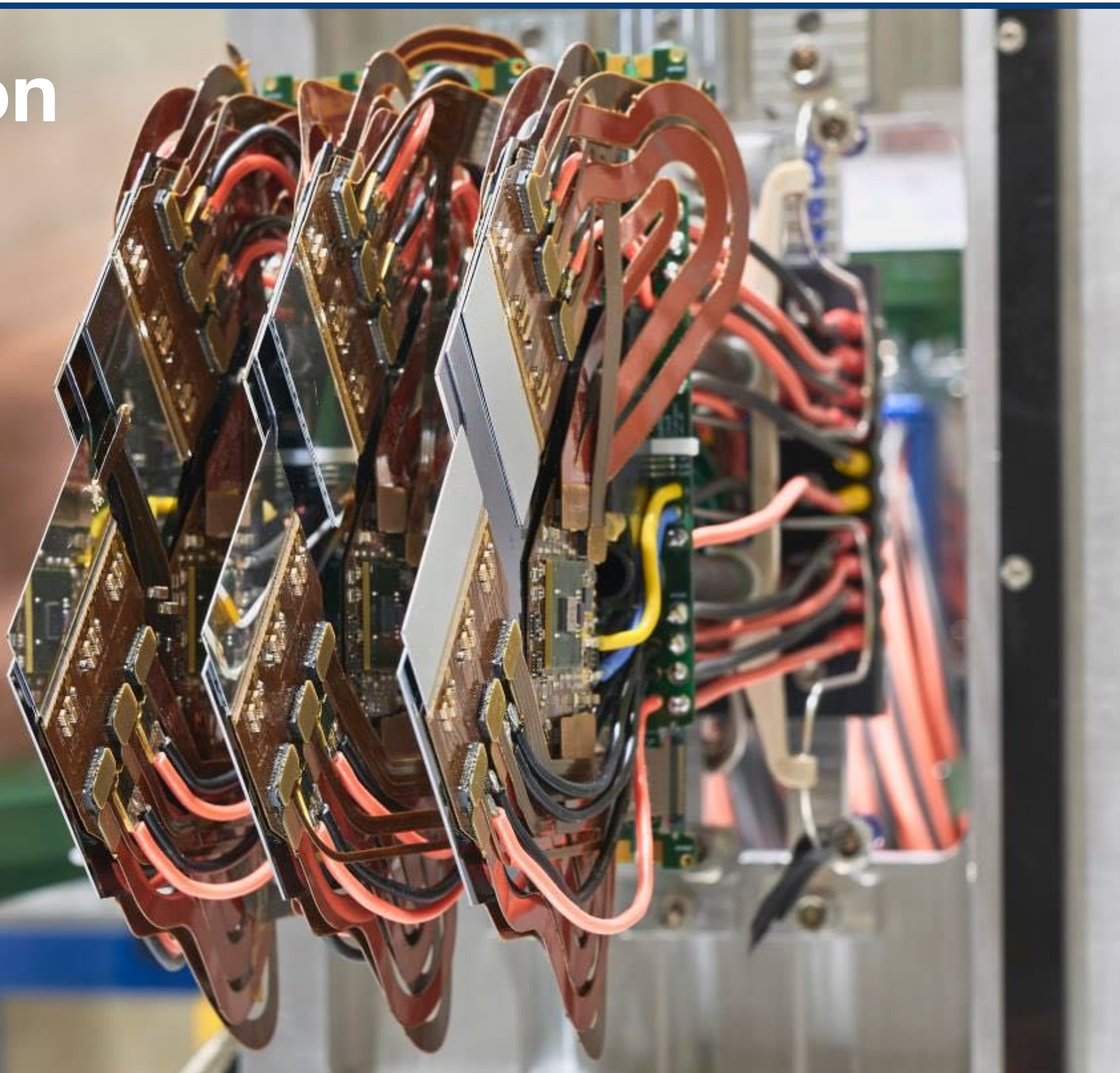
Postdoctoral Postion Interview



Vinícius Franco Lima
17th July 19

Who am I?

Brazilian PhD student currently involved in the LHCb Experiment

Bachelor and Master degrees in Physics through Rio de Janeiro Federal University (UFRJ)

Currently pursuing a PhD in High Energy Physics at University of Liverpool

Involved in Analysis of Lepton Universality and the R&D and Production of the VELO Upgrade

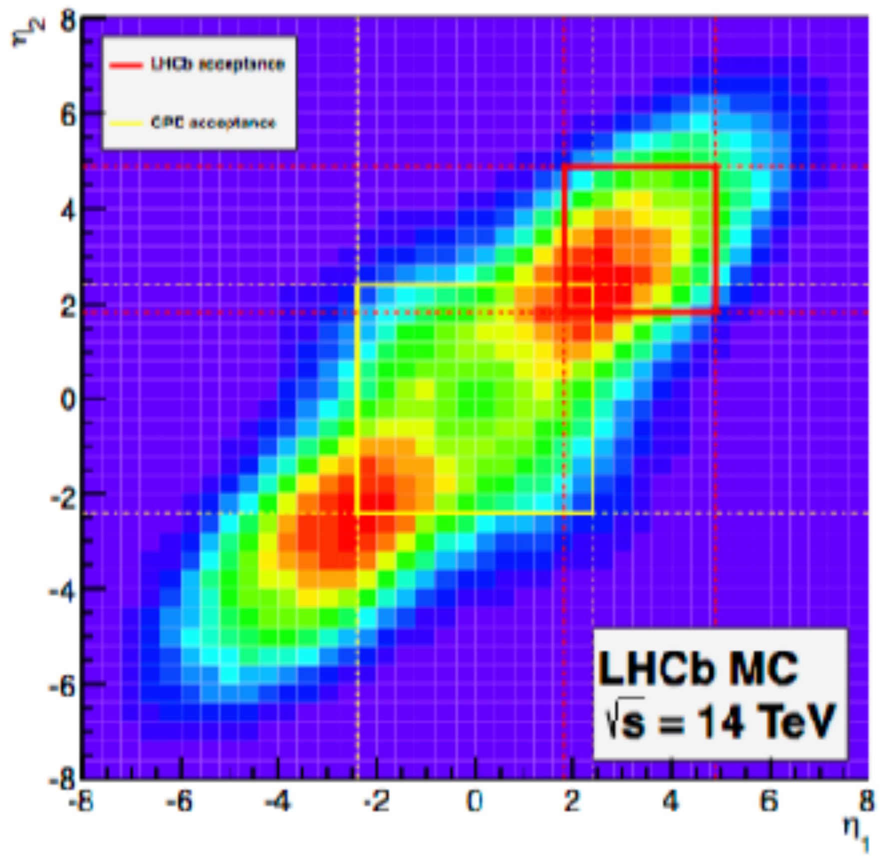
LHCb Detector

Heavy Flavour Experiment

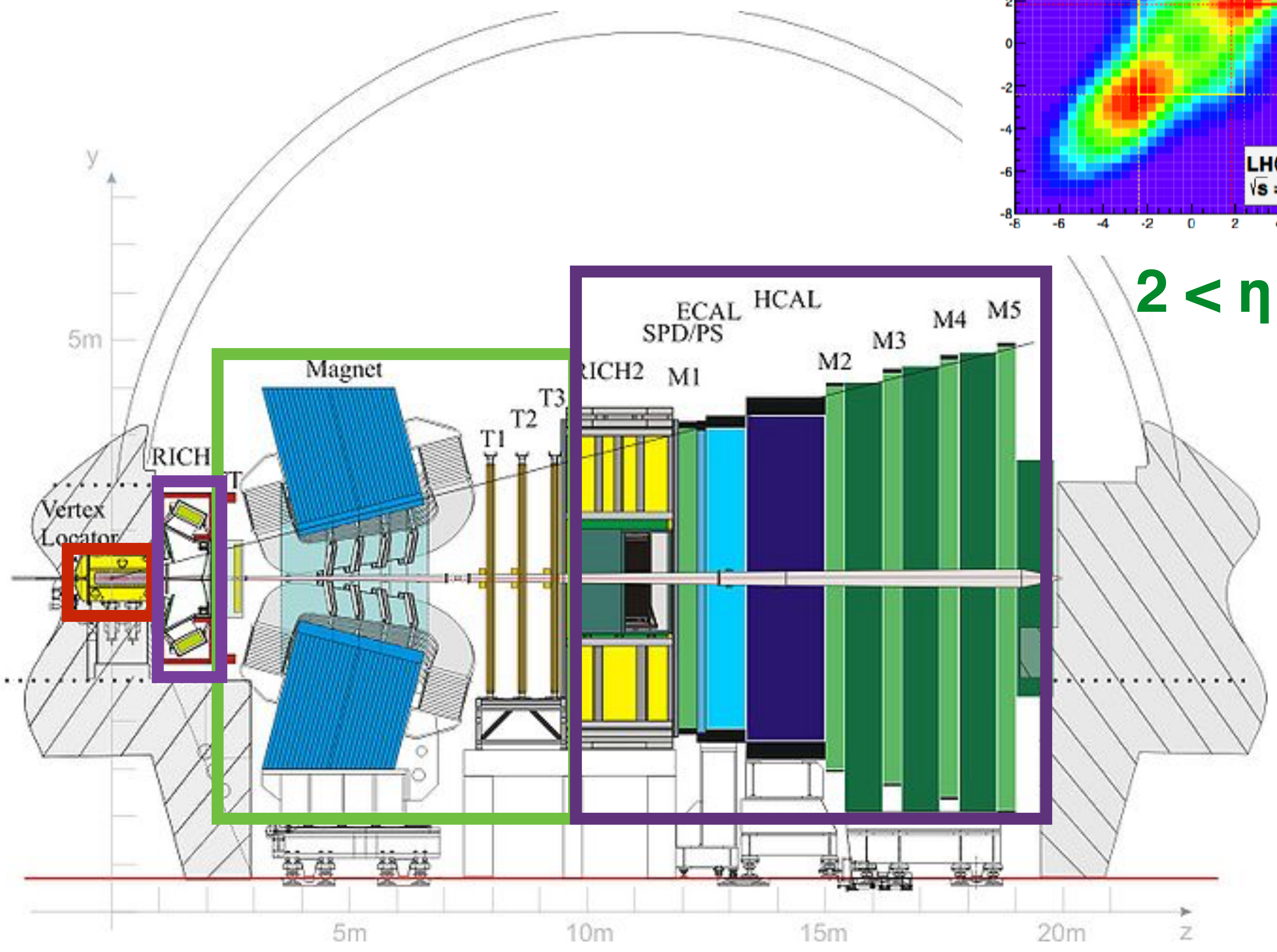
Precise vertex reconstruction

Tracking and momentum resolution

Particle identification capabilities



$2 < \eta < 5$

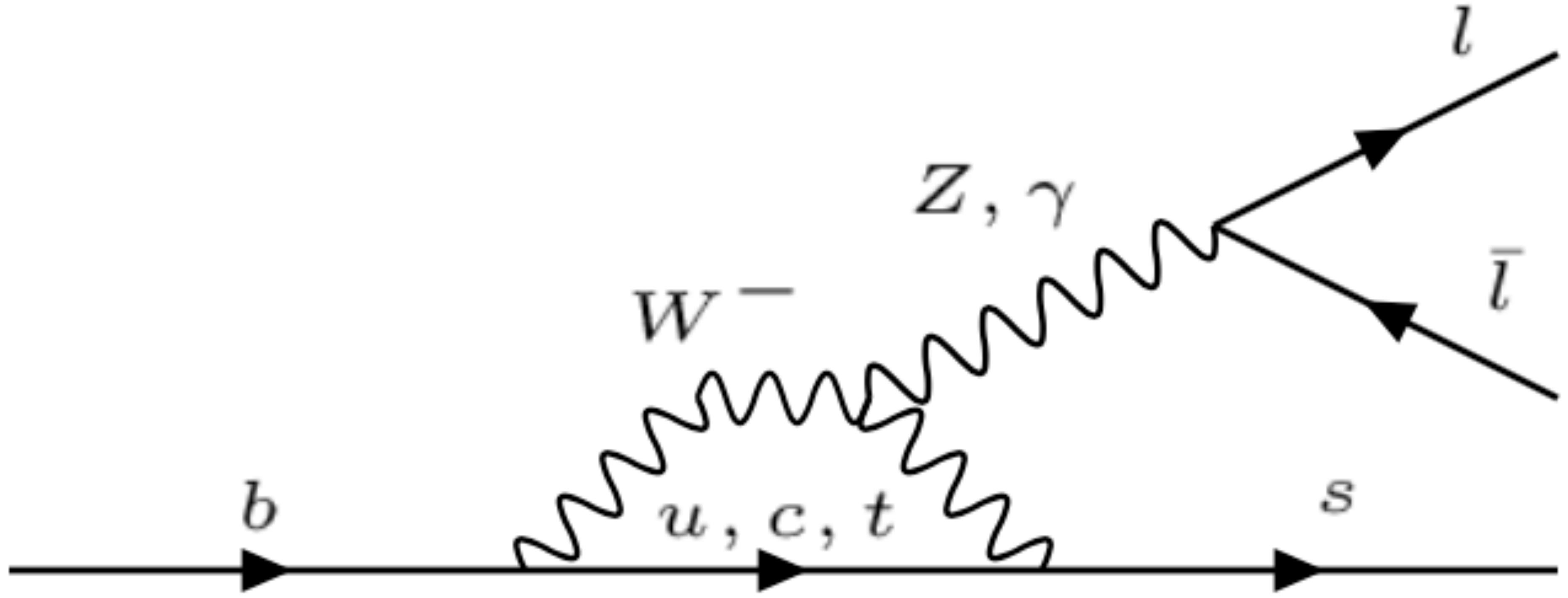


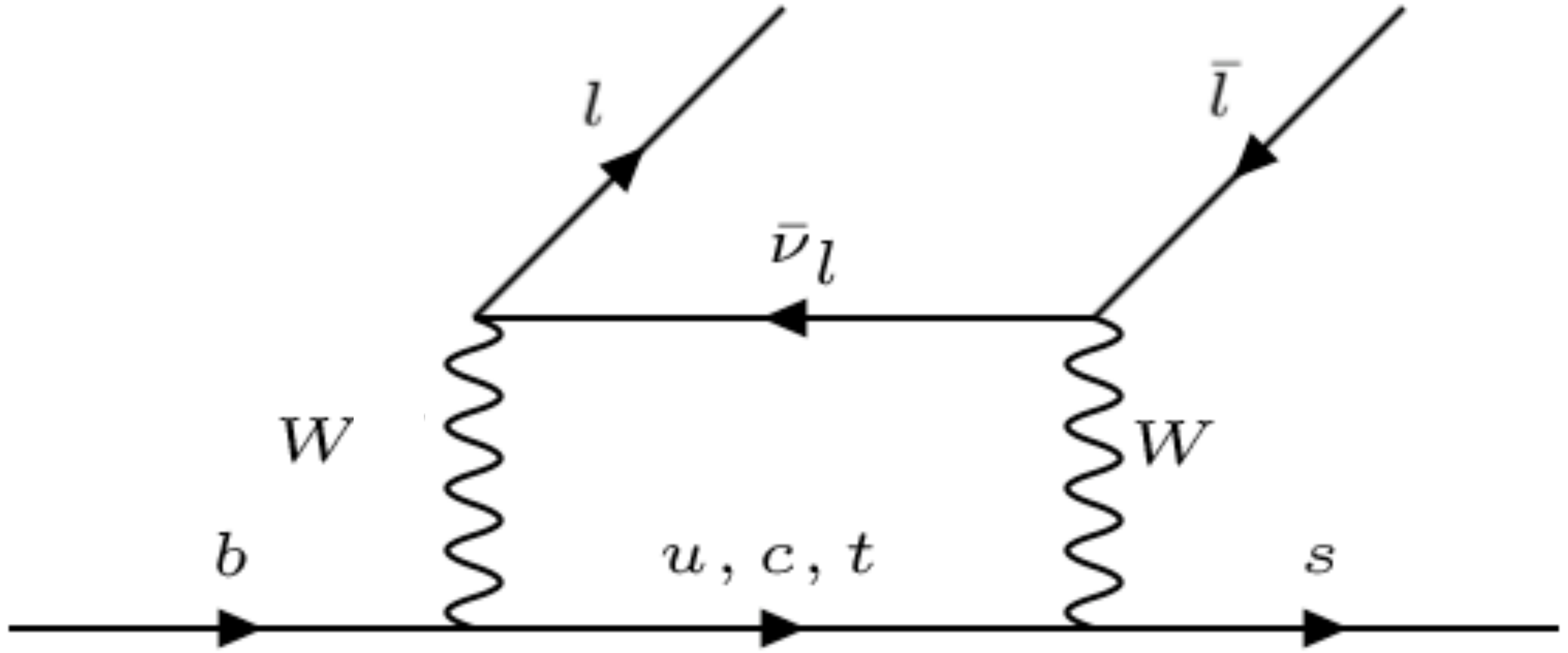
Lepton Universality

In the SM the W boson has the same coupling to all leptons.

The Z and Photon couplings were measured to have the same coupling with high precision.

Interest grew after LHCb measured the ratio between electron and muon to be 2.6 standard deviations from SM in the B->K*l^+l^- decay.





Lepton Universality

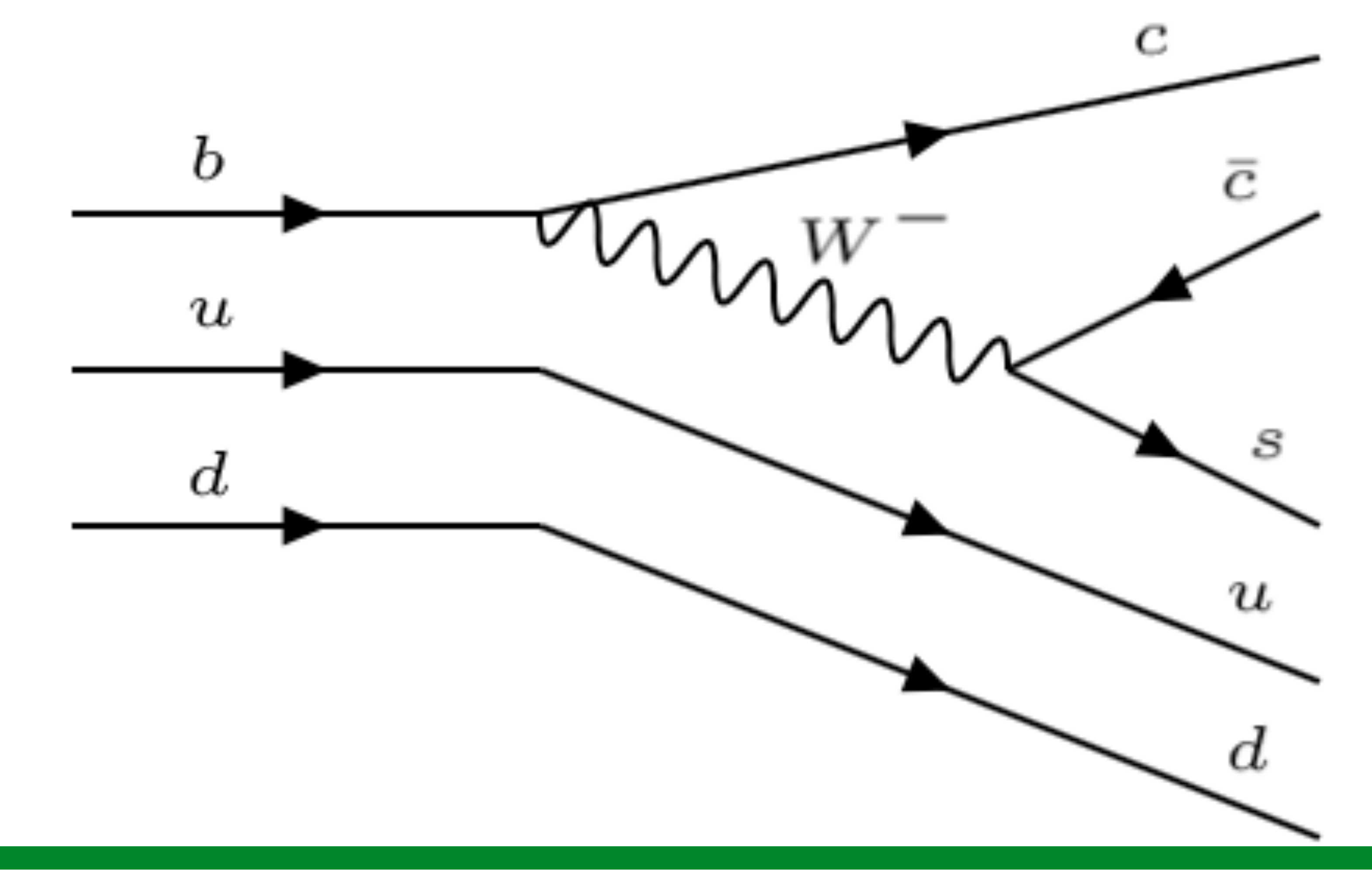
$$R_{\Lambda} = \frac{\mathcal{B}(\Lambda_b \to \Lambda(pK)\ \mu^+\mu^-)}{\mathcal{B}(\Lambda_b \to \Lambda(pK)\ e^+e^-)}$$

The number we want to measure. It is supposed to be O(1) in SM predictions.

$$\text{Ratio}_{\mu} = \frac{\mathcal{B}(\Lambda_b \to \Lambda(pK)\ \mu^+\mu^-)}{\mathcal{B}(\Lambda_b \to \Lambda(pK)\ J/\psi(\mu^+\mu^-))}$$

$$\text{Ratio}_{e} = \frac{\mathcal{B}(\Lambda_b \to \Lambda(pK)\ e^+e^-)}{\mathcal{B}(\Lambda_b \to \Lambda(pK)\ J/\psi(e^+e^-))}$$

Control Channel: J/ψ



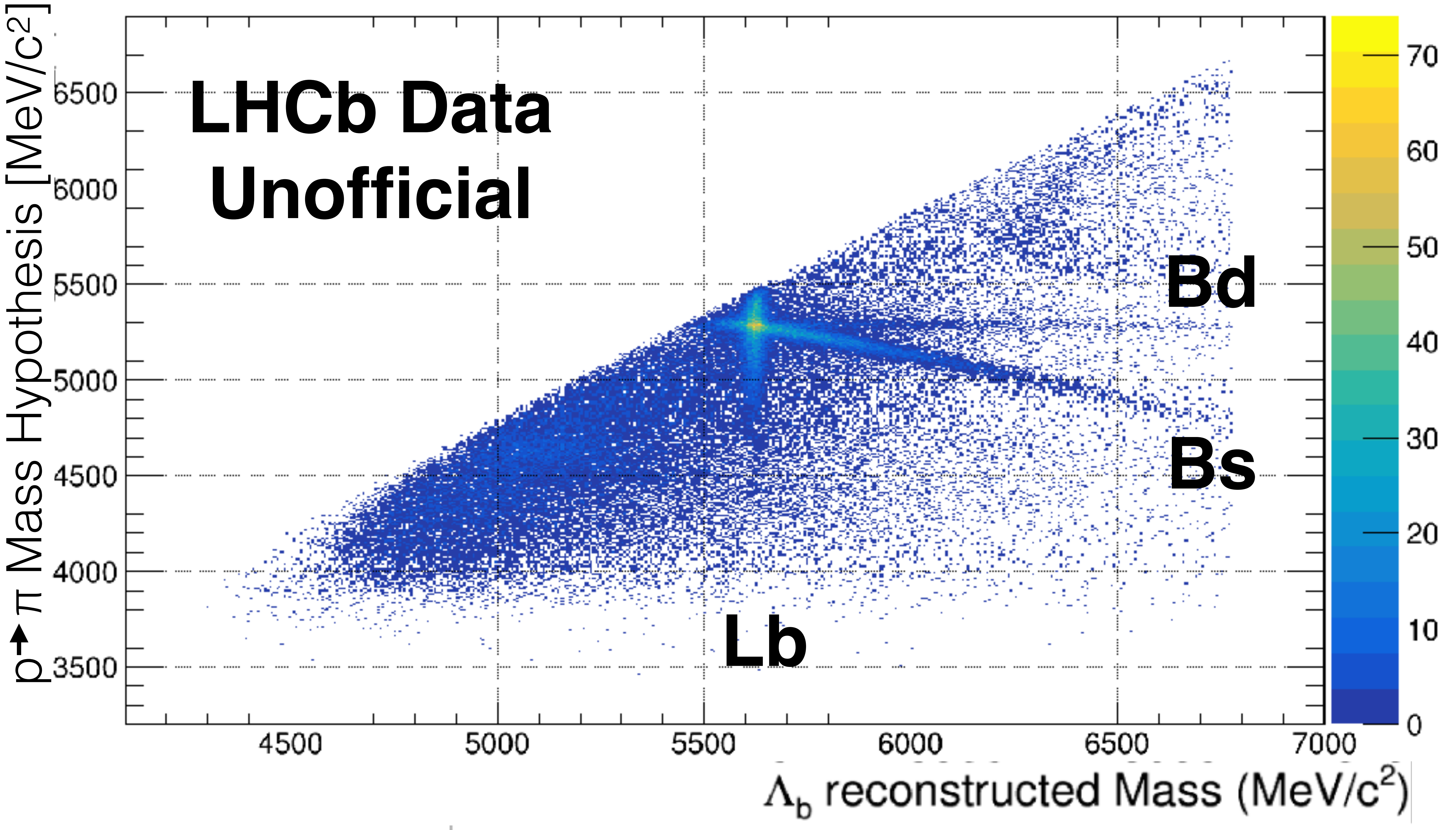
PID Studies

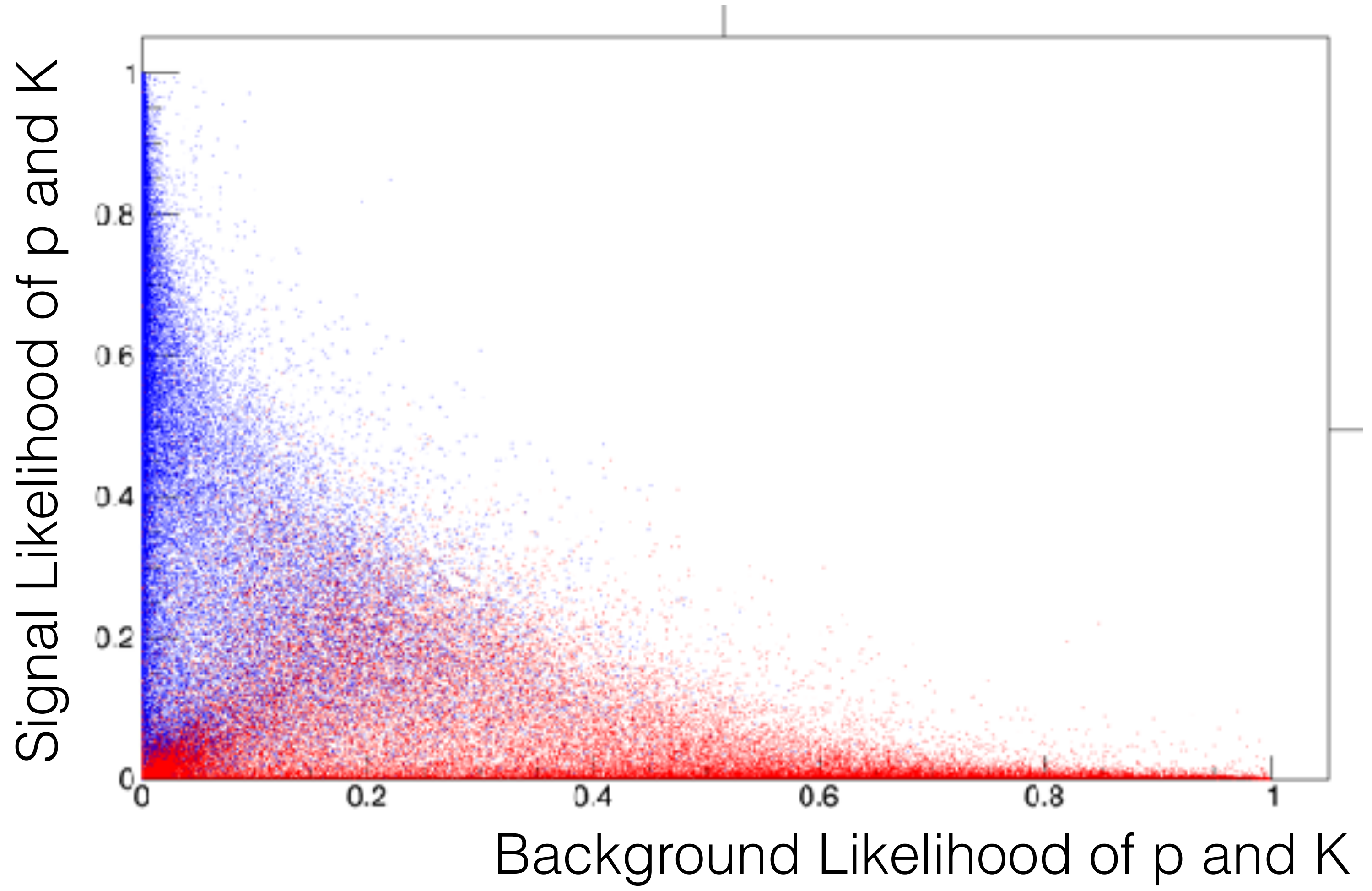
Large contribution from background modes under the Lb peak

LHCb provides a particle ID probability for each track

Biggest Background contaminations come from hadron misID

Combination of variables allow for strong bkg rejection





Blue is MC Signal

Red is MC Bkg

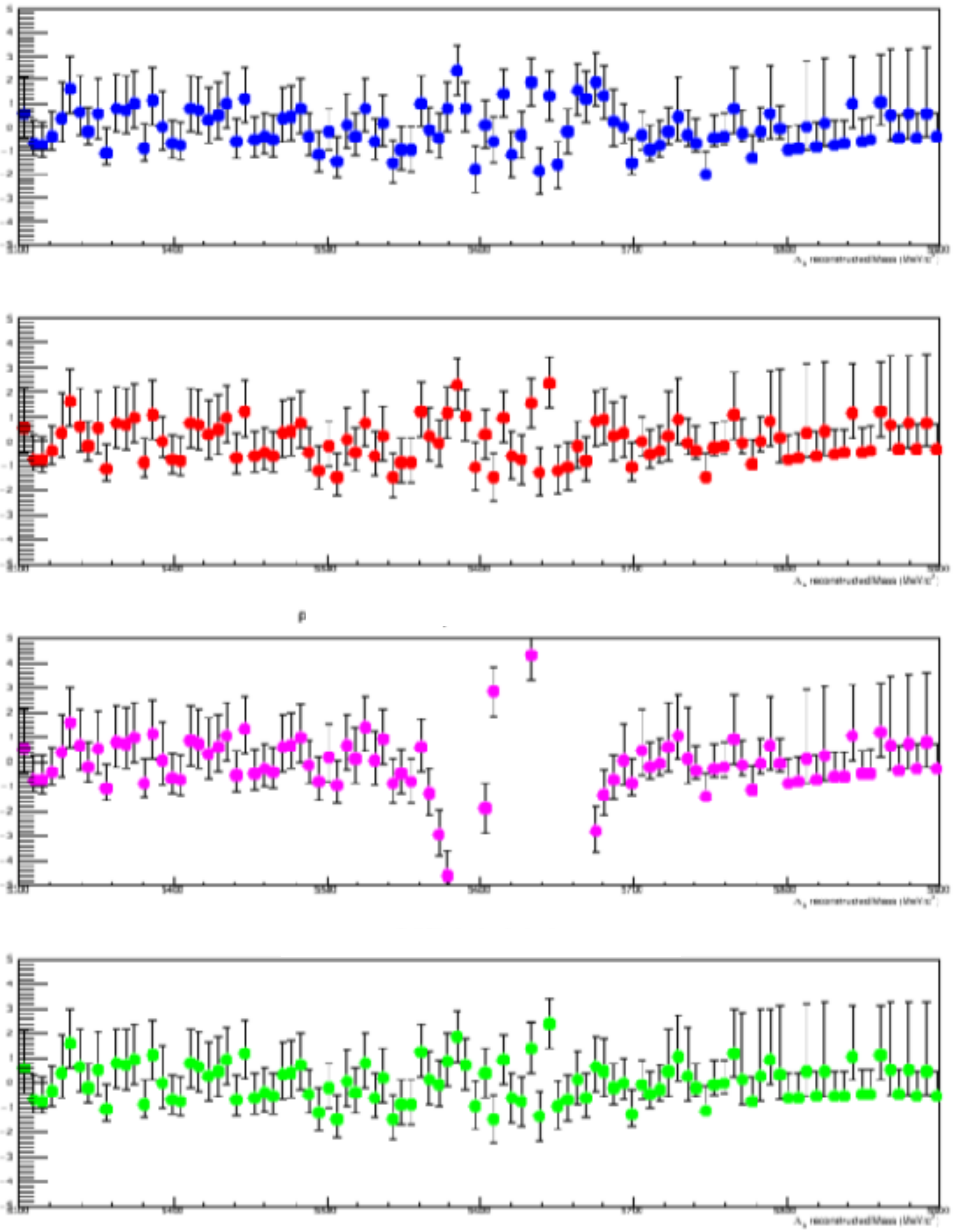
Fit Muon Channel

Breit-Wigner + Crystal Ball

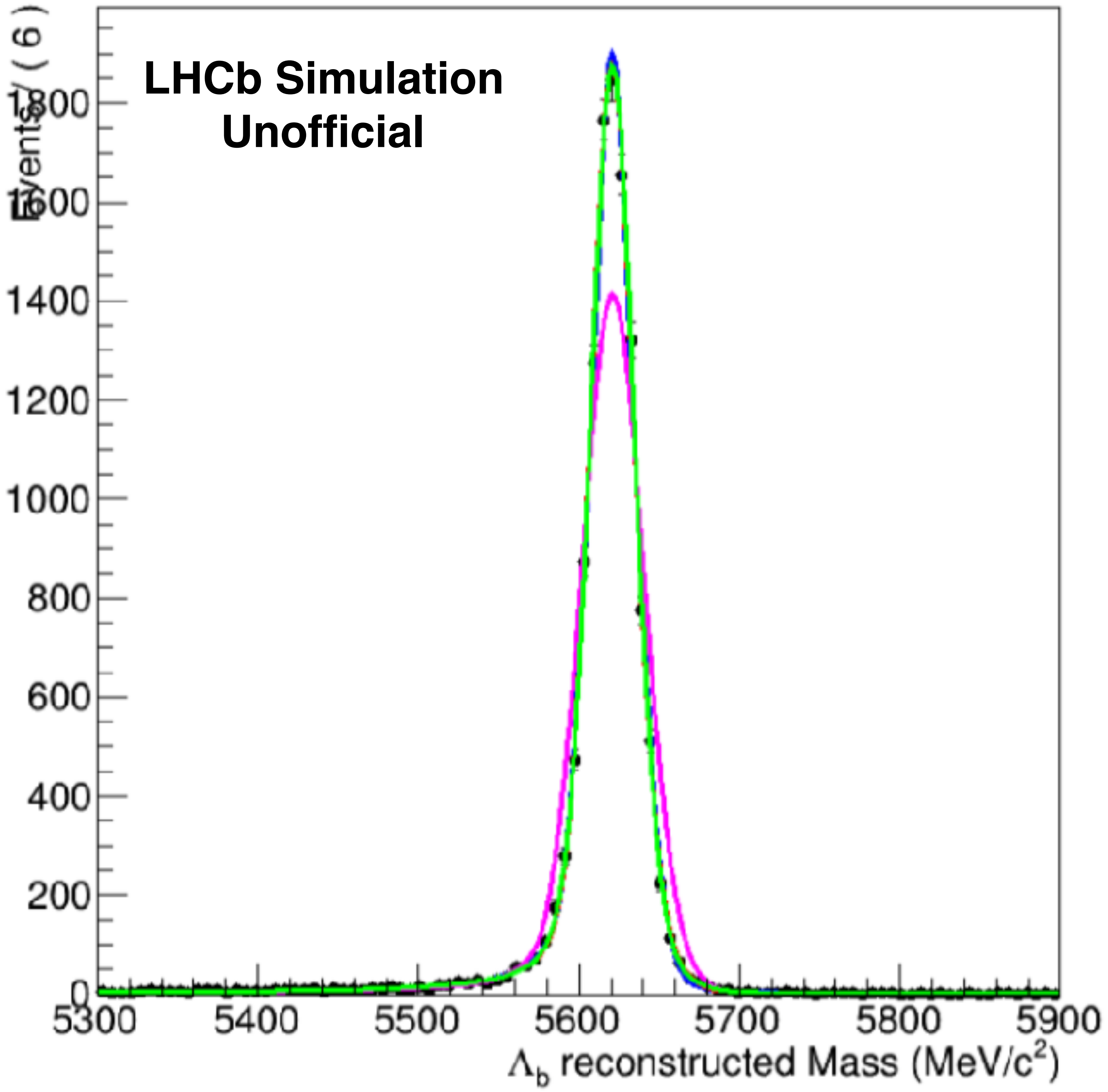
Voigtian + Crystal Ball

Double Gaussian + Crystal Ball

Ipatia x Gaussian



$$\Lambda_b \to \Lambda(pK)\,\mu^+\mu^-$$



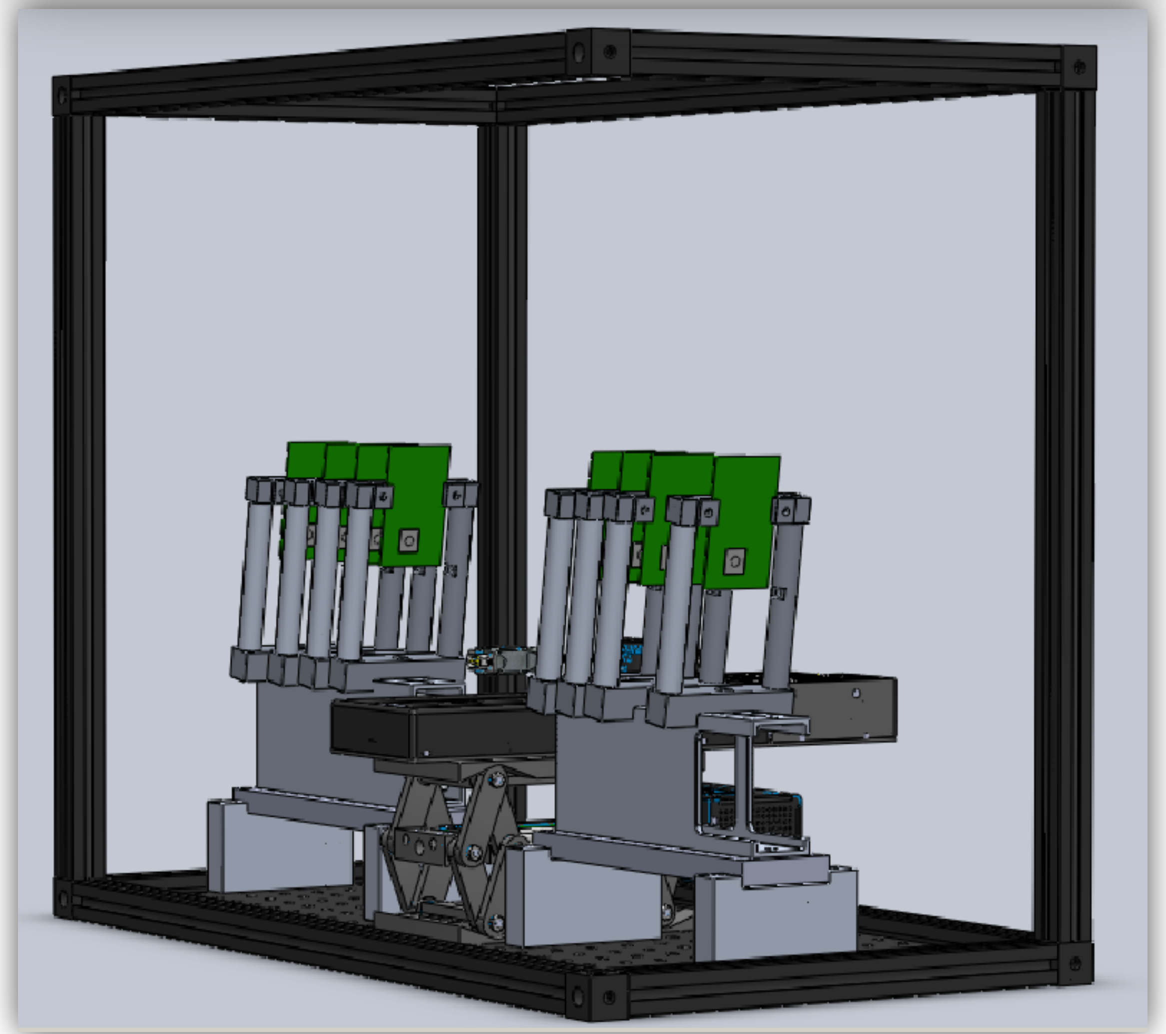
COMBAT Telescope

Master dissertation project

Build a portable, low radiation length charged beam telescope

Idea was to make a system that could be easily transported and could operate in electron beams

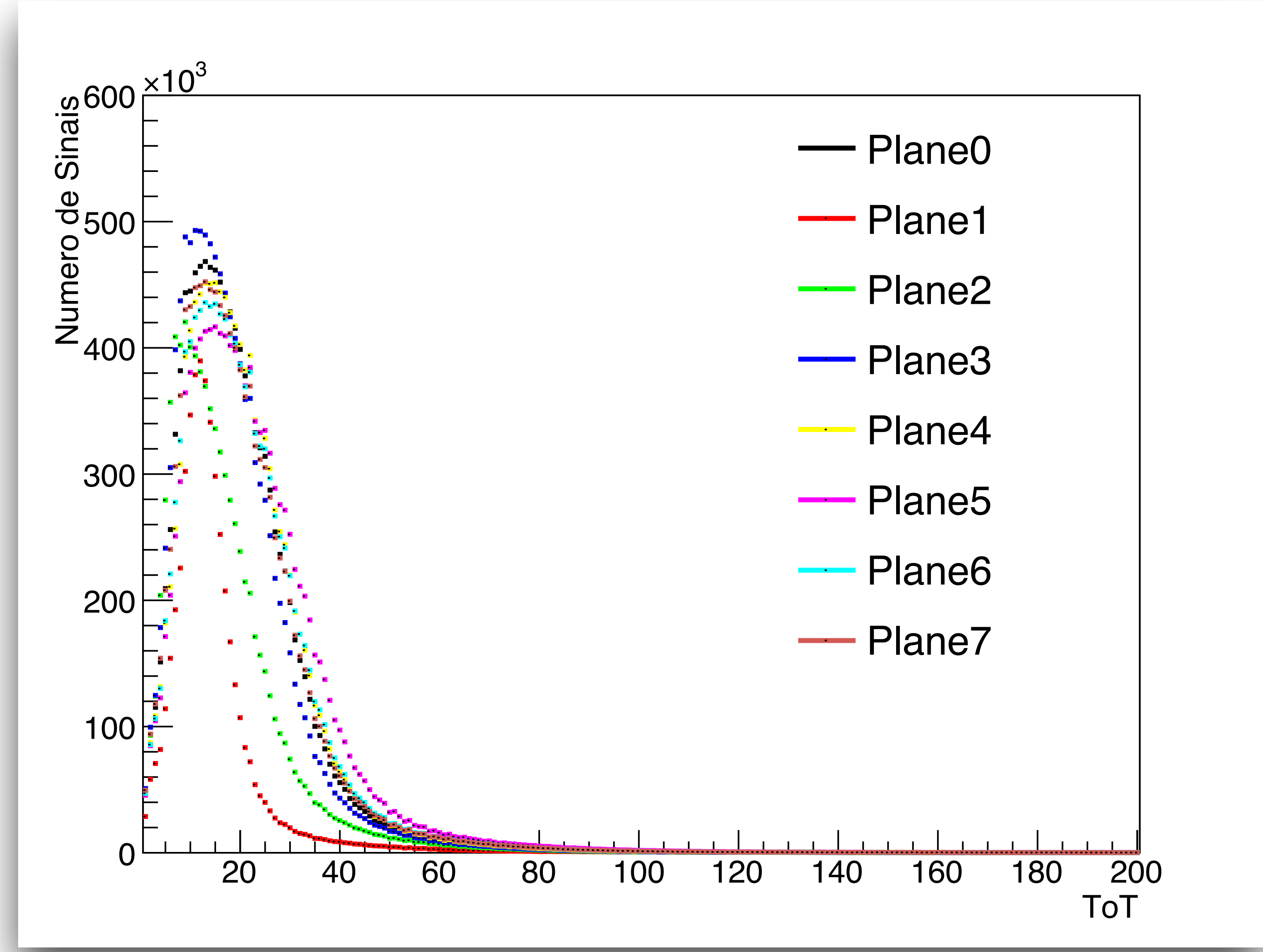
Used 8 planes with Timepix readout ASICs on 150um thick n-on-p sensors

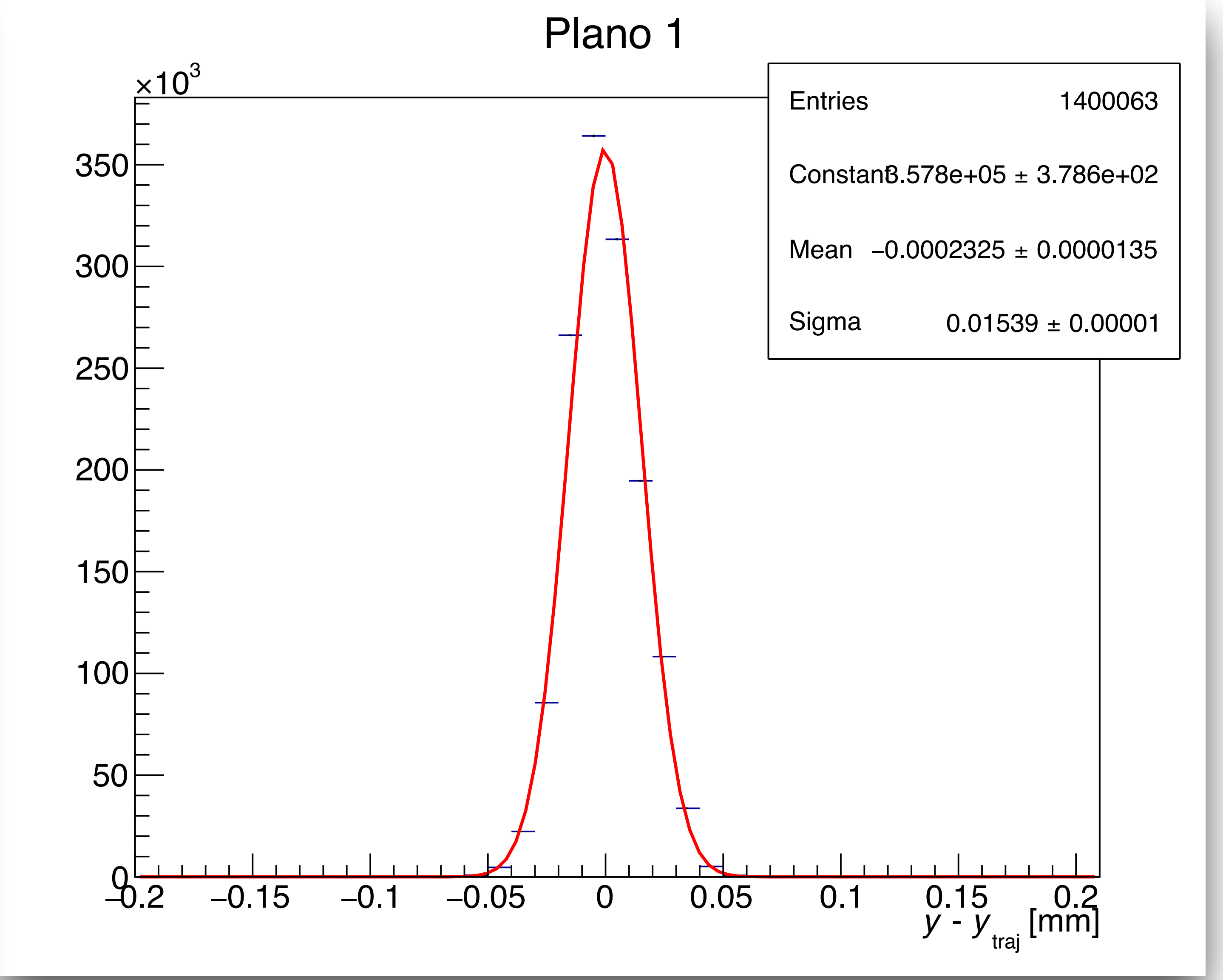


COMBAT Telescope

COMBAT was built and commissioned in Rio

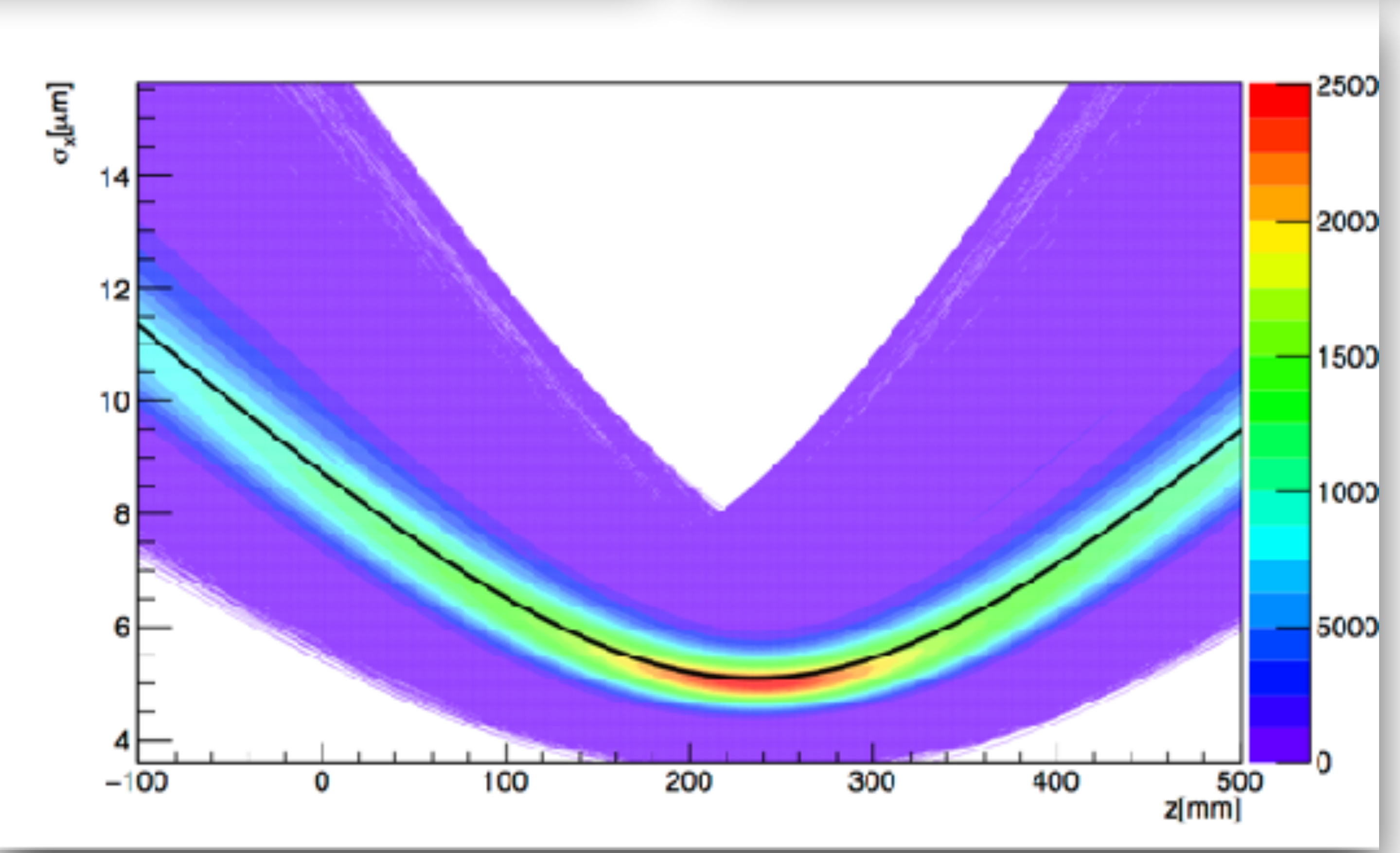
Final results obtained by taking the telescope to the SPS North Area Testbeam





After alignment the residual resolution was approx. 15µm

Telescope Pointing resolution was found to be 5.1µm



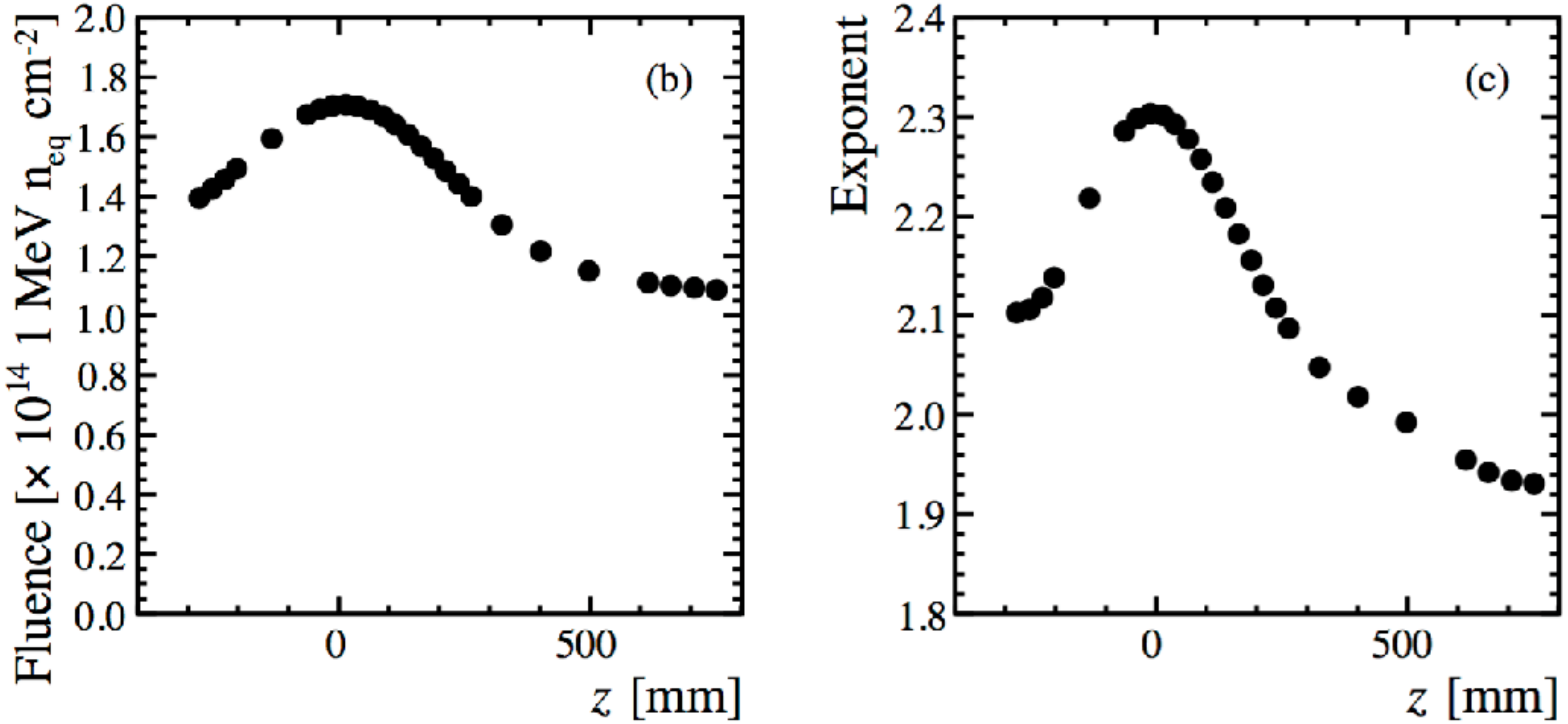
VELO Upgrade

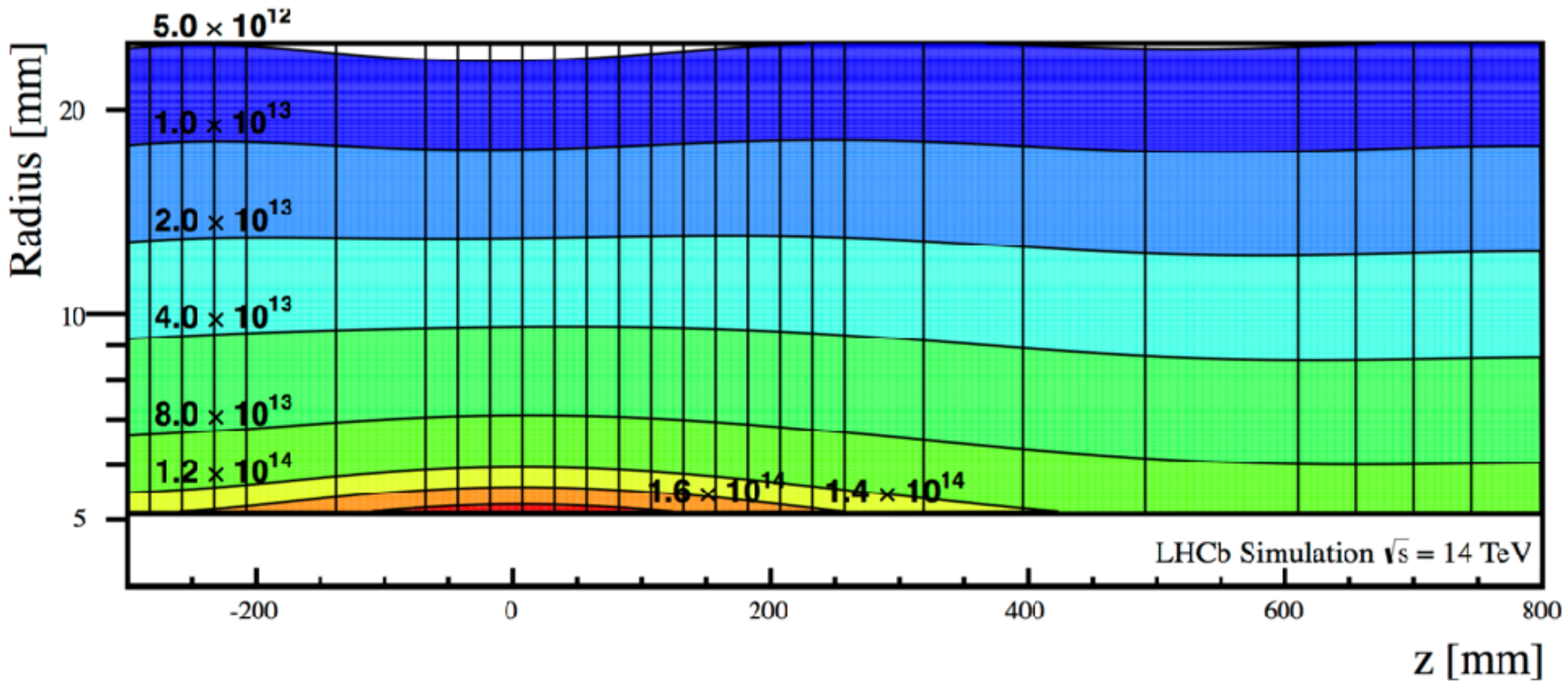
Expected fluence in the most irradiated regions up to 1.5×10^{14} 1MeV n_{eq}/ cm^2 per fb^{-1}

Radiation flux follows $r^{-2.3}$ shape.

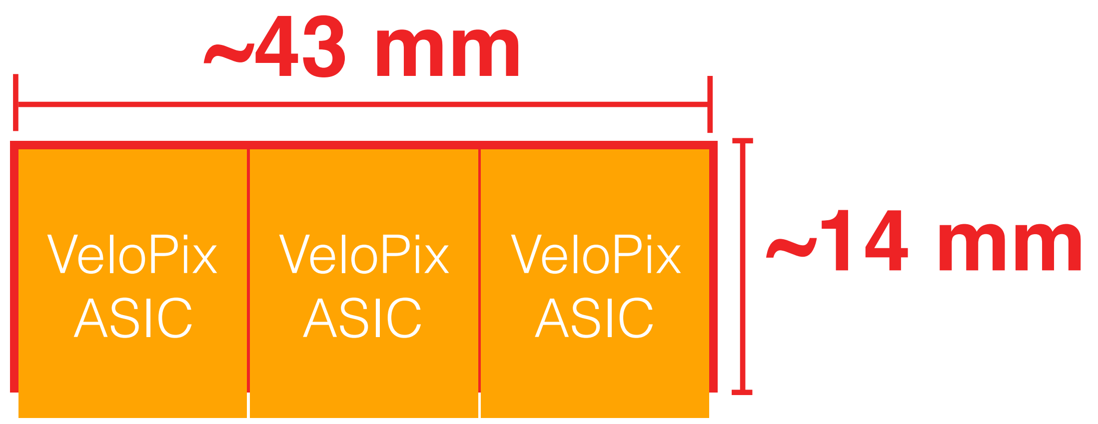
Proximity to interaction region: 5.1mm

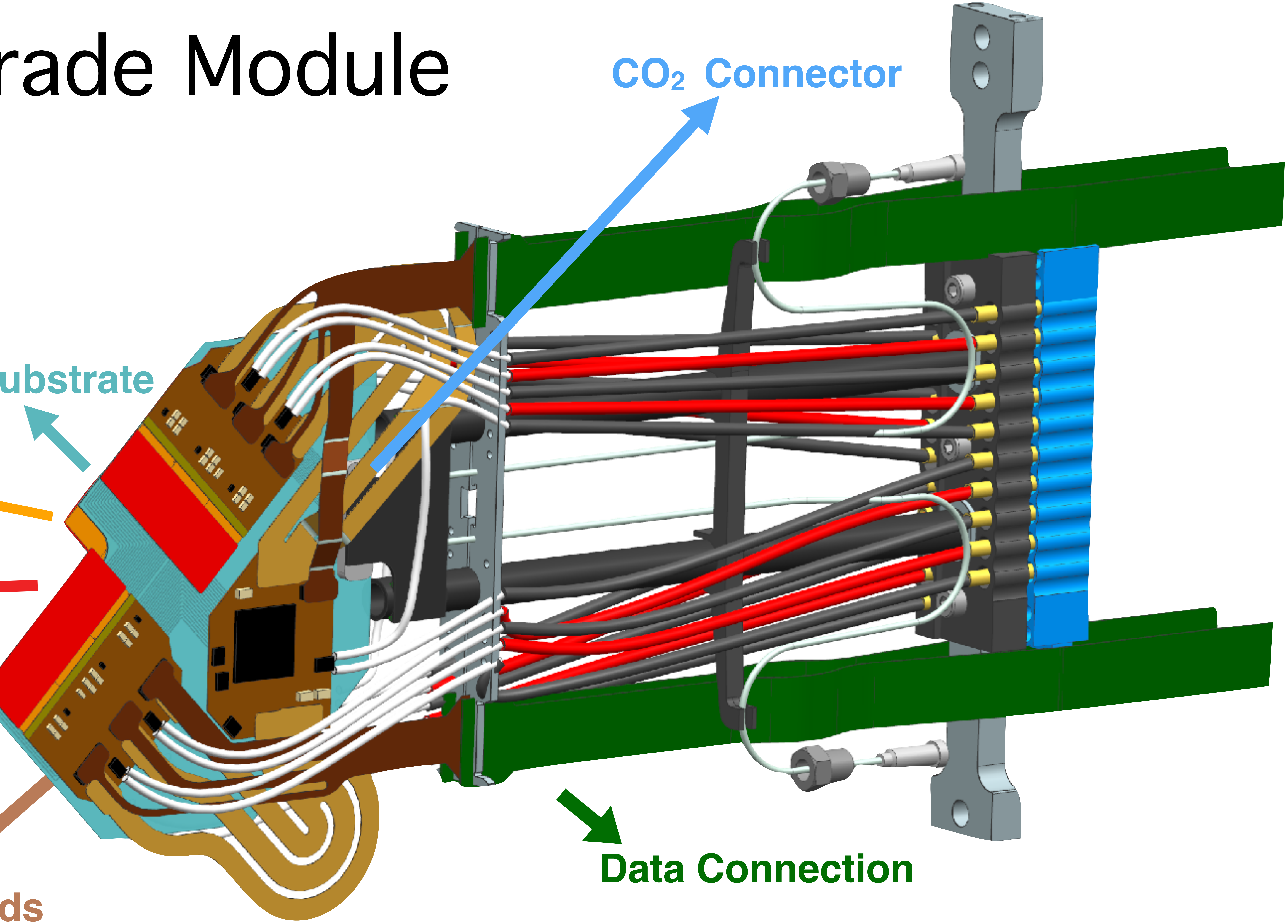
Total Integrated Luminosity: 50fb^{-1} !





VELO Upgrade Module

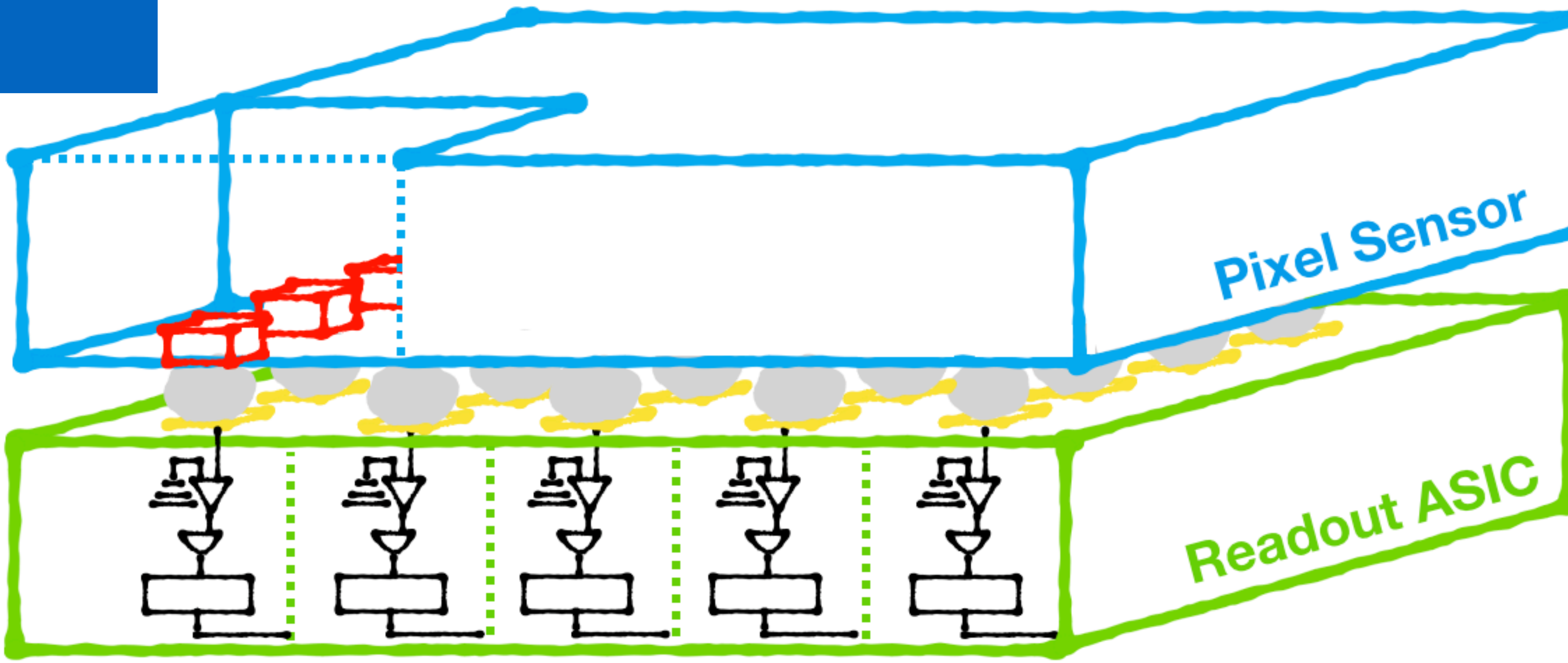




Hybrid Pixel Detectors

Technology chosen for the upgrade.

Planar silicon sensors (768x256) bump bonded to 3 custom ASICs (256x256).



ASIC has a pre-amplifier, threshold comparison and time-stamping for each pixel.

Sensors

Many options available!

n-on-p or n-on-n

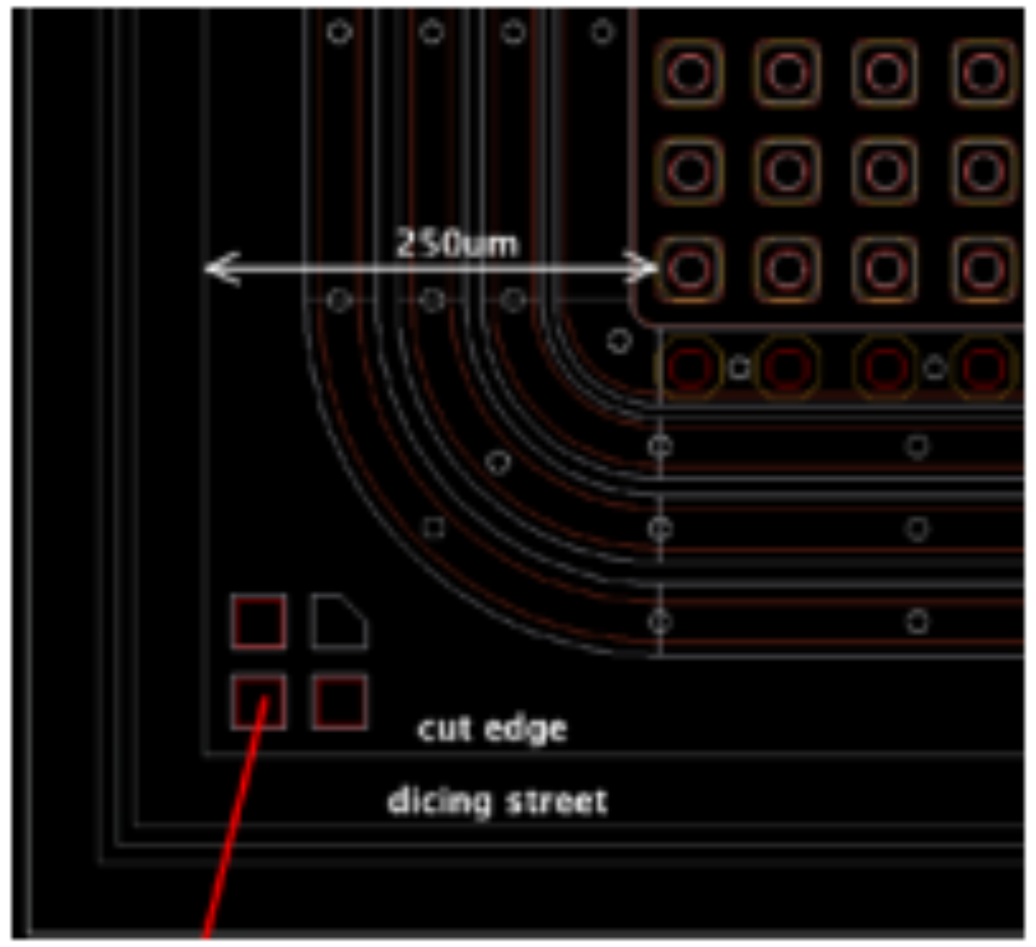
Guard Ring Sizes: 150 to 600 μm

Implant Sizes: 35, 36 and 39 μm

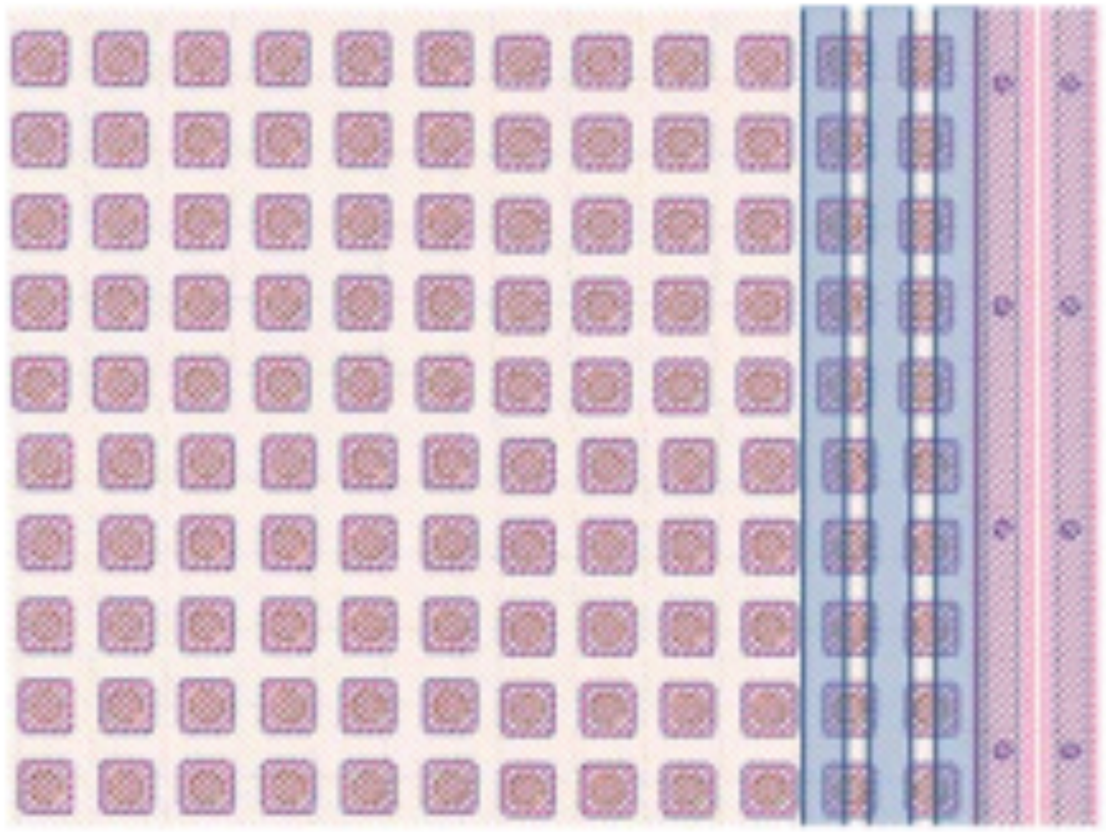
Thickness: 150 or 200 μm

Vendors: HPK or Micron

n-on-p



n-on-n



Max Operational Bias Voltage: 1000V

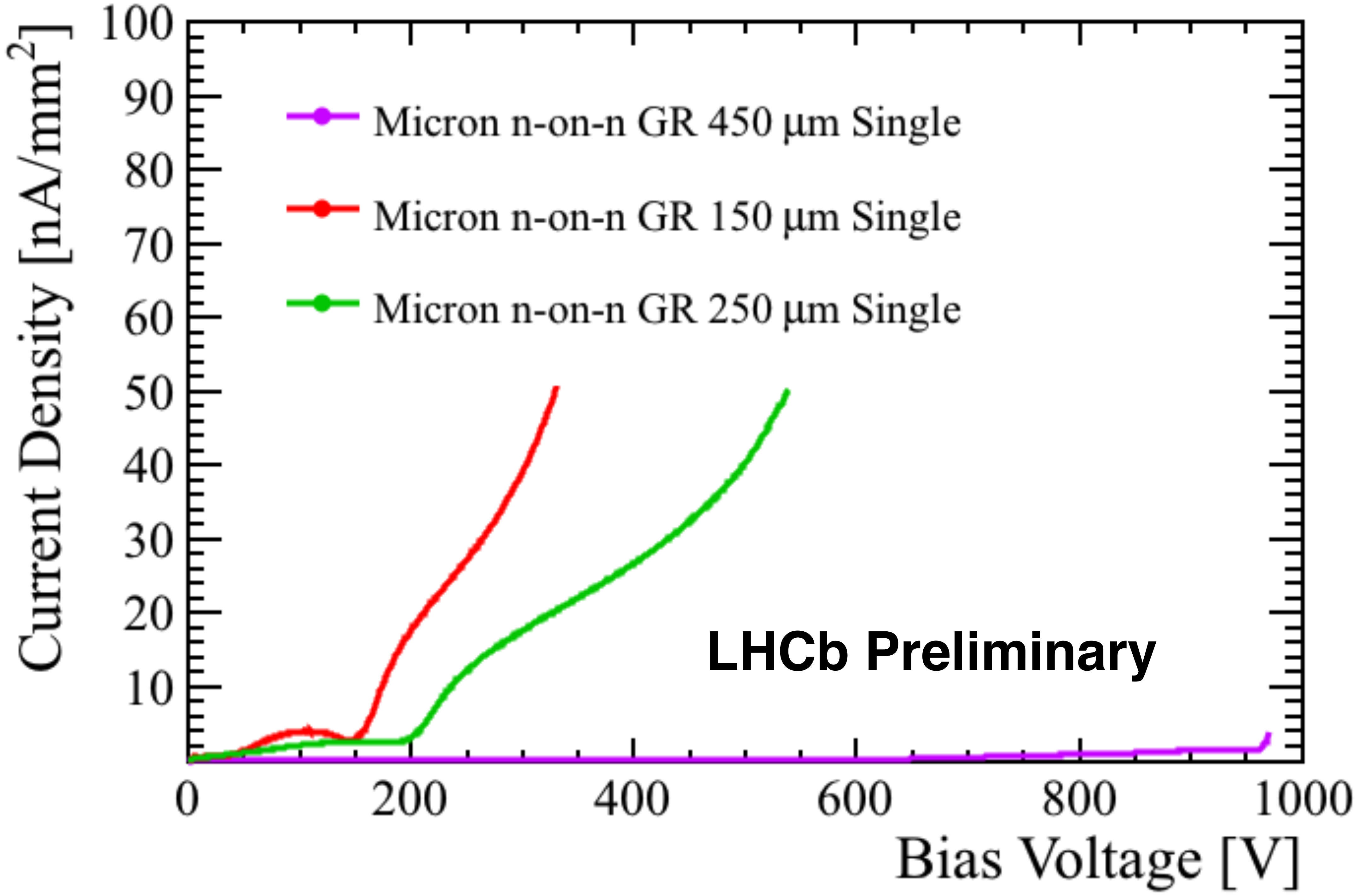
Minimum collected charge per MIP: 6000e^-

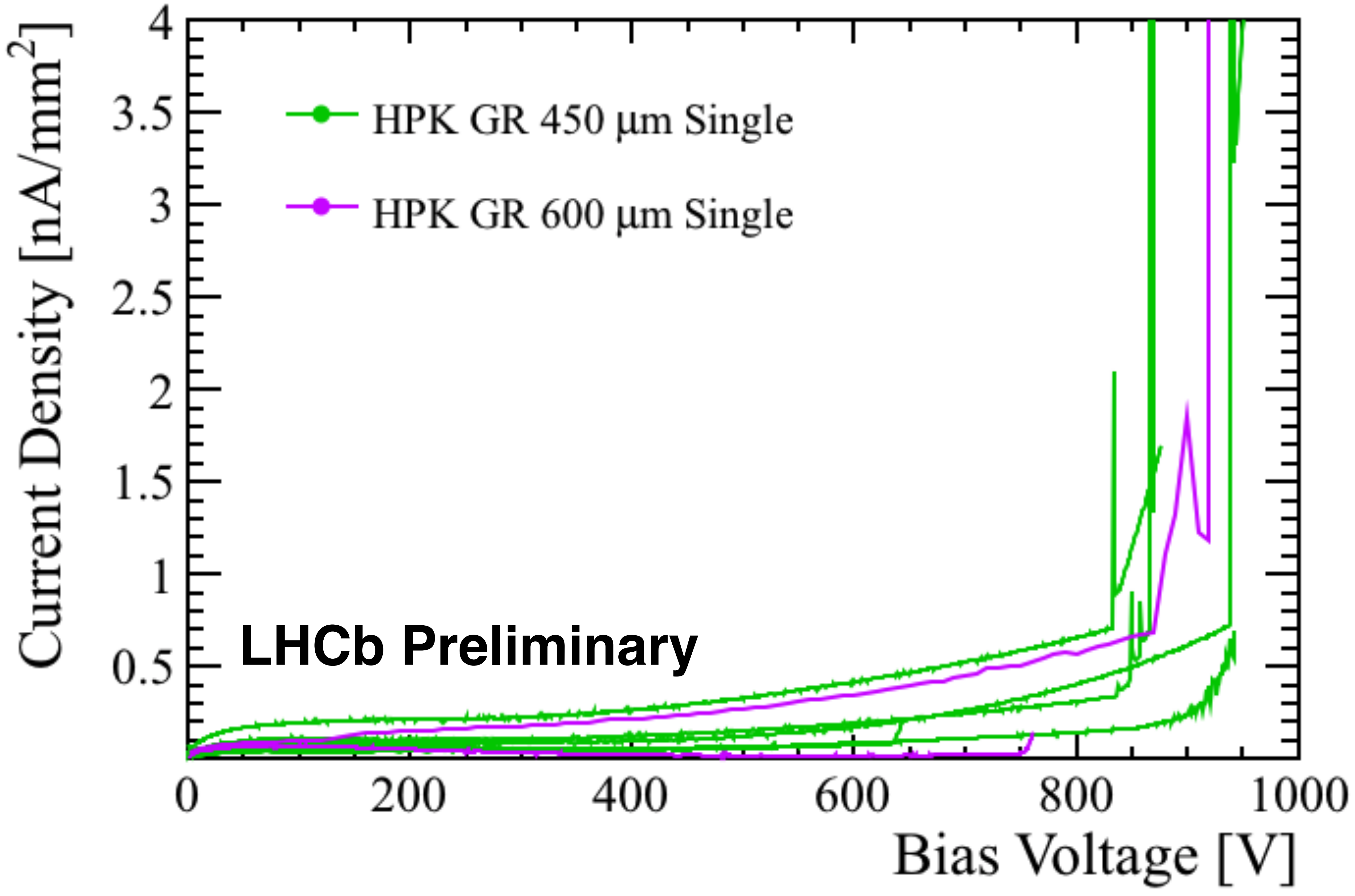
The sensors must be able to operate under these conditions up to 8×10^{15} 1MeV $n_{eq}cm^{-2}$

HV Tolerance

Max operational bias voltage after irradiation:1000V.

Ideally test all sensors before and after irradiation.

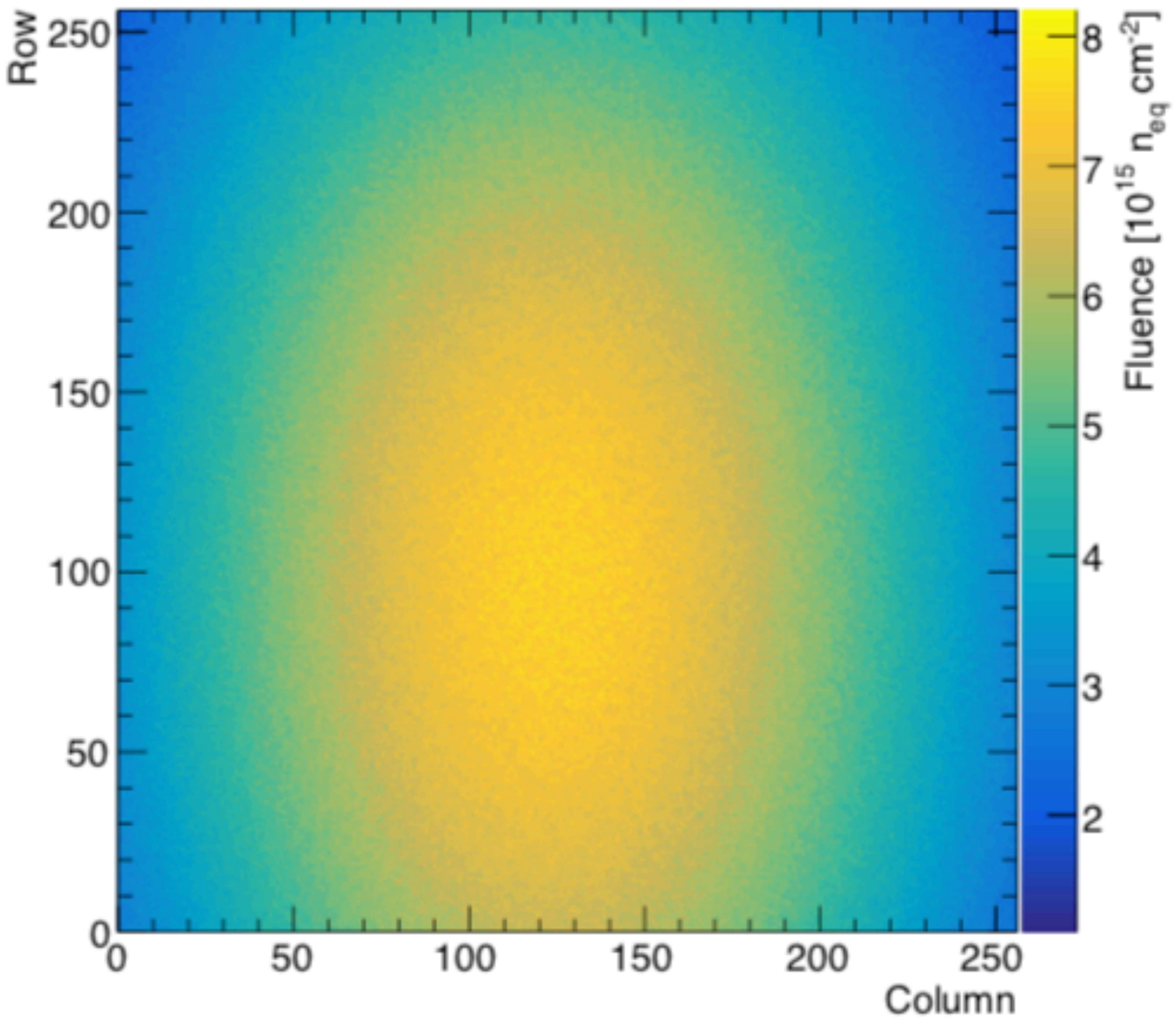




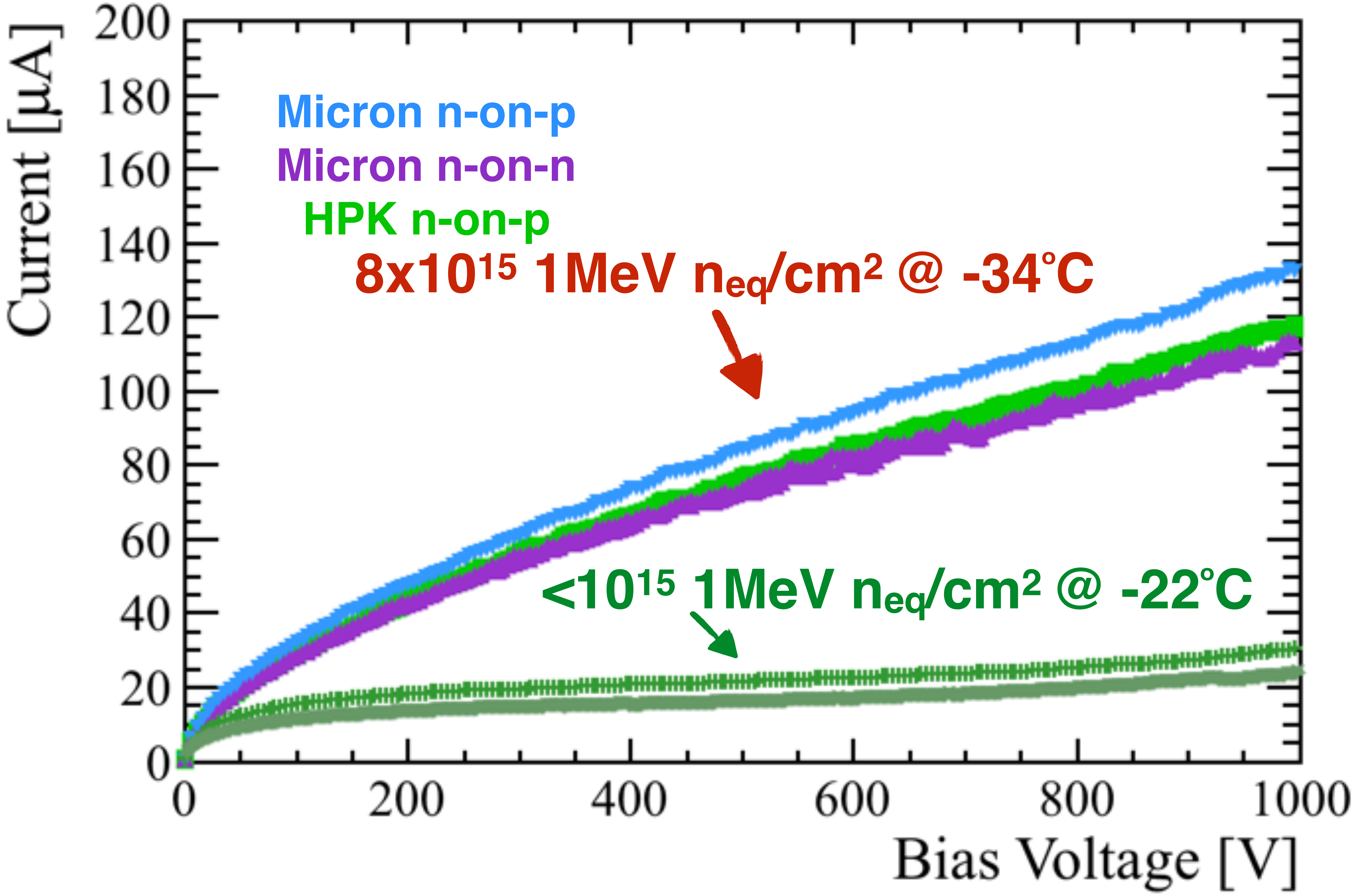
Before irradiation results show problems with smaller guard-ring designs.

HV Tolerance

Typical Irradiation profile at IRRAD

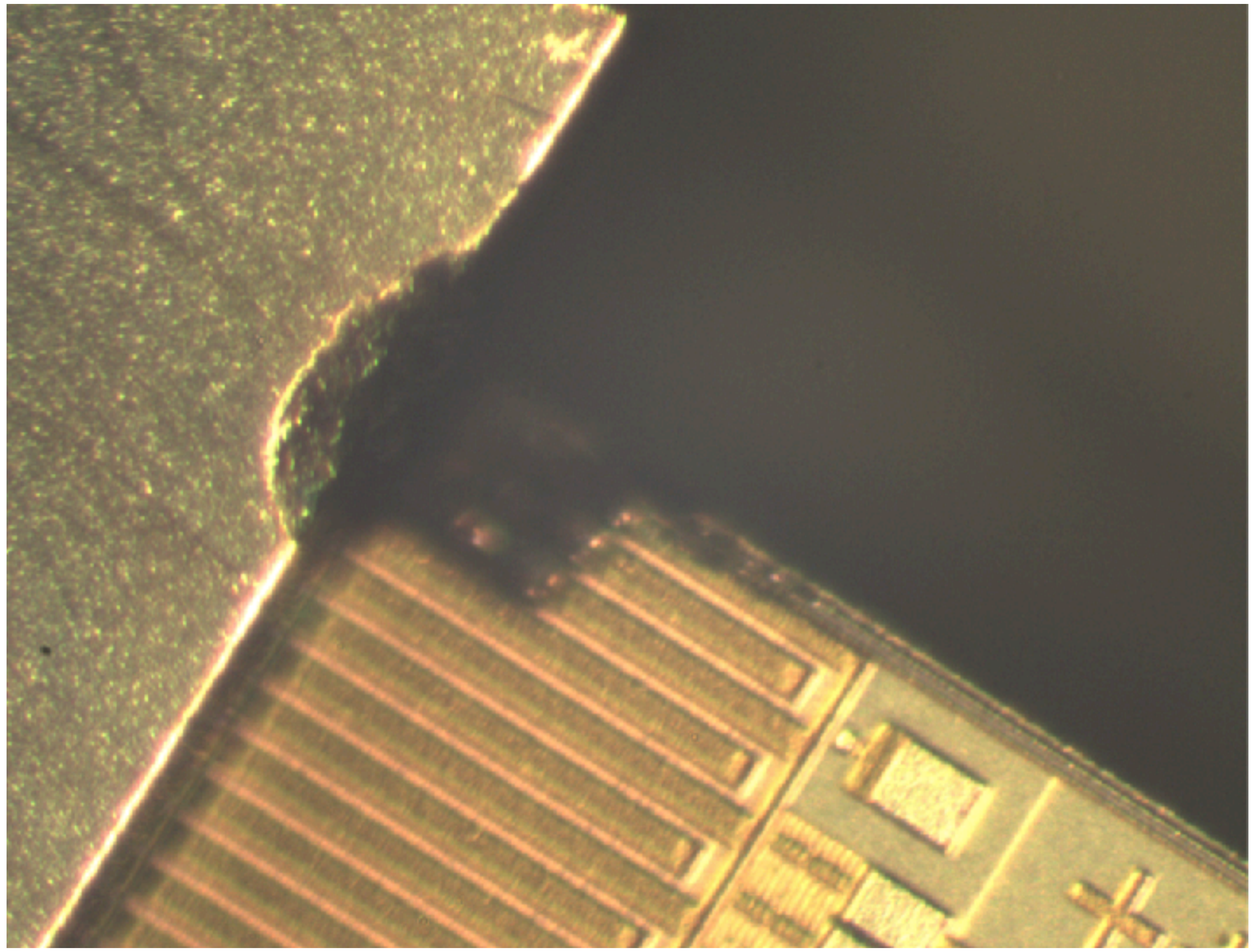


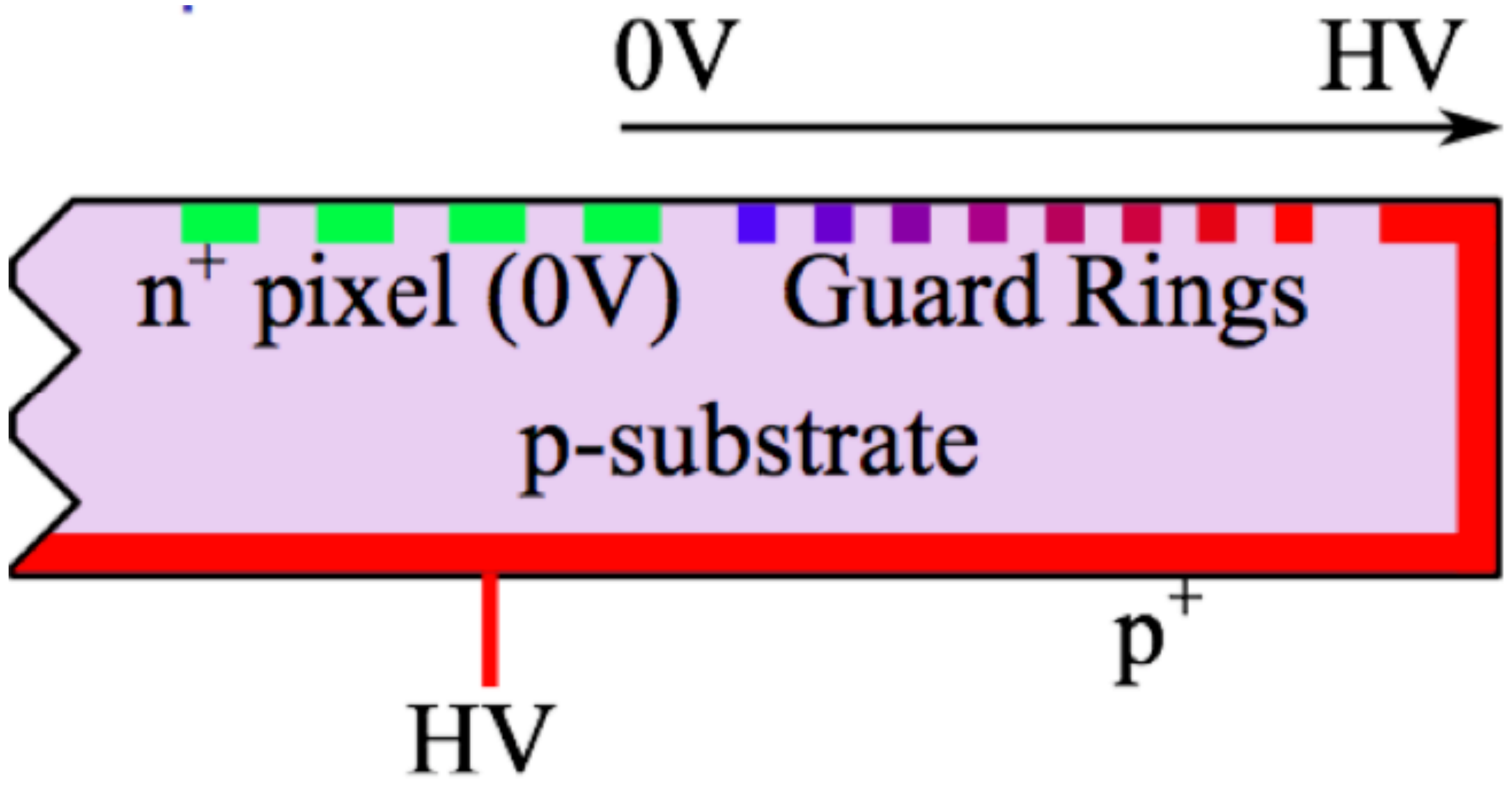
Proton Irradiated Non-Uniform Flux



Tile Quality Assurance

During prototype testing it became clear that sensors spark if biased above 400V in air.





Ground pads of the ASIC are directly below the sensor edge.

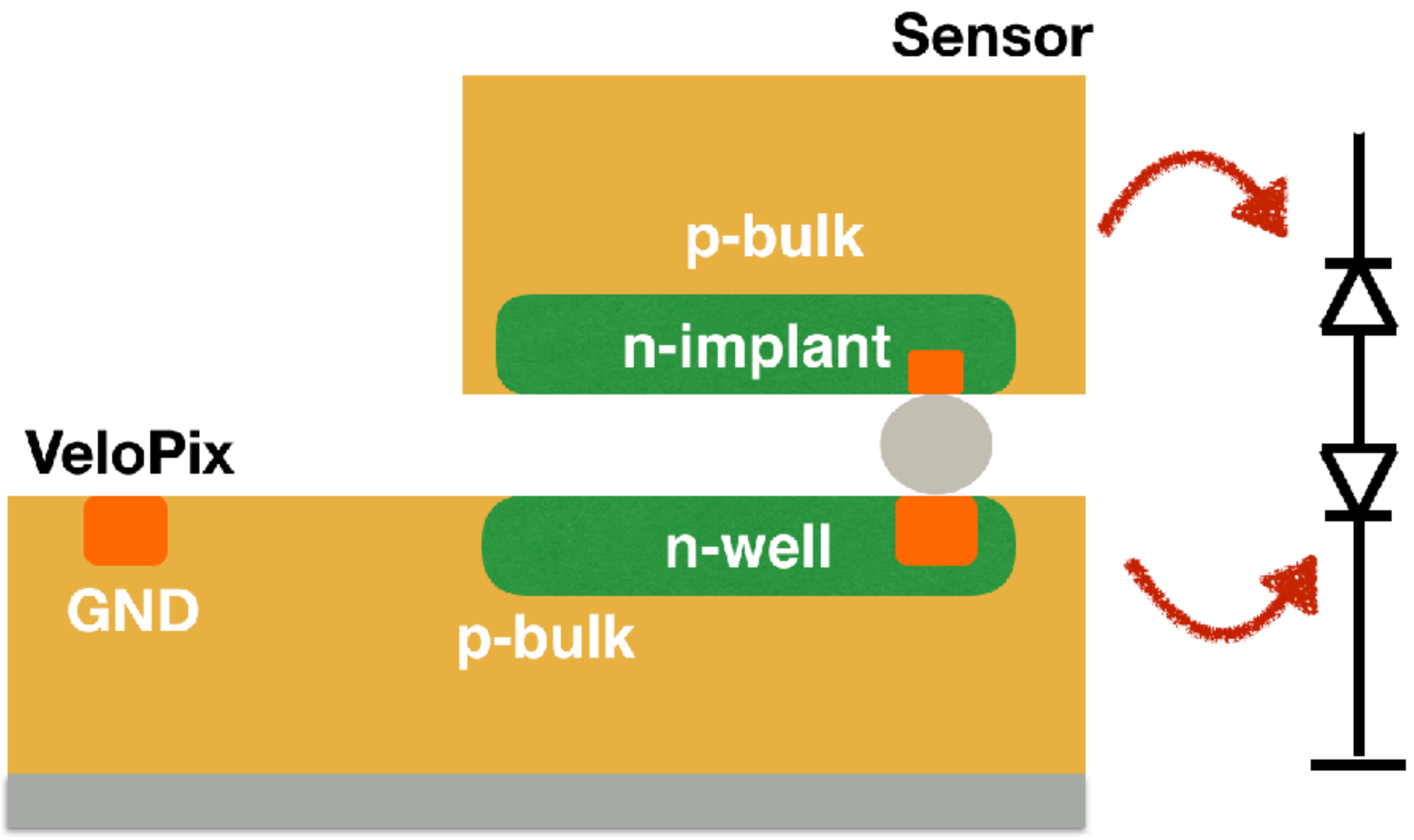
How to probe assemblies in vacuum before wire bonding?

Tile Quality Assurance

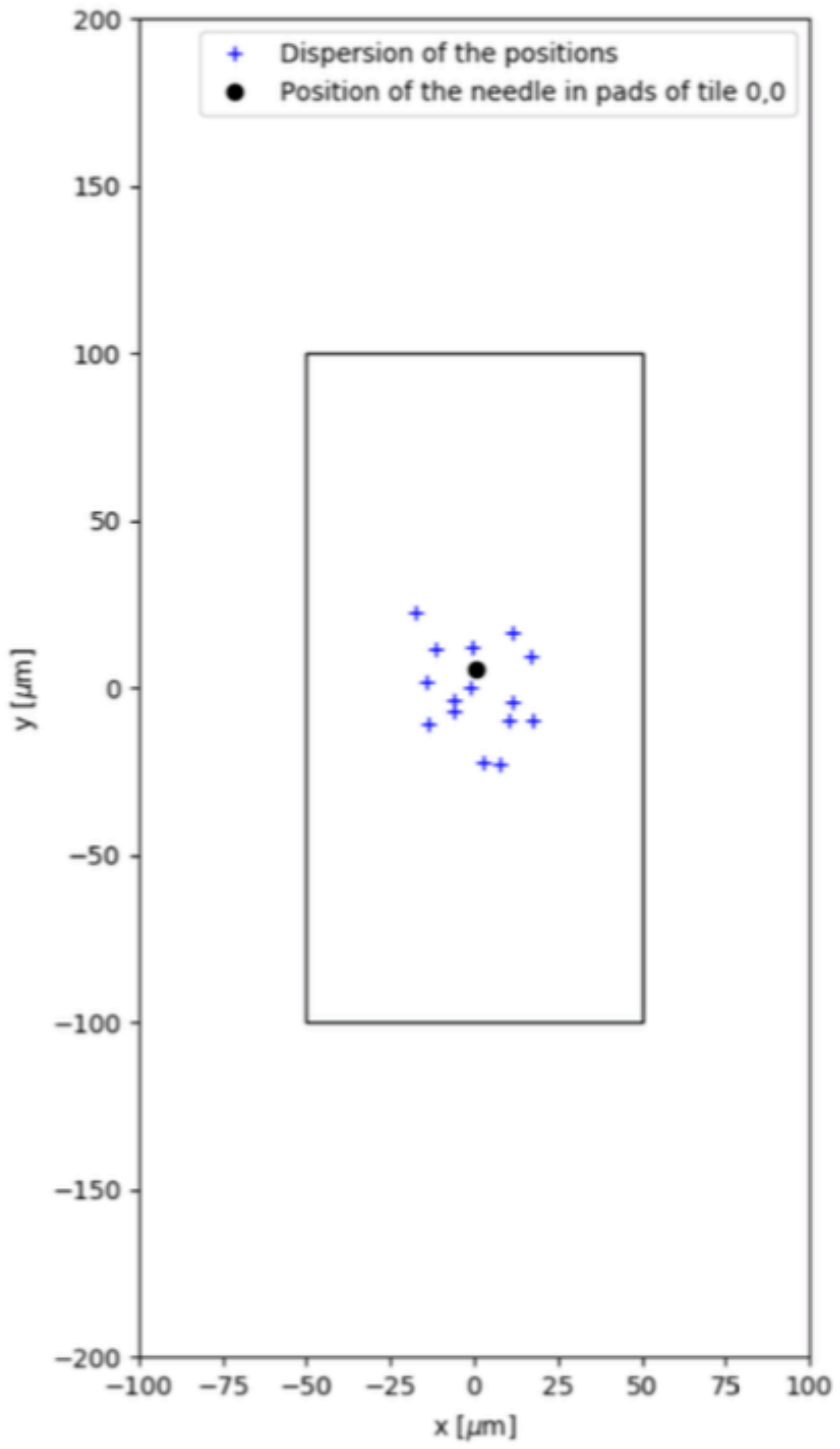
Due to the the way the VeloPix CMOS ASIC is built a diode is formed.

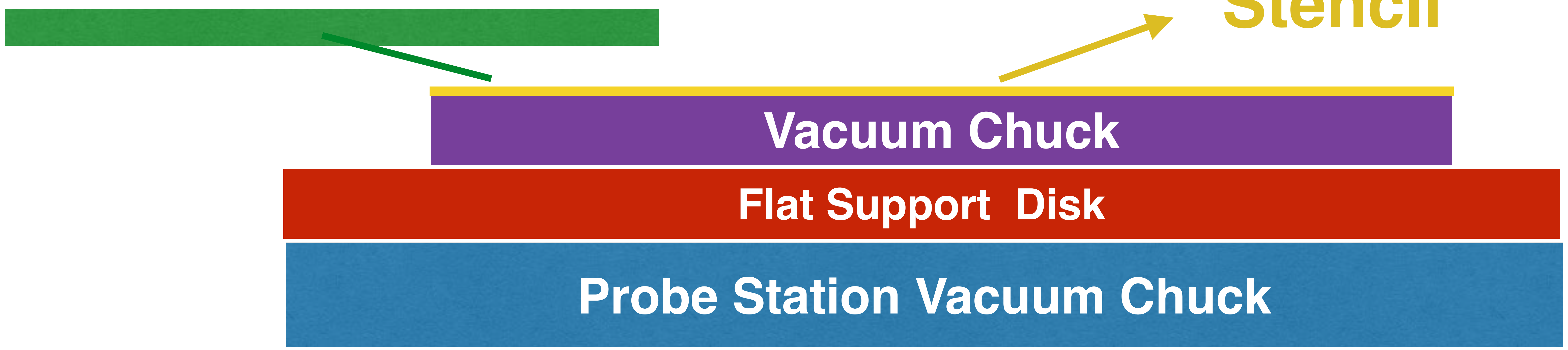
Ground is brought to the implant through the ASIC.

Reverse-biasing the sensor is forward bias in the VeloPix bulk.

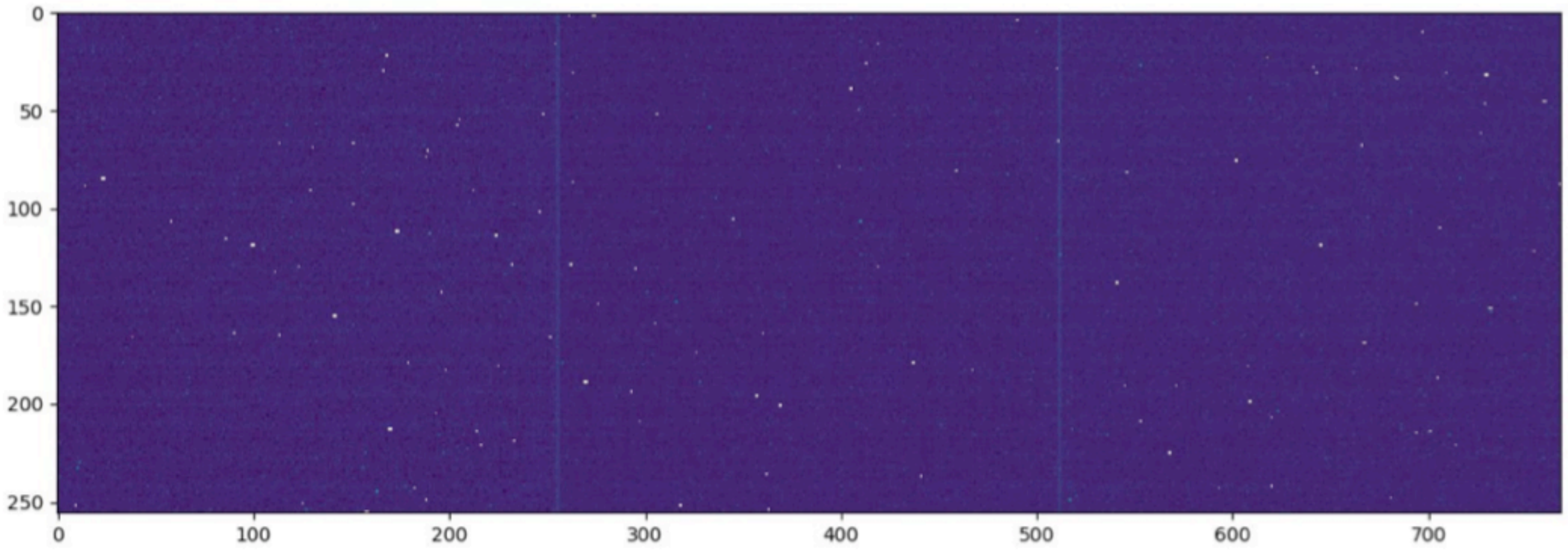


Probe Card Jig



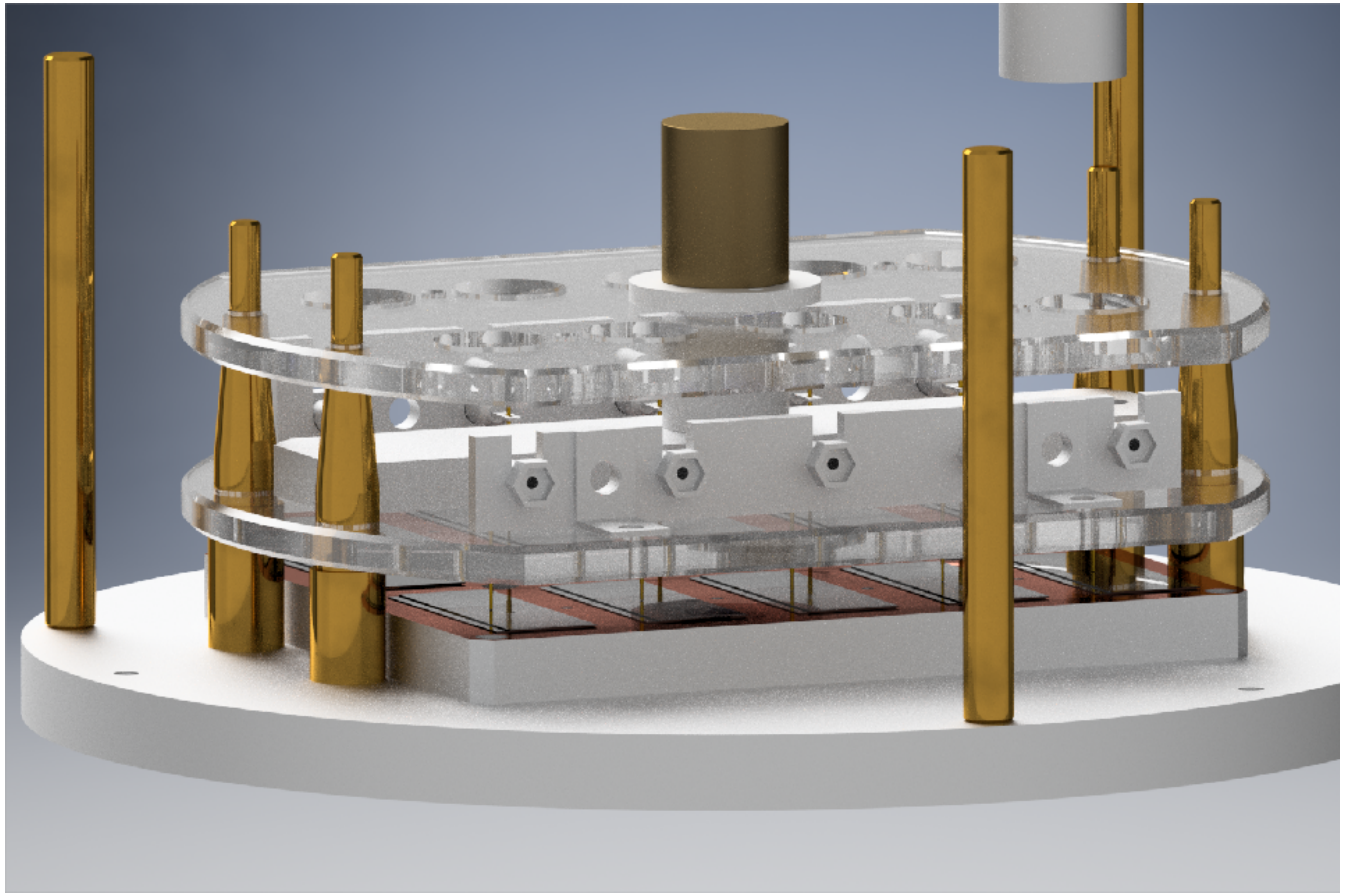


Noise Example



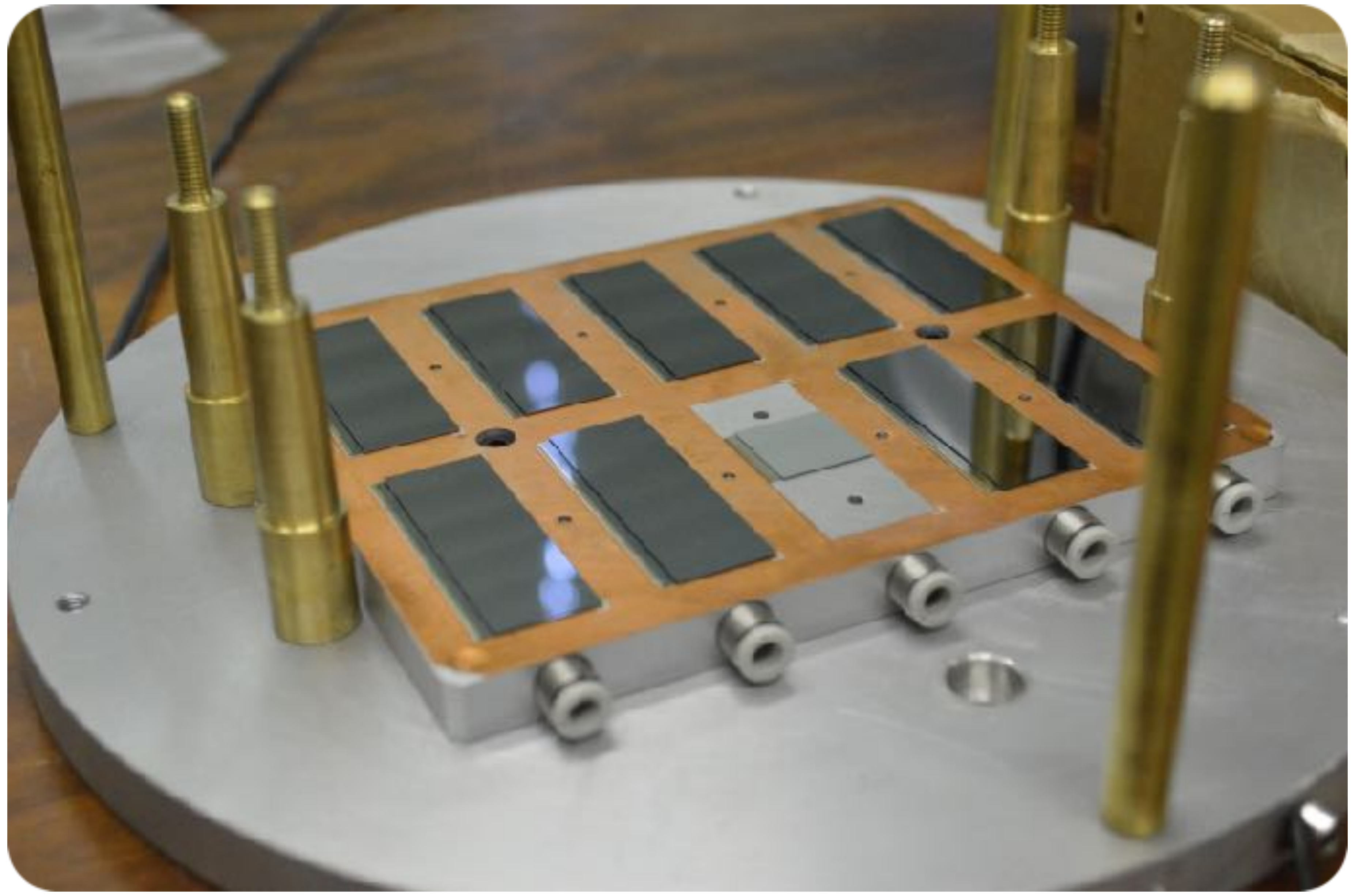
All tiles will be tested and qualified with this jig.

HV Vacuum Tests

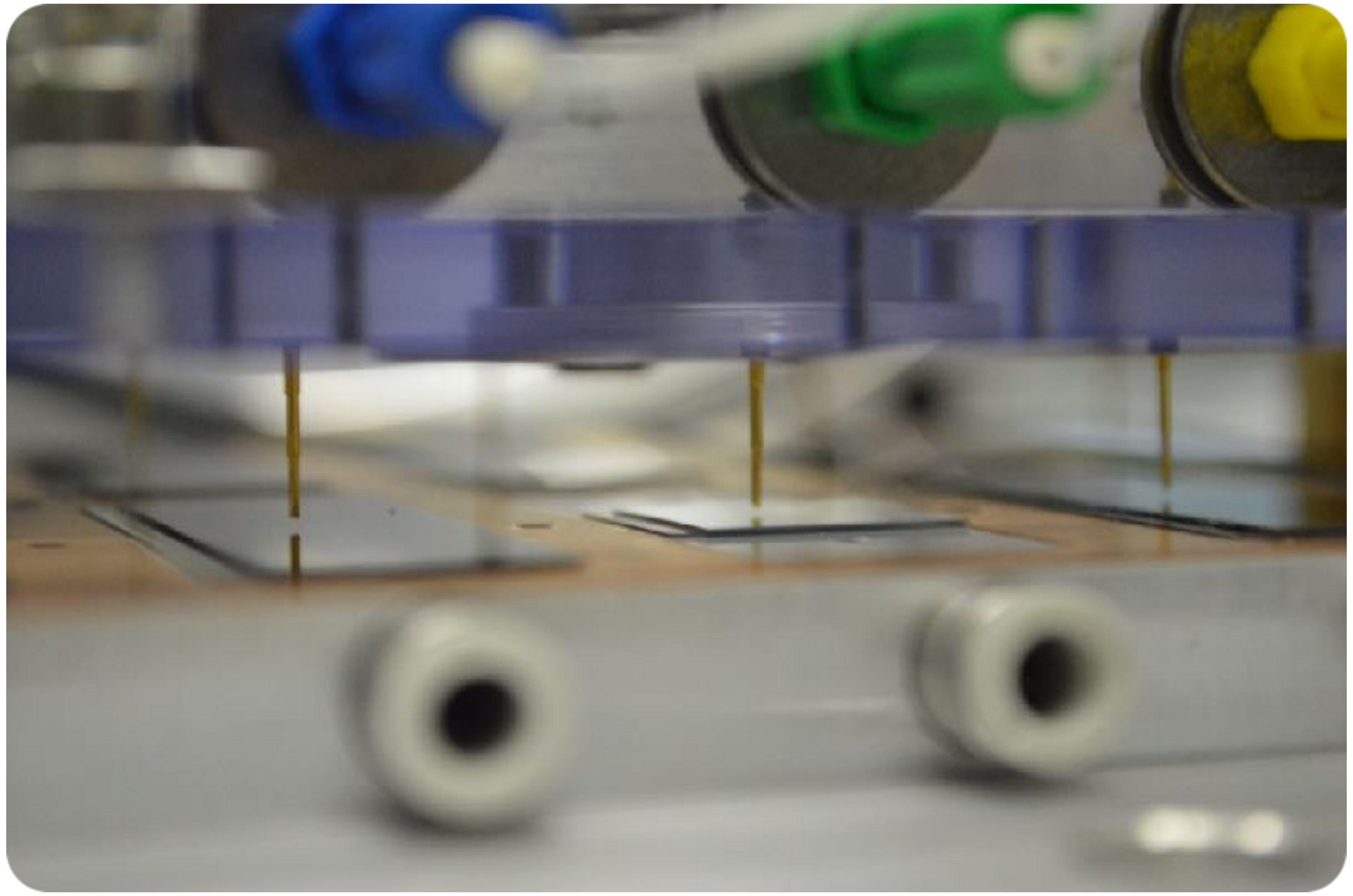


Enclosure built to do IV scans of sensors in vacuum.

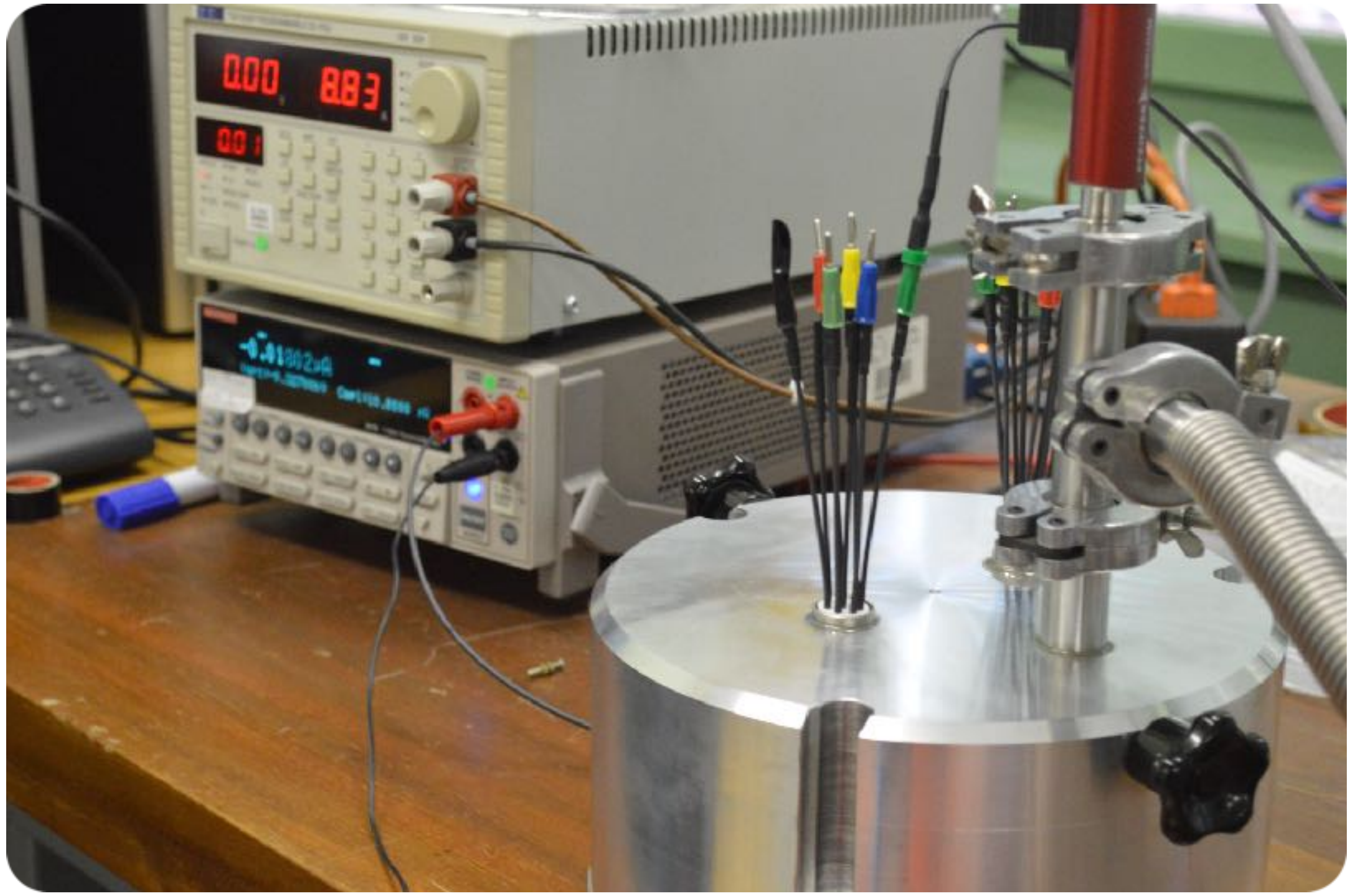
Must be careful to avoid damaging the tiles.



HV Vacuum Tests

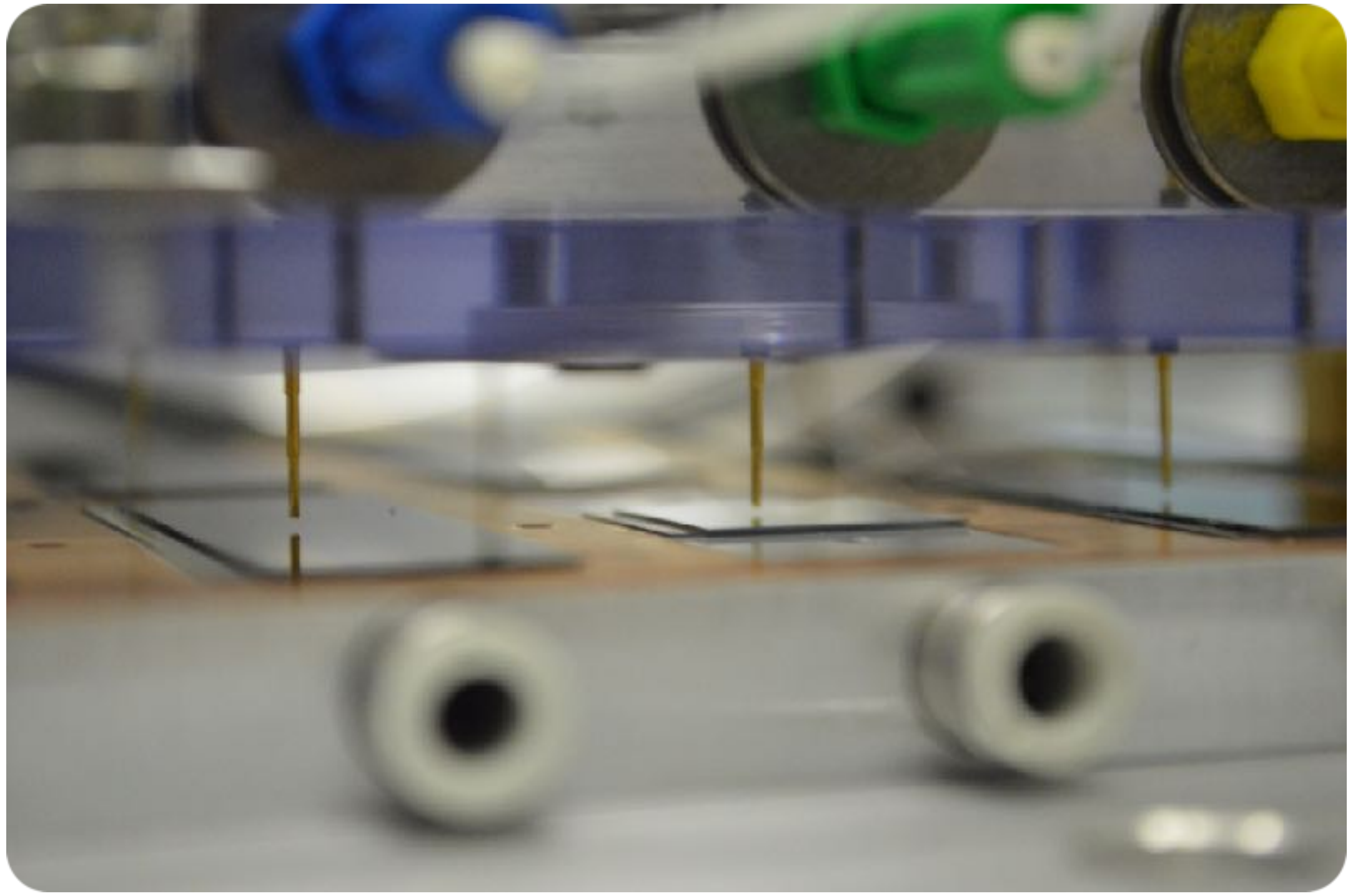


Spring loaded probe needles keep small pressure on sensors.



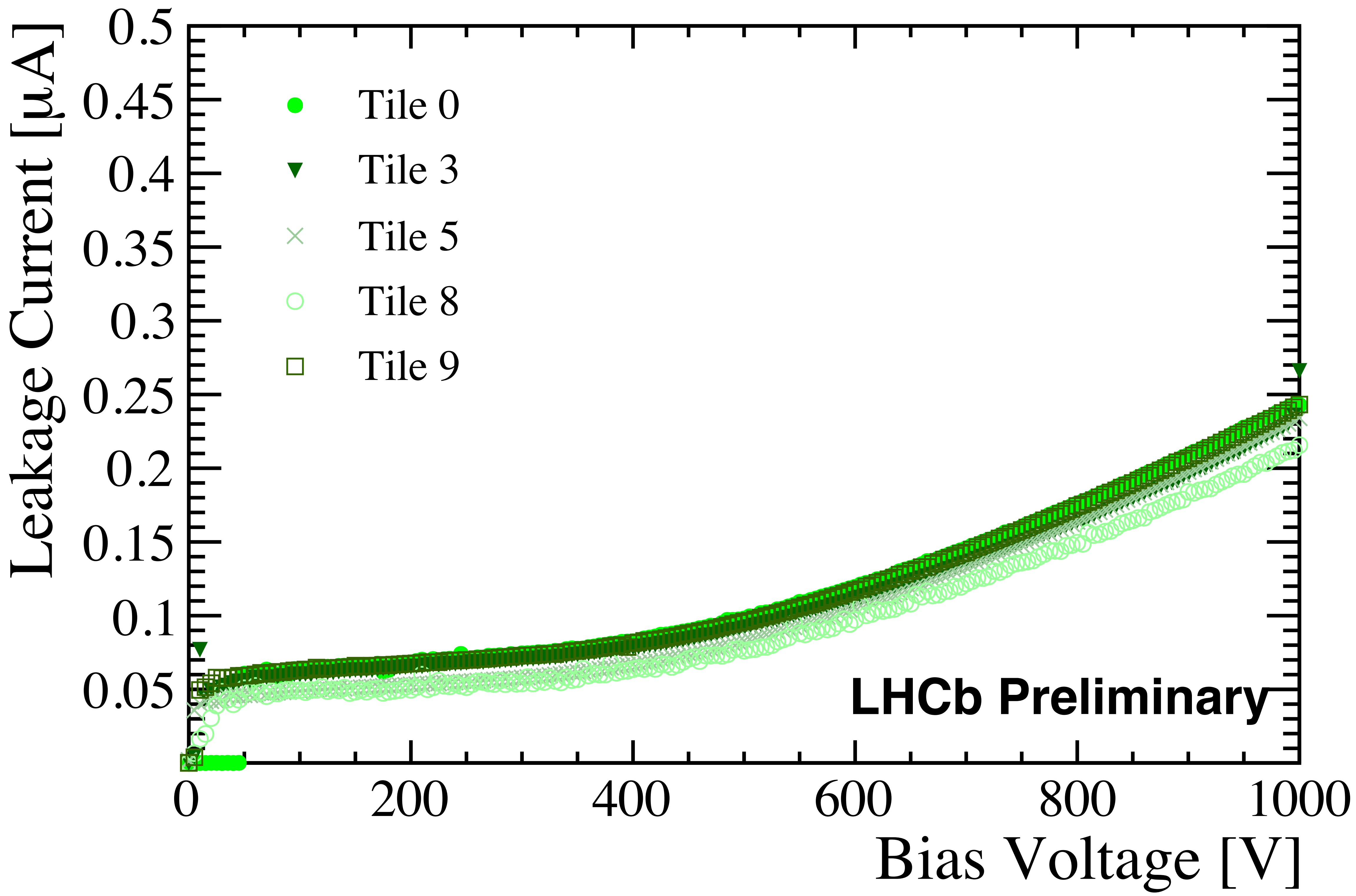
Dowels stop needles before end of spring compression.

HV Vacuum Tests



Spring loaded probe needles keep small pressure on sensors.

Example of tiles tested with this jig.



173 Tiles tested already!

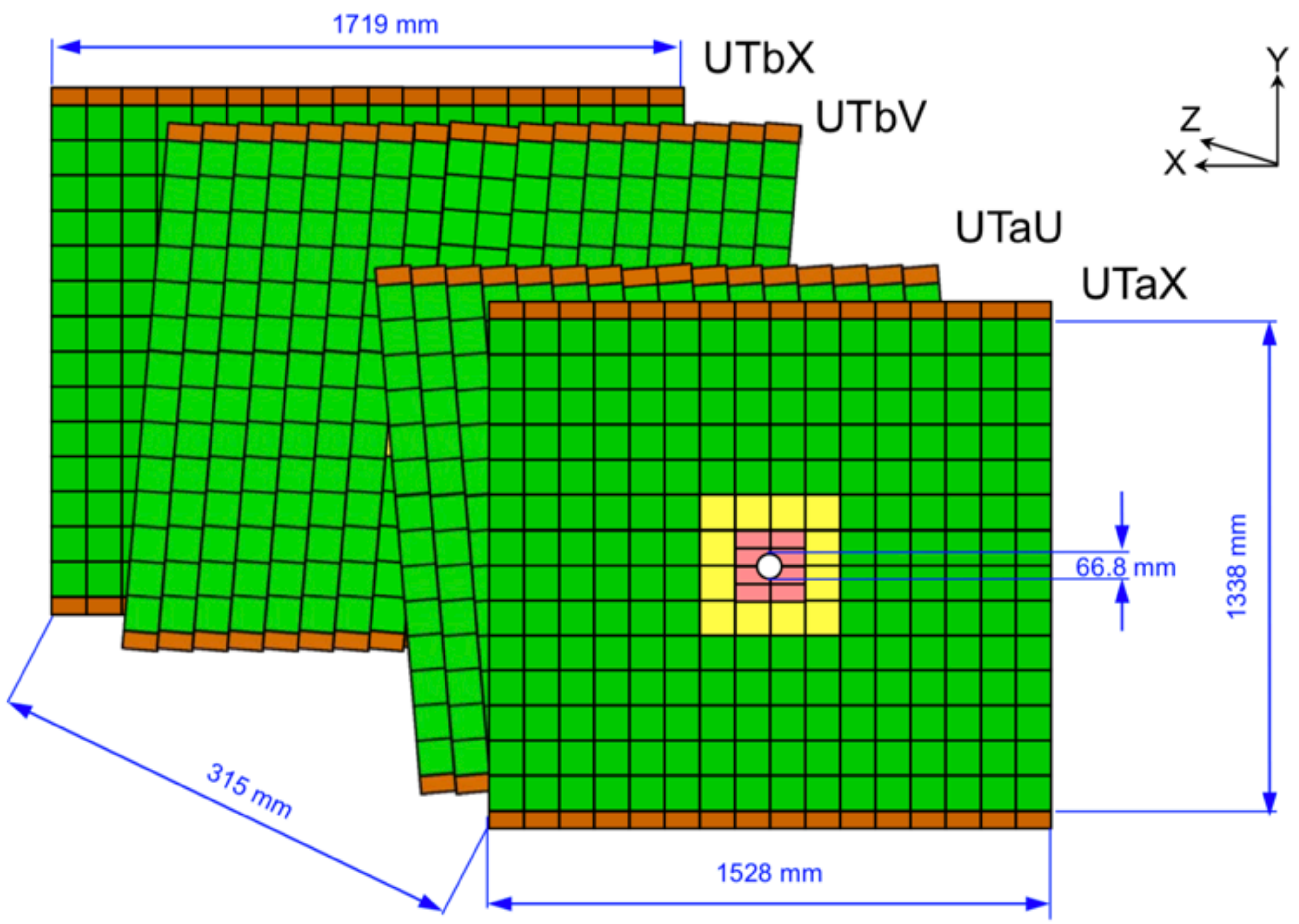
Upgrade Tracker

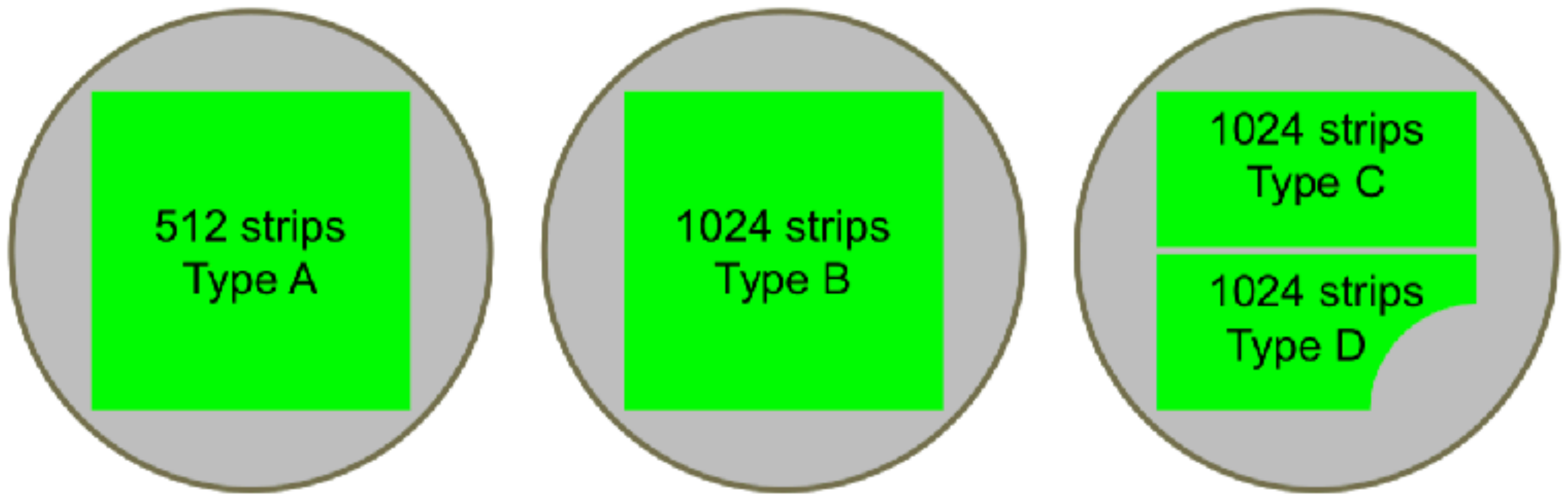
In a similar fashion to the VELO the UT is a new silicon detector to be installed in LHCb

40 MHz readout using the SALT ASIC

4 different types of silicon microstrip sensors

My intention is to contribute to the production and commissioning of the UT.





Summary

I have been involved with silicon sensors for tracking since my Master's degree with COMBAT

As part of my PhD I have also contributed to the Lepton Universality measurement using Λ_b decays

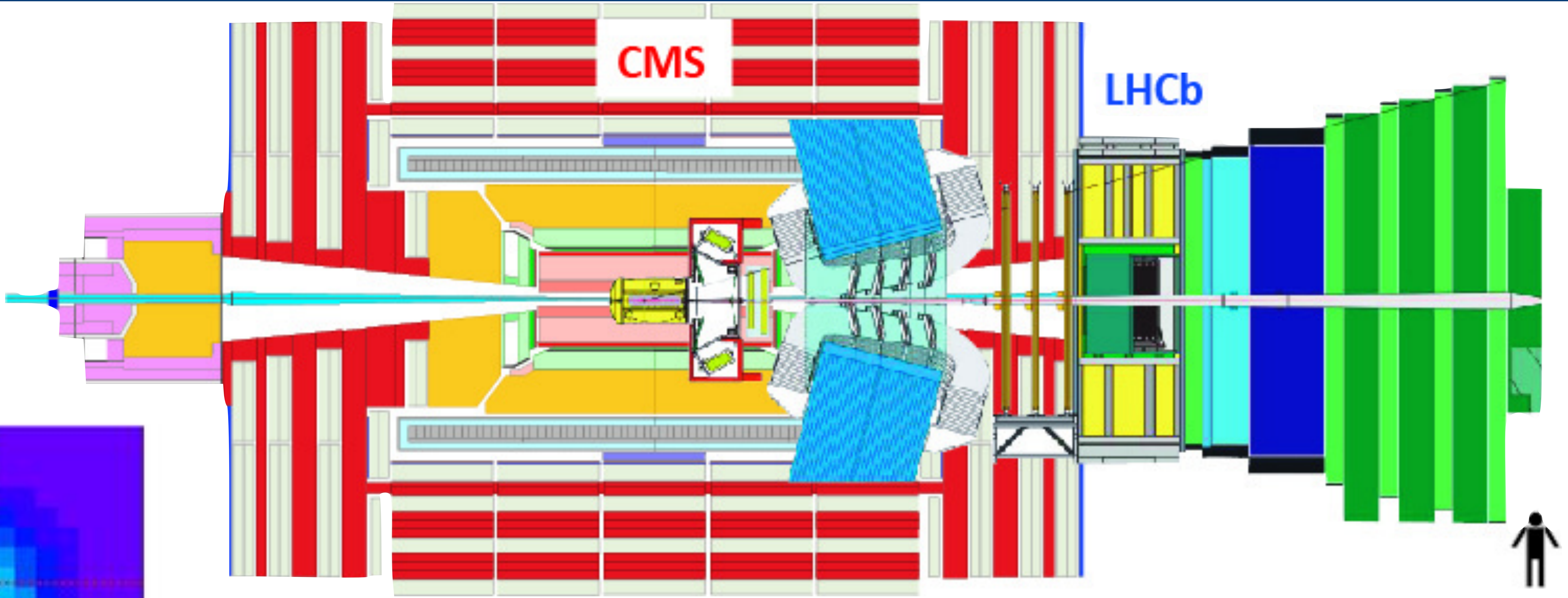
Actively participated in the R&D for VELO Upgrade being responsible for IV measurements

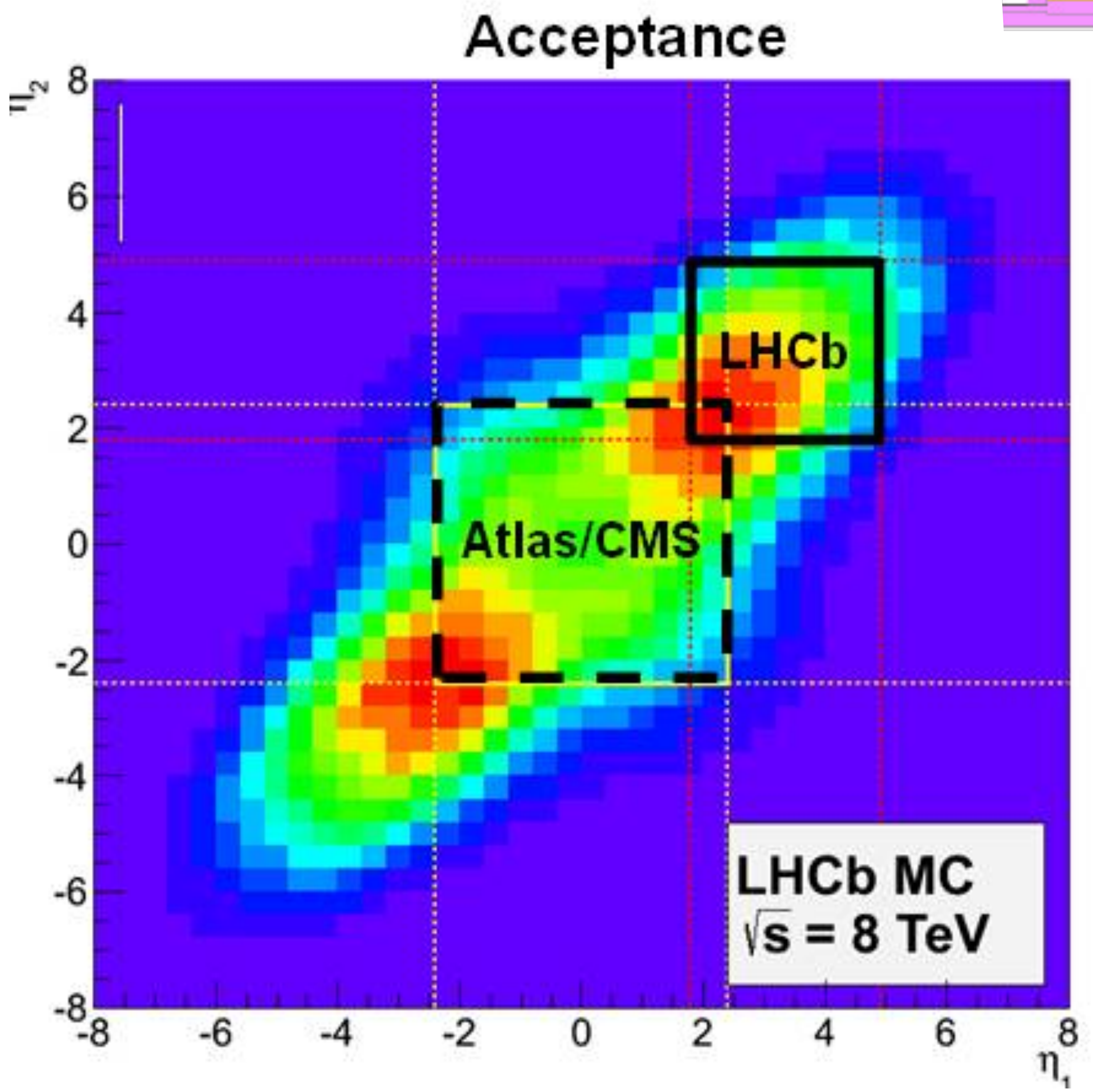
Setup for Tile quality assurance in the VELO Upgrade currently used to test all VELO sensors during production

Looking forward to contribute to the UT detector commissioning

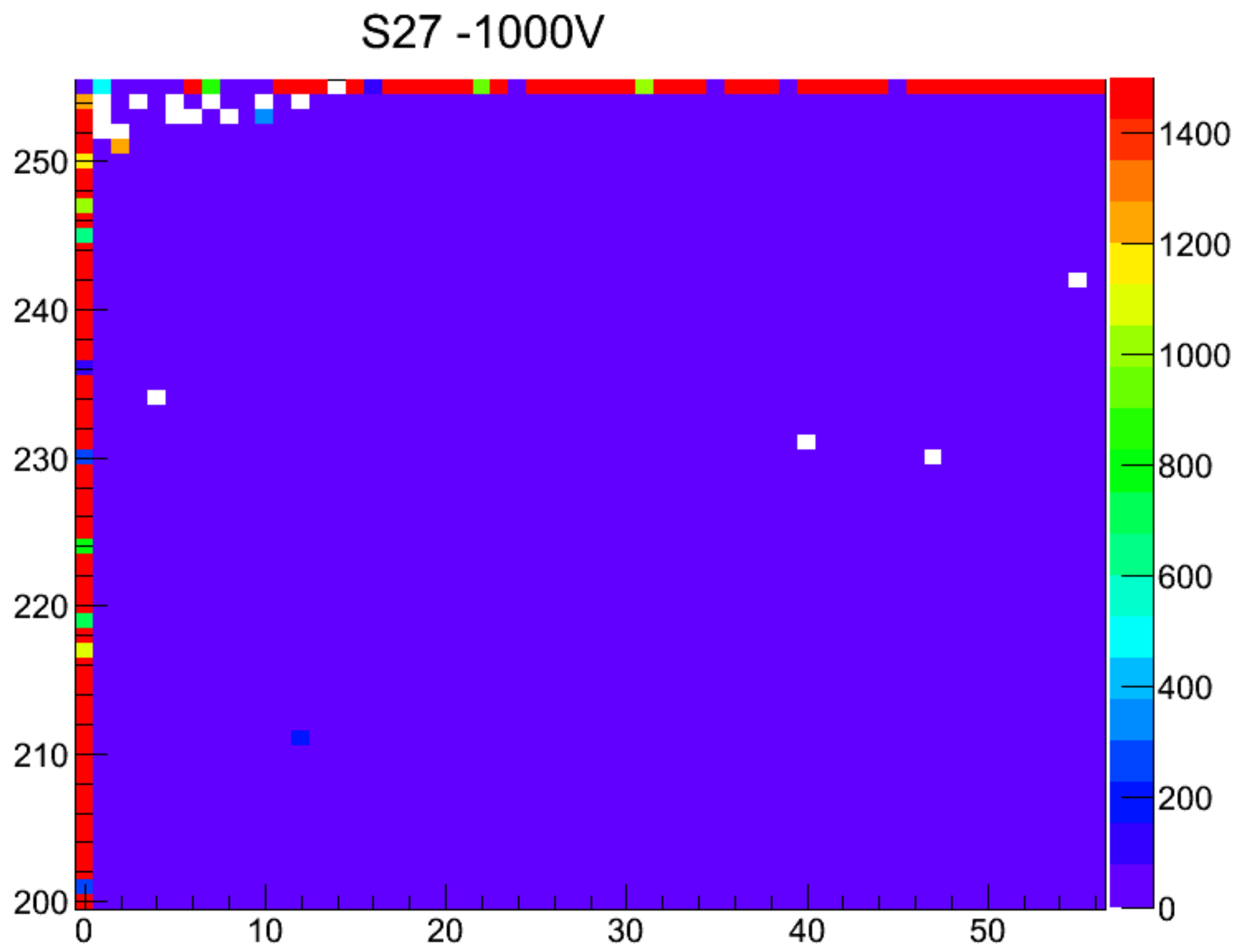
Thank you!

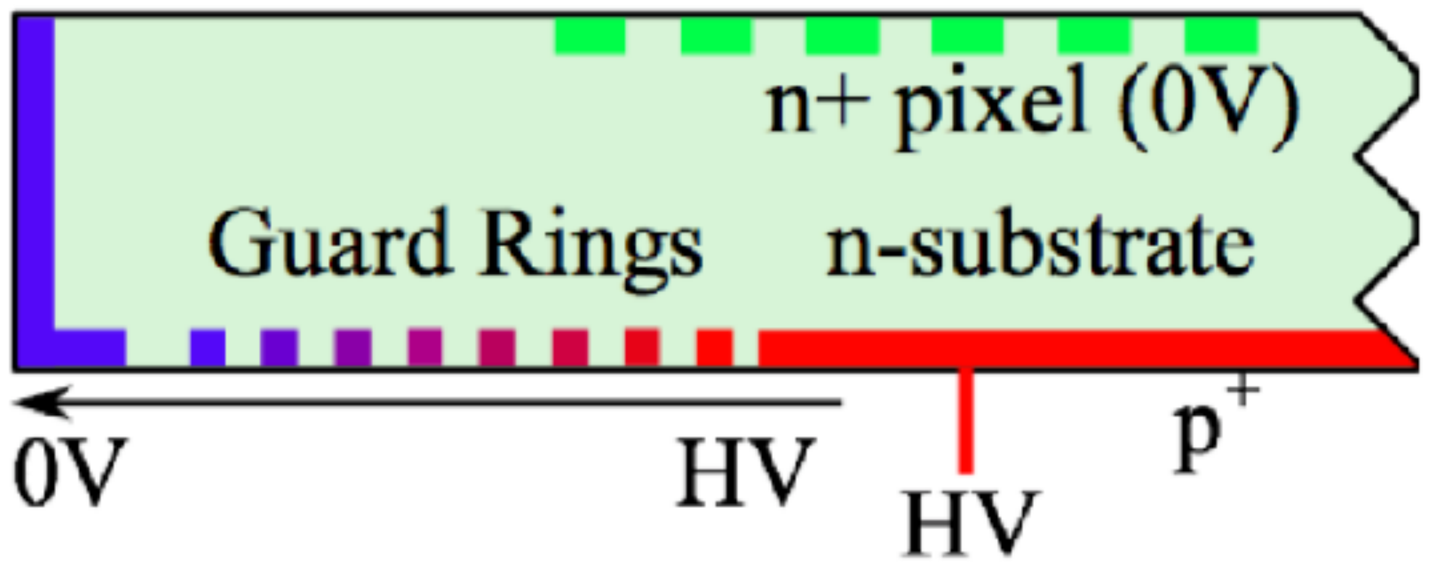
Backup


CMS
LHCb


Acceptance
LHCb
Atlas/CMS
LHCb MC
√s = 8 TeV
η2
η1

Edge Behaviour





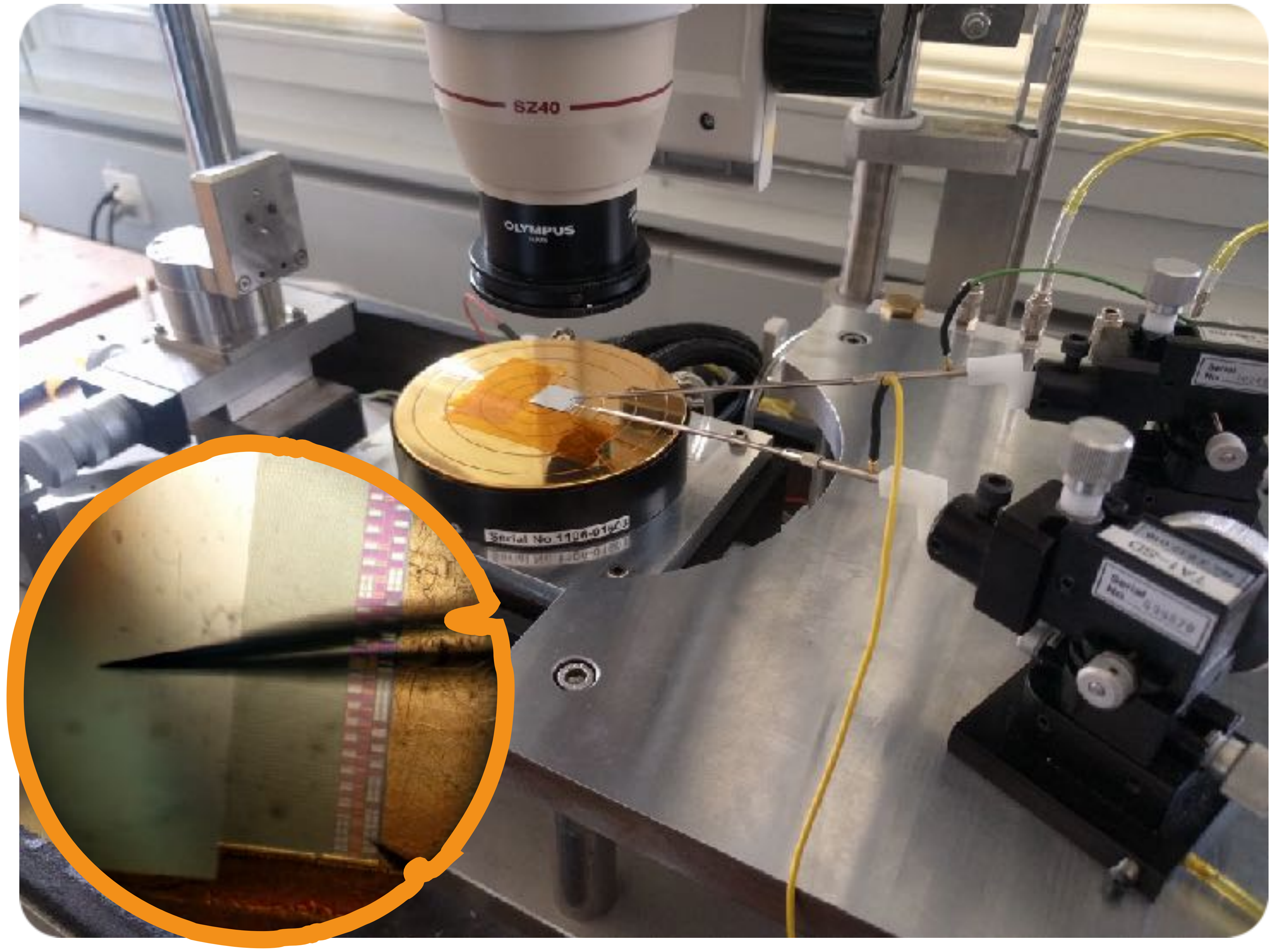
A couple of interesting features were observed at the edge of the sensors.

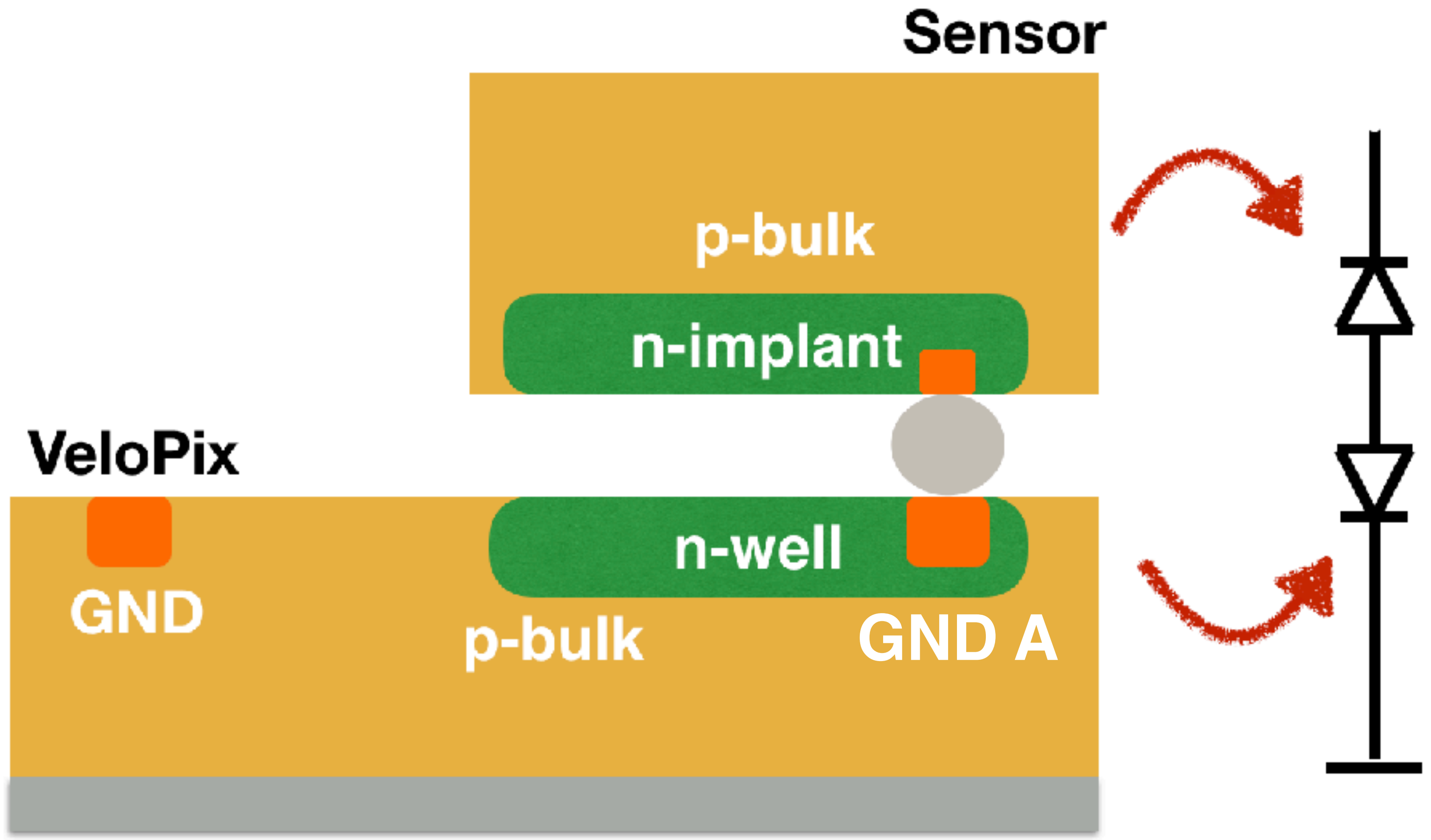
The Micron n-on-n design had a very high intensity noise at the edges.

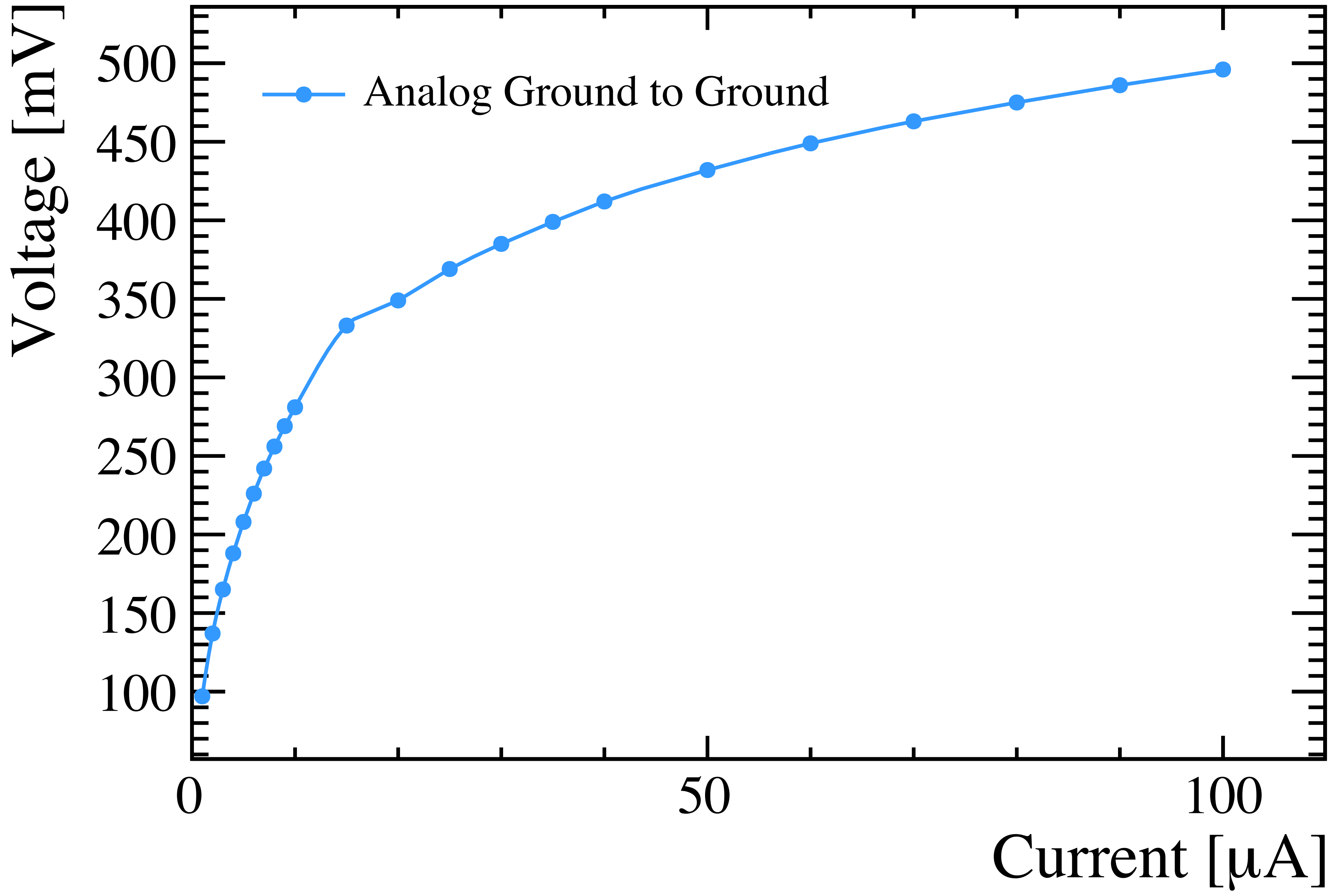
Problem mitigated when we increase leakage current compensation in the ASIC.

Consistent with leakage current being pushed through the pixels due to guard-ring structure.

Tile Quality Assurance

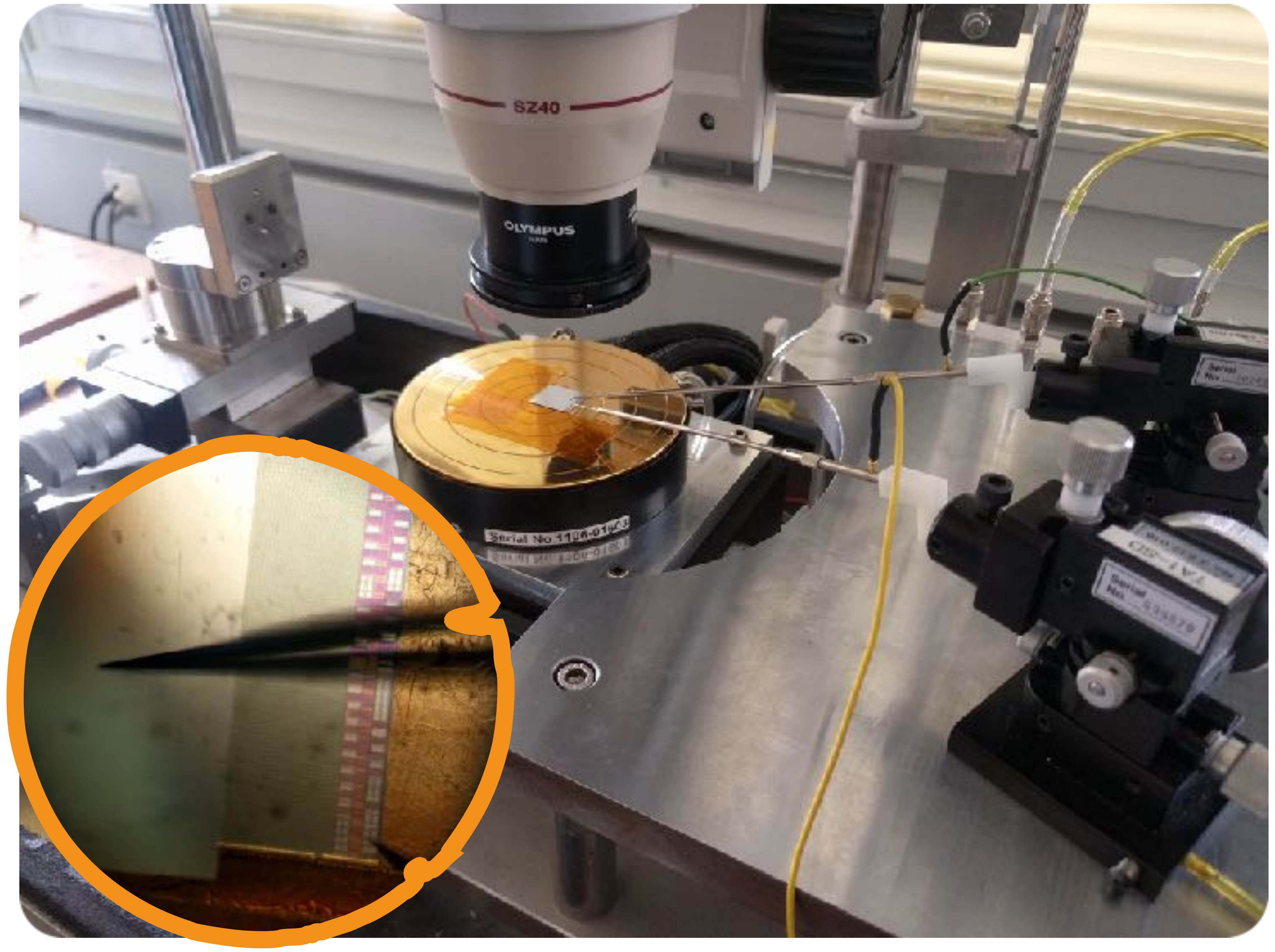




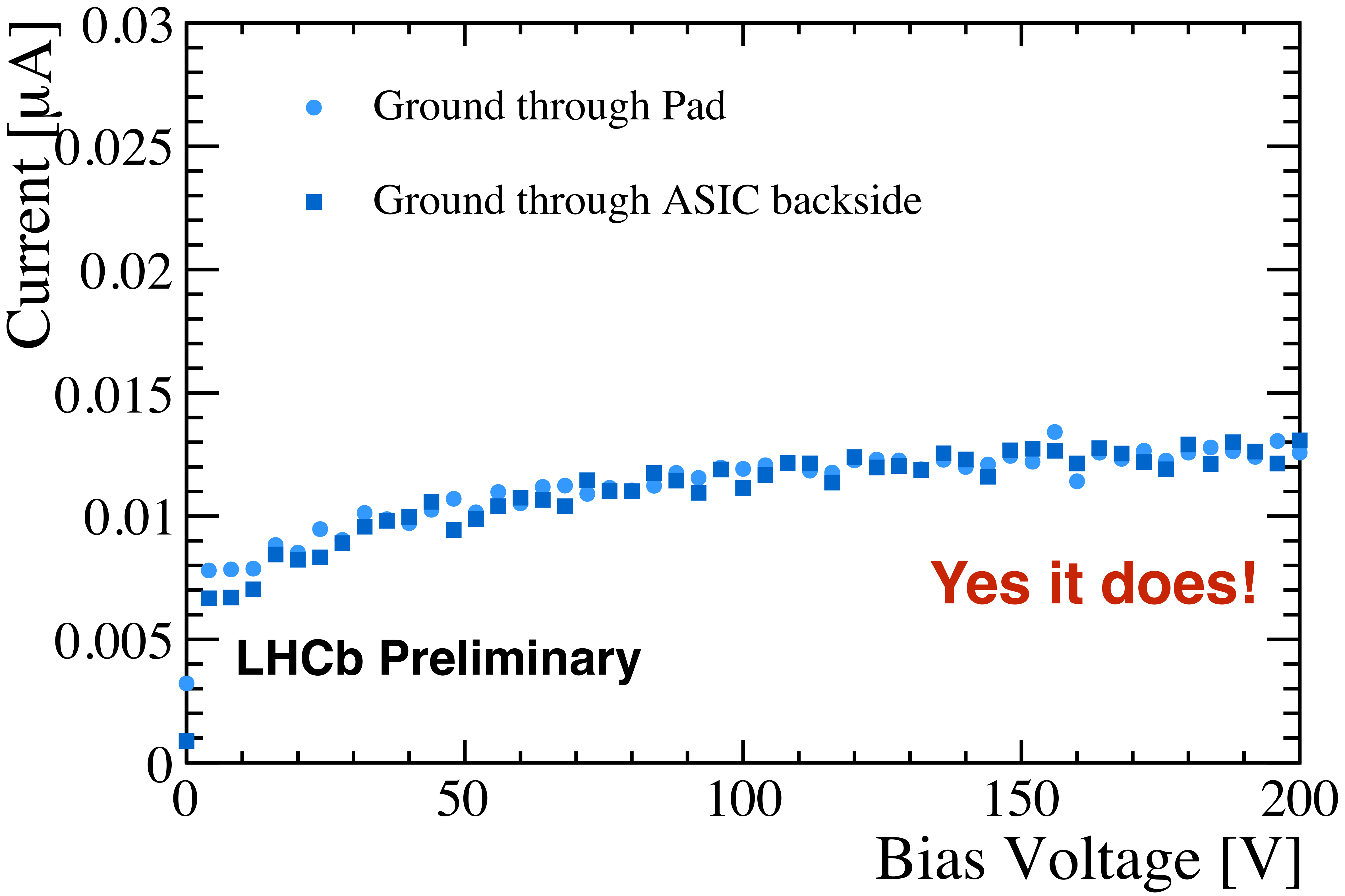


Can we can ground the sensor through the ASIC?

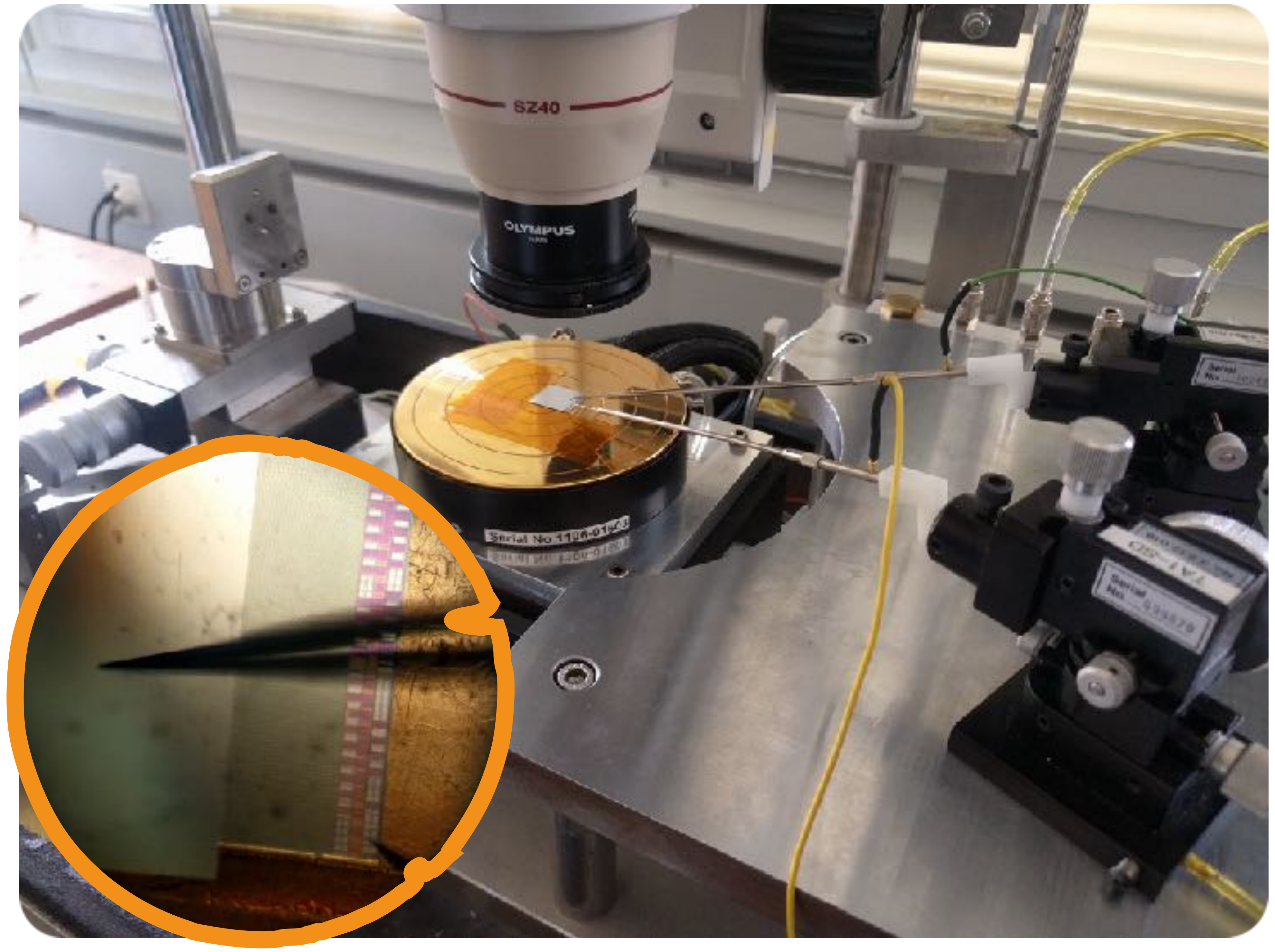
Tile Quality Assurance



Does it work with a bump-bonded tile?



Tile Quality Assurance



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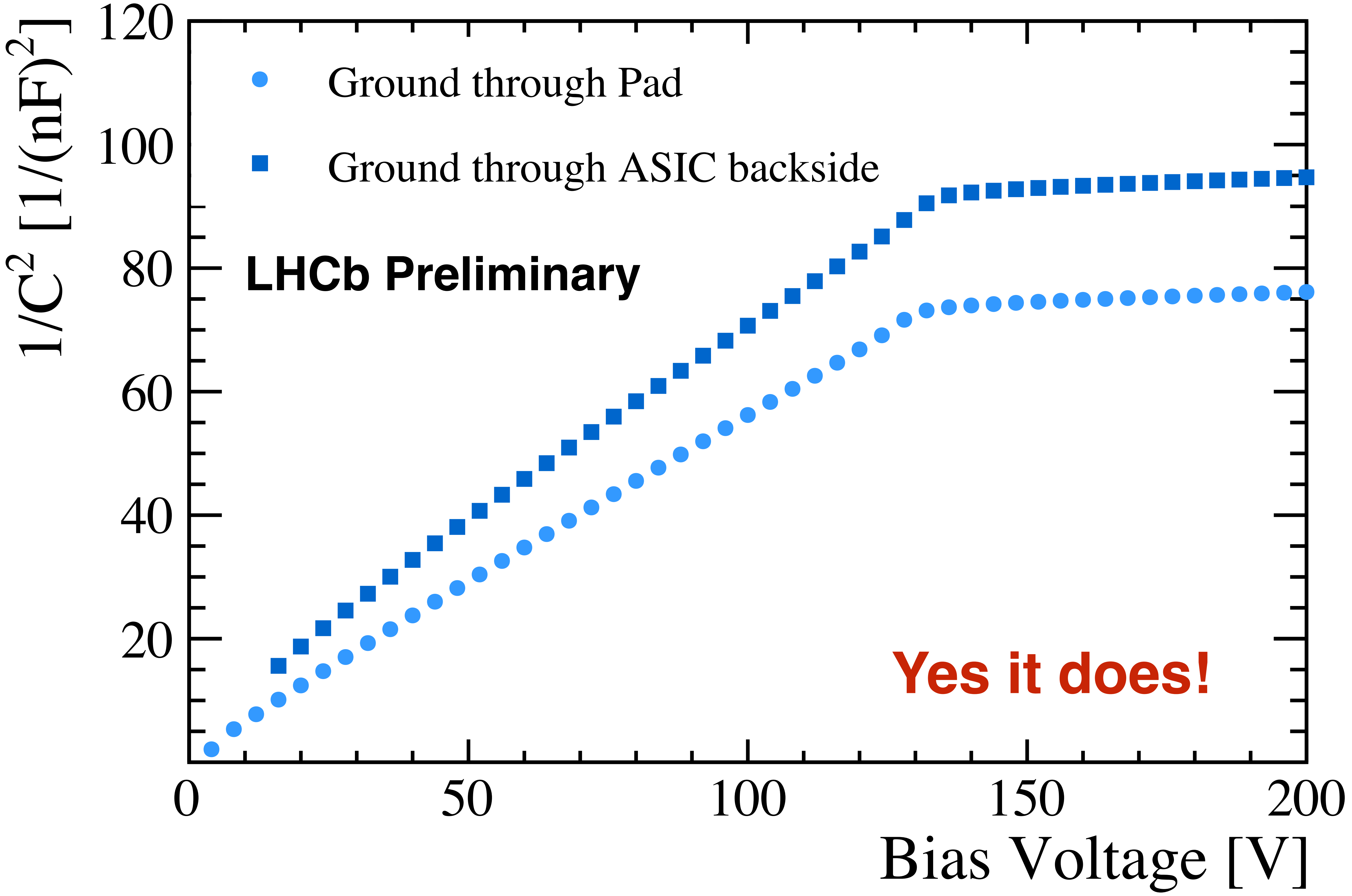
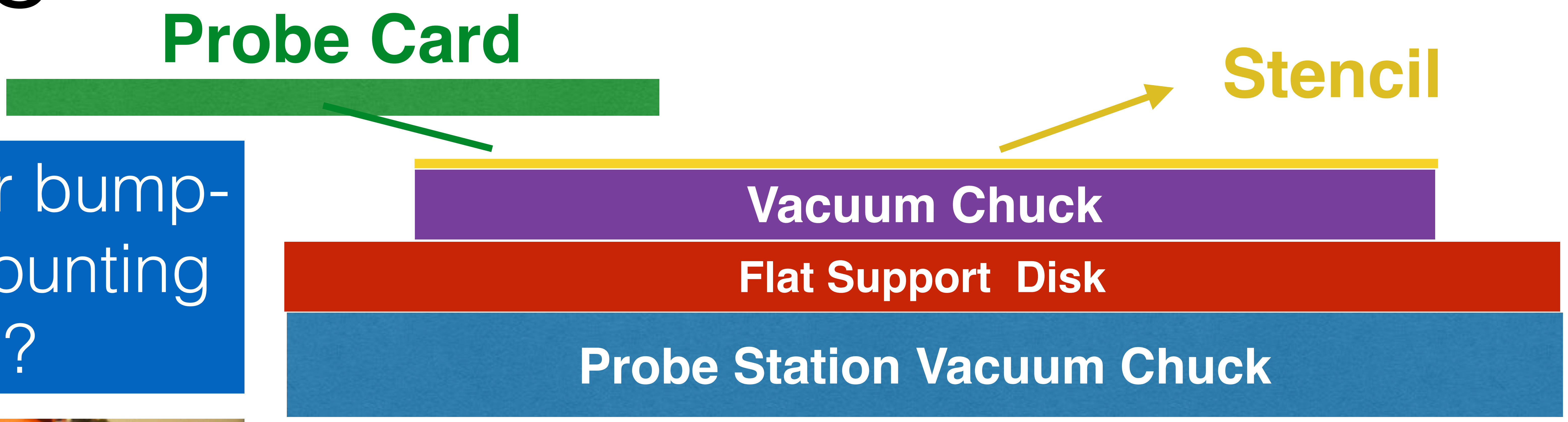
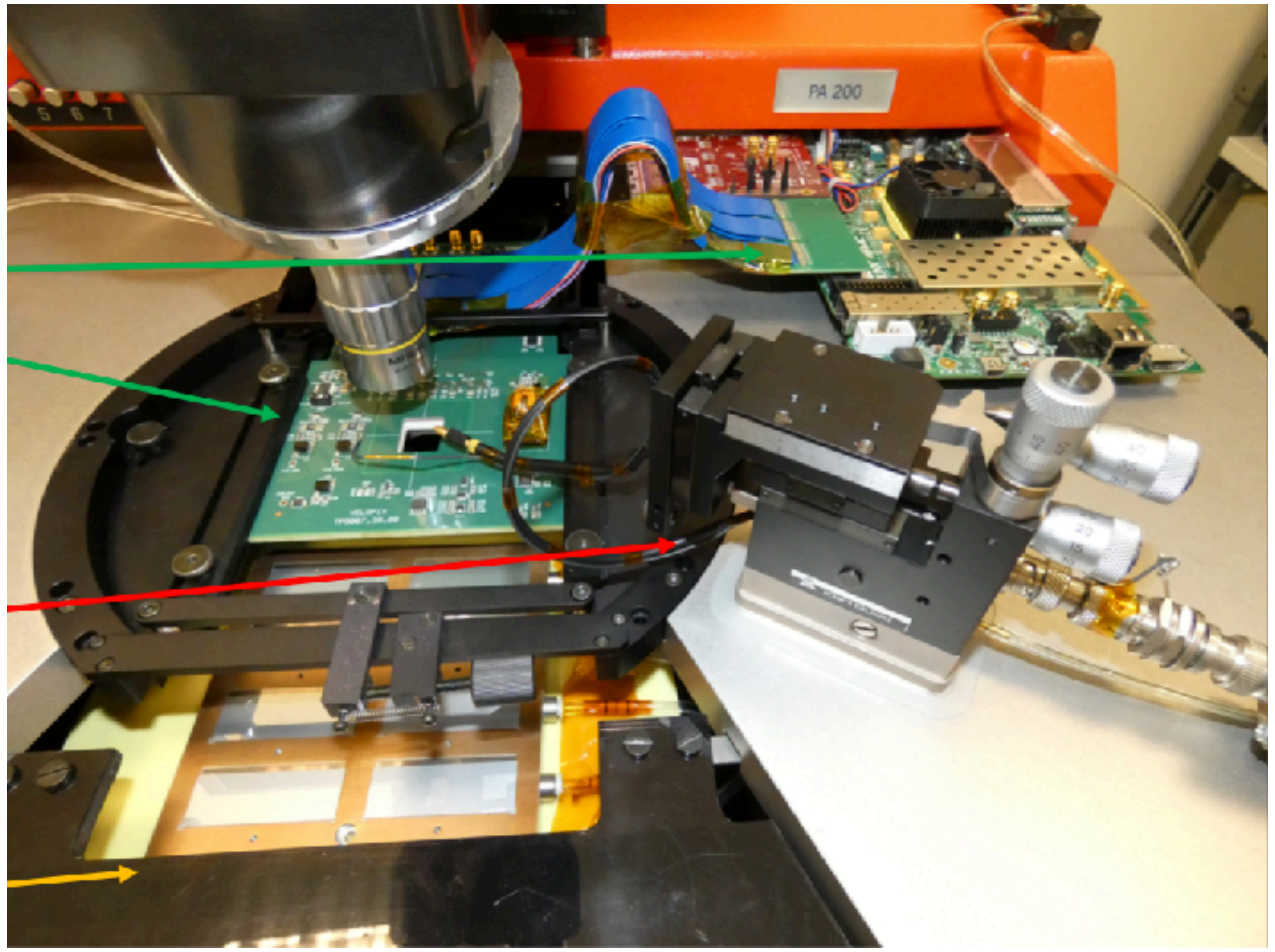
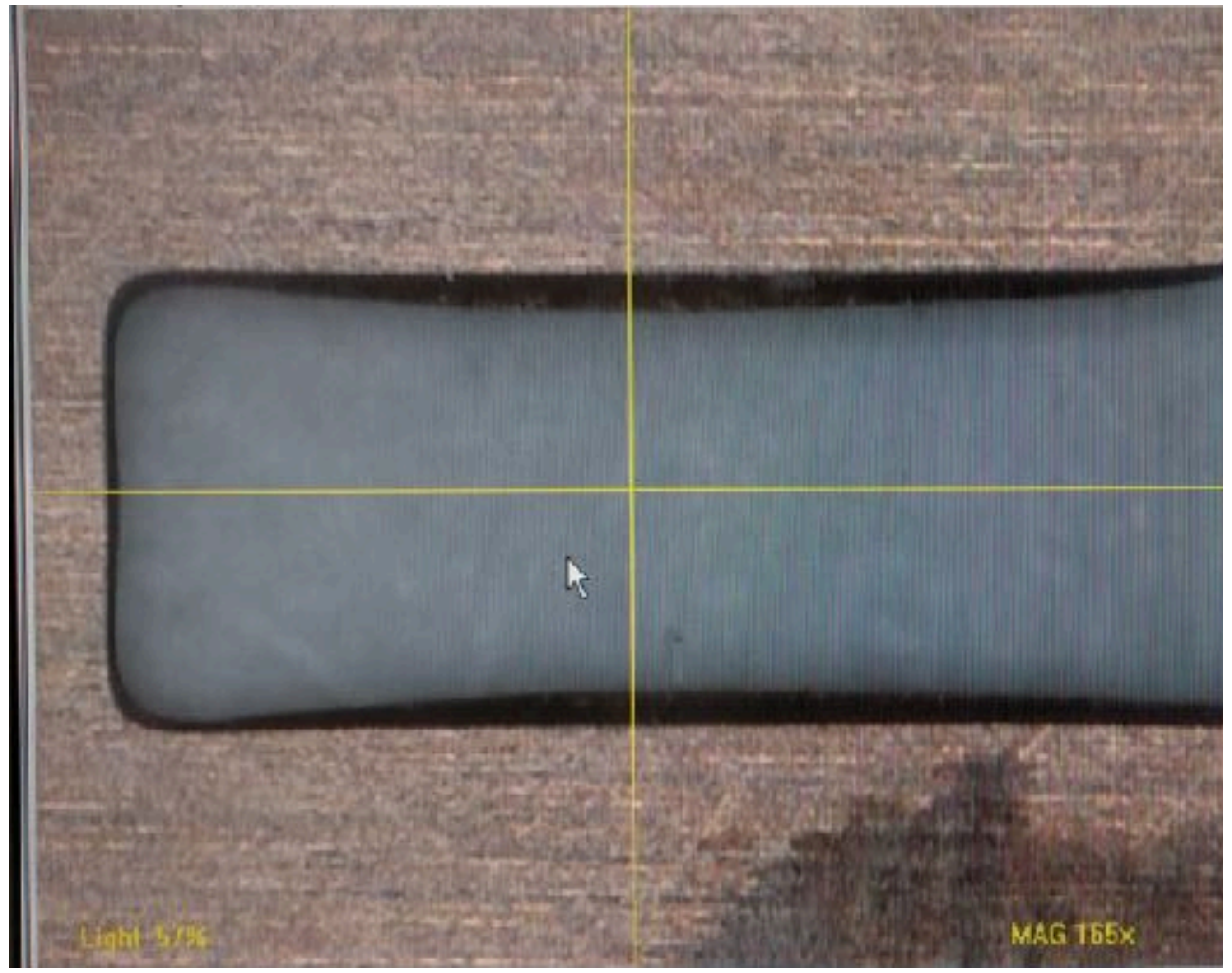


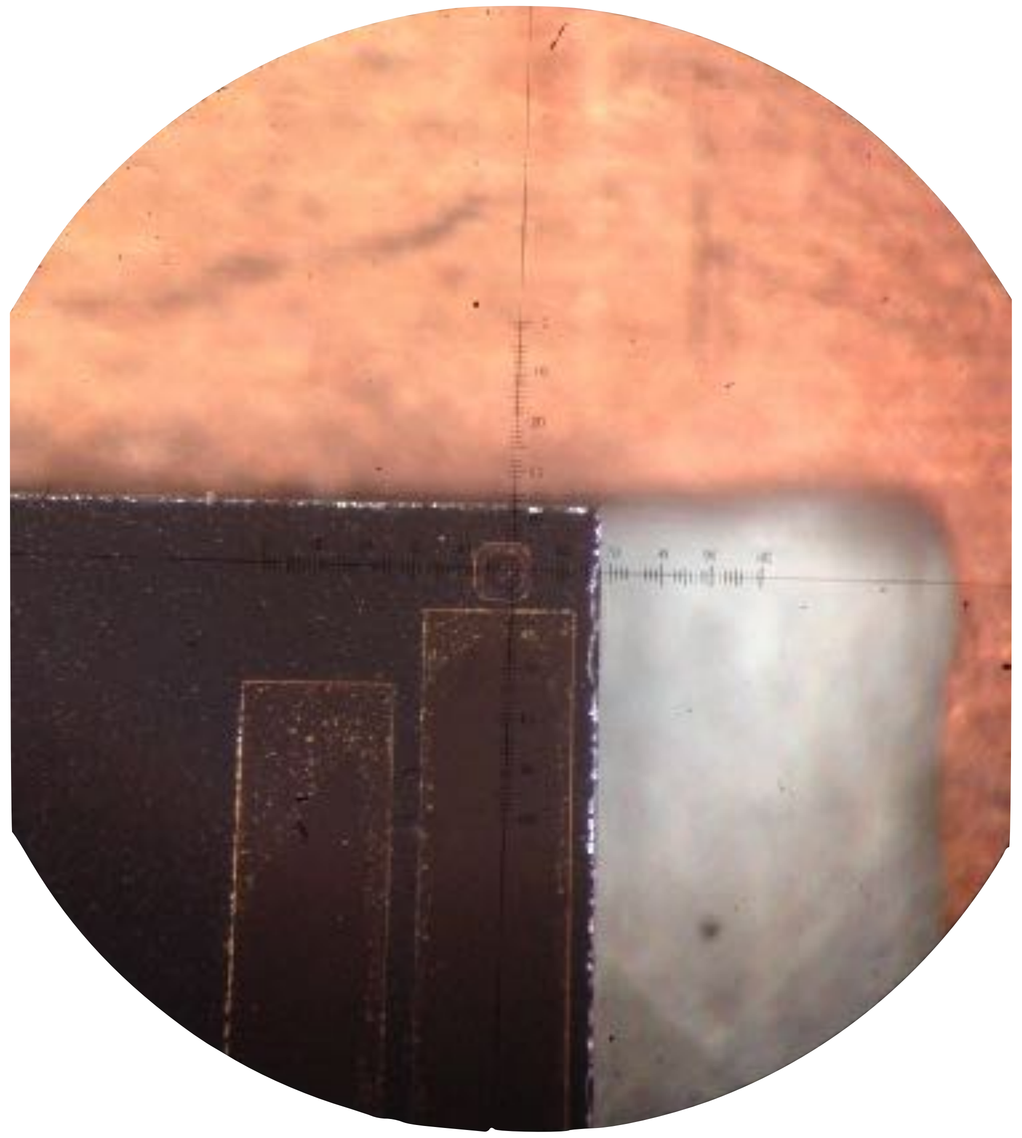
Probe Card Jig



How to test each tile for bump-bond quality before mounting them to modules?







40µm precision

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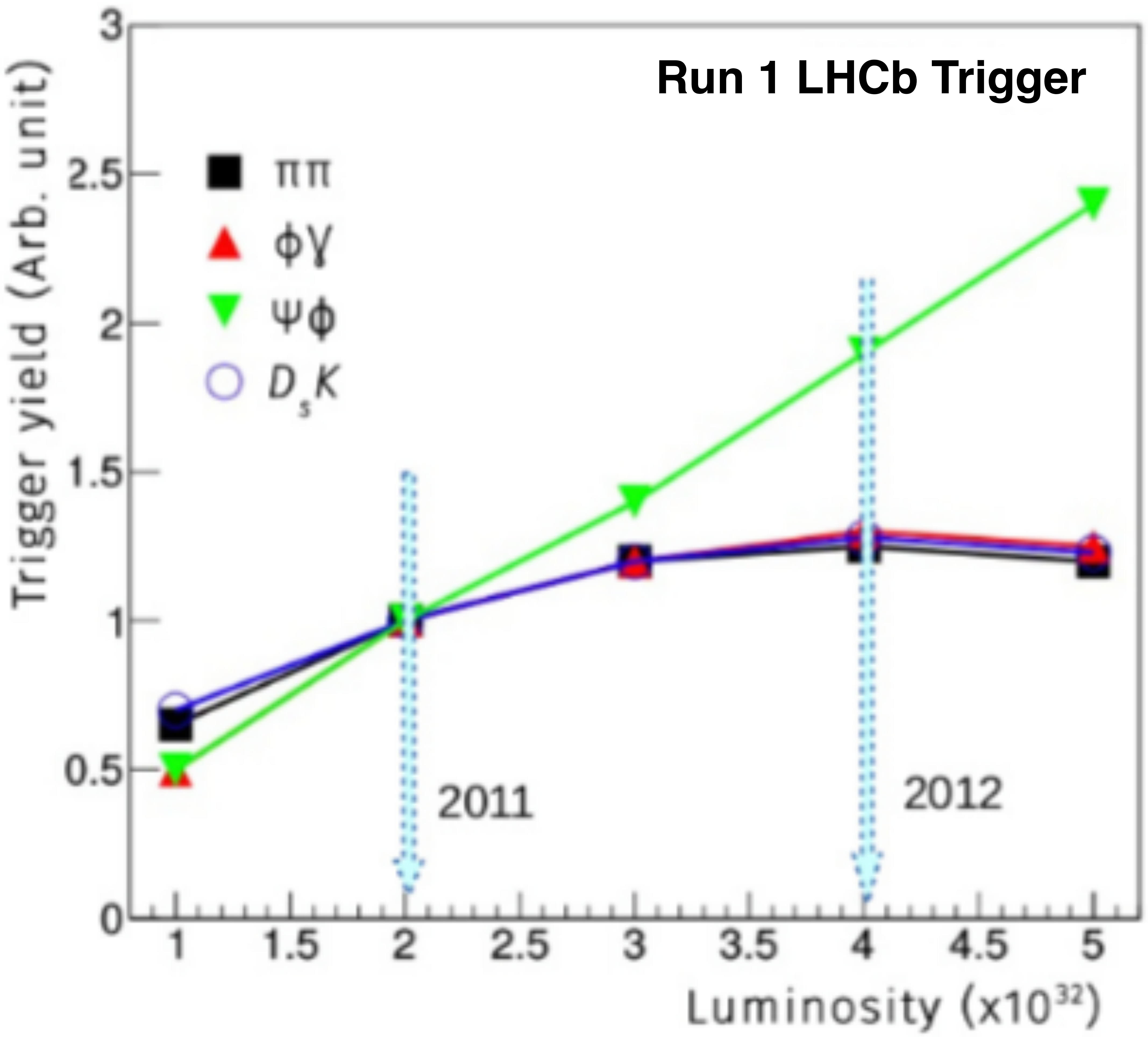
LHCb Detector Upgrade



By the end of Run II, operating at current luminosity offers diminishing returns.

Increasing Luminosity in order to achieve $50fb^{-1}$ in Run III.

$4x10^{32}$ $cm^{-2}s^{-1}$ → $20x10^{32}cm^{-2}s^{-1}$

Upgrade Trigger implemented on software only.

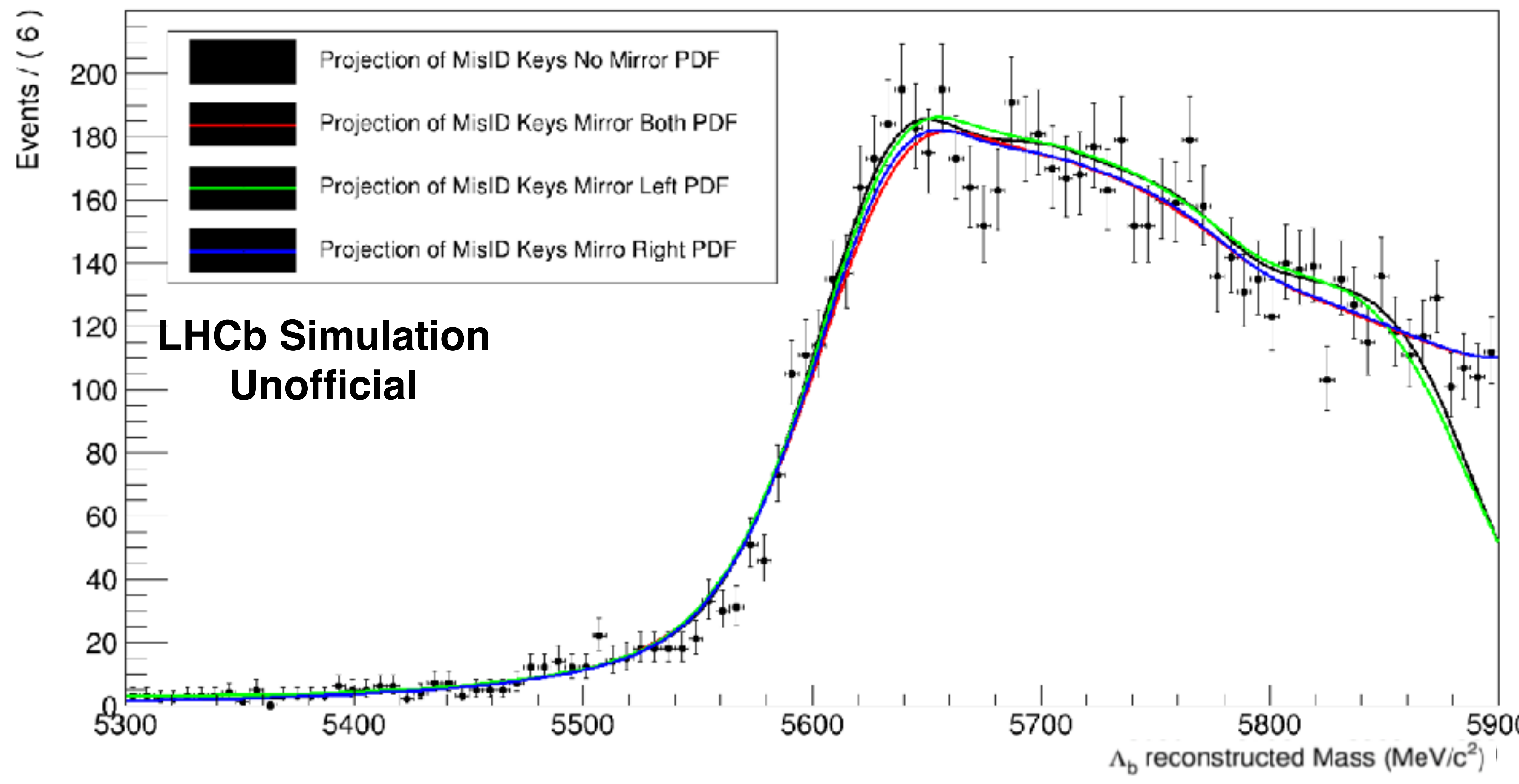
Readout: 1 MHz → 40 MHz

MisID p.d.f. Estimation

The incorrect identification of final state particles might produce a broad peak under our signal

KeysPDF is a numerical method used to generate functions from a given dataset

Different options of this method were evaluated, and we chose appropriate parameters

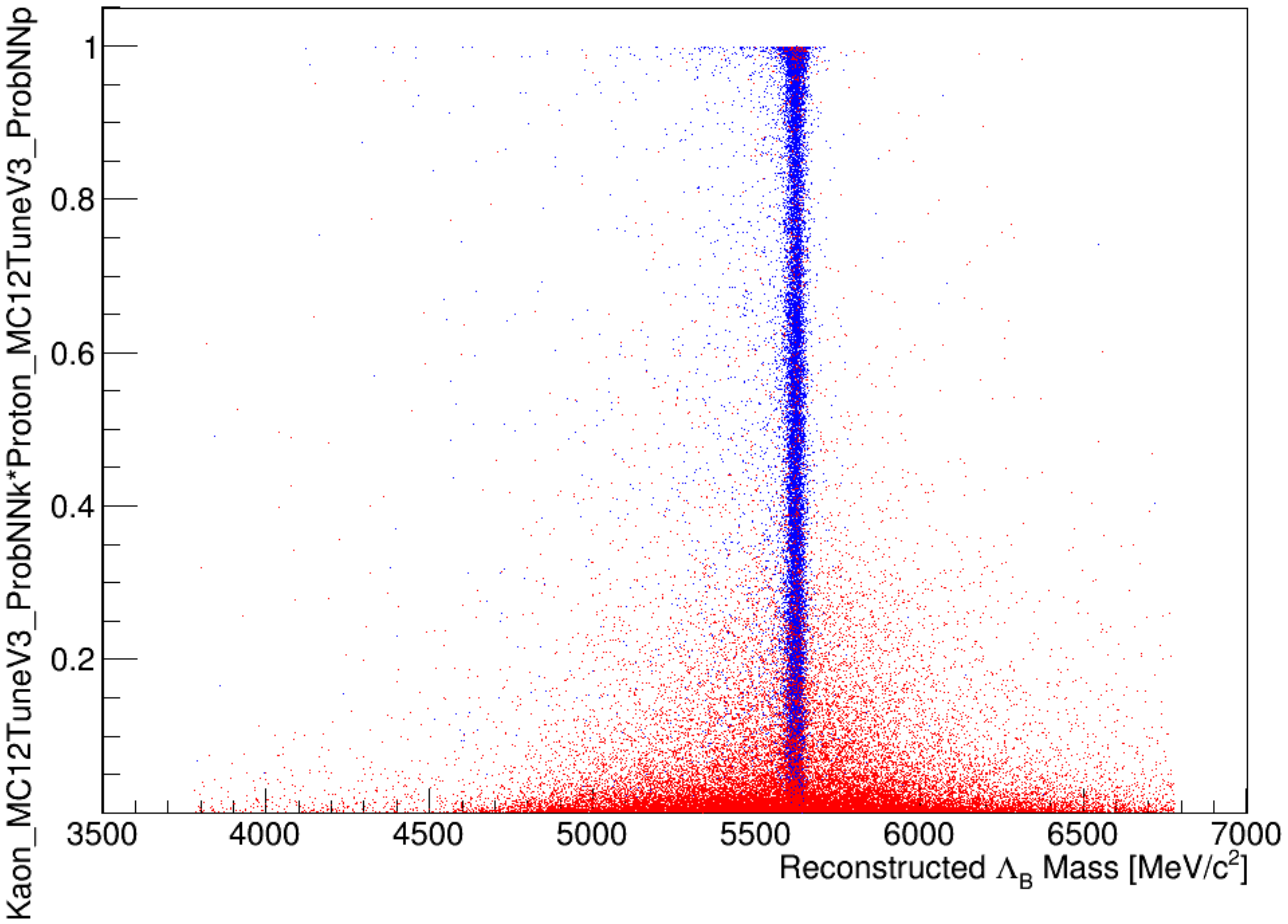


PID Studies

Large contribution from background modes under the Lb peak.

LHCb provides a combination of detectors response in the form of a PID probability

Biggest Background contaminations come from hadron misID.



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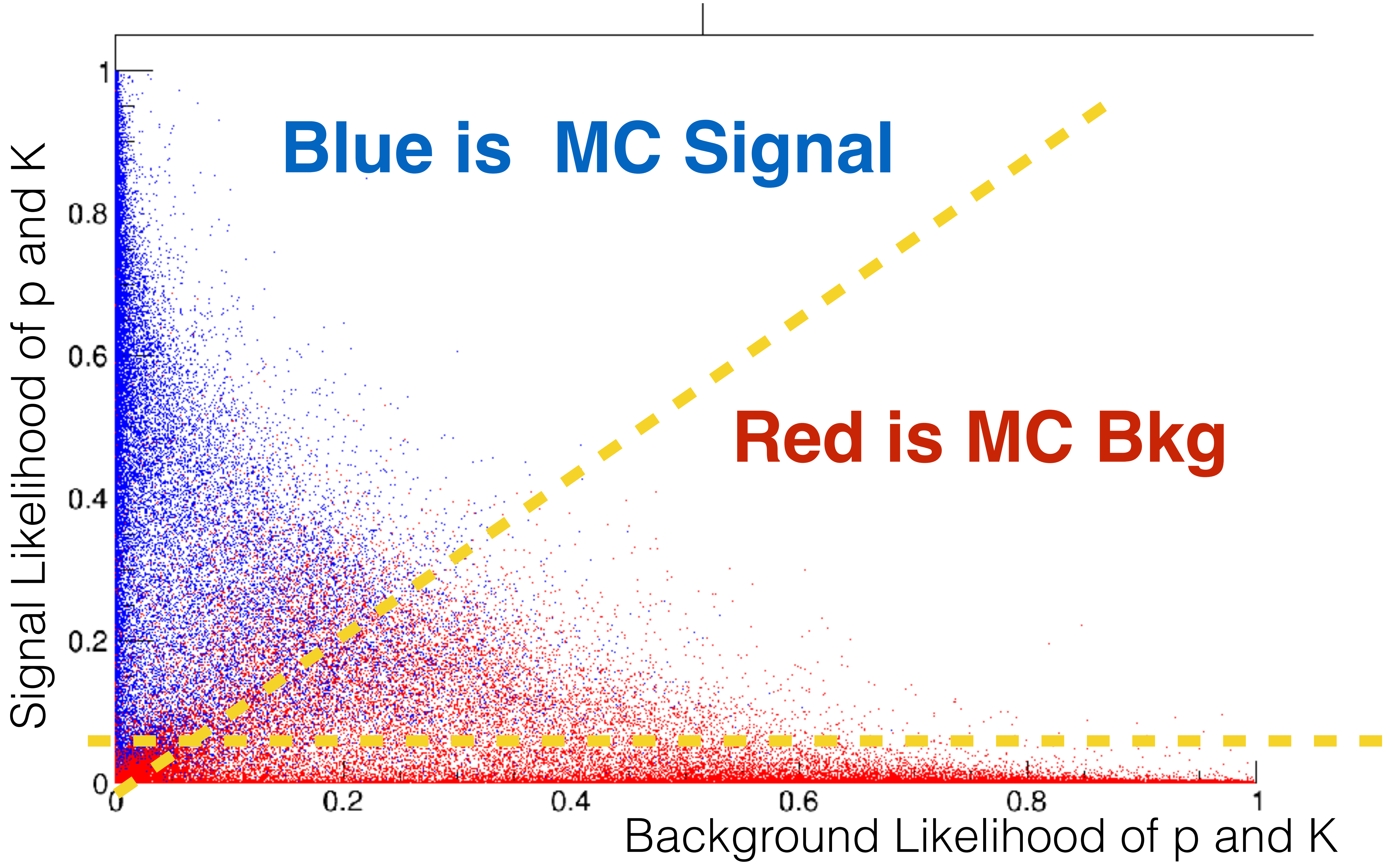
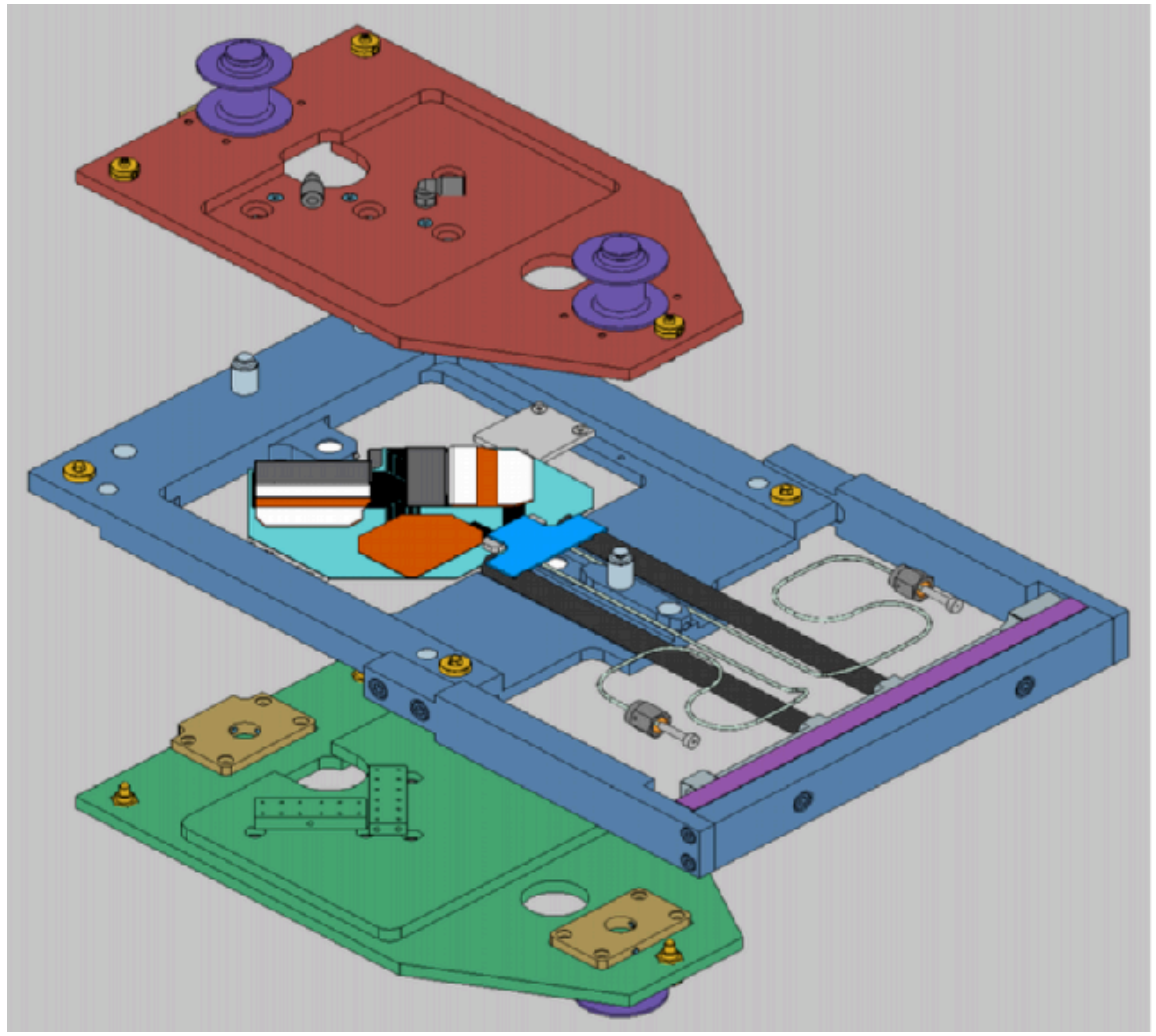
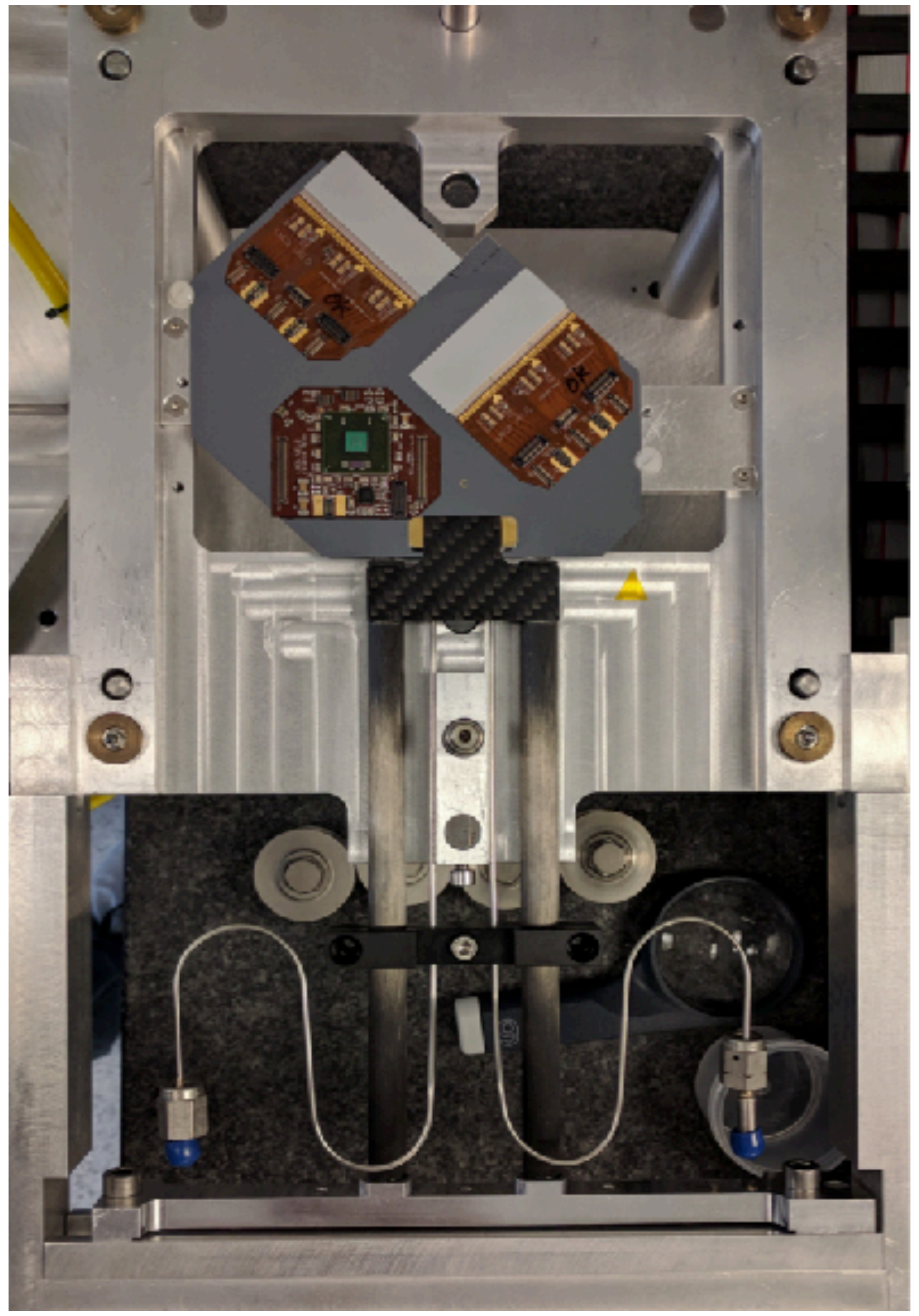
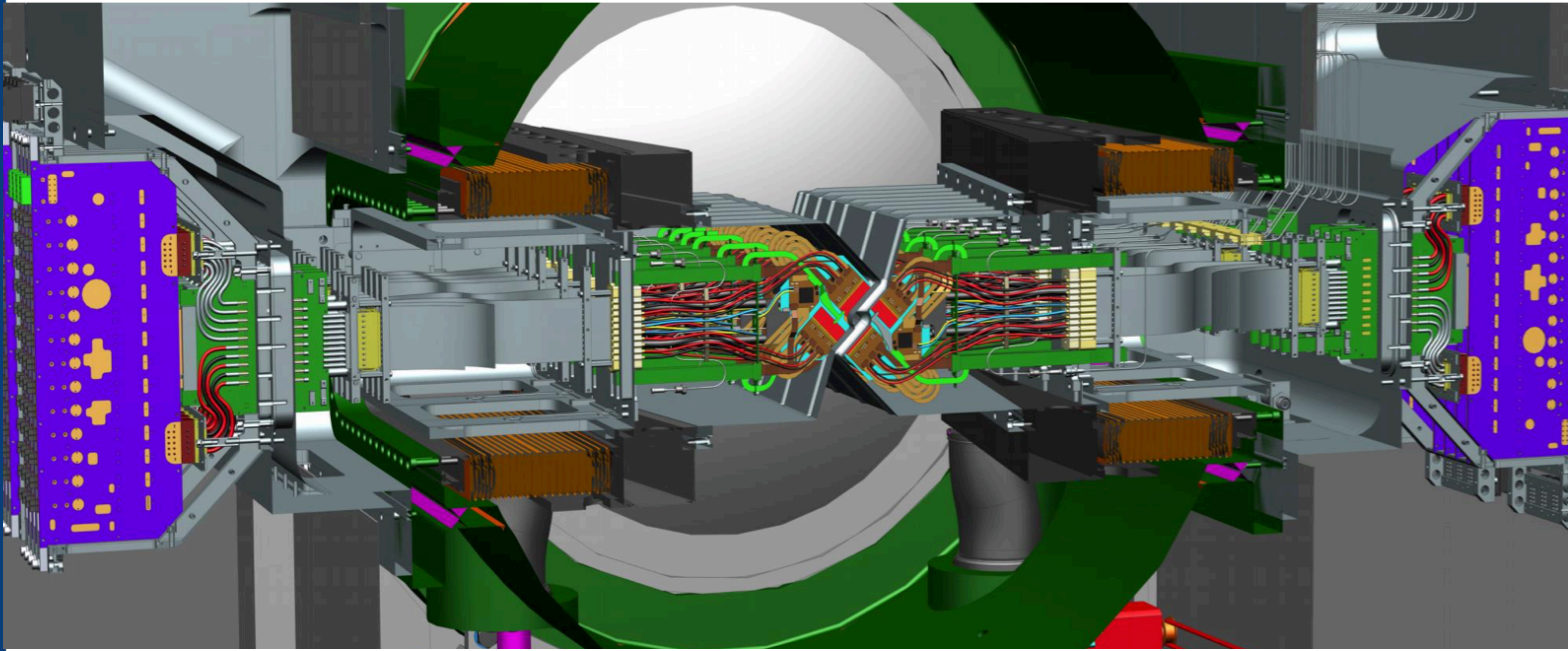
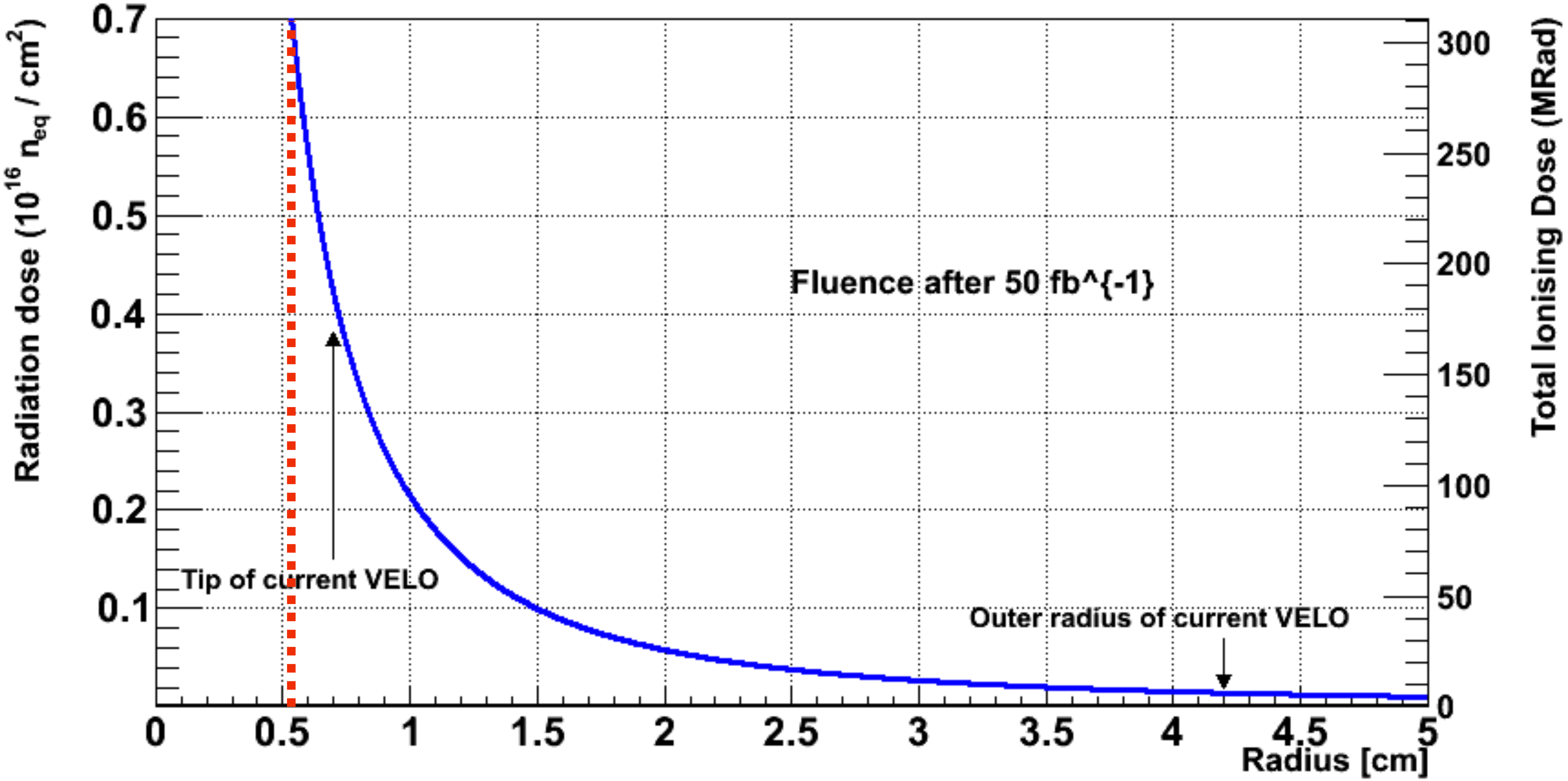




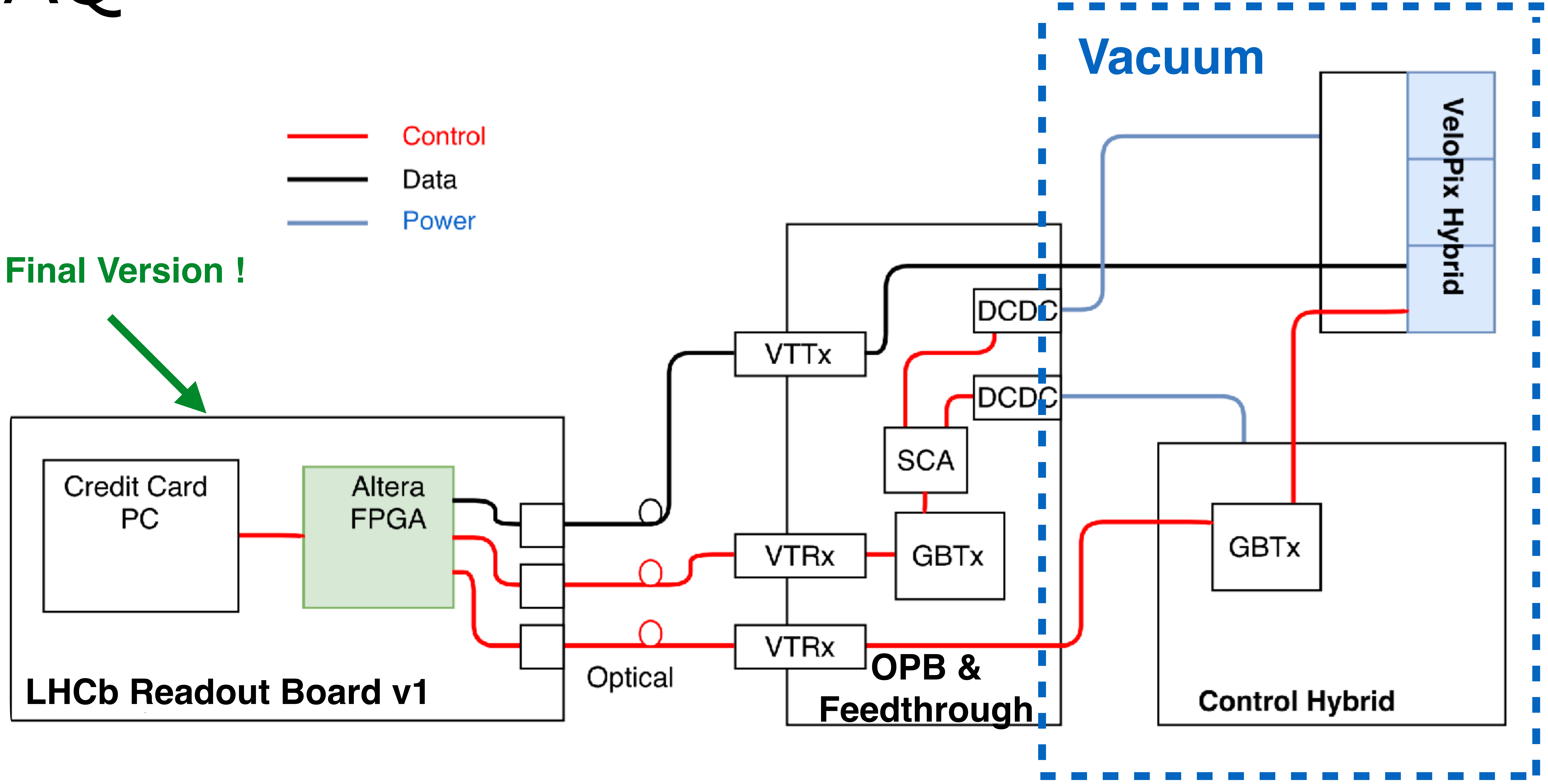





Radiation dose (10^{16} n_{eq} / cm^2)
Total Ionising Dose (MRad)
Fluence after 50 fb^{-1}
Tip of current VELO
Outer radius of current VELO
Radius [cm]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
50
100
150
200
250
300

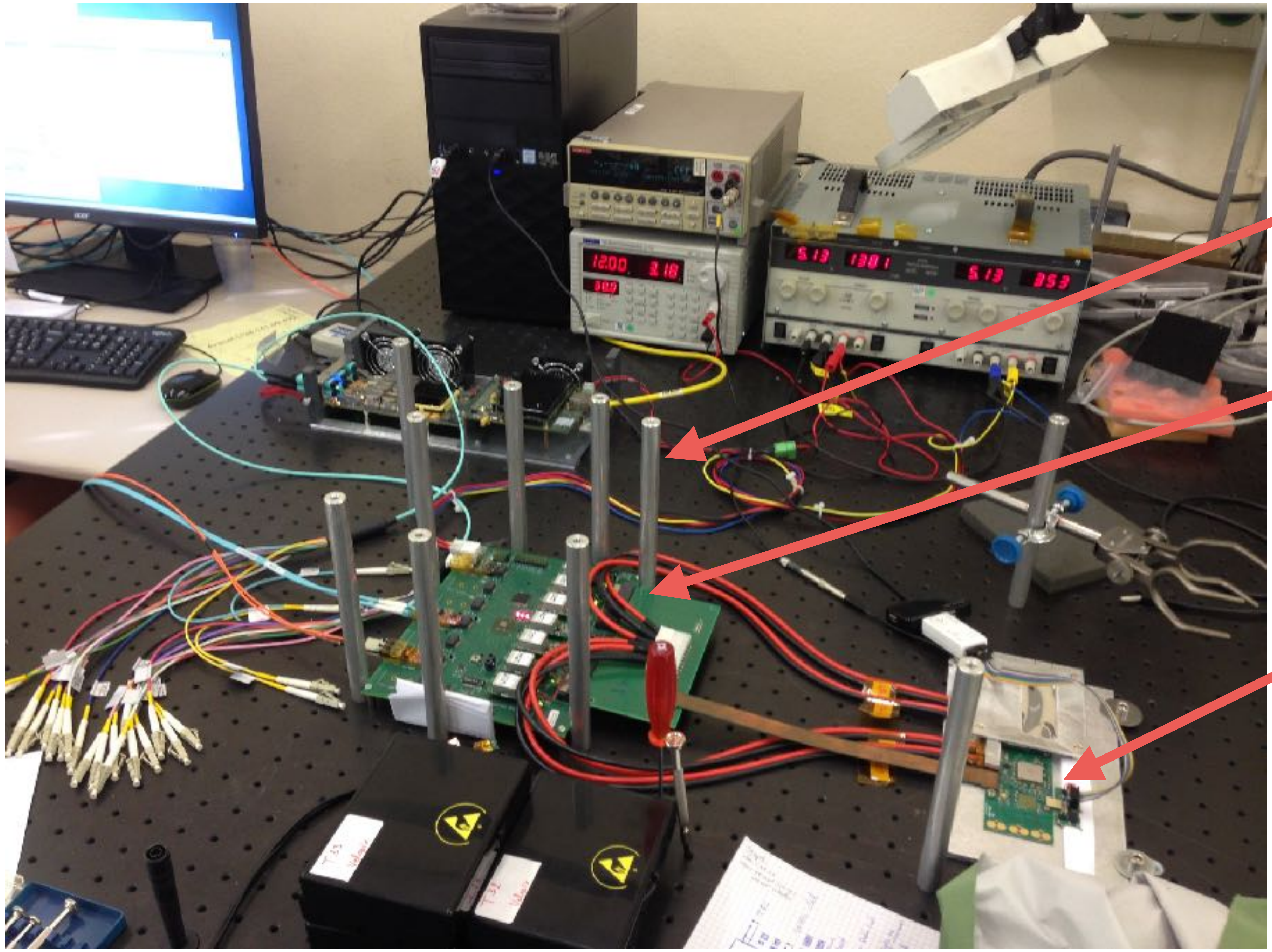
DAQ

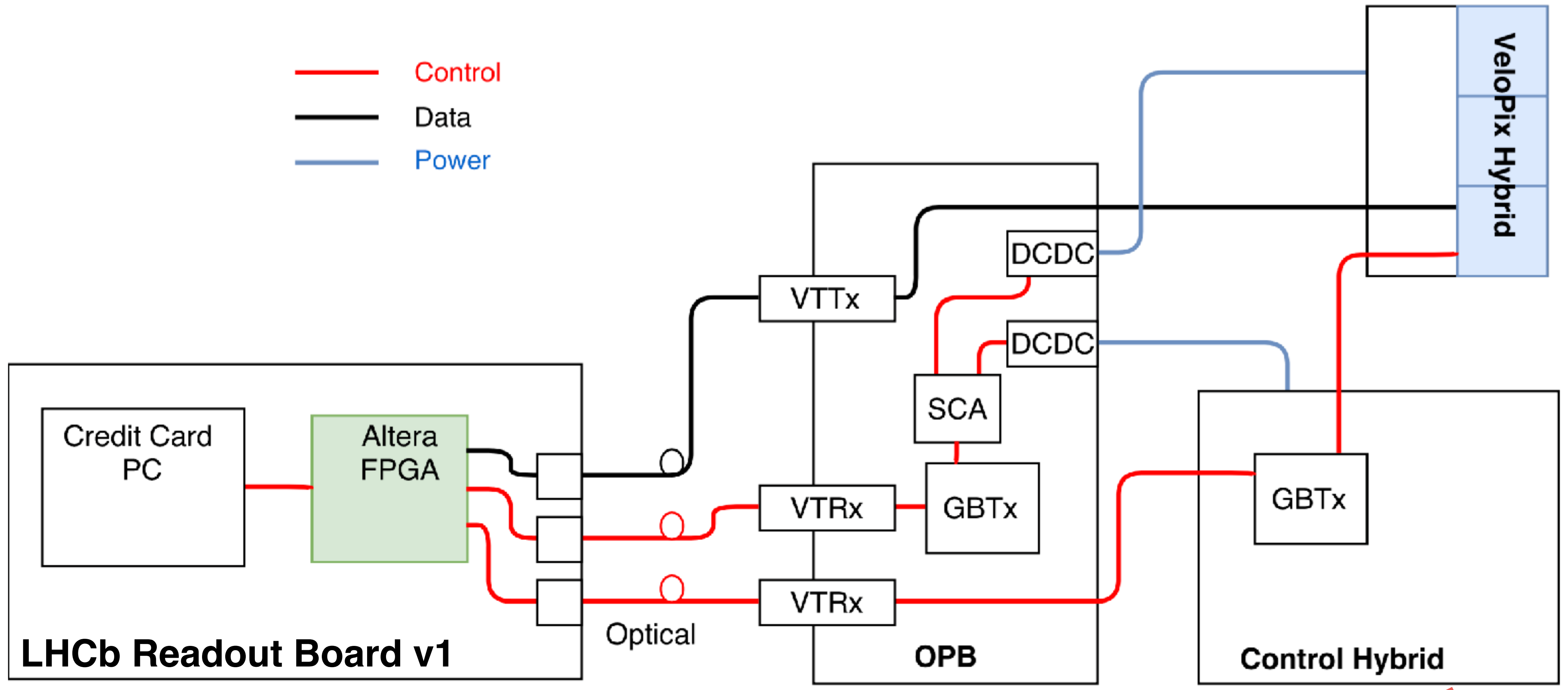
Not Final Version !



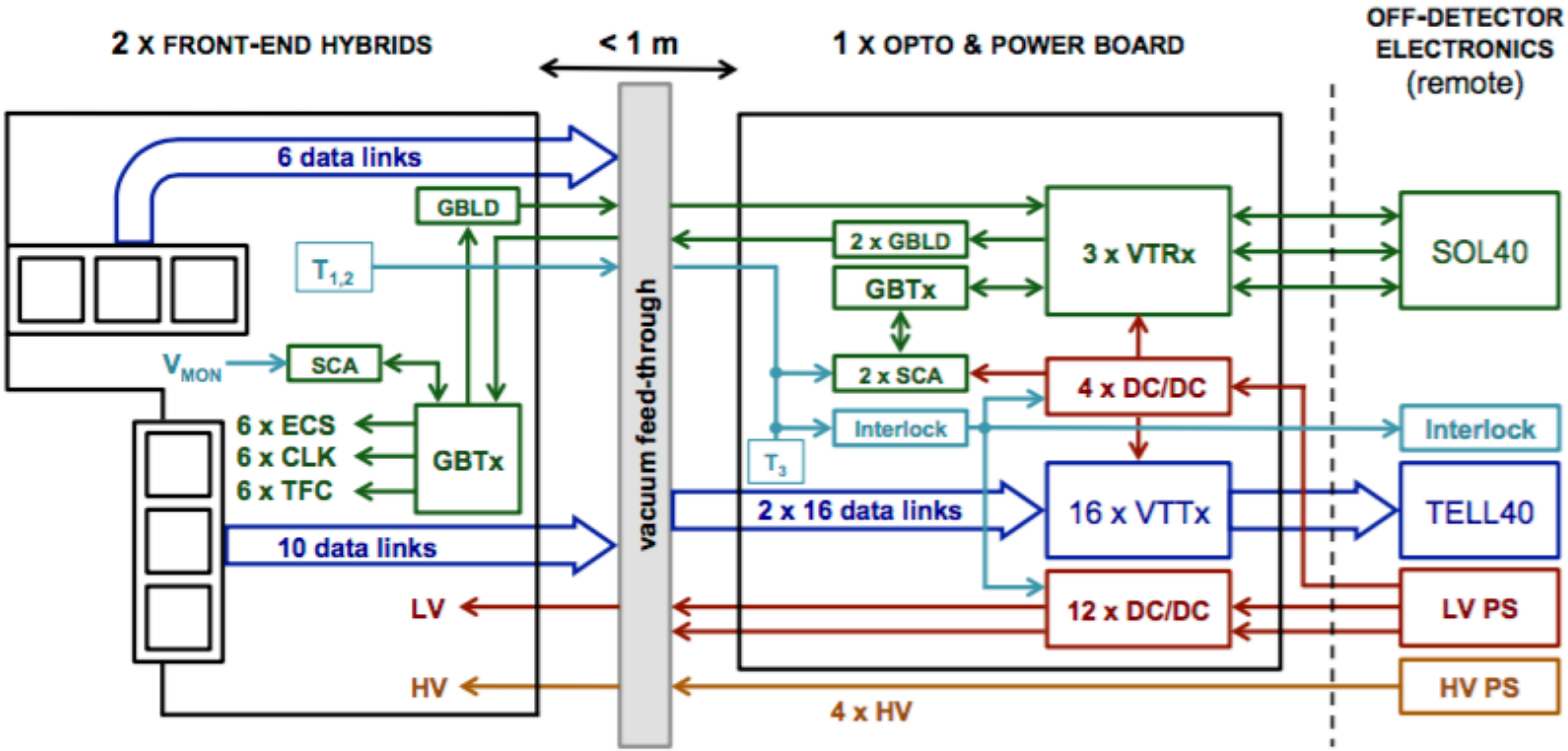
DAQ

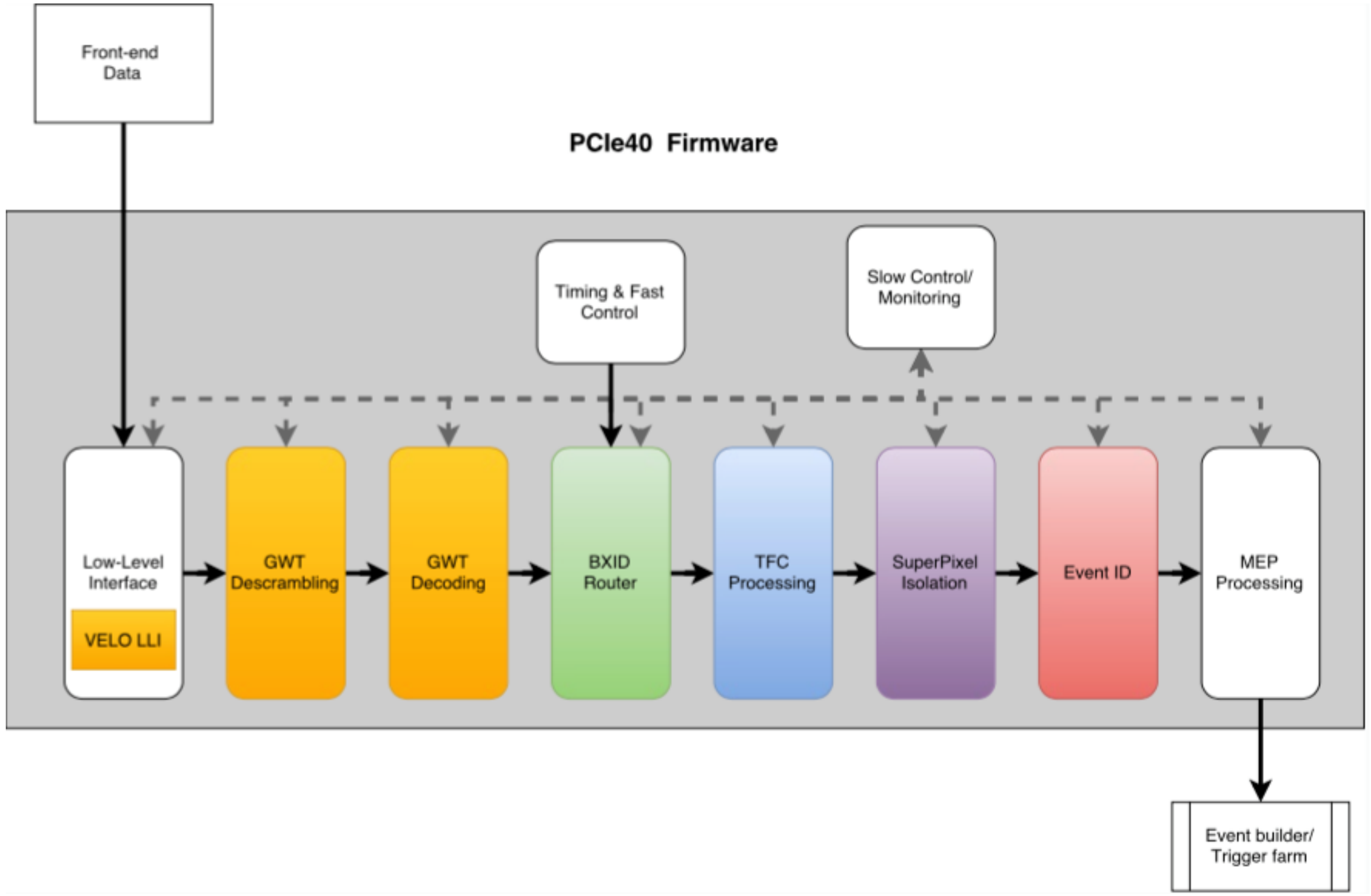
VeloPix hybrids being tested with LHCb Upgrade Readout boards.

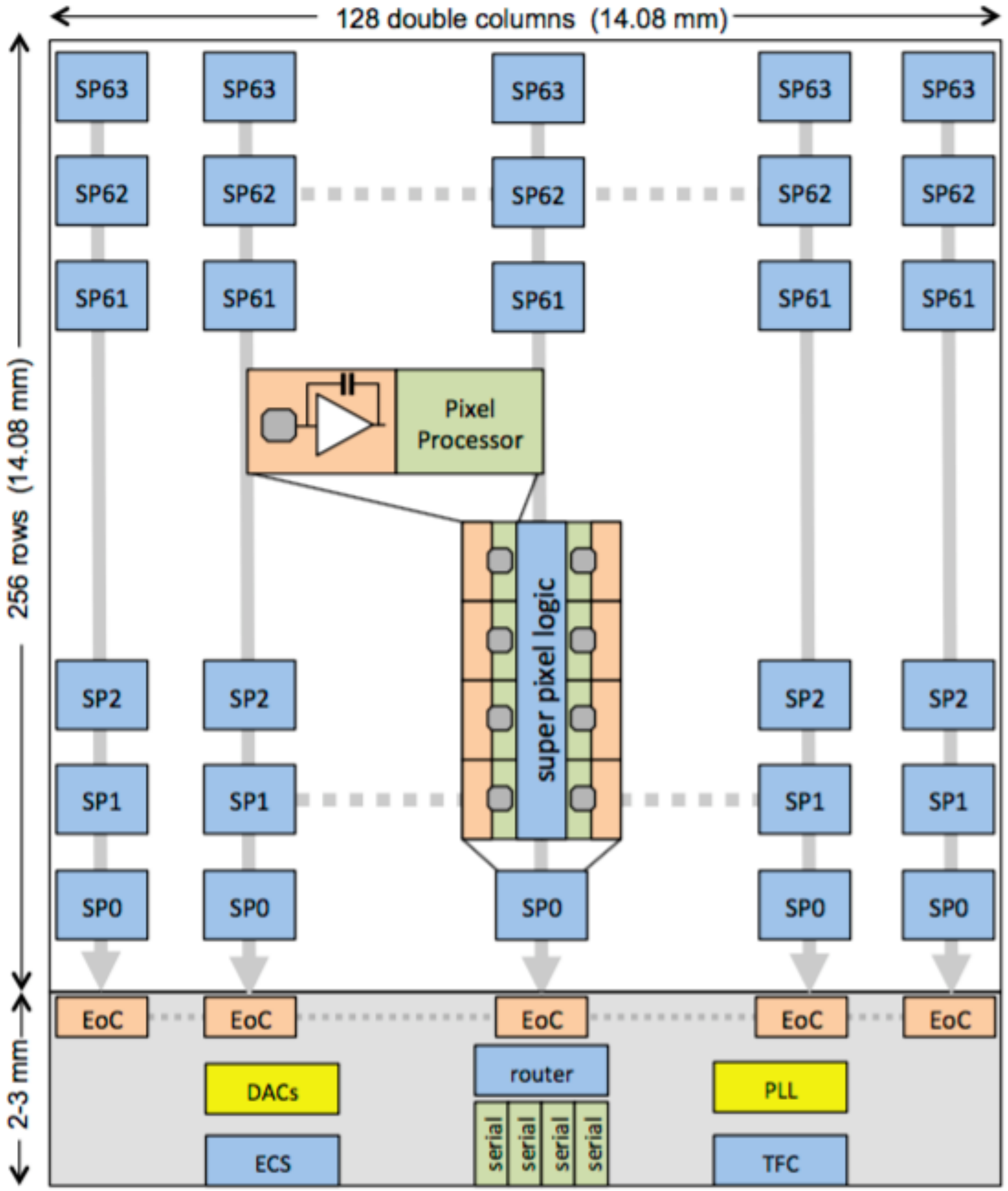




Firmware integrated pre-existing software, most necessary procedures already in place.

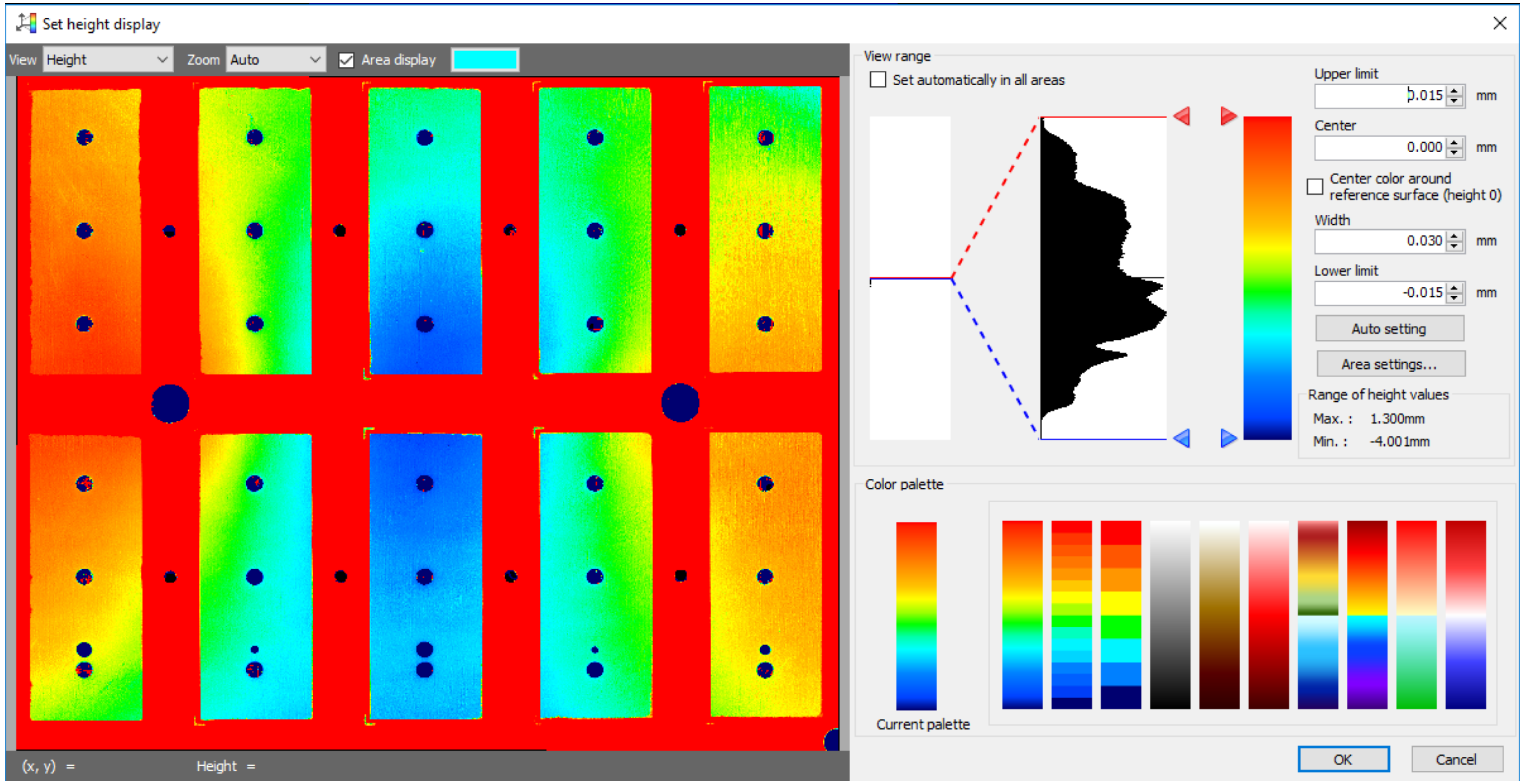

2 x FRONT-END HYBRIDS
< 1 m
1 x OPTO & POWER BOARD
OFF-DETECTOR ELECTRONICS
(remote)
6 data links
GBLD
$T_{1,2}$
V_{MON}
SCA
6 x ECS
6 x CLK
6 x TFC
GBTx
10 data links
LV
HV
vacuum feed-through
2 x GBLD
GBTx
2 x SCA
Interlock
T_3
3 x VTRx
4 x DC/DC
16 x VTTx
12 x DC/DC
2 x 16 data links
4 x HV
SOL40
Interlock
TELL40
LV PS
HV PS


Front-end Data
PCIe40 Firmware
Timing & Fast Control
Slow Control/ Monitoring
Low-Level Interface
VELO LLI
GWT Descrambling
GWT Decoding
BXID Router
TFC Processing
SuperPixel Isolation
Event ID
MEP Processing
Event builder/ Trigger farm


128 double columns (14.08 mm)
256 rows (14.08 mm)
2-3 mm
SP63
SP62
SP61
SP2
SP1
SP0
Pixel Processor
super pixel logic
EoC
DACs
router
PLL
ECS
serial
TFC

QA

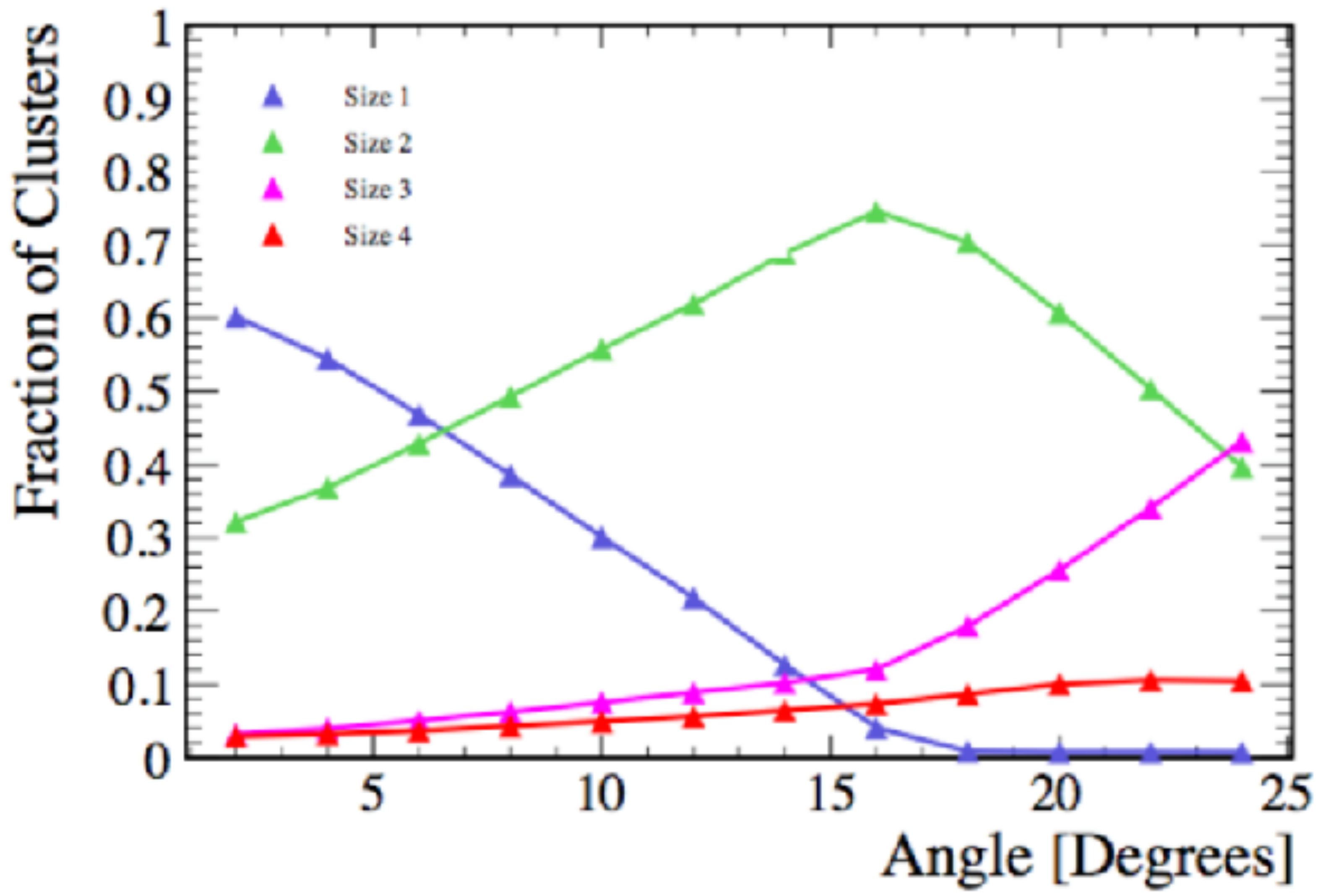
- Check the flatness of the surface using the white light interferometer.

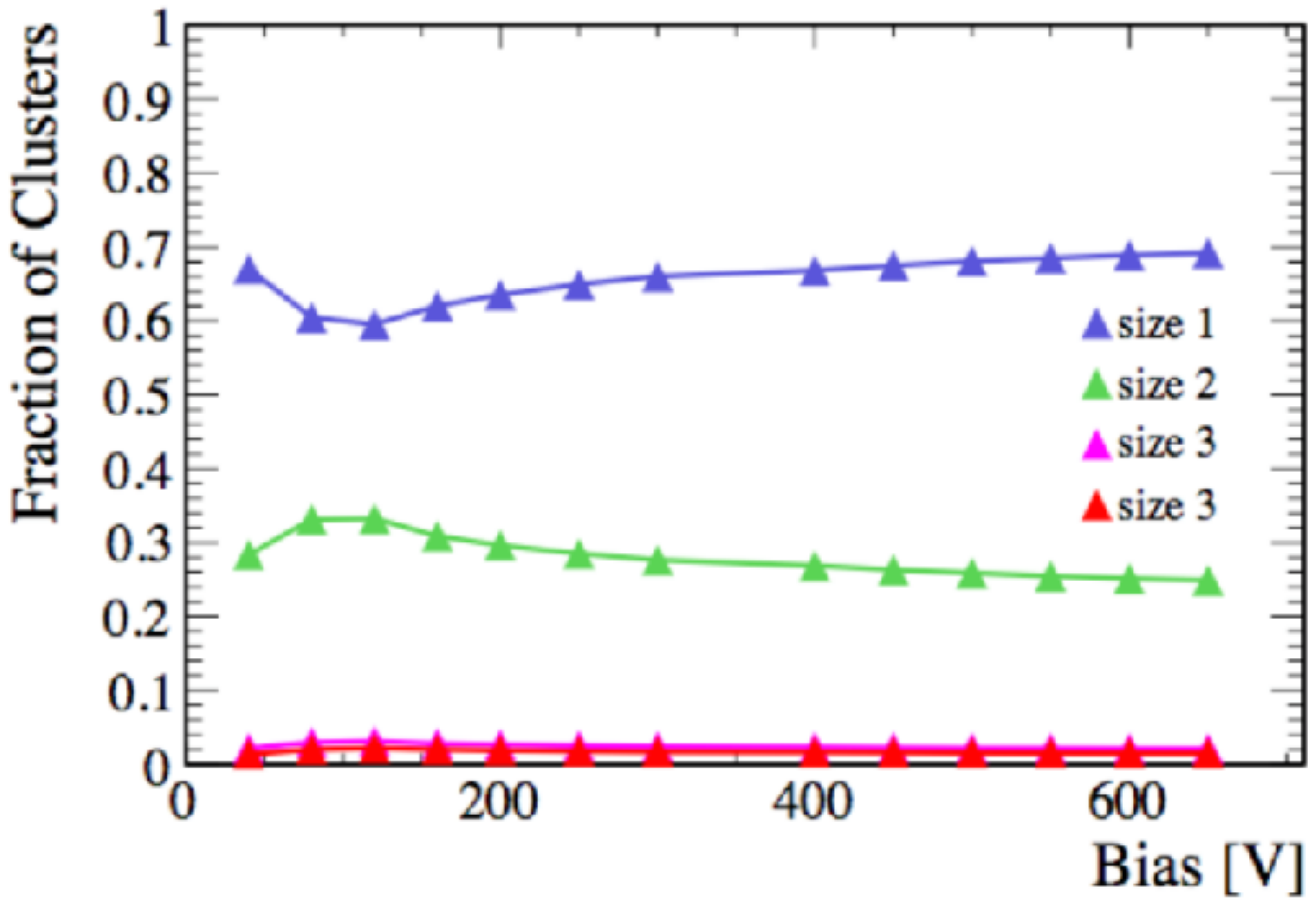


Overall height variation of 30 µm over the whole surface.

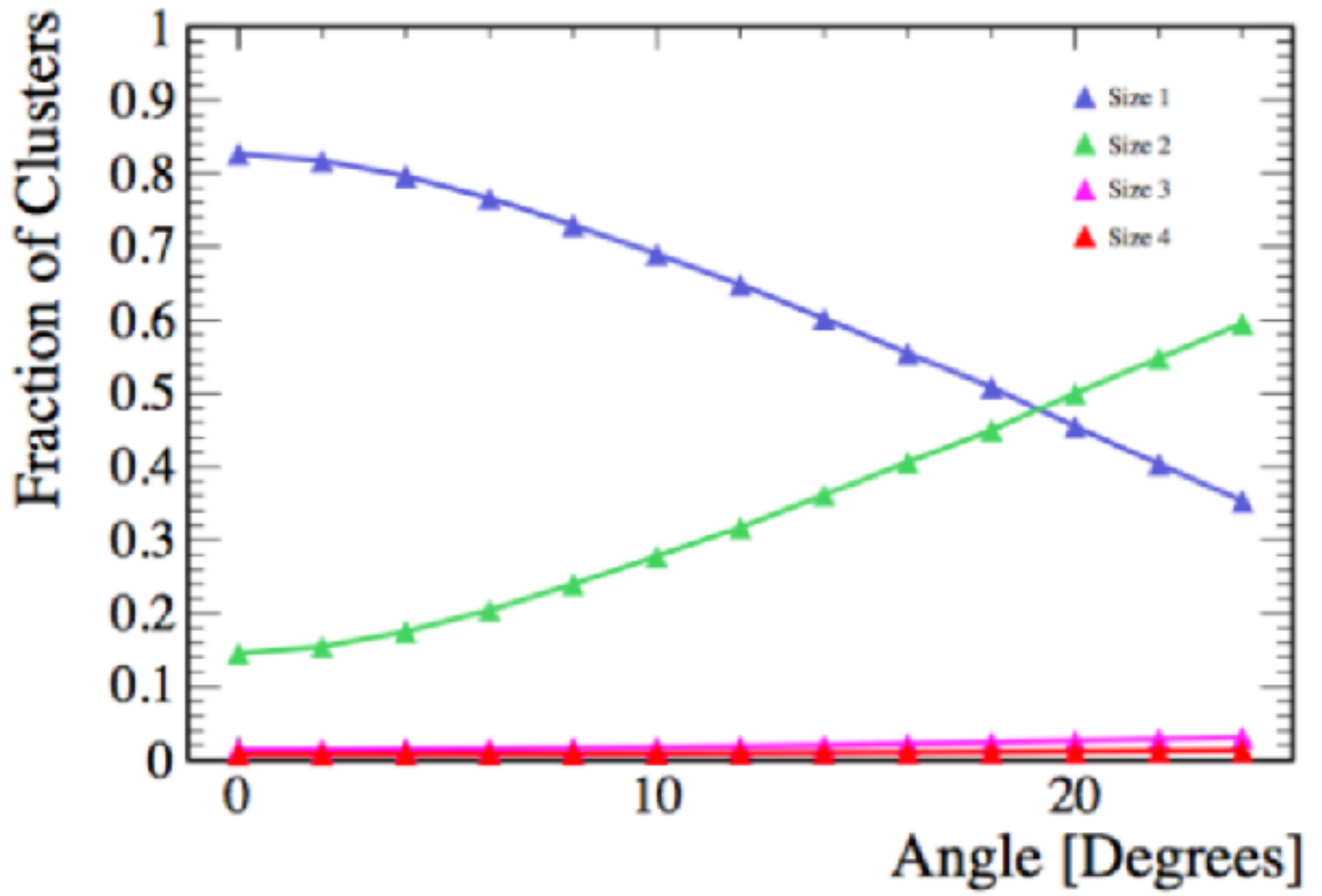
Cluster Sizes Distributions

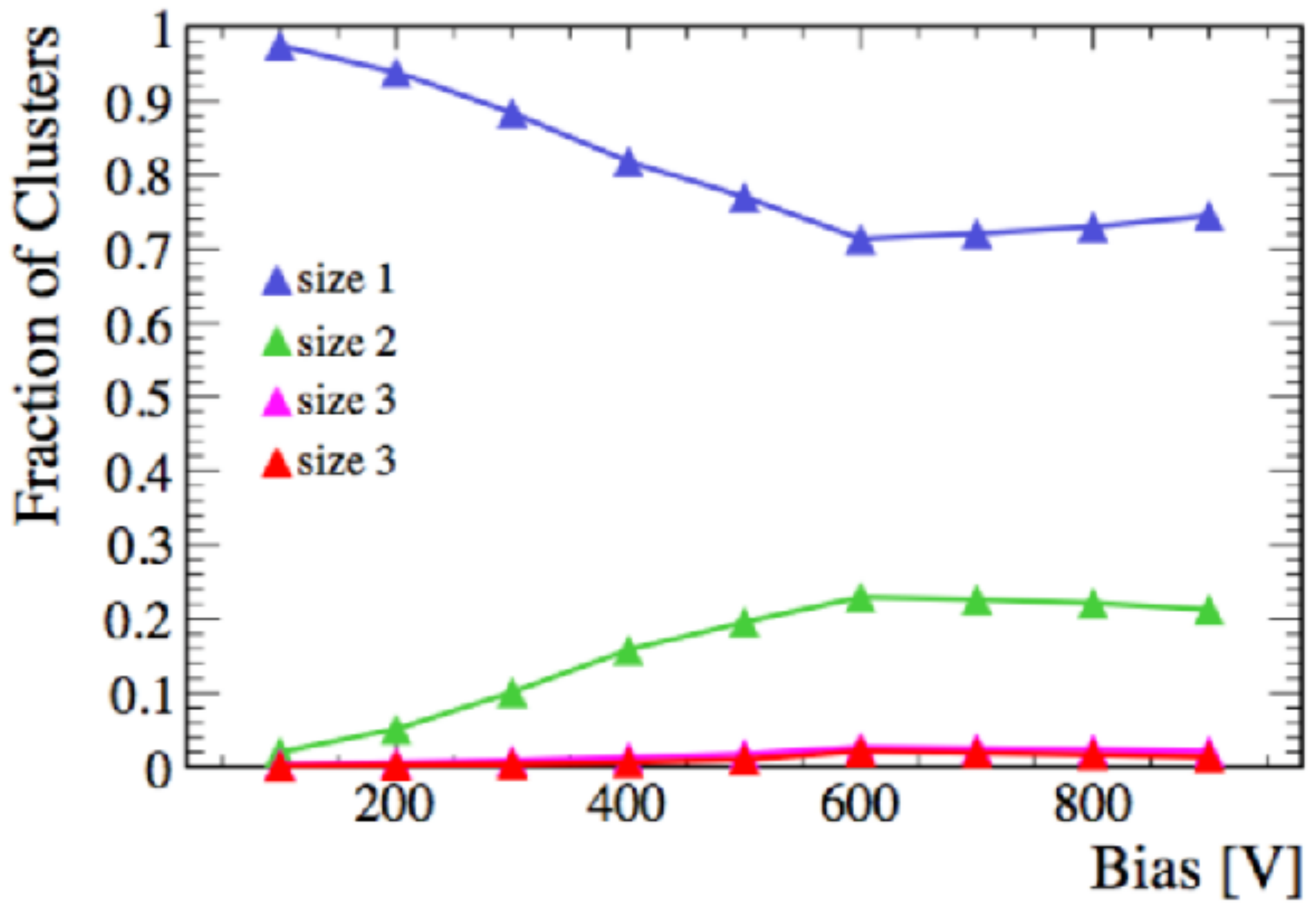
Non-Irradiated
Micron n-on-p





Post-Irradiation
Micron n-on-p



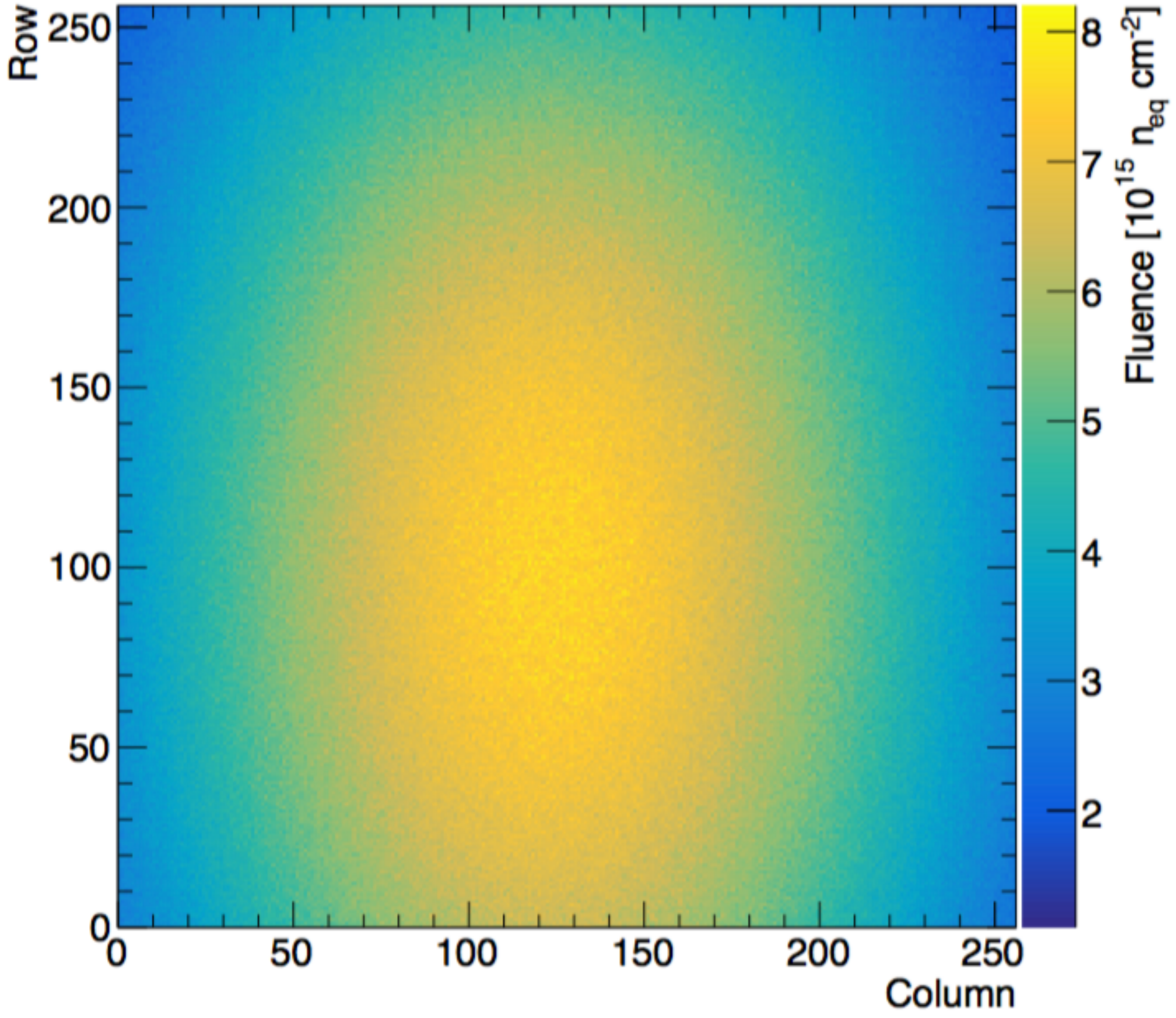


Charge Collection and Depletion Depth

Non-Uniform proton Irradiated sensors at IRRAD.

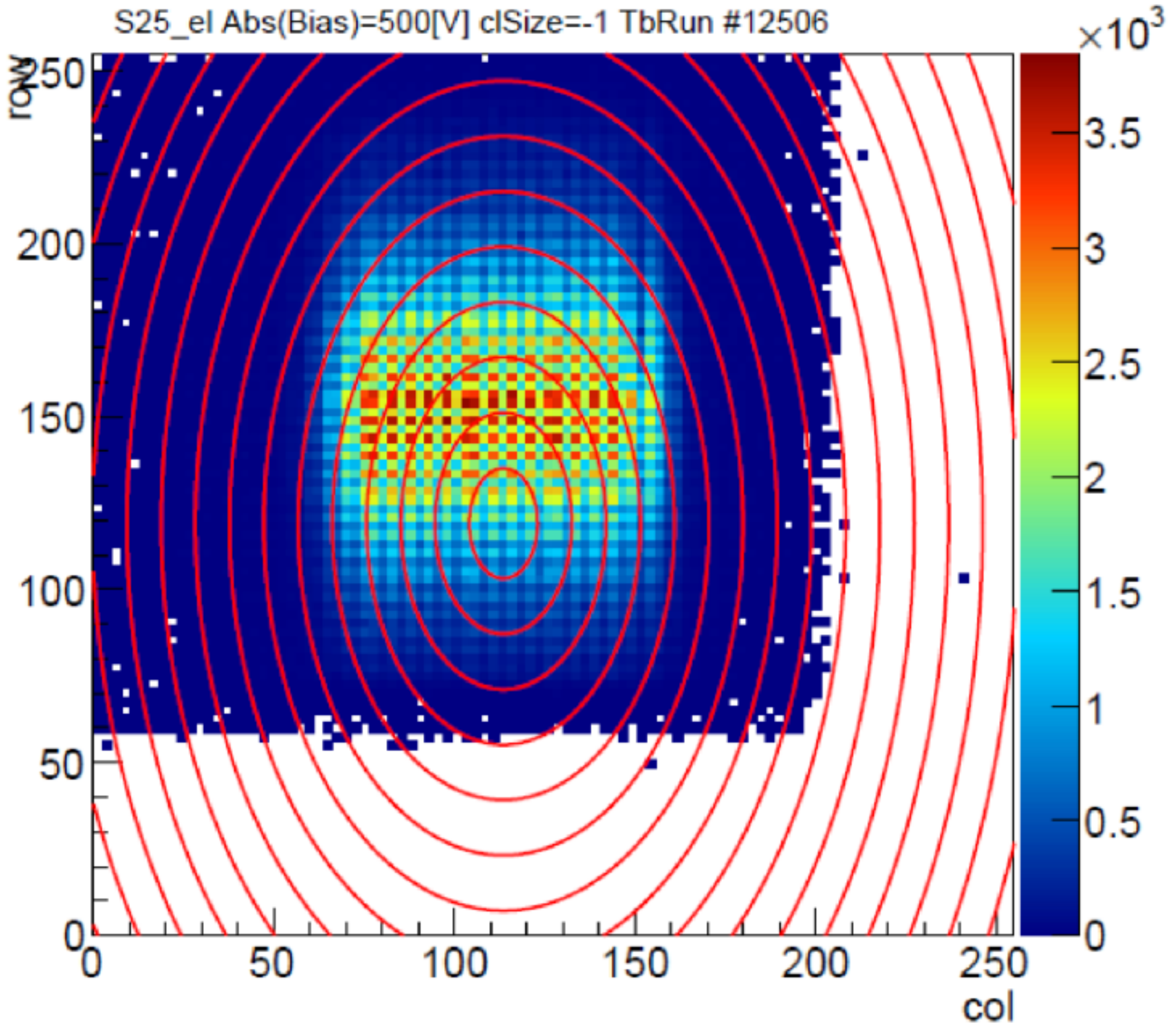
Combining dosimetry measurements to activation of the sensors.

Non-uniform profile allows study of charge collection as a function of fluence.



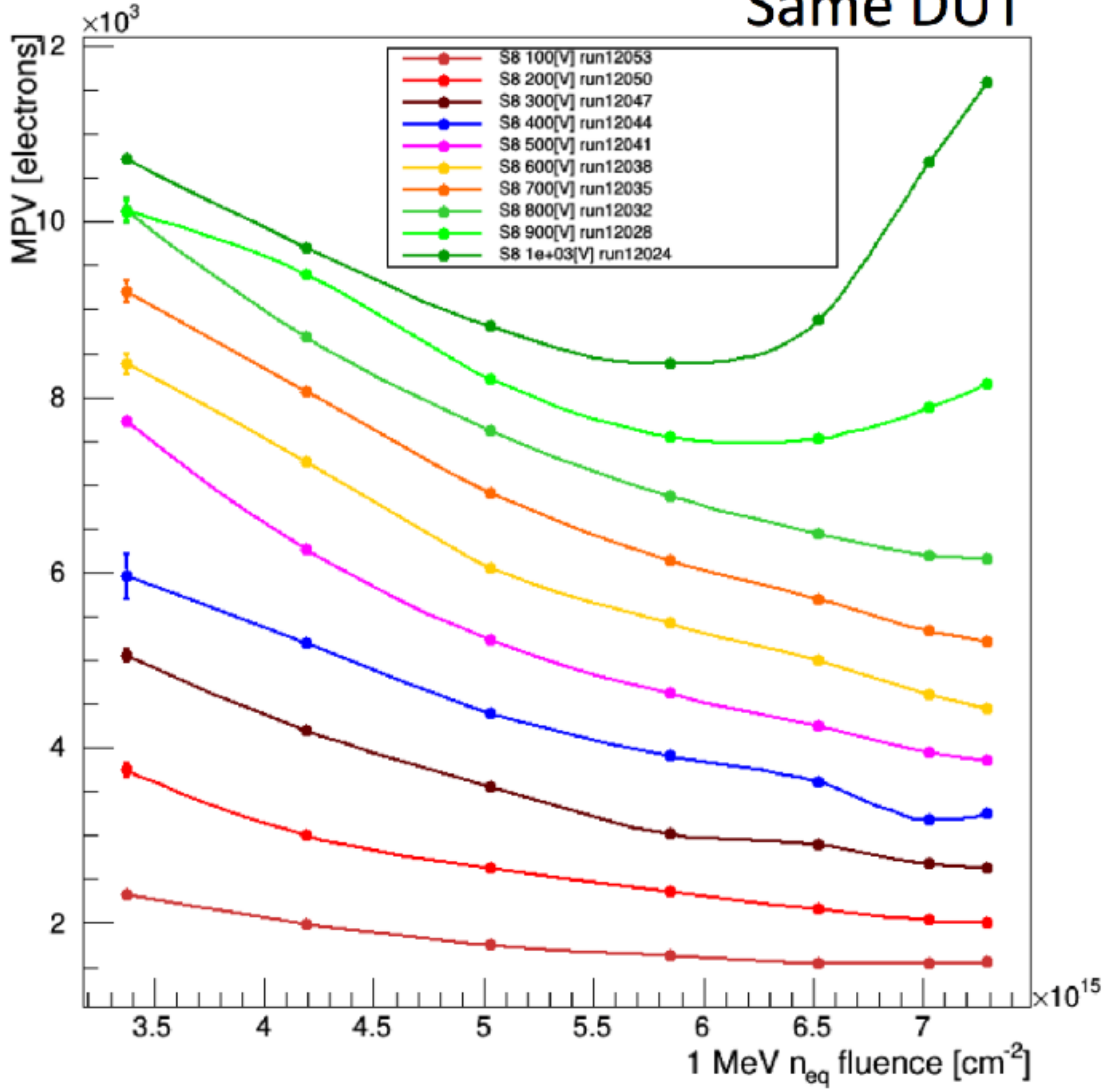
Charge Collection

Non-Uniform proton Irradiated sensors at IRRAD, binned in fluence.



Similar effect observed using a completely different method.

Same DUT

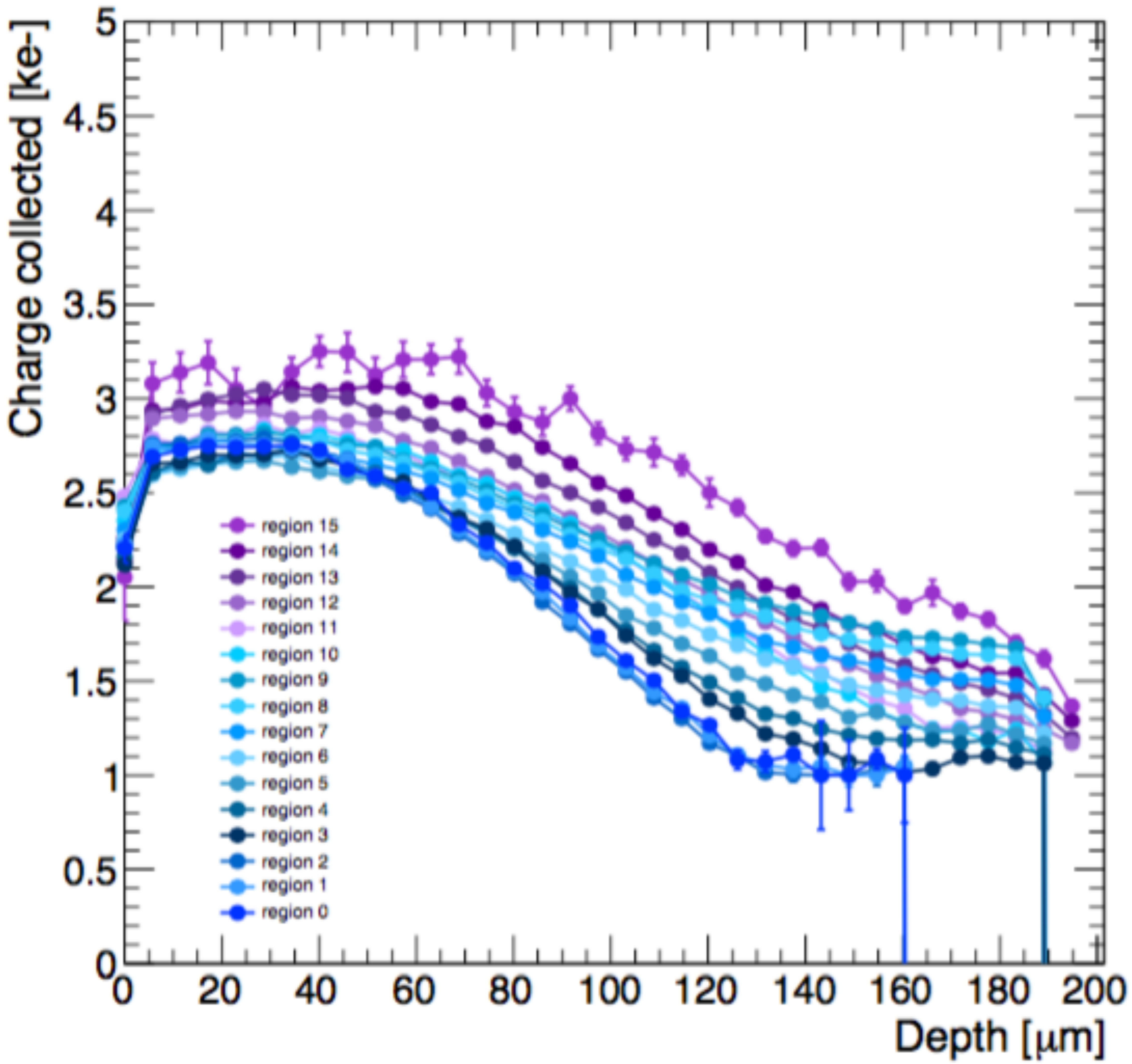


Charge Collection and Depletion Depth

Non-Uniform proton Irradiated sensors at IRRAD.

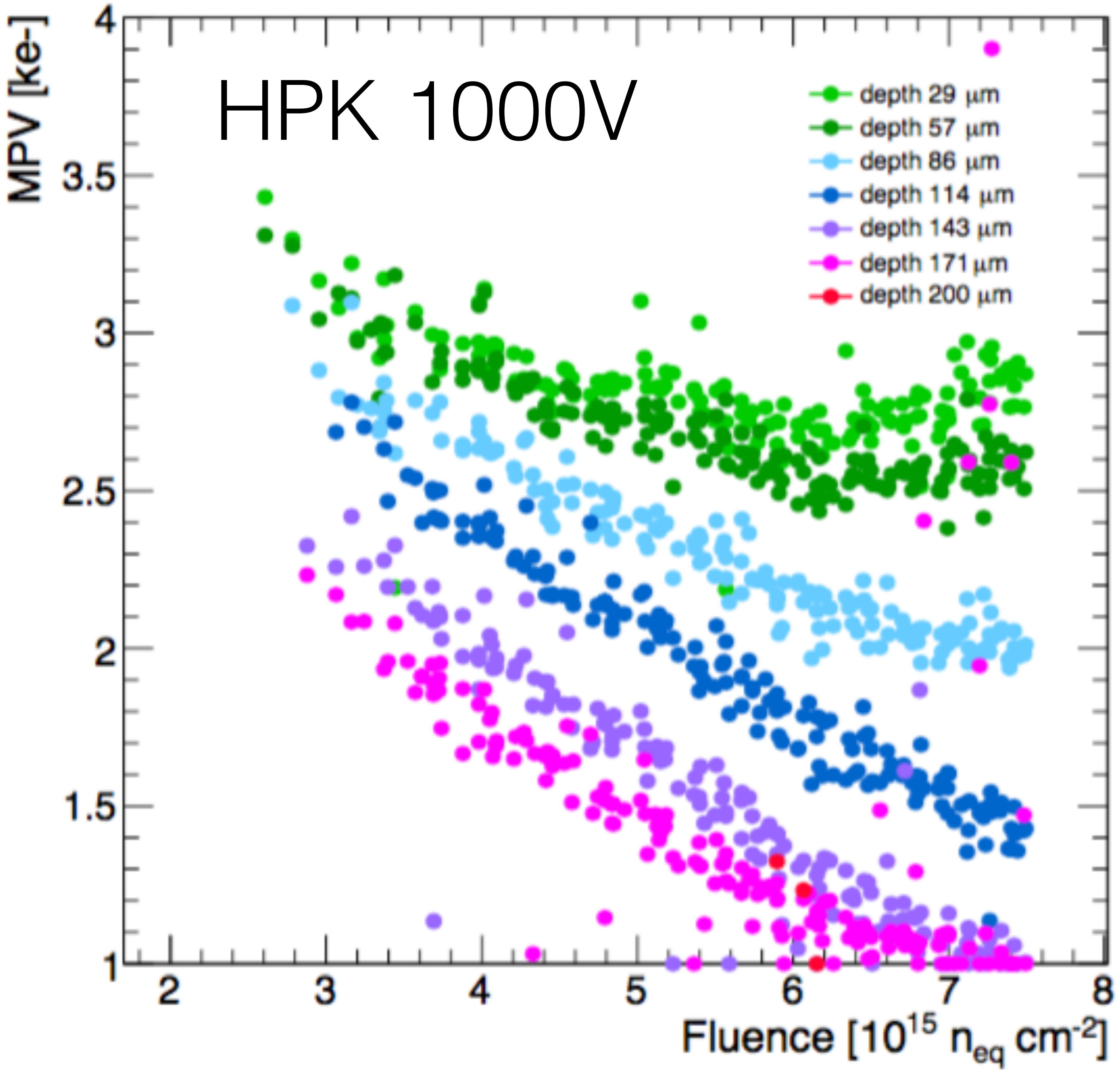
Non-uniform profile allows study of charge collection as a function of dose.

Correlate dosimetry measurements to activation on the sensors.



Charge Collection and Depletion Depth

Non-Uniform proton Irradiated sensors at IRRAD.



Uniform neutron Irradiated sensors at JSI.