

Recent Megatile results

Antoine Laudrain (JGU, Mainz)

On behalf the JGU team:

Volker Büscher, Phi Chau, Karl-Heinz Geib, Lucia Masetti, Marisol Robles, Anna Rosmanitz, Christian Schmitt

including the PRISMA detector lab team:

Peter Bernhard, Anastasia Mpoukouvalas, Quirin Weitzel

CALICE Collaboration meeting - 29/09/2020

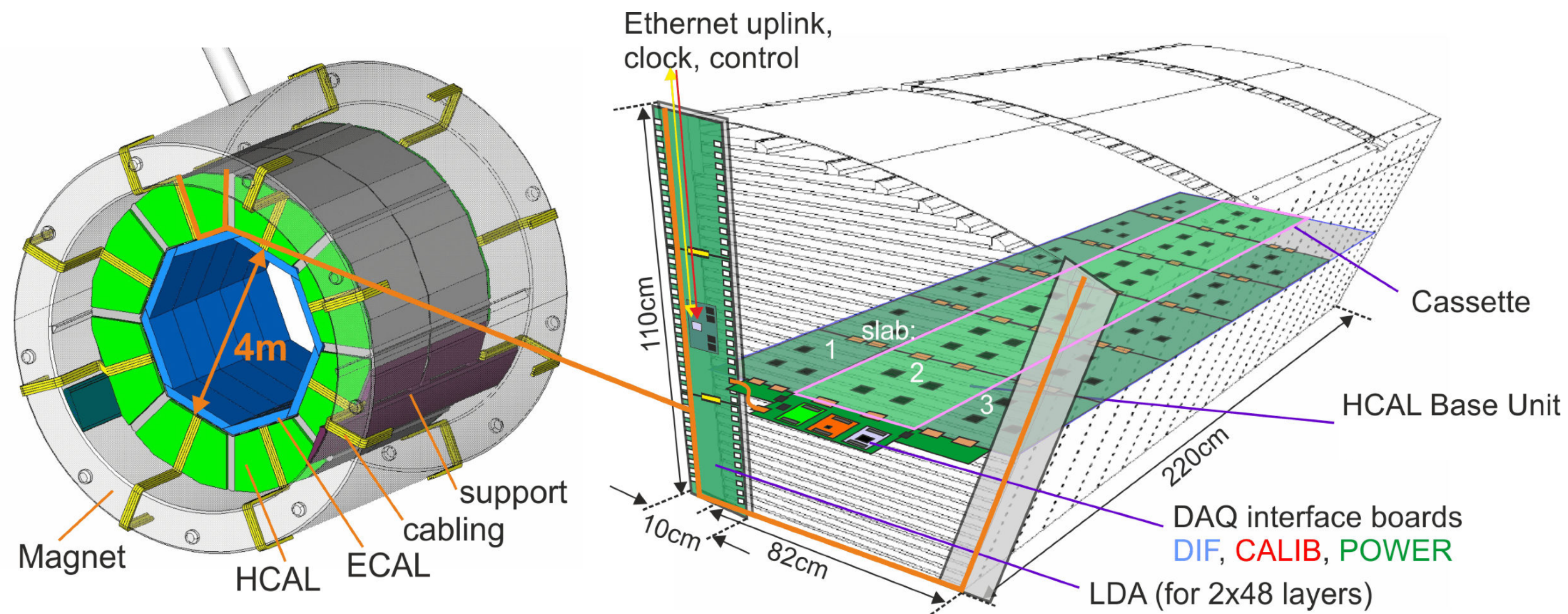


JOHANNES GUTENBERG
UNIVERSITÄT MAINZ



Reminder: current “standard” AHCAL

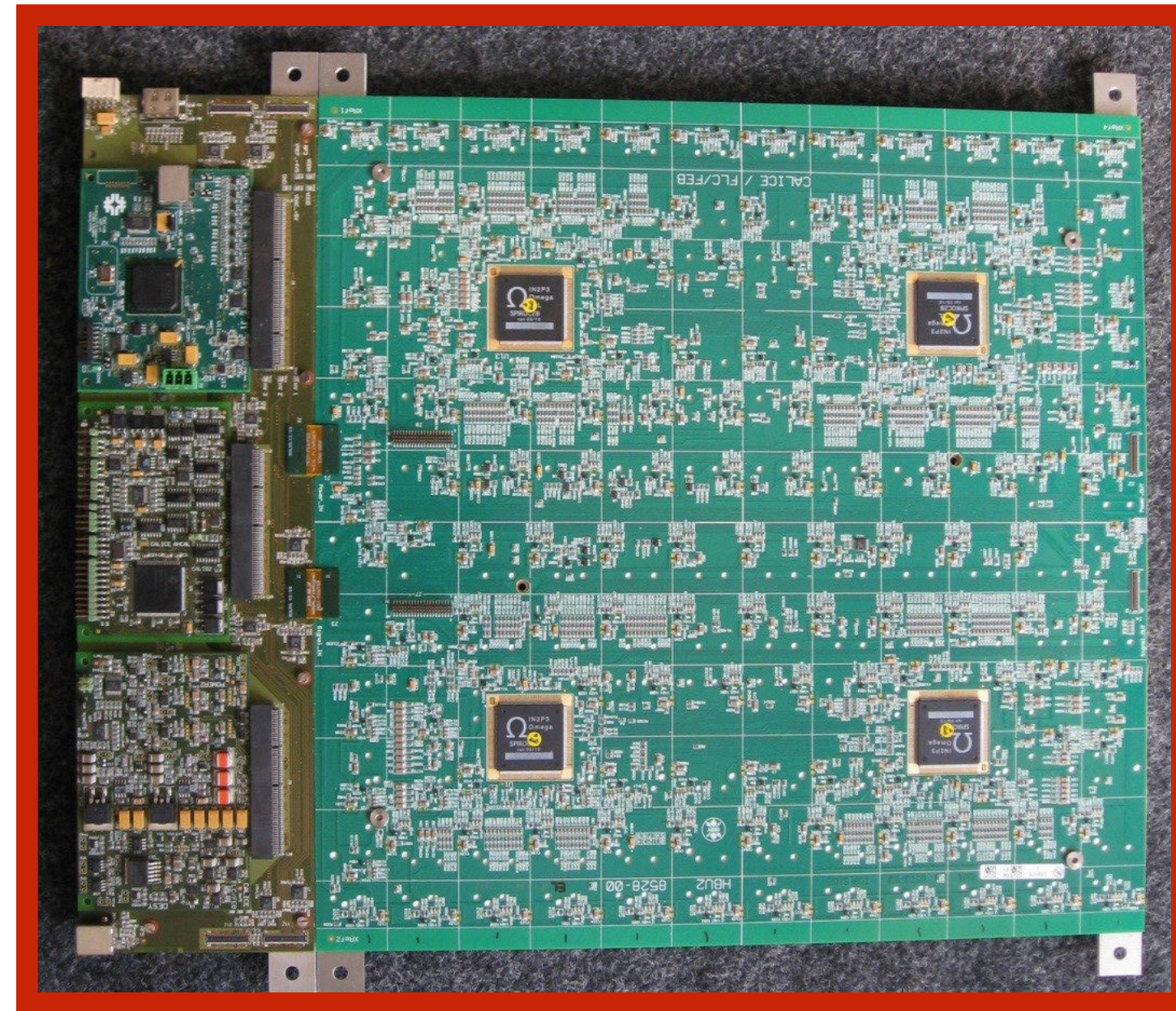
Analogue
Hadronic
CALorimeter



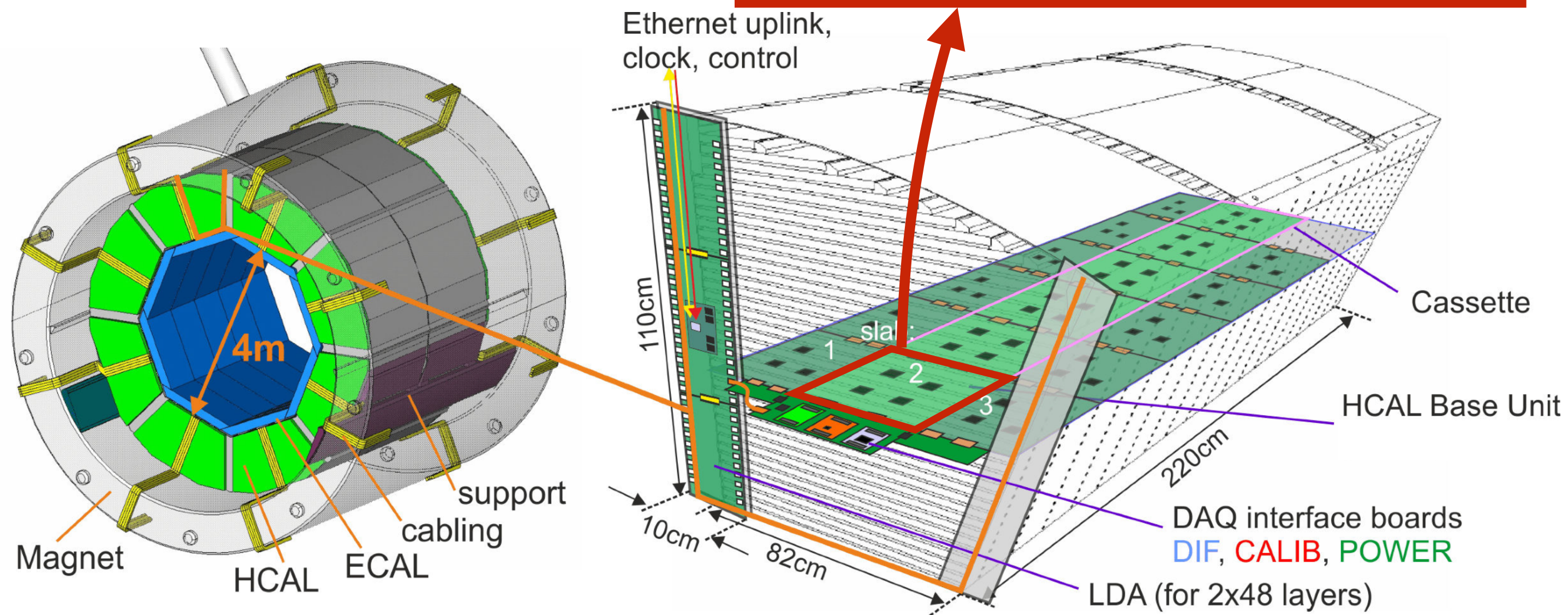
arxiv:1701.02232

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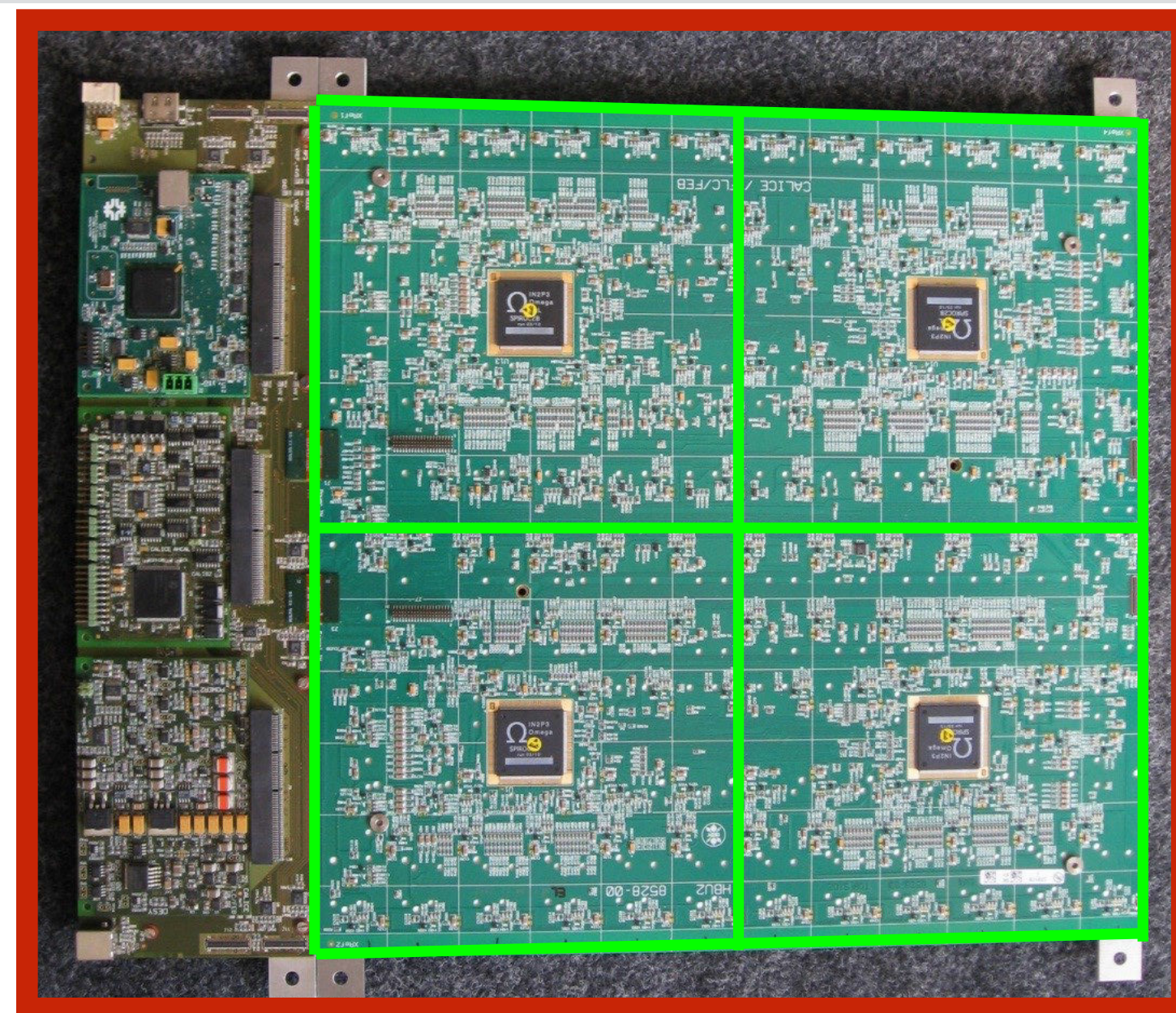
- 1 HBU (HCAL Board Unit)
- 36x36 cm²



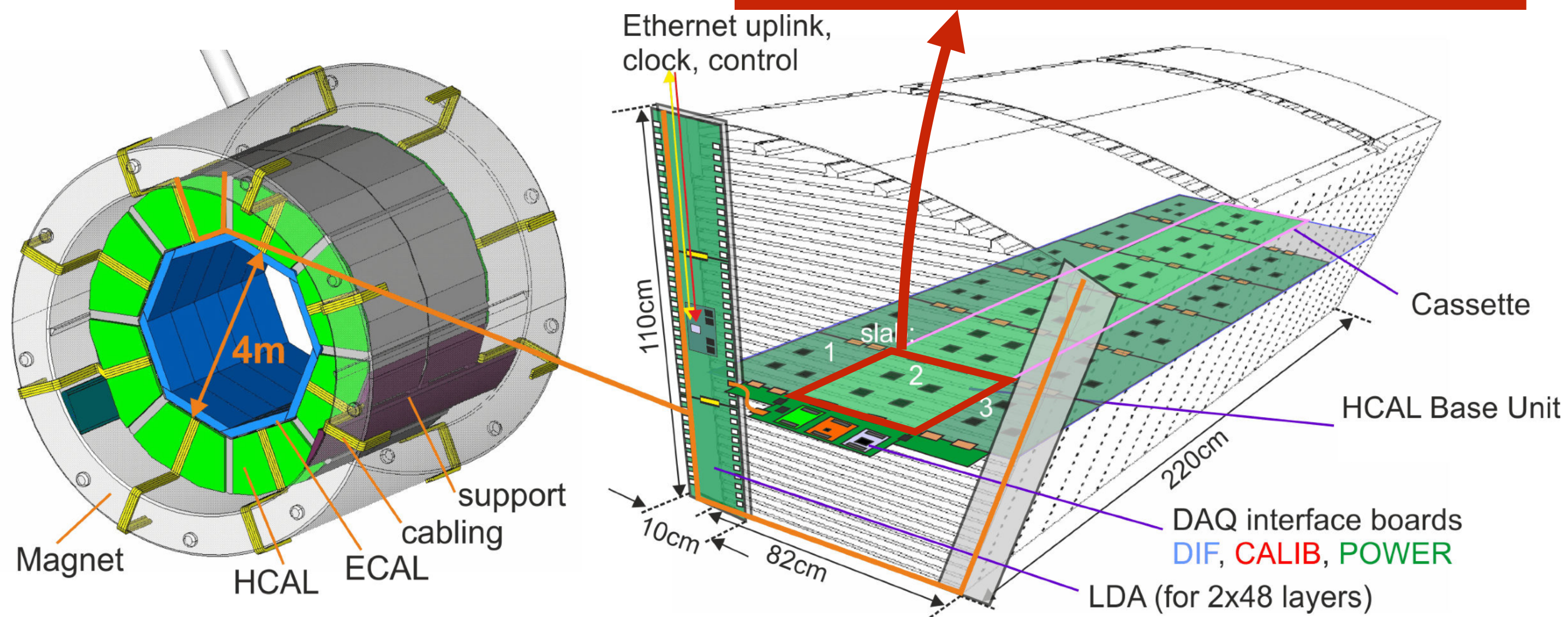
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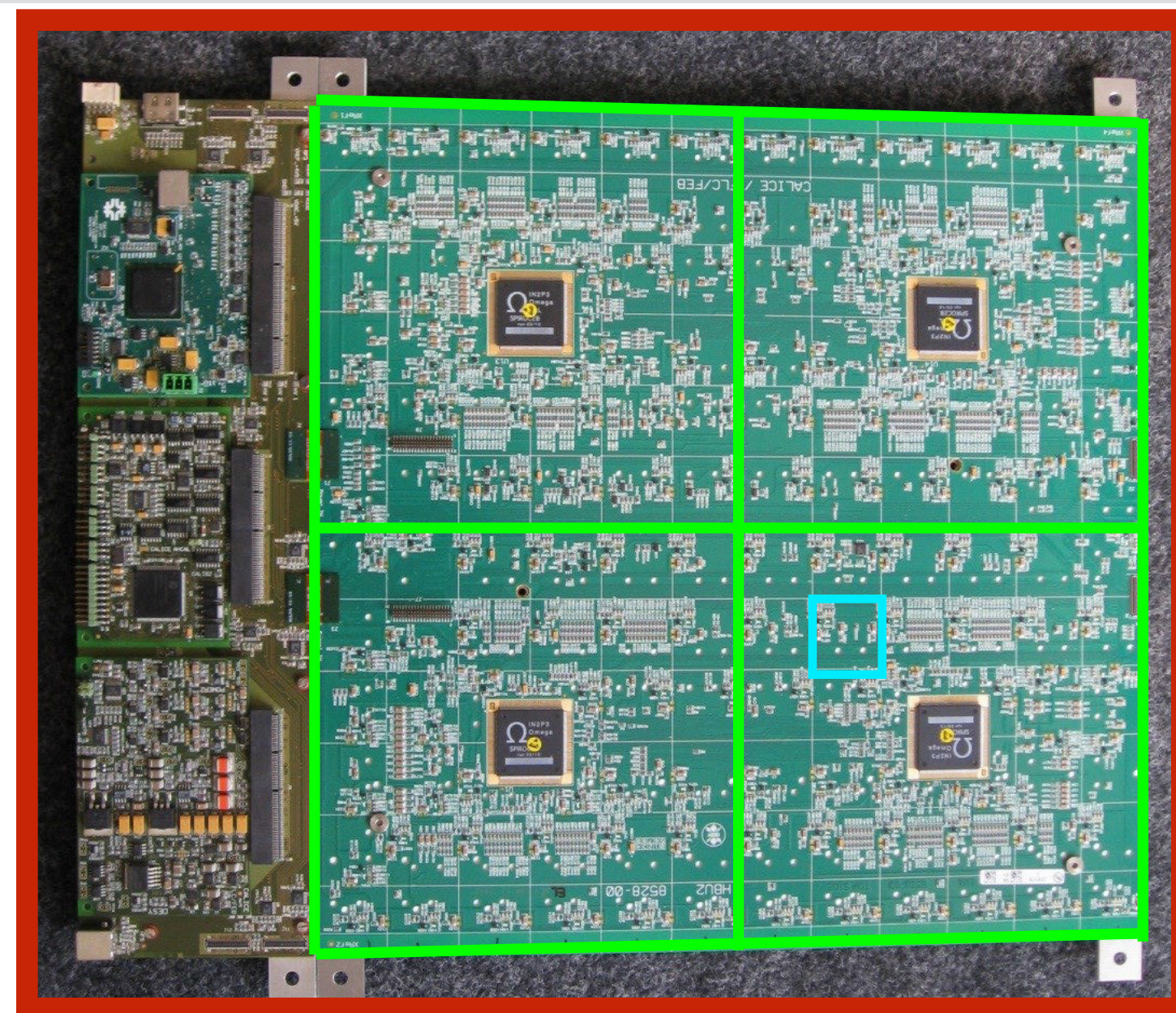
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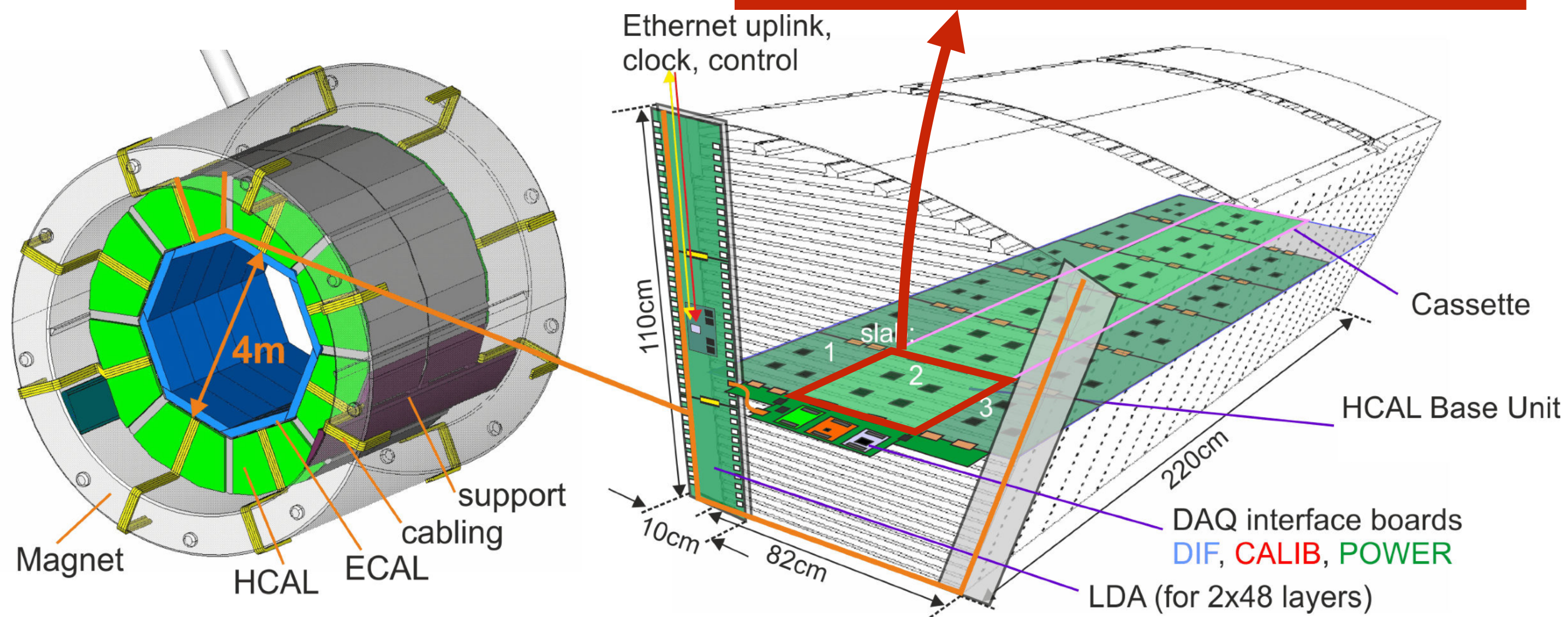
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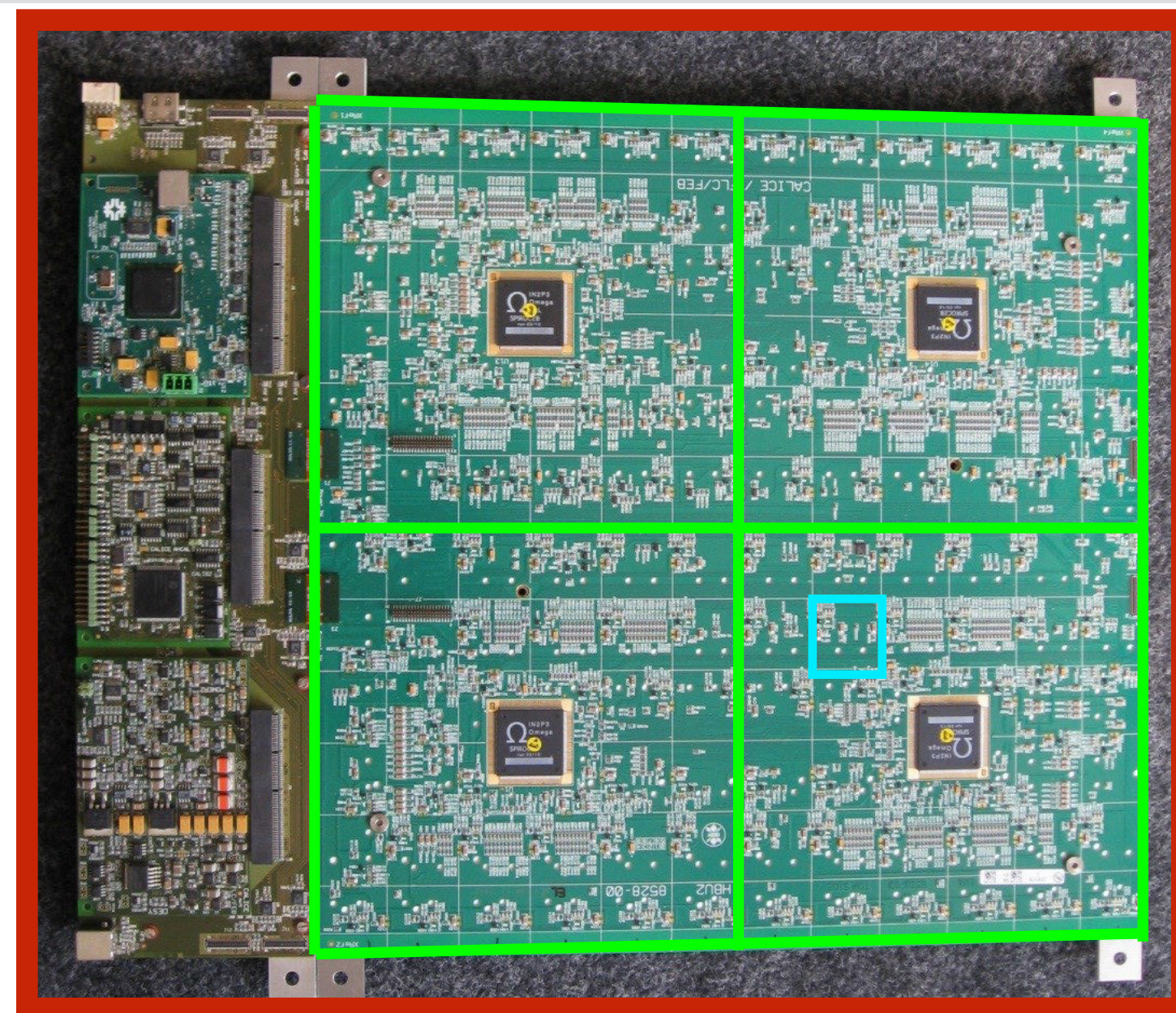
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- 4 chips (ASIC) / HBU
- 36 channels / ASIC
- 1 channel =
 - 1 tile (30x30 mm²)
 - 1 SiPM (other side)



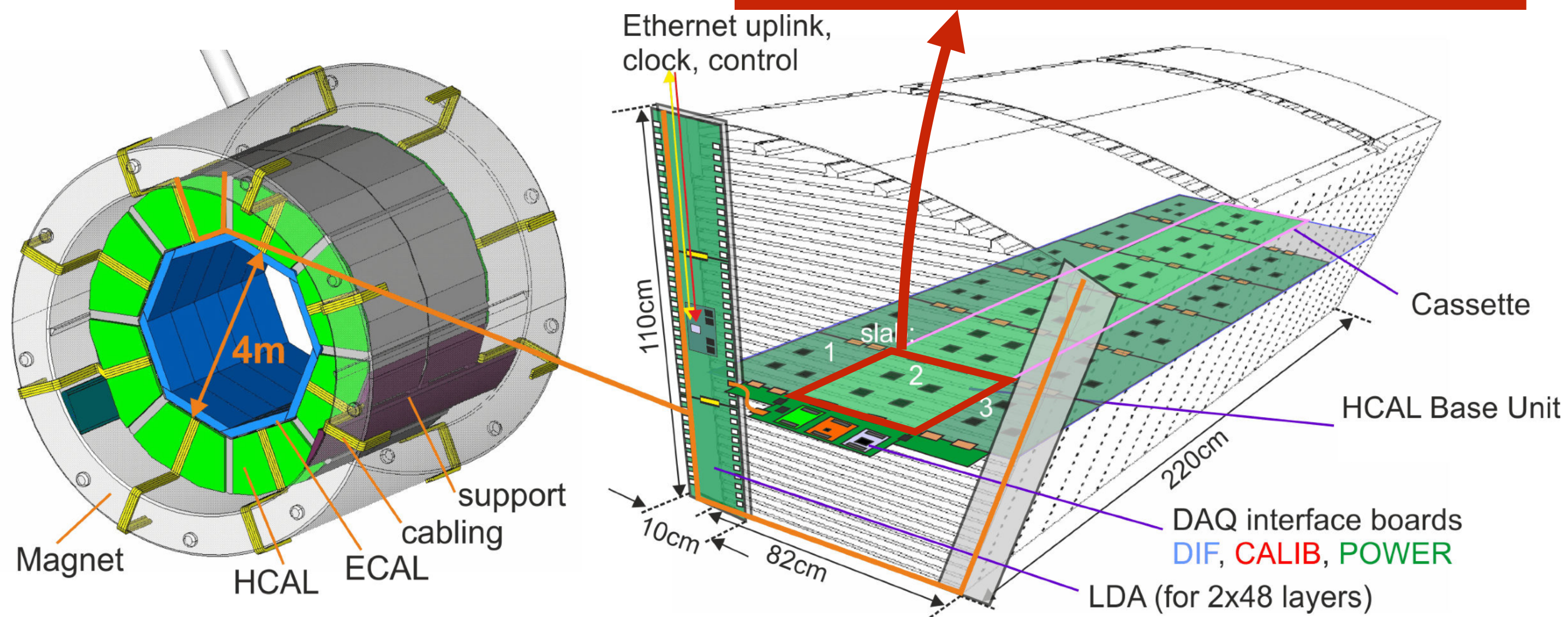
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- -> 1 HBU = 144 individual tiles



arxiv:1701.02232

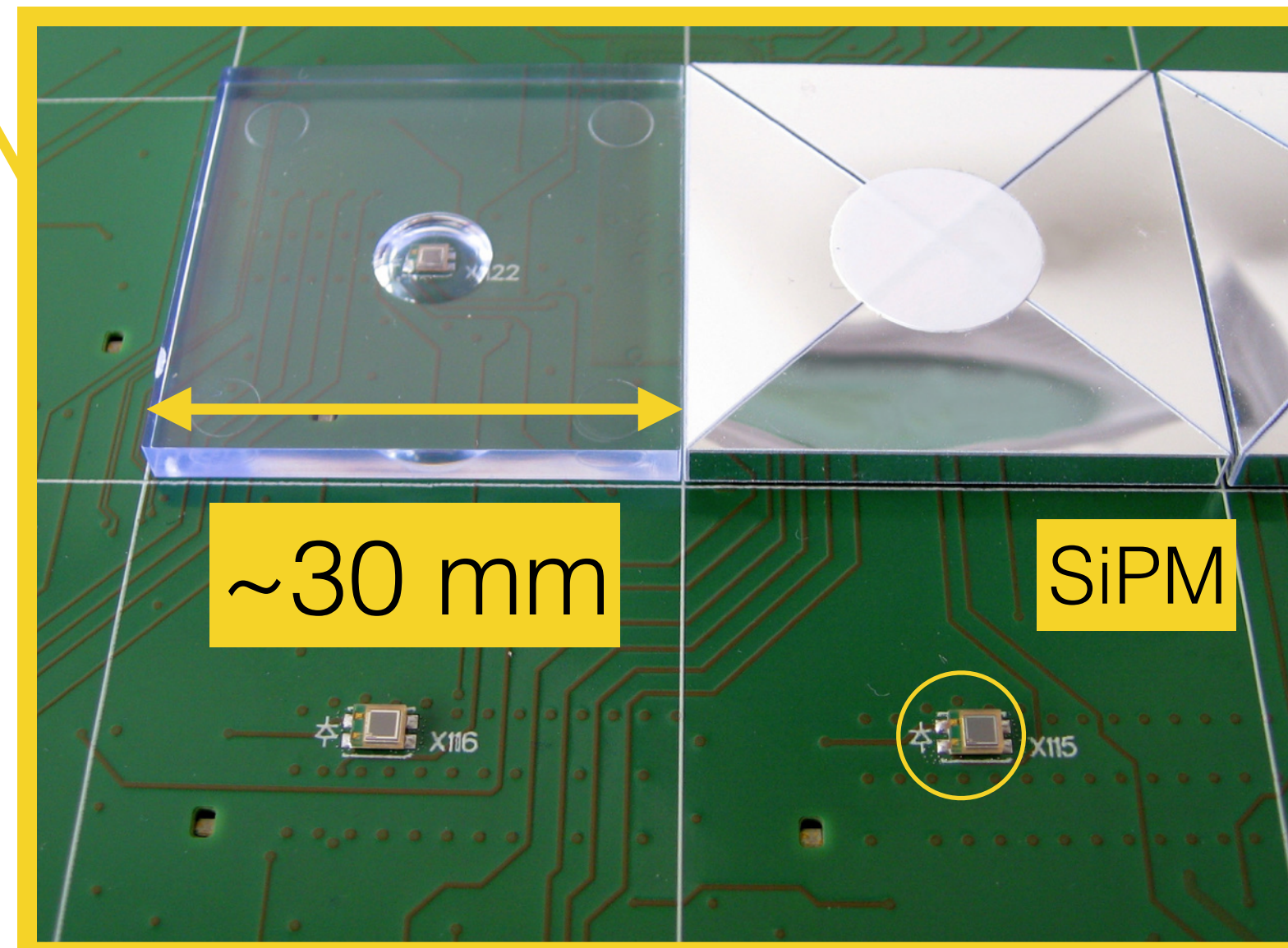
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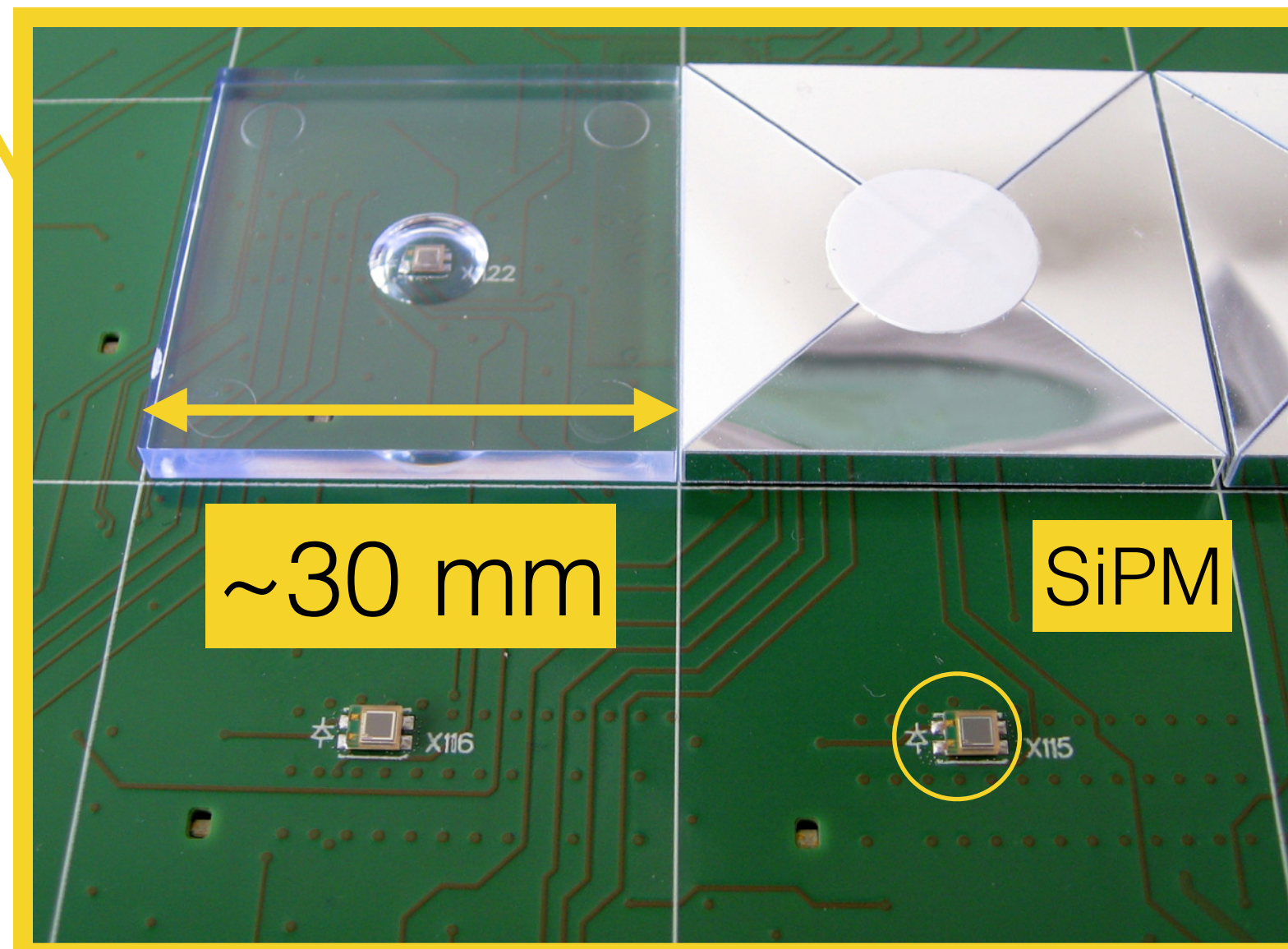
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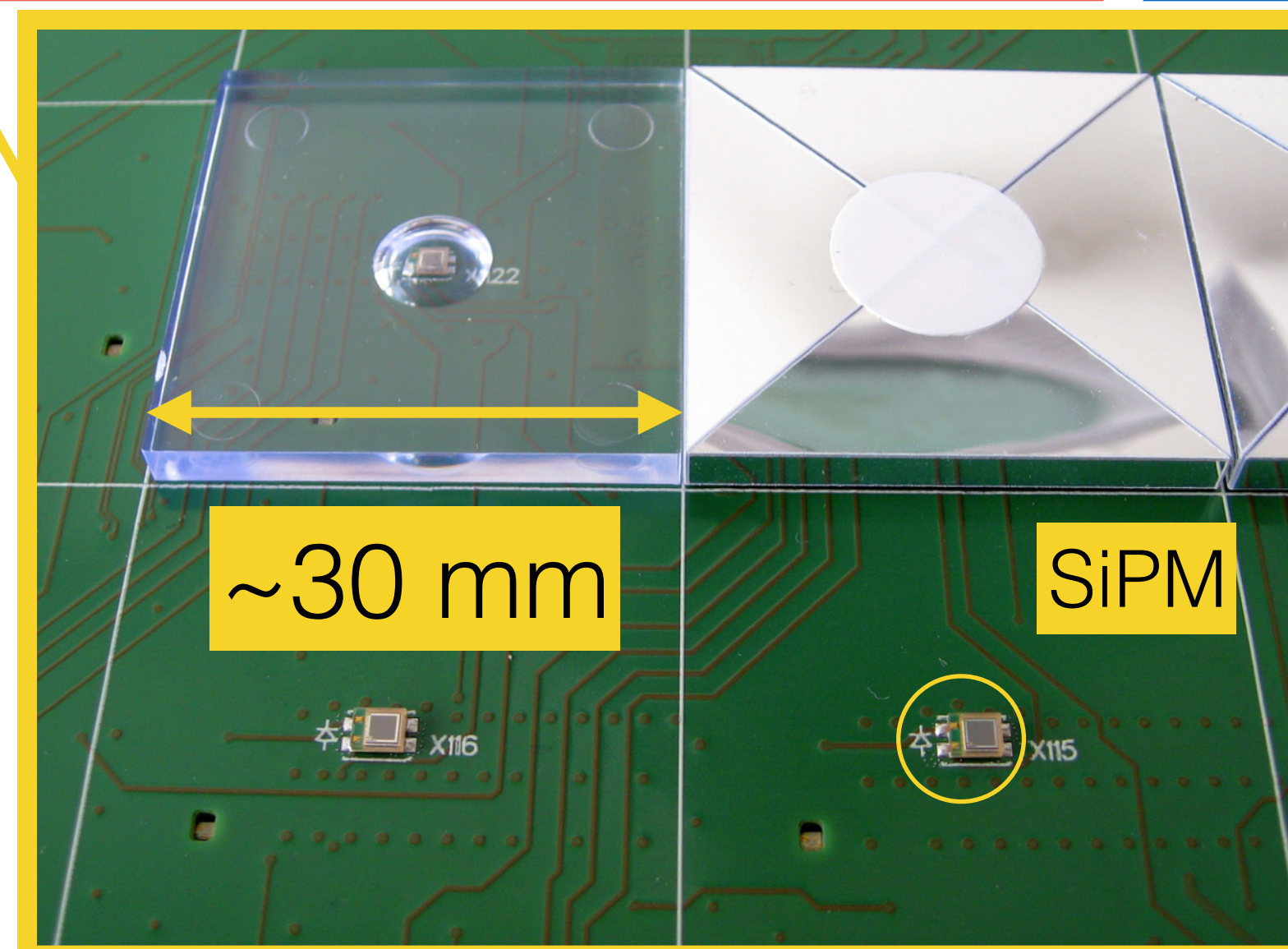
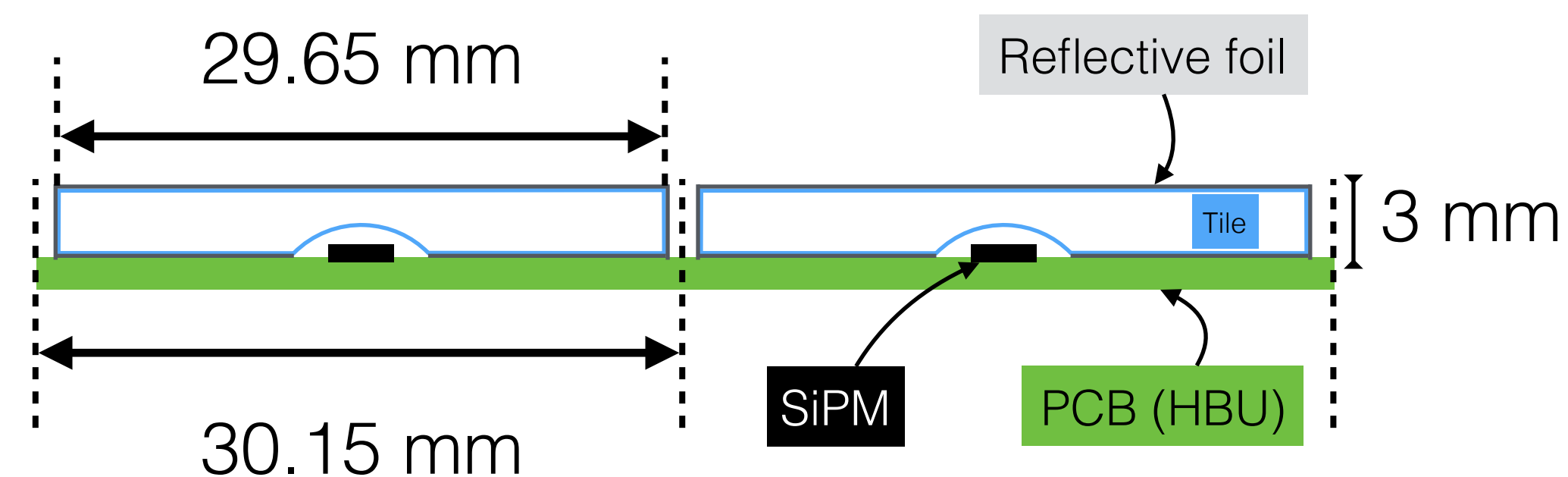
2018: large scale prototype
> 150 boards
> 20 000 tiles

Reminder: current “standard” AHCAL

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- Can be automated but...
 - not so simple,
 - dead area between tiles.



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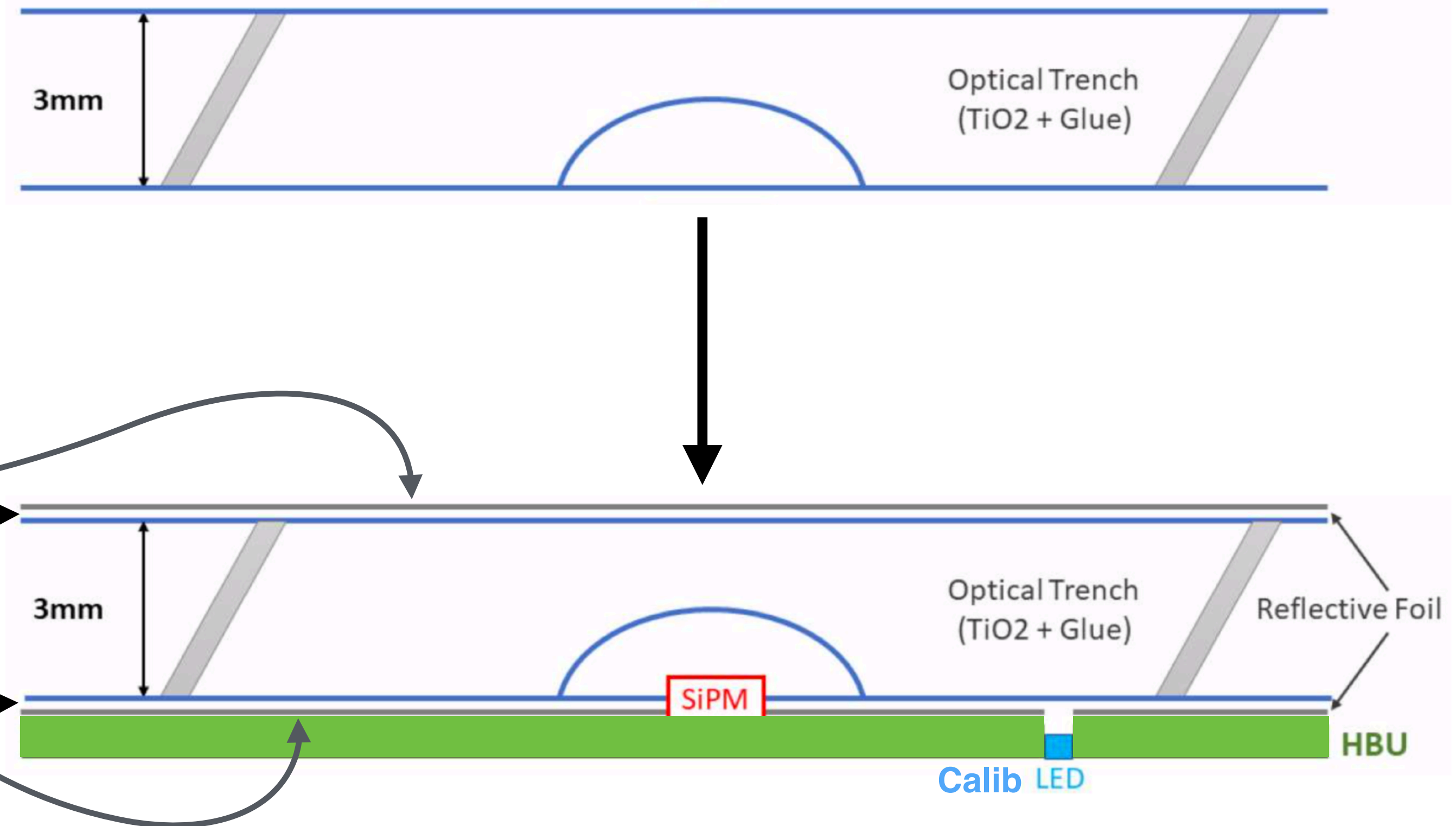
Megatile concept

- Build **one single** 36x36 cm² **tile**.
- **Segment it** with **optical insulation**: reflective glue with TiO₂.



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- Put large **reflective foil sheet** directly on HBU (with laser-cut holes for SiPM)
- **Air gap** (30-100 μm) to ensure total reflection.



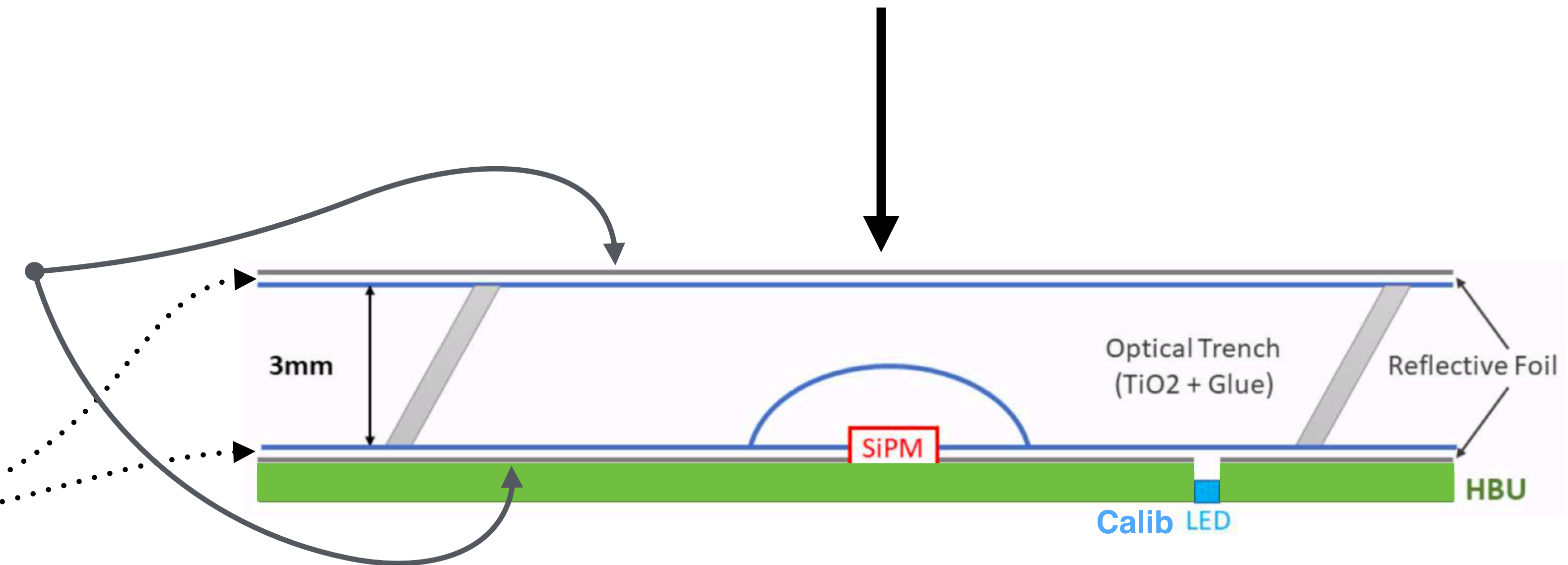
- No change to SiPM:
 - Same HBU
 - Same electronics boards
 - Same readout

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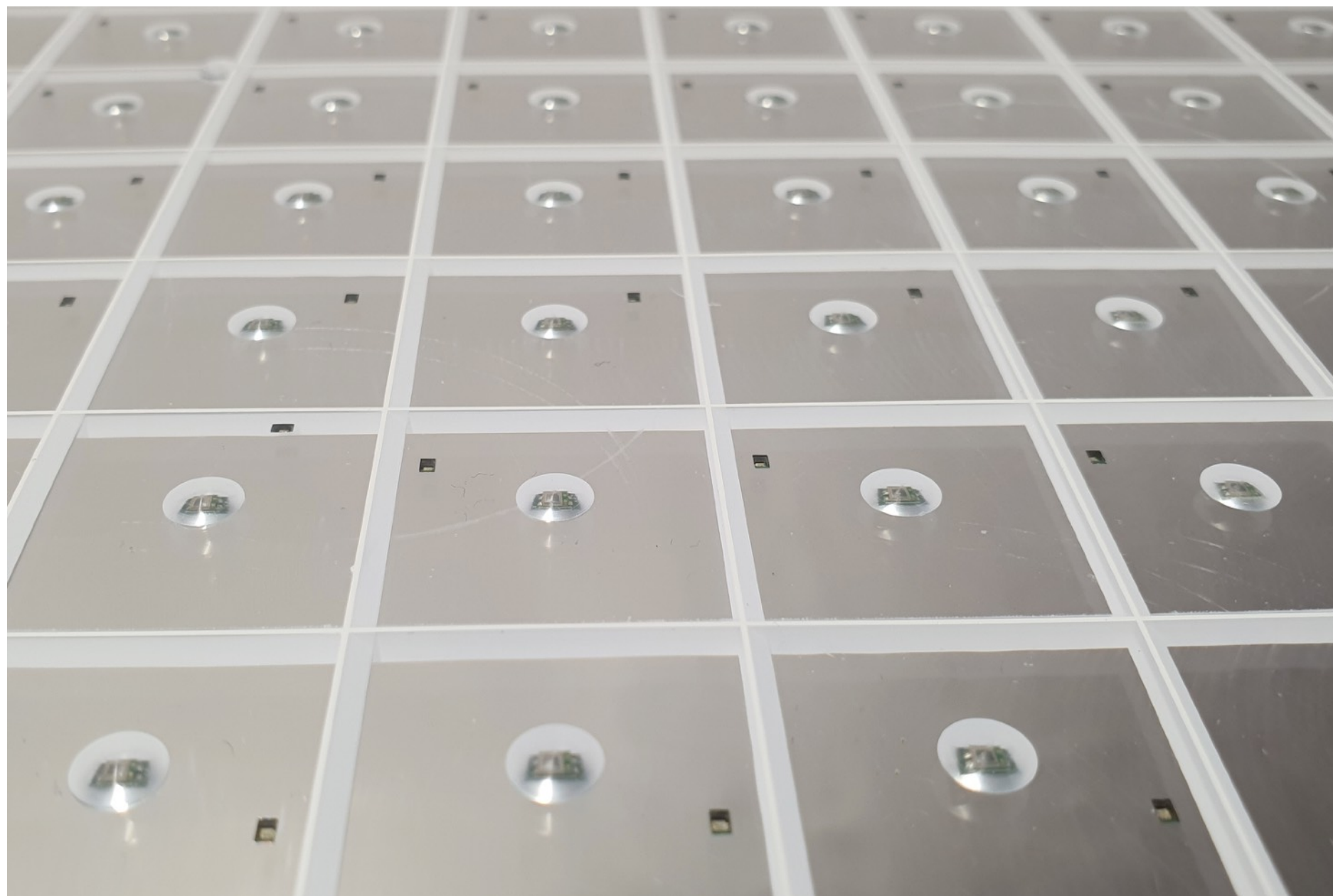


- 👍 ~ **No dead area!**
- 👍 **Easier assembly.**

- No change to SiPM:
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 - Same electronics boards
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Megatile concept

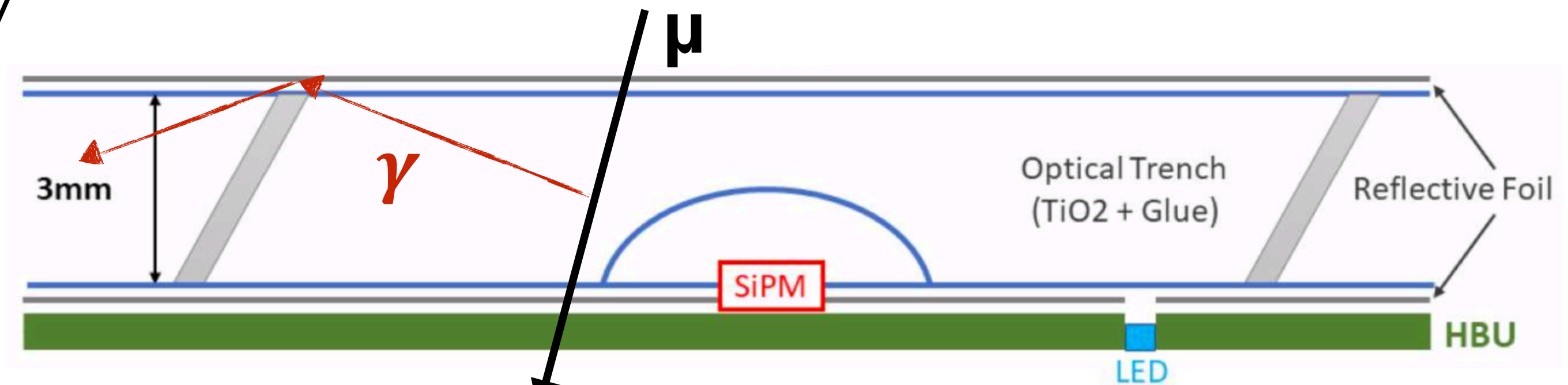
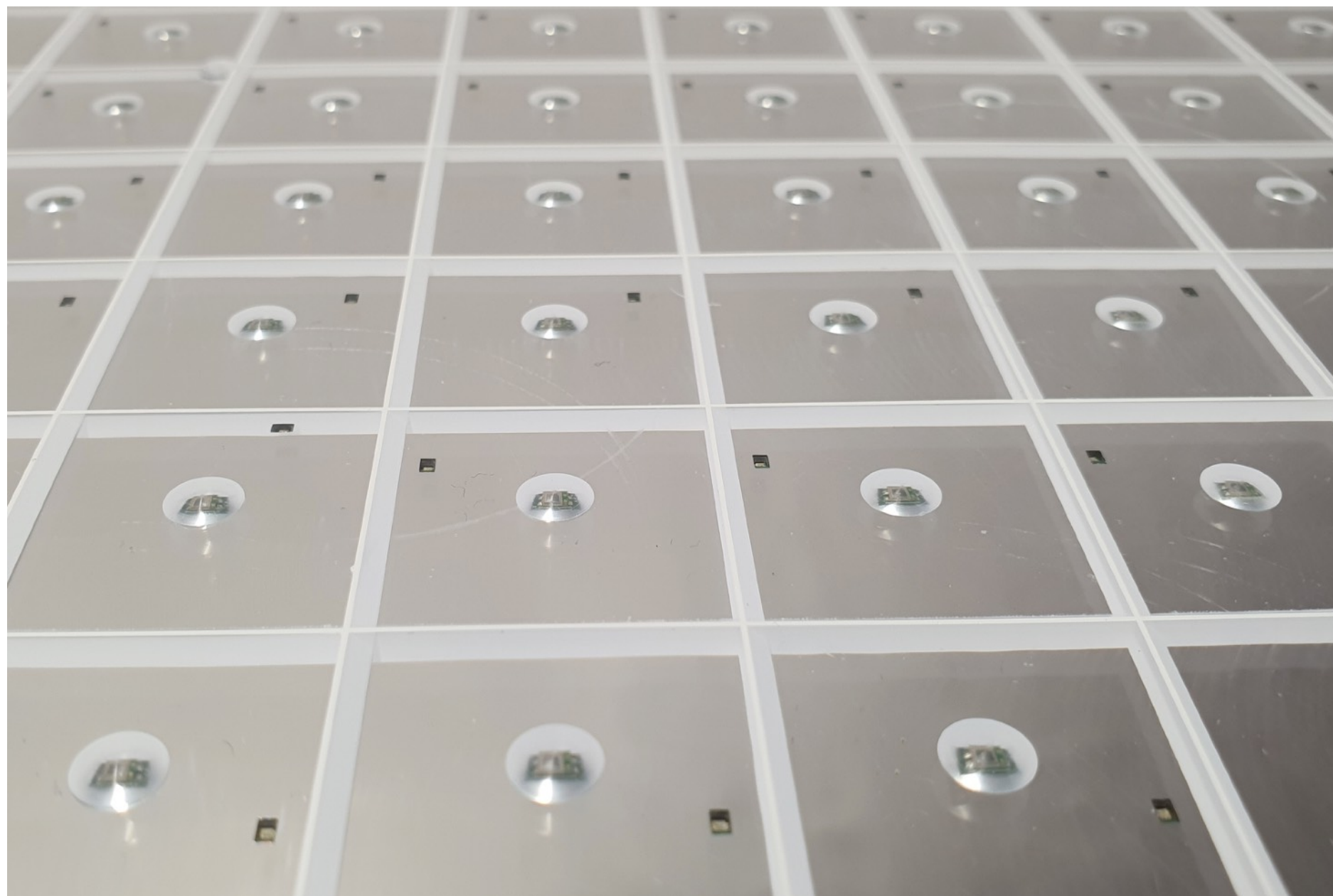
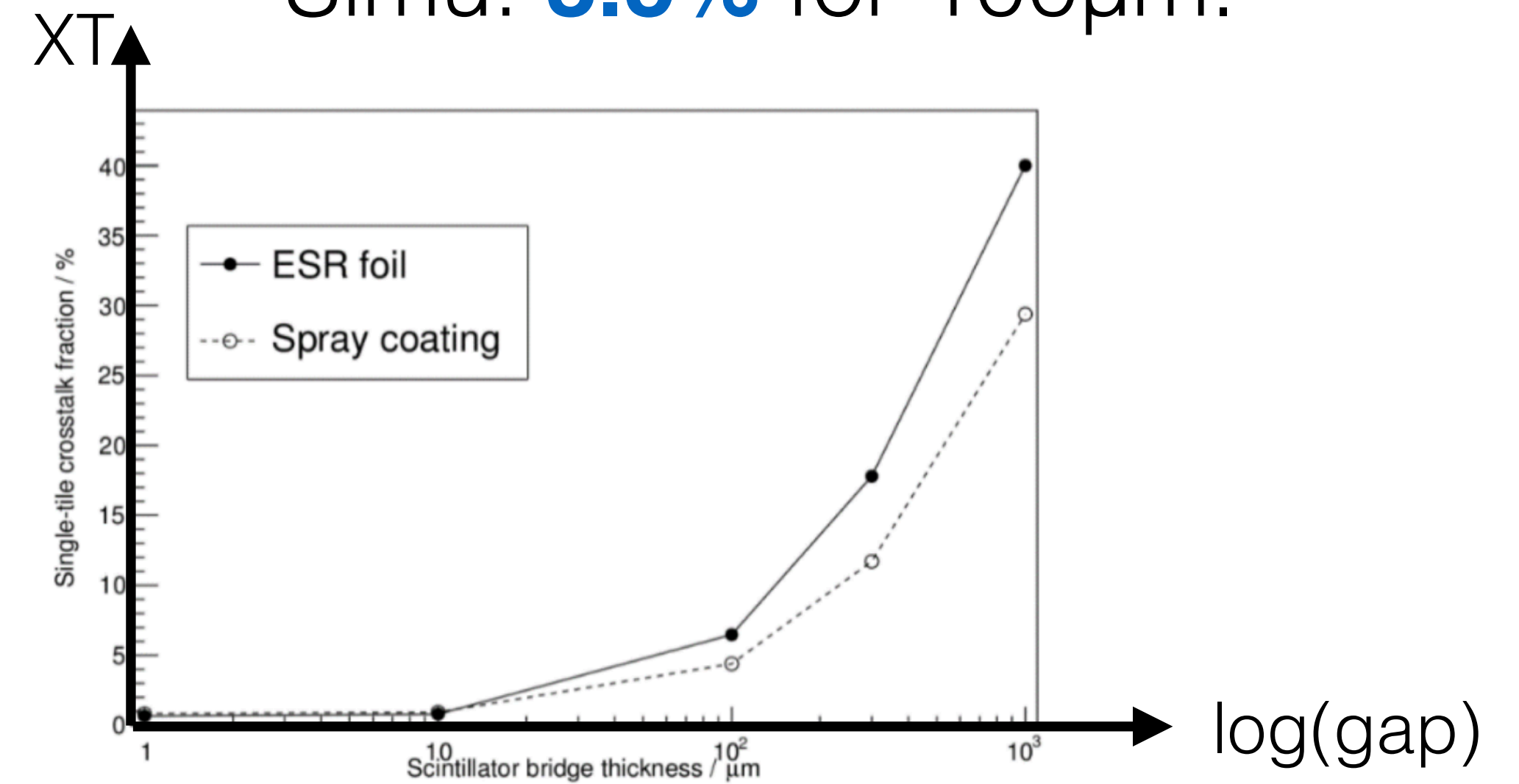
- Dimple shape: already optimised for single tiles.
- Trench angle:
 - **Optimised for light-yield** using simu.
 - Angle = 30° , minimal dead area.
- → **High light-yield \approx as single tile** 👍
- **Glue + TiO₂ dependency** (last year).



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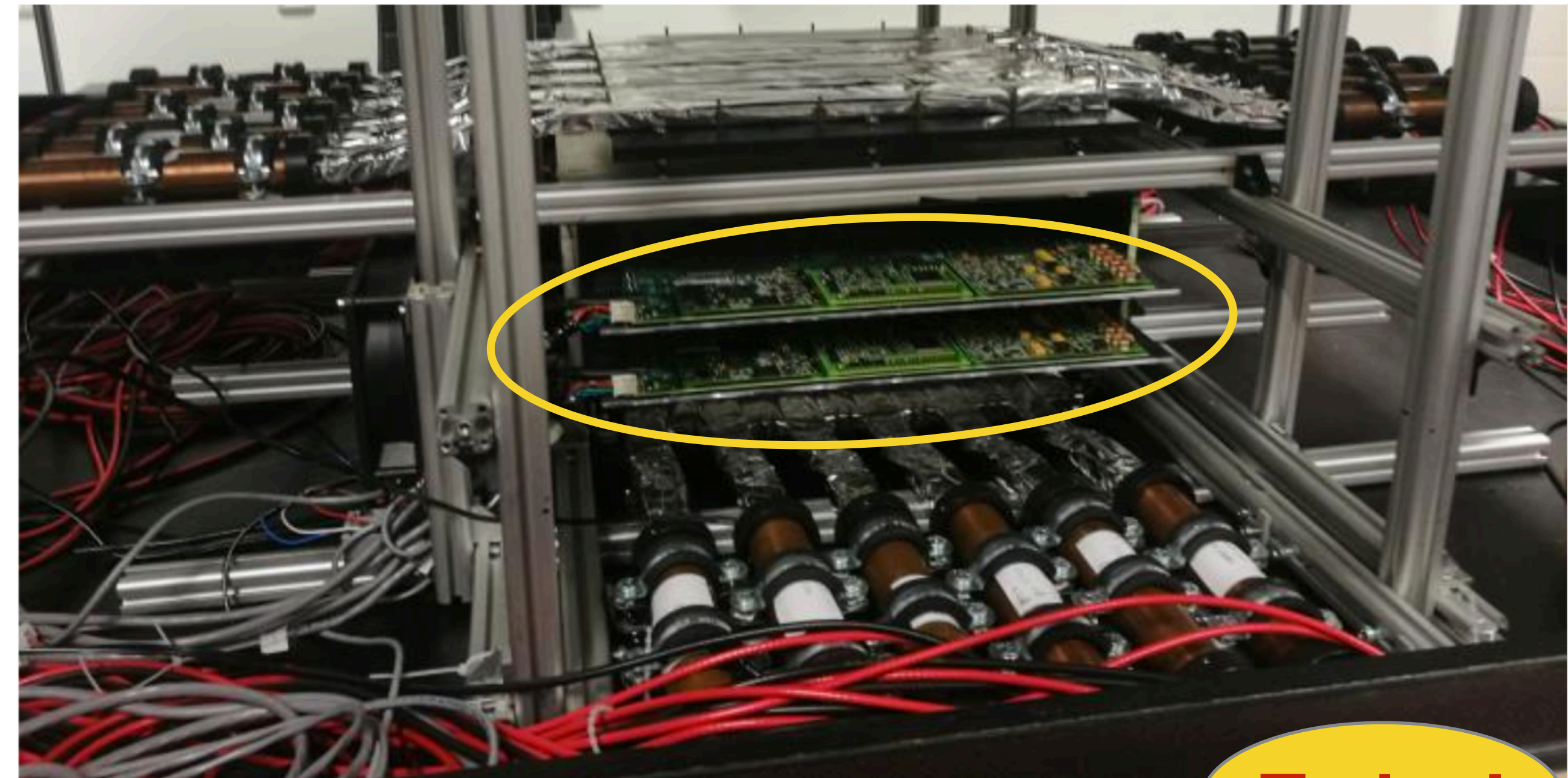
- **Must be careful with air gap**:
 - Too large → optical cross talk.
 - Simu: **3.5%** for $100\mu\text{m}$.



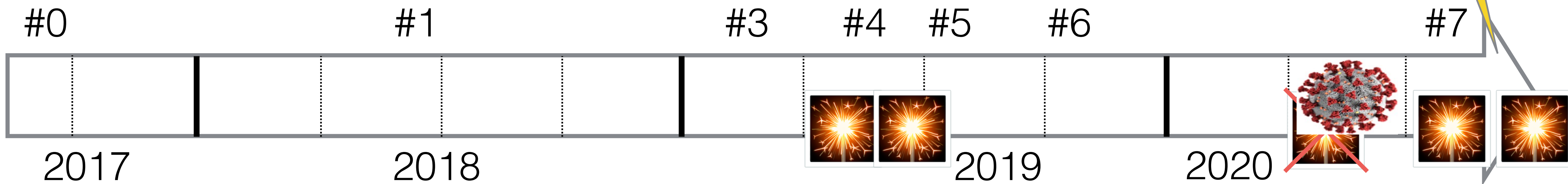
The Megatile experience

Cosmic test stand @ Mainz

- **Project started in 2017.**
- **Already 7 prototypes built** with **continuous improvement.**
- Only current status presented here, not the evolution.
- **Continuously tested** in **cosmic test stand @ Mainz.**
- Already **3 test beams @ DESY.**



Today!



Megatile: a promising concept

- **High light-yield ≈ 32 p.e.**
 \approx as single wrapped tile 👍 👍

- **Cross-talk:**

- $\lesssim 5\%$
- $\neq 0$ but **OK** 👍



Still...



The Megatile experience

Promising concept

Two main challenges encountered so far

Edges cells

Air gap

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First challenge: low light-yield for edge cells

- **Light yield:**

- 👍 **High and uniform** in the center ~ 32 p.e.
(as for wrapped single tiles)
- Edges: ~ 20 p.e.

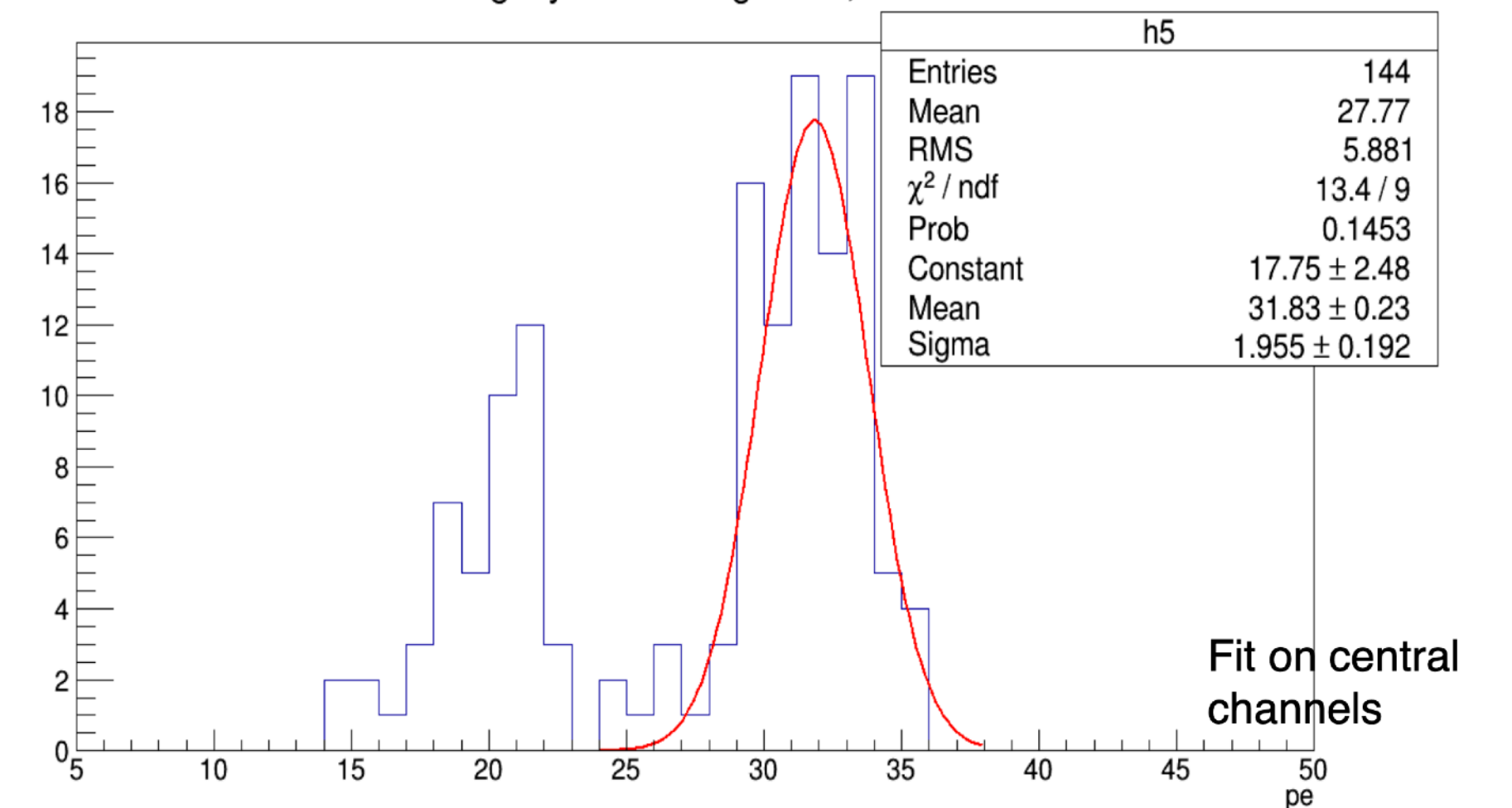
- **Reason:**

- 😞 **Coating** of edges is **technically difficult**.



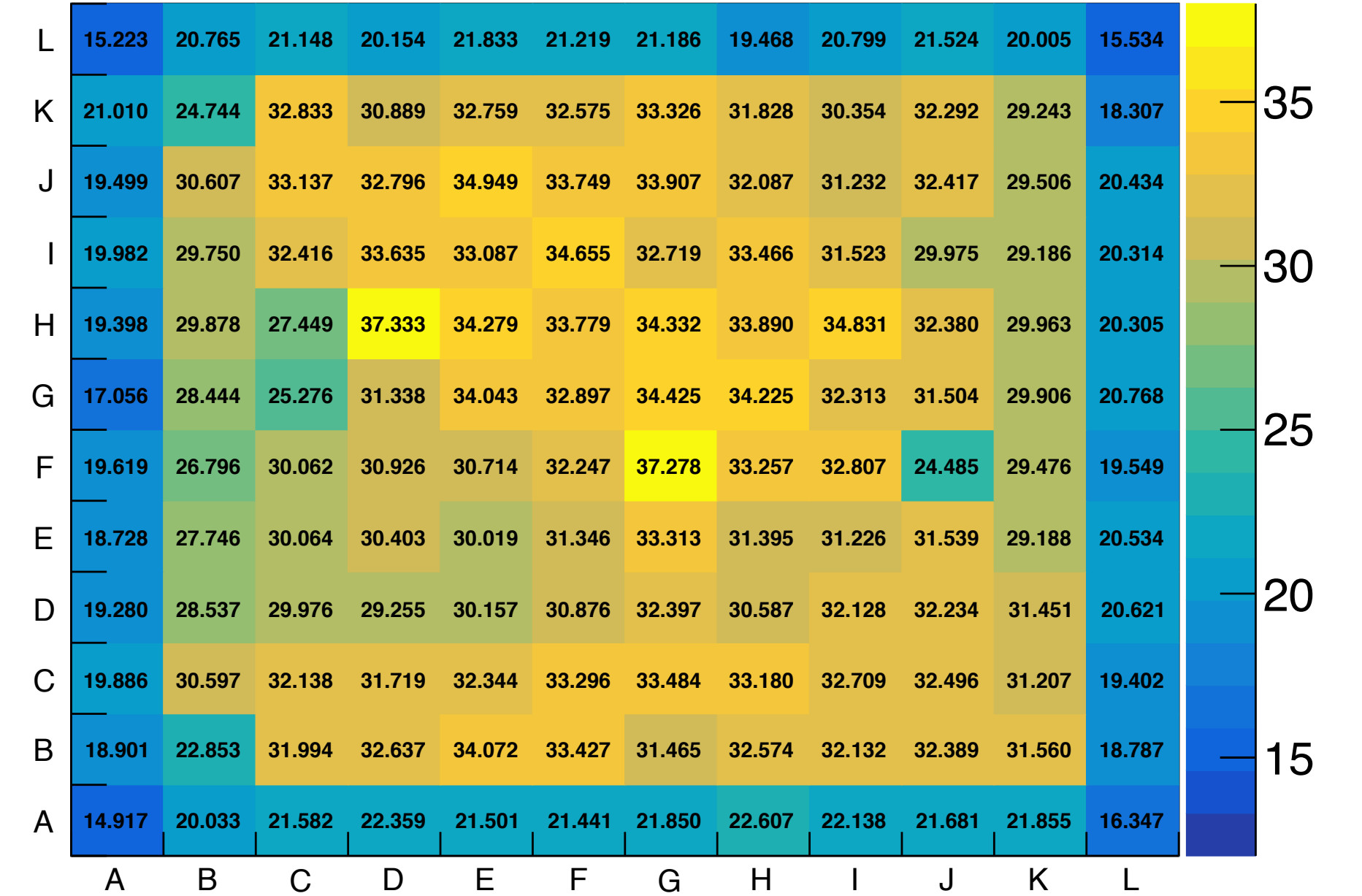
Light yield for Megatile 6, LY4

Megatile prototype 6



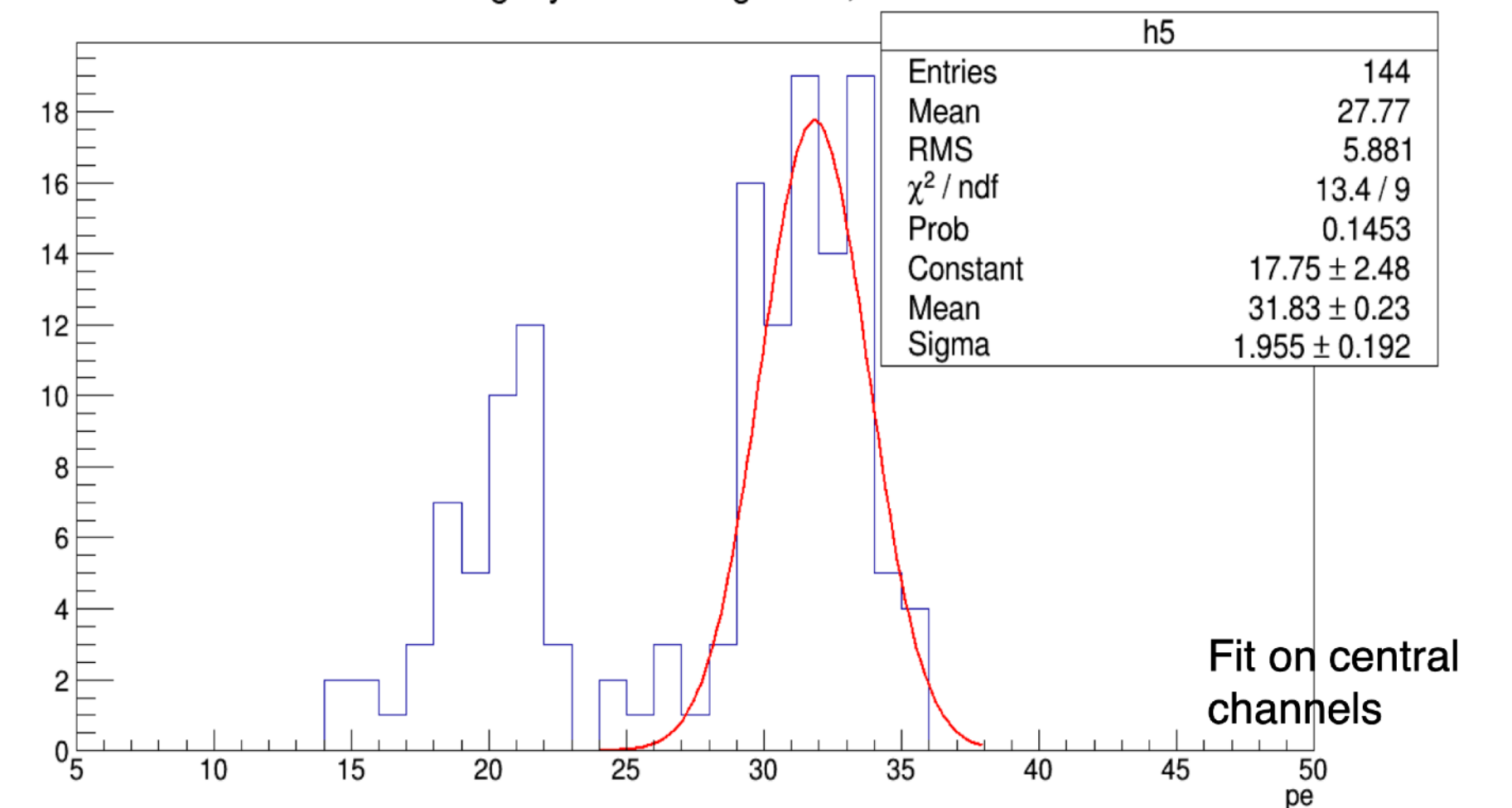
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- **Reason:**
 - 😞 **Coating** of edges is **technically difficult**.
- **Current workaround:**
 - Adhesive **reflective foil** on the edges.
 - **Not easy** either.
 - **Limited improvement**.

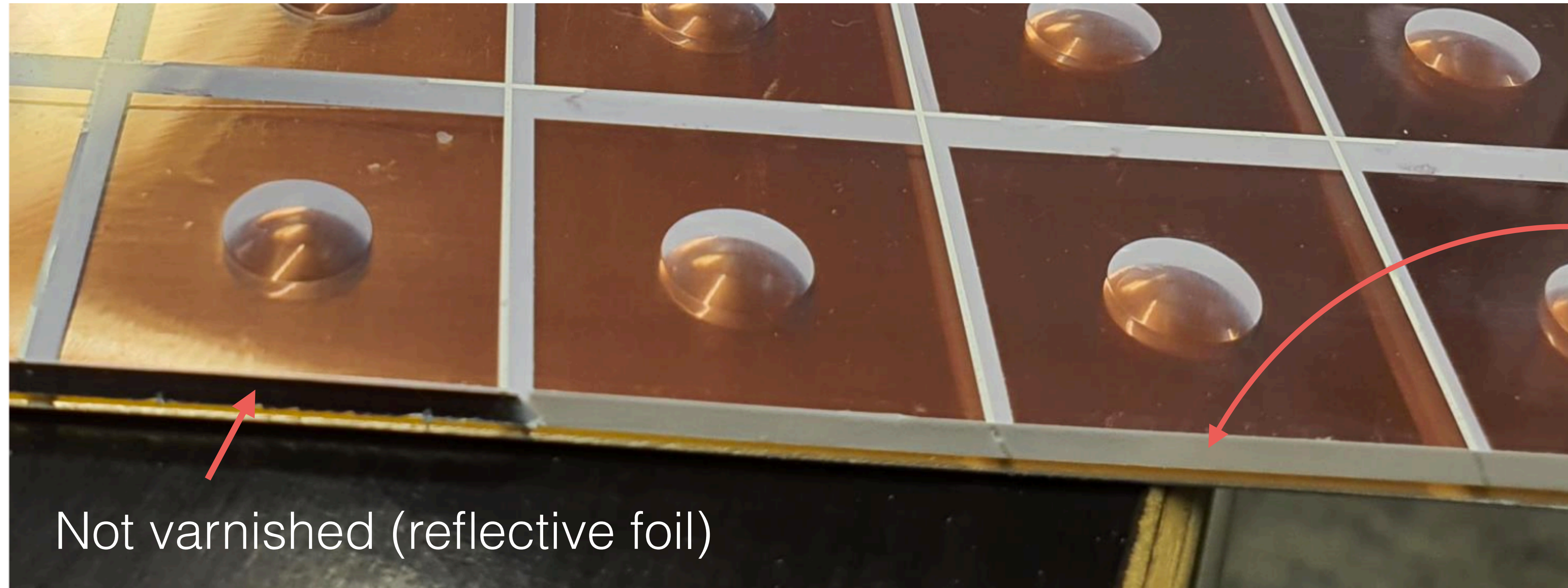


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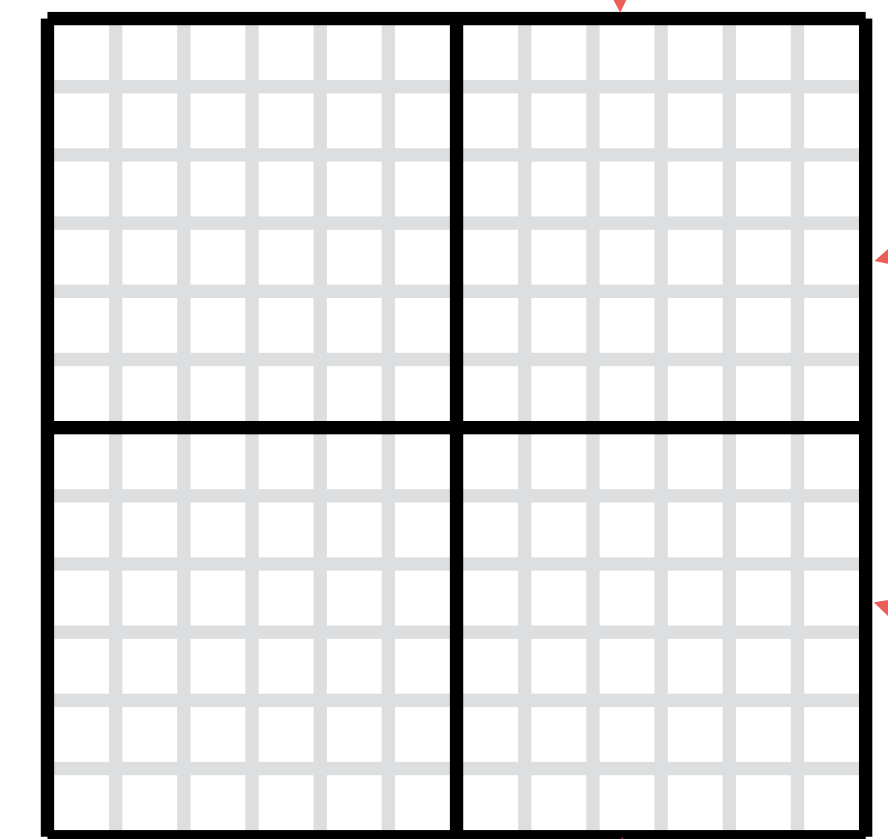
Megatile prototype 6



First challenge: low light-yield for edge cells



varnished 1

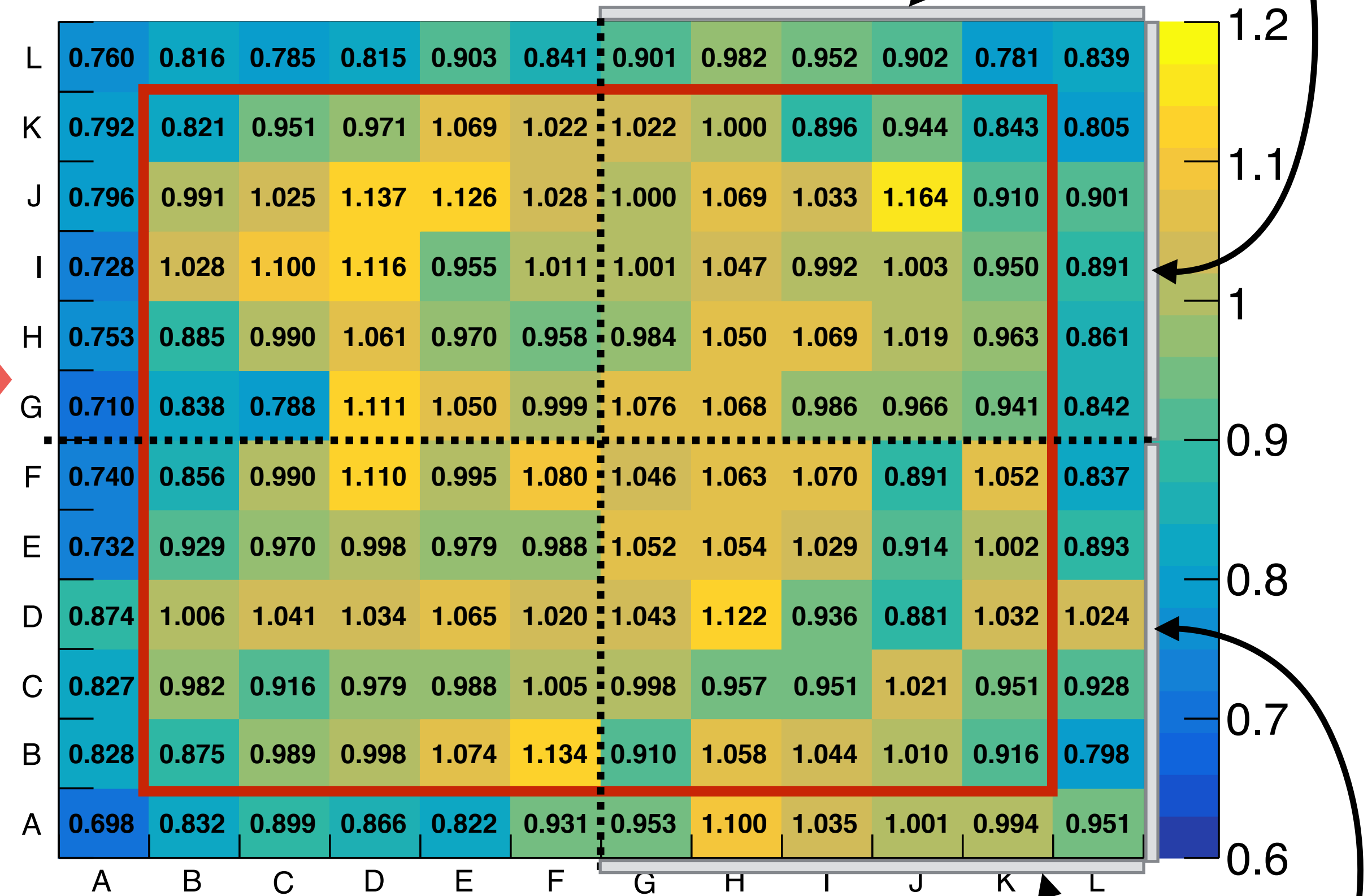
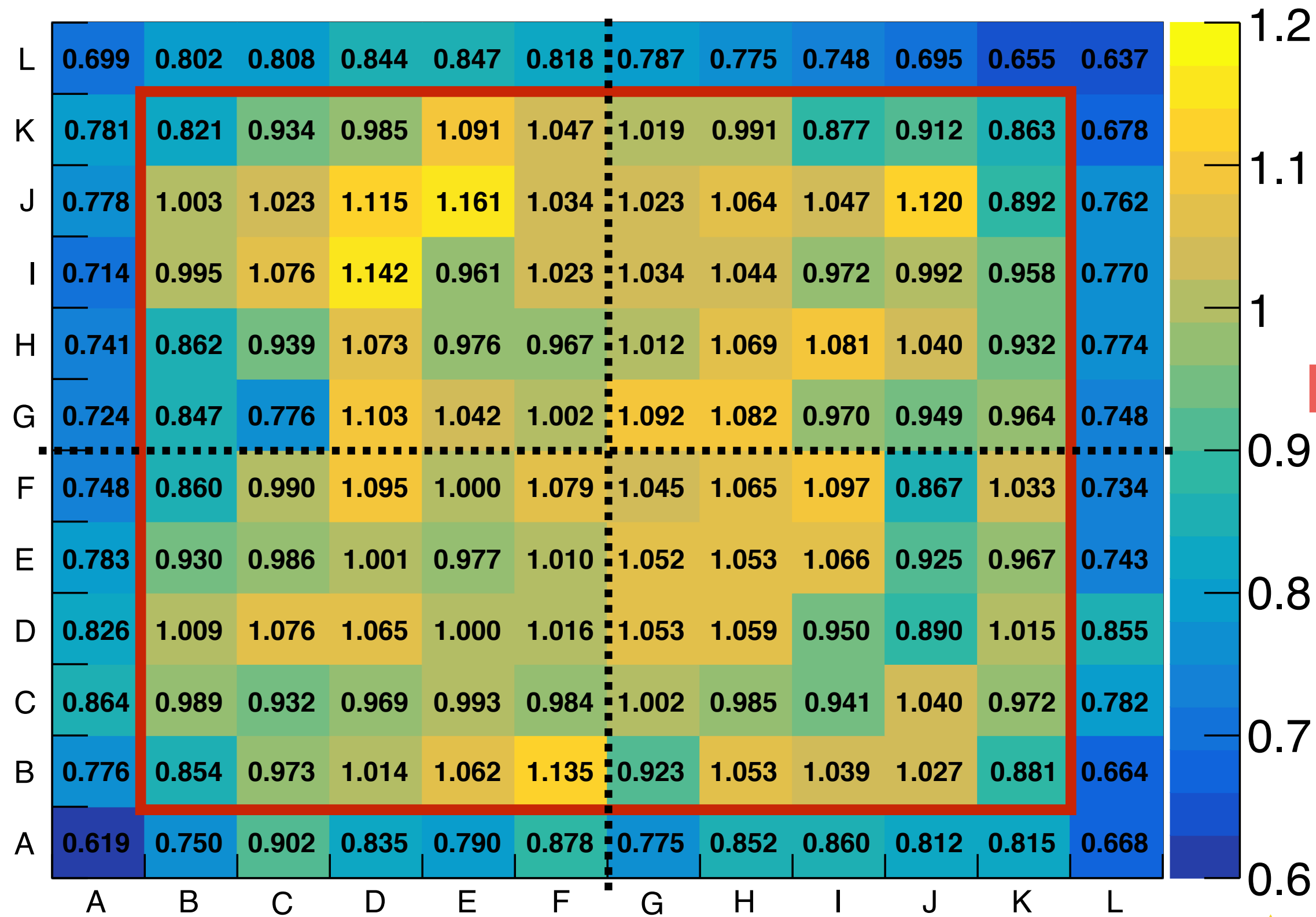


varnished 2

- **Idea: spraying of TiO₂ varnish** on edges.
- **Two** different commercial products **tried over the summer**:
 - First tests in cosmic bench: **results on next slide**.
 - Also tested in August **test-beam @ DESY** (analysis ongoing).

First challenge: low light-yield for edge cells

Ratio LY / <LY in center cells> per quadrant



- Light-Yield result for the same Megatile, **before** and **after varnishing** the edges of the top and bottom-right quarter (different varnishing products).

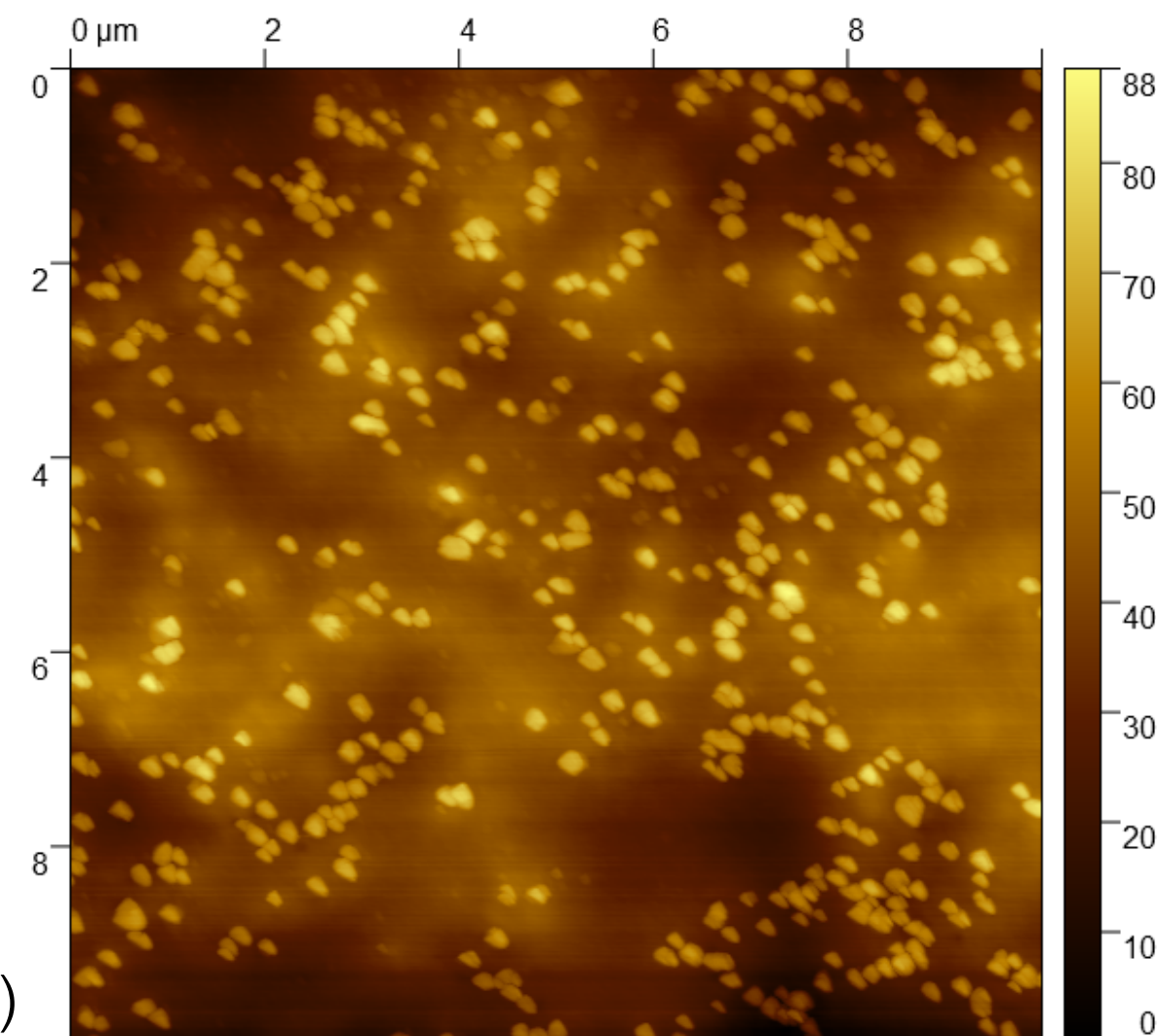


- Improvements on light-yield:**
 - 15-25% for edges
 - 35% for corner
 - uniformity within 10% of central cells!

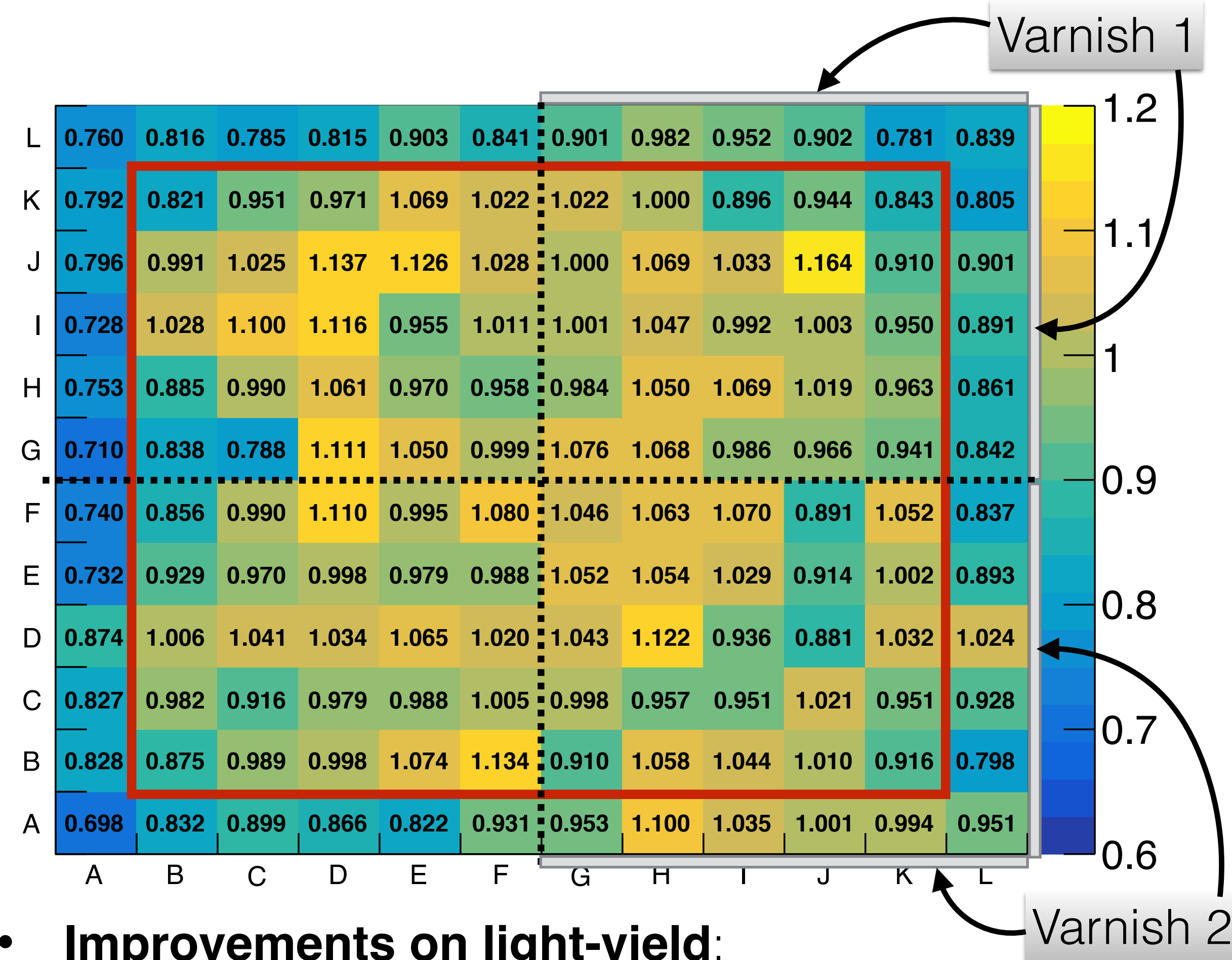
First challenge: low light-yield for edge cells

- Qualitatively **similar results**:
 - $\langle \text{Varnish 1} \rangle$: $0.73 \pm 0.05 \rightarrow 0.88 \pm 0.06$
 - $\langle \text{Varnish 2} \rangle$: $0.77 \pm 0.07 \rightarrow 0.96 \pm 0.09$
- **Second varnish** used in for all edges of prototype under **test in August test-beam**
- Varnishes ongoing **microscope study**:

TiO₂ granulate:
grain size impacts
absorption/reflectivity



AFM picture of TiO₂ glue
M. Jourdan & S. Prakash (KOMET Mainz)



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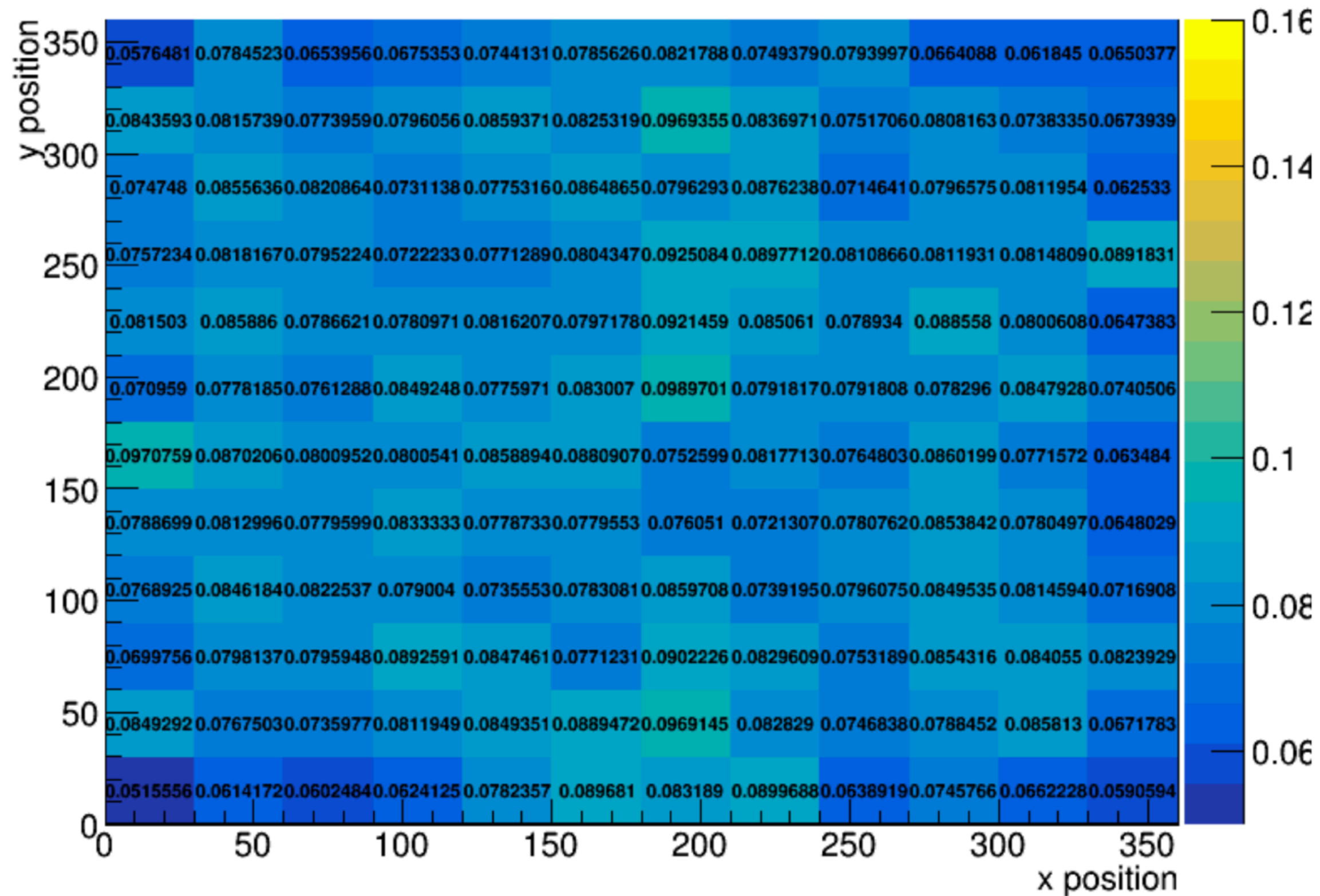
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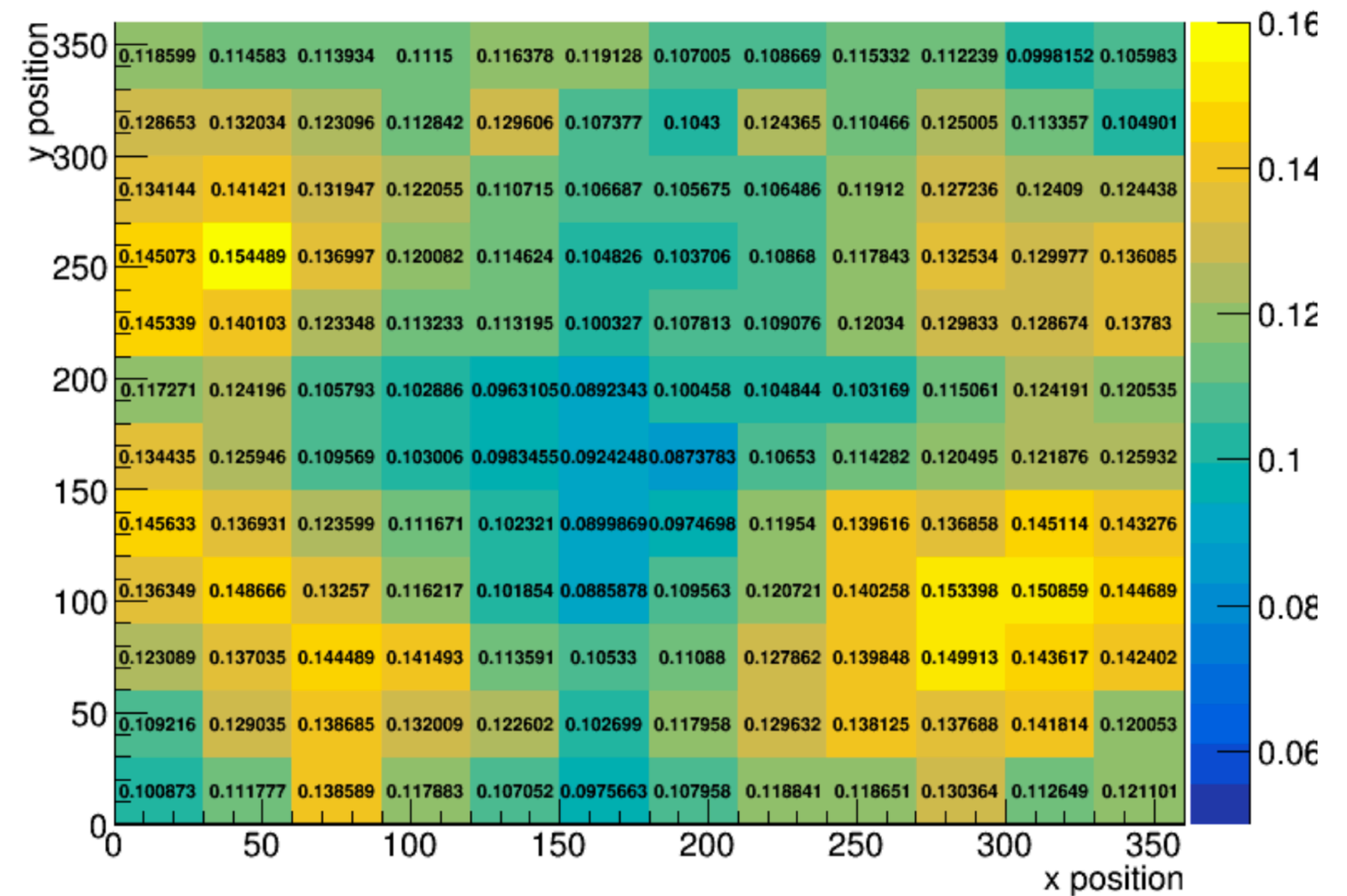
Air gap

Second challenge: TB/Cosmics X-talk difference

Cross-talk in **cosmic stand**



Cross-talk in **test beam**



- Cosmics:

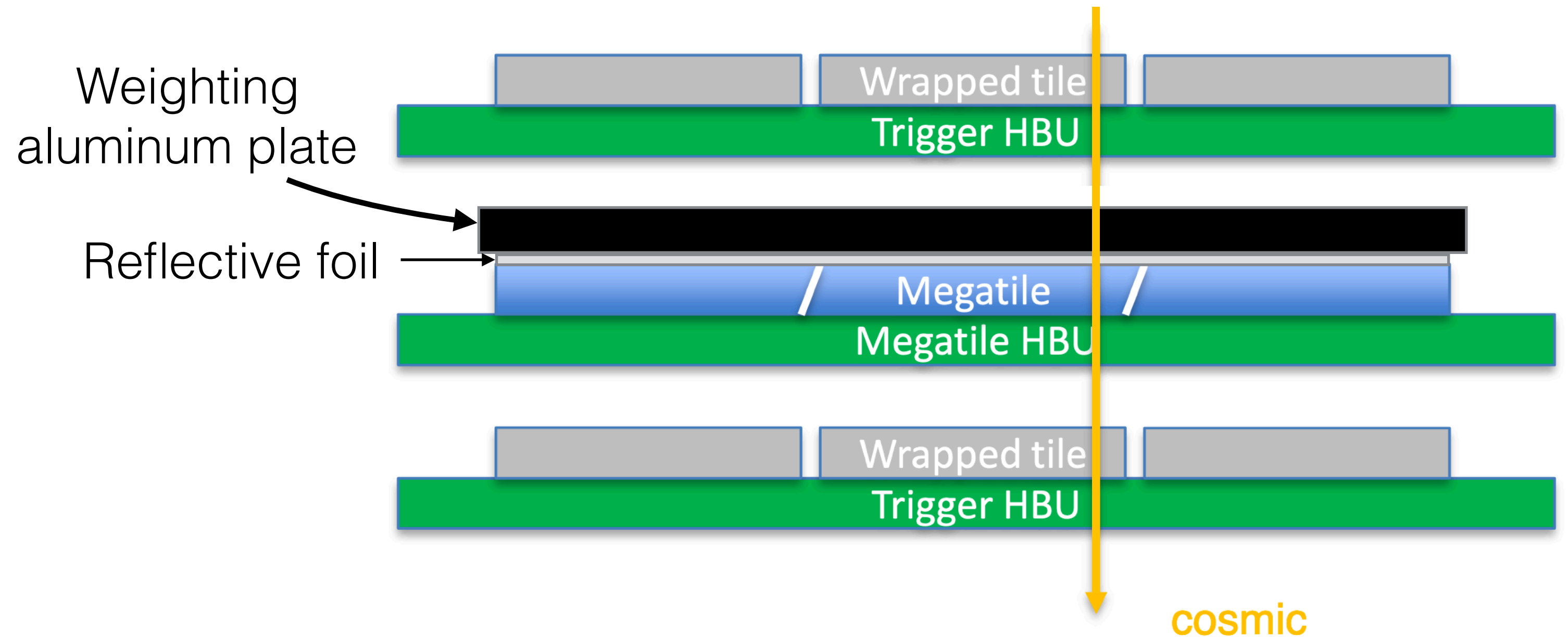
- **< ~7.5%, as expected**
- **Uniform**

Here using older prototype, better with newer

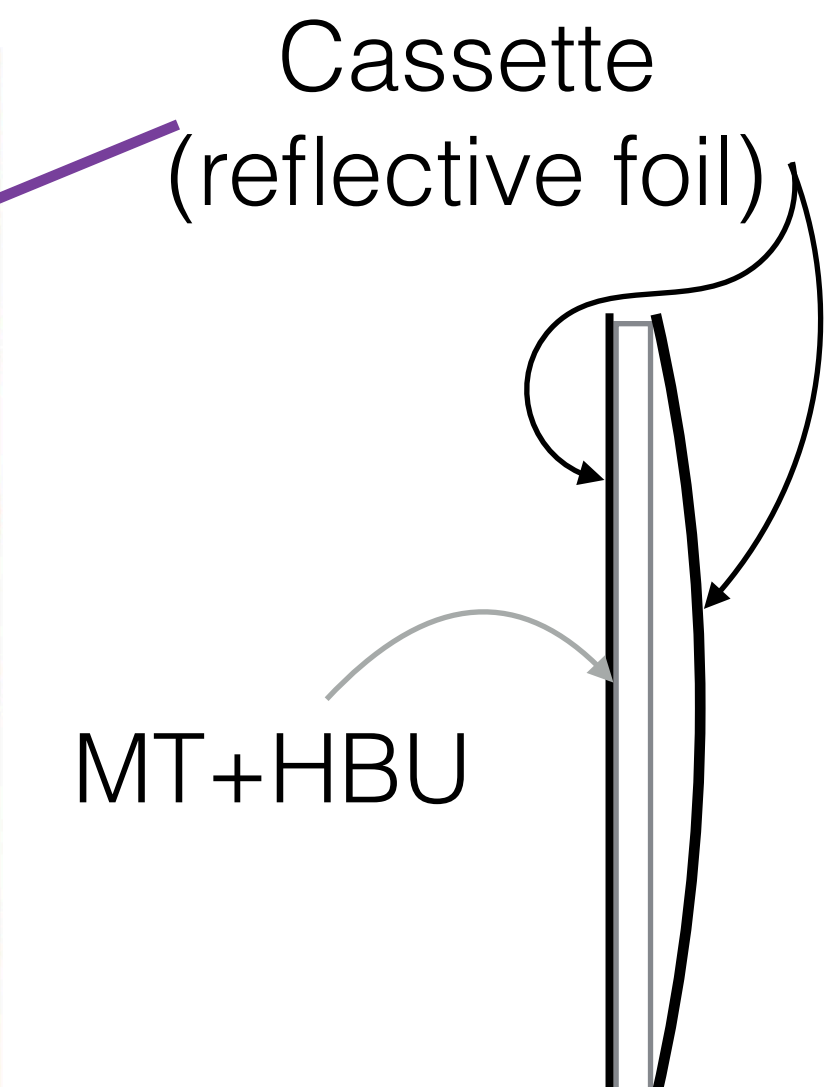
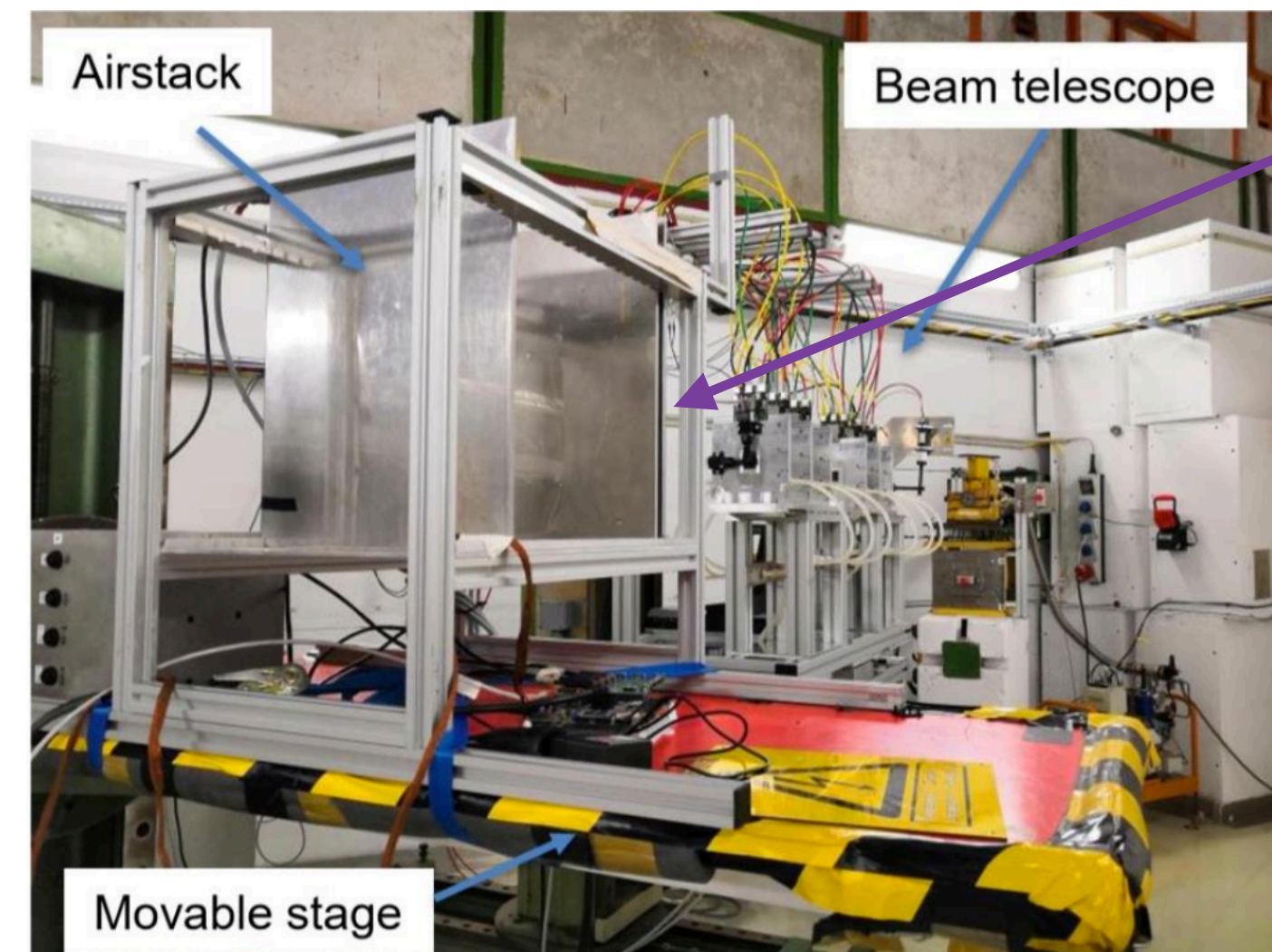
- Test beam:

- **Up to 15%**
- **Large variations**

Second challenge: TB/Cosmics X-talk difference



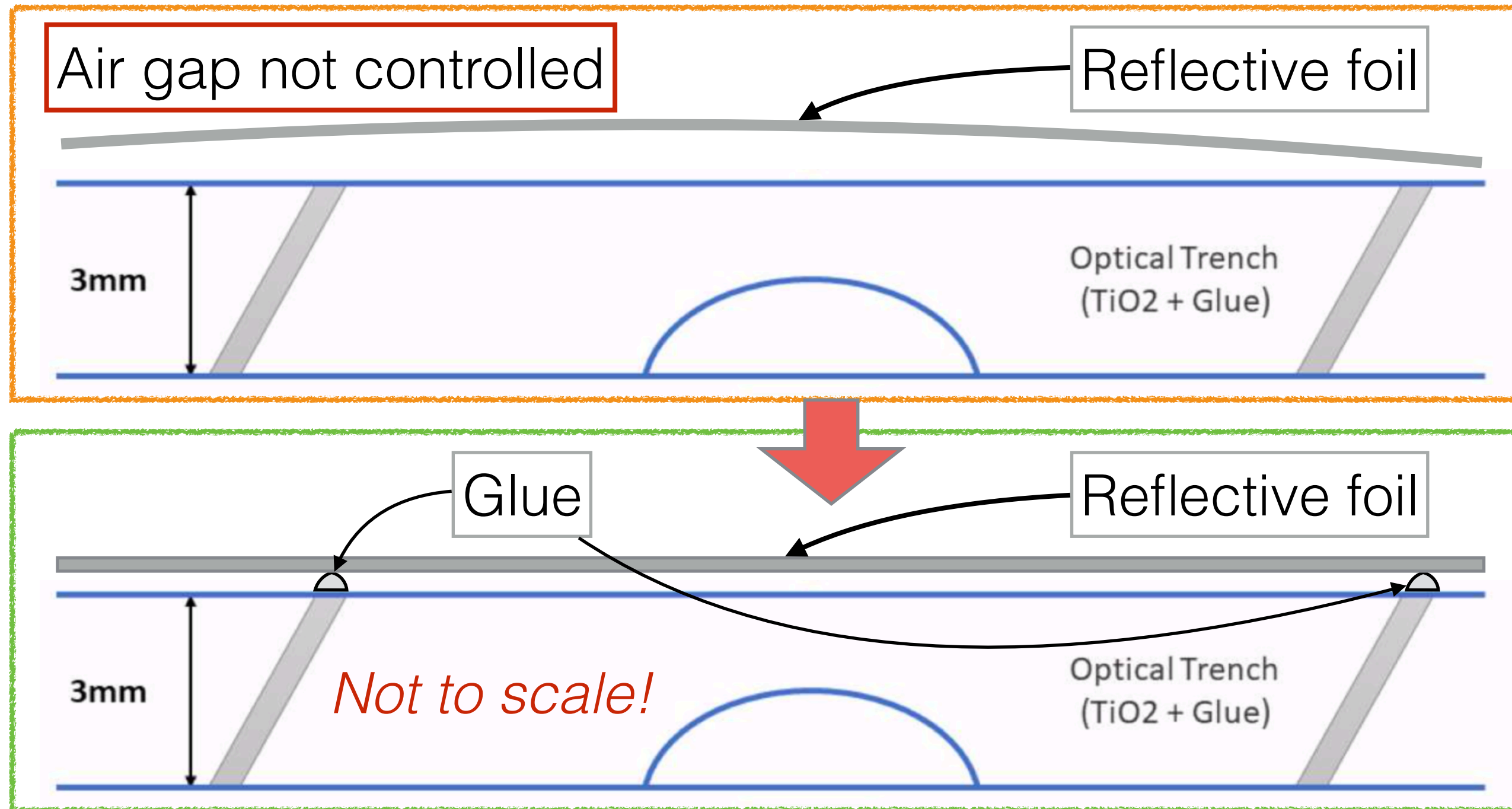
- **Due to air gap:**
 - Cosmics bench setup is vertical.
 - Test beam is horizontal.
- **Currently, air gap size is not controlled.**



Second challenge: TB/Cosmics X-talk difference



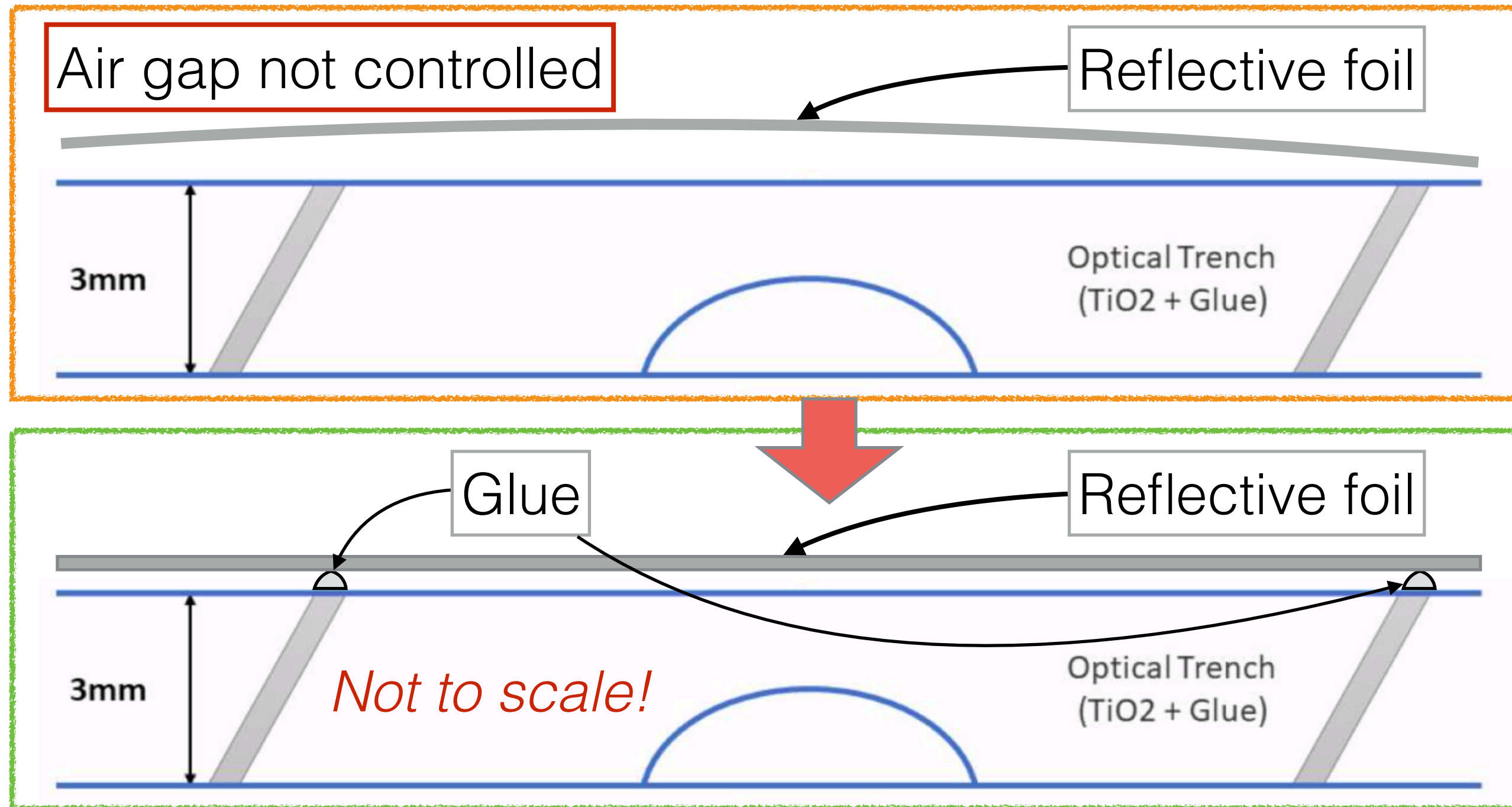
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- Tested on dummy, then applied on prototype #6.
- **Tested in TB in August: data analysis ongoing.**
- Mechanical design being improved.

Conclusion

Promising concept: improves mass production

- **Light yield as good as wrapped single tile.**
- **Reasonable cross-talk.**

Conclusion

Promising concept: improves mass production

- Light yield as good as wrapped single tile.
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Expected last two main challenges: solutions under validation

Light yield in edge cells

- Gluing reflective foil is not enough.
- **Solution: varnish with TiO₂ mixture.**
- **Promising results from cosmics data!**
- **Analysis of test-beam data ongoing!**

Air gap

- Lack of control in vertical position
- **Solution: foil gluing** directly on megatile.
- Technical issues almost solved.
- **Analysis of test-beam data ongoing!**

Ongoing and future work

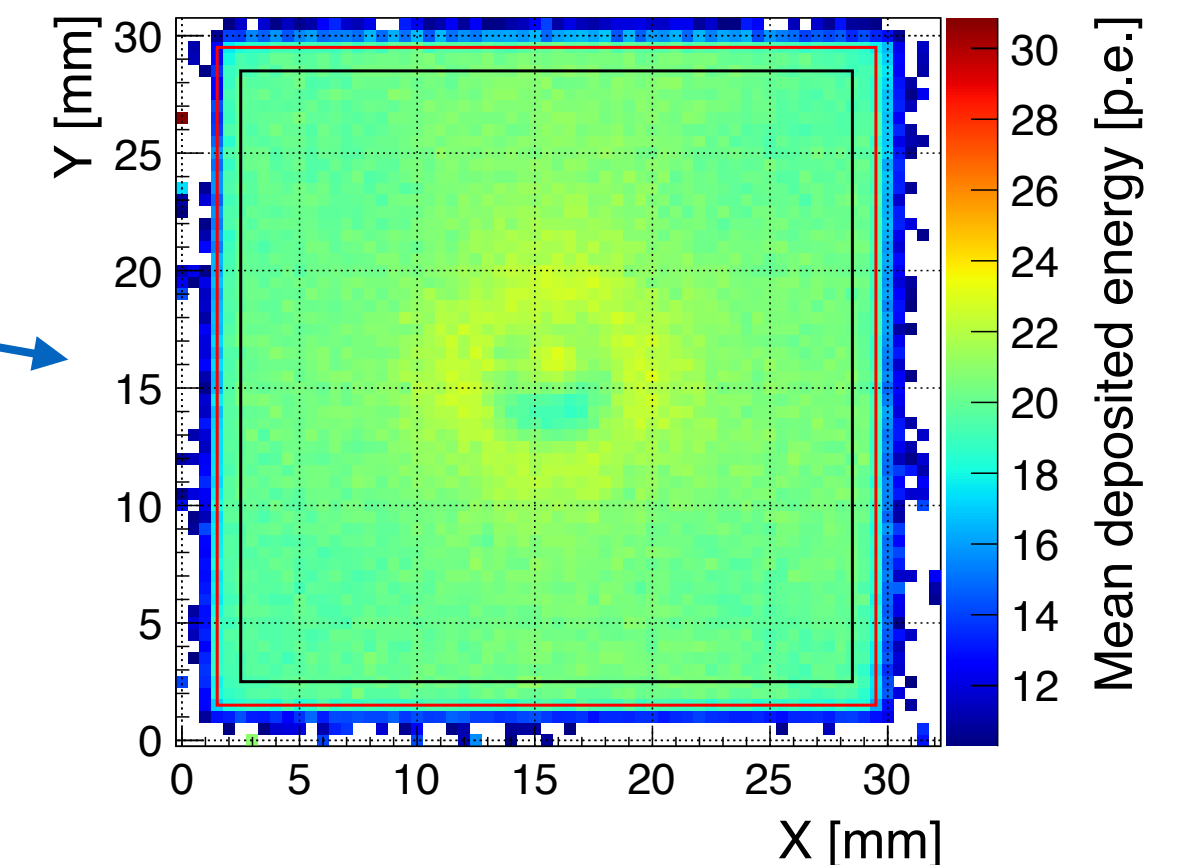
- **Prototype #6** with **edge coating** and **reflective foil gluing** test-beam in August @ DESY:
 - Analysis ongoing...
 - **Check light-yield improvement on edges** (all edges varnished).
 - **Check cross-talk difference with cosmics** (foil gluing).
 - Check **tile response uniformity** (successful telescope data taking).

- **Prototype #7 being prepared** for test-beam in October @ DESY:
 - **Choice for edge coating under study**.
 - **Try foil gluing on both sides**.
 - **Better mechanical realisation** than #6.

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Single tile uniformity



Reproduce in TB
what is done @ MPP-Munich