Overview of TEPC for high LET Radiation Monitoring in Complex Radiation Field

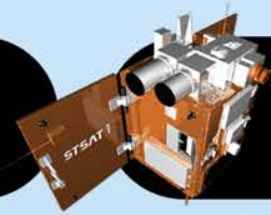
Uk-Won Nam, Jae Jin Lee, Jeonghyun Pyo, Bong-Kon Moon, Dae-Hee Lee, Youngsik Park
Korea Astronomy and Space Science Institute

Chang Hwy Lim, Myungkook Moon
Korea Atomic Energy Research Institute

Sunghwan Kim
Cheongju University

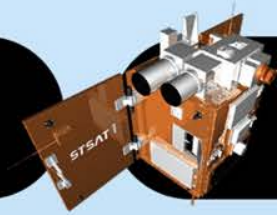
KASI 한국천문연구원
Korea Astronomy & Space Science Institute

Outline



- Introduction
- Characteristics of portable TEPC
- Calibration of portable TEPC
- Summary and Future Works

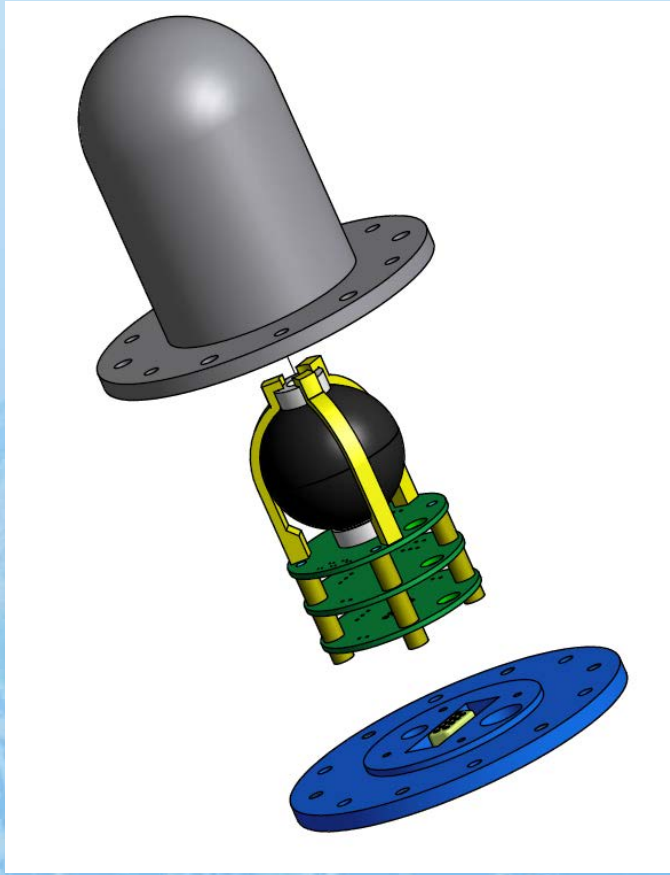
Introduction



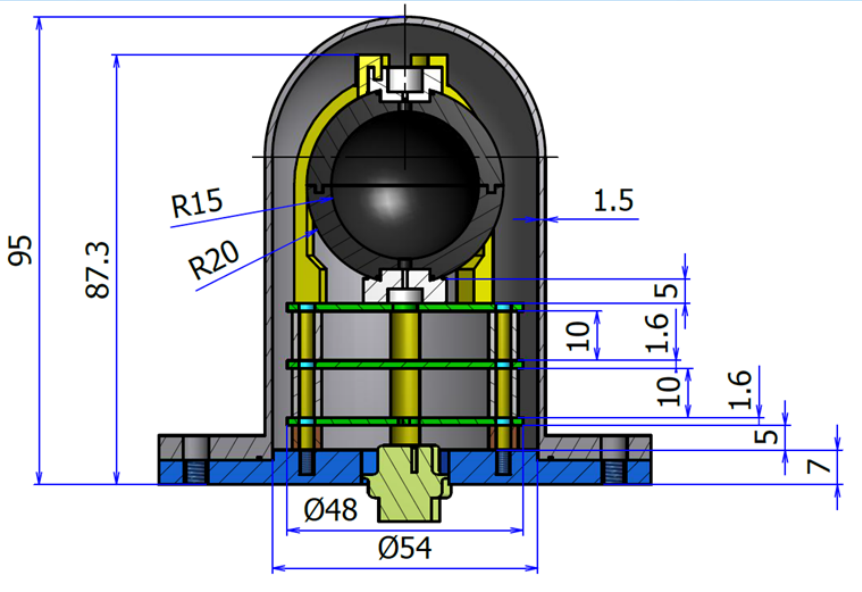
- Background
  - NASA proposed radiation monitoring in ISS as a NASA-Korean government cooperation program in 2009.
  - KASI (Korea Astronomy Space and Science Institute) has been funded for developing a spherical type TEPC since 2011.
- Our goal
  - Development and characterization of a portable TEPC which could monitor the radiation in ISS
- Requirements
  - Measurable LET range: 0.2 – 300 keV/um
  - Mass: < 5kg
  - Volume : < 6000 cm^3

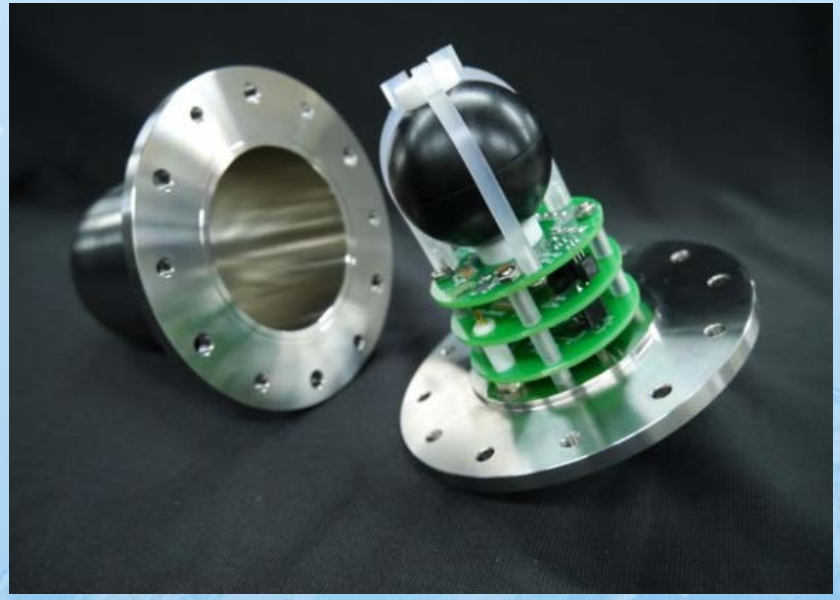
Tissue Equivalent Proportional Counter

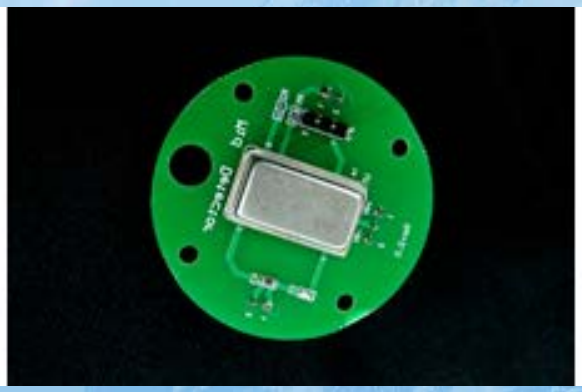
- Specification
  - Measurable range: 0.2 – 300 keV/um
  - Detector wall
    - A-150 sphere
    - inner diameter : 30 mm
    - Thickness : 5.0 mm
  - TE Gas
    - 55% C_3H_8, + 39.6% CO_2 + 5.4% N_2
    - Gas Pressure : 27.7 torr
    - Site diameter : 2 μm
  - Detector Housing
    - SUS304
    - Housing diameter : 70 mm
    - Thickness : 1.0 mm

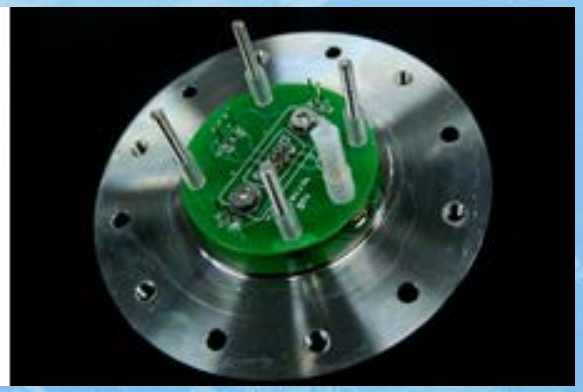


TEPC chamber

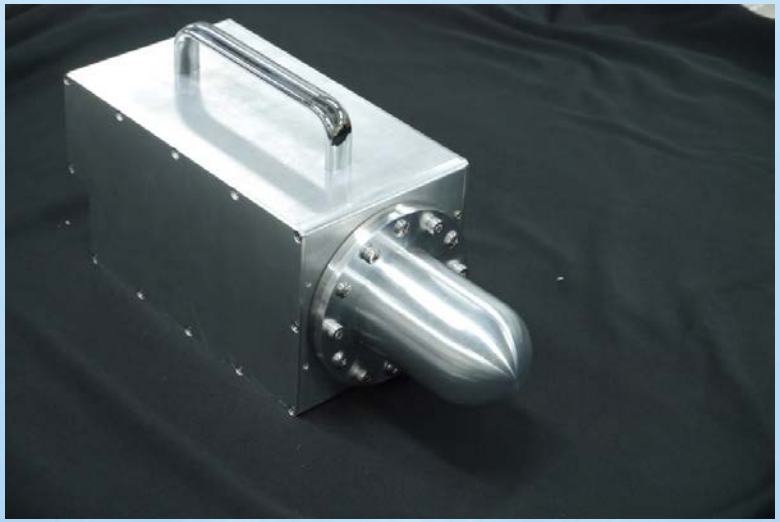


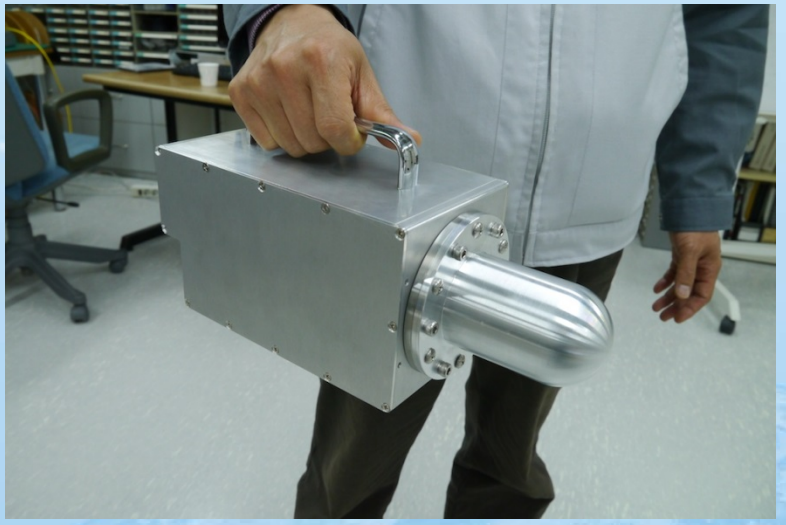


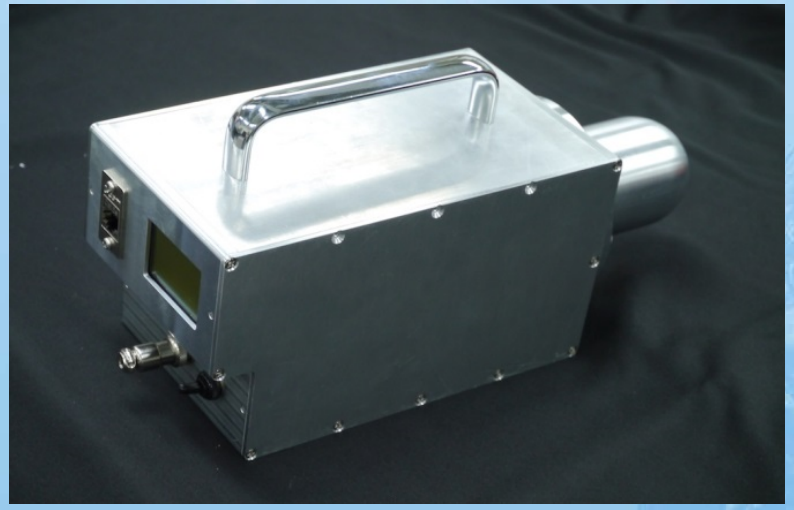




Portable TEPC







- Volume : 2,624 cm^3
- Weight : 1.8Kg

KASI 한국천문연구원 Korea Astronomy & Space Science Institute

Charge Sensitive Pre amp.

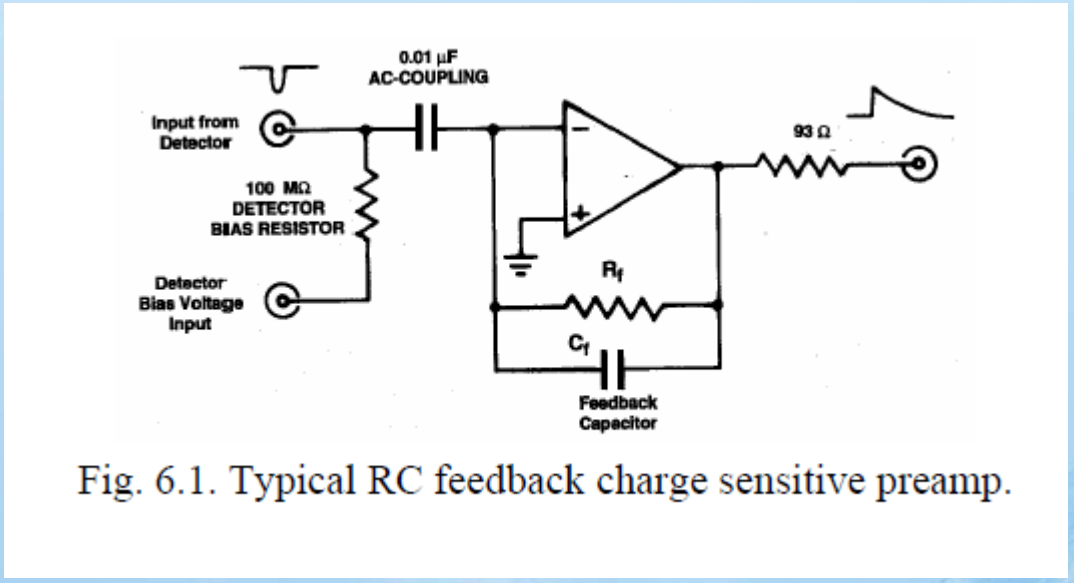
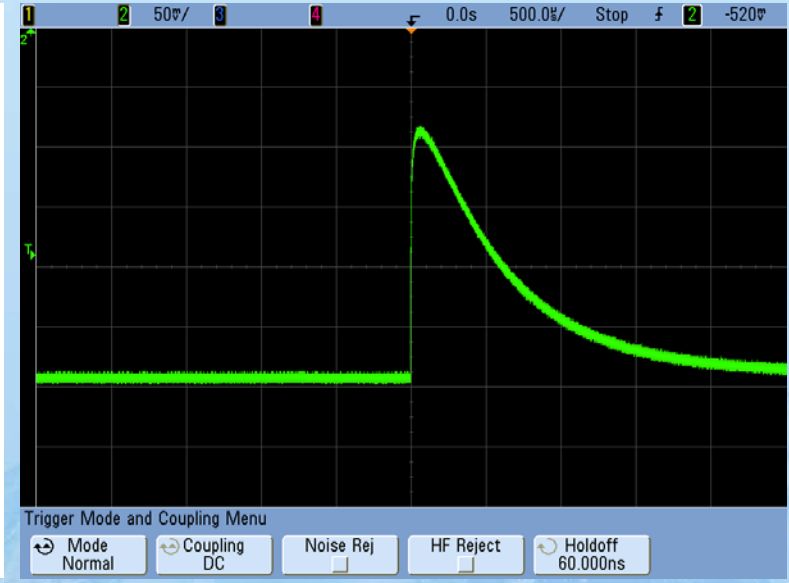
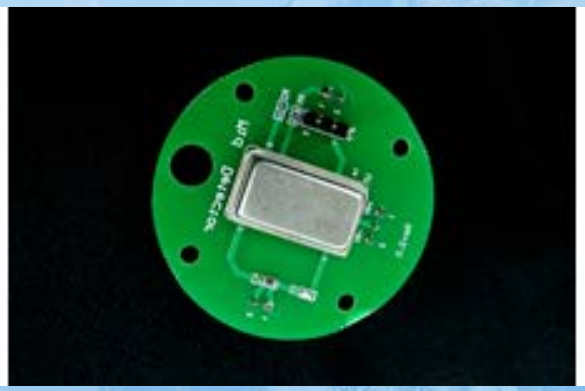
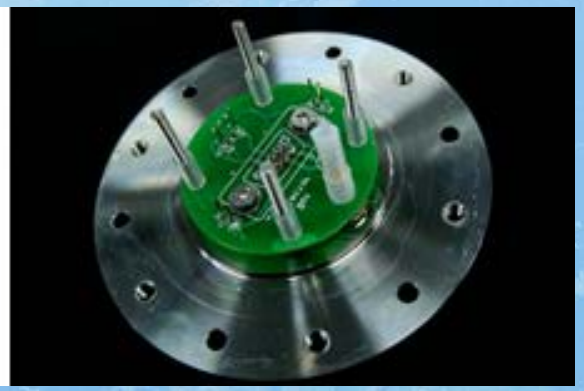


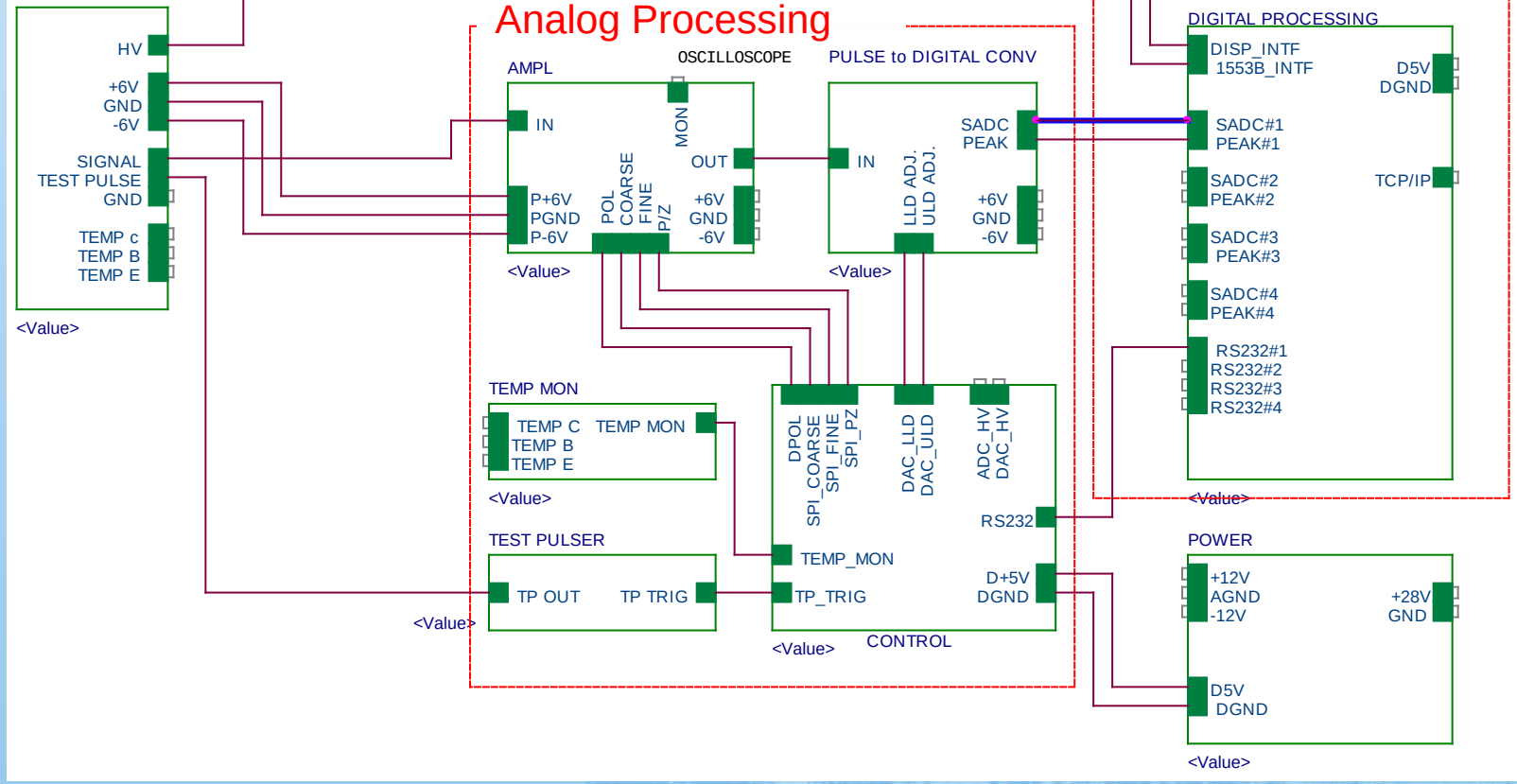
Fig. 6.1. Typical RC feedback charge sensitive preamp.



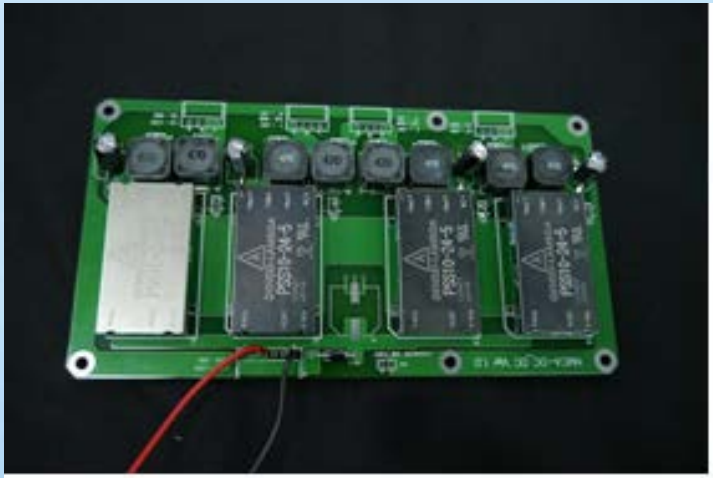




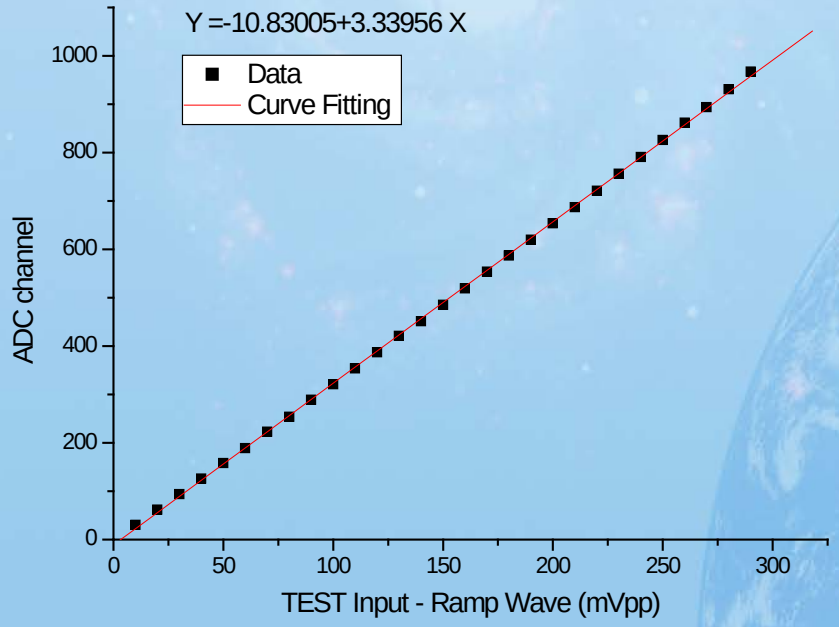
Main Electronics Design

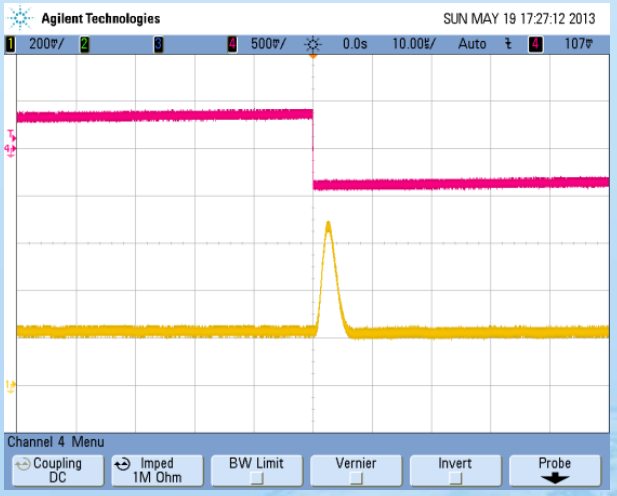


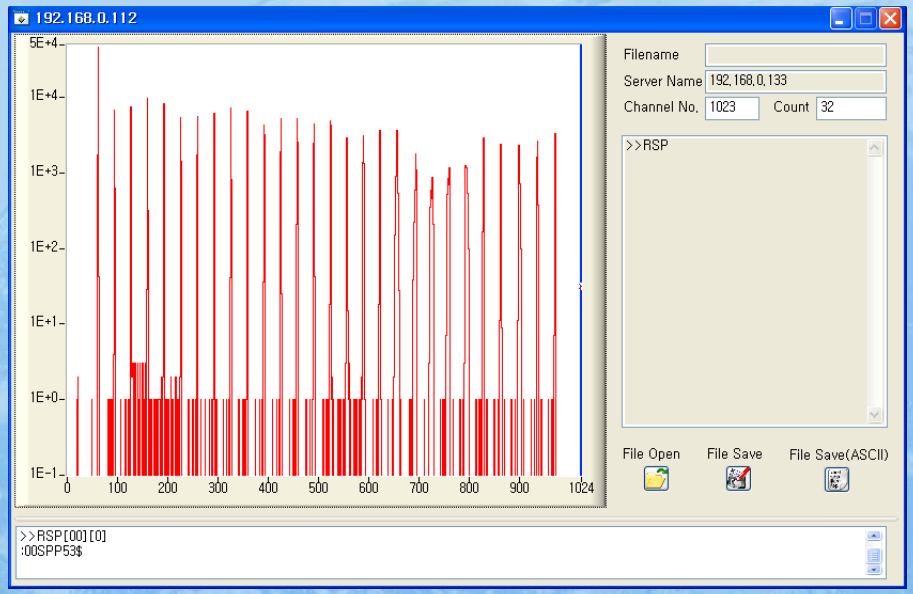
Electronic Board



Linearity of TEPC

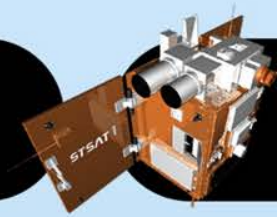






한국천문연구원
Korea Astronomy & Space Science Institute

Calibration of portable TEPC



- Channel calibration using alpha source
  - Using Am-241 5.5MeV α source
  - Range of Lineal Energy : 0.2 ~ 300 keV/μm

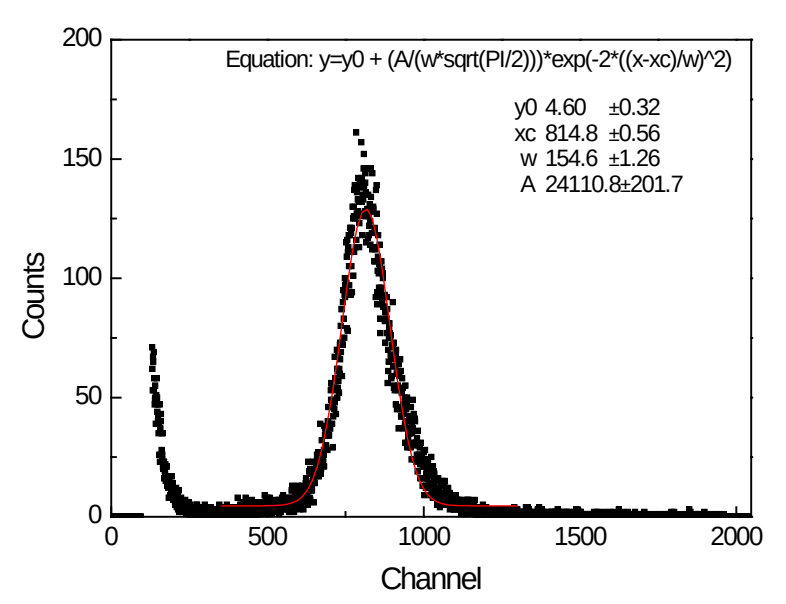
- Determine the calibration factor of TEPC using neutron source
  - Using Cf-252 neutron source at KRISS
  - Determine the calibration factor of the TEPC

Channel Calibration of TEPC using ^{241}Am

- Microdosimetry
  - Lineal Energy (y, keV/μm) = E / mean chord length(l)
  - TEPC : mean chord length = 2d/3
  - Bias voltage : 950 V
    - Peak channel of a particle – 863
    - Satisfy measurement range : 0.2~300 keV/um
  - Lineal Energy / MCA channel
    - Eα : LET of α particle in tissue equivalent material (86.5 keV/μm)
    - Iα : Peak channel of α particle on MCA

$$\frac{y}{\overline{l}} = \frac{E_\alpha}{I_\alpha} \cdot \frac{3}{2d}$$

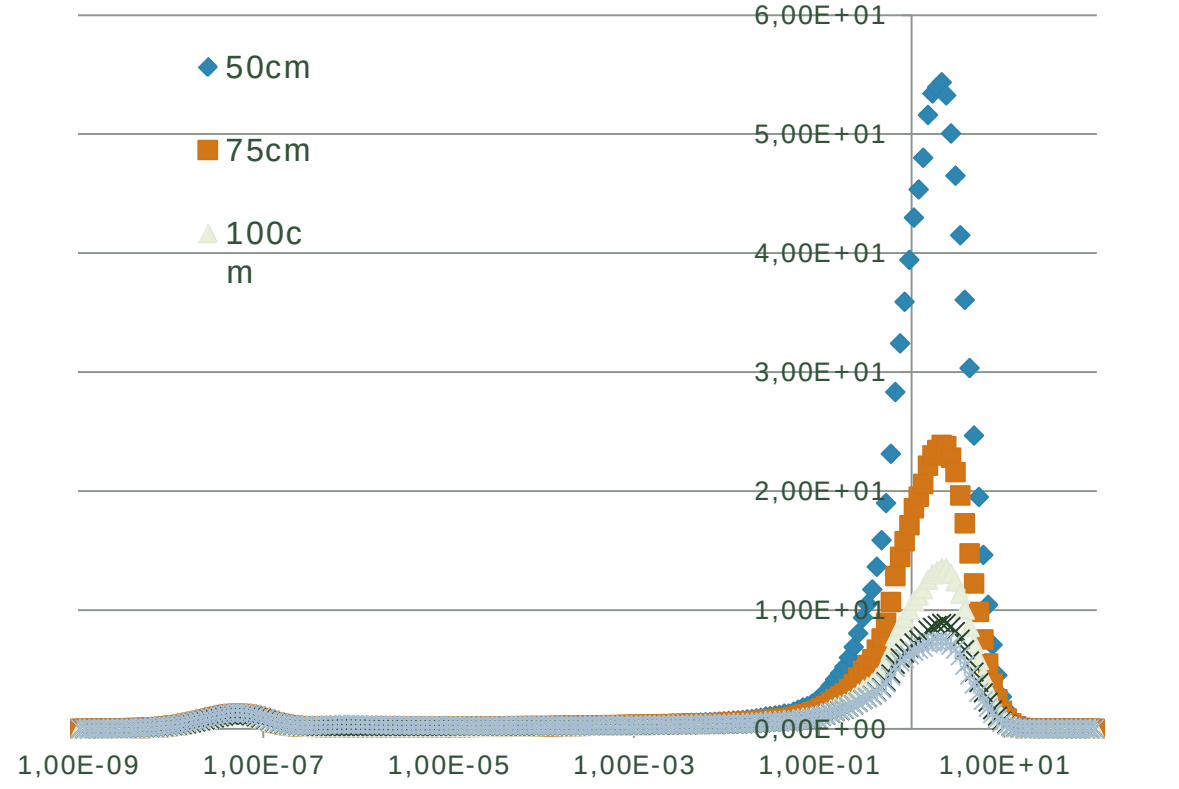
$$= 0.16 \ keV/\mu m - ch$$



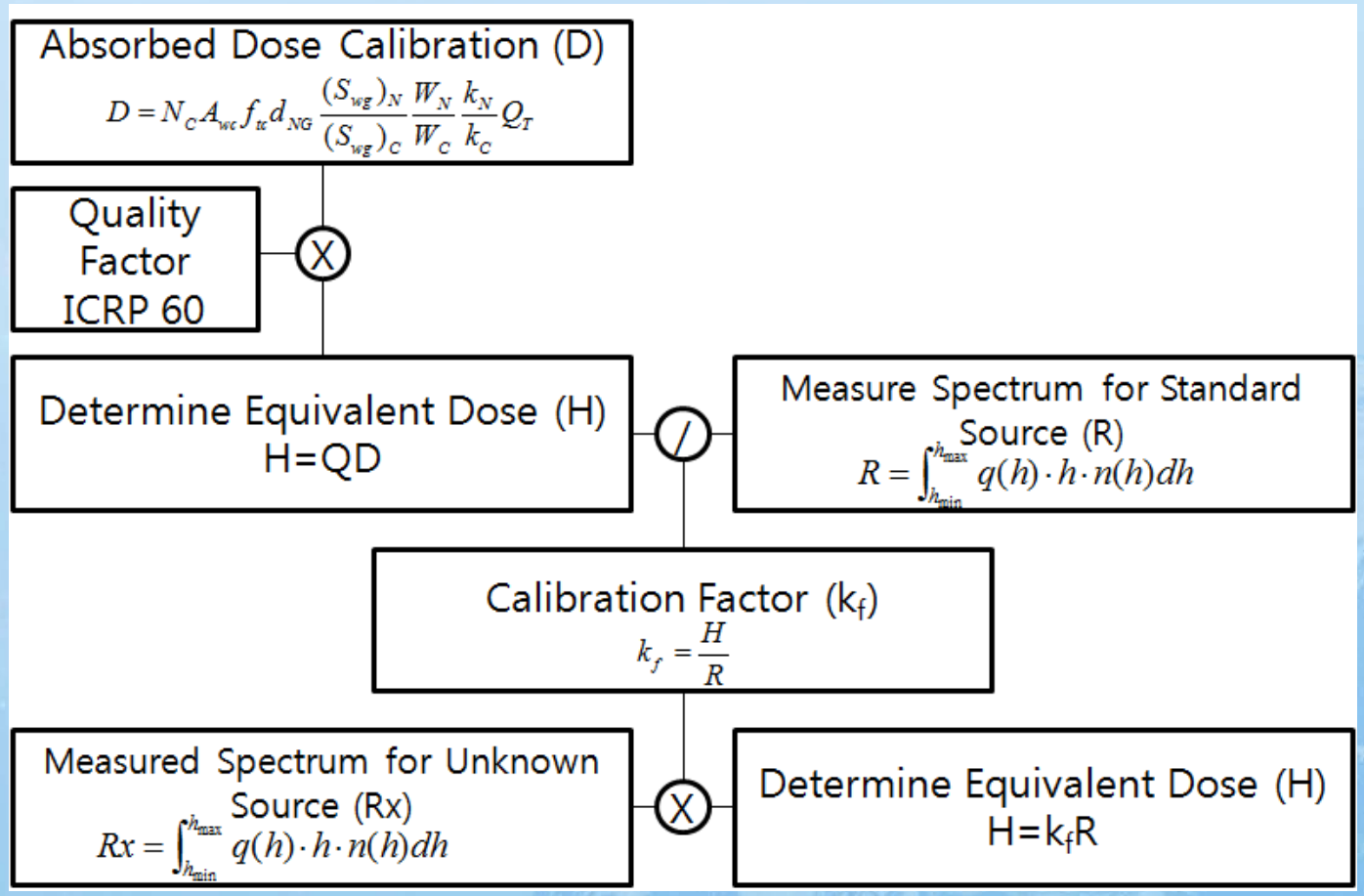
Peak (ch)	Resolution of Channel (keV/um-ch)	Max. Range @2048 ch (keV/um)
254	0.51	1046
470	0.27	565
863	**0.16**	**326**
1008	0.12	263
1300	0.10	204

Neutron Source at KRISS

- Cf-252 standard Neutron Source at KRISS (Korea Research Institute of Standards and Science)
- Neutron flux : $2.36\times10^{8}\ cm^{-2}s^{-1}$ (2012.11.09)
- Dose rate : 53.9 mSv/hr

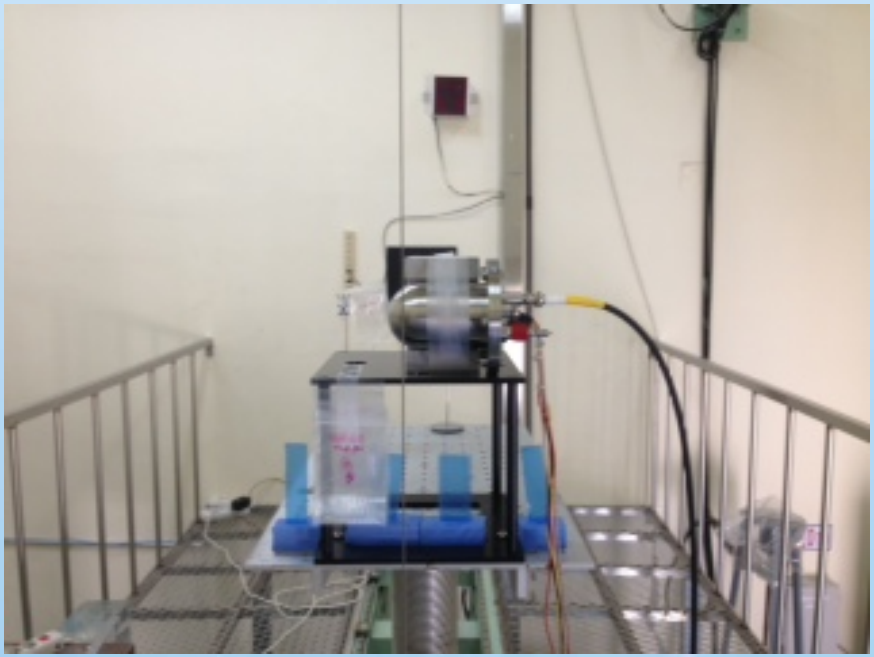


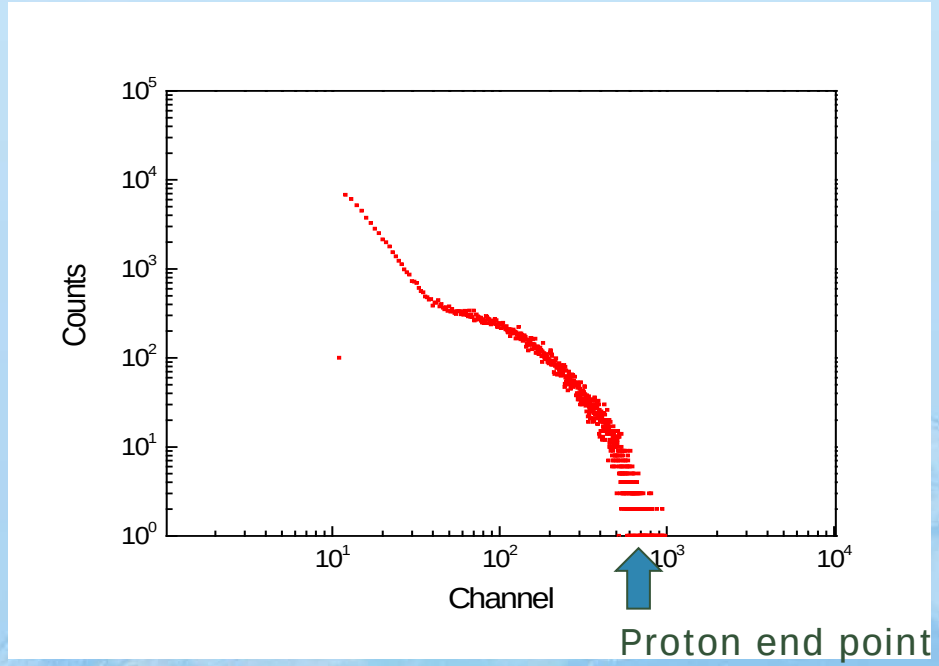
Calibration of TEPC using Cf-252



Process of Equivalent Dose Calibration

Neutron Beam Experiment using Cf-252



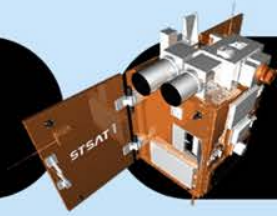


Measured Lineal Energy Spectrum of Cf-

$$H = QD = k_f R = k_f \int_{h_{\min}}^{h_{\max}} q(h) \cdot h \cdot n(h) dh$$

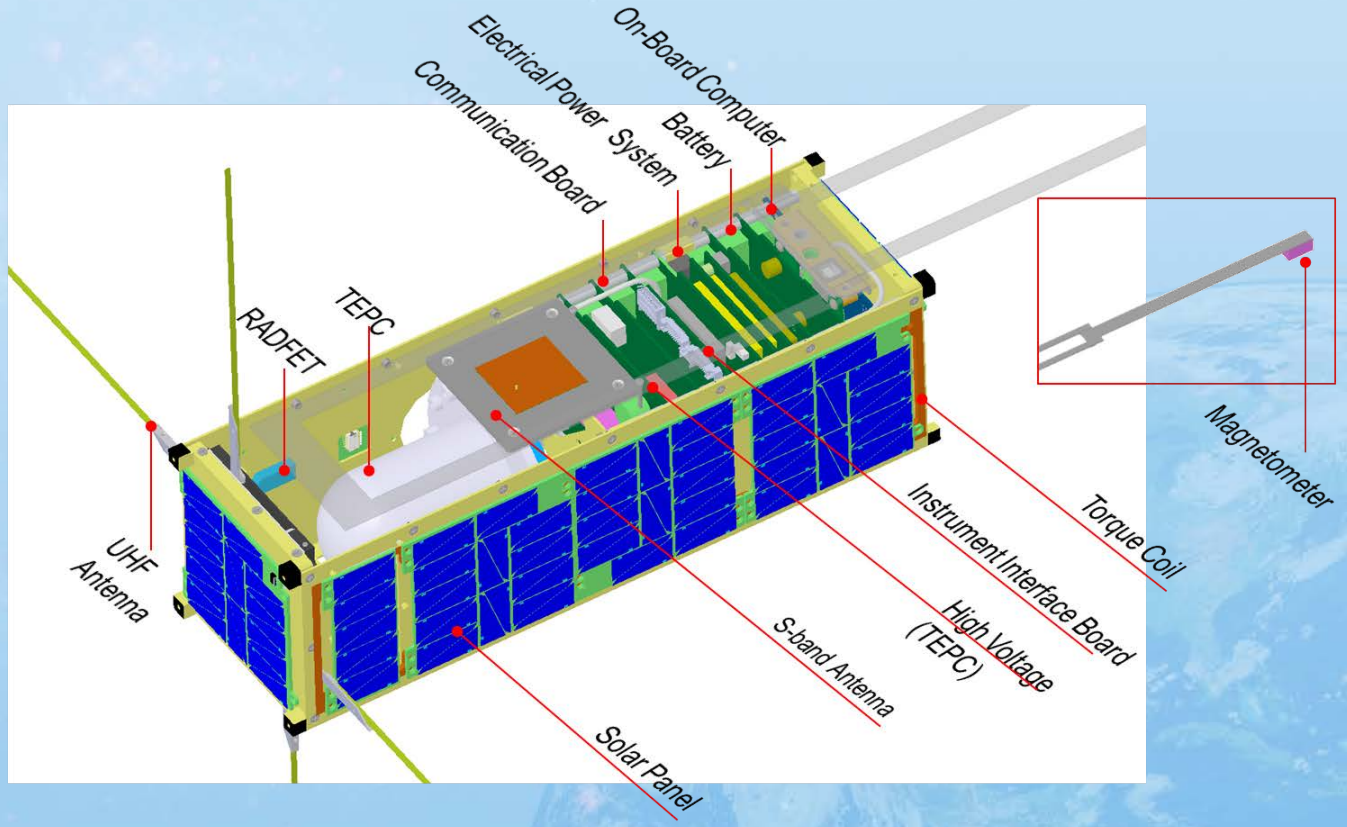
$$k_f = \frac{QD}{\int_{h_{\min}}^{h_{\max}} q(h) \cdot h \cdot n(h) dh} = 3.59 \times 10^{-4} \, \mu\text{Sv/R}$$

Summary and Future Works

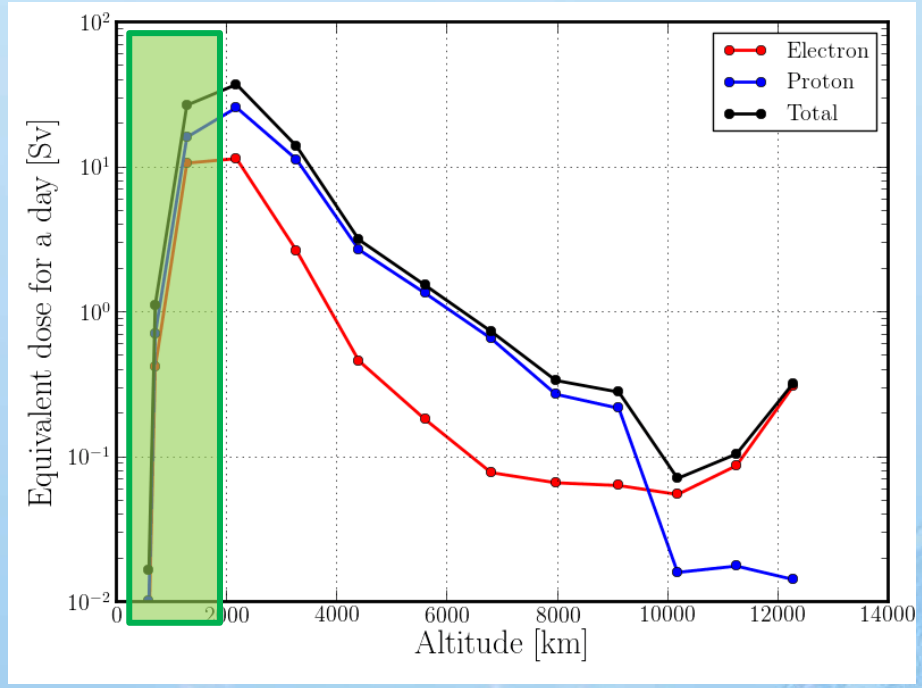


- The Engineering model of portable TEPC was designed and fabricated with A-150 ionization cavity, amplifier + preamp circuit, spectrometer, and HVPS.
- Portable TEPC have been characterized and calibrated by using Am-241 and Cf-252.
- We experimently confirmed that the TEPC was well operated below 100 keV/μm.

- Future Works
  - Development of Qualification TEPC model
  - Calibration in the range of high LET radiation in HIMAC
  - We hope that the TEPC will Launch and dosimetry in ISS.
  - More compact, lightweight and low power consumption for CubeSet application (TEPC + RadFET)
  - Future Korean Lunar program (2020s)
  - We are looking for more science applications


On-Board Computer
Electrical Power System
Battery
Communication Board
TEPC
RADFET
UHF Antenna
Instrument Interface Board
High Voltage (TEPC)
S-band Antenna
Solar Panel
Torque Coil
Magnetometer

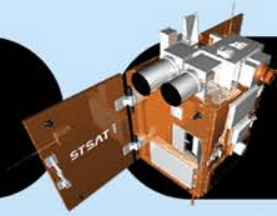
Proposed Missions of CubeSet



- Simulation of dose distribution after Solar Proton events (2013. 4. 11.) using RBSP data
- Dose level is high between 1000 km and 3000km
- Space radiation dosage is rapidly increased near 1000 km

Proposed Missions of CubeSet

: Measurement of total dose & LET spectrum in orbit
: Measurement of magnetic field of Earth



Thank you for your attention !