EC and SPD Updates

The SoLID EC Working Group

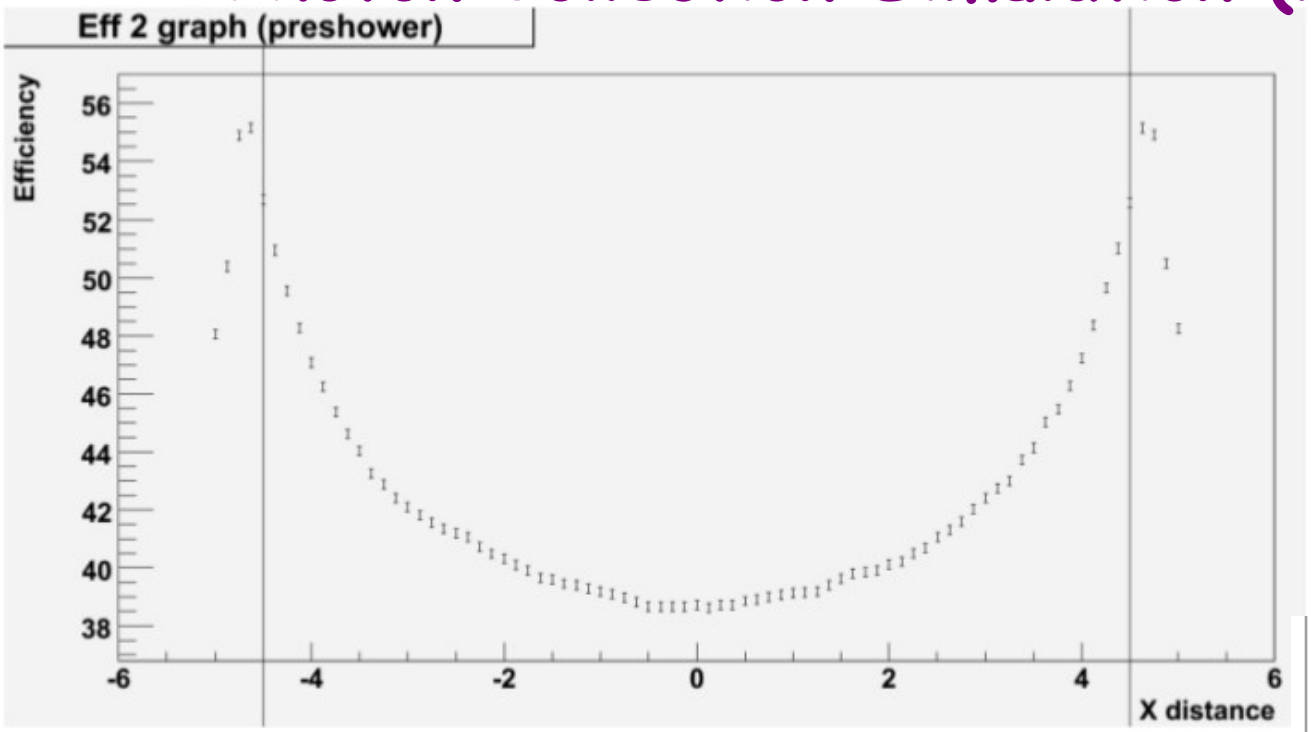
SoLID Collaboration Meeting

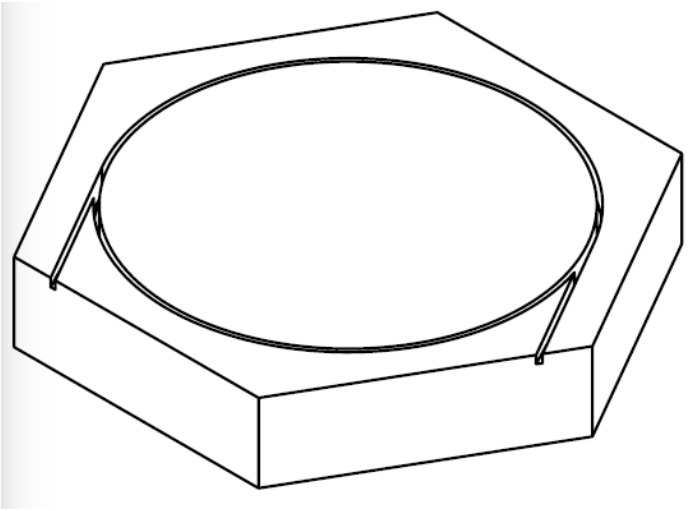
June 29-30, 2017

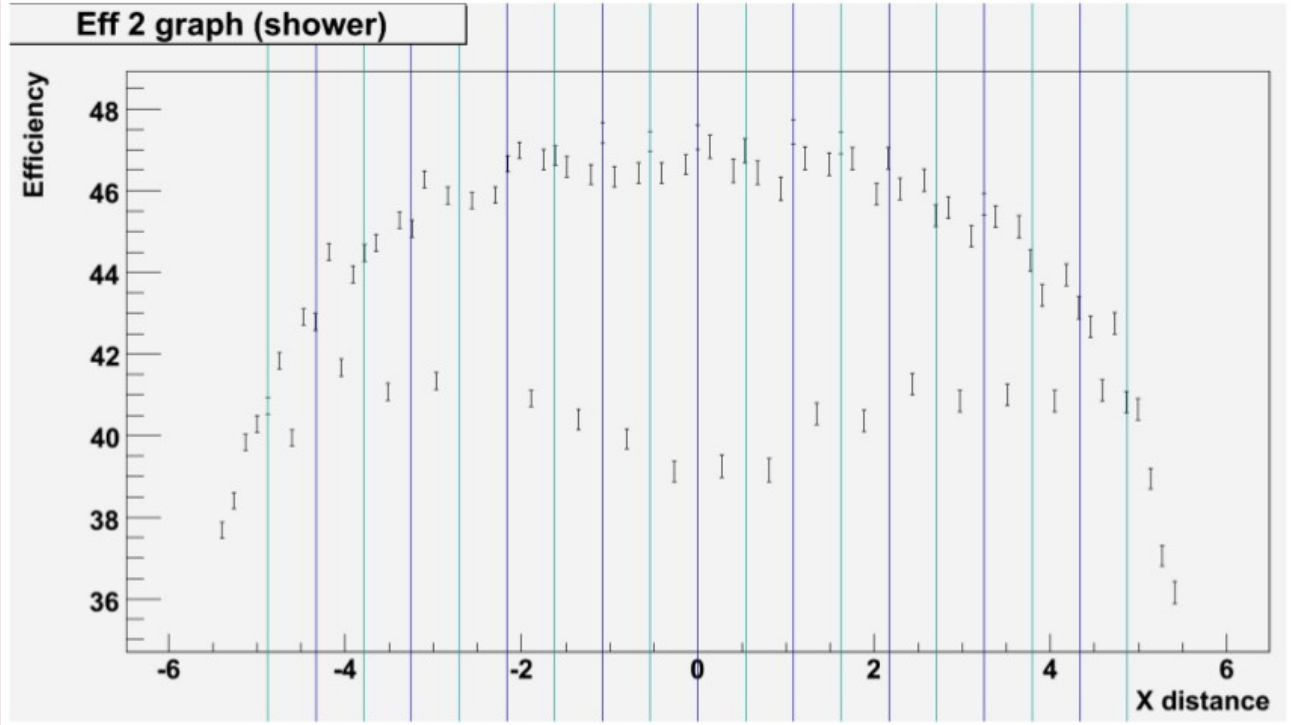
Overview

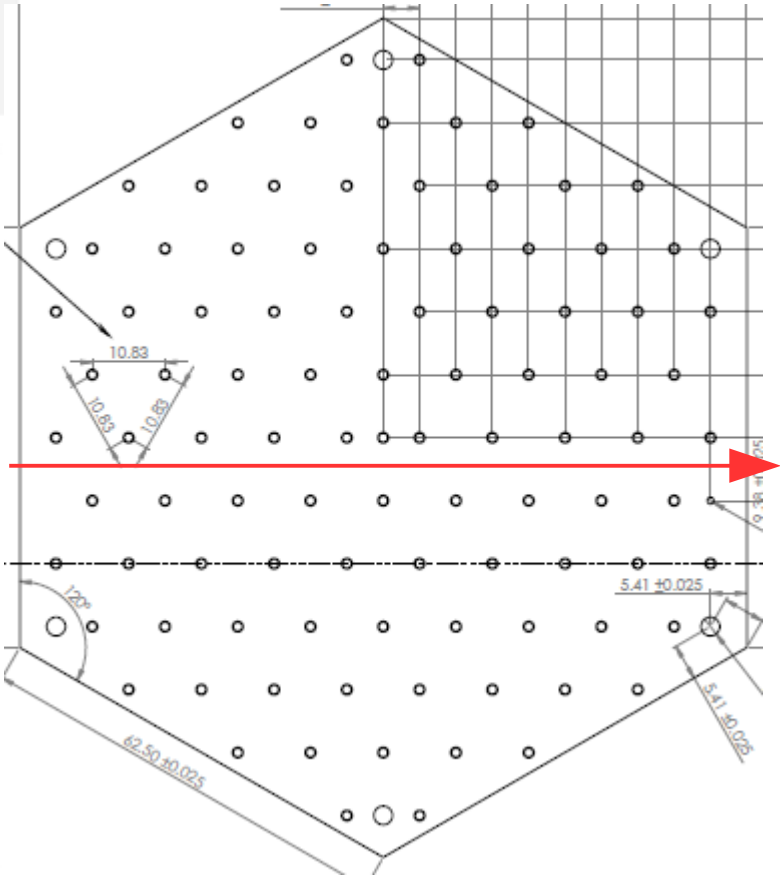
1. Cosmic test of GEM+SPD at JLab going well (Ye/SDU + Ye/Syracuse)
2. Photon collection simulation completed (undergrad) with results on uniformity
3. In the process of reproducing Ecal simulation, found problem with pre-lead thickness (Ye/Syracuse); Birk's effect and photoelectron statistics (March meeting) have to wait.
4. Also simulating for beam test in Beijing
5. Test of clear fiber attenuation ongoing (Chendi/THU)
6. Test of fiber reflective coating ongoing (Chendi/THU + Cunfeng+Ang/SDU)
7. Design of ECal support (layout) ongoing

Photon Collection Simulation (R. Cheek/UVa)

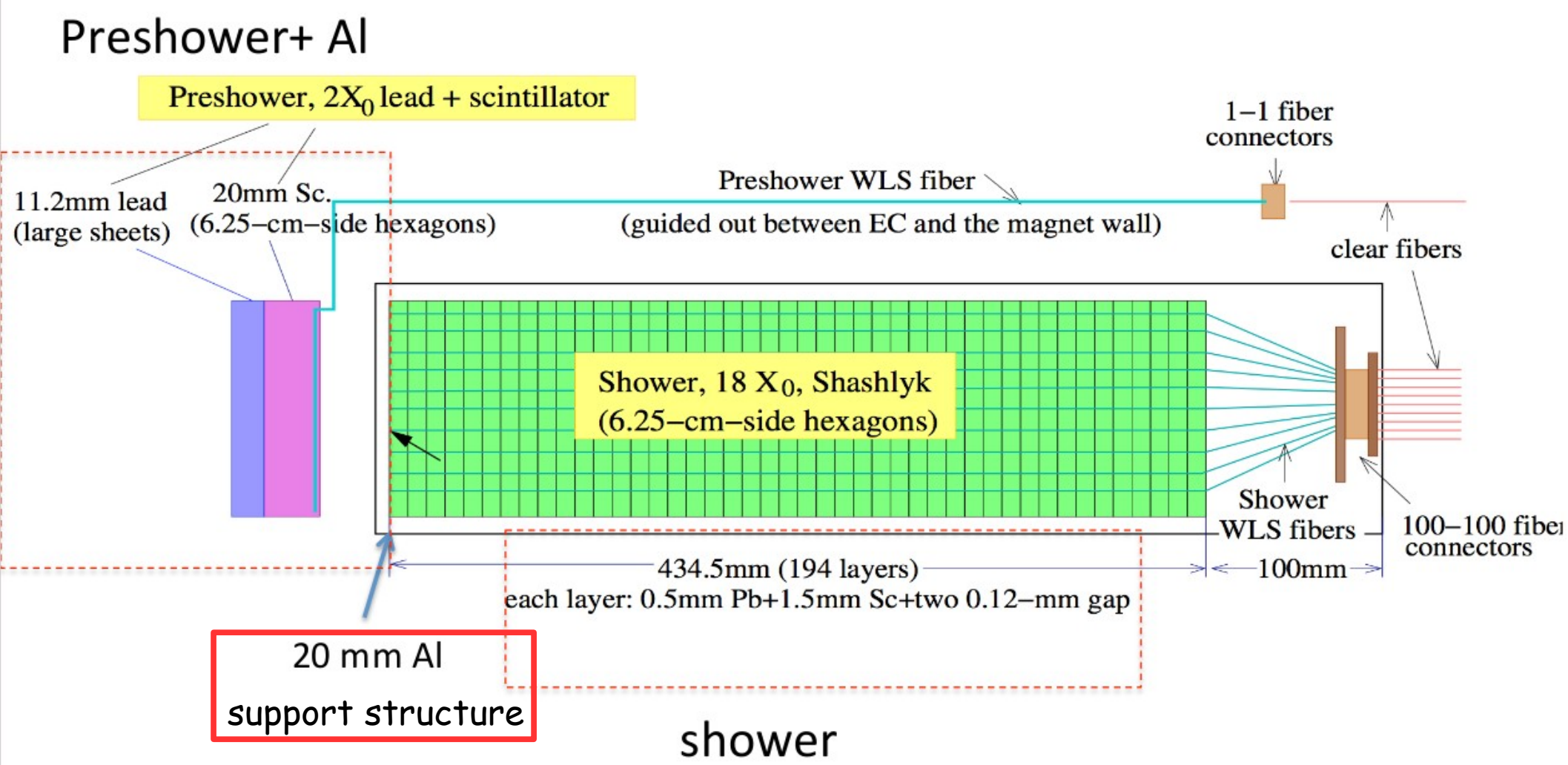








Ecal Simulation (Ye Tian/Syracuse)

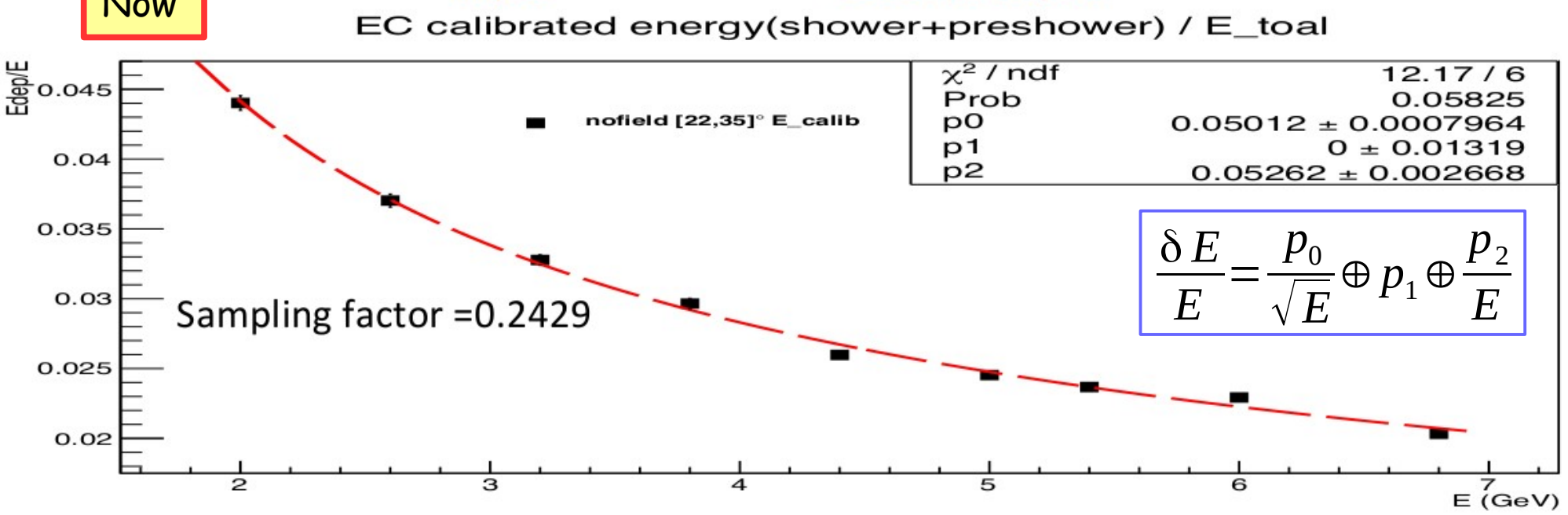


1. Ye is using the following function to fit simulation:

$$\frac{\delta E}{E} = \frac{p_0}{\sqrt{E}} \oplus p_1 \oplus \frac{p_2}{E}$$

Preshower(11.2mm Pb+20mm Scin)+20mm Al+18X_0 shashlyk(0.5mm Pb+0.12mm Mylar+1.5mm Scin+0.12mm Mylar)

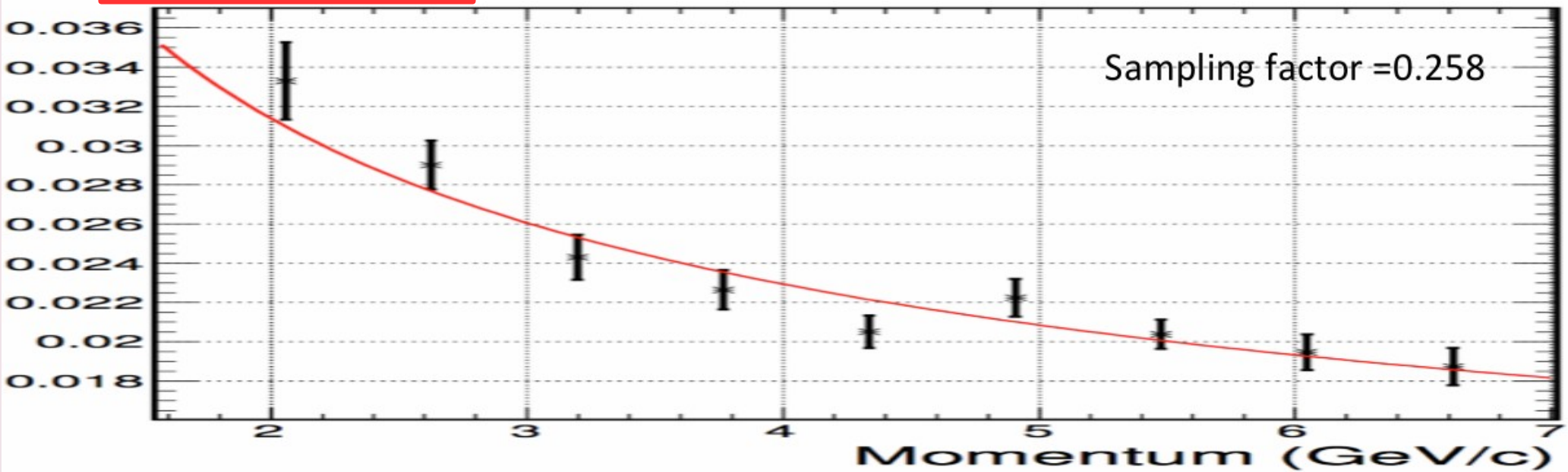
Now



$$\frac{\delta E}{E} = \frac{p_0}{\sqrt{E}} \oplus p_1 \oplus \frac{p_2}{E}$$

Preshower(20mm Scin+10.274mm Pb+15mm Scin)+18X_0 shashlyk(0.24mm+0.5mm Pb+1.5mm Scin)+Al?

Pre-CDR (no Al)

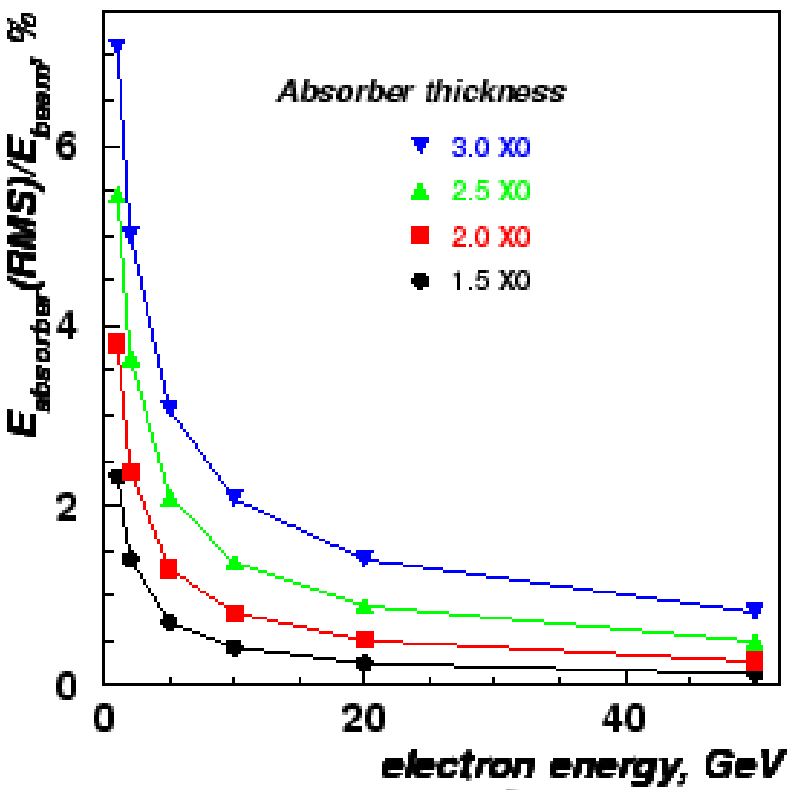


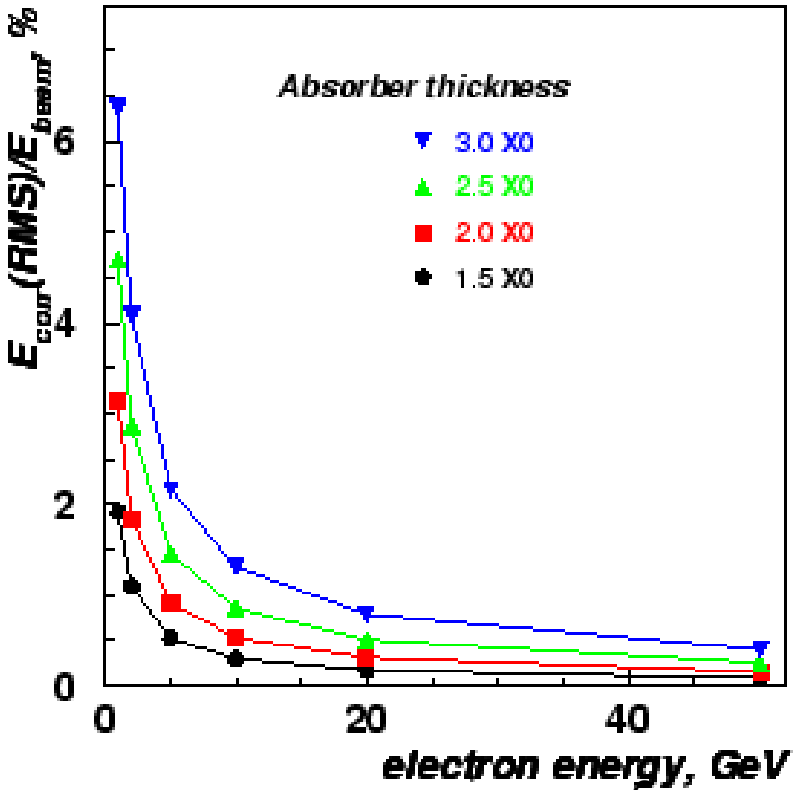
Ecal Simulation (Ye Tian/Syracuse)

1. Then try to separate the effect of incident angle (PVDIS), the 2cm Al support between the preshower and the shower, and the 2Xo of pre-lead before the preshower
2. In fact this is consistent with LHCb's study:

Ecal configuration	1 GeV e- dE/E
1748 modules, 25 deg, 2cm Al, no pre-lead	4.03 ± 0.03
1748 modules, 25 deg, 2cm Al, 2Xo pre-lead	6.20 ± 0.05
1748 modules, 25 deg, no Al, 2Xo pre-lead	5.84 ± 0.05

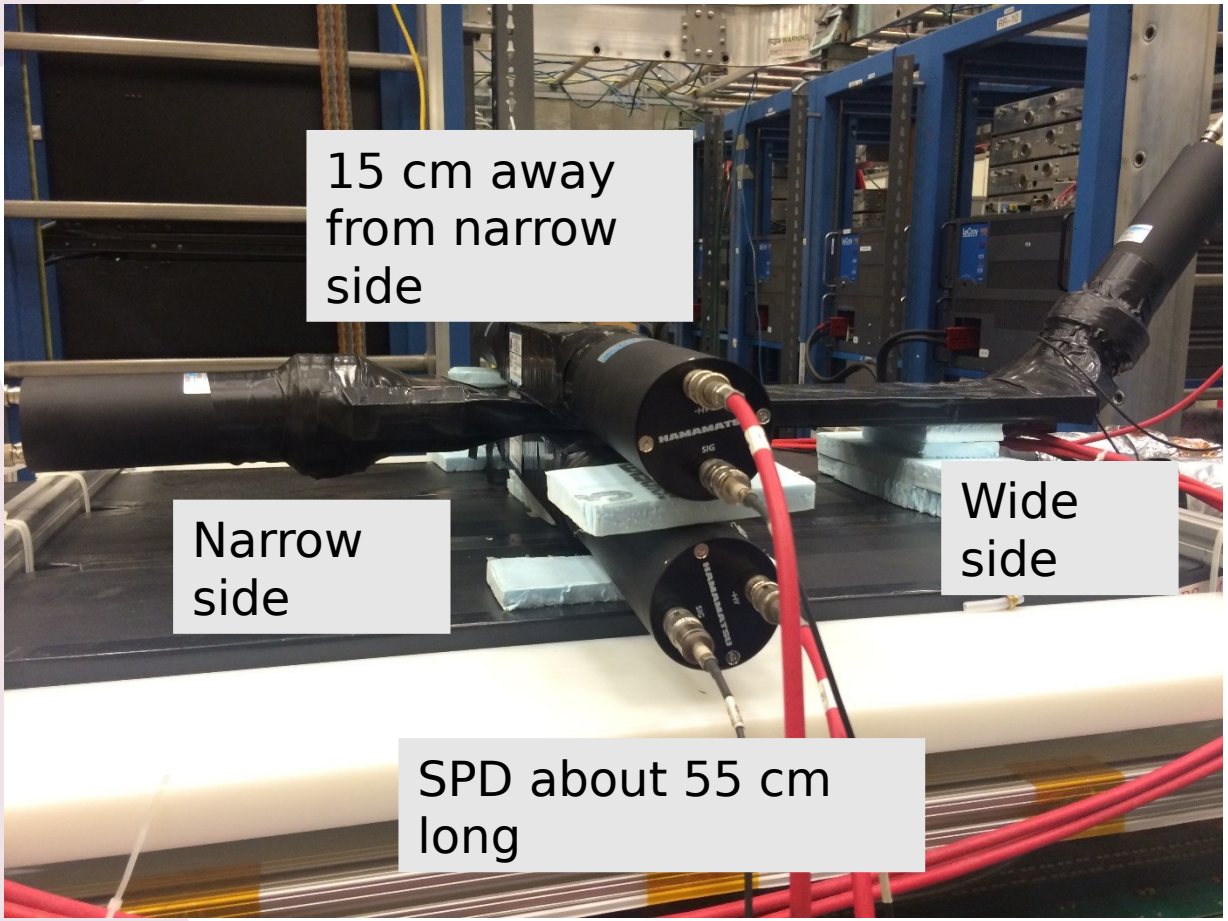
Figure 3.3 from LHCb Cal TDR: Simulation of the energy lost in lead by electrons. On the left plot the relative error on the energy measurement is shown. This should be compared with the design ECAL module resolution of 10%/sqrt(E) plus 1% constant. On the right shown is with correction of the prelead Edep using preshower signal.





JLab Test Lab Cosmic Runs (Ye Tian/SDU)

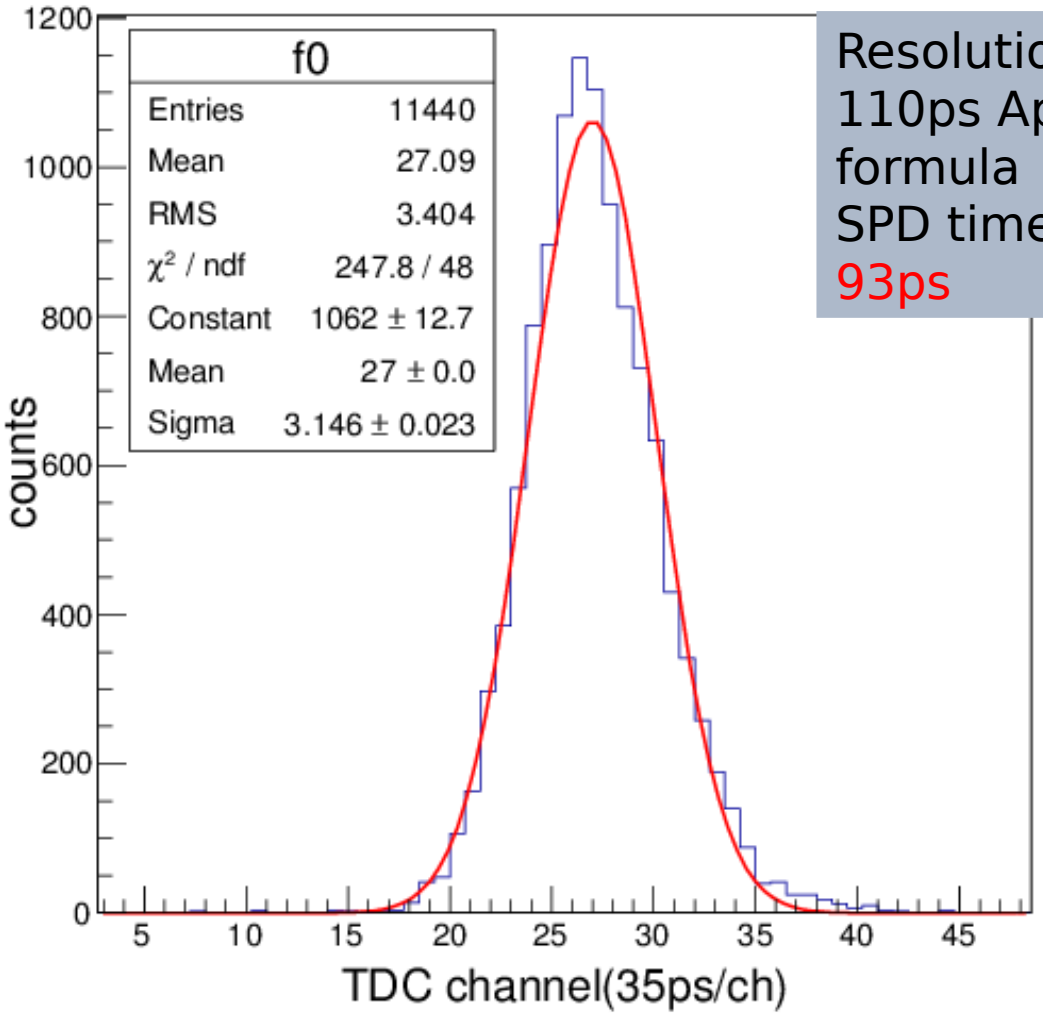
FASPD time resolution test



JLab Test Lab Cosmic Runs (Ye Tian/SDU)

Readout from both sides:

with time-walk correction and FADC cut

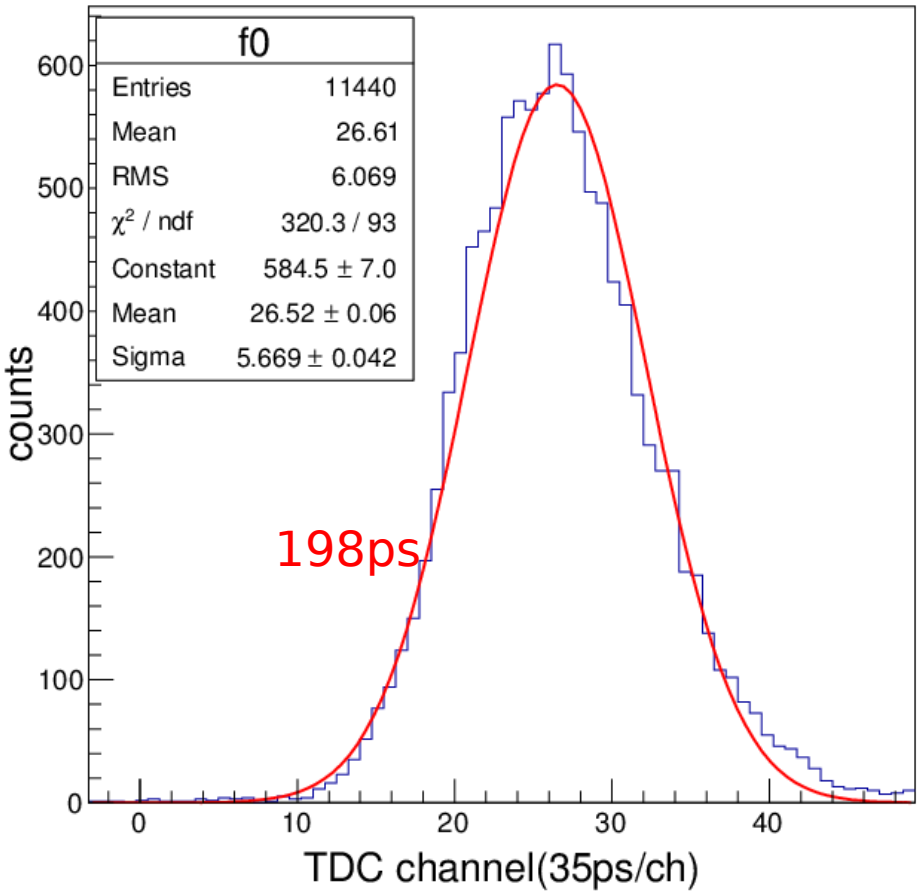


Resolution for T= 110ps Applying formula
SPD time resolution: 93ps

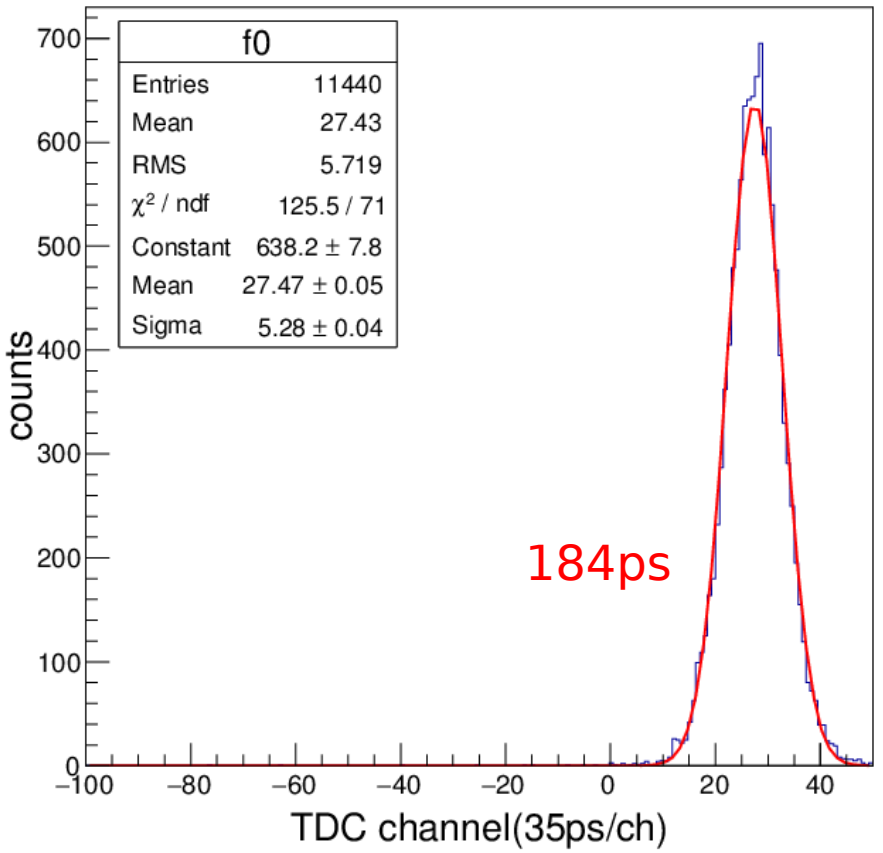
JLab Test Lab Cosmic Runs (Ye Tian/SDU)

No correction from GEM hit position yet. Trigger bars are 5cm wide

Readout from only the wide side:



Readout from only the narrow side:



JLab Test Lab Cosmic Runs (Ye Tian/SDU)

To do:

1) Apply hit positioning correction, although GEM event statistics is low.

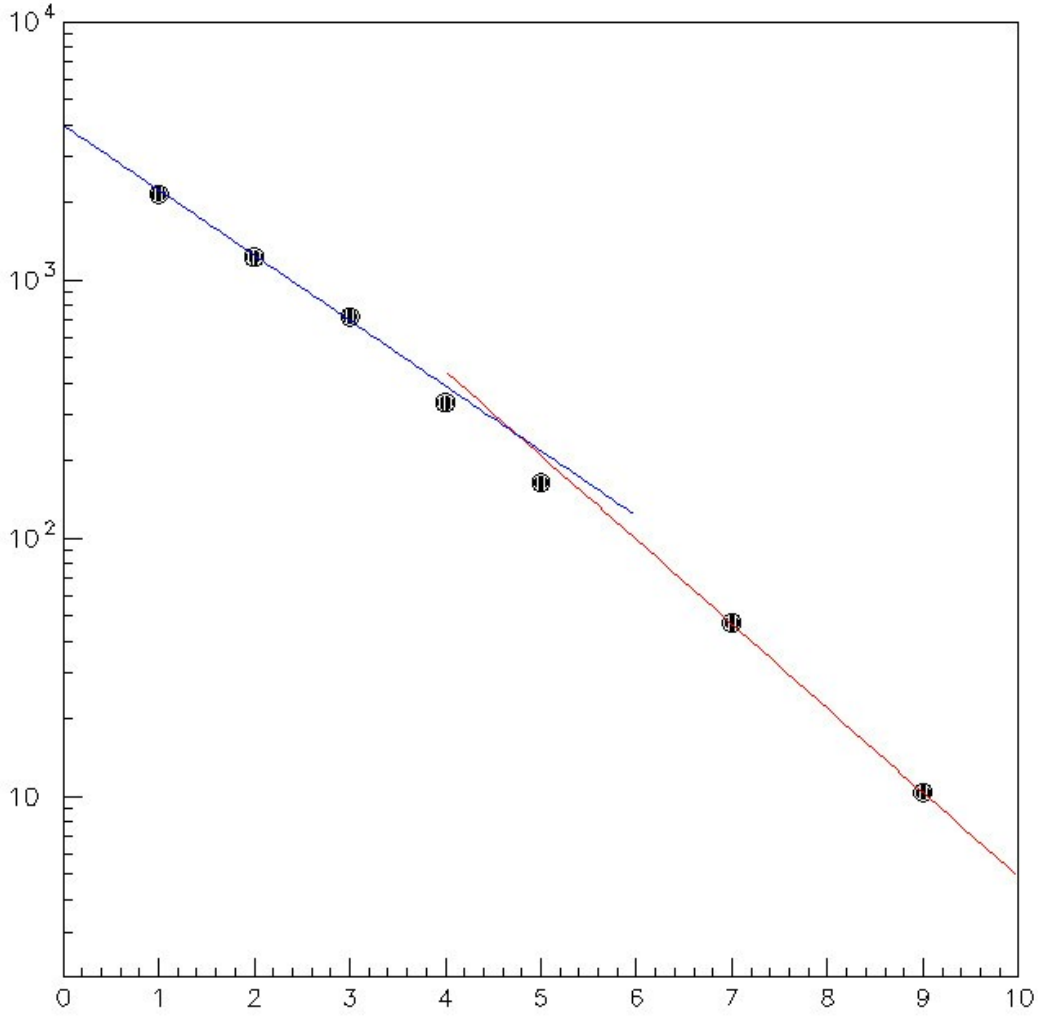
2) Can also determine Npe which should confirm proper photon statistics

3) Move trigger bar to far end and measure the largest timing resolution for real running

Clear Fiber Test (Chendi Shen/THU)

Attenuation length results on Saint Gobain BCF98 single-clad clear fiber using 420nm laser: between 1.3 and 1.7m

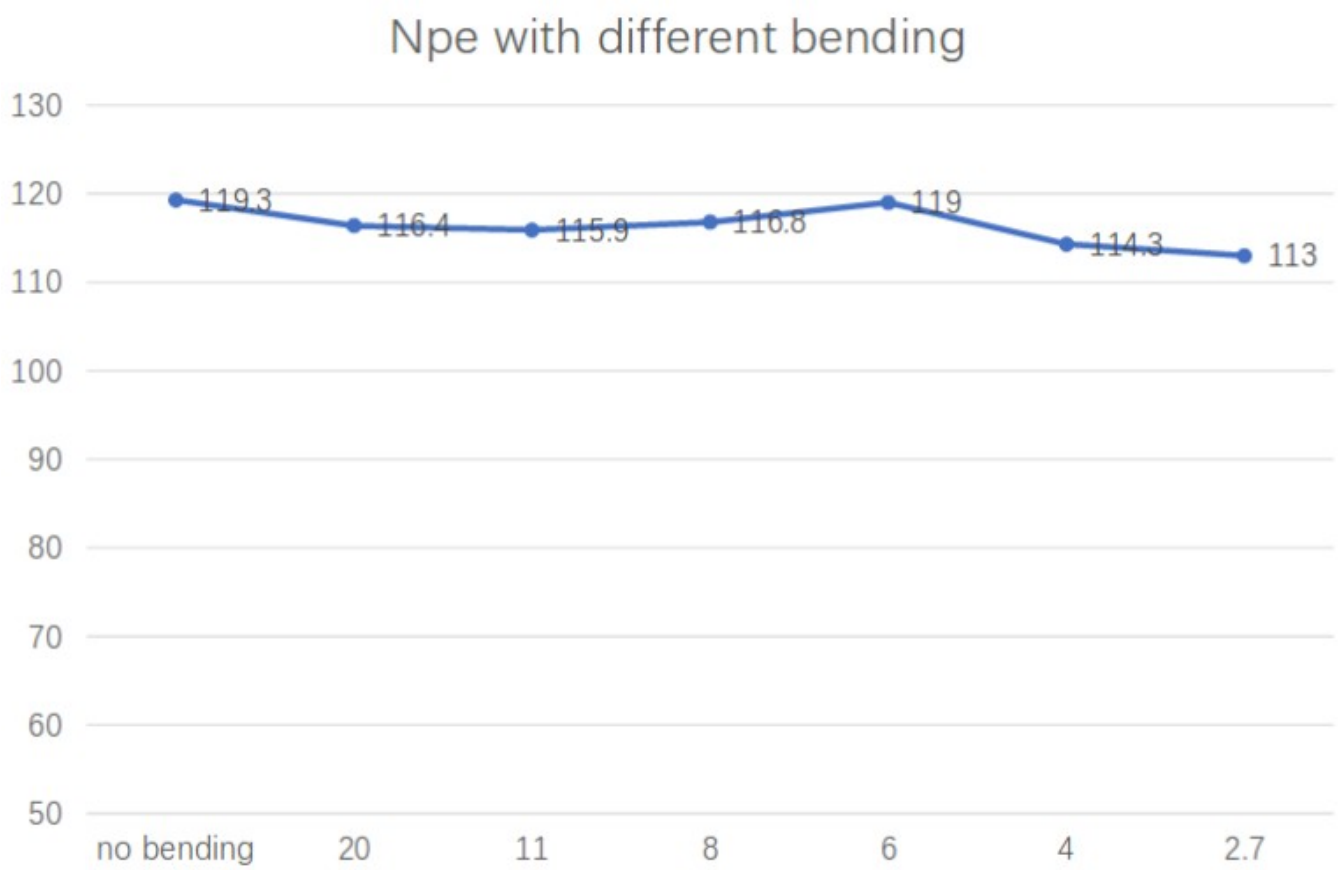
- WLS fiber emission peak is at 500nm, so the laser wavelength used is not ideal
- THU laser can produce 530nm and 470nm lights – need to re-test.
- result is shorter than S.G. spec: 2.1m (400nm); 4.3m (420nm); 10.9m (500nm); 14.5m (<600nm) – concernining
- Will also test BCF98 multi-clad fiber, but Kuraray website claims no difference in attenuation length between multi- and single-clad clear fiber.
- Will test Kuraray PSM clear fiber and samples from Raytum (US). Kuraray PSM spec is 9m (450nm); 15m(500nm); >20m (550nm), better than S.G. but expensive



Clear Fiber Test (Chendi Shen/THU)

Bending loss test for S.G. BCF98 single clad: shows nearly no loss down to a diameter of 2.7cm. This is good.

- Kuraray PSM spec: no loss down to 4-5cm of bending diameter – need to confirm;
- Raytum: glass fibers can't be bent for our SoLID routing. Will send plastic samples to THU.



The effect of bending on the clear fiber can be ignored

Shashlyk prototype and light yield overview

Prototype	scintillator	lead	reflective layer	WLS fiber	WLS fiber end	module side	cosmic vertical test Npe	cosmic horizontal test Npe
SDU1	Kedi original	US	printer paper	BCF91A	none	Tyvek → TiO2	224 → 254	48 → N/A**
SDU2	Kedi new	Chn	printer paper	BCF91A	Chn silver-plating	Tyvek → TiO2*	427 → 383*	83 → N/A**
SDU3	Kedi new	US	printer paper	Y11	Chn silver-plating	TiO2+glue (1/1)	491	107
THU1	Kedi original	Chn	mirror mylar	Y11	Italian silver shine	TiO2 (Kedi)	430-470	96
THU2 (not finished yet)	Kedi new	83.4	powder paint (喷塑)	suggest BCF91A	Italian silver shine			

update from JLab beam/cosmic test: actual yield is 2-3 times lower (THU test used wrong PMT gain)

* TiO2 side-paint was not as good as SDU1

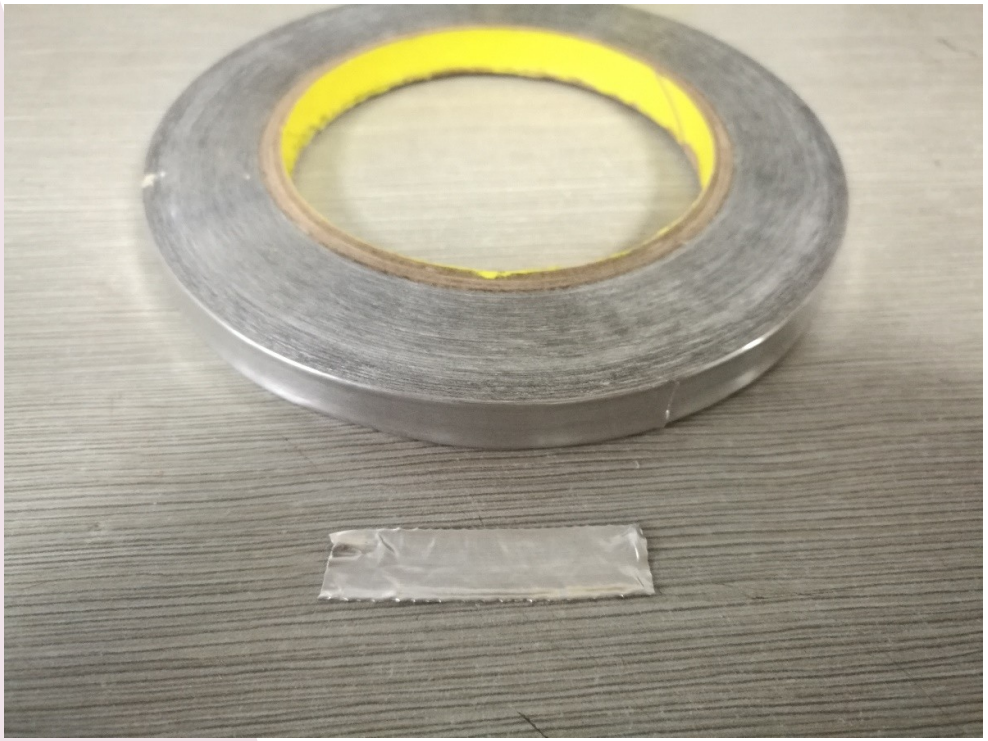
** could not finish before shipping to JLab

Yields 400/200 layers for MIP → 1333 p.e./GeV electron, factor 2-3 lower than LHCb or ALICE → 666 p.e./GeV if using clear fibers → 4% in δE/E due to photoelectron statistics

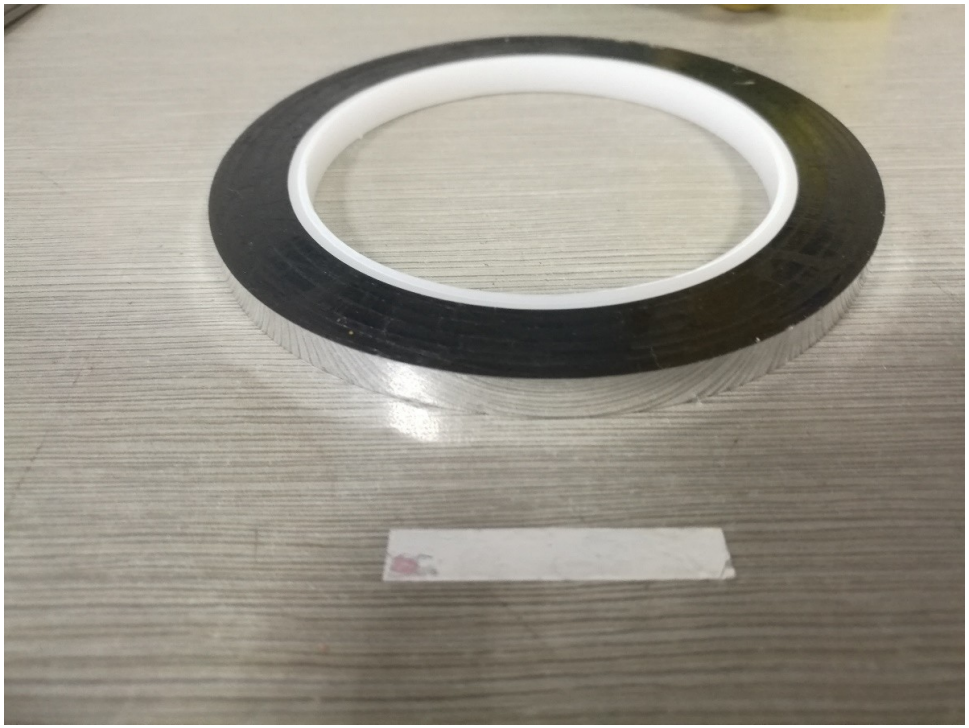
Reflective Material Study (THU+SDU)

Italian silver shine: ~30% (THU fiber test)
MCPET in place of printer paper: ~15% increase

3M tape was used for MINOS detector (glued to end of fiber) – SDU test shows up to 40% gain in light output:



Tape 1 3M 425



Tape 2 3M 850

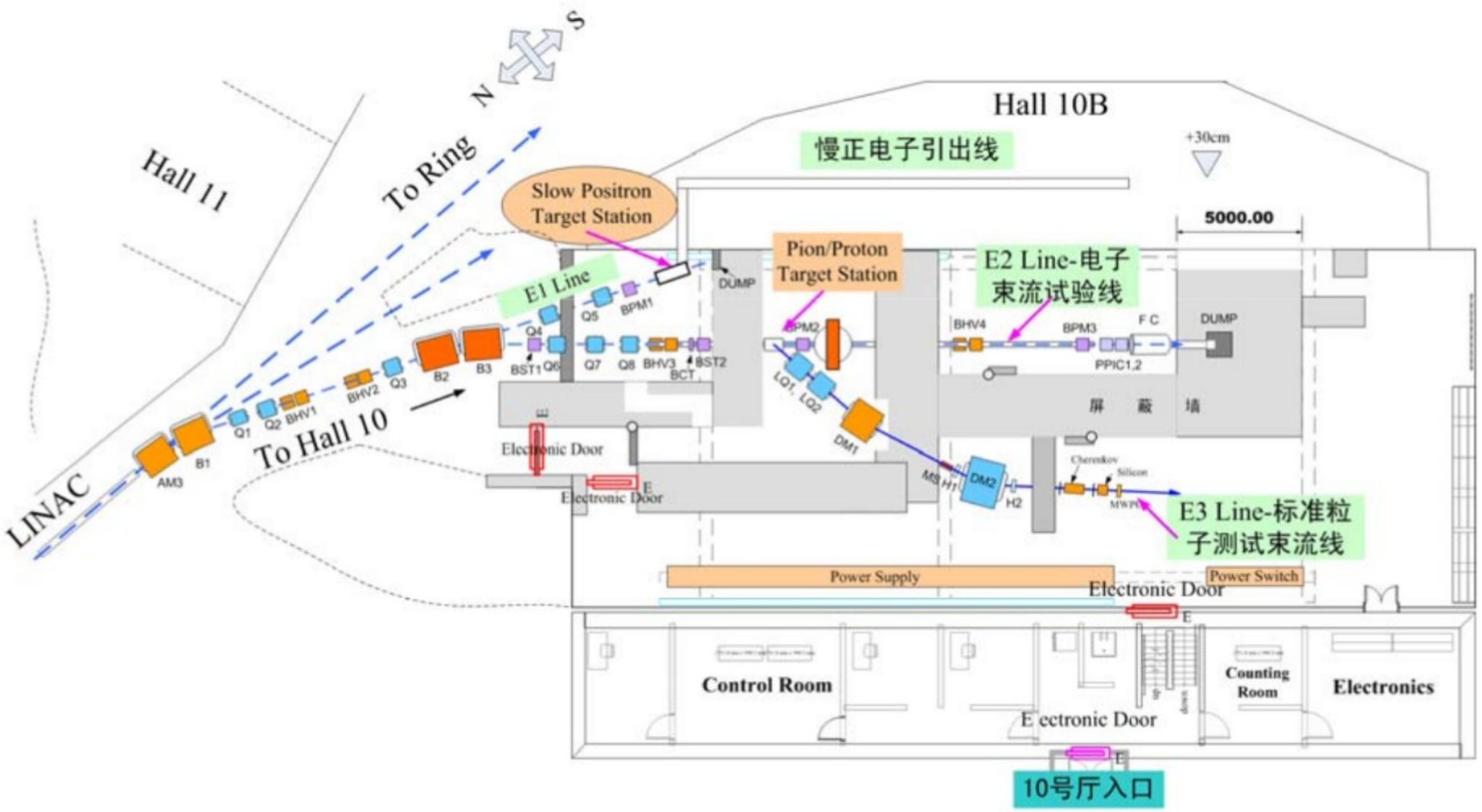
ECal + SPD cost estimate (March 2017)

Item	2014	2017
Shashlyk	$2,997,657 (1800 modules Russian IHEP)	China using 0.1454USD/Y: $3,460,567 (1800 modules); $3,630,323 (5% extra) +US $40k lead (material only)
Preshower	$280,800 (1800 modules Russian IHEP)	
SPD (Eljen)	FA: $54,900; LA: $34,680	waiting, maybe higher due to deeper grooves for FA (4.5mm vs. 3mm)
HV/CAEN	$1,026,624	$365,015 (newer, lower cost modules)
PMT/Hamamatsu	$885,600 (5% spare incl., MAPMT overestimated); FMPMT not quoted; plus MAPMT base/preamp	$797,510 (5% spare included), plus 128 units of MAPMT base/preamp at $200 each(?) → $825k?
Fiber (Saint Gobain)	$700k (~$1/m, 200kmWLS, 520km clear)	~$2.3/m!!! (still checking)
Fiber (Kuraray)	$64k ($2/m 23.5km clear, $3.2/m 6800m WLS)	WLS 200km is $2.6/m; clear still $2.15/m
Fiber connectors	$365k	$420k (incl. 5% spare)
Total	$6,411k	about the same, if not incl. fibers

ECal + SPD cost estimate (June 2017)

Item	2014	2017
Shashlyk	$2,997,657 (1800 modules Russian IHEP)	China using 0.1454USD/Y: $3,460,567 (1800 modules); $3,630,323 (5% extra) +US $40k lead (material only)
Preshower	$280,800 (1800 modules Russian IHEP)	
SPD (Eljen)	FA: $54,900; LA: $34,680	FA: $58,620 LA: $37,440
HV/CAEN	$1,026,624	$365,015 (newer, lower cost modules)
PMT/Hamamatsu	$885,600 (5% spare incl., MAPMT overestimated); FMPMT not quoted; plus MAPMT base/preamp	$797,510 (5% spare included), plus 128 units of MAPMT base/preamp at $200 each(?) → $825k?
Fiber (Saint Gobain)	$700k (~$1/m, 200kmWLS, 520km clear)	$996.5k ($1.8/m WLS 192km, $1.25m clear 520km)
Fiber (Kuraray)	$64k ($2/m 23.5km clear, $3.2/m 6800m WLS)	$82,281 ($4.67/m WLS 6.8km; $2.15/m clear 23.5km)
Fiber connectors	$365k	$420k (incl. 5% spare)
Total	$6,411k	$6,455k

Prospects of Beam Test in Beijing IHEP Test Facility



The Configuration of Beijing-BTF Upgrade at Hall 10

Prospects of Beam Test in Beijing IHEP Test Facility

E2 line: 1.1-2.5GeV, $10^{3\text{-}10}$/pulse.

E3 line is better for our detector test:

(4) E3 试验束主要性能参数：

粒子种类：	$e^{\pm}$， $\pi^{\pm}$，P	
动量范围：		
	电子	100MeV/c---300MeV/c
	介子	400MeV/c---900MeV/c
	质子	500MeV/c---1.2GeV/c
动量误差：		$\Delta P/P \leq 0.5\%$
粒子定位误差：		0.4 毫米
计数率：		3-4 赫兹

To-Do List

1. Continue LASPD timing test, get timing resolution for real running condition;
2. Continue clear fiber test, check with Saint Gobain on attenuation length;
3. Continue simulation, optimize pre-lead thickness, then proceed to other aspects (Birk effect, photon statistics, photon collection, etc.)
4. Prepare for beam test in Beijing
5. Continue SPD simulation (no update this time)
6. Continue support design/coordination;
7. From March meeting: LHCb will dismount their preshower in 2019, (in Dec 2016) asked us if we are interested.