TOF2 re-baselining

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TOF2 station optimization

- Basic element: scintillator slab 48 x 6 x 2.5 cm$^3$ with plexiglass light-guides read by Hamamatsu R7761 fine-mesh PMTs
- 2 planes: X, Y oriented to allow multi-hits rejection capability
- Each plane is made of 8 scintillator slabs
- Calibration: overlaps + laser system
- Mechanics design (CAD) with support frame in progress
Scintillation counter: basic element (mounting assembly)
Scintillation counter construction

- BC-404 or BC-420 scintillation slabs from Bicron (DTF finish)
- Home made plexiglass light guide
- Home made counter mounting (3 prototypes ready in Milano)
- Home made PMT holder
PMTs for TOF2: problems with high magnetic field

- Figure shows $|B|$ from the cooling and measurement solenoids.
- The phototubes are placed in a place with high field.
  - $B$ may be bigger than 1 T -> problems

Fine-mesh PMTs may not be enough
First step: global soft iron shield for downstream detector (GG)

This excludes R4998, but allows R7761
Solution from Ghislain: single iron slab 15-cm thick with a central hole of 40 cm-diameter

Field map covers the domain $0 < z < 135$ cm and $0 < r < 100$ cm (dashed rectangle)

B is greatly reduced well below 1 T

No problem for R7761 PMTs
Second step: systematic fine-mesh PMTs test in B-field (up to 1.2T)

Light source:
Laser diode Hitachi DL3038-011 (λ~635nm) pulsed by a pulser (Lecroy 9210, risetime 300 ps) FWHM laser pulse 300 ps.
Injection in a short optical fiber to a prism, giving light to the PMT
Output PMT signal to a Silena QVT
Test magnet at LASA. First typical results.

1. Timing measurements
2. Gain measurements
   As a function of $B, \theta$

More measurements under way
Fine-mesh phototube Properties

Table:

<table>
<thead>
<tr>
<th>Type Diameter</th>
<th>Type Number</th>
<th>Spectral Response Rangings &amp; Curve Code</th>
<th>Outline No.</th>
<th>No. of Stages</th>
<th>Cathode Sensitivity - Luminous Typ. (µA/µm)</th>
<th>Blue Sens. Index (5-56) Typ.</th>
<th>Q.E. at Peak Typ. (%)</th>
<th>Luminous Typ. (µA/µm)</th>
<th>Nominal Gain at 0 T</th>
<th>Supply Voltage for Nominal Gain at 0 T</th>
<th>Max. (V)</th>
<th>Typ. (mA)</th>
<th>Max. (mA)</th>
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<tbody>
<tr>
<td>25 mm (1&quot;)</td>
<td>R5505</td>
<td>300 to 650 400K</td>
<td>1</td>
<td>15</td>
<td>80</td>
<td>9.5 (7.0)</td>
<td>23</td>
<td>40</td>
<td>5.0 x 10^2</td>
<td>2.3 x 10^3</td>
<td>1.8 x 10^3</td>
<td>1850</td>
<td>2300</td>
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<tr>
<td>38 mm (1.5&quot;)</td>
<td>R5949</td>
<td>300 to 650 400K</td>
<td>2</td>
<td>16</td>
<td>80</td>
<td>9.5 (7.0)</td>
<td>23</td>
<td>80</td>
<td>1.0 x 10^3</td>
<td>4.3 x 10^3</td>
<td>2.9 x 10^3</td>
<td>1800</td>
<td>2300</td>
</tr>
<tr>
<td>38 mm (1.5&quot;)</td>
<td>R7761</td>
<td>300 to 650 400K</td>
<td>3</td>
<td>19</td>
<td>80</td>
<td>9.5 (7.0)</td>
<td>23</td>
<td>800</td>
<td>1.0 x 10^3</td>
<td>3.0 x 10^3</td>
<td>1.5 x 10^3</td>
<td>1800</td>
<td>2300</td>
</tr>
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<td>51 mm (2&quot;)</td>
<td>R5024</td>
<td>300 to 650 400K</td>
<td>4</td>
<td>19</td>
<td>70</td>
<td>9.5 (7.0)</td>
<td>22</td>
<td>700</td>
<td>1.0 x 10^3</td>
<td>4.1 x 10^3</td>
<td>2.0 x 10^3</td>
<td>1750</td>
<td>2300</td>
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<tr>
<td>64 mm (2.5&quot;)</td>
<td>R8506</td>
<td>300 to 650 400K</td>
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<td>19</td>
<td>70</td>
<td>9.5 (7.0)</td>
<td>22</td>
<td>700</td>
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<td>4.1 x 10^3</td>
<td>2.0 x 10^3</td>
<td>1750</td>
<td>2300</td>
</tr>
</tbody>
</table>

R7761 best candidate
Some properties of R7761 at B=0: a) absolute gain
b) timing:

PMT Hamamatsu H8409_70MOD
T.T.S. many p.e. @ 670nm, 2000V

Counts

\[ 1 \times 10^5 \]
\[ 8 \times 10^4 \]
\[ 6 \times 10^4 \]
\[ 4 \times 10^4 \]
\[ 2 \times 10^4 \]

Time [ps]

\[ -1000 \]
\[ -500 \]
\[ 0 \]
\[ 500 \]
\[ 1000 \]
\[ 1500 \]
\[ 2000 \]
\[ 2500 \]
\[ 3000 \]

fwhm = 130 ps

\[ \text{sigma} = 55 \text{ps} \]
Some properties of R7761 at $B > 0$
CAD design for TOF2 (planes)

- 2 X/Y planes
- Problem: reduced capability of cross-calibration with incoming muons (as respect to staggered solution)
- But Advantage: more easy mechanics support structure and more uniform structure/less material on beamline
X/Y planes front view
X/Y planes top view
CAD design for TOF2 (planes+support)

- X,Y planes
- Mechanics support (L-shaped)
Plexiglass lightguides

Here we will hang to support structure the scintillation counters via a comb.
G4MICE

- G4MICE installed in Milano, to optimize TOF performances design (with help from Alessandra and Yangmur)
- Run with standard default options, for different slab widths
Some preliminary results.

- Double hits at 5% level (?) for 6 cm slab width
X/Y planes multiplicity in TOF0,1,2

Apparently strange behaviour in TOF0 Y
Re-run G4MICE with 1 cm slabs

Still 5% of double hits ... ?

Maybe something wrong
Conclusion for all TOFes

- TOF0, TOF1/TOF2 design updated
- CAD design in progress
- Some checks with G4MICE under way
- Tests to be done soon for:
  - PMTs timing behaviour in B-field (for R7761 and R4998 mod)
  - Rate effect for R4998 mod