPGA board
- ADC

HV board incl.
LVPS (DC/DC)

hv (-300 V)

FPGA

DAC

ADC

ADC

CTRL MON

3.3V +/- 12V

DC/DC

HV (-300 V)

PI 部中枢

28V/COM1

Max: 3000cps/検出器
■ ADC: >= 10bit
■ HV: 1系統 (APD板上で分配)
■ 制御DAC: 8bit
■ Temp分解能: < 1deg
■ Temp. sensorの個数: APDと同じ(C-R板上)

■ 5系統パラレル
（ADCはmultiplexer内蔵ならまとめてもよい）
Analogue circuit

Preamp基板

CSA

Shaper基板

Shaper

10V max

Lower DISC.

Peak Hold

10V max

Shaper/PH基板

ADC/FPGA基板

ADC

DAC

3.3Vプルアップ

FPGA

抵抗はADC基板側

LLD set

(1素子あたり8ch)

PH reset (3.3 V)

(抵抗分割)
Test of the analogue electronics board

• The analog board was fabricated
• Performance test was conducted with artificial test pulses
• The board was found to work well for test pulses (see the next figure)
- Test pulse is injected to generate **CSA output**
- **The CSA output** is shaped and its peak value is held at Peak-holder (**PH**)
- The digital electronics reads the **PHOUT** value when **LLD “LOW”** is detected
  - Then send the **RESET** signal to flush the **PHOUT**
Detector: Avalanche photodiode

- リーチスルータイプAPDを用いる
- 印加 HV 150-250V
- 面積 ~5 x 5 mm²
- 空乏層の厚み70um
- 不感層の厚み~0.2um/2um
- Energy resolution
  - < 20% (>20 keV)
  - < 30% (10-20 keV)
## Specification

<table>
<thead>
<tr>
<th>Items</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target</strong></td>
<td>Electron</td>
</tr>
<tr>
<td><strong>Energy coverage</strong></td>
<td>20 keV – 100 keV</td>
</tr>
<tr>
<td><strong>Energy resolution</strong></td>
<td>10-20% depending on the incident energy</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>$\sim 10^{-3}$ cm$^2$-sr Per detector</td>
</tr>
<tr>
<td><strong>FOV</strong></td>
<td>80 deg cone (envelope) Centre of FOV points the direction perpendicular to the rocket spin axis.</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>100mm x 100mm x 200mm</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>2 kg</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>6 W, AMP: 3W, HV: 1W, CNTL: 2W</td>
</tr>
<tr>
<td><strong>Data rate</strong></td>
<td>300kbps</td>
</tr>
</tbody>
</table>
Summary

• We have designed energetic electron detector with 2-pi str FOV, which should be installed on future planetary explorers

• We have tested an analogue circuit board
  • It works well as expected

• We’re preparing for
  – Check of APD performance
    • Especially the EUV rejection property