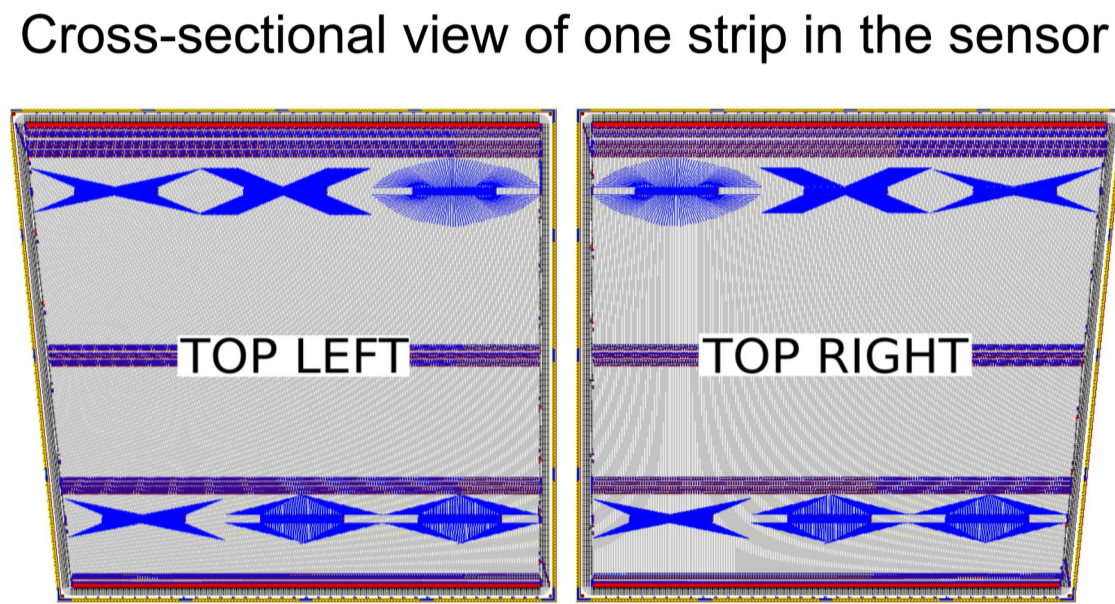
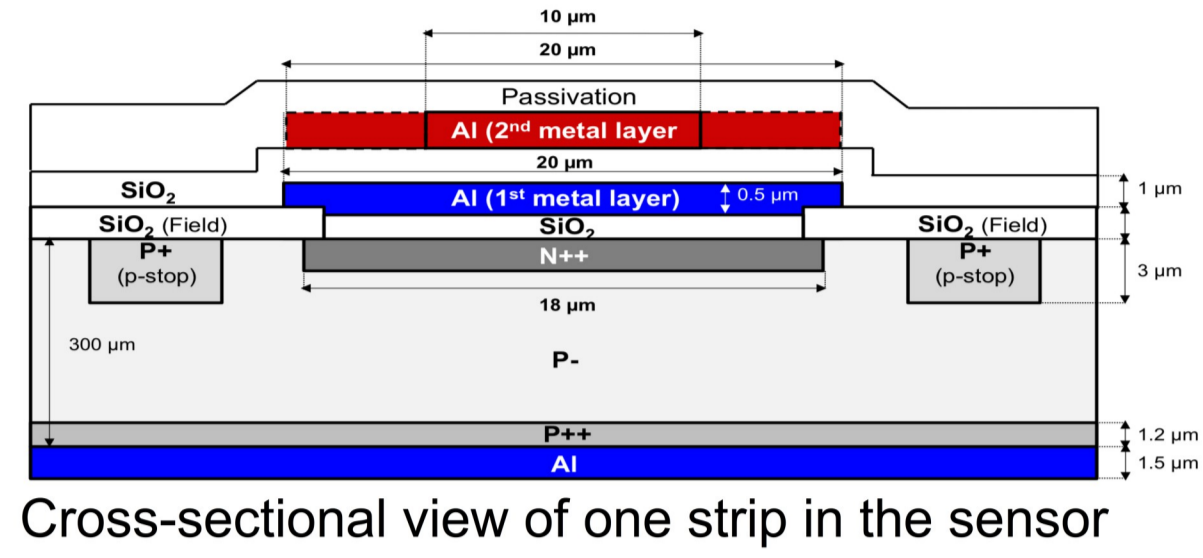
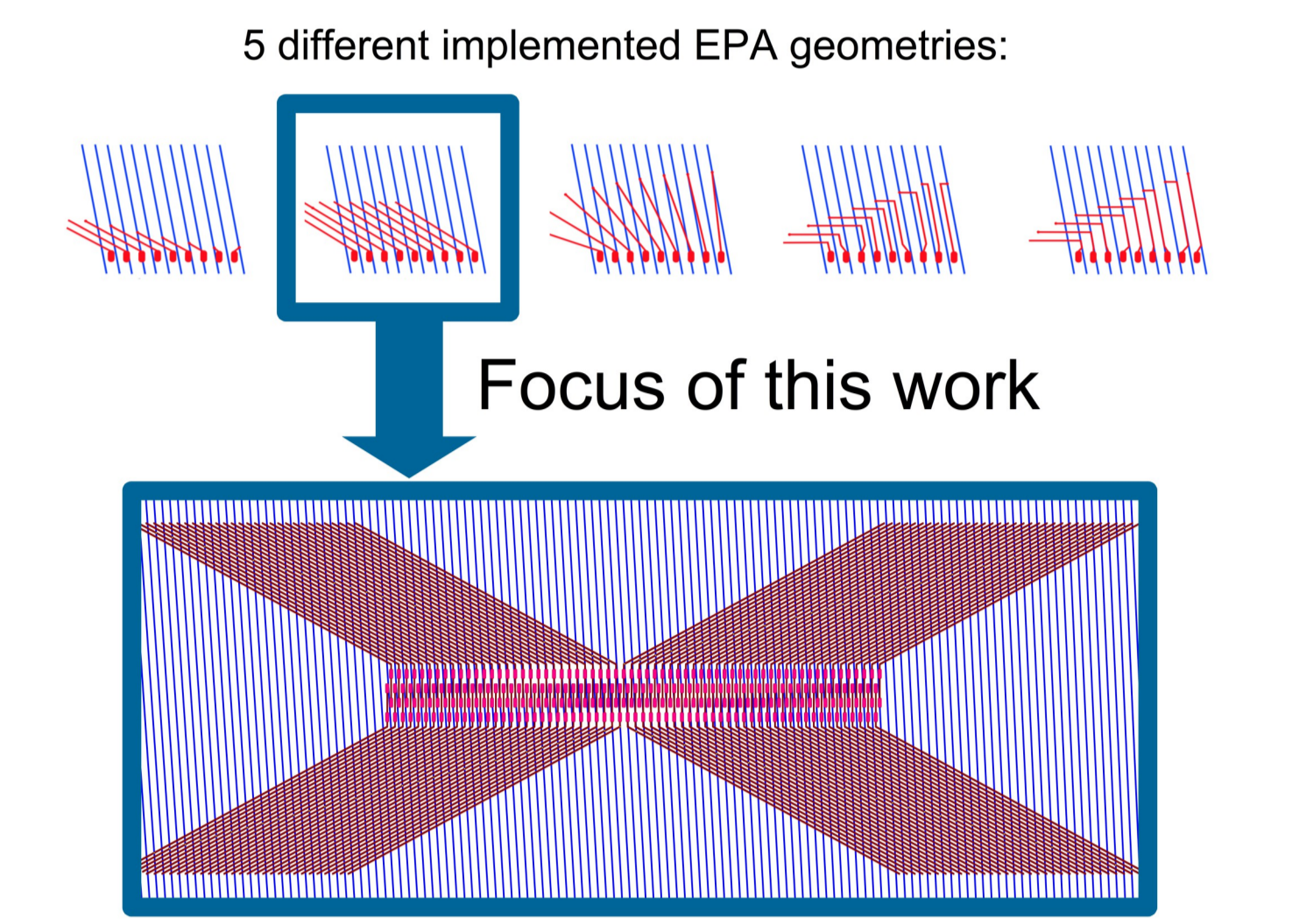


Embedded Pitch Adapters (EPAs)

Moving the pad-pitch adaption into the sensor by implementing a 2nd metal layer. Connections between 1st and 2nd metal layer by vias. **Advantage:** facilitation of detector module assembly.



Sensors: 300 μm thick silicon sensors with radially oriented strips, as used for the tests described in this work. EPAs shown in blue.



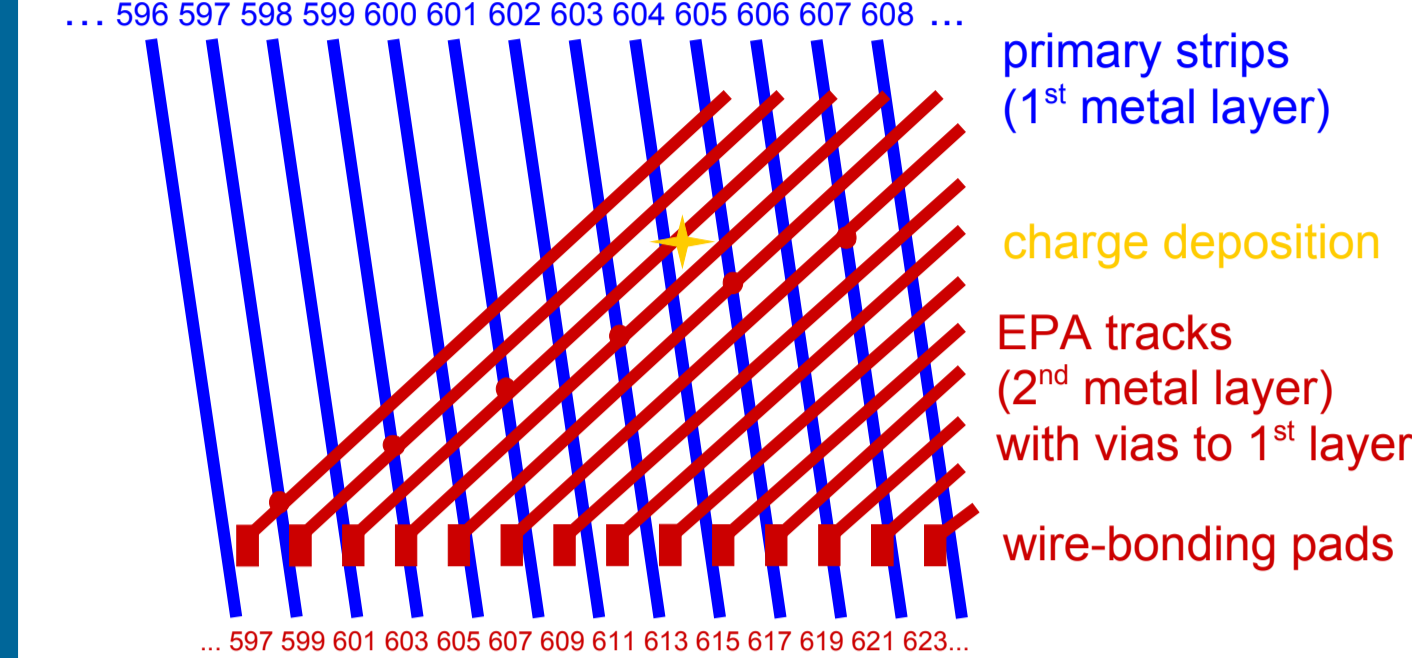
Focus of this work

- Constant length of and angle between 2nd metal tracks (red)
- 20 μm track width (same as 1st metal, blue)
- Highest density of 2nd metal tracks ("worst case")

Possible Challenges in Sensors with EPAs

- Noise enhancement due to higher interstrip capacitance
 - Cross-talk: coupling between tracks of the two metal layers
- Previous + ongoing studies

- **Pick-up:** coupling of charge induced in the silicon bulk into the EPA tracks



Part of the EPA geometry under study that adapts channels with odd numbers, indicating readout channel numbers of 1st and 2nd metal layer tracks, and example photon interaction location

Example: charge induced near strip 604 can be picked up by 2nd metal track of strip 601

- **Partial pick-up:** signal in channel 601 and in channel 604 → fake signal
- **Full pick-up:** signal in channel 601 → information loss and fake signal

- Effect restricted to area with EPA → Investigate EPA architecture with highest density of 2nd metal tracks.
- Pick-up: Present? Threshold-dependent? Location-dependent?

Experimental Setup and Performed Measurements

Testbeam

- Synchrotron radiation from Diamond Light Source
- Monochromatic 15 keV photon beam
- Micro-focussed beam (~2 μm * 3 μm beam spot)
- 1.2 ± 0.2 photons/10 ns, 51% int. probability each

Implications

- Energy deposition only ~1/5 that of a MIP → no quantitative results
- Very high spatial resolution → obtain detailed map of effects
- Avg. no. of photon interactions per event: 1.4 ± 0.3

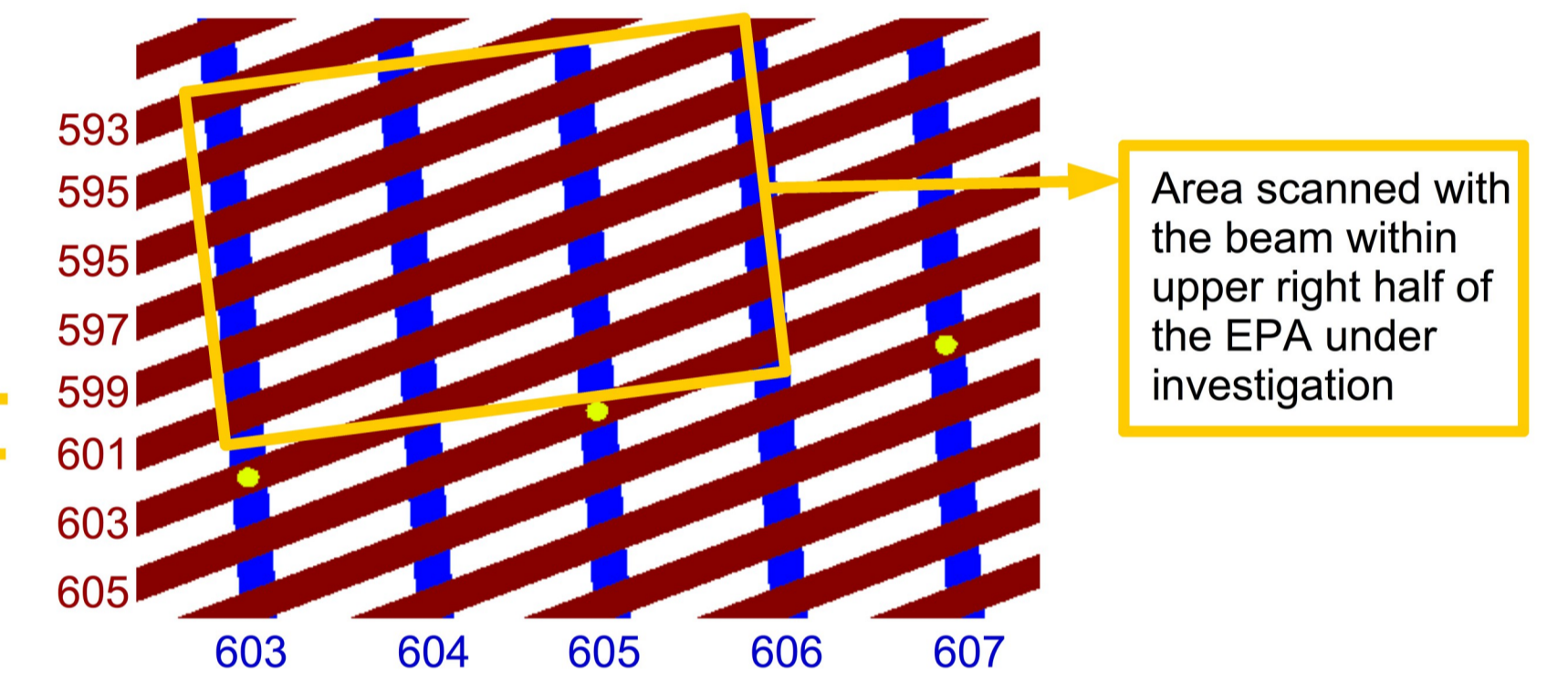
Tested Device and Measurements

- ATLAS ITk strip tracker end-cap prototype module [1]
- 300 μm thick high-resistivity wedge-shaped n-in-p sensors with radially oriented strips and EPAs [2,3]
- Binary readout with ABCN-25 ASICs [4] → no information on deposited charge → threshold scans, hits above threshold
- Low range of discriminator thresholds probed: 54.4 mV to 80 mV to measure small effects

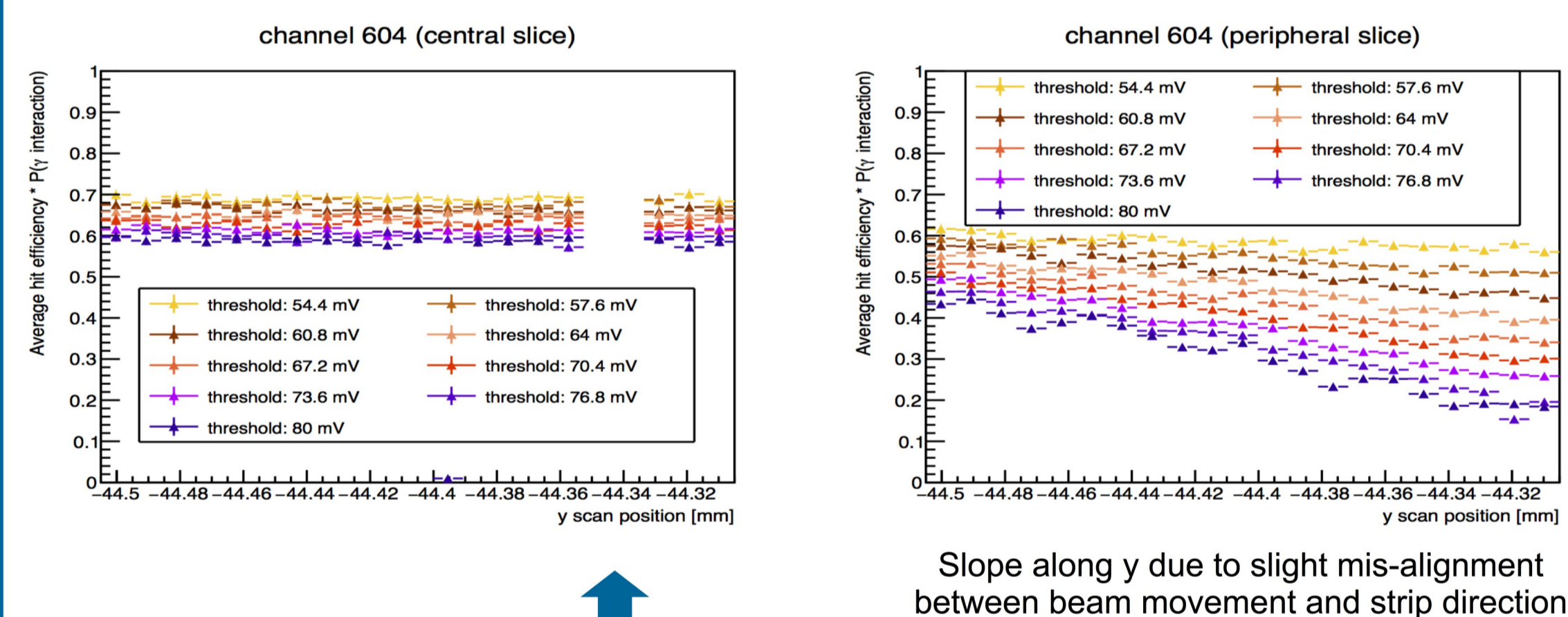
- [1] S. Kuehn *et al* 2017 *JINST* 12 P05015
- [2] V. Benítez *et al* 2015 *CERN* ATL-COM-UPGRADE-2015-027
- [3] M. Ullán *et al* 2016 *NIM A* 821
- [4] W. Dabrowski *et al* IEEE Nucl. Sci. Symp. Conf. Rec. (NSS/MIC) (2009) 373

Investigated Sensor Area

- 300 μm * 200 μm in steps of 15 μm * 10 μm (primary strip pitch: ~100 μm)
- Covering ~4 1st metal and ~5 2nd metal tracks



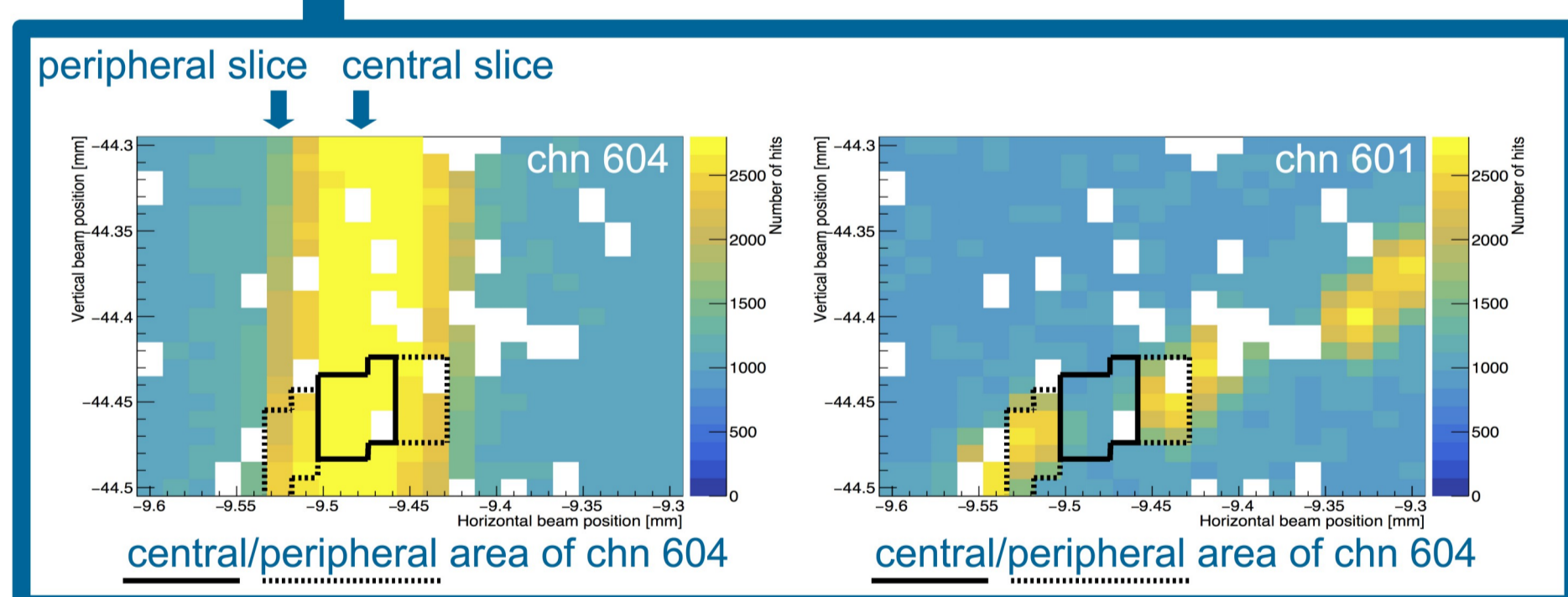
Threshold/Centrality Dependence



Central: response uniform along strip

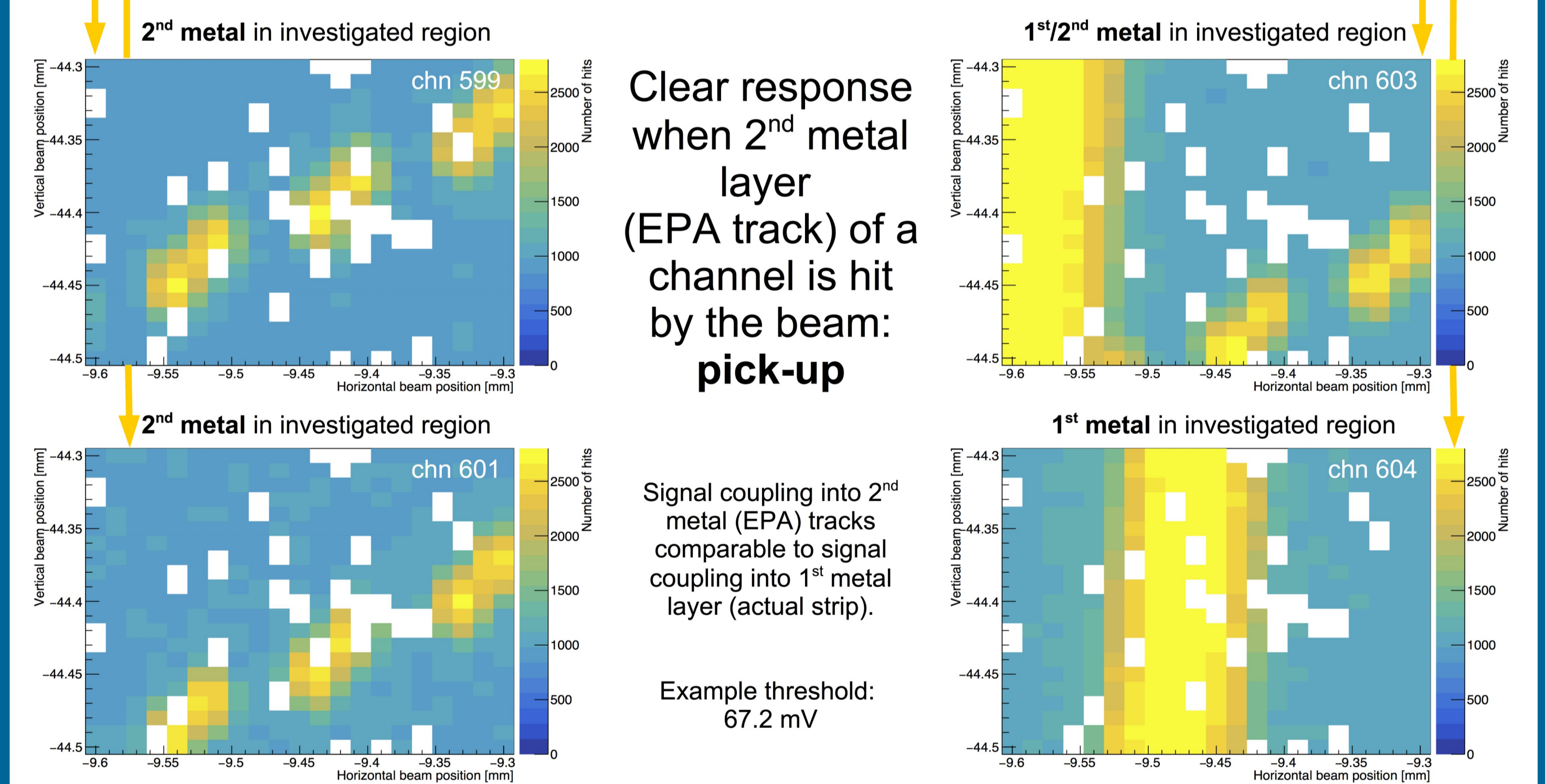
Peripheral: dips in hit efficiency at positions of 2nd metal tracks → pick-up

Slope along y due to slight mis-alignment between beam movement and strip direction



Visualizing the Effect

Hitmap: response of single channel over all beam positions (white areas → no data available)

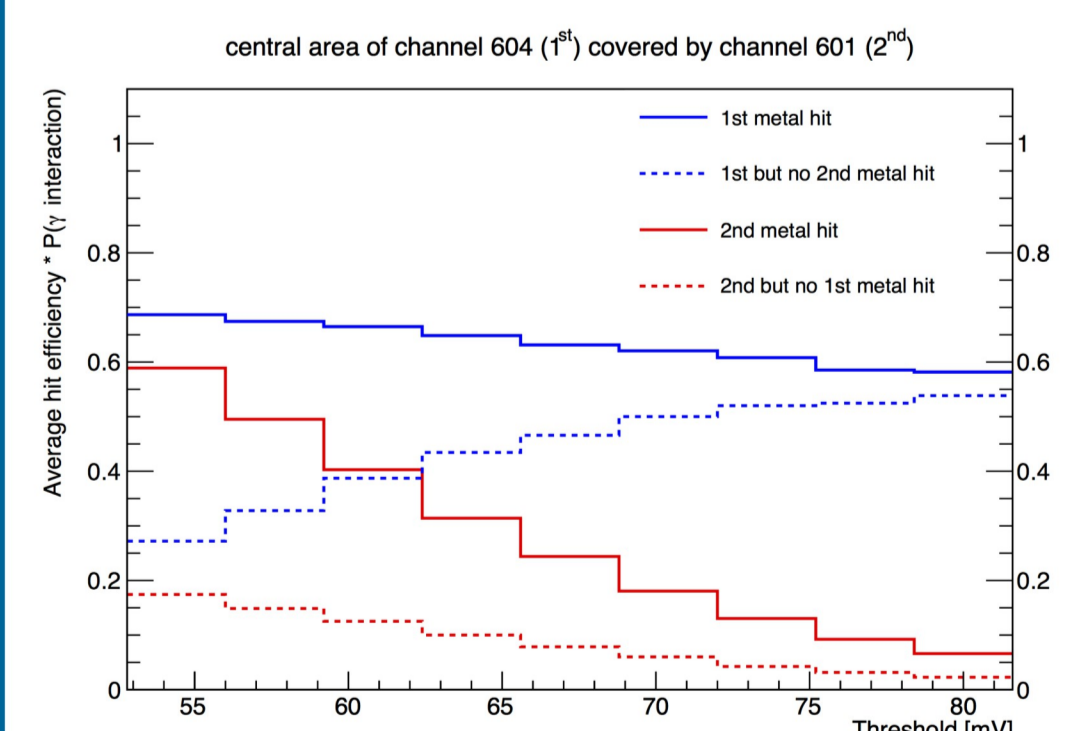


Clear response when 2nd metal layer (EPA track) of a channel is hit by the beam: pick-up

Signal coupling into 2nd metal (EPA) tracks comparable to signal coupling into 1st metal layer (actual strip).

Example threshold: 67.2 mV

central area



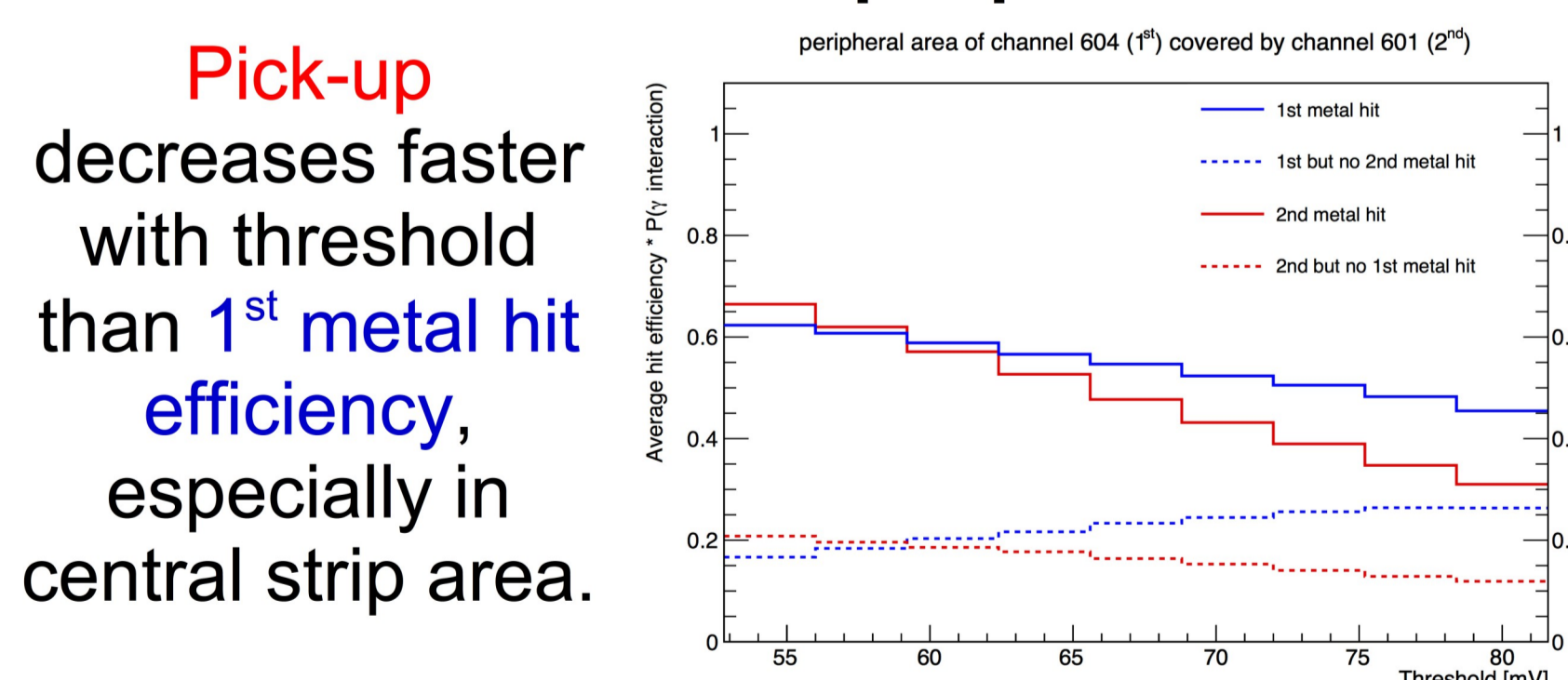
Pick-up decreases faster with threshold than 1st metal hit efficiency, especially in central strip area.

Potential fake signal

Signal lost from original strip

Control channel – noise only

peripheral area



Potential fake signal

Signal lost from original strip

Control channel – noise only

Conclusions and Outlook

- First testbeam results on sensors with embedded pitch adapters
 - 15 keV micro-focussed photon beam → no MIPs, no quantification, but good mapping out of effect
- Pick-up present in unirradiated sensors for
 - low thresholds of binary readout
 - EPA architecture with largest 2nd metal area ("worst case scenario")
- Effect decreases fast towards operating threshold
- Effect possible only in EPA region (< 10% of sensor area)
 - strongest in peripheral strip area

Up next:

- Compare with irradiated sensor
- Extend measurement to higher thresholds
- Repeat measurement for more favored EPA architecture
- Compare with measurements from particle testbeam

Perspective: Can the effect be deployed for obtaining 2D information on interaction location?