CERN Summer REU Research Project

EE Chamber Commissioning

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CERN REU Presentations
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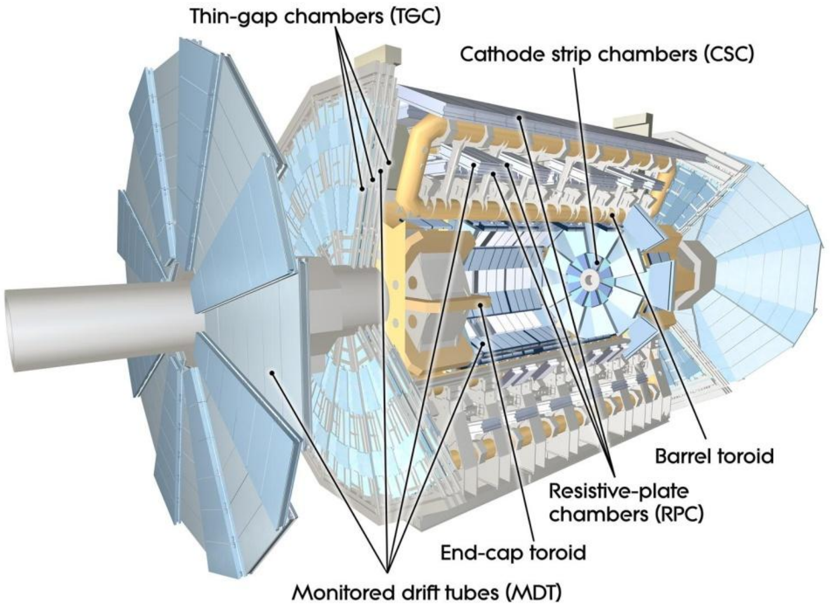
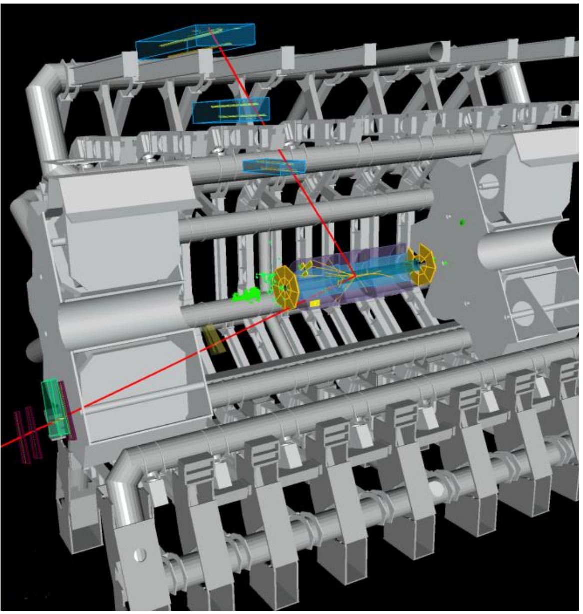
ATLAS Muon Detection System

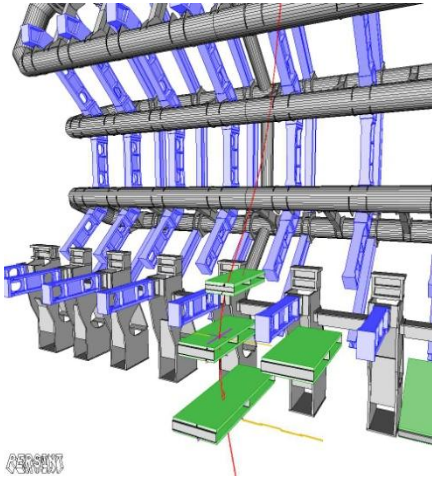
Size: 25m in diameter and 44m long



• The muon spectrometer consists of multiple layers of detectors on both the barrel and end caps , called “Big Wheels”.



• The muon spectrometer also has an air core toriodal magnet between two layers of detectors. These magnets are in the barrel and end caps and produce a 2 T field.



• There is also a trigger system which makes quick decisions about the quality of the event and either allows the detector to keep the data or dump it before it leaves the detectors.

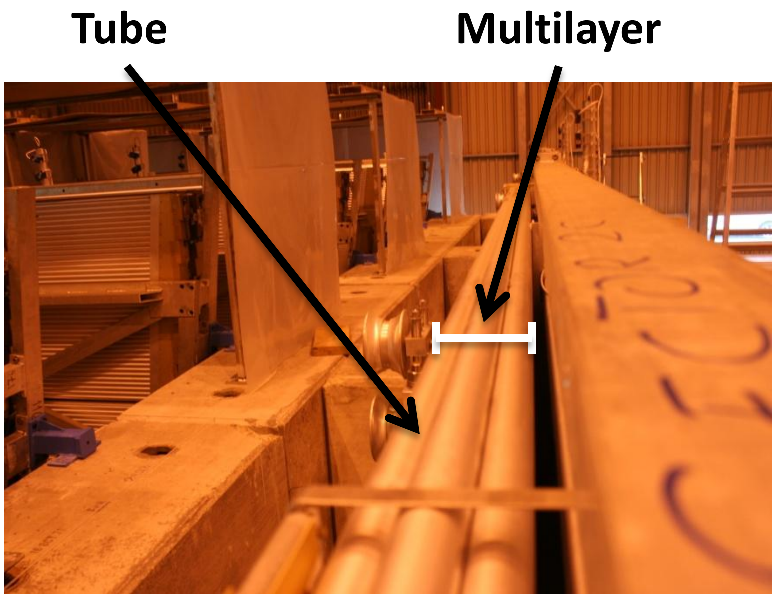
EE Chamber Hardware

- There are 62 sectors of EE chambers in the Muon Detection system.

- Two chambers per sector.

- The sector and chambers have 2 multilayers.

- Each multilayer is made of 3 layers of tubes.



EE Chamber Hardware

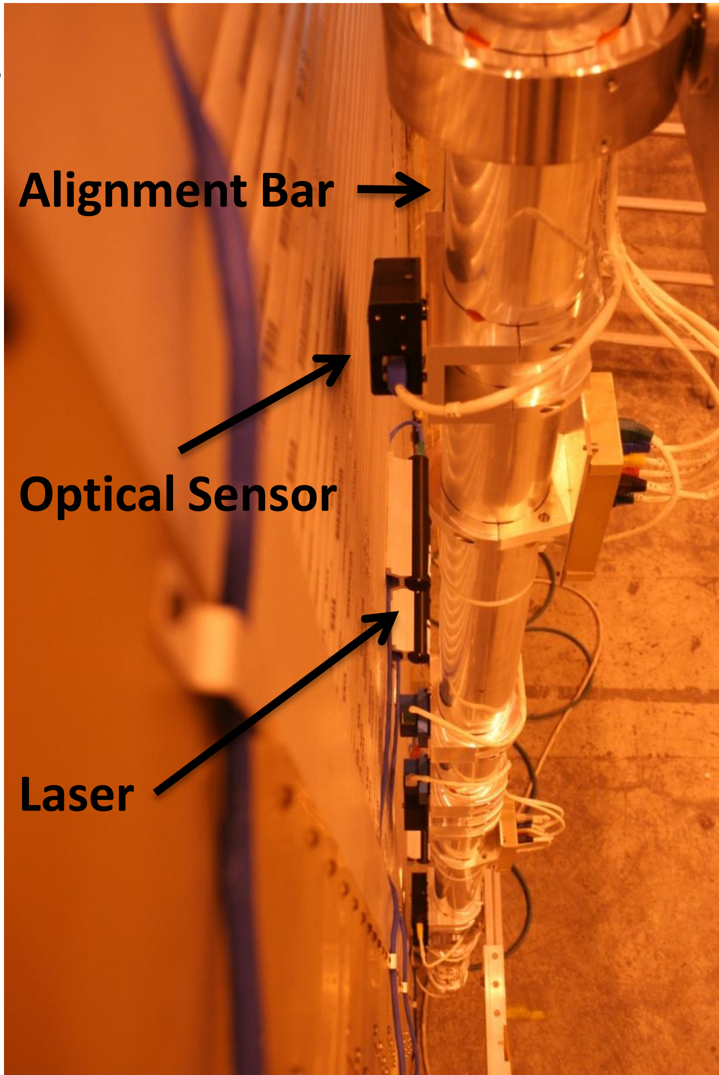
• The alignment bar gives the relative location of the chamber to other chambers using lasers.

• Each tubes has a temperature sensor to help monitor how the gas pressure and size of the chamber changes with temperature.

• The lower chamber has magnetic field sensors.

  • These sensors map the B field in the Muon Spectrometer.

  • The sensors also help give a better P_T measurement.

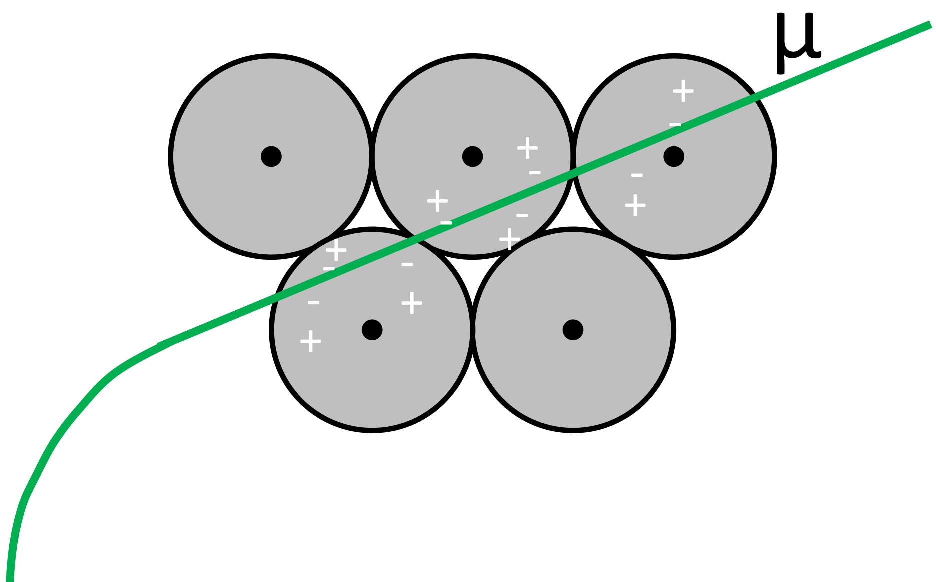


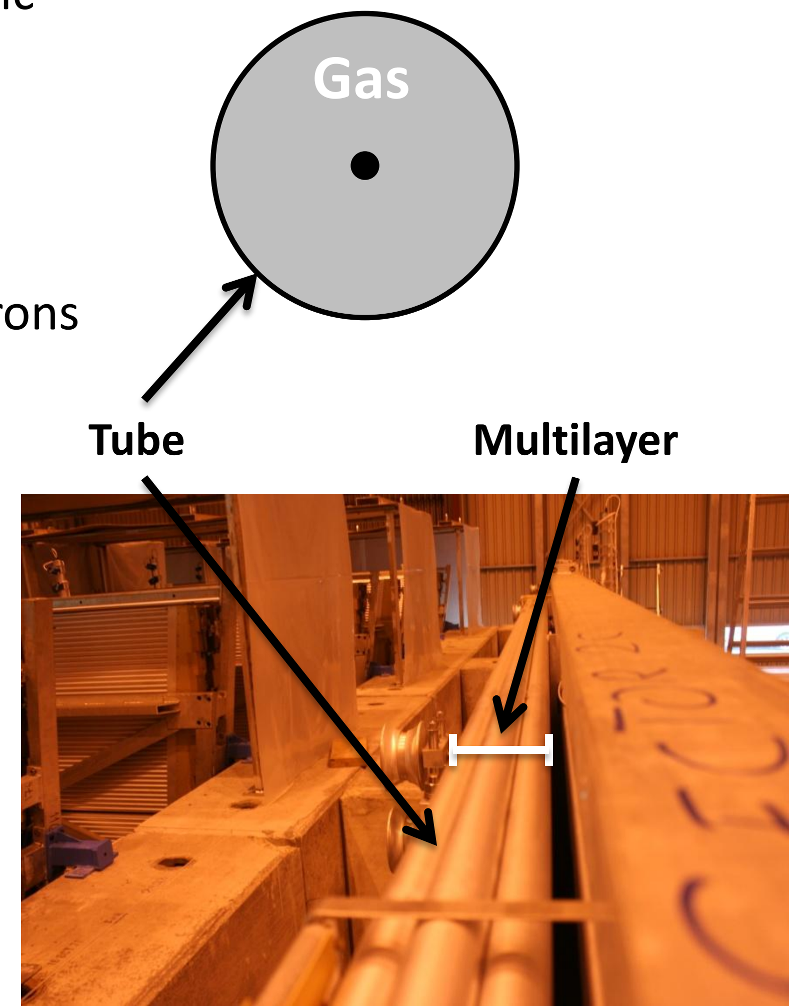
EE Chamber Hardware

Muon Drift Tubes (MDT)

- Each tube has a wire held at 3080V and a 3 bar pressure of 93% Argon and 7% CO_2.
  - We use he lowest gas gain fulfills the electronic noise and spatial resolution requirements.
  - Too much gain results in a lot of noise and significant ageing affects.

- A signal is created in the wire by the ionized electrons changing the electric field in the tube.





EE Chamber Electronics

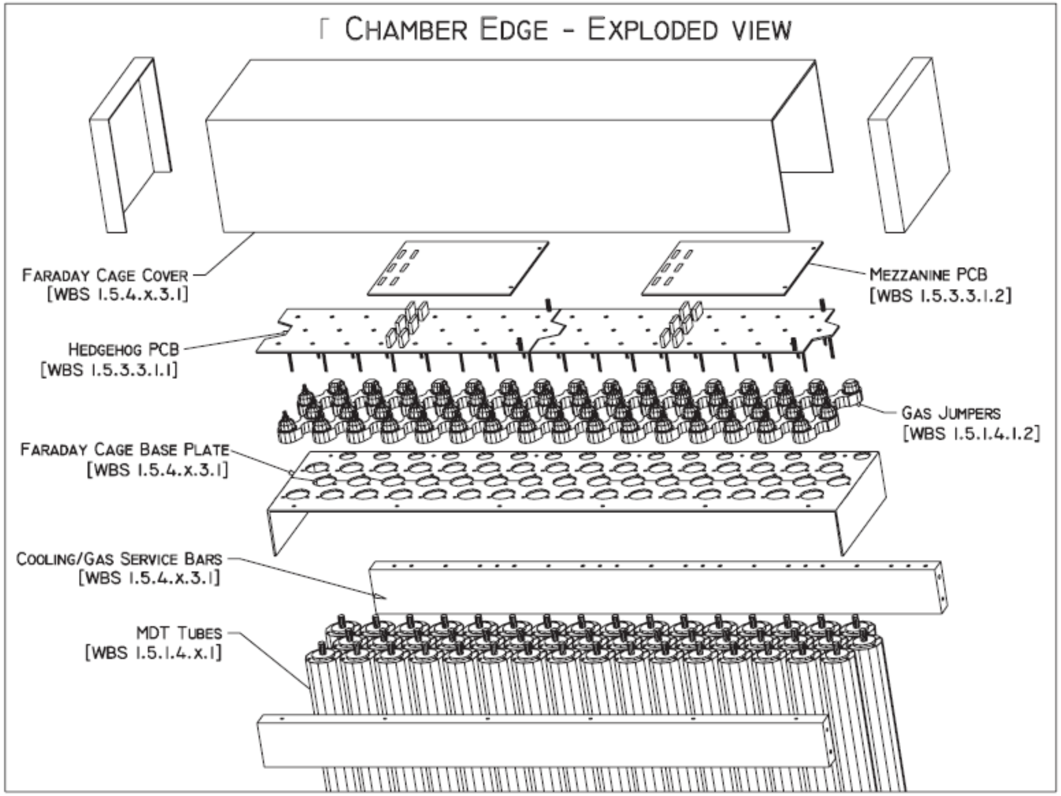
• The signal from the drift wire goes to the ASD (Amplifier, Shaper, Discriminator) Chip on the Mezzanine Card.

•The Mezzanine card processes 24 tubes using 3 ASD chips and a TDC (Time to Digital Converter) chip.

- •The TDC Chip changes the analog signal from the tube into a digital signal.

• Each Mezzanine card is surrounded by a Faraday Cage and its output is sent to a Motherboard.

• Sometimes Mezzanine cards break during testing and are replaced.

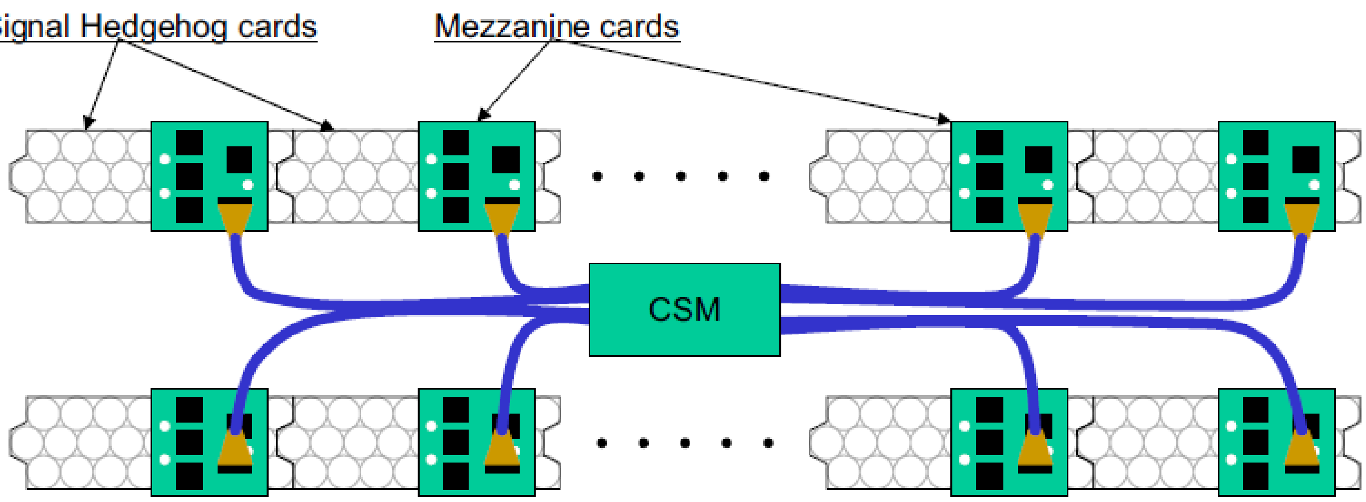


EE Chamber Electronics

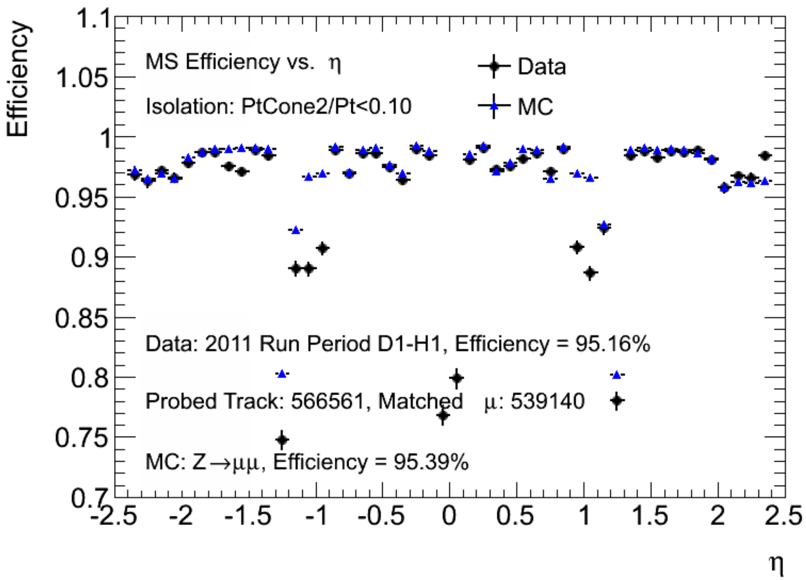
- The Motherboard simply sends the information from the Mezzanine Card to a CSM (Chamber Service Module) which is mounted on the Motherboard.

- The CSM, via optical cables, receives information from the TTC (trigger, timing, and control system) and outputs to the DAQ (data to the data acquisition system).

- The CSM is the junction between the Chamber Read Out system and the DCS (Detector Control System) which monitors the temperature, B-field, and voltage of the chamber.
    - The electronics are equipped with temperature sensors to keep from over heating.

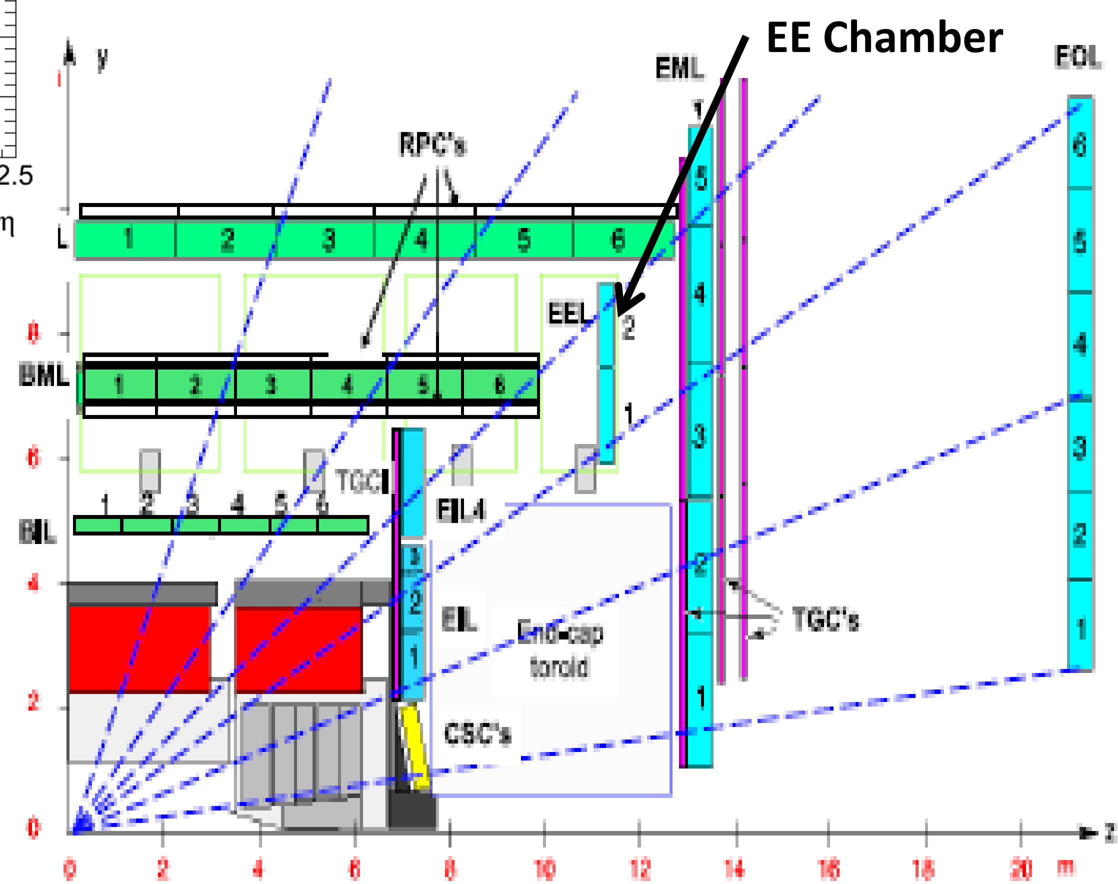


Importance of the EE Chambers



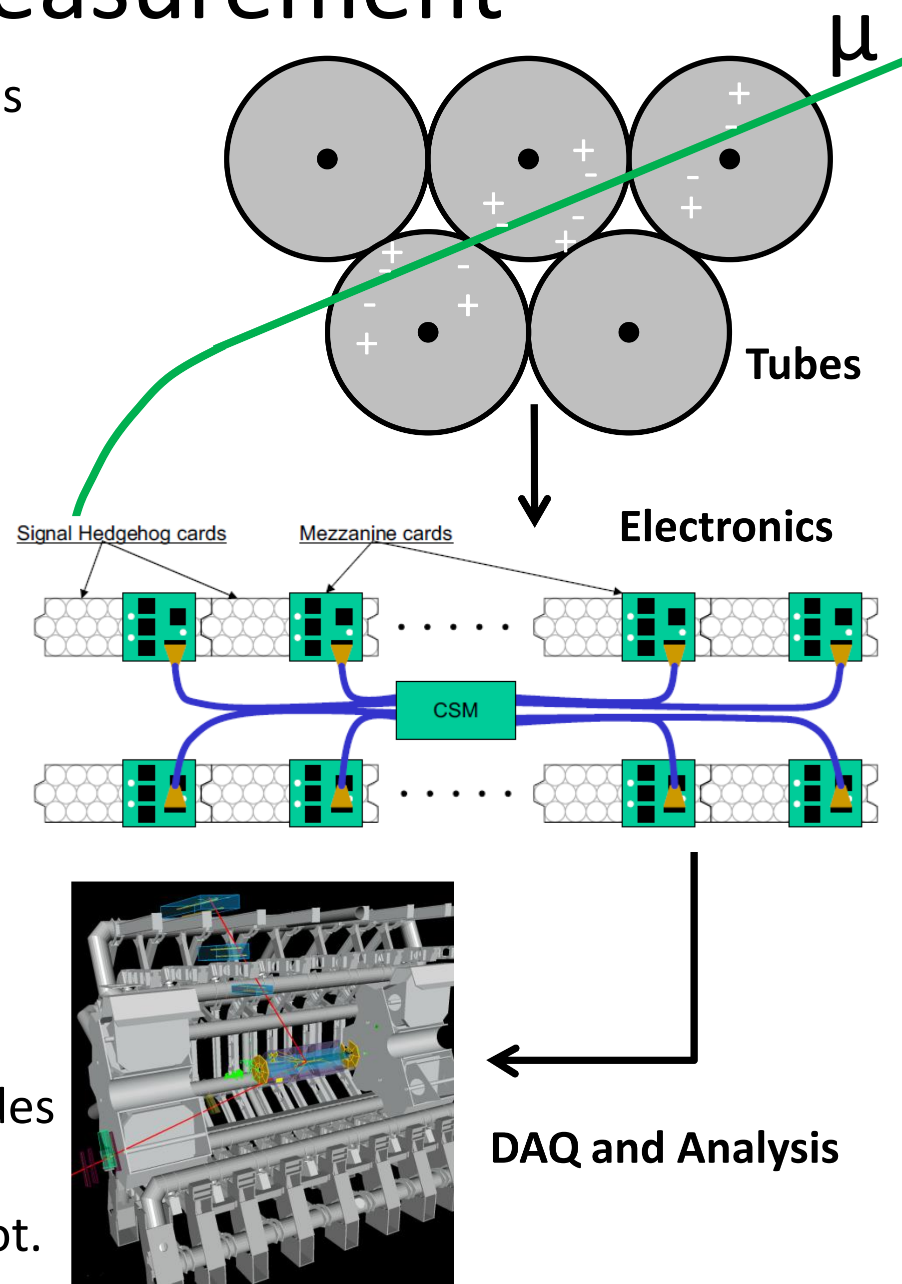
- Without the EE Chambers we currently have terrible efficiency where the endcap and barrel meet.

- The EE Chambers will provide us with an extra measurement which will help with the Muon Spectrometer efficiency.



Making the Measurement

1. The muon ionizes the gas and the electrons float towards the high voltage wire.
2. The change in the electric field creates a signal which travels down the wire, to the Mezzanine Card.
3. The Mezzanine Card then processes some information using the installed chips.
    - ASD Chip, TDC Chip
4. The output of the Mezzanine Card goes through the Motherboard and to the CSM.
5. The CSM then sends the data to the DAQ where it is reconstructed and must pass other triggers before being saved.



* Before any data is recorded the Trigger decides if this event is worth keeping and either allows the data to be sent to the DAQ or not.

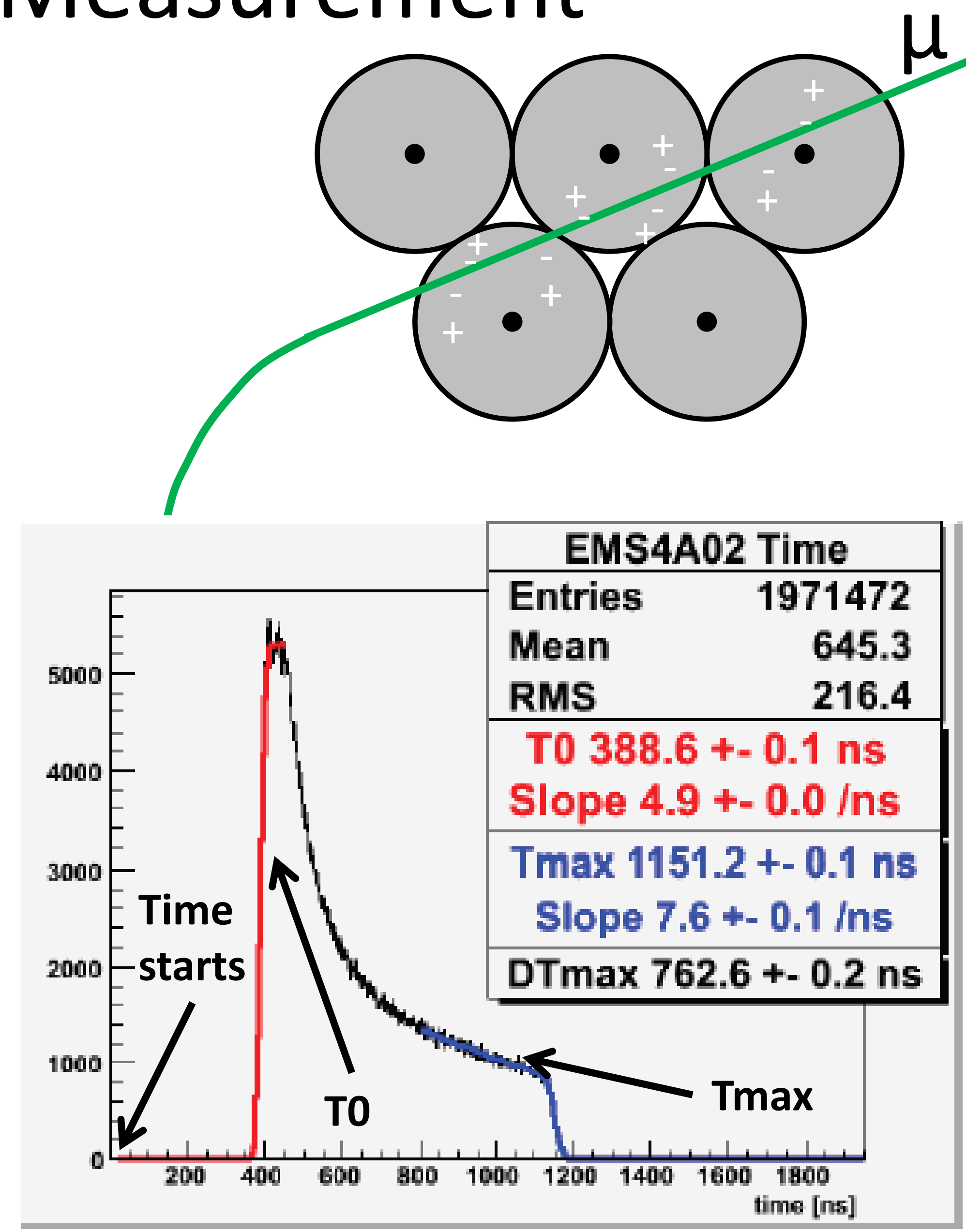
Making the Measurement

1. The muon will travel through the chamber, where it will ionize the gas in the tubes and start the measurement.

2. If the event passes the trigger, time starts. There is a short time between T0 and Tmax where data can be taken.

3. T0 is due to the time it takes the signal to travel down the wire.

4. Once Tmax comes, the Mezzanine Card will no longer take data.



Making the Measurement

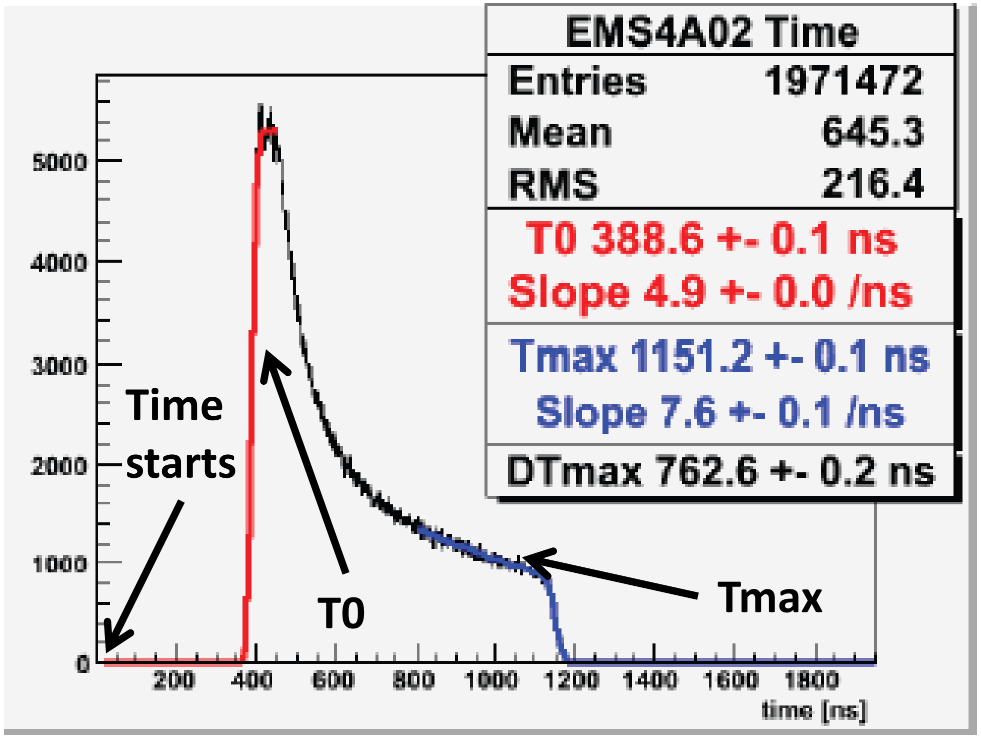
• In order to know where the muon went through the tube we must precisely measure how long it takes the ions to reach the wire and the signal to reach the Mezzanine Card.

- This is done by plotting the number of hits versus time, which gives us the plot below. The sharp rise corresponds to the fastest time the drift wire could send a signal. This fastest time corresponds to a muon passing directly through the wire. We call this time T0.

• Once the trigger decides to take the data there is a certain period after T0 that data can be taken. Ending at Tmax.

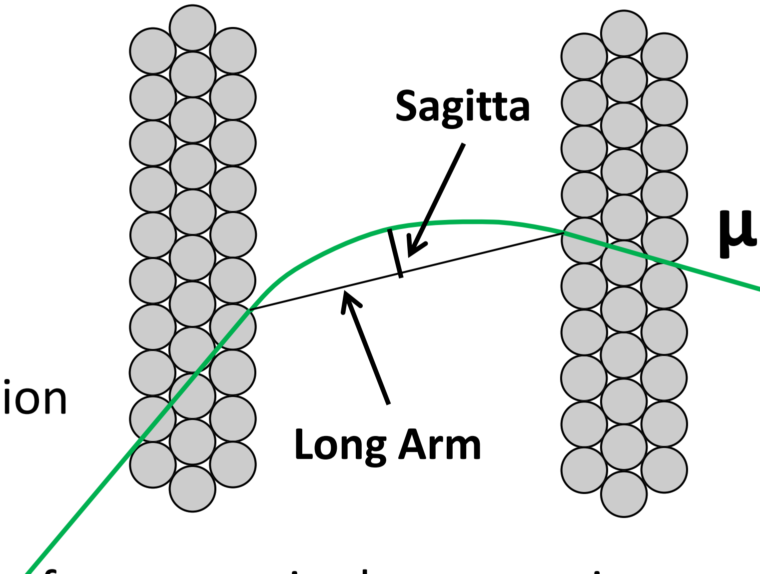
• Depending on how long it takes to receive a signal from the drift wire we know how far away the muon track is from the center of the wire.

Number of TTC hits vs. Time



Tracking Principles

- The Sagitta is used to find the muon's P_T.
  - The designed resolution is 50 microns. This was chosen in order to measure the sagitta of a 1 TeV muon with a 10% error.



- By using the geometry of this system and the equation

$$\frac{Pv}{r} = evB$$

Where P is the transverse momentum, r is the radius of curvature in the magnetic field, and L is the long arm. The sagitta and the momentum can be related by

$$S = \frac{eB\,L^2}{8P}\,.$$

- From this equation we can see some important relations needed when designing a detector.
  - $S \sim {}^{1}/_{P}$
  - $S \sim L^2$
  - $S \sim B$

Tracking Principles
Multiple scattering

- Multiple scattering occurs when a muon's path is altered as it travels through a dense medium.

- Multiple scattering can skew our analysis, thus the detector cannot be too dense.
    - Filling the tubes with gas instead of some solid material.
    - Having air core magnets instead of stronger iron core magnets.