

# Particle Composition of Ultra-High Energy Cosmic Rays

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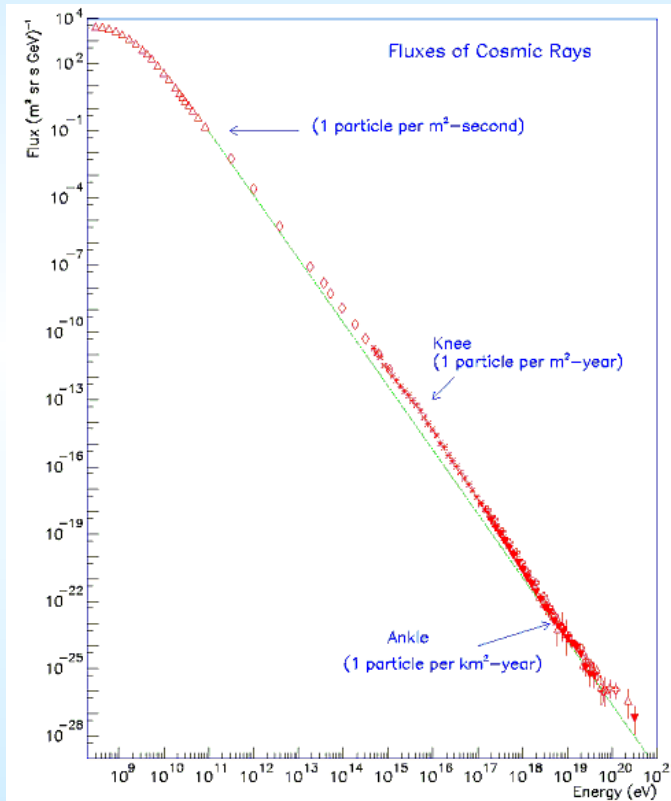
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The Academy of Sciences of the Czech Republic  
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# Summary of presentation

- Ultra-High Energy Cosmic Rays
- Pierre Auger Observatory
- Astrophysical Sources
- Restrictions on sources
- Motion in Galactic magnetic field
- Results of modelling

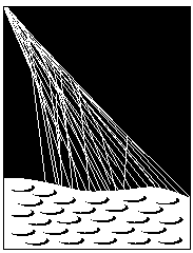
# Ultra-High Energy Cosmic Rays

Are cosmic rays with energy higher than  $10^{19}$  eV.



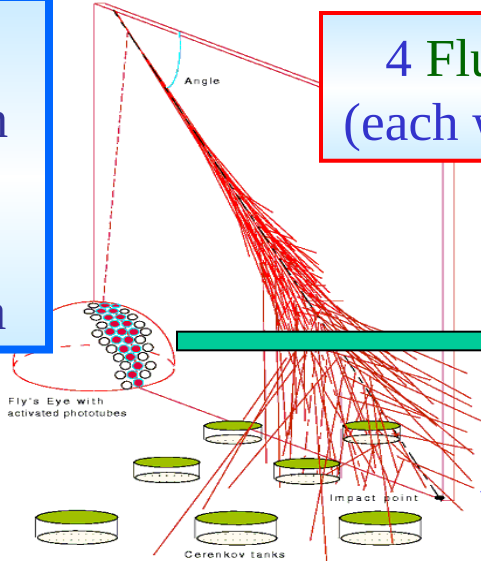
- the highest energy ever detected  
 $\sim 3.2 * 10^{20}$  eV  
(1 particle with energy 51 J !)
- very rare events  
(1 particle/ $\text{km}^2\text{/yr}$ )
- indirect detection by extensive air showers

# Pierre Auger Observatory

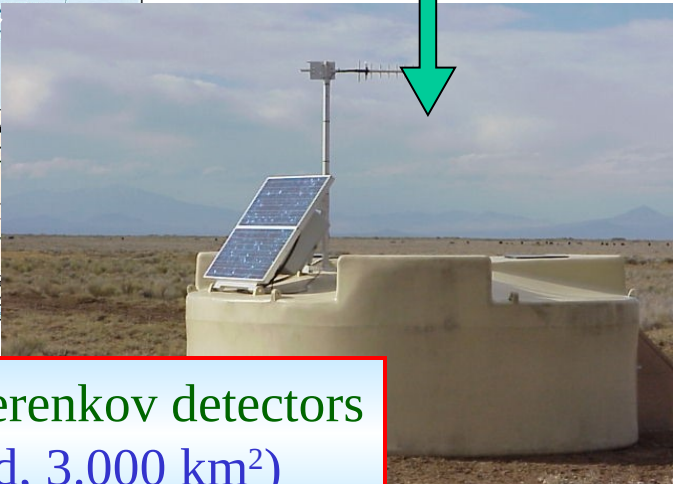
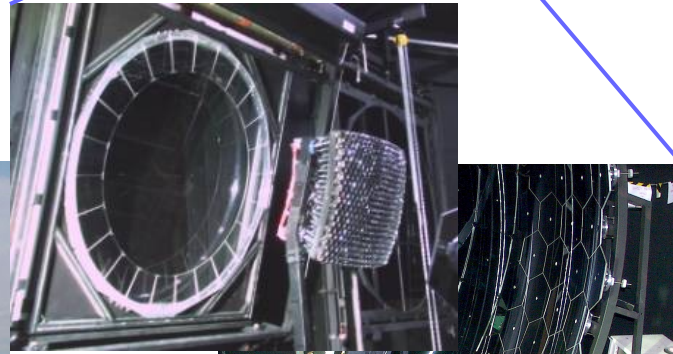
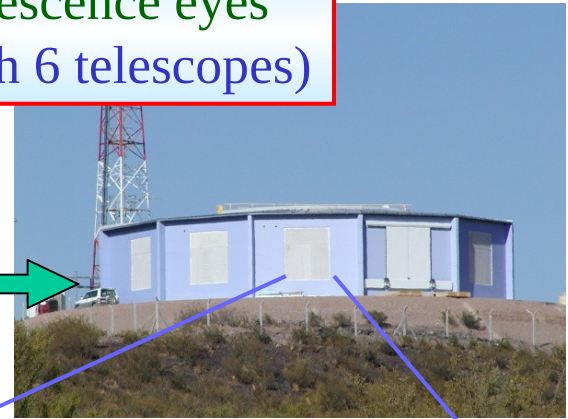


PIERRE  
AUGER  
OBSERVATORY

- largest in the world
- 2 method of detection
- two sites:
  - Utah, USA
  - Mendoza, Argentina



4 Fluorescence eyes  
(each with 6 telescopes)

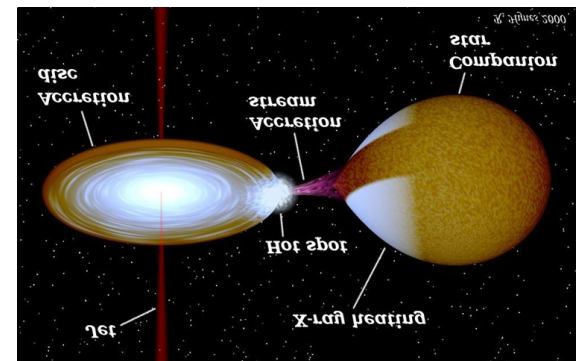
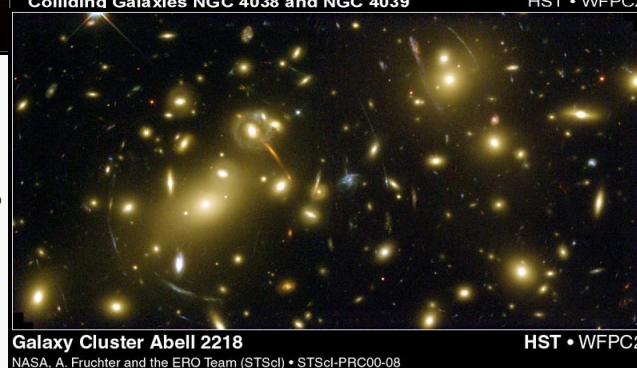
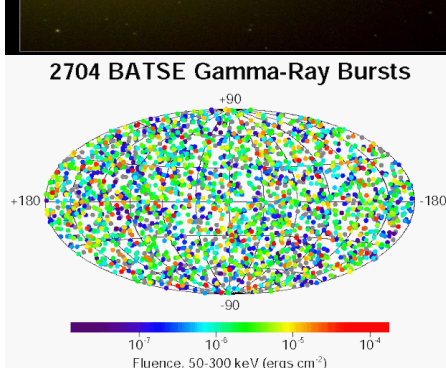
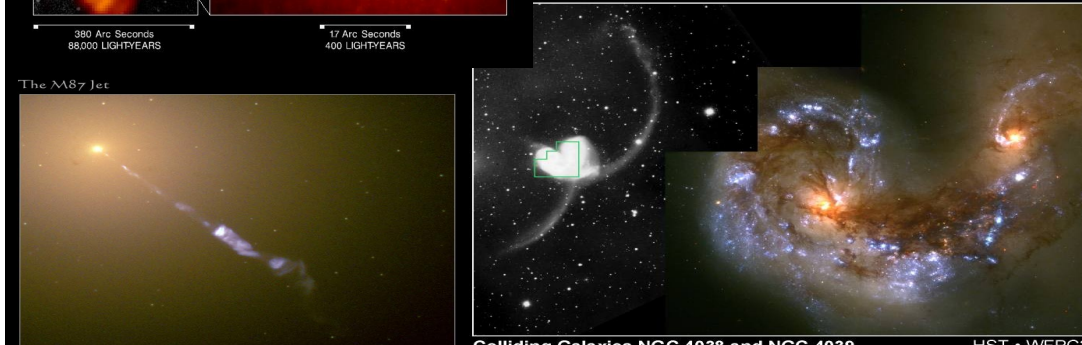
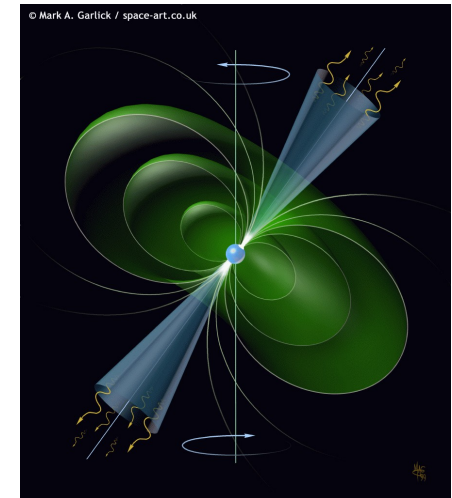
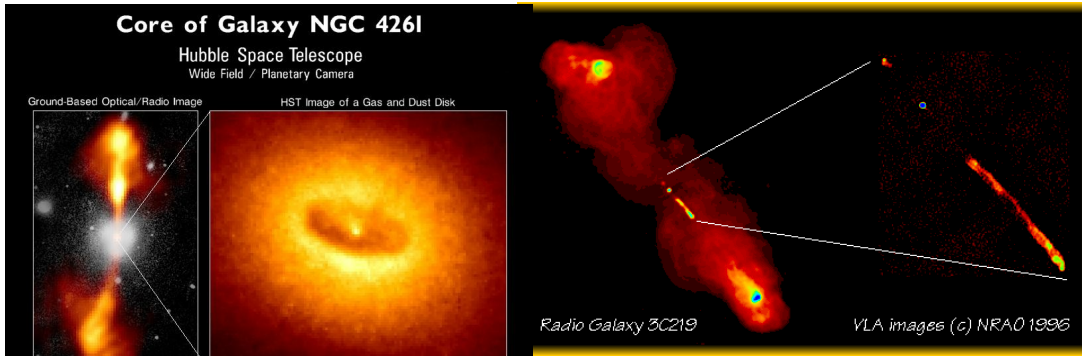


1600 water Cherenkov detectors  
(1.5 km grid, 3.000 km<sup>2</sup>)

# Astrophysical sources

Extragalactic

Galactic



# Restrictions on sources

- efficient accelerators
  - enough energy, small losses of energy
- power law flux ( $\sim E^{-2.7}$ )
- distance  $< 100$  Mpc
  - interaction with cosmic microwave background above  $(5 \div 6) * 10^{19}$  eV
- isotropic distribution (?)
- chemical composition (?)
  - influence of magnetic fields

# Motion in Galactic magnetic field

## 1) Regular component - global

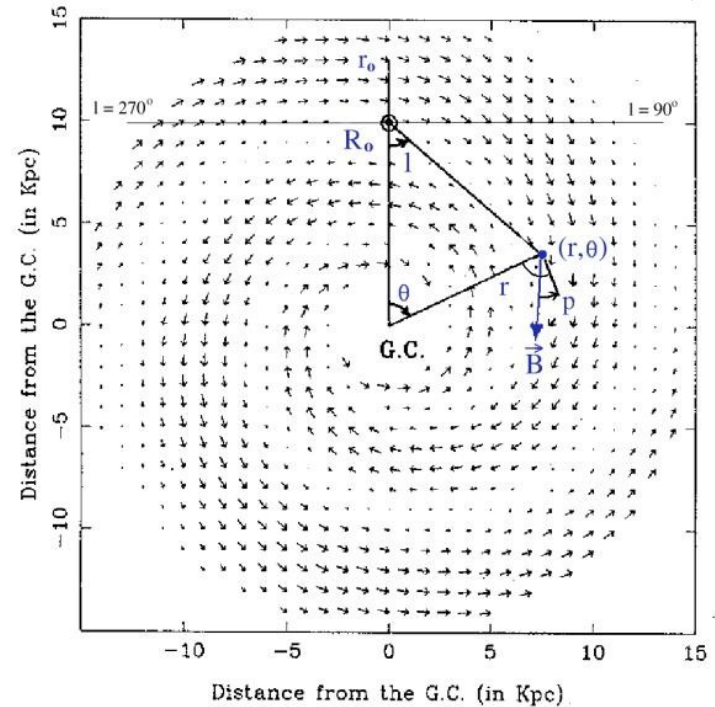
- Bisymmetric model with spiral structure (Han & Qiao, 1994)
- We have included (with M. Prouza) also poloidal (magnetic dipole) and toroidal field (in Galactic halo).

## 2) Turbulent components (are not included within global GMF)

From observations we know that have following properties:

- small length scale ( $< 150$  pc)
- even three times stronger
- random orientation

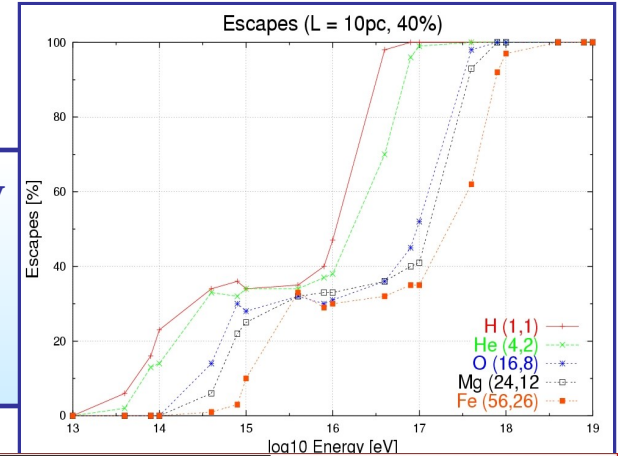
We have modelled them by the cells located in random positions, which have turbulent field inside (random strength and orientation).



# Results of computer modelling

- Change in flux of particles around  $10^{16}$  eV (close to the position of observed feature in energy spectra known as a **knee**)

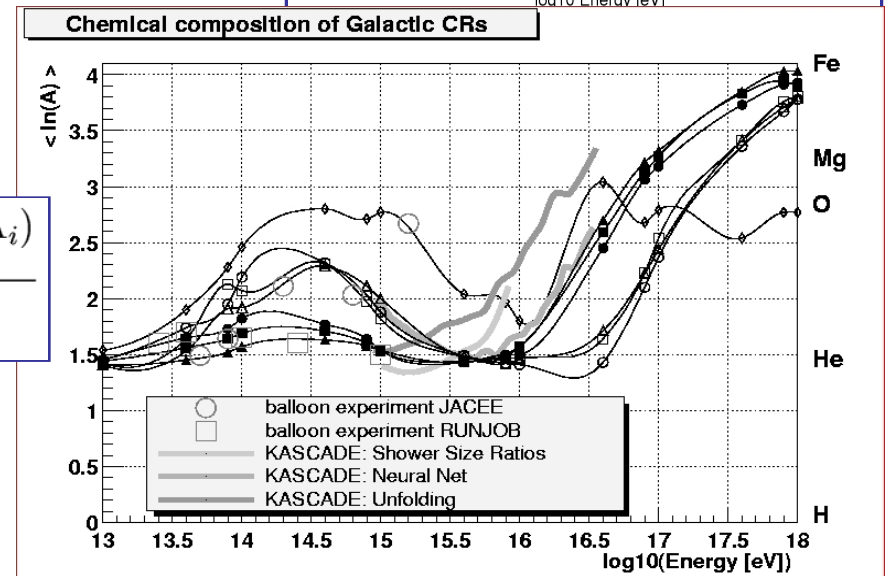
- All nuclei with energy higher than  $10^{18}$  eV escaped from Galaxy after 100.000 yr



- Change of the **chemical composition** above position of the knee (higher fraction of heavy nuclei)

$$\langle \ln A \rangle = \frac{\sum_i n_i (\ln A_i)}{\sum_i n_i}$$

**Good agreement with experiments.**



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Thank you for your attention!