Astroparticle research at JINR

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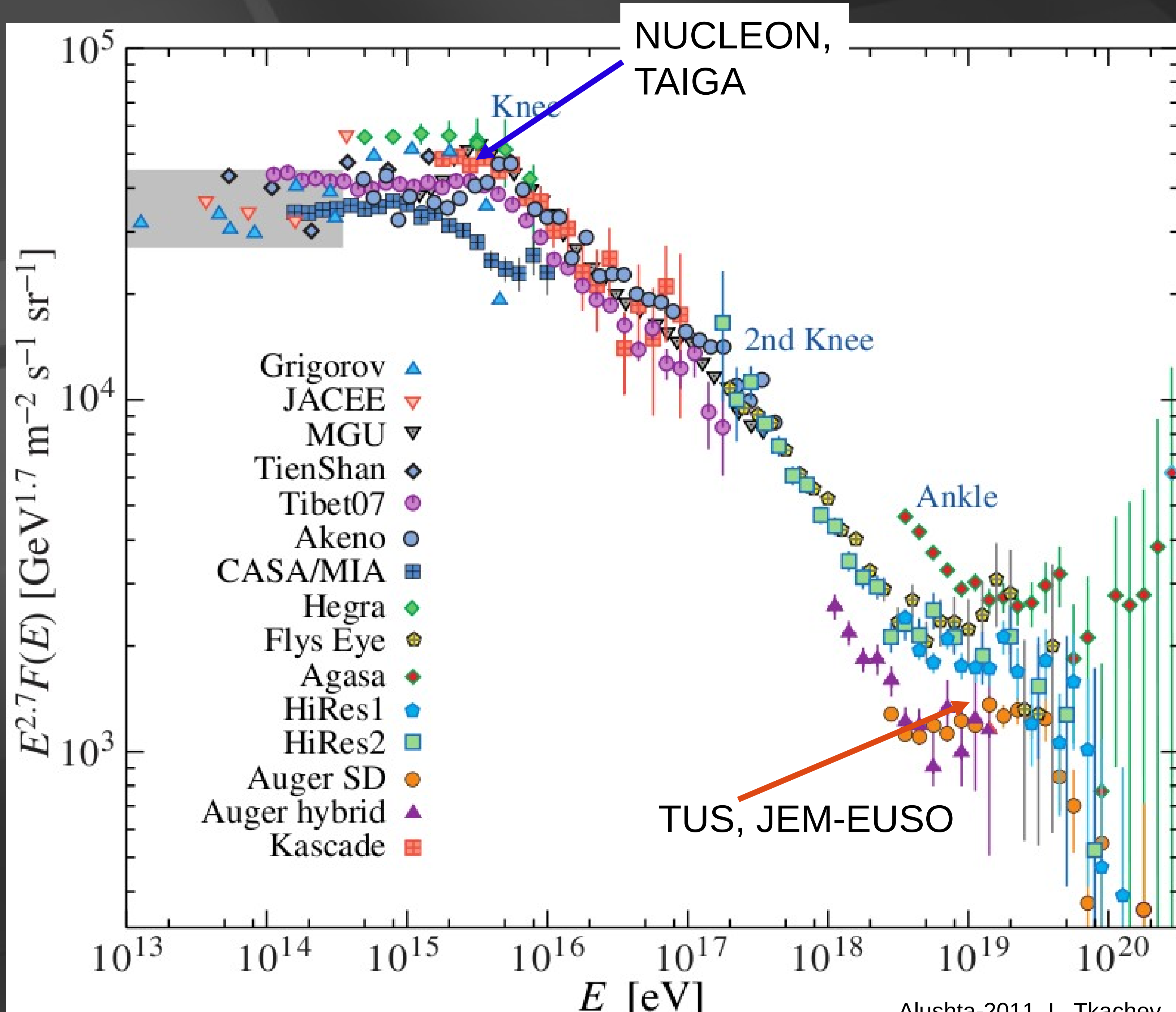
Hamburg, 2015

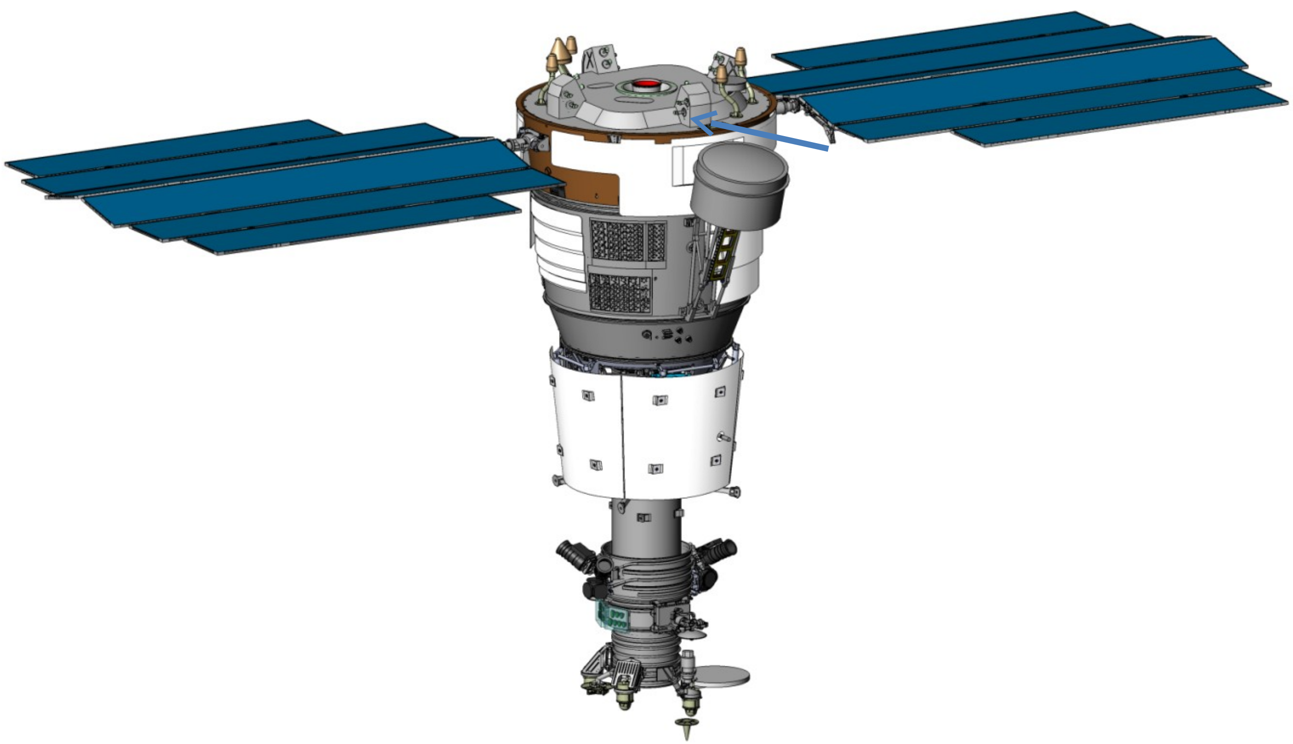
Contents

Cosmic rays energy spectrum



NUCLEON apparatus consists of

- NUCLEON detector as a monoblock inside of pressure container,
- Special **telemetry** system inside of separate container,
- Antenna-fider system,
- Mechanical support interface of the connection with base satellite system.

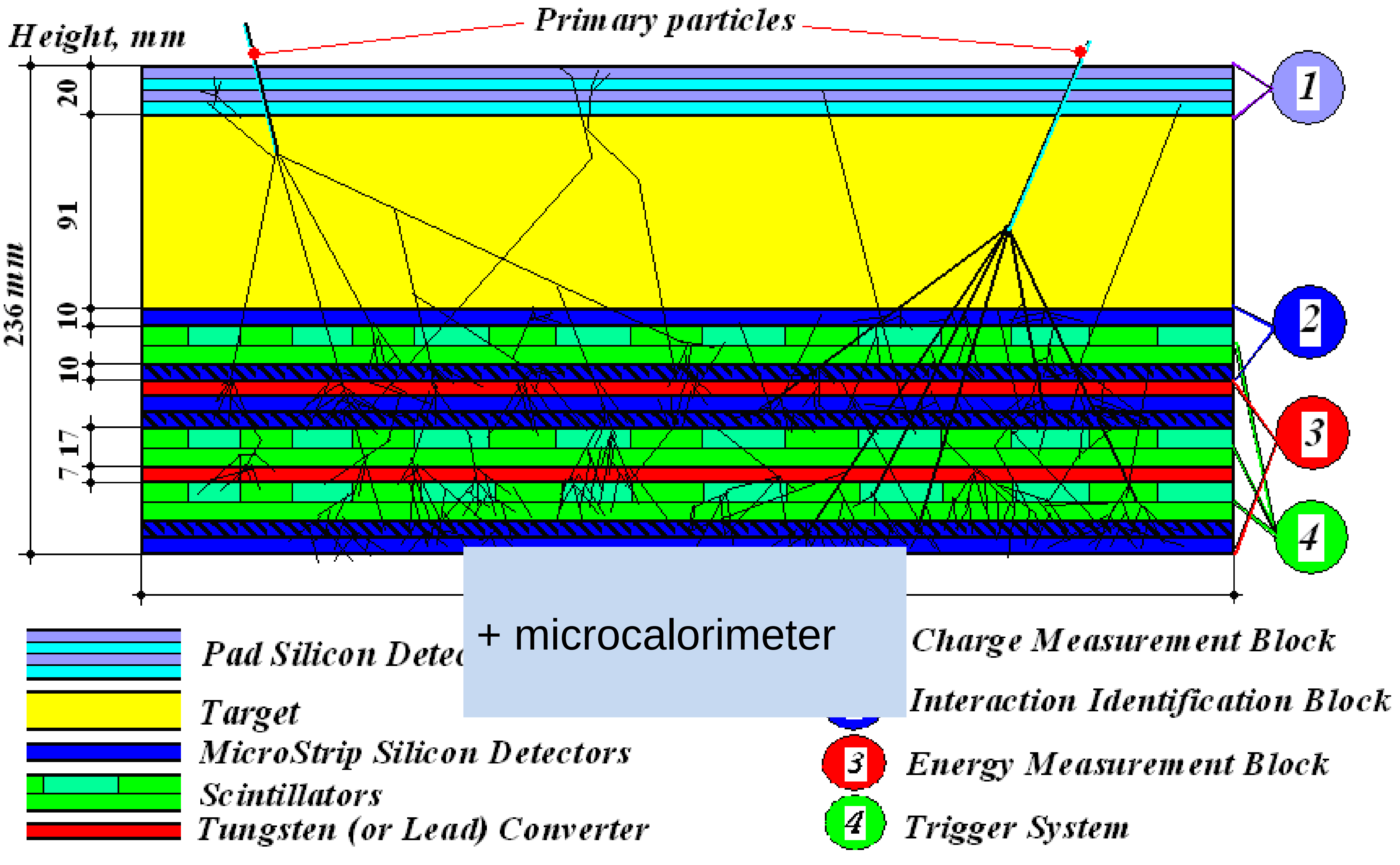


NUCLEON on the RESURS-П satellite

Main NUCLEON parameters:

-Total weight ~ 265 kg (for detector ~165 kg);
-Power cunsumtion~150 W (for detectors ~ 120 W);
- Number of chan. 14000
- Telemetry ~270 MB/day;
- Data taking period ≥5 years.

NUCLEON эксперимент

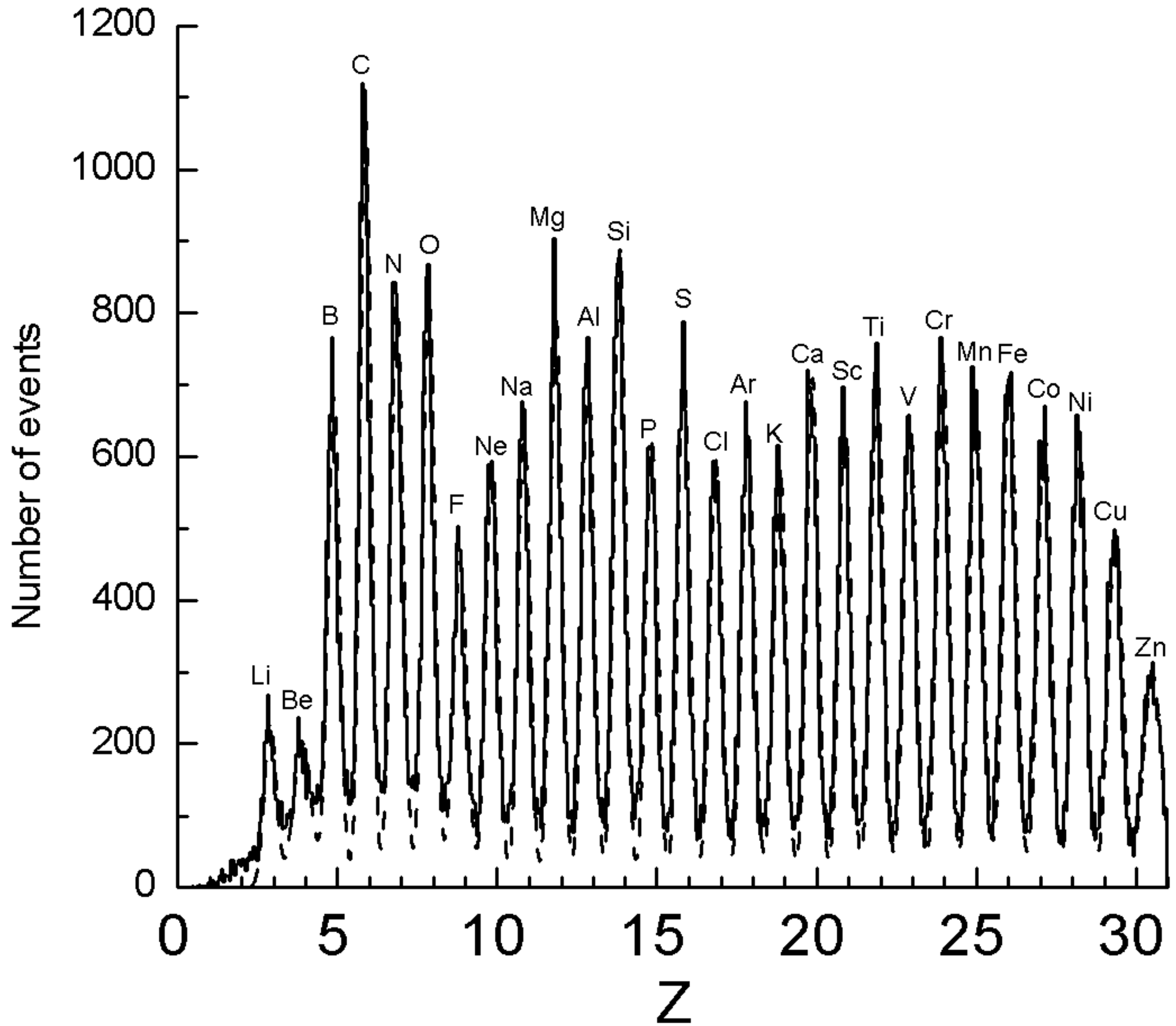


+ microcalorimeter

Charge reconstruction calibration

Charge is reconstructed with rank statistics method:

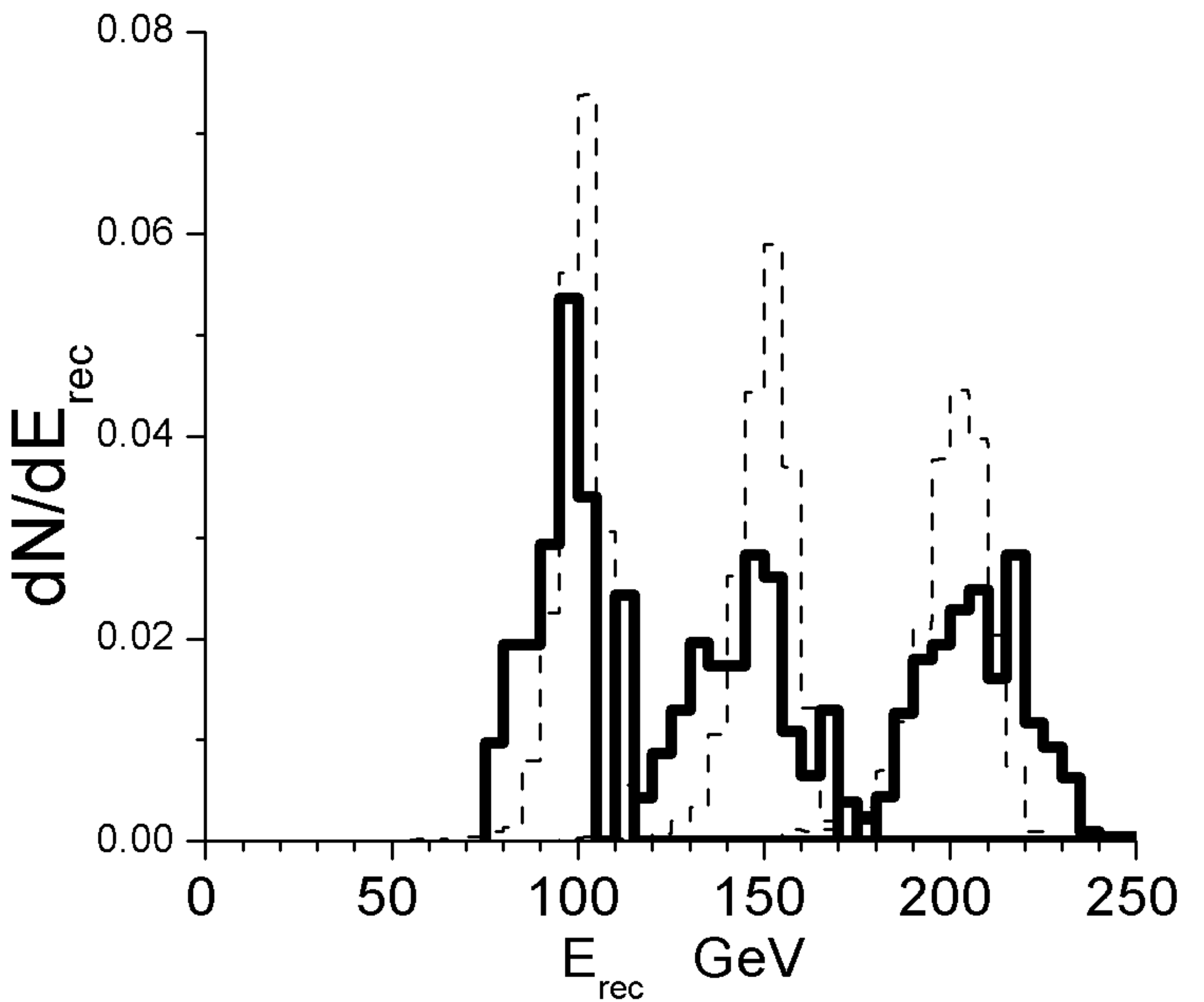
- 4 layers of silicon detectors each reconstruct particle charge independently
- 2nd largest of those charges is uses as an estimate of the true charge
- This method provides better result than the average of the values since fluctuations are highly asymmetrical



Beam test charge distribution

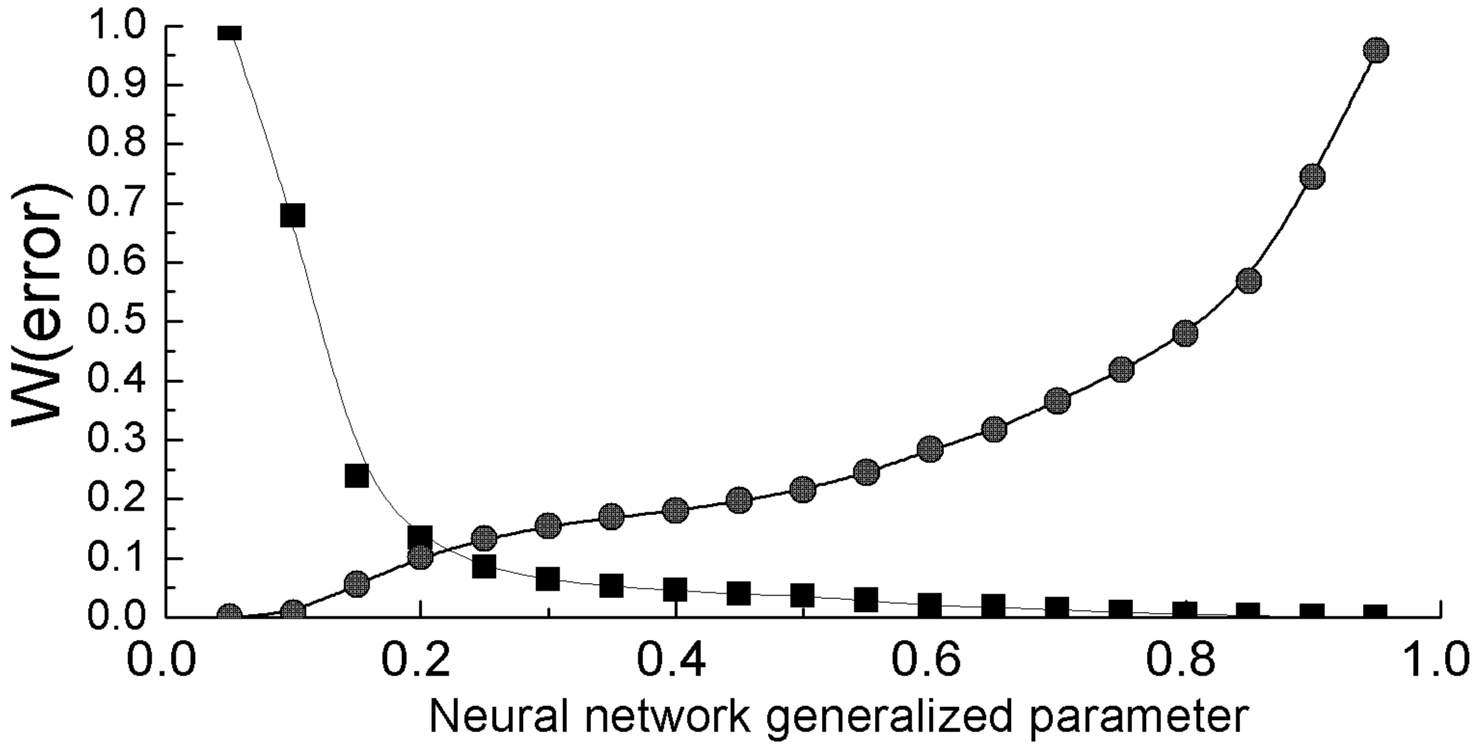
Energy reconstruction calibration

Energy reconstruction is based on generalized kinematical method (KLEM method) developed for emulsion and gives an energy resolution of 70% or better, according to simulation.



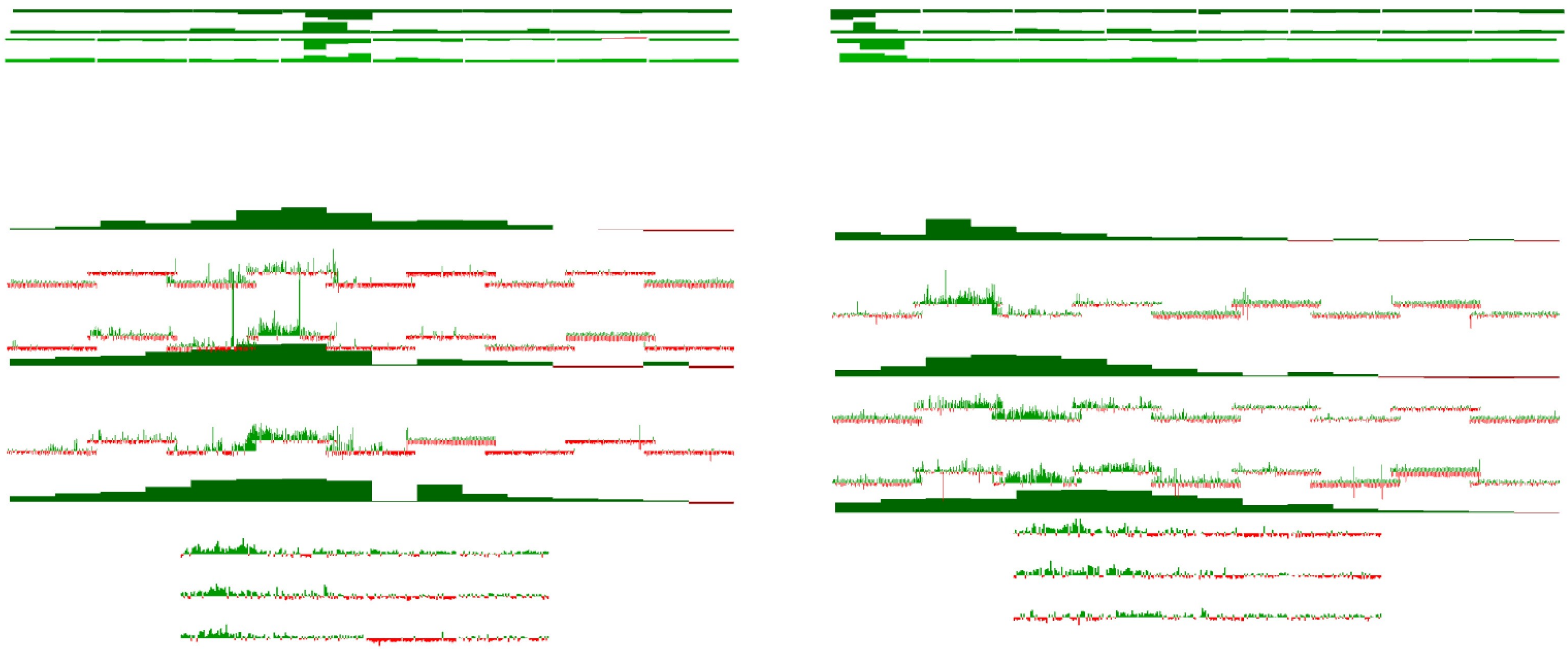
Calorimeter reconstructed energy distributions for 100, 150 and 200 GeV electron beams (solid line) in comparison with simulation results (dashed line).

Lepton and barion discrimination



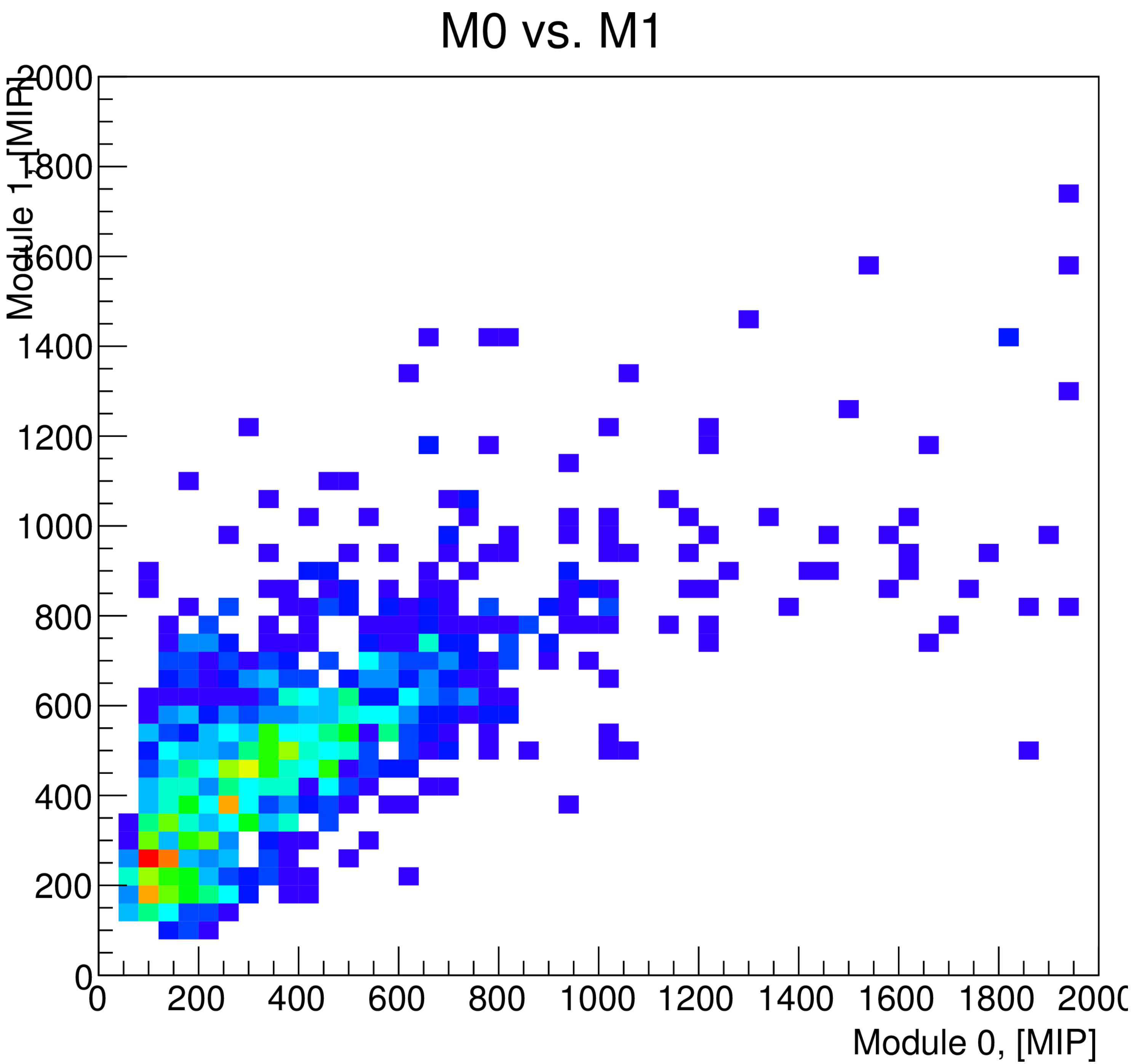
Error probability dependences on neural network generalized parameter. Probability of electron registration as pion is marked by squares and probability of pion registration as electron is marked by circles.

First data from NUCLEON

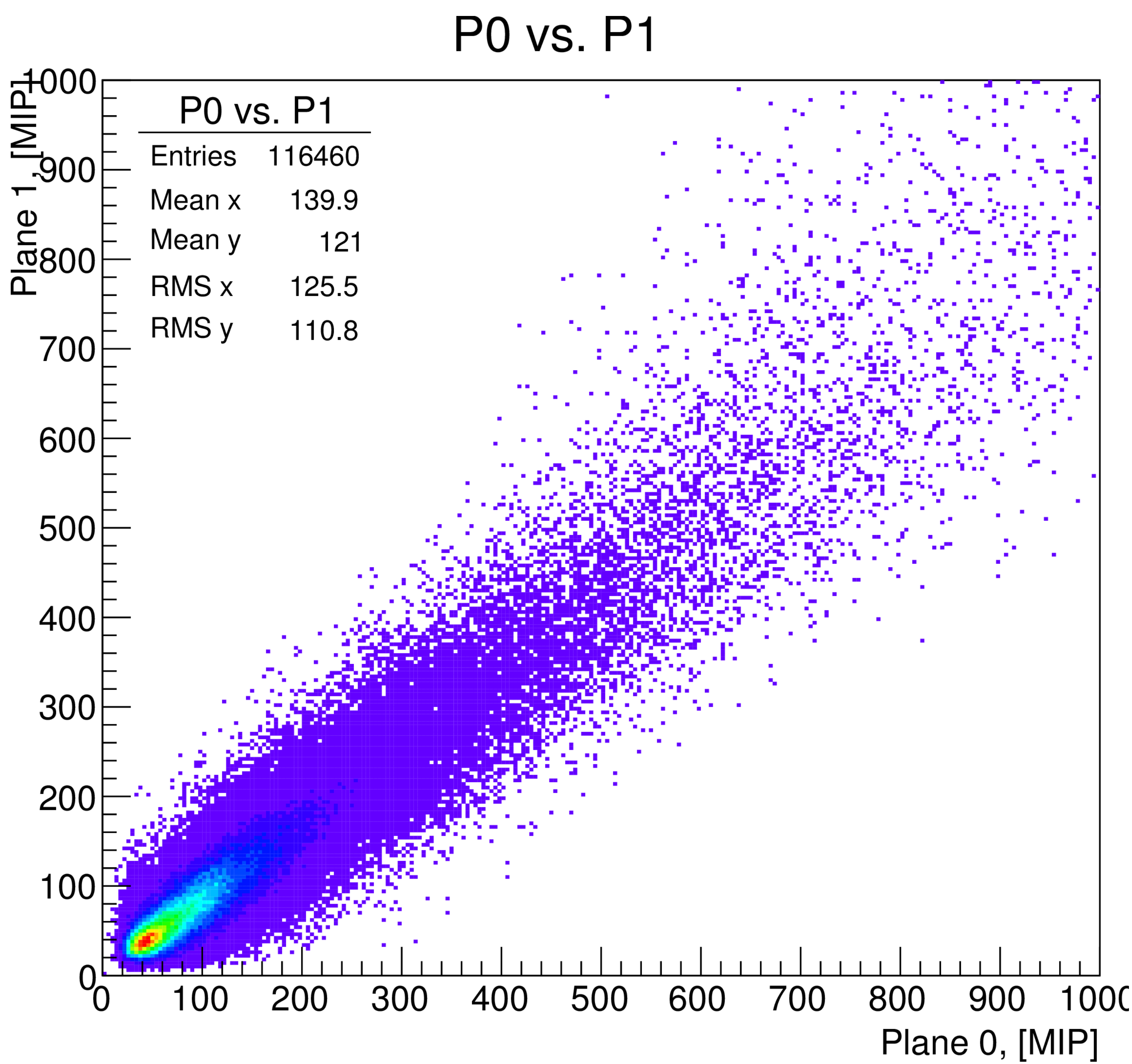


Example of CR event in the NUCLEON experiment from the event display viewer program. Signals of four layers of the charge measurement system are seen at the top of picture, then 3 layers of trigger signals in the deep-green color together with the light green signals of silicon tracker between and electromagnetic calorimeter signals at the bottom.

Correlation between signals from different modules

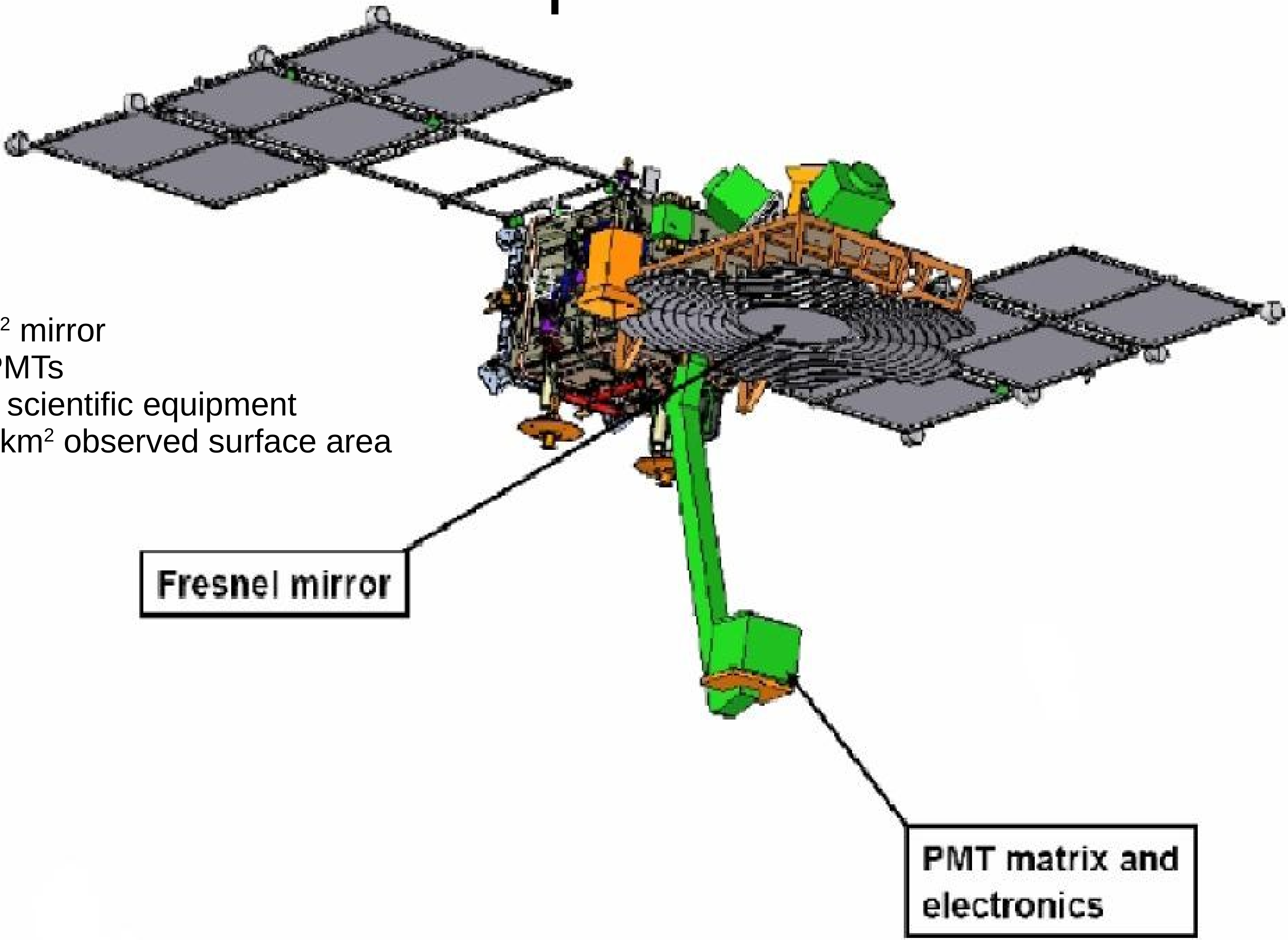


Correlation between signals from different planes of the same module



TUS experiment

- 1.8 m^2 mirror
- 256 PMTs
- 65 kg scientific equipment
- 6400 km^2 observed surface area



Mirror optical measurements

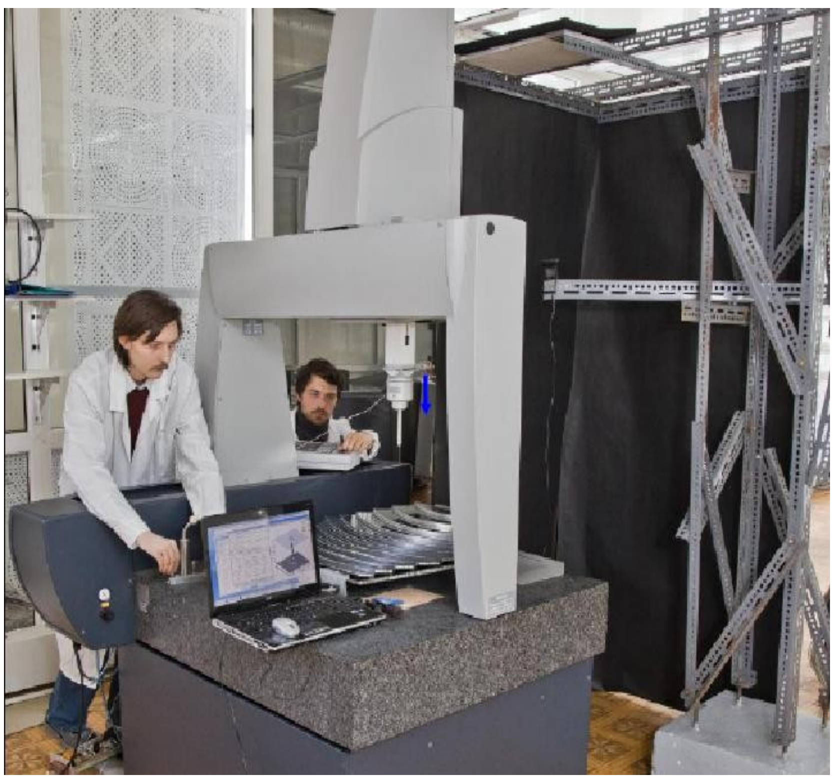
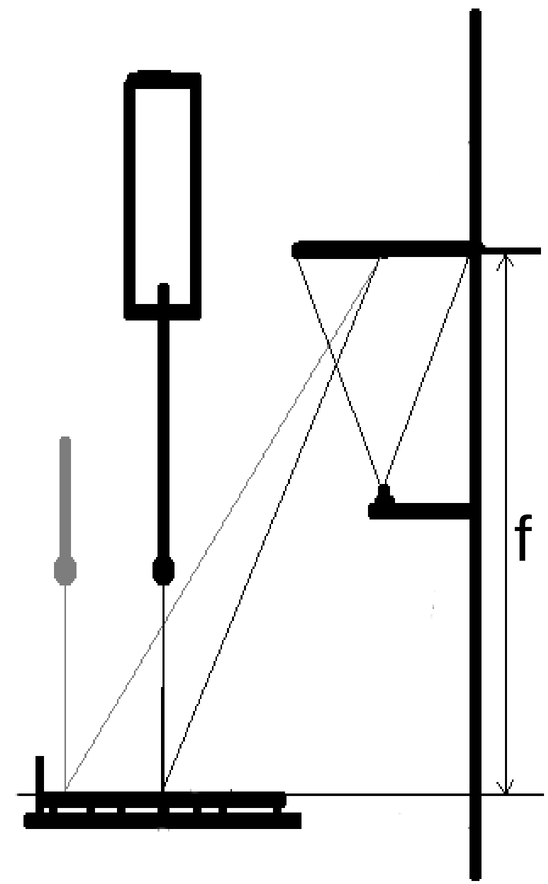
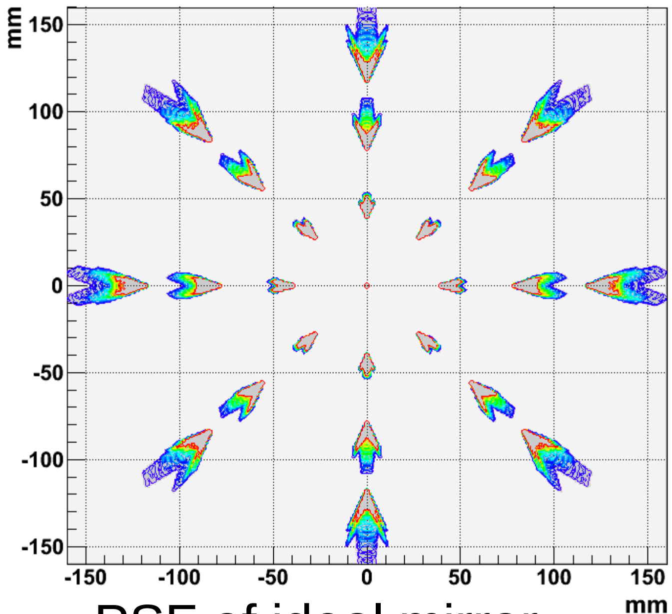


Photo of measurement equipment

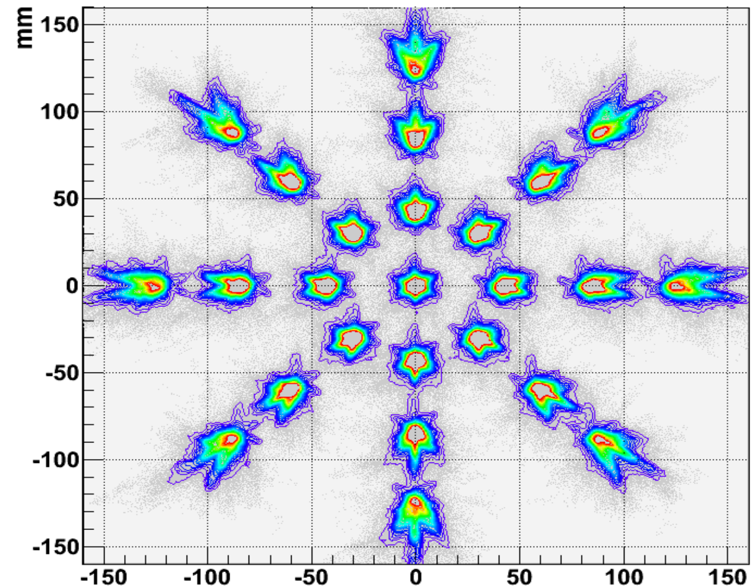


Schematic diagram of measurements

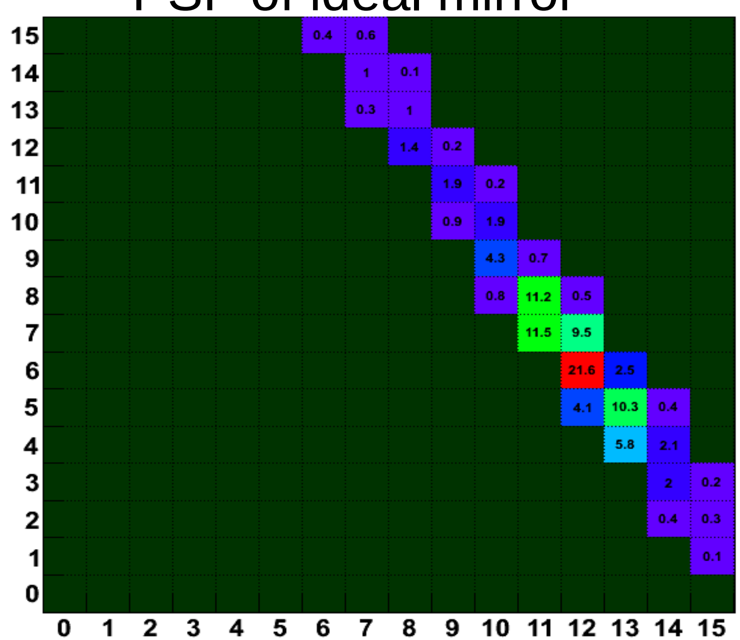
Results of optical simulation

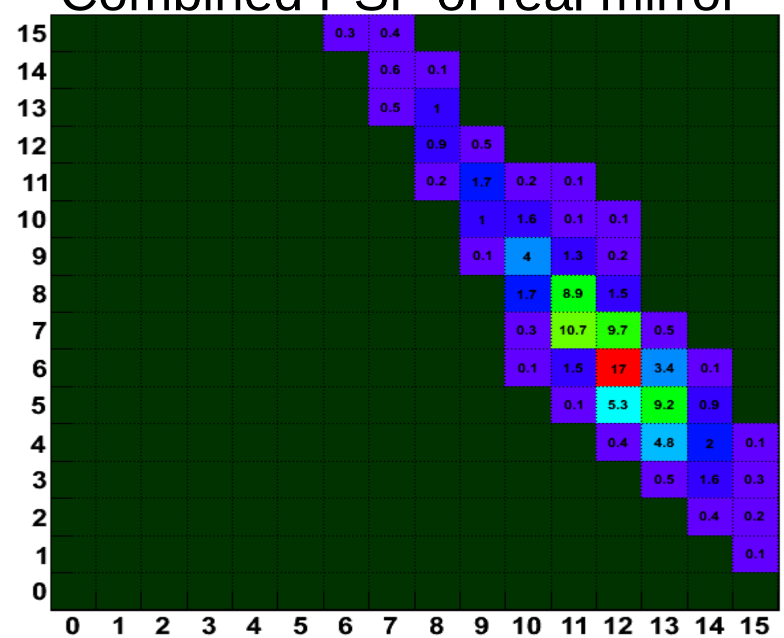


PSF of ideal mirror

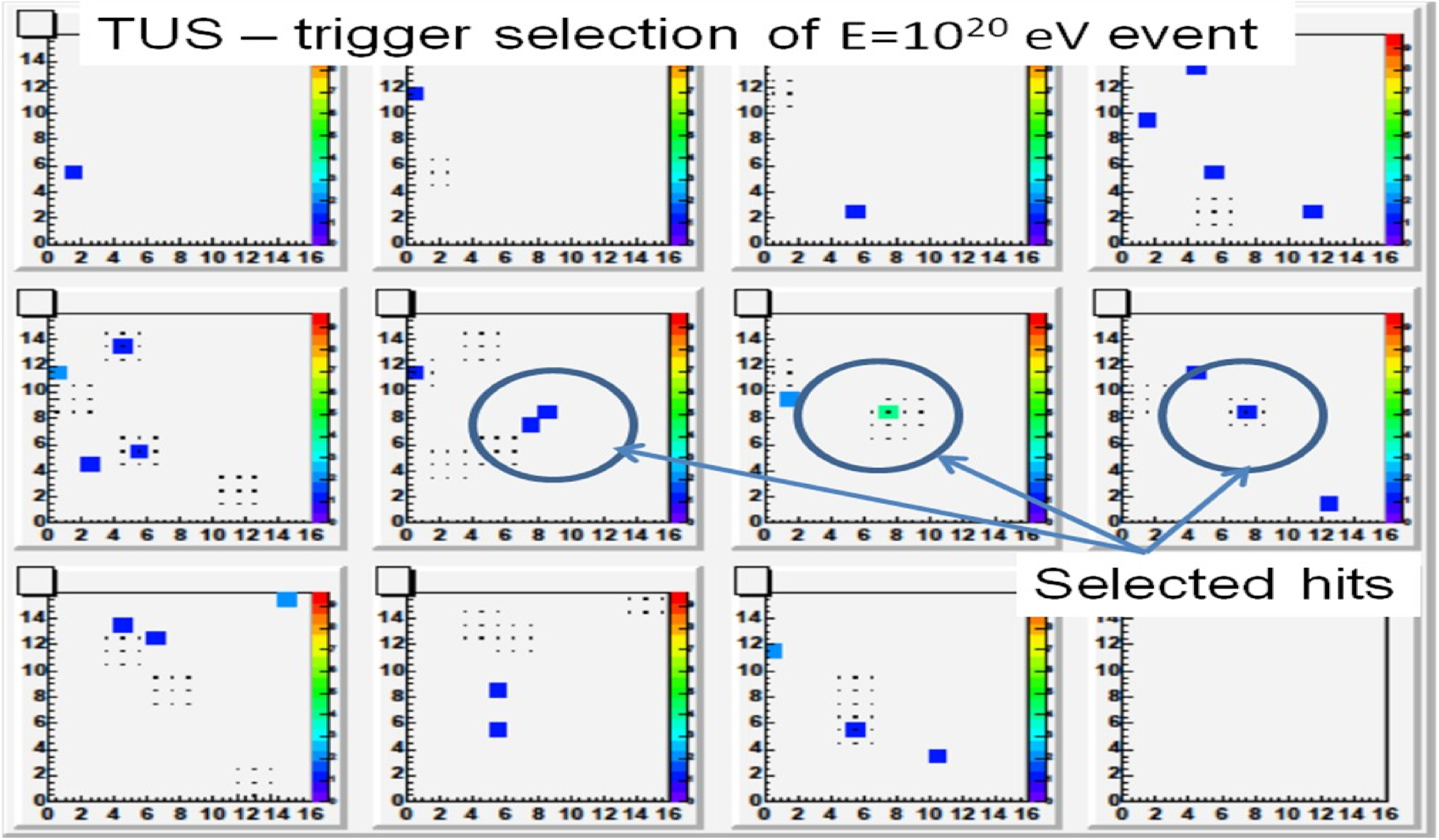


Combined PSF of real mirror





Photons from the same event on the PMT matrix simulated with ideal and corrected optics



Maximum of sliding sums of the signal over 16 time frames
3 consecutive times of that maximum exceeding fixed trigger level
in the same or 8 adjacent pixels

Current status

Detector TUS at “Mikhail Lomonosov” satellite during tests at 2013

Ready for launch
Scheduled for the end of 2015

Nadir (2 yrs)

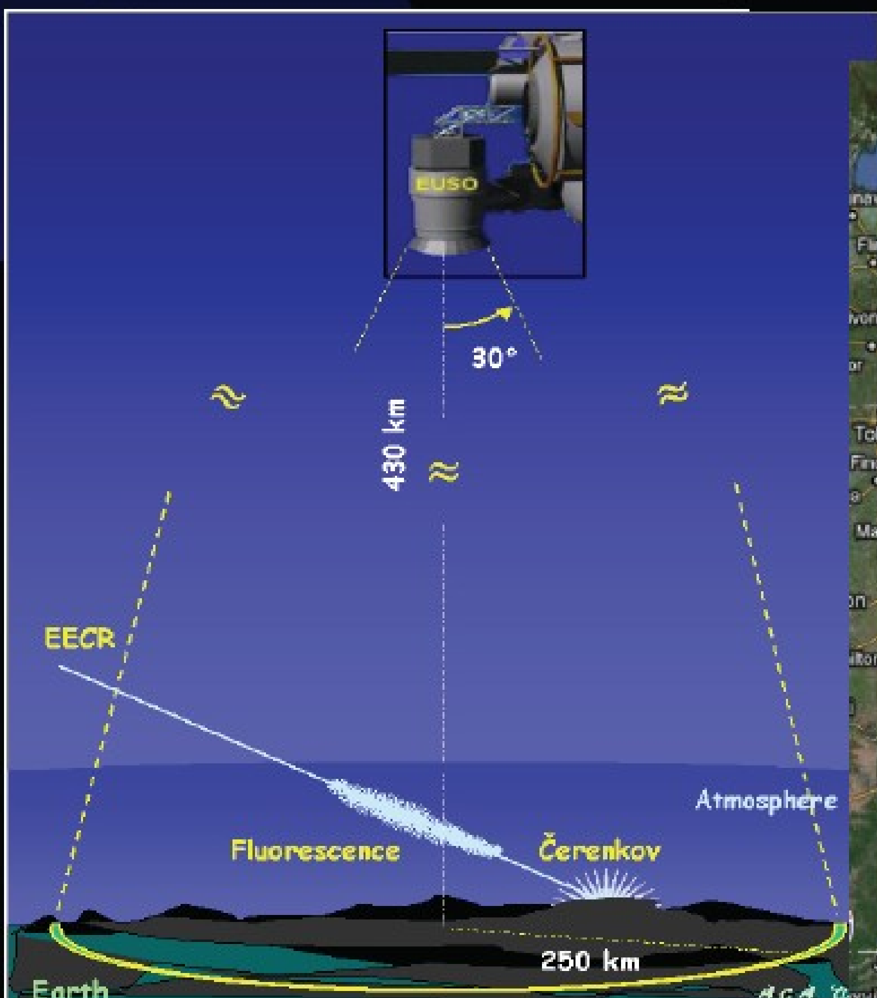
35° tilt (3 yrs)

- 3 x area

$E_{th} \sim 10^{20}$ eV

Fluorescence only

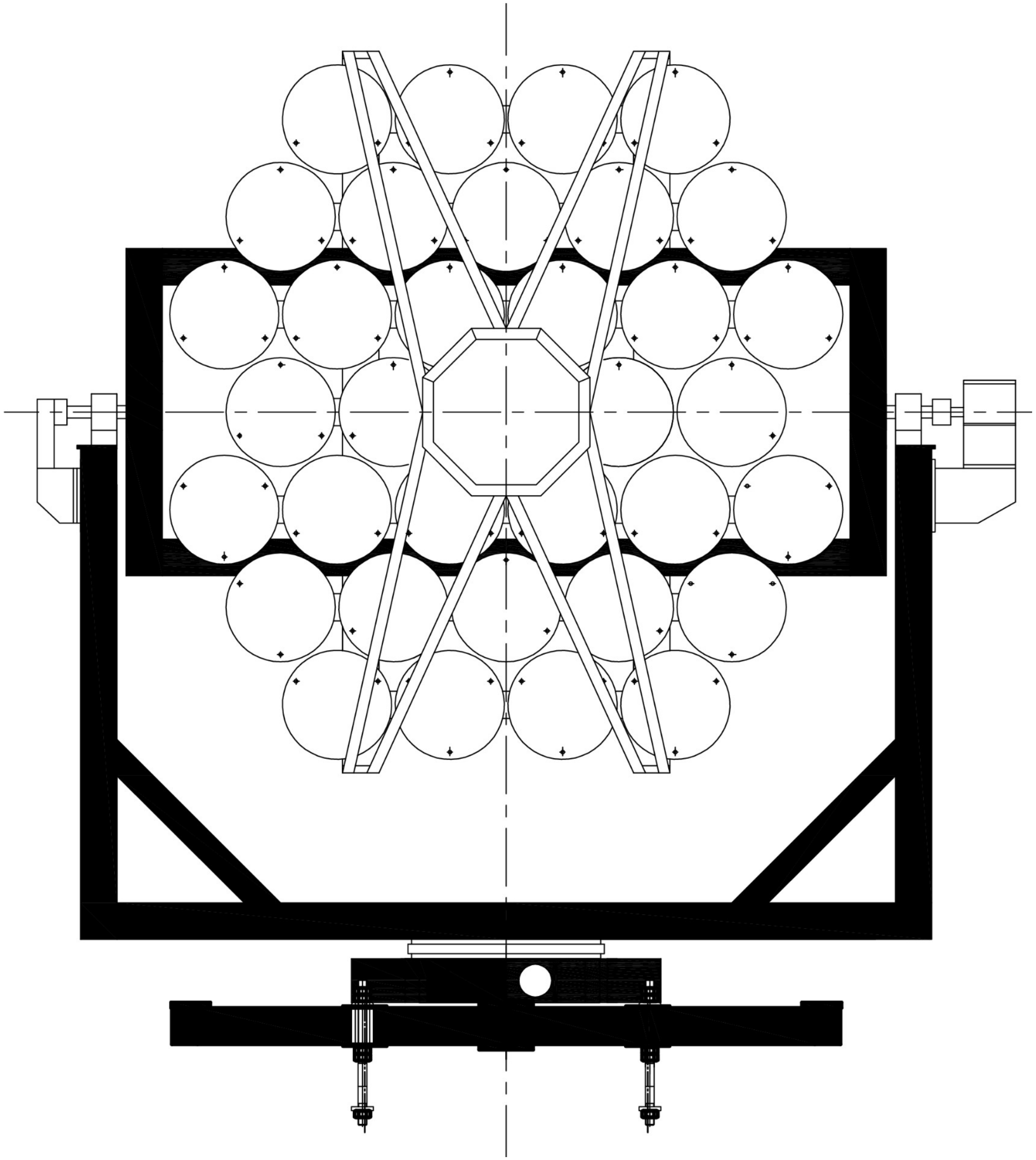
~ 20% duty cycle



JEM-EUSO stages

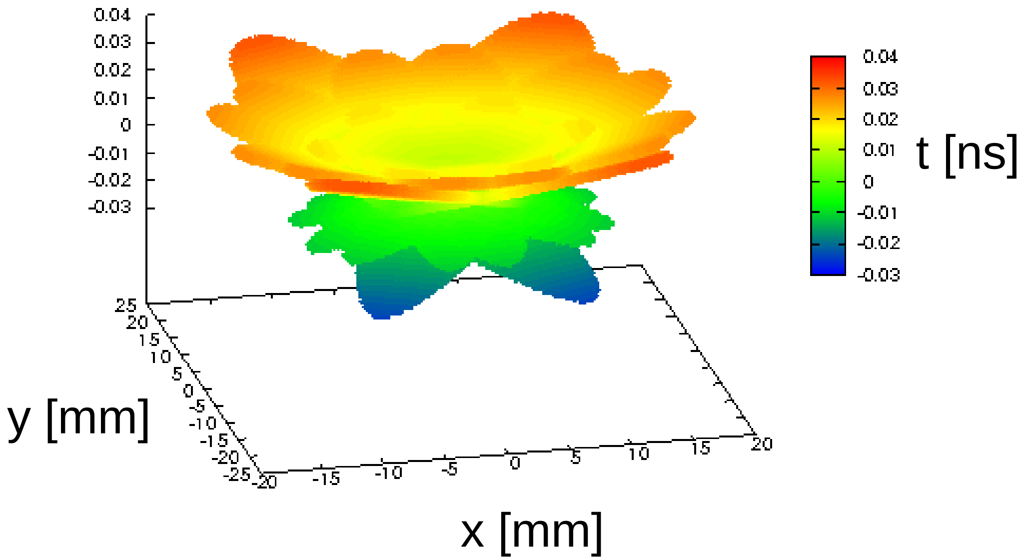
- EUSO-TA -Working
- EUSO-Balloon -Successful flight
- Mini-EUSO -Approved, planned for 2016
- JEM-EUSO -Planned for 2018?

TAIGA experiment

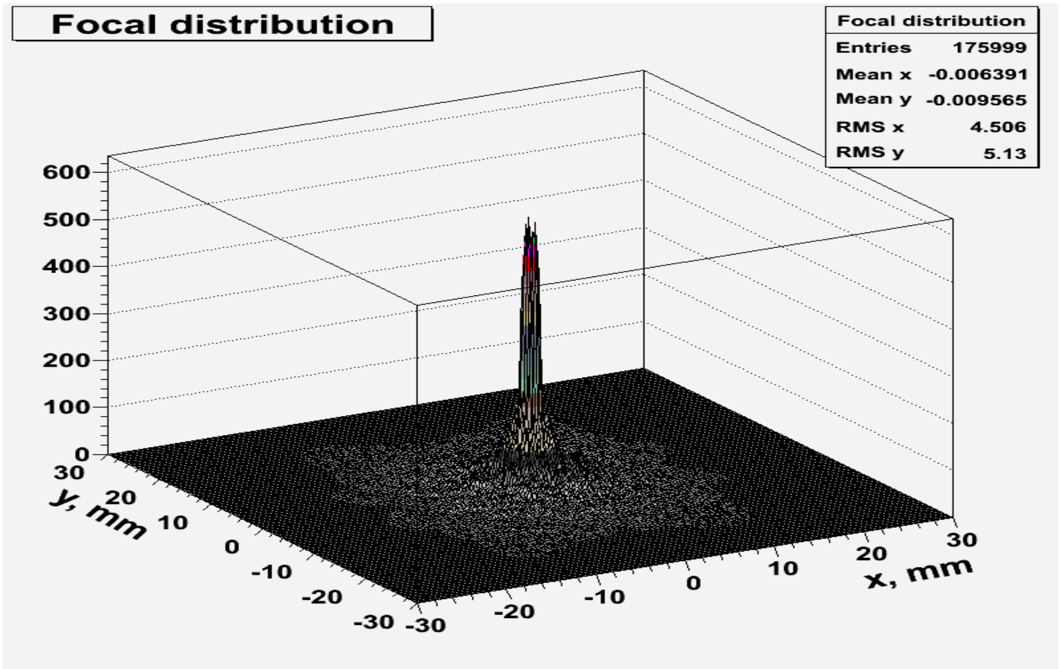


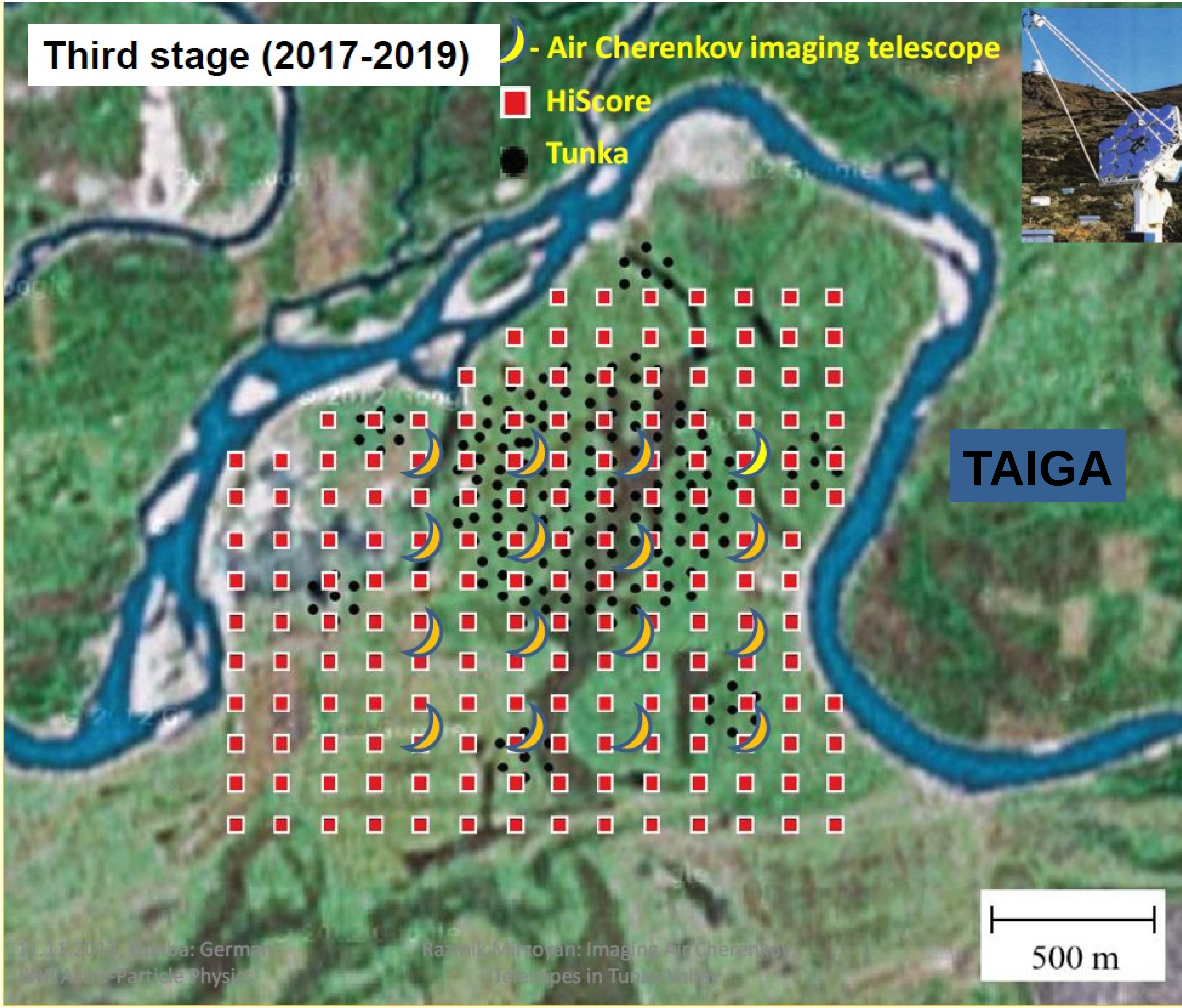
Focal distance 4750 mm
34 spherical mirror segments
Diameter of each segment – 60 cm

Focal spot



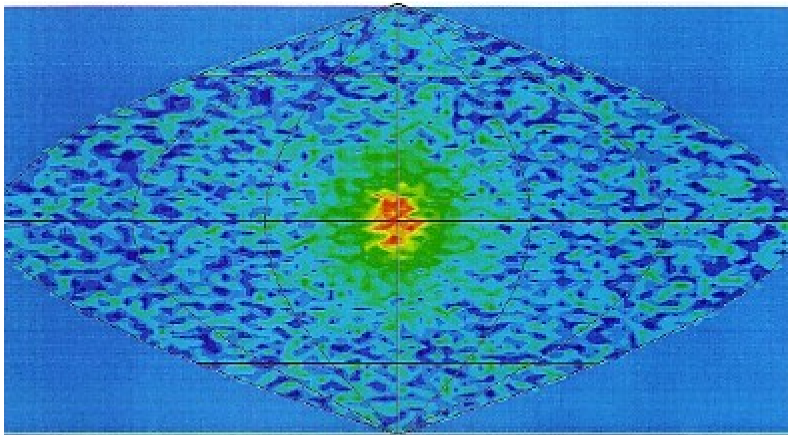
Focal spot with aligned mirror segments (center of each mirror segment reflects light parallel to optical axis into the same spot)
Z axis and color indicate time delays caused by optics

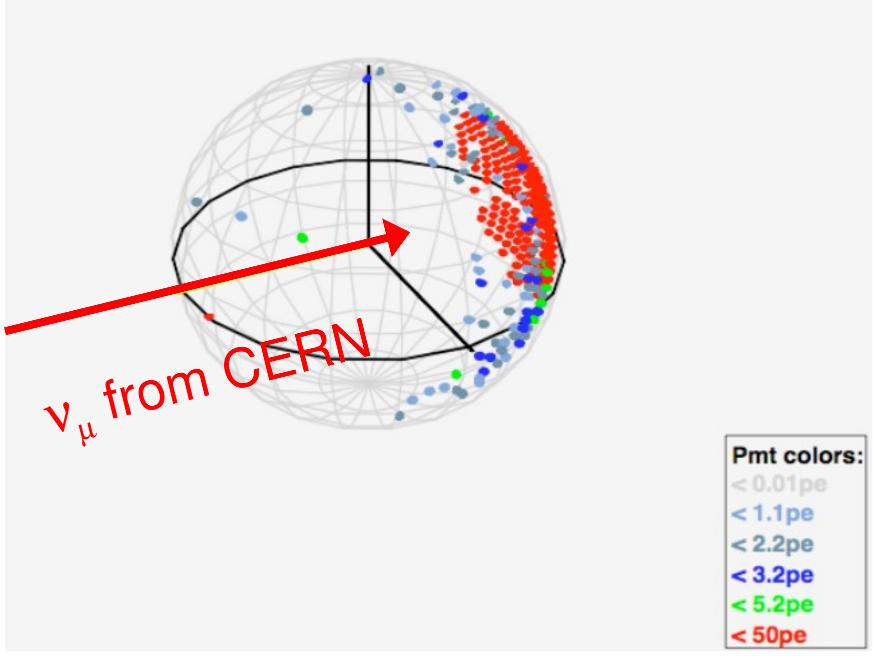


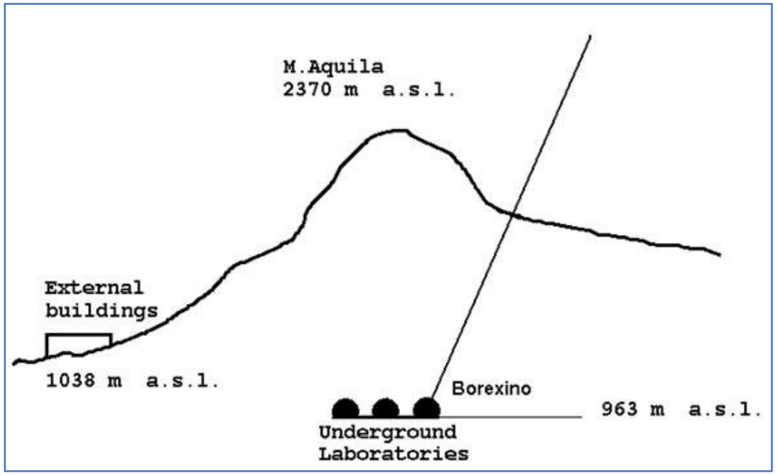

Third stage (2017-2019)
- Air Cherenkov imaging telescope
HiScore
Tunka
TAIGA
500 m

Neutrino experiments

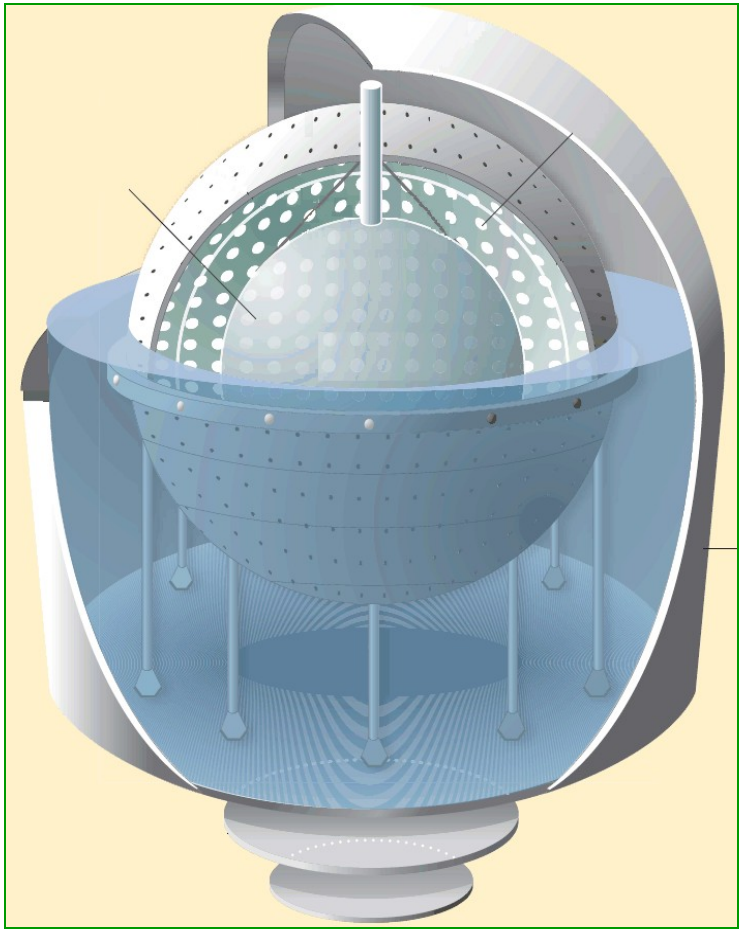
The Sun by Neutrinograph

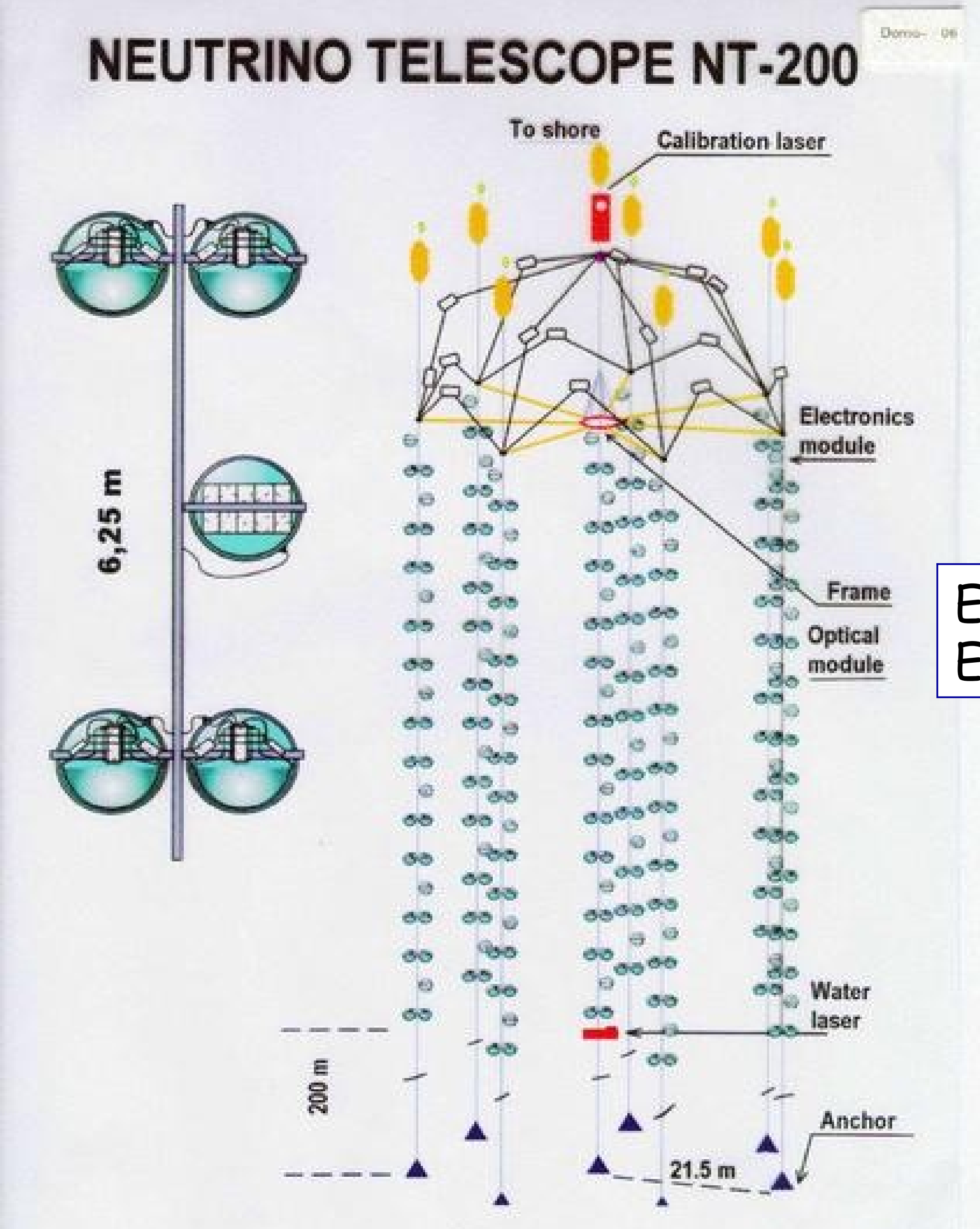






Borexino





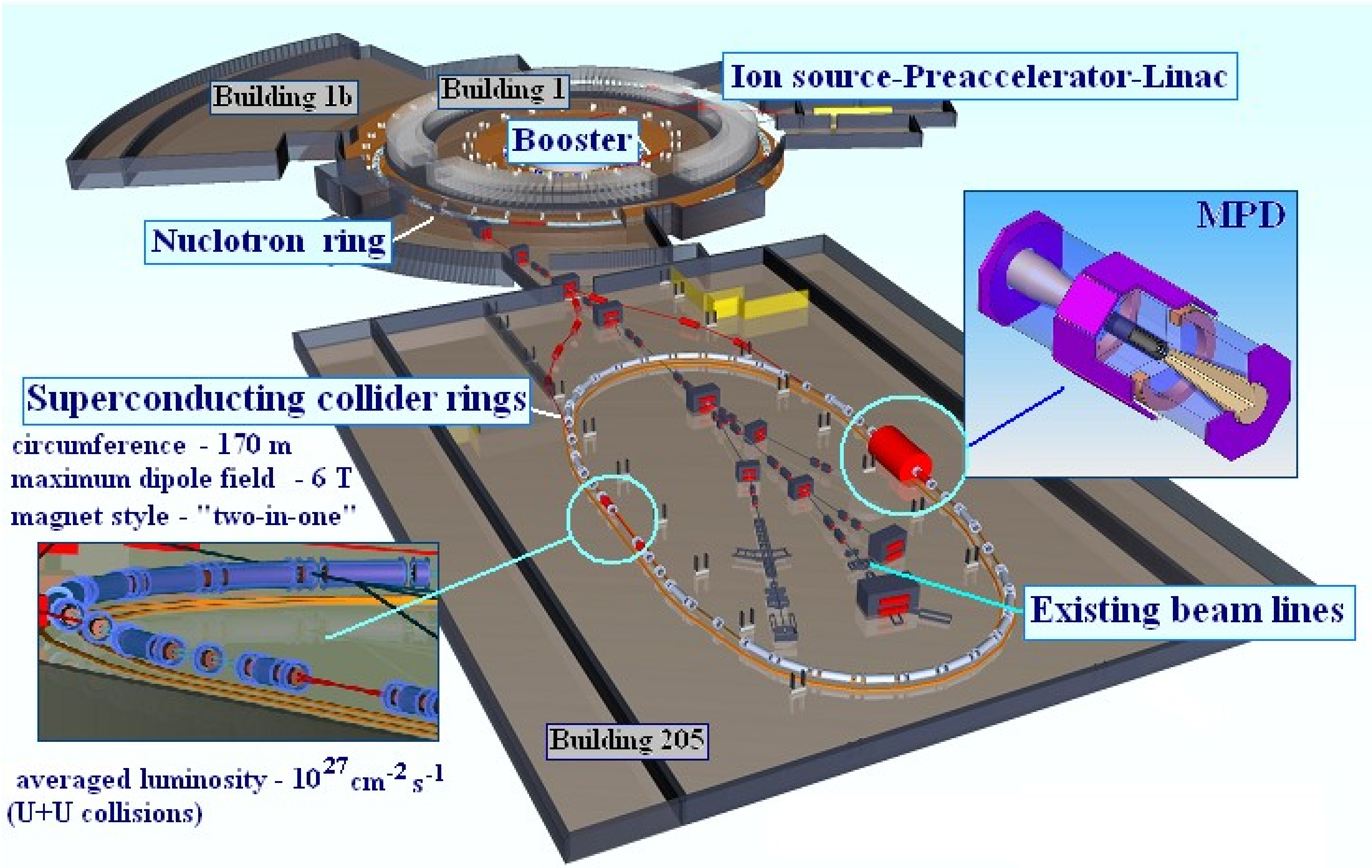
- 8 strings: 192 optical modules
  - → 96 measuring channels
  - → T, Q measure
    - *Timing ~ 1 nsec
    - *Dyn. Range ~ 10^3 ph.e.

Effective muon-area: 1 TeV~2000m^2
Eff. shower volume: 10TeV~ 0.2Mt

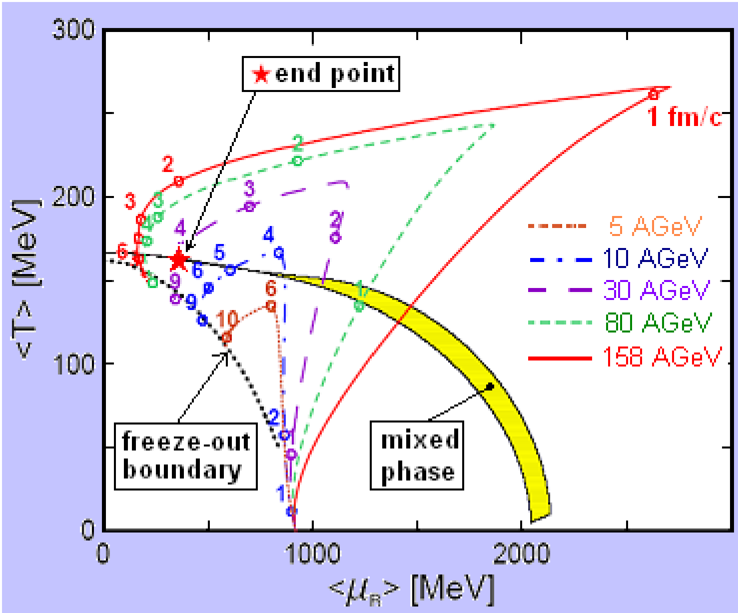
Quasar PMT: d = 37cm

Height x ∅ = 70m x 40m, V_{geo}=10^5m^3= 0.1Mton

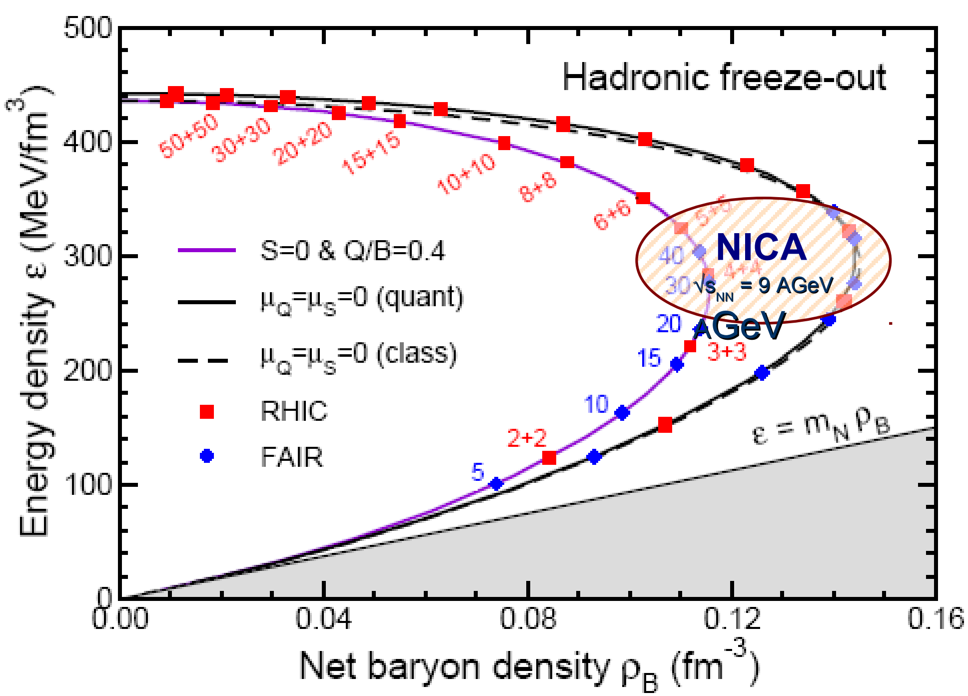
NICA experiment



Construction schedule:
Start up configuration stage - 2019
Full scale experimental setup - 2023



Phase trajectories in the phase diagram calculated within the 3-fluid hydrodynamic model for central Au+Au collisions at different energies (Yu. Ivanov V.N.Russkikh, V.D.Toneev, 2005; A.N.Sissakian, A.S.Sorin, M.K.Suleymanov,V.D.Toneev, G.M.Zinovjev, 2005, 2006). Freeze-out curve is shown by dots, the shaded region is a mixed phase for baryon and strange conserved charges. For E_{lab} = 30 AGeV ($\sqrt{s_{NN}}$ = 8 GeV) the trajectory goes near the critical end-point. Points with numbers indicate the time of the system evolution (1 fm/c ~ $3.3\cdot10^{-24}$ sec).



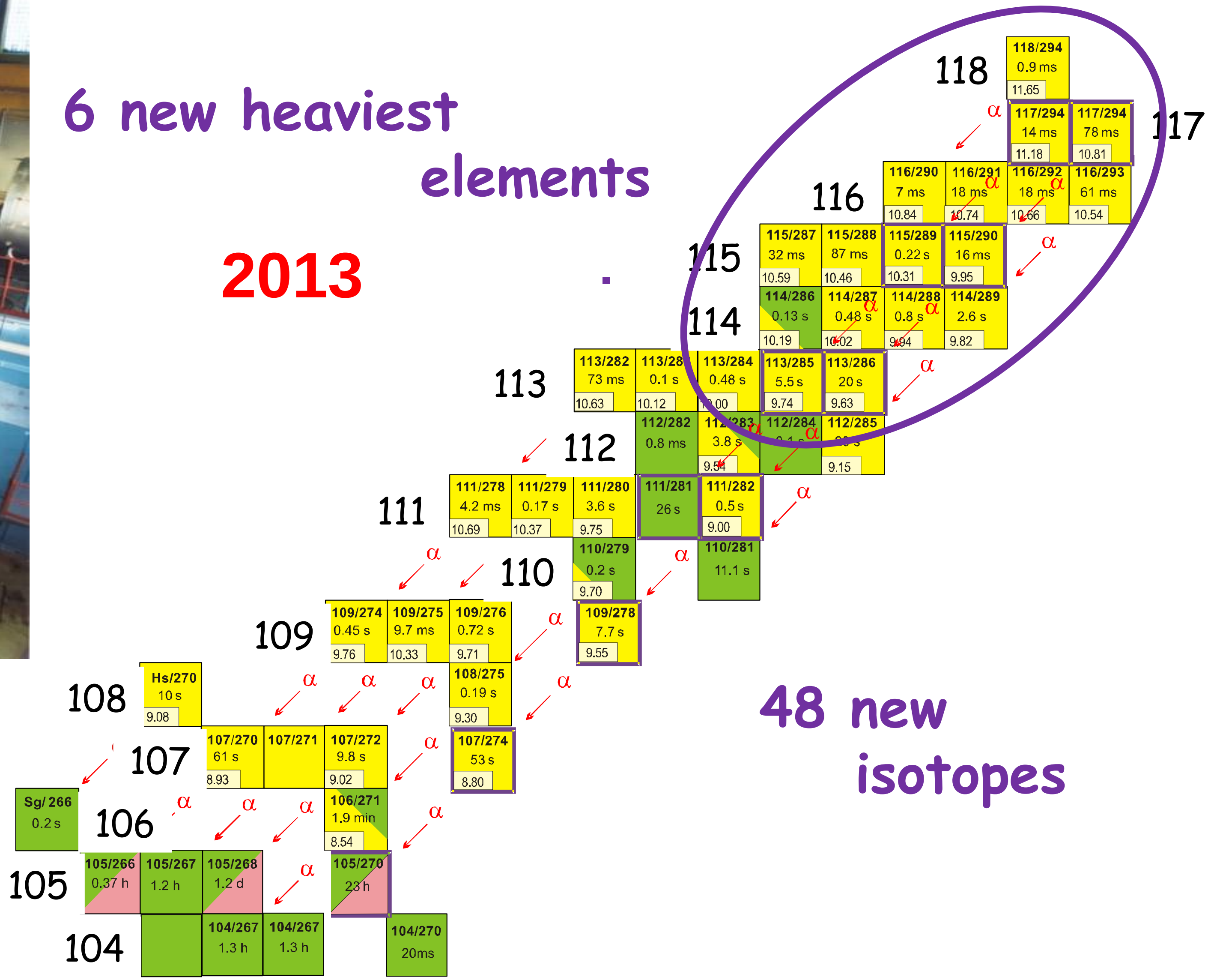
Freeze-out (cease of particle interactions in the system) estimated for different colliding energies (J.Randrup and J.Cleymans, 2006). Freeze-out baryon density is maximal at collider energy $\sqrt{s_{NN}}$= (4+4) GeV. The blue colored numbers stand for energy in the laboratory system, the red ones - in the system of centre of mass.

Super-heavy nuclei research

U400 CYCLOTRON

6 new heaviest elements

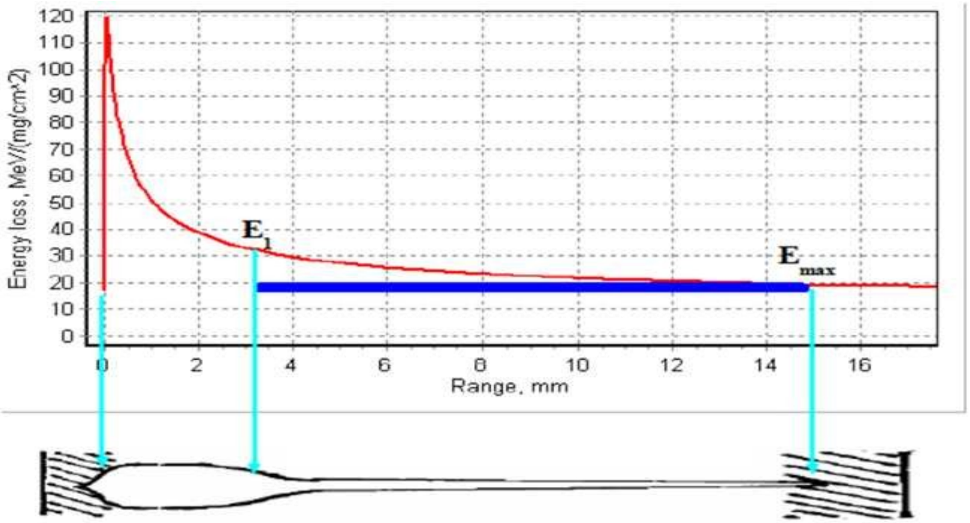
2013



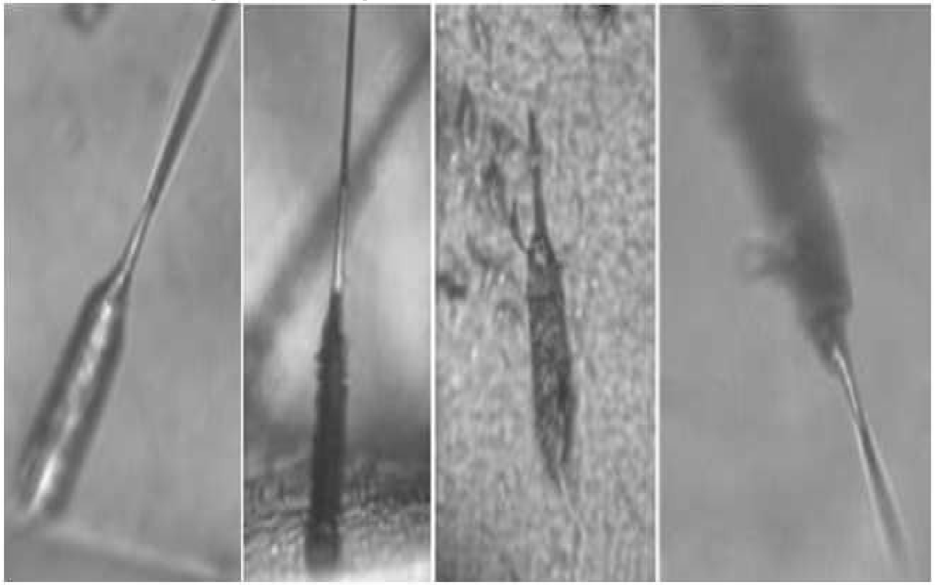
48 new isotopes

Identification of superheavy elements in meteorites

- Olivines – transparent inclusions in meteorites a few mm in diameter
- Several hundred million years of CR bombardment
- Experimental calibration is possible for up to Z = 92
- A few tracks with estimated Z > 105 were observed by different groups
  - V. P. Perelygin et al., 2003, Yadernaya Fizika, 66(8)
  - A.V. Bagulya et al., 2013, JETP Letters, 97(12)



Energy deposition (top) and examples of tracks (bottom)



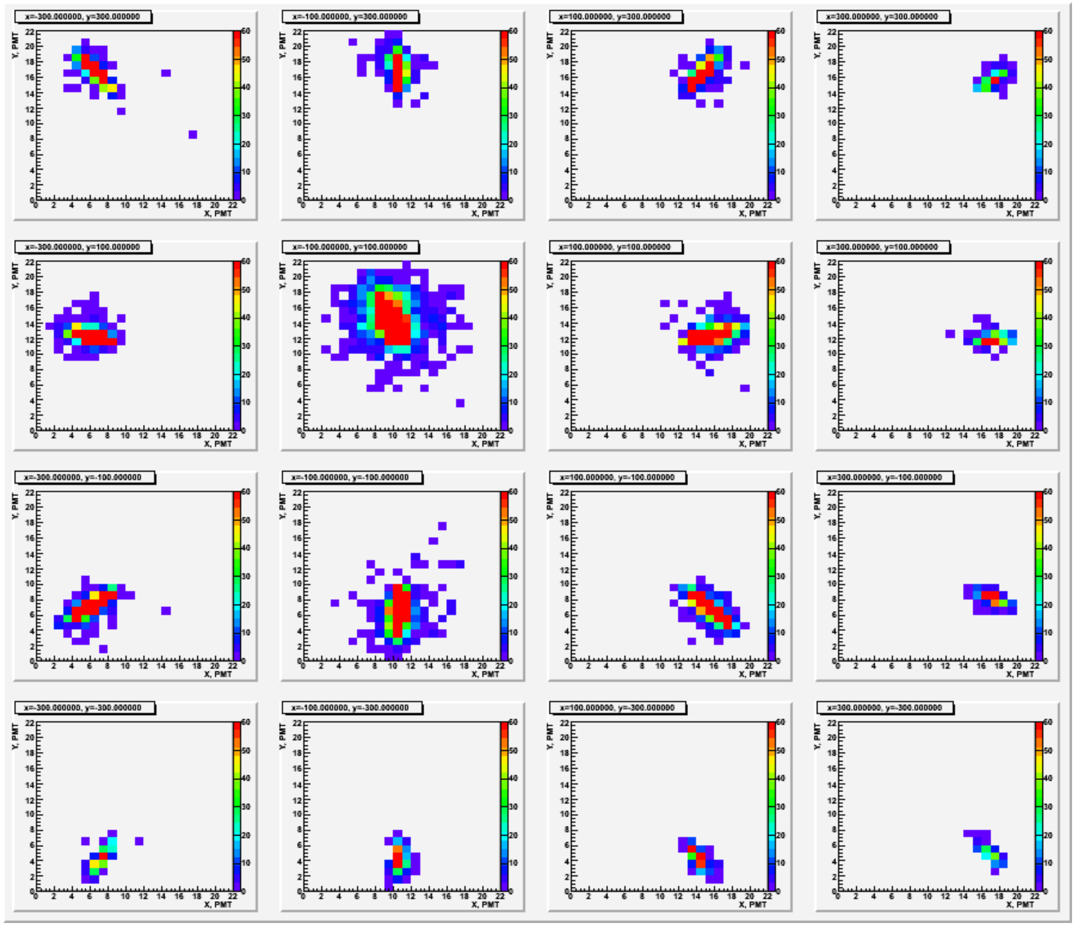
Conclusions

- JINR astroparticle research program involves experiments with varied approaches and energy regions
- Several experiments are successfully taking data and several are under construction
- Astroparticle research is closely connected to other areas of research at JINR

Thank you for your attention

Backup slides

Example of a simulated event for TAIGA
(telescopes here are closer than they will really be)



Gamma
E – 85 Tev
Θ – 25.9°, φ - 176°