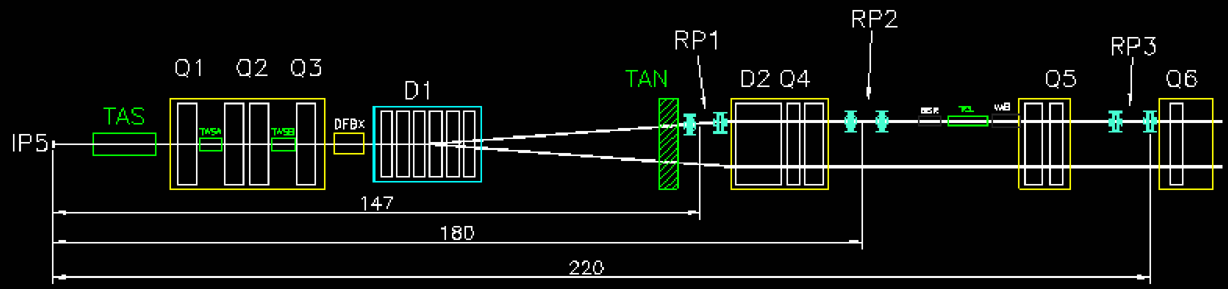
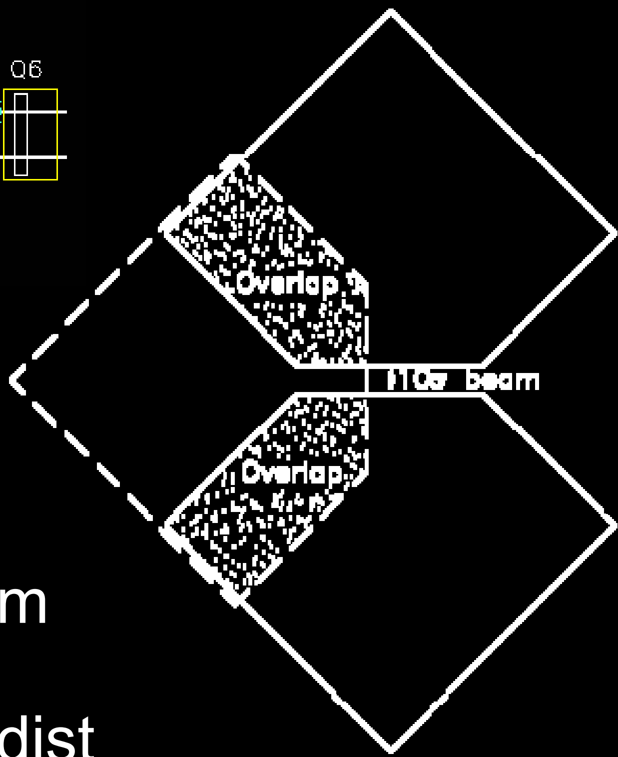
TOTEM: Roman Pot Testing

Advisers: Gennaro Ruggiero and Hubert Niewiadomski

Goals of TOTEM

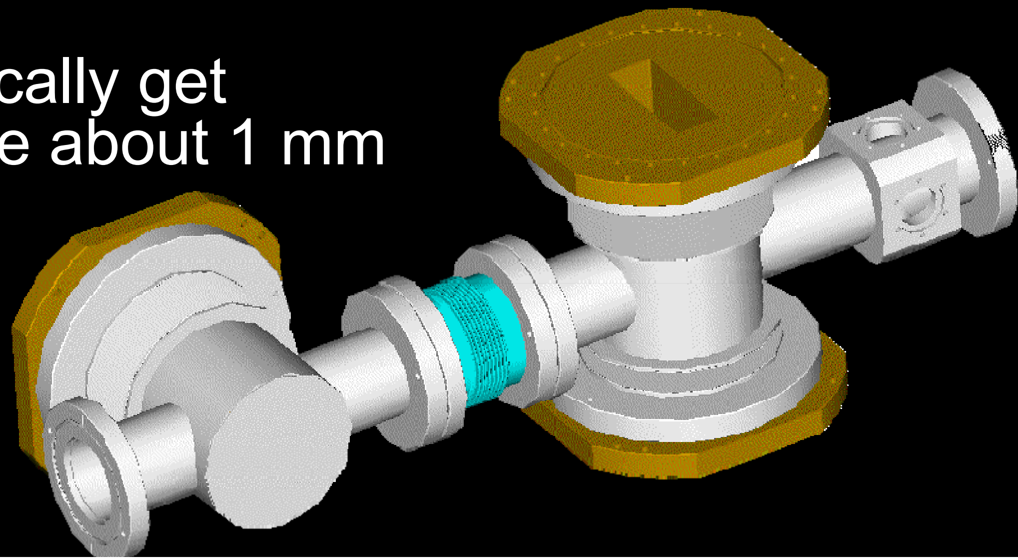
- To gain a better understanding of diffractive physics at very high pseudo-rapidity.
- To determine experimentally the scattering cross-section of protons
- To begin to understand the nature of pomerons.



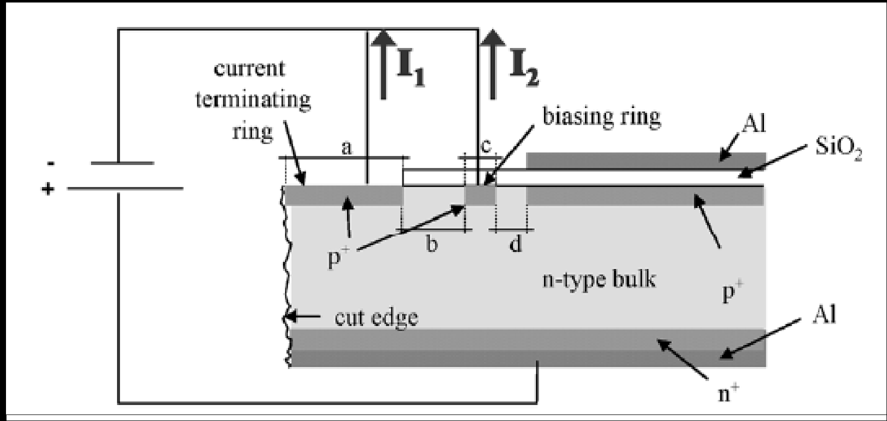


Roman Pots

- Placed directly in the beam pipe.
- ~1 μrad deflection with a dist to IP of ~1000 m gives us 1 mm
- We can physically get detectors to be about 1 mm of the beam.

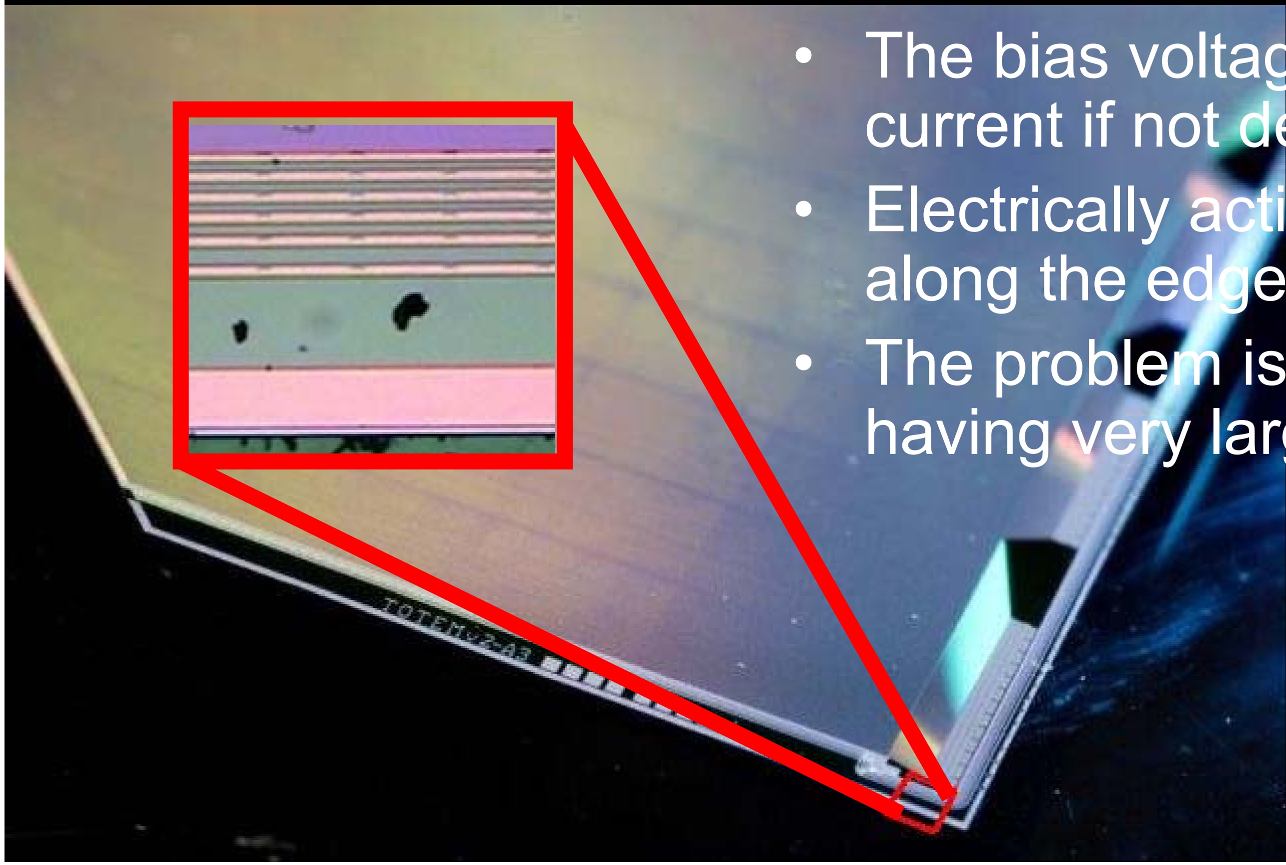


The Problems



- Large Dead Zones
- Radiation Hardness (i.e. ability to withstand large does of radiation and still function)
- Effects of Temperature Change

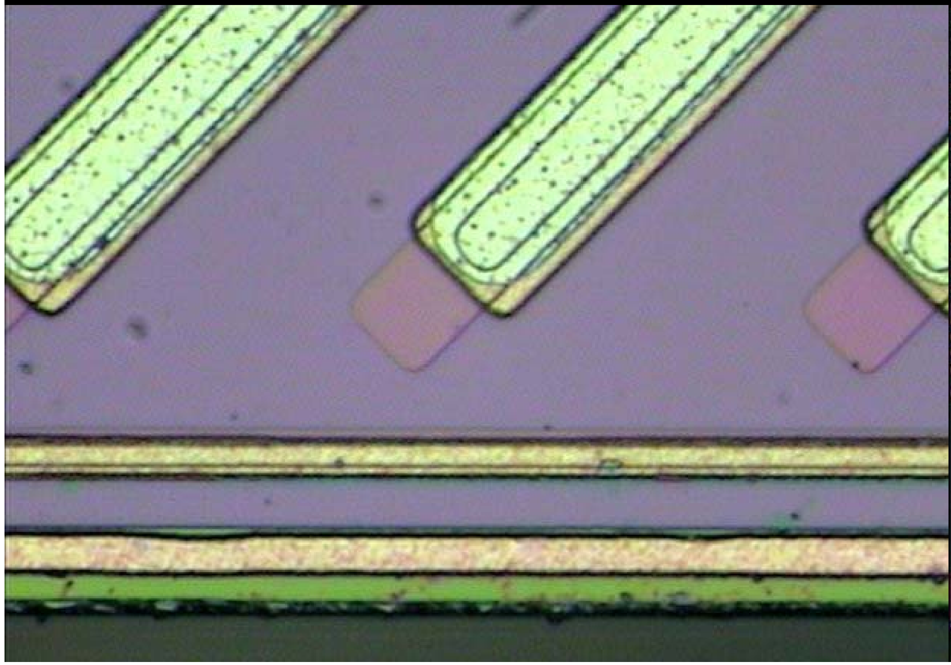
Voltage Termination

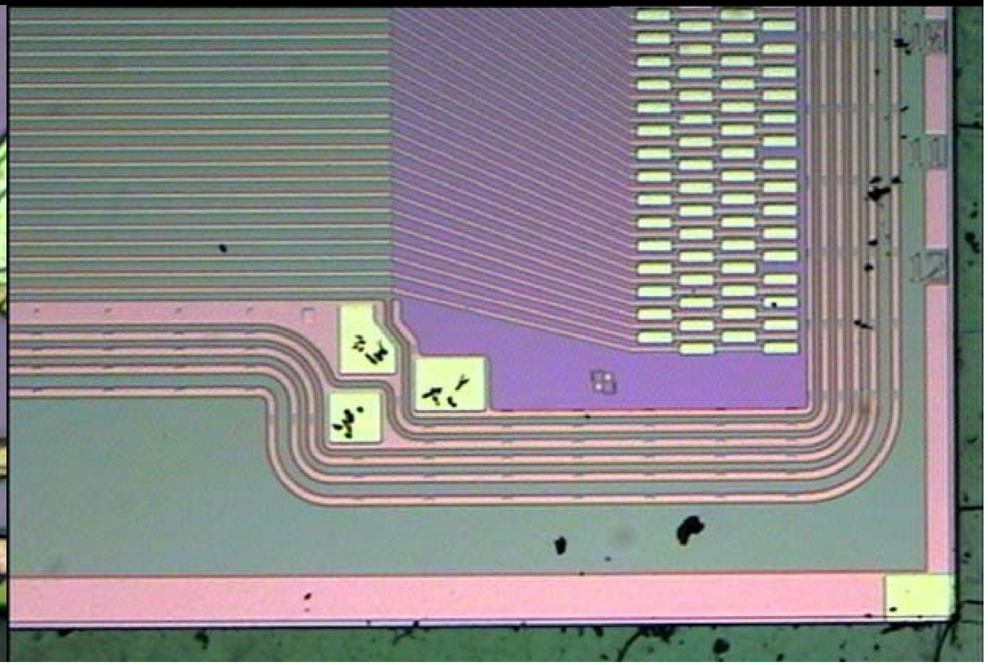


- The bias voltage will generate current if not decreased gradually
- Electrically active imperfections along the edge generate current.
- The problem is typically solved by having very large “dead zones”.

Current Termination

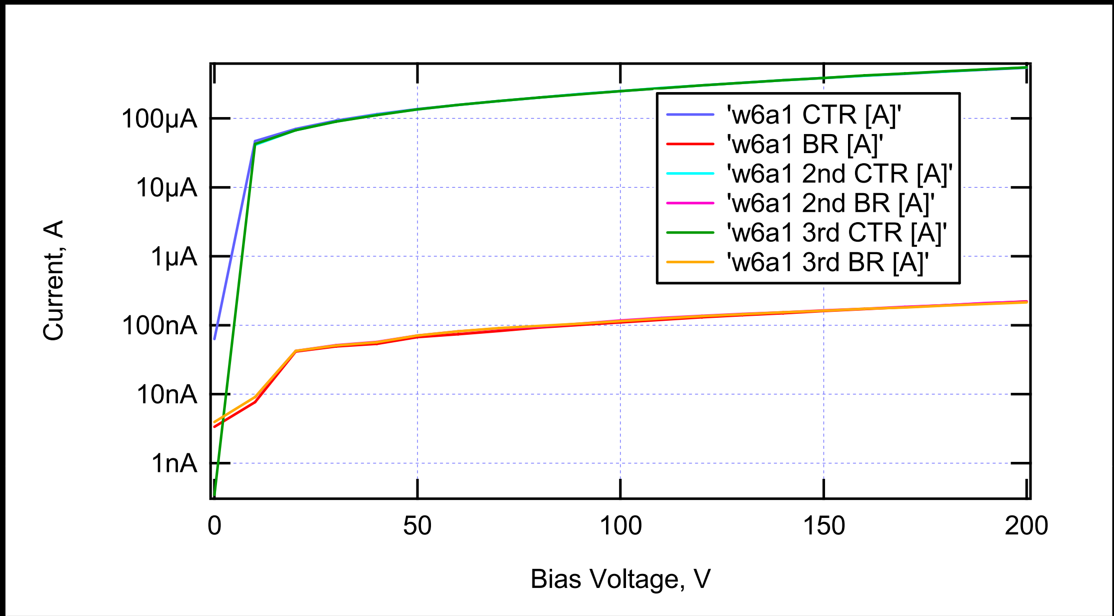
- Instead of having strips which reduce the voltage. We now have bands which take away the current.



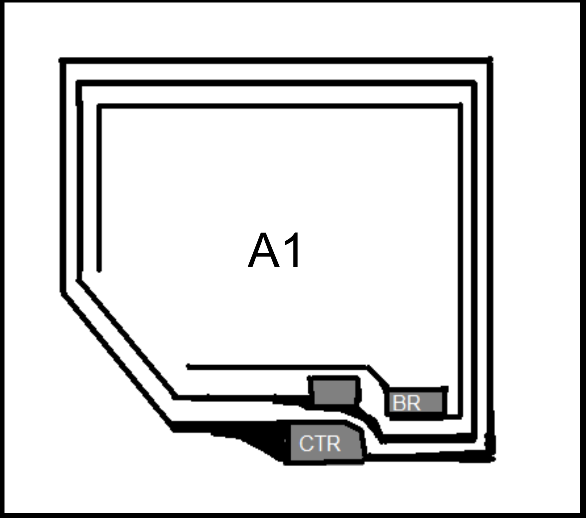


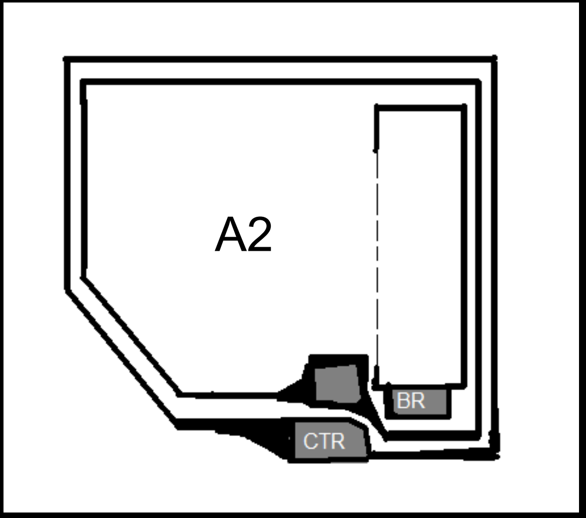
Does it Work?

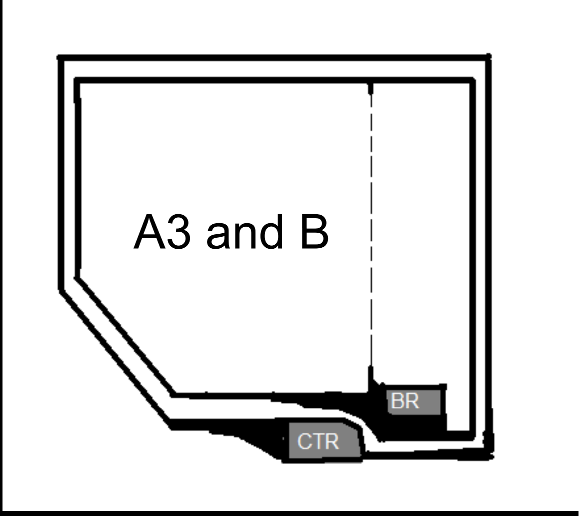
- Yes it does…
- Active edges 50 µm from edge



Different Designs…



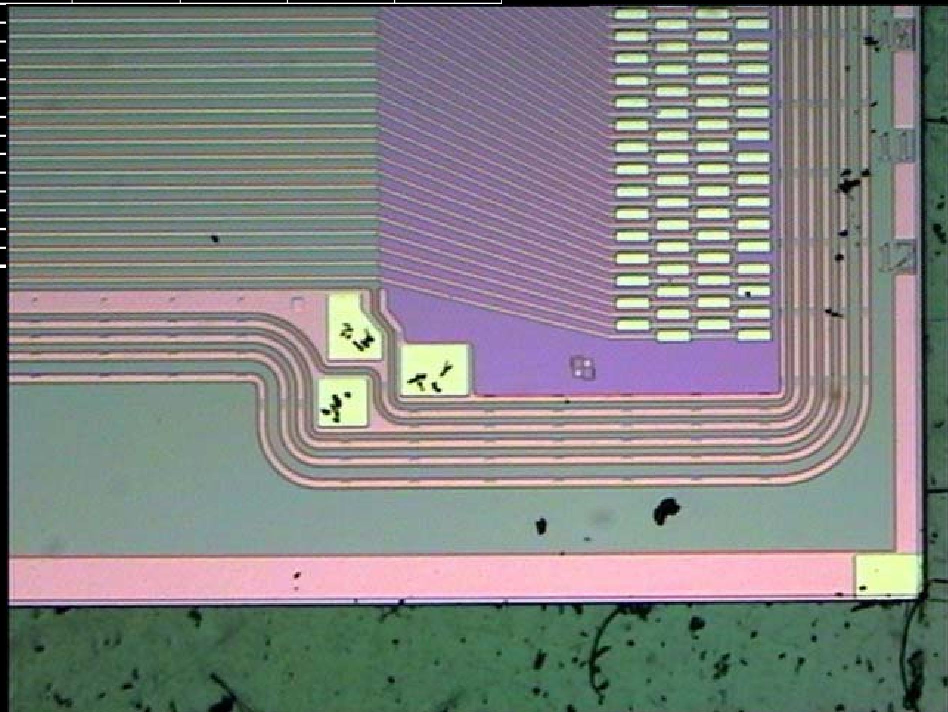




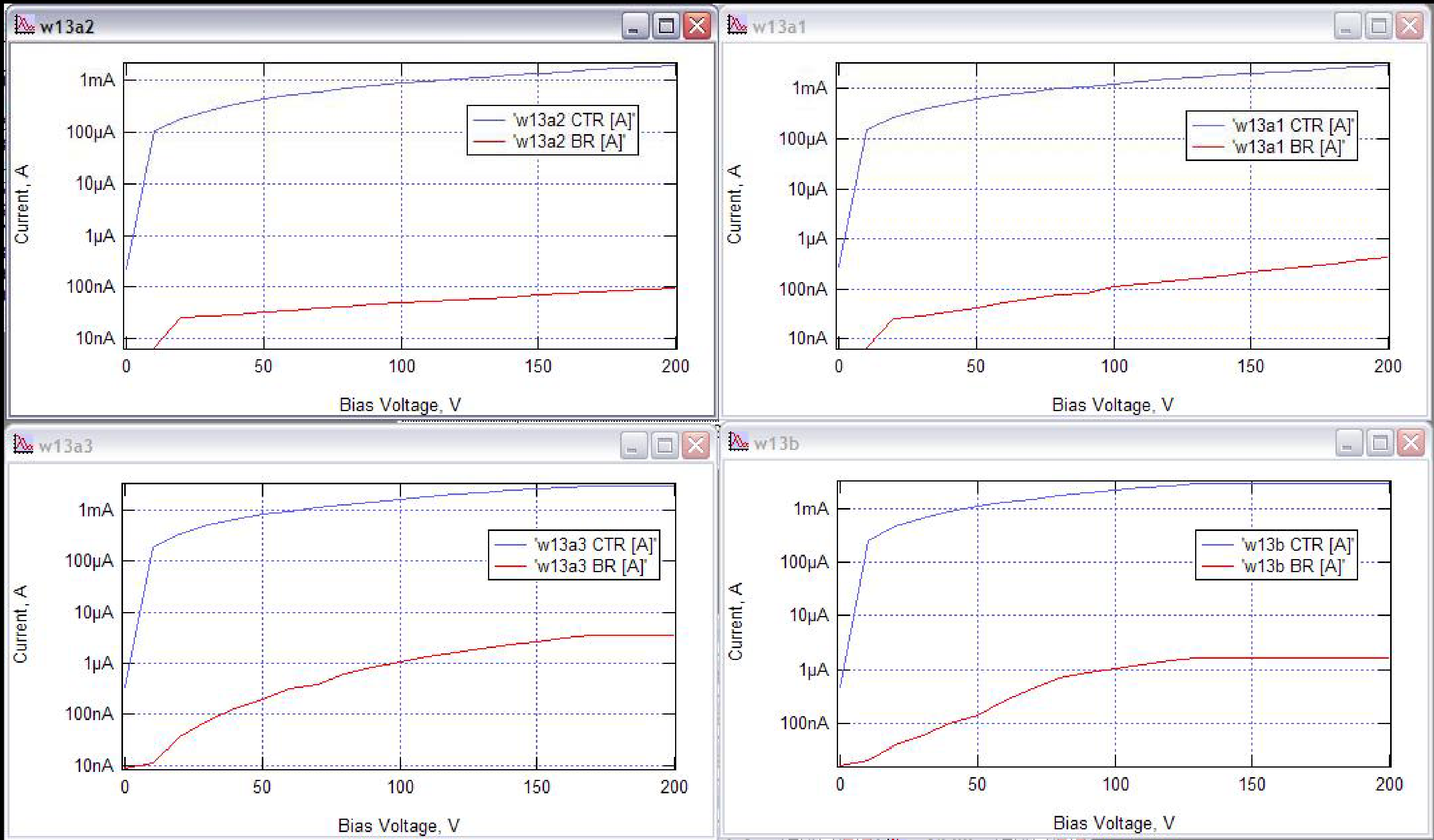
Point	'w6a1 3rd BR [A]'	'w6a2 BR [A]'	'w6a2 2nd BR [A]'	'w6a3 BR [A]'	'w6b BR [A]'	'w8a1 BR [A]'	'w8a3 BR [A]'	'w8b BR [A]'	'w10a1 BR [A]'	'w10a3 BR [A]'	'w10b BR [A]'
0	3.97e-09	4.052e-09	2.538e-09	8.661e-09	2.429e-08	-1.0043e-08	1.3925e-08	-3.239e-08	4.021e-09	-4.107e-08	-3.97e-09
1	9.108e-09	7.745e-09	6.897e-09	1.3565e-08	4.815e-08	7.914e-09	1.708e-08	4.206e-08	7.68e-09	2.998e-08	2.305e-08
2	4.264e-08	4.447e-08	2.983e-05	5.468e-08	3.93e-08	3.409e-08	4.962e-08	3.938e-08	3.101e-08	2.412e-08	2.958e-08
3	5.099e-08	4.556e-08	3.806e-05	6.908e-08	4.464e-08	4.174e-08	8.191e-08	4.422e-08	3.464e-08	4.364e-08	3.495e-08
4	5.717e-08	5.241e-08	3.018e-05	7.197e-08	4.993e-08	4.442e-08	1.2054e-07	5.03e-08	3.768e-08	5.591e-08	4.035e-08
5	7.098e-08	5.58e-08	0.0002519	1.0205e-07	5.561e-08	4.715e-08	1.6352e-07	5.764e-08	4.133e-08	6.767e-08	4.544e-08
6	8.173e-08	5.948e-08	4.3e-12	1.1985e-07	6.128e-08	5.003e-08	2.089e-07	6.581e-08	4.534e-08	7.728e-08	5.025e-08
7	9.133e-08	6.373e-08	1.8e-12	1.3842e-07	6.683e-08	5.311e-08	2.682e-07	7.393e-08	4.854e-08	8.569e-08	5.459e-08
8	9.843e-08	6.825e-08	2.5e-12	1.5677e-07	7.235e-08	5.628e-08	3.218e-07	8.257e-08	5.161e-08	9.335e-08	5.879e-08
9	1.0554e-07	7.327e-08	5.2e-12	1.7536e-07	7.811e-08	5.964e-08	3.785e-07	9.16e-08	5.36e-08	1.0068e-07	6.29e-08
10	1.1569e-07	7.89e-08	5.3e-12	1.9446e-07	8.449e-08	6.333e-08	4.392e-07	1.0074e-07	5.503e-08	1.0807e-07	6.43e-08
11	1.262e-07	8.509e-08	7.8e-12	2.139e-07	9.165e-08	6.727e-08	5.055e-07	1.0984e-07	5.883e-08	1.1544e-07	7.147e-08
12	1.3544e-07	9.225e-08	8.4e-12	2.341e-07	1.0003e-07	7.161e-08	5.421e-07	1.1917e-07	5.952e-08	1.2357e-07	7.601e-08
13	1.4455e-07	1.0059e-07	8.1e-12	2.554e-07	1.0968e-07	7.655e-08	6.512e-07	1.2863e-07	6.231e-08	1.3114e-07	8.058e-08
14	1.5386e-07	1.1065e-07	8.6e-12	2.785e-07	1.2122e-07	8.245e-08	7.309e-07	1.386e-07	6.519e-08	1.3842e-07	8.577e-08
15	1.634e-07	1.2265e-07	1.53e-11	3.038e-07	1.3529e-07	8.904e-08	8.149e-07	1.4935e-07	6.798e-08	1.4585e-07	9.153e-08
16	1.7268e-07	1.3781e-07	9.4e-12	3.321e-07	1.5189e-07	9.612e-08	9.053e-07	1.5237e-07	7.092e-08	1.5339e-07	9.756e-08
17	1.8134e-07	[illegible]	[illegible]	3.618e-07	1.7052e-07	[illegible]	[illegible]	1.7394e-07	[illegible]	1.5868e-07	1.0421e-07
18	1.9242e-07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	2.037e-07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	2.145e-07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21											

Different Performance...

- In general the a2 detectors have the best performance for a given series. Then typically the a1 or b and lastly comes the a3.



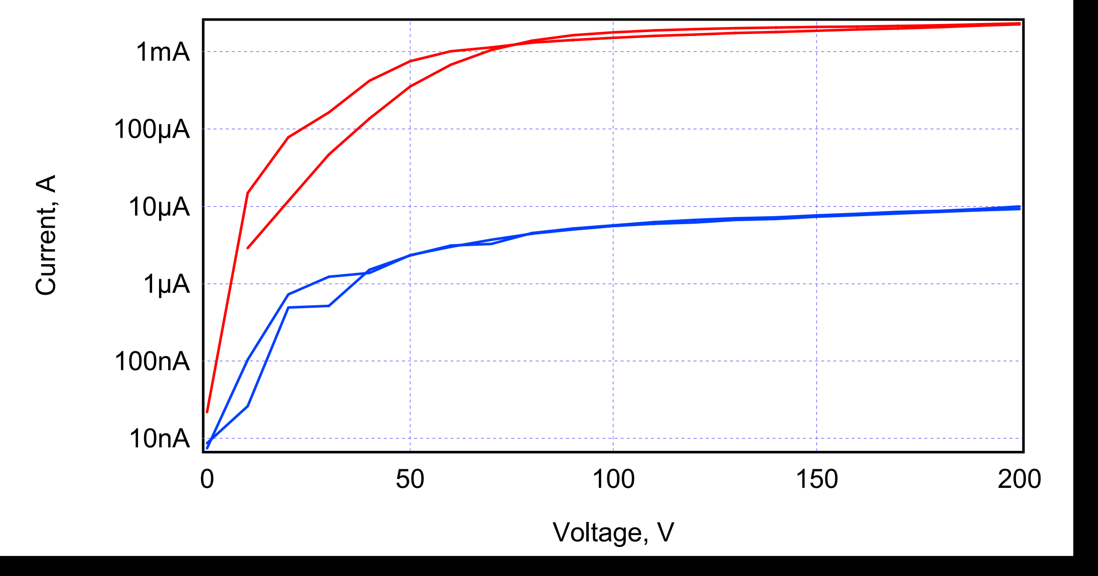
The Data



w13a2
1mA
100μA
10μA
1μA
100nA
10nA
Current, A
0
50
100
150
200
Bias Voltage, V
'w13a2 CTR [A]'
'w13a2 BR [A]'
w13a1
Current, A
Bias Voltage, V
'w13a1 CTR [A]'
'w13a1 BR [A]'
w13a3
Current, A
Bias Voltage, V
'w13a3 CTR [A]'
'w13a3 BR [A]'
w13b
Current, A
Bias Voltage, V
'w13b CTR [A]'
'w13b BR [A]'

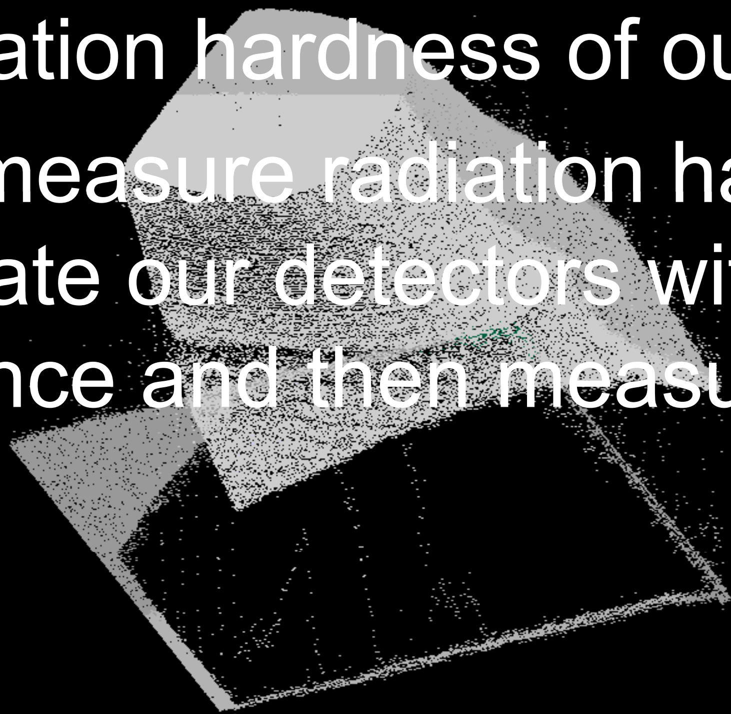
Plasma Etched Detectors

- Shows little or no improvement
- This one is 2 order of magnitude worse than w6a1.

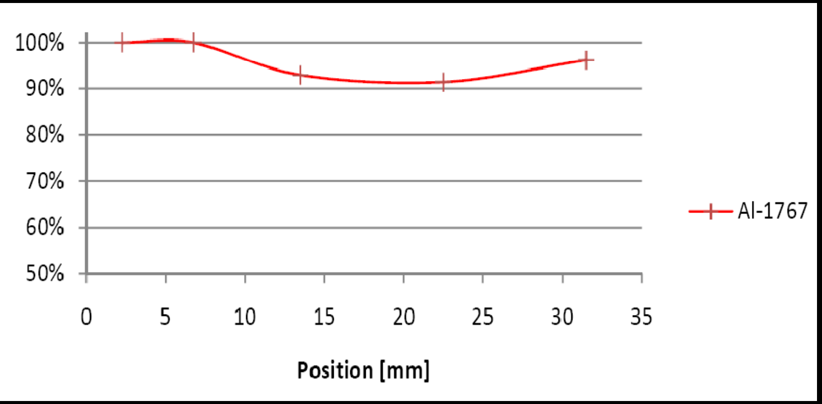


Radiation Hardness

- We now turn our attention to the radiation hardness of our detectors.
- To measure radiation hardness, we radiate our detectors with a specific fluence and then measure the effect



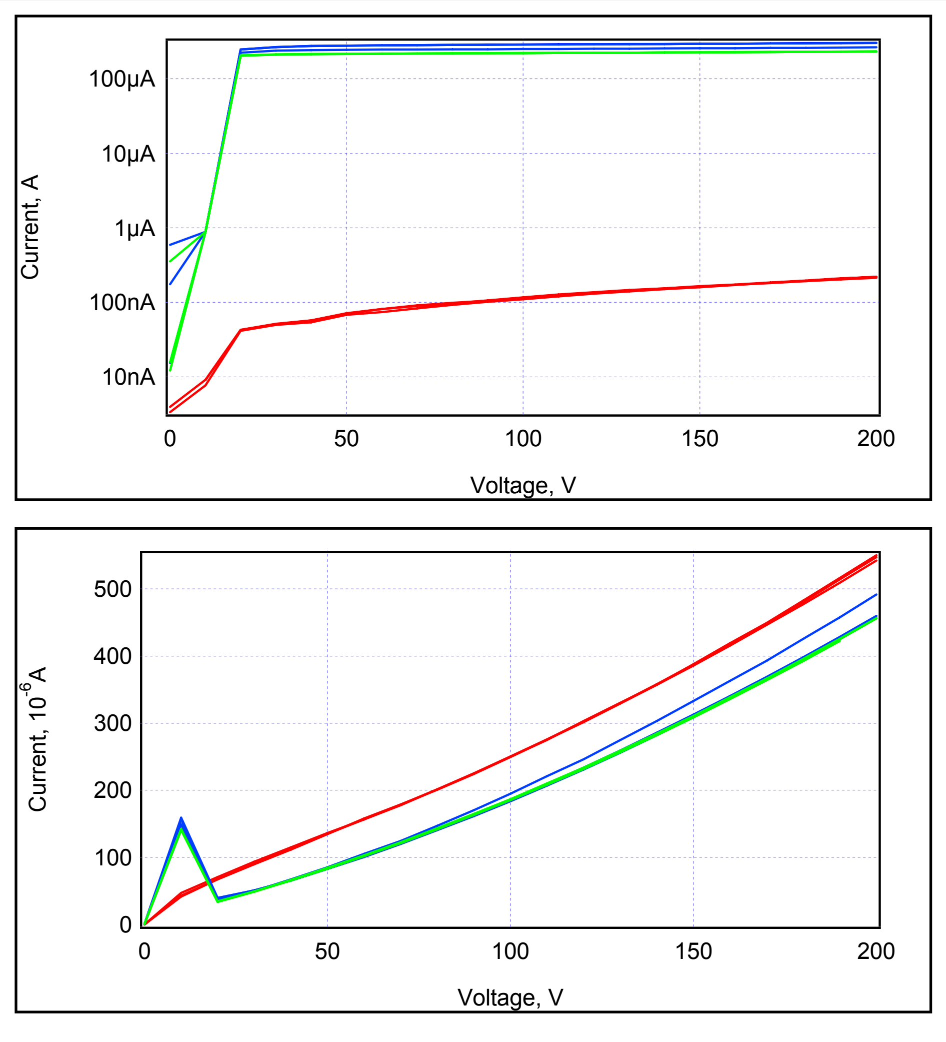
The Plan

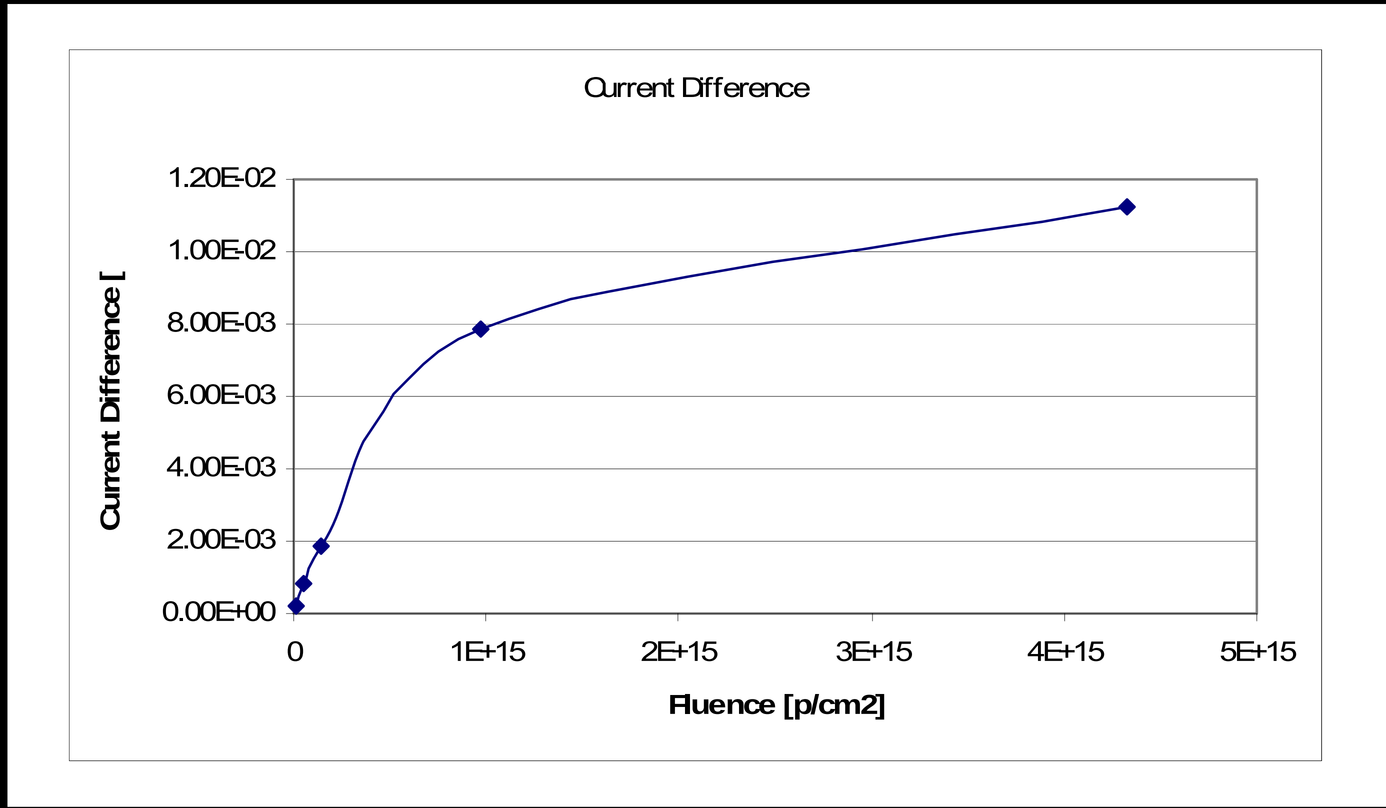


- First we irradiated five detectors with difference fluences:
  - w6a1 (10^{13} p/cm^2)
  - w6a2 (4.97×10^{13} p/cm^2)
  - w6a3 (1.44×10^{13} p/cm^2)
  - w8a3 (9.77×10^{14} p/cm^2)
  - w10a1 (4.32×10^{15} p/cm^2)
- Next, it was necessary to measure how the current changed.

Measurements

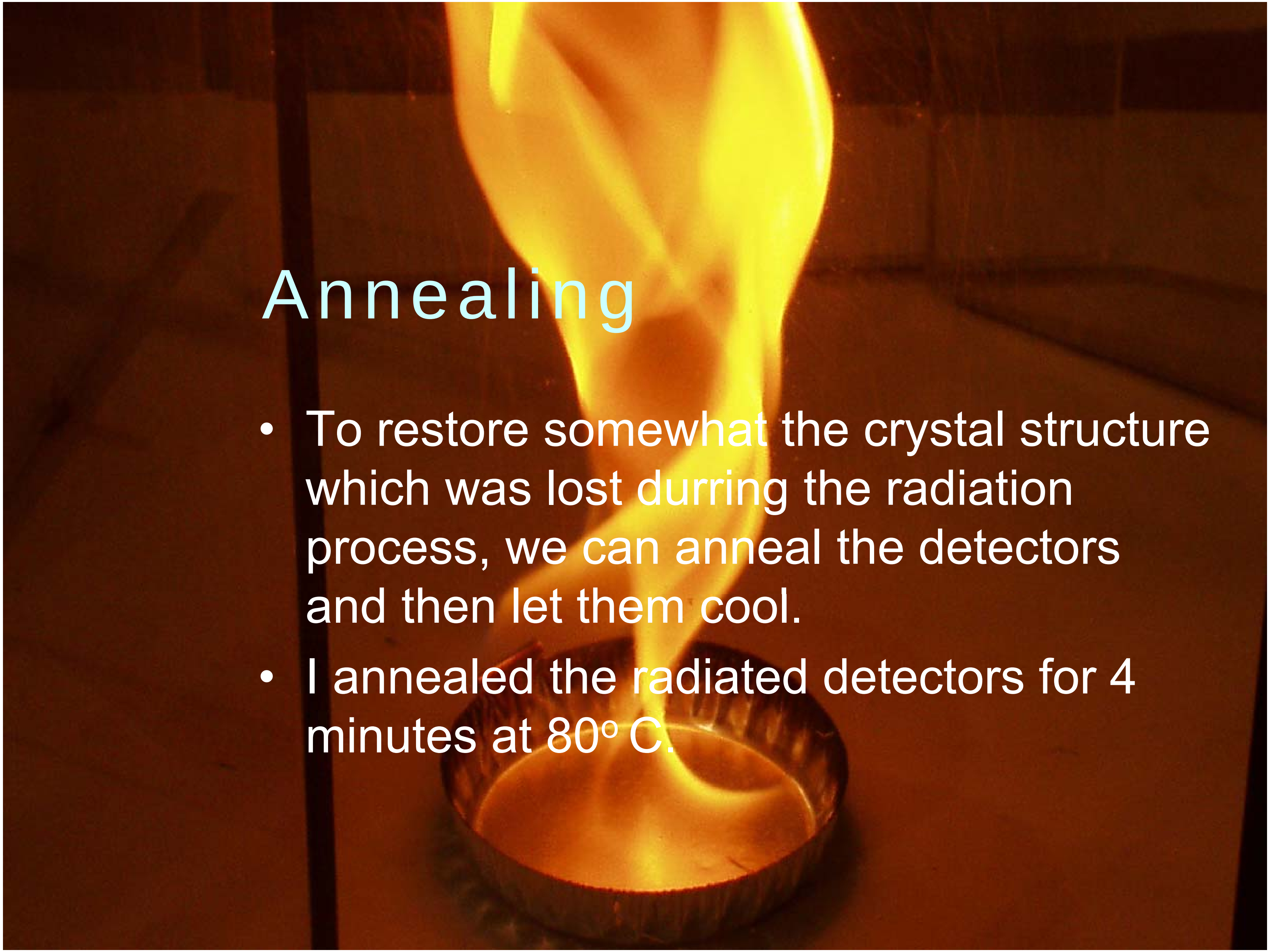
- Dramatic increase in the BR current (two to four orders of magnitude)
- Small decrease in the CTR current





Quantitative Connection

- As we can see from this graph, the current in the BR of the microchips increases as the fluence increases.
- Energy deposited by the radiation strikes in center increasing current in BR but having little effect near CTR.

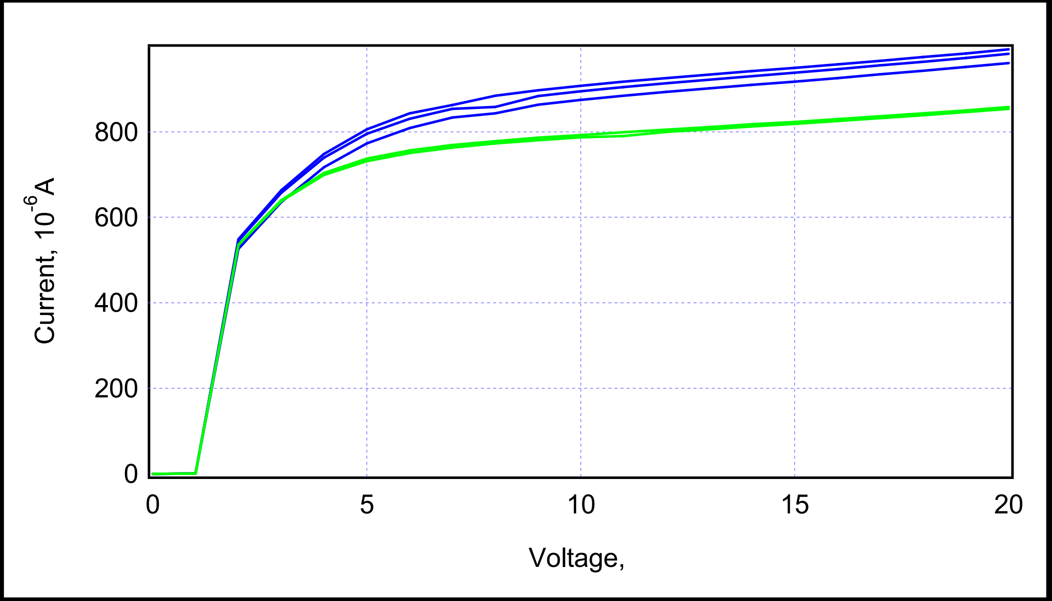


Annealing

- To restore somewhat the crystal structure which was lost durring the radiation process, we can anneal the detectors and then let them cool.
- I annealed the radiated detectors for 4 minutes at 80^{o} C.

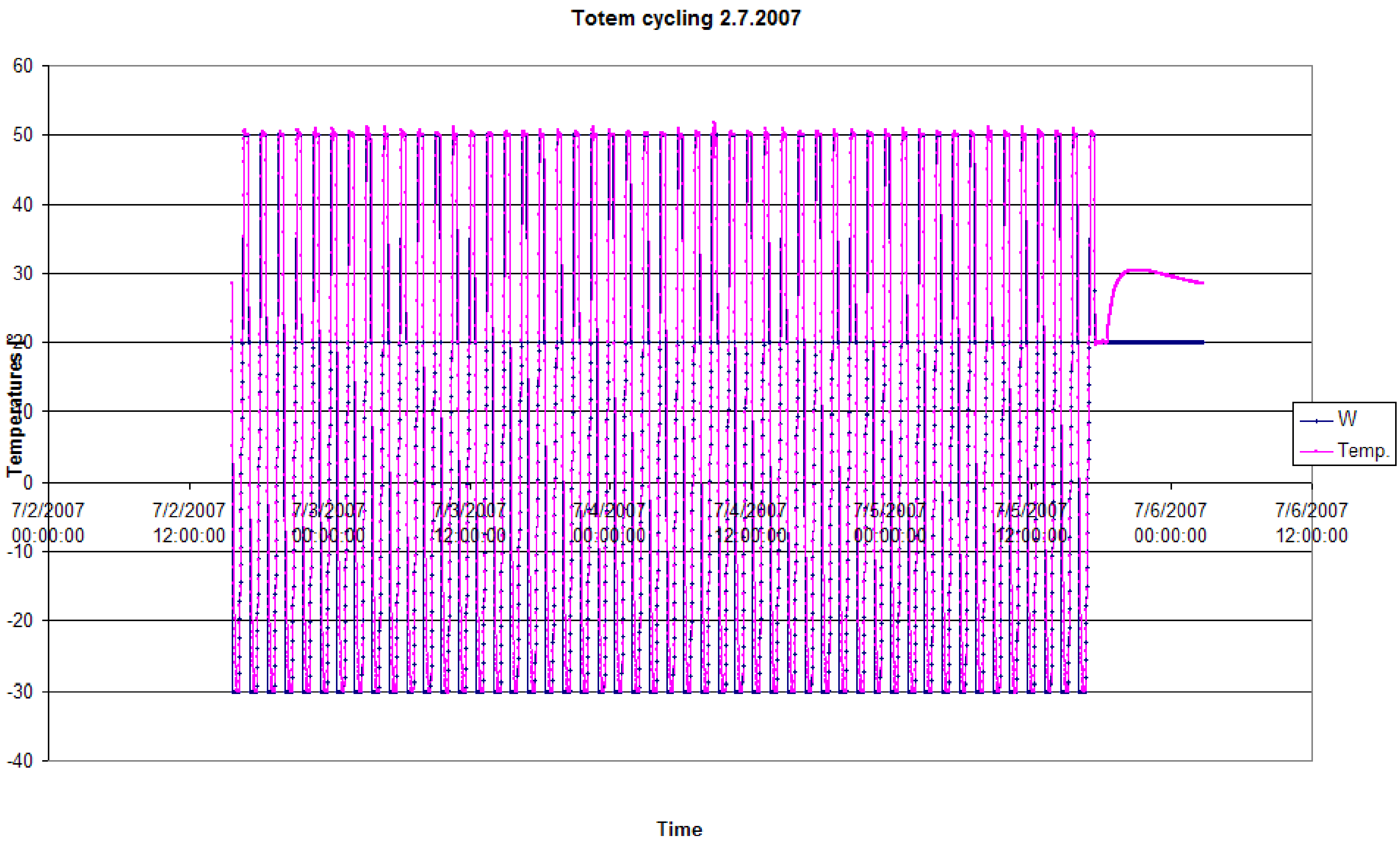
The Results

w3a3	15.88%
w6a1	19.69%
w6a2	12.56%
w8a1	8.25%
w11a3	9.96%
w12a1	13.92%



- In this graph you can see that the annealing does decrease the current in the BR.
- This decrease ranges from 8% to 20% depending on the chip.

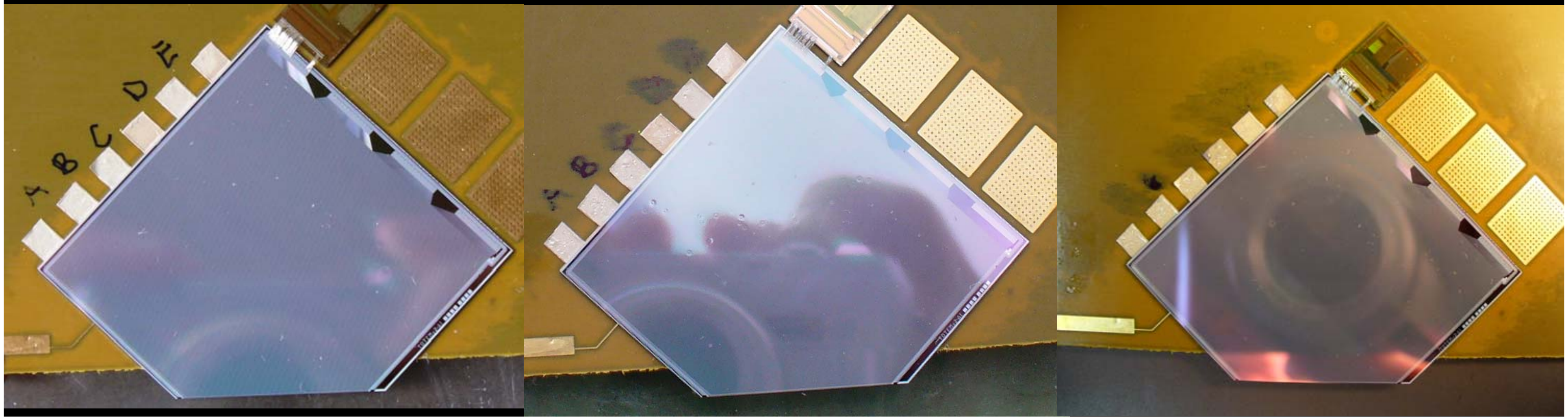
[redacted]



[redacted]

Analysis

- Nothing happened that couldn’t be attributed to water condensation and dirty detectors



Summary

- My research shows that the TOTEM detectors will be able to fulfill their purpose.
- The edgeless planar detectors are very capable of terminating the current and thereby maintaining sensitivity within 50 microns of the edge.
- Furthermore, the detectors should age well (they only begin to show serious problems at a fluence of about 10^{15} p/cm^2) provided the beam is not lost in their vicinity.
- Although annealing does help the detectors somewhat. It is not sufficient to counteract heavy radiation.
- It seems that rapid temperature fluctuations do not aversely affect the detectors.

Thanks

Dr. Gennaro Ruggiero

Mr. Hubert Niewiadomski

- The University of Michigan
- CERN Summer Students Program
- The National Science Foundation
- All of the Summer Students

Special Thanks To:

- Professor Jean Krisch
- Professor Hommer Neal
- Professor Steven Goldfarb
- Mr. Jeremy Herr

What I’ve Done Here

- Made friends
- Traveled around Europe
- Got in a Polish newsletter
- Sleep on a bench and get “attacked” by a Swiss Animal
- Went to Mass with the Royal Family of Liechtenstein
- Danced in a Salsa Club
- Ate brain
- Had a BLAST!!!