

RD51 @ TI

Recent Picosec Results: Multipad, Photocathodes, Protection, ...





Comprendre le monde, construire l'avenir









All following results are highly preliminary!

An accurate analysis of all data is currently ongoing and most of the presented results have been calculated during the data taking with fast and simple algorithms and mostly under the lack of sufficient sleep!

Recent Picosec Results

Outline

- Short introduction to Picosec
- Multipad
- Resistive detector
- Metallic photocathode
- Carbon based photocathode
- Protection layer
- Gain Measurement



PICOSEC @ RD51





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Multipad





Data:

- Detector operation point: A +300 V / D -475 V.
- 1,164,507 events (159,713 with signal in MCP).
- Pad 10 (CH2, CERN), Pad 9 (CH4, CERN), Pad 5 (CH4, Saclay)

Analysis description:

- Each pad independently analysed (30% CF, cubic interpolation).
- Analysis results are combined using the SRS event number.
- Slewing W(Q_i) & resolution R(Q_i) curves are calculated for each pad.
- Multipad SAT is calculated by Spyros formula SAT(W(Q_i), R(Q_i)).

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5



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Time resolution field scan for a single pad





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Time resolution for each pad



- Time resolution is **36 ps** for all cases!
- The time resolution is <u>compatible</u> with the value obtained for the small area trigger scans of Pad 9 (<u>38.8 ps</u>).

Element	Mean (ns)	Res (ps)
Pad 10	-2.2618	35.6 ± 0.3
Pad 9	-2.0800	35.9 ± 0.4
Pad 5	-0.9242	37.4 ± 0.4



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Multipad time resolution calculated out of the SAT



- The Multipad SAT distribution has been calculated by Spyros' formula, which uses slewing W(Q_i) & resolution R(Q_i) curves.
- Time resolution is 36 ps, for a <u>MCP circle of 5 mm</u>.



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SAT distribution for the MCP—PMT



- The Multipad SAT distribution has been calculated by Spyros' formula, which uses slewing W(Q_i) & resolution R(Q_i) curves.
- Time resolution is 36 ps, for a <u>MCP circle of 5 mm</u>.
- Time resolution is constant for impact points in this circle.
- SAT & time resolution still have a surface dependence.



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Resistive strip grounded

Resistive readouts operate stably at high gain in neutron fluxes of 10⁶ Hz/cm².

> T. Alexopoulos *et al.*, *NIMA* **640** (2011) 110-118.





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• Values not far from the Picosec bulk readout.

-Resistive strips: <u>41 ps</u> (10 M Ω / \Box), <u>35 ps</u> (300 k Ω / \Box).

-Floating strips: <u>**28** ps</u> (25 M Ω).

• Resistive readouts worked during hours in intense pion beam.

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- Ion back flow damages CsI photocathode under higher particle flux
- IBF > 60 % at high detector gain
- Robust photocathodes needed

Measurement of the IBF in a pion beam at different field					
V_{anode} [V]	V_{drift} [V]	I_{anode} [mA]	I_{drift} [mA]	IBF	
+450	-350	98.00	23.40	24	
+450	-375	193.85	53.00	28	
+450	-325	45.47	10.65	23	
+425	-400	193.50	53.10	28	
+425	-375	87.30	23.95	27	
+425	-350	44.48	10.99	25	
+400	-425	178.84	112.39	<u>63</u>	
+400	-400	88.55	25.54	28	
+400	-375	41.28	11.10	27	
+400	-350	20.42	4.44	22	

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Time resolution 140 5 mm MgF₂ + 10 nm Al Anode = 250 V 130 Anode = 275 V $\sigma = 58 \text{ ps}$ 120 Anode = 300 V Time resolution (ps) Anode = 325 V 110 Anode = 350 V 100 Anode = 375 V 90 80 70 2 60 \bullet 50 560 580 600 540 440 460 420 480 520 500Drift voltage (V)

- For each photocathode material the working point with the best time resolution has to be determined
- The time resolution, quantum efficiency and efficiency are compared
- Reference single photon measurements and tracking data are necessary

Recent Picosec Results





Comparison of different materials

MgF ₂	Substrate	Nphe	Res (ps)	Opt. A/D
3 mm	5.5 nm Cr +18 nm Csl	10.4 ± 0.4	24.0 ± 0.3	+275/-475
3 mm	20 nm Cr	0.66 ± 0.13	189.4 ± 5.3	+425/-425
3 mm	6 nm Al	1.69 ± 0.01	71.4 ± 1.8	+275/-525
5 mm	10 nm Al	2.20 ± 0.05	57.6 ± 0.6	+275/-600

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• Field scan with 20 nm

DLC in Bulk Picosec

• Up to 80 ps has been

reached with 40 nm

DLC in resistive

Micromegas

Recent Picosec Results







• A similar quantum efficiency

as the metallic photocathodes

has been reached

Time resolution correlates

with photoelectrons

• Efficiency of ~85%

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CsI photocathodes coated with some atomic layers of protective material

	LiF	MgF2	(DLC)
Electric Field Amp (V) / Drift (V)	+250 / -625 Run1319	+250 / -550 Run1352	+250 / -575 Run1251
Time Resolution (ps)	87.7 ± 3.7	45.6 ± 1.5	67.4 ± 1.3
Efficiency (estimated)	38 %	90 %	85 %
Quantum Efficiency (p.e./µ)	< 1	3.55 ± 0.08	2.69 ± 0.11

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- Picosec gain under different gas pressure has been measured
- Measurements with single p.e. emittance (candle) and Polya fit
- Gain distribution starts a plateau at lower
 pressure as previously
 prospected in
 Micromegas studies

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- Picosec has a gain of ca.
 1,000,000 at the common operation point for a fast time resolution
- At lower pressure the gain is up to a factor 4 better with preamplification
- More detailed studies are scheduled for later this year

Recent Picosec Results

The PICOSEC Collaboration

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