COSMIC RAYS
and
ACCELERATORS

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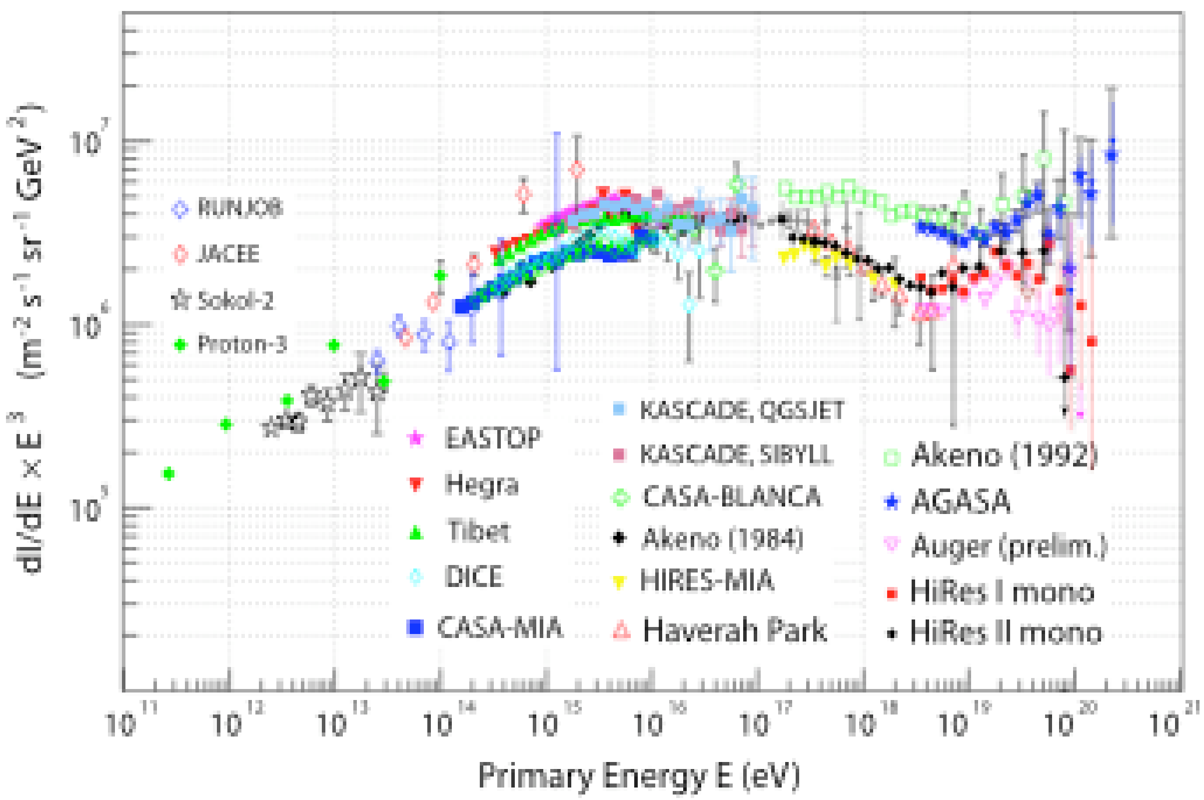
All Particle C.Ray E-Spectrum



>20 Exp. Differences largely due to incomplete simulations

C.Ray E-Spectrum

At E < 100 GeV the spectrum is determined by experiments in space

Presently “AGILE” and “PAMELA” are in space and working
“GLAST” is due for launch next spring (hopefully)
“”AMS”” is pending

Reminder: The legacy of EGRET is:
hundreds of unidentified sources
and a diffusive galactic flux, quantitative understanding NOT achieved yet. ???Dark Matter????

PAMELA

Particle type	Number of events expected	Energy range
positrons	3×10^5	50 MeV – 270 GeV
antiprotons	3×10^4	80 MeV – 190 GeV
electrons	6×10^6	50 MeV – 2 TeV
protons	3×10^8	80 MeV – 700 GeV
light nuclei (up to Z=6)		100 MeV/n – 200 GeV/n
light isotopes (^{2}H, ^{3}He)		100 MeV/n – 200 GeV/n
limit on antinuclei		$\overline{He}/He \sim 10^{-8}$

Table 1. Design goals of the PAMELA instrument.

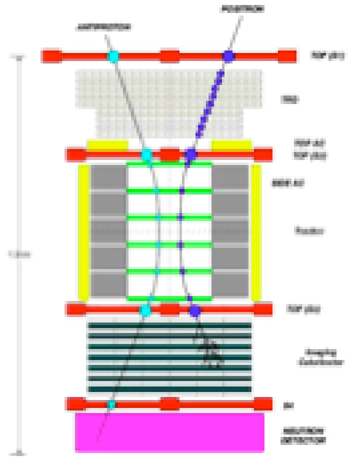


Figure 5. A schematic view of the PAMELA instrument.

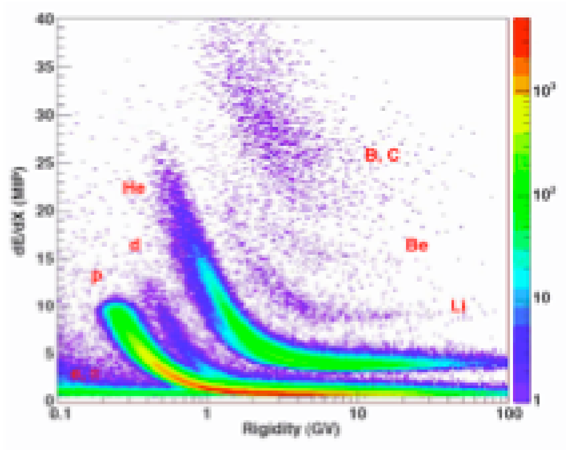


Figure 6. Correlations of the energy loss in the DSSDs and the rigidity measured by the spectrometer.

GLAST

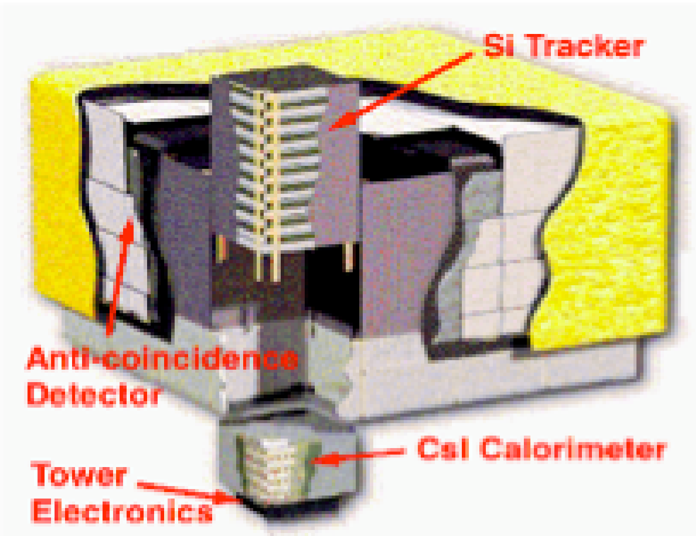


Figure 20. Schematic view of GLAST/LAT instrument.

Mostly detecting

Gamma Rays

Long lifetime expec.

> 10 times EGRET

Air Shower Detectors

Milagro
Tibet AS
ICETOP
KASCADE-GRANDE

Mostly arrays of
ch. particle detectors
> TeV and <100PeV

MAGIC, VERITAS (northern)
CANGEROO, HESS (southern)

Tscherenkov telescope
Arrays
>50Gev and <100TeV

Many, > 70 (at present) TeV-gamma ray sources,
both galactic and extragalactic have been discovered.
And more to come!!!

KASCADE-GRANDE

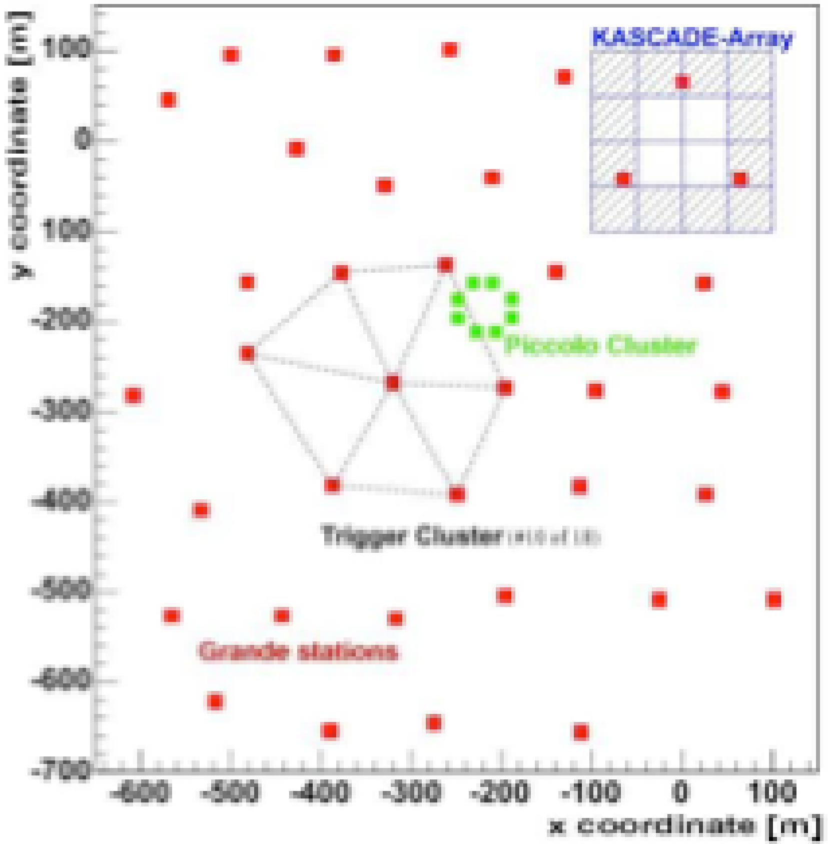


Figure 3. Sketch of the KASCADE-Grande experiment.

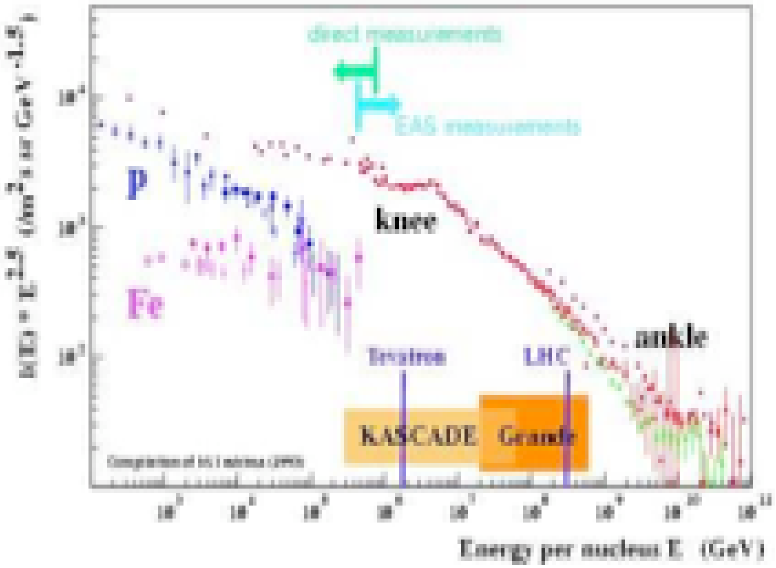


Figure 1. Primary cosmic ray flux and primary energy range covered by KASCADE-Grande.

Chemical Elements in C.Rays

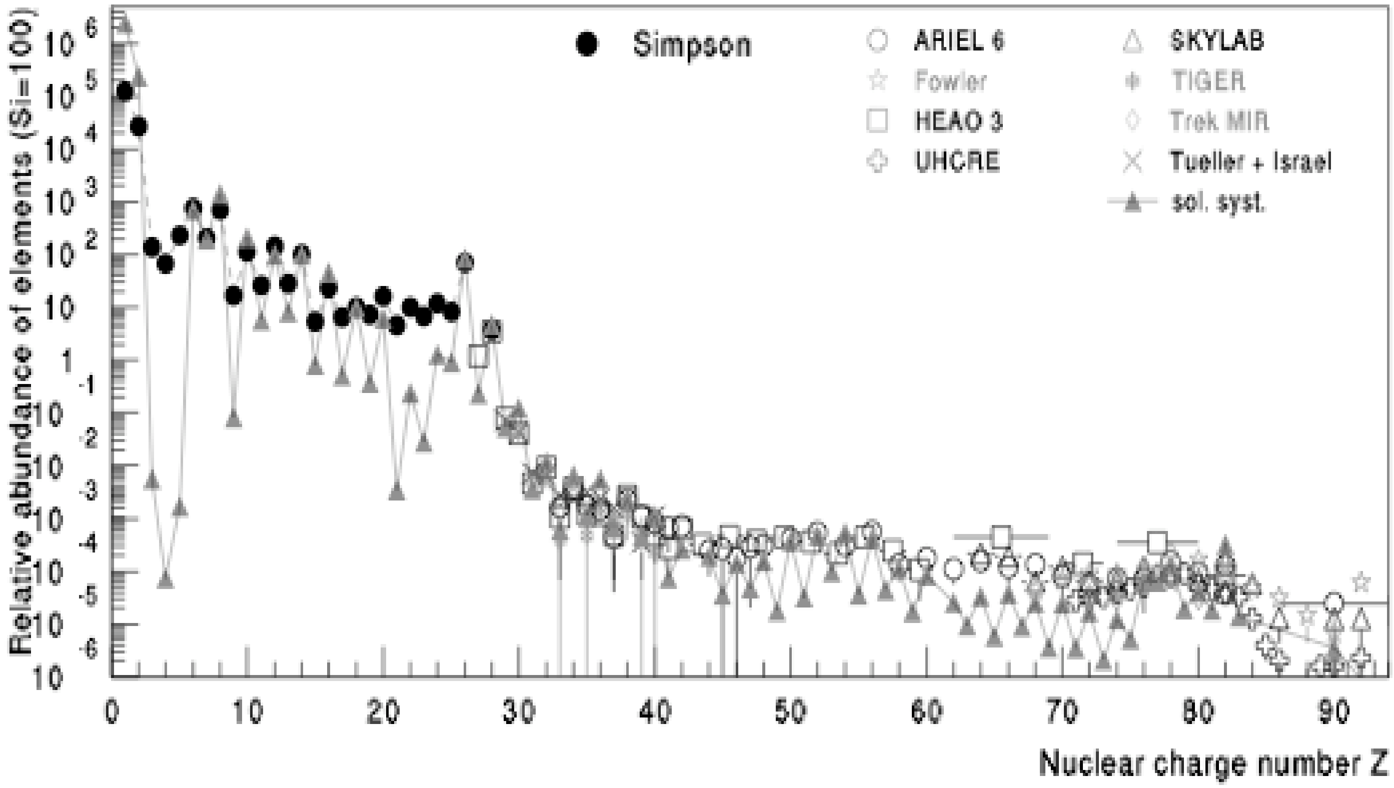


Fig. 3. Abundance of elements in cosmic rays as function of their nuclear charge number Z at energies around 1 GeV/n, normalized to $Si = 100$. Abundance for nuclei with $Z \leq 28$ according to Simpson (1983). Heavy nuclei as measured by ARIEL 6 (Fowler et al., 1987), Fowler et al. (1977), HEAO 3 (Binns et al., 1989), SKYLAB (Shirk and Price, 1978), TIGER (Lawrence et al., 1999), TREK/MIR (Weaver and Westphal, 2001), Tueller and Israel (1981), as well as UHCRE (Donelly et al., 1999). In addition, the abundance of elements in the solar system is shown according to Lodders (2003).

Primary Charge (H.E.S.S.)

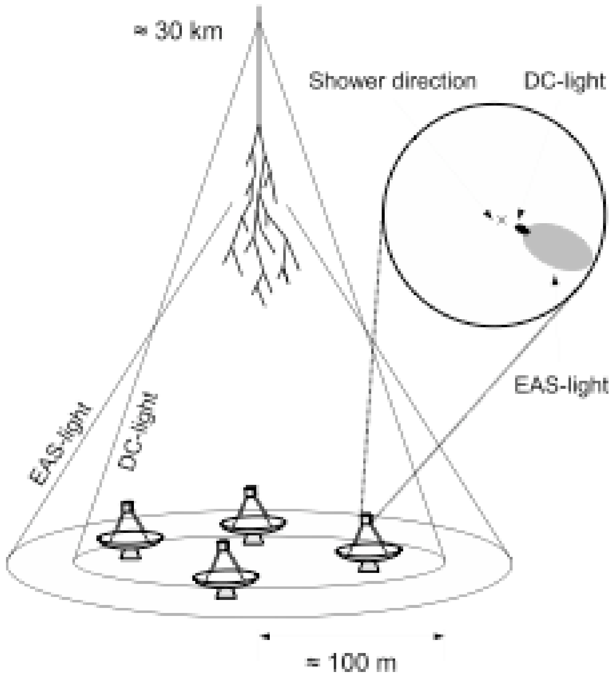
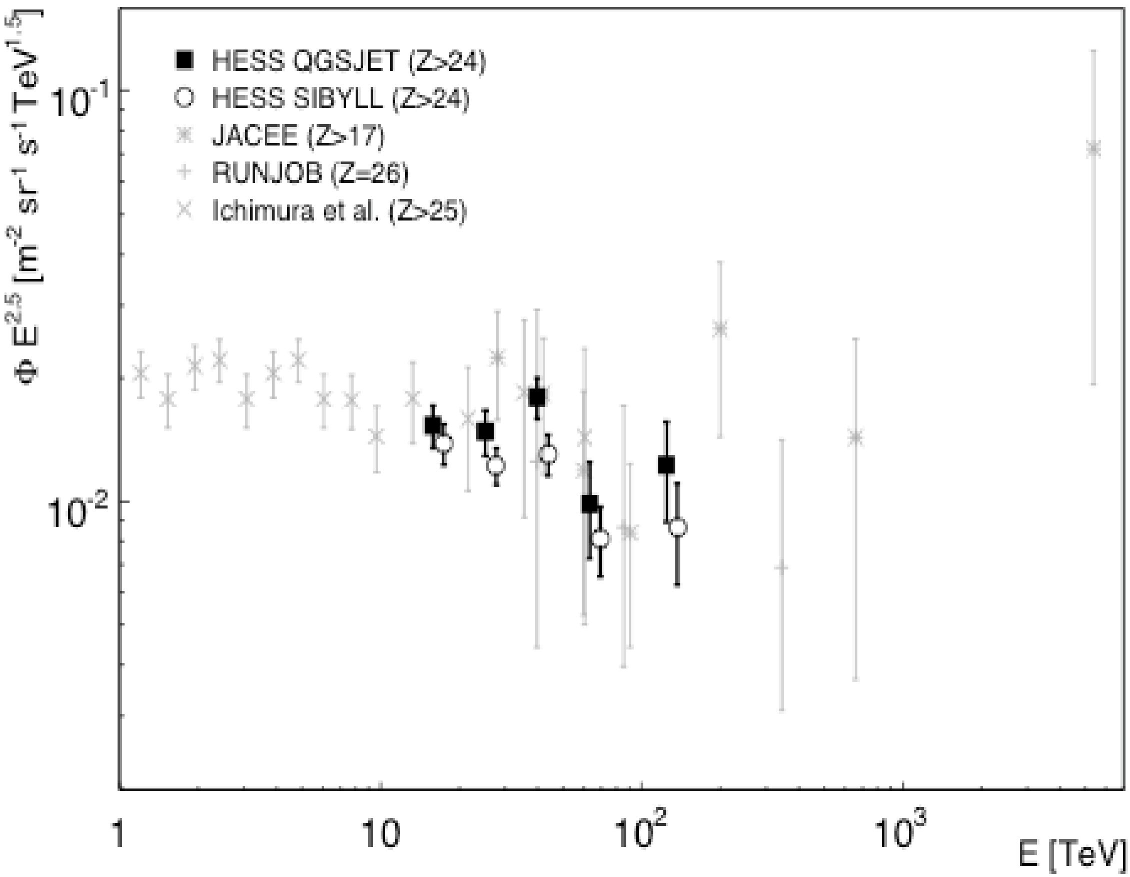


FIG. 1: Schematic representation of the Cherenkov emissi
from a cosmic-ray primary particle and the light distributi
on the ground and in the camera plane of an IACT.



C.Ray Exper. at >10E(17) eV

AGASA
HIRES I+II — In the northern hemisphere
YAKUTSK

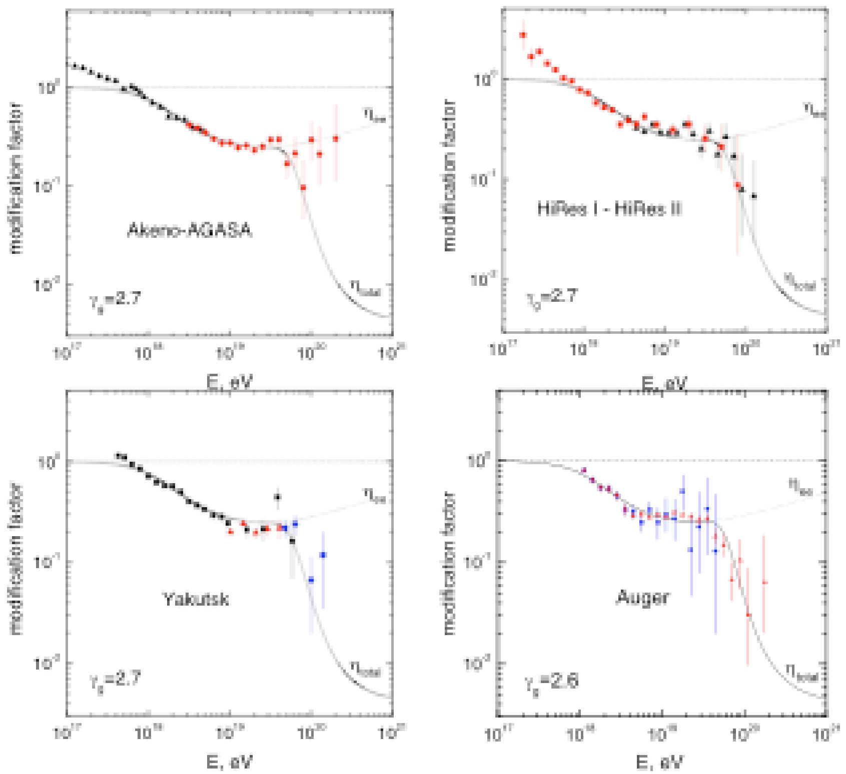
AUGER — In the southern hemisphere

Q: is there a "Dip" due to proton + photon in e(+) + e(-)+proton ???

Q: is there a "cutoff" due to single pion production, protons on MW
the famous GZK (Greisen, Zatsepin,Kuzmin)

Q: "mostly protons" from deep in the universe

Photoproduction of Pairs on MWB



Proton E-Loss on MW Background due to Photoproduction of Electron Pairs.

Neutrino Flux on Earth

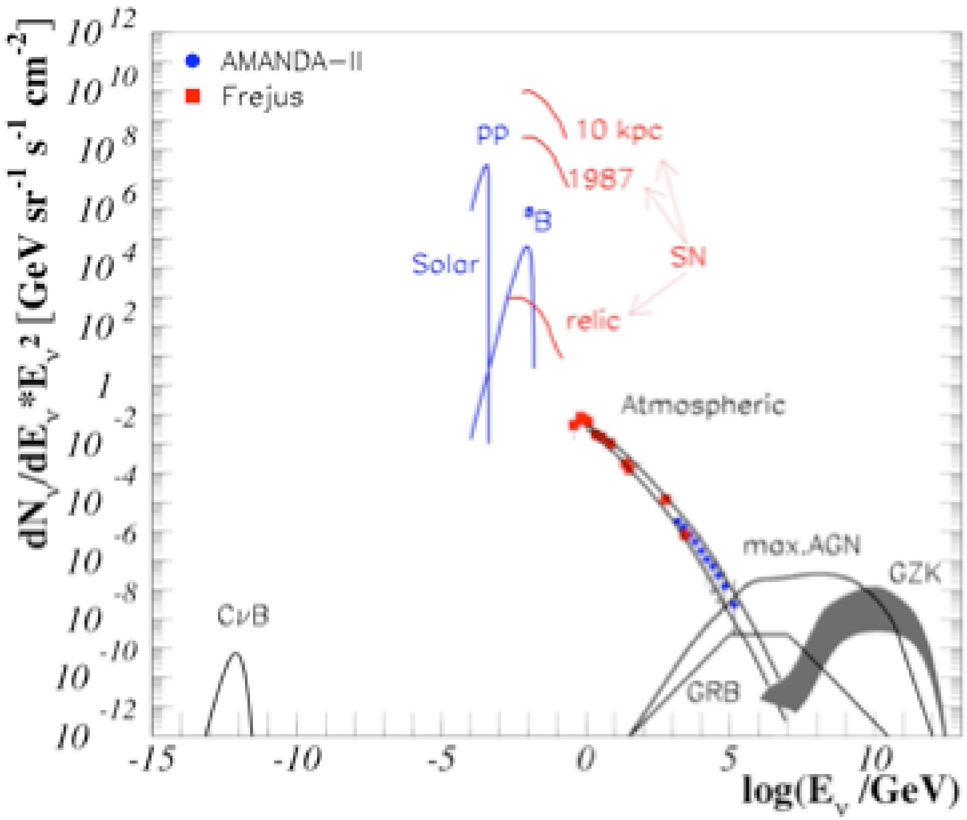


Figure 1: The neutrino sky from the lowest energy neutrinos produced in the big bang to the highest energies associated with the sources of the cosmic rays, here assumed to be gamma ray bursts or, alternatively, active galaxies. These will be the target of kilometer-scale neutrino detectors such as IceCube and KM3NeT. Neutrinos at intermediate energies, produced in the sun, supernovae and in collisions of cosmic rays in the atmosphere, have been studied by SuperK and similar detectors[8]

Neutrino Experiments

BAIKAL ANTARES	Northern hemisphere
AMANDA ICECUBE	Southern hemisphere

AND, horizontal AIR-Showers!! In particular for TAU-Neutrinos, socalled DOUBLE BANG events

(should one have an AIROBICC like Array????)

ICECUBE + ICETOP

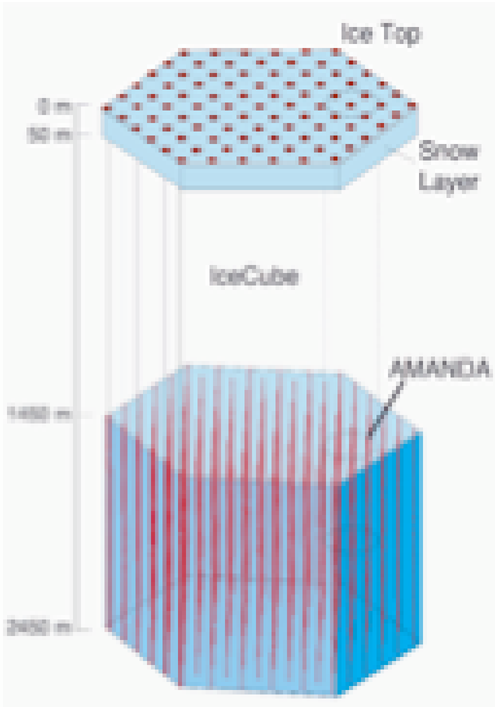
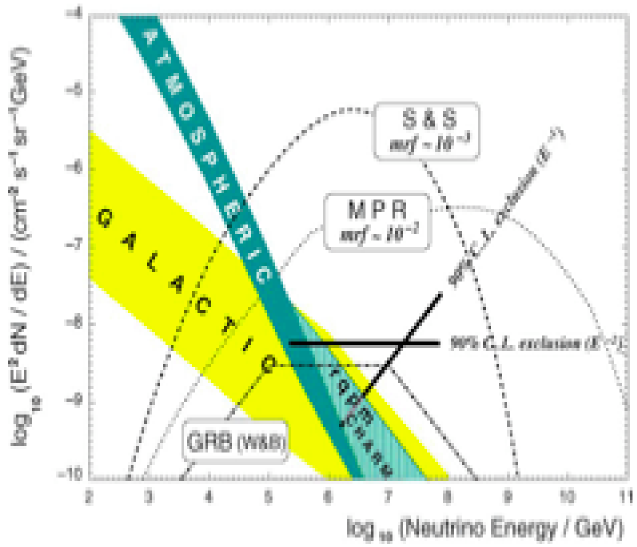


Figure 7. A schematic view of the IceCube Observatory.

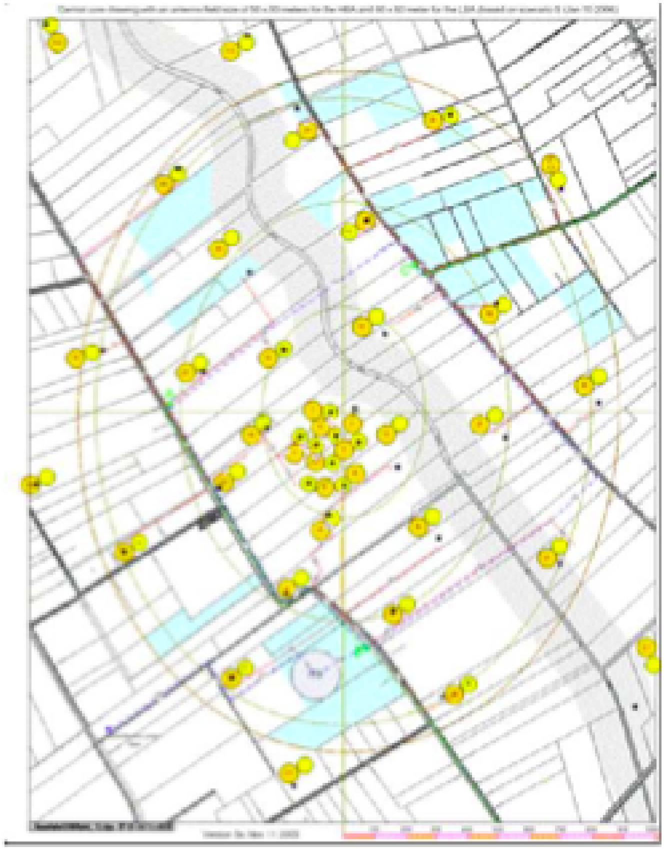


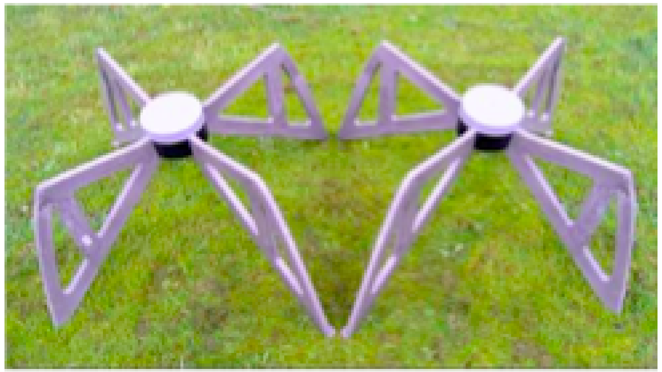
“Radio”-Detection

LOPES with KASCADE - GRANDE
Proof of the Geo-synchrotron mechanism

LOFAR is underway, starts in the Nederlands

LOFAR, the beginning





ft) The low-frequency antenna, optimised for the 30-80 MHz
iised for the 115 - 240 MHz range.

Fig. 2. (*left*) The location of the 32 LOFAR stations in th
Odoorn in the Northern province of Drenthe. (*right*) The ir

“GZK” NEUTRINOS

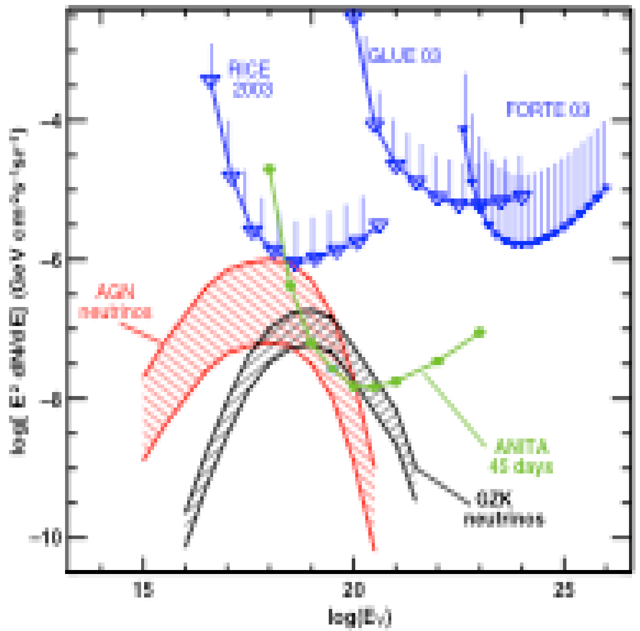


Figure 11. Expected sensitivity of the ANITA experiment compared with the predicted flux of GZK neutrinos.

ANITA,
radio-photons
due to the Askaryan effect
Ballon with horn antennas
Circulating the South Pole
> 40 days

MC dependence of Composition

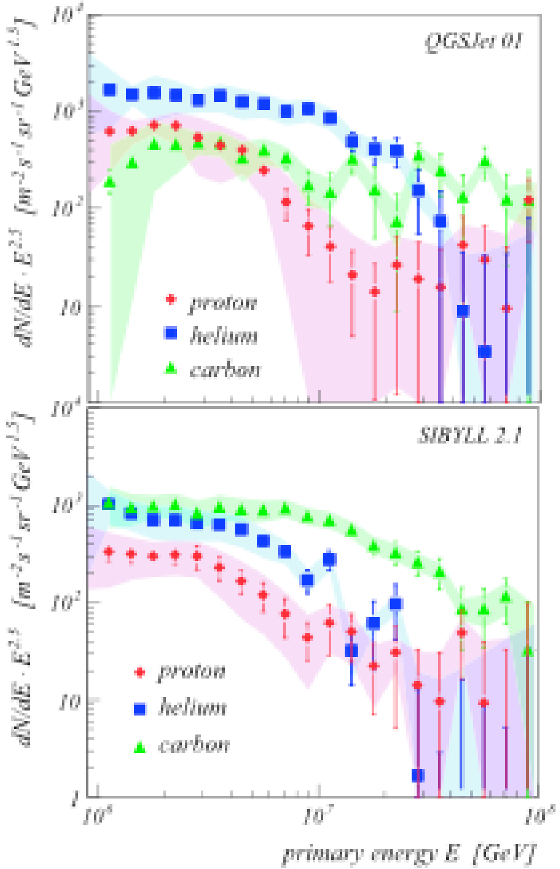


Figure 4. Unfolded CR energy spectrum of p, He, and C mass-groups from KASCADE. The spectra are obtained by using QGSJET and SYBILL for the generation of the EAS response matrix p_A [20].

Urgent, resolve differences between simulations

SYBILL
QGSJET
EPOS

Monumental effort, but crucial to have improvements, experiments ....

Neutral and leading particles

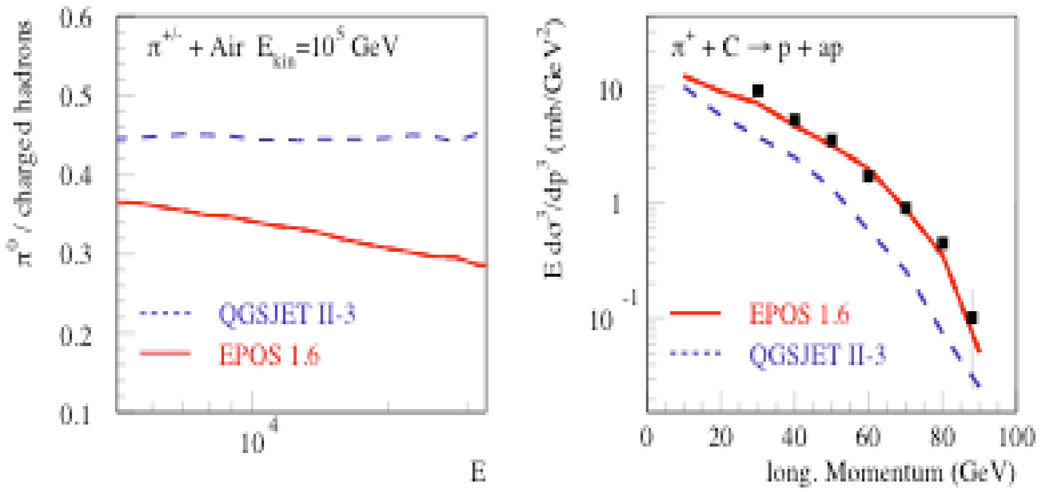


Fig. 4: Left: Ratio of the number of π^0 over the number of charged particles as a function of the energy of the secondary particles at 10^5 GeV kinetic energy with EPOS (full line) or QGSJET II-3 (dashed line) in pion-air. Right: Longitudinal momentum distributions of protons in pion carbon collisions at 100 GeV from EPOS (full) and QGSJET II-3 (dashed) compared to data.

Sooo! important for shower development

e.g. X(max)
Energy determin.

Muons Underground

“photoproduction main source of Bkg, e.g. low energy neutrons

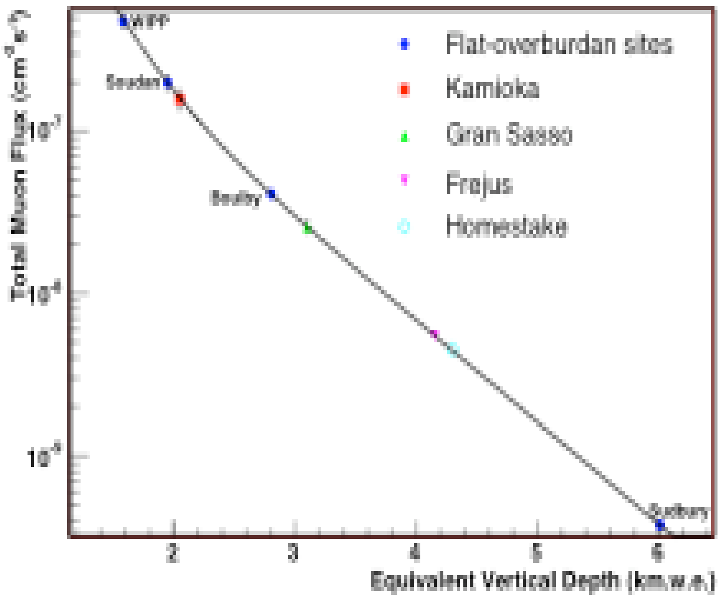


FIG. 3: The total muon flux measured for the various underground sites summarized in Table I as a function of the equivalent vertical depth relative to a flat overburden. The smooth curve is our global fit function to those data taken from sites with flat overburden (equation (4)).

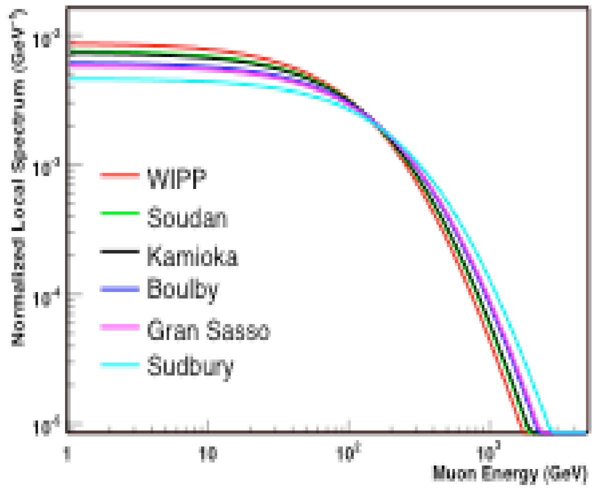


FIG. 6: The muon energy spectrum local to the various underground sites calculated using equation (8). The areas under the curves are normalized to the vertical muon intensity for comparison purposes.

CONCLUSION