

Update on 3x100 MCP-PMTs

ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

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NATURWISSENSCHAFTLICHE
FAKULTÄT

Last time

Properties of sensors:

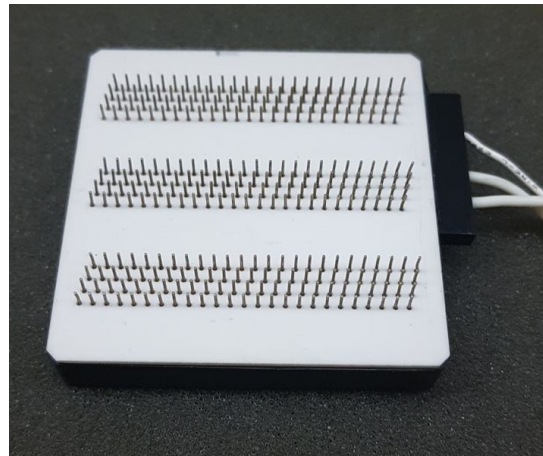
- 943P541
- 946P541
- O37P541

QE problem with ES440
(possibly with 943P541
and 946P541)

Strange feature of O37P541

Now

- Further measurements of sensors
- First measurements of new sensor 105P541



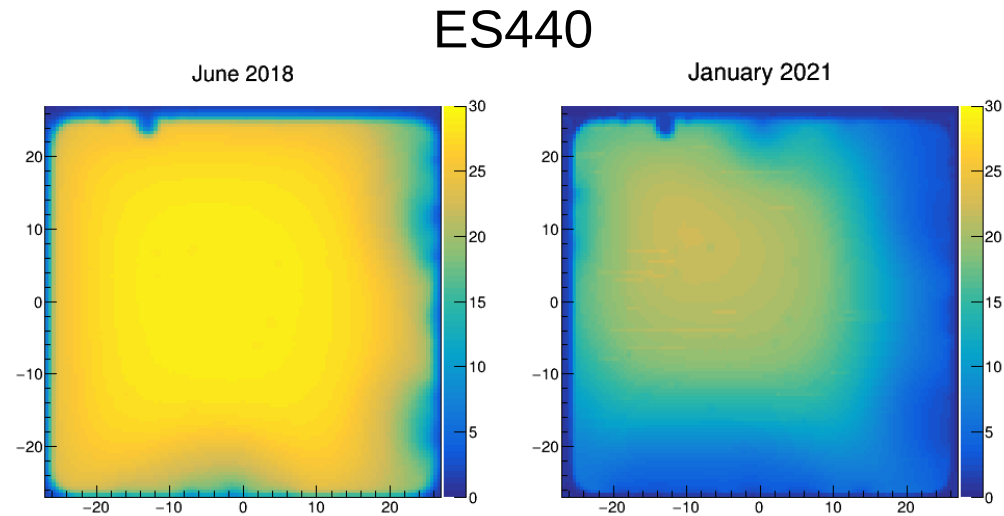
Backplane of 943P541

Photonis sensors
3x100 anode pixels
MCPs 10 μm pores

QE problem

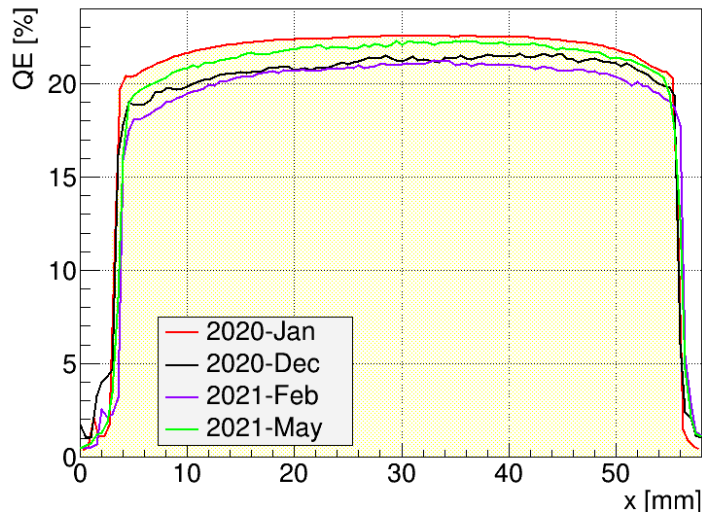
Reminder:

- Photonis ES440 shows uniform QE drop without illumination (still in Gießen)
- Same issue with 943P641 and 946P541?

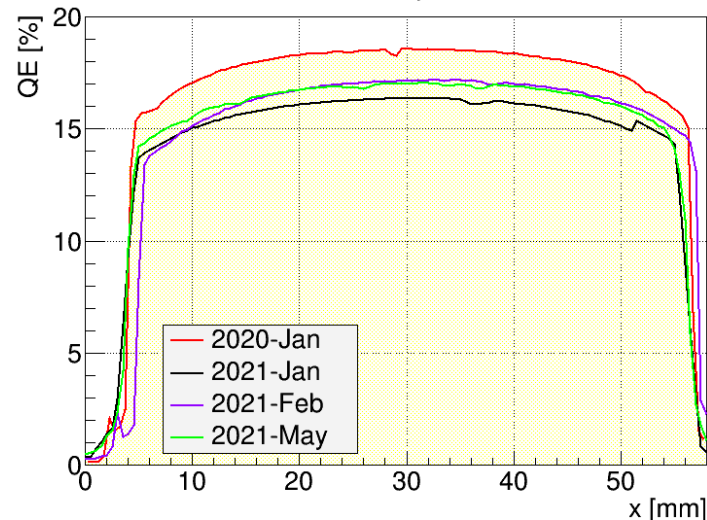


Newest scans of 943P541 and 946P541 → No problem with QE so far

943P541 at y = 0 mm



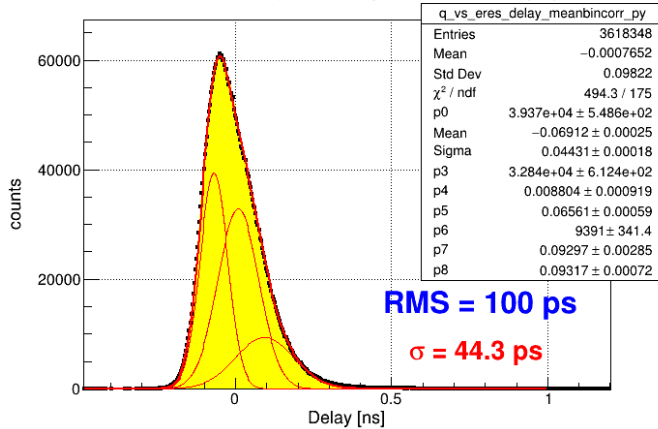
946P541 at y = 0 mm



Time resolution at 10^6 gain

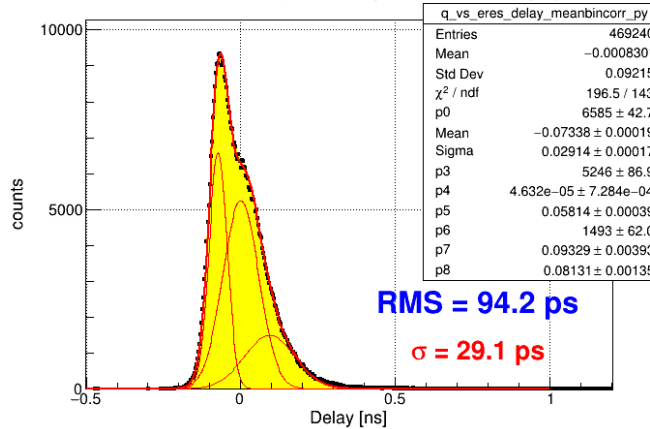
943P5410

Time Resolution ($Q > -0.14$ pC && $Q < -0.04$ pC)



946P541

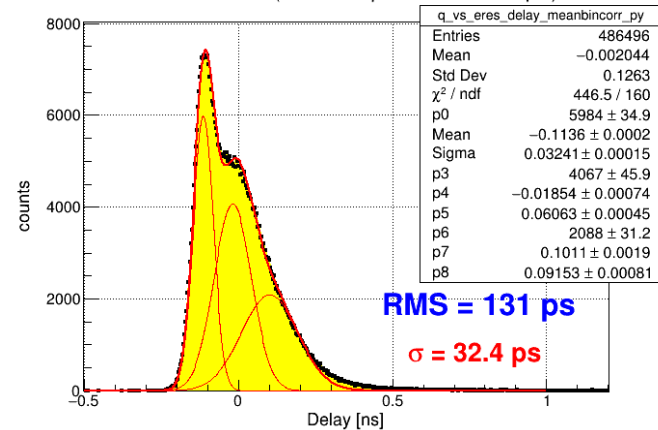
Time Resolution ($Q > -0.14$ pC && $Q < -0.04$ pC)



Tube	RMS in ps	σ in ps
943P541	100	44.3
946P541	94.2	29.1
O37P541	130	32.4
105P541	137	43

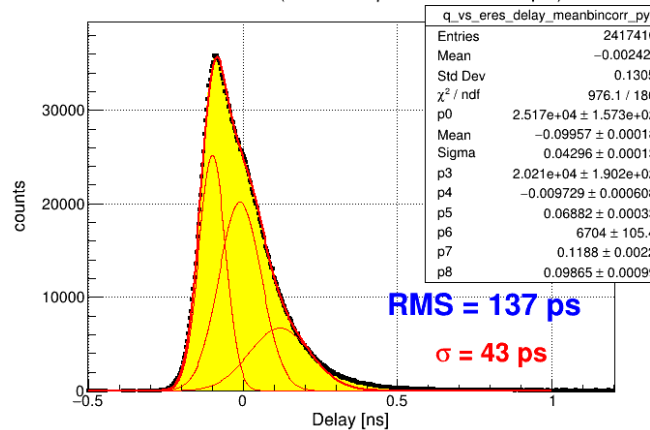
O37P541

Time Resolution ($Q > -0.30$ pC && $Q < -0.10$ pC)



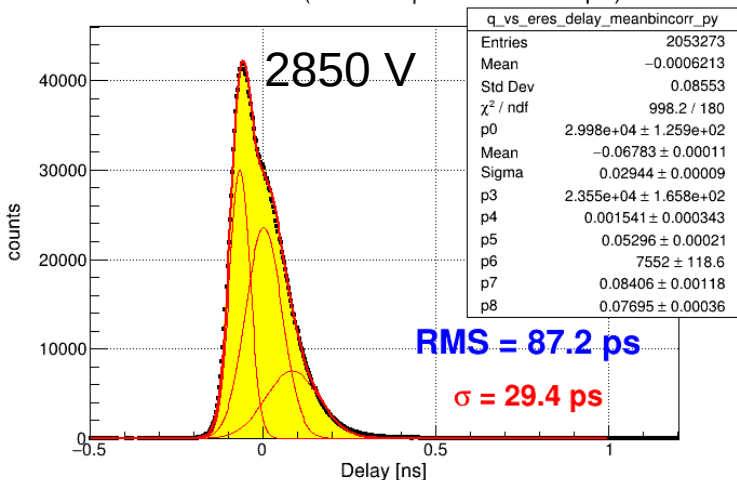
105P541

Time Resolution ($Q > -0.30$ pC && $Q < -0.10$ pC)



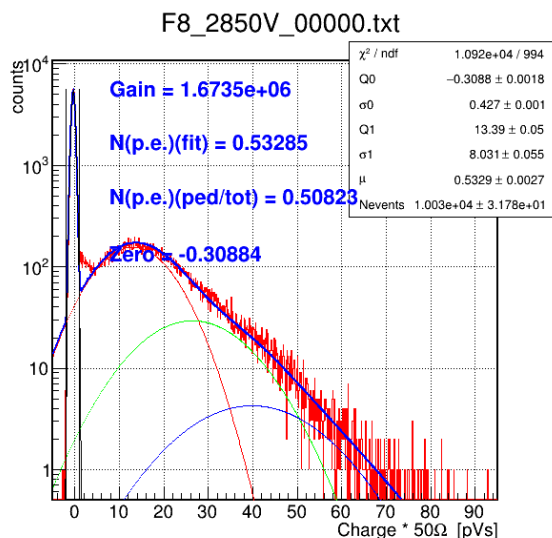
- Measured at one central pixel
- New boards
→ better resolution
- Time window for RMS:
-0.5 – 2.0 ns

Time resolution at different gains

 Time Resolution ($Q > -0.50$ pC & $Q < -0.10$ pC)


946P541

Voltage in V	Gain	RMS in ps	σ in ps
2550	$2.87 \cdot 10^5$	97.9	32.8
2600	$4.47 \cdot 10^5$	94.2	30.5
2650	$5.96 \cdot 10^5$	94.2	29.1
2850	$1.67 \cdot 10^6$	87.2	29.4
3000	$3.07 \cdot 10^6$	84.6	29.6

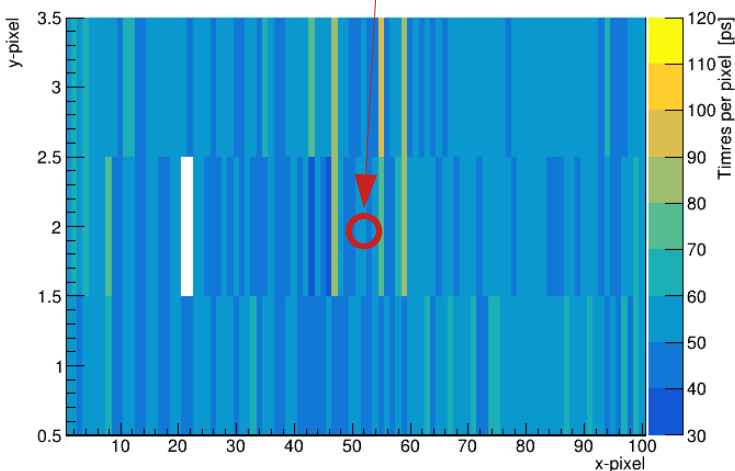


- Time window for RMS: -0.5 – 2.0 ns
- Time resolution slightly better at higher voltages
- Higher overall voltage → higher PC-MCP voltage

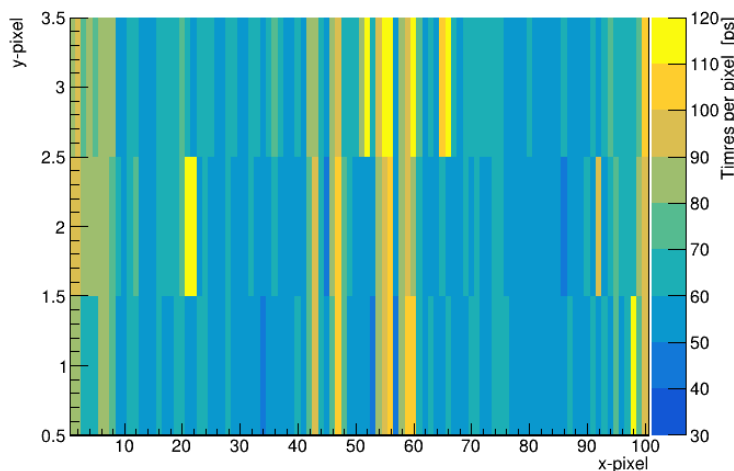
Scope measurement


TRB Scans TTS

943P541 Timeres pixel map



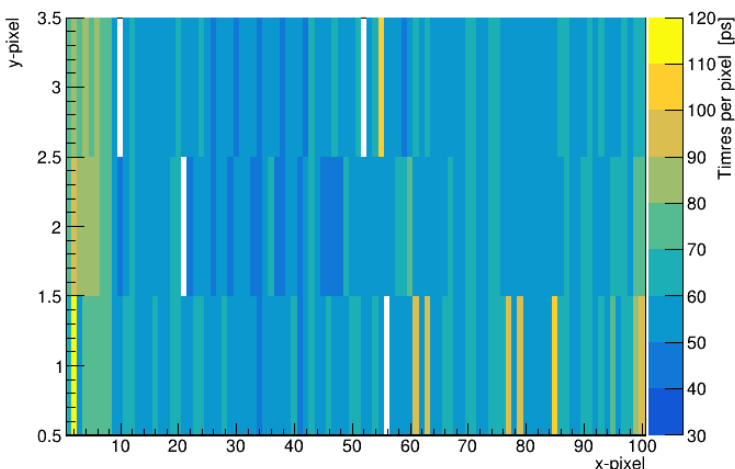
O37P541 Timeres pixel map



Scope:
best case:
Only one point illuminated 
→ better time resolution

TRB:
Average of whole pixel

946P541 Timeres pixel map



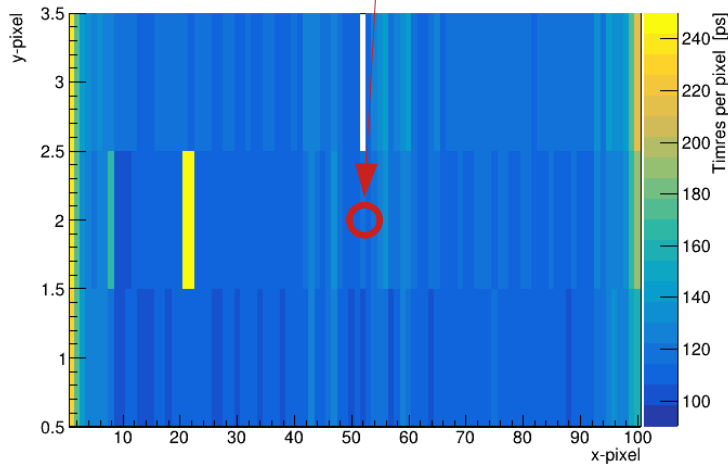
Tube	Average σ per pixel in ps	σ in ps at single point (Oscilloscope)
943P541	52	44.3
946P541	56	29.1
O37P541	62	32.4

Scope measurement

TRB Scans RMS

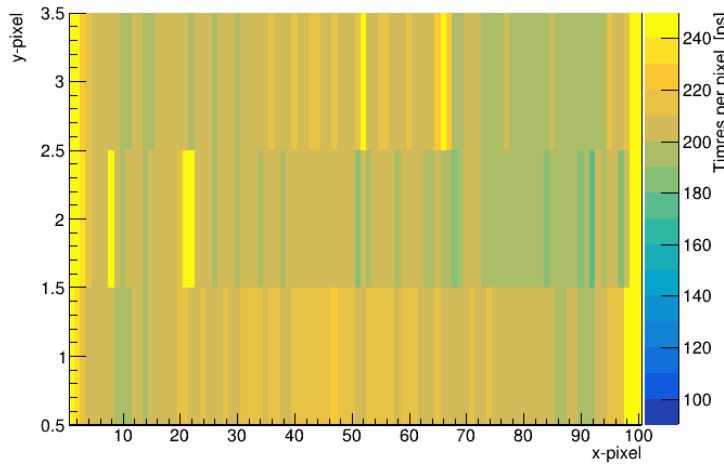
943P541

RMS pixel map pixel cut walk corrected



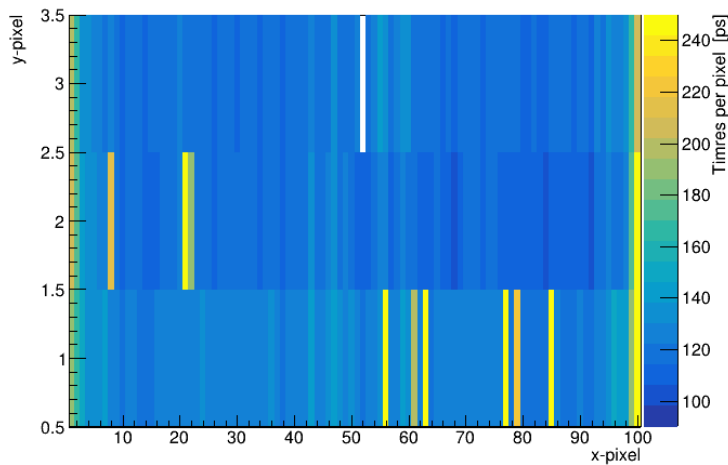
O37P541


RMS pixel map pixel cut walk corrected



946P541

RMS pixel map pixel cut walk corrected



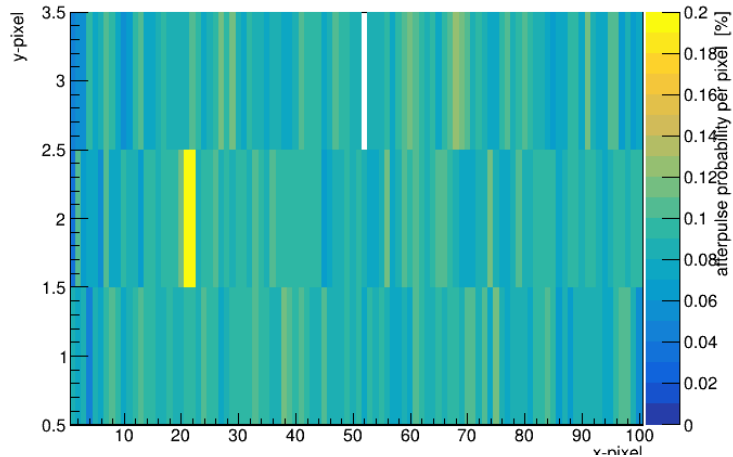
Scope:
best case:
Only one point illuminated 
→ better time resolution

TRB:
Average of whole pixel

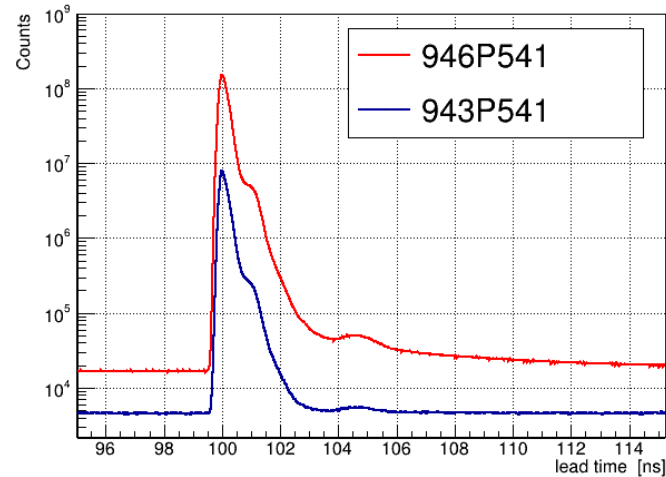
Tube	Average RMS per pixel in ps	RMS in ps at single point (Oscilloscope)
943P541	115	100
946P541	122	94.2
O37P541	207	130

TRB Scans Afterpulse

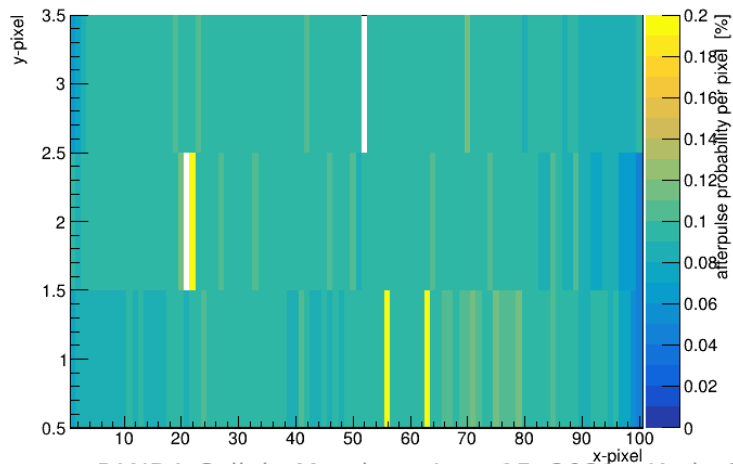
943P541 afterpulse probability pixel map



afterpulse shifted time whole sensor for (py 0, px 0) channel 0



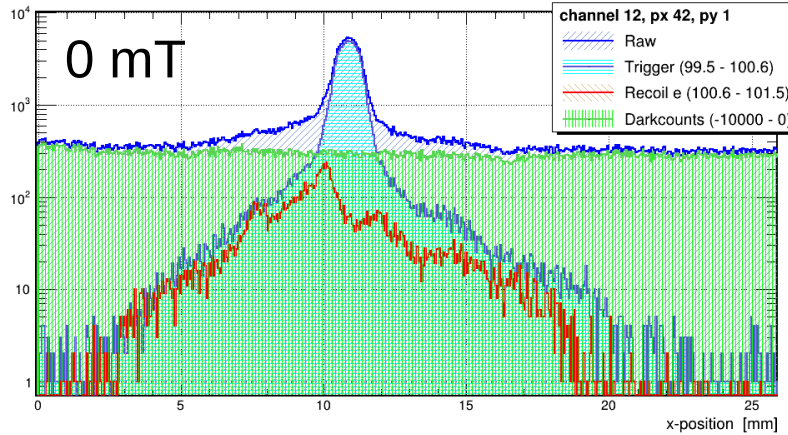
946P541 afterpulse probability pixel map



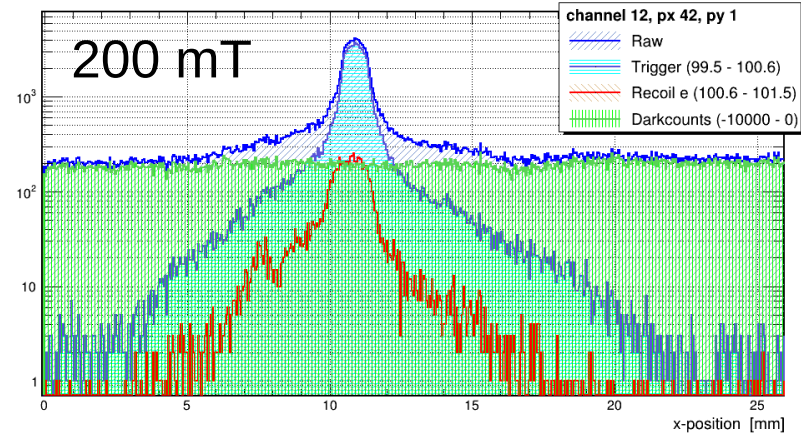
Tube	Average afterpulse probability per pixel
943P541	0.09%
946P541	0.09%

TRB Scans in B-field

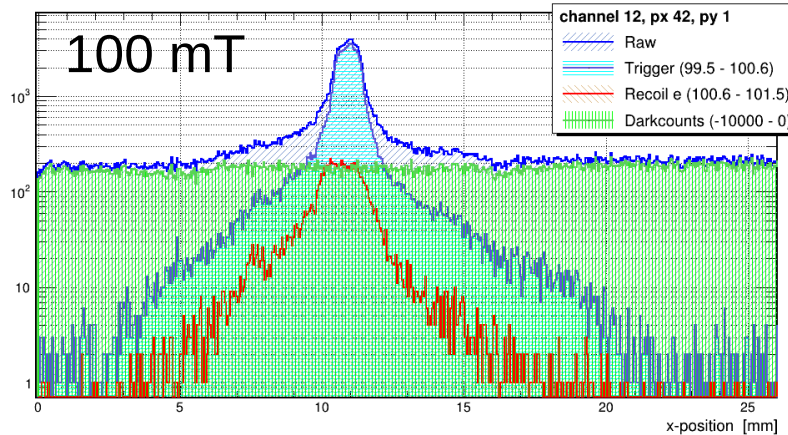
x-position vs y-position (all hits) for (py 1, px 42) channel 12



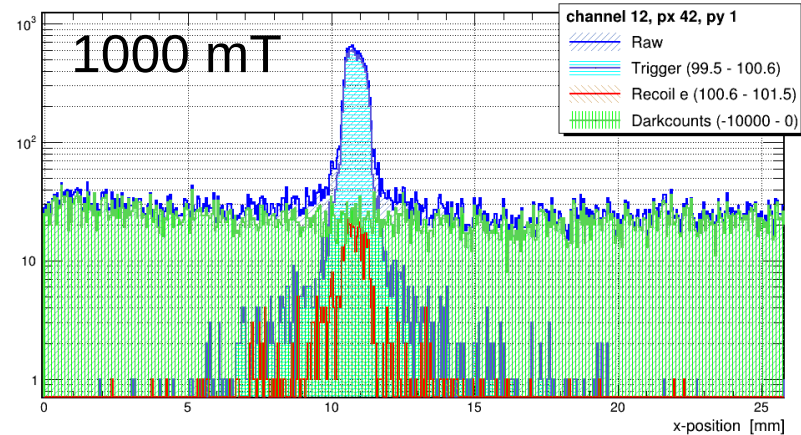
x-position vs y-position (all hits) for (py 1, px 42) channel 12



x-position vs y-position (all hits) for (py 1, px 42) channel 12



x-position vs y-position (all hits) for (py 1, px 42) channel 12

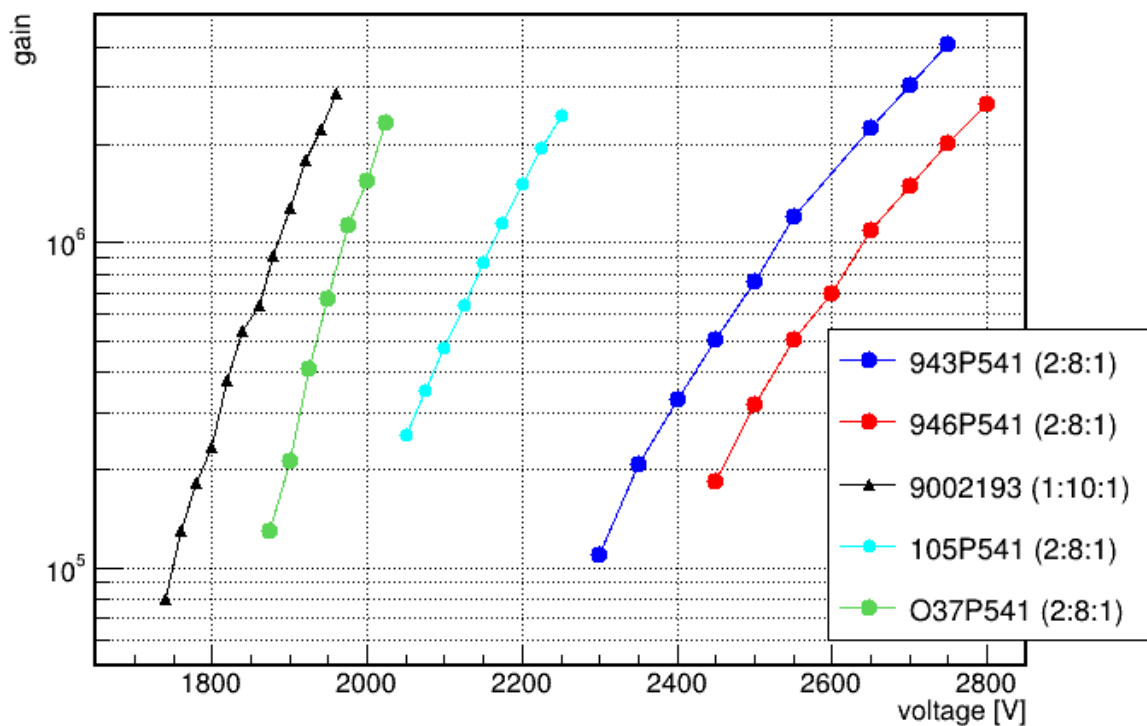


- Gain drops in magnetic field → less events
- Less recoil, more focused recoil in magnetic field

New Sensor Photonis 105P541

Gain curve

Gains

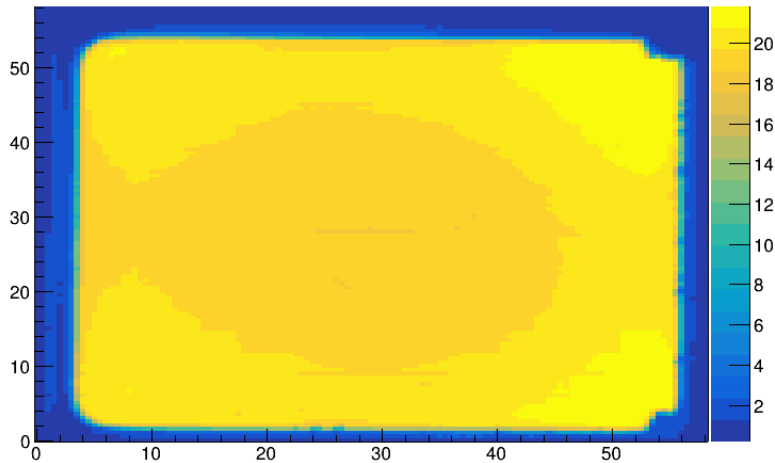


- Measured with scope at central region

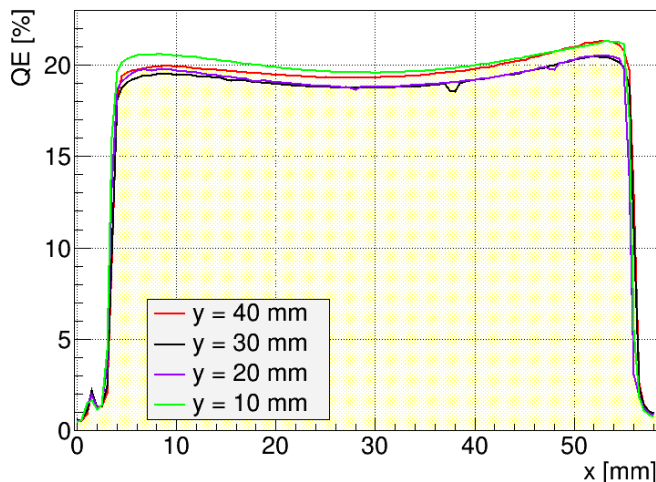
Tube	10 ⁶ gain at
943P541	2550 V
946P541	2650 V
O37P541	1975 V
105P541	2175 V

QE

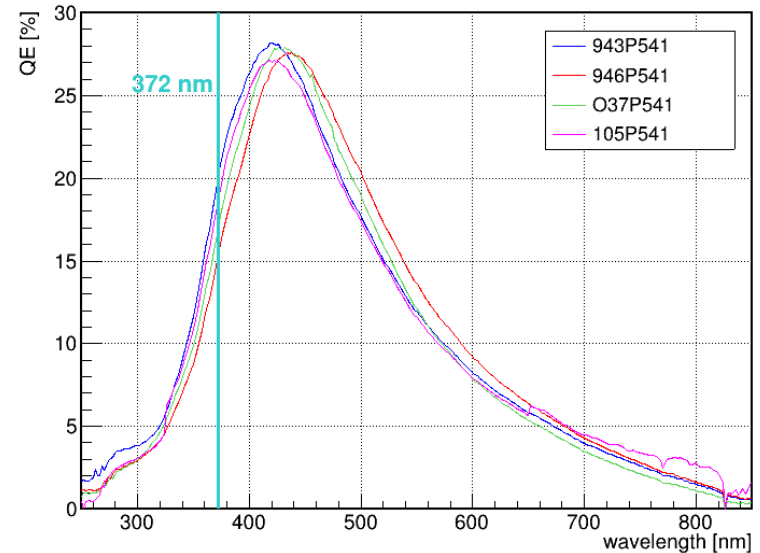
QE scan



105P541



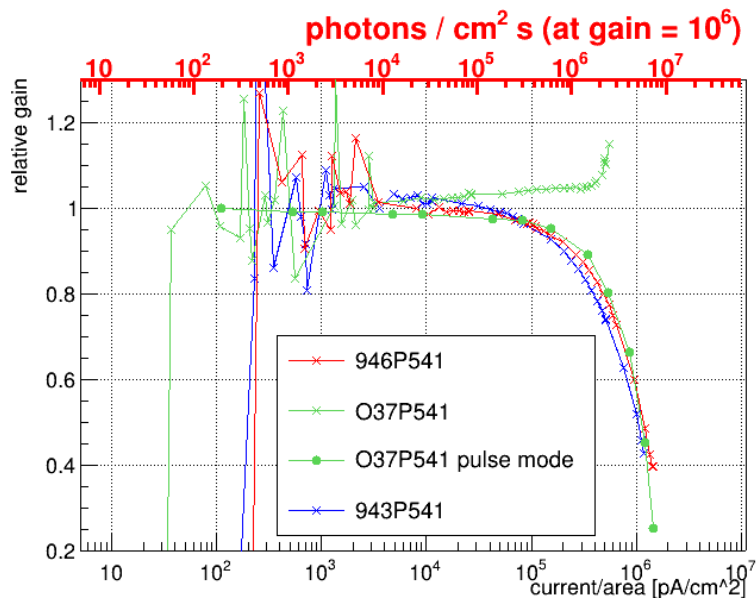
spectral QE



Tube	Peak QE	At λ	Max QE (@372 nm)
943P541	28.2 %	420 nm	21%
946P541	27.6 %	438 nm	17%
O37P541	27.9 %	426 nm	18.5%
105P541	27.1 %	422 nm	21.8%

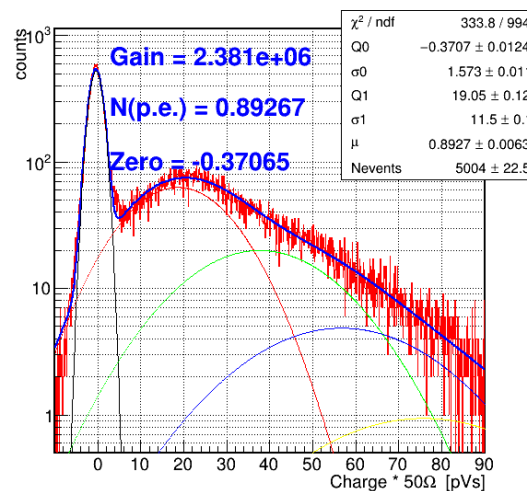
Strange feature of O37P541 and 105P541

Relative GAIN (averaged & corrected)

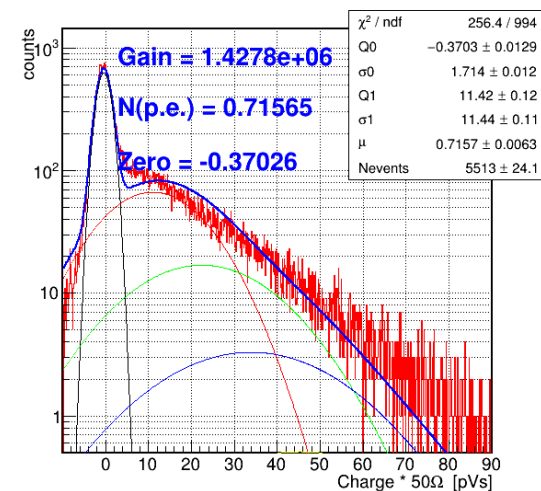


O37P541

2025 V



2050 V



Reminder:
O37P541

- High voltage or illumination → high anode currents ($\sim 200 \mu\text{A}$)
- Relative gain seems to increase in current mode
- Actually gain loss (spectra)

105P541 shows same issue already at $\sim 2175 \text{ V} - 2200 \text{ V}$ (max. voltage: $\sim 2350 \text{ V}$)

Summary

- No QE problem with 943P541 and 946P541
- Good time resolution measurements → small dependence on gain
- TRB scans:
TTS and RMS higher than on single point
- New Sensor 105P541
 - Good QE
 - Problem with anode currents (like O37P541)

Tube	10 ⁶ gain at	Peak QE	Max QE (@372 nm)	RMS in ps	σ in ps	RMS in ps (TRB)	σ in ps (TRB)
943P541	2550 V	28.2% (@420 nm)	21%	100	44.3	115	52
946P541	2650 V	27.6% (@438 nm)	17%	94.2	29.1	122	56
O37P541	1975 V	27.9% (@426 nm)	18.5%	130	32.4	207	62
105P541	2175 V	27.1 % (@422 nm)	21.8%	137	43		