The cosmic ray e⁺+ e⁻ flux measurement with the AMS-02 detector on the ISS

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The Flux Measurement

Φ= Absolute flux (m⁻² sr⁻¹ s⁻¹ GeV⁻¹)

$$\phi(E, E+\Delta E) = \frac{N_{obs}(E, E+\Delta E)}{\Delta E \, \Delta T_{exp} \, A(E)}$$

N_{obs} = Number of collected events

ΔE = Bin width

ΔT_{exp} = Exposure time (s)

A = Effective acceptance (m²sr)

Electron plus Positron Flux

- More statistics compared with separate flux measurements (minimal quality selection required)
- Systematic uncertainties minimized (measurement not sensitive to charge sign evaluation systematics)
- Maximum energy reach up to TeV
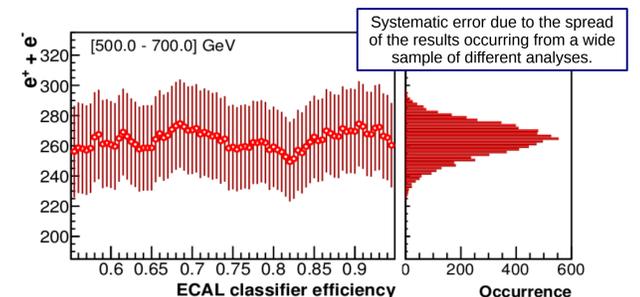
Electron and Positron Counts

e⁺/⁻ background discrimination: complementary measurements from Transition Radiation Detector (TRD) and Electromagnetic Calorimeter (ECAL)

ECAL and TRD classifiers efficiently discriminate signal from background

see M. Graziani contribution

electrons / positrons / spillover protons / protons

sign(Q) * TRD classifier
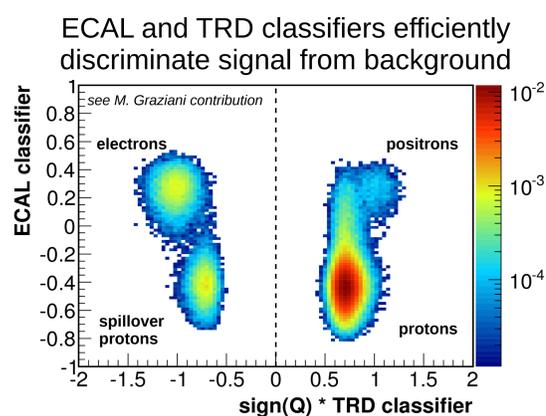
1) Proton bulk removed with a selection based on calorimeter shower shape (ECAL classifier).
2) e± counts extracted by fitting TRD classifier reference shapes to selected data.

[148.8 – 169.9] GeV
Entries: 3240
Fit to data
Sig: 1890 ± 46
Bkg: 1350 ± 40
TRD classifier
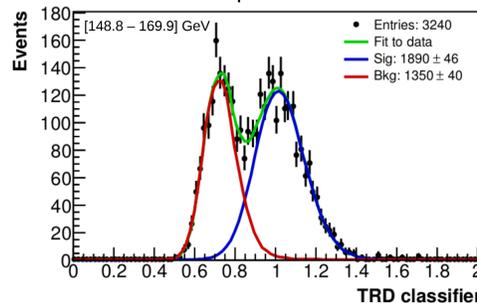
Signal extraction systematic error
Verify the stability of the measurement by varying all possible analysis parameters

[500.0 - 700.0] GeV

Systematic error due to the spread of the results occurring from a wide sample of different analyses.

ECAL classifier efficiency / Occurrence

Measurement performed with a calorimetric selection that maximizes the signal sensitivity.
Systematic negligible up to 200 GeV. Result stable up to TeV.

Acceptance

Acceptance evaluated from a full Monte Carlo simulation of the detector response including all the selection cuts used in the analysis

Acceptance evaluated using Geant4 Monte Carlo full detector simulation
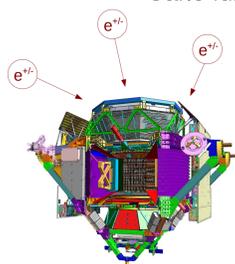
$$A(E) = A_{gen} \times \frac{N_{sel}(E)}{N_{gen}(E)}$$

- A_{gen} = acceptance of the cubic generation surface (m² sr)
- N_{gen} = events generated isotropically from the generation surface
- N_{sel} = events passing the selection criteria

Electron and Positron Acceptance
After geometrical selection (particle crossing the whole AMS-02 detector) and after e⁺/⁻ selection criteria

Geometrical Acceptance
Analysis Selection Acceptance
Energy (GeV)
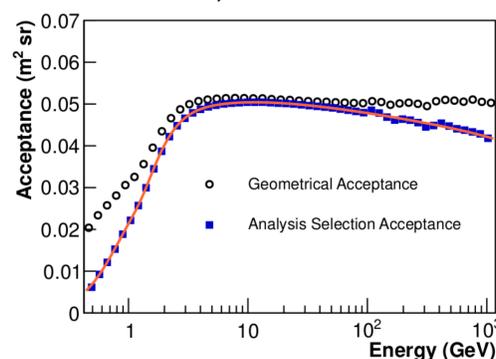
Acceptance systematic error
Evaluated via the disagreement in the selection efficiency between data and MC simulation for each analysis cut

Example: TRD reconstruction quality


Data / MC
Data/MC comparison
Energy (GeV)
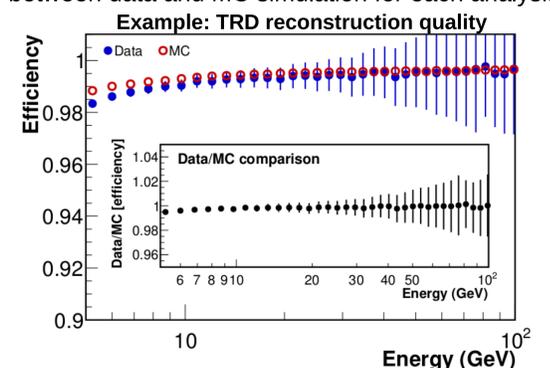
For most of selection criteria, MC simulation agrees with data better than 1% from 3 GeV on.
A global systematic of few % from all the analysis cuts contributes to the flux measurement.

Energy Measurement

Very accurate measurement of the electron energies using ECAL

The stability of the energy scale, calibrated during Test Beams on ground, is verified **comparing the measurement of the energy (E) in the ECAL and the momentum (P) in the tracker.**
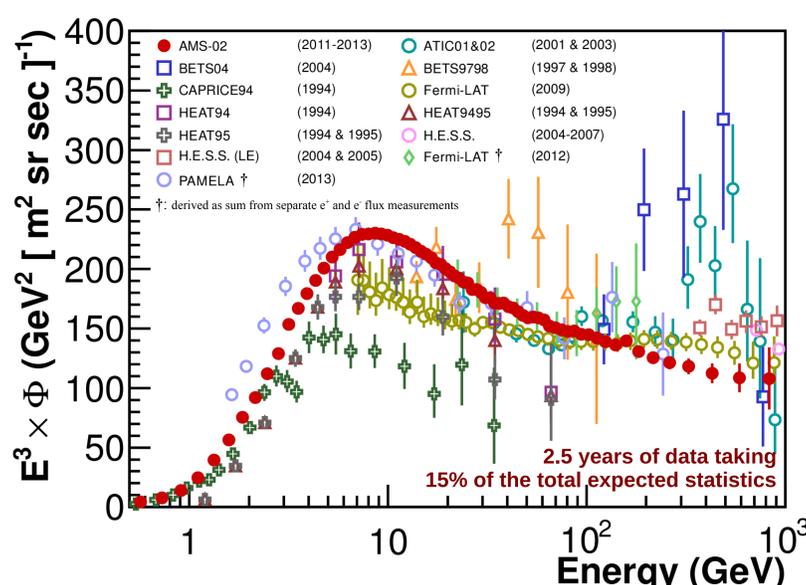No time dependence is observed within the systematics.

E/P / <E/P> peak
Time
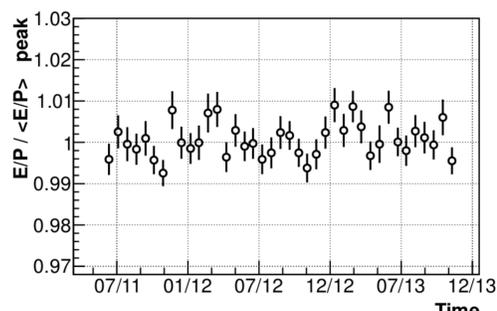
The stability and precision of the ECAL measurement allows an energy measurement with a systematic of 2% between 10 GeV and 290 GeV

Cosmic Electron plus Positron Flux Measurement

10.5 million electrons and positrons collected by AMS-02 have been analyzed to measure the e⁺+e⁻ spectrum up to 1 TeV

AMS-02	(2011-2013)	ATIC01&02	(2001 & 2003)
BETS04	(2004)	BETS9798	(1997 & 1998)
CAPRICE94	(1994)	Fermi-LAT	(2009)
HEAT94	(1994)	HEAT9495	(1994 & 1995)
HEAT95	(1994 & 1995)	H.E.S.S.	(2004-2007)
H.E.S.S. (LE)	(2004 & 2005)	Fermi-LAT †	(2012)
PAMELA †	(2013)		

†: derived as sum from separate e⁻ and e⁺ flux measurements

E³ × Φ (GeV² [m² sr sec]⁻¹)

2.5 years of data taking
15% of the total expected statistics

Energy (GeV)

- Electron plus positron spectrum measured with unprecedented precision up to 1 TeV.
- Systematic of measurement within few percent in a wide energy range.
- No evidence of fine structures observed.