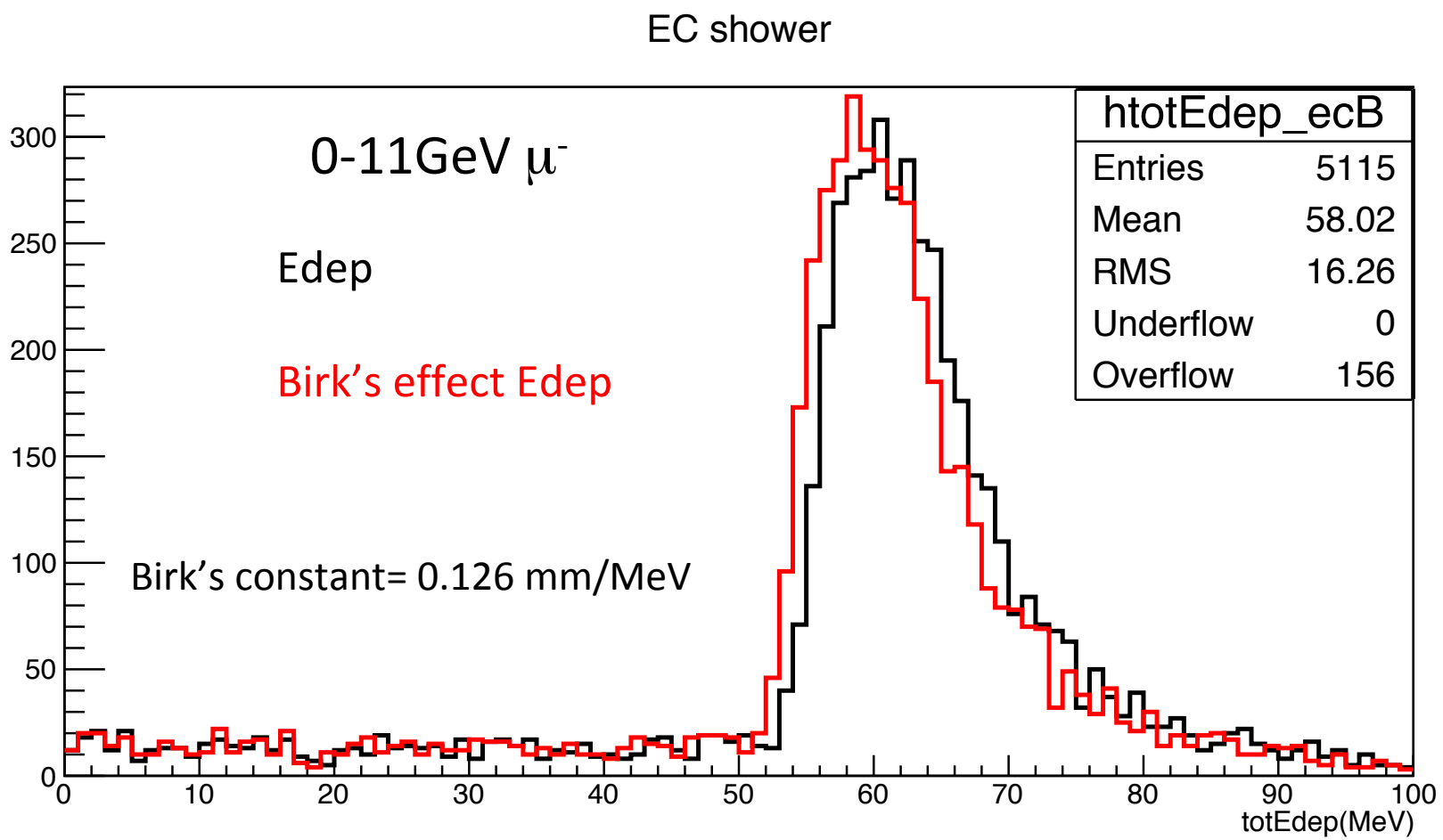
ECAL Digitization Updates

1) Add Birk's Effect to the ECAL hit process for shower and preshower----ZhiWen

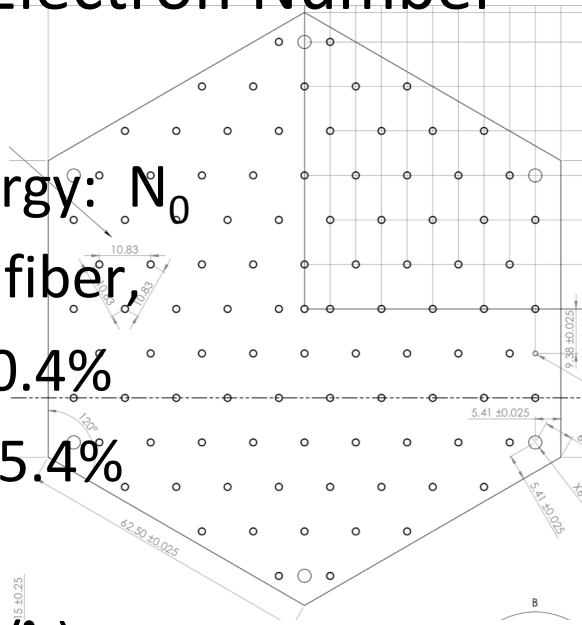
2) Convert simulated ECAL deposit energy to photon number and photon electron number, which is based on the vertical cosmic test result of the SDU/ THU modules.
   GEMC ECAL simulation configuration:
   a) 1 Module with shower only
   b) no EM field
   c) 0-11GeV μ^- hit on the ECAL module (shower only)



The dependence of light output from energy deposition is usually not linear in organic scintillators.

- A high density of excited molecules along the particle track causes deexcitation without photon emission (quenching effect).
- Light output becomes saturated

Convert ECAL Deposit Energy to Photon Electron Number



1) scintillation photons per MeV of deposited energy: N_0
2) efficiency of light collection from scintillator to fiber,

   $96*\pi*(0.15/2)^2\ cm^2/6*0.5*6.25*\cos 30^o\ cm^2=10.4\%$
3) trapping efficiency in fiber: from manufactory: 5.4%
4) attenuation in fiber:

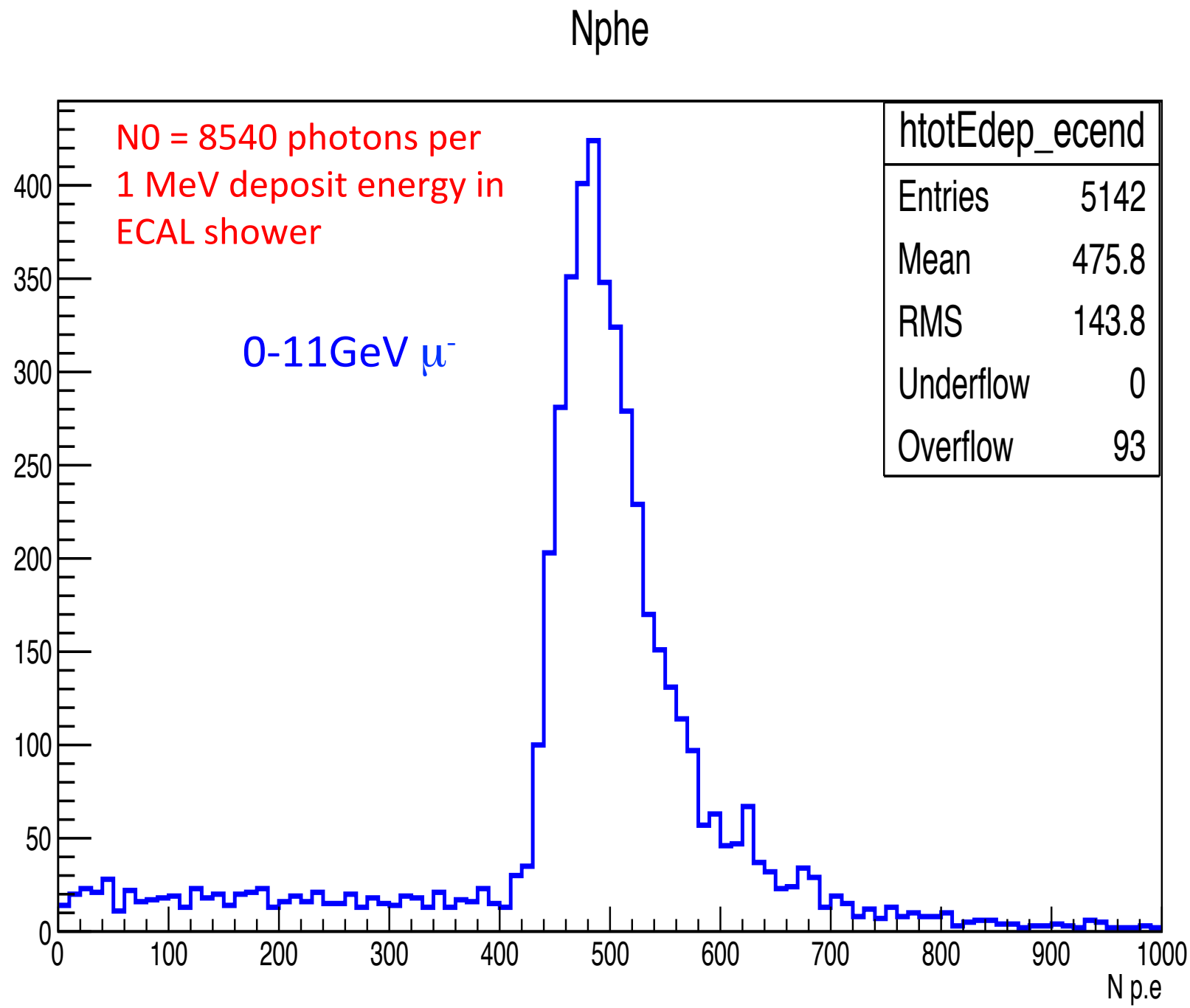
   $A = 0.5*EdepB*\exp(-x1/\lambda)+0.5*EdepB*\exp(-x2/\lambda)$

   x1: distance travelled to the module end

   x2: distance travelled backward then reflect back to the module end

   λ: 360 cm attenuation length of WLS fiber
3) quantum efficiency of PMT: 20%:

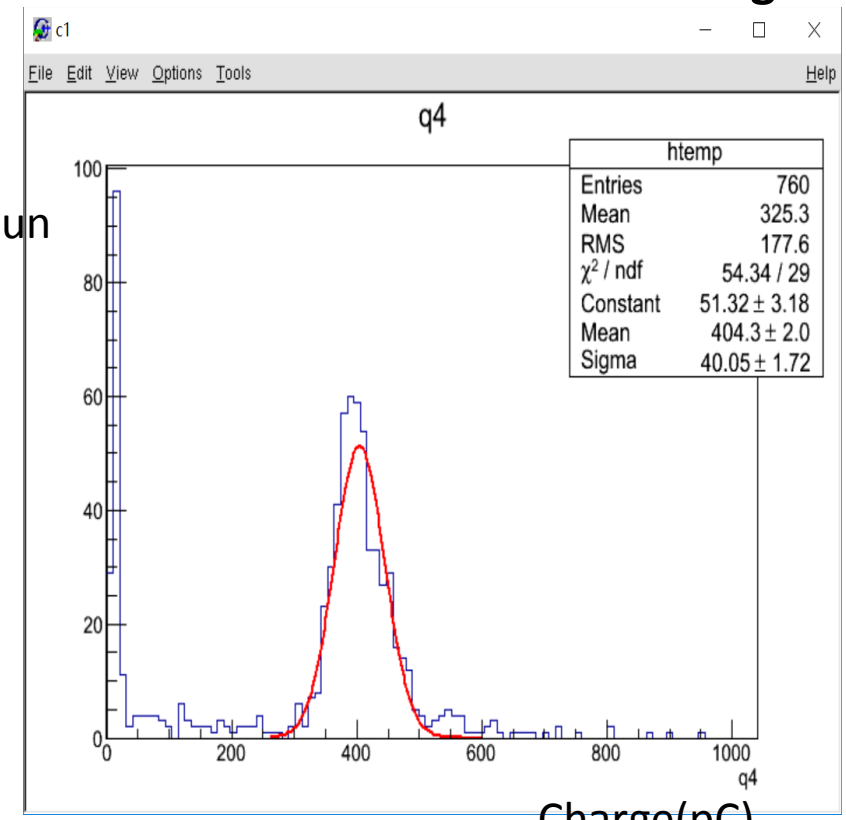
$$Np.e= Edep(Birk's\ effect)*N_0*10.4\%*5.4\%*A*20\%$$


Nphe
N0 = 8540 photons per
1 MeV deposit energy in
ECAL shower
0-11GeV μ-
htotEdep_ecend
Entries 5142
Mean 475.8
RMS 143.8
Underflow 0
Overflow 93
0
50
100
150
200
250
300
350
400
0
100
200
300
400
500
600
700
800
900
1000
N p.e

Vertical test result

SDU#3 -----Ye Tian

Signal



Pedestal

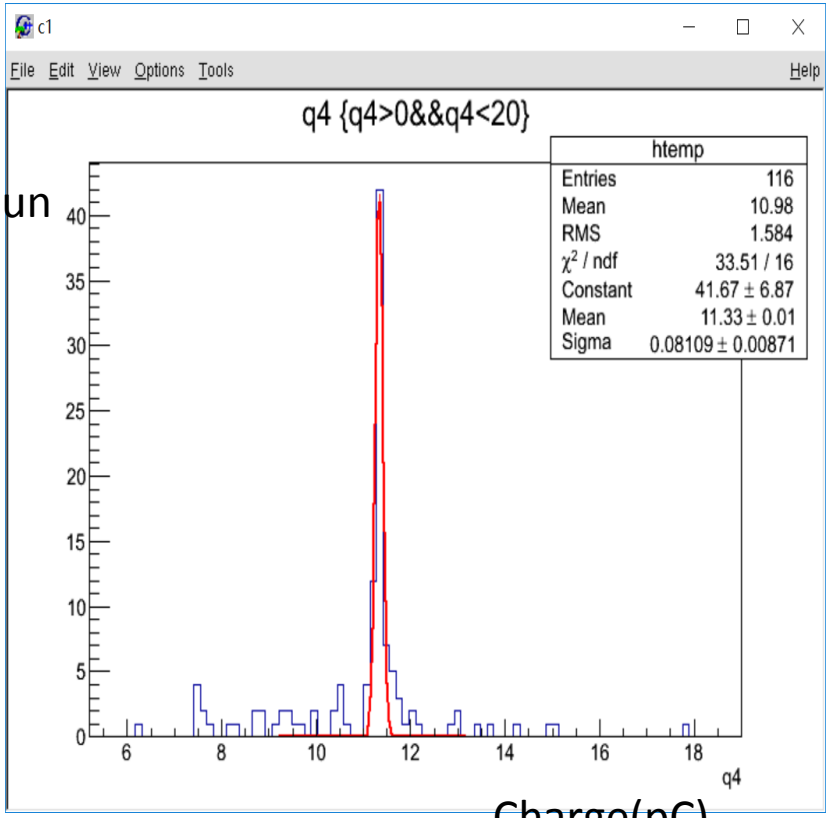


photo-electrons calculated as (MPV-Pedestal)/(e*Gain) = 491.3 p.e. with (Gain=5*10^6)

For preshower test at UVa (used IHEP preshower), Y11 light yield is twice of BCF91. Comparing with SDU #2(426.5), our result is only 15% better. (Maybe SDU #3 mirror quality is bad or maybe because the UVa preshower test use IHEP not Kedi scintillator, could the wavelength be different?)

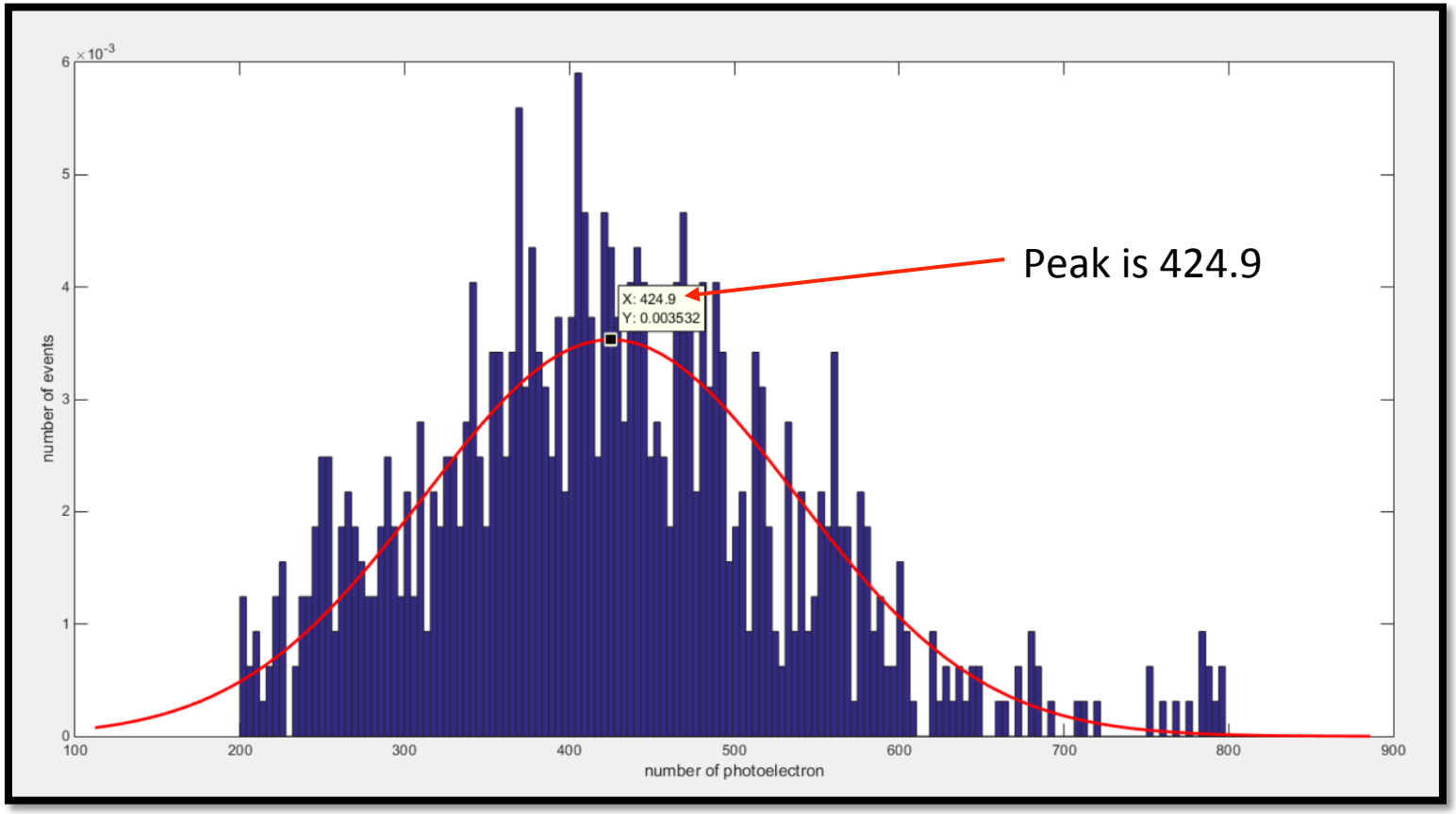
Vertical Test result

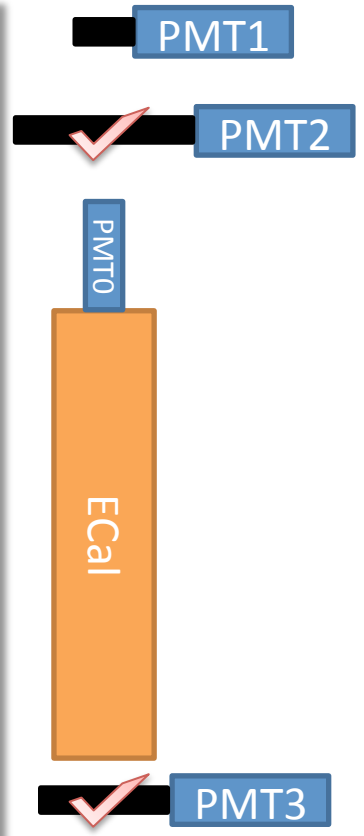
THU#1-----Chendi

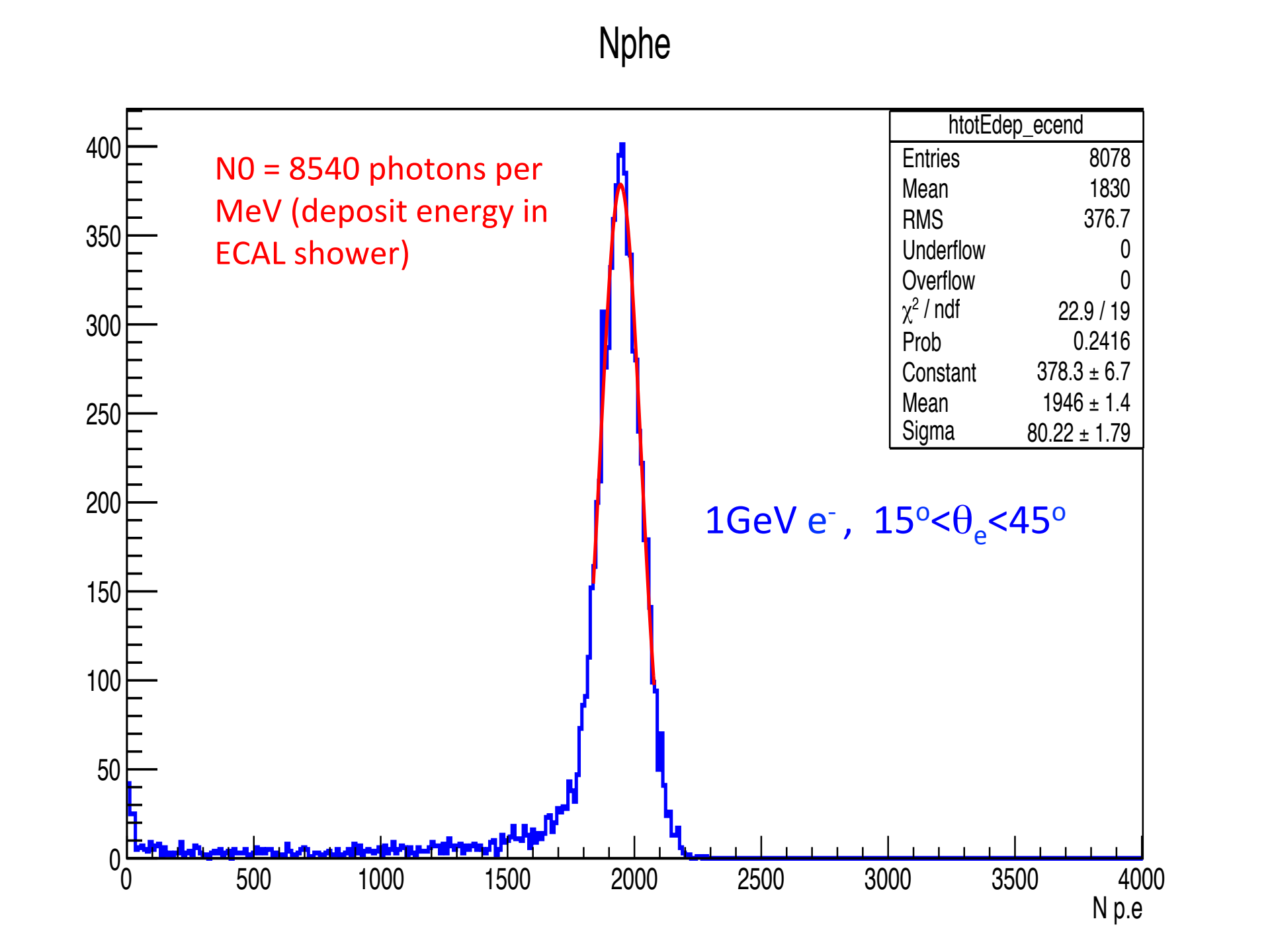
Gain of PMT: 2.5×10^{6}

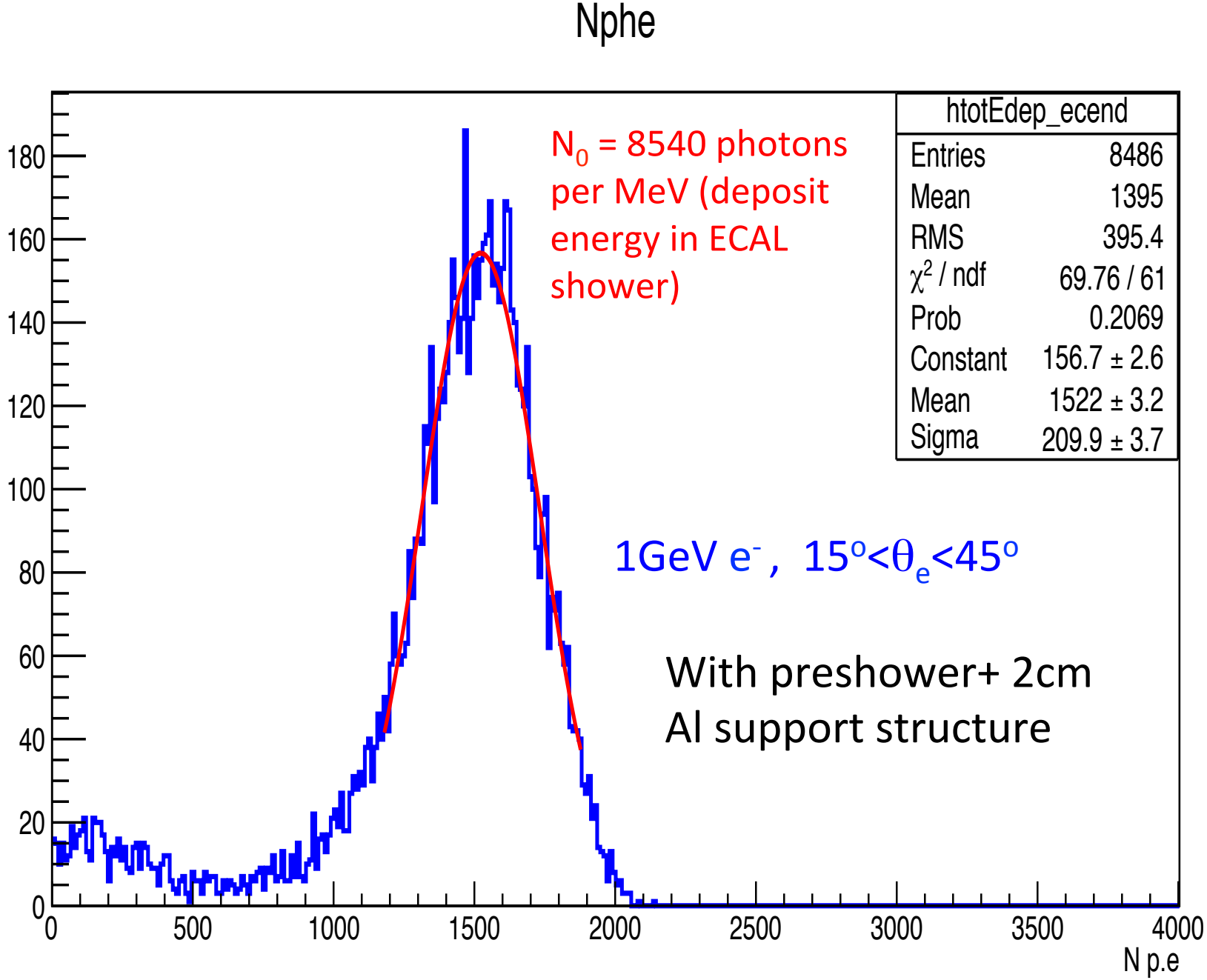
QDC: 0.1pc/channel

Triggered by two scintillators






Nphe
N0 = 8540 photons per MeV (deposit energy in ECAL shower)
htotEdep_ecend
Entries 8078
Mean 1830
RMS 376.7
Underflow 0
Overflow 0
χ² / ndf 22.9 / 19
Prob 0.2416
Constant 378.3 ± 6.7
Mean 1946 ± 1.4
Sigma 80.22 ± 1.79
1GeV e⁻, 15°<θe<45°
0
50
100
150
200
250
300
350
400
0
500
1000
1500
2000
2500
3000
3500
4000
N p.e


Nphe
htotEdep_ecend
Entries 8486
Mean 1395
RMS 395.4
χ² / ndf 69.76 / 61
Prob 0.2069
Constant 156.7 ± 2.6
Mean 1522 ± 3.2
Sigma 209.9 ± 3.7
N0 = 8540 photons per MeV (deposit energy in ECAL shower)
1GeV e-, 15o<θe<45o
With preshower+ 2cm Al support structure
0 20 40 60 80 100 120 140 160 180
0 500 1000 1500 2000 2500 3000 3500 4000
N p.e

Next steps

- Update with beam test results

Any comments and suggestions ?

Back up

SoLID EC Design Weekly Meeting Minutes

Using the above highest MIP light yield, which is about 500 p.e./200 layers 1.5mm layers (0.3MeV MIP energy per layer or 60 MeV MIP energy total), scale up to 1 GeV electron (20% sampling factor or 200MeV energy deposit in the scintillators), we obtain (500/60*200=1666 p.e.) for 1 GeV electrons. This is 1.67 p.e./MeV, which is still factor 2-3 lower than LHCb 2.6-3.5 p.e./MeV, ALICE 4-4.4 p.e./MeV, and KOPIO 53 p.e./MeV

PMT Quantum efficiency: 20%

Shashlyk prototype and light yield overview

Proto-type	scintillator	lead	reflective layer	WLS fiber	WLS fiber end	module side	cosmic vertical test Npe	cosmic horizontal test Npe	PMT gain method
SDU1	Kedi original	US	printer paper	BCF91A	none	Tyvek → TiO2	224 → 254	48 → N/A**	SPE/SDU
SDU2	Kedi new	Chn	printer paper	BCF91A	Chn silver-plating	Tyvek → TiO2*	427 → 383*	83 → N/A**	SPE/SDU
SDU3	Kedi new	US	printer paper	Y11	Chn silver-plating	TiO2+glue (1/1)	491	107	SPE/SDU
THU1	Kedi original	Chn	mirror mylar (reflective)	Y11	Italian silver shine	TiO2 (Kedi)	430-470	96	not measured
THU2	Kedi new	Chn	powder paint (喷塑) (diffusive)	BCF91A	Italian silver shine	Tyvek wrapping (now)	748	90-103	SK/SP (Beijing Hamamatsu)

* TiO2 side-paint was not as good as SDU1 ** could not finish before shipping to JLab

Yields 500/200 layers for MIP → 1666 p.e./GeV electron, factor 2-3 lower than LHCb or ALICE → 833 p.e./GeV if using clear fibers → 3.5% in δE/E due to photoelectron statistics

SDU is planning to construct SDU4.

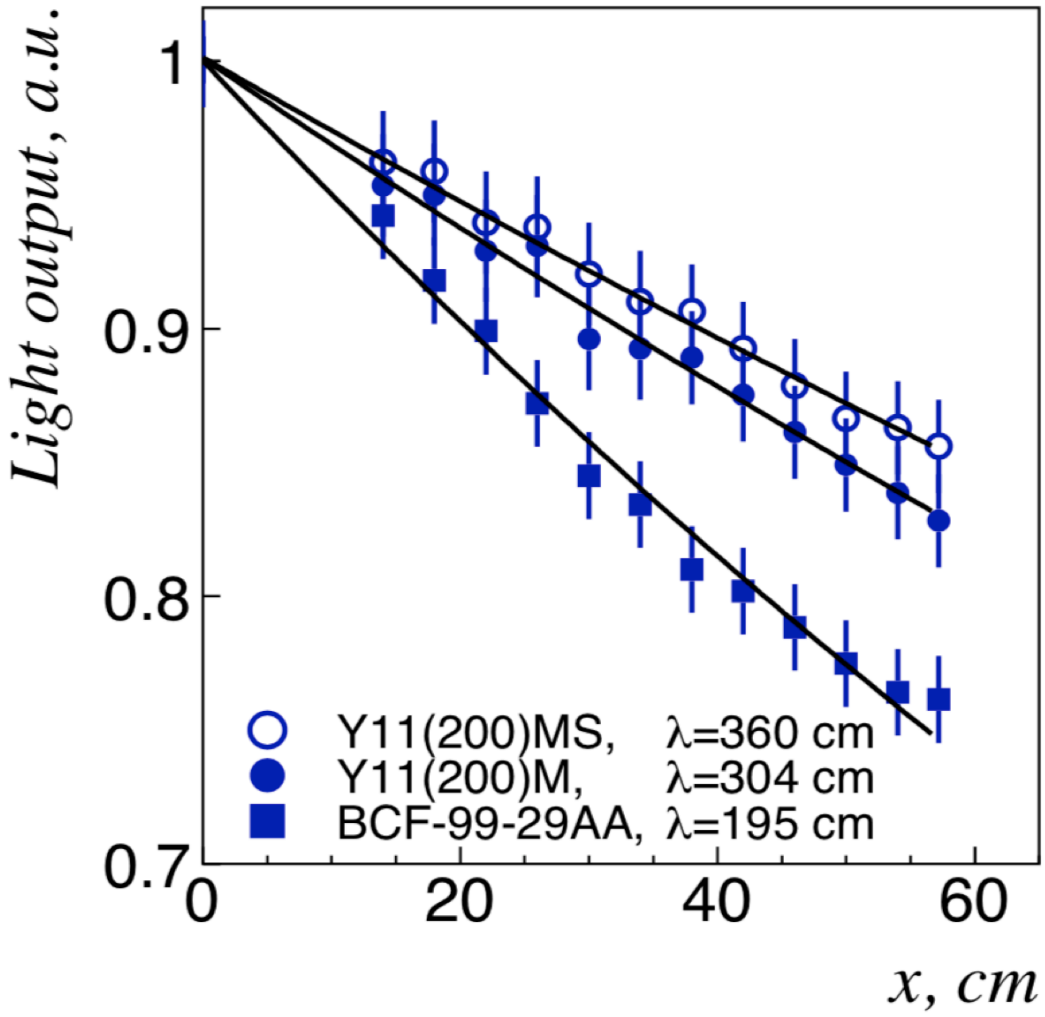
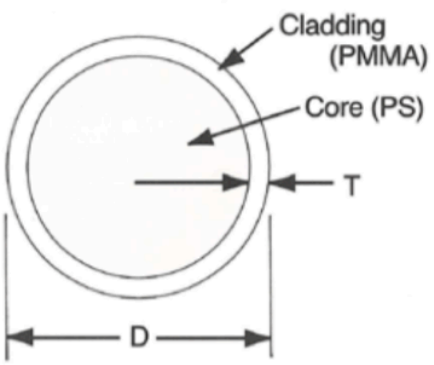
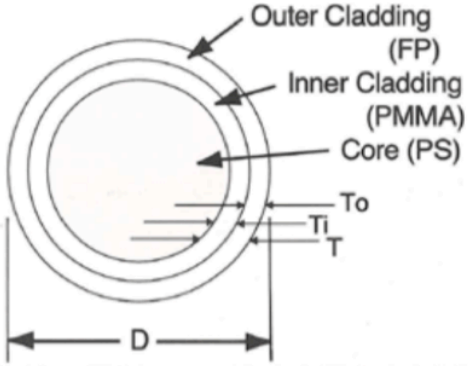
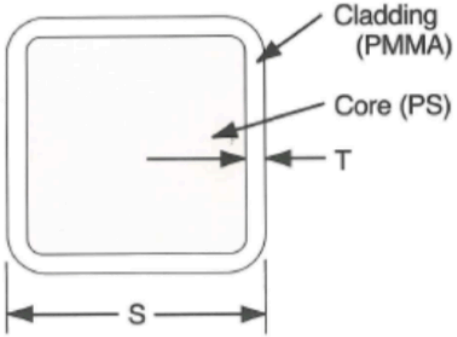


Fig. 4. The effective attenuation of the light in the fibers of Shashlyk module. Experimental data (marks) are fit by the exponential dependence $\exp(-x/\lambda)$ (solid lines), where x is the distance to the photo-detector and λ is the effective attenuation length.

	Single Cladding	Multi Cladding (M)
Round Fiber (D)	 Cladding Thickness : T=3% of D Numerical Aperture : NA=0.55 Trapping Efficiency : 3.1%	 Cladding Thickness : T =3% (To)+3% (Ti) =6% of D Numerical Aperture : NA=0.72 Trapping Efficiency : 5.4%
Square Fiber (SQ)	 Cladding Thickness : T=2% of S Numerical Aperture : NA=0.55 Trapping Efficiency : 4.2%	Not available