

Status of G4 validation with TB2004 data from CMS HCAL

HB TB2004 analysis and simulation team at Fermilab:

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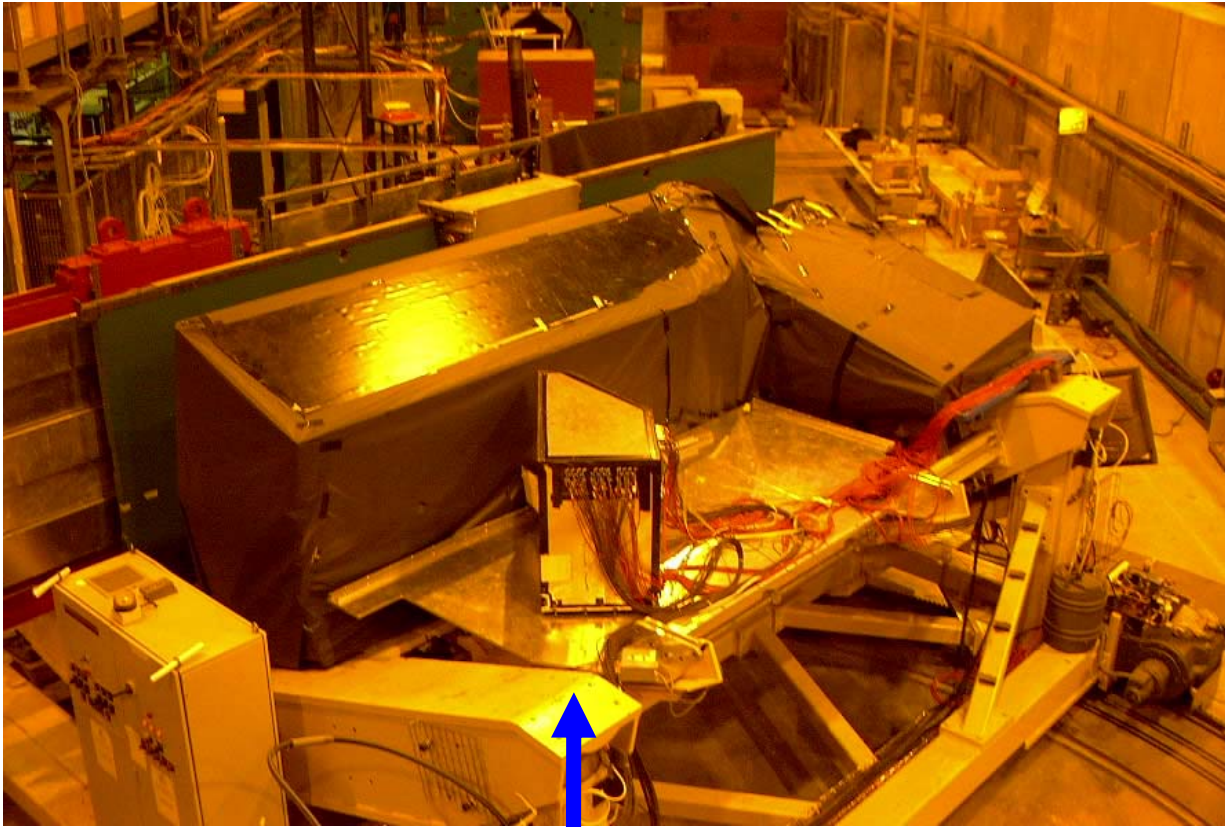
All HCAL members:

Huge effort by the CMS HCAL group

December 1, 2004

Test Beam: 2002-2003

2 HB production wedges, 1 HE prototype wedge
HO layers on a movable table at CERN H2 beam line.



beam

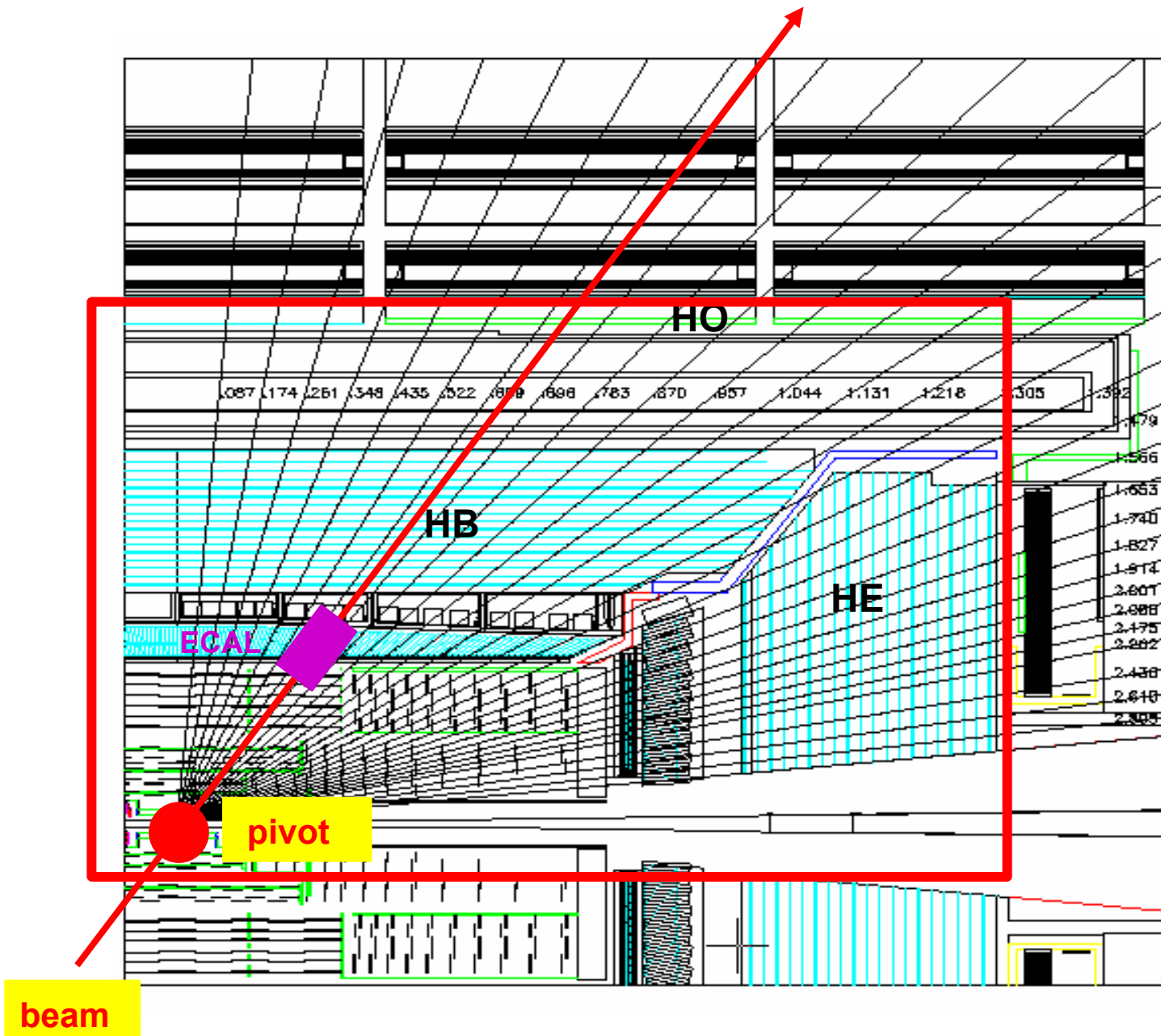
2002/03: pi- 20-300GeV, e- 20-100GeV, mu- 225GeV

Goal:

- Test the integrated system with production modules
- Verify γ source calibration
- Source/ADC vs. GeV/ADC
- Operate all calibration tools and look for improvement.
- **measure basic parameters for MC, e.g.**
 - **pulse shape**
 - **signal timing**
 - **attenuation**
 - **noise**
 - **gaps between modules**
 - **resolution and linearity**

All achieved! (repeat in 2004)

HCAL on a Table



*Pivot of table
= IP at LHC*

A phi slice of
CMS HCAL

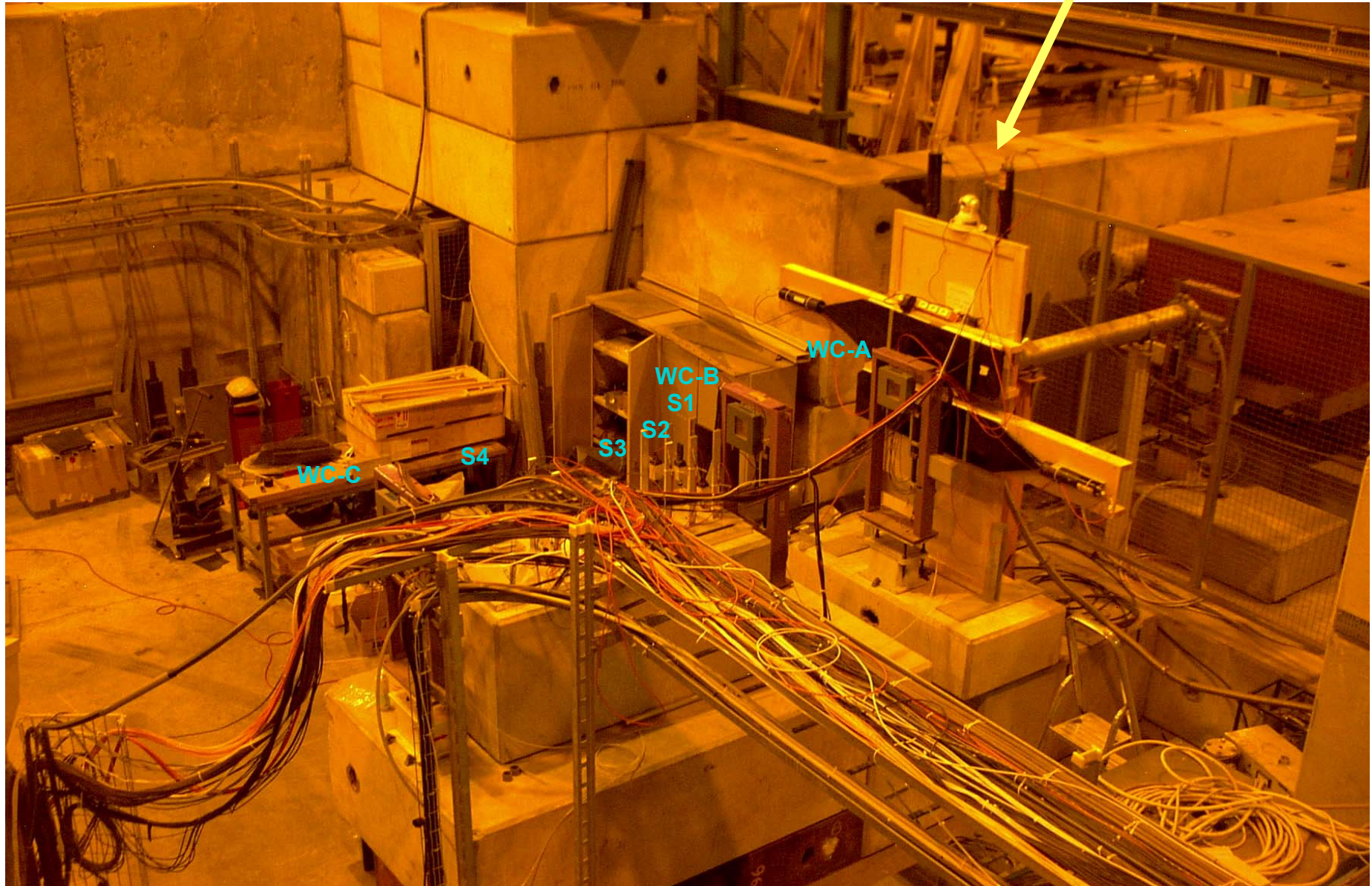
HB: 2 wedges
8 segments
□□ = 40deg.

HE: 4 segments
□□ = 20 deg.

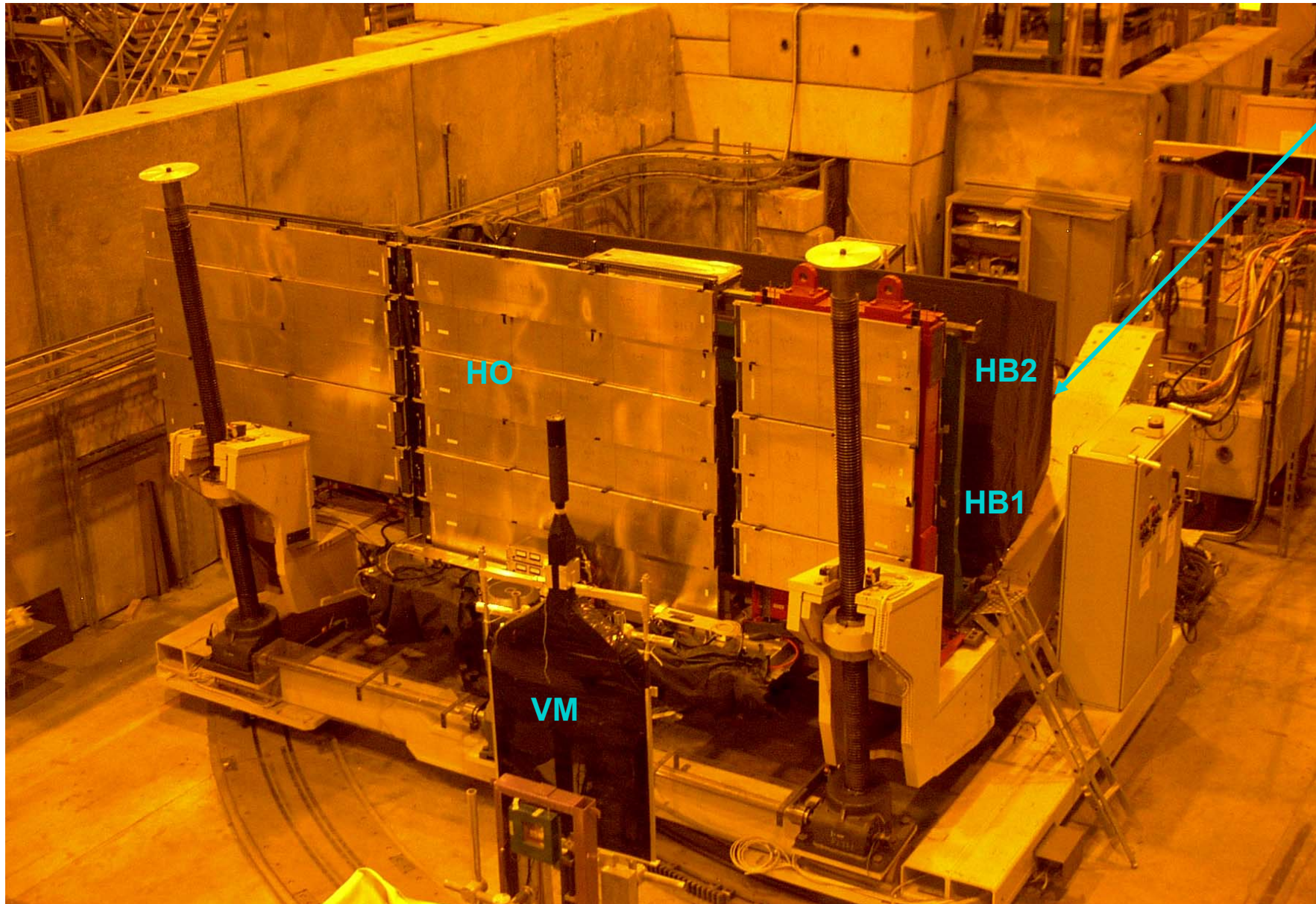
HO: 6 sector
□□ = 30 deg.

ECAL: 7x7 crystals

HCAL Triggering Counters and a webcam



HO



Beam

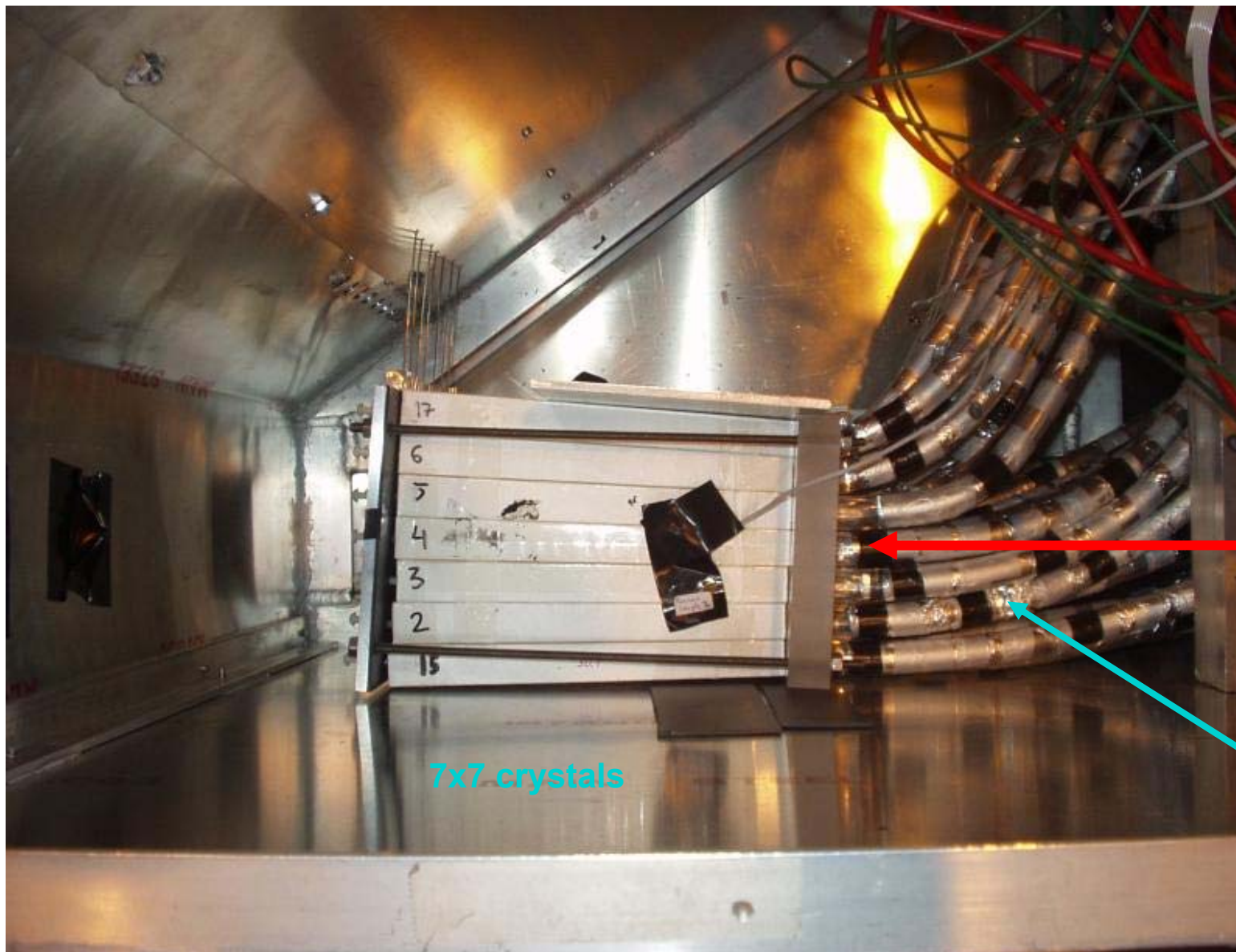
HO

HB2

HB1

VM

ECAL 7x7 matrix



View from top

BEAM

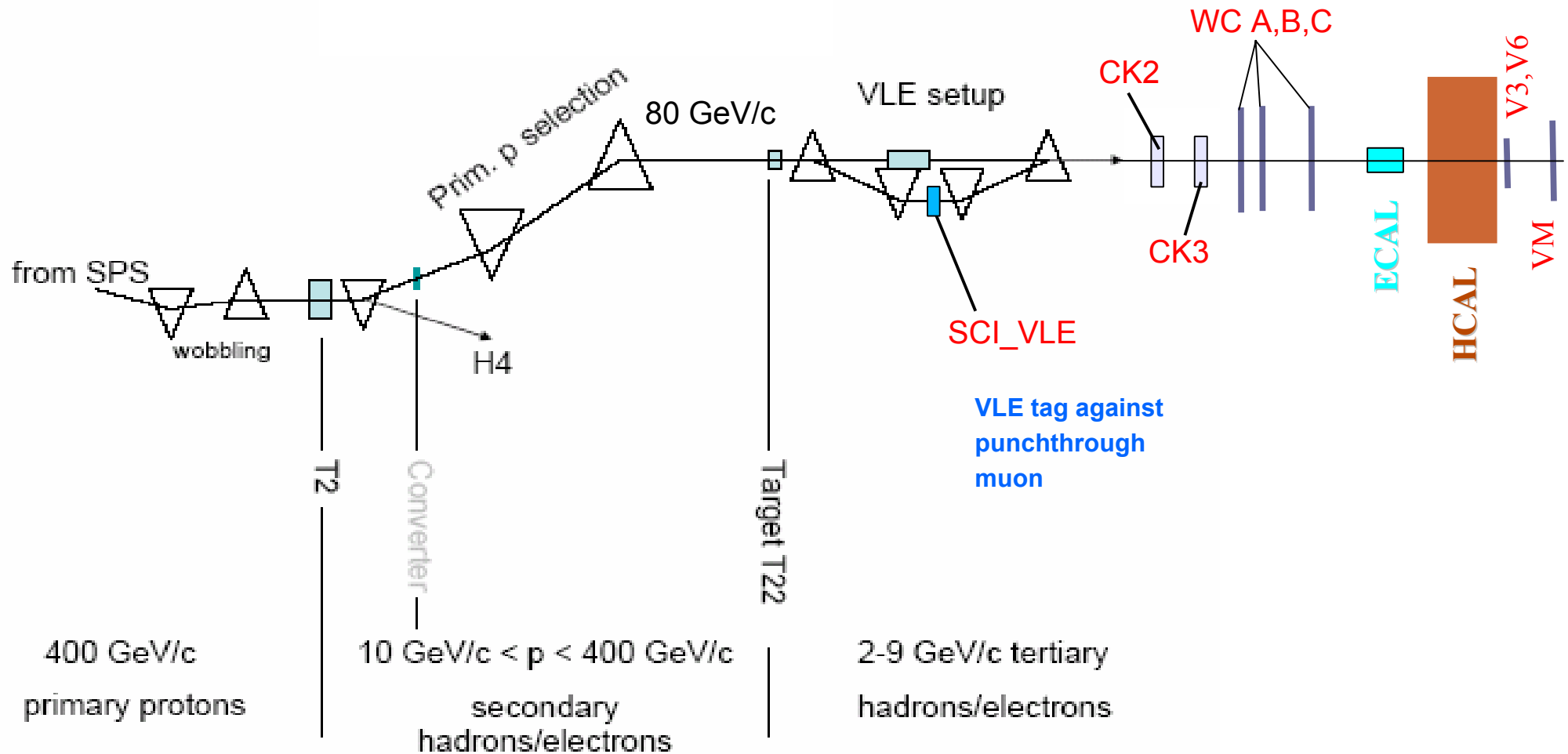
7x7 crystals

Light guides
to PMTs

Summary of TB2004 runs

- **May 17-Jun8 , High energy run**
- Jun 8-14, no beam time install HO
- **Jun 14-21 25 ns run time**
- Jun 25- Jul 7: first HF run
- **Jul 7-14 : 1st week of VLE run**
- Jul 14- Aug11 : second HF run
- **Aug 11- 18: 2nd week of VLE run**
- Aug 18- Sep 22: other experiments in H2
- Sep 22-Oct 4: HCAL-EMU setup
- **Oct 4-11 25ns HCAL-EMU run : *energy 10 – 100 GeV***
- **Oct 13-18: 3rd week of VLE run**
- **Nov. Wire source calibration run**

VLE Beam Line at H2



P-ID:

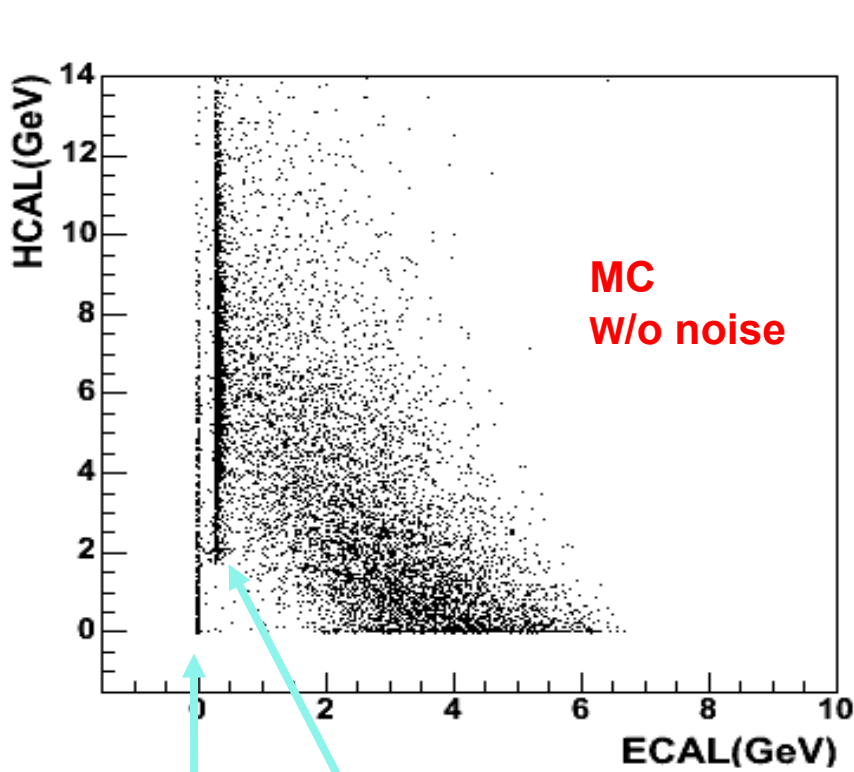
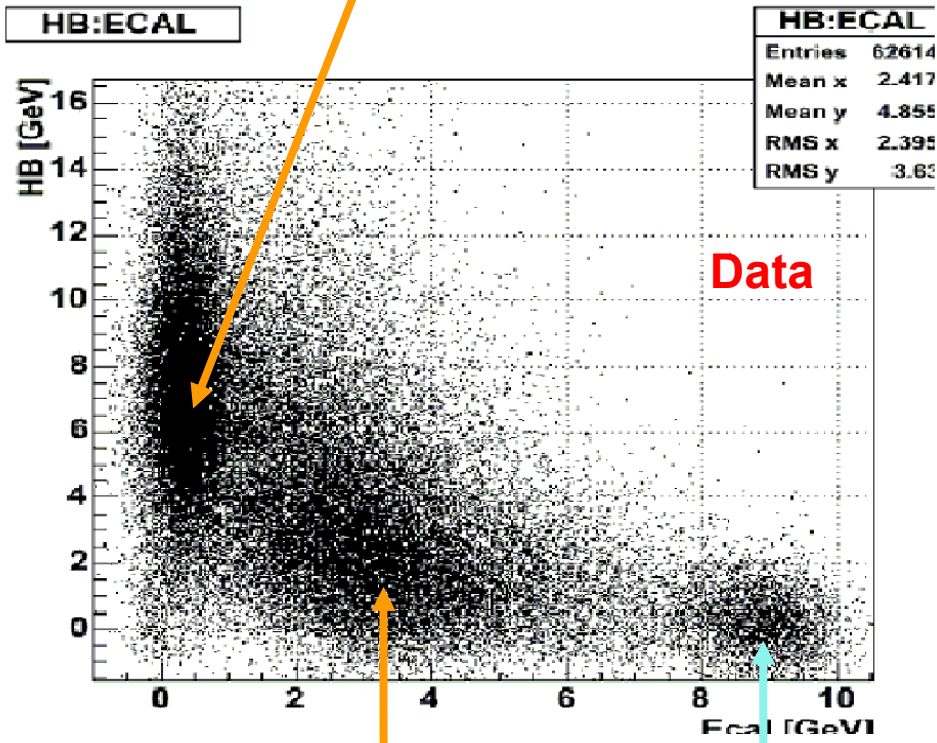
CK2- electron
 CK3- pion / kaon / proton
 V3, V6, VM – muon

WC

single hit to reject
 interaction in beam line

9 GeV pi+ beam

mip in ECAL, i.e. no-interaction in ECAL



Interactions in ECAL e+

→ decays in beam line

Interactions in beam line

Need a lot of clean-up !

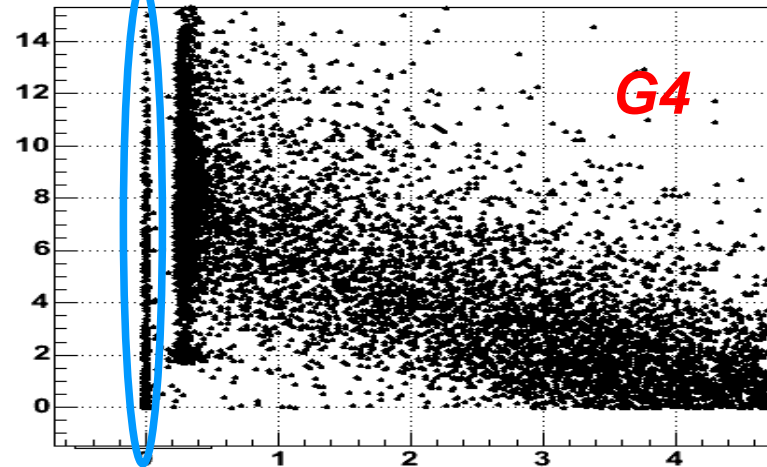
Rejection of Interactions before ECAL

Events, which miss ECAL: there should be almost no energy in the tower behind ECAL

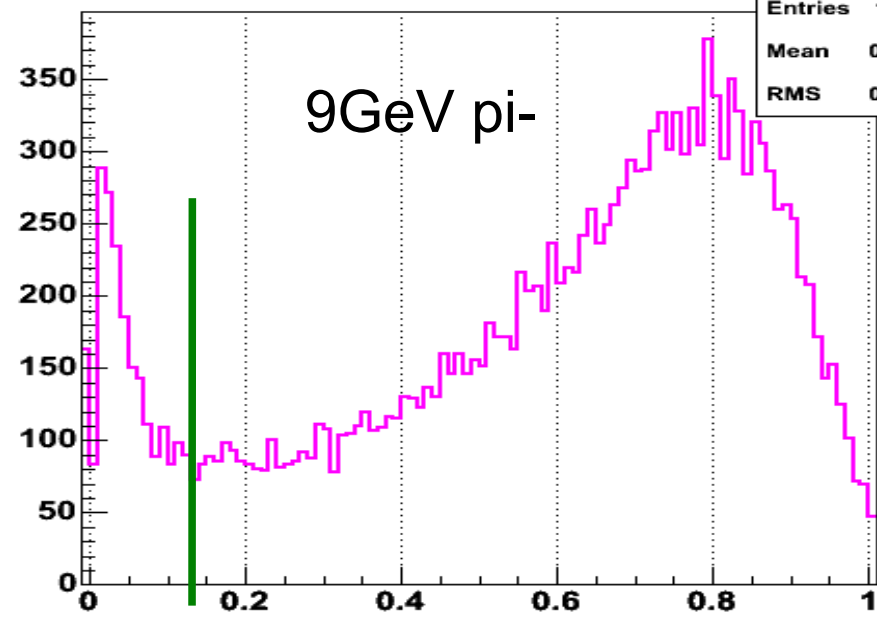
Does not cut muon and 0,0 events

Ratio of the energy in the central tower over the energy in 3x3 towers, $E_{cal} < 0.8 \text{ GeV}$

MC : HB2:ECAL) Beam started at WC-A



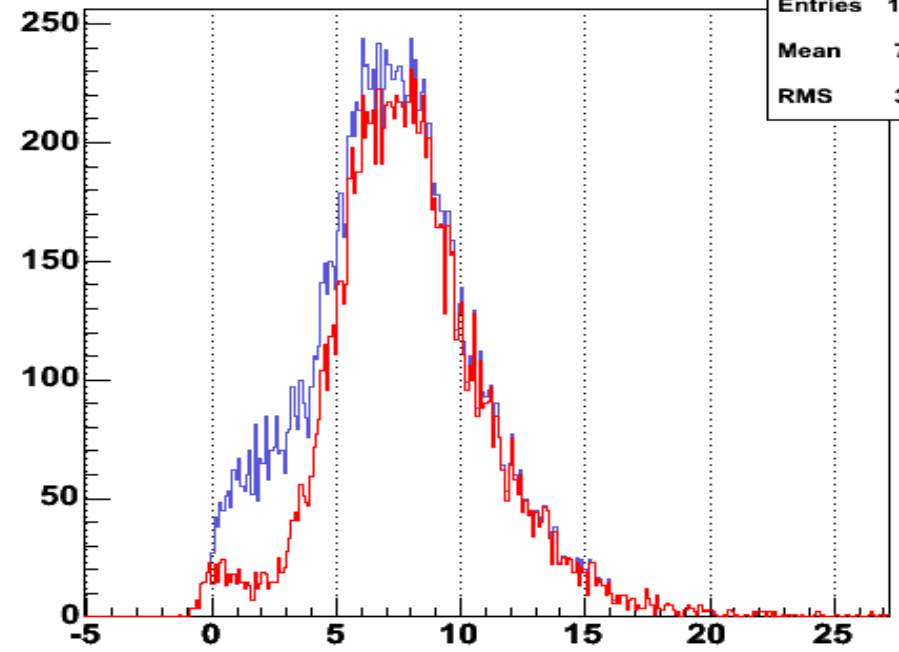
Tc/T3x3



9GeV pi-

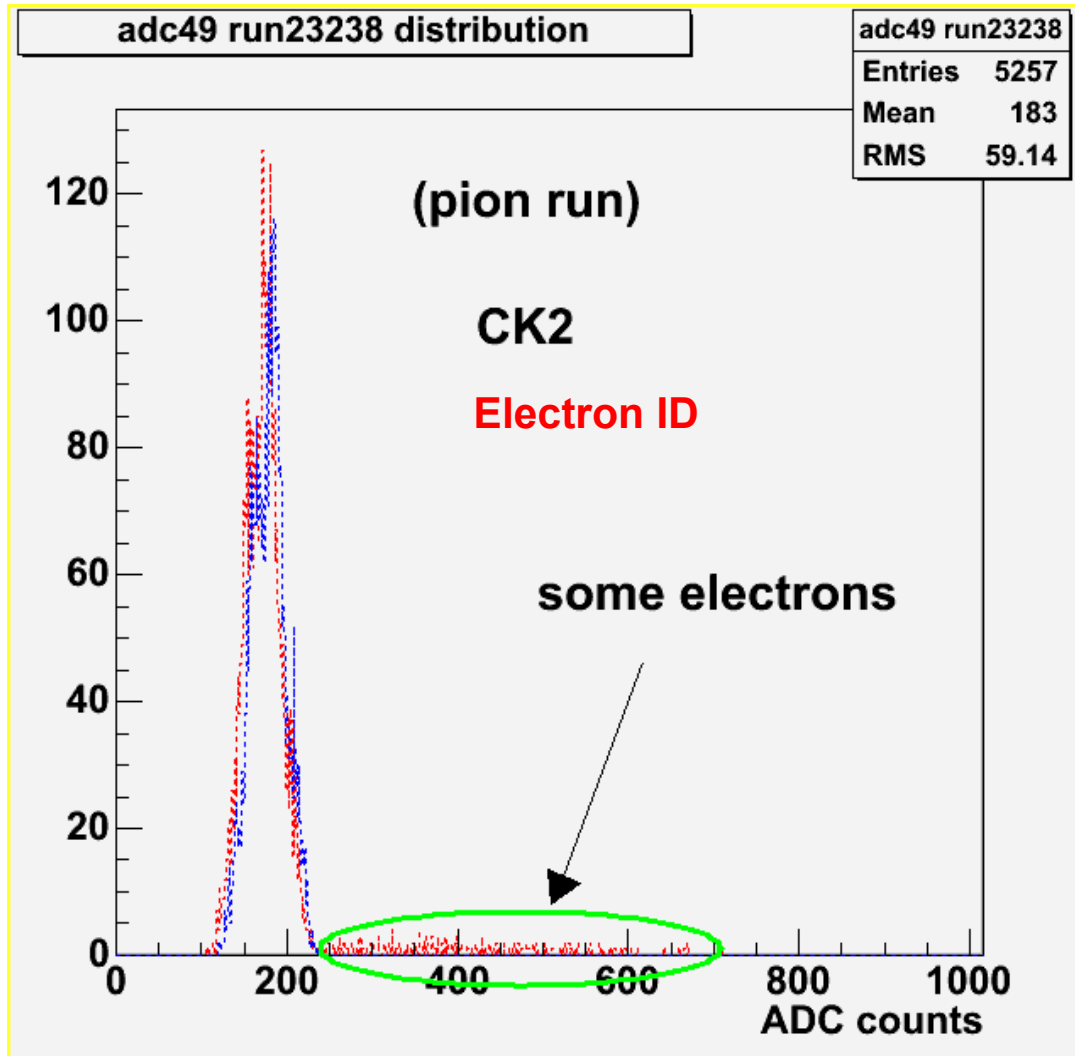
hIE	
Entries	19477
Mean	0.5779
RMS	0.2789

HCAL pions & MIP ECAL



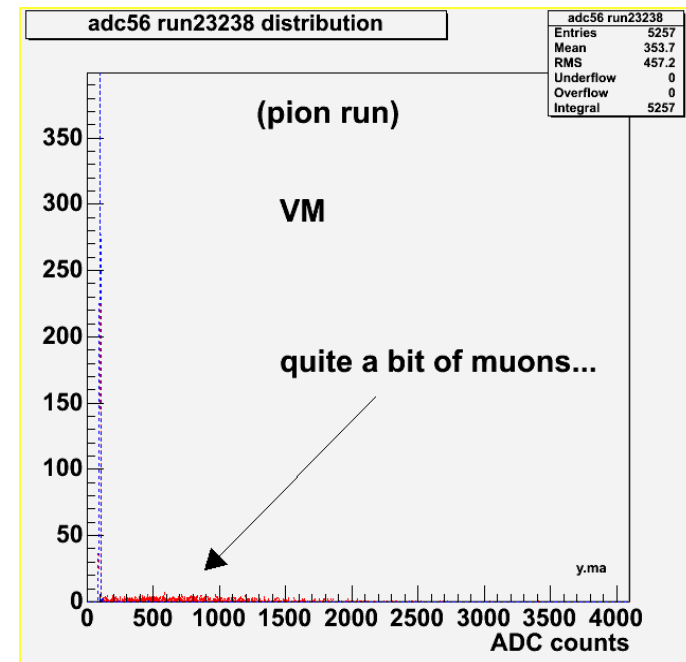
Em0	
Entries	16300
Mean	7.326
RMS	3.487

P-ID with Cerenkov Counter 2 (CK2)



9GeV pion tune

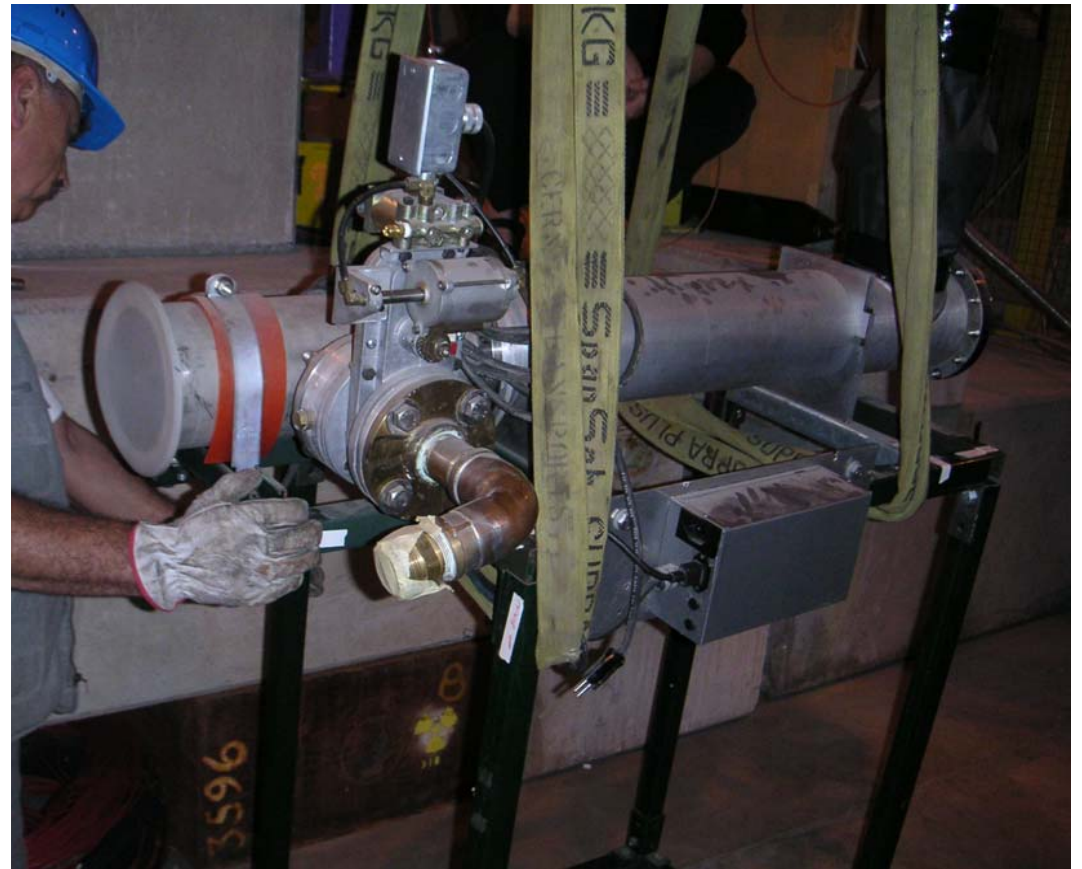
Muon tag with VM



P-ID with Cerenkov Counter 3 (CK3)

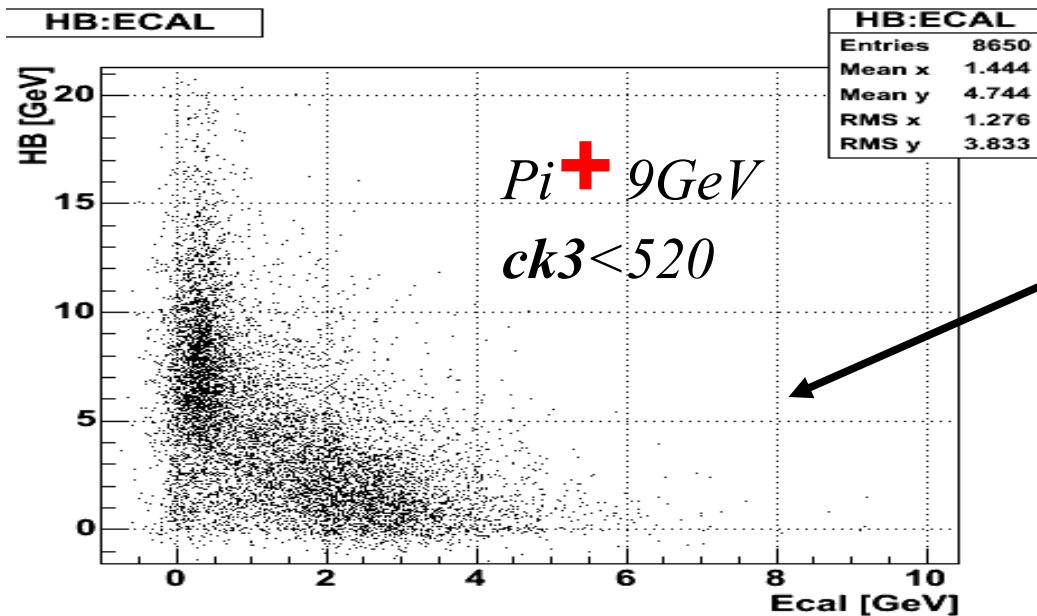
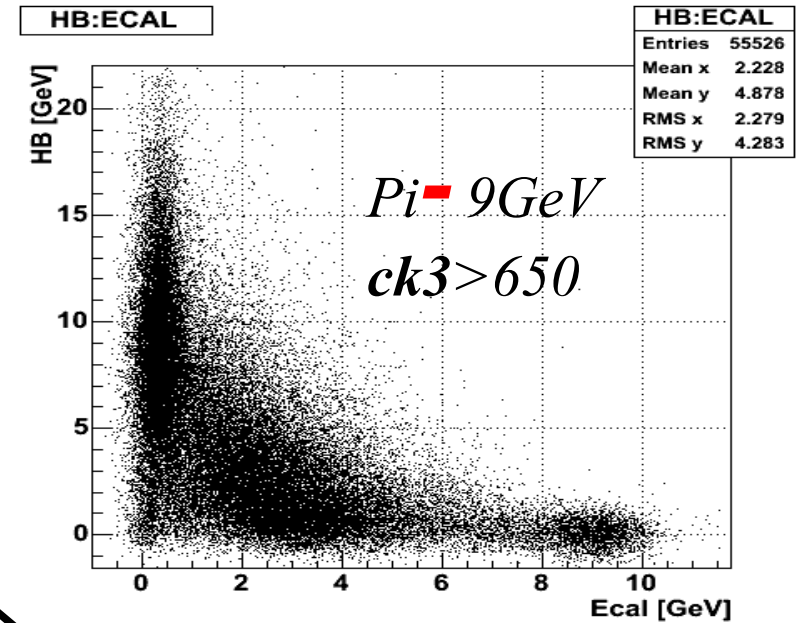
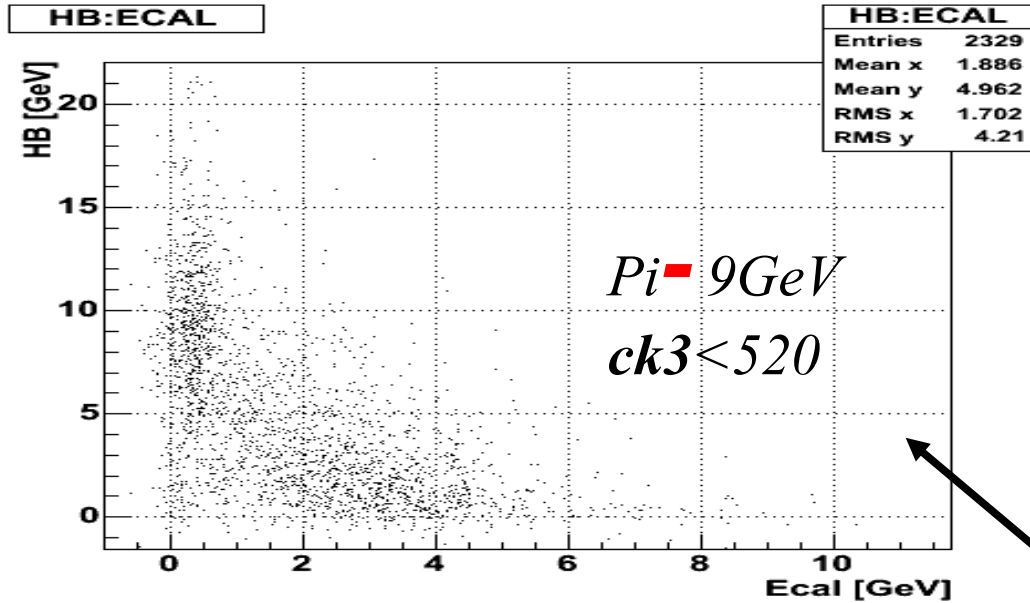
The momentum thresholds [GeV]
for the range of dn are:

dn *E-6	P(π)	P(μ)	P(p)	P(K)
2432	2.0	1.51	13.5	
1557	2.5	1.89	16.8	
1082	3.0	2.27	20.2	
795	3.5	2.65	23.5	12.35
609	4.0	3.03	26.9	
481	4.5	3.41	30.3	
390	5.0	3.79	33.6	



Freon Cerenkov Counter

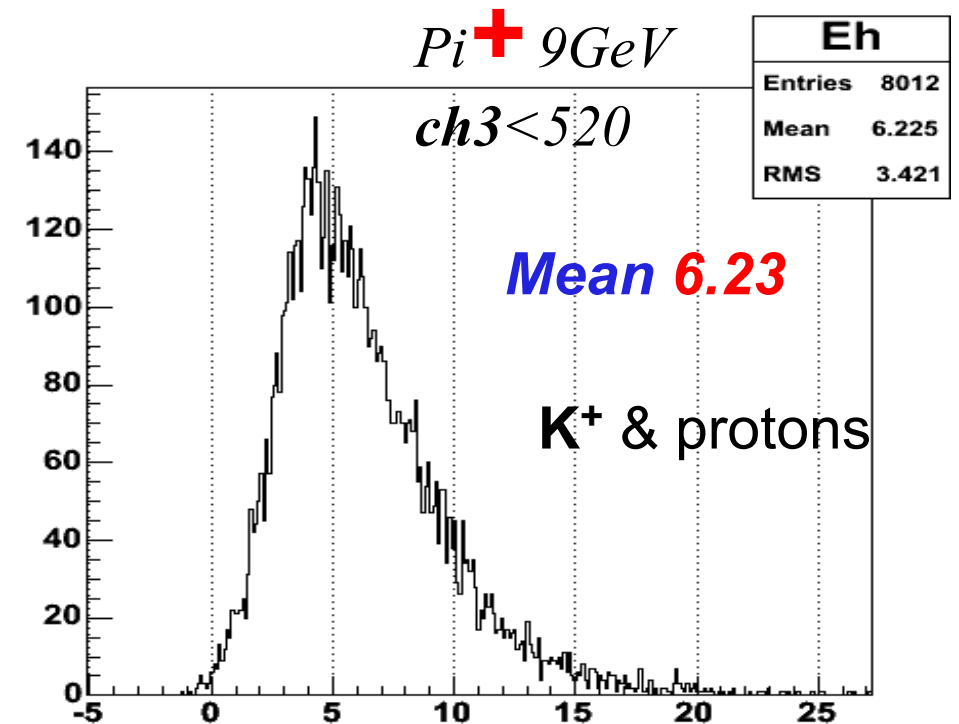
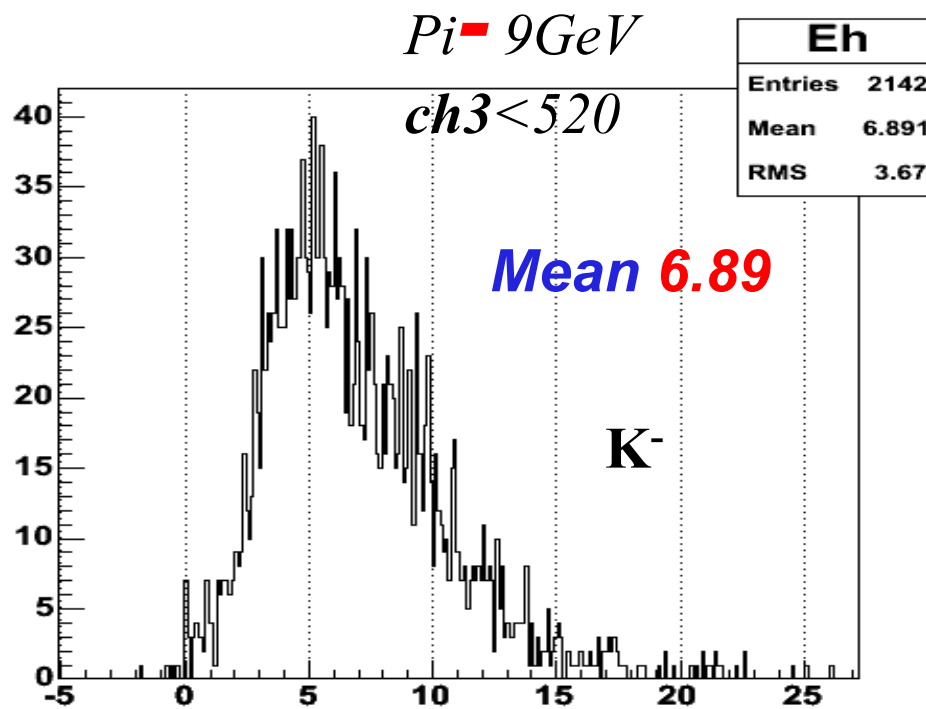
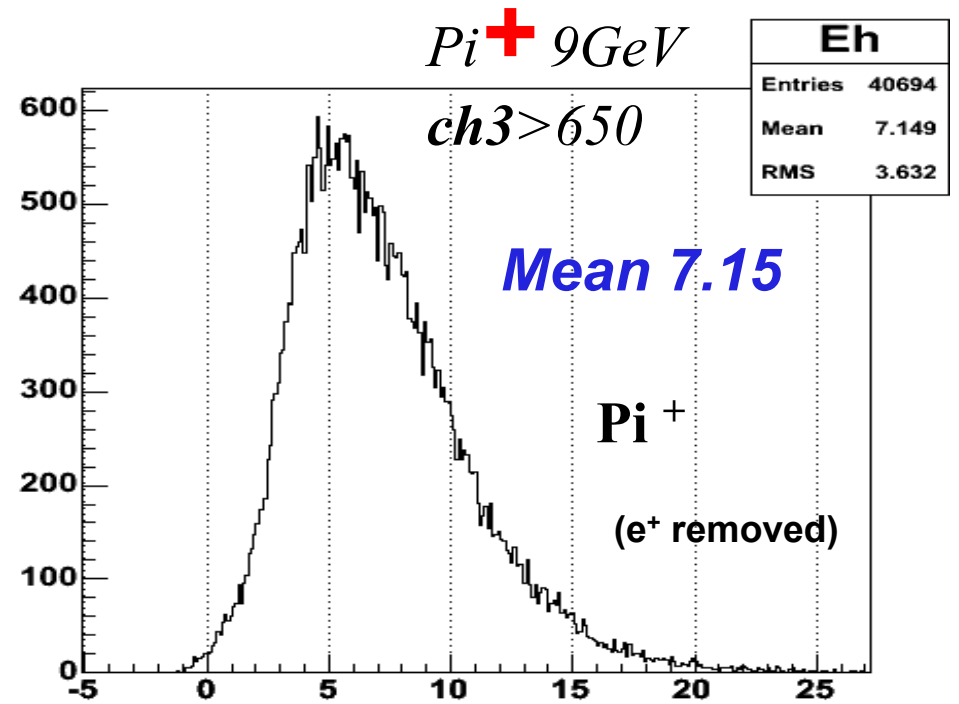
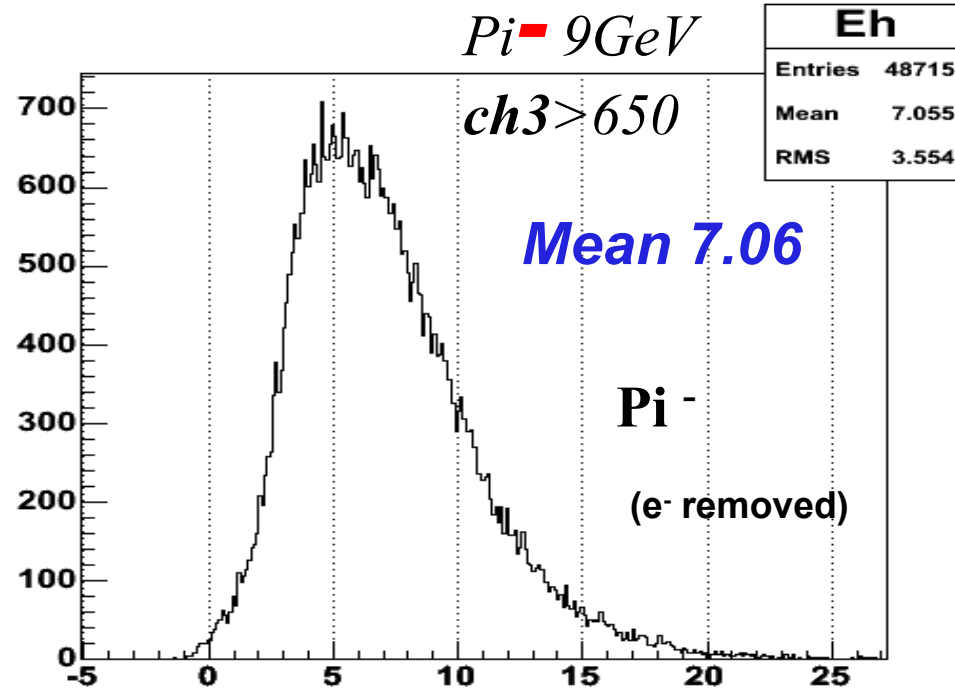
Cherenkov 3 Cut



Cut: $ck3 < 520$

Mainly non-muon events

ECAL +HB1



pion / kaon / proton separation with Cerenkov 3

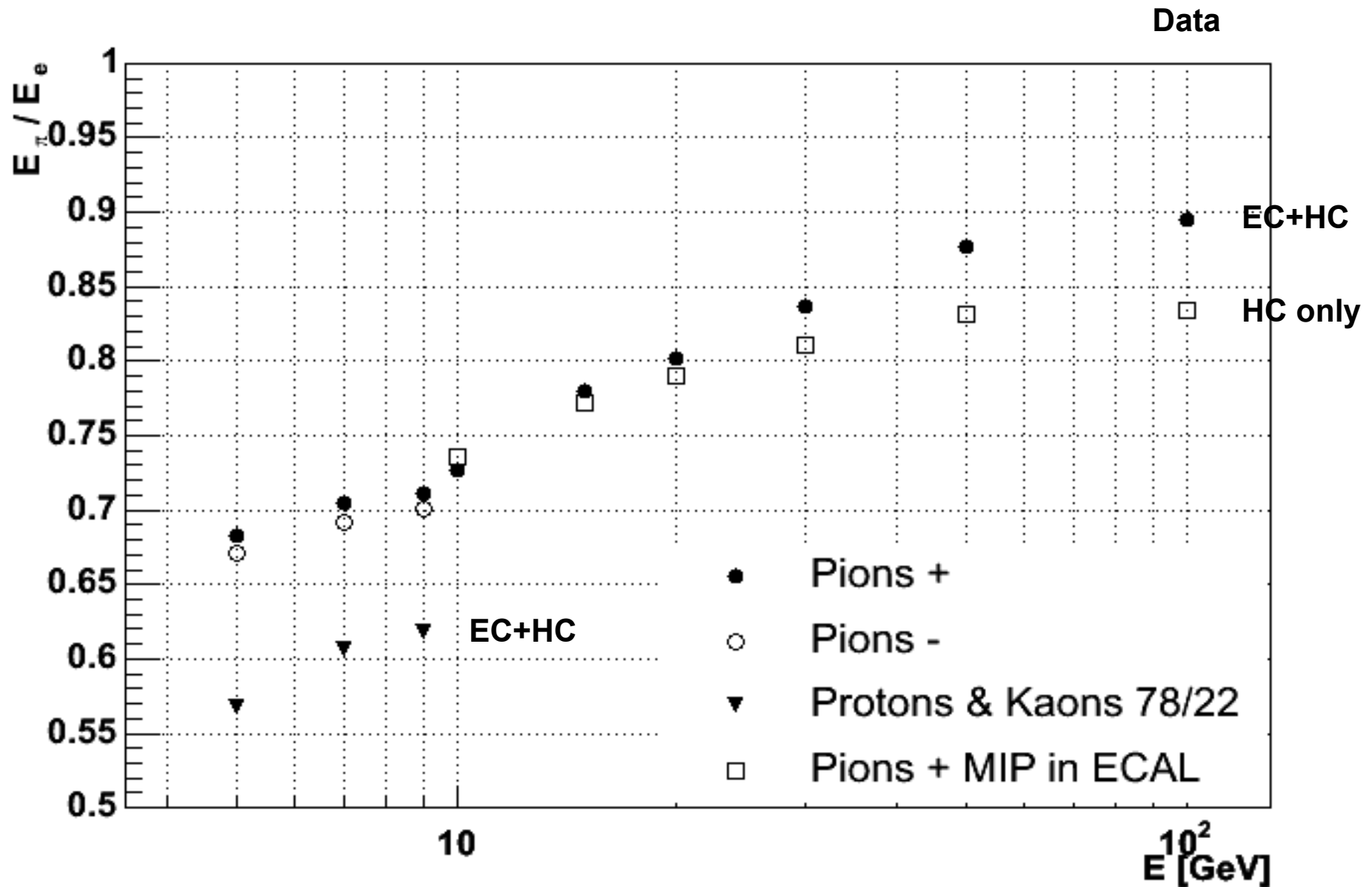
9 GeV Beam

	Pi- run	Pi+ run
ck3>650	48715 events	40694 events
ck3<520	2142 events	8012 events

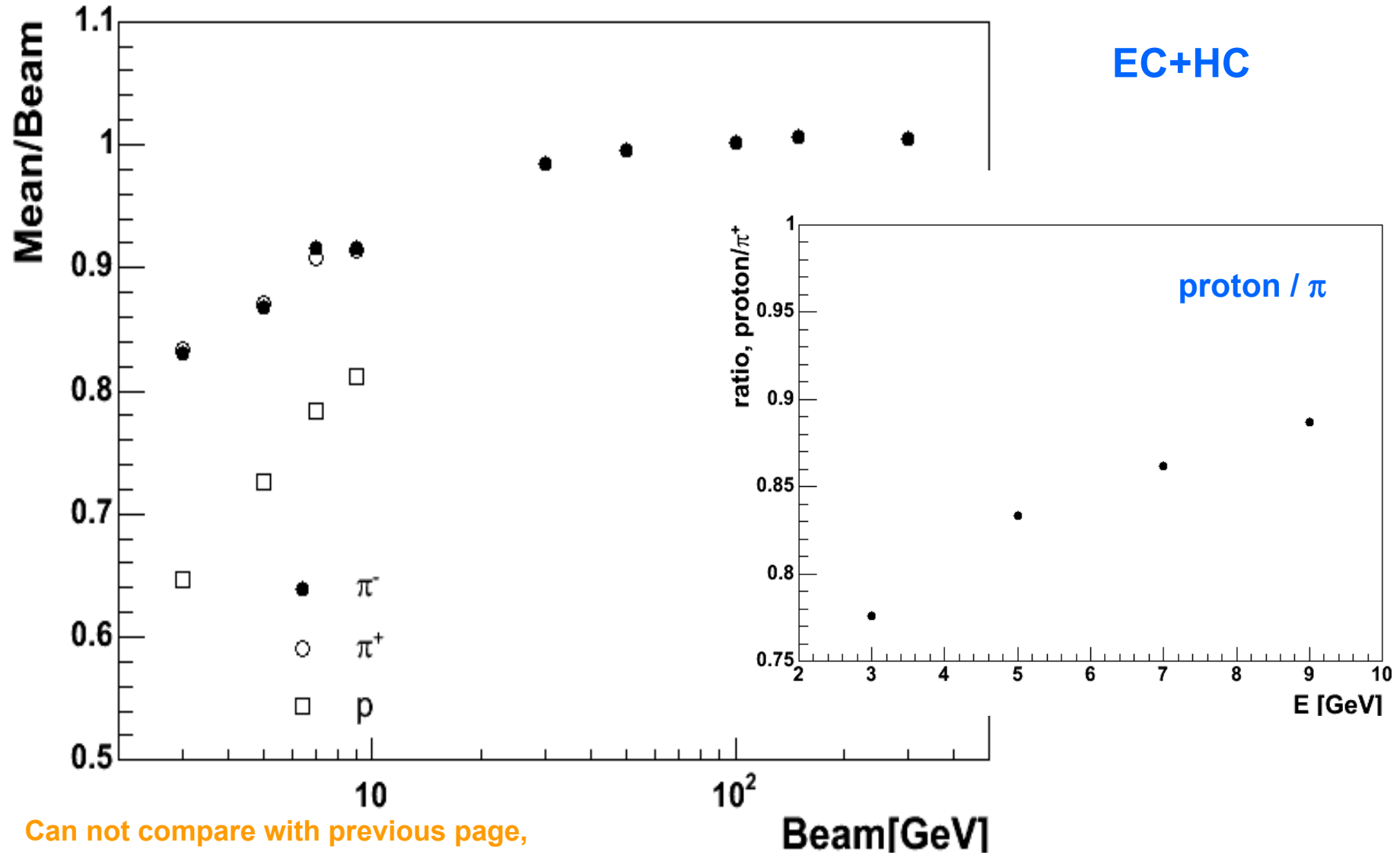
	Pi- run	Pi+ run
ck3>650	1.00	1.00
ck3<520	0.044	0.197
	K ⁻	K ⁺ & protons

78% protons & 22% kaons

Data: \square/e (*very preliminary*)



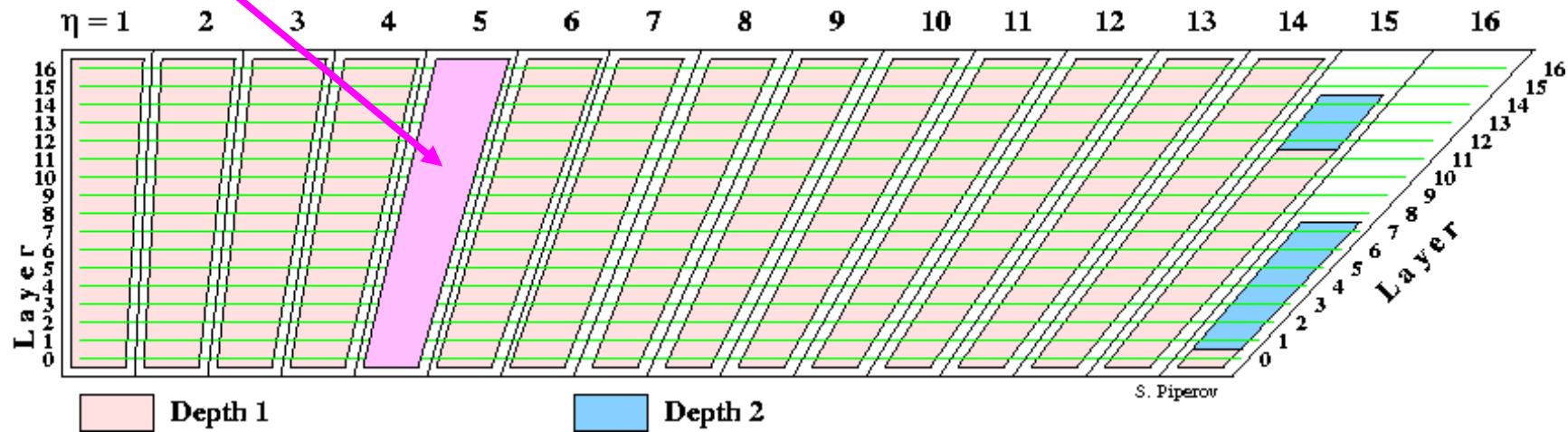
G4 Prediction



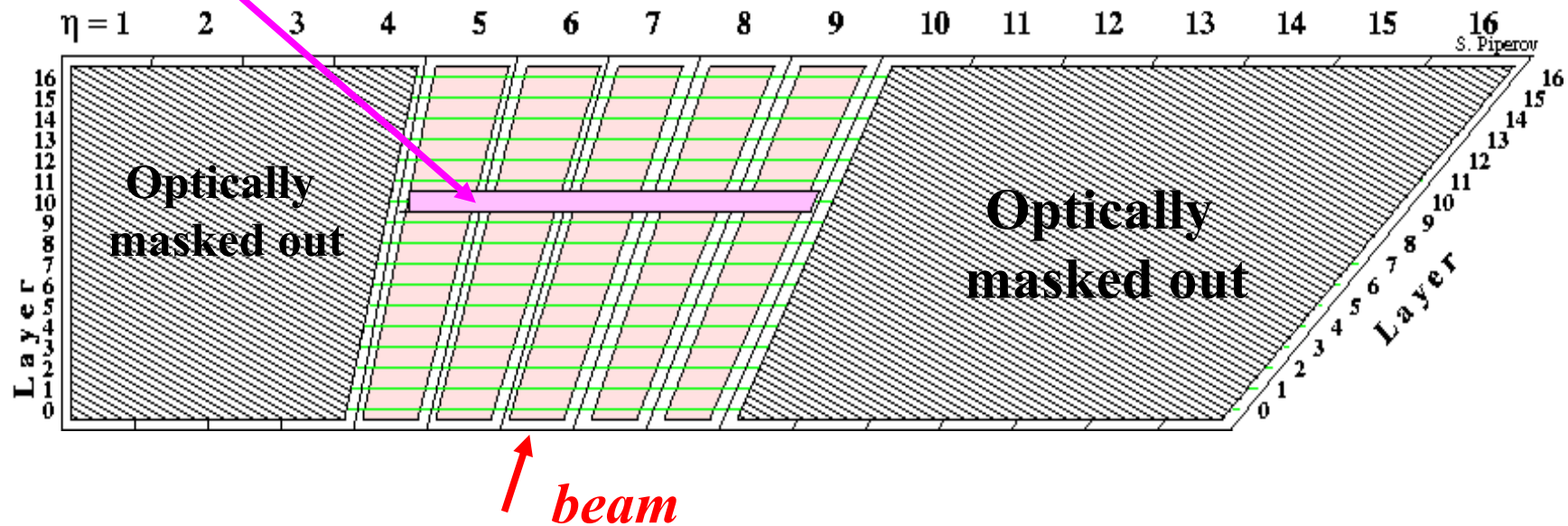
Can not compare with previous page,
Because of different calibration.

Wedges readout structure

HB1: tower like – layers summed optically



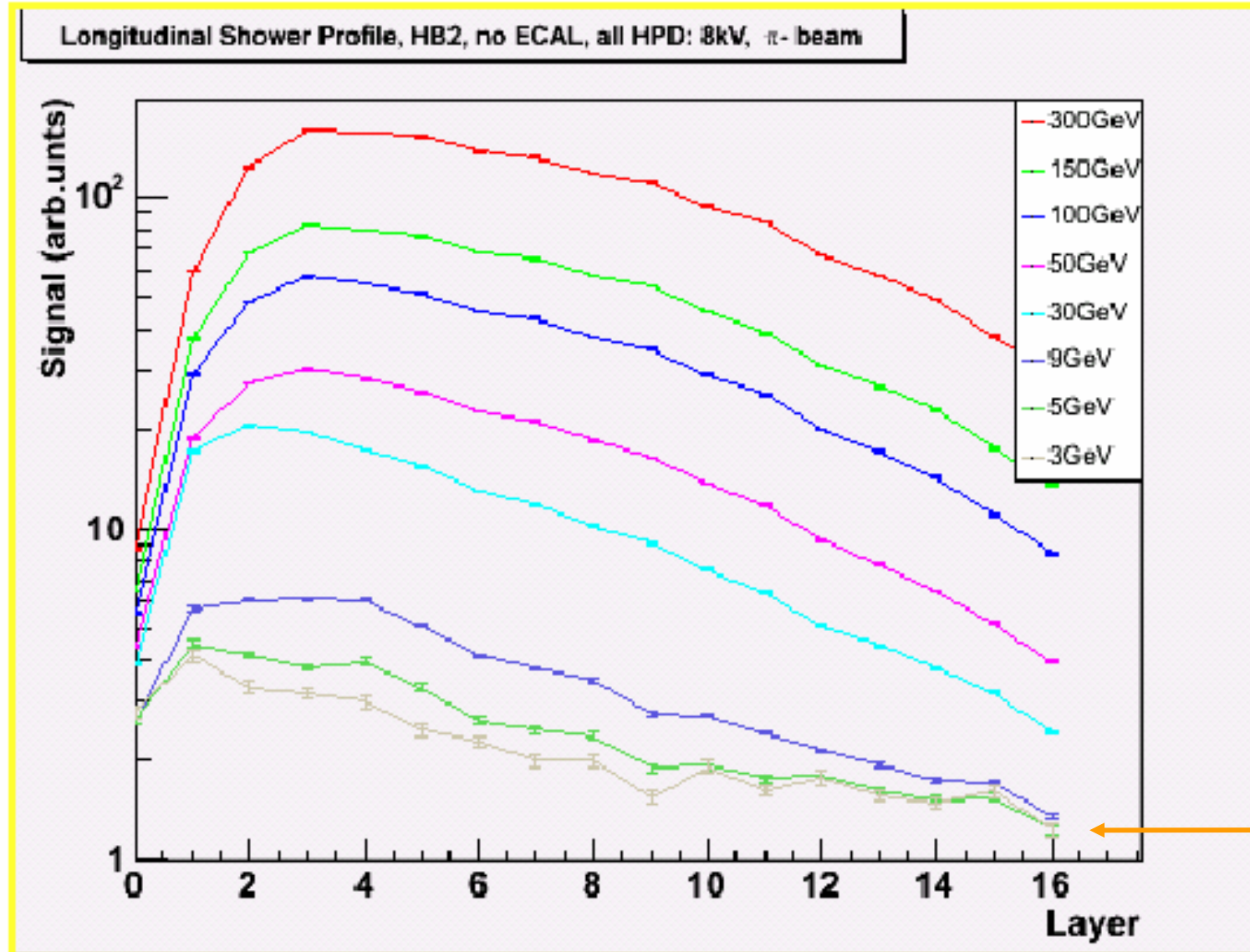
HB2: layer like – *longitudinal shower profile*



First look of Longitudinal Shower Profile

Data

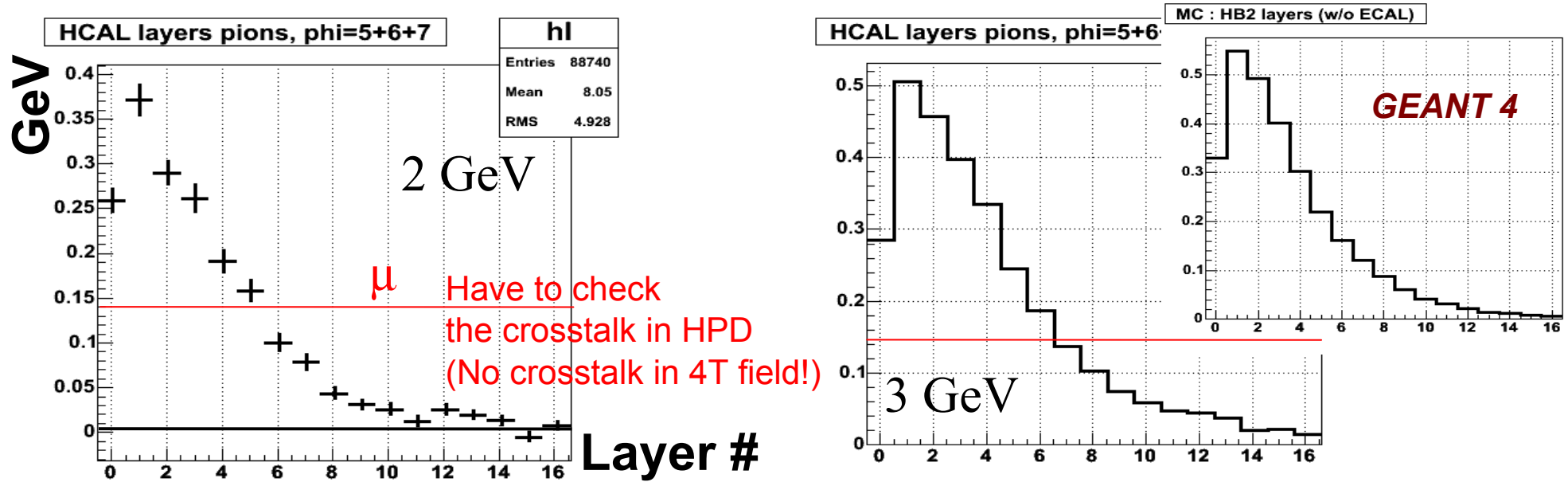
HB2 only



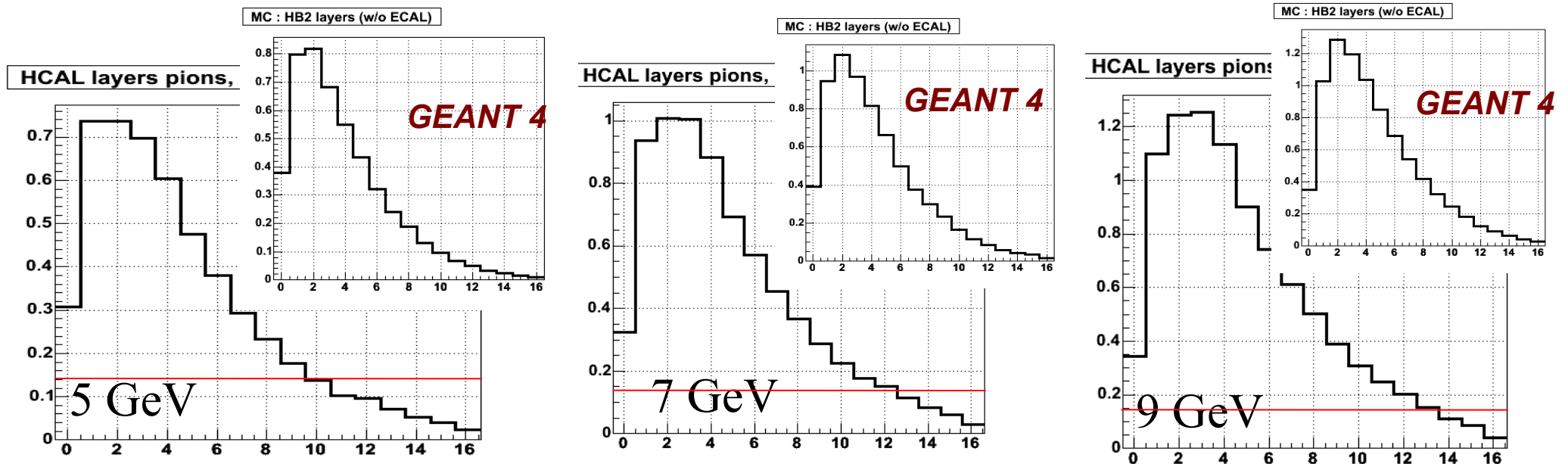
Pions
3-300 GeV

Need
Clean-up

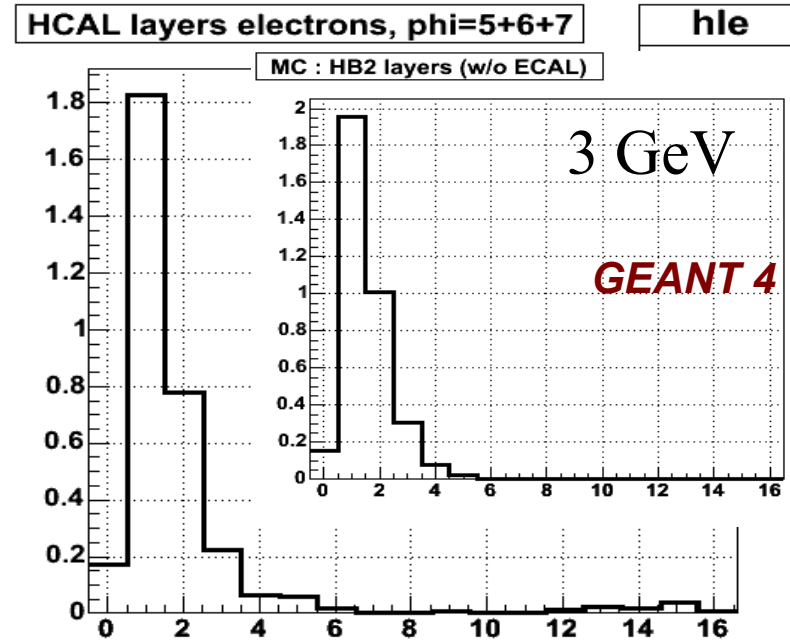
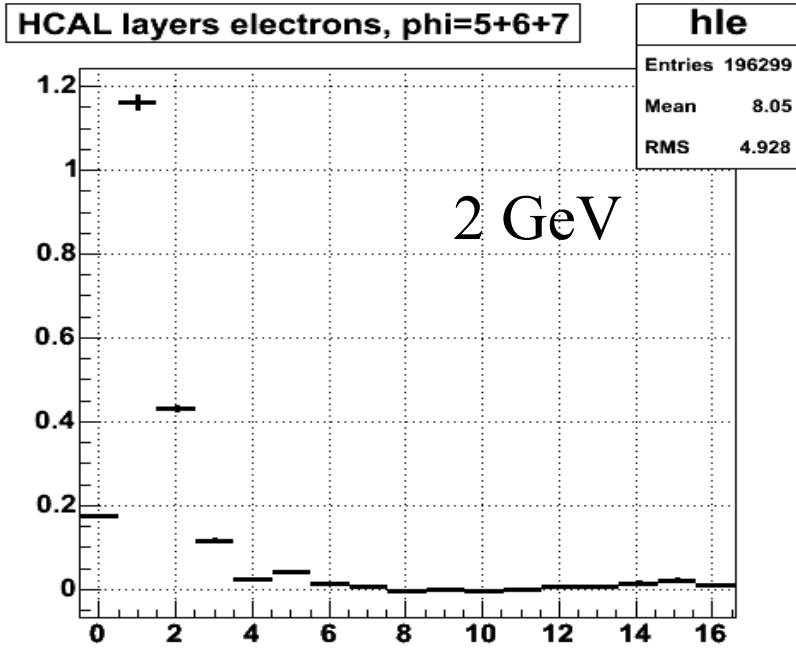
VLE longitudinal shower profile for **Pions** (data vs G4)



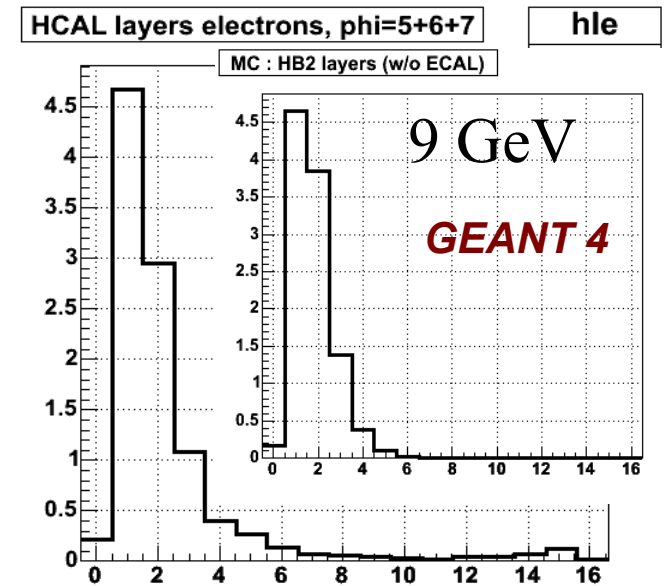
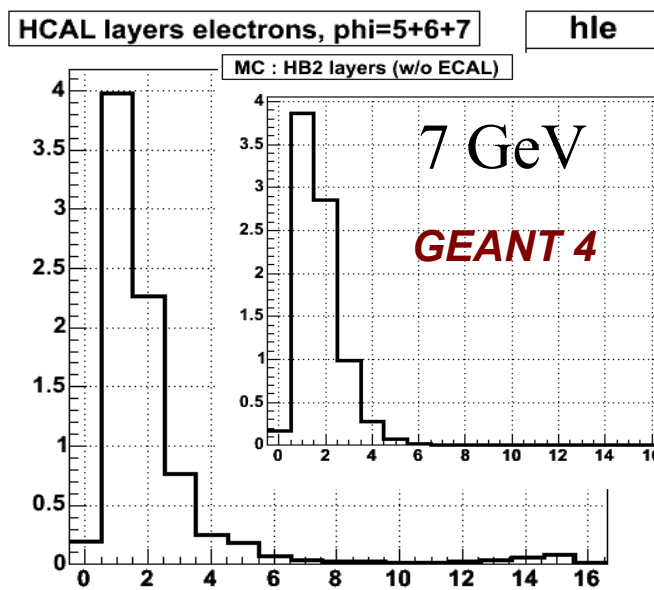
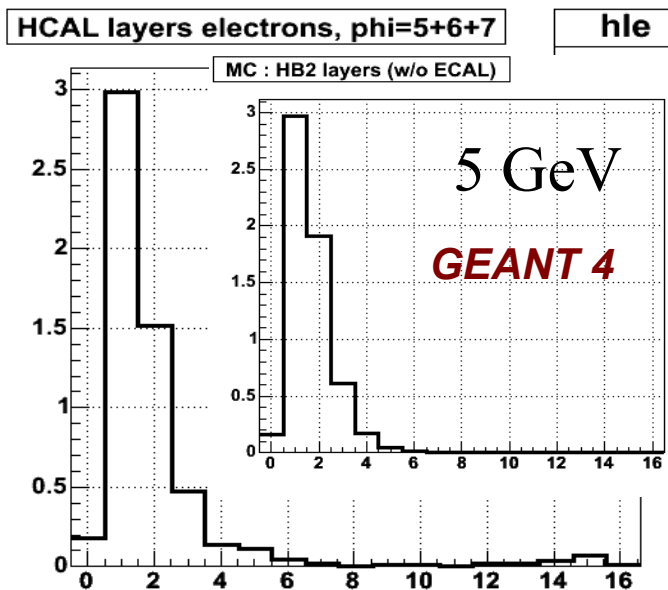
Uniform layer's calibration with muons (phi=6)



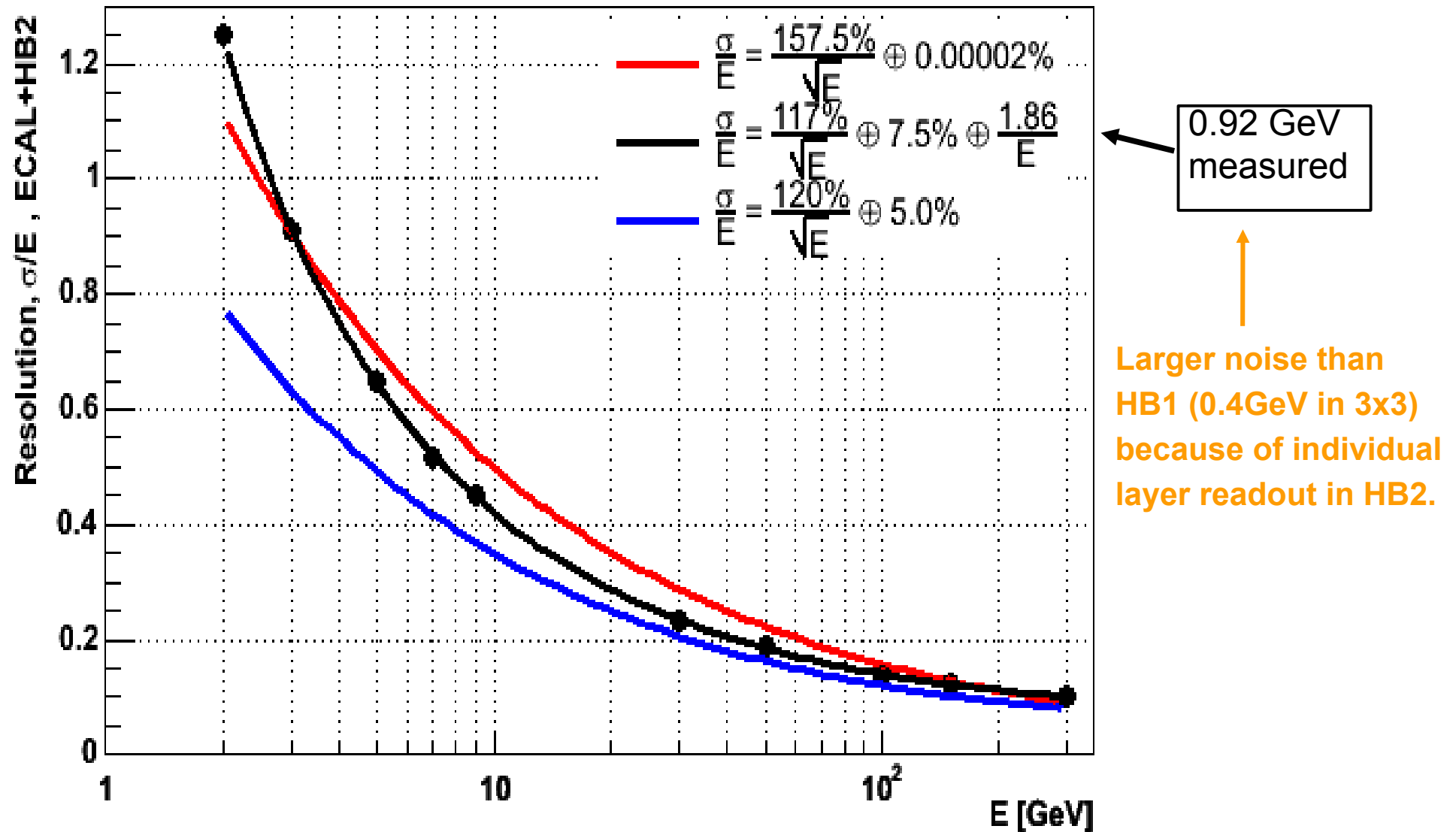
VLE longitudinal shower profile for *Electrons* (in pion beam)



Uniform layer's calibration with muons (phi=6)



Resolution with ECAL+HB2



Summary

We took the last data sets on Oct. 18, 2004.

- **Good data sets from 2-300 GeV with P-ID below ~10GeV.**
- This may be the last data before the LHC turn-on.

Analysis is now focussed on data analysis & simulation for

- e/pi, resolution, shower profile.
- **Very promising data for test of G4.**
- ***...but still long way to go in the data analysis***