RECENT RESULTS FROM AMS

2nd of October 2014

Vincent Poireau, LAPP Annecy
On behalf of the AMS collaboration

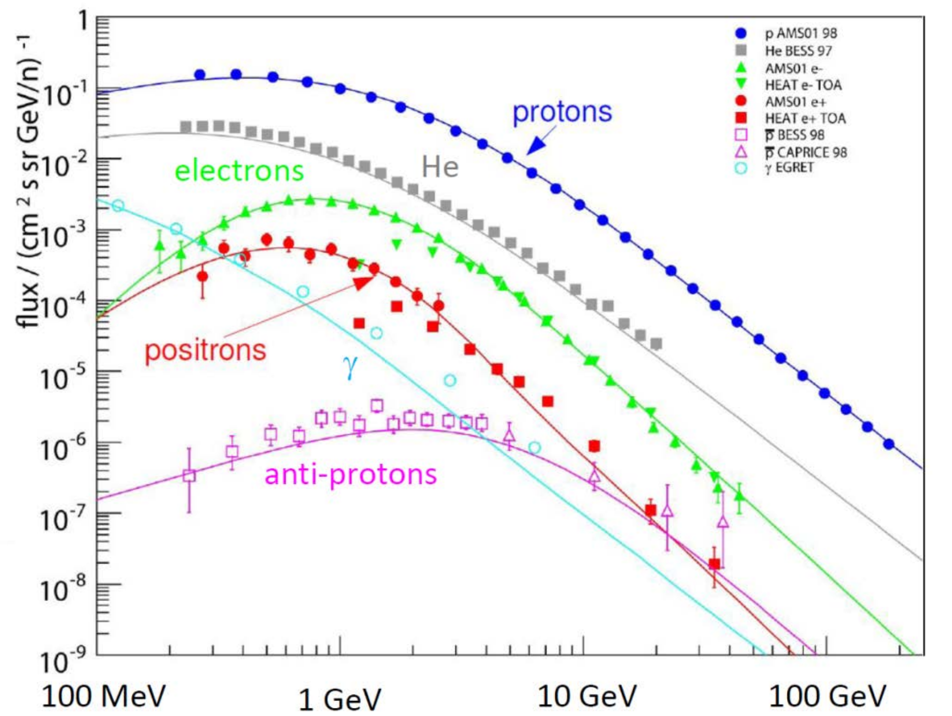
INTRODUCTION

- The AMS collaboration published two new important results on the 18th of September

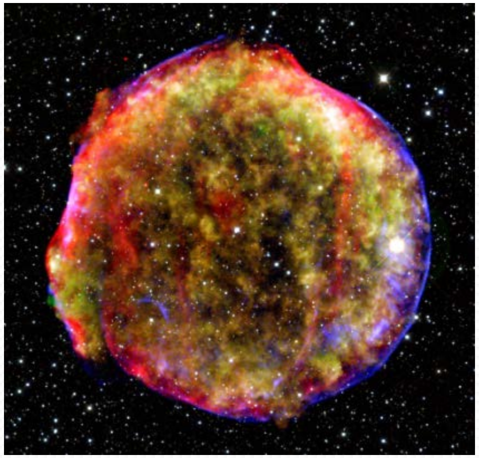
- New results on the physics of electrons and positrons
  - Positron fraction
    - Phys. Rev. Lett. 113, 121101 (2014)
  - Electron flux
    - Phys. Rev. Lett. 113, 1211012 (2014)
  - Positron flux
    - Phys. Rev. Lett. 113, 121102 (2014)
  - Combined ($e^- + e^+$) flux
    - Preliminary results, submitted to Phys. Rev. Lett.

COSMIC RAYS

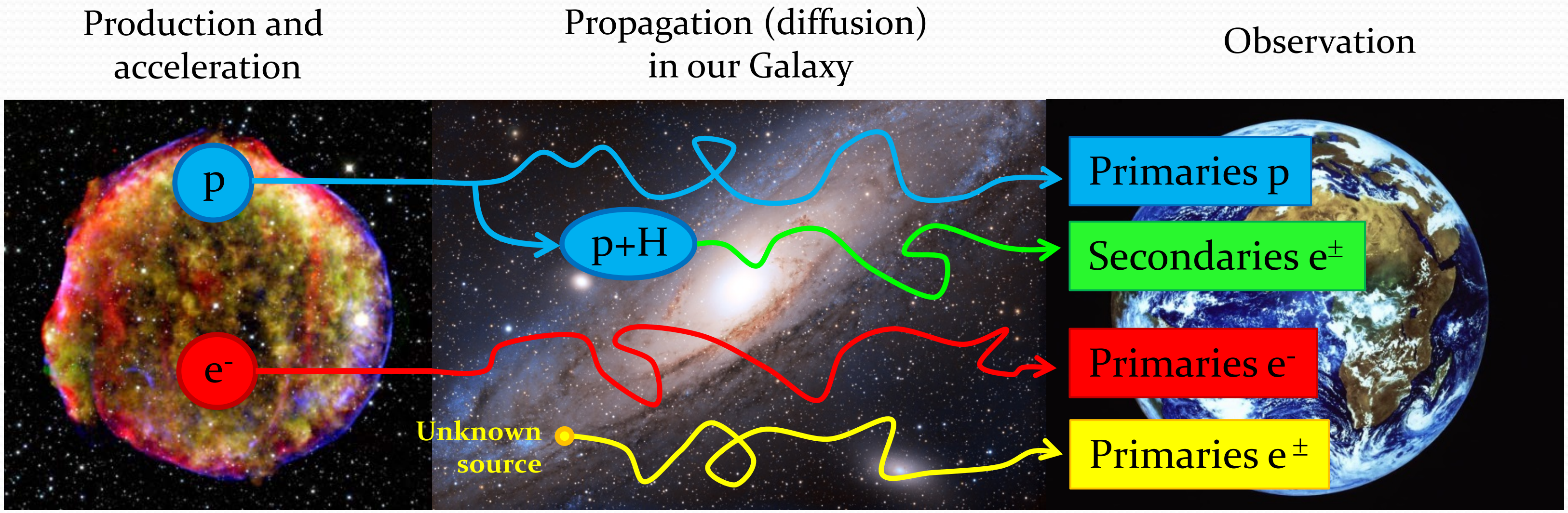
- Charged cosmic rays
  - 99% **nucleons**
    - 89% **protons**, 10% **helium**, 1% heavier **nuclei**
  - **Electrons** 1%, **positrons** 0,1%



- Cosmic rays with E<10^{16} eV come from our Galaxy
  - Accelerated in **supernova remnants**
  - Produce naturally a power law for the flux
    - $\phi \propto E^{\gamma}$ γ = -2.7 to -3.5 (**spectral index**)



COSMIC RAYS

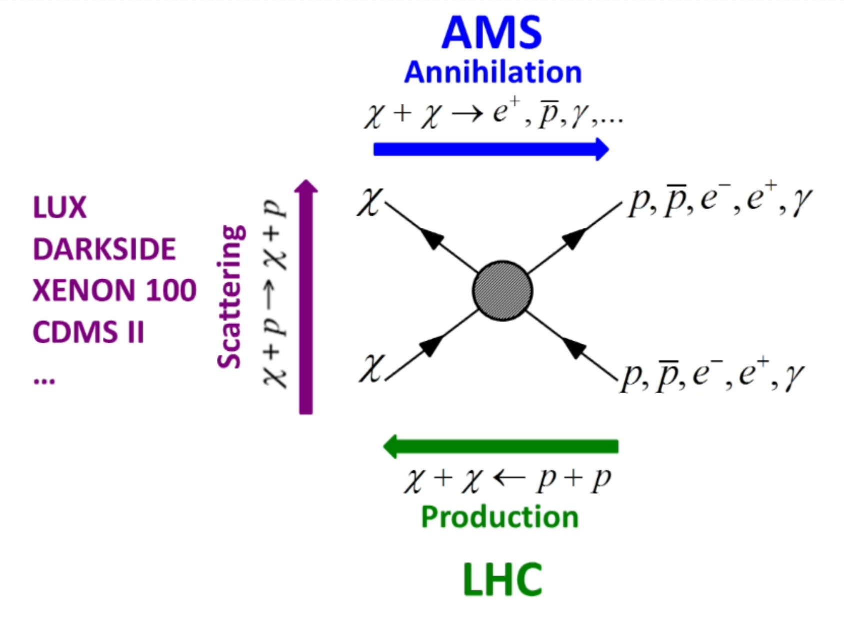


- Primary cosmic rays
  - Produced direcly **in the source**
  - Known sources (for $E<10^{16}$): **supernova remnants**
  - Primaries include
    - Electrons, protons, helium, carbon, …
- Secondary cosmic rays
  - Originate from the **interaction** of primaries on **interstellar medium**
  - Secondaries include
    - Positrons, antiprotons, bore, …
- Additional sources of electrons and positrons?

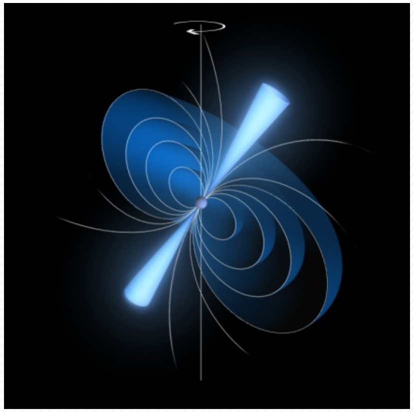
COSMIC RAYS

- Additional sources ?

- From particle physics: dark matter



- From astrophysics: pulsars



- AMS is bringing essential information to answer these questions

AMS-02

- A particle detector in space
  - Detect **charged** particles and **gamma** rays
  - From **100 MeV** to **a few TeV**

5m x 4m x 3m
7.5 tons

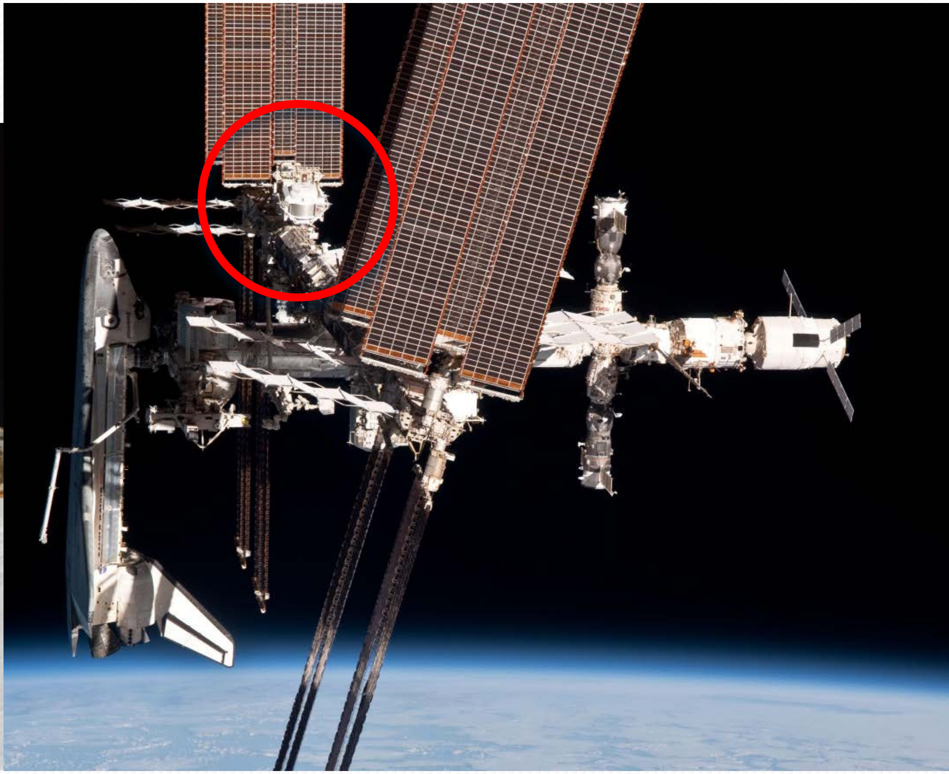
  - **280** physicists

AMS-02

- Launch from Cap Canaveral on the 16th of May 2011

AMS-02

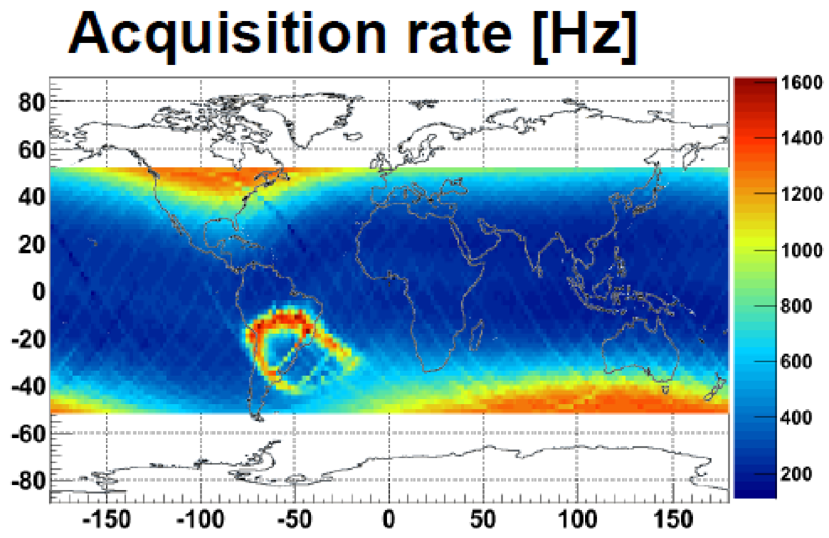
- Installation on the ISS on the 19th of May 2011
  - Orbit at **400 km** altitude
  - One orbit every **90 minutes**



- Detect the cosmic rays before they interact in the atmosphere

FLIGHT OPERATION

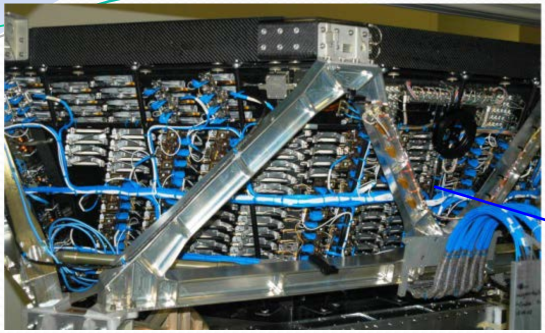
- Acquisition rate from 200 to 2000 Hz
- Continuous operation 7d/7 24h/24
- Acquisition
  - ~**40 millions** events a day
  - ~**100 GB** transferred every day
  - **35 TB** of data every year
  - **200 TB** of reconstructed data every year



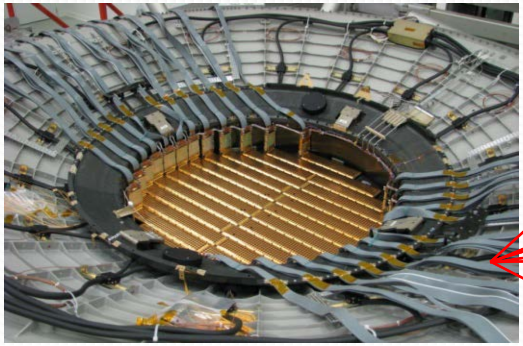
- 54 billions of events recorded since May 2011 (40 months)
  - Much more than all the cosmic rays collected **in the last 100 years**
- Will operate at least until 2020
  - Analyses presented here up to **November 2013**

DETECTOR

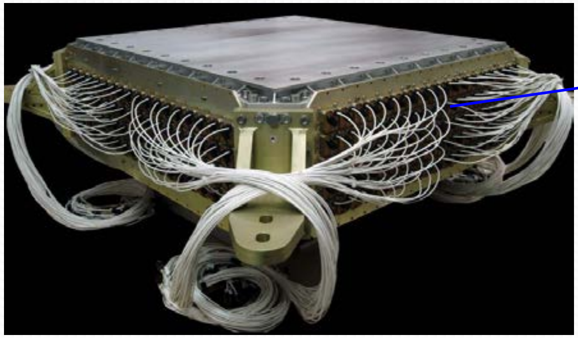
Transition radiation detector
Identifies e$^+$, e$^-$

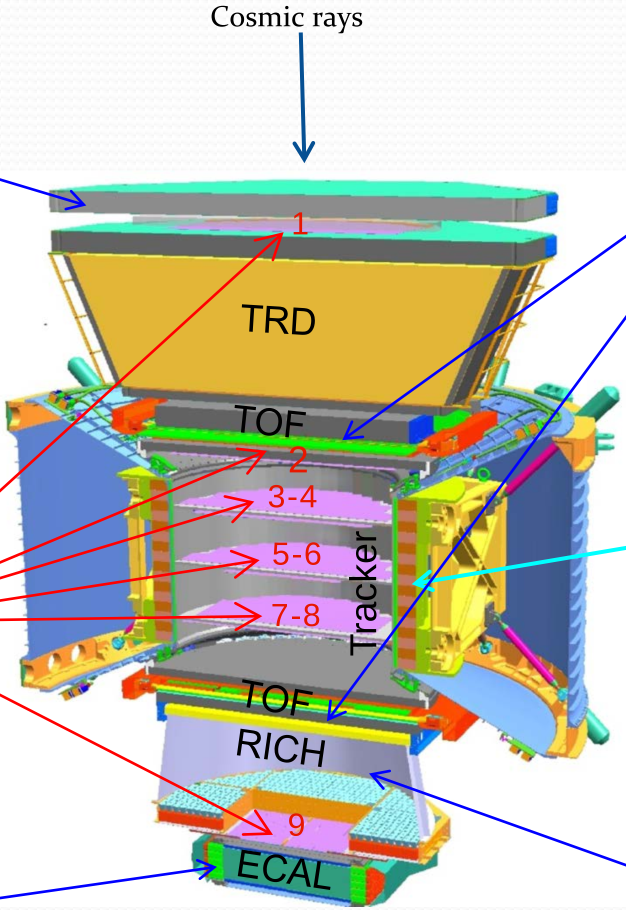


Silicium tracker
Z, P



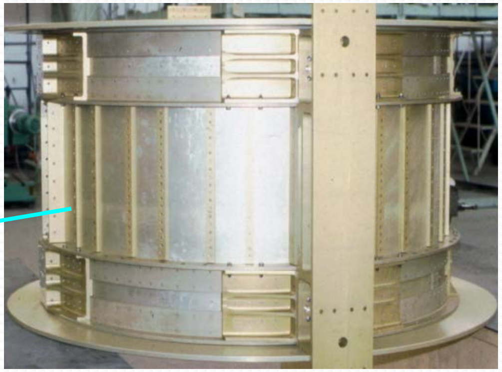
EM calorimeter
E of e$^+$, e$^-$, γ



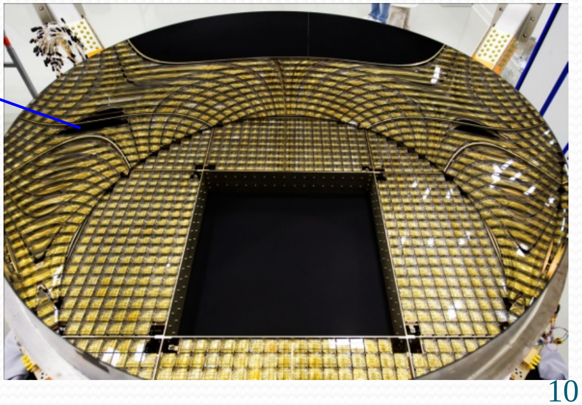


Time of flight
Z, E

Magnet 0,14 T
±Z

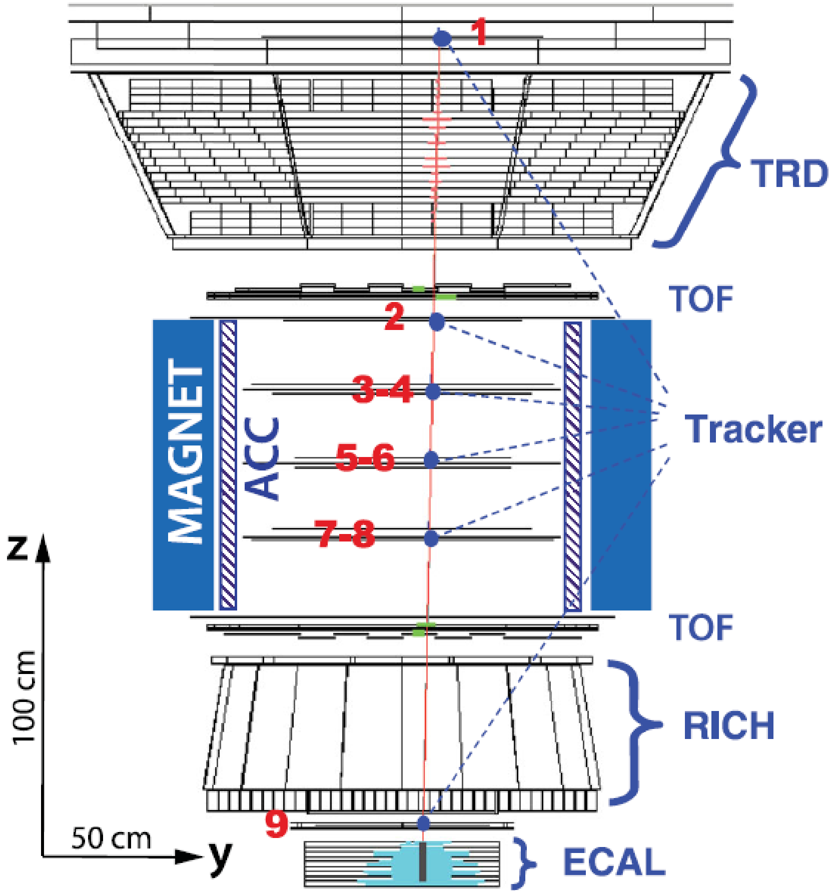


Cherenkov detector
Z, E



DETECTOR

- Minimal material before ECAL
  - 0.65 X_0
- Alignment of the tracker planes (temperature variations) performed with cosmic rays
  - **3-4 µm** precision



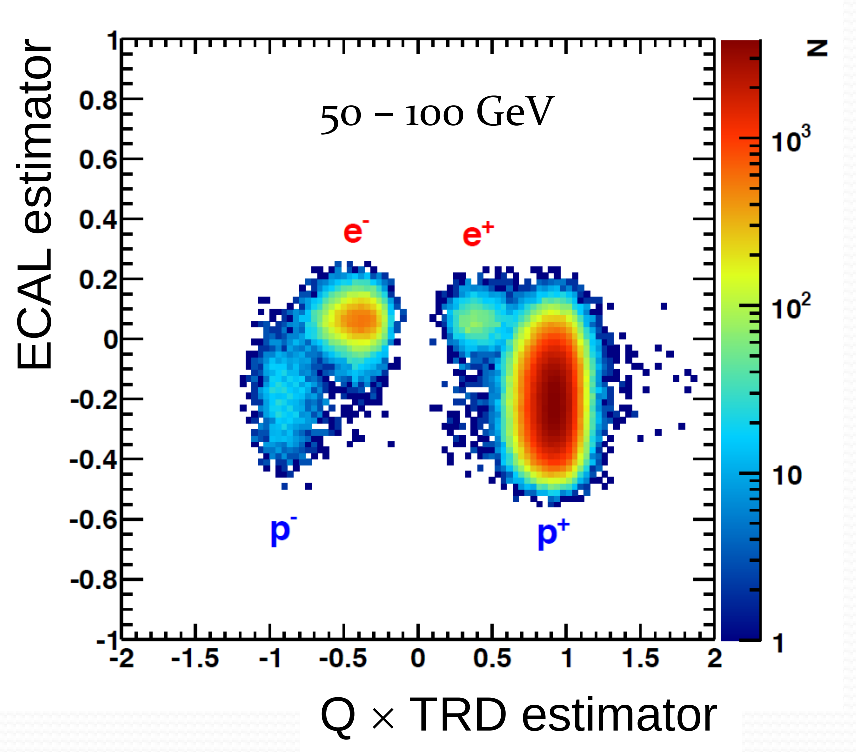
A 369 GeV positron event

LEPTON IDENTIFICATION

- Challenge
  - **100 times** more protons than electrons
  - **2000 times** more protons than positrons

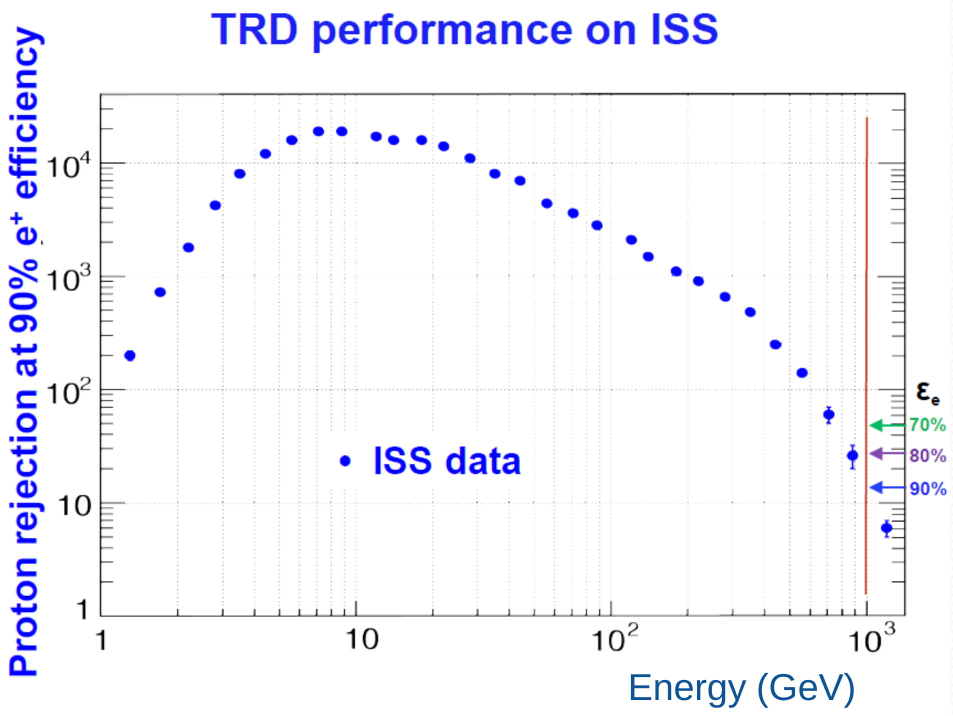
  ⇒ Need to divide number of protons by **10^6**

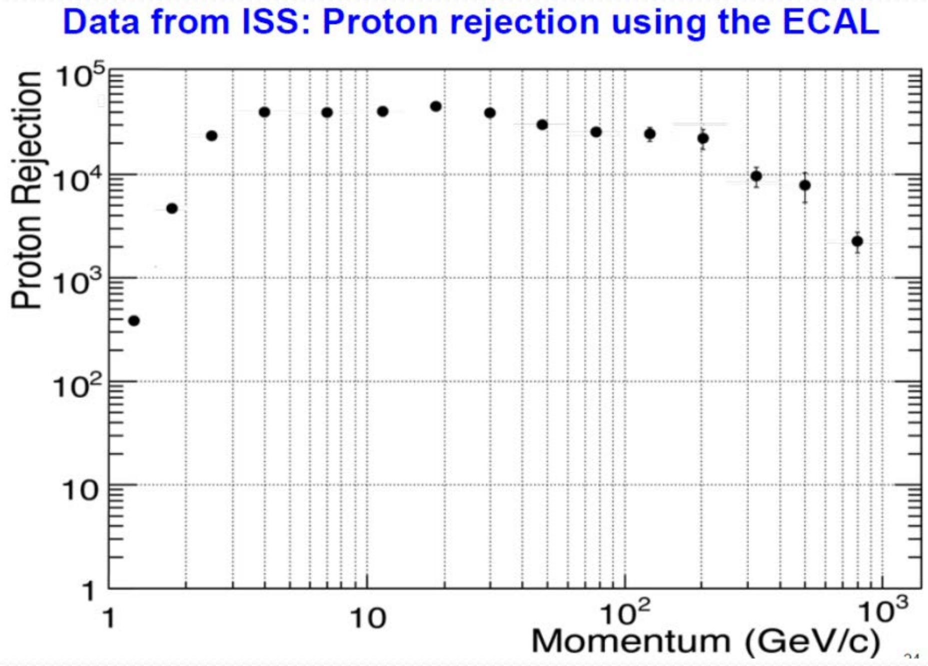
- Key detectors for this measurement
  - **TRD**
  - **Tracker**
    - E/p close to 1 for electrons/positrons
  - **ECAL**
    - Based on 3D shower shape



LEPTON IDENTIFICATION

- Performance on proton rejection for TRD and ECAL





POSITRON FRACTION

Phys. Rev. Lett. 113, 121101 (2014)

POSITRON FRACTION

- Positron fraction

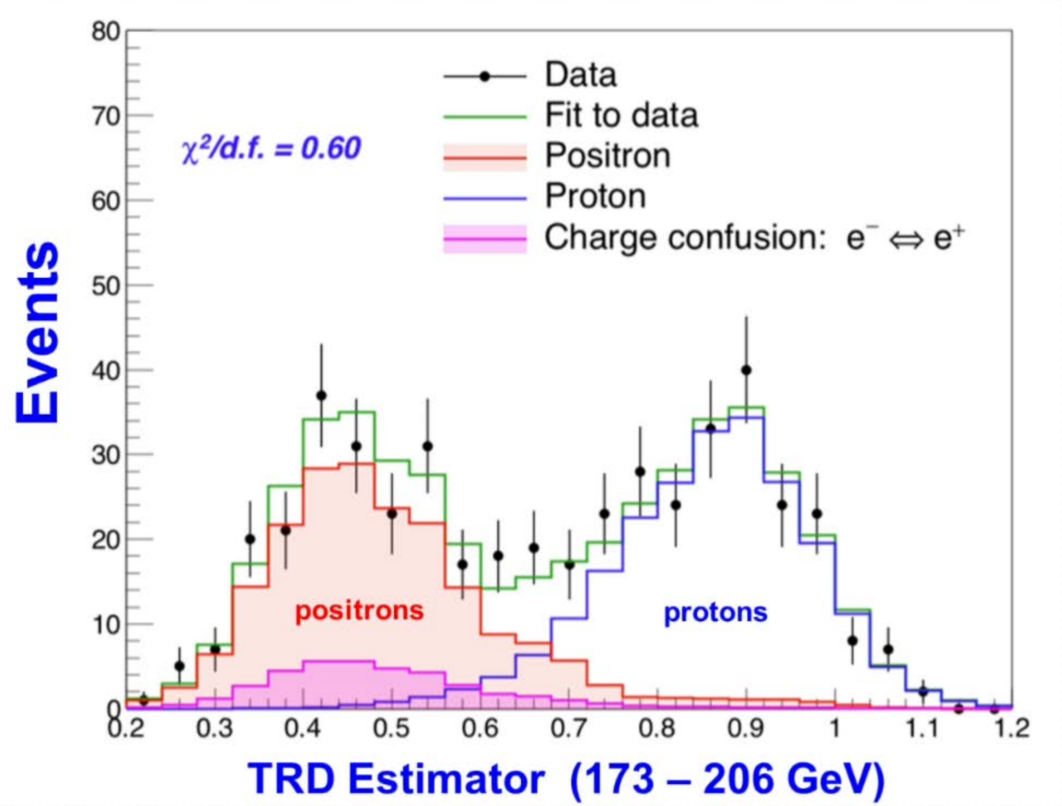
$$F = \frac{\Phi_{e^+}}{\Phi_{e^+} + \Phi_{e^-}} = \frac{N_{e^+}}{N_{e^+} + N_{e^-}}$$

- Positrons: expected only as secondary
- Positron excess with respect to the secondary prediction = source of primary positrons

- Energy range from 0.5 GeV to 500 GeV based on 10.9 million positron and electron events
  - **Extends** the energy range of our previous observation and **increases its precision**

POSITRON FRACTION

- Counting leptons after selection with a fit
  - **Z > 0** : counting **positrons**



  - **Z < 0** : counting **electrons**

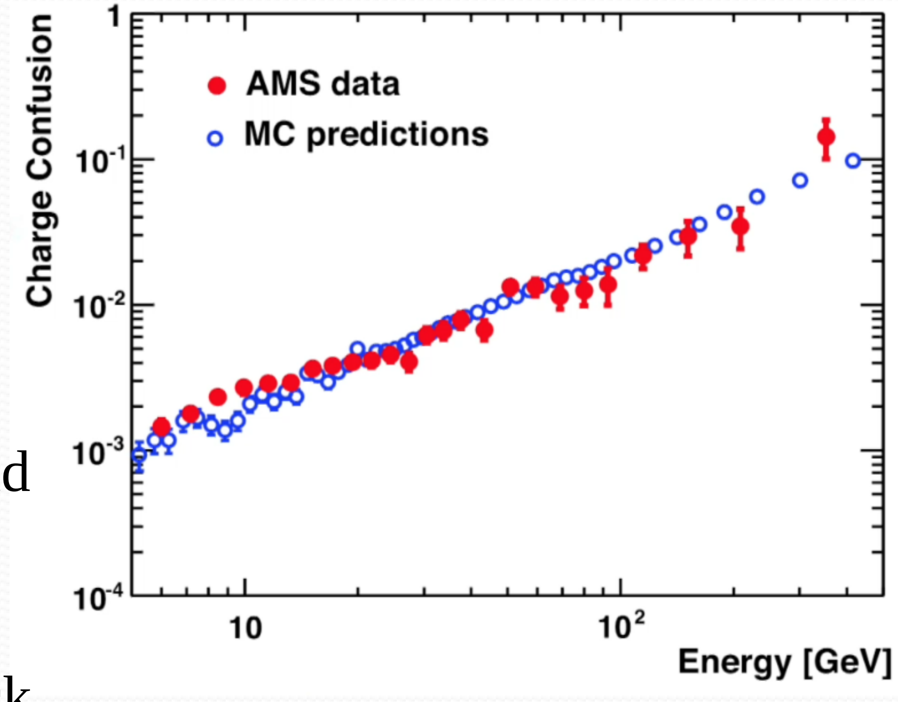
POSITRON FRACTION

- Systematics
  - **Acceptance** assymmetry
    - Negligible above 3 GeV
  - **Selection** dependence
    - Analysis repeated 1000 times for each energy bin with different selection
  - Absolute **energy scale**
    - 5% at 0.5 GeV, 2% for 10-290 GeV, 3% at 500 GeV
  - Bin-to-bin **migration**
    - Negligible contribution
  - **Reference** spectra
  - **Charge confusion**

CHARGE CONFUSION

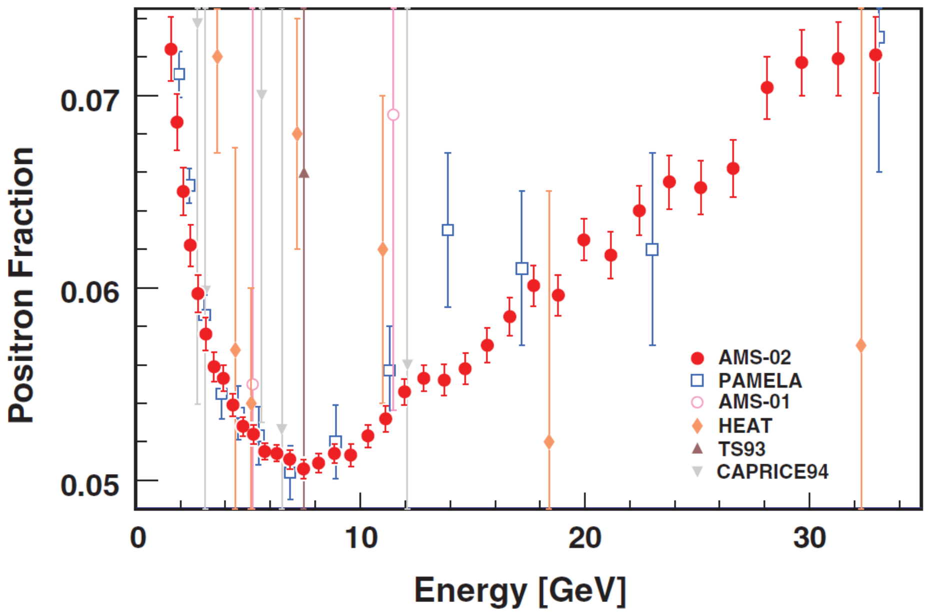
- For some energy range, difficulty to measure the sign of the charge ⇒ confusion

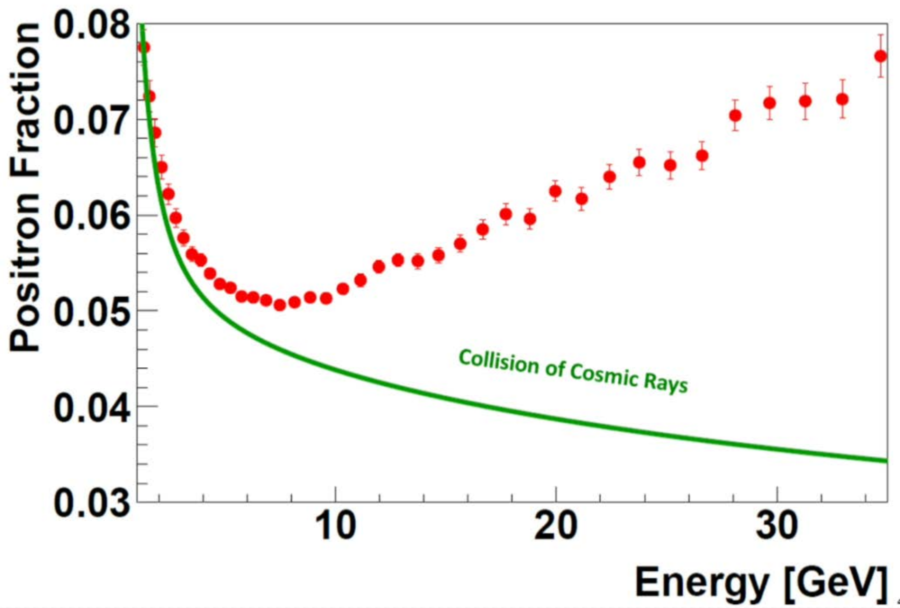
- Two sources
  - Finite resolution of the tracker and multiple scattering
  - Production of secondary tracks along the path of the primary track



POSITRON FRACTION

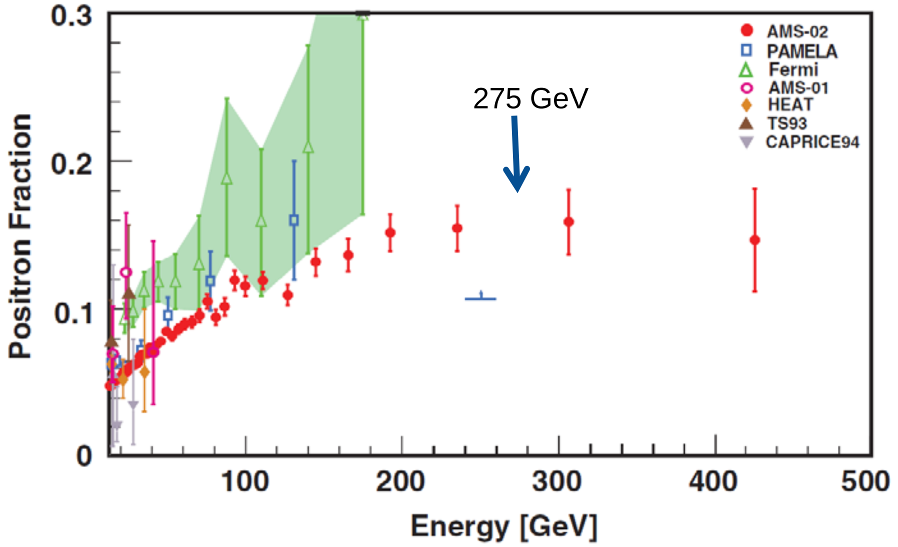
- Result for the positron fraction below 35 GeV
  - Fraction begins to increase **above 10 GeV**
  - **Incompatible** with secondary positrons only

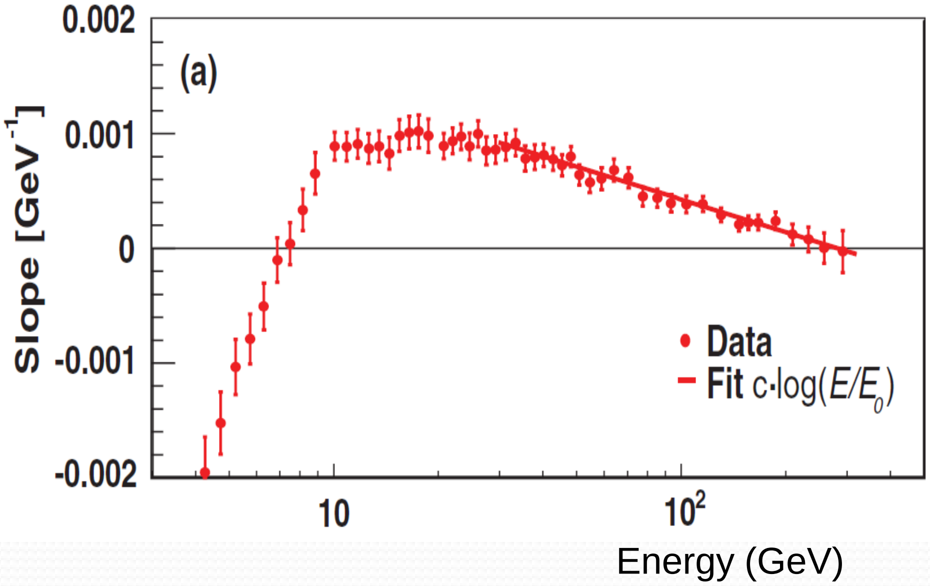




POSITRON FRACTION

- Fraction at high energy

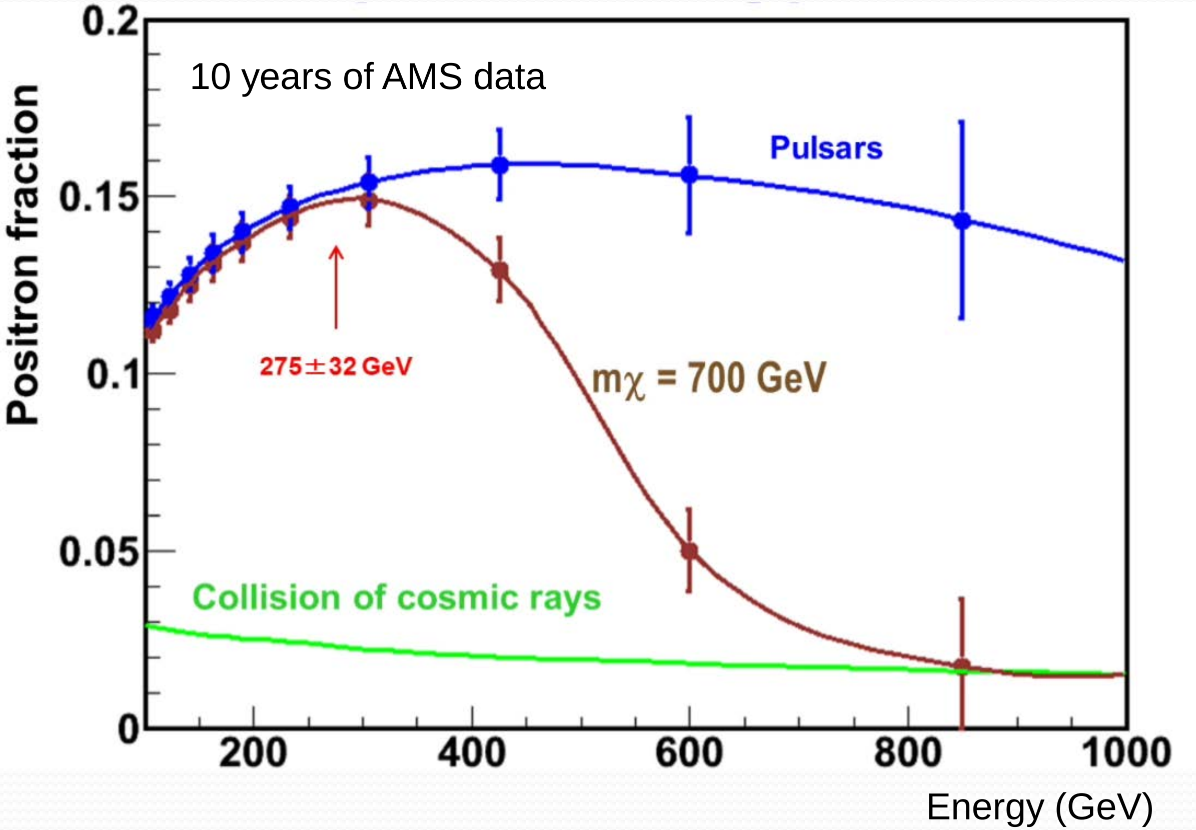




- No sharp structure
- Fit of the slope
  - Cease to increase at **275 ± 32 GeV**
- With the current sensitivity, the flux is isotropic

POSITRON FRACTION

- In the near future, AMS will extend its energy range, and will be able to discriminate between the dark matter and pulsar hypotheses



ELECTRON FLUX
POSITRON FLUX

Phys. Rev. Lett. 113, 121102 (2014)

FLUX MEASUREMENT

- Obtaining the flux via

$$\frac{N}{A \times \varepsilon_{Trig.} \times \varepsilon_{sel.} \times T \times dE}$$

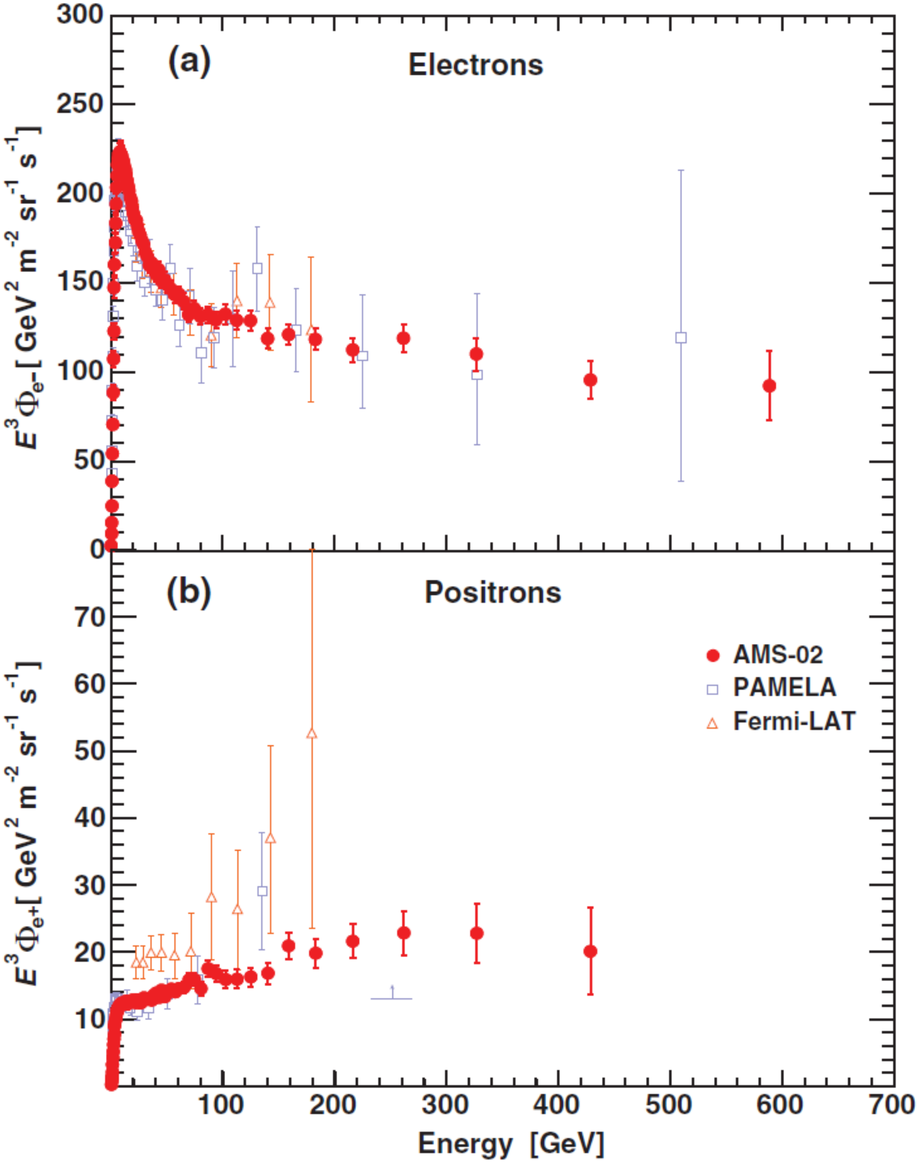
  - N **number** of positrons or electrons
  - A **acceptance**
  - ε_{Trig} and ε_{sel} **trigger** and **selection efficiencies**
  - T exposure **time**
  - dE energy **bin size**

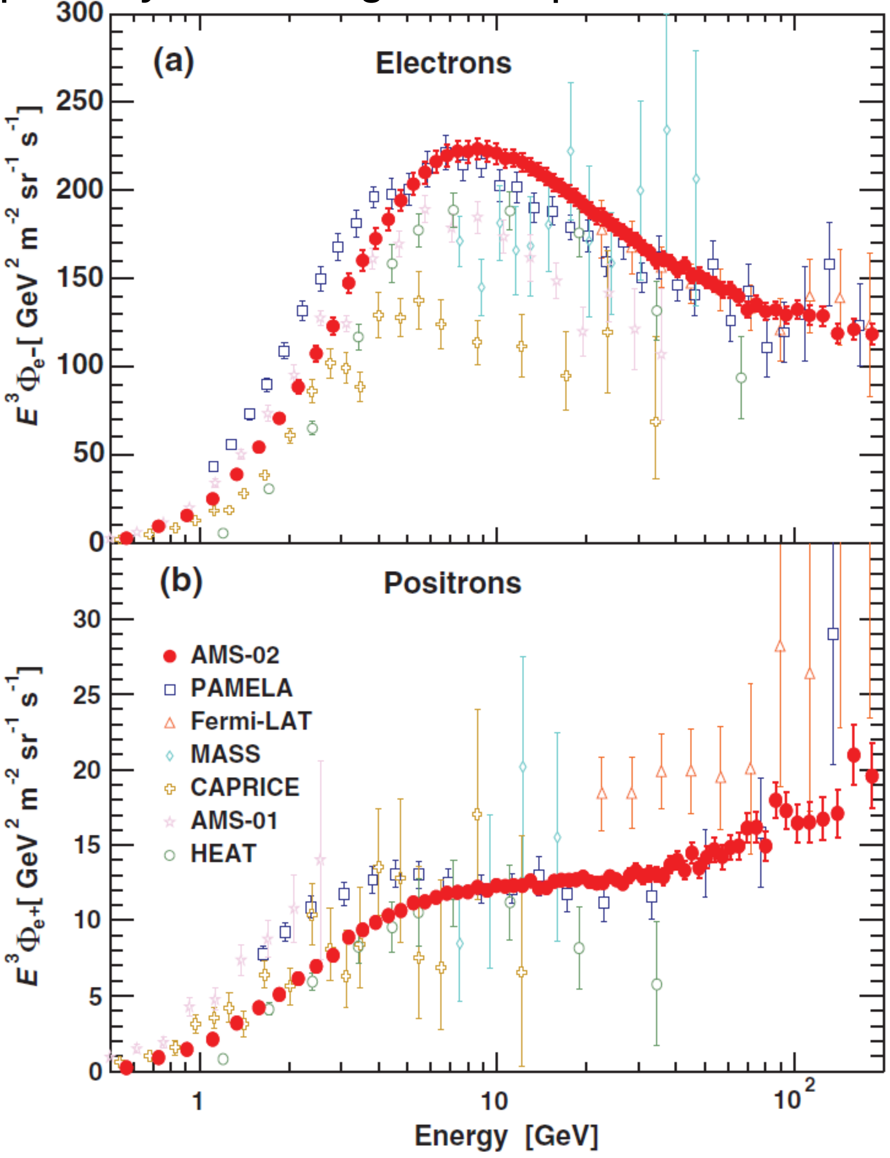
FLUX MEASUREMENT

Linear scale

Flux multiplied by E^3

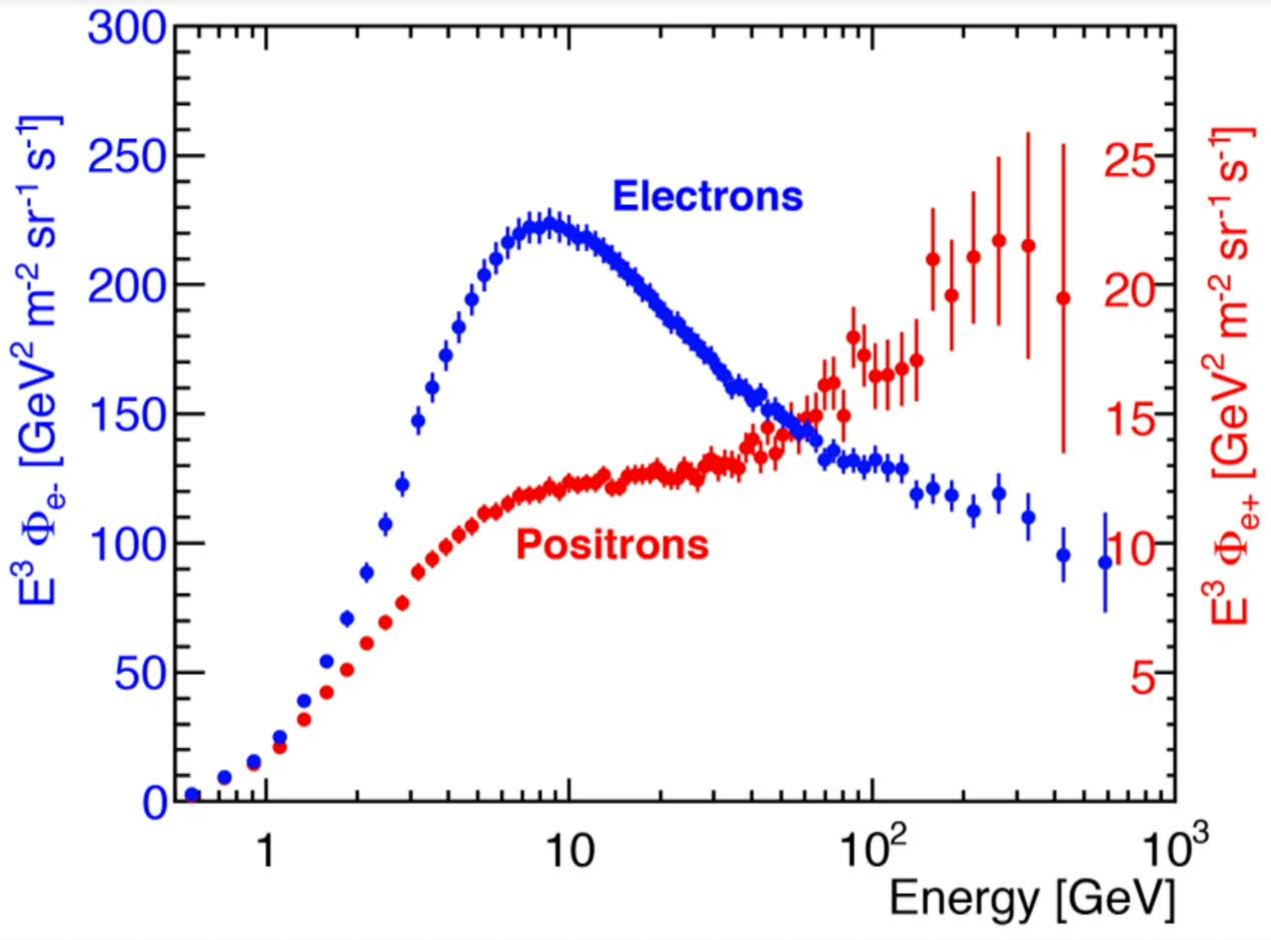
Log scale up to 200 GeV





FLUX MEASUREMENT

- The electron and positron fluxes are different in their magnitude and energy dependence

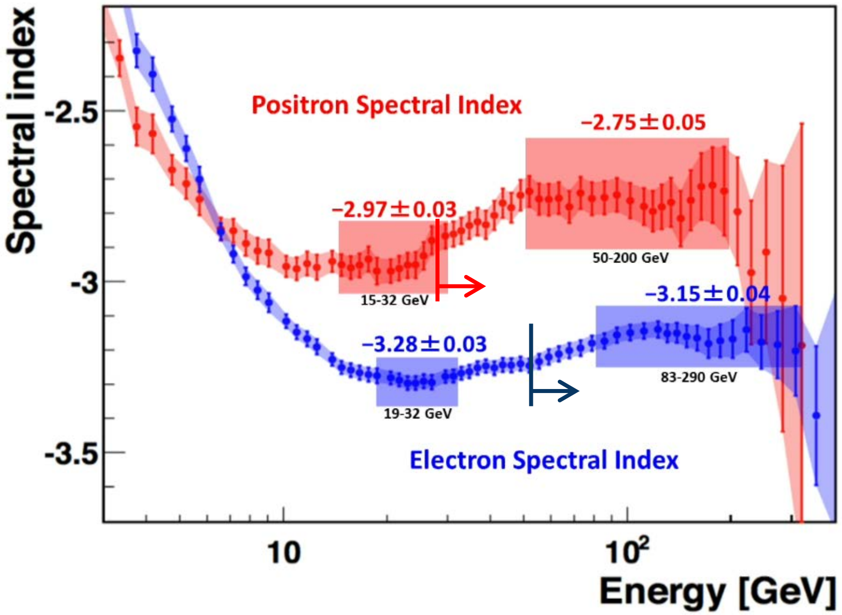


FLUX MEASUREMENT

- Calculation of the spectral indices

$$\Phi_{e^\pm}(E) = C_{e^\pm} E^{\gamma_{e^\pm}} \quad \text{or} \quad \gamma_{e^\pm} = d[\log(\Phi_{e^\pm})]/d[\log(E)]$$

- Observations
  - Both spectra **cannot be described** by single **power laws**
  - The spectral indices of electrons and positrons are **different**
  - **Change of behavior** at ~30 GeV



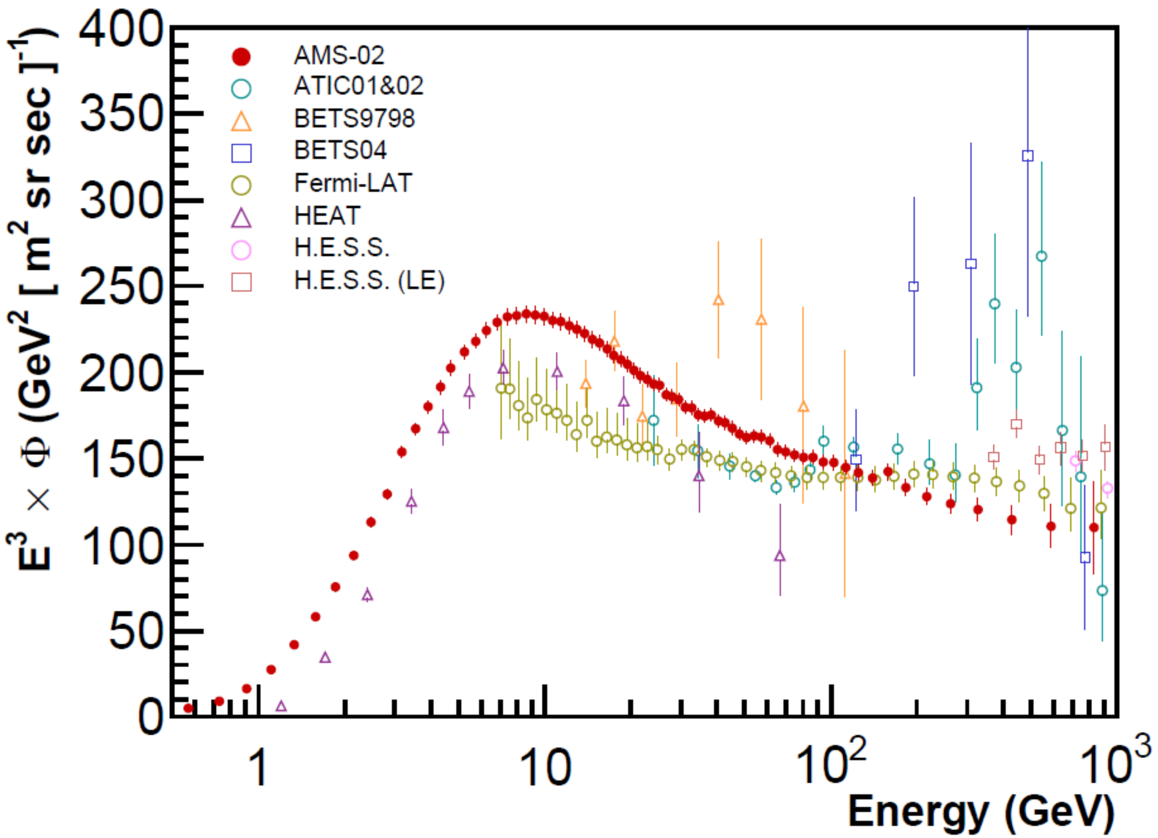
- Lower energy limit for single power law distribution description
  - **Positrons**: 27.2 GeV
  - **Electrons**: 52.3 GeV

COMBINED $(e^+ + e^-)$ FLUX

Preliminary, submitted to Phys. Rev. Lett.

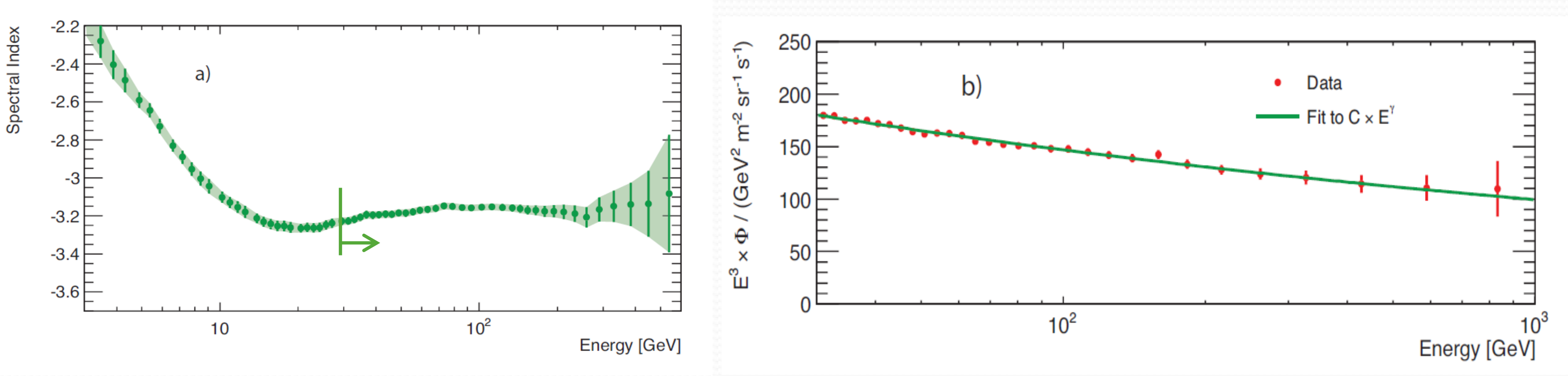
COMBINED FLUX

- This measurement
  - Independent from **charge sign** measurement = **no charge confusion**
  - **High selection efficiency** (70% at 1 TeV)



COMBINED FLUX

- Calculation of the spectral index $\phi(e^+ + e^-) = C\,E^\gamma$



- The flux is consistent with a single power law above 30 GeV
  - $\gamma = -3.170 \pm 0.008$ (stat + syst) ± 0.008 (energy scale)

MINIMAL MODEL

MINIMAL MODEL

- Fit of the AMS data using a minimal model
- Positrons
  - Secondary production
  - + source

$$\Phi_{e^+} = C_{e^+} E^{-\gamma_{e^+}} + C_s E^{-\gamma_s} e^{-E/E_s}$$

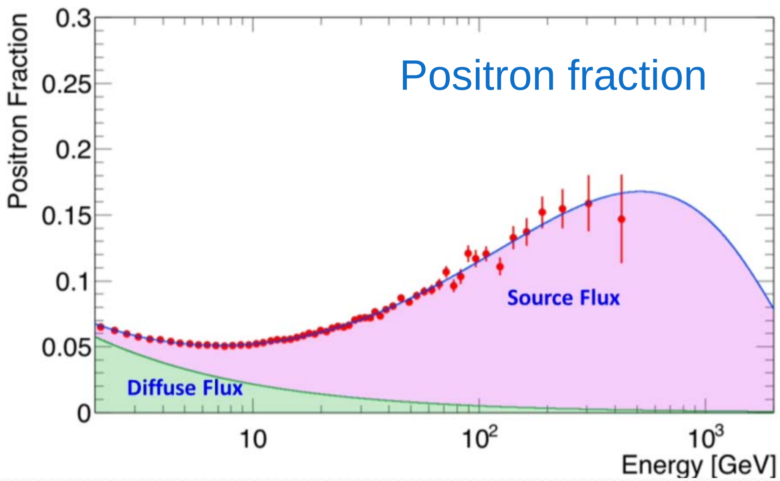
- Electrons
  - Primary and secondary production
  - + same source

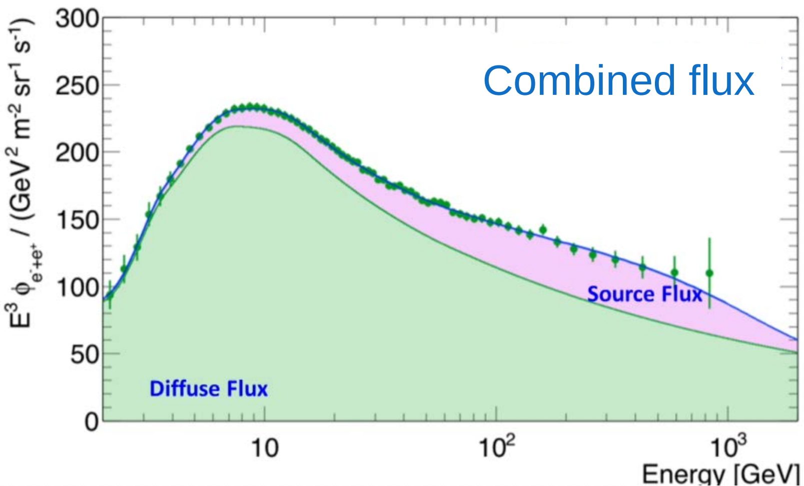
$$\Phi_{e^-} = C_{e^-} E^{-\gamma_{e^-}} + C_s E^{-\gamma_s} e^{-E/E_s}$$

- Simultaneous fit to
  - Positron fraction from 2 GeV
  - Combined flux from 2 GeV

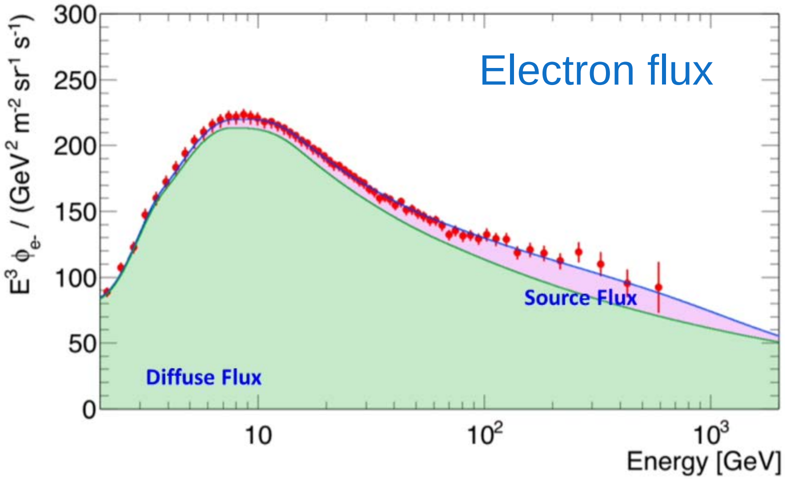
MINIMAL MODEL

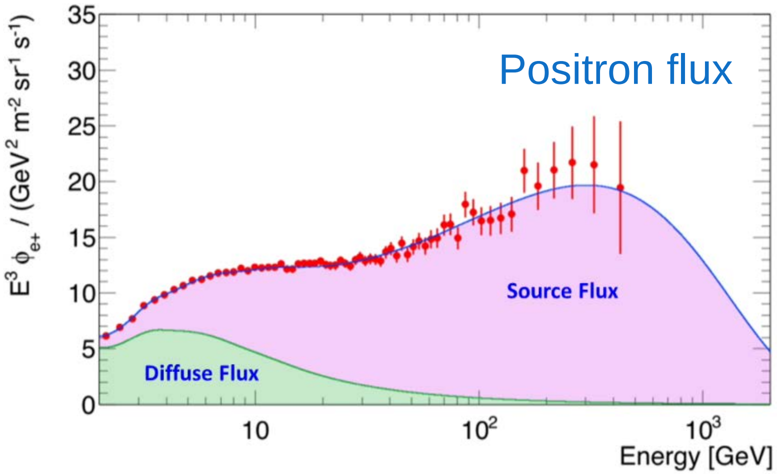
Result from the fits





Prediction from the fits





Fits are satisfactory, which shows that the data can be described by a common e$^+$/e$^-$ source

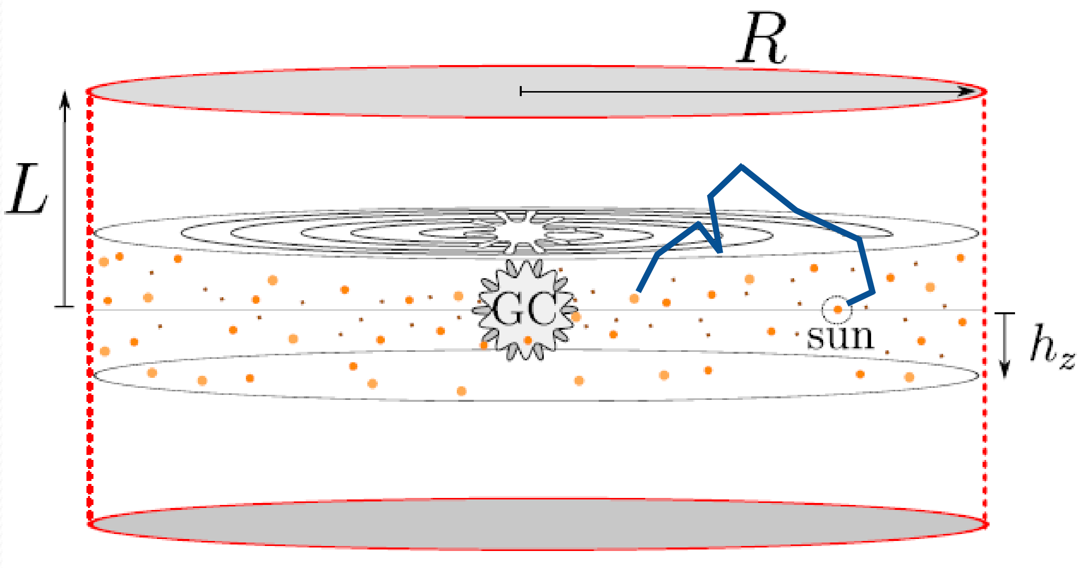
CONCLUSIONS

- The AMS experiment operates since May 2011 and recorded 54 billions of events
  - All the subdetectors are **working nominally**
- Measurement of the positron fraction
  - A **source** of positrons (and electrons) is needed
  - Fraction does **no longer** exhibit an **increase** with energy
- Measurement of the positron and electron fluxes
  - Provides important information on the **origins** of cosmic-ray electrons and positrons
- Measurement of the combined flux
  - **Smooth** and following a **power law** spectrum above 30 GeV
- AMS is expected to run at least until 2020
- Many important measurements are yet to come
  - Protons, helium, antiprotons, B/C, antimatter, etc.

BACKUP SLIDES

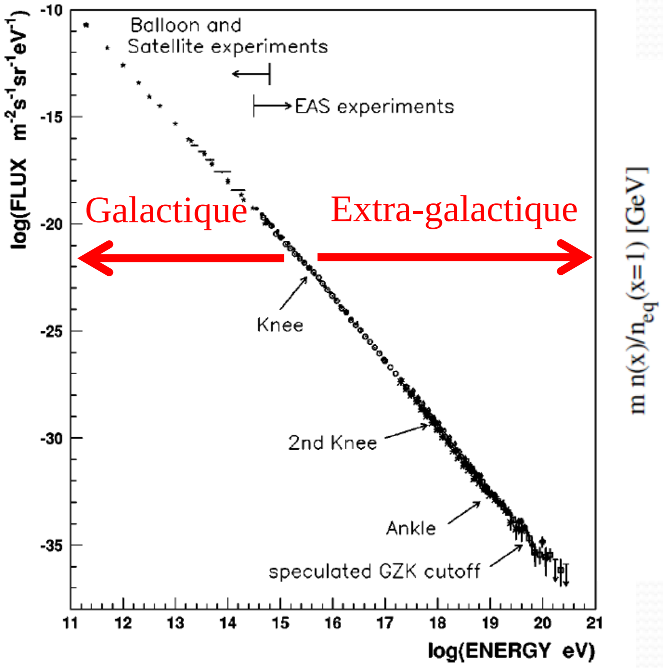
PROPAGATION

- Rayons cosmiques chargés : propagation équivalente à une diffusion dans le milieu galactique
  - **Champ magnétique irrégulier** du halo diffusif = marche au hasard
  - Coefficient de **diffusion** $K(E) = K_0 \beta R^\delta$ $(R=p/Z)$
    - Paramètres libres : K_0, δ, L, V_c, V_a
  - Les incertitudes sur ces paramètres sont transcrits en **trois jeux de paramètrisations**
    - Min, Med, Max



h_z=200 pc, L=1-15 kpc, R=25 kpc

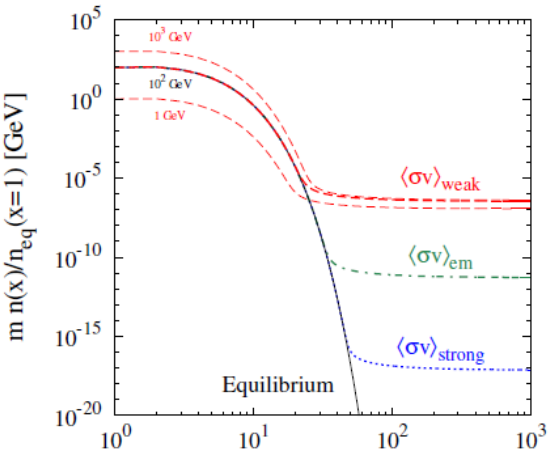
COSMIC RAYS

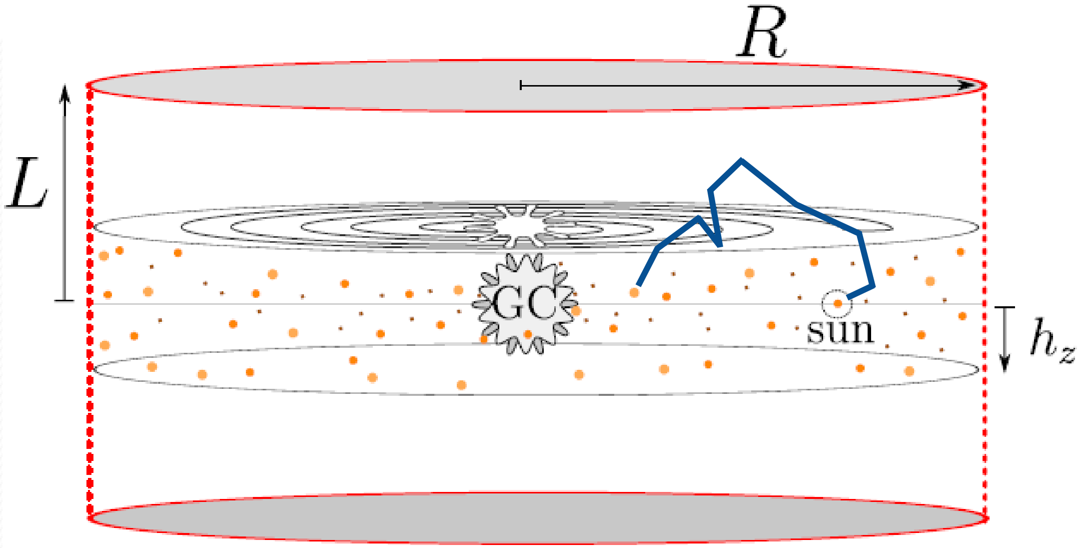


$$p + H \longrightarrow X + \pi^{\pm}$$

$$\pi^{\pm} \longrightarrow \nu_\mu + \mu^{\pm}$$

$$\mu^{\pm} \longrightarrow \nu_\mu + \nu_e + e^{\pm} .$$





$K(E) = K_0 \beta R^{\delta}$ $(R=p/Z)$

Free parameters :

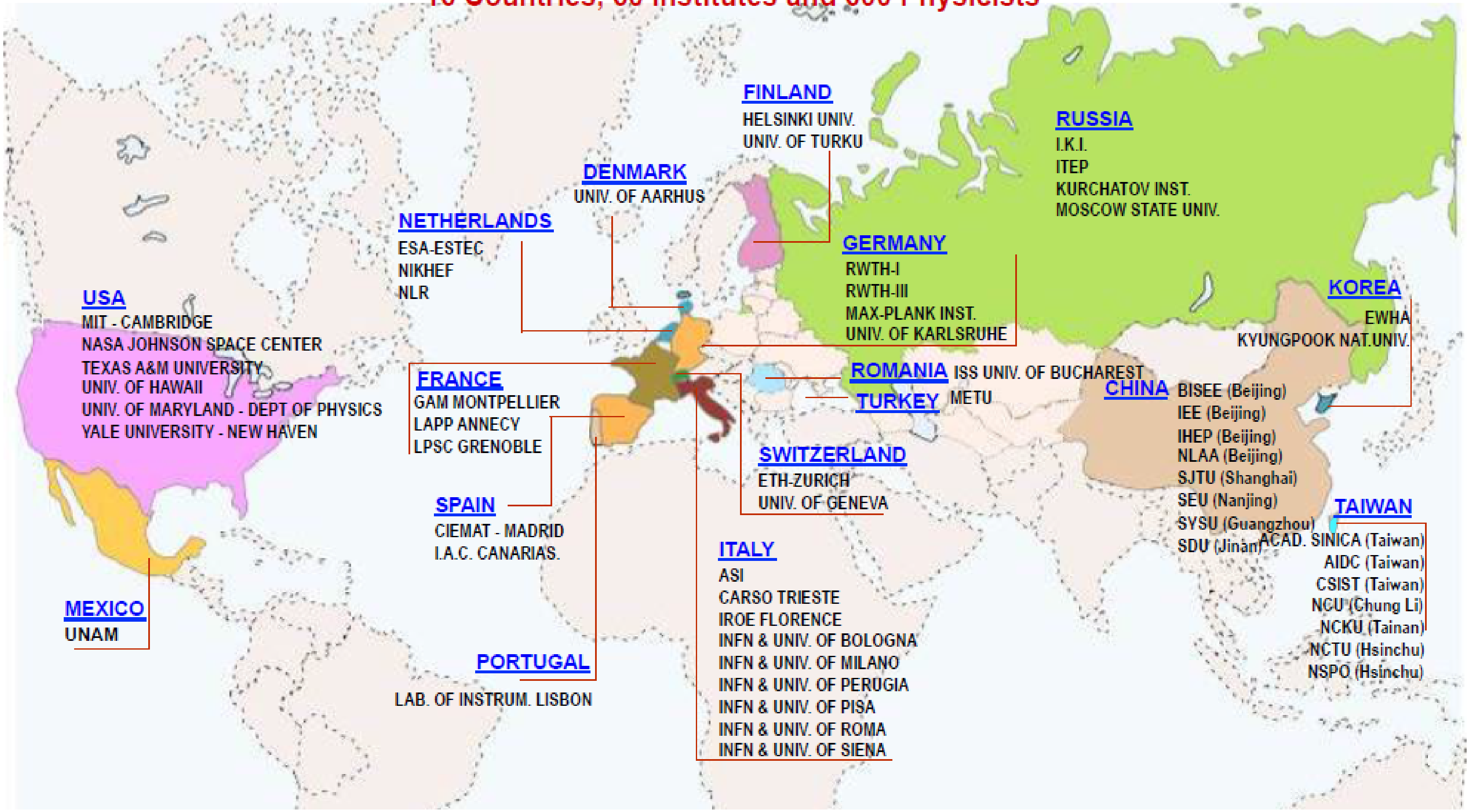
K_0, δ, L, V_c, V_a

h_z=200 pc, L=1-15 kpc, R=25 kpc

COLLABORATION

AMS: a U.S. DOE sponsored international collaboration

16 Countries, 60 Institutes and 600 Physicists



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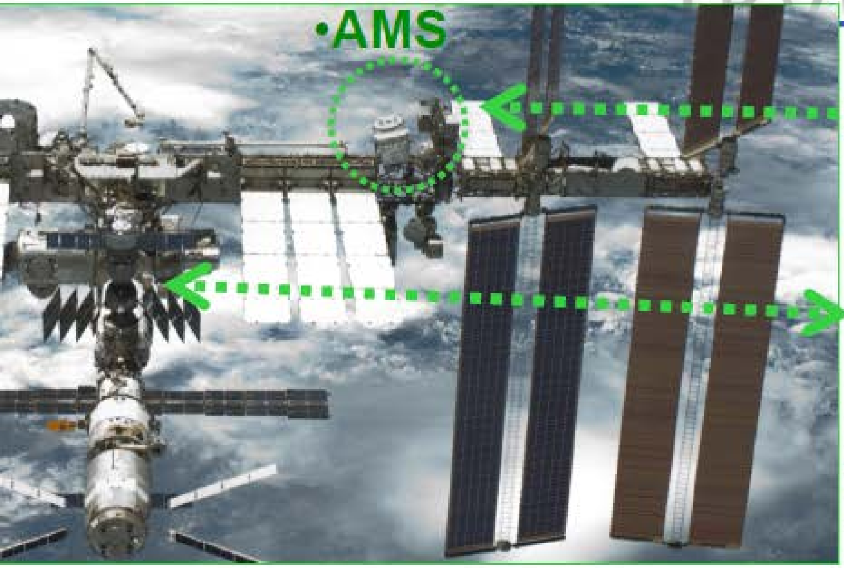



Astronaut at ISS AMS Laptop

Ku-Band
High Rate (down):
Events <10Mbit/s>

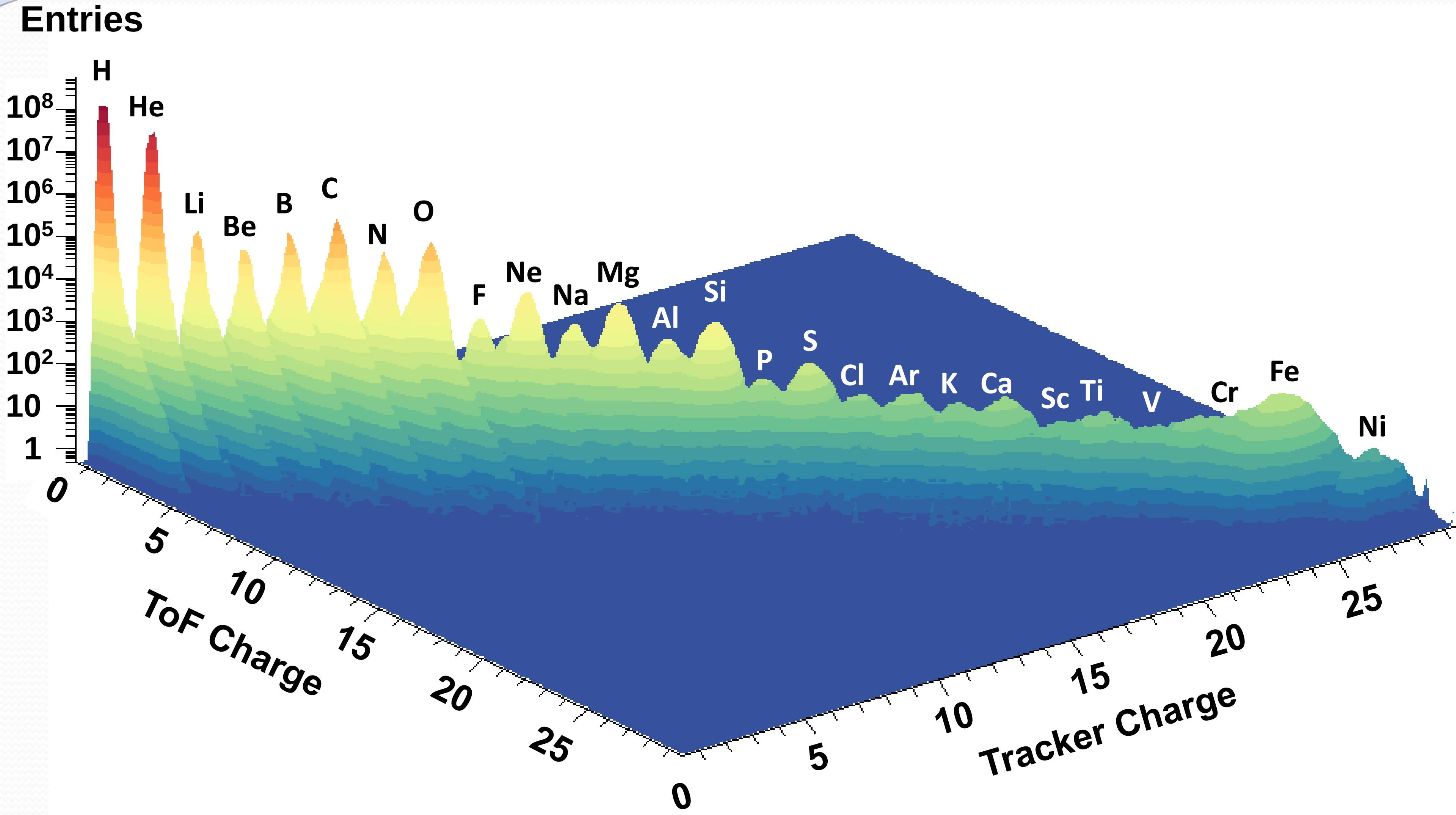
S-Band
Low Rate (up & down):
Commanding: 1 Kbit/s
Monitoring: 30 Kbit/s


White Sands Ground Terminal, NM


AMS Payload Operations Control and Science Operations Centers (POCC, SOC) at CERN since June 2011

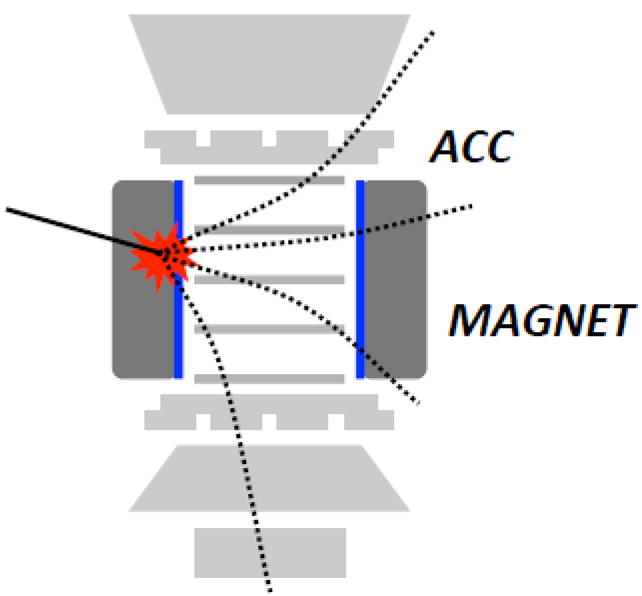

AMS Computers at MSFC, AL

AMS Nuclei Measurement on ISS



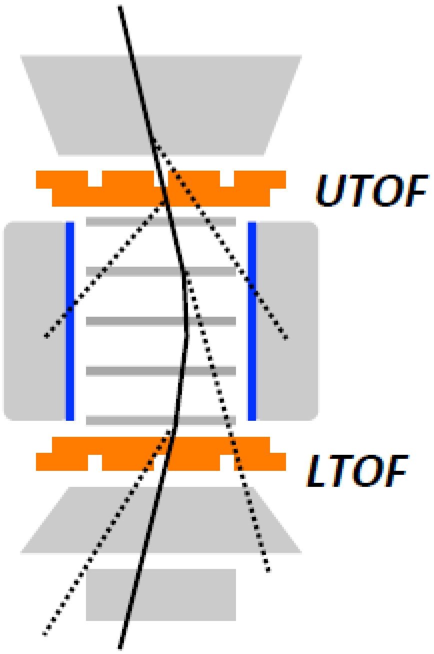
AMS-02 Trigger

Trigger efficiency is estimated with an unbiased trigger sample.



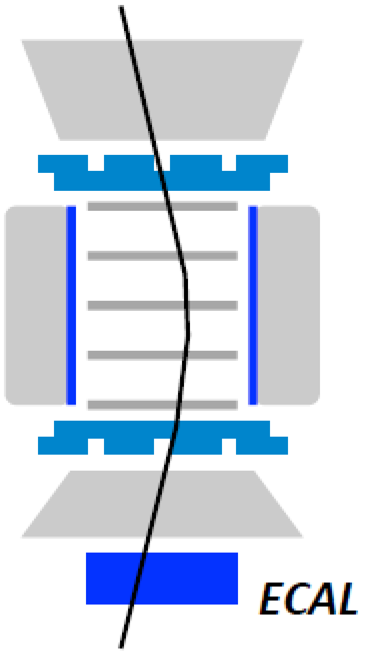
Horizontal Particle

Rejected



High-Z particle

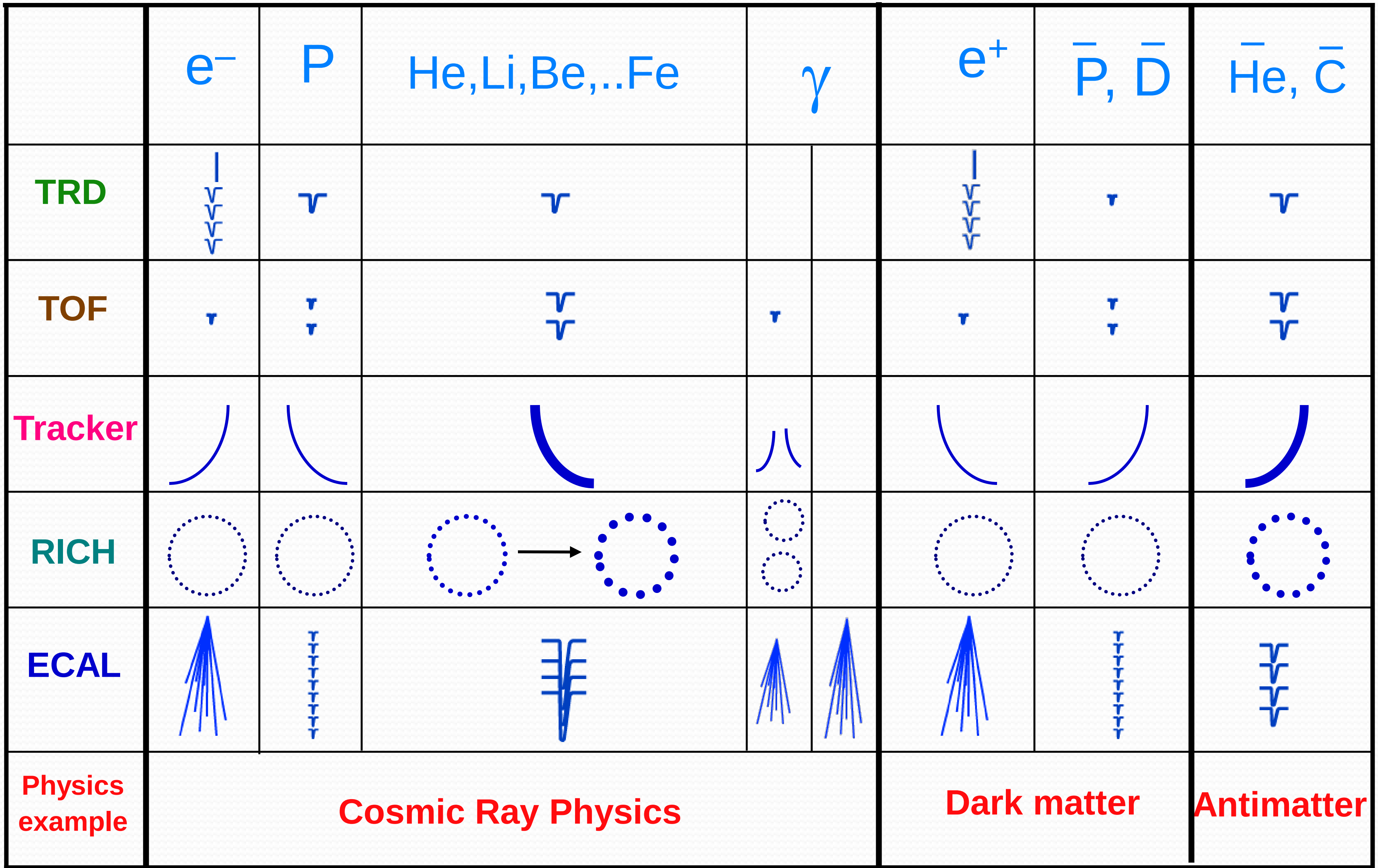
Accepted



TOF + ECAL Trigger

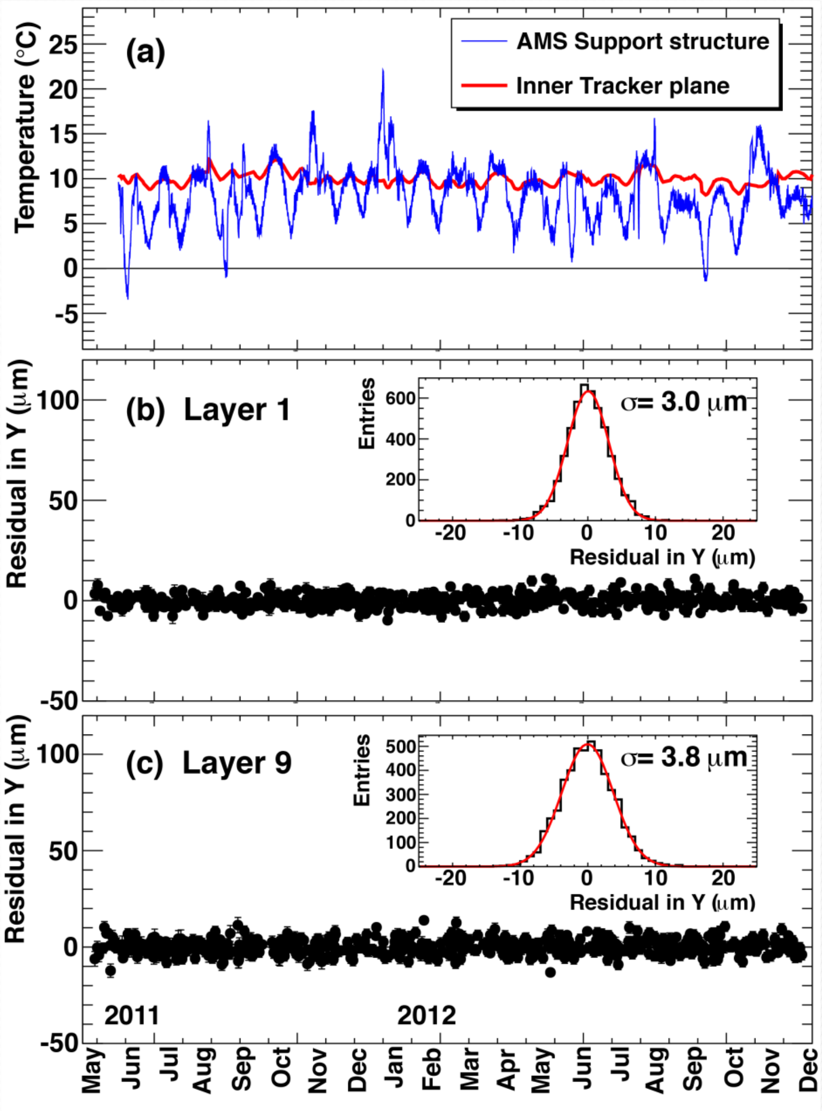
Accepted

DÉTECTEUR



	e^-	P	He,Li,Be,..Fe	γ		e^+	$\bar{P}, \bar{D}$	$\overline{He}, \bar{C}$
TRD								
TOF								
Tracker								
RICH								
ECAL								
Physics example	**Cosmic Ray Physics**					**Dark matter**		**Antimatter**

TEMPERATURES



Event Selection

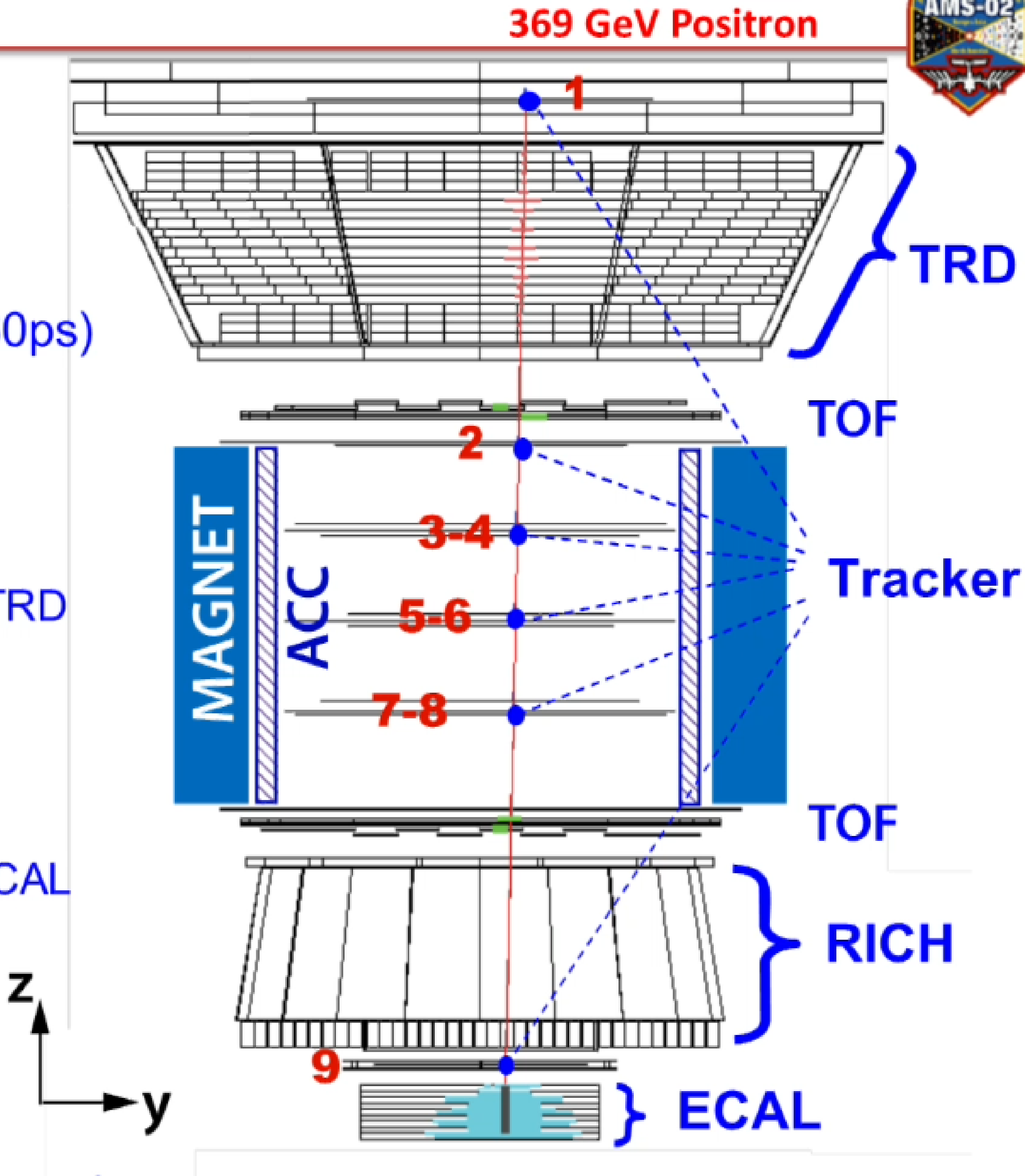
- **TRD:** at least 12 hits

- **TOF:** down going particle (160ps)
  β>0.8, 0.8<Z<2

- **TRACKER:**
  - Good Track quality
  - Geometrical match with TRD Track and ECAL shower
  - Z<1.5

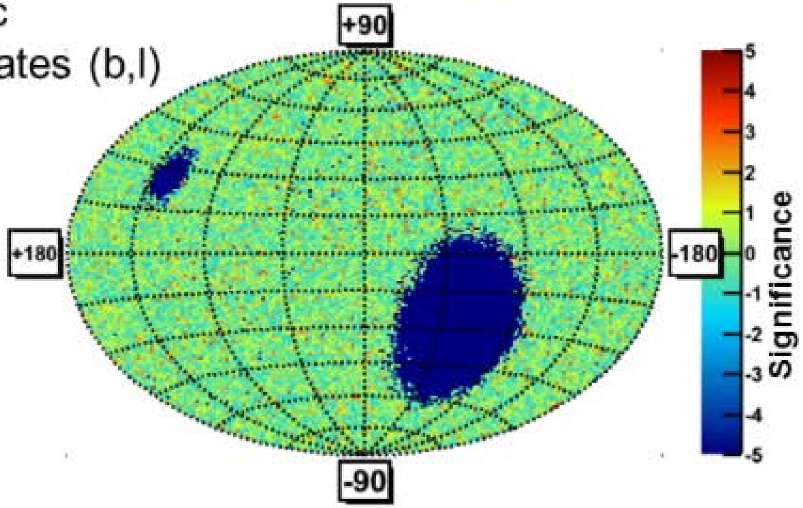
- **ECAL:**
  - Shower axis within the ECAL fiducial volume
  - Shower with electromagnetic shape

- **Geomagnetic cutoff**
  - 1.2 times absolute Størmer value



(v) The isotropy.

Galactic coordinates (b,l)



The fluctuations of the positron ratio e^+/e^- are isotropic.

The anisotropy in galactic coordinates: **$\delta \leq 0.030$ at the 95% confidence level**

$\delta = 3\sqrt{C_1/4\pi}$ C_1 is the dipole moment

Arrival directions of electrons and positrons are used to build a sky map in galactic coordinates, (b, l), containing the number of observed positrons and electrons. The fluctuations of the observed positron ratio are described using a spherical harmonic expansion

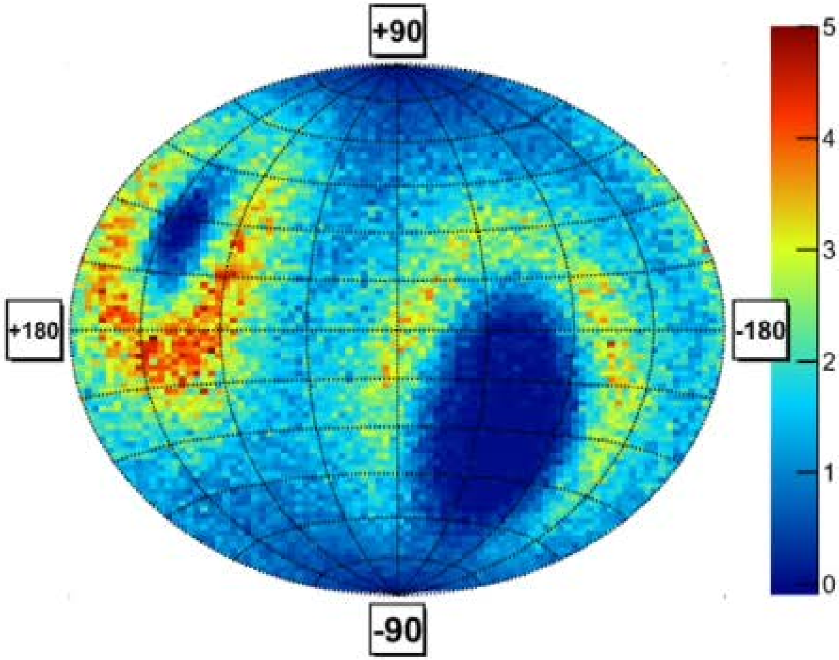
$$\frac{r_e(b,l)}{< r_e >} - 1 = \sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} a_{\ell m} \, Y_{\ell m}(\pi/2 - b, l),$$

where $r_e(b,l)$ denotes the positron ratio at (b,l); $< r_e >$ is the average ratio over the sky map; $Y_{\ell m}$ are spherical harmonic functions and $a_{\ell m}$ are the corresponding weights. The coefficients of the angular power spectrum of the fluctuations are defined as

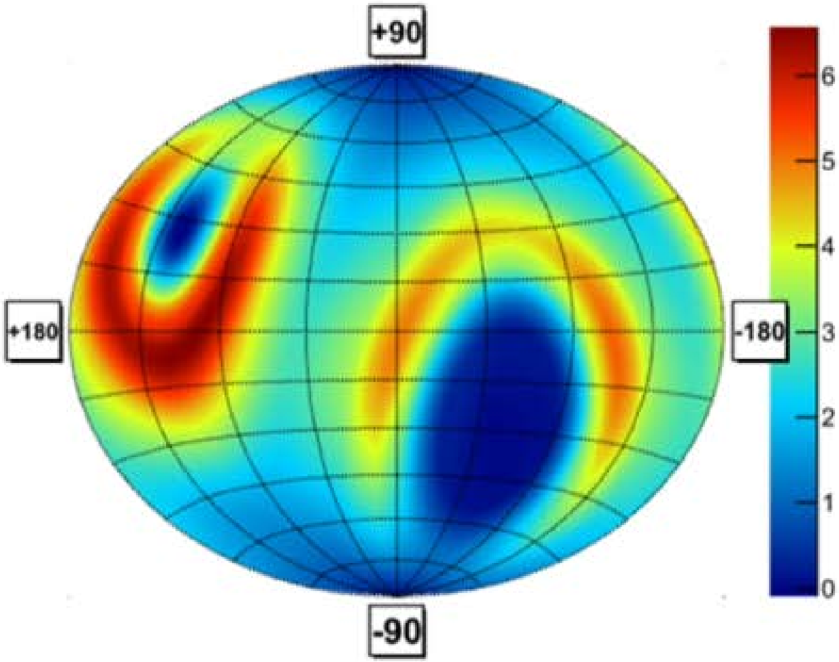
$$C_\ell = \frac{1}{2\ell+1} \sum_{m=-\ell}^{\ell} |a_{\ell m}|^2. \qquad \delta = 3\sqrt{C_1/4\pi}$$

Electron Anisotropy

Measured Distribution

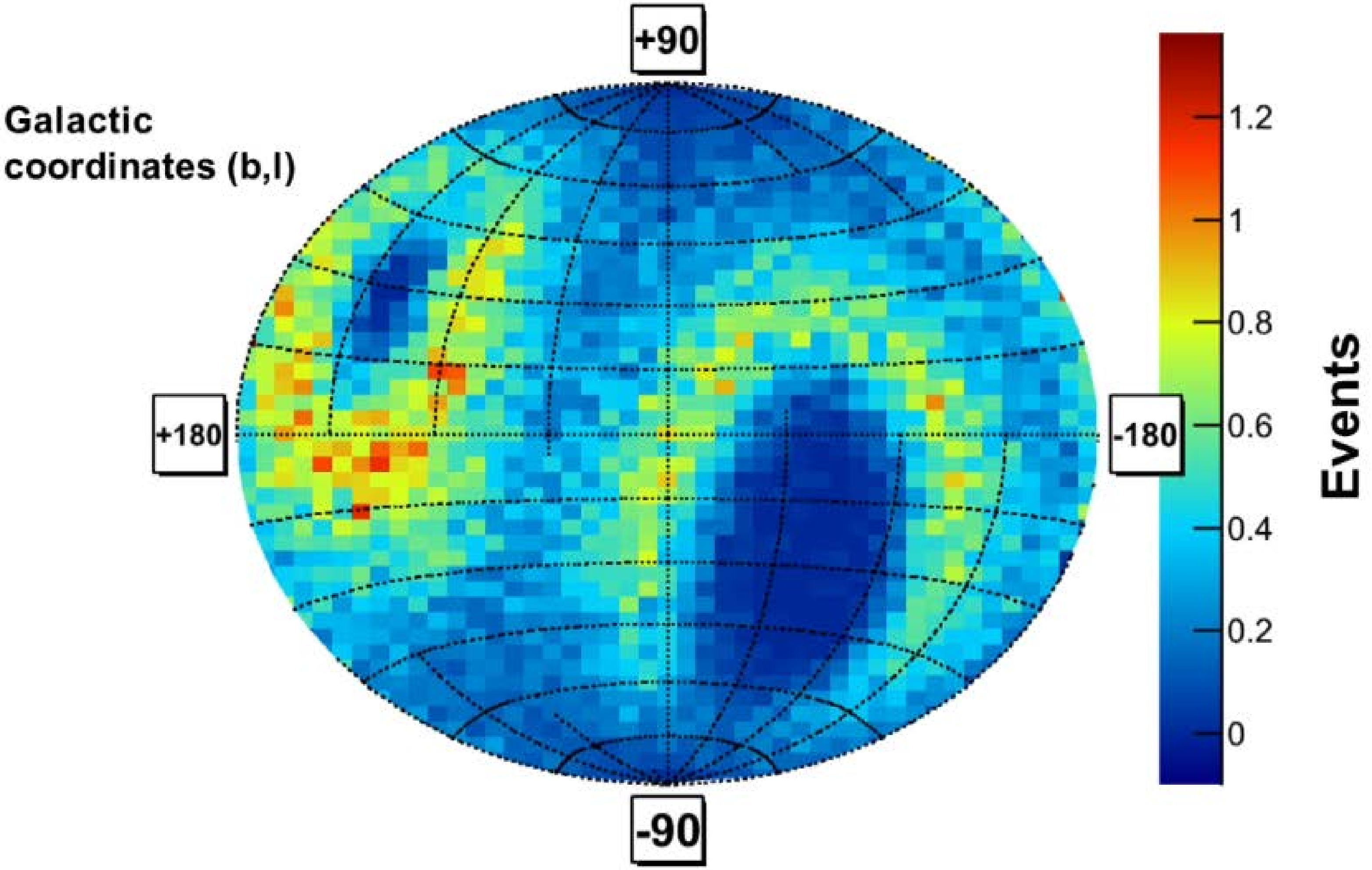


Expected Isotropic Distribution



The incoming direction of electrons above 16 GeV in galactic coordinates yields **δ ≤ 0.01 at the 95% confidence level**

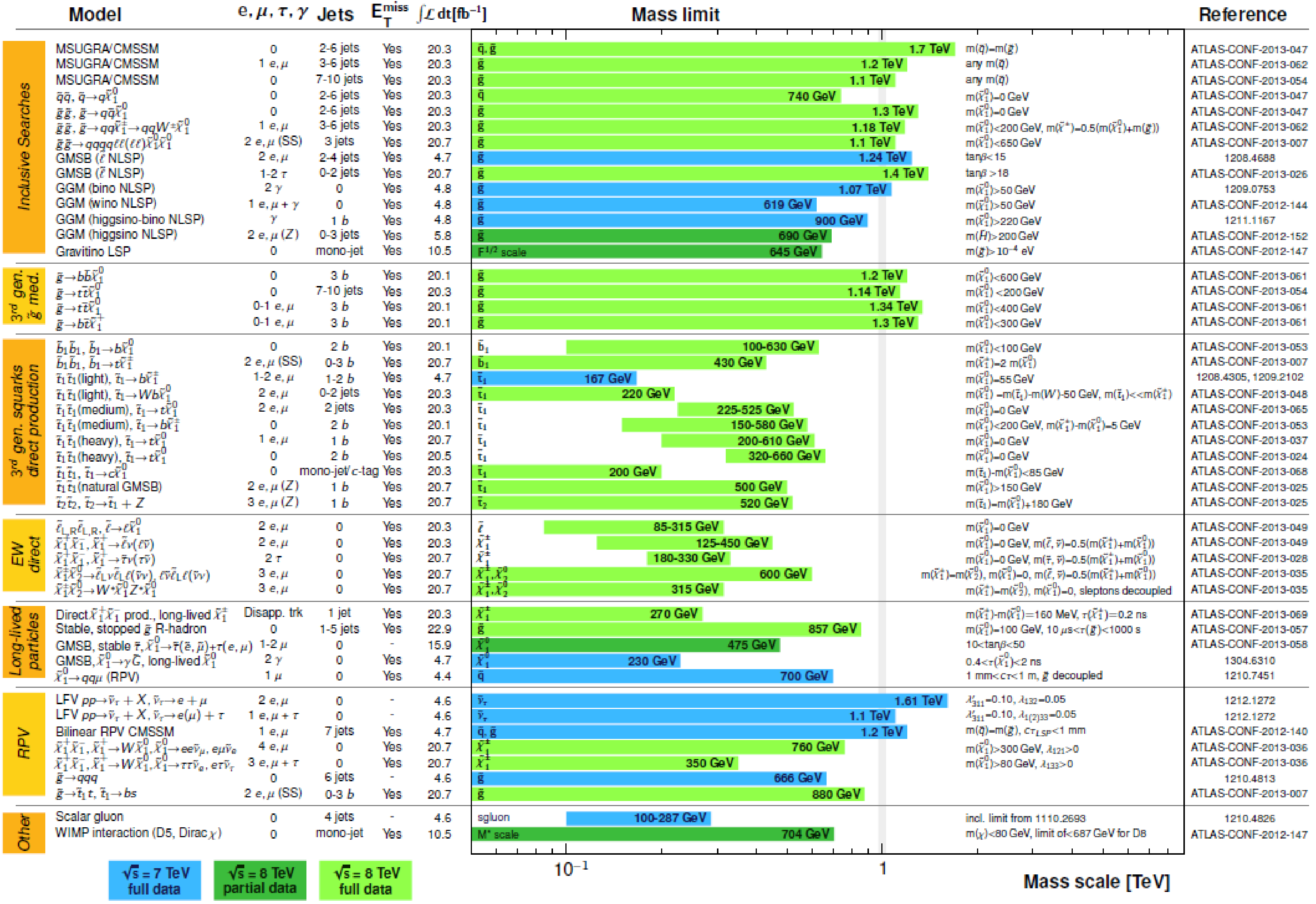
Positron Anisotropy



The incoming direction of positrons above 16 GeV in galactic coordinates yields **δ ≤ 0.03 at the 95% confidence level**

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: EPS 2013



	Model	e,μ,τ,γ	Jets	E_T^{miss}	$\int\mathcal{L}\,dt[fb^{-1}]$	Mass limit			Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q},\tilde{g}$	1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-054
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$	740 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}_1^{\pm}\to qqW^{\pm}\tilde{\chi}_1^0$	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.18 TeV	$m(\tilde{\chi}_1^0)<200$ GeV, $m(\tilde{\chi}^{\pm})=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}\to qqqq\ell\ell(\ell\ell)\tilde{\chi}_1^0\tilde{\chi}_1^0$	2 e,μ (SS)	3 jets	Yes	20.7	$\tilde{g}$	1.1 TeV	$m(\tilde{\chi}_1^0)<650$ GeV	ATLAS-CONF-2013-007
	GMSB ($\tilde{\ell}$ NLSP)	2 e,μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	$\tan\beta<15$	1208.4688
	GMSB ($\tilde{\tau}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$	1.4 TeV	$\tan\beta>18$	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	0	Yes	4.8	$\tilde{g}$	1.07 TeV	$m(\tilde{\chi}_1^0)>50$ GeV	1209.0753
	GGM (wino NLSP)	1 $e,\mu+\gamma$	0	Yes	4.8	$\tilde{g}$	619 GeV	$m(\tilde{\chi}_1^0)>50$ GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0)>220$ GeV	1211.1167
	GGM (higgsino NLSP)	2 e,μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$	690 GeV	$m(\tilde{H})>200$ GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale	645 GeV	$m(\tilde{g})>10^{-4}$ eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$	1.2 TeV	$m(\tilde{\chi}_1^0)<600$ GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.14 TeV	$m(\tilde{\chi}_1^0)<200$ GeV	ATLAS-CONF-2013-054
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.34 TeV	$m(\tilde{\chi}_1^0)<400$ GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)<300$ GeV	ATLAS-CONF-2013-061
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$	100-630 GeV	$m(\tilde{\chi}_1^0)<100$ GeV	ATLAS-CONF-2013-053
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}_1^{\pm}$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$	430 GeV	$m(\tilde{\chi}_1^{\pm})=2\ m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^{\pm}$	1-2 e,μ	1-2 b	Yes	4.7	$\tilde{t}_1$	167 GeV	$m(\tilde{\chi}_1^0)=55$ GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e,μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	220 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{t}_1)$-$m(W)$-50 GeV, $m(\tilde{t}_1)<<m(\tilde{\chi}_1^{\pm})$	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}_1^0$	2 e,μ	2 jets	Yes	20.3	$\tilde{t}_1$	225-525 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-065
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^{\pm}$	0	2 b	Yes	20.1	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)<200$ GeV, $m(\tilde{\chi}_1^{\pm})$-$m(\tilde{\chi}_1^0)=5$ GeV	ATLAS-CONF-2013-053
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e,μ	1 b	Yes	20.7	$\tilde{t}_1$	200-610 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$	320-660 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	200 GeV	$m(\tilde{t}_1)$-$m(\tilde{\chi}_1^0)<85$ GeV	ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e,μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$	500 GeV	$m(\tilde{\chi}_1^0)>150$ GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$	520 GeV	$m(\tilde{t}_1)=m(\tilde{\chi}_1^0)+180$ GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$	85-315 GeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	$\tilde{\chi}_1^{\pm}$	125-450 GeV	$m(\tilde{\chi}_1^0)=0$ GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	0	Yes	20.7	$\tilde{\chi}_1^{\pm}$	180-330 GeV	$m(\tilde{\chi}_1^0)=0$ GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.7	$\tilde{\chi}_1^{\pm},\tilde{\chi}_2^0$	600 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)=0$, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to W^*\tilde{\chi}_1^0Z^*\tilde{\chi}_1^0$	3 e,μ	0	Yes	20.7	$\tilde{\chi}_1^{\pm},\tilde{\chi}_2^0$	315 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)=0$, sleptons decoupled	ATLAS-CONF-2013-035
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^{\pm}$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^{\pm}$	270 GeV	$m(\tilde{\chi}_1^{\pm})$-$m(\tilde{\chi}_1^0)=160$ MeV, $\tau(\tilde{\chi}_1^{\pm})=0.2$ ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$	857 GeV	$m(\tilde{\chi}_1^0)=100$ GeV, 10 μs$<\tau(\tilde{g})<1000$ s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	0	-	15.9	$\tilde{\chi}_1^0$	475 GeV	$10<\tan\beta<50$	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	0	Yes	4.7	$\tilde{\chi}_1^0$	230 GeV	$0.4<\tau(\tilde{\chi}_1^0)<2$ ns	1304.6310
	$\tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ	0	Yes	4.4	$\tilde{q}$	700 GeV	1 mm$<c\tau<$1 m, $\tilde{g}$ decoupled	1210.7451
RPV	LFV $pp\to\tilde{\nu}_\tau+X$, $\tilde{\nu}_\tau\to e+\mu$	2 e,μ	0	-	4.6	$\tilde{\nu}_\tau$	1.61 TeV	$\lambda'_{311}=0.10$, $\lambda_{132}=0.05$	1212.1272
	LFV $pp\to\tilde{\nu}_\tau+X$, $\tilde{\nu}_\tau\to e(\mu)+\tau$	1 $e,\mu+\tau$	0	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	$\lambda'_{311}=0.10$, $\lambda_{1(2)33}=0.05$	1212.1272
	Bilinear RPV CMSSM	1 e,μ	7 jets	Yes	4.7	$\tilde{q},\tilde{g}$	1.2 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}<1$ mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to ee\tilde{\nu}_\mu$, $e\mu\tilde{\nu}_e$	4 e,μ	0	Yes	20.7	$\tilde{\chi}_1^{\pm}$	760 GeV	$m(\tilde{\chi}_1^0)>300$ GeV, $\lambda_{121}>0$	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e$, $e\tau\tilde{\nu}_\tau$	3 $e,\mu+\tau$	0	Yes	20.7	$\tilde{\chi}_1^{\pm}$	350 GeV	$m(\tilde{\chi}_1^0)>80$ GeV, $\lambda_{133}>0$	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6 jets	-	4.6	$\tilde{g}$	666 GeV		1210.4813
	$\tilde{g}\to\tilde{t}_1t$, $\tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$	880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon	0	4 jets	-	4.6	sgluon	100-287 GeV	incl. limit from 1110.2693	1210.4826
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale	704 GeV	$m(\chi)<80$ GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

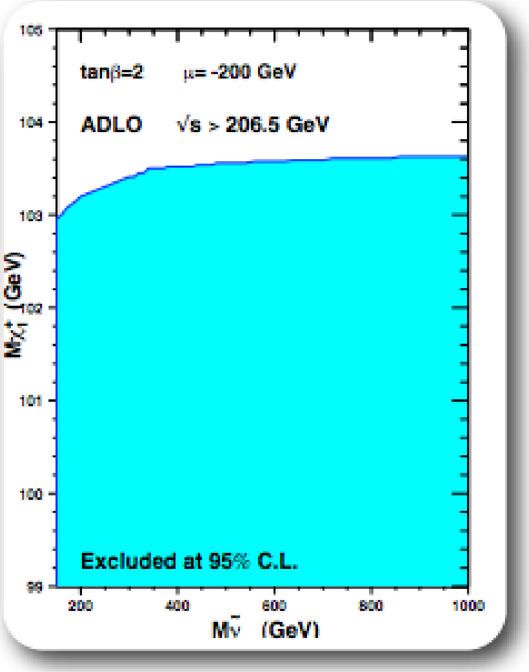
*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

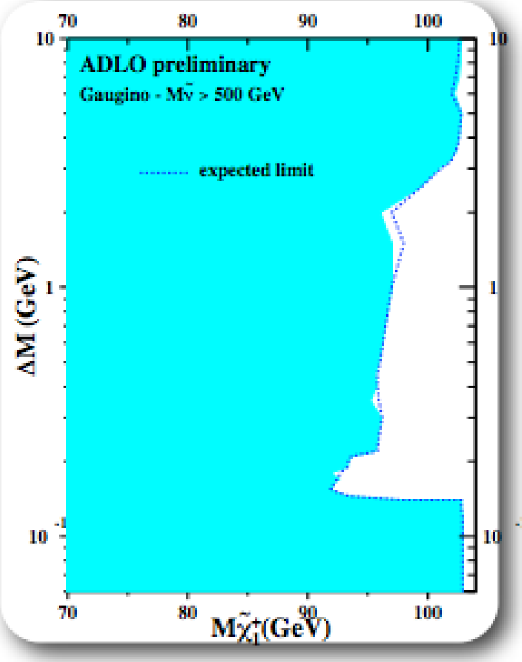
Current limits: neutralino/chargino ⑦

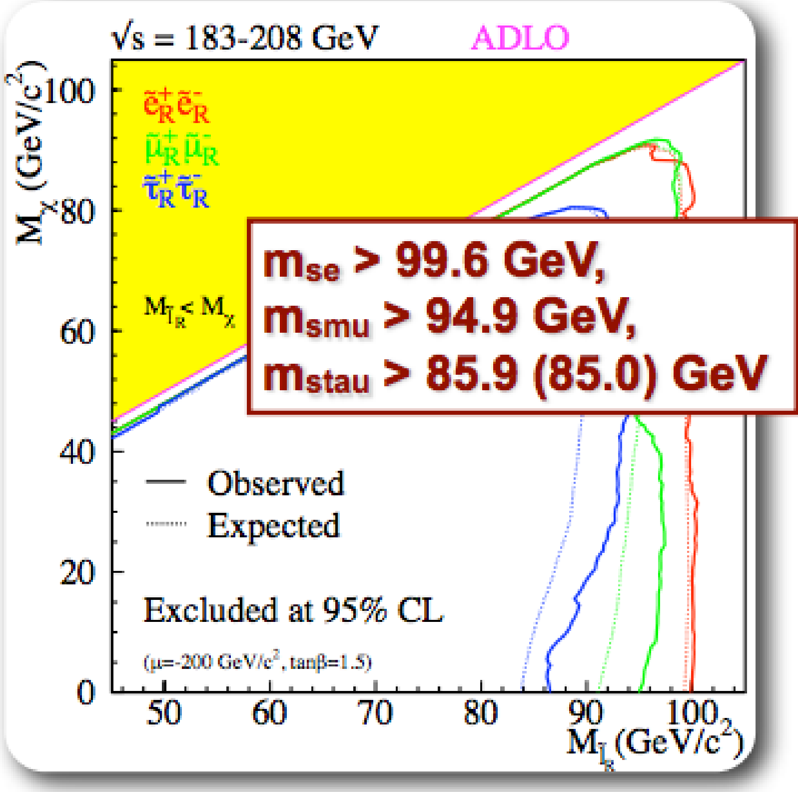
canonical case

degenerate case

$m\chi_1^0 > 47/50$ GeV
(CMSSM, mSUGRA)
No mass limit in general







$m_{se} > 99.6$ GeV,
$m_{smu} > 94.9$ GeV,
$m_{stau} > 85.9$ (85.0) GeV

$m\chi_1^\pm > 103.5$ GeV
for $m_{snue} > 300$ GeV

LEPSUSYWG/01-03.1

$m\chi_1^\pm > 91.9$ /92.4 GeV

LEPSUSYWG/02-04.1

S. Su

LEPSUSYWG/04-01.1