SEVAN detector & Boltek electric field mill @ UFS

22 May 2023

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https://www.desy.de
https://astroparticle-physics.desy.de
https://astroparticle-physics.desy.de/outreach/education_projects

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YerPhI (CR Division) Yerevan

http://crd.yerphi.am
http://adei.crd.yerphi.am

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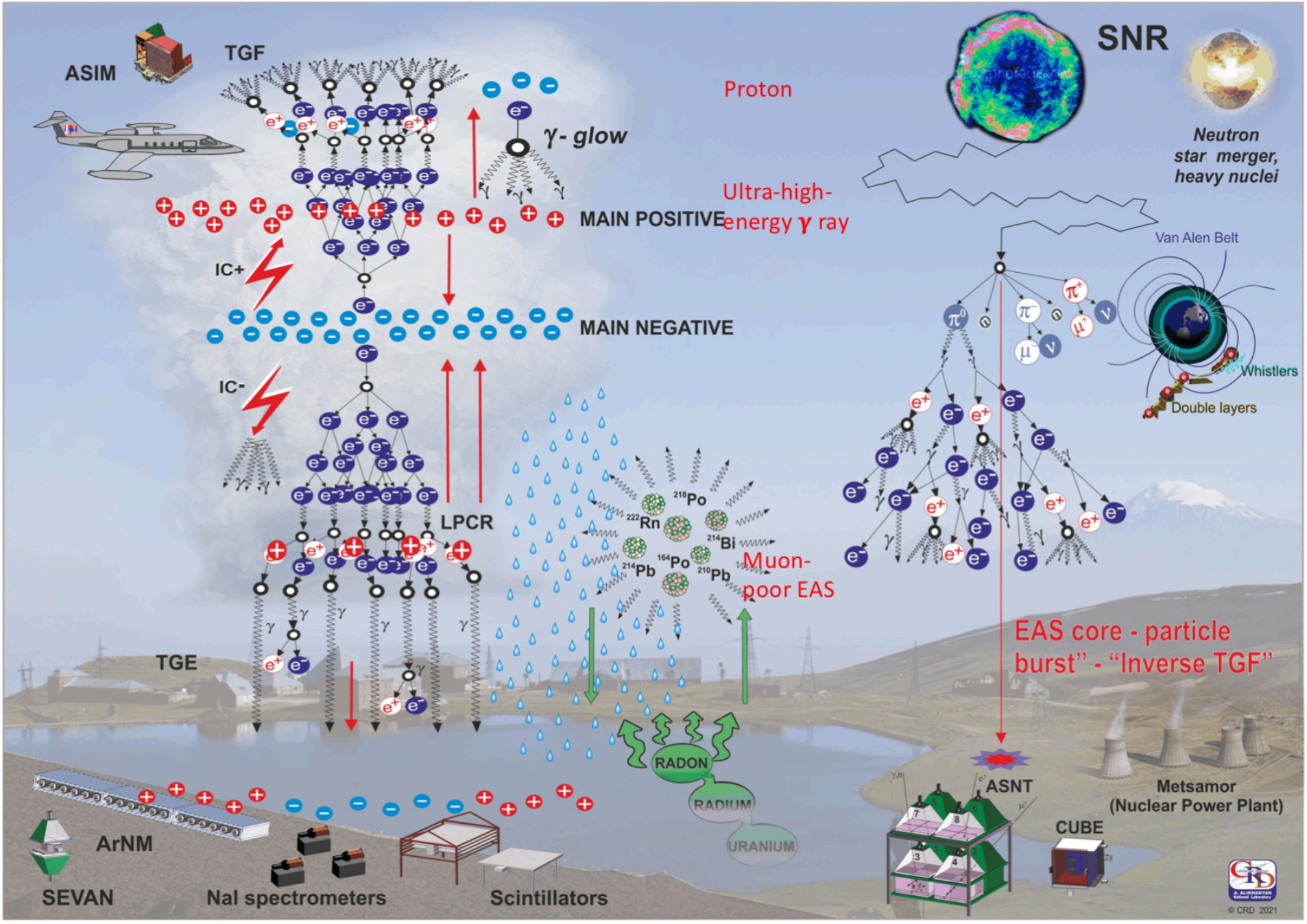
The detectors
What is measured
Physics objectives

A **SEVAN-light particle detector** and a **Boltek electrical field monitor** set up by an German-Armenian team in April 2023.

The former records **rates of electrons, photons, muons and neutrons** in the atmosphere that stem from **cosmic rays, solar winds,** and from **particle interactions within the atmosphere**.
The latter records the **electrical state of the atmosphere and the lightning activity**.
Their combination allows addressing the puzzle of **Lightning initiation**
Space weather observation and **Forewarning**

The SEVAN detector at the UFS operates in a network with several such set-ups on high mountain tops in Armenia (Aragats), Bulgaria (Mussala), Slovakia (Lomnitzcki Stit) and Czechia (Mileshovka), up to 3500 km apart, each with its own complementing instrumentation.
The network provides useful information on wide-spread (global) **solar physics events, space weather and the solar-terrestrial connection**.


ASIM
TGF
γ- glow
MAIN POSITIVE
IC+
MAIN NEGATIVE
IC-
LPCR
TGE
Proton
Ultra-high-energy γ ray
SNR
Neutron star merger, heavy nuclei
Van Allen Belt
Whistlers
Double layers
Muon-poor EAS
EAS core - particle burst" - "Inverse TGF"
RADON
RADIUM
URANIUM
ASNT
CUBE
Metsamor (Nuclear Power Plant)
ArNM
SEVAN
NaI spectrometers
Scintillators
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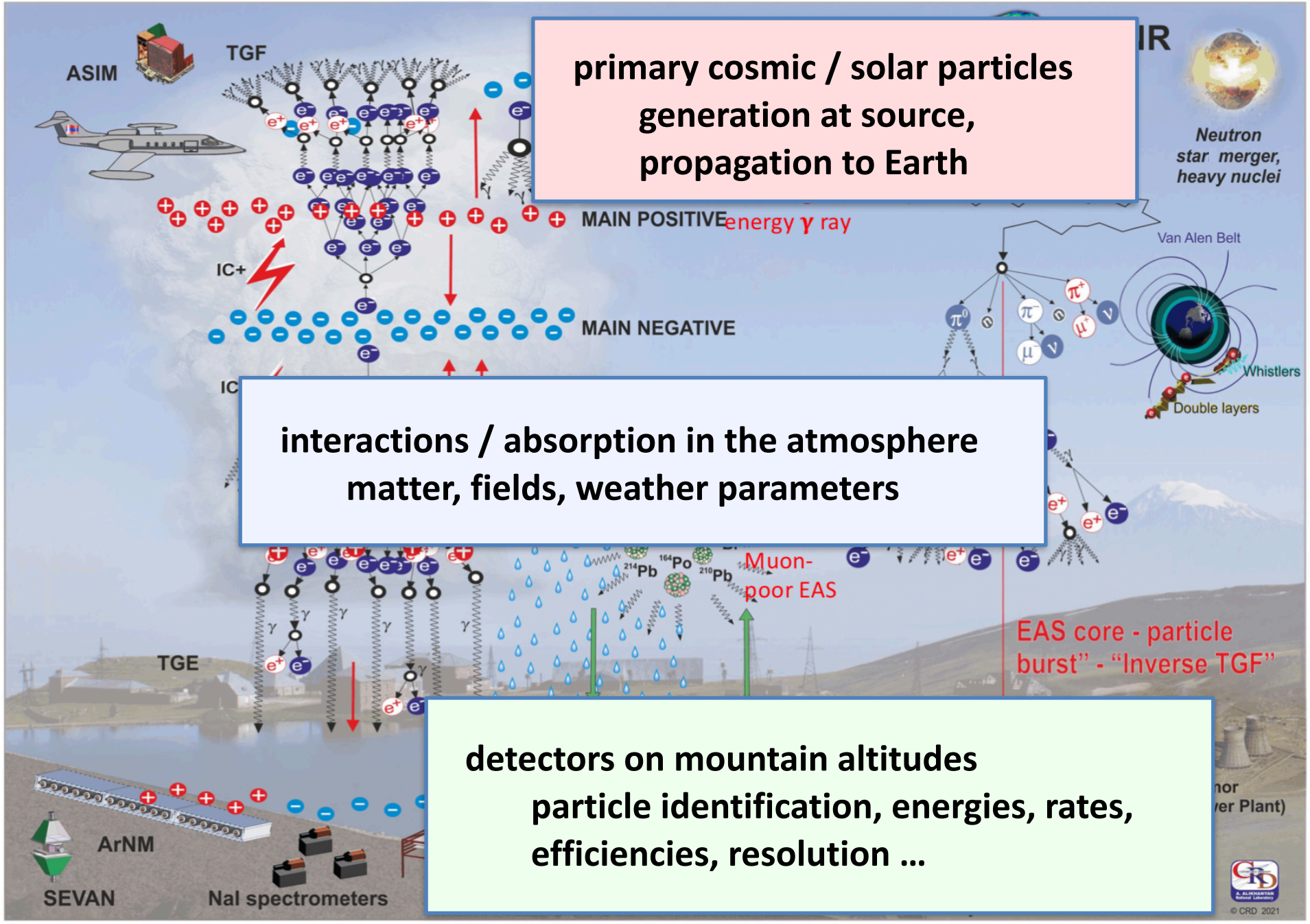

primary cosmic / solar particles
generation at source,
propagation to Earth
interactions / absorption in the atmosphere
matter, fields, weather parameters
detectors on mountain altitudes
particle identification, energies, rates,
efficiencies, resolution …
ASIM
TGF
IR
Neutron
star merger,
heavy nuclei
MAIN POSITIVE
energy γ ray
IC+
MAIN NEGATIVE
IC
Van Alen Belt
Whistlers
Double layers
Muon-
poor EAS
EAS core - particle
burst" - "Inverse TGF"
TGE
ArNM
SEVAN
NaI spectrometers
© CRD 2021

Physics with
SEVAN & Boltek field mill

plus: weather data, data from other observations

Cosmic ray fluxes:
different triggers for e, gamma, mu, n (only statistical)
pressure, temperature dependent

SEVAN Network:
other SEVAN detectors, Armenia, Czech Rep., Bulgaria, Slovakia, Germany
+ various spectrometers (gamma…), different sized particle detectors

Solar physics / Space weather:
Sun is getting quite active right now.
Forbush decreases CMEs, solar physics in coincidence
potentially very energetic CMEs via muons.
Forewarning?

The electric atmosphere:
Thunderstorms, lightning, atmospheric physics,
particle multiplication in thunderclouds, … only local.
with Boltek field mills, lightning networks

Detector Technologies and Data Analysis:
Calibration, Systematical Errors, Statistical evaluation, …

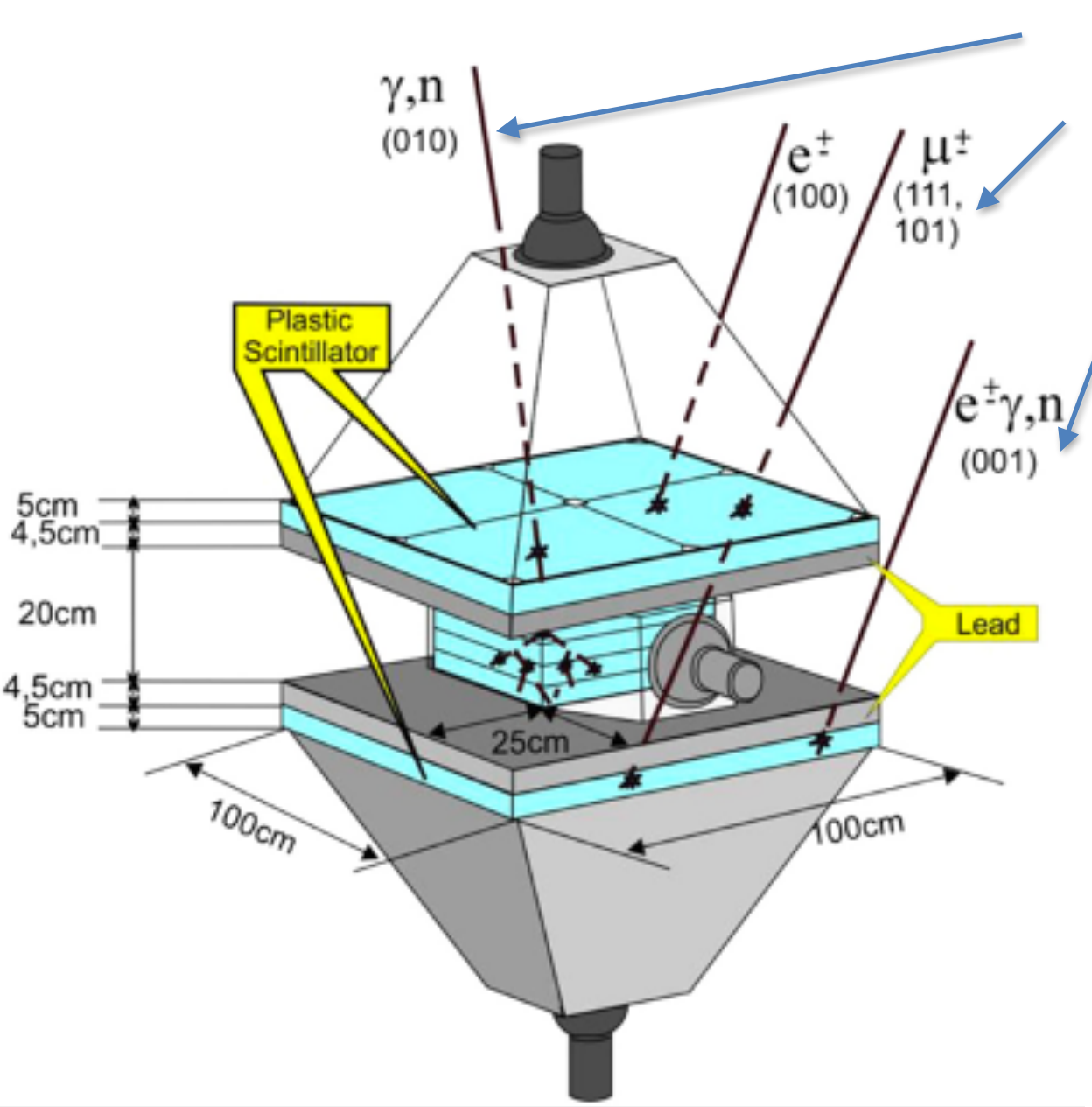
DESY: SEVAN data are used for Outreach

Data used for DESY Outreach

(from detectors on Polarstern,
Neumayer polar station
Mini muon Hodoscope on Zugspitze,
Mini-Neutron monitor,
SEVAN-light ...
plus some other similar detectors.)

used by school / student projects,
“Jugend Forscht” activities, …


SEVAN
Space
Environmental
Viewing and Analysis Network



coincidences between 3 channels

A simple detector for secondary cosmic rays

put many on mountains
operate in a network

complement with local
weather parameters,
electric fields, lightning,
magnetometers,
sky cameras,
& other particle detectors

power, heating,
wind protection,
internet connection

Triggers

100 – absorption in first 4.5 cm lead plate
low energy charged particle (5 MeV < E < 100 MeV)

010 – traversal of the neutral particle

111 – traversal of both lead plates and the middle scintillator
high energy muon (> 250 MeV)

101 – traversal of both lead plates
high energy muon (> 200 MeV)

new electronics with a
log-ADC for energy measurements
in central detector

Sevan is also the name of
a large lake in Armenia

SEVAN:

Space Environmental Viewing and Analysis Network

Rates (1/min) at Earth surface of **secondary**:

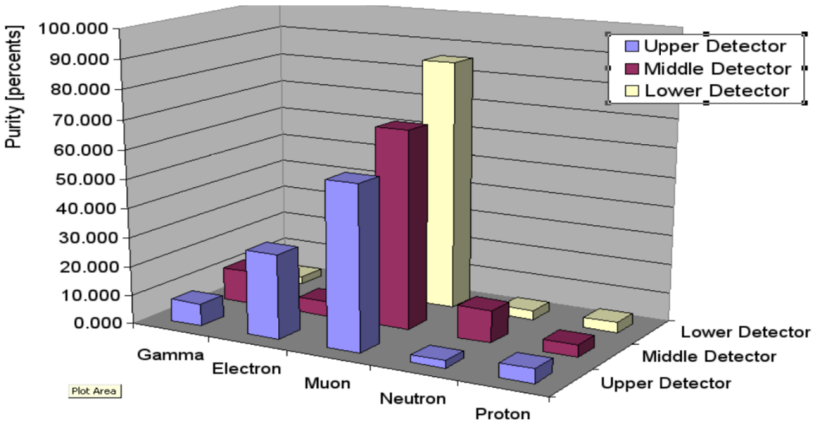
gamma rays	1000 :	typical energies: 1-10 MeV
electrons, positrons	100 :	
muons (from pion decays in hadronic showers)	10 :	
neutrons	1	
hadrons		

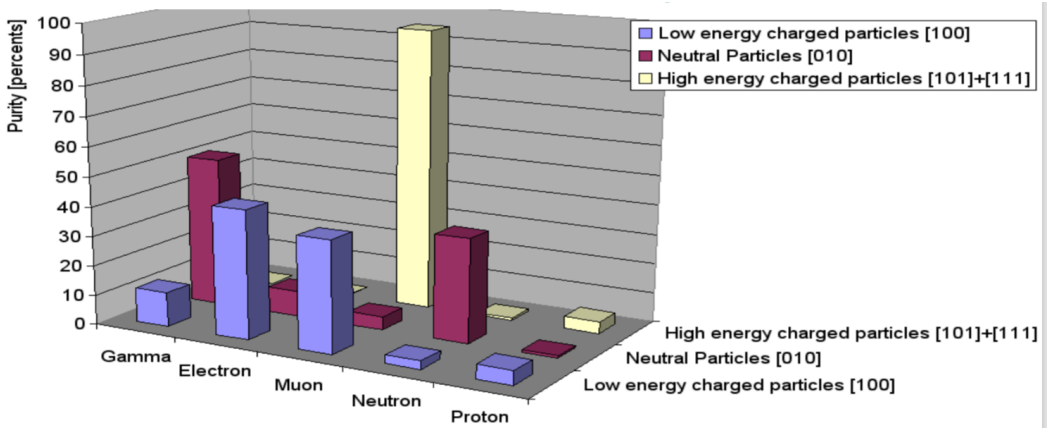
Trigger Coincidences
Energy deposits…

produced in atmospheric showers
by **primary** cosmic rays
(protons, neutrons)

from **solar wind**	(… keV … MeV)
flares (acceleration)	(… - 50 GeV)
galactic cosmic rays	(MeV - TeV - PeV)
extragalactic cosmic rays	(PeV - EeV -ZeV)

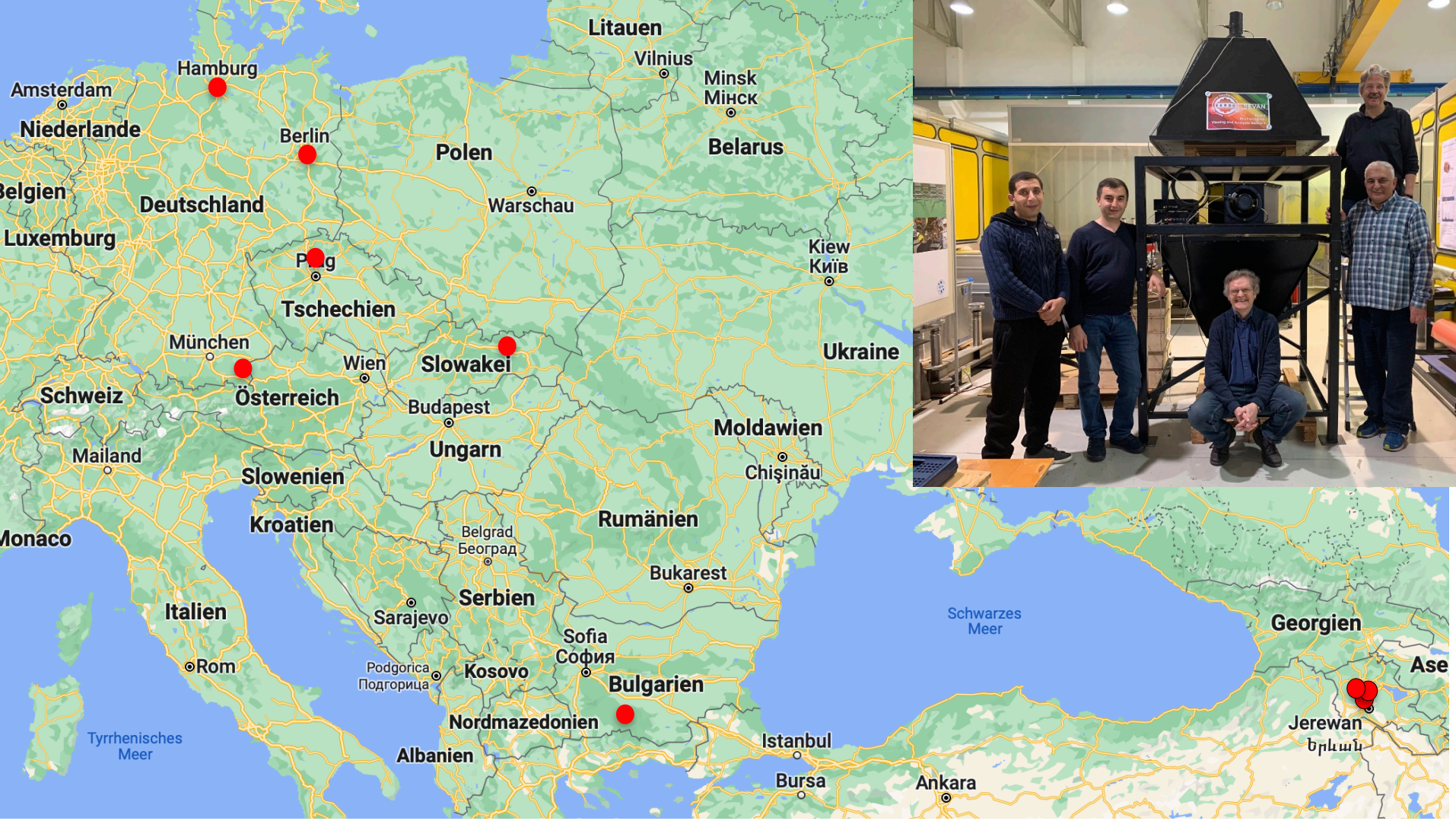
Purity and Efficiency of triggers / layers





	Gamma ray	Electron	Muon	Neutron	Proton
Registered particles Purity by detecting coincidences					
Low energy charged particles [100]	11.605	43.300	37.380	2.838	4.804
Neutral Particles [010]	50.612	8.837	4.494	**35.071**	0.972
High energy charged particles [101]+[111]	0.002	0.106	94.904	0.808	4.077
Registered particles Purity by count rate of the 3 scintillators					
Upper Detector	7.616	28.952	56.080	2.448	4.814
Middle Detector	11.550	5.223	67.913	**11.038**	4.167
Lower Detector	2.696	4.438	85.873	3.267	3.634

realistic detector simulations and particle spectra.



The SEVAN Network

~3500 km apart

Coincidences between them:

signals come from far outside the Earth atmosphere

e.g. massive CME with a Forbush decrease in some / all locations.

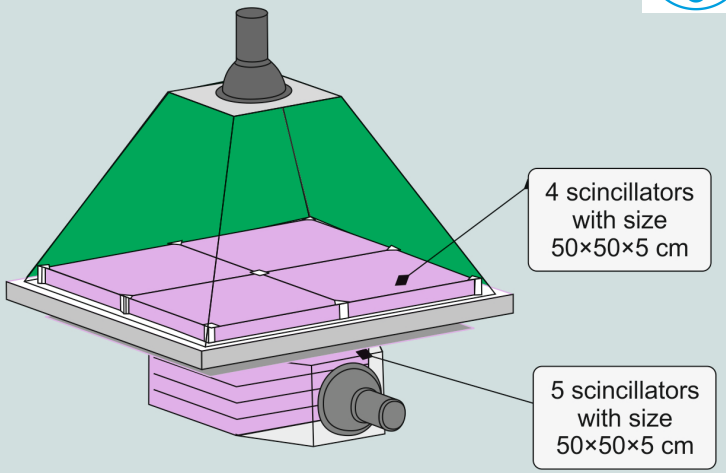
large-scale space weather events

Locations of operating SEVAN stations:

Armenia	Yerevan	1000 m asl	
	Nor Amberd	2000 m asl	
	Aragats Station	3200 m asl	
Czech Republic	Milesovka	836 m asl	
Slovakia	Lomnizcky Stit	2634 m asl	
Bulgaria	Musala	2925 m asl	
Germany	DESY Hamburg / Berlin	near sea level	
	Zugspitze (UFS)	2650 m asl	(new)

SEVAN - light

Space Environmental Viewing and Analysis Network



SEVAN - light detector

(recording electron, muon, gamma ray and neutron rates and energy deposits)

and **Boltek field mill**

(measuring polarity and strength of electrical field)

Boltek EFM C100 electric field mill

Data of the UFS SEVAN and Boltek are archived and publicly available

- in Yerevan (with data from all detectors in the SEVAN network)
  http://crd.yerphi.am/ADEI

- at DESY
  http://cosmicatweb.desy.de

User interfaces are offered for visualisation and analysis…
Are similar feature available for all experiments in the Kugelalm Hut??

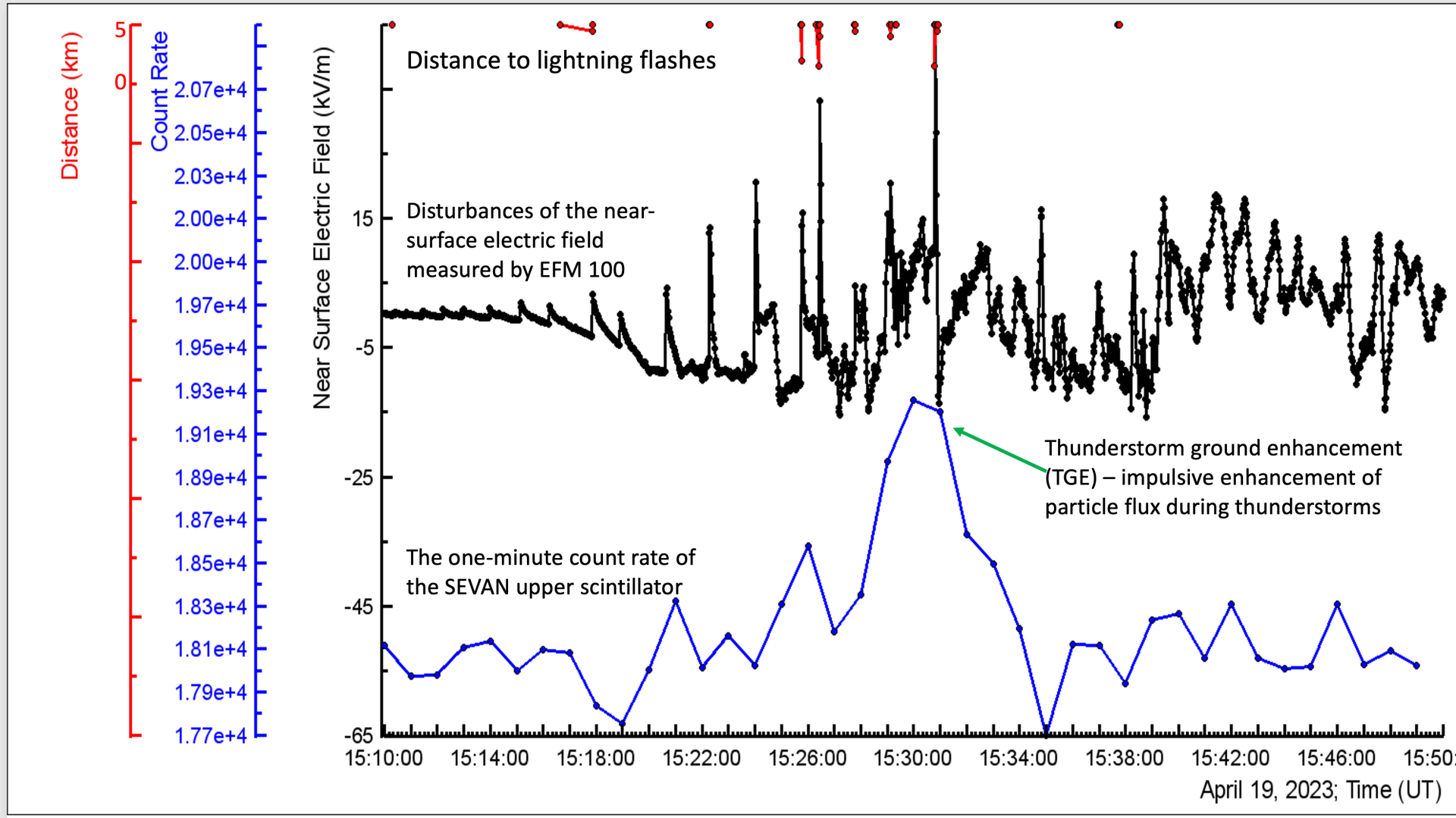
A common data platform for all expts. at the Kugelalm?
would require to know the formats of all data to be stored
with a suitable description of it, to be useful for non-experts …

Would likely be a **rather labour intensive**.

Apply for funds from the Helmholtz Metadata Collaboration
https://helmholtz-metadaten.de/en
needs 2 Helmholtz centres: KIT and DESY ?
up to 200k requiring also 200k own funds **???**

Aragats: SEVAN registered a large TGE event on the 19 April

an example …



Some Science Results

Kinematics of Interacting ICMEs and Related Forbush Decrease: Case Study
D. Maricic et al.
Solar Phys (2014) 289:351–368 DOI 10.1007/s11207-013-0314-8

FB

The SEVAN Worldwide network of particle detectors: 10 years of operation
A. Chilingarian et al.
Advances in Space Research 61 (2018) 2680–2696

Significant enhancements of secondary cosmic rays and electric field at the high mountain peak of Lomnický Štít in High Tatras during thunderstorms
J. Chum et al. Earth, Planets and Space (2020) 72:28 DOI: 10.1186/s40623-020-01155-9

TGE

Maximum strength of the atmospheric electric field
A Chilingarian et al.
Physical Review D, 103, 043021 (2021) DOI: 10.1103/PhysRevD.103.043021

E-field ≈ 500 MV

Muon Tomography of Charged Structures in the Atmospheric Electric Field
A Chilingarian et al.
Geophysical Research Letters, 48, e2021GL094594 (2021) DOI: 10.1029/2021GL094594

E-field

Stopping muon effect and estimation of intracloud electric field
A.Chilingarian et al.
Astroparticle Physics 124 (2021) 102505

E-field

Continental thunderstorm ground enhancement observed at an exceptionally low altitude
Ivana Kolmašova et al.
Atmos. Chem. Phys., 22, 7959–7973 (2022) DOI: 10.5194/acp-22-7959-2022

TGE

Forbush decrease observed by SEVAN particle detector network on November 4, 2021
A.Chilingarian et al.
in prep

FB

Spectrometry of high-energy photons on high mountain observatory Lomnizcky Stit during Thunderstorms
Jakub Slegl et al.
Radiation Protection Dosimetry (2022), Vol. 198, No. 9–11, pp. 623–627 DOI 10.1093/raddos/ncac108

What do we want / need at UFS?

SEVAN Detector & Boltek electric field mill

Space in Kugelalm Hut: ca. 2 m^2	✔
Electricity for detectors and computers	✔
Network connection for automatic data transfer	✔
Stable temperature in hut (recorded)	**good enough ?**

Weather parameters: (local temperature, pressure in atmosphere, …) **?**

Occasional technical support

Connection to other expts. at the Kugelalm hut (useful for cross-calibration),

✔ Neutronmonitor	(University Kiel)
✔ Bonner Sphere Spectrometer (neutron det.)	(Helmholtz Zentrum München HMGU)
✔ Cosmic Ray Neutron Sensor (Hydroinnova)	(Helmholtz Zentrum für Umweltforschung UFZ)
Szinti (equivalent dose rate)	(Helmholtz Zentrum München HMGU)
Gammasonde SARA (NaJ)	(Helmholtz Zentrum München HMGU)
Gammadetector GROWTH	(Czech Academy of Sciences)
TIMEPIX (hybrid pixel detector)	(Czech Technical University in Prague)

… may be modified, once we know better what all those can provide.

What next:

We are committed to continue the DESY-YerPhI cooperation and the operation of SEVAN @ UFS Zugspitze.
Near term objectives are the stable operation and the integration and cross calibration with other relevant detectors locally.

The current level of financial support from DESY may be maintained, allowing some contribution to the operation of the Kugelalm Hut.

However, due to current financial constraints in many DESY projects, longer term funding is uncertain. Staff shortage is a mitigating factor, too. Discussions are ongoing,

… requiring at least approximate numbers…