Particle ID in VLE

Efe Yazgan

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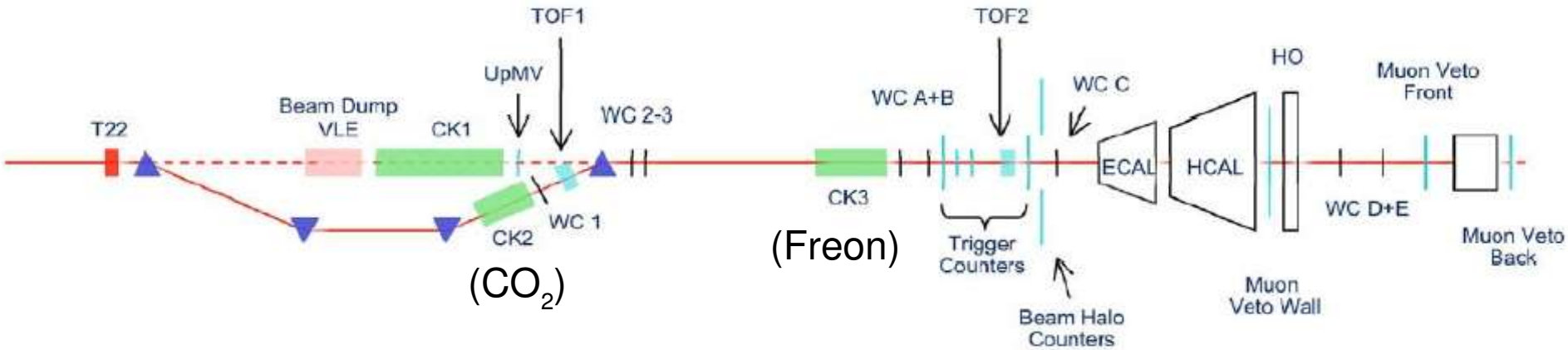
Many of the plots of this talk are taken or stolen from Jordan Damgov and Fermilab Roc Monitor.

H2 Test Beam-line at the SPS



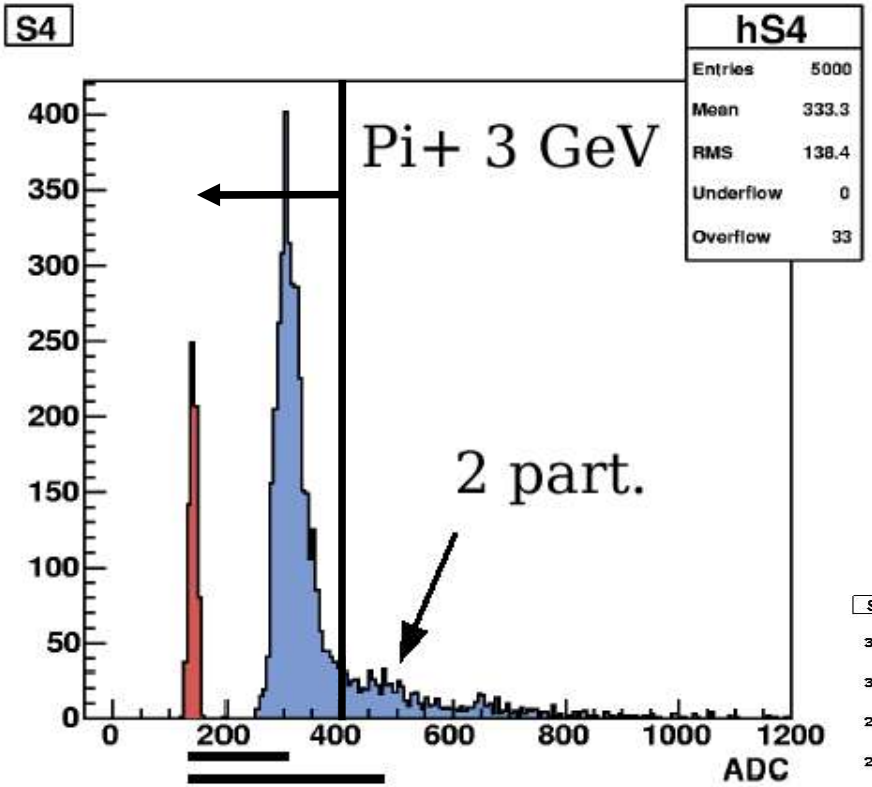
Beam Cleaning:

- Require **single hit** in S1,S2 and S4 trigger counters
- Remove wide angle secondaries using Beam Halo counters (BH1-4) 7x7 cm hole

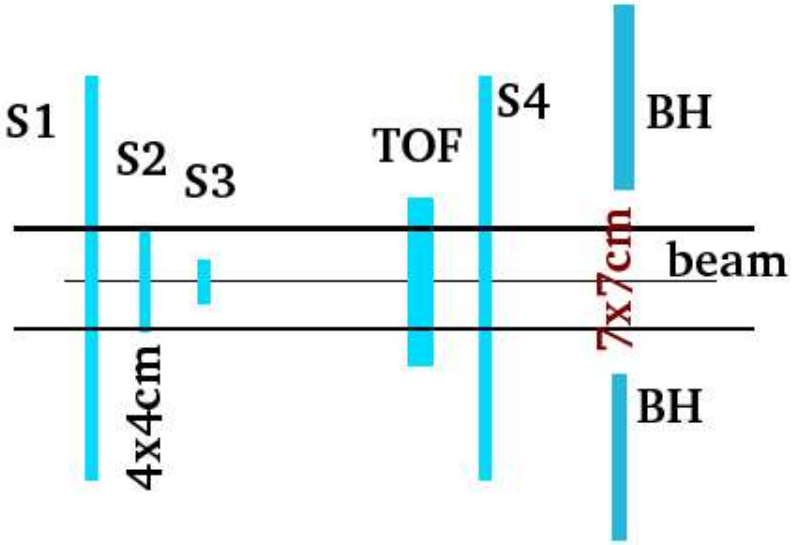
Particle ID for VLE:

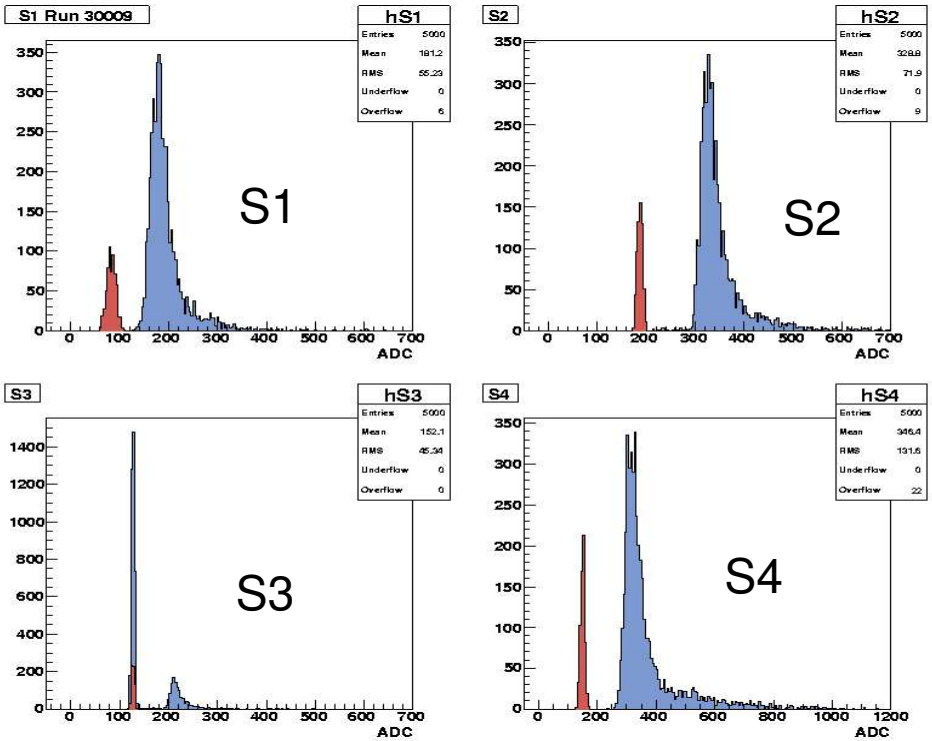
- **Muons**: Muon Veto Back (VMB), Muon Veto Front (VMF), Muon Veto Wall(VM1-8)
- **Electrons**: Cherenkov Counters CK2(on) for <9 GeV & CK3(on) for <3 GeV
- **Protons**: CK3(off) and TOF for 1-9 GeV
- **Kaons**: TOF for <4 GeV & CK3(off) and not-proton for p>5 GeV
- **Pions**: all the rest

Cleaning the interaction in the beam line

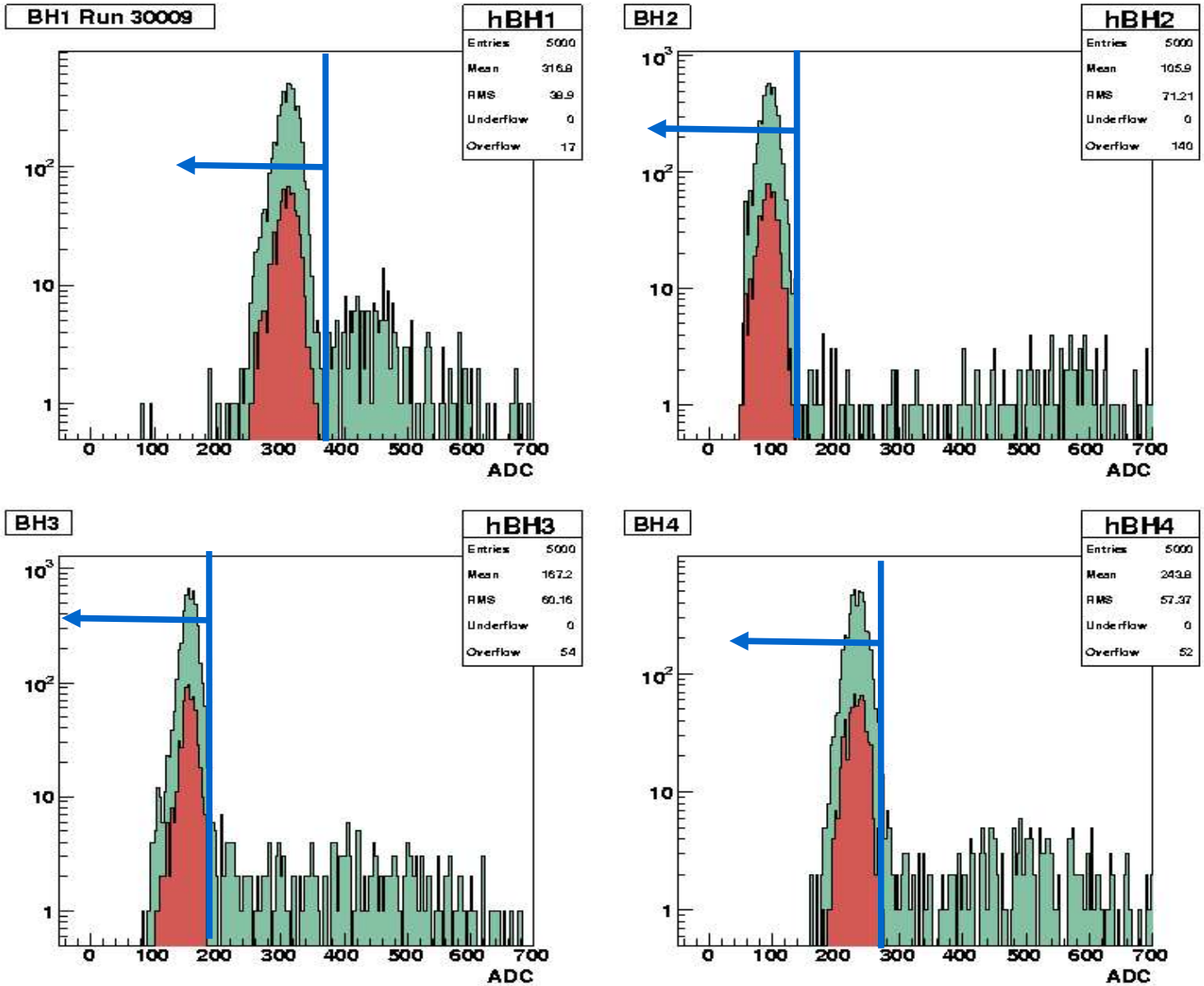


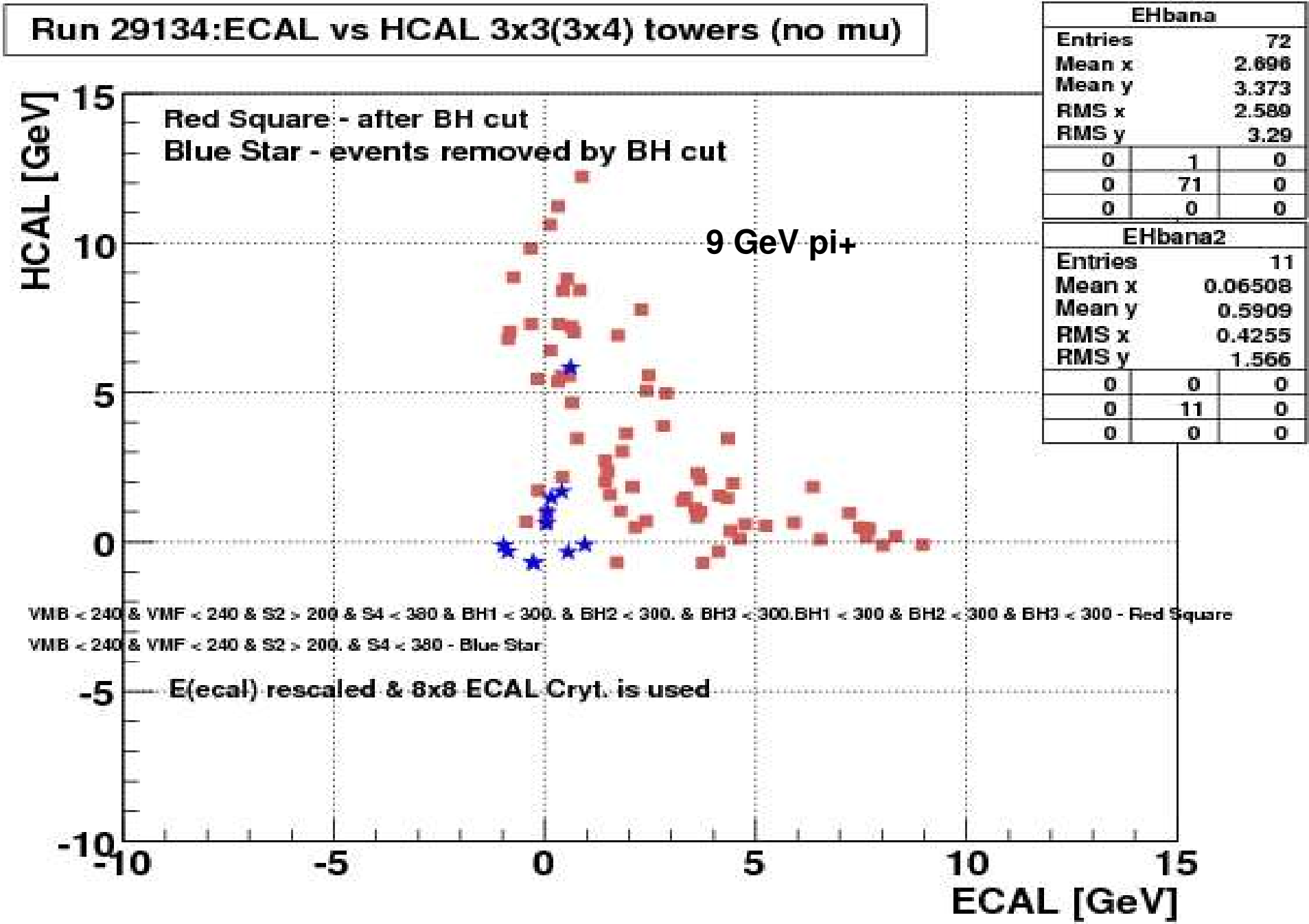
Trigger counters have the resolution to distinguish single particle from multi-particles.





Beam Halo QADc



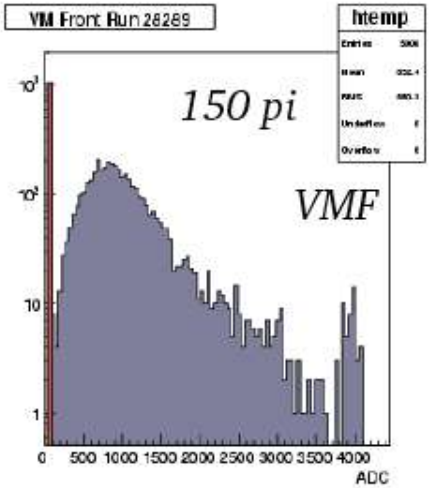

Run 29134:ECAL vs HCAL 3x3(3x4) towers (no mu)
Red Square - after BH cut
Blue Star - events removed by BH cut
9 GeV pi+
VMB < 240 & VMF < 240 & S2 > 200 & S4 < 380 & BH1 < 300. & BH2 < 300. & BH3 < 300.BH1 < 300 & BH2 < 300 & BH3 < 300 - Red Square
VMB < 240 & VMF < 240 & S2 > 200. & S4 < 380 - Blue Star
E(ecal) rescaled & 8x8 ECAL Cryt. is used
HCAL [GeV]
ECAL [GeV]
EHbana
Entries 72
Mean x 2.696
Mean y 3.373
RMS x 2.589
RMS y 3.29
0 1 0
0 71 0
0 0 0
EHbana2
Entries 11
Mean x 0.06508
Mean y 0.5909
RMS x 0.4255
RMS y 1.566
0 0 0
0 11 0
0 0 0

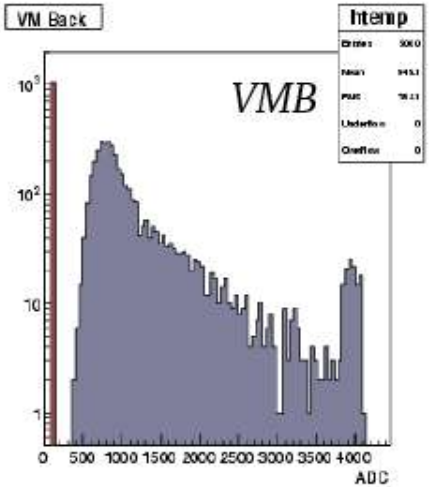
Cleaning the beam contamination muons

Muons High energy

Used only the VM Back.

VM Front is not shielded.

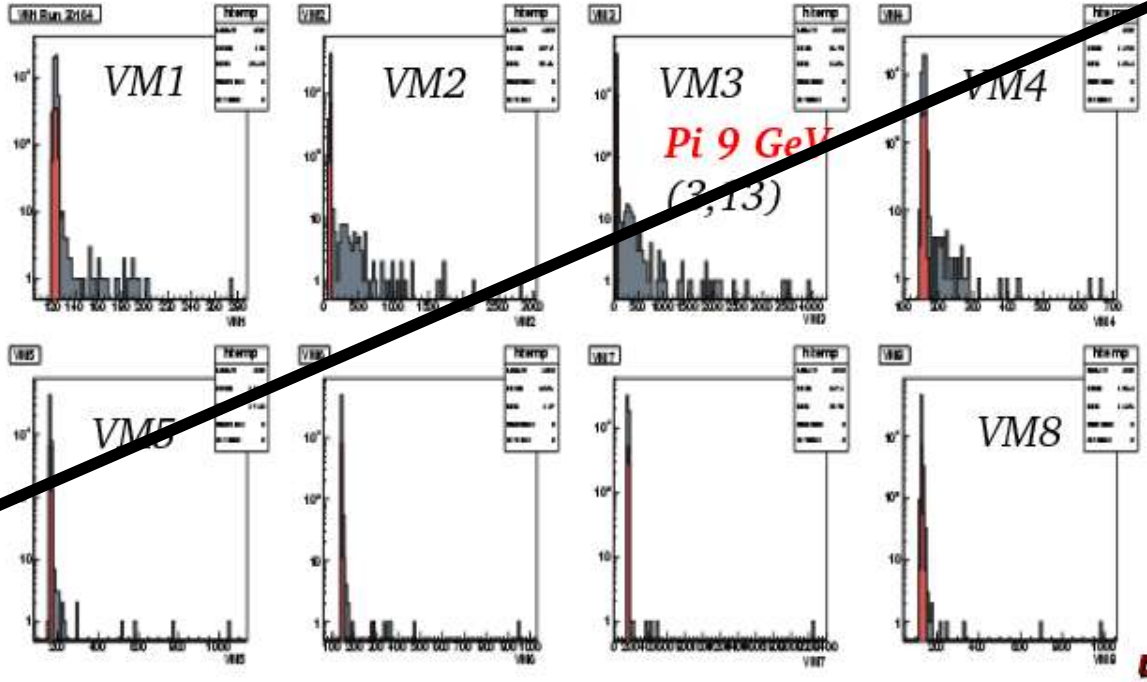


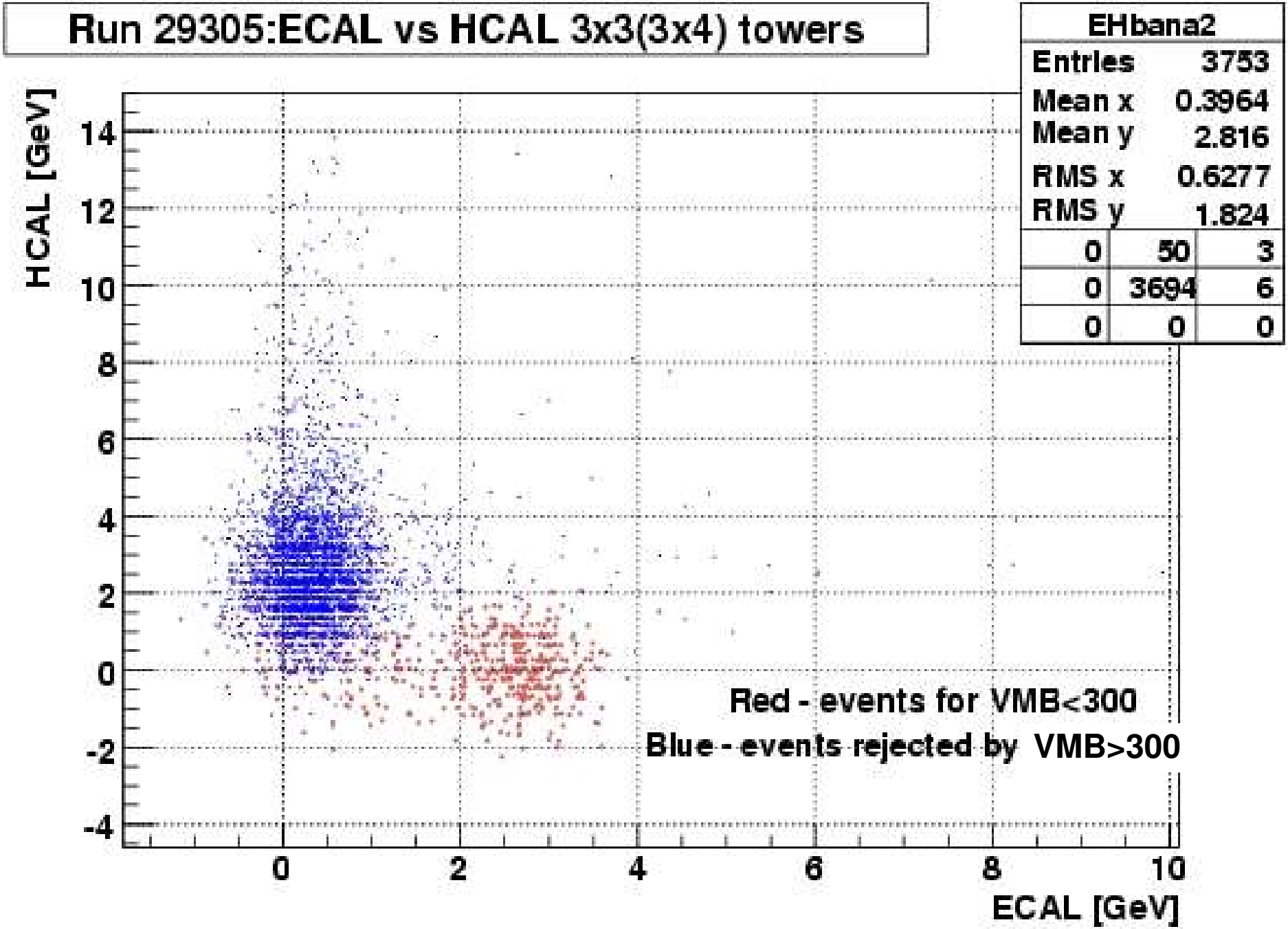


Muons at low energy

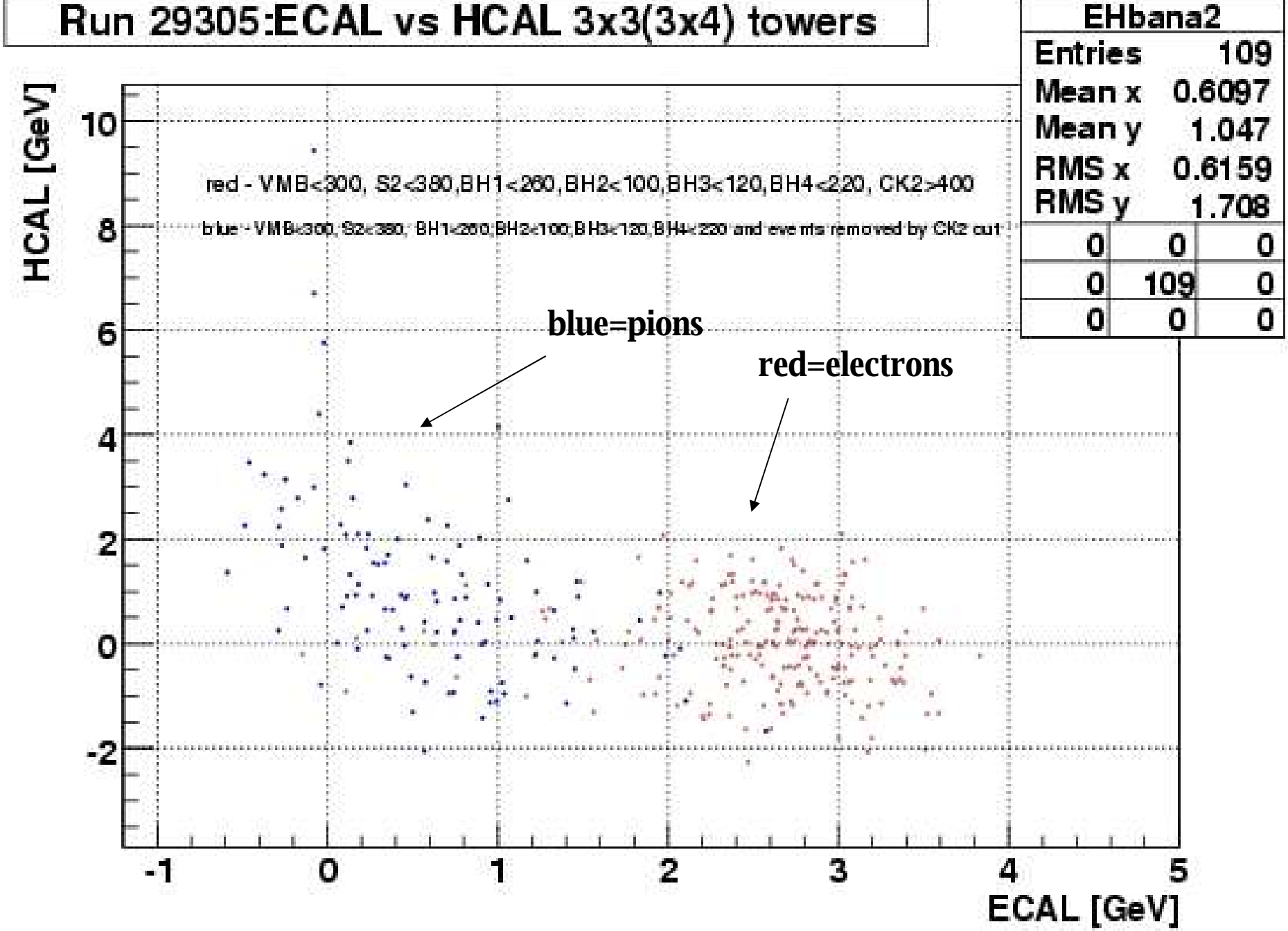
(VMB in the trigger)

VLE uses all veto counters.



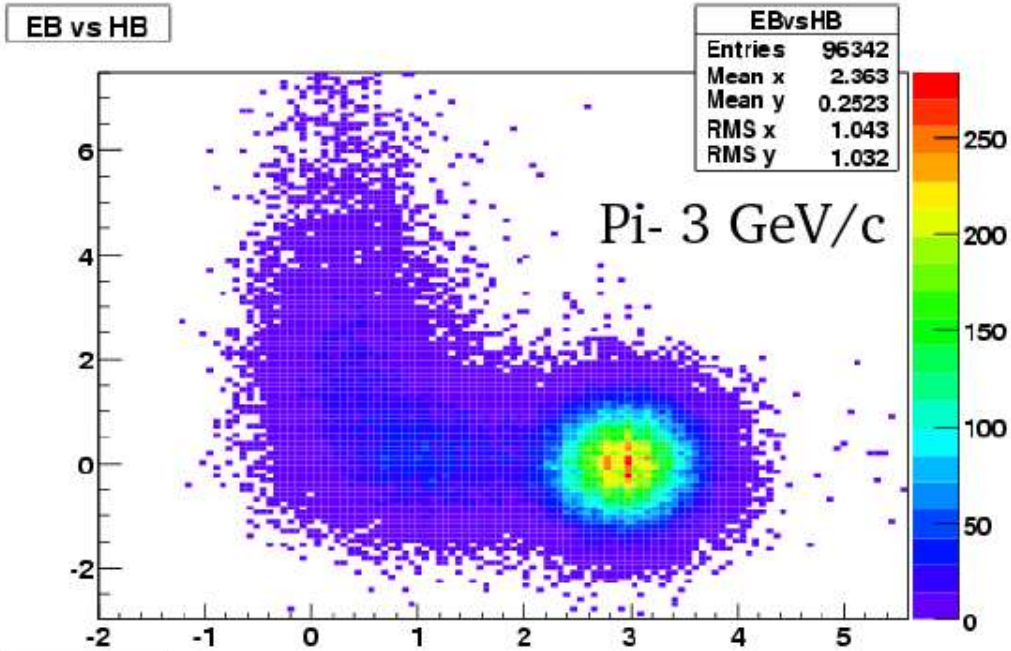

Run 29305:ECAL vs HCAL 3x3(3x4) towers
EHbana2
Entries 3753
Mean x 0.3964
Mean y 2.816
RMS x 0.6277
RMS y 1.824
0 50 3
0 3694 6
0 0 0
HCAL [GeV]
ECAL [GeV]
Red - events for VMB<300
Blue - events rejected by VMB>300

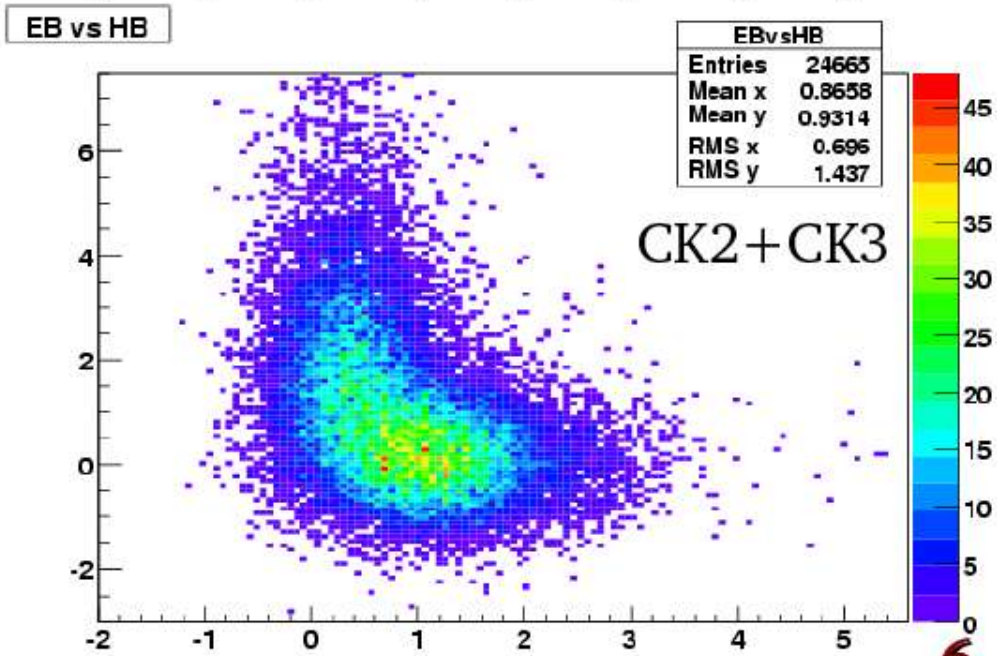
Run 29305:ECAL vs HCAL 3x3(3x4) towers



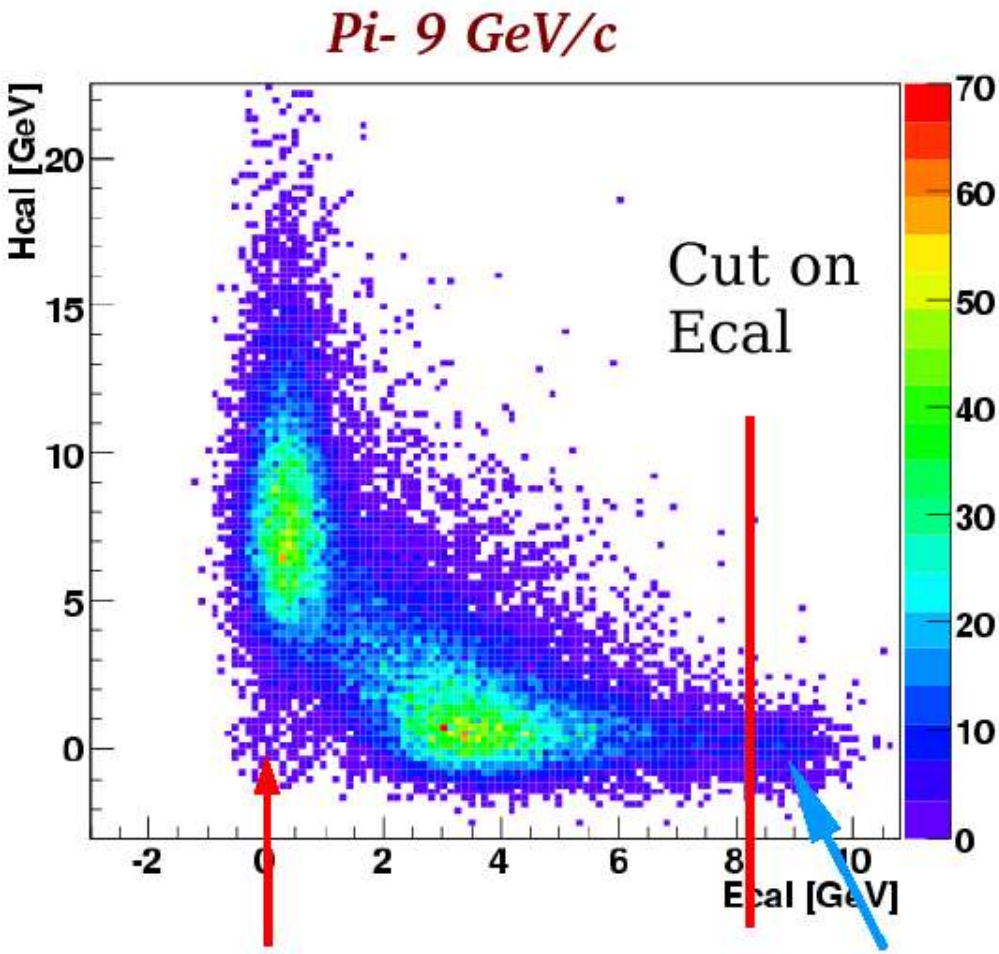
Cleaning the beam contamination- electrons

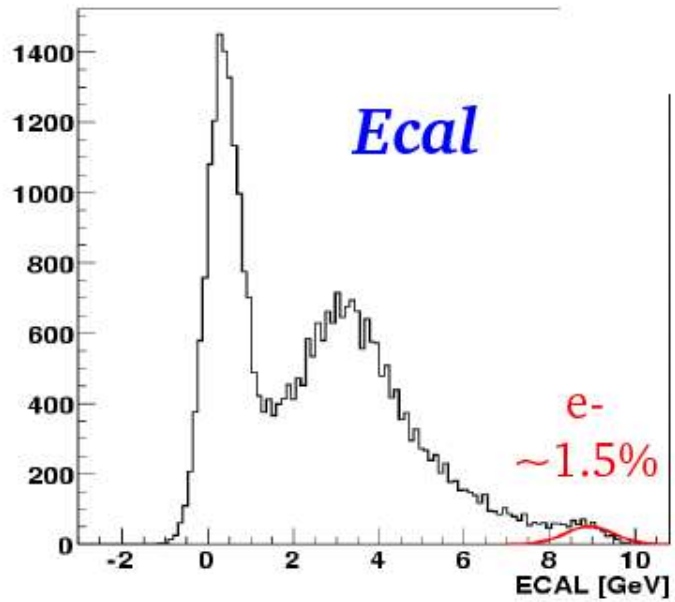
CK2 is dedicated to the electrons tagging at VLE
At lower beam momentum the electron contamination in pion tunes becomes dominant.
For 1-3(4) GeV CK3 is used for double electron tagging.





VLE data after clean-up





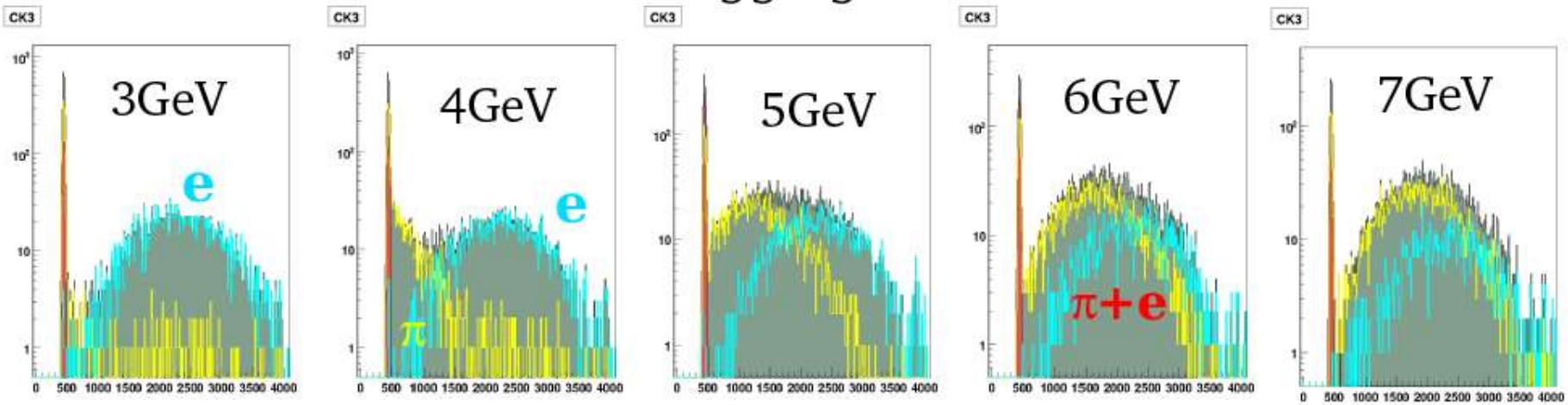
9 GeV ~1.5% e-
6 GeV ~4.0% e-

Remaining interaction
in the beam line is ~0.3%

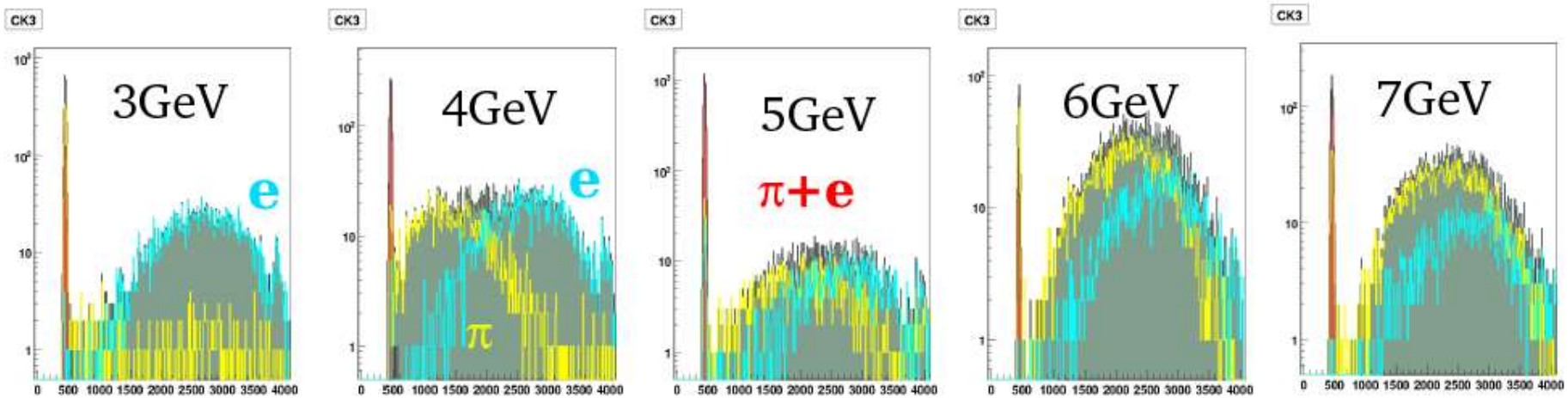
Electrons are removed with cut on Ecal
Negligible source of systematics.

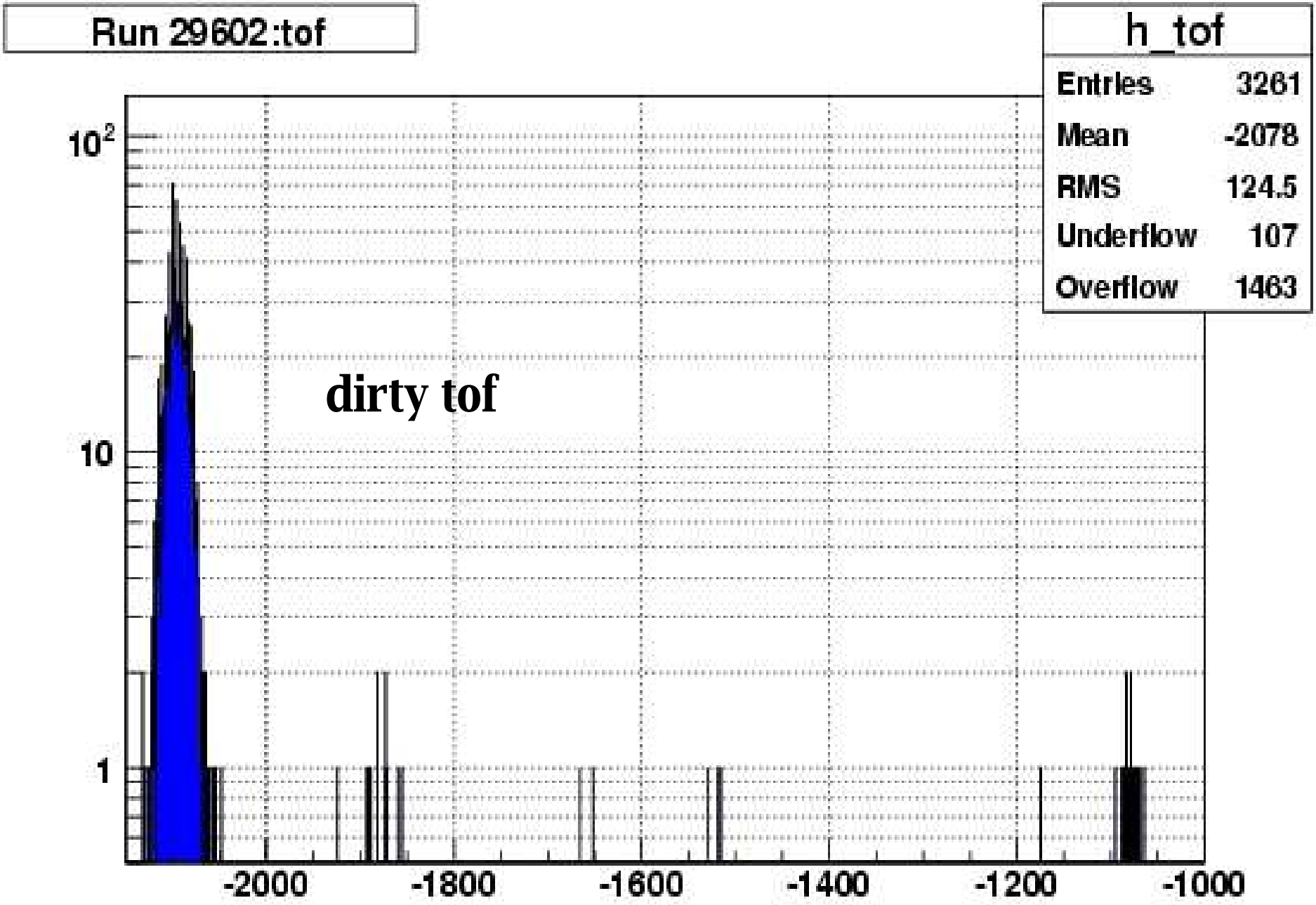
Cerenkov 3

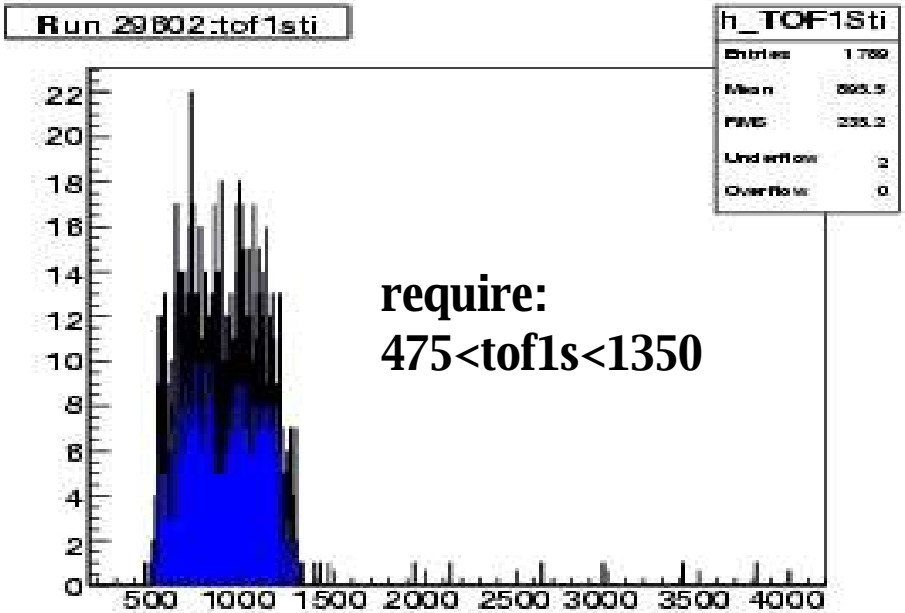
0.88 bar: double electron tagging <4 GeV

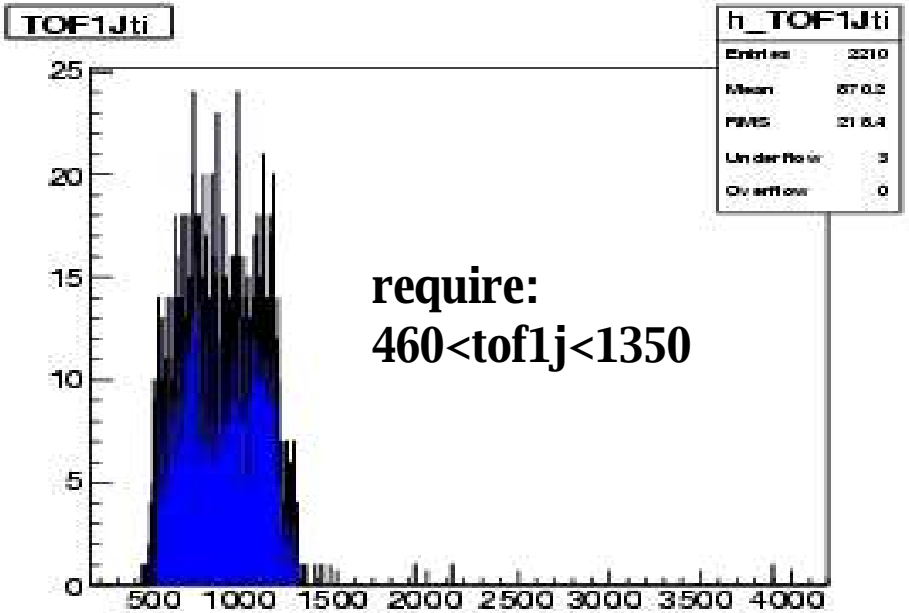


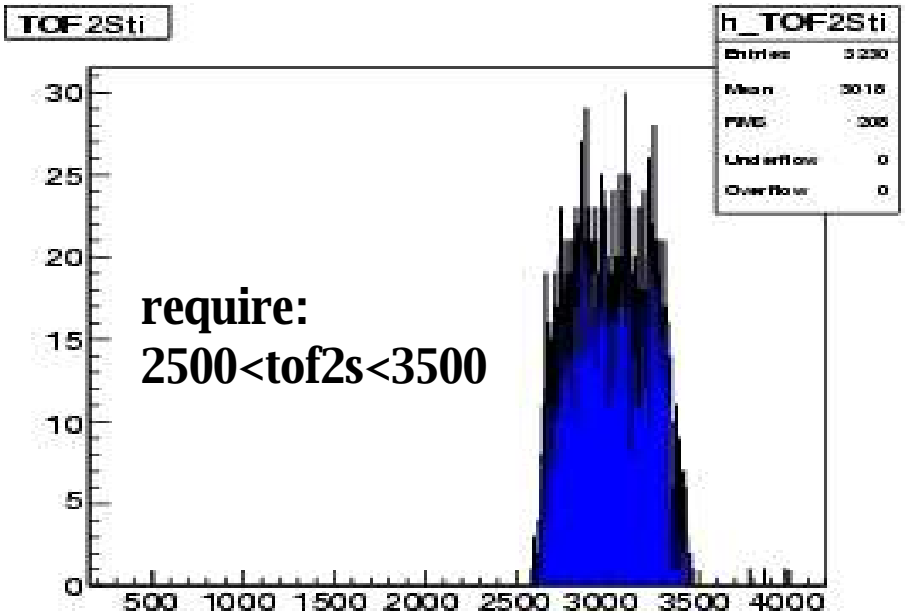
1.20 bar pi / p,K separation >4 GeV

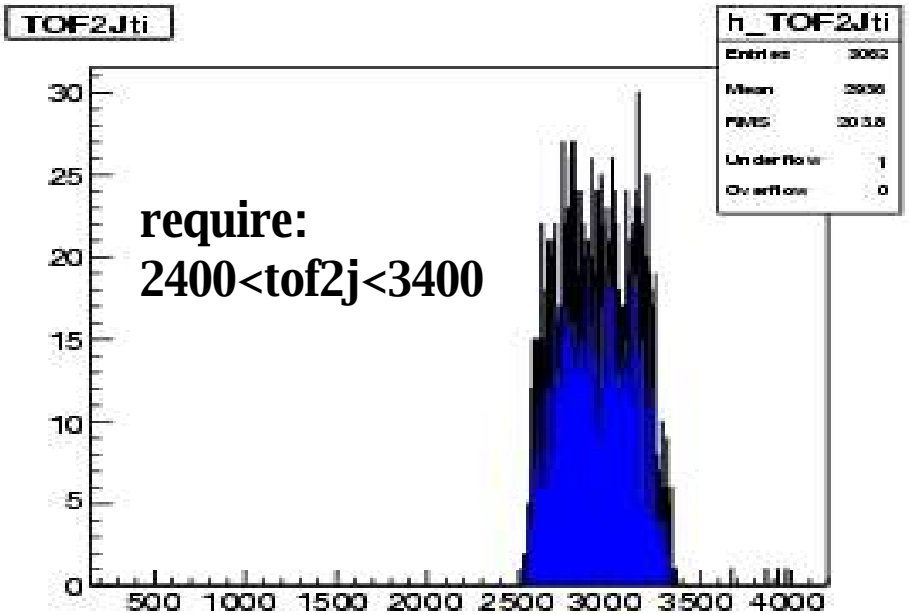


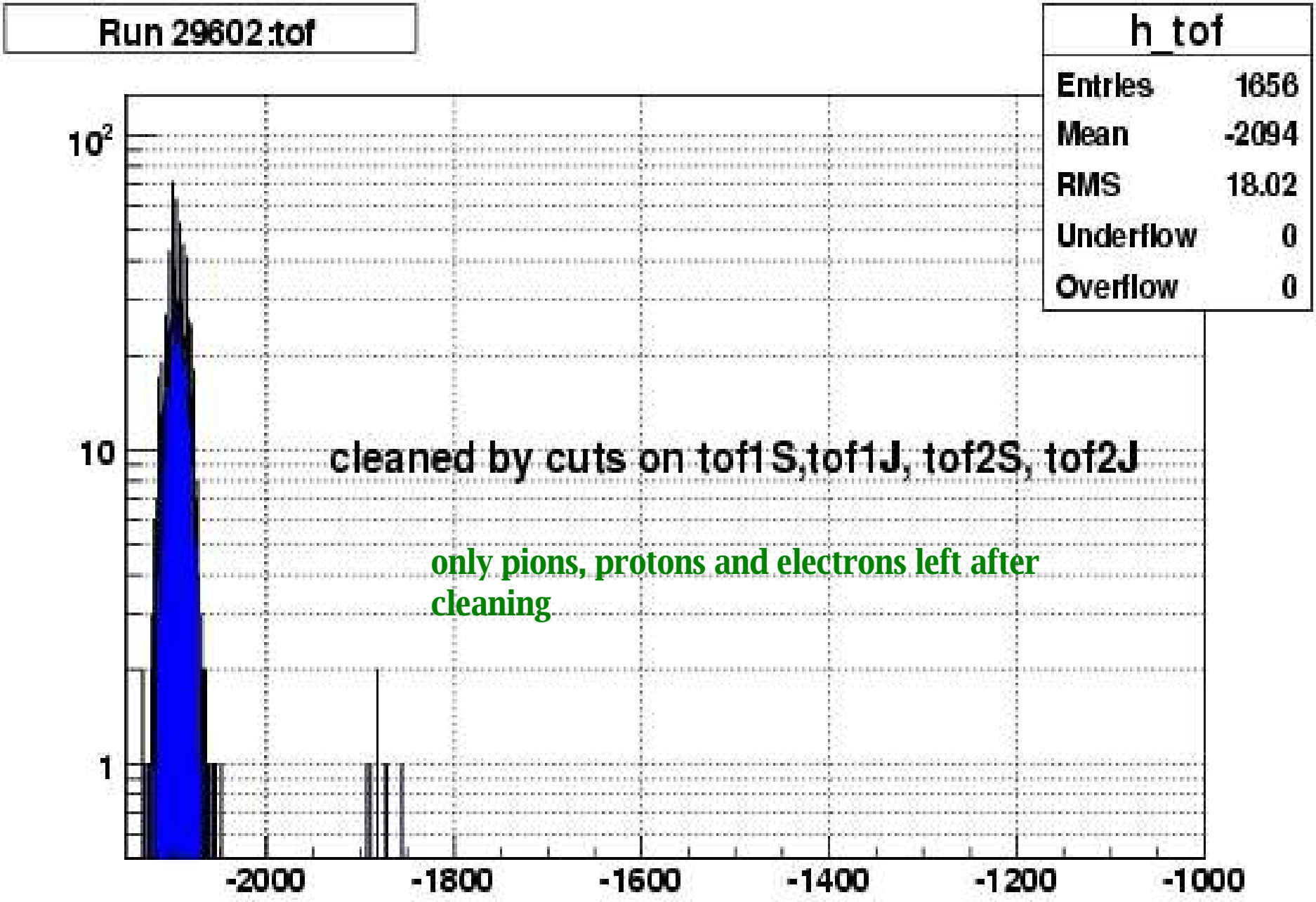

Run 29602:tof
h_tof
Entries 3261
Mean -2078
RMS 124.5
Underflow 107
Overflow 1463
dirty tof
10^2
10
1
-2000
-1800
-1600
-1400
-1200
-1000

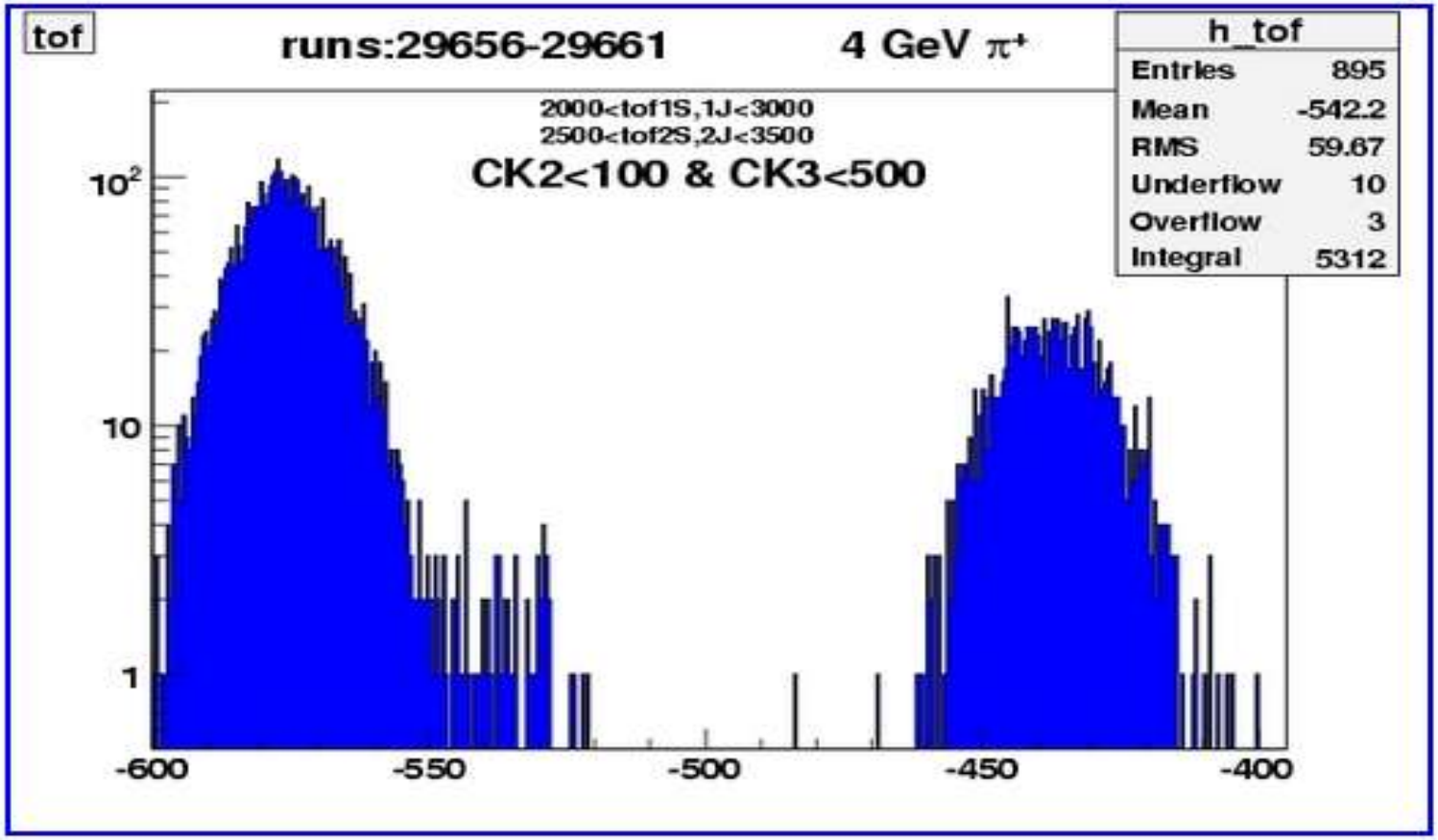

Run 29802:tof1sti
h_TOF1Sti
Entries 1789
Mean 895.5
RMS 235.2
Underflow 2
Overflow 0
require:
475<tof1s<1350


TOF1Jti
h_TOF1Jti
Entries 2210
Mean 670.2
RMS 216.4
Underflow 3
Overflow 0
require:
460<tof1j<1350


TOF2Sti
h_TOF2Sti
Entries 3230
Mean 3016
RMS 208
Underflow 0
Overflow 0
require:
2500<tof2s<3500

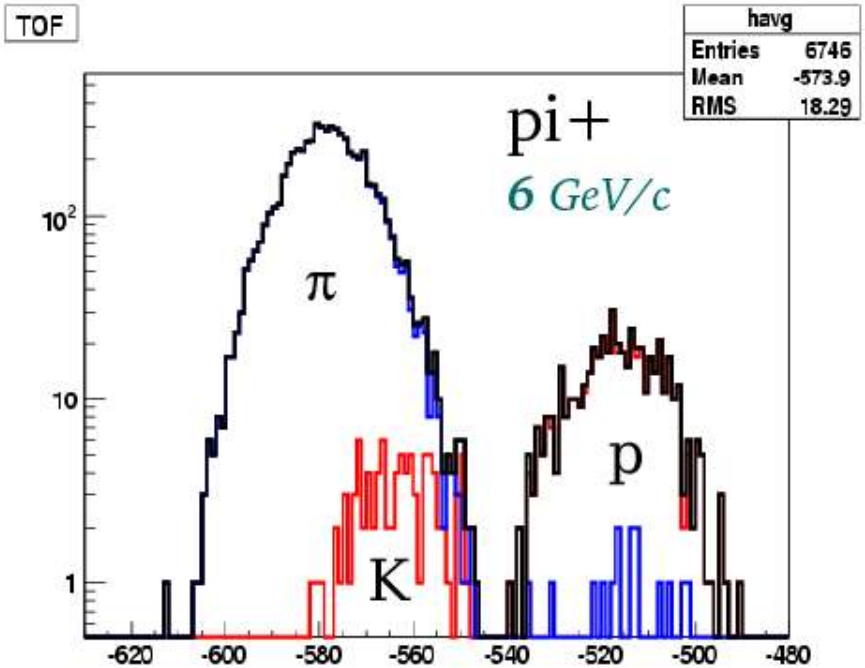

TOF2Jti
h_TOF2Jti
Entries 3062
Mean 2936
RMS 203.8
Underflow 1
Overflow 0
require:
2400<tof2j<3400


Run 29602:tof
h_tof
Entries 1656
Mean -2094
RMS 18.02
Underflow 0
Overflow 0
10^2
10
1
-2000
-1800
-1600
-1400
-1200
-1000
cleaned by cuts on tof1S,tof1J, tof2S, tof2J
only pions, protons and electrons left after cleaning



The leftmost peak is produced by pions, the rightmost one is protons.
proton - Kaon separation is 93.1 counts.
The proton gaussian mean is at -437. So, the events around -530.1 should be Kaons.
Sigma for protons is 9.657 cnts. So, all the protons are confined in ~2.5sigma around the mean.
And the number of protons is then 1260.
The pions peak at -575, taking 2.5 sigma from the peak, the number of pions is 3975.
Taking 2.5sigma around -530.1, the number of kaons is 76.
Therefore,

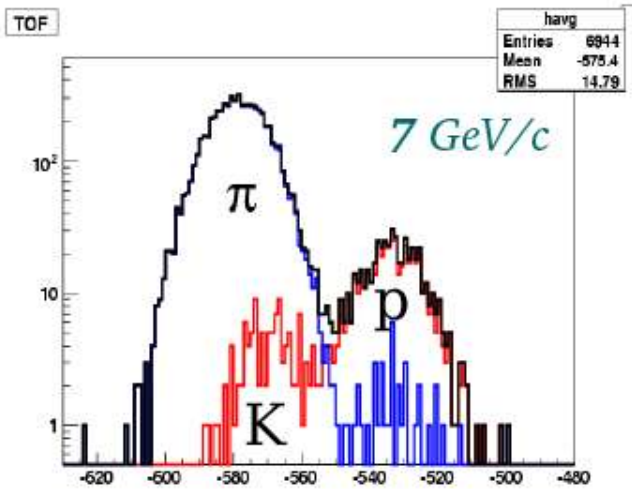
K/pi=0.0191
K/P= 0.0603
P/pi=0.3170

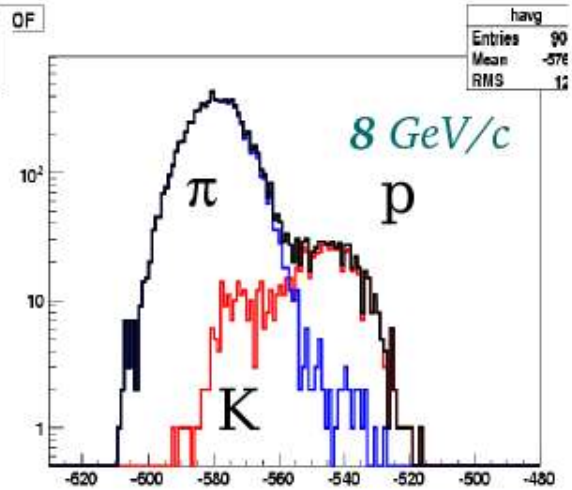


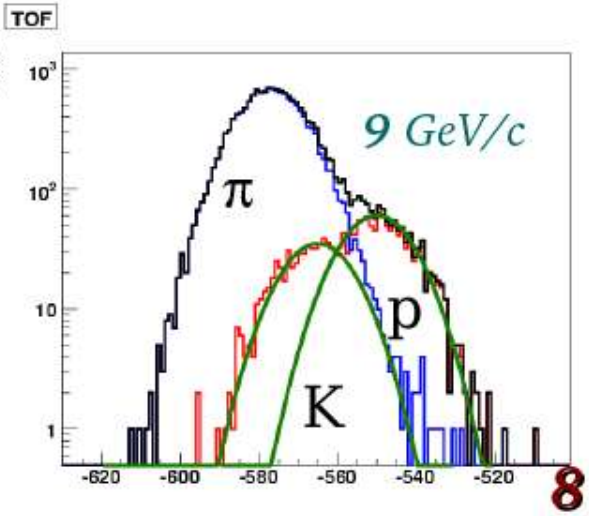
p/K in pion beam

TOF and CK3

Protons: 1-6GeV/c clean separation with TOF.
CK3 is fully efficient for pions at beam momentum above 5GeV for all of the pressure settings used during the data taking.







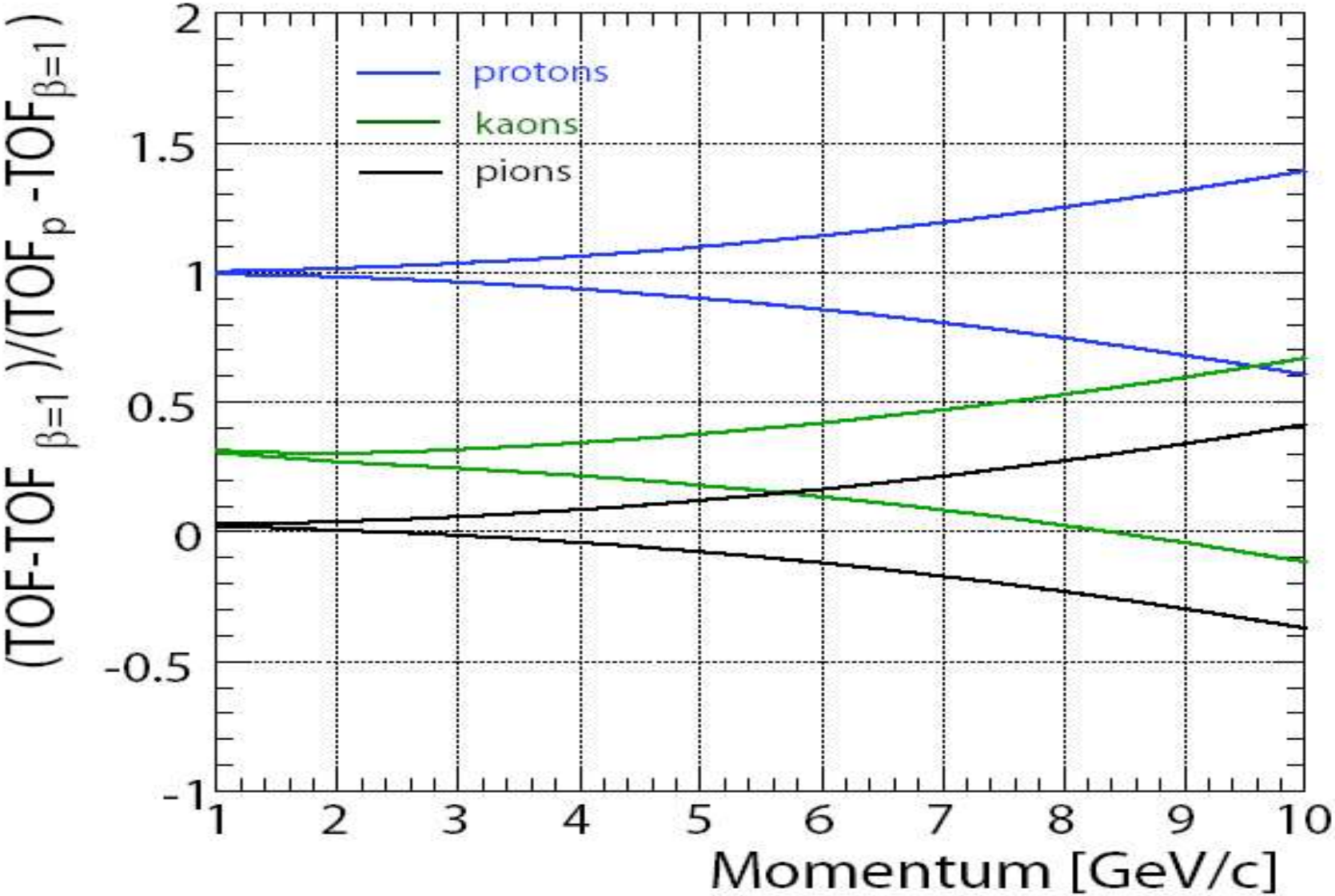
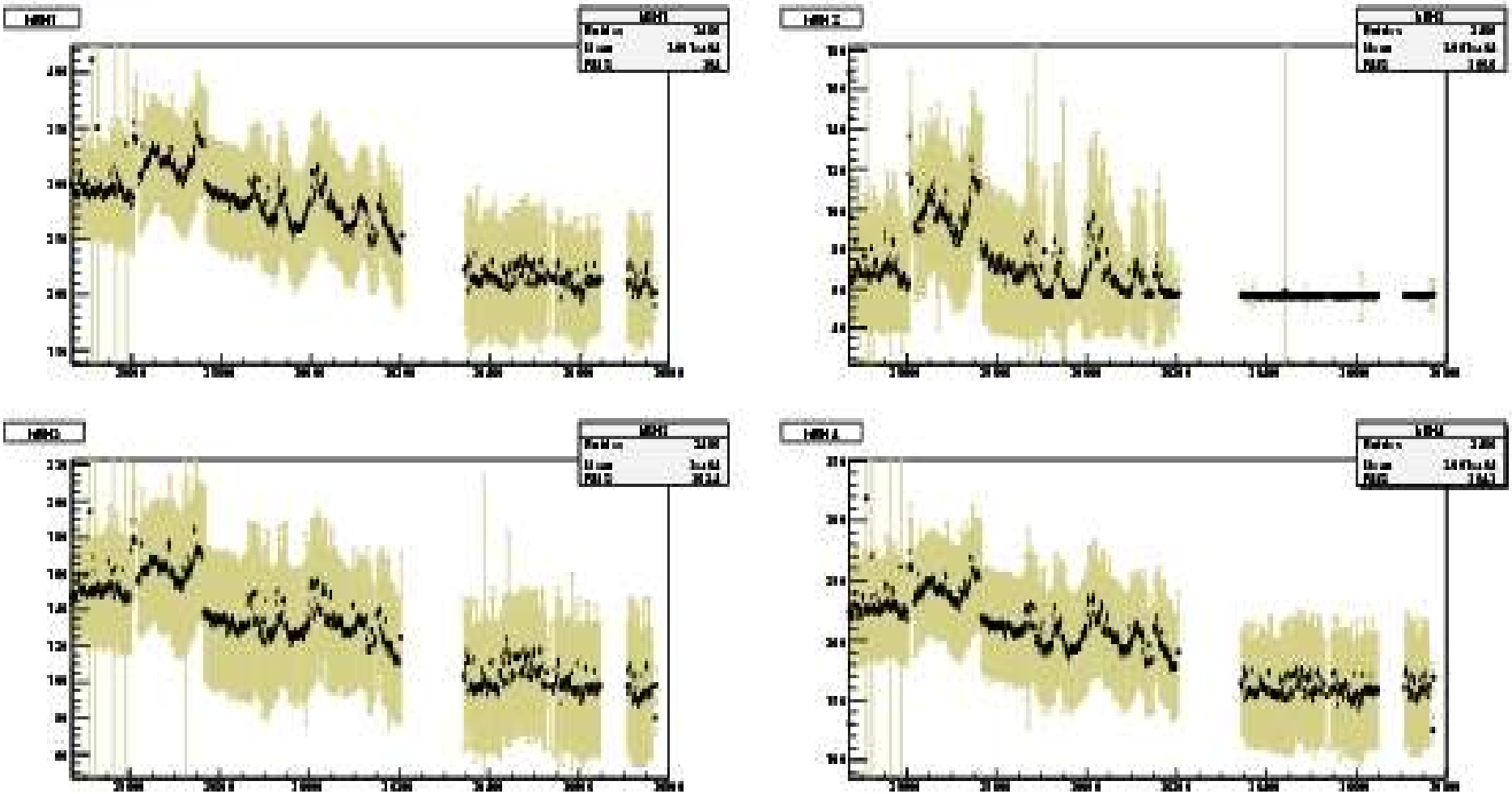


Figure 5: TOF along with 1σ of the resolution.

Table 1: $\pi-$ beam content.

Beam Mom. [GeV/c]	π^- [%]	e^- [%]	$\bar{p}$ [%]	K^- [%]
9	73.0	22.1	2.7	2.3
8	56.9	39.8	1.9	1.4
7	61.8	35.5	1.7	1.0
6	57.7	40.1	1.5	0.77
5	53.2	44.9	1.2	0.67
4	40.9	58.0	0.87	0.21
3	25.9	73.7	0.34	0.054
2	10.6	89.3	0.06	0.0046

The Cerenkov counter CK2 is 1.85m logn CO_2 filled. The gas pressure was adjusted to provide electron identication at low energy.The light yield as a function of the particle momentum is shown on fig. 3.Pions with momentum below 9 GeV/c emit no Cerenkov light in CK2.



~stable cuts on BHs for R30336 --- to the end of TB06.
BH1<280
BH2<65
BH3<150
BH4<220

For all the energies:

S1	S2	S4	VMB	BH1-BH4
210	360	370	160	per-run

VLE data:

CK2	CK3
48	480

VMF

120

VLE pi+/pi- selection

Mom	TOF	CK3
1	-540<TOF<-500	<480
2	<-545	<480
2.5	<-545	<480
3	<-545	<480
4	<-545	~
5	<-545	~
6	<-545	>480
7	<-550	>480
8	<-555	>480
9	<-565	>480

VLE (anti-)protons

CK2<48 CK3<480

Mom	TOF
1	>500
2	>-200
2.5	>-300
3	>-400
4	>-470
5	>-530
6	>-545
7	>-545
8	>-545
9	>-545

for 1 GeV: S1 300, S2 440, S4 500

VLE K+/K-

CK2<48 CK3<480

Mom	TOF
4	-547<TOF<-500
5	<-530
6	<-538
7	<-550

SUMMARY of PID

Beam cleaning - single particle.

S1-S2-S4 - single MIP

BH1-BH4 - pedestal - no wide angle secondaries.

Particle Id HighE

muons - VMB (VMF cuts also some of the late shower)

electrons - ECAL/HCAL (if needed)

SUMMARY of PID

Cleaning the pion (+/-) beam

Beam Momentum	mu	el	pro/K
1	TOF,VMB,VMF,VMwall	CK2,CK3	TOF
2	VMB,VMF,VMwall	CK2,CK3	TOF
2.5	VMB,VMF,VMwall	CK2,CK3	TOF
3	VMB,VMF,VMwall	CK2,CK3	TOF
4	VMB,VMF,VMwall	CK2,CK3?	TOF
5	VMB,VMF,VMwall	CK2	TOF,CK3?
6	VMB,VMF,VMwall	CK2	TOF,CK3
7	VMB,VMF,VMwall	CK2	TOF,CK3
8	VMB,VMF,VMwall	CK2	TOF,CK3
9	VMB,VMF,VMwall	CK2	TOF,CK3

SUMMARY of PID

Cleaning the (anti-)proton "beam"

Beam Momentum	mu	el	pi	K
1	TOF,VMB,VMF,VMwall	TOF,CK2,CK3	TOF	TOF
2	TOF,VMB,VMF,VMwall	TOF,CK2,CK3	TOF	TOF
2.5	TOF,VMB,VMF,VMwall	TOF,CK2,CK3	TOF	TOF
3	TOF,VMB,VMF,VMwall	TOF,CK2,CK3	TOF	TOF
4	TOF,VMB,VMF,VMwall	TOF,CK2,CK3	TOF	TOF
5	TOF,VMB,VMF,VMwall	TOF,CK2,CK3	TOF,CK3	TOF
6	TOF,VMB,VMF,VMwall	TOF,CK2,CK3	TOF,CK3	TOF
7	TOF,VMB,VMF,VMwall	CK2,CK3,TOF	TOF,CK3	TOF
8	VMB,VMF,VMwall	CK2,CK3,TOF	TOF,CK3	TOF
9	VMB,VMF,VMwall	CK2,CK3,TOF	TOF,CK3	TOF?

SUMMARY of PID

Cleaning the K+/- "beam"

Beam Momentum	mu	el	pi	pro
1 no K				
2 no K				
2.5 no K				
3?? few K	TOF,VMB,VMF,VMwall	TOF,CK2,CK3	TOF	TOF
4	TOF,VMB,VMF,VMwall	TOF,CK2,CK3	TOF	TOF
5	VMB,VMF,VMwall	CK2,CK3	CK3?	TOF
6	VMB,VMF,VMwall	CK2,CK3	CK3	TOF
7	VMB,VMF,VMwall	CK2,CK3	CK3	TOF
8?	VMB,VMF,VMwall	CK2,CK3	CK3	TOF
9?	VMB,VMF,VMwall	CK2,CK3	CK3	TOF?