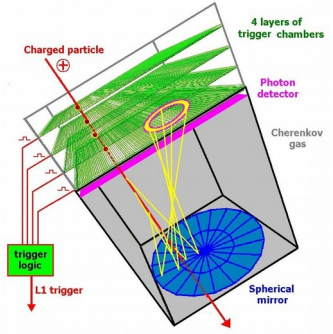
MWPC / CCC option for MuonID

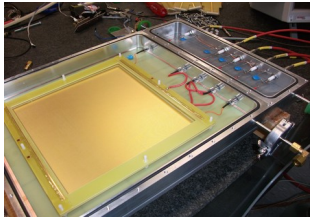
dezso.varga@cern.ch et al for Wigner RCP ALICE group,
contributions from G. Bencédi, G. Barnaföldi, G. Hamar, etc.

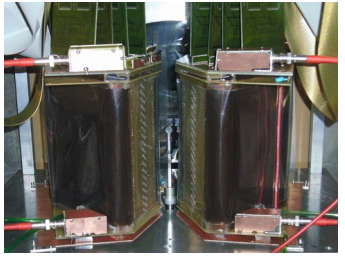
- MWPC-s well understood for over five decades
- **High efficiency, low cost** (relative to scintillators or RPC-s) – reasonable time and position resolution
- Should tolerate modest B-field.
- **Gas**: non-flammable, non-greenhouse gas (unlike RPC-s): Argon+CO_2 mixture (typical flow 1 litre/hour for 1 m^2). **No aging**
- **Rate capability**: Expected 0.1kHz/cm^2, MWPC-s 100kHz/cm^2
- High voltage conveniently below 1.7kV
- Available earlier experience (see next slide)

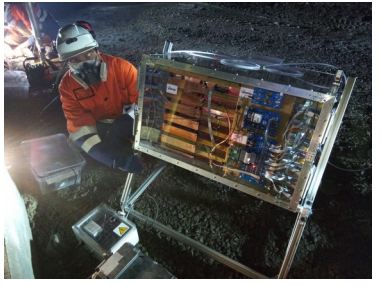
Experitise and Capabilities at Wigner RCP

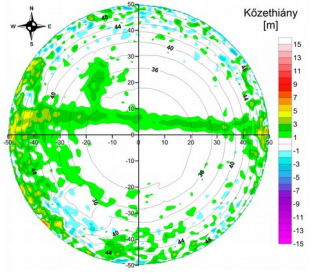
- ALICE VHMPID + HPTD :
  Tracking d. + Cherenkov d.
- ALICE GEM TPC :
  GEM QA, Uniformity scan
- NA61 LMPD :
  TPC for backscattering
- Muography : imaging hill-sized objects via measuring the absorption of cosmic muons
- Gaseous det. lab.,
  Clean room, Construction hall

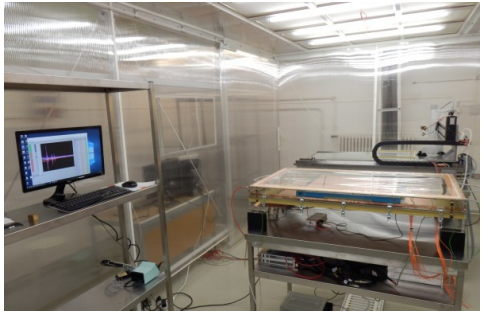


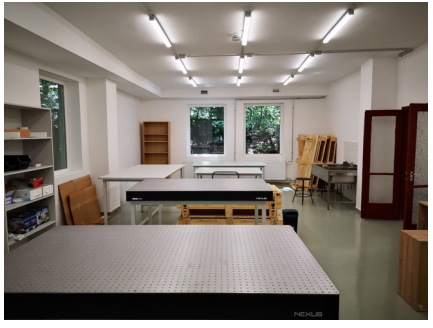






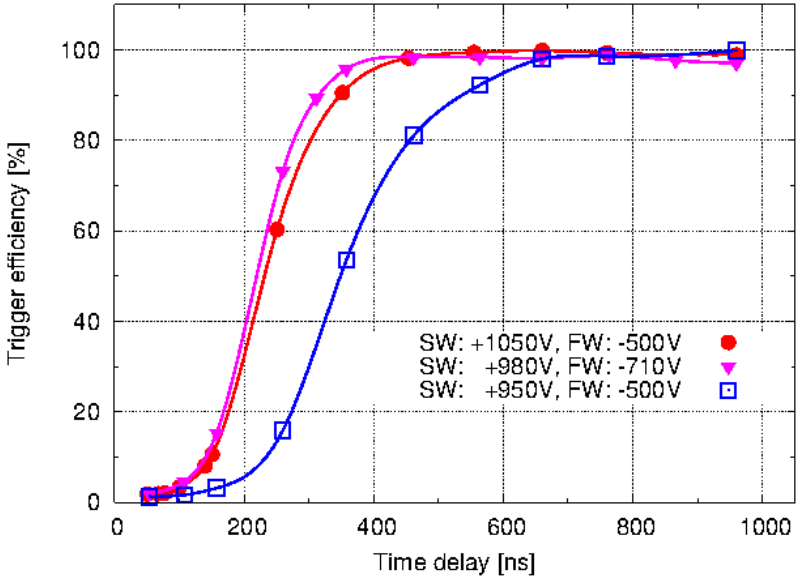






Option A: Close Cathode Chamber – available beam tests, results

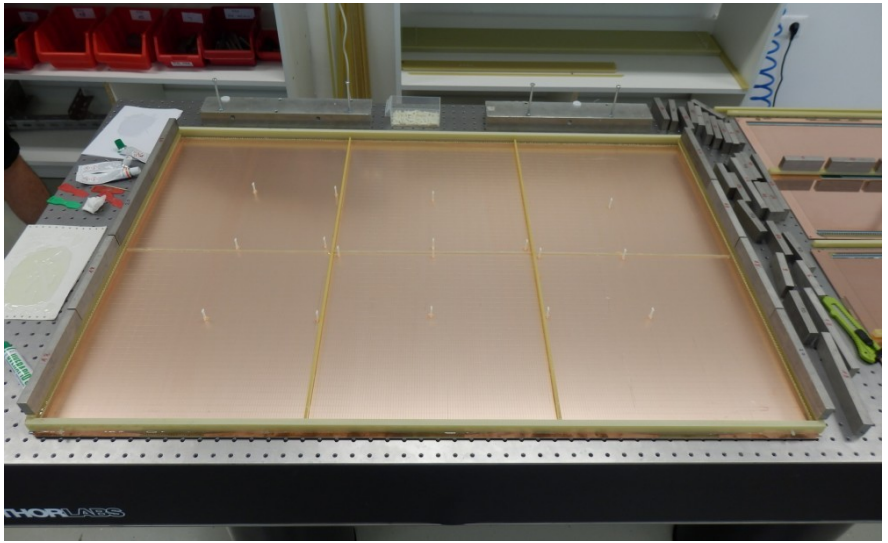
- Easy construction, **high (>99%) single layer** efficiency. Time resolution <200ns
- Position resolution better than 5mm (if needed)
- Approx. 12kg single layer weight (per m^2)

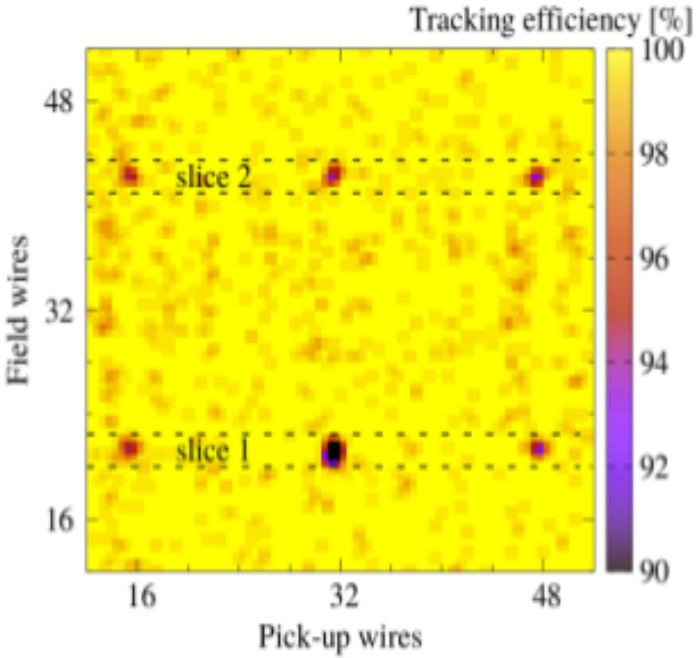


NIMA 698 (2013) 11.
NIMA 639 (2011) 274.
NIMA 648 (2011) 163
Nucl.Phys. Proc. Supp. 197 (2009) 296

Option B: Standard MWPC-s: robust option

- If conditions favour conventional MWPC-s, technology from cosmic muon imaging
- More than 120 m^2 produced by now. 12 mm segmentation in 2D. Weight 15kg /m^2



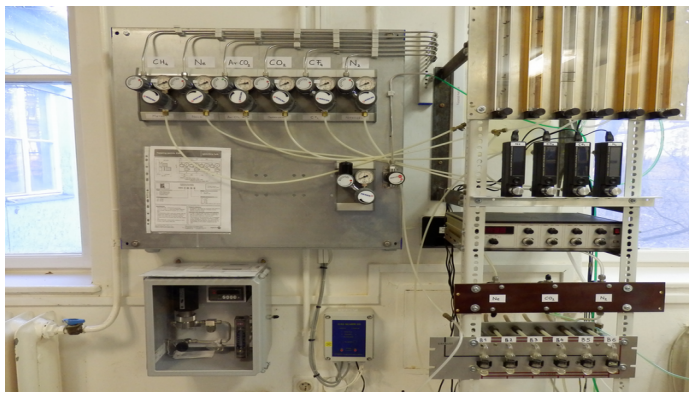


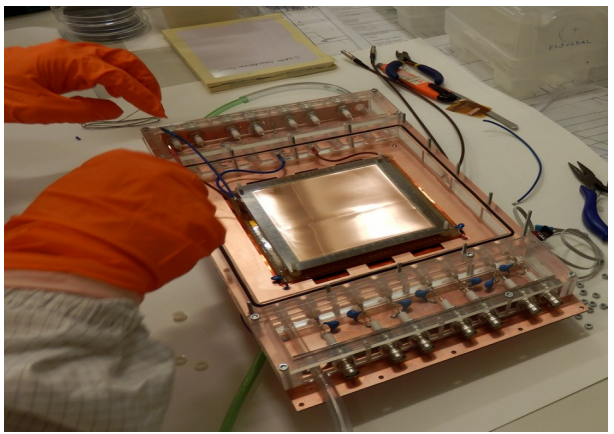
Eur. J. Phys. **36** 065006 (2015)
arXiv:1607.08494, AHEP
Scientific Reports, Volume 8, Article number: 3207 (2018)

NOTE: above 99% efficiency!!

Vesztergombi Laboratory for High Energy Physics

- Coordinated allocation, maintenance and improvement of the laboratory infrastructure
- Both internal and external “users”
- Lab spaces, gas systems, expertise
- Underground laboratory (10-20-30m)
- Electronics, readout, HV supplies, ...



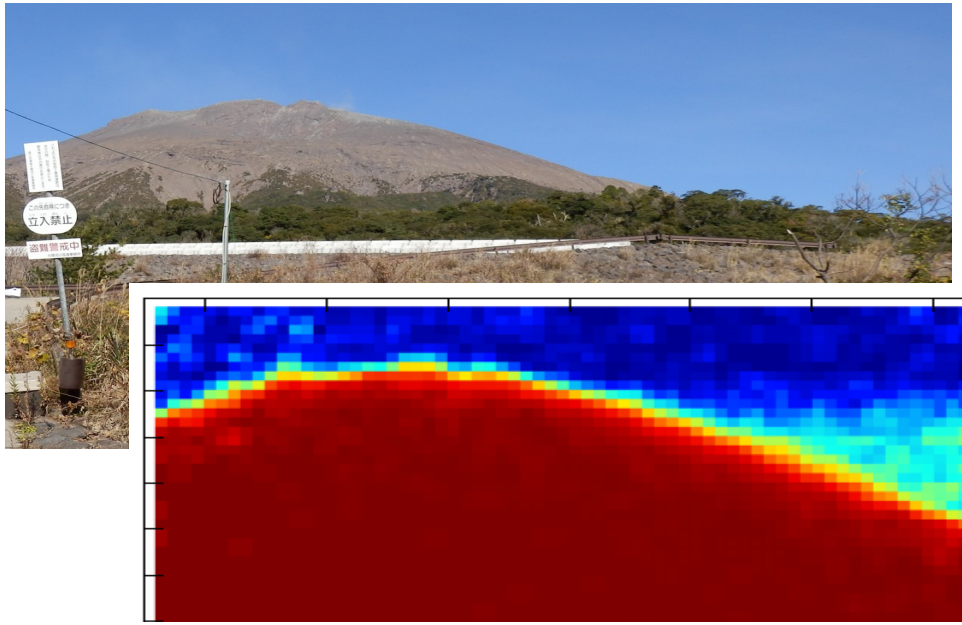


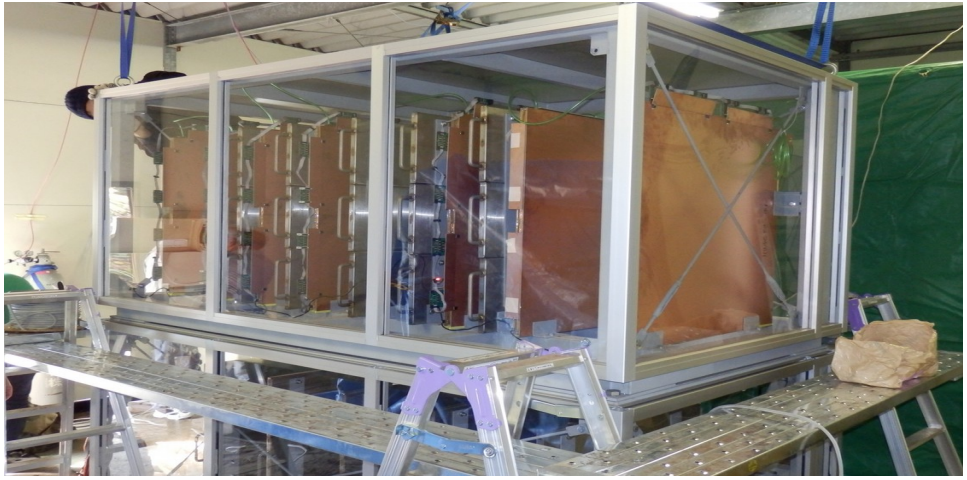
Laboratory environment

- Expansion completed by early 2022
- High production rate (2-4 m^2 / week) as of now

Application and tech-transfer highlight: Sakurajima Muography Observatory

- Currently running at Sakurajima (Kyushu), funded and managed by University of Tokyo. Joint patent (2016) licensed by NEC Corporaion. **Now total 8 square meter**, the world's largest



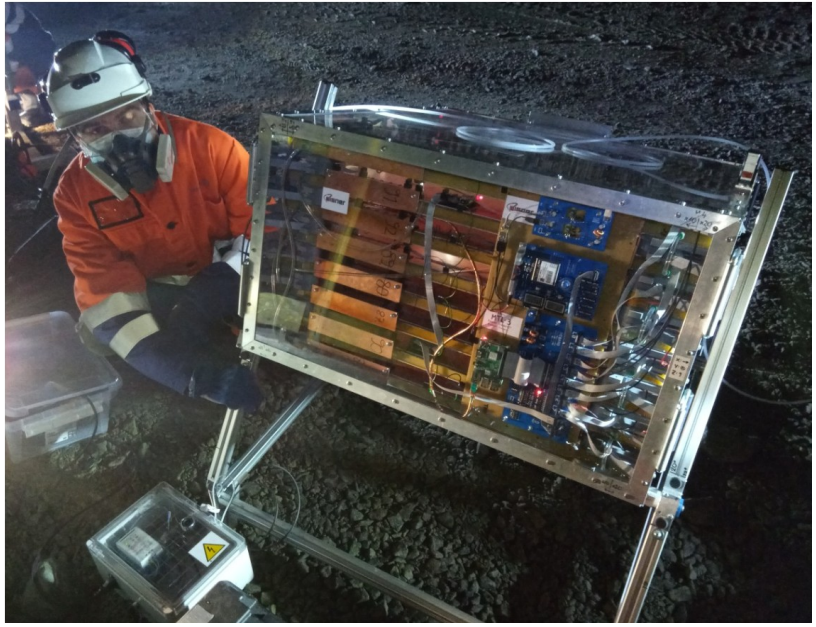


Patent: H. Tanaka, K. Tarou, D. Varga, G. Hamar, L. Oláh: Muographic Observation Instrument, Japanese Ref. No.: 2016-087436, date 25/04/2016, PCT WO2017187308A1

Tracking system for underground muon imaging

From lab…

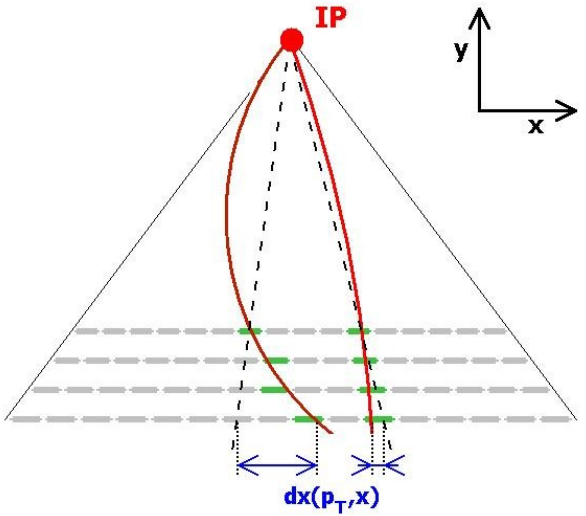
… to an operational mine



Development of Muographic Instruments: Outstanding Project financed by NRDI Fund

Practical realization of MuonID w. “tracking”

- Total net area 180 m^2: may be 3 layers with MWPC (540m^2 total detector area)
- Multiple layers and 1cm position resolution enables **“tracklet” pattern recognition** – suppression of leaking hadron showers
- **Simple and low cost electronics** allows high number of channels (144k ?)
- Suggestion for testing: test chambers within the present ALICE environment, at an analogous position!



Low vs. high pT

What timing information is needed?

- Hit rate (from A. Ortiz, UG week): **9 (4) Hz/cm2 pp (PbPb)**
- Single channel rate (100 cm2 segmentation): **0.9 kHz**
- Time resolution **1** (0.2) microsec **most pessimistic** (realistic)
- Occupancy: **0.1 % per event** (0.03% realistic)
- Note that the steel absorber rejection is higher than this!
- This is with NO UPGRADES, using optimized DAQ can reach considerably better if needed (presently seem to be irrelevant)

Combined detector?
Scintillator + MWPC tracker

- Timing from Scintillator (less layers needed, e.g. one layer with 1D data + timing)
- Tracklet from MWPC

- (May be justified if simulations suggest shower leakage which degrade rejection with scintillator-only configuration)

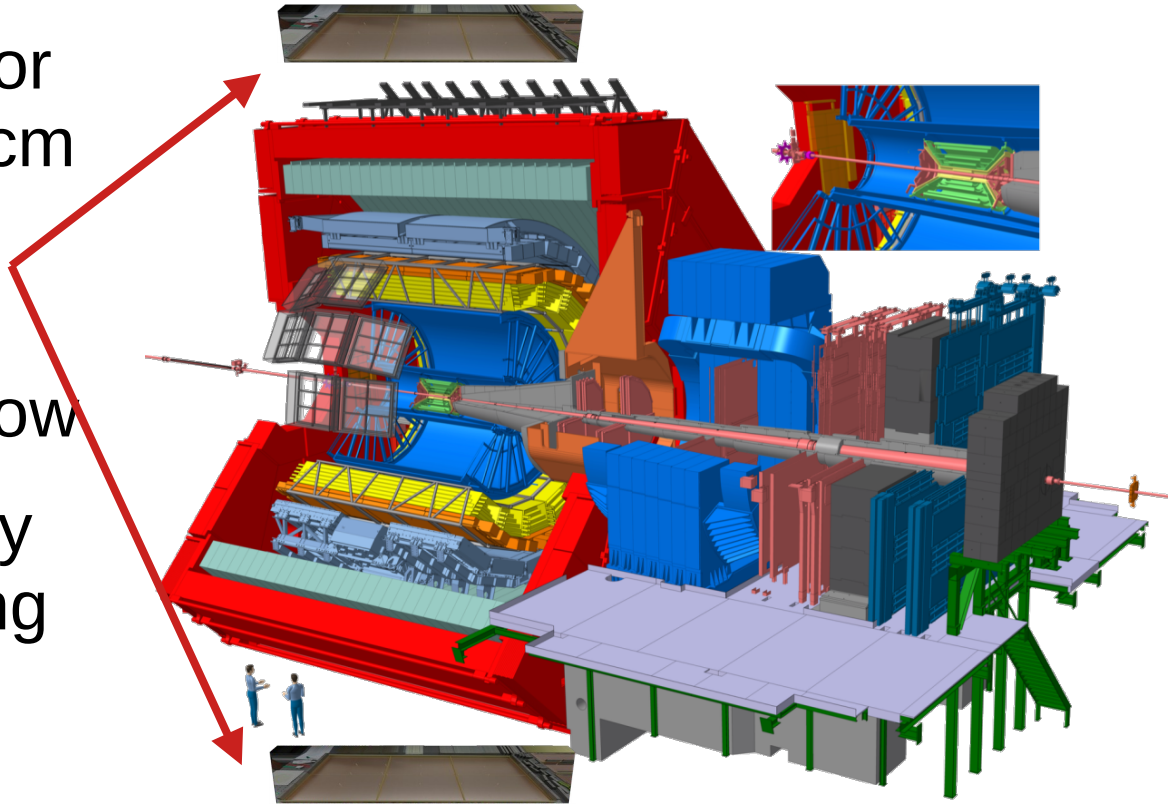
Preliminary cost and HR estimates

- Detector cost (1 layer, 2D): 1,5 k/m2 including FEE-s and manpower cost, excluding DAQ
- Total area 200m2 1 layer 2D: 300k EUR
- Proposed for tracklets: 3 layers (all 2D) 900k EUR

- Manpower availability: 2 FTE/year dedicated for the project (simulation + detector R&D and construction)

Proposal for a pilot live study

- Placing few layers MWPC or CCC modules, 80cm x 80 cm size above and under the ALICE magnet
- Detectors available as of now
- Measure the hit rate (mostly muons), and test data taking & triggering.
- In parallel → simulations



A) CCC vs B) MWPC

1 m^2	MWPC	CCC
Weight	15kg	12kg
Position Resolution	12 mm	< 5 mm
Time resolution (confirmed):	<400 ns	<200 ns
Power	5W/module (*)	5W/module
Gas: Ar-CO_2	1 l/h	1 l/h
Efficiency (per layer)	99%	99%

* Power of FEE-s only, to this the DAQ to be added

Conclusions

- Seems to be a reasonable option for MuonID: high efficiency, robust, cost efficient, friendly gas
- Detector design, production capability and expert manpower fully available
- Weak timing resolution (multi-100ns) well compensated by low occupancy due to high segmentation
- Good position resolution allows “tracklets” directional info
- Possibly in combination with better timing detectors

Backup

- Rate capability
- No observed ageing for non-CH-based quencher