MI CE TOF0 prototypes

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Outline

- Introduction
- Considerations on scint. thickness
- Considerations for PMT choice
- Tests for R4998 conventional PMTs
- Conclusions
Problems for high resolution scintillator based TOF ($\sigma_t < 100$ ps)

- $\sigma_{pl}$ dominated by geometrical dimensions $\sim \sqrt{(L/N_{pe})}$
- $\sigma_{scint} \sim 50-60$ ps (mainly connected with produced number of $\gamma$’s fast and scintillator characteristics, such as risetime) choice BC404
- $\sigma_{PMT}$ dominated by PMT TTS (160 ps for R4998)

$$\sigma_t = \sqrt{\frac{\sigma_{scint}^2 + \sigma_{PMT}^2 + \sigma_{pl}^2}{N_{pe}}} + \sigma_{ele}$$

- Additional problems in harsh environments:
  1. B field (shielding?)
  2. High incoming particle rates
The environment

The beamline design puts harder and harder requests on TOF0 station

- Higher and higher particle rates (now 2.3-2.8 MHz, it was ~1 MHz at beginning)
- Request for thinner and thinner scintillators (but now 2” total thickness for TOF0 seems OK)
- Good late news from Kevin: it seems that B is very small (it was ~150 gauss)
TRD SEPT04 Layout

- ISIS Beam
- Proton Absorber
- TOF0
- TOF1
- Diffuser
- Iron Shield
- Ckov1
- TOF2
- Ckov2
- Cal

6/4/05 VC meeting
### Summary of Rates (Sept04 from Tom Roberts)

<table>
<thead>
<tr>
<th>Description</th>
<th>LAHET</th>
<th>Geant4</th>
<th>MARS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOF0</td>
<td>2355</td>
<td>2693</td>
<td>2834</td>
</tr>
<tr>
<td>TOF1</td>
<td>462</td>
<td>529</td>
<td>557</td>
</tr>
<tr>
<td>Tracker1</td>
<td>422</td>
<td>482</td>
<td>507</td>
</tr>
<tr>
<td>Tracker2</td>
<td>284</td>
<td>324</td>
<td>342</td>
</tr>
<tr>
<td>TOF2</td>
<td>281</td>
<td>321</td>
<td>338</td>
</tr>
<tr>
<td>Good (\mu^+)</td>
<td>277</td>
<td>316</td>
<td>333</td>
</tr>
</tbody>
</table>

Values are events per millisecond of Good Target; absorbers empty, no RF.

Good \(\mu^+\) = TOF0 & TOF1 & Tracker1 & Tracker2 & TOF2 & TOF1(\(\mu^+\)) & TOF2(\(\mu^+\))

**Major changes from before:**

- 2 in. total thickness of TOF0 and TOF1 \(\Rightarrow\) ~20% reduction in Good \(\mu^+\)
- ~50% larger target acceptance \(\Rightarrow\) ~10% increase in TOF0 singles, ~1% in Good \(\mu^+\).
## Summary of Rates (Jun 04 from T. Roberts)

<table>
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<tr>
<th>Description</th>
<th>LAHET</th>
<th>MARS</th>
<th>Geant4</th>
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<tbody>
<tr>
<td>TOF0</td>
<td>2173</td>
<td>2676</td>
<td>2548</td>
</tr>
<tr>
<td>TOF1</td>
<td>513</td>
<td>631</td>
<td>601</td>
</tr>
<tr>
<td>Tracker1</td>
<td>462</td>
<td>569</td>
<td>542</td>
</tr>
<tr>
<td>Tracker2</td>
<td>343</td>
<td>442</td>
<td>402</td>
</tr>
<tr>
<td>TOF2</td>
<td>339</td>
<td>418</td>
<td>398</td>
</tr>
<tr>
<td>Good $\mu^+$</td>
<td>336</td>
<td>414</td>
<td>394</td>
</tr>
</tbody>
</table>

Values are events per millisecond of Good Target and good RF.

Good $\mu^+ = \text{TargetDet} \& \text{TOF0} \& \text{TOF1} \& \text{Tracker1} \& \text{Tracker2} \& \text{TOF2} \& \text{TOF1}(\mu^+) \& \text{TOF2}(\mu^+)$
TOF0

TRD Size 480x480

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TOF0 X/Y singles projection

With 4 cm width slabs max counter rate seems < 400-500 KHz. R4998 maybe OK with booster or active divider circuit (studies under way)
Good muons X/Y projections at TOF0 (from T. Roberts)

Question for Tom: X/Y projections for good particles seem not fully compatible with XY scatter plot (X projection bet -150, +150 instead of -240, +240 mm)
Considerations on scintillator thickness

- Shown time resolution is FWHM vs scintillator thickness L
- Green/red lines from BC408; blue line is BC404 (faster)
- Data from MEG tests at BTF

Actual choice: $\sigma \sim 60$ ps

Thin solution: $\sigma \sim 100$ ps if all goes right (perfect detector calibration, ...) I will retain thick solution (1” slabs)
Single scintillator counter layout

- BC404 scintillator (compromise between cost and performances: decay time 1.8 ns, att length ~ 160 cm, max emission at 408 nm well matched with R4998 max response at 420 nm)
- $L=480$ mm to avoid particles hitting lightguides
- $W=40$ mm to reduce rate with a sensible counter number
- $T=1''$ to have good timing resolution
Mechanics for TOF0

View of X/Y plane, some counters may be missing along X: eg 12 vertical counters, 6 horizontal counters.
TOF0 support structure
Considerations for TOF0 PMT choice

1. Rate capability (up to some MHz)
2. Good timing properties (TTS)
3. Sustain magnetic field (we now assume <50 gauss for TOF0)

In house soilenoid built for tests up to 50 gauss (M.Bonesini, F.Strati INFN Milano).
PMT test setup

Laser source to simulate MIP signal (about 300 p.e.) :

• fast AVTECH pulser AVO-9A-C (risetime 200 ps, width 0.4-4 ns, repetition rate 1KHz-1MHz) with NDHV310APC Nichia violet laser diode (~400 nm, 60 mW) NEW!!
• fast PLP-10 laser on loan from Hamamatsu Italia

Laser sync out triggers VME based acquisition (TDC + QADC) // MCA SILENA system

Home made solenoid test magnet (B up to 50 gauss, d~20 cm, L~50 cm) see later for details
Rate capabilities of PMTs

To have a linear signal the mean average anode current (100 $\mu$A for R4998) must not be exceeded -> damage to dynodes ... shorter PMT lifetime

This gives a theoretical rate capability of:

267 KHZ with R4998

**BUT !!! Divider can be modified for R4998 (going up to 1.67 MHZ) with booster or active divider**
Solenoid test magnet (B up to 50 gauss)
Used laser light source (PLP 10)

Light source: Hamamatsu fast laser (λ≈405 nm, FWHM 60 ps, 250 mW peak power) PLP-10

Optical system: x,y,z flexure movement to inject light into a CERAM/OPTEC multimode fiber (spread 14 ps/m)

PMT under test

Laser light Signal ~ 300 p.e. to reproduce a MIP as measured with an OPHIR Laser powermeter
Used laser light source (Avtech)

- Light source: Nichia violet diode (\(\lambda\approx408\) nm, FWHM 4-4 ns, 60 mW peak power)
- Optical system: x,y,z flexure movement to inject light into a CERAM/OPTEC multimode fiber (spread 14 ps/m)
- Avtech pulser

This system well suited to simulate scintillator signals
R4998 PMT rate studies

R4998 with modified divider circuit: booster for last dynodes

<table>
<thead>
<tr>
<th>Structure</th>
<th>R 4998</th>
<th>R 5505</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stages</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Gain</td>
<td>$5.7 \times 10^6$</td>
<td>$5 \times 10^5$ B=0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$1.8 \times 10^4$ B=1 T</td>
</tr>
<tr>
<td>Rise Time</td>
<td>0.7 ns</td>
<td>1.5 ns</td>
</tr>
<tr>
<td>Transit Time</td>
<td>10 ns</td>
<td>5.6 ns</td>
</tr>
<tr>
<td>Transit Time</td>
<td>Jitter</td>
<td>0.16 ns</td>
</tr>
</tbody>
</table>

Nominal: up to 1.5 MHz

6/4/05 VC meeting
One specimen on loan in July 2004 for tests
R4998 tests

- Some tests done last year (see later)
- more tests now
- Most probable choice: R4998 in H6533mod assembly
  - Active divider (instead of booster)
  - Mod cables out (RG58 instead of RG174, standard HV cable)
  - Mu metal shielding
Gain in magnetic field for R4998
Timing properties of R4998 in B field

LASA tests 07/04 z H6533 mod booster + mu metal

- ◯ pos 1 – along Y
- △ pos 1 – along x
- ◊ pos 3 – 50 days to Z

6/4/05 VC meeting
Rate effects studies for R4998

- done with available R4998 with modified divider from Hamamatsu (booster on last dynodes)
- Light signal corresponds to ~ 300 p.e.
Plan of future work

- tests of R4998 with test solenoid up to 50 gauss
- tests (for TOF1/TOF2) fine-mesh PMTs at LASA
- Begin to think about rate problem for QADC/TDC (tests? Help from Emilio?)
- Follow up of TOF0 prototype
Conclusions

- the idea is to have ~18 fully equipped scintillator counters (BC404 + R4998 PMTs as RH6533MOD assembly) to assemble a complete TOF0 station:
  - 12 counters along Y/6 counters along X funded by UNIGE
- Open problems:
  - R4998 can be equipped with a booster or an active divider (same performances according to Hamamatsu engineers, but easier to handle)
  - Choice of QADC/TDC: tests must be done