Test of two different fiber & mirror painting (2)

- Laser source:
  - $\lambda$: 420 nm
  - Frequency: 1 MHz

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

- Fibers:
  - Length: 50 cm
  - Have been polished

- WLSF:
  - WLSF (Y11)
  - WLSF (BCF91A)
  - WLSF (Y11) + silver shine 415001
  - WLSF (BCF91A) + silver shine 415001
  - WLSF (Y11) + Al
  - WLSF (BCF91A) + Al
  - WLSF (Y11) + Al (bending)
  - WLSF (BCF91A) + Al (bending)

Mirror painting or nothing
Test in the dark box

Get the data of Npe
Waveform sampling oscilloscope

3.9 cm
1.6 cm
44.5 cm
WLSF

Light spot
Fibers were fixed on the light spot

Laser source

trigger
Set up

- Laser source
- White light
- Filter sheet (420nm)
- Attenuates light spot
- SiPM
Gain of the SiPM (SPE)

\[
\text{Gain} = \frac{\text{Center2} - \text{Center1}}{2} + \frac{\text{Center3} - \text{Center1}}{3} + \frac{\text{Center4} - \text{Center1}}{4} + \frac{\text{Center5} - \text{Center1}}{5} + \frac{\text{Center6} - \text{Center1}}{6} + \frac{\text{Center7} - \text{Center1}}{7} + \frac{\text{Center8} - \text{Center1}}{8}
\]

\[
= \frac{143.6 \text{pvs}}{100 \cdot R \cdot e} = 1.8 \times 10^5
\]

143.6 pvs = 1 PE

Preamplifier 50Ω for oscilloscope
WLSF (Y11) \hspace{1cm} 1\text{mWb}=1000\text{pVs}

\[ N_{pe} = \frac{1954.6\text{pVs}}{143.6\text{pVs}} = 14 \]
WLSF (BCF91A)

\[ N_{pe} = \frac{2029.8 \, \text{pVs}}{143.6 \, \text{pVs}} = 14 \]
WLSF (Y11) + silver shine 415001

\[ N_{pe} = \frac{2369.3 \text{pVs}}{143.6 \text{pVs}} = 16 \]
WLSF (BCF91A) + silver shine 415001

\[ N_{pe} = \frac{2475.1 \, \text{pVs}}{143.6 \, \text{pVs}} = 17 \]
WLSF (Y11) + Al

\[
N_{pe} = \frac{1924.3 \text{pVs}}{143.6 \text{pVs}} = 13
\]
WLSF (BCF91A) + Al

\[
N_{pe} = \frac{1984.1\, pVs}{143.6\, pVs} = 14
\]
(set up) Al+bending

Same location with different fiber

(the diameter of the cup is about 6cm)
WLSF (Y11) + Al (bending)

\[ N_{pe} = \frac{1574.4 \text{pV}s}{143.6 \text{pV}s} = 11 \]
WLSF (BCF91A) + Al (bending)

\[ N_{pe} = \frac{618.4 \, pVs}{143.6 \, pVs} = 4 \]
## Compared results

<table>
<thead>
<tr>
<th></th>
<th>BCF91A</th>
<th>Y11</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Al (reference group)</strong></td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td><strong>No mirror painting</strong></td>
<td>14  (no difference)</td>
<td>14 (no difference)</td>
</tr>
<tr>
<td><strong>Silver 415001</strong></td>
<td>17 (+21.4%)</td>
<td>16 (+23%)</td>
</tr>
<tr>
<td><strong>Al+bending</strong></td>
<td>4 (-71%)</td>
<td>11 (-15%)</td>
</tr>
</tbody>
</table>

Our result is consistent with the LHCb Calo TDR

A comparison of Y11 and BCF91A multi-clad fibers has shown that Y11(250) double-clad S-type fiber from KURARAY [18] and BCF91A from BICRON [19] give about the same light yield, but that the Y11 S-type has better mechanical properties [20]. The BCF91A fiber has less mechanical stability against bending at small radius.