

**Astrophysical investigation in
TAIGA experiment
(project continuation)**

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TAIGA collaboration (~80 in list of authors)

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7. IZMIRAN, Moscow Region, Russia
8. DESY, Zeuthen, Germany
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10. JINR, Dubna, Russia
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13. ISS, Bucharest, Romania
14. Altai State University, Barnaul, Russia

HIGH ENERGY GAMMA-RAY ASTRONOMY

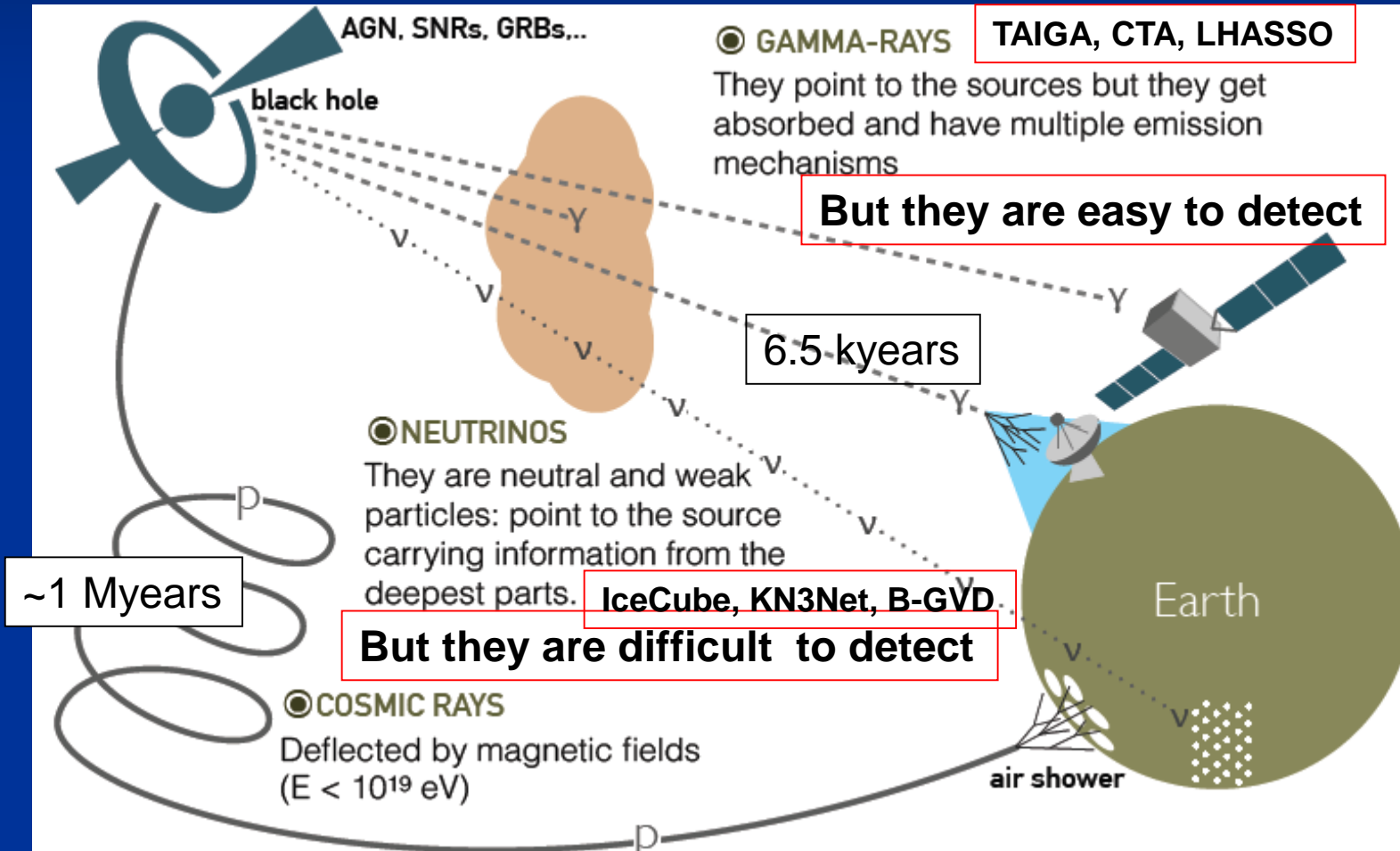
- Sources and methods of investigations. Multimessenger astronomy.

PROJECT TAIGA CONTINUATION

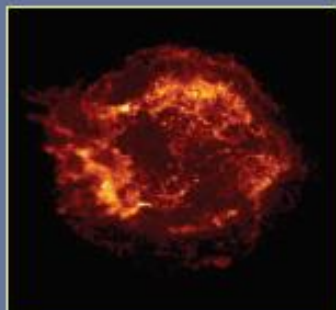
- TAIGA detector. Preliminary results.
- Future detectors
- TAIGA project continuation

Why gamma-ray astronomy?

To understand how Cosmic Accelerators work we need to detect cosmic rays, gamma – rays and neutrinos



Physics objectives



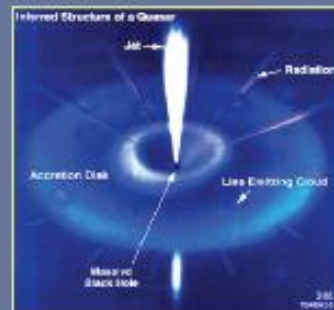
SNRs



Pulsars
and PWNe



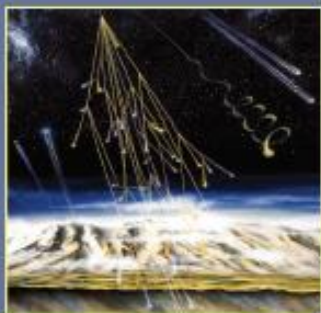
Micro quasars
X-ray binaries



AGNs



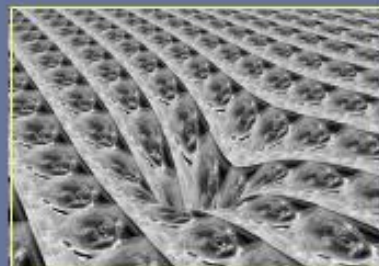
GRBs



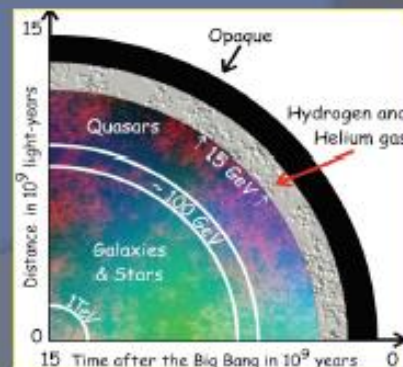
Origin of
cosmic rays



Dark matter

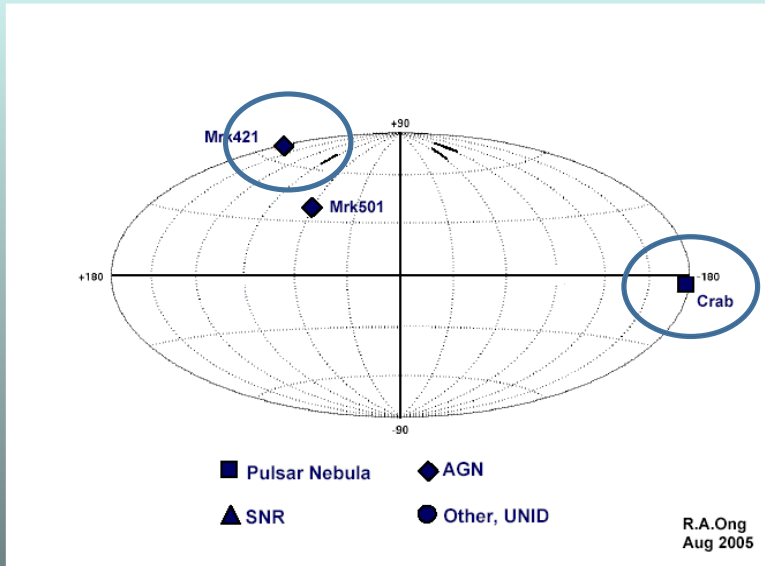


Space-time
& relativity



Cosmology

The VHE Sky - 1995

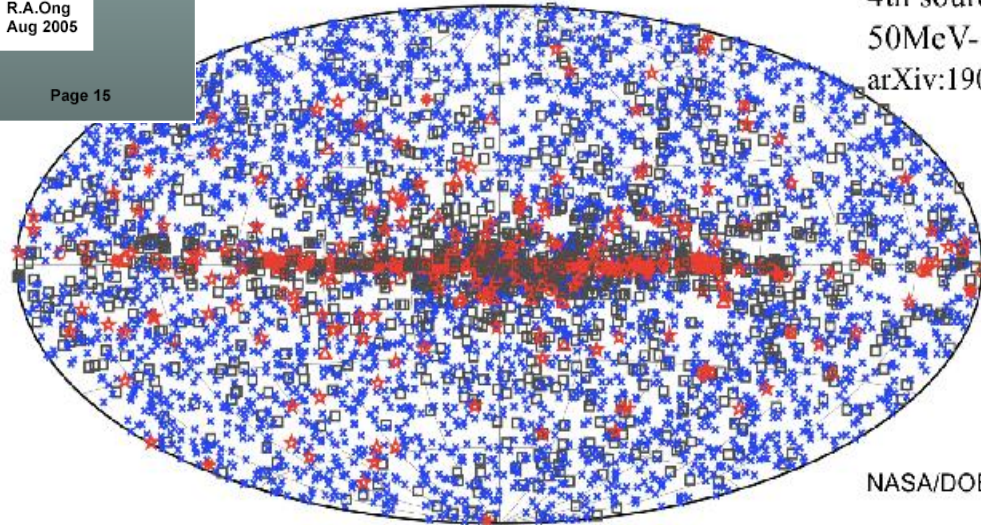


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Fermi-LAT γ -ray sky

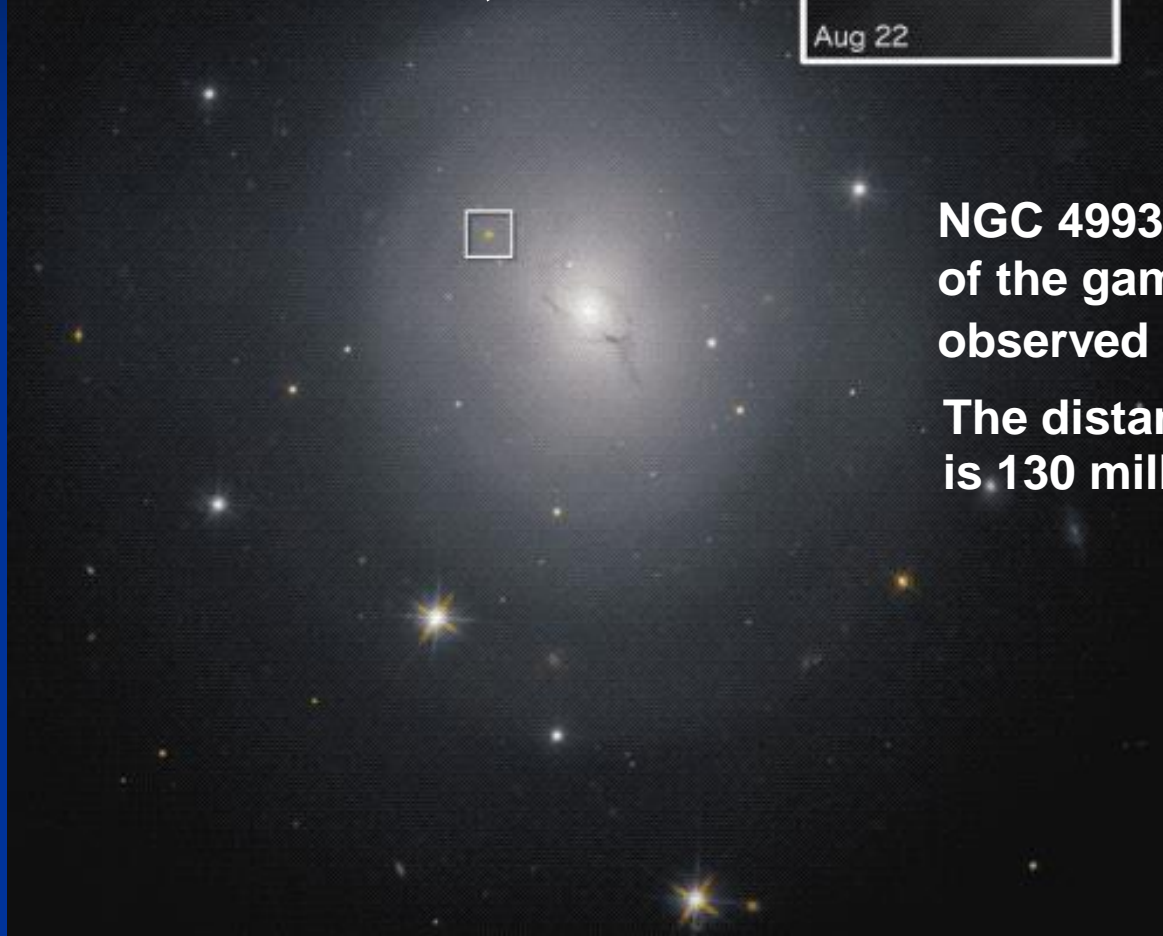
4th source catalog
50MeV-1TeV (8 yrs)
arXiv:1902.10045_v3



 No association	 Possible association with SNR or PWN	 AGN
 Pulsar	 Globular cluster	 Starburst Galaxy
 Binary	 Galaxy	 PWN
 Star-forming region	 Unclassified source	 Nova

- > 5000 sources > 100 MeV
- > 1550 sources above 10 GeV (3FHL) *Fermi-LAT Collab., ApJS, 232 (2017)*

**Simultaneous observation
gravity signal GW170817 and
gamma-ray burst GRB170817A
(Fermi и INTEGRAL)**



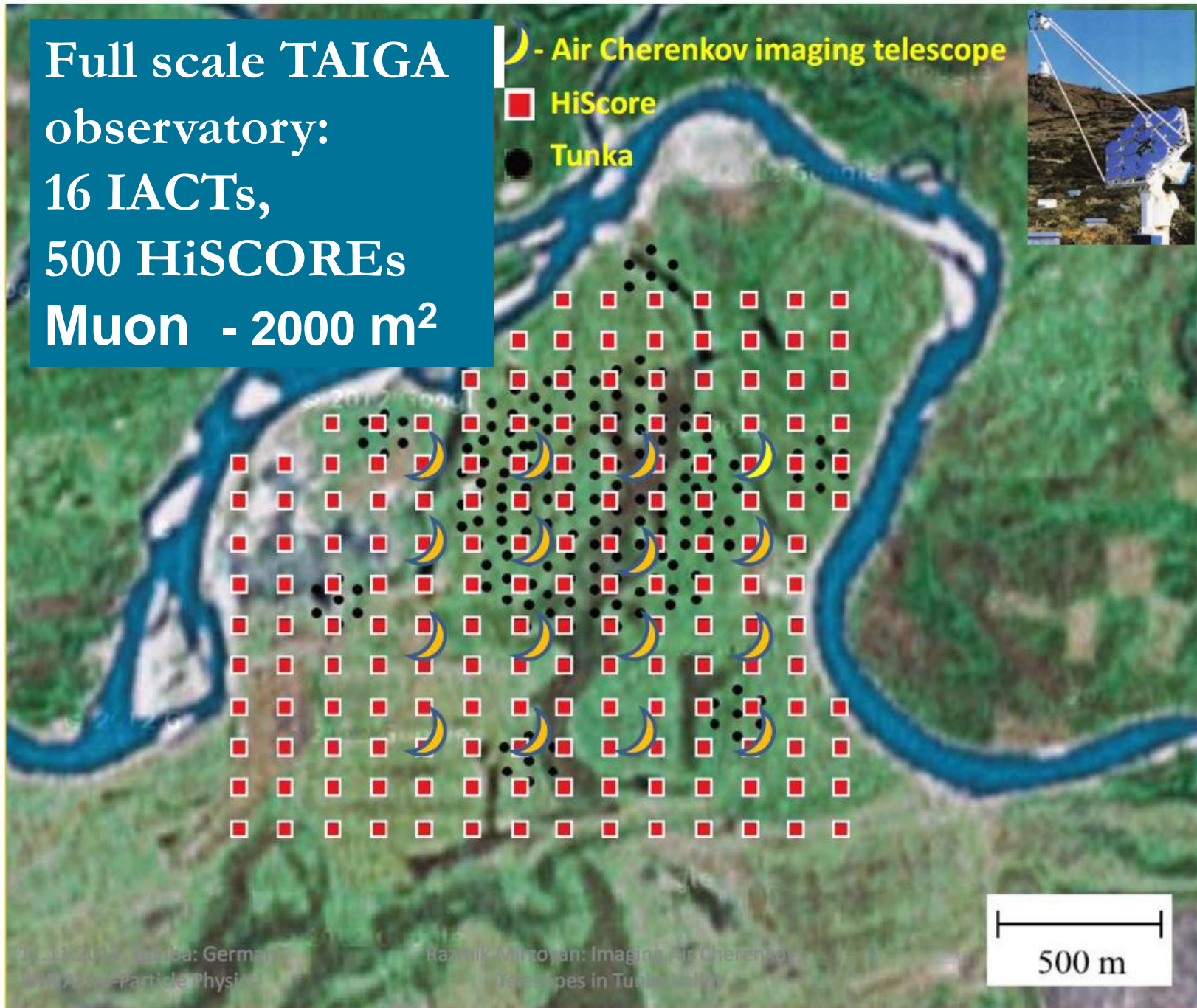
**NGC 4993 and the optical afterglow
of the gamma-ray burst (inset)
observed at Hubble space telescope**

**The distance to the source
is 130 million light years**

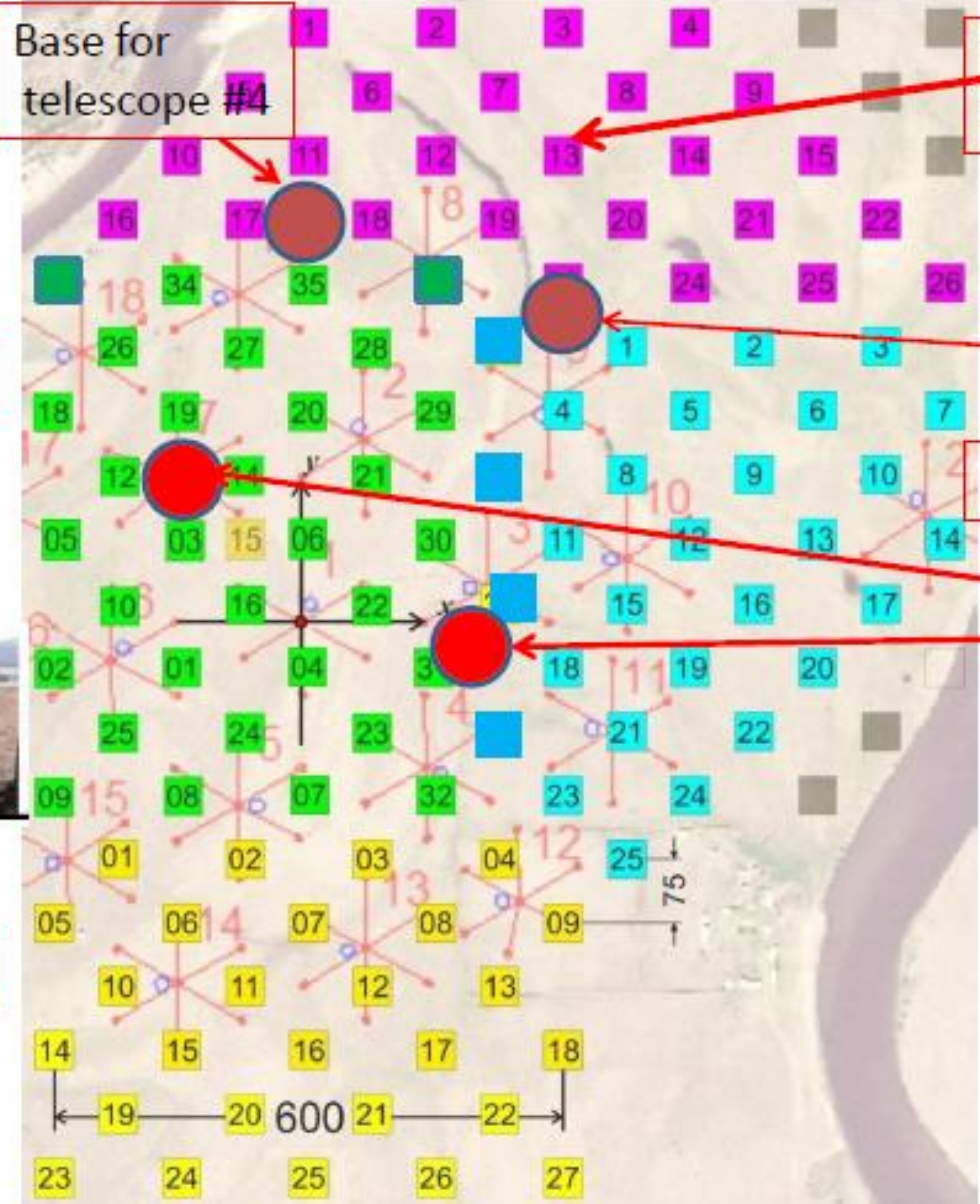
TAIGA EXPERIMENT

Full scale TAIGA
observatory:
16 IACTs,
500 HiSCOREs
Muon - 2000 m²

- ☾ - Air Cherenkov imaging telescope
- HiScore
- Tunka



TAIGA EXPERIMENT 2020



Base for telescope #4

Cluster #4(30 station autumn 2020)

Cluster#1

Telescope #3 autumn 2020



Cluster #2



IACT#2
20/01

2018

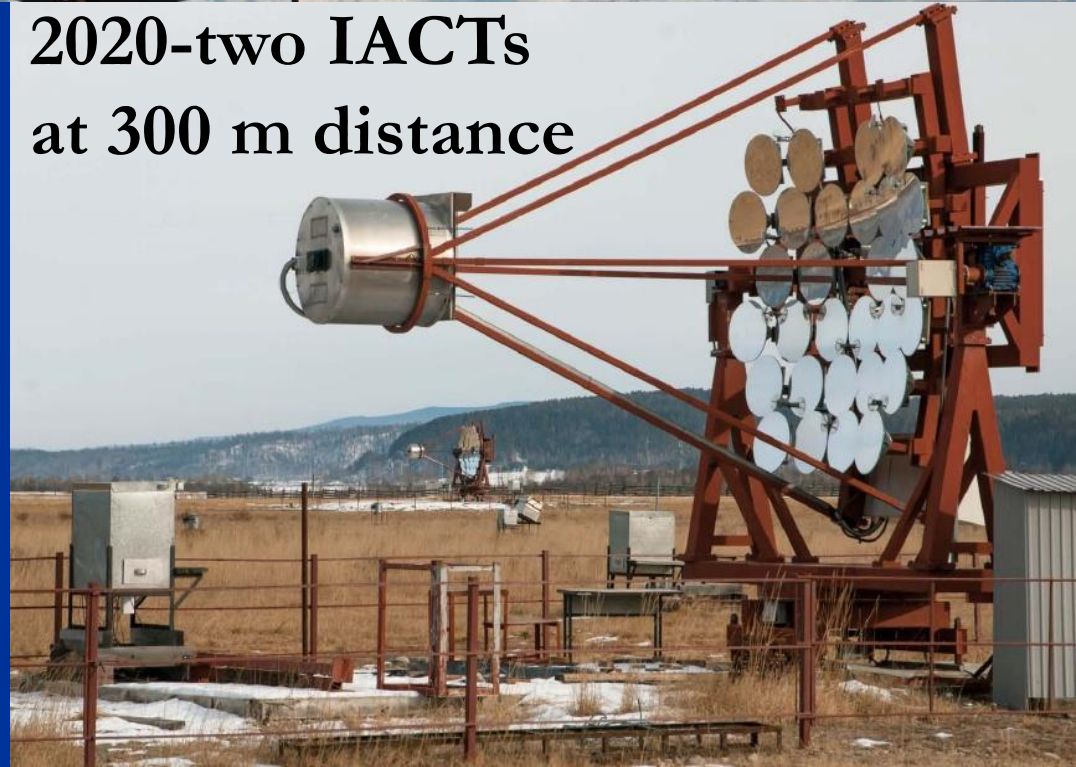


2019



TAIGA-HiSCORE

2020-two IACTs
at 300 m distance



Main IACT parameters;

Spherical shape of 34 mirror modules with \varnothing 60 cm and with a total mirror area of 9.6 m²;

Viewing angle \pm 4.86°;

Turn around the horizontal axis (θ angle) -10 + 95°;

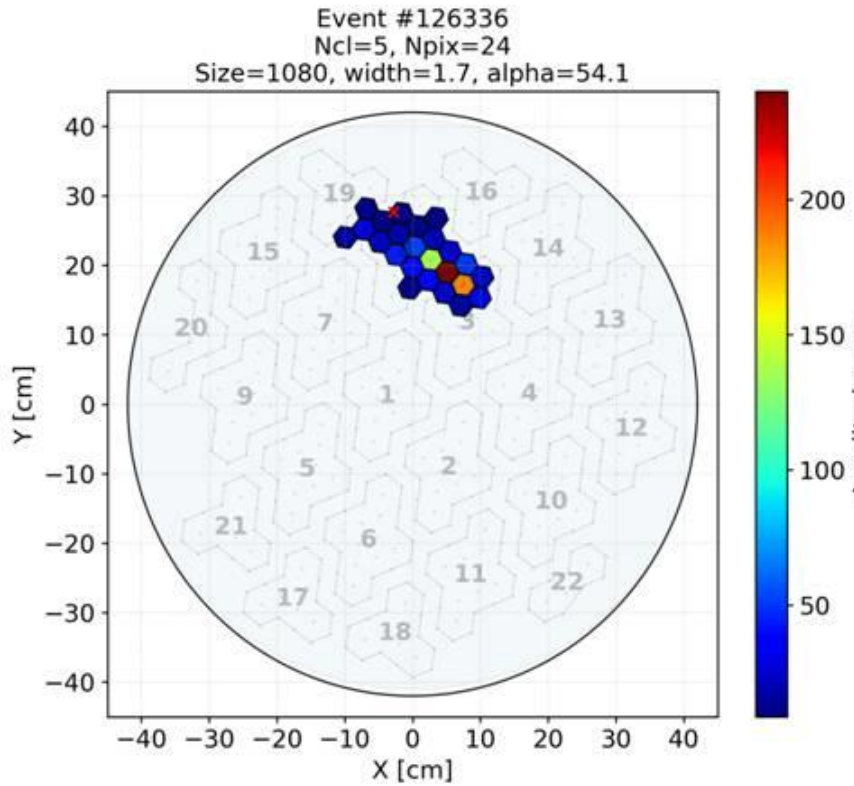
Turn around the vertical axis (φ angle) 0-410°;

The angular accuracy is 0.01°;

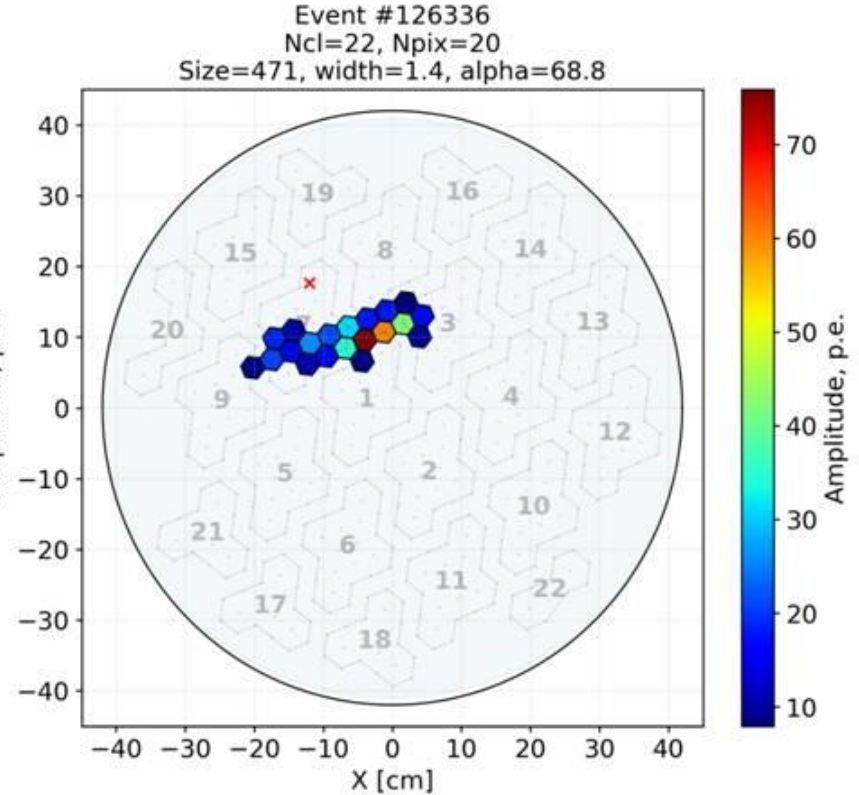
Driving and positioning system – remote with the possibility of computer control;

The rotation speed is \sim 2 deg/sec;

The camera with diameter of \sim 95 represents the matrix of PMTs with FE and DAQ electronics. The weight of the camera is \sim 200 kg and it is fixed at a focal length of 475 \pm 1 cm from the dish. Operating conditions – temperature: минус 40 to plus 30°C and high humidity



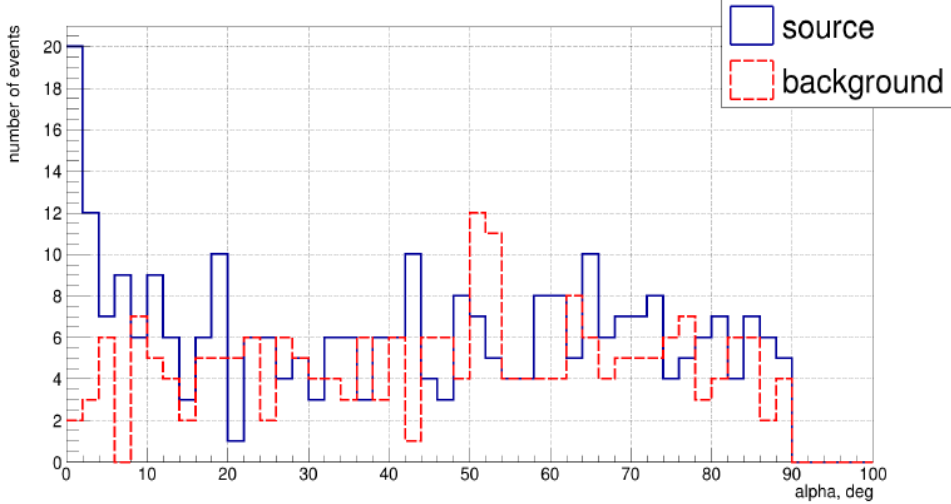
Size = 1080 pe, Width = 0.20 °



Size = 471 pe, Width = 0.17 °

An example of EAS event that was measured by two TAIGA-IACTs

Data analysis 2019-2020

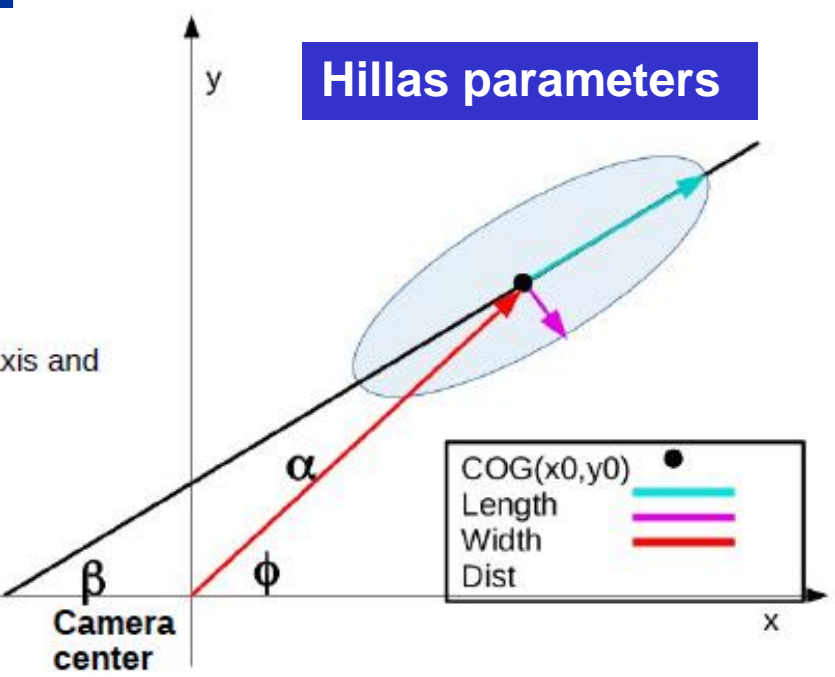


60 h

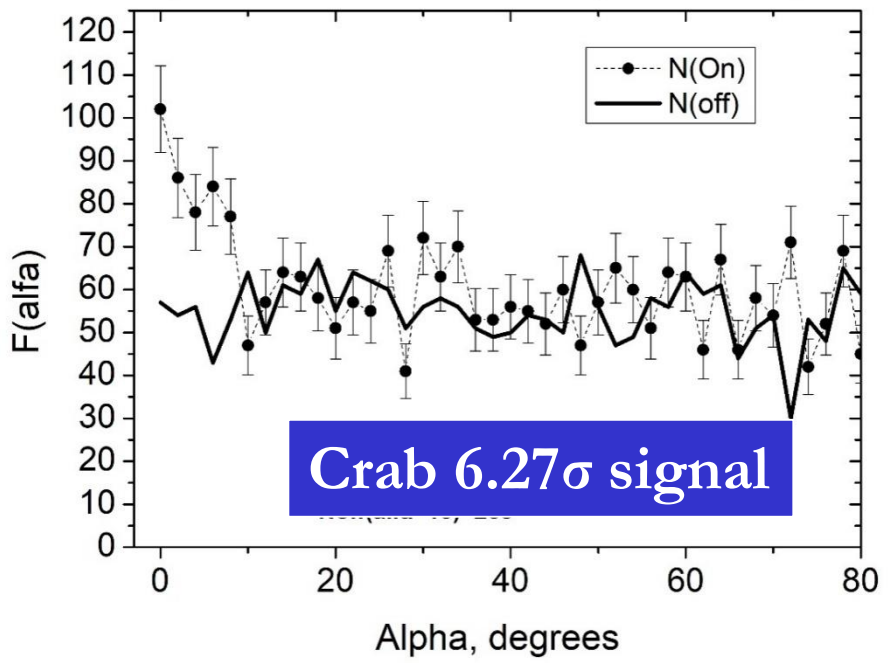
Mrk-421 5σ signal

Alfa < 8°, Size > 170 p.e : non = 48, non1 = 11. nexc = 37

Significance (Li&Ma) = 5.00



$S > 120$ p.e. $\text{dist} = 0.36^\circ - 1.5^\circ$, $W \ll 0.075 \cdot \lg S - 0.046$ $L < 0.3^\circ$, $C > 0.54$



JINR activity – production, tests and delivery 4th IACT R&D and fabrication of the mirror facets for IACTs

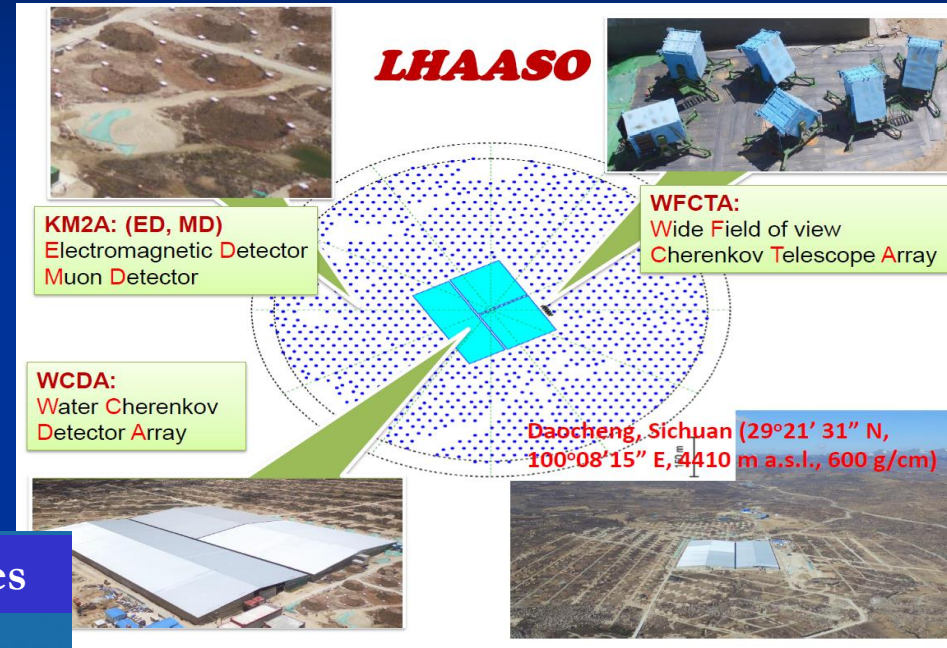
3rd IACT commission and tests
in JINR



Foundation of 4th IACT in Tunka

Energy spectrum of gamma: $\sim E^{-2}$. For Multi-Tev Gamma – ray astronomy we need array with area more than 1 km²

FUTURE DETECTORS

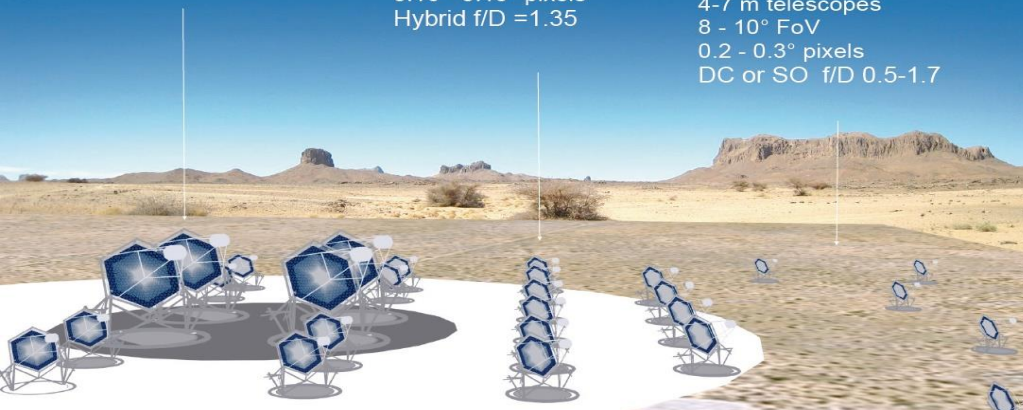


~23m telescopes
4 - 6° FoV
0.08 - 0.12° pixels
Parabolic/Hybrid f/D~1.2

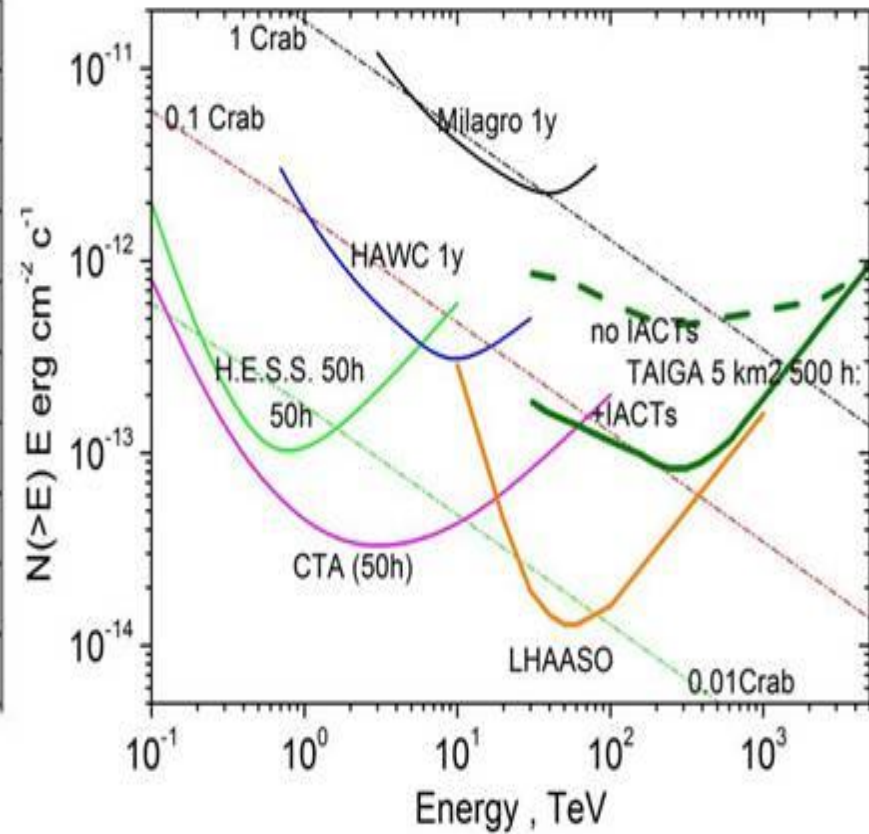
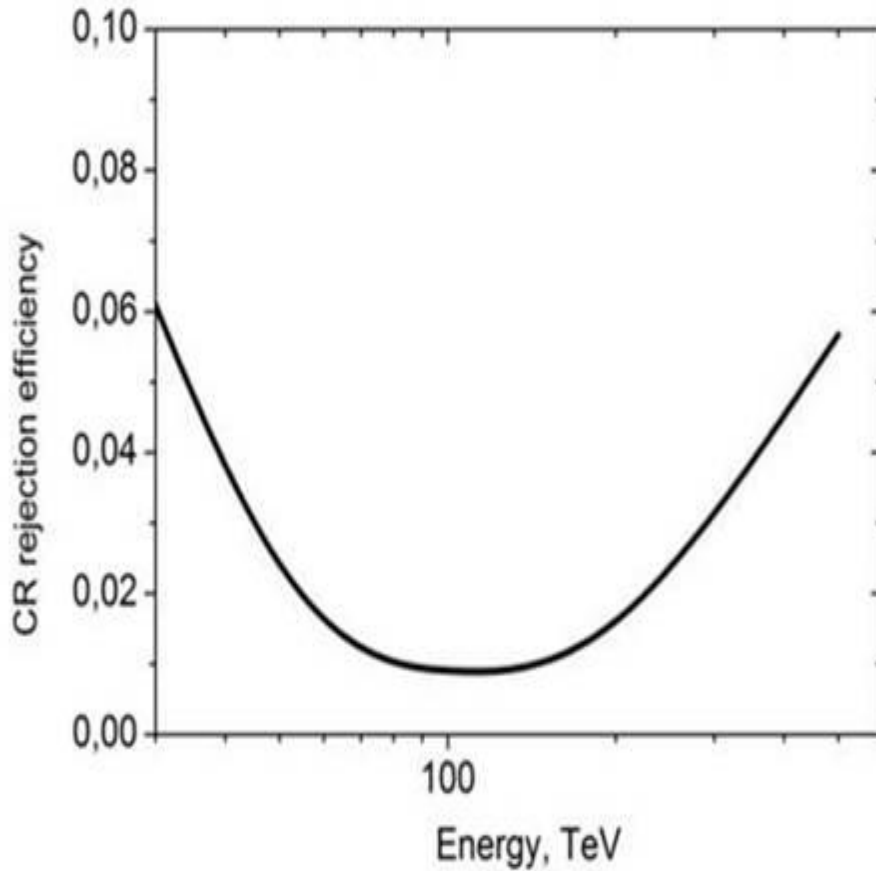
12m telescopes
7 - 8° FoV
0.16 - 0.18° pixels
Hybrid f/D =1.35

4-7 m telescopes
8 - 10° FoV
0.2 - 0.3° pixels
DC or SO f/D 0.5-1.7

TA ~100 telescopes



**LHAASO Tibet 4400 m a.s.l.
1 sq.km,
~10000 different detectors**



Left: Cosmic rays rejection efficiency. Right: Integral sensitivity for point sources for a 5 km² observatory. The dashed line marks the sensitivity without IACTs.

Expenditure for project (k\$)

Astrophysical investigation in TAIGA experiment

Expense items	Total	2021	2022	2023
Direct expenditure				
1.LNP Design bureau (hours)	1000	800	100	100
2.LNP Workshop (hours)	1400	800	300	300
3.NPO “Atom” (hours)	30	30		
4.Materials	60	40	10	10
5.Equipment	60	40	10	10
6.Research work (contracts)	15	5	5	5
7.Business trips, including:				
- to states outsides rouble zone	30	10	10	10
- to states insides rouble zone	24	8	8	8
Total direct expenditure	189.0	103	43	43
RSF grant, Mpyб	12	6	6	-

Conclusion

- Mechanics of three IACTs have been designed, produced in JINR and delivered to Tunka astrophysical center at 2016-2020

Plans for 2021-2023:

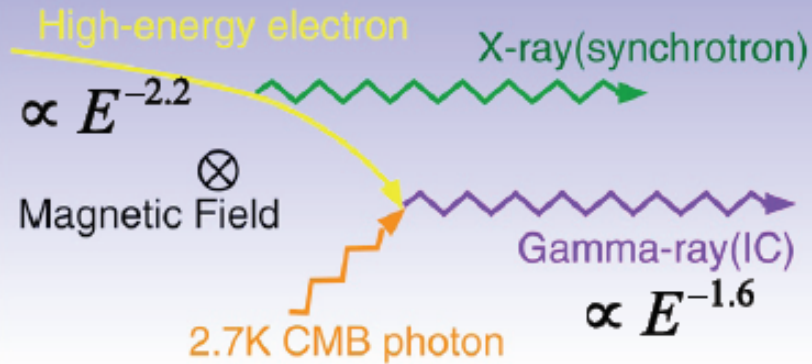
- 4th IACT fabrication and tests equipped with Dubna's focusing mirror facets - 2020-2021 (Kirichkov, LT, Borodin, Skrypnik, Pan, Grinyuk, Sagan)
- 4th IACT delivery and commission at Tunka (LT, Borodin, Pan)
- **Dubna's group activity - 2020-2023**
 - in MC simulation (Grinyuk, Satyshev, Lavrova, Pan)
 - in data taken at Tunka area (Sagan, Pan)
 - in physical analysis (LT, Grinyuk, Satyshev, Lavrova, Pan, Grebenyuk)
- full scale TAIGA project preparation (LT, Borodin, Grinyuk)

A group of 18 people, including men and one woman, are posing for a group photo in a large industrial factory. They are arranged in several rows, with some standing on a large, complex metal structure that appears to be a mold or part of a machine. The structure is made of grey metal beams and plates, with many triangular and rectangular components. The background shows the factory's interior with high ceilings, steel beams, and large windows on the left side. A blue banner with the text "THANK YOU" is superimposed over the top part of the image. The people are dressed in casual work clothes, including t-shirts, polo shirts, and jackets. One man in the back row is wearing a black t-shirt with "JACK DANIEL'S" printed on it. The overall atmosphere is professional and appreciative.

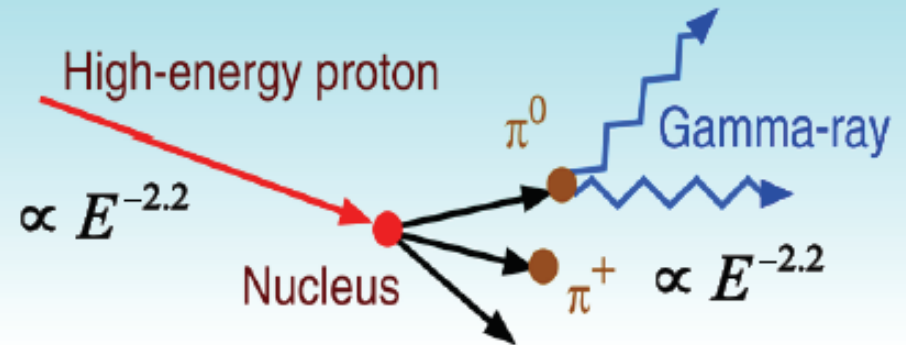
THANK YOU

HIGH ENERGY GAMMA RAYS SOURCES

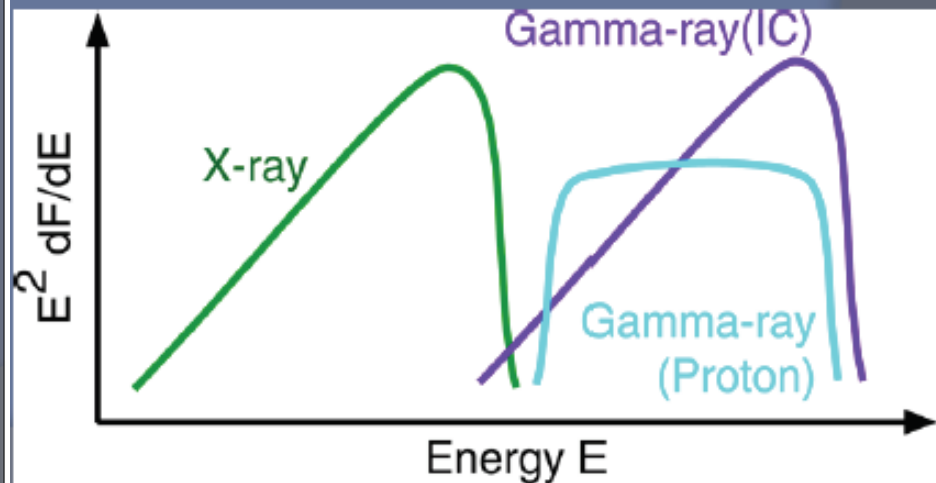
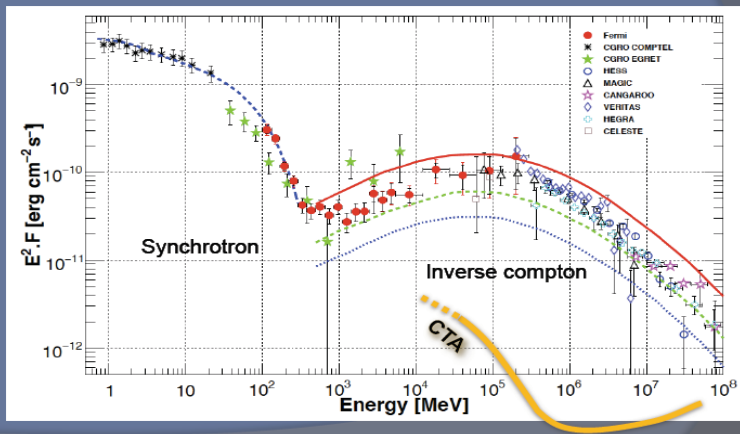
Electron acceleration

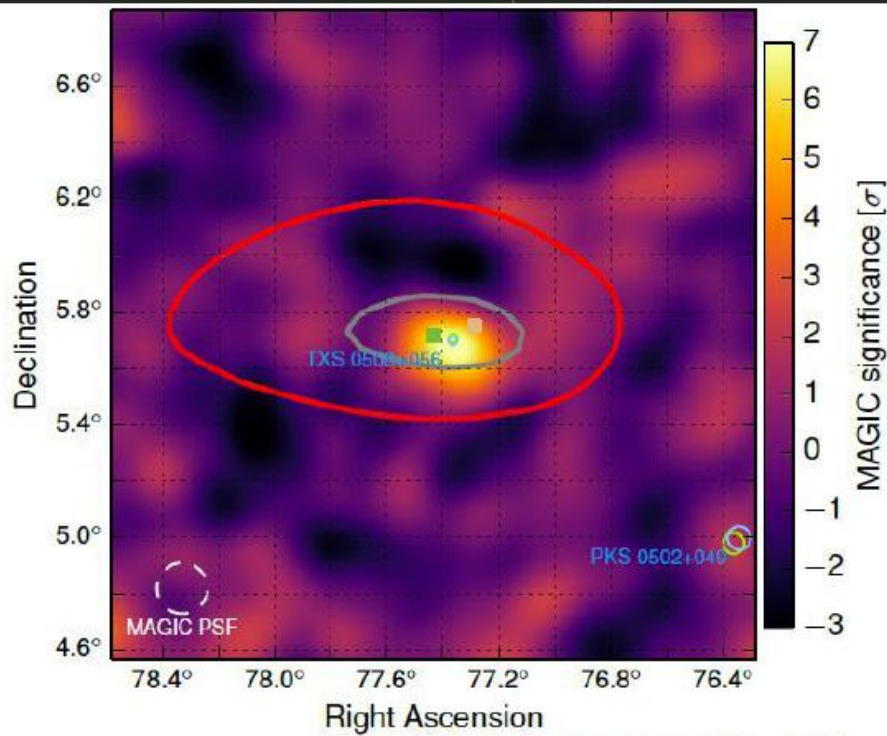


Proton acceleration



Crab Nebula





IceCube 170922

$Z=0.34$ distance ~ 1.7 Gpc

$E_\nu \sim 290$ TeV

Fermi
detects a flaring
blazar within 0.06°

MAGIC
detects emission of
> 100 GeV gammas

Корреляция на уровне 3σ

