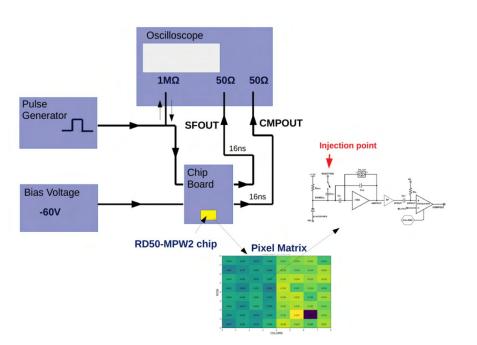
# Timing Results MPW2

**Douwe Nobels** 

### The Setup

- Keysight 81110A Pulse Pattern Generator
- Pulse frequency 60 Hz
- Pulse width 50 µs
- HV bias 100 V
- Threshold 970 mV(at this level the trimDACs show no signal but still some noise hits without being the highest trimDAC)
- Baseline 900 mV
- Infrared laser 980 nm
- Attenuator
- 1.9 kΩcm



#### The Setup

Pulse

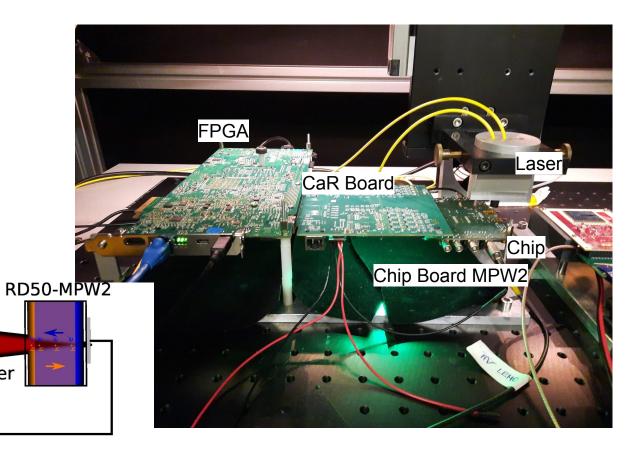
Generator

• Laser is shot in from the backside

Laser

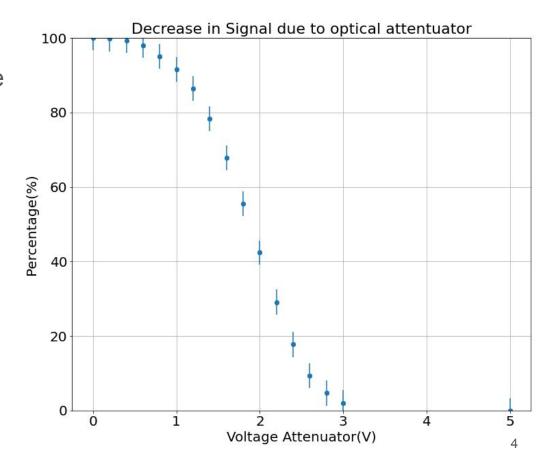
Diode

Focuser



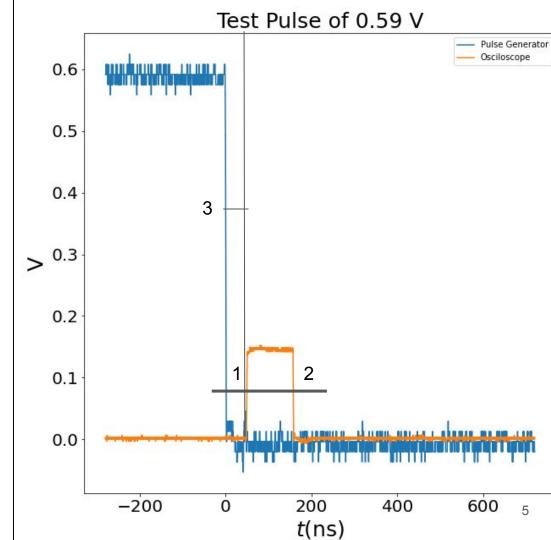
#### Attenuator

- An Attenuator was added to the setup to lower the laser amplitude and retain a stable signal.
- Higher voltage attenuator
  →Lower signal amplitude



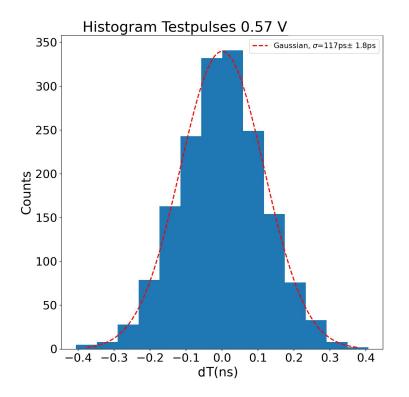
#### What we Measure

- Time over Threshold:
  - ToT= Δt= t2-t1
  - Where 1 is the time of 50% of the rising edge
  - 2 is the time of 50% of the falling edge
- Time resolution:
  - Is the spread in the time difference where the the time difference is:  $\Delta t = t1-t3$
  - Where 3 is the time of 50% falling edge if the pulse generator



#### Determining the Time Resolution

- Plot a Histogram of the spread of the time difference
- Fit a normal distribution and determine the spread of the distribution.
- The time resolution is equal to the spread

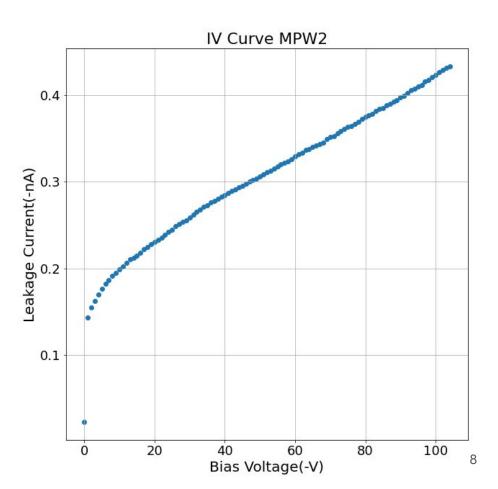


#### Measurements

- IV-Curve
- Calibration with Test Pulses 0.43 V to 1.79 (with steps of 0.20 V)
- Laser scans 200 waveforms per pixel with Laser amplitude of 2.4 V and a varying attenuator amplitude from 1.6 V to 2.6 V with steps of 0.2 V

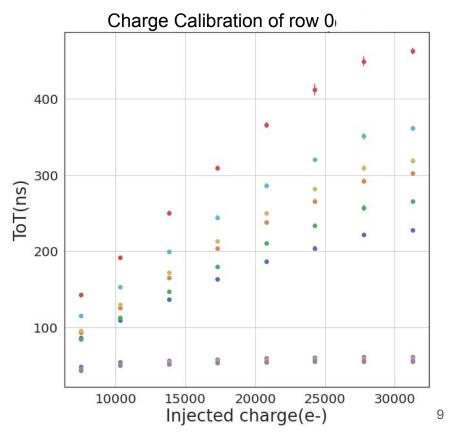
#### Measurements: IV-Curve

• From -1.0 V to -104 V with steps of -1.0 V



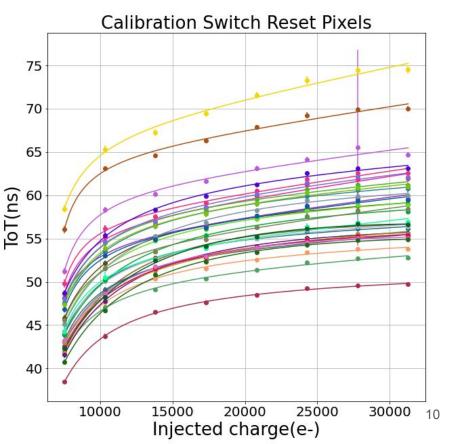
#### Charge calibration with test pulses

- Test pulses injected by the injection circuit
- Clear difference between
  Continuous and switch reset pixels



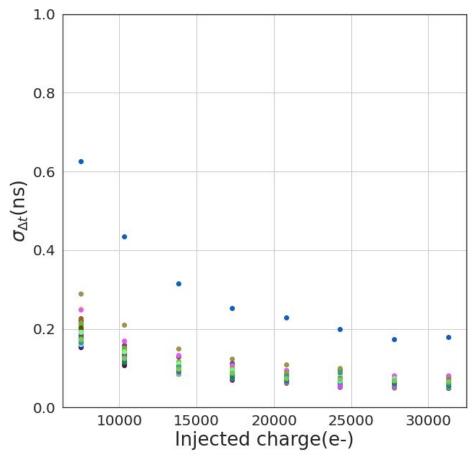
#### Zoomed in on the Switch reset pixels

- Charge Calibration of all Switch reset pixels
- Fit function:
  - Q= a\*ToT+b+ c/(ToT-d)
- The Switch reset pixel's ToT should not be affected by charge but it has a small effect



#### **Time Resolution Test Pulses**

- Time resolution of all pixels injected with test pulses
- No clear distinction between the 2 types of pixels
- Highest injected charge gives a mean of 64ps for the time resolution



#### Measurements: ToT scans 1.6-2.8 V

- 200 Waveforms per pixel
- Laser amplitude 2.4 V
- Changing attenuator
- Clear Difference between Continuous and switch reset pixels

Time over Threshold, Attenuator = 1.6 V

					, ,					
	314	236	286	358	50.9	50.5	61.4	45.7		- 500
9	215	312	444	330	53.8	49.7	45.3	50.6		
۰ ص	379	340	360	349	50.6	50.5	51.5	51.5		-400
4 du	357	277	425	199	59.8	51.5	57.2	47.2		- <sup>300</sup> S
Column 3 4	382	450	454	386	50.2	52.7	52.5	51.7		Ë
2	310	301	528	351	52.8	53.6	56	48		-200
н <sup>.</sup>	272	298	304	362	47.9	55.8	64.7	52.5		
0	145	179	151	258	53.8	49	52.1	47.8		-100
	Ó	1	2	з Ro	4 w	5	6	7	20	

#### Measurements: ToT scans 1.6-2.8 V

- 200 Waveforms per pixel
- Laser amplitude 2.4 V
- Changing attenuator
- Clear Difference between Continuous and switch reset pixels

Time over	Threshold,	Attenuator = 2	2.0 V
-----------	------------	----------------	-------

L.	199	142	183	224	46.9	46.5	57.7	37.5		- 300
9	141	202	282	210	51.2	46.8	41.2	42.3		25.0
ю·	240	214	227	227	48.1	47.9	48.7	42.6		-250
4 A	229	175	265	131	57	48.7	53.2	38.3		-200
Column 3 4	249	287	286	240	47.8	50.5	48.8	42.9		۲ 150 -
5	200	199	320	228	48.9	50.9	52.5	40.1		
н ·	168	186	191	225	45.1	53.1	60.6	43.7		- 100
0	99.5	110	94.1	154	45.7	39.9	42.4	39		- 50
	Ó	1	2	з Rc	4 w	5	6	7	2	-

#### Measurements: ToT scans 1.6-2.8 V

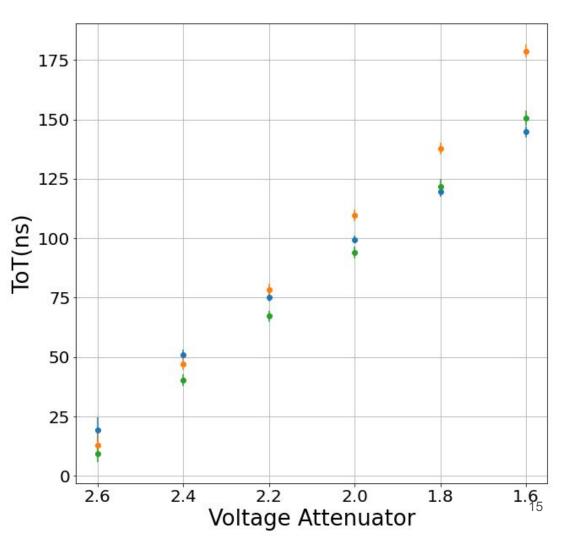
- 200 Waveforms per pixel
- Laser amplitude 2.4 V
- Changing attenuator
- Clear Difference between Continuous and switch reset pixels

Time over Threshold, Attenuator = 2.6 V

2	37.7	7.98	36.5	45.3	28.1	29.3	34.6	25.5	60
9	35.8	45	60.5	42.5	31.3	30.3	25.9	28.8	- 60
۰C	41.9	49.7	46.5	53.5	28.7	28.8	30.1	30.1	- 50
4 d	53.8	32.2	49.8	37	33.7	30.3	32.5	27.4	-40 م
Column 3 4	57.7	67.3	52	47.3	28.2	33.3	29.2	30.4	US
2	42.9	47.5	58.4	44.5	28.3	30.5	31.2	29.4	- 30
L .	25.1	43.7	48.7	52.3	28.7	32.6	40.8	29.3	- 20
0	19.4	12.9	9.49	24.5	29.2	26.5	29.4	23.6	- 10
	Ó	1	2	з Rc	4 w	5	6	7	

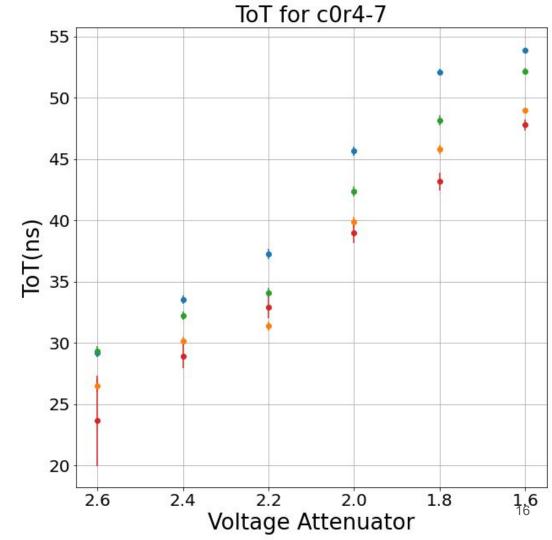
### Change in ToT(green)

• Continuous reset pixels behave linear



### Change ToT(Blue)

 Switched reset pixels smaller ToT



#### Measurements: Time resolution scans 1.6-2.8 V

- 200 Waveforms per pixel
- Laser amplitude 2.4 V
- Changing attenuator
- No clear difference between the two types of pixels

Attenuator	=	1.6	V

	2	0.167	0.184	0.174	0.146	0.147	0.161	0.16	0.203		-0.50
	9	0.177	0.153	0.181	0.142	0.168	0.109	0.152	0.201		-0.45
	ъ	0.152	0.15	0.139	0.131	0.126	0.164	0.197	0.197	3	-0.40
шп	4	0.197	0.14	0.17	0.133	0.125	0.158	0.202	0.184		-0.35
Column	m	0.137	0.173	0.169	0.132	0.113	0.135	0.118	0.216		- <sub>0.30</sub>
	2	0.142	0.228	0.131	0.13	0.114	0.153	0.183	0.201		-0.25
	1	0.144	0.159	0.21	0.173	0.166	0.121	0.132	0.151		-0.20
	0	0.177	0.162	0.149	0.195	0.169	0.164	0.161	0.515		-0.15
		0	1	2	з Ro	4 ow	5	6	7		17

# Measurements: Time resolution scans 1.6-2.8 V

- 200 Waveforms per pixel
- Laser amplitude 2.4 V
- Changing attenuator
- No clear difference between the two types of pixels

			V							
٢	0.229	0.226	0.188	0.177	0.226	0.18	0.192	0.261		-0.45
9	0.215	0.202	0.204	0.157	0.177	0.184	0.192	0.231		-0.40
S	0.203	0.206	0.163	0.178	0.163	0.21	0.257	0.247		-0.35
4 4	0.215	0.218	0.214	0.165	0.173	0.186	0.215	0.285		
Column 3 4	0.172	0.174	0.164	0.189	0.194	0.154	0.179	0.324		-0.30 N
2	0.201	0.246	0.188	0.184	0.169	0.228	0.195	0.344		-0.25
1	0.184	0.193	0.198	0.22	0.18	0.165	0.211	0.177		-0.20
0	0.24	0.228	0.198	0.297	0.254	0.255	0.248	0.464		
2	0	1	2	з Ro	4 SW	5	6	7	2-1	

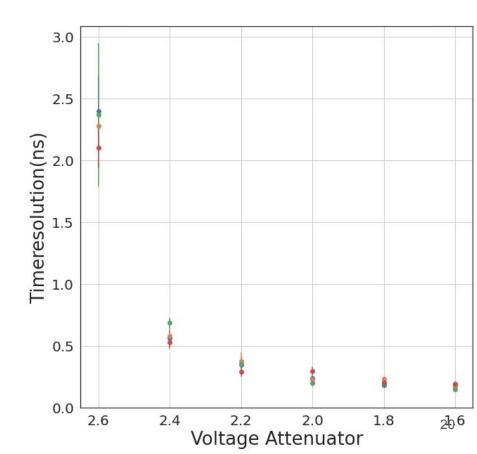
## Measurements: Time resolution scans 1.6-2.8 V

- 200 Waveforms per pixel
- Laser amplitude 2.4 V
- Changing attenuator
- No clear difference between the two types of pixels

	-				uunu	ator -	- 2.0	V	8 Y	
7	1.17	4.22	0.957	0.703	0.614	0.639	0.691	1.01		-7
9	0.866	0.977	0.975	0.87	0.621	0.578	0.684	1.27		-6
ъ	0.982	0.619	0.914	0.864	0.557	0.658	0.781	0.958	2	-5
Jolumn 3 4	0.774	1.16	1.02	0.777	0.439	0.612	0.726	1.07		-4 su
n coll	0.712	0.729	0.88	0.896	0.432	0.508	0.615	1.06		
2	0.876	1.37	0.791	1.07	0.585	0.774	0.61	0.961		-3
Ч	1.35	0.976	0.77	0.793	0.688	0.862	0.75	1.06		-2
0	2.4	2.28	2.37	2.1	1.07	1.06	0.954	7.31		-1
	0	1	2	з Rc	4 SW	5	6	7		

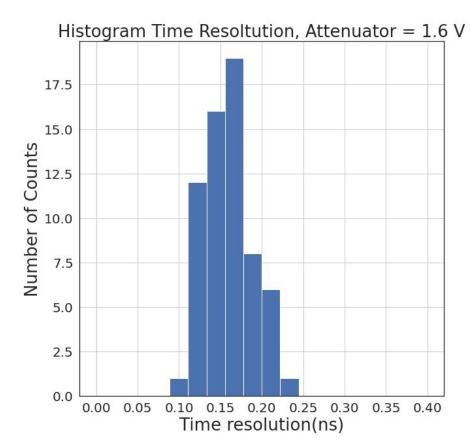
#### **Time Resolution**

- Time resolution improves when the laser intensity goes up
- Bigger error for low intensity



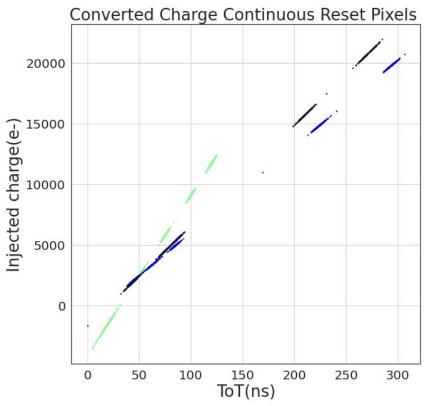
#### Histogram of the Time Resolution

- Mean of 165ps
- Standard deviation 52ps



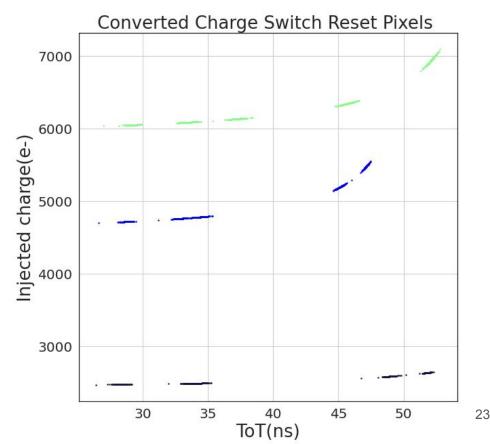
#### Laser ToT to charge conversion

- Pixels r0c0-2
- Not enough low test pulses
- Discontinuos laser amplitude
- Lower end not well defined
  → Results in negative charges
- Unable to bin the data since the binsize differ too much



#### Laser ToT to charge conversion Switch Reset Pixels

- Similarly as the previous slide we need more low test pulses to make a good calibration.
- However, we should not that the reset pixels behave like binary pixels and thus the ToT does not get influenced a lot by a change in charge



#### Outlook

- More Test pulses for better calibration
- Calibration with radioactive sources
- Back to back laser scans(when our lab is reopened)

#### **Backup slides**

- ToT maps
- Time resolution Maps
- Histograms of ToT of some pixels

#### Time over Threshold, Attenuator = 1.6 V314 236 286 358 50.9 50.5 61.4 45.7 2 215 330 53.8 49.7 45.3 50.6 312 444 0 379 50.6 50.5 51.5 51.5 S -340 360 349 Column 3 4 357 425 199 59.8 51.5 57.2 47.2 277 382 450 386 50.2 52.7 52.5 51.7 454 m

351

362

258

3

Row

52.8

47.9

53.8

4

#### Measurement

310

272

145

0

N

1

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301

298

179

1

528

304

151

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- 500

-400

- 300 S

-200

56

64.7

52.1

6

53.6

55.8

49

5

48

52.5

47.8

Ż

-100

	Time	over	Three	shold	, Atte	nuato	r = 1	8 V	
٢	263	222	236	294	50	49.6	60.6	41.3	-400
9	181	261	364	271	53.1	48.9	44.1	45.7	- 350
S	313	280	298	289	49.7	49.7	50.6	45.8	- 300
4 4	295	228	349	166	58.2	50.6	56.1	41.3	-250
Column 3 4	318	371	373	315	49.4	51.7	51.8	45.6	-200
2	257	252	415	294	51.8	52.8	55	42.8	-150
1	220	227	229	295	47.1	54.8	63.6	47.3	-100
0	120	138	122	207	52.1	45.8	48.2	43.2	- 50
	0	1	2	з Ro	4 w	5	6	7	2

1. 1.1 A LL - . . . . . L - ... 0 1/ 1

27

	Time	over	Three	shold	<u>, Atte</u>	nuato	$\mathrm{pr}=2$	2.0 V		
~	199	142	183	224	46.9	46.5	57.7	37.5		- 300
9	141	202	282	210	51.2	46.8	41.2	42.3		25.0
ы.	240	214	227	227	48.1	47.9	48.7	42.6		-250
4 du	229	175	265	131	57	48.7	53.2	38.3		- 200
Column 3 4	249	287	286	240	47.8	50.5	48.8	42.9		- 150
2	200	199	320	228	48.9	50.9	52.5	40.1		
ч	168	186	191	225	45.1	53.1	60.6	43.7		- 100
0	99.5	110	94.1	154	45.7	39.9	42.4	39		- 50
	Ó	1	ź	з Rc	4 w	5	6	7	2.	28

2011 Time a aver Thrachold Attanuator

28

Time over Threshold, Attenuator = $2.2 V$												
Ľ	45.1	77.2	77.6	62.6	27.5	29.5	41.3	31.7		- 180		
9	60.9	110	137	74.7	31.9	31.8	30.6	35.5		-160		
ю·	104	122	116	93.2	30.6	31.6	36.6	35.1		- 140		
un 4	120	101	138	63.4	37.6	33.8	40.1	33.7		- 120		
Column 3 4	137	176	147	109	32.5	37.9	36.3	37.7		- 100		
2	116	127	186	125	34.3	35.8	39.8	35.4		- 80		
ч	84	133	139	130	34.5	38.6	48.3	37.3		- 60		
0	75.2	78.4	67.3	110	37.3	31.4	34.1	32.9		- 40		
	Ó	i	Ż	з Ro	4 w	5	6	7	2	2		

29

	Time	over	Three	shold	, Atte	nuato	pr = 2	2.4 V			
r -	60.6	40.4	72.7	84.2	31.9	32.3	39	29.6		- 120	
9	62.1	86	116	85.9	35.9	33.7	28.9	32.2			
ы	91.8	93.8	94.6	95.1	33.6	33.4	33.9	33		- 100	
4 4	99.4	71.8	106	62	40.2	34.8	37	30.4		- 80	S
Column 3 4	107	124	111	93.3	33.5	38	33.2	34.1			ns
2	85.8	90.1	127	100	33.7	35.4	36	32.1		- 60	
н.	62.5	86.9	95.2	97.3	32.9	37.8	45	32.7			
0	51	47.1	40.4	68.8	33.5	30.1	32.2	28.9		-40	
	Ó	1	2	з Ro	4 w	5	6	7	23	30	)

A \ / ı. 1 . . 1.1 \_ .

Time over Threshold, Attenuator = $2.6 V$											
	37.7	7.98	36.5	45.3	28.1	29.3	34.6	25.5		- 60	
9	35.8	45	60.5	42.5	31.3	30.3	25.9	28.8		-00	
Ю·	41.9	49.7	46.5	53.5	28.7	28.8	30.1	30.1		- 50	
4 du	53.8	32.2	49.8	37	33.7	30.3	32.5	27.4		-40	
Column 3 4	57.7	67.3	52	47.3	28.2	33.3	29.2	30.4		20	
2	42.9	47.5	58.4	44.5	28.3	30.5	31.2	29.4		- 30	
н.	25.1	43.7	48.7	52.3	28.7	32.6	40.8	29.3		- 20	
0	19.4	12.9	9.49	24.5	29.2	26.5	29.4	23.6		- 10	
0 1 2 3 4 5 6 7 Row										31	

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31

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#### Measurements: Time resolution scans 1.6-2.8 V

- 200 Waveforms per pixel
- Laser amplitude 2.4 V
- Changing attenuator
- No clear difference between the two types of pixels

Atten	uator =	1.6	V

7	0.167	0.184	0.174	0.146	0.147	0.161	0.16	0.203	-0.50
9	0.177	0.153	0.181	0.142	0.168	0.109	0.152	0.201	-0.45
L.	0.152	0.15	0.139	0.131	0.126	0.164	0.197	0.197	-0.40
hn 4	0.197	0.14	0.17	0.133	0.125	0.158	0.202	0.184	-0.35
Column 3 4	0.137	0.173	0.169	0.132	0.113	0.135	0.118	0.216	-0.30 <sup>C</sup>
~	0.142	0.228	0.131	0.13	0.114	0.153	0.183	0.201	-0.25
-	0.144	0.159	0.21	0.173	0.166	0.121	0.132	0.151	-0.20
C	0.177	0.162	0.149	0.195	0.169	0.164	0.161	0.515	-0.15
	0	1	2	з Ro	4 ow	5	6	7	32

	Attenuator = 1.8 V												
7	0.195	0.172	0.152	0.182	0.147	0.207	0.176	0.171		-0.45			
9	0.201	0.195	0.202	0.148	0.142	0.165	0.179	0.252		-0.40			
S	0.156	0.163	0.143	0.169	0.136	0.17	0.169	0.194	~	-0.35			
4 h	0.178	0.155	0.183	0.174	0.13	0.196	0.18	0.228		-0.30 v			
Column 3 4	0.139	0.176	0.168	0.184	0.157	0.17	0.103	0.263		-0.25			
2	0.175	0.216	0.152	0.183	0.154	0.148	0.203	0.223					
г	0.159	0.236	0.198	0.193	0.178	0.177	0.145	0.256		-0.20			
0	0.18	0.232	0.196	0.205	0.191	0.178	0.193	0.485		-0.15			
	0	1	2	з Ro	4 w	5	6	7		33			

	Attenuator = $2.0 V$												
٢	0.229	0.226	0.188	0.177	0.226	0.18	0.192	0.261		-0.45			
9	0.215	0.202	0.204	0.157	0.177	0.184	0.192	0.231		-0.40			
2	0.203	0.206	0.163	0.178	0.163	0.21	0.257	0.247		-0.35			
Joiumn 3 4	0.215	0.218	0.214	0.165	0.173	0.186	0.215	0.285		0.55			
nion Bion	0.172	0.174	0.164	0.189	0.194	0.154	0.179	0.324		-0.30			
2	0.201	0.246	0.188	0.184	0.169	0.228	0.195	0.344		-0.25			
Ч	0.184	0.193	0.198	0.22	0.18	0.165	0.211	0.177		-0.20			
0	0.24	0.228	0.198	0.297	0.254	0.255	0.248	0.464					
	0	1	2	з Ro	4 DW	5	6	7		3			

Column

34

	Attenuator = 2.2 V											
٢	0.742	0.401	0.408	0.561	0.87	0.69	0.294	0.4				
9	0.561	0.292	0.368	0.53	0.616	0.538	0.36	0.438				
S	0.43	0.315	0.329	0.438	0.485	0.483	0.41	0.444				
4 4	0.318	0.274	0.322	0.4	0.388	0.439	0.31	0.362				
Column 3 4	0.325	0.257	0.315	0.329	0.322	0.336	0.249	0.392				
2	0.316	0.4	0.234	0.32	0.322	0.421	0.319	0.367				
П	0.356	0.31	0.285	0.312	0.312	0.385	0.322	0.342				
0	0.346	0.377	0.351	0.29	0.326	0.433	0.347	1.4				
0 1 2 3 4 5 6 Row												

-1.0 -0.8 2 -0.6 -0.4

-1.2

	Attenuator = 2.4 V											
7	0.66	0.696	0.423	0.446	0.391	0.409	0.494	0.612		-2.50		
9	0.431	0.45	0.513	0.406	0.402	0.414	0.369	0.669		-2.25		
ß	0.424	0.394	0.364	0.414	0.372	0.309	0.512	0.495		-2.00 -1.75		
3 4	0.386	0.413	0.333	0.411	0.377	0.384	0.481	0.531		ر س 1.50-		
m M	0.446	0.386	0.334	0.443	0.341	0.303	0.339	0.606	4	⊆ -1.25		
2	0.403	0.472	0.337	0.362	0.313	0.355	0.409	0.509		-1.00		
1	0.42	0.421	0.342	0.454	0.376	0.403	0.429	0.435		-0.75		
0	0.561	0.577	0.687	0.528	0.501	0.48	0.479	2.55		-0.50		
	0	1	2	з Ro	4 SW	5	6	7		36		

Column

A hhave the second	2 1	~ \/
Attenuator =	18	$\gamma v$
/		

					LICITA	acor	2.0	v
٢	1.17	4.22	0.957	0.703	0.614	0.639	0.691	1.01
9	0.866	0.977	0.975	0.87	0.621	0.578	0.684	1.27
ŋ	0.982	0.619	0.914	0.864	0.557	0.658	0.781	0.958
4 4	0.774	1.16	1.02	0.777	0.439	0.612	0.726	1.07
Column 3 4	0.712	0.729	0.88	0.896	0.432	0.508	0.615	1.06
2	0.876	1.37	0.791	1.07	0.585	0.774	0.61	0.961
Ч	1.35	0.976	0.77	0.793	0.688	0.862	0.75	1.06
0	2.4	2.28	2.37	2.1	1.07	1.06	0.954	7.31
	0	1	2	з Ro	4 SW	5	6	7

-6 -5 -4 <u>S</u> -3 -2

#### **Time resolution**

- Due to the fact the laser was used during measurements there are some variations to the maps. Meaning that with a decrease of intensity we saw for some pixels a decrease in time resolution this was the case for the following measurements:
  - 1.6-1.8: c1r2 c2r5 c2r1 c3r6 c4r0 c4r6 c5r5 c5r6 c7r3
  - 1.8-2.0: c0r7 c1r1 c1r5 c1r7 c2r6 c3r1 c3r2 c3r5 c4r3 c4r5 c6r7
  - 2.2-2.4: c2r4 c3r5 c4r4 c4r5 c5r0 c7r0 c7r4
- Some examples of these measurements can been seen at the next 2 slides

#### Backup Slides: Histograms delta t

