

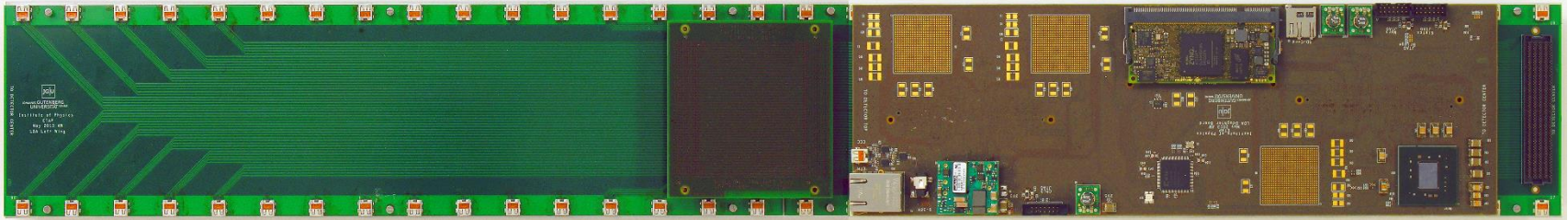
# Mass Assembly

10.9.13 – Calice Collaboration Meeting  
LAPP Annecy

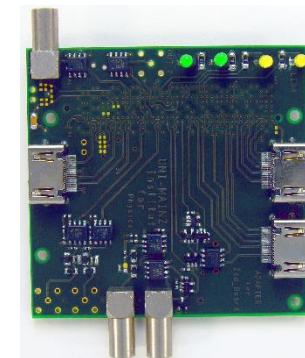
JGU Mainz - Phi Chau

Bruno Bauss, Volker Büscher, Julien Caudron, Reinhold Degele, Karl Heinz Geib, Sascha Krause, Yong Liu, Lucia Masetti, Uli Schäfer, Rouven Spreckels, Stefan Tapprogge, Rainer Wanke

# Wing LDA/CCC Status



- AHCAL wing data aggregator has been built
- Initial power-up tests successful
- System integration started (André, Rouven,...), but further effort required
  - Firmware for Kintex FPGAs
  - Firmware / Software for Zynq processor (“MARS ZX3”)
- VME-sized clock/control unit acting as MARS test bench
  - Issues in firmware load stage observed on engineering sample
  - Further effort required to debug on production silicon available now
- For the time being cover all immediate needs (AHCAL LDA/CCC) with adapter modules on “Zedboard”
  - Clock/control adapters available
  - Data aggregator adapter ready for production
  - New batch of clock fan-out units in production
  - Julien working on software integration



# Need for an automatic production

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- AHCAL (final design)
  - About 8.000.000 tiles have to be placed on HBU boards
  - With an effort of 10 s per tile → ~ 8 years are necessary for the assembling
    - We need an automatic placement
    - With 1 second per placement we need 1 year

# Mass production

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- DESY: Production of HBU boards
- ITEP: Production of the tiles
- Heidelberg University: Characterisation of tiles/SiPM
- Wuppertal: LEDs calibrations
- Mainz University: Placement of the tiles on the HBU board, functionality tests of the assembled boards

# Automatic placement

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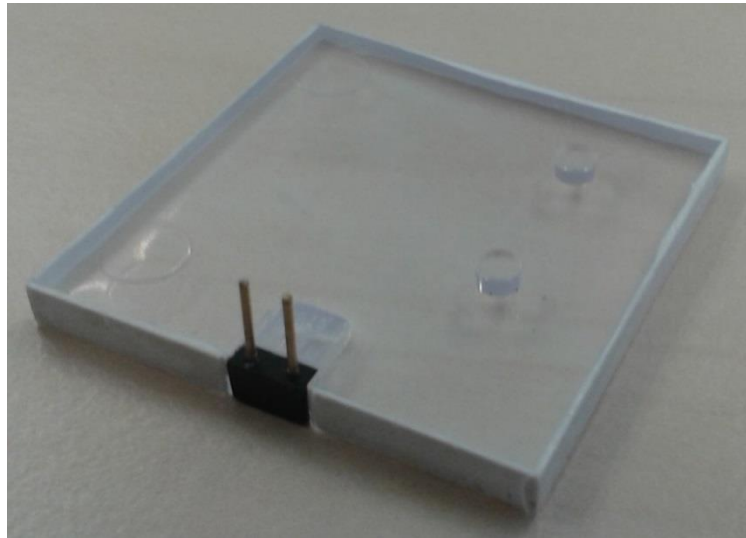
Pick-and-place  
machine

- Pick-and-place machine
  - Camera detects tiles/SiPMs and suction cup places them on the HBU (SiPM pins through the pin holes)
  - Vision system detects tiles and the SiPM pins → quality assurance
  - Problem: Reflective surface of the tiles
    - Pick-and-place machines with Vision systems works with light to detect the pins



# Camera tests

- We have produced dummy tiles for camera tests at machine manufacturers

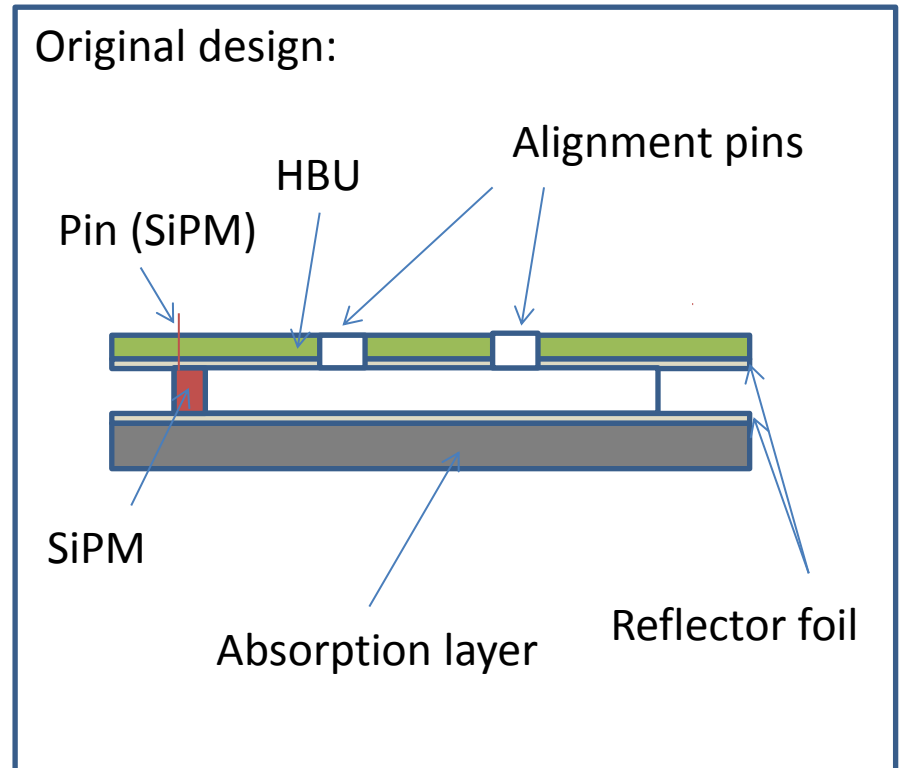


- 3 companies have confirmed, that vision system can handle the tiles



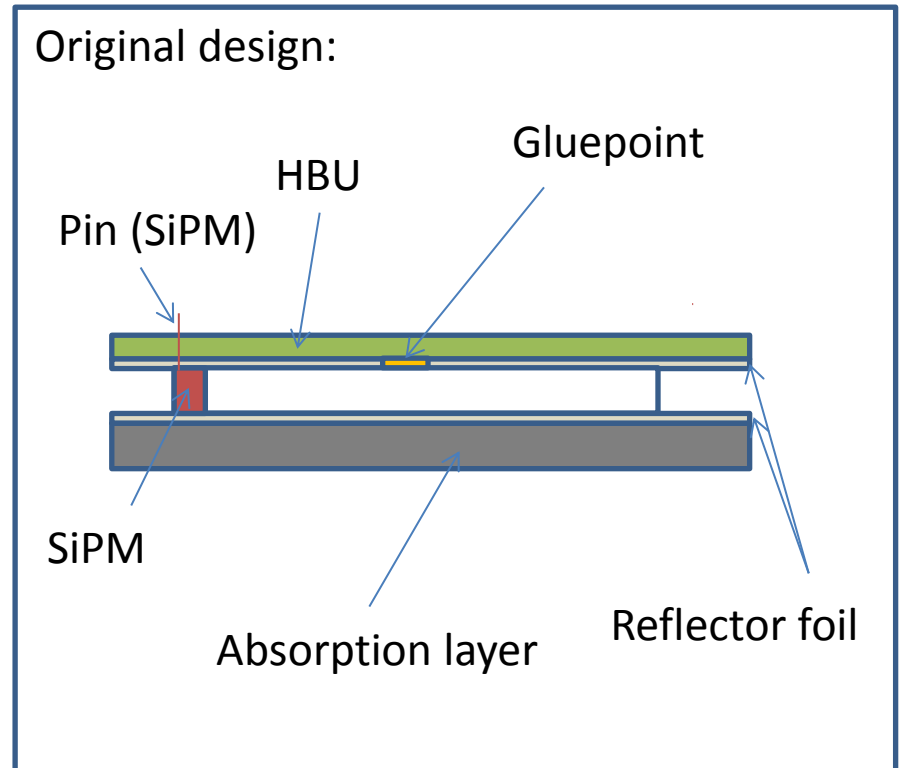
# Current design

- Mounting of tile on HBU board:
  - Tiles have to be pushed into the alignment pin holes
  - Very small tolerances are needed to fit
  - With 4 pins (2 SiPM pins, 2 alignment pins), tolerances have to be quite big



# Modified design: Option 1 – Not wrapped tile

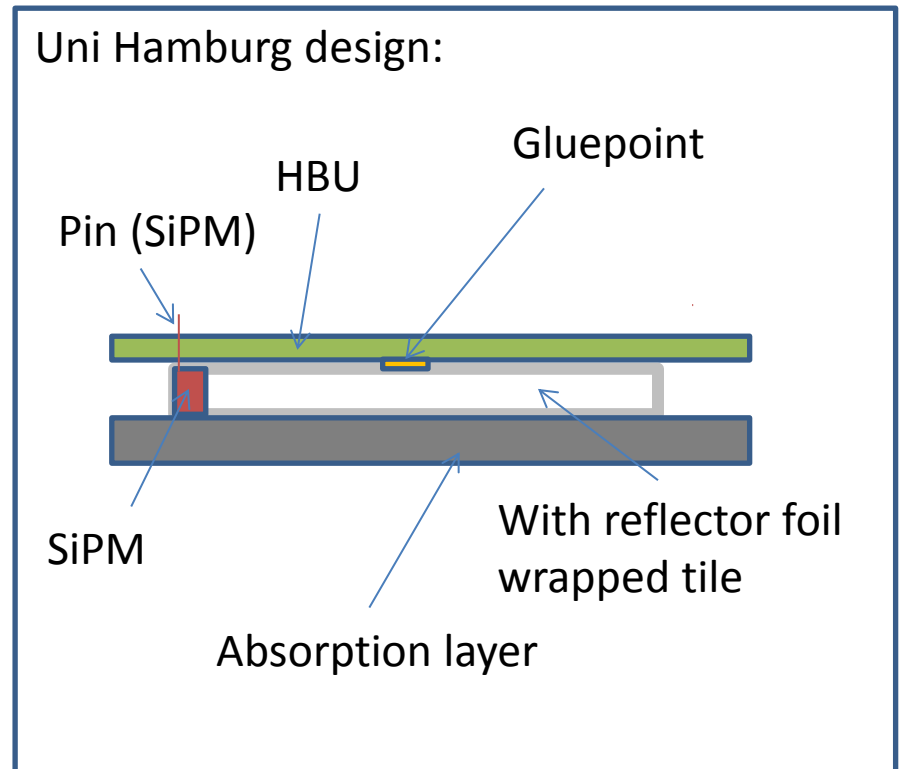
- Mounting of modified tile on HBU board:
  - Plane tiles without alignment pins
  - Requires: Fixation of the tile with gluepoint between tile and reflector foil
  - Just 2 pins (from SiPM) → tolerances are less demanding



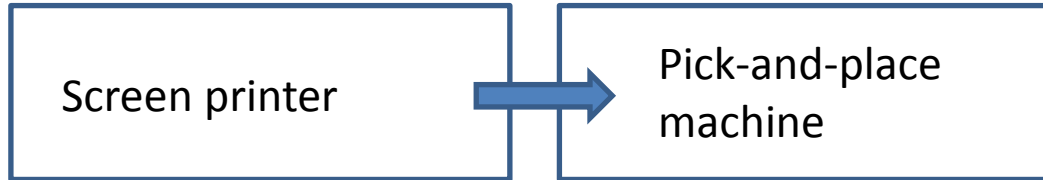


# Modified design: Option 2 – wrapped tile (Uni Hamburg)

- Mounting of modified wrapped tile on HBU board:
  - Tile is wrapped with reflector foil and flex pin connector
  - Fixation of the tile with gluepoint between HBU and reflector foil



# Automatic placement



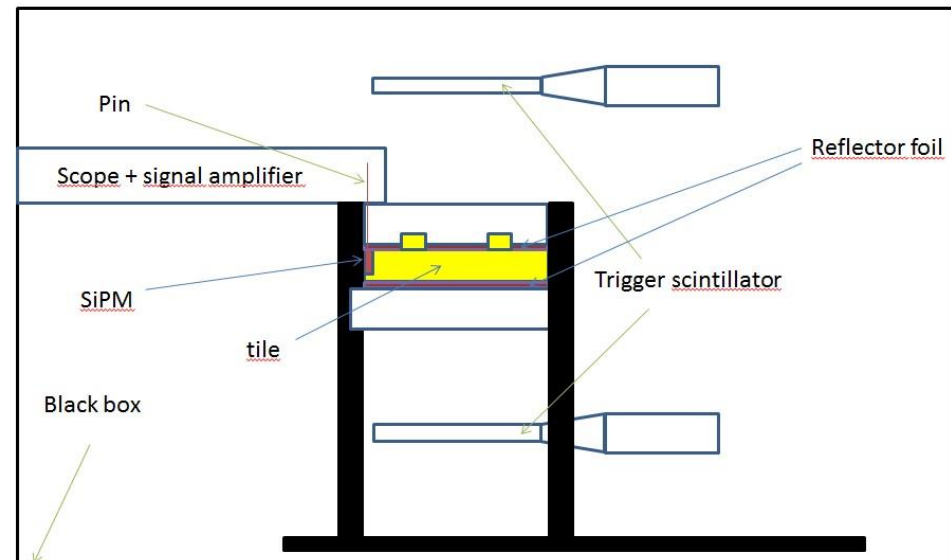
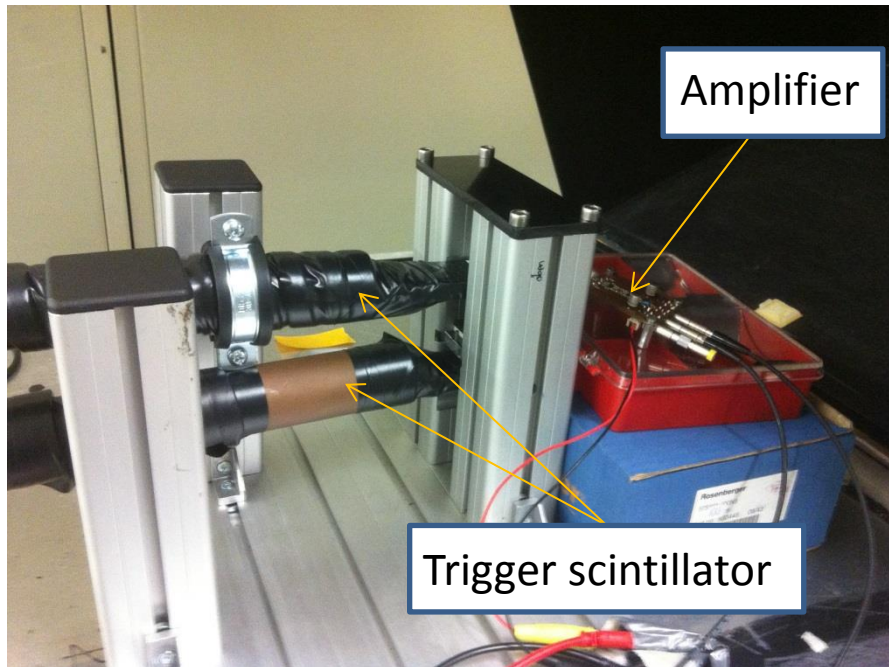
- **Screen printer**

- Sets gluepoints on the surface of the HBU
- High adhesive glue is needed, because we don't want any time for drying-out the glue
  - Silicone
    - Potential issue: Does Gluepoint reduce light yield? → Tests



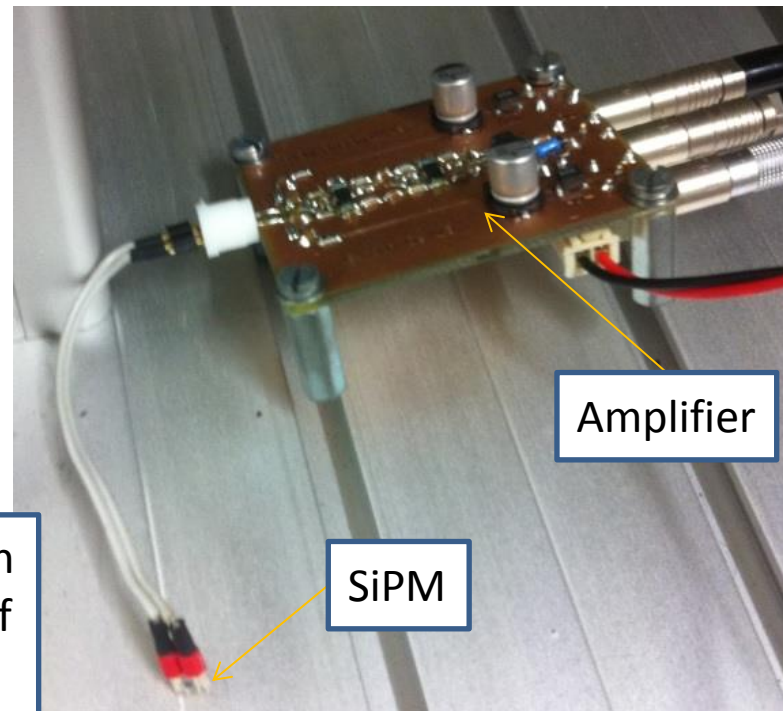
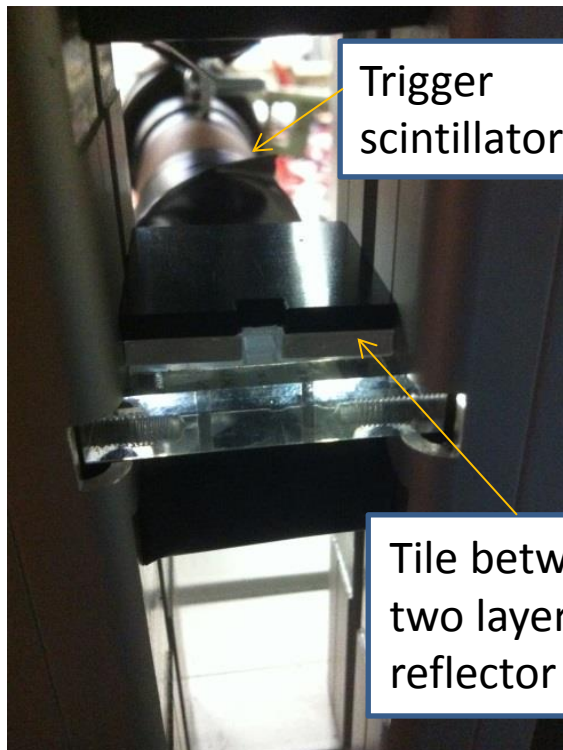
# Measurement Set-up

- Measurement of the influence on the optical properties with cosmics



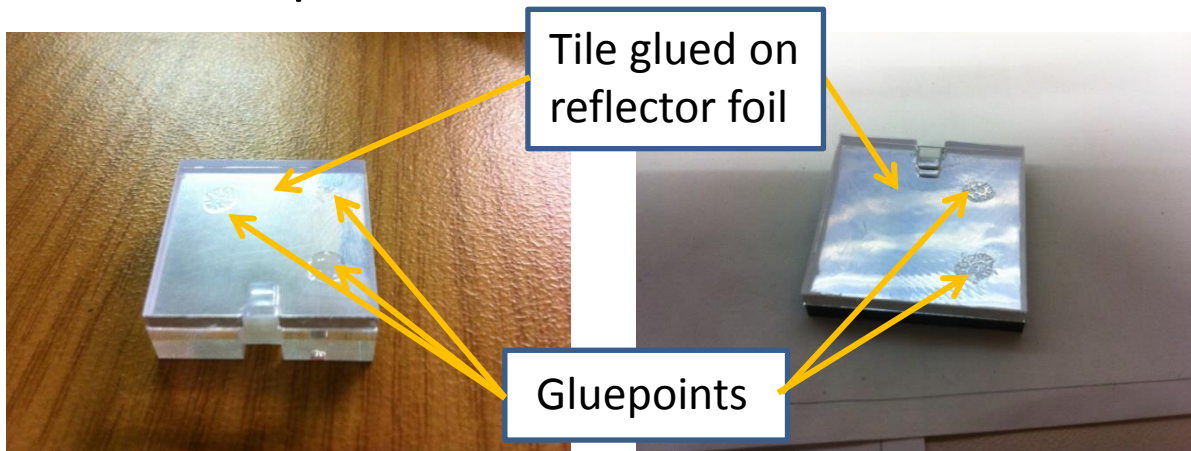
# Measurement Set-up

- Measurement of the influence on the optical properties with cosmics



# First measurement

- The first measurements are finished
  - 2 ITEP tiles with 2 Hamamatsu MPPC S10943-8584(X) are measured with cosmics
    1. Unmodified without gluepoints
    2. Without alignment pins with gluepoints (alignment pins are removed,  $\ll 1$  ml silicone is placed on tile)



# First results

Configuration	Integrated charge in arbitrary units	Normalized to measurement without glue	Numbers of measurements
Tile 1/SiPM 1	2,74±0,03	100%	1115
Plane Tile 1/ Silicone / SiPM 1	3,15±0,02	115%	2568
Tile 2/SiPM 2	4,14±0,04	100%	1238
Plane Tile 2/ Silicone/ SiPM 2	4,39±0,04	106%	1420

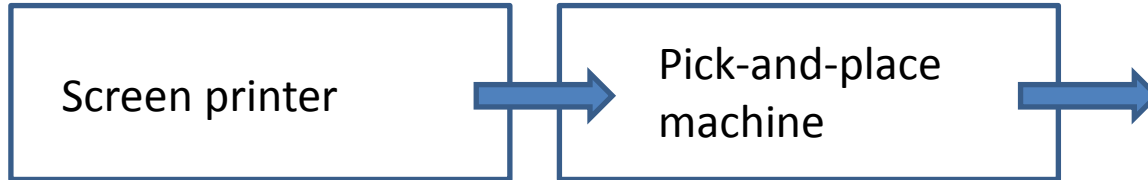
# Result

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- Light yield of the modified design is better than light yield of current design
- Later tests can determinate the configuration with the best optical properties. We want to test different settings with
  - Different glue
  - Glue shapes
  - Quantity of glue
  - Position of the glue



# Automatic placement



- Conveyor

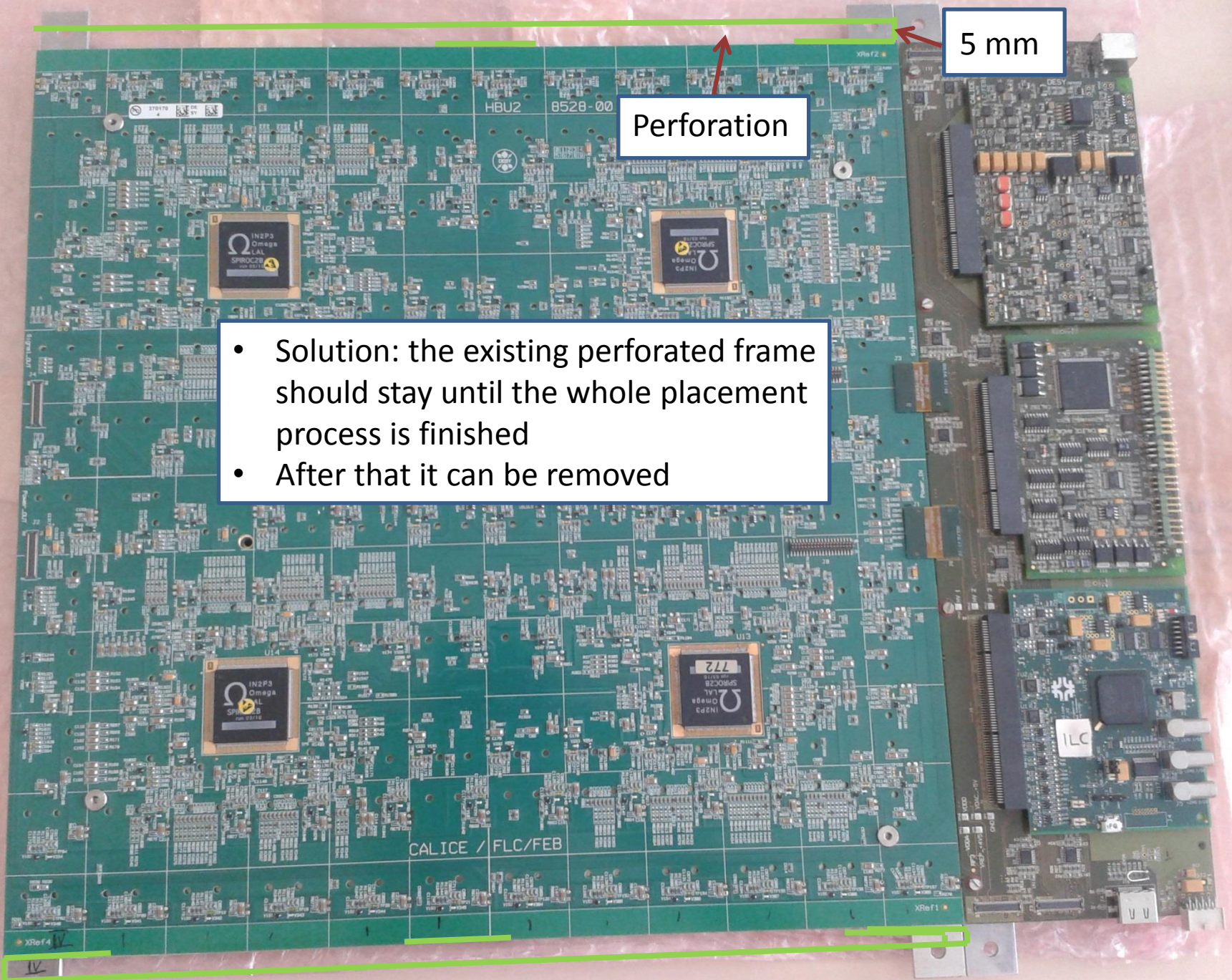
- Transports the boards from Pick-and-place machine to soldering machine
- Problem: Board is completely filled with tiles  
→ Transportation is not possible



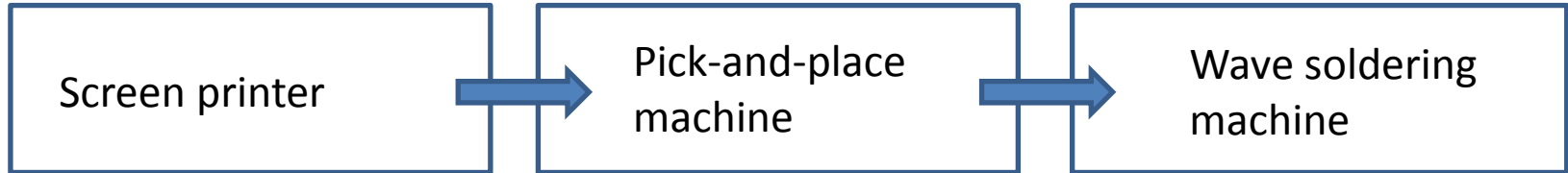
5 mm

Perforation

- Solution: the existing perforated frame should stay until the whole placement process is finished
- After that it can be removed



# Automatic placement



selective soldering would take 3-8s per soldering position (x144 soldering positions per board)

→ Wave soldering machine

- Fastest soldering technique

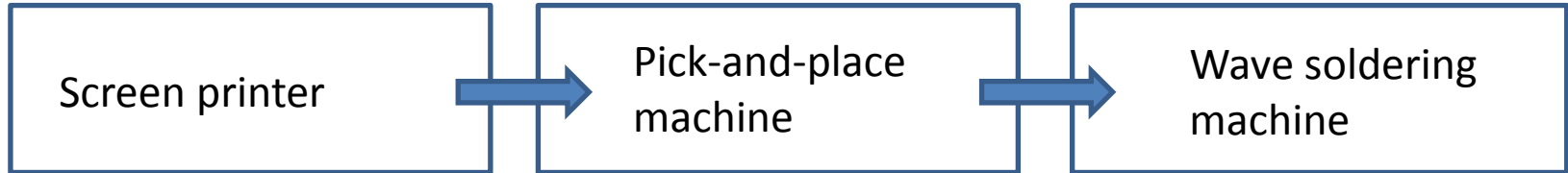


# Wave soldering machine



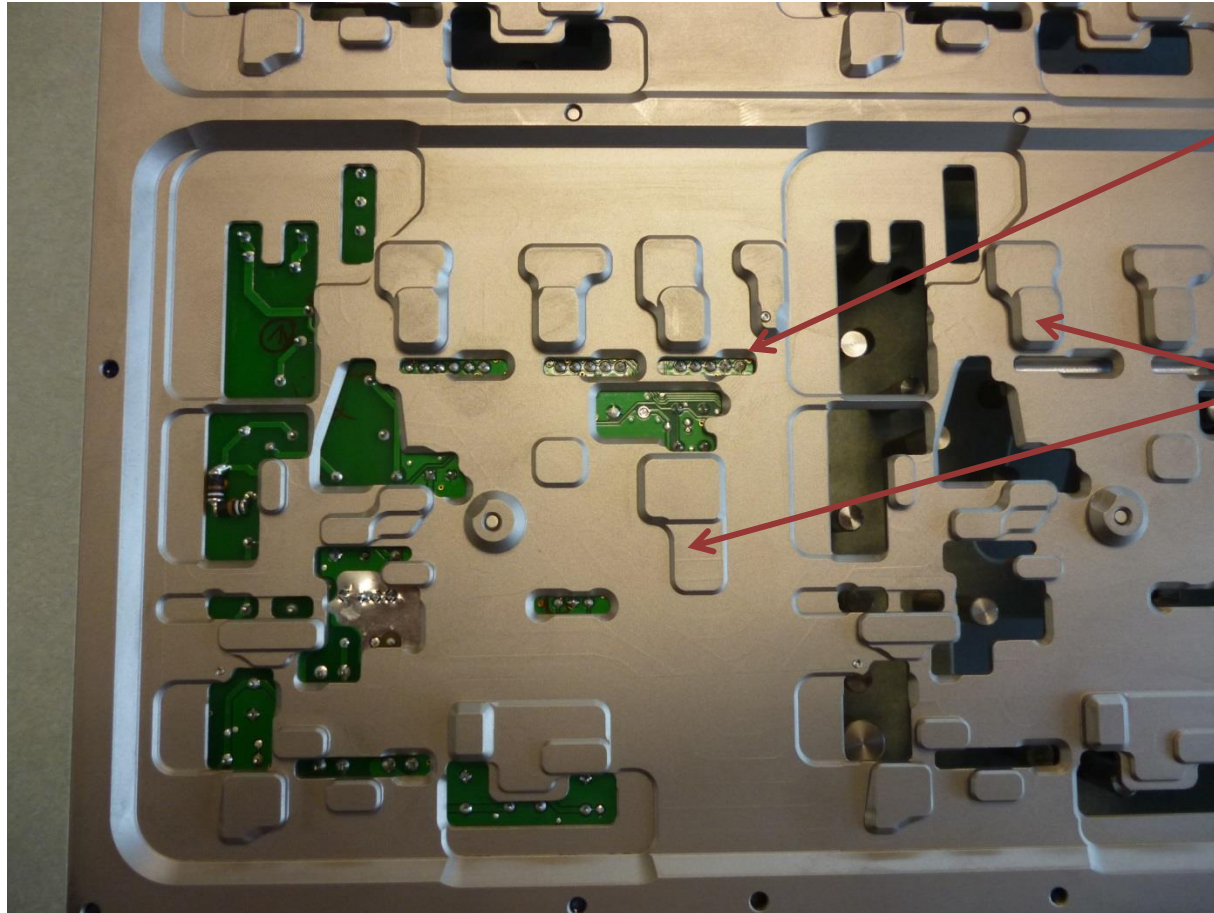
<https://www.youtube.com/watch?v=inHzaJIE7-4>

# Automatic placement



- Wave soldering machine
  - Problem: Board is already assembled
  - We need a soldering mask

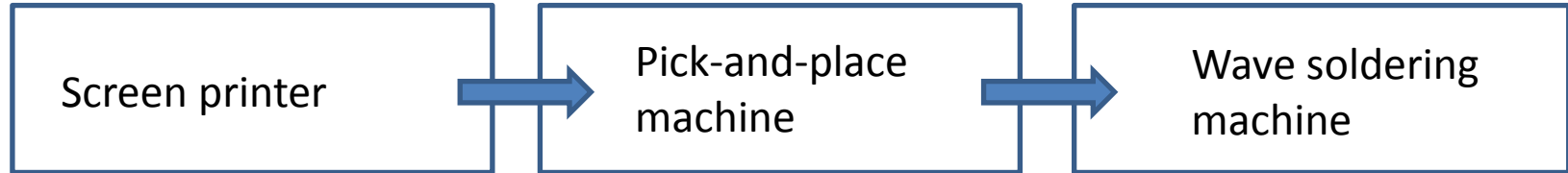
# Soldering mask



Soldering positions

Protective bag for SMD components

# Automatic placement



- **Wave soldering machine**

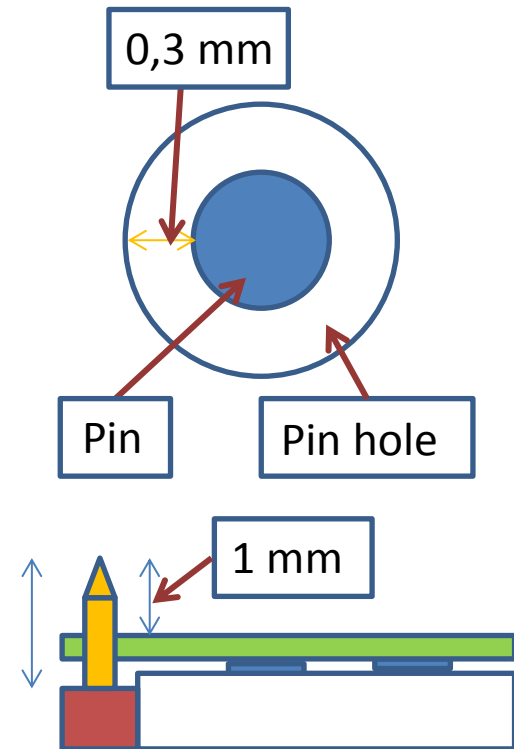
- Soldering process defines (and limits) the design of the HBU board and the structure of the SiPM pins:
  - the diameter of the SiPM pins and bore holes
  - position of components
  - SiPM pin hole position

→ Modifications of the HBU board is needed



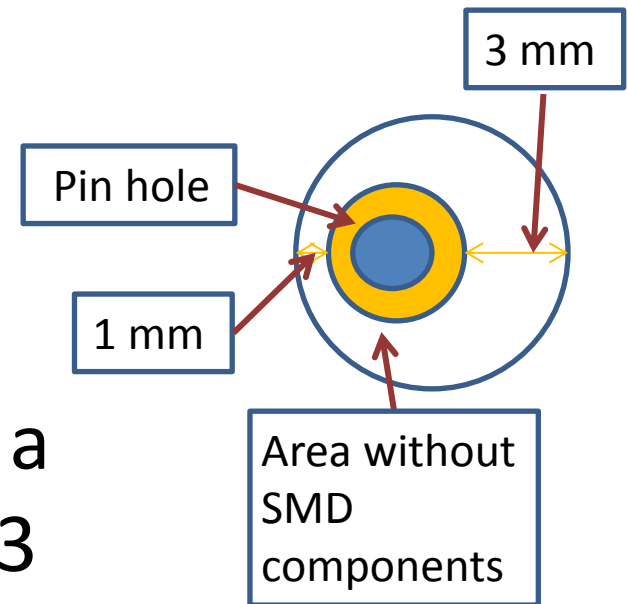
# SiPM pin-, boreholediameter and shape

- pin holes should be 0,3 mm larger than the pins
- We also want maximally robust pins
  - Pins could be pushed away from the solder → Pins with  $\sim 0,5$  mm diameter are optimal
  - The pin length should be around 1 mm outside the hole



# SiPM pin-, boreholediameter and shape

- Recommended Area around the SiPM holes without any SMD components: 3 mm radius
- Asymmetric Area around the SiPM holes without SMD components are possible with a minimum radius of 1 mm and 3 mm on the other side



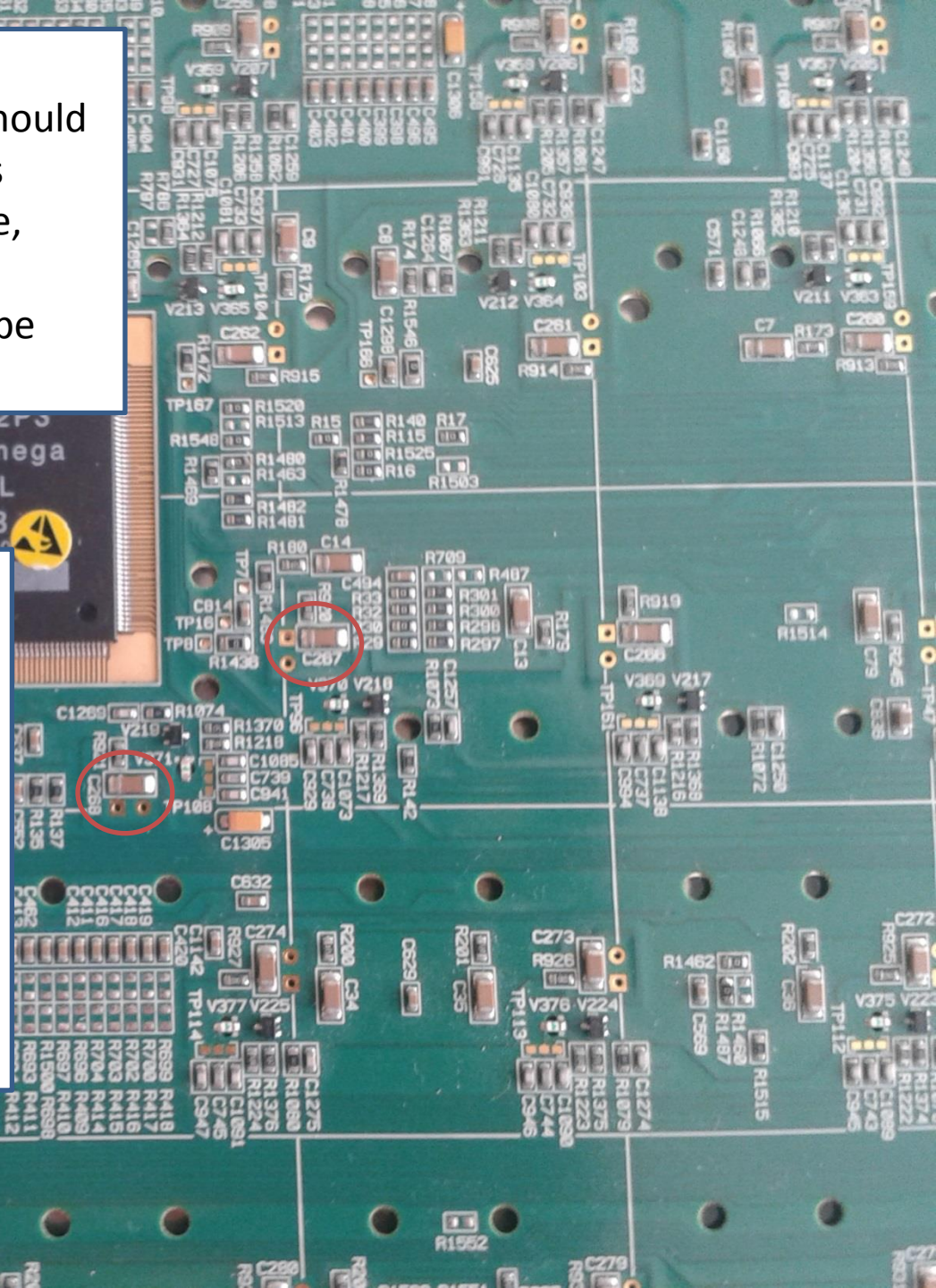


### Additional advice:

Components near the SiPM connectors should be placed with the short side to the holes

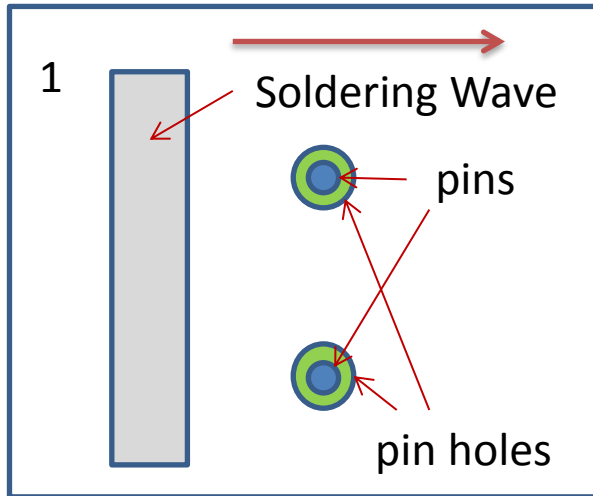
→ The components stay fixed on one side, even if one pad is heated up

→ components near the pin holes can't be soldered out

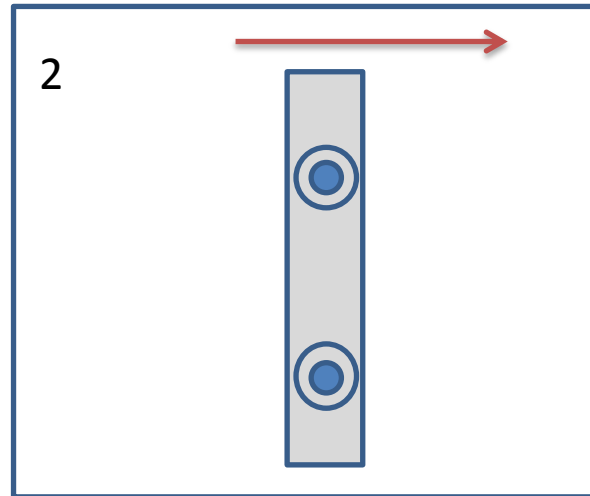


# Bridge effect

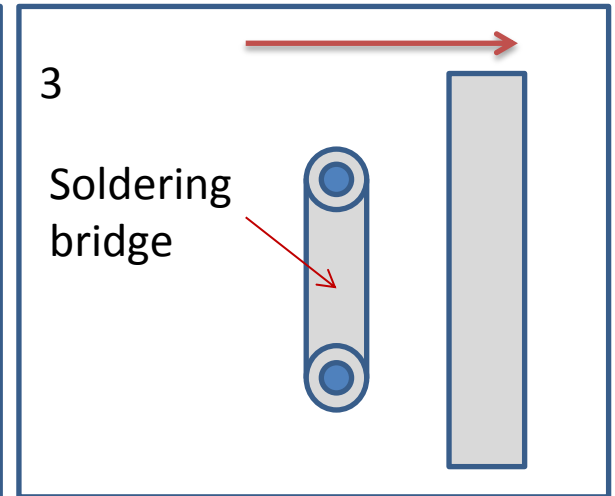
In this orientation → problematic for some wave soldering machines



The HBU board is transported from right to left (In the coordinate system of the board → Wave moved from left to right)

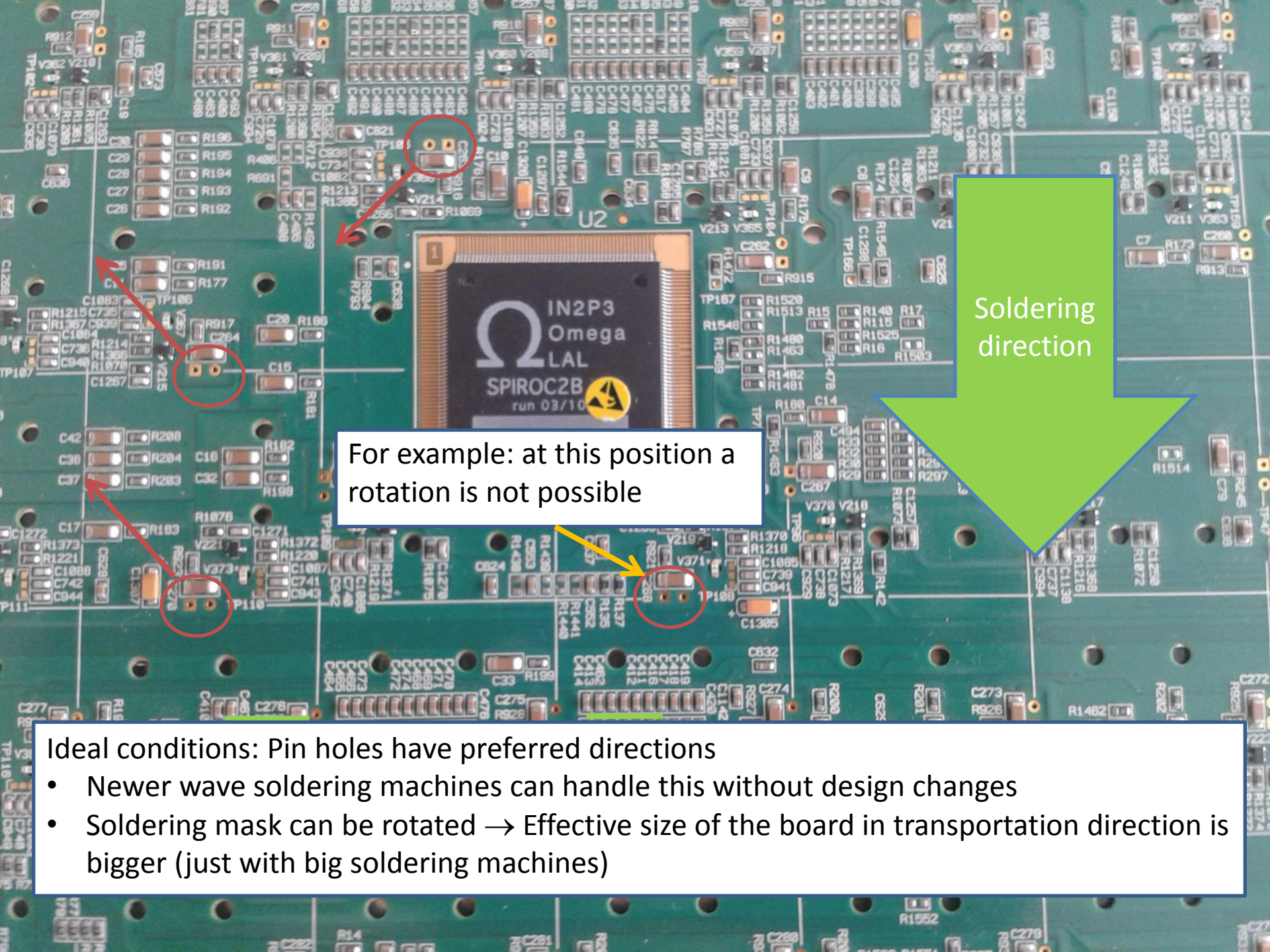


The pinholes are filled with solder



With this orientation, the bridge effect can occur





Soldering  
direction

For example: at this position a rotation is not possible

Ideal conditions: Pin holes have preferred directions

- Newer wave soldering machines can handle this without design changes
- Soldering mask can be rotated → Effective size of the board in transportation direction is bigger (just with big soldering machines)

# Additional tests for soldering

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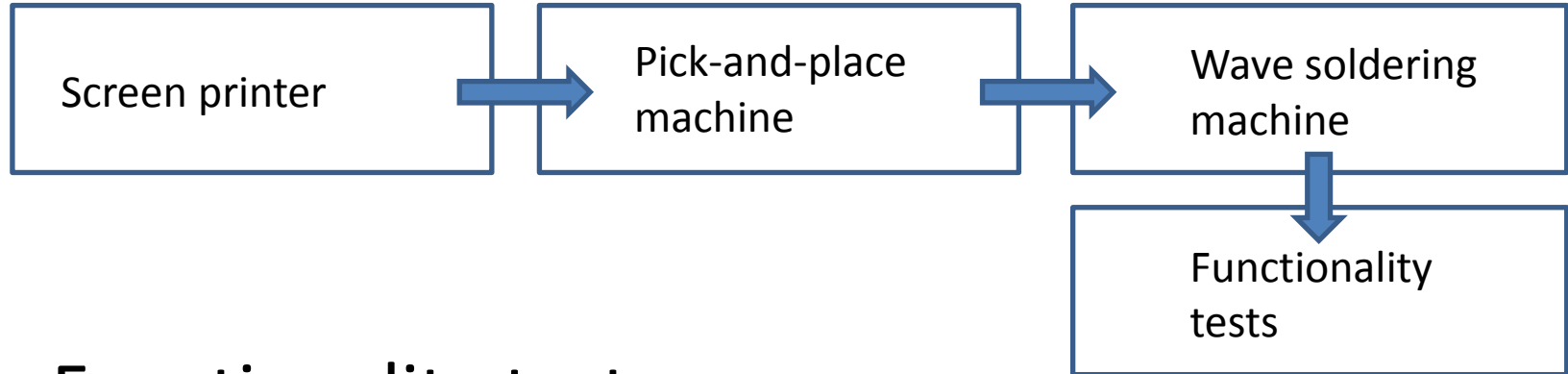
- Temperature tests for every component (simulation of Soldering wave)
- If HBU board could be change → Create a soldering mask and soldering tests

# SMD SiPMs

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- With SMD SiPMs the assembling would be easier
  - We won't need a soldering machine and the THT optimization
  - More in the presentation by Yong Liu

# Automatic placement



- **Functionality tests**

- Fully assembled HBU test set-up (with LEDs on the Board)
- Currently setting up AHCAL DAQ for fast testing

# Conclusion

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- Procedure for fast mass assembly has been defined
- Mass assembly requires numerous design modifications
- Initial tests successful
- Full production line will be set up in Mainz for demonstrating mass assembly with the large prototype



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Thank you for your attention!



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# Backup

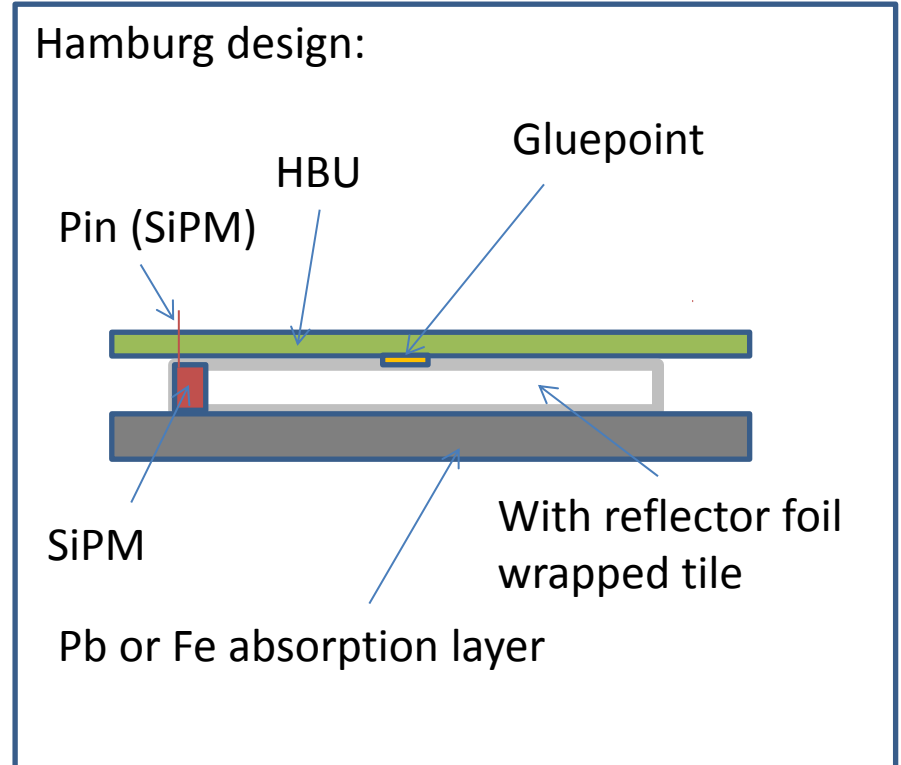
# Reference points

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- Finetuning advice: More reference points on the perforated frame (Mydata)
  - Existing points can't be recognized after assembling
  - Reference points should be on the side of the tiles and they should be on the frame

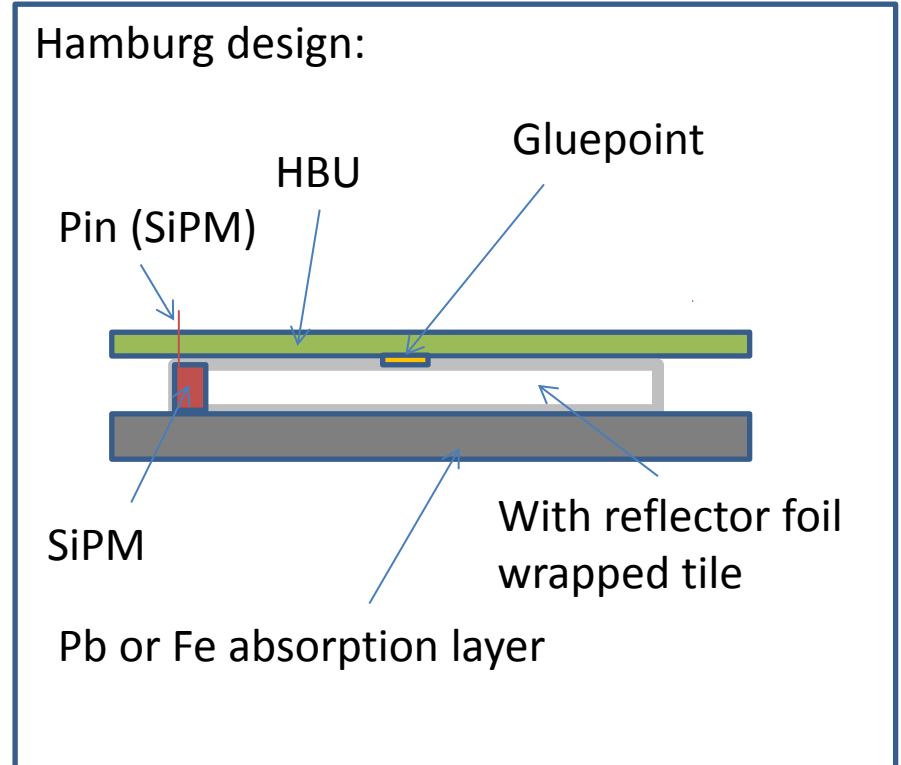
# Tiles/SiPM

- Mounting of Hamburg tile on HBU board:
  - Black surface of the wrapped tile → optical capture with cameras is easier to realize



# Tiles/SiPM

- Mounting of Hamburg tile on HBU board:
  - No tests till now for wrapped surface (tests of suction cup of pick-and-place machine)



# SiPM pin shape

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- Round pins are easy, rectangular pins are more difficult to solder (distances in the hole aren't constant)