Shashlik coat painting and mirror reflector update

Ye Tian, Liping Wang

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Shandong University

Outline

- **Painting**
- **Fiber mirror**

PART 1: Painting method

- Purpose: wrap the surface of shashlik module, to enhance light yield and provide shield from light
- Material: mixture of TiO2 + water + glue(1: 0.8: 1)
- Thickness: not sure, total thickness less than 0.5mm, paint twice now
- Good painting quality

Shashlik EC test result

Coating material	Without coating	Tyvek	Glue once	Glue twice	Glue twice + tyvek coating
SDU#3	381.3		491.3(28.5%)		
new					
SDU#4(powder painting)	261.5	346.8(32.7%)	360.5(37.9%)	371.3(42.0%)	370.7
SDU#5(tyvek)	220.4	269.9(22.4%)		279.6(26.9%)	278.6

The coating improvement of SDU#5 is significantly smaller than SDU#4. Since the improvement of both tyvek coating and painting are smaller than SDU#4, the painting quality should not be the main reason. Not sure the reason(Maybe the reflector layer also influence side reflectivity?).

PART 2: Fiber end mirror reflector: Silver mirror

- Visited the factory
- The evaporation method process

Fiber protection

Evaporation machine

Clean fibers

Add silver wire

Final product

Silver mirror discussion and problem

- Advantage:
  1. Easy to deal with fiber
  2. Fiber could be hide totally in module
- Disadvantage:
  1. High price(ask more than ￥10/each end)
  2. Quality control
  3. Easy to shed
  4. Aging problem

For the recent fiber batch that showed in last slide, we sent more than 200 fibers that polished by factory, but the mirror is slightly easy to shed and only get 50% light improvement. (disappointed and tired)

Other choice will be adding other mirror reflector. And I will focus on this efficient method from now on.

Other mirror reflector by pasting

Mirror reflector by pasting also have good reflectivity, and is more economical and stable than silver mirror, however the challenge are how to hide the fiber end in module and how to fix and align fibers to the mirror.

- Any reflector with good mirror reflection could be the choice
- The fiber could be glued to mirror or touched the reflector by force
- The reflectivity is highly influenced by fiber end polishing quality

  Results shows that good polishing quality at fiber end improve the mirror reflectivity, and also even without any mirror, good polishing fiber have more light yield.(The result is compared from fiber polished by factory and ourselves.)

Some reflectors in choice

3M™ Enhanced Specular Reflector series (3M ESR)

Typical ESR

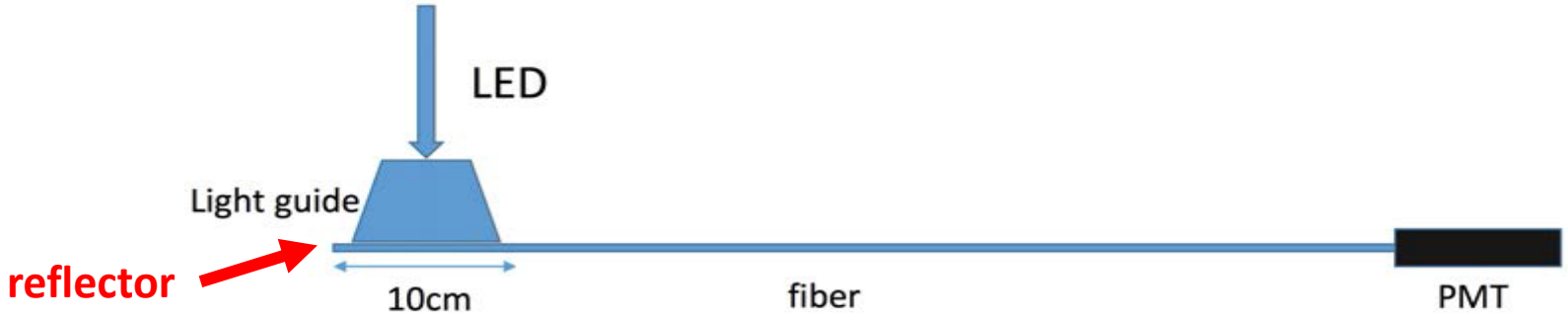
ESR + white layer

ESR + black layer

Silver film tape

Both silver layers
(similar material as ESR, but not goo quality as ESR)

Test method and result



Mirror material	1	2	3	4	5	6	improvement
No mirror	375	446	394	434	377	418	
Silver film tape	601(60%)	690(55%)	550(40%)	677(56%)	573(52%)	700(67%)	55%
ESR	676(80%）	821(84%)	697(77%)	783(80%)	675(80%)	764(81%)	80%
ESR+black	629(68%)	807(81%)	718(82%)	775(79%)	685(82%)	755(81%)	80%
Both silver layers	642(71%)	736(65%)	605(54%)	727(68%)	578(53%)	715(71%)	60+%
ESR+white	673	821	720	762	664	755	79%

All ESR serial have similar reflectivity, which could read 80%, could be a good reflector choice.

Fiber mirror reflector applied to Shashlik module

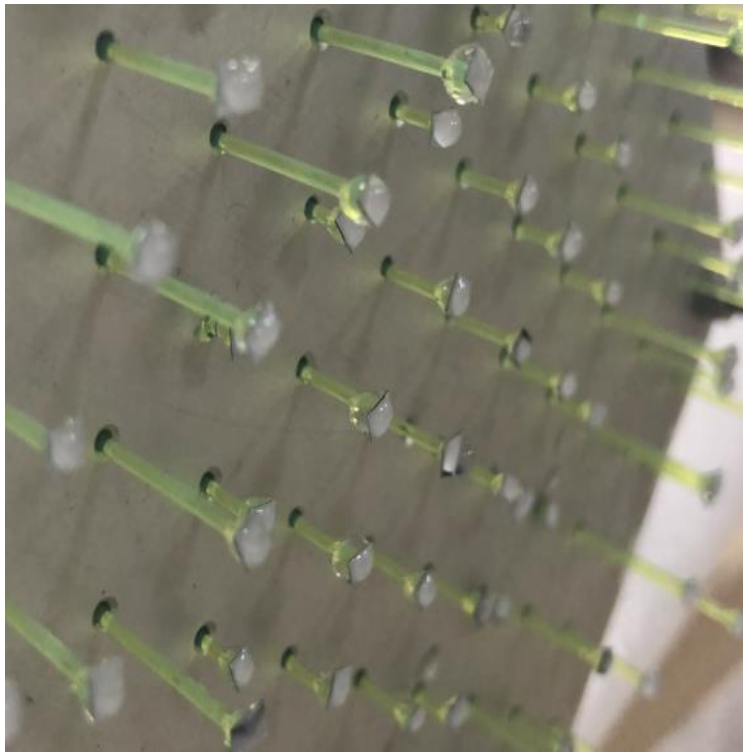
SDU#4 and SDU#5 are already inserted fiber without any reflector, to fully utilize the fiber for test, we plan to add the fiber reflector(also, we could replace all the fibers with new bundle).

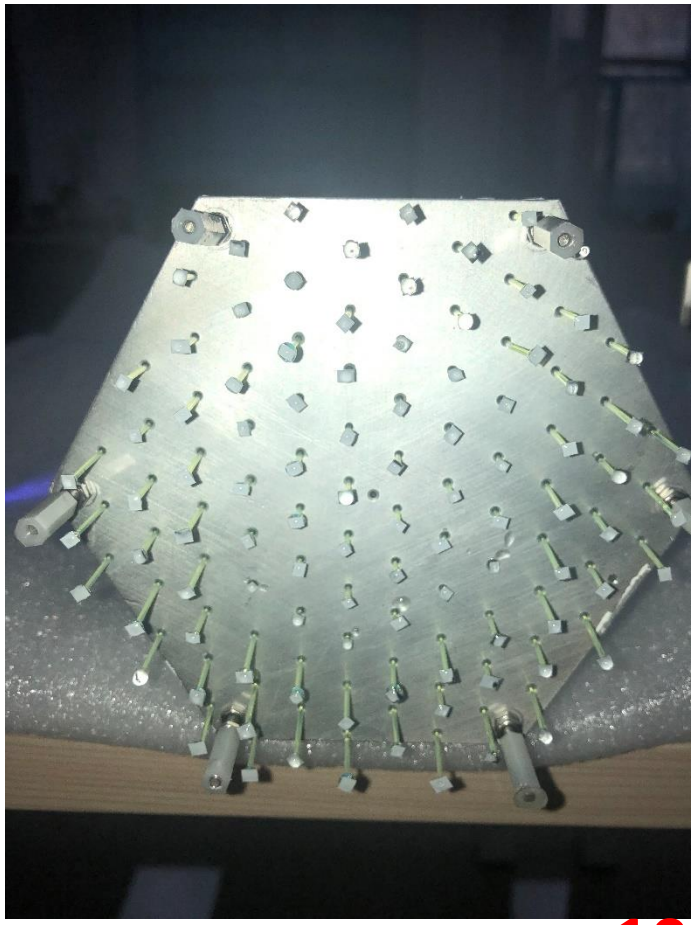
Reflector for SDU#4

- We add separate reflector at each end of fiber using ESR+white, and fix it by UV(ultraviolet) glue.

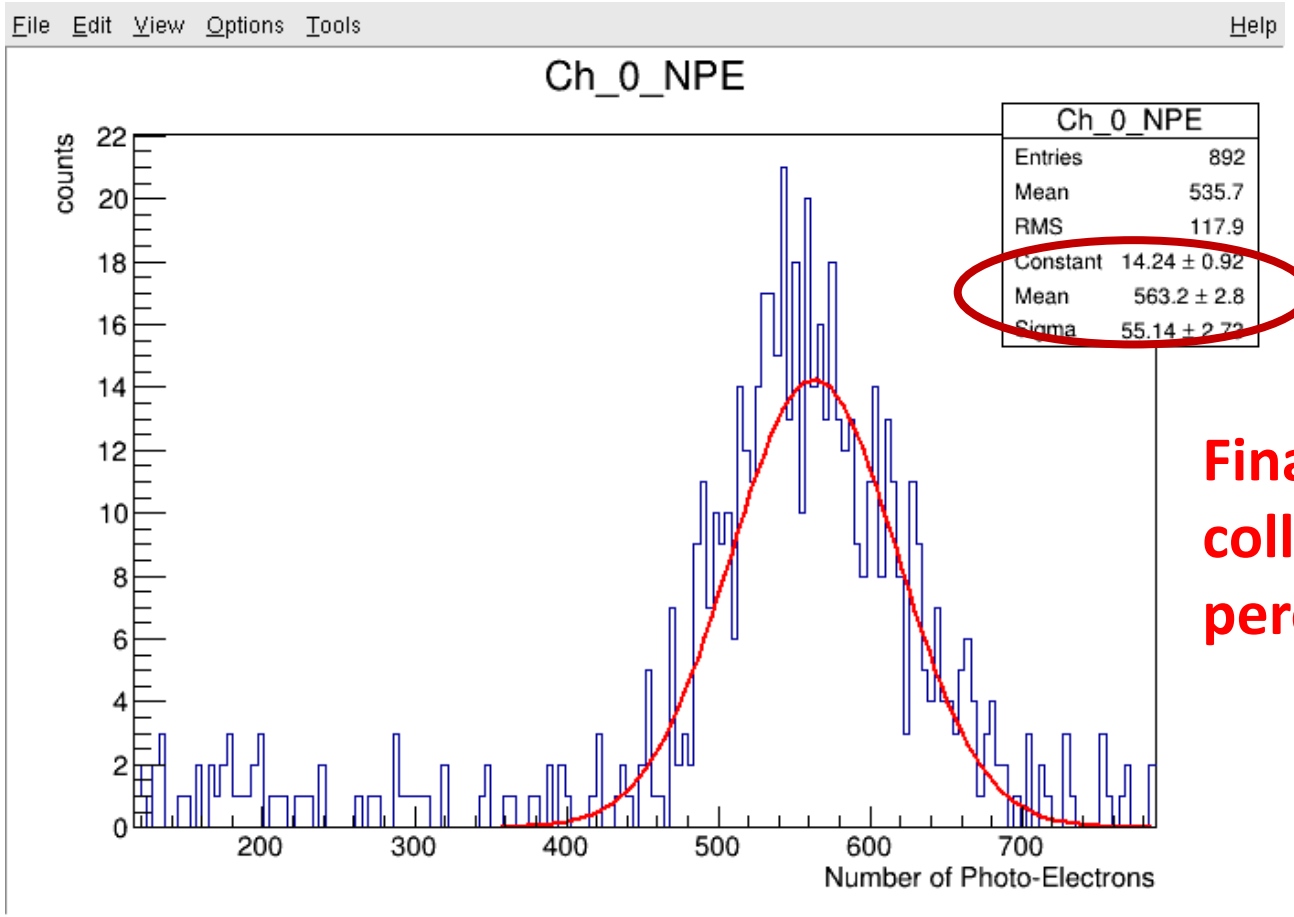
- Since the surface of fiber and reflector is very smooth, more glue is needed to wrap the reflector totally.
- Disadvantage:

  Low efficiency, hard to handle small piece. Glue gap exists between reflector and fiber end, lead to the surface of fiber end and reflector not parallel.





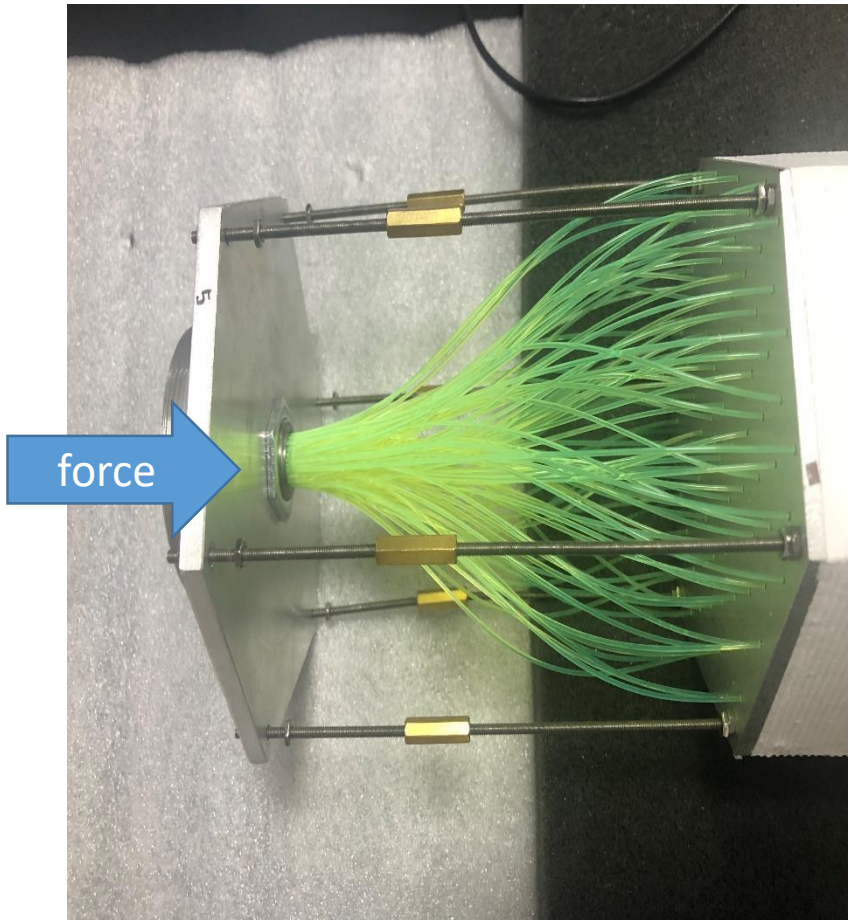
SDU #4 test result

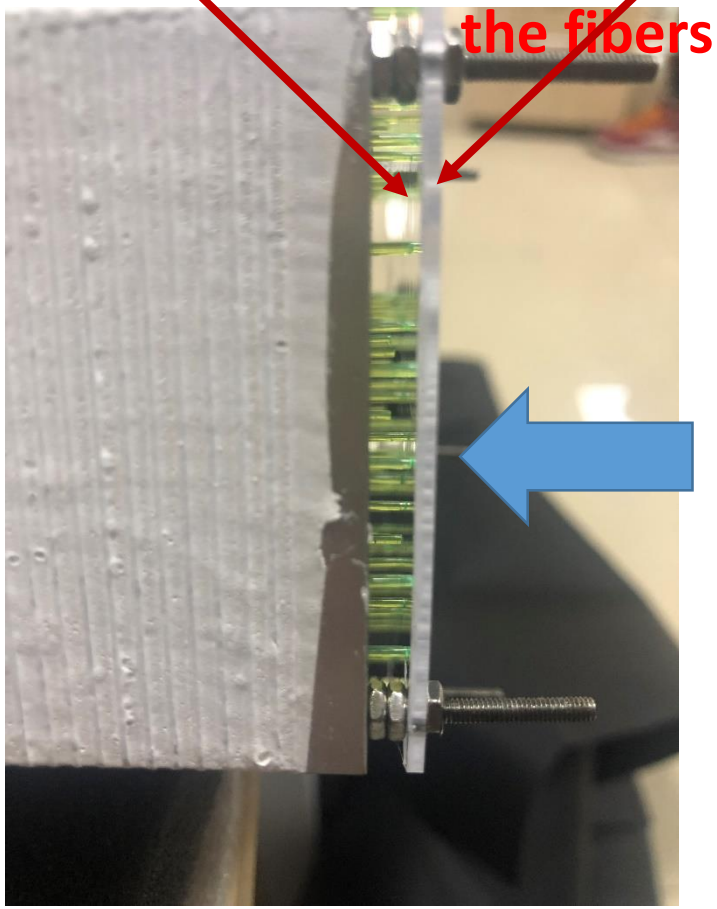


Finally 563.2 photo electrons collected. Improved 52% percent by adding reflector.

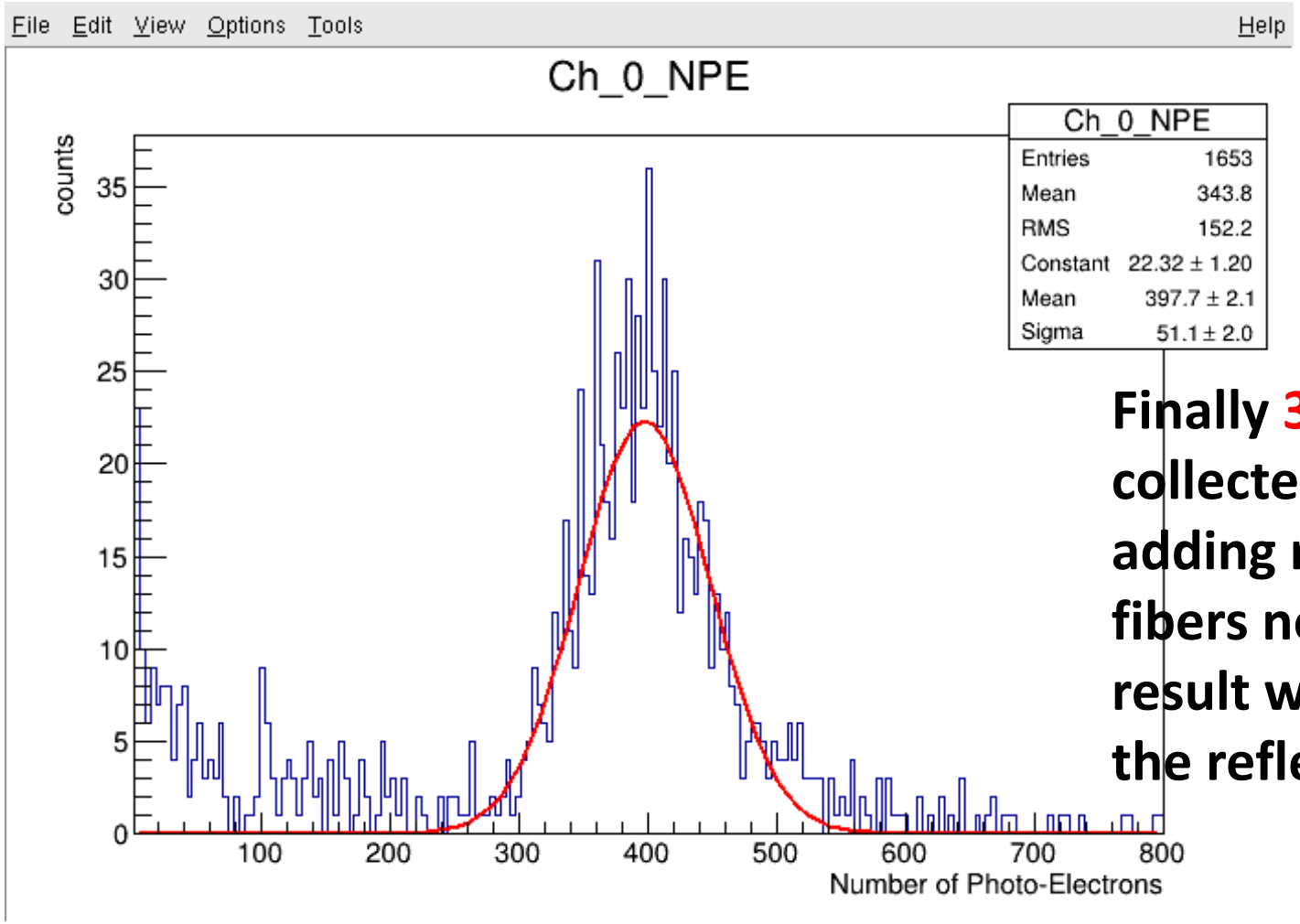
Reflector for SDU#5

- Use a larger reflector layer for all fibers, impose fiber end to reflector by force.
- Very easy to handle. However, about 1/3 fibers may not touch with reflector.
- Will be tested soon.





SDU #5 test result



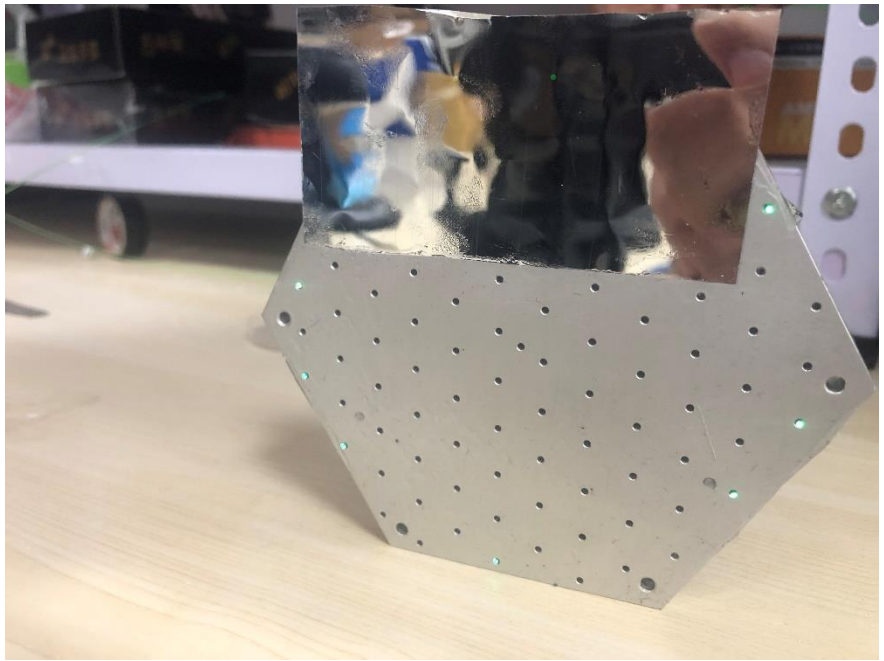
Finally 397.7 photo electrons collected. Improved 42.8% percent by adding reflector. Because a part of fibers not touch the reflector, the result will be better if all fibers touch the reflector.

The reflector design in future

- For SDU group, we don’t have the technique that polishing the fiber bundle when the fibers are already in module, which means we need to polish fiber firstly then put it into module. We are working on to solve this problem. If it solved, the fiber process will be much more efficient and easier.

Then the process of fiber will be:

1. Polish one end of fiber in batch
2. Insert polished fiber end to a fixed plate, make sure alignment of fiber end and surface of plate.
3. Glue fiber and reflector(impose force also could be the choice)
4. Handle other side of fibers, gather to a bundle(now) or to clear fiber

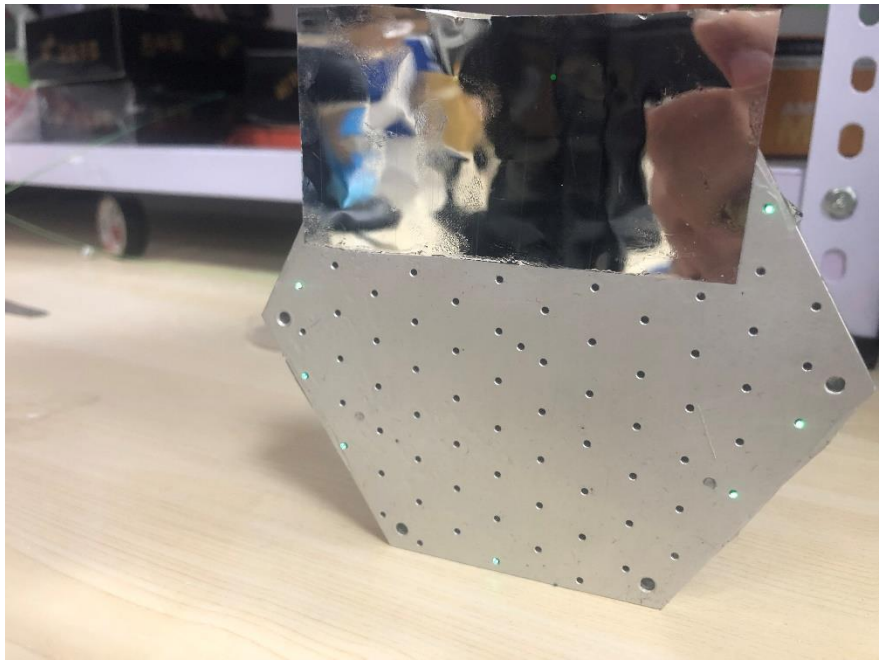


Single fiber test result using one large reflector

Fiber No.	Without mirror	Add large reflector	improvement
1	434	735	69%
2	340	569	67%
3	405	693	71%

Discussion:

- Achieve 70% light yield improvement compared to original 80%.
- We use UV glue now, optical AB glue standby. The glue is not stable, could be shed by force, but not very easily. (UV glue is still soft when curdling, better to use AB glue.)
- The Aluminum plate could be re-designed to add reflector.



Conclusions

Coat painting:

- TiO2 painting have good quality and could improve 40% light yield for the best one

Fiber mirror:

- Evaporation method on fiber end will be shelved.
- 3m ESR will be tried to apply to new module as reflector.
- New reflector design will decrease the price and also have very good reflectivity.
- Polishing quality influence the reflectivity
- SDU group will focus on fiber polishing.

- The mirror reflector of SDU#2 and SDU#3 both have good reflectivity

SDU#4 and SDU#5 light yield summary:

	original	Add coating	Add fiber reflector(final)
SDU#4(powder painting)	261.5	371.3(42.0%)	563.2(52%)
SDU#5(tyvek)	220.4	279.6(26.9%)	397.7(42.8%)

Next work

- Test new powder painting lead plate
- Solve fiber polishing technique
- WLS fiber to clear fiber cnnector