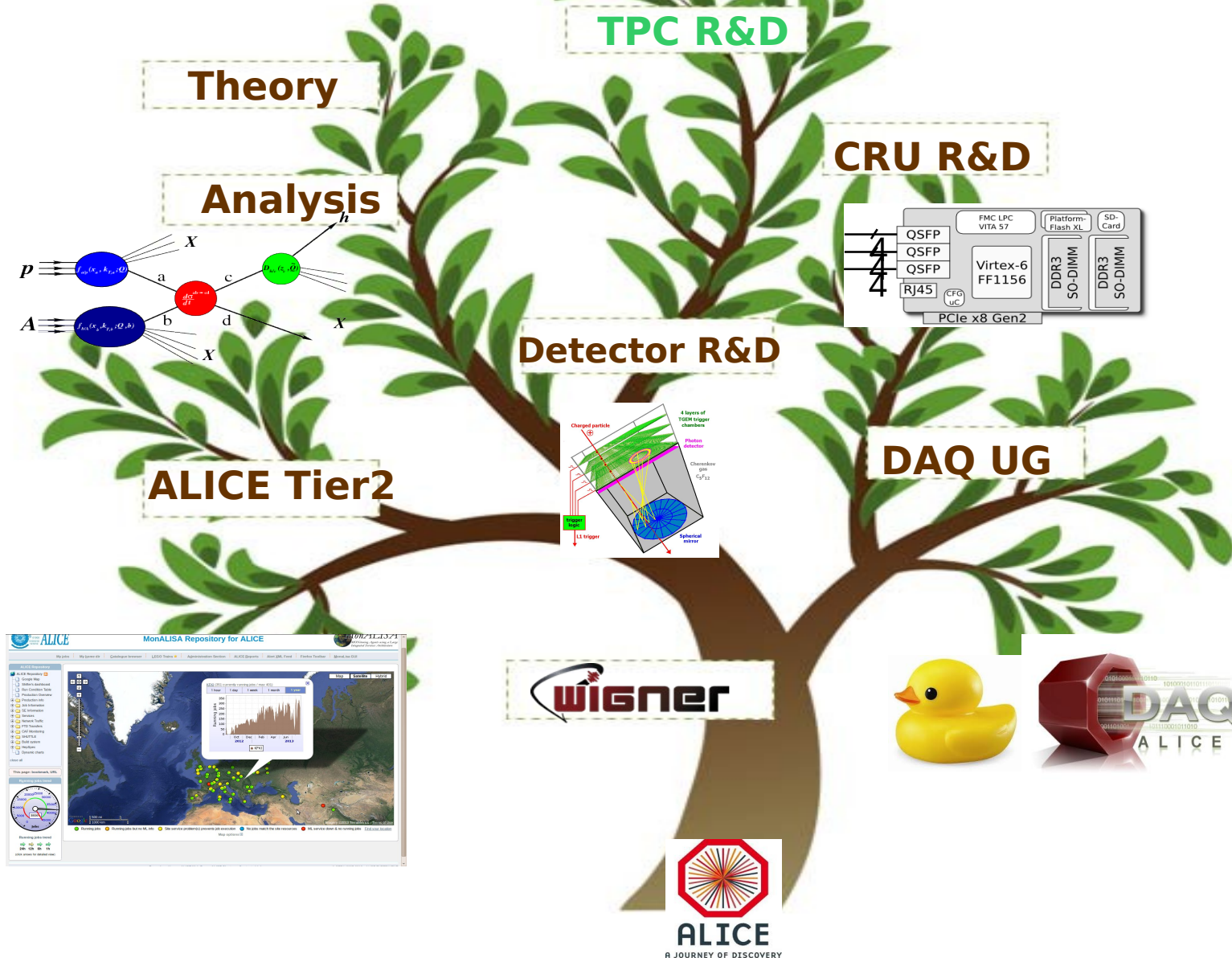


# R&D in High-Energy Physics at Wigner RCP Budapest

dr. Gergely Gábor Barnaföldi,  
Heavy Ion Theory Group, Wigner RCP of the H.A.S.  
UiB, Bergen, Norway 16<sup>th</sup> April 2018



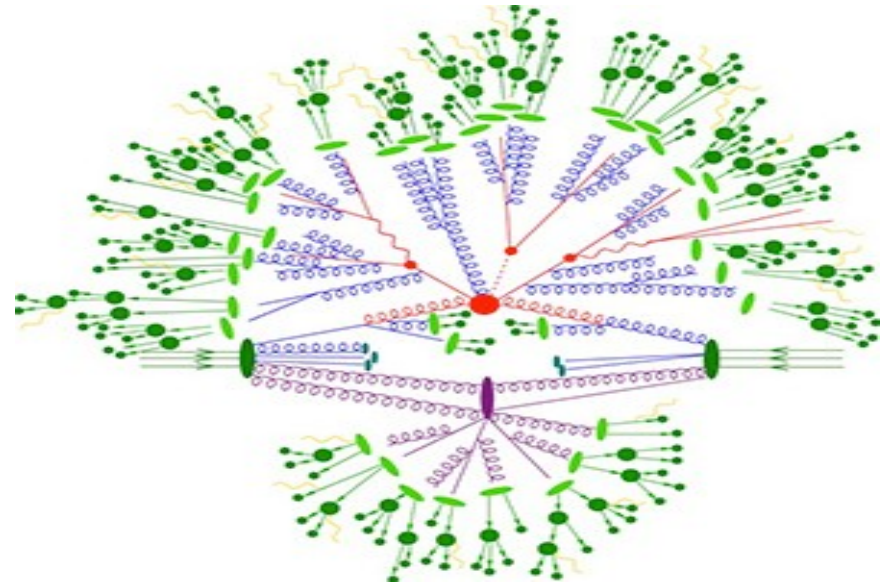
# Heavy Ion & Applied Physics from Wigner



# Theoretical calculations

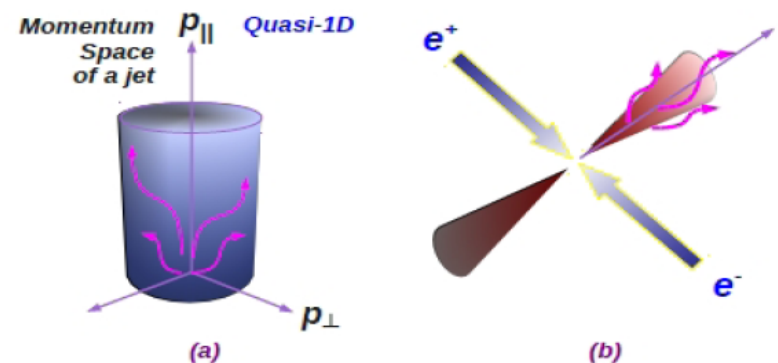
# Physics/Analysis & Theory

- Theoretical background  
High- $p_T$  @ pQCD



## New theoretical developments

- Microcanonical Jet-Fragmentation in pp at LHC energies:  
Phys. Lett. B701 (2011) 111
- Generalized Tsallis distribution in  $e^+e^-$  collisions  
Phys. Lett. B718 (2012) 125





# Heavy Ion Theory Research Group

- Investigation of Low Energy Hadron Spectra
  - Low energy hadron spectra,  $SU(3) \times SU(3)$  symmetric sigma model, transport code; GSI HADES experiments theoretical background  
Wolf Gy, Kovács P, Zétényi M, [Almási G](#), Balassa, [Jóföldi Zs](#), [Váróczy J](#).
- Perturbative and non-perturbative QCD
  - Perturbative QCD: nuklear effects in high-energy collisions; Non-perturbative QCD, mass gap, equation of state; theoretical background for ALICE  
BGG, Gyulassy M, Vaghtang G, [Karsai Sz](#), [Berényi D](#), [Biro G](#), [Takács Á](#)
- Modelling Hadronization and Fragmentation
  - Hadronization models by Tsallis-Pareto like distributions, jet-fragmentation and fragmentation functions  
BGG, Biró TS, Shen K-M, [Bíró G](#), [Takács Á](#)
- New Thermodynamical Approaches
  - Non-extensive thermodynamics, hidrodinamical and statistical approaches, Unruh effect, termodinamics in curved space-time  
Bíró TS, BGG, Ván P, Ürmössy K, [Kovács R](#).

# The Hungarian ALICE Group



Hungarian ALICE Group, Wigner RCP  
of the HAS, Budapest Hungary



## Resources: Wigner ALICE group in numbers

- cc. 15 FTE
  - 5 staff in addition technicians + engineers
  - 15 students (Eötvös University, Technical University)
- Supports:
  - ALICE OTKA K120660 (2016-20),
  - CERN UG Support by the NKFIH
- Fully equipped Wigner mechanical workshop (5 eng.+techn.)
- DAQ & SC Magnet lab & Gaseous Detector R&D labs,
- Access to clean rooms at Wigner RCP



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of the HAS, Budapest Hungary



**ALICE**  
JOURNEY OF DISCOVERY

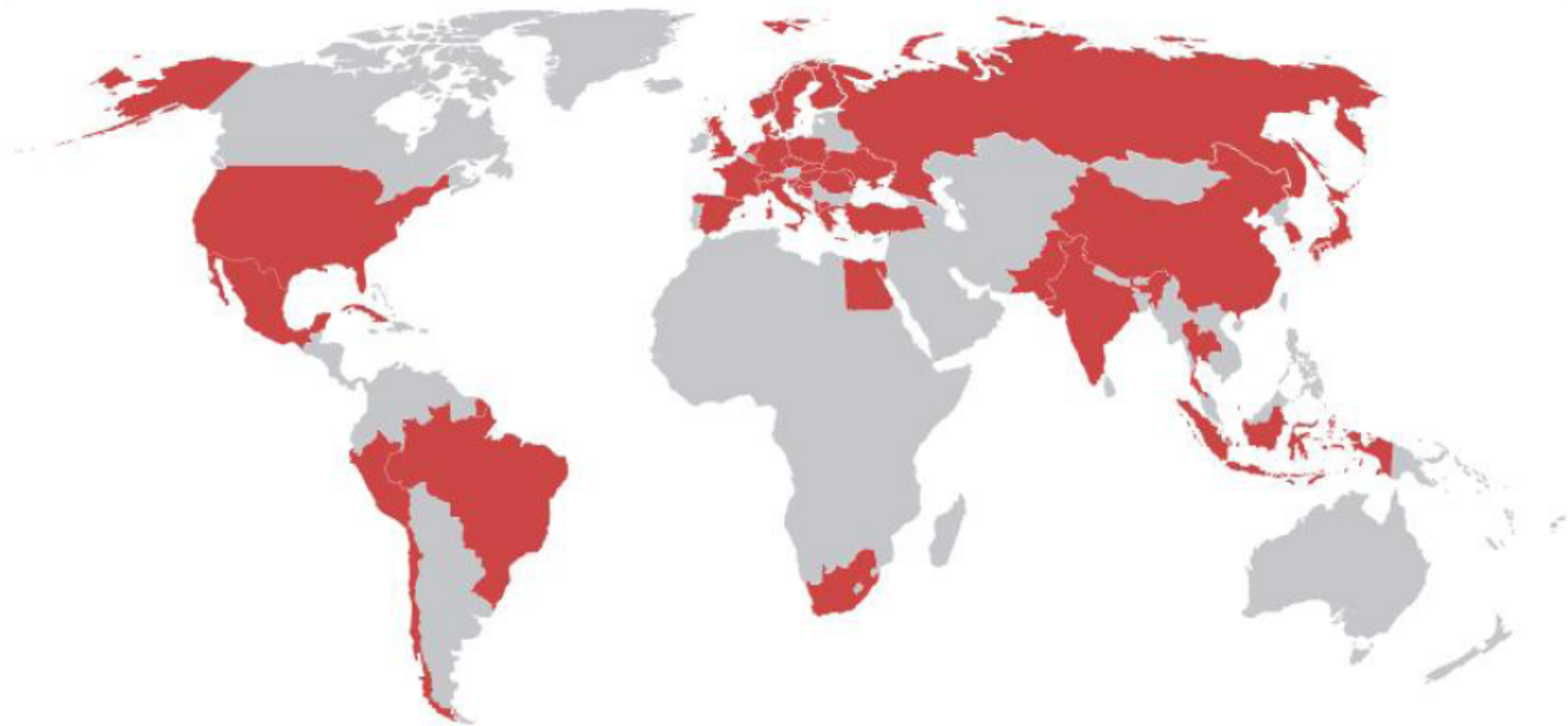
A Large Ion Collider Experiment



**ALICE**

## THE ALICE COLLABORATION

36 COUNTRIES – 151 INSTITUTES – 161'451 KCHF CAPITAL COST



## THE ALICE COLLABORATION

### History of the ALICE Experiment:

1990-1996 Design

1992-2002 R&D

2000-2010 Construction

2002-2007 Installation

2008 -> Commissioning

4 TP addenda along the way:

1996 Muon spectrometer

1999 TRD

2006 EMCAL

2007 DCAL

2012 Lol for the Upgrade

2012-2014 R&D

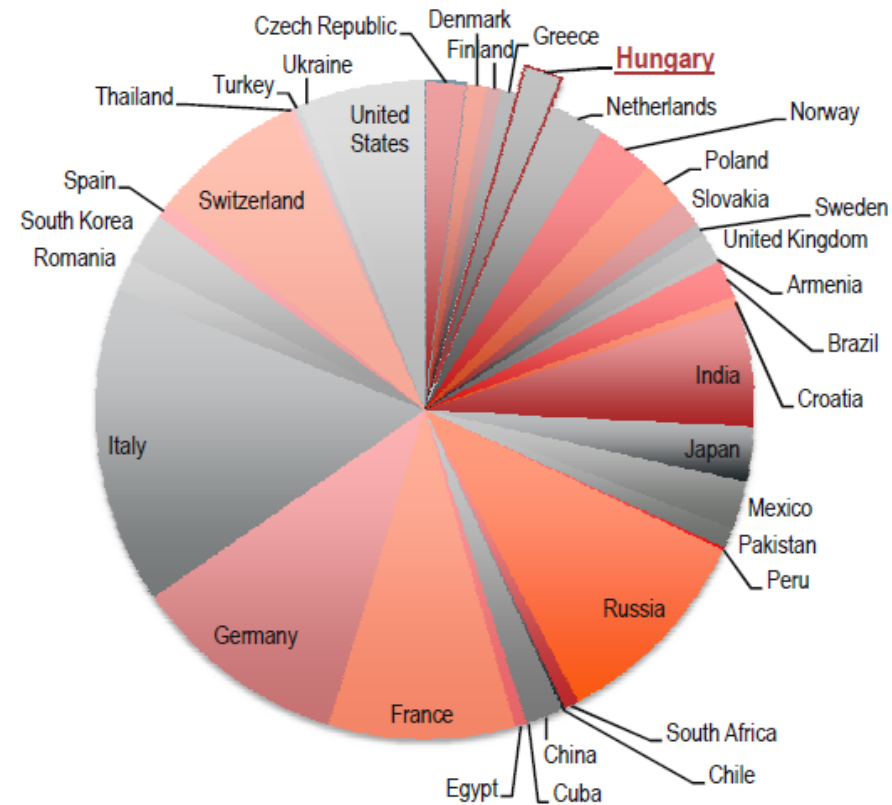
2014-2016 Procurement/Fabrication

2016-2017 Integration, pre-commissioning

2018-2019 Installation, commissioning

2019-2020 Full deployment of DAQ/HLT

### The 1472 ALICE Collaborators by country





Hungarian ALICE Group, Wigner RCP  
of the HAS, Budapest Hungary



A Large Ion Collider Experiment



## HUNGARIAN COLLABORATORS

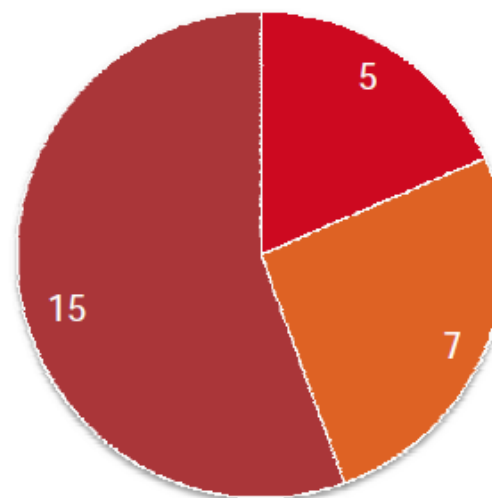
27 Collaborators coming from

**Wigner Research Centre for Physics  
of the Hungarian Academy of Sciences**



**Team leader: Gergely G. Barnaföldi**

Collaborators by status



■ Scientists ■ PhD Students ■ Other Status





Hungarian ALICE Group, Wigner RCP  
of the HAS, Budapest Hungary



A Large Ion Collider Experiment



## HUNGARIAN FINANCIAL CONTRIBUTION - 1/3

FUNDING AGENCIES: NATIONAL INNOVATION OFFICE (NIH)

NATIONAL SCIENTIFIC RESEARCH FUND (OTKA)

- ✓ Construction: 522 kCHF including 400 kCHF for the Data Acquisition (DAQ) (CERN-RRB-2014-013)
- ✓ 2014 Maintenance and Operation (category A): 38.6 kCHF for 5 Scientists (CERN-RRB-2013-118)
- ✓ Common Fund for Upgrade: 43.7 kCHF for 5 Scientists (ALICE RRB-2013-125)
- ✓ DAQ Upgrade Project: 200 kCHF



Hungarian ALICE Group, Wigner RCP  
of the HAS, Budapest Hungary



A Large Ion Collider Experiment



## HUNGARIAN FINANCIAL CONTRIBUTION - 2/3

FUNDING AGENCIES: NATIONAL INNOVATION OFFICE (NIH)

NATIONAL SCIENTIFIC RESEARCH FUND (OTKA)

Investment into the ALICE project in the WIGNER RCP, Hungary  
(salary of employed team members and experts, laboratories, etc.)  
during the 5 year period of 2009-2013:

- ✓ VHMPID project: 1000 kCHF [ ] Letter of Intent, EPJ Plus 129 (2014) 91
- ✓ HMPID project: 200 kCHF (data analysis is running)
- ✓ DAQ Upgrade: 50 kCHF (in the period 2009-2013)
- ✓ TPC Upgrade: 150 kCHF (Wigner Innovative Detector Laboratory, 2013)



Hungarian ALICE Group, Wigner RCP  
of the HAS, Budapest Hungary



**ALICE**  
A JOURNEY OF DISCOVERY



**ALICE**

A Large Ion Collider Experiment

## HUNGARIAN FINANCIAL CONTRIBUTION - 3/3

**FUNDING AGENCIES: NATIONAL INNOVATION OFFICE (NIH)**

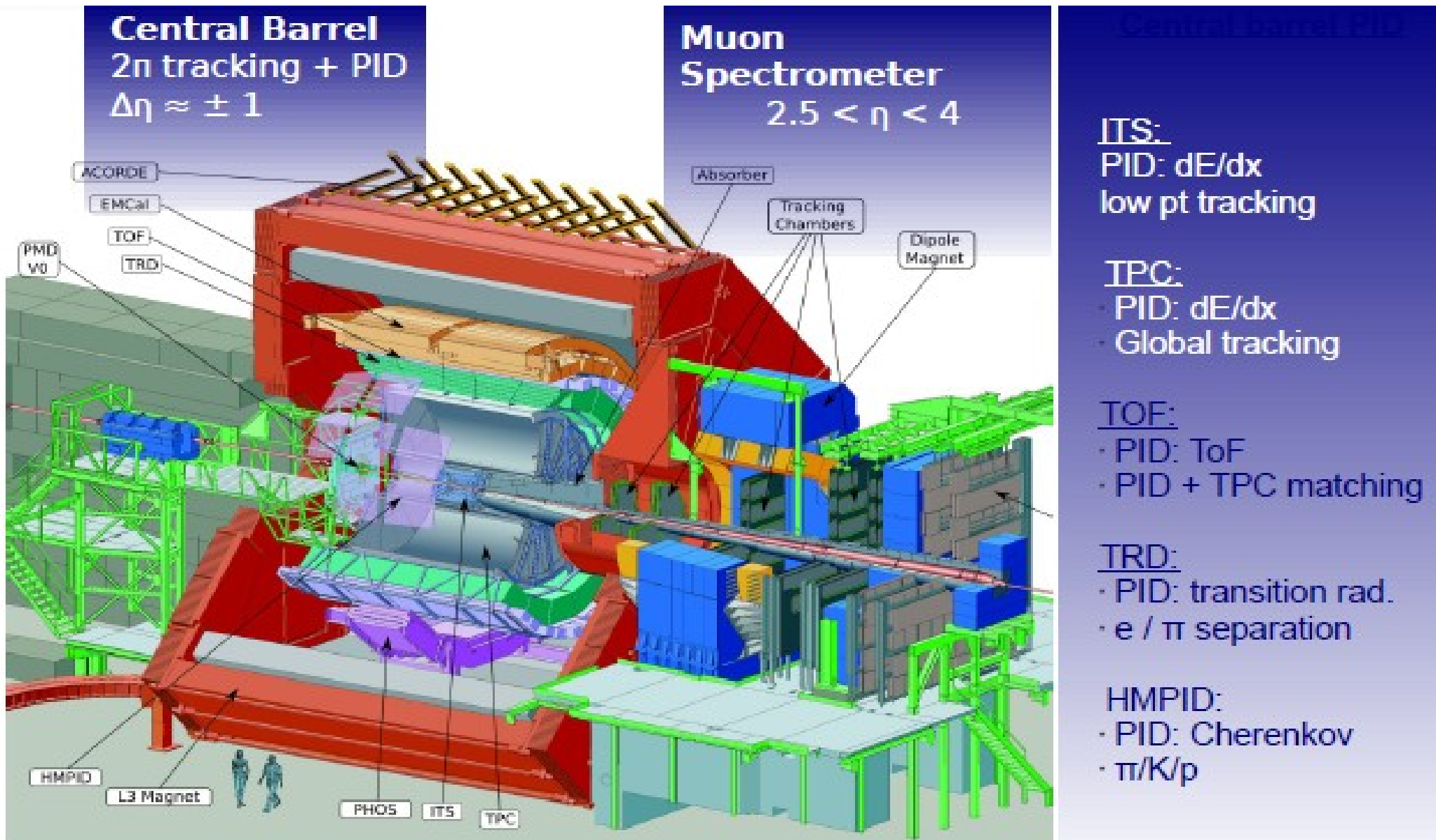
**NATIONAL SCIENTIFIC RESEARCH FUND (OTKA)**

Wigner Research Centre for Physics group joined  
to the TPC Upgrade project after the termination of the VHMPID:

- ✓ 5 researchers + students started to work
- ✓ Establishment of the Wigner Innovative Detector Laboratory in 2013
- ✓ 200 kCHF for TPC upgrade expected as yearly local cost (2014 - )

- DAQ – DAQ UG/service group
  - Strongly involved in the ALICE DAQ UG, CRU2 development
  - Kiss T, Dávid E, Imrek J, [T.M. Nguyen](#)
- P/A – Physics/Analysis group
  - High  $p_T$ , jets, PID, heavy quarks, correlation
  - BGG, Lévai P, Vértesi R, Varga-Kőfaragó M, [Bencédi Gy](#), [Szigeti B](#)
- DDG – Detector Development group
  - Gaseous detector R&D, TPC UG,
  - Varga D, Boldizsár L, Hamar G, [Gera Á](#)
- GRID – ALICE Tier-2 Site
  - T2 Budapest: 1000 cores, 750 TB HDD
  - BGG, [Bíró G](#)

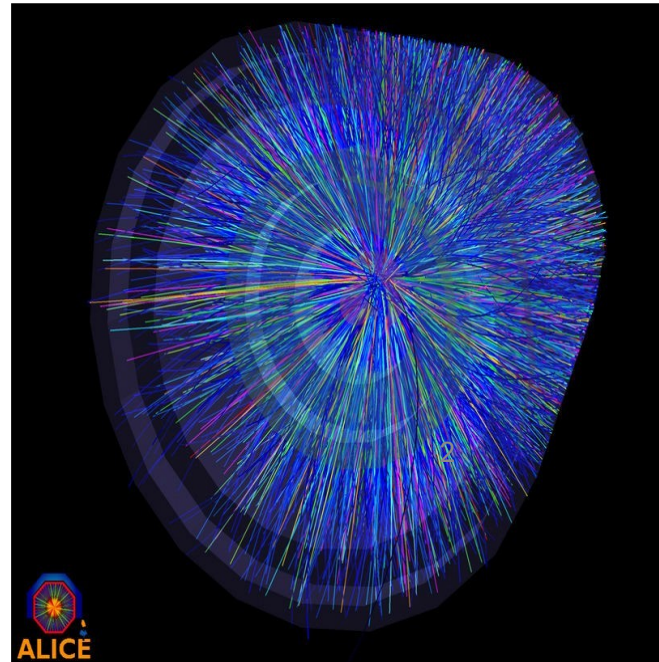
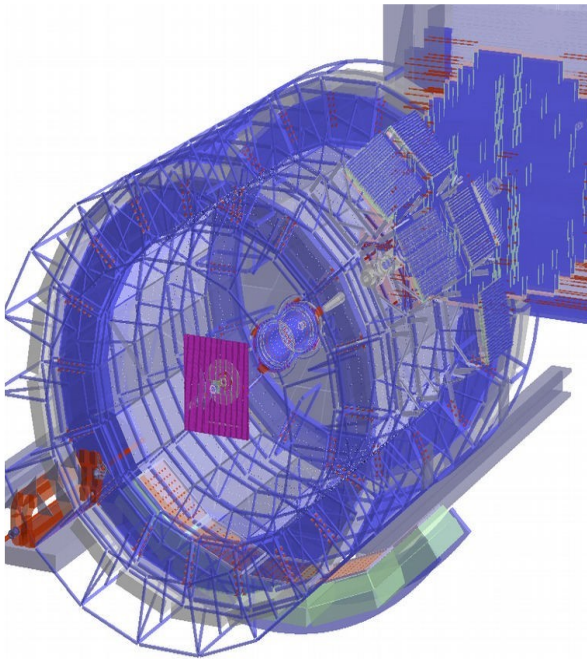
# Participation in CERN ALICE collaboration: HMPID & TPC





# ALICE TPC: World's Largest TPC

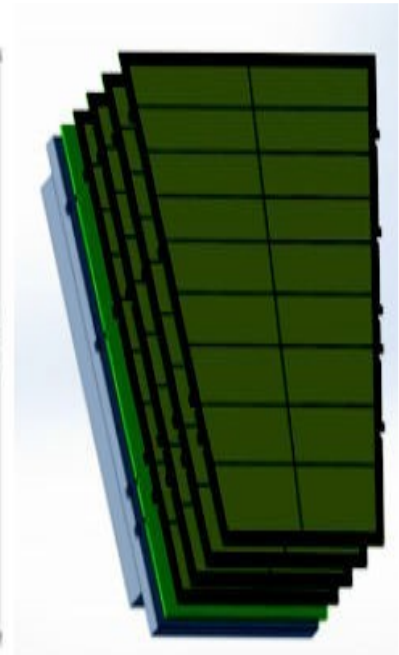
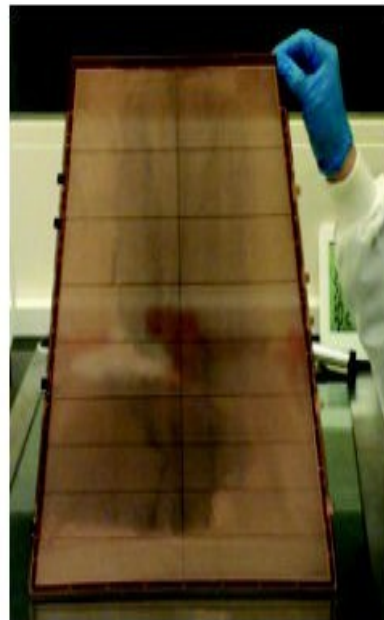
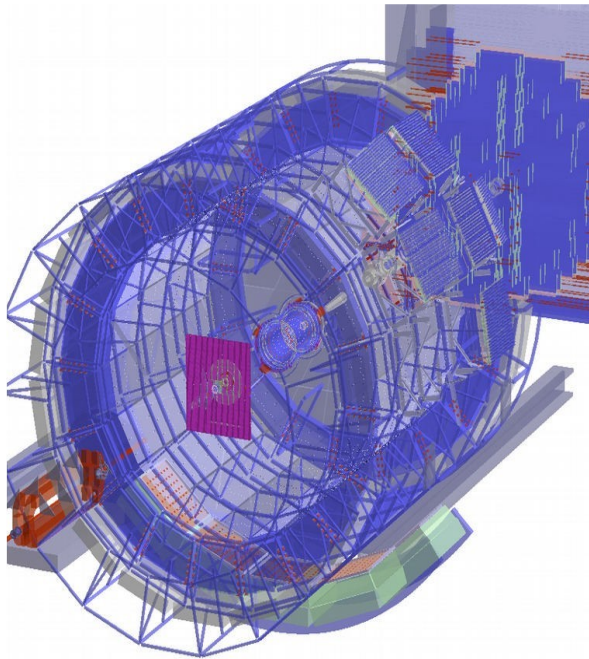
- Measuring the path of the particles with the World's largest 90m<sup>3</sup> Time Projection Chamber





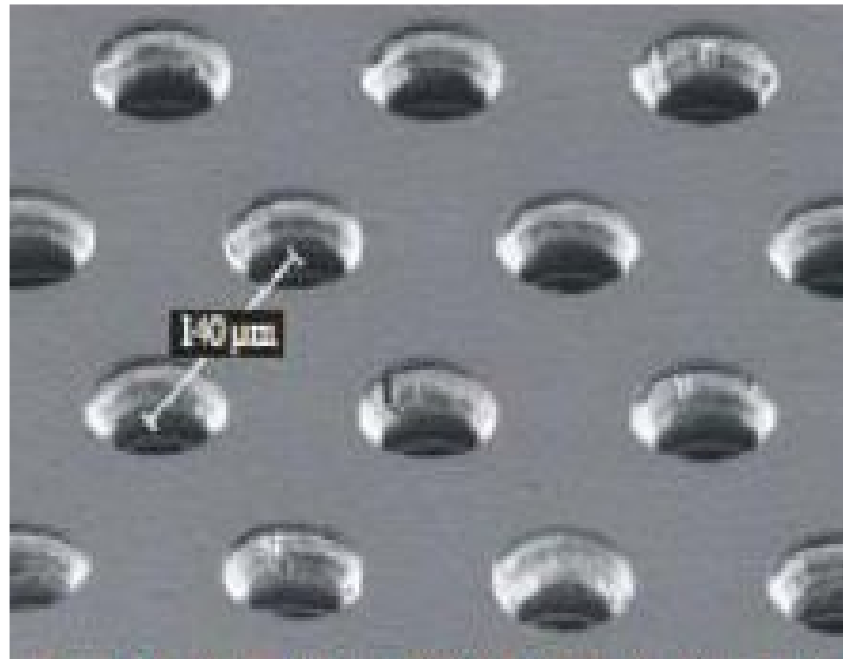
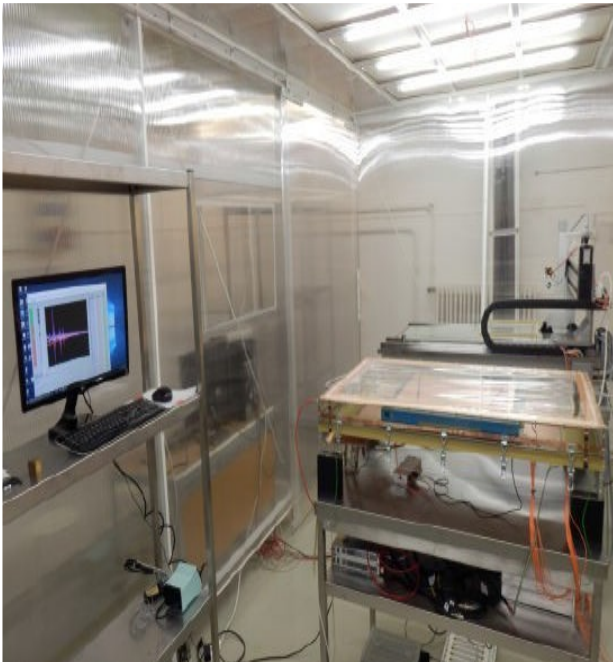
# ALICE TPC: World's Largest TPC

- Measuring the path of the particles with the World's largest 90m<sup>3</sup> Time Projection Chamber



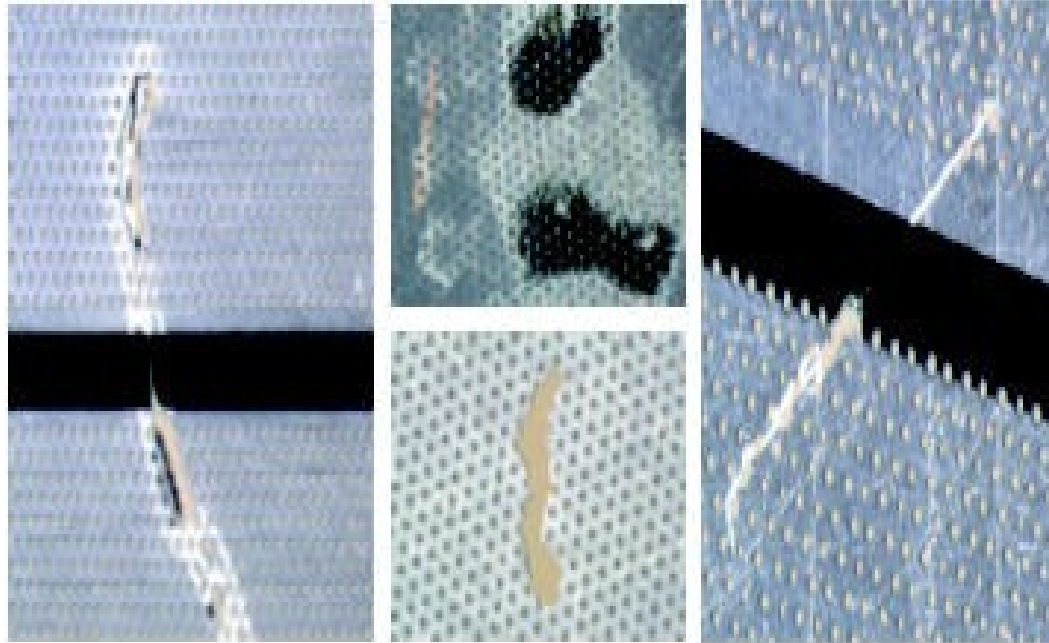
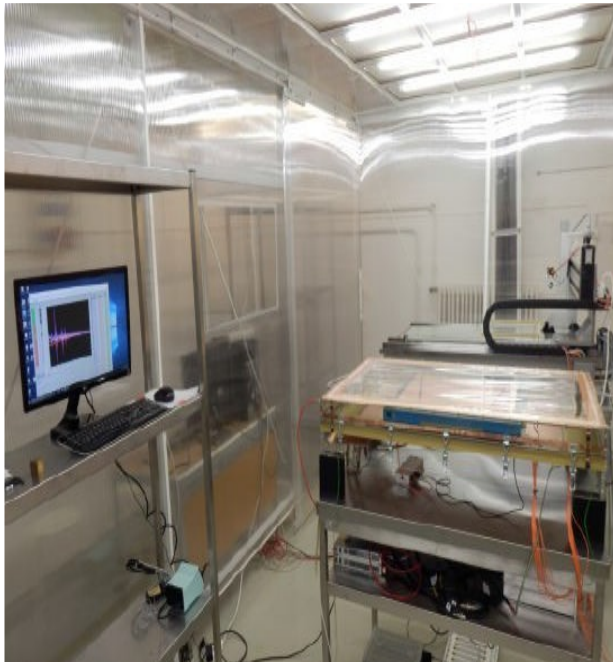
# ALICE TPC: World's Largest TPC

- Measuring the path of the particles with the World's largest 90m<sup>3</sup> Time Projection Chamber



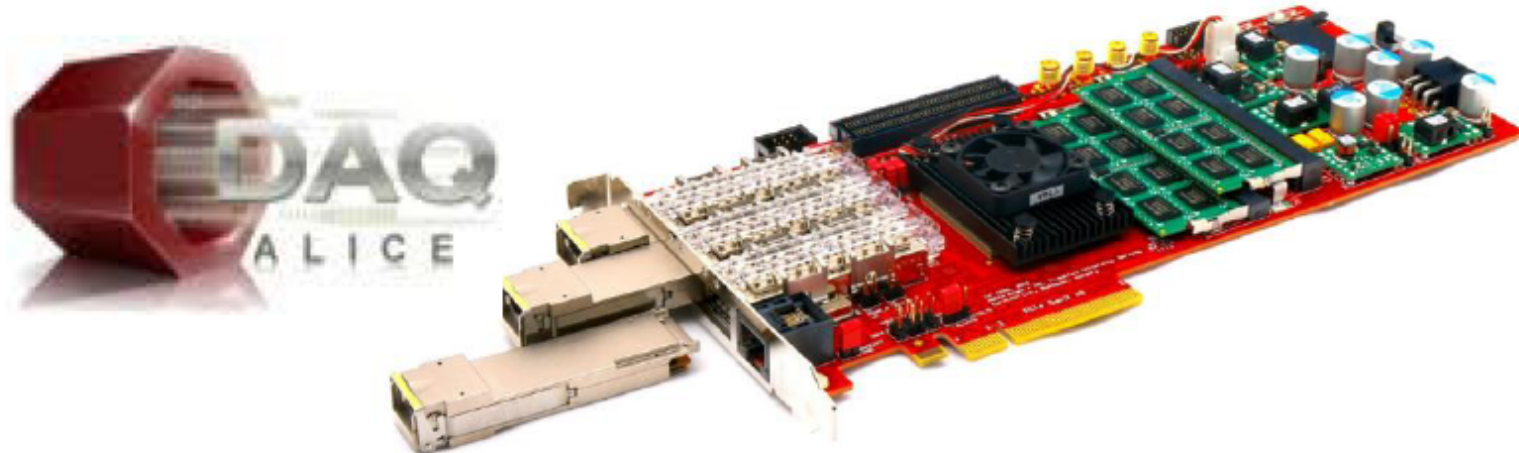
# ALICE TPC: World's Largest TPC

- Measuring the path of the particles with the World's largest 90m<sup>3</sup> Time Projection Chamber



## HUNGARIAN CONTRIBUTION TO DATA ACQUISITION (DAQ)

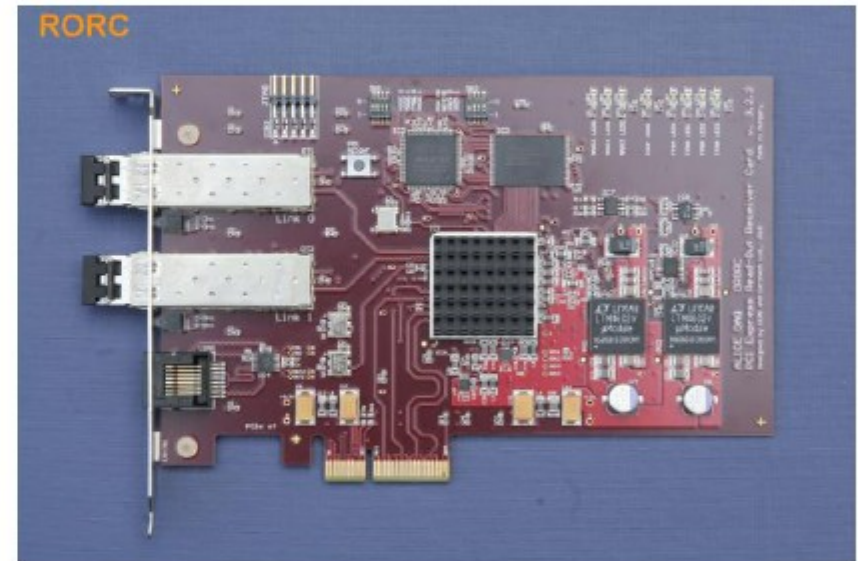
- ✓ Major role in the ALICE DAQ system
- ✓ Designed and produced the optical links (DDLs) and the computer adapters for these links (D-RORCs) which transmit the data from all the detectors to the DAQ computers. There are currently 500 DDLs running at 2 Gbit/s in use in ALICE.



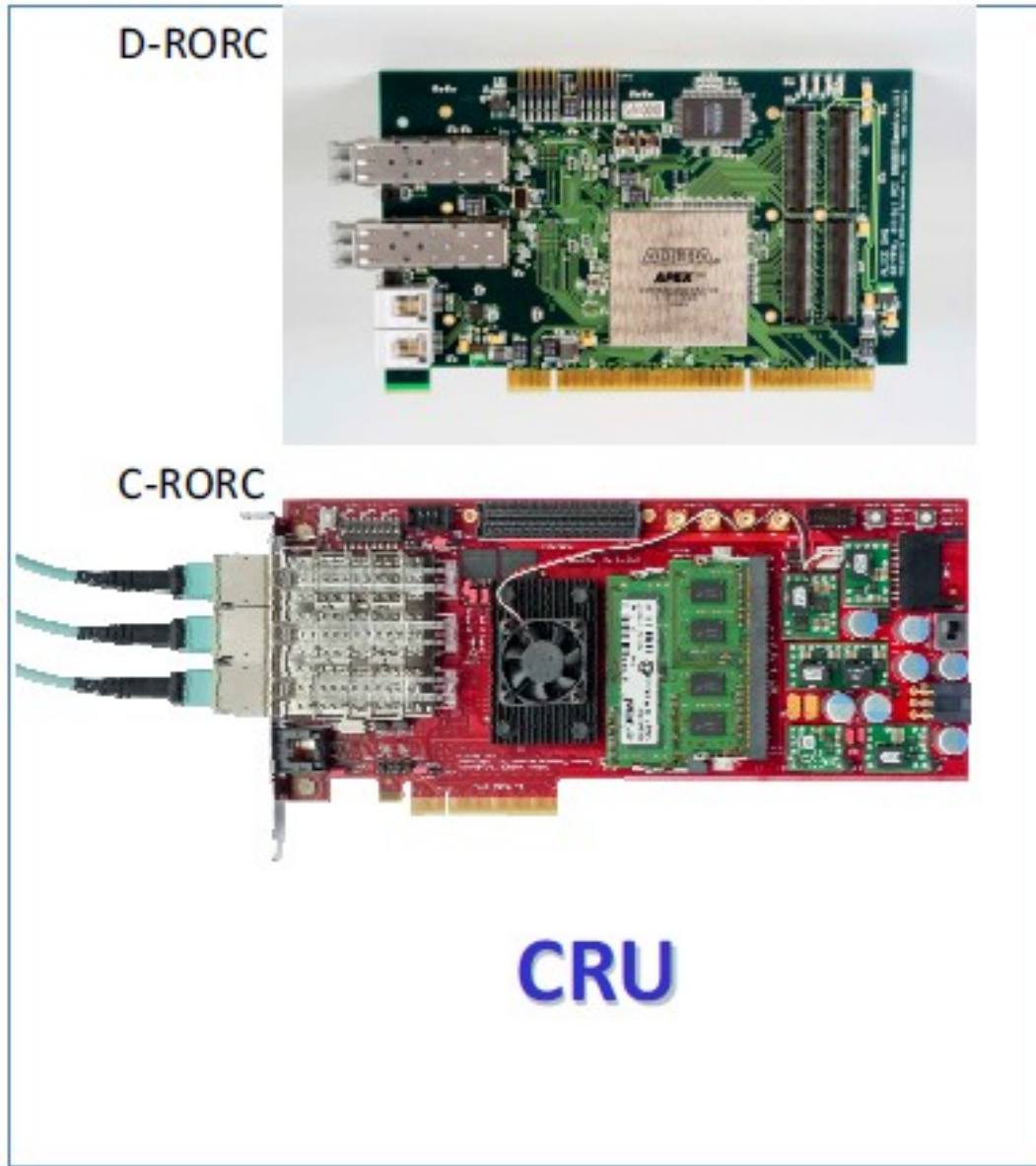


# HUNGARIAN CONTRIBUTION TO DATA ACQUISITION

- ✓ Providing a **readout bandwidth of 1 Tbit/s**. They are also used in the reverse direction to configure the electronics of some detectors (e.g. TPC or MCH). The same links are used to transmit the data to the HLT computers.
- ✓ Developed the system drivers used with the DDLs and the DRORCs.
- ✓ Funded the DDLs and part of the D-RORCs.



# ALICE DDL/DAQ: data on the Highway



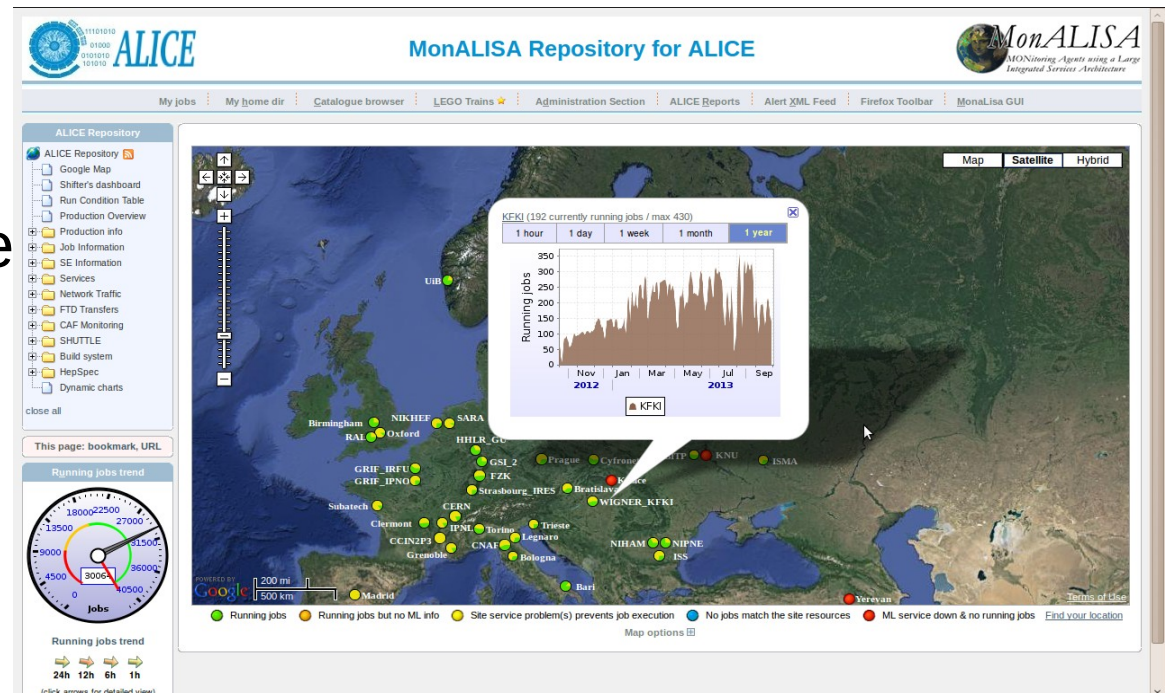
- **Standardised detector data links (DDL) as the common interface between the detectors read-out and the DAQ (online system)**
- **Run1:**
  - **2.125 Gb/s custom DDL & D-RORC**
- **Run2:**
  - **4.25 Gb/s custom DDL2 & C-RORC**
- **Run3:**
  - **Common Read-out Units (CRUs) as common detector, an trigger, and control interface**
  - **10..40 Gb/s commercial DDL3 (10 GbE or PCI Express over fiber)**



# GRID – ALICE Tier-2

## High Performance Computing: Wigner GPU Lab

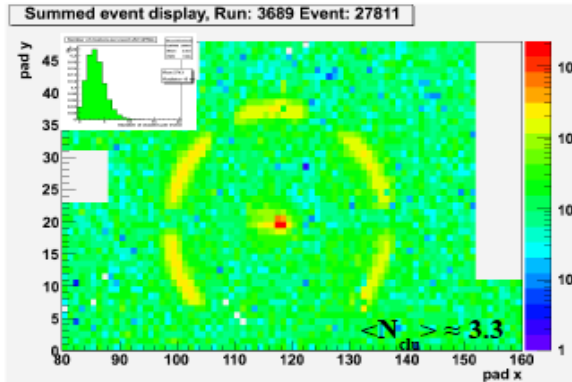
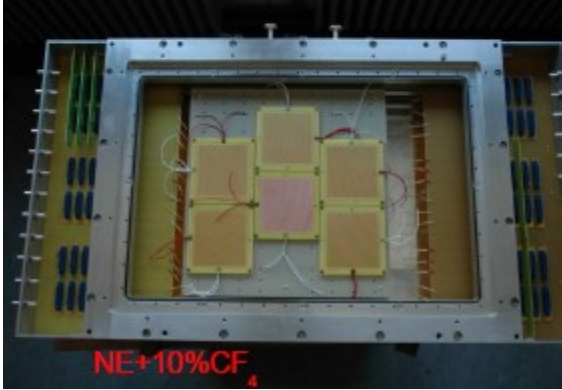
- HR: 1-2 technicians
- 1000 cores shared between ALICE & CMS
- Storage Element 740 TB
- Local CAF for R&D
- GPU Lab &
- Other special machine



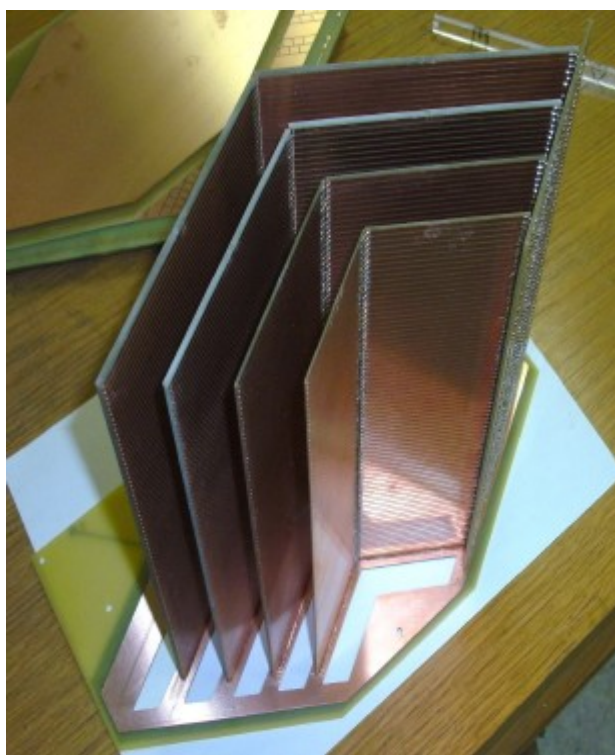
# Collaboration in Applied Physics

# ALICE TPC fits into ReGaRD's portfolio

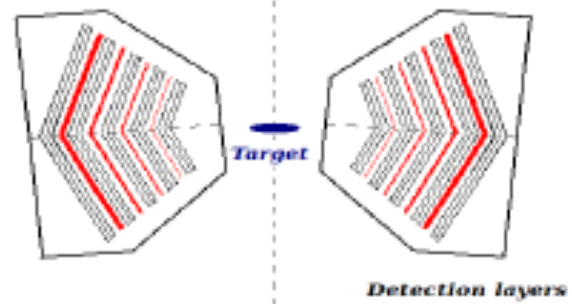
## VHMPID



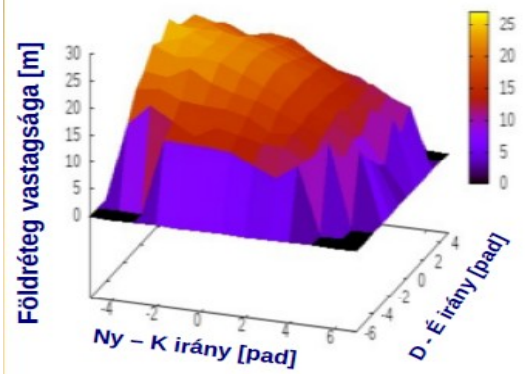
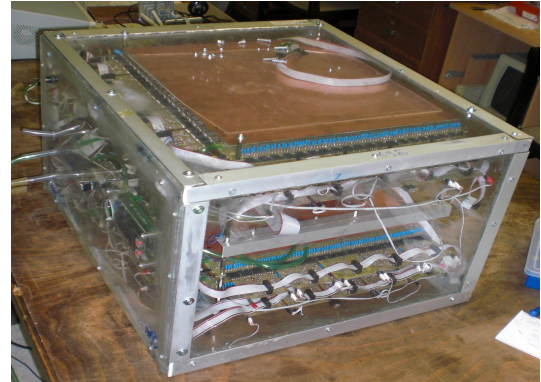
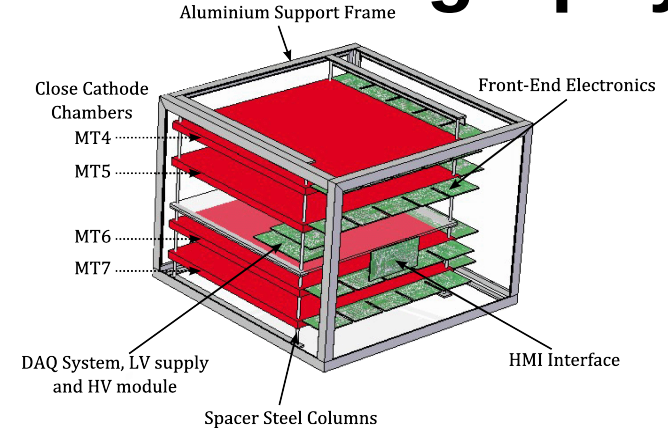
## NA61 SHINE



Absorber layers



## Muontomography

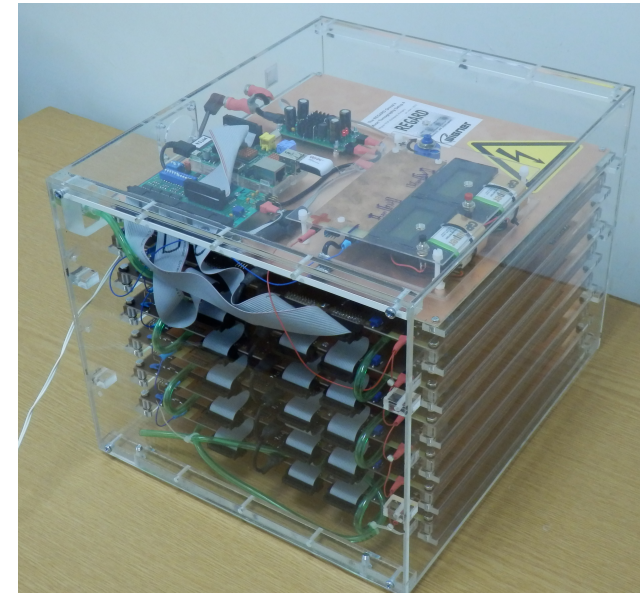
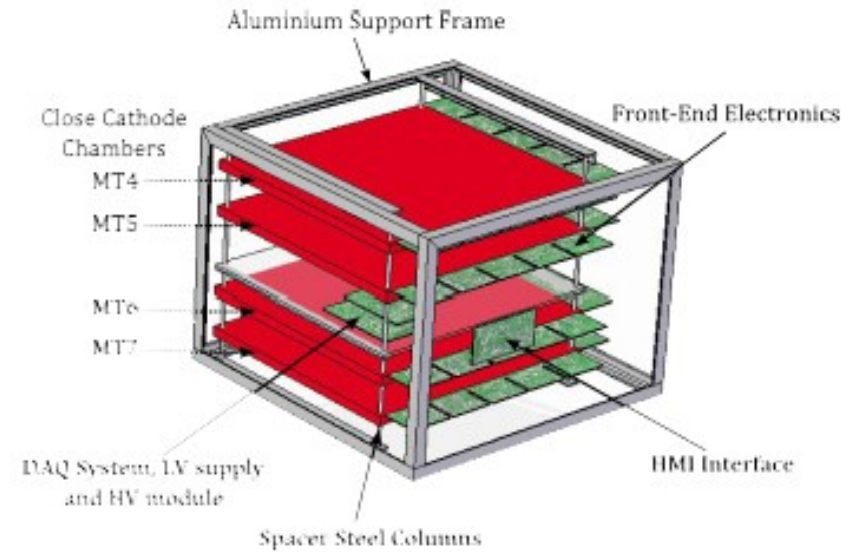




# Cosmic Muon Tomography

## Mountomograph

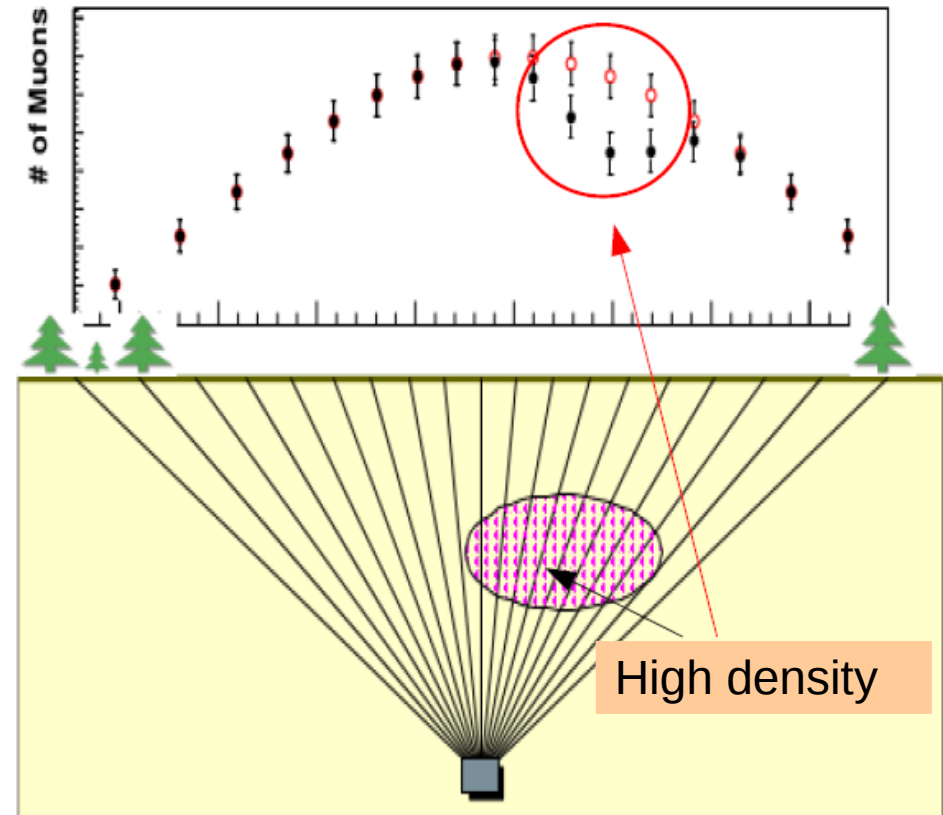
- Size: 50x50x50 cm<sup>3</sup>
- Sensitive area: about a A4 page
- Resolution < 10 mrad
- Mass: 10-13 kg
- Power consumption: < 5W
- Gas Ar+CO<sub>2</sub> 1l/hour
- For sale 3000 EUR+TAX+shipment



# Cosmic Muon Tomography

## Muon tomography – the idea

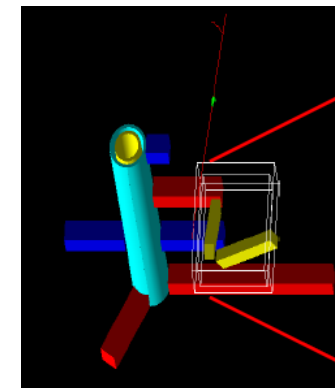
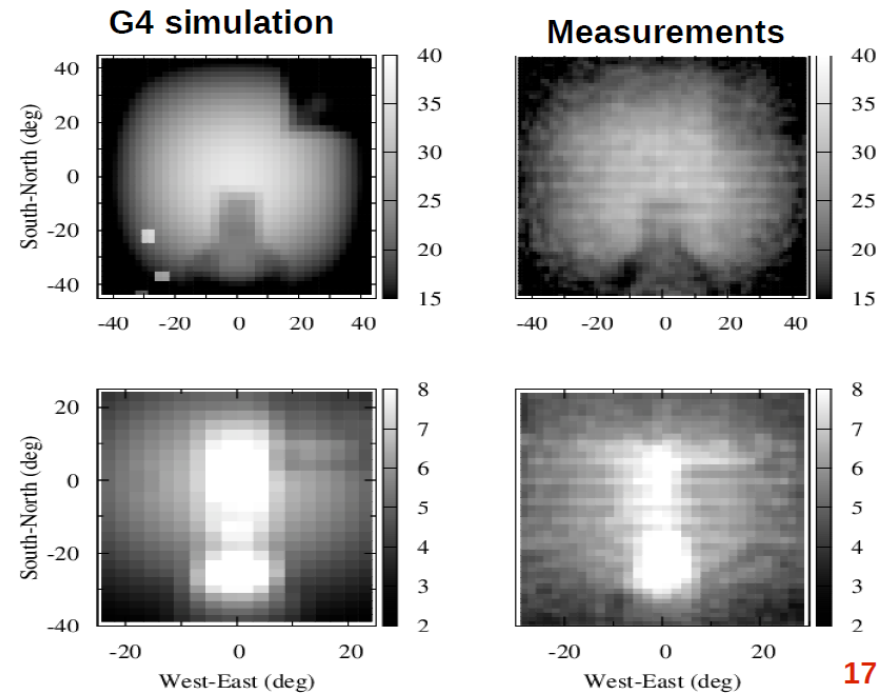
- Cosmic muon angular distribution & flux is well known
- Underground measurements can be done to measure large-scale inhomogeneities
- It can be used to explore underground structures: caves, pyramids, pipes, mines, volcanoes..



# Cosmic Muon Tomography

## Mountomograph references

- HZDR Dresden, Germany  
Underground Laboratory background
- Saud Arab Emirates  
Archeology & mine technology
- University of Tokio, Japan  
Volcano Scanning for eruption research
- Hungary  
Speleology (cave research)  
Civil Engineering  
Homeland Security

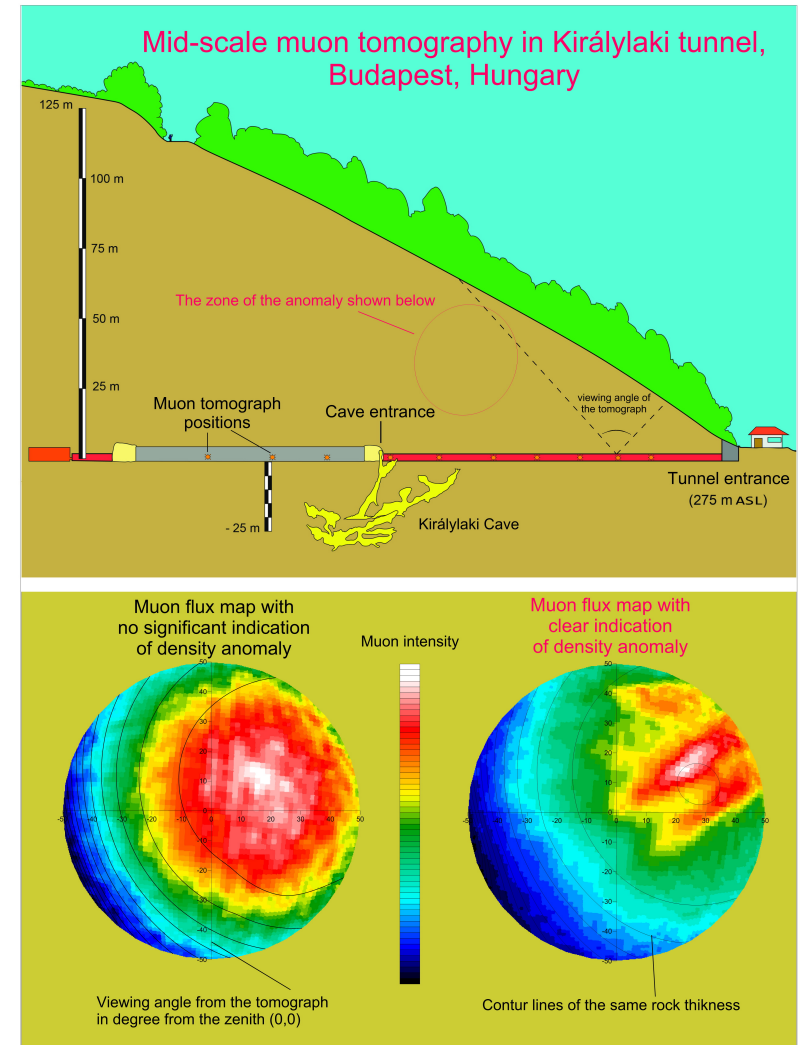




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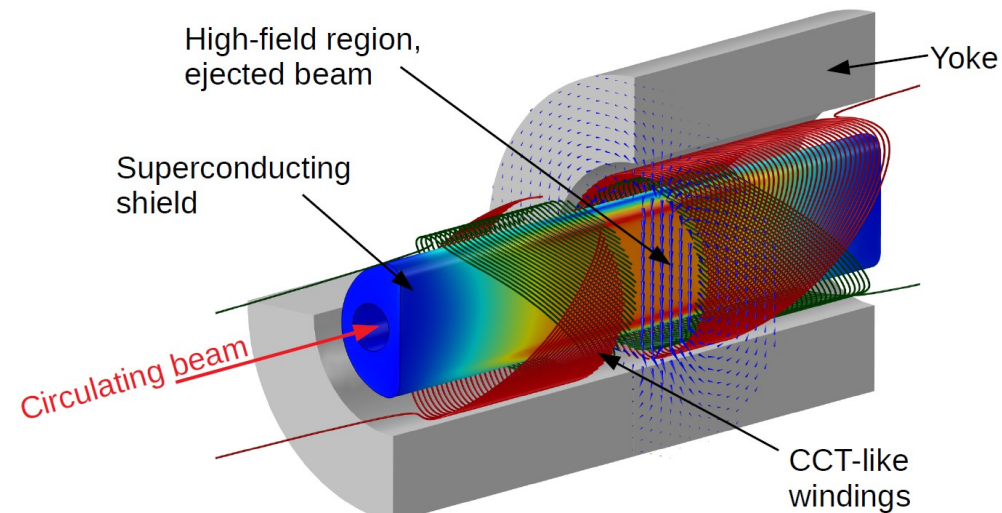
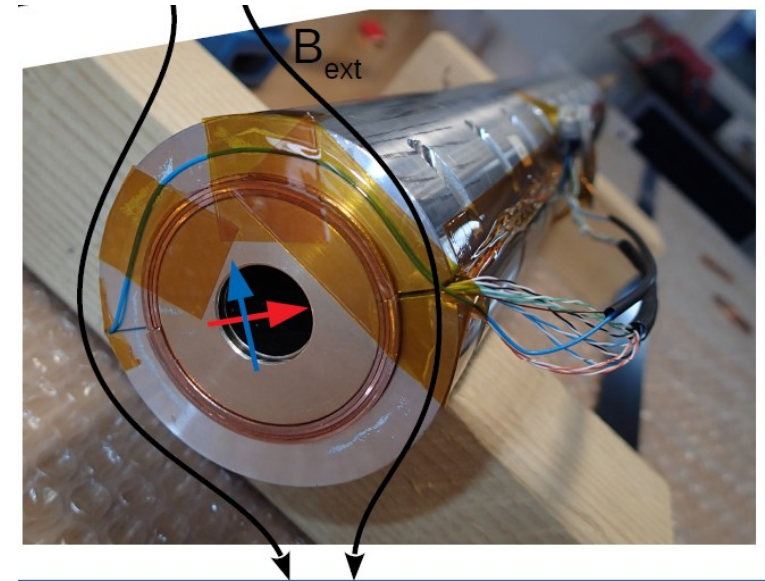
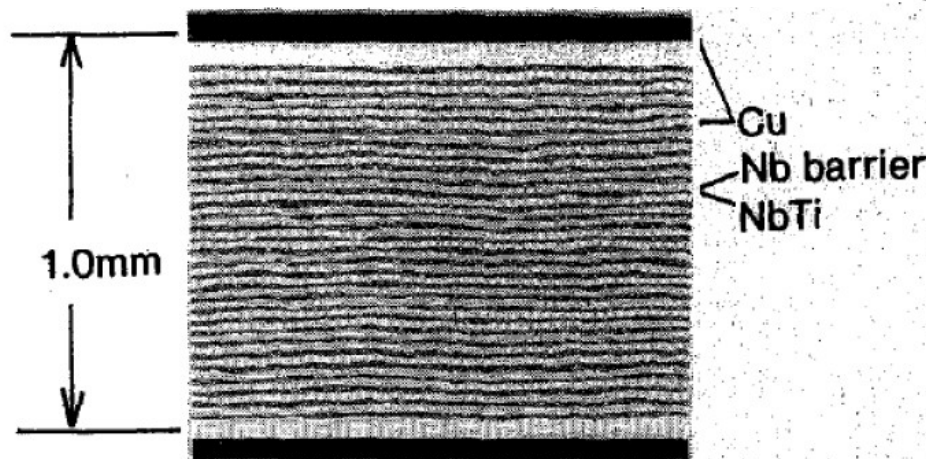
# SuShi Superconducting Shield for FCC

## Kickoff Magnet for beam dump

Deflection by extraction septa	1.14 mrad
Integrated field	190 Tm
Available space	120 m

Goal:  $\geq 3$  T field,  $\pm 1\%$  homogeneity

30 layers of NbTi, 8-10 micron thick, alternated with Cu for stabilization



# Wigner GPU Laboratory

# Software R&D for parallel computing

## Wigner GPU Laboratory

gpu.wigner.mta.hu

GPU Day – Schools & Workshops

Support of projects

Academy: WDC, CERN Openlab

Partners: Lombiq, KHRONOS

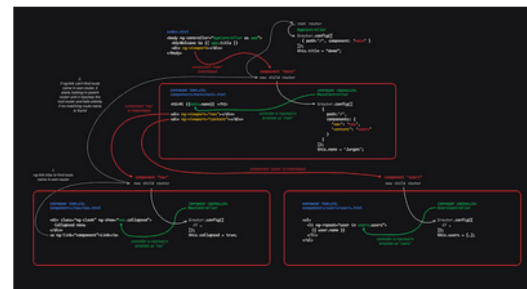
ColSpotting: CERN IT as USER(!)

2 years of running:

- Fellowships (1-2 month)
- 10 IF papers
- 3-5 ongoing projects



## We Offer



### Development environment for GPU codes

The machines of the GPU Lab are built to be a testbed for experimenting with the different GPU technologies and to test algorithms utilizing multiple cards. There are configurations hosting NVIDIA cards with CUDA support and OpenCL capable devices in the form of AMD GPUs and Intel Xeon Phis

### Developer assistance and consulting

The associates of the GPU Lab are keen to help in understanding the architecture of CPU and GPU hardware and answer the questions arising in programming and API usage.

# Points for joint R&D

- 1) Participation in the design
  - Looking for local beamtest facilities
  - Check for the Wigner's and Debrecen ATOMKI accelerator
- 2) Heidelberg test beam
  - Telescope set test in June
- 3) Wigner GPU Laboratory
  - <http://gpu.wigner.mta.hu>
  - GPU Day 2018 <http://gpuday.com> (21-22 June 2018)
- 4) Wigner DAQ Laboratory
  - Interest in DAQ development (need to check with Tivadar)
- 5) Mechanical design