EC and SPD Updates

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The SoLID EC Working Group

SoLID Collaboration Meeting

May 6-7, 2016

To Do List from Previous Collab Meeting

- Determine the final design of module
  - Use paper sheets or not, what kind of paper / Lego Lock ?
  - Most materials are ready (awaiting WLS fiber), more modules can be assembled soon
- Add real-time pressure and compression monitoring
- How to let fibers go through module
- Measure mechanical property of the scintillator
- Cosmic test → Beam test
- Resumed working with ANL/Chicago engineer on the Ecal support
- Learn from other experiments
- Funding application

More To do Items from 2015 Collab Meeting

1. Tests requiring beam → spring 2016
   - FASPD uniformity test
   - LASPD timing test
   - preshower prototype radiation resistance

More To do Items from 2015 Collab Meeting

1. Tests requiring beam → spring 2016
   - FASPD uniformity test
   - LASPD timing test

   both need tracking, maybe summer (if GEM is ready) or Fall 2016 (with beam)

   - preshower prototype radiation resistance — 8 preshower prototypes (4 from Kedi — 科迪； 4 from CNCS — 北京核仪器厂) radiated during the Hall A Spring 2016 run, need to measure their post-radiation performance — summer 2016

Table: Preshower Tile and Ion Chamber Correspondence

Preshower Tile ID	Ion Chamber ID	Location	Ion Chamber EPICS Variable	Dose Reading: 2/23/2016 Time: 09:30	Dose Reading: 3/10/2016 Time: 10:50	**Final** Dose Reading: 4/25/2016 Time: 14:30
Kedi 4	Compton IIC1P03	On Ion Chamber	SLD1H06GDOSC	id 40: 2.5 kRad id 83: 9.86 kRad	id 40: 4.6 kRad id 83: 13.8 kRad	id 40: kRad id 83: kRad
Kedi 3	Target chicane IIC1H05	Beamline Girder between BPMs	SLD1H03GDOSC	id 40: 23.275 kRad id 83: 10.6 kRad	id 40: 25 kRad id 83: 12.3 kRad	id 40: kRad id 83: kRad
Kedi 2	Target Left 1H04	Upstream of Target Chamber	SLD1H05GDOSC	id 40: 4.4 kRad id 83: 13 kRad	id 40: 9.23 kRad id 83: 18.5 kRad	id 40: kRad id 83: kRad
Kedi 1	N/A	Beam Right at Lumis	N/A	id 40: 20.5 kRad id 83: 28.9 kRad	id 40: 45.4 kRad id 83: 62.3 kRad	id 40: kRad id 83: kRad
CNCS 1	N/A	Beam Left at Lumis	N/A	id 40: 21.1 kRad id 83: 27 kRad	id 40: 43.7 kRad id 83: 54.8 kRad	id 40: kRad id 83: kRad
CNCS 2	Target Right 1H04A	On Target Scattering Chamber (beam right)	SLD1H04GDOSC	id 40: 5.2 kRad id 83: 11 kRad	id 40: 11 kRad id 83: 17 kRad	id 40: kRad id 83: kRad
CNCS 3	N/A	On Target Scattering Chamber (beam left)	N/A	_______	id 40: 5.4 kRad id 83: 12.2 kRad	id 40: kRad id 83: kRad
CNCS 4	Hall A Dump IIC0014	Beam Right in Hall A Dump Cage	SLD1H08GDOSC	_______	_______	id 40: kRad id 83: kRad

On Ion Chamber

Upstream of Target Chamber

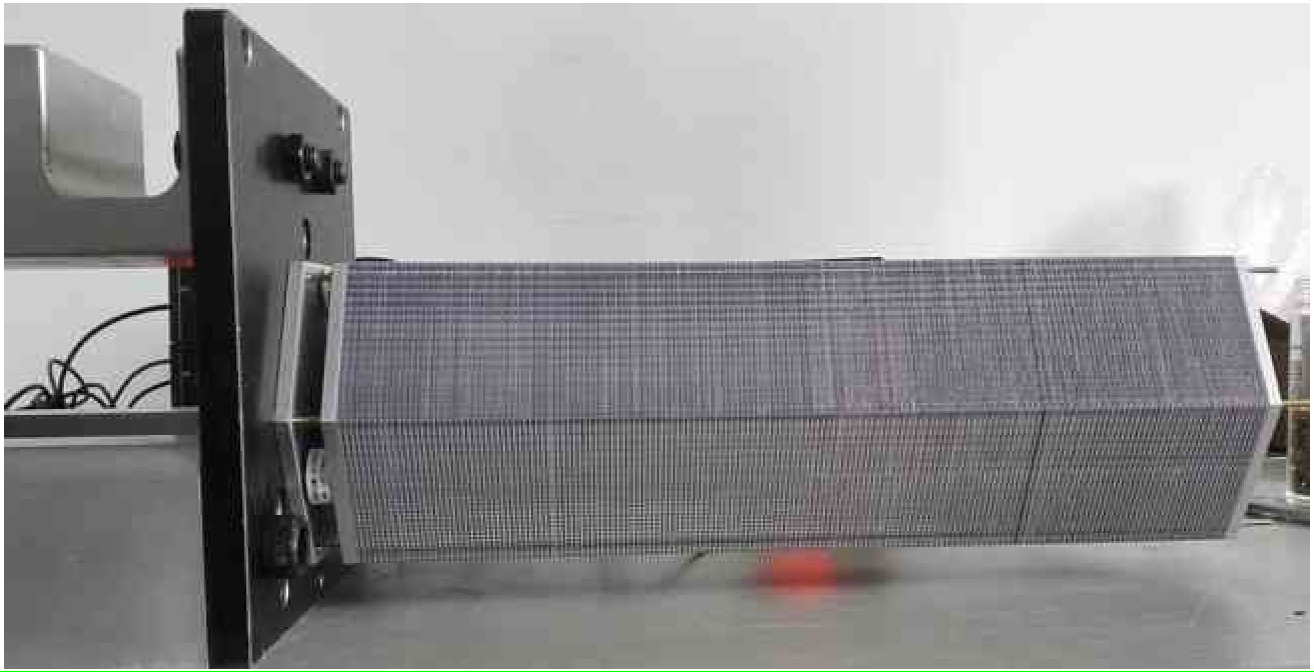
To Do List from Previous Collab Meeting

- Determine the final design of module
  - Use paper sheets or not, what kind of paper / Lego Lock ?
  - Most materials are ready ~~(awaiting WLS fiber)~~, more modules can be assembled soon

also studying pressure vs. temperature (-30,30C) (THU) and how to use spring washer to stablize the inner compression

- Add real-time pressure and compression monitoring — ongoing (SDU, THU)
- How to let fibers go through module — ongoing (SDU, THU)
- Measure mechanical property of the scintillator — done (UVa, tensile, comparable to regular polysterene)
- Cosmic test → Beam test
- Resumed working with ANL/Chicago engineer on the Ecal support — ongoing
- Learn from other experiments
- Funding application — China, plan to apply for US NSF PIRE
- Preliminary test of light yield

Progress - Some Pictures

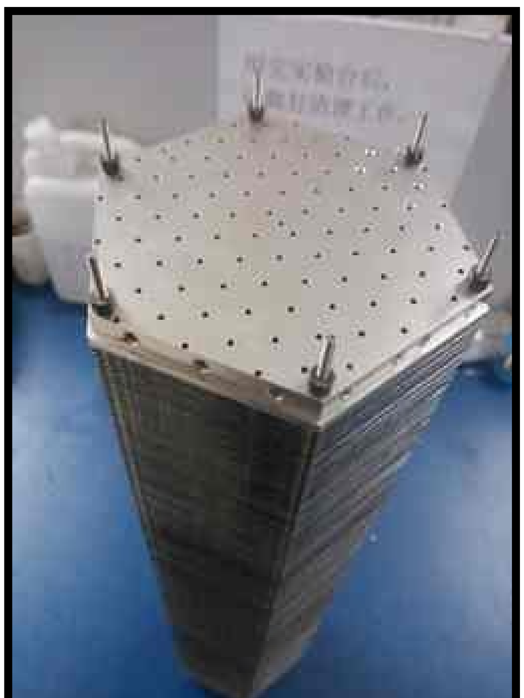


SDU now have two modules (no fiber), one 170-layer with inner sensor for mechanic testing; one full module

Kedi TiO2-based coating (ALICE BC622A; LHCb: IHEP chemically-treated)

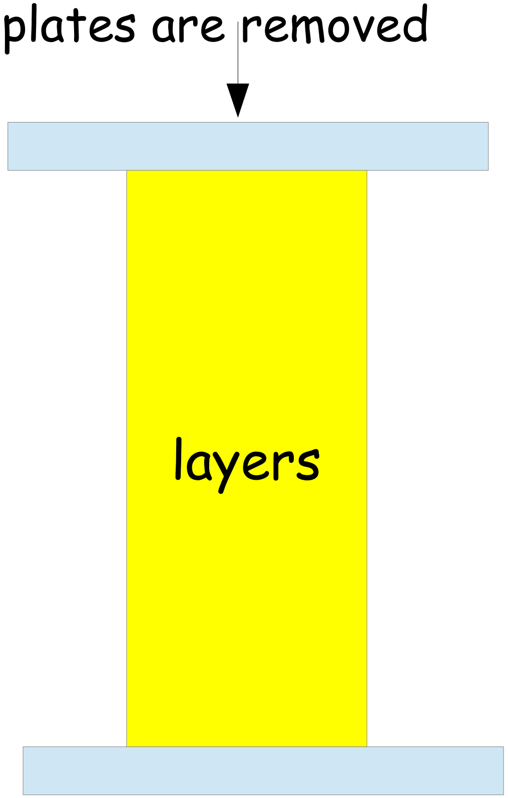
THU also have two modules (no fiber), one for compression testing; one full module

UVa: no module,small tests; sending Y11 fibers to China; giving weekly instructions; also FMPMT paper accepted by NIM



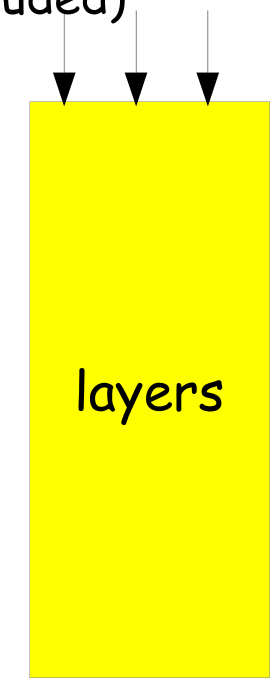
Module Load Calculation — from Sept. 2015

500kg force to flatten layers; put in rods, turn nuts to snug; 78 lbf load on 6 rods after assembly plates are removed



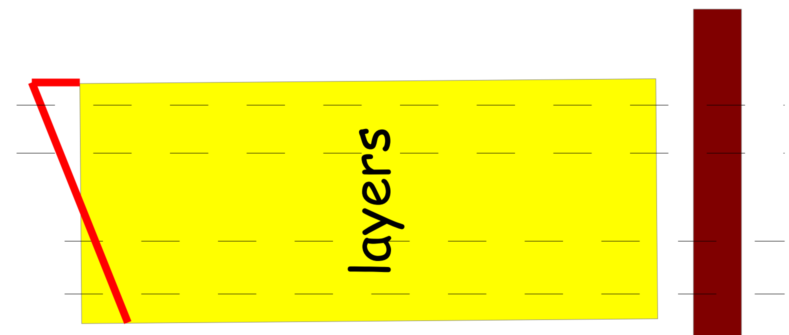
Preloading on assembly stand

Turn nuts further so weight is completely balanced by static friction (642 lbf load on 6 rods, factor 2 included)



loading

Cantilevering add more stress to top 3 rods, 400 lbf alone on top rod (2 included)

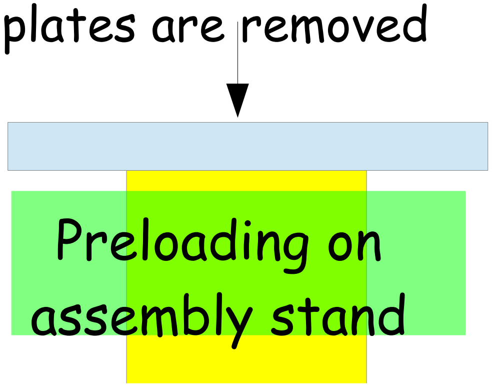


cantilevering on back support

Do not need support between preshower and shower ???

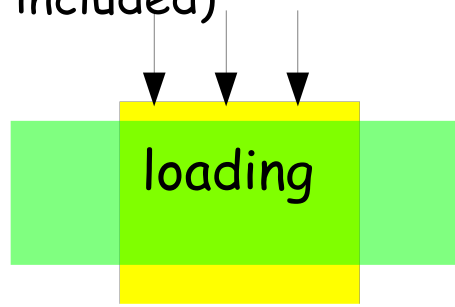
Module Load Calculation — Progress

500kg force to flatten layers; put in rods, turn nuts to snug; 78 lbf load on 6 rods after assembly plates are removed



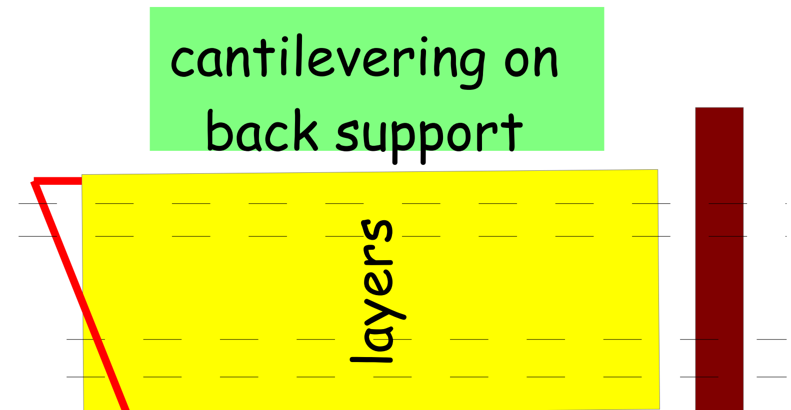
- 500kg achieved at both SDU and THU;
- procedure works mostly, but inner compression is half of the outer compression value after removing compression plates. (SDU result, brass rods, using inner sensors) (Note this partial reduction is expected and determined by the Young's modulus of all material)

Turn nuts further so weight is completely balanced by static friction (642 lbf load on 6 rods, factor 2 included)



- calc based on 0.1 static friction. Actual value is 0.1 if using Tyvek, or 0.2 if using printer paper (measured at SDU), affects light yield
- need to establish an relation between torque wrench and inner compression, since inner sensors won't be available (ongoing)
- need mechanical test to measure minimum compression for friction-support (SDU/THU ongoing)

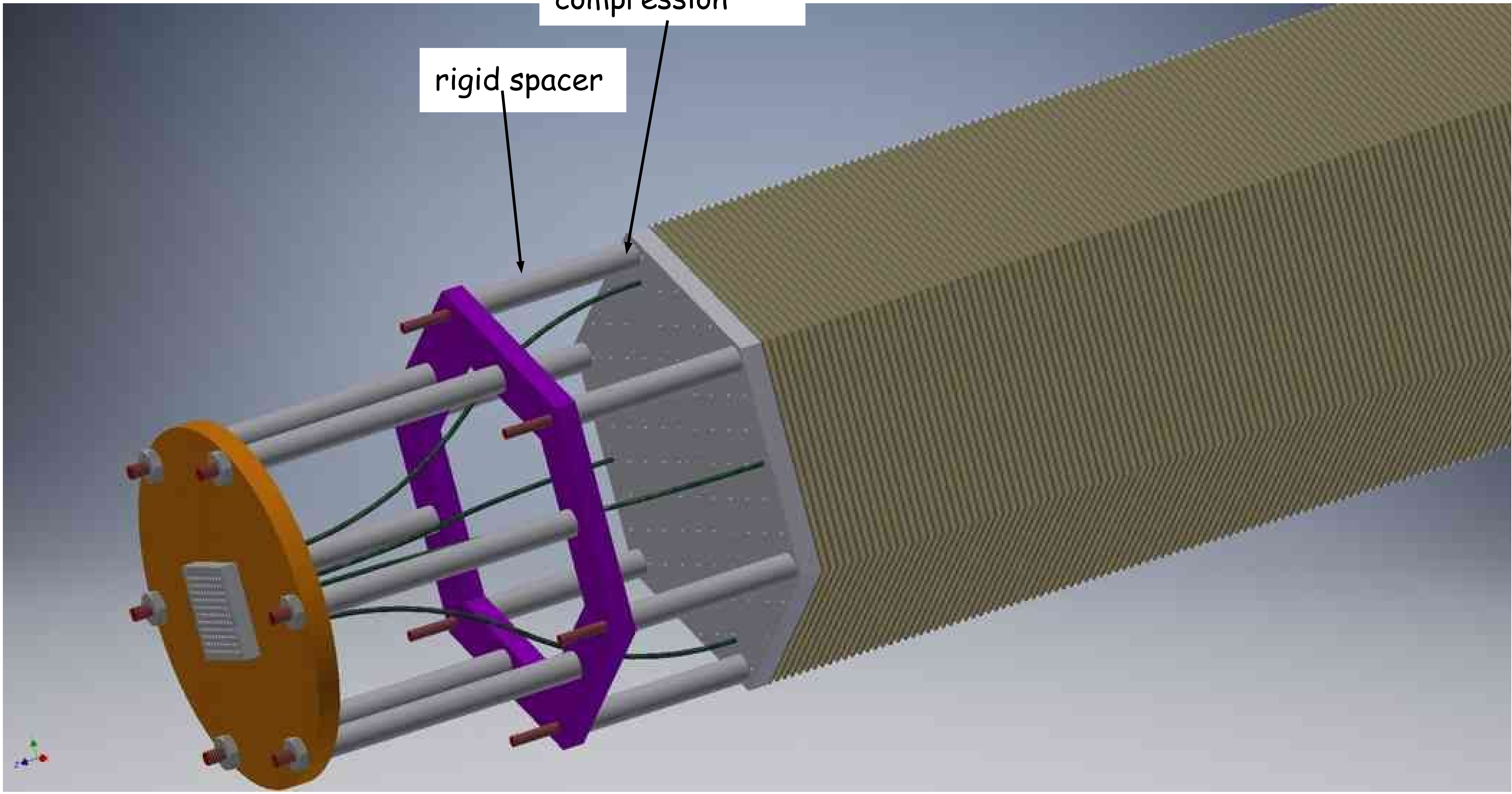
Cantilevering add more stress to top 3 rods, 400 lbf alone on top rod (2 included)



- Two planes, one for preshower, one for cantilevering Shower.
- "If back-support plane alone works for the Shower, it would be the simplest solution. So we start from here, until there is a show stopper."
- need stainless steel rods and at least the top rod needs to be 3mm dia (current 2.5mm)
- Need full mechanical tests to finalize. Decision on the use of side plates (ALICE) and a 3rd support plane between PS and Shower both depend on these test outcome.

ECal Support Design (4/21/2016)

assume 10cm fiber bending radius (no loss)



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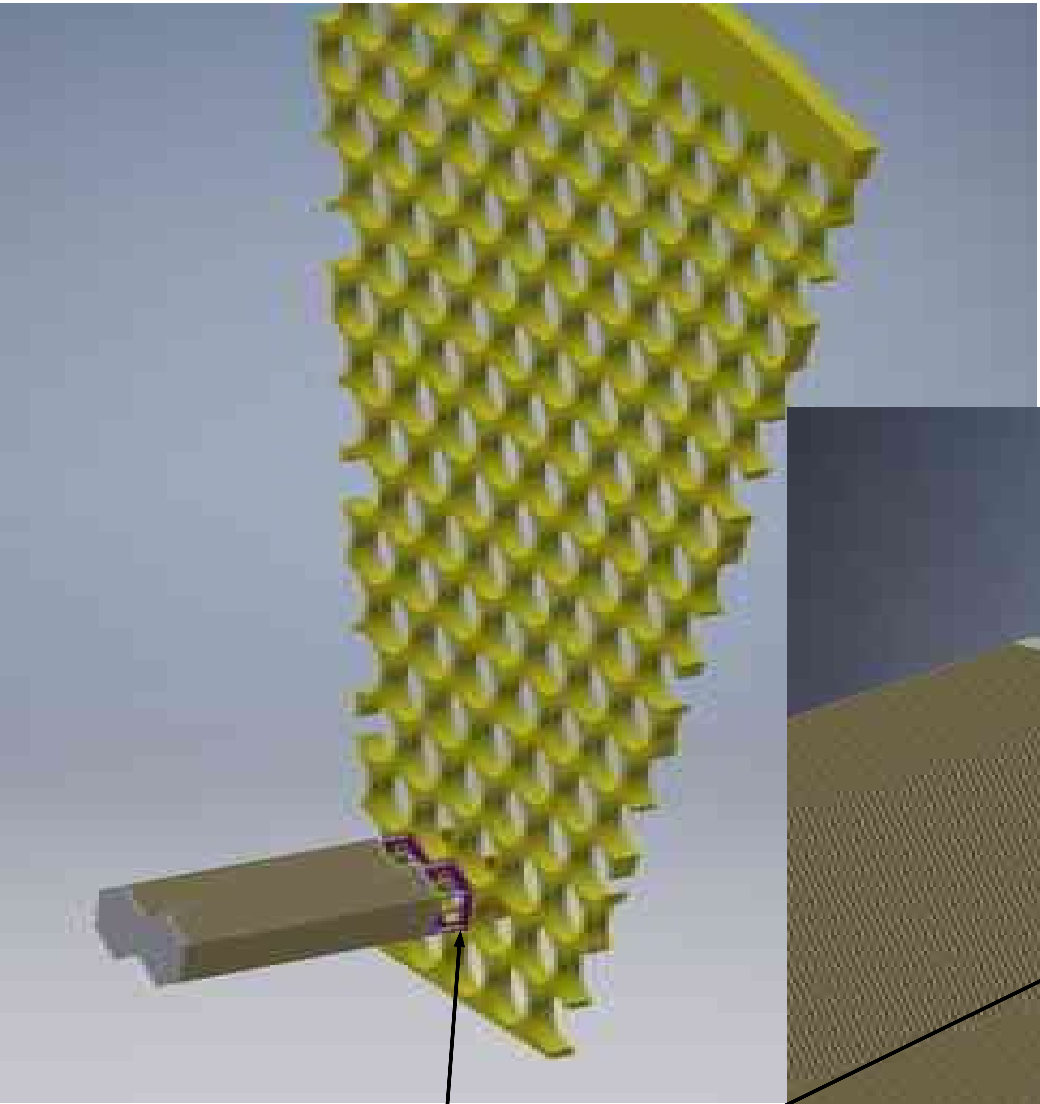
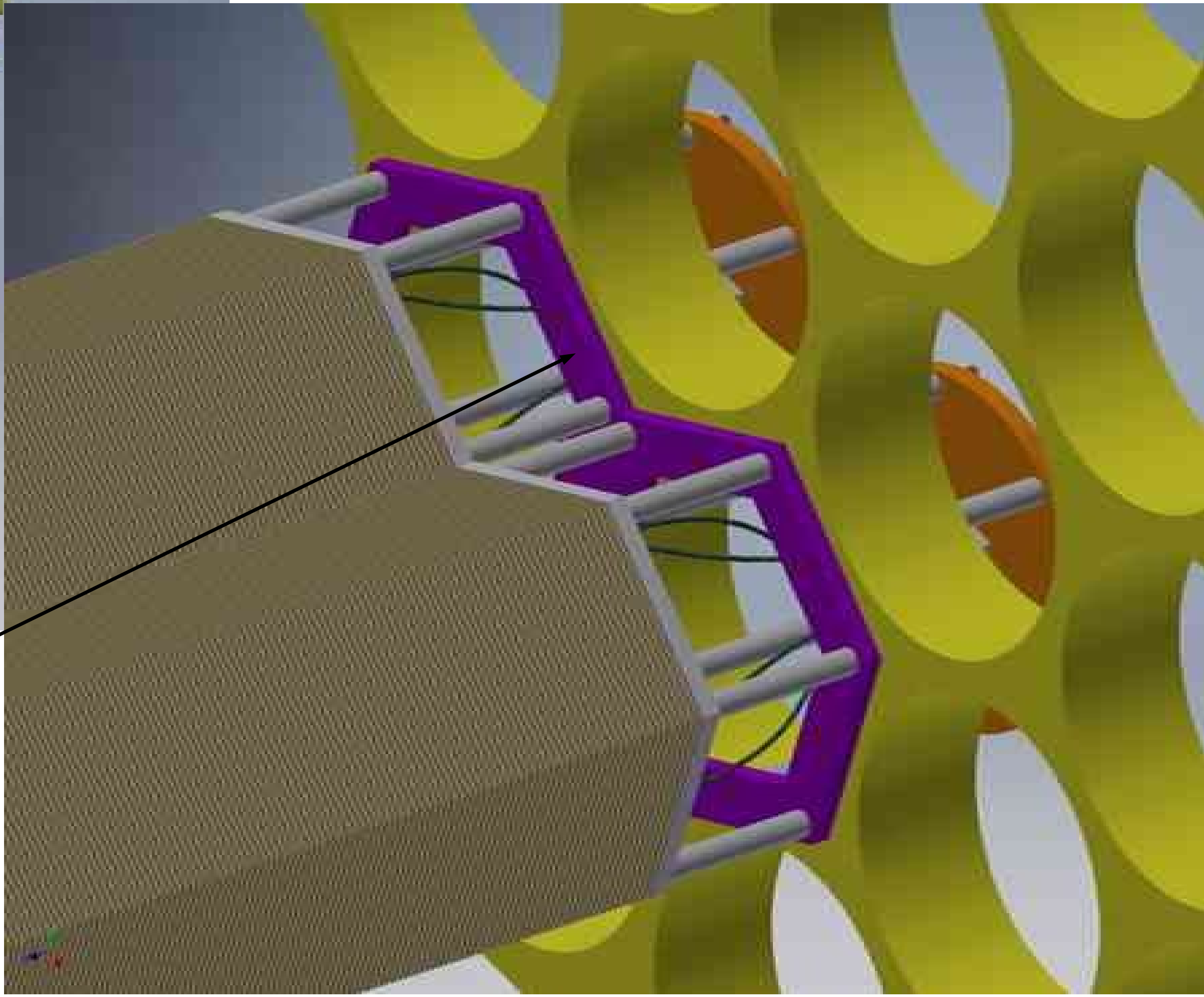


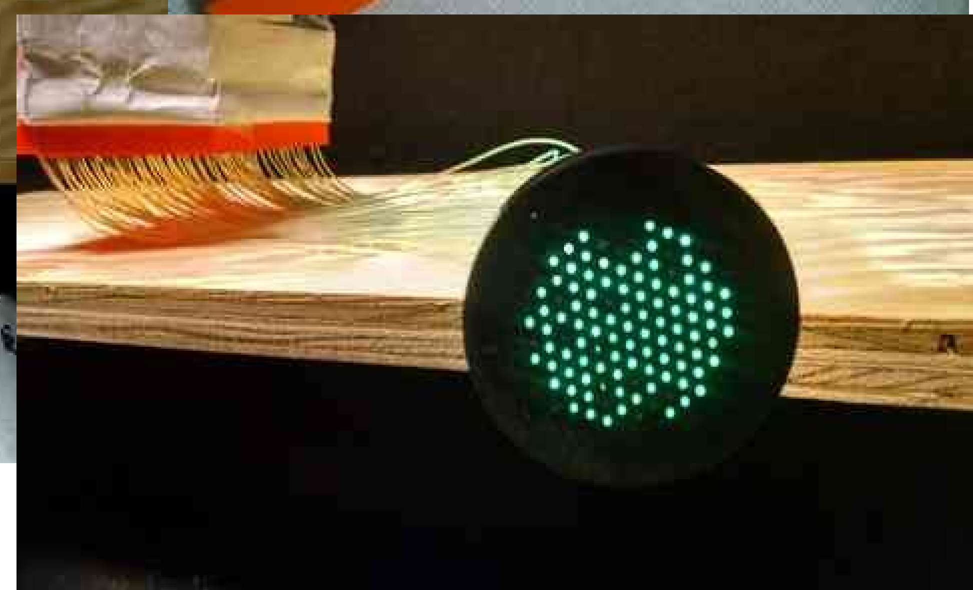


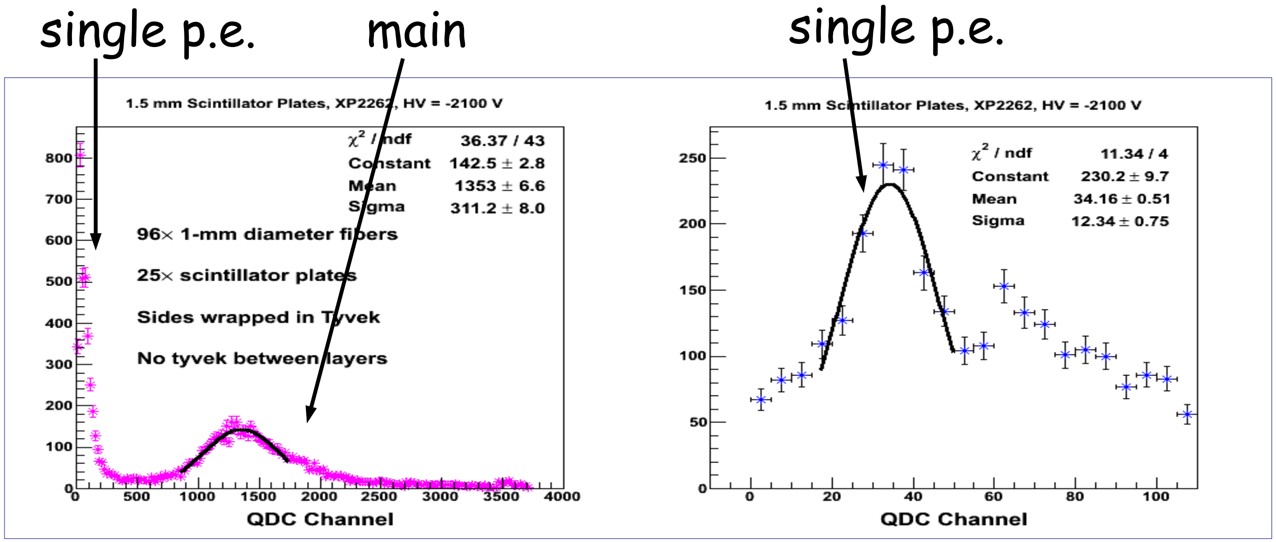
need improvement/testing to minimize module sagging (currently 2.9mm if cantilevered by rods only — SDU results)

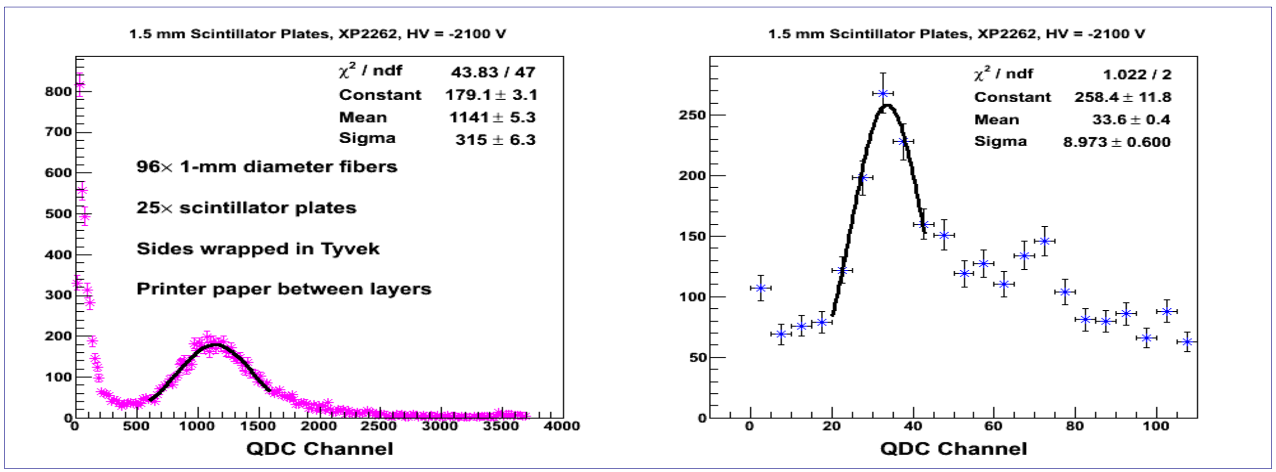
Light Yield Test — "hedgehog" test

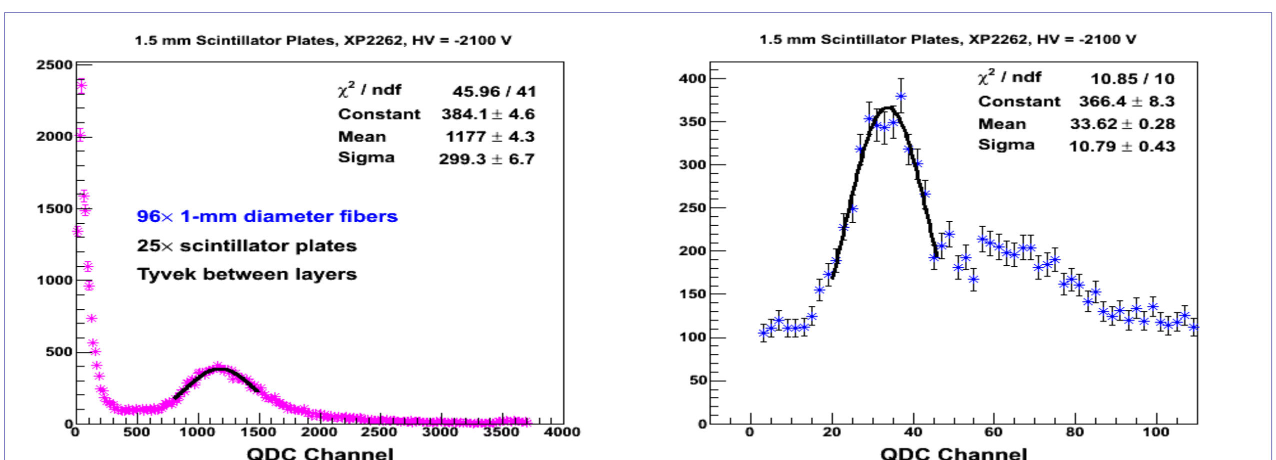
LHCb used "hedgehog" test for screening the scintillator plate quality, but there is no detailed picture/diagram for the setup. We built our own "hedgehog" setup at UVa:

- alternating layers of scintillator and reflective material on a plastic holder
- 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.









Caveat: All tests done without lead sheets, so “no reflector” is not the same as “no reflector in shashlyk module”

printer paper with loose edge wrapping:

34p.e./25 layers = 1.36p.e./layer

no reflector:

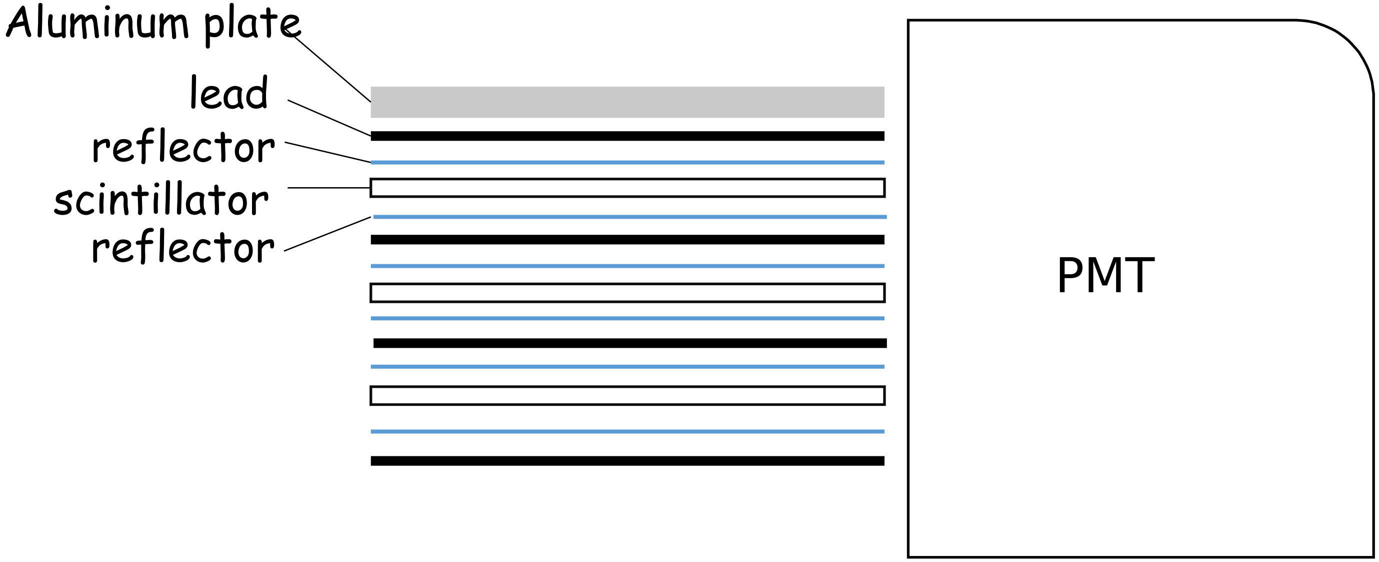
39p.e./25 layers = 1.56p.e./layer

Tyvek with loose edge wrapping:

36p.e./25 layers = 1.44p.e./layer

(Also Tyvek w/o edge wrapping: 28.5p.e/25 layers = 1.14 p.e./layer, no picture yet)

Light Yield Test — side readout (SDU)



The reflectors are changed everyday: print paper, aluminum, Tyvek, or nothing.

Currently, about 10 p.e./layer, could be consistent with the hedgehog test considering the 10% fiber trapping efficiency (multi-cladding).

Tyvek slightly higher than printer paper and aluminum (these two are comparable)

Light Yield — Projection

	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

this is 0.36p.e./MeV, compare to:

LHCb: 2.6-3.5 p.e./MeV (4mm sci, 2mm lead)

ALICE: 4-4.4 p.e./MeV (1.76mm sci, 1.44mm lead)

KOPIO: 53 p.e./MeV (0.275mm lead, 1.5mm sci, no paper, no optical contact between sci and lead; APD)

(all similar fiber density, Y11(200)MS)

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Additional #2: Our Tyvek is from LOWES (with blue prints). Anyone knows where to find pure white Tyvek 1055B?

Assuming: for 1 GeV electron, 0.2 GeV is Edep in scintillators (actually sampling may be different — need beam test)

From Preshower test, but LHCb reported similar light yield (ordering BCF91A-MC now, but won't ship until Sept.)

specific to SoLID

Additional #1: LHCb simulation reported *3 light yield for mirrored tile edge vs. transparent edge, and *2 for chemically-treated edges (diffusive reflection, can also use Bicron TiO2 paint BC622A) (ordering BC622A now)

If taking the optimistic direction in all cases, our light yield should be within 20% or factor two of other experiments (quality of Tyvek?), and may reach 3.2%

Light Yield – Projection

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If taking the pessimistic direction in all cases, we will

* use Y11 instead of BCF91A ($200k → $600k)

* eliminate clear fiber (-$500k) and try APD or SiPM readout – APD has S/N ratio (low gain, ~100); SiPM has radiation issue. – cost to be studied

Plan

1. SDU and THU will continue with mechanical testing, providing inputs to support design
2. SDU and THU will assembling full modules and carry out cosmic (horizontal) test. Vertical test will be ideal but hard to do. (within 2016?)
3. UVa hedgehog test:
   - white Tyvek; BCF91A; TiO2 paint on edge; add lead layers; (hopefully by early fall 2016)
   - PMT base tests? – need to follow up with Jlab detector group;
4. After all these tests, hopefully we will have a better idea on:
   - choice of reflective material
   - light yield
   - module infrastructure (compression, etc.)
5. Then we can talk about beam tests for the shashlyk modules;
6. Fall 2016 parasitic or cosmic+GEM tests of FA and LASPDs
7. Awaiting PIRE solicitation

Pre R&D Need – end of 2015

- At least 1/2 postdoc to "develop an end‐to-end realistic simulation and reconstruction to further optimize cost and physics reach and derive clear performance requirements for the individual subdetectors."
- Resources to build 4 more prototype modules, PMTs and HVs, combine with the SDU prototypes and conduct in-beam test:
  - construction: $34k material + ($10k-$20k) assembly stand, 1/4 postdoc, 1/2 tech or grad students, 3 summer undergrad.
  - testing: partial postdoc, 1/2 grad student
- Other items underway and covered by UVa
  - FASPD uniformity test
  - LASPD timing test with GEM
  - radiation resistance test
  - continue working with ANL engineers on module&support
  - continue working with JLab detector group on PMT base design&testing
  - misc: fiber, fiber connector, … …

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➔ THU has picked up these 4 remaining modules. Still need to cover WLS fiber+PMT cost and material for the hedgehog test.

➔ If light yield remains an issue, will need to order IHEP prototypes

Pre R&D Need – present

- At least 1/2 postdoc to “develop an end-to-end realistic simulation and reconstruction to further optimize cost and physics reach and derive clear performance requirements for the individual subdetectors.”

We have always assumed IHEP will make the Shashlyk modules for us. But communication has been difficult and political issues persist (also price inflation everytime I contact IHEP). Now it looks promising for the Chinese SDU+THU groups to make the 8 prototype modules (and may save some $$$ at mass production), but need significant pre-R&D and R&D and fund to buy material. The ECal design is still depending on these test results. ECal pre R&D should be one of the top priorities.

  - radiation resistance test
  - continue working with ANL engineers on module&support
  - continue working with JLab detector group on PMT base design&testing
  - misc: fiber, fiber connector, … ...