Sealed mode gaseous muography detector

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HUN-REN Wigner Research Centre for Physics

3rd DRD1 Collaboration Meeting

MINE.IO
A Holistic Digital Mine 4.0 Ecosystem

MŰEGYETEM 1782

NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION OFFICE HUNGARY
PROJECT FINANCED FROM THE NRDI FUND

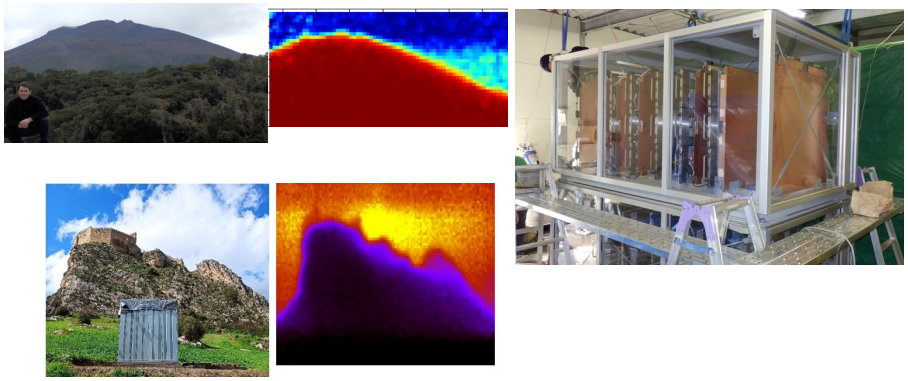
All colors of Physics

Overview

- Cosmic muon imaging: an expanding interdisciplinary field, strongly relying on hardware developments
- Gaseous detectors: continuous gas supply is an issue (safety, logistics, complexity…) “sealed mode operation” worth a study (WP9)
- Now: **report on 6 weeks continuous (underwater) operation** of an MWPC-based tracking detector

Motivation of a sealed mode detector

- Low gas consumption is anyway good (e.g. 5l/day demonstrated outdoors)
- Sealed mode: see e.g. **LIP (A. Blanco)** developments on **sealed RPC!** (presentaton at previous DRD1 CM)

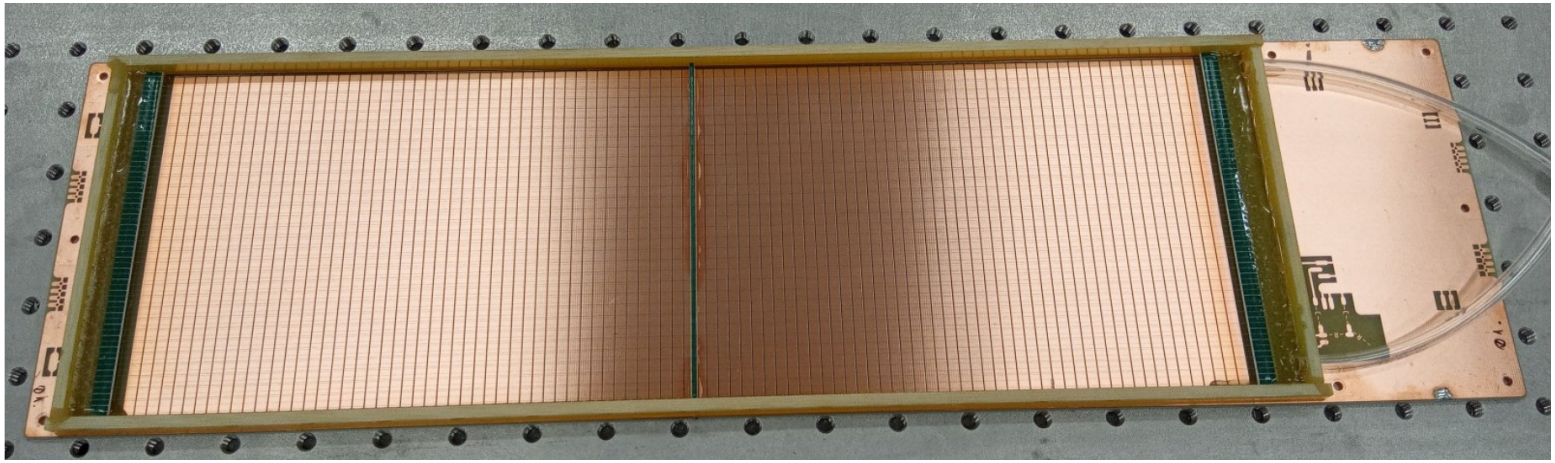


- “Borehole detectors”: overcomes the limitation of accessibility
- Many boreholes, or interesting targets are underwater

G. Nyitrai, J. of Applied Physics 129, 244901
L. Olah, Sci.Rep., Vol. 8, no. 3207 (2018)

- **Can one make an underwater-capable imaging detector? MINE.IO HEU project objective to study flooded mines**

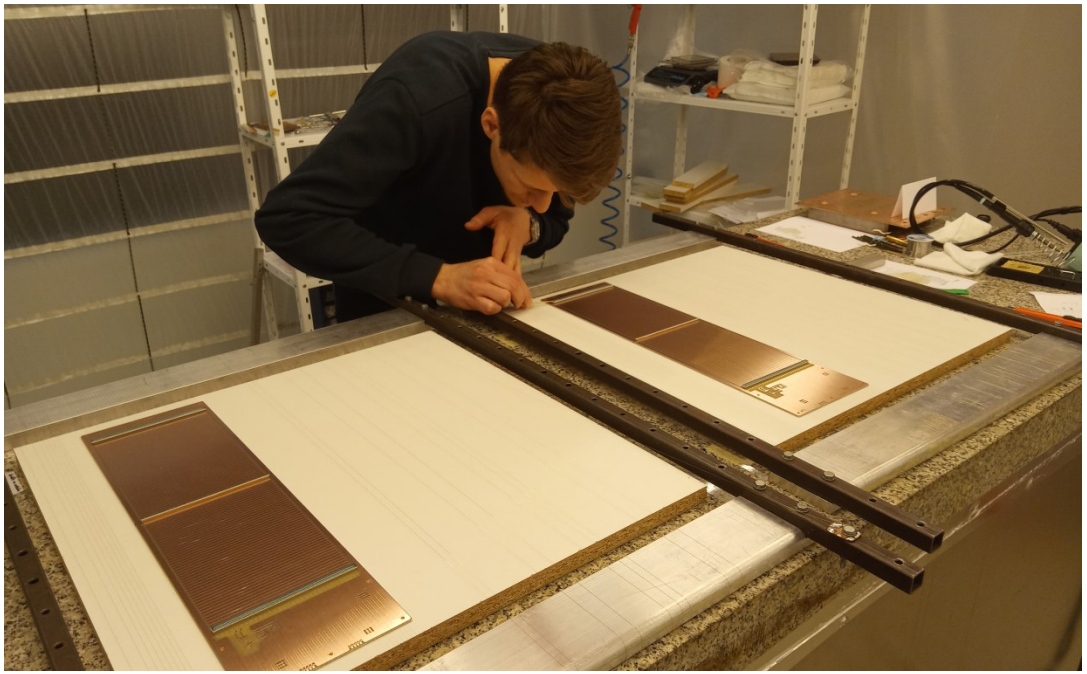
Very conservative MWPC design

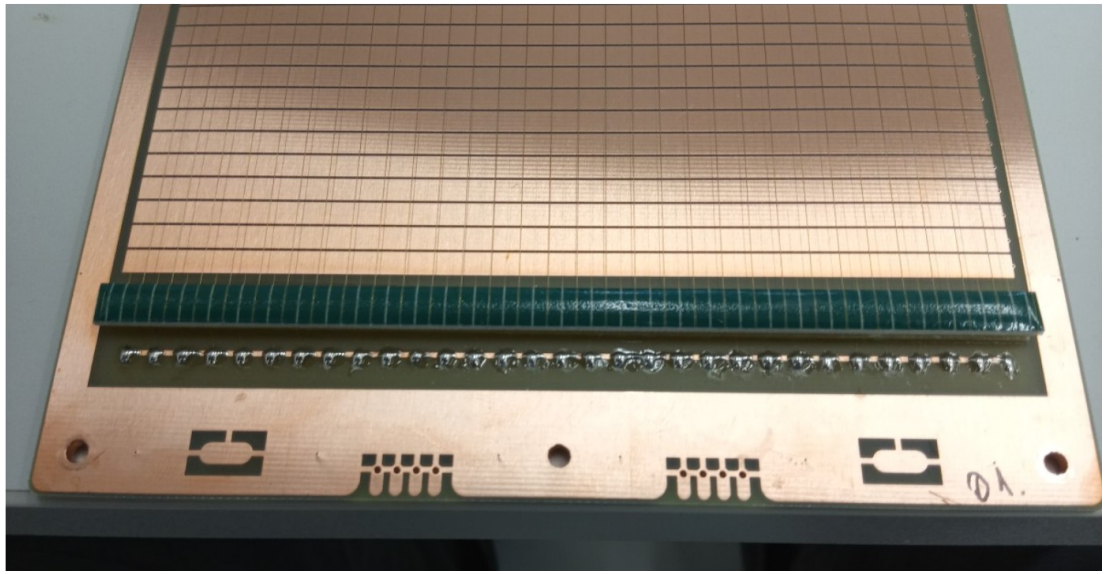


- 32 wire pairs (32 field-wires and 31 anode wires)
- 96 cathode strips : 128mm x 384mm sensitive area
- 4mm wire spacing
- 3.5mm wire-strip distance
- 8mm gas gap

Construction process

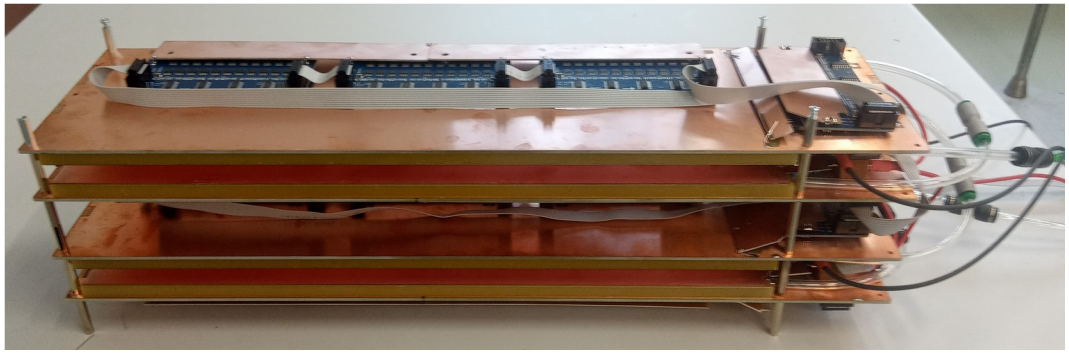
- Glue: Araldite AY-103-1 (HY991), seemed fine for up to 50 degrees
- All frames from G10, glued (no disassembly)
- Wires glued to support, then soldered. All connectors covered with glue
- Gas tubes PU 6mm



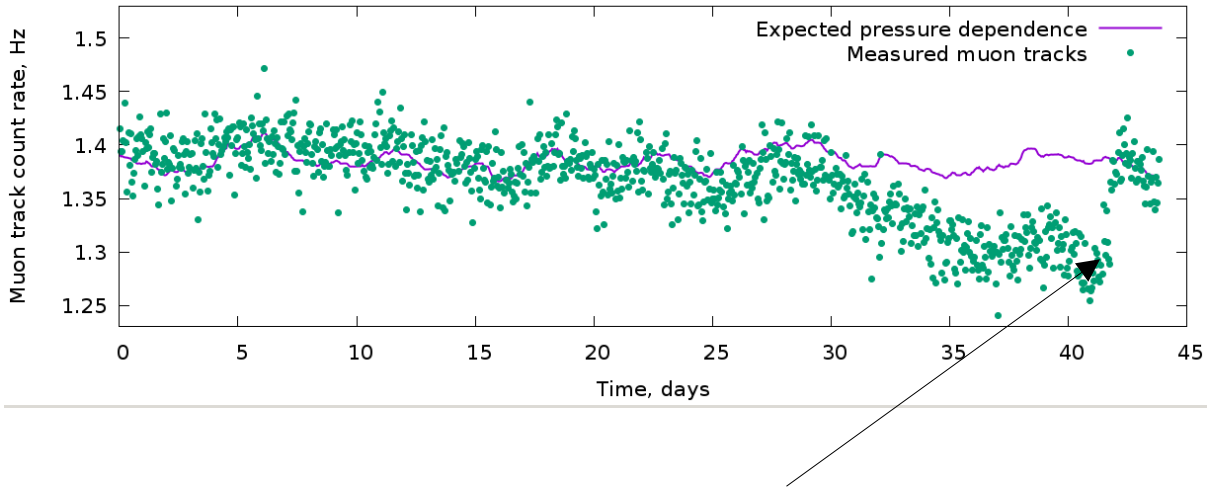


Laboratory testing in sealed mode

- Input closed
- Output with 6m long PU tube (pressure inside detector follows ambient)



- Detector was running **in sealed mode for 6 weeks**! Track rate drops by less than 10%

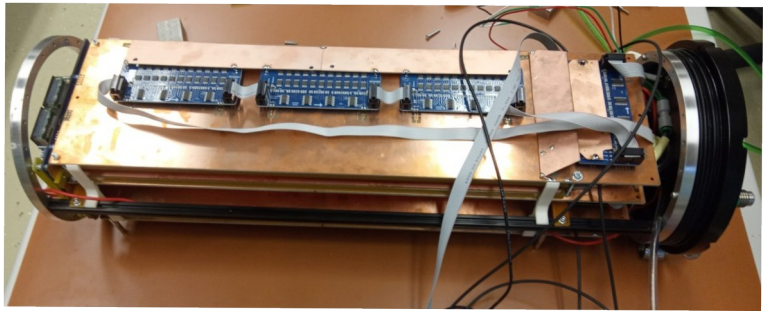


Gas restored

Watertight vessel (INESC TEC, Portugal)

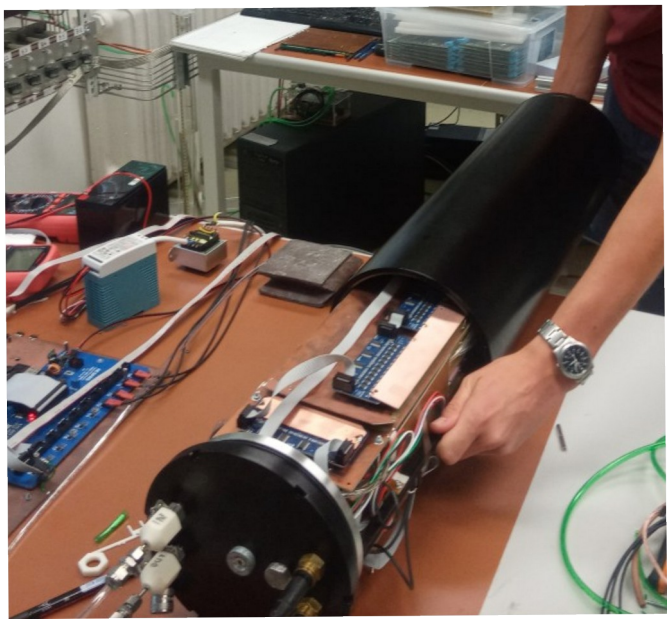
- Detector chambers, electronics, **High Voltage unit** in working gas atmosphere

  (Ar+CO2 82:18)



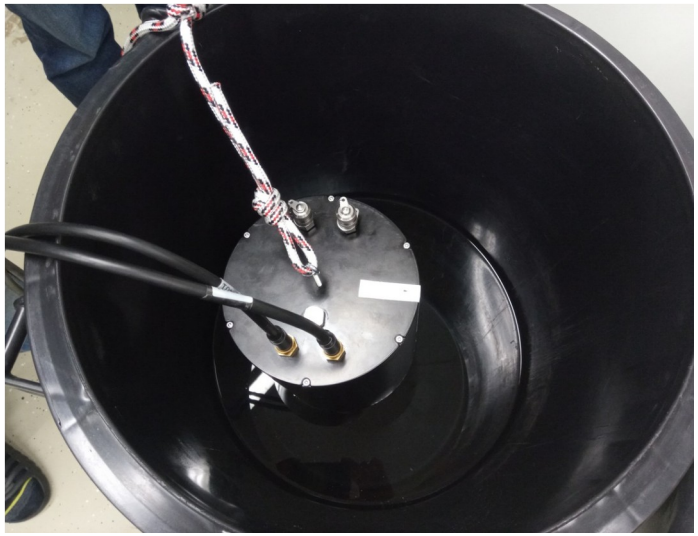
- HV 1400V

- Gas enters chambers, then 2m pigtail, then fills cylinder



Underground / underwater testing

- Tunnel at 20m depth (18m overburden)
- Immersed in water tank (1m depth) the whole object has density around 0.85
- Fully sealed mode since leaving the laboratory
- Cear 4-point tracks



Cathode strip signal

Field wire signal

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Event 5640000 ,   2024-12-09_22:23:12 ,  dt : 1315903
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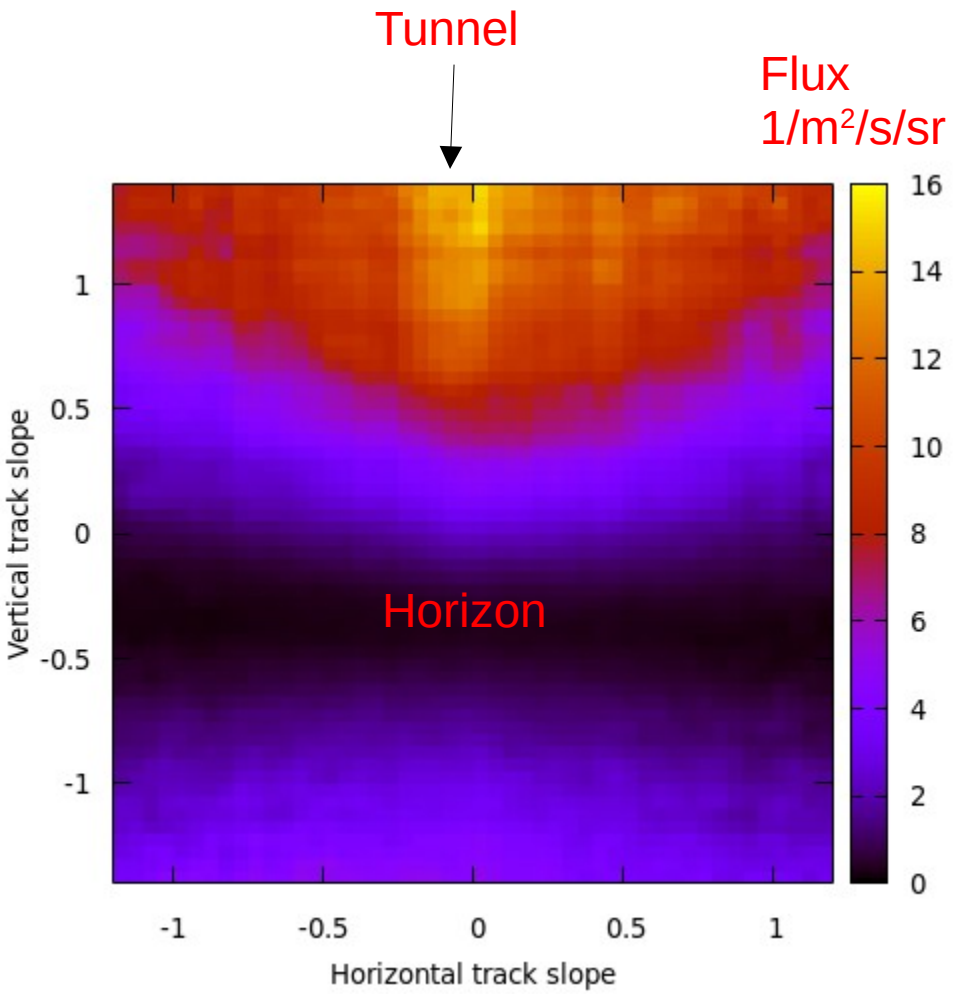
Adc :    1988     2024     2772     2196
THP :  Thp: T= +15.50 oC, H= 26.0 %, P= 941.0 mBar, ThpId: 0
```

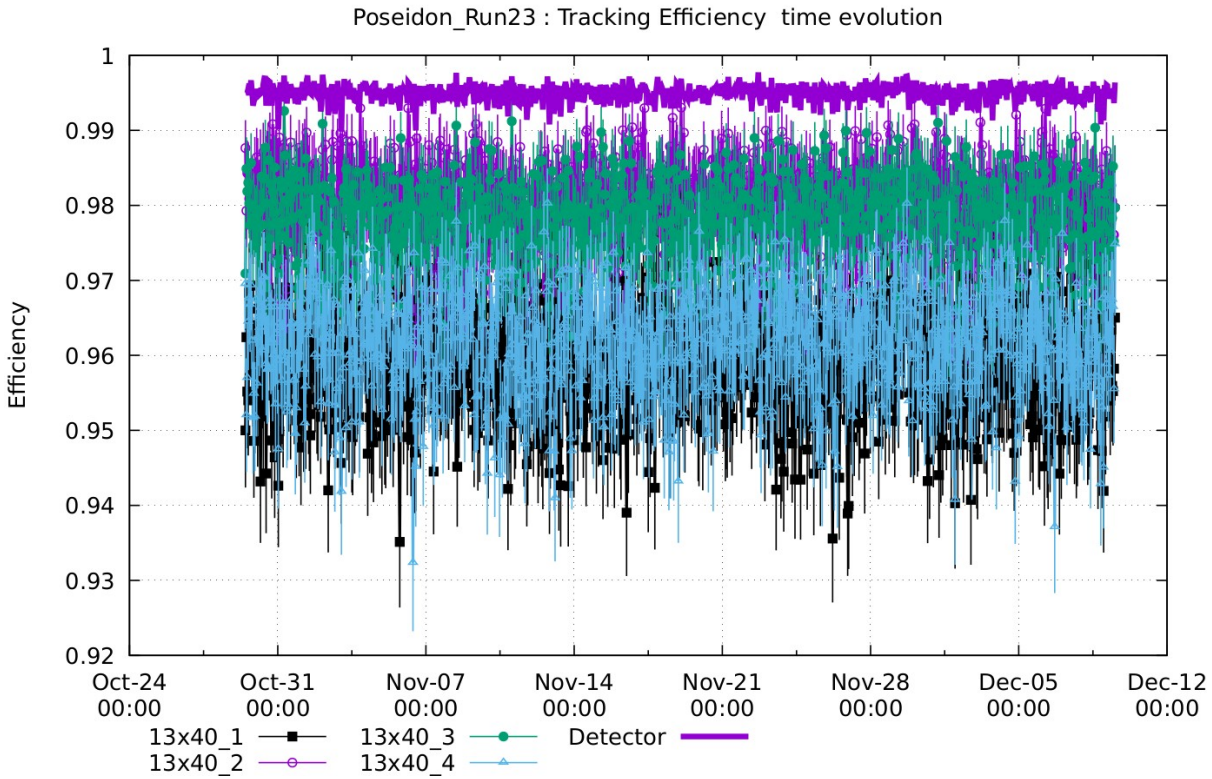
Image of 10m-level tunnel from 20m depth

- Muon flux shows no background (horizon appears clearly)
- Figure: tan(angle) of tracks in both directions, in detector coordinate system
- Typical flux 15% of surface flux



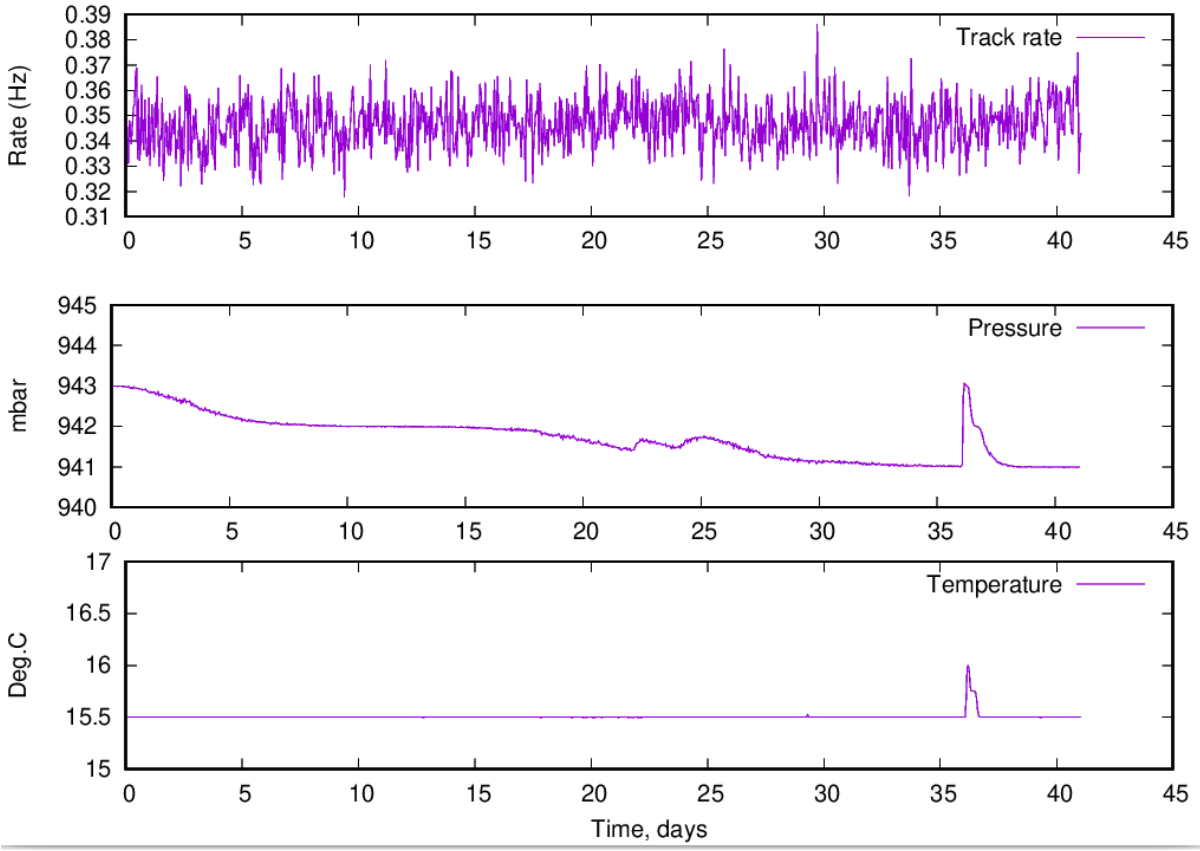
Stability of tracking efficiency

- Single chamber tracking efficiency stable at 96-98%
- Tracklets with 3 points above 99%



Stability of track rate, pressure, temperature

- 20m underground temperature is constant; closed container: no pressure change
- Track rate constant (small ambient pressure dependence expected)



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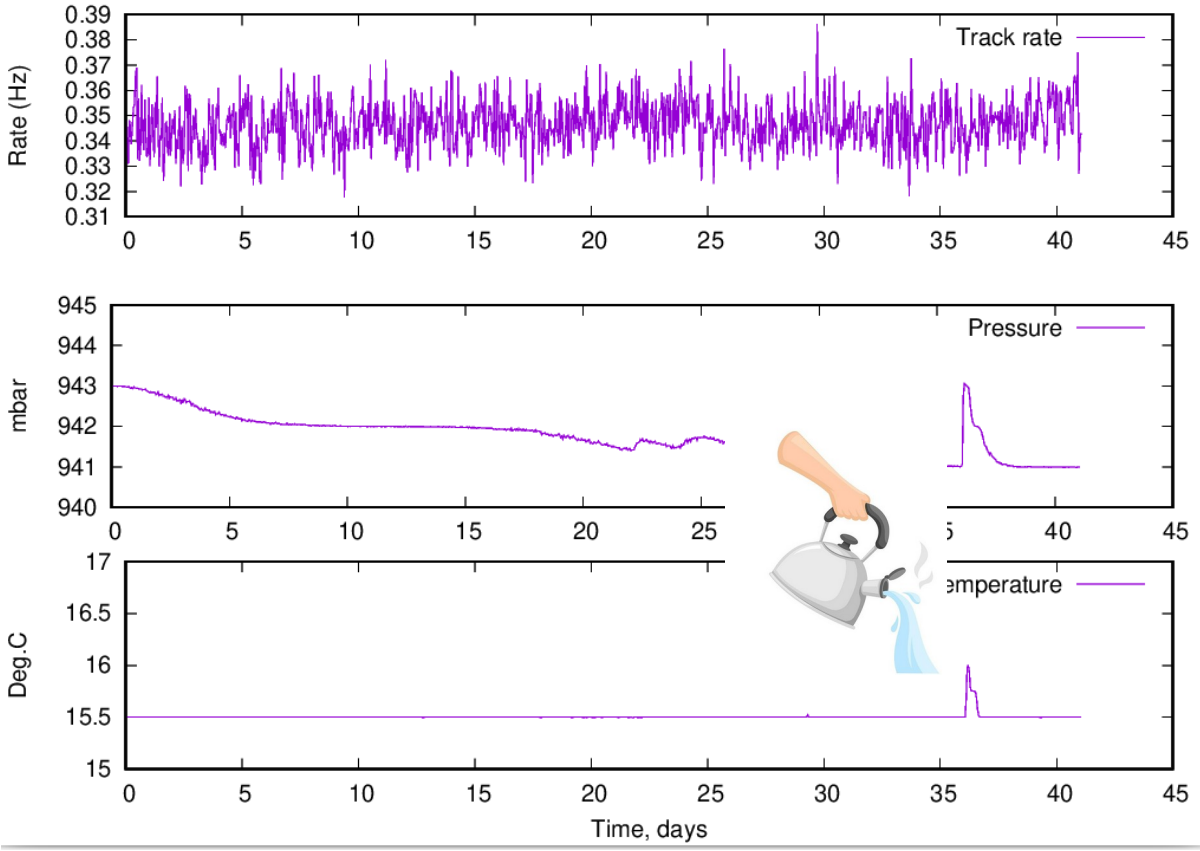


Conclusions

- Gaseous detectors continue to be viable options for BHEP applications, particularly cosmic muon imaging
- Low flow / Sealed mode operation continues to be of interest, in combination with sufficient quality tracking
- Possible solution for an underwater (borehole-like) detector was demonstrated with imaging capability at 20m depth, operation of 1.5 months (keeps counting)

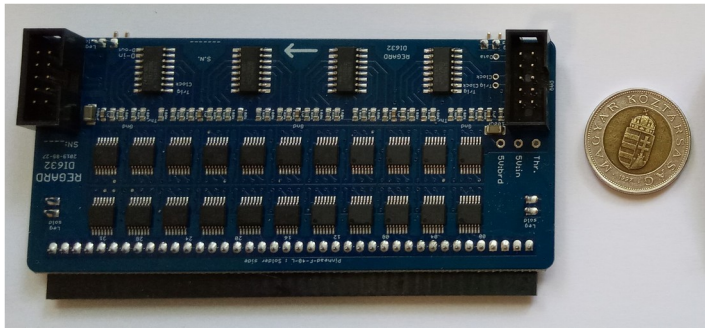
Backup

Readout: custom designed front-ends

Power consumption below 2 mW/channel,
cost below 2 Eur/channel

No ADC: common discrimination threshold

32 channel, serial readout



single channel trigger + ADC, serial readout