Fiber update

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WLS fiber comparison

Table 1
Optical properties of each type of WLS fibers before the irradiation. Average light output at 140 cm and RMS, average attenuation length (L_{att}) and RMS, for ten fibers of each type. The values are normalized to I_{140} of the Y11(200)MSJ fibers

Fiber type	I_{140}	RMS (%)	L_{att} (cm)	RMS (%)
BCF91A MC	0.98	9.6	280	9.5
Y11(200)MSJ	1.00	1.8	280	1.6
S250-100	0.81	5.7	230	5.6

Table 2
Relative light output at $x = 140$ cm, for total doses of 1.16 and 6.93 kGy

Fiber type	$\frac{R(140)}{R(30)}$ for 1.16 kGy			$\frac{R(140)}{R(30)}$ for 6.93 kGy		
	0 days	1 day	10 days	0 days	1 day	10 days
BCF91A MC	0.83	0.86	0.85	0.54	0.56	0.56
Y11(200)MSJ	0.87	0.92	0.91	0.71	0.72	0.74
S250-100	0.60	0.70	0.81	0.52	0.55	0.64

Design Consideration

- Shashlik type EC has enough light, but less comparing to other type. (400 p.e./MIP for COMPASS module). we still want to minimize light loss.
- Fiber aperture is about 20-30 degree. Use optics to reduce area in fiber connection could mean large light loss. We plan to 1 to 1 connection with same size fiber to reduce light loss.
- X to 1 connection without area reduction doesn’t show design or cost advantage so far.

Fiber cost

	1mm WLS	1mm clear	0.5mm WLS	0.5mm clear	Total cost
Length(km)	170	510	3.4	3.4	
Saint-Gobain/ Bicron	BCF91A $0.87/$87 $150k	BCF98 $0.64/$64 $330k	BCF91A $0.72/$1.44 $2.5k	Assume $2.5k	$500k
KURARAY	Y-11(200)MS $3.39/$339 576k	Clear-PSMS $2.15/$215 $1097k	Y-11(200)MS $2.04/$4.08 $7k	Assume $7k	$1700k

- Length estimation based on 1700 modules
  1. 100*1m of 1mm WLS fiber per module shower part
  2. 100*3m (average of 1200*2m and 500*5m) of 1mm clear fiber per module shower part
  3. 2*1m of 0.5mm WLS fiber per module pre-shower part
  4. 2*3m of 0.5mm clear fiber per module pre-shower part
- Other notes
  1. Quote will change slightly according to quantity
  2. We have 2mm fiber quote from both suppliers, they cost about 4 times of 1mm fibers so the price scale by volume. It doesn't save us.

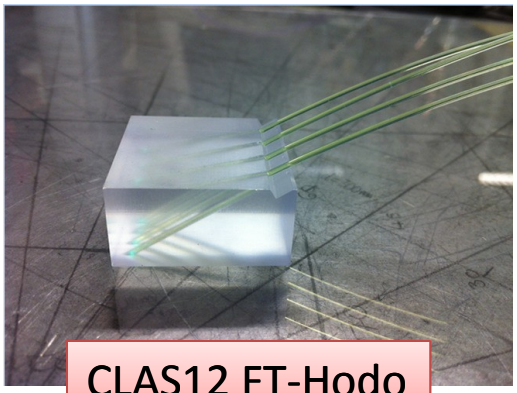
Meeting with Saint-Gobain

- Met with Saint-Gobain sales on 2/7
- What we learned
  - Bicron has fibers in square or round shape. The square one is a bit more expensive due to larger volume.
  - We need to check with IHEP what shape was used in COMPASS module or what's better used for us.
  - Their world fiber production facility is at Ohio, so if we need large volume fibers shipped to Russia, there will be cost and time.
  - They make scintillator with various thickness. To embed WLS, they can do groove drilling. They think the mold-with-hole method Fermi lab used could have scintillation light reduced by half, but it could still be enough for EC use.
- What we asked
  - Keep contact and update quote as the project moves forward.
  - The price quote were based on spool, they can look into cost if they have fibers cut at our required length.
  - They will look into feasibility and cost of making fiber connection, e.g. glue 1 to 1 and sealed within a plastic tube.

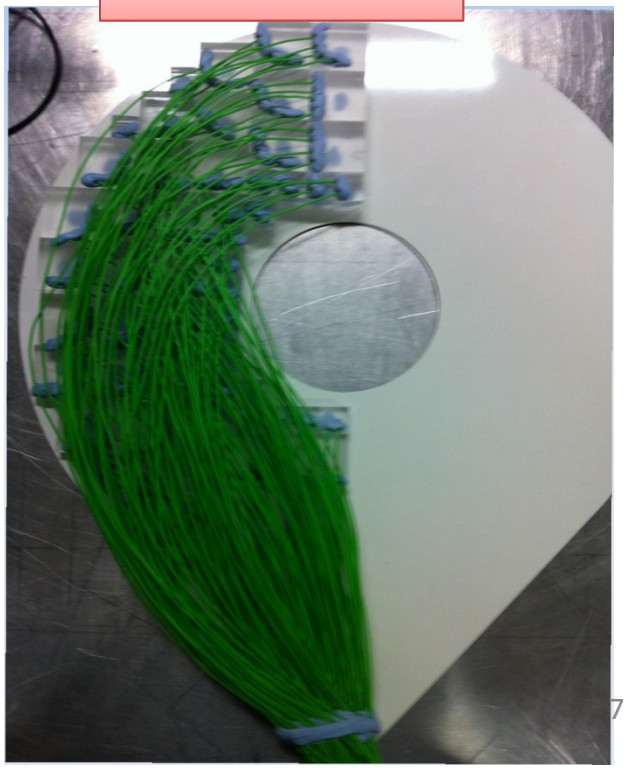
backup

WLS fiber in scintillator pad

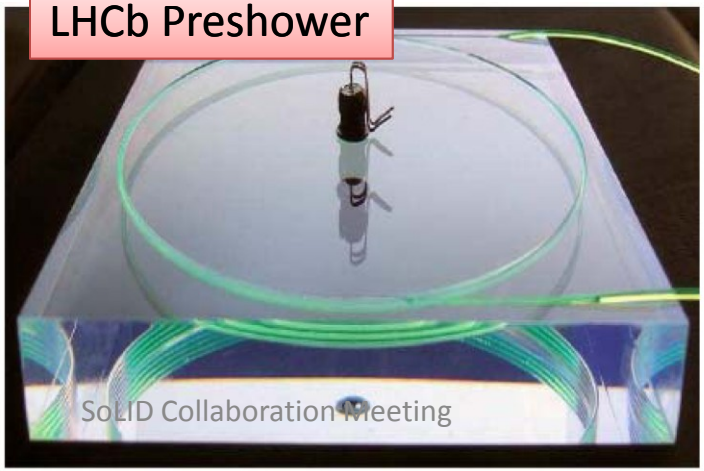
- Drill on scintillator and glue WLS in
- Used by LHCb etc.
- Will use by CLAS12 FT-Hodo



CLAS12 FT-Hodo

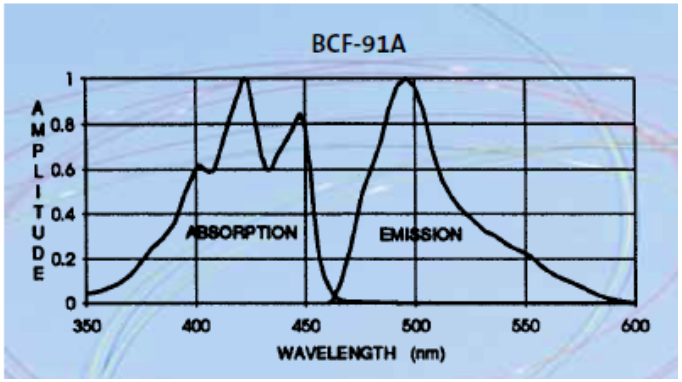


LHCb Preshower

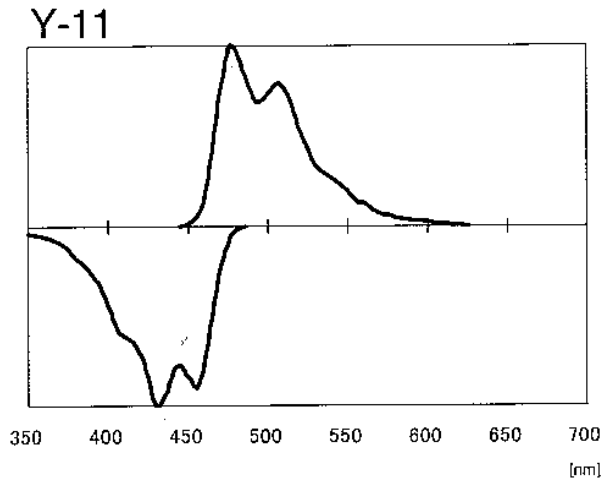


Fiber

- WSL fiber in shower, 100/module
  - Bicron BCF-91A
    - multi-clad, 1/e length >3.5m
    - 1mmD, bend 20cmD (?)
    - $0.87/m
    - less rad hard

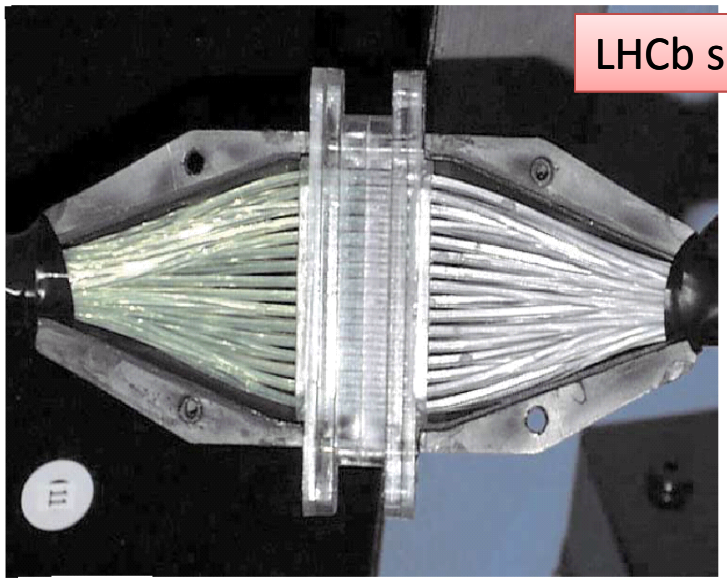


- WLS fiber in preshower pad, 1-2/module
  - KURARAY Y-11(200)MS
    - multi-clad, 1/e length >3.5m
    - 0.5mmD, bend 5cmD
    - $1/m
    - more rad hard
- Clear fiber for both, 101-102/module
  - Bicron BCF-98
    - $1/m

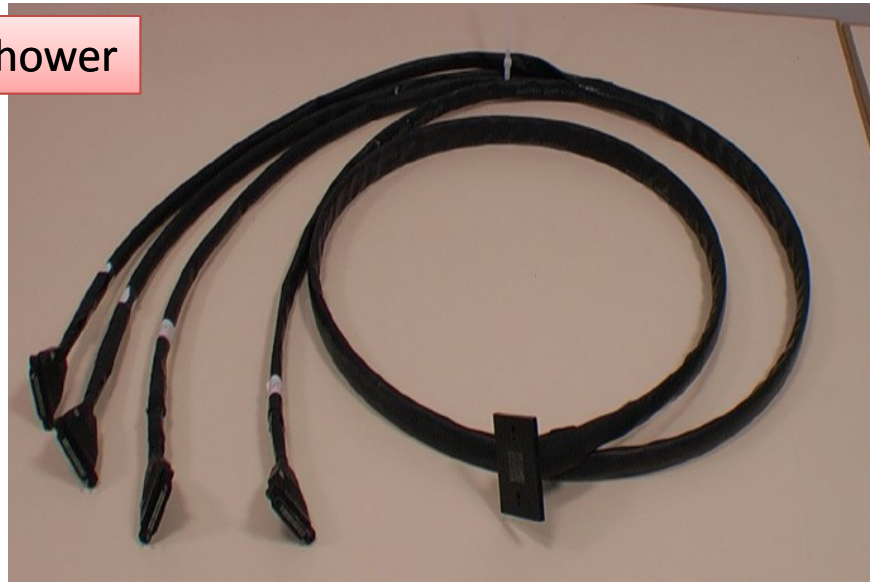


Fiber connection

- Shower will use 1-1 bundle fiber connector.
  Used in previous experiments (LHCb, Minos)
  custom made fiber connector $175/module, quote by LEONI
- Preshower will use comercial 1-1 single fiber connector, a few $ each.



LHCb shower



- fiber bundle to PMT connector, cost estimate $25/module

Optimization: WLS fiber pattern

T2K tile design

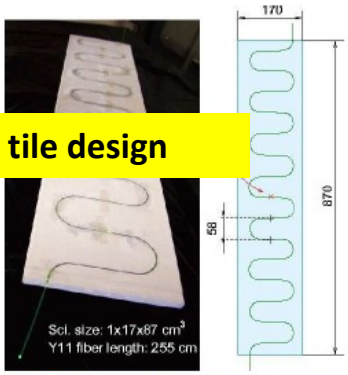
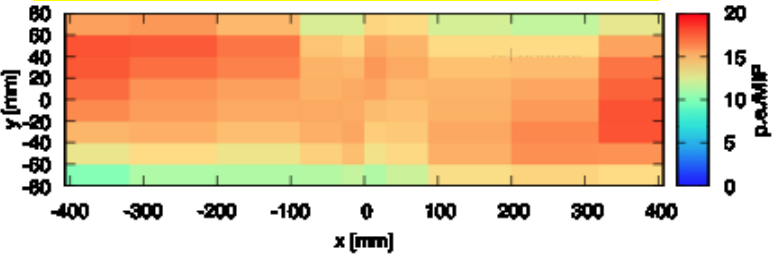


Figure 13: Scintillator slab with S-shaped fiber readout: photograph (left) and schematic view (right).

T2K Light collection uniformity

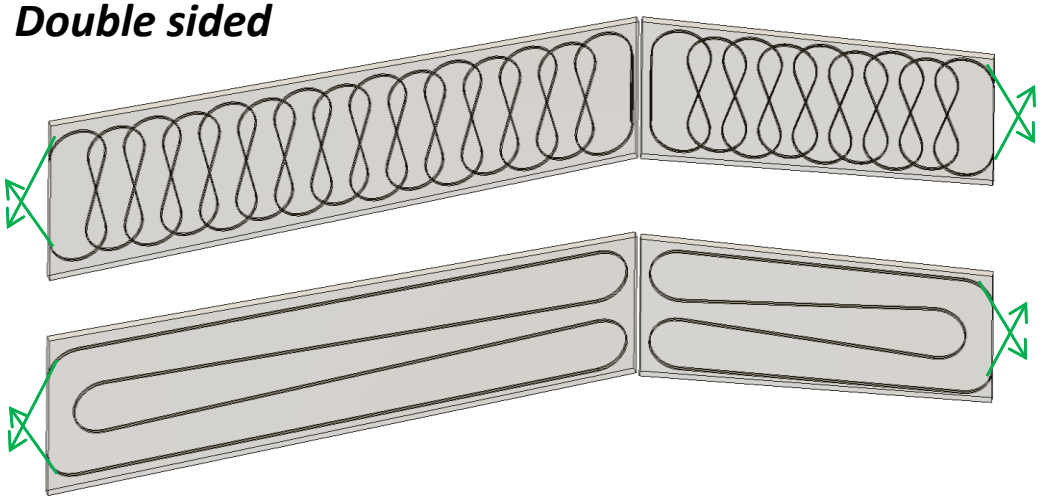


Design rules:

- **-Minimum bending diameter of 55mm;**
- **-Maximum point-to-fiber distance of 27mm**
- **-WLS fibers uncut**

sPHENIX tile design

Double sided



Single sided

Response uniformity measurements with cosmic muons are now ongoing at INR