Kaon/proton separation with the Aerogel

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The aim of this work is to study the response of the Areogel Detector in order to better select kaons.

In the beginning we select different samples of particles in order to study the different responses of Aerogel.
Due to the difficulty to select a pure sample of kaons we have extracted the real response from pions and scaled it to simulate the one from kaons. To check if the procedure is correct we have compared the simulated response of protons with the response from protons data, and the agreement is satisfactory.

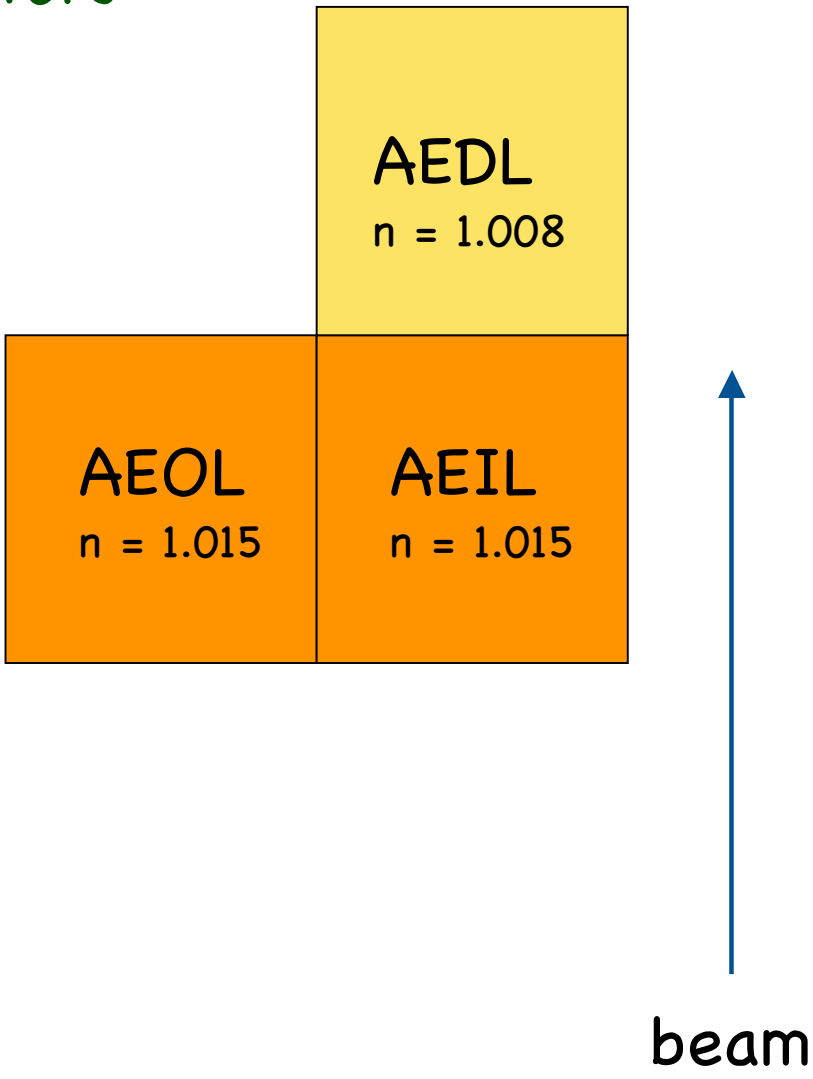
Then we try to evaluate the proton's contamination in our Kaon sample. To do this we have divided the data in bin of 0.5 Gev/c of the positive track and then we look at the ADC and/or TDC Aerogel responses.
The results are given for the three modules of the aerogel.

Given the ADC and TDC responses for different partcles is obtained from the 2008 data, I have introduced them in the Monte Carlo simulation.

Cherenkov response

Particle type	Heavy Gas	Aerogel	Nitrogen
pion	✪ p>2.7GeV	✪ (1.008)p>0.9GeV (1.015) p>1.1GeV	✪ p>5.5GeV
proton	✖	✪ (1.008)p>7.5GeV (1.015)p>5.3GeV	✖
kaon	✖	✪ (1.008)p>3.9GeV (1.015)p>2.9GeV	✖
electron	✪	✪	✪

Aerogel detectors



Pure beam of Pions and Protons

Pion ->

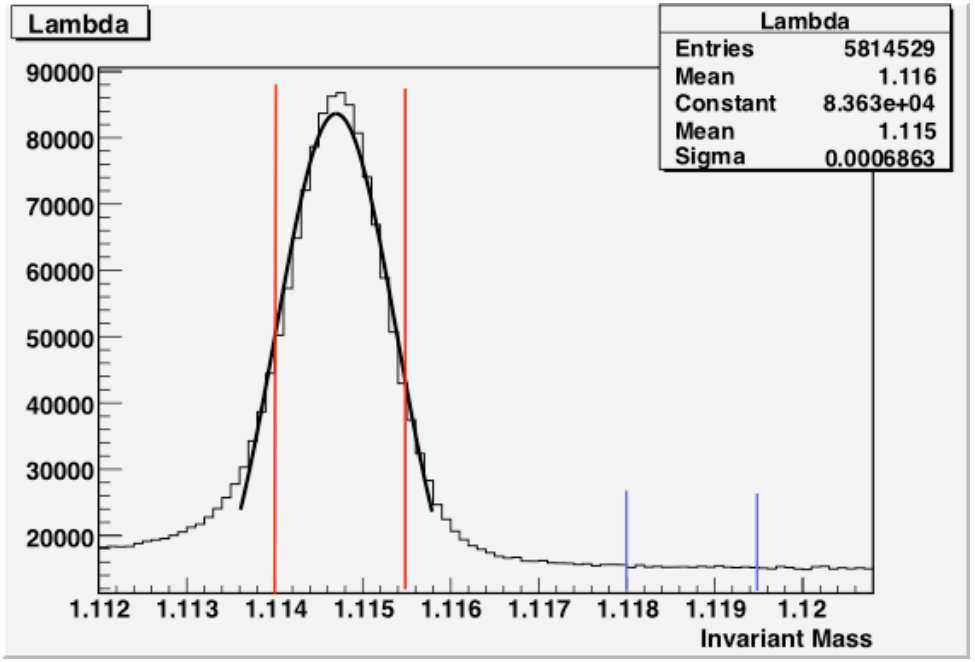
- Trigger T4 + no electron
- track extrapolation in HG and Ampl > 50
- 0.6 10^6 <time(HG) - time(VH) < 0.65 10^6
- track extrapolation in N_2 cherenkov behind Aerogel
- -- Ampl N_2 > 50 if p> 5.5 GeV
- -- Ampl N_2 < 50 if p< 5.5 GeV

Proton ->

- Trigger T4+ Kaon trigger + no electrons
- track extrapolation in HG and Ampl < 50
- if p<4.5 GeV -> tvh(2)-tvh(1) >0.
- track extrapolation in N_2 and Ampl < 30
- Invariant mass prot-pi and select 1.114 < InMass < 1.1155 GeV

- subtract the same signal but with 1.118 < InMass < 1.1195 GeV

Pure beam of Kaons



Kaon ->

- Trigger T4 + kaon trigger + no electrons
- track extrapolation crossing the HG and Ampl<50
- dt VH prompt (|dt| <0.5 ns)
- track extrapolation crossing the N_2 cherenkov behind Aerogel
- Ampl N_2 < 30

Pions to "simulate" kaons ?

Amplitude in Cherenkov is proportional to :

$A = k*F$

$F = 1 - 1/(n*beta)^2$

beta = $p/sqrt(p^2+m^2)$

n = refraction index (1.015 AEIL AEOL) or 1.008 (AEDL)

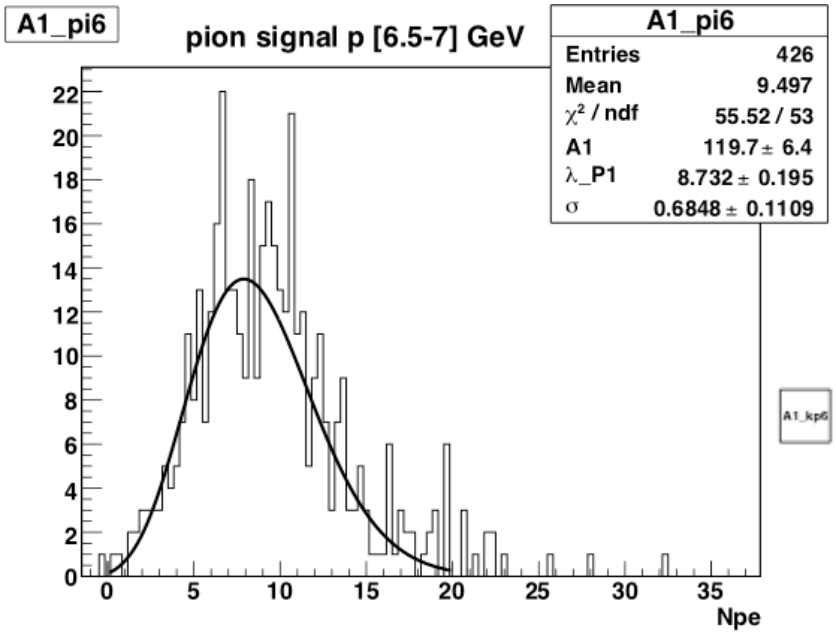
I calculate F(pion) and F(kaon) event by event

I extract the Mean npe from Pion distribution = $Mean_{pion}$

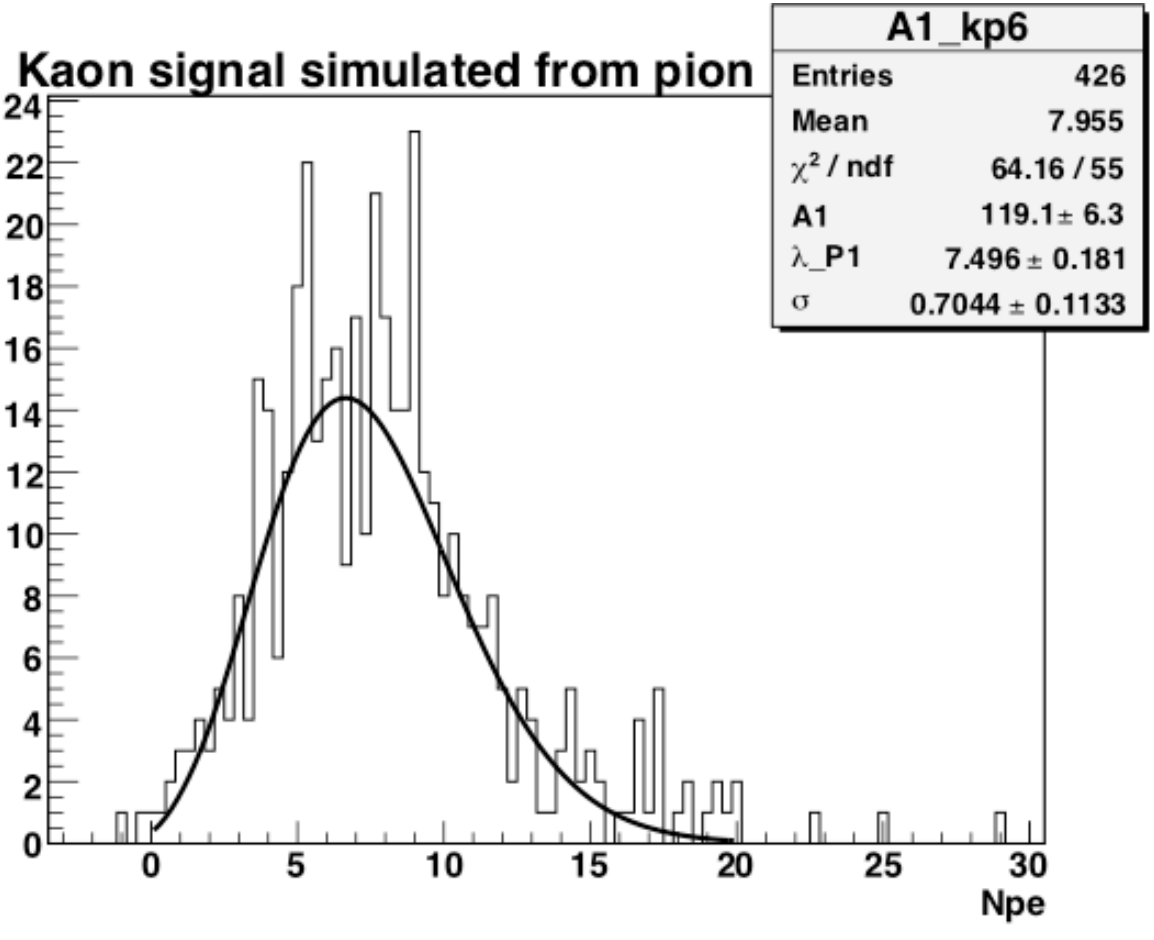
$Npe(kaon) = Mean_{pion}*F(kaon)/F(pion) +$ ← $Mean_{kaon}$

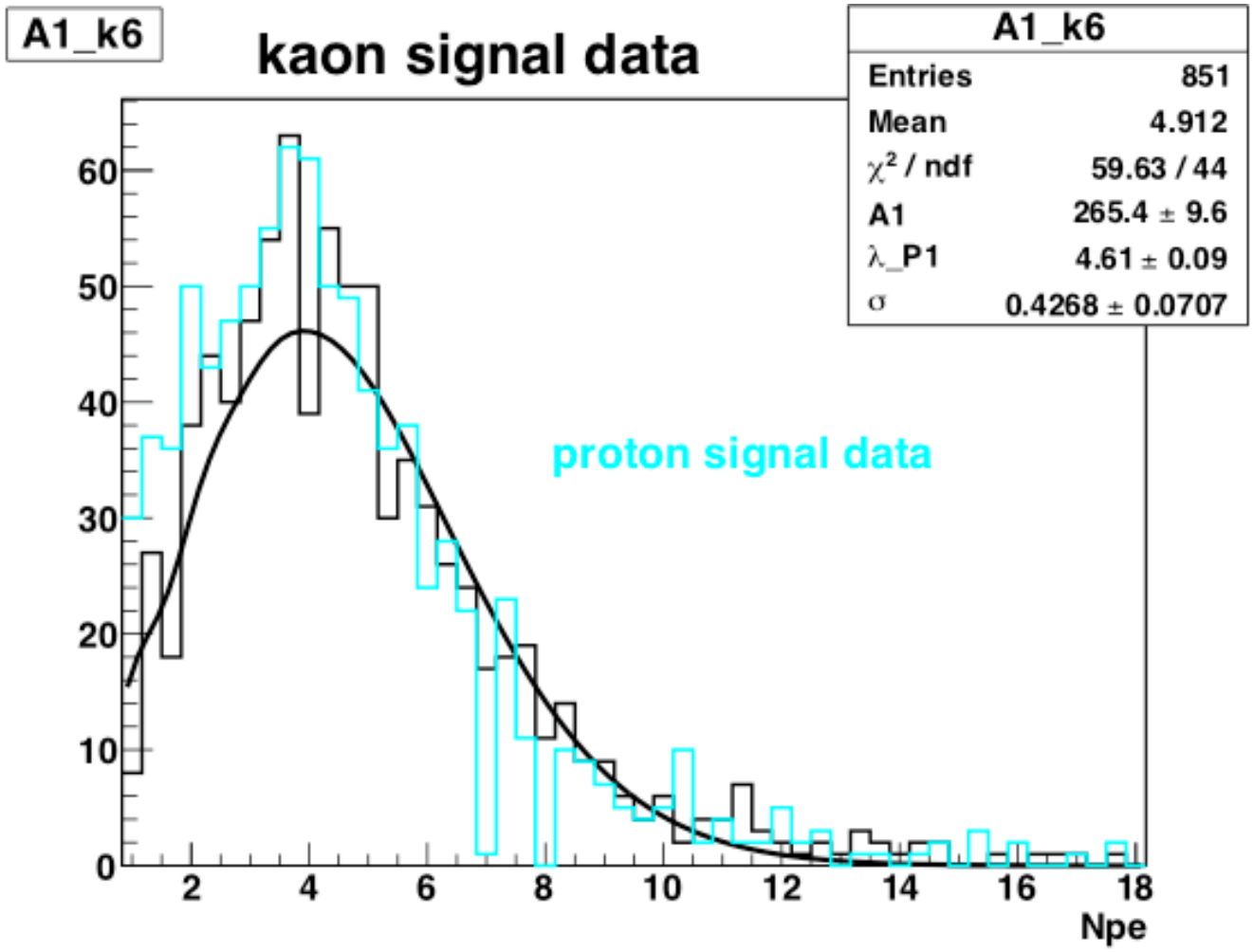
$(Npe - Mean_{pion})*sqrt(F(kaon)/F(pion))$ → RMS_{pion}

Event by event .. $Npe = ADC_{PM1}/Npe^{PM1}_{ADC} + ADC_{PM2}/Npe^{PM2}_{ADC}$


A1_pi6
pion signal p [6.5-7] GeV
A1_pi6
Entries 426
Mean 9.497
χ² / ndf 55.52 / 53
A1 119.7 ± 6.4
λ_P1 8.732 ± 0.195
σ 0.6848 ± 0.1109
A1_kp6
Npe

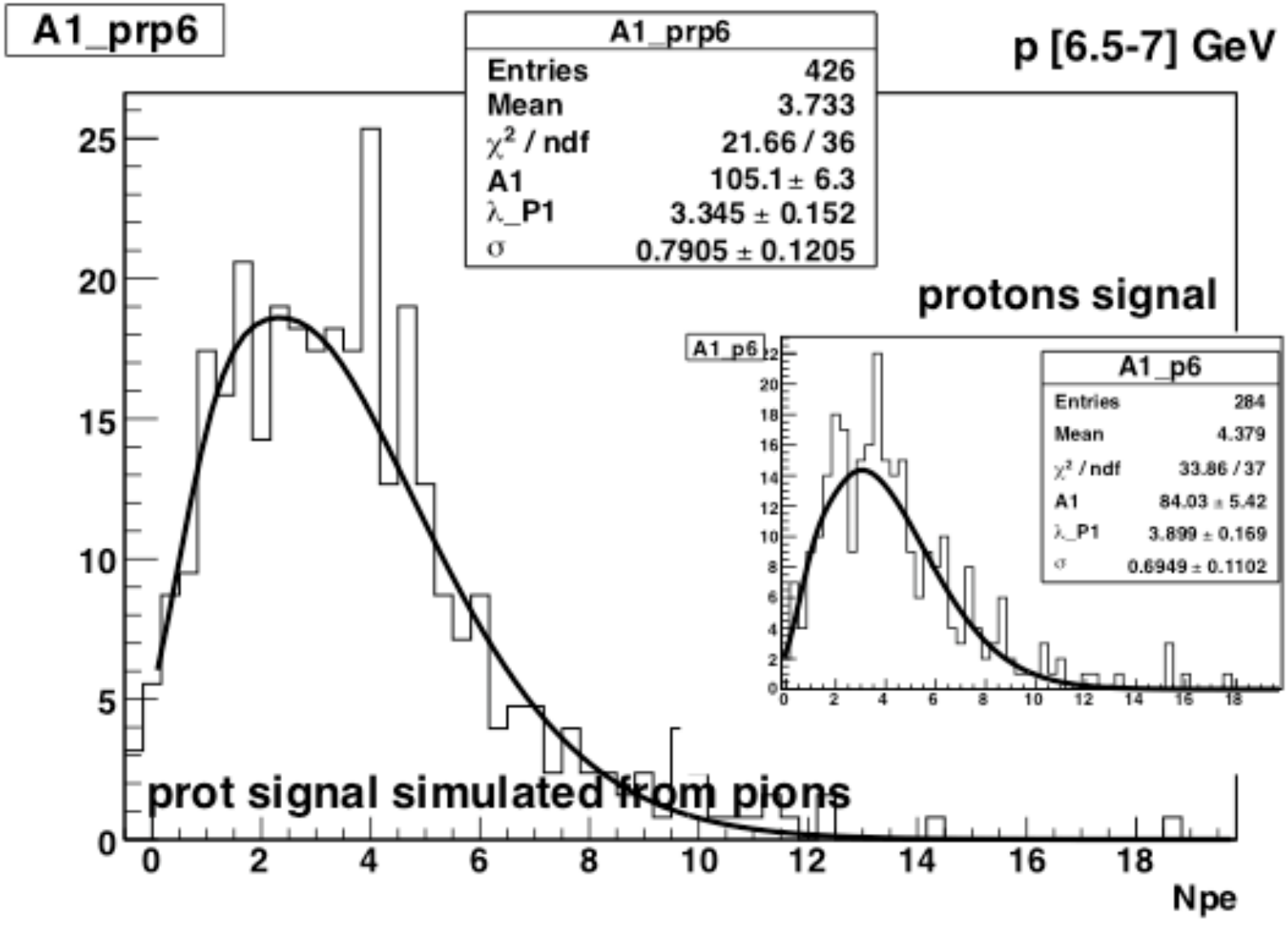
AEIL n=1.015


Kaon signal simulated from pion
A1_kp6
Entries 426
Mean 7.955
χ² / ndf 64.16 / 55
A1 119.1 ± 6.3
λ_P1 7.496 ± 0.181
σ 0.7044 ± 0.1133
Npe



P [6.5-7]GeV

AEIL

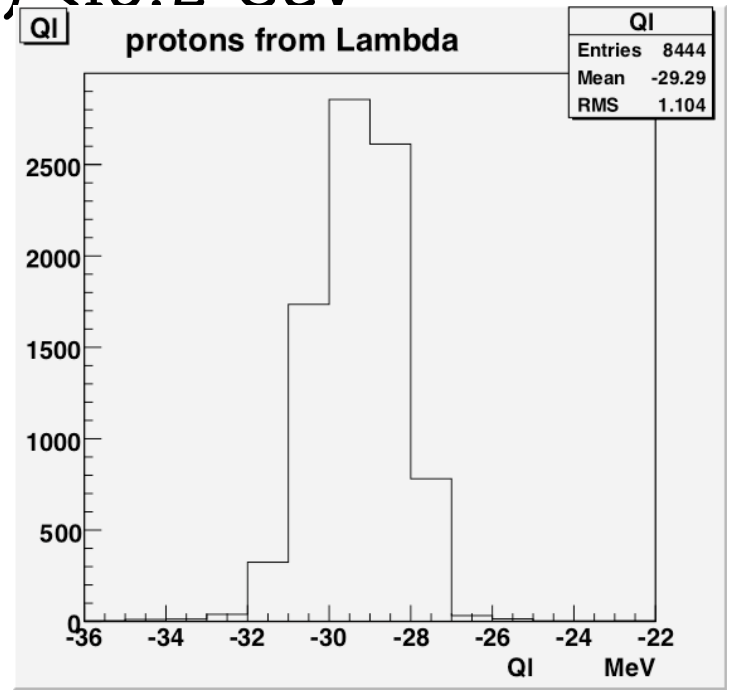

A1_prp6
A1_prp6
Entries 426
Mean 3.733
χ² / ndf 21.66 / 36
A1 105.1 ± 6.3
λ_P1 3.345 ± 0.152
σ 0.7905 ± 0.1205
p [6.5-7] GeV
protons signal
A1_p6
A1_p6
Entries 284
Mean 4.379
χ² / ndf 33.86 / 37
A1 84.03 ± 5.42
λ_P1 3.899 ± 0.169
σ 0.6949 ± 0.1102
prot signal simulated from pions
Npe

Proton contamination in our Kaon sample

I do select kaon from our 2008 data :
selection discussed before + analysis cuts:

- -25Mev < Ql < 45 MeV
- Q_T < 10 MeV
- 5.1 GeV < P(pion) + P(kaon) <10.2 GeV
- 1.1 Gev< P(pion) <2.2 GeV

Ql reconstructed
as it was a Kp event



Event selection : Number of Event : Kaon-like events and Proton-like events in AEIL

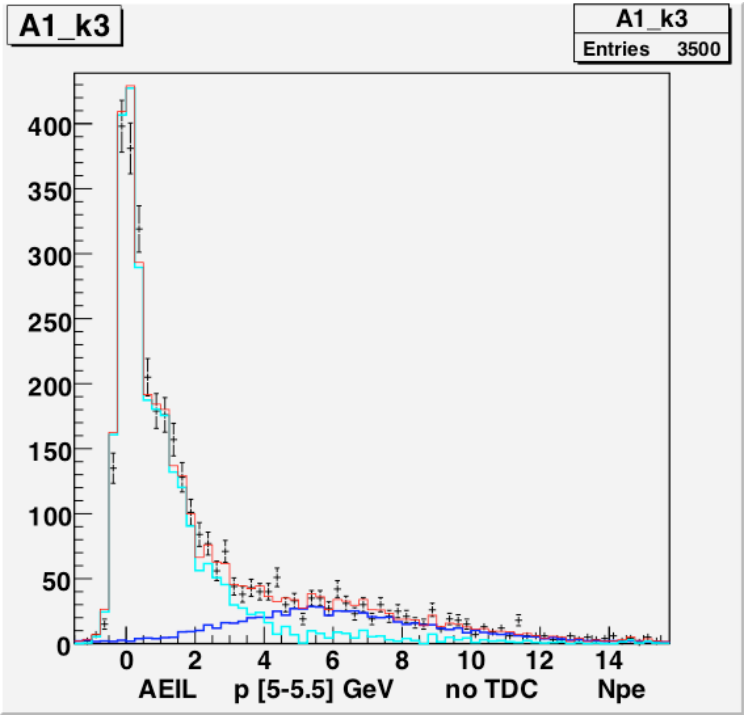
Mom. Bin	KAONS-like no TDC AEIL	PROT-like requested	KAON-like TDC AEIL	PROT-like requested
P 4-4.5 GeV	340	3664	139	270
P 4.5-5 GeV	1793	5568	548	509
P 5-5.5 GeV	3456	5498	1243	1179
P 5.5-6 GeV	3928	4161	2175	2115
P 6-6.5 GeV	3389	2419	2277	1587
P 6.5-7 GeV	2361	931	1730	699

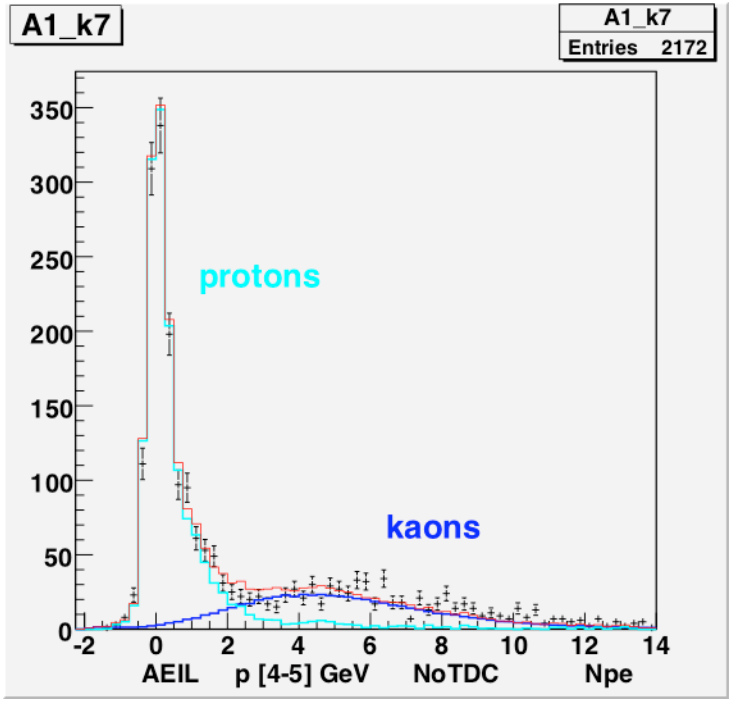
PROT-like events are protons from the Lambda selected with the criteria seen before (p.9)

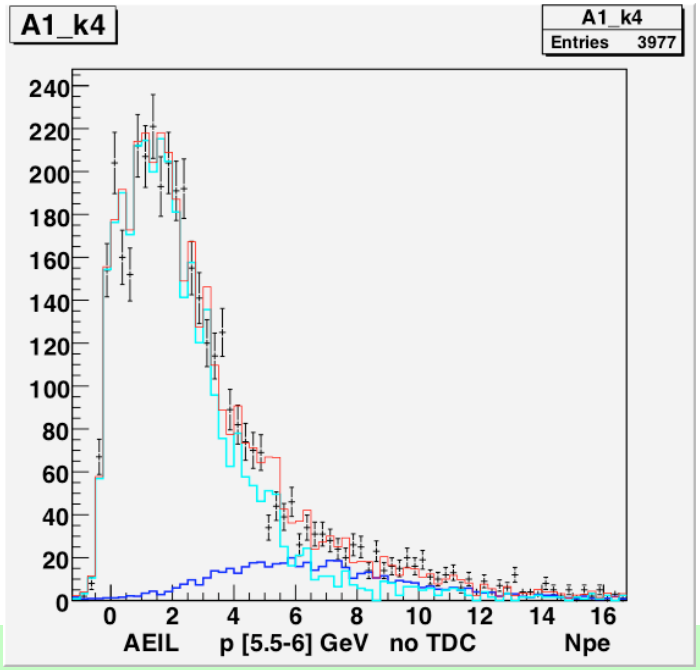
KAON-like events are K-pi events like we have in our analysis (p.10)

This are data selected from 2008 data taking, very preliminary preselection. The ntuples were created with very loose cuts with Downstream tracking alone, and with K^+pi^- hypotesis. 9381267 events survived this first ntuple creation.

AEIL Kp selection







Proton contamination and kaon efficiency in AEIL

Momentum bin	Npe 1	Npe 1.5	Npe 2	Npe 3	
P 4-4.5 GeV	Eff(k)=95% Cont(p)=38%	91% 25%	87% 17%	75% 11%	Aereogel TDC NOT Requested
P 4.5-5 GeV	96% 61%	94% 40%	91% 31%	82% 24%	
P 5-5.5 GeV	96% 1.3	95% 95%	93% 68%	86% 41%	
P 5.5-6 GeV	97% 4.5	96% 3.7	95% 3.0	89% 2.0	
P 6-6.5 GeV	98% 6.4	97% 5.8	96% 5.1	91% 3.8	
P 6.5-7 GeV	98% 25	98% 24	96% 22	89% 19	

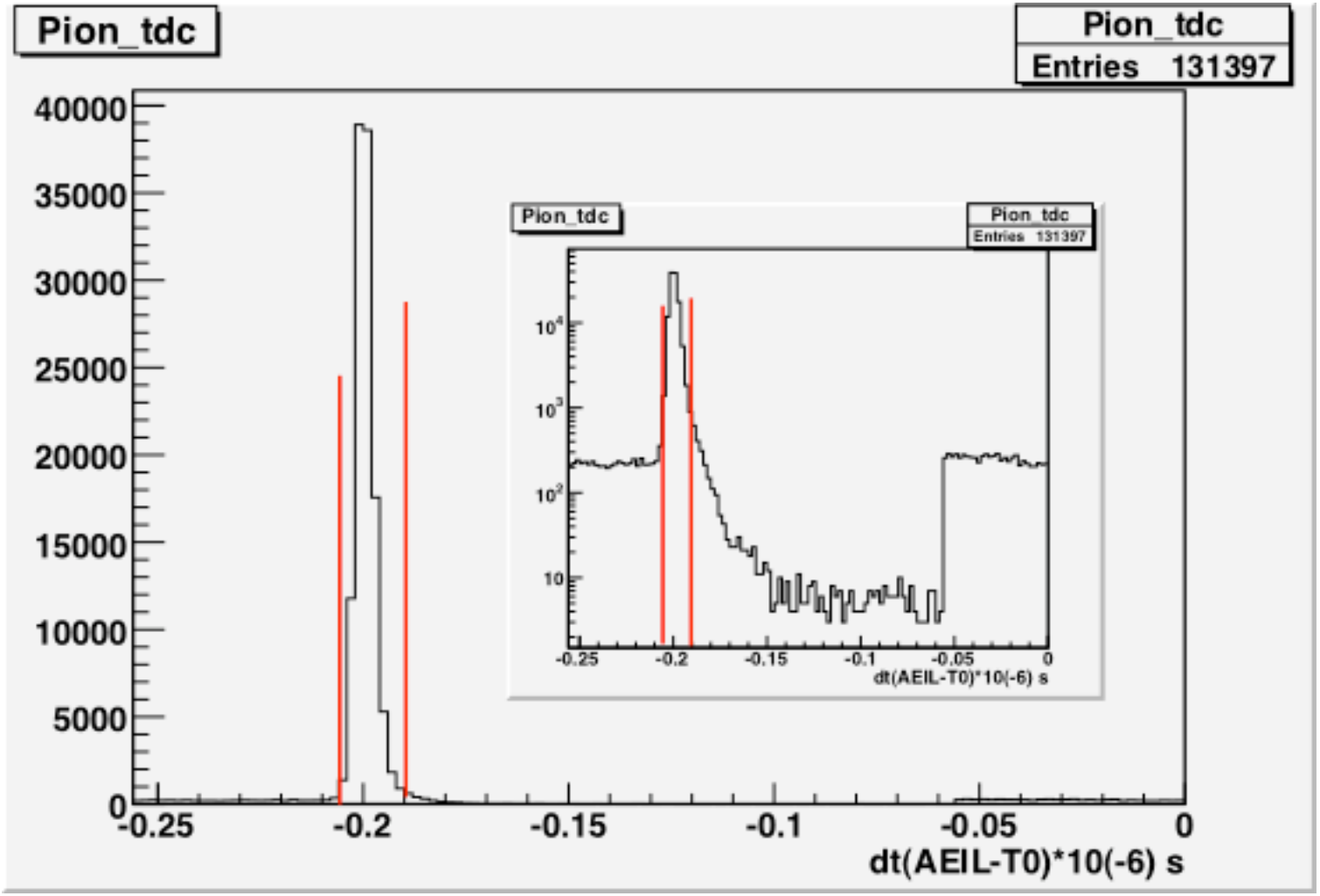
Eff(k) = # Kaon (Npe>cut)/Tot Kaons

Cont(p) = # prot (Npe>cut)/# Kaon (Npe>cut)

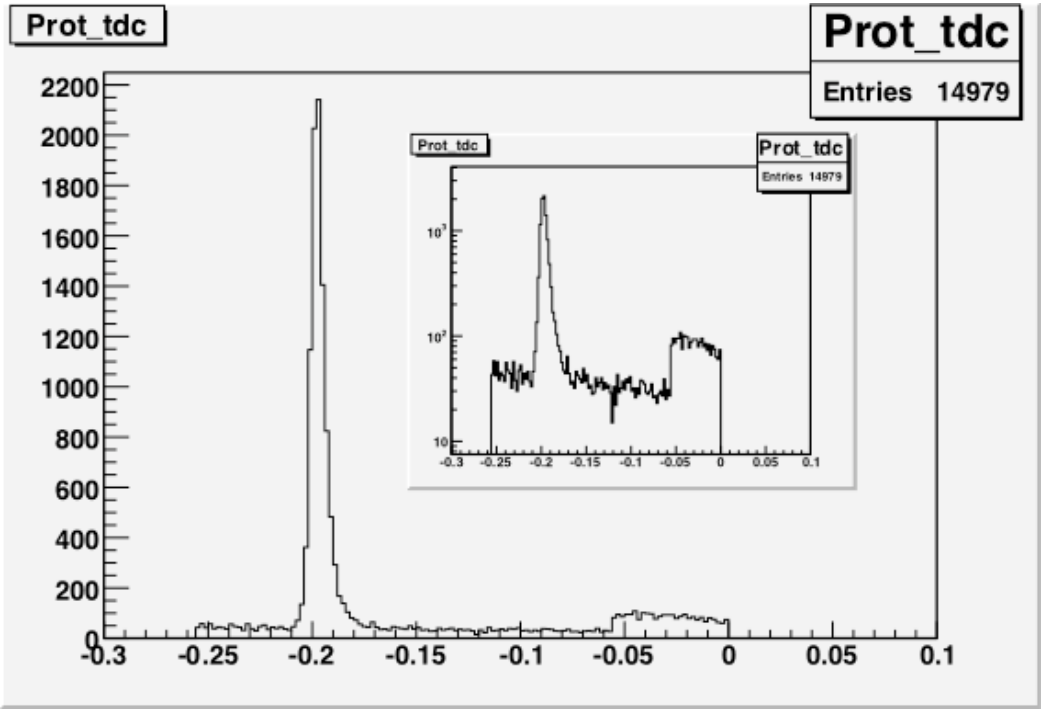
From the fit : Number of Events for Kaons and Proton in AEIL

Momentum bin	All	Npe 1	Npe 1.5	Npe 2	Npe 3	
P 4-4.5 GeV	K = 115 P = 225	108 41	105 26	100 17	86 10	Aereogel TDC **NOT** Requested
P 4.5-5 GeV	474 1318	455 279	446 180	433 134	391 93	
P 5-5.5 GeV	768 2687	741 1005	731 698	713 487	660 273	
P 5.5-6 GeV	547 3380	535 2405	527 1991	520 1571	489 970	
P 6-6.5 GeV	404 2984	397 2577	394 2322	390 2007	370 1405	
P 6.5-7 GeV	84 2276	82 2118	81 1985	80 2841	78 1504	

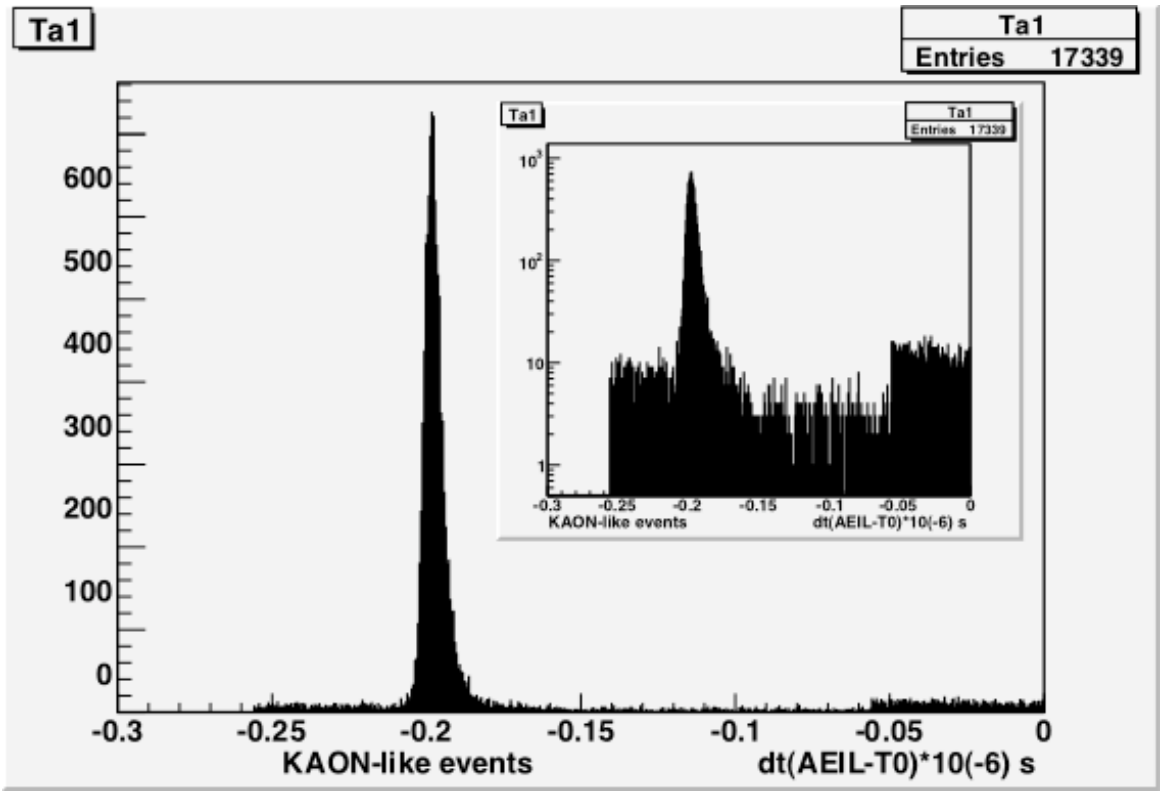
TDC information



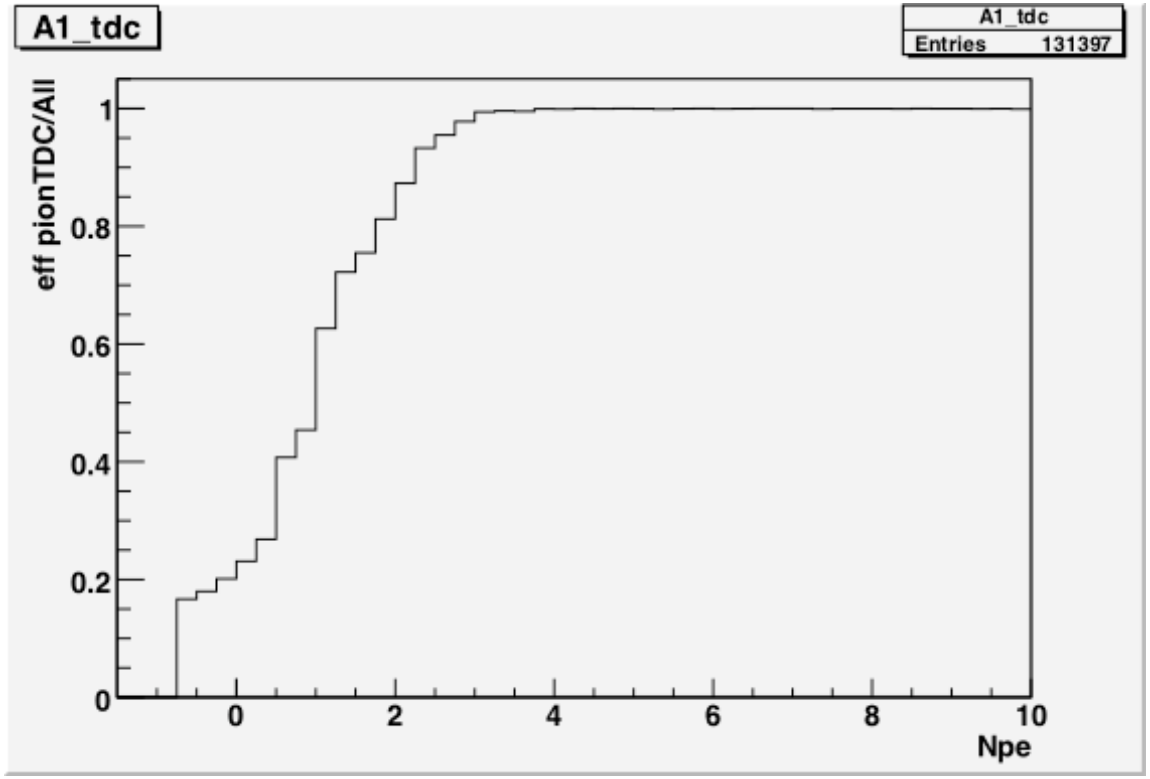
Proton-like events

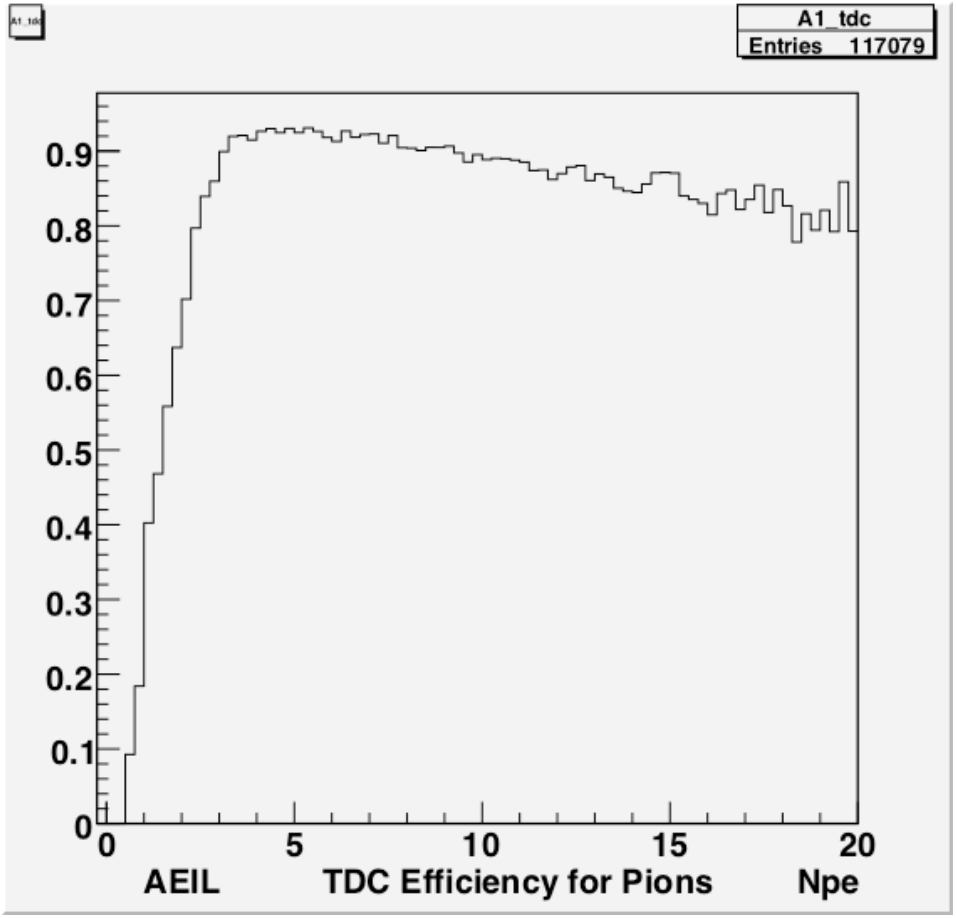


Kaon-like events



Efficiency for pions of having a TDC hit





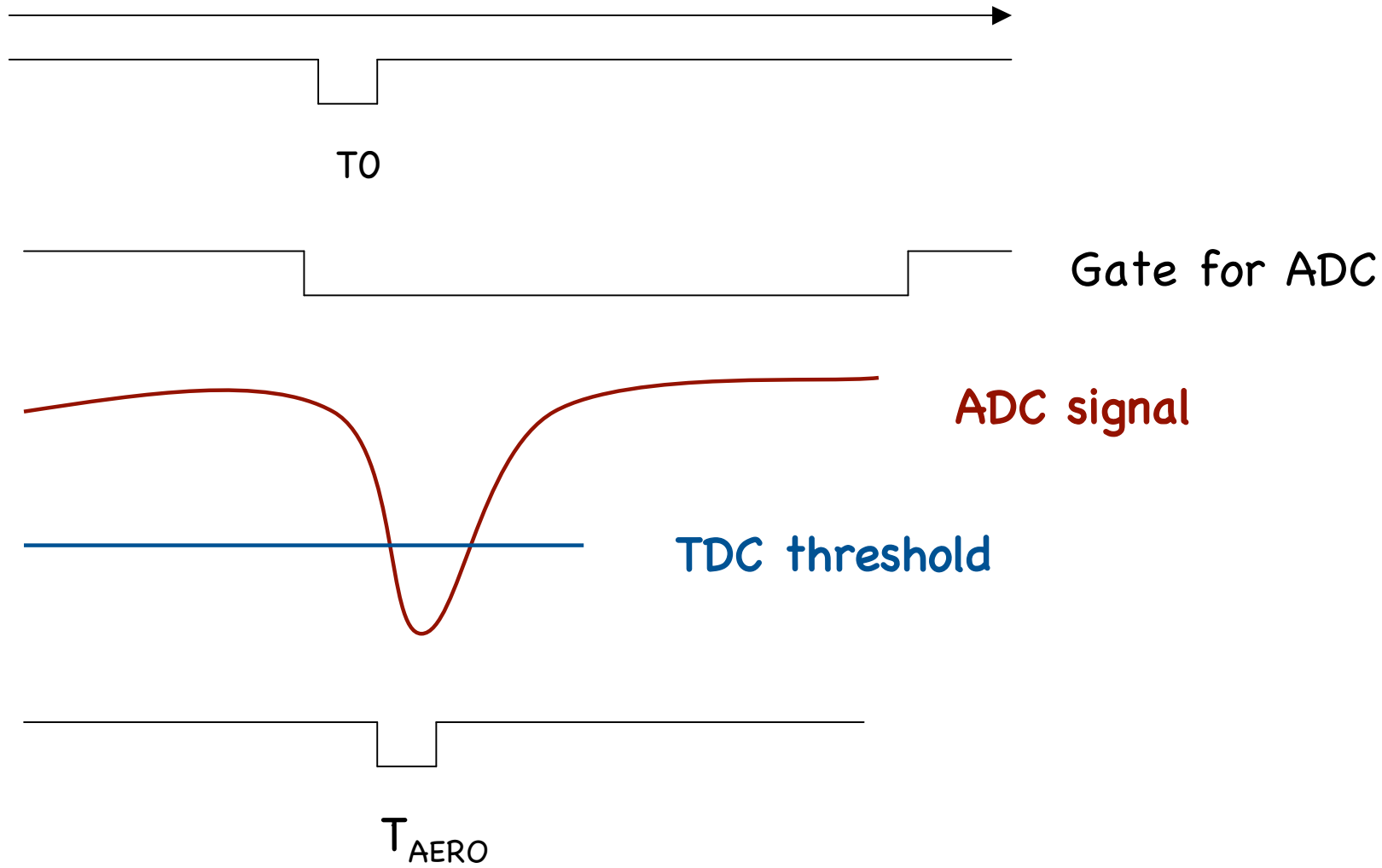
I use this histogram to correct the simulation of Kaon from pions, in order to take into account the TDC effect in Aereogel.

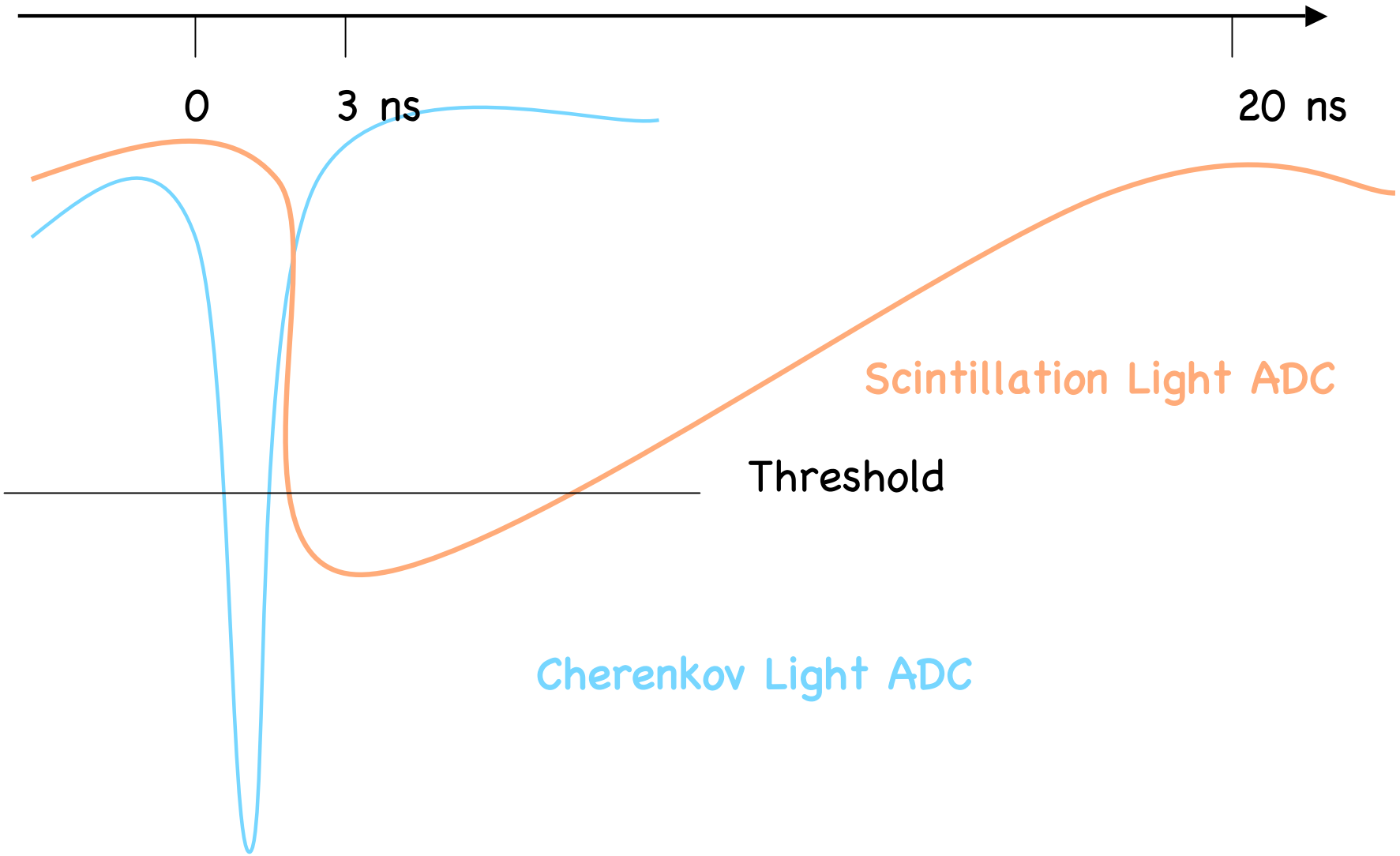
$Npe_{KAON\_TDC} = Npe_{kaon(sim\ pion)} * eff_{TDC}(Npe)$

Good TDC hit

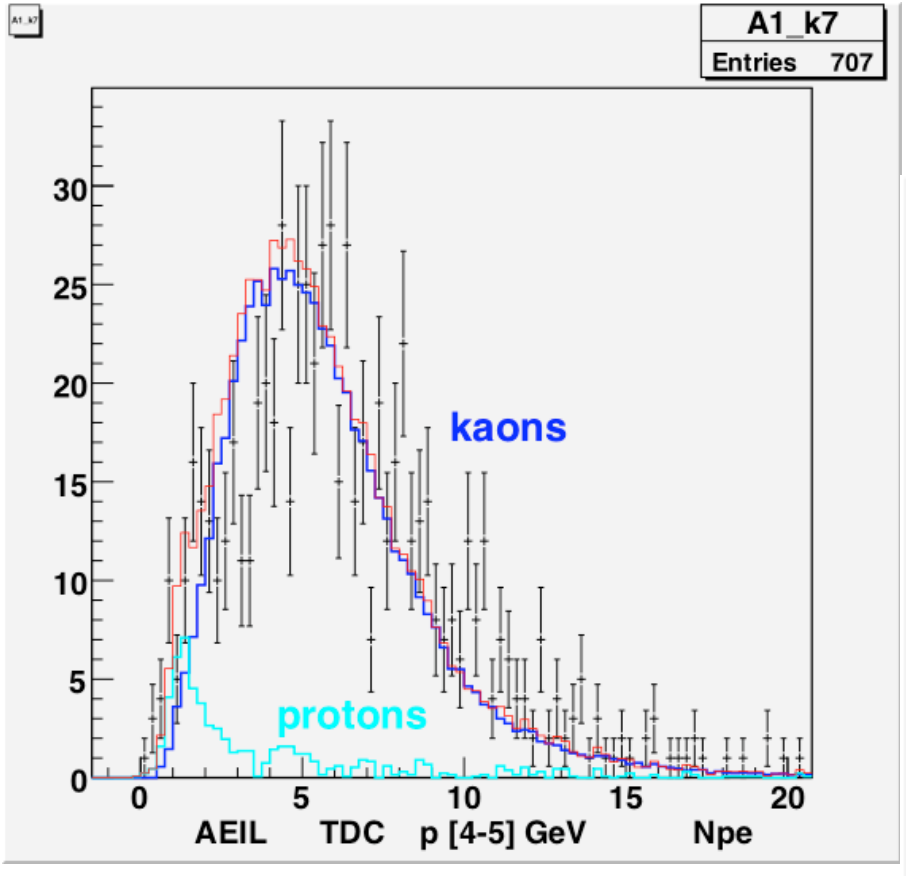
TDC/ADC signal

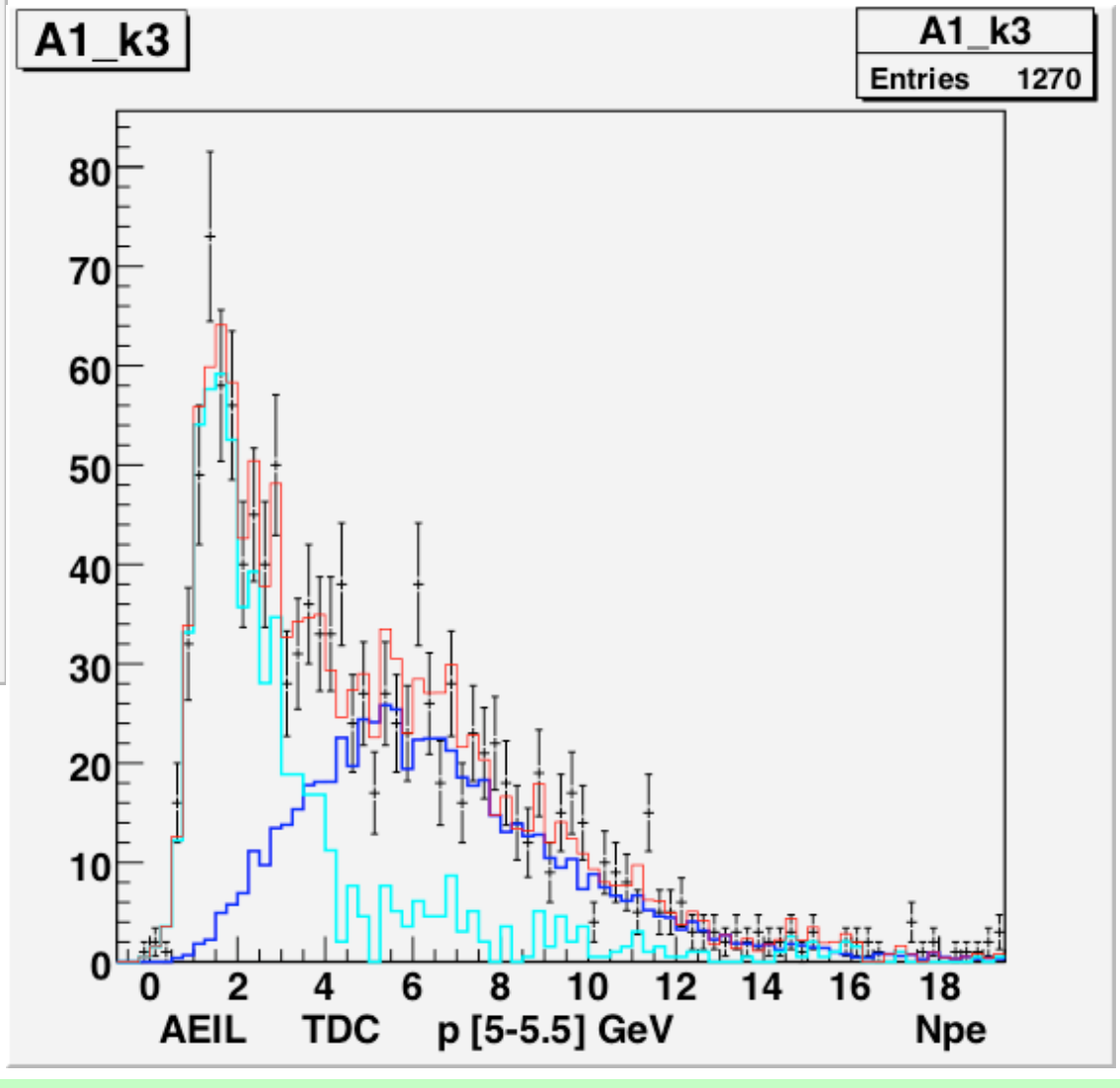
Trigger starts from the VH(+) -- > T0




0
3 ns
20 ns
Scintillation Light ADC
Threshold
Cherenkov Light ADC

TDC Aereogel Requested





AEIL efficiency to detected kaon in the range 4-5 GeV

Npe 1	1.5	2	3
Eff(k) = 95.1% Cont(p) = 50%	92.4% 33%	88.7% 25%	77.8% 18%

No TDC

Npe 1	1.5	2	3
Eff(k) = 99.6% Cont(p) = 8%	98.2% 6%	95.5% 5%	85.1% 4%

TDC

AEIL TDC requested: Proton contamination and kaon efficiency

Momentum bin	Npe 1		Npe 1.5		Npe 2		Npe 3	
P 4-4.5 GeV K = 132 P = 7	Eff(k)=95.6% Cont(p)=4.6%	131 6	98% 3.3%	129 4	95% 2.5%	125 4	83% 1.7%	109 2
P 4.5-5 GeV K = 488 P = 59	99.7% 11%	487 53	98.7% 8.5%	482 41	96.7% 7%	472 33	88.4% 6%	432 26
P 5-5.5 GeV K = 641 P = 601	99.8% 86%	640 550	99% 69%	636 438	97.5% 52%	625 326	91% 32%	584 189
P 5.5-6 GeV K = 514 P = 1660	99.8% 3	513 1584	99% 2.8	509 1421	98% 2.3	505 1182	93.1% 1.5	478 749
P 6-6.5 GeV K = 374 P = 1902	99.9% 5	373 1876	99.6% 4.7	372 1761	98.8% 4.2	370 1565	94% 3.2	353 1131
P 6.5-7 GeV K = 208 P = 1521	99.8% 7.2	207 1504	99% 7	206 1447	98.6% 6.6	205 1365	95.6% 5.6	198 1125

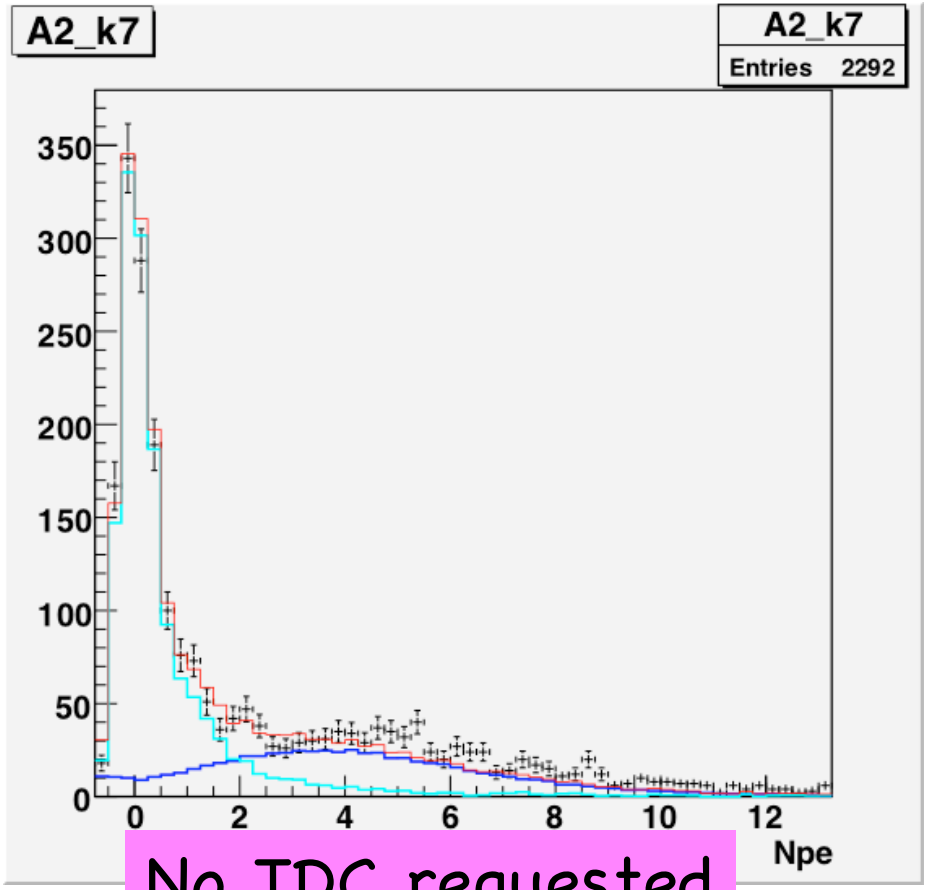
AEOL no TDC requested

Momentum range	Npe > 1	Npe > 1.5	Npe > 2	Npe > 3
4-4.5 GeV K = 413 P = 564	Eff(k) = 70% 291 Cont(p) = 37% 107	66% 275 26% 70	62% 255 20% 50	50% 209 15% 31
4.5-5 GeV K = 378 P = 887	84% 319 58% 186	81% 307 40% 124	77% 292 31% 92	66% 251 23% 57
5-5.5 GeV K = 54 P = 191	93% 51 87% 44	90% 49 62% 30	88% 48 46% 22	79% 43 30% 12
4-5 GeV K = 810 P = 1433	72% 586 48% 282	68% 555 33% 186	63% 517 26% 135	52% 426 19% 84

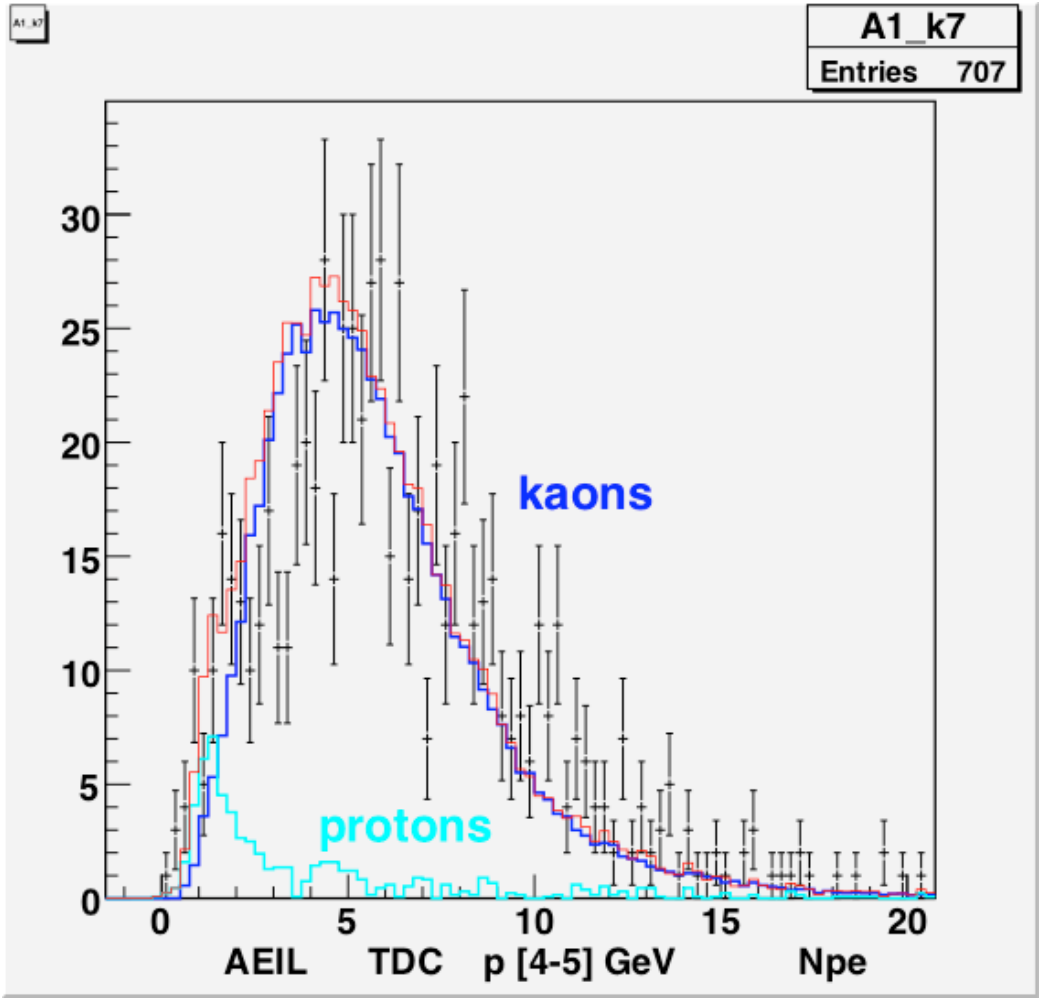
AEOL with TDC good

Momentum range	Npe > 1	Npe > 1.5	Npe > 2	Npe > 3
4-4.5 GeV K = 365 P = 31	Eff(k) = 98% 359 Cont(p) = 7.3% 26	94% 345 5.5% 19	89% 325 4.5% 15	73% 267 3.7% 10
4.5-5 GeV K = 348 P = 80	99% 344 19% 68	96% 335 16% 54	92% 320 14% 44	79% 277 11% 32
5-5.5 GeV K = 56 P = 7	99% 56 11% 6	97% 55 7% 4	94% 53 5% 3	85% 48 4.6% 2
4-5 GeV K = 729 P = 191	98.4% 718 11% 80	95% 692 8.6% 60	89% 652 7.3% 47	74% 541 6% 32

AEOL p [4-5] GeV



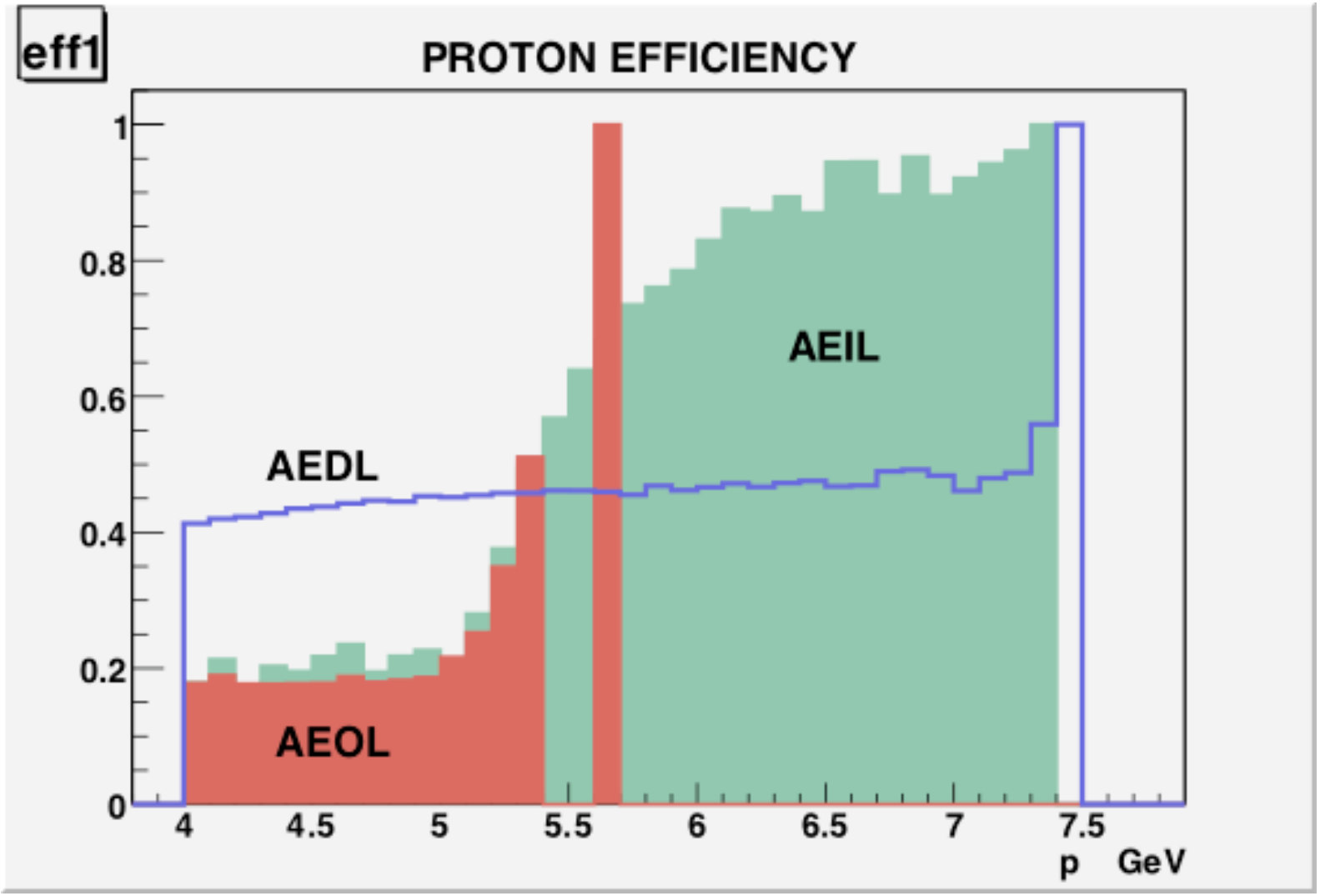
No TDC requested



TDC requested

Proton efficiency in the Aereogel

1 Npe



Data selection : standard + signal in AEIL > 1 Npe

AEDL No TDC requested

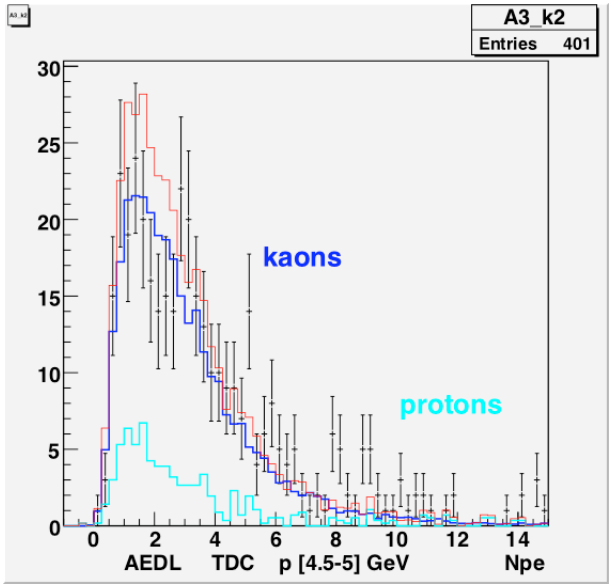
Momentum bin	Npe 1		Npe 1.5		Npe 2		Npe 3	
P 4-4.5 GeV	Eff(k)=43%	8	31%	6	22%	4	36%	2
K = 20	Cont(p)=8.8	76	9	57	10	47	4.7	32
P = 152								
P 4.5-5 GeV	65%	51	54%	43	44%	35	29%	23
K = 79	7	363	6.5	285	6.2	285	6	142
P = 679								
P 5-5.5 GeV	75%	456	66%	405	58%	353	41%	251
K = 608	1.2	540	1	425	92%	326	83%	210
P = 1077								
P 5.5-6GeV	80%	370	72%	336	66%	304	50%	226
K = 463	2.3	880	2	672	1.7	541	1.4	331
P = 1846								
P 6-6.5GeV	84%	104	77%	96	71%	88	58%	72
K = 123	7	743	5.7	556	5	433	3.8	280
P = 1573								
P 6.5-7 GeV	82%	89	75%	82	70%	76	58%	63
K = 109	3	276	2.4	201	1.9	148	1.4	91
P = 584								

Data selection : standard + signal in AEIL > 1 Npe

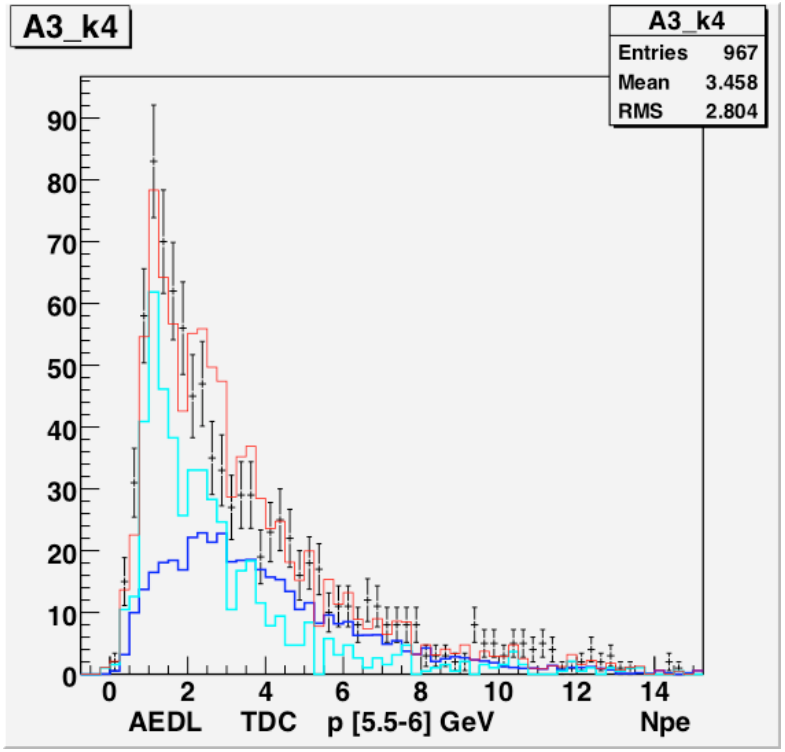
AEDL TDC requested

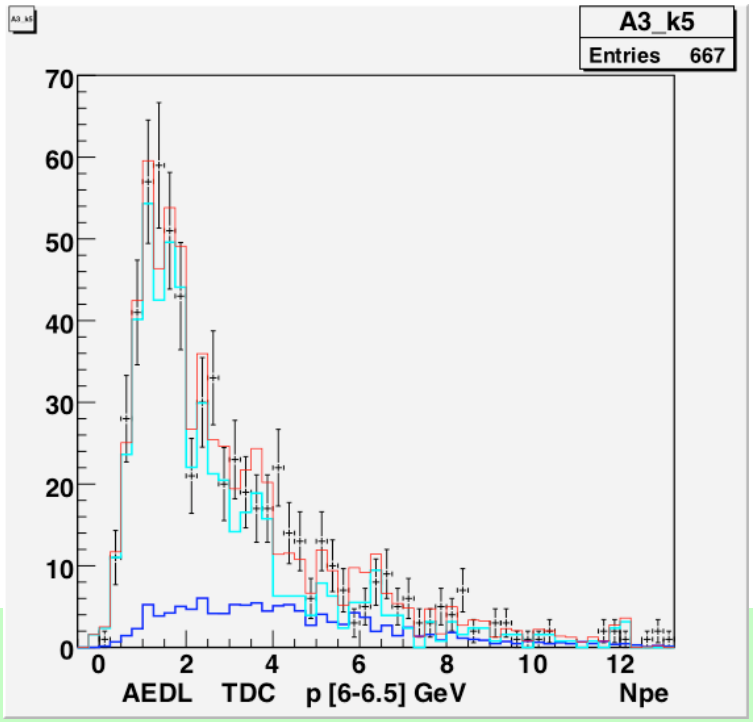
Momentum bin	Npe 1		Npe 1.5		Npe 2		Npe 3	
P 4-4.5 GeV K = 21 P = 70	Eff(k)=78% Cont(p)=3.8	16 62	58% 4	12 50	42% 4.5	9 40	22% 5	5 24
P 4.5-5 GeV K = 316 P = 72	88% 22%	280 62	75% 21%	237 50	62% 20%	197 39	40% 20%	125 26
P 5-5.5 GeV K = 663 P = 105	92% 15%	615 105	83% 13%	549 74	72% 12%	479 57	50% 11%	337 36
P 5.5-6GeV K = 435 P = 511	94% 1.1	407 444	86% 90%	372 336	77.6% 81%	337 272	57% 62%	248 153
P 6-6.5GeV K = 126 P = 526	96% 3.7	121 447	89% 3.1	112 350	82% 2.5	103 256	67% 2	84 162
P 6.5-7 GeV K = 107 P = 157	95% 1.3	102 133	88% 1	94 98	82% 85%	87 75	67% 68%	72 49

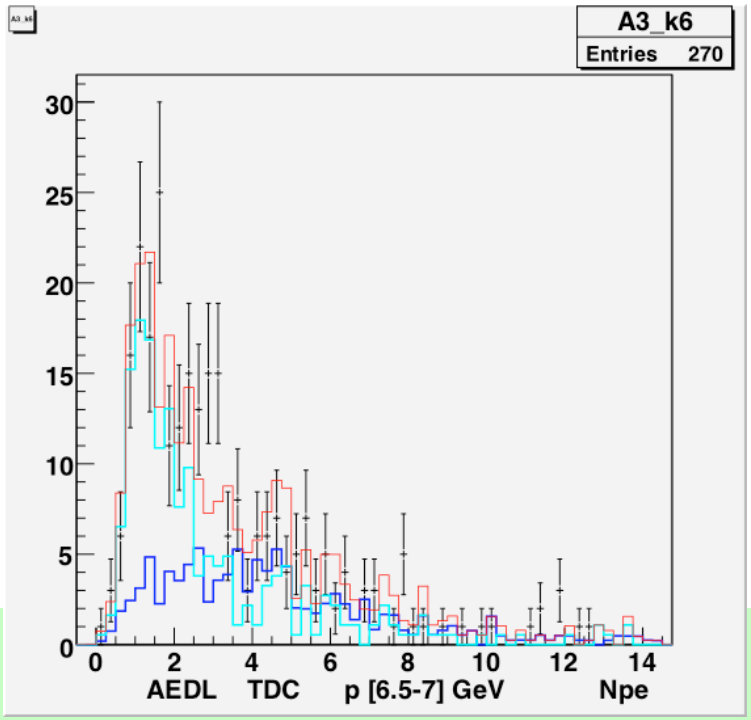
AEDL (in coincidence with AEIL)



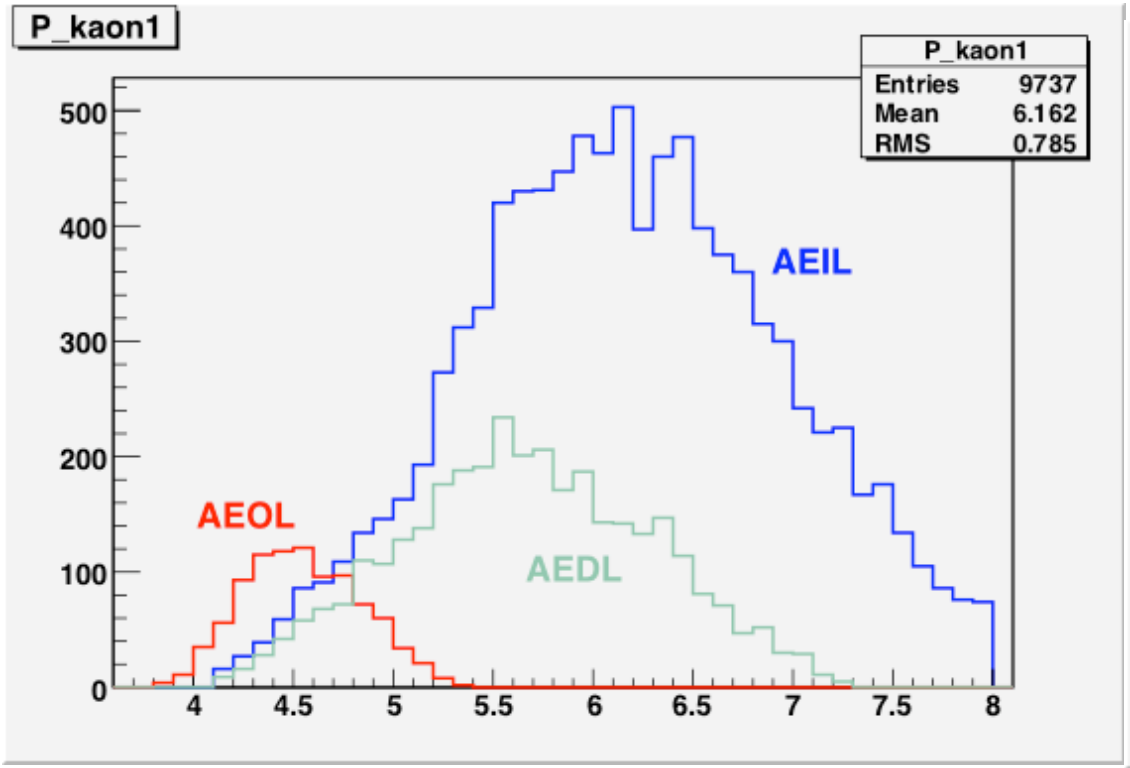
TDC requested

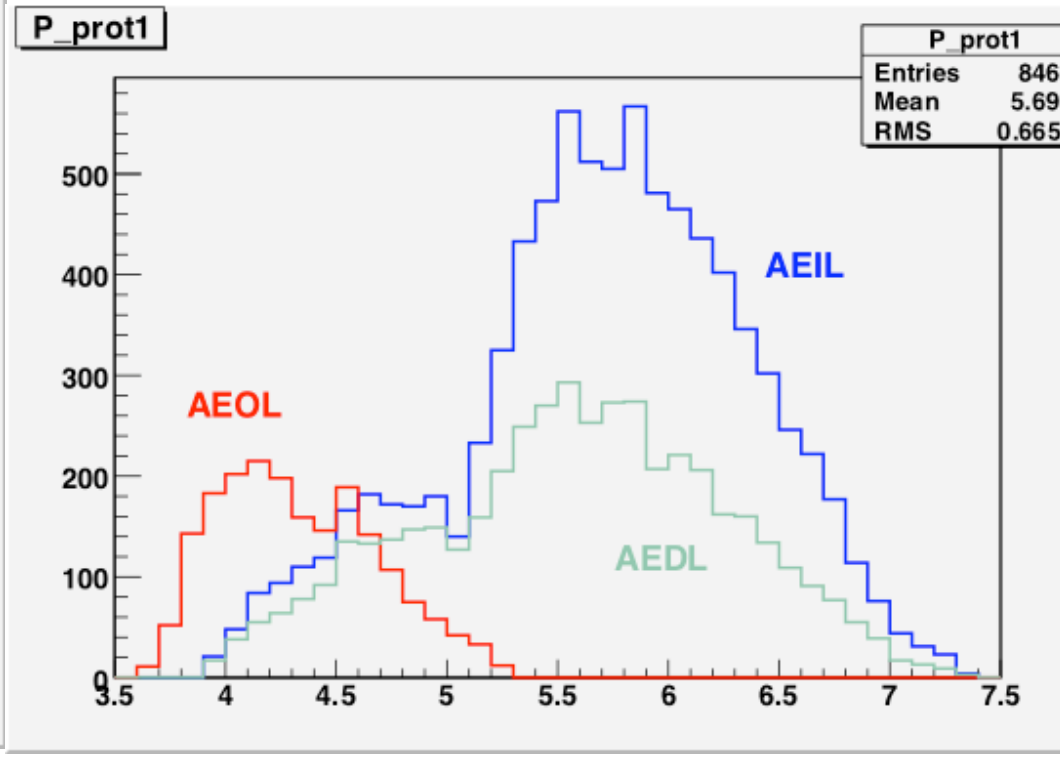






This could be the reason why we have such different contamination of protons for AEIL and AEOL for momentum 5-5.5 GeV
-> In AEOL the max momentum is below 5.3
That is the Cherenkov threshold for protons





Conclusions

Protons give a lot of light in the Aerogel 1.008 where they should not give any light (max 10%)

We have now an estimation of the **momenta distribution of protons** given by the relative aboundance regards to kaons, we could use it as **input to the Geant simulation**, we need to **describe the response in the aerogels precisely**, reconstruct proton-pion events (CC and NC) **evaluating their Ql distribution**, and see how/if we have to fit our Ql distribution from data to extract the Atoms signal.