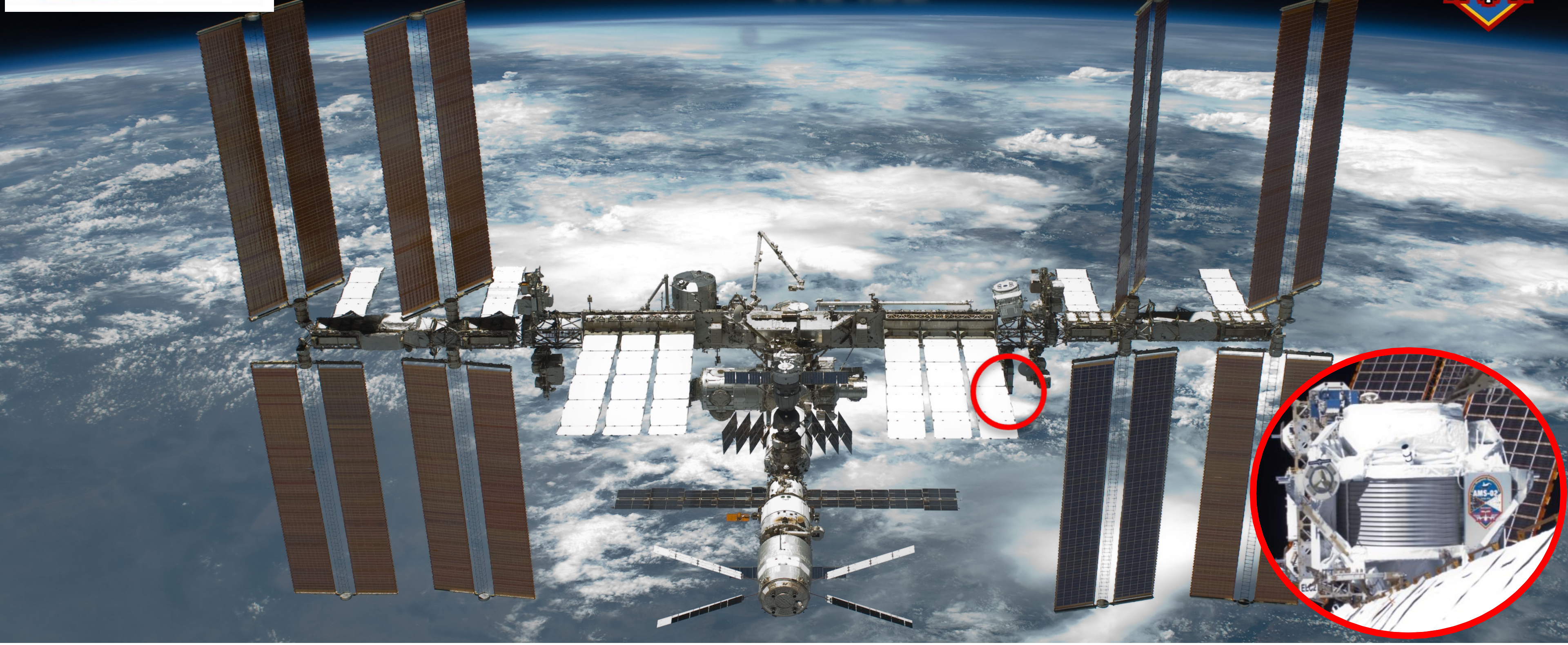
Electron and positron fluxes in primary cosmic rays measured with the AMS-02 detector on the ISS



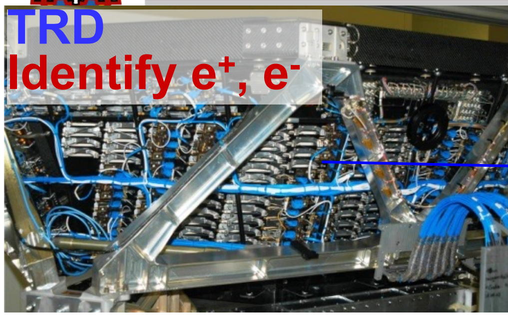
Matteo Duranti

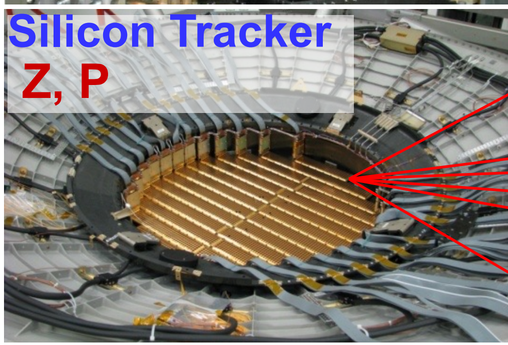
INFN Sez. Perugia

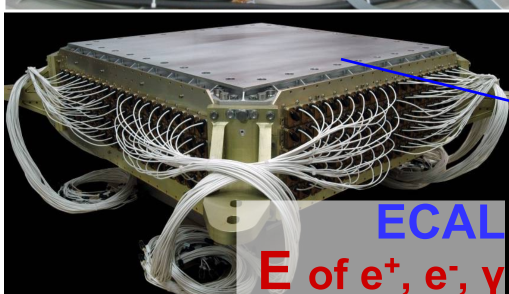
on behalf of the AMS Collaboration

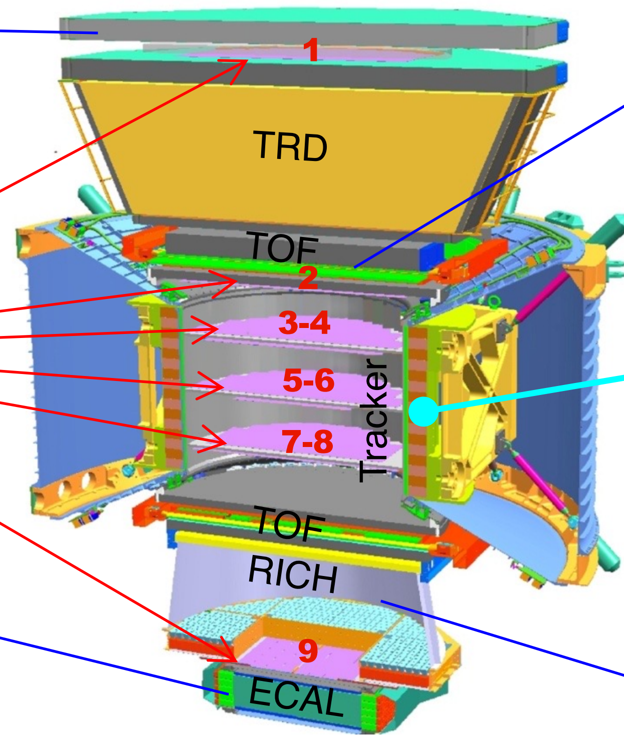
A precision, multipurpose, TeV spectrometer

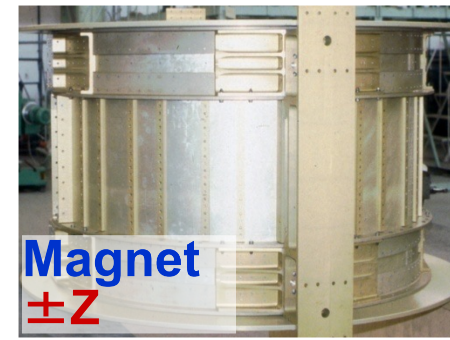
***Z, P* are measured independently by the Tracker, RICH, TOF and ECAL**

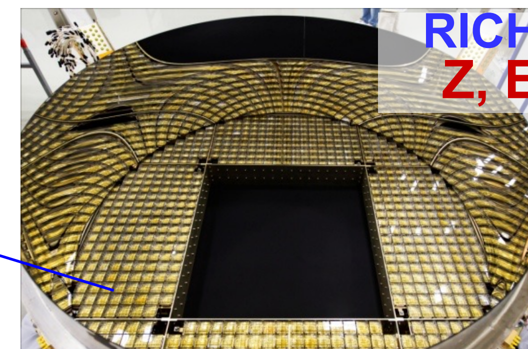




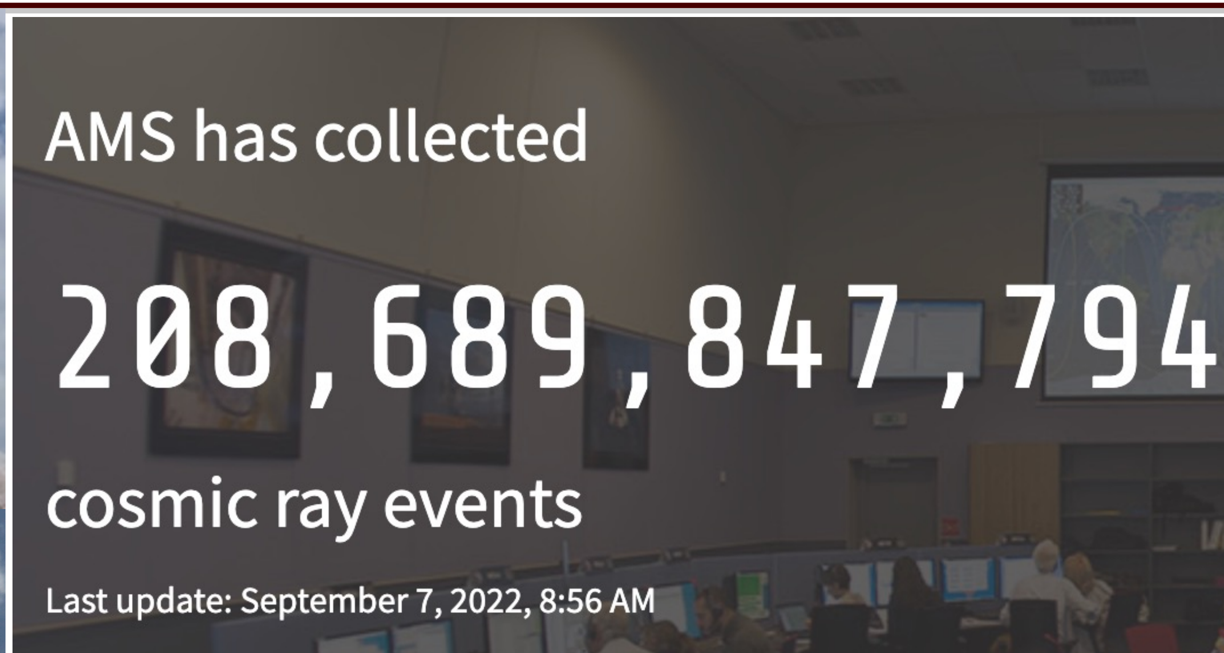








A precision, multipurpose, TeV spectrometer



The challenge of positrons and electrons at high energy

In this talk we'll:

- quickly highlight the major challenges of the high energy e^+ and e^- measurements

- discuss the power of a multi-purpose complete and redundant detector like AMS

Key requirements

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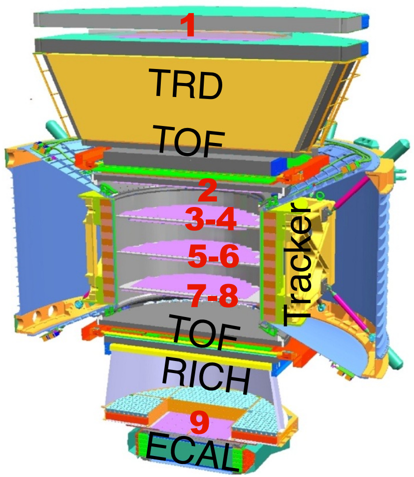
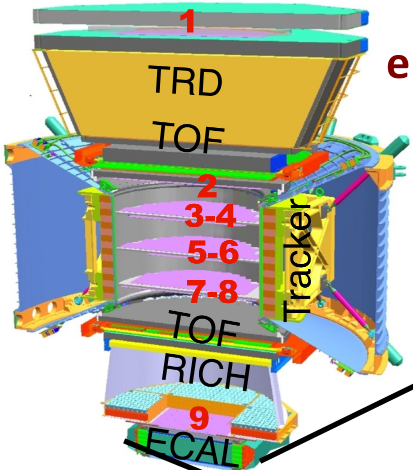
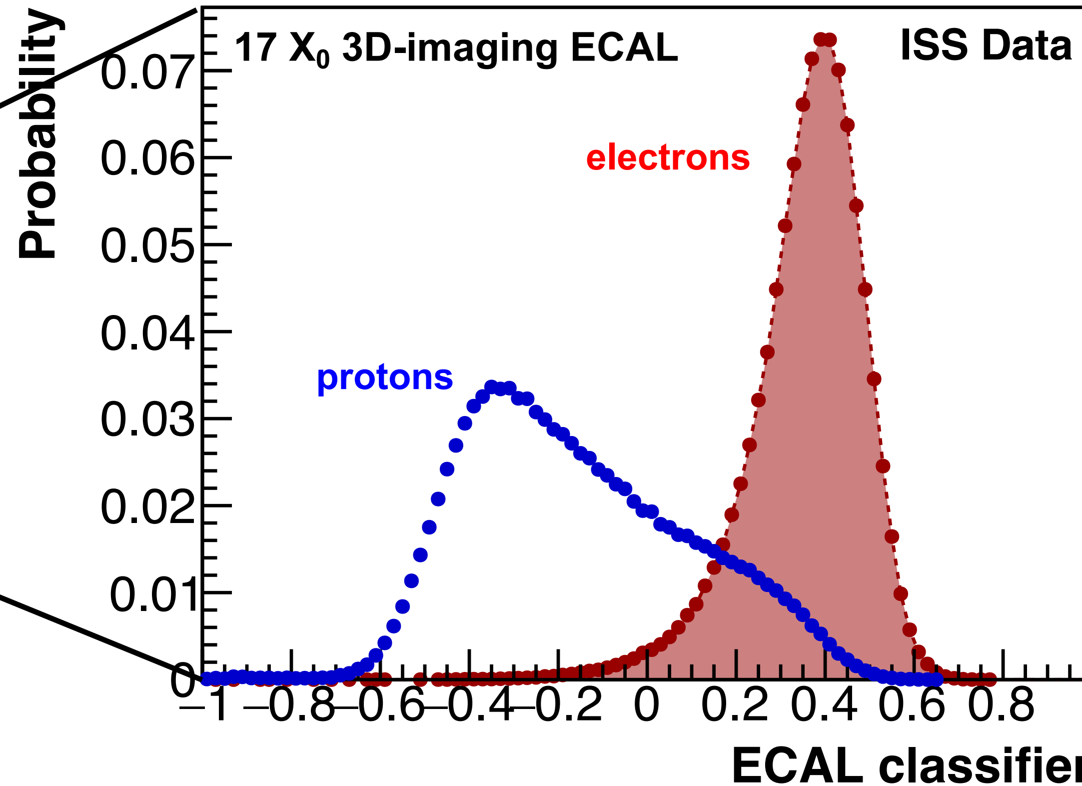
⇒ Redundancy and Complementarity!



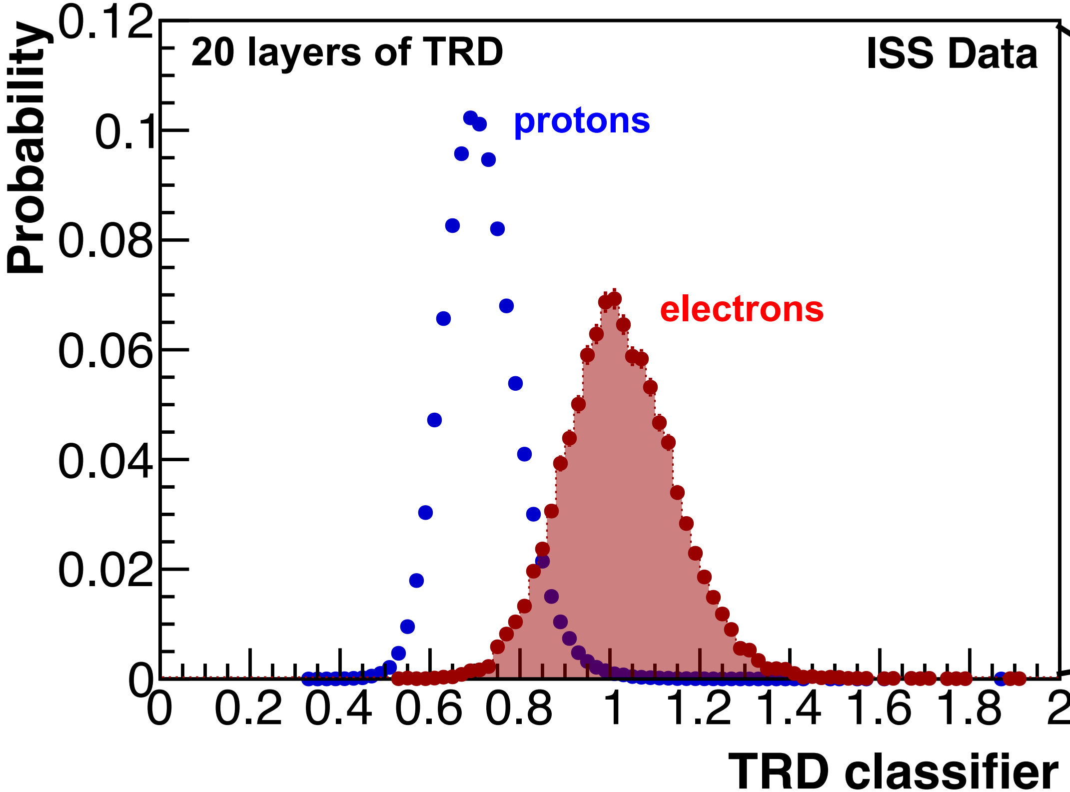
e/p separation: ECAL

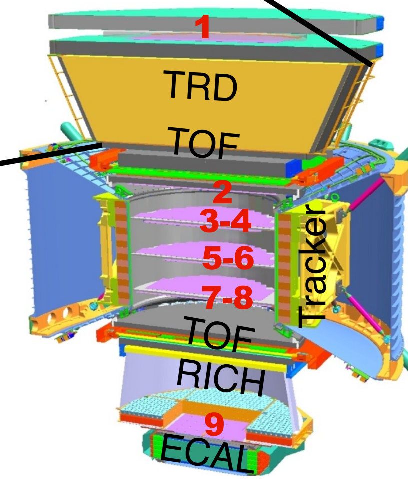
Exploring the shower topological differences between hadronic and electromagnetic particles, is possible to obtain an e/p separation up to 10^5





e/p separation: TRD



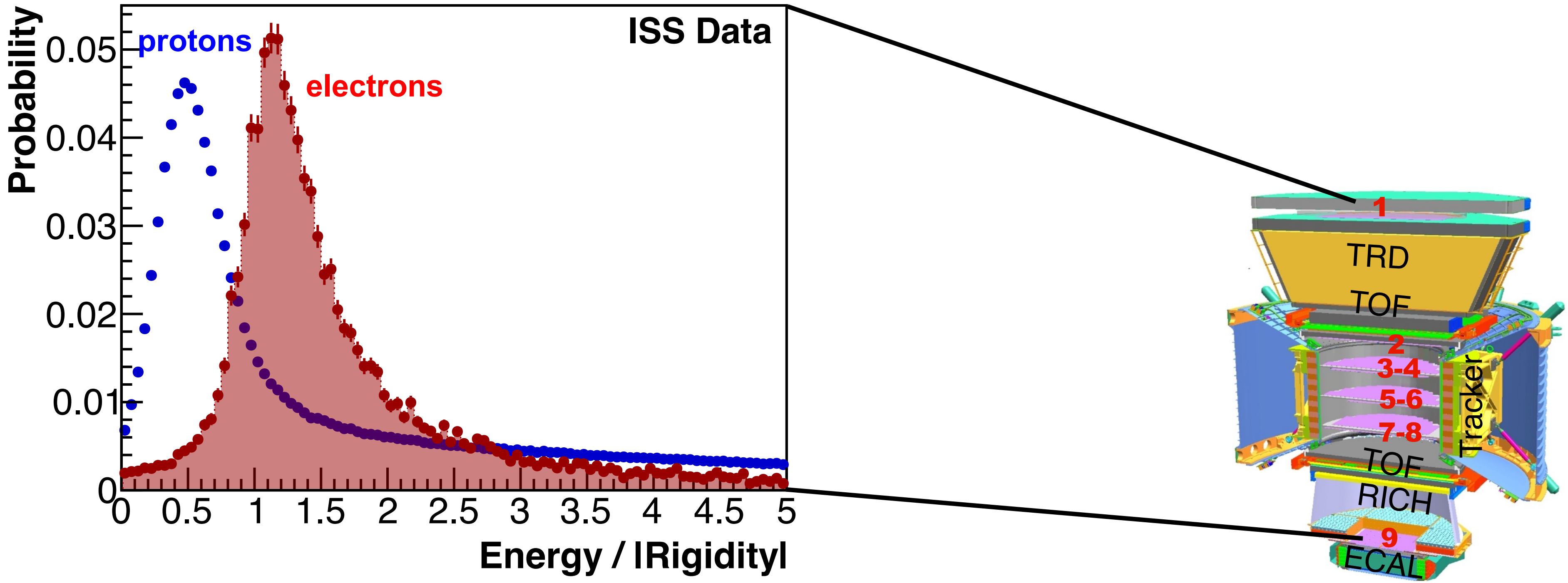


Thanks to the different energy deposits of light and heavy particles, the TRD is capable to achieve an e/p separation up to 10^4

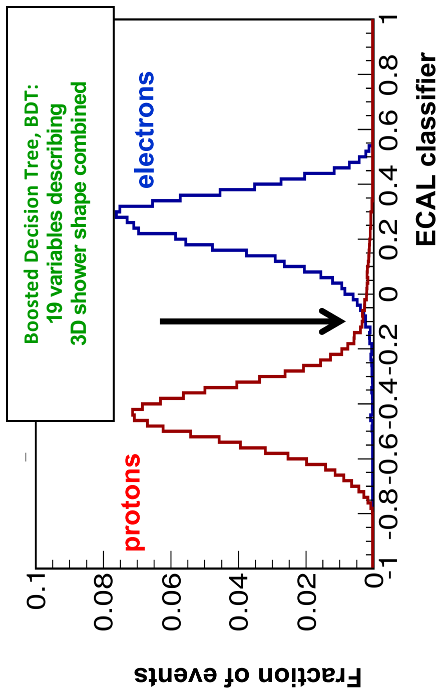
e/p separation: Tracker+ECAL

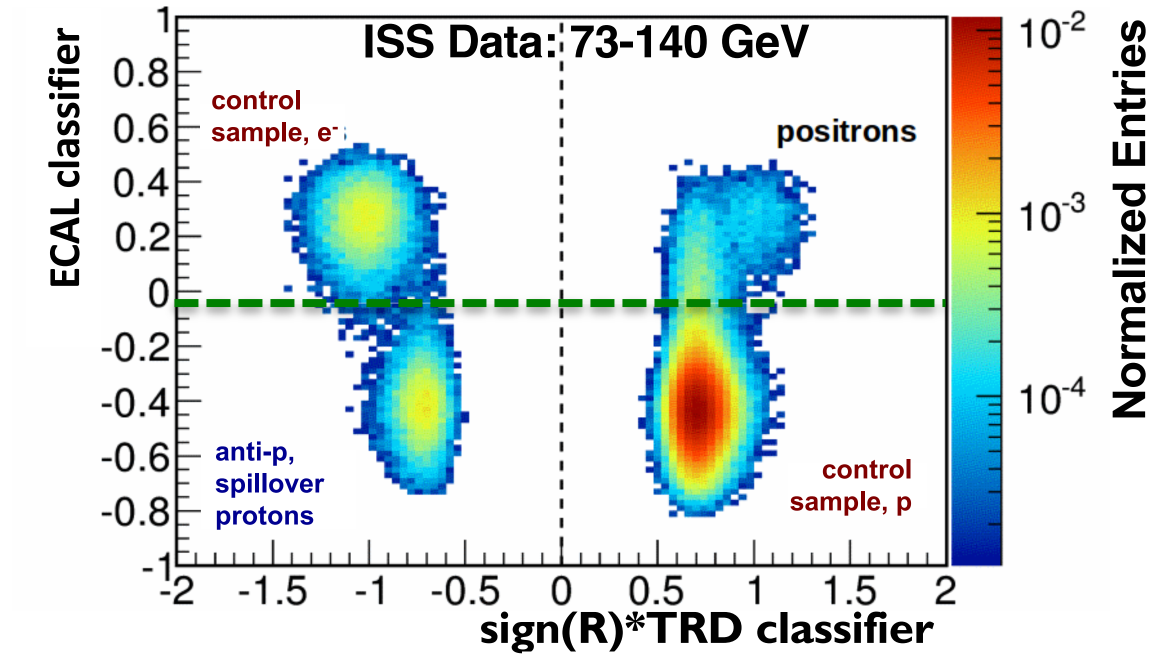
Additional e/p discrimination is achieved by the comparison of the ECAL calorimetric energy and Tracker spectrometric rigidity measurements.

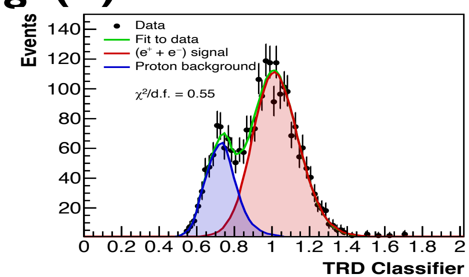
Given the natural abundances of p^+, p^-, e^- and e^+, even a selection only based on the <u>sign of the Rigidity</u> is possible to obtain quite pure sample of p^+ and e^-



e/p separation: redundancy and complementarity



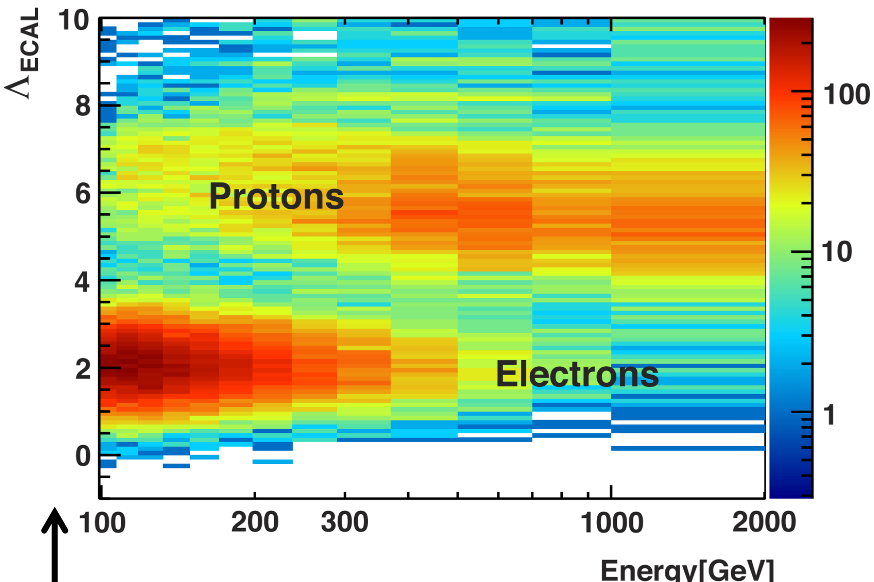




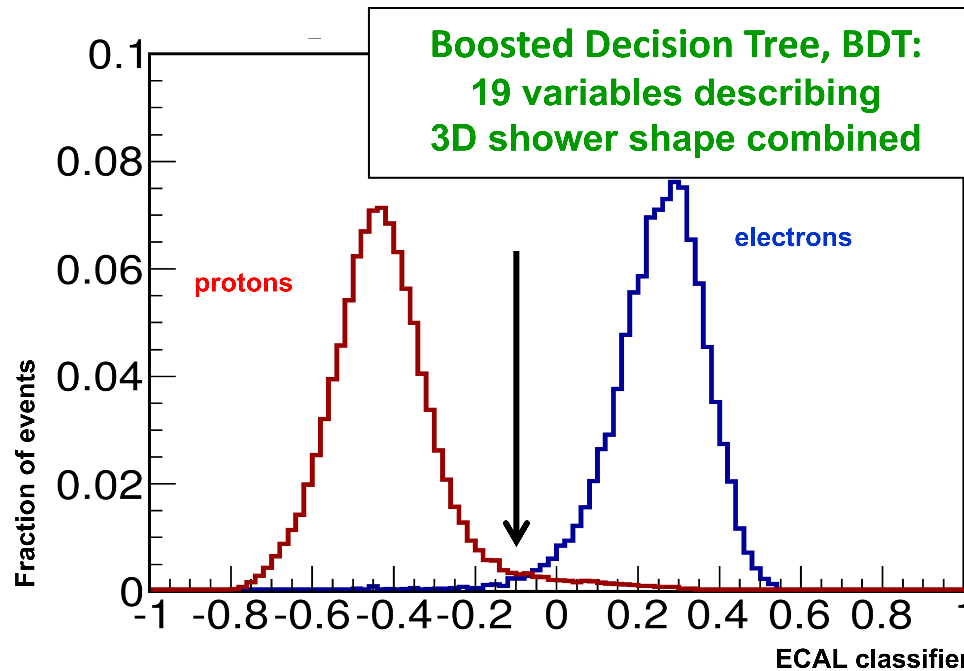
By combining different sub-detectors is possible to easily distinguish the different components

Proton background rejection

NIM-A A 869 110–117 (2017)



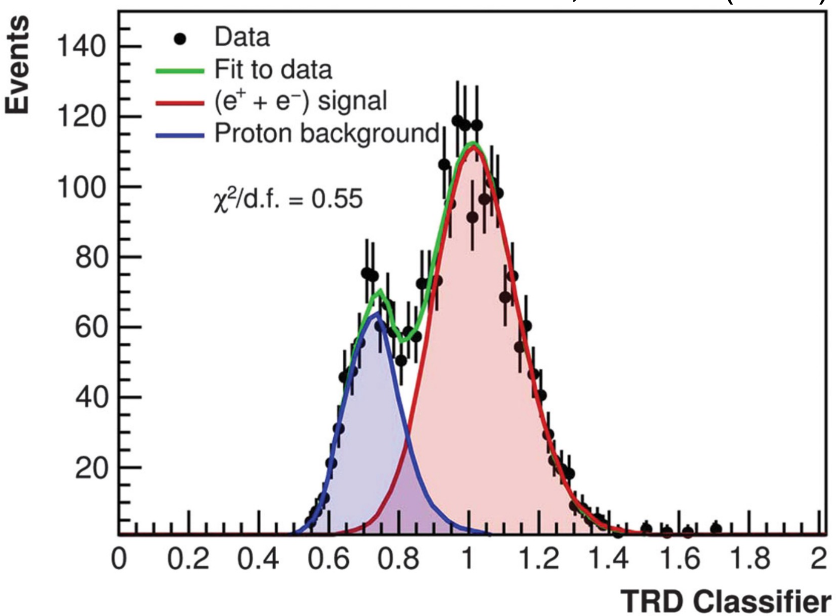
Tipically the strategy is:
- remove the bulk of background by means of ECAL



In the years the collaborations improved the tools:
- BDT used for the first measurements
- Likelihood developed for the ultra-TeV analyses

Proton background rejection

PRL 113, 221102 (2014)



- template fit the residual background with TRD

Tipically the strategy is:
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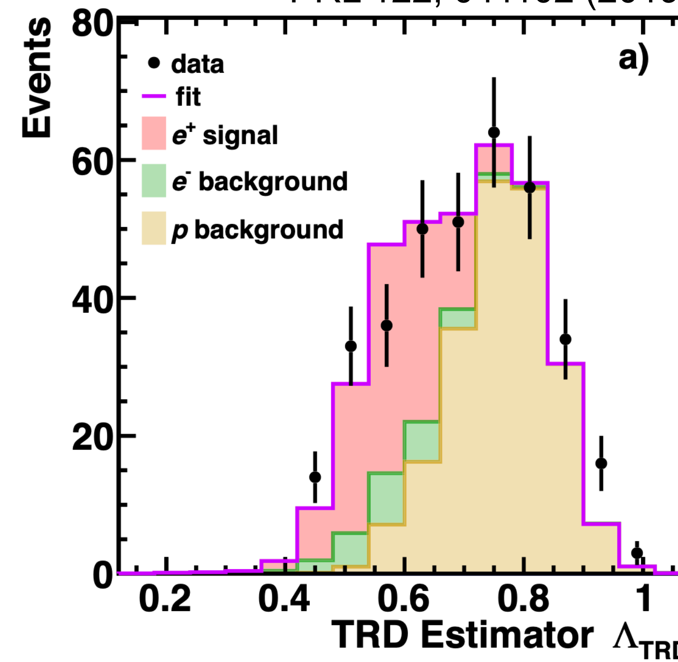
PRL 122, 041102 (2019)



Key requirements – high energy positrons

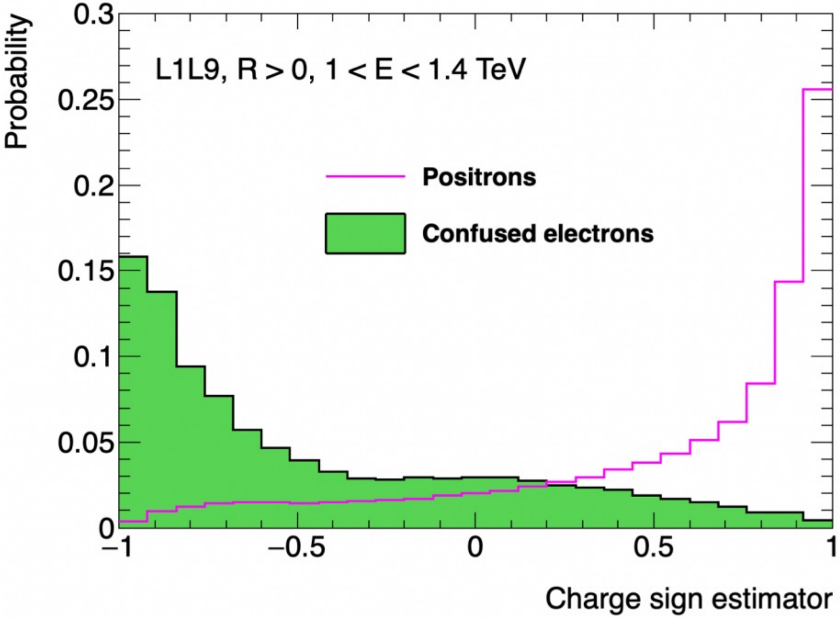
In the e^+ measurement, the key requirements of the detector/experiment are:

- **rejection of the large background (mainly protons, $p/e^+ > 10^3$);**

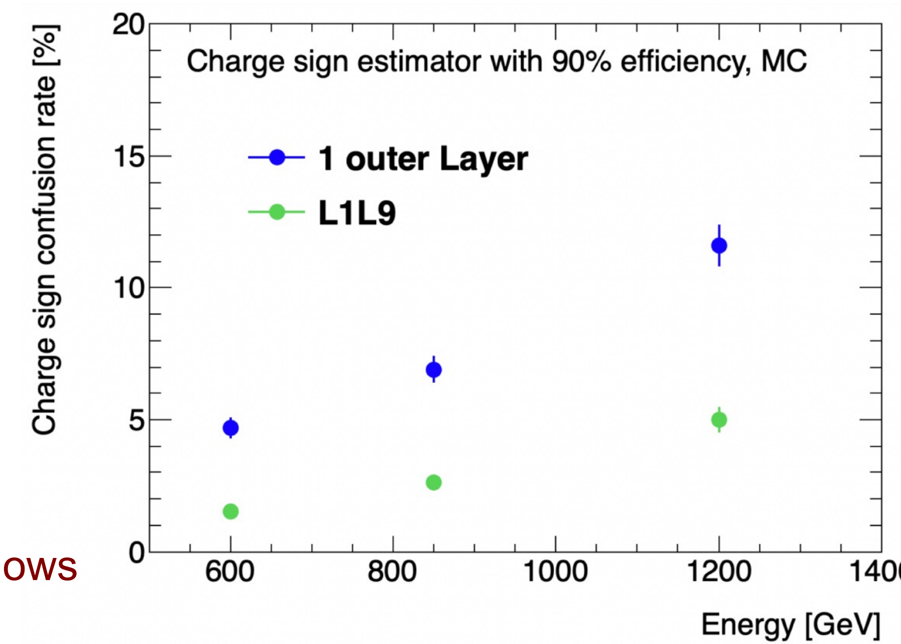
- **rejection of the charge-confused electron background;**

→ as the energy increases, these requirements become more and more crucial

Charge Confusion control



Parameters from track fits (χ^2, residuals, etc…), as well as information about E/P and charge measurement are used to built a BDT based Charge Sign Estimator and separate positrons from confused electrons



- Charge sign estimator allows to constrain charge sign confusion rate below 12% at TeV energy for track configuration "at least 1 outer layer"
- Requirement for hits on track in both L1 and L9 allows to significantly decrease charge sign confusion rate

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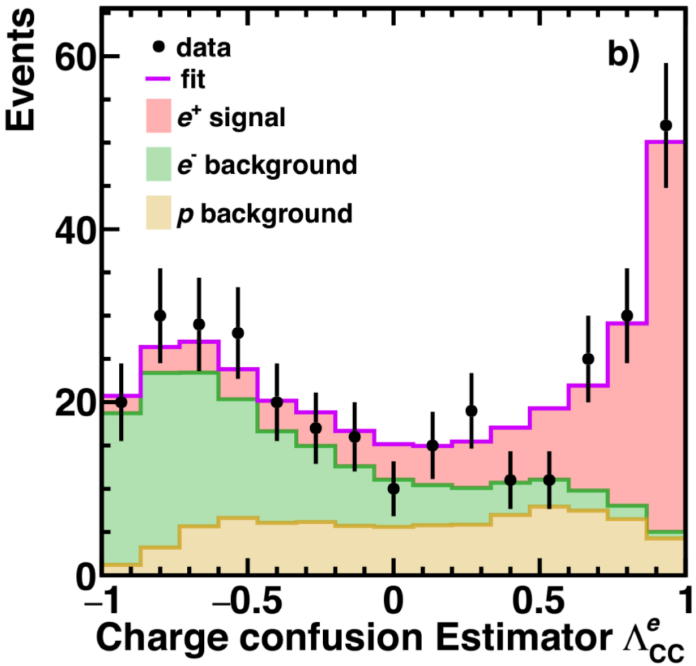

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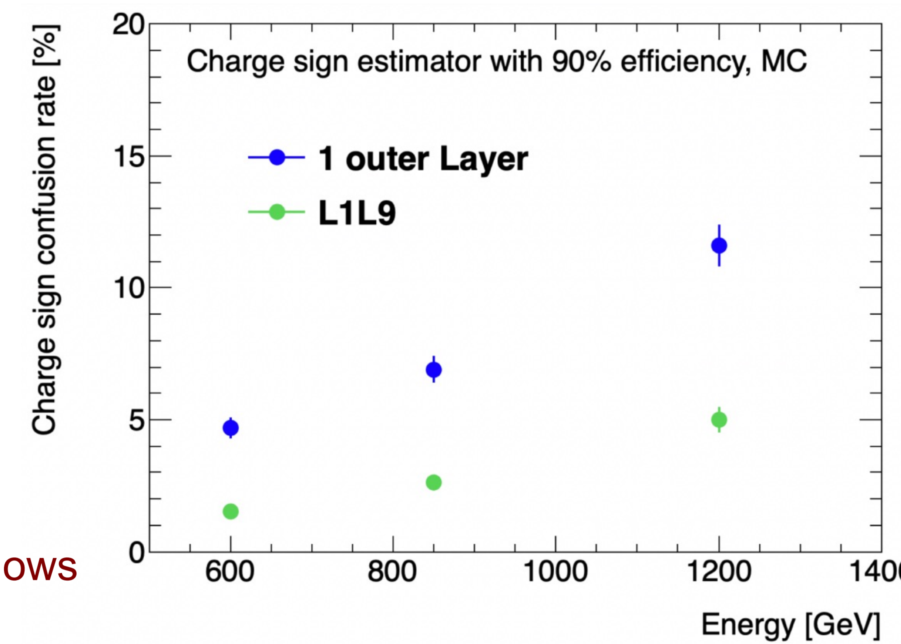

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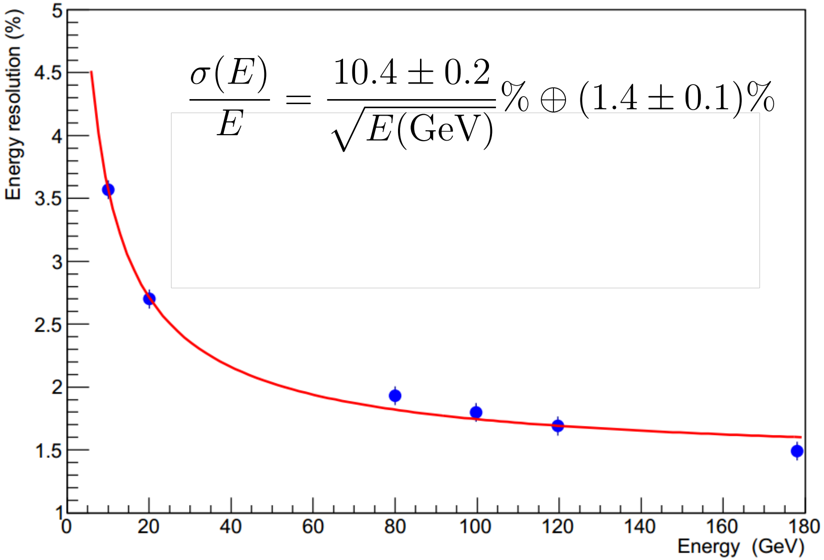
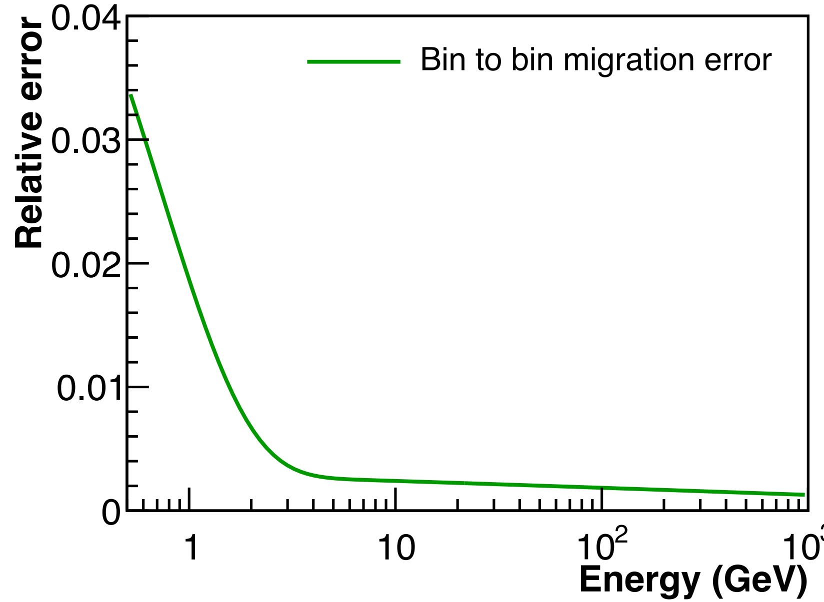
Energy resolution





The excellent energy resolution of ECAL results in a negligible effect of on the measurement error above few GeVs.

Detector acceptance and efficiency control

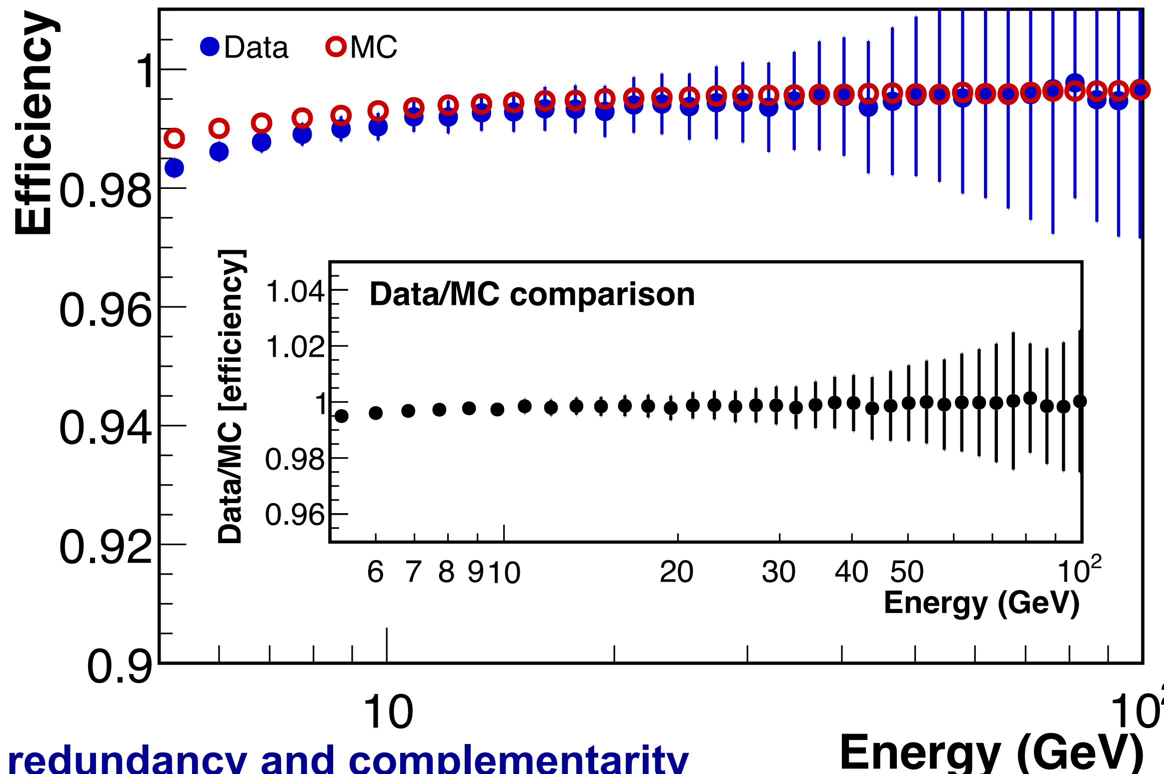
The detector acceptance has been evaluated using a dedicated MC simulation

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

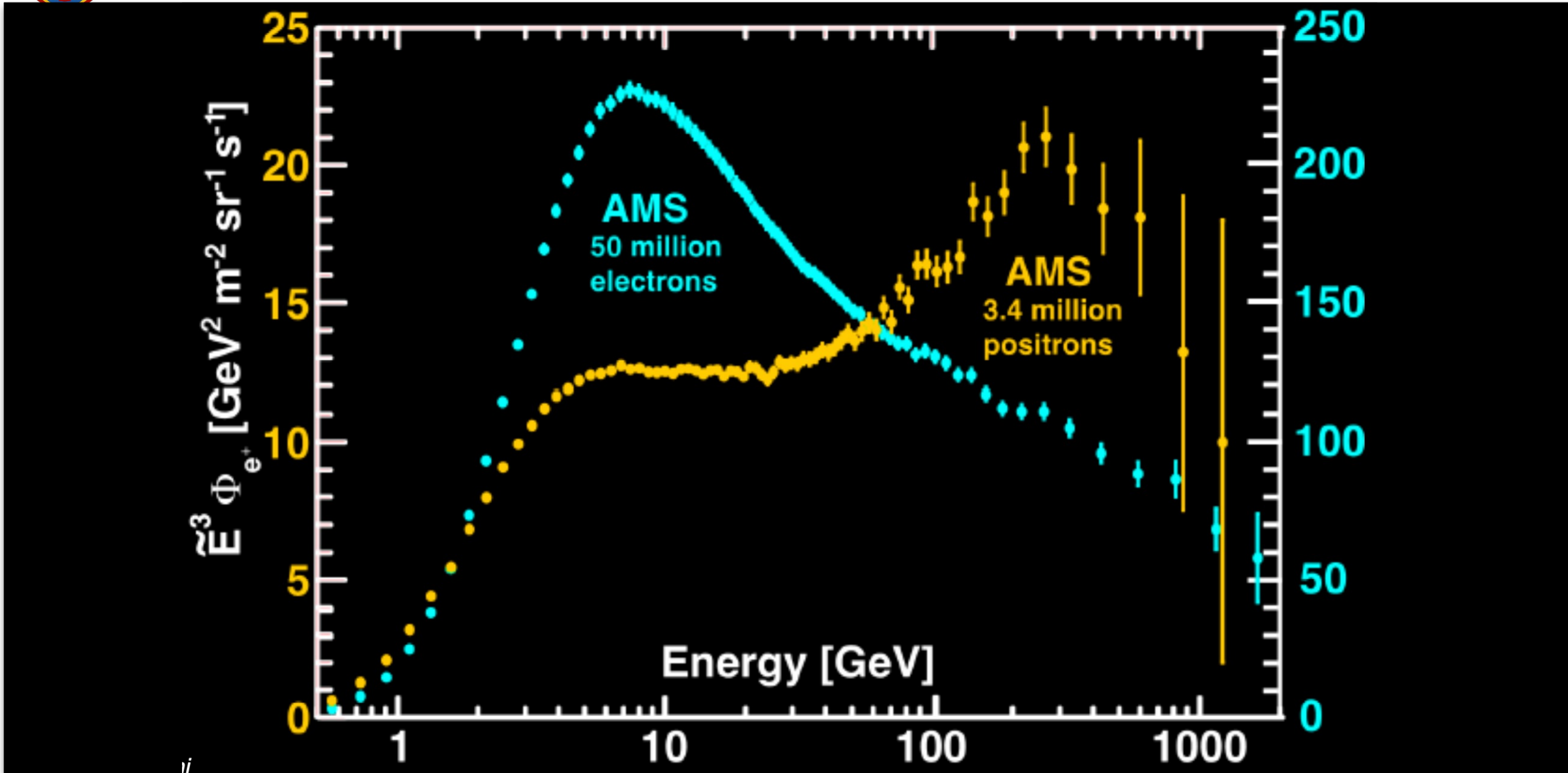
$$A_{eff} = A_{geom}\,\varepsilon_{sel}(1+\delta)$$

Example : TRD acceptance + quality cut



This is possible thanks to the AMS redundancy and complementarity

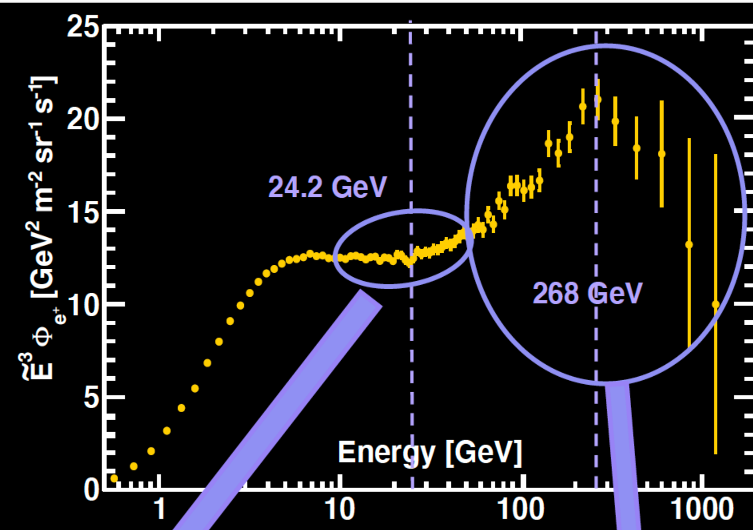
Positrons and electrons

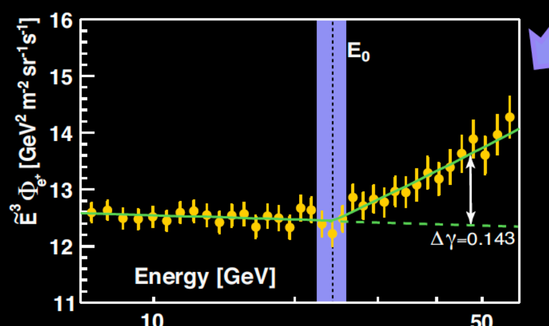


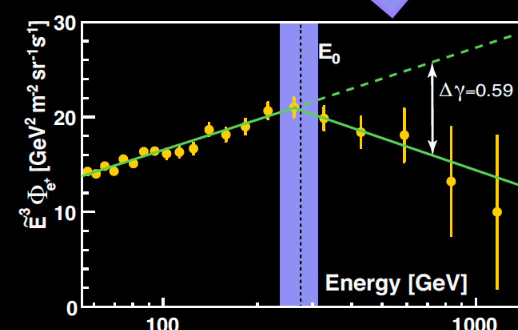
Positrons

Fits of the data to

$$\Phi_{e^+}(E) = \begin{cases} C\boldsymbol{E}^{\gamma}, & E \leq E_0; \\ C\boldsymbol{E}^{\gamma}(E/E_0)^{\Delta\gamma} & E > E_0. \end{cases}$$







7.8σ excess above $E_0 = 24.2 \pm 1.1$ **GeV**

4.8σ sharp drop-off at $E_0 = 268^{+35}_{-33}$ **GeV**

Electrons

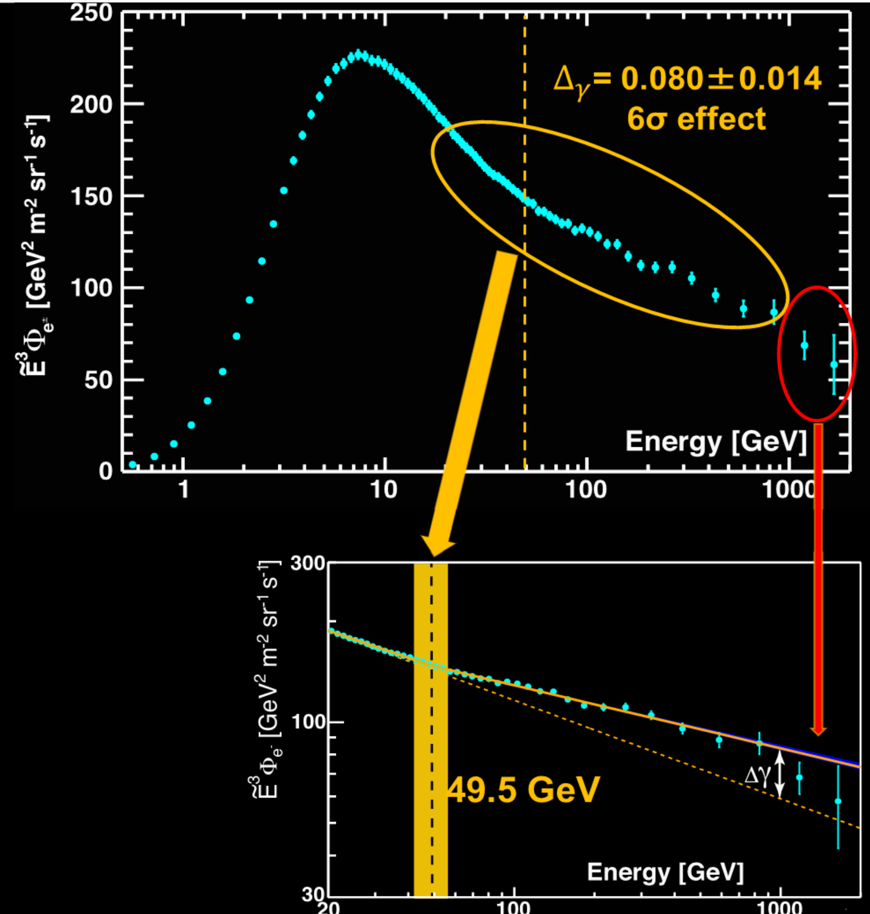
Traditionally, Cosmic Ray spectrum is described **by a power law function.**

Change of the behavior at **~50 GeV** and **at ~1 TeV**

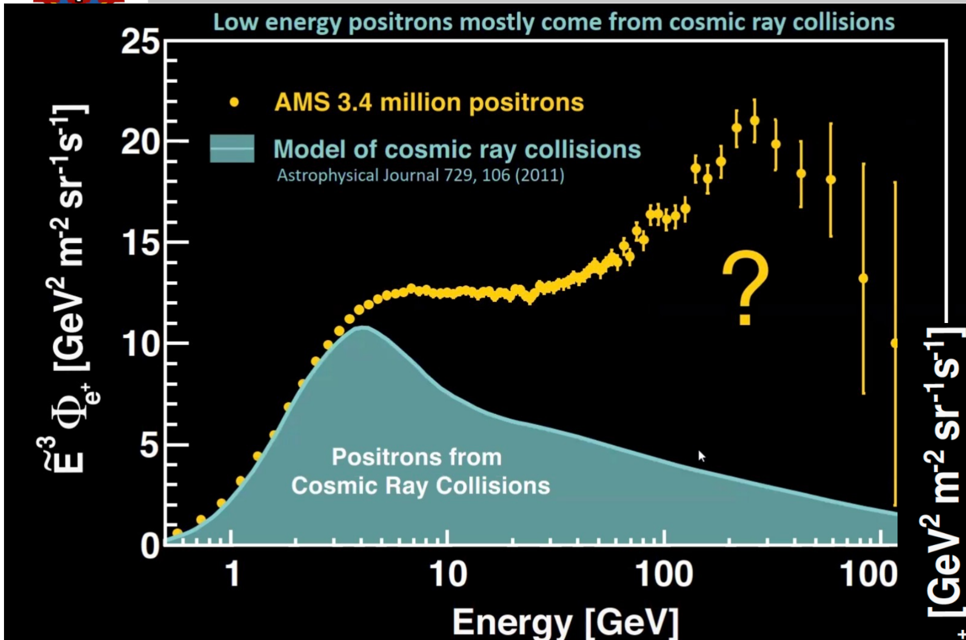
Fit to data

$$\Phi_{e^-}(E) = \begin{cases} CE^{\gamma}, & E \le E_0; \\ CE^{\gamma}(E/E_0)^{\Delta\gamma}, & E > E_0. \end{cases}$$

A significant excess at E_0 = 49.5 ± 5.6 GeV



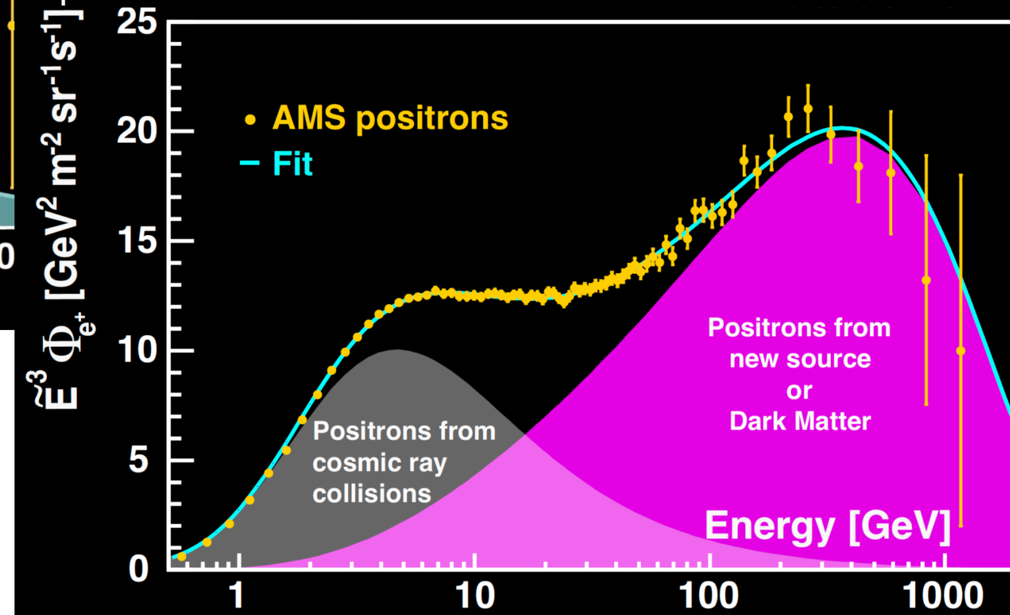
Positrons



The high energy origin of positrons and electrons is still debated

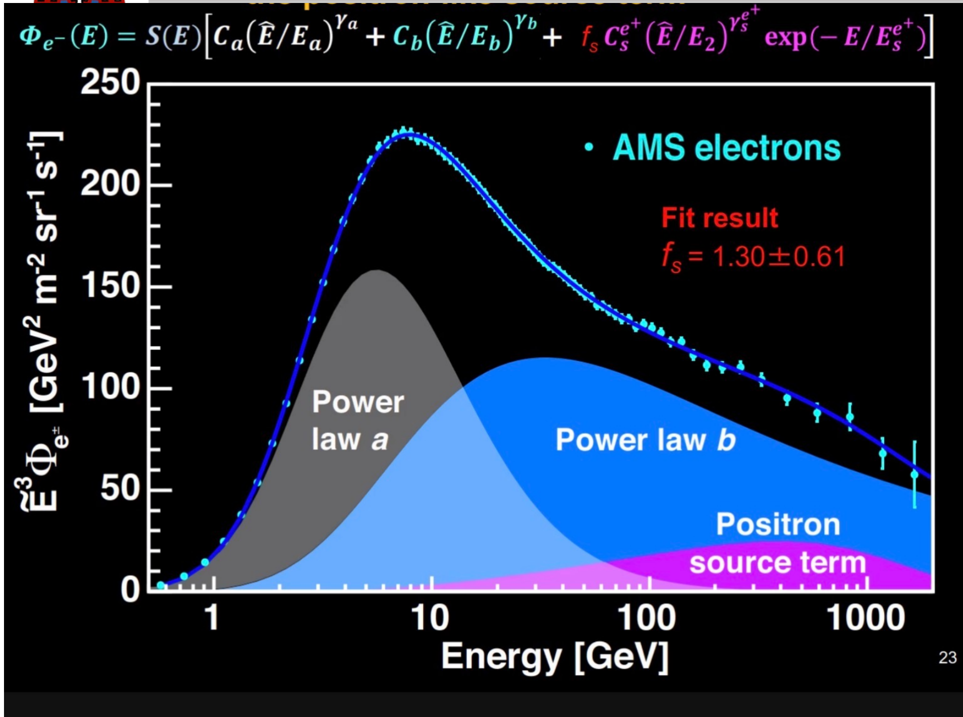
$$\Phi_{e^+}(E) = \frac{E^2}{\hat{E}^2}\left[C_d(\hat{E}/E_1)^{\gamma_d} + C_s(\hat{E}/E_2)^{\gamma_s}\exp(-\hat{E}/E_s)\right]$$

Collisions — Pulsars or Dark Matter



Understanding the high energy spectra is crucial to shed light on Dark Matter

Electrons and positrons



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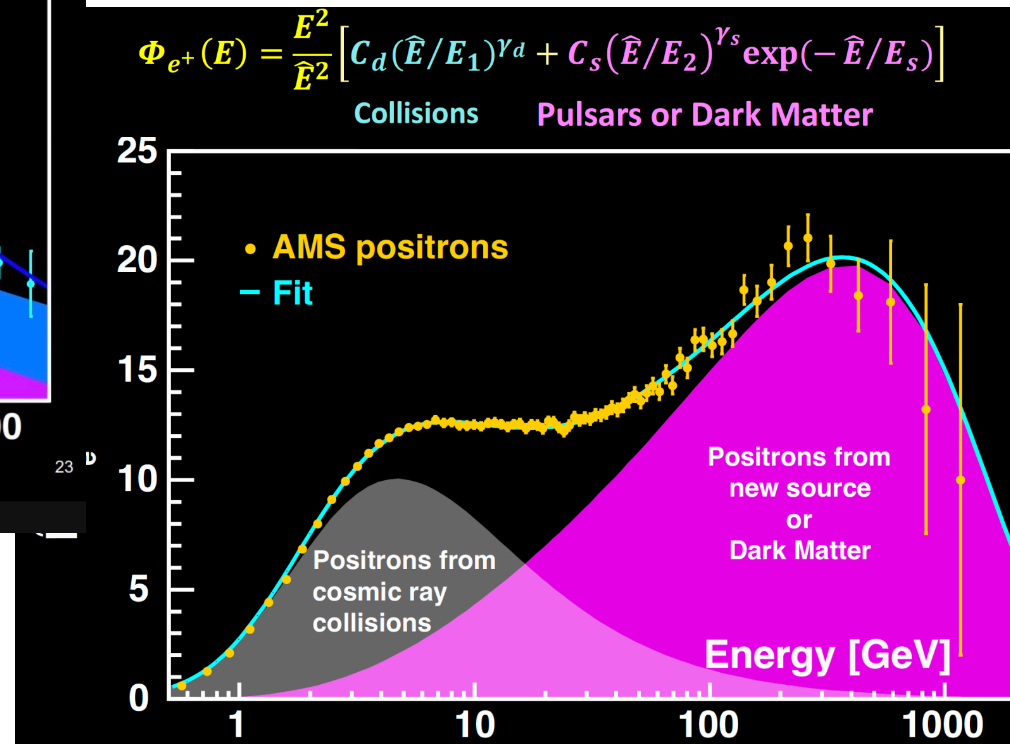


Understanding the high energy spectra is crucial to shed light on Dark Matter

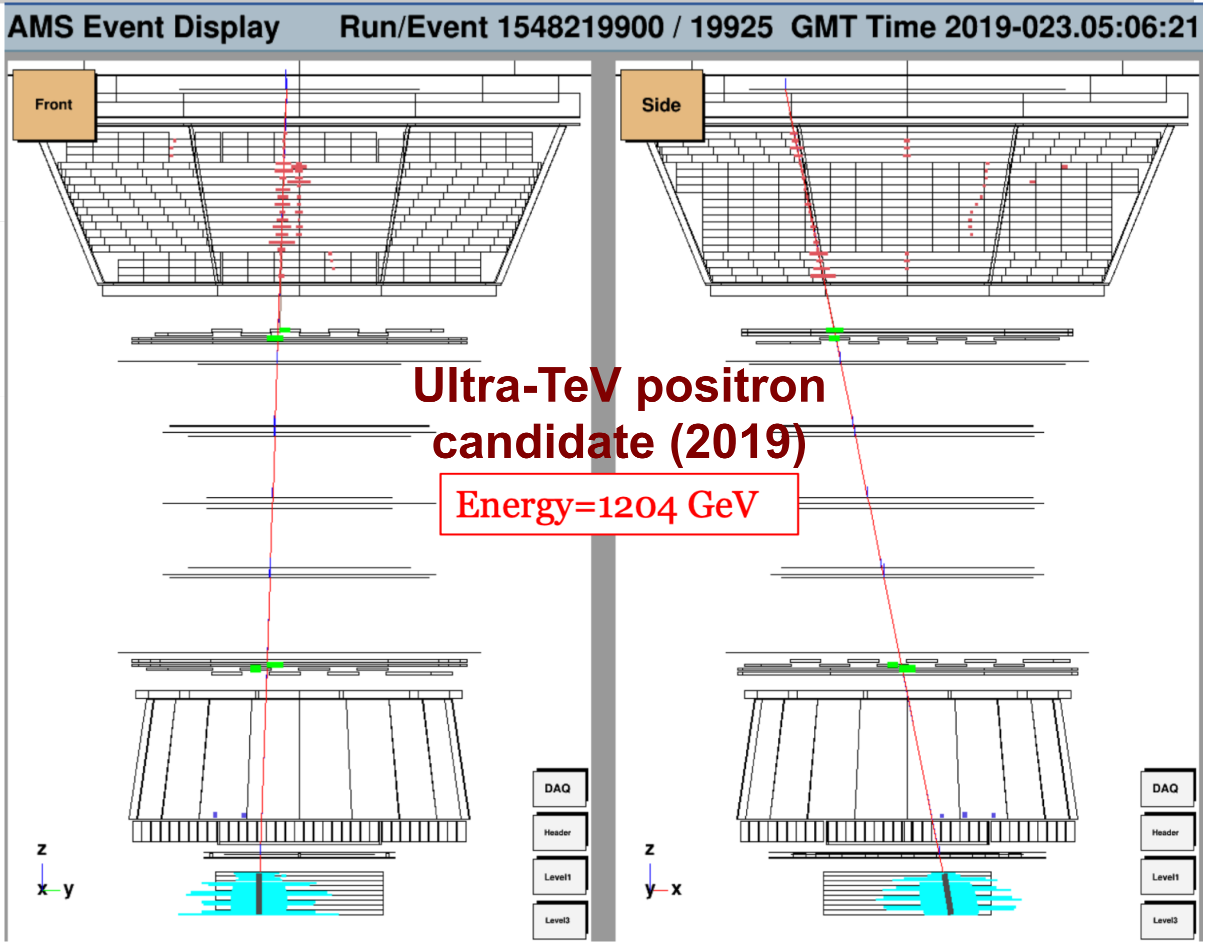
Conclusion

We presented the challenges, on the ultra-TeV positron and electron measurement:

• redundancy and complementarity is the key for ultra-TeV positron measurement

• pushing the electron and positron analysis to the highest energies is crucial to shed light on DM

• collecting more and more statistics will further improve the scientific gain




Stay tuned!
AMS-02
STS-134
AMS Lead
AMS Tracker
BFCR 7
Chips Ahoy