s

QUARTIC Monte-Carlo Status

S.Kuznetsov, V.Petrov, R.Ryutin, V.Samoylenko, A.Sobol.

IHEP, Protvino

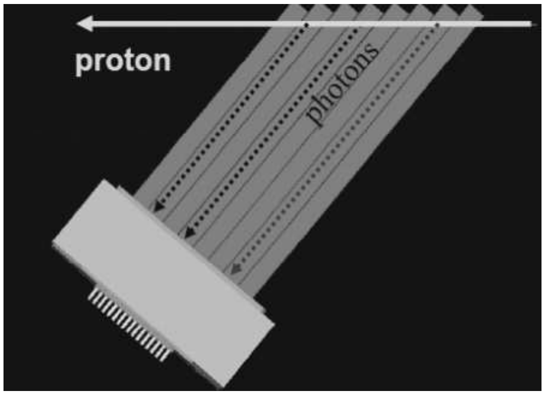

Figure 1: QUARTIC Detector

Monte-Carlo Model:

- The Bar 6x6x90 mm^3
- Material - fused silica with $n(\lambda)$, $\lambda = 300 - 600$ nm
- Surface – Polish, dielectric-dielectric
- PhotoReadout: MCP (Micro Channel Plate) with
- TTS (Time Transition Spread) – 35 ps
- Quantum Efficiency – $Q(\lambda)$
- Amplitude Single Photoelectron Width – 50%.
- Angle to Beam – 46^o

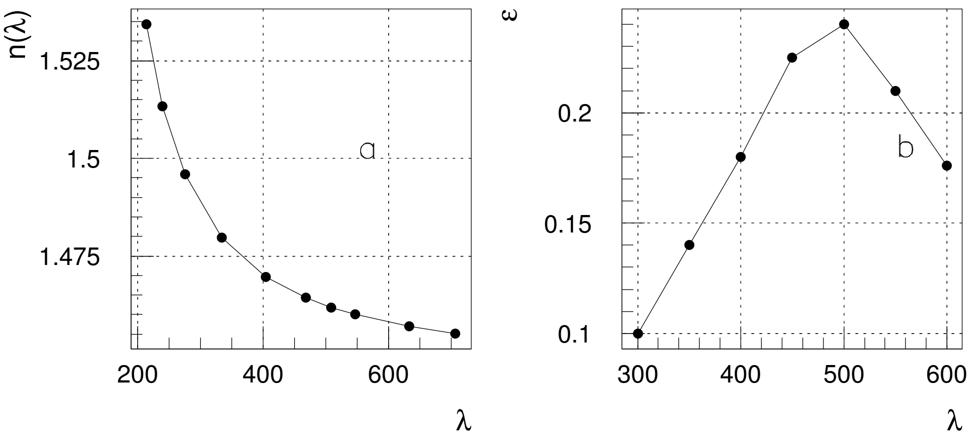

Figure 2: Refraction Index of Fused Silica (a). MCP Quantum Efficiency (b)

Cherenkov Light Flash

Take into account optical photons in the interval $\lambda = 300 - 600$ nm. Due to optical dispersion of the fused silica the cherenkov light flash has the duration

$$\delta t = \frac{r}{\beta c}(tg\theta_2 - tg\theta_1), \tag{1}$$

where $\theta = arccos(1/\beta n(\lambda))$, r - the distance from a particle to photoreadout. In our case $\delta t \approx 1.2$ ps.

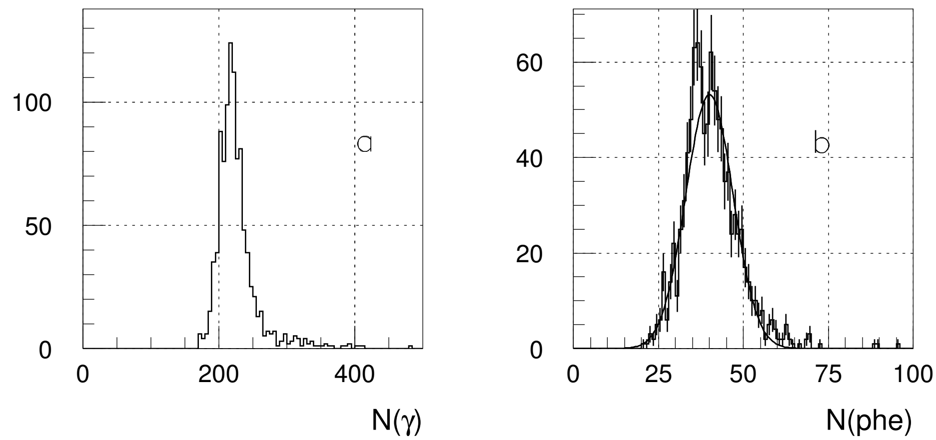

Figure 3: The number of optical photons in Bar (a). The number of photoelectrons (b)

The cherenkov optical photon number estimation (in assumption $n(\lambda) = const$)

$$N = 2\pi\alpha Z^2 L(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}) sin^2\theta \approx 350. \qquad (2)$$

The optical photon number distribution is Poisson with $\mu \approx 40$. These numbers are in good agreement with results (NIM A 528(2004) 763 - 775), (NIM A 560(2006) 303 - 308) in which a similar radiator and MCP used.

Light Flash Time Distribution

About 80% of the optical photons arrived to Sensitive Detector during first 20 ps. The MCP Signal rise time is ≈ 100 ps (Fig. 4d), a some better than usually in References (for insance in NIM A 560(2006) 303 - 308). Its can explained the role of the signal cable (and his length) which acts as a frequency filter. The relative long tile is arise from multiple internal reflection. The MCP noise and possible signal distortion did not takes into account.

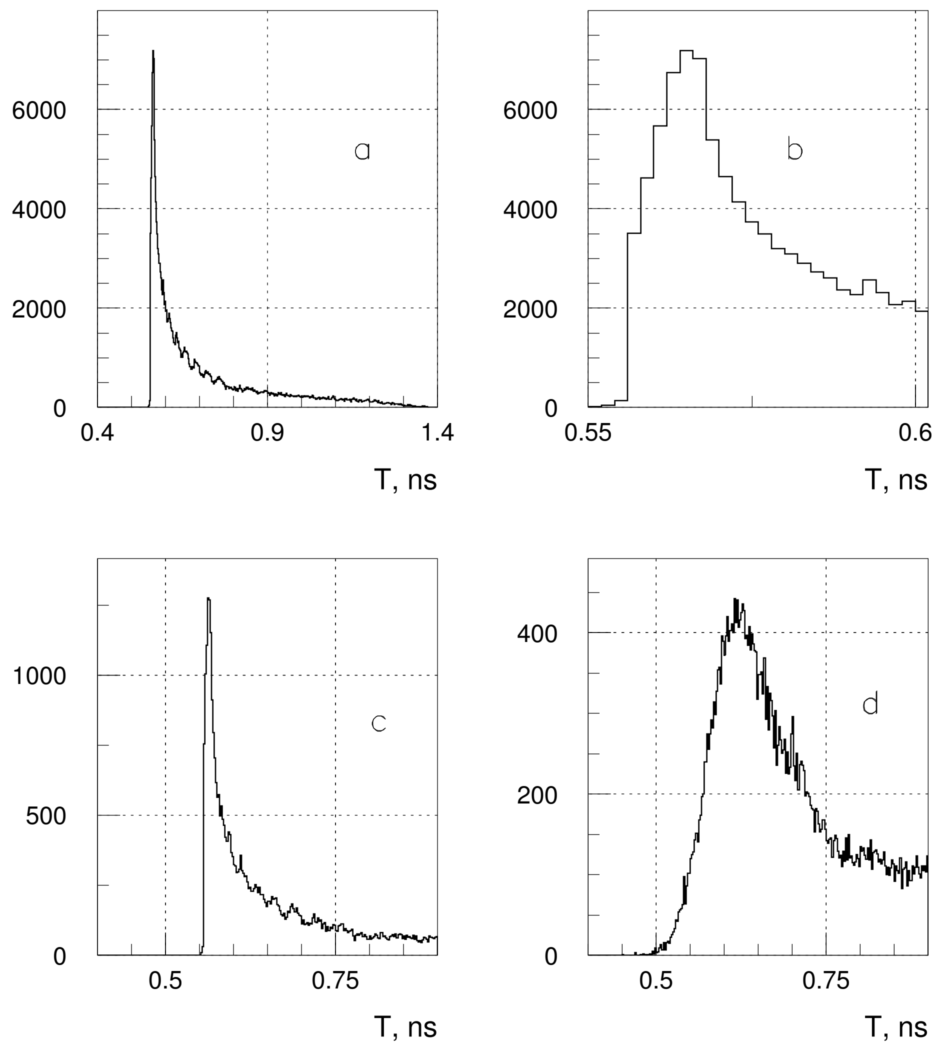

Figure 4: The Time distribution of optical photons arrived in Sensitive Detector (a). The same with fine scale (b). The Time distribution of the photoelectrons (c). The MCP Output Time distribution – Signal Shape (d).

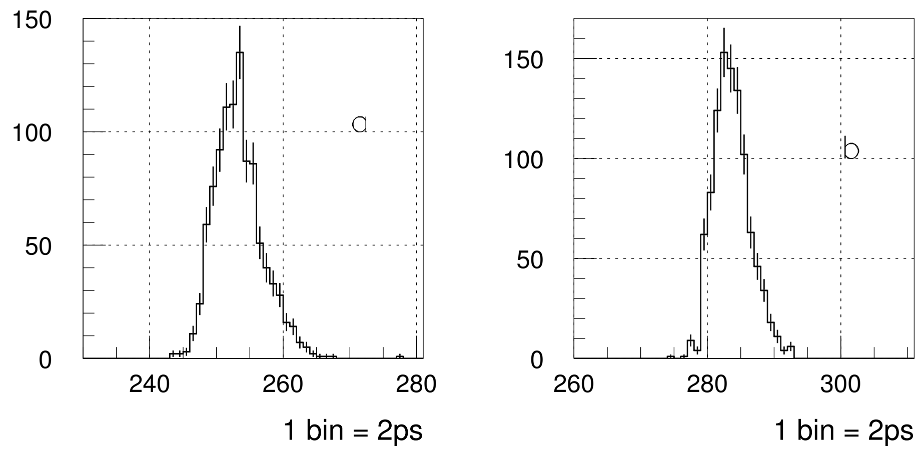

Figure 5: The Time Resolution for LED method (a). FWHM is about 15 ps. The Time Resolution for CFD method (b). FWHM is about 13 ps.

Timing Methods: Leading Edge Discriminator (LED) and Constant Fraction Discriminator (CFD)

The Threshold for LED is usually $\approx 10\%$ from maximal amplitude. It should recall that Cherenkov energy loss is not like a Landau distribution, but more narrow. This fact makes LED usage simple and reduces usual for scintillator counter the role of walk-effect. There is opinion that CFD has an advantage compare with LED, but the adjustment of the internal delay for signal's rise time is very critical. In Monte-Carlo the delay is about a half of rise time. The results obtained for these two methods are very close.

Timing Methods: Signal Shape Fit

Signal is digitize by Flash ADC (let 8 bits) with very high rate. Good but complicated method. Require practicale absolute timing for digitizing strobe. Now not clear perspectives.

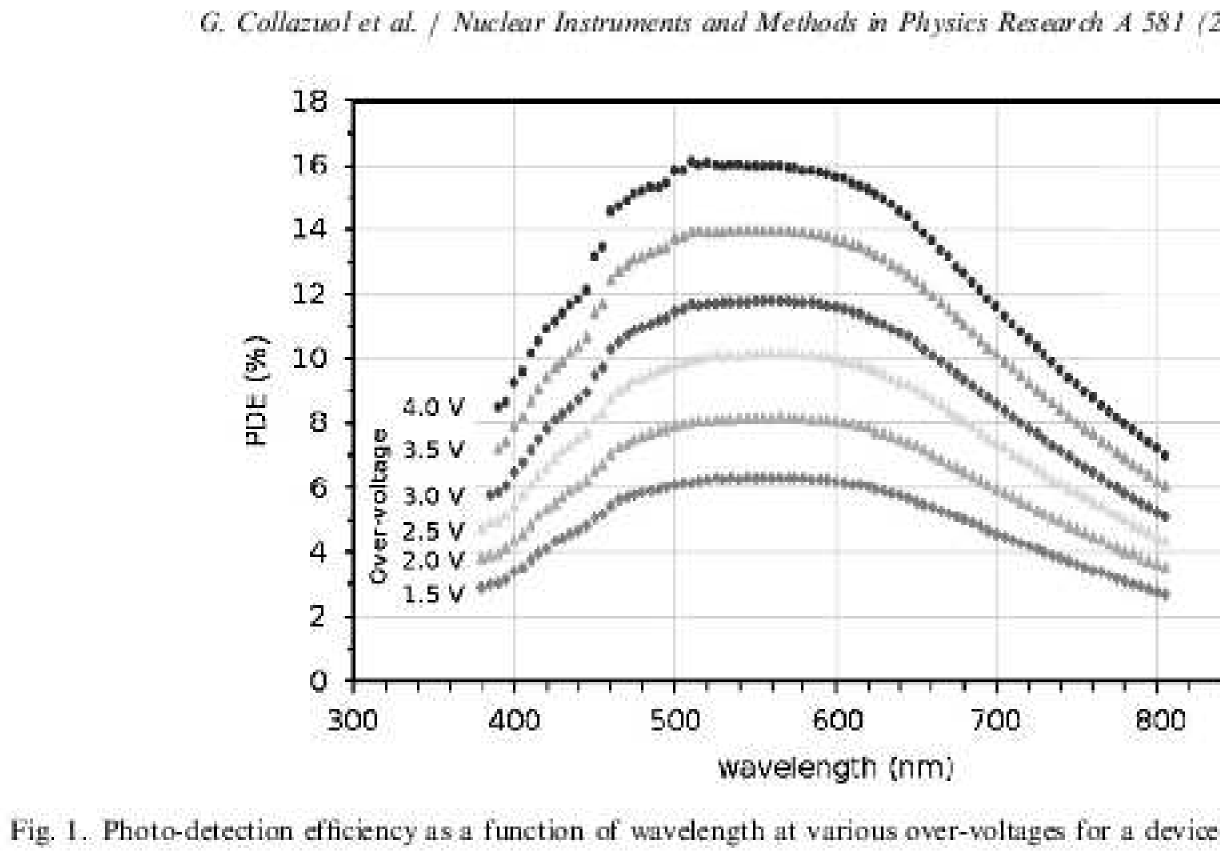

Figure 6: The SiPM Spectrum Sensitivity

PhotoReadout Methods: look on SiPM

G.Collazuol etc, NIM A 581(2007) 461-464.

PhotoReadout Methods: look on SiPM

G.Collazuol etc, NIM A 581(2007) 461-464.

Very good Timing Resolution for appropriate number of the Photoelectrons $<$ 70 ps(next Page).

High Quantum Efficiency

Small Size

464 *G. Collazuol et al. / Nuclear Instruments and Meth*

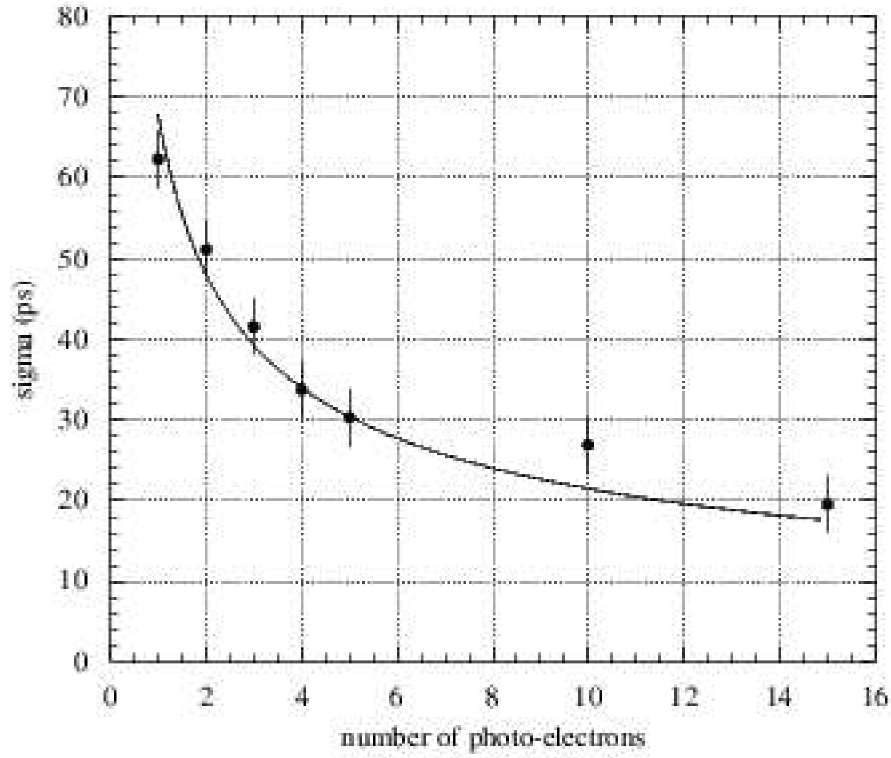

Fig. 3. Time resolution σ_t as a function of the number of simultaneous photoelectrons $N_{p.e.}$ at $\lambda = 400$ nm and over-voltage $\Delta V = 4$ V (circles). The best fit to the function $\sim 1/\sqrt{N_{p.e.}}$ (Poisson statistics) is also shown (line).

Figure 7: The Time Resolution

Conclusion

- Monte-Carlo Simulation for QUARTIC was performed.
- The distributions of photon arrival time and signal shape was obtained.
- The Time Resolution for different timing methods are 15 (LED) and 13 (CFD) ps.
- A factors which makes the Time Resolution worse: amplifier's and cable's finite frequences interval (cut highest harmonic in signal), internal discriminator jitter due to charge sensitivity, possible temperature unstability, noise are now under consideration. Sure experiment can help.
- Interesting test SiPM PhotoReadout for Silica Bar Promising high Time Resolution.