Scintillator fiber readout with MPPCs

TUDa Tests

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(Following the discussions of the meeting at GSI on the 30/04/15)

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About the used MPPCs (SiPM)

	$1x1mm^2$	$3x3mm^2$
Pixels	25um # 1600	25um # 14400
Capacitance	30pF	300pF
Charge	tenths of fC to tenths of pC	tenths of fC to hundret of pC

Aim

- Affordable single-channel readout (<25 Euro/ch)
- Energy resolution 20% (FWHM)
- Trigger timing 10ns
- → What is the ToT time-resolution needed?

(incomplete) Table of possible solutions

	CITIROC (Wiroc/ Omega)	PETsys LIP/INFN	STiC Heidelberg	PADI-8 GSI	N-XYTER/ GEMEX GSI	Gassiplex
Know-how	No	No, but ready solut.	No, but nearby dev	Yes	Yes	Yes
Dedicated for MPPCs	Yes	Yes	Yes	No	No	No
Dynamic range	2000 pe	160fC – 320pC	100fC – 300pC		20 fC?	300 fC?
Output Type	Shaping/ Multiplex	ToT Analog-based TDC	ToT Digital-based TDC	ToT	Shaping/ ADC	Shaping/ Multiplex
channels	32	64	64	8→8	128	16
Price/ch (Euro)	5 (chip only)	16 (full readout)	10 (full readout)	2 (chip only)	25 (full readout)	
Power/ch	6 mW		25 mW	>30 mW		
Packaging	TFBGA		BGA (homemade)			

Options discussed in the meeting

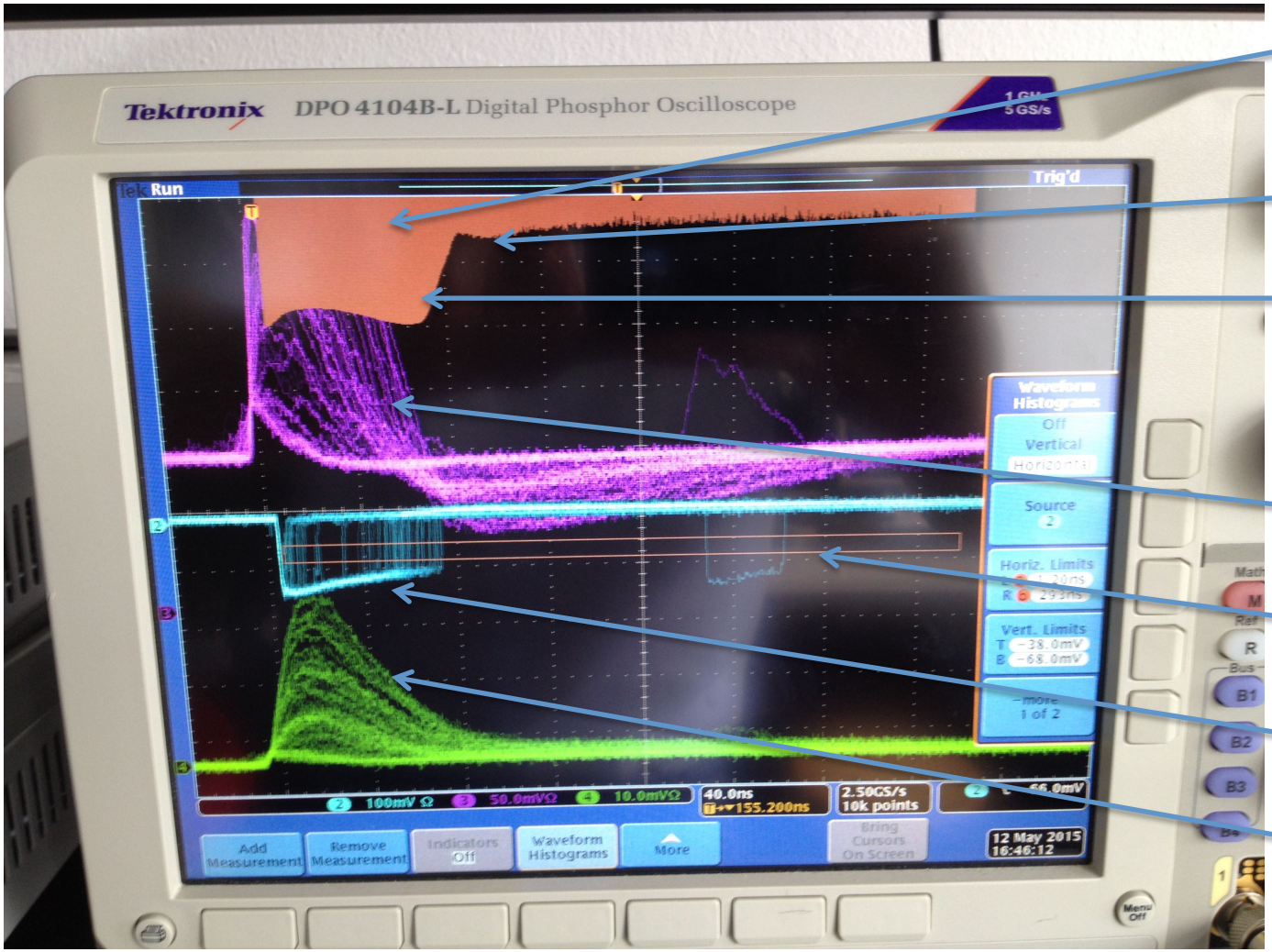
- PADI front end and VUPROM or TAMEX2 readout depending on time-resolution requirements
- New ASIC with PADI front end and integrated TDC
- N-XYTER/GEMEX2
- Existing ASICs (commercial or not)

Options not discussed in the meeting

- PADI front end and GET4

PADI tests

3x3mm^2, LaBr3 scintillator, ^{137}Cs source (662 keV)



ToT projection histogram

1.4 MeV peak

662 keV Cs peak

PADI "Threshold" and shaped output

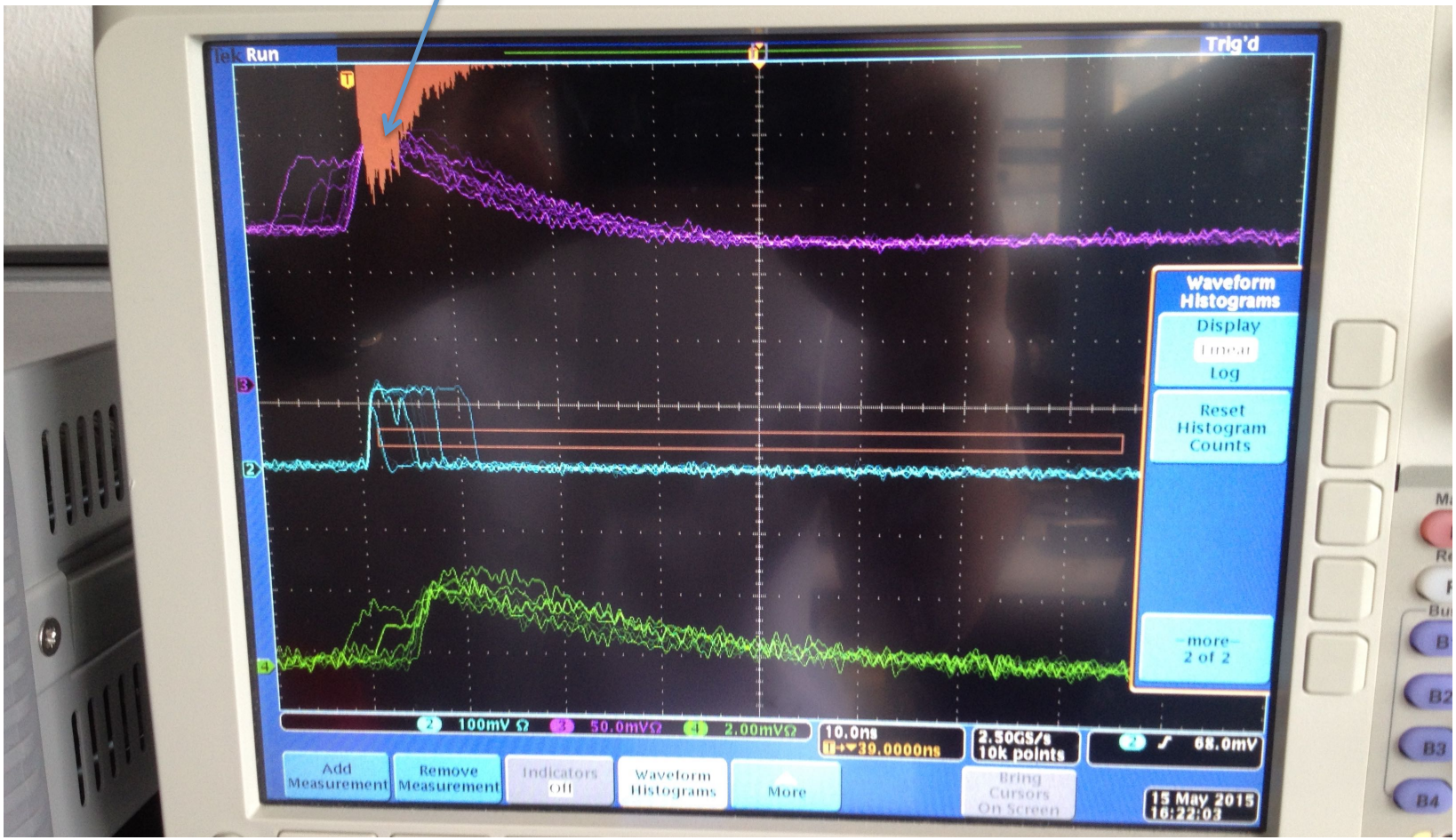
ToT projection region for histograming

PADI ToT output

Raw signal (from splitter)

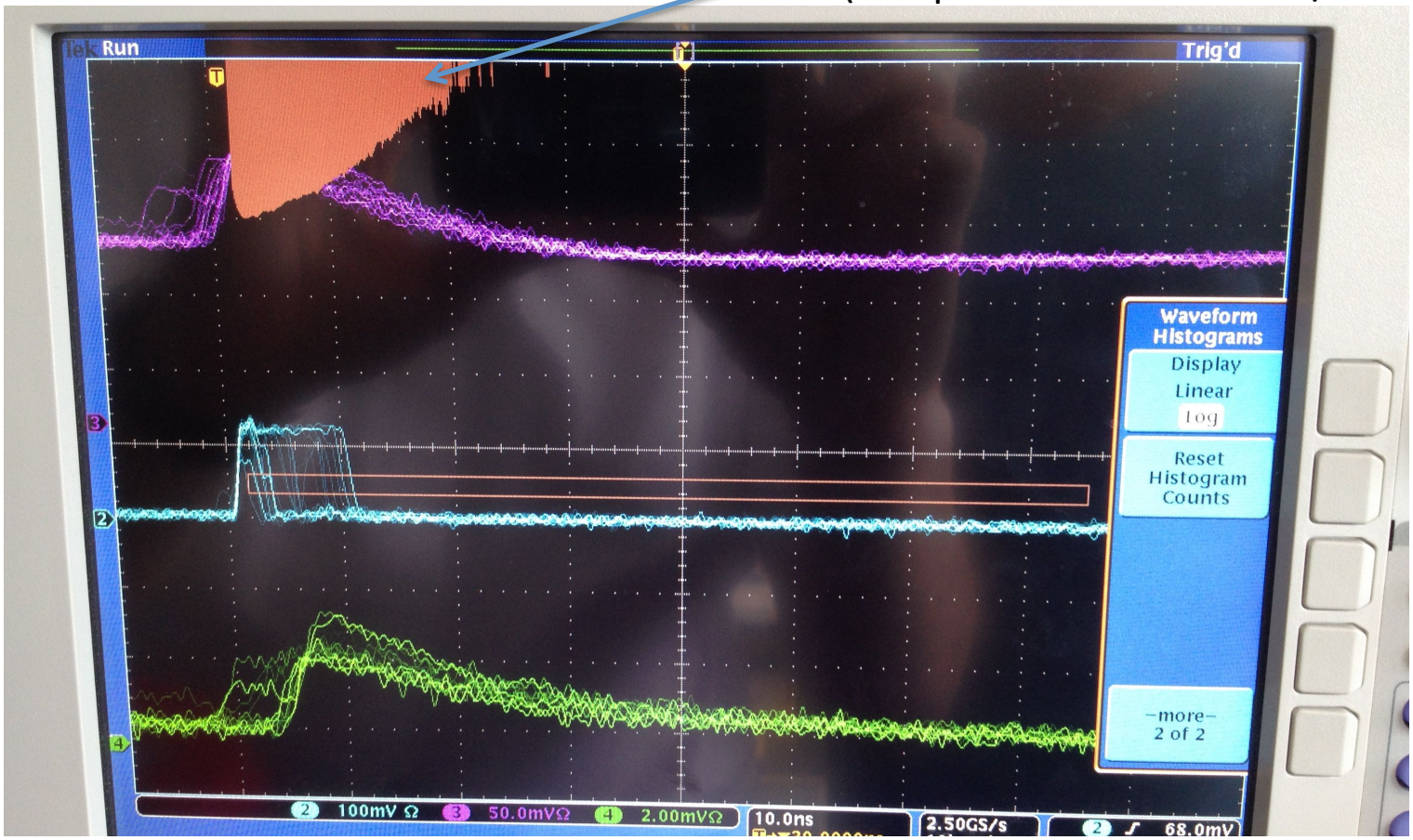
Dark count spectrum 3x3mm^2

Single photo electron peaks

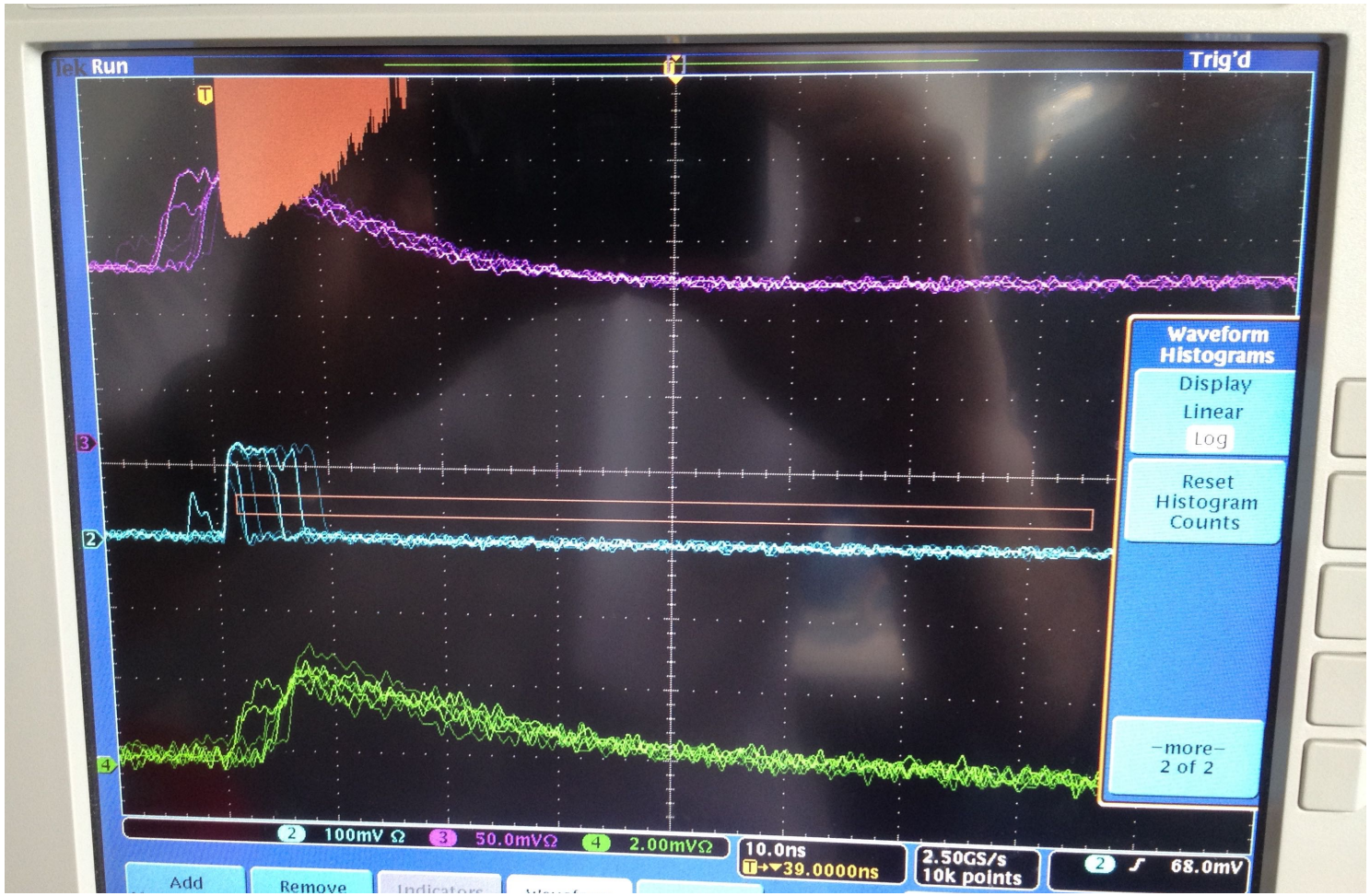


3x3mm^2, with fiber bundle, ^{90}Sr electron source

Some excess counts due to source
(compared to next slide w/o source)

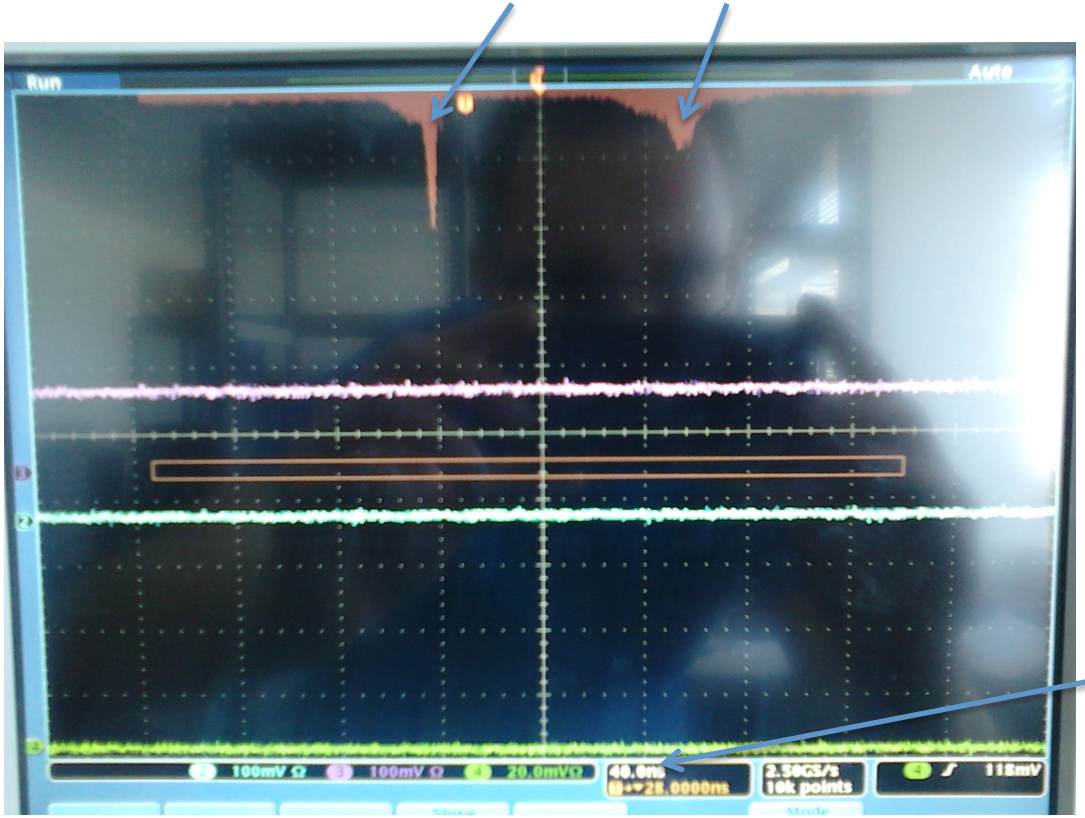


3x3mm^2, with fiber bundle, NO Source



3x3mm^2, large 1 inch plastic scintillator, Cosmics

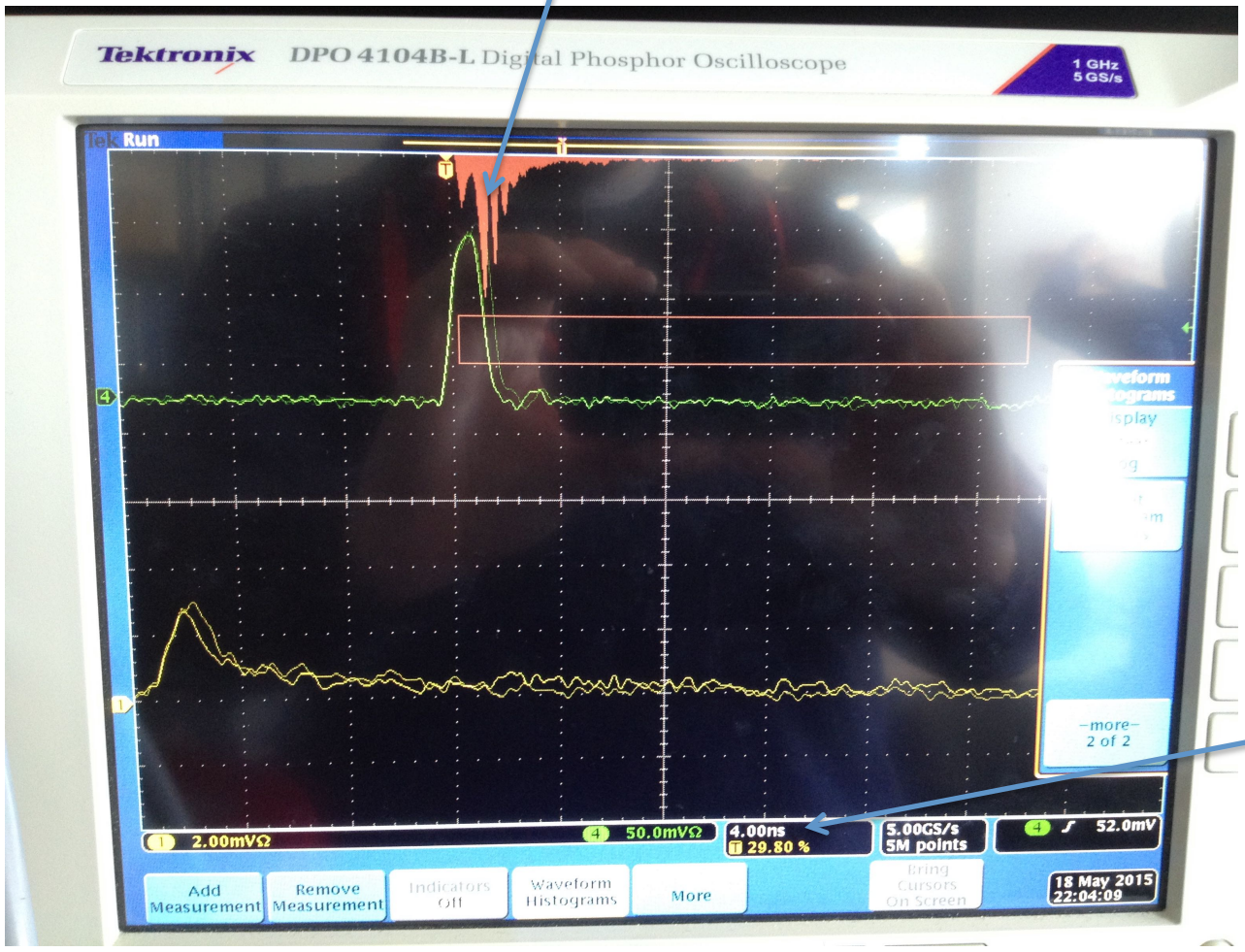
Cosmics loose about 5 MeV in detector
Few hundred pixels expected to fire
About 100 ns between leading and trailing edge for raw signals higher than 110mV



40 ns/div

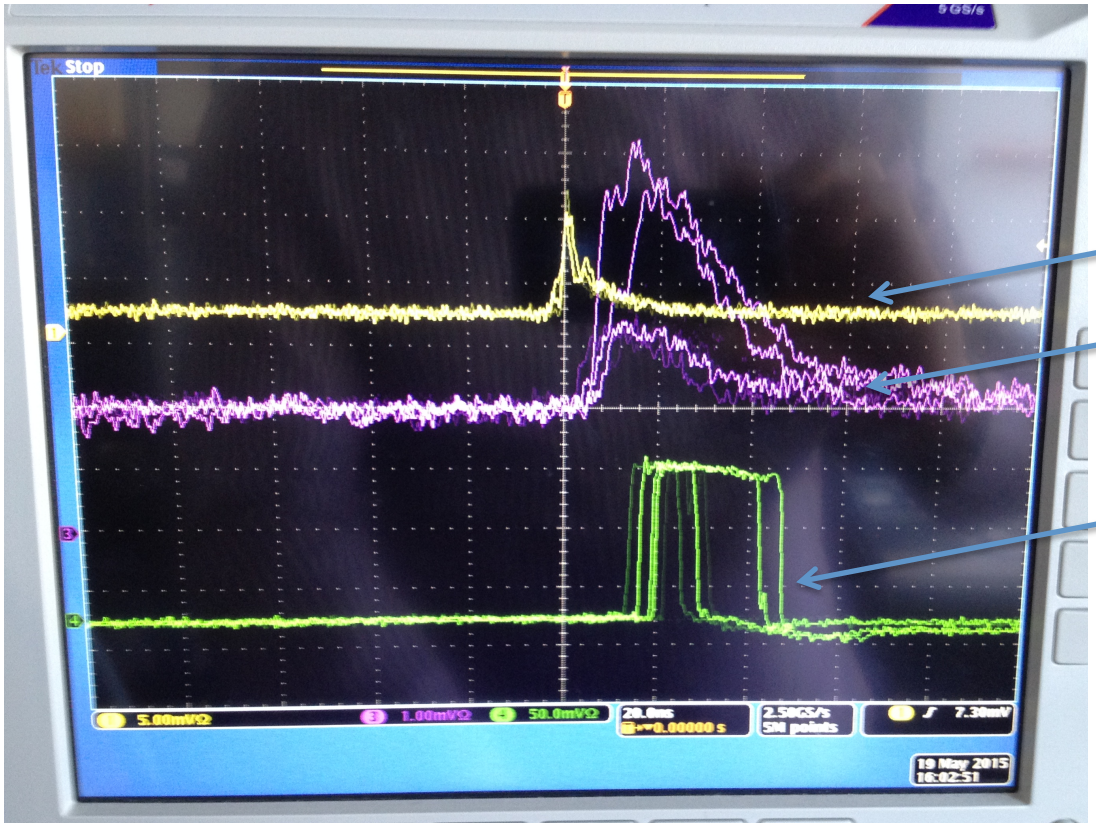
1x1mm^2, Dark counts spectrum

Single photo-electron peaks



4 ns/div

Coincidences at two ends of fibers, with LED in the middle, one end readout by 3x3mm^2, the other end with the 1x1mm^2



1x1 mm^2 MPPC (triggered)

3x3 mm^2 MPPC

ToT of purple

Preliminary Conclusions

- PADI ToT threshold signal for MPPC readout works well and provides reliable energy information (at least for the signals from the 3x3 mm^2)

- Most results were carried out with 3x3mm^2 MPPC, **BUT** the 1x1mm^2 (only in last two photos) is faster (smaller capacitance) and a more natural choice for our detector size, it also seems to perform well with PADI but more tests are needed

- **To resolve single photons (see next to last photo) better than 0.5 ns time resolution is needed (our aim is to be able to resolve few photons signal from noise so few photon resolution (~2ns) could suffice, BUT it is always reassuring to be able to measure these single photon spectra)**

- Logarithmic relation of ToT to charge is beneficial since large signals can fit in couple of hundred ns pulses, plus we do not need such fine resolution when signals are large.

- **Actual fiber detector**, only LED succeeded, more realistic tests needed. Very small and rare signals for electron and gamma sources mix with dark count signal → alpha measurements are in preparation

- LaBr3 has been used in the first test since it has high light output and excellent energy resolution. Some care must be taken in the interpretation of these results since LaBr3 and large plastic scintillators have slightly different pulse shapes

- Remaining problem: Have not been able to control the software thresholds via the Vulom at TUD

To Do

- Perform more tests with the 1x1mm^2
- Probe larger dynamic range, bigger pulses
- Debug the software threshold control
- Attempt digitization with DAQ instead of scope, using e.g. TAMEX2 for more quantitative results