

# Design and construction of magnetised mini-ICAL detector module

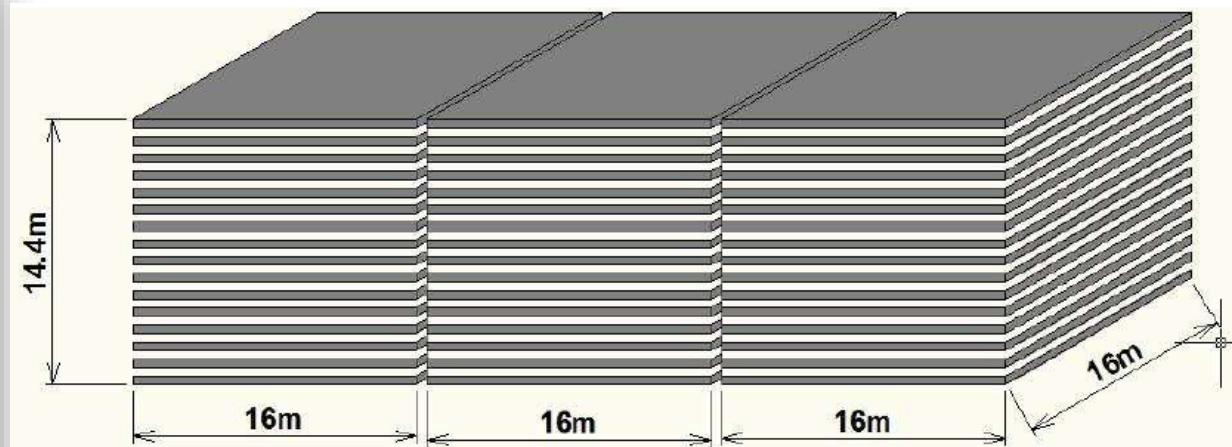
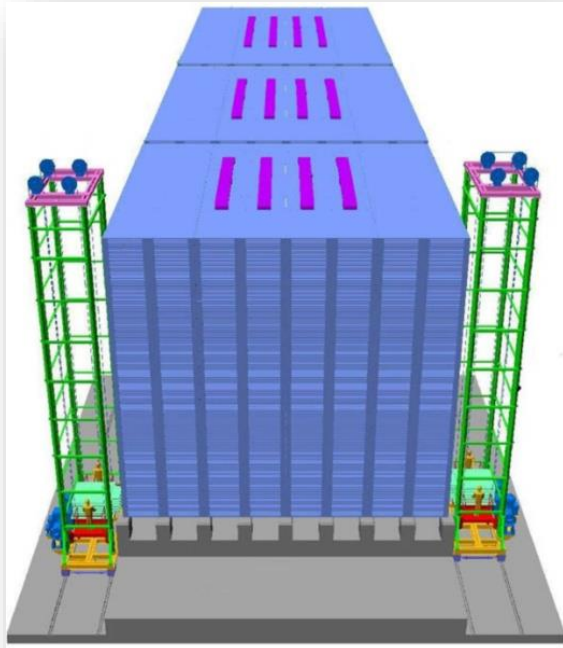
Gobinda Majumder, TIFR, Mumbai

**INO collaboration**

- Introduction
- Construction Magnet system
- Magnetic field measurement
- Noise in RPC signal with/without magnetic field
- Muon trajectory
- Conclusion



# Motivation to set up mini-ICAL

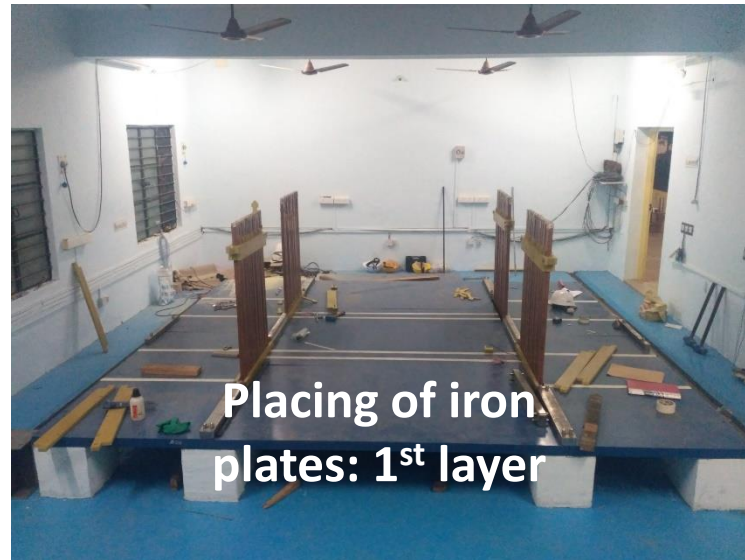


RPC is sensitive detector inside 1.3T magnetic field in iron plate.

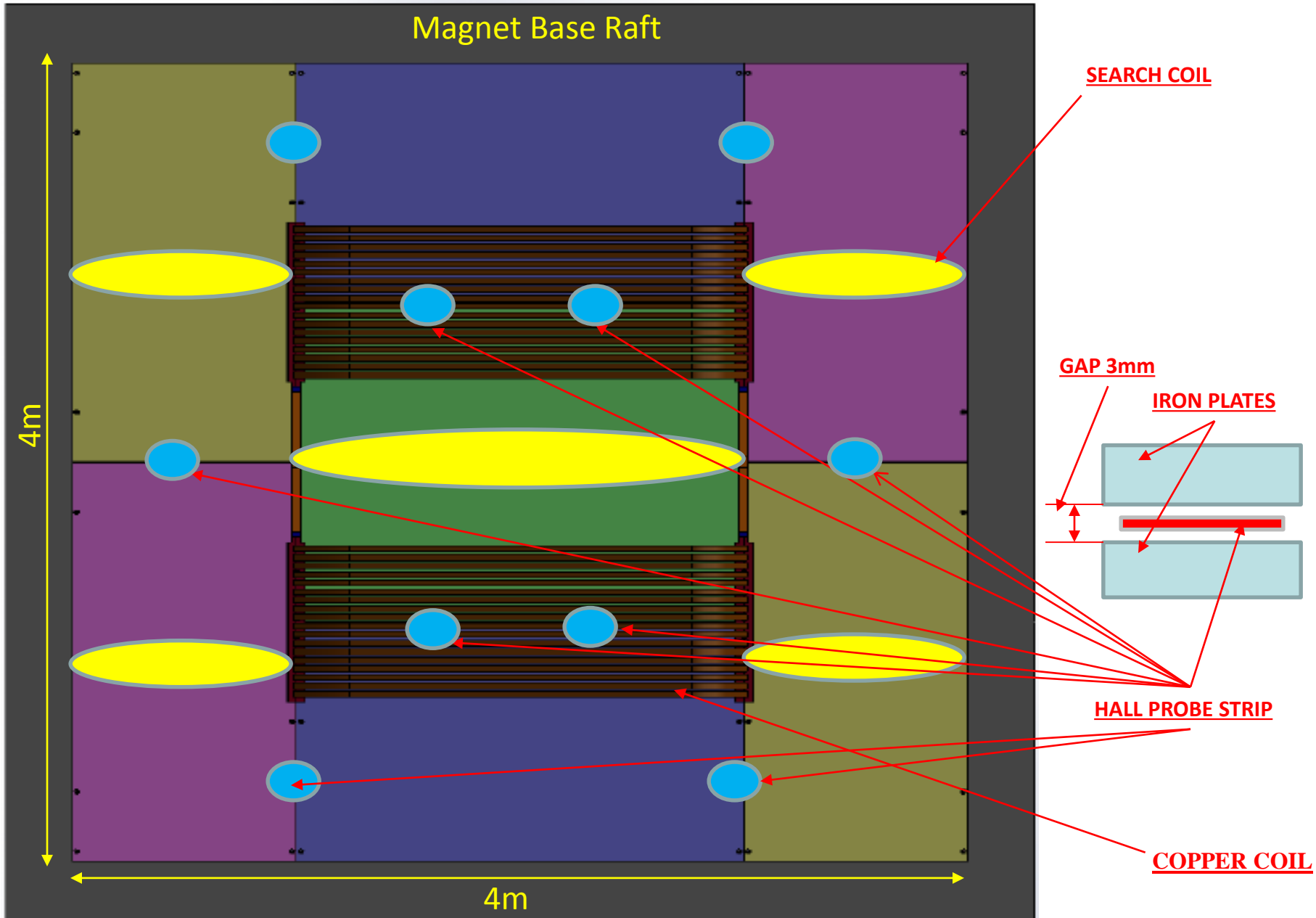
- Performance of Magnet: Measured magnetic field (*using pickup coils and Hall probes*) vs 3D simulation
- Performance of RPC including DC-DC supply, FE electronics in fringe B-field, EMI, closed loop gas system
- Feasibility of Muon Spin Rotation ( $\mu$ SR) for information about B-field complementary to sense loop and hall probe data
- Measure  $\Phi(\mu^+)$ ,  $\Phi(\mu^-)$  for  $\sim 0.5 \text{ GeV} < E < 1.3 \text{ GeV}$  at Madurai (near equator) and compare with simulation (by Athar, Honda)
- Proof of principle test of cosmic muon veto detector



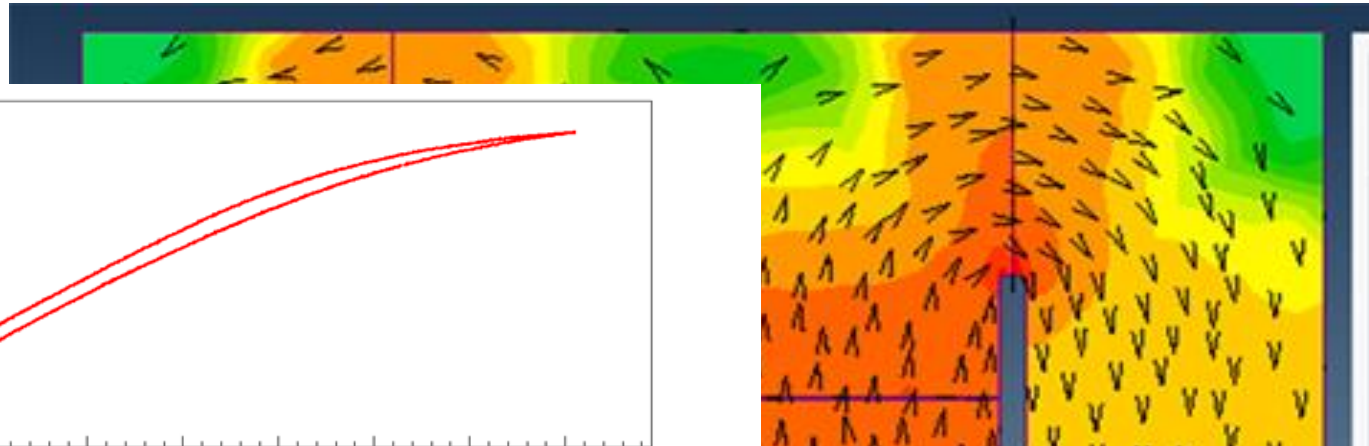
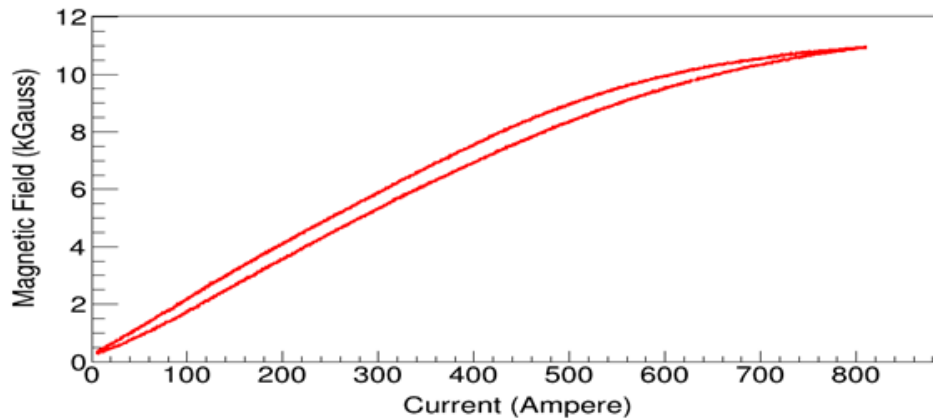
# Assembly of magnet system



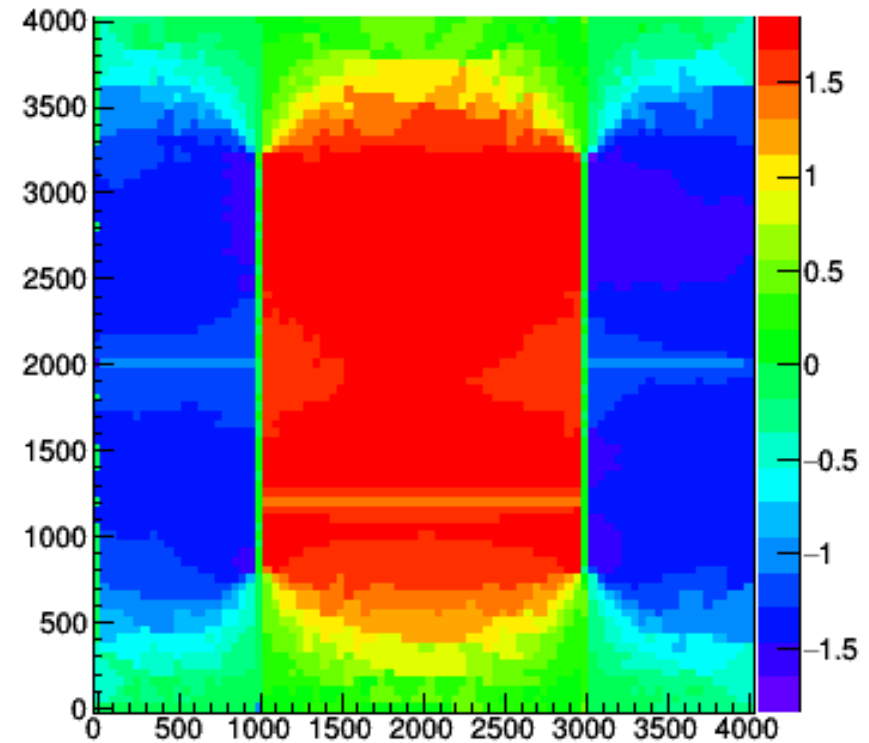
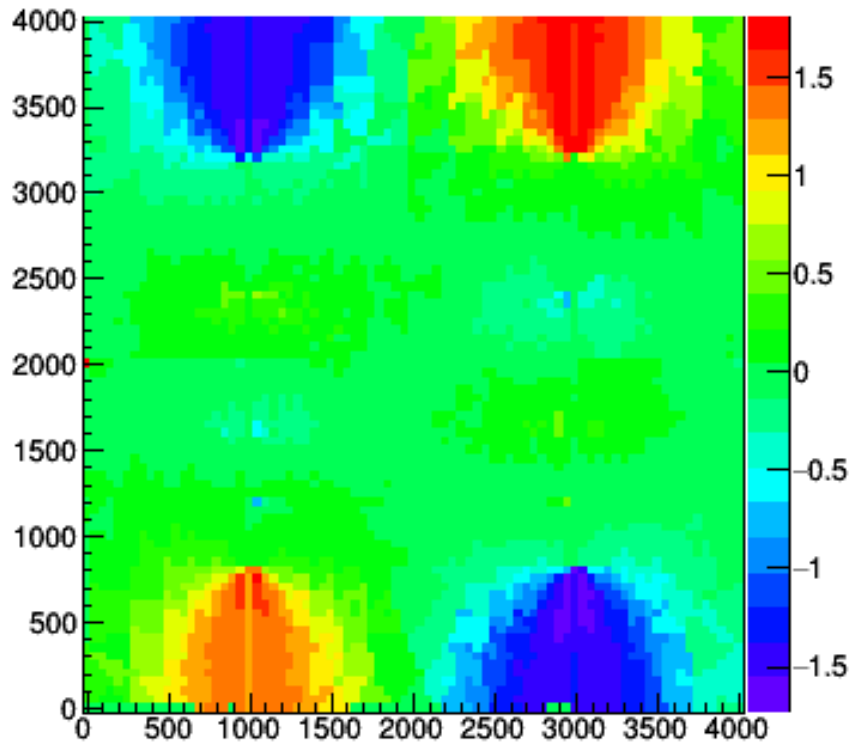
# Measurement of Magnetic field



# Magnetic flux lines in a layer of mini ICAL magnet at 24kAT

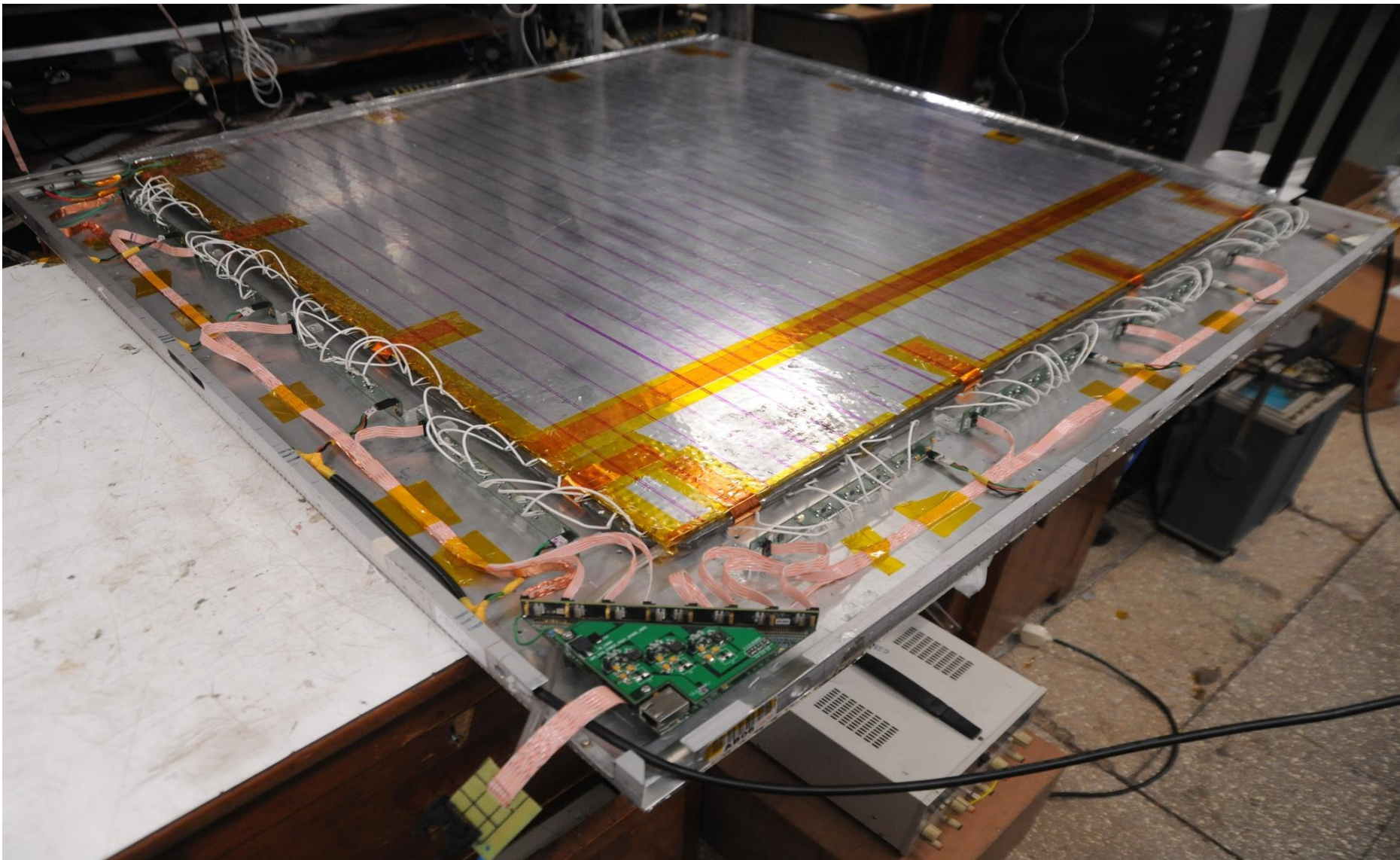


$B_y$  for  $I = 900$  A





# RPC tray with electronics



- Same detectors were tested for two years without magnetic field.

# Installing a refurbished RPC tray



- Insert RPC tray one by one

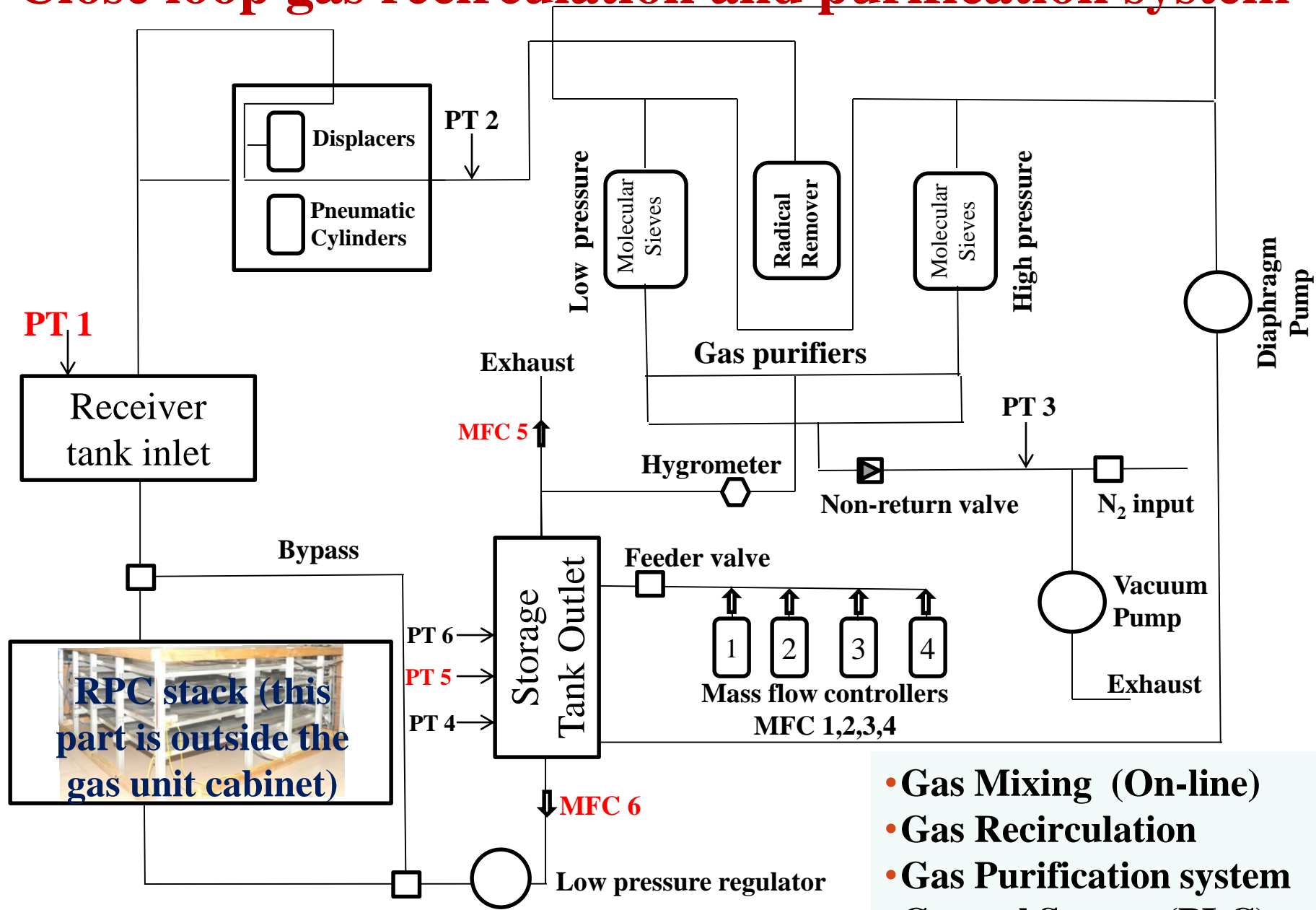


# Final assembly with electronics



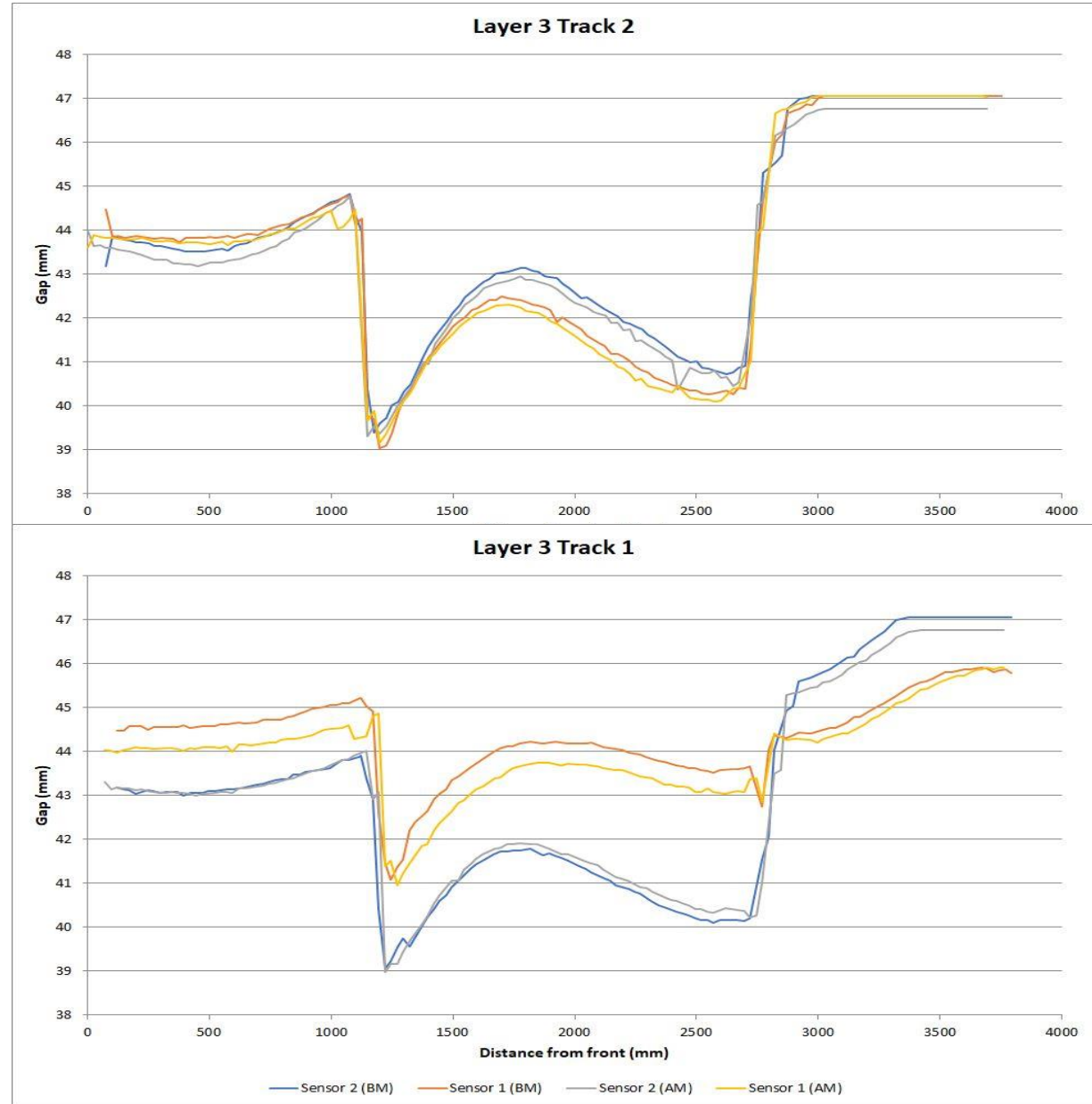


# Close loop gas recirculation and purification system



- Gas Mixing (On-line)
- Gas Recirculation
- Gas Purification system
- Control System (PLC)

# Change of gap before and after magnetisation

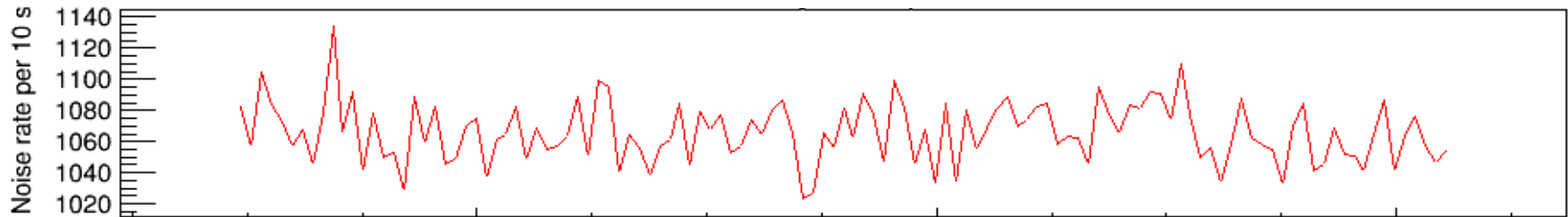


A small change due to magnetisation

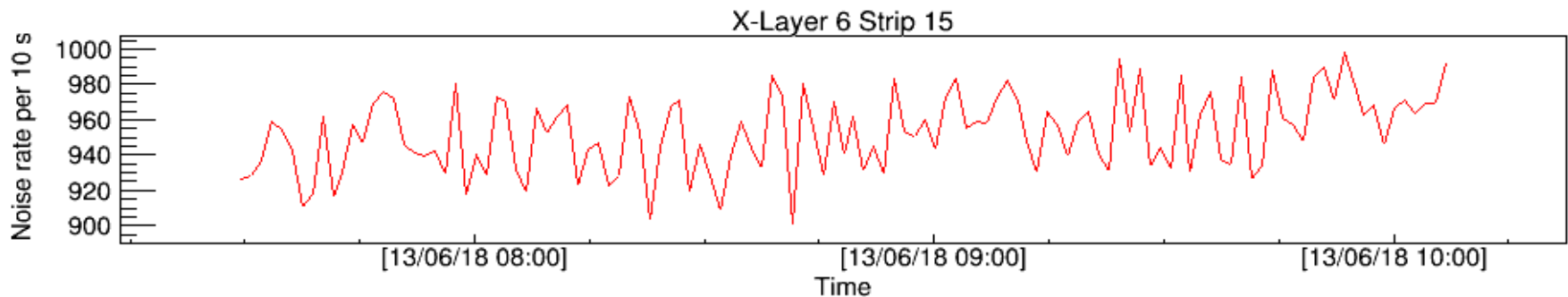
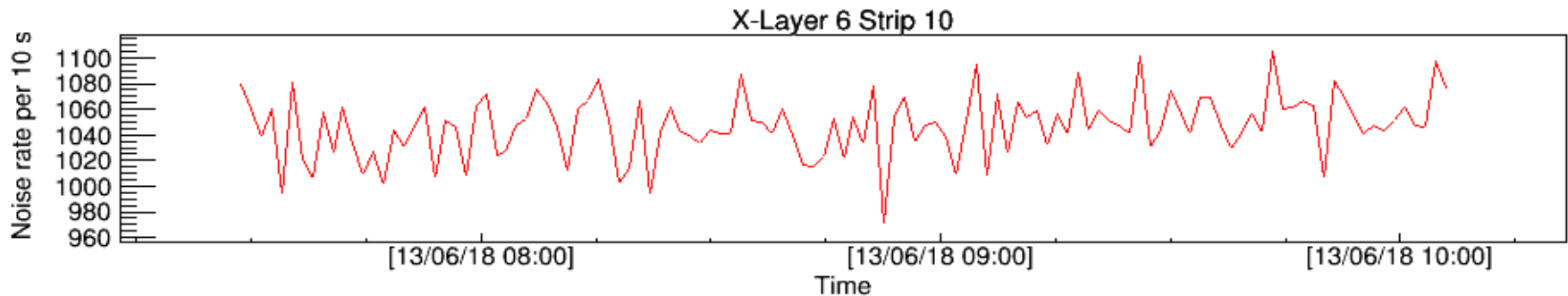


# Noise rate in presence of magnetic field

**In three hour current reduces from 900A to 0A**

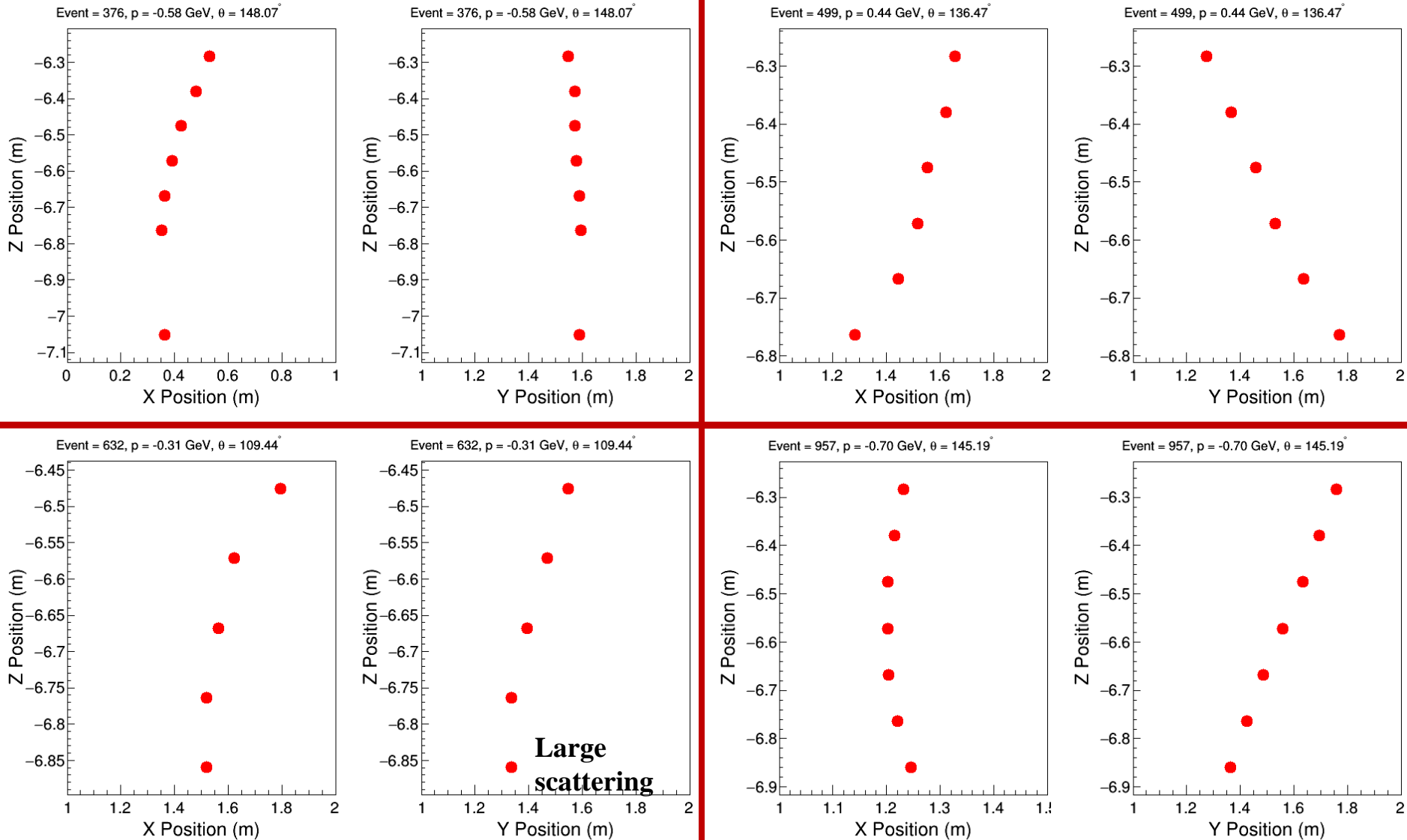


**900A** → **0A**



- **Almost no change in noise rate with magnetic field**
  - **RPC and onboard electronics found to work well in the fringe field**

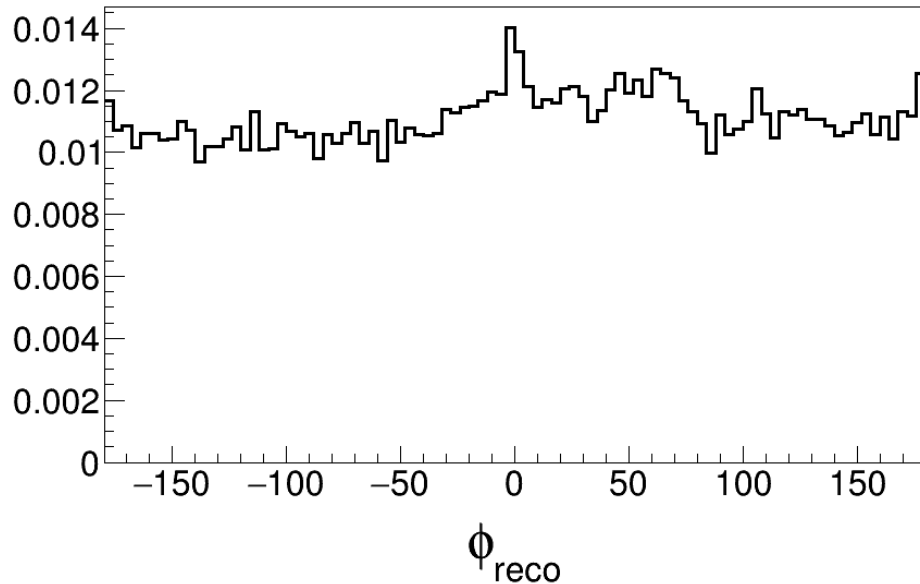
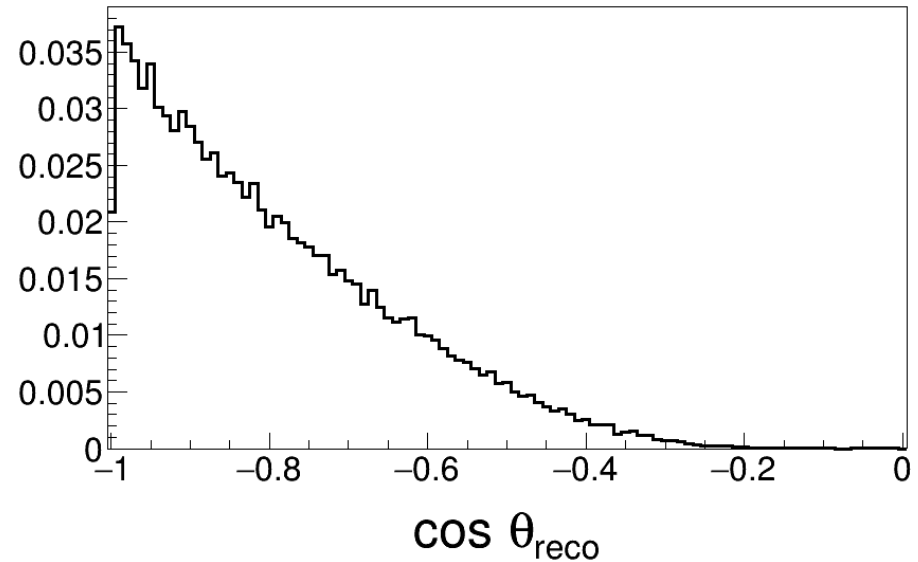
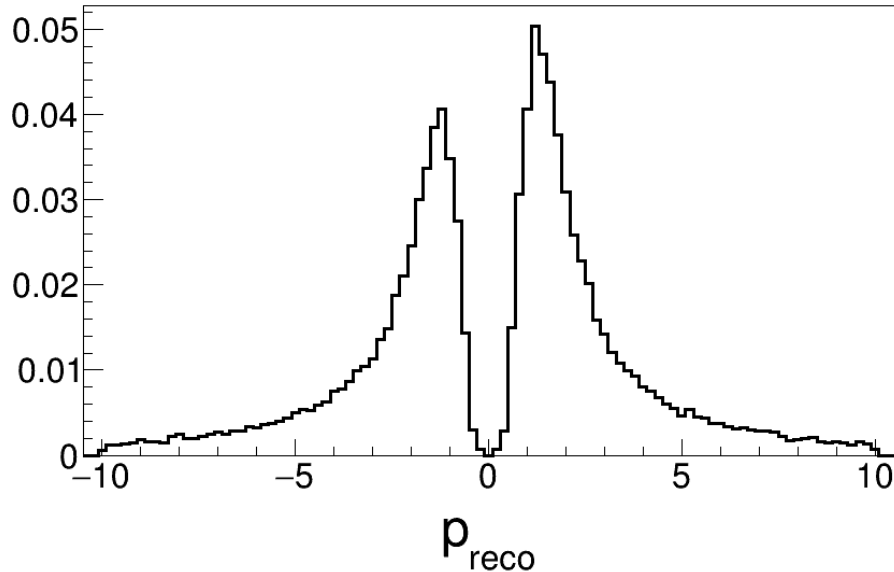
# Few clean muon trajectories



- Bending in X-side due to magnetic field in Y-direction.



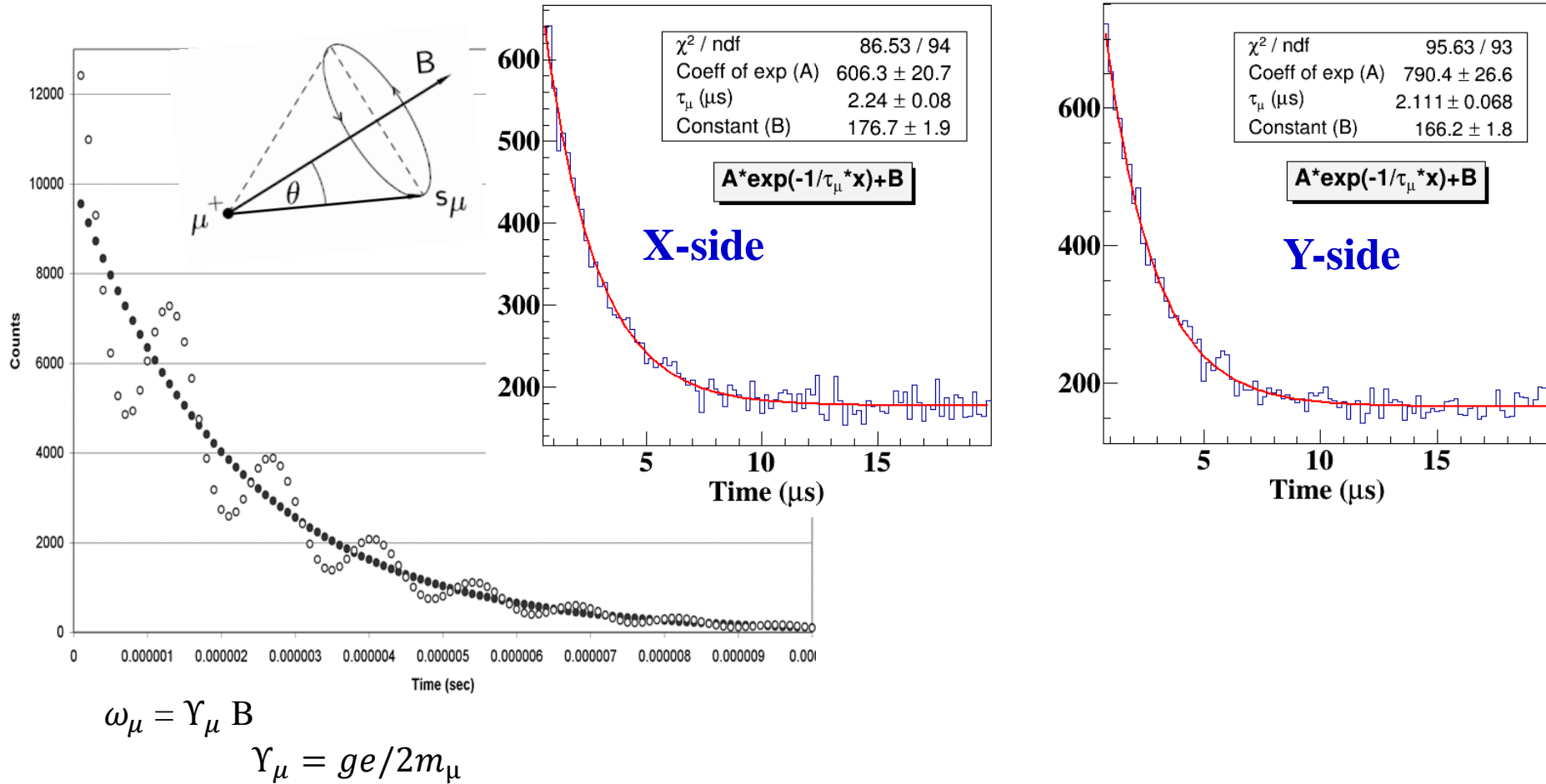
# First result of cosmic muon spectrum



**This is just observation, due to small variation of efficiency is different region of a RPC as well as variation of RPC in different layer, this results need to be corrected for efficiency before comparing with theoretical calculation.**

- Expected ratio of # of  $\mu^+$  and  $\mu^-$ , though measurement has large uncertainty**

# Muon lifetime towards magnetic field measurement

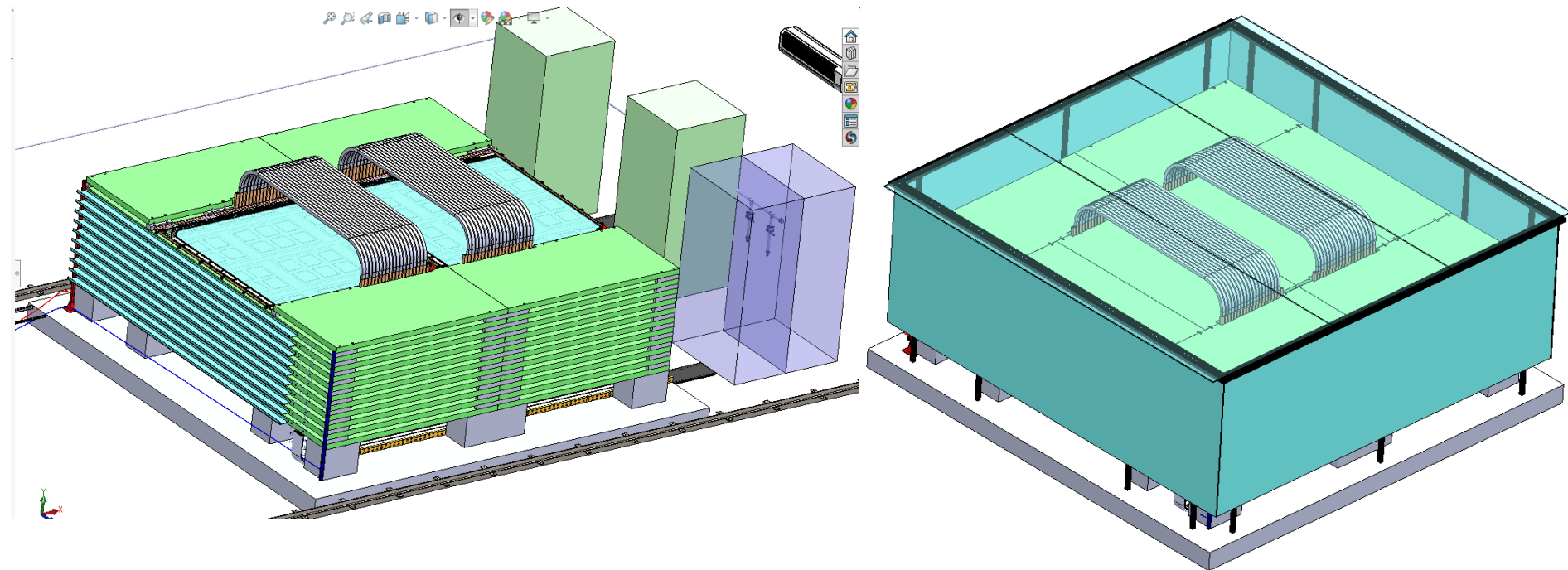


- Though estimated lifetime is matched with world average, yet to understand the huge level of background.



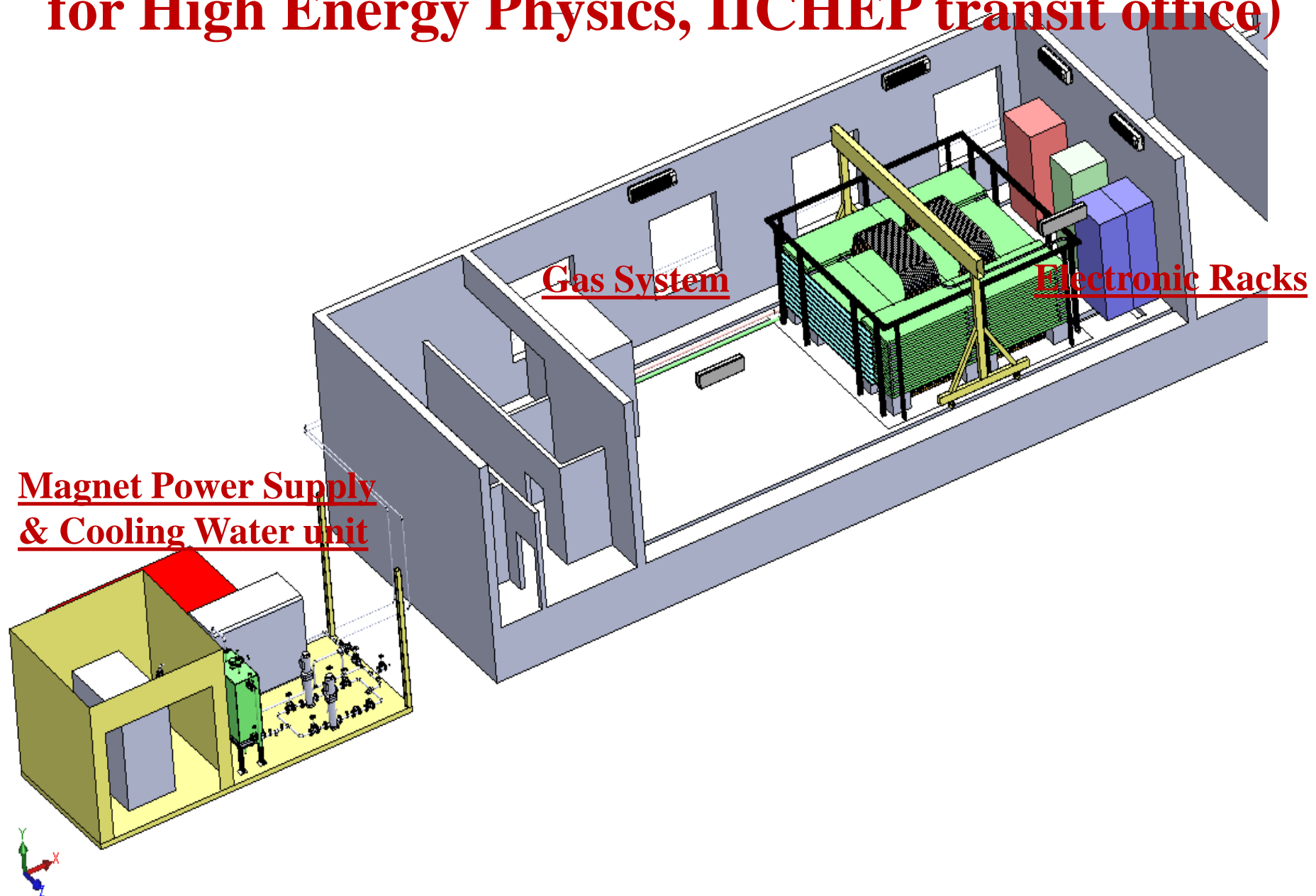
# Status of miniICAL

- We had only one RPC in a layer
- Will move the second one soon
- Put cosmic muon veto detector around miniICAL detector



**EXTRA**

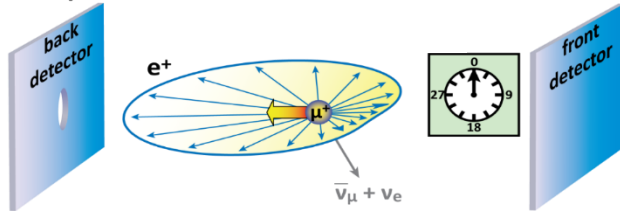
# Layout of Mini-ICAL (Inter Institutional centre for High Energy Physics, IICHEP transit office)





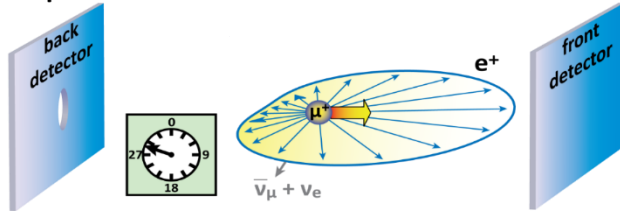
# Muon Spin Rotation ( $\mu$ SR )

before spin relaxation

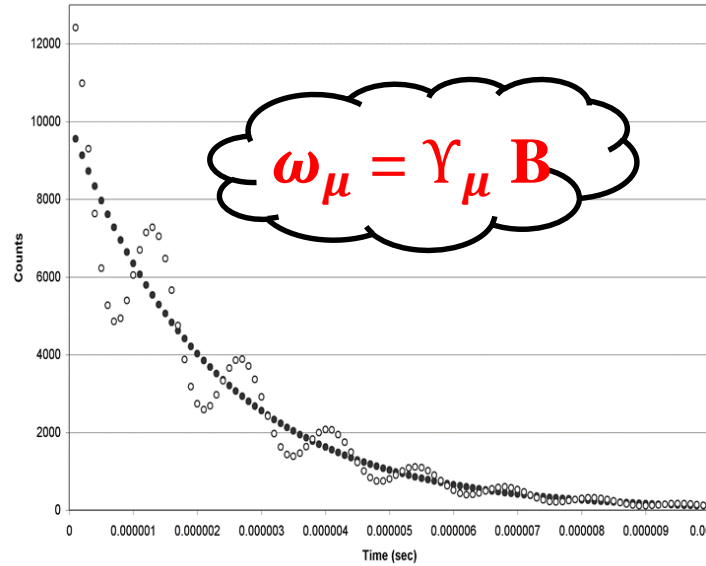


$t = 0$ : spin-polarisation = 100%  $\rightarrow$  no relaxation (yet)

after spin relaxation

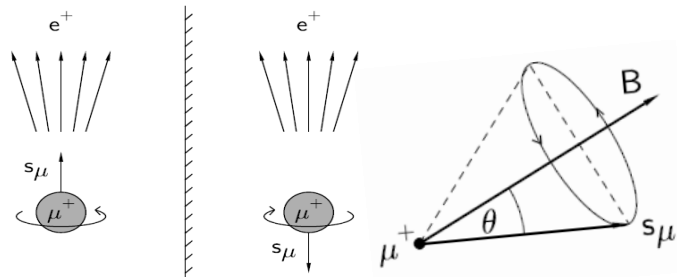


$t > 0$ : spin-polarisation < 100%  $\rightarrow$  spin relaxation



Asymmetry Factor

$$A(t) = \frac{N_B(t) - N_F(t)}{N_B(t) + N_F(t)}$$



$$\omega_\mu = \gamma_\mu B$$

$$\gamma_\mu = ge/2m_\mu$$

Energy  
Spectra

Polarization

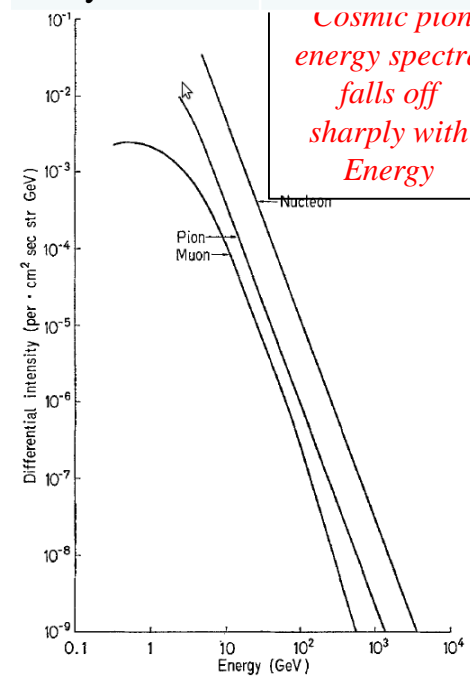
Flat

ZERO

Asymmetric

NON-ZERO

*Cosmic pion  
energy spectra  
falls off  
sharply with  
Energy*



*Cosmic Ray muons are partially  
longitudinally polarized*