Prospects for (part of) Astroparticle Physics

Pierre Auger Observatory
air shower radio detection
the situation in Germany

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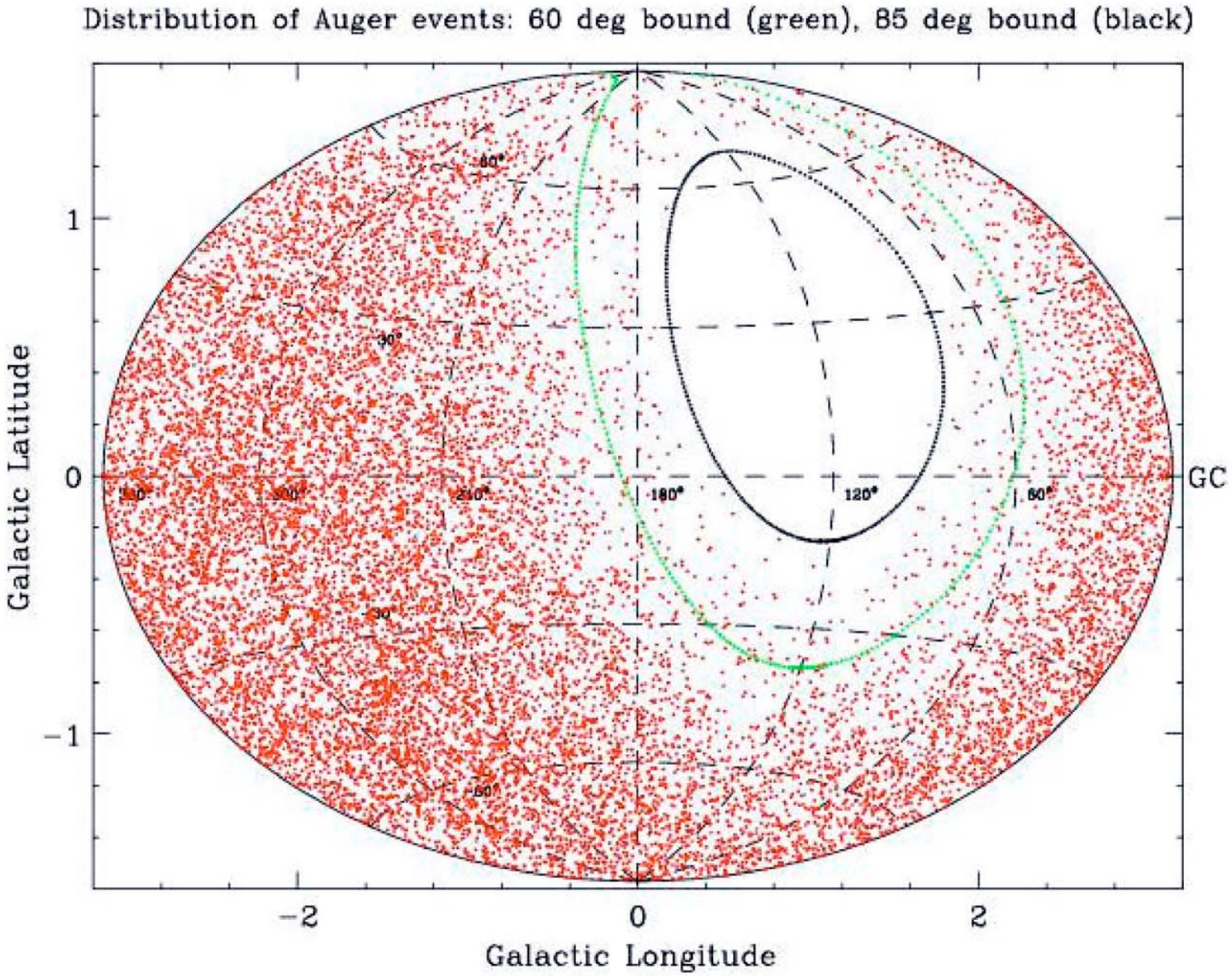
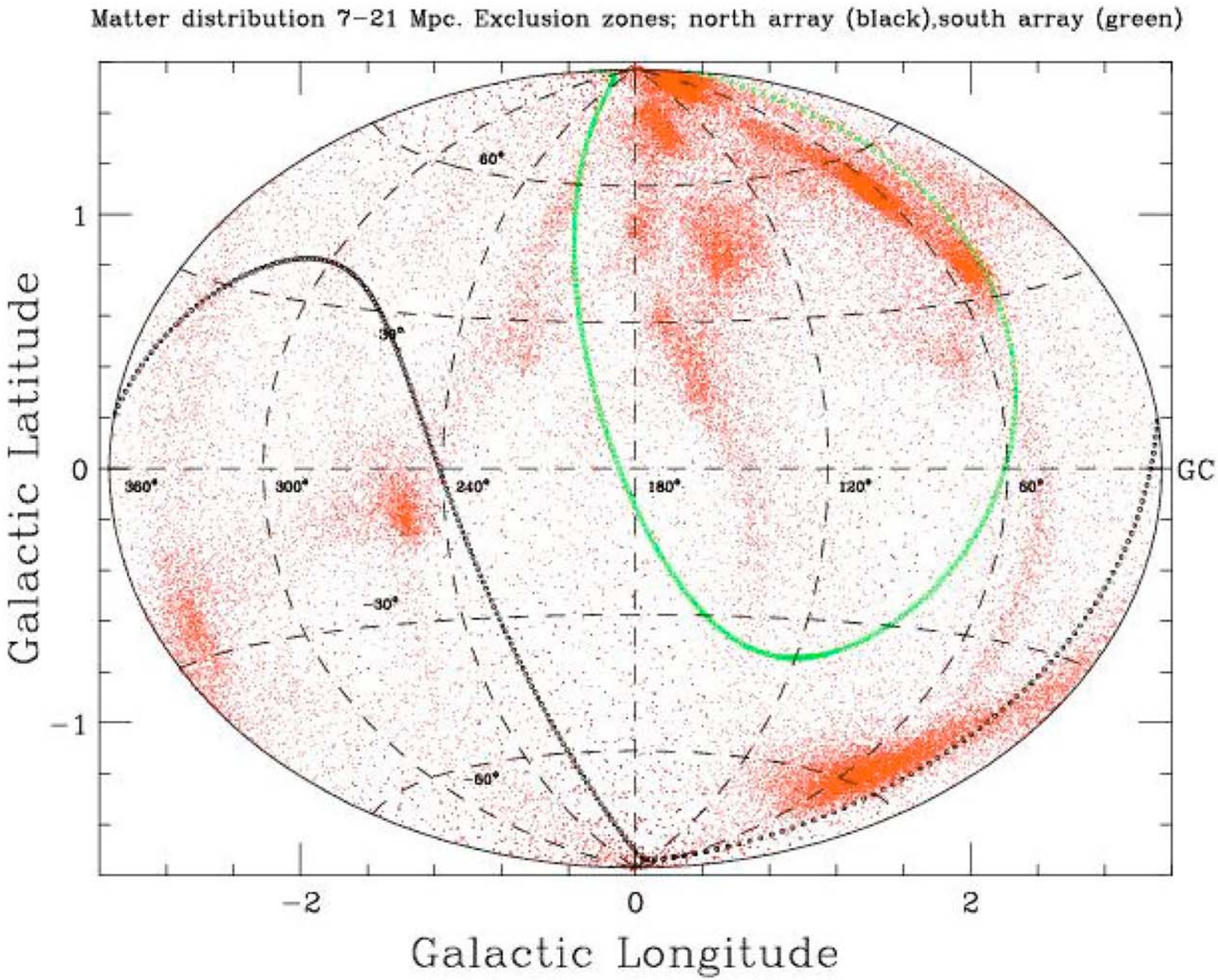
Towards full-sky coverage

- top priority: completion of the Southern Observatory
- Auger North scientific case
  - matter distributions N/S are very different ⇒ effect on possible point sources & energy spectra
  - anisotropy searches much better ⇒ new physics?
- site: Utah or Colorado
  - decision June 2005
  - one (1) Auger Collaboration running two observatory sites
- observatories be functionally equivalent
  - for seamless data integration
  - options:
    - larger area
    - novel technologies
    - optimized designs

Auger sky map

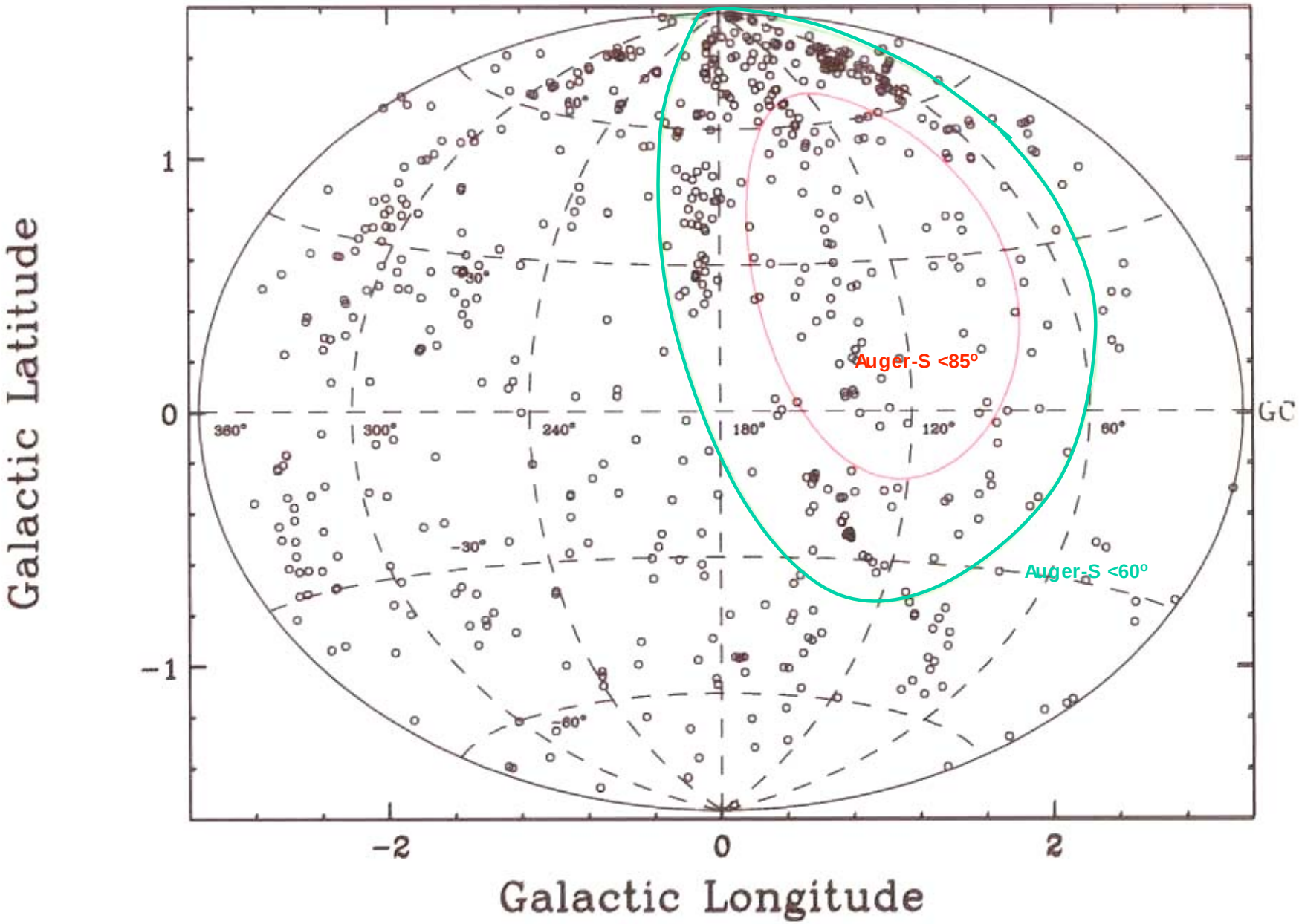


Northern and Southern matter distributions...

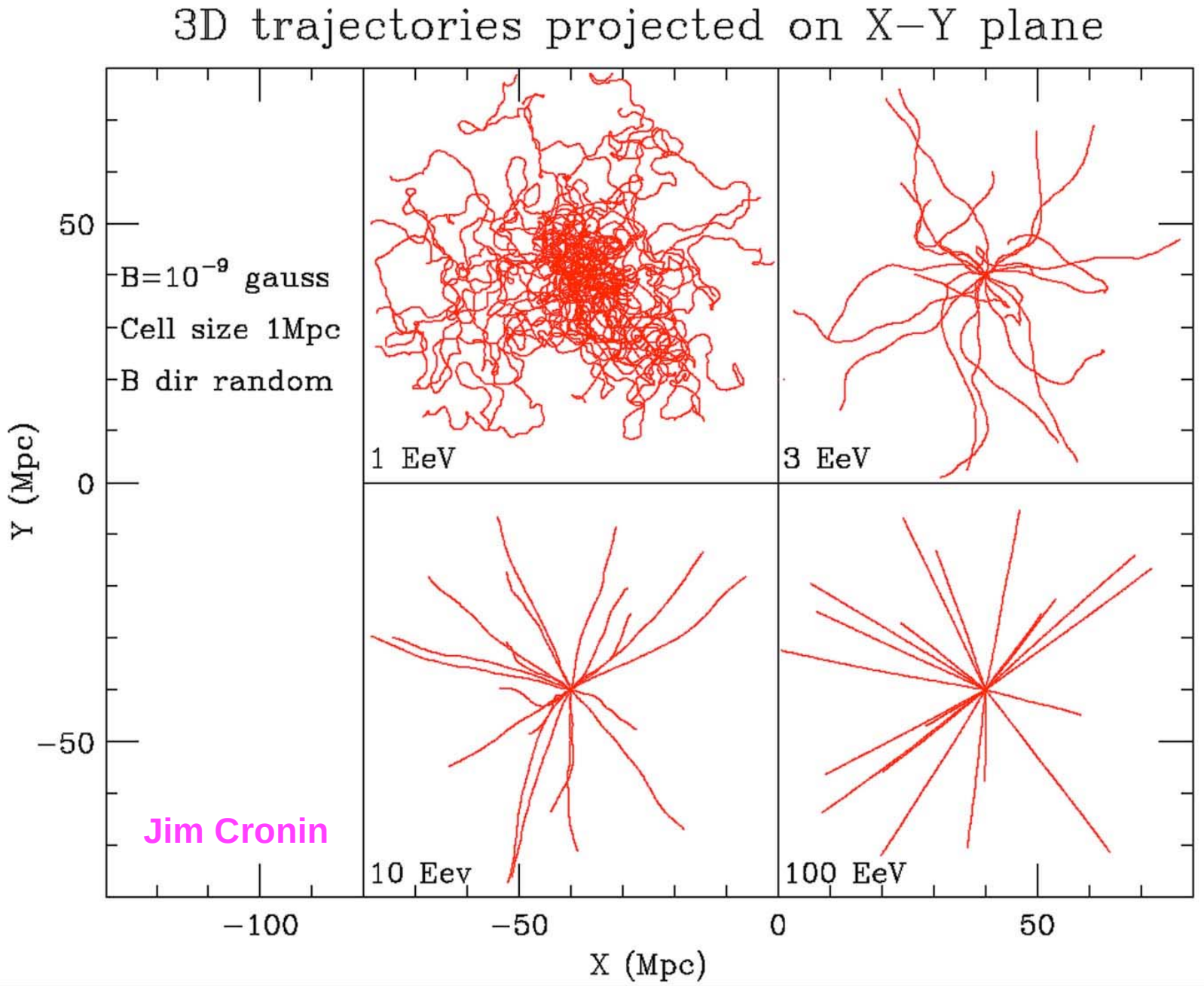


Northern and Southern matter distributions...

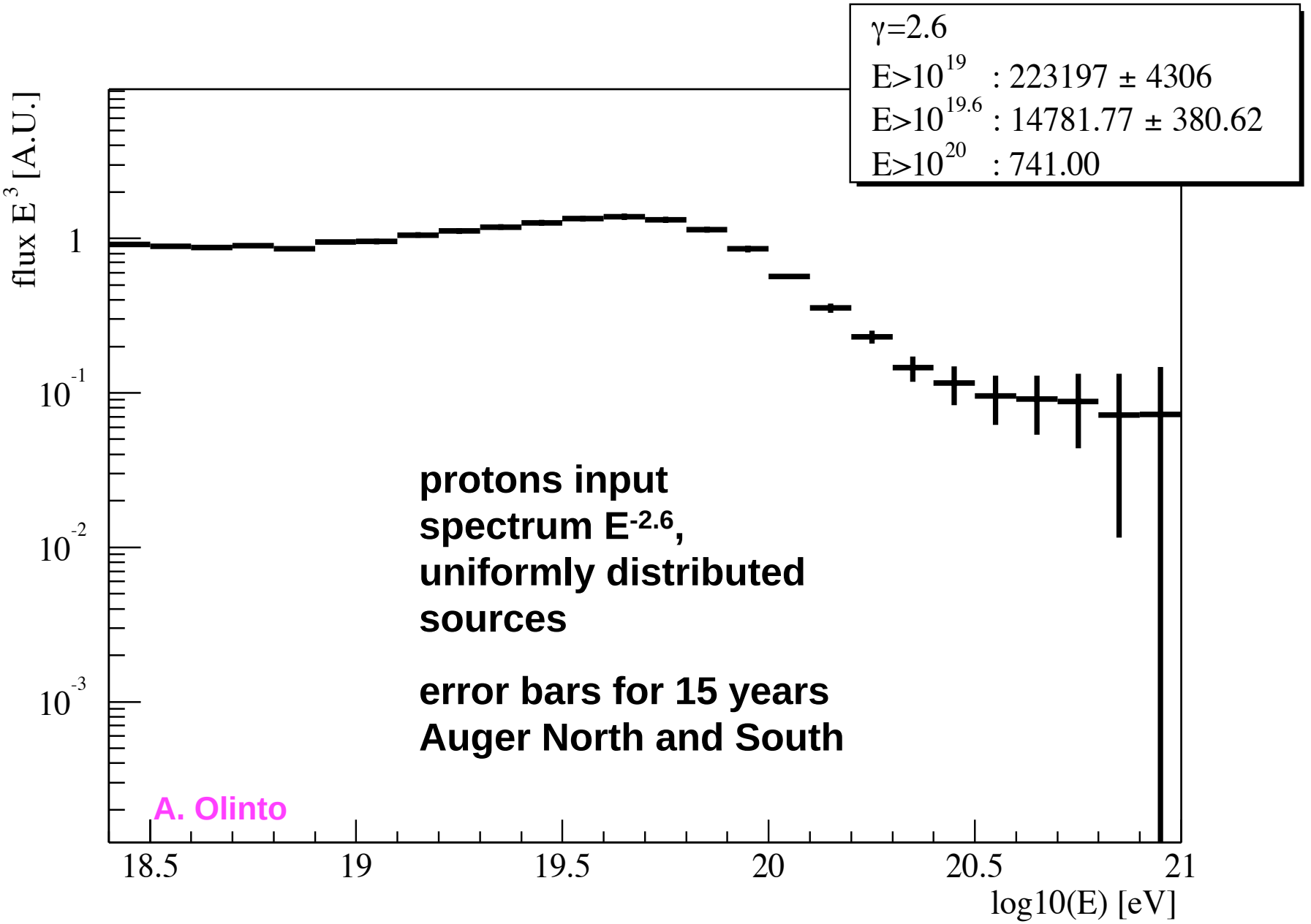
Distribution of Radio Galaxies from IPAC Catalog (0 < Z < 0.02



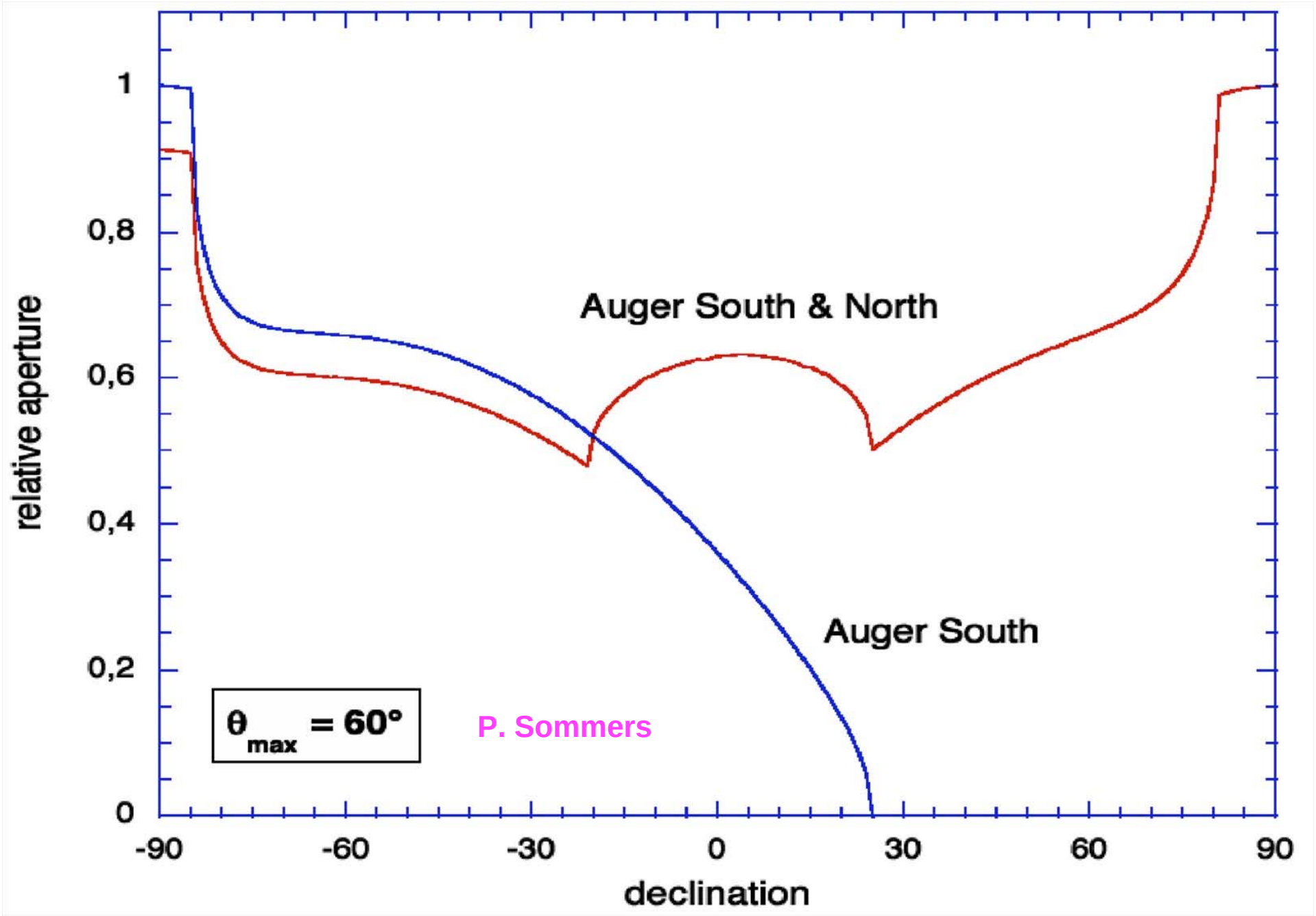
proton astronomy



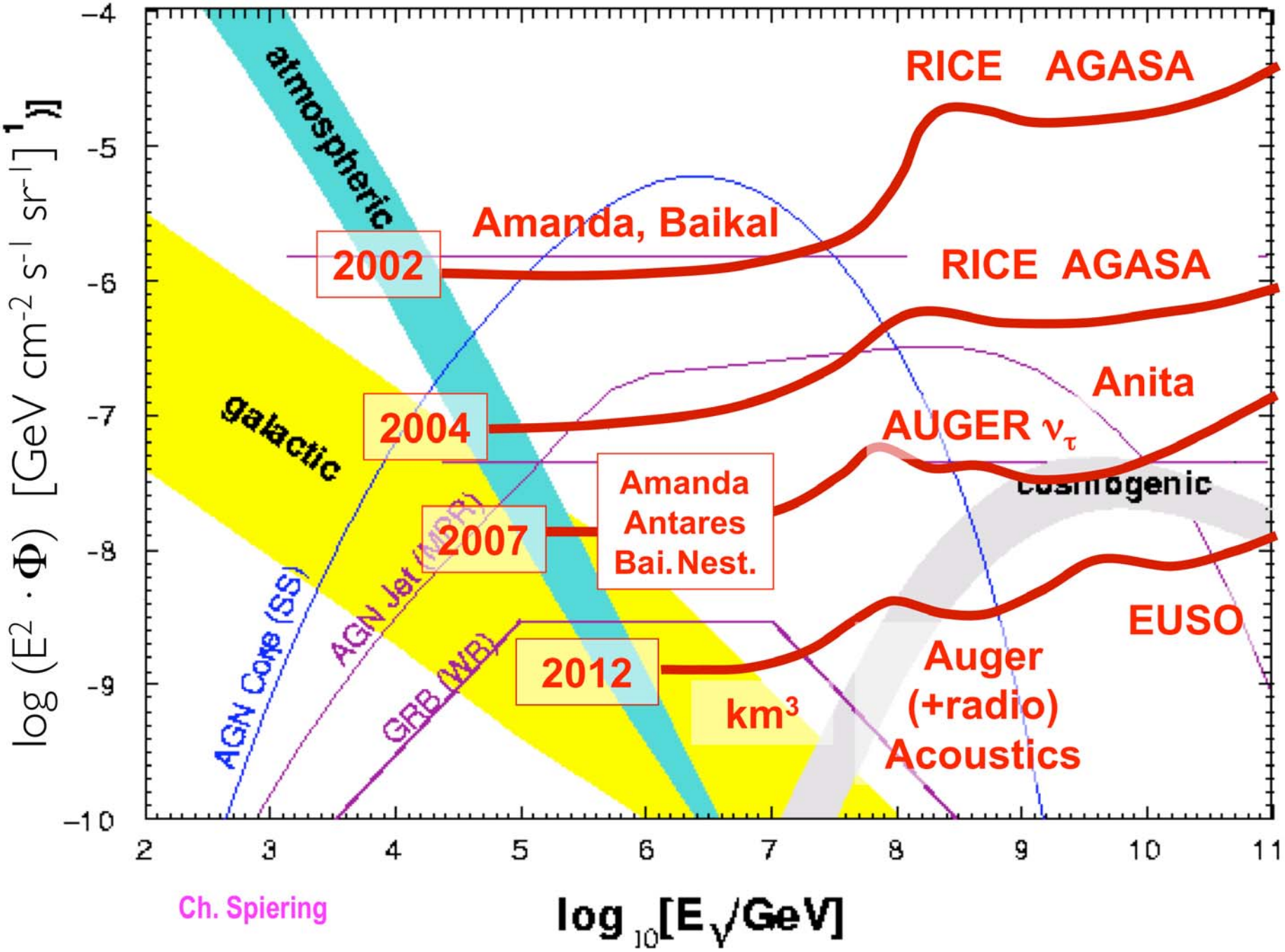
Auger N+S statistical power



relative apertures S+N for anisotropy study



neutrino sensitivity roadmap




Edmonton
Saskatoon
Calgary
Regina
Winnipeg
Victoria
Thunder Bay
Olympia
Helena
Bismarck
Québec
Ottawa
Salem
Saint Paul
Pierre
Boise
Eugene
Lansing
Montpelier
Sioux Falls
Des Moines
Salt Lake City
Lincoln
Detroit
Worcester
Utah
Denver
Gary
Washington
Dover
Sacramento
Jefferson City
Frankfort
Colorado
San Jose
Colorado Springs
Springfield
Charleston
Fresno
Las Vegas
Santa Fe
Salinas
Oklahoma City
Los Angeles
Raleigh
Phoenix
Amarillo
Lubbock
Atlanta
Dallas
Little Rock
El Paso
San Diego
Austin
Baton Rouge
Jacksonville
San Antonio
Hermosillo
Houston
Orlando
Ciudad Obregón
Saint Petersburg
Monterrey
Torreon
Nassau
Fort Lauderdale
Culiacán
La Habana
Pinar del Río

Site Comparison

	Southern Site	Northern Sites under Consideration	
Location/Geography			
Country	Argentina	USA	USA
State (Province)	Mendoza	Utah	Colorado
Latitude	35 -35.3 South	39 North	37 45' North
Longitude	68.9 – 69.4 West	112 West	102 45' West
Altitude	1300 m (E) 1500 m (W)	1400-1450m	1330 m (SW) 1220 m (NE)
Maximum Area (confirmed)	5,800 km^2	7,200 km^2	15,000 km^2
Geography	Flat with a gentle slope	Great Basin	High plains, gentle slope
Land Usage	Ranching (goat, cattle), small farming	Ranching, farming	Ranching, farming
Infrastructure			
Nearby Local Town	Malargue	Delta / Fillmore	Lamar
Population	18,000	3,000 / 2,000	9,000
Major City/ Airport	Mendoza, San Rafael	Salt Lake City	Denver
Distance to Site	420 km, 200 km	210 km	320 km
Weather			
Temperature (Summer)	January 20°C	July mean 24°C	July mean 25°C
(Winter)	July 4°C	January mean -3°C	January mean -2°C
"Cloudiness"		≈ 10%	≈ 7.5%
Irradiance	≈ 380 W/m^2	≈ 253 W/m^2	≈ 250 W/m^2
Land Ownership			
Private	≈100 owners (95%)	≈200 owners (20%)	≈280 owners (95%)
Federal-Owned	0 %	BLM (75%)	negligible
State-Owned	≈ 5%	≈ 5%	≈ 5%

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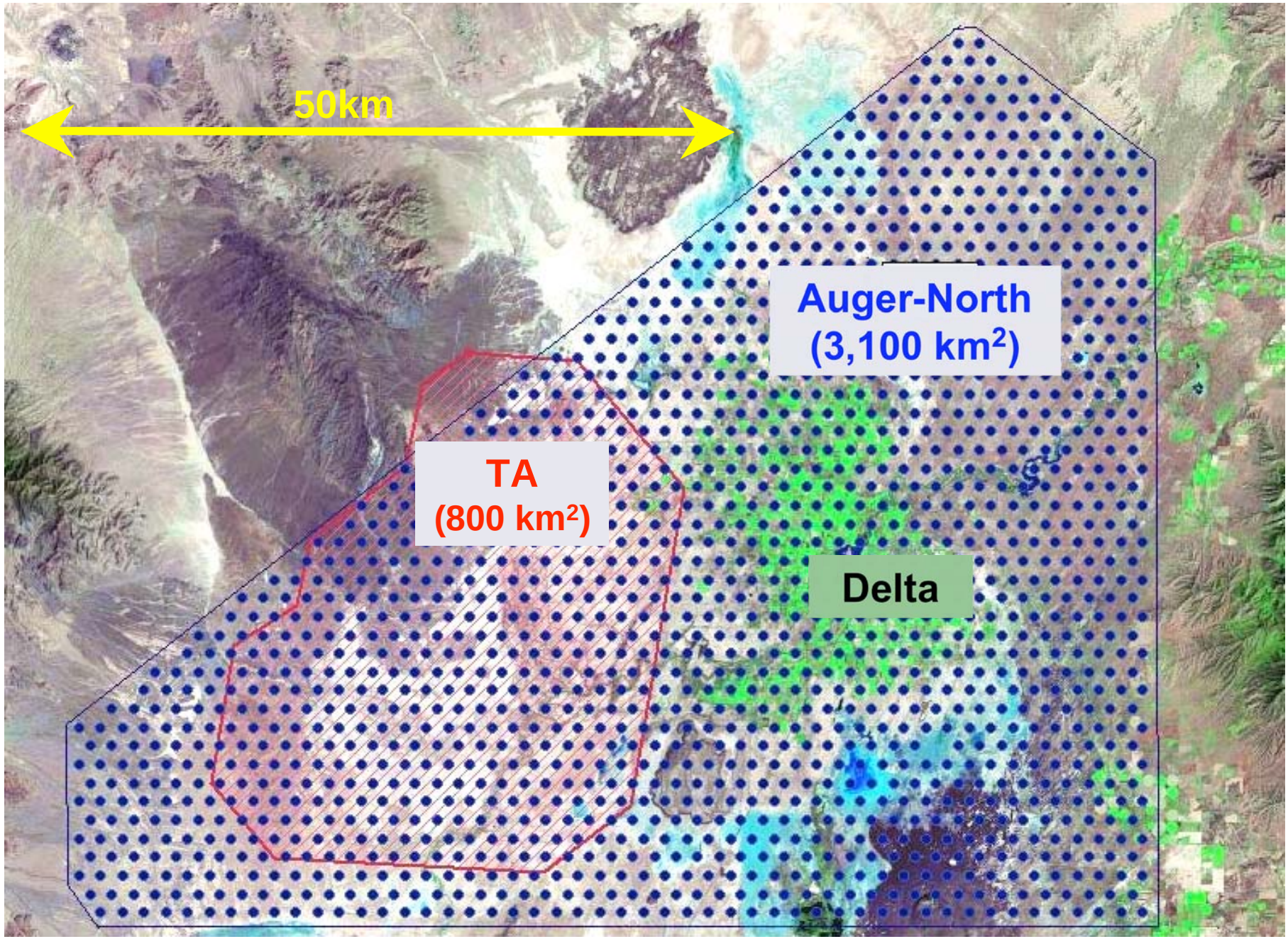
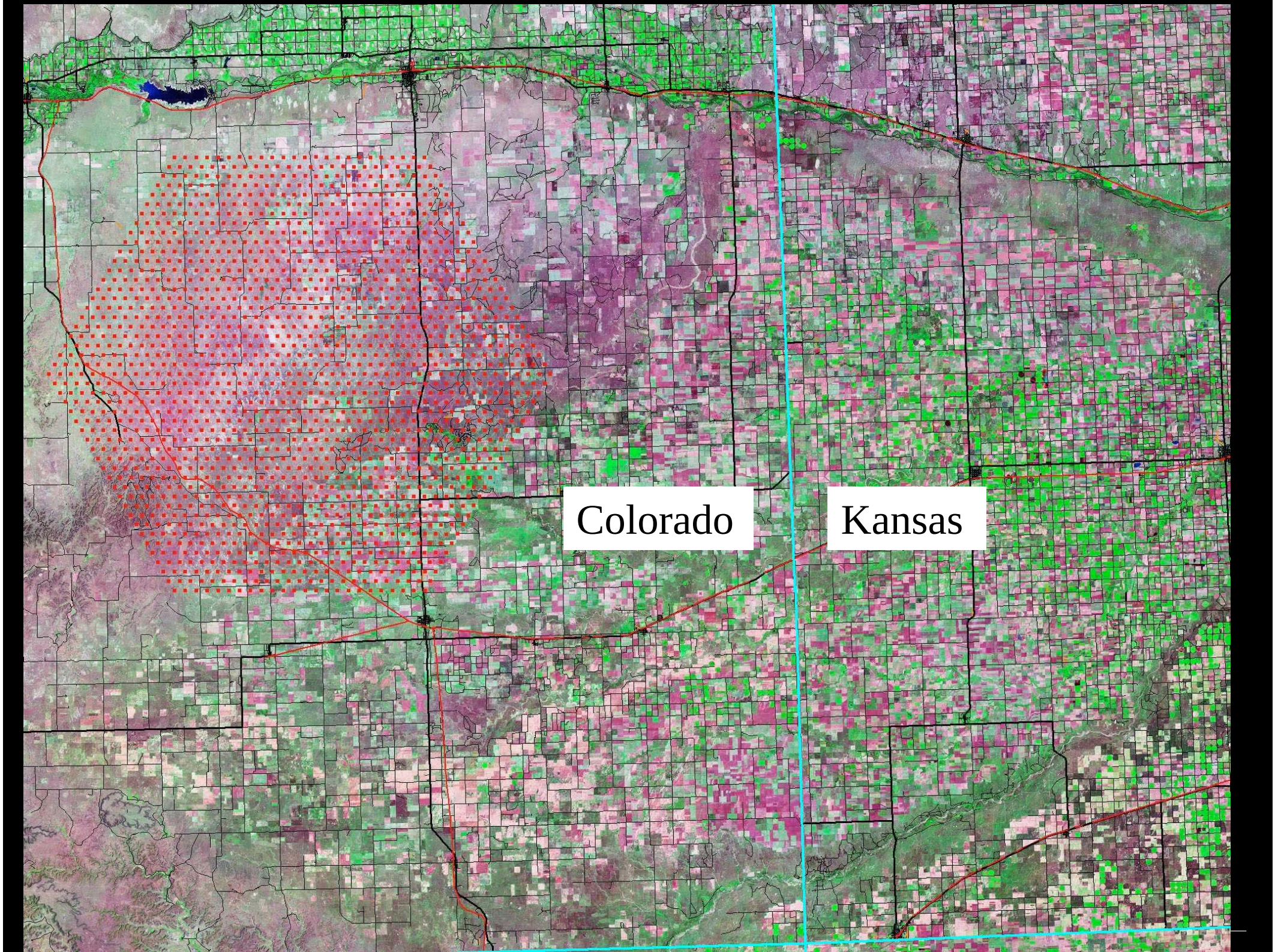
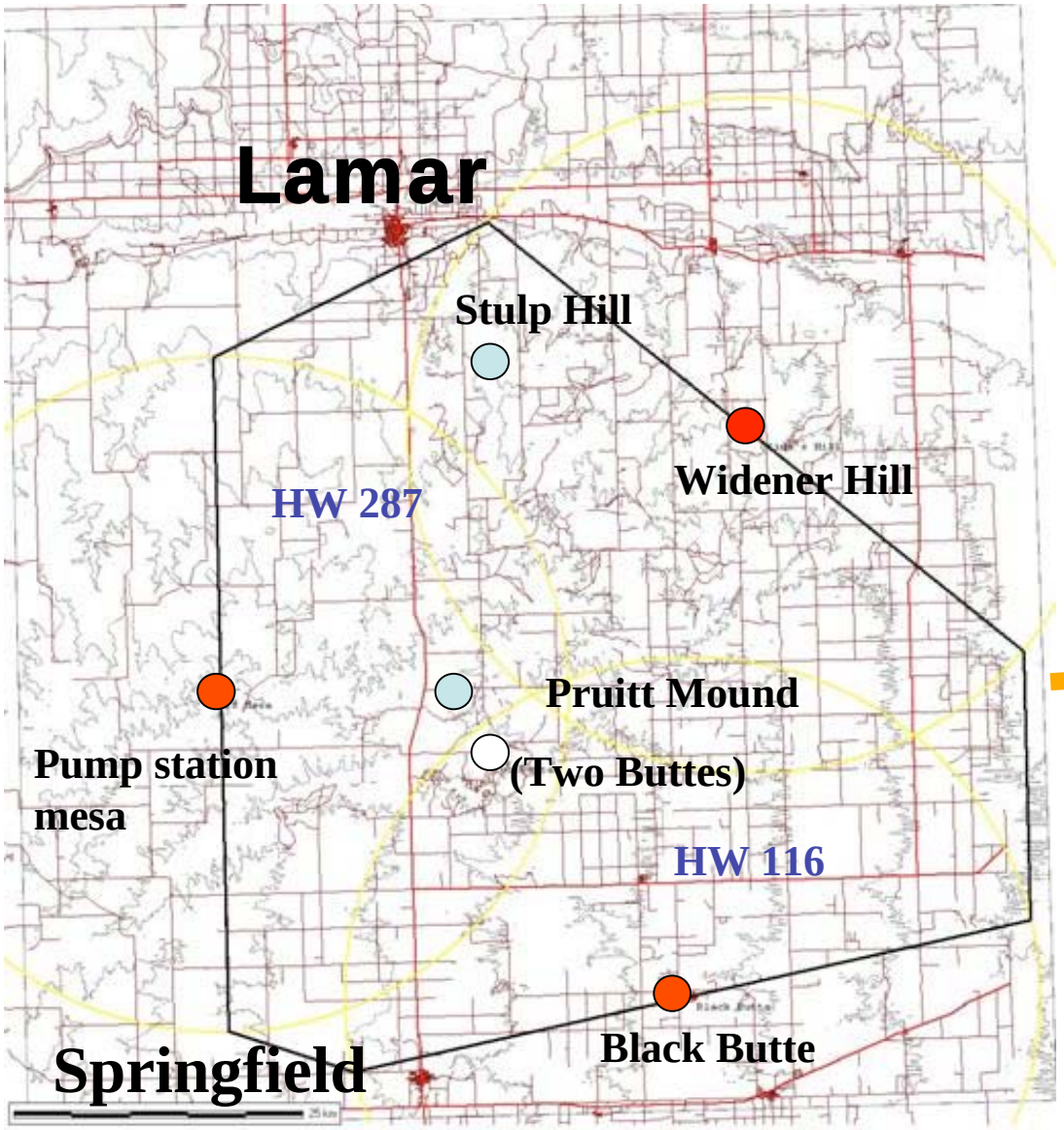
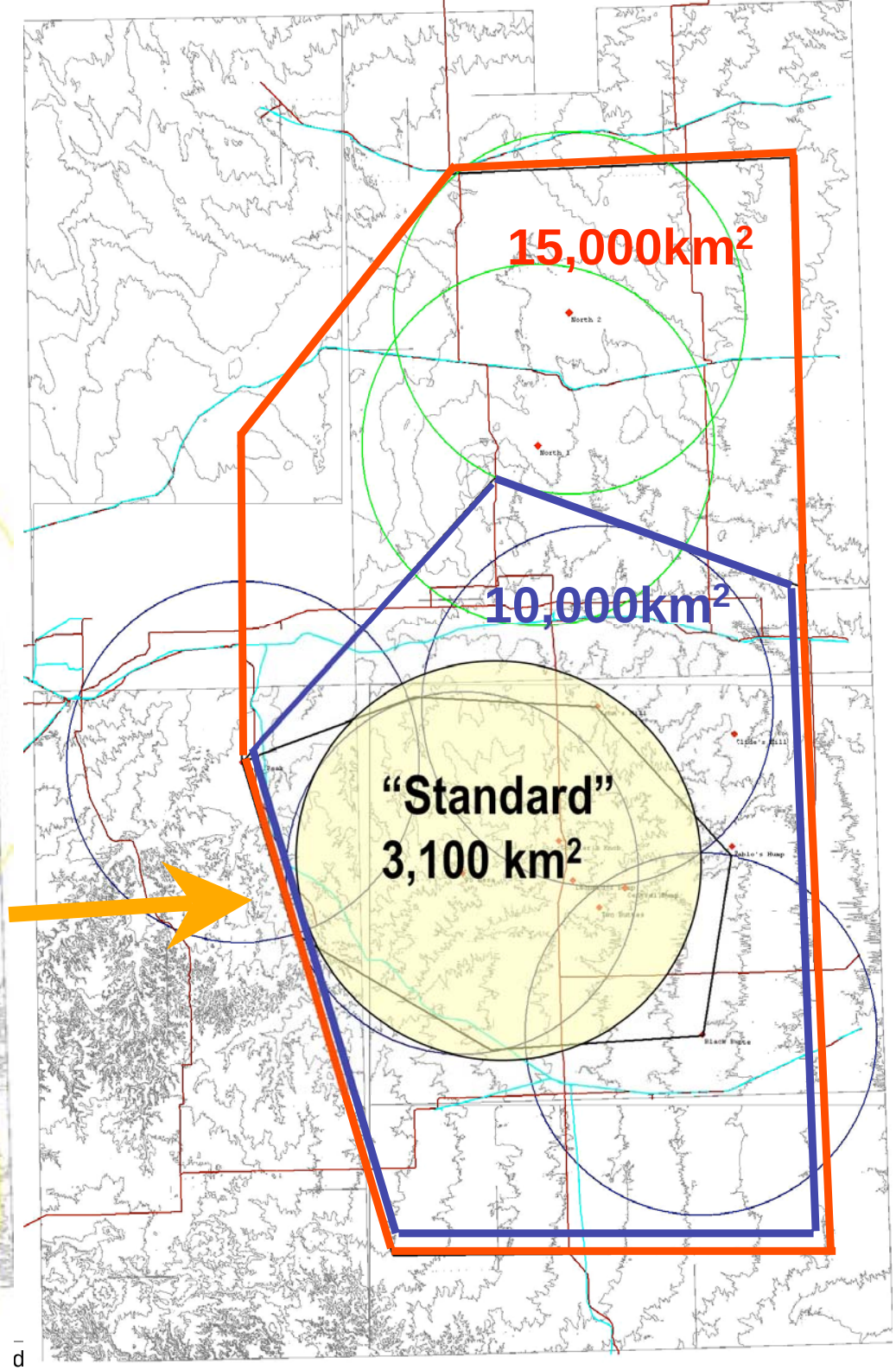
Utah Site




Colorado
Kansas

Colorado Site





air shower radio detection

history

LOFAR

LOPES & KASCADE

it works !

air shower radio detection: historic plots

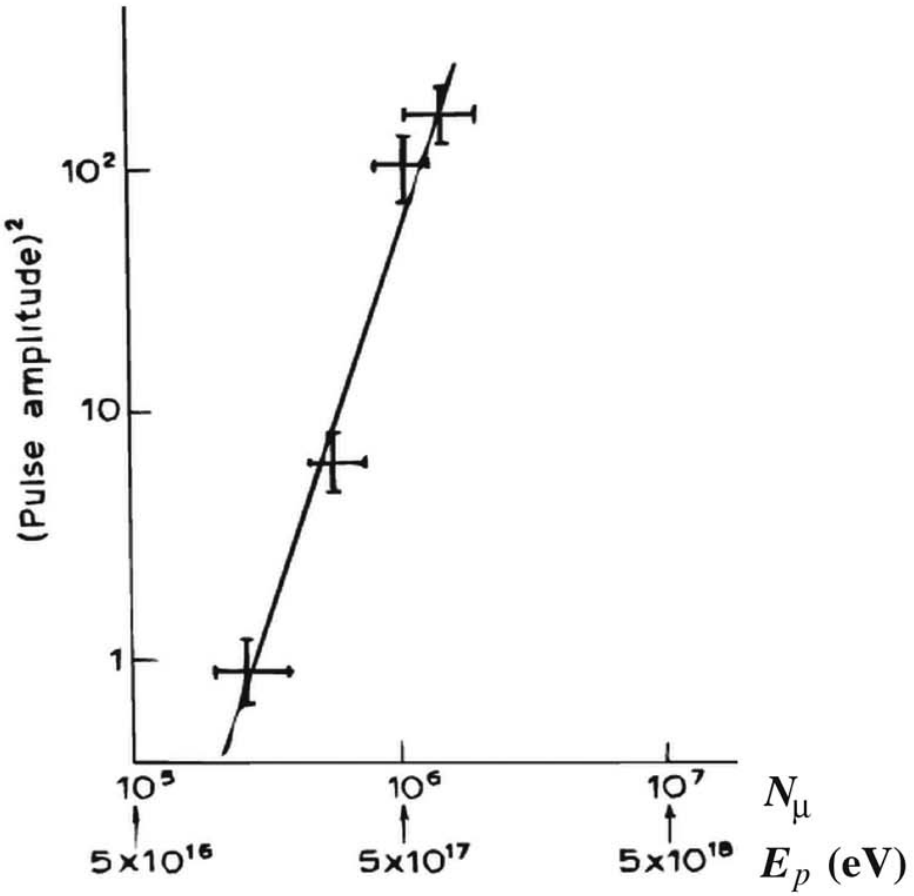


Figure 6. The dependence of EAS radio flux on the primary particle energy as measured by Vernov et al. (1968) following roughly a E_p^2 power-law. Some earlier papers found somewhat flatter dependencies.

taken from Falcke et al astro-ph/0409229

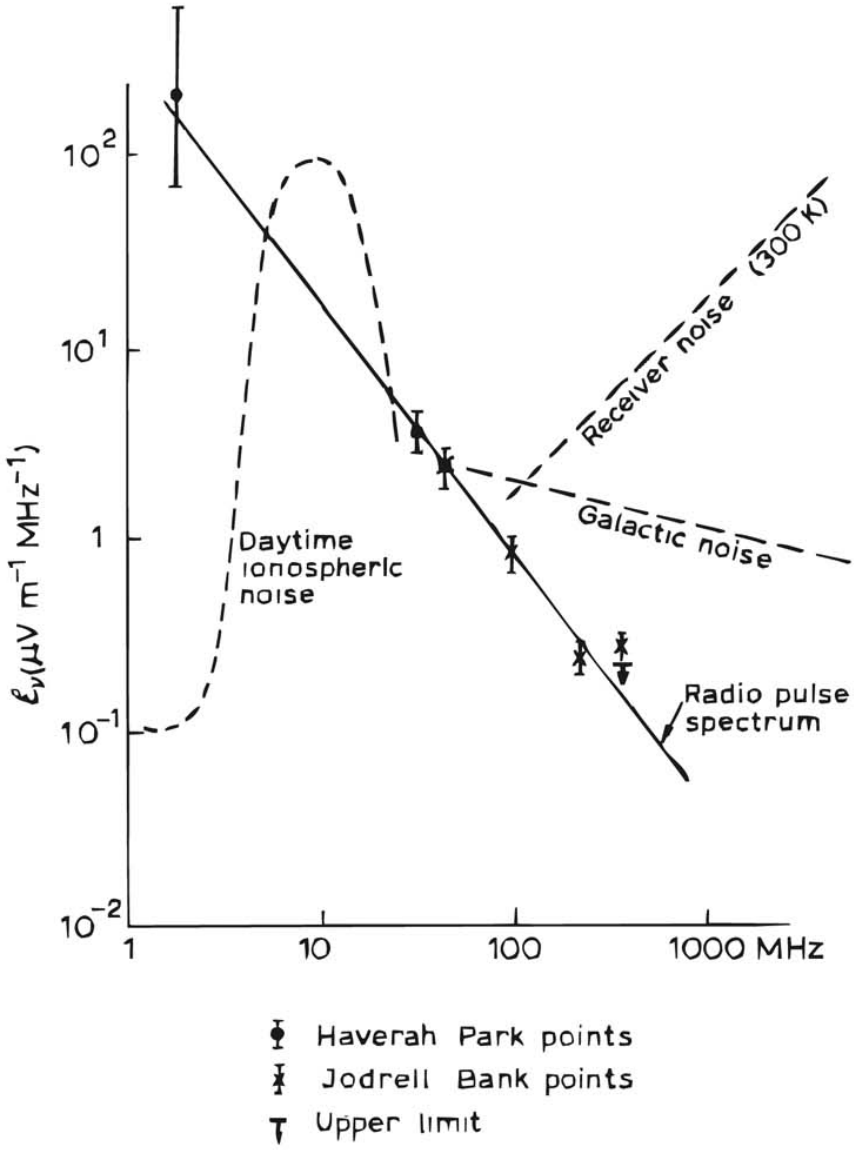
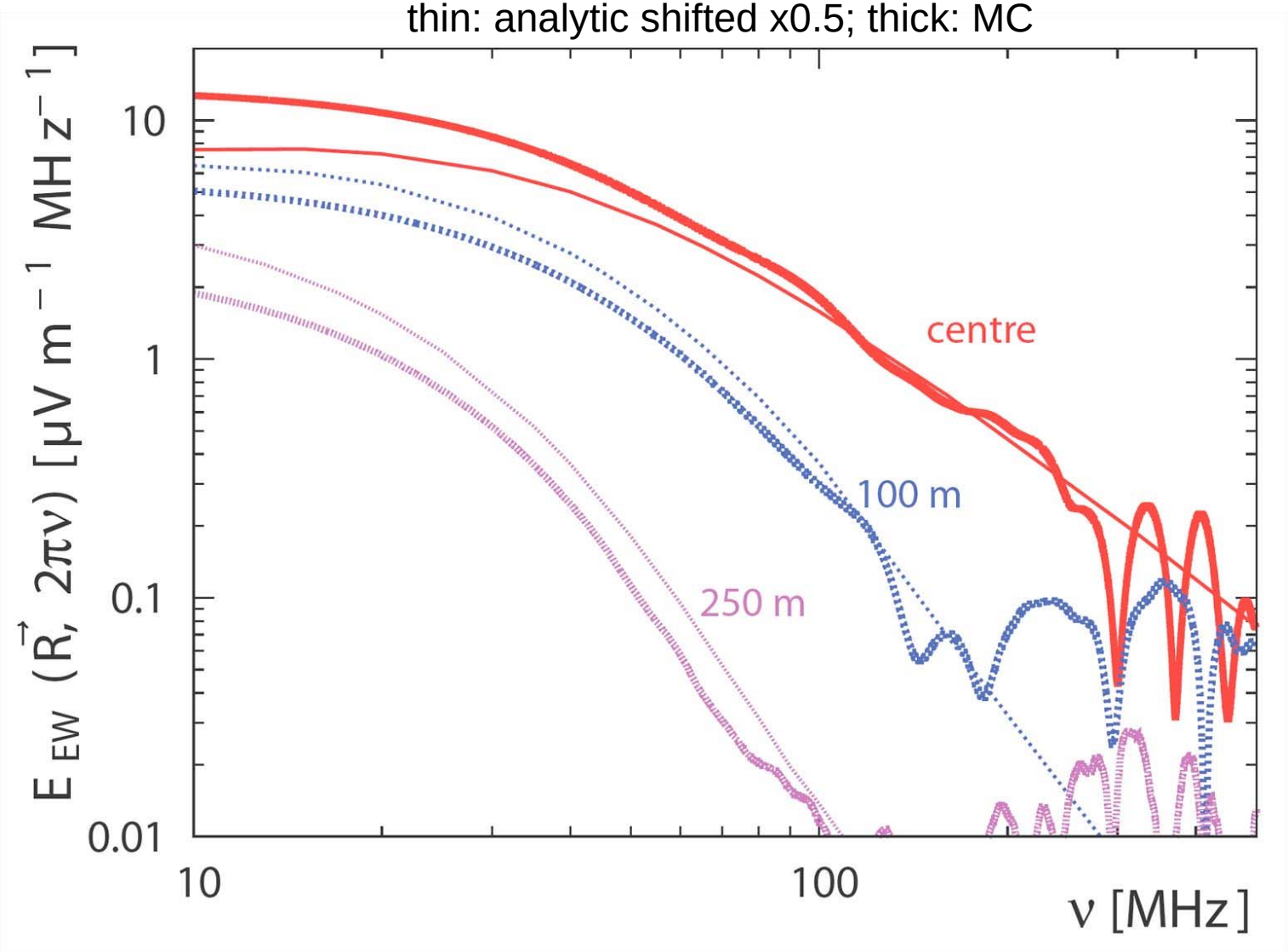


Figure 7. A tentative radio pulse spectrum for 2 MHz to 520 MHz. The data are not simultaneous. From Allan (1971) and Spencer (1969).

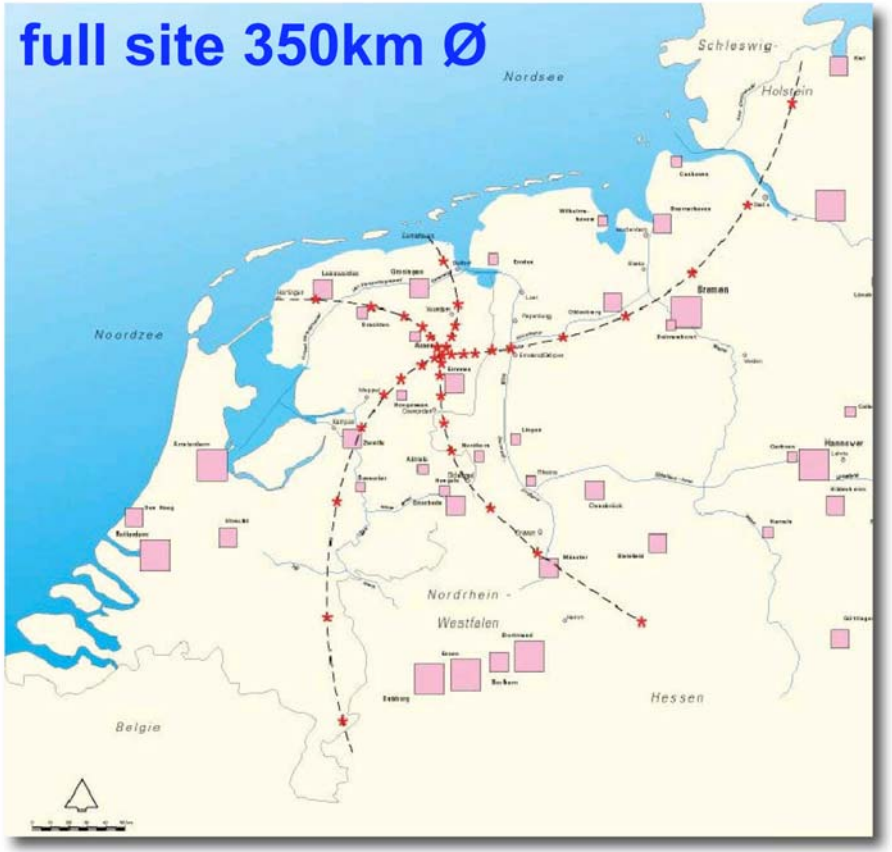
Radio detection of air showers

spectra from10^{17} eV vertical shower for 3 distances to North
thin: analytic shifted x0.5; thick: MC



the Geosynchrotron paper:
Huege T., Falcke H. 2003, Astronomy & Astrophysics, Vol. 412, p. 19-34

LOFAR: Low Frequency Array



The five key areas of science to be addressed by LOFAR are:

1. **The High Redshift Universe**: the study of the most distant radio galaxies and quasars
2. **The Epoch of Reionization**: detection of the global signature, and mapping of structures
3. **Mapping Galactic Cosmic Rays**: to map the 3D distribution of the Galactic cosmic ray electron gas
4. **The Bursting and Transient Universe**: to detect short lived transient events – bursts from Jupiter-like planets, merging and interacting compact objects.
5. **Solar-Terrestrial Relationships**: to detect Coronal Mass Ejections possibly in combination with a Solar Radar, and to study the Earth's Ionosphere.

Radio detection of air showers

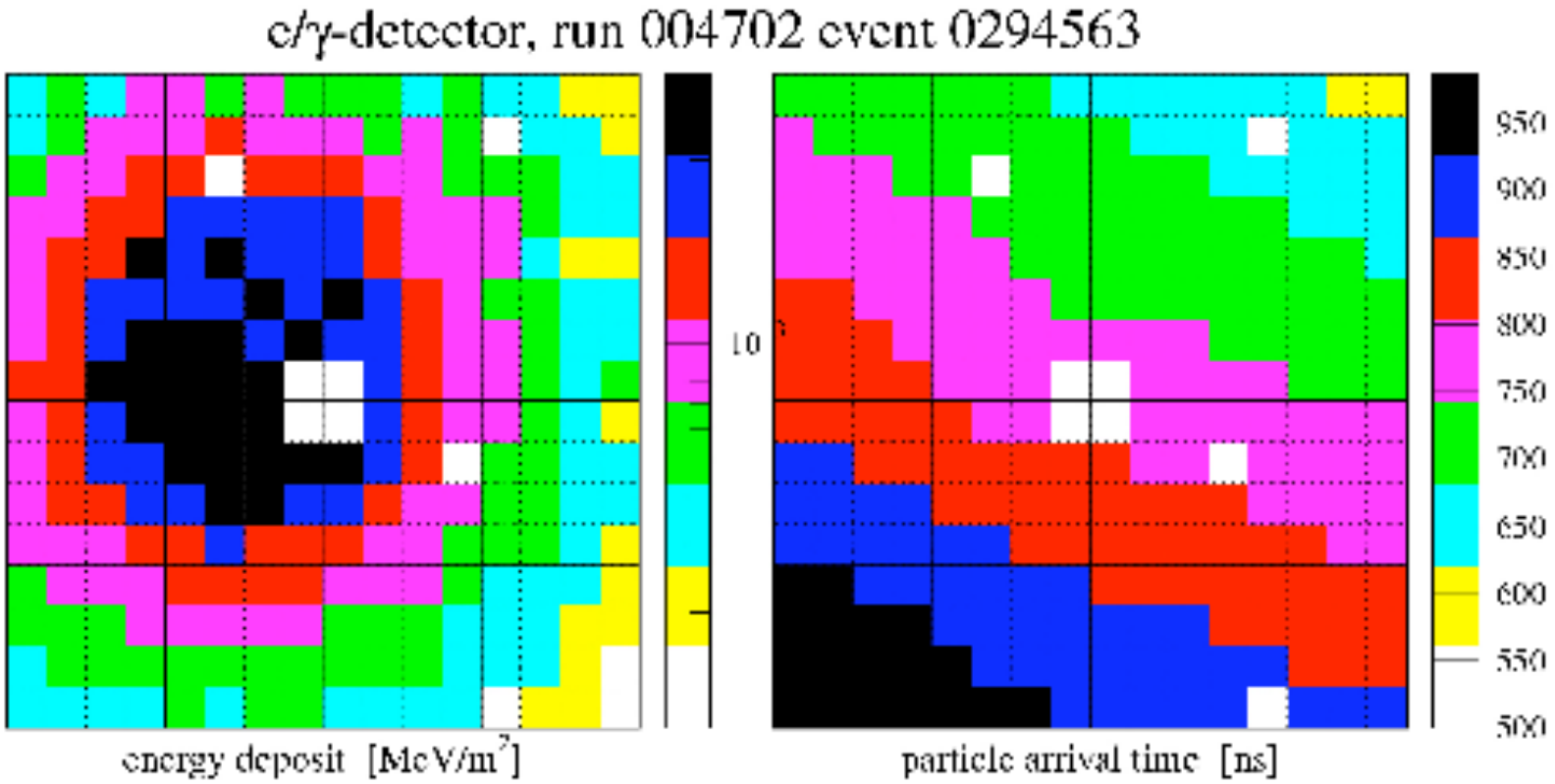
LOPES collaboration:

- KASCADE-Grande
- U Nijmegen, NL
- MPIfR Bonn
- Astron, NL
- FZK-IPE

2003:
10 antennas inside KASCADE
frequency band 40-80 MHz
trigger: >10/16 cluster of KASCADE, $E_0 > 10^{16}$ eV

the LOPES project

first promising event: KASCADE view

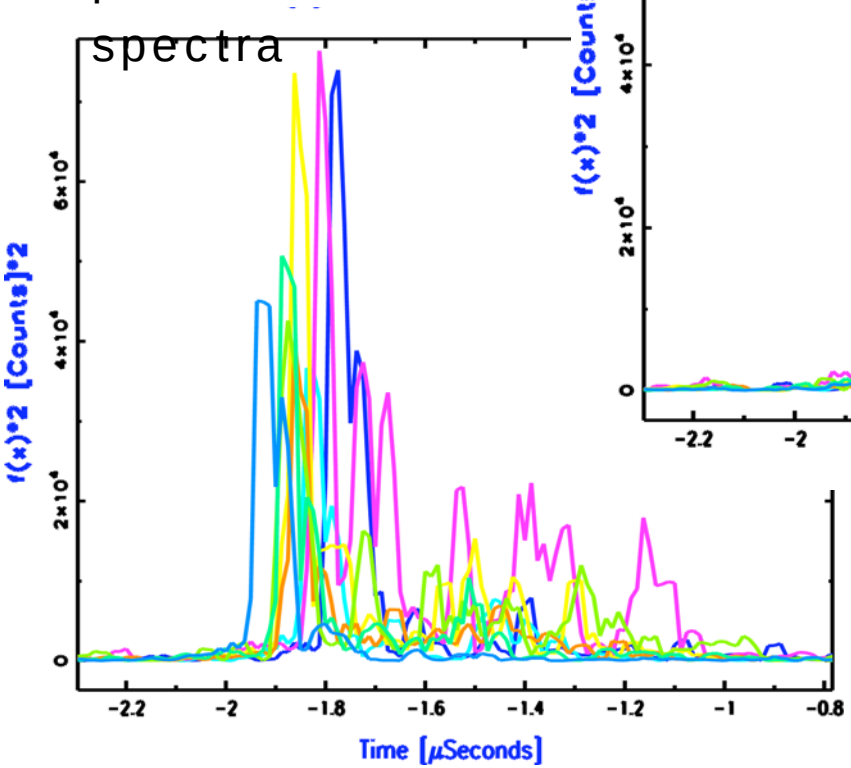


event in KASCADE

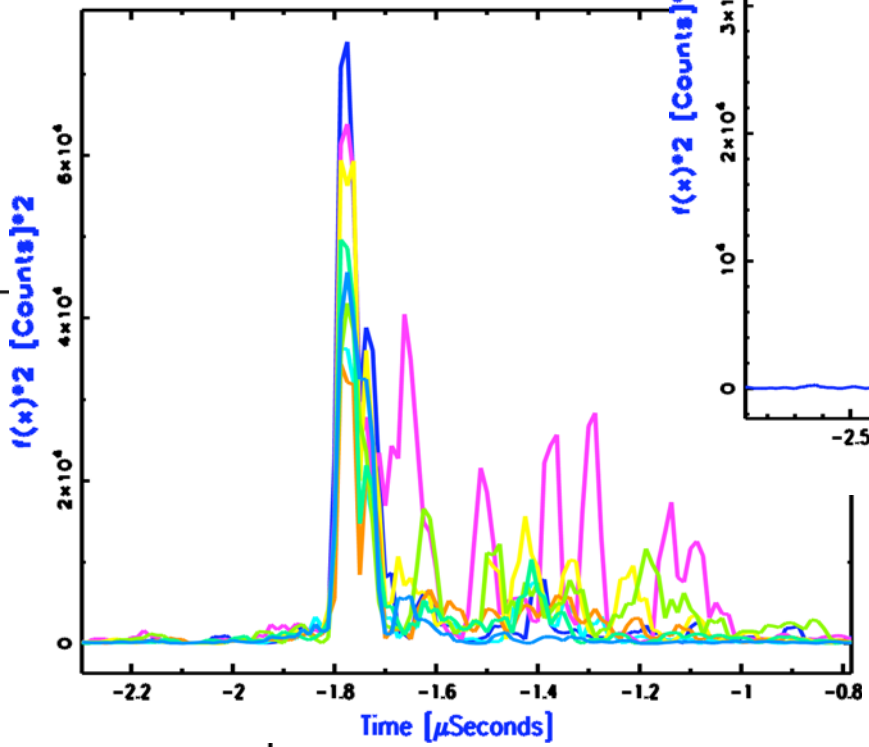
- energy ≈ 10^{17} eV
- EAS core inside antennas
- $\Theta = 25.5°$, $\Phi = 42.5°$
- 8 antennas were working and show signals
- signal is coherent

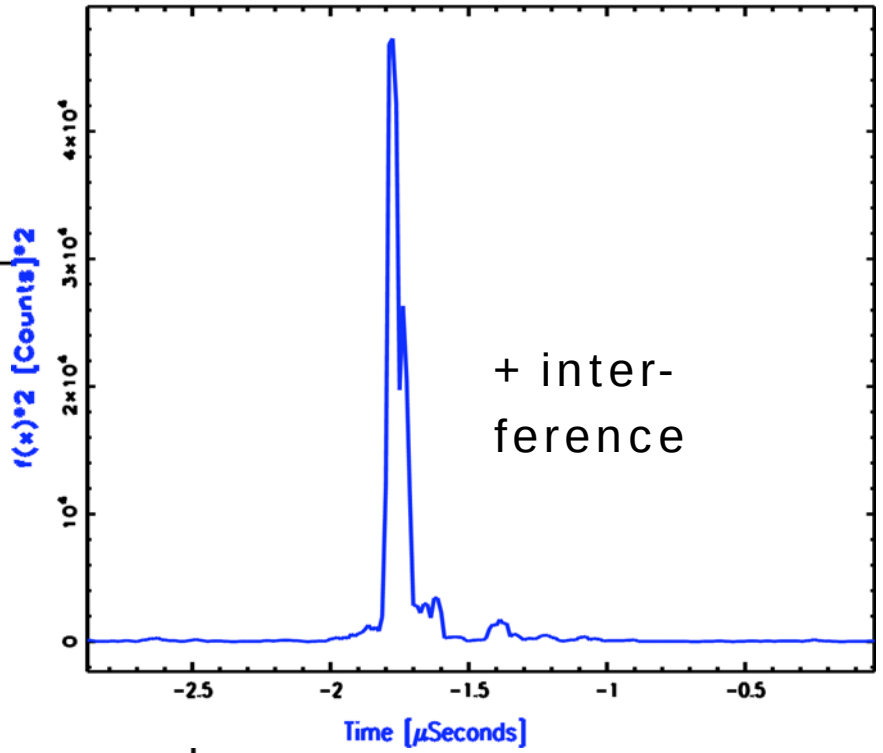
first promising event: LOPES view

raw power spectra



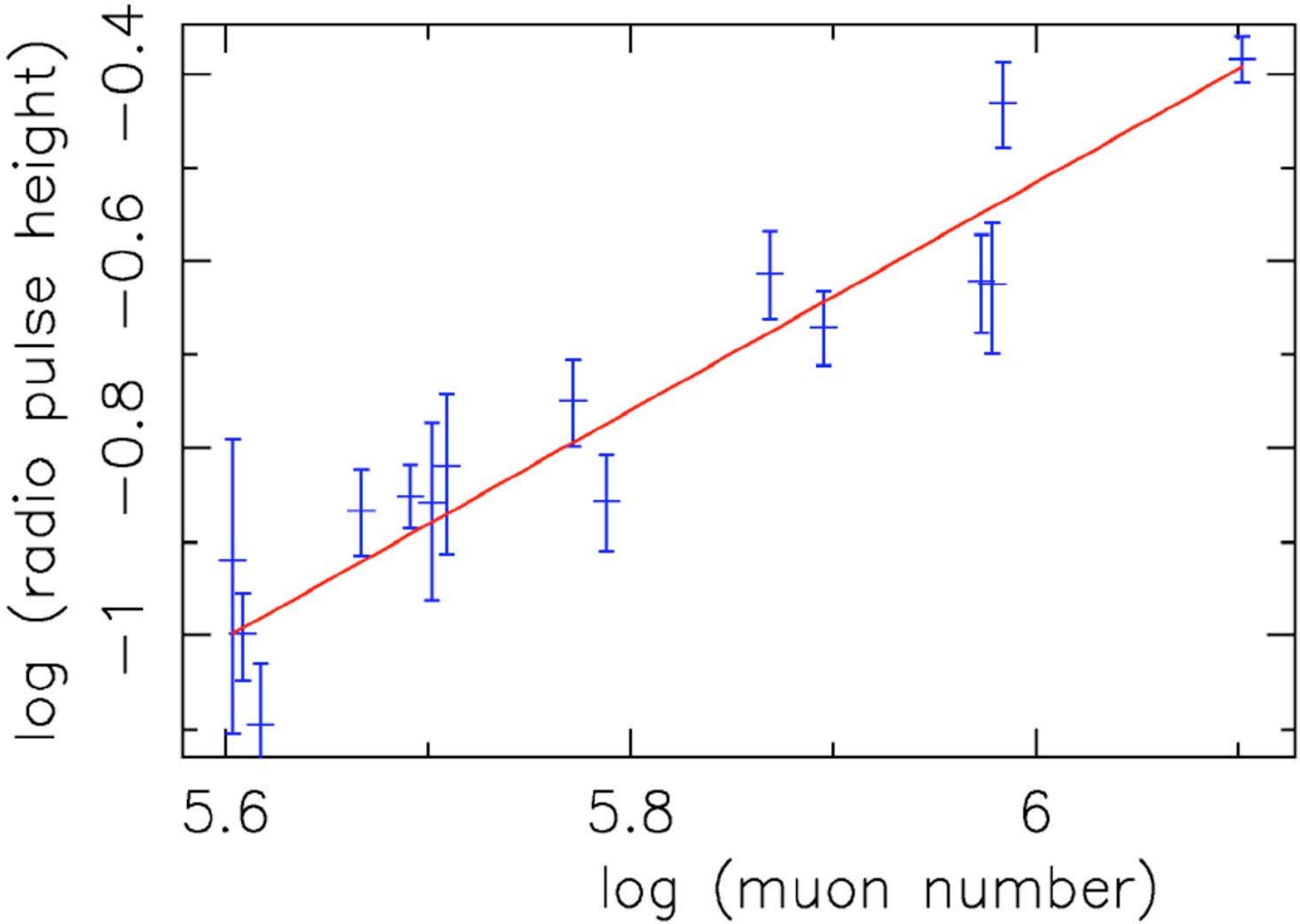
+ beam forming





+ inter-ference

correlation with KASCADE measurements



Pierre Auger Observatory

- the apparatus works extremely well, beyond expectations
- 636 tanks and 6+6 telescopes in data acquisition + more in the field
- Feb 2005: 85% of AGASA exposure (1700 km^2 sr yr)
- data look very interesting indeed
- data set for first analysis:
  - present run until March 2005
  - statistical power about "1 AGASA"
  - spectral shape by SD, energy scale by FD (both are work in progress)
  - release for the ICRC in August 2005
- continuing deployment
  - tanks until mid-2006
  - telescopes: 18 within few months, 4^{th} building done by Mendoza Province
- further strengthening of the collaboration towards full-sky coverage
  - German Universities, Netherlands, Korea, ...

related work to be done

- Preparation for Auger North
  - surface detectors
    - climate impact
    - Liners
    - PMT enclosures
  - communications
    - wireless broadband
    - GPS receivers
  - frontend electronics redesign
  - addition of Cherenkov and radio detection

- upgrade Southern site
  - low energy extension
  - upward-looking fluorescence telescopes
  - denser partial array
  - muon counters

both are part of the same endeavour
strengthen the collaboration
additional funds

Astroparticle Physics in Germany

community

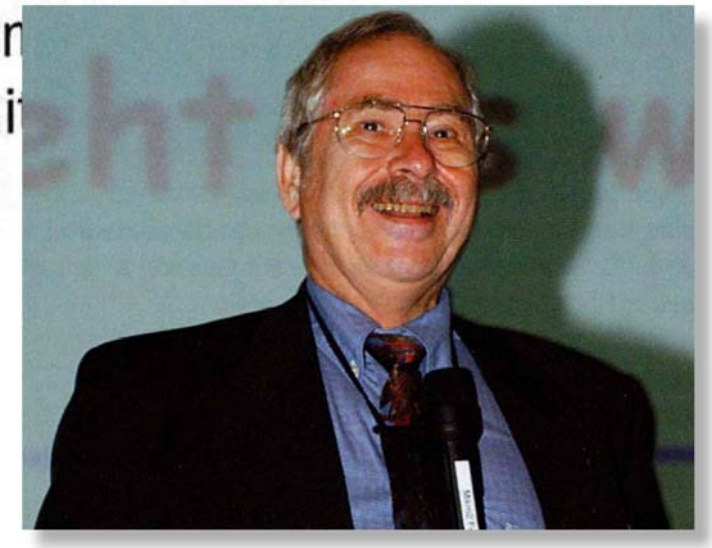
structures

Helmholtz Virtual Institutes

KAT

On 16–18 September 2003 German astroparticle physicists and ministry representatives met at the University of Karlsruhe to discuss recent scientific advances, future funding and organizational support by the German Ministry of Education and Research (BMBF). The Karlsruhe workshop was the third in a series initiated by BMBF deputy director-general Hermann-Friedrich Wagner to maintain a close contact between scientists and the ministry. These open discussions have allowed each side to understan
better, and have led to the very fast and frui
astroparticle physics in Germany.

CERN Courier March 2004



workshop participants:

1999 Zeuthen	57	■■■■■■
2001 Zeuthen	124	■■■■■■■■■■■■
2003 Karlsruhe	240	■■■■■■■■■■■■■■■■■■■■■■■■
2005 Zeuthen	Oct 4+5	?

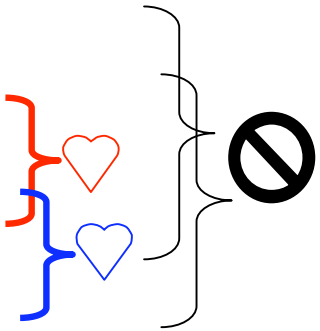
definition of an astroparticle physicist (m/f)

I think to be an astroparticle physicist, so I am an astroparticle physicist

Komitee für Astroteilchenphysik

- one member for each research field, elected by the community

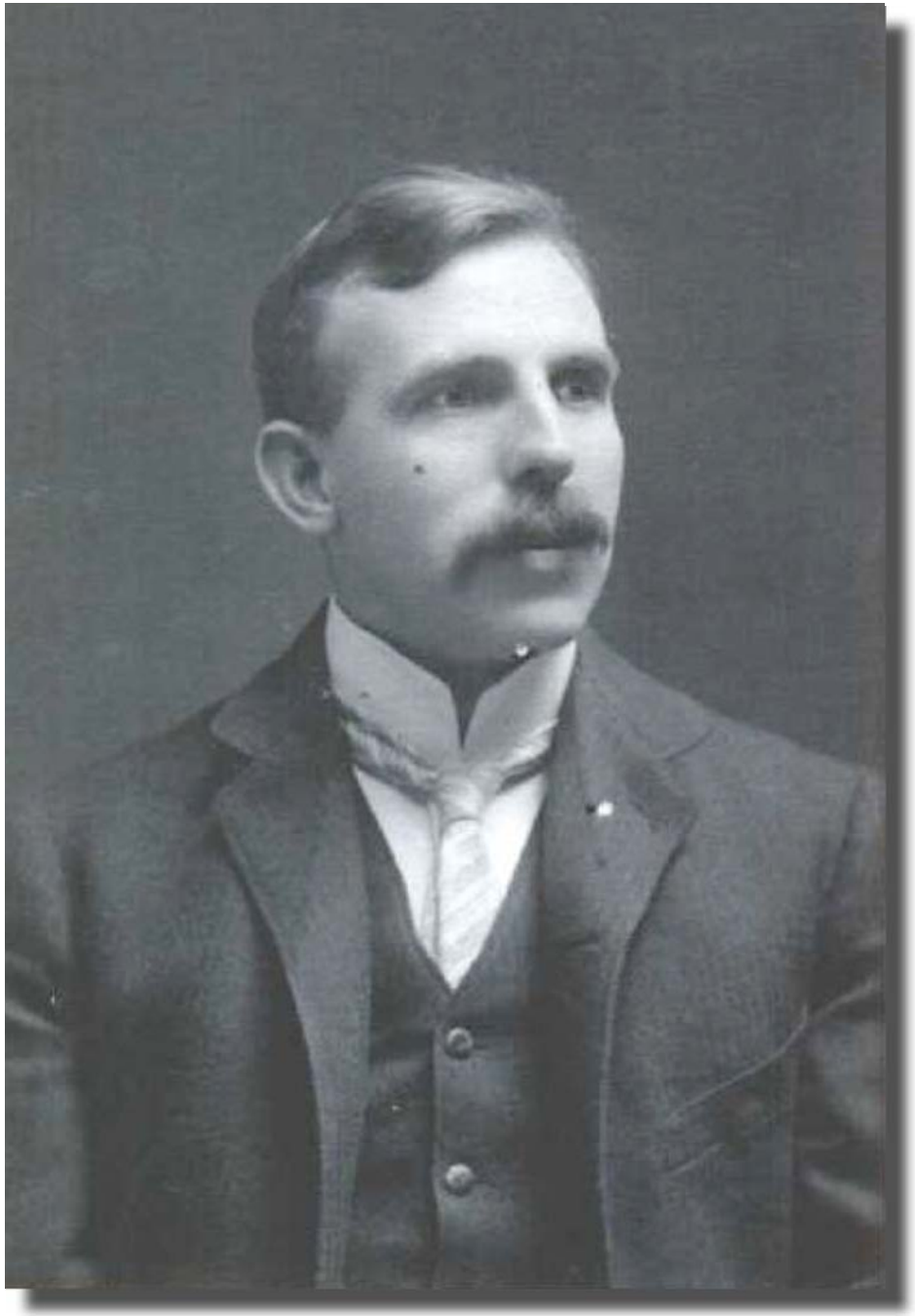
- ex-officio members representing other bodies:
  - Komitee für Hadronen und Kerne, KhuK
  - Komitee für Elementarteilchenphysik, KET
  - Council of German Astronomers
  - APPEC
  - Deutsche Forschungsgemeinschaft DFG €
  - Max Planck-Gesellschaft MPG €€€€
  - Verbundforschung Astroteilchenphysik €€€€€ →Universities!
  - Helmholtz Association HGF €€€€€€€€€

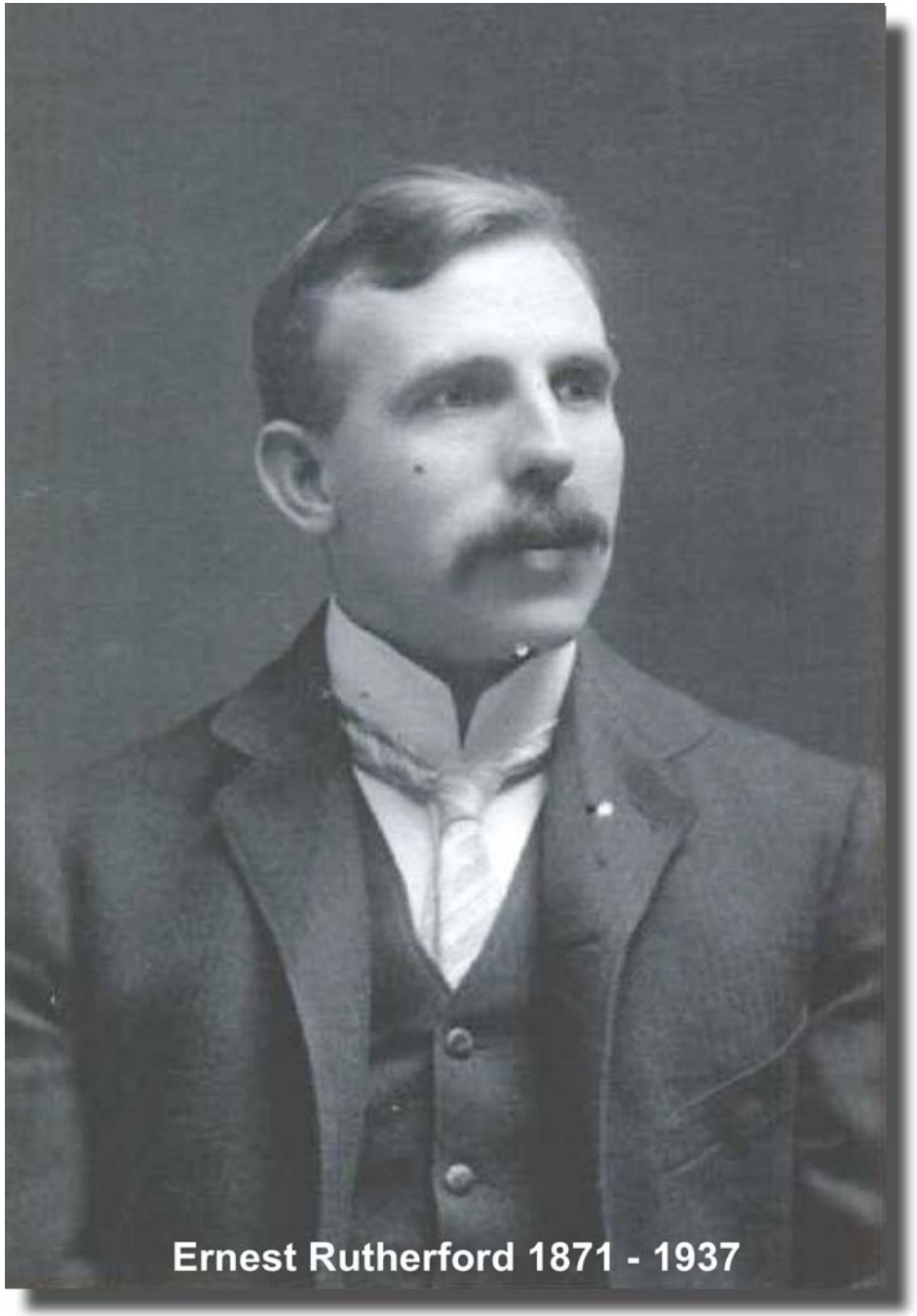


KAT election January 2004

Anton	Gisela	HE neutrinos	Erlangen
Blümer	Johannes	cosmic rays	Karlsruhe
Danzmann	Karsten	gravitational waves	Hannover
Drexlin	Guido	neutrino properties	Karlsruhe
Hofmann	Werner	gammy astronomy	Heidelberg
Jochum	Josef	dark matter	Tübingen
Raffelt	Georg	theory	Munich
Rolfs	Claus	nuclear astrophysics	Bochum
von Feilitzsch	Franz	LE neutrinos	Munich

Anton	Gisela	Komitee für Hadronen- und Kernphysik (KHuK)
Bartelmann	Matthias	Rat Deutscher Sternwarten RDS
Berghöfer	Thomas	Verbundforschung Astroteilchenphysik
Koepcke	Rainer	BMBF, Referat 411
Koepke	Lutz	Komitee für Elementarteilchenphysik KET
Kleinschmidt	Michael	Deutsche Forschungsgemeinschaft DFG
Krückeberg	Stefan	
Völk	Heinz	APPEC
Schmidt	Sebastian	Helmholtz-Gemeinschaft HGF
Echinger	Stefan	Max Planck-Gesellschaft MPG





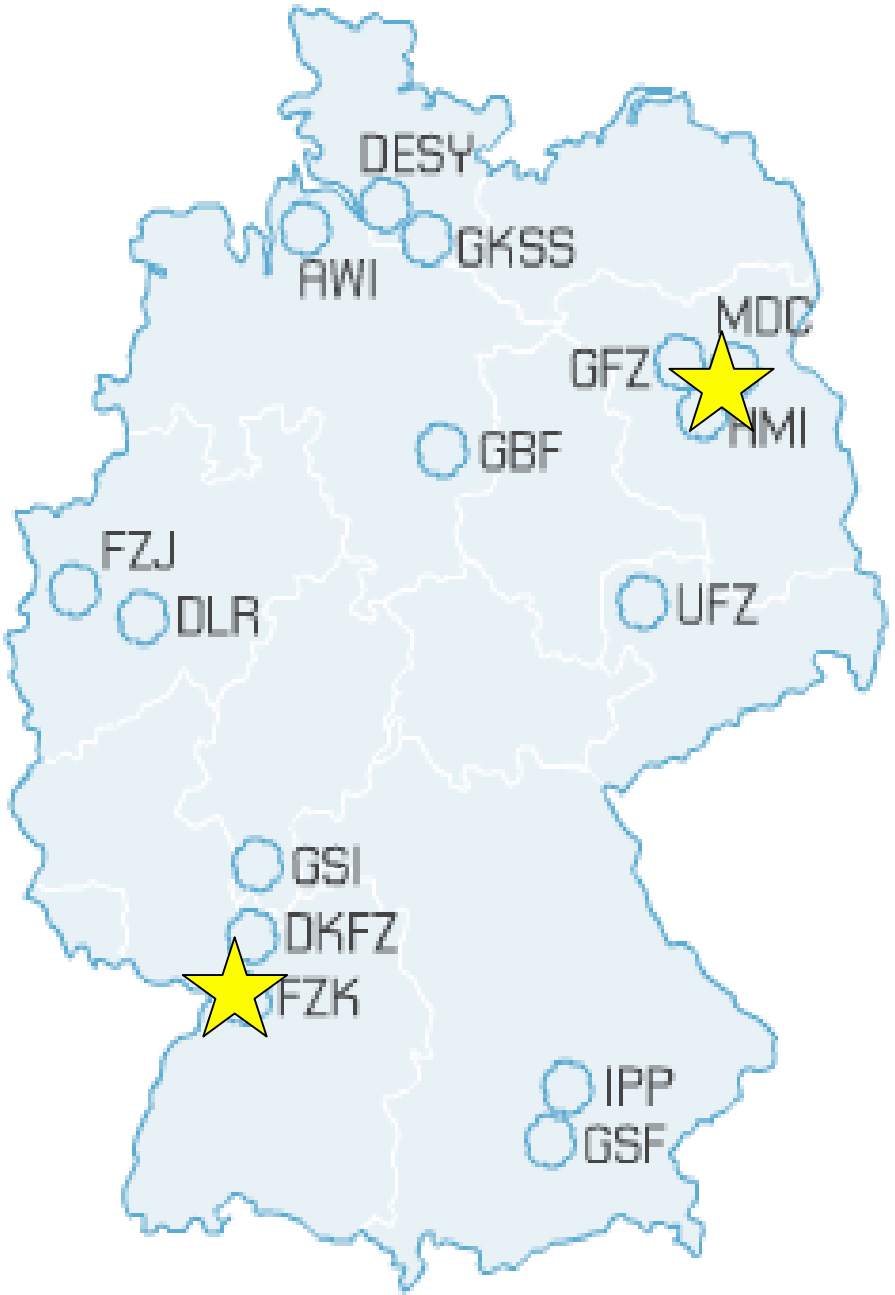
Ernest Rutherford 1871 - 1937

Hermann von Helmholtz 1821-94

Helmholtz Research Centres (HGF)

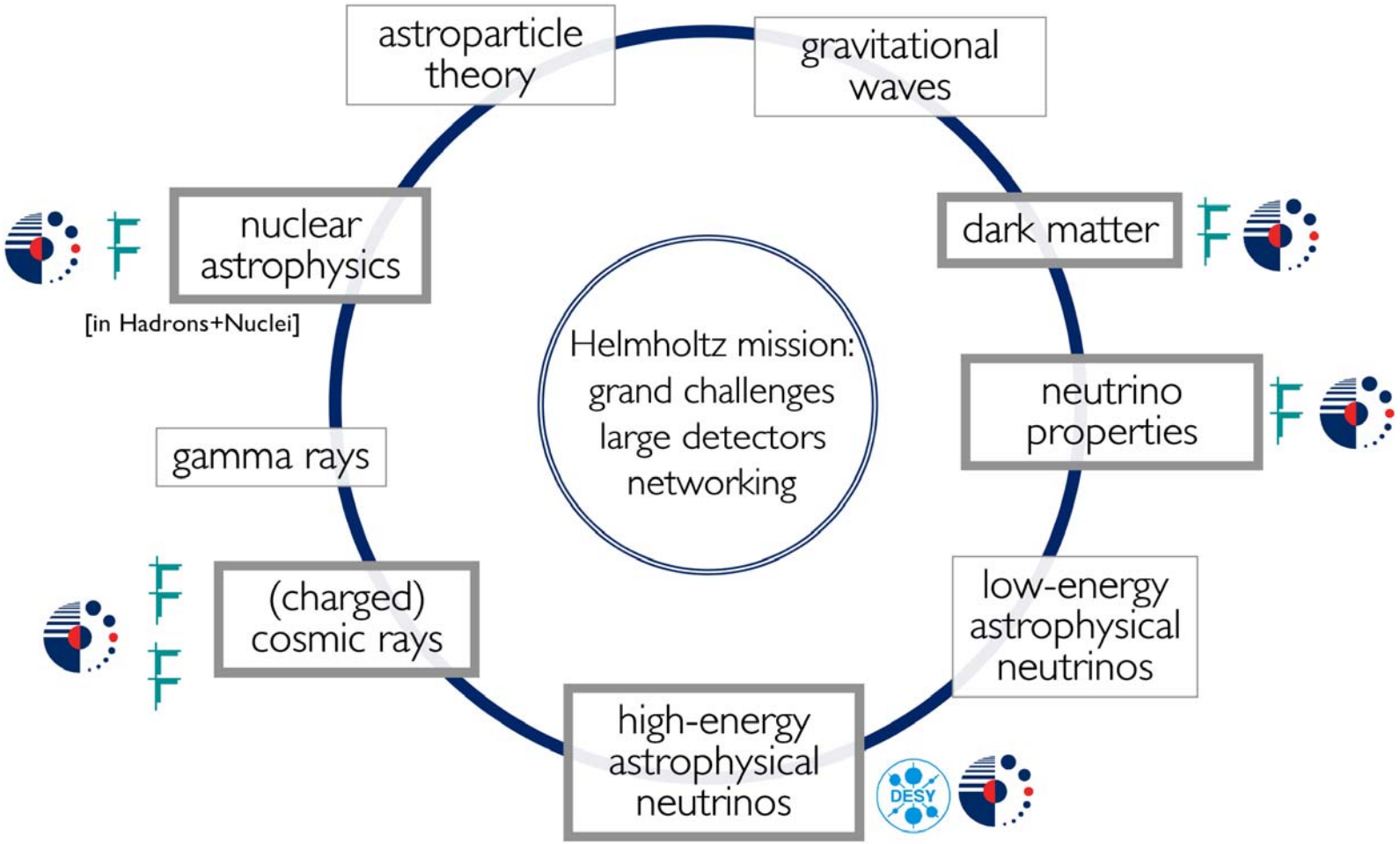
Six Research fields

- Energy,
- Earth and Environment,
- Health,
- Key Technologies,
- Transport and Space
- **Structure of Matter**
  - Elementary Particles
  - Hadrons and Nuclei
  - Photons, Ions and Neutrons
  - Condensed Matter
  - **Astroparticles**
    - DESY Zeuthen
      - **BAIKAL**
      - **AMANDA, IceCube**
    - FZK
      - **KASCADE-Grande**
      - **Pierre Auger**
      - **CORSIKA/CONEX**
      - **KATRIN**
      - **EDELWEISS**

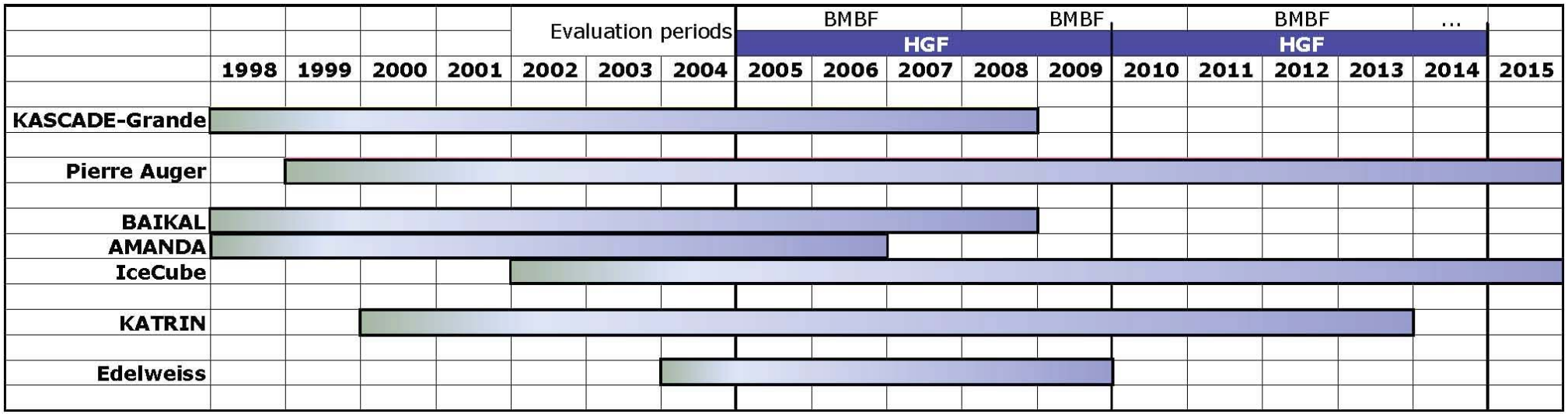


HELMHOLTZ GEMEINSCHAFT now works in five-years cycles starting 2005

BMBF now works in three-years cycles starting 2005



Helmholtz timelines



Helmholtz Virtual Institutes

funded by the Helmholtz President's Networking and Innovation fund with 240k€ each

VIDMAN

Eine gemeinsame Einrichtung des Helmholtz-Zentrums Forschungszentrum Karlsruhe mit den Universitäten Bonn, Darmstadt, Karlsruhe, Mainz, TUM München, Tübingen sowie dem Max Planck-Institut MPK Heidelberg

Virtuelles Institut für Dunkle Materie und Neutrinophysik

1 Helmholtz Centre, 7 Universities, 2 Max Planck, 100 people

VIHKOS

Eine gemeinsame Einrichtung der Helmholtz-Zentren Karlsruhe und DESY mit den Universitäten Aachen, HU Berlin, Bochum, Erlangen-Nürnberg, Dortmund, Frankfurt, Hamburg, LSW Heidelberg, Karlsruhe, Mainz, Siegen, Wuppertal, Würzburg sowie den Max Planck-Instituten MPIfR Bonn, MPK Heidelberg und MPI München

Virtuelles Institut für Hochenergiestrahlungen aus dem Kosmos

2 Helmholtz Centres, 12 Universities, 3 Max Planck, 180 people

concluding remarks

- astroparticle physics is growing fast, still continuing
- money follows people with long delays
- some self-organization is desirable
  - bottom-up basis like KAT works ok in Germany
  - European: APPEC
    - EU FP6, FP7, ILIAS, ...?
  - World: PANAGIC

- UK should (continue to) play a highly visible role in the Pierre Auger project
- inter-disciplinarity is extreme in astroparticle physics (by definition)
- watch at the whole field, opportunities for 1.5-2 decades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LORD
RUTHERFORD
OF
NELSON
THIS NOTE IS LEGAL TENDER FOR
ONE HUNDRED
DOLLARS
100