DarkSide-20k production

Y1 student presentations
Tuesday 14th June 2022

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[1] Supervisory team

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Detector Development Manufacturing Facility

DARKSIDE

Outline

1. A brief look at the experimental design
    - The University of Liverpool’s contribution

2. Specific contributions made to the project

Part 1 - Experiment

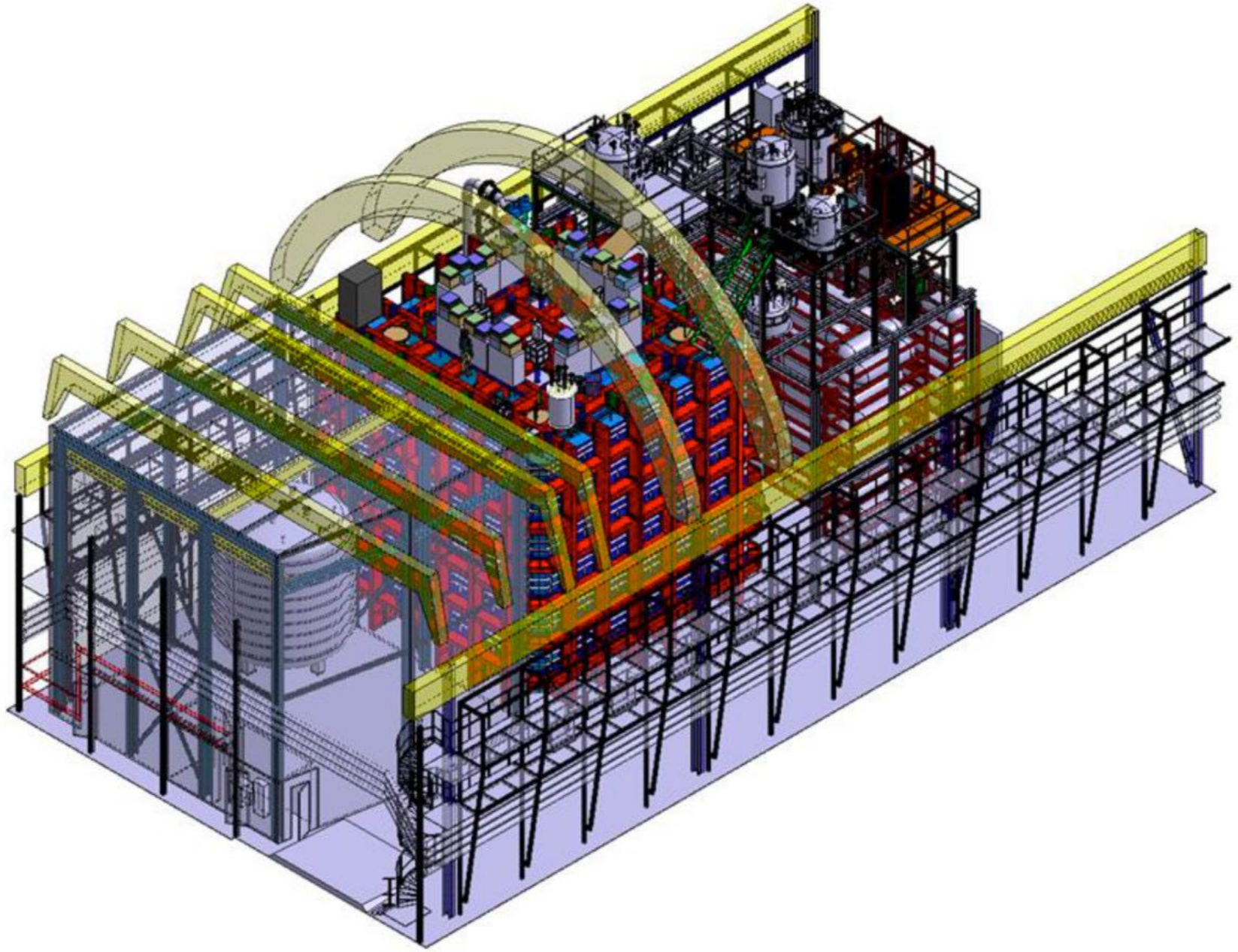
- Dark Matter (DM) direct detection experiment
- Low background radiation
- Long running experiment

- DM candidate:
  - Weakly Interacting Massive Particle (WIMP)
  - Beyond standard model particle

Laboratori Nazionali del Gran Sasso
Gran Sasso d'Italia

https://www.lngs.infn.it/en/lngs-overview

LNGS Hall C



Kish, A. https://indico.cern.ch/event/1041835/

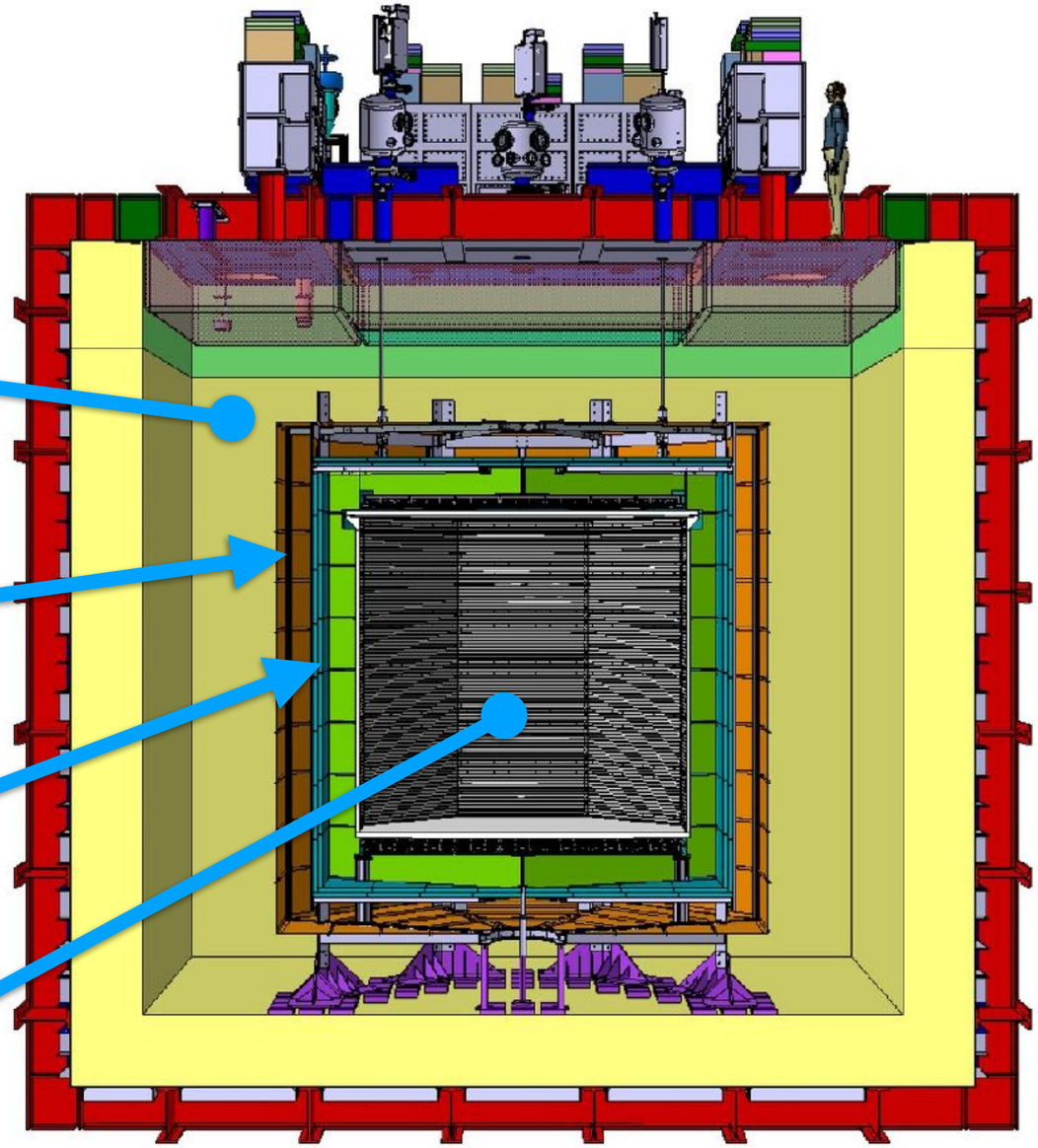
Cryostat

passive shielding, LAr (700t)

copper Faraday cage

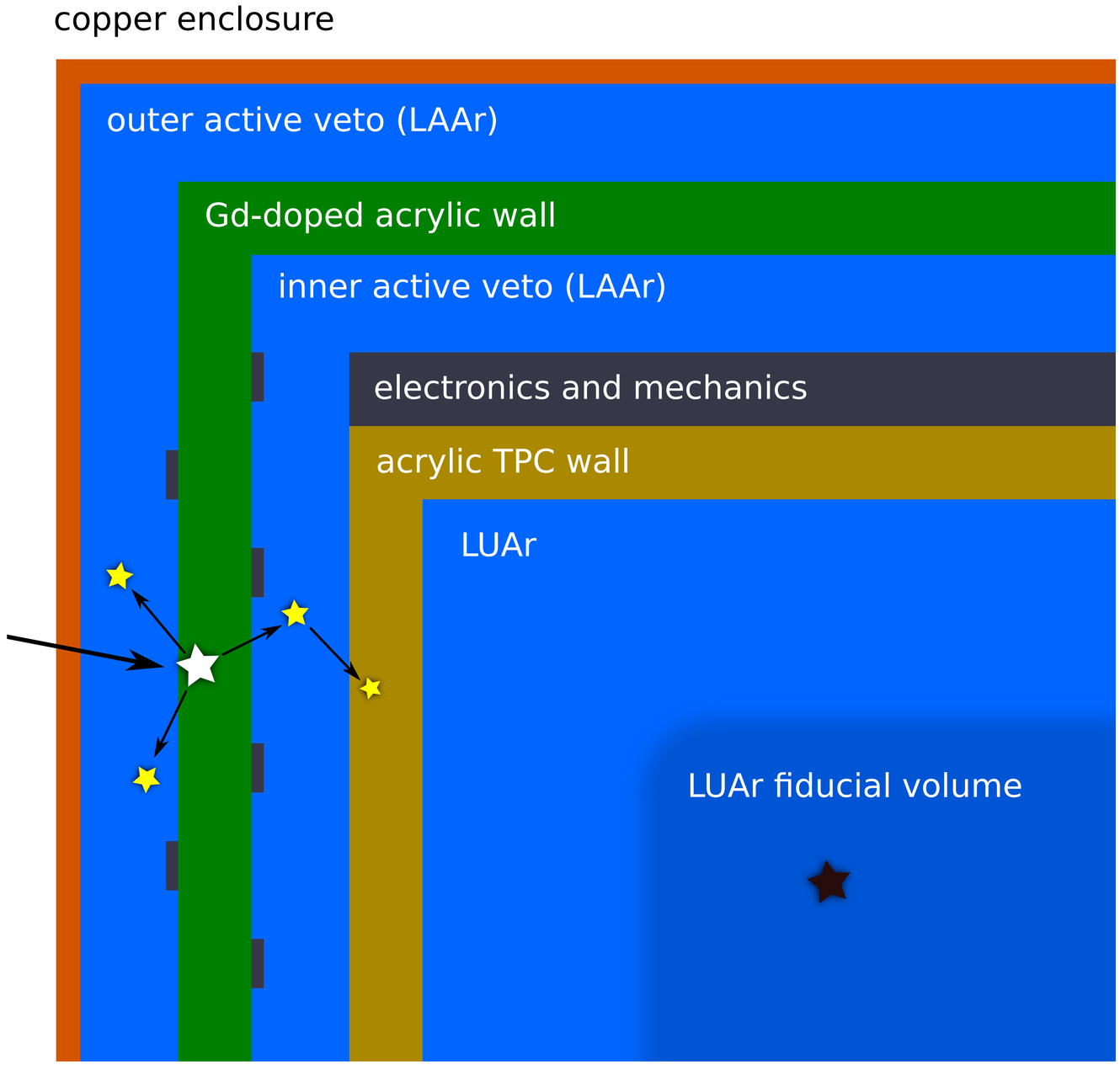
veto structure

TPC LAr (50t), fiducial volume 20t



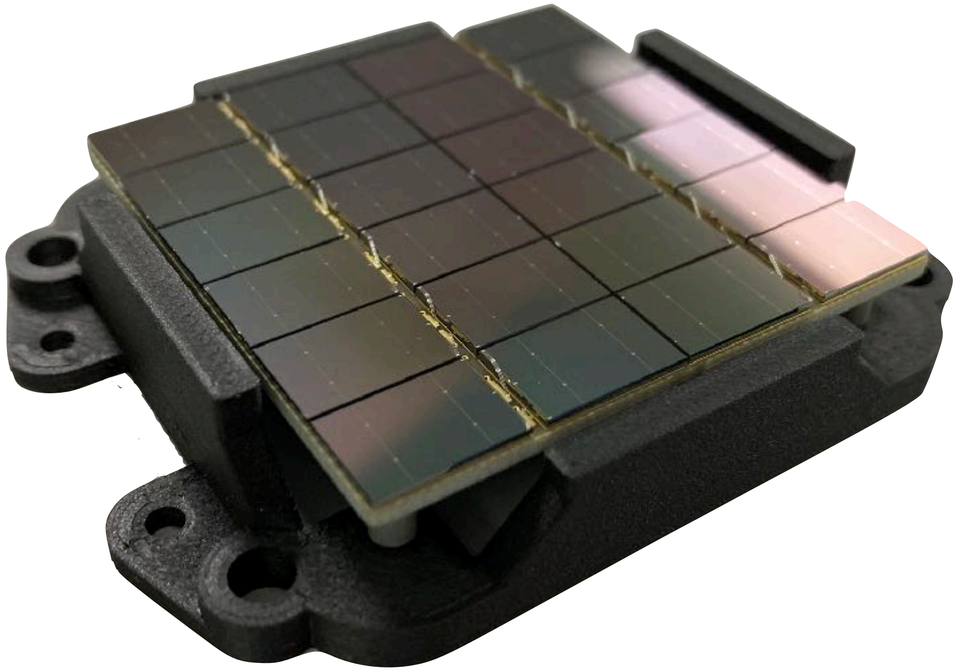
Kish, A. https://indico.cern.ch/event/1041835/

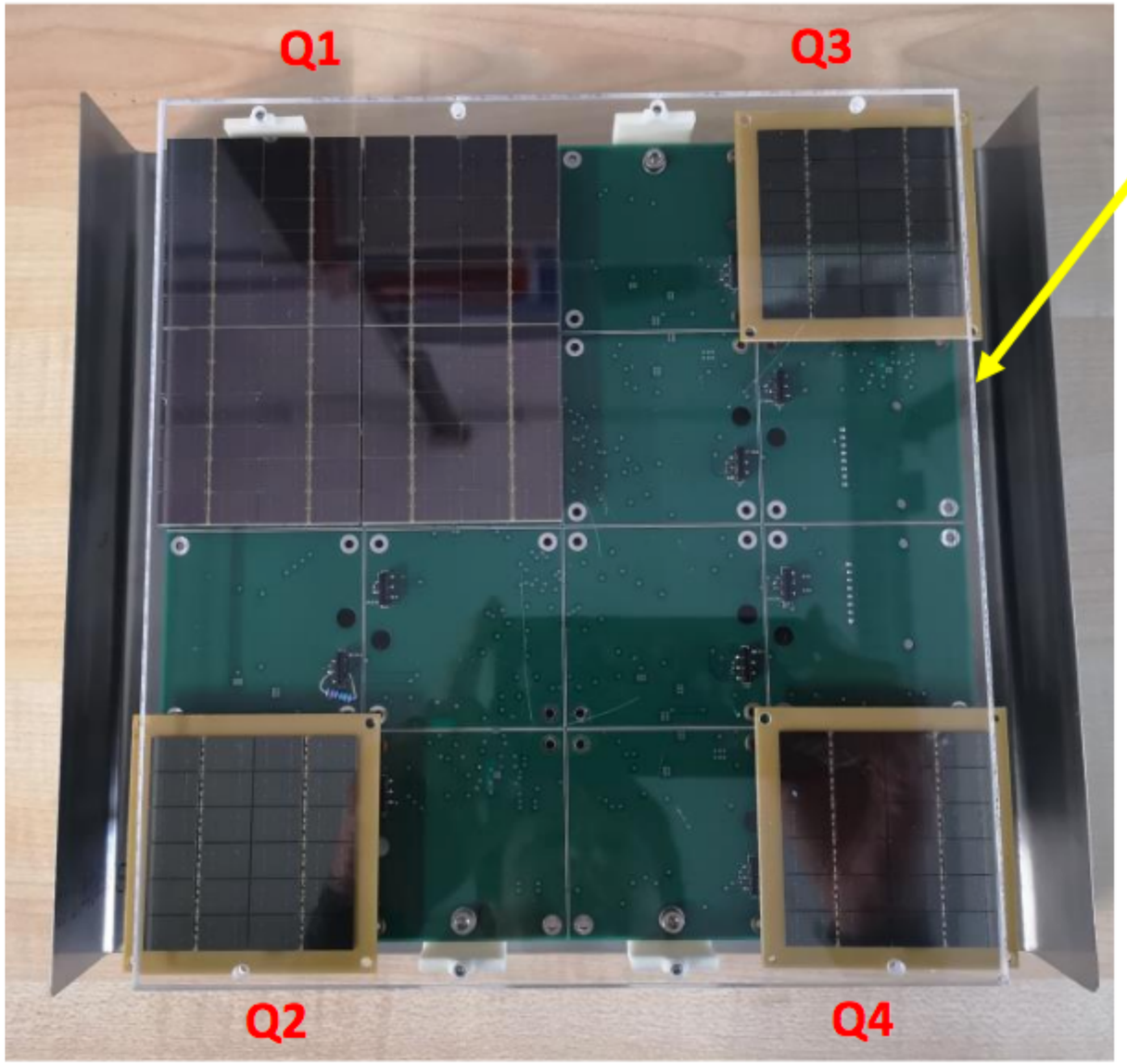
Veto schematic



Adapted from Santone, D., https://indico.cern.ch/event/797094/contributions/3367967/attachments/1827415/2991228/ds20k_santone.pdf

Tile integration





Adapted from Santone, D., https://indico.cern.ch/event/797094/contributions/3367967/attachments/1827415/2991228/ds20k_santone.pdf

Part 2 - Contributions

- Software
  - QR code reading, generation, tiling: database integration
  - Visualising SmartScope log files

- Tooling, handling techniques for edgeless veto tiles
- Numerous “Glue” and flux trials

- Manufacture of prototype tiles early in the project lifecycle
  - Early electrical and mechanical characterisation

QR Codes

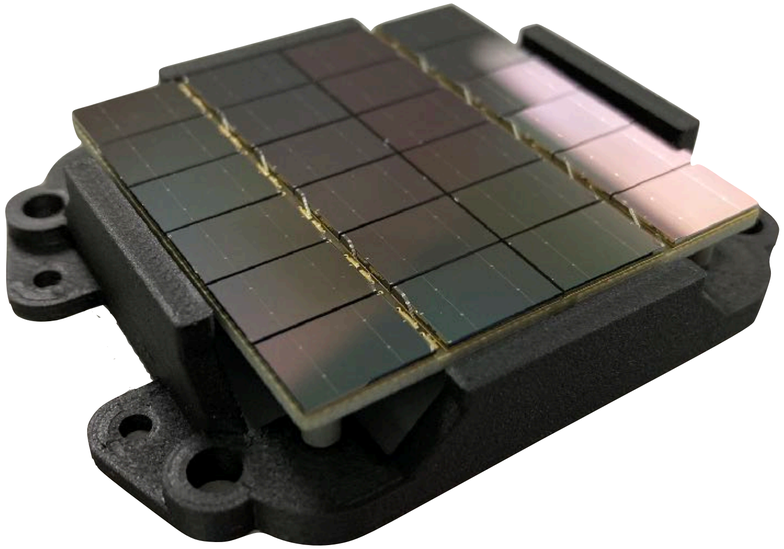
- Cross-platform software to read QR codes for use at all UK sites
  - Database integration
  - Packaged as a wheel for easy installation
  - Python, OpenCV [1]

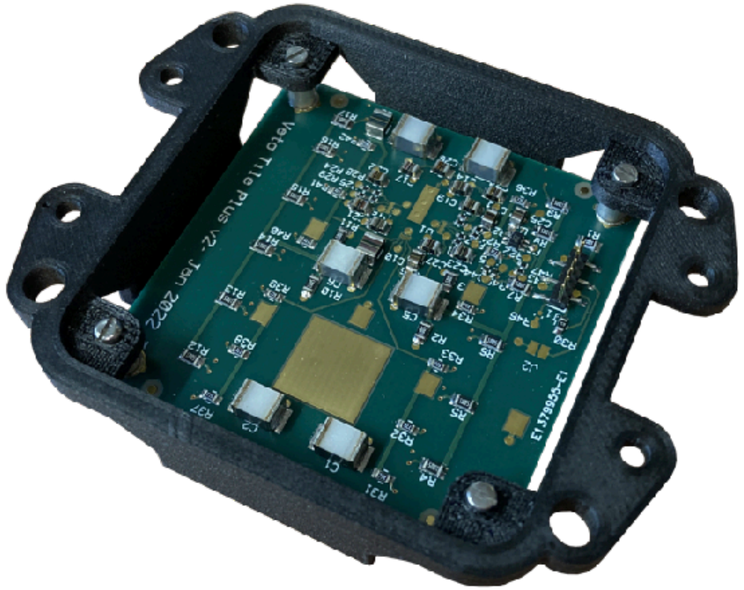
- Software to automate generation of QR codes for multiple PCBs
  - Etch a sheet of PCBs in a single operation
  - Python, qrencode [2, 3], ImageMagick [4]

[1] https://opencv.org
[2] https://fukuchi.org/works/qrencode/
[3] https://github.com/fukuchi/libqrencode
[4] https://imagemagick.org

Visual inspection, handling bracket

- **Allows scanning of the wire-bonded front-side**





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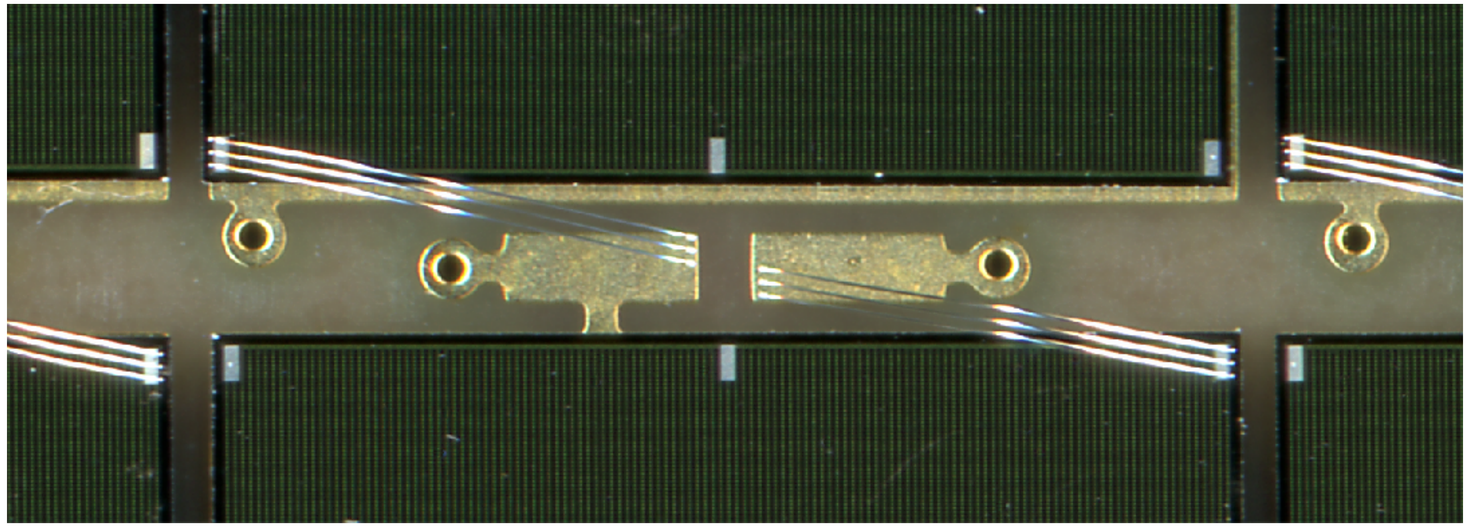
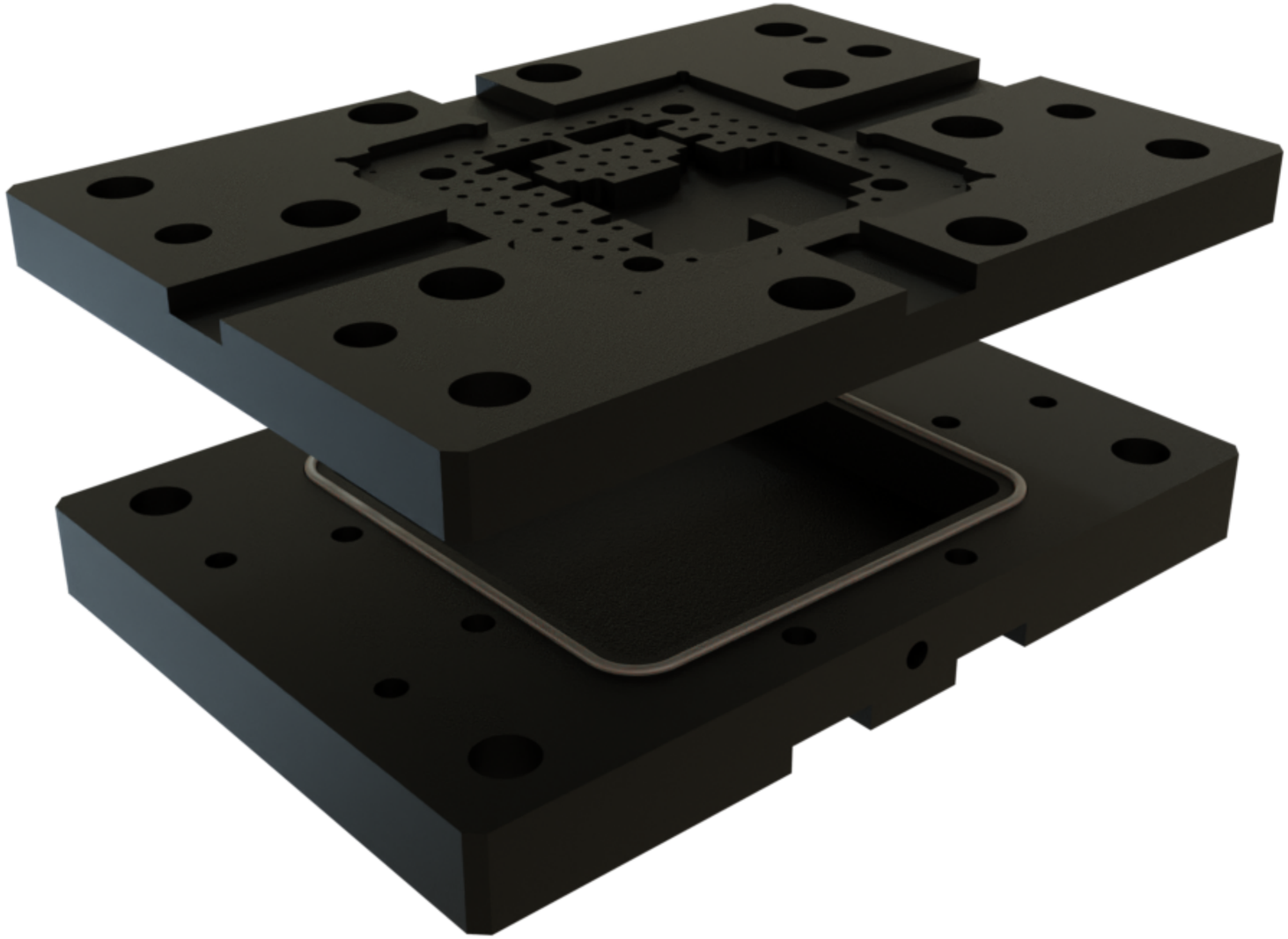
Visual inspection

- Automated inspection techniques underway (RHUL)
  - Can be tricky: specular reflections from wire bonds



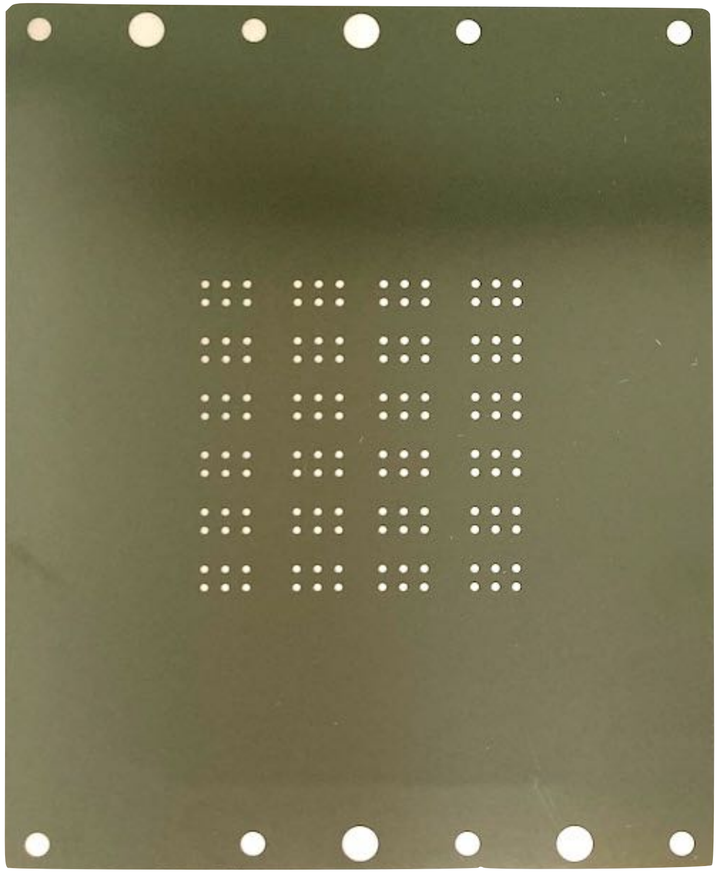
Vacuum tooling



Affords the ability to deposit solder and mount SiPMs with precision

13

Stencils



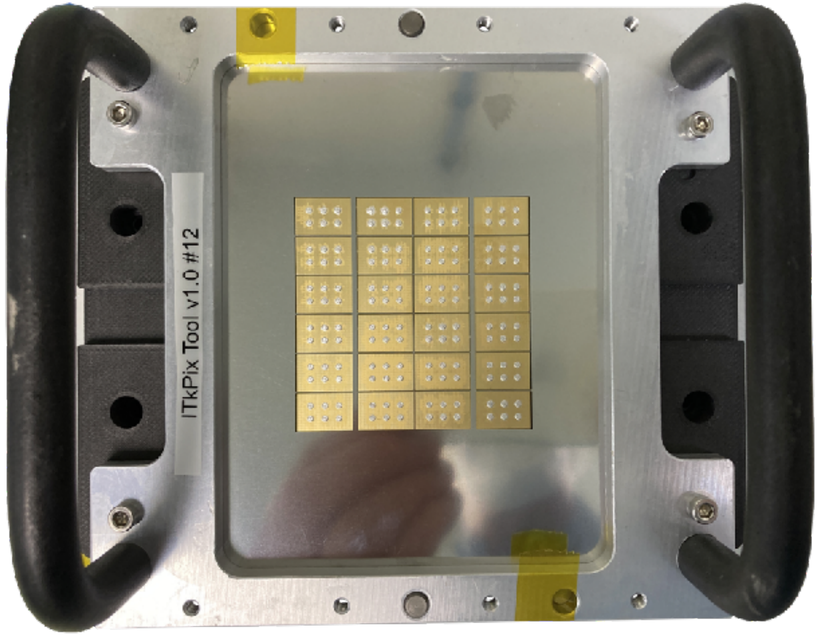
solder deposition
(laser cut)

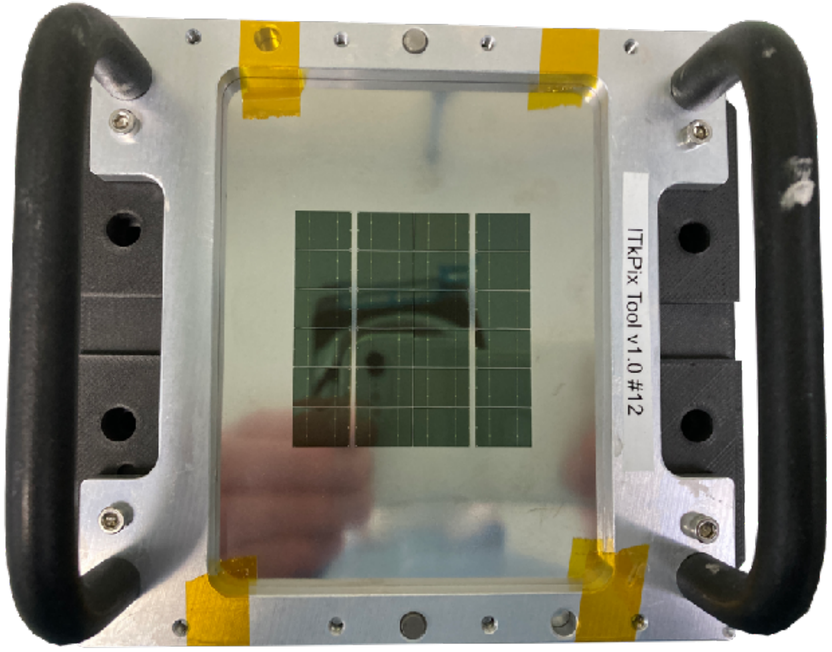
SiPM alignment
(chemically etched)

14

Front-side components: place SiPMs

- **Re-use of ATLAS tooling for solder deposition and SiPM alignment**





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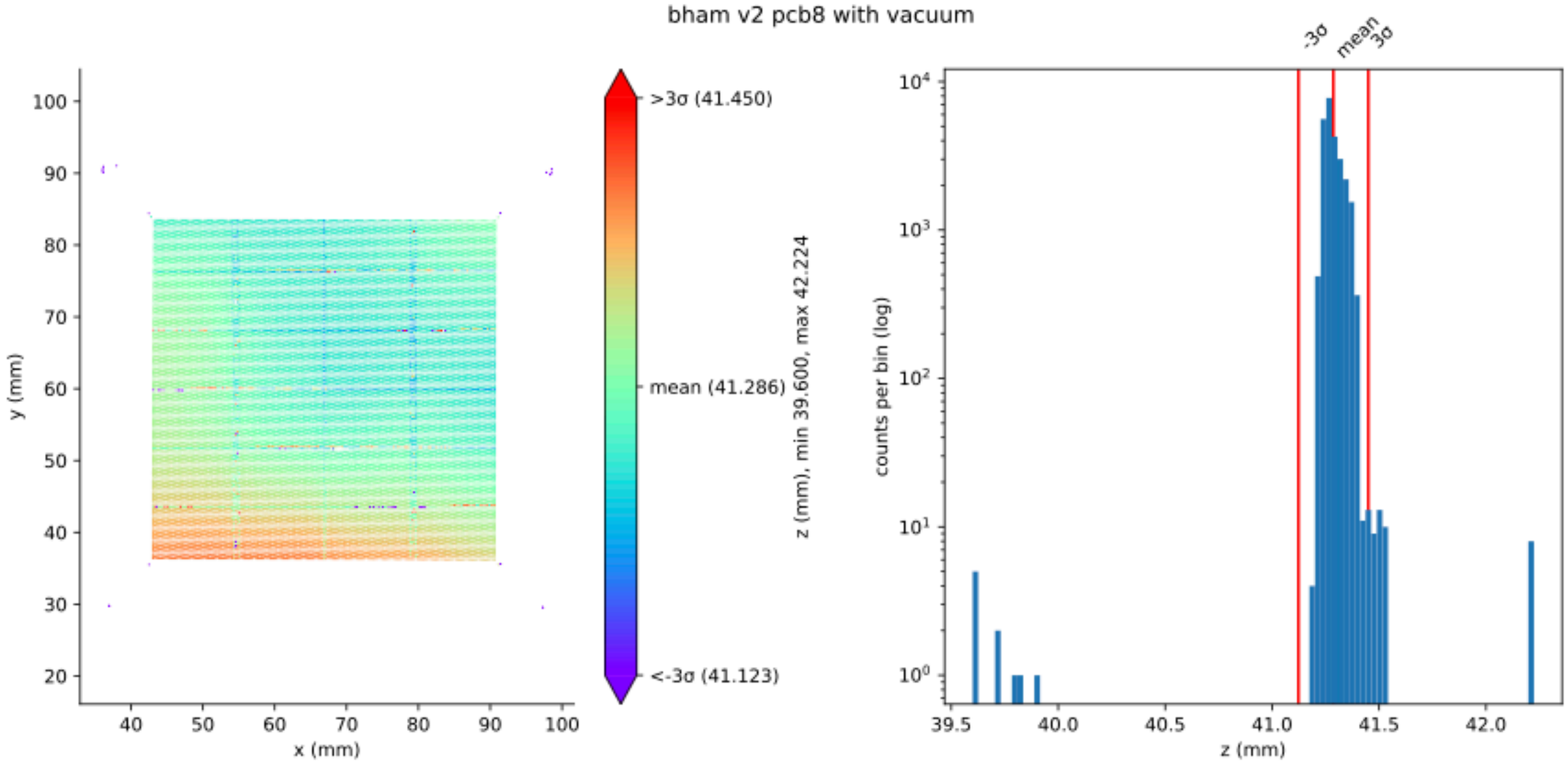
Metrology: front-side component flatness



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vPDU production and testing

DarkSide collaboration meeting - Sardinia, Italy
Wednesday 4th June 2022

Z. Balmforth[5], L. Boynton[3], S. Cross[6], P. Franchini[2], D. Hollywood[3], T. Jones[3], S. Hill[5], S. Jois[5], I. Katsioulas[1], S. Koulosousas[5], P. Knights[1], E. Leason[5], J. Lipp[6], O. Macfadyen[5], I.Manthos[1], J. Monroe[5], K. Nikolopoulos[1], D. Price[4], G. Rogers[1], D. Santone[5], D. Sim[3], P. Sinclair[3], M. Spangenberg[7], A.Taylor[3], J. Taylor[3], J. Vossebeld[3], M. Whitley[3]

University of Birmingham, 2. Lancaster University, 3. University of Liverpool, 4. University of Manchester,
5. Royal Holloway University of London,6. STFC Interconnect, 7. University of Warwick

https://agenda.infn.it/event/31211/contributions/172319/

Future

- Transition from manual to automated production for DarkSide-20k
  - Gantry system

- Work packages 2 and 3
  - LSDC detector assembly automation
    - Flip-chip bonder
    - New generation probe station

- UV-SiPM research

Backup slides

Two-stage assembly

Indium Corp.
52In48Sn, 118°C

2

130°C for 5 min
140°C for 10 sec

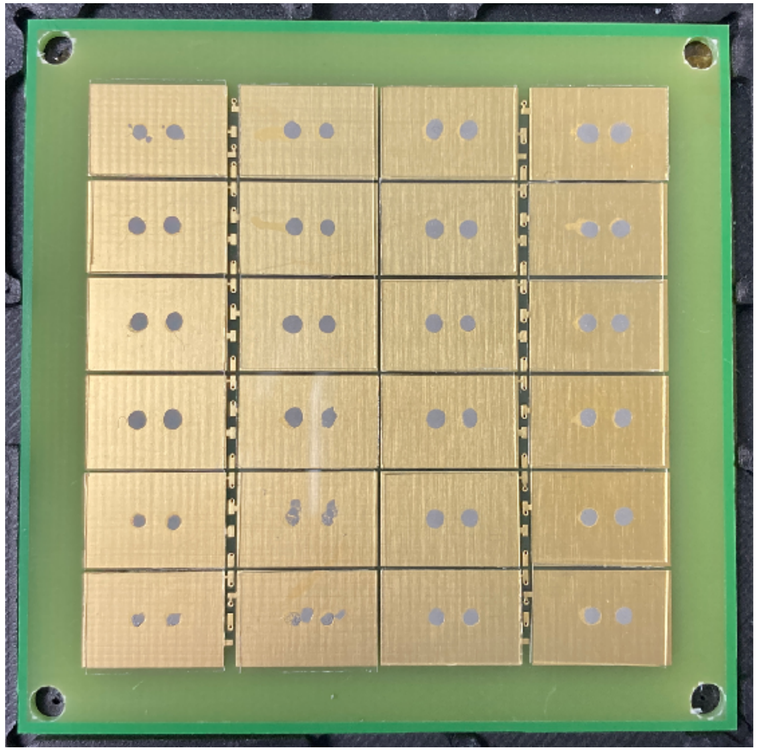
CHIPQUIK
42Sn57.6Bi0.4Ag, 138°C

1

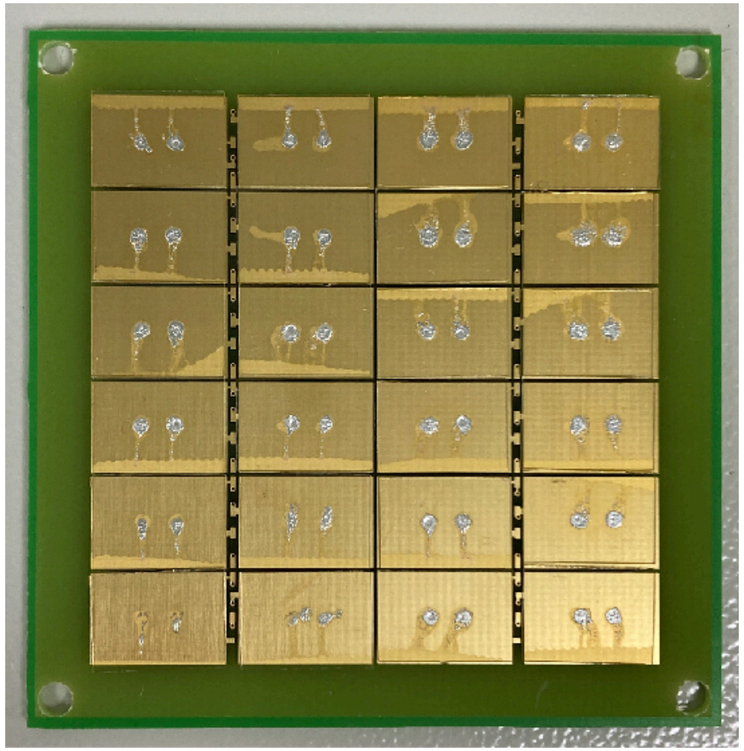
150°C for 5 min
200°C for 1 min

24x glass chips, flux dispersion

X-offset 1.4625mm



Pre-bake



Post-bake

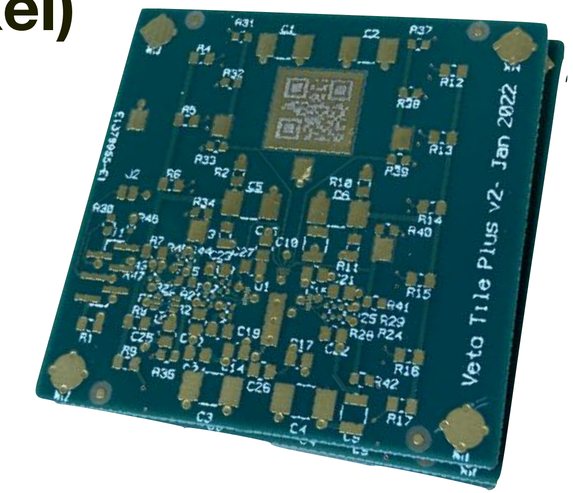
QR
etch

QR-codes

- Facilitates database integration
- Target: 1cm square copper/gold pad

- Selected solution: QR Code Model 2 Version 1
  - Widely adopted standard, readable on most devices/libraries

  - The minimum possible QR code matrix (21 x 21 pixel)
  - Maximum physical pixel size (~0.37mm square)
  - Maximum available error correction
  - Can store: 17 numerals (raw space: 72-bits)



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QR etch

QR-code data format

- **Human-readable contents: 2204080301234 5123**

Year	Month	Day	Production flag	Version	Serial No.	Part No.
YY	MM	DD	F	V.V	**SSSSS**	**PPP**
22	04	08	0/1	9.9	**99999**	**999**

- **Recent change from 9999/9999 to 99999/999 (S. No. / P. No.)**
- **Possibility to store more data with bit-packing**

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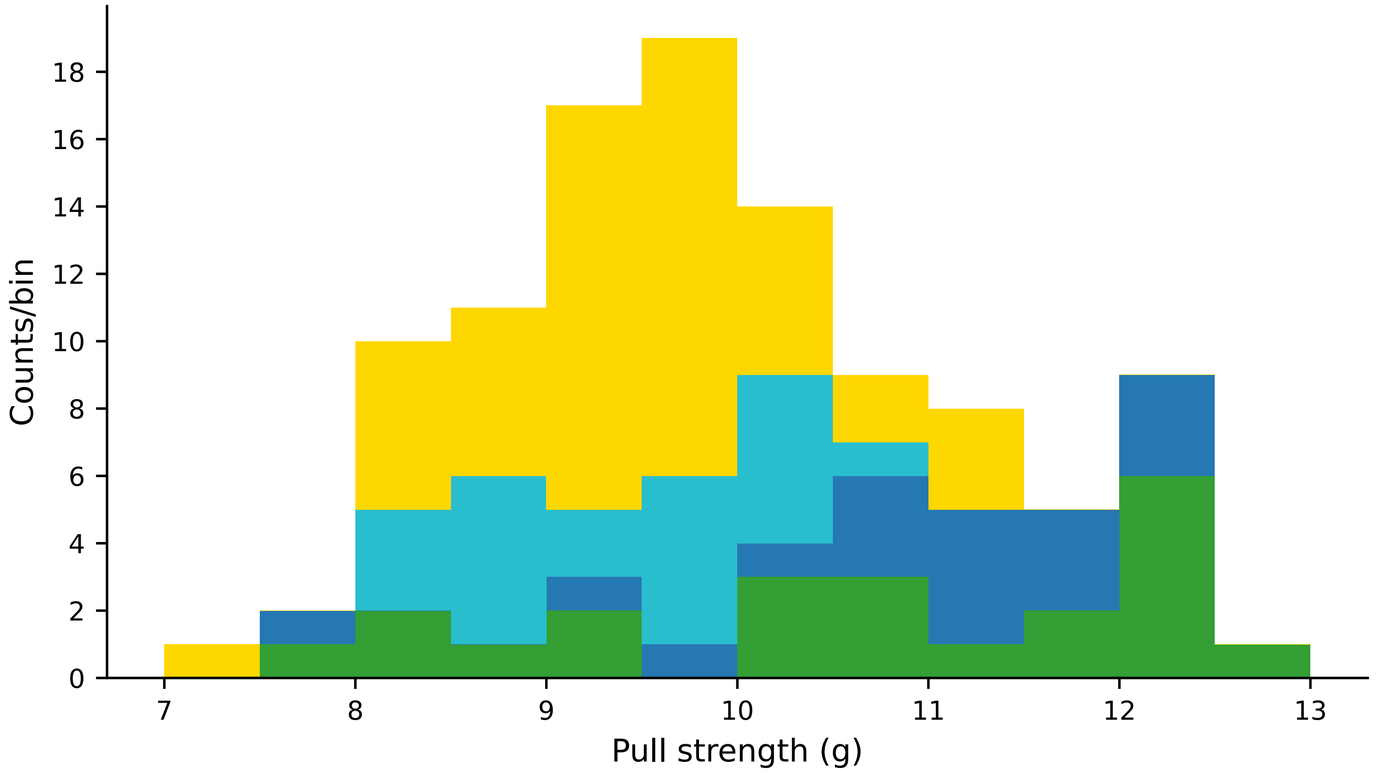
Wire-bond pull tests: strength



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Wire-bond pull tests: failure modes

Failure type	Tile5	990	1208	1226
0 = No Recording (user error)	0	0	0	0
1= Source Heel Break [A]	**14**	**8**	**19**	**37**
2= Dest Heel Break [B]	**8**	**9**	**4**	**10**
3= Source foot lift [C]	0	0	0	0
4= Destination foot lift [D]	0	0	0	0
5= Span Break [E]	0	0	0	0

[A] bond separates at the SiPM pad, [B] bond separates at the PCB pad,
[C] pad separates from SiPM, [D] pad separates from PCB,
[E] wire bond breaks

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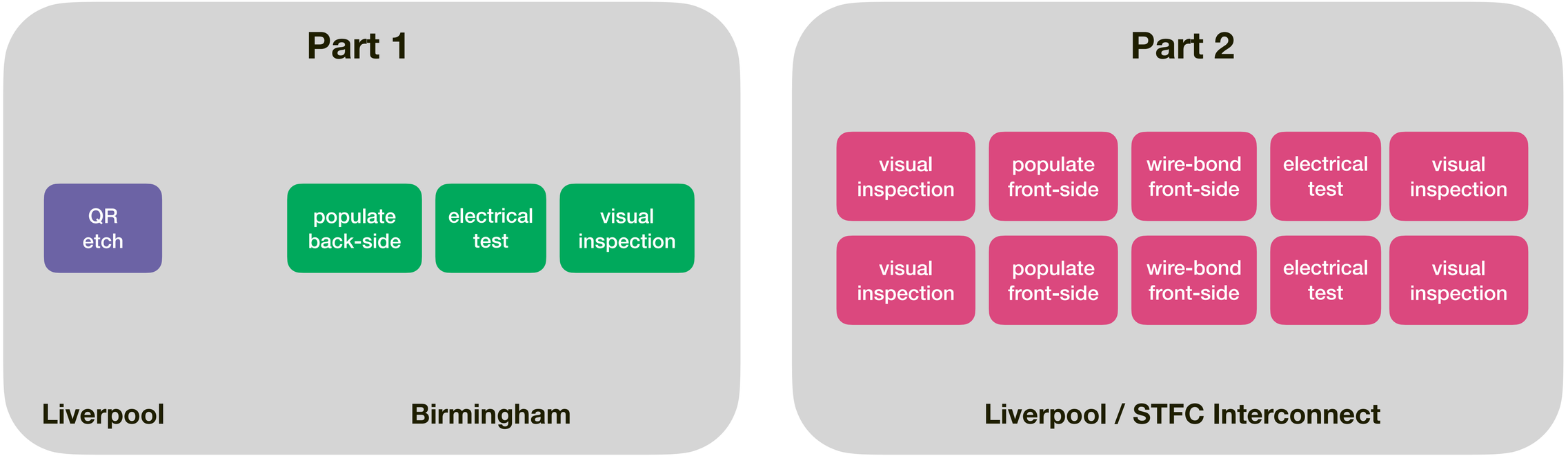
1. Abridged production pipeline



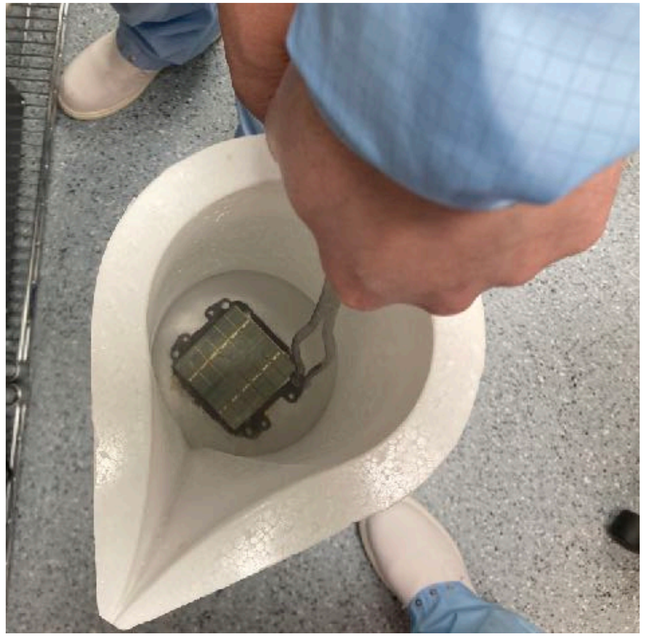
LN_2 dip

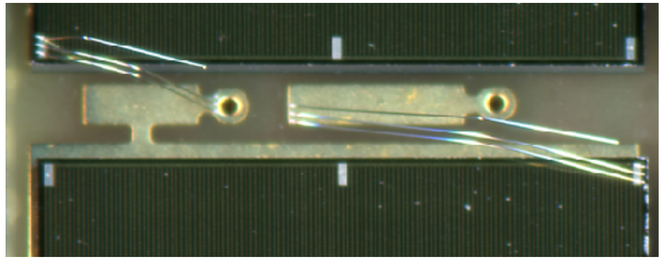
- Dip duration approximately 30 seconds, until boiling effect subsided
- Dipped parts were moved to an oven at 60°C with a nitrogen supply to avoid condensation formation

- Tests performed on:
  - BHAM vTile+ PCB 14, Gold-backed SiPMs, initial ¼ wafer
  - BHAM vTile+ PCB 15, Ti/TiN SiPMs, 3 wire bonds per pad

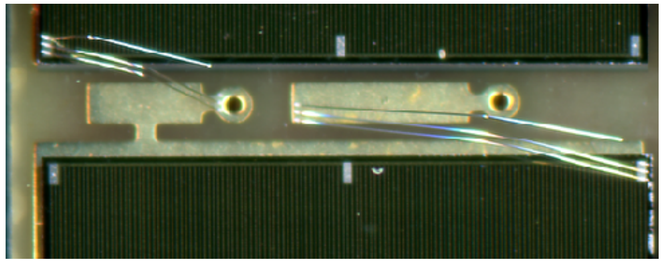
LN_2 dip

- **Positions of SiPMs / wirebonds remained unchanged during thermal cycling:**
  - **Room temperature**
  - **LN_2**
  - **Oven 60°C (nitrogen)**
  - **Room temperature**





PCB 15 before



PCB 15 after

populate front-side

Population - front side

- Manual (Liverpool)
  - Allowed manufacture of prototype tiles early in the programme
  - Solder and SiPM alignment stencil based assembly method
  - Aims to add gantry automation date TBC
- Automation (STFC)
  - Indium solder deposition (Asymtek)
  - Precision SiPM placement (FC150)
  - Application of pressure (FC150)

- “Low temperature” bake: 130-140°C - no component shedding

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UKRI Science and Technology Facilities Council

Further information

Kish, A., 2021, *DarkSide-20k dual-phase argon TPC for particle dark matter detection*

https://indico.cern.ch/event/1041835/