# SCORE: Physics and Concept


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- What is SCORE and why ?
- Particle and Astroparticle Physics with the highest energies
- The SCORE detector
- First simulation results

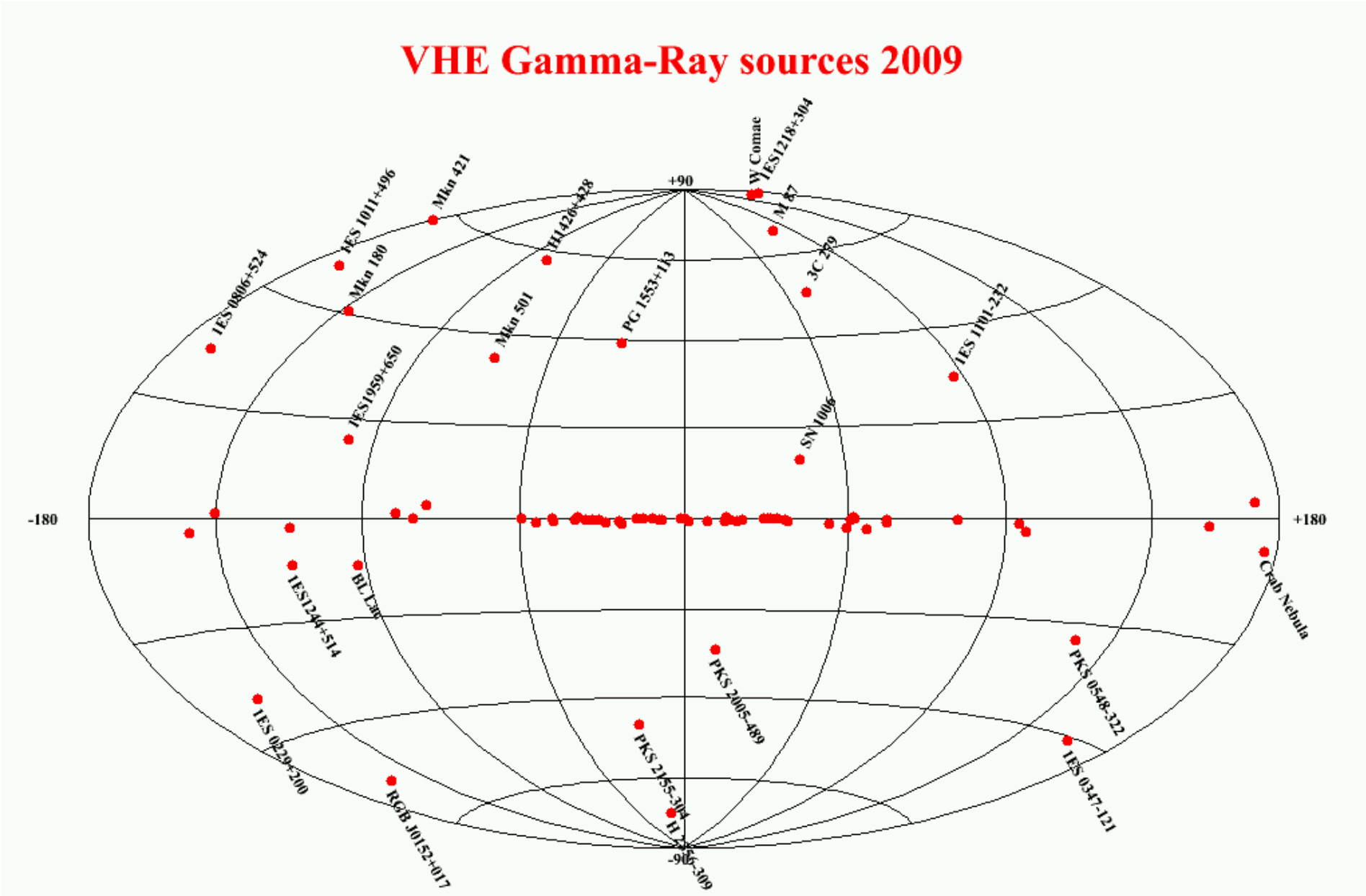
# What is SCORE ?

- **S**tudy for a **C**osmic **OR**igin **E**xplorer
- **High energies**
  - Gamma-rays: E > 10 TeV
  - Cosmic-rays: 100 TeV < E < 1 EeV
- **Large area**: 10 km²
- **Large Field of view**: 1 sr
- Astroparticle physics Roadmap phase I: *recommendation for development of ground-based wide-angle gamma-ray detectors*

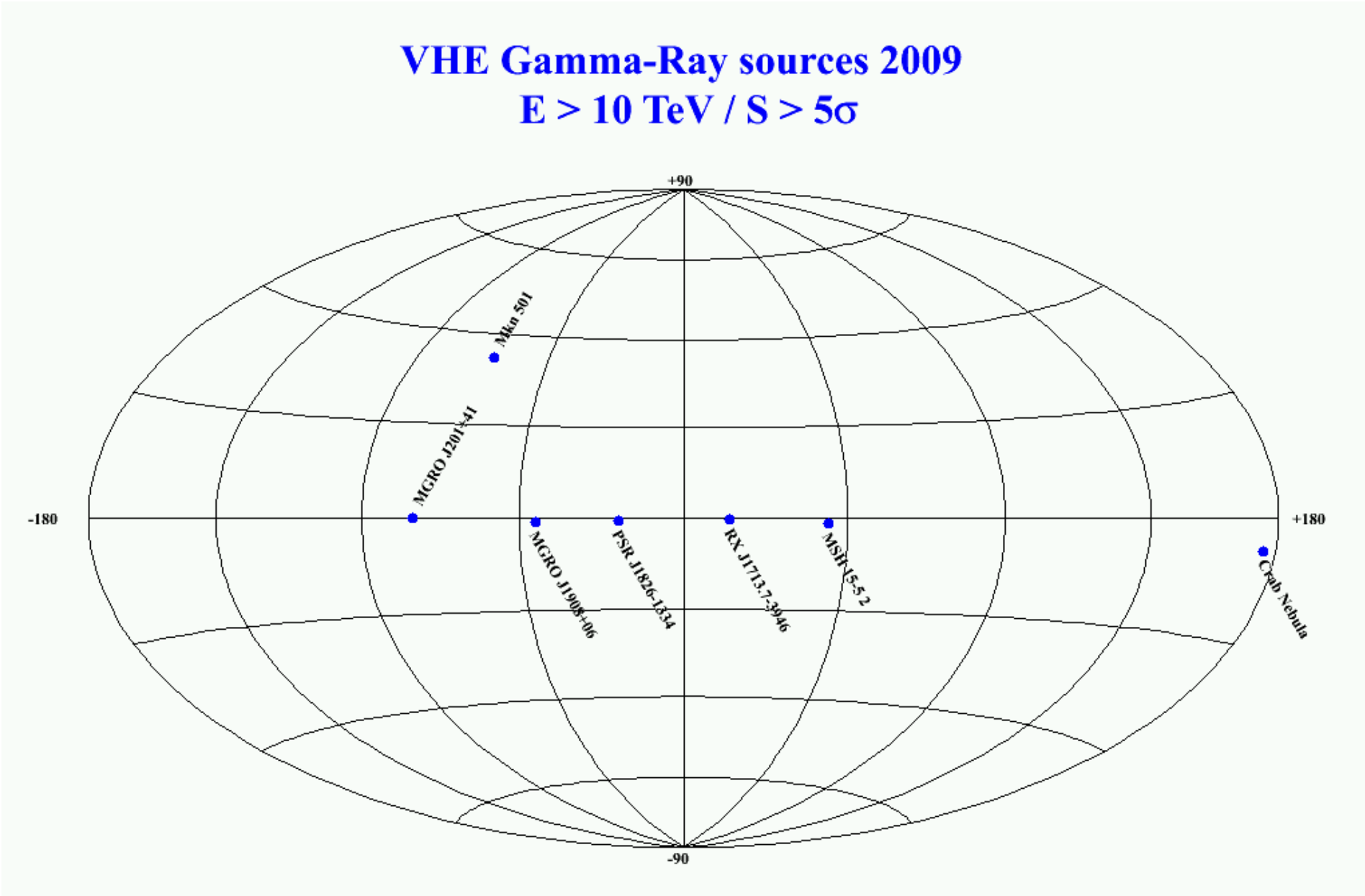
# Why SCORE?

- **Gamma-ray Astronomy**
- **Cosmic-ray physics**
- **Particle physics beyond the LHC scale**

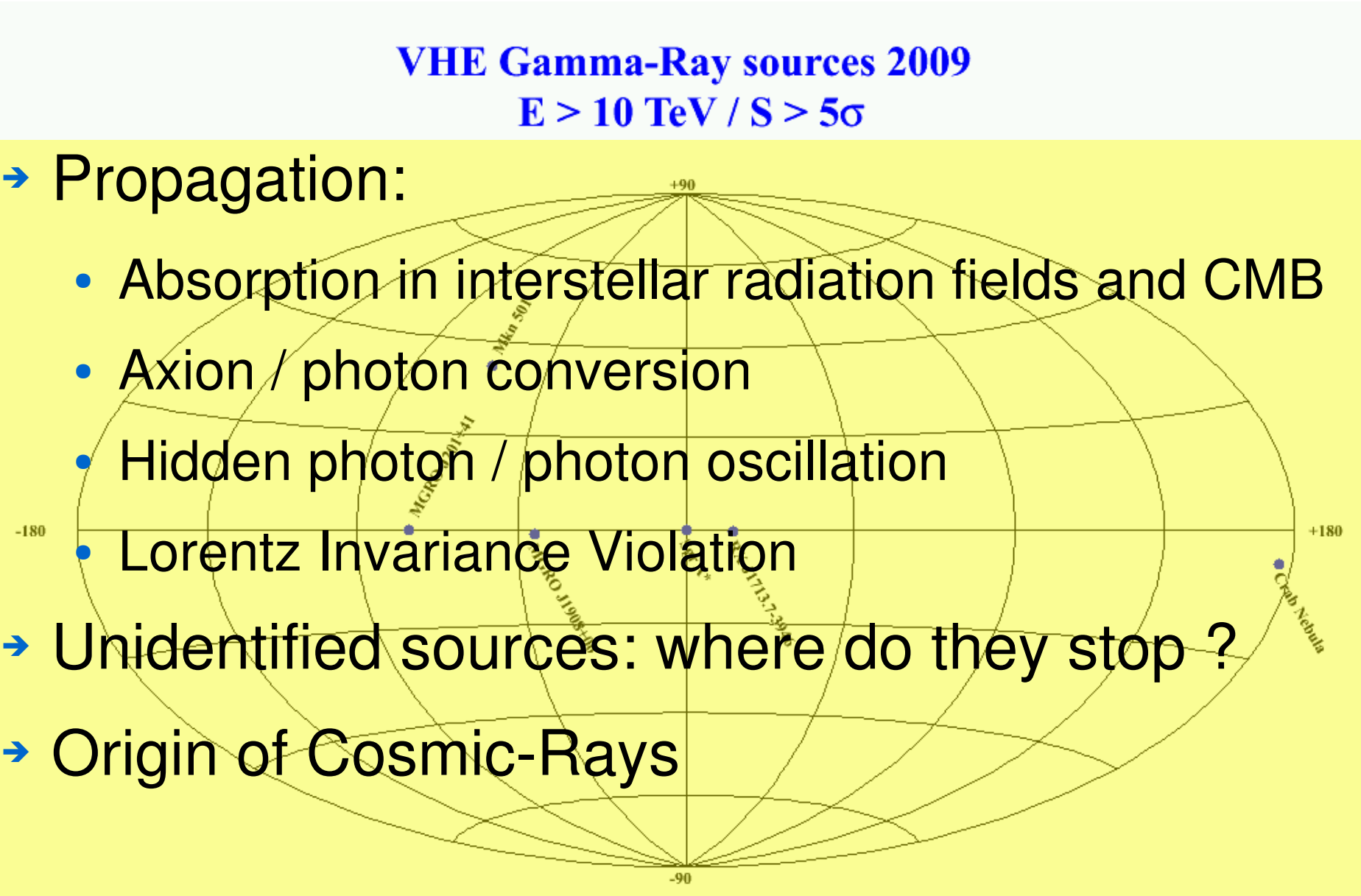
# Gamma-Ray Sky



# Gamma-Ray Sky

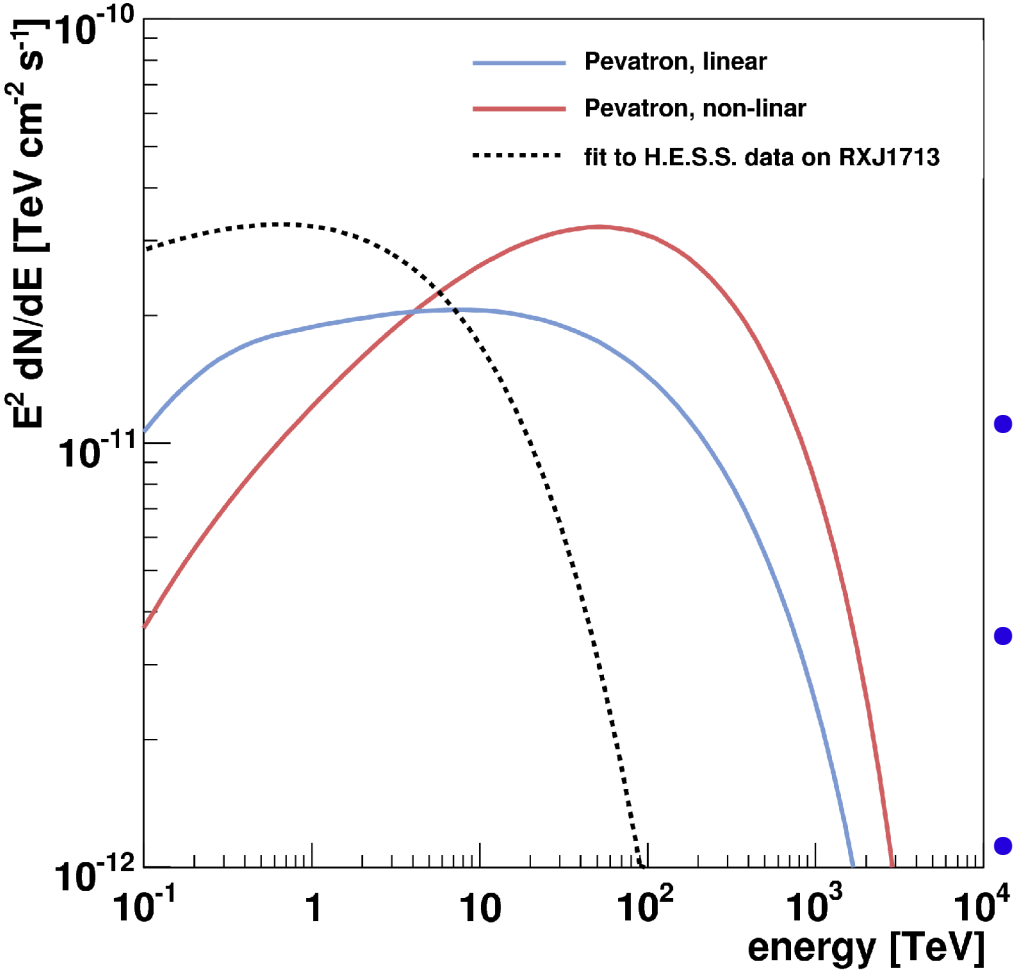


# Gamma-Ray Sky




- Propagation:
  - Absorption in interstellar radiation fields and CMB
  - Axion / photon conversion
  - Hidden photon / photon oscillation
  - Lorentz Invariance Violation
- Unidentified sources: where do they stop ?
- Origin of Cosmic-Rays

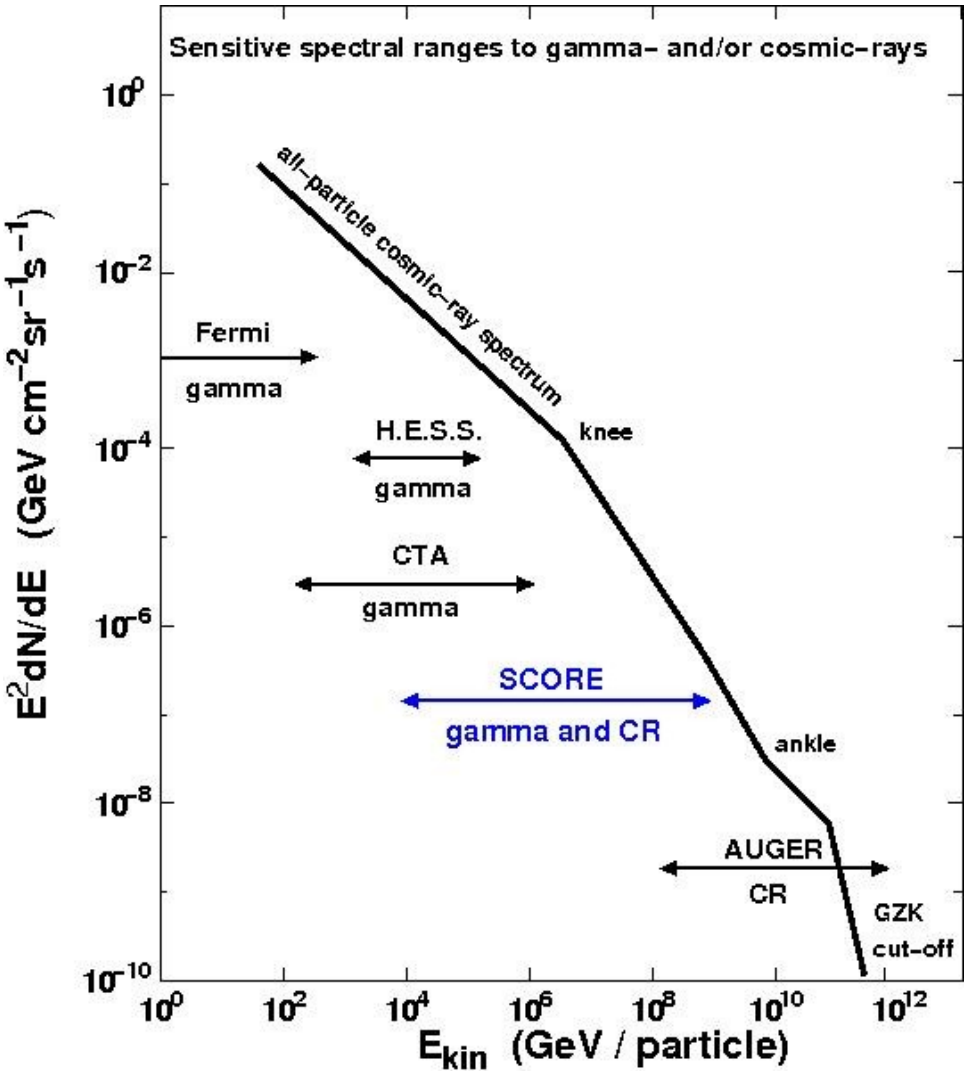
# Origin of Cosmic-Rays




- **Find Cosmic accelerators:**
  - hard spectra beyond 10 TeV
  - No ambiguity: Inv. Compton in Klein-Nishina regime
- **Infer CR contributions** from candidate populations: large FoV
- Current instruments are not optimized for hadronic pevatrons!
- Extended structures ?

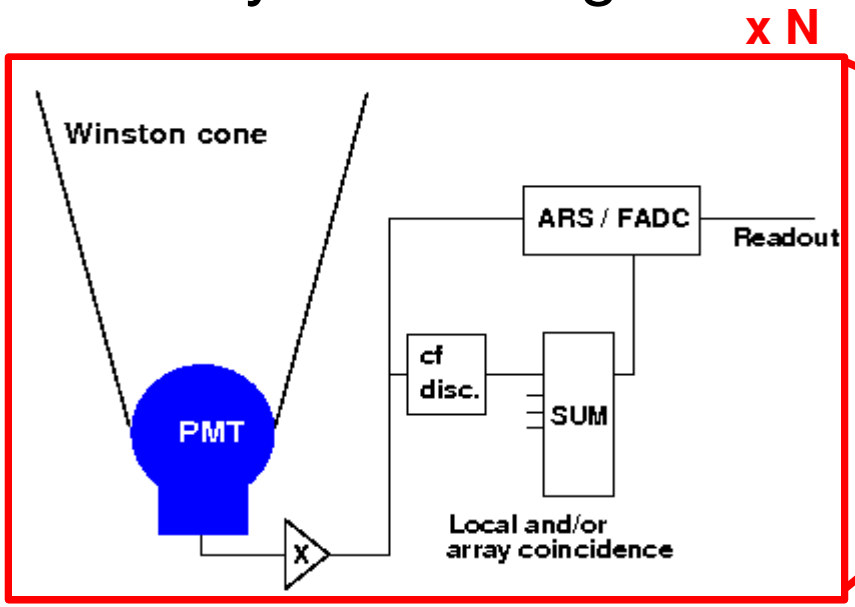
# Diffuse Emission

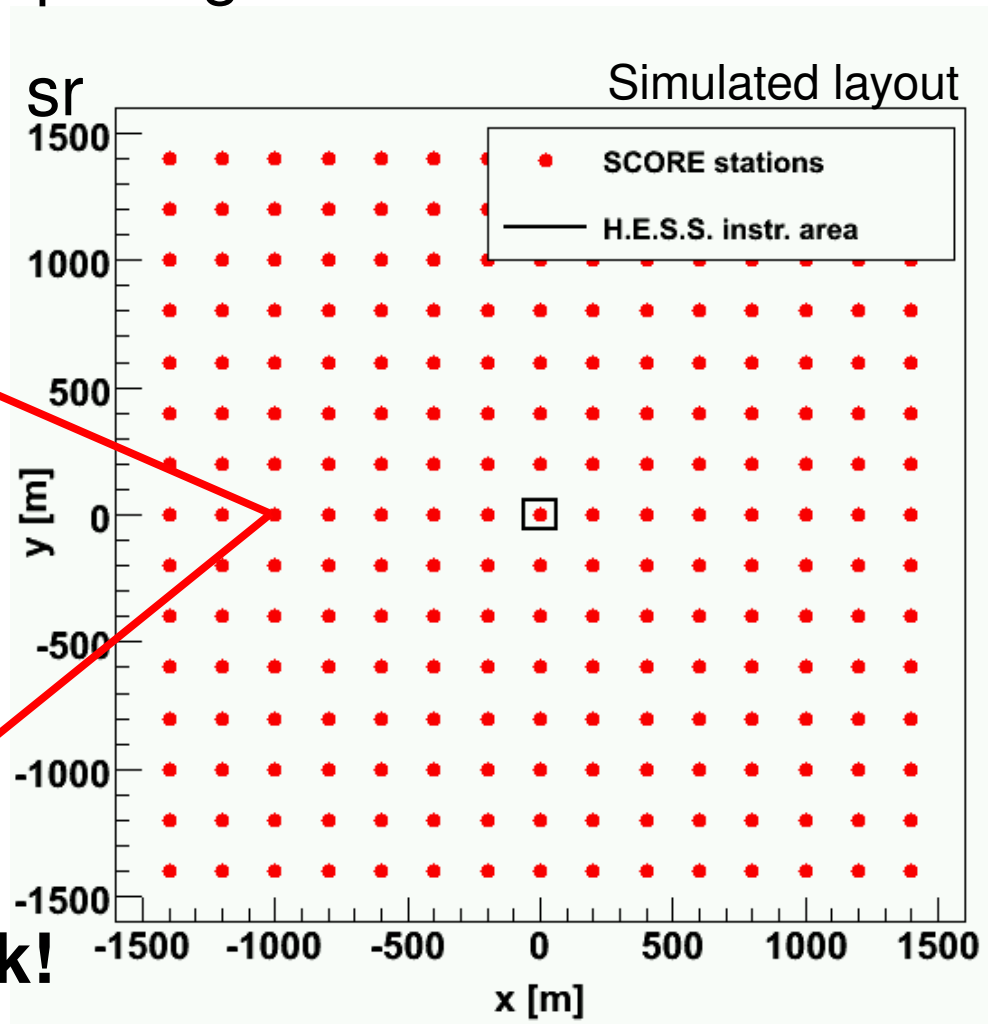
- **Extended γ-ray emission**
  - Superbubbles as Pevatrons?
  - MILAGRO sources
- **Galactic plane**
- **Local Supercluster**
  (T. Kneiske, this conference)
- **Charged Crs with SCORE:**
  - composition / anisotropies
  - Sub-knee to pre-ankle !



# The SCORE Detector

- Non-imaging Cherenkov light-front sampling array
- 1.5 m² detector stations, 200 m spacing
- Large $A_{eff}$ / wide FoV: 10 km² / 1 sr
- Intensity and timing




Reconstruction: **D. Hampf, next talk!**

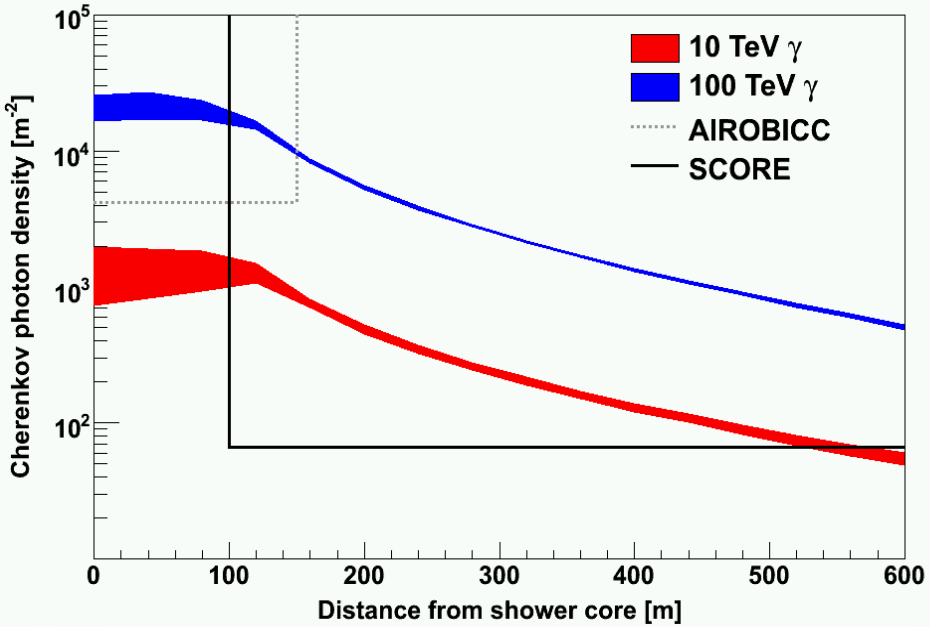
# Non-Imaging Cherenkov Technique

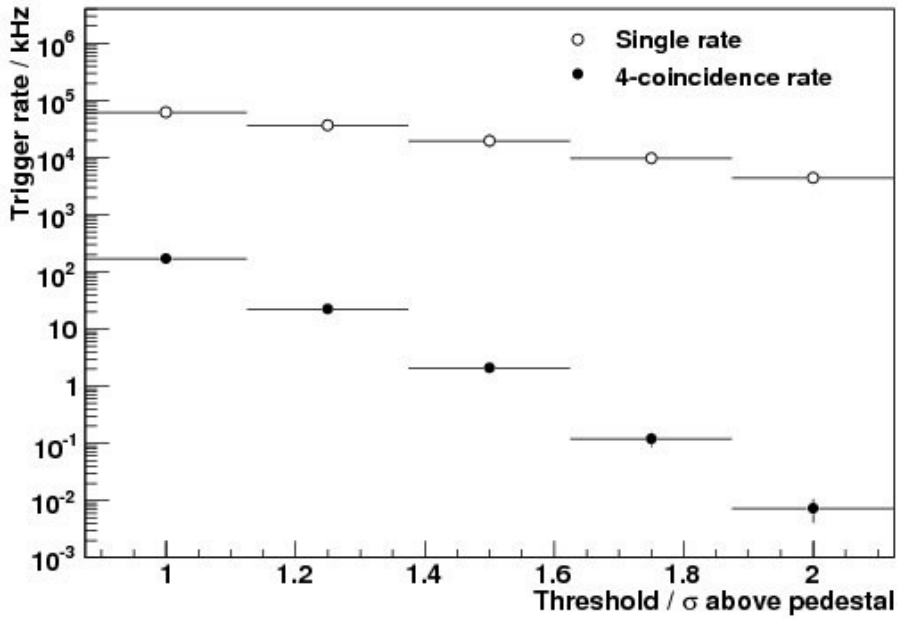
## Benefits

- High photon statistics
- Lateral density falls off slowly
- >120m core: low fluctuations

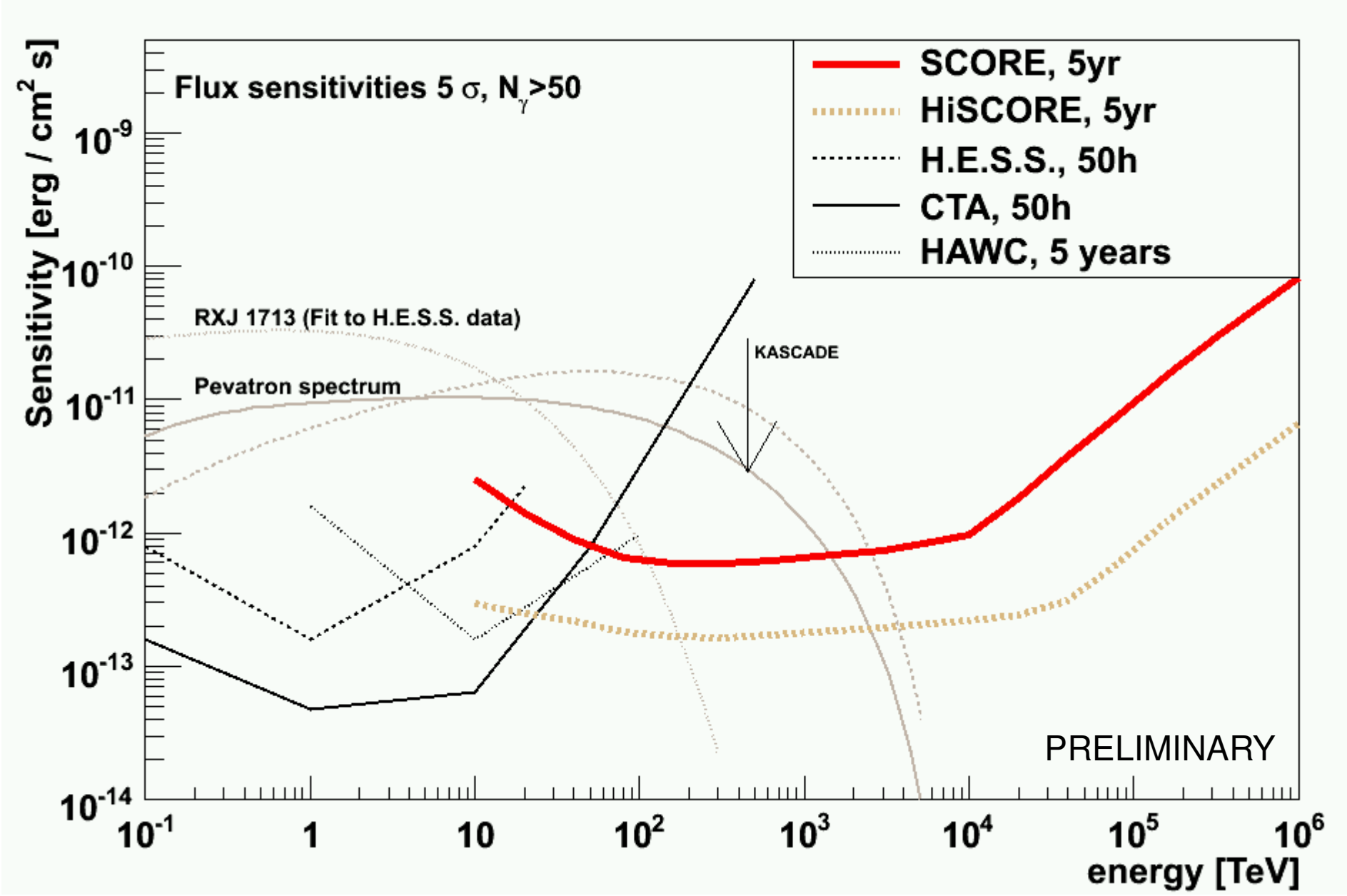
## Limiting factors

- Channel-per-km$^2$
  - ➔ IACTs: ~25000
  - ➔ SCORE: < 200 !
- Nigh-Sky-Background



# SCORE First Simulation Results



# Summary

- **Many physics cases beyond 10 TeV primary energy**
  - Gamma-ray astronomy
  - Cosmic-ray physics
  - Particle physics
- **SCORE**
  - Opens the last remaining Gamma-ray observation window
  - Spans sub-knee to pre-ankle CR-energy range

# Outlook

- **We invite for collaboration !**
- **H$_i$SCORE**
  Hundred Square-km Cosmic ORigin Explorer
- **Extension** / **Synergies** with other techniques
  - Radio (LOFAR)
  - Szintillation counters (hybrid array)
  - Possible combination with imaging Cherenkov technique

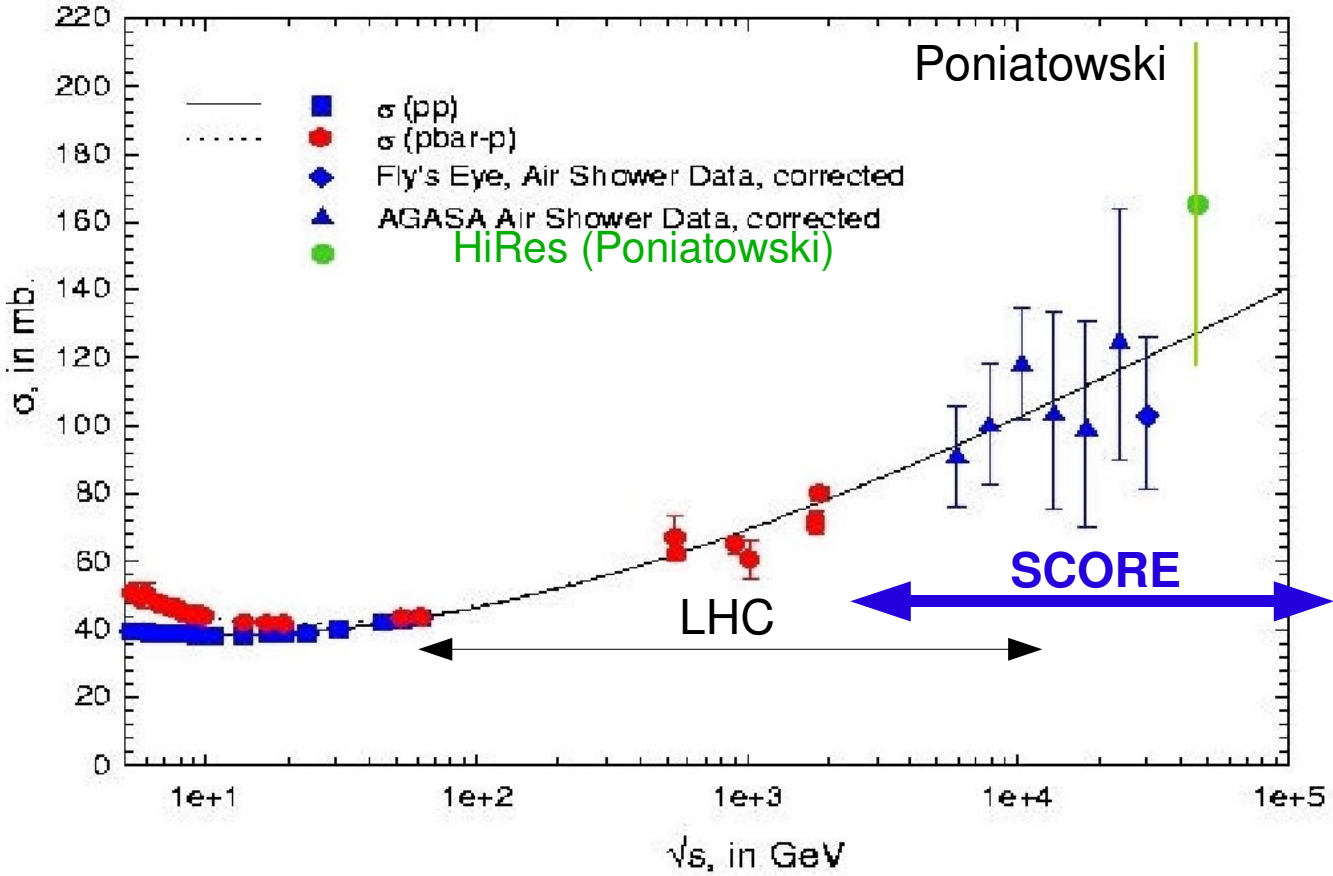
# Status

- Full detector simulation ready
- Studies of first Hardware components in progress
- Funding of first prototype (8 stations) in 2009
- Funding for first SCORE stage pending
- Collaboration from other institutes is welcome !

# p-p cross-section

- Correlation shower depth / first interaction
  → measure interaction length in air **σ(p-p)**
- SCORE: $1 < E_{CM} < 150$ TeV

- Overlap: LHC, CR experiments

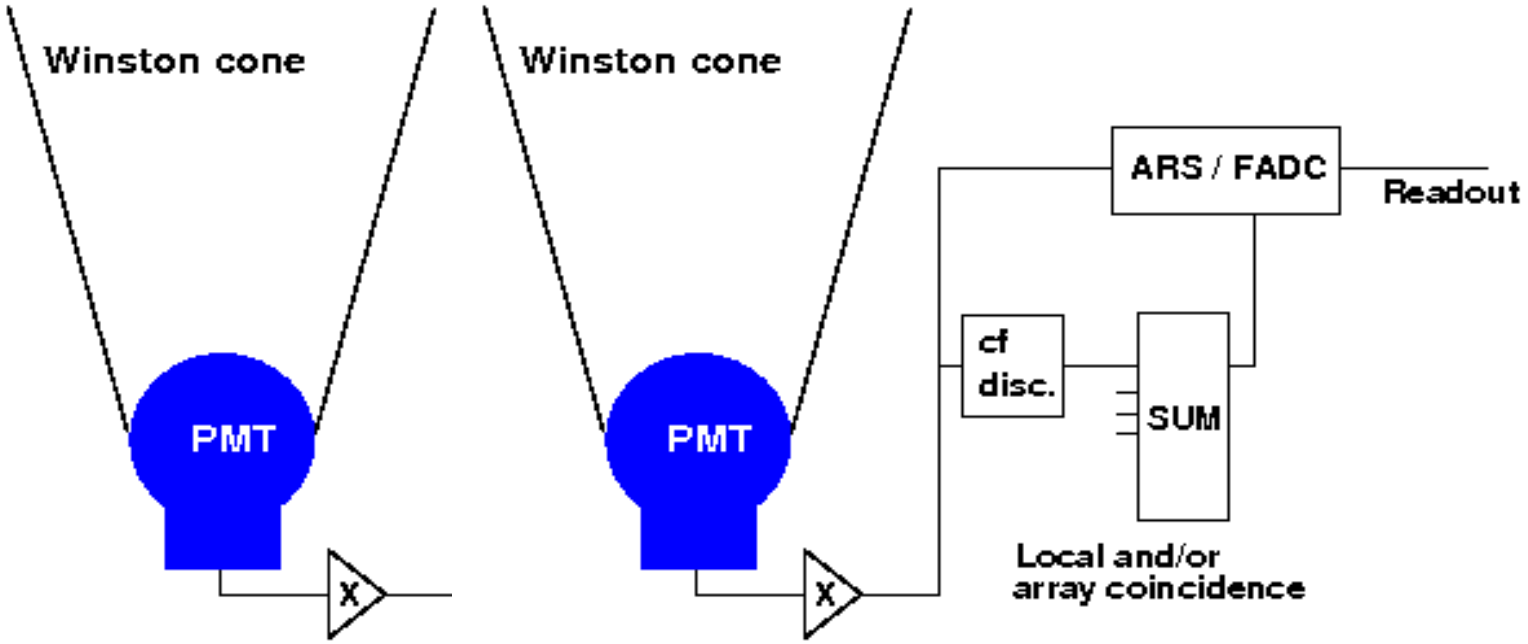


# Alternatives / Extensions

- Daytime-measurements with scintillator material in lid: 100% duty cycle
- Combination with imaging technique:
  - provide core-reconstruction for low-density telescope grid (even monoscopic ?)
  - Instrumentation of larger area for highest energies
- Combination with radio detection technique ?
- ...

# Trigger levels

- Local station trigger:
  - multi-PMT station, e.g. 4 channels
  - 4-fold local coincidence (Δt = 1ns)

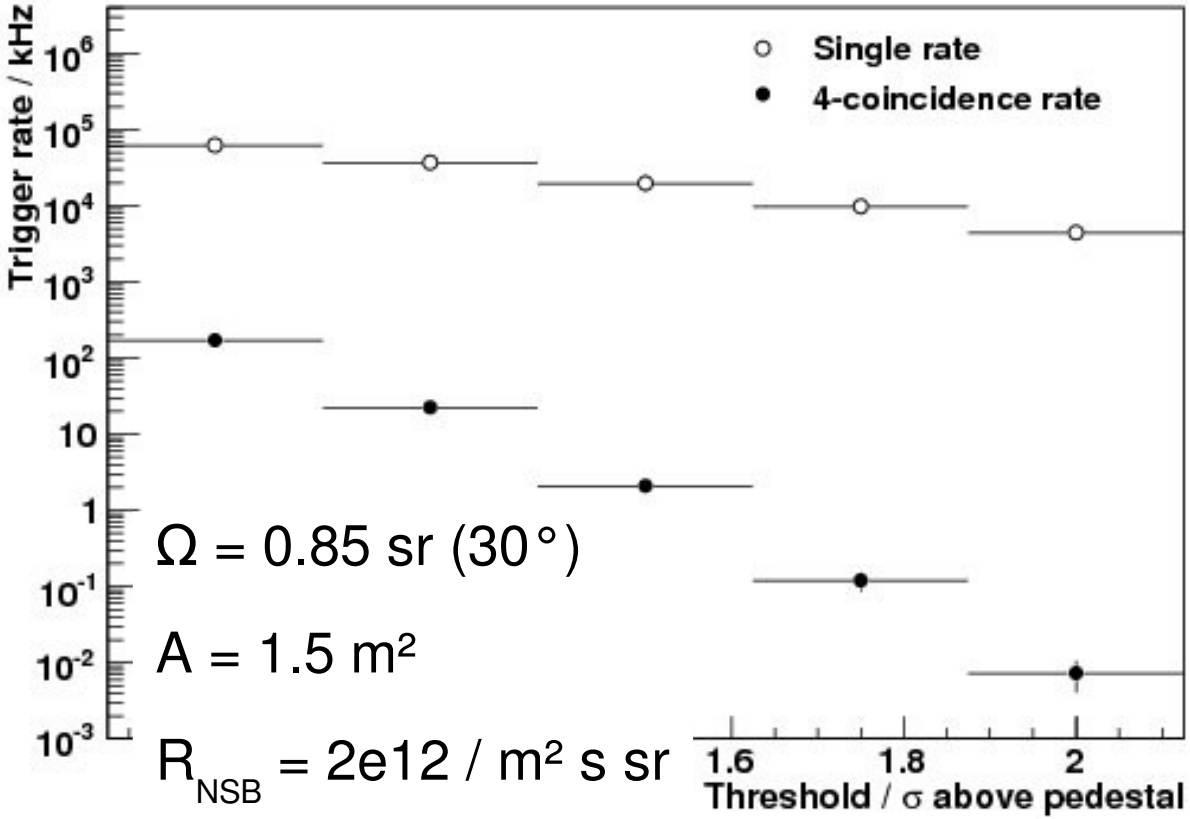


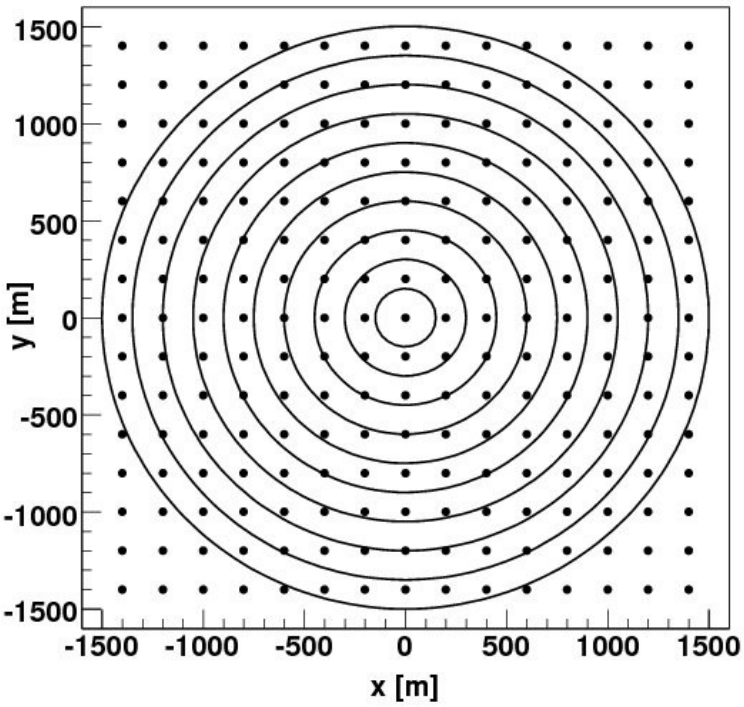

- Array trigger: next-neighbour station trigger (Δt = 1μs)

# Coincidence: benefits

**Suppress NSB → Channel threshold as low as possible:**

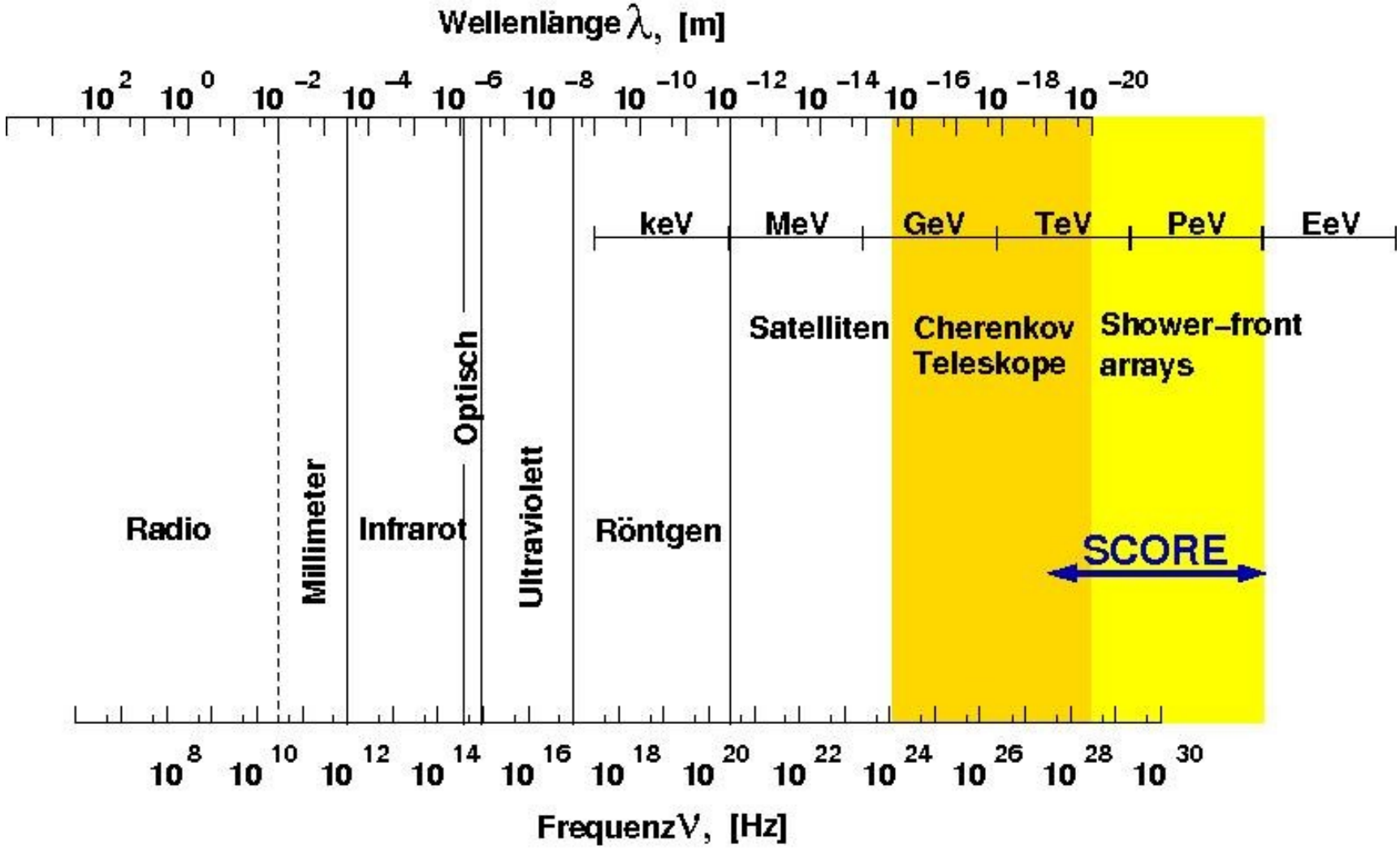
- Trigger threshold energy
- Station stacking: sum weak signals in concentric circles around core




**→Reconstruction: D. Hampf, this conf.**

# The last Observation Window




**SCORE = Study for a Cosmic ORigin Explorer**

**Aim at: 10 TeV < E < 1 EeV**

# (Some) Physics Cases for SCORE

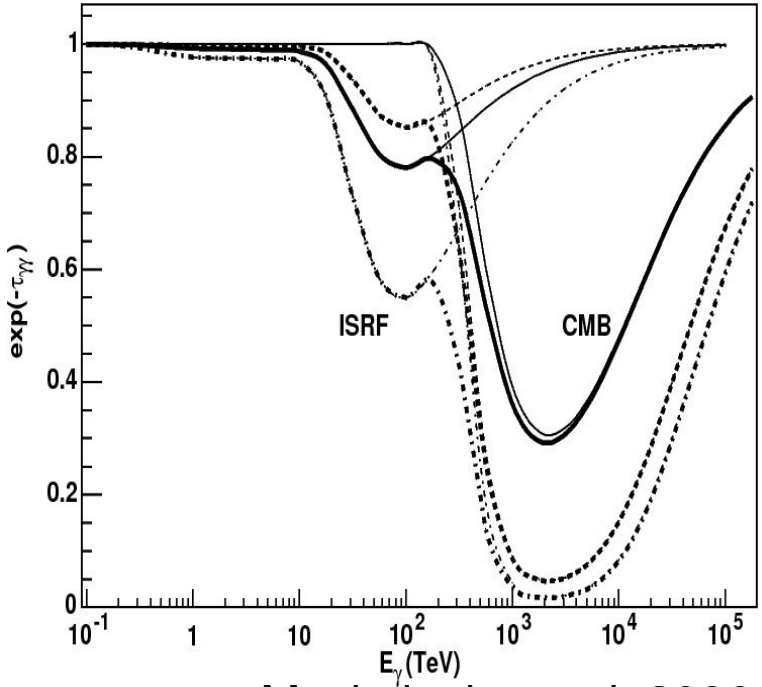
**Gamma-rays: E > 10 TeV**

**Cosmic-Rays: 100 TeV < E < 1 EeV**

- **Astroparticle physics**
  - **Origin of Cosmic-Rays**
  - **Unidentified sources: where do they stop?**
  - **Local Supercluster**
  - **Absorption in Galactic radiation fields and CMB**
- **Particle physics**
  - **Axion / hidden photon search (propagation)**
  - **Lorentz Invariance violation (propagation)**
  - **Measurement of p-p cross-section**

# Propagation: Galactic Absorption & CMB

- $e^+e^-$ pair production: Interstellar radiation field (ISRF) and CMB
- **estimate ISRF density**
- CMB well known: **distance estimate?**
- Weakening of absorption by:
  - **Photon / axion conversion** in Galactic Magnetic field
  - **Photon / hidden photon oscillation**
  - **Lorentz invariance violation** (modification of $e^+e^-$ threshold)



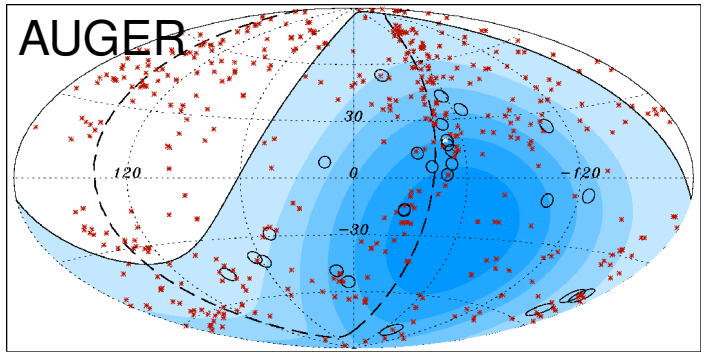

Moskalenko et al. 2006

# Local Supercluster and UHECRs

- UHECRs confined in **local supercluster. Expect diffuse emission:** see T. Kneiske

TANJAs PLOT !!!

- **Point-sources** from AGN ?
  - IC Pair-cascading
  - Haloes ?



# Shower-front sampling arrays

| | SCORE | HiSCORE | TUNKA | BLANCA | AIROBICC |
|---|---|---|---|---|---|
| instrumented area [km²] | 10 | 100 | 1 | 0.2 | 0.04 |
| detector station area [m²] | 1.5 | 1.5 | 0.2 | 0.1 | 0.13 |
| field of view [sterad] | 0.84 | 0.84 | 1.8 | 0.12 | 1 |
| station spacing [m] | 200 | 200 | 85 | 35 | 30 |
| # of modules | 256 | 2601 | 133 | 144 | 49 |

# Station Stacking