



6th Roma International Conference on AstroParticle Physics

The AMS-02 detector on the ISS

Status and highlights, after the first 5 years on orbit

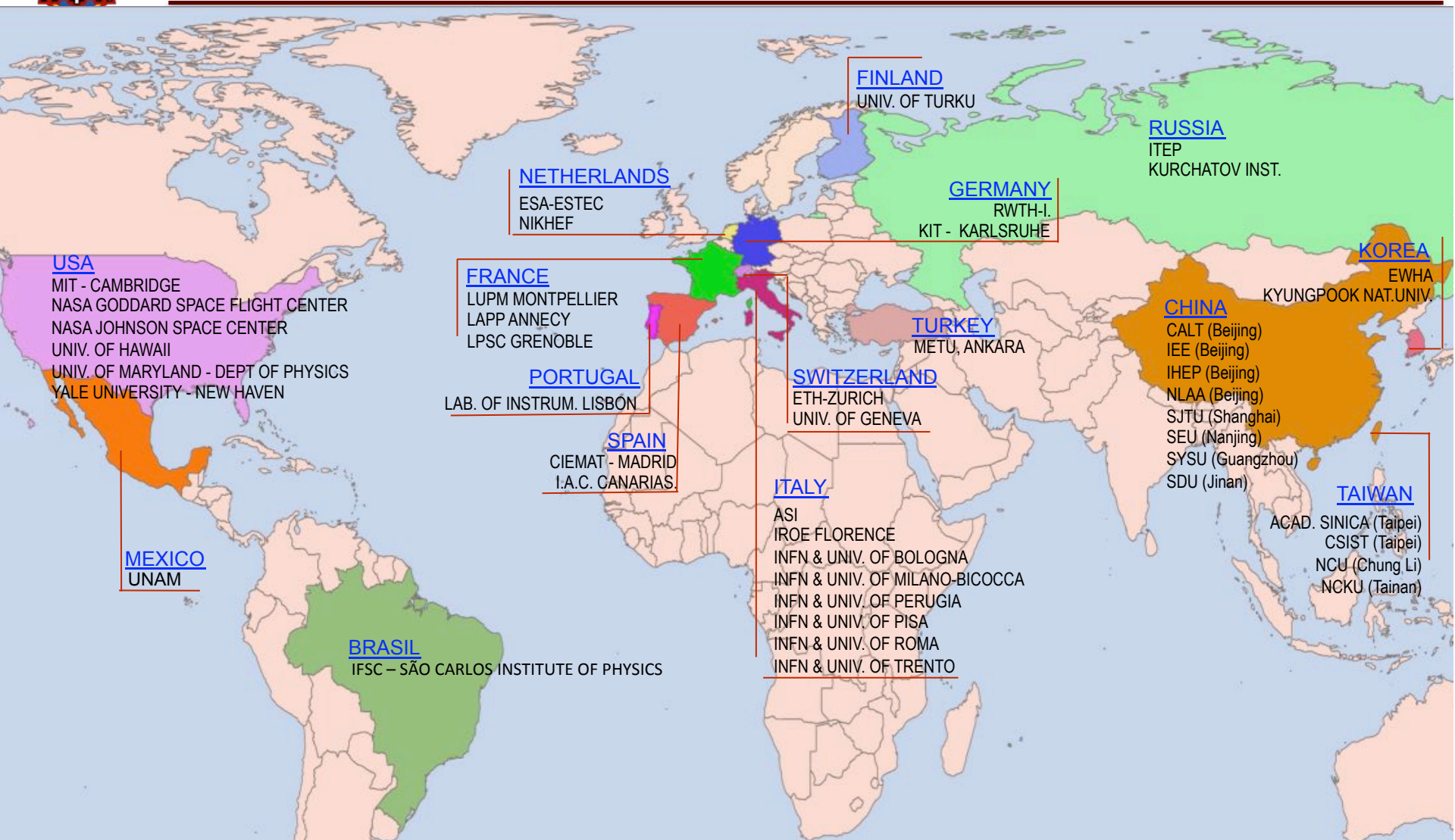


Matteo Duranti on behalf of the AMS collaboration
Università degli Studi and INFN Sez. Perugia





The International Collaboration





Objectives

- Fundamental physics and antimatter:
 - primordial origin (signal: anti-nuclei)
 - “exotic” sources (signal: positrons, anti-p, anti-D, γ)

- Origin and composition of CRs
 - sources and acceleration: primaries (p, He, C, ...)
 - propagation in the ISM: secondaries (B/C, ...)

Dark Matter search

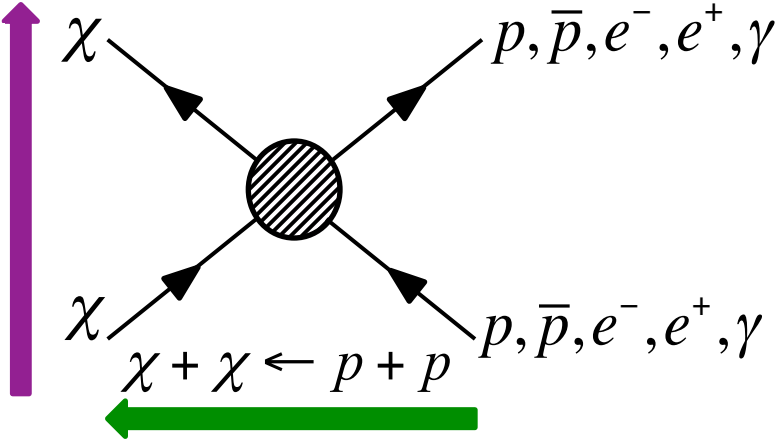
Annihilation

$$\chi + \chi \rightarrow p, \bar{p}, e^-, e^+, \gamma$$



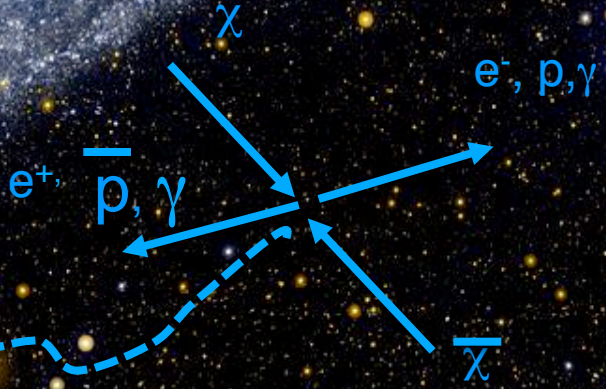
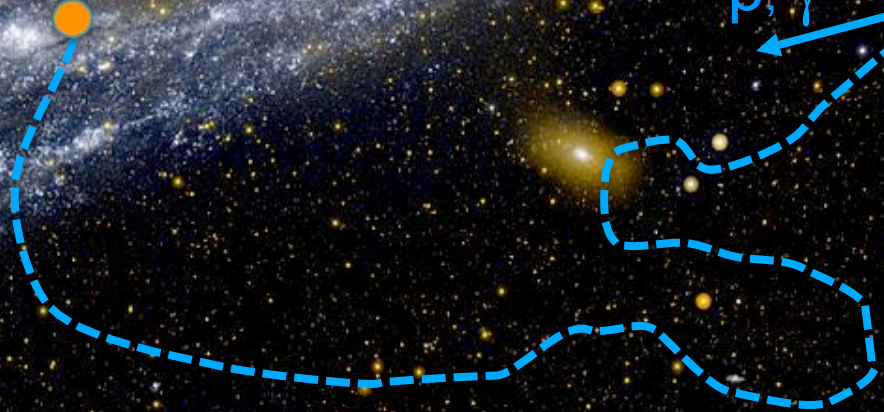
Scattering

$$\chi + p \rightarrow \chi + p$$

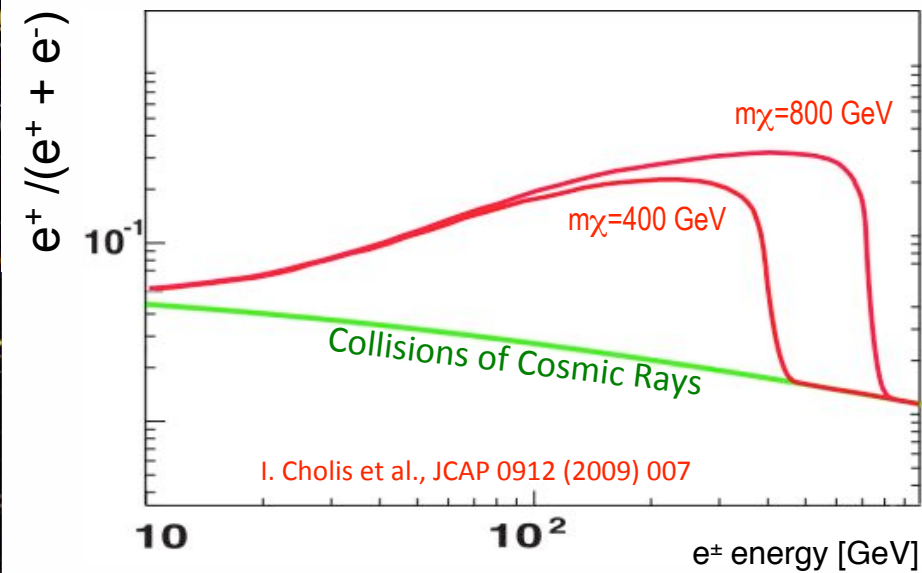


Production

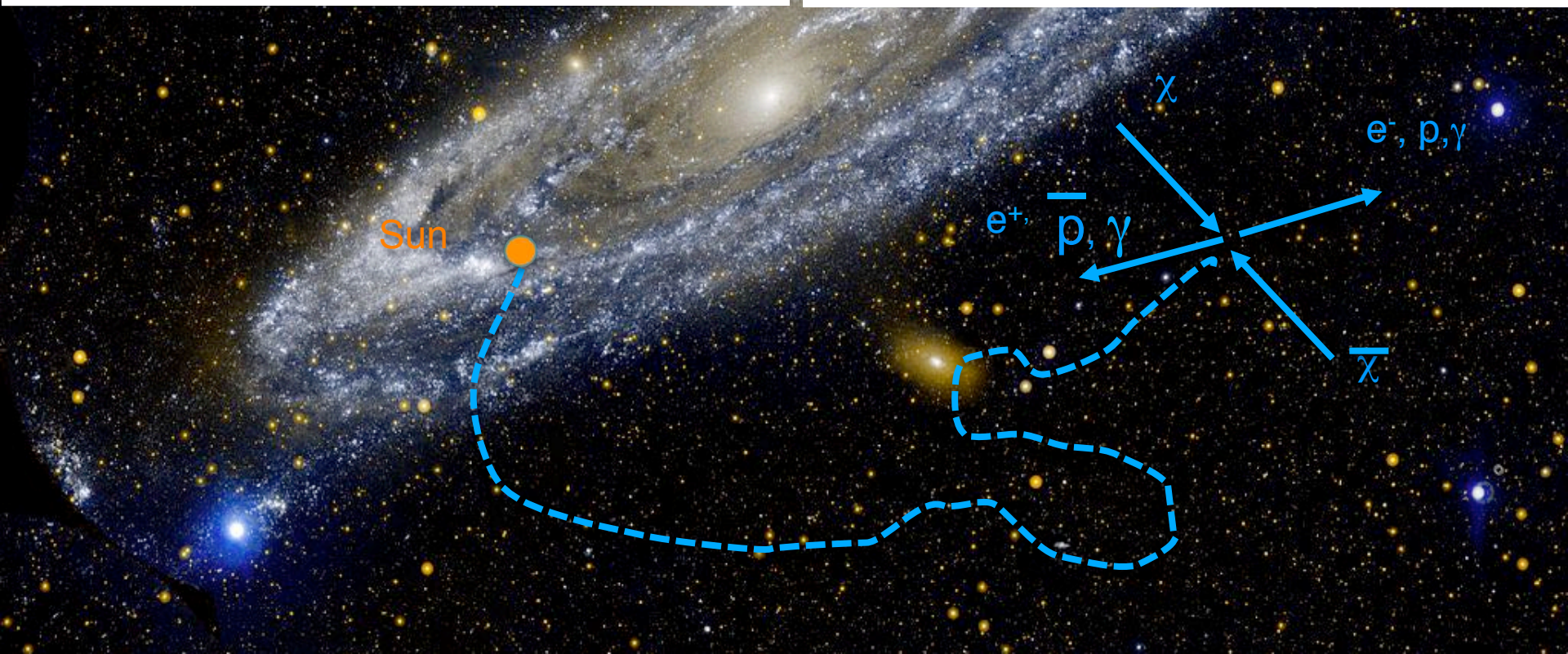
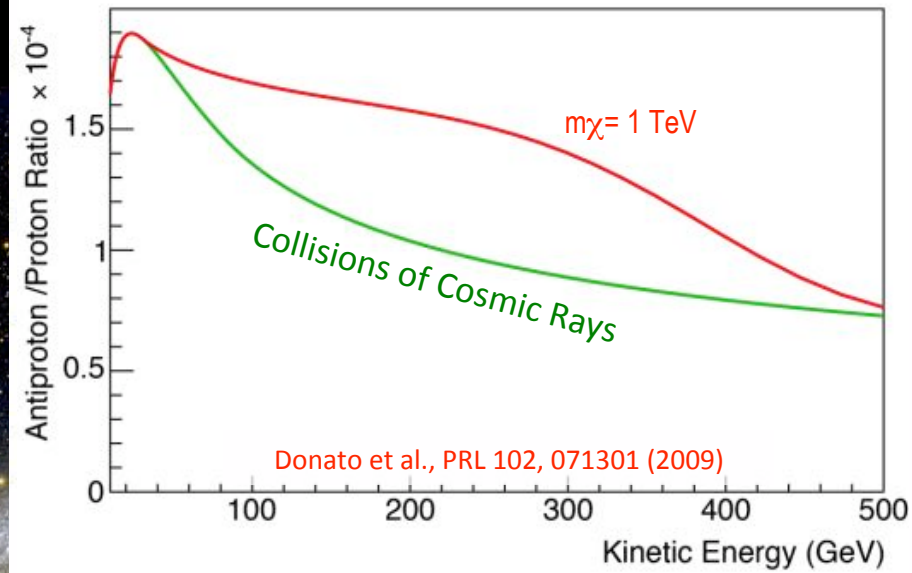
Sun

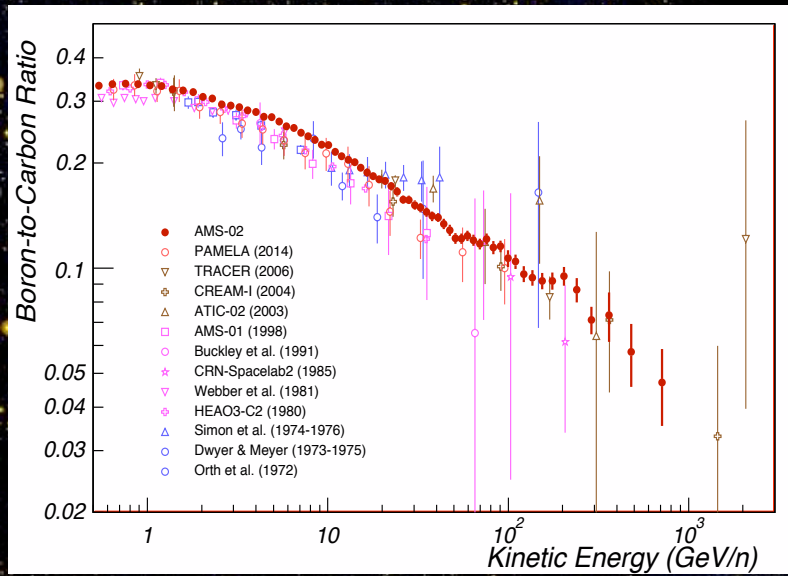


Positrons: $\chi + \chi \rightarrow e^+ + \dots$



Antiprotons: $\chi + \chi \rightarrow \bar{p} + \dots$



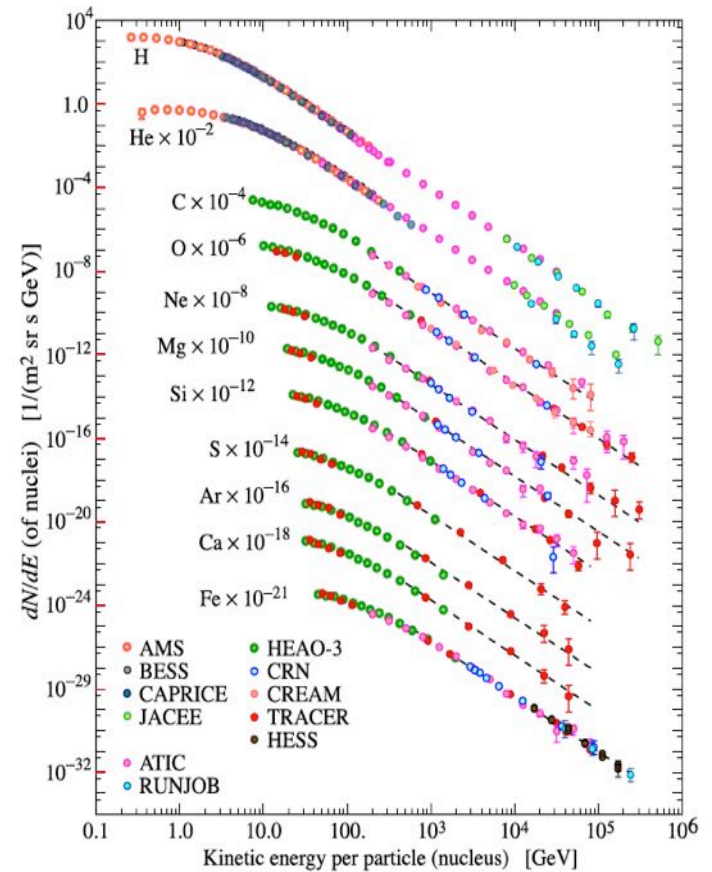


$p, He, C..., e^-$

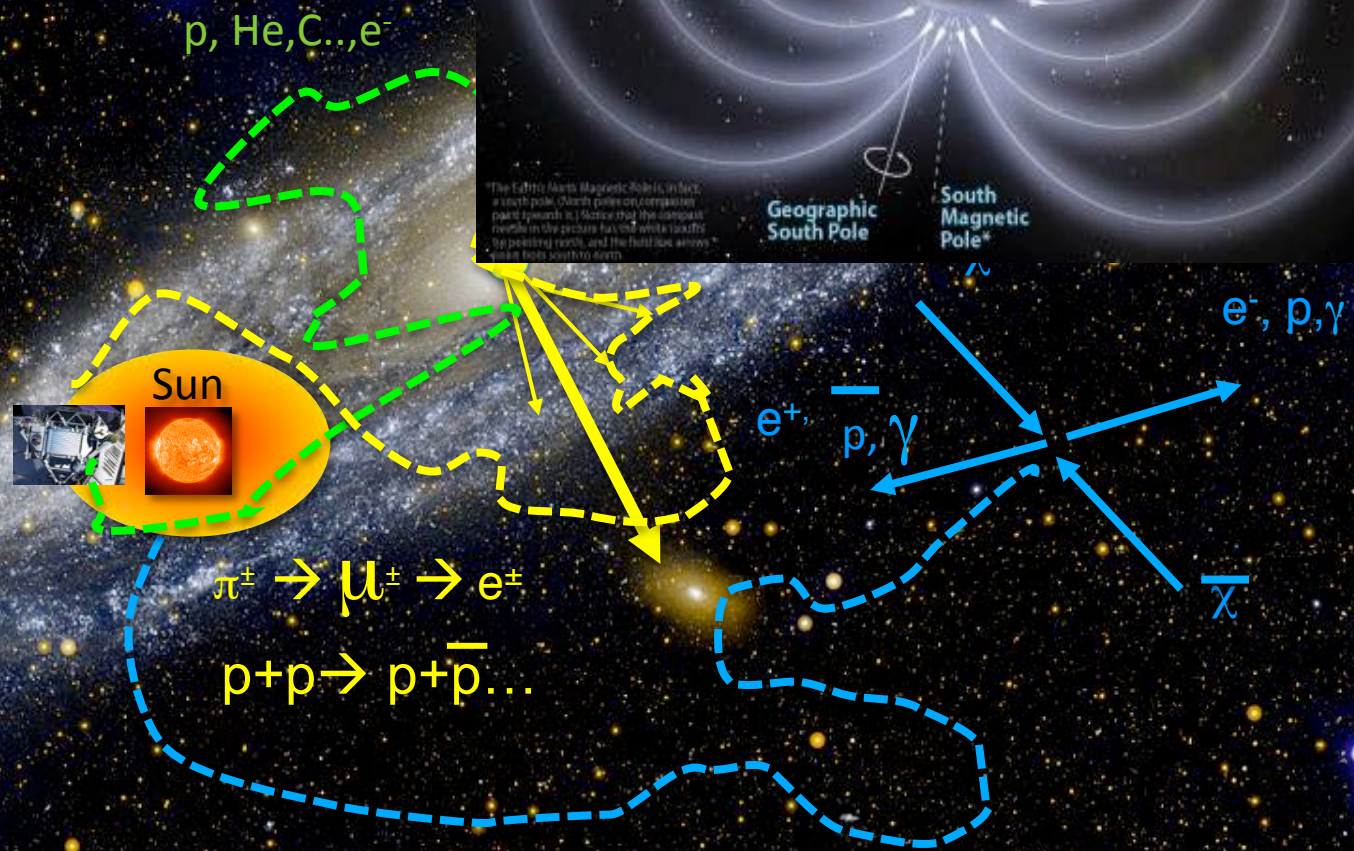
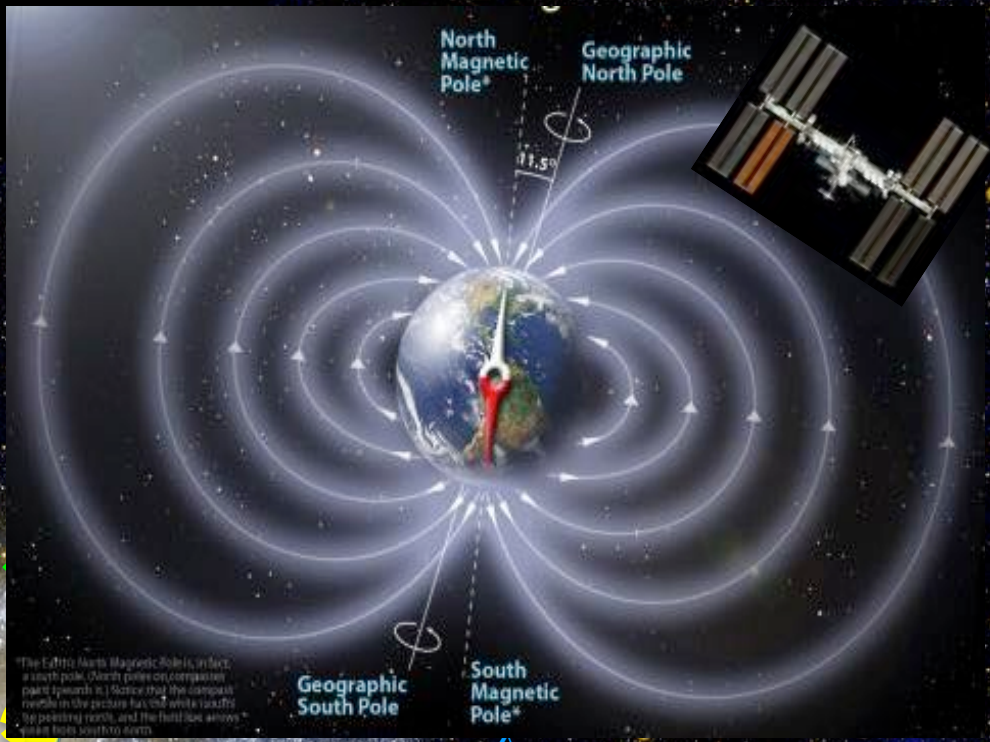
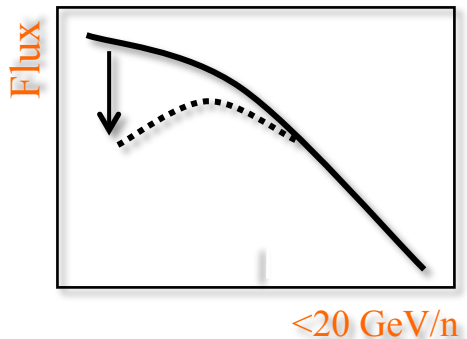
Sun

$\pi^\pm \rightarrow \mu^\pm \rightarrow e^\pm$

$p+p \rightarrow p+\bar{p}...$

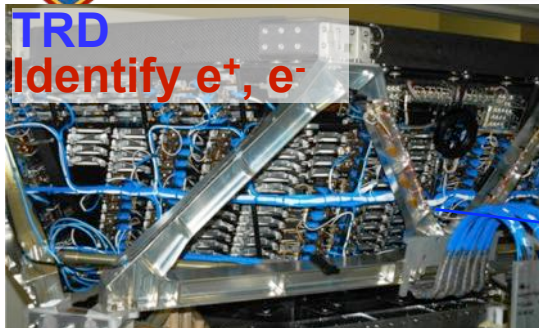


Solar modulation

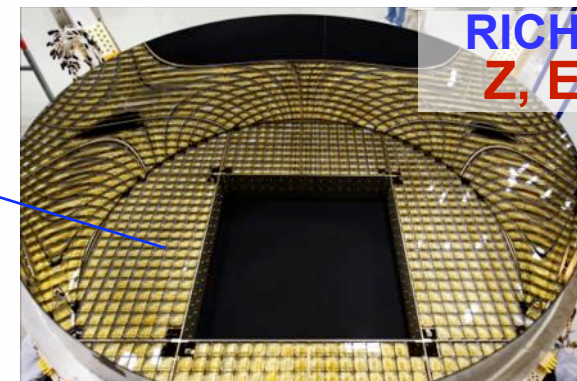
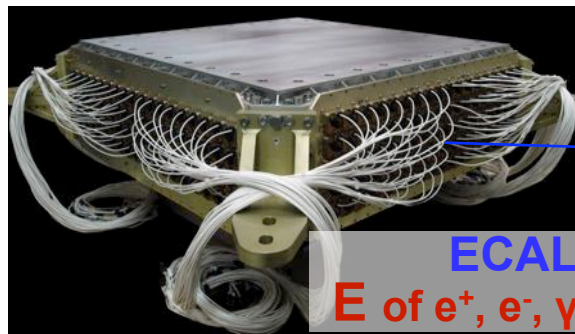
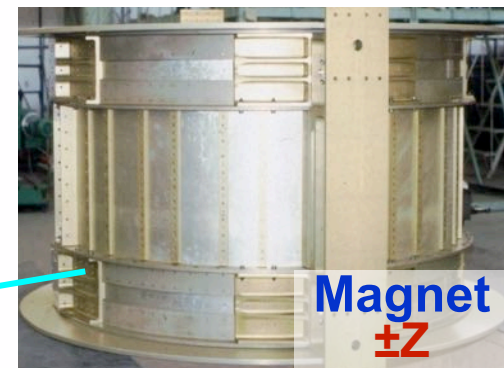
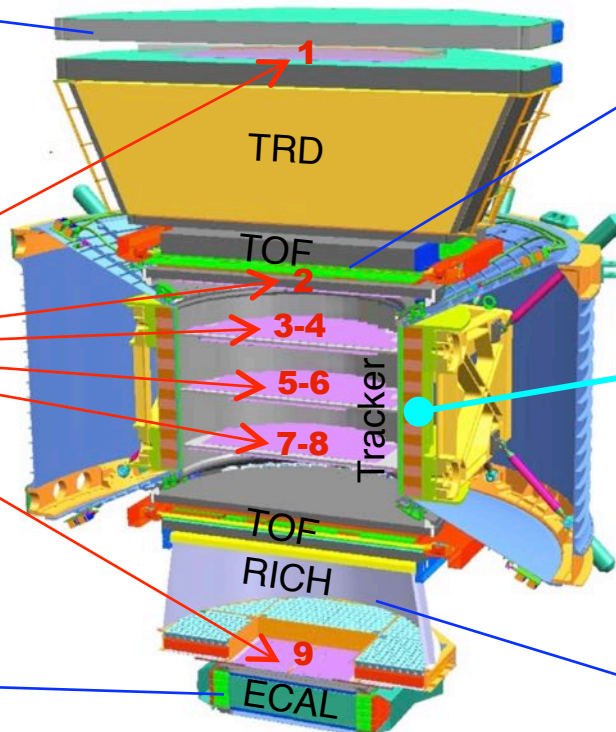




Alpha Magnetic Spectrometer – AMS-02



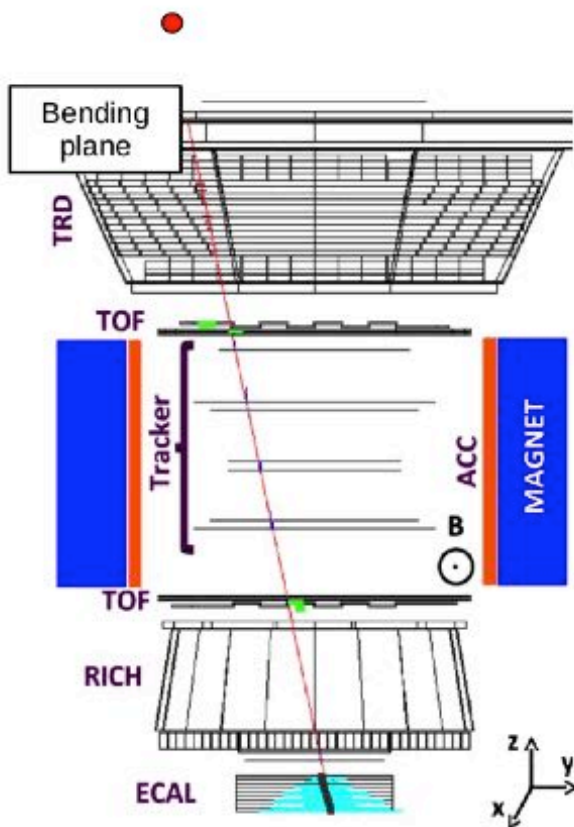
Z , P are measured independently by Tracker, RICH, TOF and ECAL





Single particle identification

Full coverage of **anti-matter** and **CR physics**

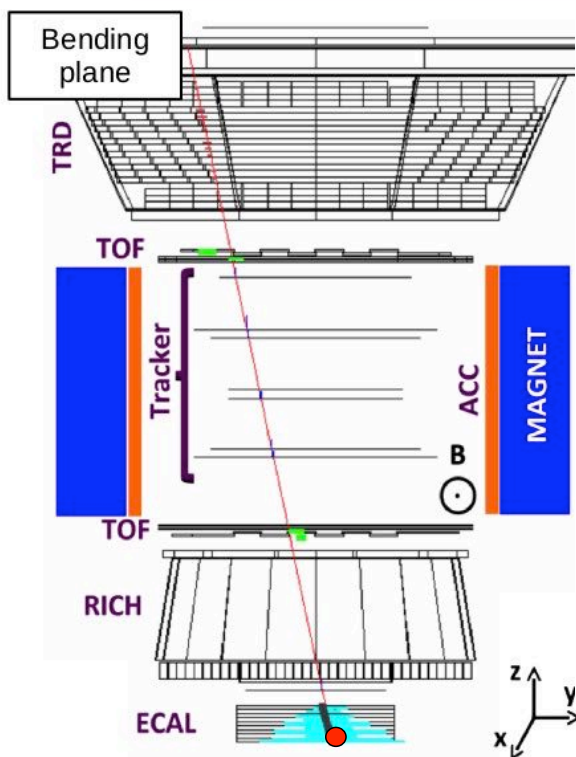


	e^-	p	He
TRD 20 layers	=====	=====	=====
TOF 4 layers	=====	=====	=====
TRK 9 layers	=====	=====	=====
RICH	=====	=====	=====
ECAL 20 layers	=====	=====	=====



Single particle identification

Full coverage of **anti-matter** and **CR physics**

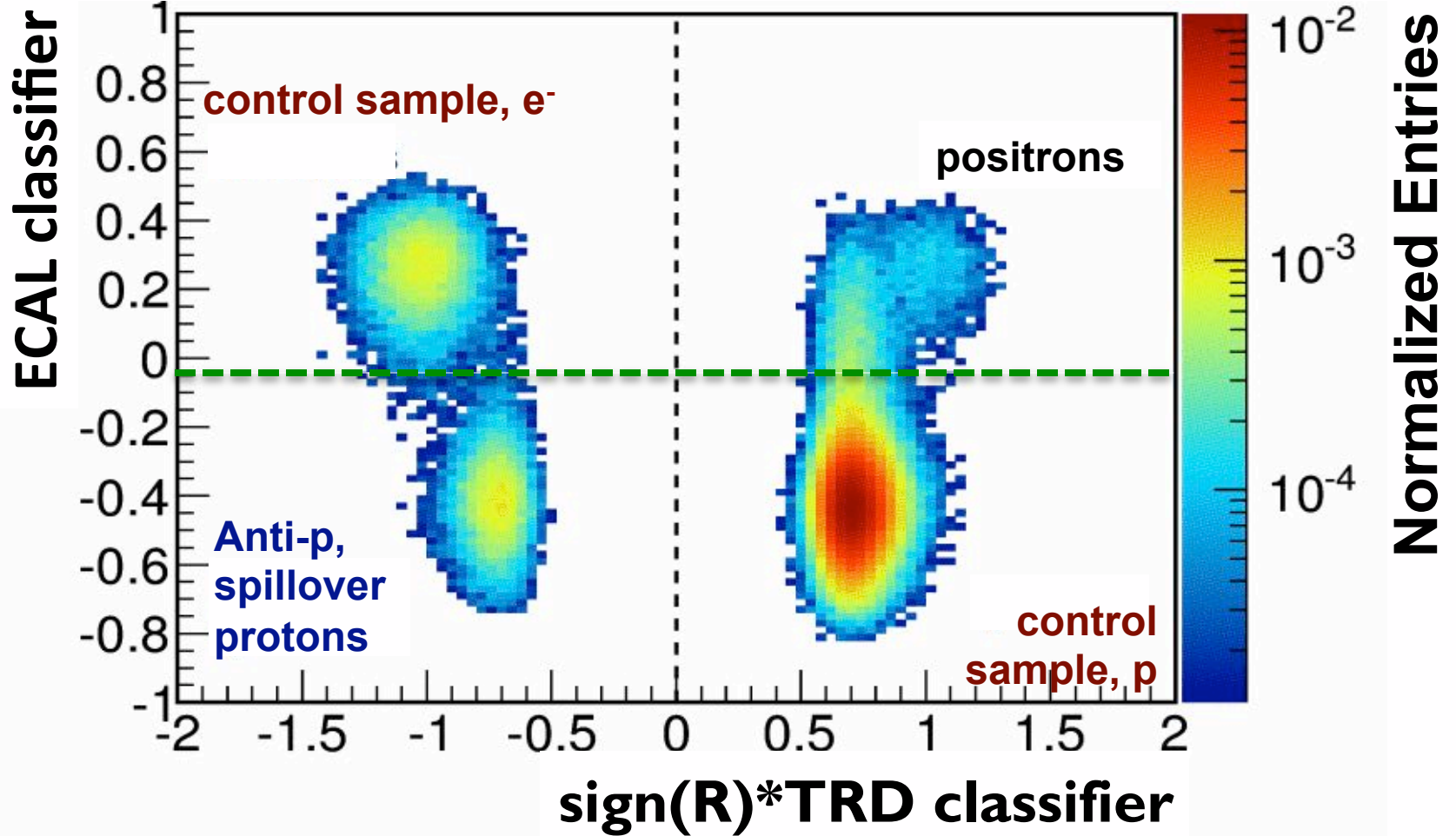


	e^-	p	He	
TRD 20 layers				e/p separation charge ($ Z $)
TOF 4 layers				trigger velocity (β) charge ($ Z $)
TRK 9 layers				momentum (p) sign ($\pm Q$) charge ($ Z $)
RICH				velocity (β) charge ($ Z $)
ECAL 20 layers				e^\pm energy e/h separation y trigger



Redundancy and complementarity

ISS Data: 73-140 GeV





AMS launch and data taking start

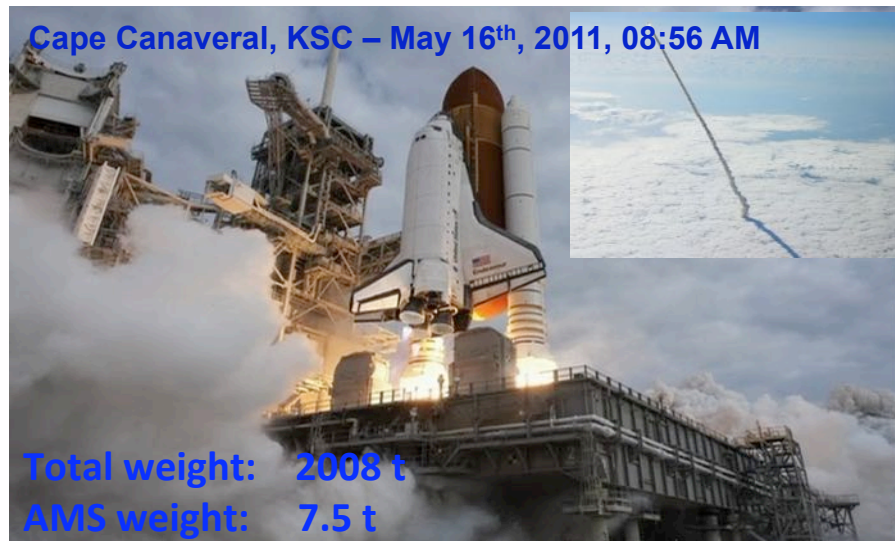


AMS in the Shuttle Endeavour (STS134) canister

© Michele Famiglietti / AMS Collaboration



Houston, JSC - May 16th, 2011 @ 07:56 AM



Cape Canaveral, KSC - May 16th, 2011, 08:56 AM

Total weight: 2008 t
AMS weight: 7.5 t

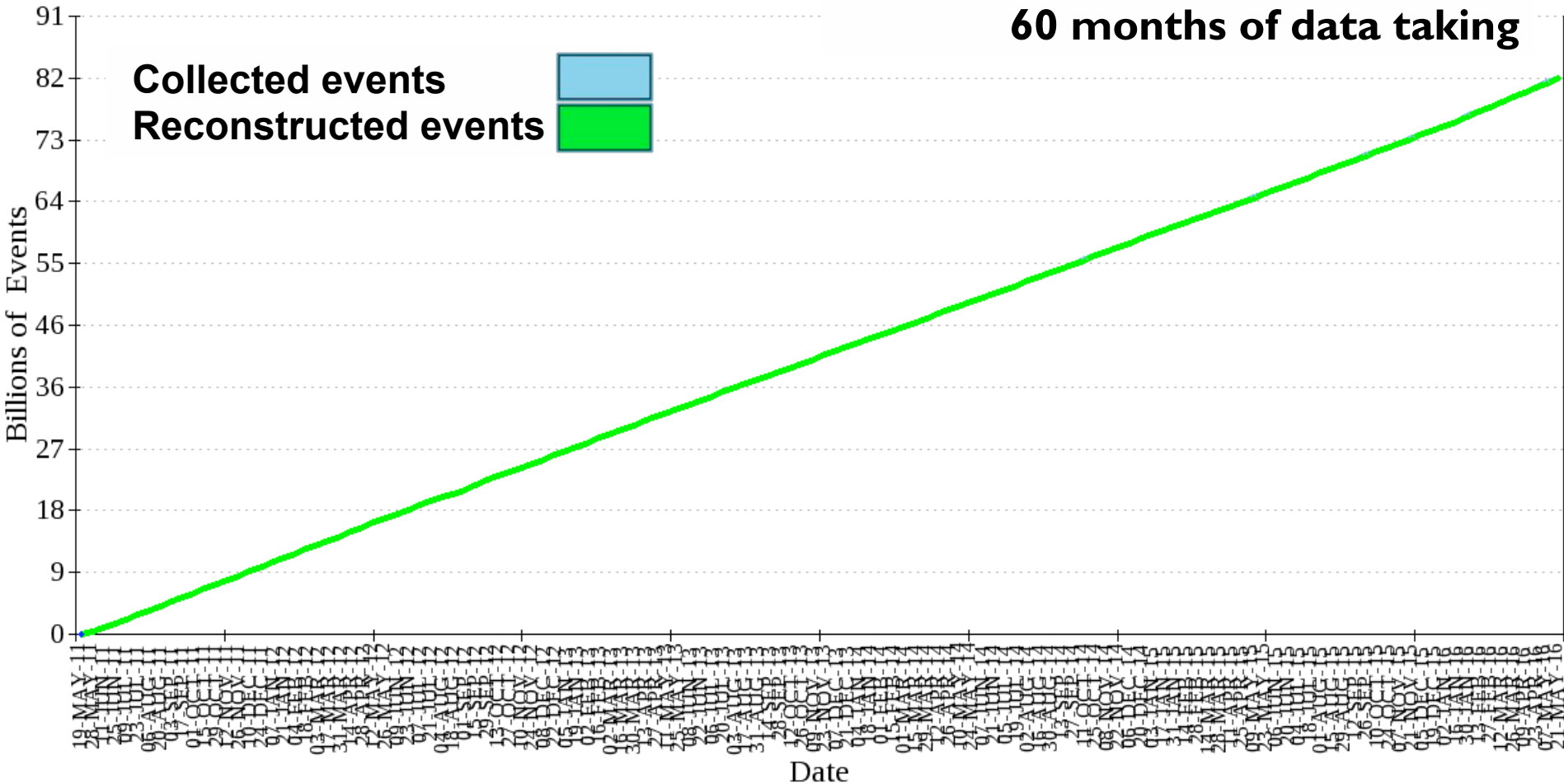


May 19th, 2011: AMS installation completed!
-> few days ago: 5 years in orbit!



The collected statistics

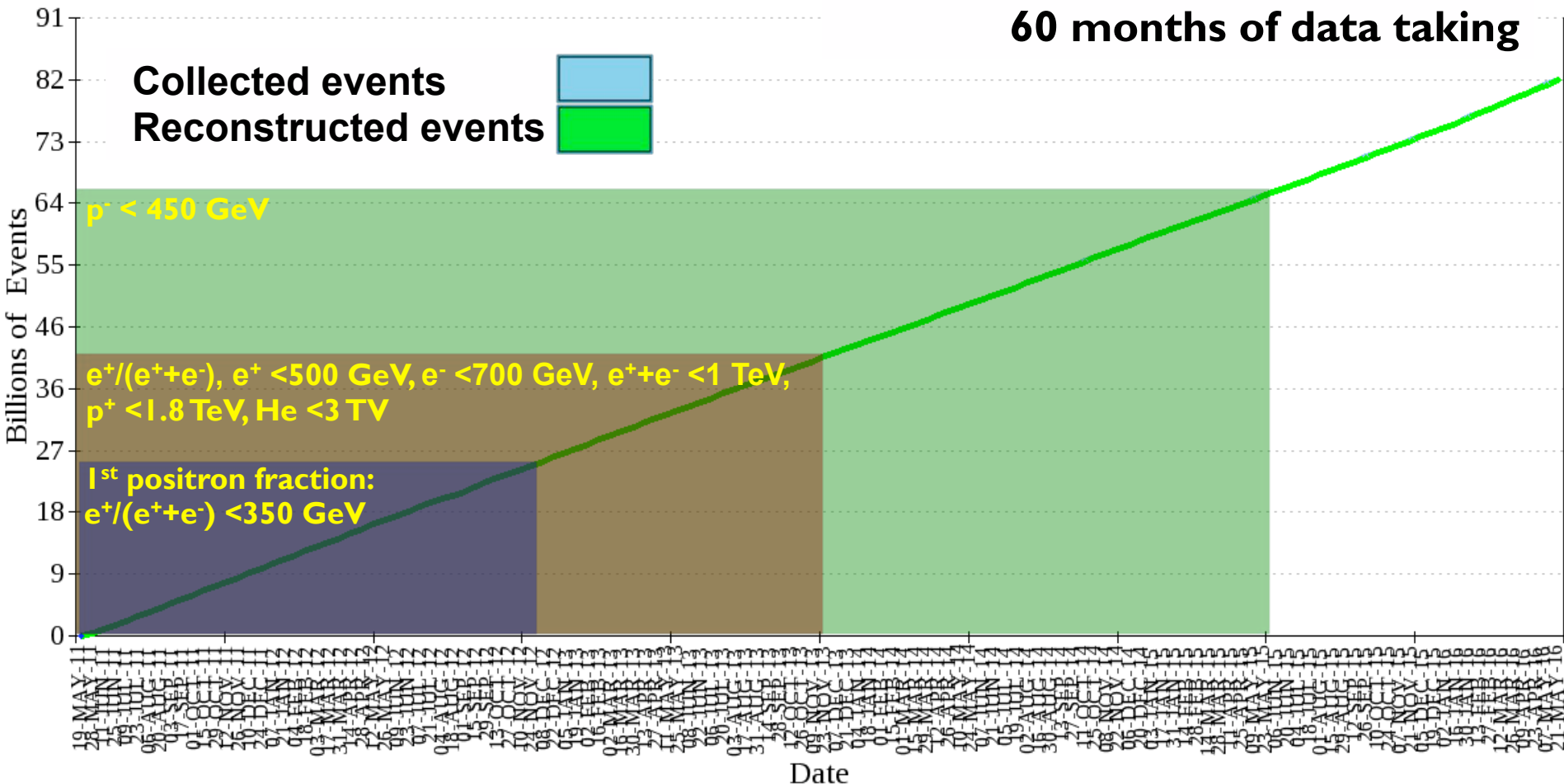
Today AMS collected ~ 82 billion of events



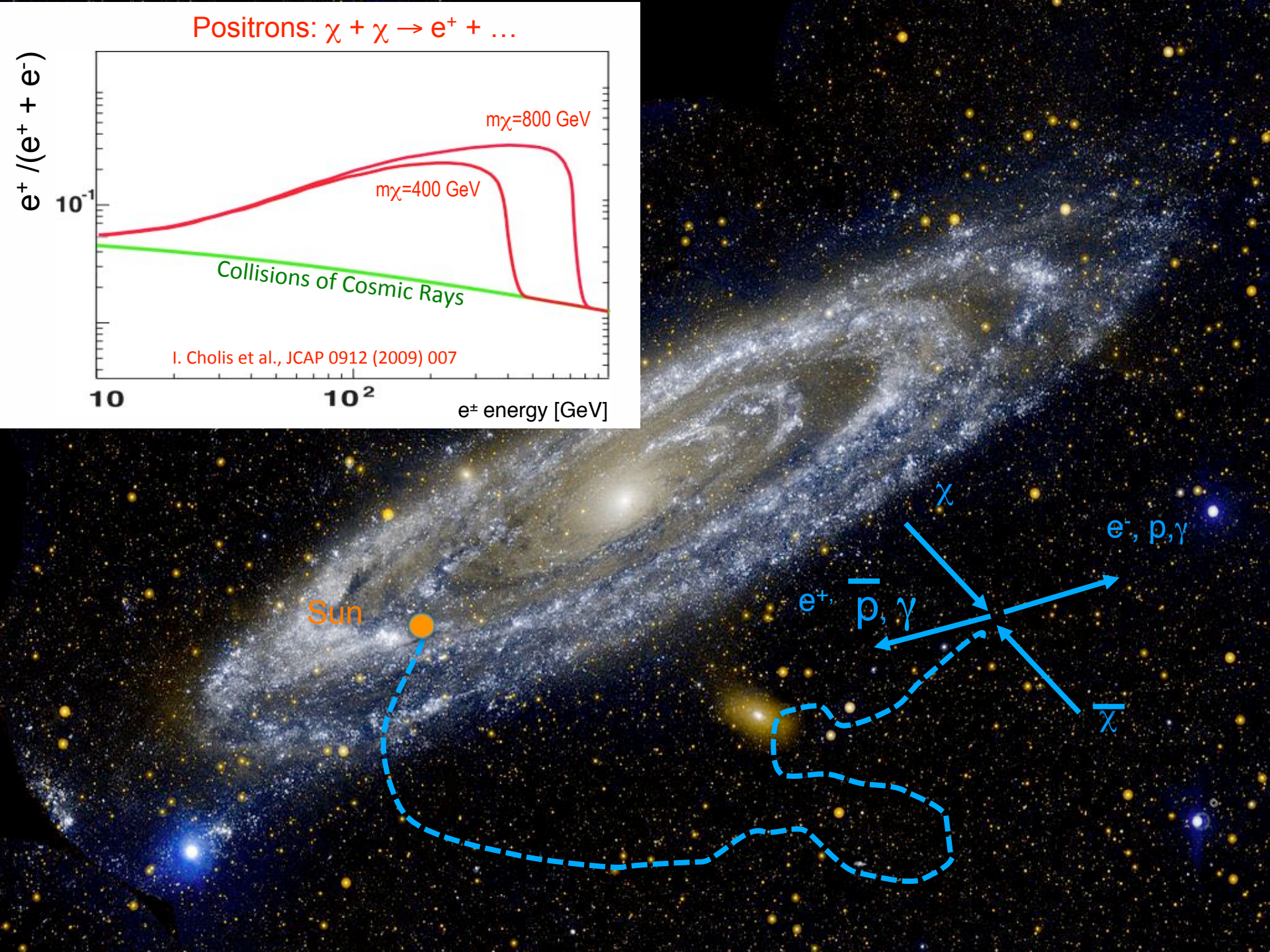
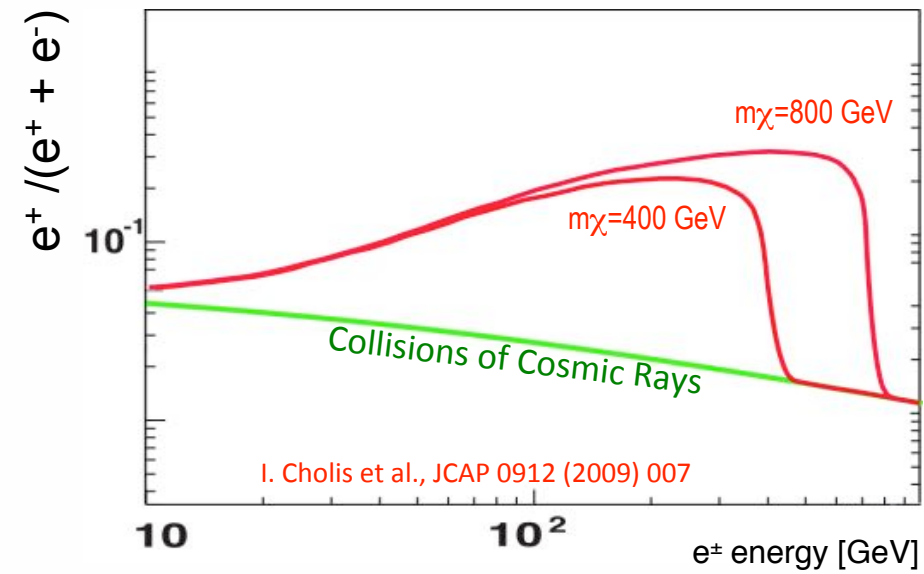


The collected statistics

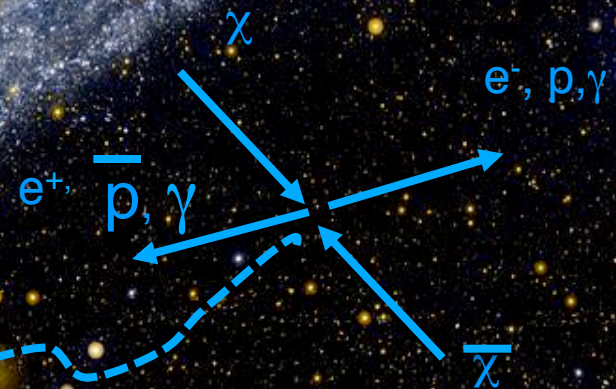
Today AMS collected ~ 82 billion of events



Positrons: $\chi + \chi \rightarrow e^+ + \dots$



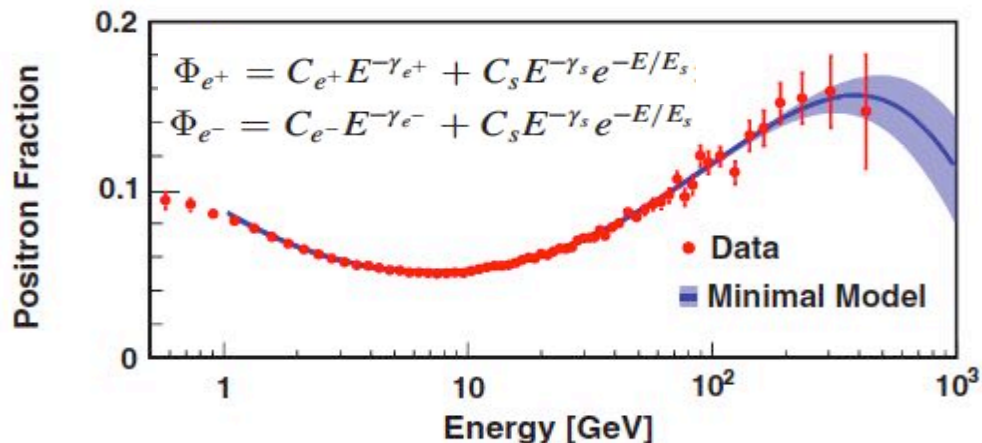
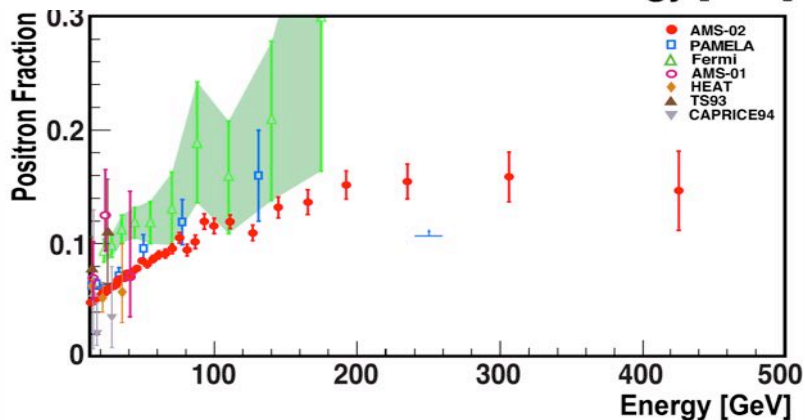
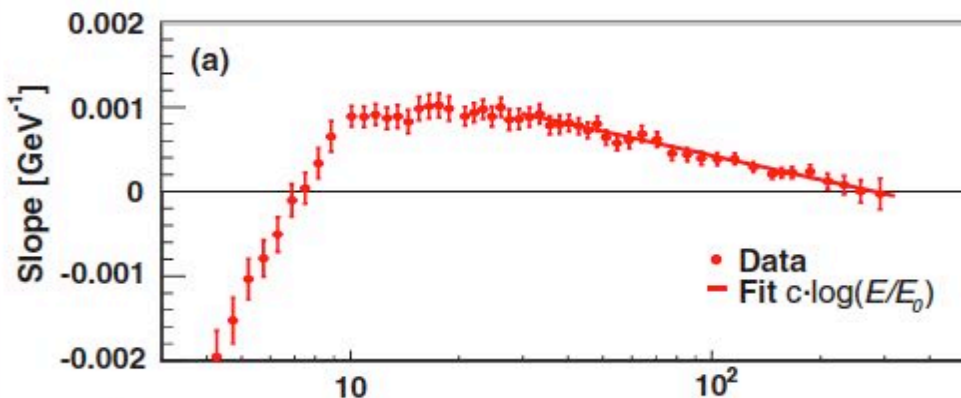
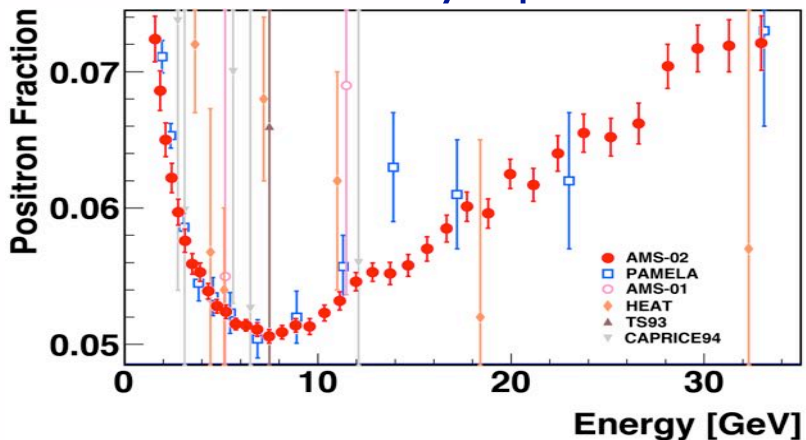
Sun





Positron fraction (PRL 110, 141102 - 2013 & 113, 121101 - 2014)

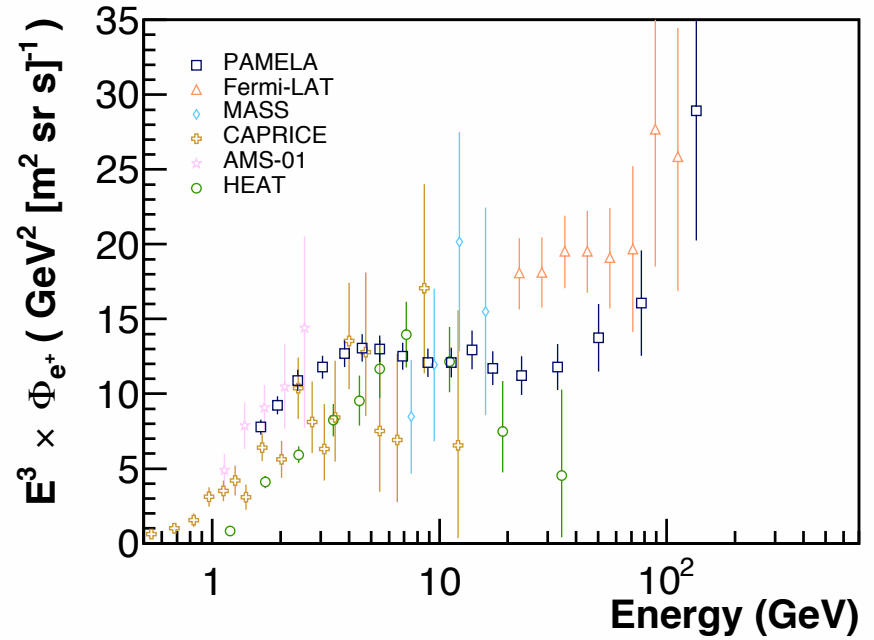
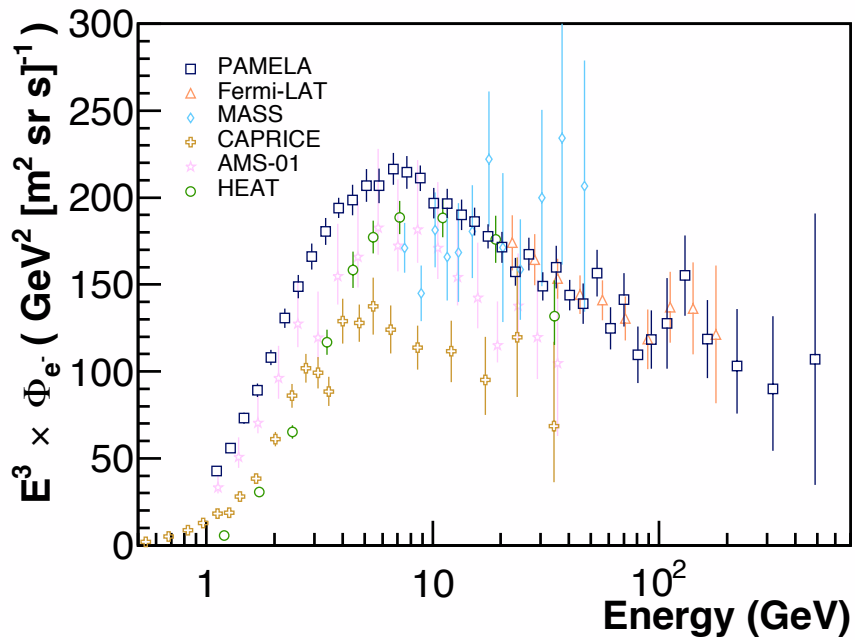
- ✓ No evidence of structures
- ✓ Steady increase up to ~ 275 GeV
- ✓ Well described by a power law + cut-off term, common for e^+/e^-



* more details were given in H.Gast talk

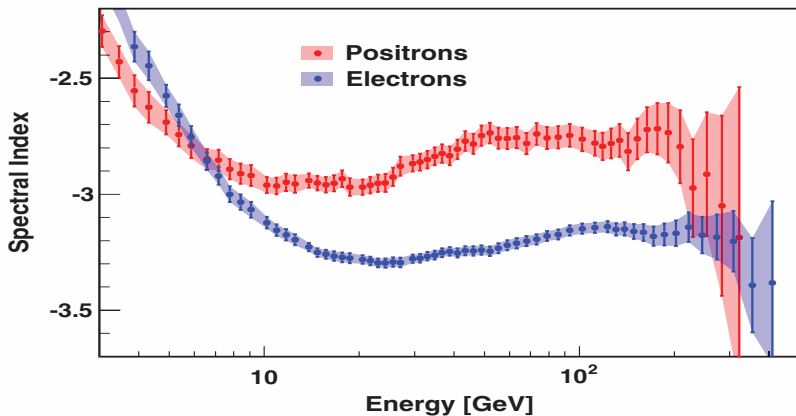
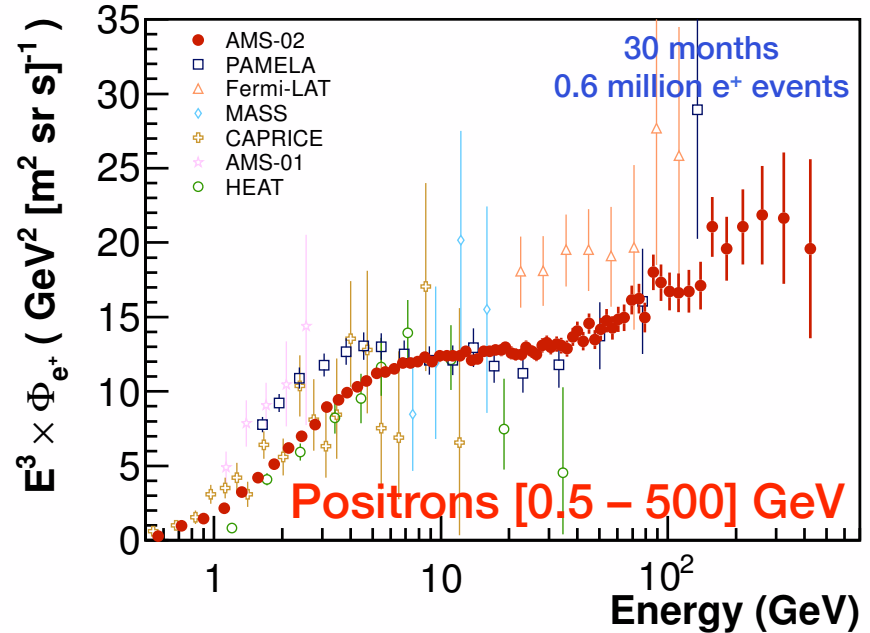
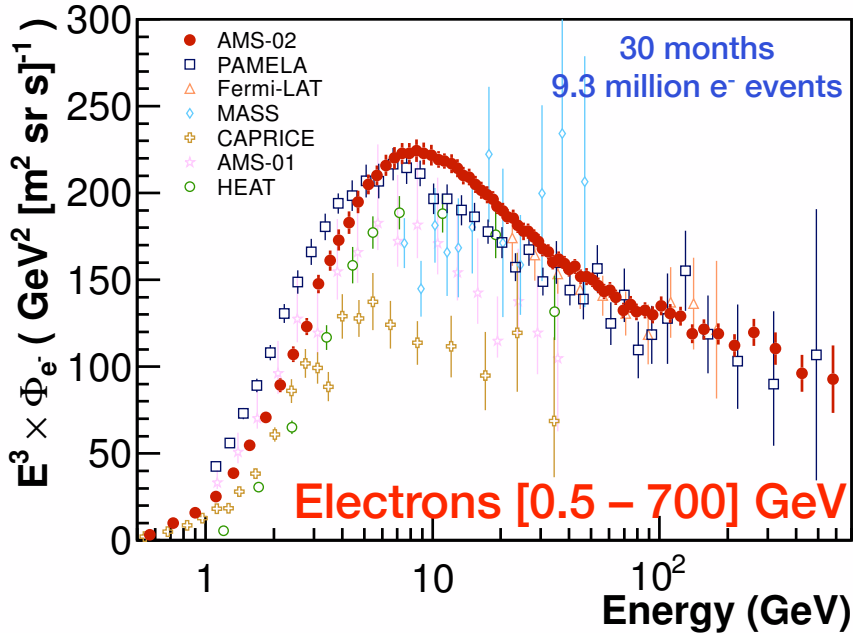


Positron and electron fluxes





Positron and electron fluxes (PRL 113, 121102 - 2014)



The two fluxes of e^+ and e^- are significantly different in absolute value and energy dependence

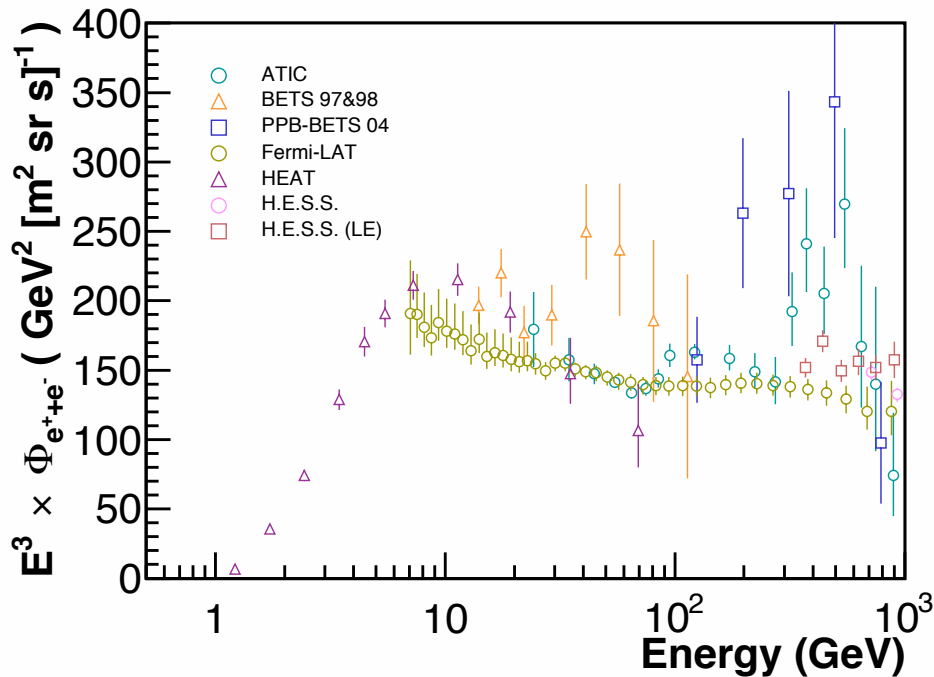
The positron “raise” is due to an **excess of positrons**, not to a lack of electrons

* more details were given in H.Gast talk



“All electrons” (electron+positron) flux

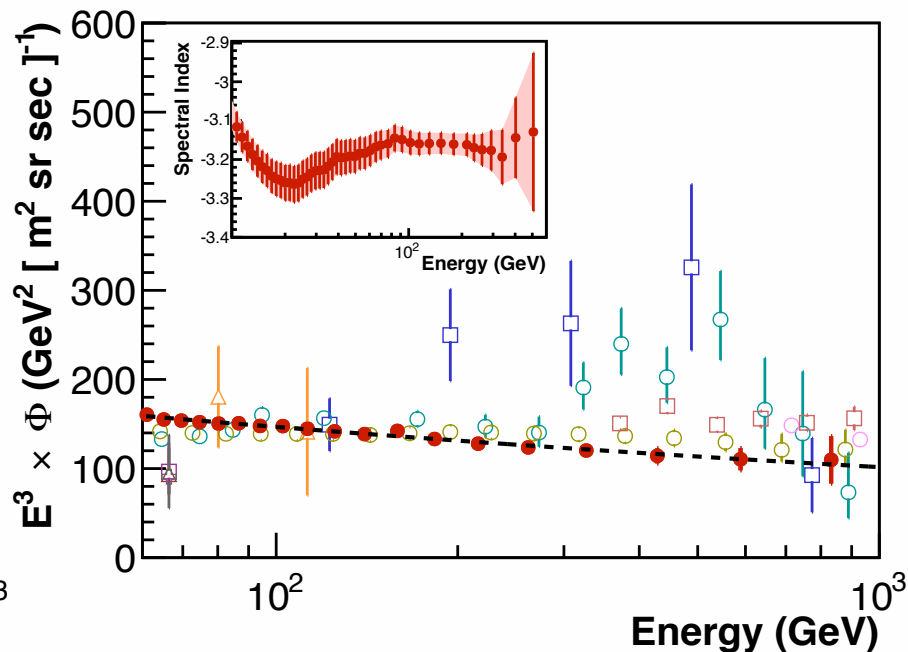
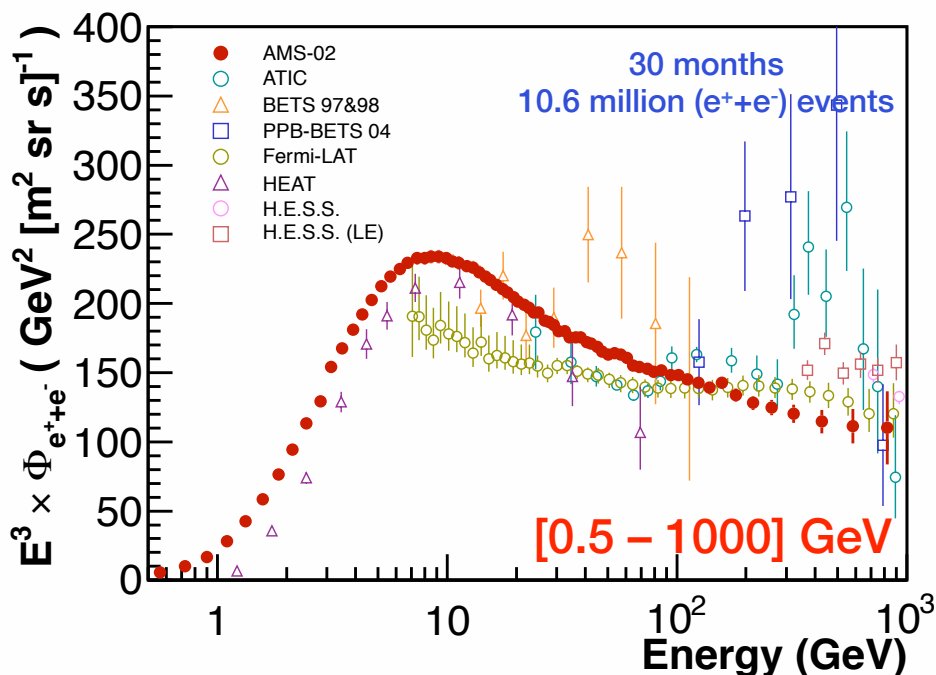
Independent measure of the total e^+e^- without identification of the charge sign.
Less systematic uncertainties, higher energy reach, directly comparable with purely calorimetric measurements.





“All electrons” flux (PRL 113, 221102 - 2014)

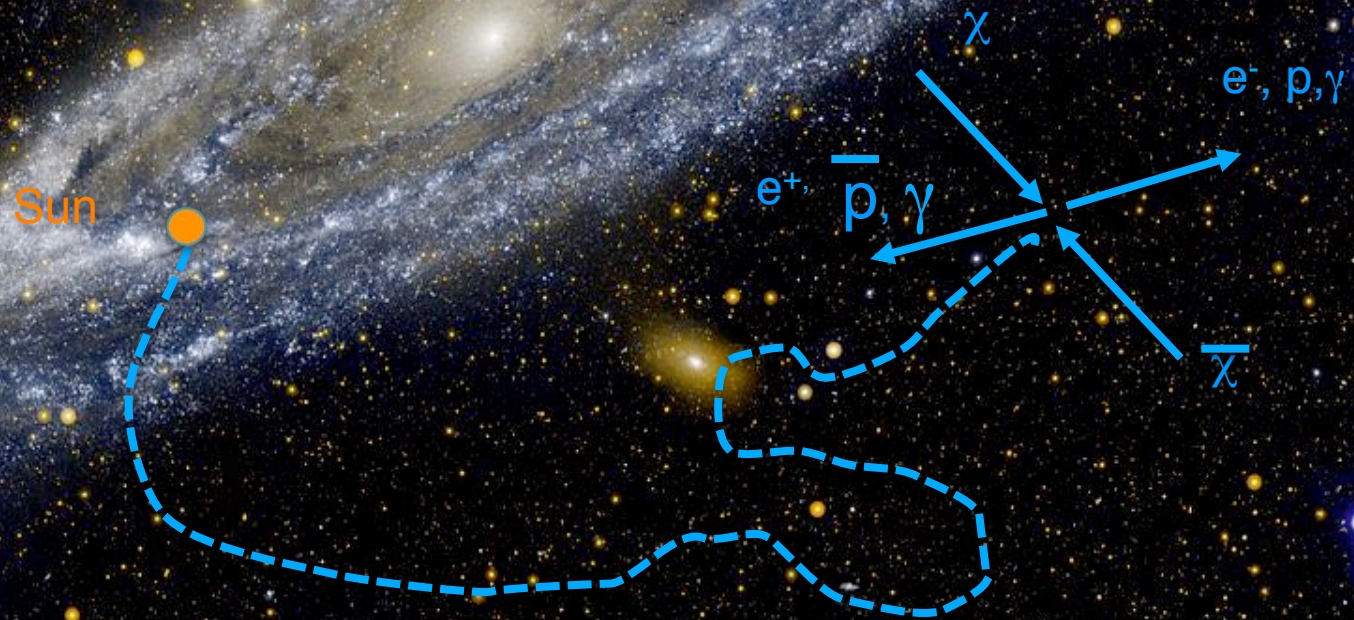
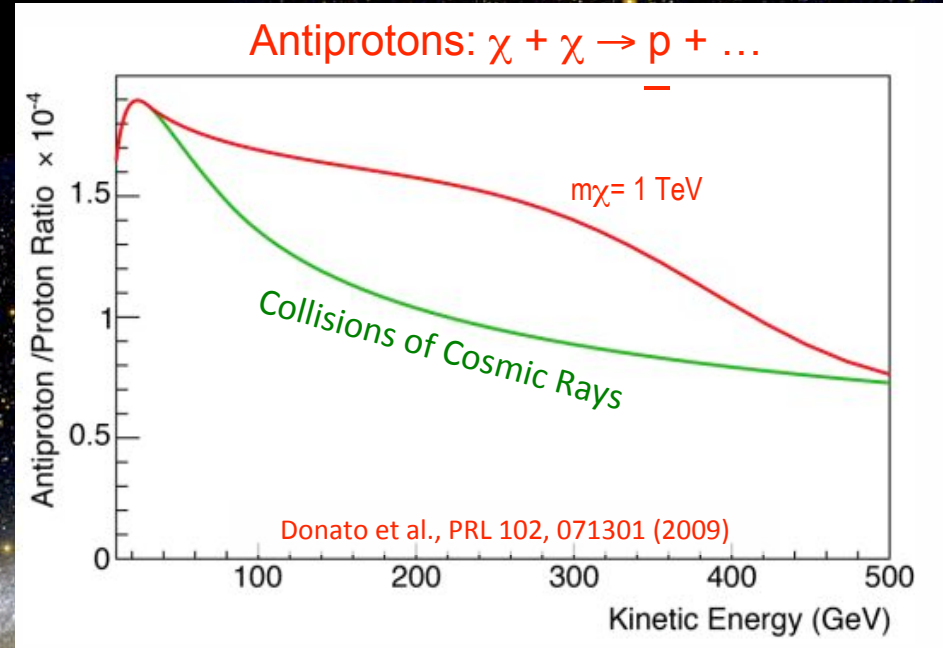
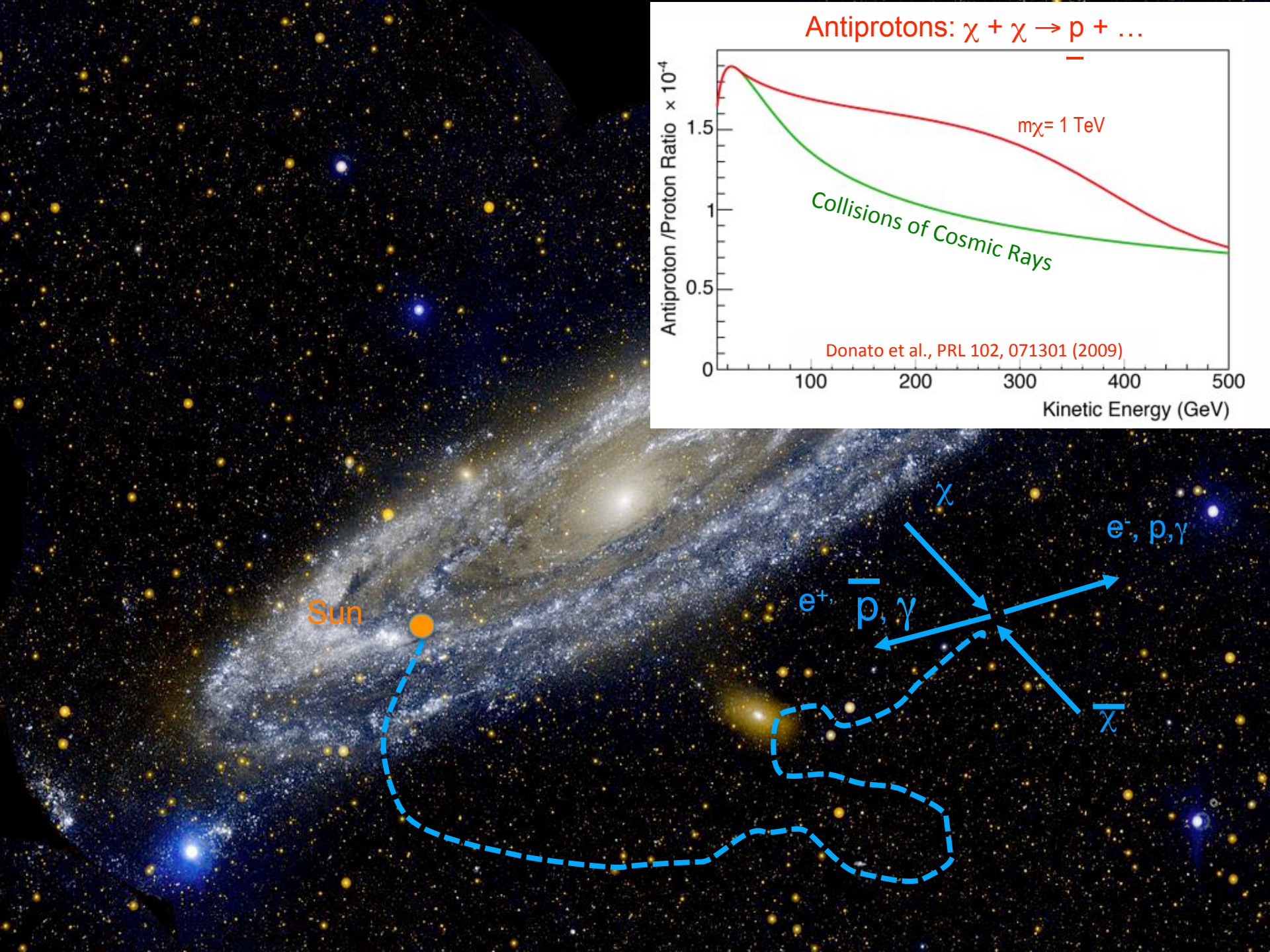
Independent measure of the total e^+e^- without identification of the charge sign.
Less systematic uncertainties, higher energy reach, directly comparable with purely calorimetric measurements.



The (e^+e^-) flux can be described by a single power-law, starting from ~ 30 GeV, and up to 1 TeV.

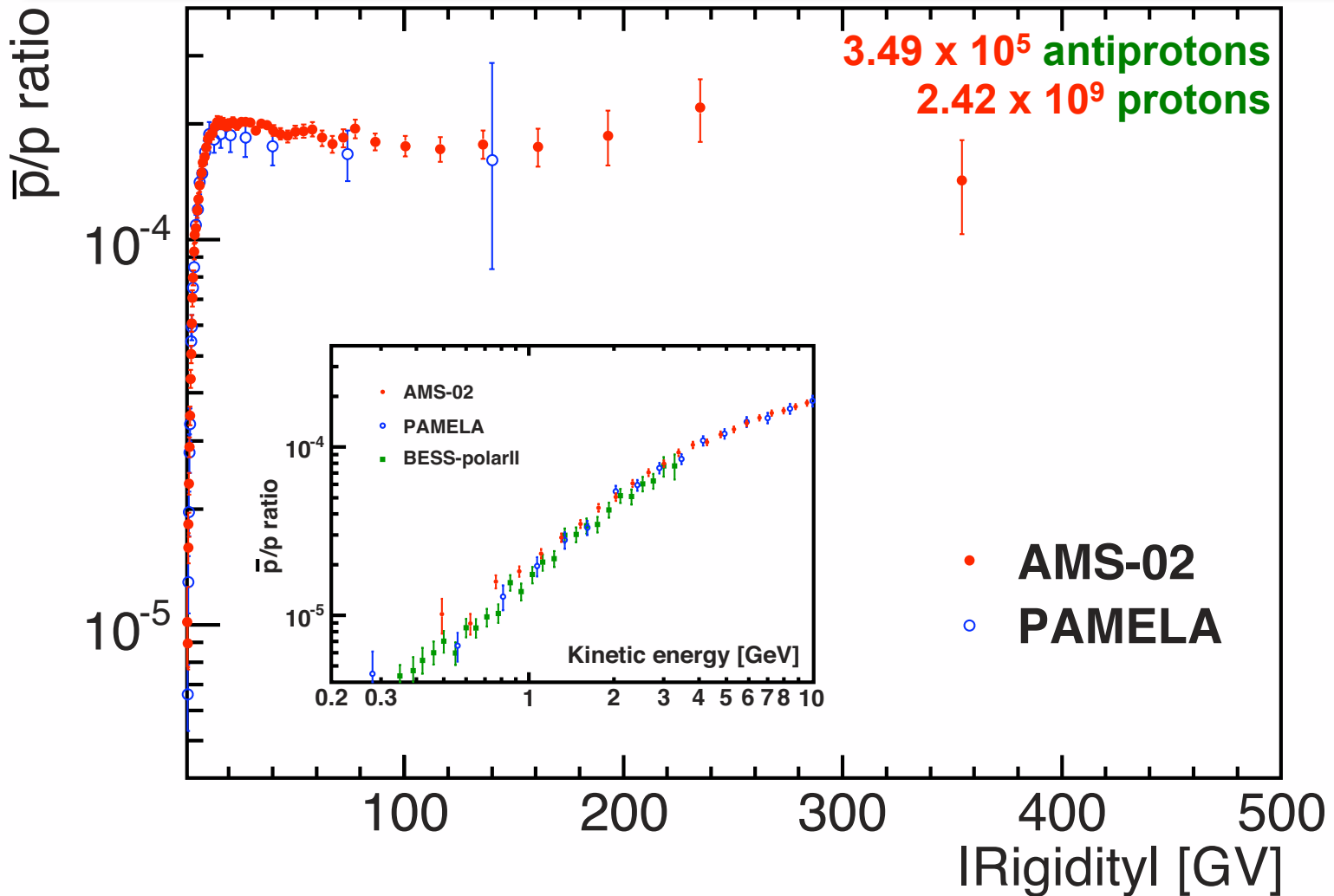
No evidence of fine structures

* more details were given in H.Gast talk

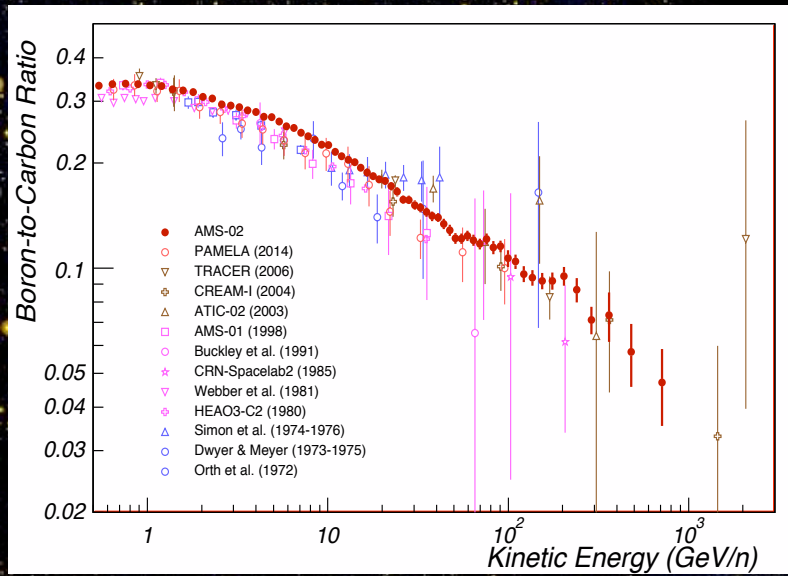




Anti-proton/proton ratio (submitted to PRL)



* more details were given in W.Xu talk

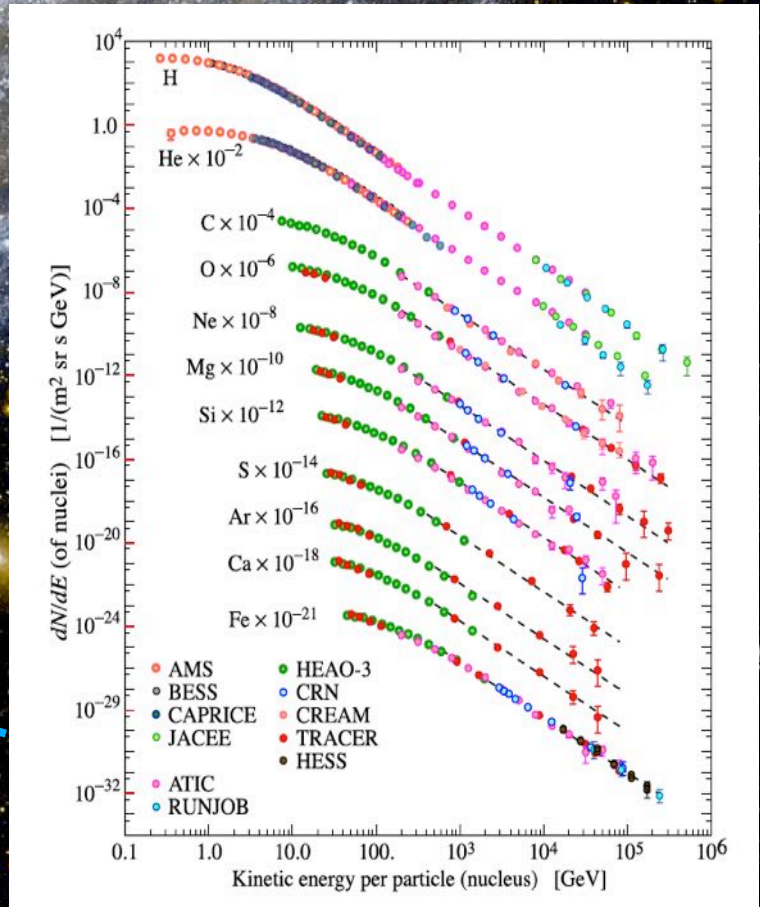


$p, He, C..., e^-$

Sun

$\pi^\pm \rightarrow \mu^\pm \rightarrow e^\pm$

$p+p \rightarrow p+\bar{p}...$



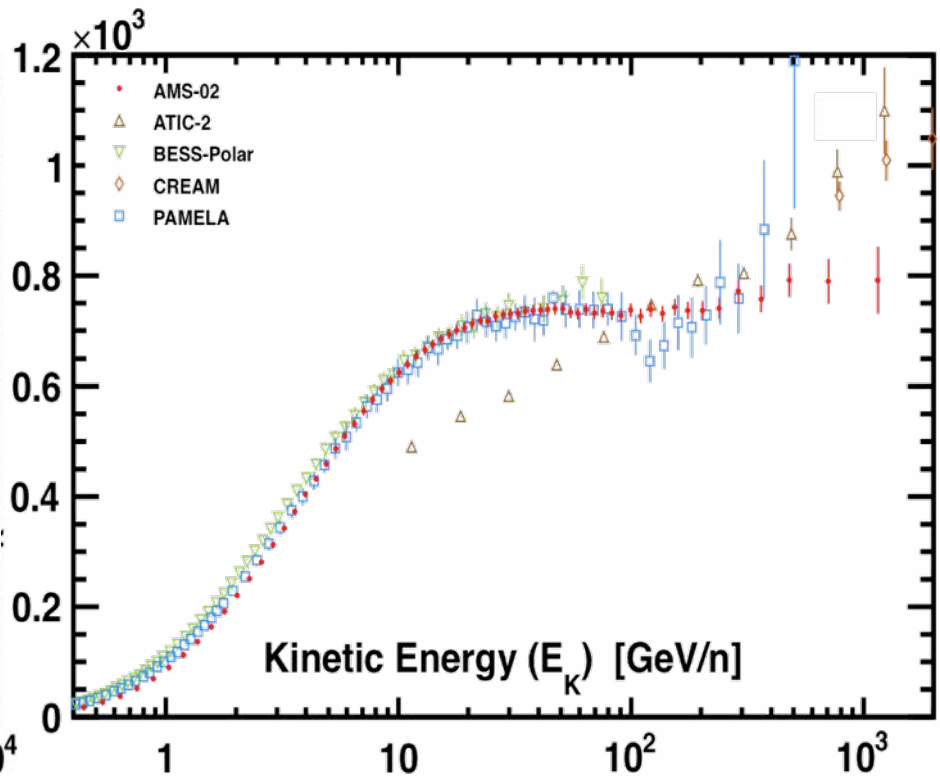
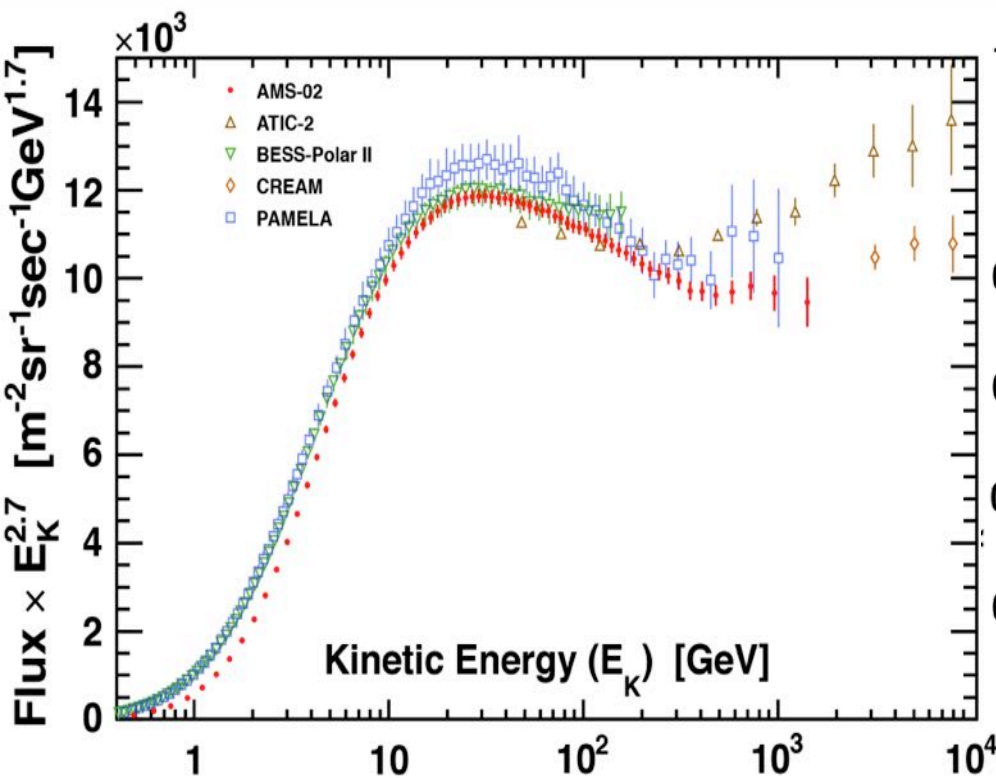


Proton and Helium fluxes (PRL 114, 171103 & 115, 211101 – 2015)

Both proton and helium fluxes show an hardening

H flux measurement:
300 million events

He flux measurement:
50 million events



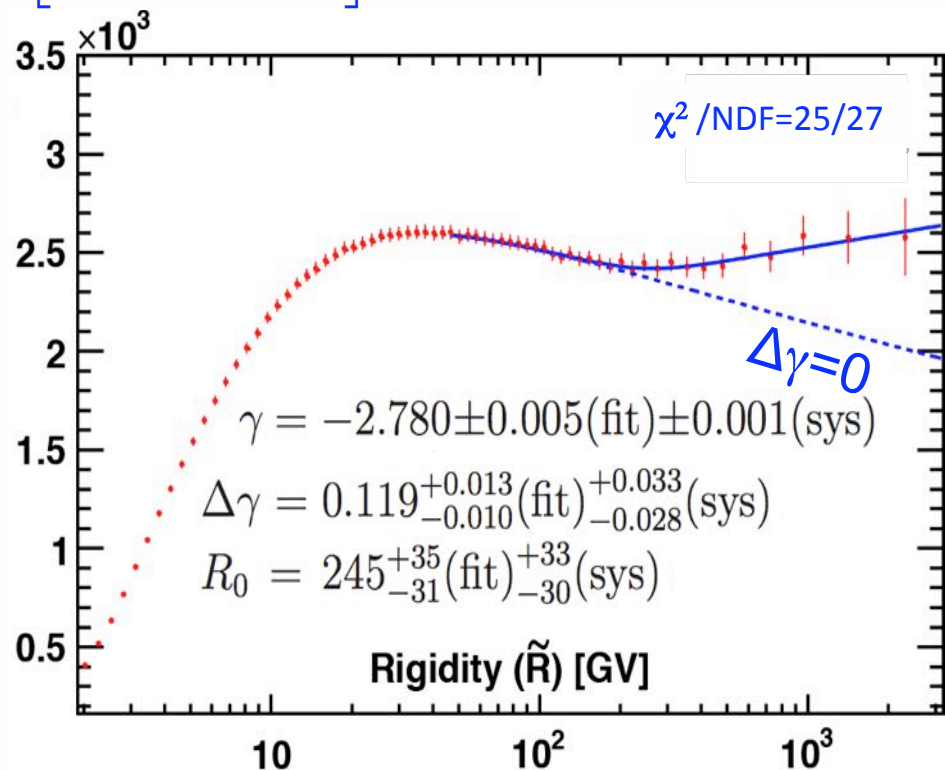
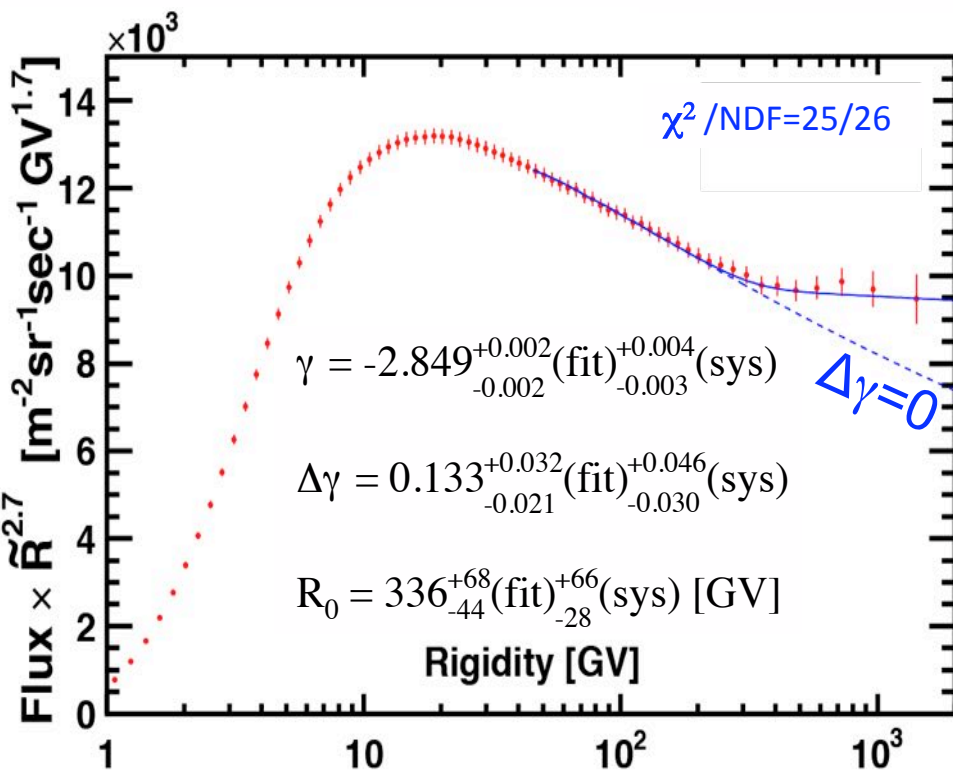
* more details were given in M.Heil talk



Proton and Helium fluxes (PRL 114, 171103 & 115, 211101 – 2015)

Two power-laws $R^\gamma, R^{\gamma+1}$ with a transition rigidity R_0 and a *smoothness* parameters: this well describe the experimental data:

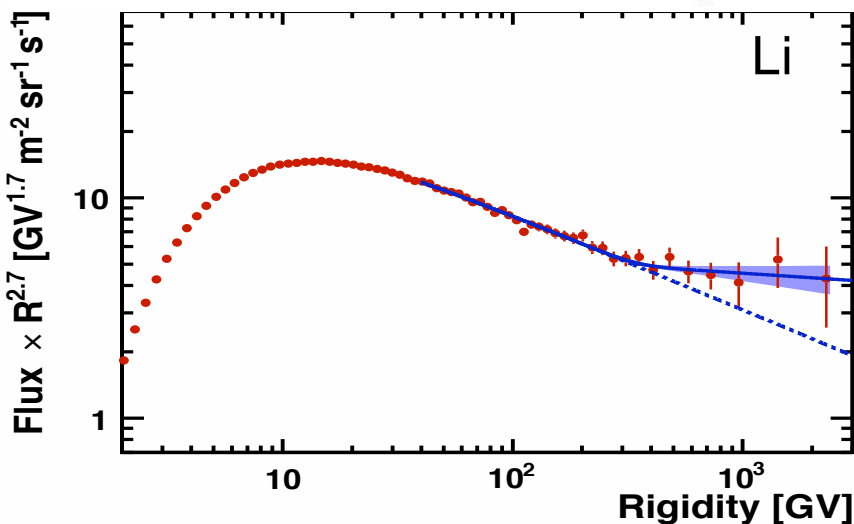
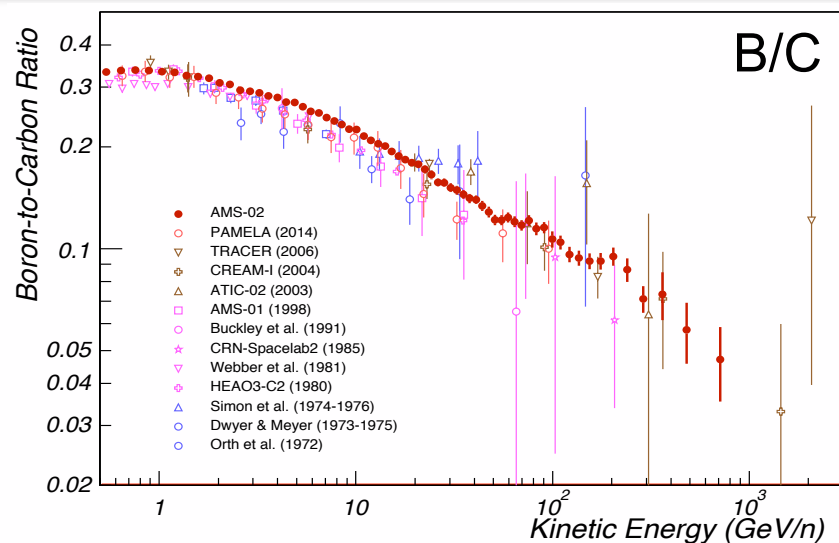
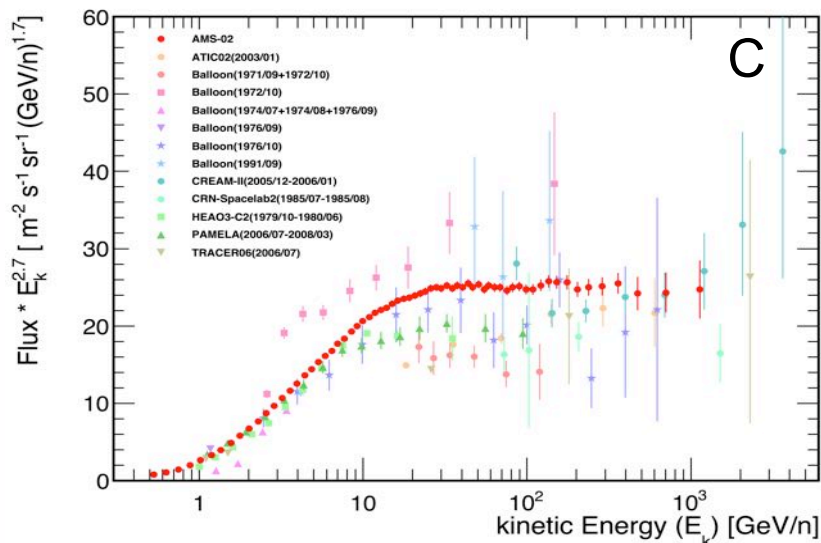
$$\Phi = C \left(\frac{R}{45\text{GV}} \right)^\gamma \left[1 + \left(\frac{R}{R_0} \right)^{\Delta\gamma/s} \right]^s$$



* more details were given in M.Heil talk



Light nuclei (current status)

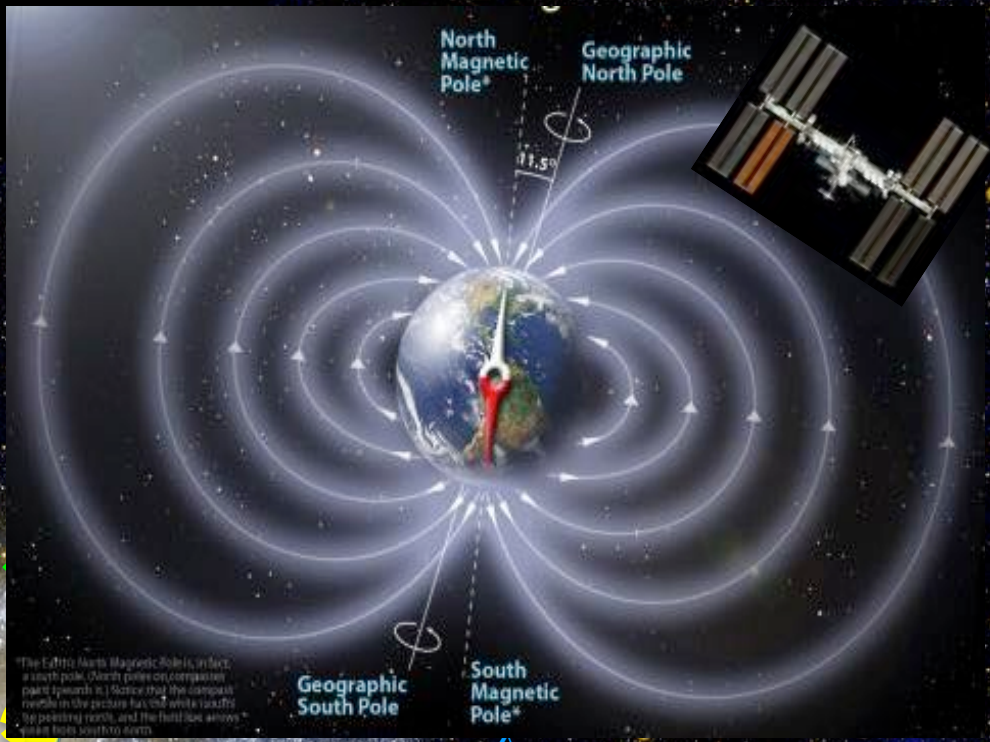
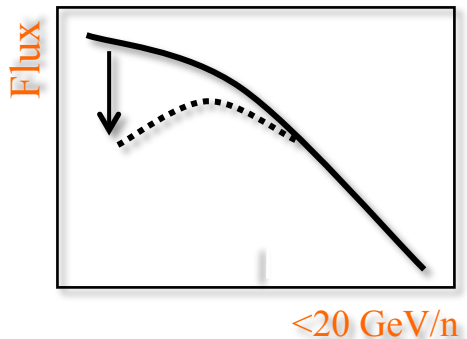


Then:

- O
- Be
- Be/B
- ...
- N
- C/O
- N/O

* more details were given in M.Heil talk

Solar modulation



$p, He, C..., e^-$

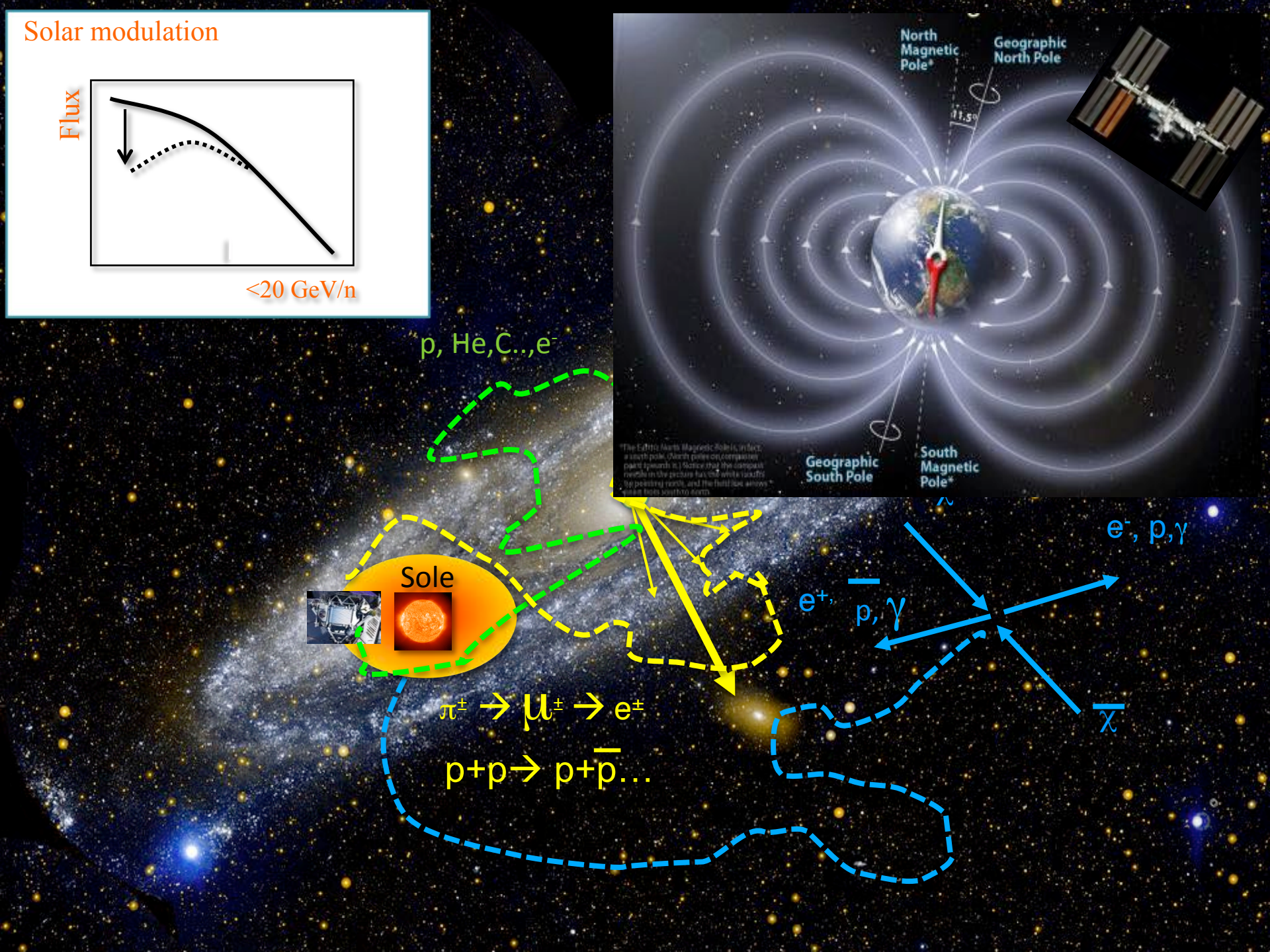


$\pi^+ \rightarrow \mu^+ \rightarrow e^+$
 $p+p \rightarrow p+\bar{p}...$

e^+, p, γ

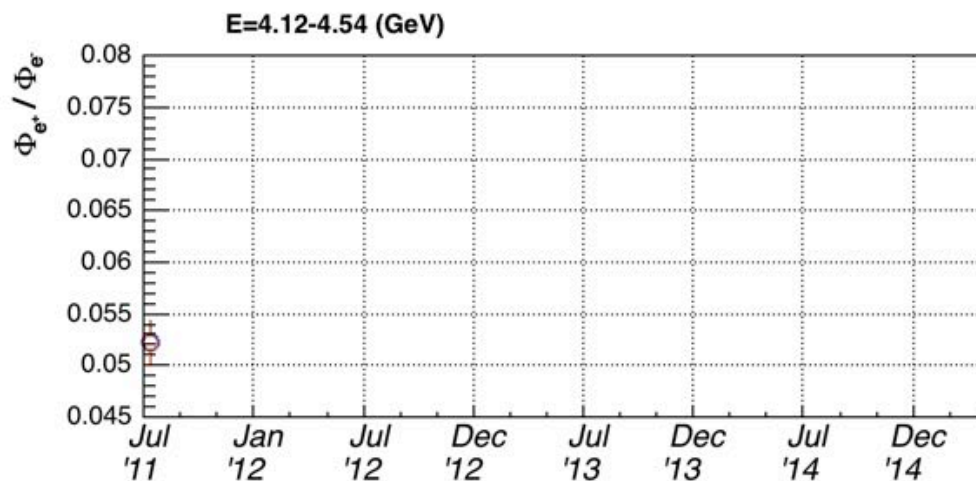
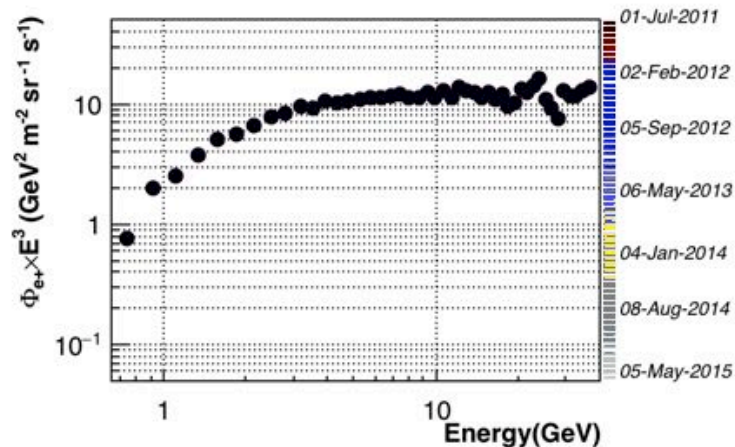
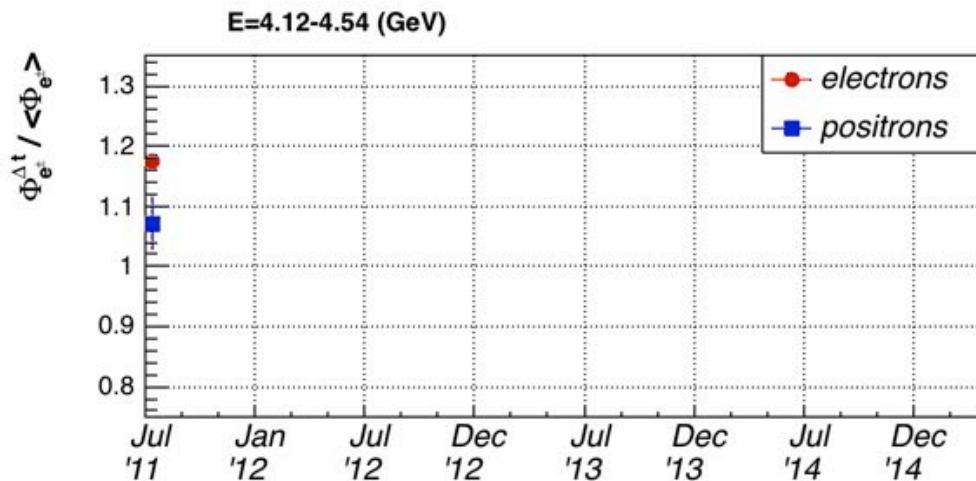
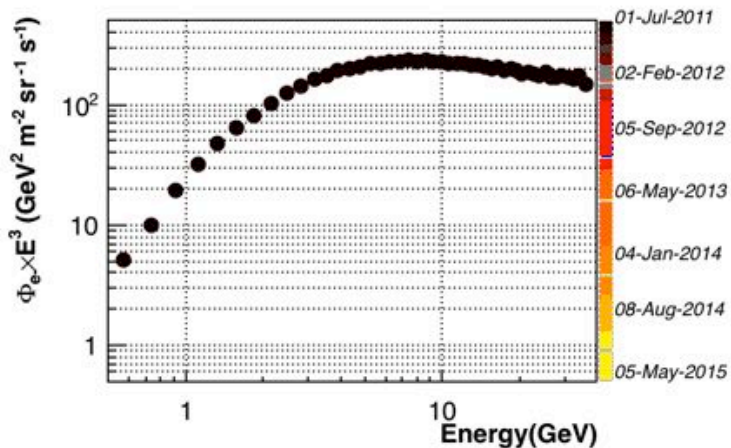
e^-, p, γ

$\bar{\chi}$





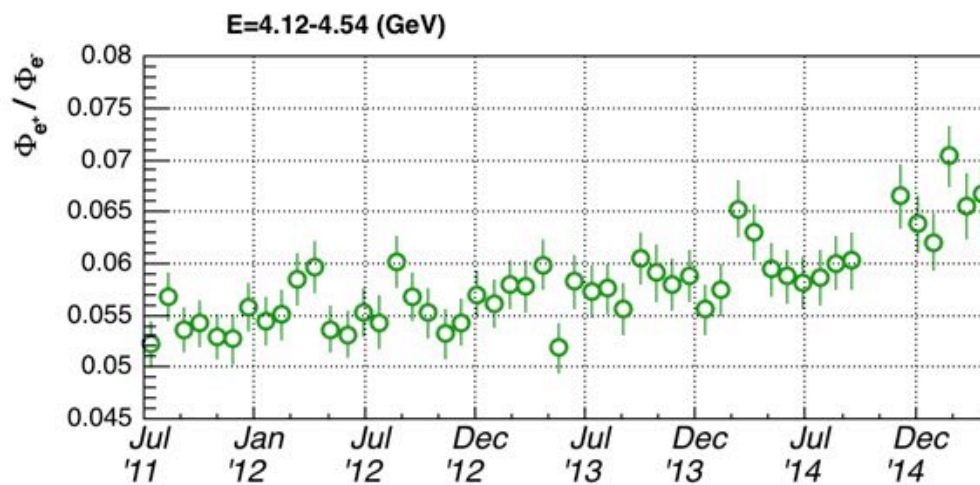
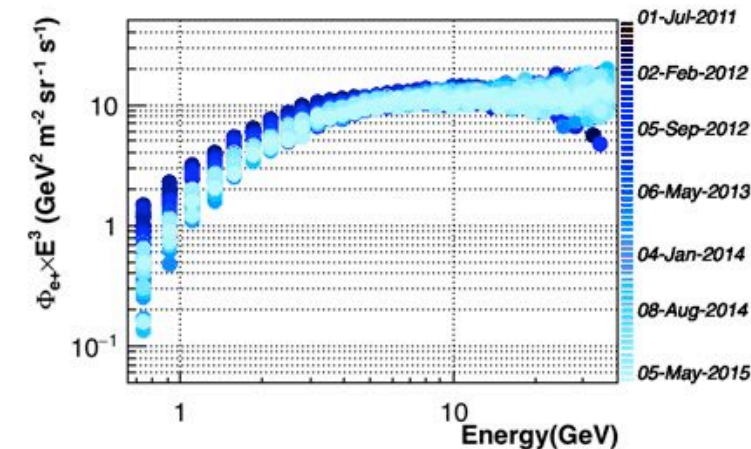
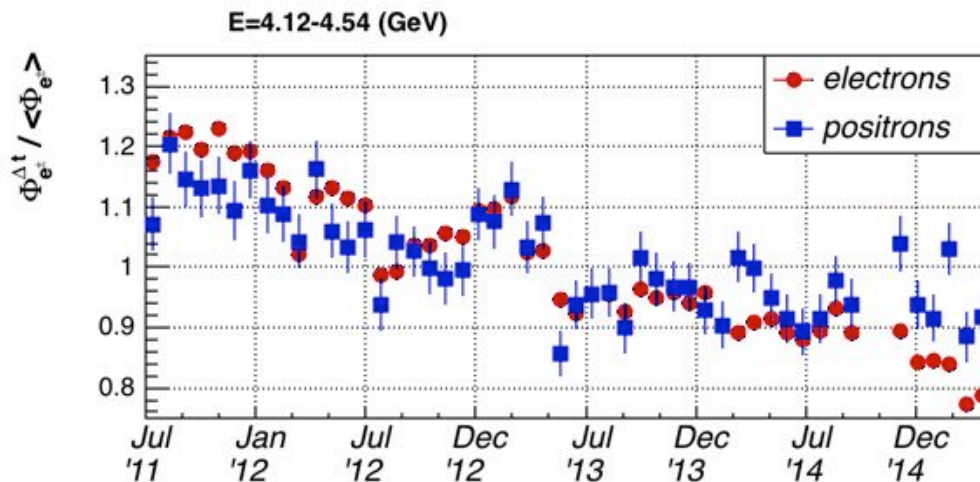
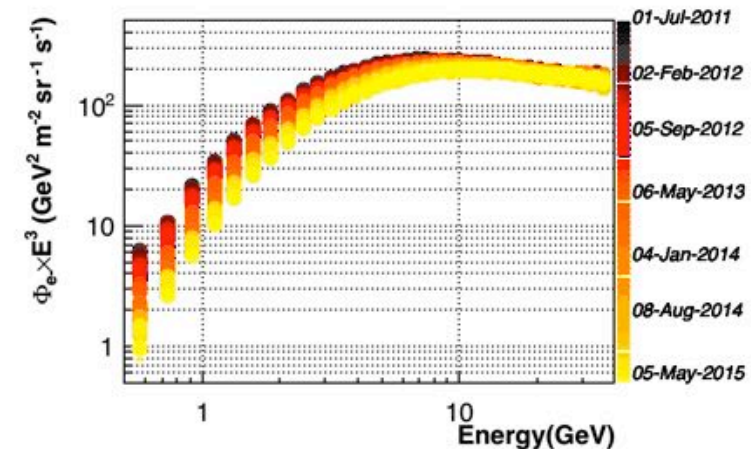
Fluxes as function of time, e^+/e^-



* more details were given in H.Gast talk



Fluxes as function of time, e^+/e^-



* more details were given in H.Gast talk

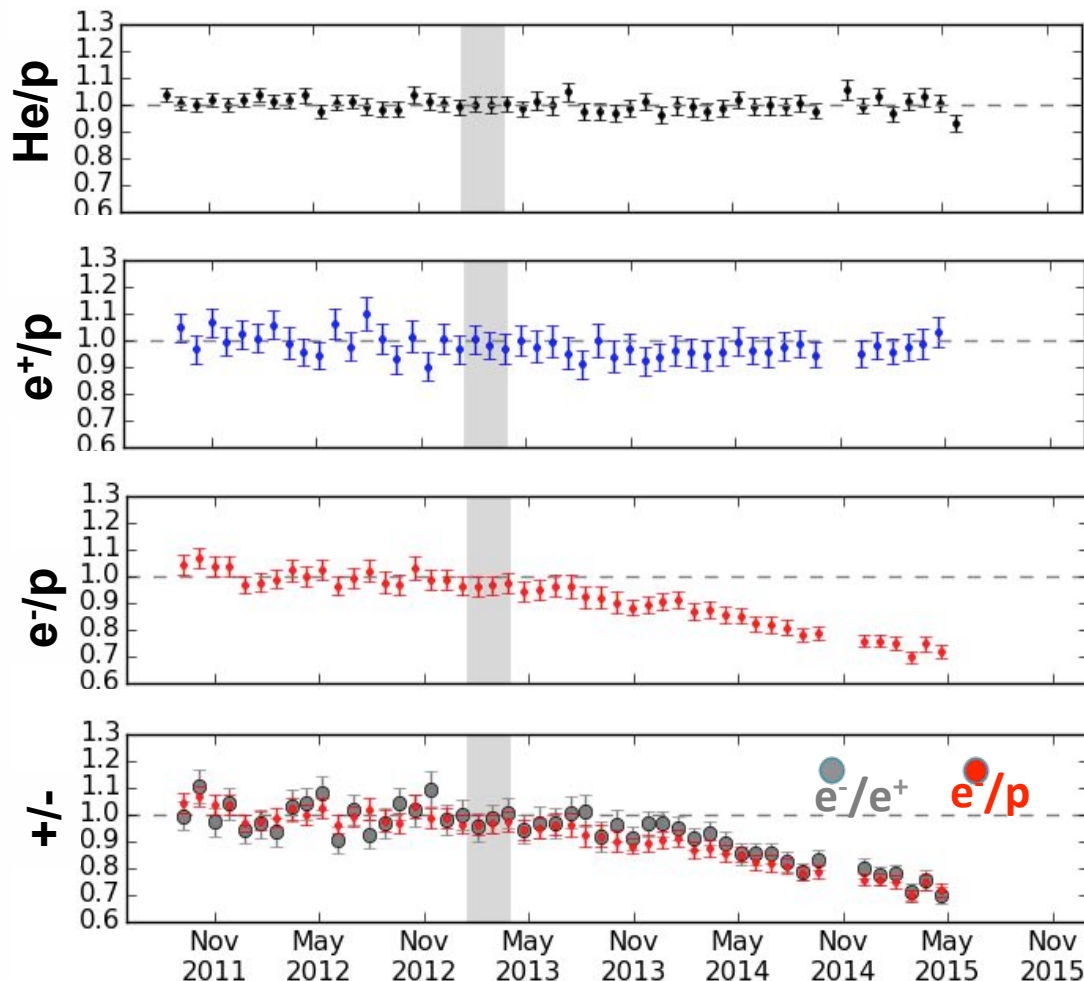


Fluxes as function of time, charge sign effects

2 GeV

Different species,
same sign of
charge

Different species,
different sign of
the charge



* more details were given in M.Heil talk



Conclusions

- AMS is the Cosmic Rays observatory of the next decade
- The collaboration is providing the absolute and relative abundances of the various species
- The accuracy of the experimental measurements is currently better than the uncertainty in the phenomenological models and is allowing very detailed studies



If nothing happens, AMS will take data up to 2024...



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