HPK EIC production sensors: laser measurements

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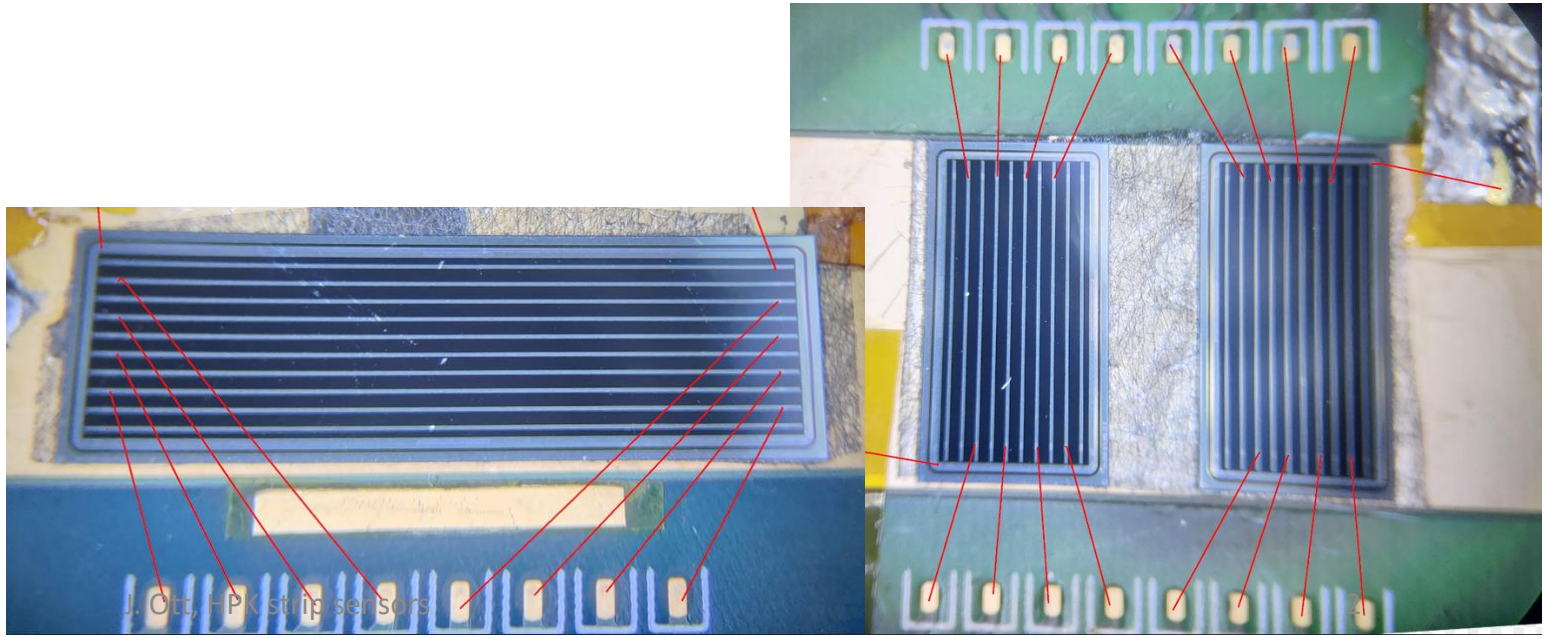
HPK sensors

- AC-LGAD production of HPK offers a large array of combinations of sensor properties
  - Very suitable for systematic evaluation

- Set of sensors at UCSC which have not been sent to LANL for irradiation: measured by IR laser TCT
  - Focus on 50 µm strip width

	A	B	C	D	F	G	H	I	J	K	L
1	HPK ID	Geometry	wafer	position	HPK n+ layer doping	Nominal dielectric C (pF/mm2)	thickness	lenght (mm)	pitch (um)	width (um)	Breakdown
2											
3	HPK1	Strip	W02		E	240	50	5	500	50	
4	HPK2	Strip	W04		C	240	50	5	500	50	
5	HPK3	Strip	W05		E	600	50	5	500	50	
6	HPK4	Strip	W08		C	600	50	5	500	50	
7	HPK5	Strip	W09		E	600	20	5	500	50	
8	HPK6	Strip	W11		C	600	20	5	500	50	
9											
10	HPK7	Strip	W02		E	240	50	5	500	100	
11	HPK8	Strip	W04		C	240	50	5	500	100	
12	HPK9	Strip	W05		E	600	50	5	500	100	
13	HPK10	Strip	W08		C	600	50	5	500	100	
14	HPK11	Strip	W09		E	600	20	5	500	100	
15	HPK12	Strip	W11		C	600	20	5	500	100	
16											
17	HPK13	Strip	W02		E	240	50	10	500	50	
18	HPK14	Strip	W04		C	240	50	10	500	50	
19	HPK15	Strip	W05		E	600	50	10	500	50	
20	HPK16	Strip	W08		C	600	50	10	500	50	
21	HPK17	Strip	W09		E	600	20	10	500	50	
22	HPK18	Strip	W11		C	600	20	10	500	50	
23											
24	HPK19	Strip	W02		E	240	50	10	500	100	
25	HPK20	Strip	W04		C	240	50	10	500	100	
26	HPK21	Strip	W05		E	600	50	10	500	100	
27	HPK22	Strip	W08		C	600	50	10	500	100	
28	HPK23	Strip	W09		E	600	20	10	500	100	
29	HPK24	Strip	W11		C	600	20	10	500	100	
30											



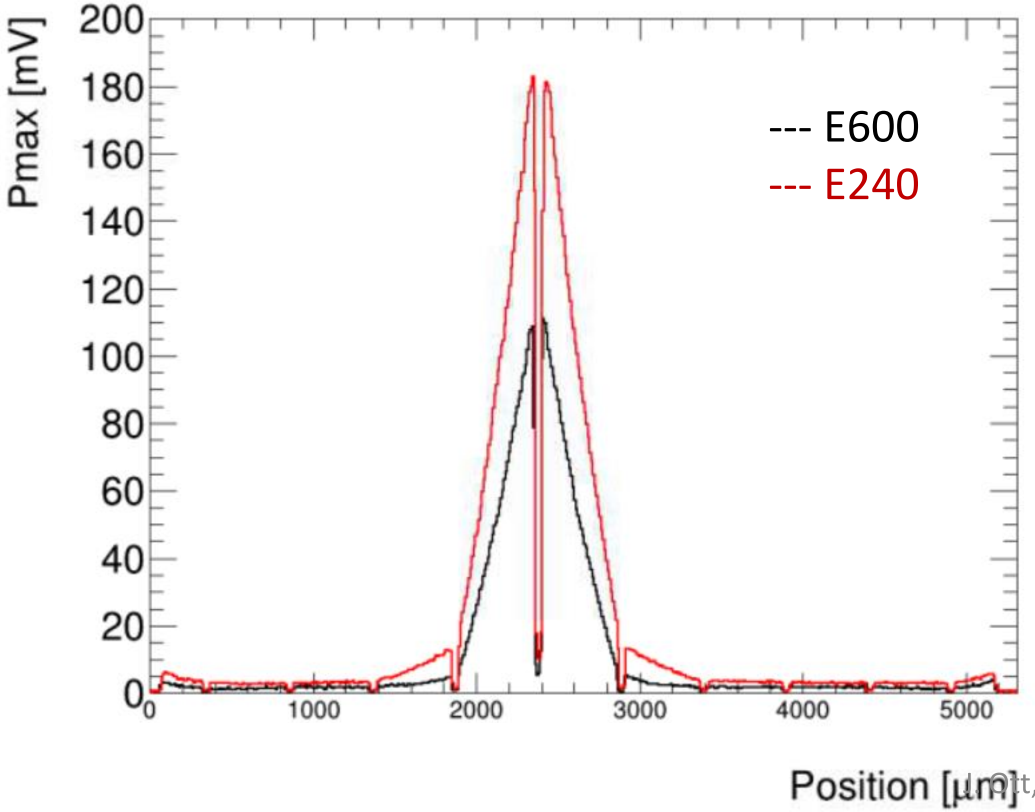
Comparison of parameters in HPK strip sensors

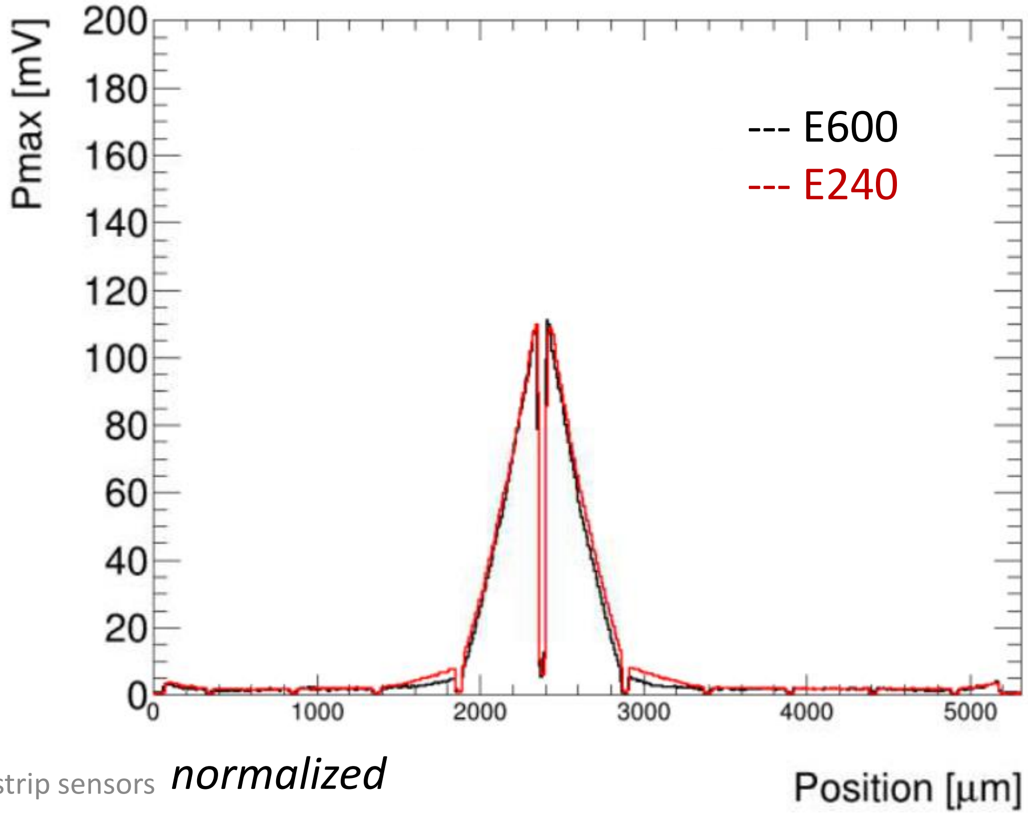
- Selection for comparison:

HPK ID	Geometry	wafer	position	size	HPK n+ layer doping	Nominal dielectric C (pF/mm2)	thickness	lenght (mm)	pitch (um)	width (um)
HPK1	Strip	W02			E	240	50	5	500	50
HPK3	Strip	W05			E	600	50	5	500	50
HPK3	Strip	W05			E	600	50	5	500	50
HPK21	Strip	W05			E	600	50	10	500	100
HPK21	Strip	W05			E	600	50	10	500	100
HPK22	Strip	W08			C	600	50	10	500	100
HPK29	Strip	W09			E	600	20	20	500	50
HPK35	Strip	W09			E	600	20	20	500	100

Dielectric capacitance (for E-type)

- Higher signal amplitude in E240 (lower dielectric capacitance)
- Relative signal sharing almost identical, slightly higher for E240





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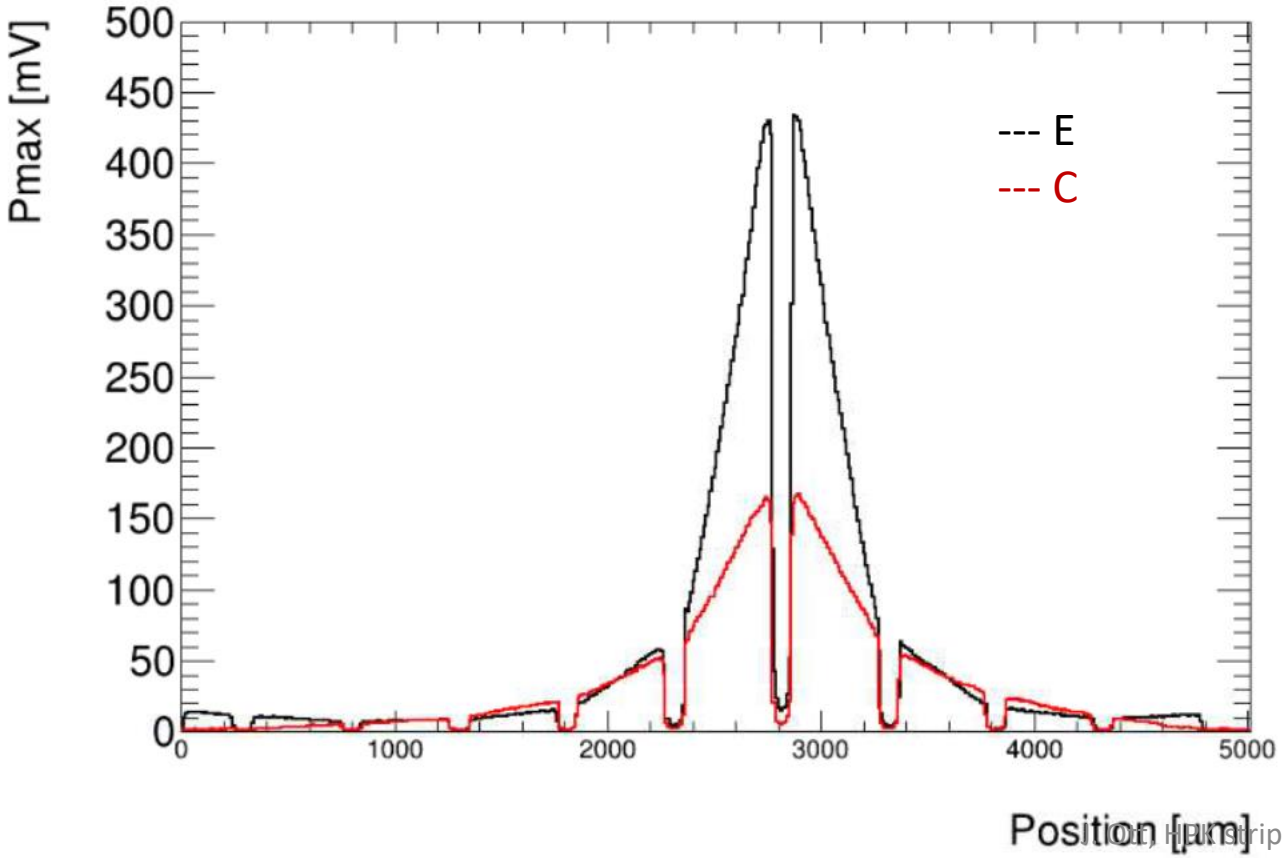
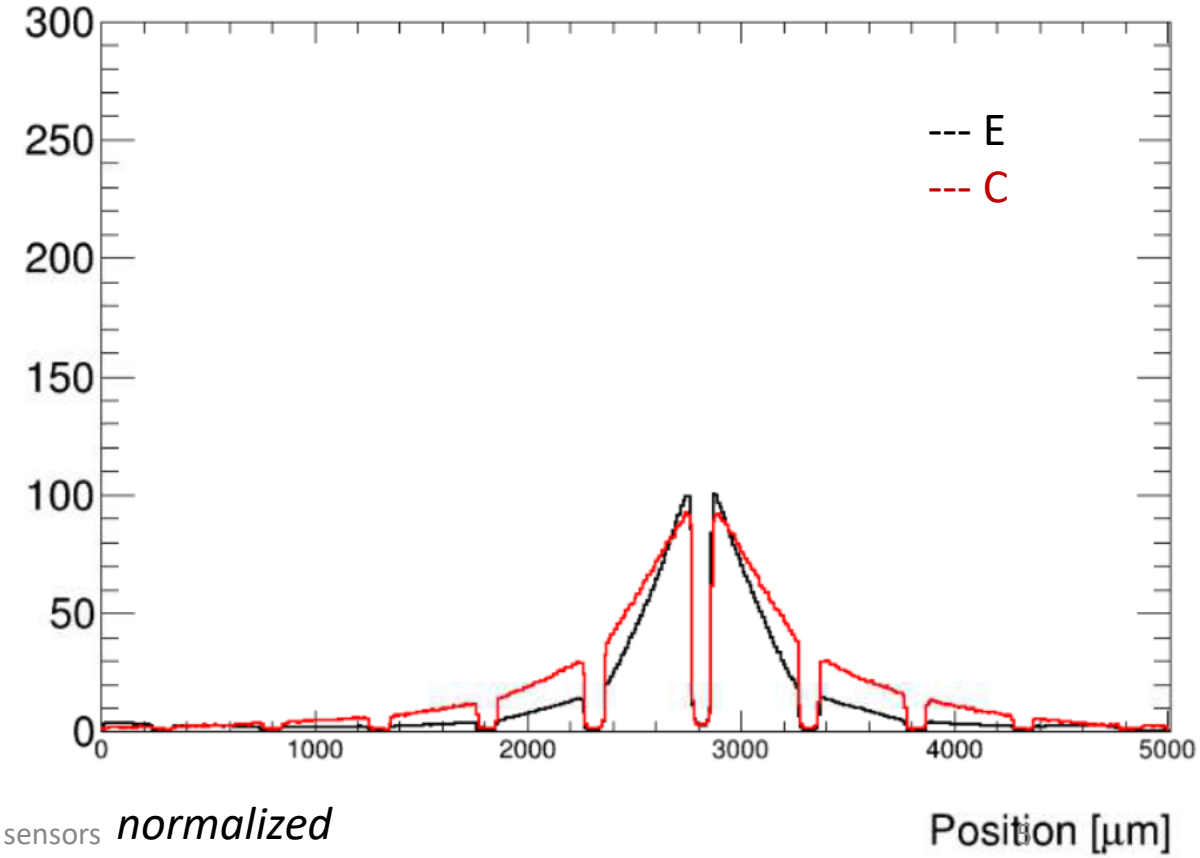
N+ resistivity

- More sharing in C type (lower n+ resistivity): factor of ~2





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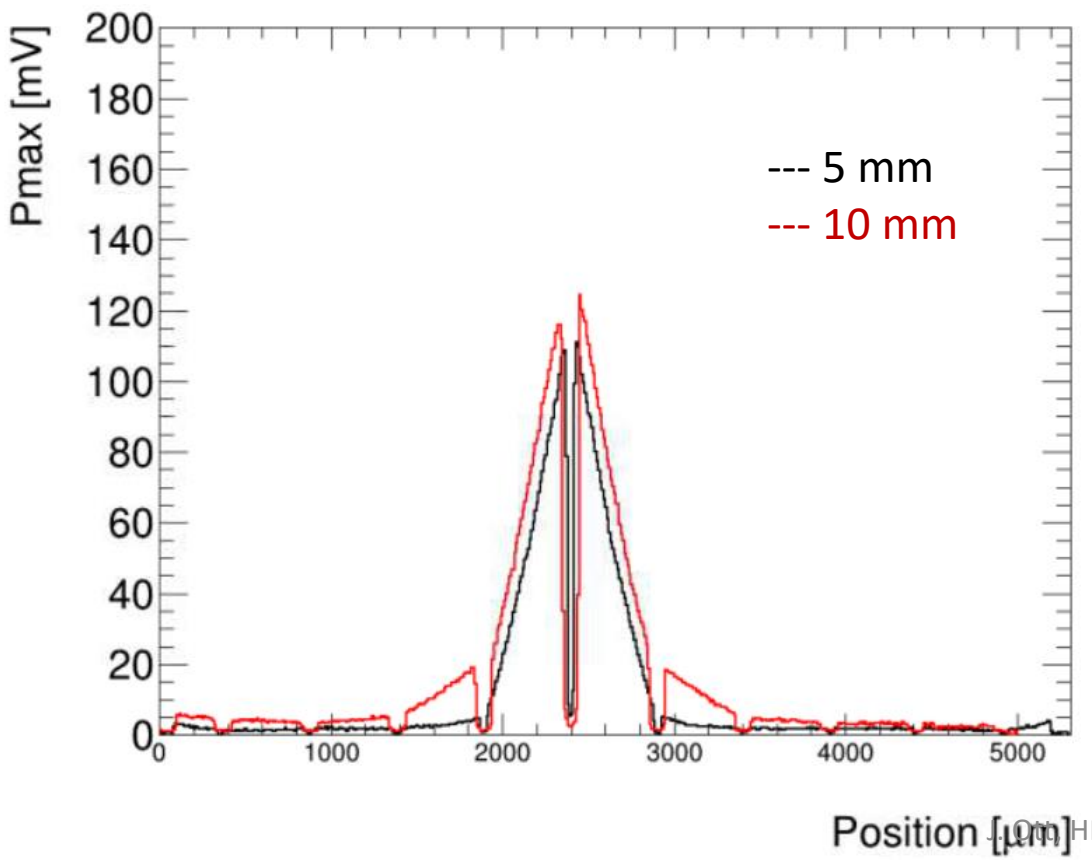
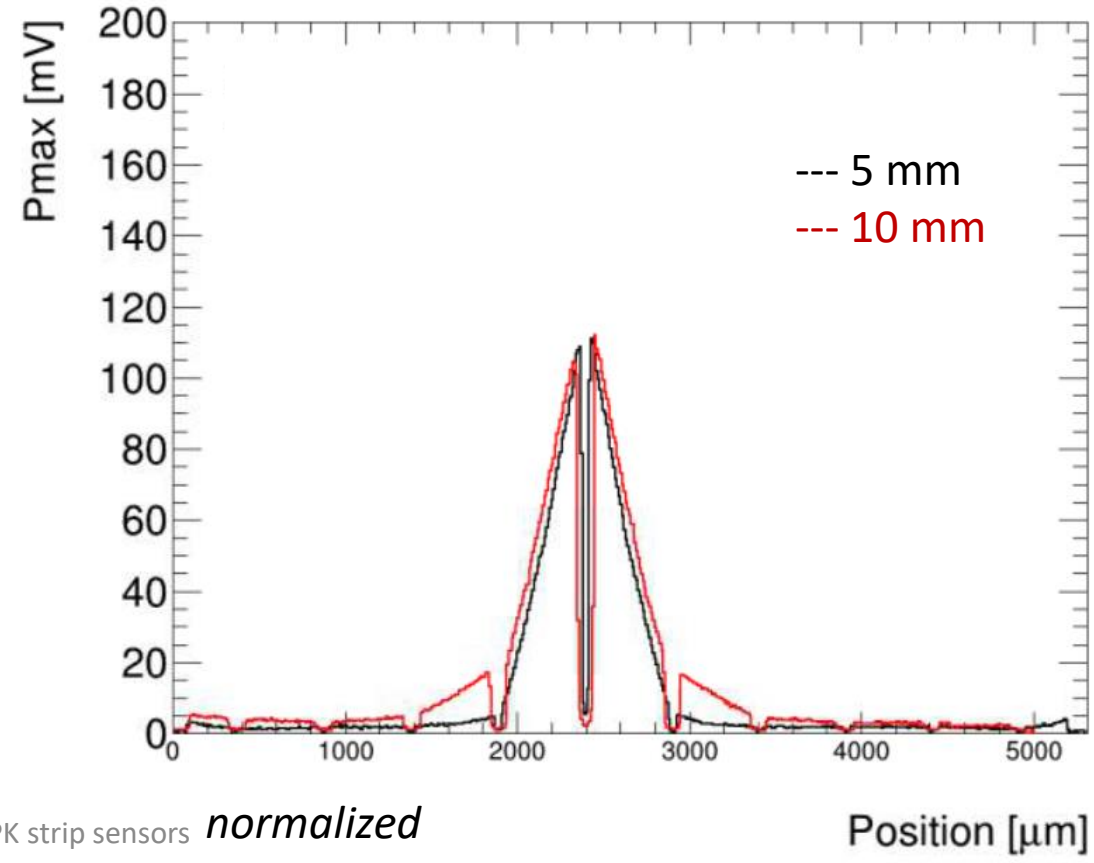
Strip length (for E type)

- Increasing strip length introduces more charge being shared beyond next neighbor: factor of >2





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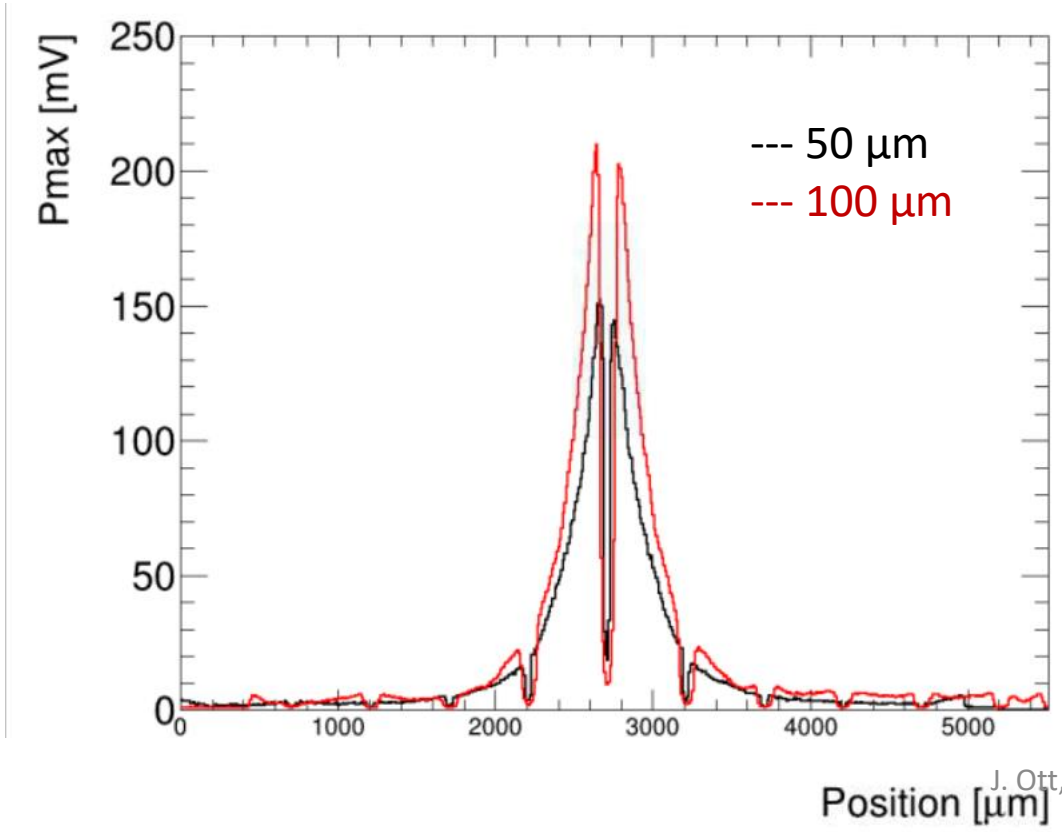
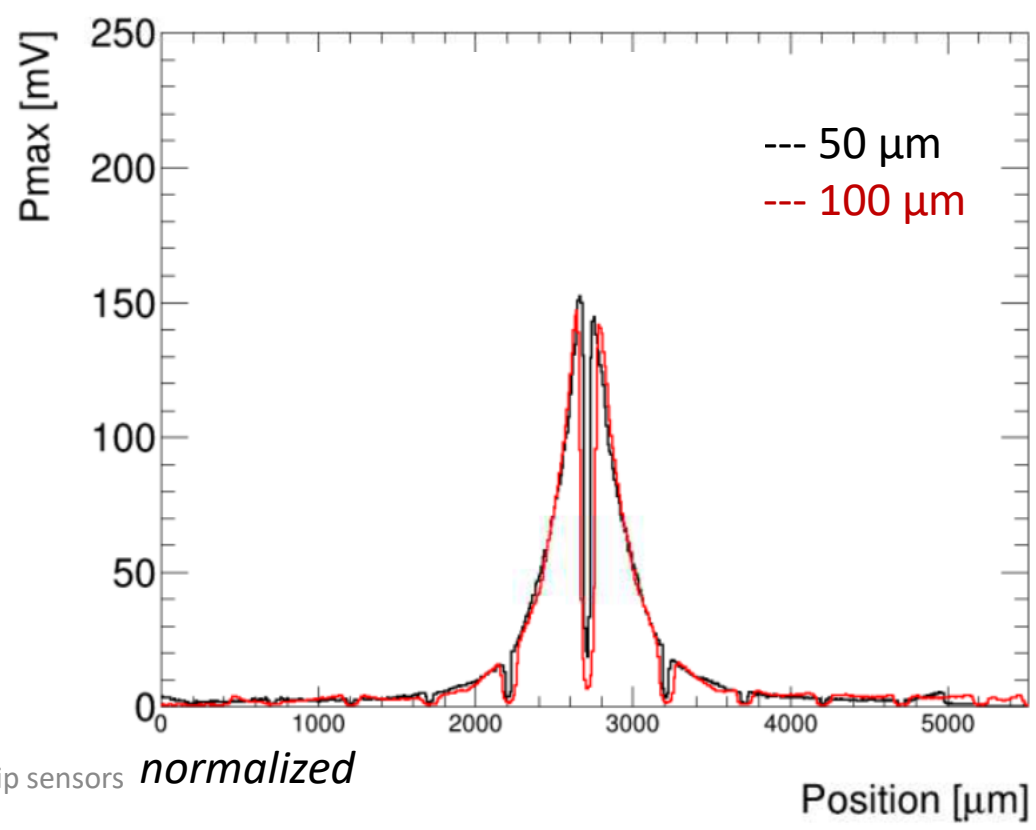
Strip width (2 cm length)

- Little impact of strip width on sharing – somewhat higher absolute signal for larger strip





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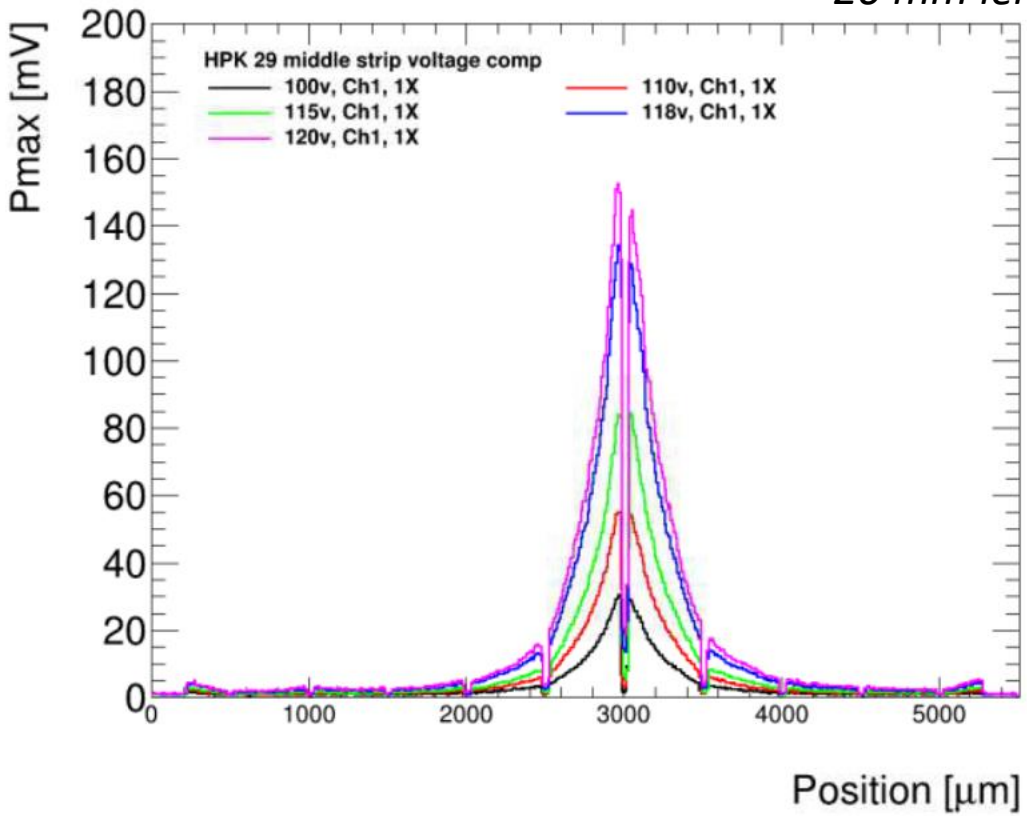
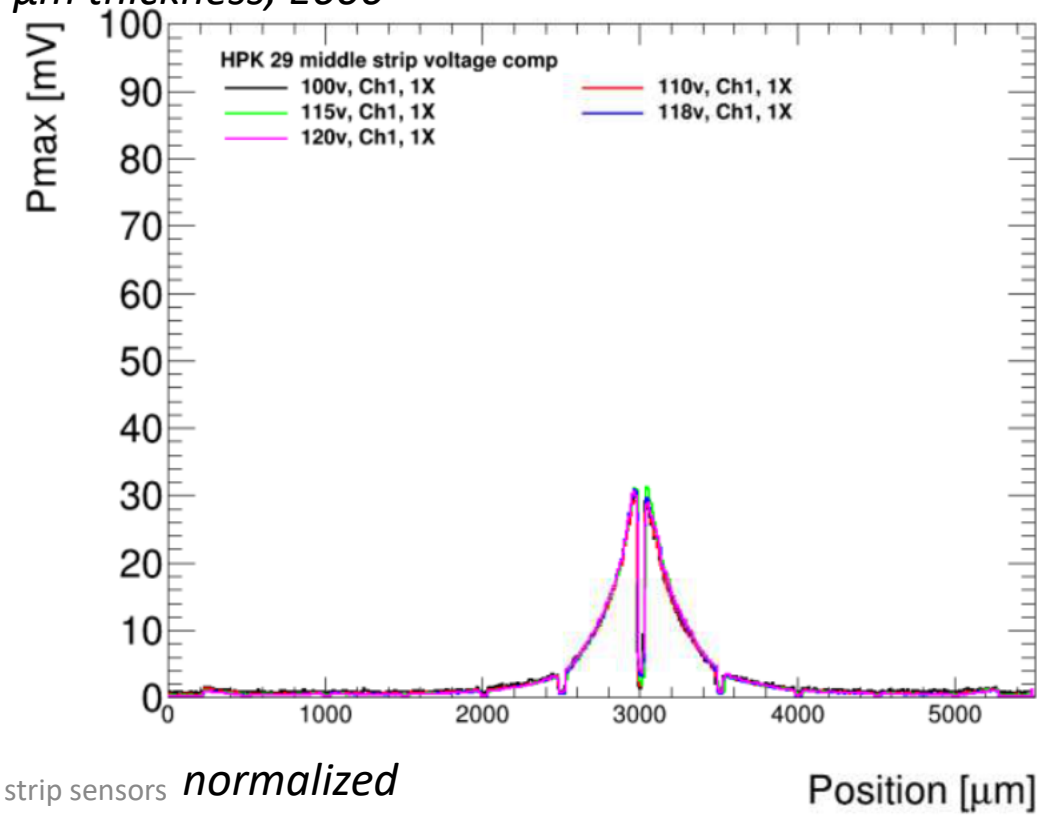
Sharing as function of bias voltage

- Relative signal sharing does not depend on bias voltage = gain

20 mm length, 20 µm thickness, E600



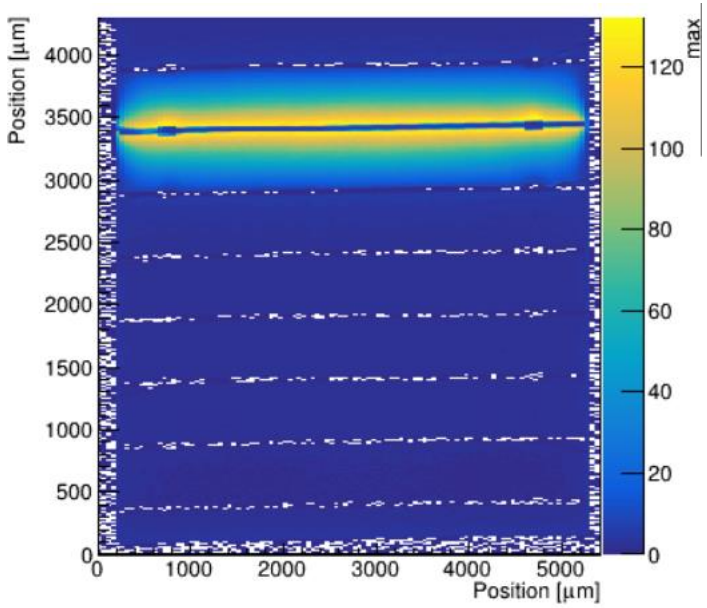


normalized

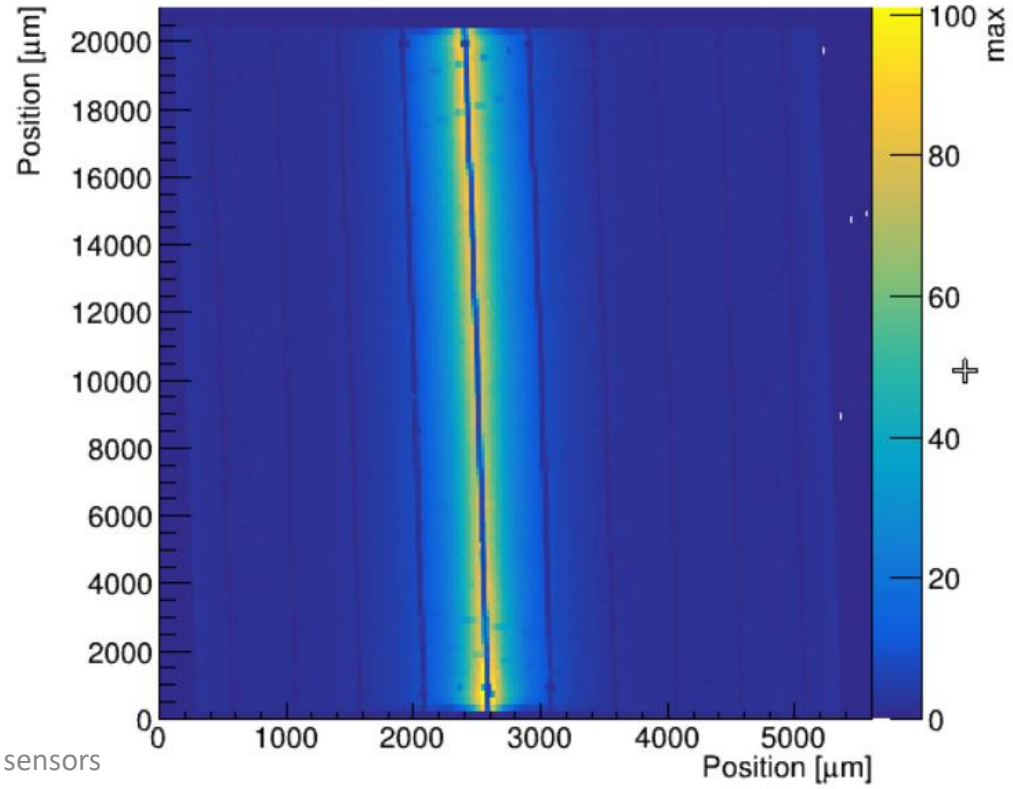
Uniformity (50 µm strip width)

- Uniformity of sensors is very good, no gain ‘hotspots’

5 mm length, 50 µm thickness, E600



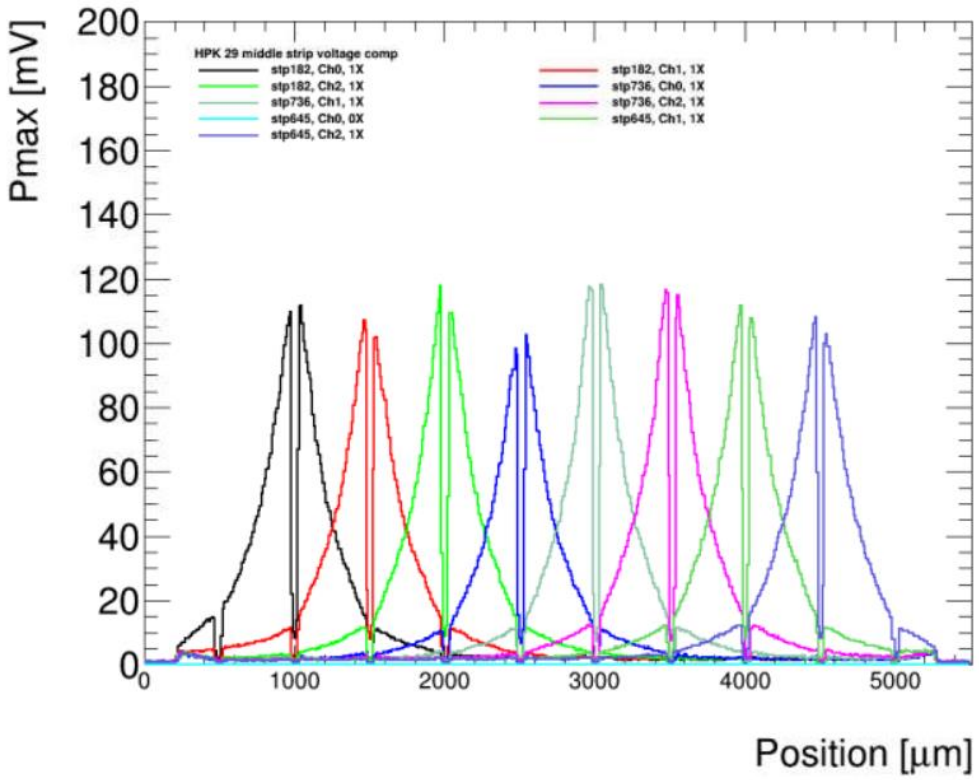
20 mm length, 20 µm thickness, E600



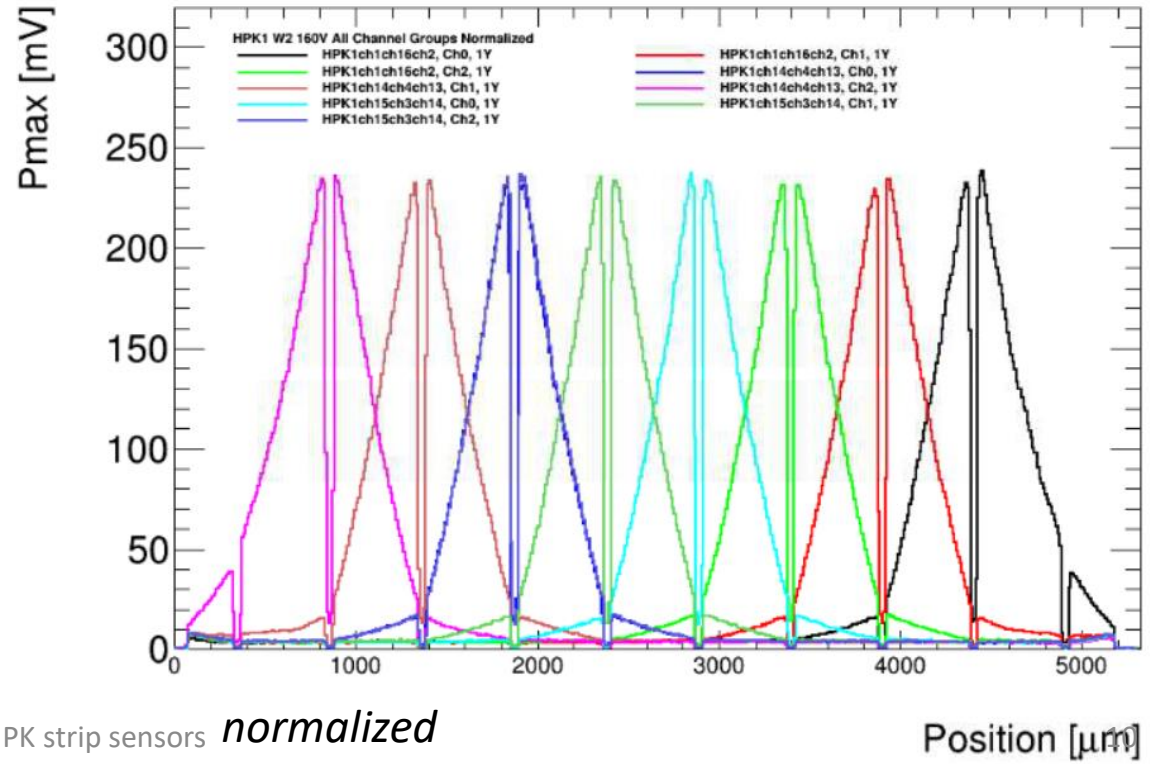
Uniformity of response

- Some variation of max. signal amplitude in 1D scans
  - To be investigated whether this might be caused by fluctuations in laser intensity
- Very unform profile shape when normalized

20 mm length, 20 µm thickness, E600



5 mm length, 50 µm thickness, E240



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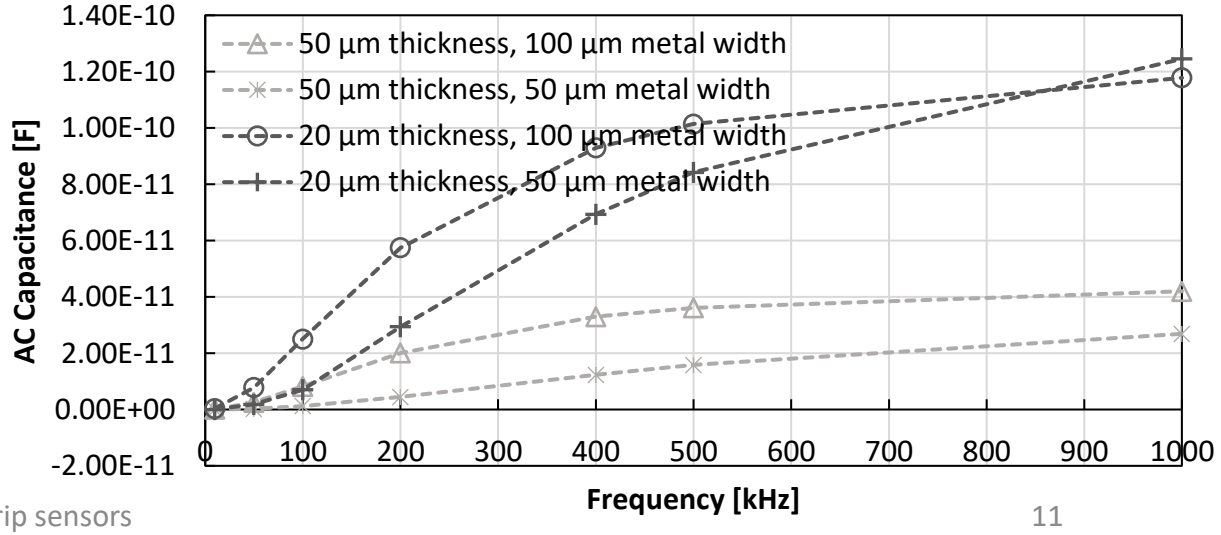
Summary

- HPK sensors are a great set of samples for systematic study

- 2 cm long sensors (of E600 type and 20 µm thickness) appear promising for use in TOF-PID: sufficient gain and signal-to-noise can be reached, signal sharing beyond first neighboring strip only ~10%
  - 50 µm sensor to be tested as well
  - 50 vs 100 µm metal width has little impact on signal sharing, but AC capacitance can be reduced by thinning the strip metal
  - Timing resolution to be verified



Next steps

- Dielectric comparison for C-type
- Repeat C vs E-type comparison for 600, compare for 240

HPK2	Strip	W04			C	240	50	5	500	50
HPK4	Strip	W08			C	600	50	5	500	50
HPK4	Strip	W08			C	600	50	5	500	50
HPK3	Strip	W05			E	600	50	5	500	50
HPK2	Strip	W04			C	240	50	5	500	50
HPK1	Strip	W02			E	240	50	5	500	50

- Profiles and comparisons for pmin (at long range), rise time, jitter, CFD50
- Quantification of charge sharing, comparison with capacitances
- Use of photodiode corrections in analysis

Timing resolution

- Rise time: depends on location between strips