Test Beam Results of Sensors with Modified Pixel Implantations

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REINER Pixel Design

REdesigned, INnovative, Exciting and Recognizable

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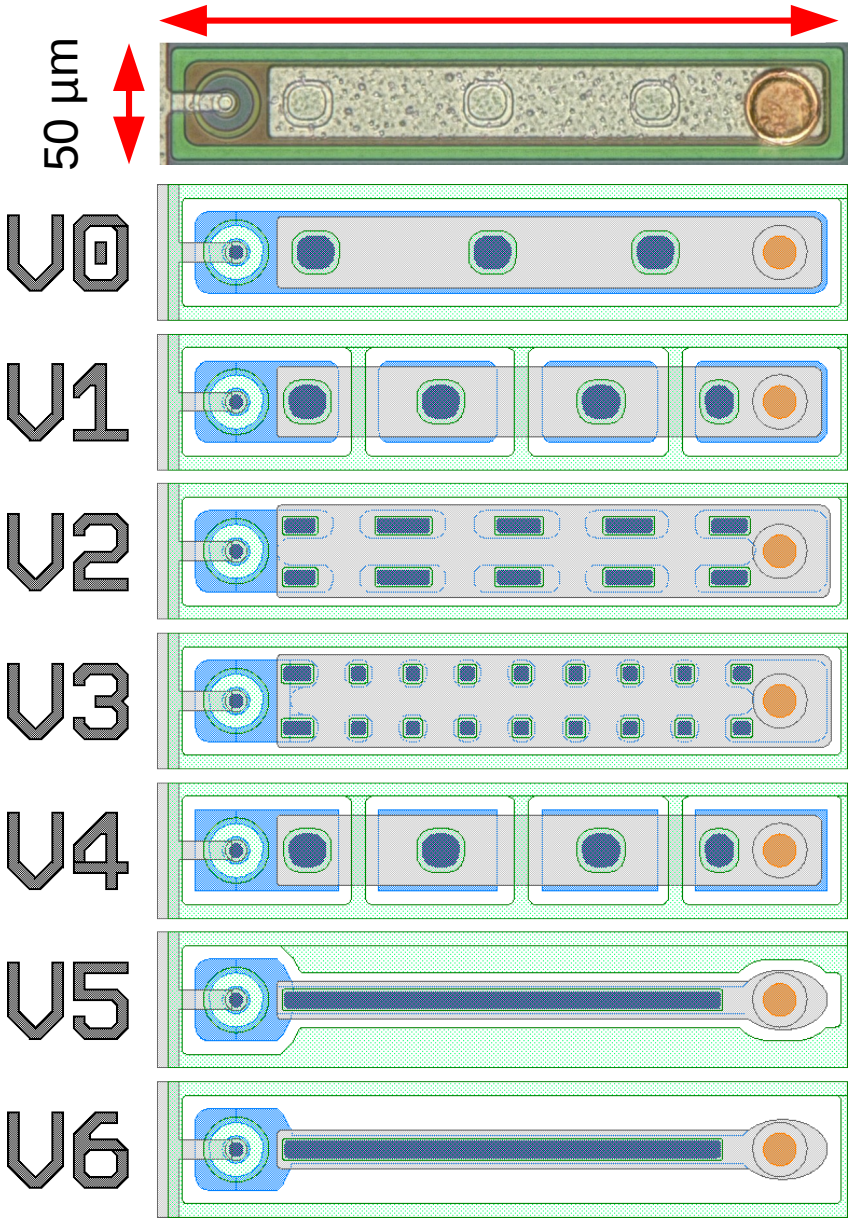
- Pixel size: 250 µm x 50 µm (same as for IBL, Innermost detector of the ATLAS Experiment)
- Six modified designs
  - Three divided in 4/10/18 sub implants
  - One with rectangular corners
  - Two with narrowed n^+ implant

V0: IBL-standard
V1-V6: modified

Blue: n^+
Grey: metal
Green: Ni openings

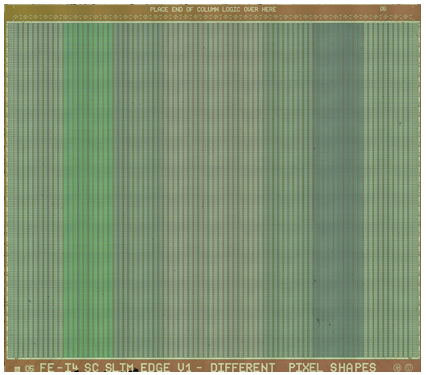
- n^+-in-n wafer process
- Sensor thickness 200 µm

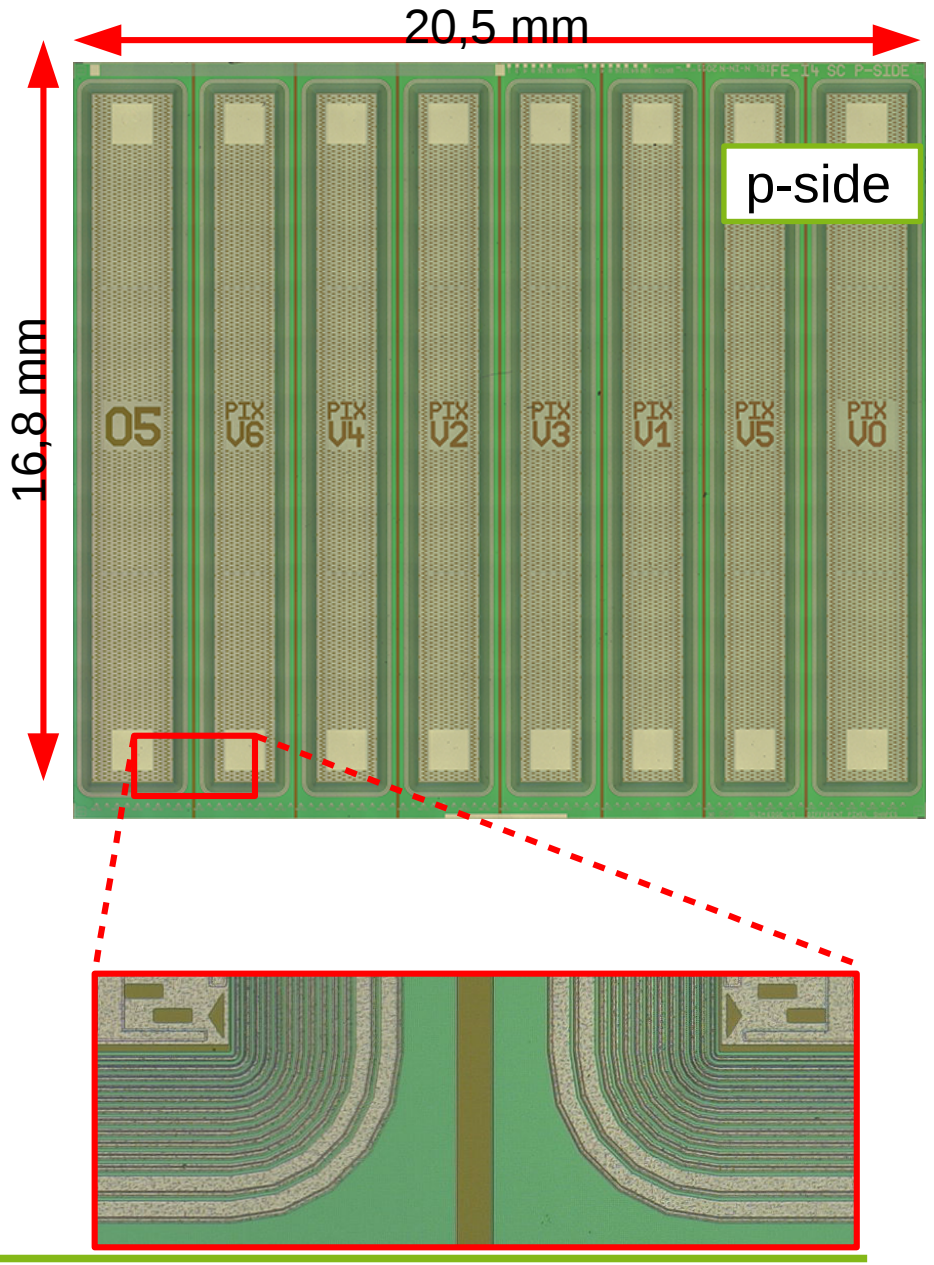


REINER Pixel Sensors

- Eight structures on one sensor
  - Two IBL designs (V0 & 05)
  - Six modified designs
- Each structure consists of 10 columns x 336 rows with the same design
- Separate HV pads
- Individual guard rings
- Readout by one FE-I4

n-side





REINER Pixel Sensors: Testbeam

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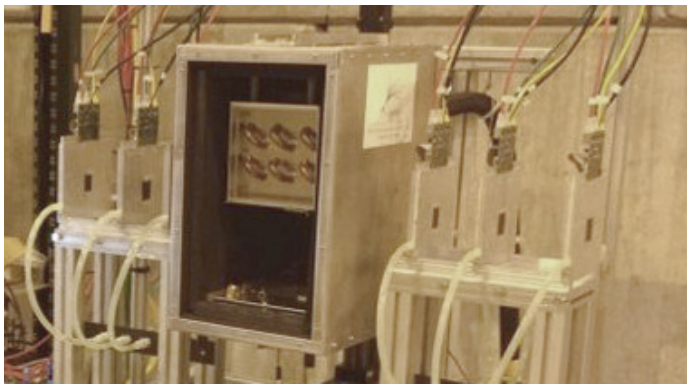
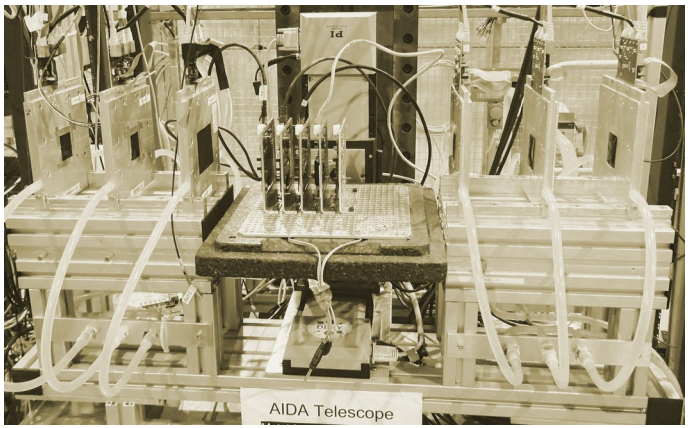
August 2016

- 120 GeV Pions
- ACONITE Telescope
- Chiller: -40°C
- R1: irrad. to 5×10^{15} n_{eq}/cm^2, Neutrons in Sandia
- R2: non-irrad.
- Different sensor positions, tunings, voltages



July 2017

- 40 GeV Pions
- AIDA Telescope
- Dry ice
- R2: irrad. to ~6×10^{15} n_{eq}/cm^2, Protons at CERN PS
- Different sensor positions, tunings, voltages



Testbeam Analysis: TBMon2

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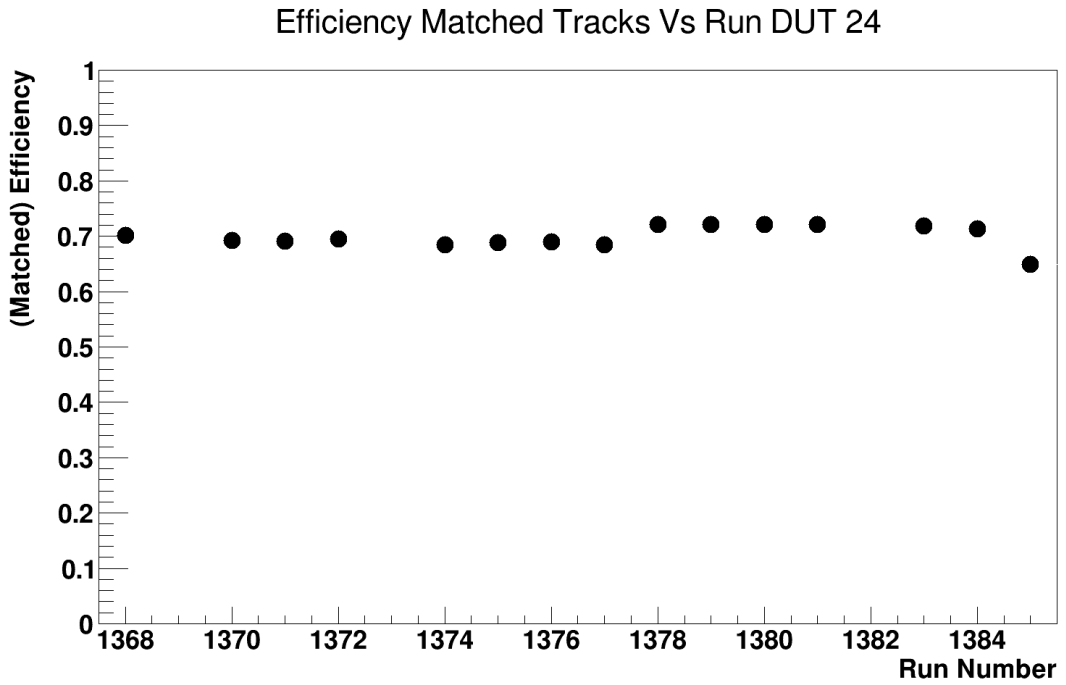
So far:

- Efficiency (complete sensor)

```
[ Efficiency ]: Efficiency (match; no edge pixels included): 0.958871 +- 0.000131935
[ Efficiency ]: DUT 24
[ Efficiency ]: Tracks raw:          6641152
[ Efficiency ]: Tracks good:         2322248
[ Efficiency ]: Tracks good region: 946581
[ Efficiency ]: Tracks:              946581
[ Efficiency ]: Tracks w/ hit:       664785
[ Efficiency ]: Efficiency (match; no edge pixels included): 0.702301 +- 0.000469971
[ Efficiency ]: DUT 25
```

- EfficiencyVsRun (complete sensor)



Testbeam Analysis: TBMon2

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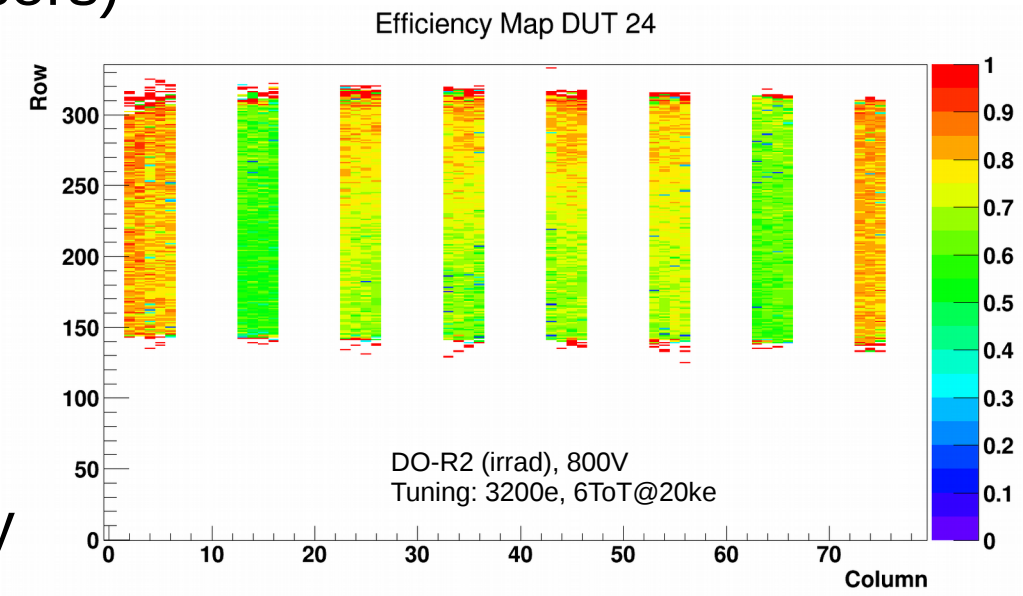
- TBMon2: Groups pixel in geometries
- REINER sensor: Interested in efficiency of each geometry
- (Special pixel type on quad sensors)



- New Tool: EfficiencyVsGeometry
  - Uses geometries
  - Efficiency vs run for each geometry
  - Efficiency vs geometry

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Testbeam Analysis: TBMon2

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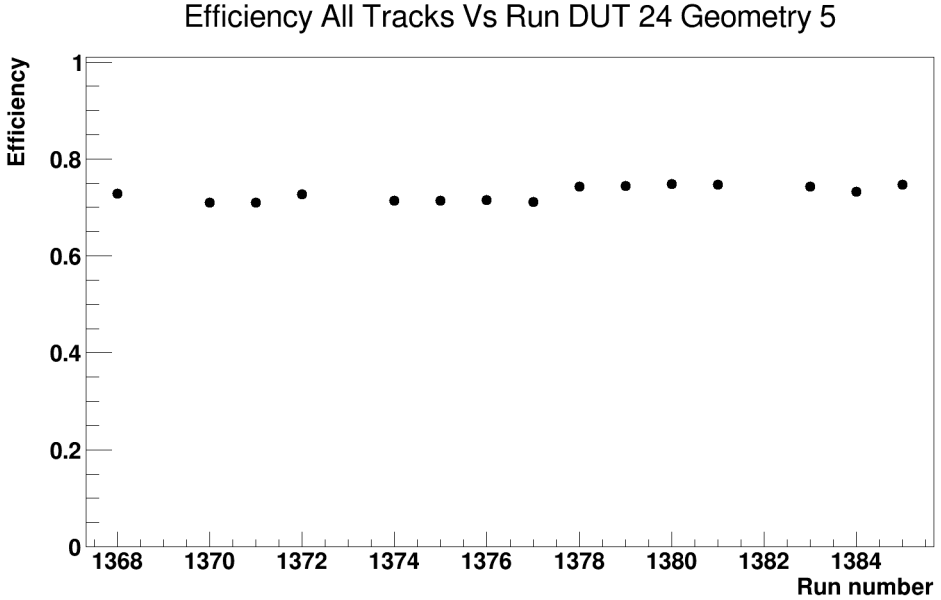
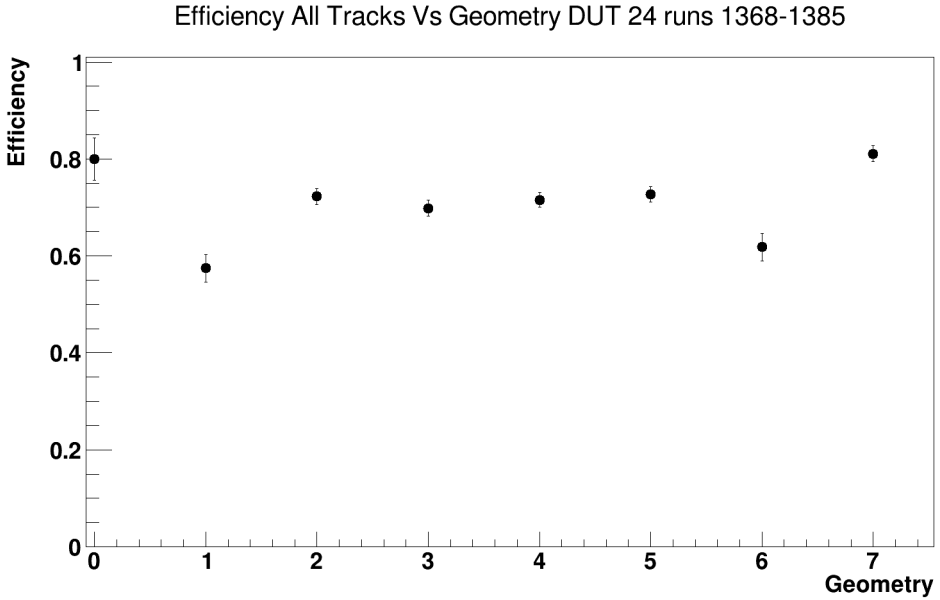
EfficiencyVsGeometry Output:

```
[ EfficiencyVsGeometry ]:          Geometry: 5 run: 1376  Efficiency: 0.715027 +- 0.00377997 tracks: 14261
[ EfficiencyVsGeometry ]:          Geometry: 5 run: 1377  Efficiency: 0.710806 +- 0.00394953 tracks: 13178
[ EfficiencyVsGeometry ]:          Geometry: 5 run: 1378  Efficiency: 0.742648 +- 0.00372067 tracks: 13806
[ EfficiencyVsGeometry ]:          Geometry: 5 run: 1379  Efficiency: 0.744087 +- 0.00364493 tracks: 14333
[ EfficiencyVsGeometry ]:          Geometry: 5 run: 1380  Efficiency: 0.748779 +- 0.00364853 tracks: 14131
[ EfficiencyVsGeometry ]:          Geometry: 5 run: 1381  Efficiency: 0.747065 +- 0.00365534 tracks: 14142
[ EfficiencyVsGeometry ]:          Geometry: 5 run: 1383  Efficiency:  0.74232 +- 0.00621757 tracks: 4948
[ EfficiencyVsGeometry ]:          Geometry: 5 run: 1384  Efficiency: 0.732719 +- 0.00548482 tracks: 6510
[ EfficiencyVsGeometry ]:          Geometry: 5 run: 1385  Efficiency: 0.747001 +- 0.0101513 tracks: 1834
[ EfficiencyVsGeometry ]: Summary Geometry: 5             Efficiency: 0.727493 +- 0.0158082 tracks: 156620
```





REINER Pixel Sensors: Results

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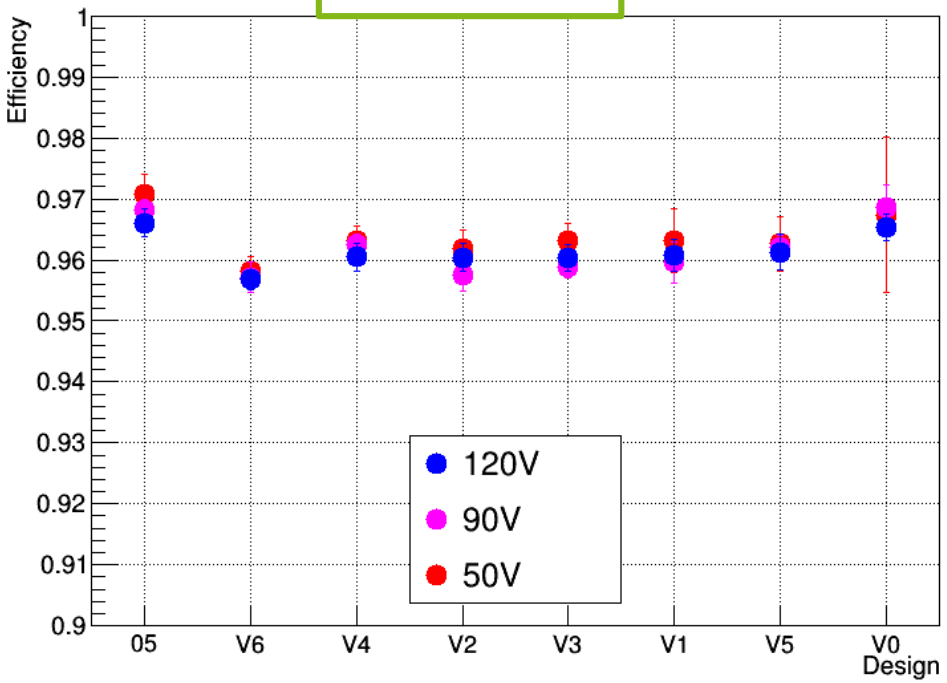
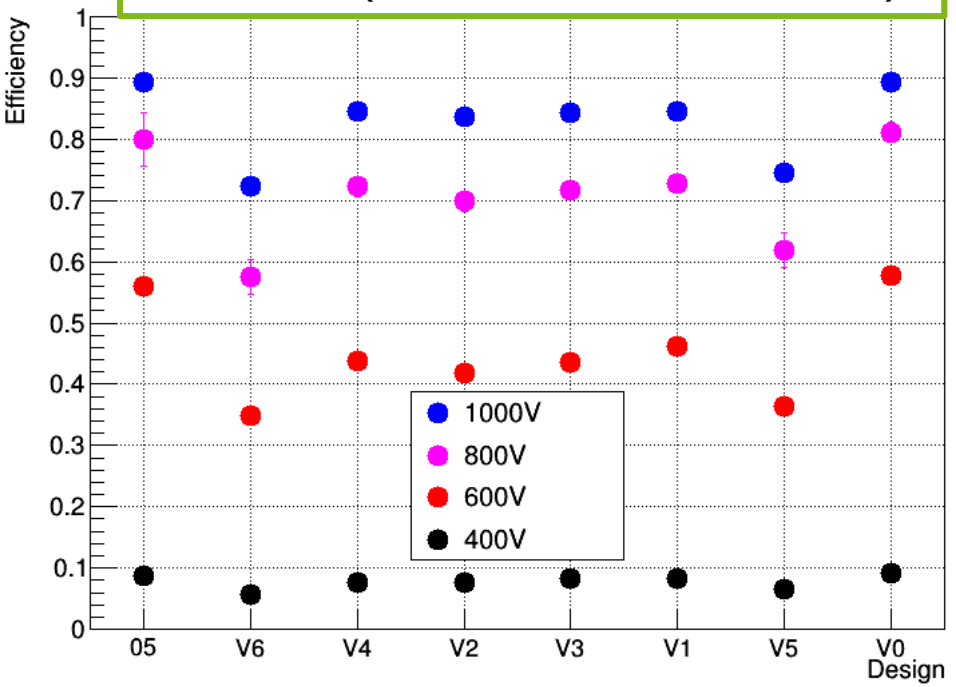
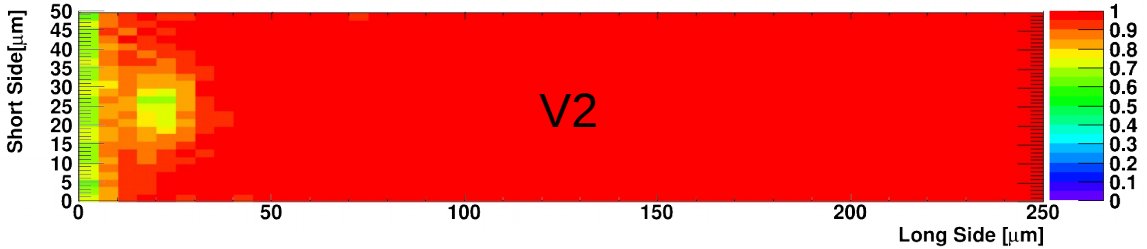
- Efficiencies of different designs for sensor DO-R2

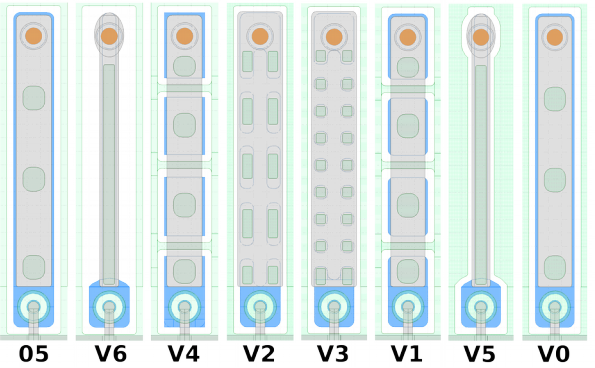
unirradiated



Irradiated (Protons 6×10^{15} n_{eq}/cm^2)







Tuning: 3200e, 6ToT@20ke

REINER Pixel Sensors: Results

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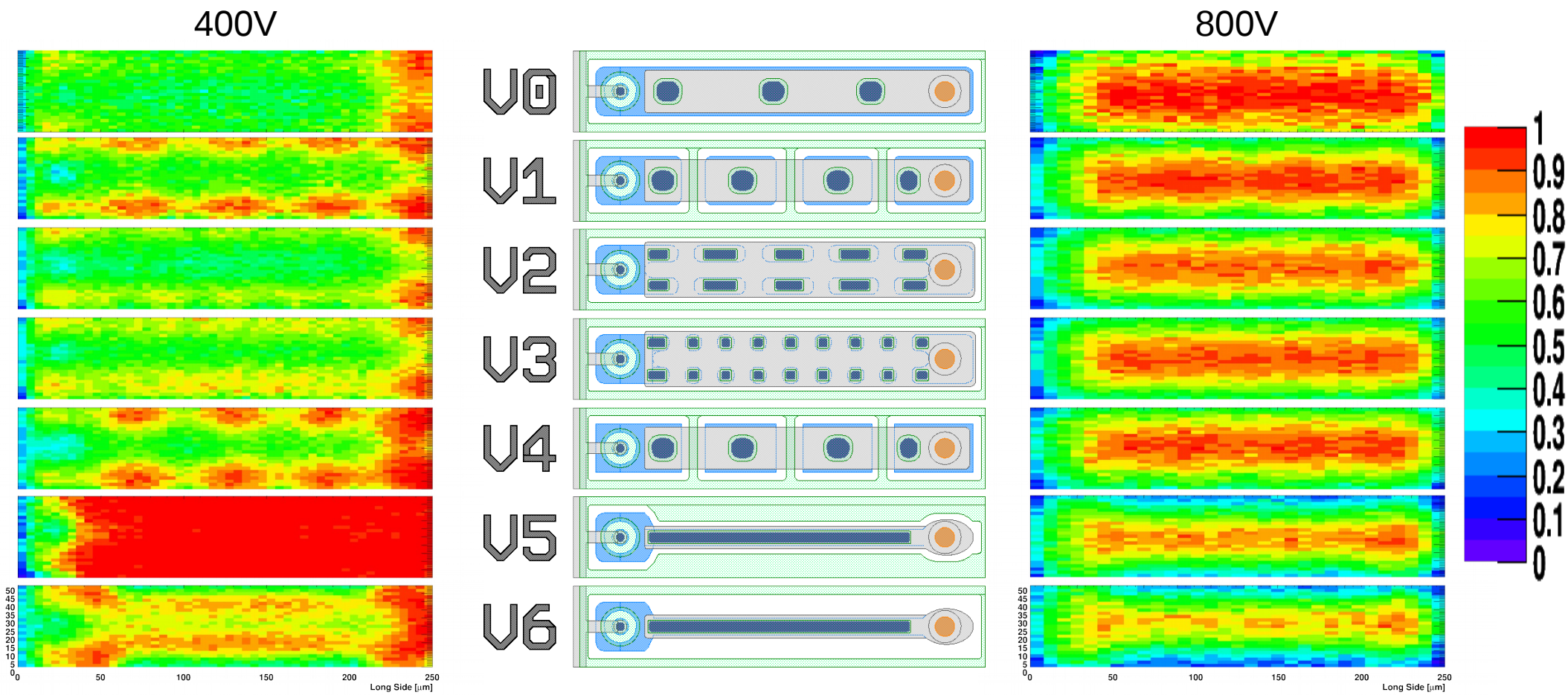
- Efficiencies of different designs for two irradiated sensors

Irradiated (Neutrons 5×10^{15} n_{eq}/cm^2)

Irradiated (Protons 6×10^{15} n_{eq}/cm^2)



Tuning: 3200e, 6ToT@20ke

REINER Pixel Sensors: Results

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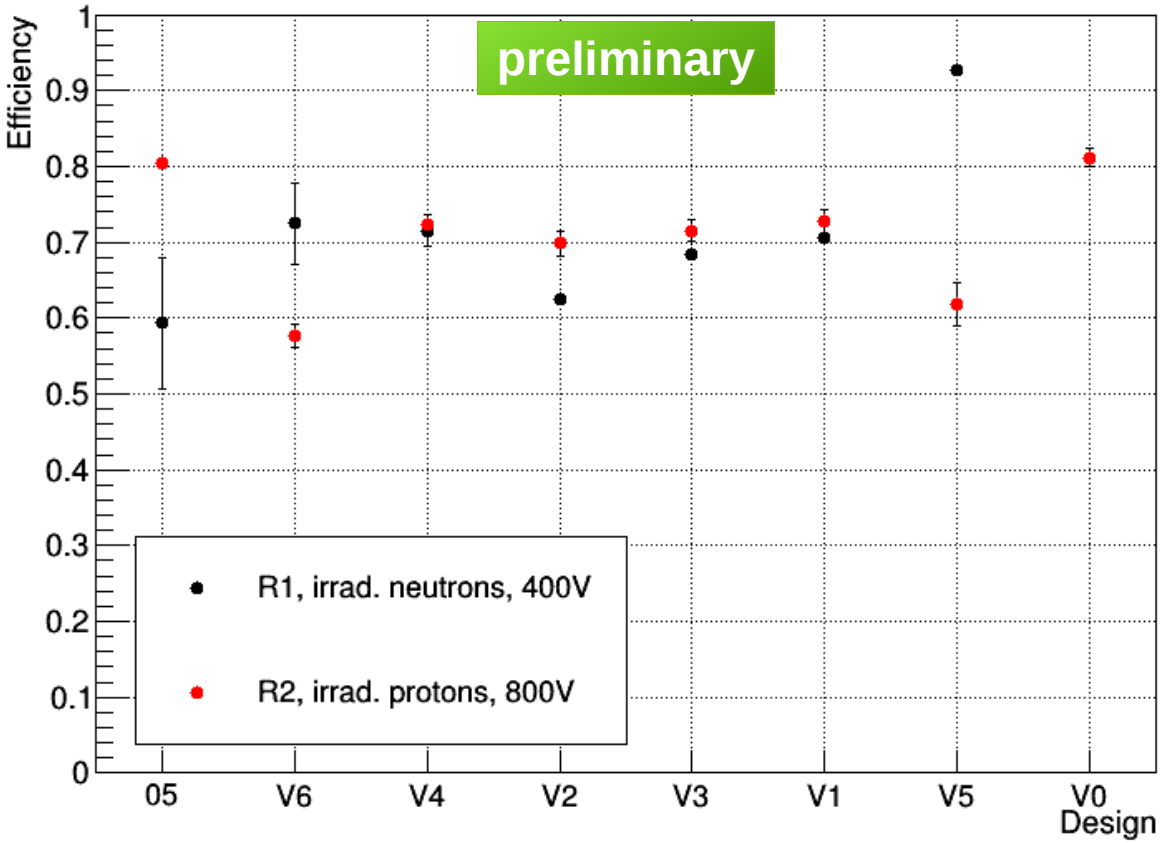
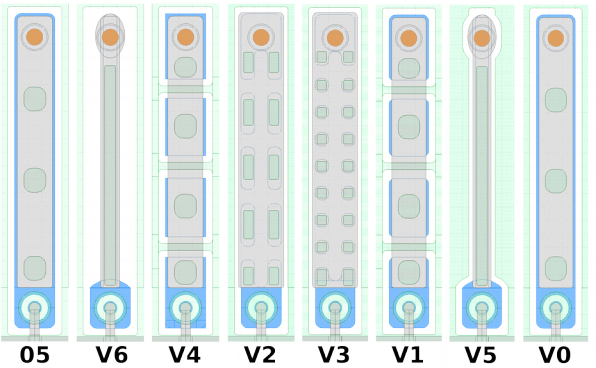
Efficiencies of different designs



Tuning: 3200e, 6ToT@20ke

- Fluences:
  - R1: 5×10^{15} n_{eq}/cm^2 (Neutrons)
  - R2: 6×10^{15} n_{eq}/cm^2 (Protons)
- Sensor temperature:
  - T(R2)<T(R1)
- Voltages:
  - R1: 400V
  - R2: 800V



Conclusion & Outlook

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- REINER Pixel Sensors:
  - Lab and testbeam measurements
  - Different results for proton and neutron irradiated assemblies
- ➔ Preparing ten modules to be irradiate to different fluences with protons and neutrons
- ➔ Further testbeam measurements

- Adapted new analysis tool for TBMon2: EfficiencyVsGeometry

REINER Pixel Sensors: Results

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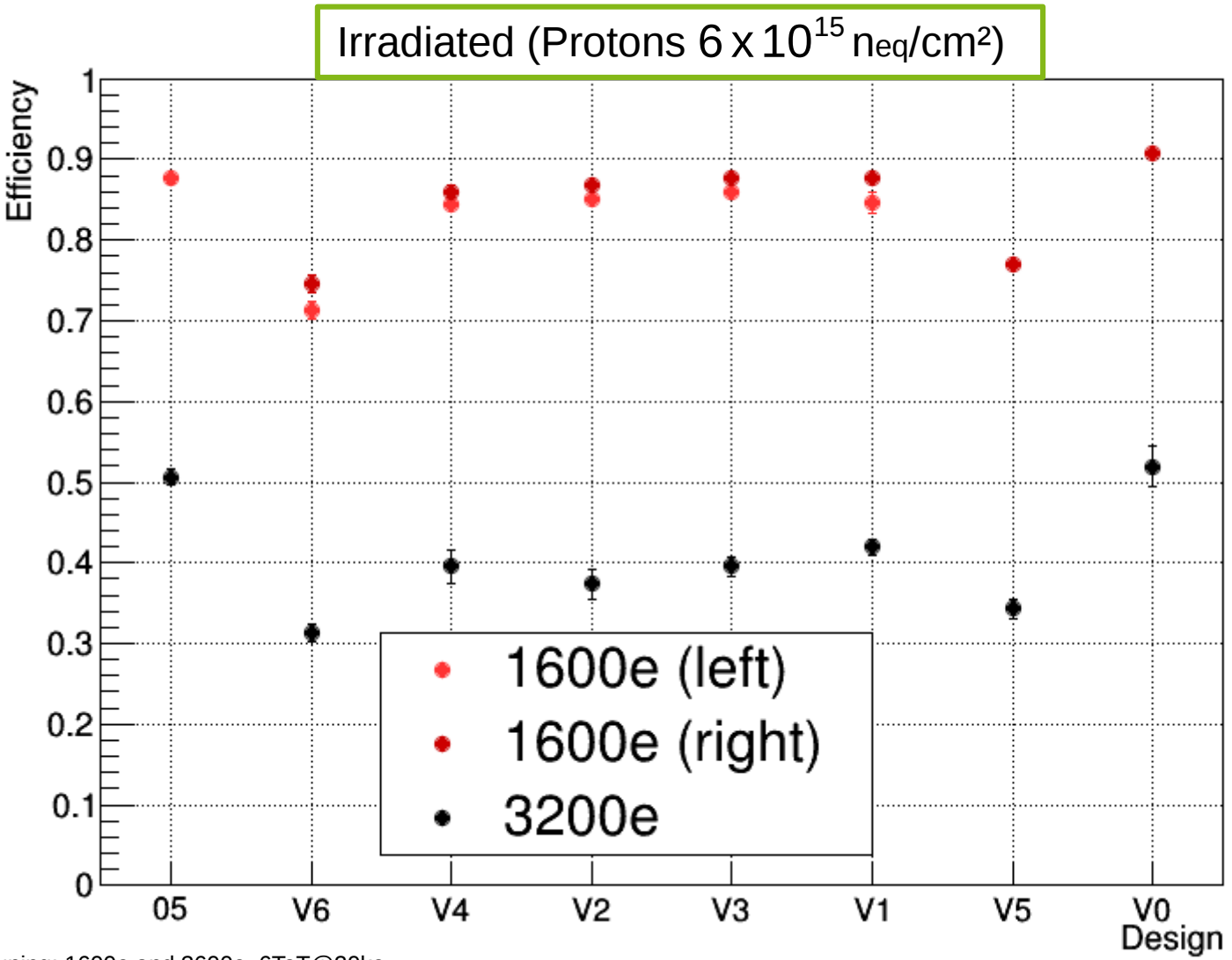
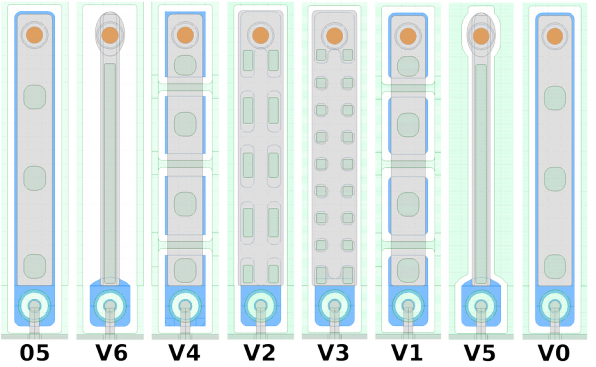
- Efficiencies of different thresholds for sensor DO-R2 at 600V





Tuning: 1600e and 3600e, 6ToT@20ke