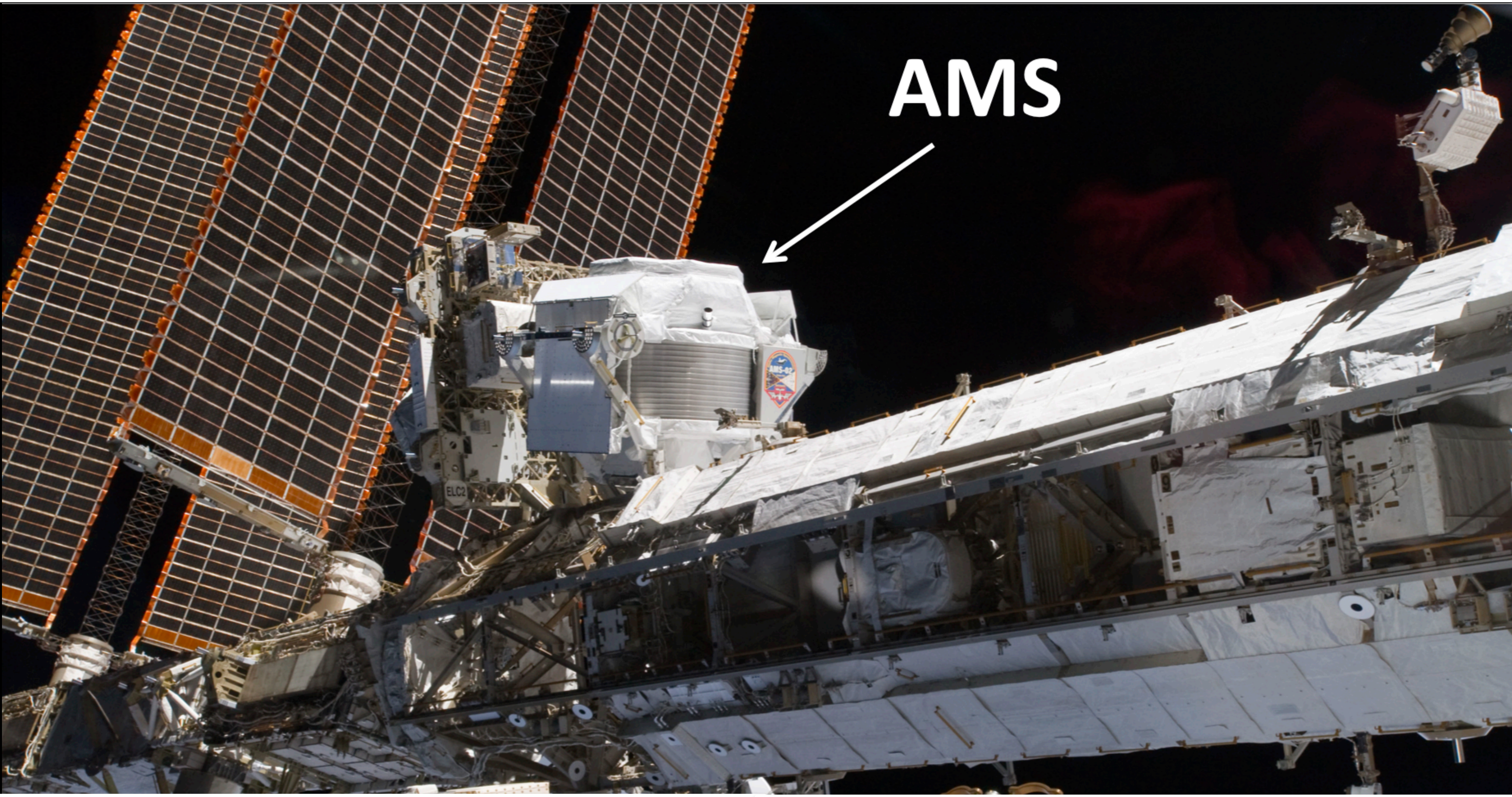
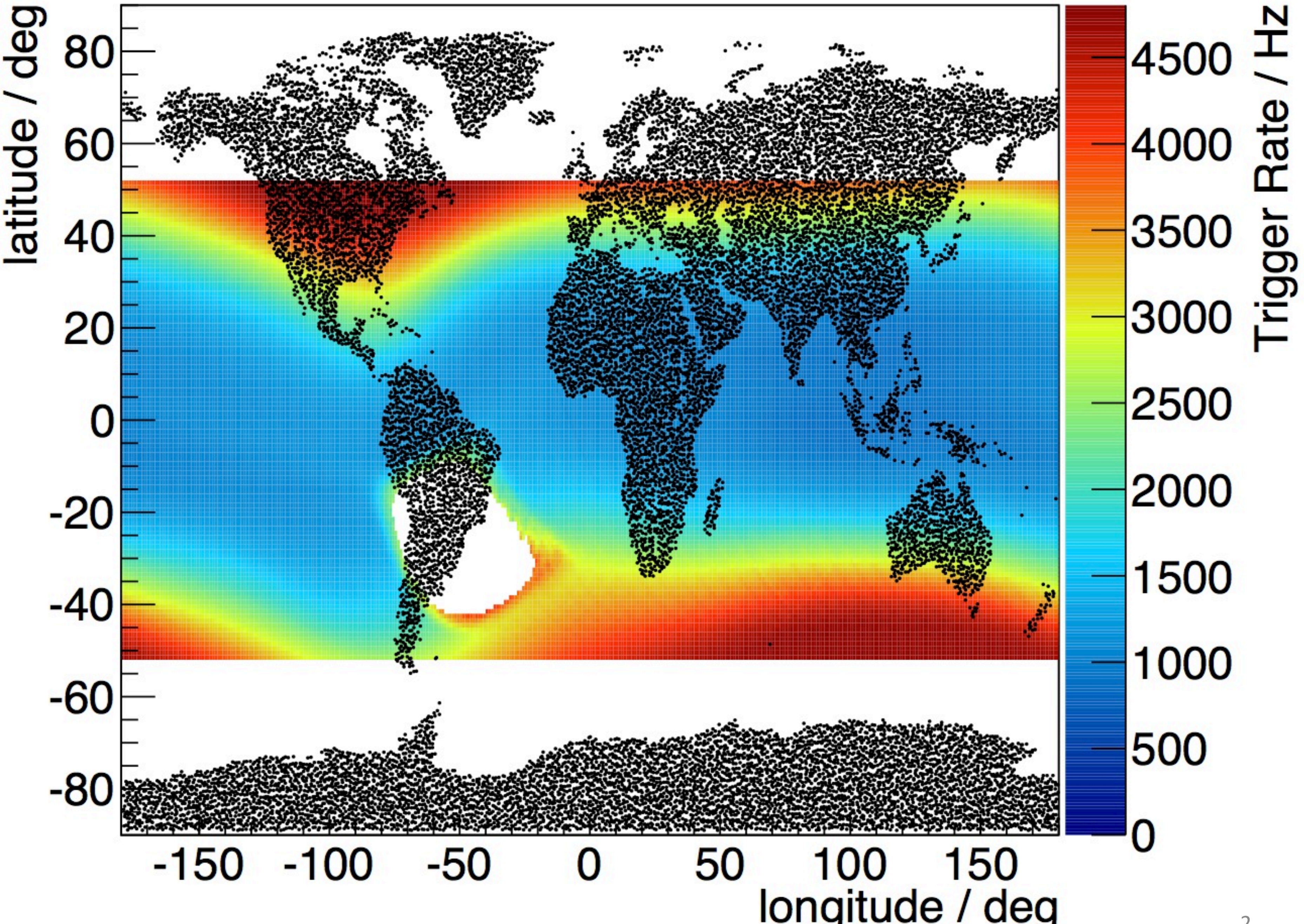
Precision measurements of the electron spectrum and the positron spectrum with AMS

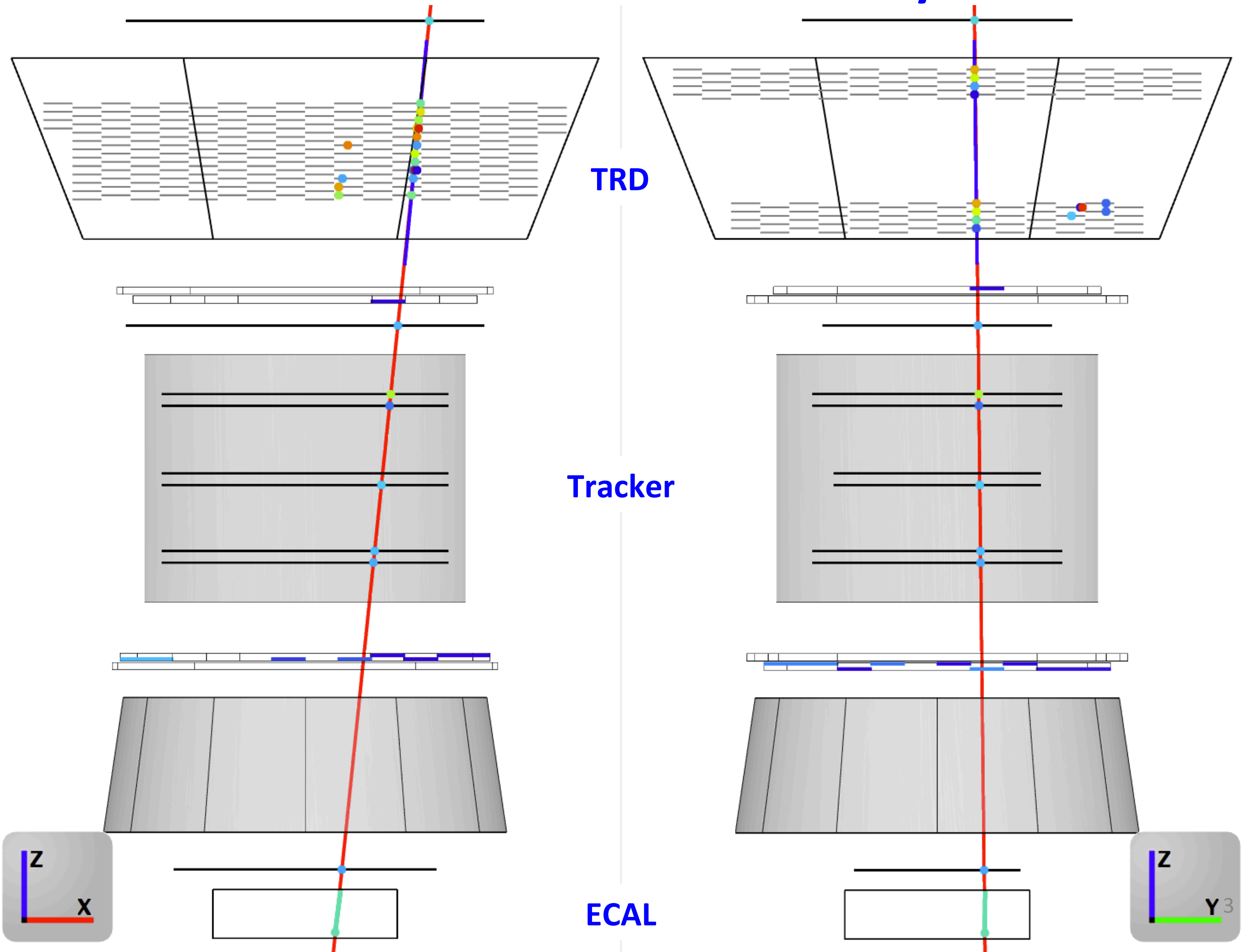


ICRC 2013

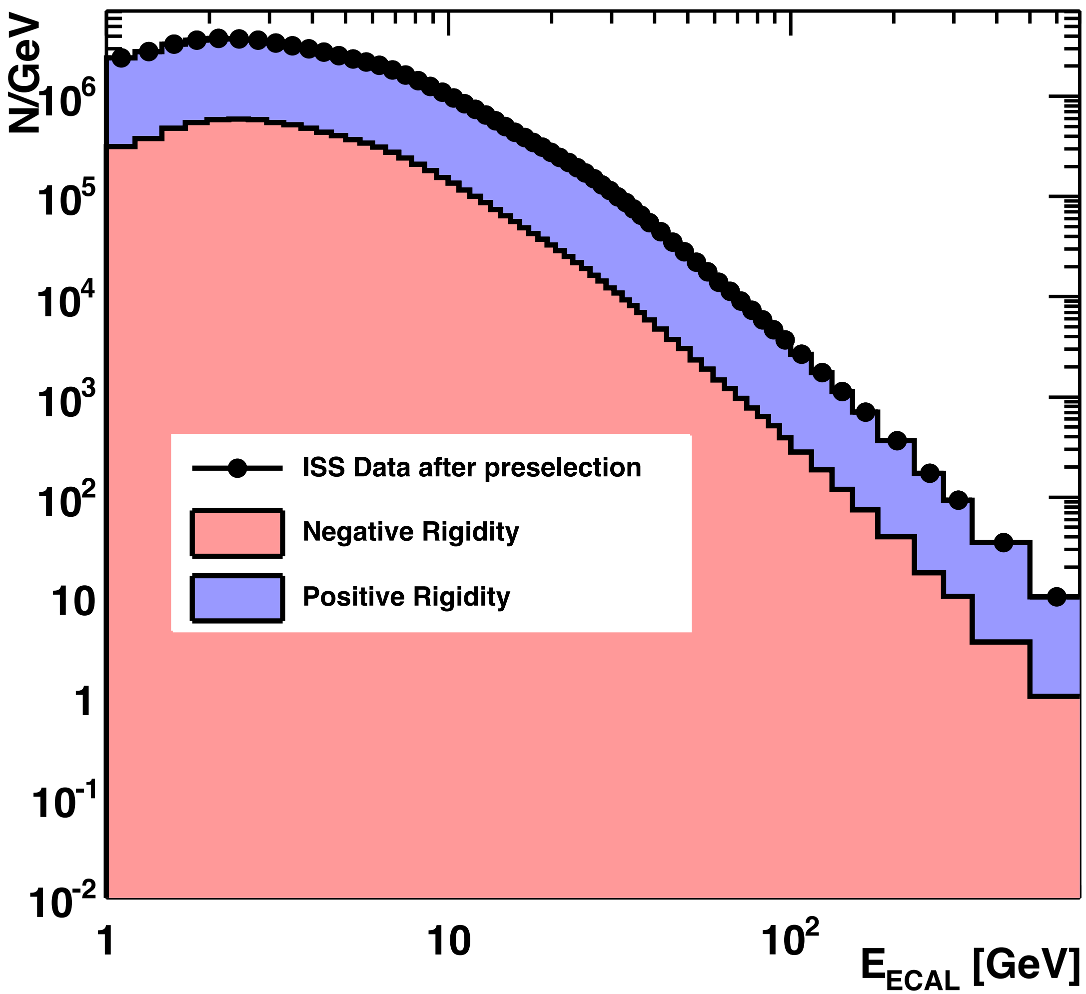
S. Schael, RWTH Aachen University
on behalf of the AMS-02 Collaboration


latitude / deg
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
longitude / deg
Trigger Rate / Hz
4500
4000
3500
3000
2500
2000
1500
1000
500
0

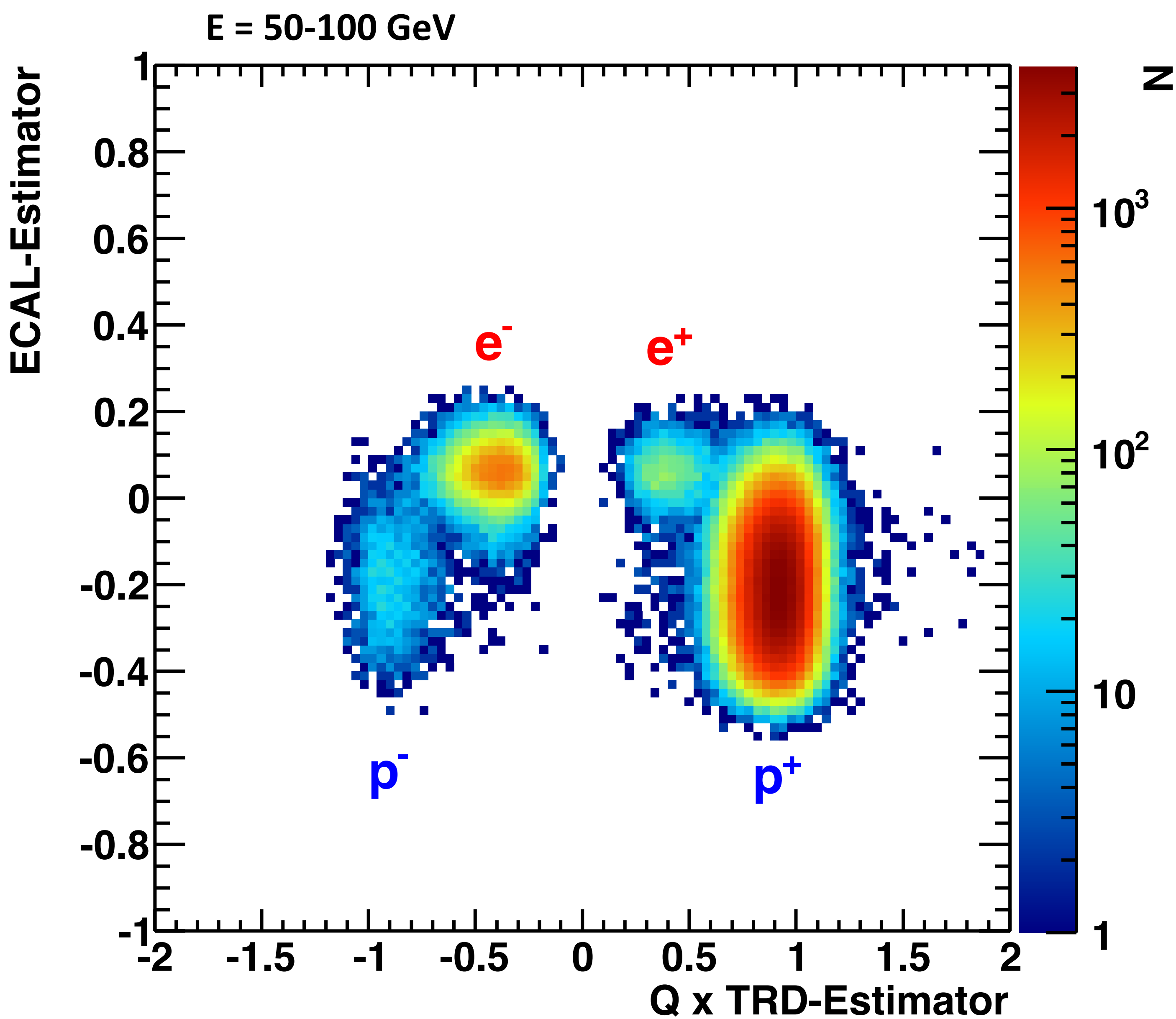
A 1.3 TeV Electron Event as seen by AMS



- From more than 30 Billion triggers we select 30 Million clean single track events, which have a reconstructed ECAL shower energy > 0.8 GeV, a matching TRD track and tracker track and a charge measured by the tracker of Z=1.



In this sample we identify four components using an ECAL Estimator (shower shape BDT) and a TRD Estimator (likelihood based on signal amplitude)



Particle Identification

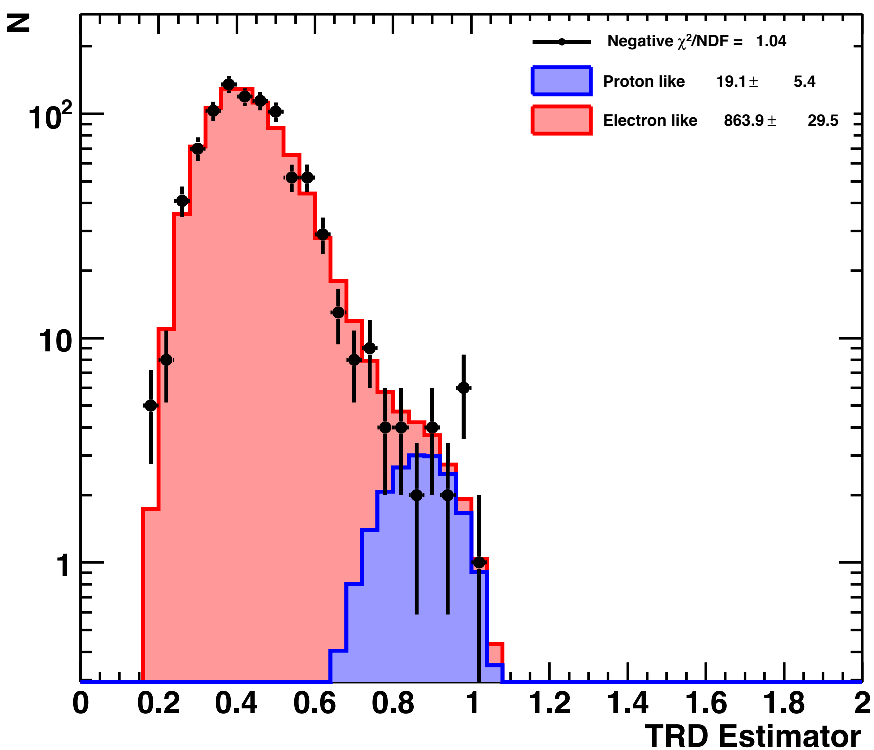
Out of these 30 Million events we produce a lepton enhanced sample by soft cuts on:

- **the ratio Energy/|Rigidity|, were the Energy is measured by ECAL and the rigidity by the Tracker.**
- **the ECAL Estimator, to separate hadronic showers from electromagnetic showers by their 3D-shape**

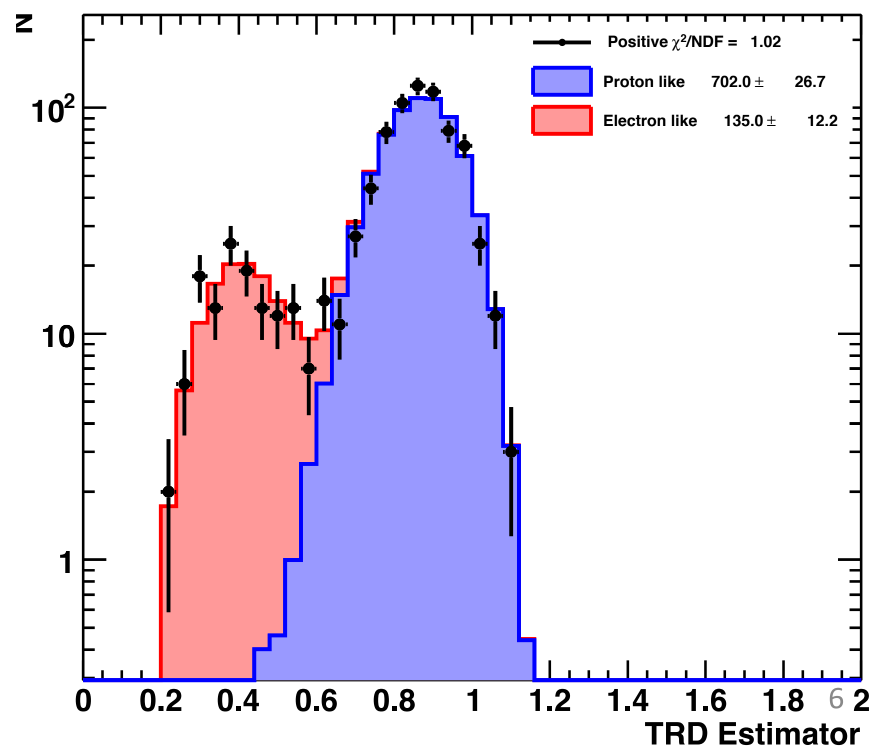
The Proton templates are taken from ISS Data, the electron templates from Monte Carlo.

E=132-152 GeV

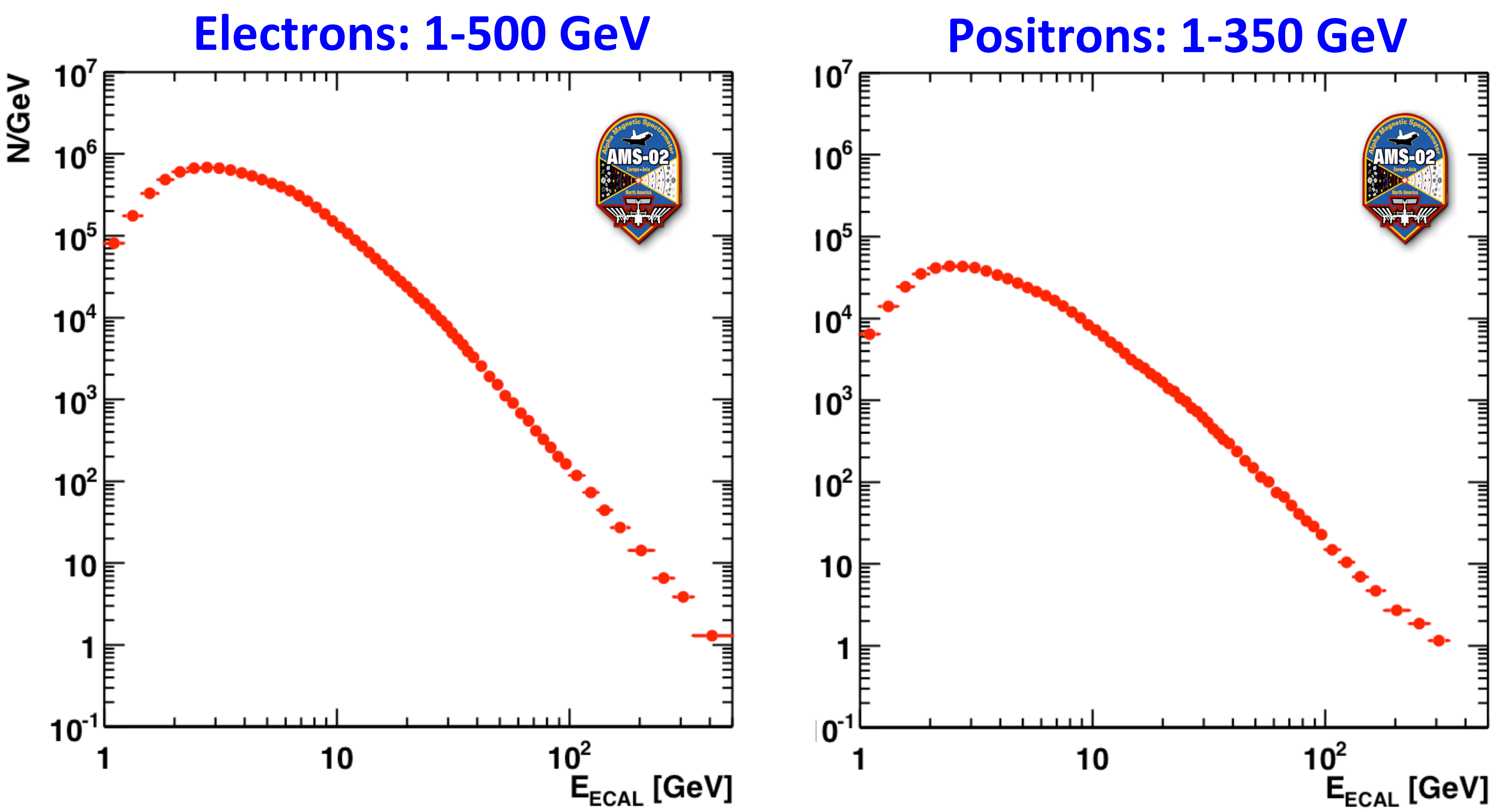
Negative Particles



Positive Particles

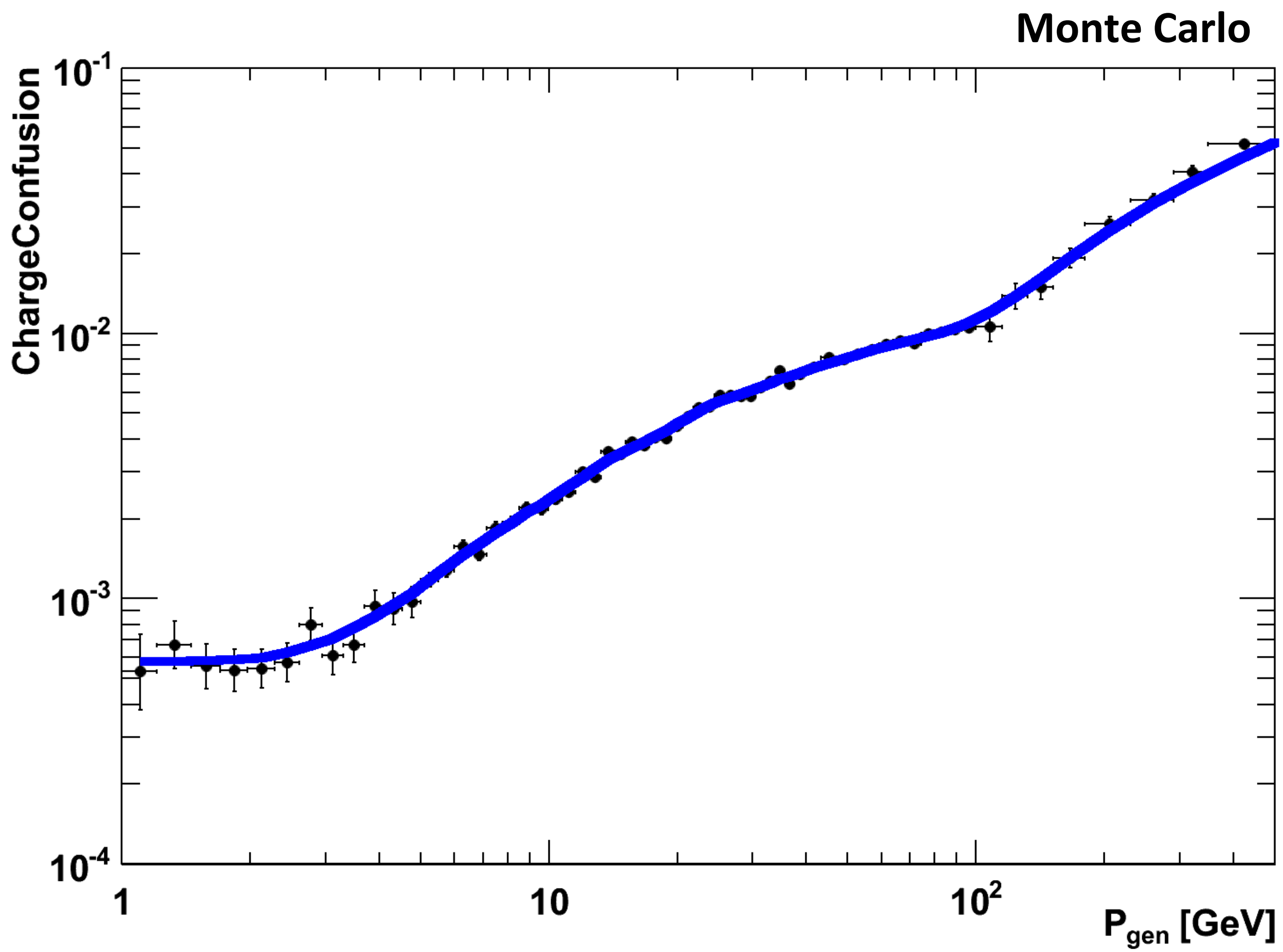


Raw Event Rates, statistical errors only



Charge Confusion

- As was already discussed in our Positron Fraction paper, we find good agreement between the charge confusion estimated from ISS data and Monte Carlo.
- Therfore charge confusion corrections from Monte Carlo are used in the following



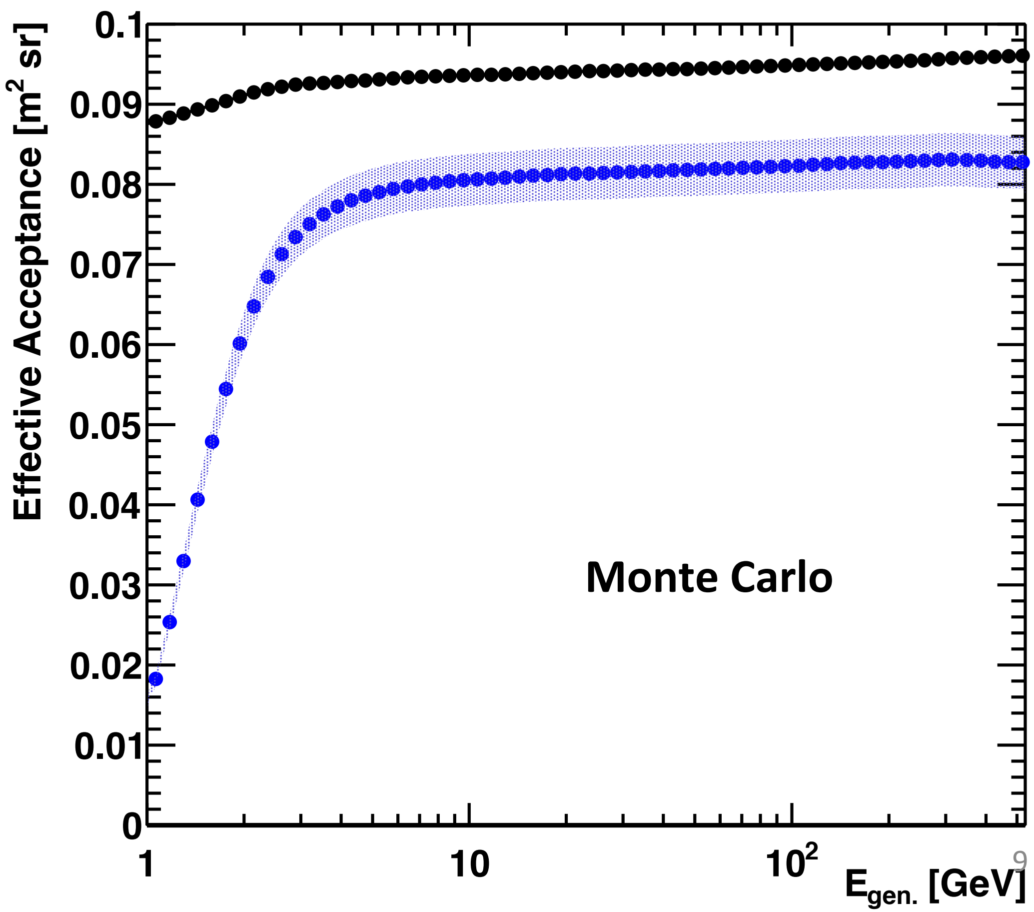
Geometrical Acceptance & Preselection Efficency

$$J(E) = \frac{N}{A \times \varepsilon_{Trig.} \times \varepsilon_{sel.} \times T \times dE}$$

A	is the acceptance in m^2 sr	🡐 Monte Carlo
$\boldsymbol{\varepsilon_{Trig.}}$	is the trigger efficiency	🡐 ISS Data
$\boldsymbol{\varepsilon_{sel.}}$	is the selection efficiency	🡐 Monte Carlo
T	is the exposure time in seconds	🡐 ISS Data

Preselection:

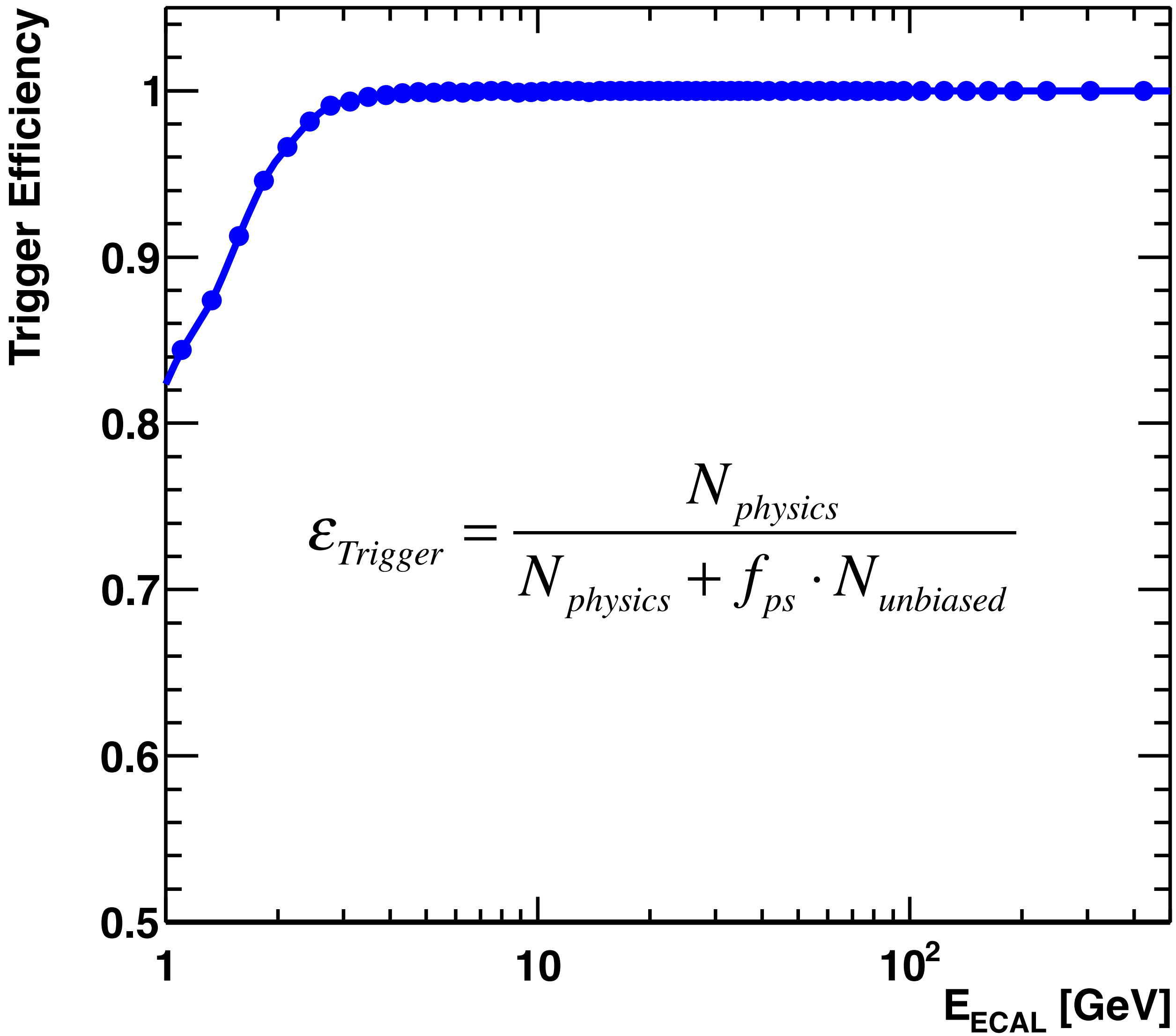
- **ECAL Shower with E>0.8 GeV**
- **Matching standalone TRD Track with more than 15 Hits**
- **Matching upper and lower ToF Clusters with ΔT>2 ns**
- **Preselection Efficiency: 90% Systematic error: 4%**



Trigger Efficiency

$$J(E) = \frac{N}{A \times \varepsilon_{Trig.} \times \varepsilon_{sel.} \times T \times dE}$$

- We record unbiased Trigger events with a pre-scaling factor f_{PS}.
- Therefore we can determine the trigger efficiency from ISS data.

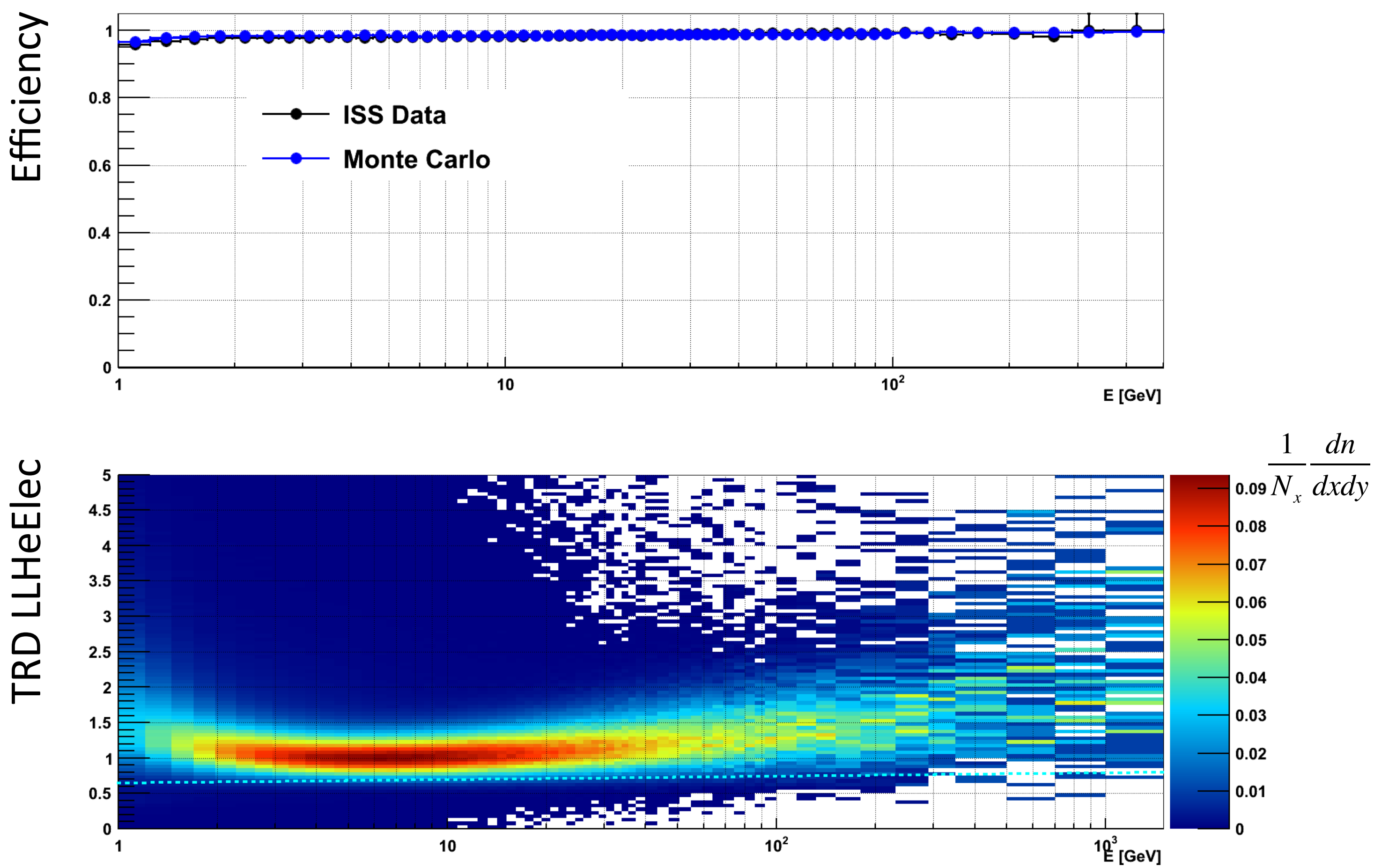


Efficiencies: Helium Rejection with the TRD

$$J(E) = \frac{N}{A \times \varepsilon_{Trig.} \times \varepsilon_{sel.} \times T \times dE}$$

Use „Tag and Probe" to compare effciciencies in Data and Monte Carlo

- **Select a sample of electron candidate events not using the TRD ⇔ this is the probe**
- **Determine on ISS Data and Monte Carlo the efficiency for an event to pass the cut that is under study**

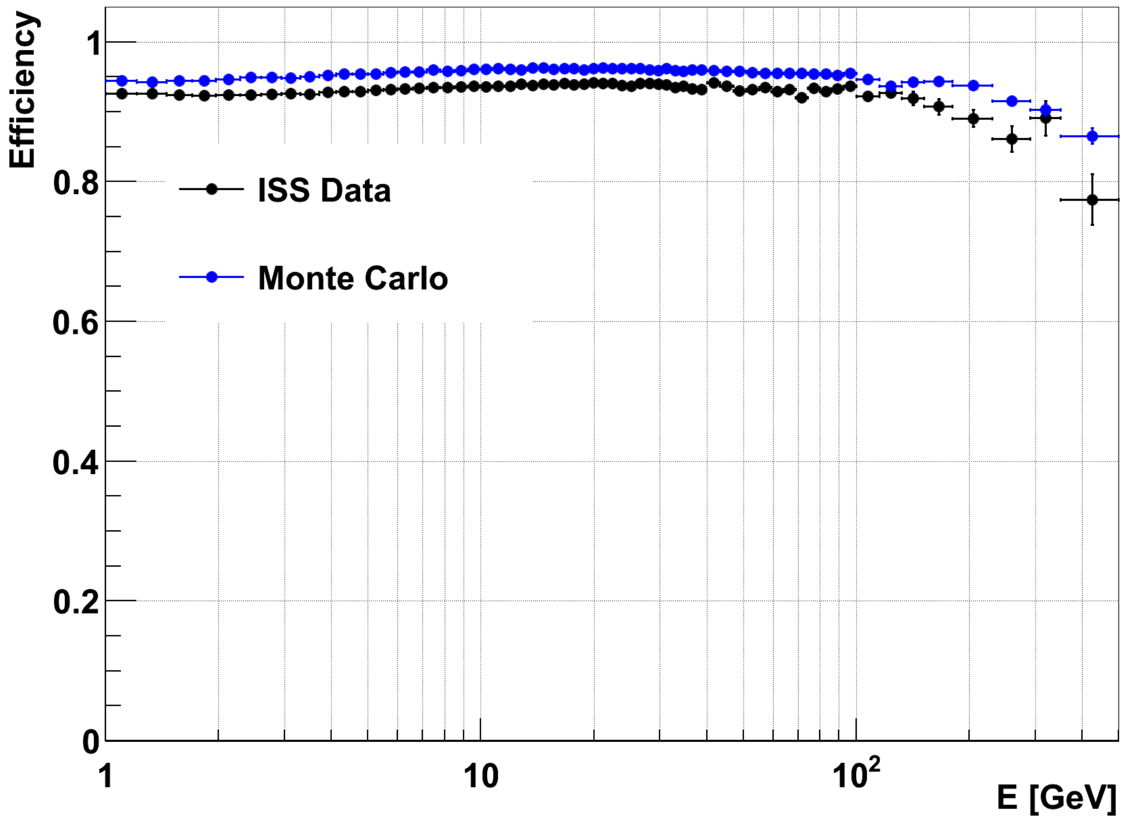


Efficiencies: Example Tracker Quality Cuts

$$J(E) = \frac{N}{A \times \varepsilon_{Trig.} \times \varepsilon_{sel.} \times T \times dE}$$

Cuts:

- **Chi2X/Ndf<15 and Chi2Y/Ndf<15**
- **Sigma(R)/R < 0.5**
- **Tracker Charge Measurement < 1.5**



- **Correct the Monte Carlo Efficiency by the ratio and take the deviation between Monte Carlo and ISS Data in the systematic error into account.**

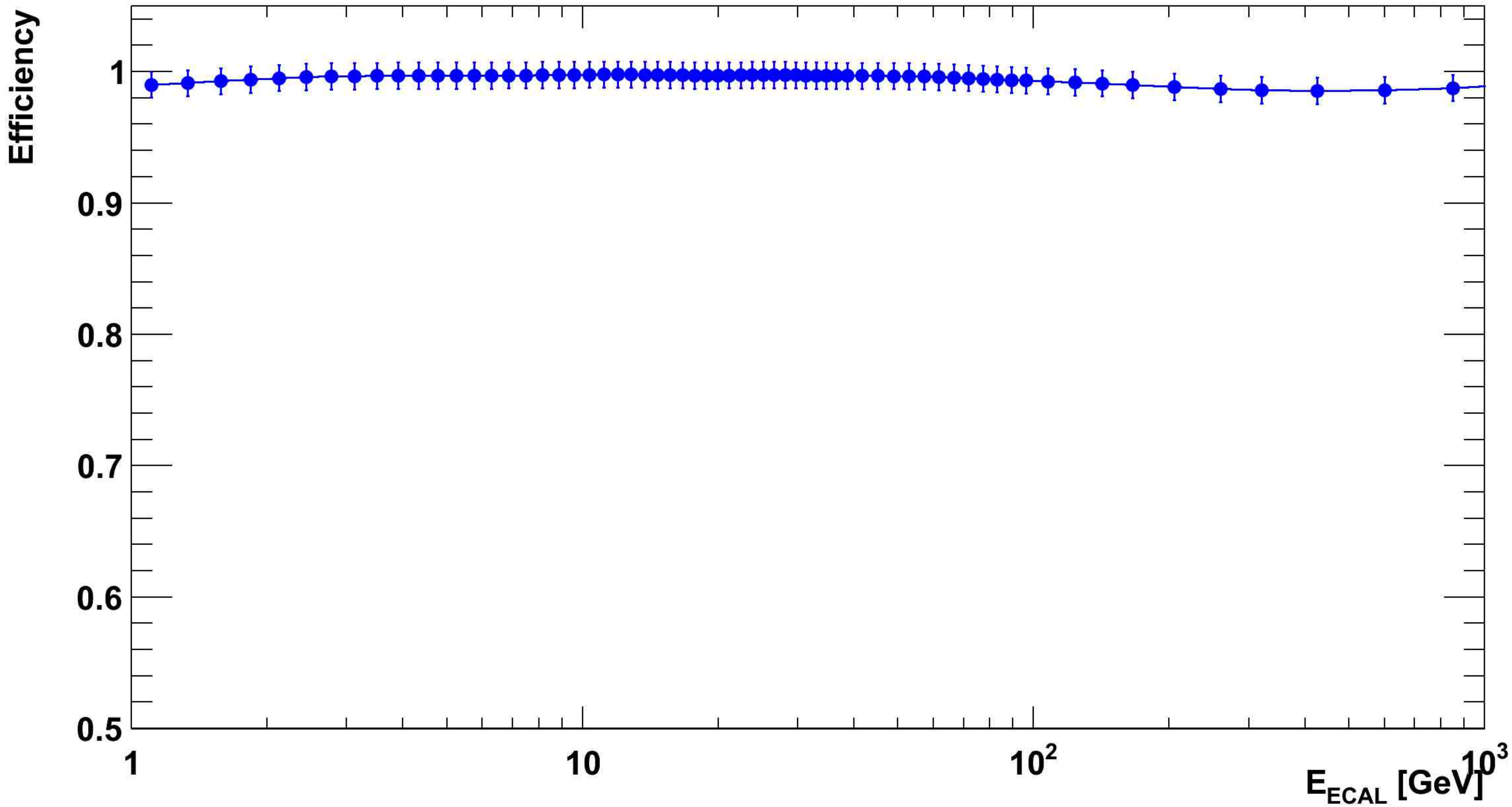
Particle Identification Effciency

$$J(E) = \frac{N}{A \times \varepsilon_{Trig.} \times \varepsilon_{sel.} \times T \times dE}$$

The final steps before the template fit were two soft cuts to enhance leptons:
- **On the ratio Energy/|Rigidity| and on the ECAL Shower Shape Estimator**

The overall systematic error on the efficiency corrections is estimated with 4%.

Monte Carlo



Data taking time

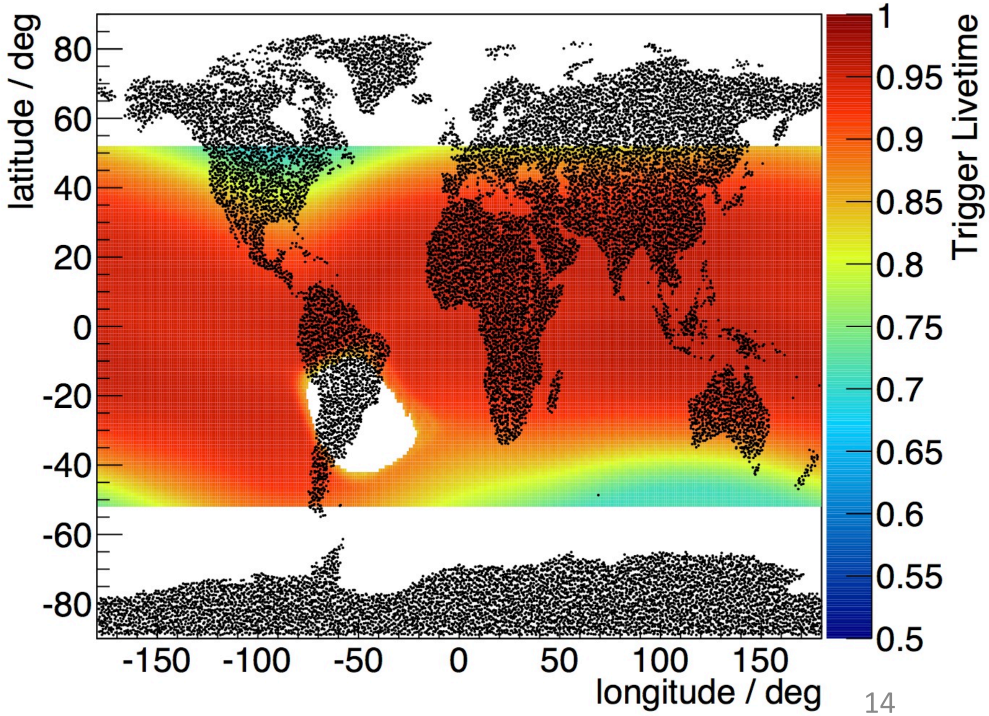
$$J(E) = \frac{N}{A \times \varepsilon_{Trig.} \times \varepsilon_{sel.} \times T \times dE}$$

We have analyzed data taken from 19 May 2011 to 11 March 2013.

For each second , the global status of AMS is defined with several parameters. The exposure time period is selected on the following basis:

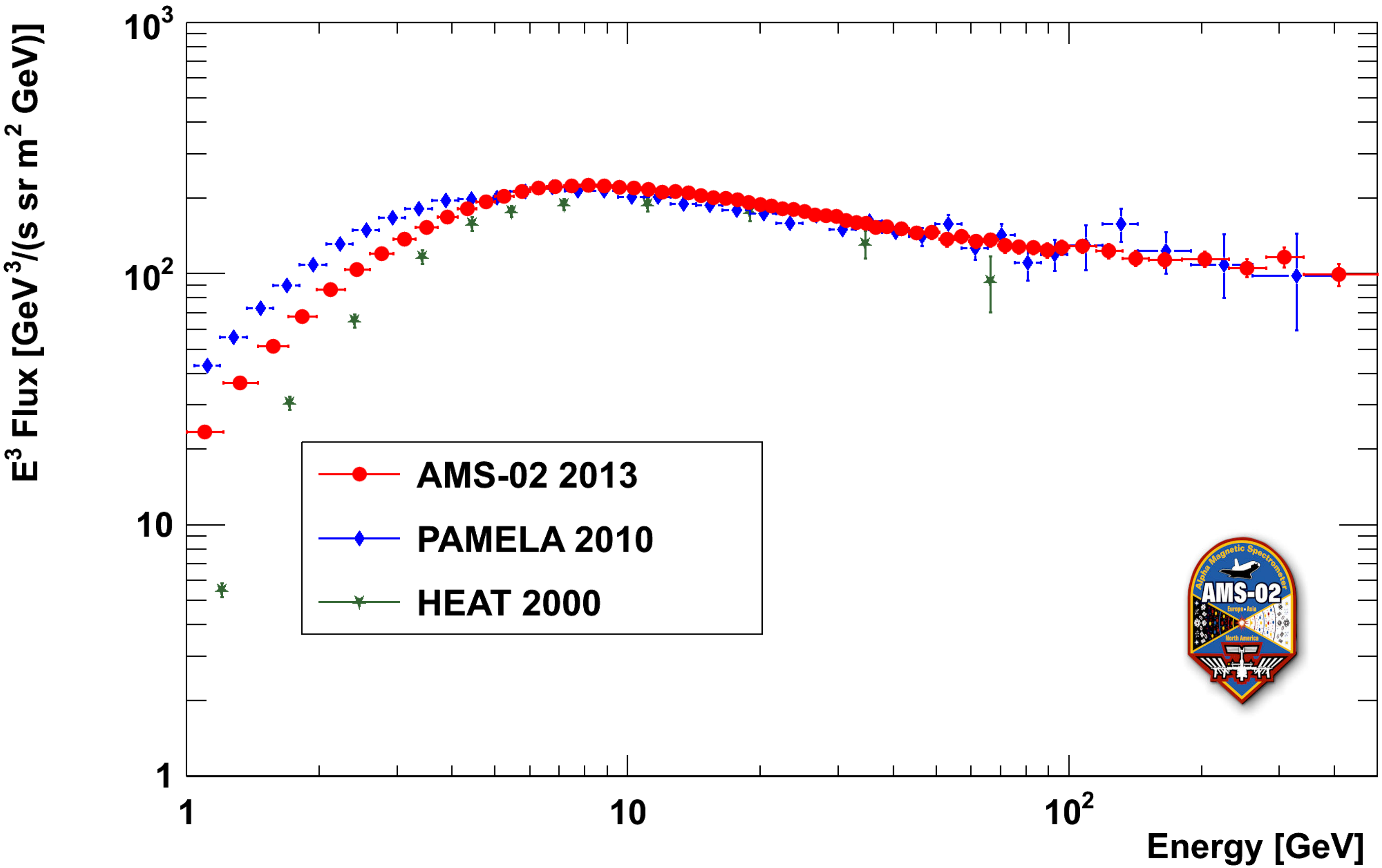
- **AMS is in the nominal data taking status,**
- **AMS vertical axis is within 25 deg of the Earth zenith axis, and**
- **the measured ECAL energy is required to exceed by a factor 1.2 the maximal Stoermer cutoff**

The total exposure time depends on the measured ECAL energy and is for energies above 30 GeV constant at $4.38 \cdot 10^7$ seconds, which corresponds to an overall average live time fraction of 80.2% for this time interval.



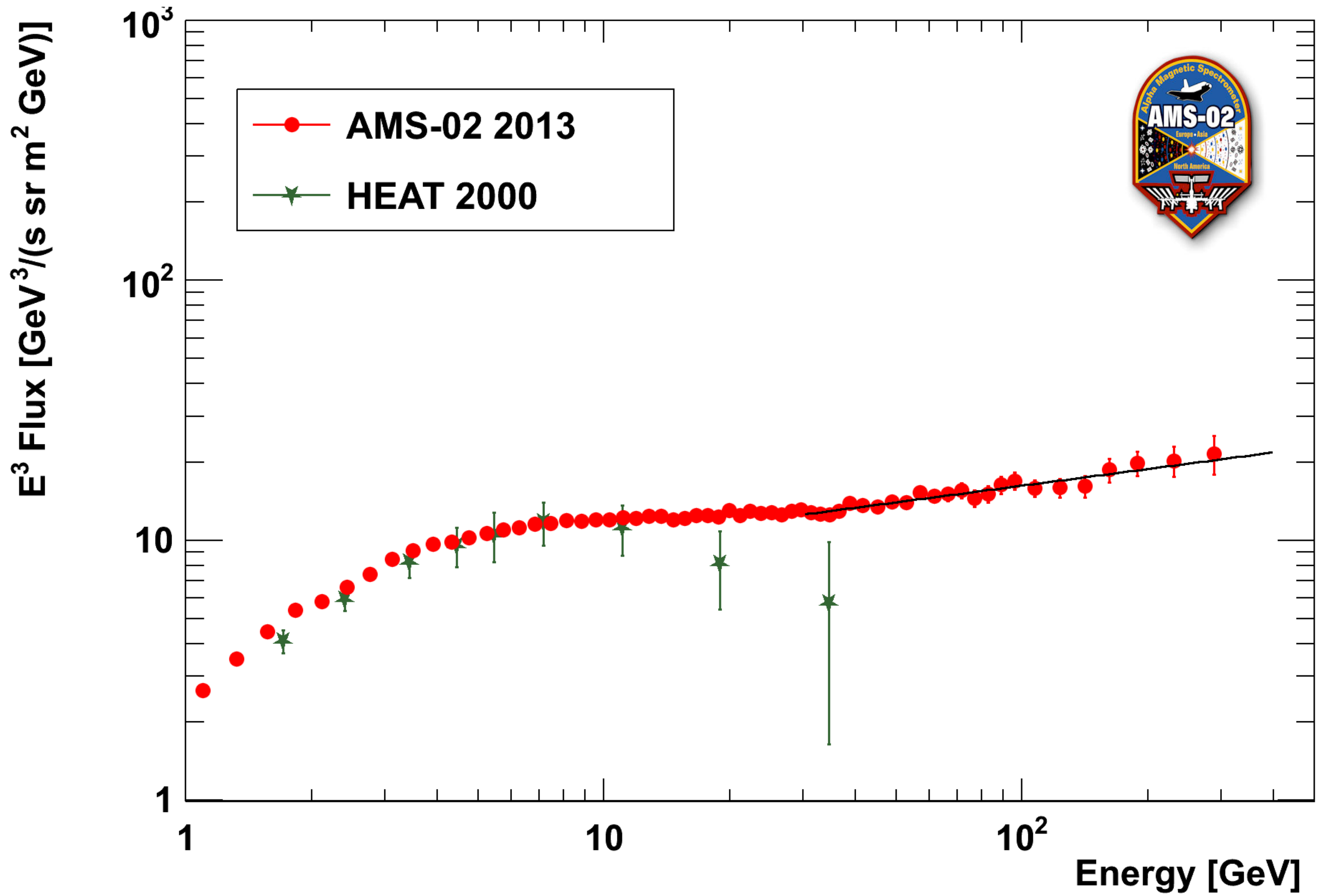
AMS-02 Electron Flux $J_{e-}(E)$

- The electron flux measurement extends up to 500 GeV.
- Multiplied by E^3 it is rising up to 10 GeV and appears to be on a smooth, slowly falling curve above.
- The measurement is in good agreement with the previous data.
- The differences at low energies can be attributed to the effect of solar modulation.



AMS-02 Positron Flux $J_{e+}(E)$

- The positron flux measurement extends up to 350 GeV.
- Multiplied by E^3 it is rising up to 10 GeV, from 10 to 30 GeV the spectrum is flat and above 30 GeV again rising as indicated by the black line in the figure.
- The spectral index and its dependence on energy is clearly different from the electron spectrum.
- In the low energy range the agreement with results reported by HEAT is good.



Summary

- A status report on the electron and positron flux measurements with the AMS-02 experiment on the ISS was given.
- The combination of a high precision silicon tracker, a 17 X_0 electromagnetic calorimeter and a 20 layer TRD allows a clear separation of electrons and positrons from the large proton background.
- An Electron spectrum in the energy range 1-500 GeV and a positron spectrum in the energy range 1-300 GeV was shown.
- The measured spectra show smooth curves with no particular bumps.
The positron spectrum shows a break at around 30 GeV energy.
- Differences in the spectral indices of electrons and positrons as expected from the published positron fraction measurement are clearly visible.
- Systematic Errors on the overall normalisation and the energy scale unfolding are still under study.