EC and SPD Updates

The SoLID EC Working Group

SoLID Collaboration Meeting

June 8-9, 2020

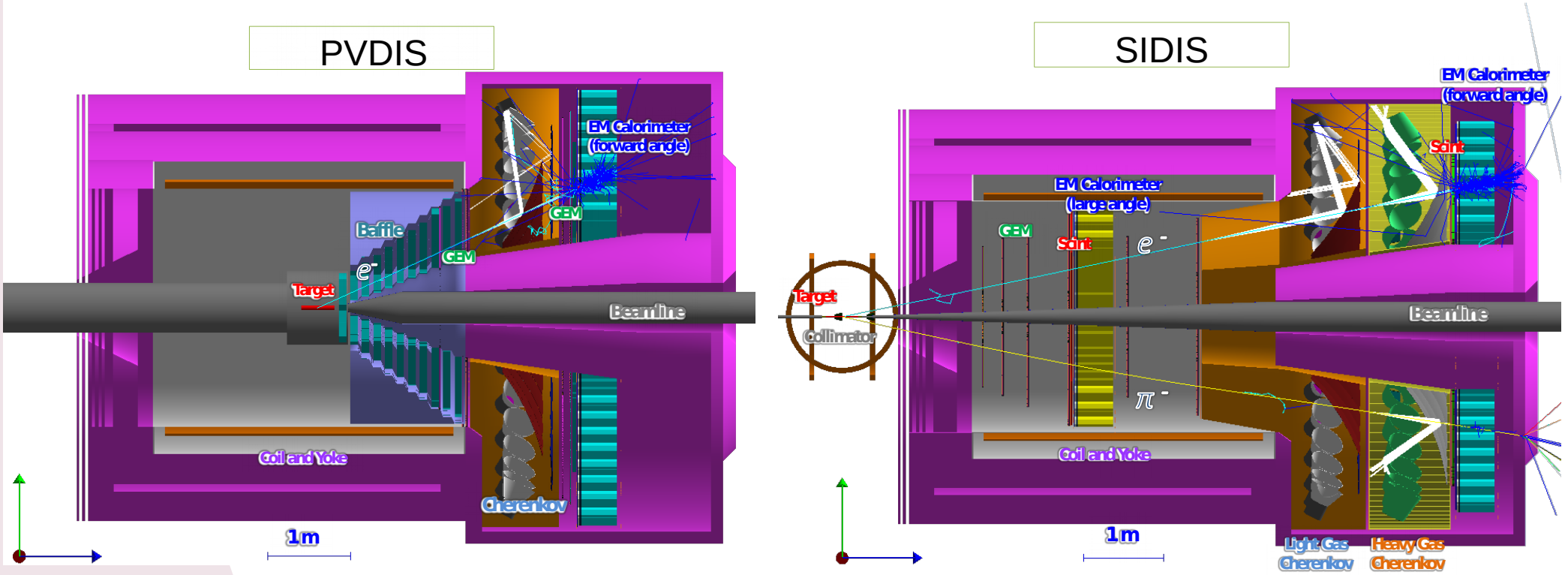
Outline

1. Overview of ECal and SPD status
2. Material testing progress since last meeting (Jan 2019)
3. Shashlyk prototype construction and testing status
4. Support structure status
5. Discussions (?)

ECal and SPD Overview

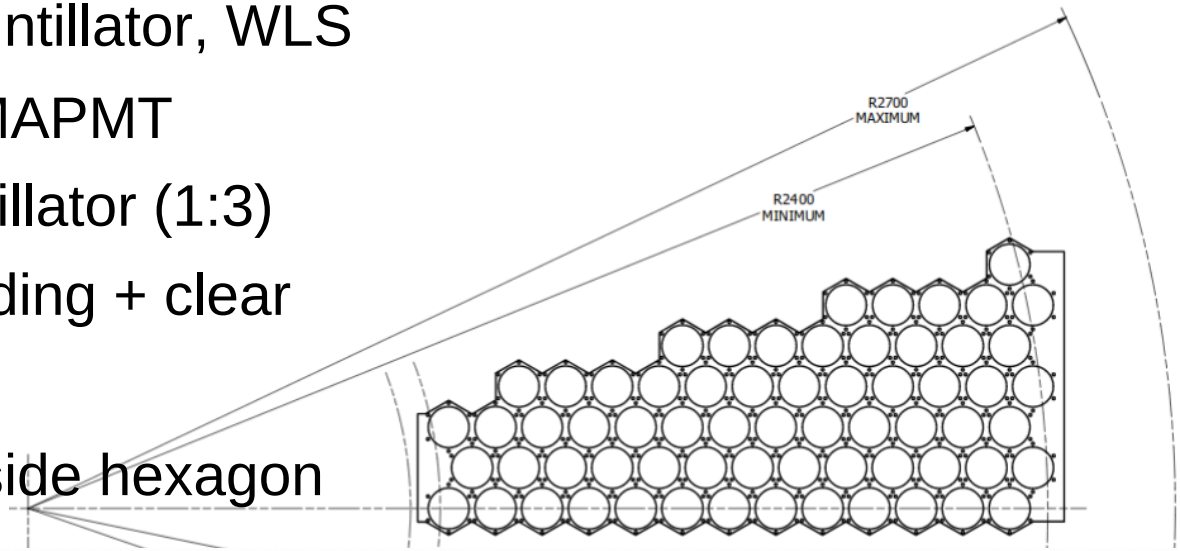
EM Calorimeter is used for PID, triggering, and background suppression. It is divided into large- and forward-angles in SIDIS configuration.

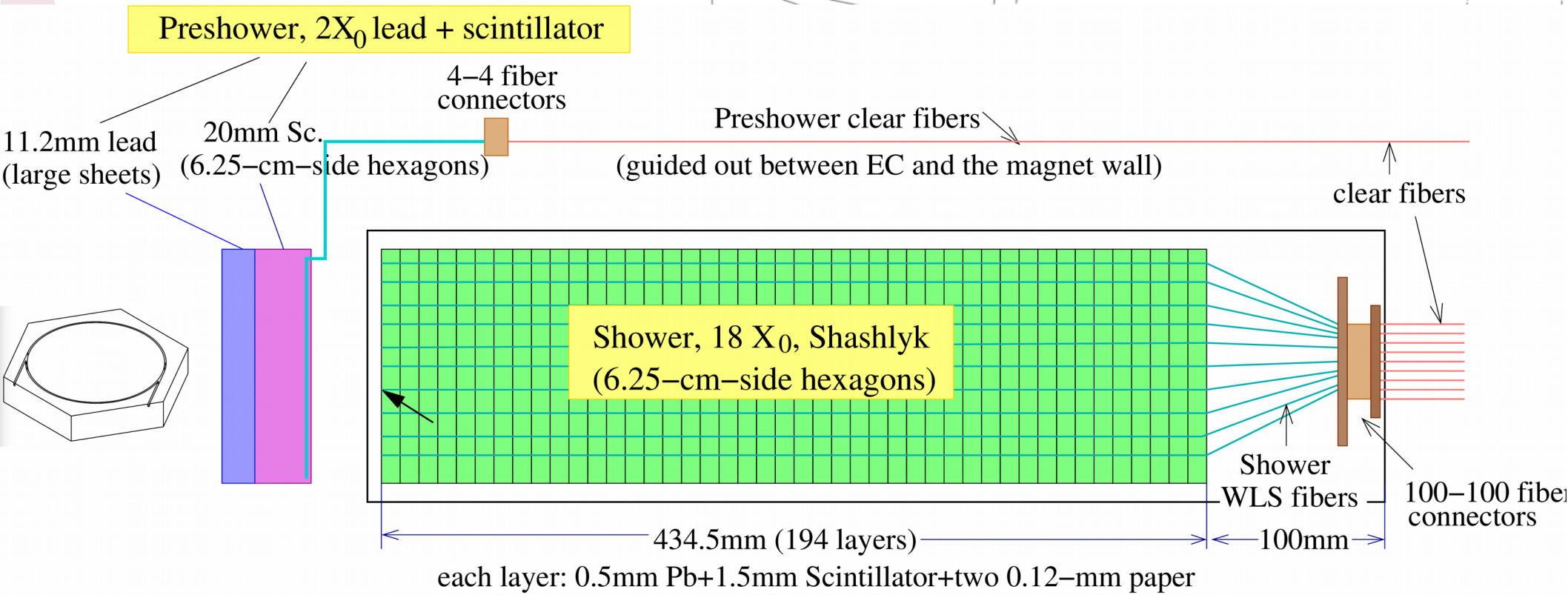
Scintillator Pad Detectors (SPDs) are used in SIDIS configuration to reject photons. It is divided into large- and forward-angles. The large angle SPD will also provide TOF.



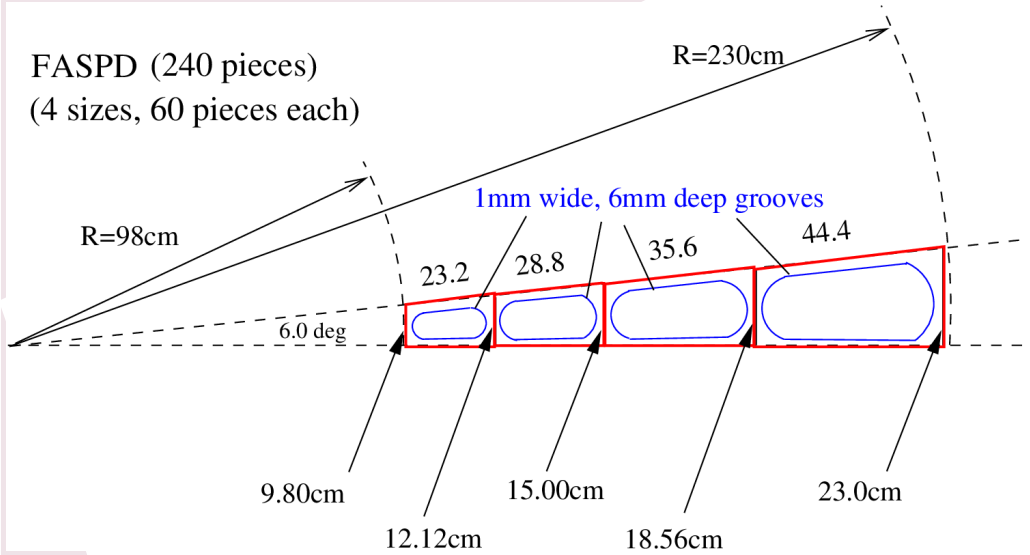
Shashlyk (Shower) design – size and sampling

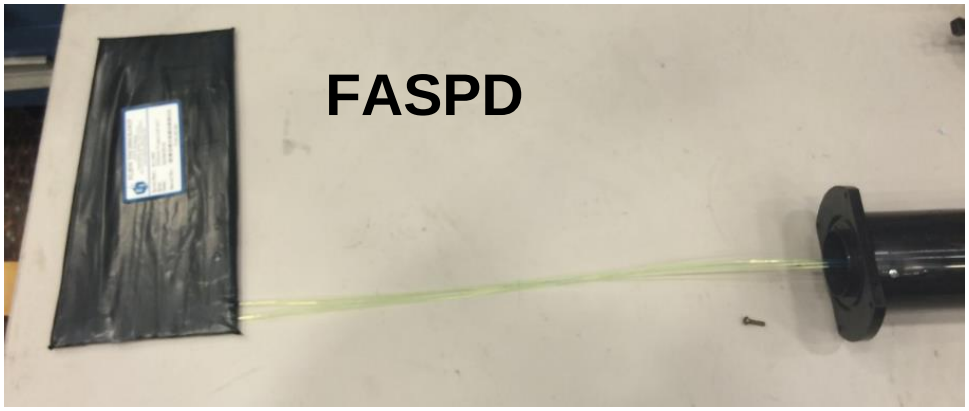
- Preshower: $2X_0$ lead + 20mm scintillator, WLS fiber embedding + clear fiber + MAPMT
- Shower: 0.5 mm Pb/1.5mm scintillator (1:3) sampling, $18X_0$, WLS fiber threading + clear fiber + PMT
- Lateral size: $100cm^2$ or 6.25cm-side hexagon



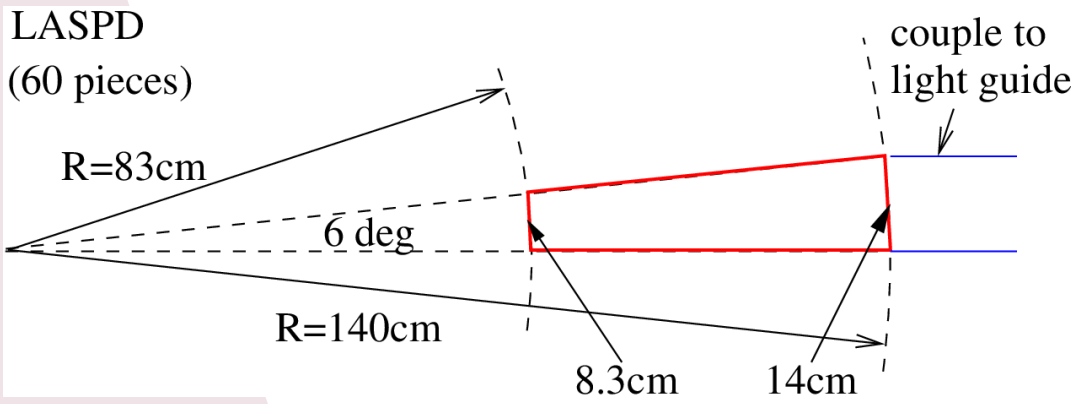


SPD Design and Prototyping





light yield: 9-11 p.e.

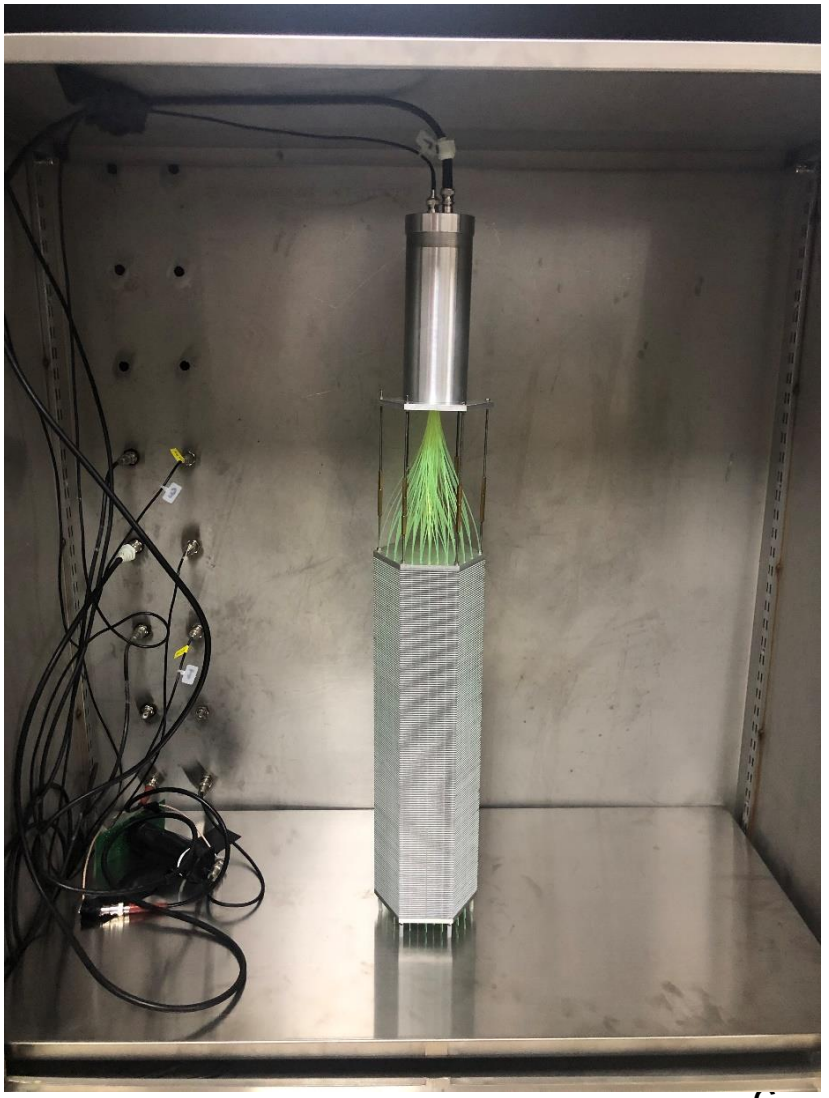


cosmic timing test: ~150ps single-side readout

Preshower design and prototyping status

Preshower light yield: 90 p.e. at best

Cosmic testing for Shashlyk modules (SDU, THU)



Shashlyk Prototype Modules

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 (SC)	none	Tyvek→ TiO2	254	48	SPE/SDU
SDU2	Kedi new	Chn	printer paper	BCF91A (SC)	Chn silver-plating	Tyvek→ TiO2*	383	83	SPE/SDU
SDU3	Kedi new	US	printer paper	Y11(200) (MC)	Chn silver-plating	TiO2+glue (1/1)	450	108	SPE/SDU
SDU4	Kedi new	Chn	powder paint	BCF91A (SC)	ESR reflector	TiO2+glue +water	562		SPE/SDU
SDU5	Kedi new	US	Tyvek (0.145mm)	BCF91A (SC)	ESR reflector	TiO2+glue +water	398		SPE/SDU
SDU6	Kedi new	Chn	powder painting (70um)	Y11(200)MC or BCF91A-MC	new/tbd	TiO2+glue			
THU1	Kedi original	Chn	mirror mylar (reflective)	Y11 (MC)	Italian silver shine	TiO2 (Kedi)	430-470	96	not measured
THU2	Kedi new	Chn	powder paint	BCF91A (SC)	Italian silver shine	Tyvek wrapping	748	90-103	SPE/IHEP
THU3	Kedi new	Chn	powder paint	BCF91A-MC					

Shashlyk Material Test and Light Yield Status

- With extensive material testing, the best combination seems to be: Kedi new scintillator; reflective power painting on lead sheet, ESR reflective tape at fiber end, and TiO2+glue mixture on module sides.

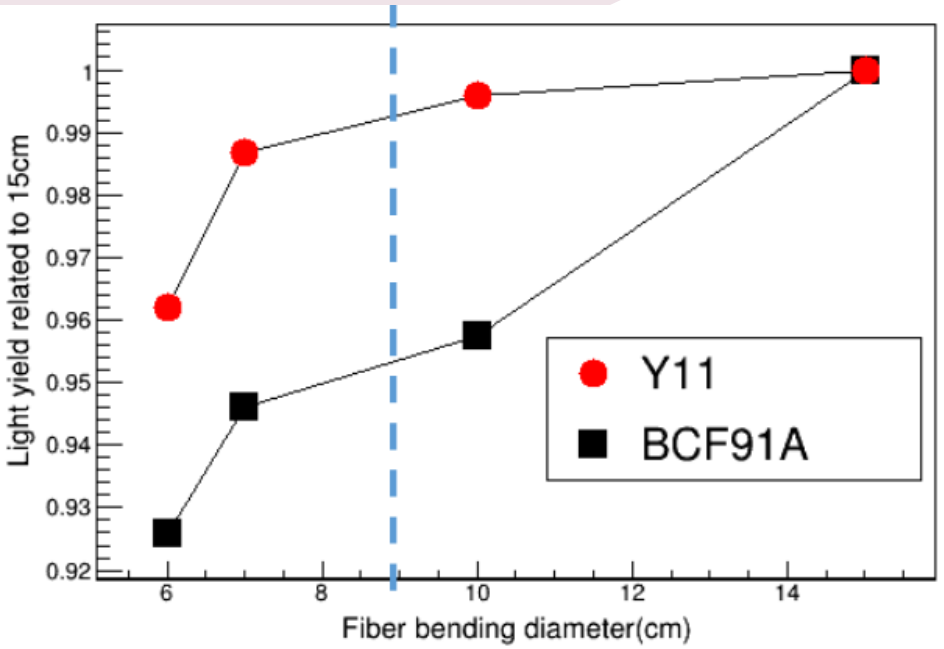
- The higher yield of THU2 module is due to PMT gain determination and was never fully understood. Most recent testing results of THU2 at SDU lab showed comparable light yield as SDU modules.

- Using the highest MIP light yield of 500 p.e./200 layers 1.5mm layers (at 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 below LHCb 2.6-3.5 p.e./MeV, ALICE 4-4.4 p.e./MeV, and KOPIO 53 p.e./MeV. We had expected the Y11 to provide factor 2 increase for SDU3, but results not as high as expected (could also be other material not optimal).

- With 1666 p.e./GeV electron, the energy resolution due to photon statistics will be 3% if also considering light loss of fiber connector and clear fibers. This is okay considering the intrinsic resolution is (5-6)%, although ideally we would like to see the effect of photoelectron statistics to be negligible.

- Fiber bending and attenuation loss ongoing

Fiber Bending Light Loss (SDU)



BCF91A lose more light than Y11 with same bending diameter, but the difference is not too much.

bend diameter (result in channel)		15cm	10cm	7cm	6cm
BCF91A (SC)	#1 (1m)	447	428	423	414
	#2 (1m)	326	313	402	402
Y11 (MC)	#1 (1m)		524	519	506
	#2 (1m)	767	760	751	758

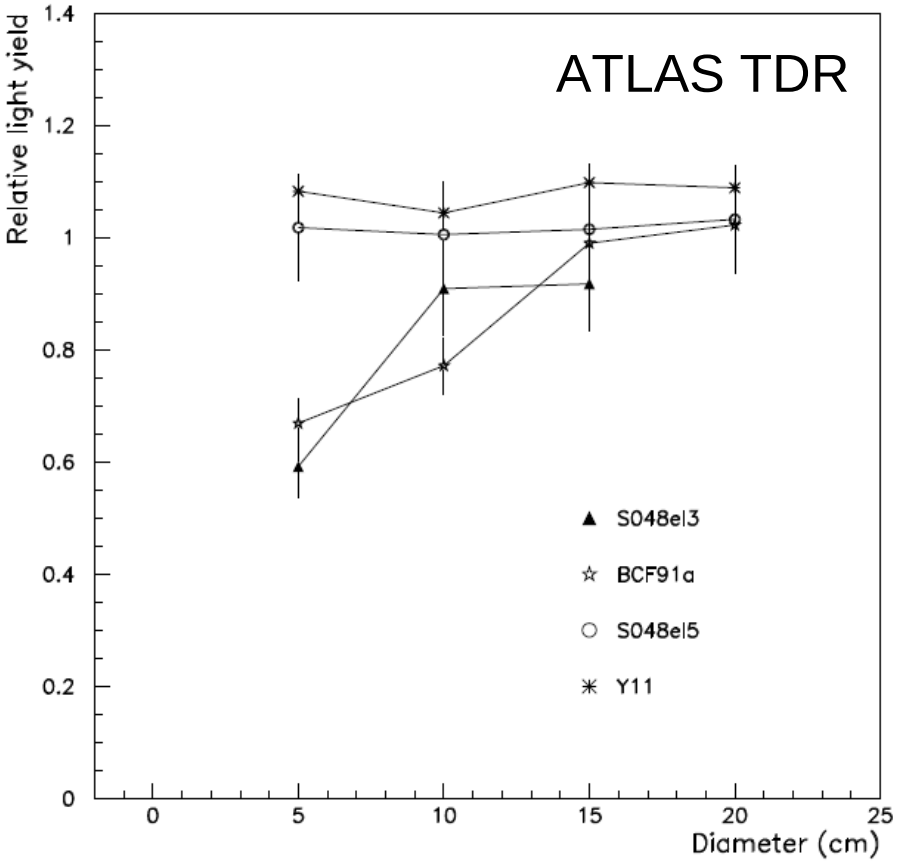


Figure 5-24 Relative light output for some fibres as a function of bending diameter.

Results encouraging;

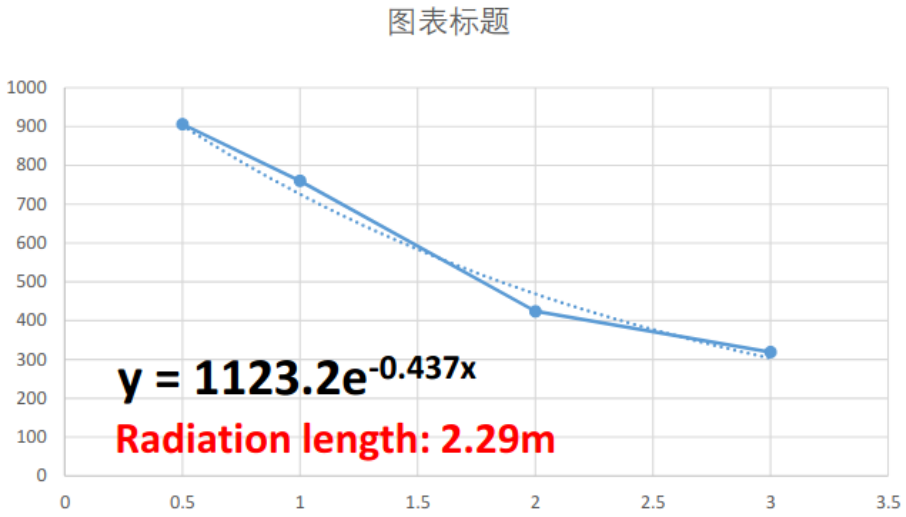
Will repeat for BCF91A-MC

Clear fiber attenuation length test **(SDU)**

Test setup:

- LED light, transfer light from WLS fiber to clear fiber with connector
- Clear fibers are polished by polishing machine in SDU
- For long fibers, bend with same 15cm diameter

Fiber length	Bend circles(15cm diameter)	QDC channel
0.5m	0	906
1m	0	771/771(two tests)
1m	0.5	771/754(two tests)
2m	3	424
3m	5	319

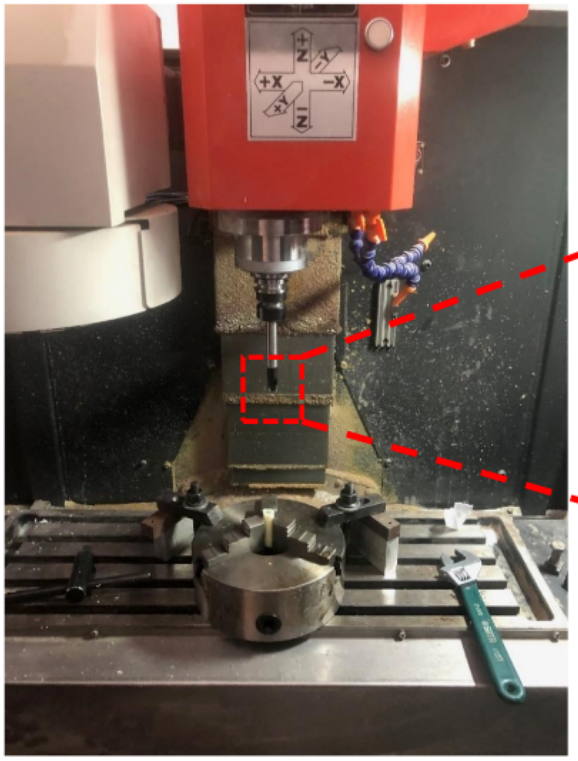


Still get very bad attenuation length result…….

- These are for SG BCF98-SC fibers. Previously tested at THU (Apr 2018, ~2m). Results shown here still not so encouraging.
- Will do bending test first and separate bending from attenuation loss, (though previous test of Kuraray PSM fiber showed very small bending loss.)
- Will repeat for BCF98-MC

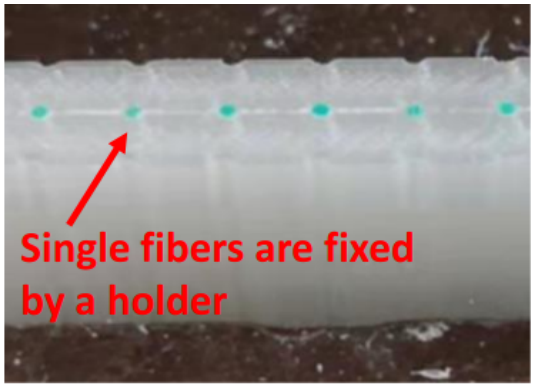
Fiber polishing in SDU

Fiber is polished in bundle or as single by a diamond milling cutter in SDU. This method shows good efficiency and quality.

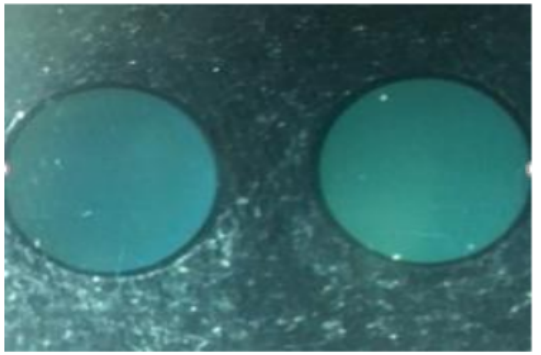


Polishing Machine tool

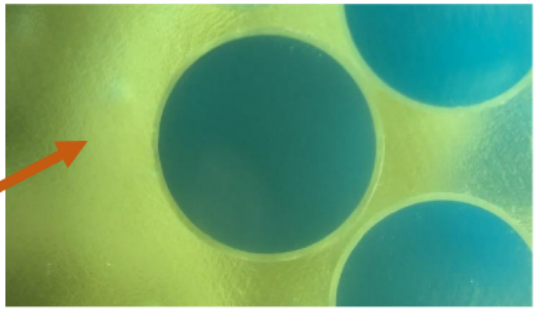
Diamond milling cutter



Loose single fiber (unglued)



Single fiber in connector



Optical glue

Fiber in bundle

Plan for material testing and more prototype construction

- UVA shipped BCF91A-MC and BCF98-MC (multicladding) fibers to China for building SDU6 and THU3;
- Because both THU and SDU have material for only one more module, we held off making new modules. And then this work was paused due to Covid-19.

Once SDU and THU can start lab testing again, we will focus on:

- Measure bending loss of BCF98-SC and BCF98-MC and separate these from attentuation loss.
- Building THU3 and SDU6 using BCM91A-MC fibers, connect to 100x BCF98-MC fibers using 10x DDK connectors and compare light yield.

Shashlyk Performance Study

- All published results are photoelectron yields in response to EM showers, and we have measured only MIP response. Determining the EM shower response and energy resolution of electrons of a few GeV will be ideal.

- Beijing IHEP test facility has only 100 or 200 MeV mixed particle beam. Simulation shows responses to electrons and pions at this (low) energy are difficult to separate. Also this facility has been going through upgrade (even before covid-19) and wasn't ready in 2019 (and is still not ready now).

- We had planned to test SDU2,3,4 in the SHMS or HMS during A1n running, but later discovered there is no space to place them in the spectrometer. Removing existing leadglass blocks required too much of effort.

- We are now back at studying the feasibility of testing these modules at FNAL's test facility, which is also shut down currently. Beam request was sent last week. Earliest possible time would be early 2021 (if we can piggyback on some other tests). We will need to bring our DAQ, and borrow logic modules from FNAL to integrate with the DAQ of their test facility.

ECal Support

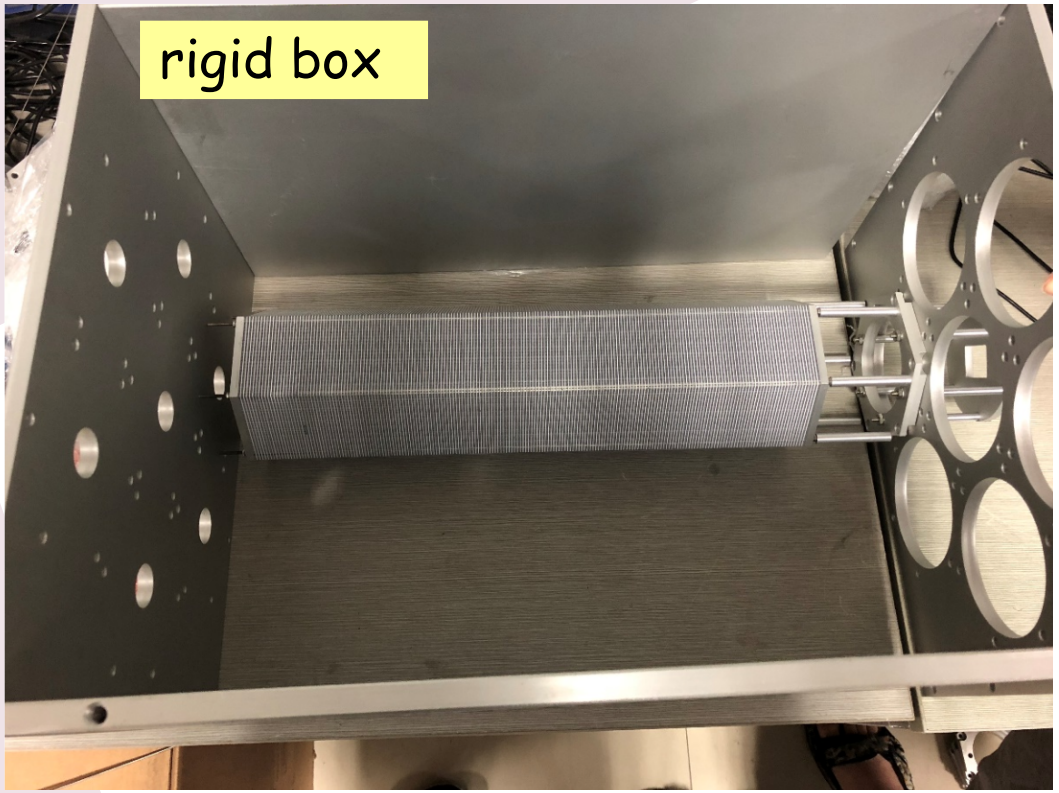
- In 2019: ANL's engineer (Vic G.) has been working on module support structure, to be integrated with the main support (JLab/eng).
  - Designed a 7-module support for the beam test, which SDU made and test out, but there are many problems (mounting module to frame, module front plate design, not possible to mount individual module, etc)
  - Has been working on EC layout for 3 configurations, but latest layout is still incorrect
  - At this point, in-person or detailed discussions is crucial for moving forward
- Paul Reimer is trying to get the latest design from Vic and see if work can be done within ANL/MEP group, but covid-19 shutdown is making this difficult.
- Module front and back plate design must be integrated with support design, will affect how modules are assembled.
- No design is done yet for preshower, lead and SPD support/mounting. Need to integrate mounting/fixture of WLS fiber with design. LED test structure can be integrated at this stage.

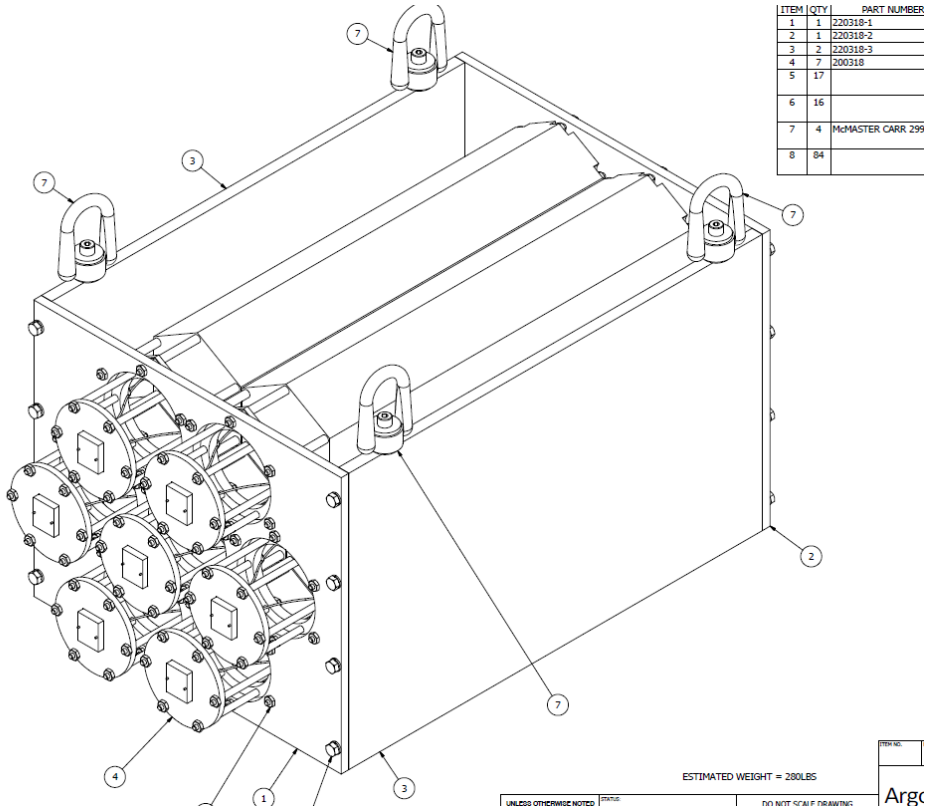
To Do Items Related to Director's Review Outcome

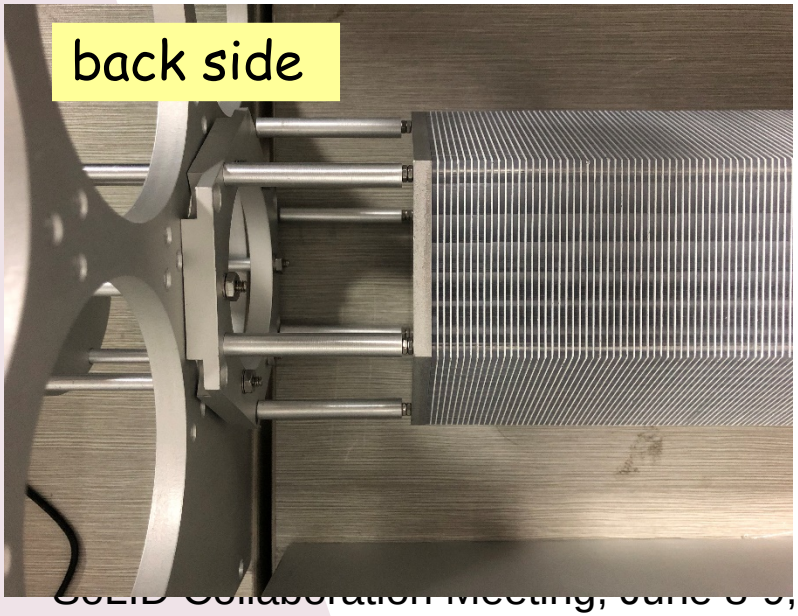
- "A complete pre-conceptual design of the detectors, their supports and installation including assembly and installation tooling would help the SoLID project with the cost and schedule analysis to develop a pre-conceptual cost."
- "The risks for the project are not yet complete and focus on technical risks. currency fluctuations, VAT and tariffs, risks related to university contribututors underperforming (or become impossible?), EH&S associated to lead heandling, hoisting and rigging etc."

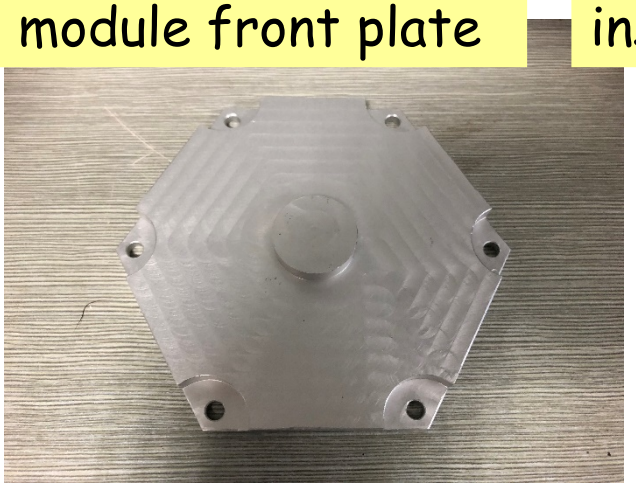
Backup Slides

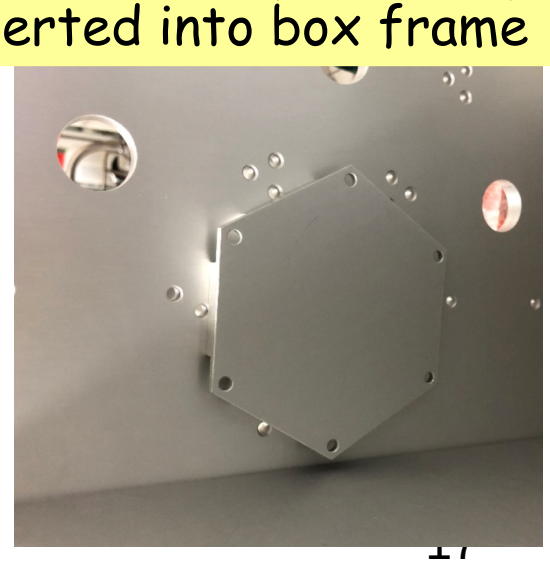
ECal Support











ECal Layout

PVDIS EC coverage : (calculations)

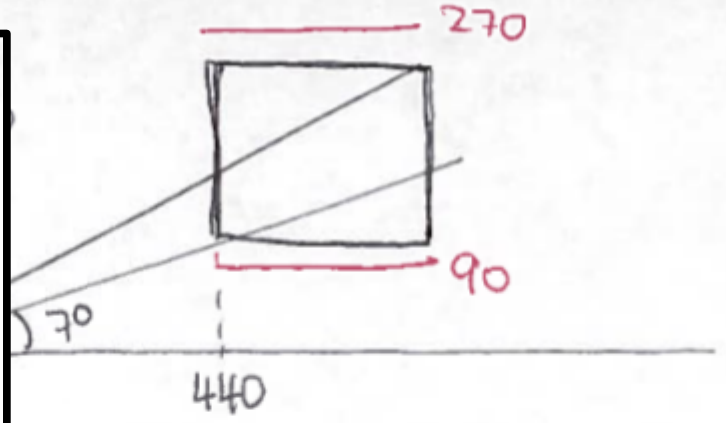
$(325-10) \times \tan 21^\circ = 120.9\,cm$

$(325+\underbrace{50}_{\text{EC length}}-10) \times \tan(34.6^\circ) = 251.8\,cm$

(2cm PS
2cm support
45-46cm shower module)

need full coverage from 120.9 cm to 251.8cm.

SIDIS FAEC
+J/ψ



$R_{in} = (440+350)\tan 7^\circ =$

$= 790 \times \tan 7^\circ$

$= 97.0\,cm$

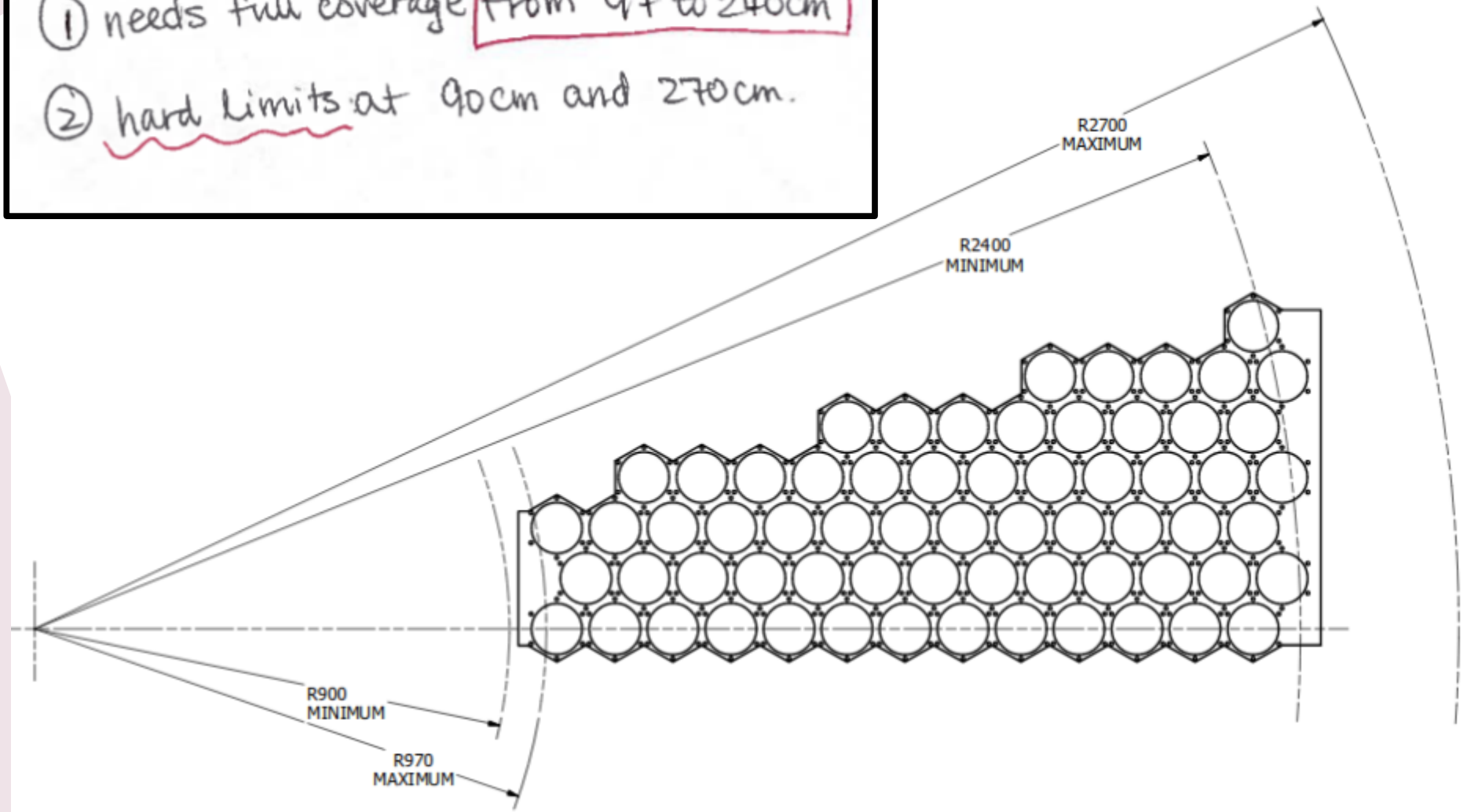
① needs full coverage from 97 to 240cm

② hard Limits at 90cm and 270cm.

From Vic, ~August 2018 (SIDIS FAEC)

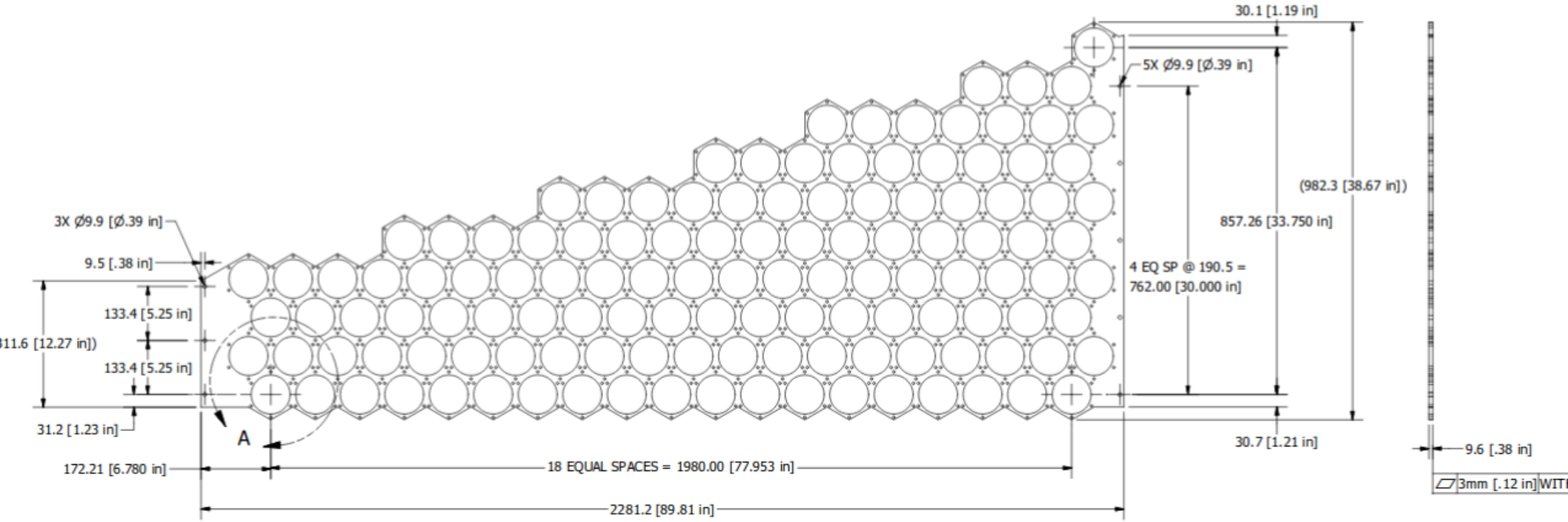
① needs full coverage from 97 to 240cm

② hard Limits at 90cm and 270cm.



ECal Layout

However, in July 2018 also received from Vic the support plate design with quote. Coverage doesn't seem correct, not sure where this one comes from.



To do:

- Lots of uncertainties in how to mount modules. In-person discussion seems mandatory;
- Continue to PVDIS and SIDIS/LAEC layout.
- Figure out where the layout for the July 31st support plate design comes from, and revise.