Industrial production of large area multiplexed detectors: status, applications & perspectives

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TIMELINE & EVOLUTION OF ACTIVITIES

1st tests of a MG1D-v1:
~90% efficiency in 1D

Aug 12

Development of genetic multiplexing

May 13

1st tests of a MG1D-v1-res (ELVIA)

May 14

1st tests of a MG2D-v1-res (CERN):
~95% efficiency in 2D

Aug 14
**TIMELINE & EVOLUTION OF ACTIVITIES**

Start of WatTo-1 experiment (220V):
- 1st MM muon telescope
- Static imaging validated

3 MG2D-v1-res (CERN)
⇒ 1st absorption muography

Dec 14

Start of WatTo-2 (solar boards):
⇒ Dynamic imaging validated

May 15

1st tests of a MG2D-v2-res (CERN):
- Less noise, better shielding
- >95% efficiency in 2D

Jun 15

Aug 15

Oct 15

1st deviation muography:
⇒ TomoMu instrument
**Timeline & Evolution of Activities**

1st meeting for ScanPyramids

- Nov 15
- Dec 15

1st MG2D-v2-res by ELVIA (x2)
- Issues on silver paste
- But work after repair!

3 new muon telescopes
- Apr 16
- 12 MG2D-v2-res
- ... incl. 8 from ELVIA!

1st live demo of TomoMu outside lab
- Jun 16
- Jul 16

Installation in Egypt
- 20 MG2D-v2-res

Completion of M-Cube setup:
- Oct 16
- 1m² muon scanner
- 34 MG2D-v2-res
- ... incl. 24 from ELVIA!!

1st discovery on Khufu pyramid

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main difficulty: top Copper (Y) strips, 100 micron thick (to allow for signal on inner X strips)

- First production lot had from 10 to 20 strip cuts on the top layer

Example with 18 cuts (detected during manufacturing)

Muon reconstructed positions in cosmic test bench

better and better quality in the latest lots (cleaner environment)

- N-2<sup>th</sup> production lot had around 10 cuts (0.1%, required value)
- N-1<sup>th</sup> production had around 5

change of the manufacturing process in 2017:

- Latest detector has 0 cut strip!
- Btw: Saclay bulk, 3rd place of birth for a MG2D-res
→ ELVIA does not have (yet) skills for this part

- Films manufactured by Rui’s team so far, can produce « easily » up to 100
- Now manufactured without interconnection between strips

→ Problem: resistivity had a tendency to decrease with time!

- Increase of the cluster size (up to 22 for last CERN lot)
- Results in problems during the demultiplexing (61 channels only…)

→ R&D started at Saclay workshop to produce these films

- First film had too low resistivity (cluster size in Y of 28 in average!)
- Waiting for new films with different resistivities to choose the optimal one
→ manufacturing requires silver paste line to connect resistive strips to HV contact

- Several defects in the first production lot
- Induced very localized shortcuts with the micromesh, visible with UV camera

→ Repaired by hand at Saclay a posteriori (painful & long)

→ Identified as badly cooked photo-imageable film (thanks Rui!)

- Fixed now, better cooking and additional thin Kapton tape on top (ELVIA)
→ all the processes are now well controlled, after early adherence problems on corners

→ Since 2016, all the bulk manufacturing is performed on the same site (Coutances)

→ No Karcher washing at the end, but last lots were operational without washing at Saclay
ONGOING PROJECTS: SCANPYRAMIDS

→ 3 missions since June 2016 (see Simon’s presentation)

Mission 1

Mission 2

Mission 3

• Internal probes (T,P,H from Yoctopuce) in mission 2 for better HV feedback
  ⇒ Thanks to Fabrizio Murtas (RD51 @ Aveiro)!
• Better gas tightness

Amplitude variation in mission 1

Amplitude variation in mission 2
ONGOING PROJECTS: M-CUBE

→ under tests since February 2017 (alignment of the 16 modules...)

- Systematic measurements of detection time for dense materials in container
- Investigation for low Z material detection
Gas tightness is challenging with these detectors:

- 2 meters of silicone seals…
- Bad Volume/Surface ratio

Overpressure (mbar) evolution in time (days)

⇒ Still some leaks (0.2 mL/h…)

Humidity evolution in time

⇒ Clear outgassing of PCB

→ Gluing of detectors?
→ Metal-metal sealing?

→ Pumping a la HARPO?
→ Other absorbers/getters?
→ Collaborations started with 2 industrials, including in civil engineering
  • *Several proofs of concept in preparation*

→ About 50 more detectors will be built soon (funded, 400 k€)
  • *MG2D-v3-res (lighter mechanics, less material in active area)*
  • *2 additional telescopes of 1 m² each*
  • *Manual flowmeters replaced by digital ones…*
  • *Ultimate goal: sealed detectors for ~ 1 year operation*
  • *M-Cube scanner upgraded from 1m² to 2m²*
  • *At least 3 more proofs of concept with other industrials & partners*

→ Plans to build a cylindrical TPC (prototype funded, 60 k€)
  • *2D multiplexing (see talk in MPGD15)*
CONCLUSION

→ Multiple projects have emerged from this activity in a few years

→ MPGDs (incl. elec.) are really robust and can cope with difficult environmental conditions

→ « Phase transition » of the development when industrial capabilities finally appeared

→ 10 m² of working detectors… perhaps the biggest Micromegas production so far?

→ Need to identify the best collaboration/structure to make all the PoC

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Thank you for your attention!