update on the ECal material testing

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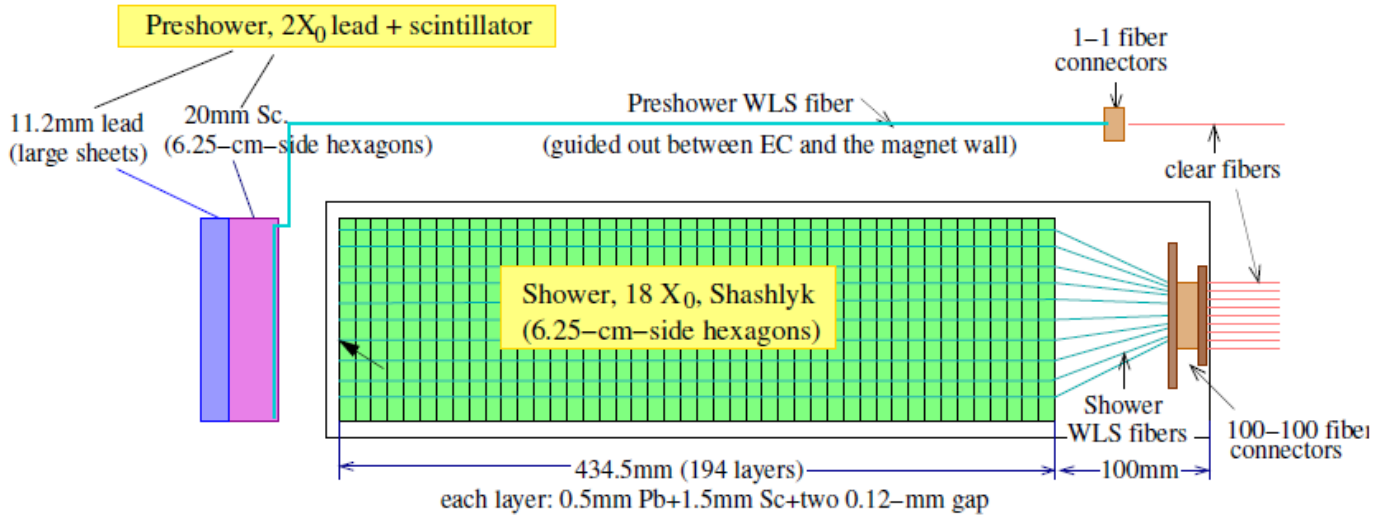
DECEMBER 15, 2021

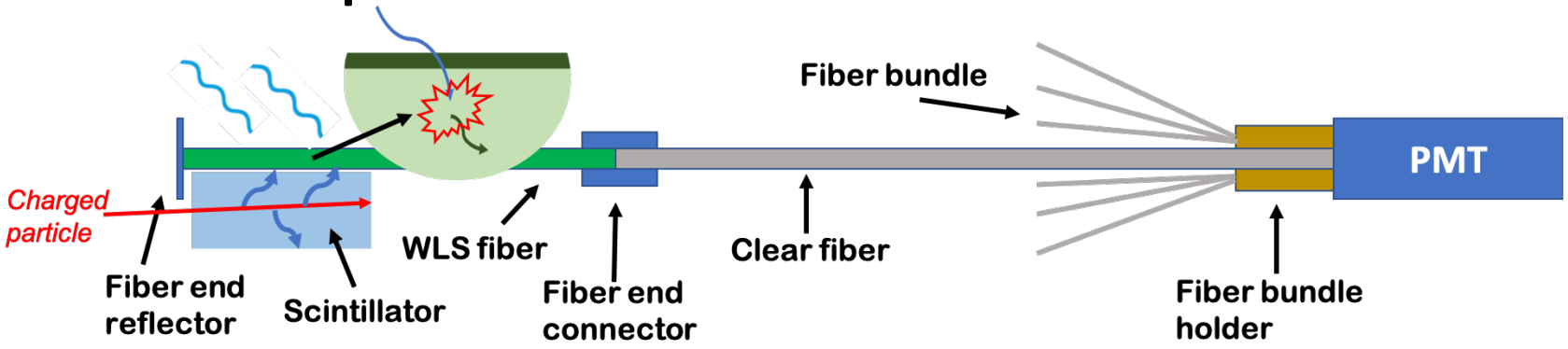
OutLine

- Shashlik ECal design in SoLID
- Prototype material selection and assembly
  - Reflector layer test
  - Fiber performance
  - Fiber end reflector test
  - Fiber connector test
  - Irradiation test
- Summary

SoLID shashlik style Ecal design



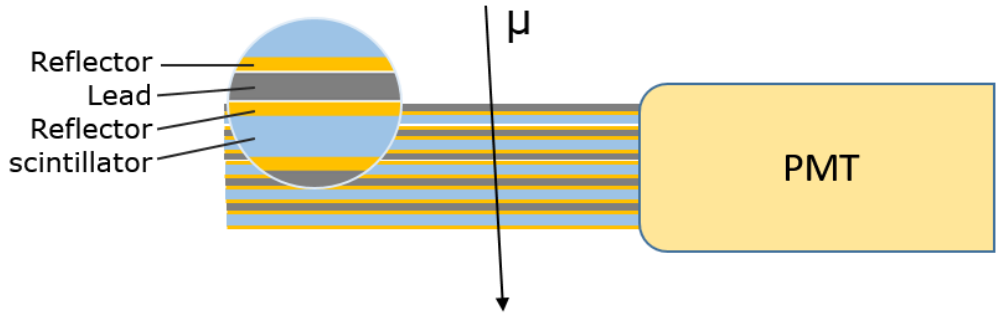
Photon detection process:



Prototype material selection and assembly

Reflector layer test

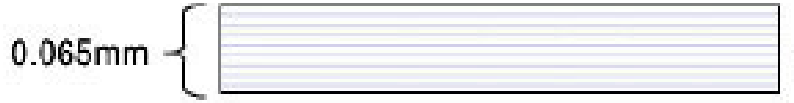
Test setup: test sample: six pieces scintillators +five pieces lead



Reflector material	Relative light yield
Lead with metal plating	1
Print Paper	1.24
Aluminum foil	1.14
Tyvek(100 μm)	1.89
TiO_2 Powder painting(70 μm)	2.02
ESR	2.3

3M™ Enhanced Specular Reflector (3M ESR)

Mirror reflector, more than 98% reflectivity
A high-performance, non-metallic, color-neutral reflector.

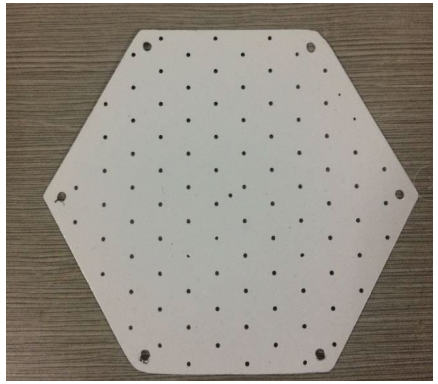


More than 1000 layers

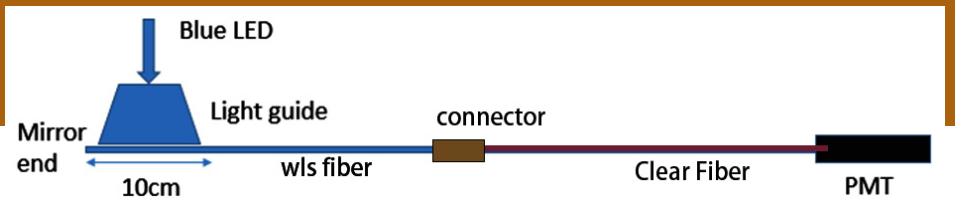
Powder painting 喷塑prefer

TiO_2 painting with bonding/glue material, painted directly on lead.

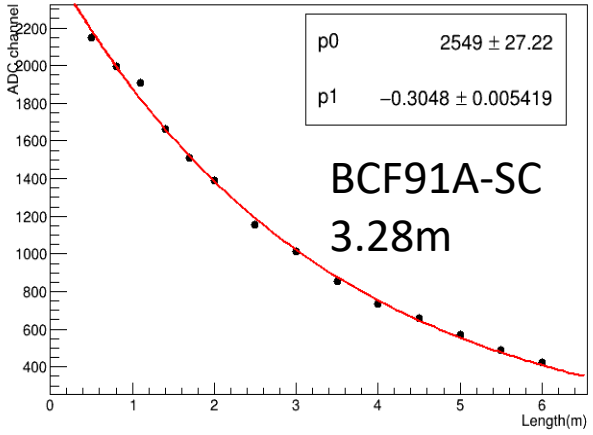
- ✓ *High reflectivity*
- ✓ *Thin thickness(could reach 50 μm)*
- ✓ *Easy to assemble module*
- ✓ *Lead protection*

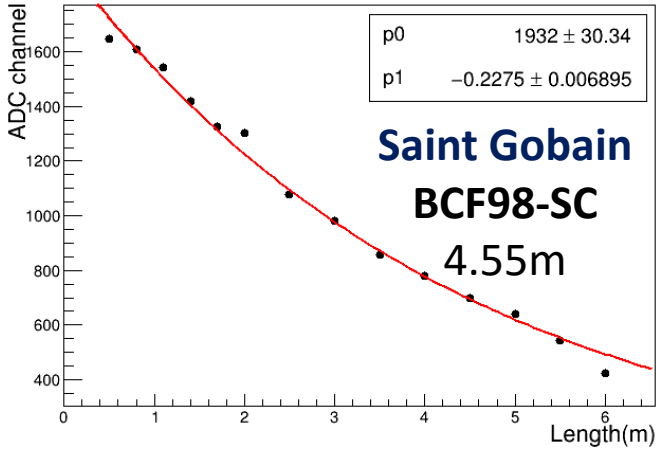


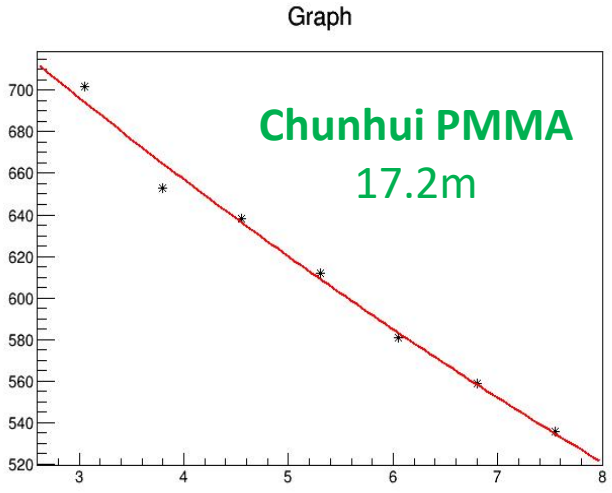
Fiber Attenuation length



Fiber type	WLS fiber			Clear fiber	
	Saint Gobain BCF91A-SC	Saint Gobain BCF91A-MC	Kuraray Y11-MC	Saint Gobain BCF98-SC	Chunhui PMMA
Cladding	Single-cladding	Multi-cladding	Multi-cladding	Single-cladding	Single-cladding
Attenuation length(1/e)	3.28m	~3.28m	~3.5m	4.55m	17.2m

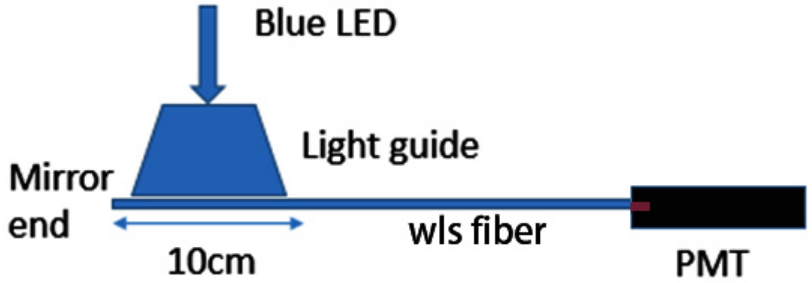


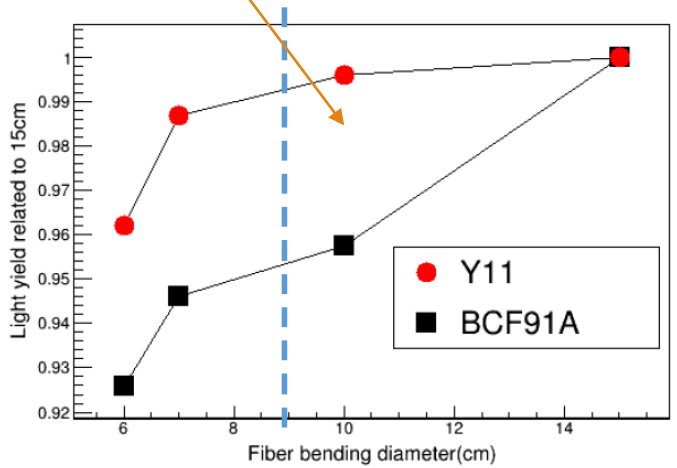




Fiber performance

Fiber type	WLS fiber		
	Saint Gobain BCF91A-SC	Saint Gobain BCF91A-MC	Kuraray Y11-MC
Cladding	Single-cladding	Multi-cladding	Multi-cladding
Light yield		~25% more yield	~40% more yield
Bending loss (9 cm diameter)	5%		1%



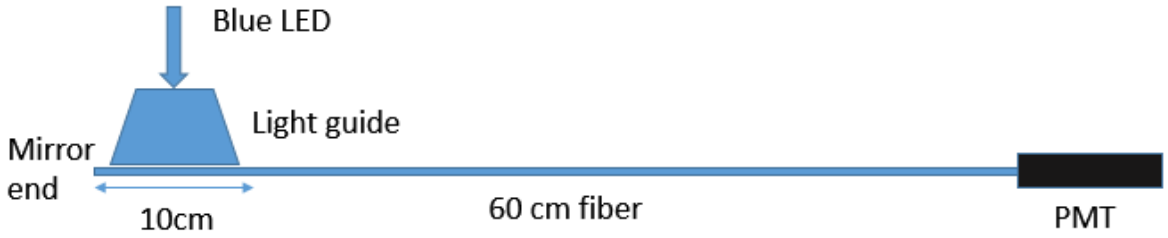


BCF91A lose more light than Y11 with same bending diameter

WLS fiber	result(ADC channel)
BCF91A-SC	2588
BCF91A-MC	3219

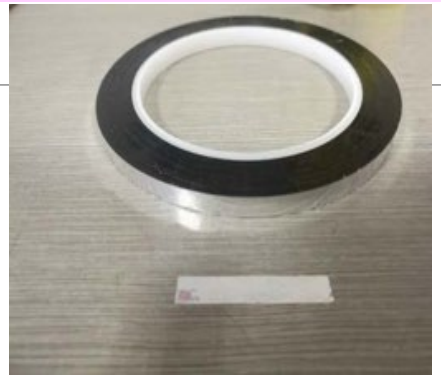
WLS fiber kindTest	Fiber No.	result(ADC channel)
BCF91A-SC	1	1337
	2	1326
Y11-MC	1	1947
	2	1898

Fiber end reflector selection

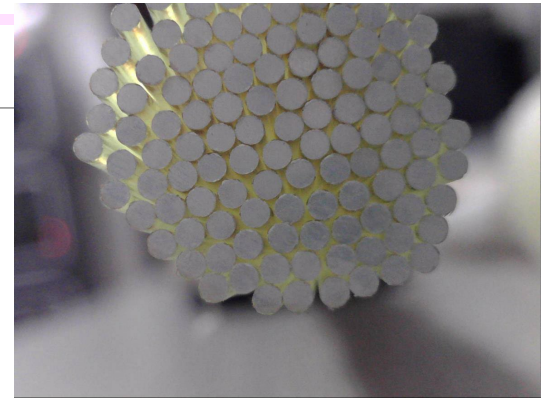


Type of reflector	Light yield improvement
Silver tape	60%
Silver mirror	~40% depend on technique and quality
ESR	~40%
TiO_2 glue NICA plan	~40%

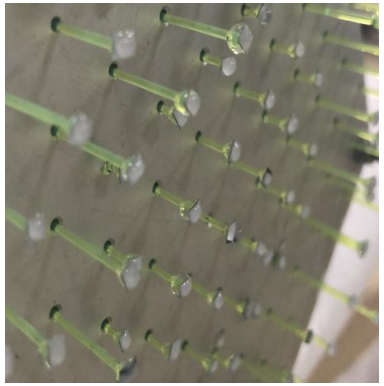
Prefer the NICA plan：
Technologies reliable . Stable
Easy to install



Silver tape



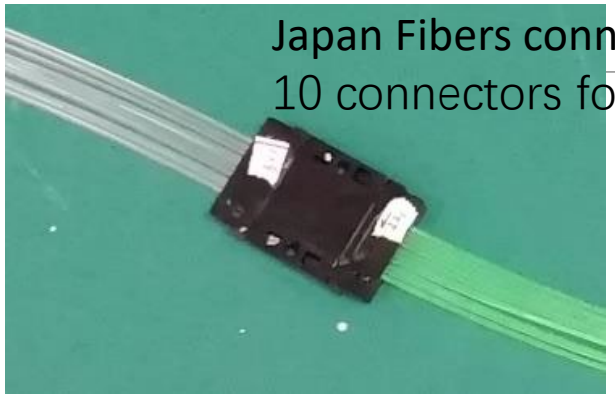
Silver mirror by plating



ESR

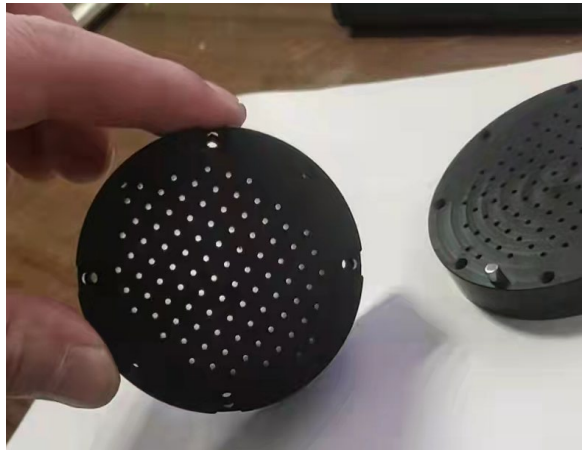
TiO_2 glue
NICA plan

Fiber connectors



Japan Fibers connector for 10 Fibers
10 connectors for each tower

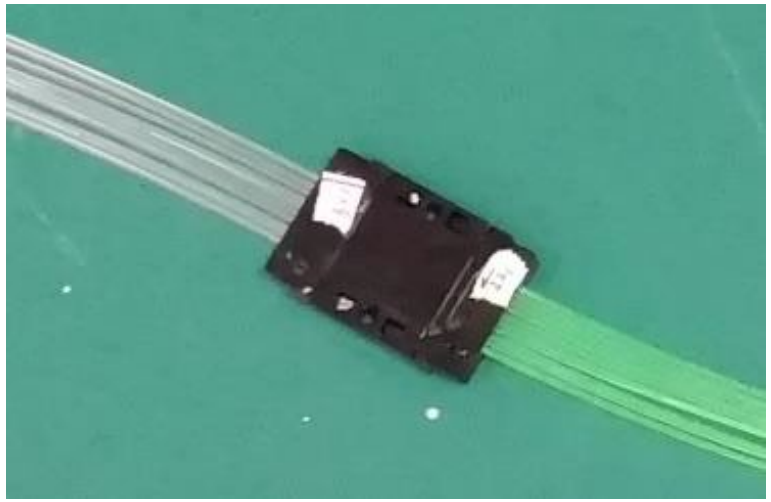
Chunhui fiber bundle connector
one piece for one Ecal tower
3m PMMA clear fiber bundle

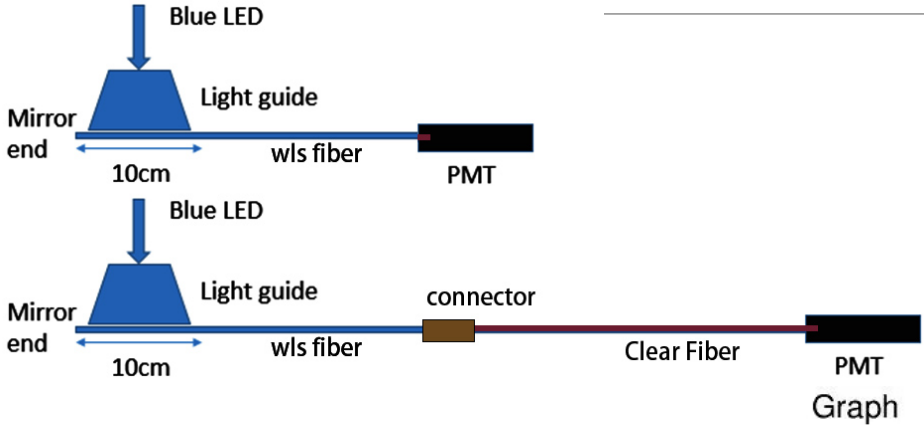


The new connector for 100 Fibers together.
Not tested yet
1 connector for each tower
Made by CNC or 3D printer

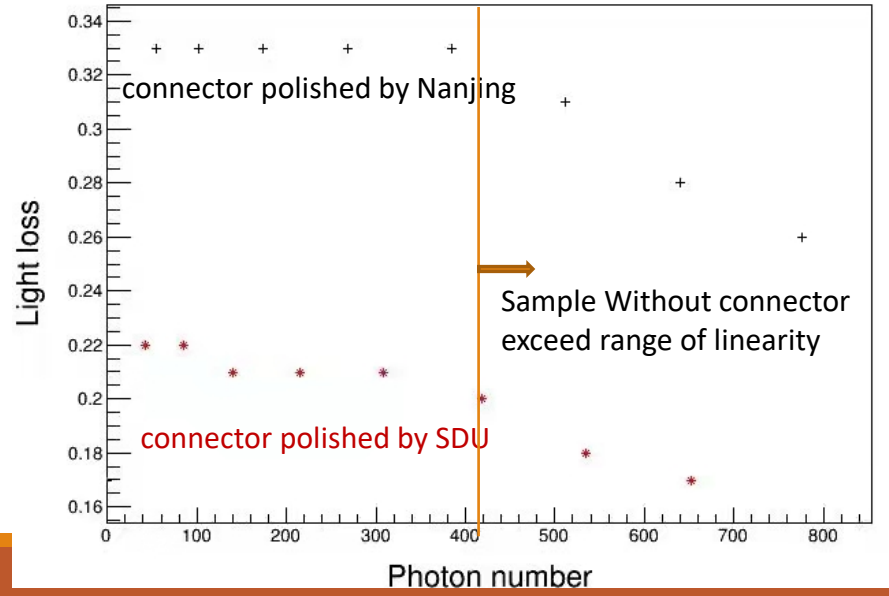
Japan Fiber connector for 10 Fibers

Test setup
Light loss test for one fiber each by LED
Clear fiber light lost removed by calculation





Graph



Fibers connector for 10 Fibers
Light loss ~21-33%:
Depend on polish technology

10 connectors for each tower
Not easy to cut 10 connectors together at one end cup

Chunhui Fiber bundle connector

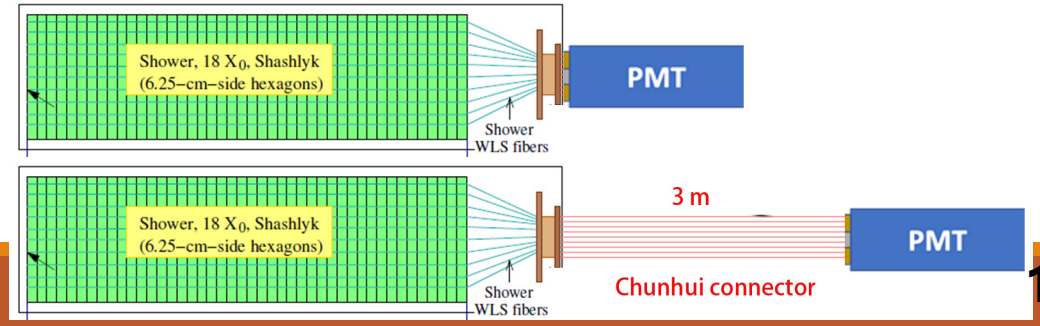
Chunhui fiber bundle connector

Here are a bundle of 500 clear thin fibers(0.5 mm diameter).

Easy to install, only one piece for one Ecal tower
Soft, could be bend easily
Radiation resistance: the same as 1mm PMMA clear fiber

Chunhui connector： light loss ~37%
Clear fiber light lost removed by calculation

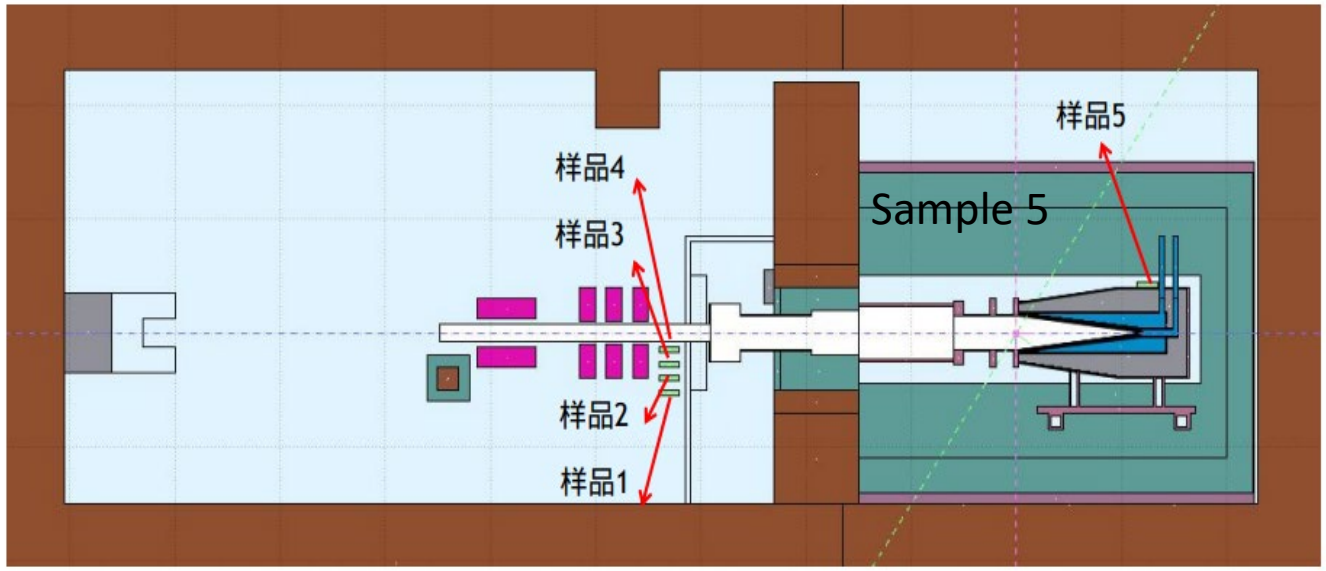
Test setup
Light loss test for all fibers together by cosmic

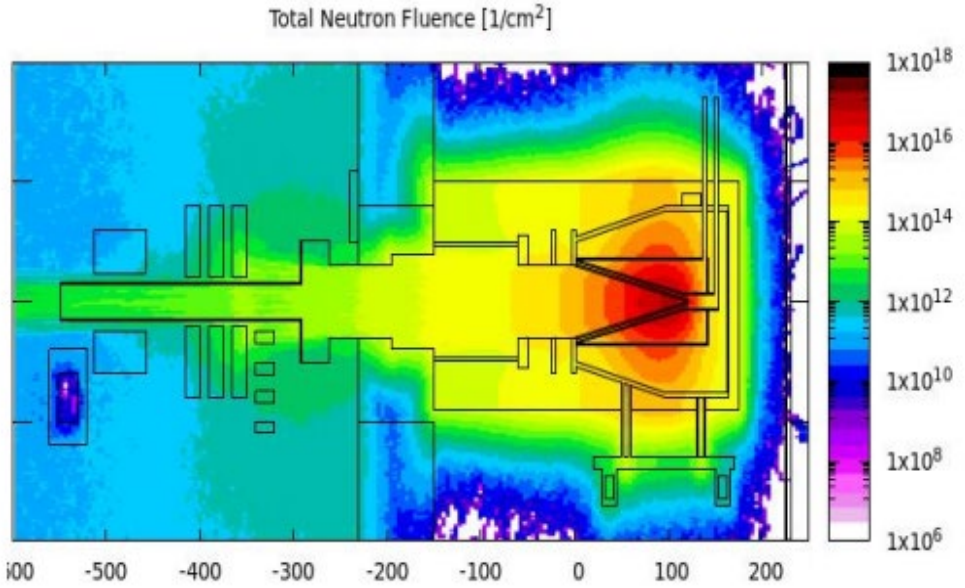


Irradiation test

Reported by Prof.Zheng Xiaochao in June 2021

Irradiation test at Institute of Modern Physics, Lanzhou, China





	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Total Irradiatio（MeV/cm^2） By simulation(uncertainty 10%)	8.6E+11	1.4E+12	2.8E+12	3.7E+13	1.1E+14 (Not tested)
Test material	clear fiber	clear fiber BCF91A-MC scintillator	clear fiber BCF91A-MC scintillator	clear fiber BCF91A-MC scintillator	BCF91A-MC scintillator

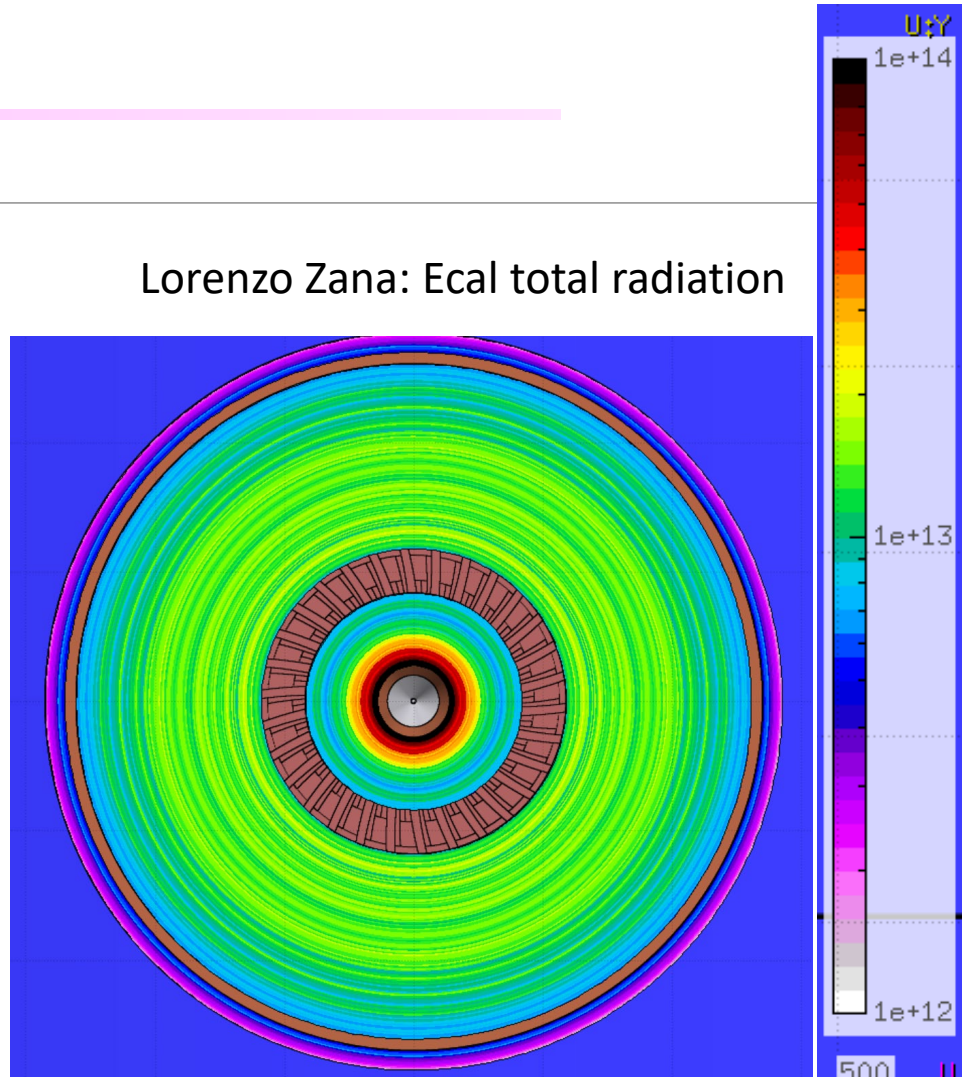
Irradiation test

- upper limit of SoLID Ecal is ~2 E+13 Neutron MeV/cm^2 from Lorenzo Zana
- Sample 4 is 3.7 E+13 Neutron MeV/cm^2

(1-n-MeV/cm^2 ~ 3.3E-11 Gy , 1Gy=100rad)

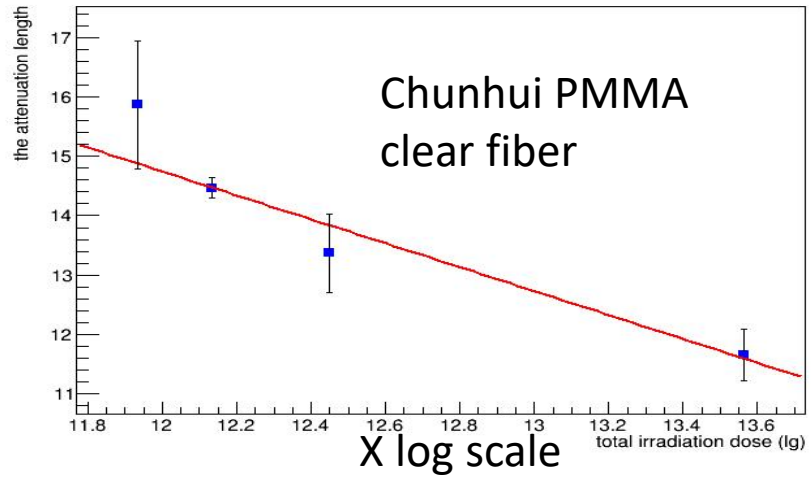
- For all tested fibers and scintillators:
  - Didn't see any difference in appearance and mechanical properties
  - Same color/elasticity after irradiation

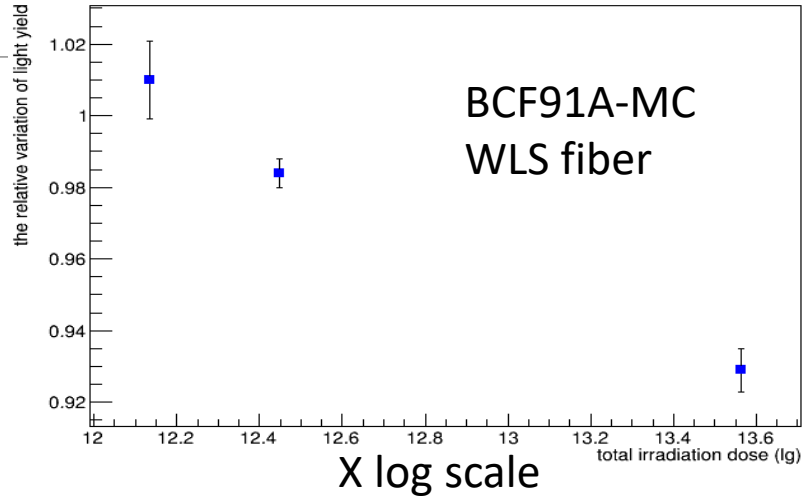
Lorenzo Zana: Ecal total radiation

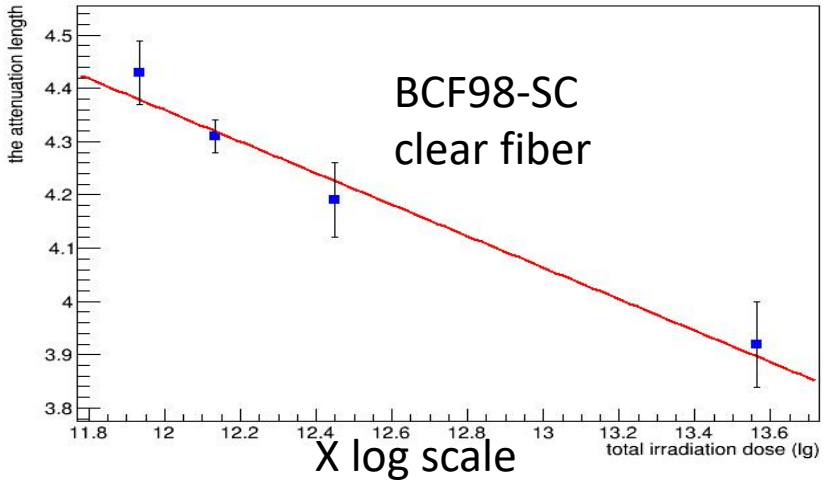


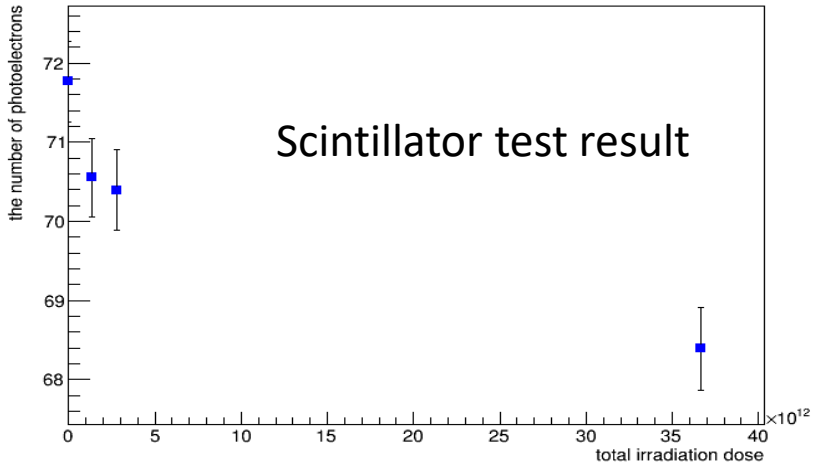
Irradiation test results

All materials should satisfy our requirements









Summary

Component	Material choice
Scintillator	Kedi HND-S2 (China)
Reflective layer	Powder painting
WLS Fiber	BCF91A-MC/Kuraray Y11-MC?
Fiber end mirror	TiO2 glue
Fiber connector	Chunhui connector?
Coating	TiO2 glue