TAIGA-HiSCORE – results from the first two operation seasons

http://taiga-experiment.info/

Presenter: Igor Yashin

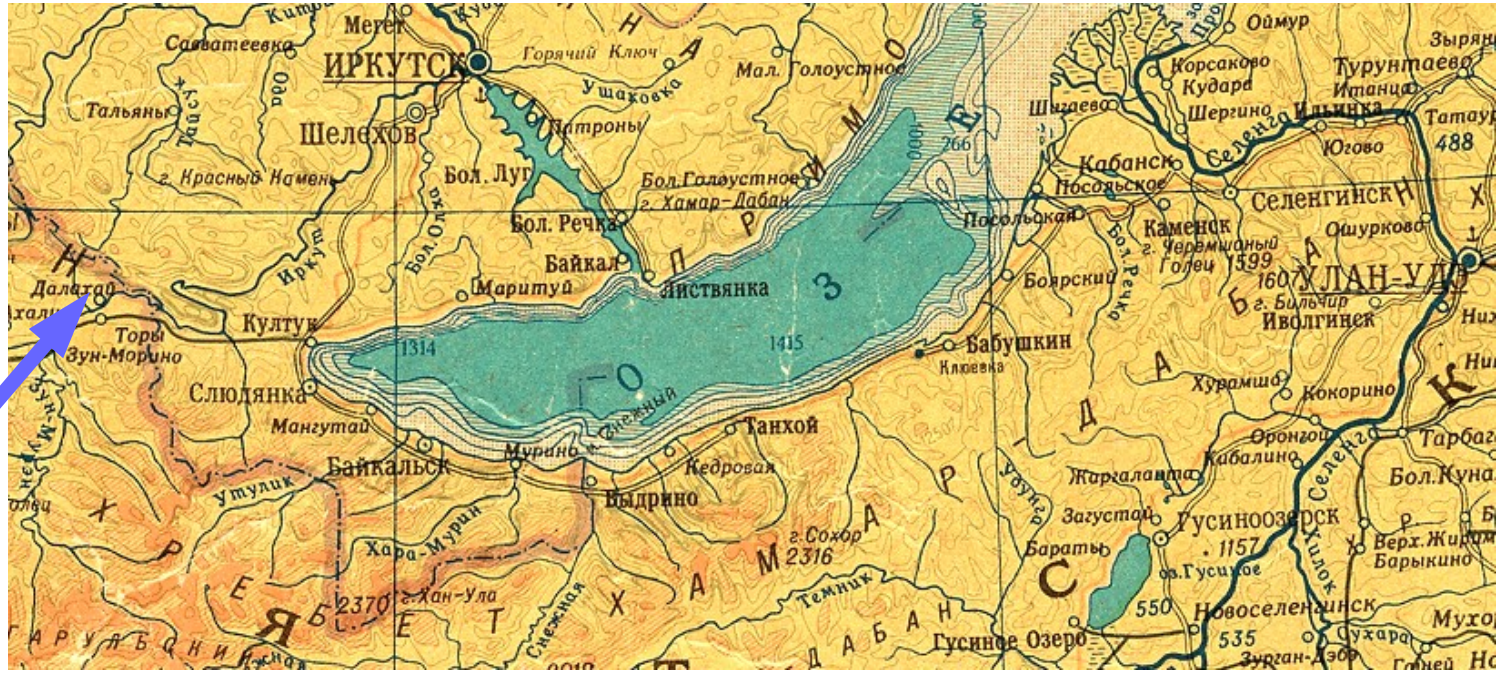
GA 299: M. Tluczykont et al. for the TAIGA Collaboration

ICRC 2017, Busan

TAIGA collaboration

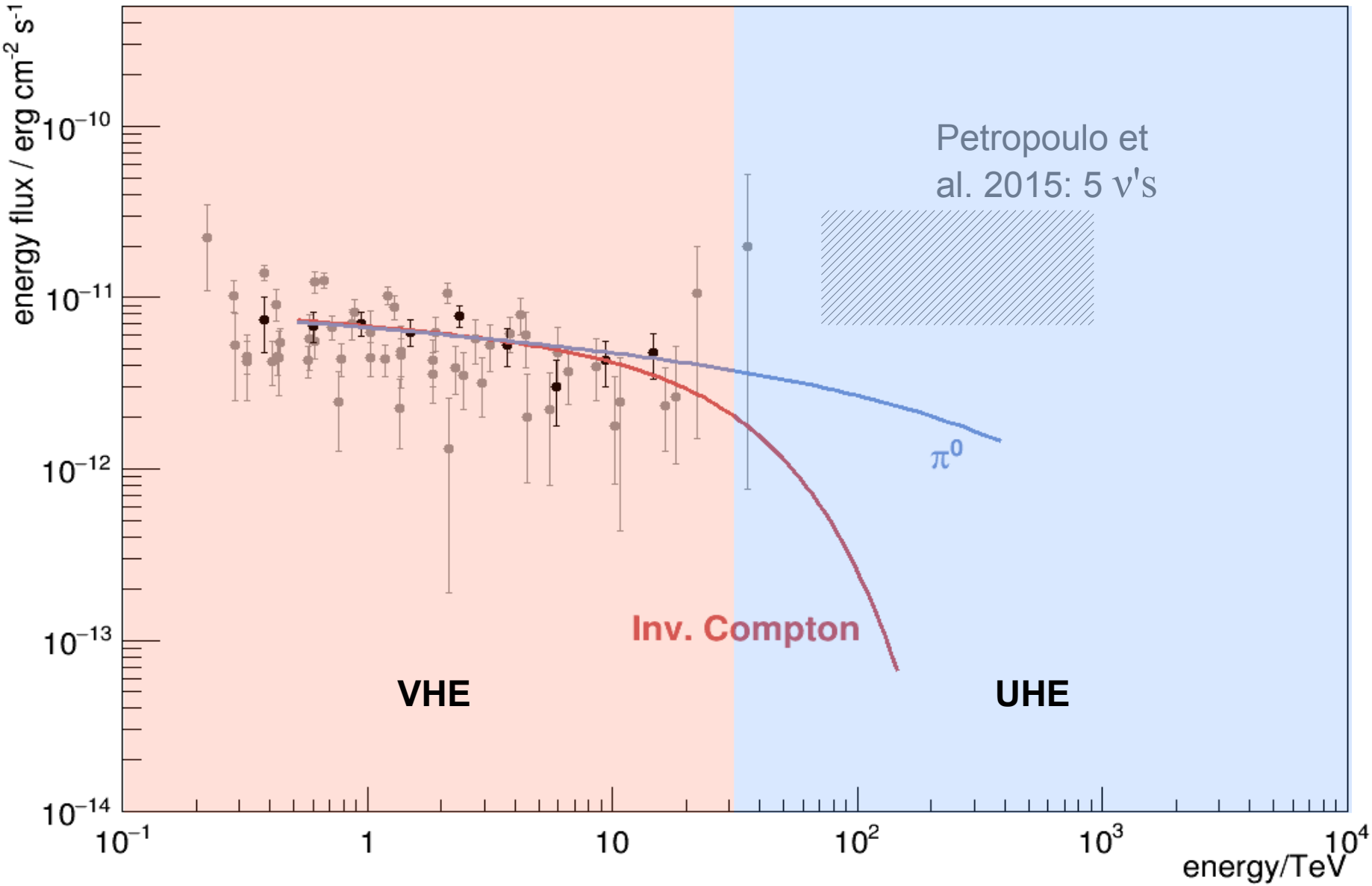
→ **see N. Budnev, this conf.**

- *Skobeltsyn Institute of Nuclear Physics MSU, Moscow, Russia*
- *Institute of Applied Physics, ISU, Irkutsk, Russia*
- *Institute for Nuclear Research of RAN, Moscow, Russia*
- *Dipartimento di Fisica Generale Universiteta di Torino and INFN, Torino, Italy*
- *Max-Planck-Institute for Physics, Munich, Germany*
- *Institut für Experimentalphysik, University of Hamburg, Germany*
- *IZMIRAN, Moscow Region, Russia*
- *DESY, Zeuthen, Germany*
- *National Research Nuclear University MEPhI, Moscow, Russia*
- *JINR, Dubna, Russia*
- *Novosibirsk State University, NSU, Novosibirsk, Russia*
- *Budker Institute of Nuclear Physics SB RAS, Novosibirsk, Russia*
- *ISS, Bucharest, Romania*



Tunka-133 site

VHE-UHE Gamma-ray astronomy



TAIGA: Tunka Advanced International Gamma-ray and cosmic ray Array

TAIGA-HiSCORE timing array

TAIGA-IACT imaging telescopes

TAIGA muon counters

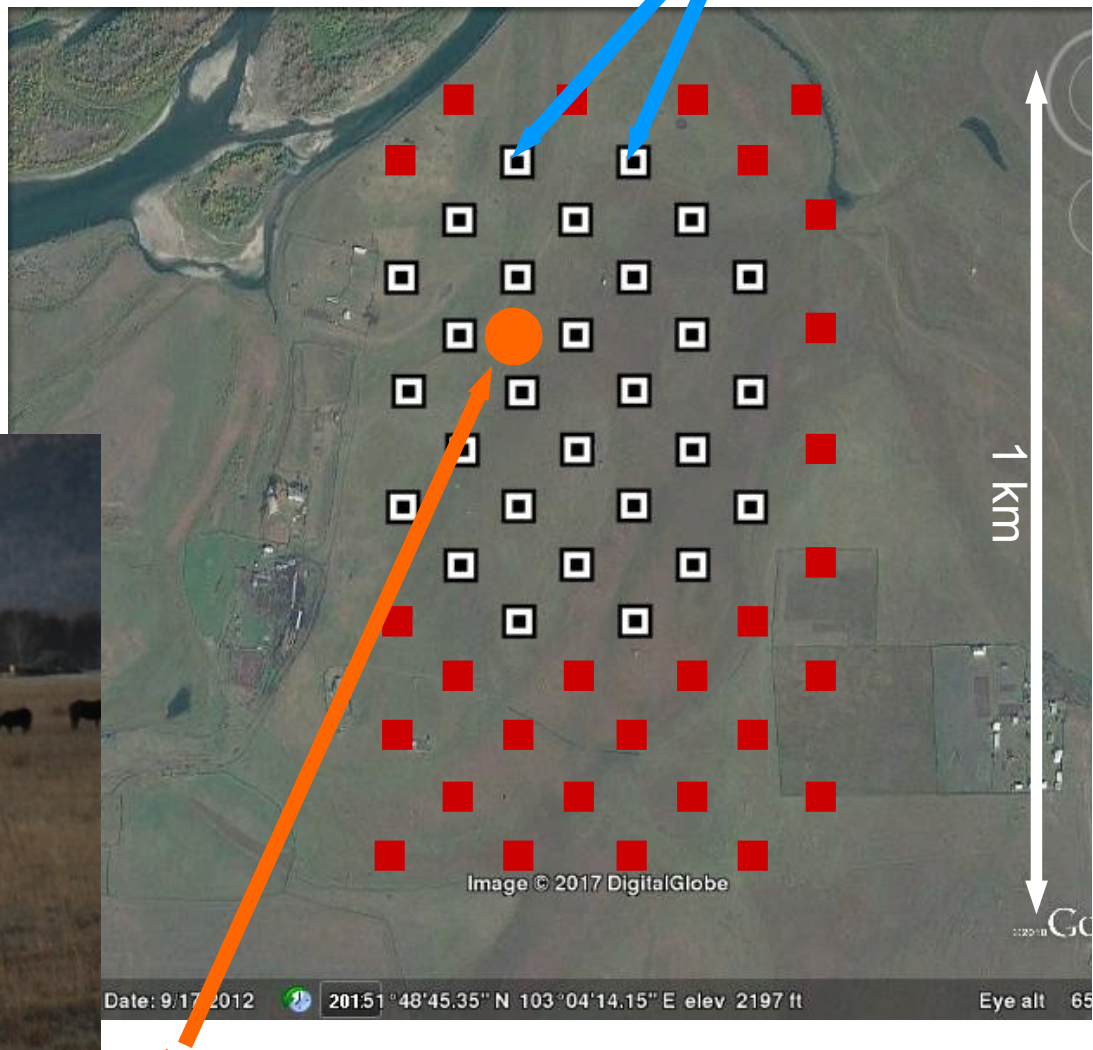
Timing array:
2015: 0.25 km² / 28 stations
2017: 0.6 km² / 60 stations
2018: 1.0km² / 100 stations
Plan: (4yrs) 5 km² / 500 st.

Imaging:
2016/17: 1 IACT
2018/19: +2 IACTs
Plan: 16 IACTs

Currently on-site: Tunka-Grande
Plan: (C8H8)n / 2000 m²

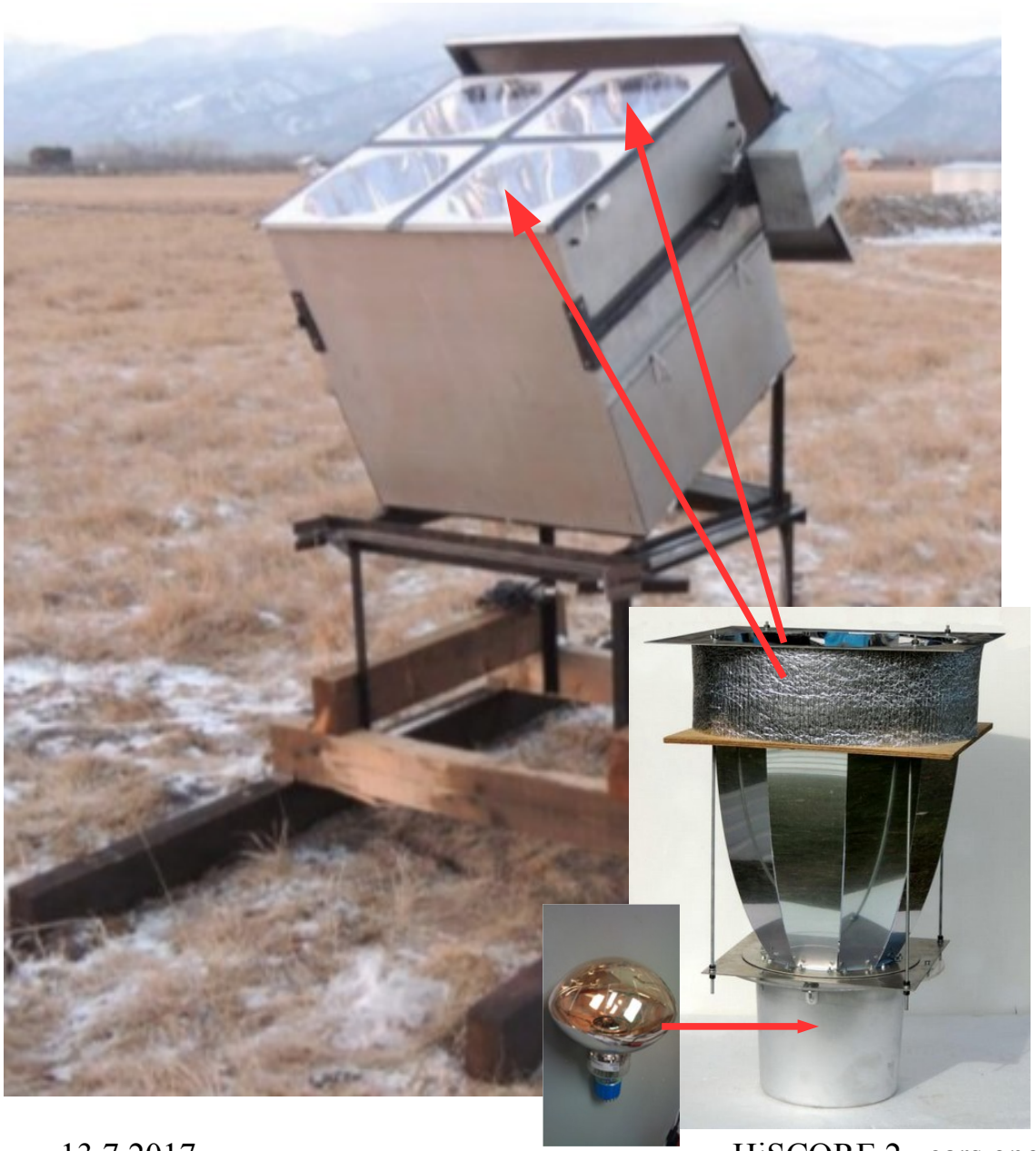
TAIGA-HiSCORE: timing stations

- Total: 28 stations (2015)
- average spacing 106 m
- instrumented area 0.25km²
- Extension plan ongoing: ■



1st TAIGA-IACT
(see N. Budnev TAIGA)

TAIGA timing stations



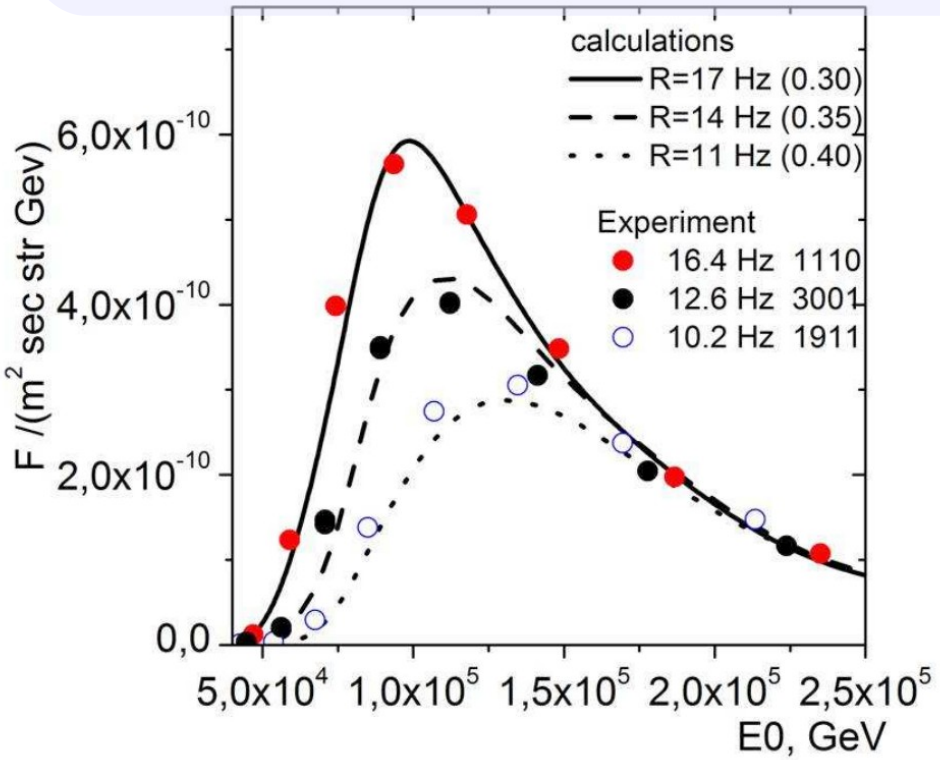
- Three-four 8" PMTs
- Winston cones
  light collection 0.5 m²
- FoV ~0.6 sr
- “Tilting” for extension of sky coverage
- GHz readout
- **Sub-ns** array-wide time synchronization
  - Crucial for angular resolution
  - 1st time successful implementation of **km-scale** sub-ns synchronization

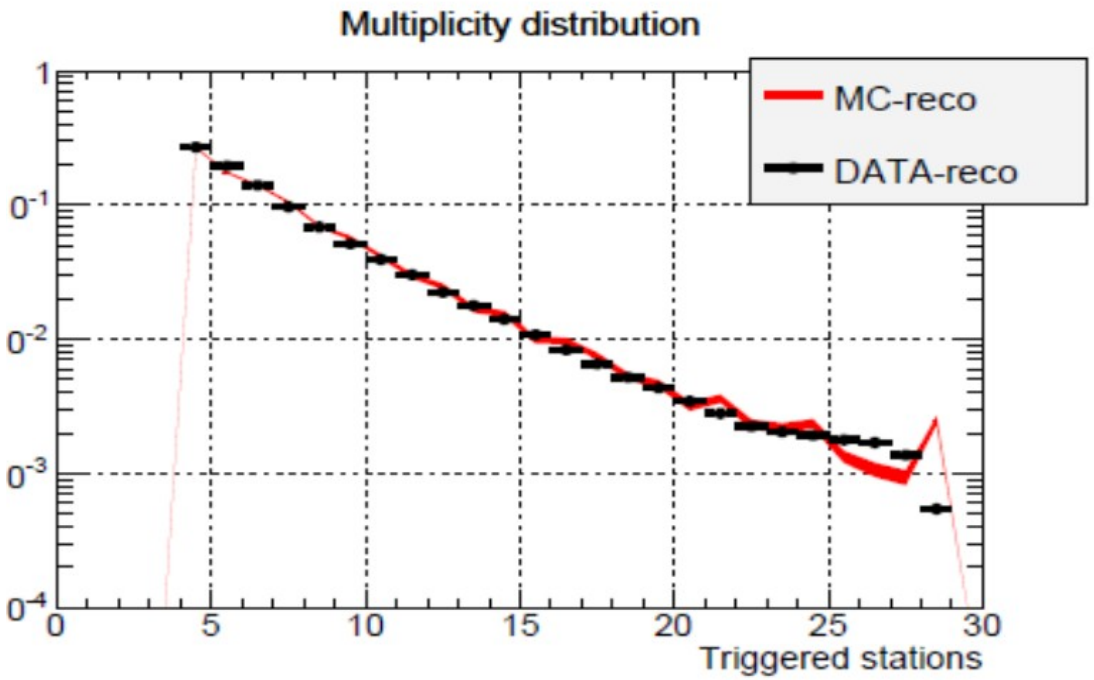
Data-MC comparison: rates

Single station trigger rates
Data reproduced with MC-A_{thr} ~ 250 p.e.

Multiplicity

28 station array: Data / MC





Protons: Ethr ~ 100 TeV
Gammas: Ethr ~ 50 TeV

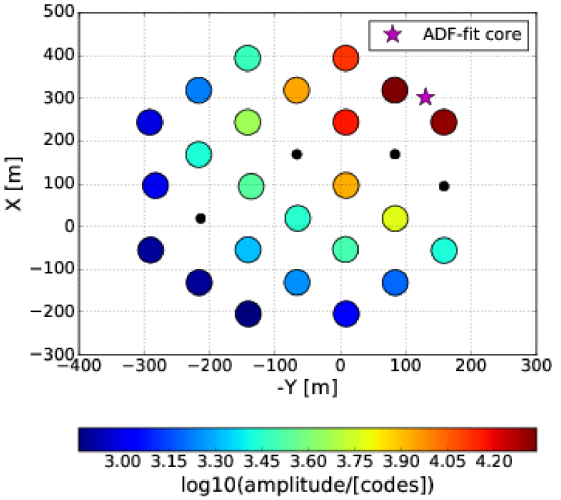
Event reconstruction

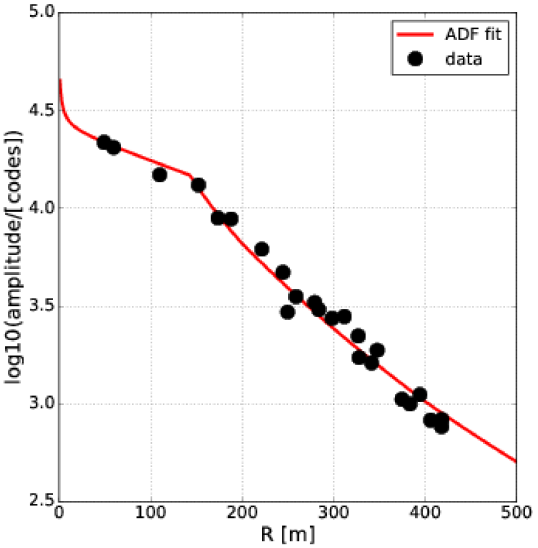
- **Station amplitudes** (LDF/ADF)

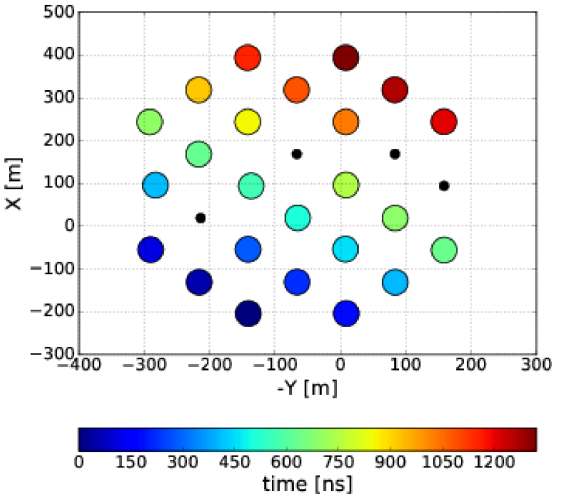
  ⟶ core impact
  ⟶ shower depth
  ⟶ primary energy

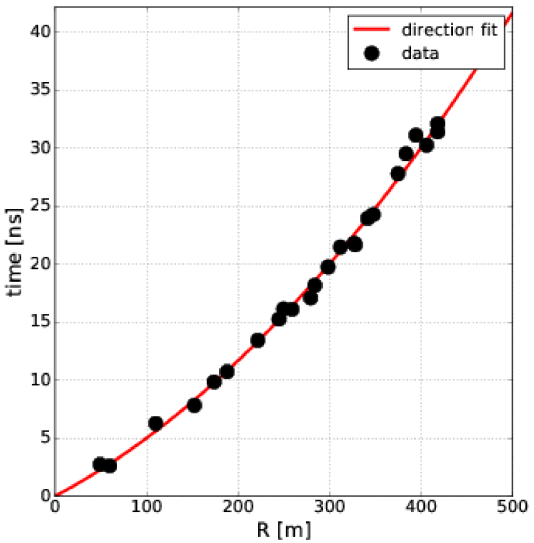
- **Station timing:** (cone fit / time-model)

  ⟶ primary direction



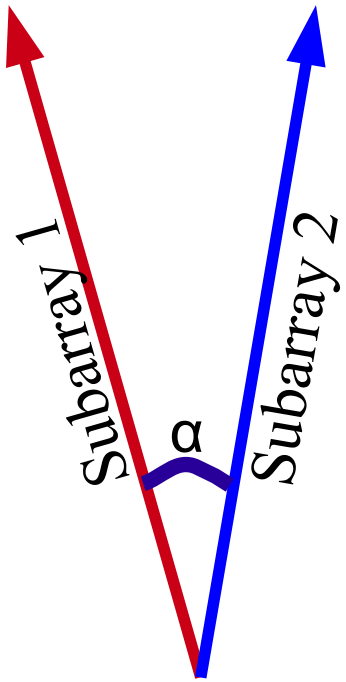






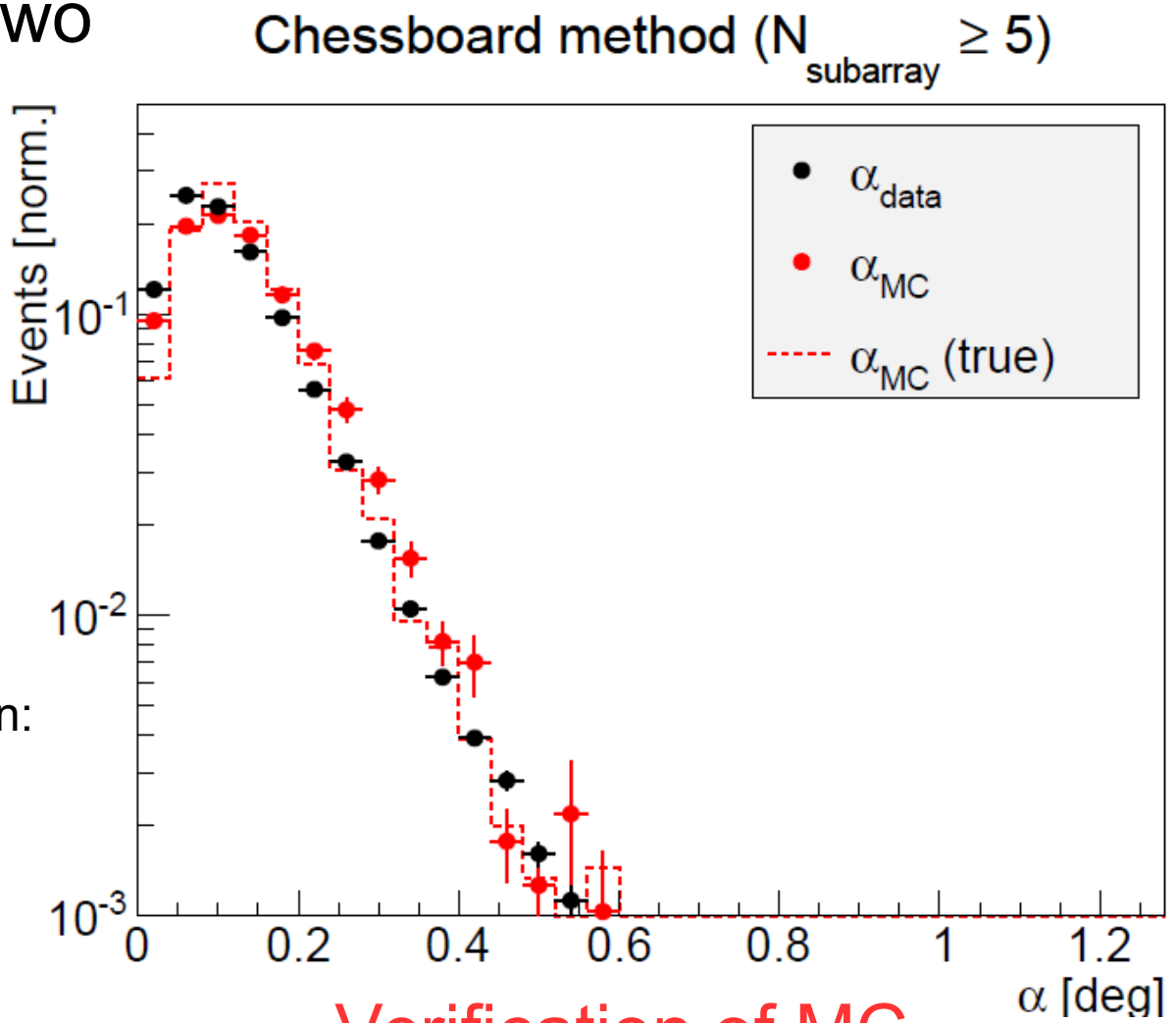
Resolution chessboard method

Reconstruction using two different subarrays



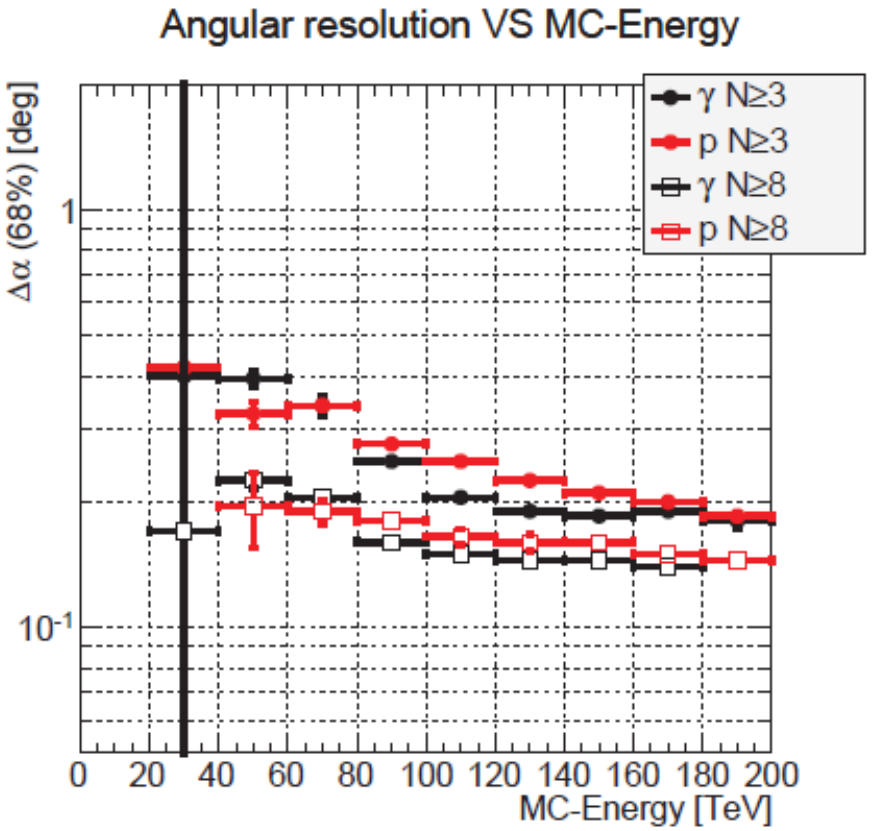
Chessboard direction:

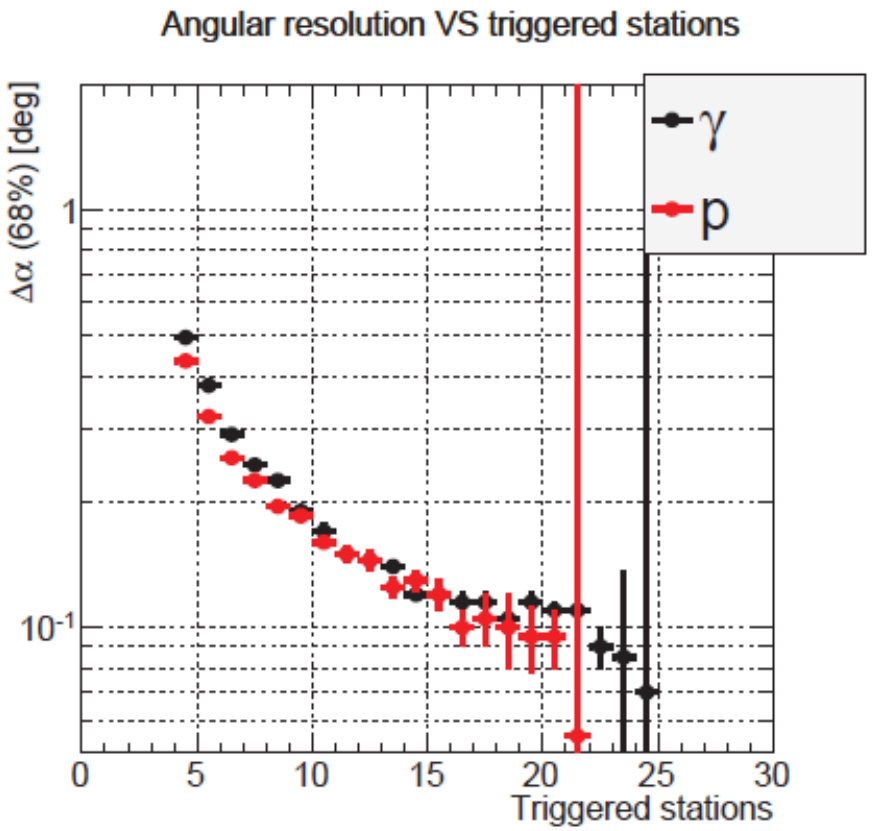
Resulting angle α



Verification of MC

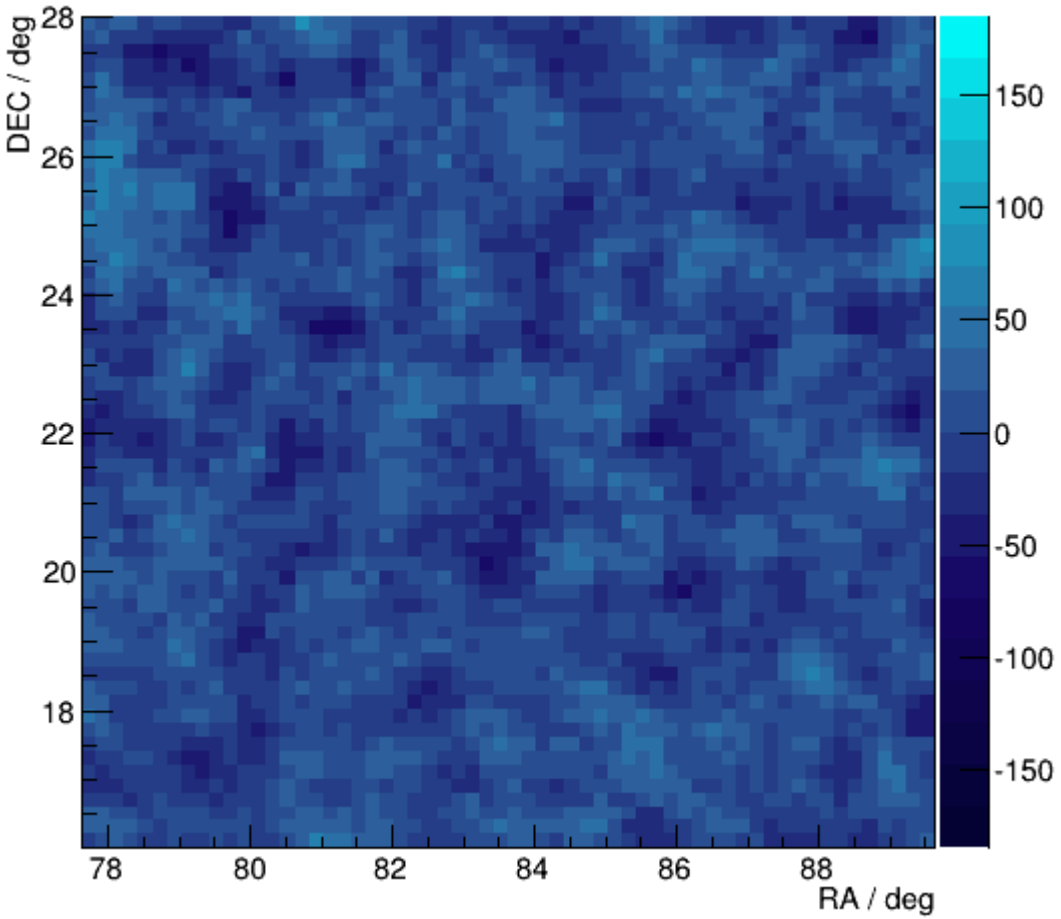
Angular resolution 28 station array

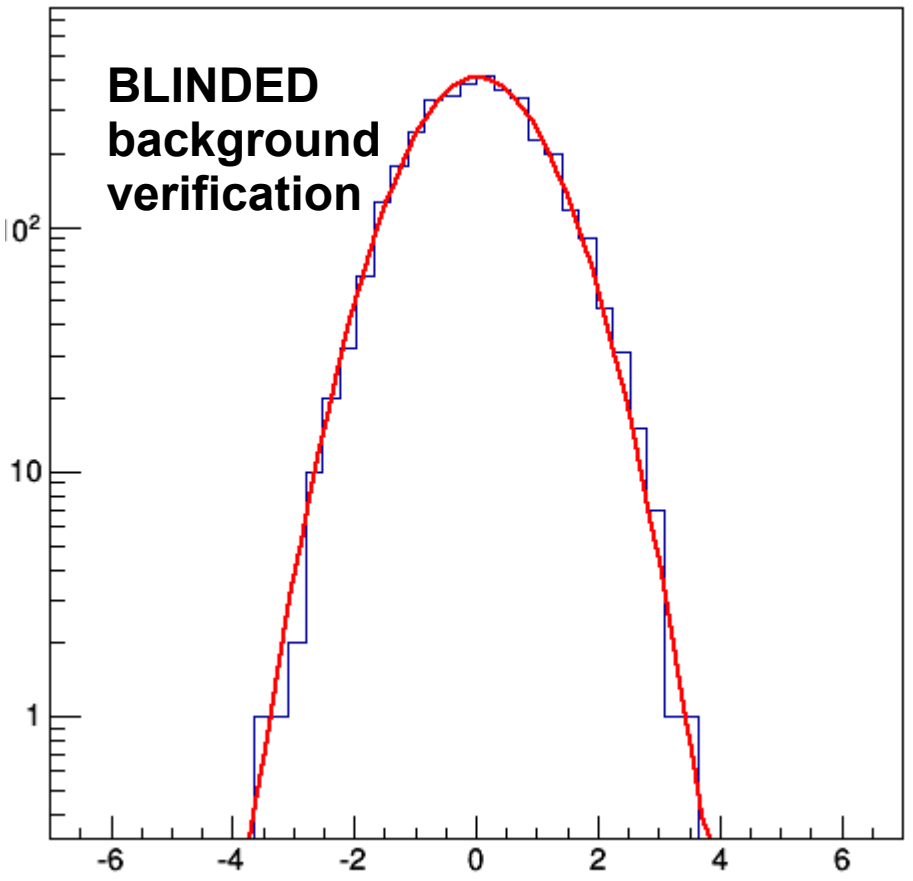




Verified MC resolution <0.2°, E>80TeV
<0.1°, E ~ PeV

Background verification





Excess skymap

Excess = Non – α Noff (α = 0.05)

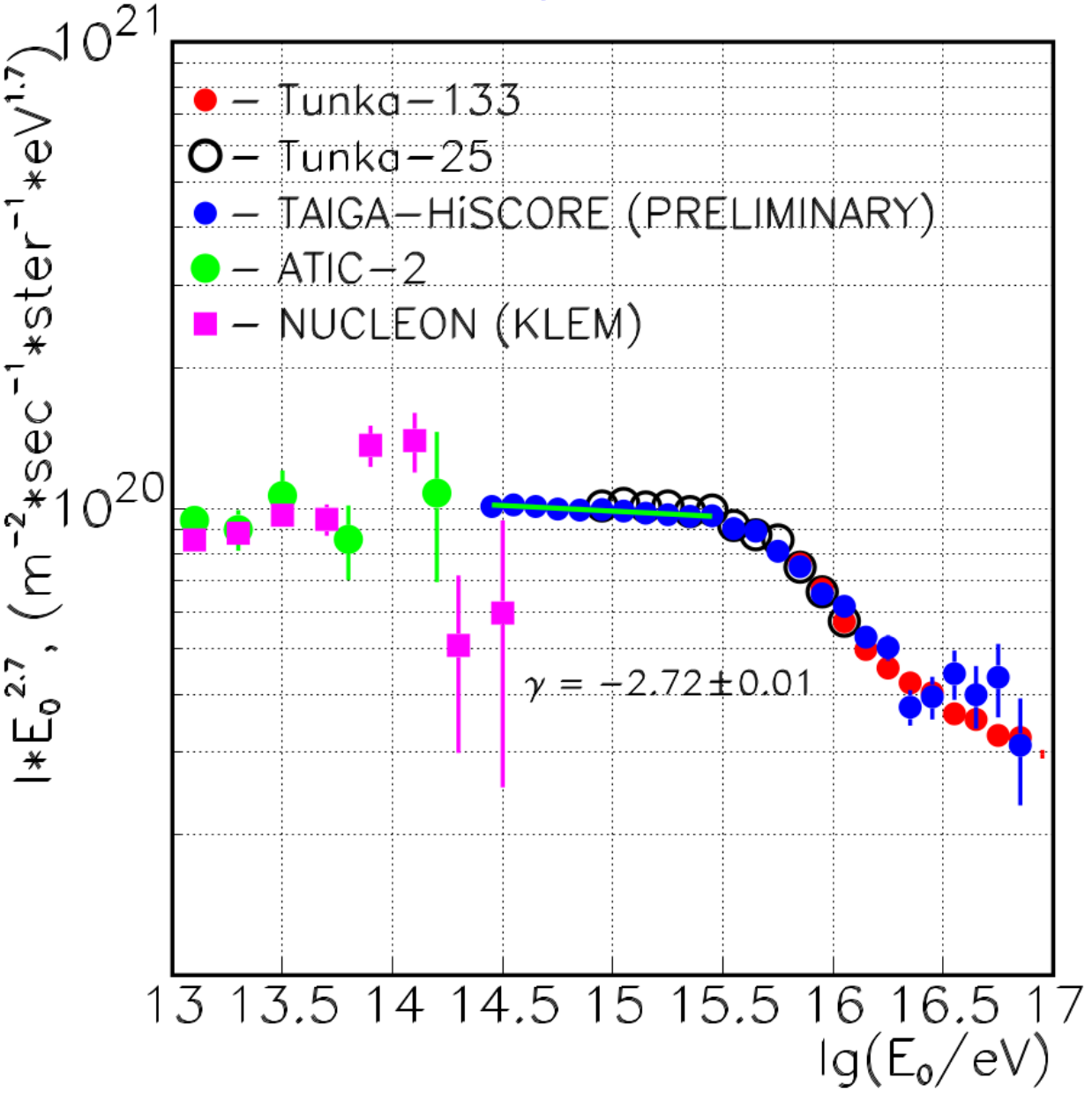
Blinded data

Significance following Li&Ma, Eq. 9

Significance distribution in foV

Crab Nebula: see L. Sveshnikova, this conference

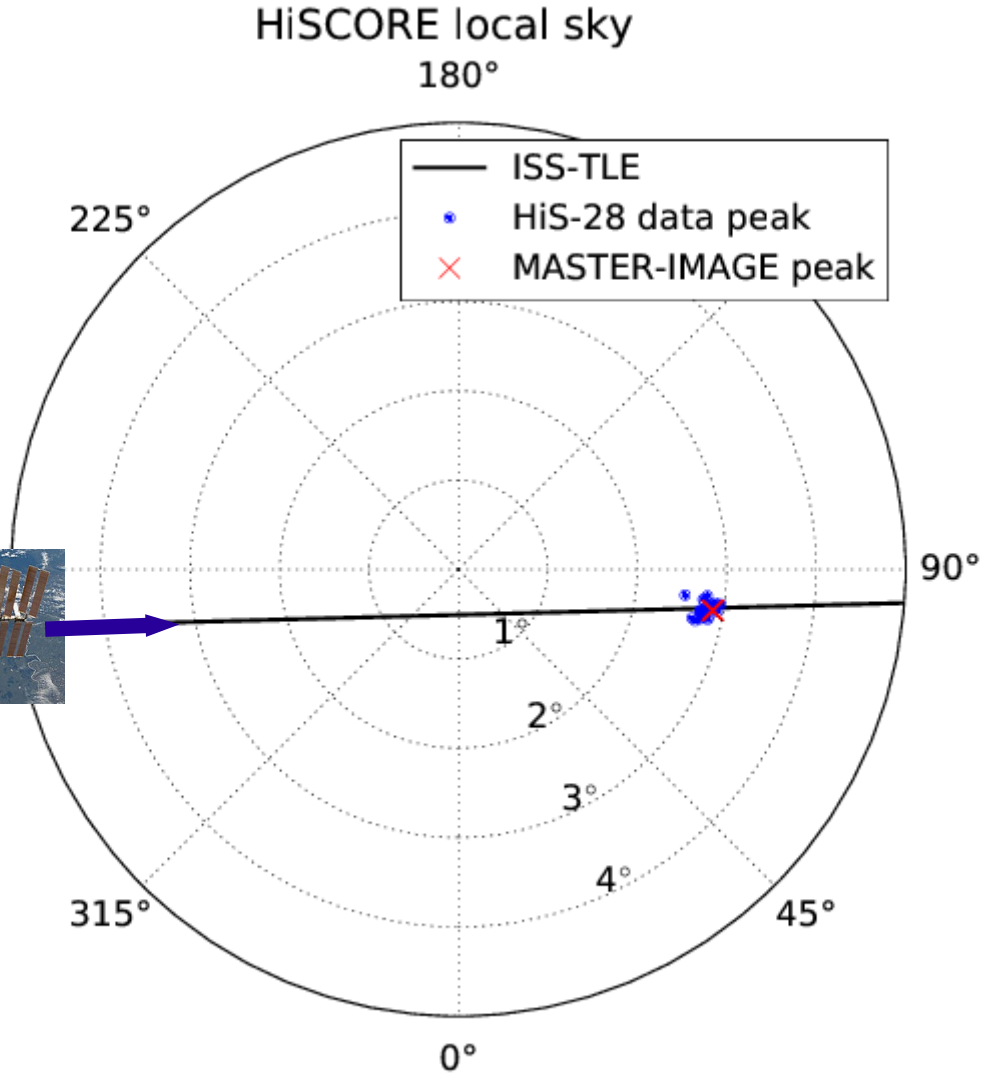
Cosmic ray spectrum



A first Point-source

In several nights:

- O(s) trigger-rate “flares”,
  4 kHz pulsed emission
- Point-like emission,
  fast moving source positio
- Coincidence with ISS
  - ➔ Onboard CATS LIDAR
    @ 1064nm, 532nm
  - ➔ 1.3 mJ per pulse
  - ➔ 2-3 different passage classes

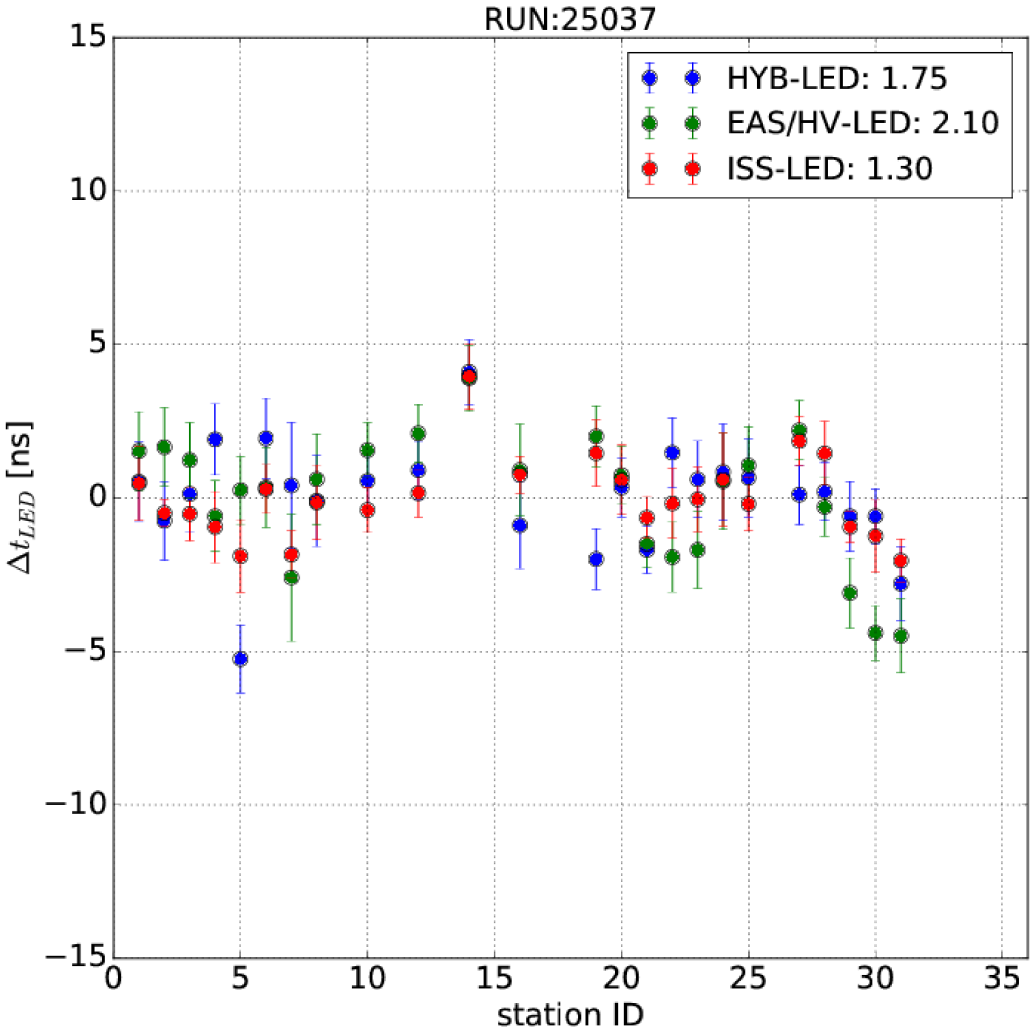


→ **talk by R. Wischnewski, this conference**

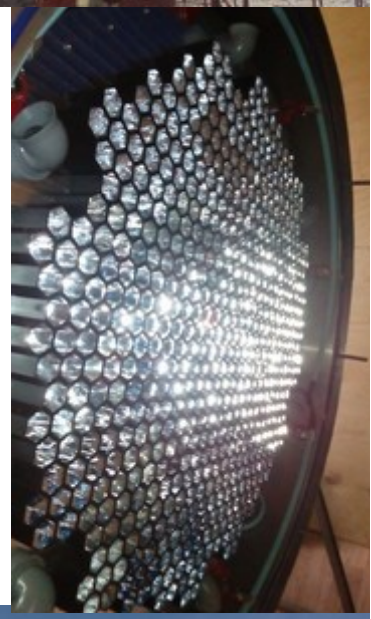
Calibration of constant station time delays

Calibration methods:

- LED calibration
- EAS front + LED
  (see R. Wischnewski, this conf.)
- ISS CATS-LIDAR



Summary



- UHE gamma-ray Astronomy with new hybrid imaging+timing approach

  Goal: 10^{-13} erg cm^{-2} s^{-1} @ 100 TeV

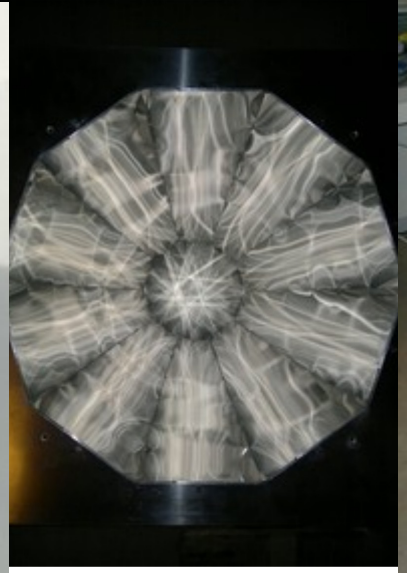
- TAIGA-HiSCORE timing array 0.25 km² operational

- First results within expectations: on-track

- First TAIGA IACT in commissioning

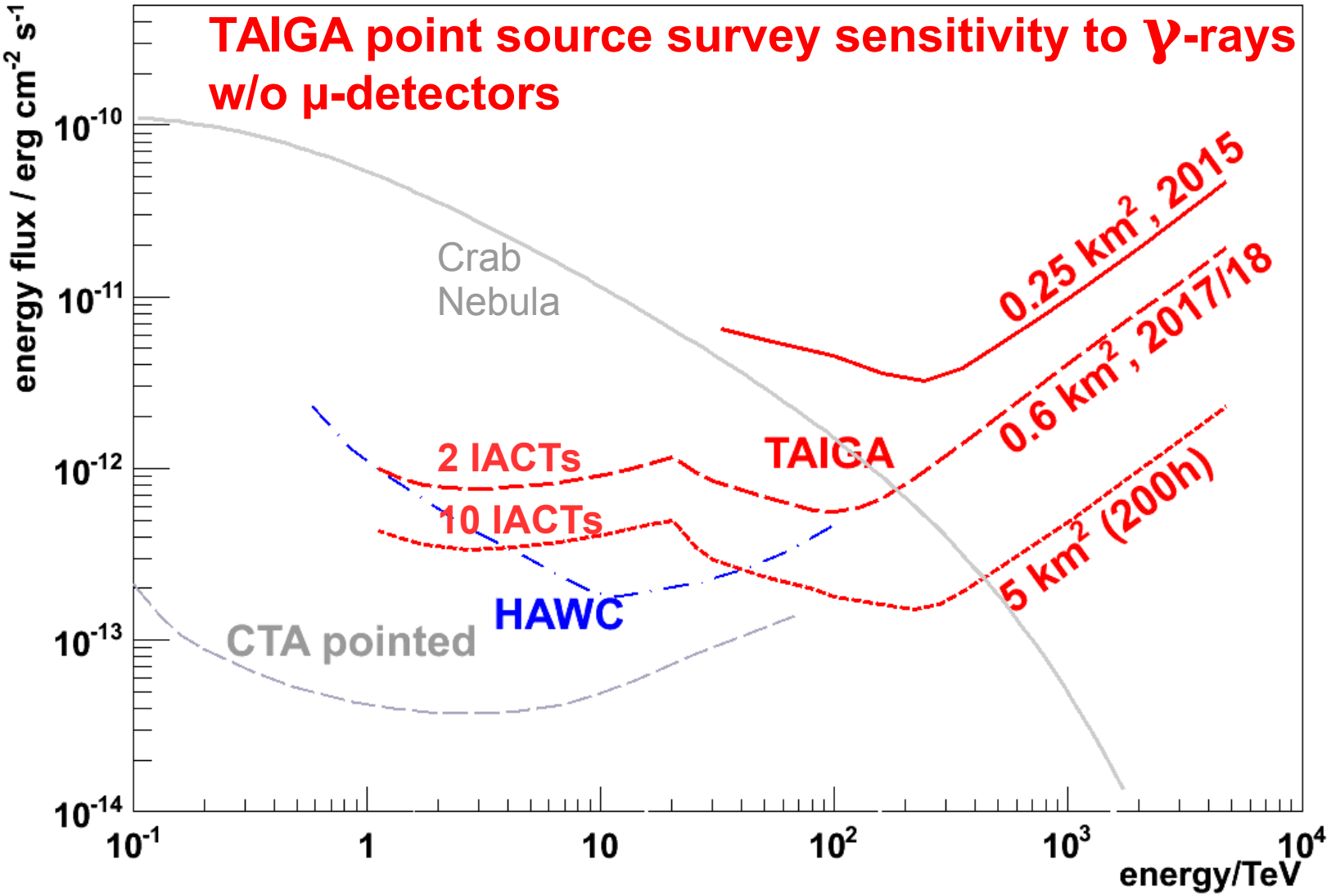
- Ongoing extension, 1km² + 3IACTs: 2.5×10^{-13} erg cm^{-2} s^{-1} @ 100 TeV

BACKUP



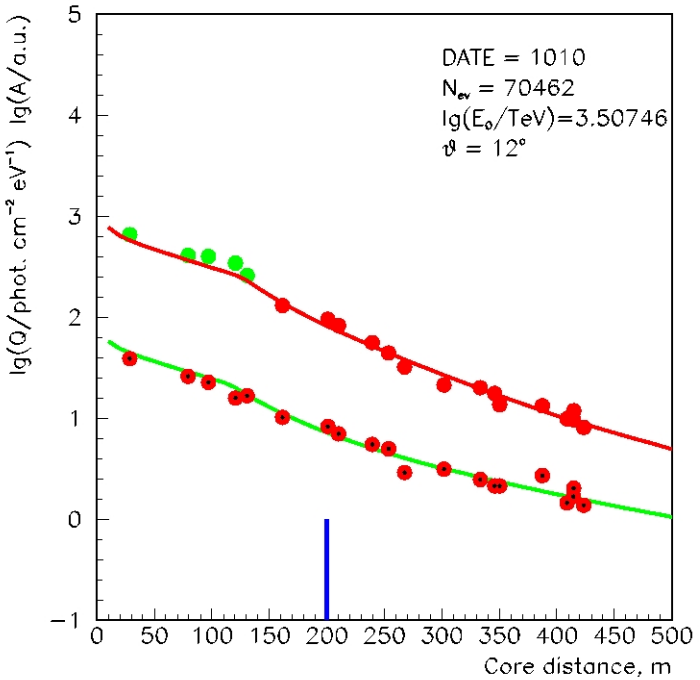
8” PMTs
ElectronTubes
Hamamatsu

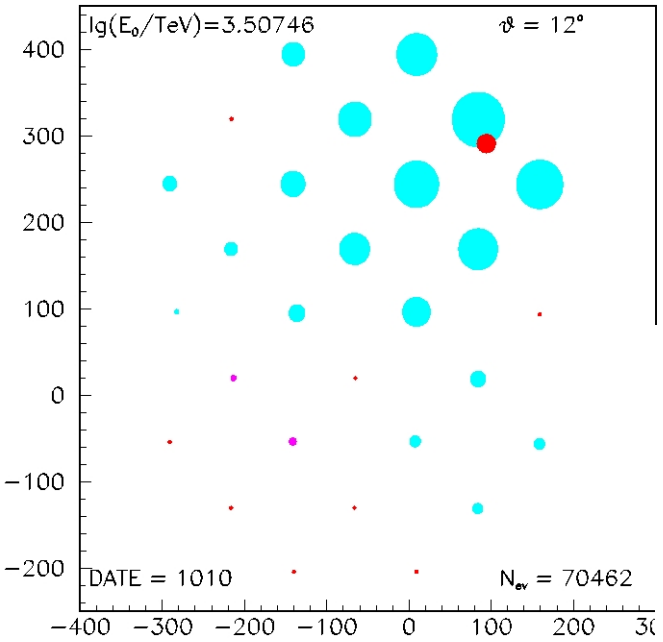
VHE-UHE Gamma-ray Astronomy

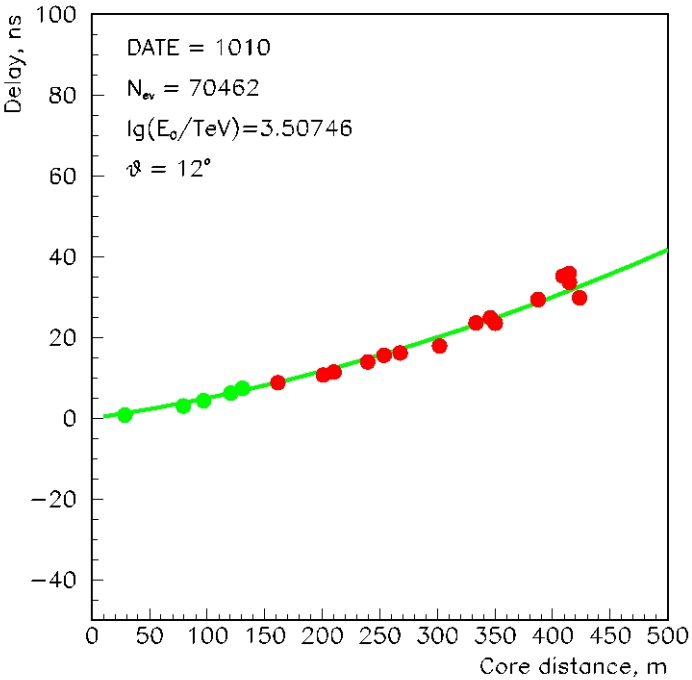


TAIGA-HiSCORE: 200 h
TAIGA-IACT: 50 h

Event reconstruction



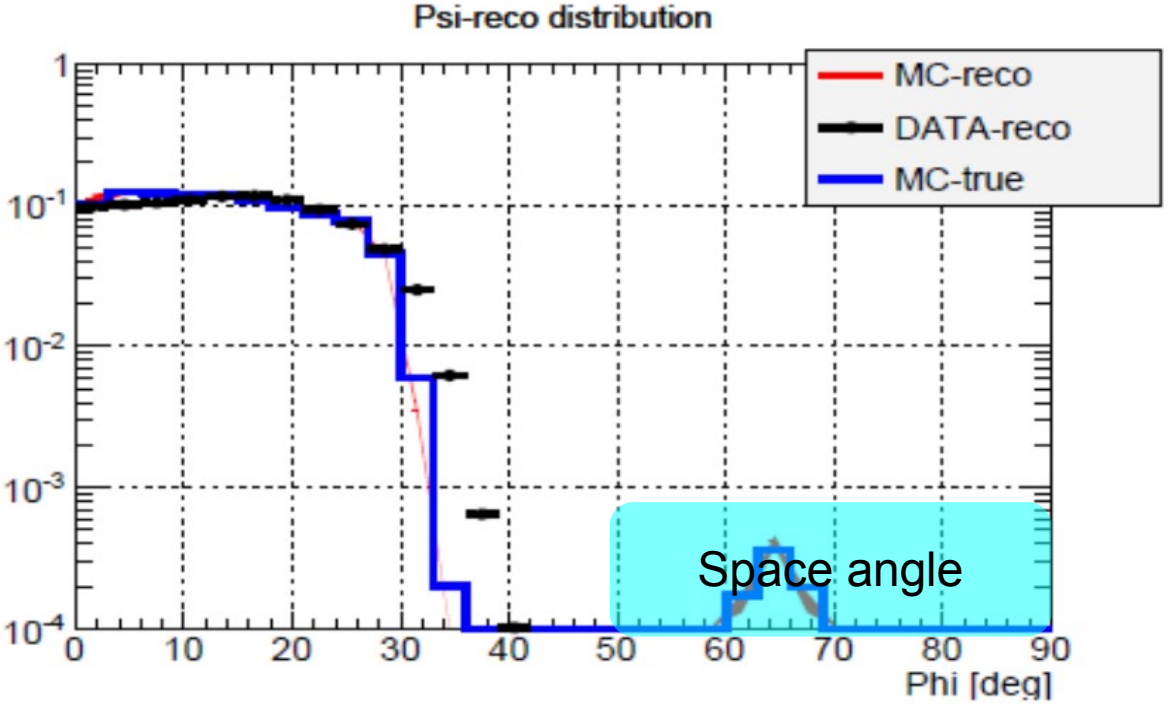


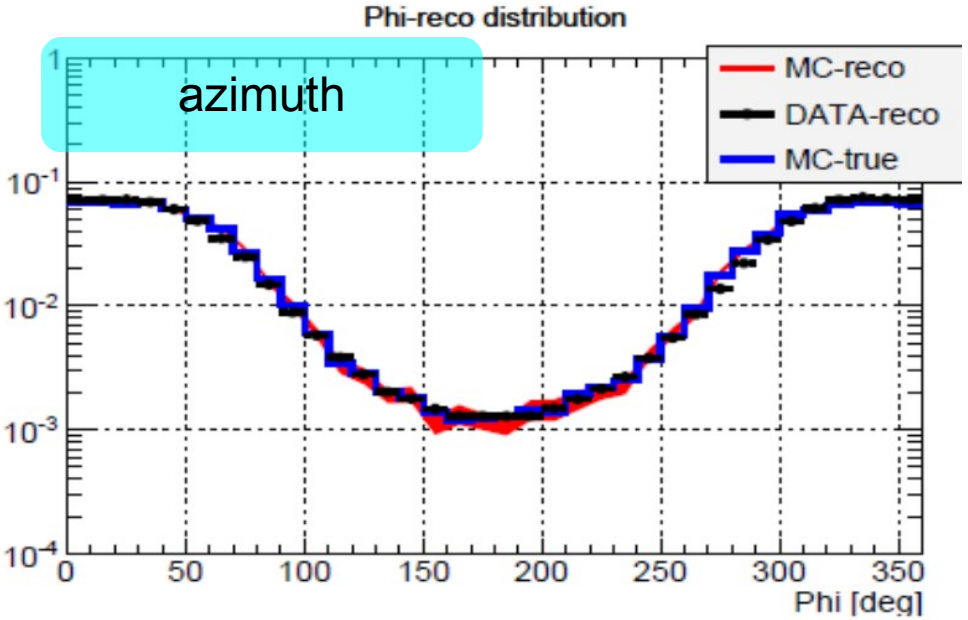


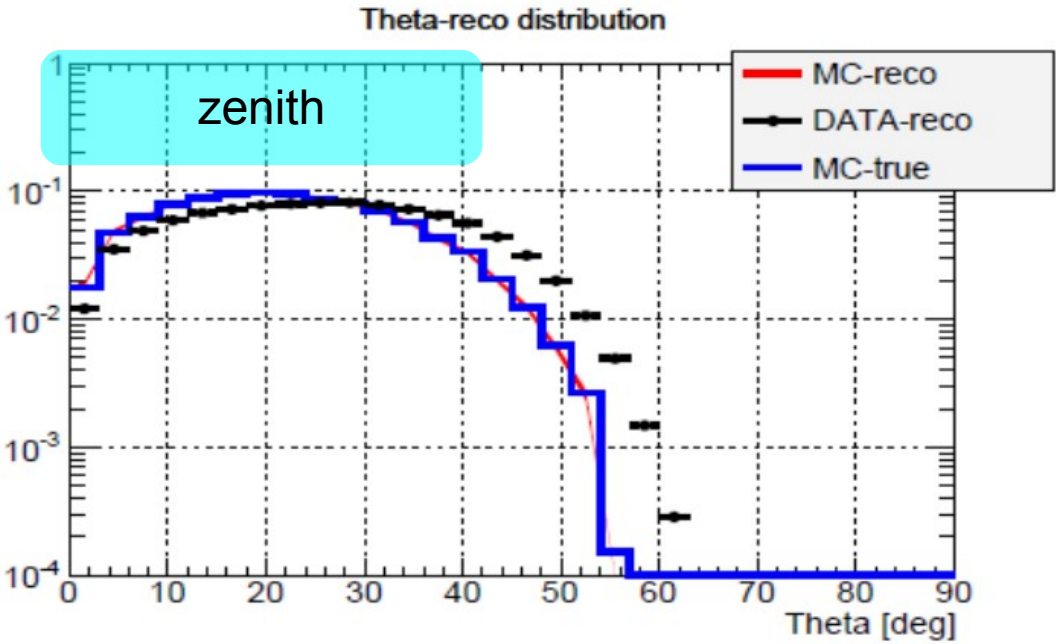
Reconstruction

Reconstructed direction

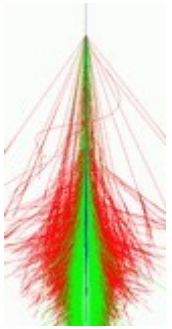
Data & MC

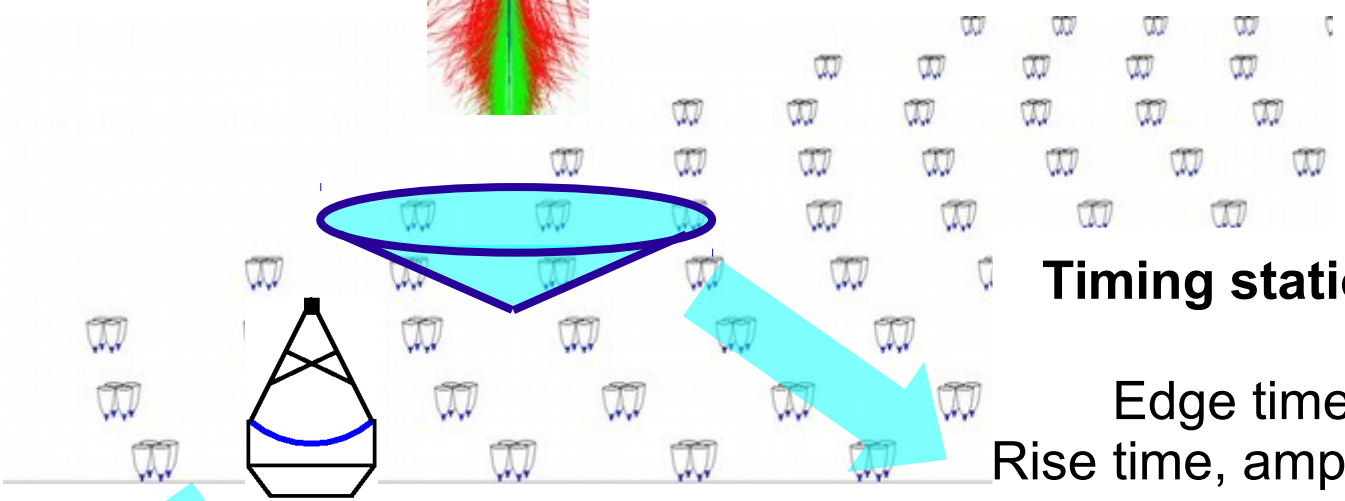






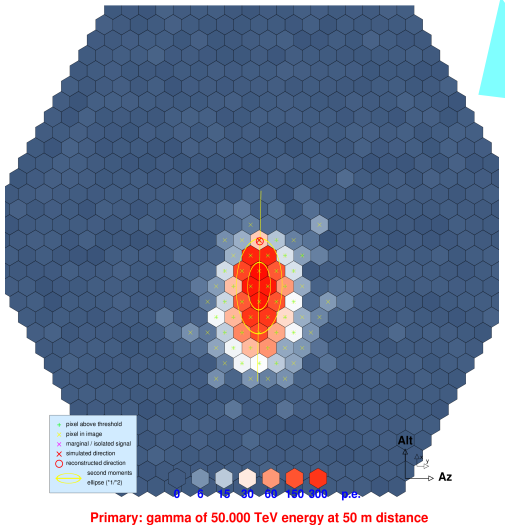
Air Cherenkov techniques: Imaging timing





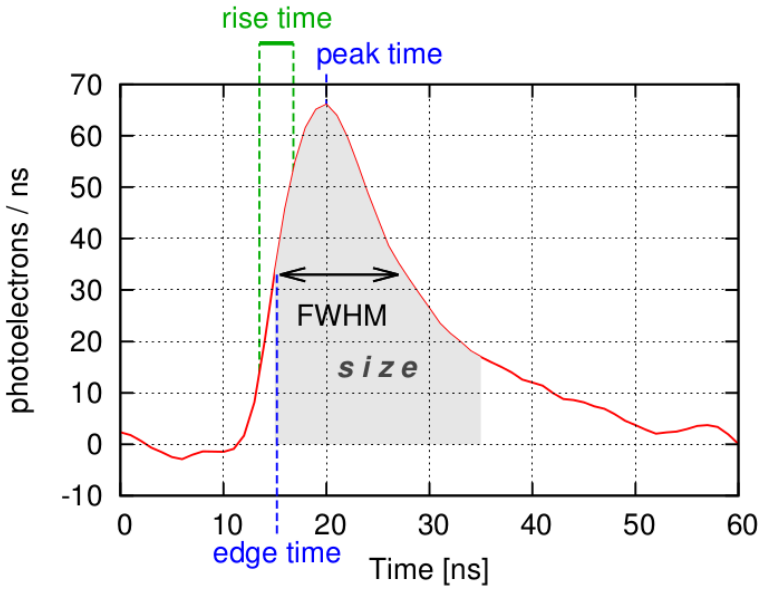
Telescope image:

Orientation,
size and shape

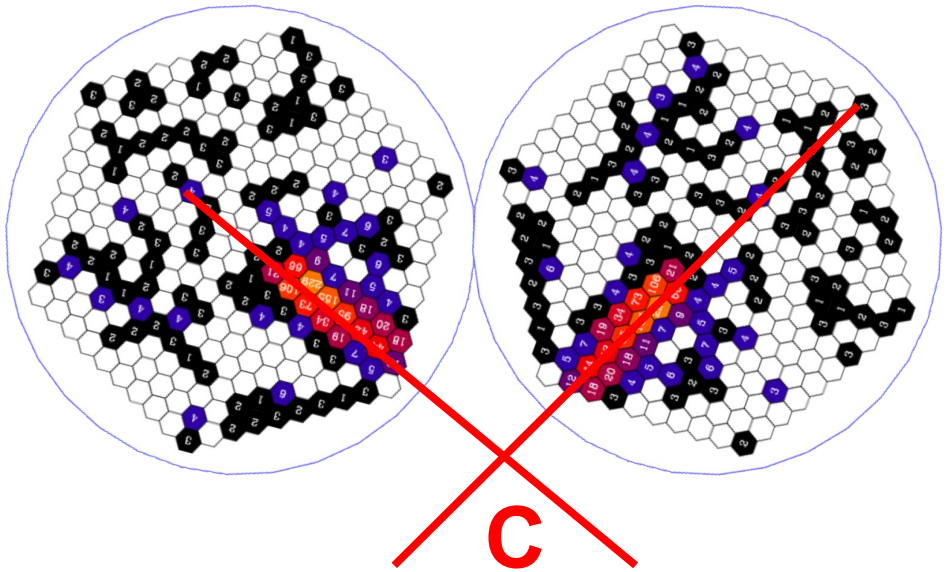


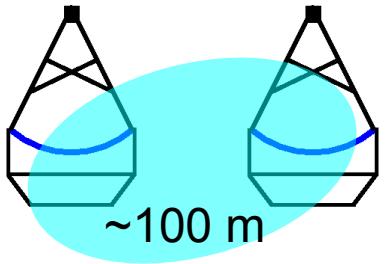
Timing station:

Edge time
Rise time, amplitude

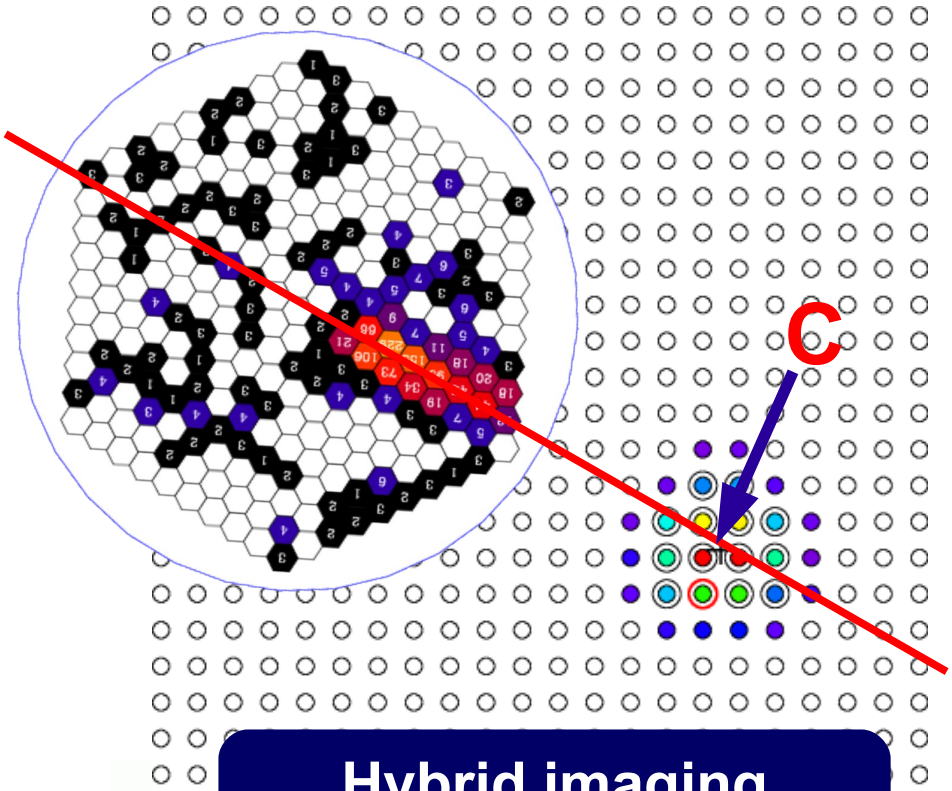


Imaging Hybrid mode

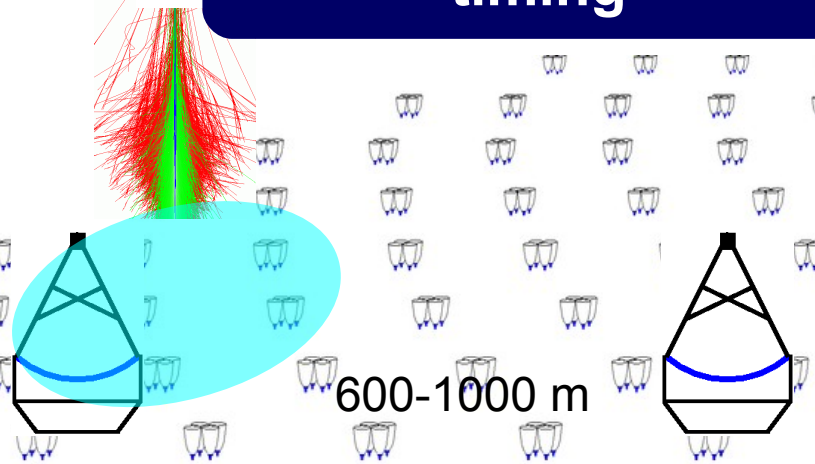




Imaging (stereo)

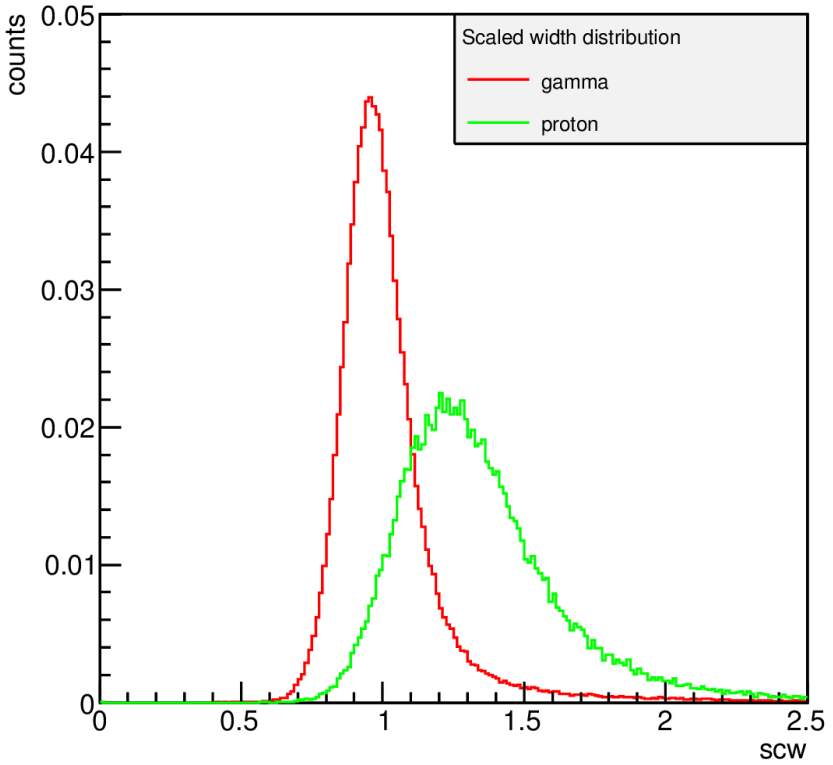


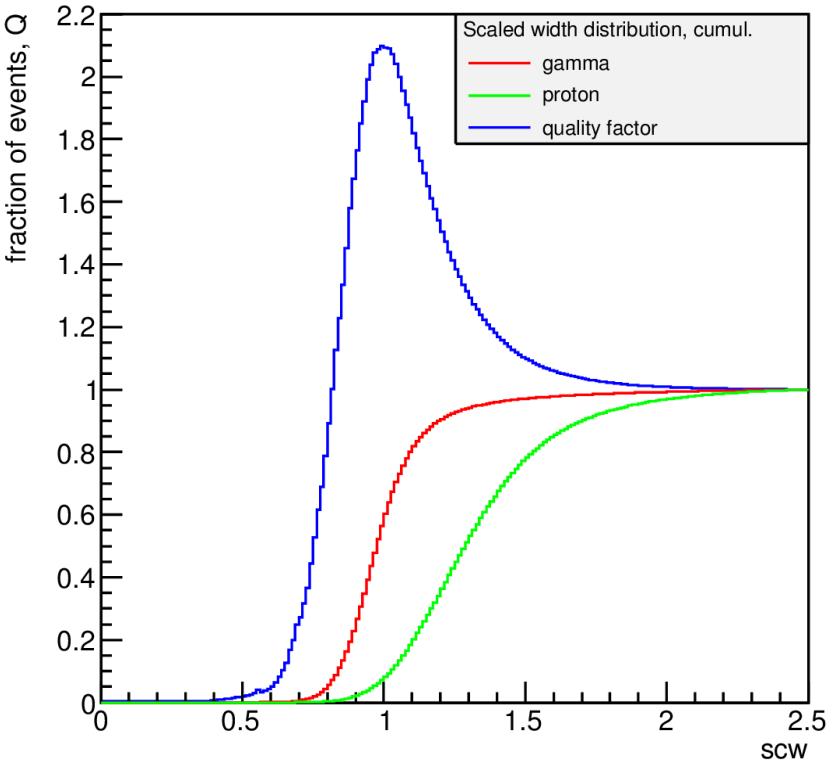
Hybrid imaging timing



g/h separation

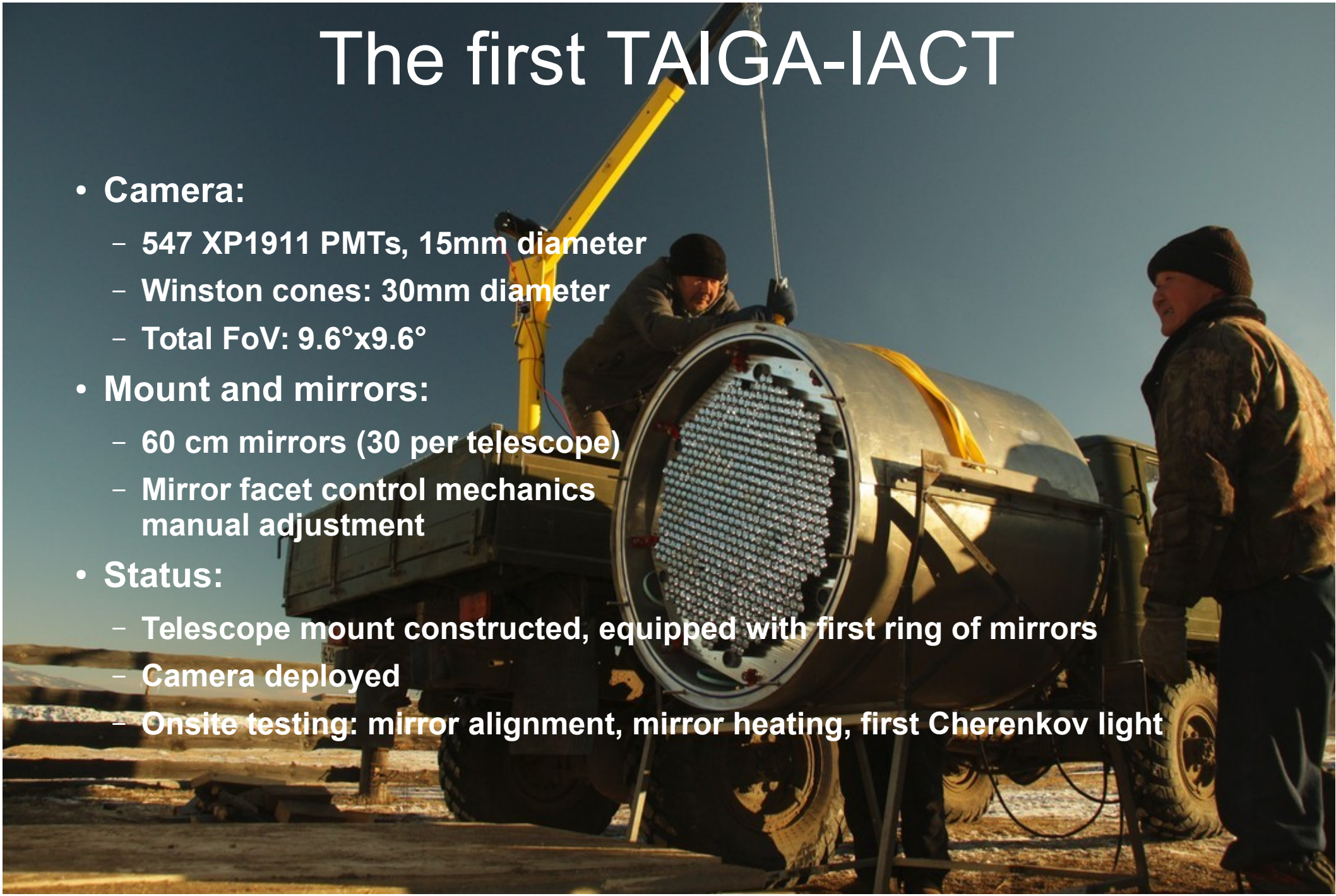
Hybrid scaled width (SCW)





Other separation parameters based on shower depth and timing

The first TAIGA-IACT



- **Camera:**
  - **547 XP1911 PMTs, 15mm diameter**
  - **Winston cones: 30mm diameter**
  - **Total FoV: 9.6°x9.6°**
- **Mount and mirrors:**
  - **60 cm mirrors (30 per telescope)**
  - **Mirror facet control mechanics manual adjustment**
- **Status:**
  - **Telescope mount constructed, equipped with first ring of mirrors**
  - **Camera deployed**
  - **Onsite testing: mirror alignment, mirror heating, first Cherenkov light**