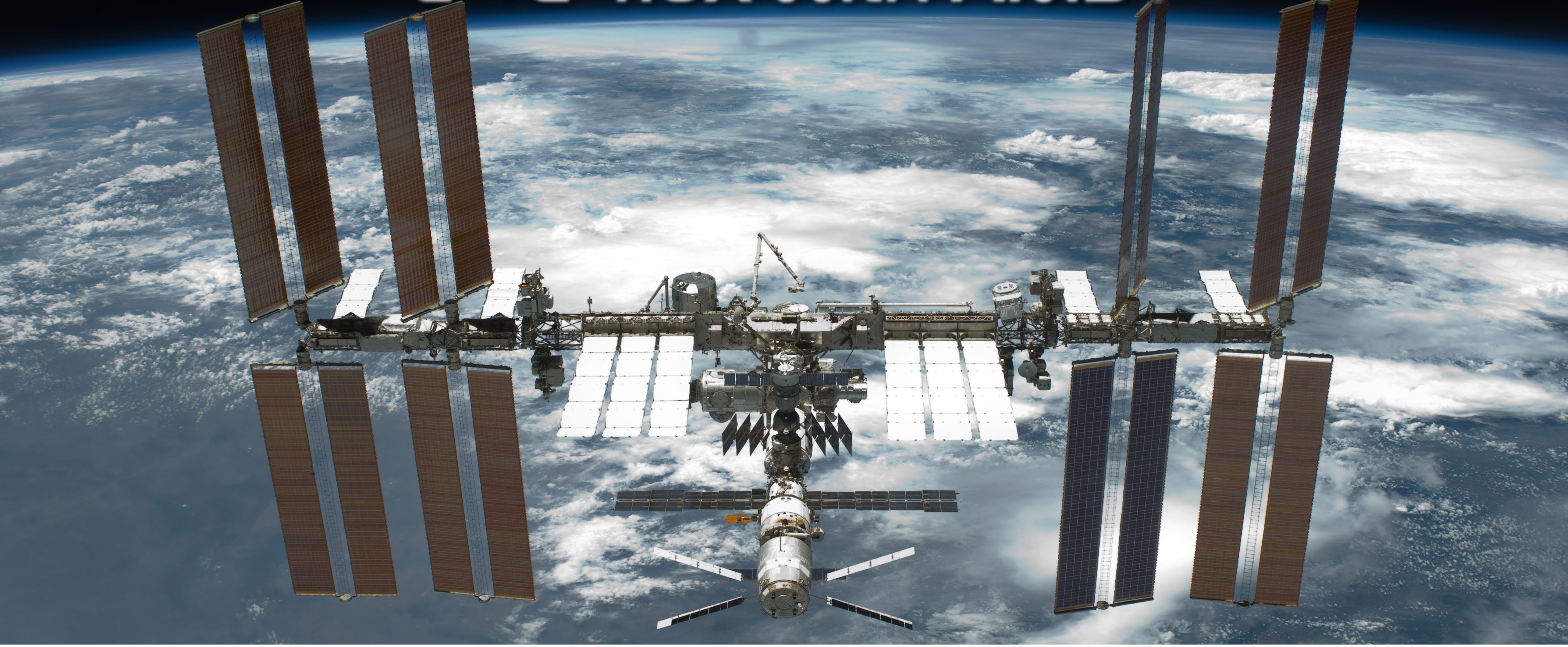
AUGUST 7-11 COLUMBUS, OHIO

TeVPA 2017

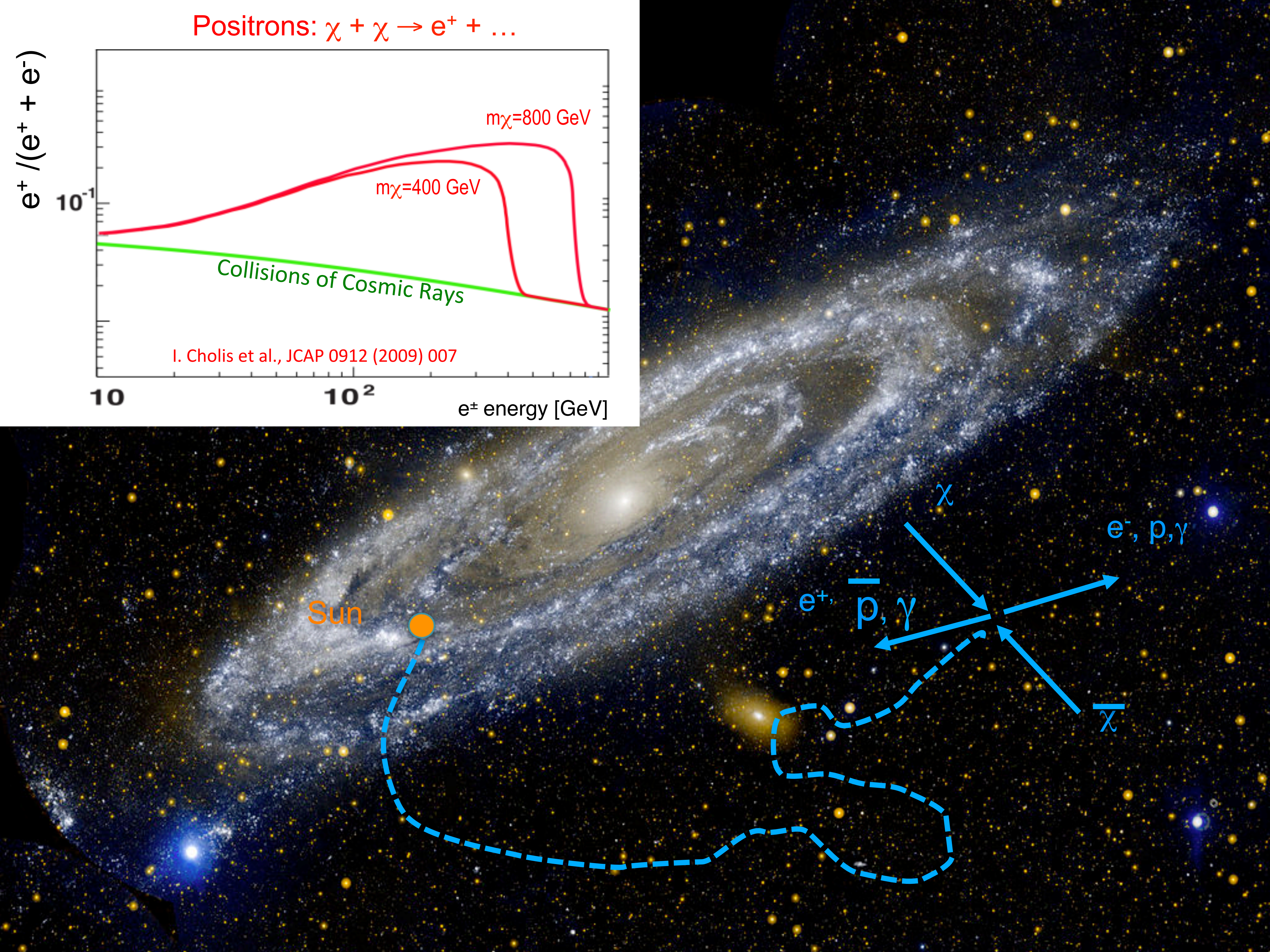
Precision measurement of the $e^{+}+e^{-}$ flux with AMS



Matteo Duranti
INFN Sez. Perugia
on behalf of the AMS Collaboration

INFN

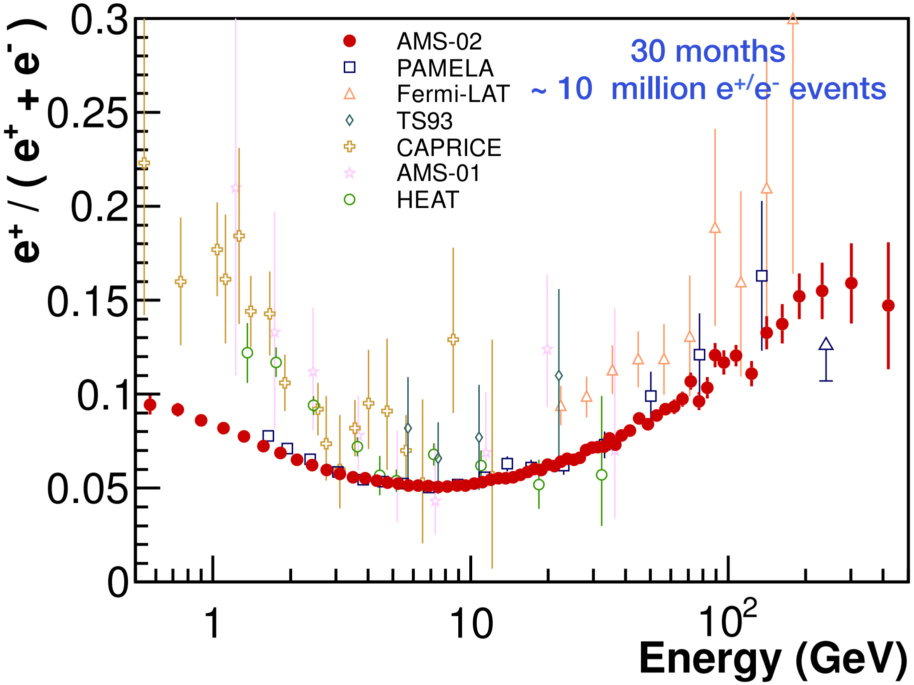
agenzia spaziale italiana

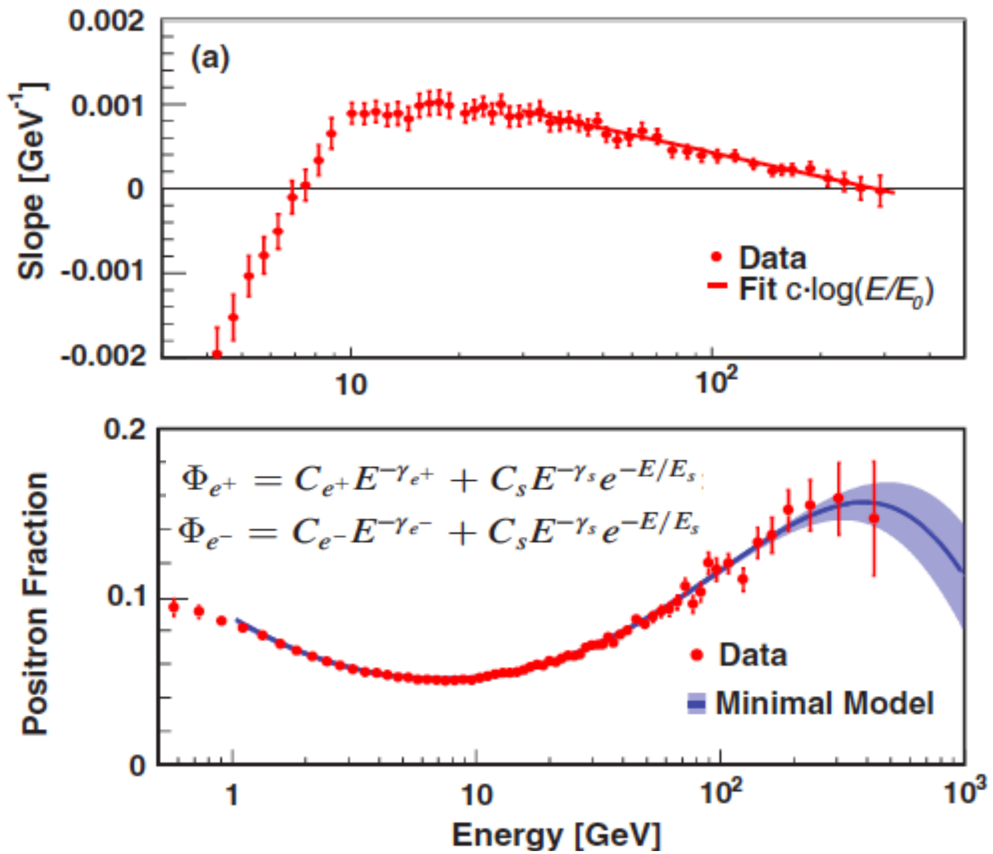


Positrons: $\chi + \chi \rightarrow e^+ + \ldots$
$e^+ /(e^+ + e^-)$
10^{-1}
$m\chi$=800 GeV
$m\chi$=400 GeV
Collisions of Cosmic Rays
I. Cholis et al., JCAP 0912 (2009) 007
10
10^2
$e^\pm$ energy [GeV]
Sun
χ
e^-, p, γ
e^+, $\bar{p}$, γ
$\bar{\chi}$

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^-



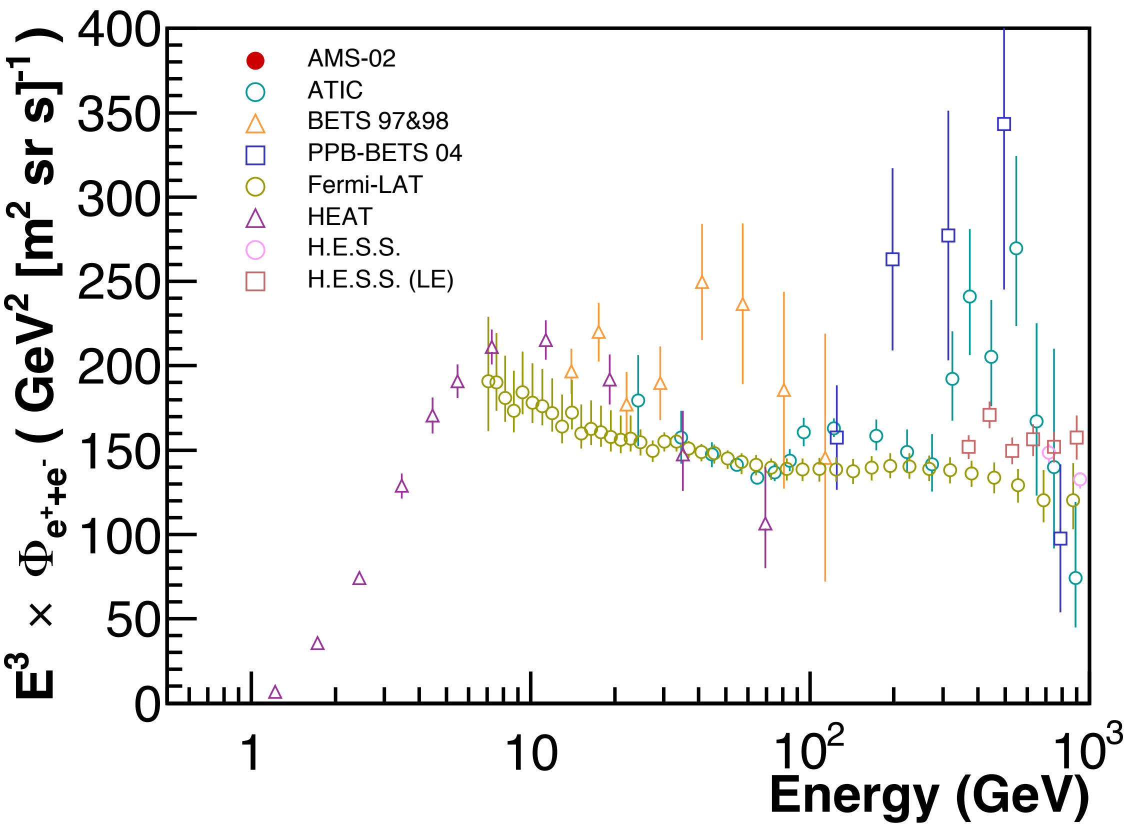


Electron+positron flux

Outline of the talk:

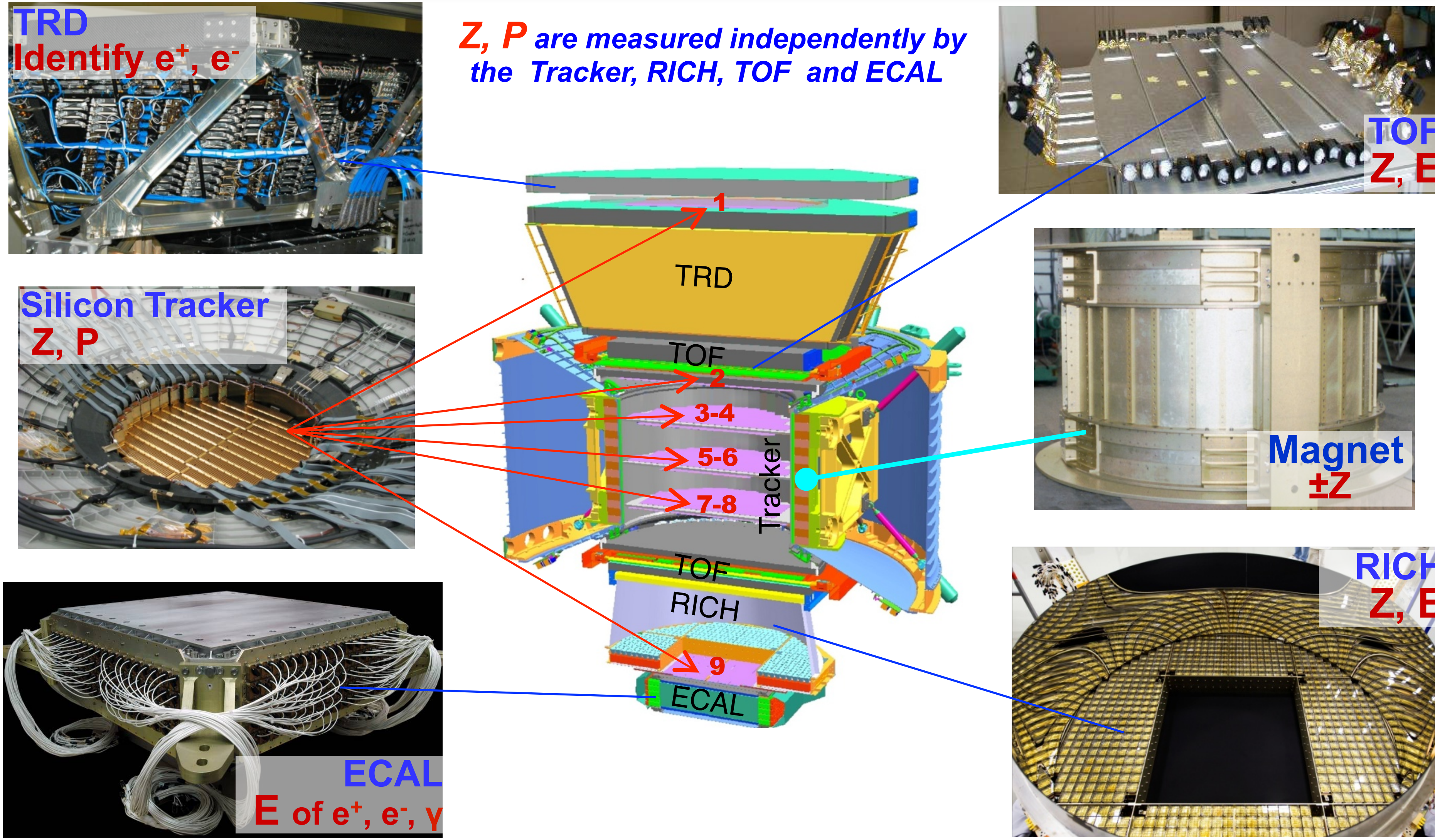
- key detectors in electrons and positrons measurements:
  - control of the background
  - control of the energy scale
- analysis technique
- systematics evaluation
- $e^+ + e^-$ flux

The denominator of the positron fraction, can be used to evaluate the absolute electron and positron fluxes.
No Rigidity sign selection → lower systematics on acceptance.
Directly comparable with calorimetric only measurements.



A precision, multipurpose, up to TeV spectrometer

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



Key requirements

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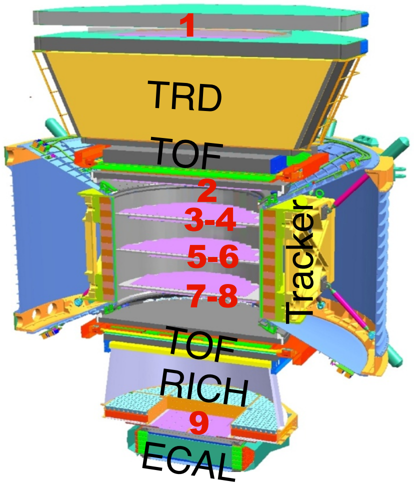
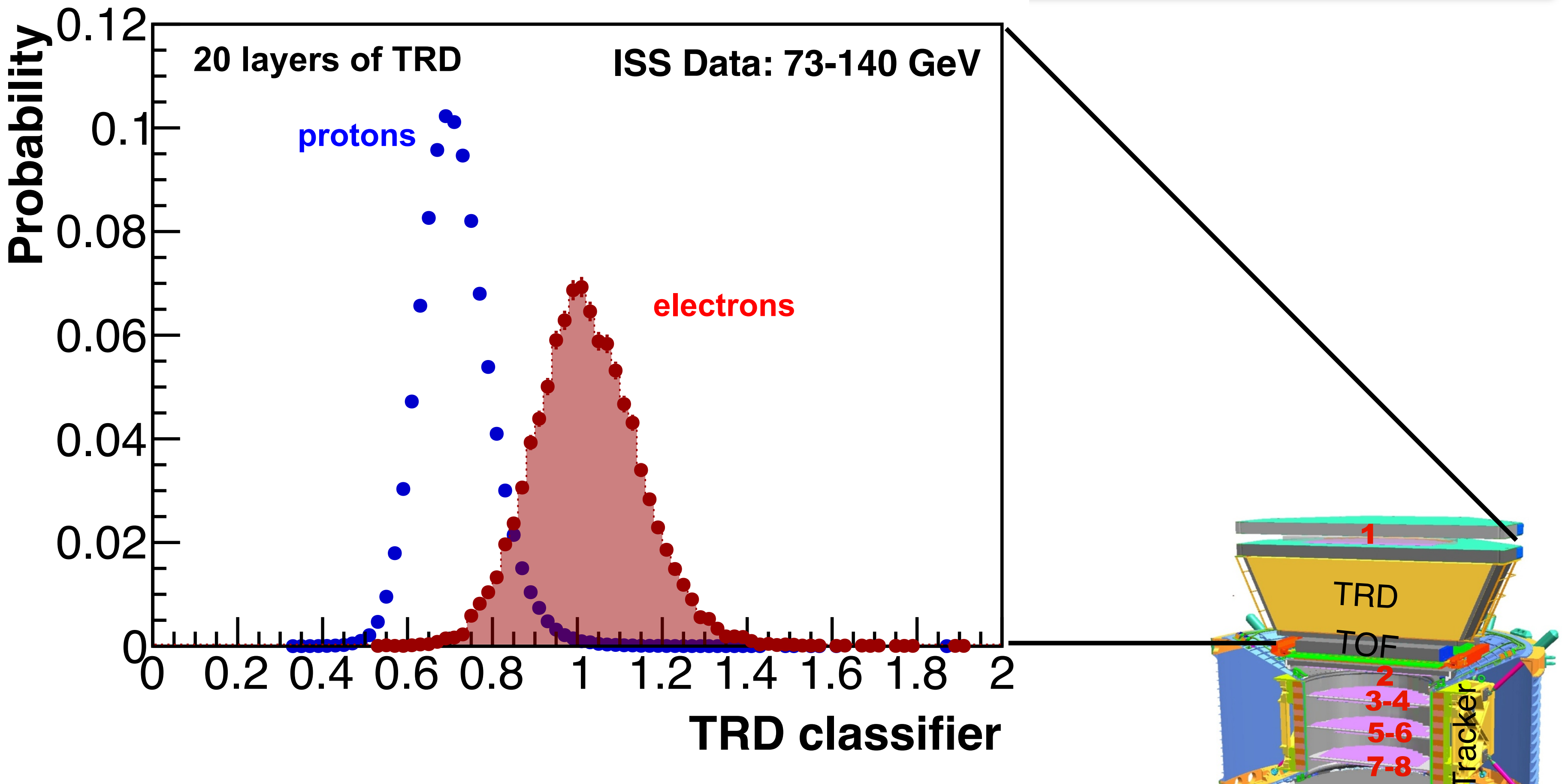
⇒ **Redundancy and Complementarity!**

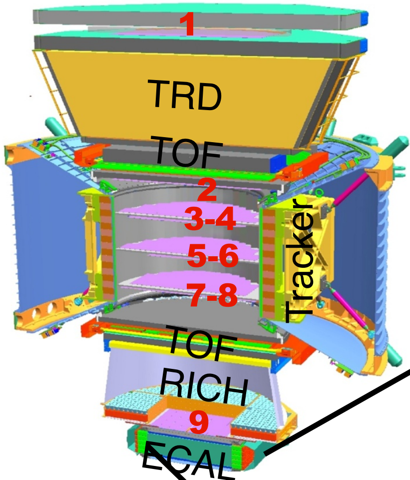


e/p separation: TRD

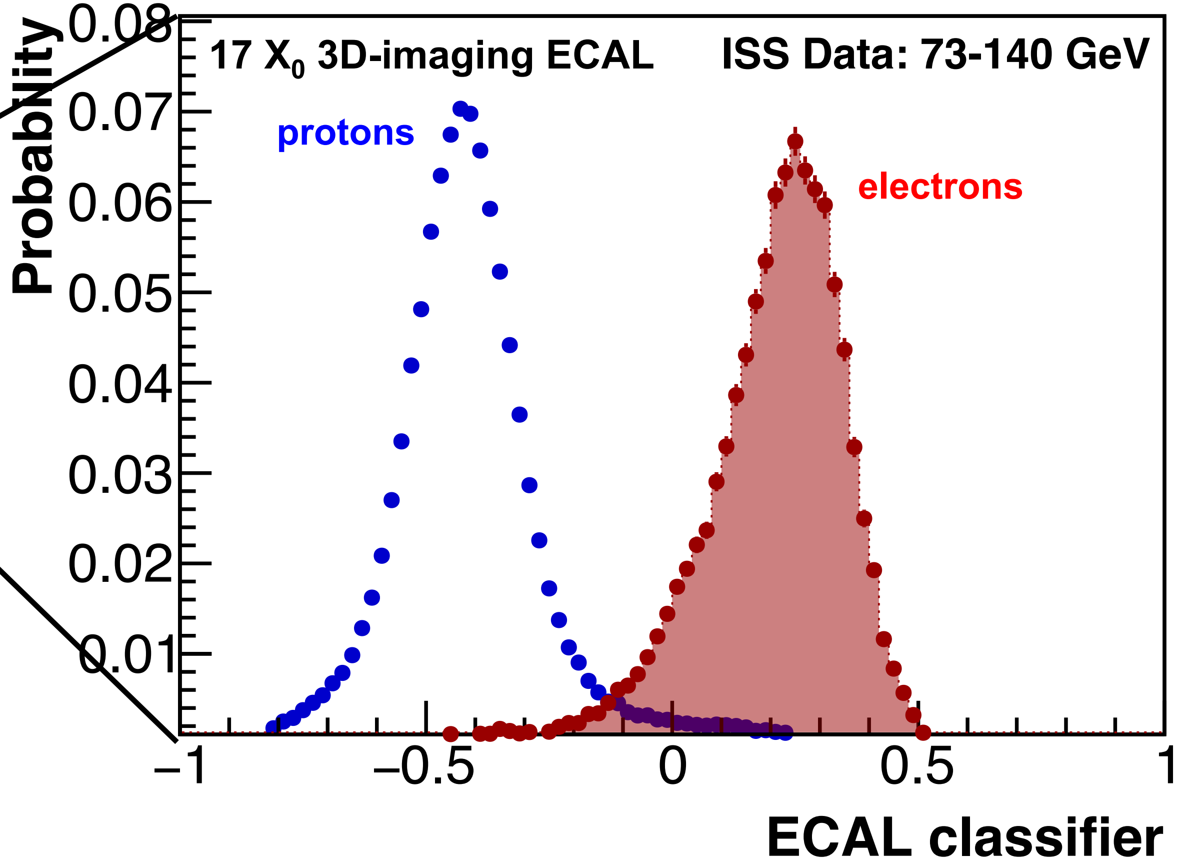


Thanks to the different energy deposits of light and heavy particles, the TRD is capable to achieve an e/p separation up to 10^4

e/p separation: ECAL

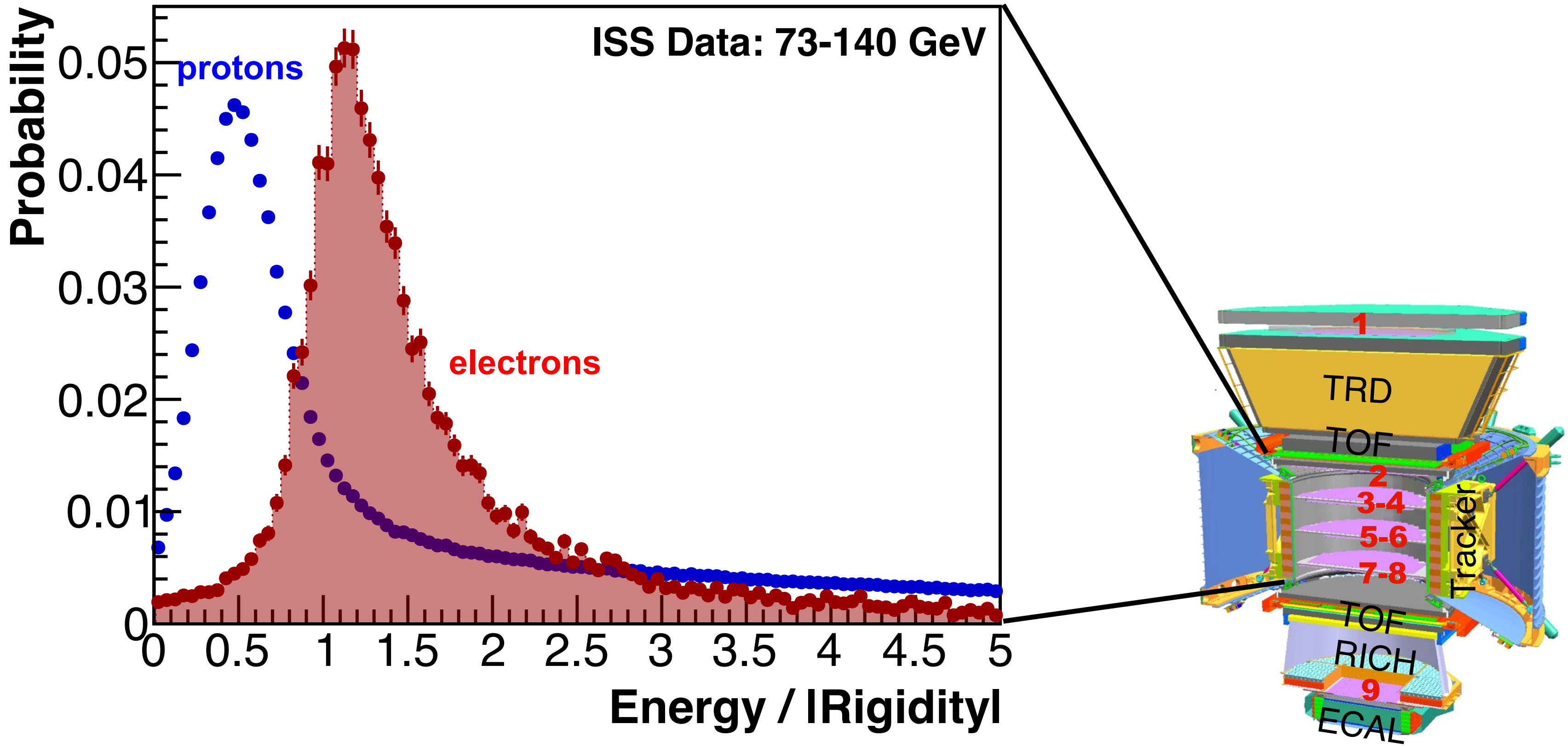


Exploring the shower topological differences between hadronic and electromagnetic particles, is possible to obtain an e/p separation up to 10^5

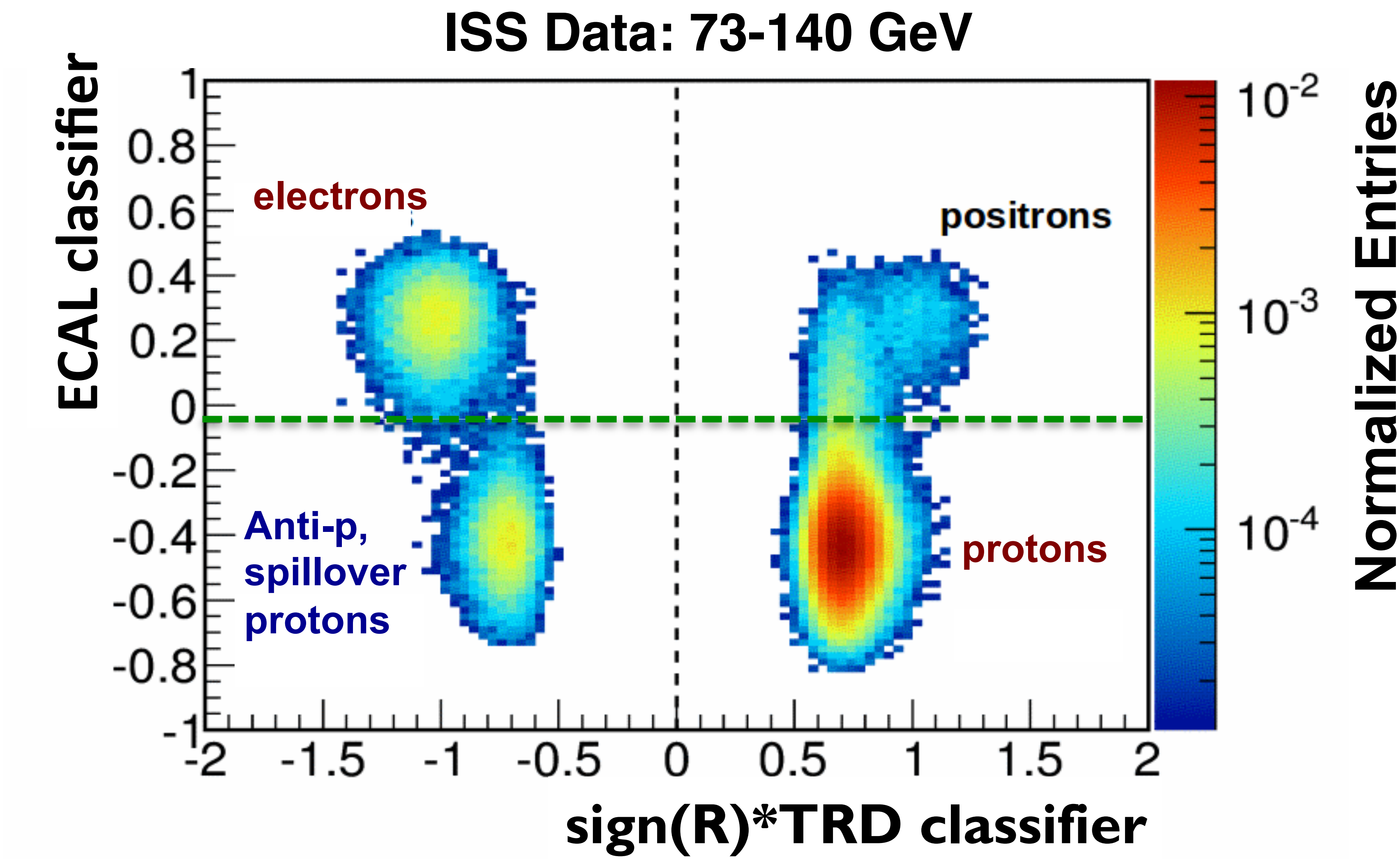


e/p separation: Tracker/ECAL

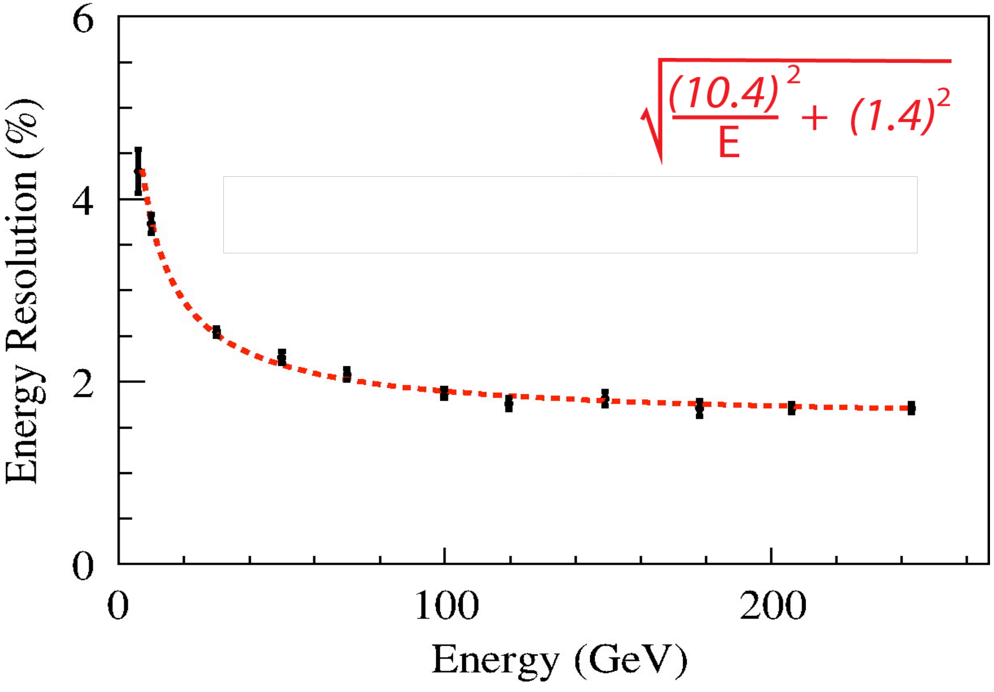
Comparing the Energy measurement by the ECAL to the Rigidity one by the Tracker is possible to discriminate electromagnetic and hadronic particles. Given the natural abundances of p^+, p^-, e^- and e^+, even a selection only based on the sign of the Rigidity is possible to obtain quite pure sample of p^+ and e^-



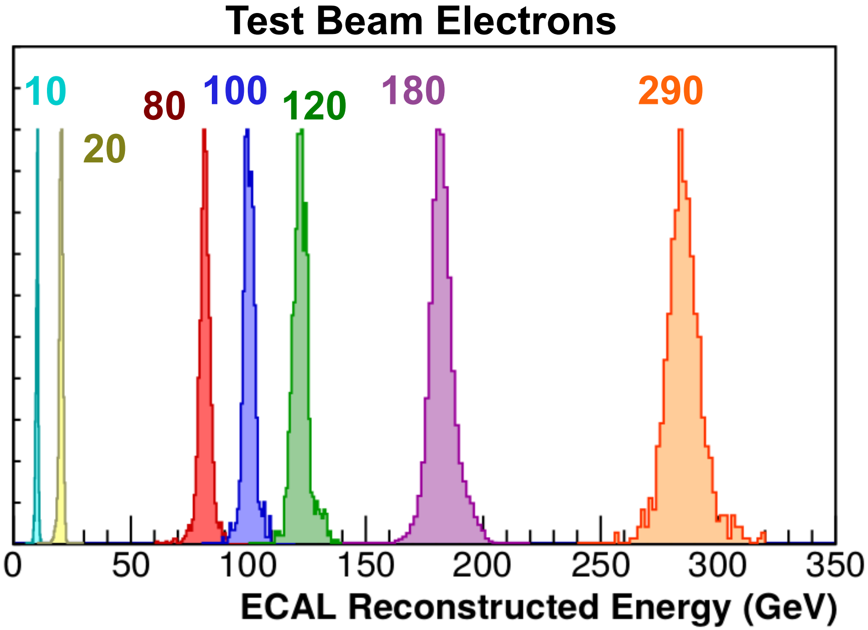
e/p separation: redundancy and complementarity!



Energy measurement



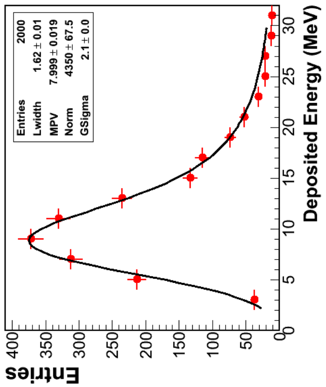
At high energies (>100 GeV), the **energy resolution is better than 2%**. This has been checked in a large Beam Test campaign and is well predicted by the MC simulation

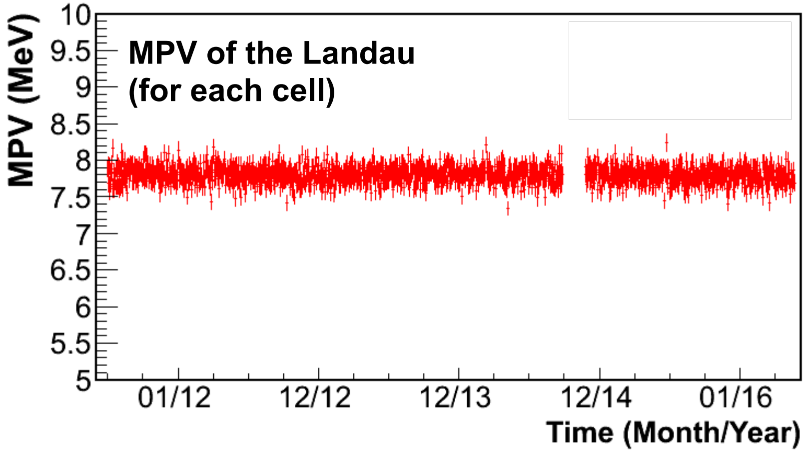


ECAL energy absolute scale
calibrated and tested during Beam Tests on ground

ECAL energy scale known at 2% level in [10.0 – 290.0] GeV

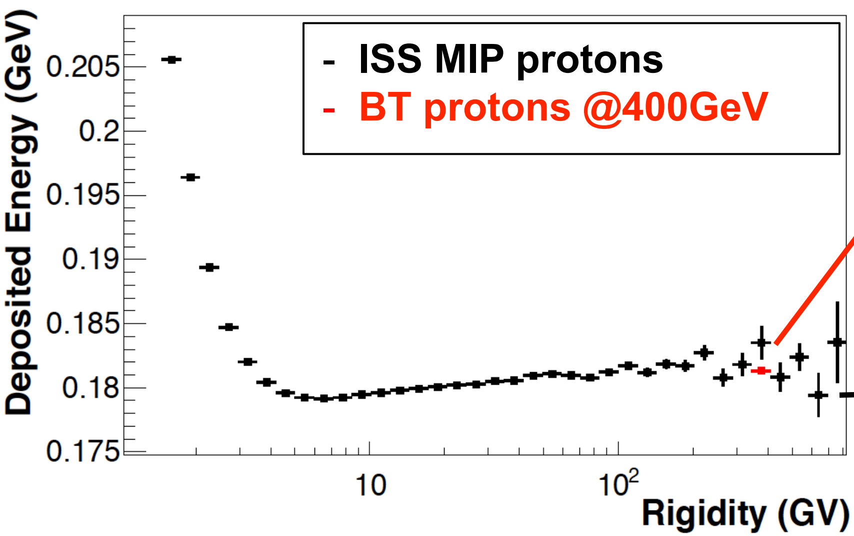
Energy equalization and calibration



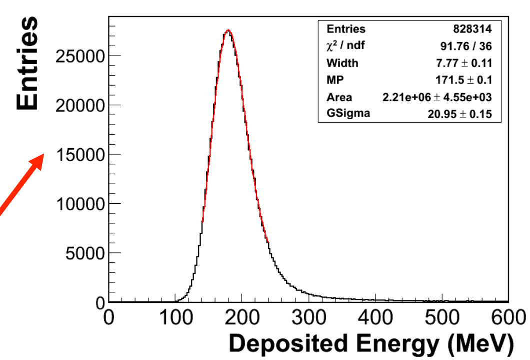


On-flight cell equalization and calibration:

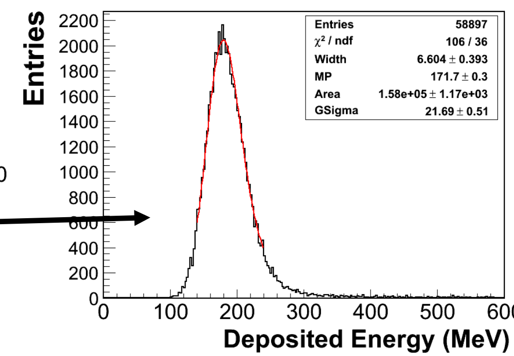
- the cells of the calorimeter are equalized and calibrated in flight, as function of time, using “MIP” protons
- the “MIP” energy deposit is equalized to the BT one



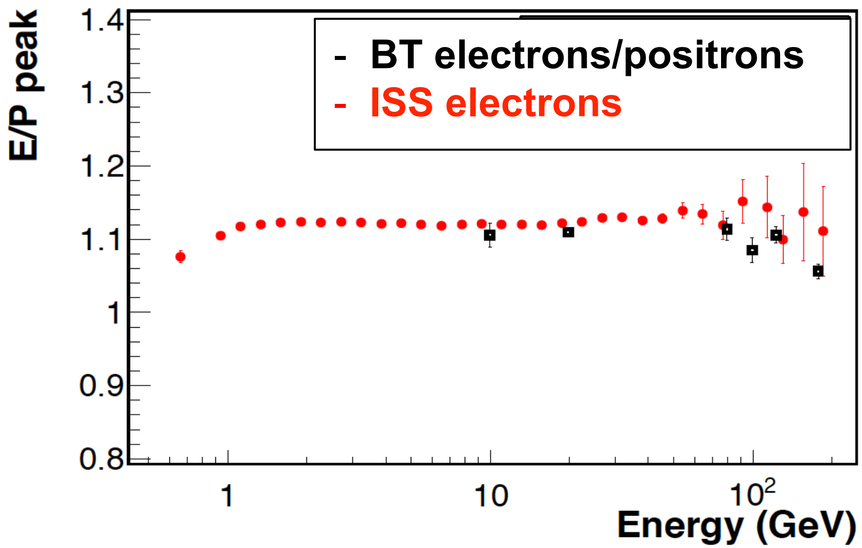
Beam Test: Protons @ 400 GV



ISS Data: Protons 350-450 GV

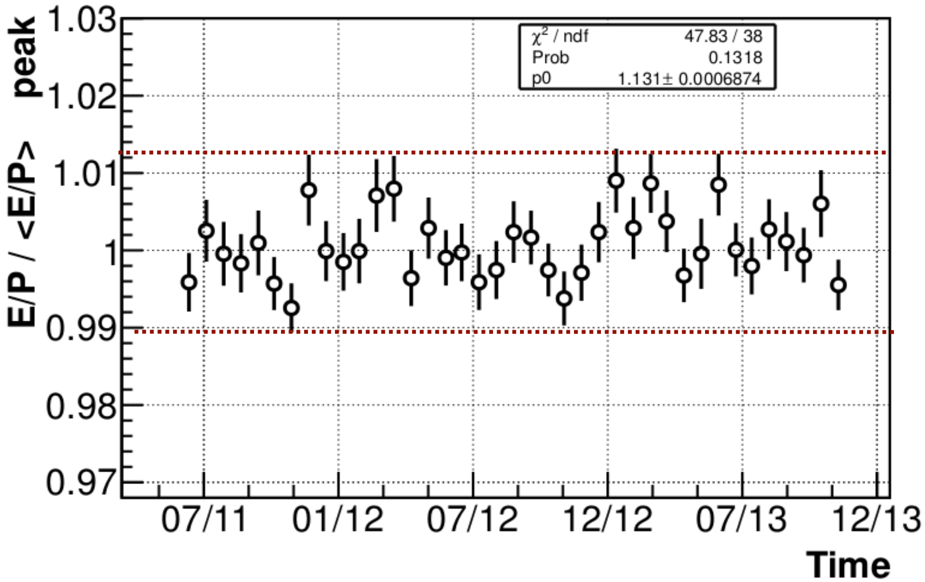


Energy absolute scale



The comparison of the ECAL energy with independent Tracker rigidity measurement used to ensure the correction absolute scale

Stability in time of the calibration **cross-checked, aposteriori**



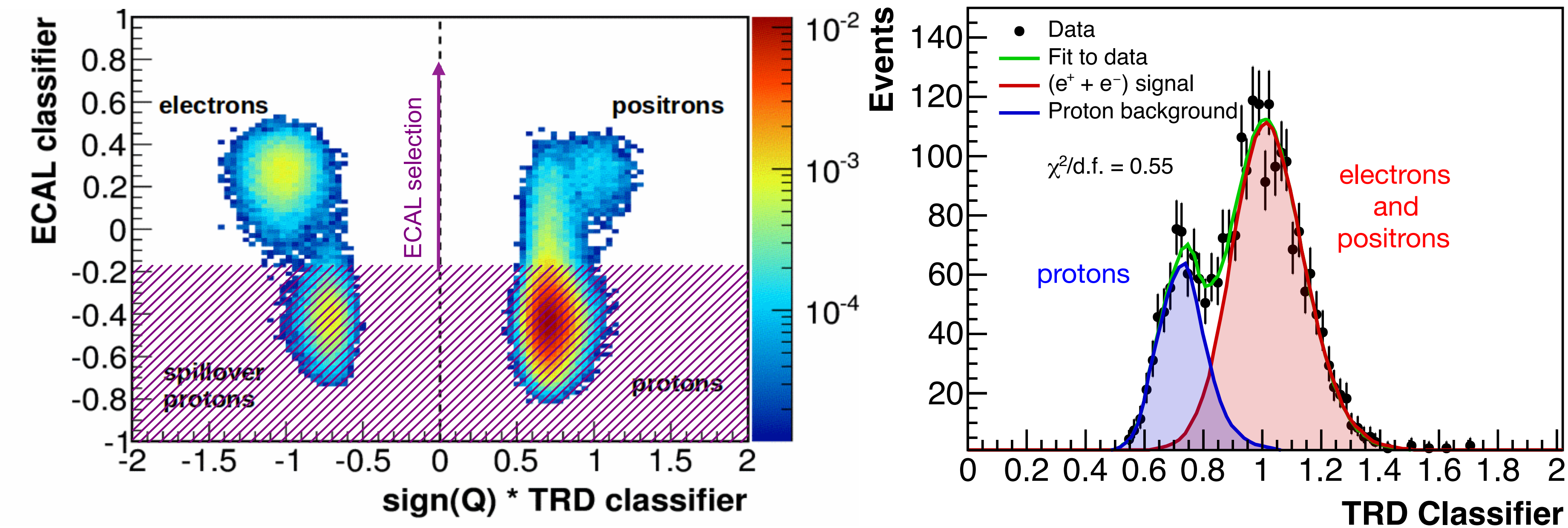
This is possible thanks to the AMS redundancy and complementarity

Data analysis

Template fit to measure N_e and N_p

Data driven background subtraction

Reference spectra for the signal and the background are fitted to data as a function of the TRD classifier for different cuts on the ECAL BDT estimator



Measurement is performed for the cut on the ECAL classifier that minimizes the overall statistical + systematic uncertainty

The flux measurement

$$\Phi(\mathrm{E},\mathrm{E}+\Delta\mathrm{E}) = \frac{N_{obs}(\mathrm{E},\mathrm{E}+\Delta\mathrm{E})}{\Delta E\,\Delta T_{\mathrm{exp}}\,A_{\mathrm{eff}}\,\epsilon_{\mathrm{trig}}}$$

Φ = Absolute differential flux (m^{-2} sr^{-1} GeV^{-1})
N_{obs} = Number of observed events
ΔT_{exp} = Exposure time (s)
A_{eff} = Effective acceptance ($m^2 sr$)
E_{trig} = Trigger efficiency

If the control of N_{obs} (i.e. rejection of the background) is important for the flux measurement, the control of the detector acceptance (geometrical one + efficiencies), $A_{eff}\varepsilon_{trig}$, is important at the same level

Detector acceptance

The detector acceptance has been evaluated using a dedicated MC

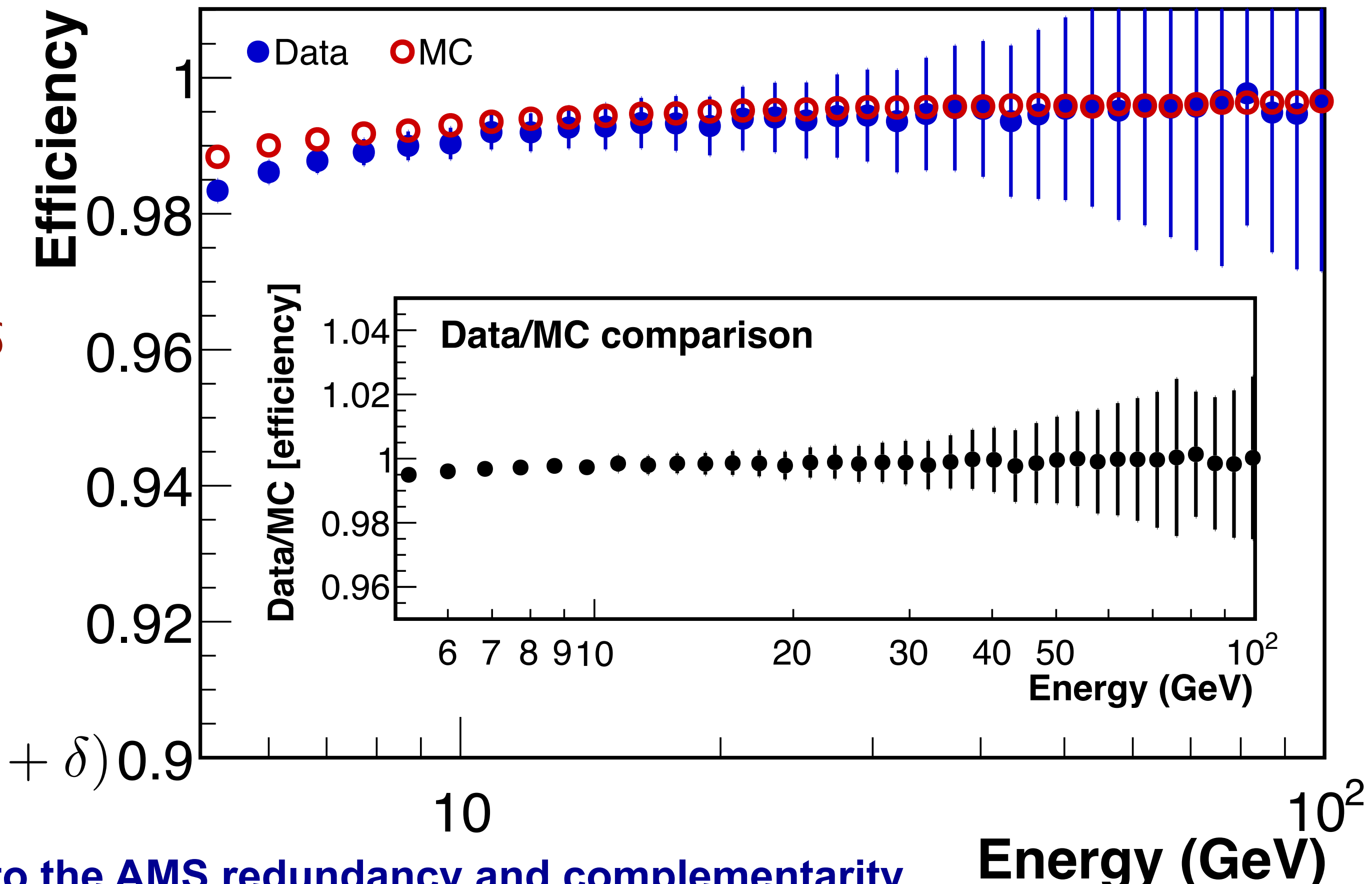
Data driven correction evaluated from the comparison of each selection cut efficiency on ISS data and MC sample

- Data/MC ratio on all cuts used to evaluate δ
- The tiny deviation from unity contributes to the measurement systematic uncertainty

$A_{geom} \sim 550\ cm^2 sr$

$$A_{eff} = A_{geom}\, \varepsilon_{sel} (1 + \delta)$$

Example : TRD acceptance + quality cut



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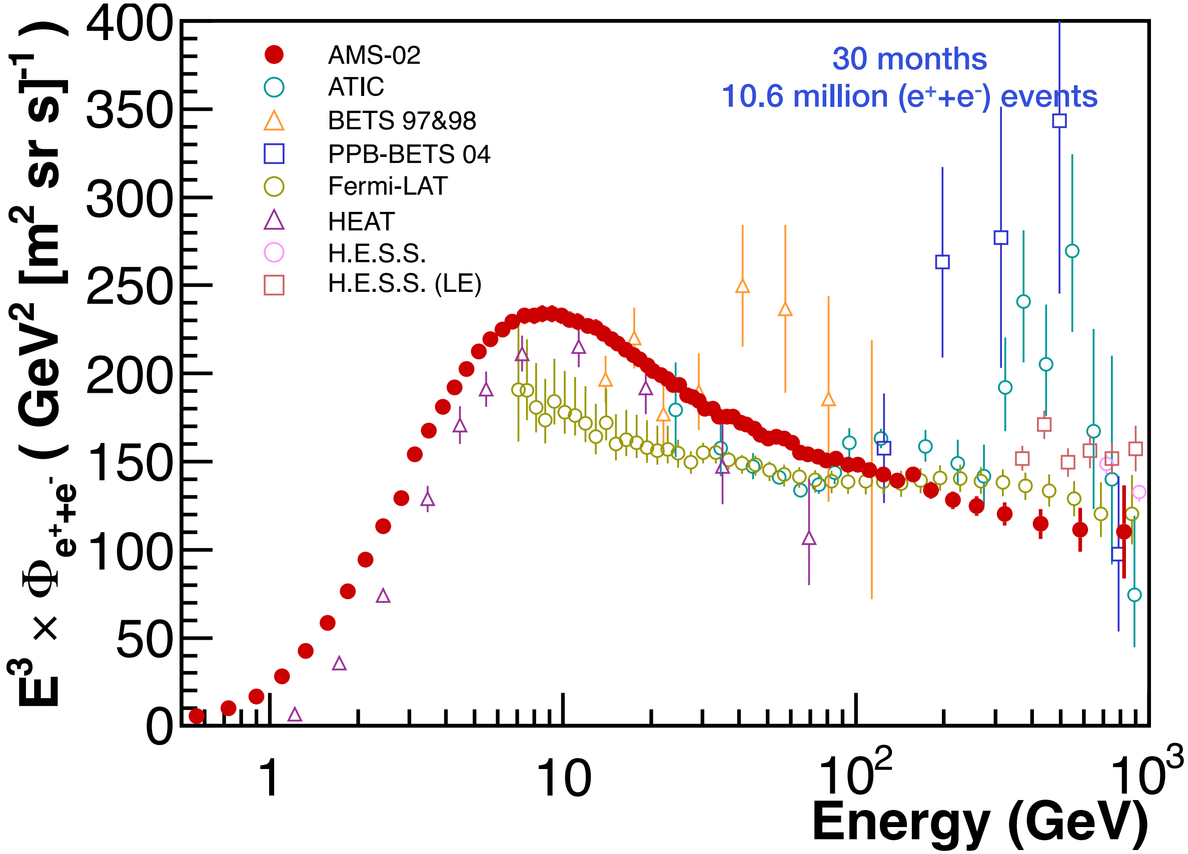
Results

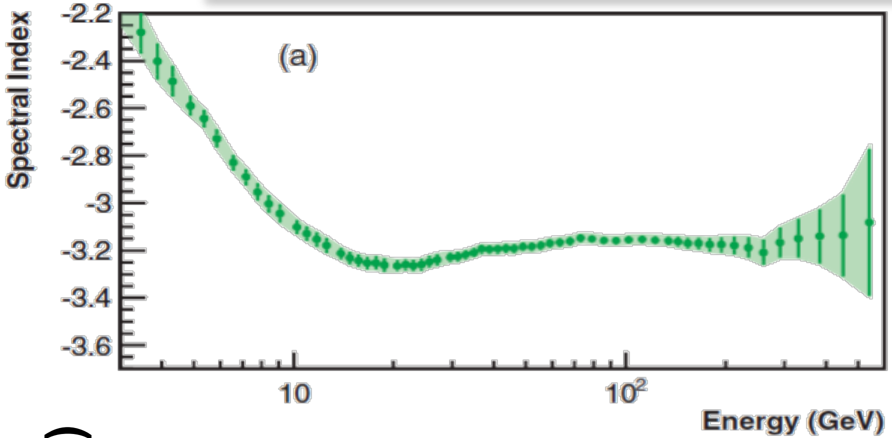
Electron+positron flux (PRL 113, 221102 - 2014)

PRL 113, 221102 (2014) PHYSICAL REVIEW LETTERS week ending 28 NOVEMBER 2014

Precision Measurement of the $(e^+ + e^-)$ Flux in Primary Cosmic Rays from 0.5 GeV to 1 TeV with the Alpha Magnetic Spectrometer on the International Space Station

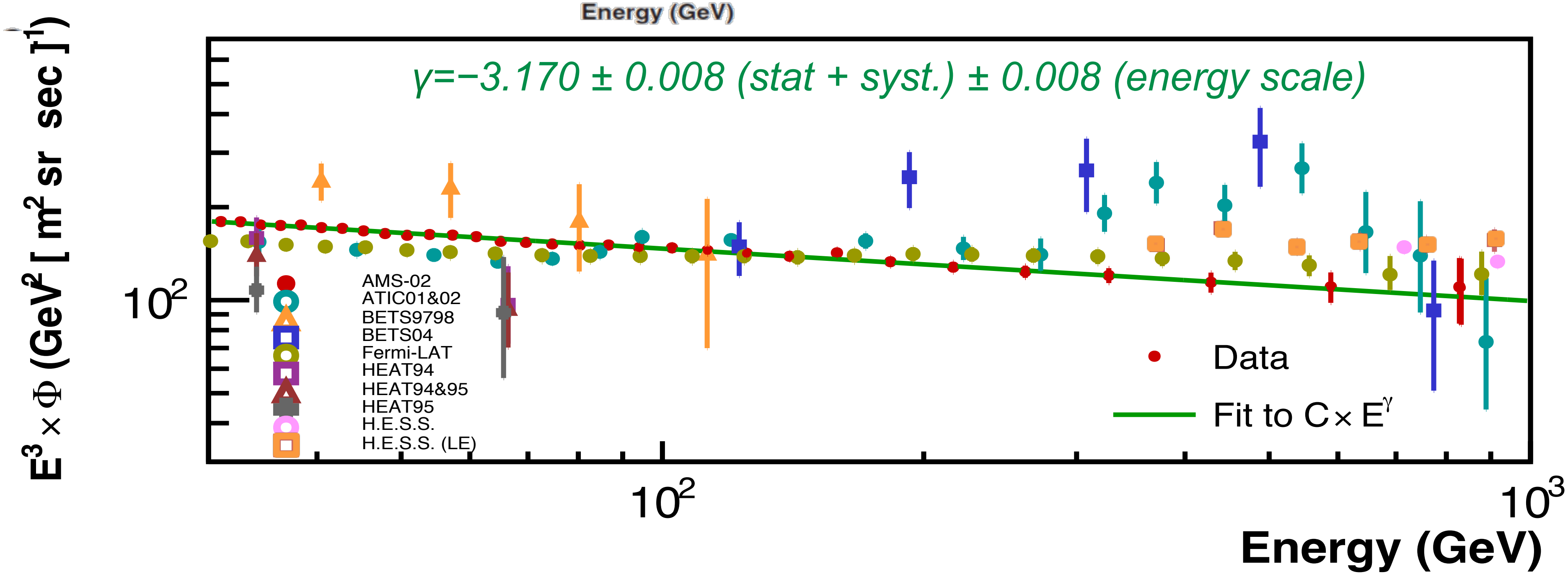


Electron+positron spectral features



The flux:

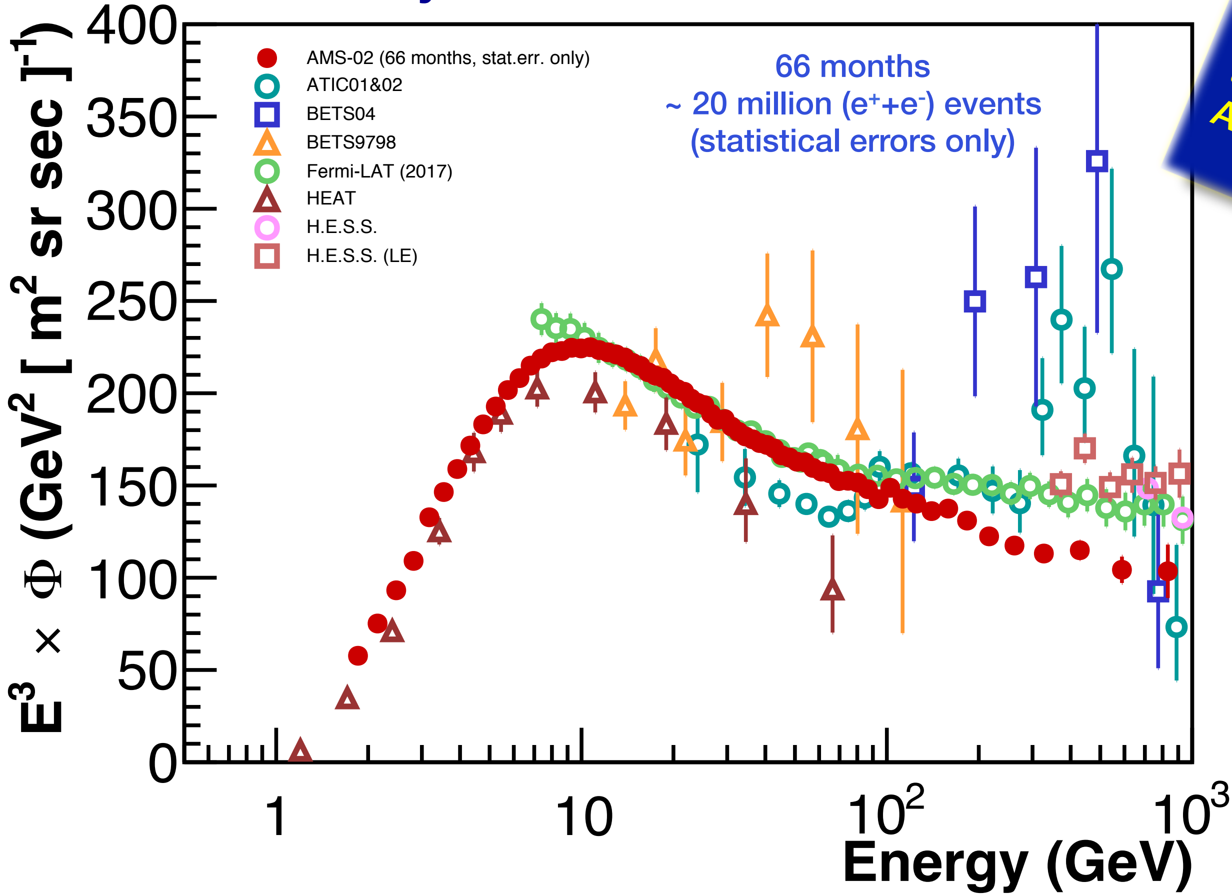
- is **smooth** and show **no structures**
- cannot be described by a single power law in the whole energy range
- is consistent with a **single power law above ~30 GeV**



Updated (Nov. 2016) electron+positron flux

The analysis is being updated: more statistics and even lower systematics.

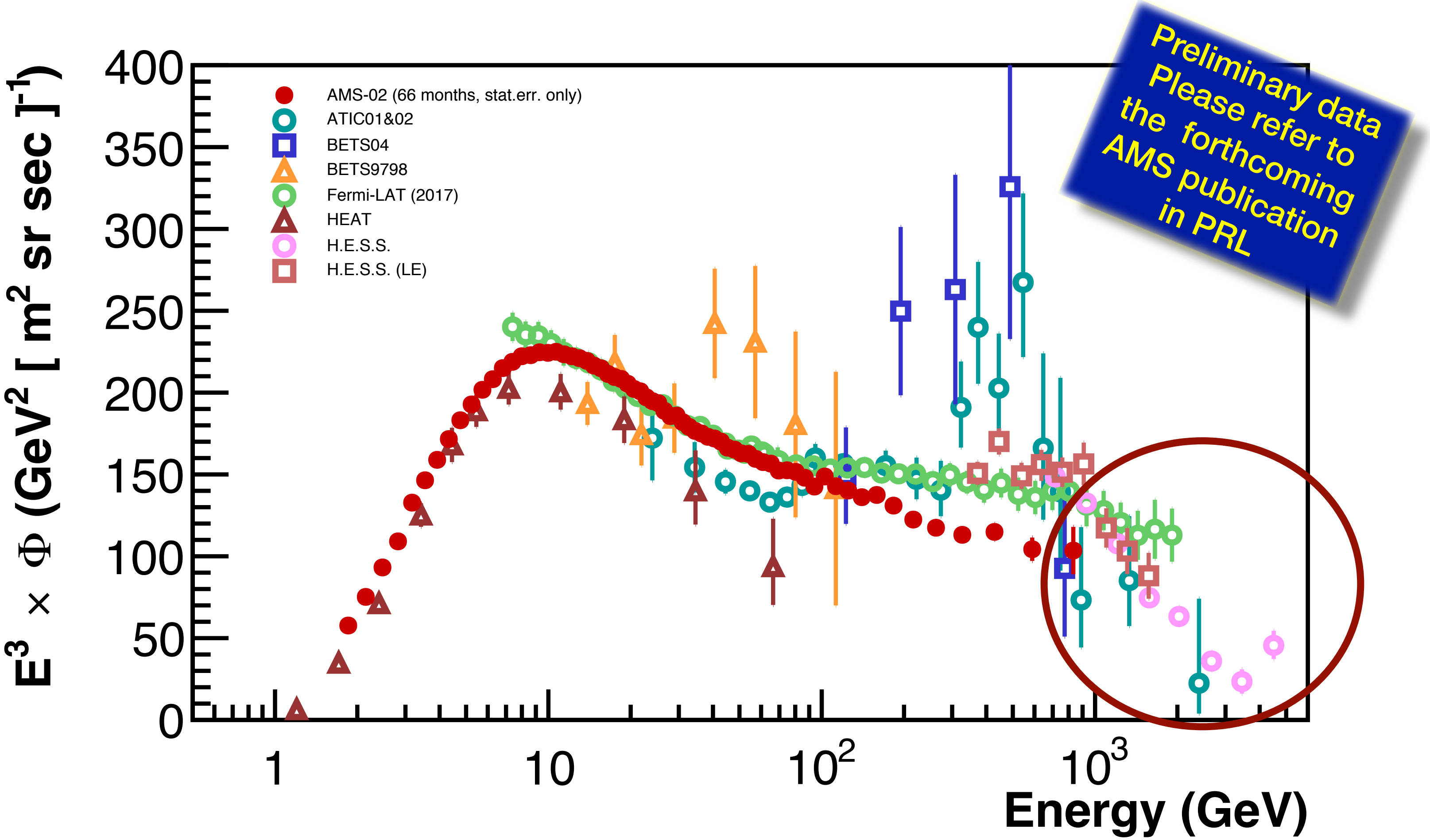
We already collected ~ 75 months of data



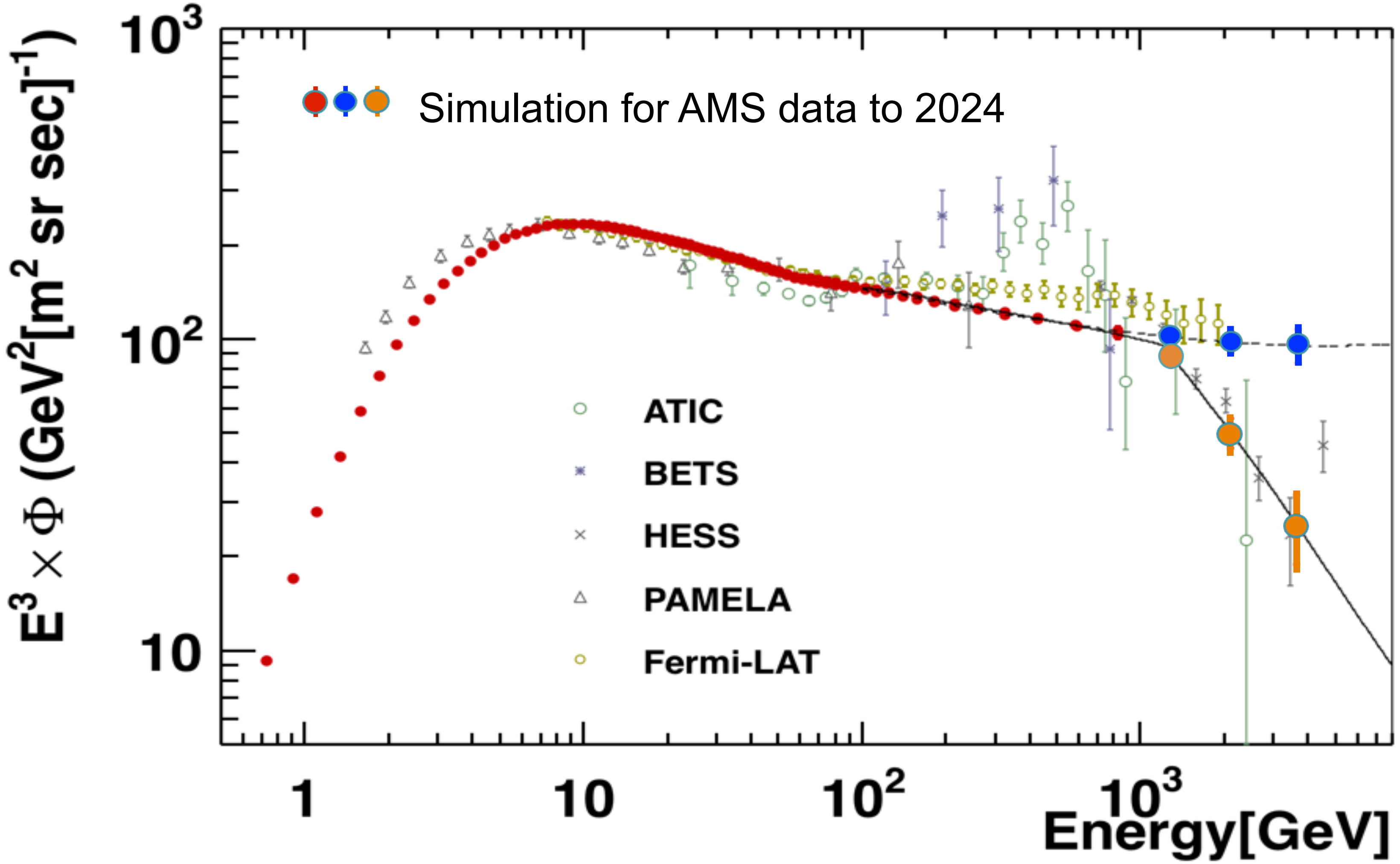
Preliminary data
Please refer to the forthcoming AMS publication in PRL

…next step

…study the ultra-TeV region and investigate the presence of the drop



AMS capability in 2024

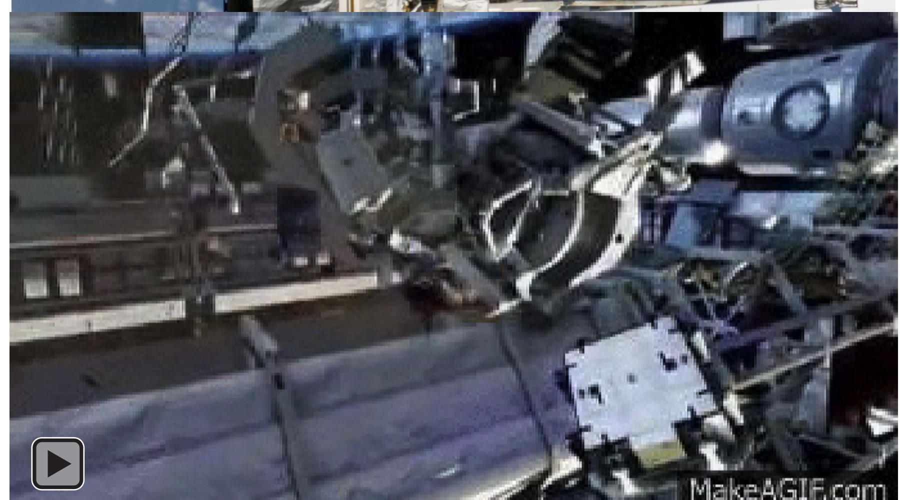


Conclusions

• Thanks to redundancy and complementarity, AMS-02 is able to measure the electron and positron flux, keeping well under control the systematics

• Since the publication (Dec. 2014), the experiment more than doubled the collected statistics: the work to fully update the result is on-going

• The collected statistics up to the conclusion of the mission (i.e. the conclusion of the ISS), will allow to better constrain the models



Stay tuned!


AMS-02
STS Crew Wake
AMS Event Display
STS-134
AMS Tracker
AMS Lead
BFCR 7
Chips Ahoy!