Update on LAPPD R&D at IJS

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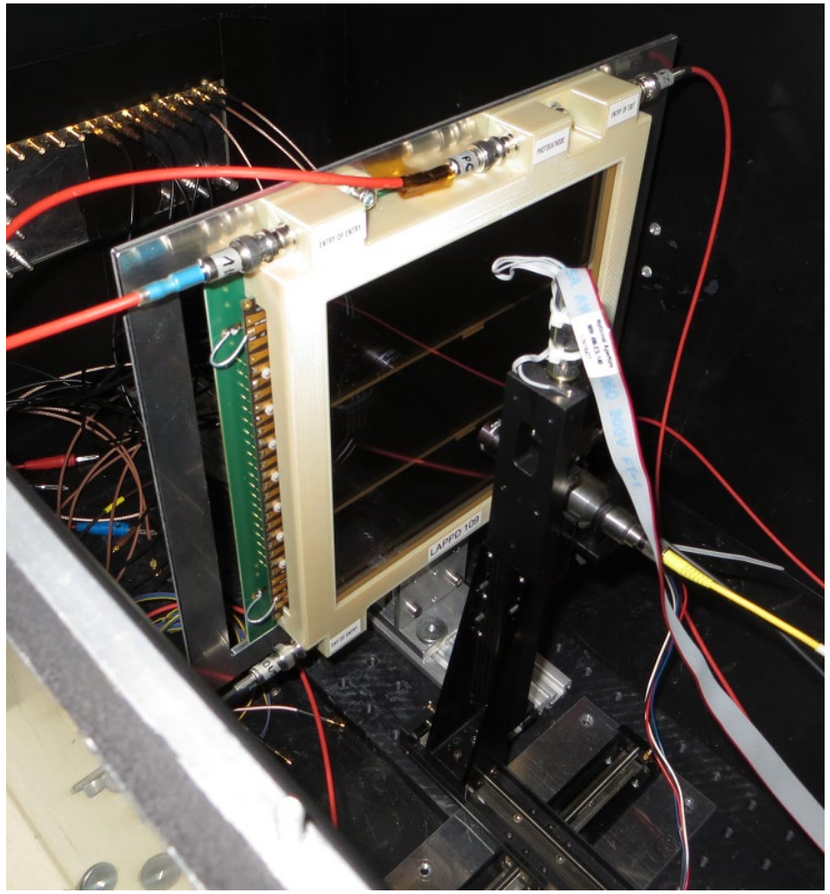
University of Maribor and Jožef Stefan Institute, Ljubljana
LAPPD Workshop, 20 April 2023

Outline:

- LAPPD, test setup
- Timing and charge sharing
  - timing variation
- Spacer dead space
- FastIC update



F9- IJS
Preliminary!

LAPPD - setup

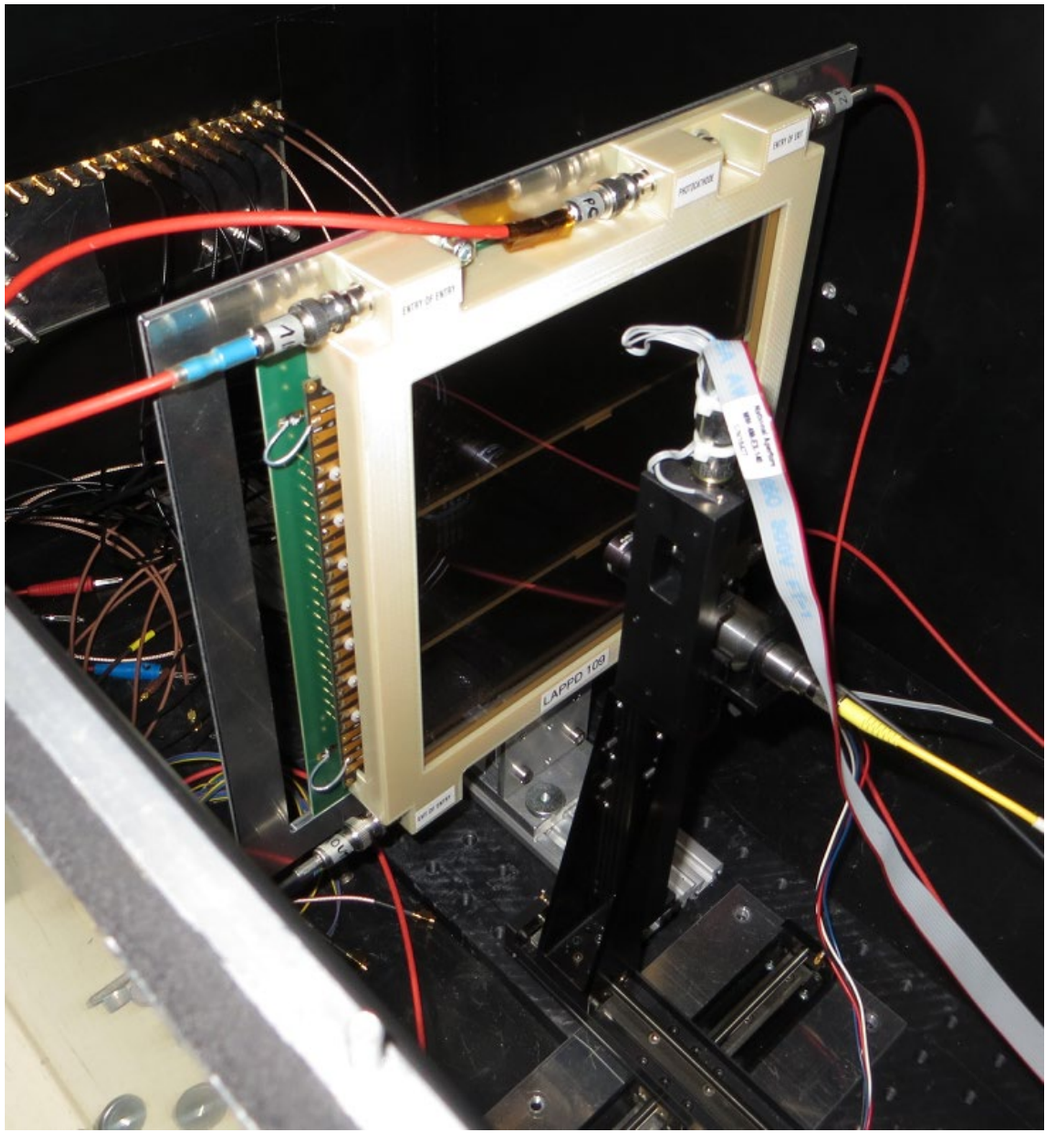
LAPPD #109:

- $\approx 200 \times 200\ mm^2$
- $20\ \mu m$ pores @ $25\ \mu m$ pitch
- resistive anode plane, capacitive coupled readout
- 5 mm thick glass backplate
- 5 HV levels: PC, MCP1in, MCP1out, MCP2in, MCP2out and resistive anode at ground potential

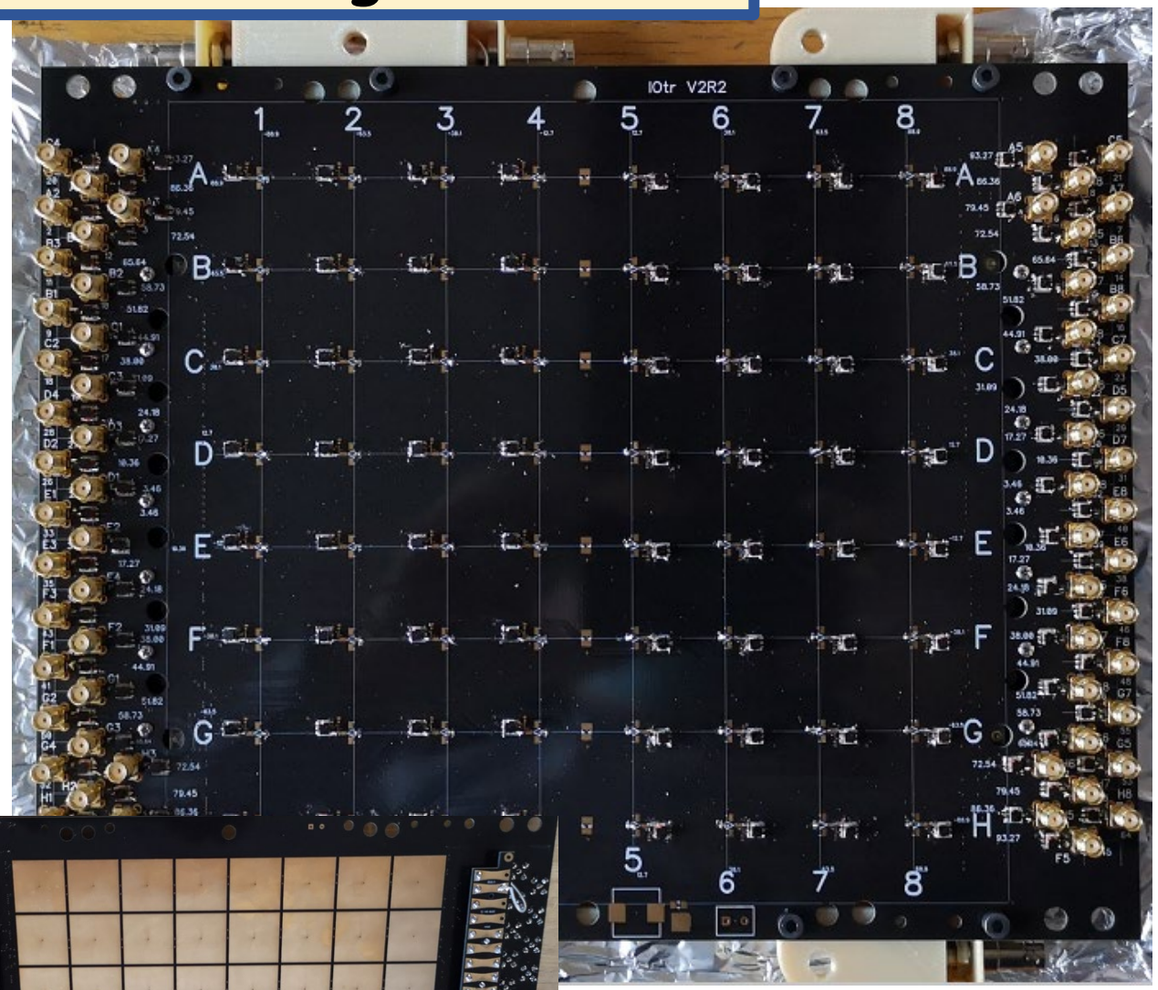
- Standard setup with QDC, TDC, 3D stage ...
- TDC value corrected for time-walk

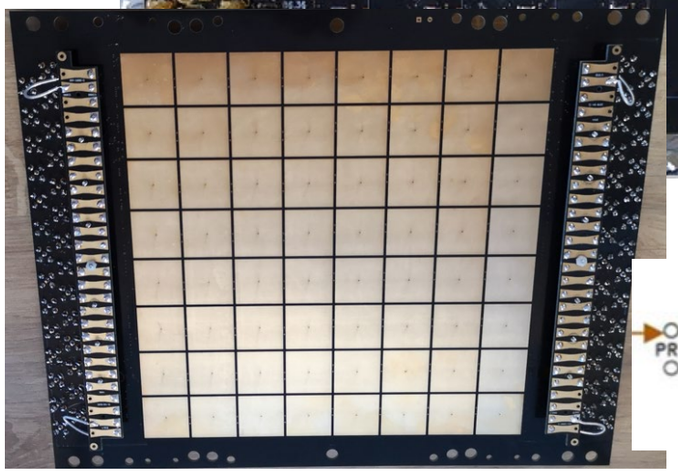
- ALPHALAS PICOPOWER™-LD Series of Picosecond Diode Lasers – 405 nm
- FWHM $\approx$ 20 ps
- light spot diameter < $100\ \mu$m

- Preliminary results.



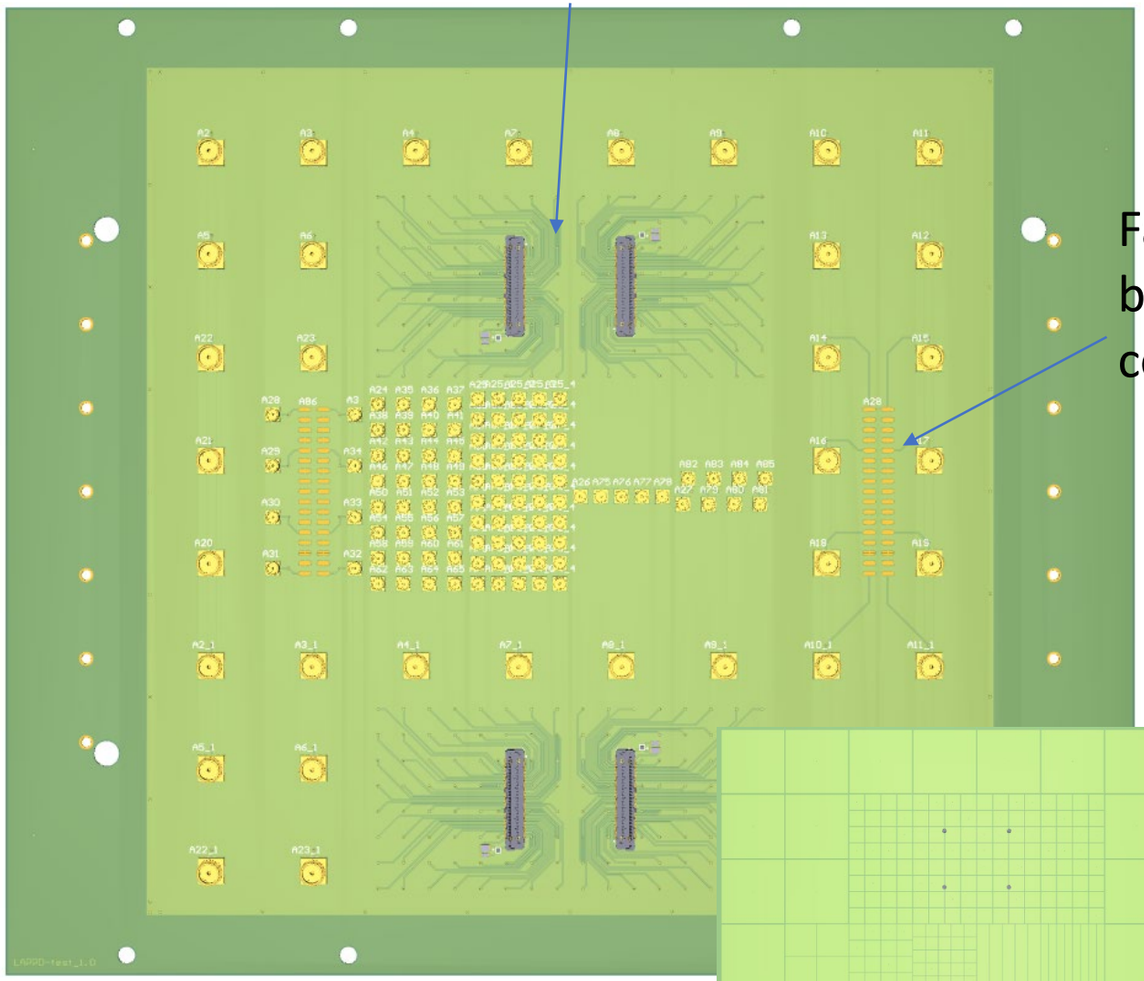
LAPPD - sensing electrodes

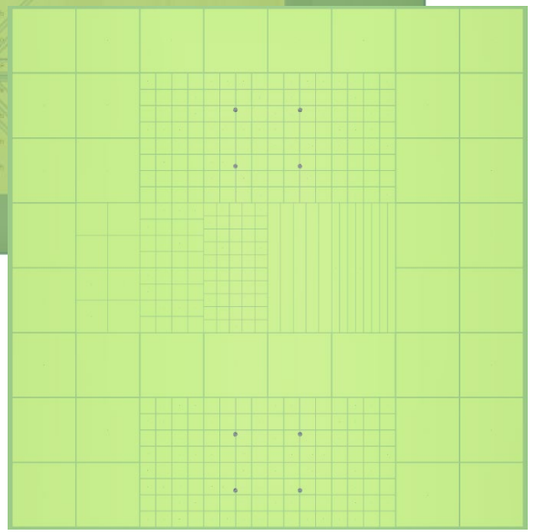




PETSYS conn.

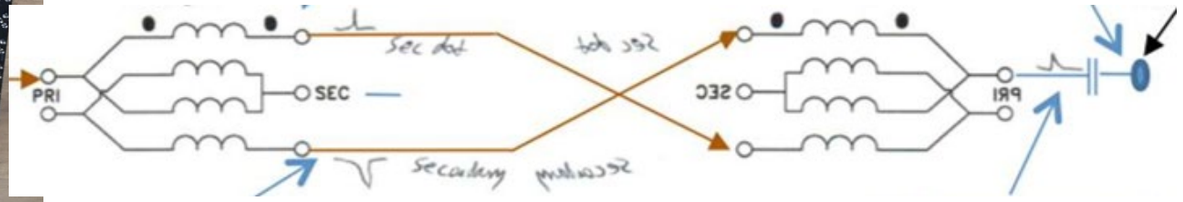
FastIC board conn.





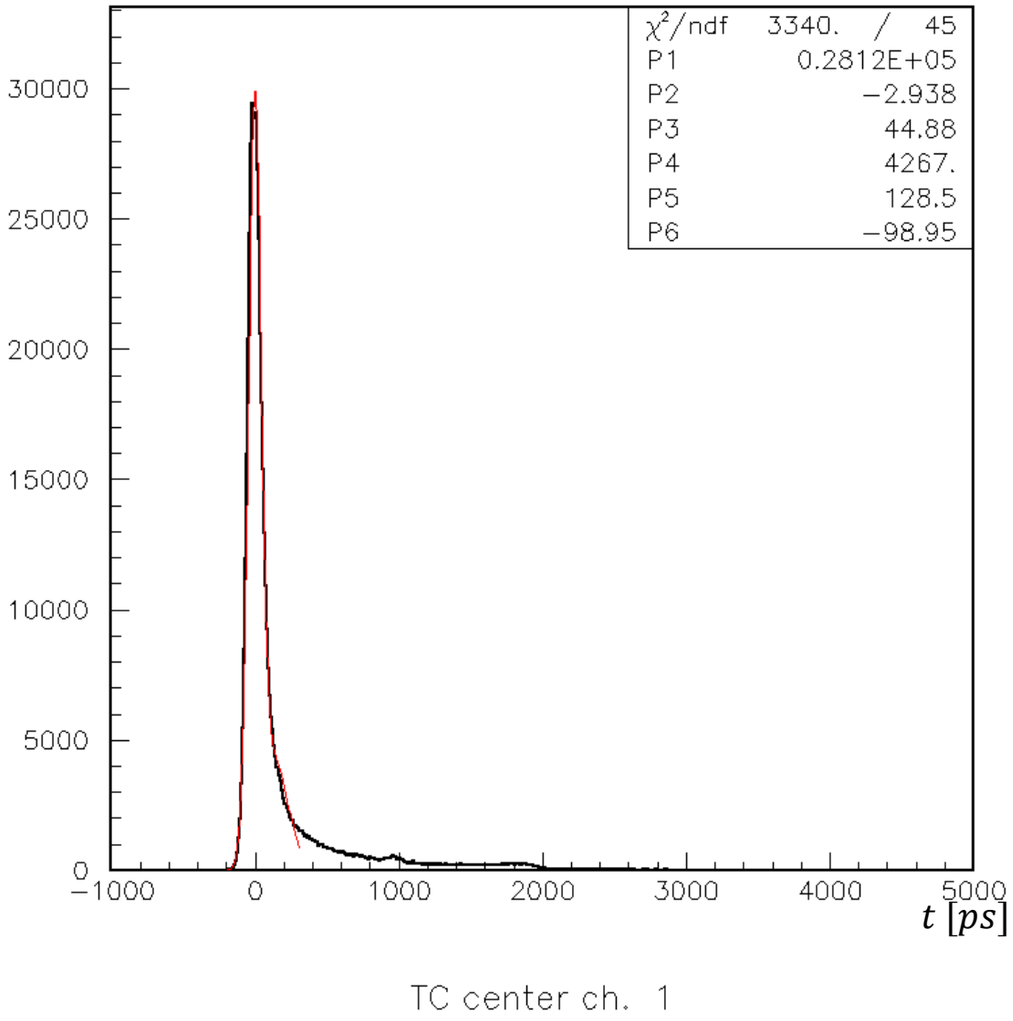
INCOM

IJS

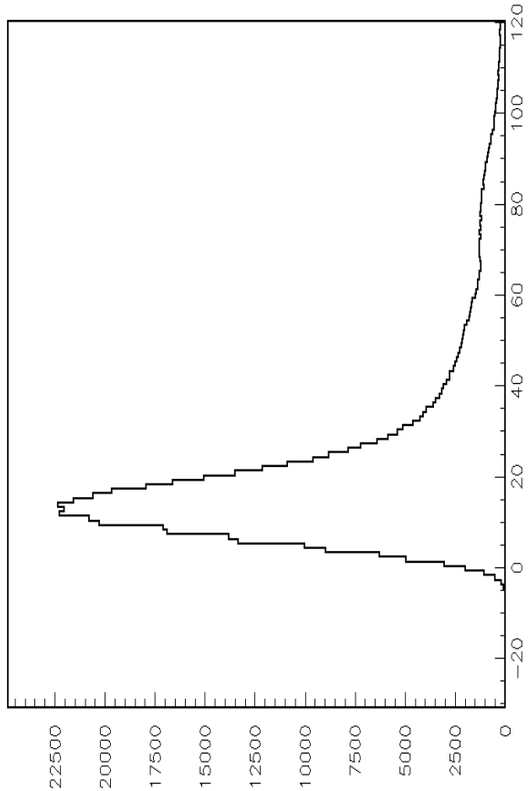


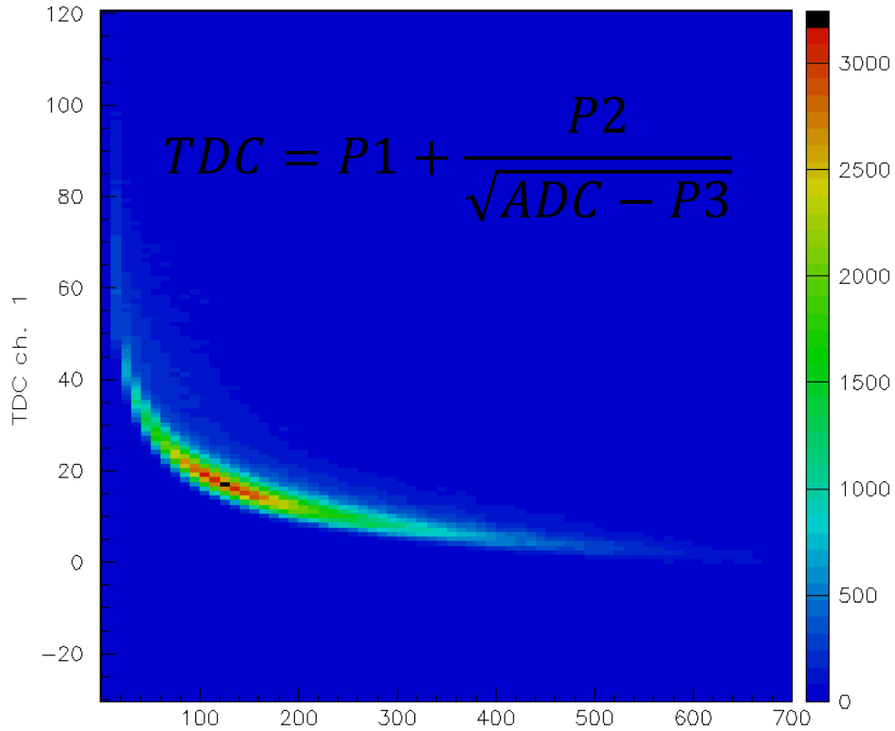
LAPPD - time-walk correction

- TDC corrected for time-walk
- timing resolution (prompt peak) $\sigma \approx 40$ ps after time-walk correction

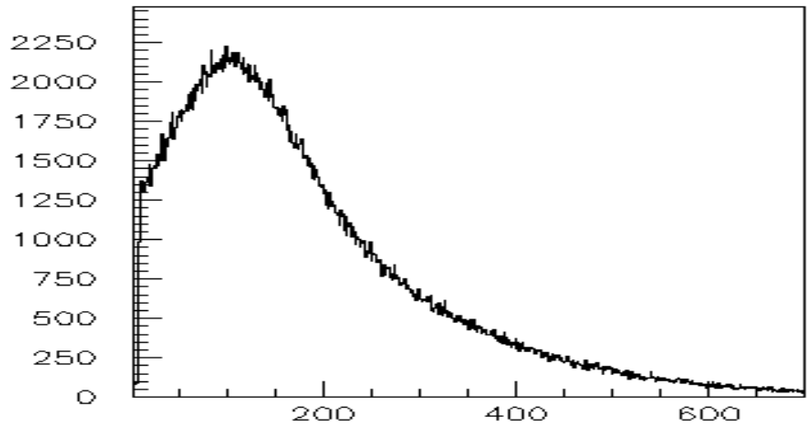


TC center ch. 1





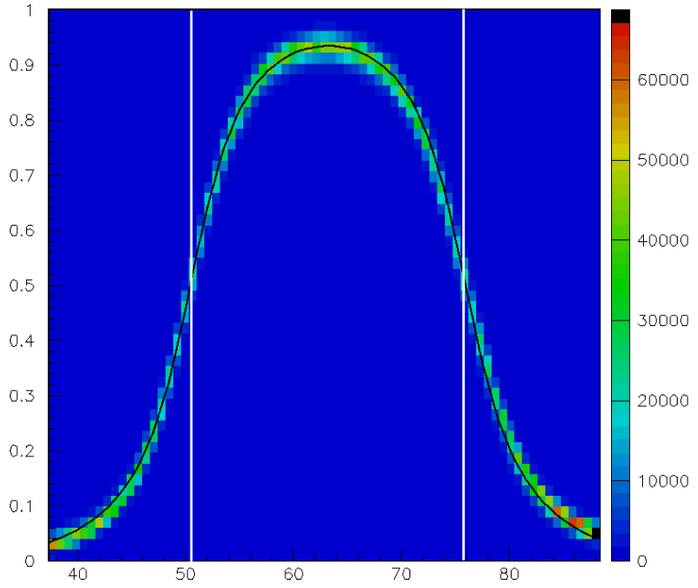
TDC vs. ADC ch. 1

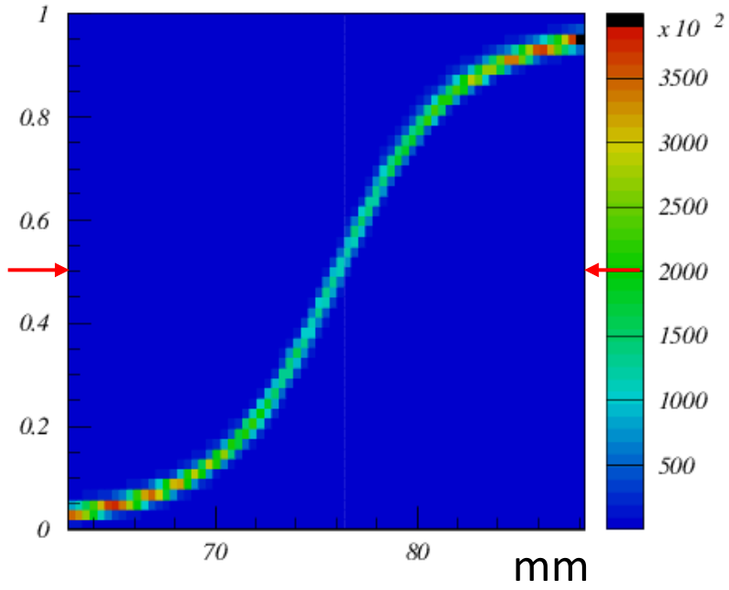


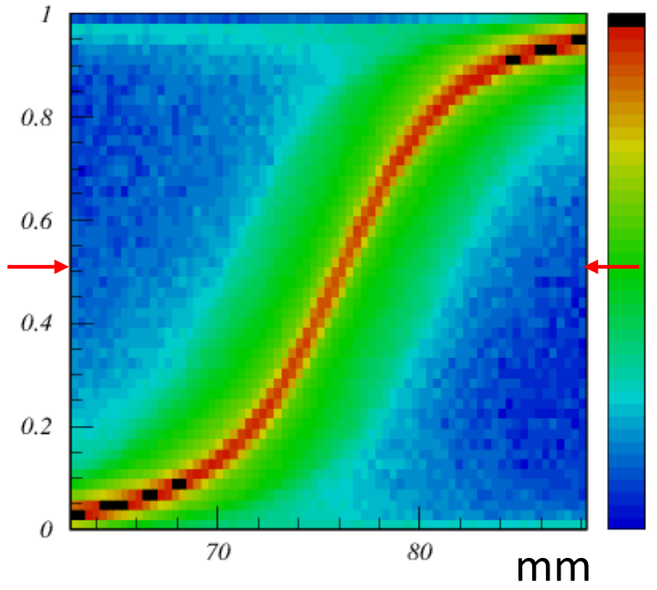
ADC max ch. 1

LAPPD – charge sharing

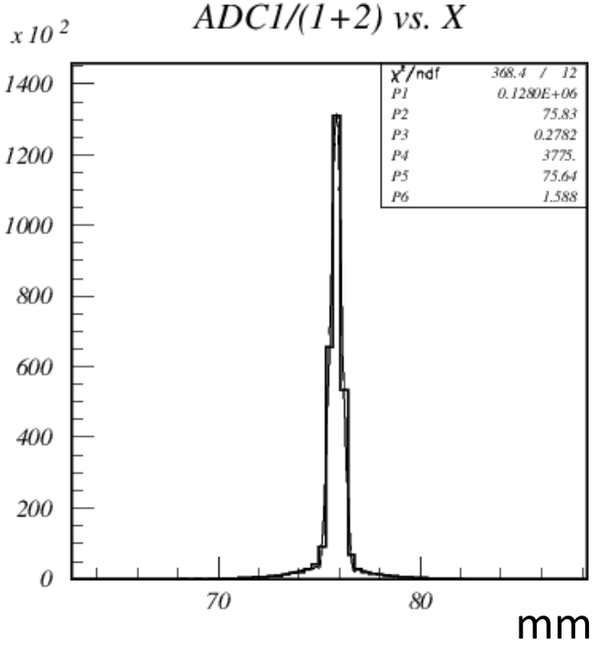
- more detailed scan between the centres of adjacent pads (top)
- central slice where signal is equally split between the pads (bottom)
- narrow peak is due to the light spot size and photoelectron spread
- longer tail from photoelectron backscattering - ≈ 6 mm on each side
  → ≈ 3 mm PC – MCP1 distance





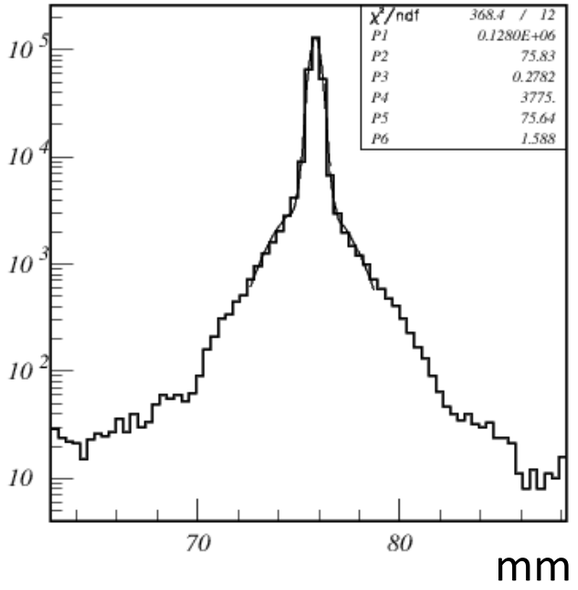


ADC1/(1+2) vs. X



601.SLIX.25

ADC1/(1+2) vs. X



601.SLIX.25

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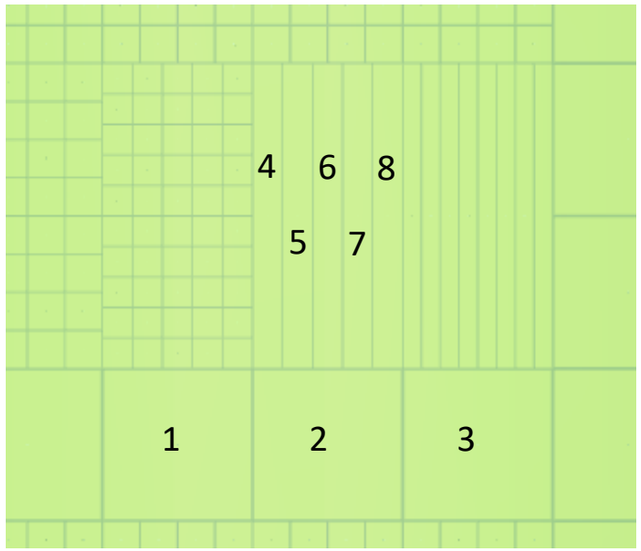
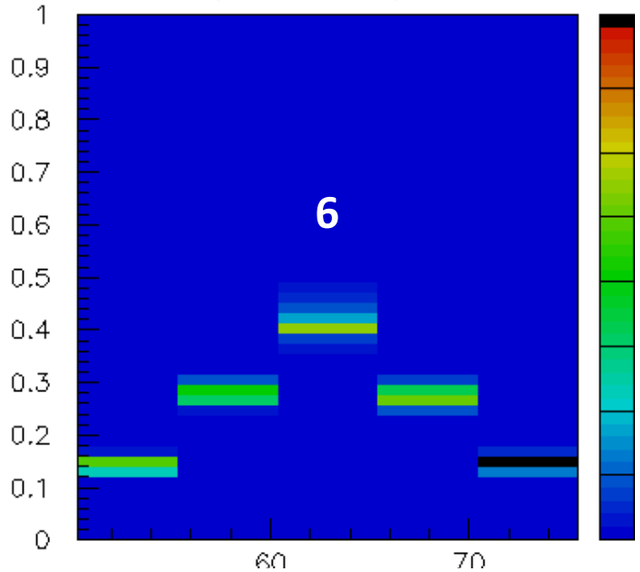
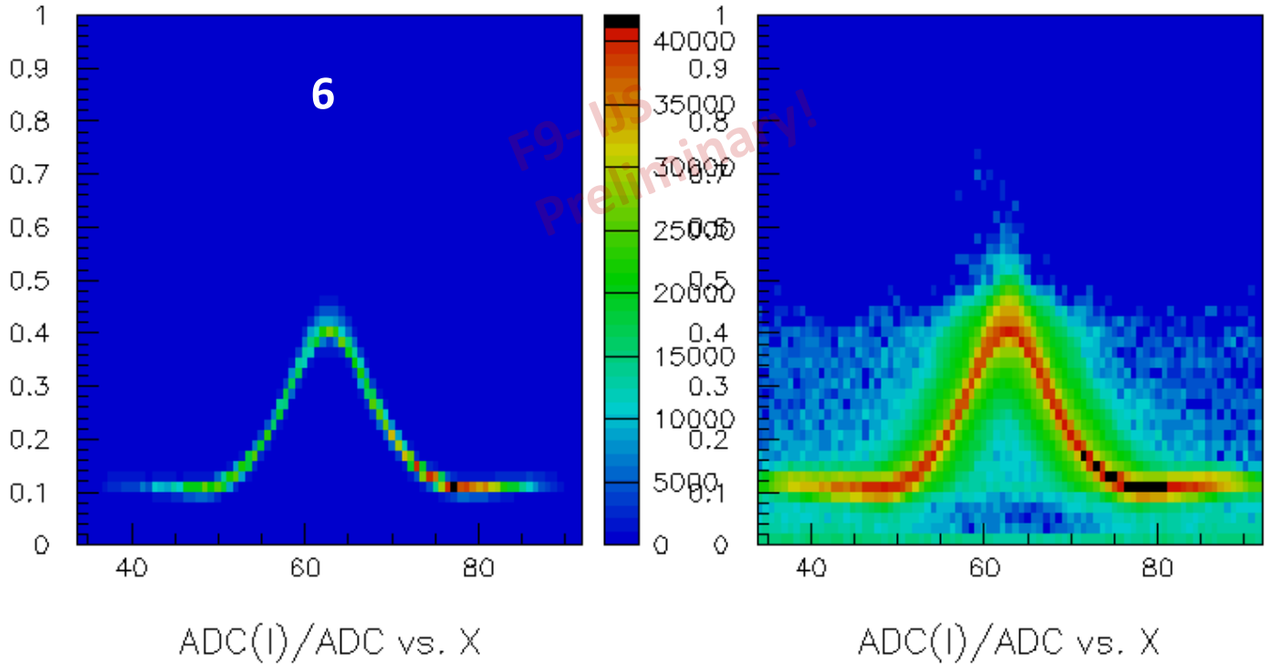
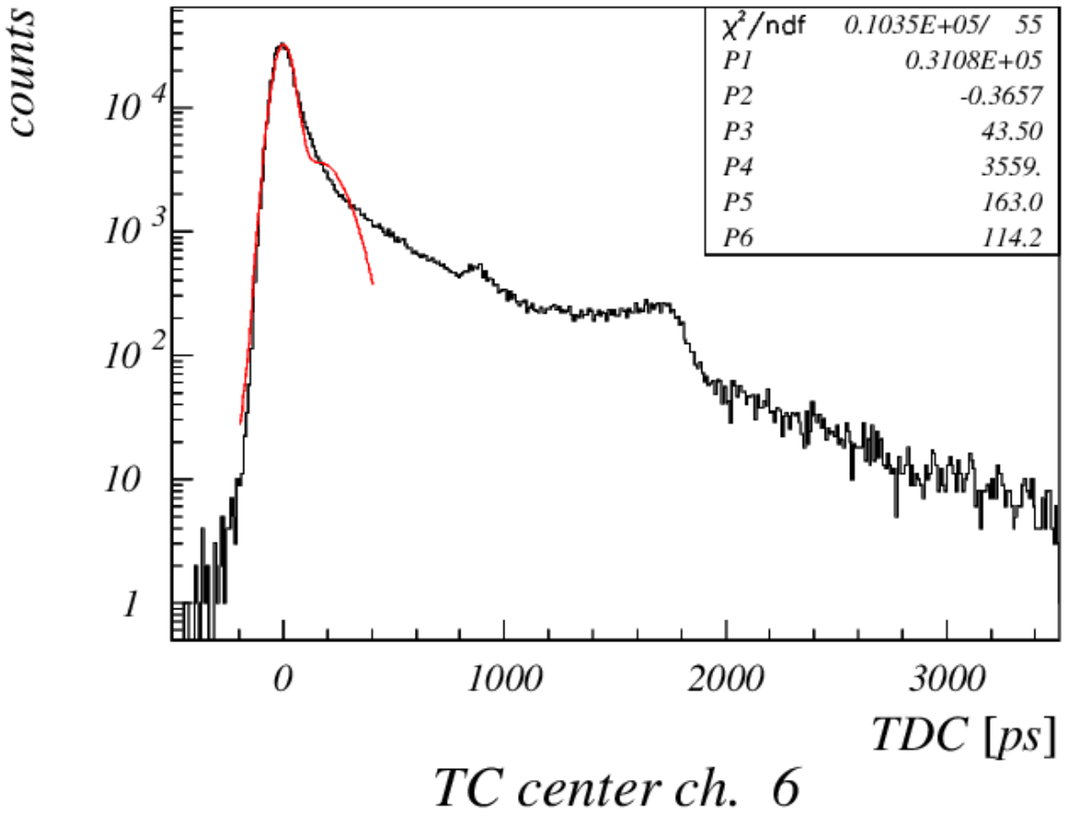
LAPPD - 5mm strips

- charge sharing for 5 mm strips

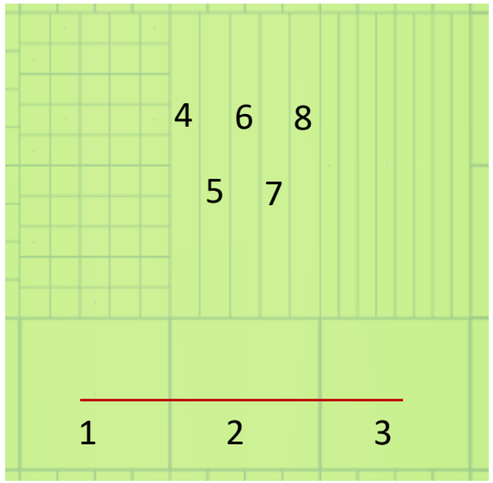




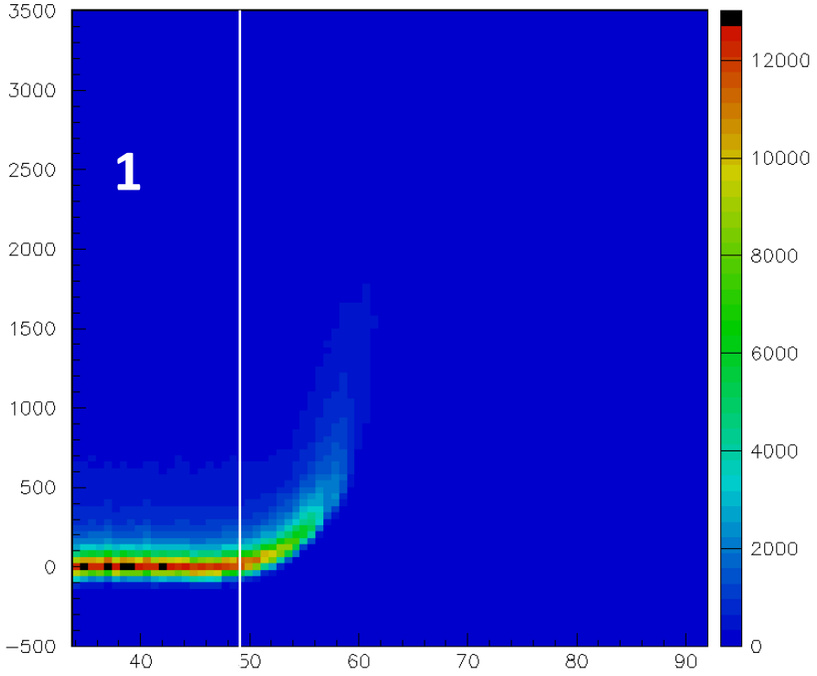


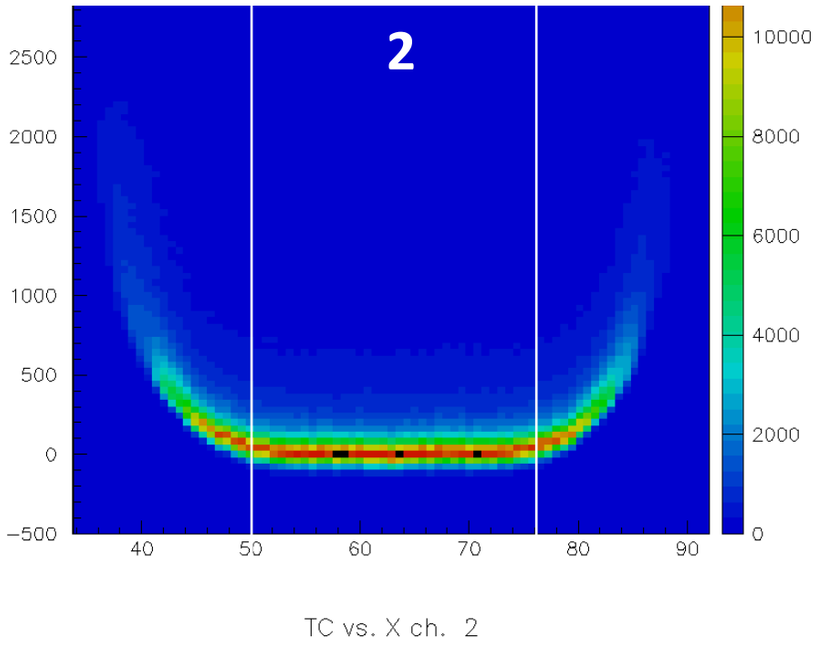


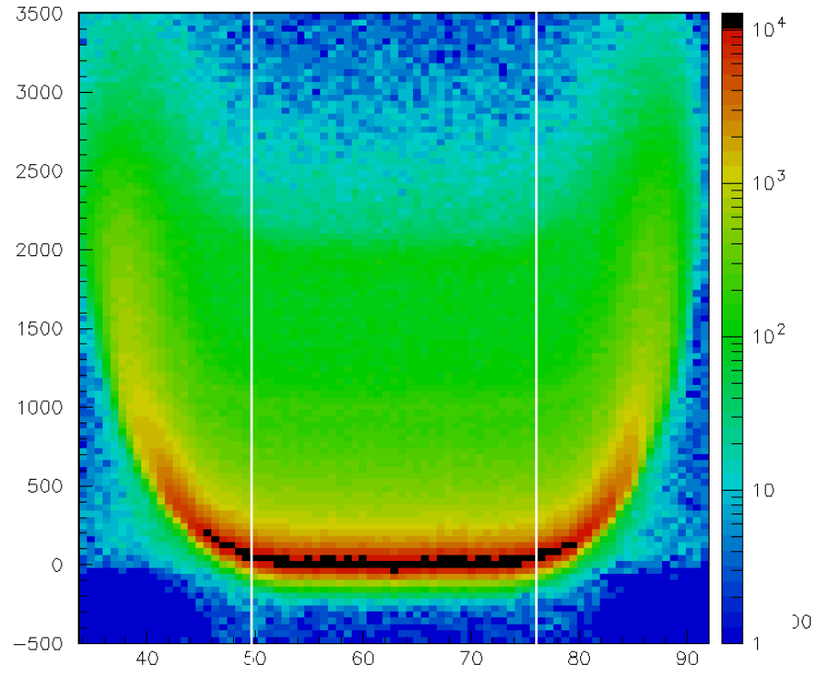
Timing variation

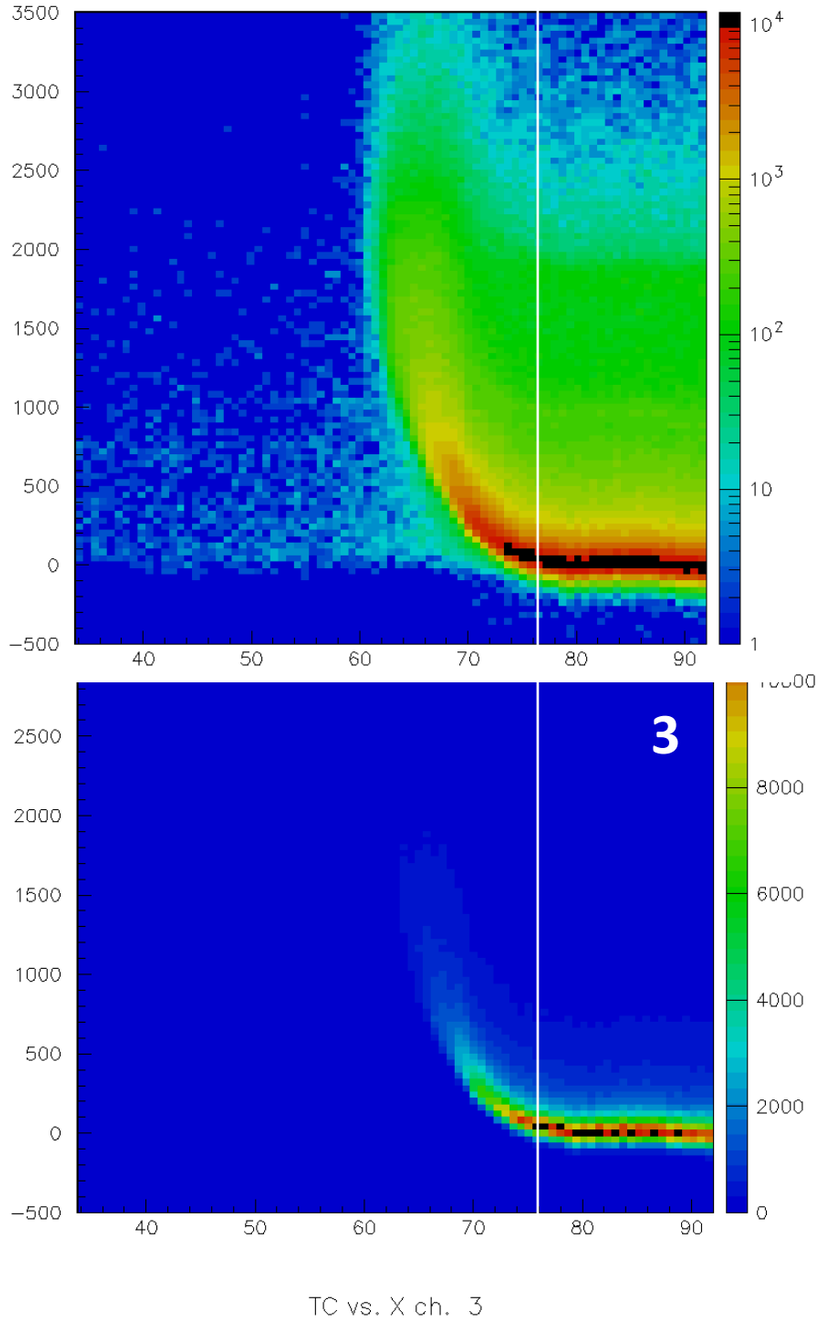


- all signals detected by channel









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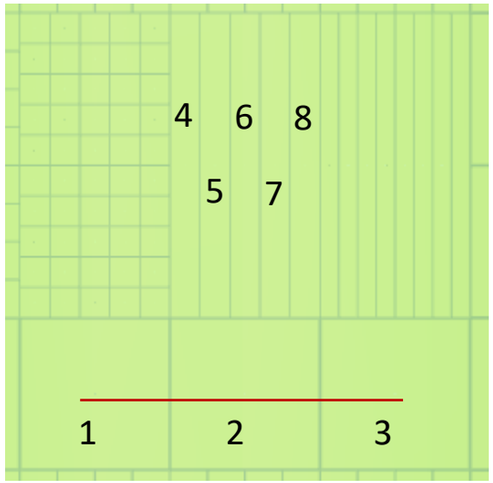
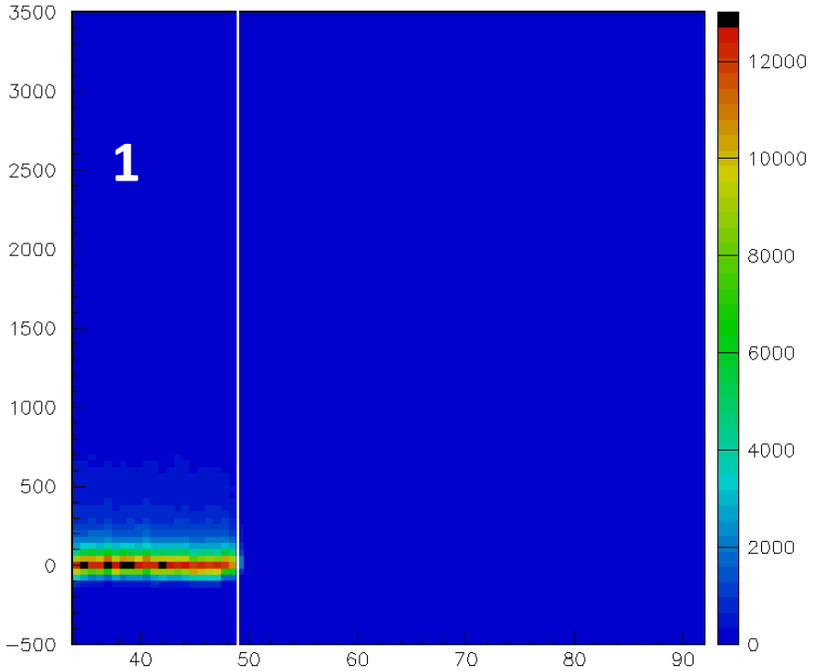
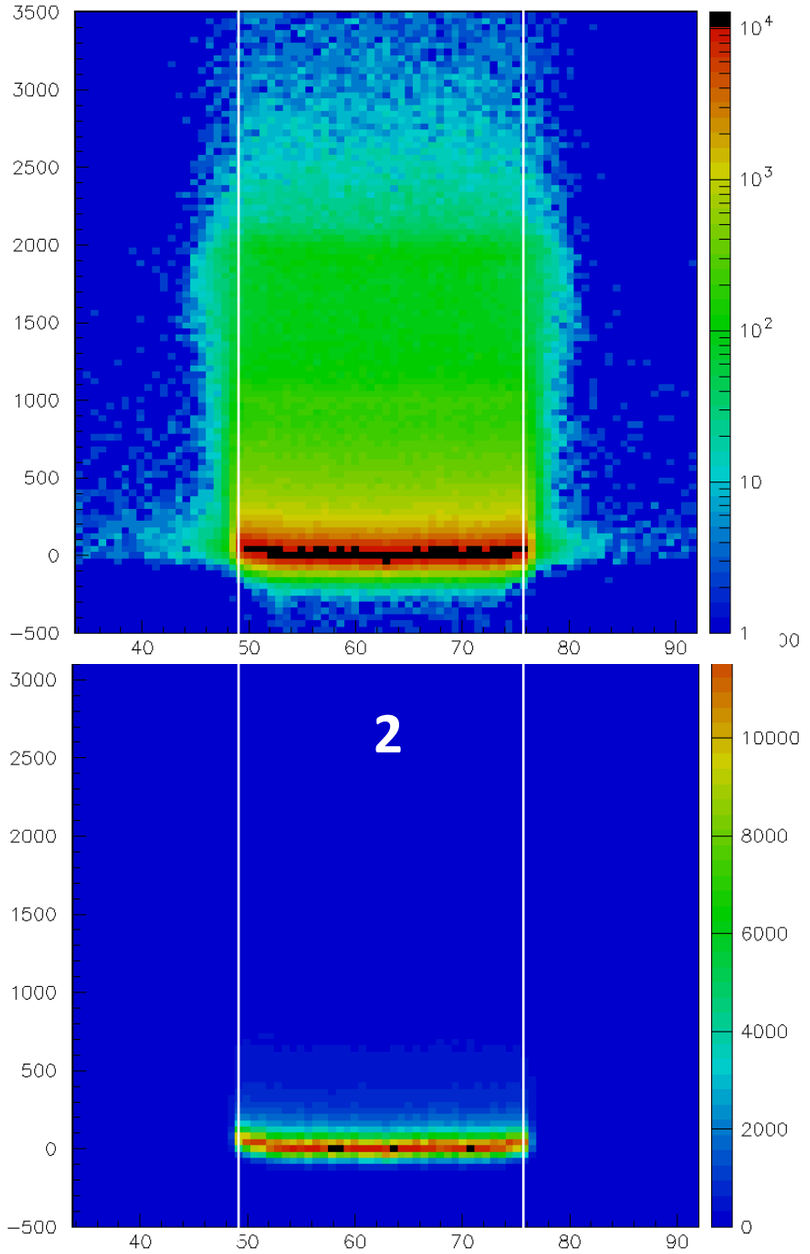
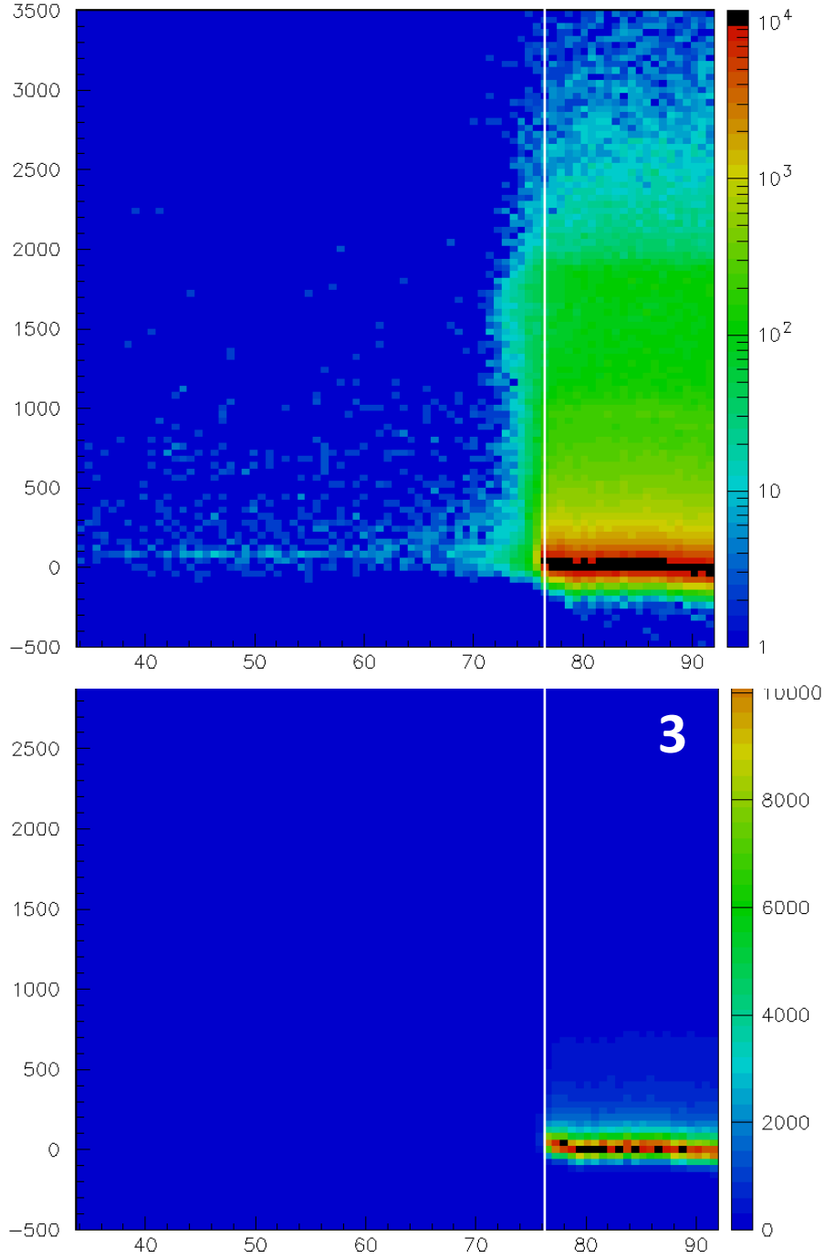
Timing variation



- max. signal detected by channel







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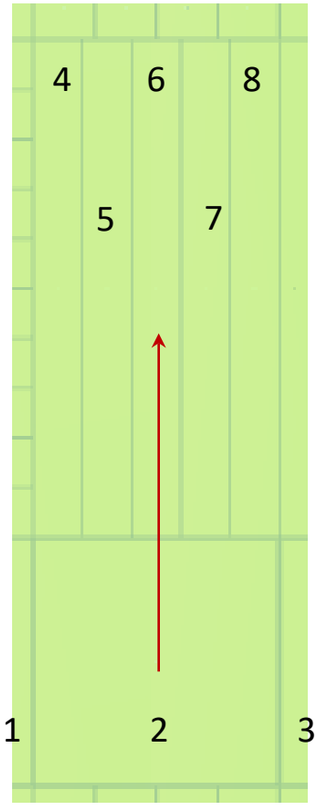
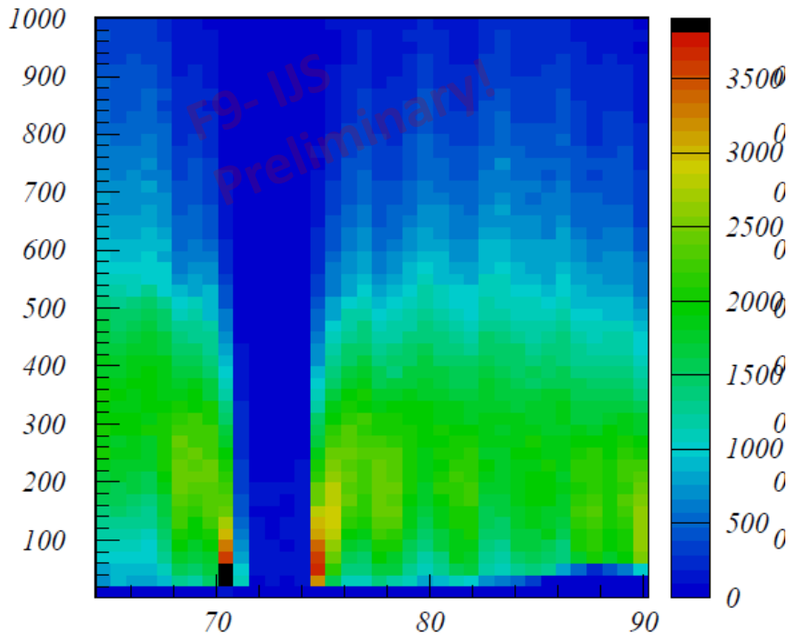
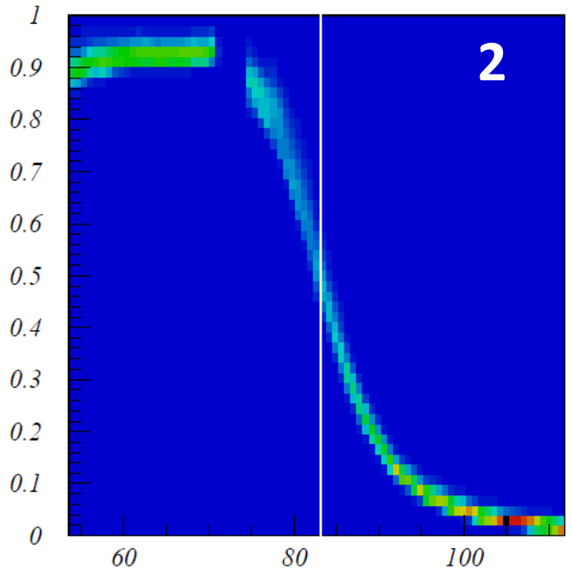
Spacer bar area

- scan across spacer bar in y direction
- gain drops within $\approx 10\ mm$ area, dead area $\approx 4\ mm$

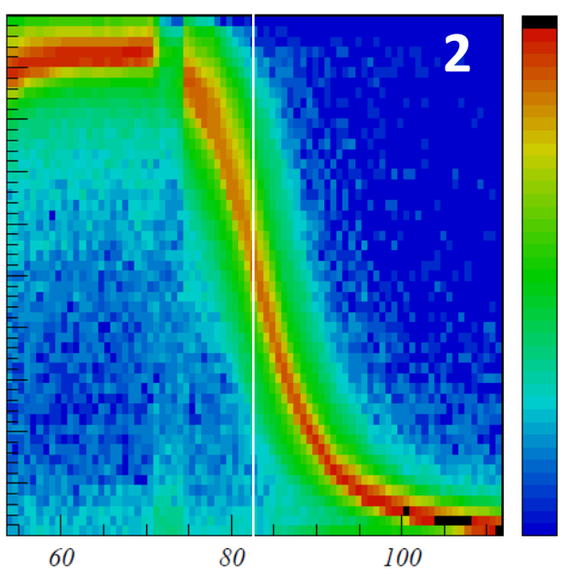




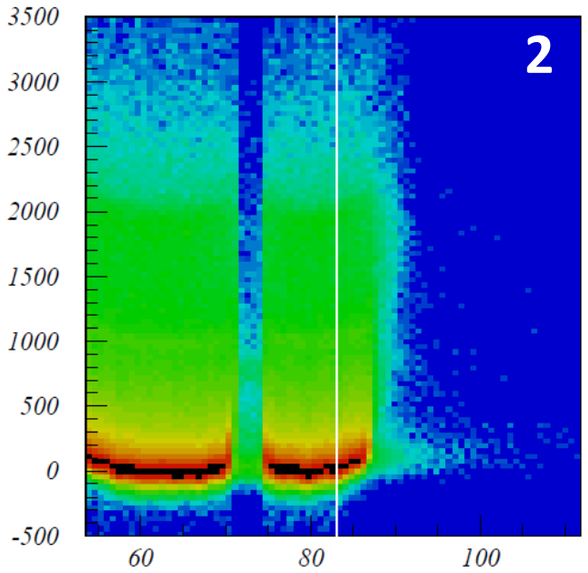
ASUM vs. Y



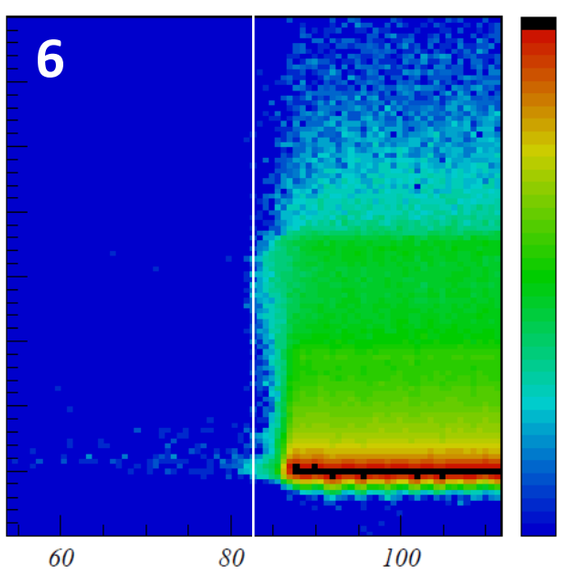
ADC(I)/ADC vs. Y



ADC(I)/ADC vs. Y



TC vs. Y max ch. 2



TC vs. Y max ch. 6

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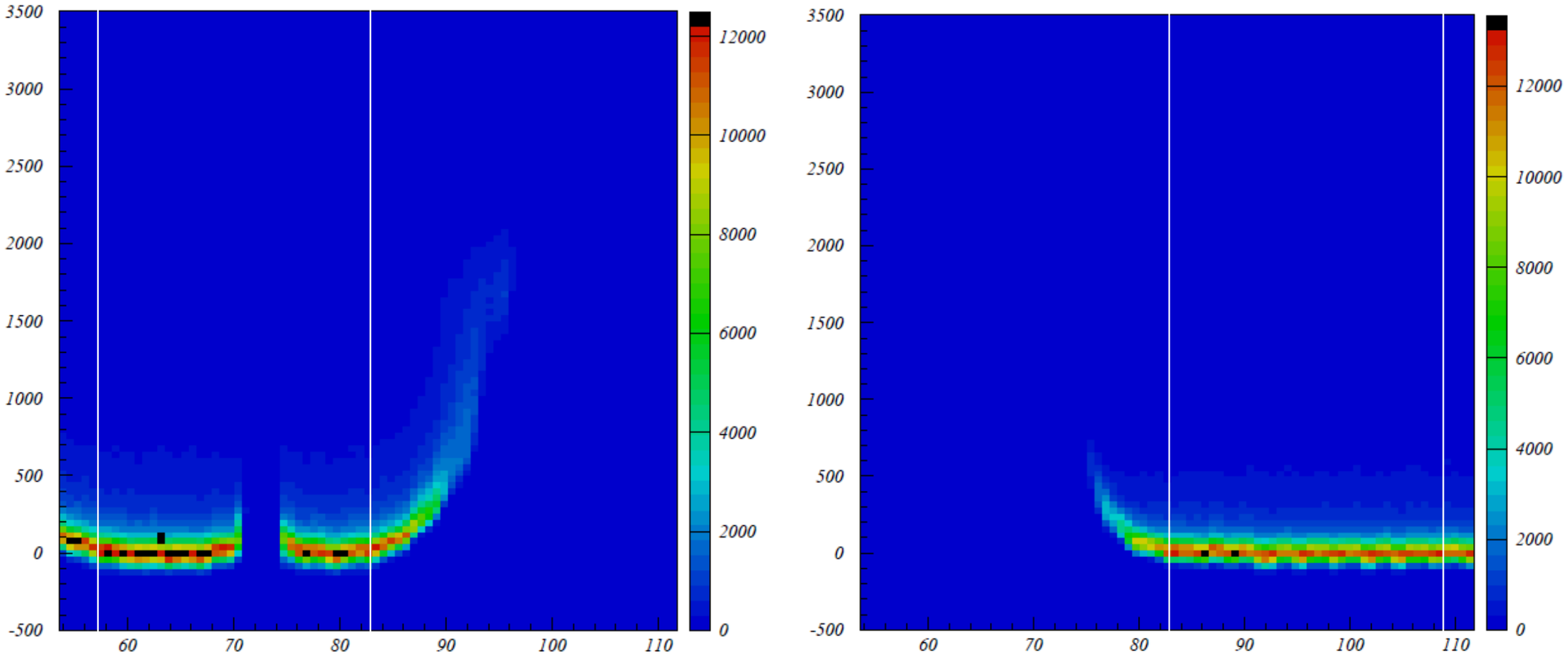
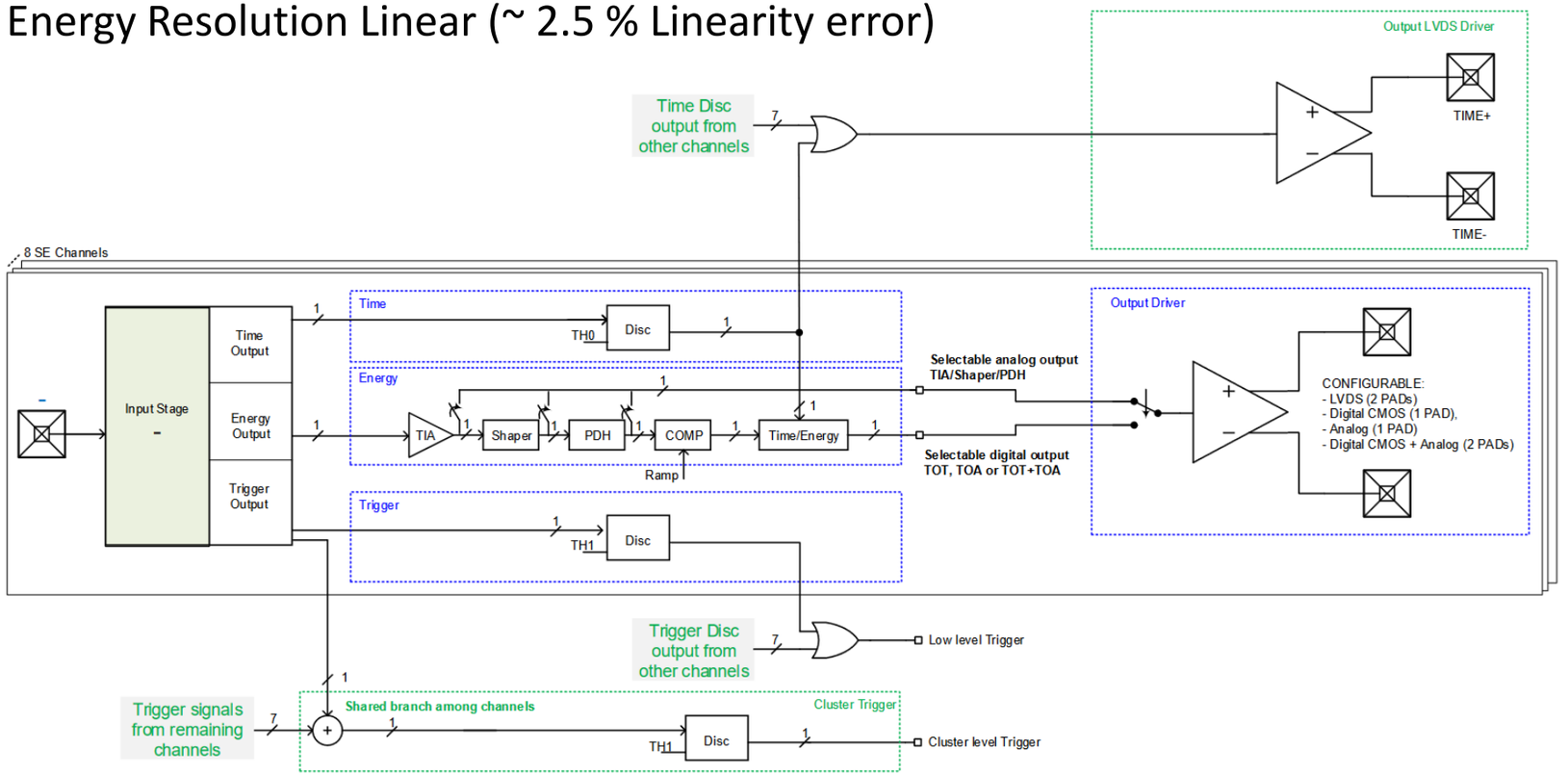
Spacer bar area

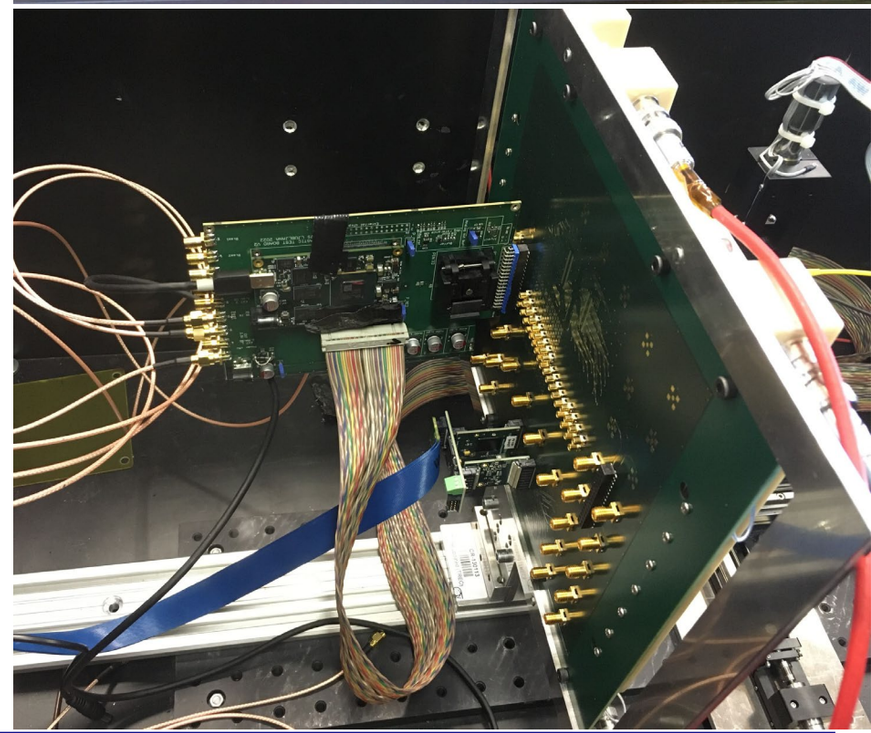
- scan across spacer bar in y direction



LAPPD + FastIC

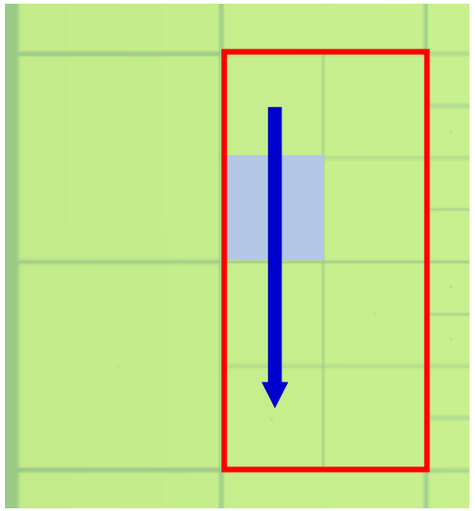
- 8 CH ASIC
- Technology 65 nm CMOS
- ~ 6 mW/ch
- Number of channels: 8 SE / 4 DIFF
- Connection Type Configurable SE (Pos/Neg polarity)DIFF, Sum of 4 (Pos/Neg polarity)
- Electronics Time Jitter ~ 25 ps rms
- Energy Resolution Linear (~ 2.5 % Linearity error)

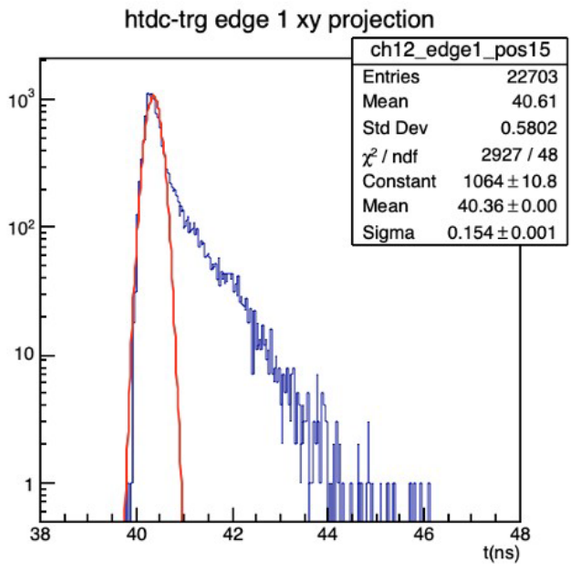


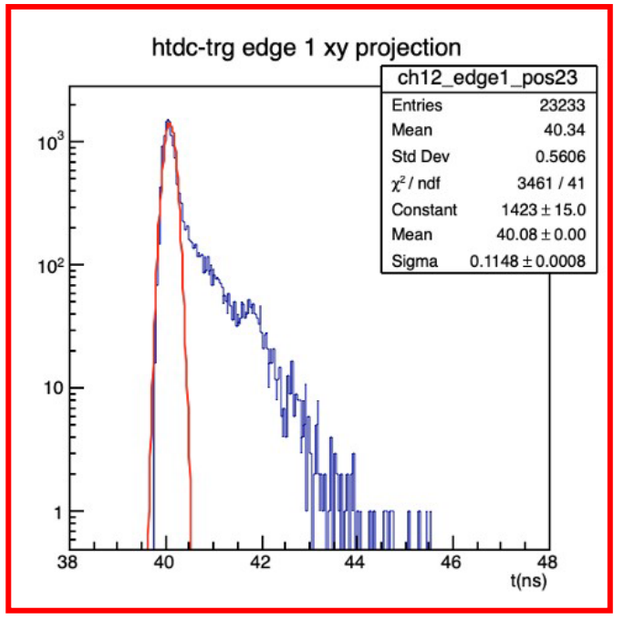


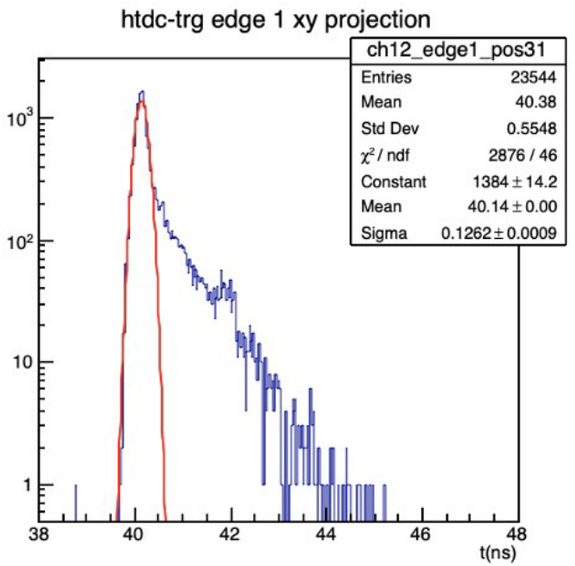
LAPPD + FastIC

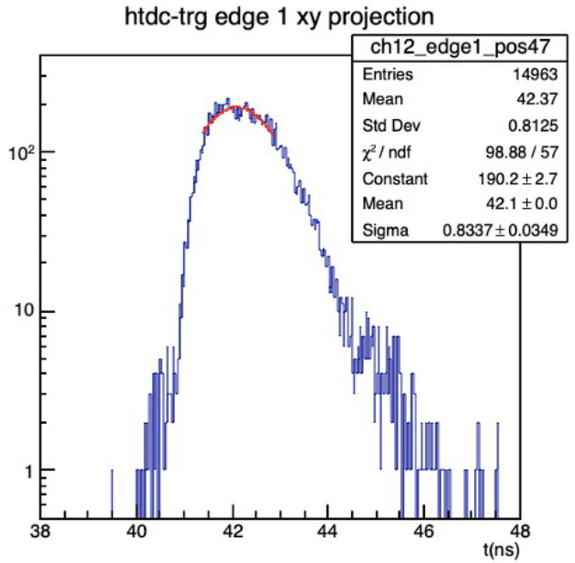
- 8 channels connected to ½'' pads
- Timing resolution at different positions of laser spot $\approx 115\ ps$ – no time-walk correction

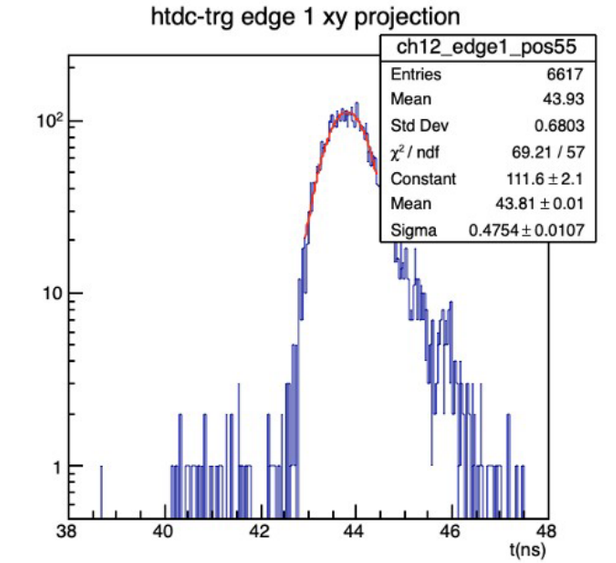


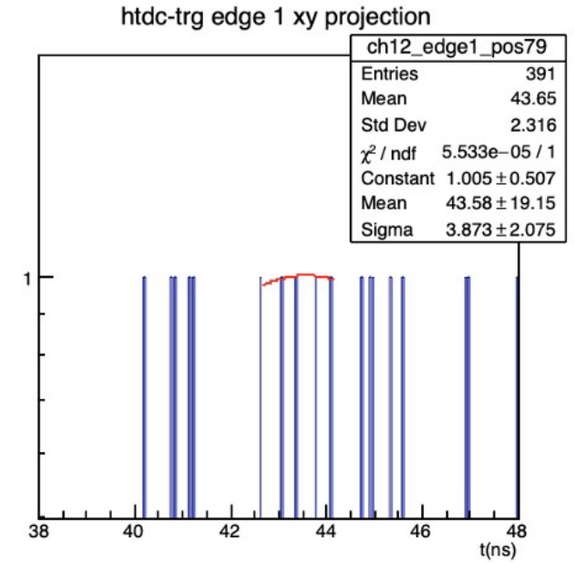






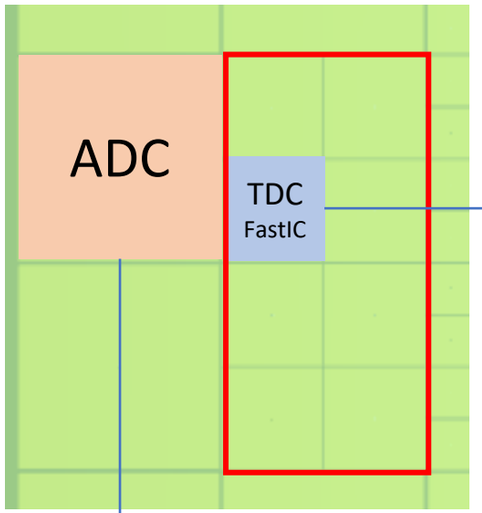


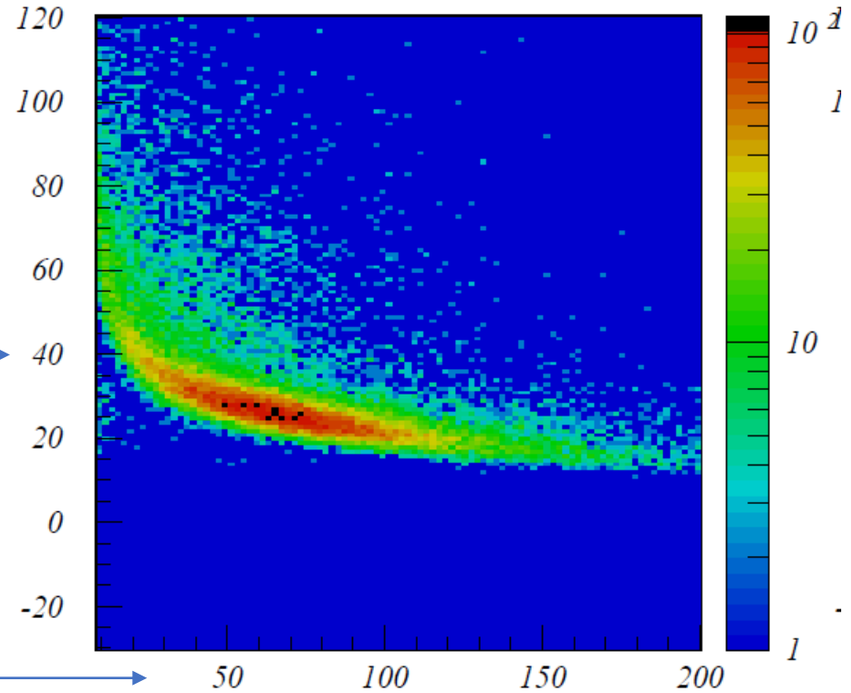




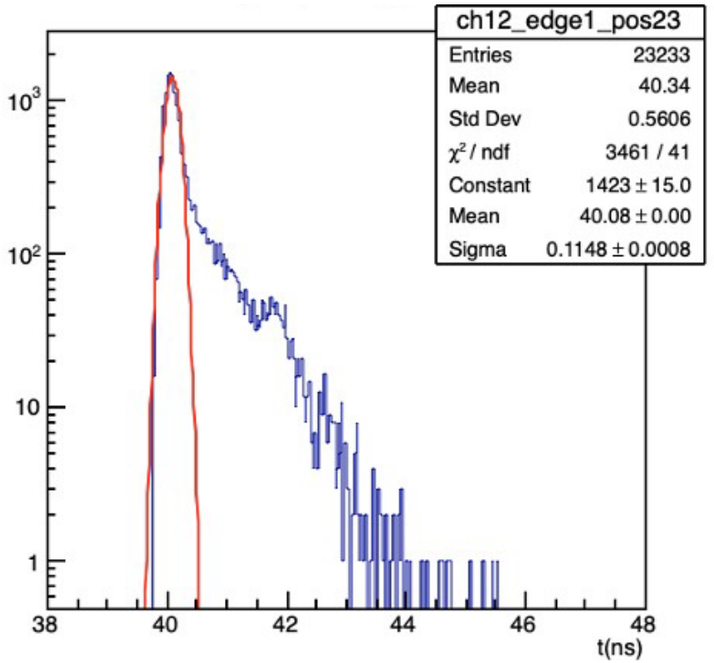
LAPPD + FastIC

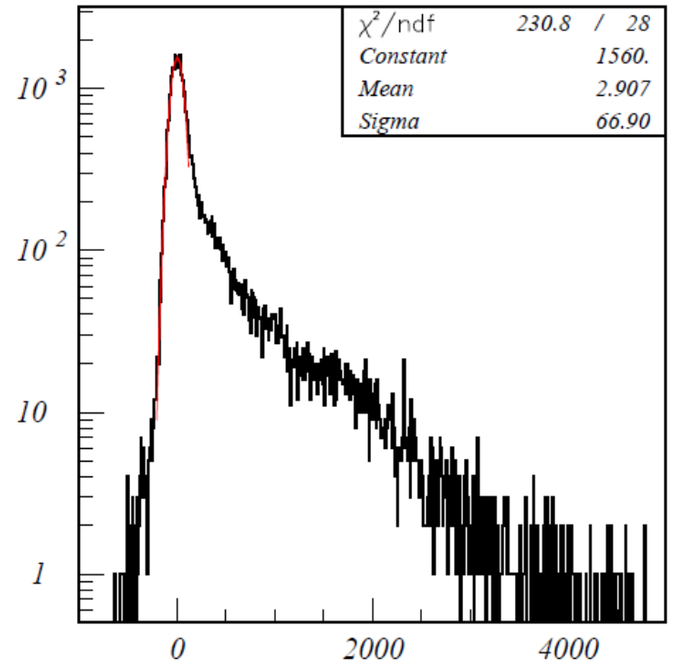
- Signal too short for TOT detection (may be possible with adjusted FastIC parameters?)
- Charge measured by charge sharing on adjacent pad
- Timing resolution corrected for time-walk by using ADC signal from neighbouring pad $\approx 70\ ps$





TDC vs. ADC ch. 1

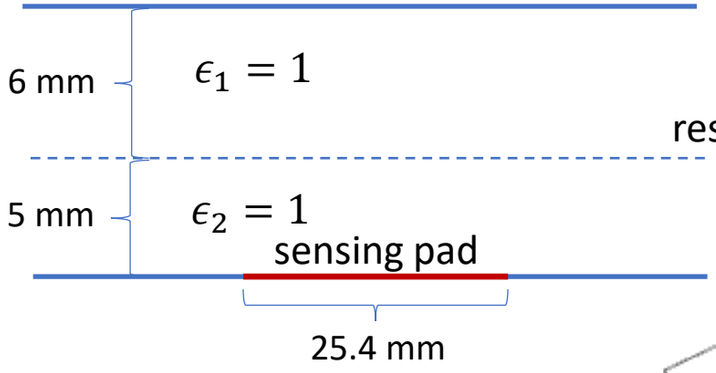




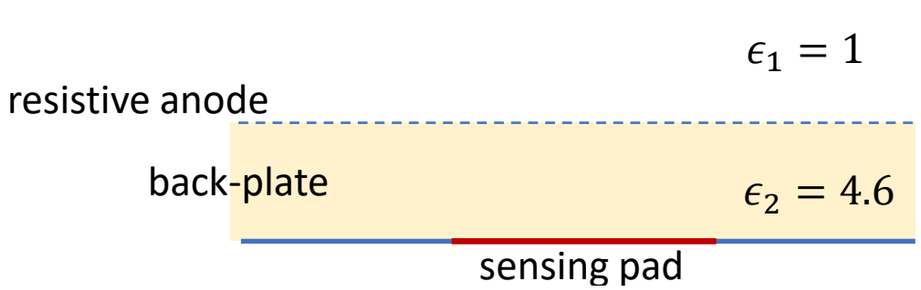
BACKUP SLIDES

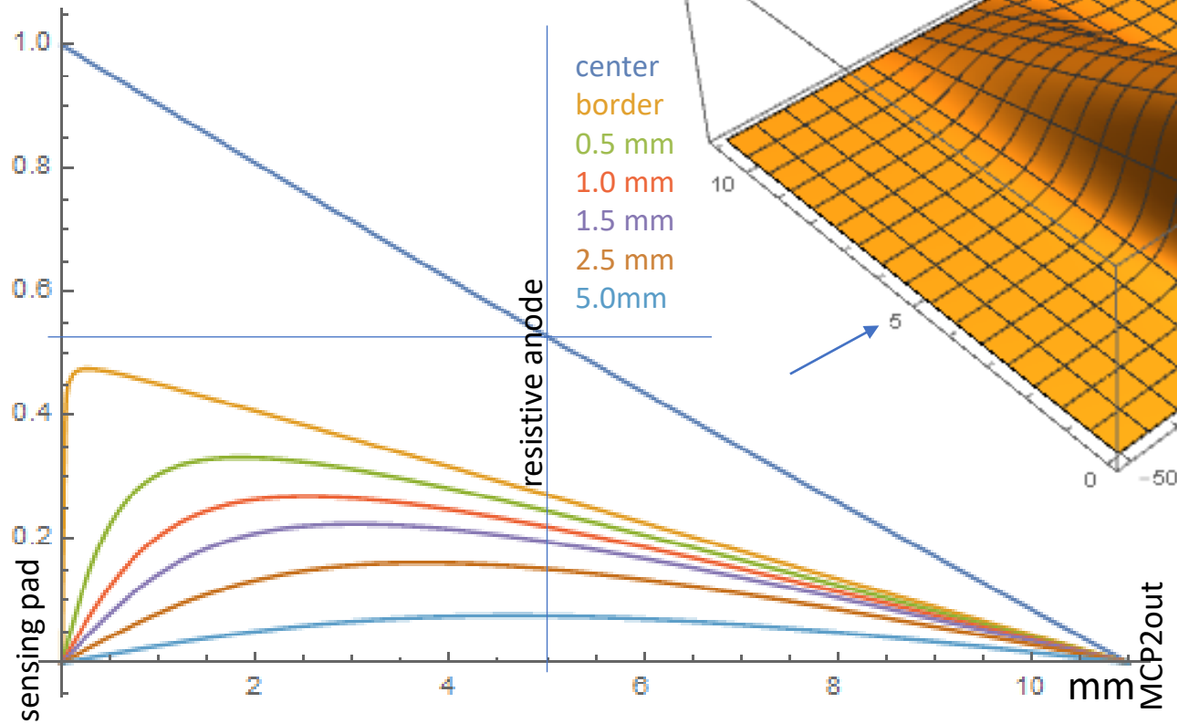
LAPPD - induced charge calculations

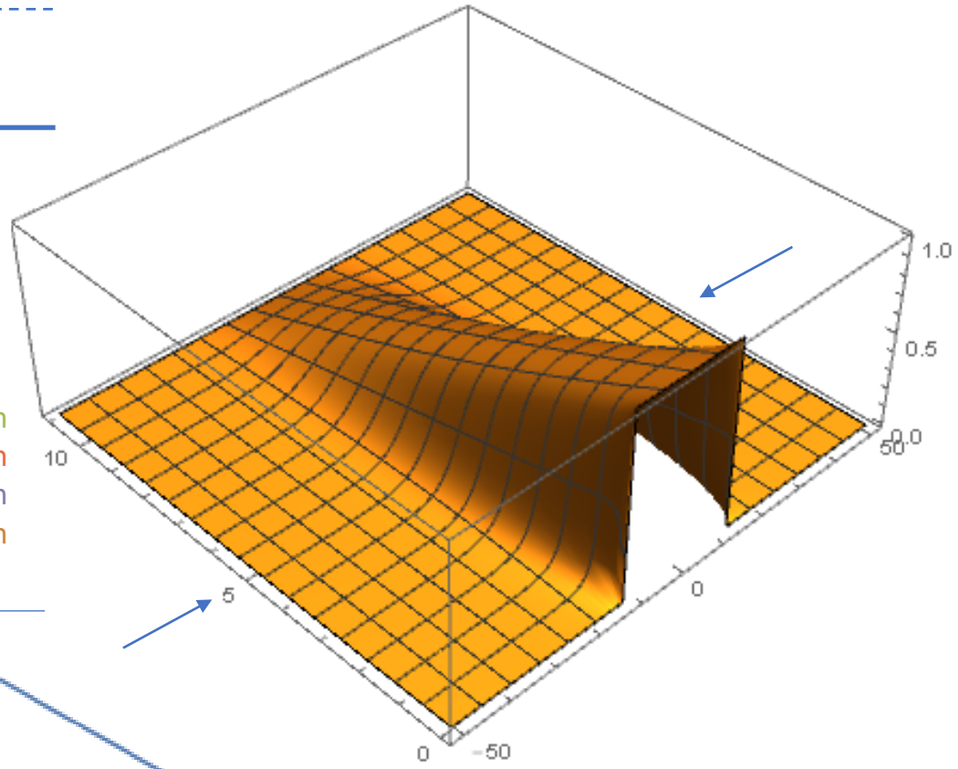
Used model for calculations

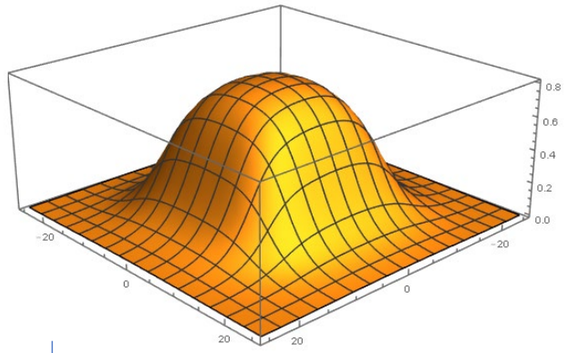


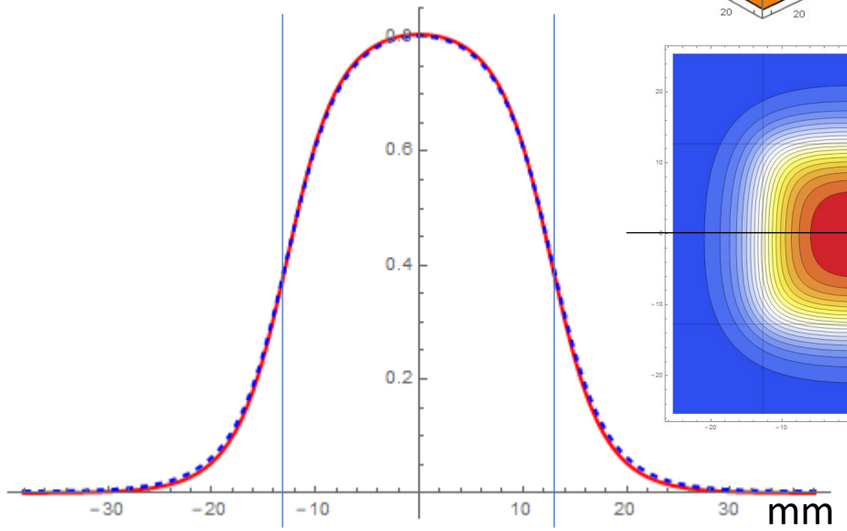
More realistic model











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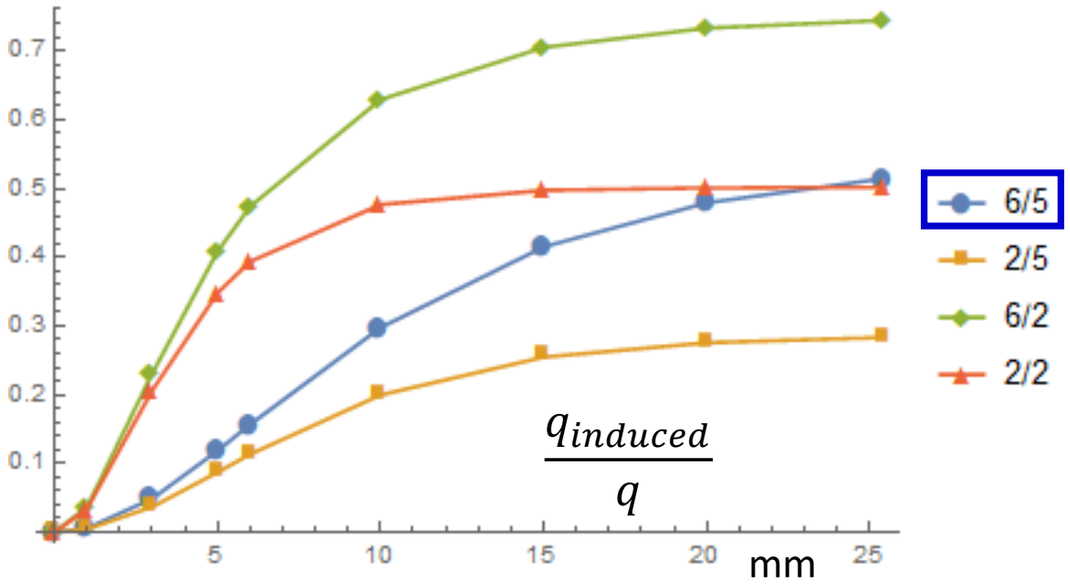
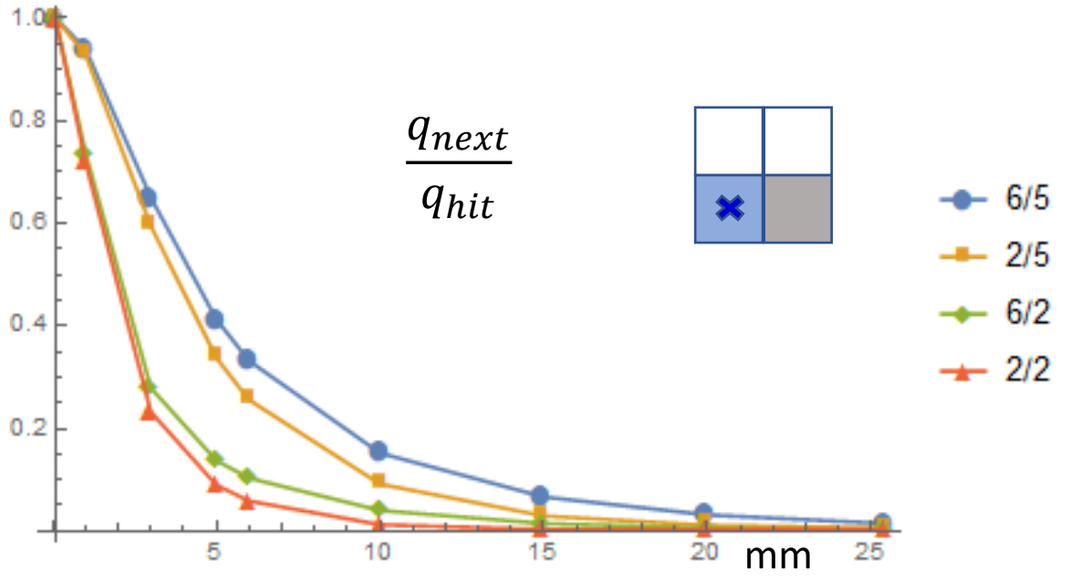
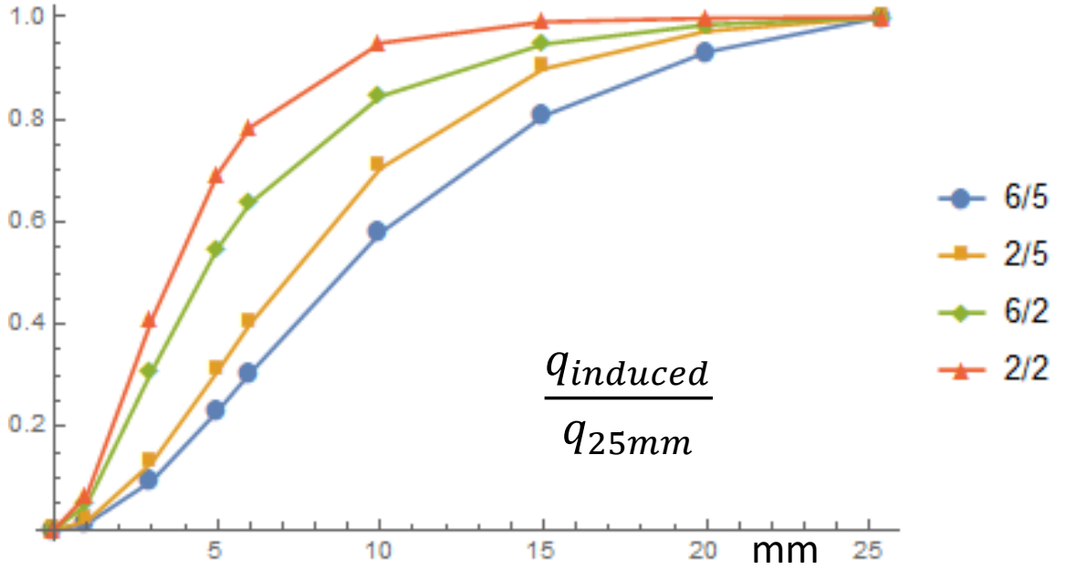
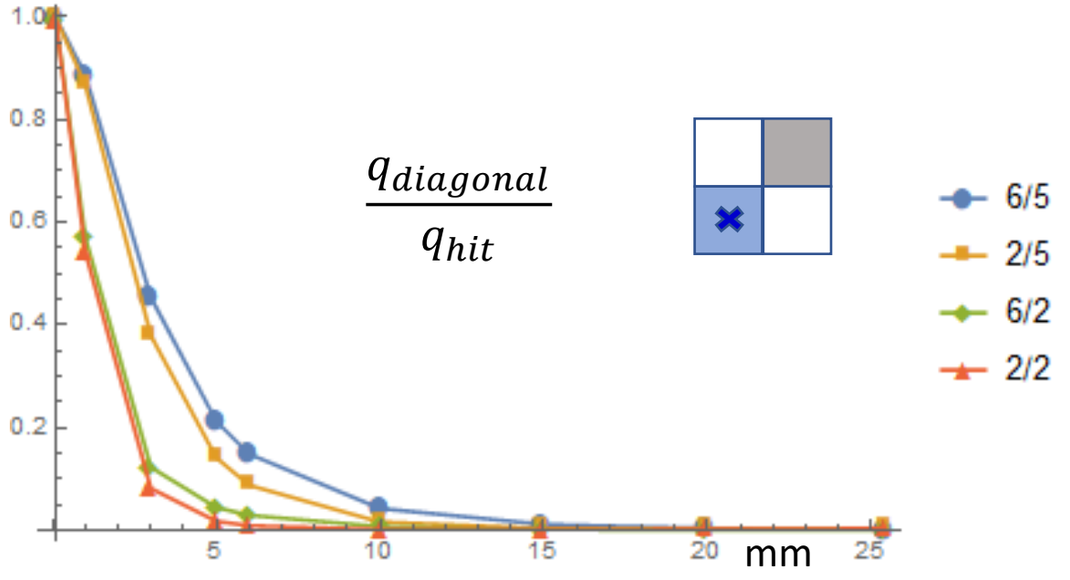
LAPPD - induced charge estimates

Collected charge by pads of different size and for different (MCP2out-A)/(A-pad) distances. ϵ not included.





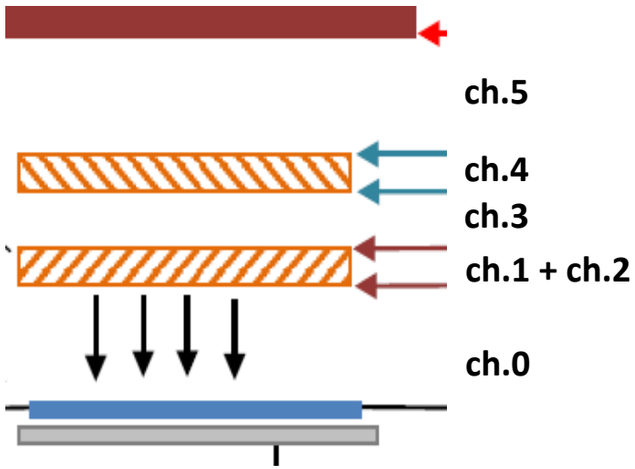




LAPPD - HV supply

CAEN HiVolta (DT1415ET), 8 Ch Reversible 1 kV/1 mA Desktop HV Power Supply – floating channels

- 1 kV/1 mA and 0.6 W(!) per channel
- ch.0 MCP2out – AN
- ch.1+ch.2 MCP2in – MCP2out (2 ch. due to power limit per channel)
- ch.3 MCP1out – MCP2in
- ch.4 MCP1in – MCP1out
- ch.5 PC – MCP1in

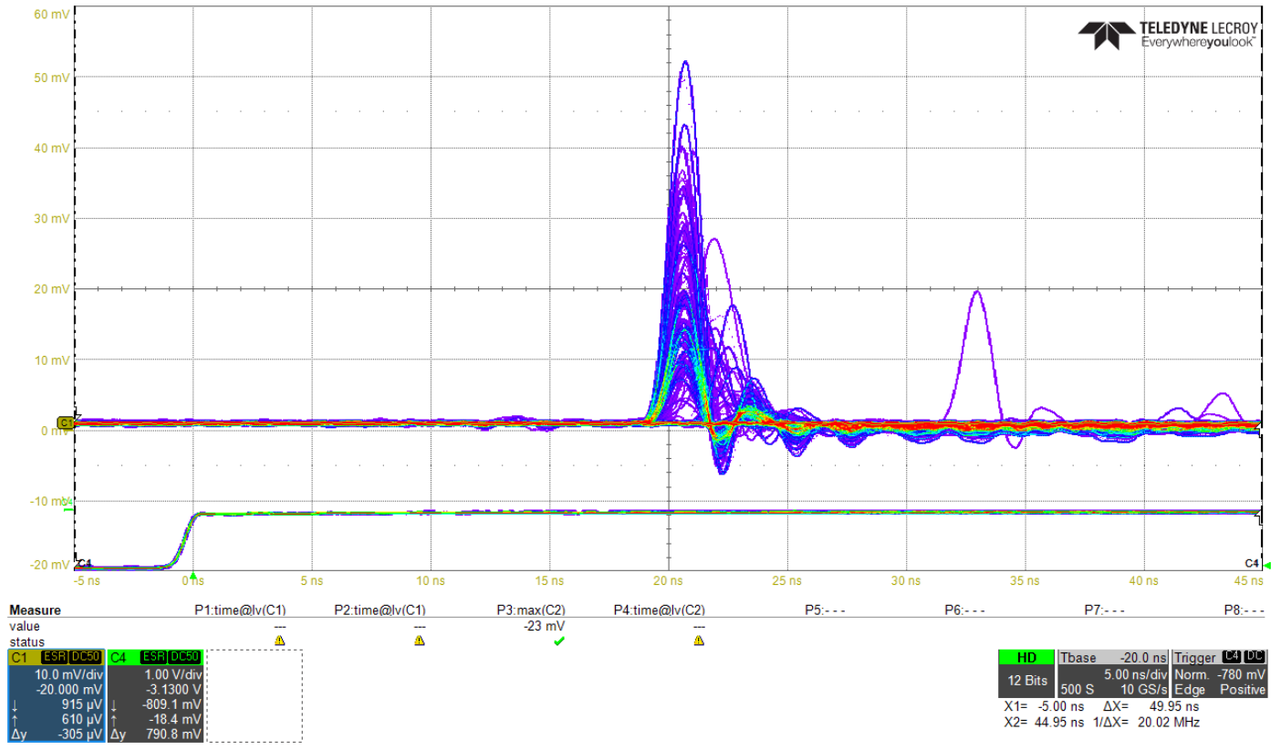


ROP voltages A-PC: 500/825(400+425)/200/825/100 V

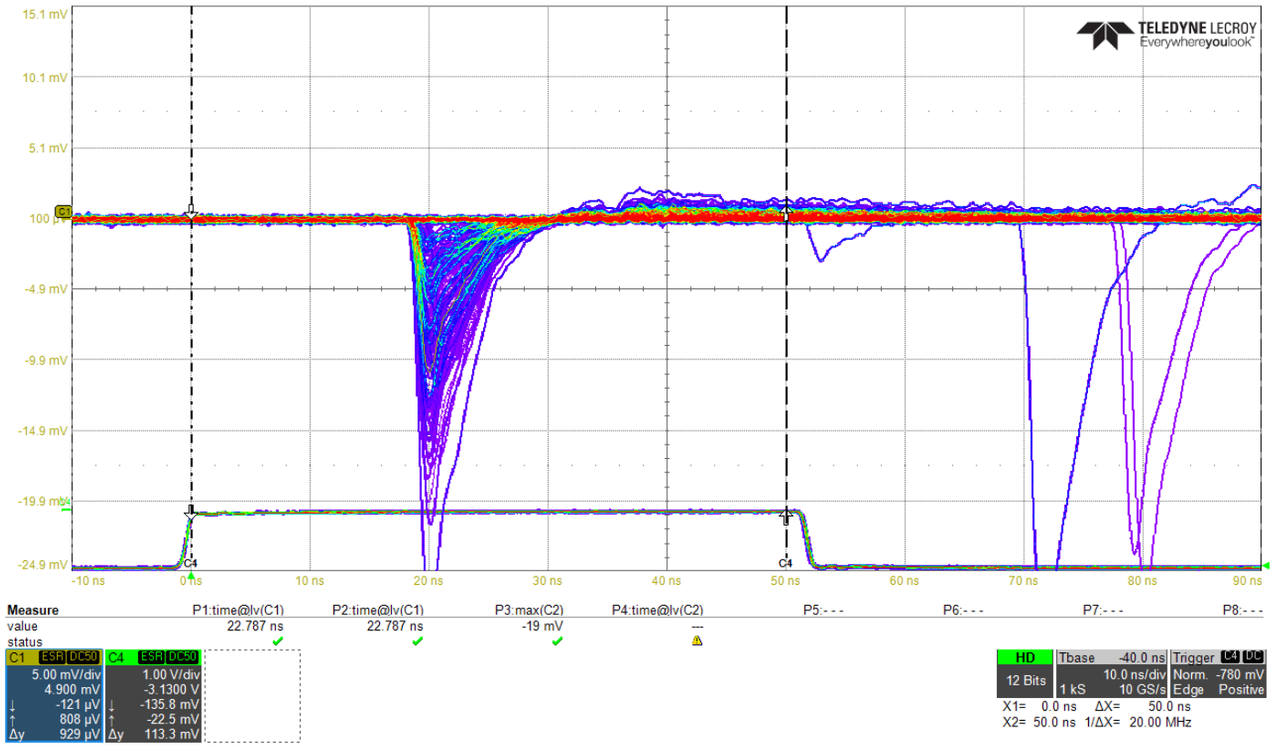
Custom	VSet	VMon	IMon	ISet	Pw	Status	SWVmax
00.000	500.00	**500.06**	**3.8730**	50.00	On		500
00.001	400.00	**400.16**	**791.5960**	900.00	On		400
00.002	425.00	**425.30**	**791.7310**	900.00	On		450
00.003	200.00	**200.22**	**15.7010**	50.00	On		200
00.004	825.00	**825.46**	**345.5840**	450.00	On		850
00.005	100.00	**100.20**	**0.0680**	5.00	On		150

LAPPD - raw signals

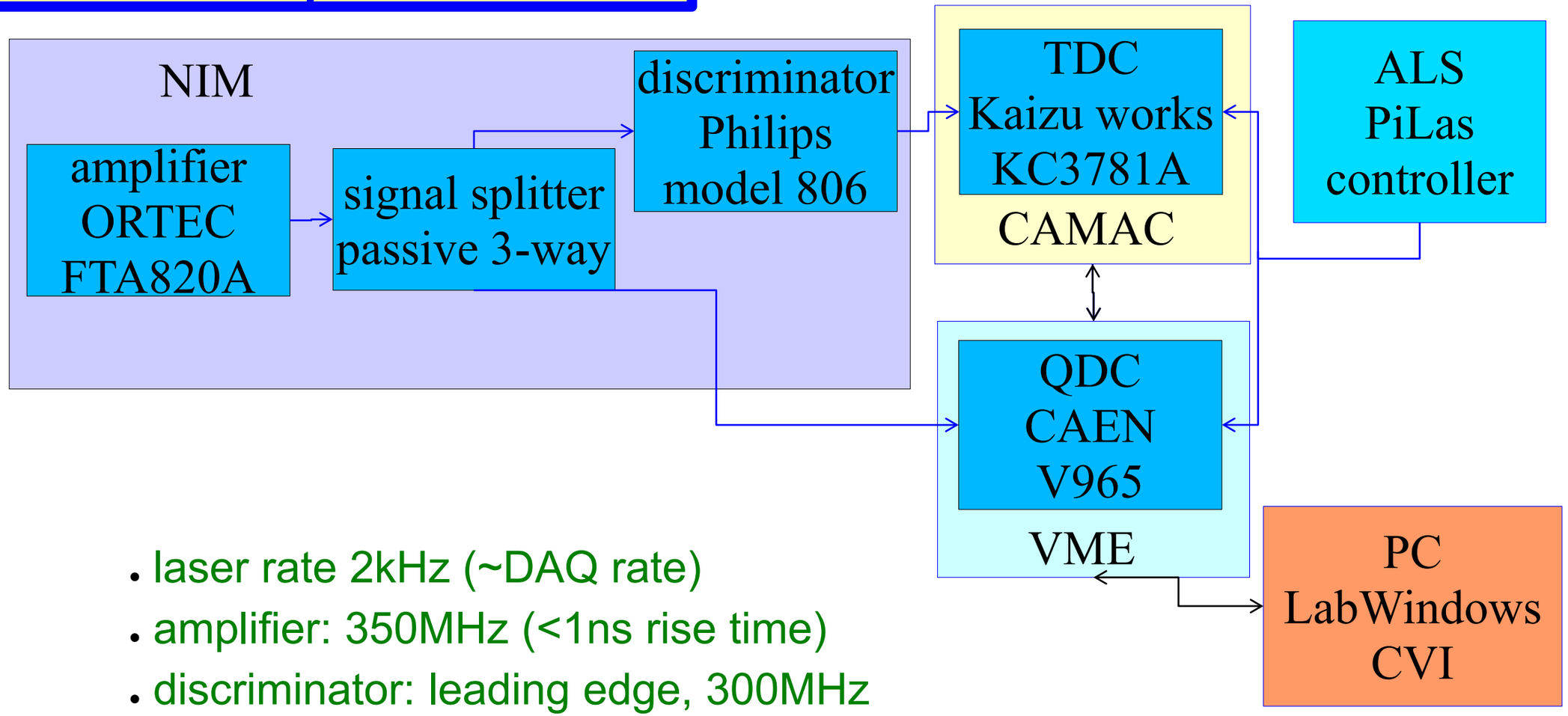
- transformed signal



- direct signal



Modular readout system for tests



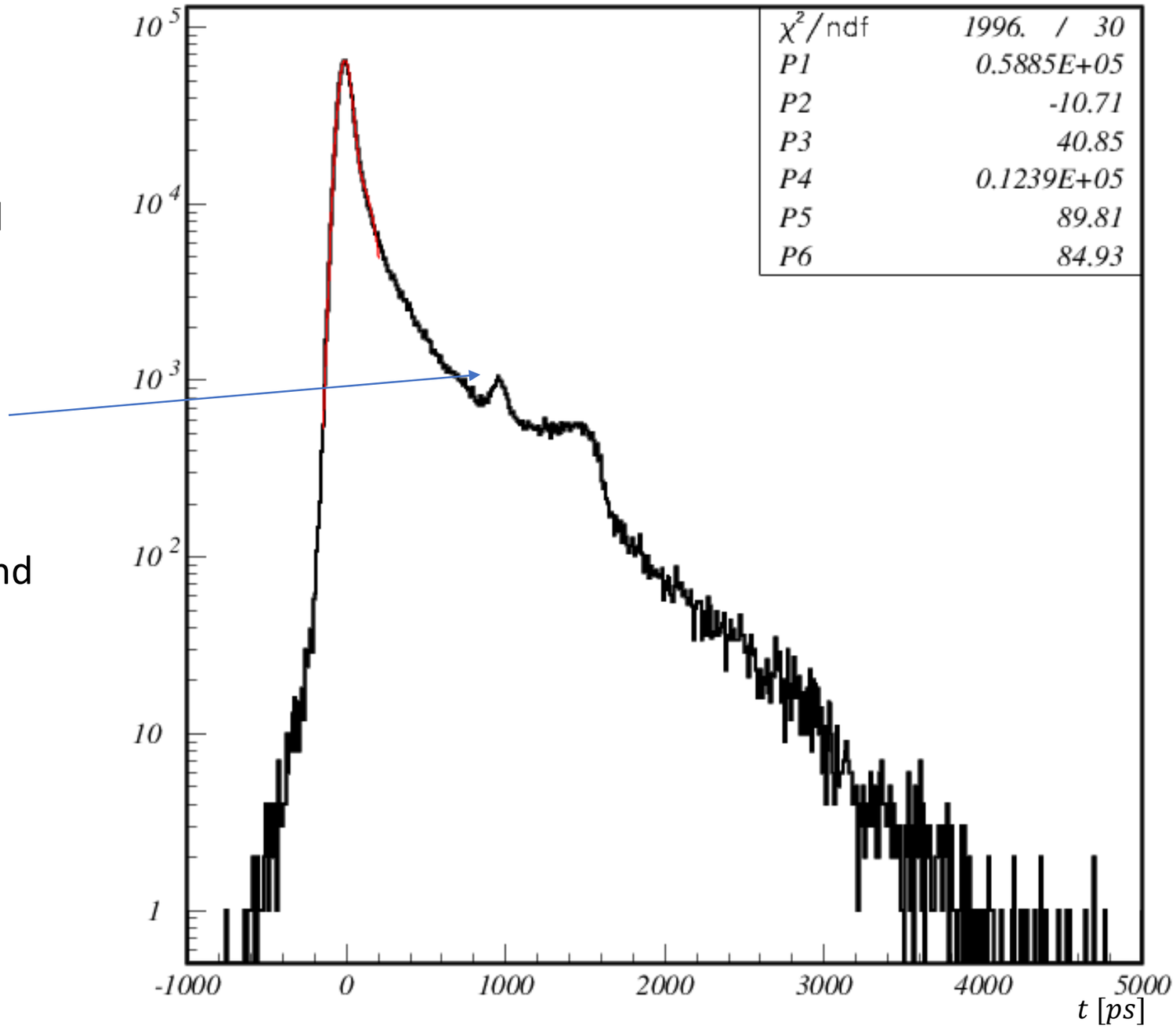
- laser rate 2kHz (~DAQ rate)
- amplifier: 350MHz (<1ns rise time)
- discriminator: leading edge, 300MHz
- TDC: 25ps LSB(σ~11ps)
- QDC: dual range 800pC, 200pC

LAPPD – timing disdribution

- measured timing distribution typical for MCP-PMT
- main prompt peak with some inelastic and elastic backscattering contribution

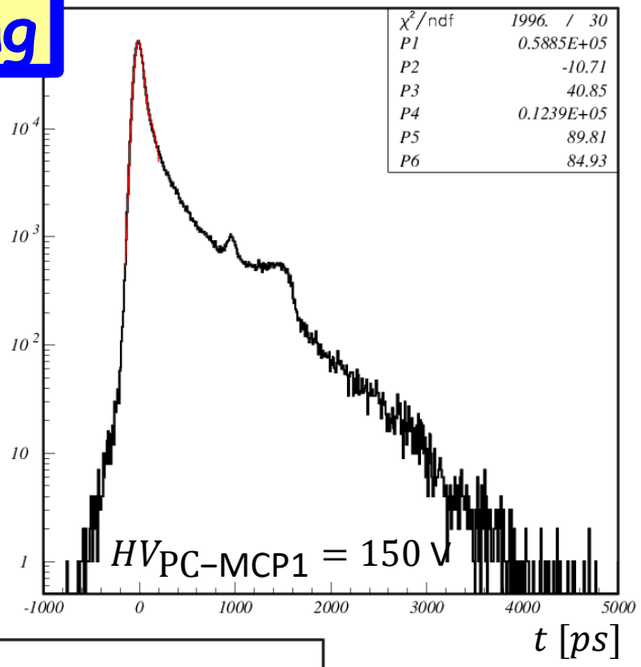
- additional small peak at about 1 ns delay probably due to some reflection (light?), delay not affected by PC-MCP1 voltage

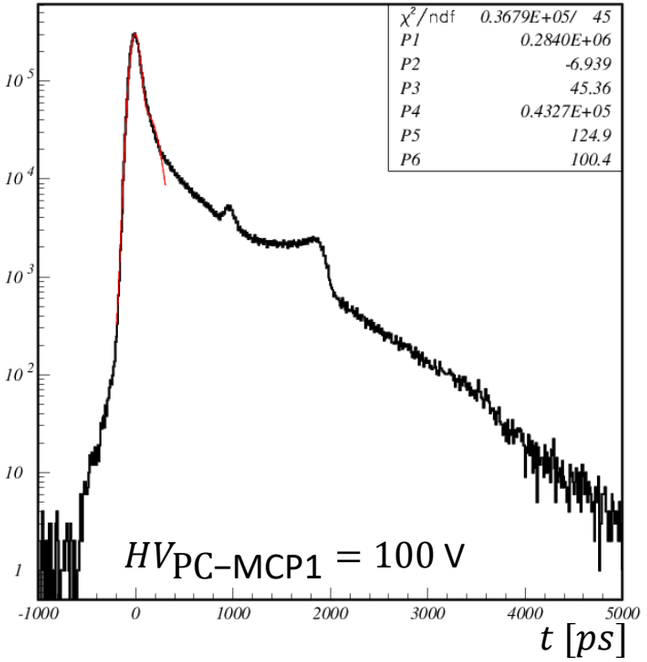
- plot is for the PC-MCP1 voltage of 150 V and ROP for others

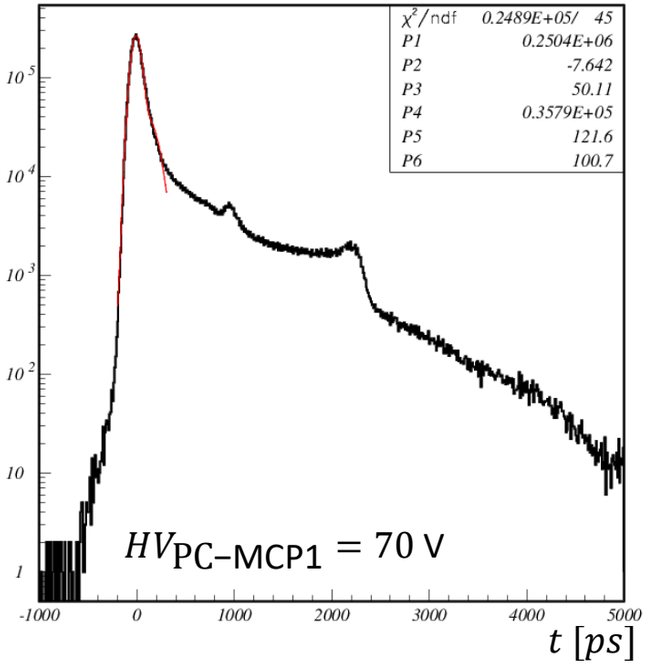


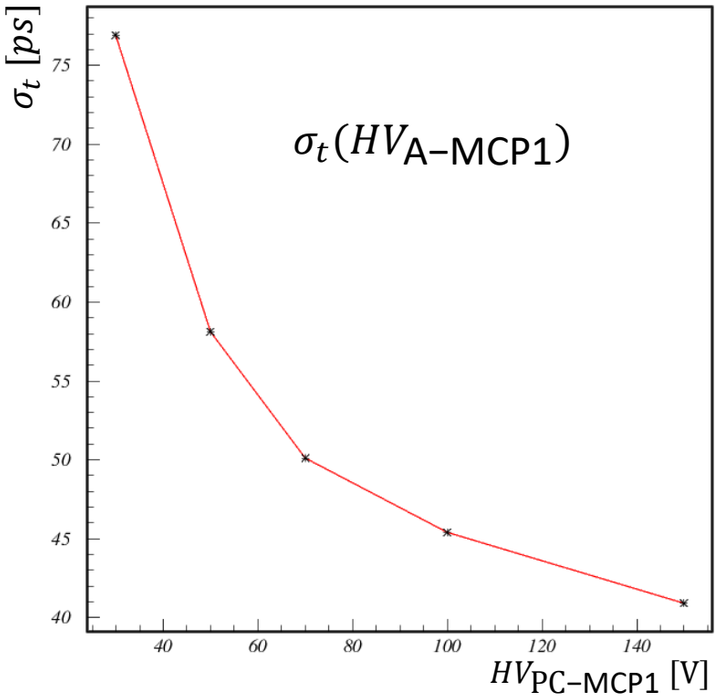
LAPPD - timing

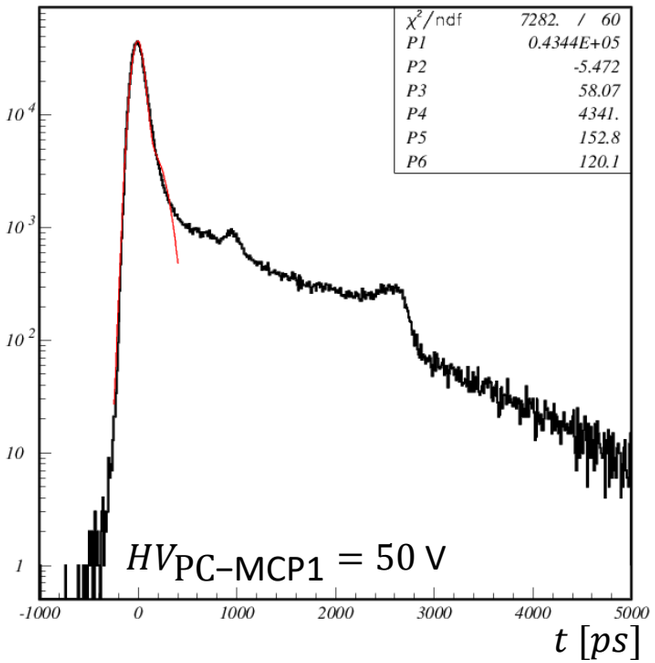
- corrected TDCs for several PC-MCP1 voltages
- time resolution vs PC-MCP1 voltage

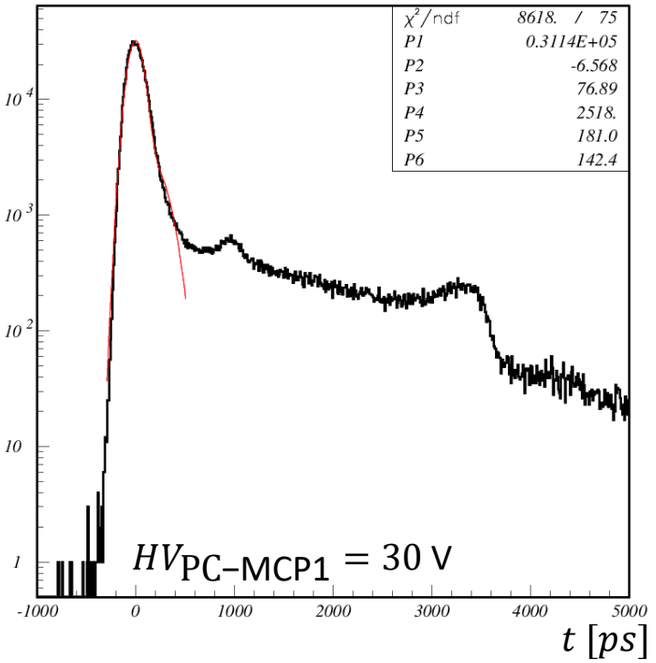












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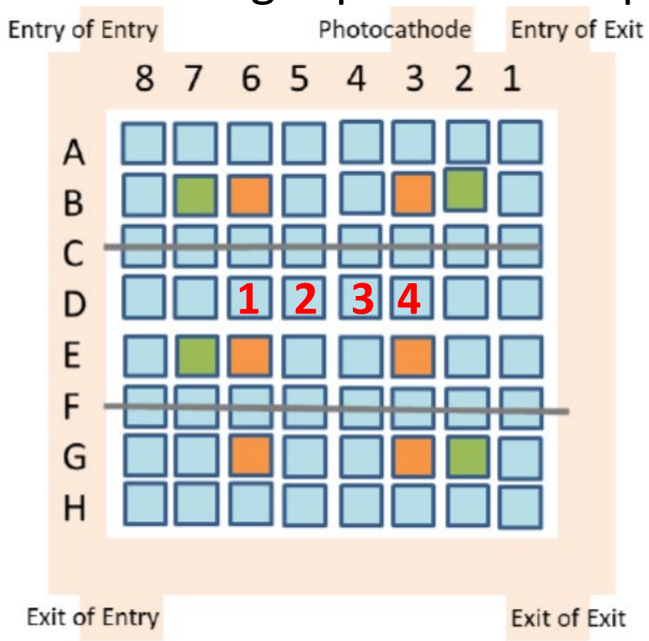
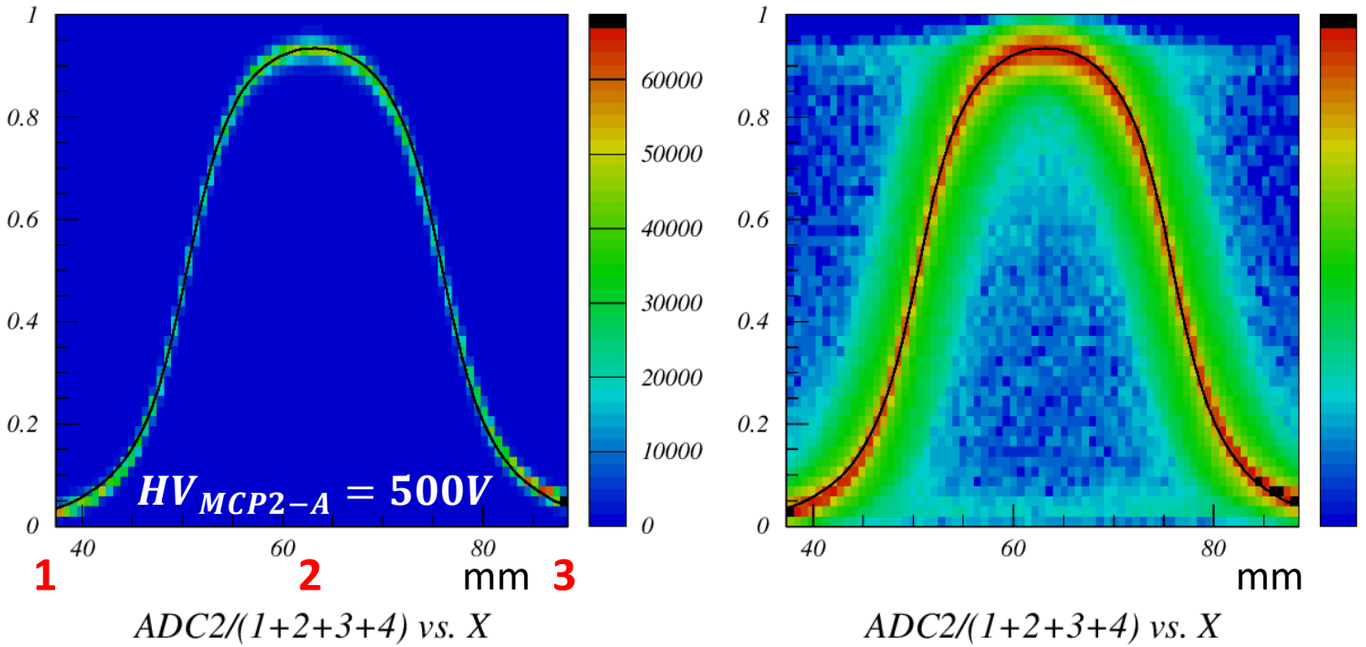
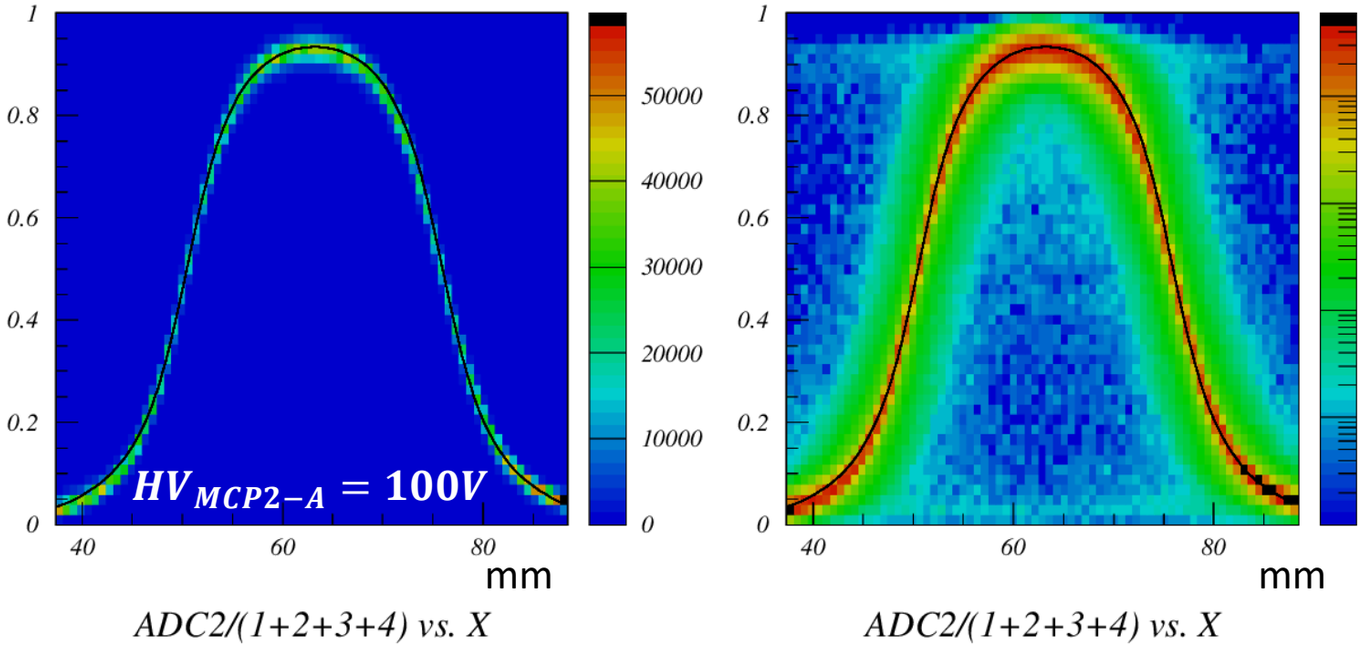
LAPPD - induced charge fraction

- fraction of the signal on ch. 2 vs laser spot x position: $f(x) = \frac{q_2}{\sum_i q_i}$
- green band (log scale) indicates the range of a backscattered photoelectrons – twice the PC-MC1 distance (on each side)
- ROP for upper plots and 100 V between MCP2 and A for lower ones
- Signal spread not mainly from electron spread but induced charge spread on coupled electrode

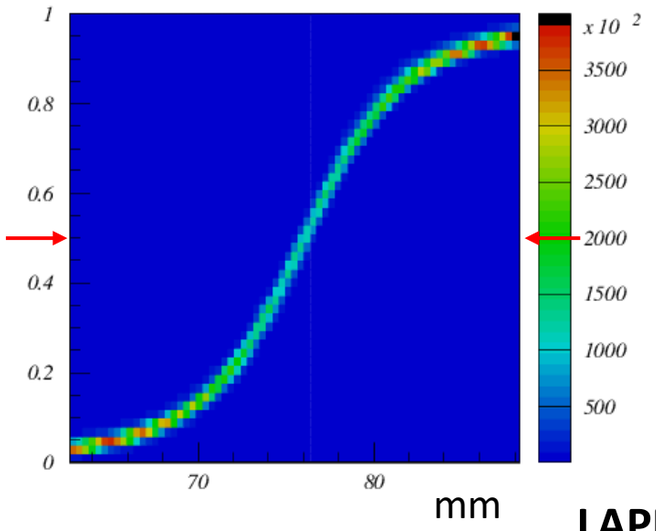


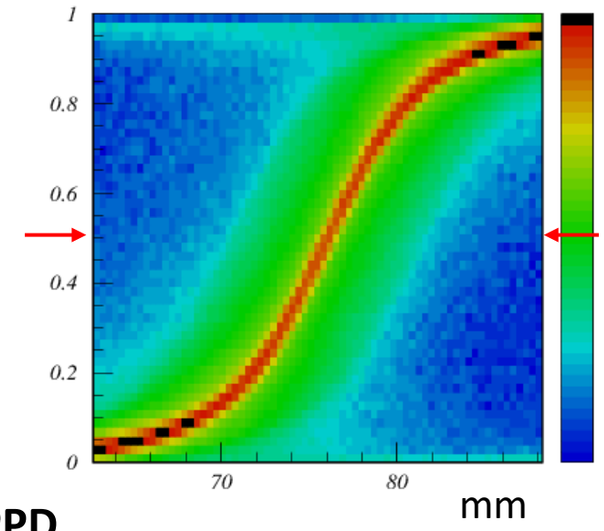




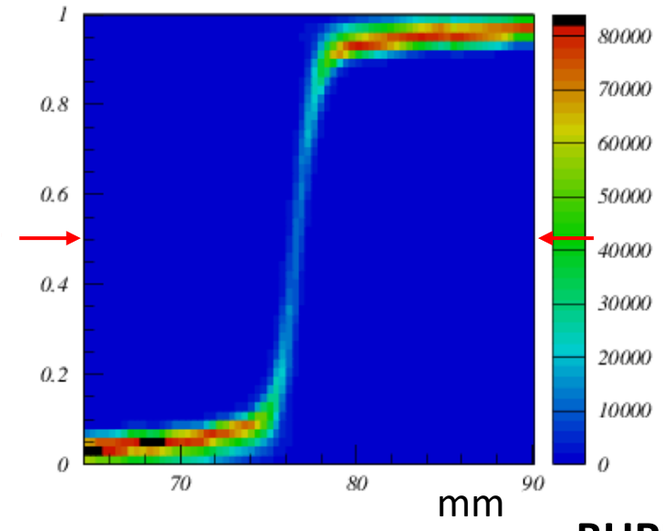
LAPPD - PLANCON

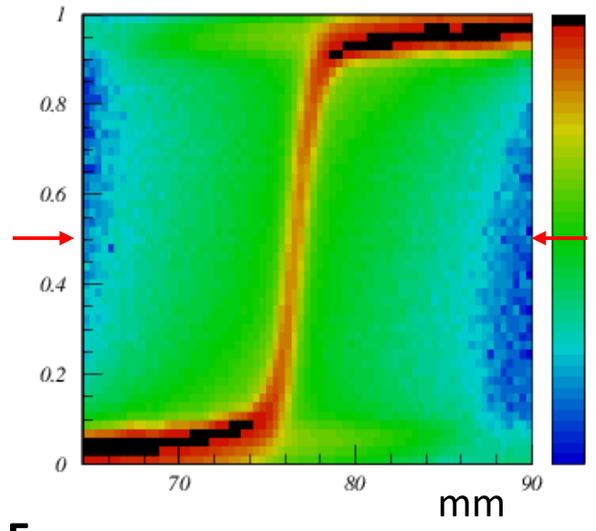
LAPPD (capacitive coupling) – BURLE PLANACON (internal anodes) signal spread comparison – same pad size, same range





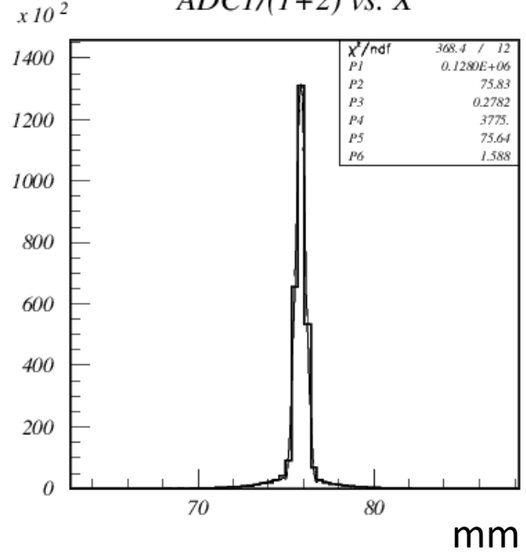
LAPPD





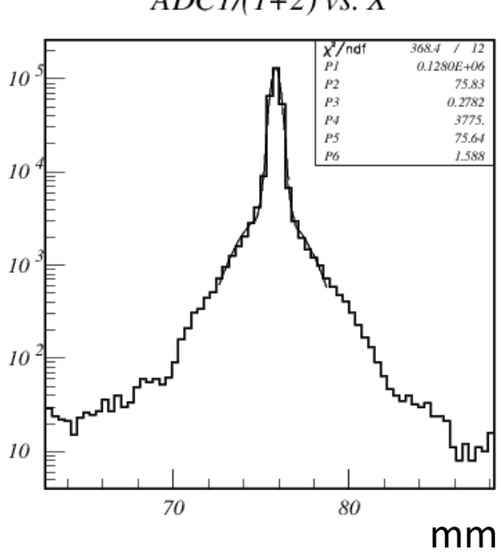
BURLE

ADC1/(1+2) vs. X



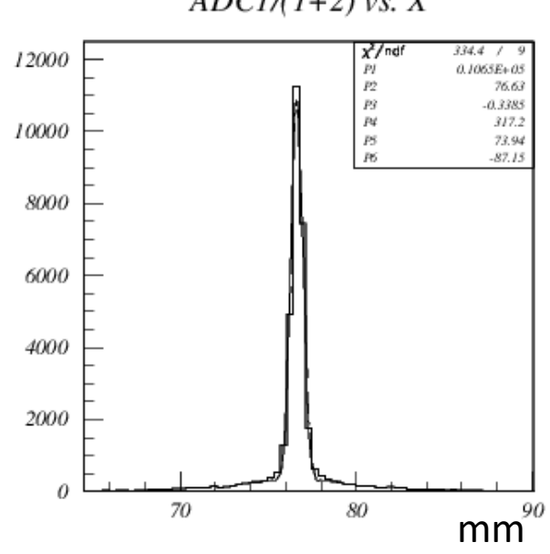
601.SLIX.25

ADC1/(1+2) vs. X



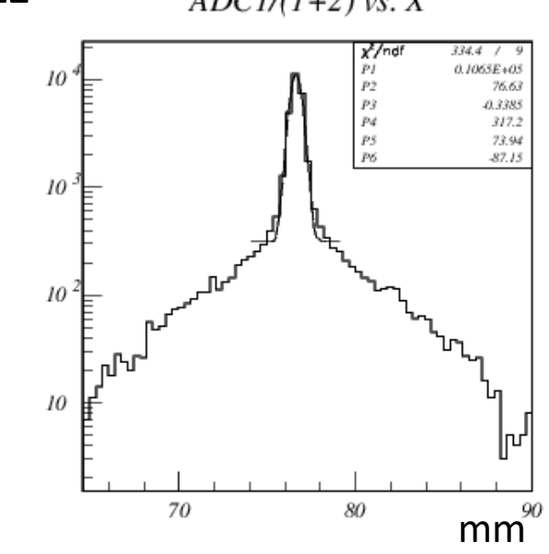
601.SLIX.25

ADC1/(1+2) vs. X



601.SLIX.26

ADC1/(1+2) vs. X



601.SLIX.26

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