ESTIMATION OF THE DOMINANT ION COMPOSITION IN SPACE USING THE LIULIN AND PHITS SIMULATIONS

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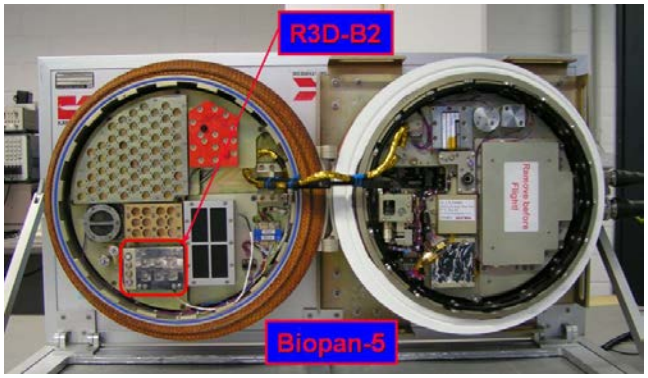
OUTLINE

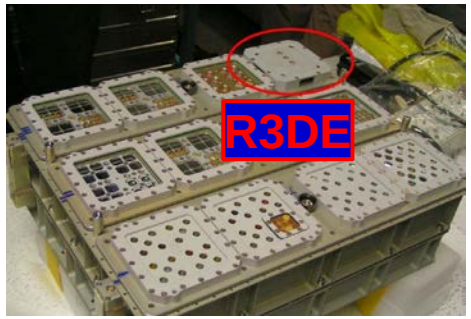
- Examples of Energy deposition spectra onboard spacecraft measured with Liulin
- Energy spectra of galactic cosmic rays generated by SPENVIS
- Energy deposition spectra in silicon diode calculated with PHITS

EXAMPLES OF THE MOUNTING OF LIULIN TYPE INSTRUMENTS IN SPACE



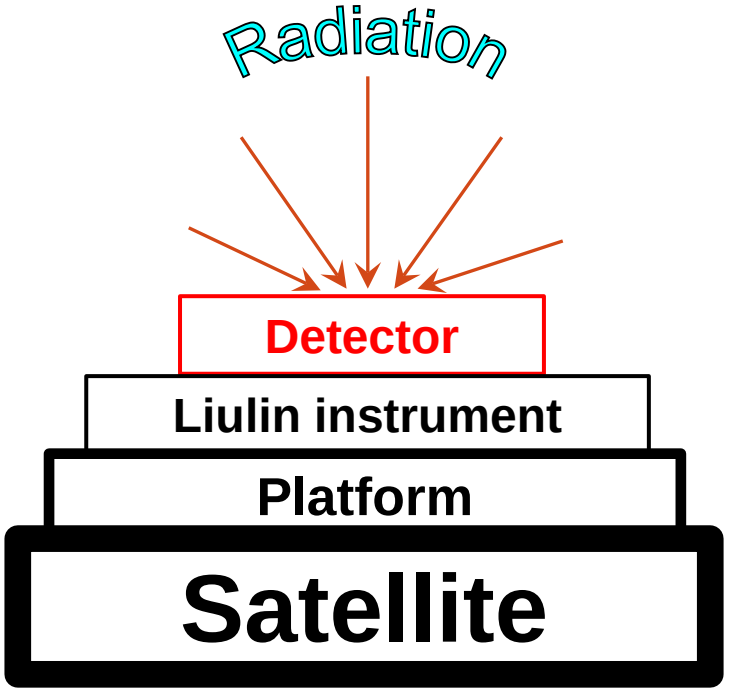
Biopan-5/6

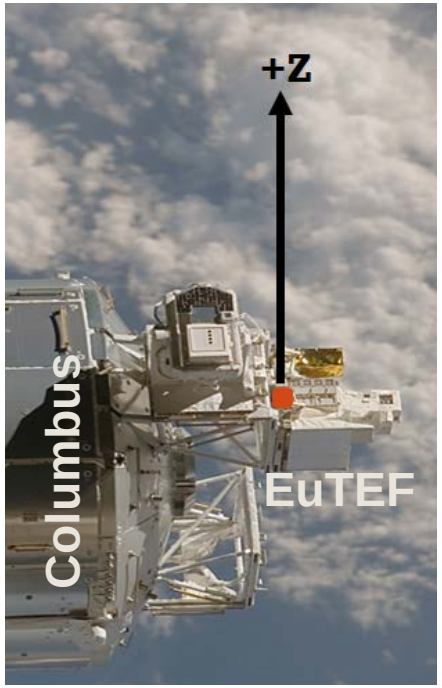
Chandrayaan-1



EXPOSE-E/R

Foton-M3/M3

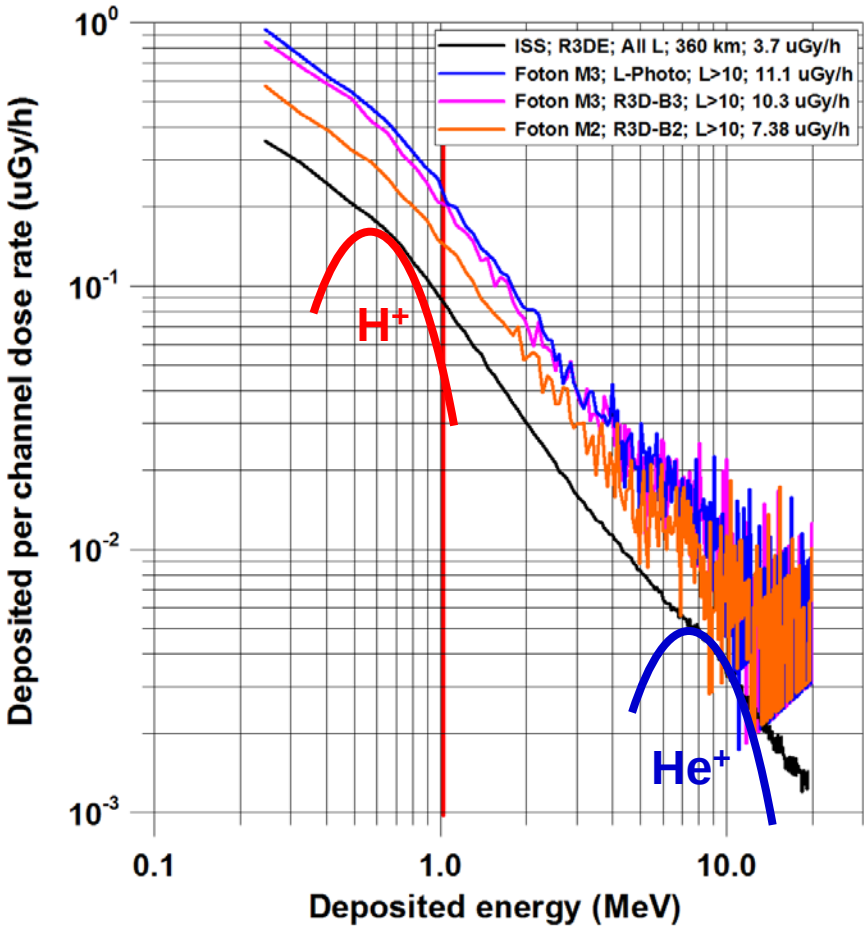




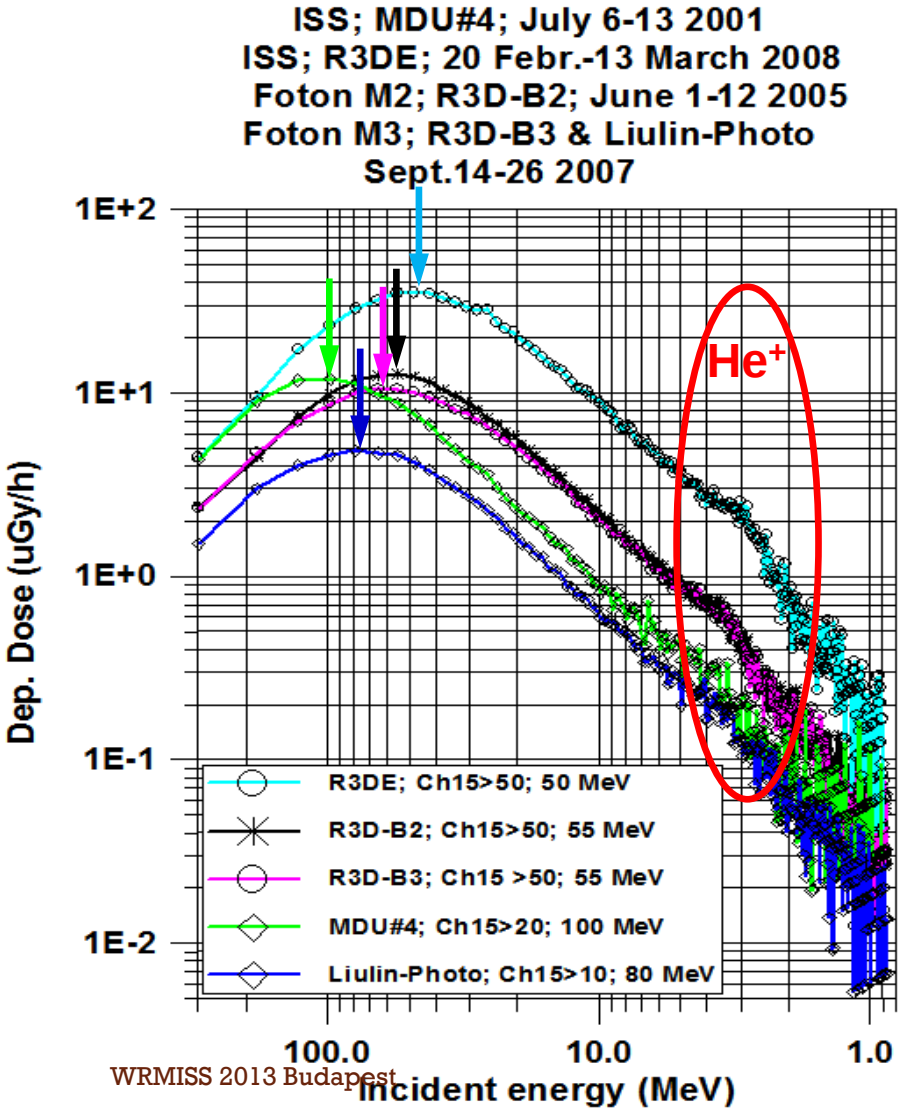
ISS

CHARACTERIZATION OF THE TYPE OF INCIDENT IONS BY THE SHAPE OF THE SPECTRA IN THE GCR

Foton M2; R3D-B2; June 1-12 2005; 1.81 g/cm^2
Foton M3; R3D-B3; Sept.14-26 2007; 0.75 g/cm^2
Foton M3; Liulin-Photo; Sept 14-26 2007; >5 g/cm^2
ISS; R3DE; 20 Febr.-31 Decemb. 2008; 0.4 g/cm^2



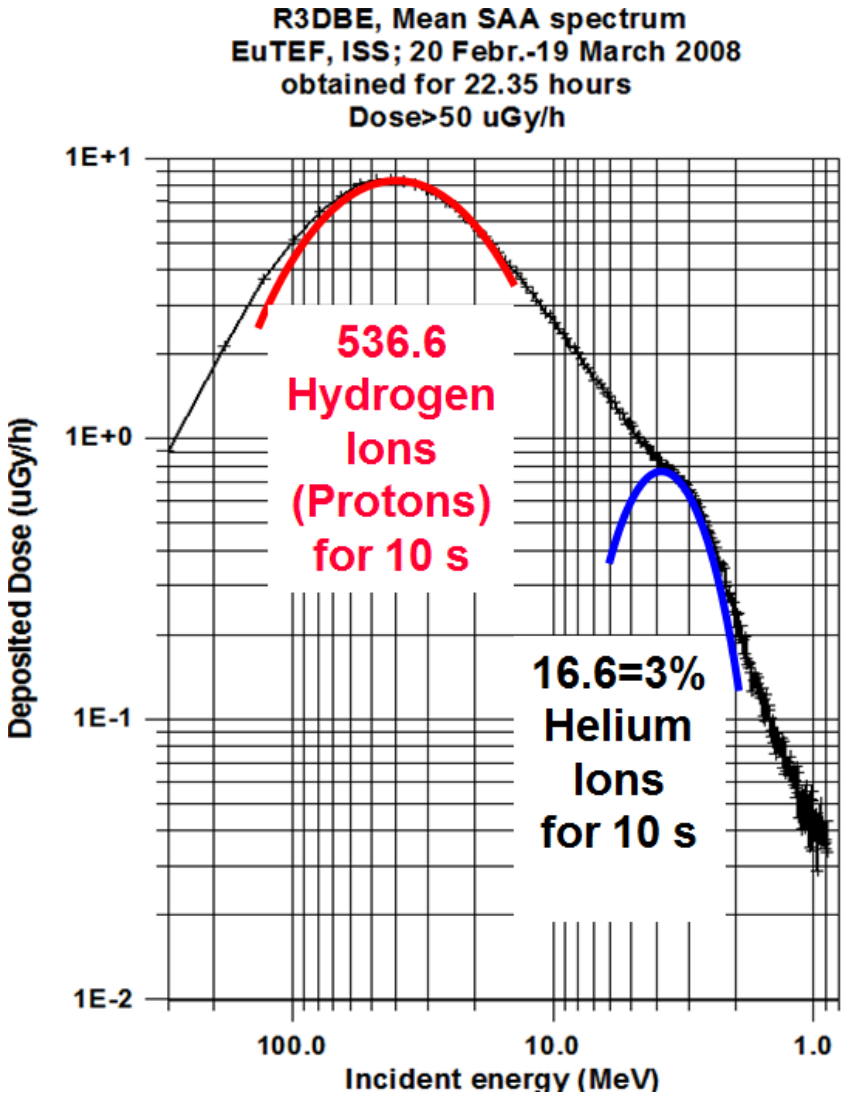
THE SAA SPECTRUM SHAPE IS SIMILAR IN ALL SPACE EXPERIMENTS. PROTON MAXIMUM MOVES IN DEPENDENCE BY THE SHIELDING OF THE INSTRUMENT



Spacecraft, Instrument	Shielding g/cm^2	Mean Energy MeV
ISS, R3DE	0.4	50
Foton M3, R3D-B3	0.75	55
Foton M2, R3D-B2	1.85	55
Foton M3, Liu-Photo	>5	80
ISS, MDU#4	> 20	100

The proton mean energy maximum of the SAA spectrum moves toward lower energies when the shielding thickness of the instrument is lower.

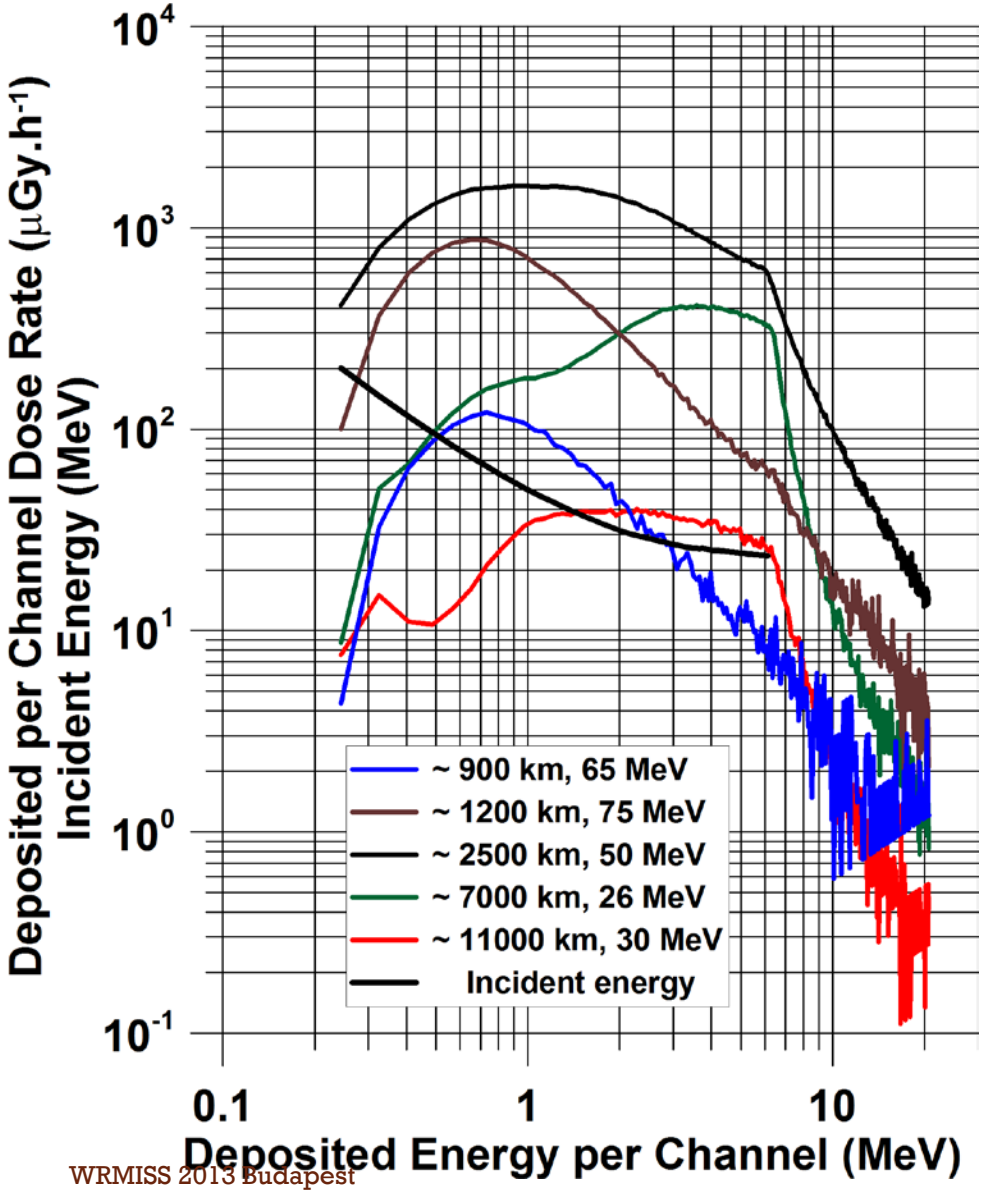
CHARACTERIZATION OF THE TYPE OF INCIDENT IONS BY THE SHAPE OF THE SPECTRA IN THE REGION OF SAA

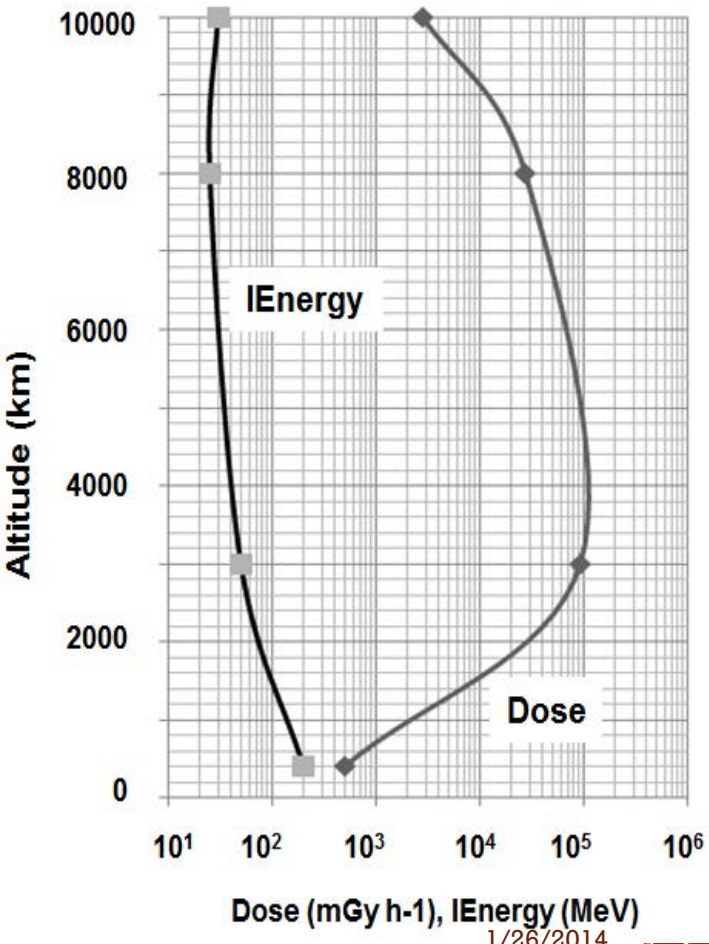


Explanation of the shape of the spectrum with 2 maximums created by protons and helium ions. About 3% of all counts in SAA are created by Helium ions and protons falling at large angle toward the detector*.

***Presented by Dachev at WRMISS-13 in Krakow, Poland in 2008**
http://wrmiss.org/workshops/thirteenth/Dachev_Liulin.pdf

VARIATIONS OF SPECTRUM SHAPES OBTAINED BY RADOM INSTRUMENT ON CHANDRAYAAN-1 SATELLITE AT DIFFERENT ALTITUDES IN THE INNER RADIATION BELT





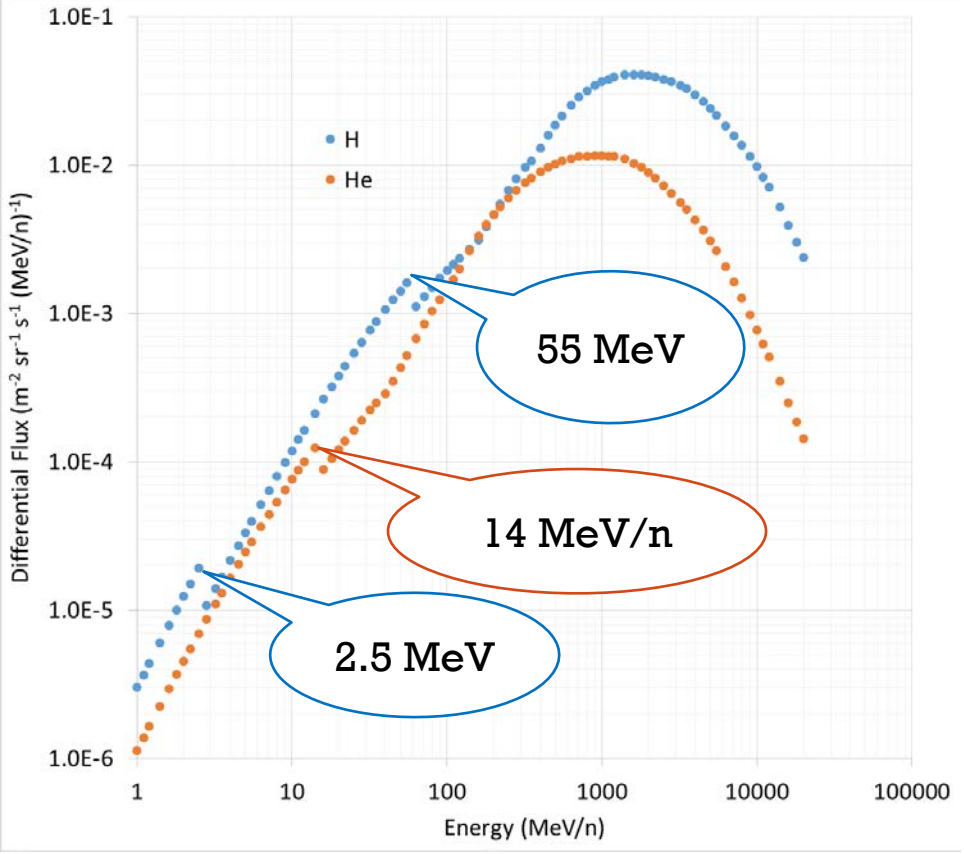
PRELIMINARY PHITS SIMULATIONS

WHY PRELIMINARY?

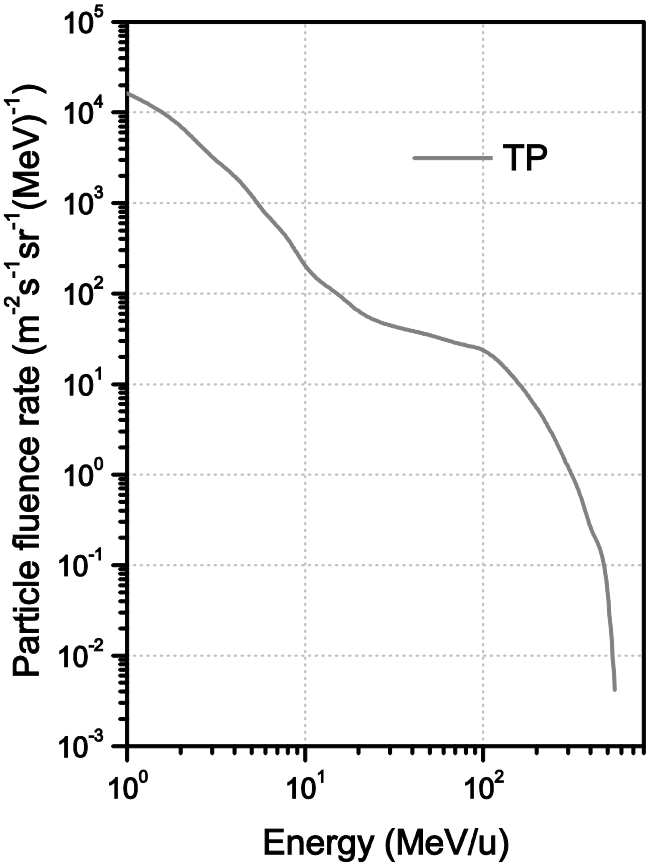
- Did I use the last trapped proton model (AP9)?
- NO
- Did I use the last GCR model (Badhwar-O'Neill 2011)?
- NO
- Did I use correct angular distribution of source?
- NO (we ignored the effect of the Earth's shadow, the angular dependence of the geomagnetic transmission factors and the East–West asymmetry in SAA)
- Did I use detail geometry of spacecraft, detector, position, etc.?
- NO

Because I used model spacecraft (aluminum cylinder) at flight orbit of ISS and spectra generated by SPENVIS. Detail simulation of a certain experiment is under construction …

GCR
ISO-15390

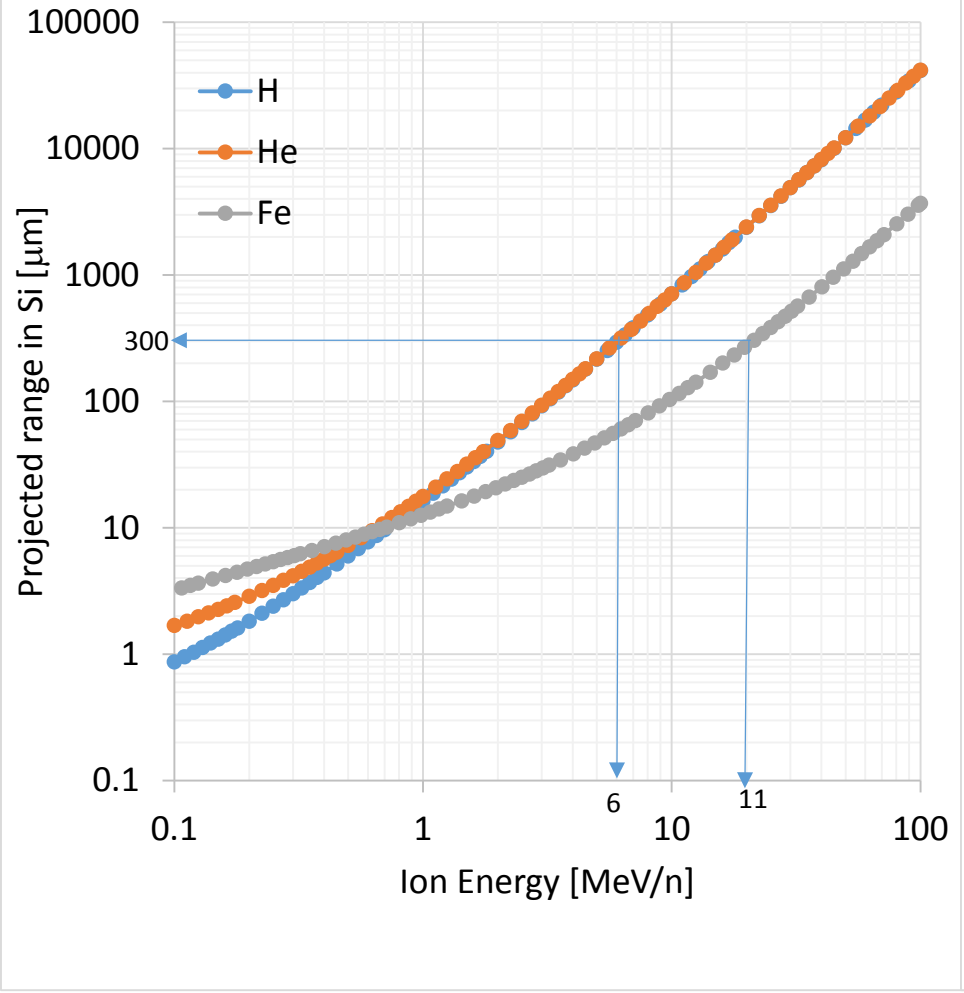


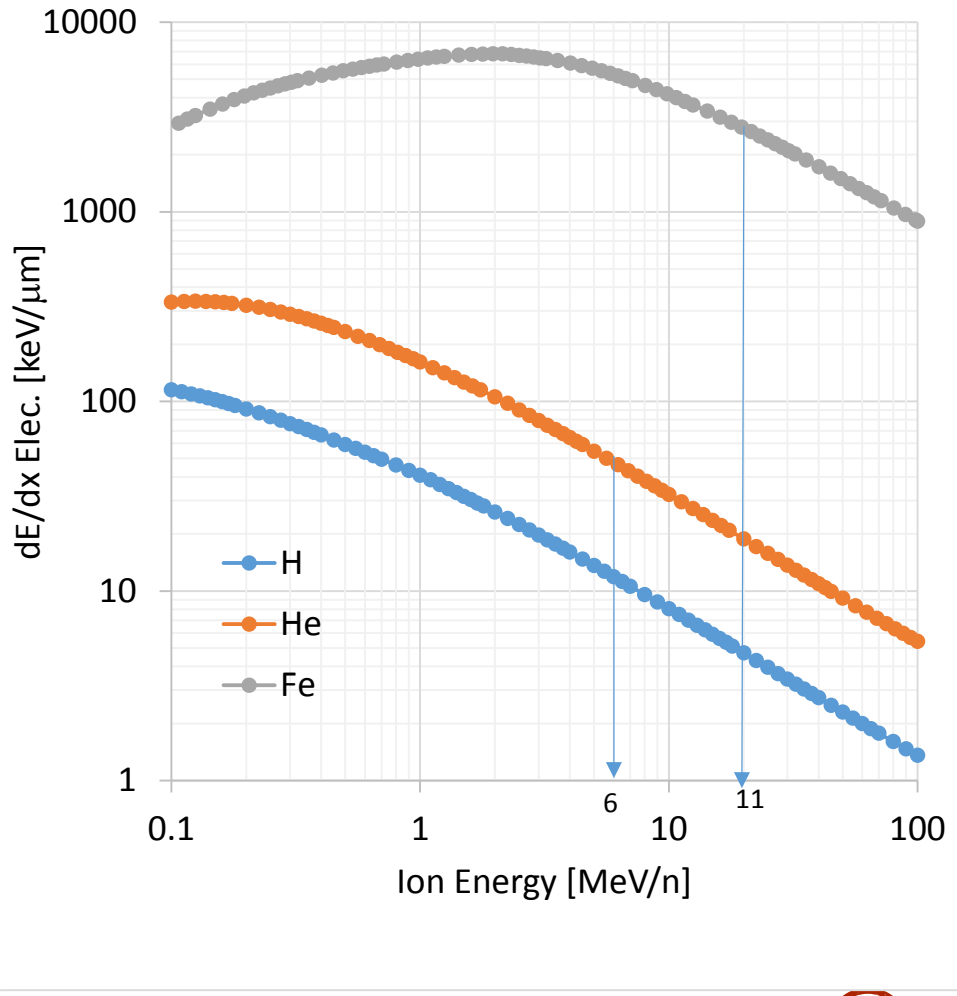
TRAPPED PROTONS
AP8MIN



Spectra generated by SPENVIS using the flight parameters of ISS
Orbit inclination 51.6°, apogee = 360km, perigee = 340km,
solar minimum, duration: 100 days

PROJECTED RANGE AND ELECTRON STOPPING POWER IN SILICON FOR SELECTED IONS





TWO EXTREME ANGULAR DISTRIBUTIONS PARALLEL BEAM AND ISOTROPIC SOURCE

- Isotropic radiation field:

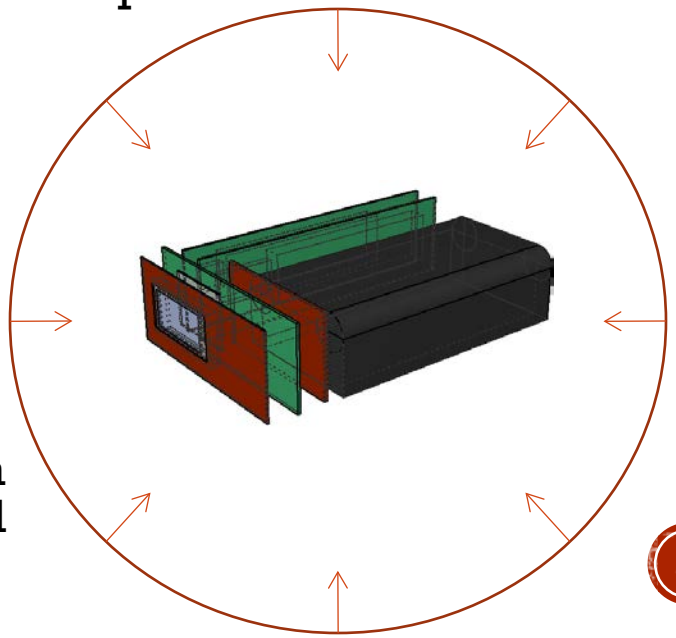
$$\Phi = \frac{1}{V}\sum_j l_j = \frac{N \cdot \bar{l}}{V} = \frac{N}{A/4}$$

- $\sum_j l_j$ … sum of all chord lengths inside the active volume V
- $\bar{l} = \sum_j l_j / N$ …mean chord length
- A … area of the body's surface

$$\bar{l} = 4V / A$$

… came from The Cauchy's Mean Value Theorem, valid for convex objects in isotropic radiation field

	Φ / cm^{-2}	
	Isotropic r.f.	Parallel beam
Liulin	N / 1.045	N / 2



Values were verified with PHITS in a simple isotropic radiation field

What is PHITS?

Particle and Heavy Ion Transport code System

Capability

Transport and collision of all particles over wide energy range

in 3D phase space
with magnetic field & gravity

neutron, proton, meson, baryon
electron, photon, heavy ions

10^{-4} eV to 100 GeV/u

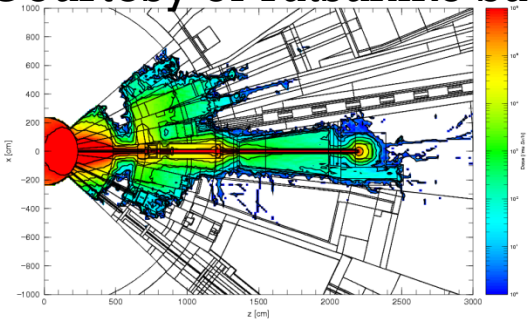
All-in-one-Package

All contents of PHITS (source files, binary, data libraries, graphic utility etc.) are fully integrated in one package

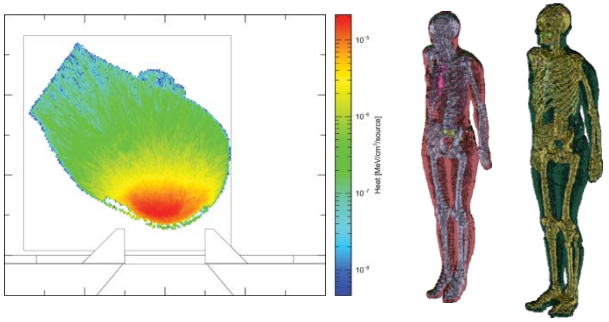
OECD/NEA Databank, RSICC (USA, Canada etc.) and RIST (Japan)

Applications

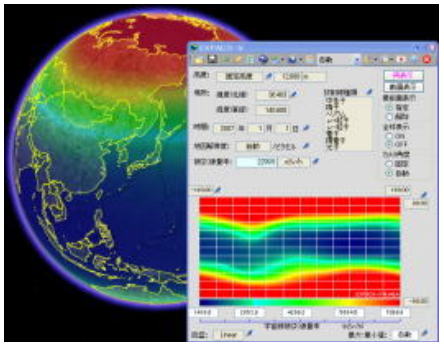
Courtesy of Tatsuhiko Sato



Accelerator Design



Radiation Therapy & Protection



Space & Geoscience

NSC - NATIONAL SUPERCOMPUTER CENTRE IN LINKÖPING SWEDEN

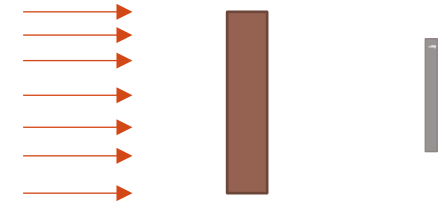
Name	Type	Cores	Usage	In use since
Triolith	Cluster	19200	SNIC	Jul 2012

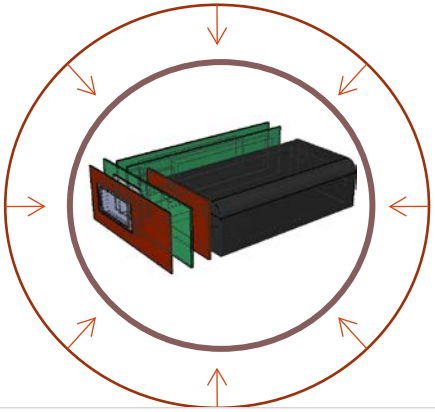
- 1200 compute nodes
- Each node: HP SL230s equipped with two Intel E5-2660 (2.2 GHz Sandybridge) processors with 8 cores each, i.e 16 cores per node.
- theoretical peak performance 338 Tflops/s
- The operating system is Linux (CentOS 6.x x86_64).

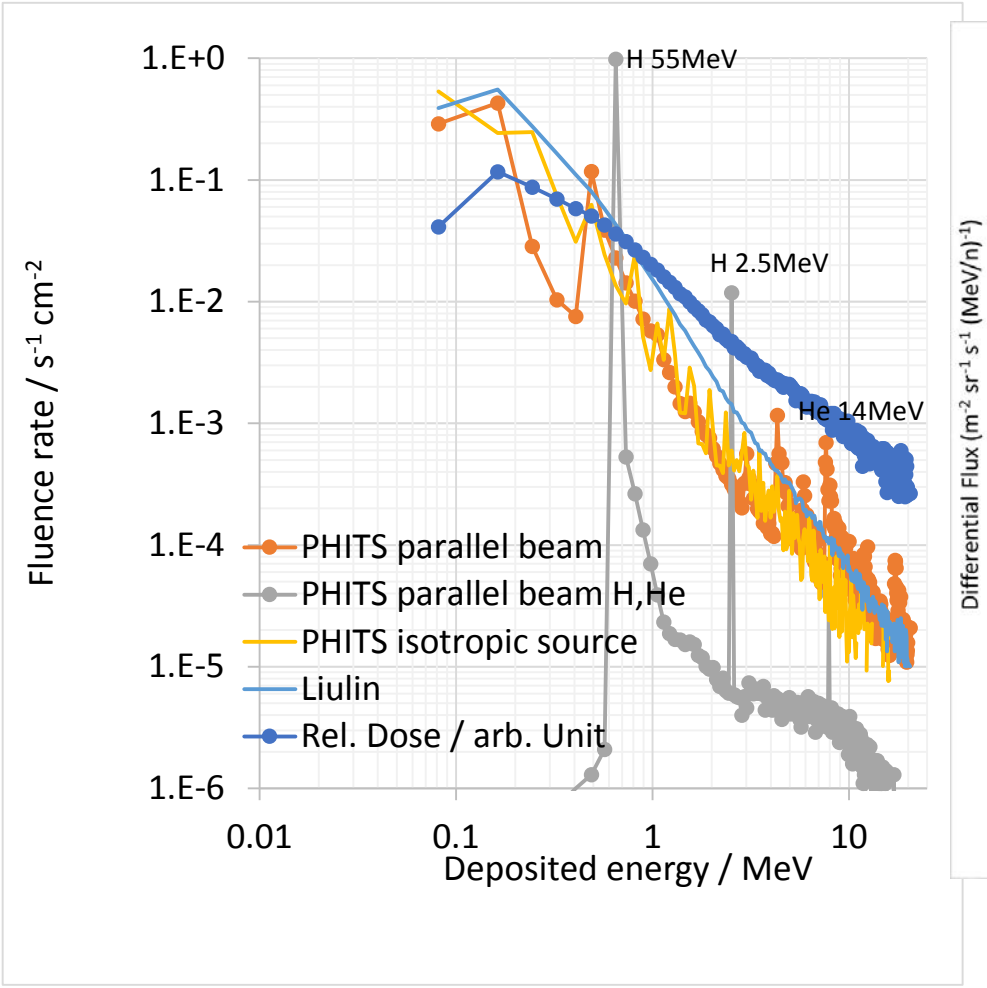
Project	Project Title	PI	Start Date	End Date
SNIC 001/12-65	Study of high-LET radiation-produced radical species and induced oxidative damage on DNA in deep space	Lembit Sihver	2012-03-27	2013-04-01
SNIC 2013/1-132	Monte Carlo simulations of health risks to normal tissues from the use of existing and emerging techniques for radiation therapy	Lembit Sihver	2013-04-12	2014-05-01

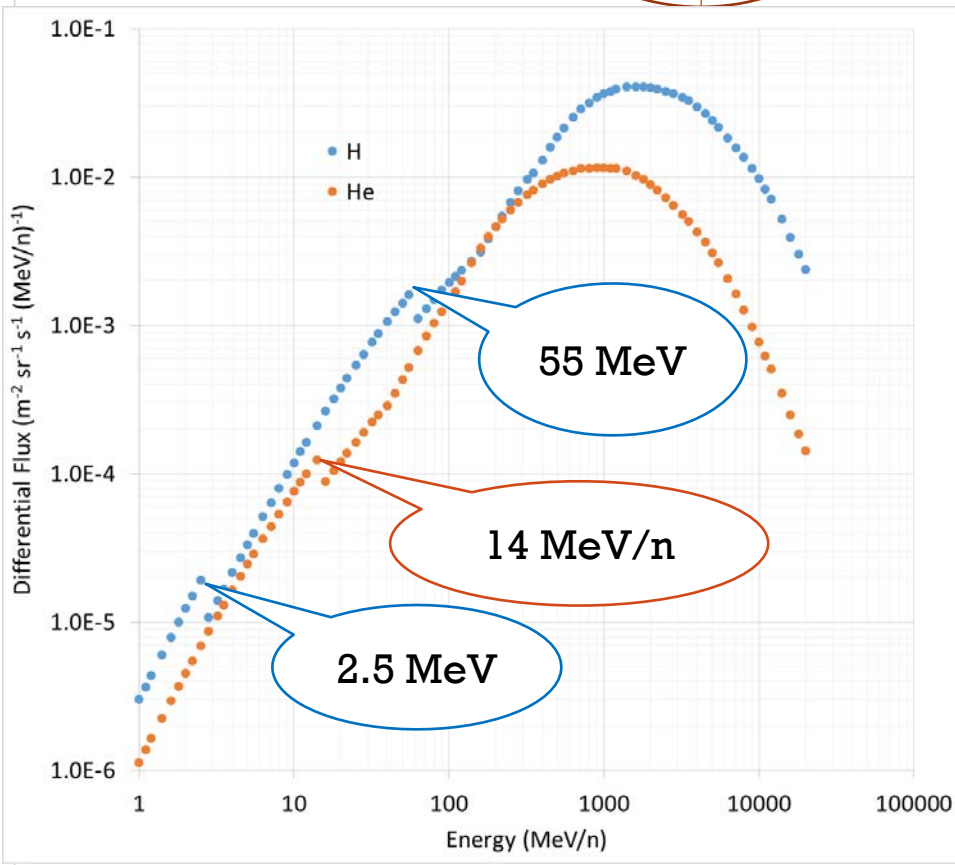
/ Protective curtains

PHITS SIMULATION
GCR SPECTRA









CONCLUSIONS

- Estimation of the dominant ion composition
  - For Edep < 6MeV: energy deposition spectra are equal to incident deposition spectra. The estimation of LET is complicated due to unknown length even for beam impinging the diode vertically.
  - For Edep > 6MeV:
    - GCR: local maxima observed in GCR spektra cause the different slope of the energz deposition spectra
- Estimation of **fluence** with Liulin is different for different angular distribution of radiation field. The factor that divides the number of events is between one and two.

FUTURE WORK

- Shall we use the last trapped proton model (AP9)?
- YES
- Shall we use the last GCR model (Badhwar-O'Neill 2011)?
- YES
- Shall we use correct angular distribution of source?
- YES
- Shall we use detail geometry of spacecraft, detector, position, etc.?
- YES

For simulation of a certain experiment with certain conditions.

It is a subject of our bilateral colaboration

THANK YOU FOR ATTENTION