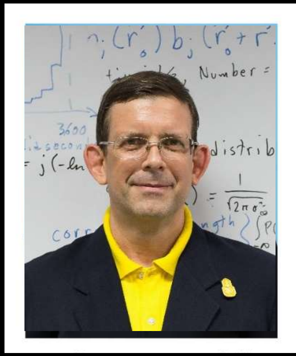
ความฝัน ที่จะวัดอนุภาคในอวกาศ

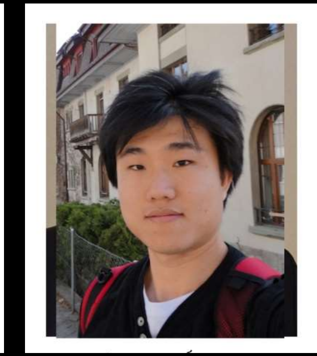
David Ruffolo & Kullapha Chaiwongkhot
Department of Physics, Faculty of Science,
Mahidol University, Bangkok, Thailand

Faculty Members
Space Physics and Energetic Particles Group
Mahidol University, Bangkok, Thailand

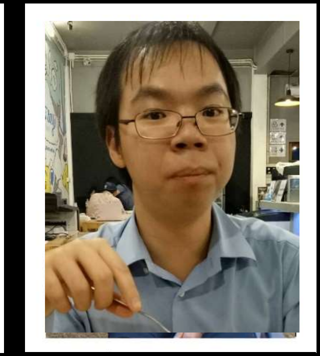


David Ruffolo

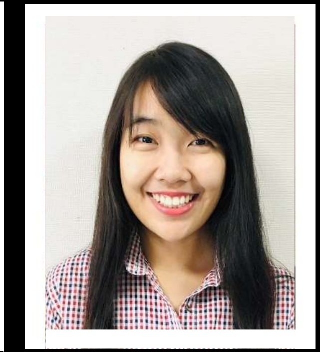
Alejandro Sáiz



Warit Mitthumsiri



Petchara Pattarakijwanich



Kullapha Chaiwongkhot

+ 1 postdoctoral researcher, 1 electronics engineer, 5 graduate students (3 Thai, 2 international), several undergraduate & high school students

Space Radiation: Key Collaborations

Contact:
david.ruf@mahidol.ac.th

Thailand
- Chiang Mai U.
- Kasetsart U.
- NARIT
- PIM
- TMEC/NECTEC
- RMUTT
- Thammasat U.
- Chulalongkorn U.

Africa
- Northwest U., South Africa

USA
- U. Delaware
- Princeton U.
- NASA/Goddard
- U. Wisconsin River Falls
- Stanford U.
- U. Hawaii Manoa
- U. New Hampshire

Asia
- IHEP, CAS, China
- Purple Mountain Observatory, China
- Shinshu U., Japan
- Yamagata U., Japan

Europe
- IRAP, France
- UCL, UK

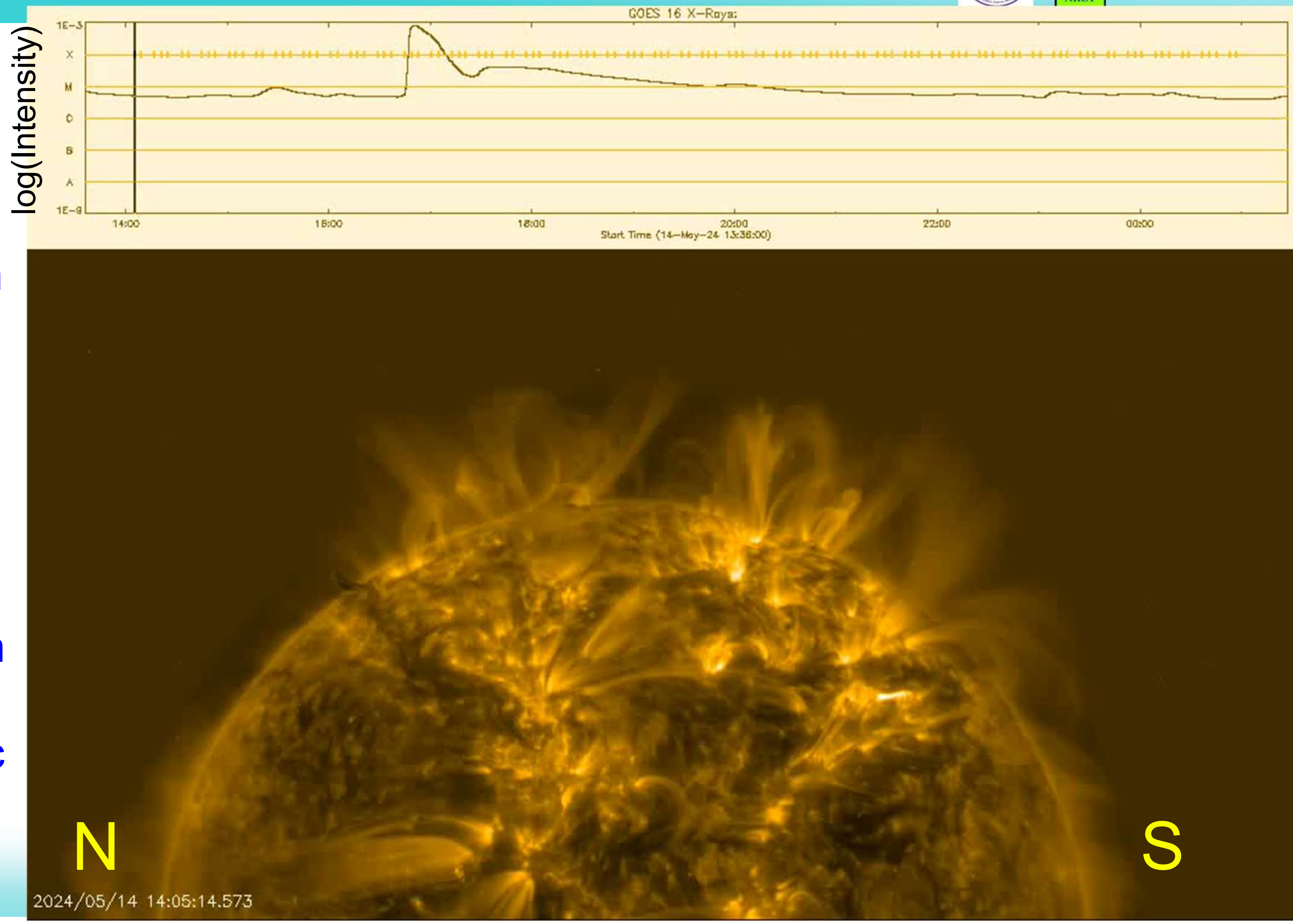
Australia/ New Zealand
- U. Tasmania
- Australian Antarctic Division
- Victoria U. Wellington

ความสำคัญ/การใช้ประโยชน์: Space Situational Awareness

Example of a solar storm: 2024 May 14.

Magnetic reconnection resulted in a flare & CME, rearranging the magnetic field lines.

The CME impacted the Earth, leading to equatorward extension of aurorae and the strongest geomagnetic storm in 20 years.



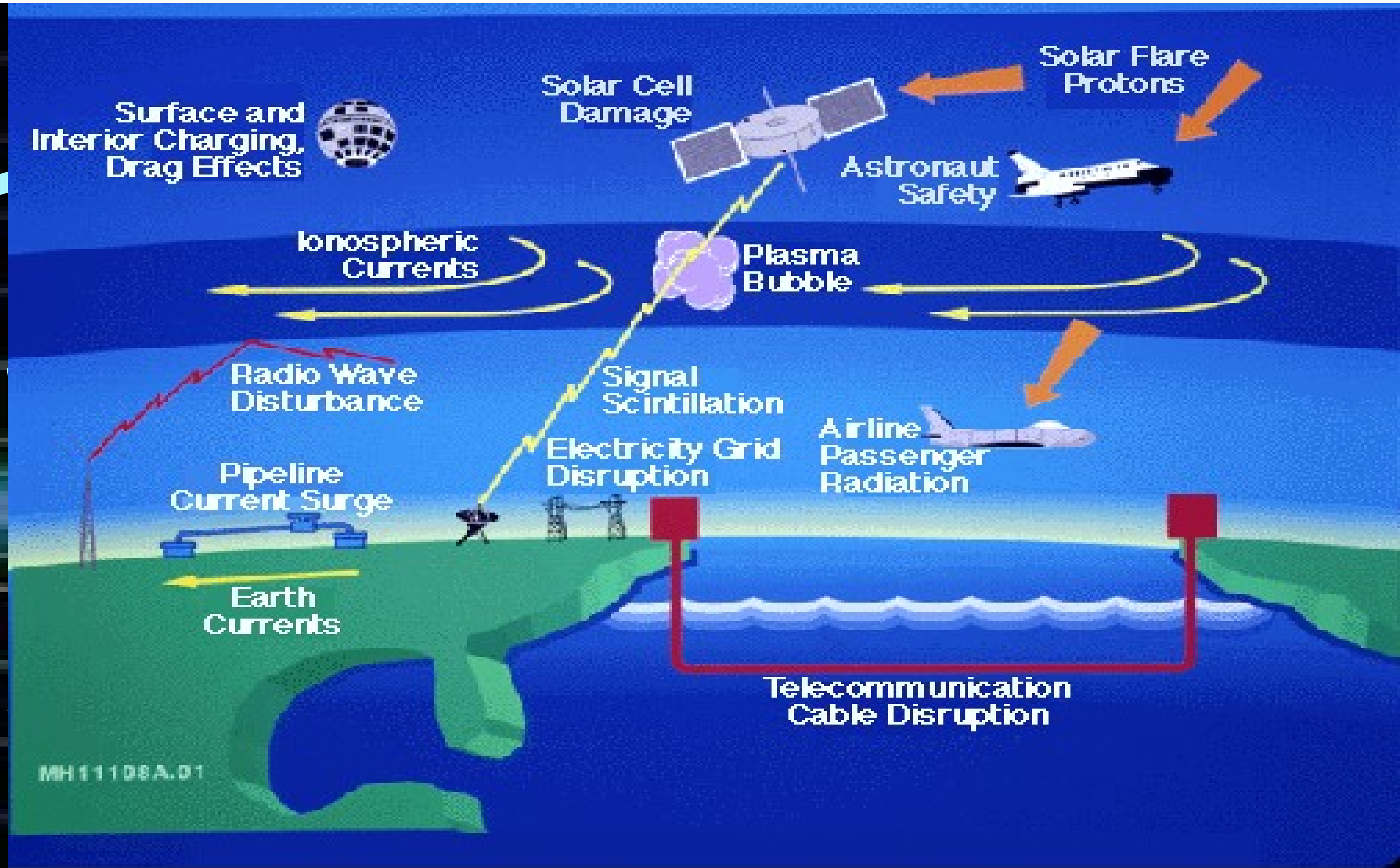
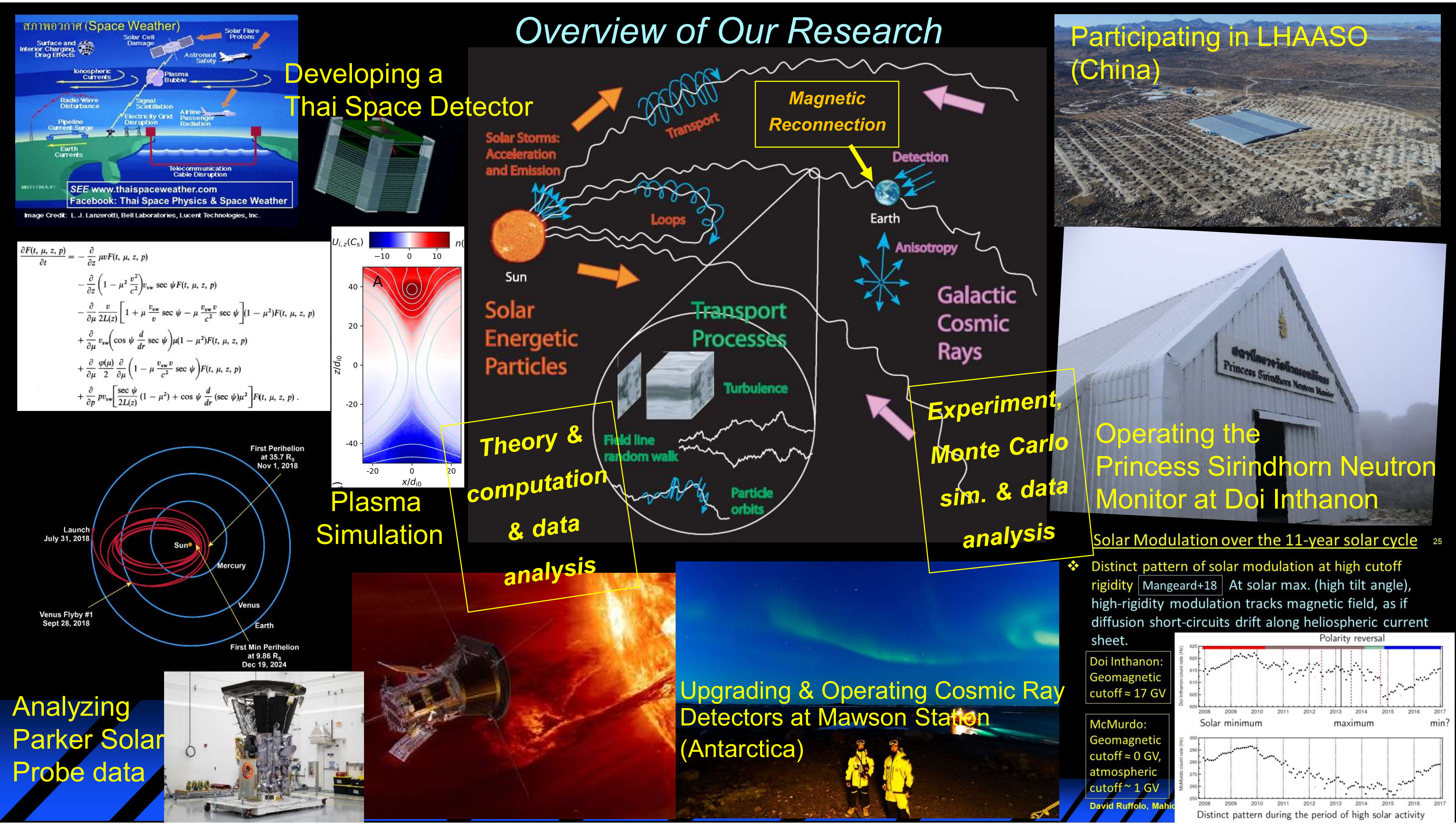


Image Credit: L. J. Lanzerotti, Bell Laboratories, Lucent Technologies, Inc.

Image credit: K. Endo, Nikkei Science Inc.


Overview of Our Research
สภาพอวกาศ (Space Weather)
SEE www.thaispaceweather.com
Facebook: Thai Space Physics & Space Weather
Image Credit: L. J. Lanzerotti, Bell Laboratories, Lucent Technologies, Inc.
Developing a
Thai Space Detector
Solar Storms: Acceleration and Emission
Transport
Magnetic Reconnection
Detection
Loops
Earth
Sun
Anisotropy
Solar Energetic Particles
Transport Processes
Galactic Cosmic Rays
Turbulence
Field line random walk
Particle orbits
Theory & computation & data analysis
Experiment, Monte Carlo sim. & data analysis
Participating in LHAASO (China)
Operating the Princess Sirindhorn Neutron Monitor at Doi Inthanon
Plasma Simulation
First Perihelion at 35.7 R_S Nov 1, 2018
Launch July 31, 2018
Sun
Mercury
Venus
Earth
Venus Flyby #1 Sept 28, 2018
First Min Perihelion at 9.86 R_S Dec 19, 2024
Analyzing Parker Solar Probe data
Upgrading & Operating Cosmic Ray Detectors at Mawson Station (Antarctica)
Solar Modulation over the 11-year solar cycle
25
Distinct pattern of solar modulation at high cutoff rigidity Mangeard+18 At solar max. (high tilt angle), high-rigidity modulation tracks magnetic field, as if diffusion short-circuits drift along heliospheric current sheet.
Doi Inthanon: Geomagnetic cutoff ≈ 17 GV
McMurdo: Geomagnetic cutoff ≈ 0 GV, atmospheric cutoff ~ 1 GV
Polarity reversal
Solar minimum
maximum
min?
Distinct pattern during the period of high solar activity
David Ruffolo, Mahid

TSC
Thai Space Consortium

A Satellite Detector Development:

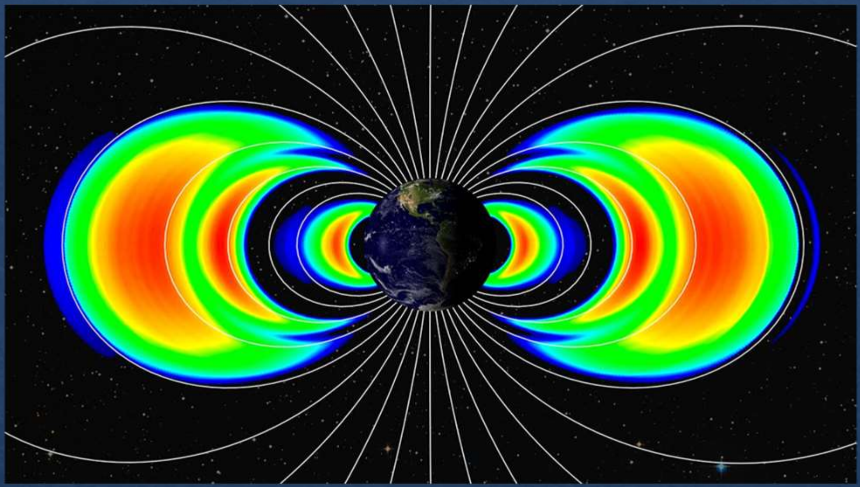
POiSE

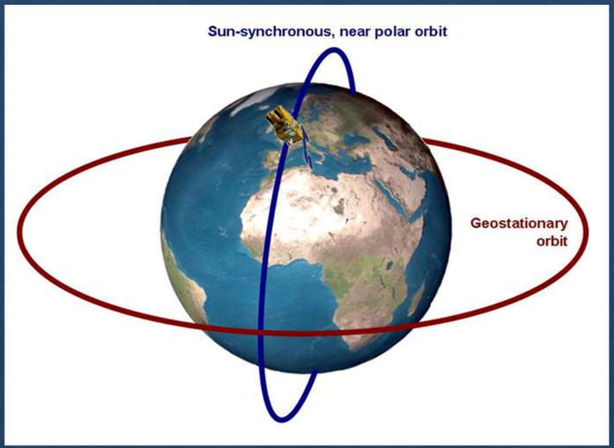
Polar
Orbiting
Ion
Spectrometer
Experiment

By POiS(ons)E

POISE

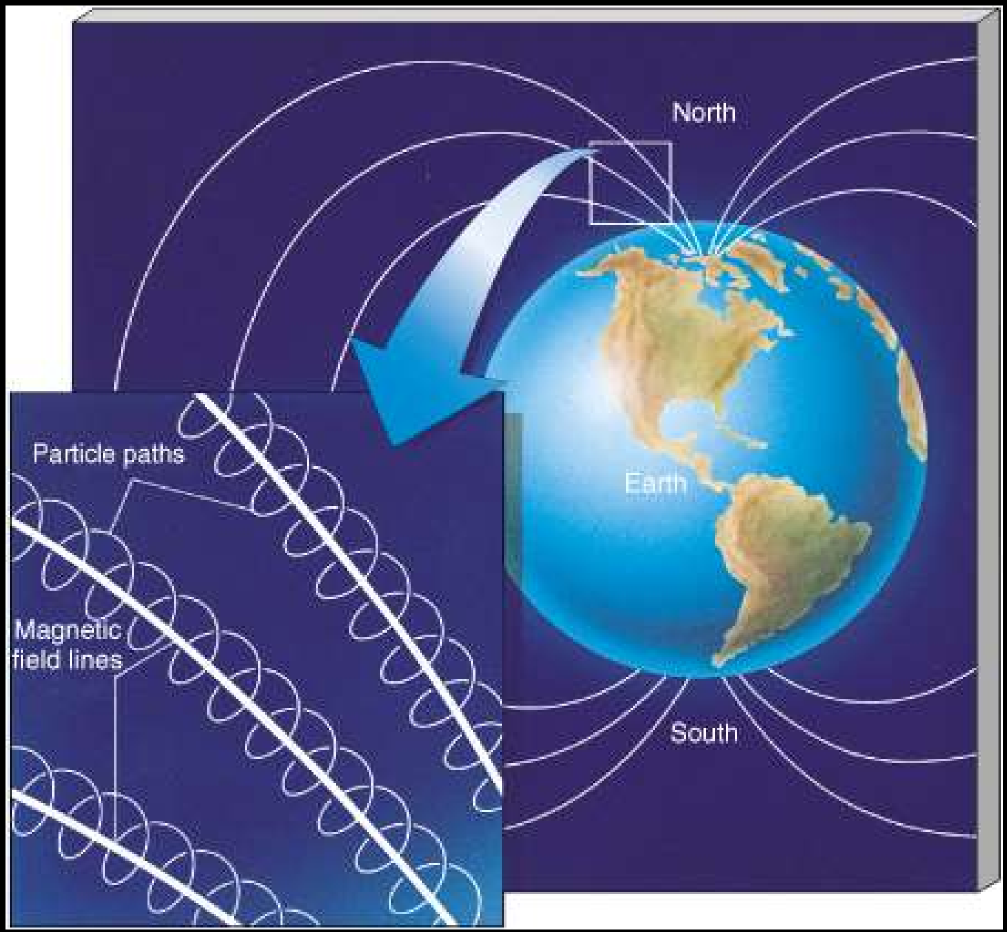
(Polar Orbiting Ion Spectrometer Experiment)





- **Short-term plan (TSC-1):**
  Detection of radiation belt & solar energetic ions of various elements, providing warning of space weather effects and determining charge states via deflection in Earth's magnetic field
  - **Warning function will reproduce some capabilities of other nations**
  - **Charge state measurements of ions ~10 MeV/n were performed over 1992-2004, and are not currently available from any other instruments**
  - **Charge state information is scientifically important (see Ruffolo 1997)**

Low-energy cosmic rays only reach Earth's polar regions; higher energy is needed to penetrate equatorial B field



The trajectory in a magnetic field depends on *pc/q* … so by measuring the magnetic latitude at which ions of a known element and energy are observed, we can infer their charge state Q.

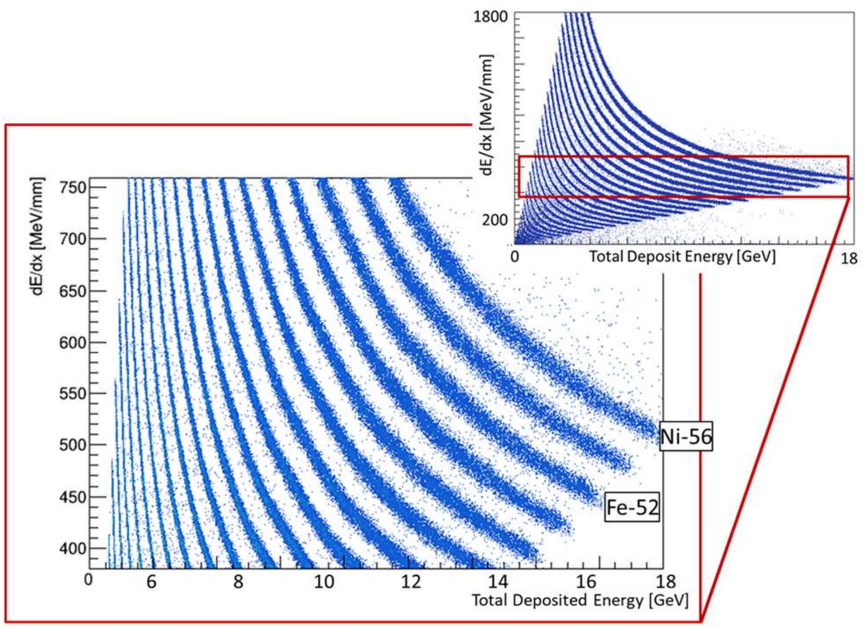
Galactic cosmic rays are fully stripped ($Q = Z$), but solar energetic particles can have $Q < Z$.

Image credit: http://astronomy.nju.edu.cn/~lixd/GA/AT4/AT407/HTML/AT40705.htm

POiSe = Polar Orbiting Ion Spectrometer Experiment (for TSC-1)

(Polar Orbiting Ion Spectrometer Experiment)

- Inspired by *SAMPEX/MAST* mission during 1992-2004
- From He to Ni (Z = 2 to 28), Energy range : ~ 15MeV/nuc - ~200MeV/nuc
- Silicon based detectors for ions identification by **ΔE – E Technique**



David Ruffolo, Mahidol University

Position sensitive detector:

2 Double-sided silicon-based detector (Mirion)

dE-detector: Silicon-based

- 4 PINs (TMEC)
- 4 PIPs (Mirion)

E-detector:

1 CsI(Tl) Scintillator + 4 SiPMs

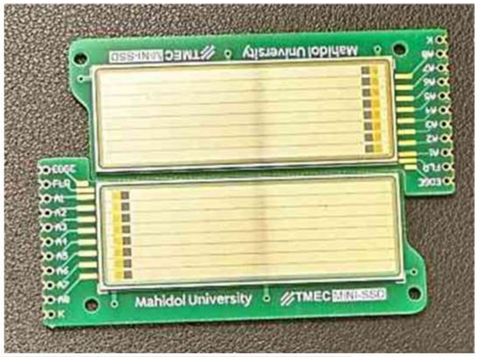
Veto-detector: Silicon-based

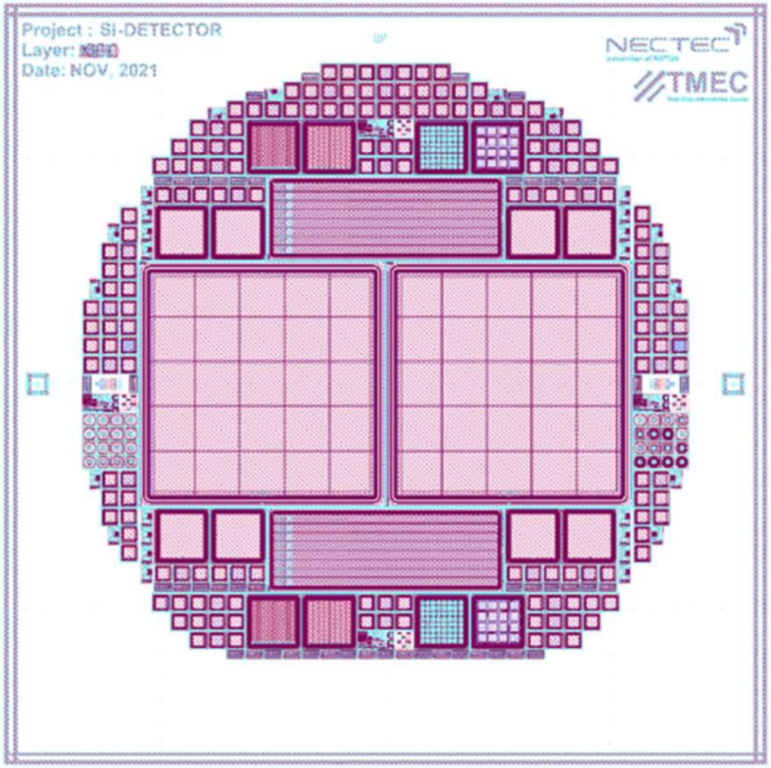
- 1 PIN (TMEC)
- 1 PIP (Mirion)

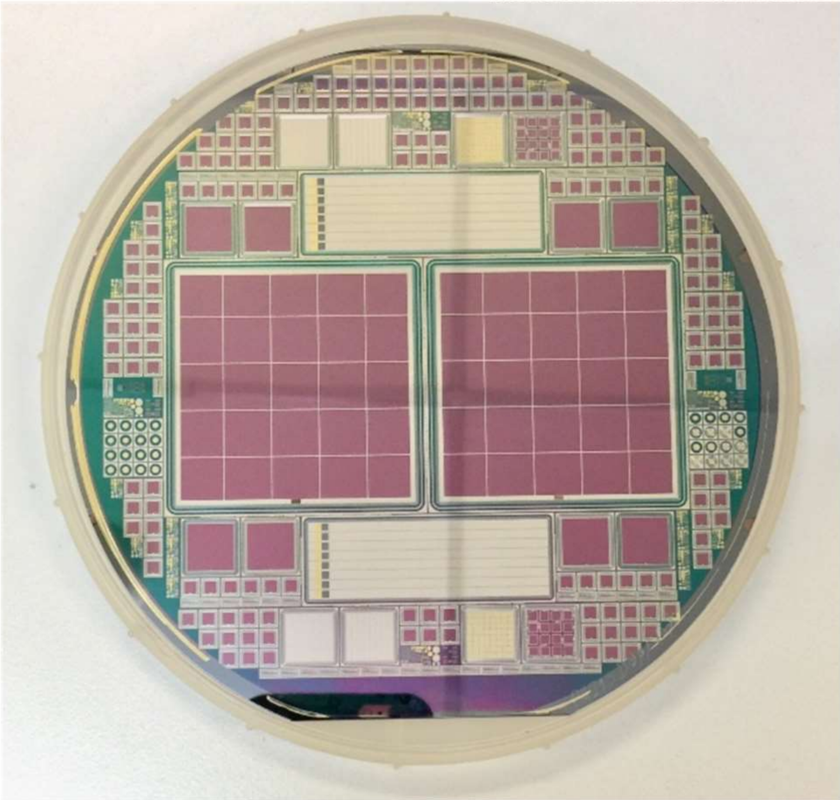
POISE
(Polar Orbiting Ion Spectrometer Experiment)

PINs

TMEC
Thai Microelectronics Center







For moderately relativistic charged particles, $-\mathrm{d}E/\mathrm{d}x \propto z^2/v^2$ and $E \approx (1/2)mv^2$.
Consider using multiple detector layers, including

- thin layers that measure $\Delta E = |\mathrm{d}E/\mathrm{d}x|\,\Delta x$
- a thick layer where the particle stops, which measures E.

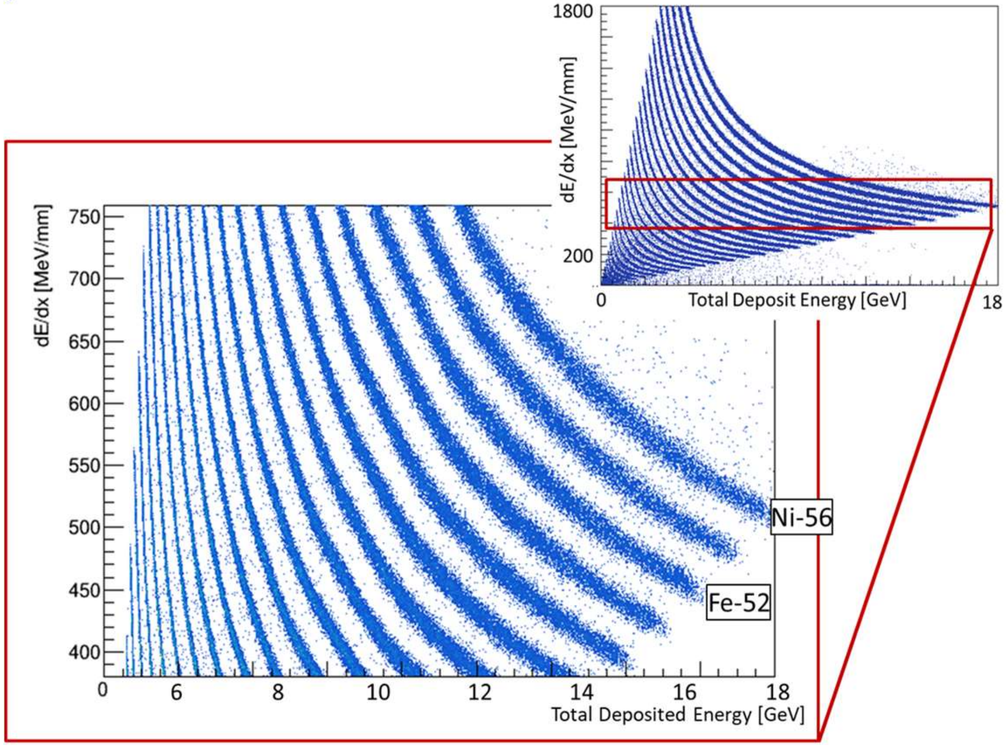
Multiplying the two,

$$\Delta E \times E \propto (z^2/v^2)\, mv^2 \propto z^2 m$$

This is the ΔE vs. E technique for identifying particle species.

For ions, $z=Z$ and $m \propto A$ are discrete:

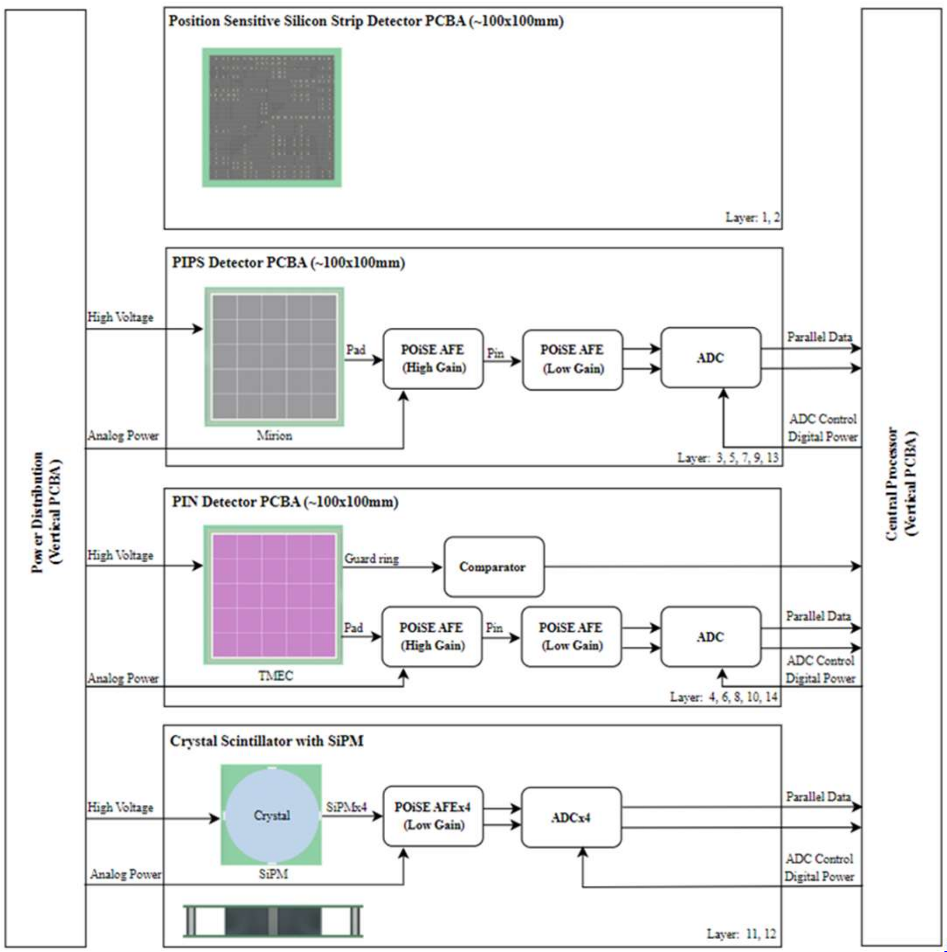
Isotope	Z	A	Z^2A
^{1}H	1	1	1
^{2}H	1	2	2
^{3}He	2	3	12
^{4}He	2	4	16
…			

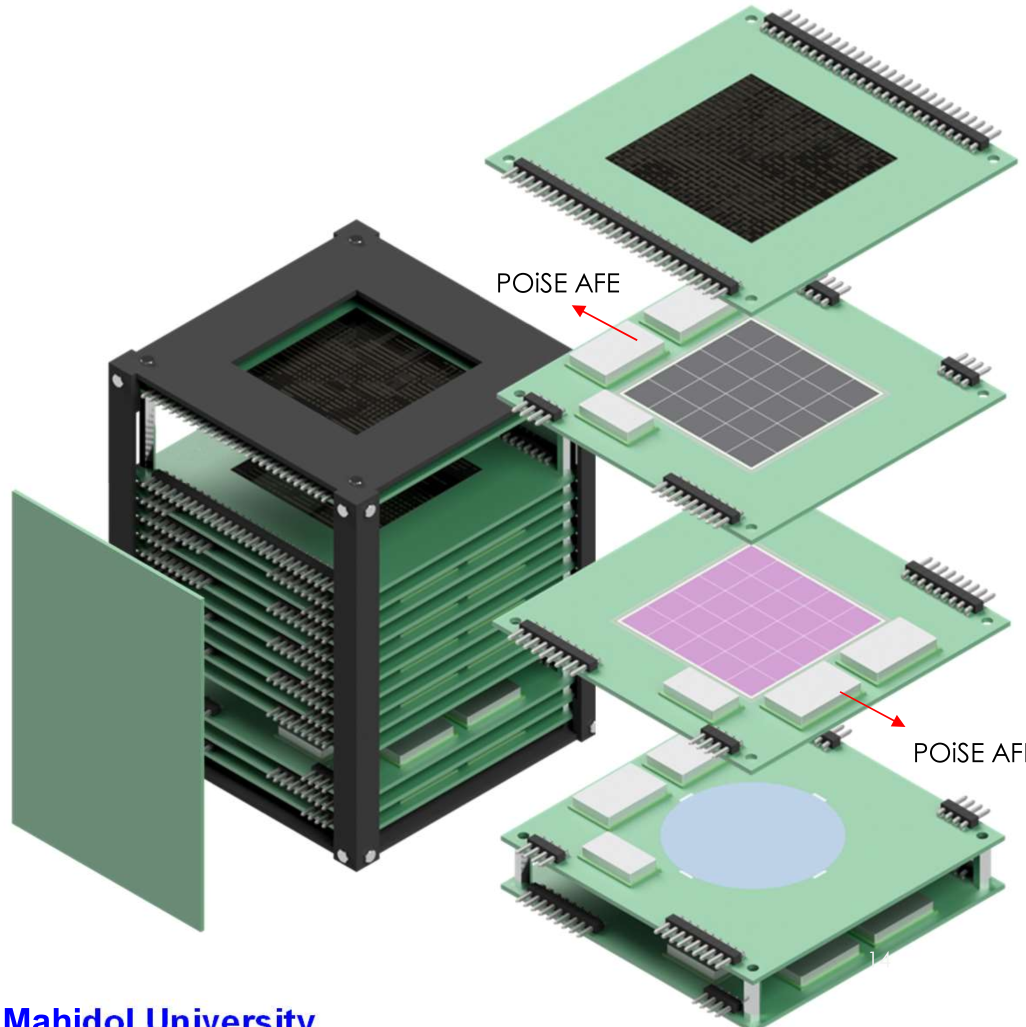


GEANT4 simulation by Dr. Kullapha Chaiwongkhot

Overview of POiSE readout electronics

1st design of the electronics interface inside our payload

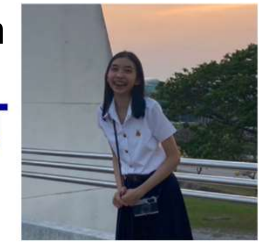




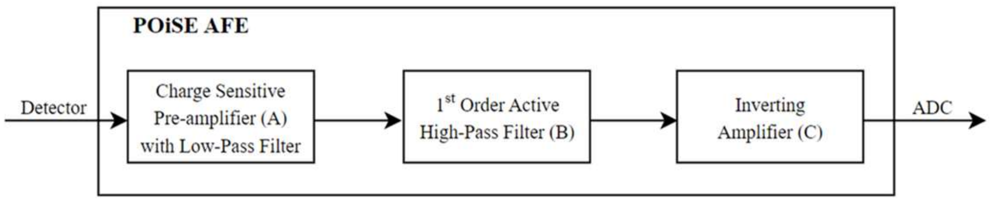
Mahidol University

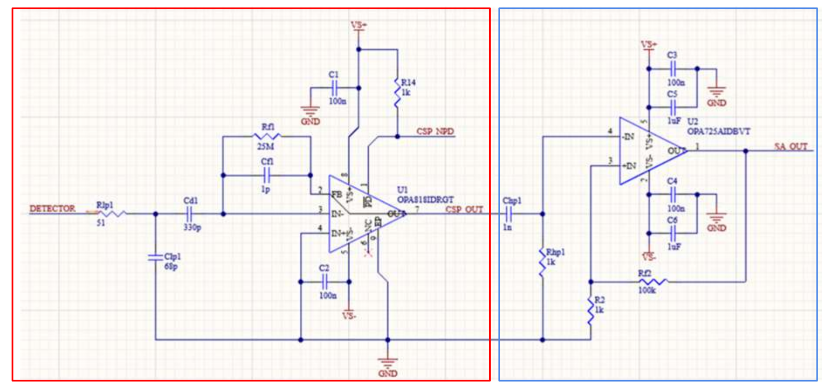
POiSE Analog Front-End

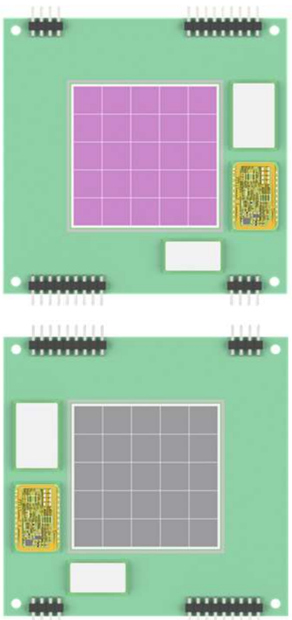
Sunruthai Burom

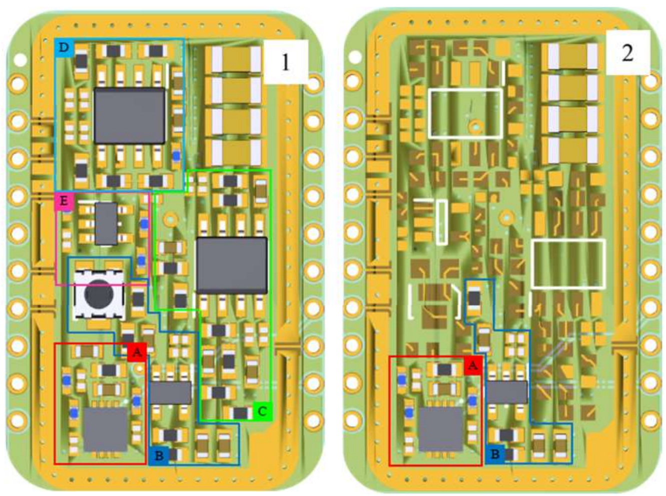


POiSE Analog Front-End module or **POiSE AFE** module for PINS/PIPs comprises three functional parts:









A top-down view of POiSE AFE module with each functional group designated.
[1] is revision C3 [2] is revision D (latest)

POiSE AFE revision D,yellow is a CSP output pulse, blue is shaping amplifier output pulse

Kunlanan Puprasit

Testing the Space Weather Payload

Radiation sources

The prototype detectors can differentiate particle energies

→

Comparing the response of the prototype detector with the commercial detector

Ion accelerator

To calibrate signal pulse height and deposited energy

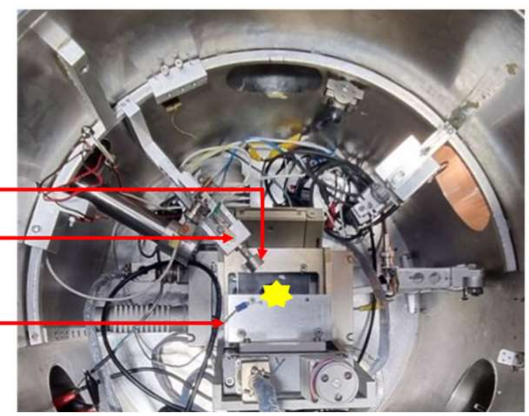
RBS stands for Rutherford BackScattering

a nuclear scattering technique used to study the composition and structure of materials at the atomic level by measuring the energy and angle of the backscattered ions.

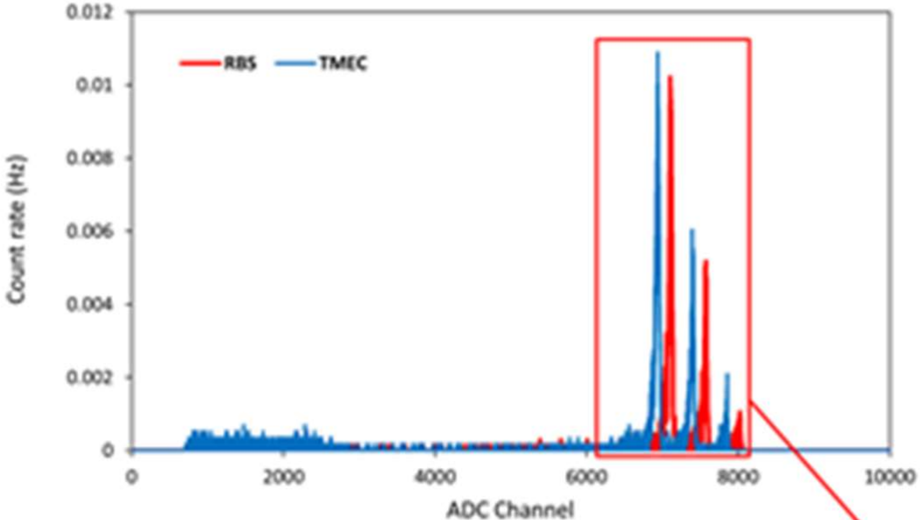
RBS detector

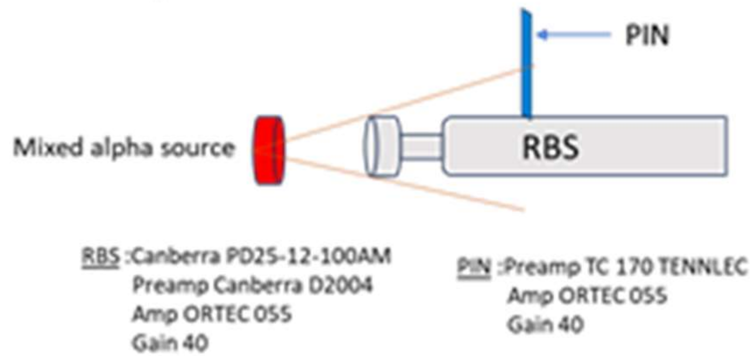
Prototype detector

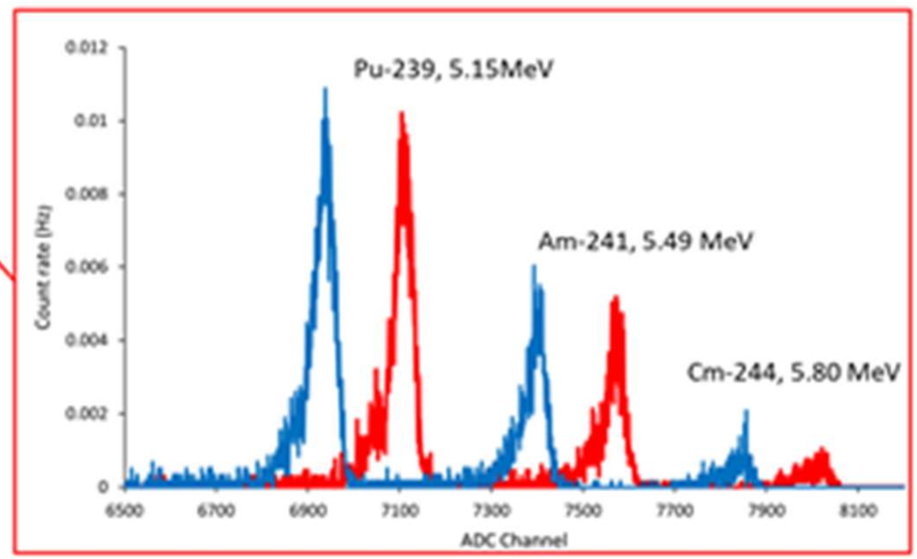
Sample Holder



Comparison of silicon surface detector response: PIN Vs RBS







"PIN represents an excellent choice for conducting RBS measurements of the ion beam experiment as well"

David Ruffolo, Mahidol University