

Results with Gießen Sensors and update on lifetime measurements

ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

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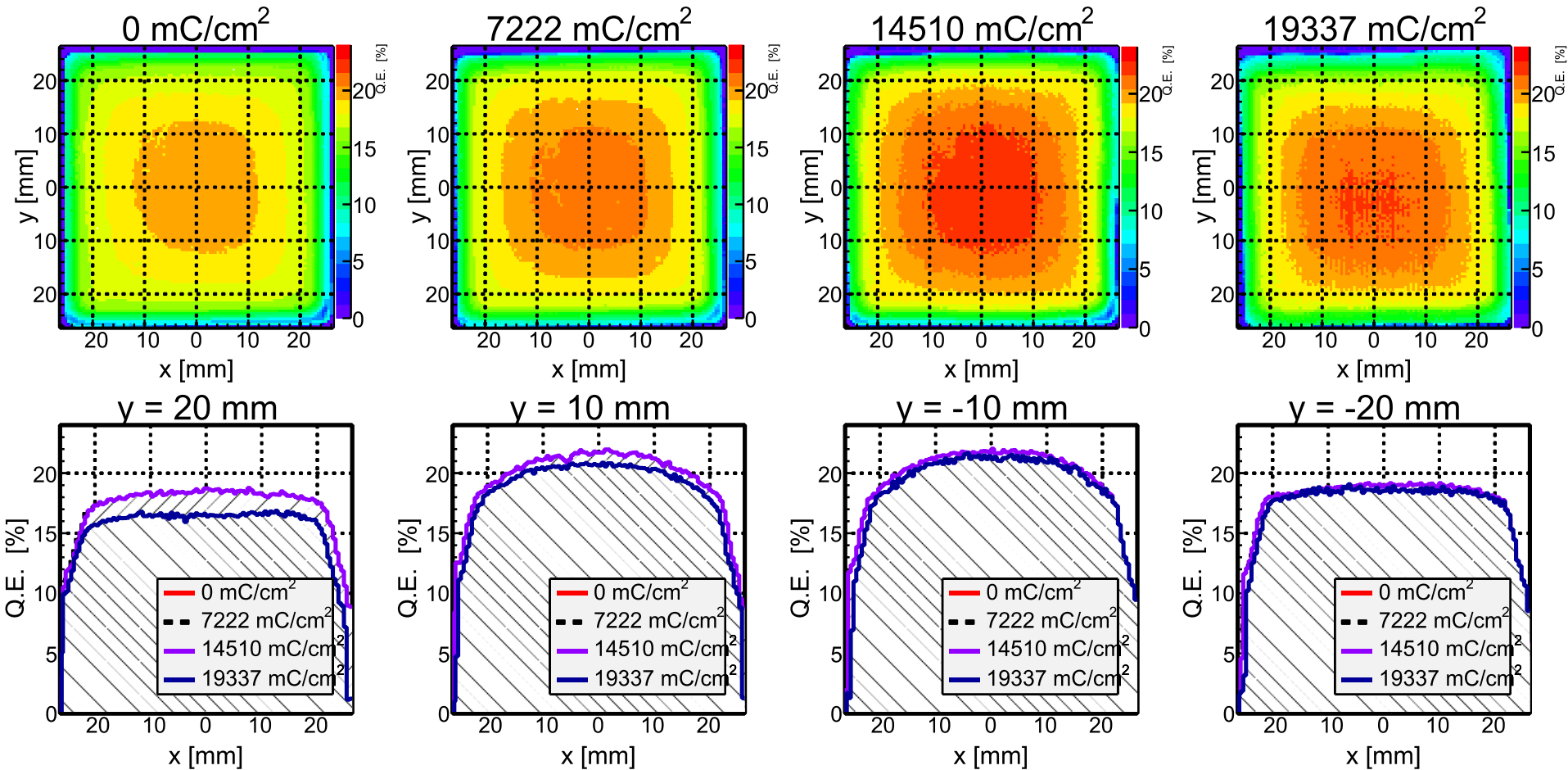
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Data from May 14, 2018

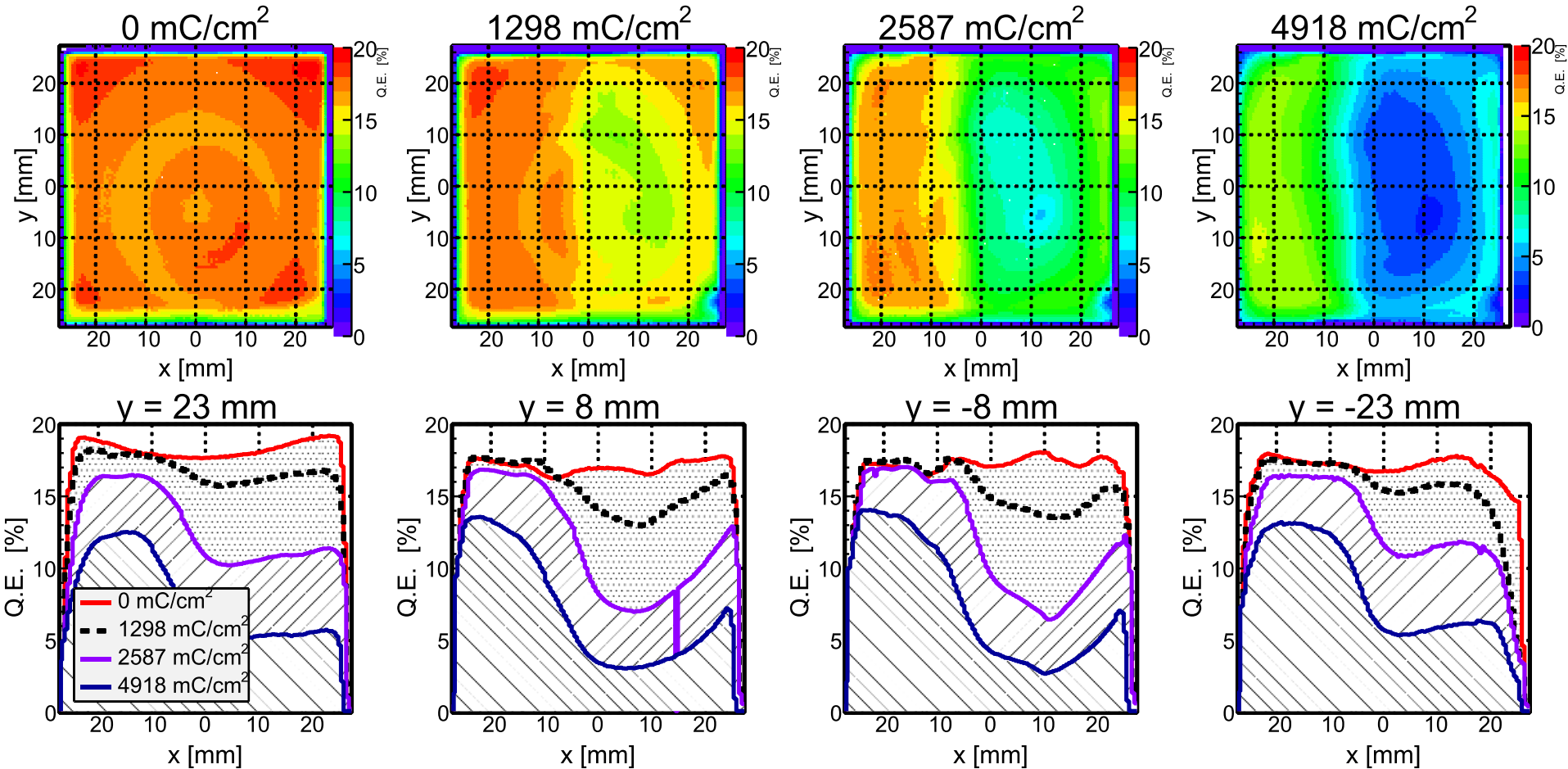
Illumination Overview QE (all sensors with ALD)

	Manufacturer	Film between MCP		Two ALD layers		Film in front of first MCP	
		Sensor ID	IAC [mC/cm ²]	QE start [%]	QE latest [%]	QE latest/QE start [%]	
2 Inch	Photinis XP85112	9001332	15909	23.0	8.2	36	
		9001393	19336	19.1	20.0	105	
1 Inch	Hamamatsu R10754X	KT0001 (M16M)	20090	21.7	5.2	24	
		KT0002 (M16M)	18978	21.1	6.1	29	
		JS0022 (64 pix.)	4918	17.4	4.5	26	
2 Inch	Hamamatsu R13266-07-M768 / M64	JS0035 (64 pix.)	6918	25.5	25.2	99	
		JS0018 (768 pix.)	1235	18.0	3.1	17	
		JS0027 (768 pix.)	2617	24.3	22.7	93	
		YH0250 (64 pix.)	491	25.4	24.6	97	

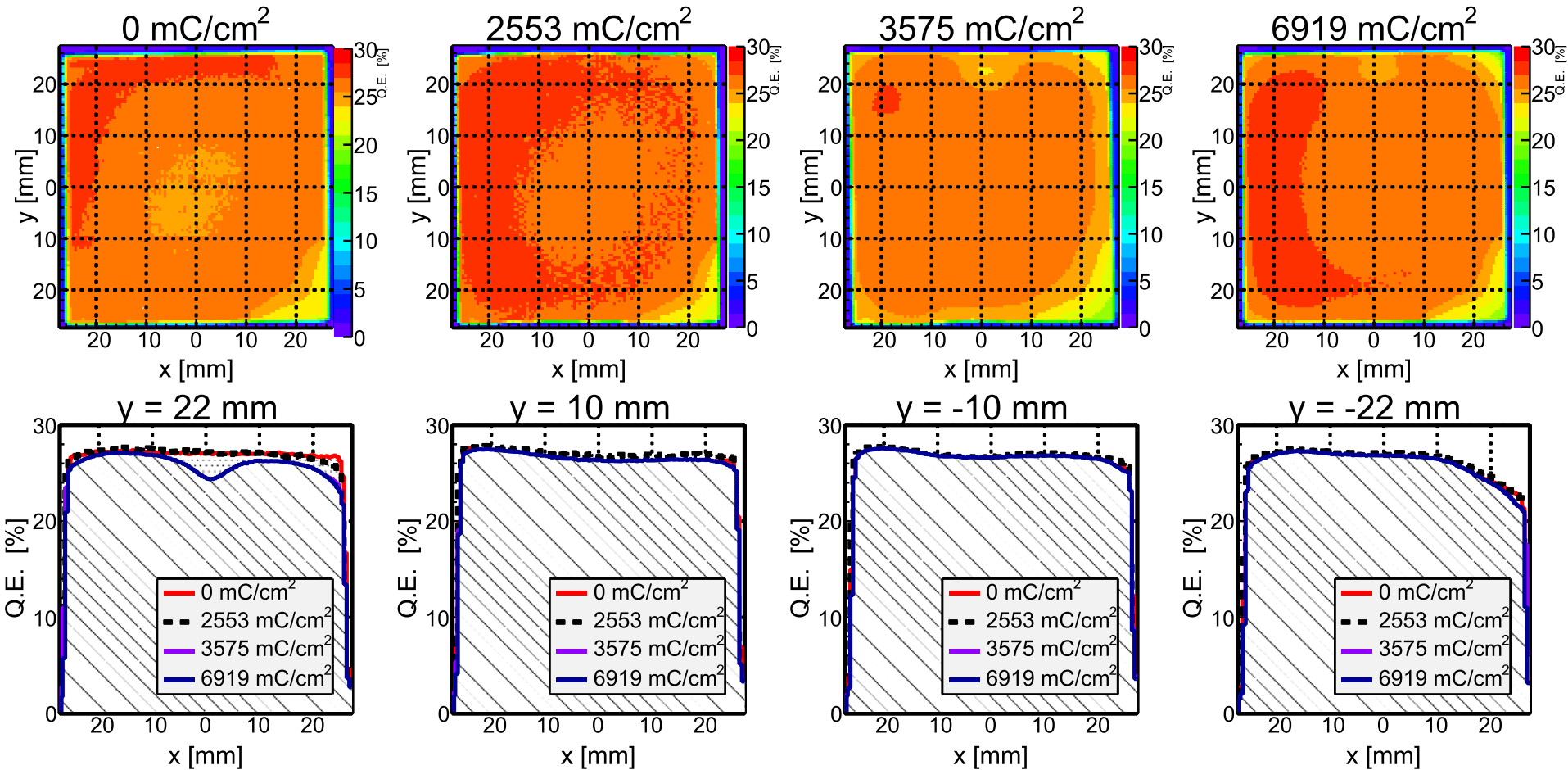
QE scan of Photonis 9001393-URD (double ALD)



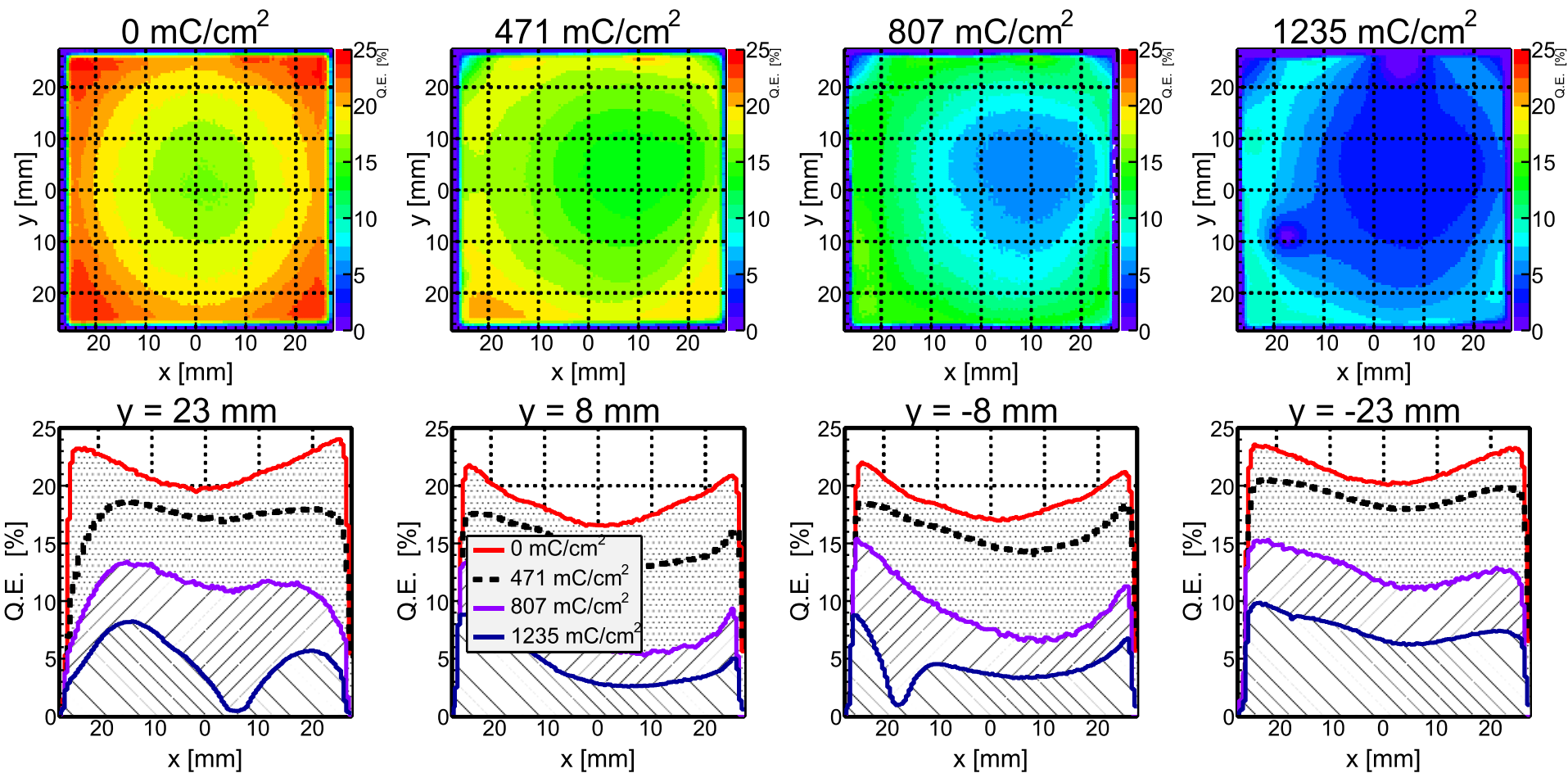
QE scan of Hamamatsu JS0022 (8x8, ALD)



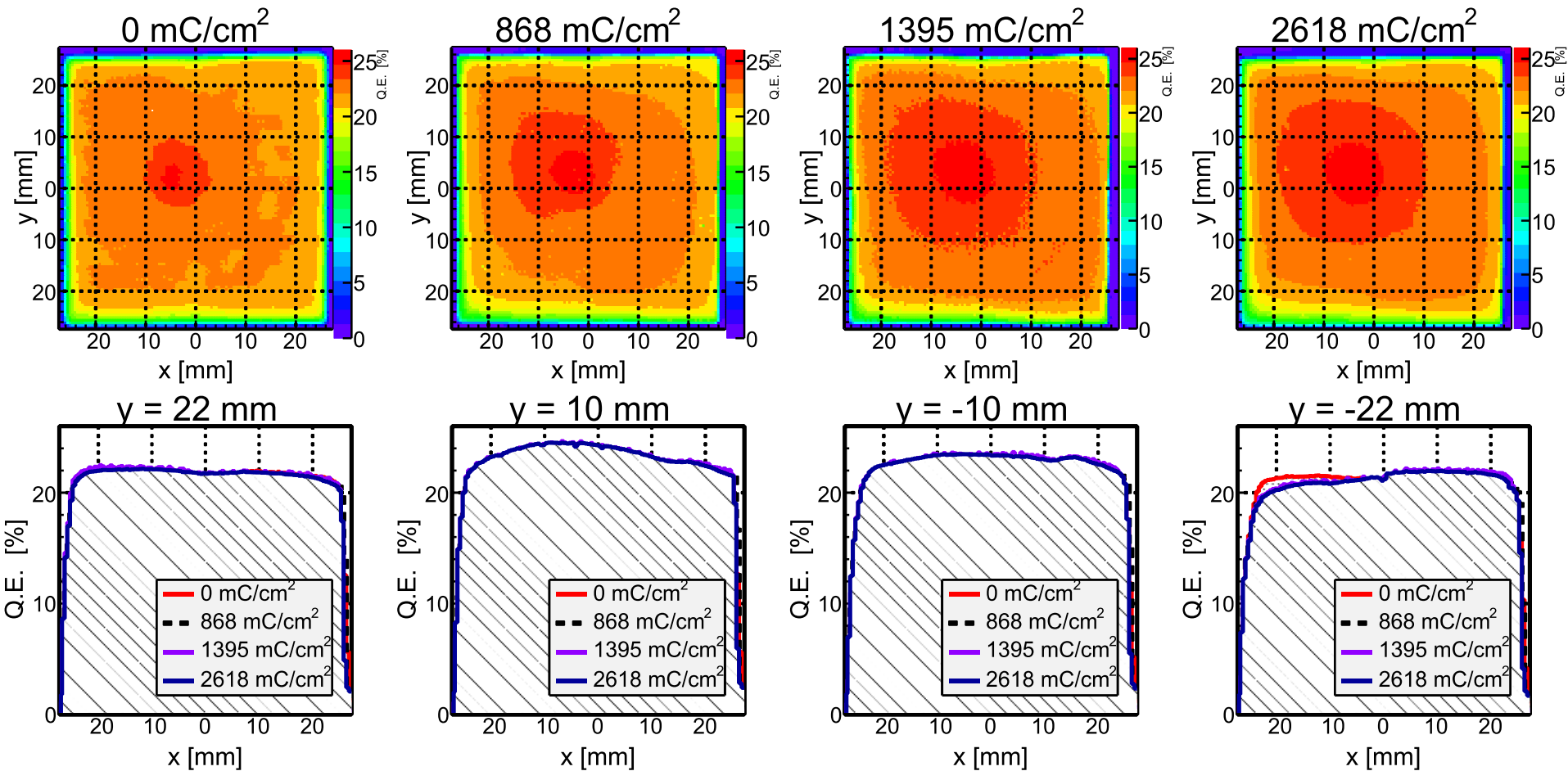
QE scan of Hamamatsu JS0035 (8x8, ALD)



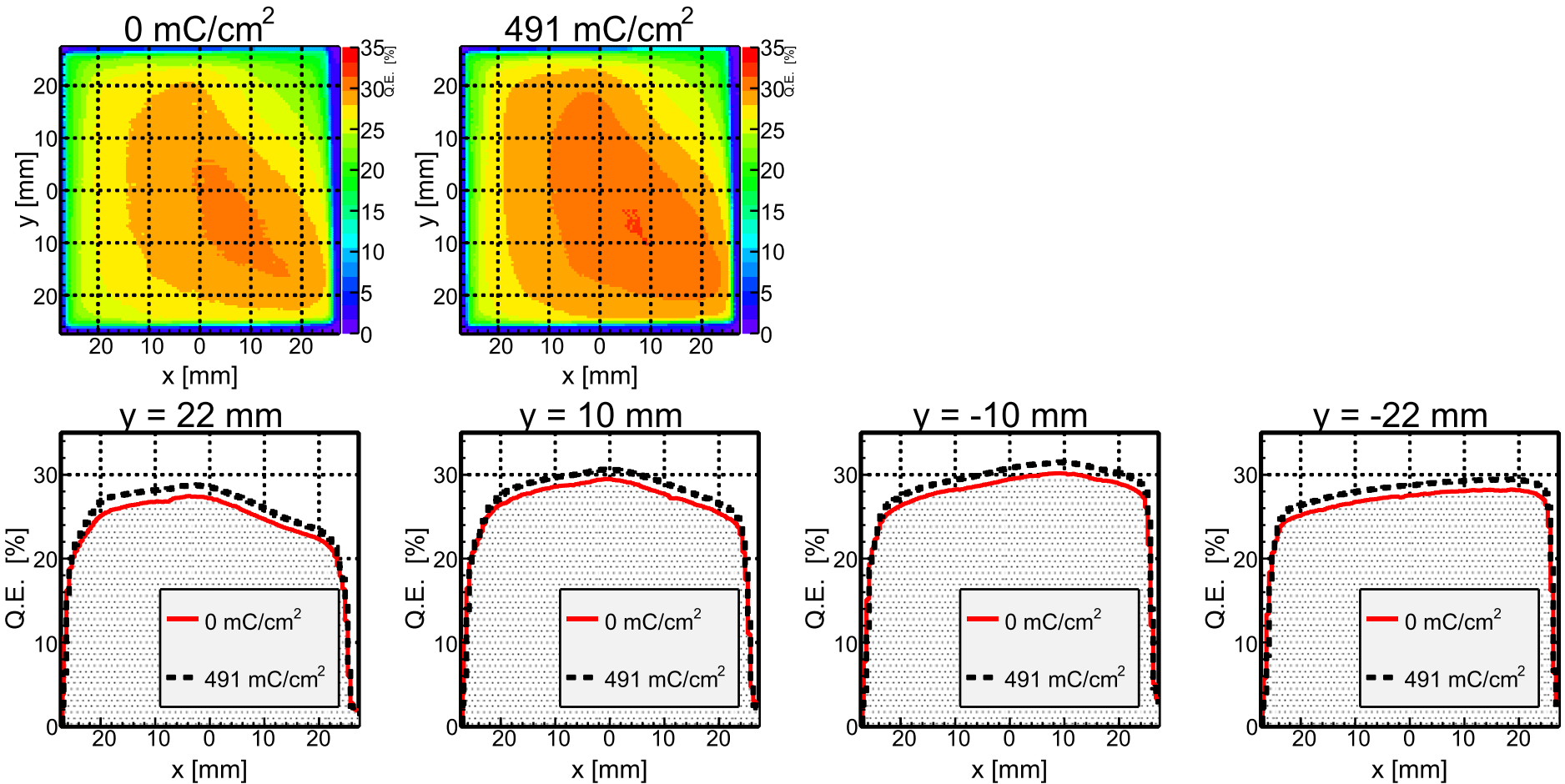
QE scan of Hamamatsu JS0018 (6x128, ALD)



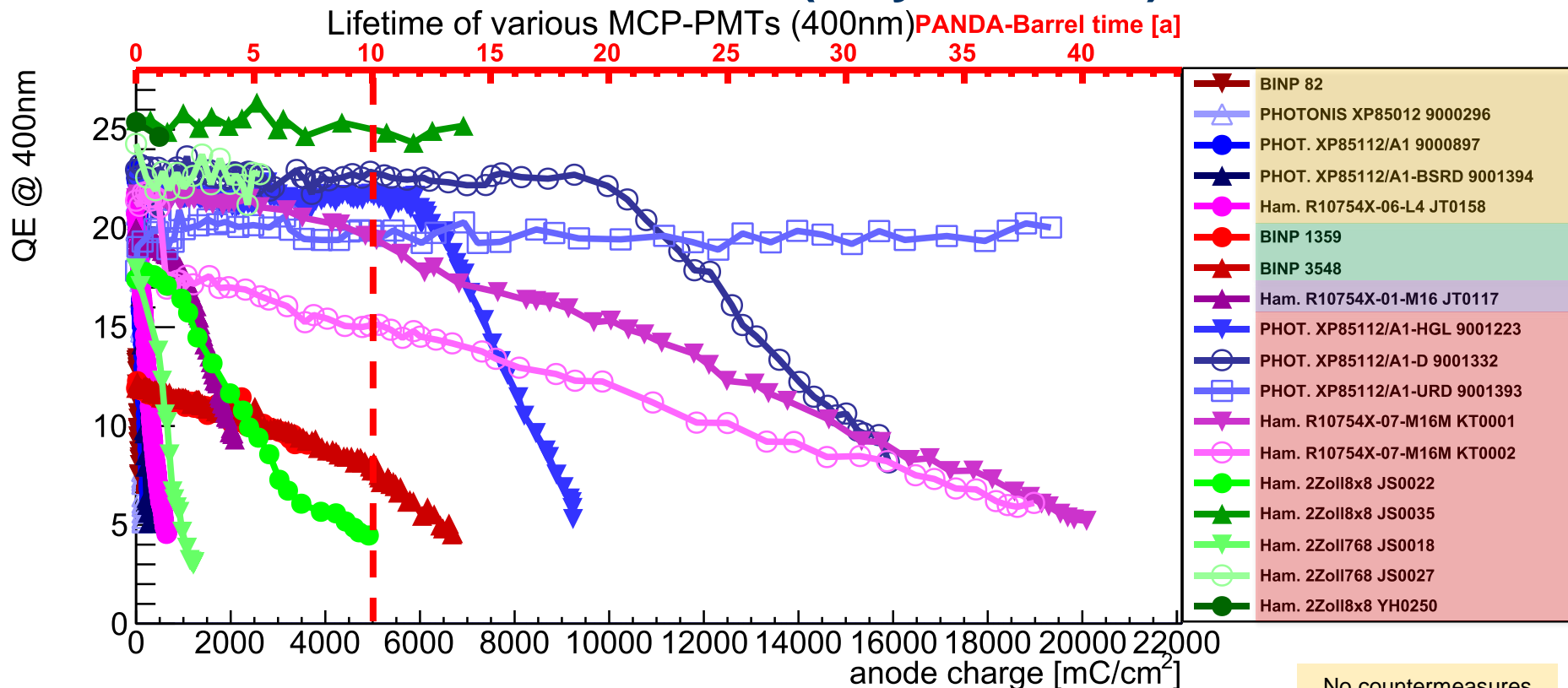
QE scan of Hamamatsu JS0027 (6x128, ALD)



QE scan of Hamamatsu YH0250 (8x8, ALD)



Lifetime data of all sensors (May 14, 2018)



- Most sensors with ALD coated MCPs have lifetime > 5 C/cm²
- All non ALD devices have a lifetime of < 200mC/cm²

No countermeasures
New cathode material
Film
ALD

Summary and outlook

- Double ALD Photonis tube (1393) at **19C/cm² without damage**
- Hamamatsu YH0250 included in lifetime setup
- Test in magnetic field in Jülich in preparation
- Test of Photonis sensors with 3x100 pixels and 8x8 pixel with direct pin readout (without Photonis backplane) planned

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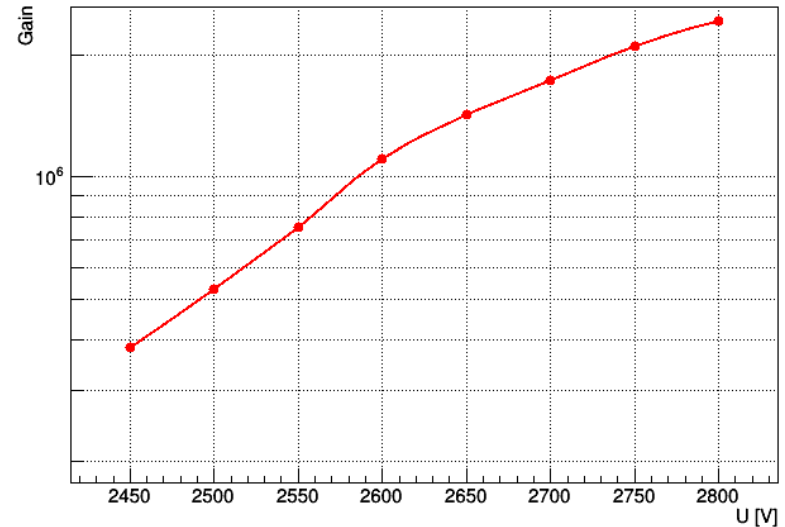
High pixelated sensors from Gießen

- Measured values:
 - Gain vs voltage
 - QE vs wavelength
 - QE surface scan
 - Current gain scan
 - Time resolution
 - Rate Stability
- Problems with two sensors:
 - Hamamatsu JS0026 low gain at max. voltage
 - Photonis 9002041 high current at cathode without applied high voltage!
- Orientation of scans:
 - Hamamatsu top right corner is cathode (looking on sensor front)
 - Photonis top is HV cable location

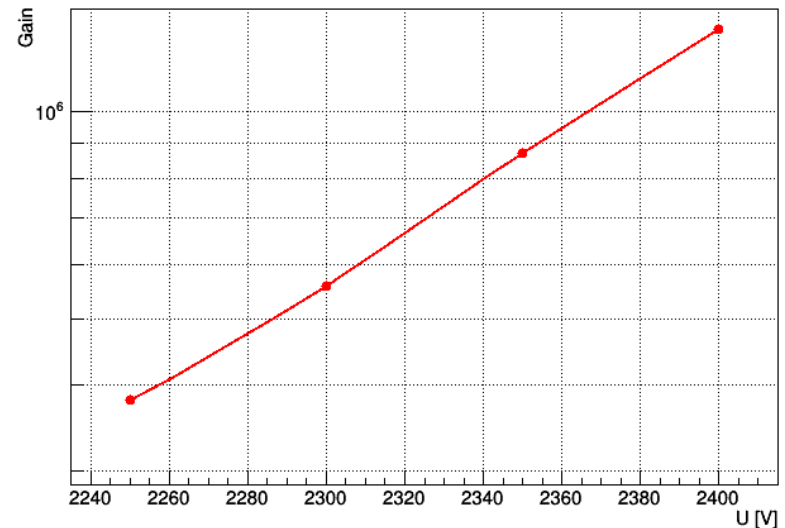
Gain vs voltage

- Measured with scope
- Signal not amplified
- Gain calculated with double gauss fit in histogram data (pedestal and signal)
- $\sim 10^6$ at:
 - 9002017: 2600V
 - YH0245: 2380V
- 9002041 high noise on signals
- JS0026 gain too low

Photonis 9002017

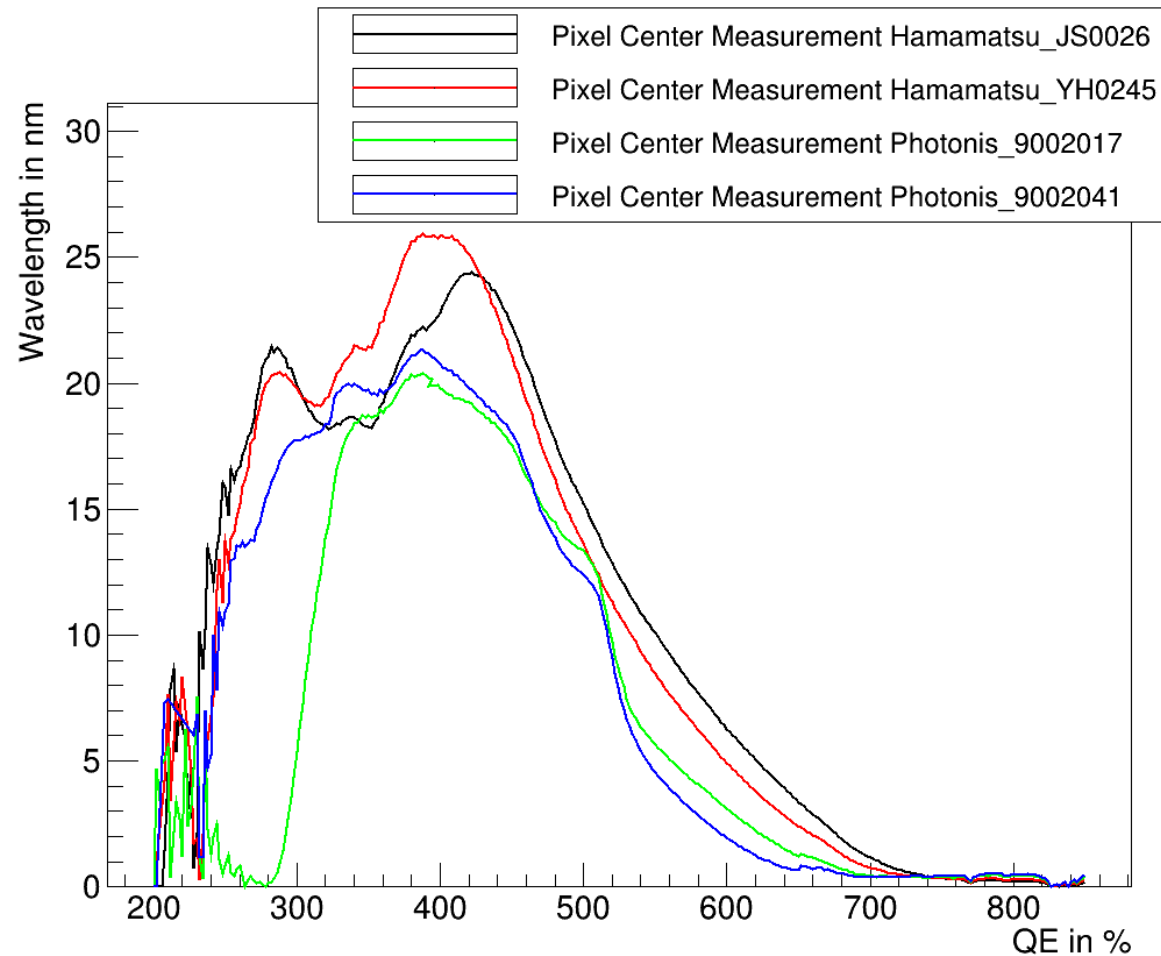


Hamamatsu YH0245



QE vs wavelength

- -200 V at cathode
- Current measured at MCP IN
- Calculated with photo diode current (known QE for each wavelength)

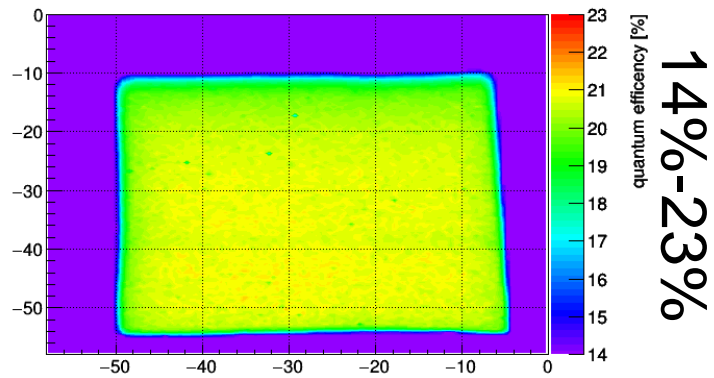


QE surface scan

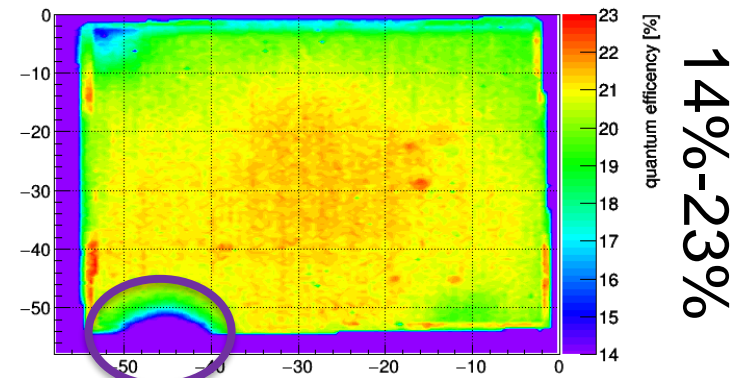
- -200 V at cathode
- Current measured at MCP IN
- Calculated with photo diode current (known QE for wavelength)
- Scanned with 372 nm (blue) and 632 nm (red) PiLas laser
- 0.5 mm steps across surface

QE surface scans with blue laser (372 nm)

Quantum Efficiency - Photonis 9002017

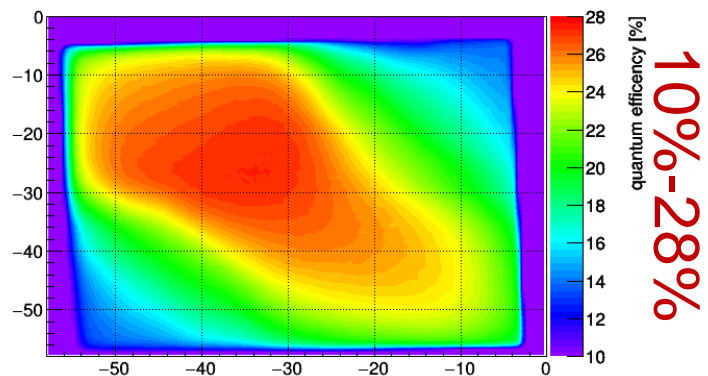


Quantum Efficiency - Photonis 9002041

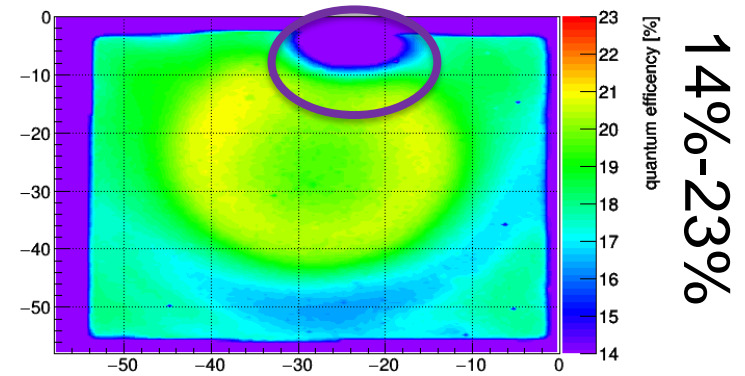


Damage

Quantum Efficiency - Hamamatsu YH0245

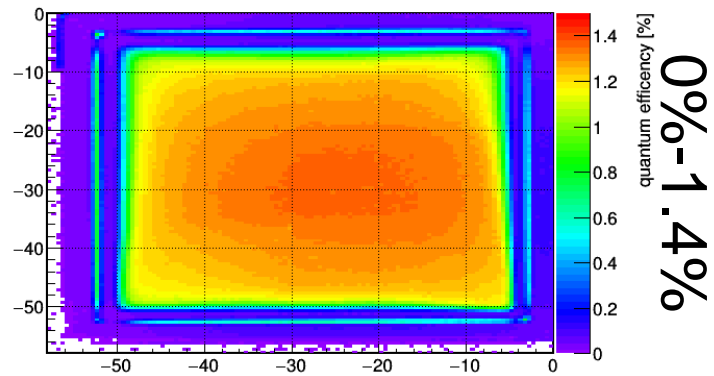


Quantum Efficiency - Hamamatsu JS0026

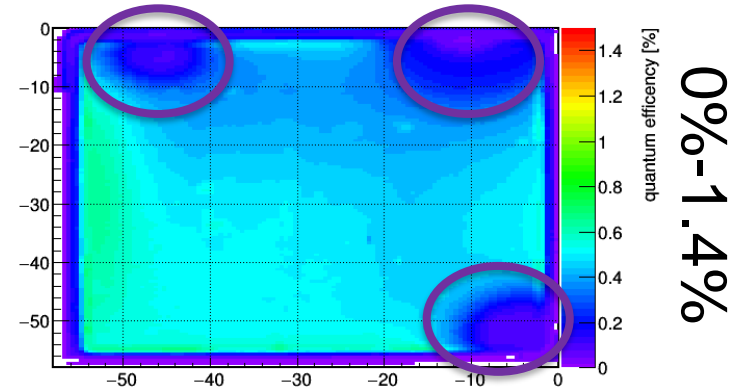


QE surface scans with red laser (632 nm)

Quantum Efficiency - Photonis 9002017

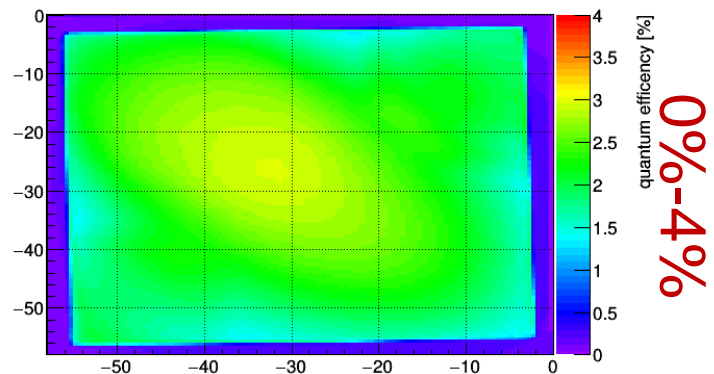


Quantum Efficiency - Photonis 9002041

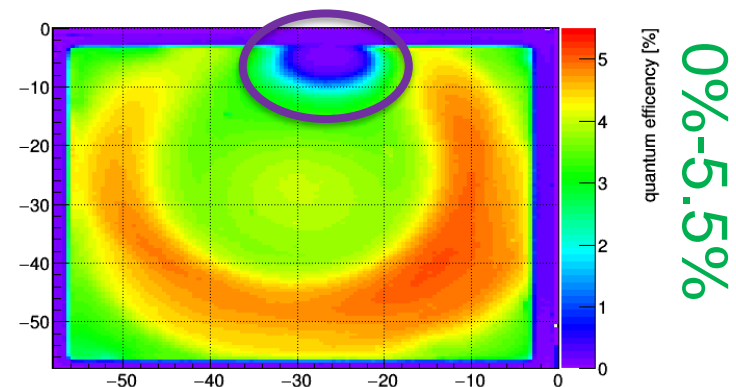


Damage

Quantum Efficiency - Hamamatsu YH0245



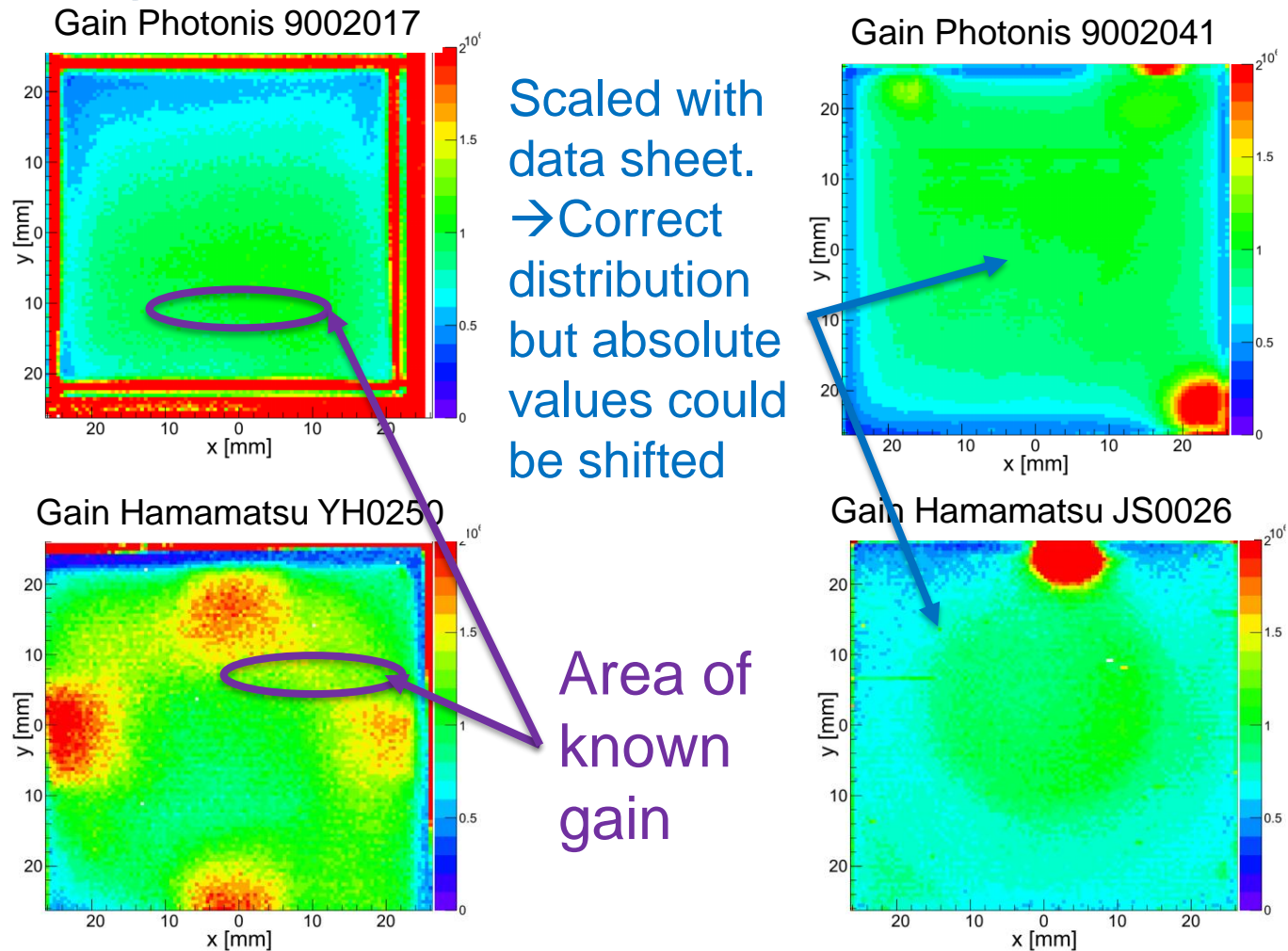
Quantum Efficiency - Hamamatsu JS0026



Current gain scan

- Scanning at approximately 10^6 gain
- Measuring shortened anode current
- Scan is folded with QE of the sensor
 - Has to be divided by QE
- Gain then scaled to known value of one pixel or block

Current gain scans with blue laser (372 nm)



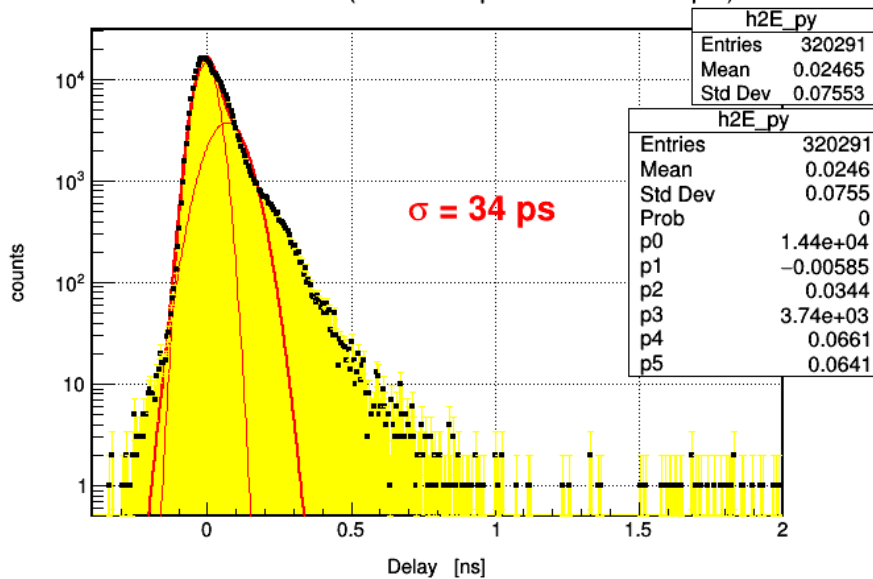
Time resolution

- Measured with scope at 10^6 gain
- Blue laser at 15 kHz and 45 % tune
- Red laser at 15 kHz and 26% tune
- 200x amplified signal then impedance matched splitting and low discriminator threshold (just above noise band)
 - 9002041: 65 mV
 - YH0245: 65 mV
- **Time walk corrected spectra**

Time resolution

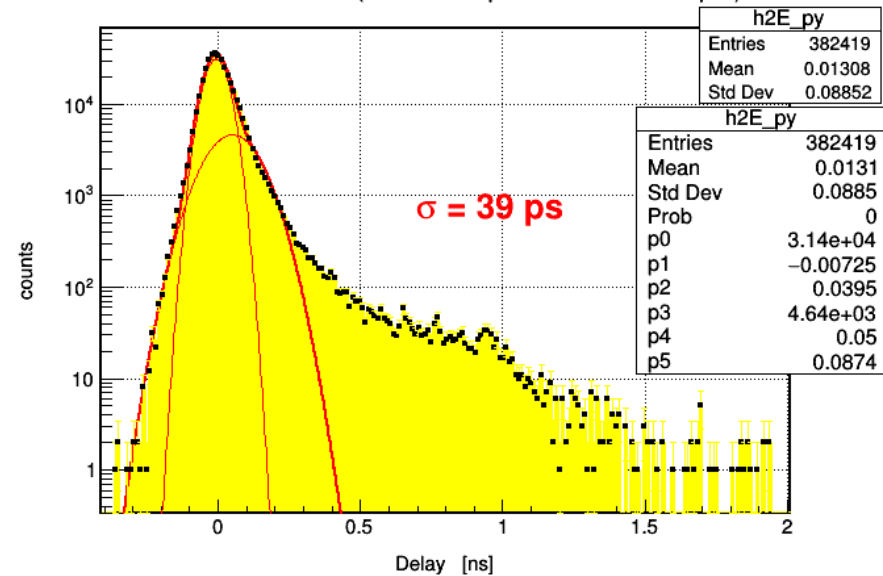
Photonis 9002017

Time Resolution ($Q > -0.26$ pC && $Q < -0.10$ pC)



Hamamatsu YH0245

Time Resolution ($Q > -0.14$ pC && $Q < -0.03$ pC)



- Taken on 1 pixel
 - 9002017: σ 34 ps (RMS 76 ps)
 - YH0245: σ 39 ps (RMS 89 ps)
- No measurement possible for other sensors

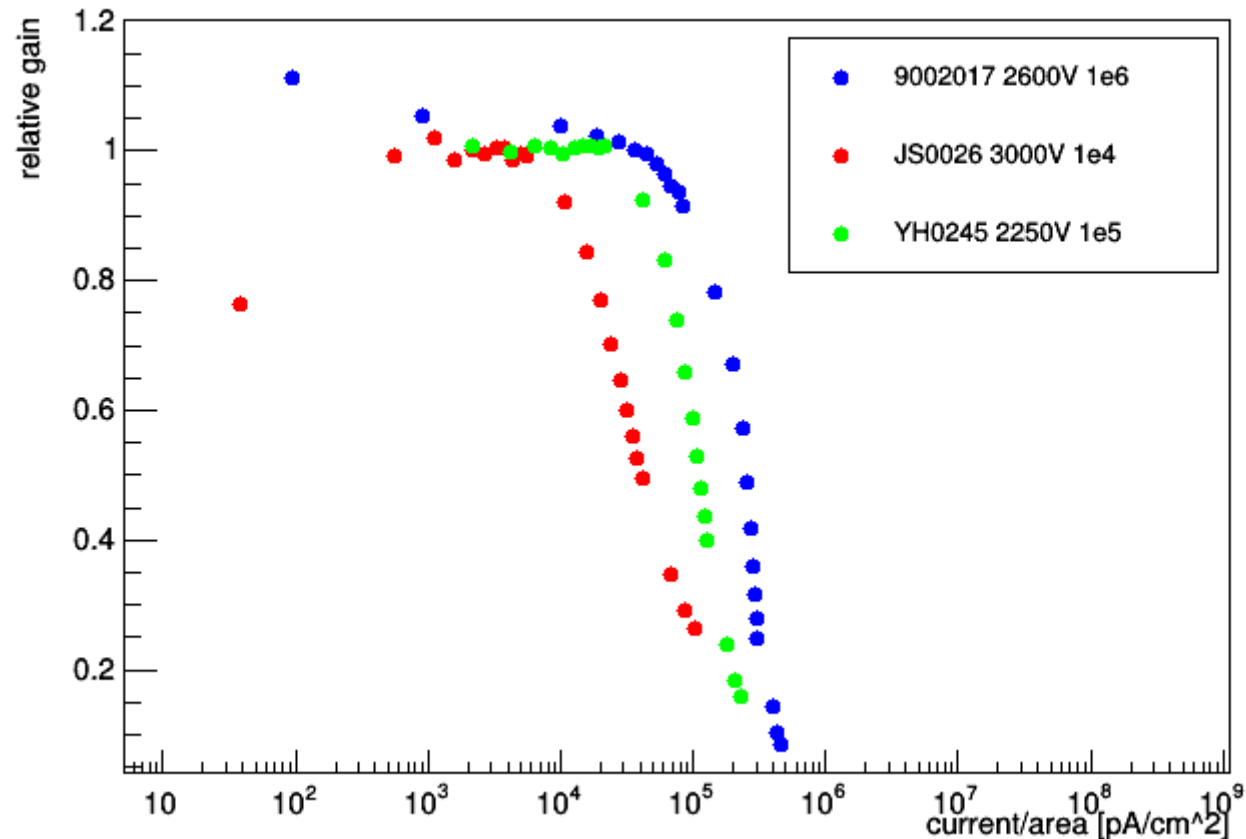
Rate Stability

- Full illuminated sensor at about 10^6 , 10^5 , 10^4 gain
- Measuring shortened anode current and current on reference diode
- Optional: Measure current at Photo cathode
- Photodiode shows linear behavior with increasing light intensity
- Anode current linear at the beginning then it saturates
- Dividing anode current by diode current which is only proportional to gain
- Normalizing this value
- With known gain and illuminated area calculation of Photons/ cm^2s possible

Rate Stability

- Each sensor measured at 10^6 , 10^5 , 10^4
- Example curves picked for each sensor
- Gain down to 80% at Photons/cm²s :
 - 9002017: 10^5
 - JS0026: $3 * 10^5$
 - YH0245: 10^6

rate stability of different tubes for different gains



Thank you for your attention!

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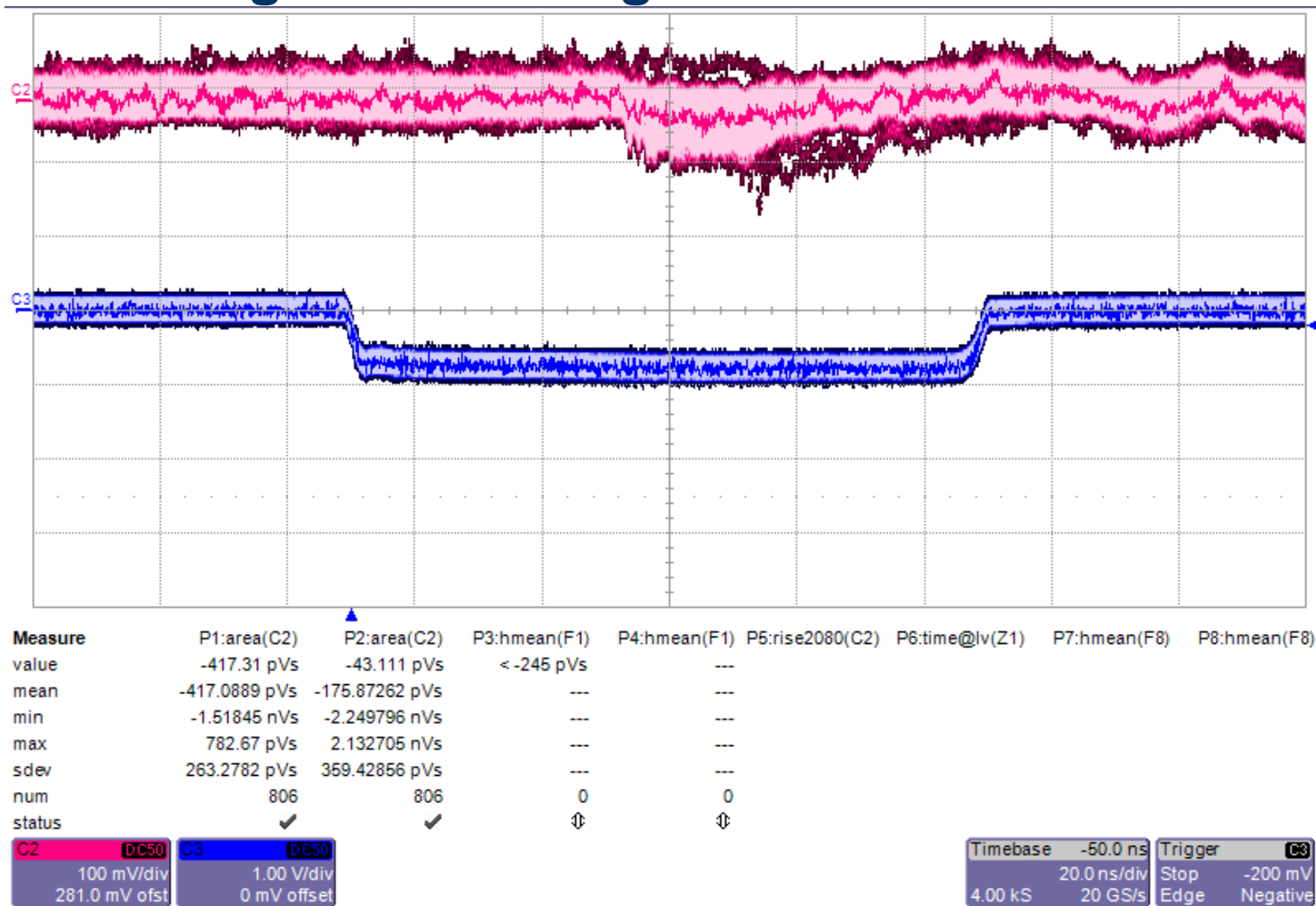
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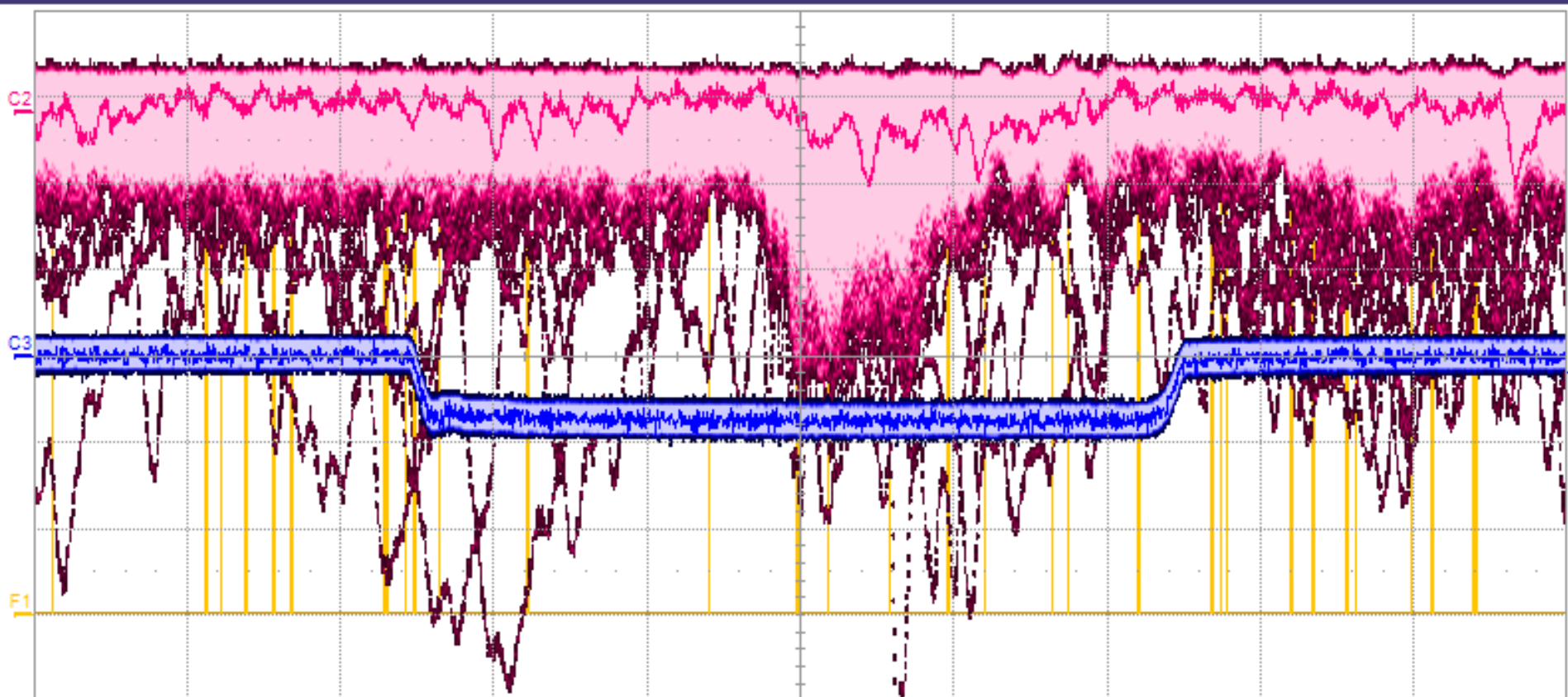


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Gain vs voltage 9002041 signal





Measure	P1:area(C2)	P2:area(C2)	P3:hmean(F1)	P4:hmean(F1)	P5:rise2080(C2)	P6:time@lv(Z1)	P7:hmean(F8)	P8:hmean(F8)
value	-495.88 pVs	-723.667 pVs	---	---	---	---	---	---
mean	-498.2234 pVs	-480.65707 pVs	---	---	---	---	---	---
min	-5.51548 nVs	-4.607814 nVs	---	---	---	---	---	---
max	421.49 pVs	794.294 pVs	---	---	---	---	---	---
sdev	865.8637 pVs	963.50785 pVs	---	---	---	---	---	---
num	1.146e+3	297	0	0	---	---	---	---
status	✓	✓	⚡	⚡	---	---	---	---

C2 DC50 100 mV/div 282.0 mV ofst	C3 DC50 1.00 V/div 0 mV offset	F1 hist(P2) 200 m#/div 20.0 pVs/div 32 #
---	---	--

Timebase -50.0 ns	Trigger C3
20.0 ns/div	Normal -200 mV
4.00 kS	Edge Negative
20 GS/s	