

The development of the Icarus T600 laser diode calibration system



INFN Milano Bicocca, Dipartimento di Fisica G. Occhialini, Milano, Italy¹, INFN Pavia, Dipartimento di Fisica, Pavia, Italy²



Introduction

As Icarus T600 will be installed with a minimal overburden, cosmics background has to be strongly reduced. Use timing properties of the 360 Icarus PMTs to reduce it \rightarrow needs PMT's timing at better than 1 ns \rightarrow requires time calibration of PMTs at better than 100-200 ps [channel time delays drifts due to temperature effects, ...]

Layout of the laser cal system





Hamamatsu PLP10 laser diode: FWHM 60 ps, peak power 200 mW



Pulse measurement with an HP 54750 sampling scope

2) Fiber characterization: MM vs SM



The PMT timing/gain equalization is performed by using fast light pulses from a laser source. The laser pulse is sent to each PMT (360) via a distribution system based on fiber patch cords, vacuum optical feedthroughs, fused fiber splitters and optical switches.

Problem: light pulses must have minimal time dispersion and signal attenuation at delivery point in front of the PMTs Strategy:

- try to characterize components for use at 400 nm, taking into account timing properties (FWHM) /attenuation
- Try to use low cost components, e.g. laser diodes (\$) instead of Q-switched lasers (\$\$) and Telecom components
- **Cons**: low peak power (< 1 W) **power budget** in the calibration system is a **must** (use multimode (MM) fibers instead of single mode(SM) fibers to reduce injection problems, losses ...)

- **To reduce** injection problems, MM instead of SM fibers.
- **Needs to study** timing, attenuation properties and delay dispersion of MM fibers

Typical timing spread increase (σ_t) vs fiber length L (m) for a MM fiber (IRVIS 50/125 OZ/OPTICS) : 1 ps/m. Similar results for other 50/62.5 µm MM fibers.



3) Tests of optical splitters/switches and feedthrough



• Optical switch: to send input signal to 1 of N output lines. MM fiber type to work at 400 nm. Insertion loss ~1.5 dB, cross -talk ~70 dB **Optical splitters 1xN** : divide input signal to N output lines.

- Fused 1xN splitters are cheaper (\$), but usually available for Telecom (850/1300 nm) not visible wavelenghts (400 nm)
- Splitting ratio may be odd at ~400 nm -> needs mode scrambler
- What happens to input signal ? Attenuation, time spread -> needs careful measurement

Results:

- Laser pulse FWHM after an optical switch (PiezoJena F-109-05) is increased at most of ~ 3% A Lightel 1x10 fused optical splitter [36 tested] increases pulse FWHM of < 4%. Uniformy of output signals is within 20% with typically 1 signal out by > 50% [to be attenuated]. Delays are within 10-20 ps. Used VACOM optical feedthroughs have no effect on the FWHM of the incoming pulse and have negligible effects on delay (~+100 ps), but attenuate signals ~ 15%.





Components characterization



INFN MIB test system: the laser pulse is detected by an Hamamatsu G4176 $(t_R, t_F \sim 40 \text{ ps})$ or a Picometrix D30 (FWHM $\sim 30 \text{ ps})$ photodetector and measured by a 20 GHz HP 54750 sampling scope (timing studies) or by an OPHIR powermeter (attenuation studies)



- CF 40/ CF200 nibble
- 4. CF40 50 mm fiber FC/FC optical feedthrough

4) Temperature dependence of components

Delas 170	T	+15 C	+5 C	0 C	-5 C	-10 C	
	V max (mV)	10.76+06	10.79+02	10.71+07	10.56+04	10.72+08	• Maggurad with a
	Risetime (ps)	58.85+-3.47	59.57+85	59.09+3.45	59.38+-5.52	58.93+-5.85	• Weusureu with u
The local division of	Width (ps)	81.95+-1.07	81.53+1.00	81.92+1.34	81.67+-0.96	81.91+-1.53	 OZ/Optics 1x4 splitter No effects seen
	Pulse delay	105.015	105.011	105.009	105.001	105.008	

For the chosen 50/125 μ m OZ/Optics fiber the delay changes of 100 fs/m ^oC and no effects are seen on timing properties in the range [-10,+50°C] An increase in attenuation of ~ 10 % is seen instead going to cryo temperatures

Conclusions

All components needed characterized at 405 nm wavelength

For temperature dependence studies we used either a LAUDA

thermal machine (precision 0.1 C) or a LN2 bath (tests at cryo temp)





Expected calibration resolution < 100-200 ps : enough for the 1 ns target of

the timing measurement with PMTs