BEXUS TECHDOSE stratospheric cosmic radiation experiment

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Introduction and experiment idea

Historical background

The Hungarian experience in cosmic radiation measurements

- Pille
- TriTel
- Track detectors

Measurements on board

- Salyut-6, -7
- Space Shuttle
- MIR
- ISS (Columbus, Zvezda)
- satellites

The experiment idea

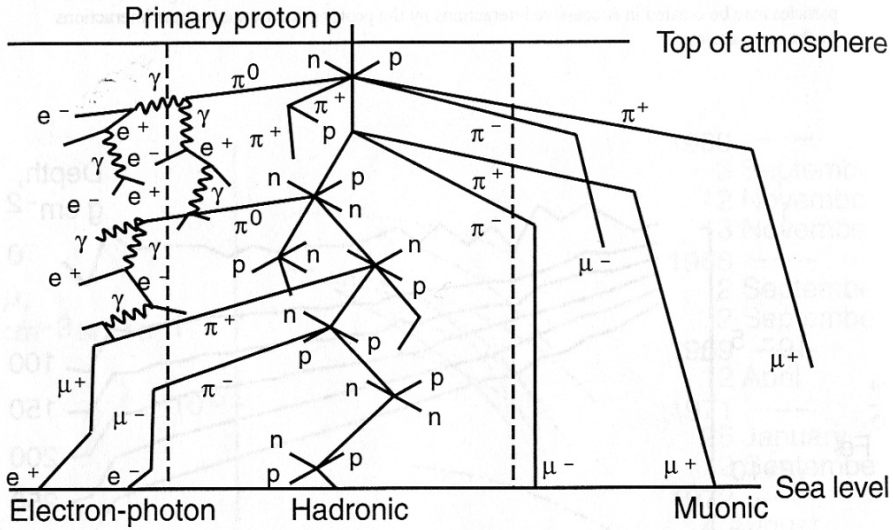
The cosmic radiation field is not well studied between 15 km and 40 km

- The contribution of neutrons in the cosmic radiation field!
- The mixed (low and high LET) radiation field of the stratosphere!
- The direction dependence of the cosmic radiation field!
- The effects of the solar activity!

To develop a balloon technology platform

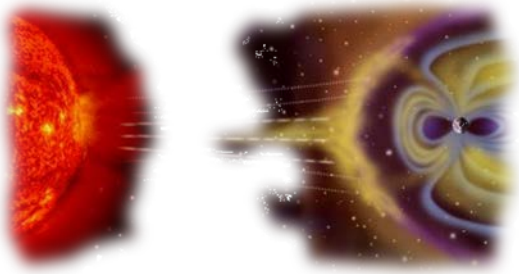
- for advanced cosmic radiation and dosimetric measurements
- to make an assessment of the cosmic radiation field at very low altitudes from the surface of the Earth up to 40 km

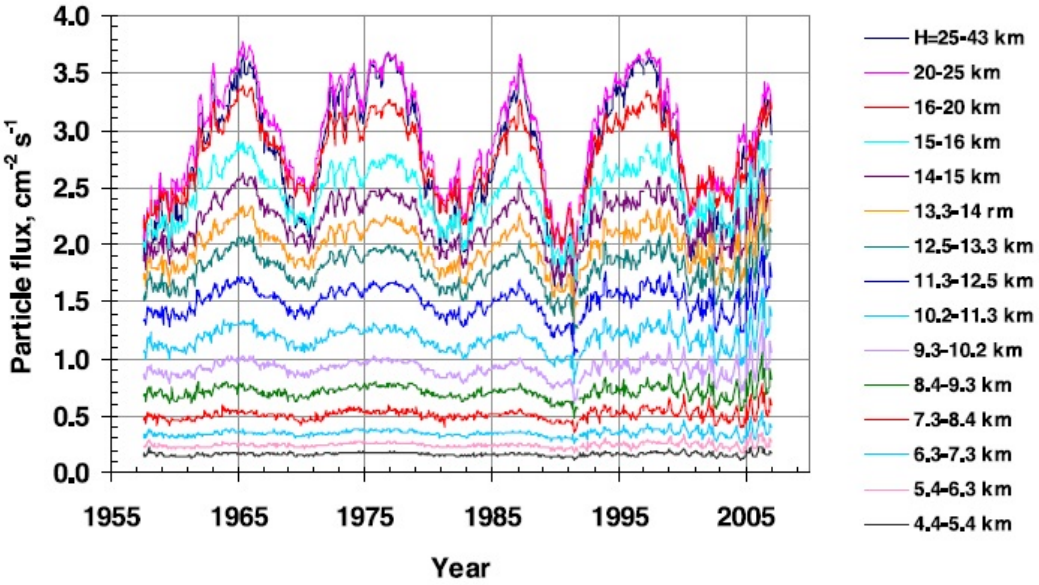
The radiation field in the stratosphere



Schematic representation of the particle production in the atmosphere.

Source: EURADOS, radiation protection 85.

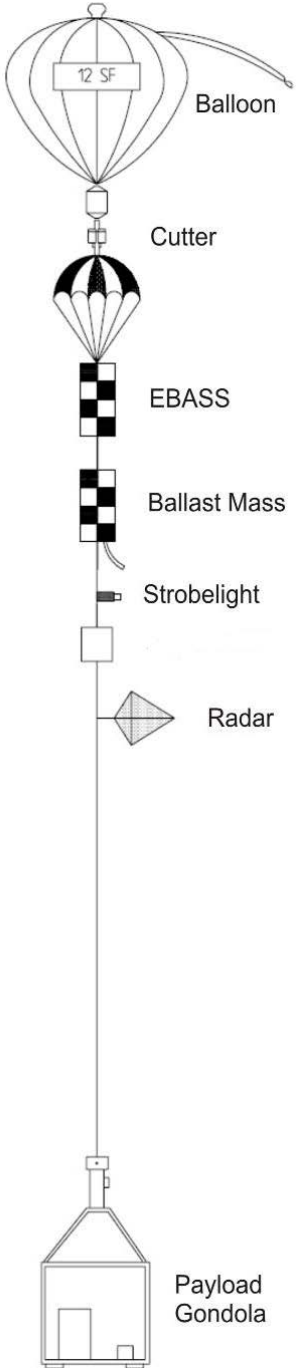


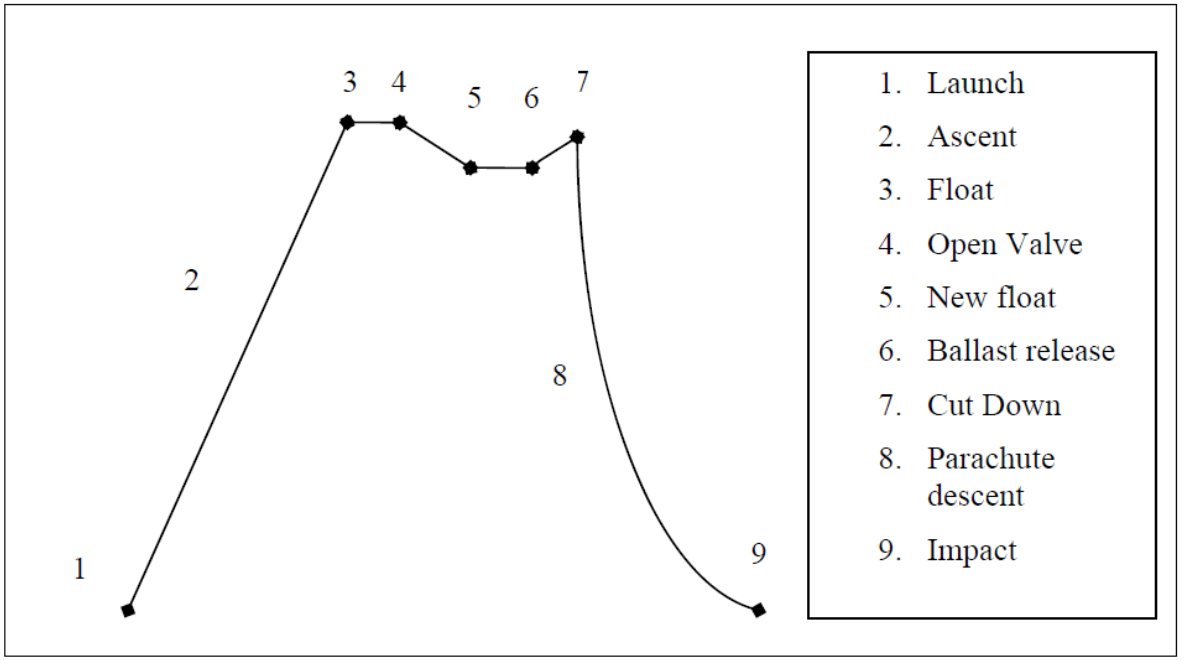


Monthly averaged fluxes of ionising particles in the atmosphere over Murmansk region as measured by Geiger counter.

Source: Bazilevskaya et al., 2008

BEXUS missions





Maximum acceleration	**+/- 25g**
Mission time	**3 – 8 hours**
Altitude range	**25 – 35 km**
Maximum weight	**~ 500 kg**

Instrumentation used

Pille thermoluminscent dosimeter system

Thermoluminescent (TL) dosimeter system

a light-weight reader device and several dosimeters

$CaSO_4$:Dy TL material, low efficiency above 10 keV/µm

The development has begun in 1970's

First flight: 1980, Bertalan Farkas, first Hungarian astronaut (cosmonaut)

The latest version is onboard ISS

as a service dosimeter system of the Russian Zvezda module

more than 30,000 measurements since 2003

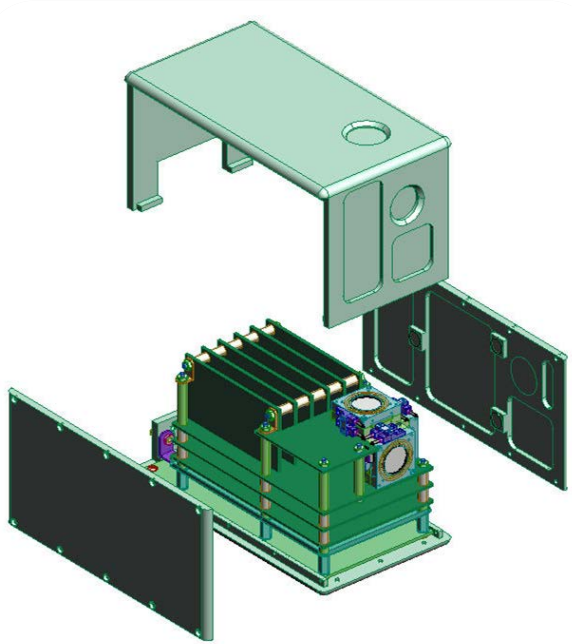
TriTel 3D silicon detector telescope

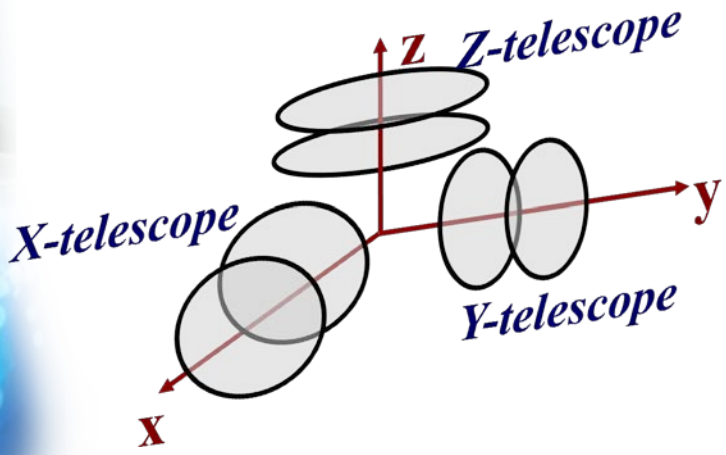
The development has began several years ago

- in the Hungarian Academy of Sciences Centre of Energy Research

To study the cosmic radiation and its dose contribution

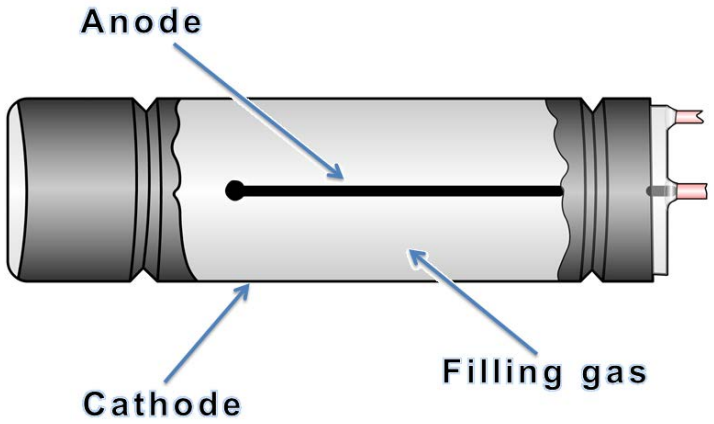
- the average quality factor of the cosmic radiation
- LET spectra in three direction
- absorbed dose, equivalent dose





Geiger-Müller counters

GM parameter	Value
Type of the used GM counters	ZP1210
Dose rate range	3×10^{-4} – 10 mGy/h
Counting rate at 10^{-2} mGy/h (-> Cs-137)	110 s^{-1}
Sensitivity	gamma radiation, charged particles
Filling gas	neon, argon, halogen



Solid State Nuclear Track Detectors

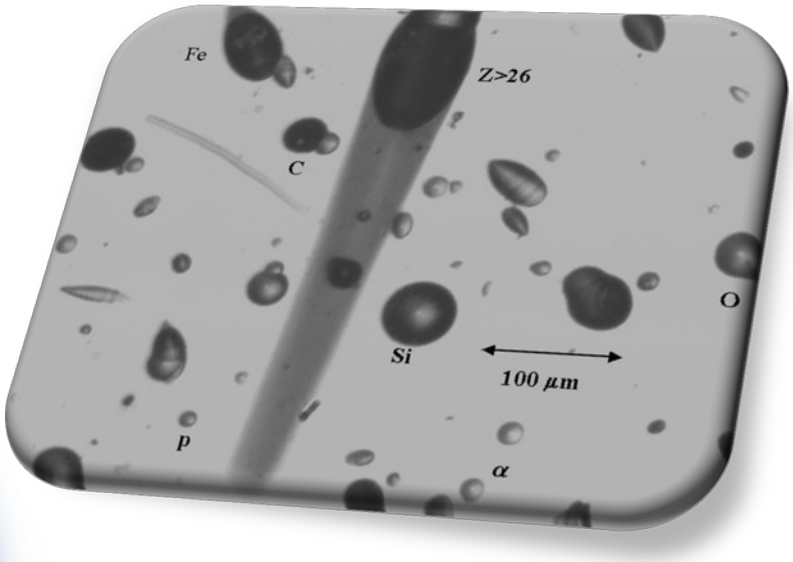
solid state isolaters (single cristal, organic polimer) with neutron converter material

the heavy charged particles provide material degradation

SSNTDs

Passive system

after chemical threatment the degradations can be studied using optical microscope

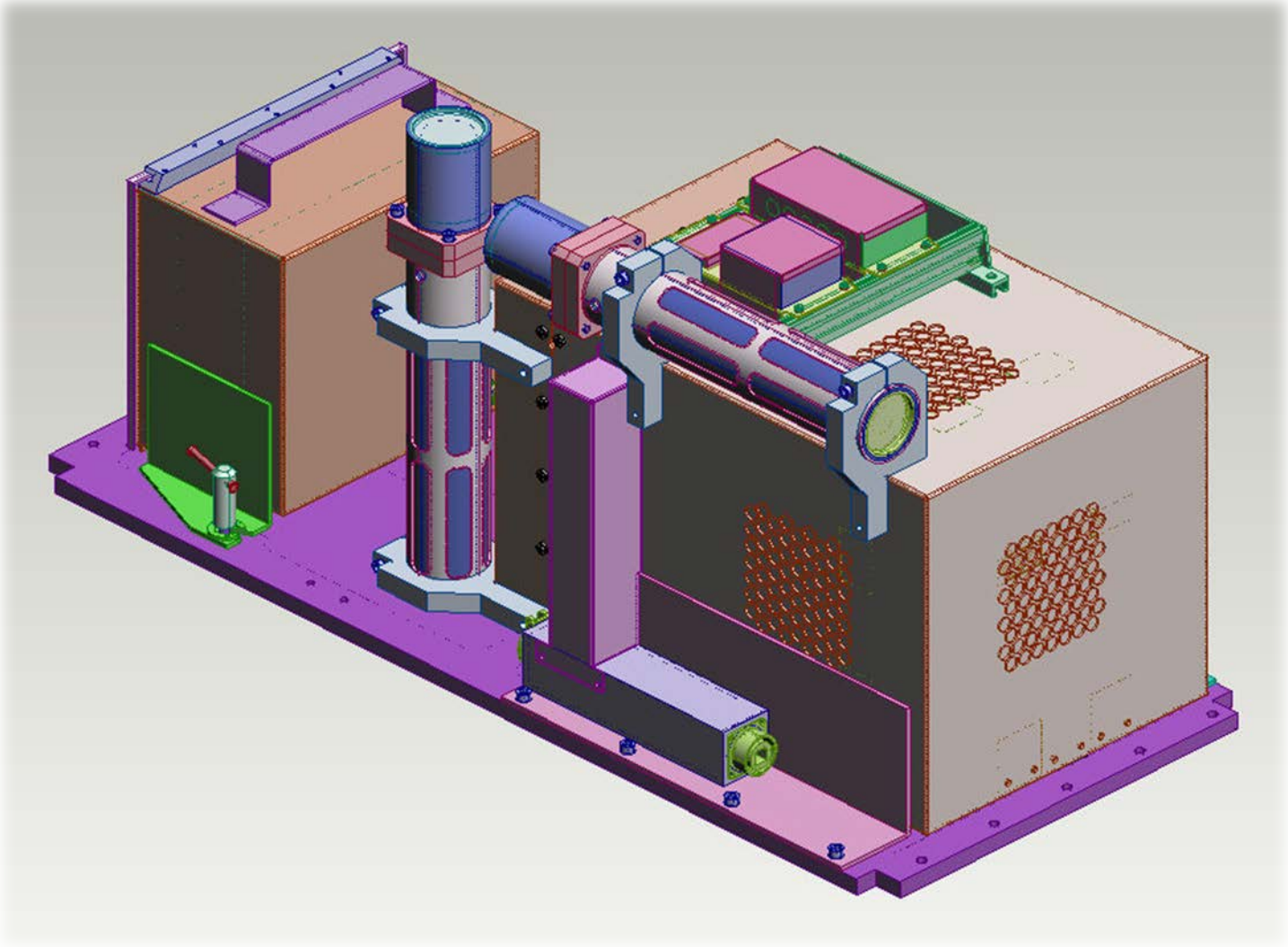


Experiment objectives

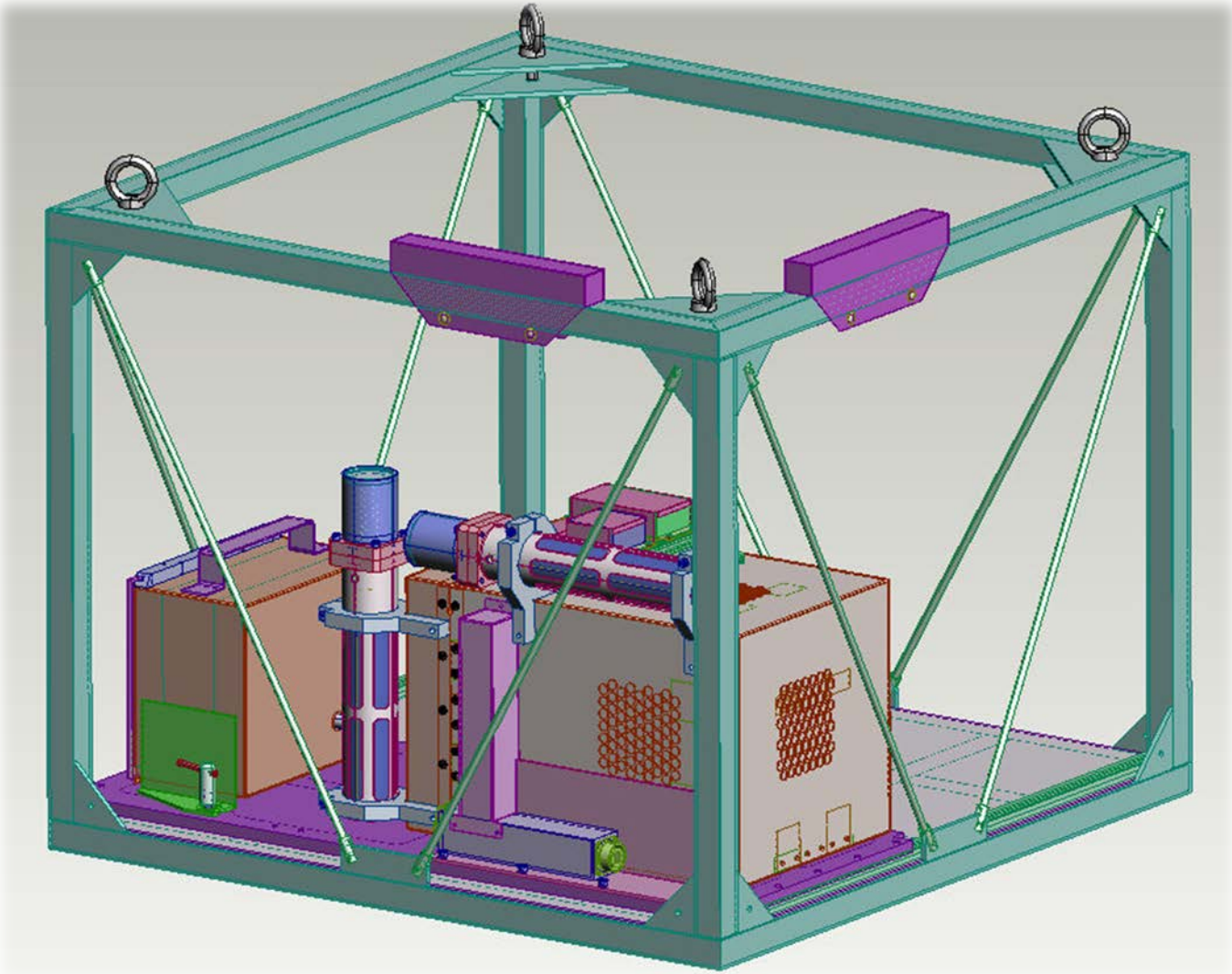
Pille	• absorbed dose and average dose rate for the total mission
TriTel	• particle flux calculated from the count rates • energy spectra, LET spectra • absorbed dose and absorbed dose rate • dose equivalent and dose equivalent rate
GM-counters	• dose rate (gamma-radiation) • direction dependence of the count rates
SSNTDs	• thermal neutron particle flux

TECHDOSE experiment and the BEXUS-14 flight

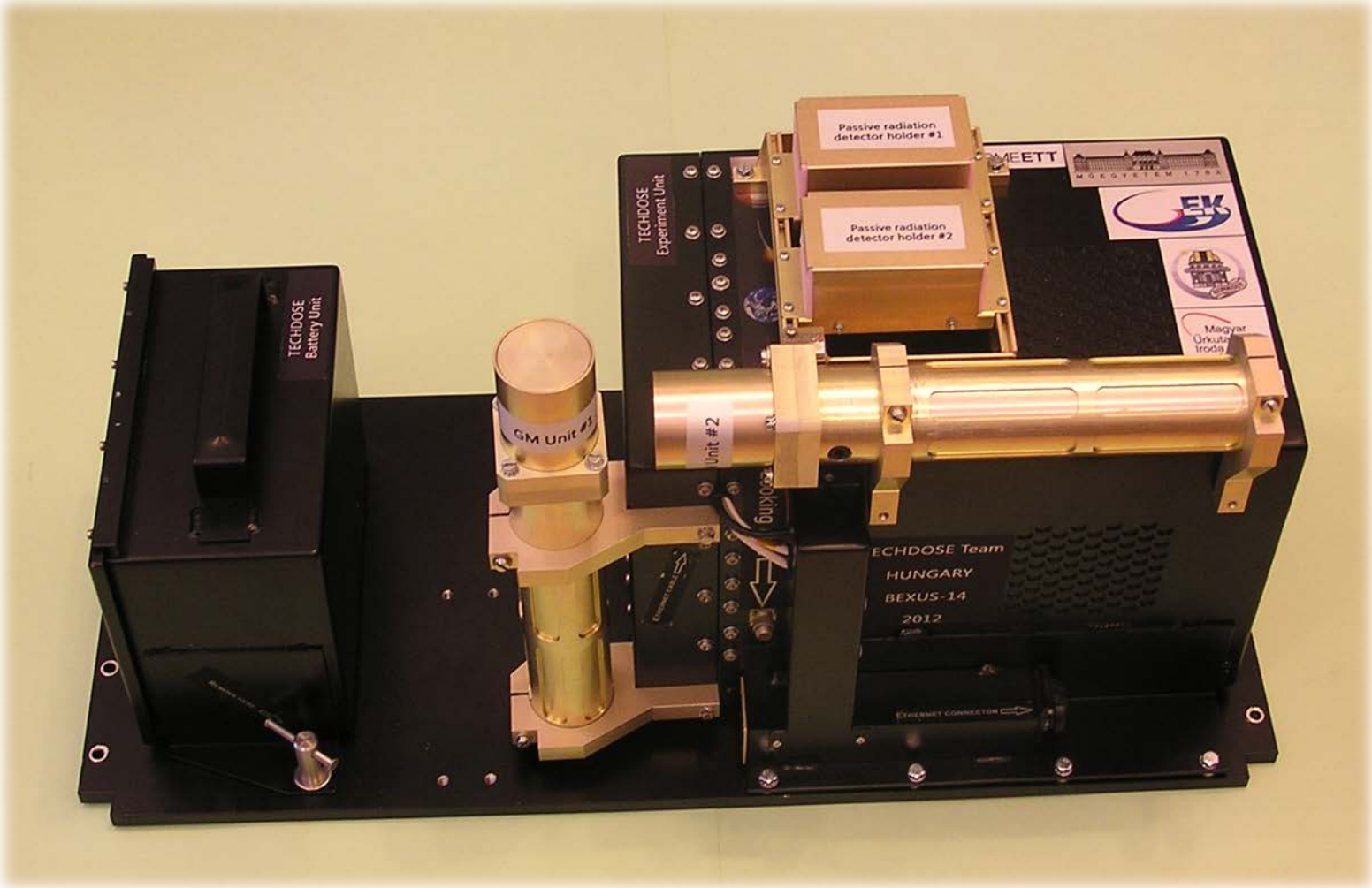
TECHDOSE experiment



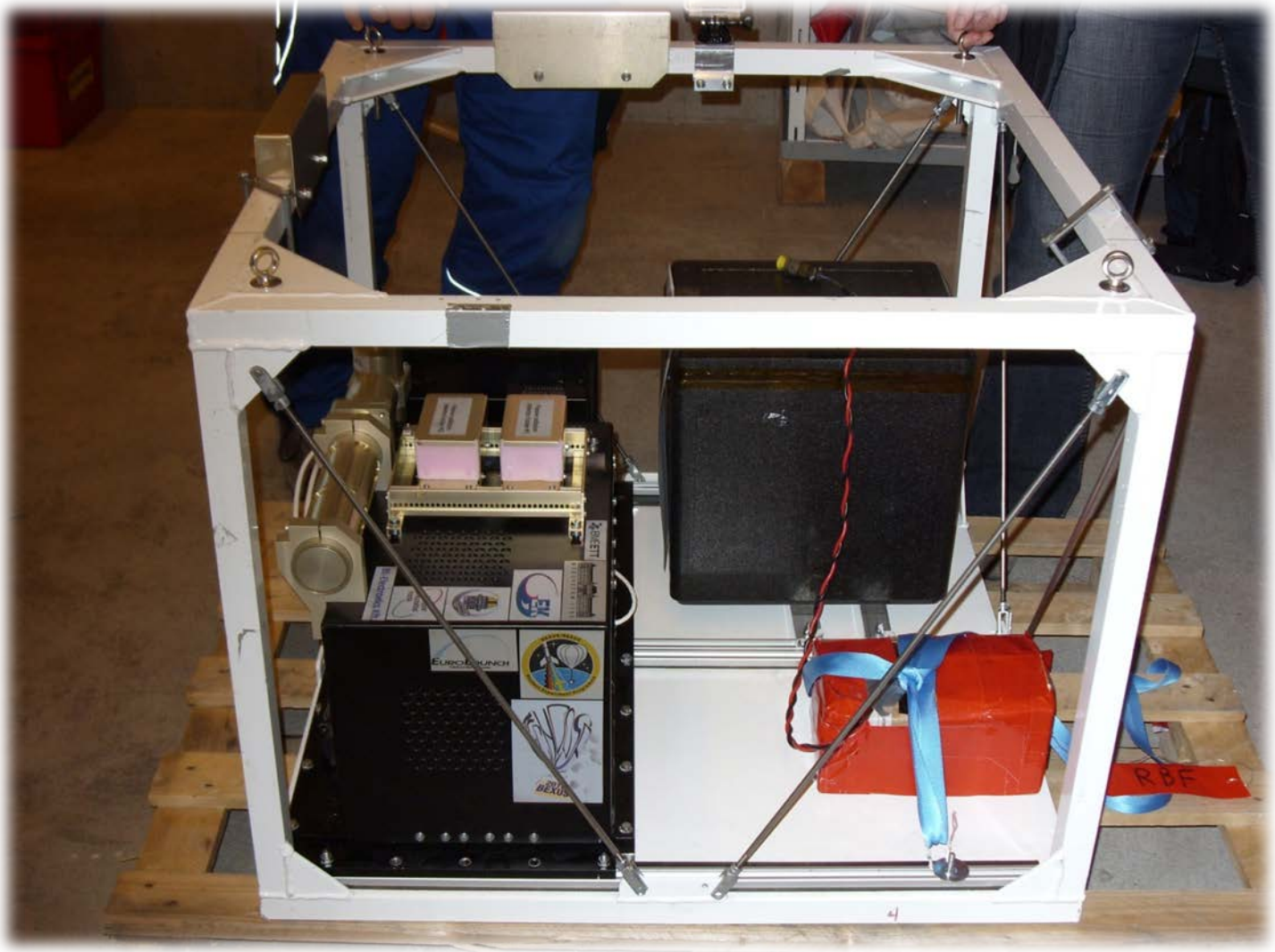
TECHDOSE experiment



TECHDOSE experiment



TECHDOSE experiment



ESRANGE – The launch site

BEXUS-14 flight

BEXUS-14
24 September 2012
ESRANGE Space Center

TECHDOSE results

Pille absorbed doses

	BEXUS-14
The noise level of the dosimeters	1.0 ± 0.2 µGy
Mission time	4.5 ± 0.1 h
Time between the read-outs	33.5 ± 0.5 h
The average flight absorbed dose	21.6 ± 1.9 µGy
The average reference absorbed dose	5.6 ± 0.1 µGy
The measured dose rate at the surface	90.0 ± 0.5 nGy/h
The excess absorbed doses	15.2 ± 1.7 µGy
The estimated error of the measurements	~ 12 %

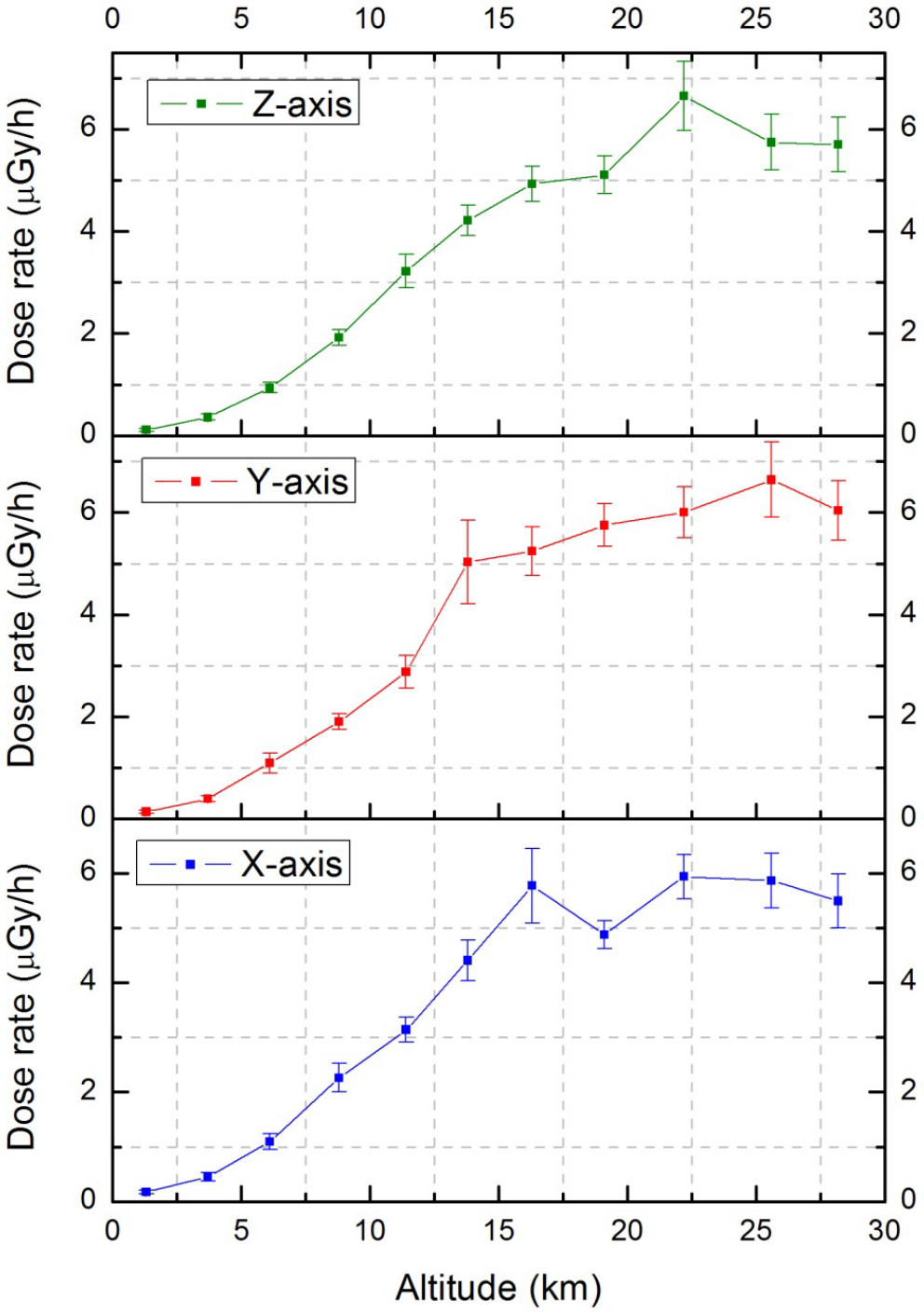
TriTel absorbed doses

	Measured absorbed doses in water (µGy)			
	TriTel X	TriTel Y (Zenith)	TriTel Z	Pille
Ascent	5.7 ± 0.2 (4 %)	5.8 ± 0.2 (4 %)	5.5 ± 0.2 (4 %)	-
Float	13.5 ± 0.5 (4 %)	13.7 ± 0.3 (3 %)	14.0 ± 0.4 (3 %)	-
Descent	0.6 ± 0.06 (10 %)	0.5 ± 0.04 (8 %)	0.6 ± 0.03 (5 %)	-
Total	19.8 ± 0.5 (3 %)	20.0 ± 0.4 (2 %)	20.1 ± 0.4 (2 %)	15.2 ± 1.7 (12 %)

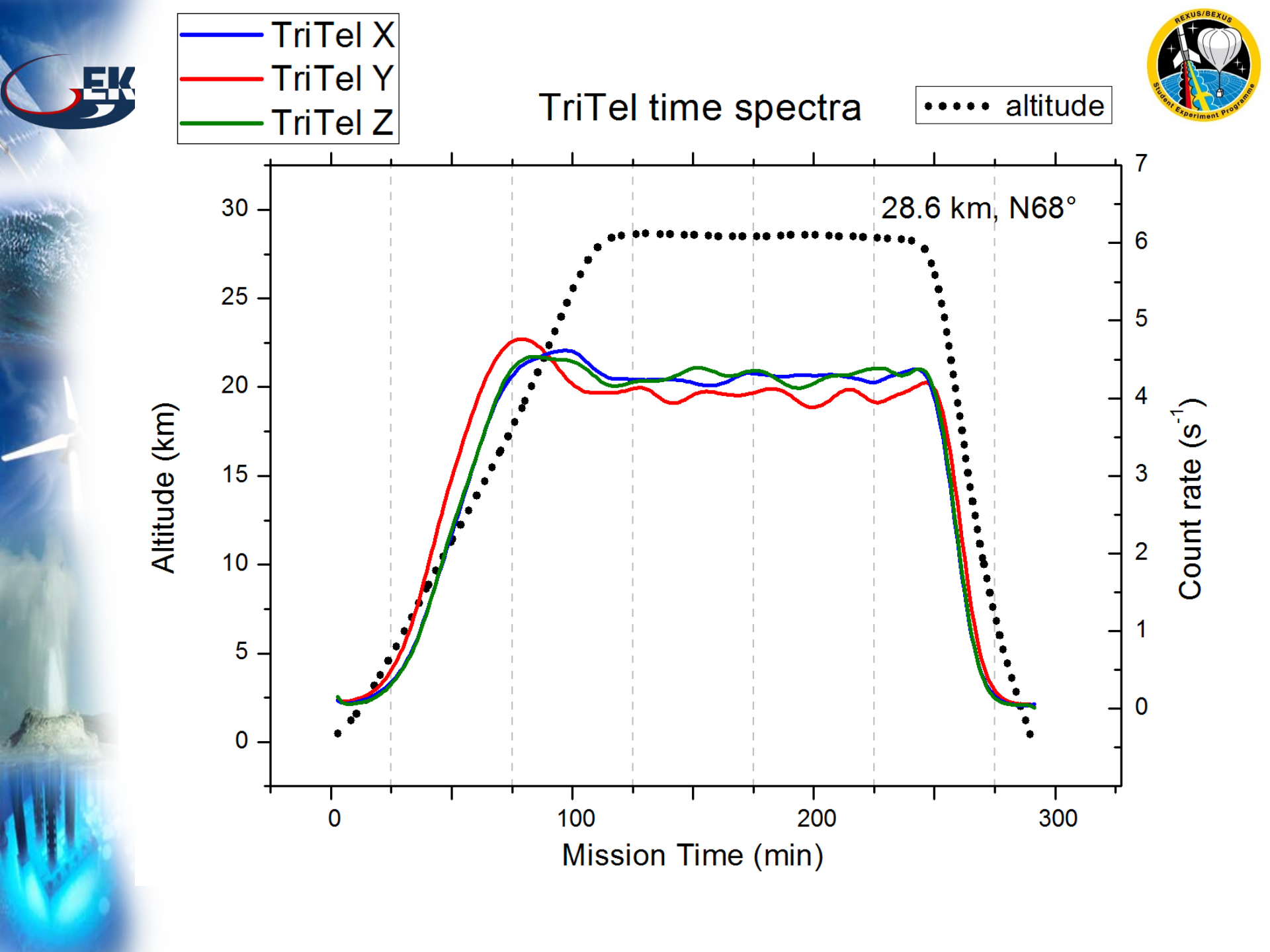
The Pille has low sensitivity to particles with LET higher than 10 keV/µm

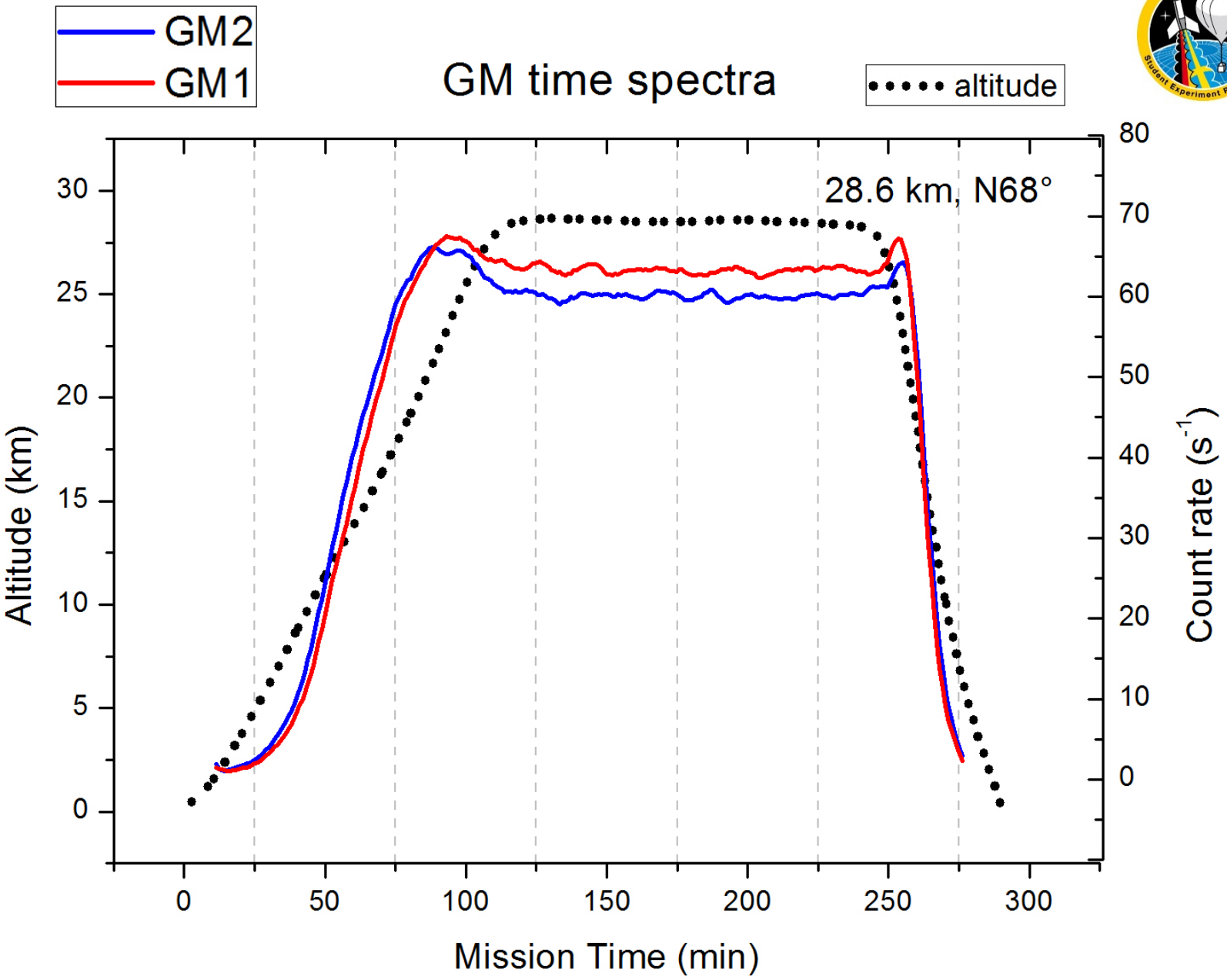
Correction factor for the Pille results

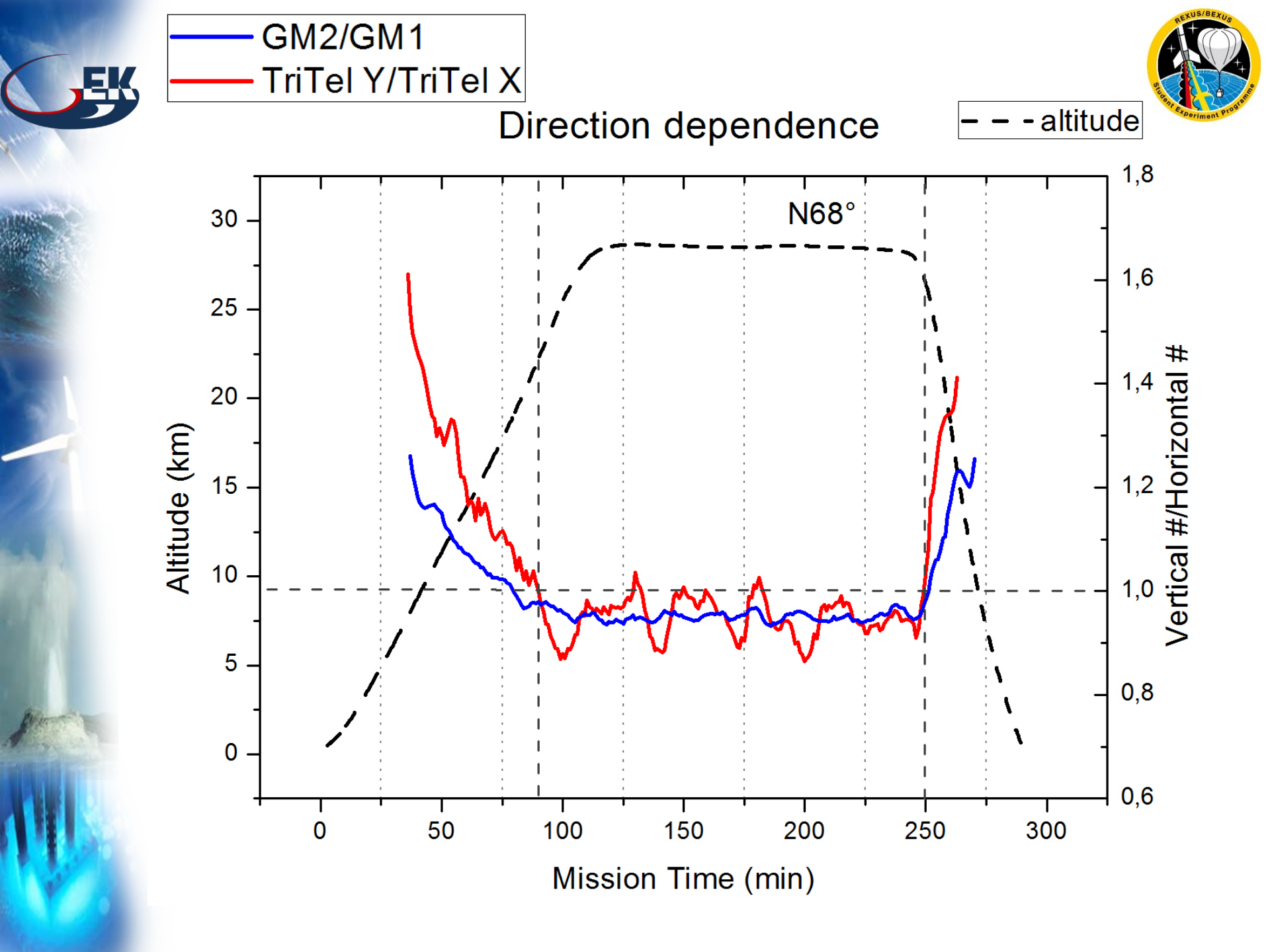
1.3 ± 0.1



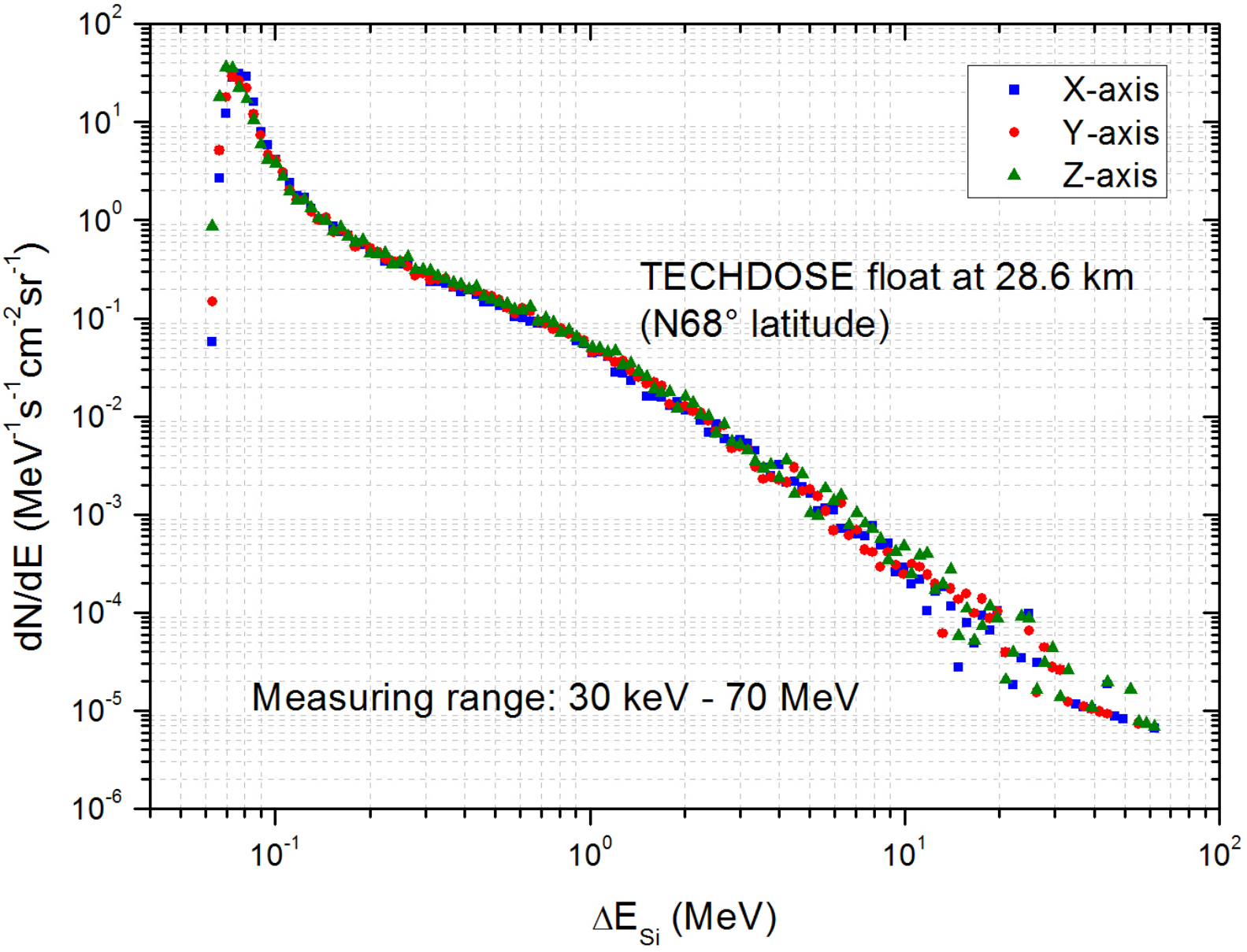
TriTel dose rates for the ascent phase (N68°)


TriTel X
TriTel Y
TriTel Z
TriTel time spectra
altitude
28.6 km, N68°
Altitude (km)
Count rate (s-1)
Mission Time (min)
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
0
100
200
300

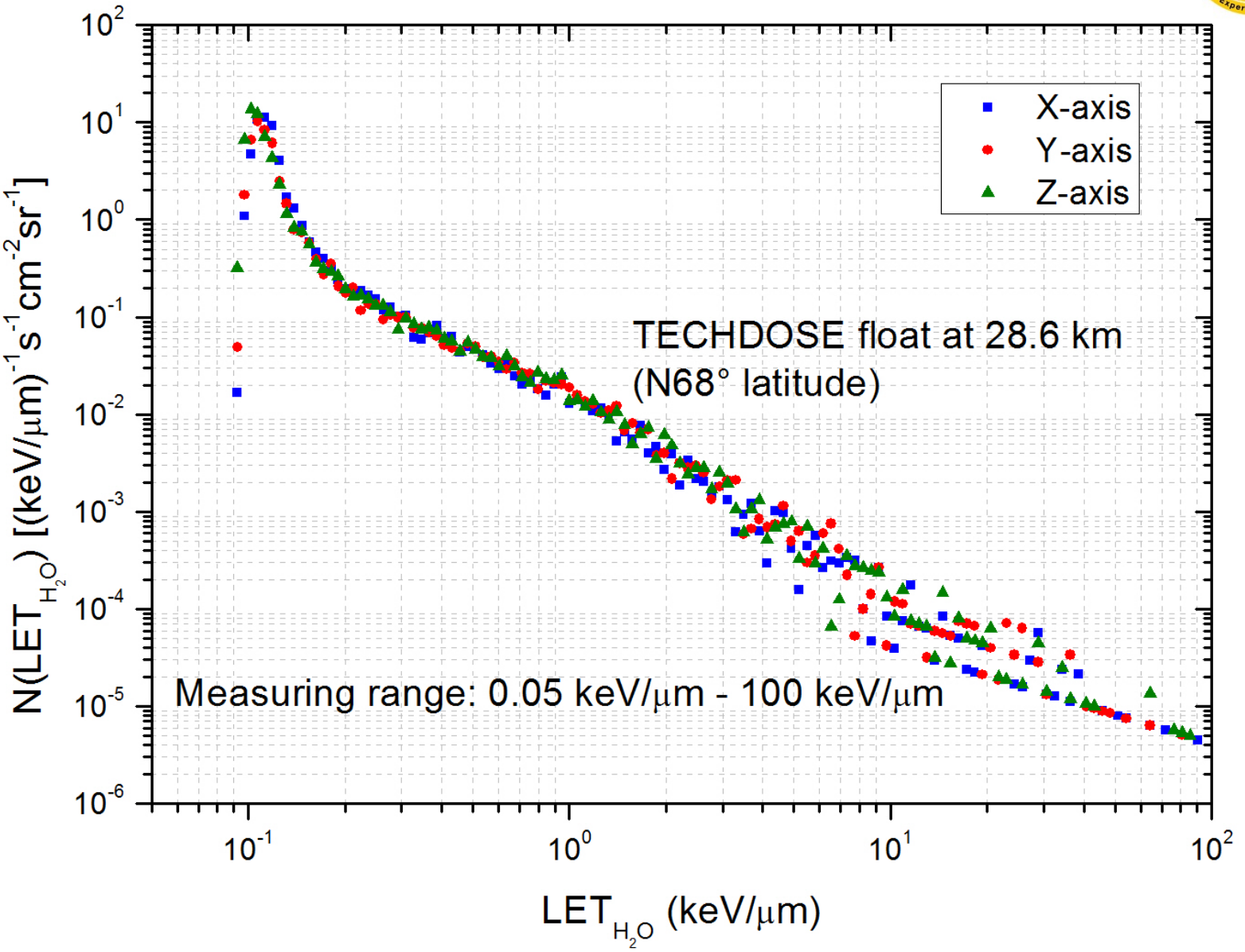

GM2
GM1
GM time spectra
altitude
28.6 km, N68°
Altitude (km)
Count rate (s-1)
Mission Time (min)
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
0
50
100
150
200
250
300


GM2/GM1
TriTel Y/TriTel X
Direction dependence
altitude
N68°
Altitude (km)
Vertical #/Horizontal #
Mission Time (min)
0
5
10
15
20
25
30
0,6
0,8
1,0
1,2
1,4
1,6
1,8
0
50
100
150
200
250
300

TriTel deposited energy spectrum

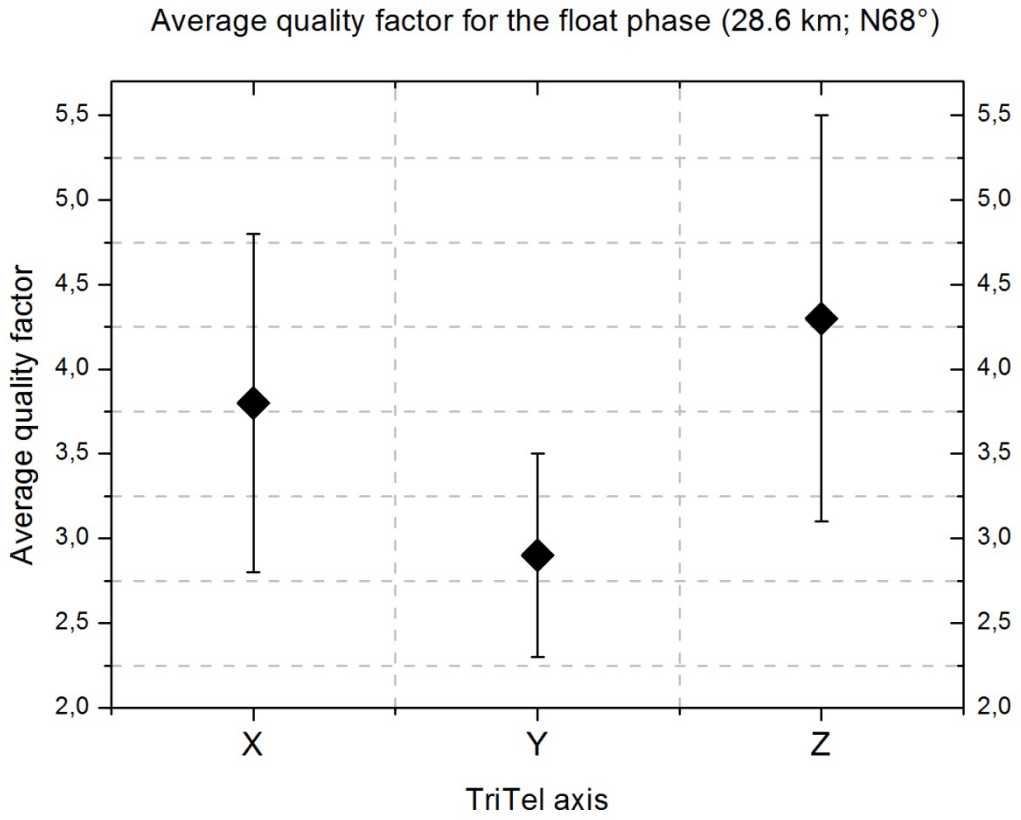


TriTel LET spectrum



Average quality factor with the TriTel for the floating phase

Average quality factor for the float phase (28.6 km; N68°)		
TriTel X	TriTel Y (Zenith)	TriTel Z
3.8 ± 1.0 (27 %)	2.9 ± 0.6 (21 %)	4.3 ± 1.2 (28 %)



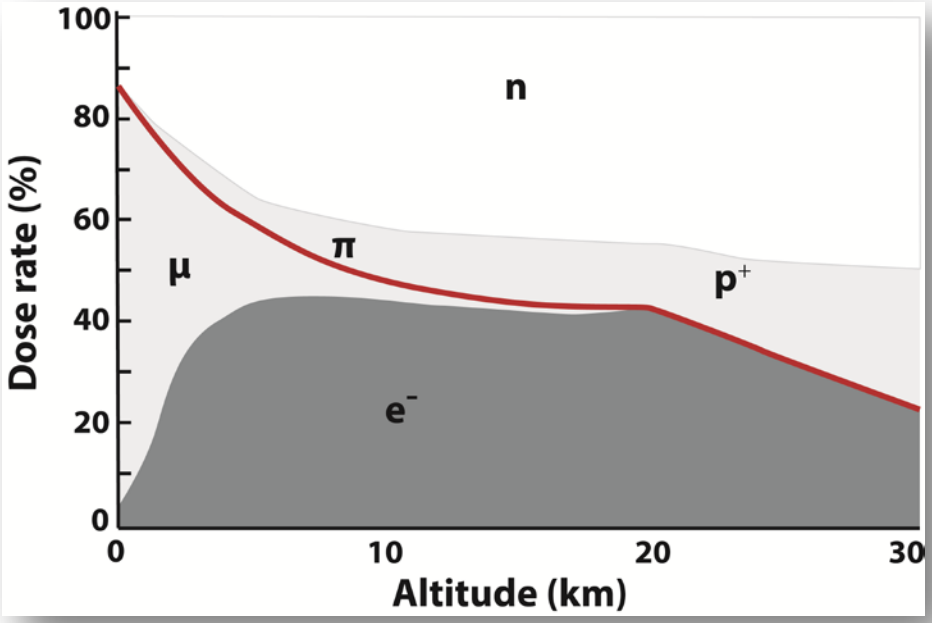
SSNTD thermal neutron flux

The measured thermal neutron flux:

$$1.33 \times 10^{-2} \pm 0.23 \times 10^{-2}\ cm^{-2}s^{-1}\ (\sim 17\%)$$

The estimated flux from the measurements of the TriTel (charged particles):

$$1.95 - 5.85\ cm^{-2}s^{-1}$$



The dose rate contributions as a function of the altitude.

Source: EURADOS, radiation protection 85.

Future outlook

STRATOS II project

STRATOS II flight

- STRATOS I (flew in 2006) improvement

expected maximum altitude

- ~ 50 – 60 km

flight time

- **5 minutes**

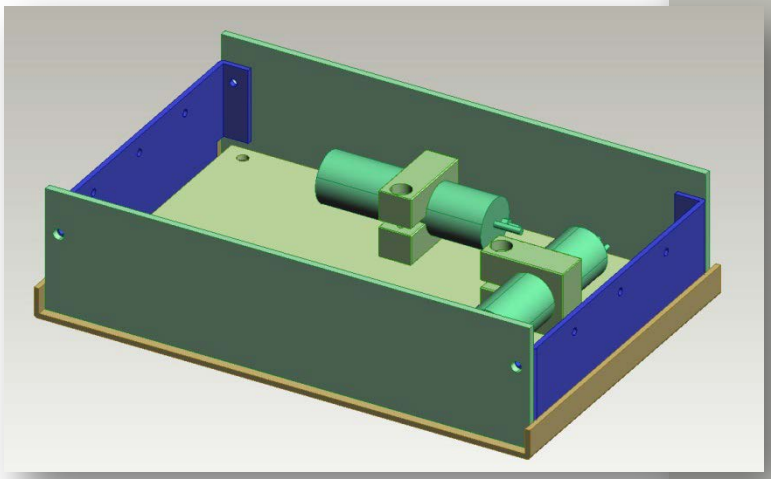
expected launch date

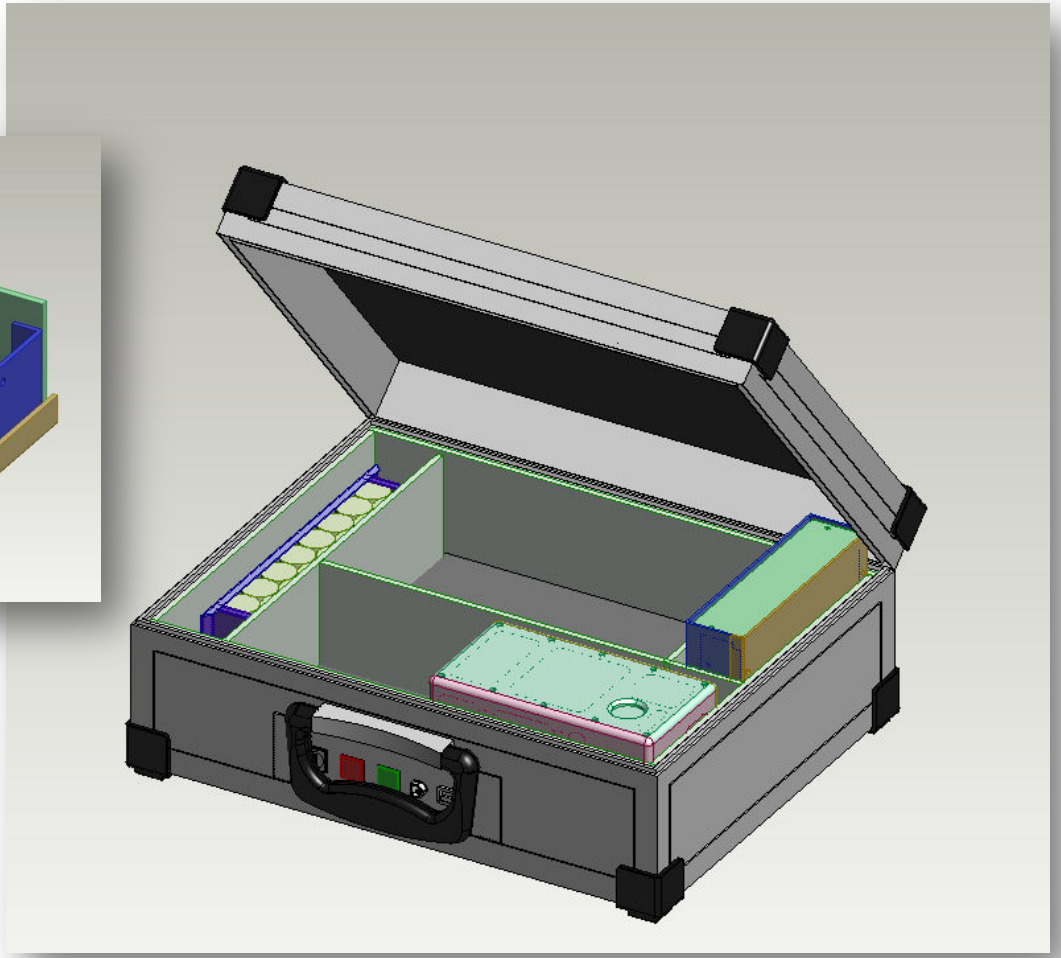
- **Beginning of 2014**

experiment setup

- 2 Geiger-Müller counters

AeroTel project



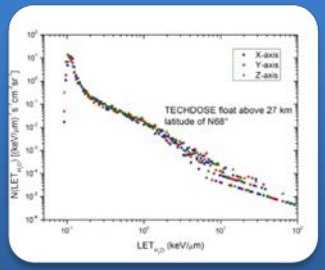


Conclusions

CoCoRAD and TECHDOSE experiments

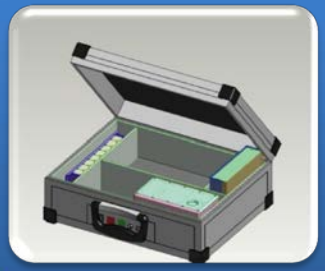
Technical achievements

- Developed balloon technology platform for cosmic radiation measurements
- We had two successful BEXUS flight



Scientific achievements

- We measured the cosmic radiation in the stratosphere with different instrumentations
- We determined the thermal neutron flux



Future outlook

- Study the effects of the solar activity
- STRATOS II mission
- AeroTel

Acknowledgements

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MTA Centre for Energy Research

Hungarian Space Office

BME ETT

BL-Electronics Kft.

European Space Agency Educational Office

The Freedom Bridge in Budapest.

Thank you for your attention!