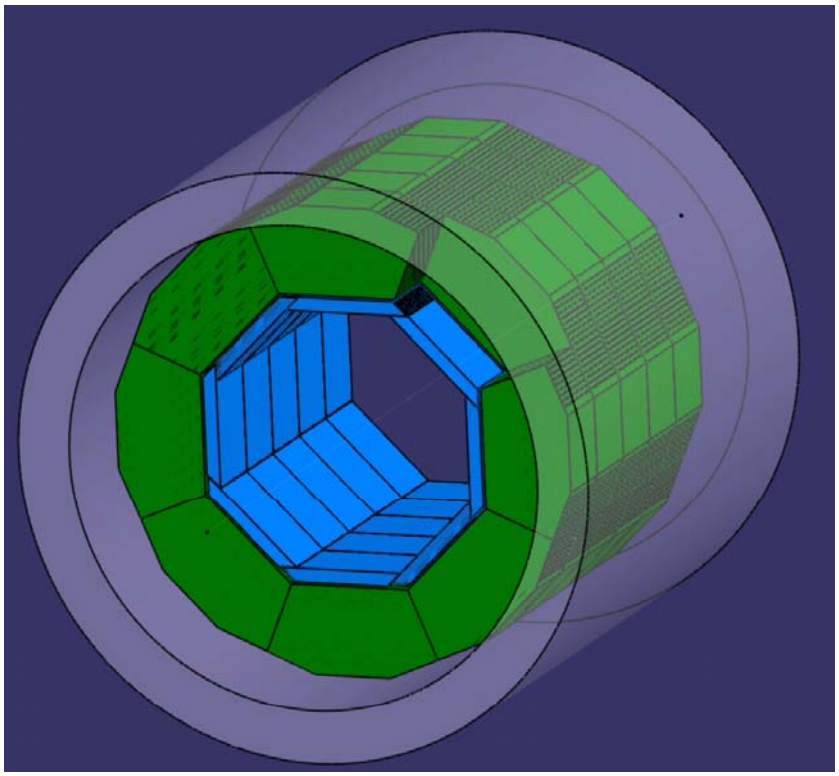

Studies on HCAL leakage estimation

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CALICE Calorimeter for ILC

DESY

EUDET

CALICE collaboration meeting
Argonne, March 19, 2008

** The work*
*** The talk*

Outline

- HCAL thickness
- Leakage estimation
- Discussion

Depth

- The HCAL depth has never really been optimized
  - R(CMS) – R(TPC) – 30 X_0(W)
- Was always criticized

- PFLOW reduces the problem (for charged particles)
  - To what extent – at high E?

- Shower shape "extrapolation"?
  - test beam

- How much does the tail catcher recover?
  - test beam

Leakage – Calorimeter energy correlation

Number of neutral hadrons per parton $(200GeV)$

	K_L^0	n
b	0.966	0.885
c	0.910	0.990
d	0.838	1.101
u	0.819	1.045

Remark:

$e^{-4} = \frac{1}{54.6}$

$e^{-5} = \frac{1}{148.4}$

Percentage of events with a leakage more then 5% of energy

16-sectors

Energy [GeV]	200	100	50	25	10
b	25.9	17.3	10.4	7.6	3.0
c	29.4	17.5	12.5	10.3	4.1
d	26.4	19.9	11.5	9.7	5.6
u	26.5	19.9	12.4	10.5	4.2
in average	27.1	18.7	11.7	9.5	4.2

8-sectors

in average	45.4	31.8	22.1	13.7	5.7

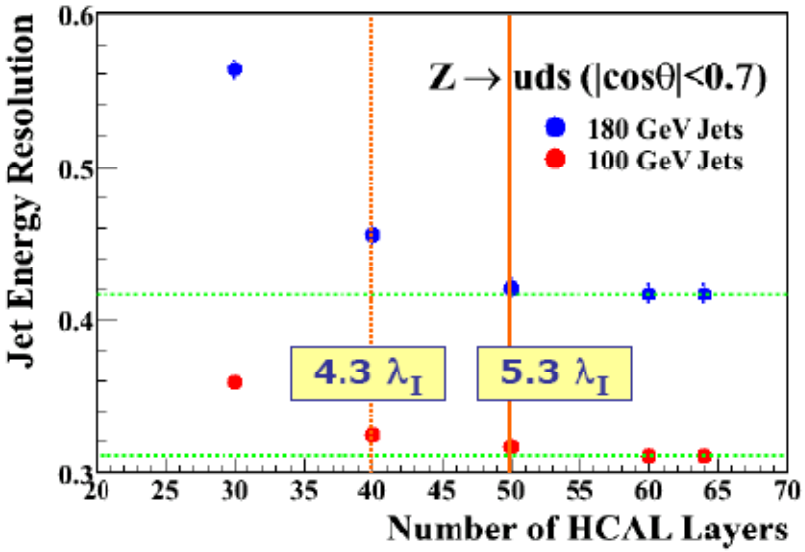
16 sectors

Vasiliy Morgunov Padova, 5-8 May 2000

Depth and PFLOW

- Recently affirmed by M.Thomson
  - May want more detailed understanding
  - No use of tail catcher in reco yet
  - No leakage estimation from shower shape yet
- Best "state-of-the-art" estimate to-date

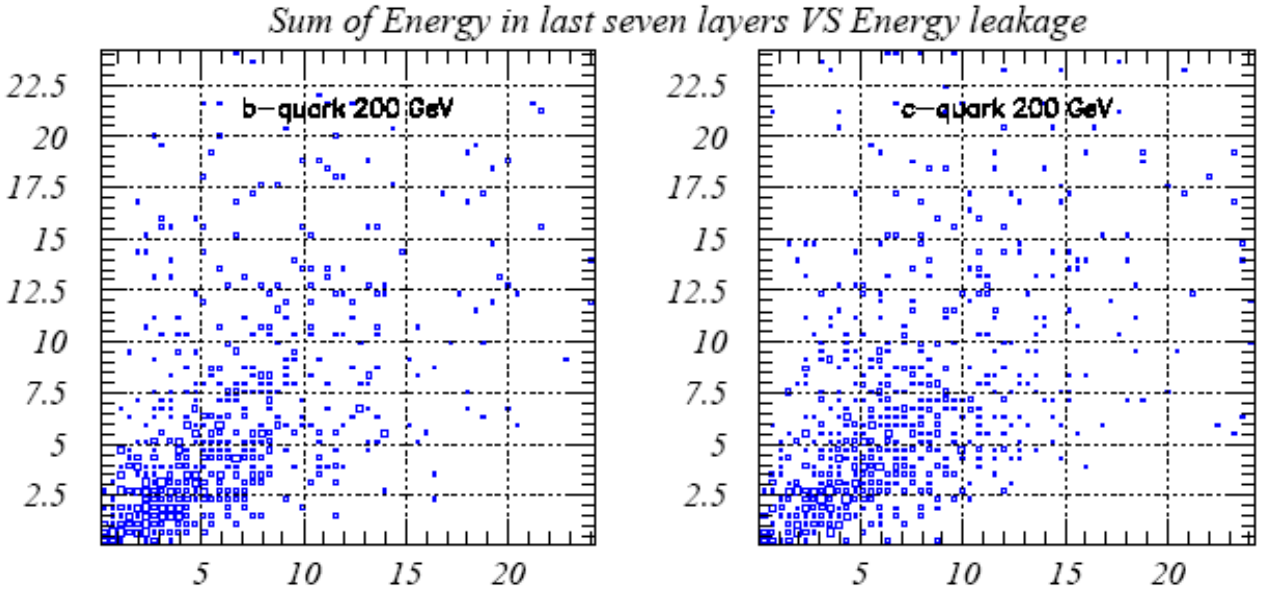
- It is logically impossible to demonstrate that it cannot be improved
  - Proponents of thinner HCAL must demonstrate equivalent performance



- Here:
  - Mokka layer 1.8 cm
- For 2cm absorber layers
  - 5.3λ = 45 layers

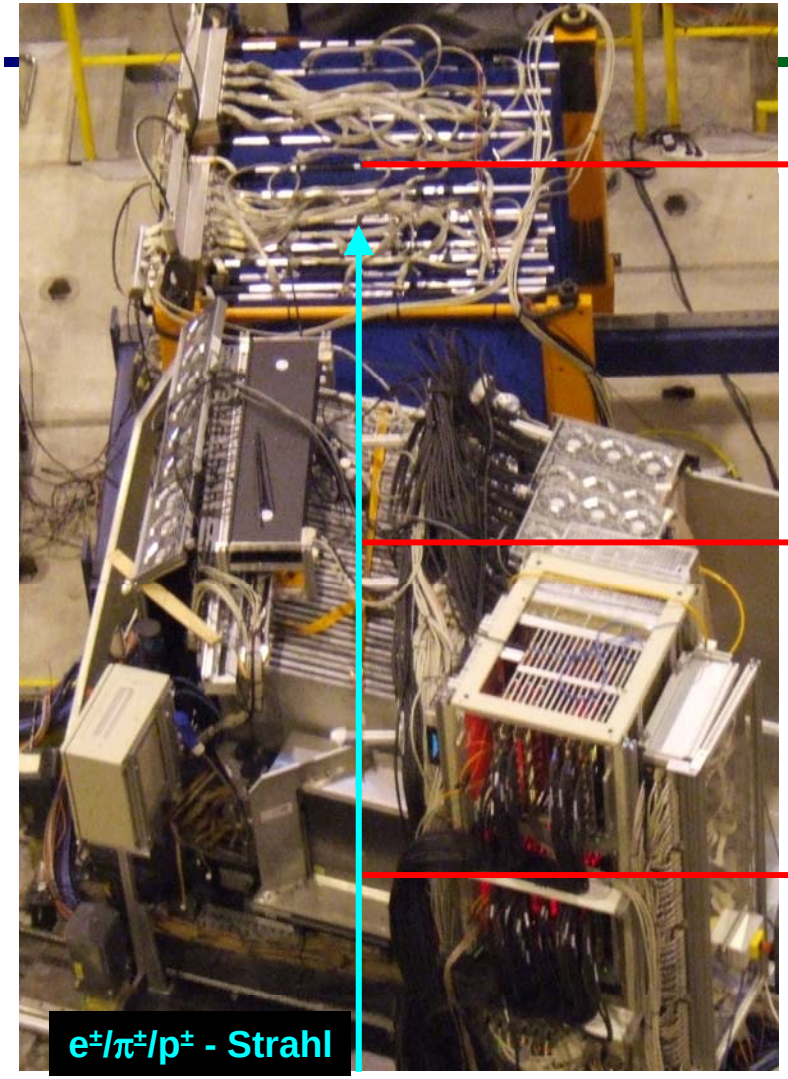
Shower extrapolation

- Naively: check the rear section of HCAL whether shower "ended"
- Problem: large shape fluctuations and disconnected fragments
  - Does not work as well as for e.m. showers



V.Morgunov

CALICE test beam



TCMT

Absorber:	Stahl
Zellgröße:	5 cm x 100 cm
Lagen Dicke:	8 x 0,13 λ
	8 x 0,65 λ
Kanäle:	320

HCAL

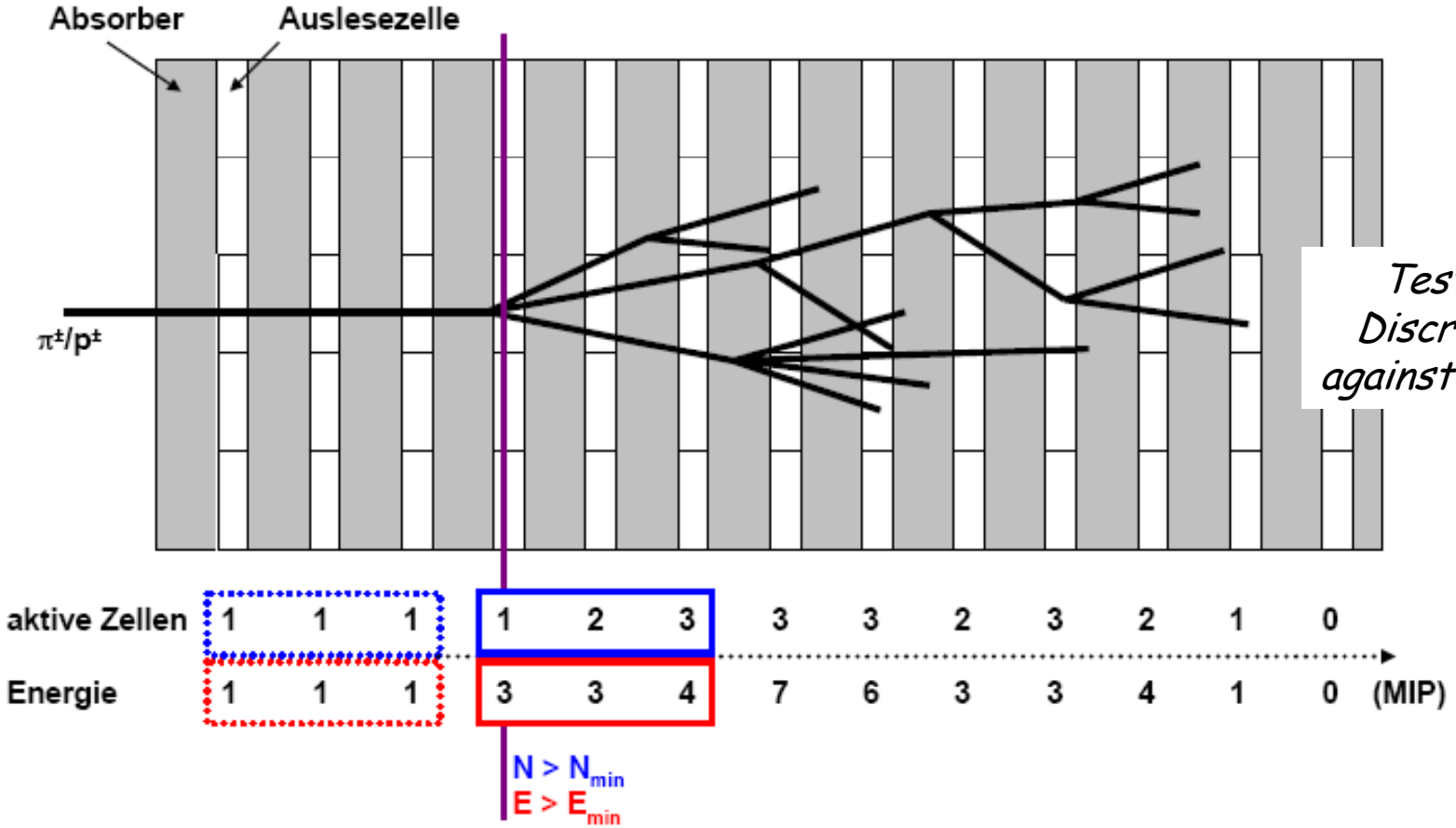
Absorber:	Stahl
Zellgröße:	3 cm x 3 cm
	6 cm x 6 cm
	12 cm x 12 cm
Lagen Dicke:	38 x 0,13 λ
Kanäle:	7608

ECAL

Absorber:	Wolfram
Zellgröße:	1 cm x 1 cm
Lagen Dicke:	10 x 0,016 λ
	10 x 0,033 λ
	10 x 0,05 λ
Kanäle:	9720

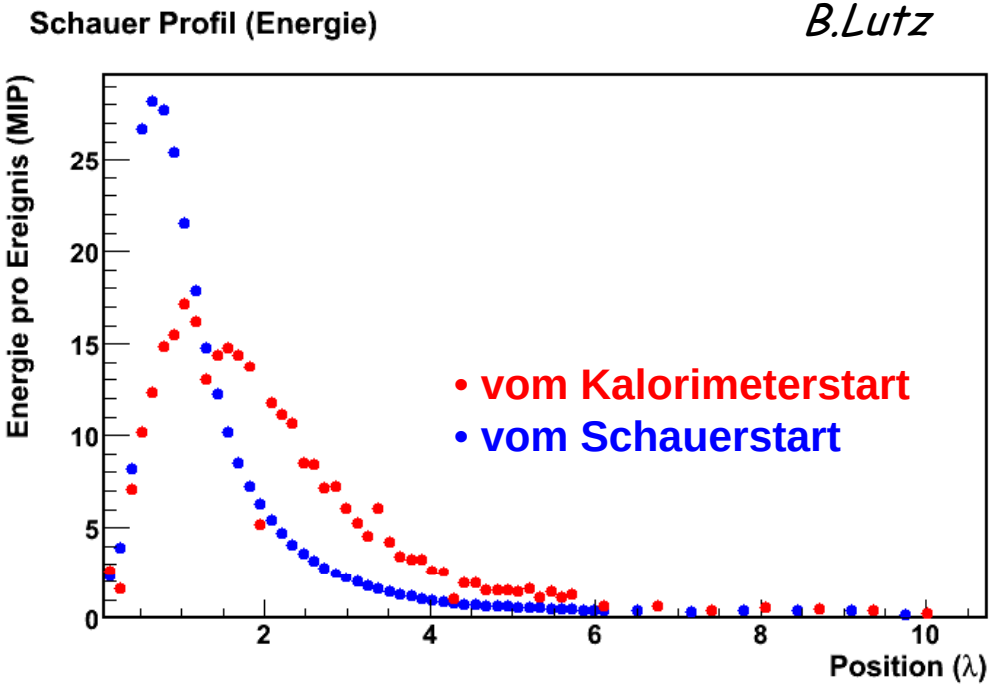
Shower starting point

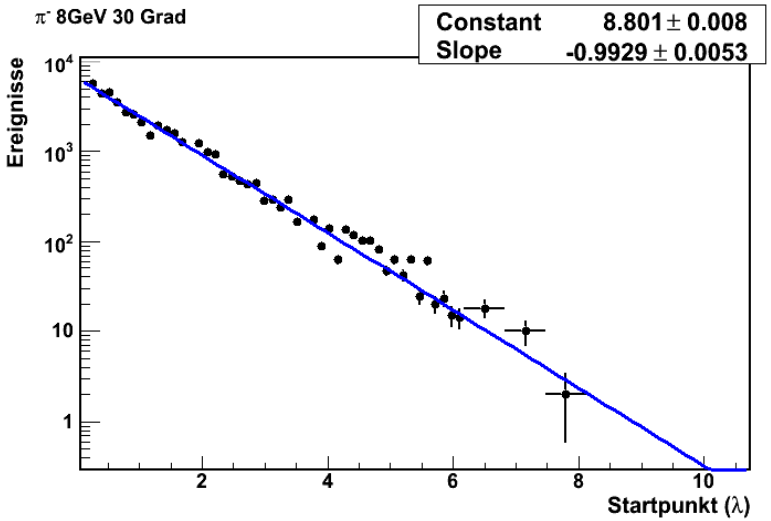
- Find first hadronic interaction

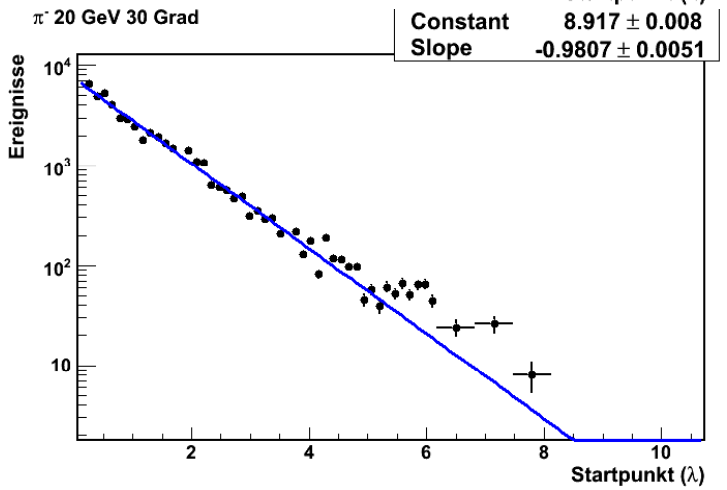


Shower profile, deconvoluted

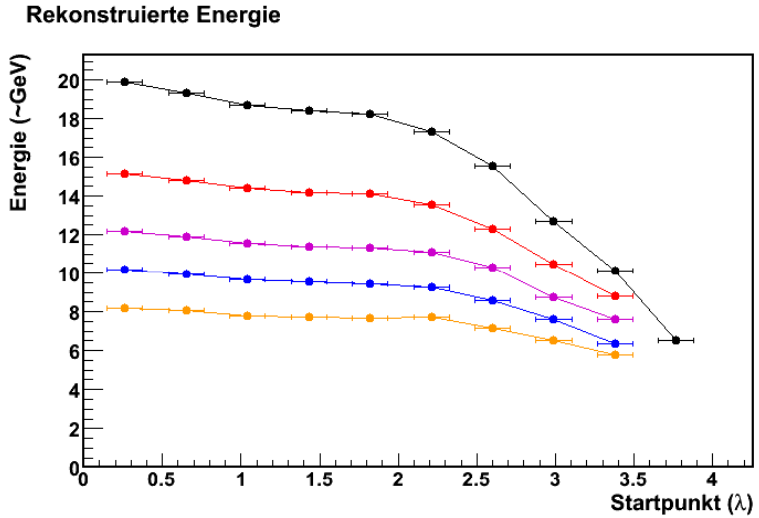
- Test beam data, HCAL + TCMT
- Reconstruct starting point
  - > 5 hits, 8 MIP in 3 consec, layers
- Shower profile:

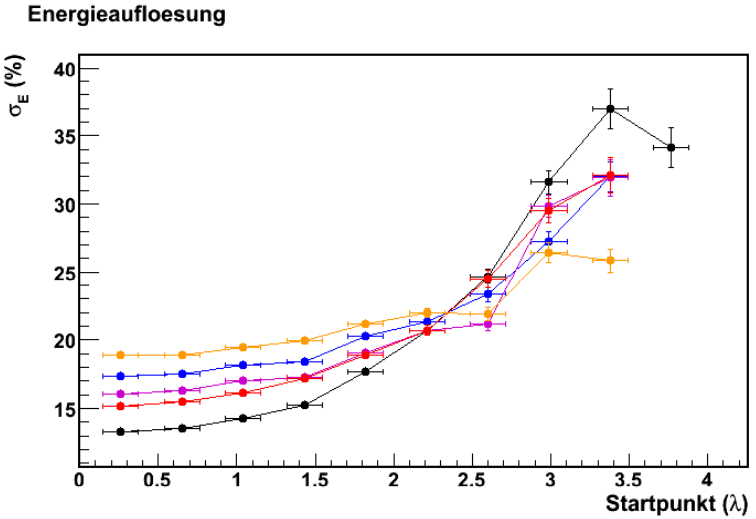


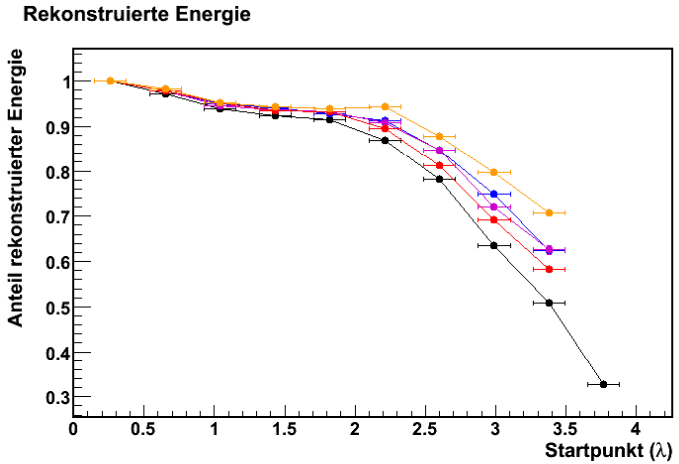




Reconstructed energy





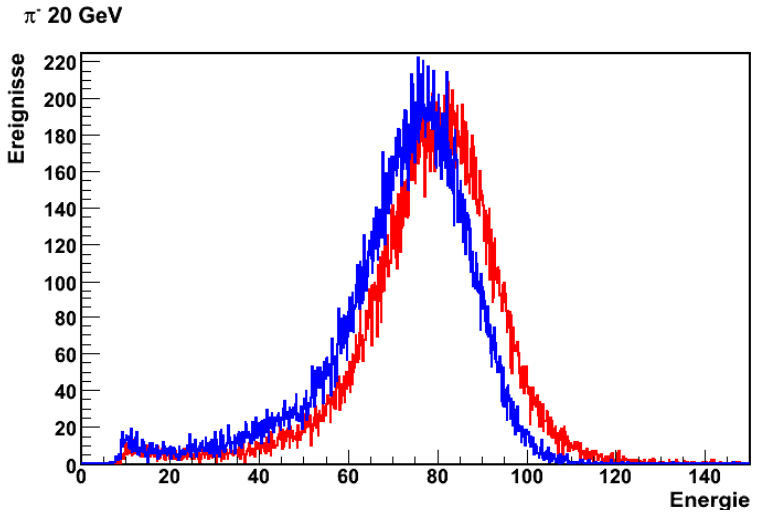


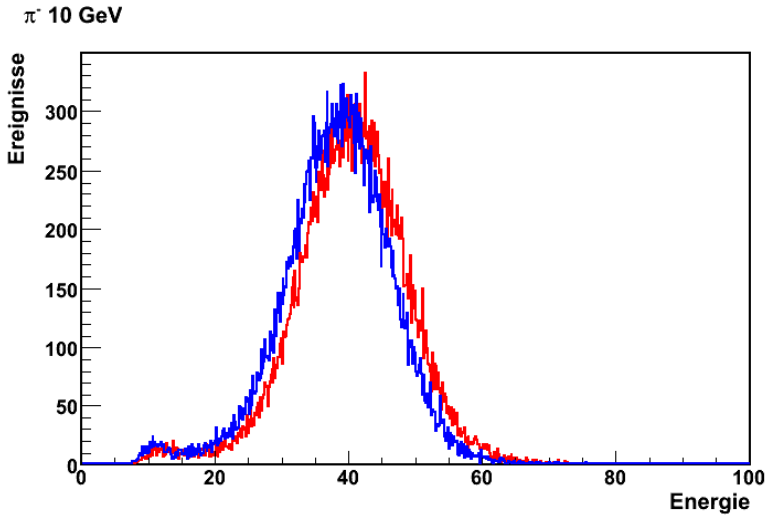
- "onset" of leakage when shower max moves out
  - Depends on energy
- Resolution degrades as energy is lost

Corrected energy

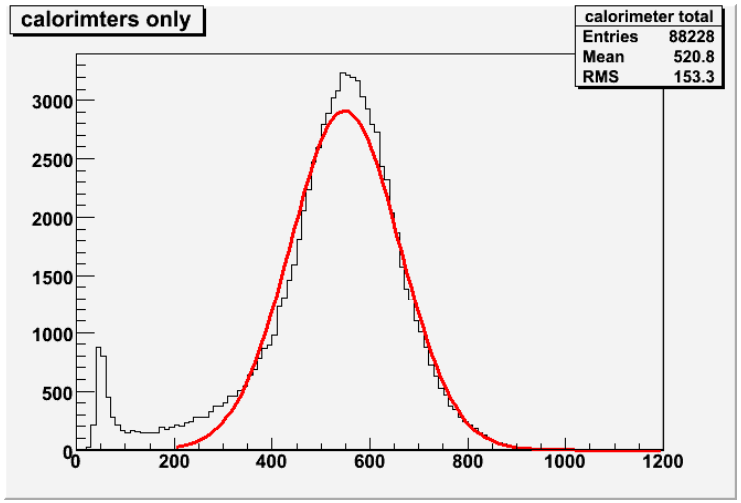
- Correct with starting-point dependent weight
- Recover correct mean
- Do not recover resolution
- Still tails: leakage from early showers

- Can certainly be optimized
  - Include more topology information
  - Multivariate analysis, NN
- However, limitations seen are intrinsic
  - Fluctuations, loss of information
- ➔ Containment is unbeatable

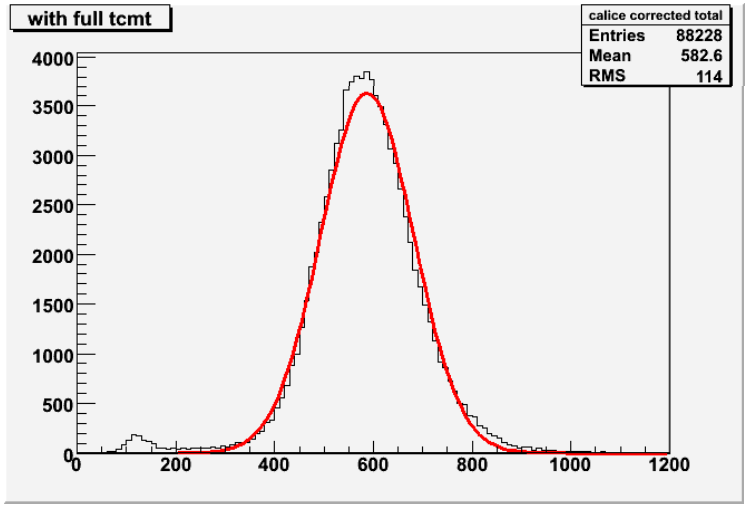


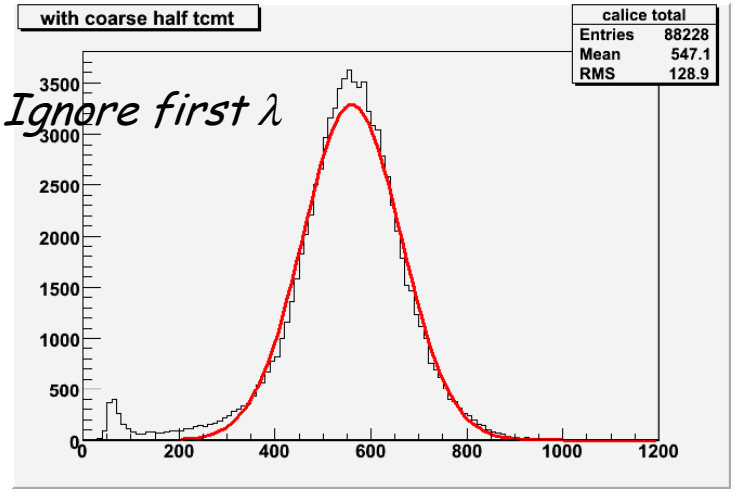


Tail catcher



V.Zutshi





- Improvement also with incomplete measurement
- No weights applied
- Keep the coil thin!

Muon identification

- Excellent muon ID in the calorimeters
- What counts is hadron rejection
  - Sail-through, punch-through, decay in flight
- Sail-through probability alone is $\exp(-n\lambda) = 0.7\%$ for $n=5$
- Should be studied in physics channels (b-tag, isolated pions,..)

- Cut-off: after coil about 3 GeV
- Would be ~2-3 times higher with a lead HCAL
  - $X_0(Fe) = 1.76$ cm, $X_0(Pb) = 0.56$cm
- Also to be studied

Summary so far

- The 4λ HCAL is too thin
- Fine granularity holds potential for topological leakage estimation
- Shower starting point one good observable
  - More refined PFLOW studies to be done
- Intrinsic limitations: loss of information not recoverable
- Instrumentation of iron yoke necessary anyway