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

BMBF scintillator R&D general meeting - 06/07/2020

CALICE Calorimeter for ILC

Bundesministerium für Bildung und Forschung

PRISMA+ DETECTOR LAB

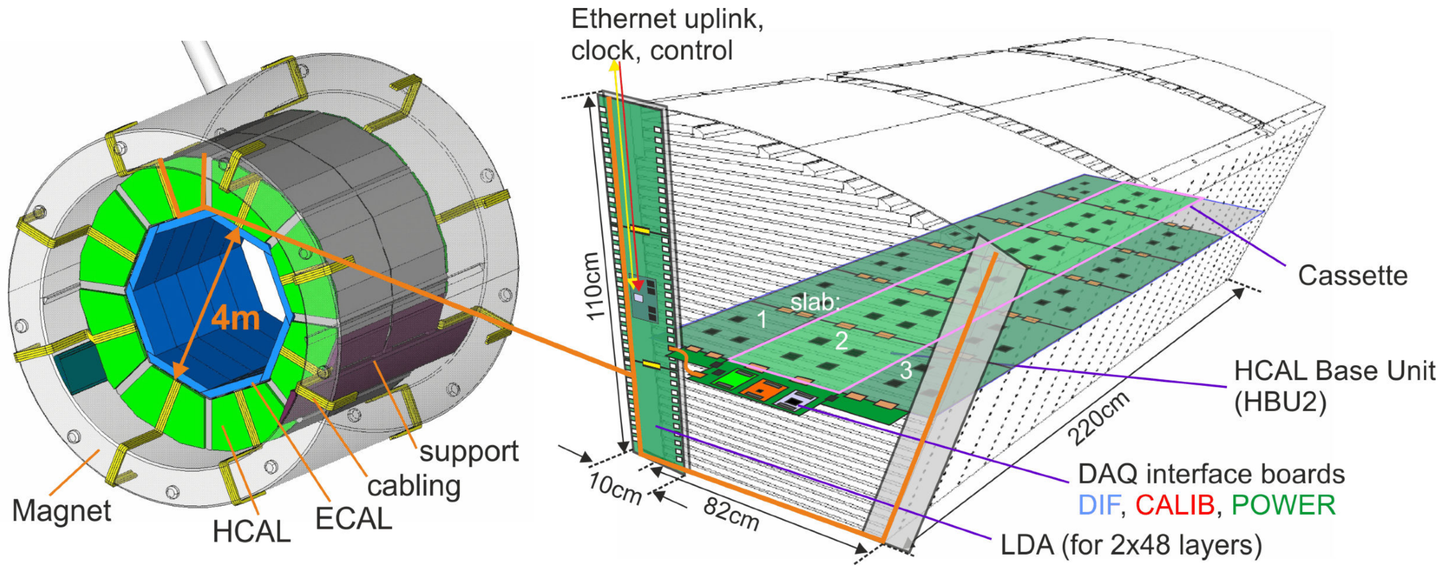
JOHANNES GUTENBERG UNIVERSITÄT MAINZ

JG|U

Reminder: current “standard” AHCAL

International
Linear
Detector

Analogue
Hadronic
CALorimeter



arxiv:1701.02232

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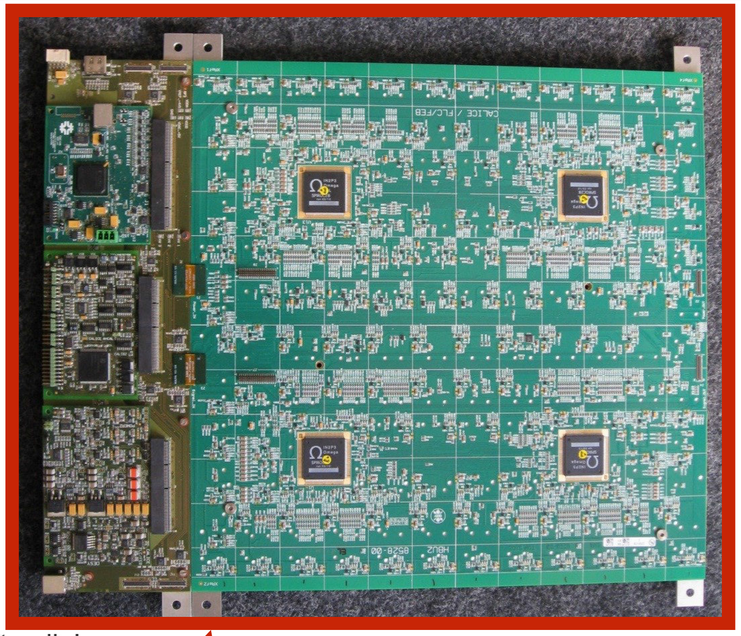
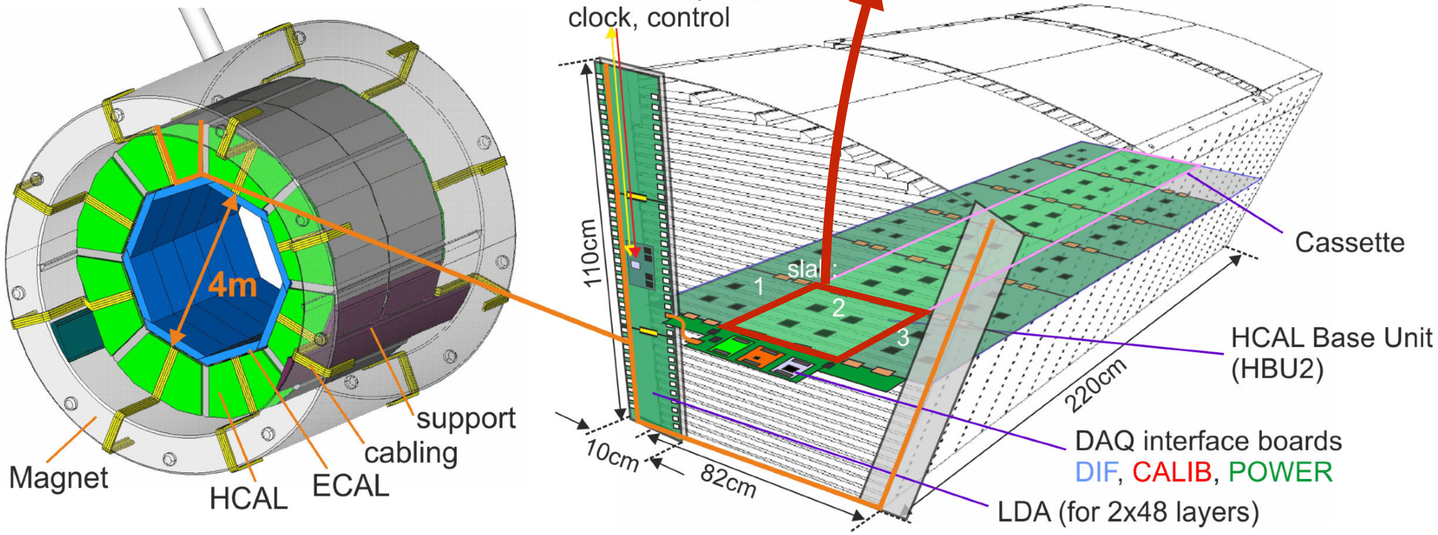


- 1 HBU (HCal Board Unit)
- 36x36 cm2



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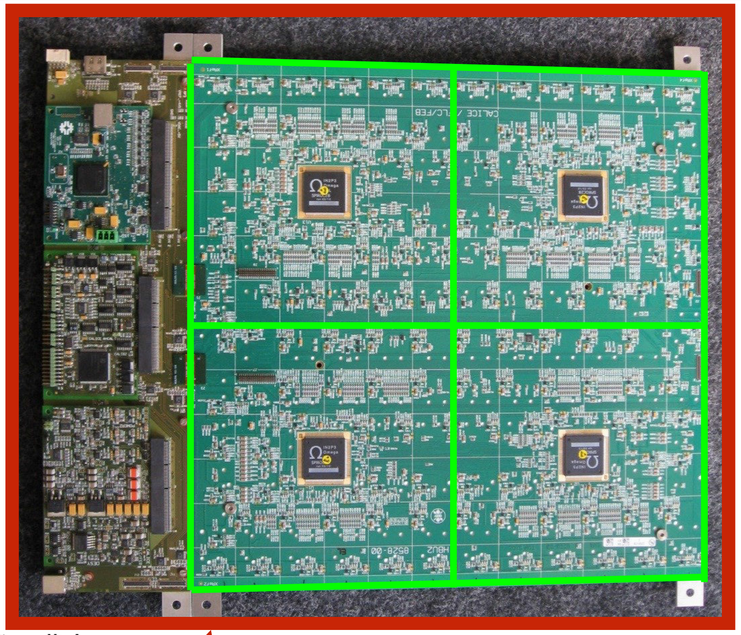

- 1 HBU (HCal Board Unit)
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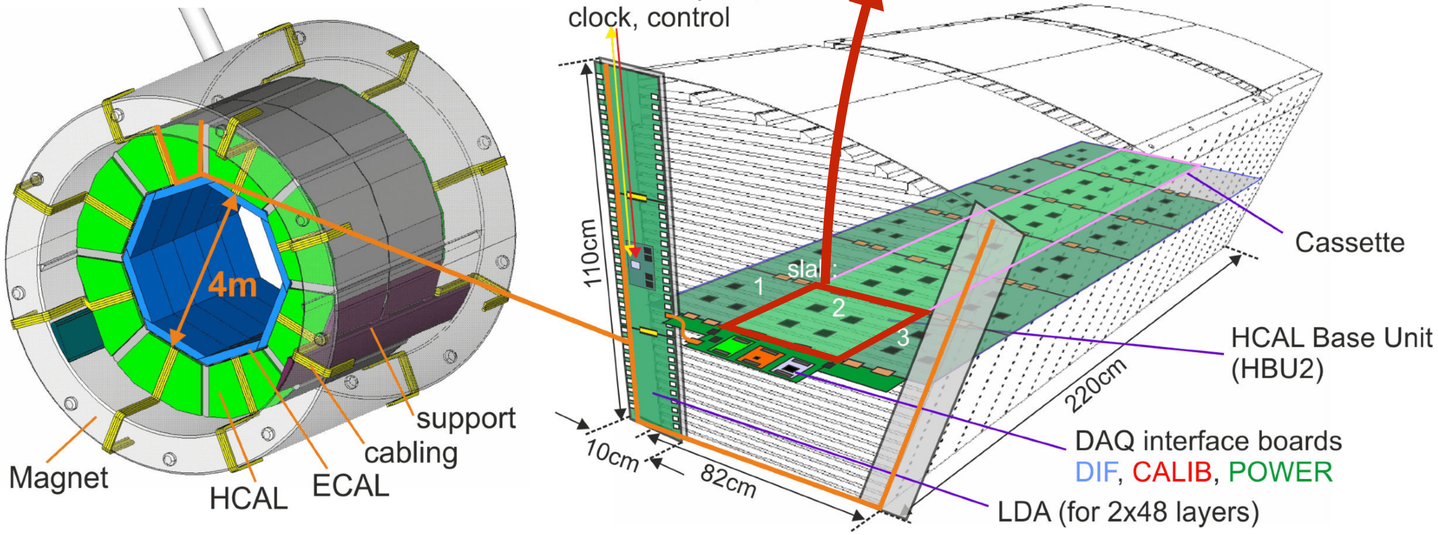
- 4 chips (ASIC) / HBU



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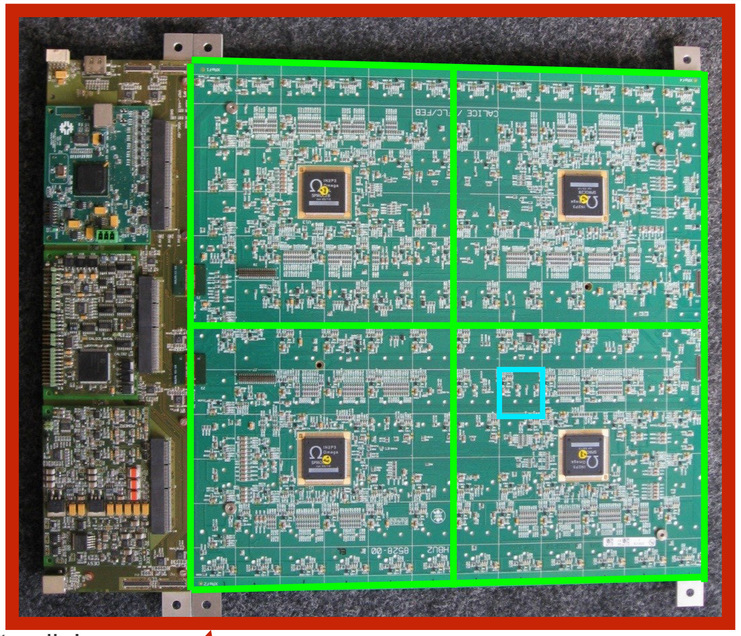
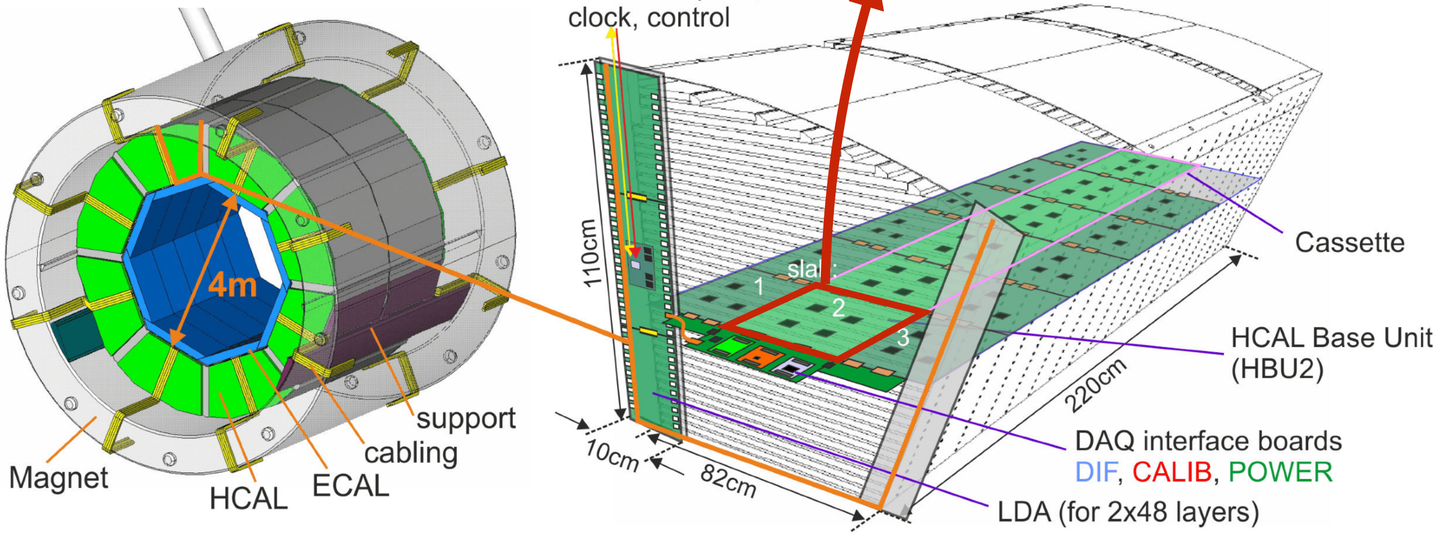


- 1 HBU (HCal Board Unit)
  - 36x36 cm2
- 4 chips (ASIC) / HBU
- 36 channels / ASIC
- 1 channel =
  - 1 tile (30x30 mm2)
  - 1 SiPM (other side)



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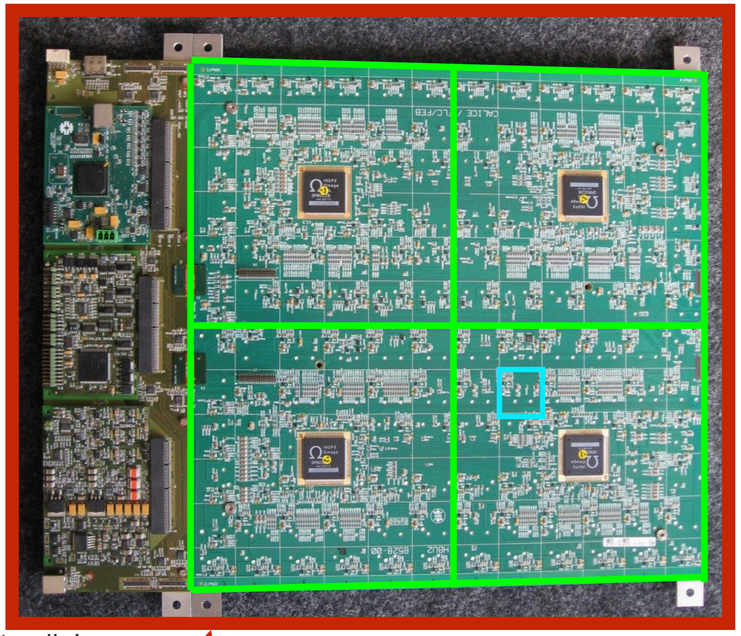

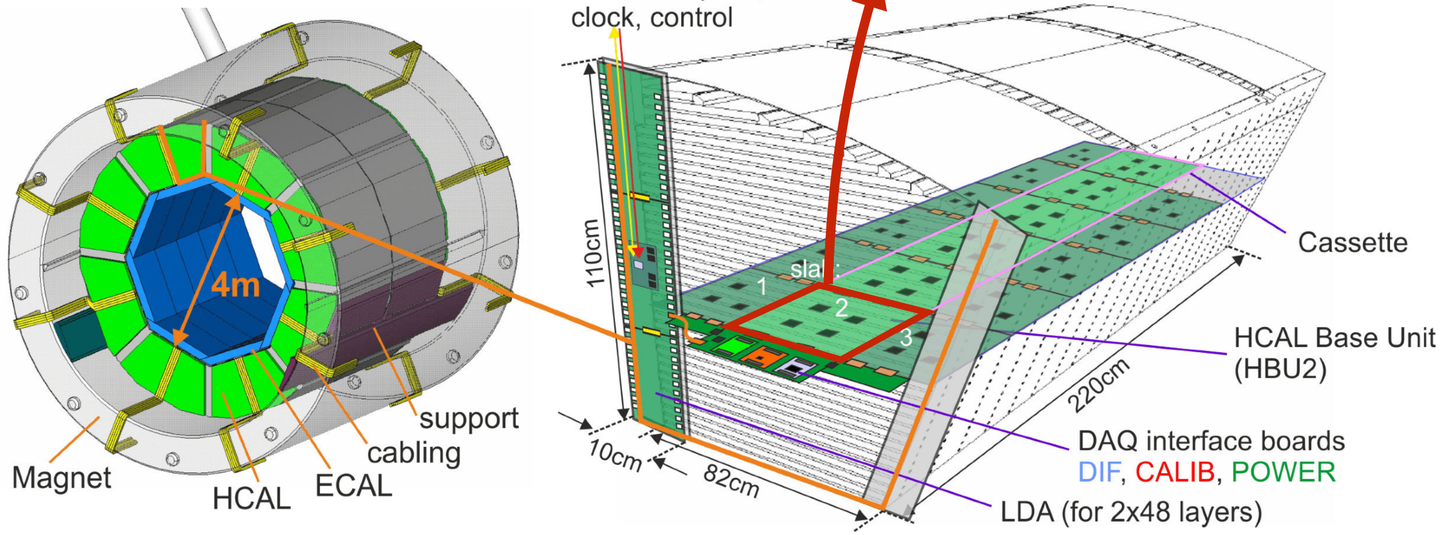

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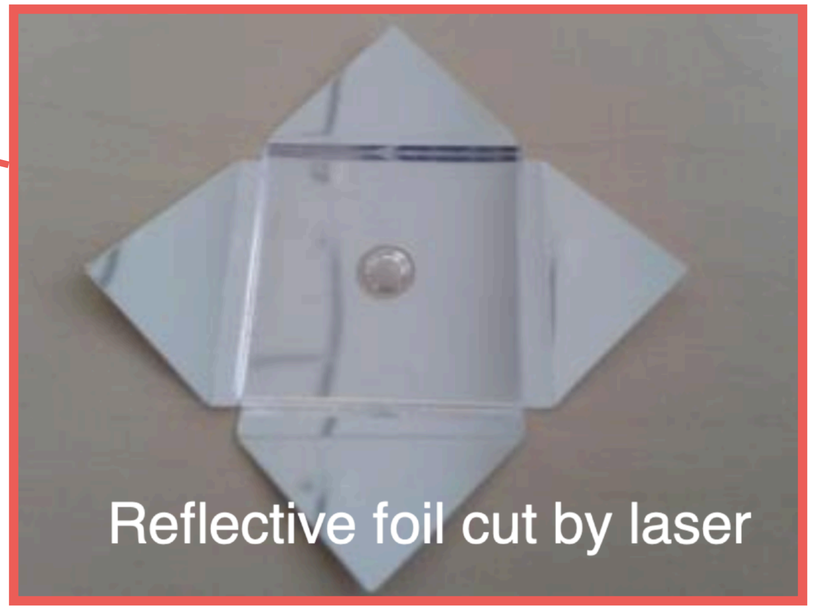
- -> 1 HBU = 144 individual tiles

arxiv:1701.02232

Reminder: current “standard” AHCAL

- Each single tile must be wrapped in reflective foil.



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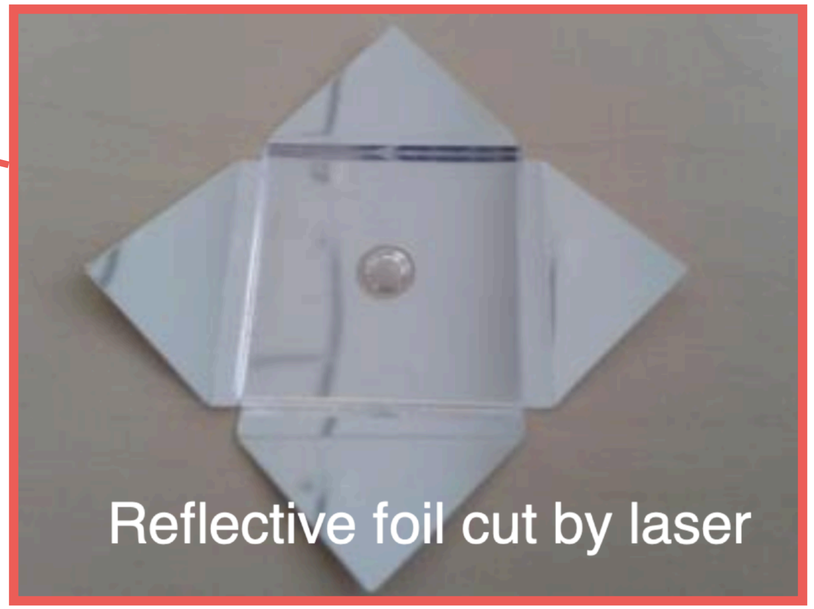
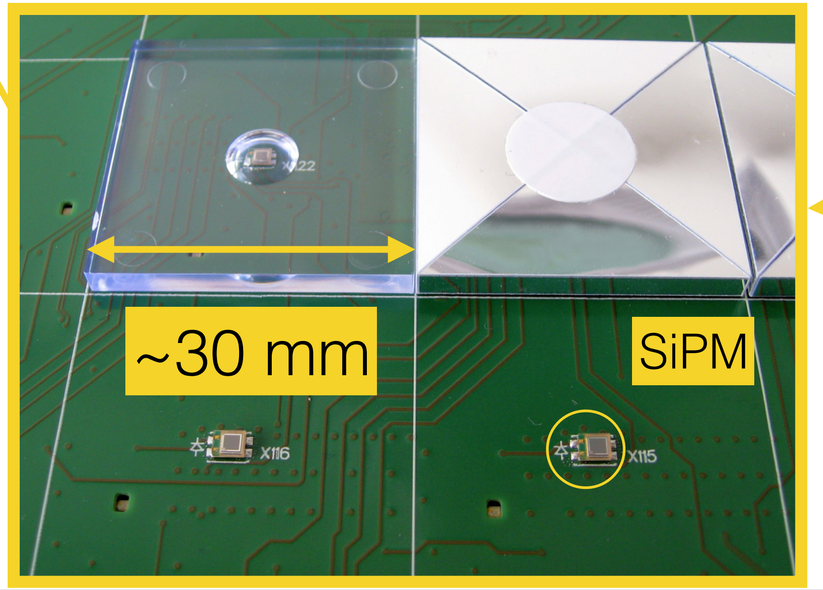
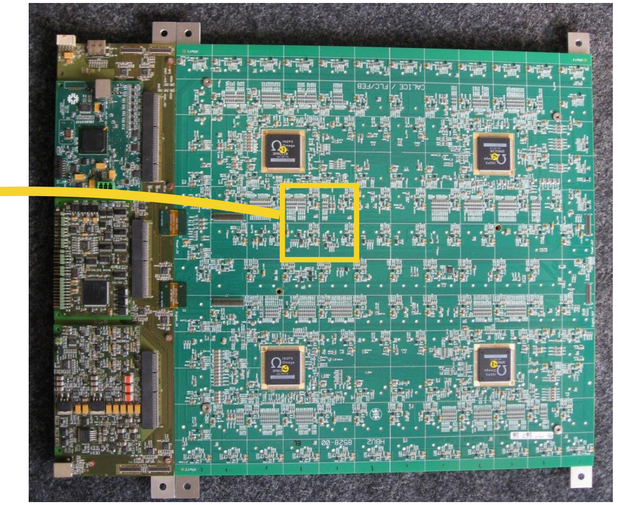




(Other side)



Reminder: current “standard” AHCAL

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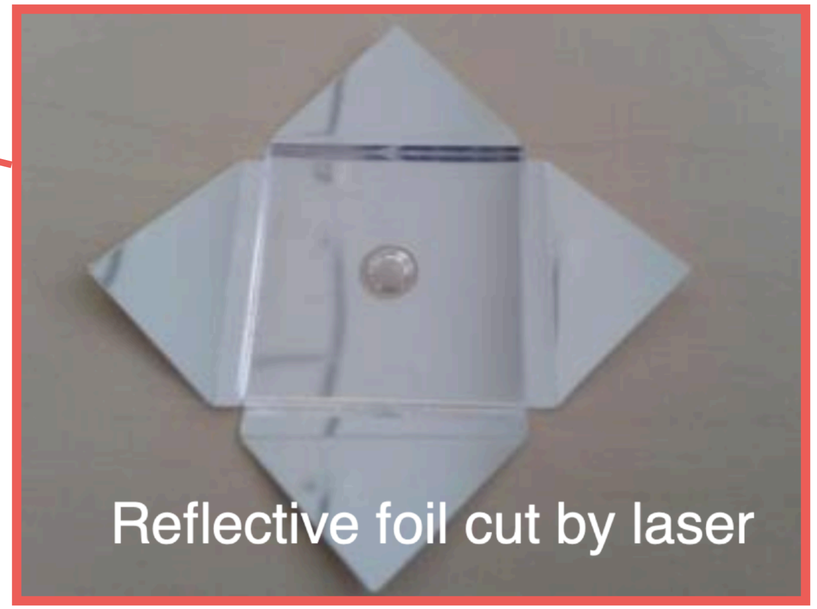
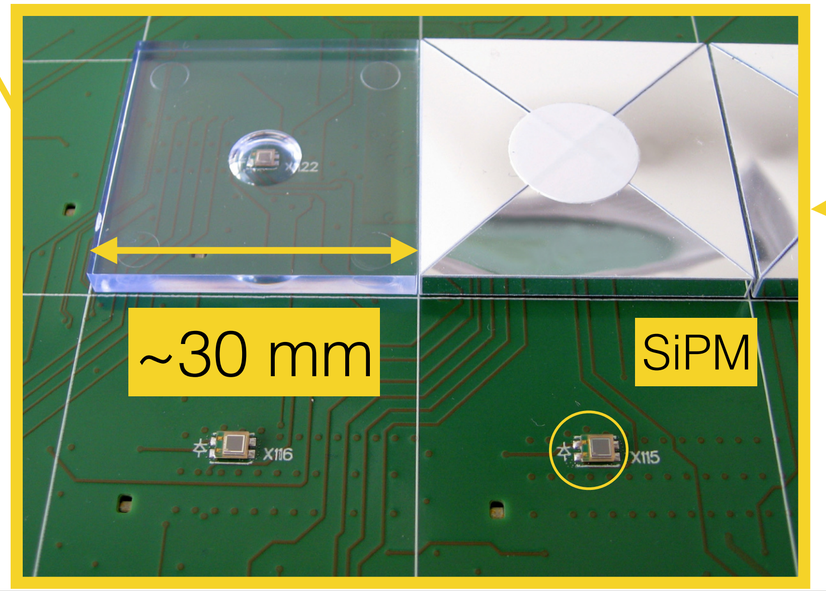
- Each tile must be placed individually on the HBU.

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





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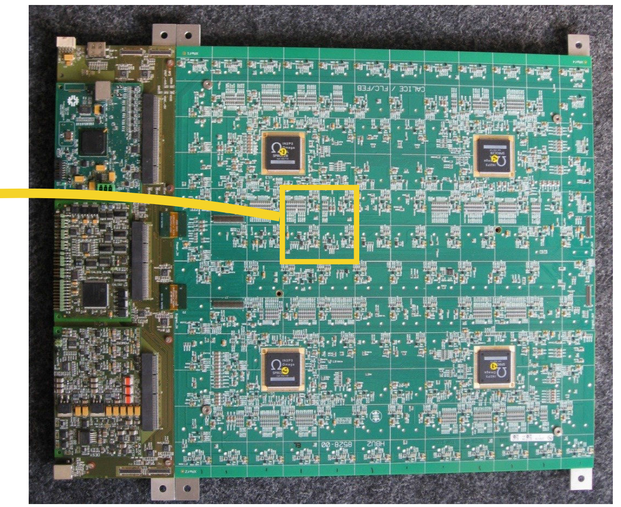

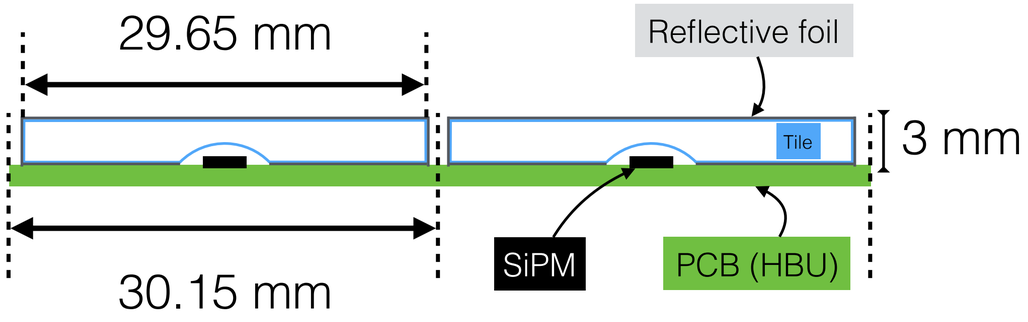

Megatile concept

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

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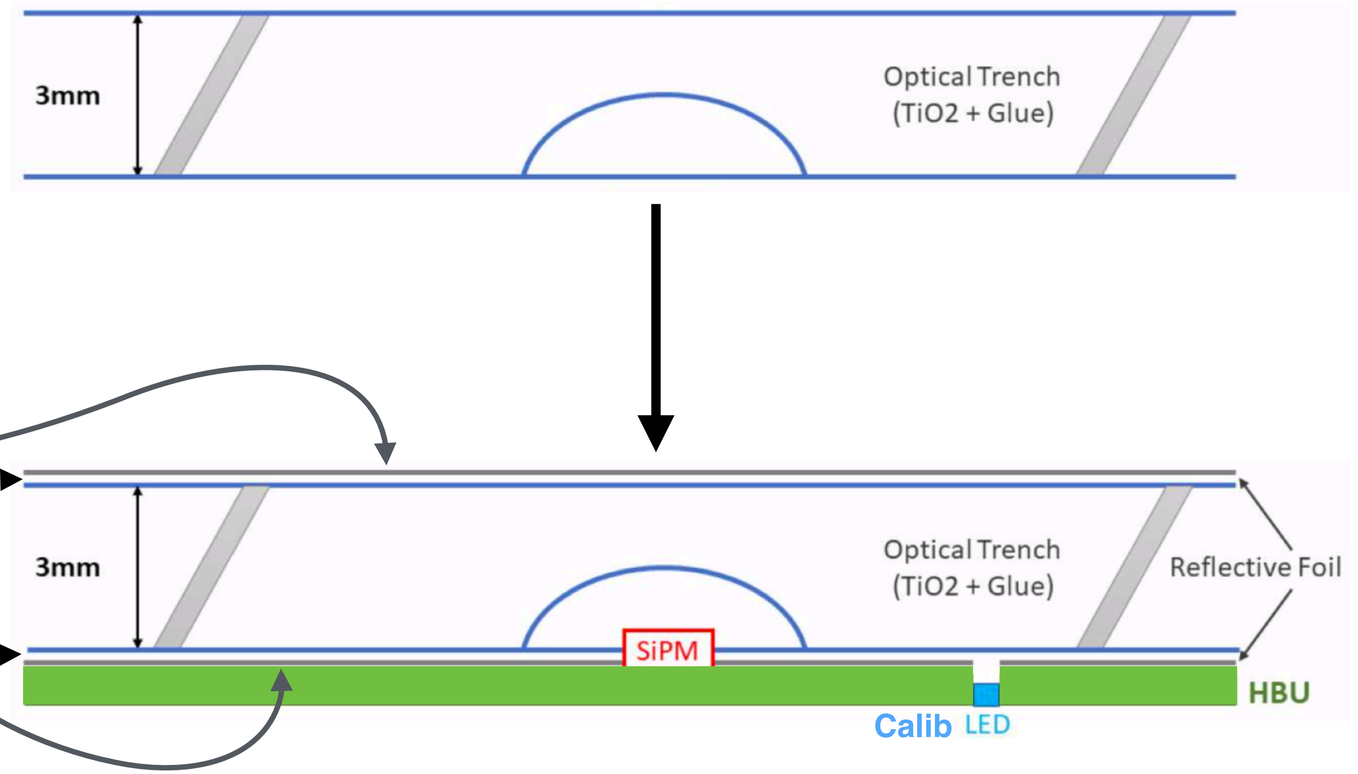

- Put large **reflective foil sheet** directly on HBU (with laser-cut holes for SiPM)
- **Air gap** (30-100 µm) to ensure total reflection.

- <u>No change to SiPM:</u>
  - Same HBU
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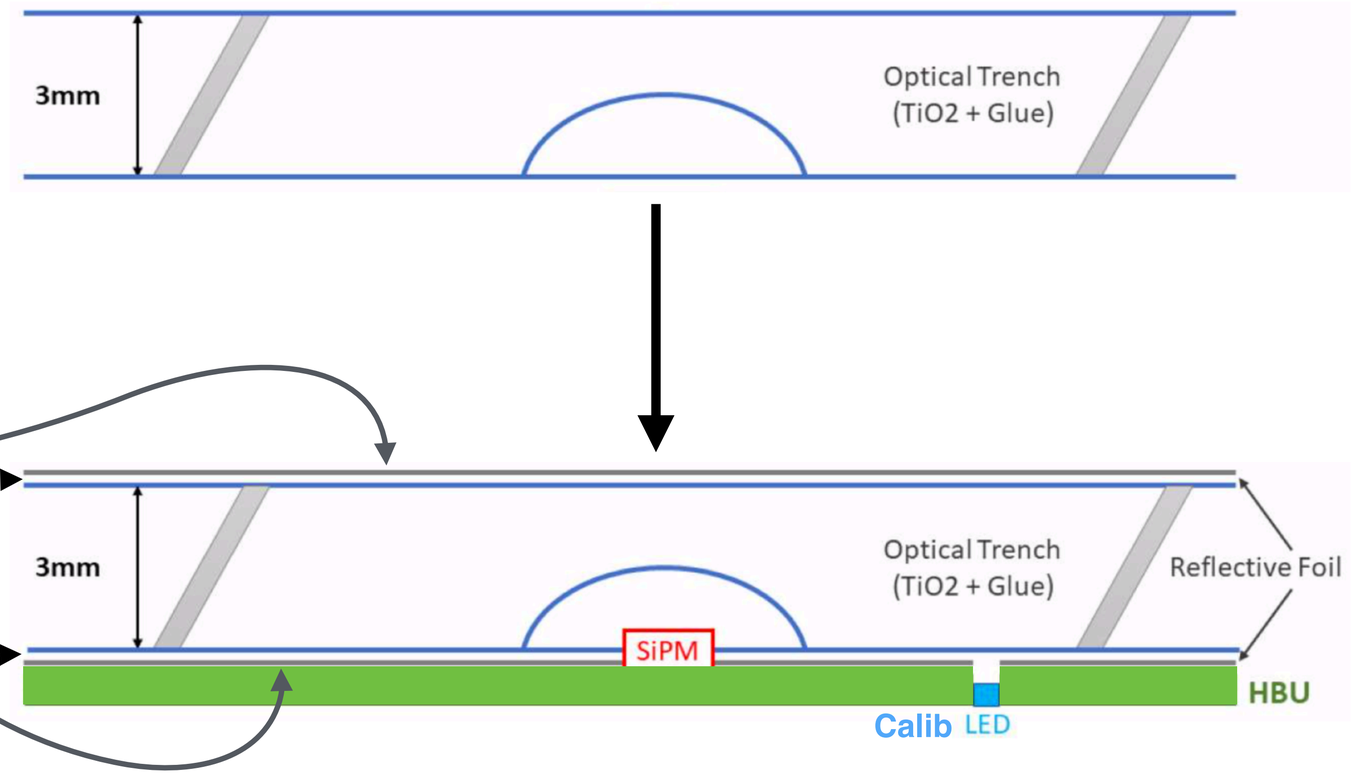

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- 👍 ~ **No dead area**!
- 👍 **Easier assembly**.

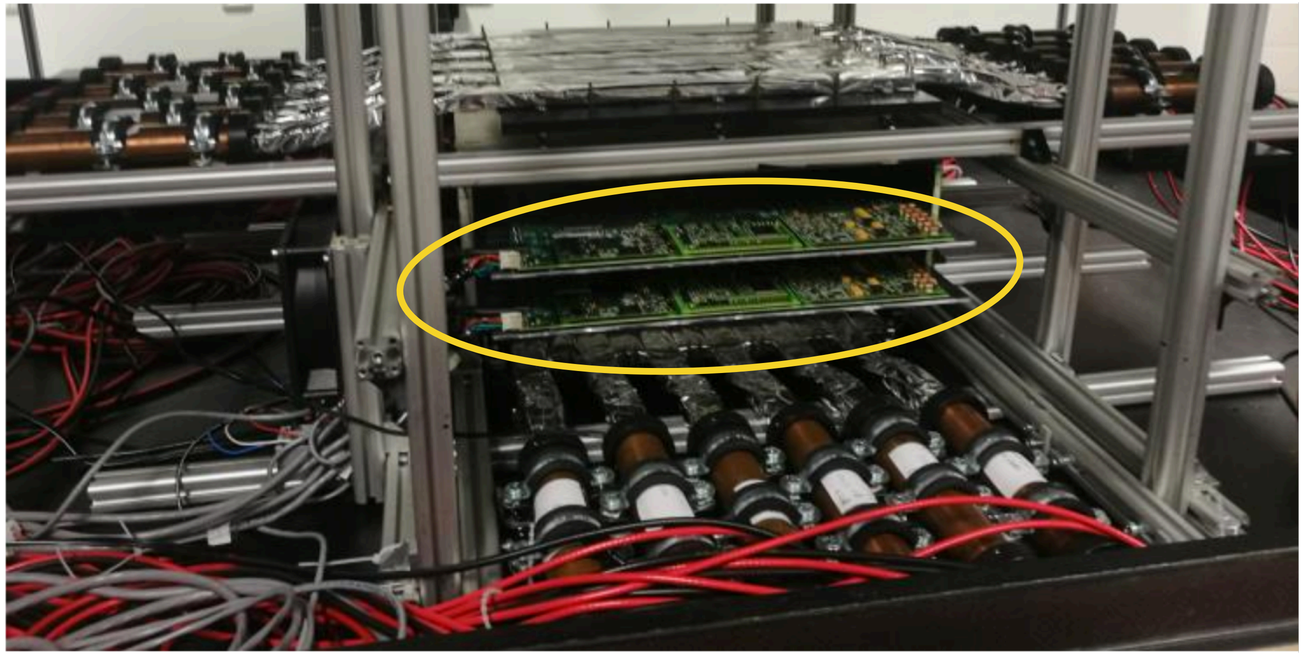
- <u>No change to SiPM:</u>
  - Same HBU
  - Same electronics boards
  - Same readout

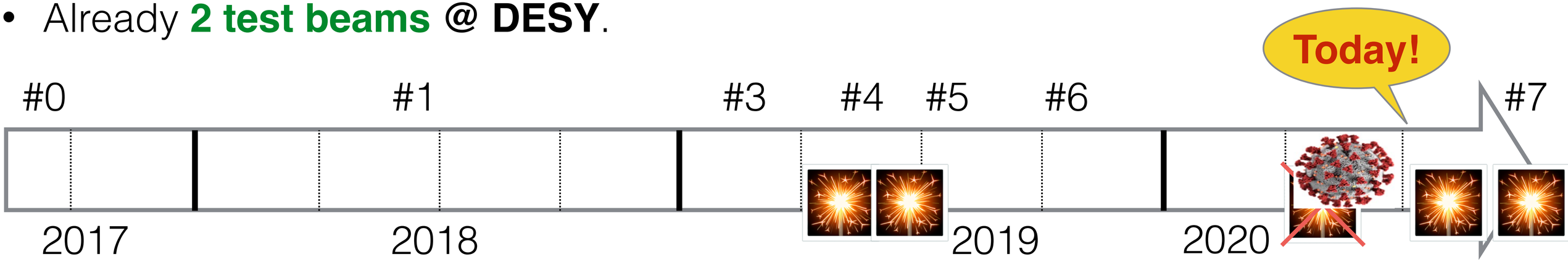
The Megatile experience

- **Project started in 2017**.
- **Already 6 prototypes built** with **continuous improvement**.
- Only current status presented here, not the evolution.

- **Continuously tested** in **cosmic test stand @ Mainz**.
- Already **2 test beams** @ **DESY**.

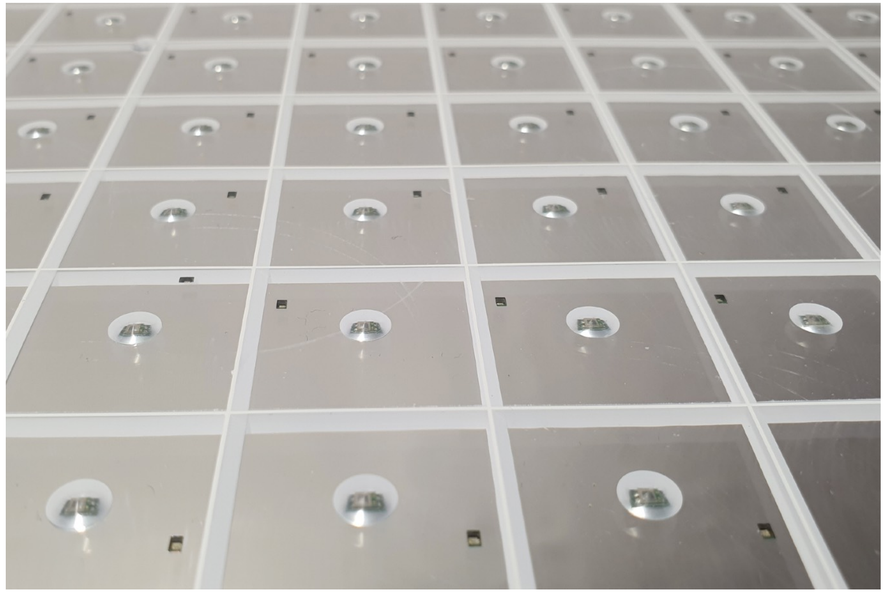
Cosmic test stand @ Mainz





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, ≈ as single tile** 👍
- **Glue + TiO2 dependency** (next slide).



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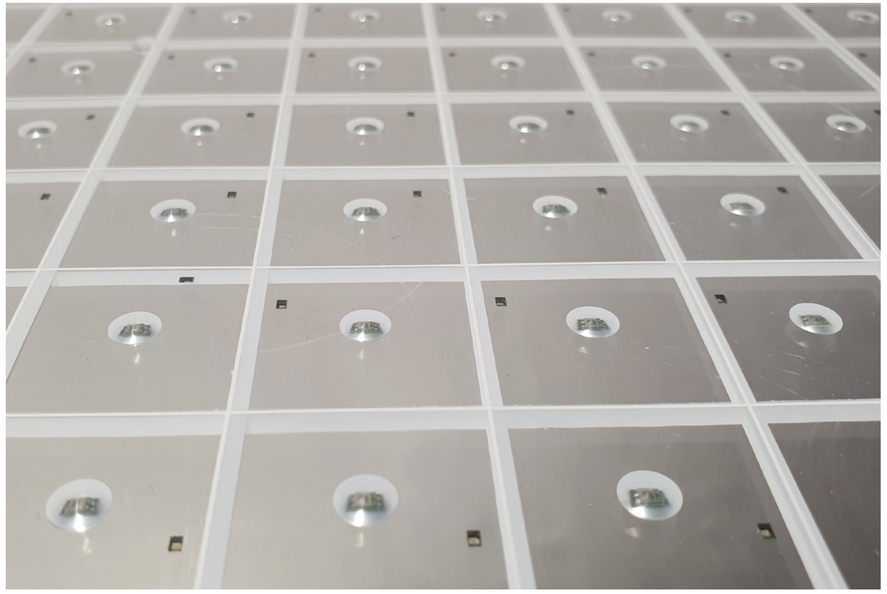
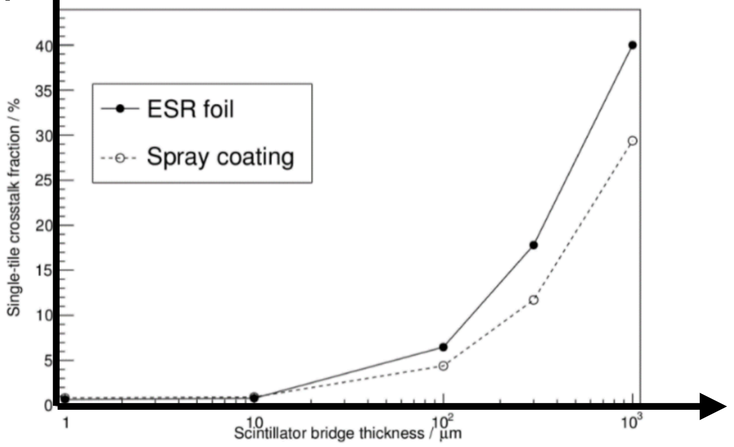
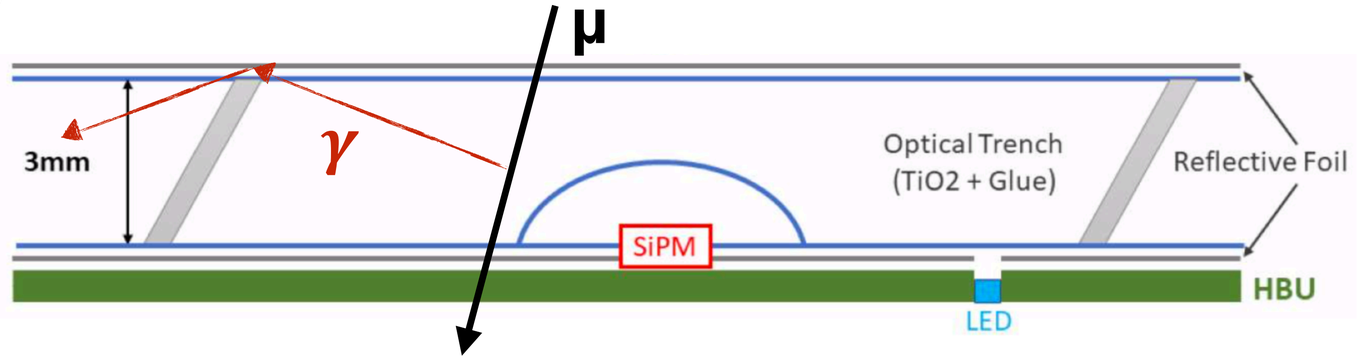


- **Must be careful with air gap**:
  - Too large ⇒ optical cross talk.
  - Simu: **3.5%** for 100µm.

XT

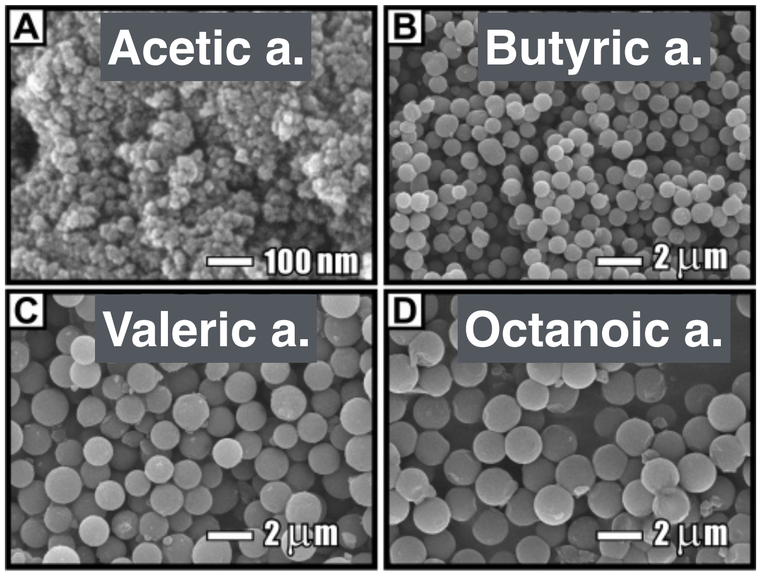


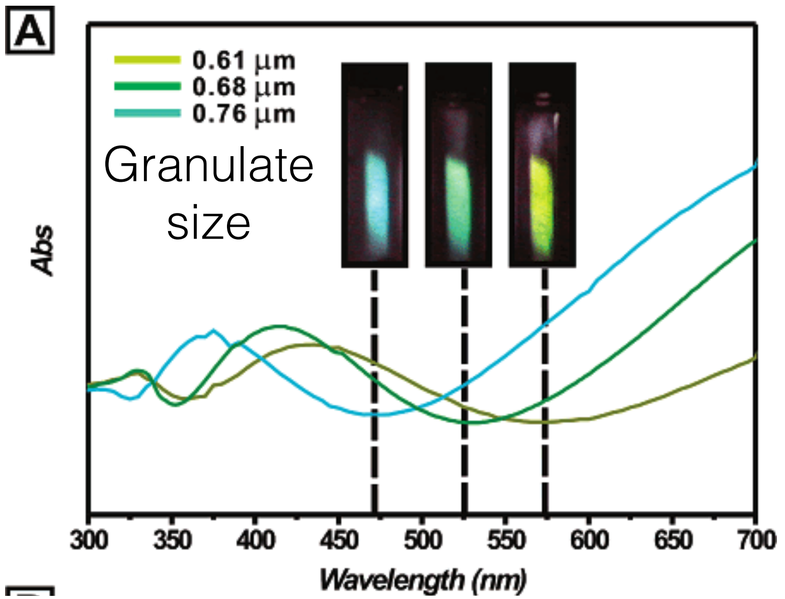
log(gap)



Glue + TiO2 mixture

- **LY depends on** what **Glue+TiO2 mixture** is filled in the trenches:
  - **Size of TiO2 granulates** depend on the solvant.
  - Absorption/reflection vs λ depends on **concentration of granulates in the glue**.





Min Chiao Tsai et al., J. Phys. Chem. C, Vol. 112, No. 7, 2008
Tailor Made Mie Scattering Color Filters Made by Size-Tunable Titanium Dioxide Particles

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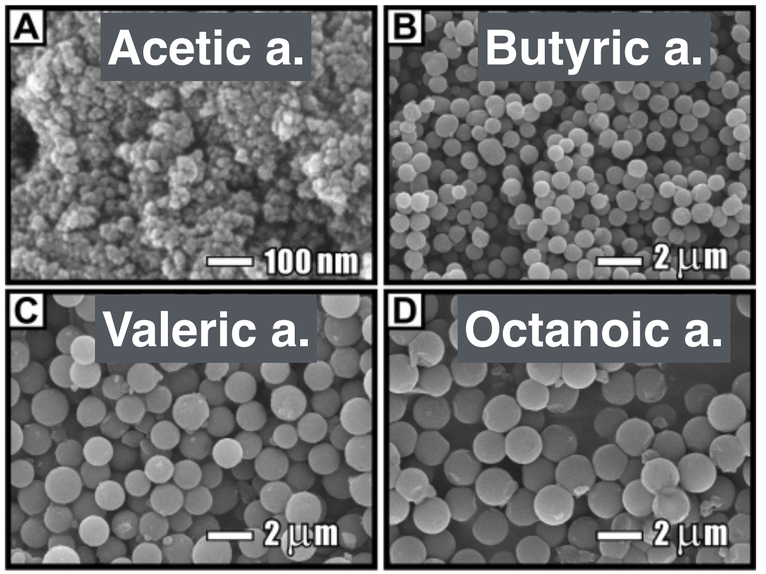
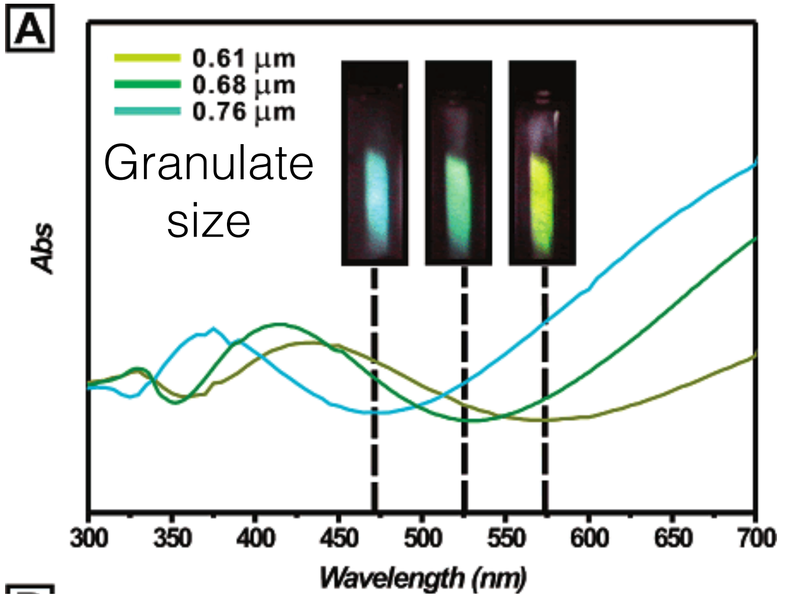


- Trade-off:
  - **Liquid enough** to flow in the trenches.
  - Adequate granularity for **reflection** (⇒ LY).



- **Tested optical properties** of various Glue + TiO2 mixtures @ **Mainz**
- **Improved in newer prototypes** (now good baseline).

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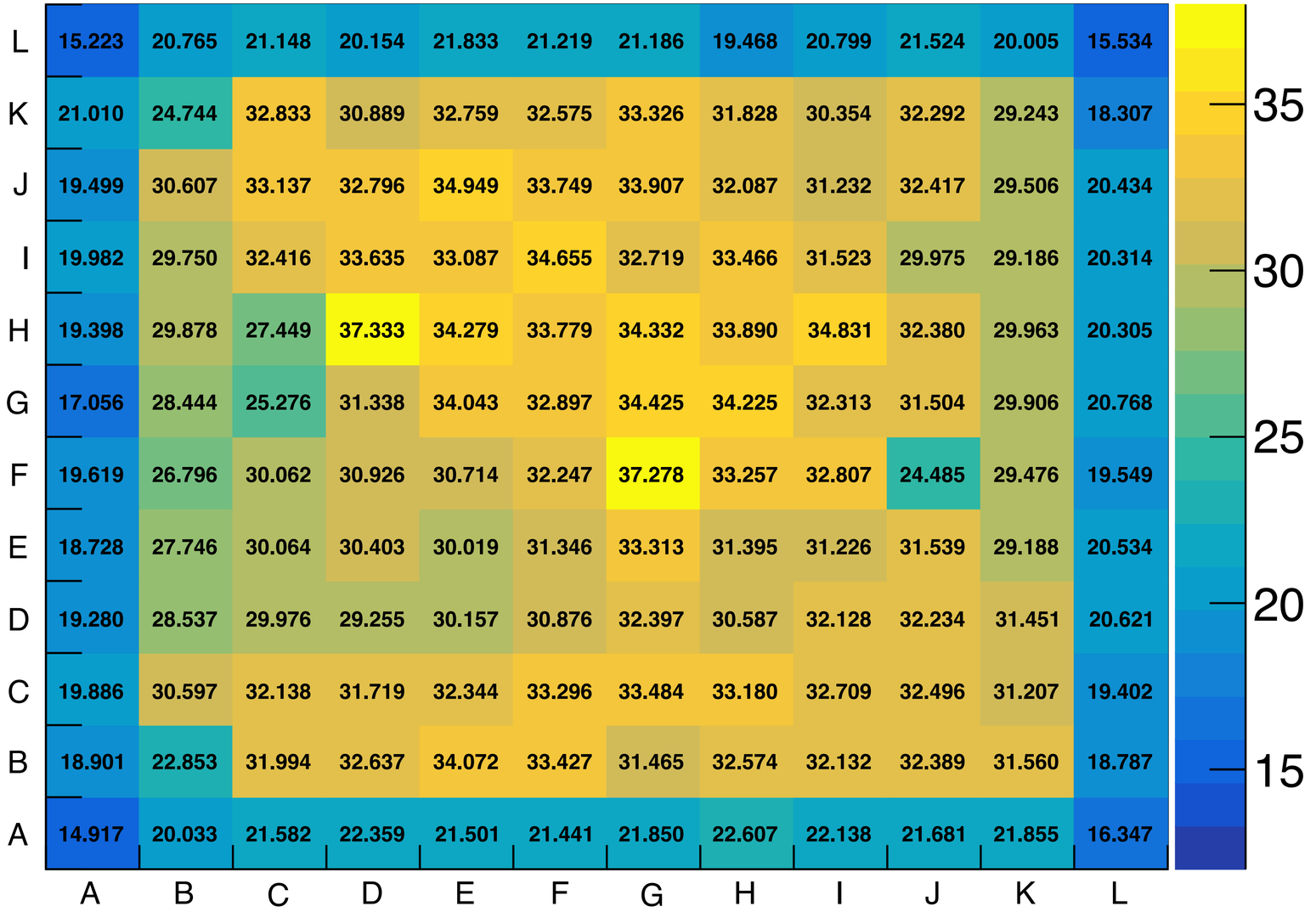
Tailor Made Mie Scattering Color Filters Made by Size-Tunable Titanium Dioxide Particles

Megatile: a promising concept

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

- **Cross-talk**:
  - ≲ **5%**
  - **≠ 0 but OK** 👍

Still…



The Megatile experience

Promising concept

Two main challenges encoutered so far

Edges cells

Air gap

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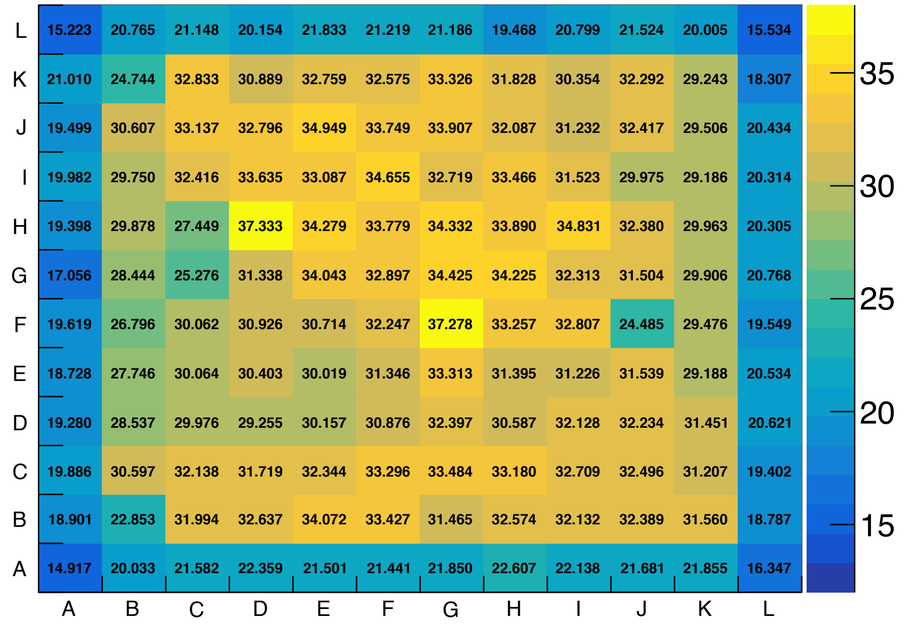
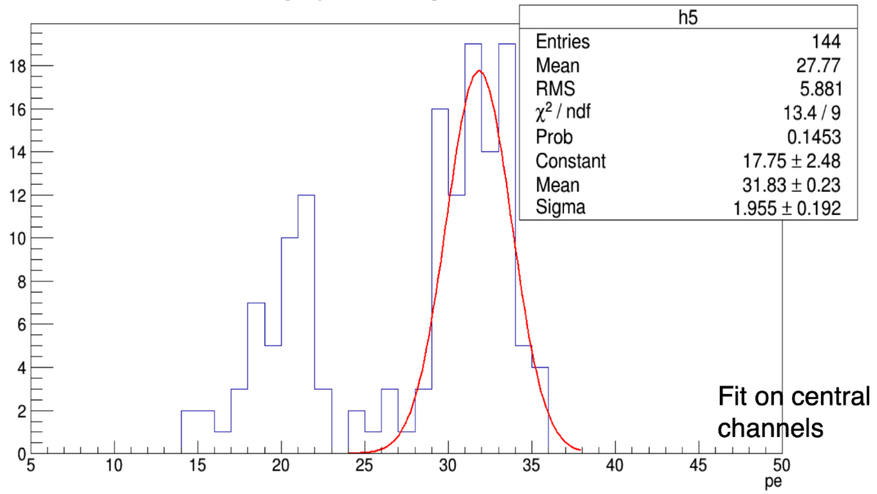
First problem: low light-yield for edge cells

- **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**.



Megatile prototype 6



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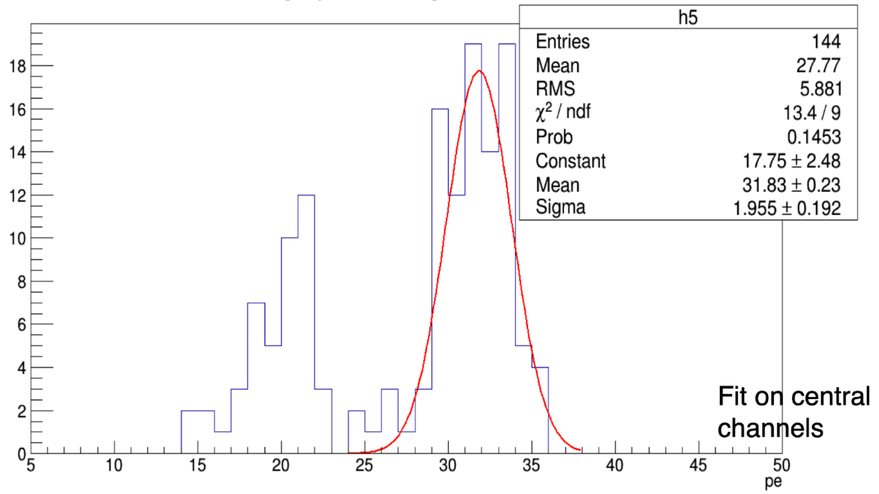
- **Reason**:
  - 😕 **Coating** of edges is **technically difficult**.

- **Current workaround**:
  - Adhesive **reflective foil** on the edges.
  - **Not easy** either.
  - **Limited improvement**.

Megatile prototype 6



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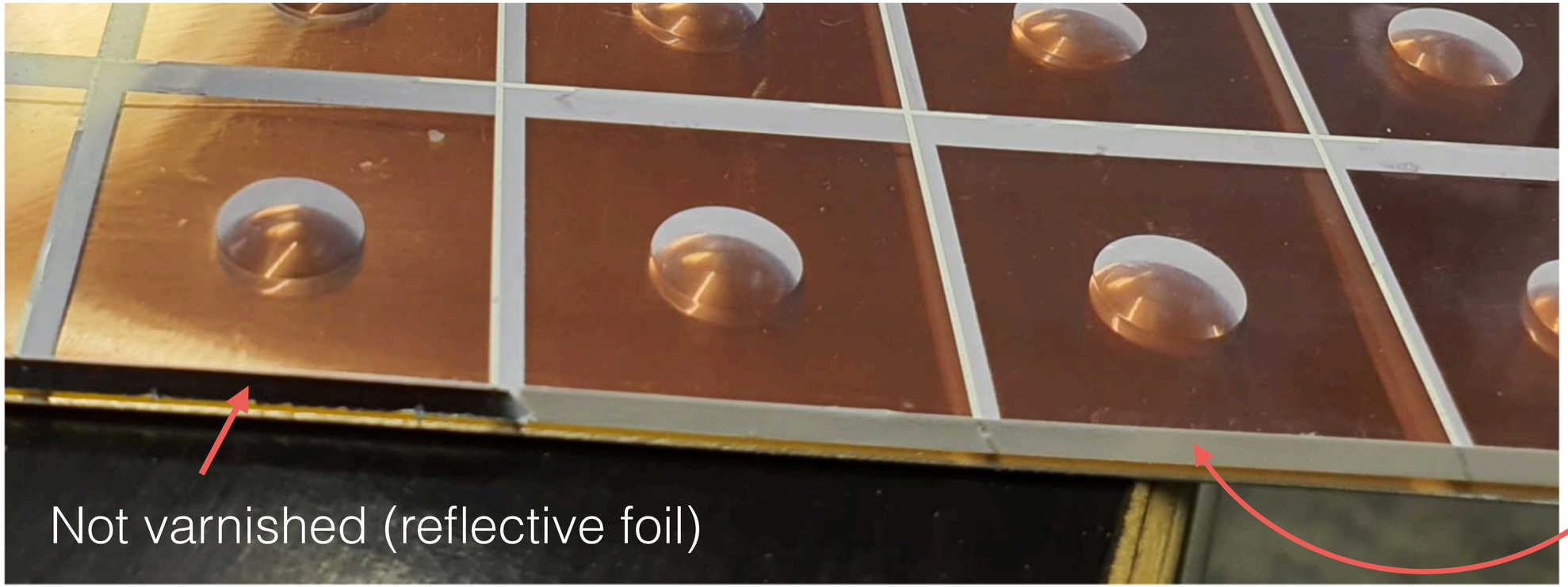
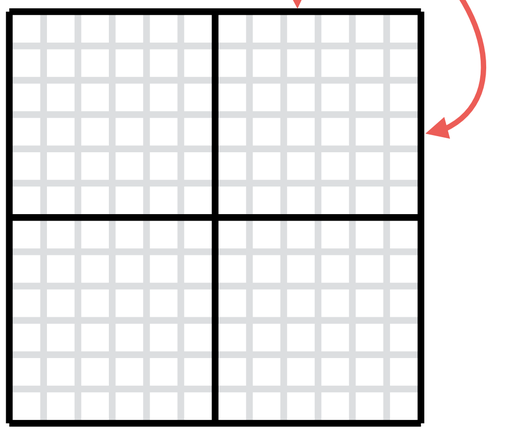


New!

varnished



- Idea: spraying of TiO2 glue on edges.
- **Recent development**: **finally found a suitable one**! 🙂
- First test in cosmic bench: analysis ongoing!
  First results on next slide.

First problem: low light-yield for edge cells

Ratio LY / <LY in center cells> in top right corner

New! Preliminary

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

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

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Promising concept

Two main challenges encoutered so far

Edges cells

Air gap

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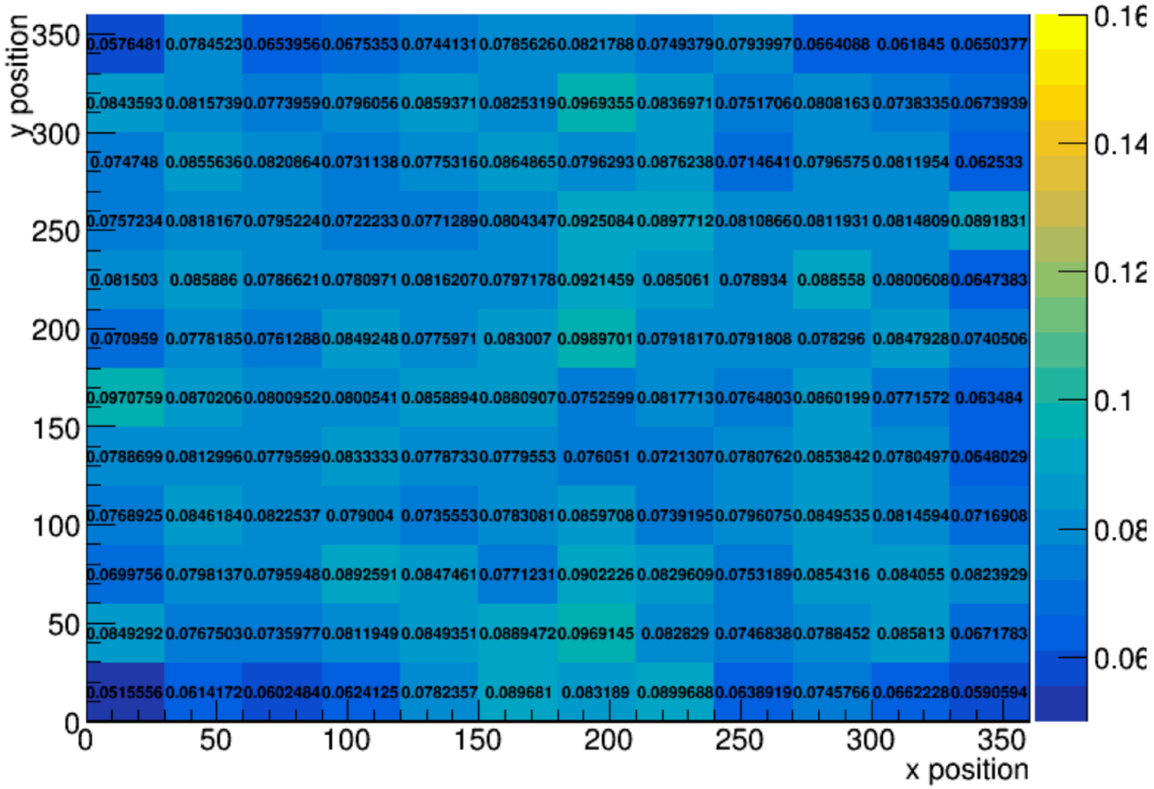
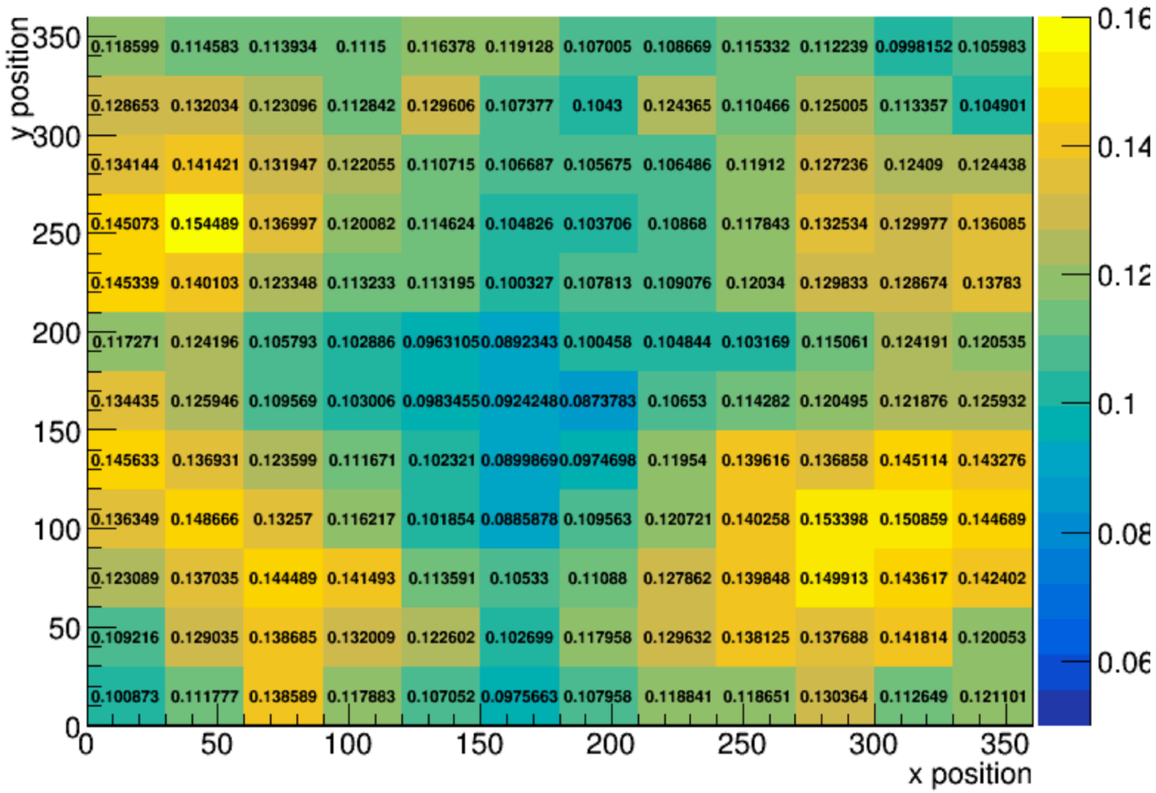
Second problem: TB/Cosmics X-talk difference

Cross-talk in **cosmic stand**



Cross-talk in **test beam**

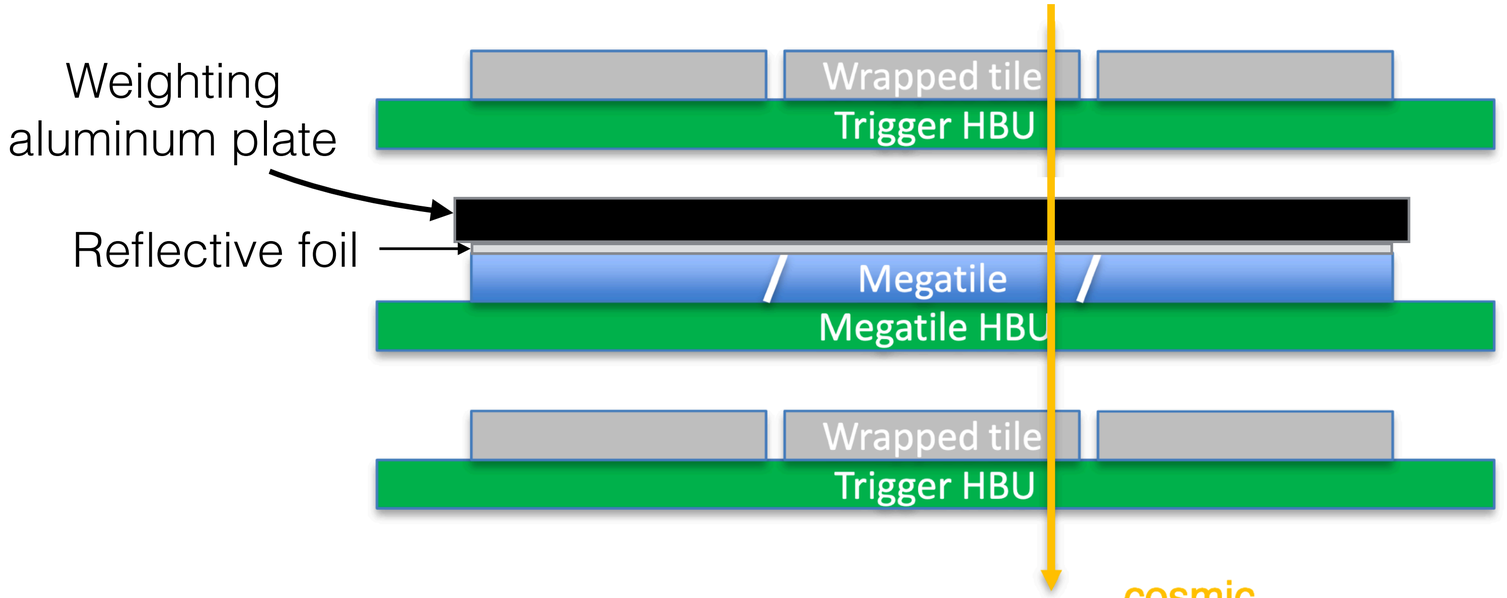


- Cosmics:
  - < ~**7.5%**, **as expected**
  - **Uniform**

Here using older prototype, better with newer

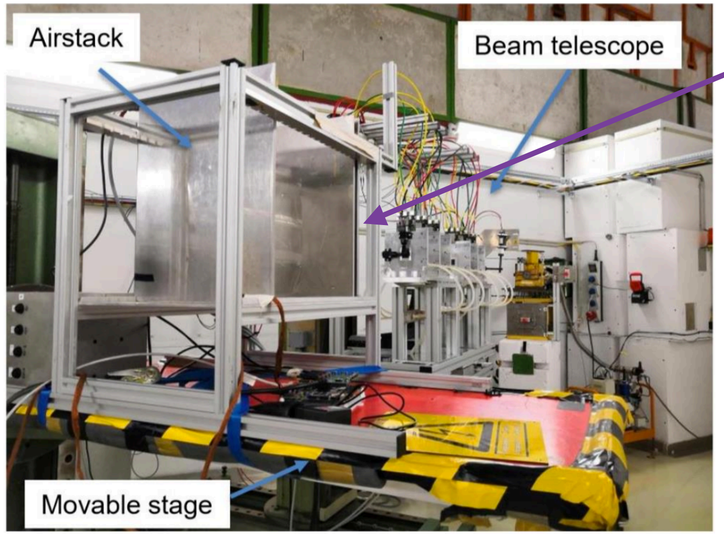
- Test beam:
  - **Up to 15%**
  - **Large variations**

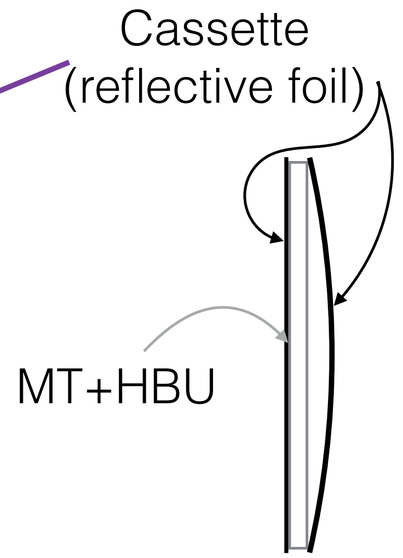
Second problem: TB/Cosmics X-talk difference



- **Due to air gap**:
  - Cosmics bench setup is vertical.
  - Test beam is horizontal.

- Currently, air gap size is not controlled.

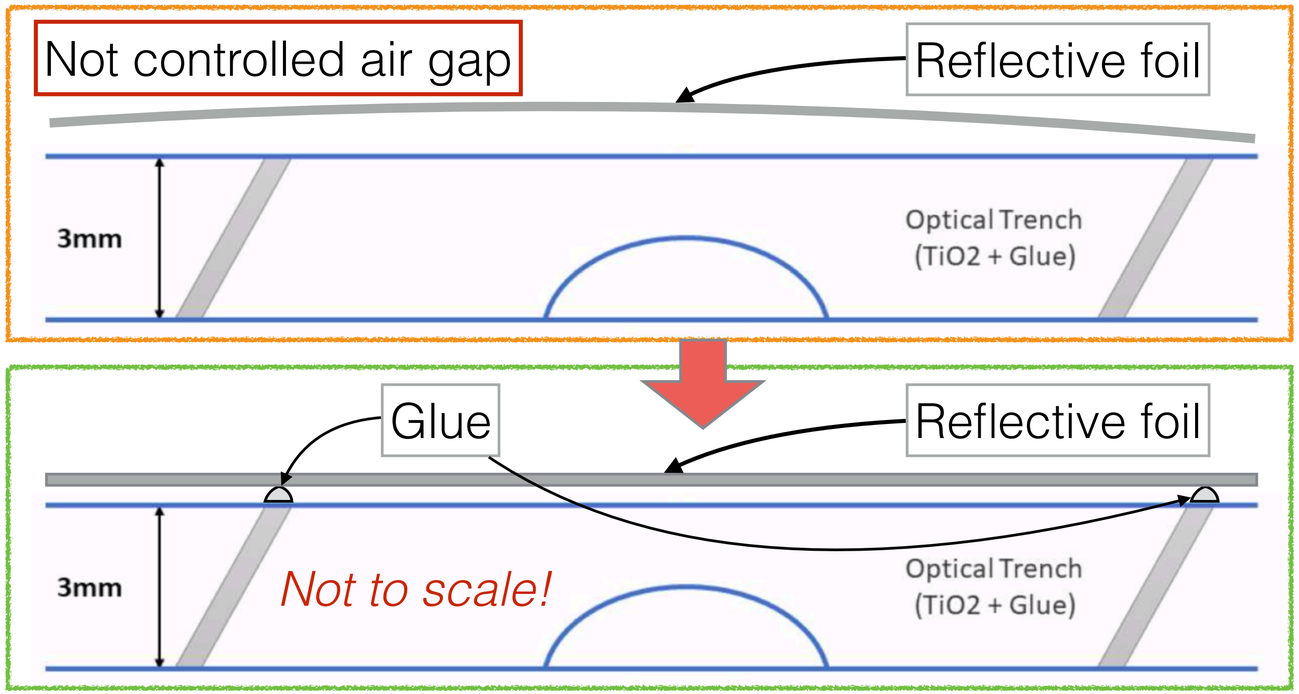




Second problem: TB/Cosmics X-talk difference

New! Ongoing

- Currently, reflective foil not attached to the Megatile (but to structures)
- Proposed solution: add some glue lines on top of the megatile



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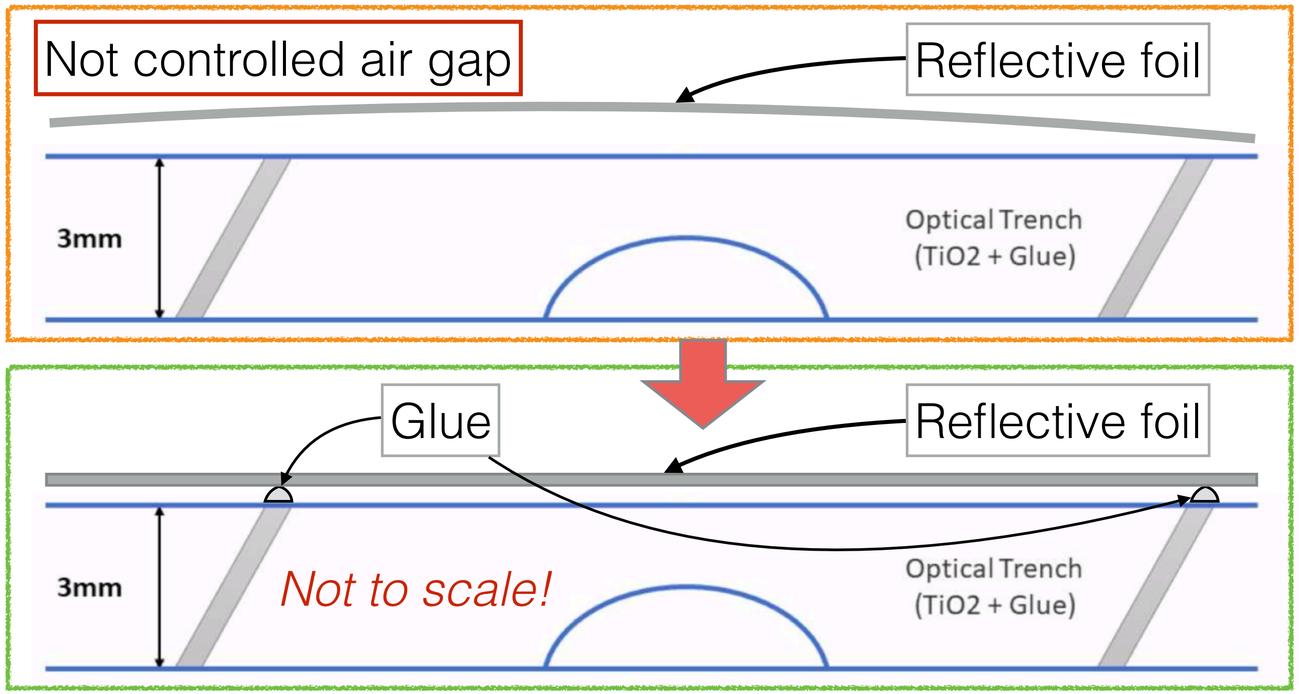

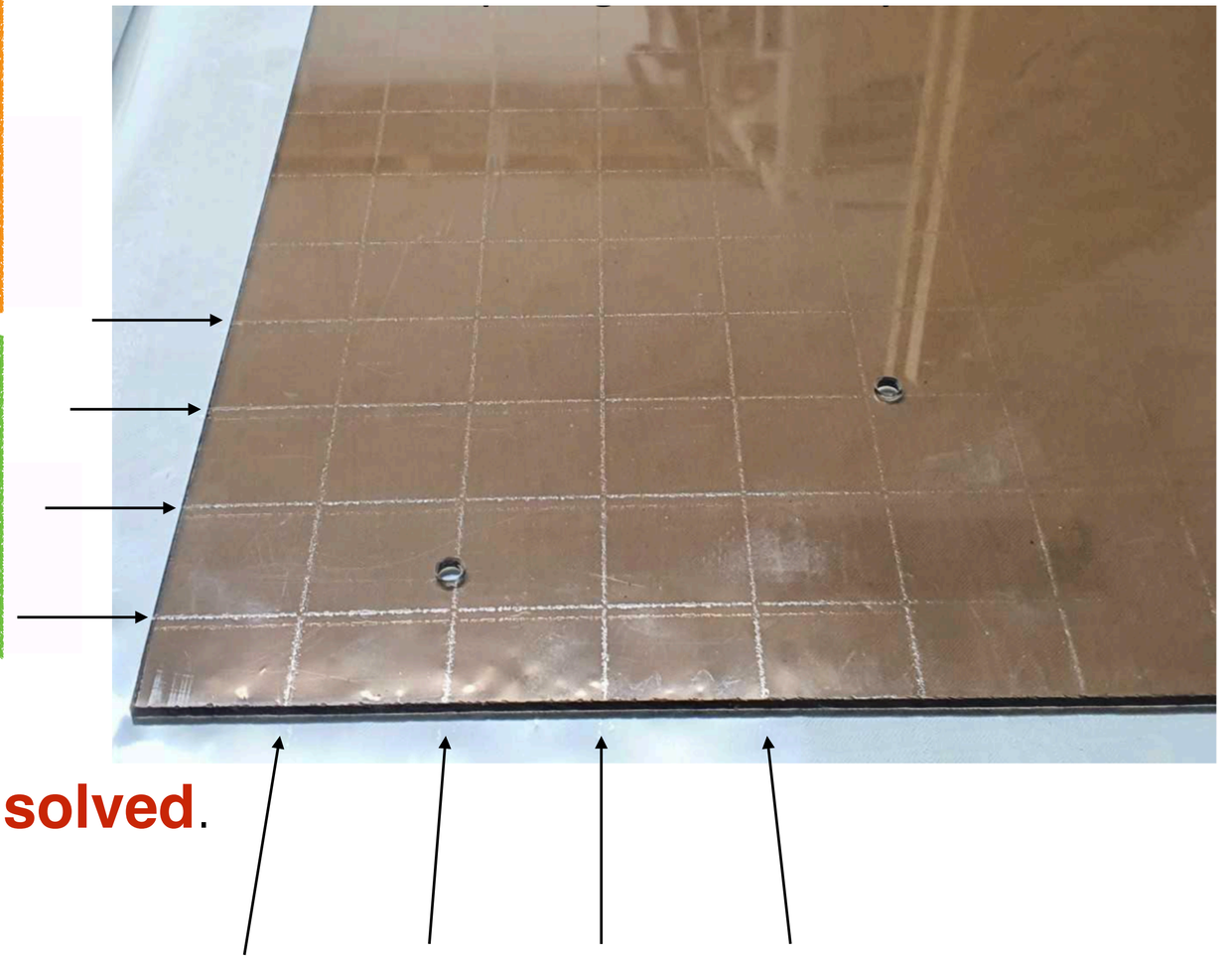

- **Tested on dummy plexiglas** (safety).
- **Technical issues** being worked out, **almost solved**.
- **Once ready, test in comics bench**.

Conclusion and future

Promising concept: improves mass production

- **Light yield as good as wrapped single tile**.
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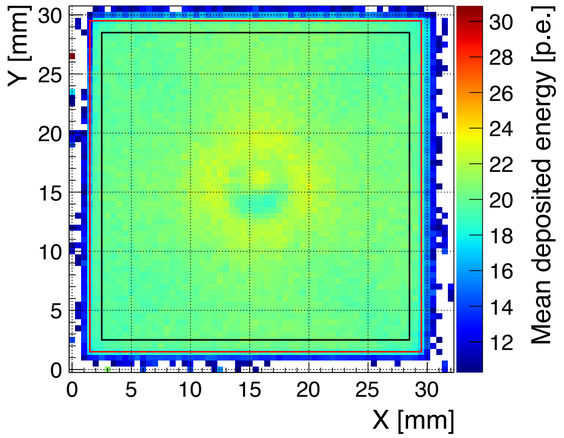
The (near) future

- **Investigations ongoing at local cosmic test stand** using MT5.
- **Planned test-beam @DESY in August**.
  - **Uniformity measurements** with new MT6.
  - **Edge coating** should be **ready**.
  - Technical **gluing issues** close to **solution**.

Reproduce in TB
what is done @ MPP-Munich

Ex: single tile uniformity



arxiv:1512.05900