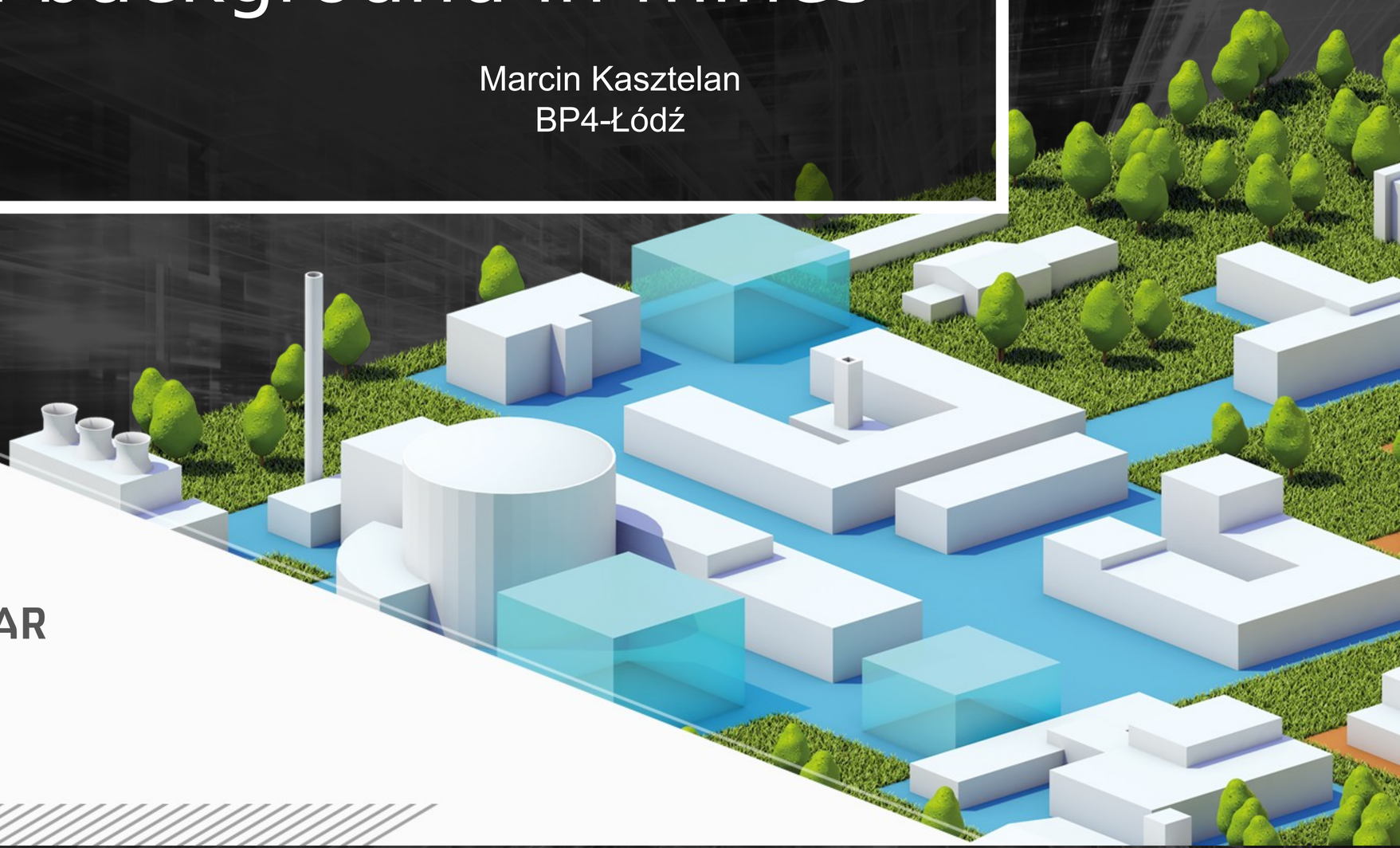
Launch of Mini EUSO & Neutron background in mines

Marcin Kasztelan
BP4-Łódź



NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

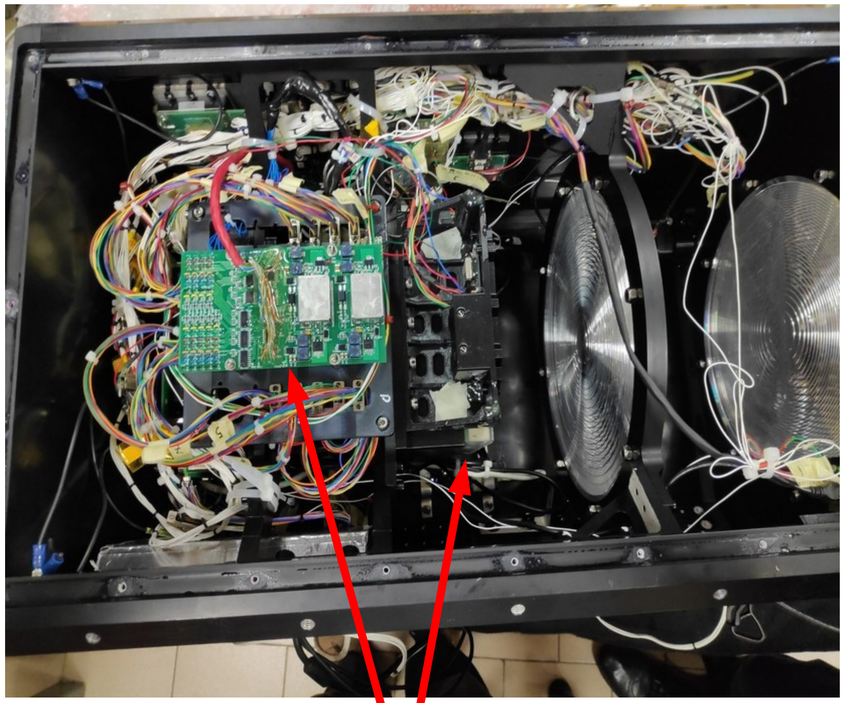
Launch of Mini EUSO

Mini-EUSO at Soyuz-MS
22/8/2019 Launch, Site 31, Baikonur Cosmodrome

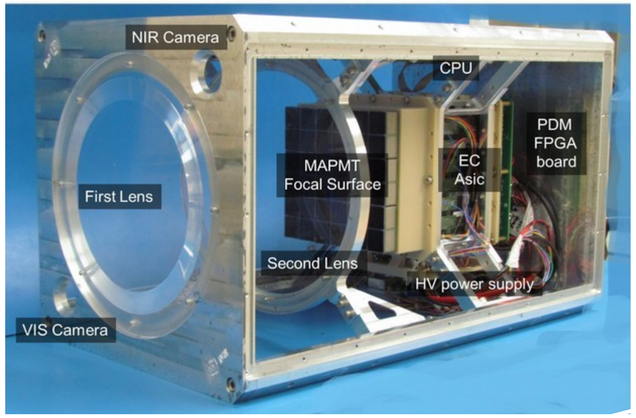
MINI-EUSO / UV-Atmosphere

Multiwavelength Imaging New Instrument for the Extreme Universe Space Observatory

JEM-EUSO collaboration 16 Countries, 93 Institutes, 351 people



HVPS subsystem design and made in NCBJ Łódź

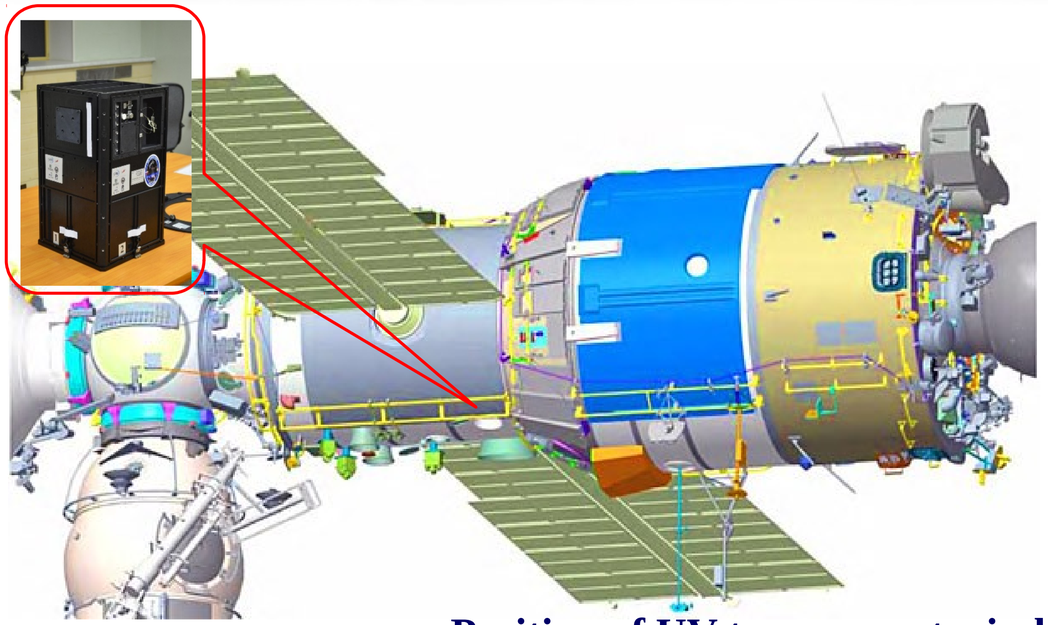


Engineering Model
Open structure with main detector items
September 2018

Flight model
June 2019

NCBJ Łódź group participated in pre-flight tests and calibrations

Placement of Mini-EUSO

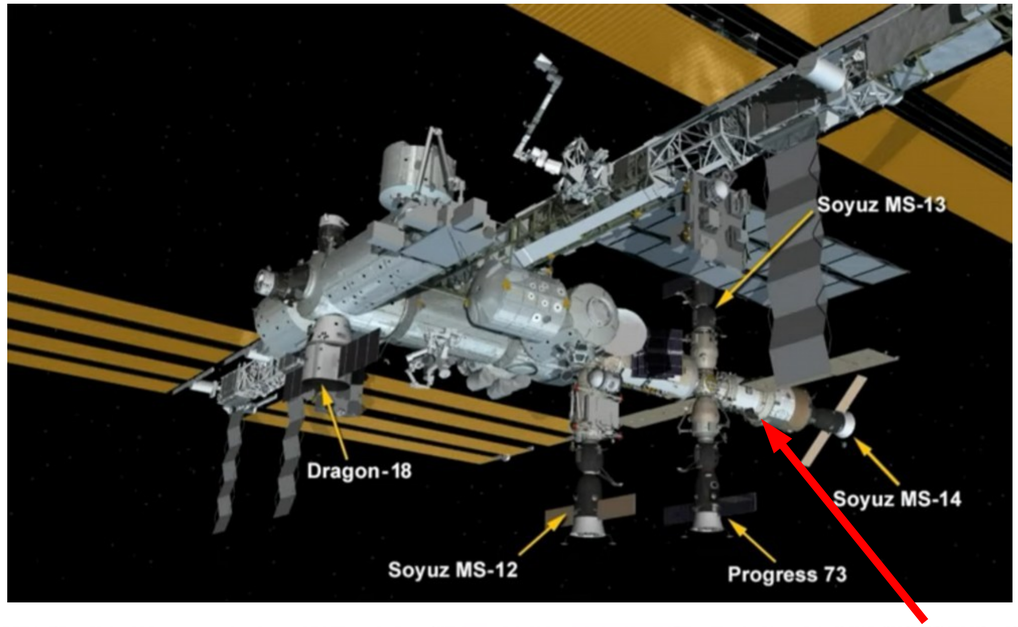


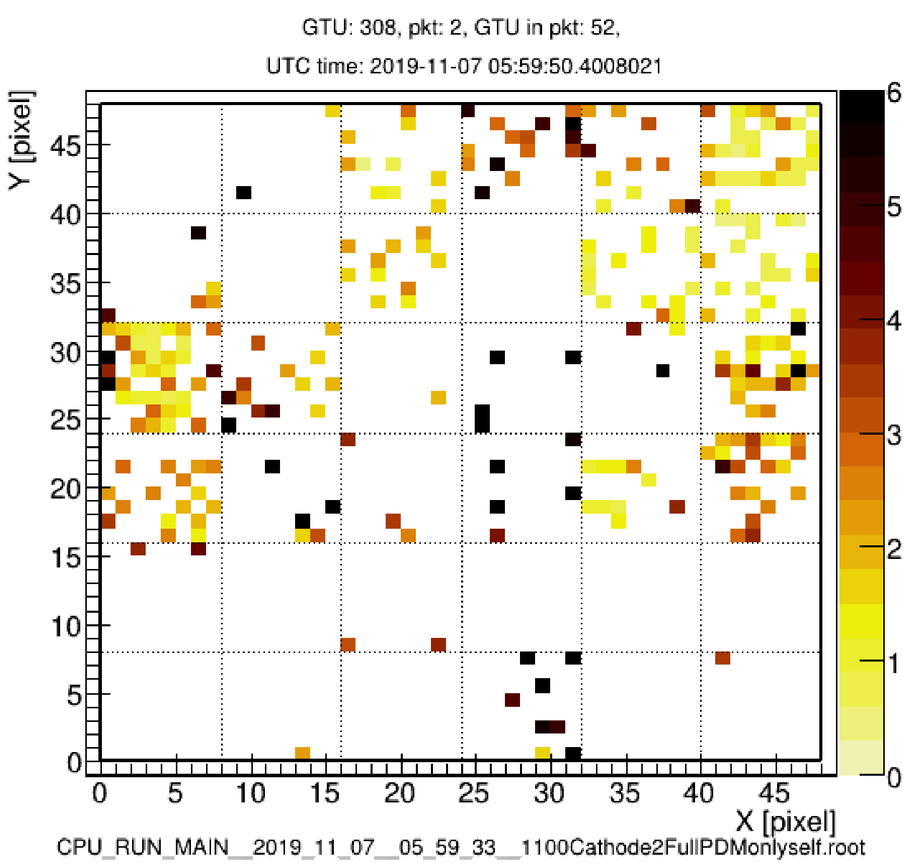
Ultra fast UV telescope to measure the Earth atmosphere during nights.
Now still in testing mode,
but TLE, lightnings, meteors, cities are visible.

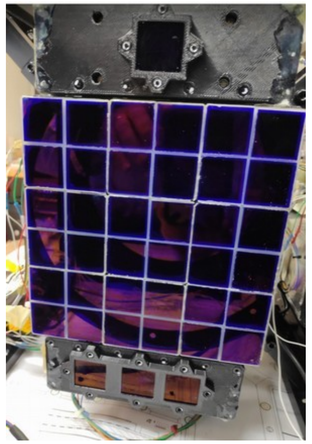
The first NCBJ made subsytem working in space:
High voltage power system for Mini-EUSO

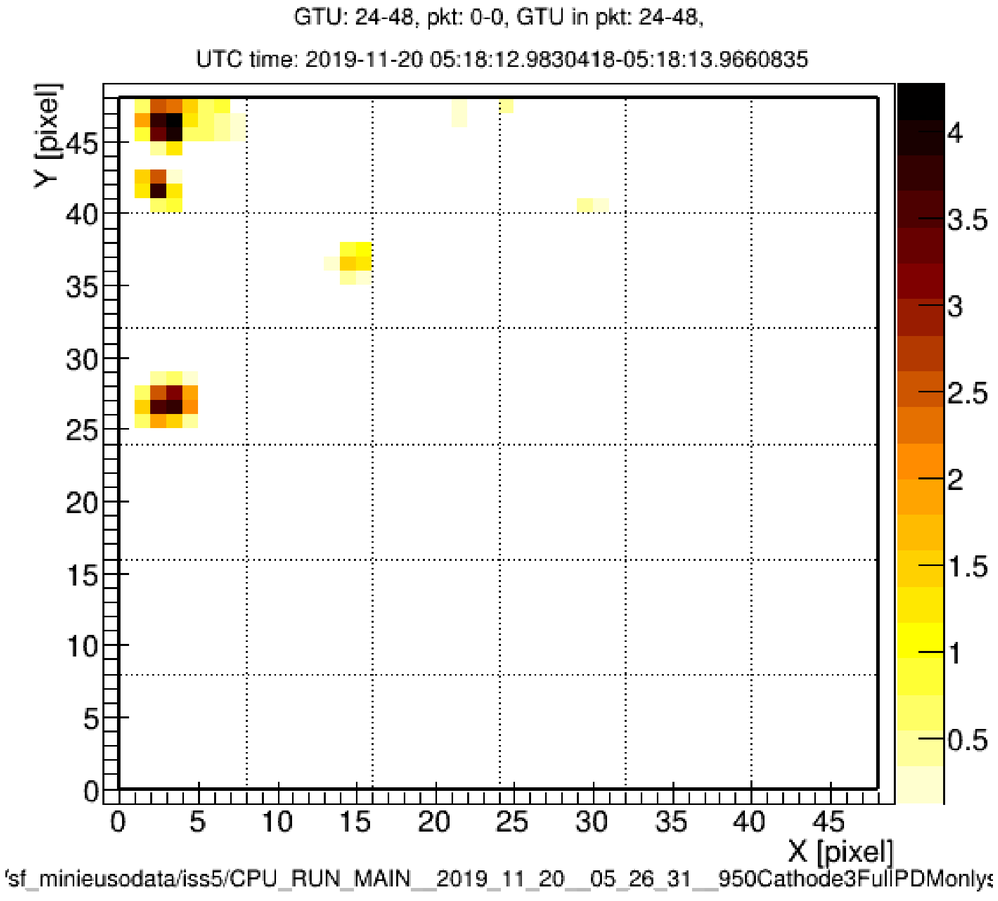
5

Position of UV transparent window in ISS









Focal plane:
36 photomultipliers
64 pixel each

200 x 200 km

NCBJ Łódź group participated in JEM-EUSO Collaboration since 2008.

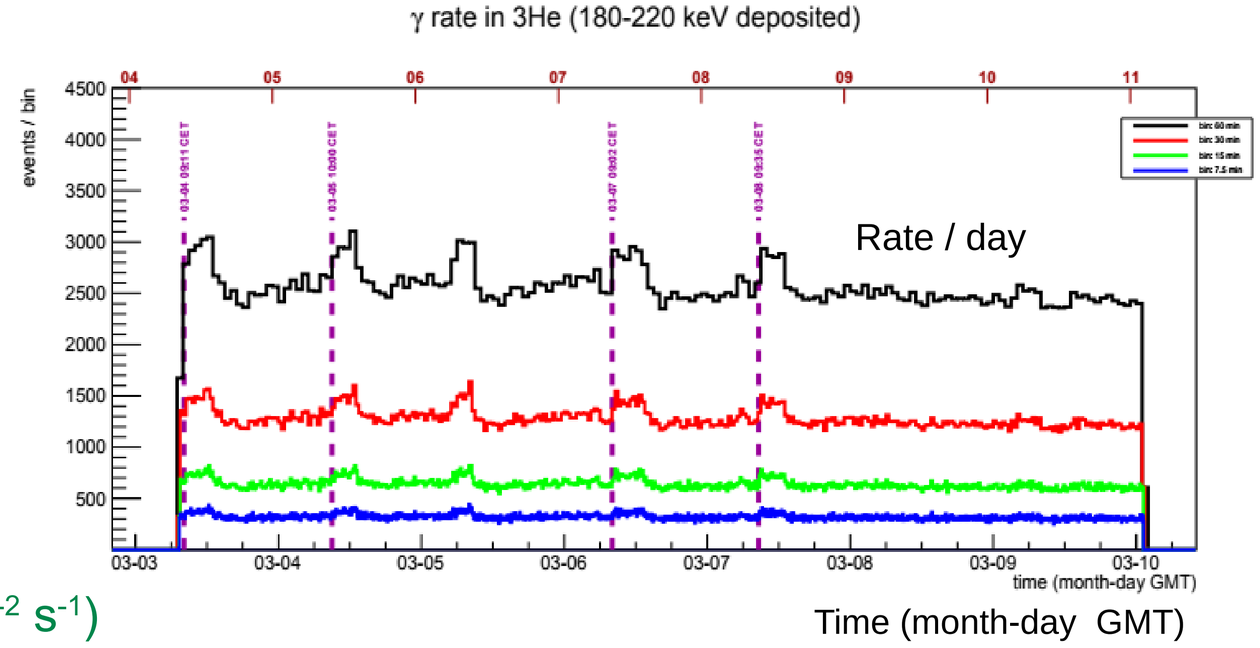
Activities in 2019:

- **EUSO-TA data analysis,**
- **EUSO-TA HVPS for EUSO-TA upgrade,**
- **production of HVPS subsystem for SPB2-EUSO (Super Preasure Balloon by NASA),**
- **participation in K-EUSO test PMT calibration in Moscow,**
- **tests and calibration of Mini-EUSO,**
- **25th JEM-EUSO Collaboration Meeting in Łódź 10-14 June, 2019**

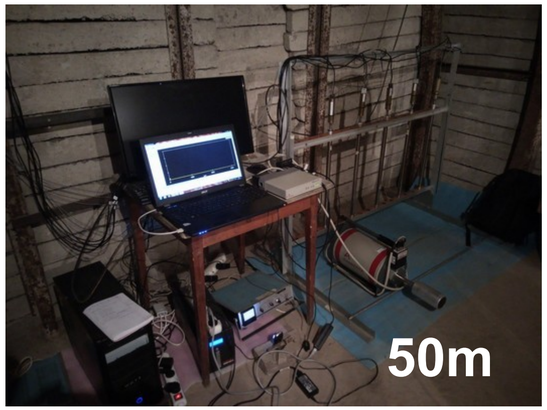
Neutron background in mines

„Barbara” mine – Poland (Mikołów)
neutrons produced by earth shock

- Search for a relationship between earth shocks and the neutron flux.
- Potential early warning signal for earthquakes.
- No effect found on neutron registration.
- Observed increase in gamma flux after explosion (possible association with fans)



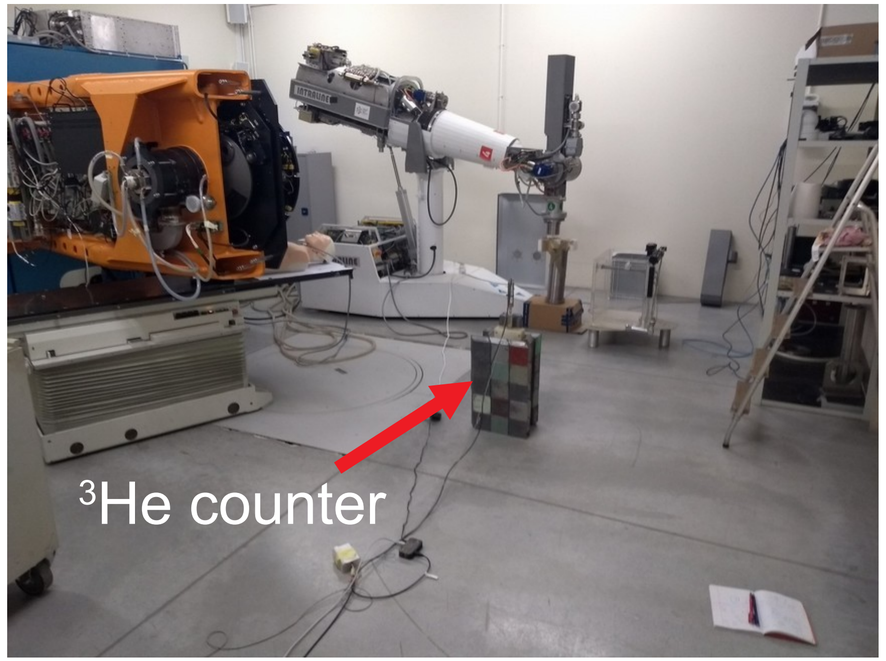
T = **172** days
~5.8±0.1 n/hour/counter
Φ_n **=** ~6.96 x 10^{-6} (neutron cm^{-2} s^{-1})



Neutrons at IntraLine – Poland (Świerk NCBJ)

neutron flux – radiation safety

- Pilot measurements of neutron flux nearby the IntraLine accelerator (several measuring series in different bunker locations),
- A large flux of gamma photons in the IntraLine vicinity made neutron measurement difficult.
- Measured neutron flux outside the bunker is at the level of the natural neutron background radioactivity.



Internal Raport

Future extended measurements planned.

$E_{electrons}$ = 9 MeV, 0.5 Gy/min

Neutron rate: 0.028 ± 0.036Hz (1 meter from beam axis)

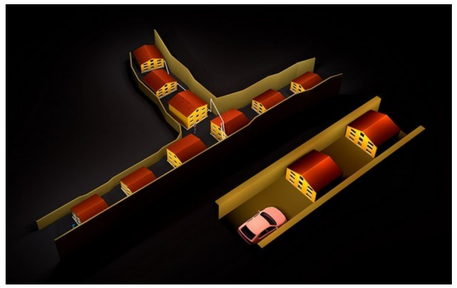
Φ_n = ~1.18 x 10^{-4} (neutron cm^{-2} s^{-1})

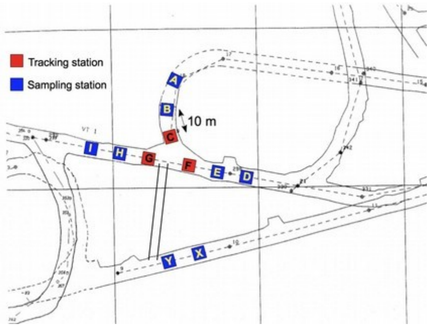
Pyhäsalmi mine - Finland

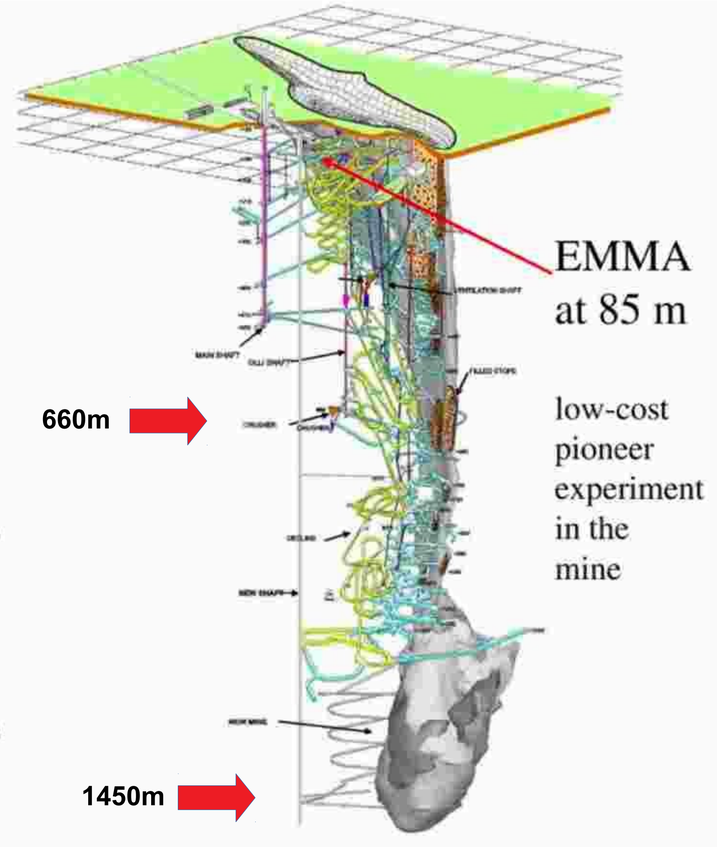
thermall neutron flux & multiple neutrons

The neutron background may be relevant for experiments looking for rare effects

(dark matter, proton decay, 0υββ decay, neutrinos, etc.).

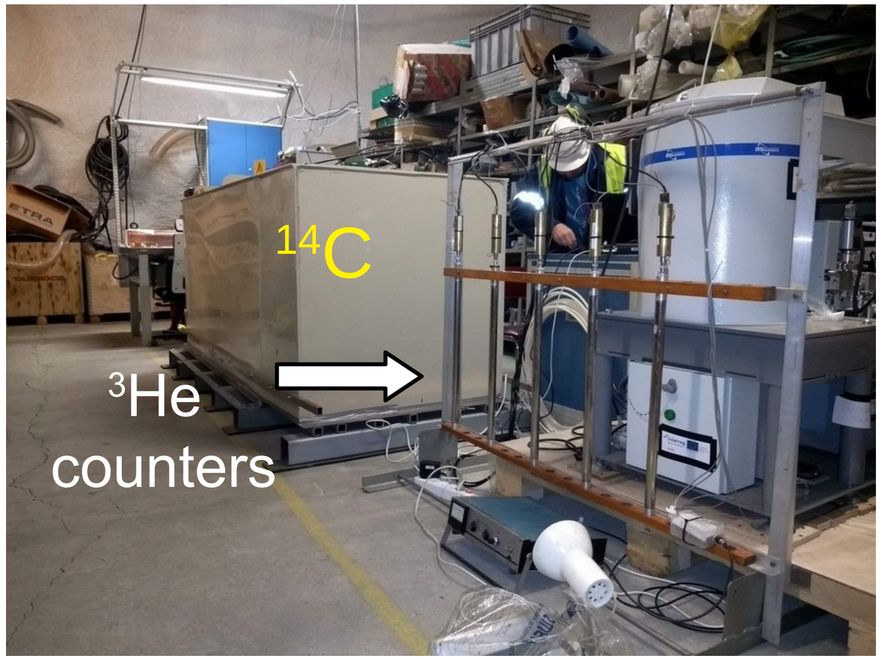






Pyhäsalmi mine - Finland

thermall neutron flux – low background laboratory



We measured neutrons next to experiment which measures radioactive purity of liquid scintillator samples (activity of ^{14}C isotope).

-1450m

-660m

Preliminary thermall neutron flux: $\Phi_n = 4.1 \cdot 10^{-6}$ (neutron cm^{-2} s^{-1})

$\Phi_n = 8.5 \cdot 10^{-6}$ (neutron cm^{-2} s^{-1})

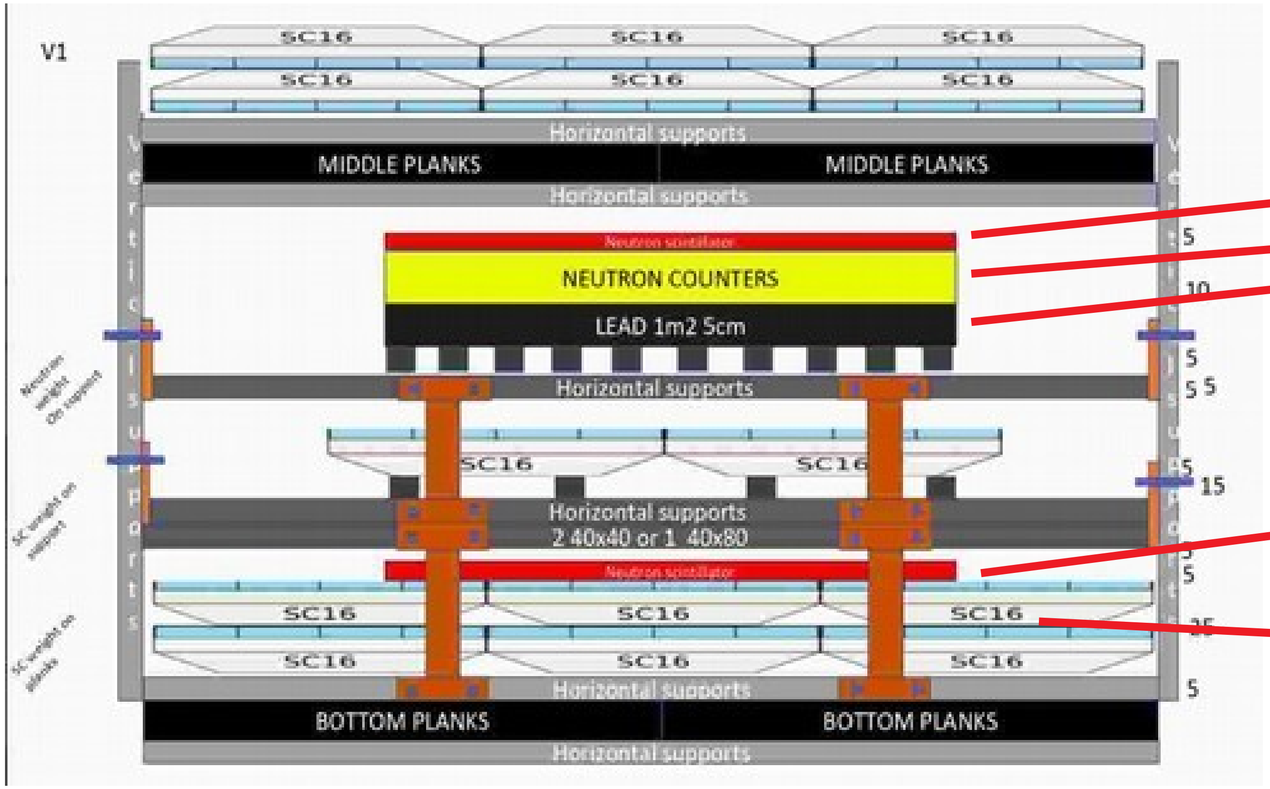
Neutrons with EMMA - Finland

multiple neutrons events generated by cosmic ray muons

- Investigation of multiple neutron events probably generated by high energy cosmic ray muons in lead target,
- The measurements began with the EMMA experiment last month,
- Our part is the measurement of neutrons with a set (tray) of helium counters and two scintillation detectors (1m^2 each),
- The Finns (University of Jyväskylä and Oulu) are responsible for the work of the muon telescope,
- Multiple neutron signals without a signal in a scintillator can provide an important background for experiments looking for rare effects (dark matter, neutrinos, etc.)

Neutrons with EMMA - Finland

multiple neutrons events generated by cosmic muons



14 neutron ^{3}He counters in poliethylene bocks (horizontal layer)

2 $1m^2$ scintillator with readout from anode and 7^{th} dynode

24 SC16 scintillators – muon telescope

Neutrons with EMMA - Finland

multiple neutrons events generated by cosmic muons

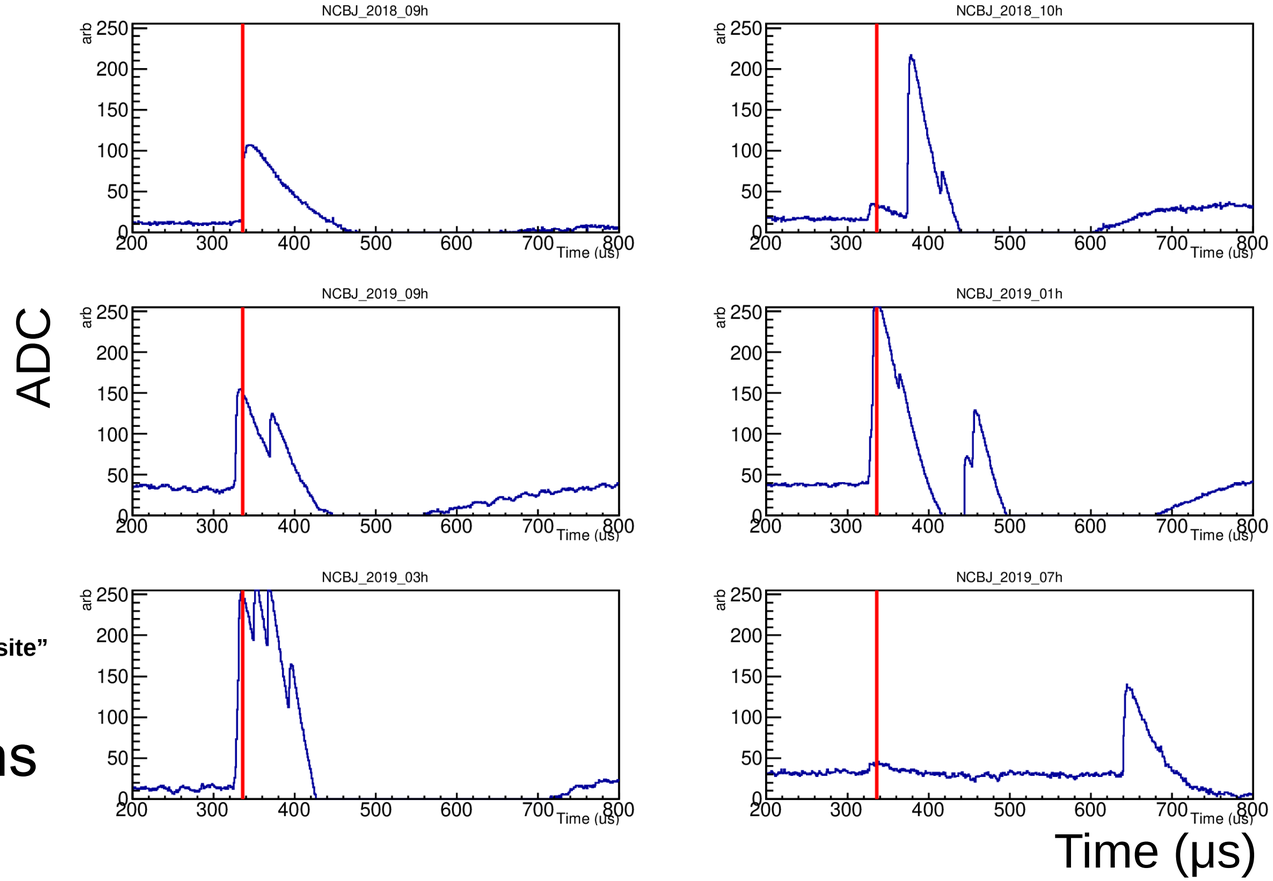
- Events with high neutron multiciplity has been observed,
- Multiple neutron events are observed also without signal in (our) scintillators,
- High multiplicity neutron events were observed in e.g. SNO, but not explained:

„Cosmogenic Neutron Production at the Sudbury Neutrino Observatory”
arXiv:1909.11728v1

„Direct measurement of neutrons induced in lead by cosmic muons at a shallow underground site”
ArXiv:1801.04838, DOI: 10.1016/j.astropartphys.2018.04.005

~16 neutrons

Data: 1573896022.308317 Sat, 16 Nov 2019 09:20:22 +0000 (GMT)



Data aquisition is planned to mid 2020, and then call for a grand for future investigation of this phenomena.

PhD:

"Influence of parameters of high energy interactions models on the development of EAS and measuring capabilities of JEM-EUSO experiment"
Zbigniew Plebaniak

„Neutron interactions, comparison of measurements with simulations"
Marcin Kasztelan

Grants:

- **The highest energy cosmic ray measurements within JEM-EUSO Collaboration - detector elements preparation, participation in measurements and data analysis**
  Grant NCN OPUS nr UMO-2017/27/B/ST9/02162

- **Experiment EUSO-TA - detector calibration and the highest energy cosmic ray measurements in coincidence with the Telescope Array experiment**
  Grant NCN PRELUDIUM nr 2015/19/N/ST9/03708

- **Studies of the influence of the high energy interaction model parameters on the development of EAS and measurement capabilities of the JEM-EUSO experiment**
  Grant NCN ETIUDA nr 2016/20/T/ST9/00589

- **BSUIN - Baltic Sea Underground Innovation Network**
  Interreg Baltic Sea Region. European Regional Development Fund. #R037

NARODOWE CENTRUM NAUKI

Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
BSUIN

Publications:

As part of JEM-EUSO collaboration, we publish several reviewed papers throughout the year.

„Ultra-violet imaging of the night-time earth by EUSO-Balloon towards space-based ultra-high energy cosmic ray observations”
Astroparticle Physics 2019, DOI: 10.1016/j.astropartphys.2018.10.008

„Detailed polarization measurements of the prompt emission of five gamma-ray bursts”
Nature Astronomy 2019, DOI: 10.1038/s41550-018-0664-0

„Phase-resolved gamma-ray spectroscopy of the Crab pulsar observed by POLAR”
Journal of High Energy Astrophysics 2019, DOI: 10.1016/j.jheap.2019.10.001

„Characterization of the radiation environment at TU Bergakademie in Freiberg, Saxony, Germany”
Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 946, 2019, 162652, ISSN 0168-9002,

„Comparison of MC Geant4 simulation with the measurements of gammas produced by neutrons.”
Mod. Phys. Lett. A Vol. 34 No 6 (2019) 1950046

We also presented the results of our research at international conferences (ICRC2019 U.S.A.)

Thank you for your attention

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