TRDs for the 3^{rd} millennium

Performance of the AMS02 TRD prototype

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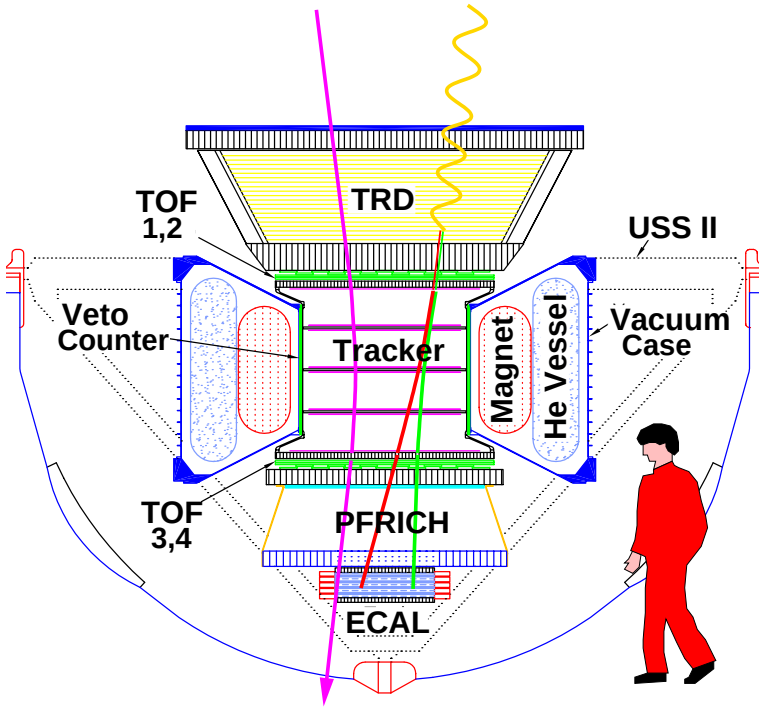
Bari, September 22^{nd} 2001

RWTH Physics AC-I

Performance of the AMS02 TRD Prototype

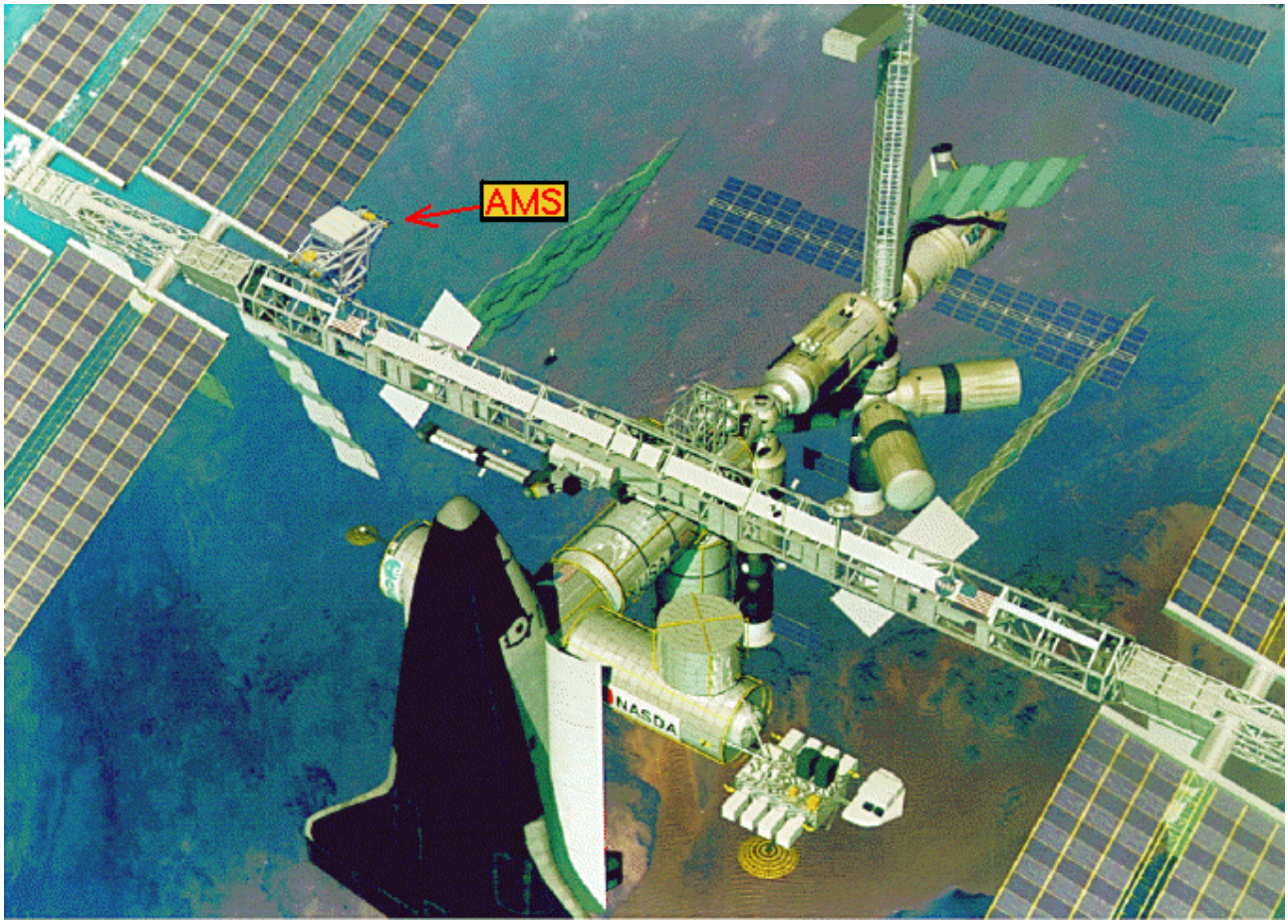
- AMS02 on ISS
- TRD Prototype Beamtest
  - Beamtest Setup
  - Calibration
  - Proton Rejection
  - Comparison Data $\leftrightarrow$ MC
- Conclusion

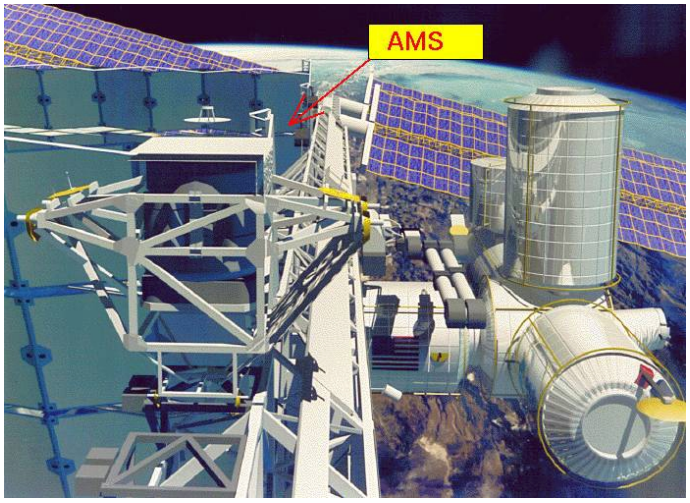


$p^+/e^+ < 10^{-2}$ (10 - 300 GeV)

$p^+/e^+ < 10^{-4}$ (10 - 300 GeV)

ISS - an experimental platform





⟸AMS02 on ISS

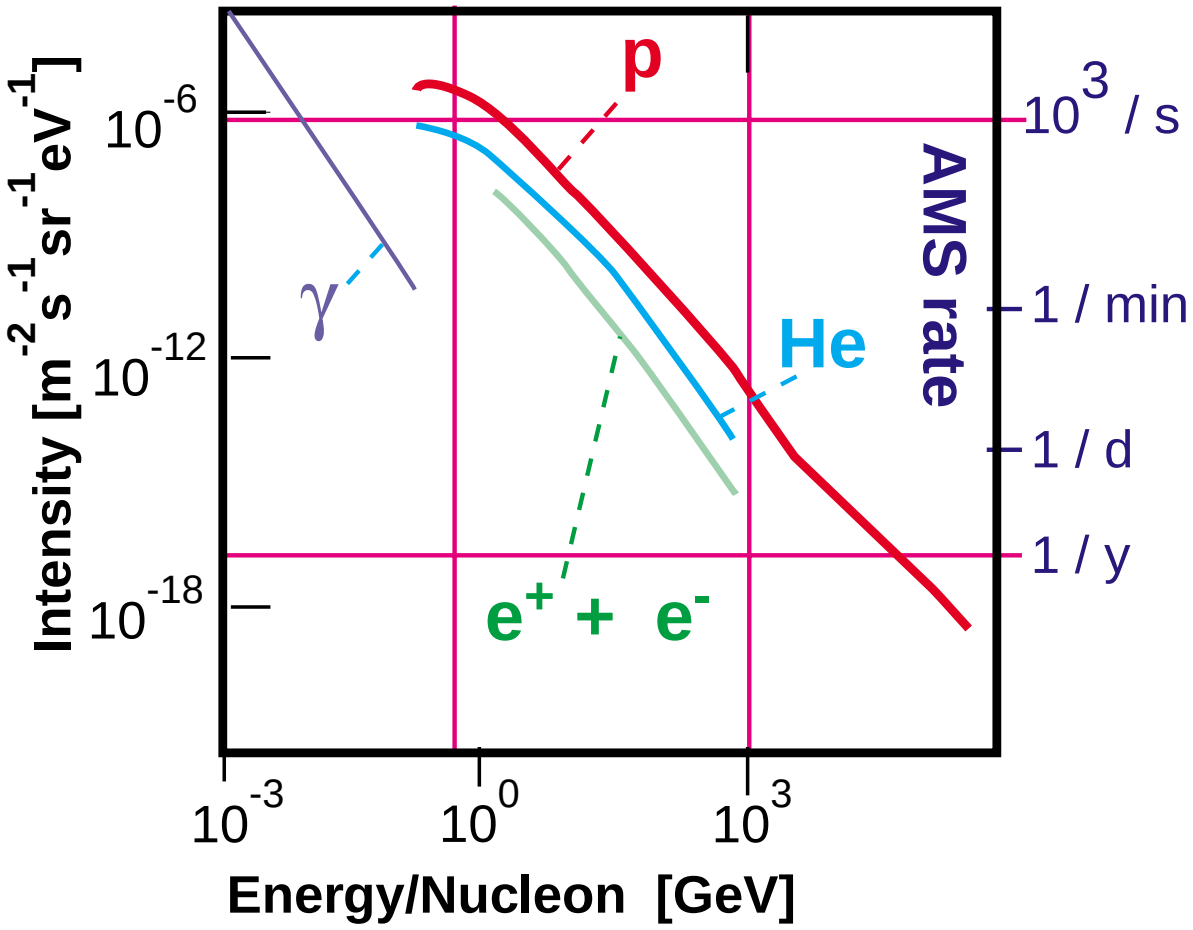
- mean altitude 400 km
- in orbit for 3 years
- large acceptance 0.5 m^2sr

$\Longrightarrow$ Cosmic Particle Spectroscopy

What would we like to measure?

$\Downarrow$

Cosmic Particle Spectrum

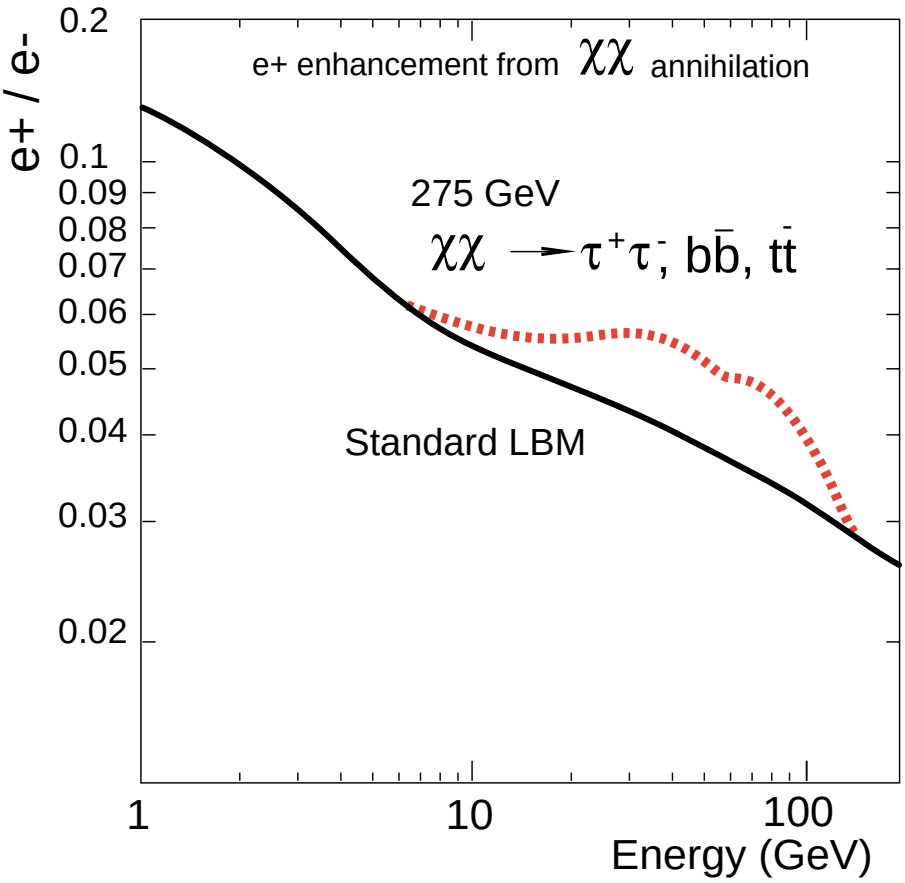


flux ratio in orbit: $p^+/e^+ \approx 10^4$

$\Rightarrow$ p^+-rejection $< 10^{-6}$

Why would we like to measure it?

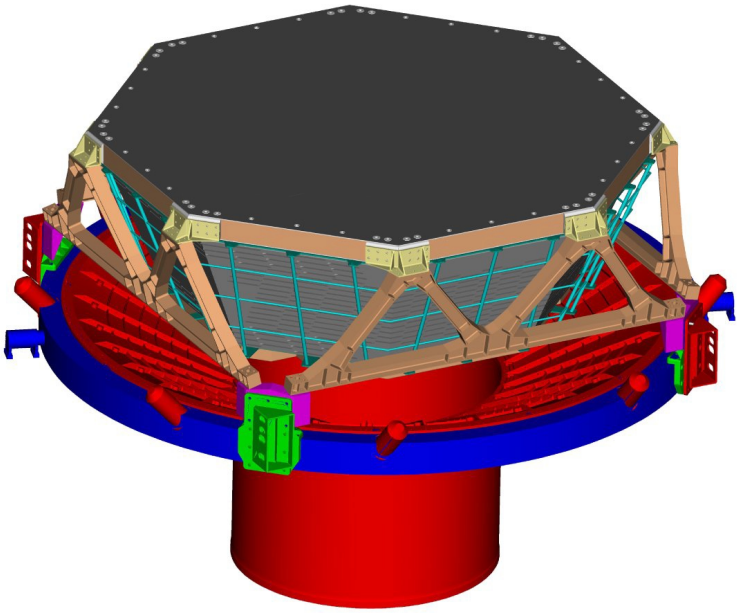
- Dark Matter Search $\Rightarrow$ $\boxed{e^+\text{-Spectroscopy}}$



$\Longrightarrow$ Cosmic-ray spectroscopy with highest-precision in

Particle identification $\boxed{p^+/e^+ < 10^{-6} \text{ to } 300 \text{ GeV}}$

Transition Radiation Detector

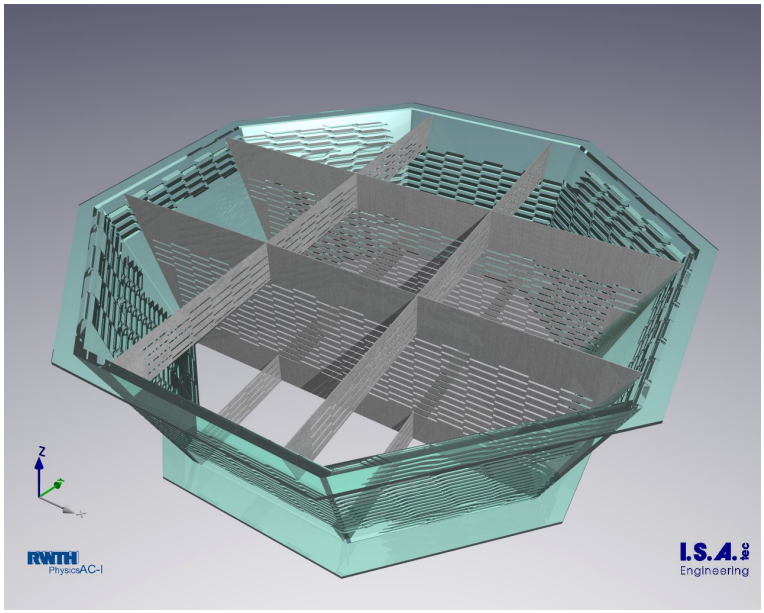


Chosen configuration for
60 cm active height:

20 Layers
each existing of

- 22 mm fleece
- ∅ 6 mm straw tubes
  Xe/CO_2 (80/20)

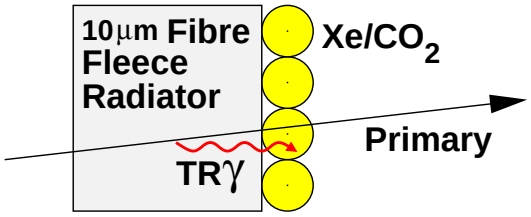
Octagon and Bulkheads support 328 Modules
with lengths from 86 to 201 cm



Upper/lower 4 layers
measure in bending plane

Middle 12 layers
measure in perpendicular plane

TRD Principle



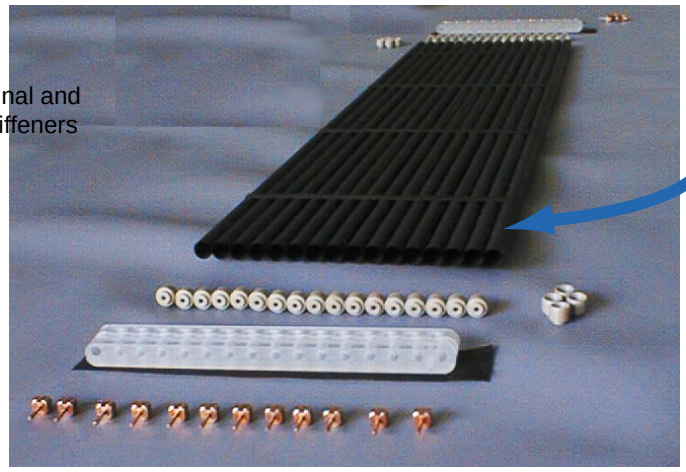
Realisation:

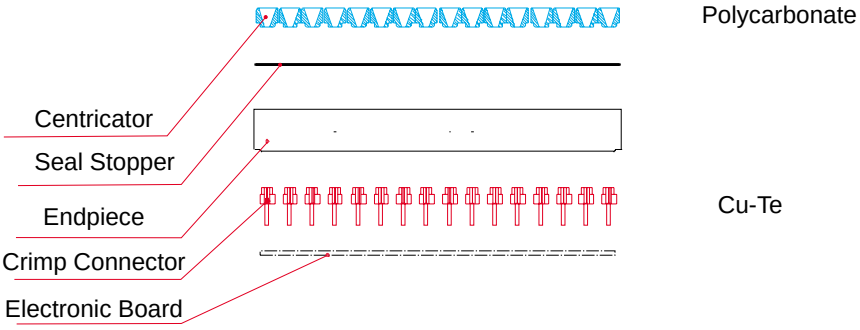
- HERA-B/ATLAS straw-tubes
- ATLAS fleece

Straw Modules

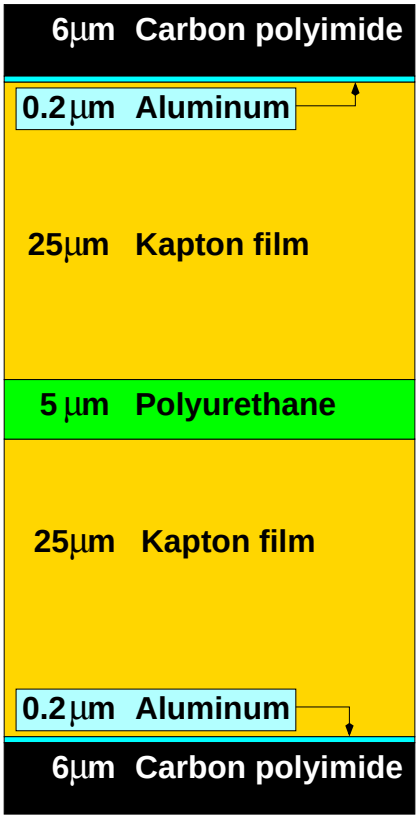
Module: 16 tubes at 6mm ∅ with 30 μm W-Au wire

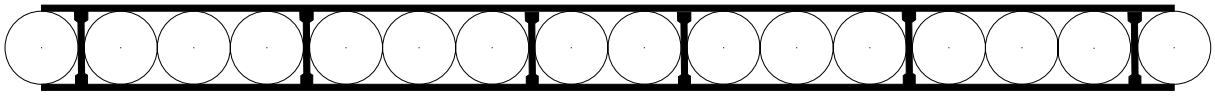
Multilayer Capton tubings





Capton wall

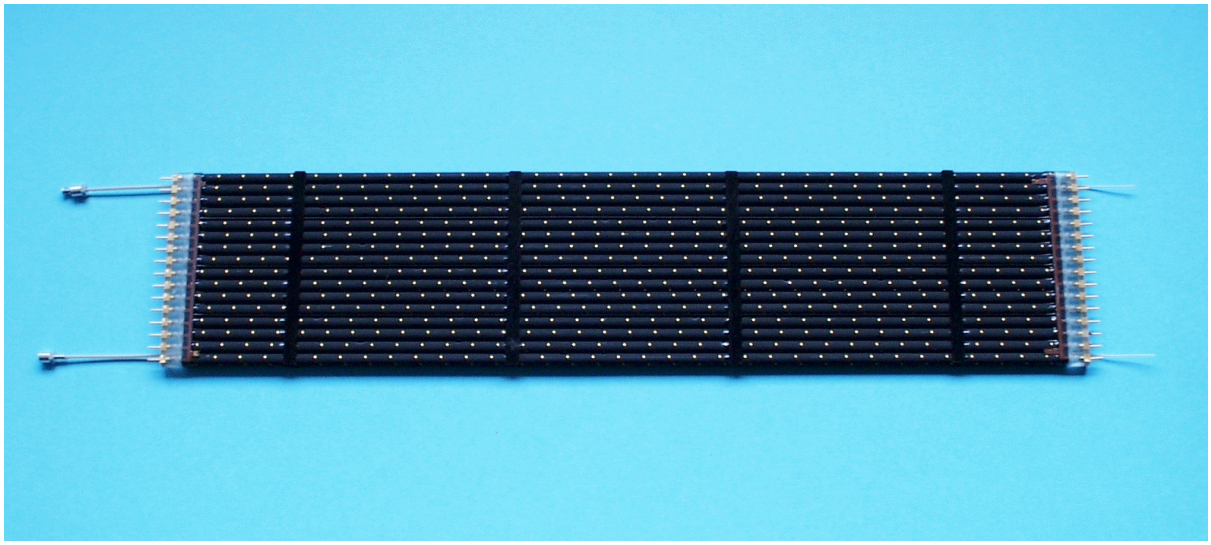




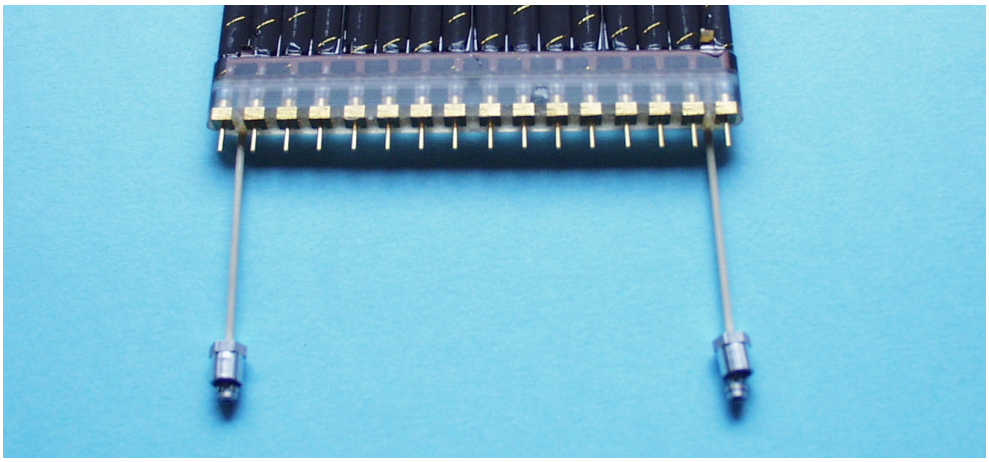
6 longitudinal stiffeners

Strips across every 10 cm

Prototype TRD Modules (L=40 cm)



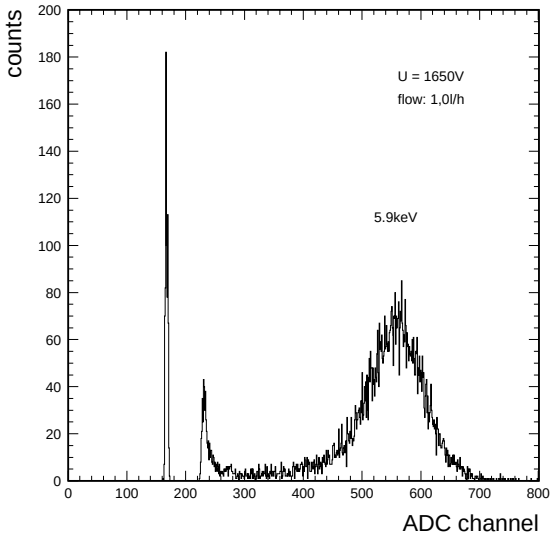
Gas manifold:

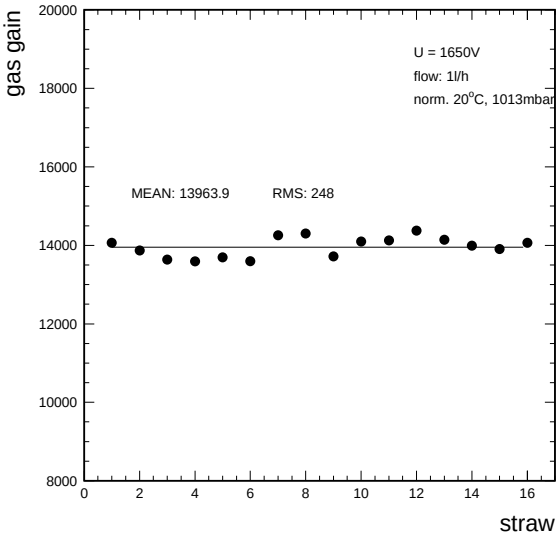


Prototype TRD Modules

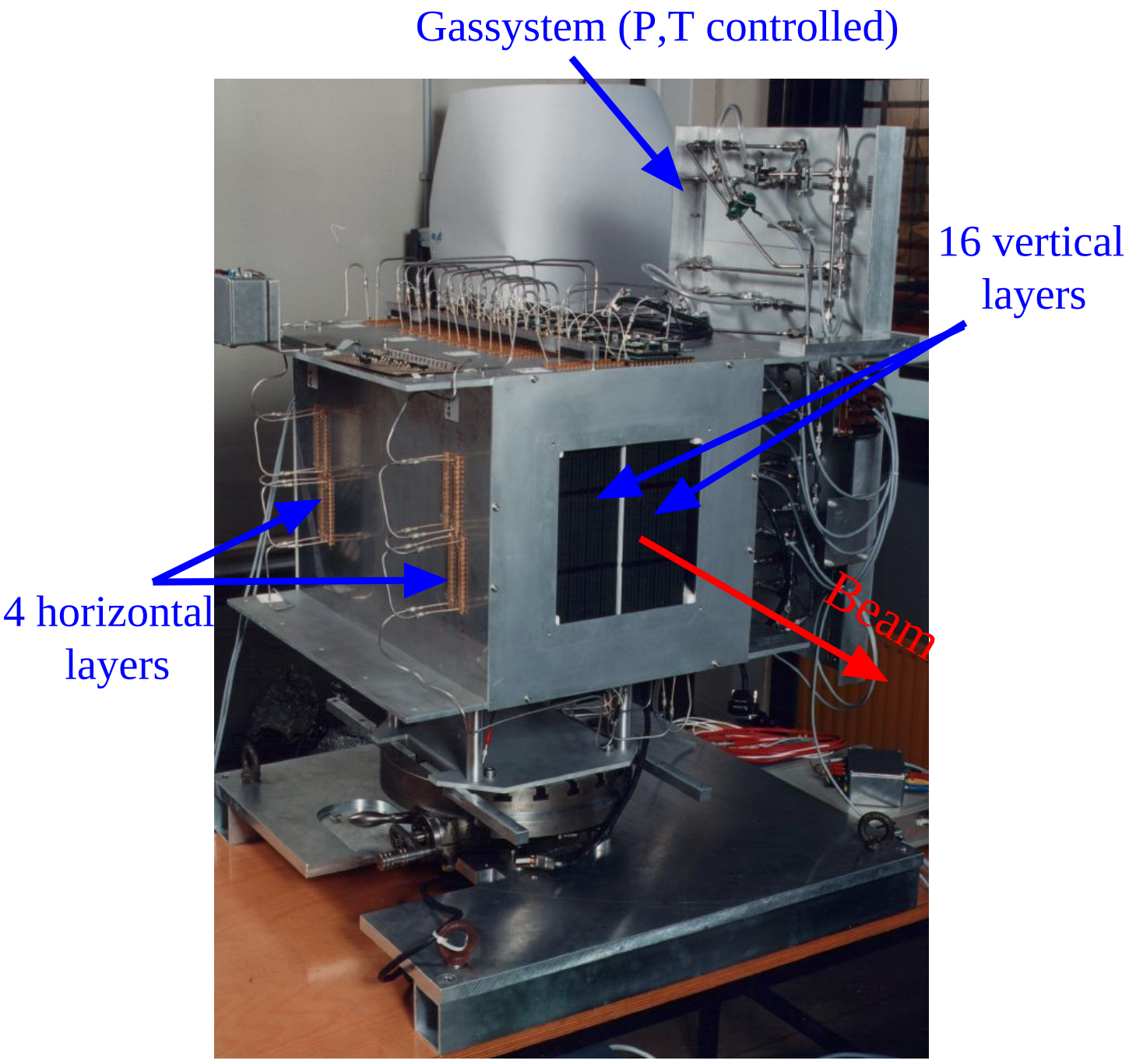
Measurements:

- Wire tension $(99.0 \pm 1.7)\ \mathrm{g}$
- Gas tightness $(10^{-4} \frac{\mathrm{mbar}}{\mathrm{s}})$
- Gasgain

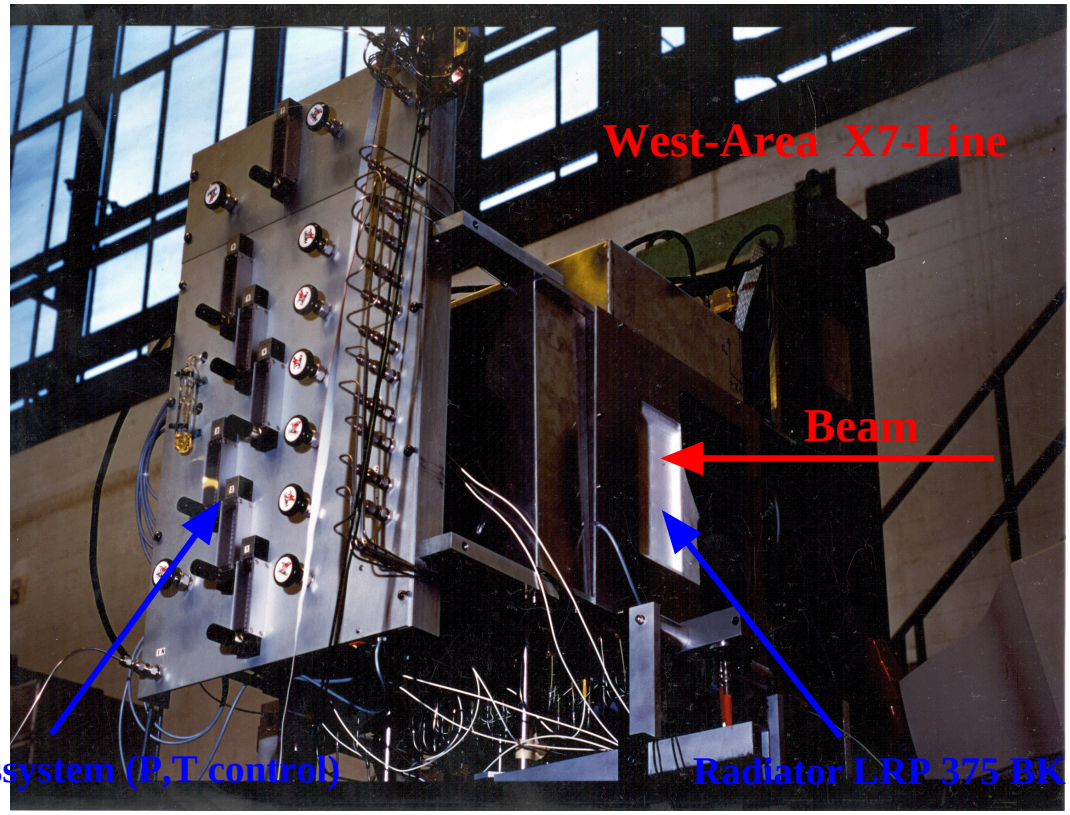


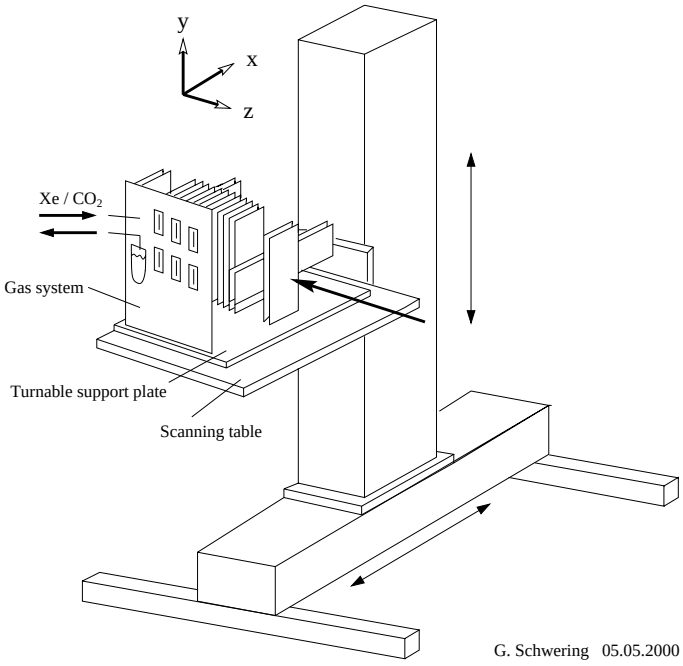


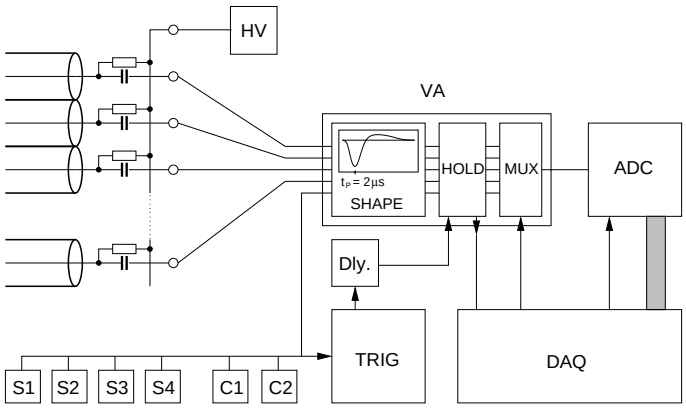
⇒ 20 Layer Prototype (40 Modules)



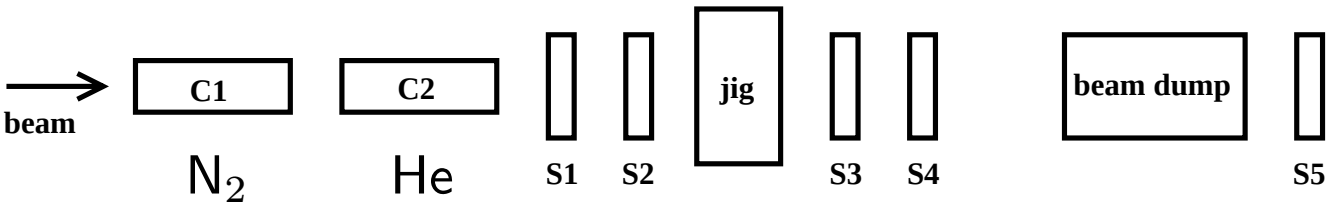
20 Layer Prototype



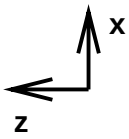




Beamlines CERN X7, H6



3 million events recorded: p^+, e^-, μ^-, π^-



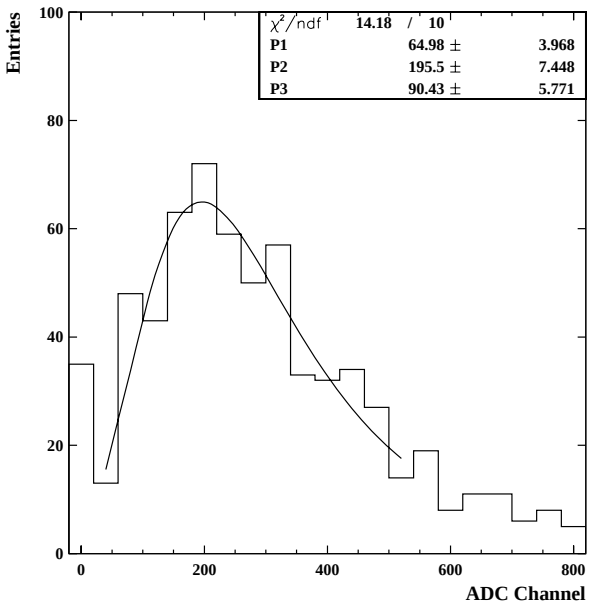
Ebeam	20 Layer T9 2000		20 Layer X7 2000				20 Layer H6 2000
GeV	#e-	#p+	#e-	#p+	#μ-	#π-	#p+
3.5	50k	71k					
5.0	21k	19k	120k				
10.0		28k	160k			20k	
15.0				45k			
20.0			150k	30k		20k	
40.0			160k	60k		20k	
60.0			180k	20k	190k	20k	
80.0			120k	20k	170k	20k	
100.0			200k	150k	110k	50k	
120.0				30k			215k
140.0				30k			
160.0				40k			290k
180.0				40k			
200.0				80k			155k
250.0				65k			

Calibration

Tube Intercalibration (with myons):

- Fit MOPs for each Tube i and Run r
- Determine runwise relative tube MOPs
- Add up runs scaled with overlapping tubes

→ Ical-Table



Gasgain Calibration

- Intercalibrated tube-avrg MOP for each run
- Correlate to gas-density

→ Gasgain correction $M' = M * [1 + (\rho/\overline{\rho} - 1) * 5.4]$

Energy Calibration

- Intercalibrated gasgain corrected Fe^{55} peaks

→ $E_{ADC} \hat{=}$ 5.9 keV / 646 ADC-Ch

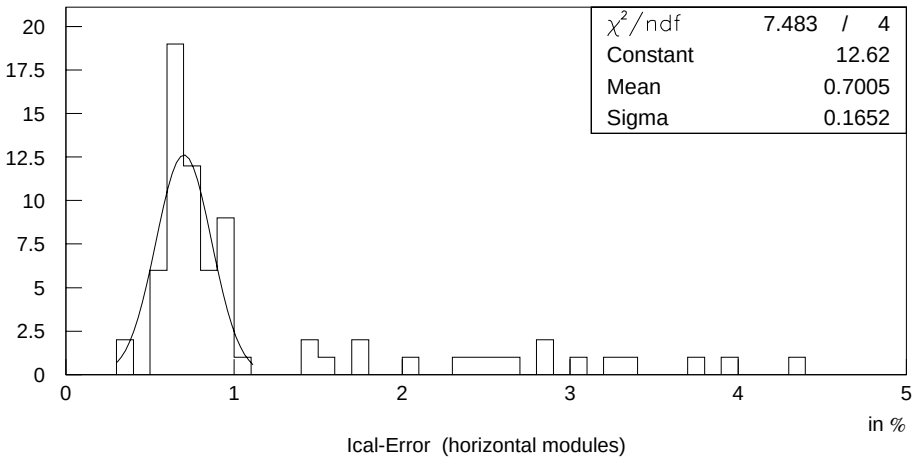
Myon Intercalibration

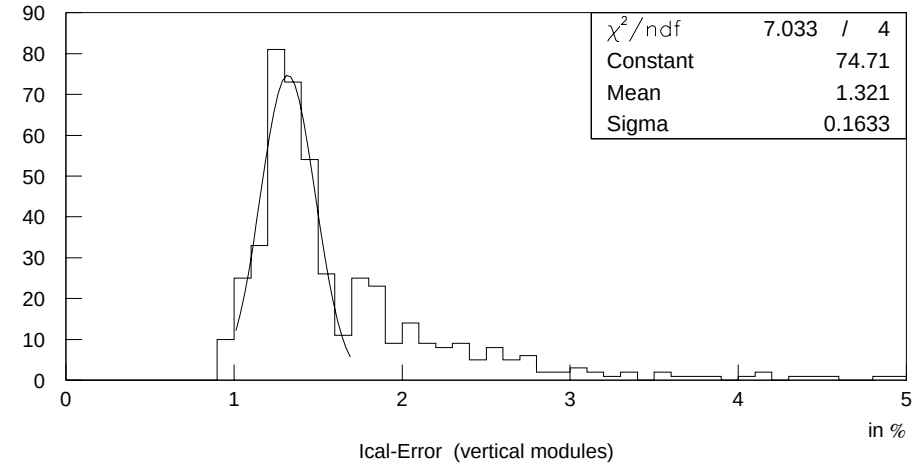
Beamtest Intercalibration

horizontal modules: $\approx$ 20000 myon/tube

vertical modules: $\approx$ 10000 myon/tube

Most of straws Ical-error $< 2\%$

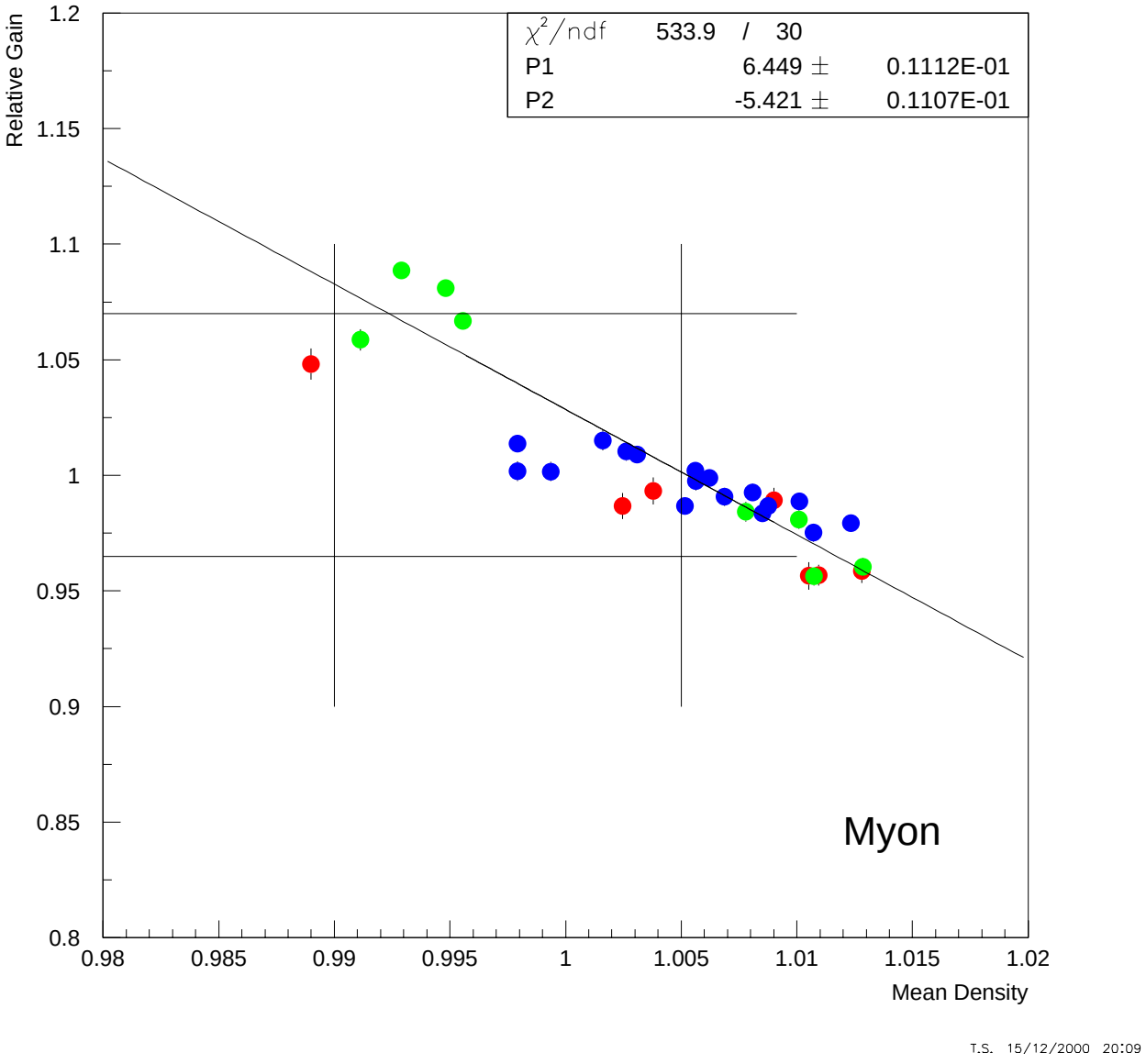




On ISS intercalibration will rely on particle data

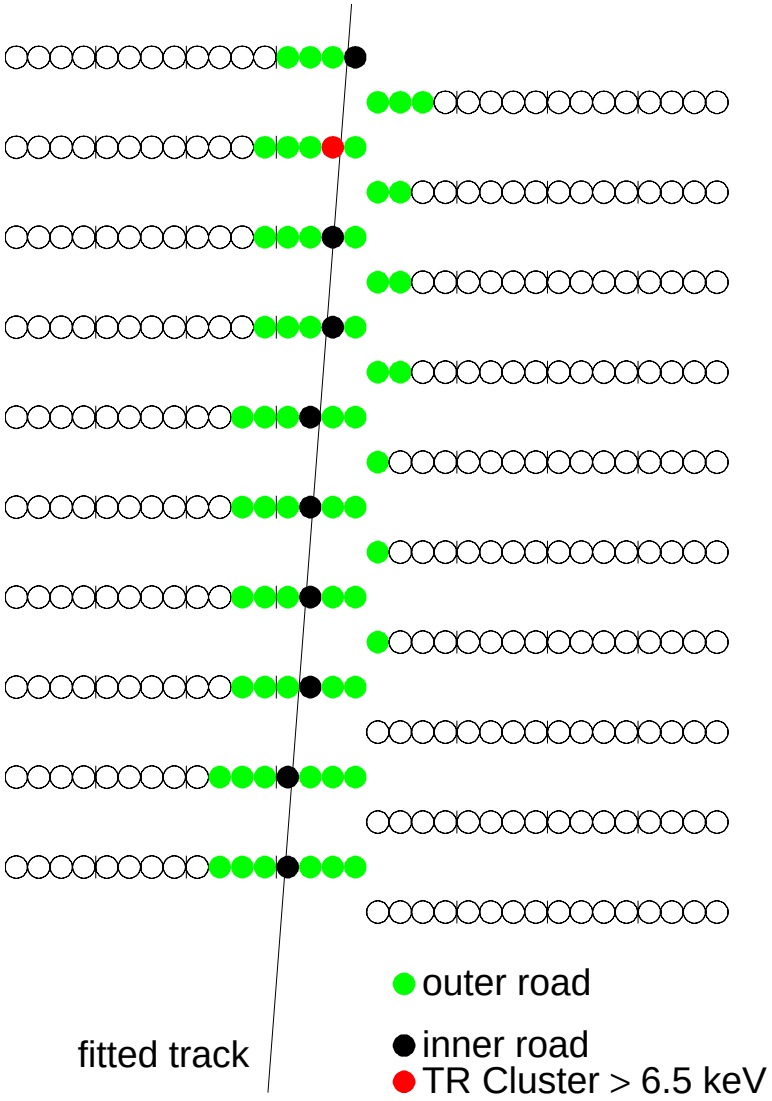
Myon Gasgain Correlation

rel. GasGain vs Mean Density Color codes Beam-Energy



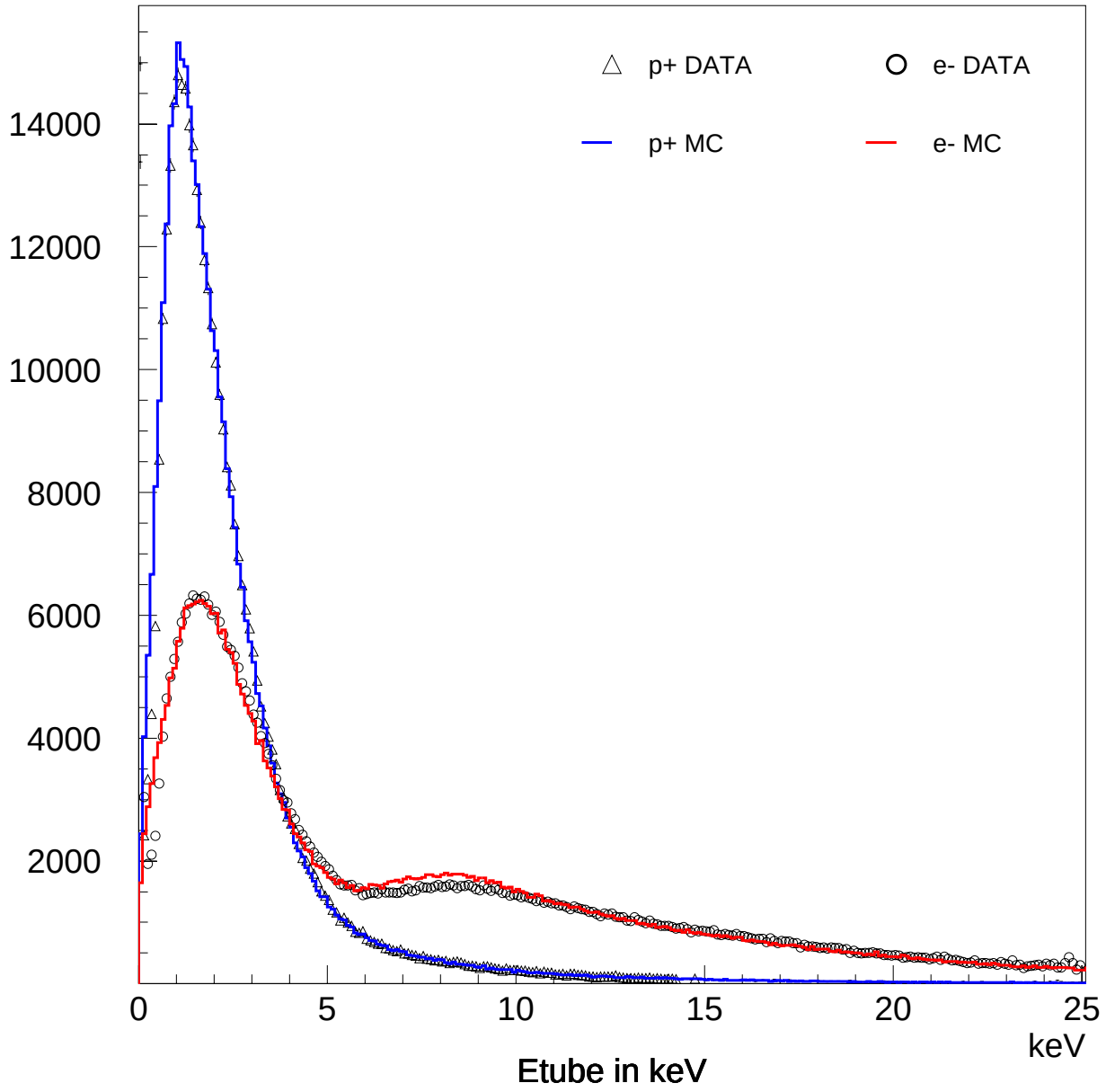
1 % density variation (3K) leads to 5.4 % gain variation

Event Selection



Require clean single track events
(single track efficiency 50% - 80%)

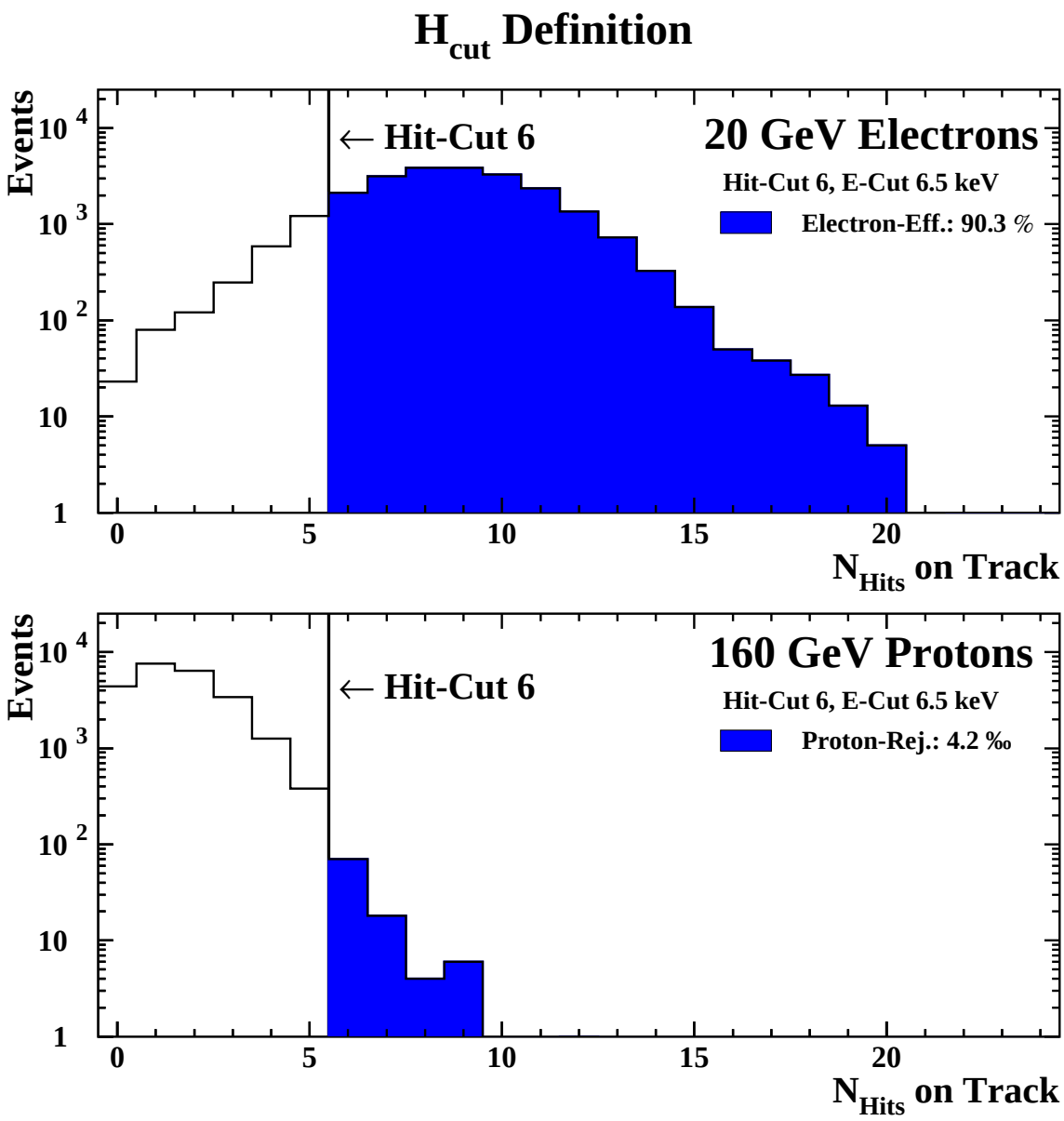
20 GeV Tube Spectra



$\Rightarrow$ CC: Hits in a tube with E $>$ 6.5 keV $\rightarrow$ TR-Hit

$\Rightarrow$ LH: energy-loss distributions $P^i_{e,p}(E_i)$ per tube for e^- and p^+.

Cluster Counting



Likelihood Method

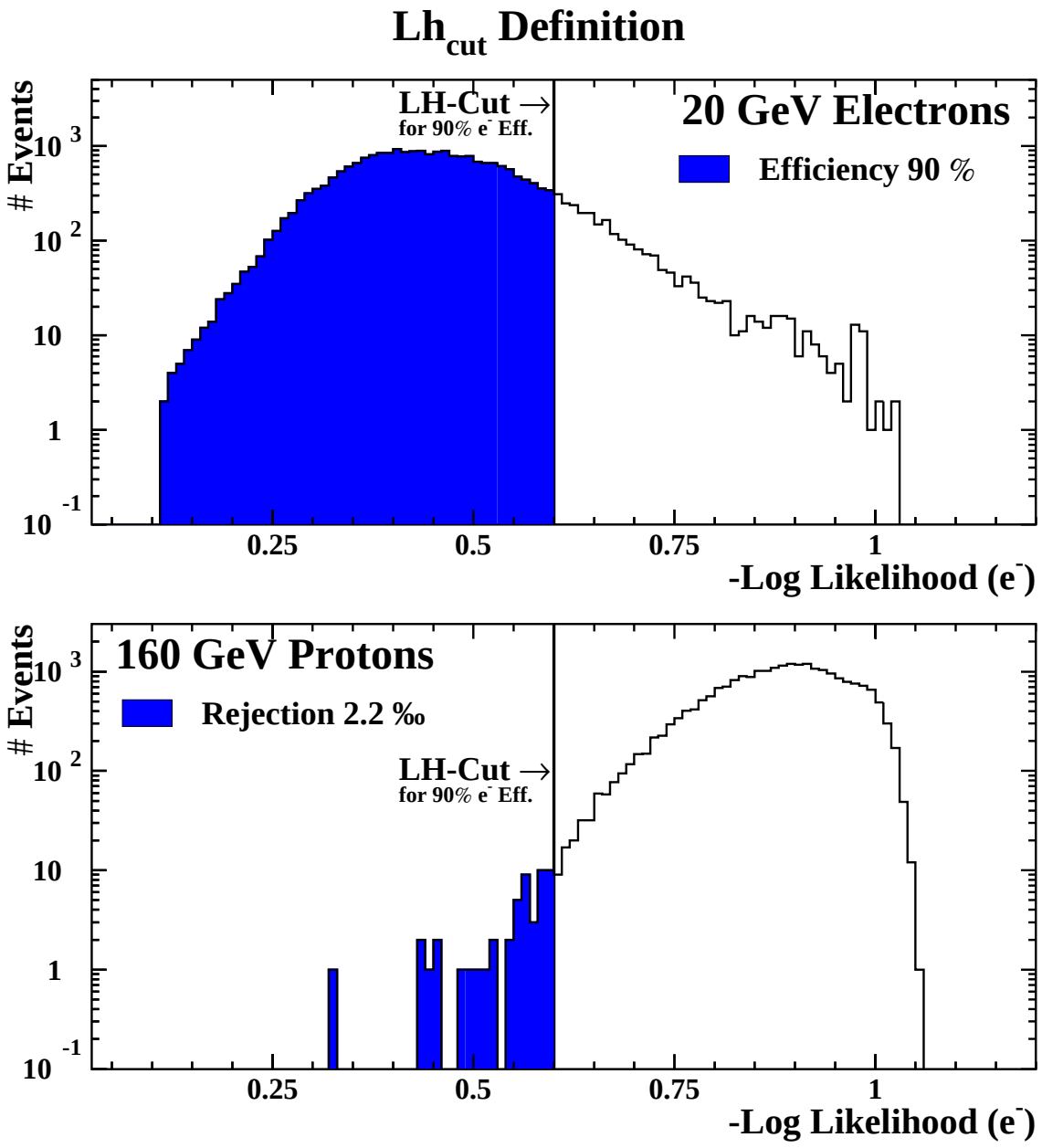
- Determine normalised energy-loss distributions $P^i_{e,p}(E_i)$ per tube for e^- and p^+.
- Use $P^i_{e,p}(E_i)$ as propability density functions
- For each Event run along the track and calculate the propability

$$W_{e,p} = \prod_{i=1}^{N} P^i_{e,p}(E_i)$$

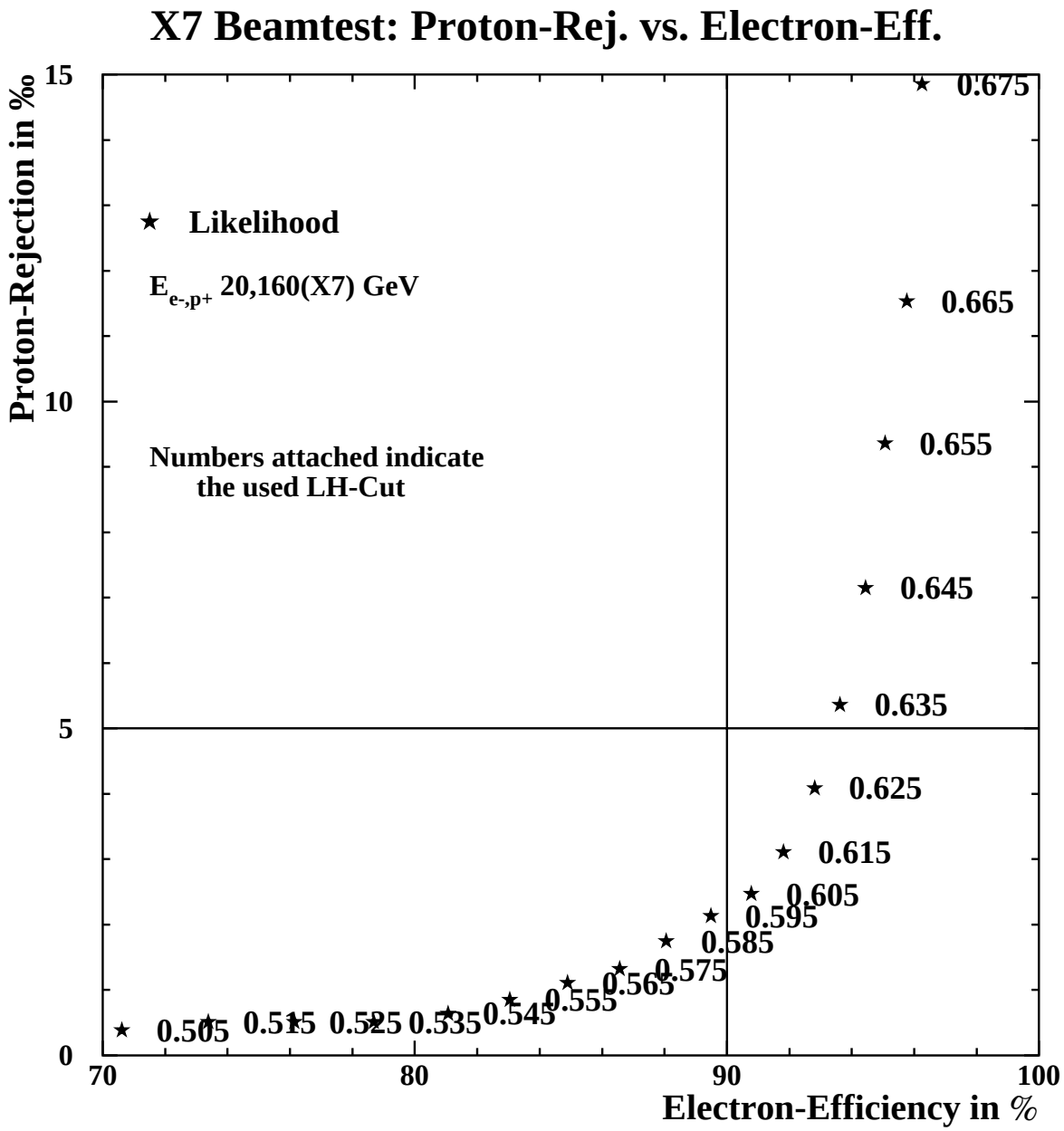
- Determine the Likelihood Ratio:

$$L_e = \frac{W_e}{W_e + W_p}$$

Likelihood


Lh$_{cut}$ Definition
LH-Cut →
for 90% e⁻ Eff.
20 GeV Electrons
Efficiency 90 %
Events
-Log Likelihood (e⁻)
160 GeV Protons
Rejection 2.2 ‰
LH-Cut →
for 90% e⁻ Eff.
Events
-Log Likelihood (e⁻)

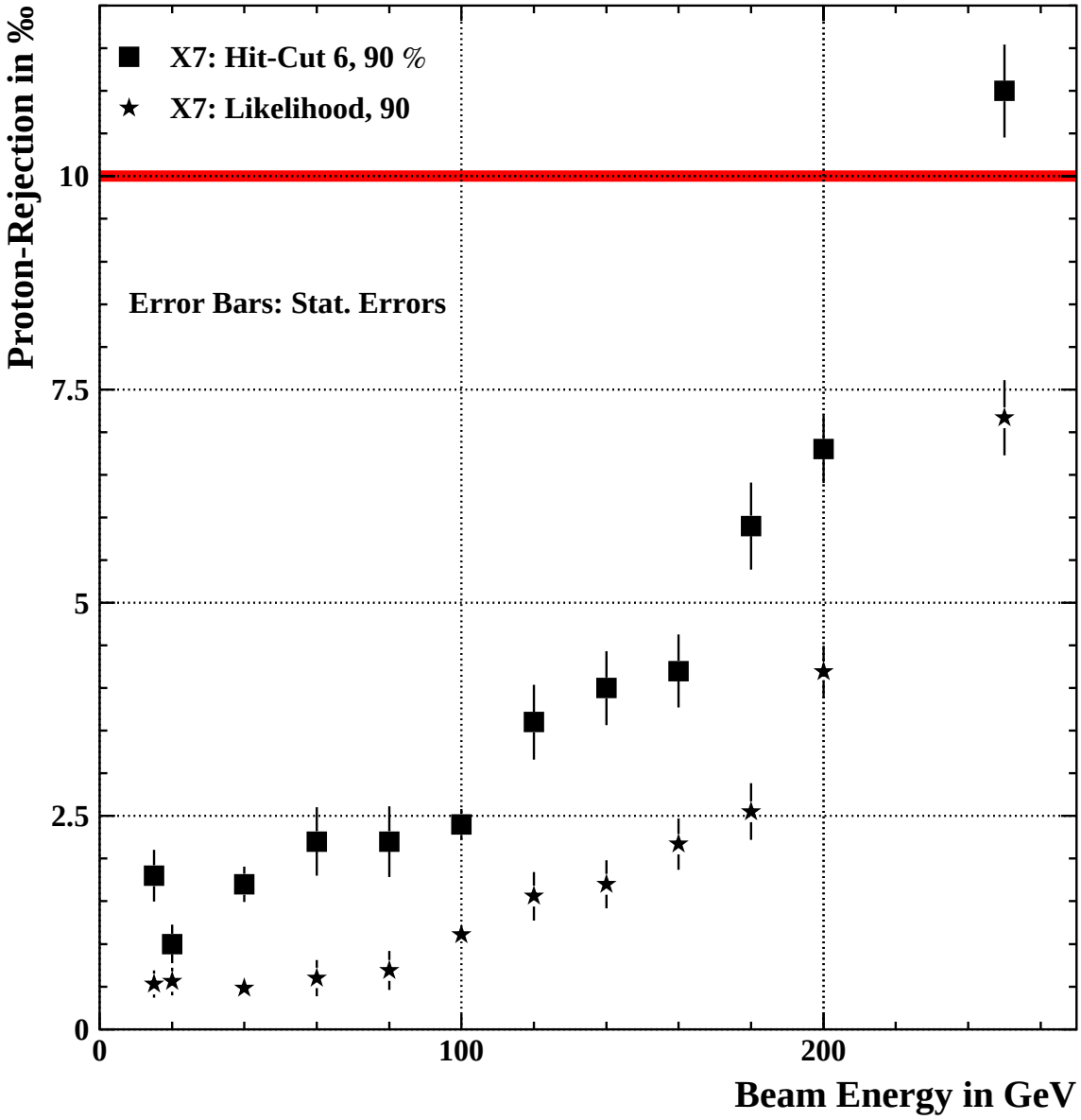
Likelihood



$\Rightarrow$ Proton-Rejection 2.2 ‰ at 90 % Electron-Eff.

X7: Rejection vs. Beam-Energy

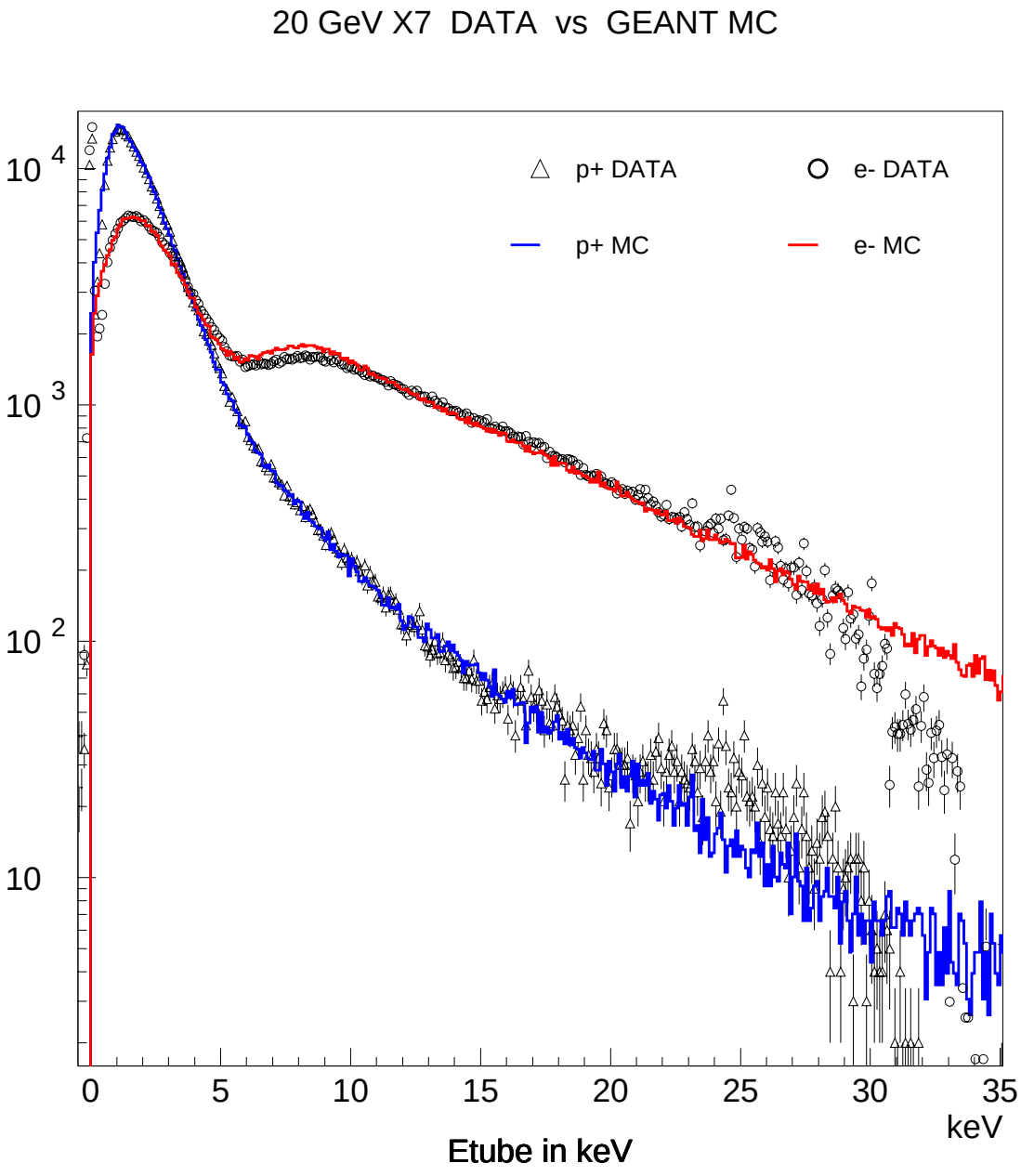
Upper Limit



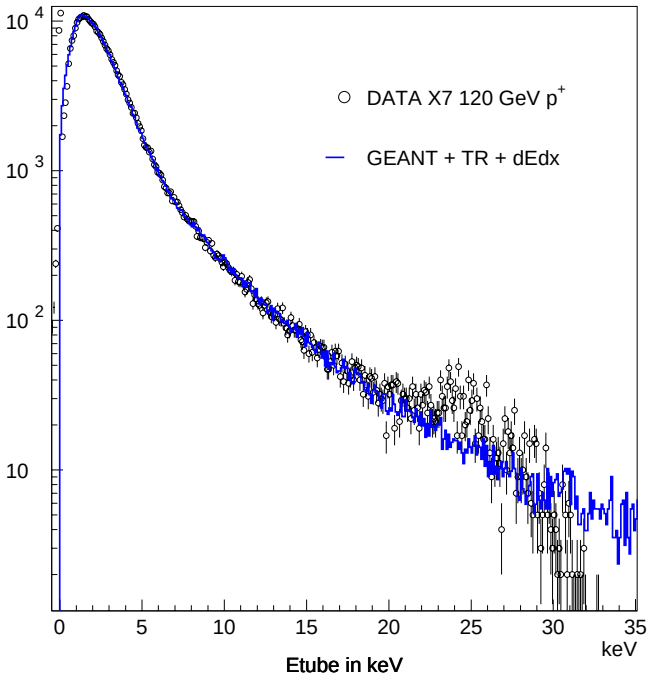
Comparison DATA $\Leftrightarrow$ GEANT

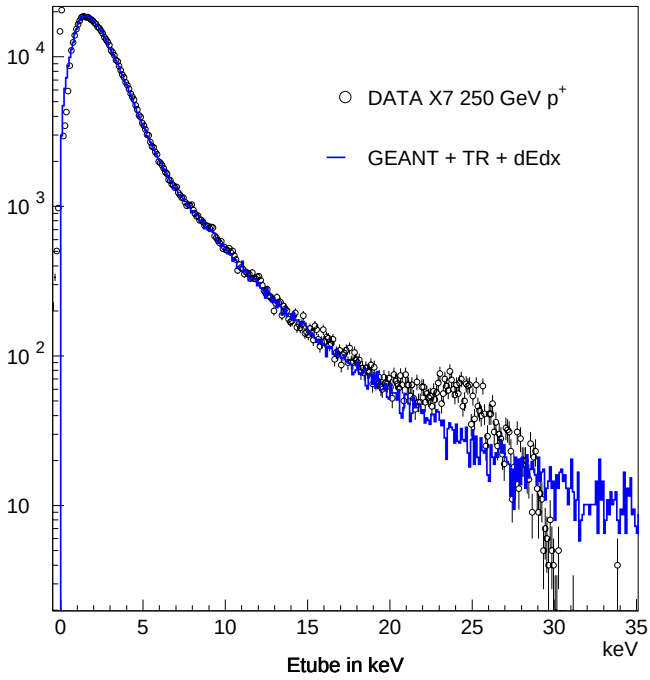
GEANT 3.21 + TR-generation/absorption:

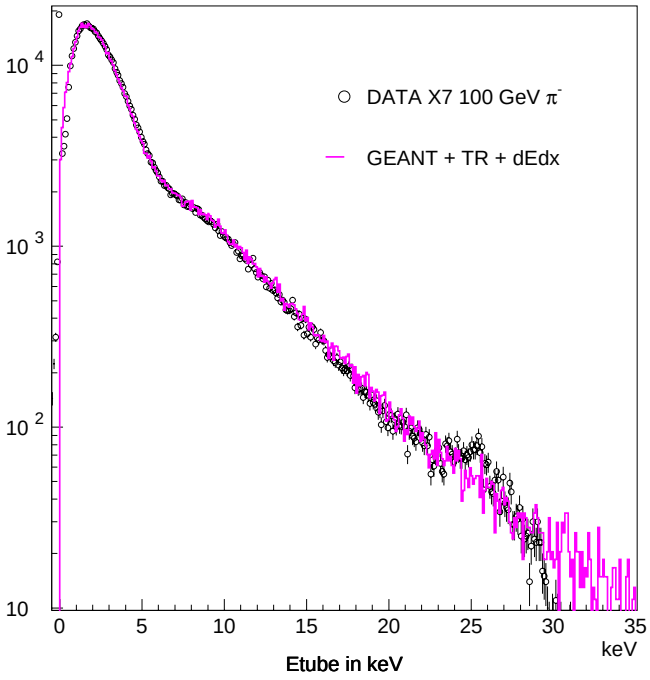
(Cherry Phys. Rev. D 10 (1974) 3594, implemented by V. Saveliev)

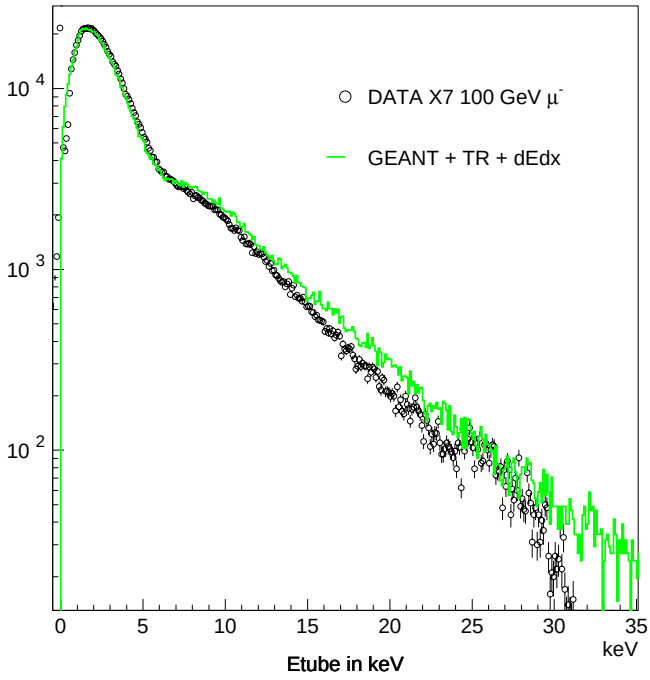


Comparison DATA ⇔ GEANT

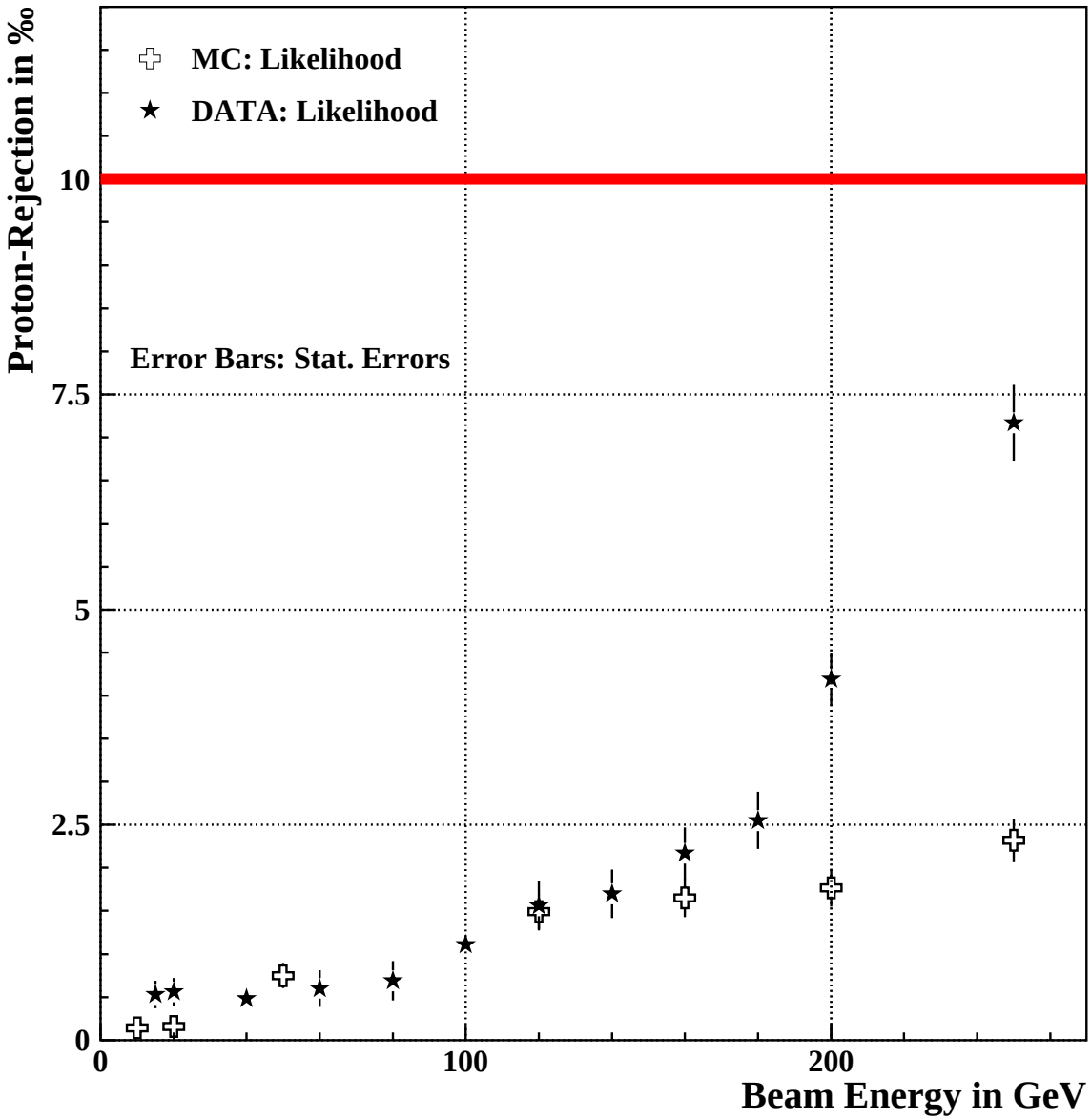








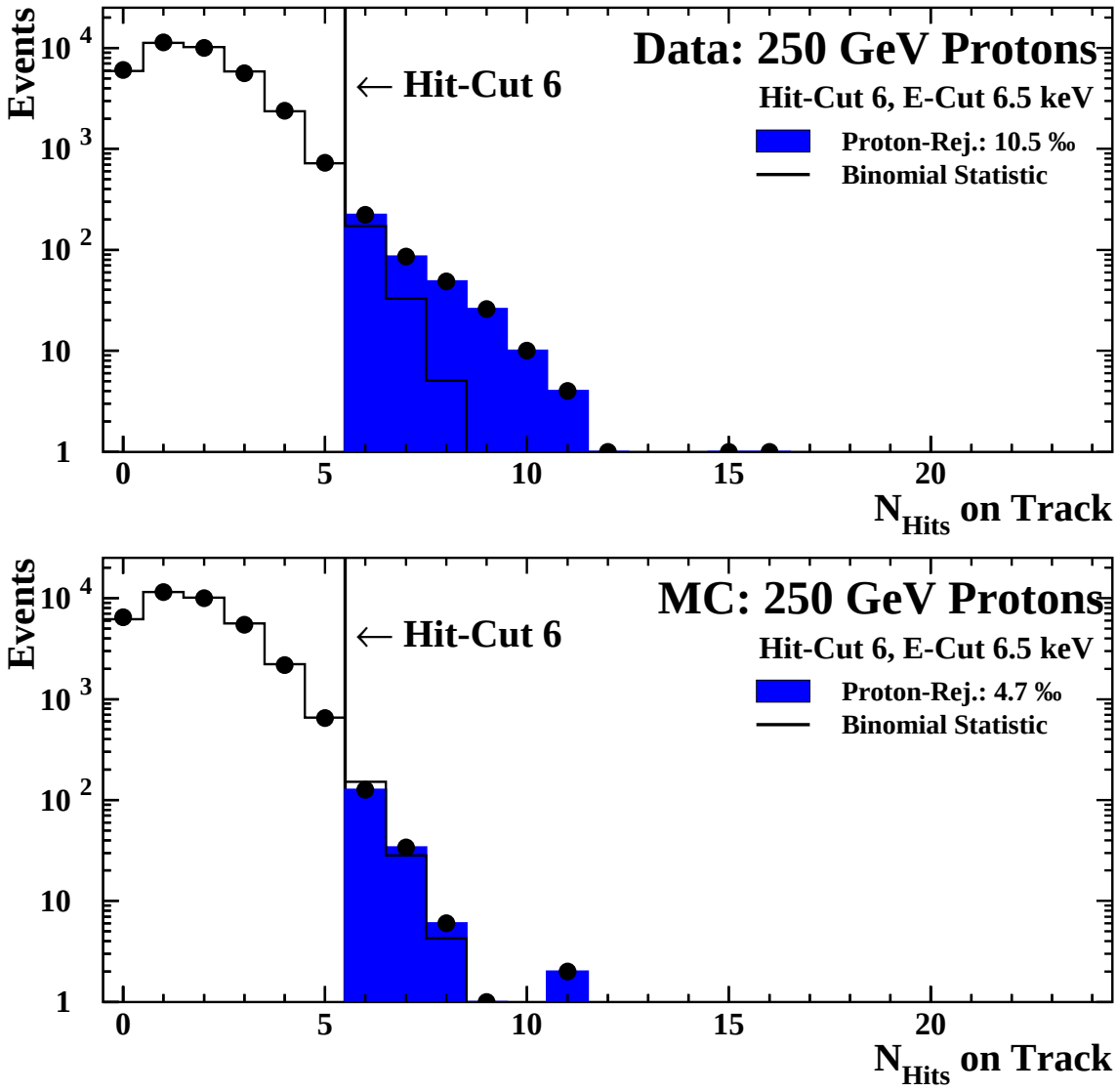
Comparison DATA $\Leftrightarrow$ GEANT



Uncertainty:
- TR in MC
- VA-Readout
- π^+-contamination in p^+-beam

Comparison DATA $\Leftrightarrow$ GEANT

Binomial Stat. vs. Cluster Counting



$\Rightarrow$ 6 ‰ Pion Contamination can explain difference

Conclusion + Outlook

- TRD prototype performed better than expected proton rejection $< 10^{-2}$ up to 250 GeV
- GEANT TR/dEdX up to 300 GeV in progress
- Cleaning of LRP 375 BK with CH_2Cl_2 does not effect TR-yield
- End of TRD-construction $\rightarrow$ Sep. 2002
  $\hookrightarrow$ Cosmictest with full TRD
- Full TRD beamtest forseen for early 2003
- AMS02 Assembly end of 2003
- Set for liftoff in Nov. 2004