A short summary of highlights from ICRC 2019 - Cosmic rays

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The highlights presented here are mainly based on the rapporteur talks by Roberta Sparvoli and Frank G. Schröder

**Direct cosmic ray measurements at the 36th ICRC**

Roberta Sparvoli
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AMS-02:
- Hardening at ~350 GV;
Spectrum

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  - Hardening at ~350 GV;

- **CALET:**
  - Hardening at ~550 GeV;
  - Is there something at 10 TeV?
Spectrum

- **AMS-02:**
  - Hardening at ~350 GeV;
- **CALET:**
  - Hardening at ~550 GeV;
  - Is there something at 10 TeV?
- **DAMPE:**
  - Hardening at ~400 GeV;
  - Softening at ~10 TeV;
- **What is the origin of these features??**

Preliminary proton spectrum 50 GeV → 80 TeV

CRD8g - Chuan Yue
Electron spectrum

- Break at 1 TeV;
- Two groups of measurements:
  - AMS-02 + CALET;
  - DAMPE + Fermi-LAT;
Electron spectrum

- Break at 1 TeV;
- Two groups of measurements:
  - AMS-02 + CALET;
  - DAMPE + Fermi-LAT;
- Better understanding of systematics in direct measurements?
Anti-particles with AMS-02

- First time observed above 60 GV (up to ~400 GV);
- No rigidity dependence for $R > 60$ GV;
- Why do they have the same slope for $R > 10$ GV??
• Hardening above 10 GeV - well established;
• Softening at ~500-600 GeV;
• What are the origins of these features?
Spectrum

\[ E^3 J(E) \text{ [km}^{-2} \text{ yr}^{-1} \text{ sr}^{-1} \text{ eV}^2]\]

- (0.11\pm0.01) \text{ EeV}
- (4.9\pm0.1) \text{ EeV}
- (0.15\pm0.02) \text{ EeV}
- (2.2\pm0.2) \text{ EeV}
- (6.2\pm0.9) \text{ EeV}
- (2.92\pm0.05) \text{ EeV}
- (3.27\pm0.05) \text{ EeV}
- (3.15\pm0.03) \text{ EeV}
- (2.68\pm0.02) \text{ EeV}
- (4.84\pm0.48) \text{ EeV}
- (5.4\pm0.6) \text{ EeV}

How can the different slopes be explained only with systematics?

New feature on Auger spectrum???
Auger data show trend towards heavier composition above ankle

Telescope Array data have less statistical separation power

Adapted from Schröder's slides
Composition - Radio

Radio $X_{\text{max}}$ reconstruction precise, but spectra preliminary.

CODALEMA: high statistics, but systematics under investigation
A. Escudie (CODALEMA) CRI7h - PoS 246

Tunka-Rex: better model for radio exposure in progress
V. Lenok (Tunka-Rex) PS3-182 - PoS 331

LOFAR systematic uncertainties:
- Choice of hadronic interaction model: 5 g/cm²
- (for $X_{\text{max}}$ reconstruction)
- Remaining uncertainty, atmosphere: ~1 g/cm²
- Atmospheric uncert:
- Possible bias, from $<X_{\text{max}}>$ vs zenith: 4 g/cm²
- Total, added in quadrature: 7 g/cm²

Adapted from Schröder’s slides
Anisotropy - TA hotspot

- number of events grows slightly slower than in the past, but still grows faster than background rate

![Diagram showing anisotropy and TA hotspot](image_url)

Hotspot from 11 years of TA SD data, from May 11, 2008 to May 11, 2019

- E > 57 EeV, in total 168 events
- 38 events fall in Hotspot (α=144.3°, δ=40.3°, 25° radius, 22° from SGP), expected=14.2 events
- local significance = 5.1 σ, chance probability → 2.9α
- 25° over-sampling radius shows the highest local significance (scanned 15° to 35° with 5° step)

Adapted from Schröder’s slides
Anisotropy - Auger dipole

- Significance of dipole increased
- Strength increases with energy
- Transition of dipole phase around 1 EeV: hint for Galactic-to-extragalactic transition

FLUX MAP FOR E > 8 EeV

equatorial coordinates, smoothed on 45° radius windows

Adapted from Schröder's slides
New CORSIKA

- New version of working horse for air-shower simulations ahead
  - modular flexible C++ framework
  - many things will be possible that are not with present Fortran code, e.g., GPU support
  - you can contribute / integrate your piece of code

Adapted from Schröder’s slides
I. What is the origin of the **hardening observed in the spectra of CR nuclei** at a rigidity of 300 GV?

II. Why is the slope of the spectrum of CR proton and helium different?

III. What is the origin of the prominent break observed at a particle energy of **1 TeV in the electron spectrum**?

IV. Why do the proton, positron, and antiproton spectra have roughly the same slope at particle energies larger than **10 GeV**?

V. What is the origin of the **rise in the positron fraction** at particle energies above **10 GeV**?

VI. What is the origin of **small scale anisotropies**?

VII. **.........**

Adapted from Sparvoli's slides

- Several important and classical question still open (new ones added!);
- Data with good statistics;
- Better understanding/estimation of systematics.