

Time of Flight detector for cosmic muons?

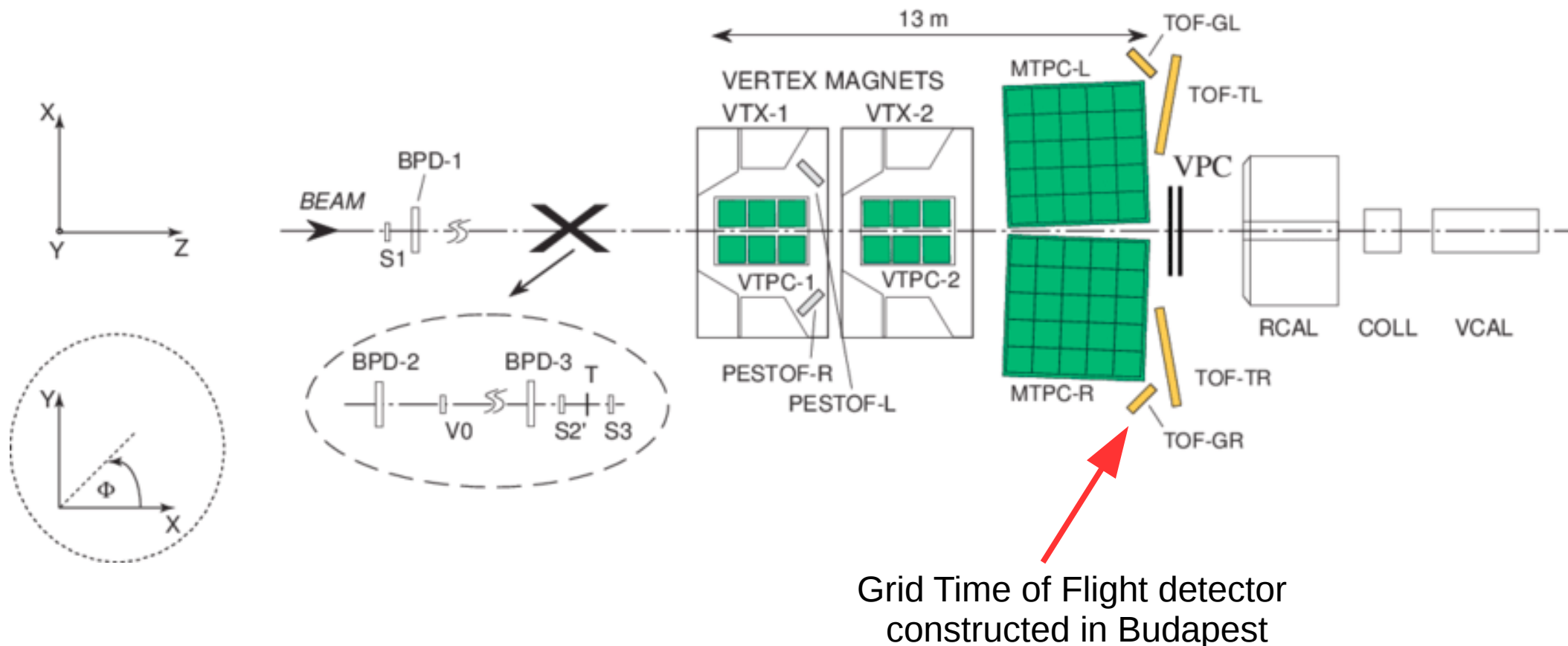


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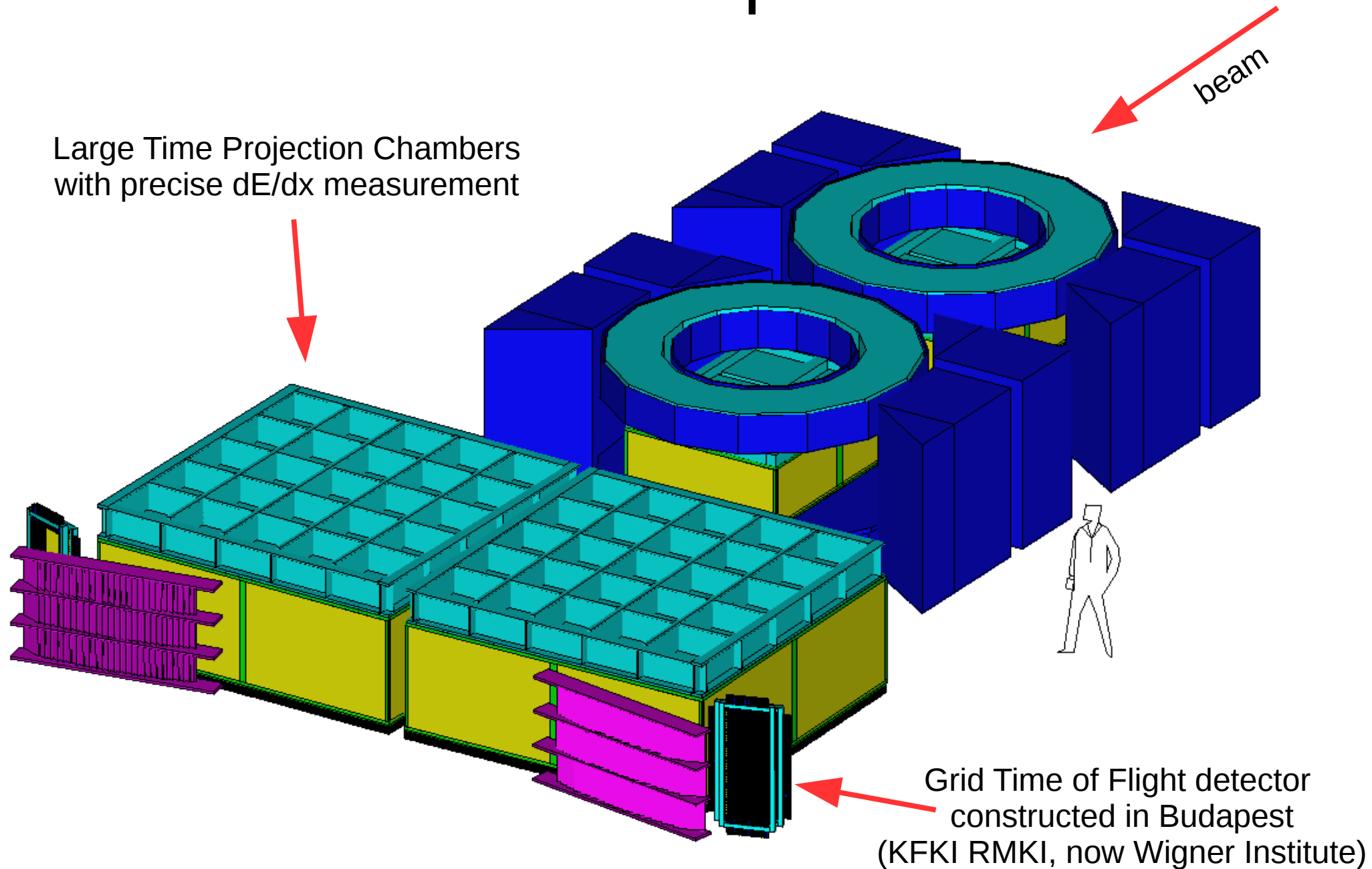
CORSIKA Cosmic Ray Simulation Workshop
Karlsruhe, 17-20 June, 2019

The NA49 experiment

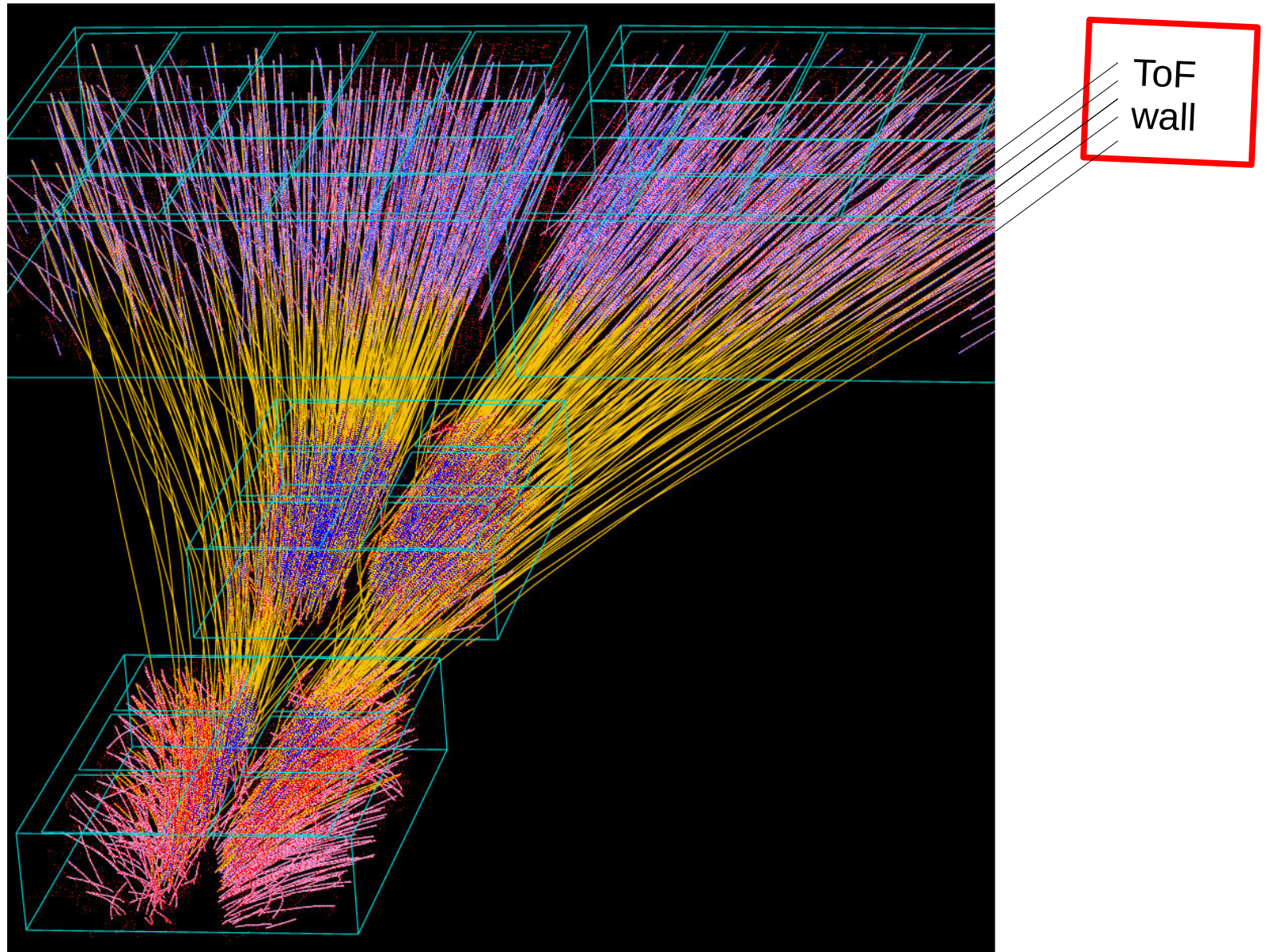
- Fixed target (p, Pb) experiment at the SPS
- Beam energy: 158 GeV ($\sqrt{s}=17.2$ GeV)
- Primary proton beam, secondary pion beams



The NA49 experiment

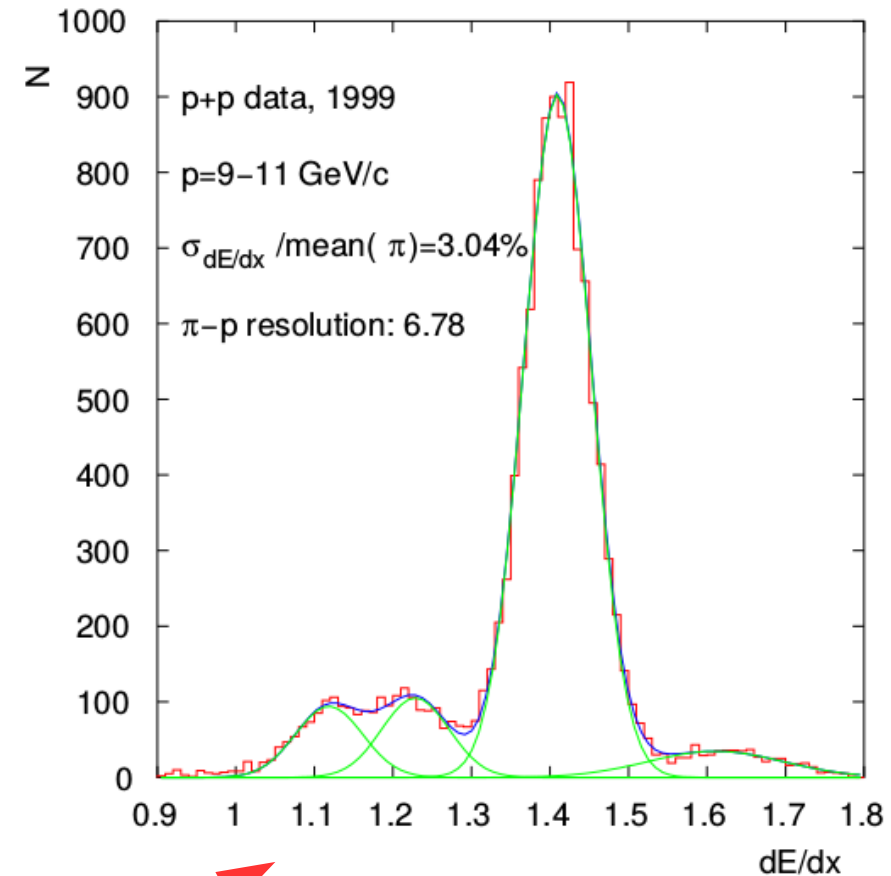
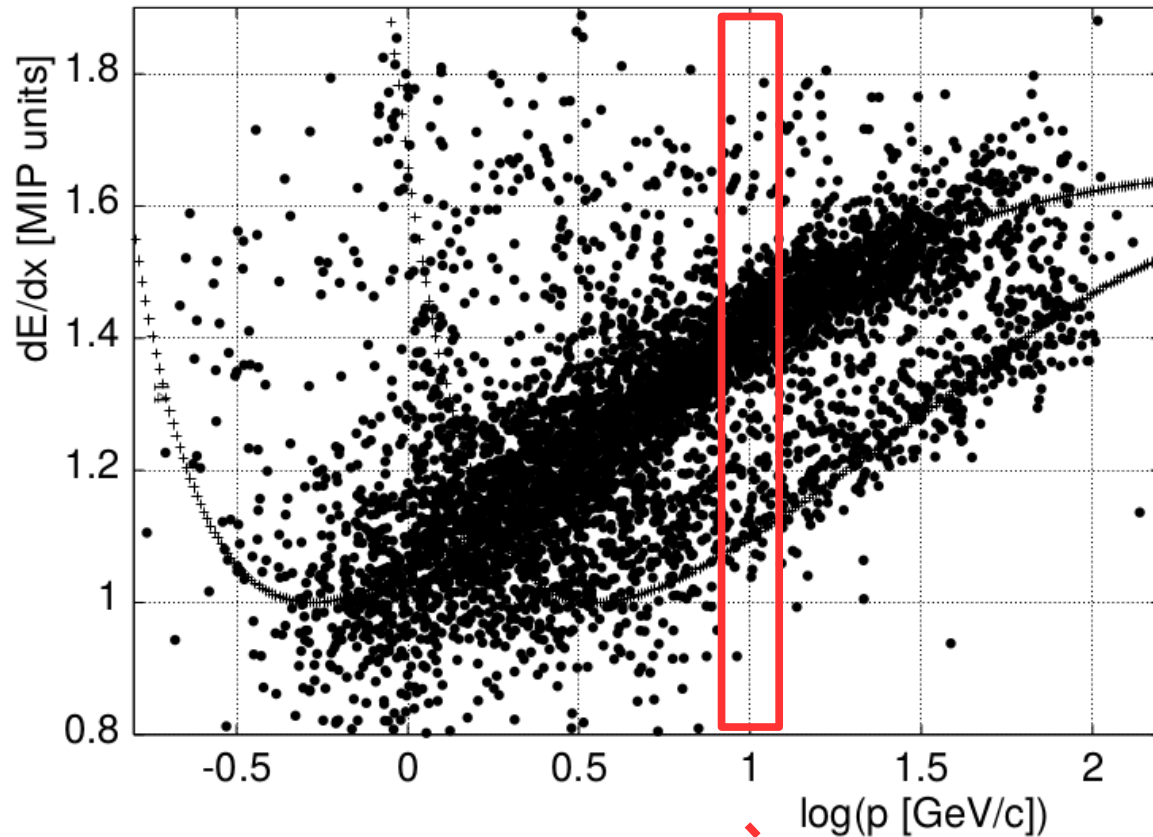


A reconstructed Pb+Pb collision



Particle identification based on dE/dx

In the Time Projection Chambers



<http://veres.web.cern.ch/veres/phdVeres.pdf>

Proton and antiproton x_F distributions in $\pi^\pm + p$ collisions

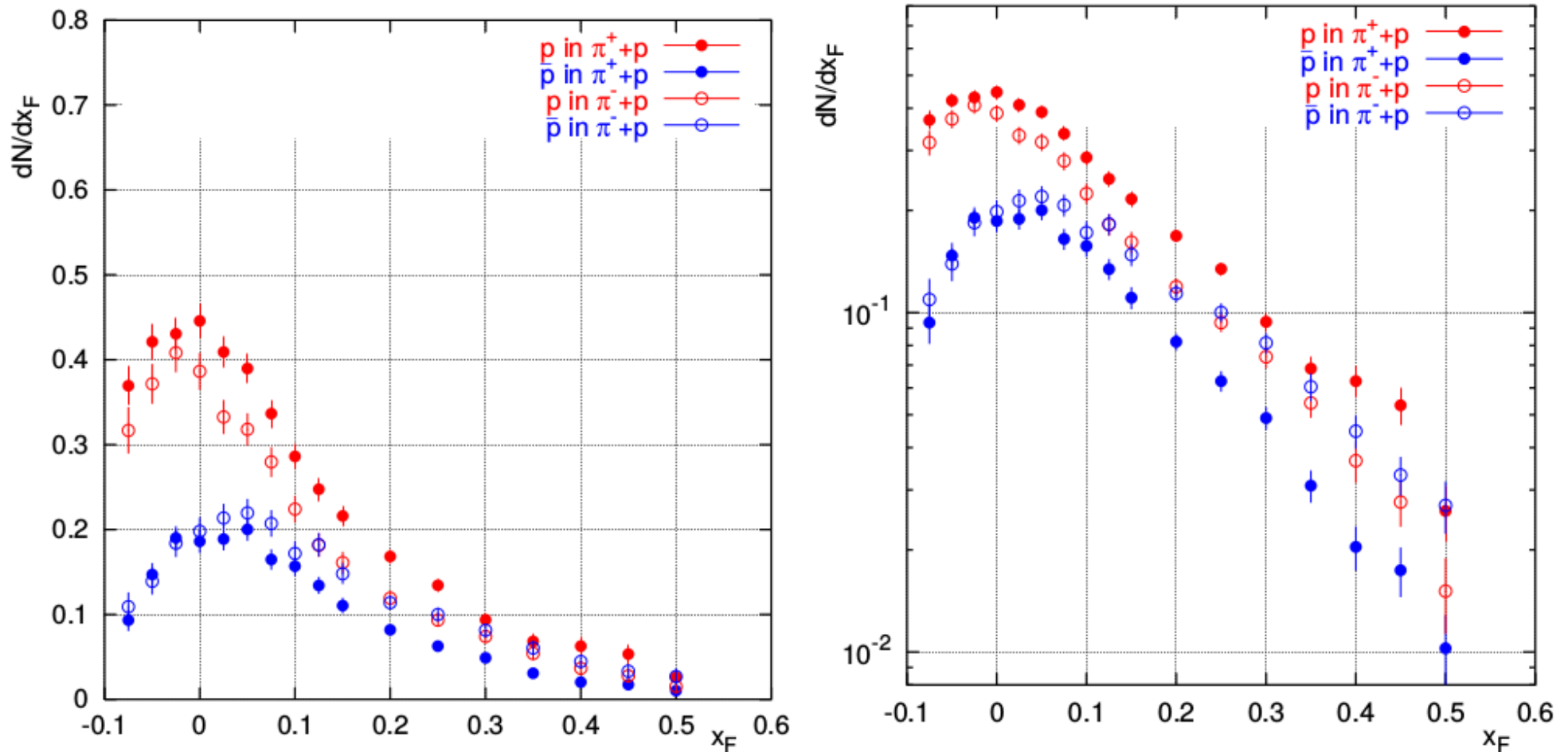
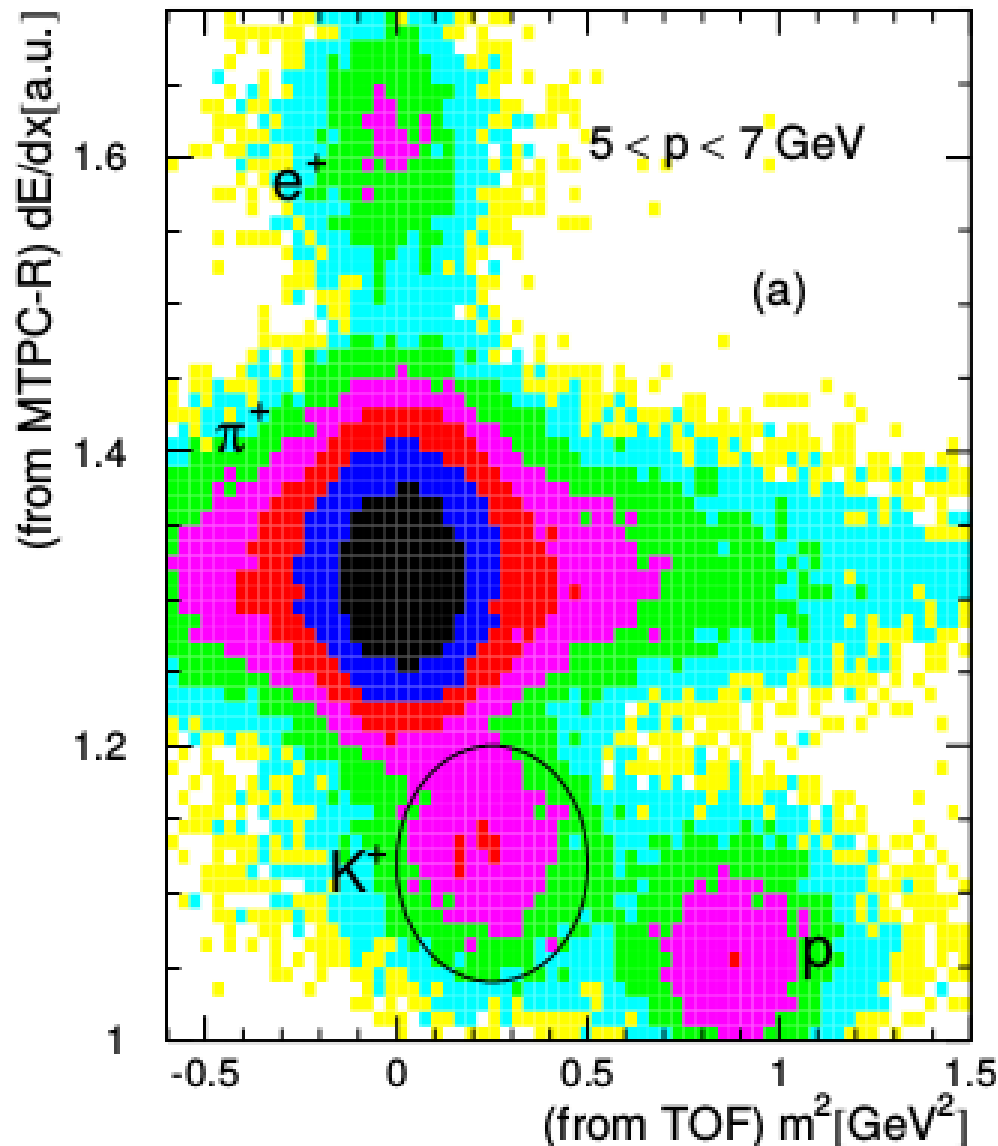


Fig. 67: Proton (red) and antiproton (blue) Feynman-x spectra in $\pi^+ + p$ (closed points) and $\pi^- + p$ (open points) collisions at 158 GeV/c beam momentum.

<http://veres.web.cern.ch/veres/phdVeres.pdf>

Particle identification using dE/dx and Time of Flight together

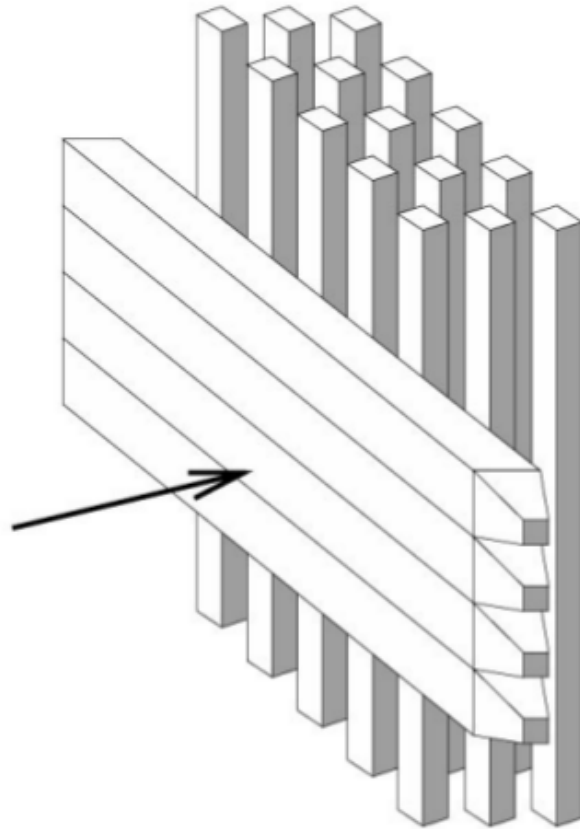
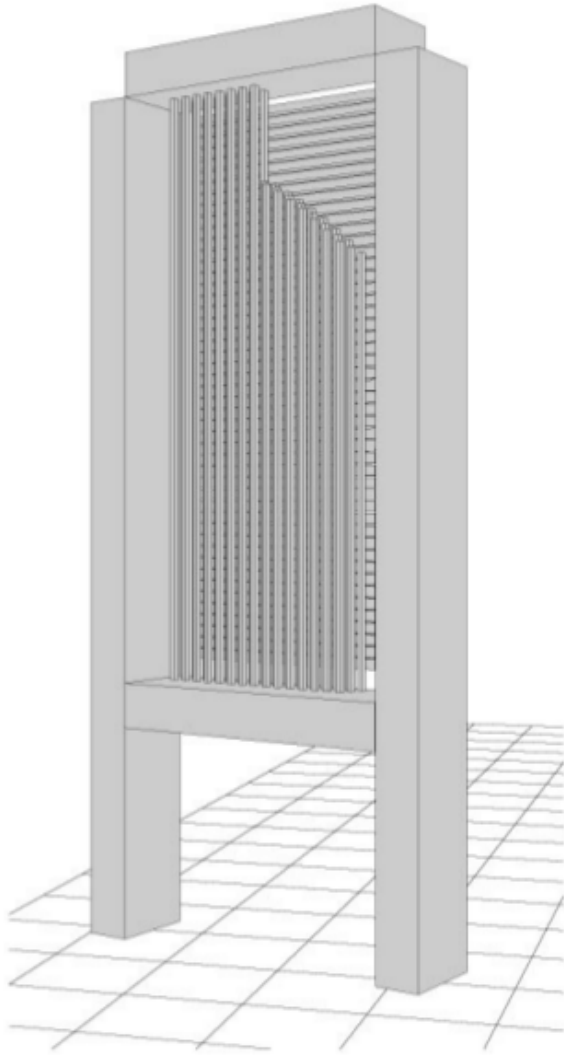


ToF information increases the kaon-proton separation

$$m^2 = p^2 \left(\frac{c^2 t_{\text{TOF}}^2}{s^2} - 1 \right).$$

$$s \approx 14 \text{ m}$$

The Grid Time of Flight wall



Made of plastic scintillator rods
BICRON 408.

3 vertical layers:
3x15 rods, 122 x 1 x 1.5 cm.

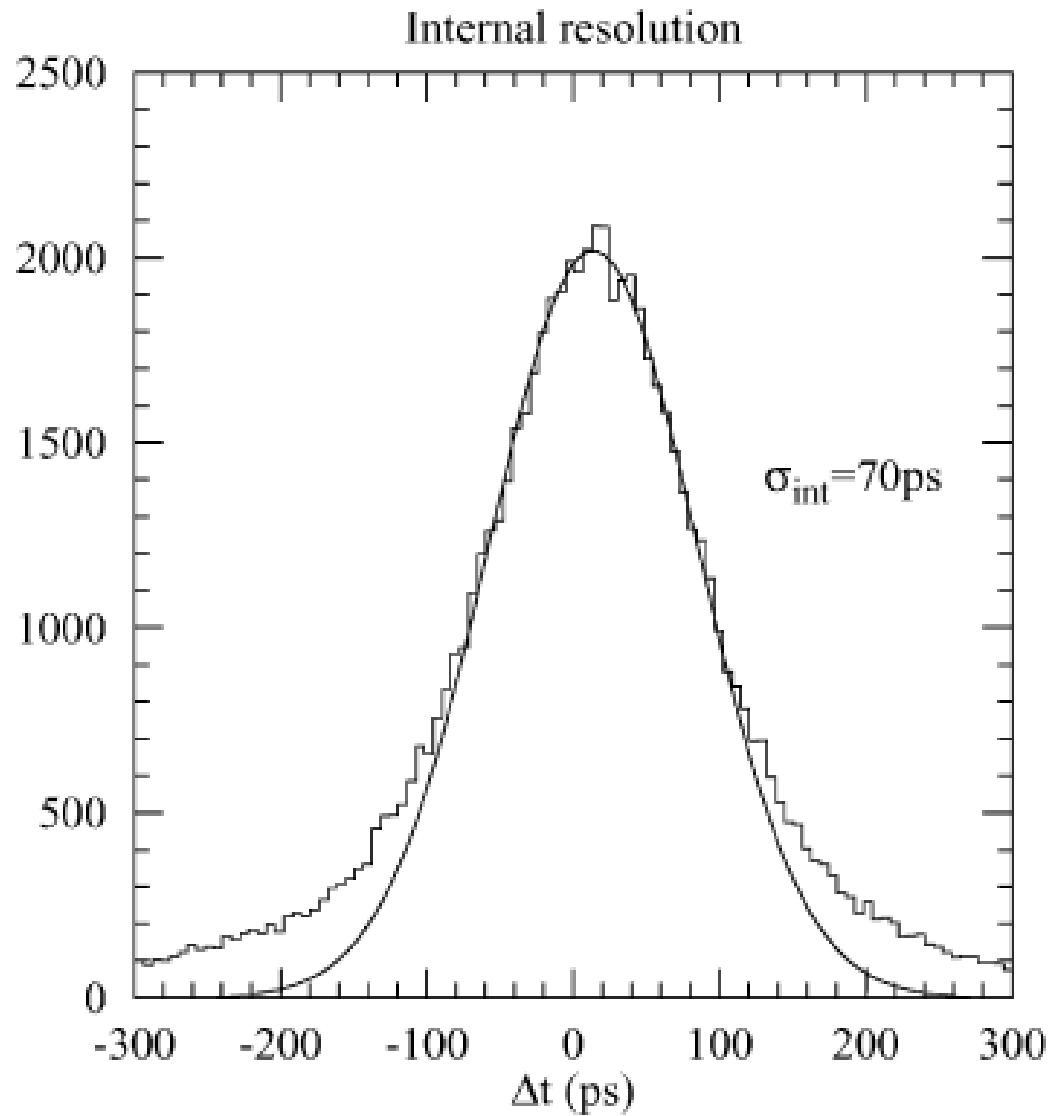
1 horizontal layer: 48 rods,
48 x 2.5 x 2.4 cm.

PMT's on each end of each rod:
372 PMTs in total

2 walls

Sensitive area: 2 x **0.576 m²**
Lateral granularity: 1 x 2.5 cm

Time resolution

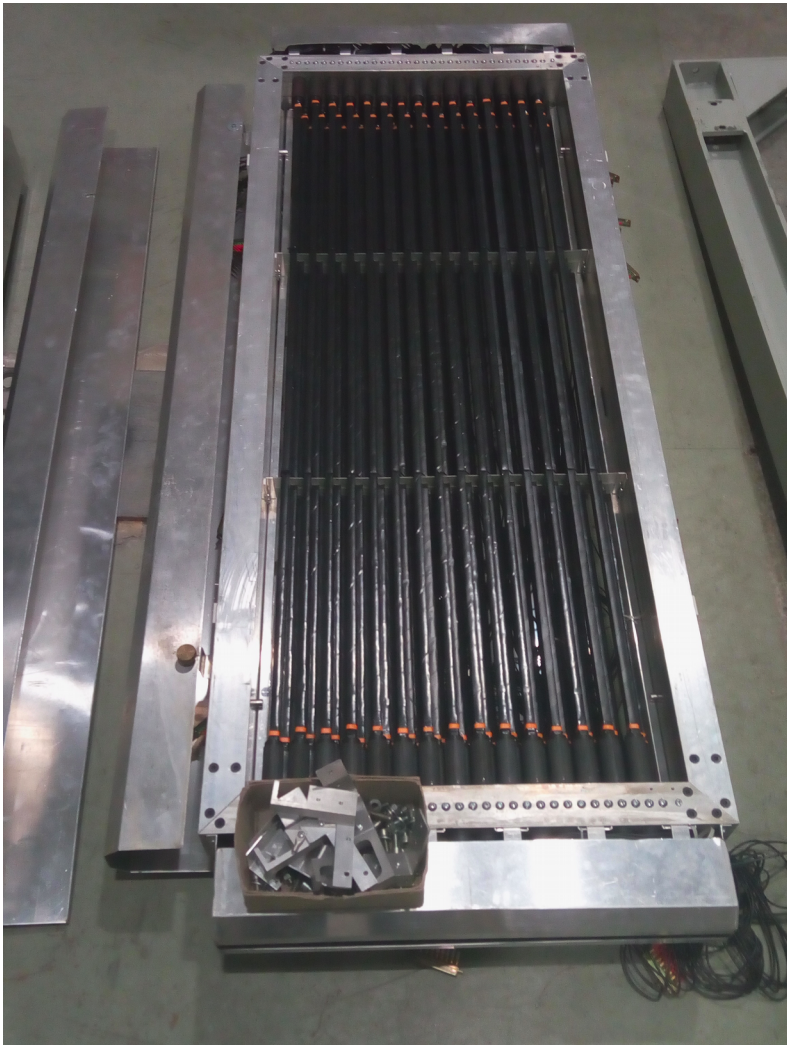


Measured using the horizontal and vertical rods, relative to each other

Time resolution of 1 wall: 70 ps

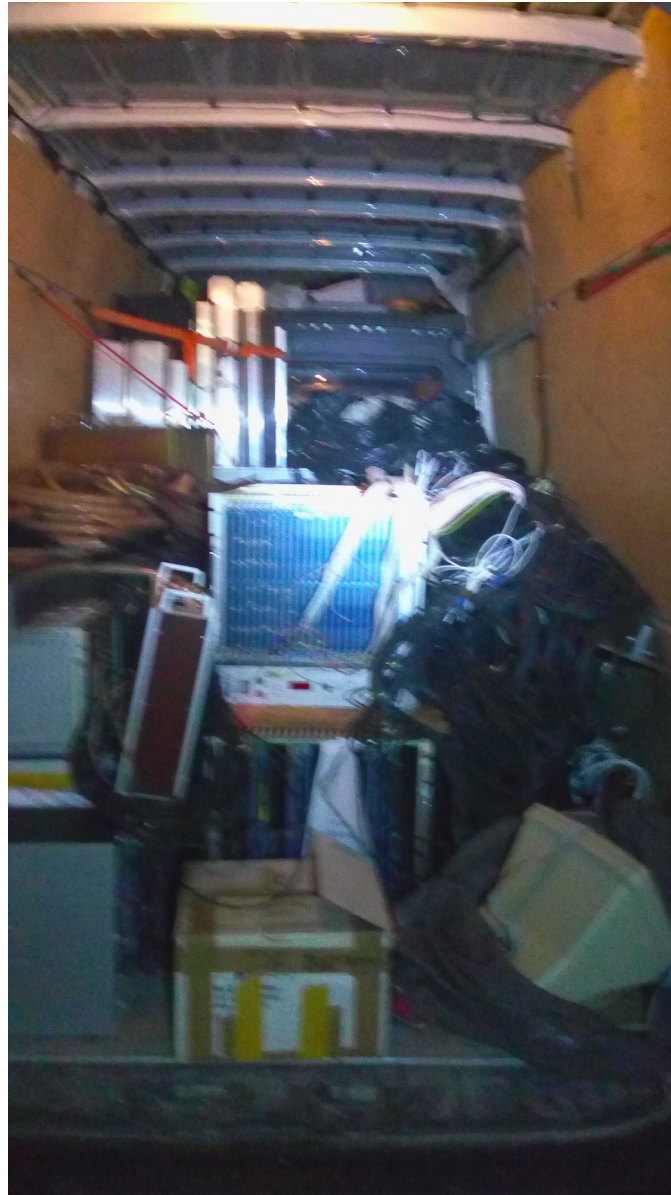
The TOF was disassembled at CERN

After 25 years, on March 8, 2019
CERN Prevezsin, North Area Hall



Night transport in a van....

Geneva →

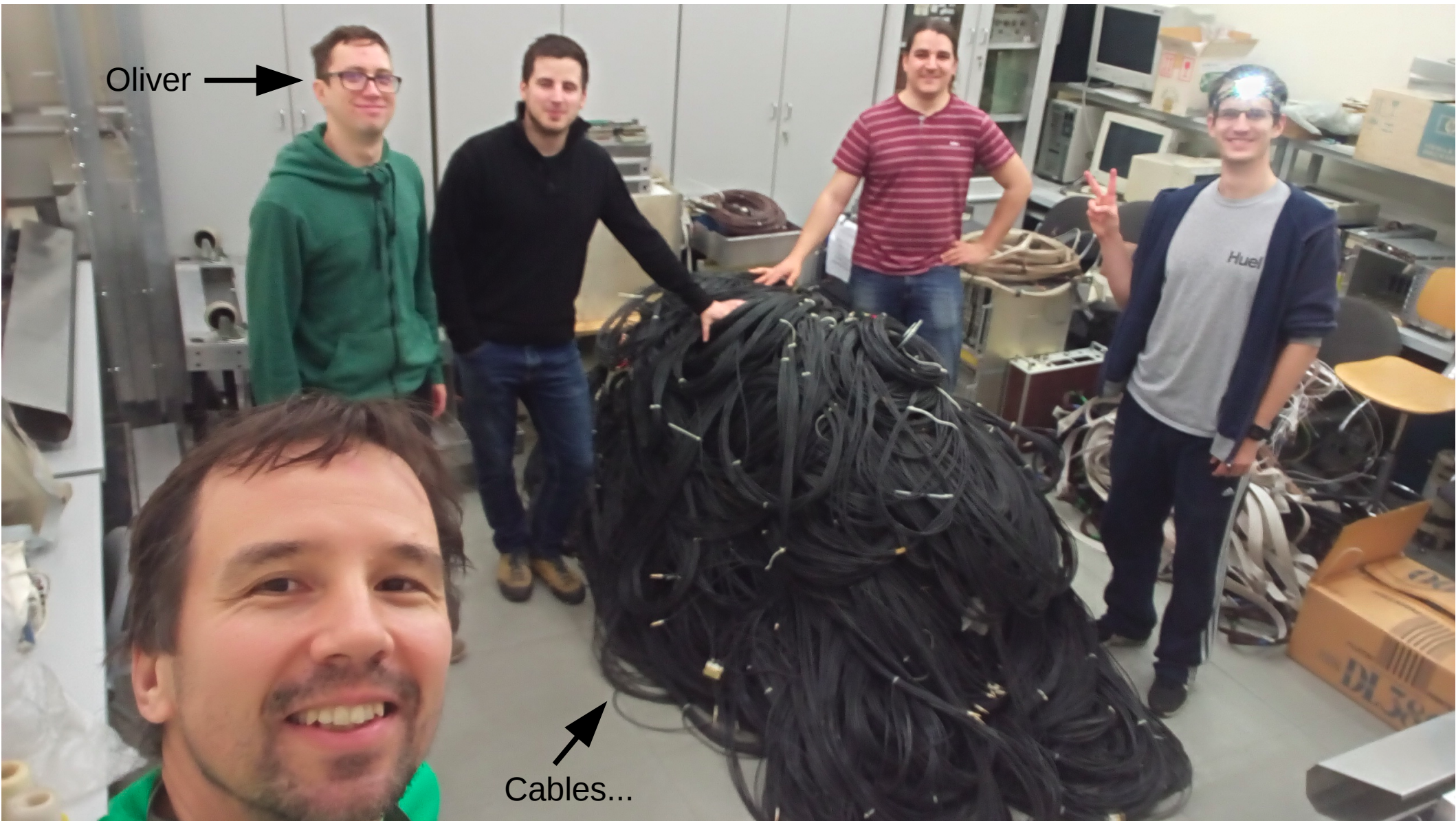


→ Budapest

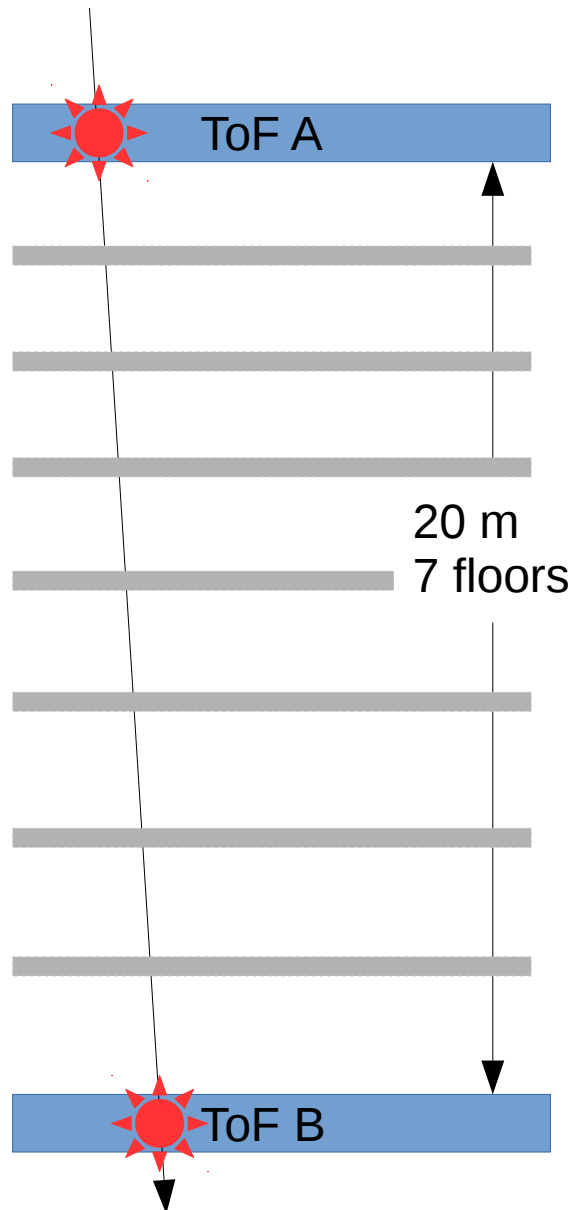
ToF wall transported back to Budapest, Eötvös Loránd University



Arrival to Budapest on 9th March, 22h



Possible uses for cosmic muons



Measuring vertical muons

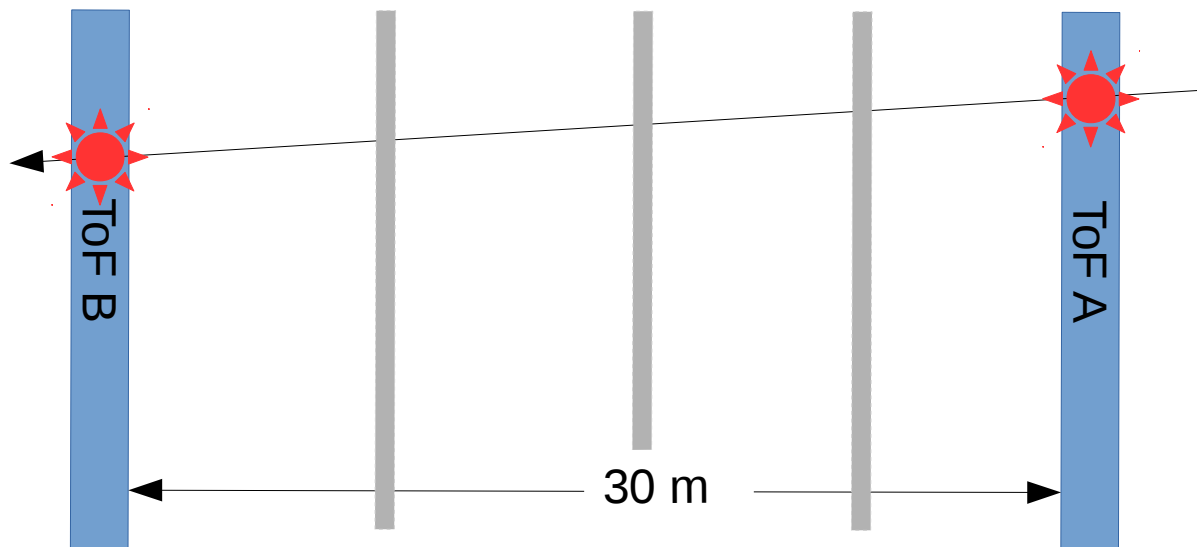
Material in between the two walls:
about 140 cm concrete

Possible uses for cosmic muons

Measuring horizontal muons

Basement level (1.5 m underground)

Material in between the two walls:
about 100 cm concrete+light building materials

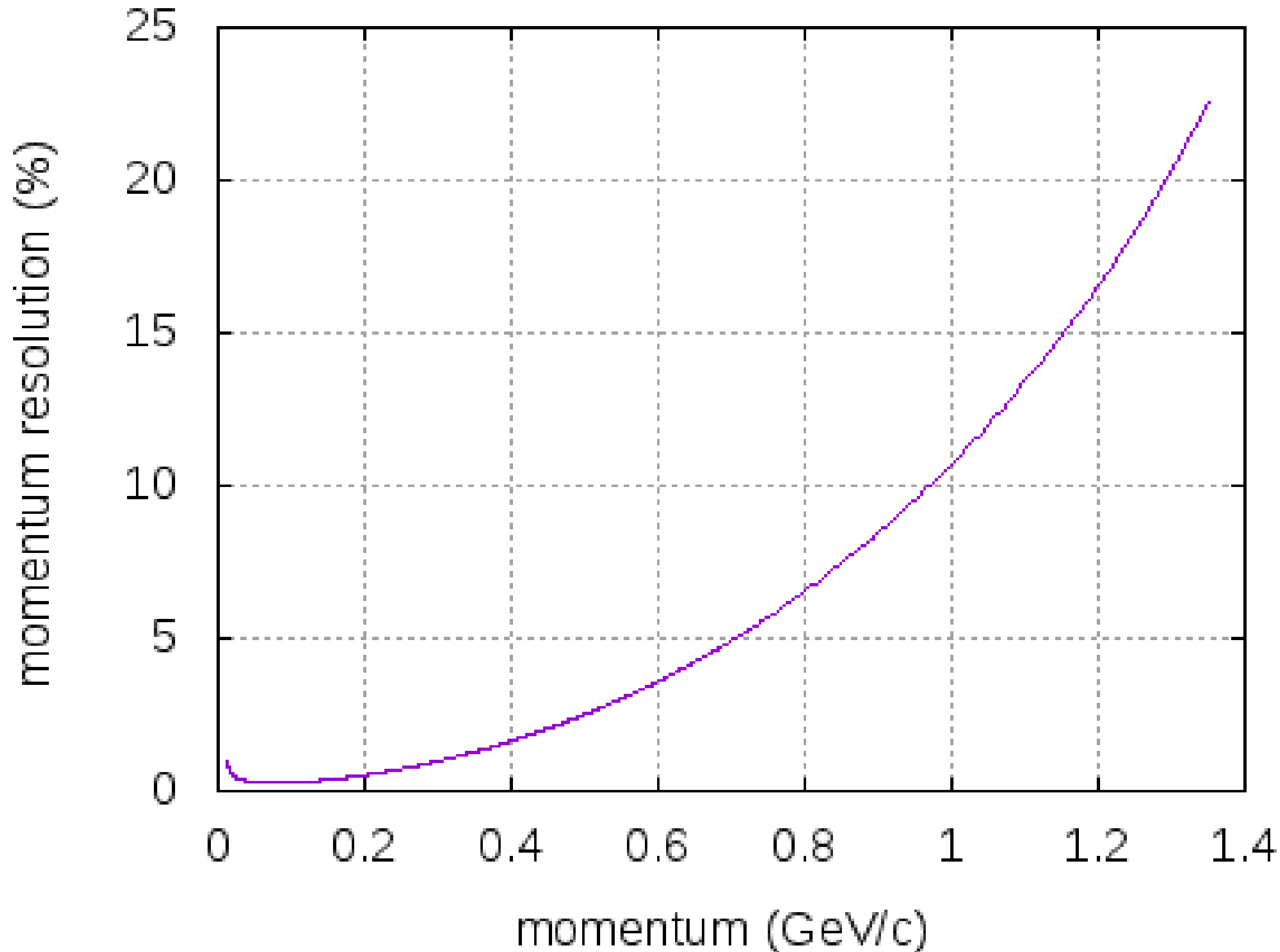


Momentum measurement of muons

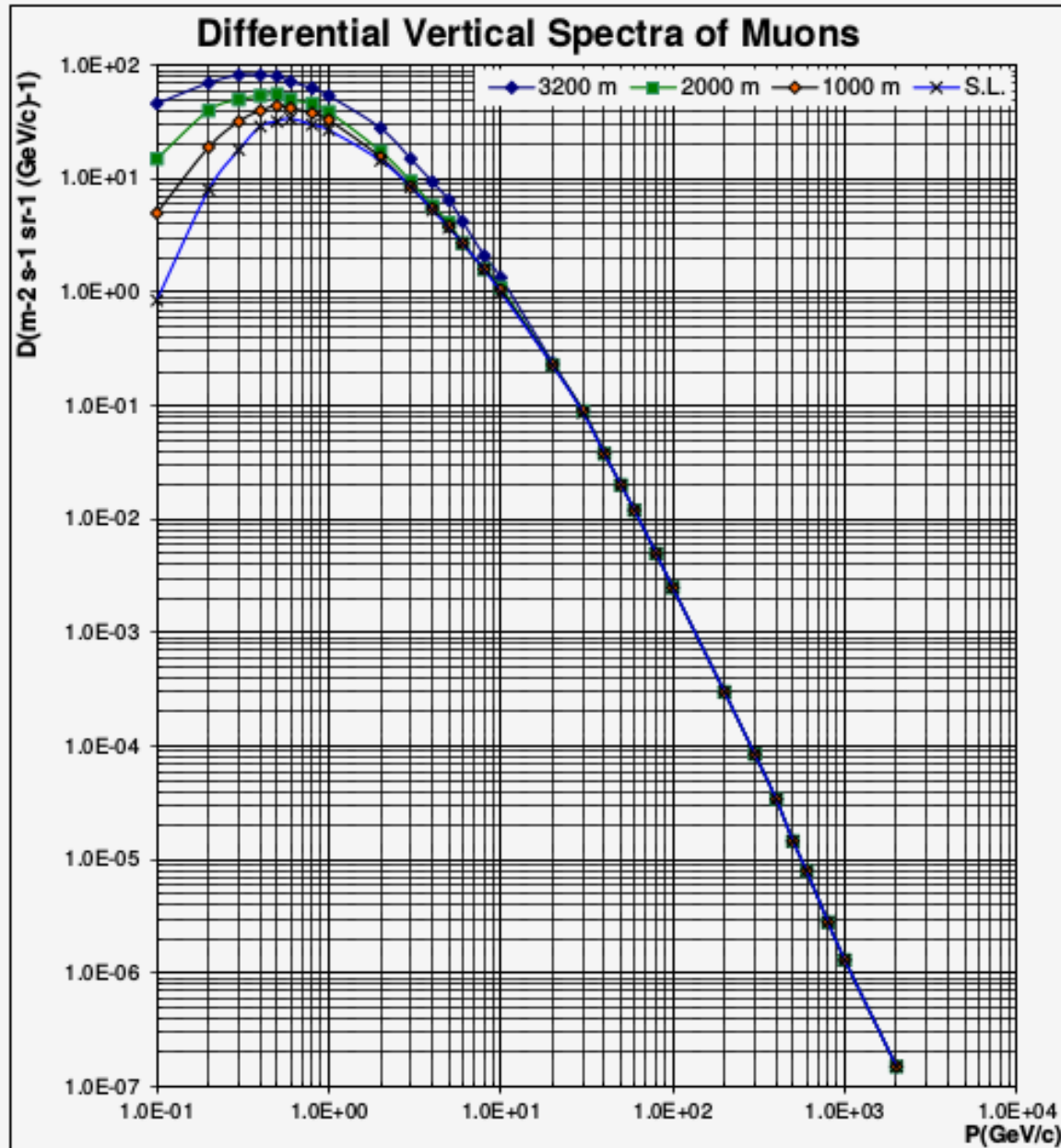
- Internal resolution of one wall: 70 ps
- Time of flight measurement resolution, using two walls: 100 ps, which is 30 light-mm.
- Assuming 30 m distance between the walls:
 - Speed measurement relative resolution: 10^{-3}
 - Better than 10% momentum resolution up to 1 GeV/c.
- Energy loss in 7x20 cm concrete (340 g/cm²):
 - Around 3.5 MeV/cm, i.e. 0.5 GeV total

Momentum resolution for muons

(no dE/dx is taken into account in the building materials)



Muon flux for vertical muons



Solid angle at 20 m distance:
1.44 msr.

Area*solid angle: **8.3 cm²sr**

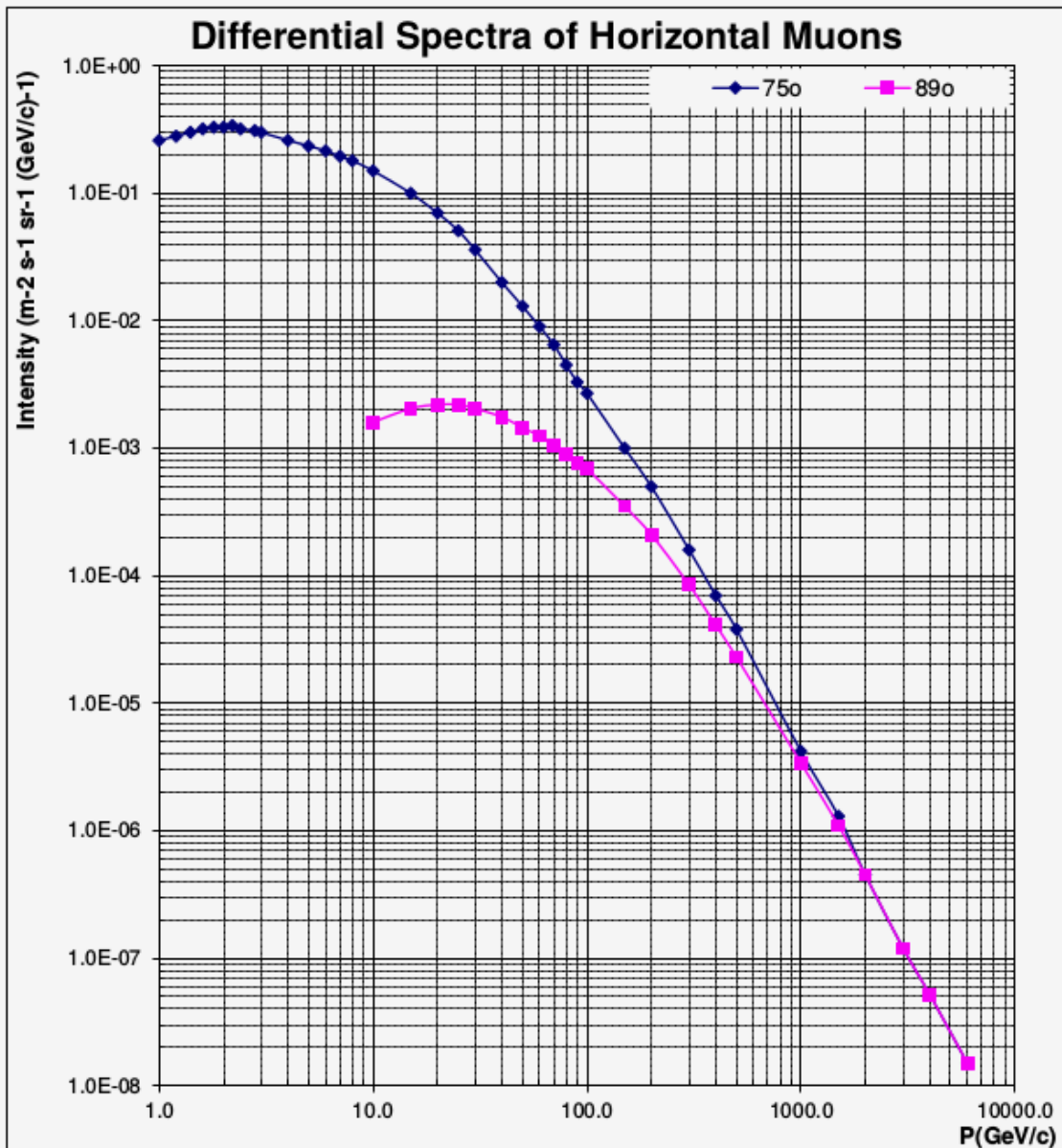
Vertical muon count rate
for 1 GeV muons: **84/h/GeV.**

Rate of all muons below 1 GeV:

70 muons/hour

<http://crd.yerphi.am/Muons>

Muon flux for horizontal muons



Solid angle at 30 m distance:
0.64 msr.

Area*solid angle: **3.7 cm²sr**

Horizontal muon count rate
for 1 GeV muons: **0.2/h/GeV.**

Rate of all muons below 1 GeV:

0.3 muons/hour

*This is assuming 75deg zenith
angle. More realistic for us is
89 deg or 84 deg.*

<http://crd.yerphi.am/Muons>

Conclusion

- We have a nice TOF 2-wall hodoscope for ‘free’
- We could measure momentum distribution of muons below 1 GeV/c momentum
- Comments are welcome, especially if you can suggest interesting use cases, or if you think this does not have added value.

THANK YOU FOR YOUR ATTENTION!