TCT measurements with slim edge strip detectors

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Experimental Setup

can only move in two dimension

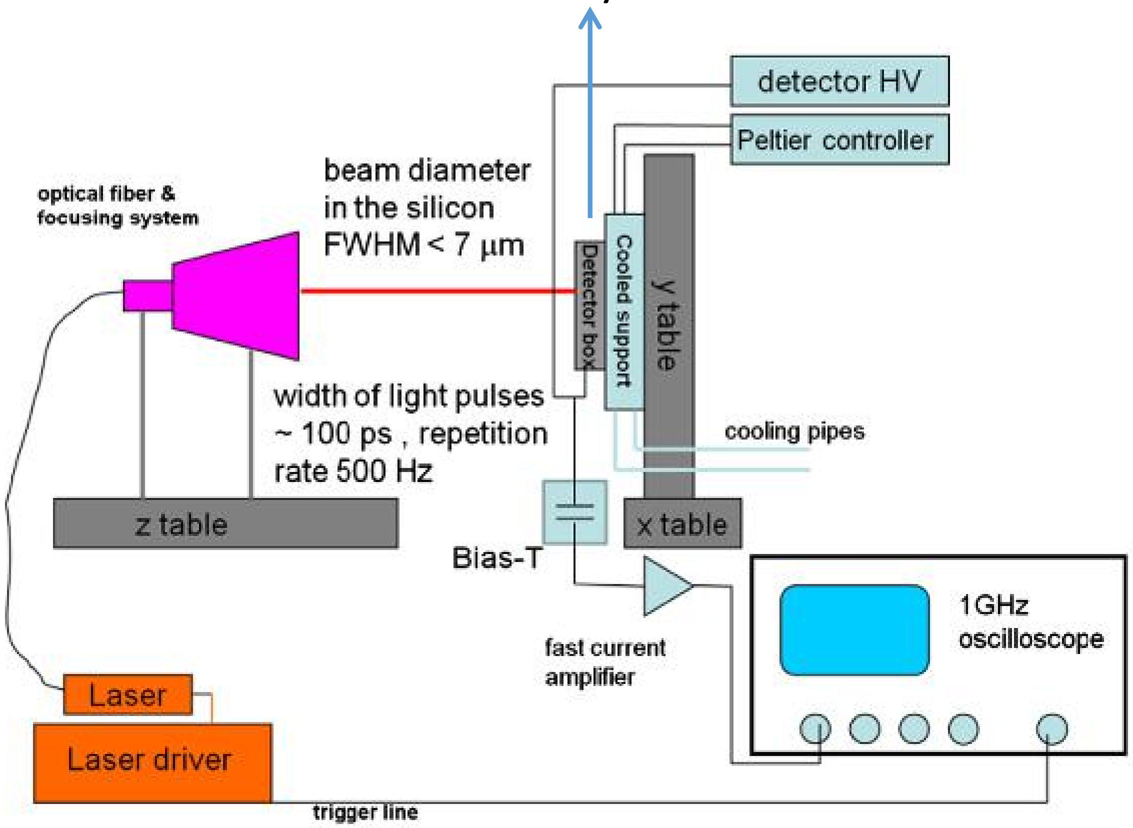


Fig. 1. Scheme of the experimental setup.

Strip detector size: $1*1cm^2$
Strip pitch: 80um
Type: n-p
Thickness: 300um
Edge to detect: thinned with SCP method
Irradiation: 1MeV neutron, $1.5e15n/cm^2$
Annealing: 80 min at 60℃

SCP method:

1. scribed by a laser or etching process
2. cleaved along the scribed line
3. passivated with Al2O3 for p-type

making edge high resistive, avoiding high edge current.

Shan

- What's the meaning of "IR"? Is it one kind of light? And what's the main difference between the red and IR laser?

- IR, Infra-Red, λ=1064 nm.

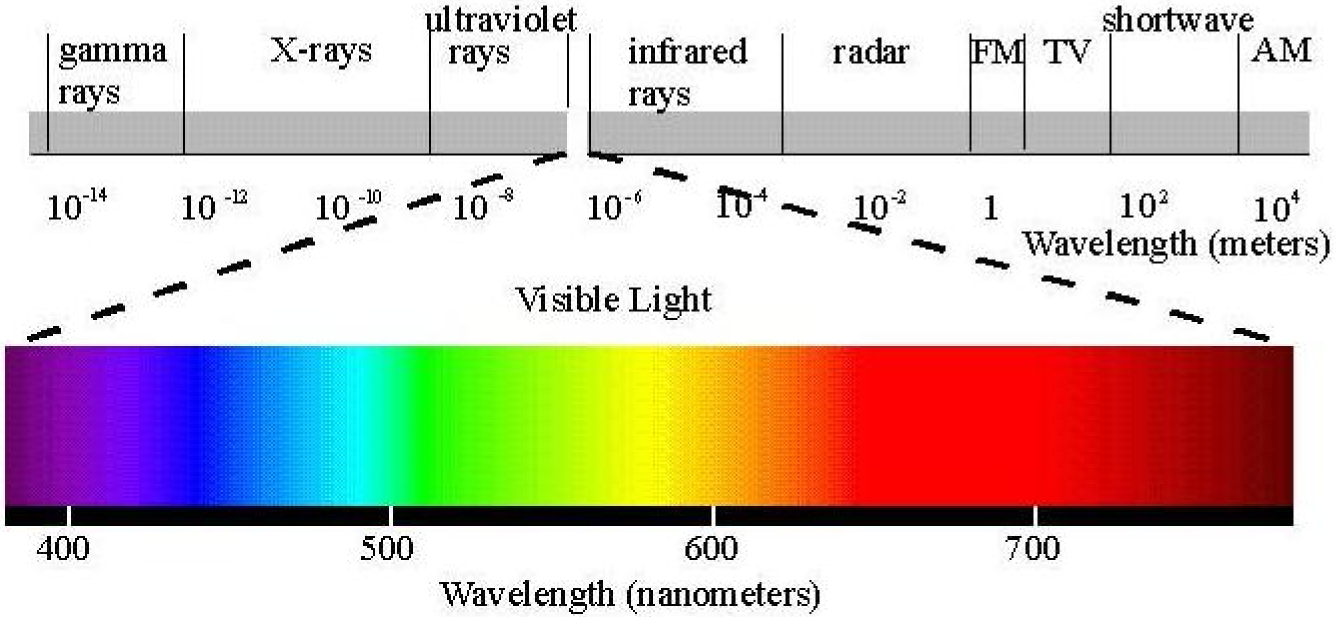
Red, λ=640nm.

The wave length is different,

causing absorption depth

different. So we can use them

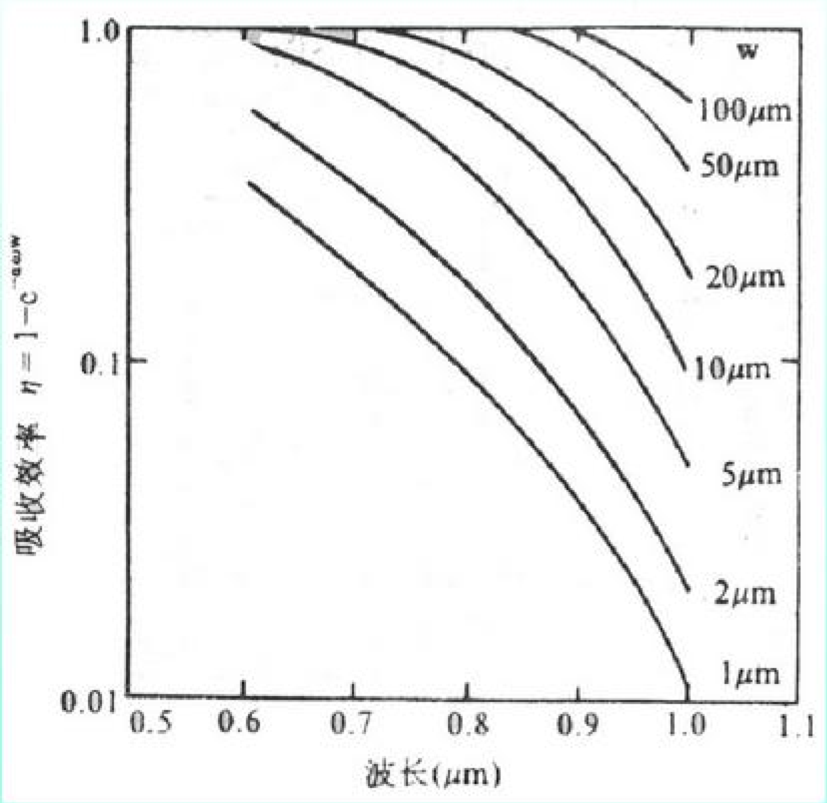
to detect different performance.



Kai

- This paper answers one question we discussed once before during the group meeting, for the laser with larger wave length, is the absorption depth longer or shorter. Could you explain a bit more details on the physics picture about the reason of this?

- The laser with larger wave length, the absorption depth shorter. You can see the trend in the right plot. Sorry I didn't find the formula.



Si探测器量子效率与波长、吸收层厚度的关系图

Amit

- Measuring with focused red laser beam is quite advantageous as it only penetrates ~3 micrometer into silicon.

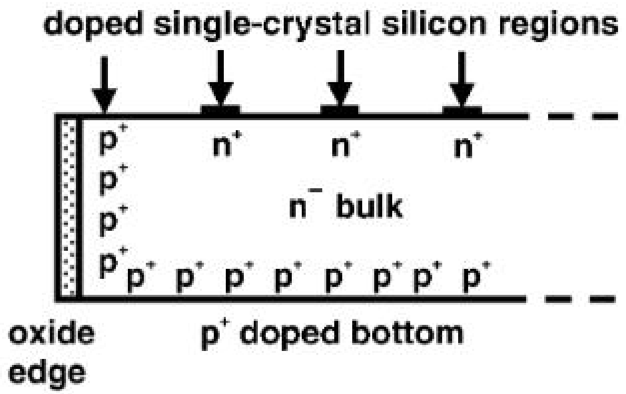
Will it create the similar environment with the high energy collision because the beams in the high energy experiments will be more energetic?

- No. It has nothing to do with the collision energy. But we use TCT to investigate the detector performance.

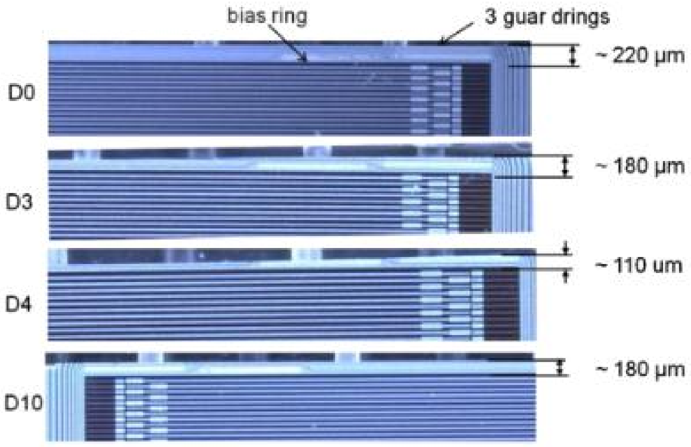
Ryuta

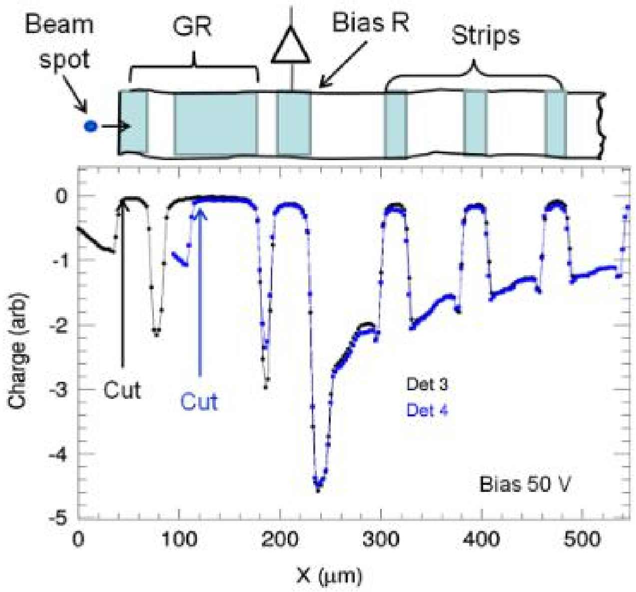
- At the introduction, several approaches to reduce inactive edge part are mentioned, where the one of them is the SCP method described in this paper. "active edge" method is also mentioned as well, but what is this "active method" ?

- I think 'active' is used to describe the working status. It means the edge can work as electrode. But for SCP method, edge is passivated with Al_2O_3, making it something like insulator(inactive).



Top-TCT measurements --- IR laser

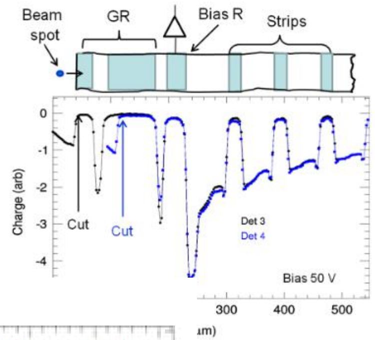


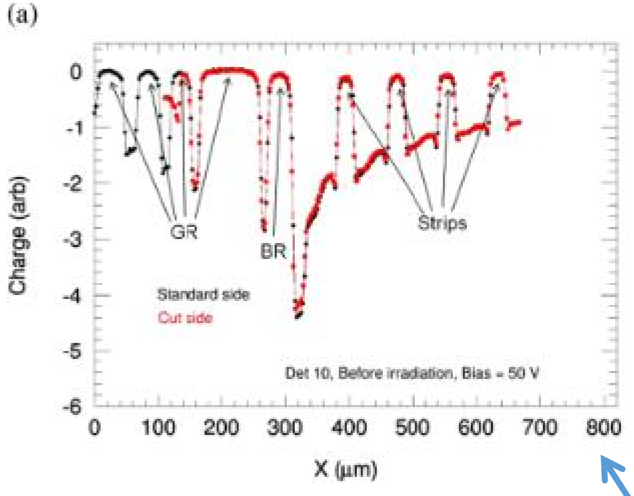


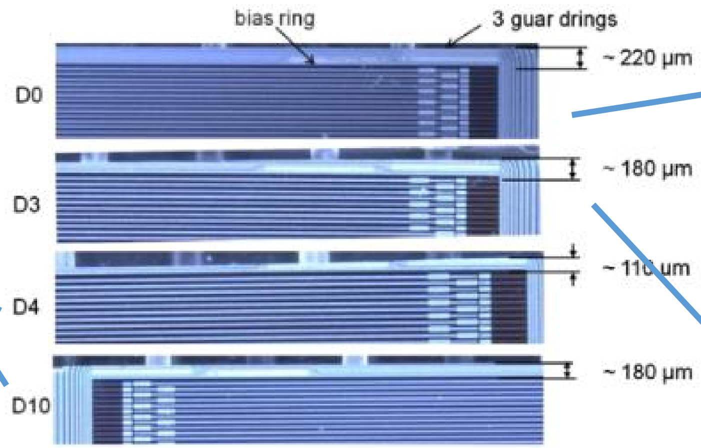
- D0: 220um wide and 3 guard rings
- D3: 180um wide and 1 guard rings
- D4: 110um wide and no guard ring
- D10: 180um wide and 2 guard rings

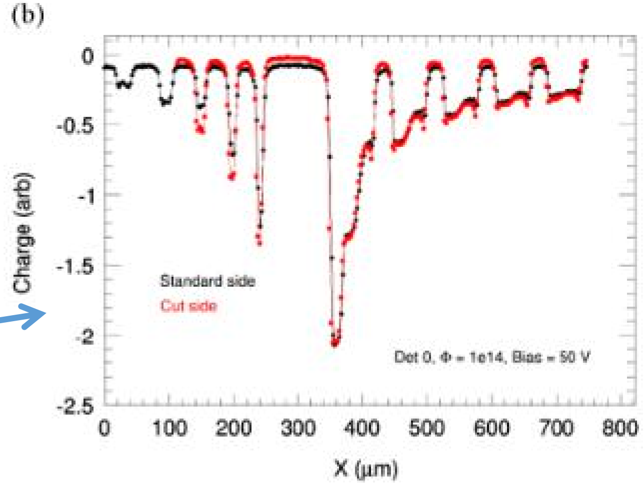
- full depletion voltage: 50V at 20℃ before irradiation

Top-TCT measurements --- IR laser









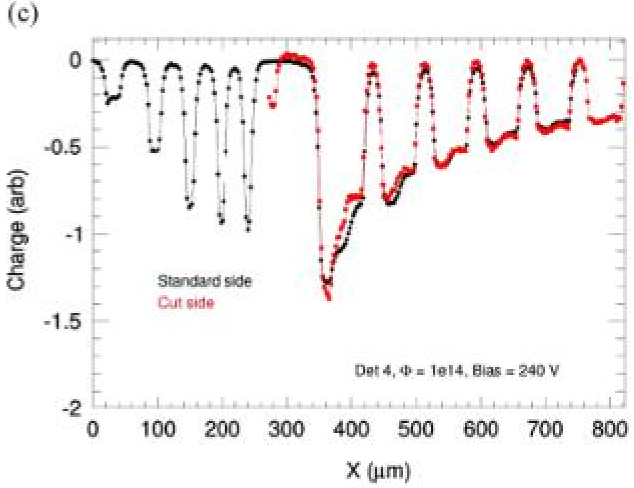


Figure 5

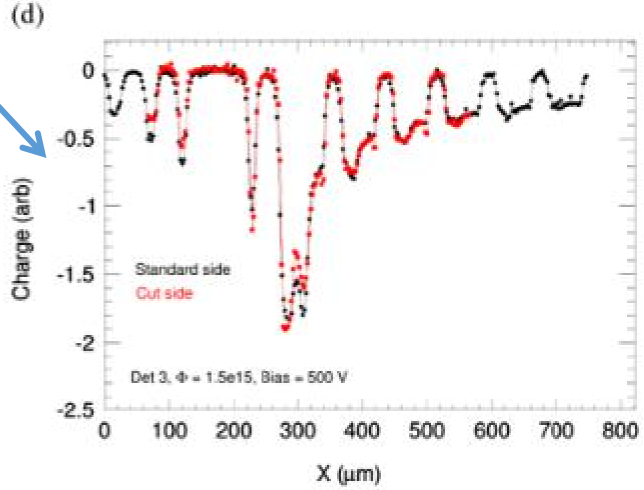


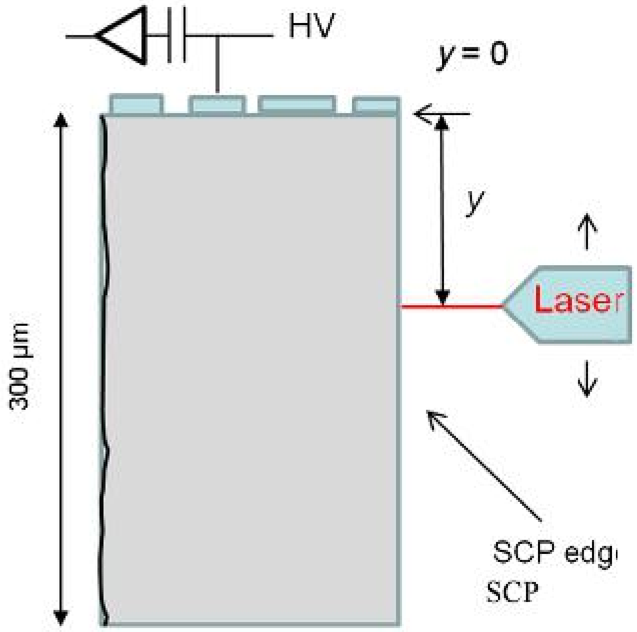
Figure 5

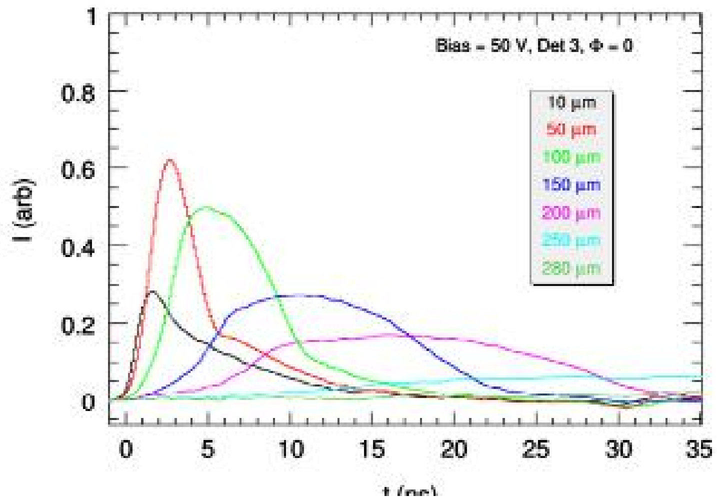
Dengfeng

- I have a small question on Figure 5. I noticed the Det 10 and Det 3 have same distances between guide ring and sensitive area, 180 um, but if we look at the top left plot and bottom right plot of Figure 5, we can find that the **charge collection in the gap between guard ring and sensitive is different**. Do they have any explanation on this difference?

- Sorry I don't know exactly and it's just my guess. D10 is fully depleted while D3 is below full depletion. Or high dose irradiation made some effect on D3.

Edge-TCT measurements --- Red light





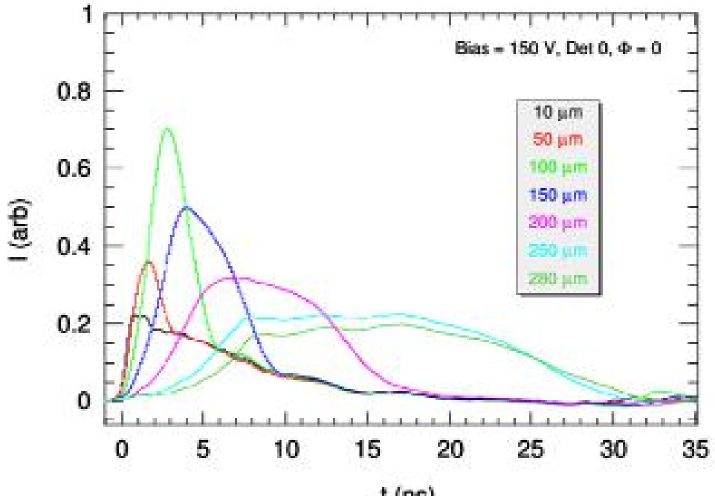
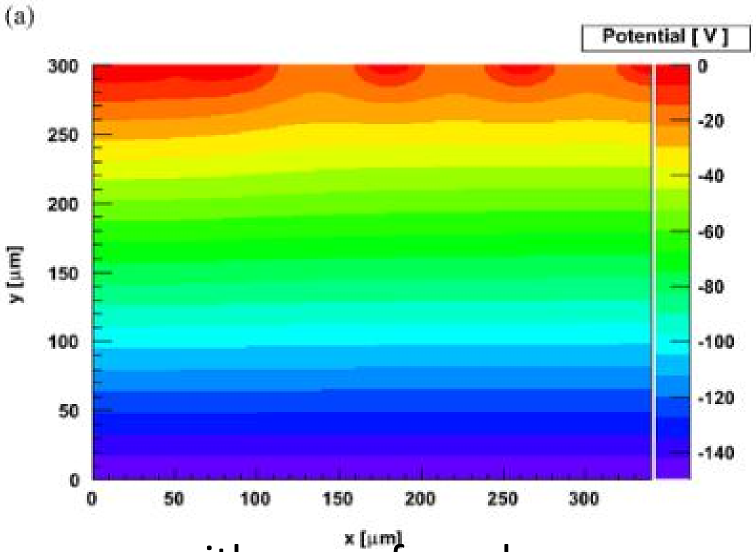
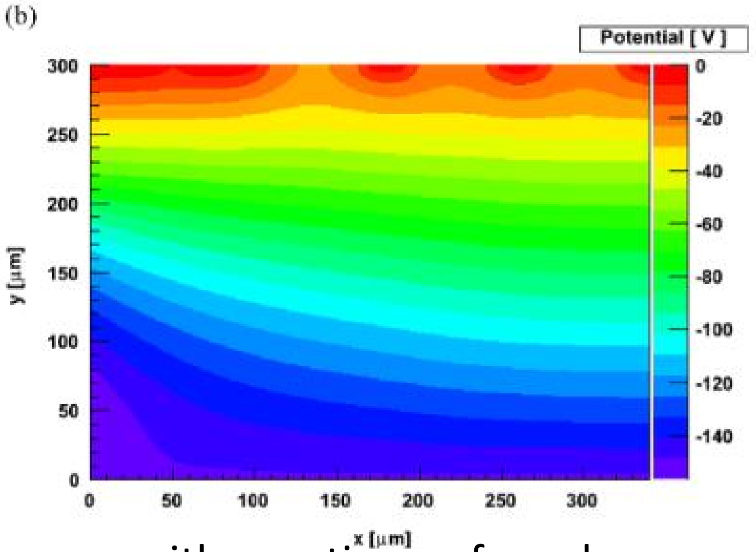


Fig7

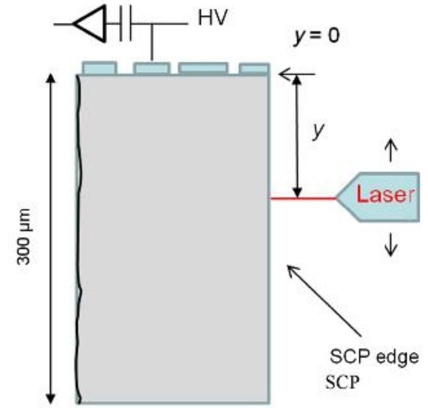


with no surface charge



with negative surface charge

Edge-TCT measurements --- Red light



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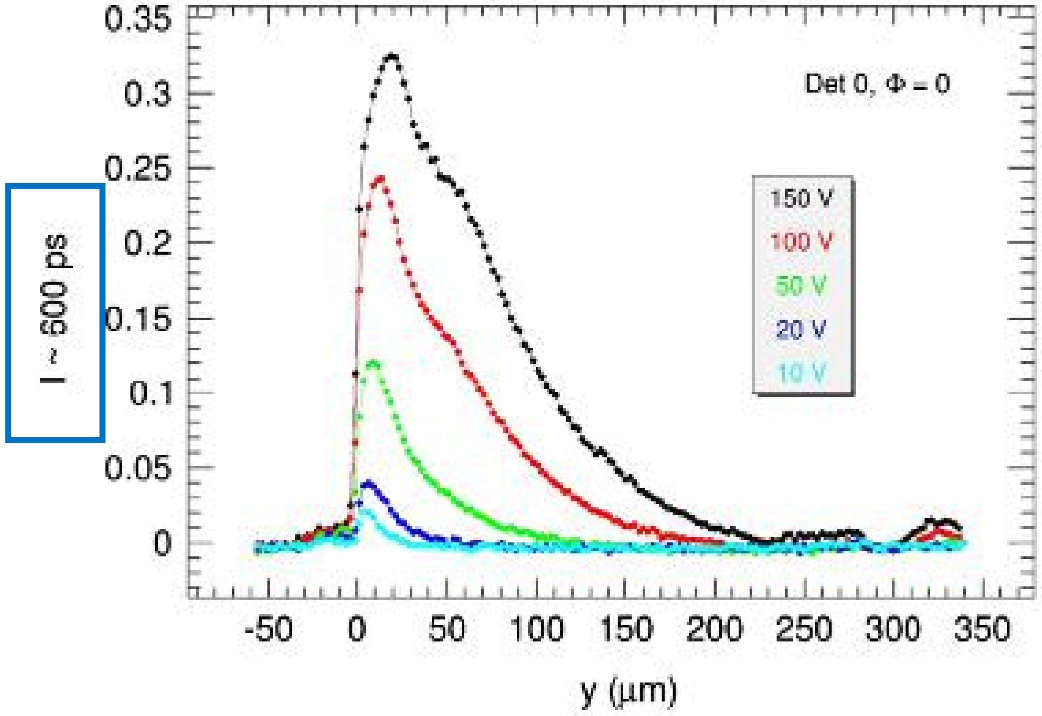


Fig8

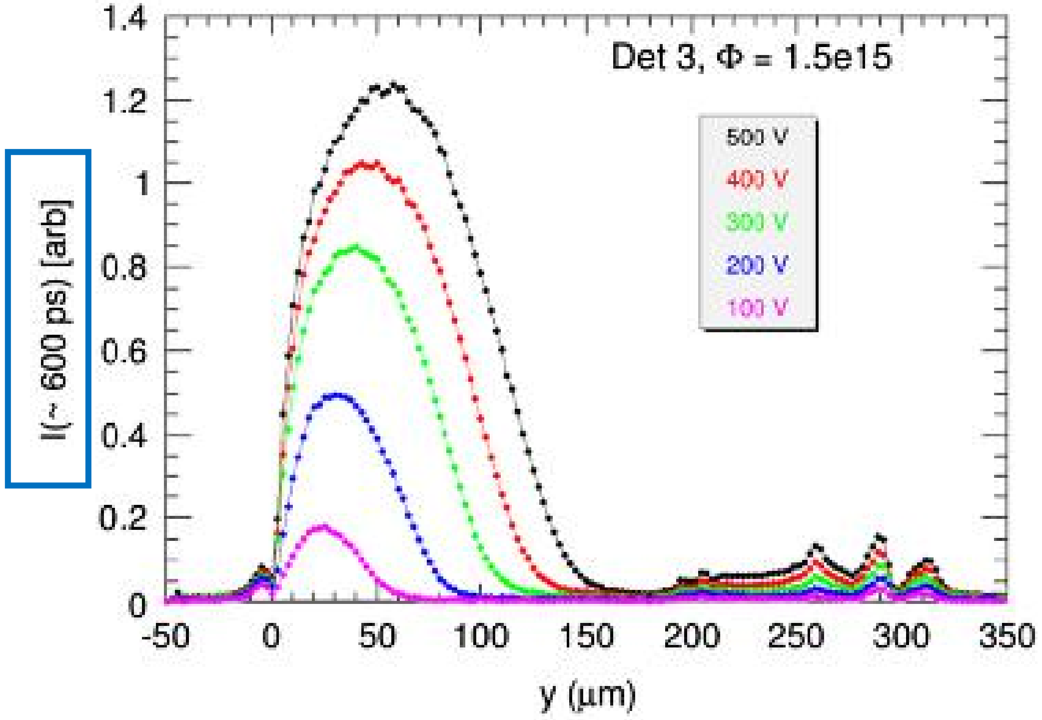


Fig10

Yuhang

- In fig.8, What is this part of 300-350um?
- Thickness of the detector strip sensor is 300um. But they did TCT measurement from -50~350um. Of cource there should be nothing in -50~0um and 300~350um. I personally think measurement in these 2 range is to comfirm whether the system works well.

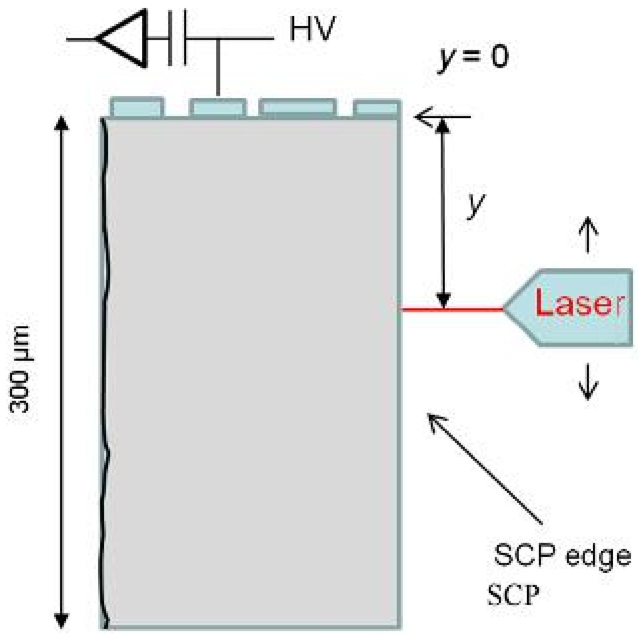
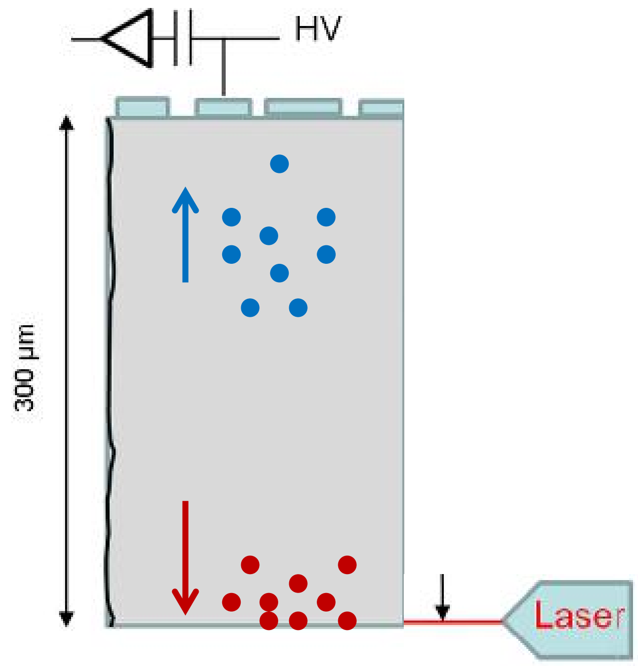


Fig. 6. Scheme explaining the Edge-TCT measurement.

Yuzhen

- In Fig10, there are some peaks at y=300um, why?

- We can easily get the conclusion that with y increasing, current at 600ps becomes smaller in total trend from Fig 7, due to how long the carriers take. Thickness of the detector strip sensor is 300um. What makes a peak at 300um may be that the carriers reach the bottom at the time they are produced. Time is shorter than y=280um for example. So the slope for 300um(if they draw the curve for 300um) must steeper than that for 280um, causing current at 600ps for 300um larger than 280um.



Comparison

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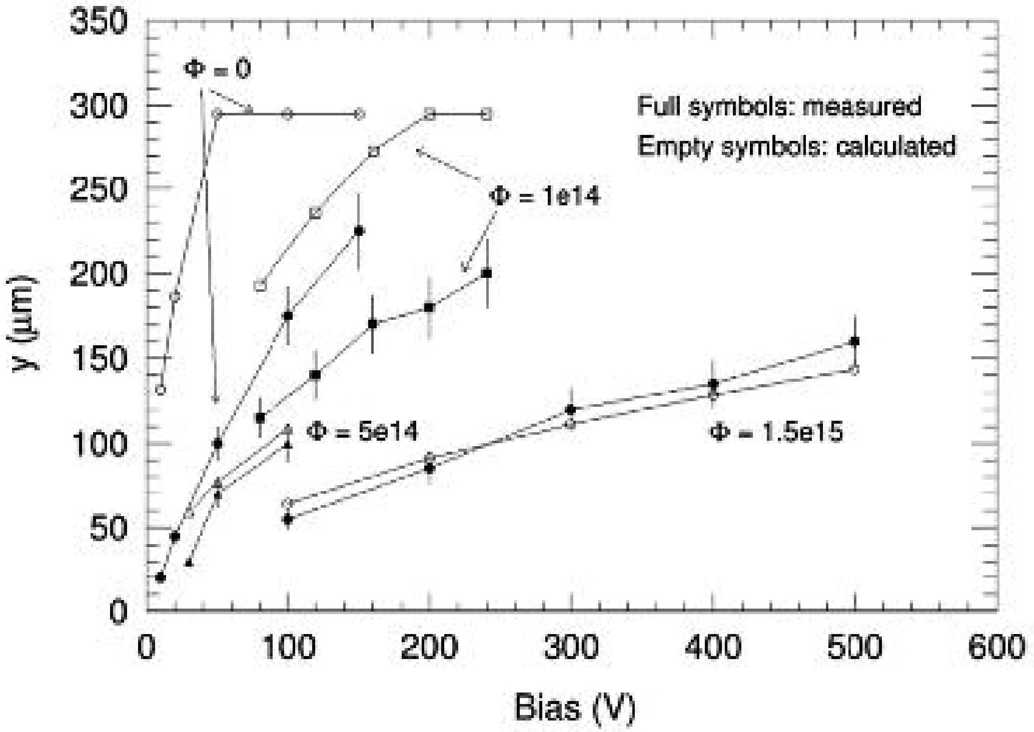

Fig. 11. Comparison of calculated depletion depth and the depth at which initial induced current $I(t\sim600\,\text{ps})$ on the detector edge measured with red light laser gets low.

Xin

- Could you explain on Fig. 11, there are quite discrepancies between measured and calculated depletion depth for phi = 0 and phi = 1e14, but fairly good agreement for phi = 1e15?

- They didn't take surface charge into consideration. For these 2 cases, influence of surface charge is important. But for irradiated case, space charge caused by neutron is more significant than surface charge.

Conclusion

- Top-TCT measurements with focused IR laser to measure charge collection properties near the processed edge
- Edge-TCT measurements with red light(penetration depth ~3um) to probe electric field on the surface of SCP treated edge

➢ Measurements with red laser confirmed the prediction that the accumulation of negative surface charge on the SCP processed edge due to passivation with Al_2O_3 would cause squeezing of equipotential lines to the top (strip) side of the detector.

➢ Measurements with IR light indicate that this field distortion does not extend far from the edge.

➢ The results with irradiated detectors indicate that the difference between the electric field profile at the edge and in the detector bulk gets smaller with increasing neutron fluence.