ATLAS Muon Spectrometer and EE Chamber Commissioning

Kareem Hegazy
University of Michigan
Advisors: Bing Zhou, Tiesheng Dia, Junjie Zhu
Commissioning: Lulu Lui, Rex Brown, Eric Seabron, Kareem Hegazy

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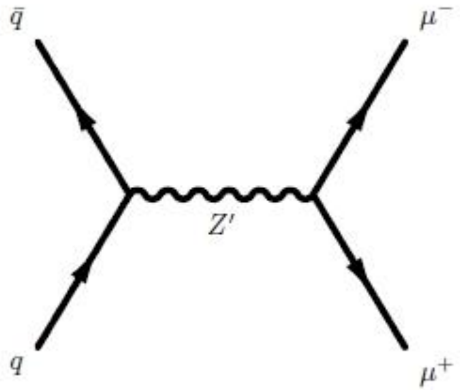
Importance of the Muon Detection

Some important decay channels:

- SM Z and $W^{\pm}$ decay to μ
- Z' -> $\mu^+\mu^-$
- $W'^{\pm}$ -> $\mu^{\pm}\nu$
- H -> ZZ -> $\mu^+\mu^-\mu^+\mu^-$



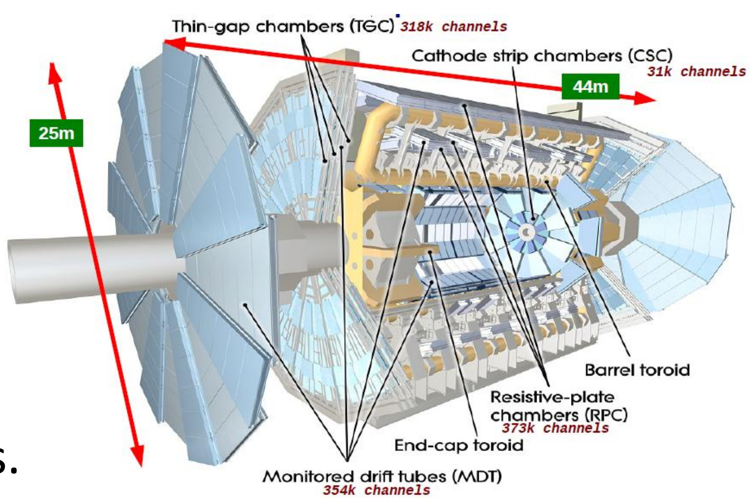
To find new physics we need high muon detection efficiency and precise momentum measurements (10% P_T resolution for 1 TeV muon) at the TeV scale because many new physics decays to muons.

The muon spectrometer surrounds the entire detector since muons are the only charged particles that penetrate through the entire detector.

The goal of the ATLAS muon detector is to measure a muon's sagitta within 50 microns for 1 TeV muon (corresponds to a 10% P_T resolution).

There are 3 main parts of the Muon Spectrometer:

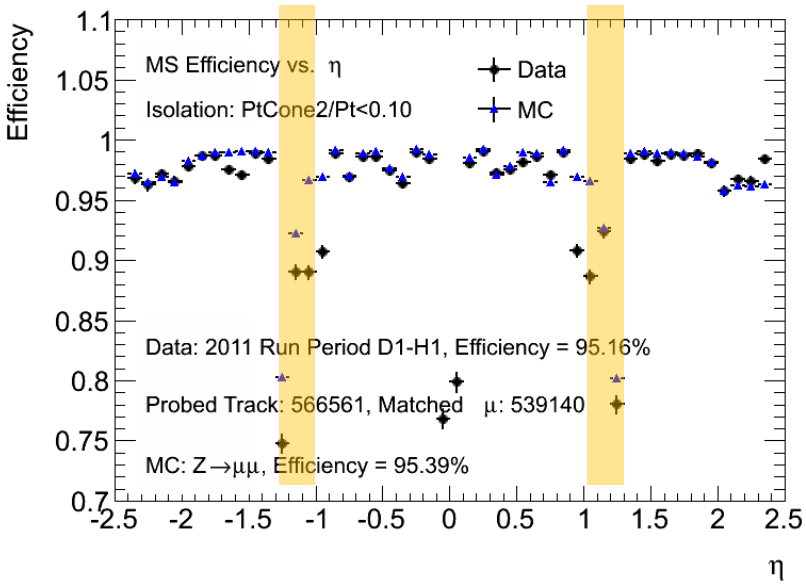
- Trigger System
- 10 Toroid 2T magnets
- Multiple layers of precision measurement chambers.



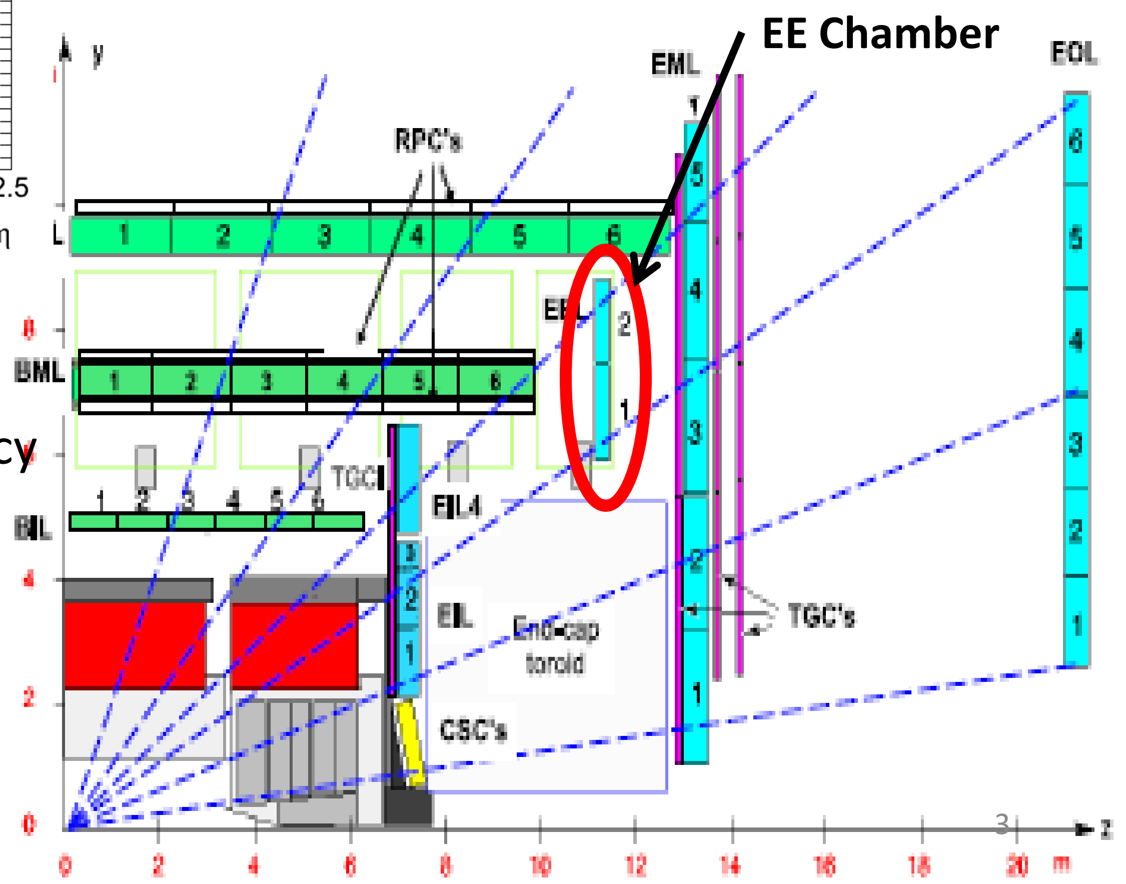
Importance of the EE Chambers

- EE stands for Endcap Extension
  - Range of the EE chambers is $1.0<|\eta|<1.3$.

•Almost all the chambers (52 out of 62) are not installed which accounts for terrible efficiency where the endcap and barrel meet.

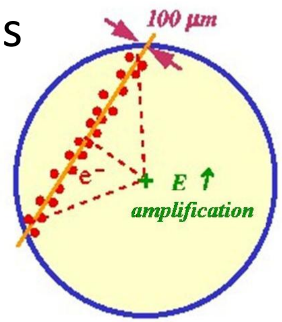


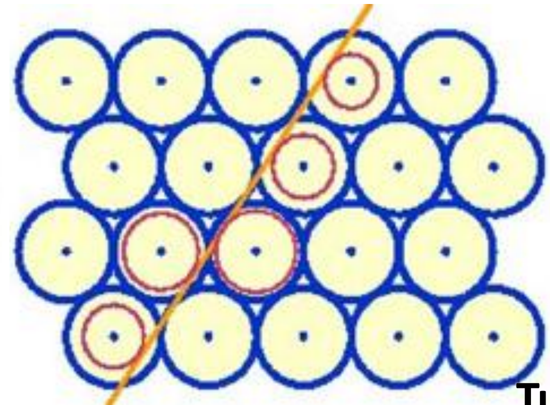
- The EE Chambers will provide us with an extra measurement which will help with the detection efficiency and momentum measurement.



Muon Signal and Data Collection

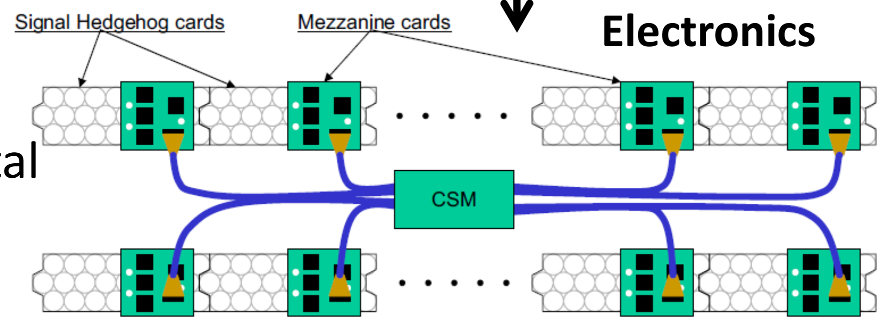
1. The muon ionizes the gas and the electrons drift towards the high voltage wire which creates a signal used to find the drift time.





Tubes

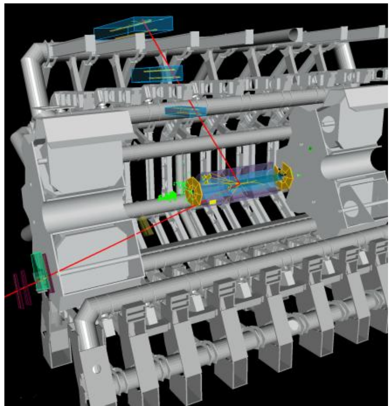
2. From the drift time we can only find the drift radius. Thus we need multiple tubes to reconstruct a track tangent to all the drift radii.



Electronics

3. The signal from the drift wires goes to front end electronics where it is converted to digital signal and partially analyzed.

4. The data is then sent to the MROD where it goes through higher level triggers and saved if it passes all the triggers.



DAQ and Analysis

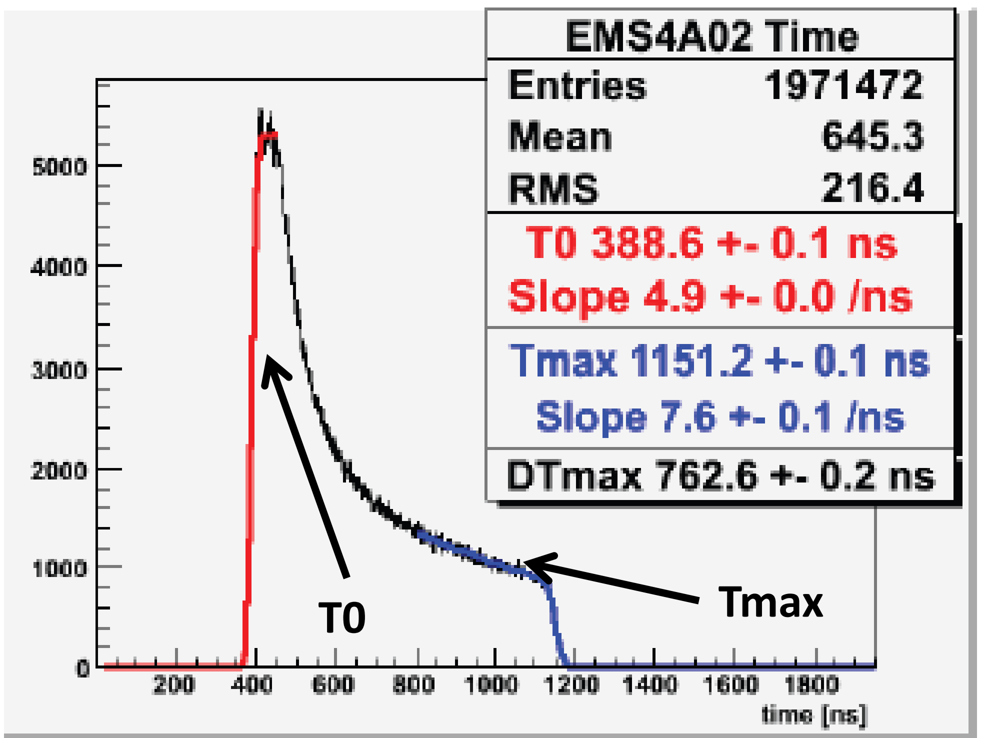
* It’s important to commission the electronics, otherwise the DAQ would not receive the raw data necessary to make calculations for analysis.

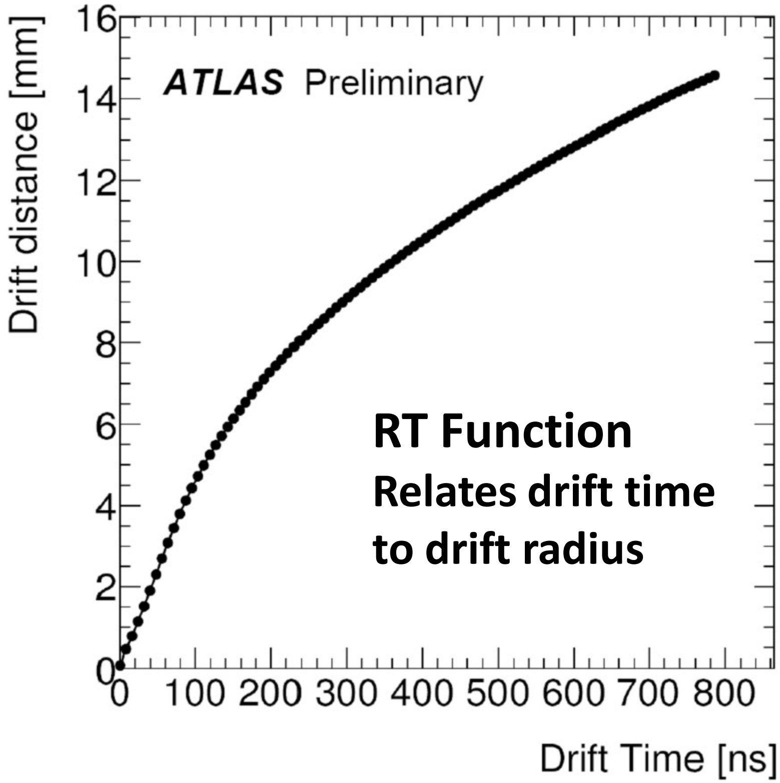
Position Measurements of Muon Hits

- In order to know where the muon went through the tube, the drift time is used for a RT function. To get the drift time we must subtract T0 from the measured time.
  - The sharp rise is the fastest time the drift wire could send a signal. This time corresponds to a muon passing directly through the wire and is called T0. T0 is caused by the delay of the signal from the length of the wire and electronics.
  - Tmax is the longest time the electrons could take and corresponds to an electron passing right by the tube wall.

TDC Distribution

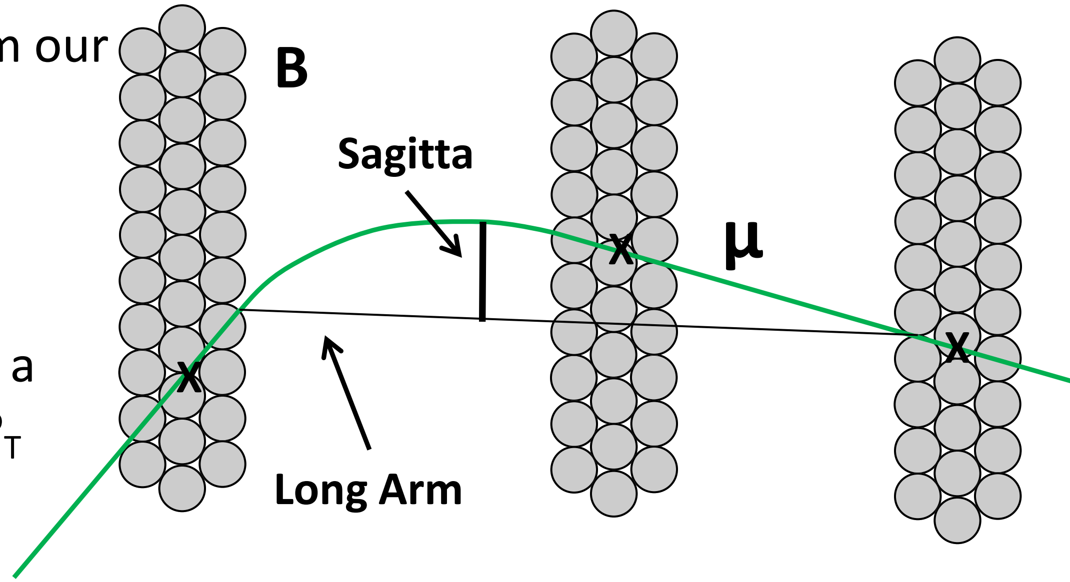
Number of hits vs. Time





Tracking Principles

- To make precise measurements of the muon's P_T we calculate the sagitta from our three measurement points and the geometry of the system. By using



$$\frac{P_T}{r} = eB$$

as well as the geometry of the system, a relationship between the sagitta and P_T is found to be

$$P_T = \frac{eBL^2}{8S}$$

- To relate the errors between P_T and the sagitta we take the derivative with respect to S and then substitute S for the equation above solved for S.

$$\left|\frac{dP_T}{dS}\right| = \frac{eBL^2}{8S^2} \xrightarrow{\text{Substitute for S}} \frac{dP_T}{P_T} = \frac{dS}{S}$$

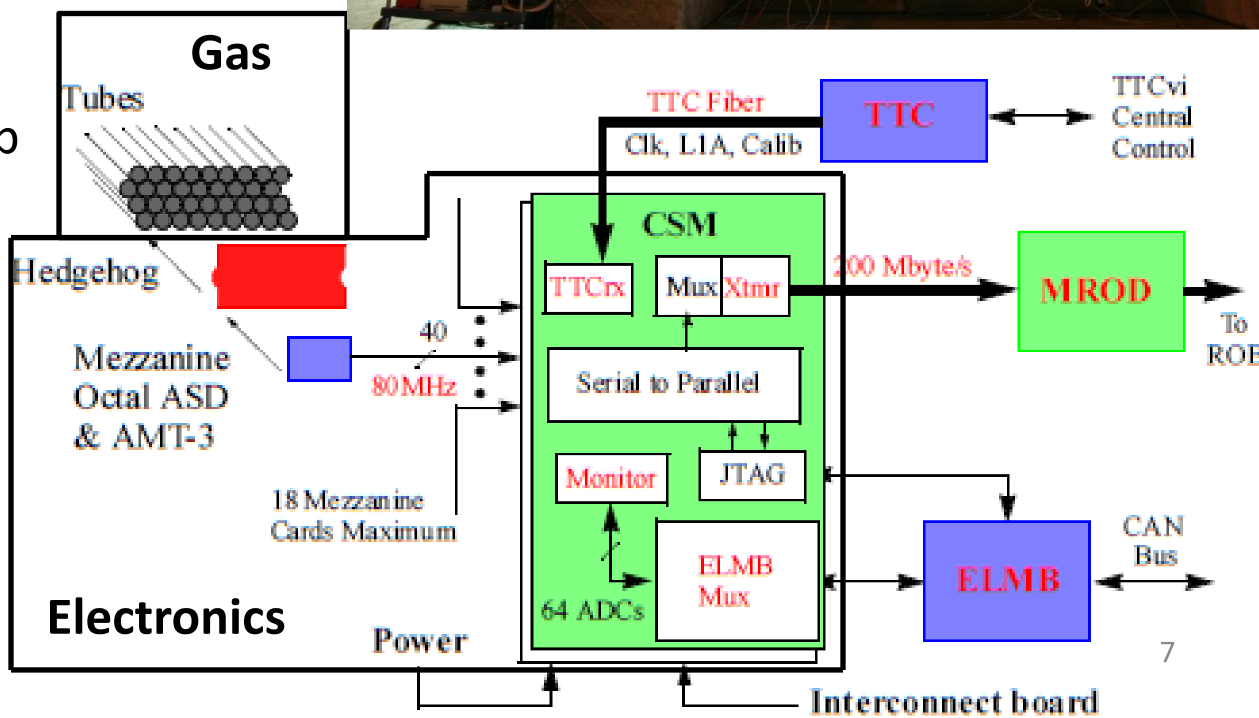
- For a 1TeV muon, ATLAS requires a 10% P_T resolution. The sagitta for a 1 TeV muon can be calculated using the above equations and is 500 microns. Thus the required sagitta resolution can be found to be

$$\frac{dP_T}{P_T} = 0.1 = \frac{dS}{500} \Rightarrow dS = 50\mu m$$

Commissioning at Building 191

The commissioning consists of 4 main parts:

- Gas commissioning (covered in Eric's talk)
- High voltage testing (covered in this talk)
- Electronics commissioning (covered in this talk)
- Alignment commissioning:
    - Done by another group and will not be covered in this talk.



Front-end Electronics:

- ASD: Amplifier, Shaper, and Discriminator.
- CSM: Chamber Service Module.
- AMT: ATLAS Muon TDC
    - Analog to digital convertor

High Voltage Commissioning

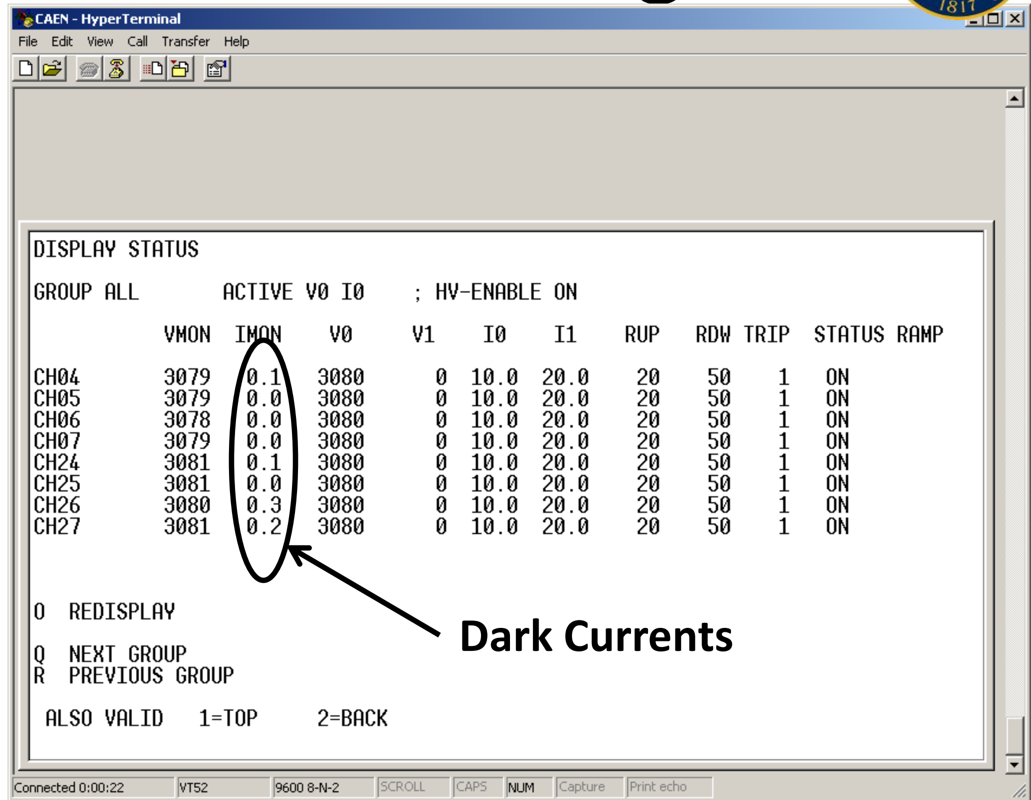
- The high voltage is kept at 3200 V instead of the regular 3080 V for 3 hours to make sure the wires can handle excess voltage.

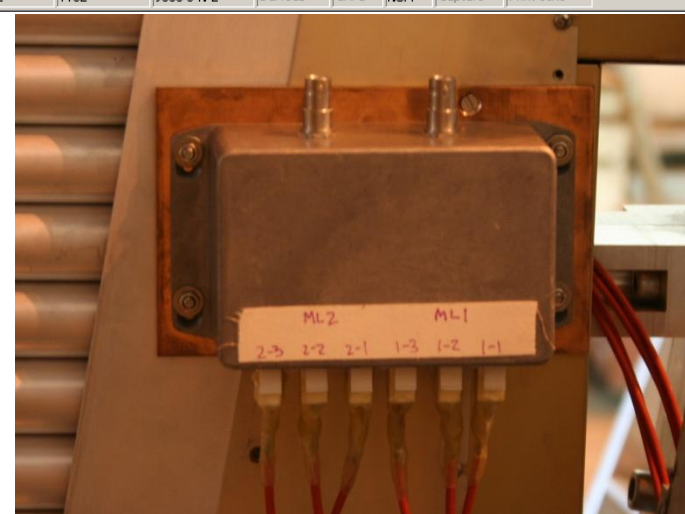
- The dark current is constantly monitored when high voltage is on to make sure it is very low.

- High voltage mapping is done to make sure the high voltage cables are correctly connected.

- High voltage is held at 3080 V for over a week to make sure the current does not exceed 1 μamp.

- When high voltage is ready we begin our long-term electronics tests.





Electronics Test

By constantly running electronics tests for 10 days straight we make sure that all the electronics can handle higher rates of data acquisition than necessary. Additionally this burns in the electronics so they will perform better and more reliably in ATLAS.

• **Injection Scan:** The Injection Scan measures the readout channel efficiency and cross talk between channels on Mezzanine Cards by using its calibration signals. Each channel corresponds to a tube.

• **Linearity Scan:** The Linearity Scan measures the electronics' timing and its resolution by setting a fixed amount of time and testing how well the electronics find it.

• **Gain Scan:** The Gain Scan checks the electronics ability to measure charge by comparing a known signal to a measured width of the same signal.

• **Threshold Scan:** To account for inherent noise the signal must pass a -50 mV threshold to register as originating from a muon. Due to their making, each channel has a different offset and must be accounted for.

• **Noise Run**

Noise Run

Mezz	Ch	NumberHits	Efficiency	NoiseRate(KHz)	ASDNoise(KHz)
0	0	112	1.077	0.02801	0.00000
0	1	117	1.125	0.02926	0.00125
0	2	143	1.375	0.03577	0.00725
0	3	104	1.000	0.02601	0.00000
0	4	108	1.038	0.02701	0.00000
0	5	115	1.106	0.02876	0.00050
0	6	118	1.135	0.02951	0.00025
0	7	102	0.981	0.02551	0.00000
0	8	103	0.990	0.02576	0.00025
0	9	99	0.952	0.02476	0.00525
0	10	100	0.962	0.02501	0.00000
0	11	97	0.933	0.02426	0.00075
0	12	91	0.875	0.02276	0.00000
0	13	104	1.000	0.02601	0.00000
0	14	132	1.269	0.03301	0.00000
0	15	111	1.067	0.02776	0.00000
0	16	122	1.173	0.03051	0.00050
0	17	115	1.106	0.02876	0.01025
0	18	105	1.010	0.02626	0.00950
0	19	102	0.981	0.02551	0.00175
0	20	115	1.106	0.02876	0.00025
0	21	101	0.971	0.02526	0.00000
0	22	108	1.038	0.02701	0.00050
0	23	89	0.856	0.02226	0.00000
1	0	104	0.993	0.02601	0.00025
1	1	133	1.270	0.03326	0.00075
1	2	118	1.127	0.02951	0.00000
1	3	102	0.974	0.02551	0.00050
1	4	111	1.060	0.02776	0.00425
1	5	97	0.927	0.02426	0.00025
1	6	95	0.907	0.02376	0.00025
1	7	114	1.089	0.02851	0.00025
1	8	98	0.936	0.02451	0.00025
1	9	113	1.079	0.02826	0.00275
1	10	101	0.965	0.02526	0.00850
1	11	109	1.041	0.02726	0.00075
1	12	113	1.079	0.02826	0.00050
1	13	105	1.003	0.02626	0.00850
1	14	98	0.936	0.02451	0.00100
1	15	90	0.860	0.02251	0.00050
1	16	83	0.793	0.02076	0.00000
1	17	108	1.032	0.02701	0.00000
1	18	91	0.869	0.02276	0.00575
1	19	103	0.984	0.02576	0.01451

The Noise Run is uses high voltage and random triggers.

- By using random triggers the chambers are constantly collecting data.

- The noise rates are found by dividing the number of hits from muons by the gate time multiplied by the trigger rate.

- This test can be used to find dead channels since it will have 0 hits, as well as very noisy electronics. The Noise Run is used for the high voltage mapping.

Commissioning Results

We have done extensive tests for 6 chambers while we have been here and dealt many problems.

• Leaking Tube: the leaking tube set us back a week from finding and fixing it. Otherwise the multilayer would not be used.

• Electronics: defective or dead Mezzanine Cards (high noise rate, Large Cross Talk, etc) had to be replaced.

• Hardware: we had to install chords, high voltage splitter boxes, and remove thousands of screws that are hard to reach once they are installed in the ATLAS Cavern.

Summary

- Worked on the commissioning test of the ATLAS EE chambers

- These chambers will be installed this winter to help improve the muon detection efficiency and momentum measurement for muons with $1.0<|\eta|<1.3$

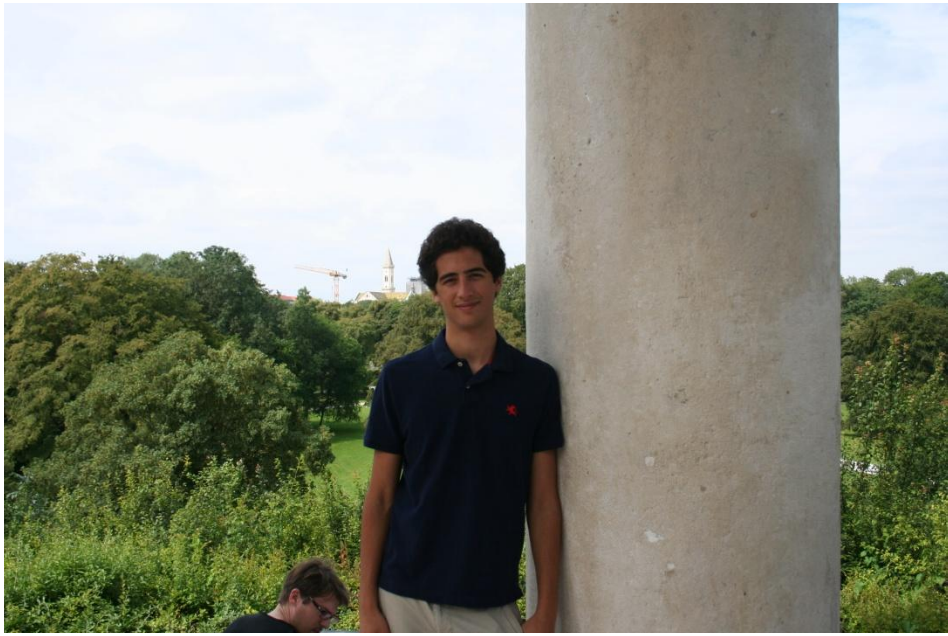
- Lessons Learned
  - Muon detection principle
  - The physics behind how the Muon Drift Tubes work
  - The complexity of the entire muon MDT detector: high voltage, low voltage, temperature sensors, use of triggers, alignment bars, front-end electronics etc.
  - Electronics used in making muon hit position measurements.
  - Methods of testing hardware and electronics.
  - Skills of finding and solving problems related to the hardware.
  - Patience while taking out many frustrating screws.
  - Cultural experiences while travelling.

Pamplona

Venice

Rome

Munich



Monte Carlo/Nice

Special Thanks

I would like to thank my advisors:

- Dr. Bing Zhou
- Dr. Junjie Zhu
- Dr. Tiesheng Dia

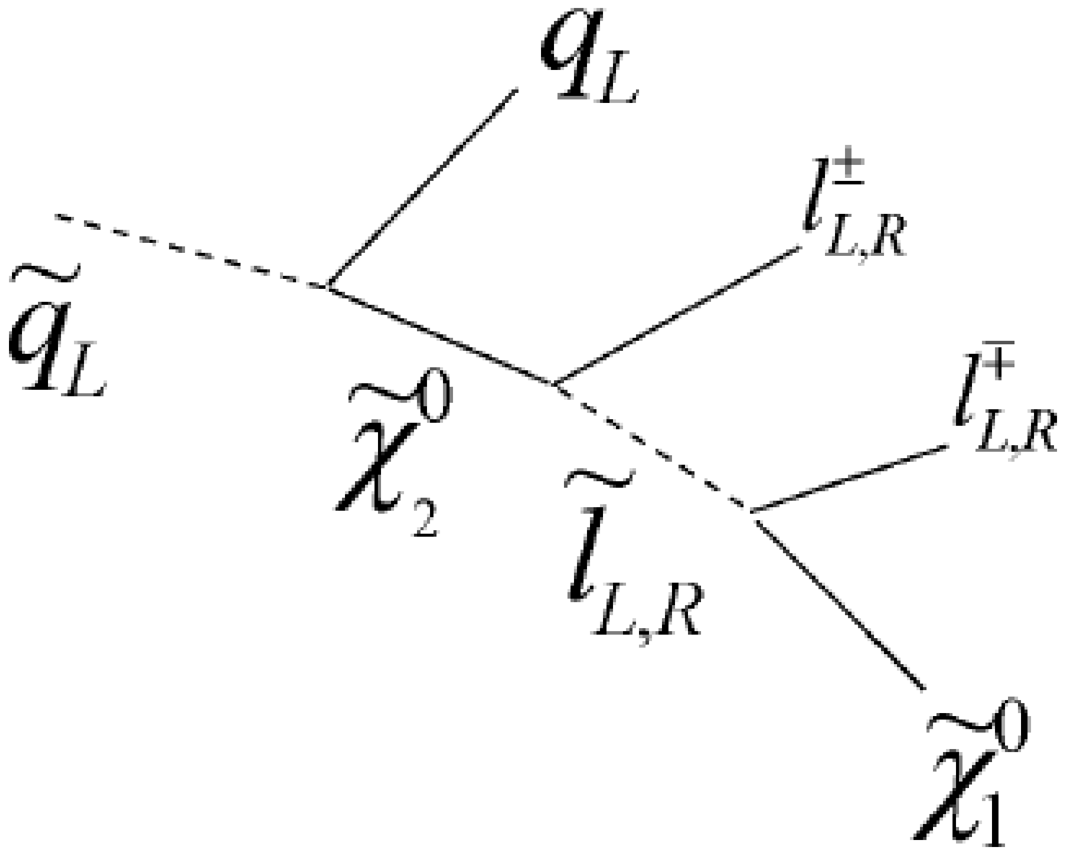
I would like to thank Dr. Neal, Dr. Krisch, Dr. Goldfarb, and Dr. Zhu for the this opportunity to learn physics at CERN and travel around Europe.

I would like to thank Lauren for helping us not be so clueless while at CERN.

Backup Slides

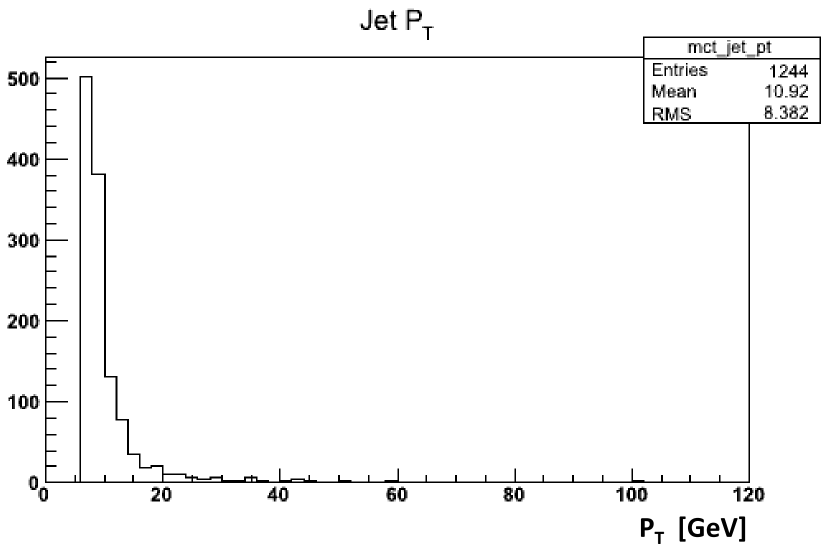
- Neutralino Search Study
- EE Chamber Commissioning
- EE Chamber Hardware

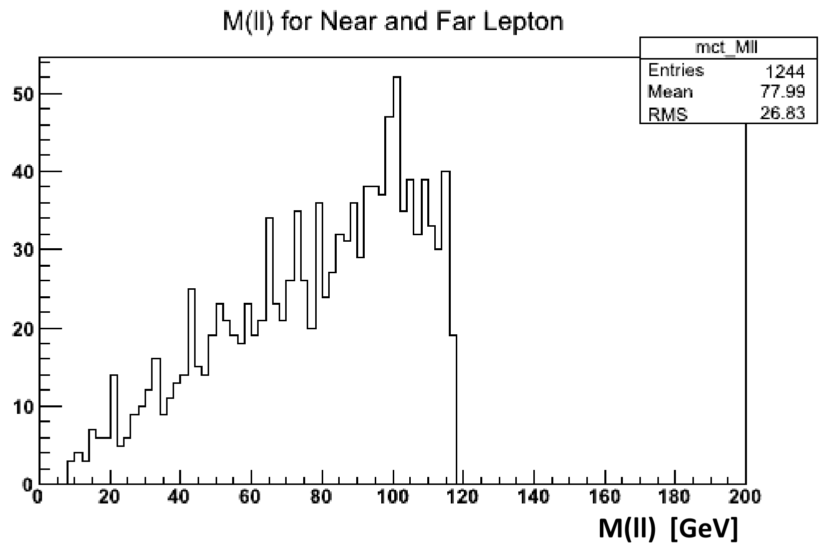
Neutralino Search Study



Neutralino Search Study

In Progress

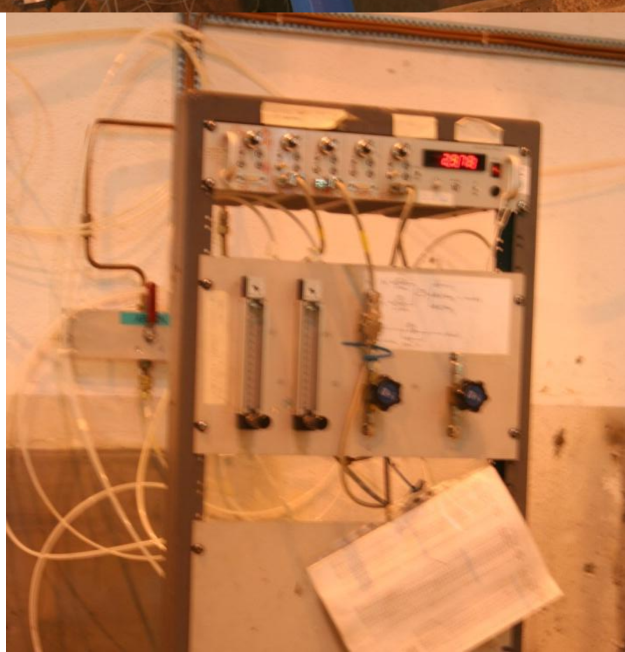




- Distributions can differ with different phase spaces.
- Distributions of the measurable particles will help us to create tight cuts.
- Calculating the maximum mass of multiple particles combined will help make cuts.
- Common SUSY search cuts:
    - Large missing transverse energy
    - Around 4 jets required

Commissioning Backup Slides

Gas System Commissioning



- First we must take the pressure to see how much the chambers have leaked in storage after more than 2 years.

- The old gas is then exhausted and new valve assemblies are installed.

- Once we have tested the valve assemblies for leaks we begin the flushing with 93% Argon and 7% CO_2.

- After one and a half days with about 5 volume exchanges the initial pressure is measured and should be around 3 bars.

- The pressure is then measured every week over a month to check for leaks

- Once flushing is done the high voltage can be turned on and tested.

Injection Scan

Board	Mezz.Serial-Number	Chan	NTrigs	InjEff	X-Talk
0	30-316-08-03018	0	10080	1.00000	0.00169
0	30-316-08-03018	1	10078	1.00000	0.00079
0	30-316-08-03018	2	10001	1.00000	0.00080
0	30-316-08-03018	3	10078	1.00000	0.00000
0	30-316-08-03018	4	10081	1.00000	0.00089
0	30-316-08-03018	5	10081	1.00000	0.00060
0	30-316-08-03018	6	10079	1.00010	0.00248
0	30-316-08-03018	7	10002	1.00000	0.00070
0	30-316-08-03018	8	10072	1.00000	0.00377
0	30-316-08-03018	9	10077	1.00000	0.00189
0	30-316-08-03018	10	10081	1.00000	0.00050
0	30-316-08-03018	11	10002	1.00000	0.00130
0	30-316-08-03018	12	10001	1.00000	0.00110
0	30-316-08-03018	13	10080	1.00000	0.00069
0	30-316-08-03018	14	10002	1.00000	0.00030
0	30-316-08-03018	15	10076	1.00000	0.00040
0	30-316-08-03018	16	10071	1.00000	0.00278
0	30-316-08-03018	17	10001	1.00000	0.00090
0	30-316-08-03018	18	10079	1.00000	0.00020
0	30-316-08-03018	19	10080	1.00000	0.00169
0	30-316-08-03018	20	10080	1.00000	0.00079
0	30-316-08-03018	21	10081	1.00000	0.00060
0	30-316-08-03018	22	10079	1.00000	0.00060
0	30-316-08-03018	23	10000	1.00000	0.00080
1	40-316-08-05665	0	10080	1.00000	0.00238
1	40-316-08-05665	1	10078	1.00000	0.00198
1	40-316-08-05665	2	10001	1.00000	0.00080
1	40-316-08-05665	3	10078	1.00000	0.00050
1	40-316-08-05665	4	10081	1.00000	0.00040
1	40-316-08-05665	5	10081	1.00000	0.00089
1	40-316-08-05665	6	10079	1.00000	0.00089
1	40-316-08-05665	7	10002	1.00000	0.00070
1	40-316-08-05665	8	10072	1.00000	0.00159
1	40-316-08-05665	9	10077	1.00000	0.00139
1	40-316-08-05665	10	10081	1.00000	0.00079
1	40-316-08-05665	11	10002	1.00000	0.00160
1	40-316-08-05665	12	10001	1.00000	0.00030
1	40-316-08-05665	13	10080	1.00000	0.00169

The Injection Scan measures the readout channel efficiency and cross talk between channels on Mezz cards by using its calibration signals. Each channel corresponds to a tube.

- The efficiency is found by checking if the channel has hits when the signal was sent to it.

- When the signal is sent the activity on other channels is measured to find the cross talk.

- Large cross talk can make one channel register a hit when it did not and thus ruin the measurements. Also, with low injection efficiency the channel may be dead and not register when it is supposed to, therefore it must be replaced.

Linearity Scan

	zz.Serial-Number	Chan	calTrigDelay	tdcTime	resolution	fracUsed
0	30-316-08-03018	0	30	1135.19	0.444	0.000
0	30-316-08-03018	0	32	1085.27	0.444	0.000
0	30-316-08-03018	0	34	1035.35	0.443	0.000
0	30-316-08-03018	0	36	985.41	0.435	0.000
0	30-316-08-03018	0	38	935.50	0.433	0.000
0	30-316-08-03018	0	40	885.56	0.432	0.000
0	30-316-08-03018	0	42	835.63	0.430	0.000
0	30-316-08-03018	0	44	785.70	0.429	0.000
0	30-316-08-03018	0	46	735.77	0.433	0.000
0	30-316-08-03018	0	48	685.85	0.427	0.000
0	30-316-08-03018	0	50	635.94	0.429	0.000
0	30-316-08-03018	0	52	586.01	0.430	0.000
0	30-316-08-03018	0	54	536.10	0.435	0.000
0	30-316-08-03018	0	56	486.16	0.431	0.000
0	30-316-08-03018	0	58	436.23	0.426	0.000
0	30-316-08-03018	0	60	386.31	0.429	0.000
0	30-316-08-03018	0	62	336.38	0.432	0.000
0	30-316-08-03018	0	64	286.46	0.430	0.000
0	30-316-08-03018	0	66	236.54	0.428	0.000
0	30-316-08-03018	1	30	1135.46	0.440	0.000
0	30-316-08-03018	1	32	1085.53	0.444	0.000
0	30-316-08-03018	1	34	1035.60	0.438	0.000
0	30-316-08-03018	1	36	985.68	0.439	0.000
0	30-316-08-03018	1	38	935.75	0.434	0.000
0	30-316-08-03018	1	40	885.82	0.437	0.000
0	30-316-08-03018	1	42	835.90	0.437	0.000
0	30-316-08-03018	1	44	785.96	0.437	0.000
0	30-316-08-03018	1	46	736.03	0.435	0.000
0	30-316-08-03018	1	48	686.11	0.429	0.000
0	30-316-08-03018	1	50	636.21	0.432	0.000
0	30-316-08-03018	1	52	586.27	0.432	0.000
0	30-316-08-03018	1	54	536.37	0.429	0.000
0	30-316-08-03018	1	56	486.44	0.427	0.000
0	30-316-08-03018	1	58	436.50	0.425	0.000
0	30-316-08-03018	1	60	386.57	0.428	0.000
0	30-316-08-03018	1	62	336.65	0.430	0.000
0	30-316-08-03018	1	64	286.73	0.425	0.000
0	30-316-08-03018	1	66	236.81	0.426	0.000
0	30-316-08-03018	2	30	1135.54	0.438	0.000
0	30-316-08-03018	2	32	1085.61	0.441	0.000
0	30-316-08-03018	2	34	1035.70	0.432	0.000
0	30-316-08-03018	2	36	985.77	0.433	0.000
0	30-316-08-03018	2	38	935.84	0.429	0.000
0	30-316-08-03018	2	40	885.91	0.432	0.000
0	30-316-08-03018	2	42	835.98	0.429	0.000
0	30-316-08-03018	2	44	786.04	0.434	0.000
0	30-316-08-03018	2	46	736.12	0.431	0.000
0	30-316-08-03018	2	48	686.19	0.431	0.000
0	30-316-08-03018	2	50	636.29	0.425	0.000
0	30-316-08-03018	2	52	586.35	0.433	0.000
0	30-316-08-03018	2	54	536.45	0.429	0.000
0	30-316-08-03018	2	56	486.52	0.422	0.000
0	30-316-08-03018	2	58	436.59	0.426	0.000

"ees1c06_linearity_scan.res" 5770L, 438228C

The Linearity Scan measures the electronics' timing as well its timing resolution.

- A certain time is set and we measure how well the electronics send a calibration at that time.

- The time resolution is measured at a fixed time with multiple measurements.

- Time measurements are very important because they allow us to reconstruct the track based upon the RT function and find the P_T.

Threshold Scan

	zz.Serial-Number	Chan	NTrigs	NDF	Xsq/DF	VOffset	Sigma	logNO
0	30-316-08-03018	0	10000	7	0.94067	-0.87148	7.83354	12.66886
0	30-316-08-03018	1	10005	7	1.68032	-3.11837	7.45662	13.02453
0	30-316-08-03018	2	10005	7	4.67298	-4.10958	7.74871	13.03501
0	30-316-08-03018	3	10045	7	1.10314	0.82175	7.63007	13.12545
0	30-316-08-03018	4	10010	7	1.08860	0.09857	7.68391	13.12680
0	30-316-08-03018	5	10000	5	1.51890	-2.86680	7.40226	13.34578
0	30-316-08-03018	6	10000	5	2.22152	-1.38025	7.19081	13.69119
0	30-316-08-03018	7	10000	5	0.46357	-2.01567	7.14429	13.41748
0	30-316-08-03018	8	10010	7	2.31034	-3.13993	7.50032	12.62723
0	30-316-08-03018	9	10010	7	2.60017	-5.63412	7.75163	12.52775
0	30-316-08-03018	10	10025	7	5.11136	2.82217	8.20418	12.55955
0	30-316-08-03018	11	10010	7	0.20277	-4.17979	7.27184	12.94728
0	30-316-08-03018	12	10030	7	3.15144	-0.50760	7.86164	12.49944
0	30-316-08-03018	13	10010	7	2.96947	-2.08445	7.20836	12.81084
0	30-316-08-03018	14	10010	5	1.70213	-3.45568	6.88227	13.51665
0	30-316-08-03018	15	10010	5	1.80174	-3.15285	6.82887	13.19968
0	30-316-08-03018	16	10000	9	3.04924	-2.20259	8.26640	12.47312
0	30-316-08-03018	17	10010	7	2.39979	-5.09779	7.92546	13.06857
0	30-316-08-03018	18	10010	7	0.43243	-5.12725	8.16083	12.90348
0	30-316-08-03018	19	10015	7	1.08042	-0.72774	8.10980	13.18708
0	30-316-08-03018	20	10015	9	0.89681	0.05524	8.43877	12.92947
0	30-316-08-03018	21	10000	7	0.62572	-1.57858	7.86677	13.26158
0	30-316-08-03018	22	10000	7	1.31641	-2.47250	7.74182	13.26892
0	30-316-08-03018	23	10000	7	3.23251	-1.70376	7.76454	12.98042
1	40-316-08-05665	0	10000	7	2.77496	-2.35190	8.21242	12.54830
1	40-316-08-05665	1	10000	7	2.61126	-3.54014	8.30160	12.29418
1	40-316-08-05665	2	10010	7	3.00555	-0.08964	7.93330	13.06921
1	40-316-08-05665	3	10000	7	2.04464	-3.11755	7.86541	13.05549
1	40-316-08-05665	4	10005	5	6.01844	-7.61211	7.97827	12.96671
1	40-316-08-05665	5	10010	7	3.24632	-0.07075	7.78276	12.96202
1	40-316-08-05665	6	10010	7	2.95068	-0.50358	7.67140	13.18121
1	40-316-08-05665	7	10000	5	1.28327	-1.76048	7.26451	13.12069
1	40-316-08-05665	8	10025	7	1.34643	-1.81546	8.27719	11.99479
1	40-316-08-05665	9	10045	7	1.44973	1.13668	7.89000	13.11131
1	40-316-08-05665	10	10010	7	1.77630	-5.86062	7.84351	12.73319
1	40-316-08-05665	11	10025	7	1.41041	-1.42521	7.71011	12.86141
1	40-316-08-05665	12	10025	7	0.88789	-1.72279	7.38002	13.10842

Board	Mezz.Serial-Number	MezzCEffi	ASD1CEffi	ASD2CEffi	ASD3CEffi
0	30-316-08-03018	0.974	0.962	0.996	0.974
1	40-316-08-05665	0.977	0.987	0.994	0.986
2	37-316-08-07039	0.923	0.957	0.955	0.964
3	35-316-08-04445	0.968	0.995	0.973	0.970
4	33-316-08-13128	0.948	0.979	0.969	0.980
5	39-316-08-03828	0.958	0.960	0.985	0.985
6	35-316-08-12824	0.752	0.913	0.978	0.956
7	28-316-08-10144	0.901	0.947	0.953	0.978
8	42-316-08-04578	0.919	0.981	0.992	0.962
9	40-316-08-05818	0.826	0.972	0.964	0.957
10	32-316-08-13226	0.980	0.992	0.962	0.991
11	31-316-08-07222	0.879	0.950	0.972	0.956

To account for inherent noise the signal must pass a -50 mV threshold to register as originating from a muon. Due to their making, each channel has a different offset and must be accounted for.

• The voltage offsets are measured to make sure they are not too large.

• Since every channel has a different offset, the pattern of all the offsets create a finger print for the Mezz Card. This pattern is compared to a data base and checked to see if each Mezz Card is where it should be.

• Since each Mezz Card is different, if one was in the wrong place all the measurements would be thrown off.

Gain Scan

Board	Mezz.Serial-Number	Chan	calCap	averageADC	resolution	fracUsed	gainRatio
0	30-316-08-03018	0	100	58.04	2.539	0.000	0.95832
0	30-316-08-03018	0	150	75.56	2.091	0.000	1.01092
0	30-316-08-03018	0	200	90.45	1.738	0.000	1.02072
0	30-316-08-03018	0	250	103.46	1.554	0.000	1.01568
0	30-316-08-03018	0	300	115.06	1.373	0.000	1.00703
0	30-316-08-03018	0	350	125.47	1.252	0.000	0.99828
0	30-316-08-03018	0	400	134.83	1.082	0.000	0.99025
0	30-316-08-03018	1	100	60.18	2.734	0.000	0.98817
0	30-316-08-03018	1	150	78.47	2.188	0.000	1.00762
0	30-316-08-03018	1	200	94.04	1.829	0.000	1.00451
0	30-316-08-03018	1	250	107.75	1.609	0.000	1.00038
0	30-316-08-03018	1	300	119.86	1.471	0.000	0.99795
0	30-316-08-03018	1	350	130.83	1.273	0.000	0.99902
0	30-316-08-03018	1	400	140.50	1.373	0.000	1.00036
0	30-316-08-03018	2	100	57.42	2.431	0.000	0.98975
0	30-316-08-03018	2	150	73.81	2.056	0.000	1.00777
0	30-316-08-03018	2	200	87.90	1.722	0.000	1.00496
0	30-316-08-03018	2	250	100.27	1.508	0.000	0.99992
0	30-316-08-03018	2	300	111.38	1.350	0.000	0.99776
0	30-316-08-03018	2	350	121.48	1.225	0.000	0.99897
0	30-316-08-03018	2	400	130.44	1.160	0.000	1.00047
0	30-316-08-03018	3	100	60.90	2.440	0.000	0.98760
0	30-316-08-03018	3	150	79.34	2.035	0.000	1.00887
0	30-316-08-03018	3	200	94.83	1.708	0.000	1.00480
0	30-316-08-03018	3	250	108.41	1.517	0.000	0.99975

The Gain Scan checks the electronics ability to measure charge by comparing a known signal to a measured signal.

- A known signal is sent from the computer where the leading and trailing edge is measured by the electronics.

- The measured results are compared to the known signal to find the electronics' precision.

Board	Mezz.Serial-Number	Chan	minWidth	V0OverI	IntTOverR	MSError	CHI2	minRes	maxRes	minFrac	maxFrac	minGainR	maxGainR
0	30-316-08-03018	0	32.10	0.285	980.4	1.48412	0.5697	1.082	2.539	0.000	0.000	0.95832	1.02072
0	30-316-08-03018	1	25.94	0.350	681.4	0.40180	0.1215	1.273	2.734	0.000	0.000	0.98817	1.00762
0	30-316-08-03018	2	26.78	0.313	705.4	0.36791	0.1243	1.160	2.431	0.000	0.000	0.98975	1.00777
0	30-316-08-03018	3	26.66	0.350	677.6	0.45761	0.1553	1.253	2.440	0.000	0.000	0.98760	1.00887
0	30-316-08-03018	4	21.13	0.291	728.1	0.36152	0.1444	0.994	2.093	0.000	0.000	0.98720	1.00762
0	30-316-08-03018	5	28.83	0.362	673.2	0.42434	0.1402	1.037	2.376	0.000	0.000	0.98673	1.00653
0	30-316-08-03018	6	30.72	0.387	655.8	0.50942	0.1558	1.033	2.463	0.000	0.000	0.98352	1.00559
0	30-316-08-03018	7	25.68	0.297	730.9	0.45393	0.1782	1.019	1.912	0.000	0.000	0.98253	1.00701
0	30-316-08-03018	8	22.57	0.293	726.5	0.34327	0.1319	1.067	2.169	0.000	0.000	0.98933	1.00786
0	30-316-08-03018	9	28.80	0.395	640.0	0.39079	0.1156	1.187	2.854	0.000	0.000	0.98900	1.00613
0	30-316-08-03018	10	23.38	0.275	744.0	0.33891	0.1392	0.976	1.972	0.000	0.000	0.98719	1.00626
0	30-316-08-03018	11	25.46	0.311	710.7	0.37058	0.1364	1.029	2.209	0.000	0.000	0.98745	1.00655
0	30-316-08-03018	12	24.81	0.396	669.8	0.51722	0.1587	1.314	2.690	0.000	0.000	0.98573	1.00911
0	30-316-08-03018	13	32.27	0.417	639.2	0.49777	0.1628	1.125	2.586	0.000	0.000	0.98885	1.00822
0	30-316-08-03018	14	22.24	0.284	728.9	0.31502	0.1453	1.099	1.817	0.000	0.000	0.99180	1.00848
0	30-316-08-03018	15	27.53	0.382	668.8	0.62582	0.1948	1.098	2.389	0.000	0.000	0.97827	1.00623
0	30-316-08-03018	16	30.37	0.372	676.2	0.37086	0.1150	1.121	2.604	0.000	0.000	0.98986	1.00671
0	30-316-08-03018	17	25.39	0.280	749.0	0.27441	0.1100	1.002	2.077	0.000	0.000	0.99126	1.00600
0	30-316-08-03018	18	34.37	0.407	662.5	0.48848	0.1253	1.218	2.914	0.000	0.000	0.98558	1.00516
0	30-316-08-03018	19	30.80	0.418	655.9	0.45517	0.1346	1.204	2.842	0.000	0.000	0.98932	1.00772
0	30-316-08-03018	20	22.92	0.277	746.4	0.29090	0.1238	0.950	1.867	0.000	0.000	0.98957	1.00630
0	30-316-08-03018	21	28.92	0.435	627.5	0.48813	0.1504	1.135	2.748	0.000	0.000	0.98752	1.00710
0	30-316-08-03018	22	23.59	0.289	827.5	0.82792	0.3345	0.984	2.014	0.000	0.000	0.96671	1.01110
0	30-316-08-03018	23	30.99	0.342	692.2	0.43302	0.1803	1.073	2.024	0.000	0.000	0.98881	1.00743
1	40-316-08-05665	0	34.39	0.295	988.0	1.55771	0.5965	1.071	2.710	0.000	0.000	0.96117	1.02122
1	40-316-08-05665	1	23.89	0.332	691.9	0.33200	0.1115	1.069	2.469	0.000	0.000	0.98879	1.00540

EE Chamber Harware Backup Slides

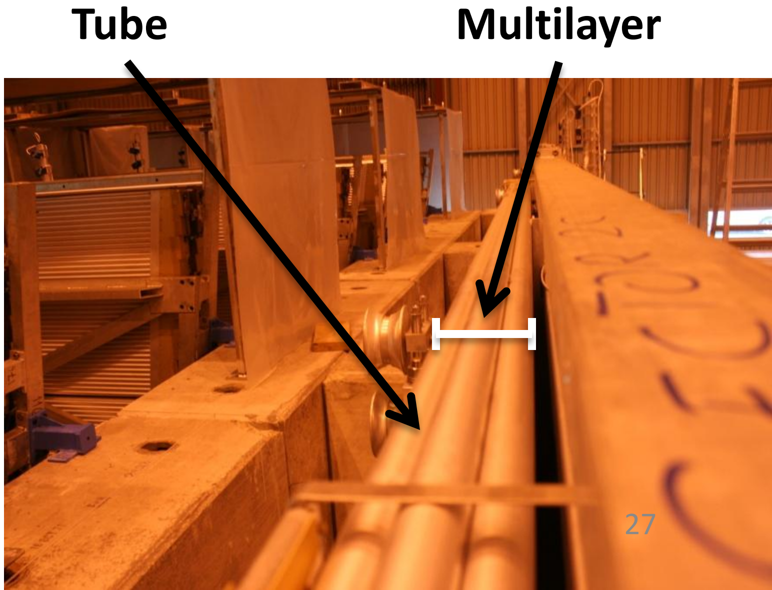
EE Chamber Hardware

- 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.

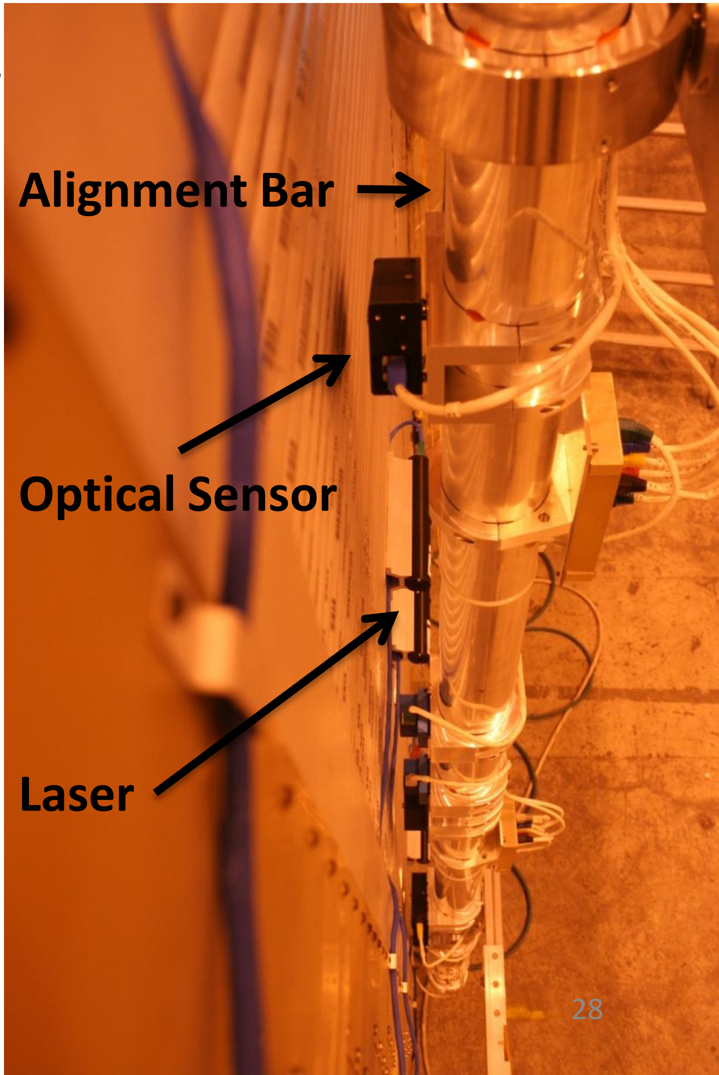


EE Chamber Hardware

• 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.

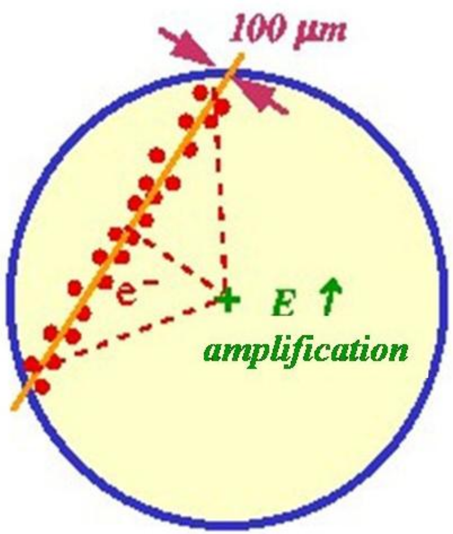


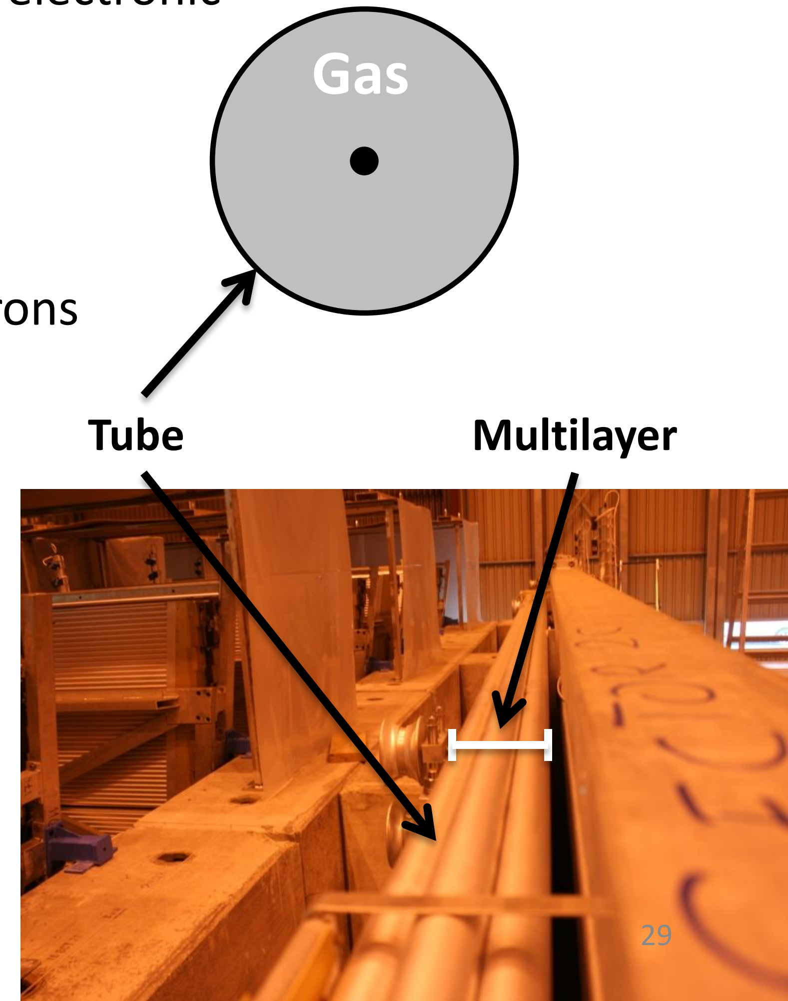
EE Chamber Hardware

Muon Drift Tubes (MDT)

- Each tube has a wire held at 3080 V and a 3 bar pressure of 93% Argon and 7% CO_2.
  - The gas gain is the lowest gain that 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

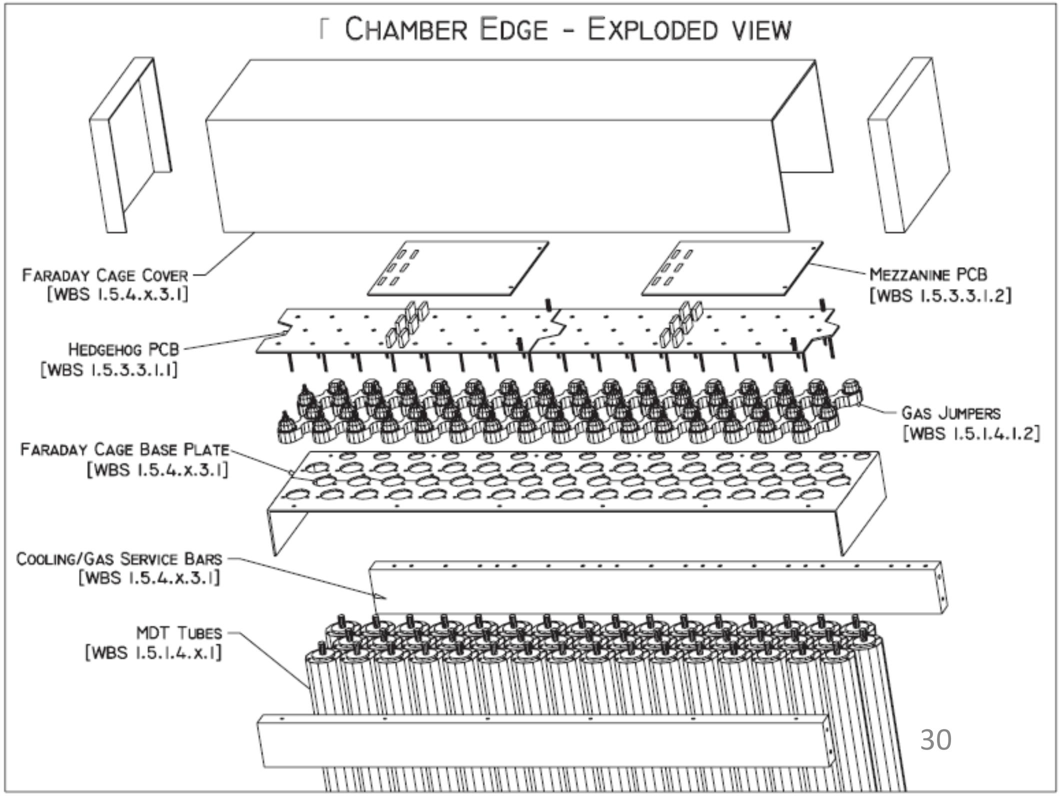
• The signal from the drift wire goes to the ASD (Amplifier, Shaper, Discriminator) Chip on the Mezzanine Card.

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

- •The AMT 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.