Interaction Tagger status

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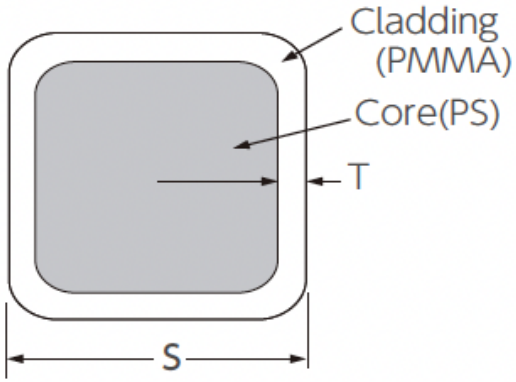
What is ongoing in Genova

There are two main activities ongoing at INFN Genova:

- Characterization of SciFi sample produced by Luxium and Kuraray;
- Studies of timing resolution achievable with SciFi, OnSemi SiPM with fast output, and the ALCOR DAQ chain.

Scintillating Fiber

- We have two samples of SciFi from Luxium and Kuraray
- They are 2mm squared-section SciFi with single cladding.



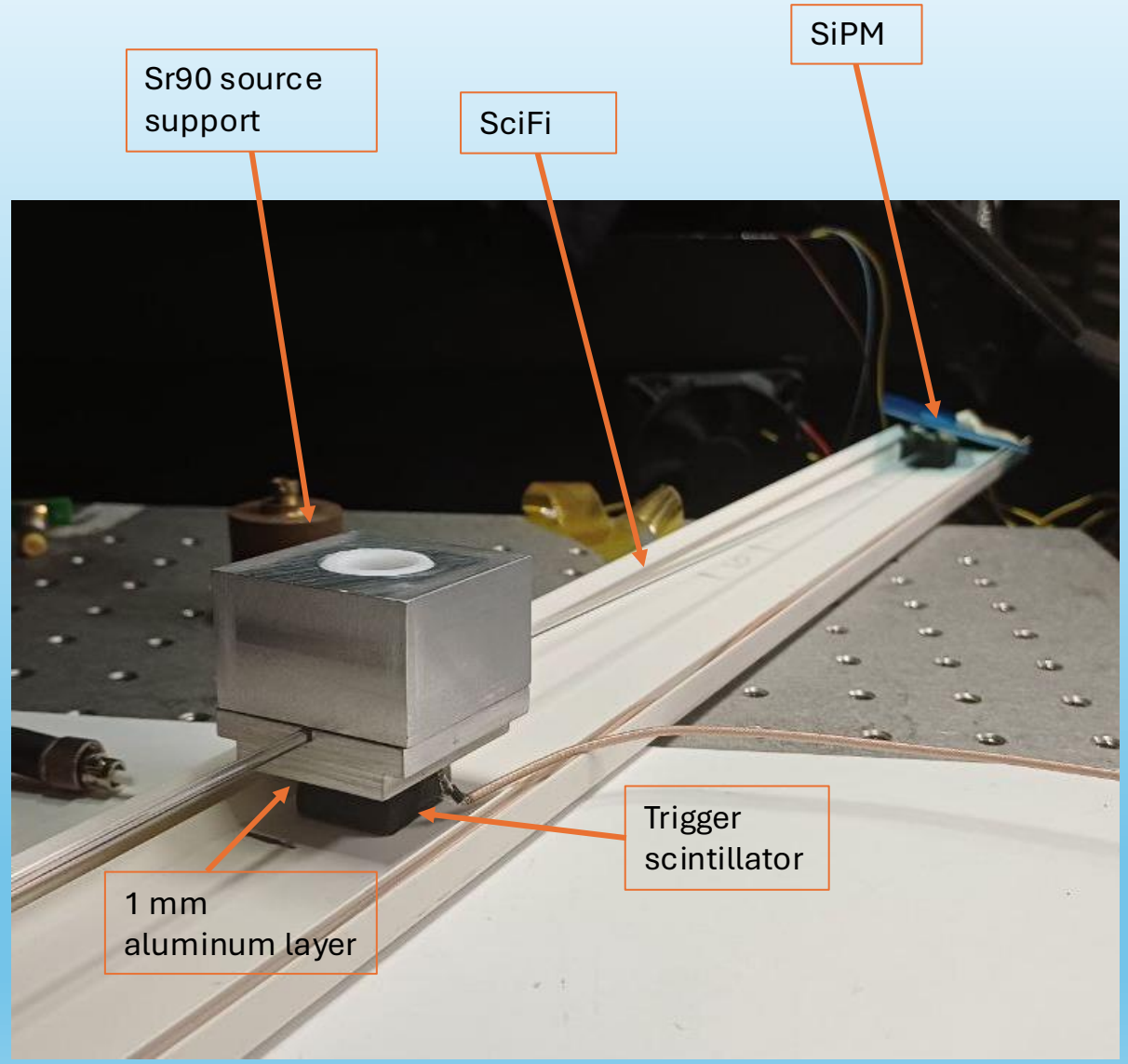
Cladding Thickness : T=2% of S
Numerical Aperture : NA=0.55
Trapping Efficiency : 4.2%

Description	Emission			Decay Time [ns]	Att.Leng.[2] [m]	Characteristics
	Color	Spectra	Peak[nm]			
SCSF-78	blue	See the following figure	450	2.8	>4.0	Long Att. Length and High Light Yield
SCSF-81	blue		437	2.4	>3.5	Long Attenuation Length
SCSF-3HF(1500)	green		530	7	>4.5	3HF formulation for Radiation Hardness

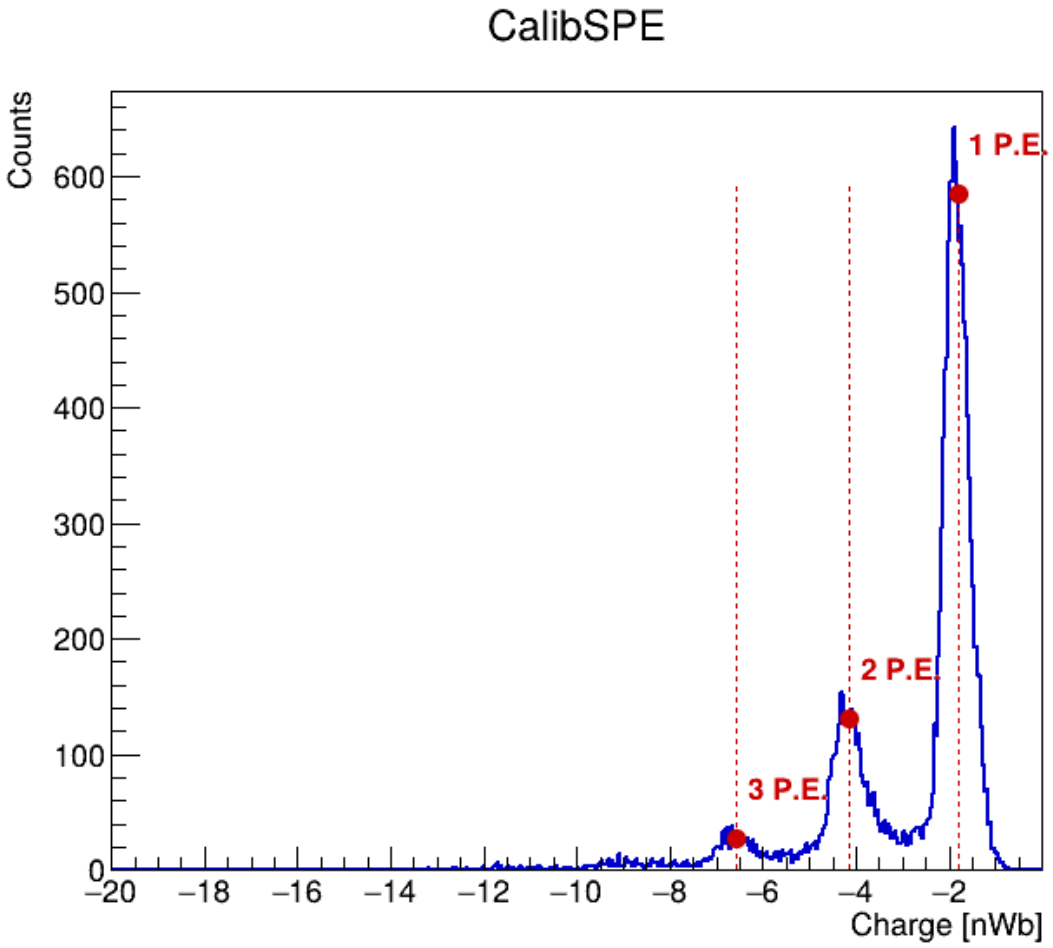
Fiber	Emission Color	Emission Peak, nm	Decay Time, ns	# of Photons per MeV*	Attenuation Length (m)**	Characteristics / Applications
BCF-10XL	blue	432	2.7	~8000	>4	General purpose; optimized for diameters >250μm
BCF-12XL	blue	435	3.2	~8000	>4	Improved transmission for use in long lengths

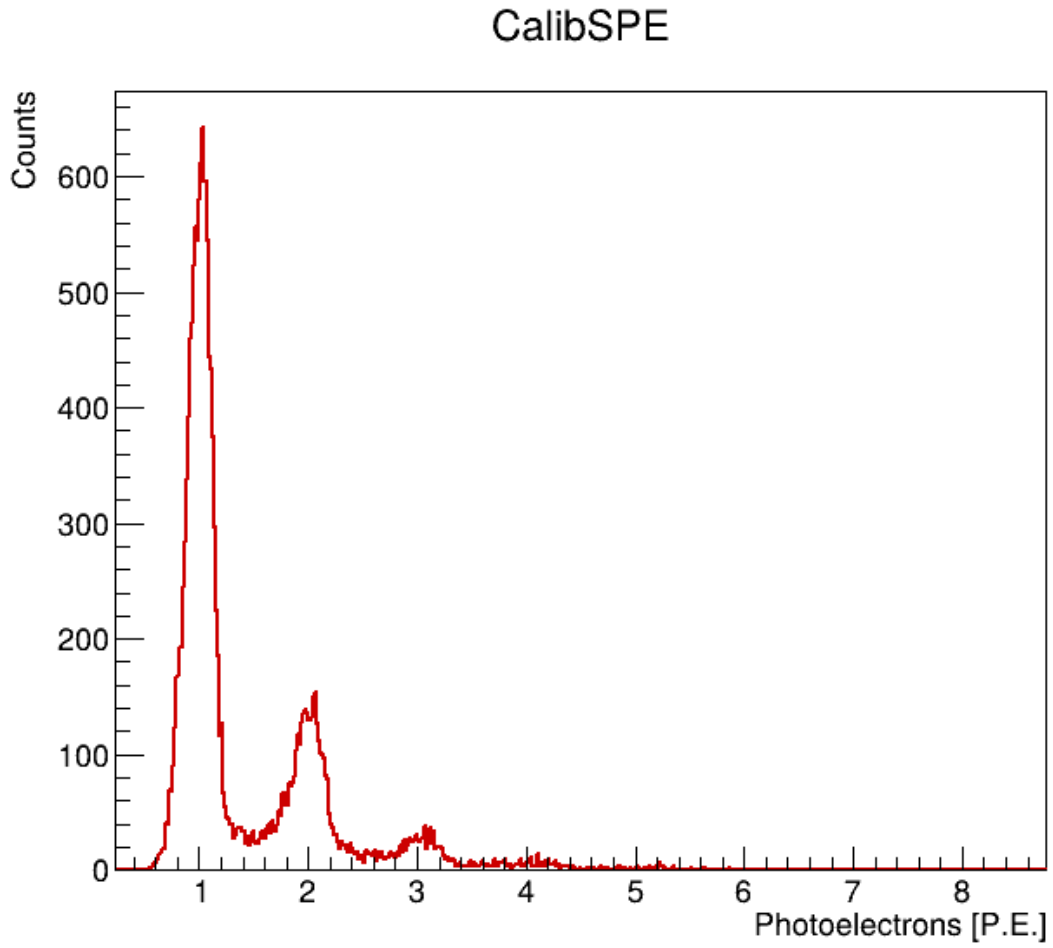
Test setup

- Support for a Sr90 source, with a 1 mm collimator, to select electrons passing directly through the SciFi placed in the dedicated groove.
- 1mm aluminum layer to stop low energy electrons.
- Trigger scintillator to select $\mathcal{O}(1\text{MeV})$ electrons comparable with a MIP.
- The SciFi goes directly to the SiPM.



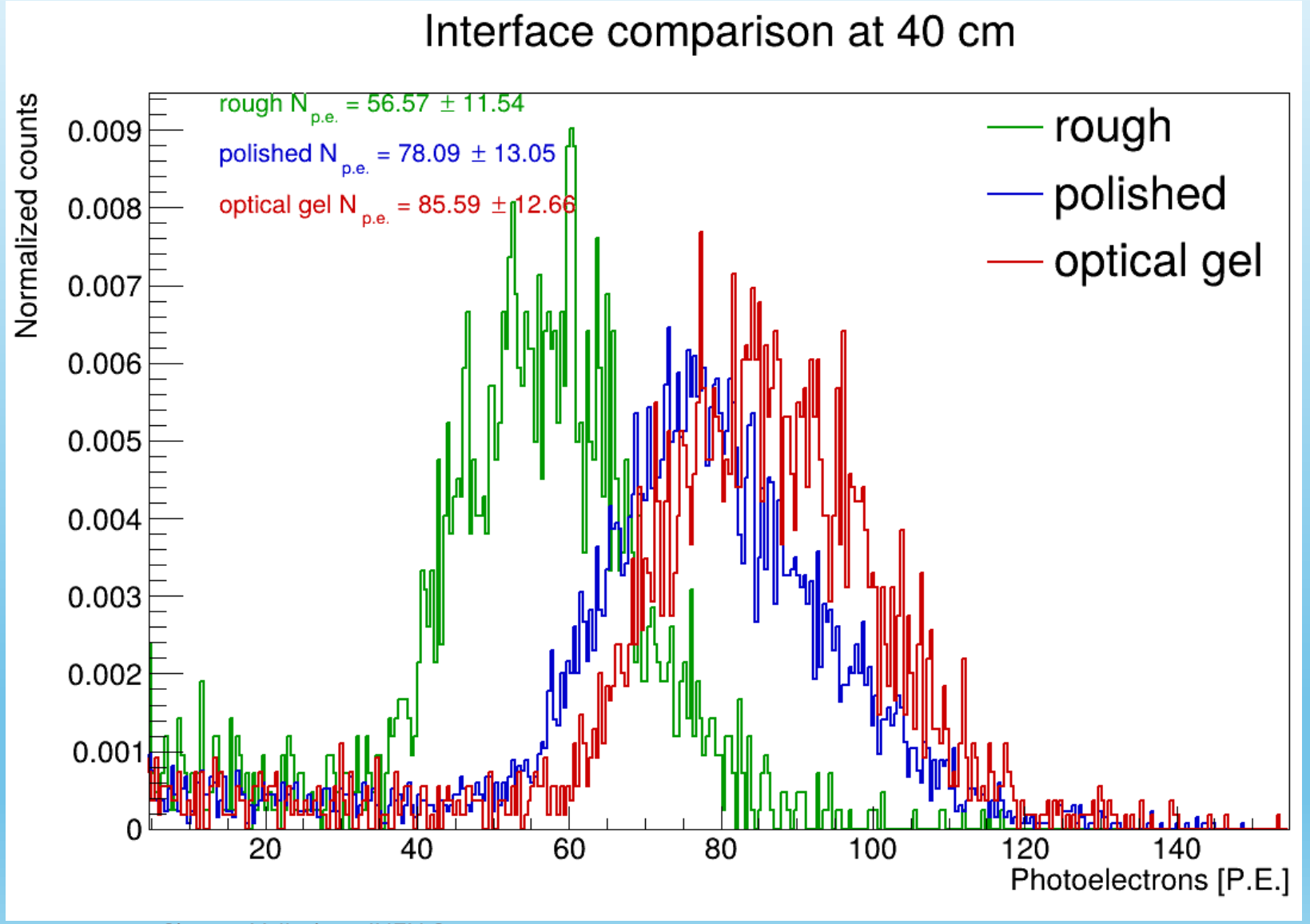
SiPM calibration





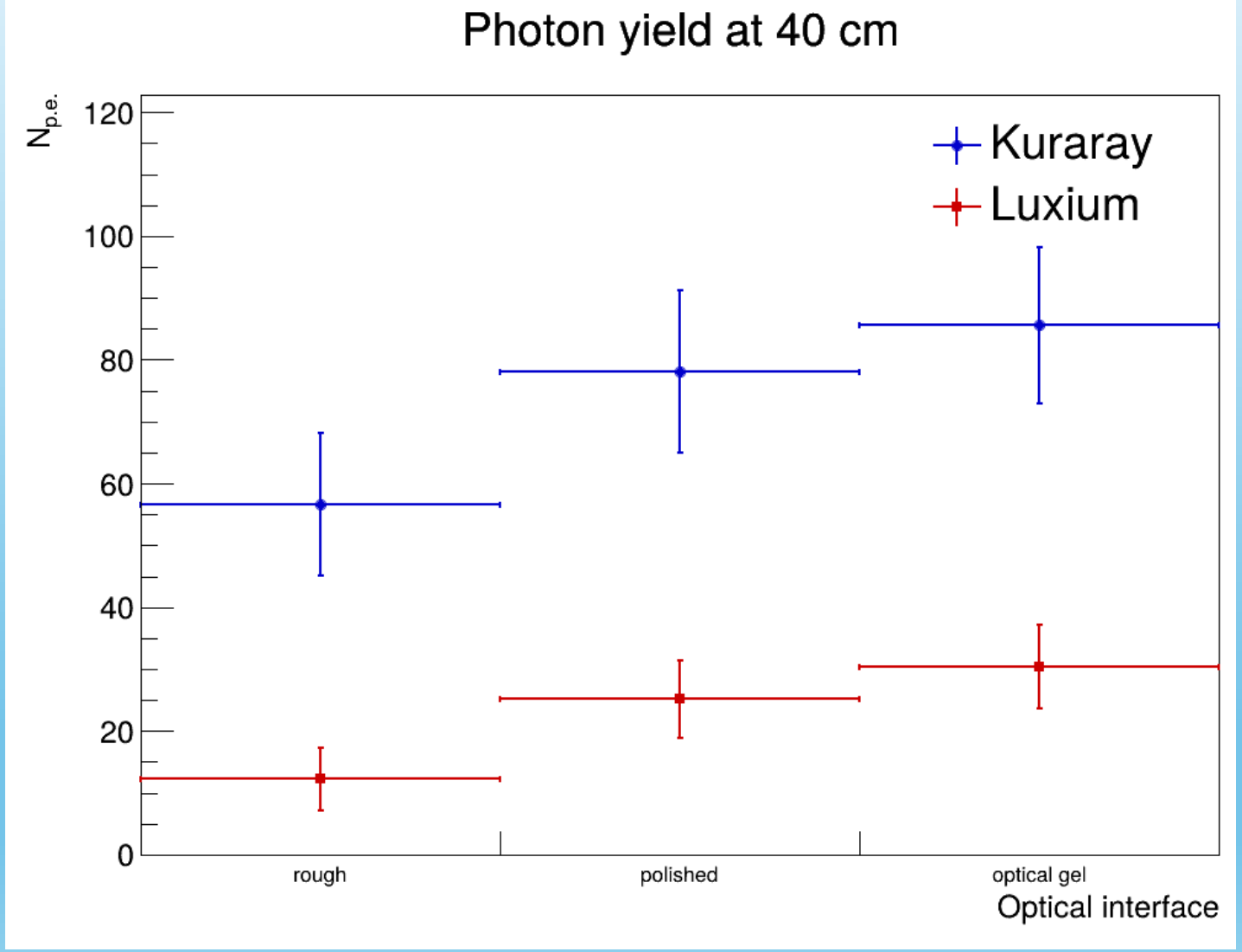
SciFi SiPM interface study

- Number of P.E. measured with rough, polished, and optical-gel-covered interface.
- To polish the surface is needed, the effect of the optical gel is not negligible.



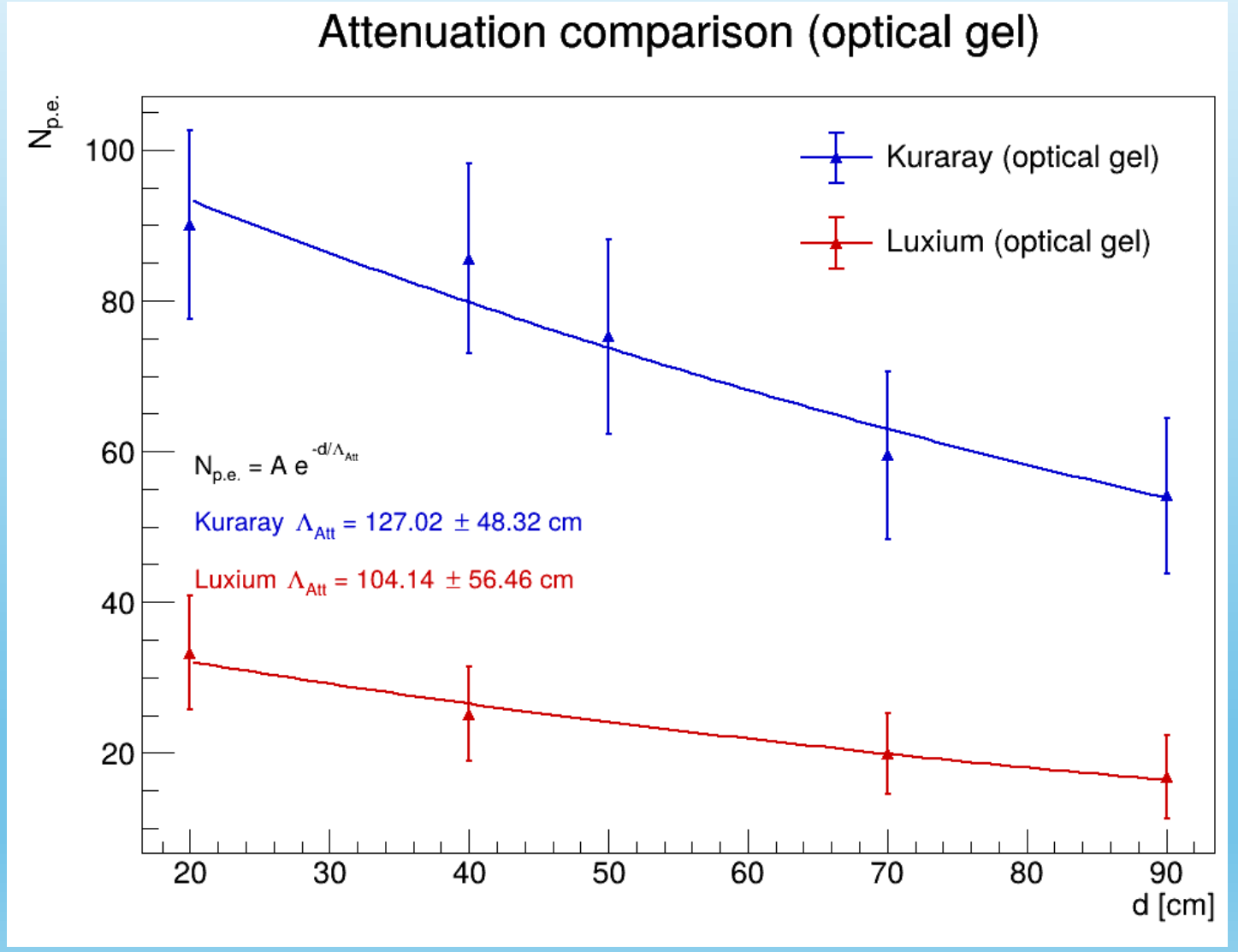
Comparison of Luxium and Kuraray SciFi

- A preliminary estimation of 20 P.E. per MIP was extremely conservative.
- The Kuraray SciFi has a light yield of ~3 the Luxium SciFi.
- The gain introduced by treating the interface is similar.
- The Kuraray performance in term of photon yield is clearly better than Luxium.

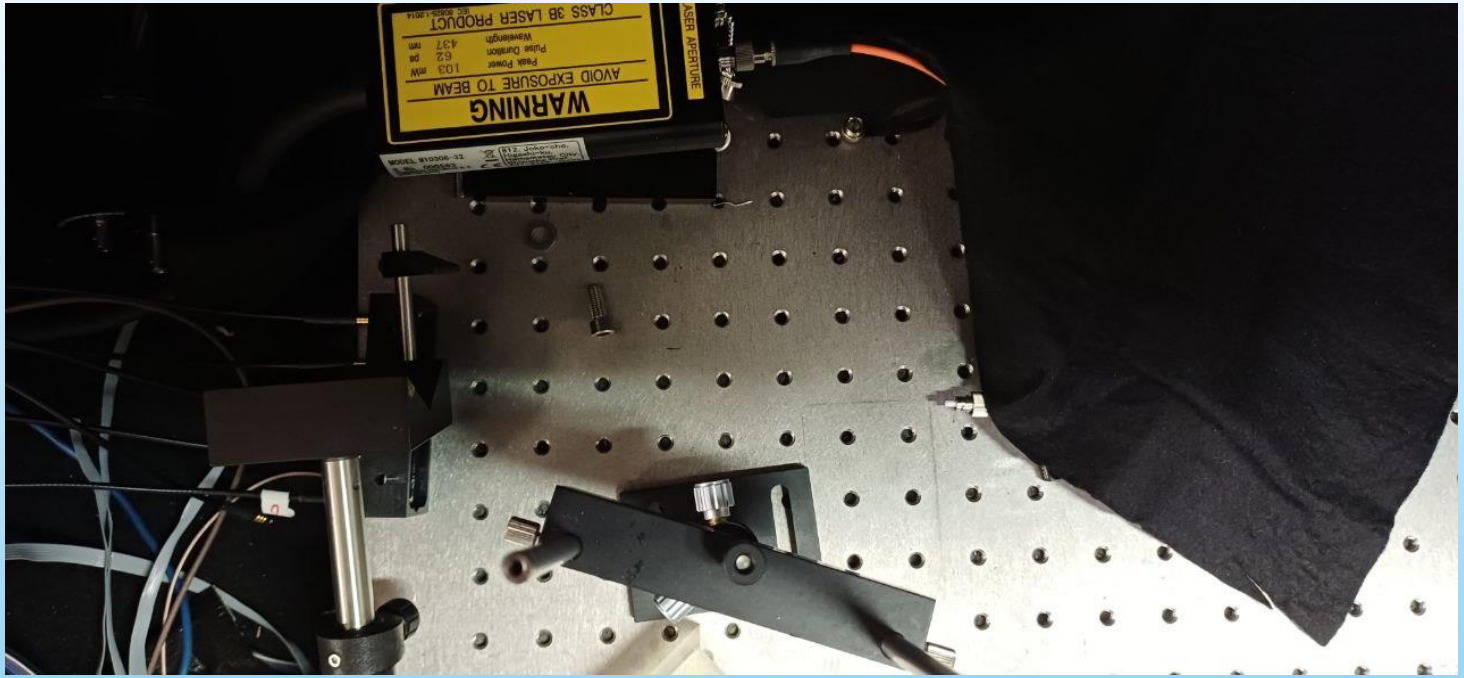


Attenuation length

- $N_{P.E.} = A\, e^{-d/\Lambda_{att}}$
- The attenuation length for the Kuraray SciFi is larger rather than the Luxium sample.
- The attenuation length was measured, still with a large uncertainty.
- The expected maximum length for the Interaction Tagger SciFi is ~2m, a new test with a longer sample and larger statistics will be performed in next weeks.

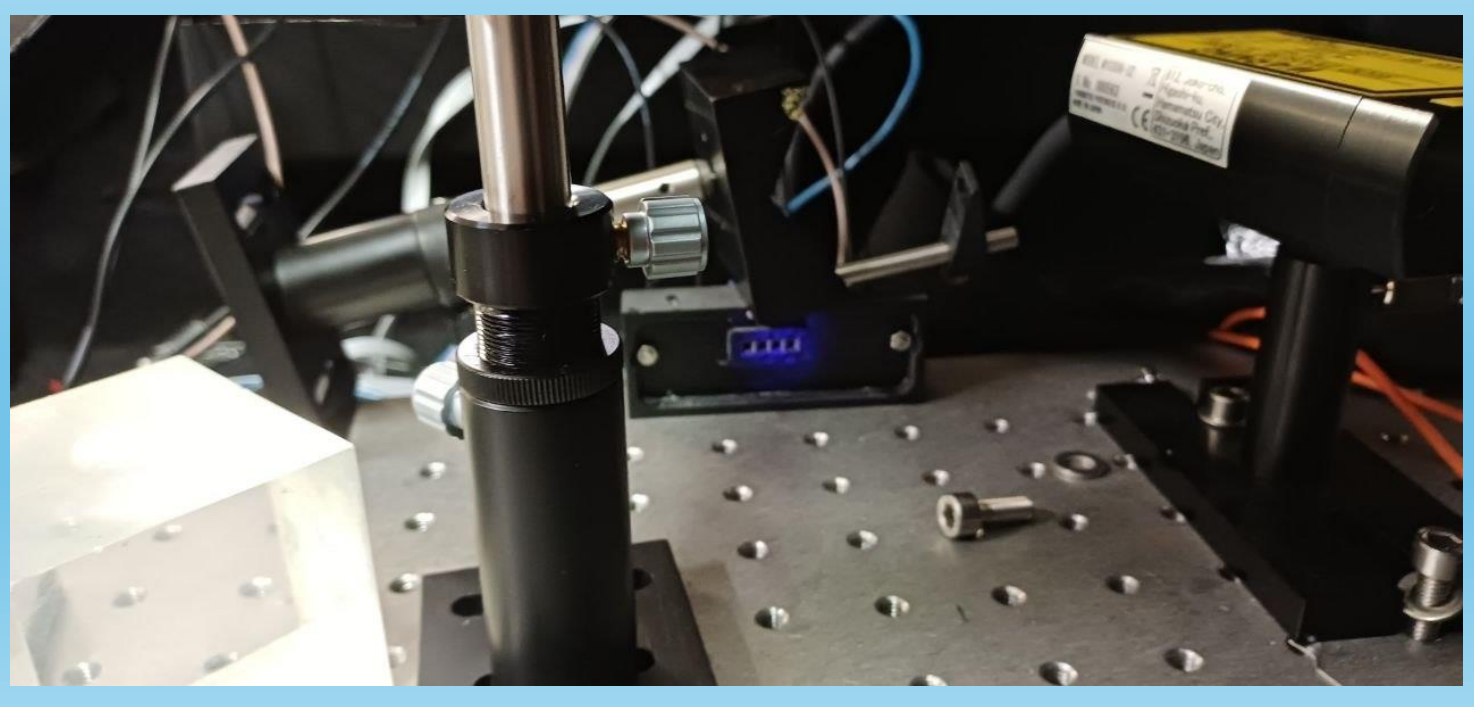


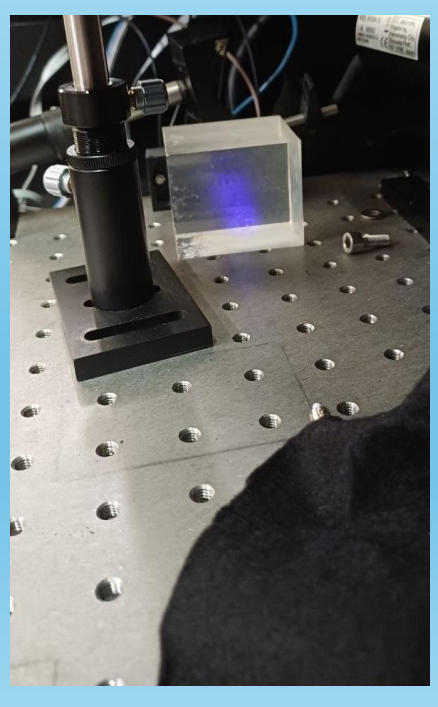
Timing study



Experimental setup

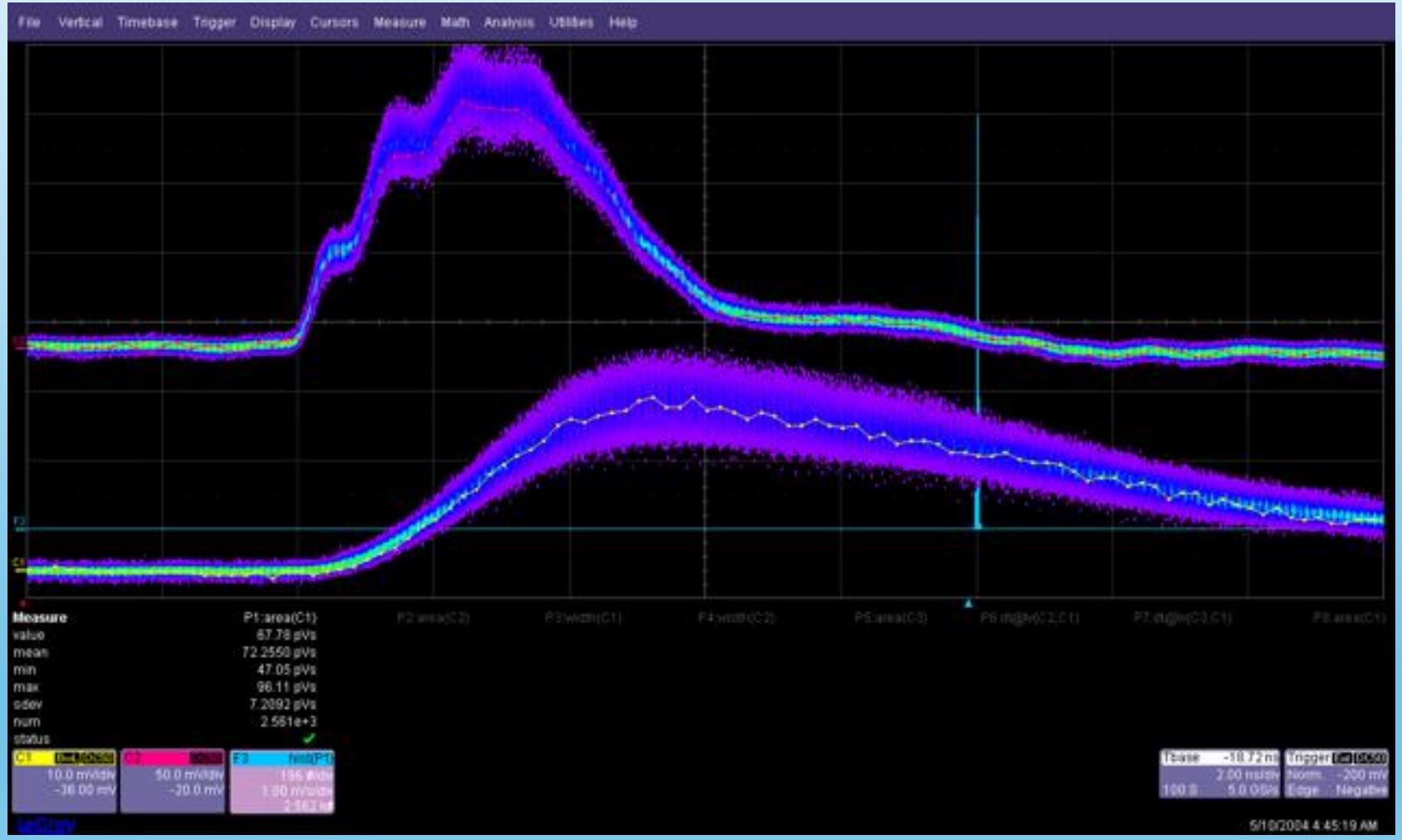
- Laser at 10 kHz;
- Laser pulse duration ~100 ps;
- W/o plastic diffuser;
- Oscilloscope or ALCOR readout.

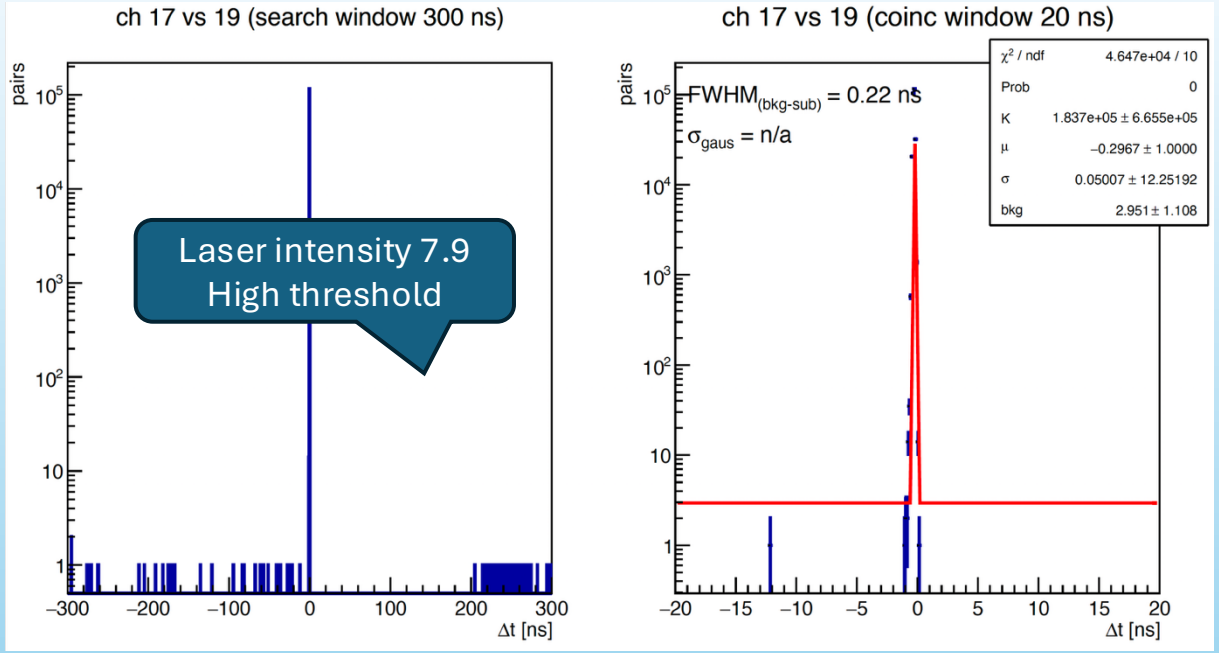


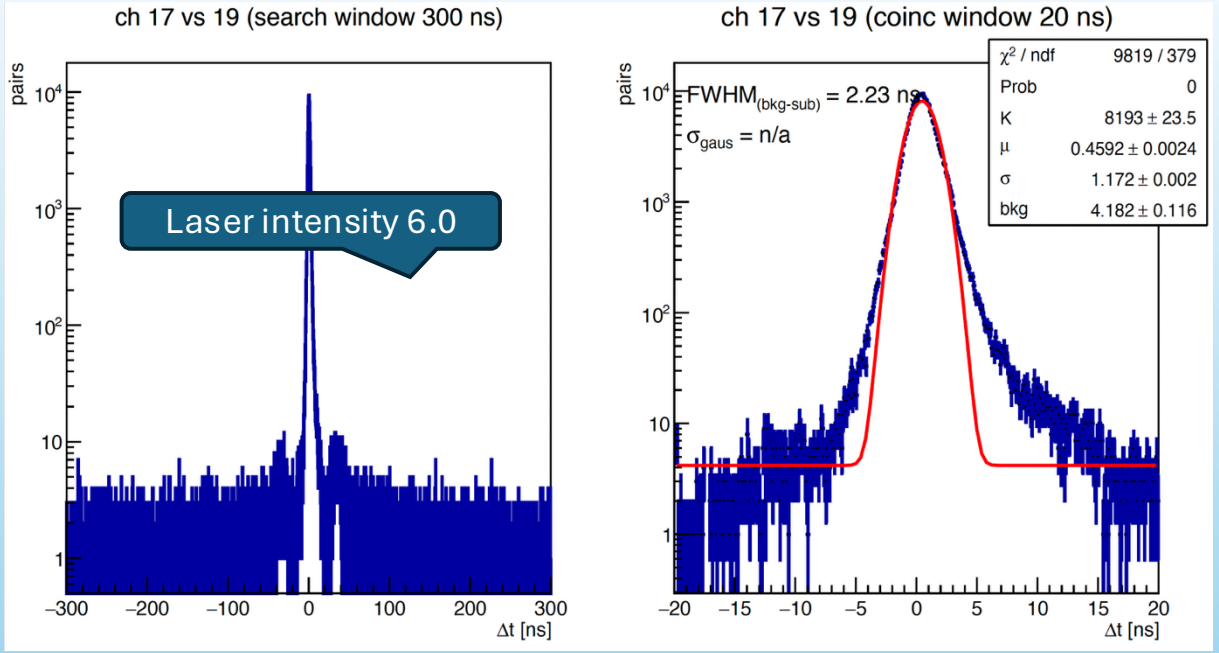


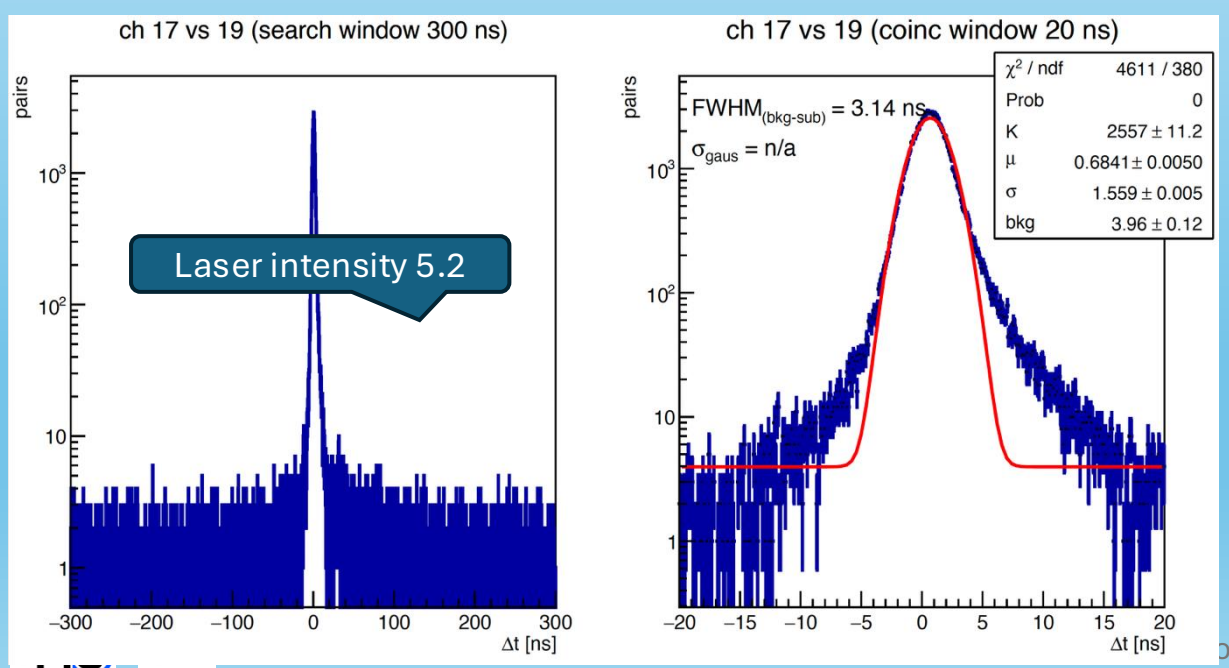
Timing resolution

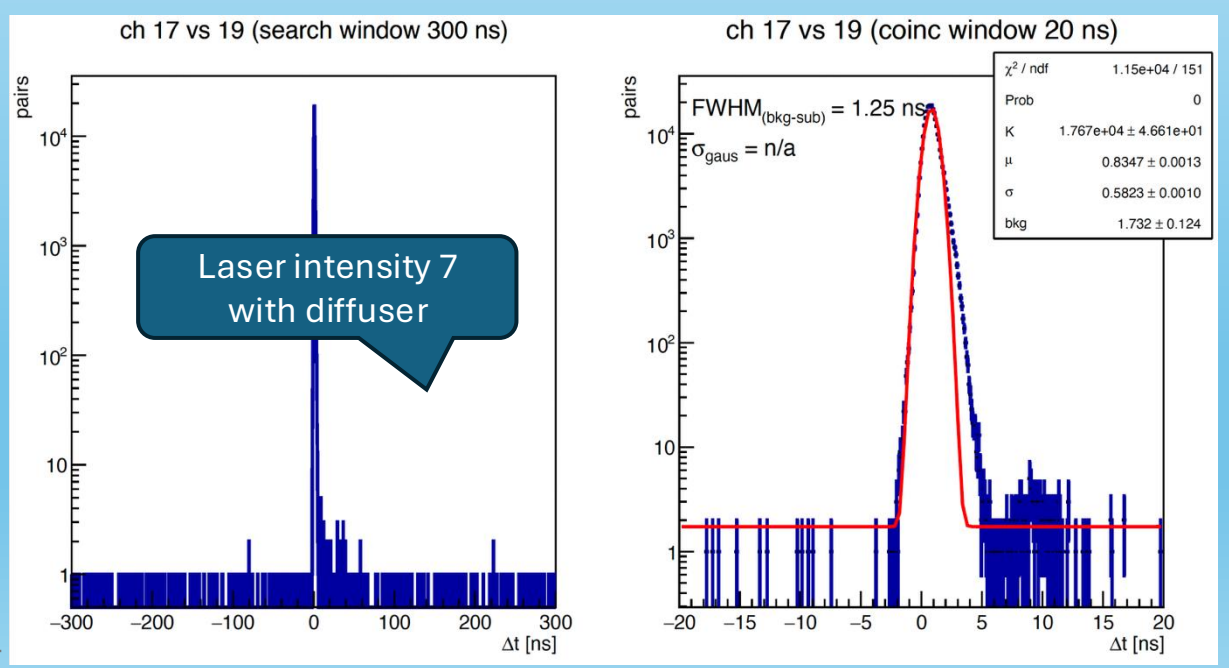
- Laser on SiPMs, fast output
- Top: full bandwidth signal
- Bottom: 20 MHz limited bandwidth
- ALCOR: 25-35 MHz limit in bandwidth.




ch 17 vs 19 (search window 300 ns)
pairs
Δt [ns]
Laser intensity 7.9
High threshold
ch 17 vs 19 (coinc window 20 ns)
FWHM(bkg-sub) = 0.22 ns
σgaus = n/a
χ² / ndf 4.647e+04 / 10
Prob 0
K 1.837e+05 ± 6.655e+05
μ −0.2967 ± 1.0000
σ 0.05007 ± 12.25192
bkg 2.951 ± 1.108

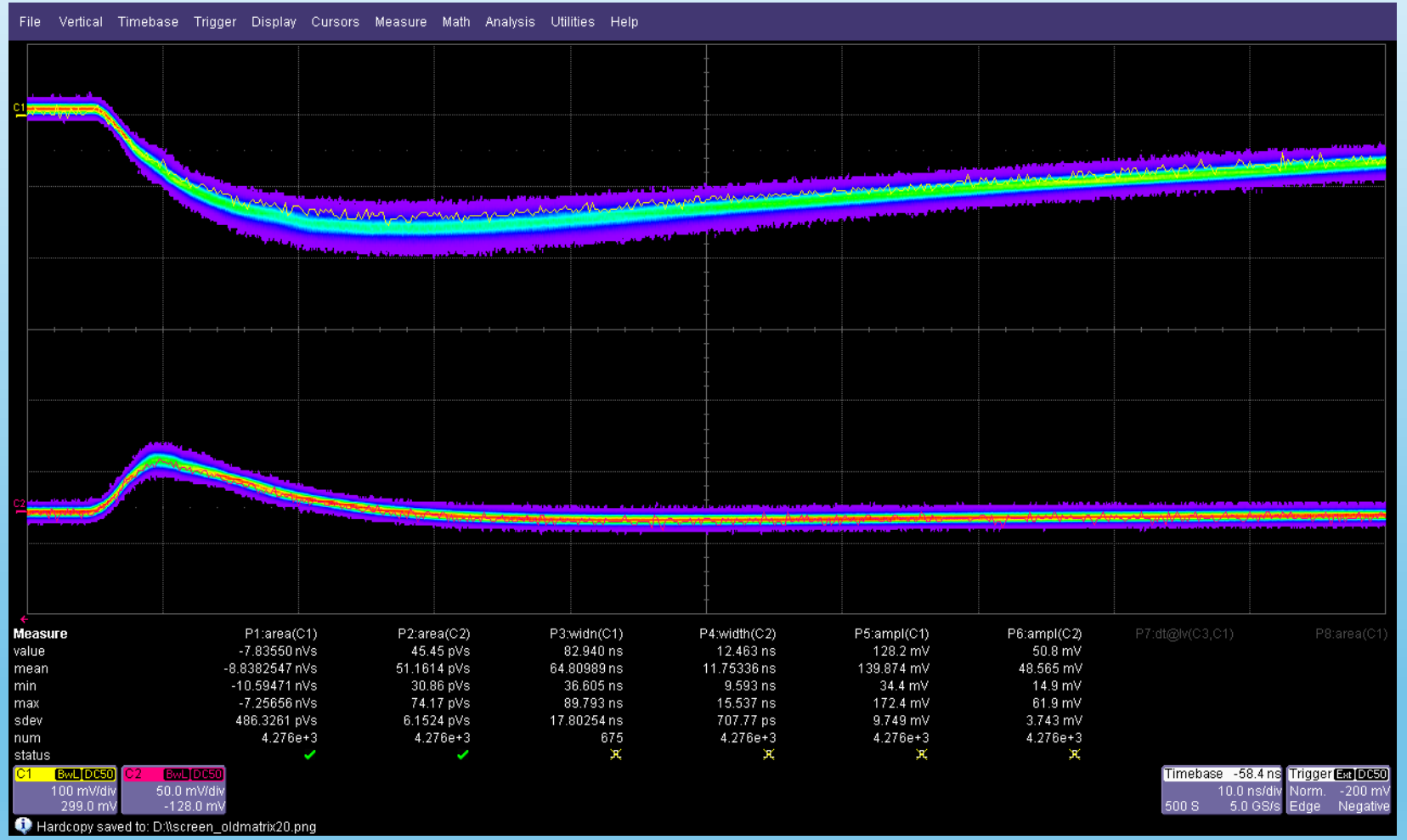

ch 17 vs 19 (search window 300 ns)
pairs
Δt [ns]
Laser intensity 6.0
ch 17 vs 19 (coinc window 20 ns)
FWHM(bkg-sub) = 2.23 ns
σgaus = n/a
χ² / ndf 9819 / 379
Prob 0
K 8193 ± 23.5
μ 0.4592 ± 0.0024
σ 1.172 ± 0.002
bkg 4.182 ± 0.116


ch 17 vs 19 (search window 300 ns)
pairs
Δt [ns]
Laser intensity 5.2
ch 17 vs 19 (coinc window 20 ns)
FWHM(bkg-sub) = 3.14 ns
σgaus = n/a
χ² / ndf 4611 / 380
Prob 0
K 2557 ± 11.2
μ 0.6841 ± 0.0050
σ 1.559 ± 0.005
bkg 3.96 ± 0.12


ch 17 vs 19 (search window 300 ns)
pairs
Δt [ns]
Laser intensity 7
with diffuser
ch 17 vs 19 (coinc window 20 ns)
FWHM(bkg-sub) = 1.25 ns
σgaus = n/a
χ² / ndf 1.15e+04 / 151
Prob 0
K 1.767e+04 ± 4.661e+01
μ 0.8347 ± 0.0013
σ 0.5823 ± 0.0010
bkg 1.732 ± 0.124

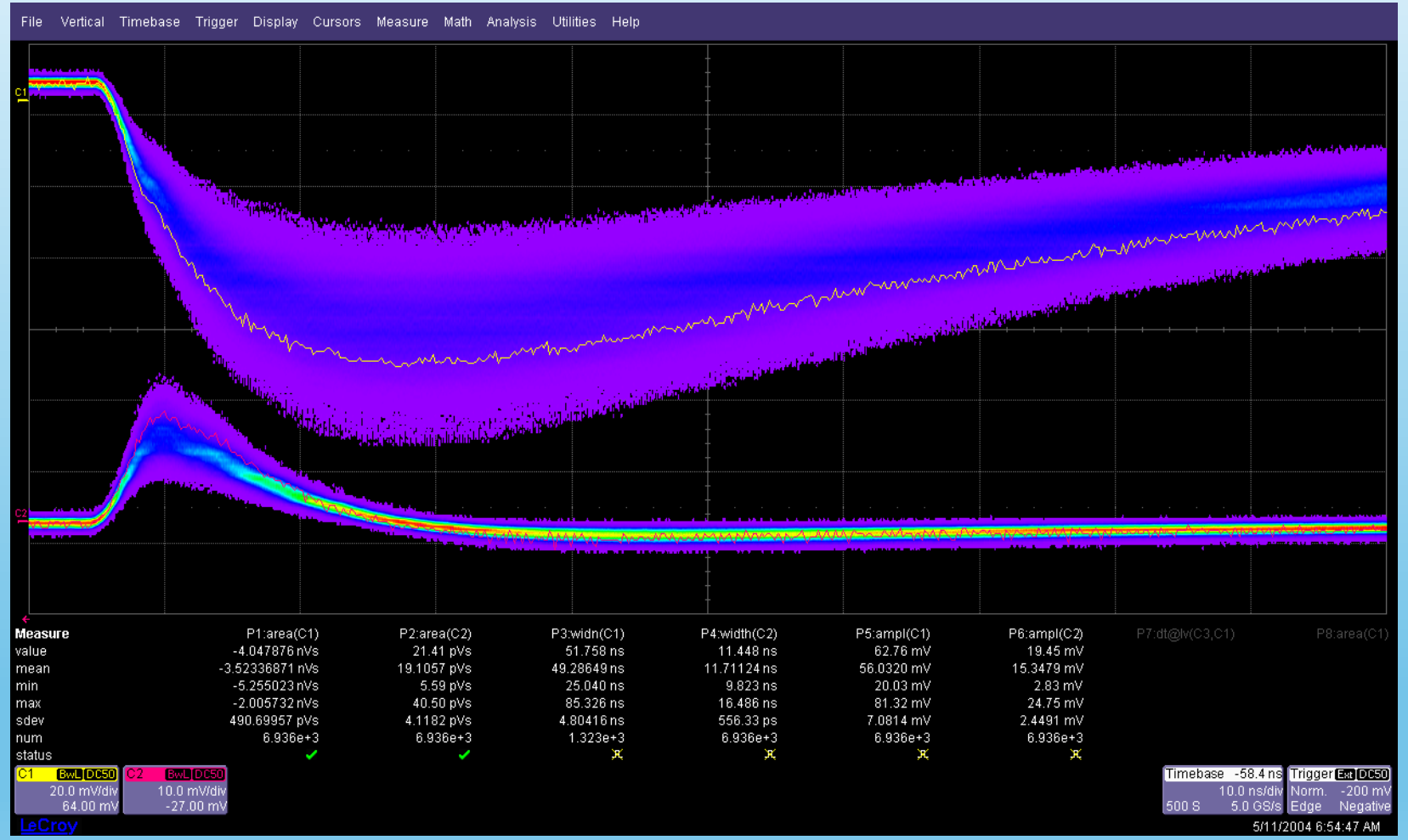
Timing resolution

- Laser on SiPMs
- Top: standard output signal, 20 MHz bandwidth.
- Bottom: fast output signal, 20 MHz bandwidth.



Timing resolution

- Laser on plastic tile in front of SiPM, fast output
- Top: cathode readout SiPM, 20 MHz bandwidth.
- Bottom: fast output, 20 MHz bandwidth.
- FWHM
  - Std: 50 ± 5 ns
  - Fast: 11.7 ± 0.6 ns
- OnSemi suggested a modification in the readout to improve the stability, it was applied this morning and not yet tested.



Conclusion and outlook

- The Scintillating Fiber produced by Kuraray fits very well with the requirement for the Interaction Tagger
  - Large photon yield
  - Attenuation length > 1m
- The attenuation length preliminary measurement is shorter rather than the expected performance by a factor 3 for Kuraray and factor 4 for Luxium. The method used by the producer is different, so a test following their methods can clarify this difference.
- The timing performance obtained with OnSemi fast output is not satisfactory. For large signal a timing < 1 ns is achievable, but with a smaller signal it is in the order of several ns that is not compatible with the requirements of the Interaction Tagger.
- The circuit modification proposed by OnSemi can improve the situation, it will be tested soon.

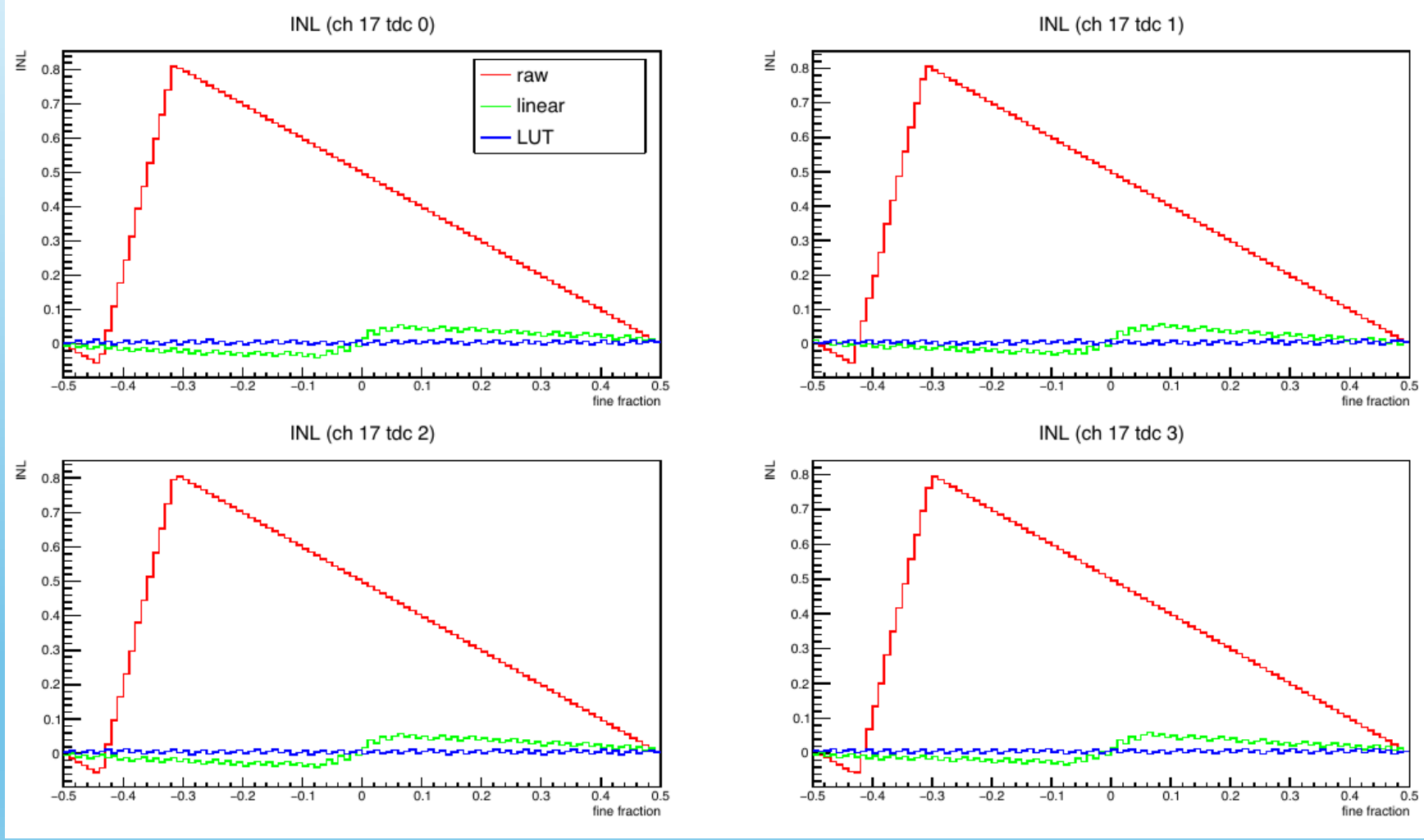
Backup

Look-Up-Table validation

The LUT is defined for each physical TDC and provide a better normalization rather than the standard linear correction

$$INL(b) = CDF_{EMP} - \frac{b - 0.5}{B}$$

Where CDF is the empirical Constant Distribution Fraction, B is the total of bin.



Results

MEASURE	LASER INTENSITY	LASER RATE kHz	DIFFUSER	SIPM RATE kHz	SIPM FWHM (ns)
1	7.9	10	No	10	0.2
2	6.0	10	No	9	2.2
3	5.2	10	No	6	3.1
4	7.9	10	Yes	1	1.3