The Progress On ECal R&D

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On Behalf Of SoLID EC Working Group

8th Workshop on Hadron Physics in China and Opportunities Worldwide

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Outline

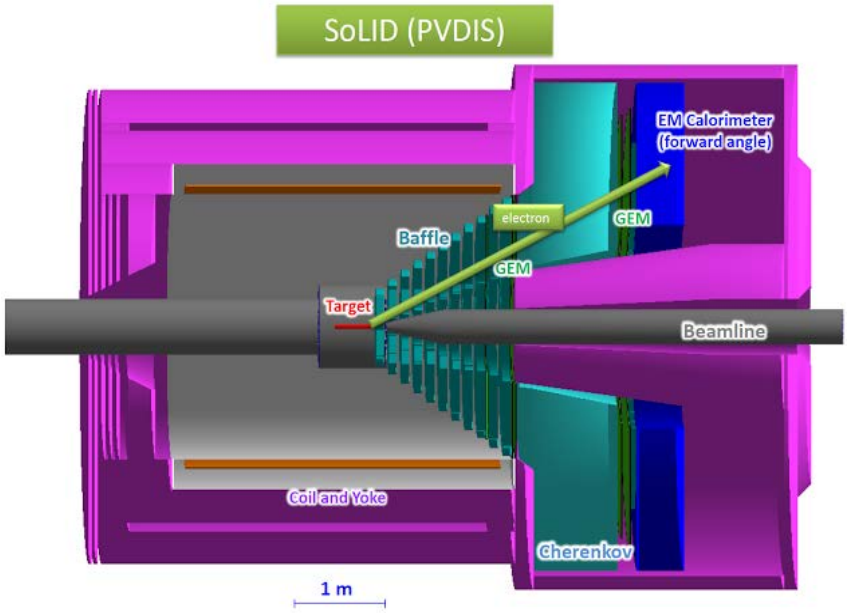
- Introduction
- Progress
  - Material Preparation
  - Material Test
    - Plating of fiber; Light yield of scintillator; Reflection layer
  - Assembly Process
    - Assembly tools; Fiber polish, Sputtering & Shaping
  - Cosmic Test of Module
- Summary & Discussion
- Next To Do

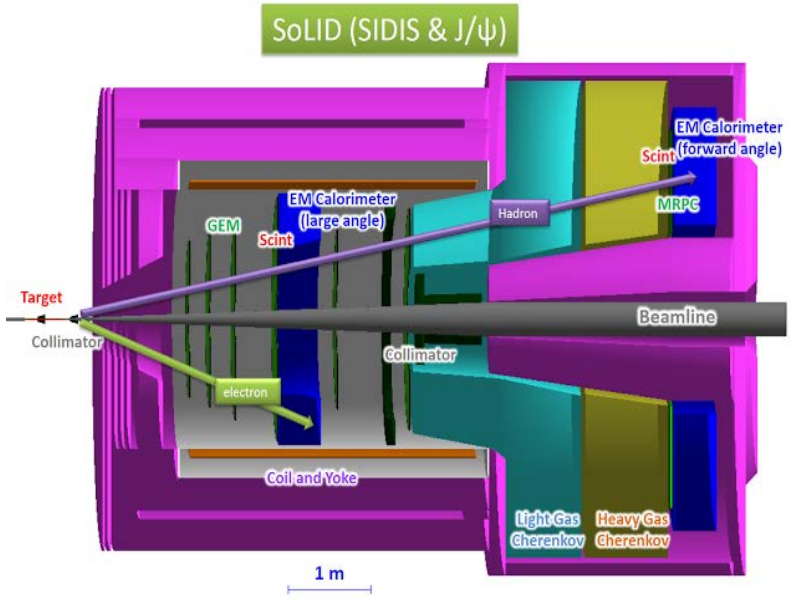
Introduction

- **Electromagnetic Calorimeters (EC) are used in PVDIS, SIDIS and J/ψ.**

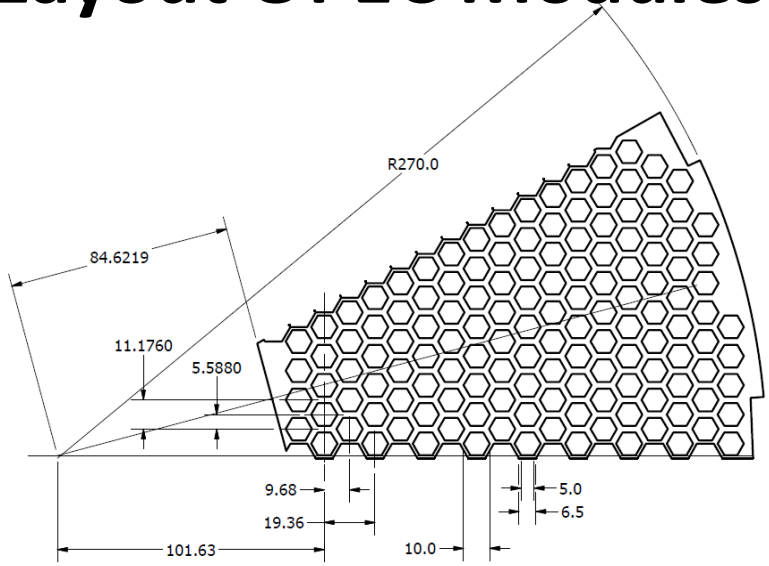
SoLID Coverage

	PVDIS FAEC	SIDIS FAEC	SIDIS LAEC
z (cm)	(320, 380)	(415, 475)	(-65, -5)
Polar angle (degree)	(22,35)	(7.5,14.85)	(16.3, 24)
Azimuthal angle	Full coverage		
Radius (cm)	(110, 265)	(98, 230)	(83, 140)
Coverage area (m^2)	18.3	13.6	4.0



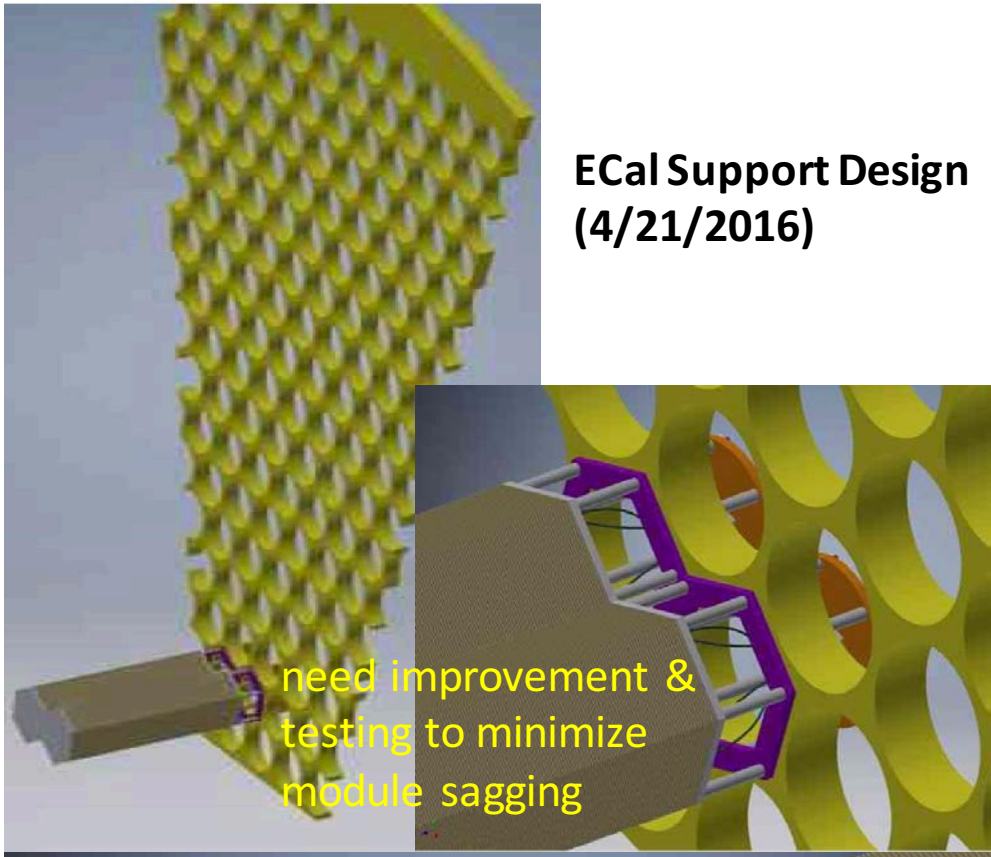


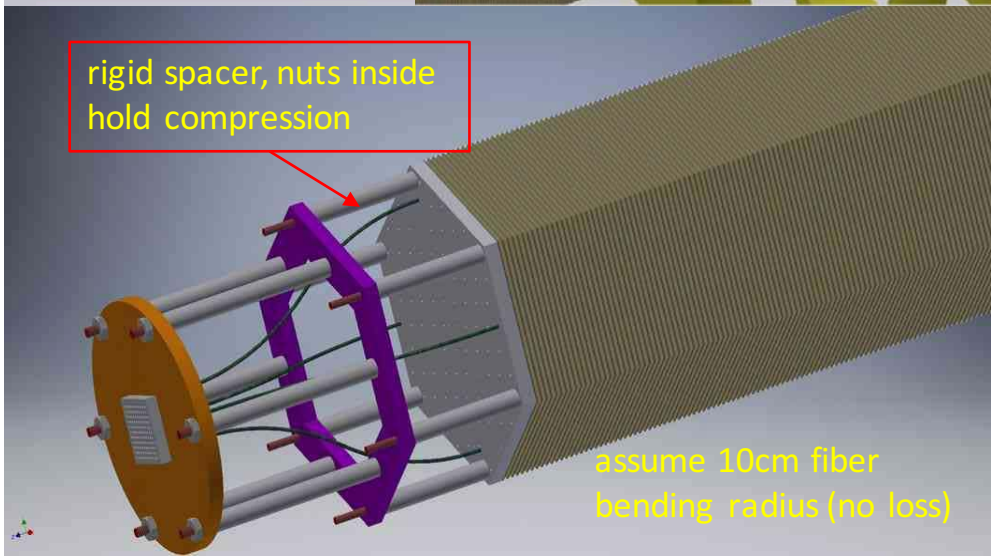
Layout Of EC Modules



- The view of PVDIS FAEC (portion) along the beam direction.
- 147 modules/30-degree wedge of the FAEC for the PVDIS configuration.
- The cross section of module is hexagon-shaped/ area is 100 cm^2/ side length is 6.25 cm.
- Modules from PVDIS FAEC will be split and rearranged into SIDIS FAEC and LAEC.

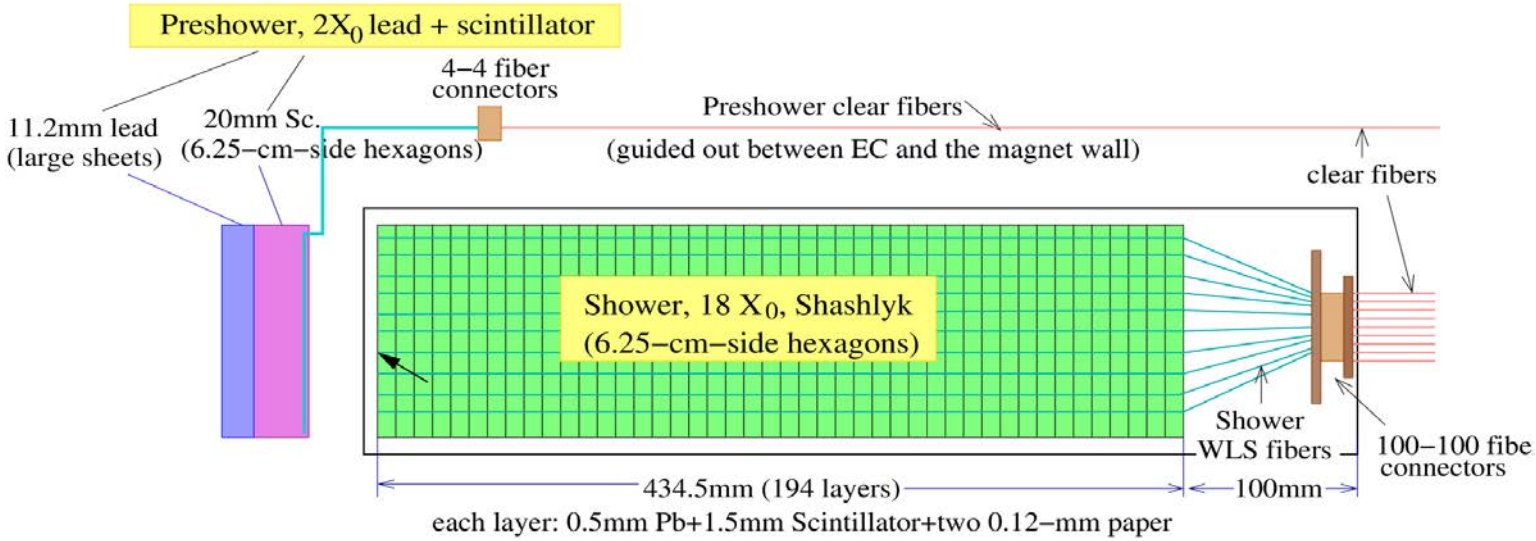
ECal Support Design (4/21/2016)





Structure Of EC Module

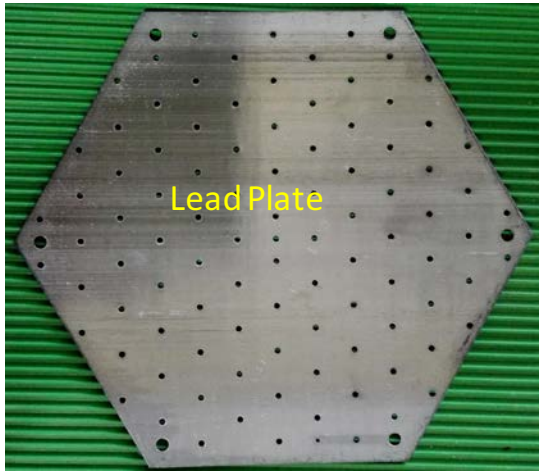
- Preshower: 2 X_0 lead + 20 mm plastic scintillator, WLS fiber embedded in scintillator.
- Shower: shashlyk module (0.5 mm lead + 1.5 mm scintillator + 0.1 mm paper sheet ×2) ×194, WLS fiber ×96 penetrating layers longitudinally.
- Overall: 20 X_0, energy resolution is less than $10\%/\sqrt{E}$

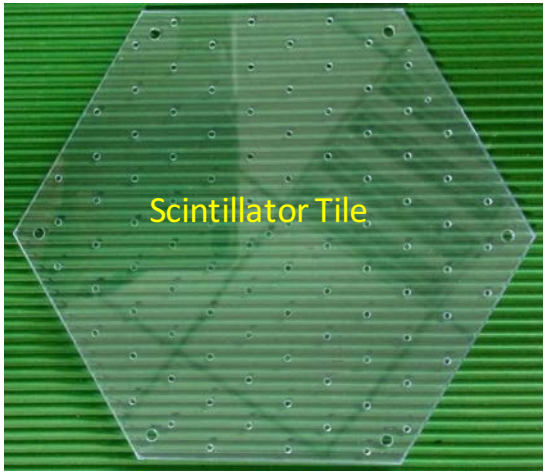


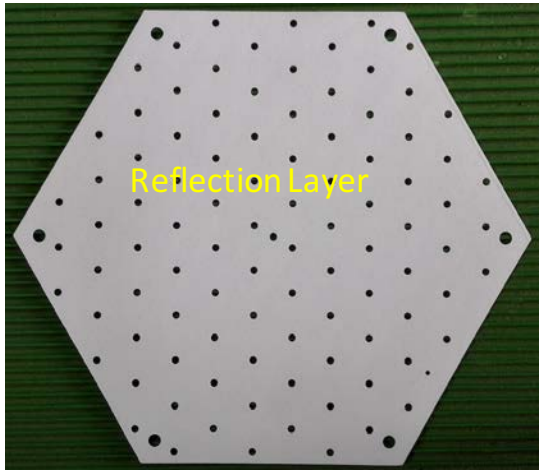
Progress

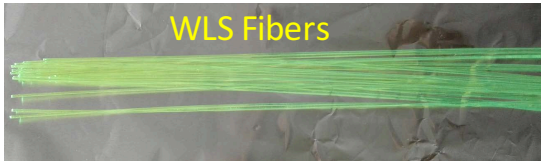
- New collaborators from THU, see Chendi's talk
- Sufficient materials are ready (SDU, THU).
- Assembly tools are designed and constructed (SDU, THU).
- Various tests are done to the materials (SDU, THU, UVa).
- 2 Prototypes are built (SDU, THU).
- Cosmic test is done to the prototypes (SDU).
- Resumed working with ANL/Chicago engineer on the Ecal support (UVa)
- Tests requiring beam (UVa)
  - FASPD uniformity test
  - LASPD timing test
  - Preshower prototype radiation resistance

Main Materials







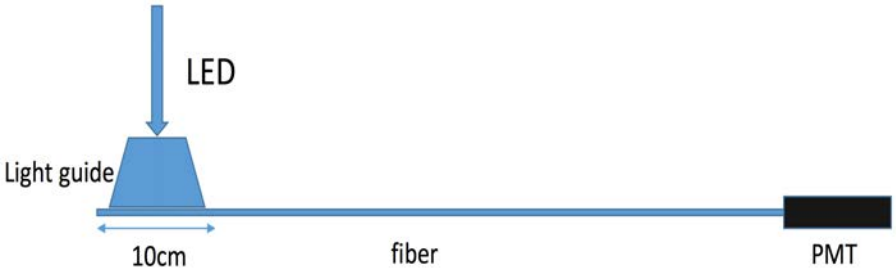


The geometry size of scintillator tiles, lead plates and reflection papers are all fine.

- Scintillator Tile: 2 different types by Kedi Company.
- Lead Plate: by several company.
- Reflection Layer: print paper by SDU factory.
- WLS Fiber: BCF91A by Saint Gobain Company.

Test of Materials (SDU)

The light incident on the side. PMT collects light from one end.

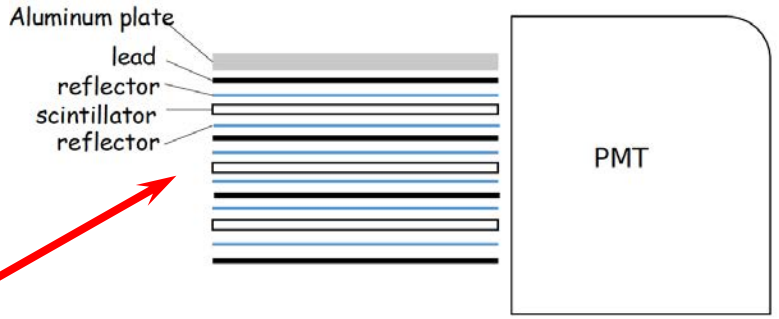


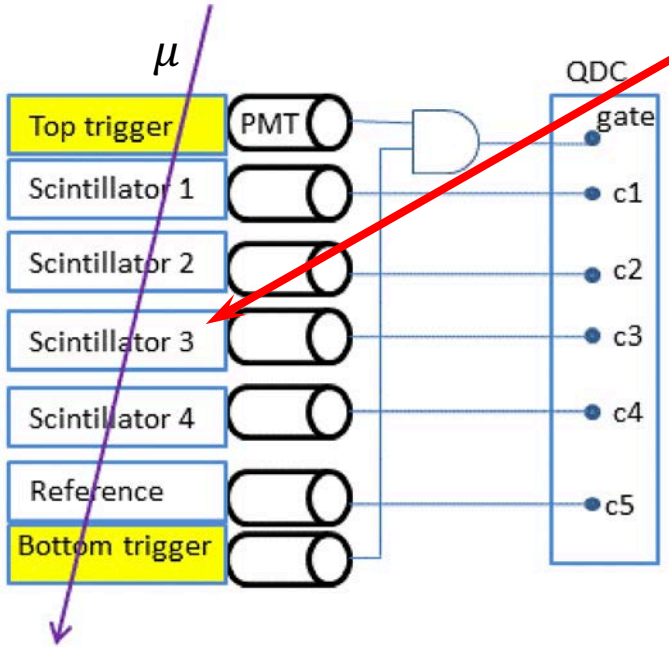
4: no plating, 1,2,3: silver plating

No.	FWHM(full width at half maximum)(ns)	Amplitude(mV)	Charge(pC)	Compared to No. 4
4	20.2	56	12.7	
	20.3	54	12.6	
1	20.5	104	24.2	1.92
2	20.7	92	21.5	1.706
3	20.6	96	22.5	1.786

Test of Materials (SDU)

Two pre-shower scintillators at the bottom and top as trigger detectors.
5 shashlyk scintillators in 5 floors.
The 5th is for reference.





Type 1	17.9±0.27	16.7±0.22	12.4±0.22	20.6±0.31
Type 2	40.9±0.52	30.9±0.36	38.1±0.43	28.5±0.33

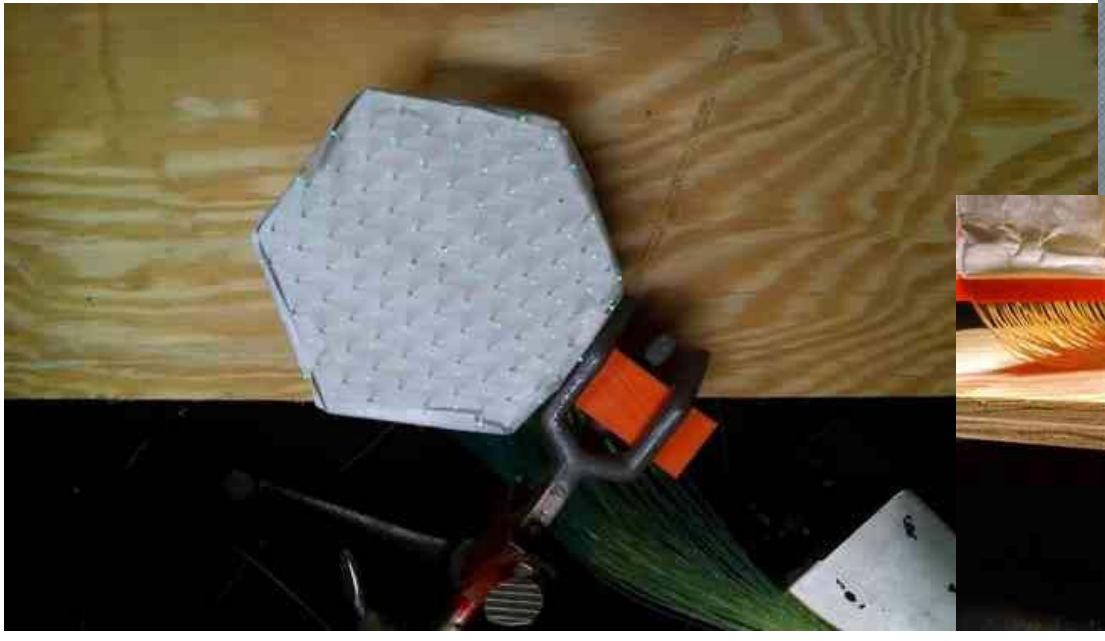
Reflection Layers	None	Print paper	foil	Tyvek
Light yields (relative)	0.85±0.02	1.06±0.06	0.97±0.08	1.61±0.16

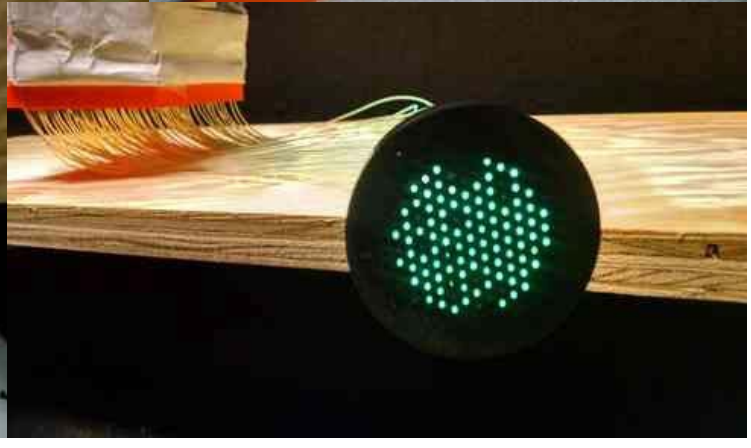
Currently, the absolute light yield is about 10 p.e./layer

Test of Materials (UVa)

LHCb used “hedgehog” test for screening the scintillator plate quality, but there is no detailed picture/diagram for the setup. UVa built their own “hedgehog” setup:

- alternating layers of scintillator and reflective material on a plastic holder, no lead plate is used
- 96 Y11(200)MS fibers “sticking out” from holes (no mirrored end)
- fibers glued to a permanent cylinder (with holes) and coupled to XP2262 PMT through optical grease
- loose reflective layer on the tile edge.





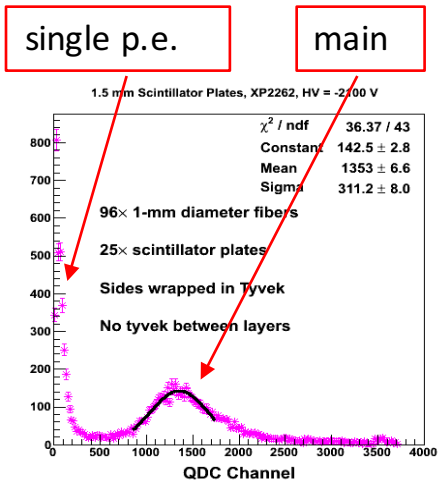
UVa results

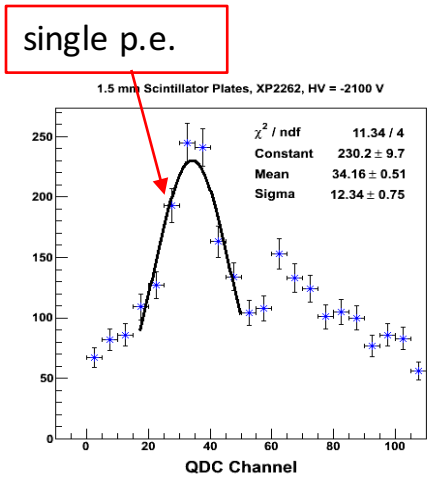
1) no reflector:
39p.e./25 layers = 1.56p.e./layer

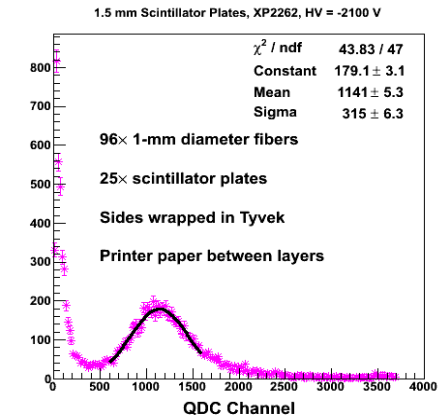
2) printer paper with loose edge wrapping:
34p.e./25 layers = 1.36p.e./layer

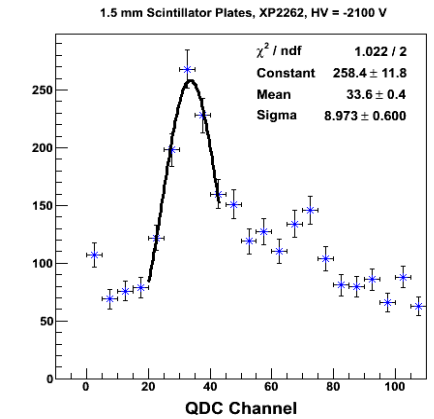
3) Tyvek with loose edge wrapping:
36p.e./25 layers = 1.44p.e./layer

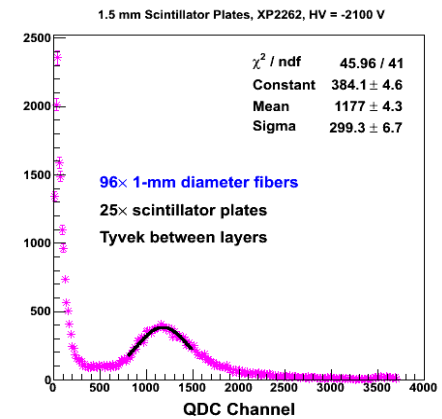
The results of SDU & UVa are consistent with eath considering the 10% fiber trapping efficiency (multi-cladding).

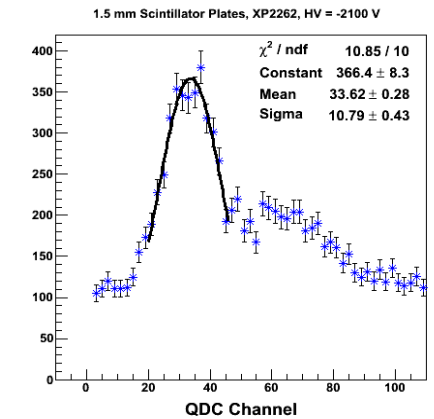




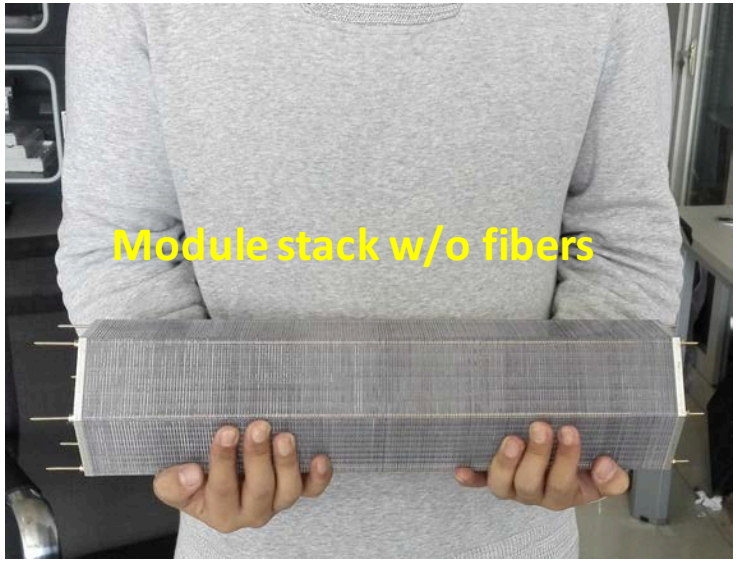


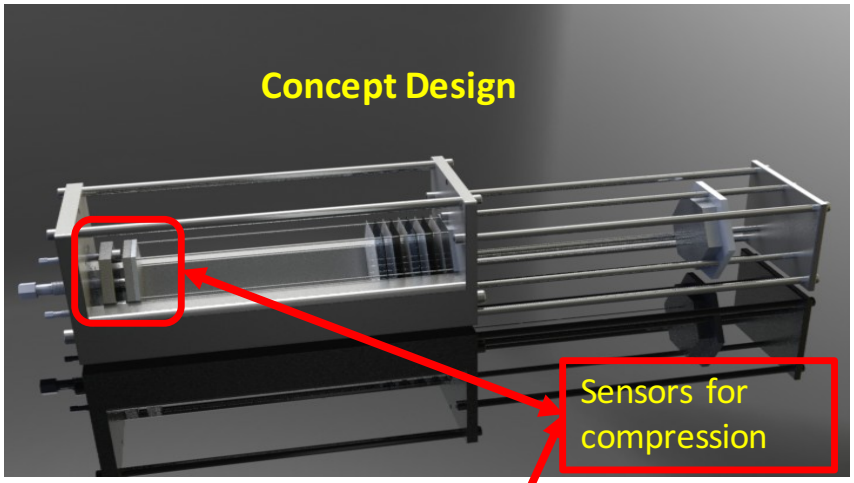


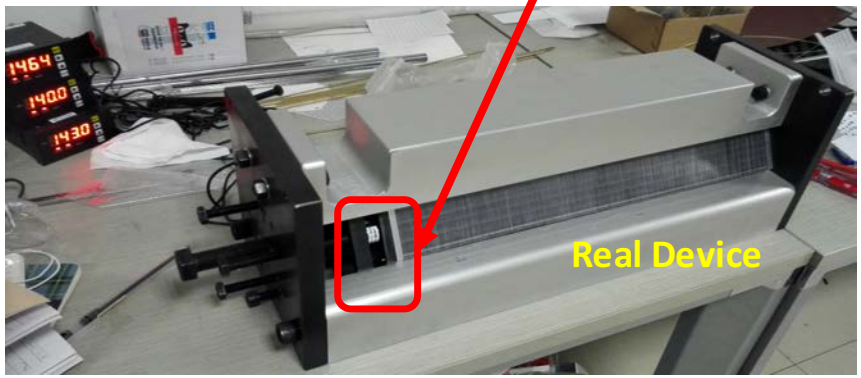




Assembly Tools





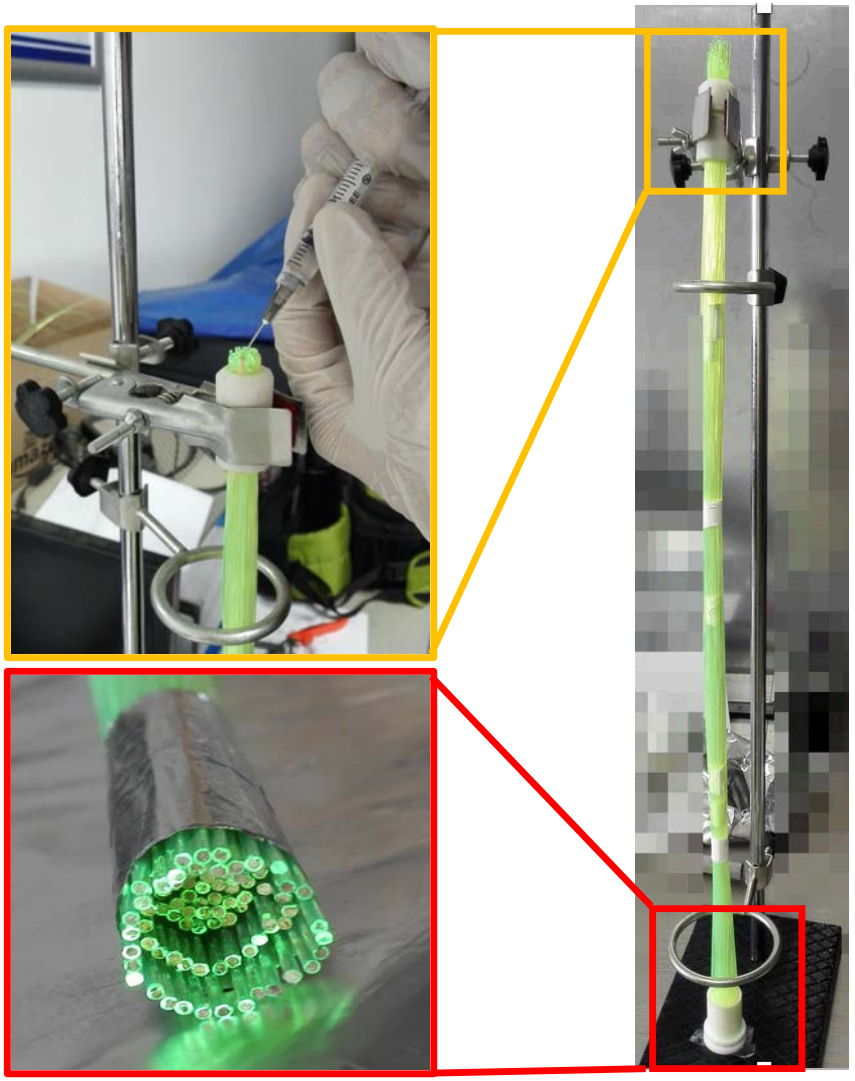


- Stack all the scintillator tiles, lead plates, and reflectors together
- Compress the module stack
- Suspension test

Shaping Tools

Glue fibers & hold together, fibers beyond the hold are the redundancy for cut and polish

The unbundled end of fibers are separated into 3 different lengths for fiber insertion

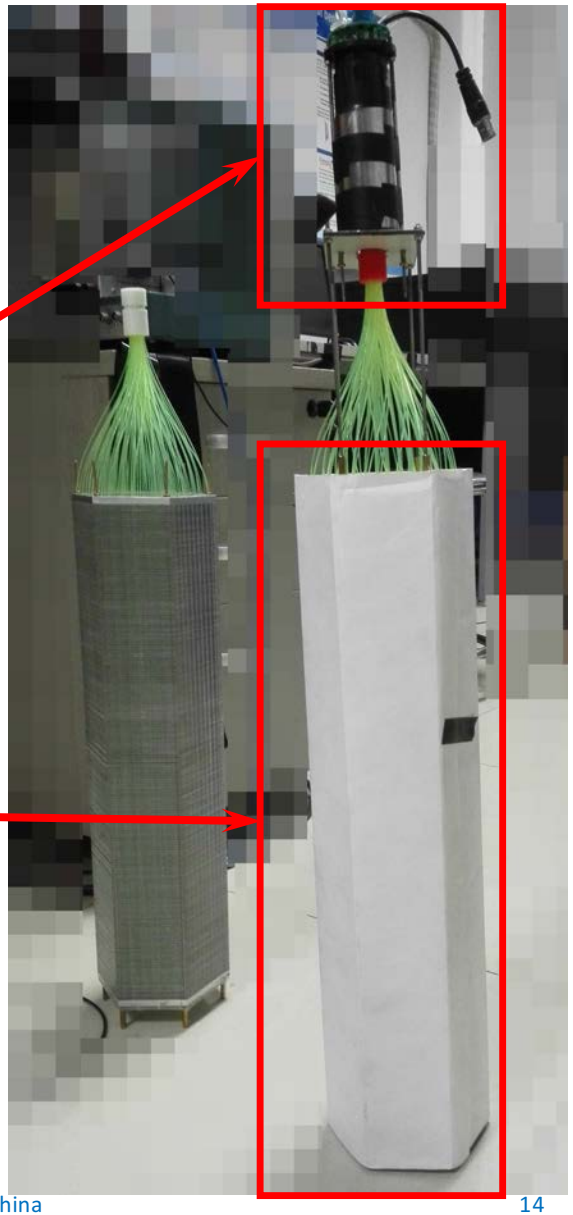


Module Prototype

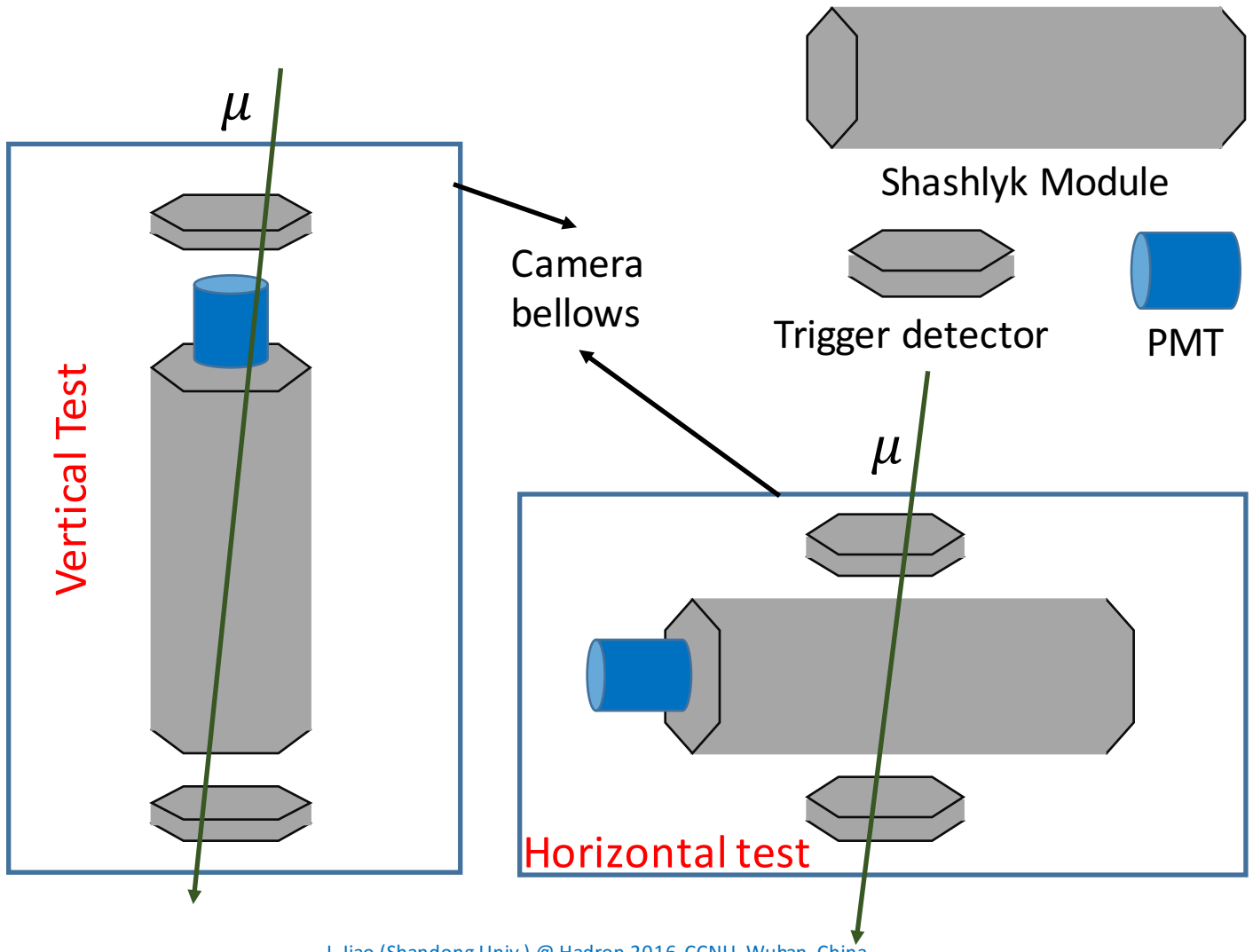
Two module prototypes are ready for cosmic test

PMT: Hamamatsu R11102
(Set the Gain equal to 5*10^6)

- Scintillator tiles (2 types) from Kedi company;
- Lead plates from USA company;
- Print paper from SDU factory.
- Side of module wrapped with tyvek layer

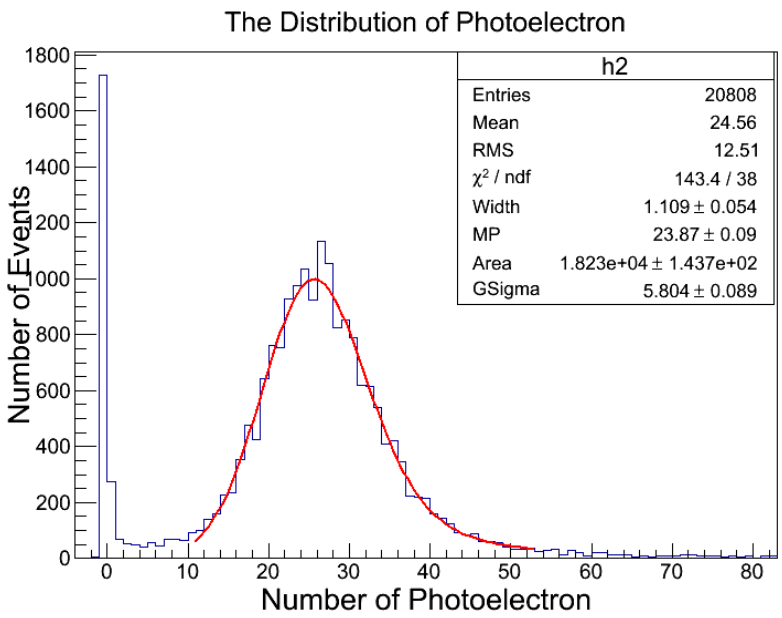


Cosmic Test

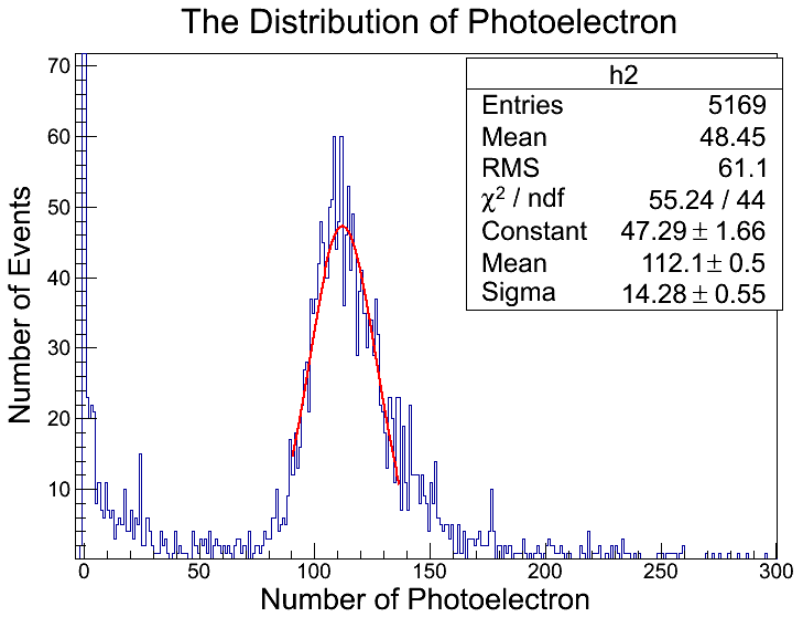

μ
Vertical Test
Camera
bellows
Shashlyk Module
Trigger detector
PMT
μ
Horizontal test

Test of Module 1

1. no reflection mirror on fiber end
2. Scintillator tile of type 1 (low light yield)
3. Connect to PMT directly



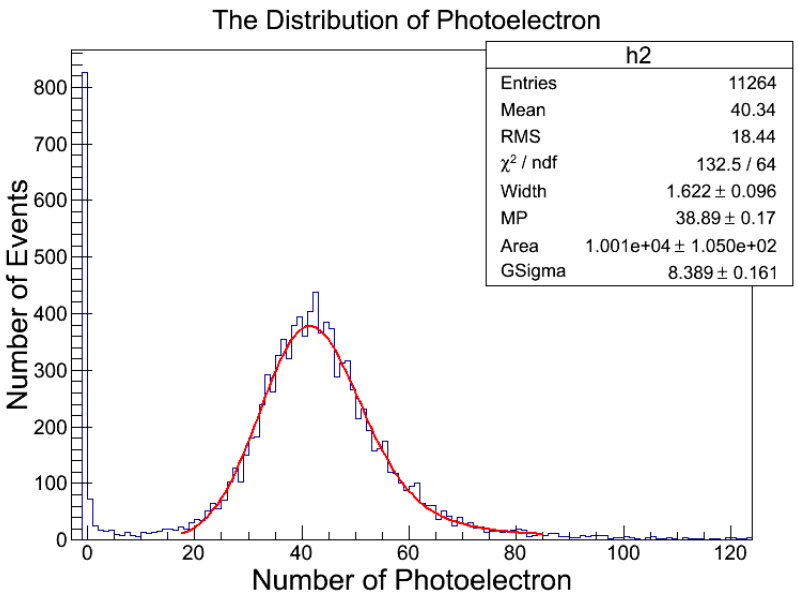
horizontal



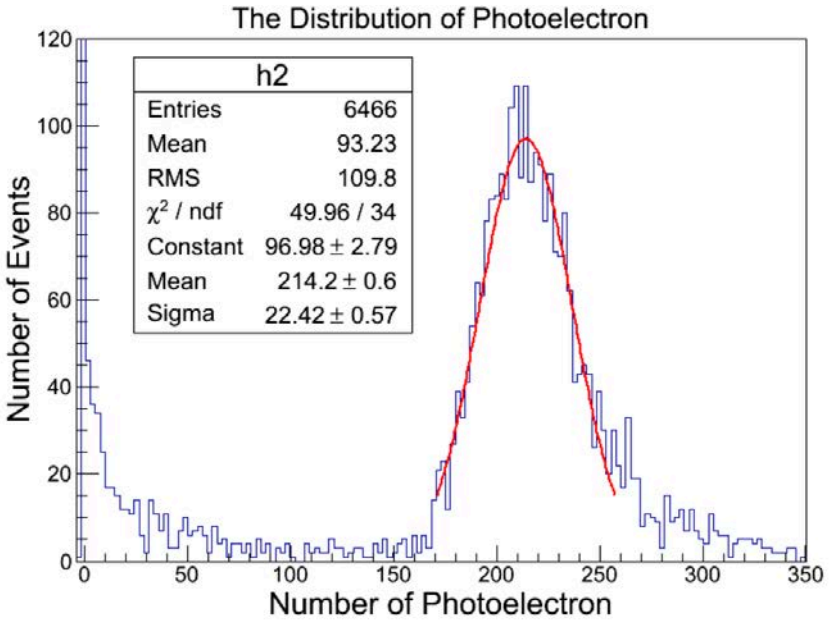
vertical

Test of Module 2:

1. silver reflection mirror on fiber end
2. Scintillator tile of type 2 (high light yield)
3. Connect to PMT with grease



horizontal



vertical

Test results comparison

Module	Vertical	Horizontal	Horizontal (no Tyvek wrapped)
1	112.1	23.9	19.3
2	217.9	38.9	N/A

	A	B	C	D	E	F	G
1	number of p.e. per shashlyk layer, hedgehog test	# p.e. per 1 GeV electron in shashlyk module, SoLID running condition, assuming 20% sampling fraction and light yield proportional to energy deposit in scintillator					expected # of p.e. for shashlyk module cosmic horizontal test (assuming 10cm vertical thickness, 7.5cm of which is scintillator)
2		Y11, no mirror at end of fiber, light yield directly out of WLS	if using BC91A instead of Y11	after light loss of connectors and clear fibers (use 50%)	adding mirror to end of fiber (use +60%)	energy resolution due to photoelectron statistics	
3	0.500	300.000	150.000	75.000	120.000	0.091	25.000
4	1.000	600.000	300.000	150.000	240.000	0.065	50.000
5	1.500	900.000	450.000	225.000	360.000	0.053	75.000
6	2.000	1200.000	600.000	300.000	480.000	0.046	100.000
7	2.500	1500.000	750.000	375.000	600.000	0.041	125.000
8	3.000	1800.000	900.000	450.000	720.000	0.037	150.000
9	3.500	2100.000	1050.000	525.000	840.000	0.035	175.000
10	4.000	2400.000	1200.000	600.000	960.000	0.032	200.000
11	4.500	2700.000	1350.000	675.000	1080.000	0.030	225.000

Summary & Discussion

Two prototypes of Shashlyk modules are produced and various tests are done. The material tests of SDU and UVa about the light yield are consistent with each other taking into account the trapping efficiency. The light yields of the prototypes are lower than the requirement of design from the results of cosmic test. Need to do some change to improve the light yield.

- Change fibers?
- Change the reflection layers?
- Wrap the side of module?
- Use optical grease?
- Etch the surface of scintillator?
- ……

More tests need to do in the future

Next To Do

- Continue with the test of materials to improve light yield
- Continue with mechanical testing
- Determine the final design of module & support
- Continue with the cosmic test
- Do beam test for the shashlyk modules;
- Tests the FA and LASPDs with cosmic+GEM
- Apply funding
- ……

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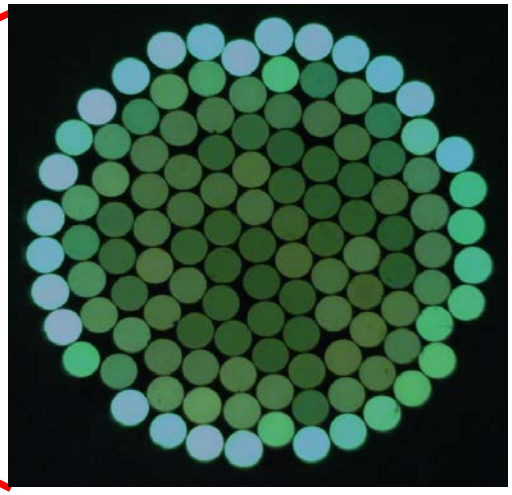
Thank you!

Backups

Cut & Polish Tools

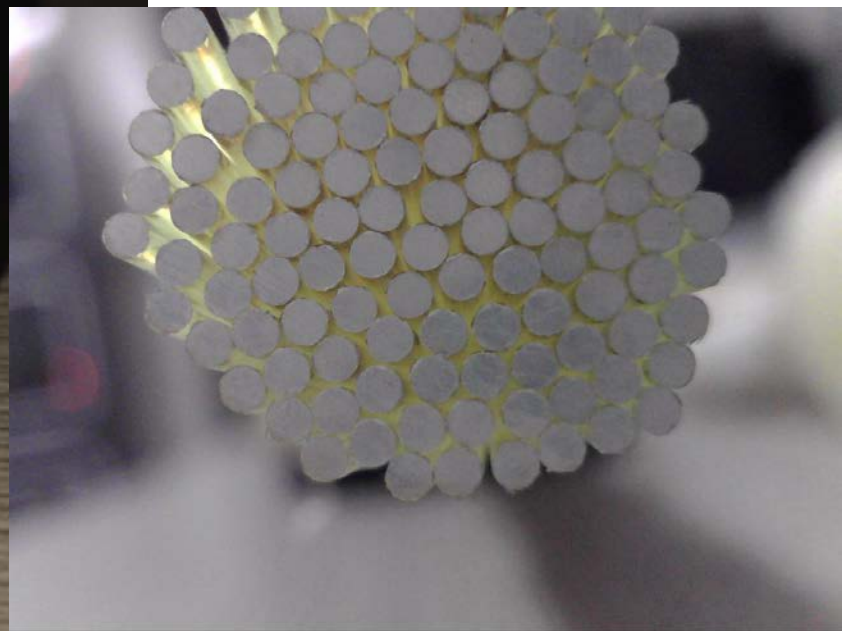


The new milling cutter with 1cm diameter is used for cut & polish

The cut & polish result (new cutter) is good even under microscope

Sputtering Plating

The end of fiber is plated with silver, but the edge of plating mirror is easily peeled off



Progress

Test of Materials:

----scintillators & reflectors

Two pre-shower scintillators at the bottom and top as trigger detectors.

5 shashlyk scintillators in 5 floors. Test results will be available soon.