An optimized prototype of Electromagnetic Calorimeter for SOLID

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SoLID: **Solenoidal Large Intensity Device**

High Intensity \((10^{37} \sim 10^{39} \text{ cm}^{-2}\text{s}^{-1})\) and, Large Acceptance \((8<\theta<24, 0<\Phi<360, 1<P_e<7\text{GeV}/c \text{ for SIDIS})\)

**Two Configurations**
Introduction of ECal

- Preshower: $2X_0$ lead + 20mm scintillator
- Shower: 0.5mm lead / 1.5mm scintillator sampling
- Total length: $20X_0$ (< 2% leakage)
This assembling steps:

- Stack lead and scintillator accurately to ensure that every fiber can be inserted freely.
- The ECal can be pressurized by 500kg force.
- The pressure can be put under close monitor by pressure sensors.
- The pressure can be transferred from pressure bar to 6 stainless steel rods.

1. Introduction of ECal
Test of two different fiber & mirror painting

Schematic diagram of vertical cosmic ray experiment setup

For laser source:
- 420 nm
- 1 MHz

For SiPM:
- Gain: $1.8 \times 10^5$
- 143.6 pWb = 1 pe
- Voltage = 26.0 V

For the fibers:
- 50 cm
- Have been polished

WLSF (Y11)
WLSF (BCF91A)
WLSF (Y11) + silver shine 415001
WLSF (BCF91A) + silver shine 415001
WLSF (Y11) + bending
WLSF (BCF91A) + bending
WLS Fiber test

WLS Fiber test Set up

- SiPM
- Dark box
- Light spot
- Attenuates
- Filter sheet (420nm)
- Laser source White light
## WLS Fiber test

### Compared results

<table>
<thead>
<tr>
<th></th>
<th>BCF91A</th>
<th>Y11</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mirror painting</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Mirror painting</td>
<td>17 (+21.4%)</td>
<td>17 (+30.1%)</td>
</tr>
<tr>
<td>Bending (φ6)</td>
<td>4 (-71%)</td>
<td>11 (-15%)</td>
</tr>
</tbody>
</table>

A comparison of Y11 and BCF91A multi-clad fibers has shown that Y11 double-clad S-type fiber from KURARAY and BCF91A from BICRON give about the same light yield, but that the Y11 S-type has better mechanical properties. The BCF91A fiber has less mechanical stability against bending at small radius.
Clear Fiber test

For laser source:
- 420 nm
- 1 MHz

For SiPM:
- Gain: $1.8 \times 10^5$
- $143.6\text{pWb}=1\text{pe}$
- Voltage=25.0 V

For the fibers:
- 1m, 2m, 3m, 4m, 5m, 7m and 9m
- Have been polished
- BCF98, single cladding
Clear Fiber test

To measure the light loss due to bending
The effect of bending on the clear fiber can be ignored.

No bending loss for clear PSM above a diameter of (4-5) cm.
### 4. Optimized Prototype

Materials of THU #1 and THU #2

<table>
<thead>
<tr>
<th>Material</th>
<th>THU #1</th>
<th>THU #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead plate</td>
<td>Beijing, China</td>
<td></td>
</tr>
<tr>
<td>Reflective materials (WLS fiber)</td>
<td>Silver ink from Italy</td>
<td></td>
</tr>
<tr>
<td>Scintillator plate</td>
<td>Kedi #1</td>
<td>Kedi #2</td>
</tr>
<tr>
<td>Reflective materials</td>
<td>Sliver paper (Mirror reflection)</td>
<td>Powder painting (Diffuse reflection)</td>
</tr>
<tr>
<td>(between scintillator and lead)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WLS fiber</td>
<td>Kurrary Y11</td>
<td>Saint Gobain BCF91A</td>
</tr>
</tbody>
</table>

Top of the WLS fiber (connect to the PMT)  
End of the WLS fiber (mirror painting)  

THU #2
Cosmic test

Schematic diagram of vertical cosmic ray experiment setup

First Ecal module in THU (Sep 2016)
Experimental device has been built
Cosmic ray test is currently underway
we will present the test results soon
Cosmic test

THU#1

light yield test results in UVa

For the result, the peak of Npe in horizontal test is 48 and the peak of Npe in vertical test is 209. Through the result of the vertical and horizontal cosmic ray test, we have obtained that the prototype need to be improved to increase the light yield.
Cosmic test

THU#2

light yield test results in UVa

Peak of Npe in horizontal test
Npe is 94

Peak of Npe in vertical test
Npe is 744

For the result, the peak of Npe in horizontal test is 94 and the peak of Npe in vertical test is 744. Through the result of the vertical and horizontal cosmic ray test, we have obtained that THU#2 has been optimized.
5 Summary

Finished

- The cosmic test for THU #1 has been finished, JINST 12 (2017) no.03, C03026.
- Fiber R&D
  - WLS fiber (BCF91A & Y11) test has been finished, the results show that:
    - Y11 double-clad S-type fiber from KURARAY and BCF91A from BICRON give about the same light yield without bending
    - Italian silver shine: ~30%
  - Clear fiber (BCF98, single cladding) test has been finished, the results show that:
    - no bending loss for clear PSM above a diameter of (4-5)cm
- The optimized prototype (THU #2) has been assembled and cosmic test has been finished. For horizontal test, Light yield increased by 100%. For vertical test, Light yield increased by 350%. For the results, The first reason is because the material is replaced, the second is the production process has been improved.

Next to do

- Re-test the BCF98 single-cladding clear fiber with 470nm lights
- Will also test BCF98 multi-cladding fiber and kurrary PSM clear fiber (bending loss, attenuation length......)
- Prepare for beam test and compare with the results of cosmic ray test.
Thanks For your attention

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