Background Cosmic Ray Flux Measured by Balloon Flight Engineering Model

GLAST-LAT Collaboration Meeting

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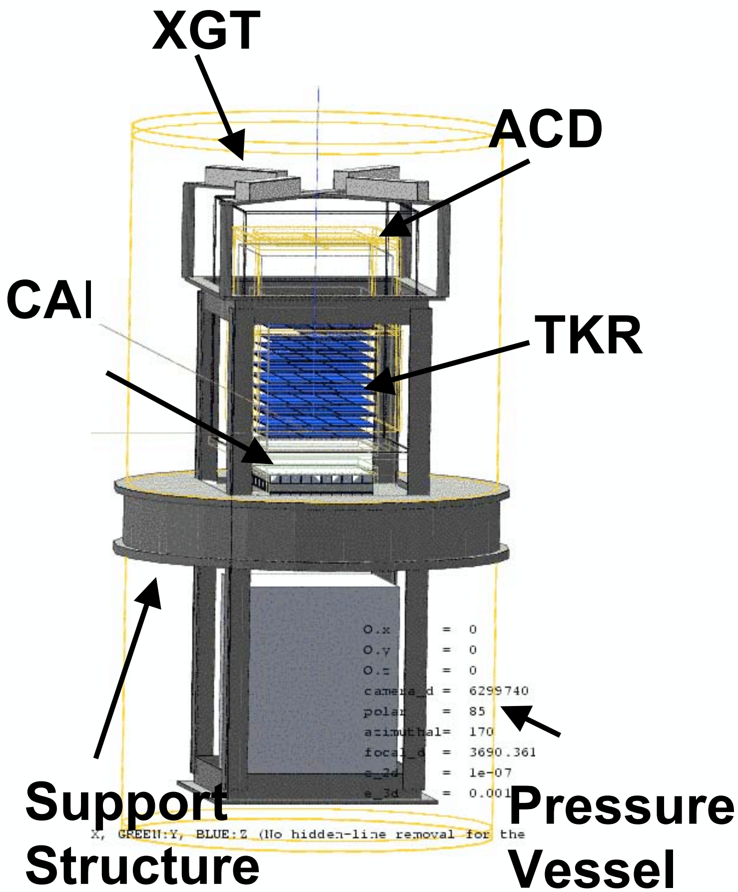
(Real work done mostly by T.Mizuno)

Balloon Engineering Flight Model

- **Monte-Carlo detector simulator** using Geant4 toolkit.
- **Cosmic-ray spectral models** referring to previous measurements.
  - proton: primary/secondary
  - alpha: primary
  - electron/positron: primary/secondary
  - gamma: primary, secondary (downward/upward)
  - muon: secondary

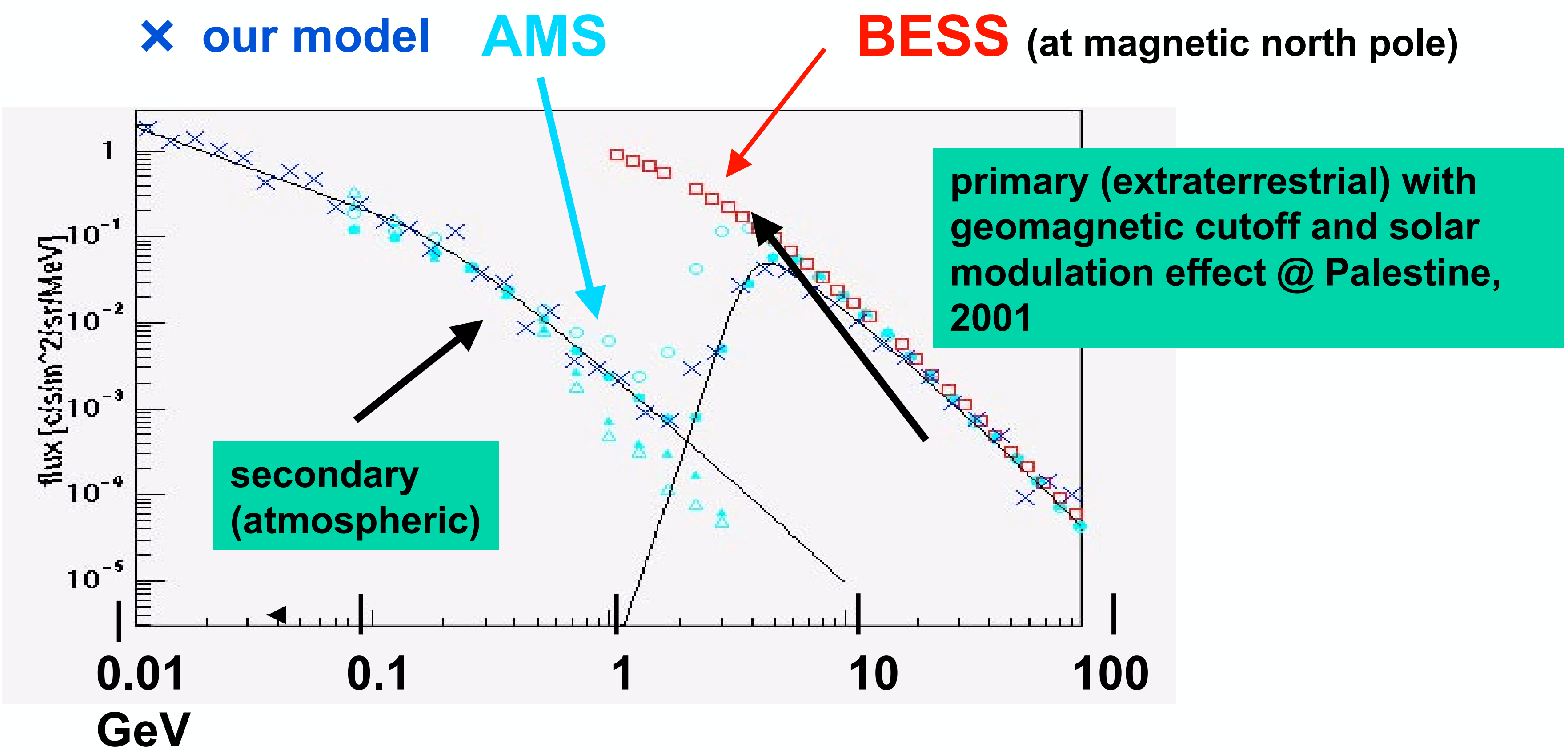
(All but secondary downward gamma will be present in the low earth orbit.)

- BFEM data and G4 simulation are compared.



Cosmic-Ray Model: Proton(1)

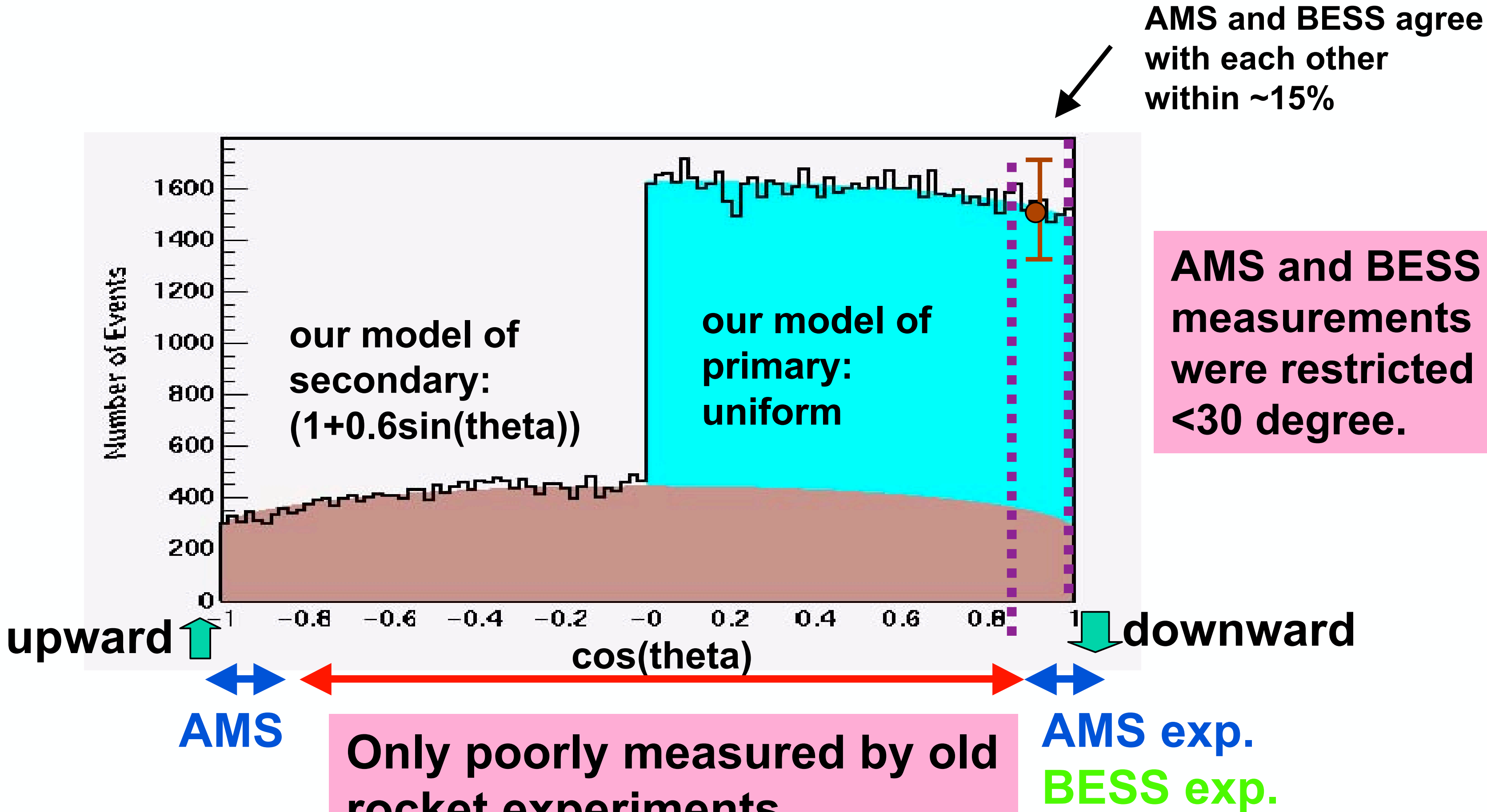
Energy spectrum from zenith downward: well measured



- The flux in high geomagnetic latitude (~0.73 radian) shown here corresponds to the maximum flux expected in the GLAST orbit.

Cosmic-Ray Model: Proton(2)

Proton zenith angle distribution: only poorly known



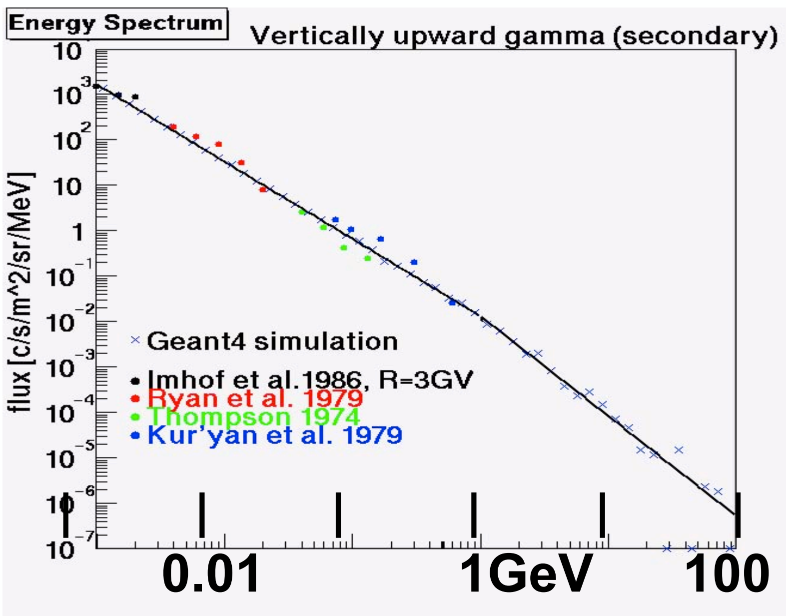
AMS and BESS measurements were restricted to <30 degree.

Only poorly measured by old rocket experiments.

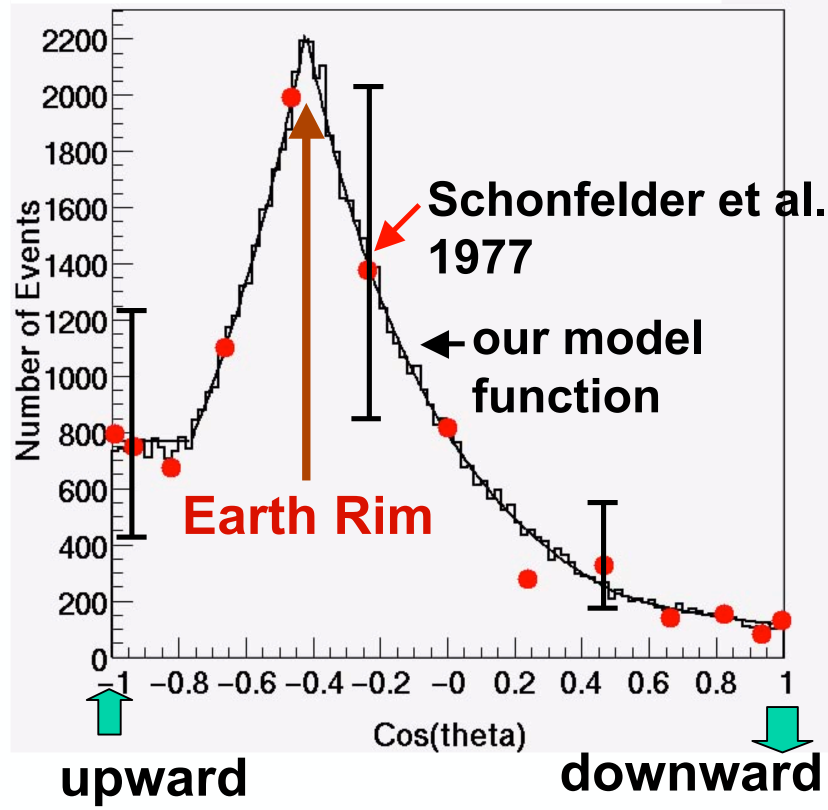
Cosmic-Ray Model: Gamma

Energy spectrum

Atmospheric gamma (upward)



Zenith angle dependence



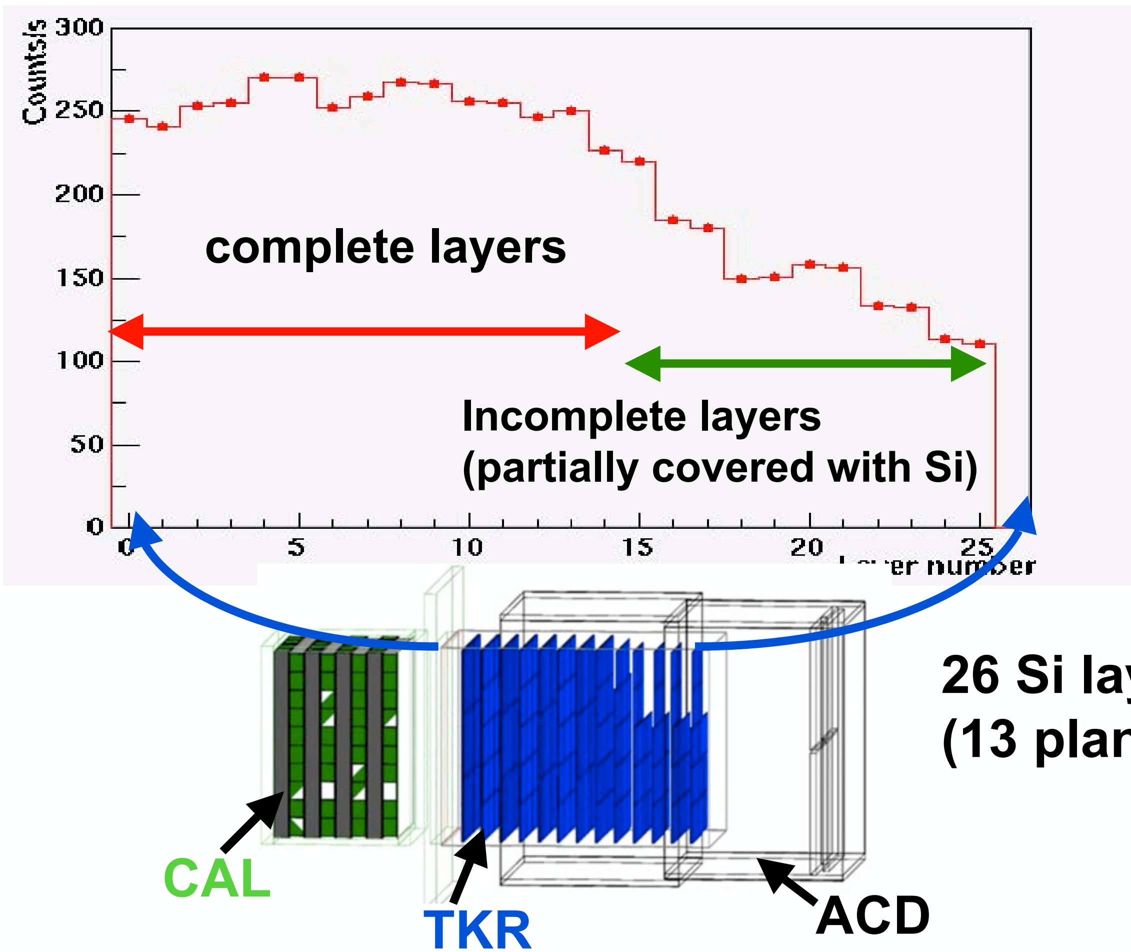
Upward gamma-ray flux will be similar to that in GLAST orbit.

Angular dependence of the flux is poorly known.

We also implemented alpha, e-, e+, and muon spectra.

Count Rate per Layer for "Charged Events": Real Data

"Charged Events" = Events with one or more hits in ACD

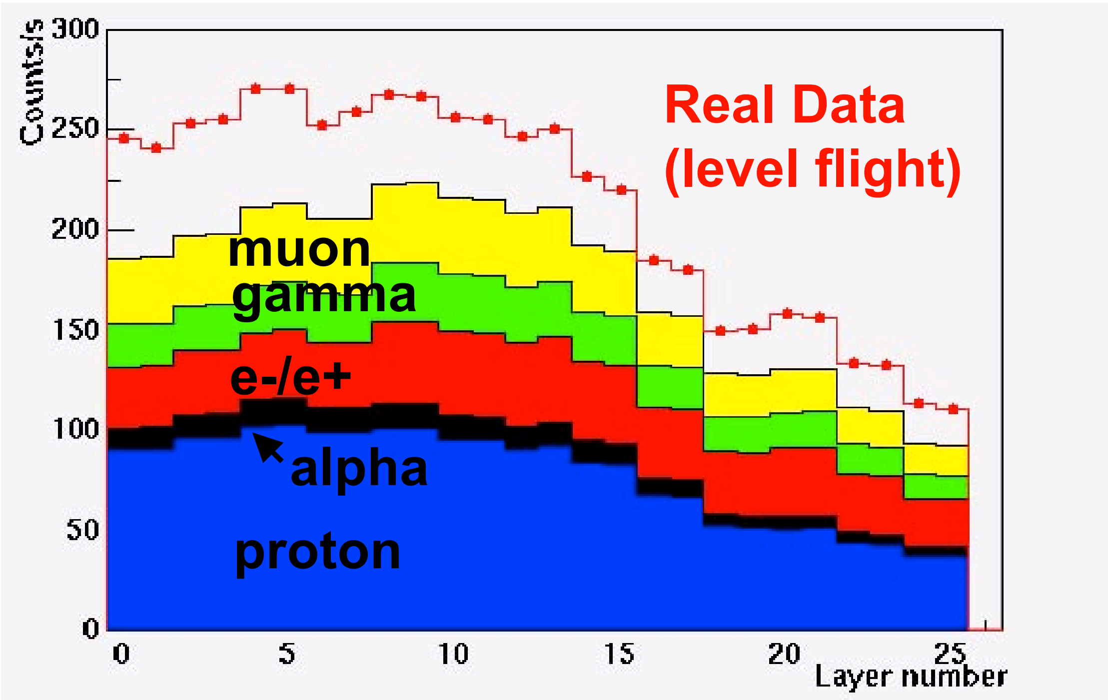


26 Si layers
(13 planes: x-y pair)

Count Rate per Layer for "Charged Events": Data vs. Simulation

- Trigger rate (Data)
  ~445Hz
- Simulation total
  (<u>our prediction before the flight</u>)
  ~350Hz
  - proton : 145Hz
  - alpha : 18Hz
  - e- : 45Hz
  - e+ : 30Hz
  - gamma : 50Hz
  - muon : 62Hz

Count rate per layer



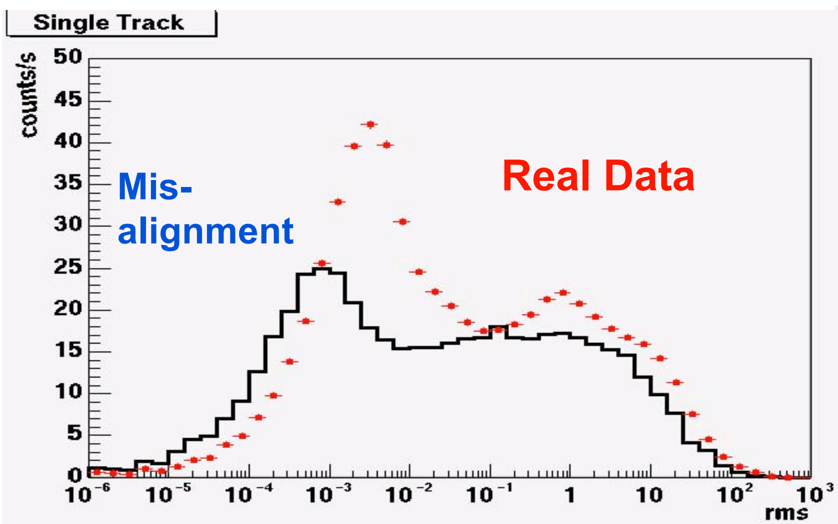
- Our model reproduced the shape of the distribution very well.
- Our prediction of the trigger rate is ~20% smaller than observed data.

"Chi-square" Distribution of Straight Tracks

Root mean square of reconstructed track (simulation)

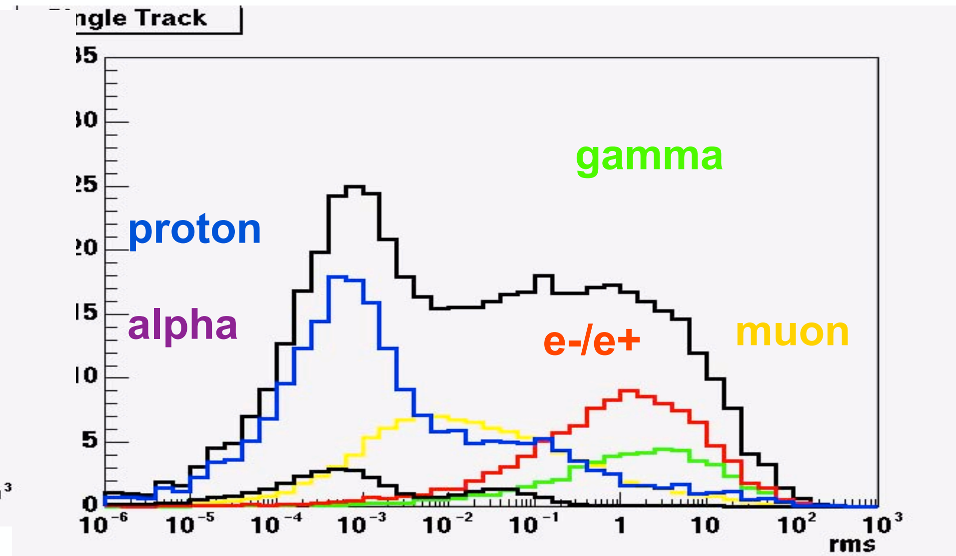
"Chi-square" for tracks without CAL data assumes E=30MeV electron

data vs. simulation



"Chi-square" of straight tracks

Simulation (total)

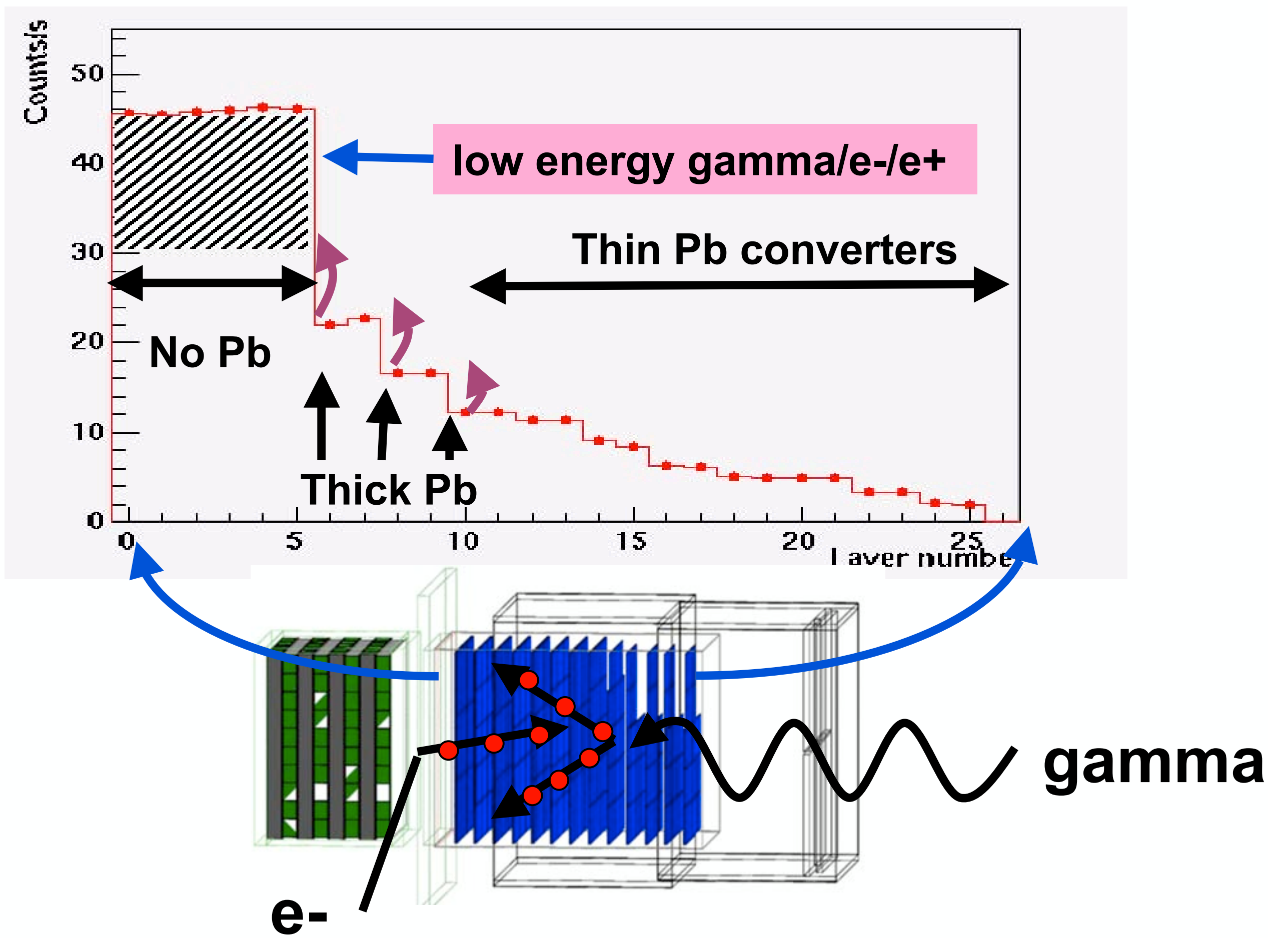


"Chi-square" of straight tracks

•We can separate proton/alpha/muon from e-/e+/gamma, select straight track events and study the angular distribution of them.

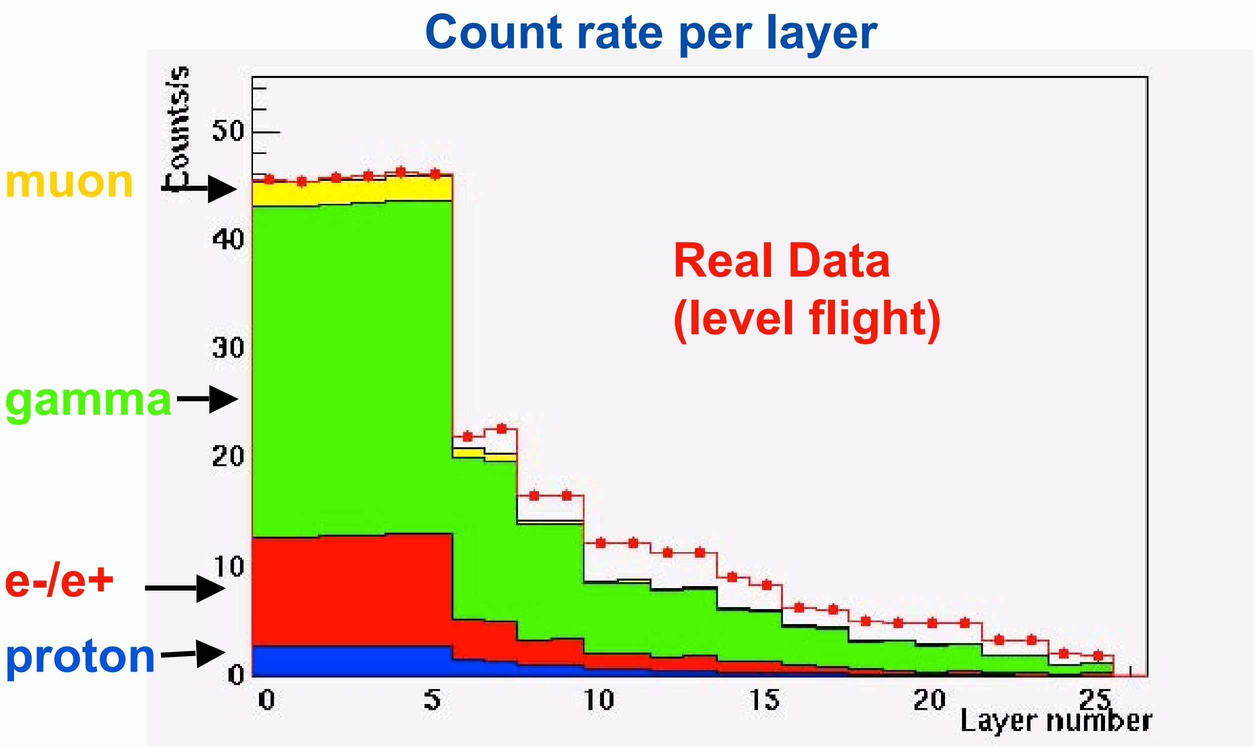
Count Rate per Layer for “Neutral Events”: Real Data

“Neutral Events” = Events without hit in ACD



Count Rate per Layer for Neutral Events: Data vs. Simulation

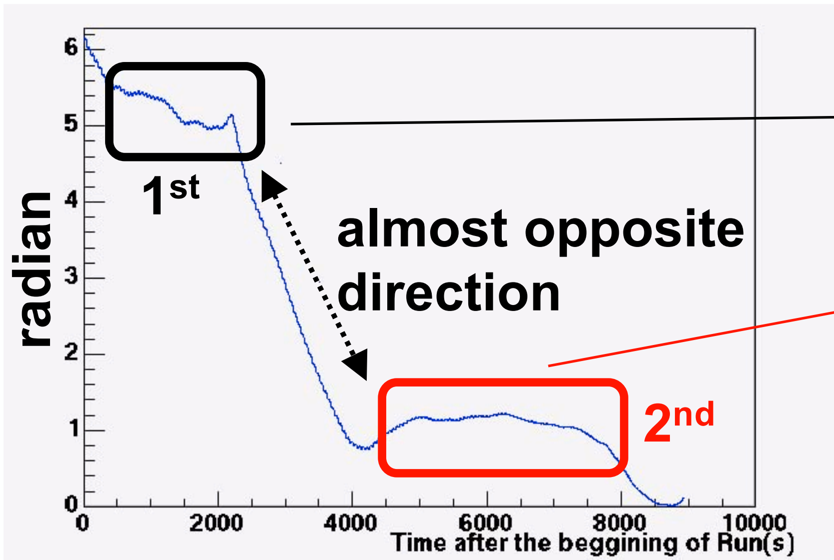
- Trigger rate (Data) ~55Hz
- Simulation total (<u>our prediction before the flight</u>) ~52Hz
  - proton : 3.1Hz
  - alpha : ~0Hz
  - e- : 6.9Hz
  - e+ : 3.9Hz
  - gamma : 35.5Hz
  - muon : 2.4Hz



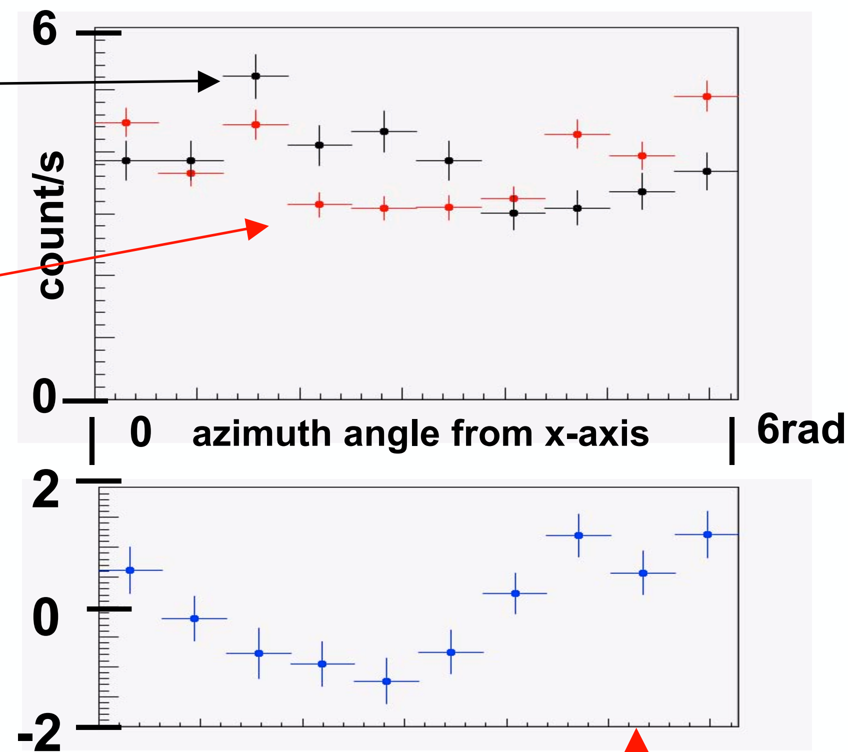
- Overall agreement is good between data and prediction.
- Count rate in upper layers are smaller than data.
- Need a reconstruction program for low-energy (<=100MeV) gammas to study angular dependence.

East-West Effect Seen in Data

Time history of azimuth direction of the BFEM



Azimuth dependence of "charged" straight tracks (0.5<cos(theta)<0.7)



Direction was stable in the level flight.

We see the east-west effect.

Difference btwn the two regions

particle comes from east in 2nd region

Study of Particle Composition by Straightness of Tracks

Study shown in a previous slide opened a possibility to study composition of tracks.

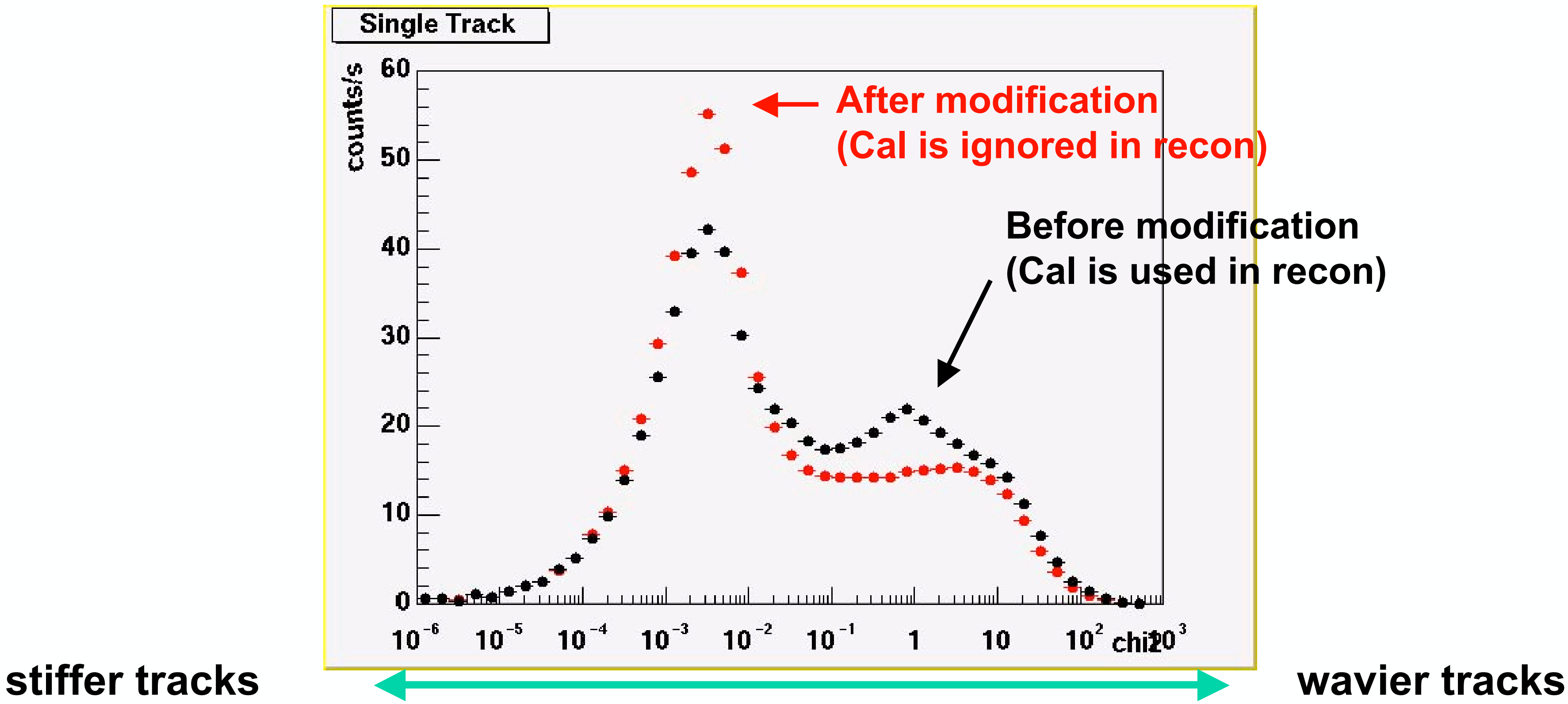
A few disagreements were there btwn Data and Simulation:

1) Obvious effect of misalignment in "chi-square" <10**(-2)
2) "Anomalous" bump in "chi-square" at around 1.0

Resolution:

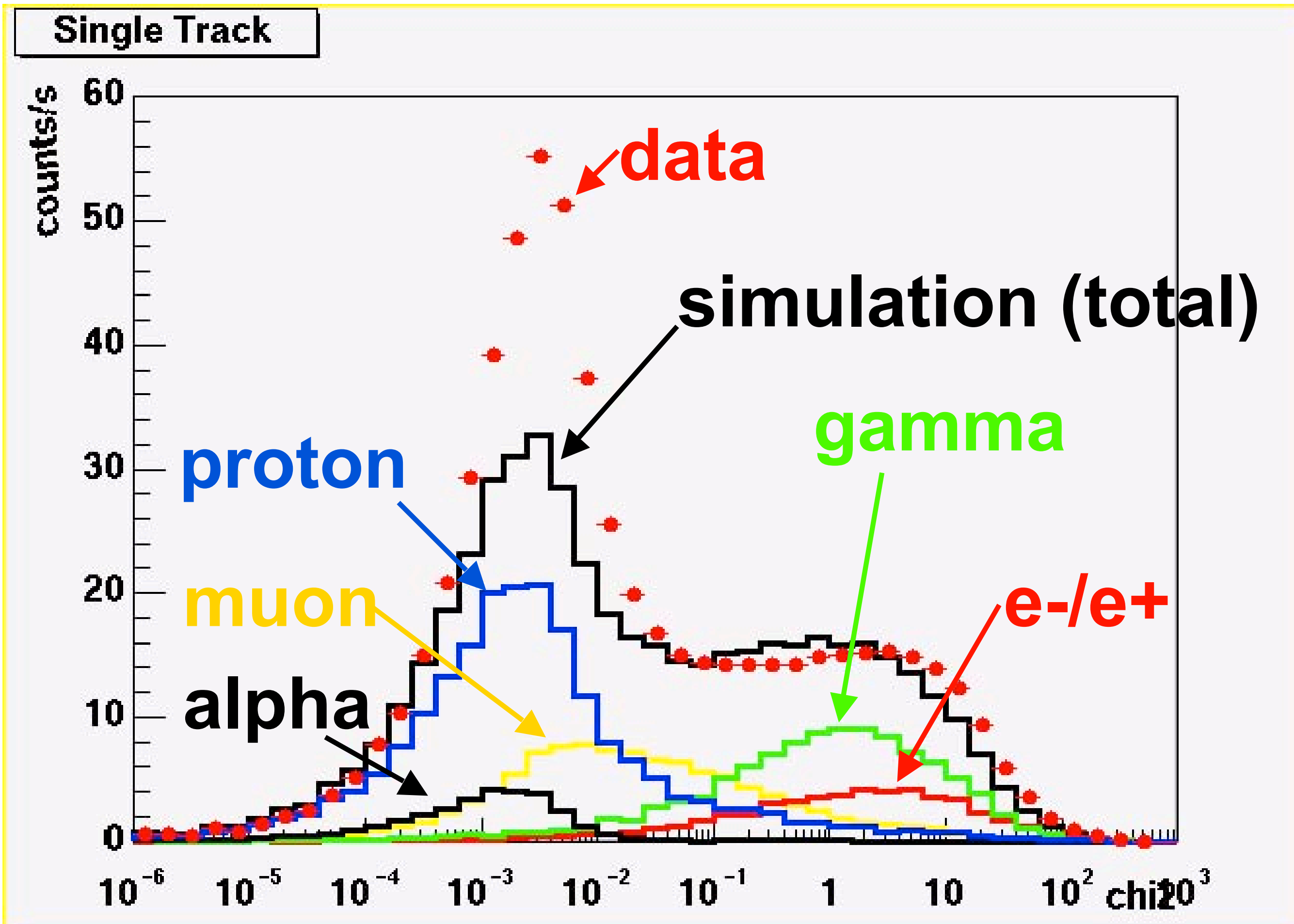
Res.1) Hiro Tajima ran his SSD alignment program (under development for LAT) and fixed it.

Res. 2) With Leon's help, we found that inaccurate CAL calibration in BFEM lead to a strange "local minimum ch-square". We ignored CAL data.



New "Chi-square" Distribution of Tracks: data and simulation

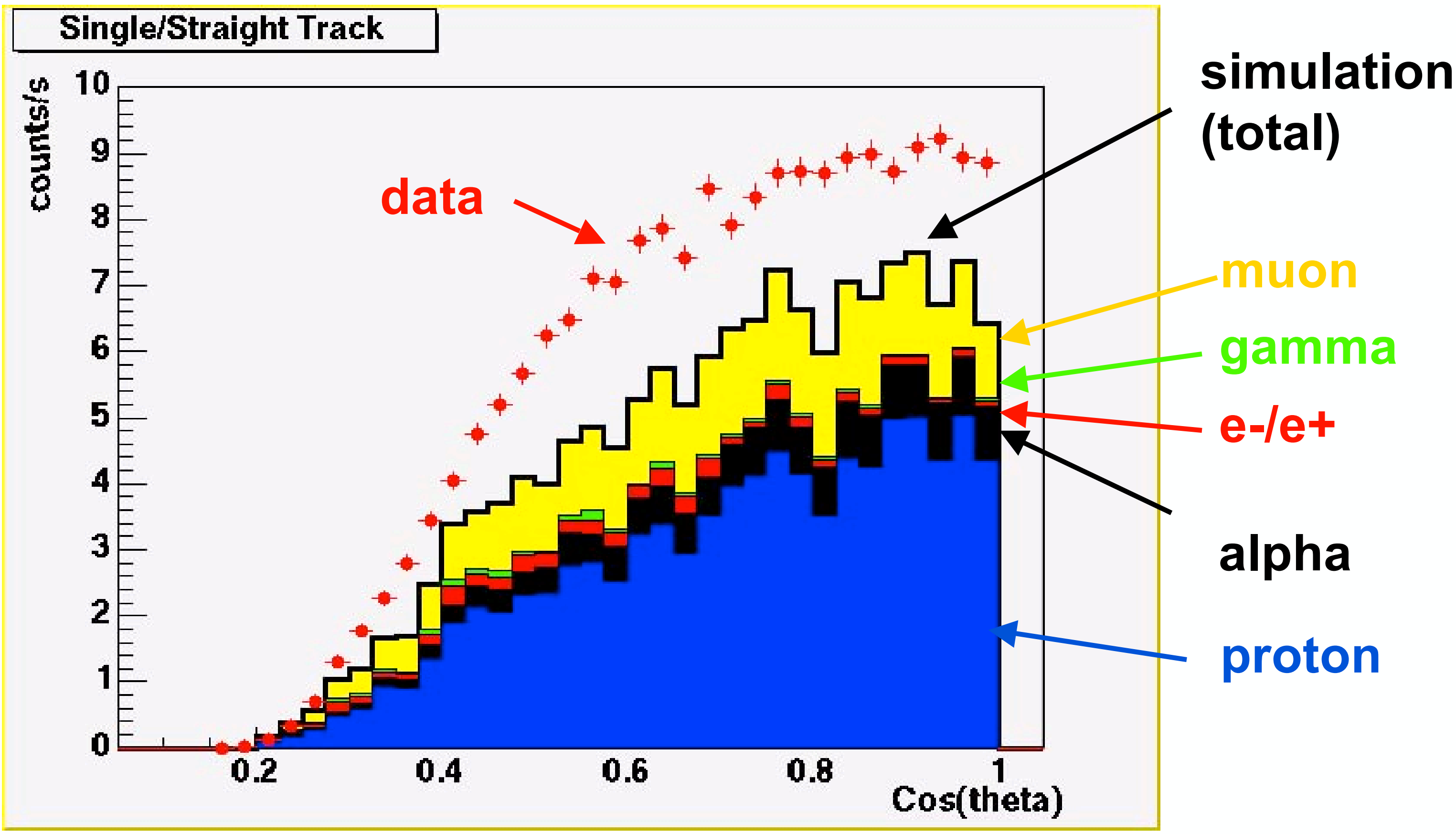
CAL data ignored in recon.



Agreement is better but we find more "stiff tracks" in the BFEM data.

Revisit the angular dependence of single/straight tracks

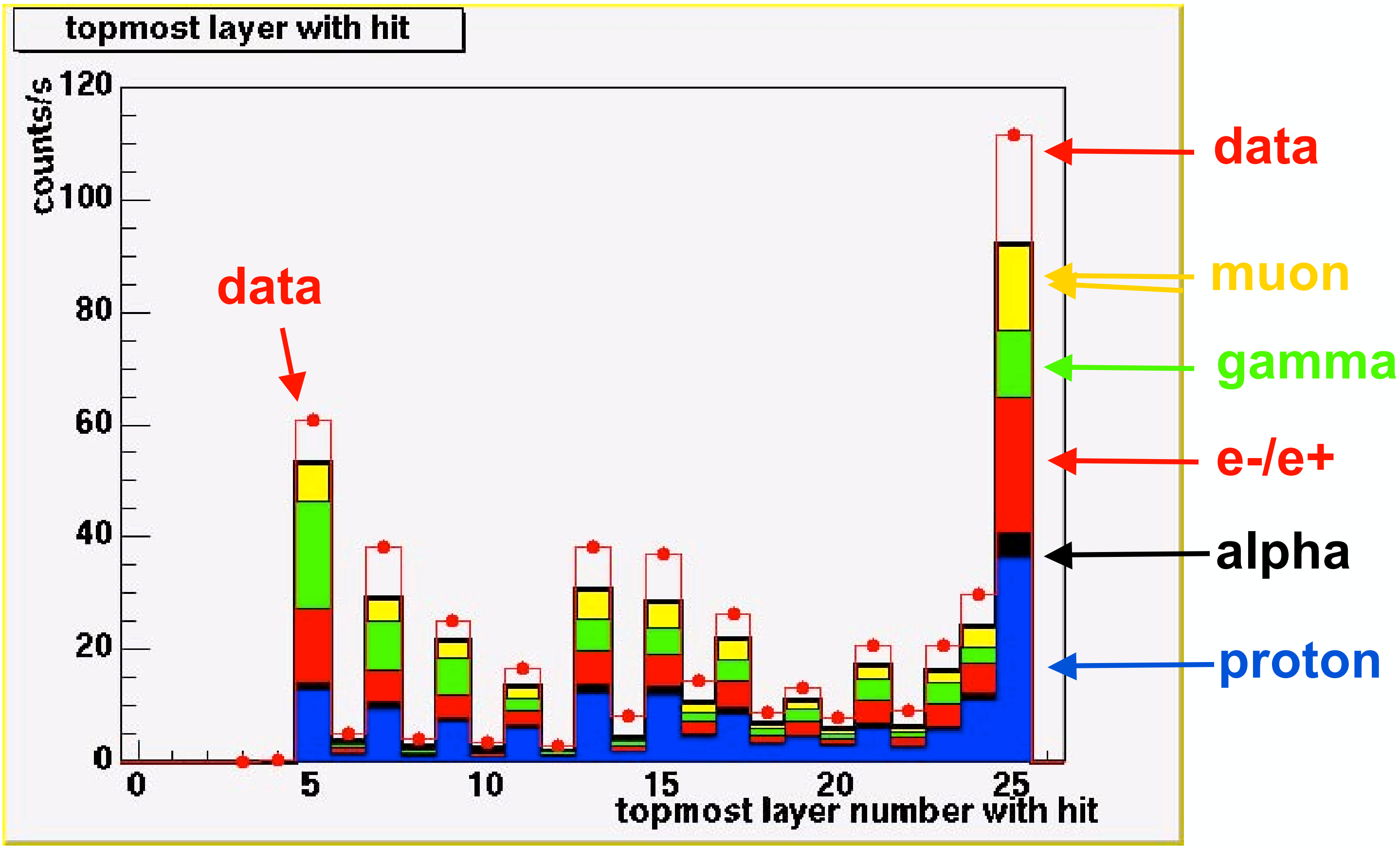
Zenith angle distribution of single and straight (chi^2<=0.1) tracks.



Now the agreement near cos(theta)=1 with BESS and AMS is gone! WHY?

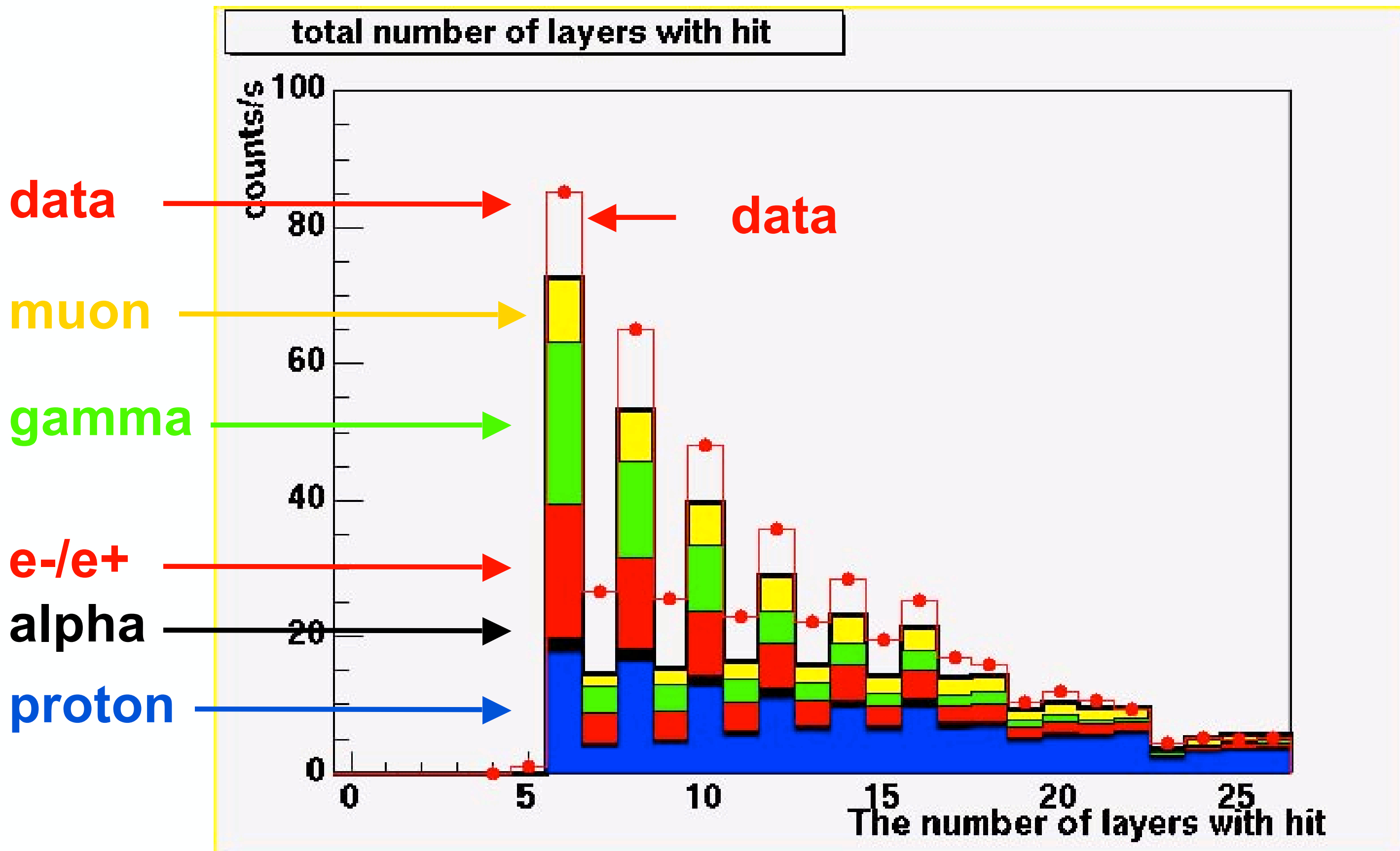
Other Disagreement?: Topmost Layer Distribution

No Chi-square selection



The Shape of two distribution appears to be in agreement.

Other Disagreement?: Total Number of Layers with Hits

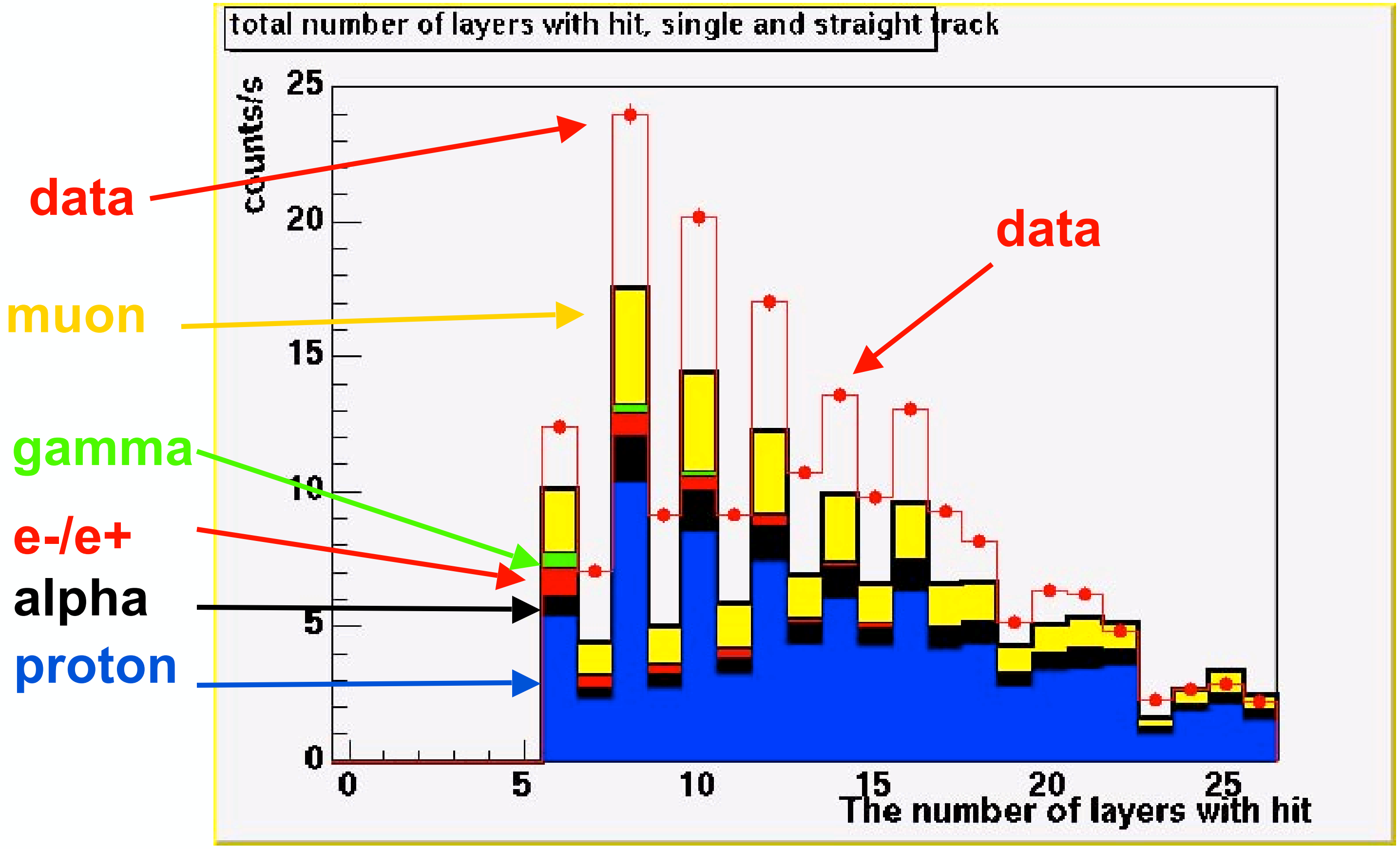


No Chi-square selection

Data show typically 10-20% more layers spill over to odd numbers for total numbers less than 17.

Other Disagreement?: Total number of layers for straight tracks

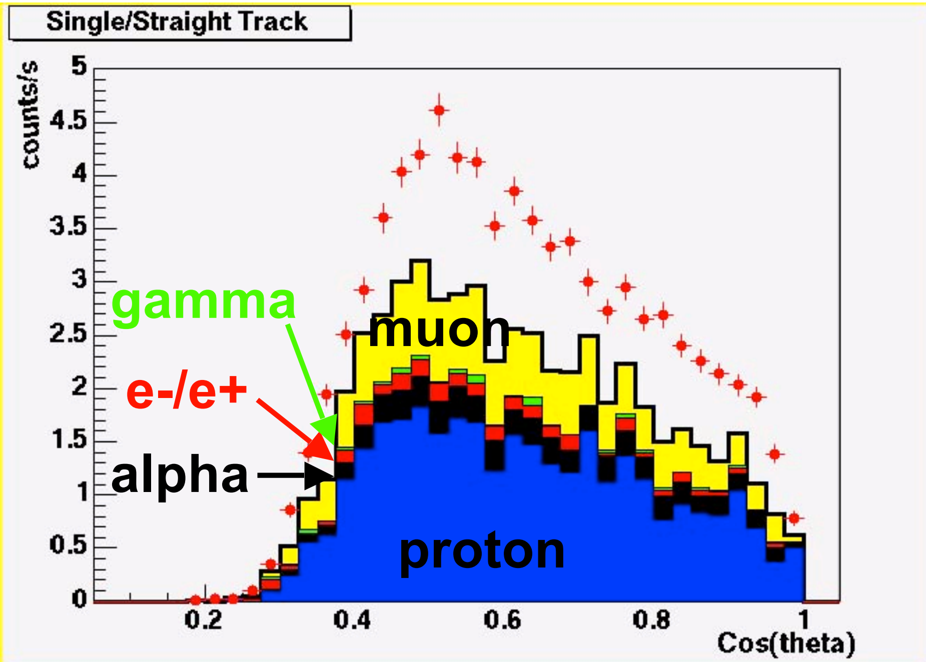
Single and straight ($chi^2 <= 0.1$) tracks selected



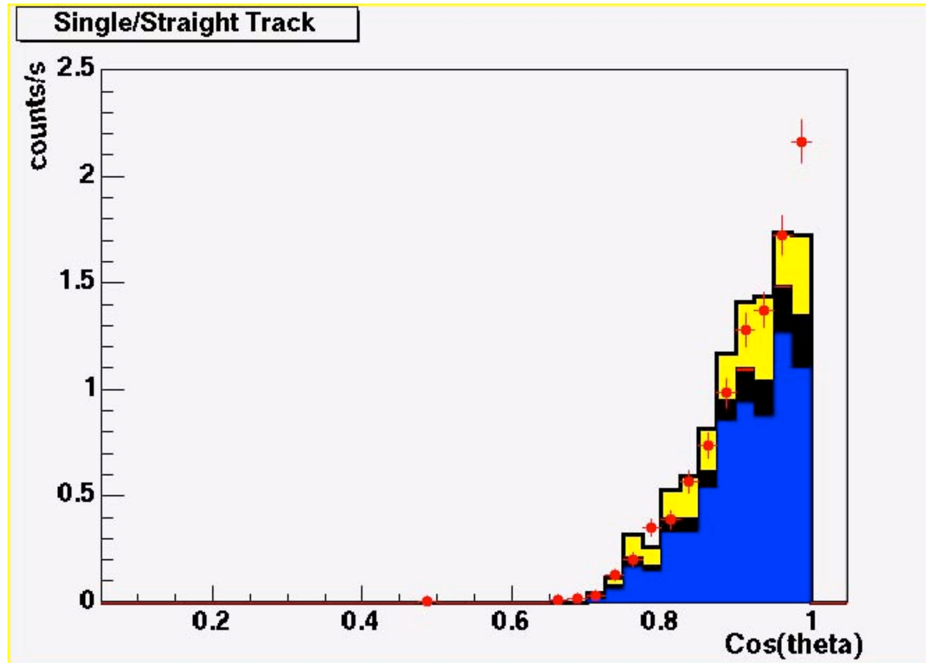
Odd numbers are filled more in data by ~20% for total number 6-18

Revisit Angular Dependence of Single/Straight Tracks

Total number of layers with hit = 8-12



Total number of layers with hit = 23-26

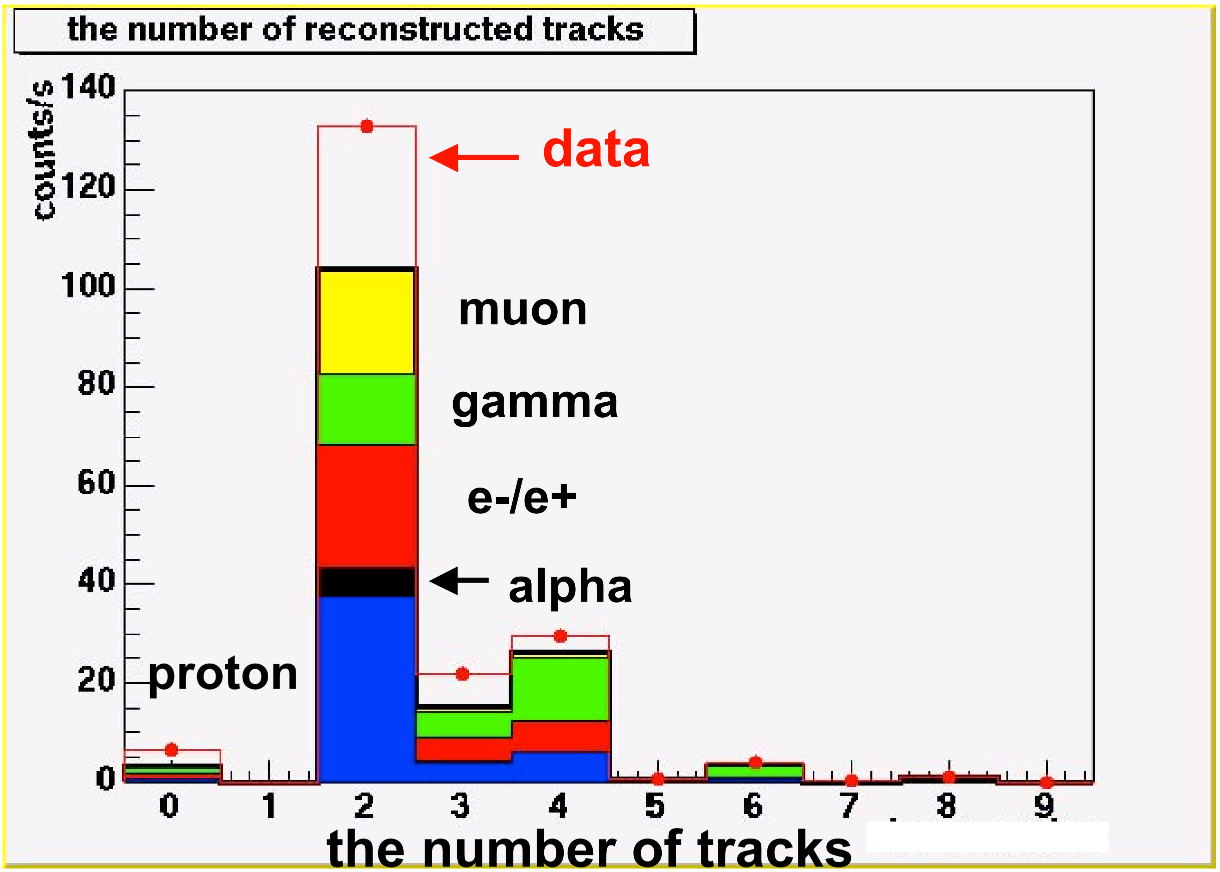


Normalization is off by 30%.

Good agreement btwn Data and Simulation

Number of reconstructed tracks

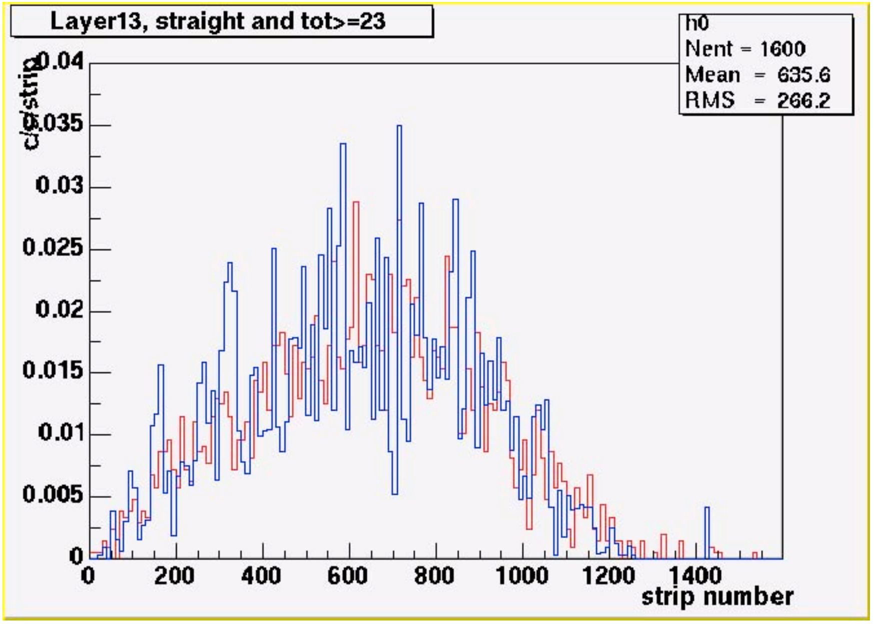
Number of layers with hit = (8-12) selected. Note that the number of tracks is 2 for single track events (x and y tracks).

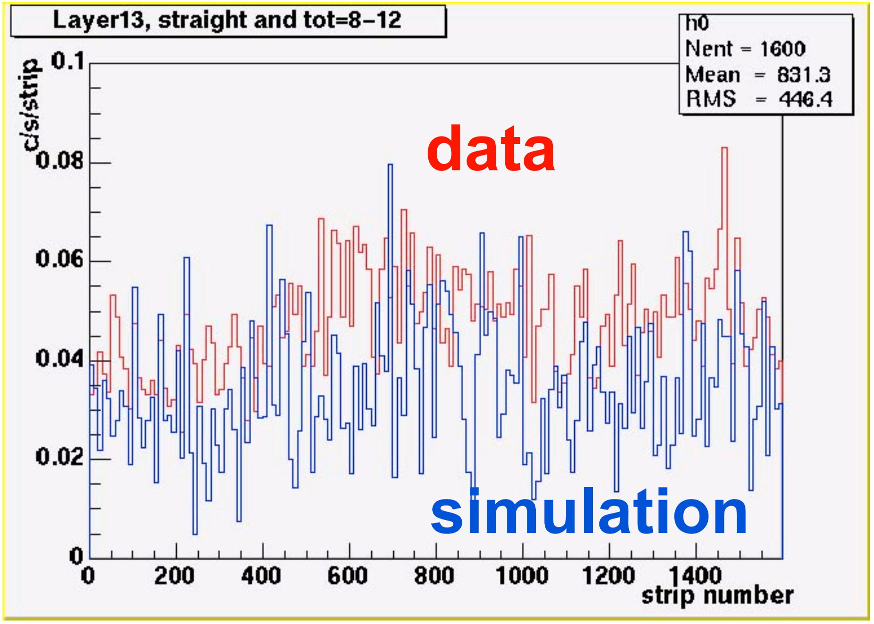


Hit Strip Distribution

Total number of layers with hit is large (23-26).

Total number of layers with hit is small (8-12).





Data and simulation agree in the shape of distribution.

Summary and Future Plan

- We see ~20% more charged tracks in BFEM data than our Cosmic Ray model predicts.
- We found straightness (least square) of tracks can be used in filtering e-/e+ from protons.
- When incorporating the CAL energy in the straightness of tracks analysis, inaccurate CAL measurements can mislabel protons as e-/e+.
- Simulation reproduces data well when the number of layers with hit is large, but it underestimates data when the number of layers is small and the ratio btwn #layer even and odd is off.
  - ~20-30% additional stray hits may explain this: stray X-rays and noise?
  - Simplification of honeycomb structure problematic: delta-rays?
  - ACD leakage on the 4 side corners: measured to be small.
  - Inclusion of protons with E>100GeV?
  - And ~ 20% higher proton flux?
- Eye scanning of short tracks and stray hits.
- Improved use of CAL data
- Reconstruction of gamma rays