NEU CMS Weekly - November 2nd

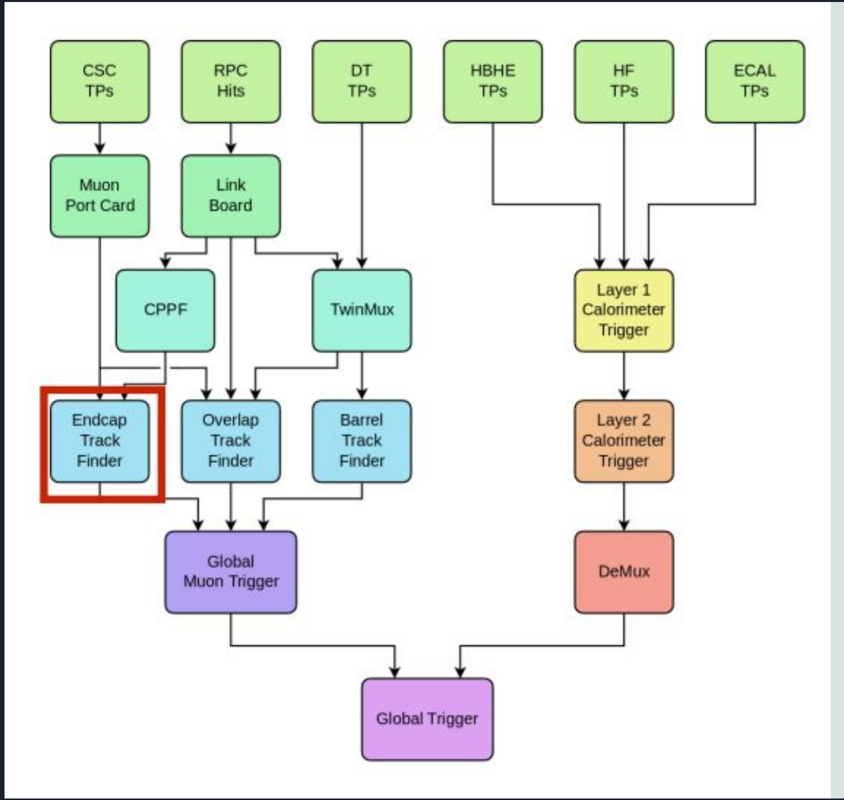
Nicholas Hurley

Outline

- Recap
  - EMTF and Efficiency
- Alignment Analysis
- Custom Alignment Calibration
- DQM Monitoring WebTool

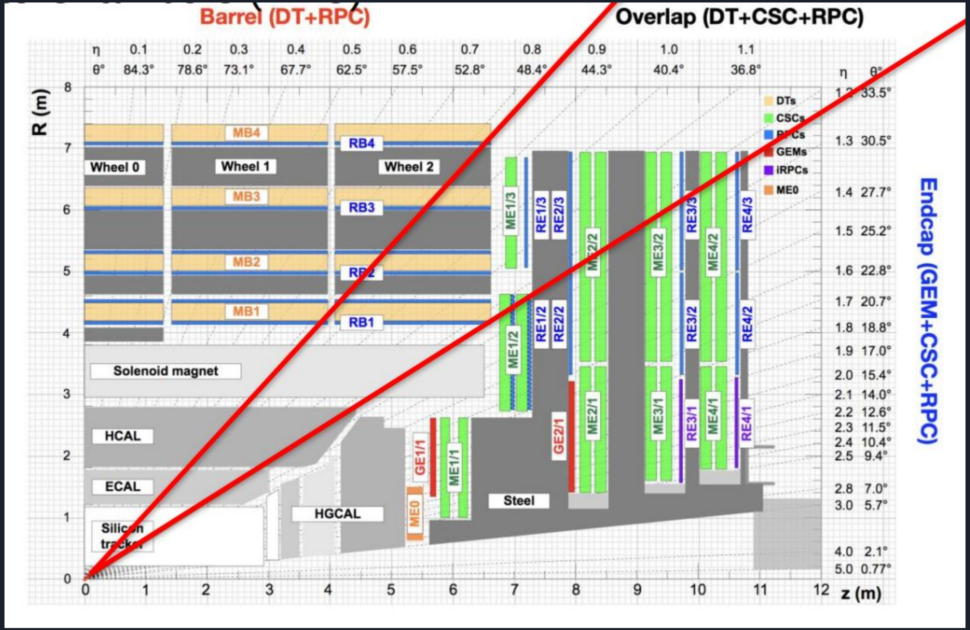
EMTF: Endcap Muon Track Finder

- The L1 trigger selects ~100k events per second out of ~40 million which is further reduced to ~1k events per second at the High Level Trigger (HLT)
- The system is split into 3 track finders (TF) that assigns η, φ, q, and pT to muon tracks that are then sent to μGMT
  - Redundancy from multiple muon systems



EMTF: (cont.)

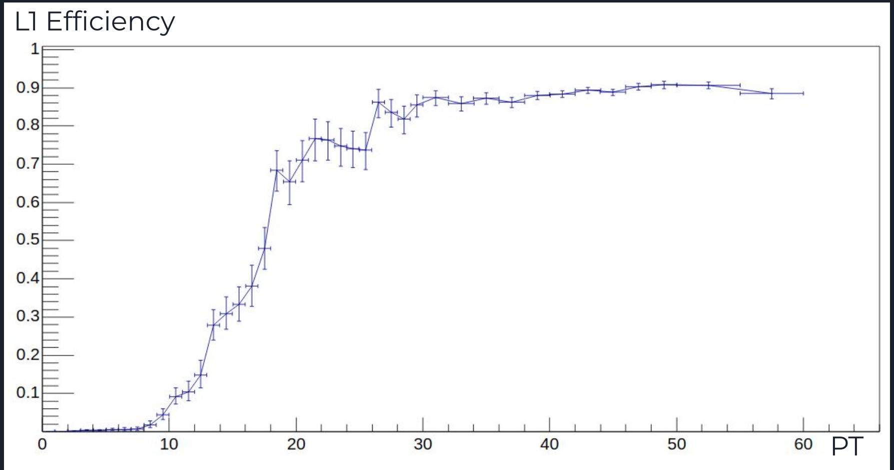
- Part of L1 muon-trigger system, uses info from detectors to build track
  - RPC: Resistive Plate Chambers
  - CSC: Cathode Strip Chambers
  - GEM: Gas Electron Multiplier
- Machine learning methods such as **Boosted Decision Trees** (BDT's) and **Neural Networks** (NN's) use these deltas to predict a track's PT and Dxy quickly with a Lookup-Table (LUT)
  - **Δφ** is the most important for PT determination (keep this in mind)
  - Other systems use Karman Filters



Efficiency Calculations: Tag and Probe Method

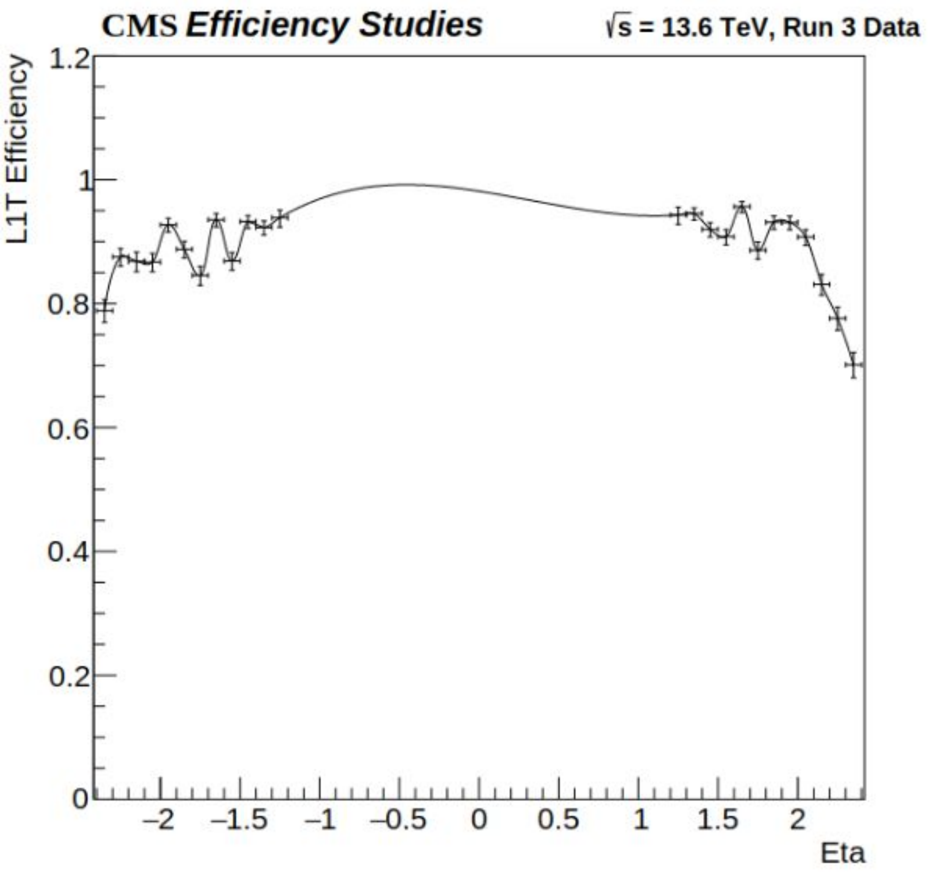
- A muon is triggered and recorded if its track PT is above a given threshold (i.e. 26GeV / c)
- Difficulty estimating detector efficiency with data because only events with a successful trigger are recorded
- Circumvent this issue by identifying triggering muons ("tags") per event and determining whether other muons in the same event ("probes") also successfully triggered
- Accomplished by comparing probe's reconstructed PTs (more accurate) against EMTF L1 Track PTs (less accurate, but determine the trigger)
- The efficiency is the number of probes that generated triggerable tracks divided by the total number of probes (usually binned at a given reconstructed PT)

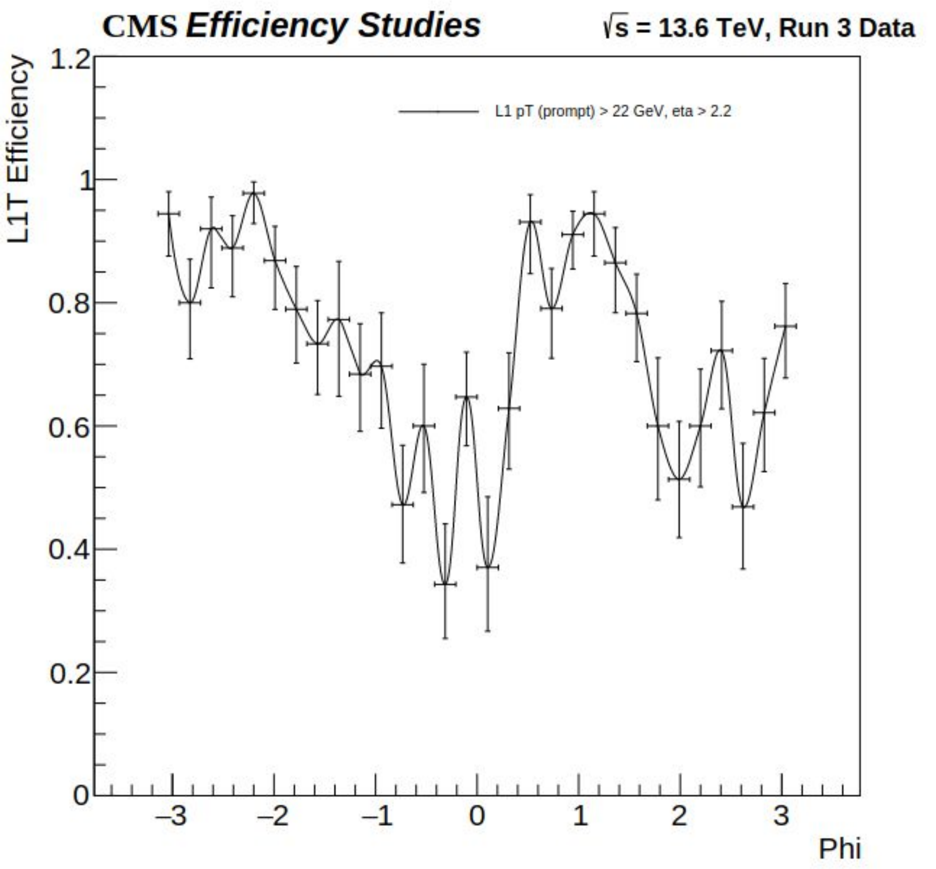
PT vs. Trigger Efficiency



Inciting Incident

Efficiency Asymmetry: Lower efficiency was detected in the positive endcap in July

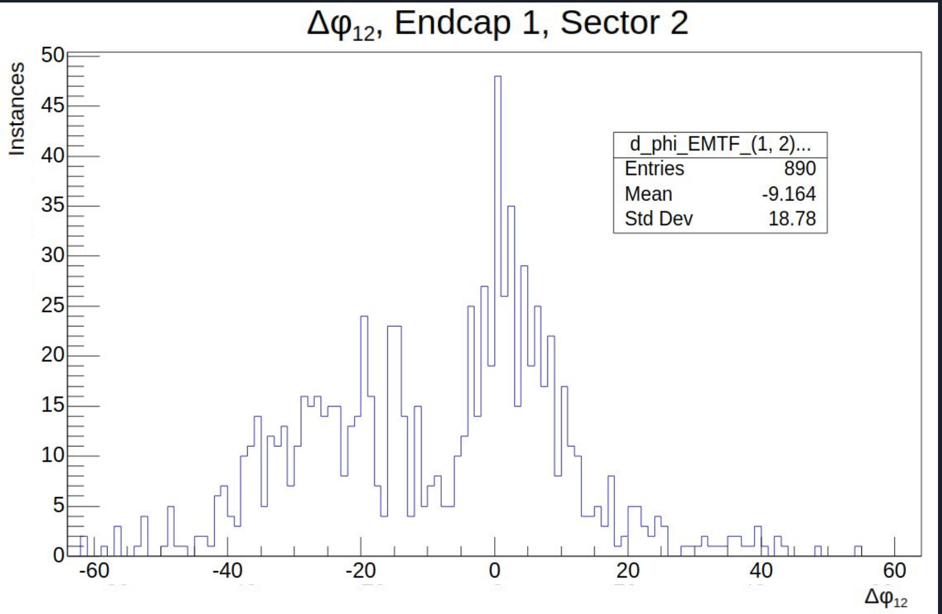




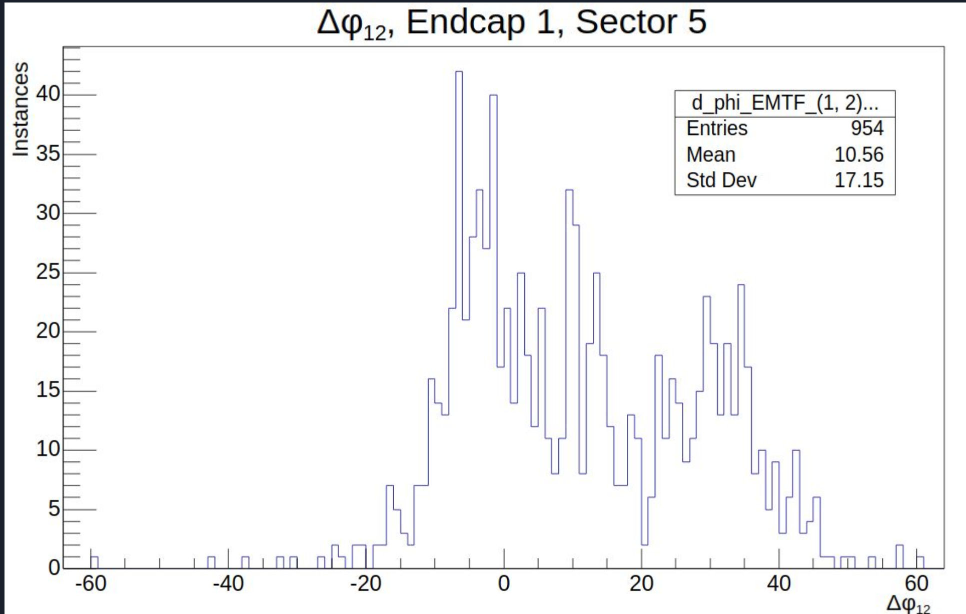
$\Delta\varphi_{+12}$

$\Delta\varphi$ between muon hits in stations 1 and 2 was not centered

Sector 2

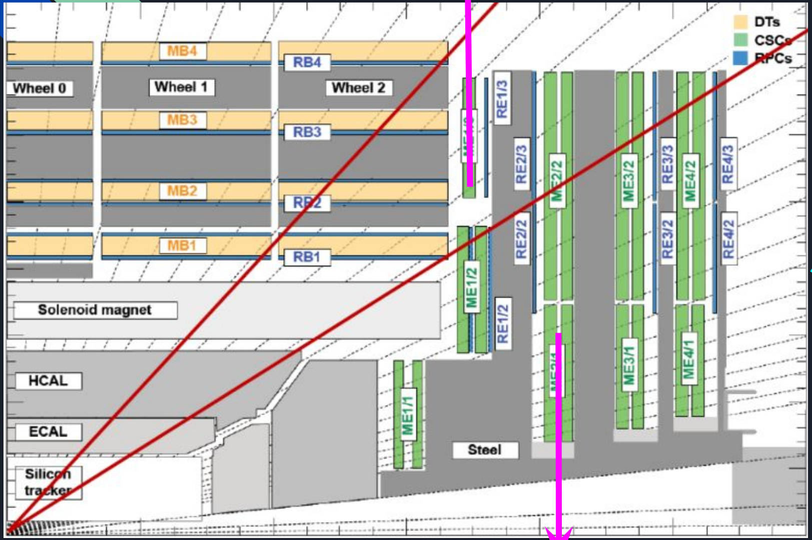


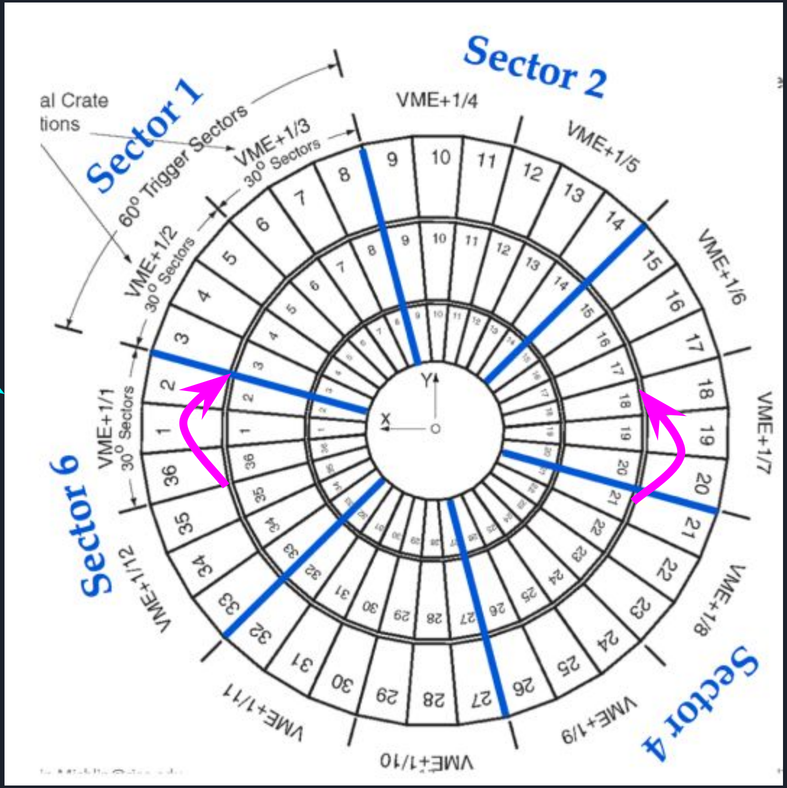
Sector 5



EMTF Geometry

Theory: Misalignment between EMTF stations in the positive endcap caused lower efficiency





Example: Station 1 is upward relative to station 2. This could cause distorted measurements of Δφ between stations (especially at certain sectors).

Δφ determines the trigger's PT measurement, which determines the trigger's efficiency

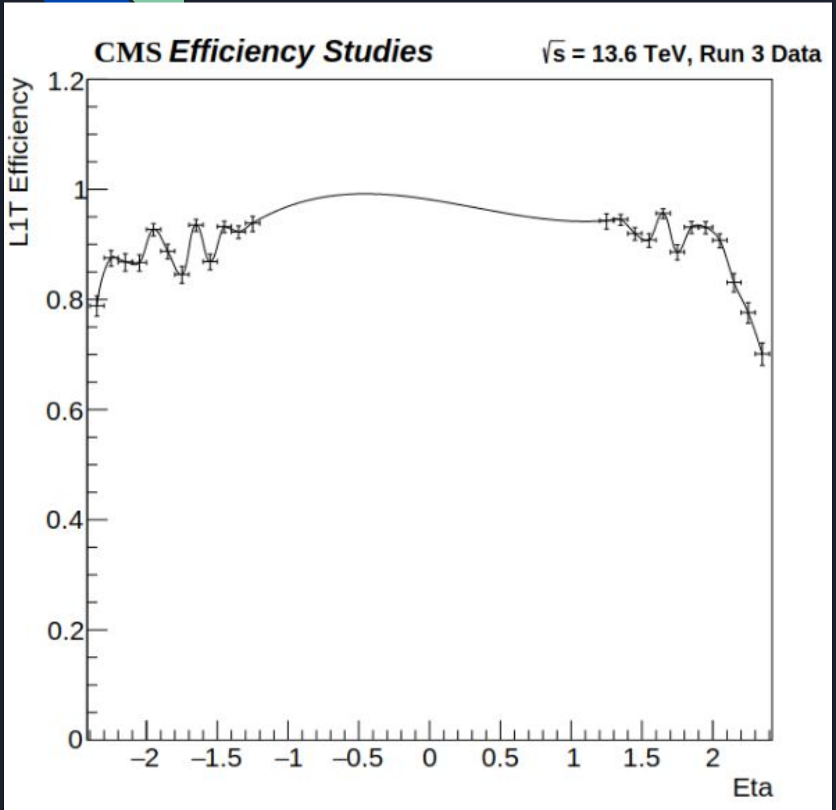
EMTF Geometry Background

- Coordinate look-up tables (LUTs) are used to convert chamber strips to phi, wires to theta quickly
- These LUTs are derived offline using CMS geometry record. This was last done in 2018.
- CMS was opened and muon chambers were removed and reinstalled during LS2. May have caused changes in geometry
- Requested new geometry record from Muon DPG and new LUTs were generated
- These LUTs were used in the EMTF emulator and validated with EMTF re-emulation, as shown in the following slides
- LUTs were updated in firmware Thursday, October 6th

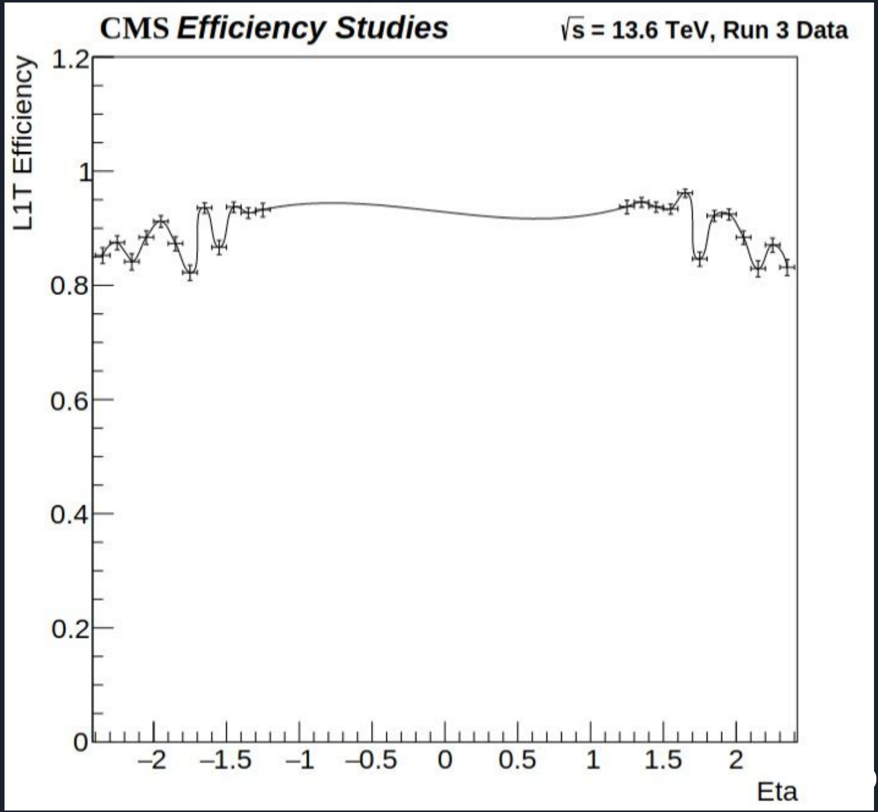
Efficiency Vs. Eta

Better symmetry between positive and negative endcaps with Run 3 Geometry

Run 2 Geometry



Run 3 Geometry



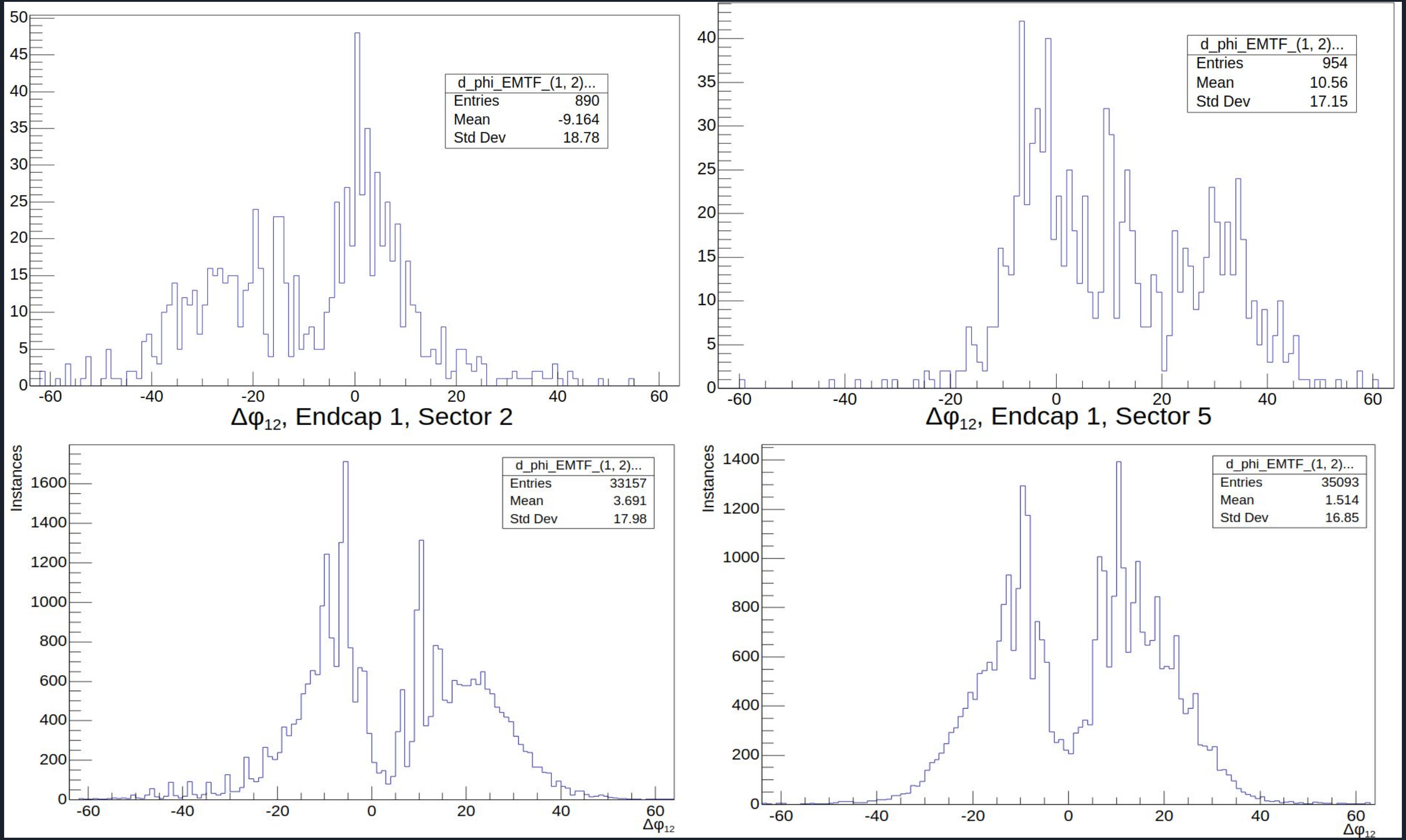
$\Delta\varphi_{+12}$

$\Delta\varphi$ between muon hits in stations 1 and 2 was not centered

Sector 2 | Sector 5

R2 Geometry

R3 Geometry

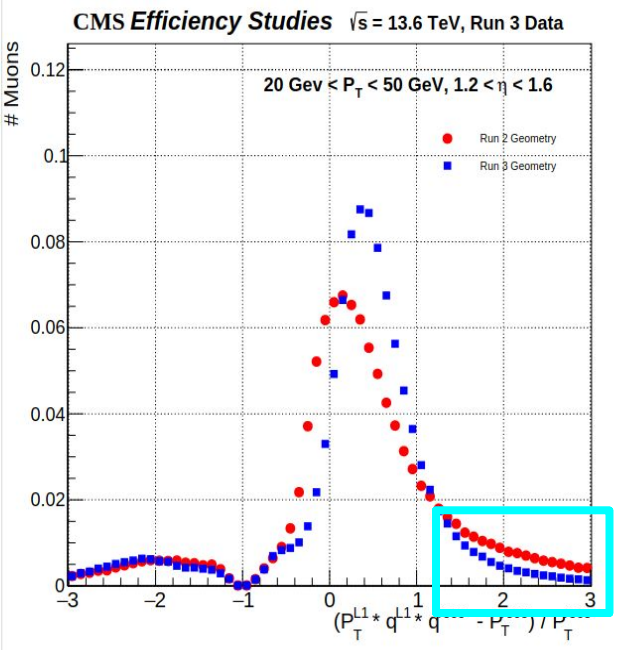


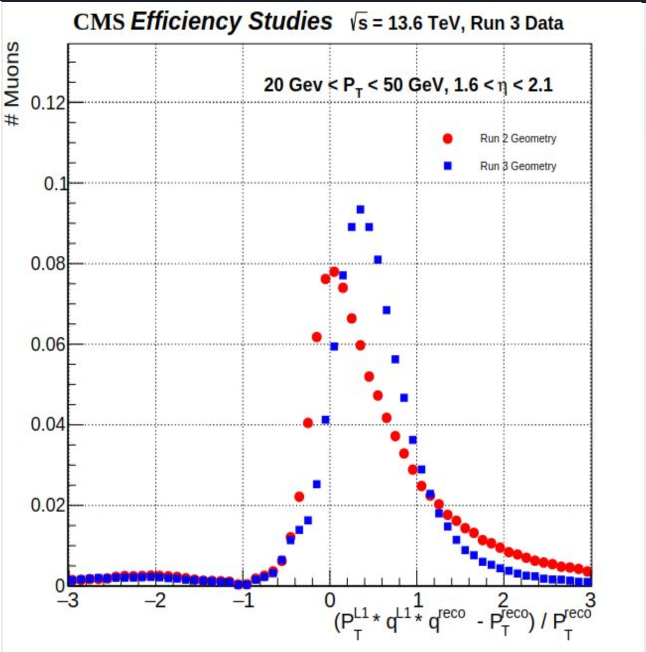
PT Resolution in the Positive Endcap

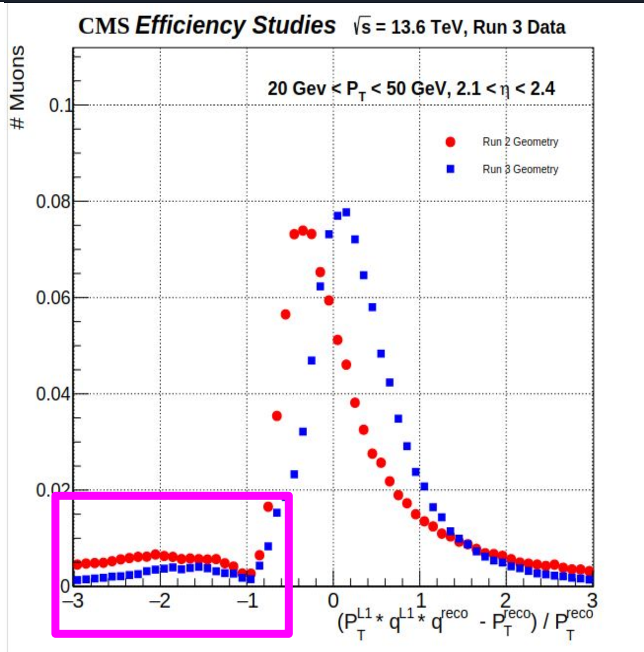
Run 3 PT resolution (normalized) is sharper and has slightly increased scale

Fewer instances < -1, meaning less charge misidentification

Fewer instances at the high-end tail, meaning less PT overestimation

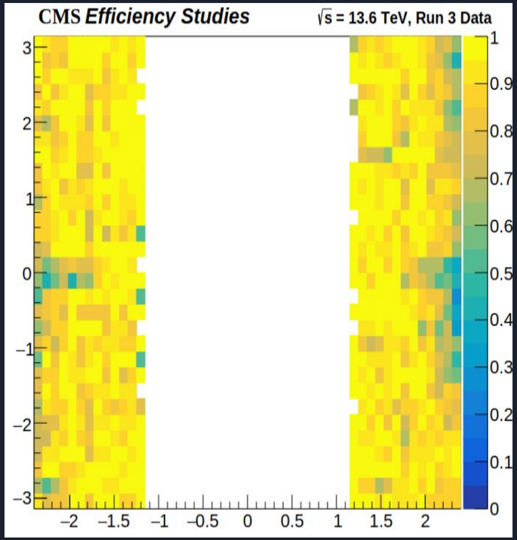




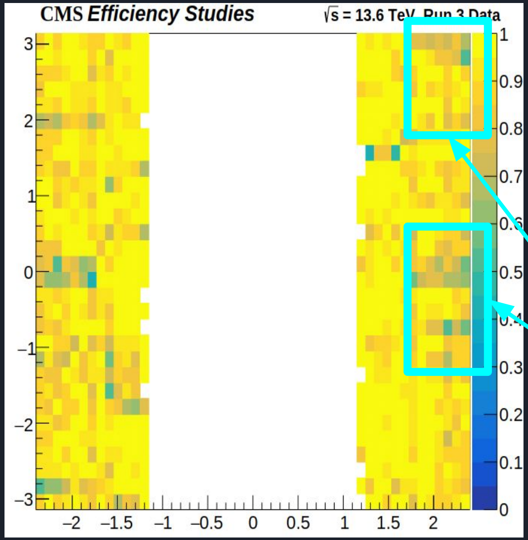


Efficiency in Eta and Phi

Run 2 Geometry



Run 3 Geometry

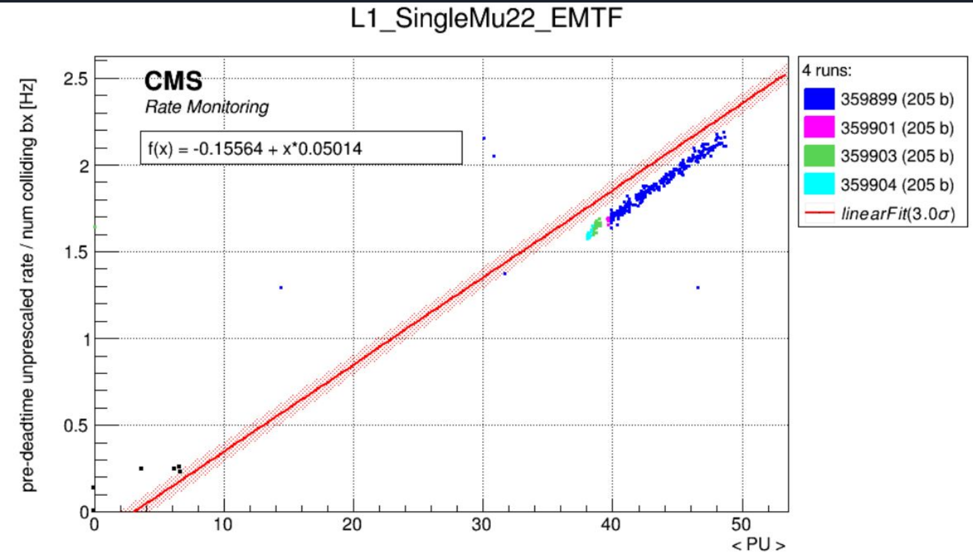


Main regions of improvement

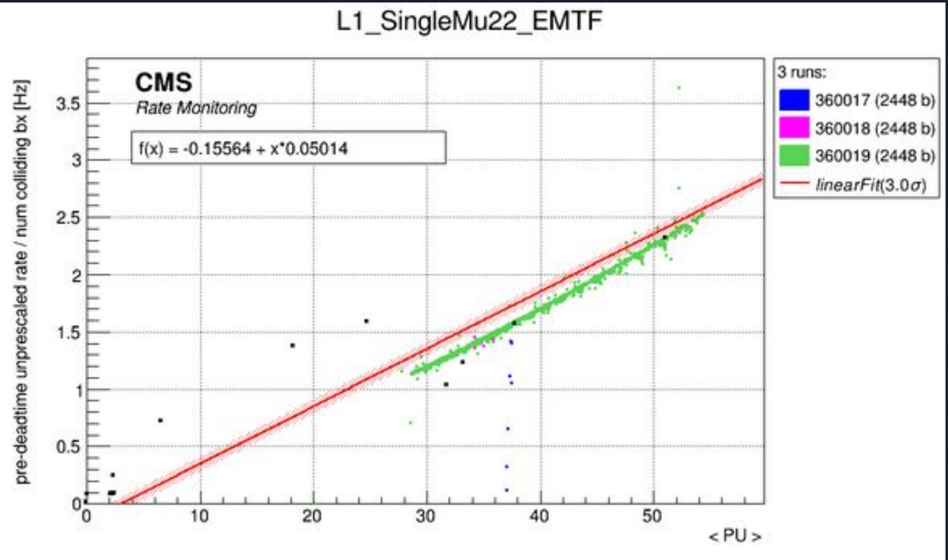
Rate Comparison from Data

Rate is unchanged

Oct. 6th ~12:00 - before new LUTs were added to firmware



Oct. 8th ~12:00 - after new LUTs were added to firmware



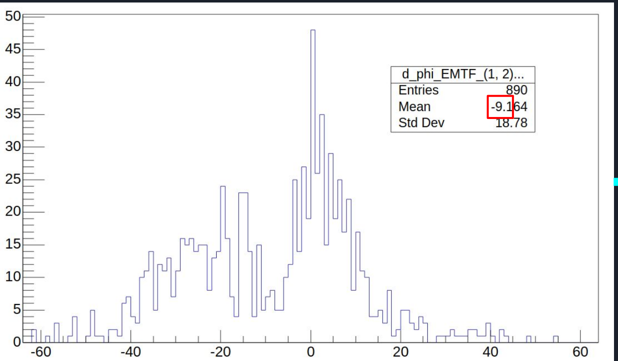
Custom Alignment: Motivation

- These geometry records from Muon DPG were clearly successful
- However, it took time to get this carefully calibrated geometry into our hands, costing us weeks of missed events
- What if we had a “quick-and-dirty” way of improving alignment without relying on external measurements?

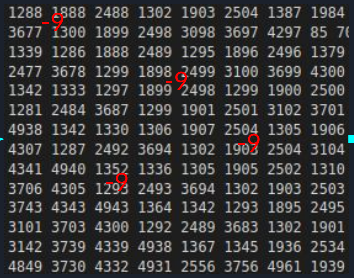
Custom Alignment: Method

- **Well,** we can improve the alignment with the same data we used to identify it
- We can do as follows:
  1. Find average Δφ between stations for each sector, and each station transition
  2. Find the station with the lowest average $\Delta\varphi^2$, call this the *reference station*
  3. Adjust the LUT coordinates of the other stations' sectors according to their Δφ from the reference station
  4. Re-emulate with this custom-geometry and perform new efficiency analysis

Find sector delta phi with respect to the determined reference station



Add this shift to the chambers in this sector,station



1288	1888	2488	1302	1903	2504	1387	1984
3677	1300	1899	2498	3098	3697	4297	85 70
1339	1286	1888	2489	1295	1896	2496	1379
2477	3678	1299	1898	2499	3100	3699	4300
1342	1333	1297	1899	2498	1299	1900	2500
1281	2484	3687	1299	1901	2501	3102	3701
4938	1342	1330	1306	1907	2504	1305	1906
4307	1287	2492	3694	1302	1903	2504	3104
4341	4940	1352	1336	1305	1905	2502	1310
3706	4305	1293	2493	3694	1302	1903	2503
3743	4343	4943	1364	1342	1293	1895	2495
3101	3703	4300	1292	2489	3683	1302	1901
3142	3739	4339	4938	1367	1345	1936	2534
4849	3730	4332	4931	2556	3756	4961	1939

Repeat for each sector/station-transition/ endcap

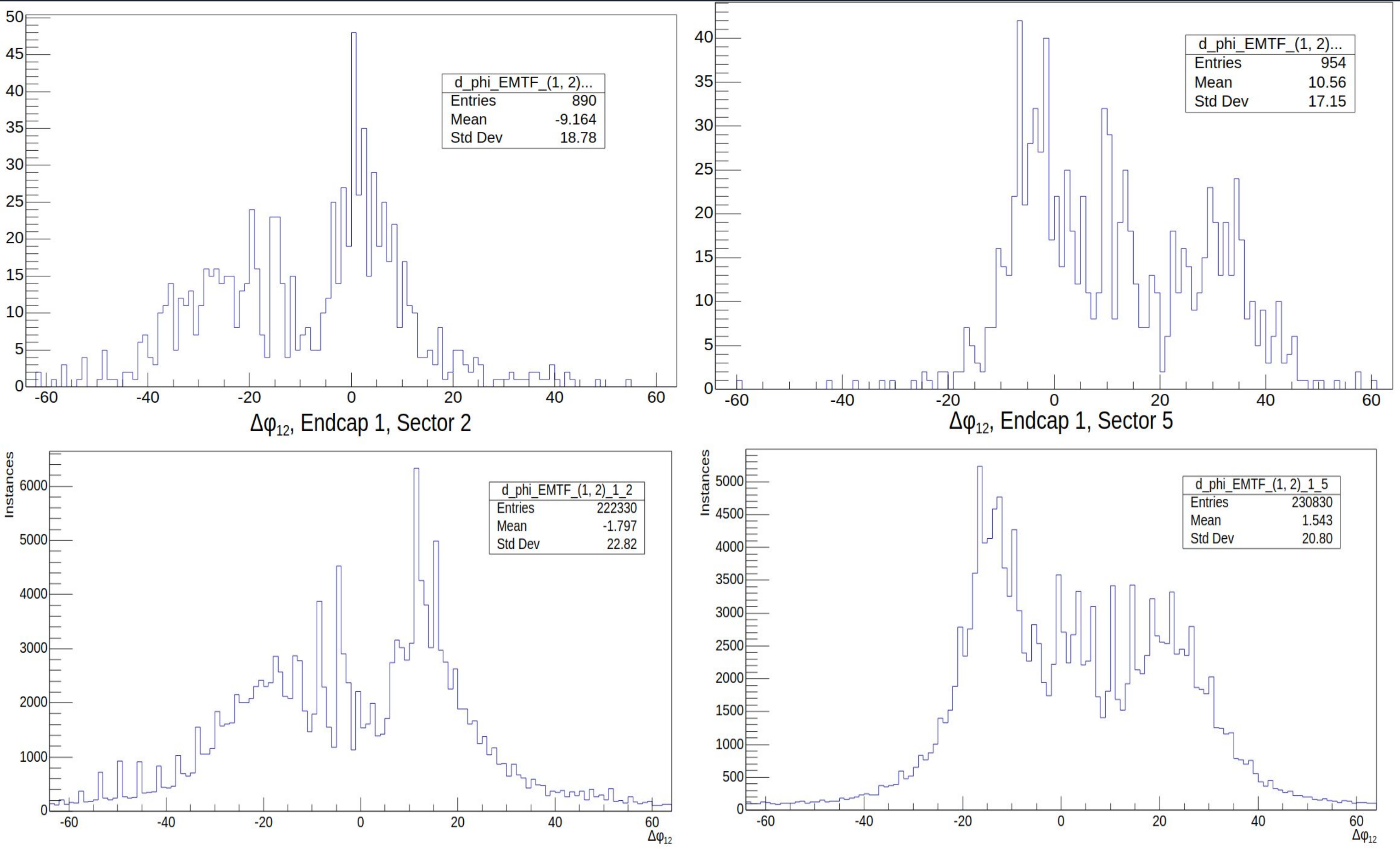
$\Delta\varphi_{+12}$

Δφ between muon hits in stations 1 and 2 is improved

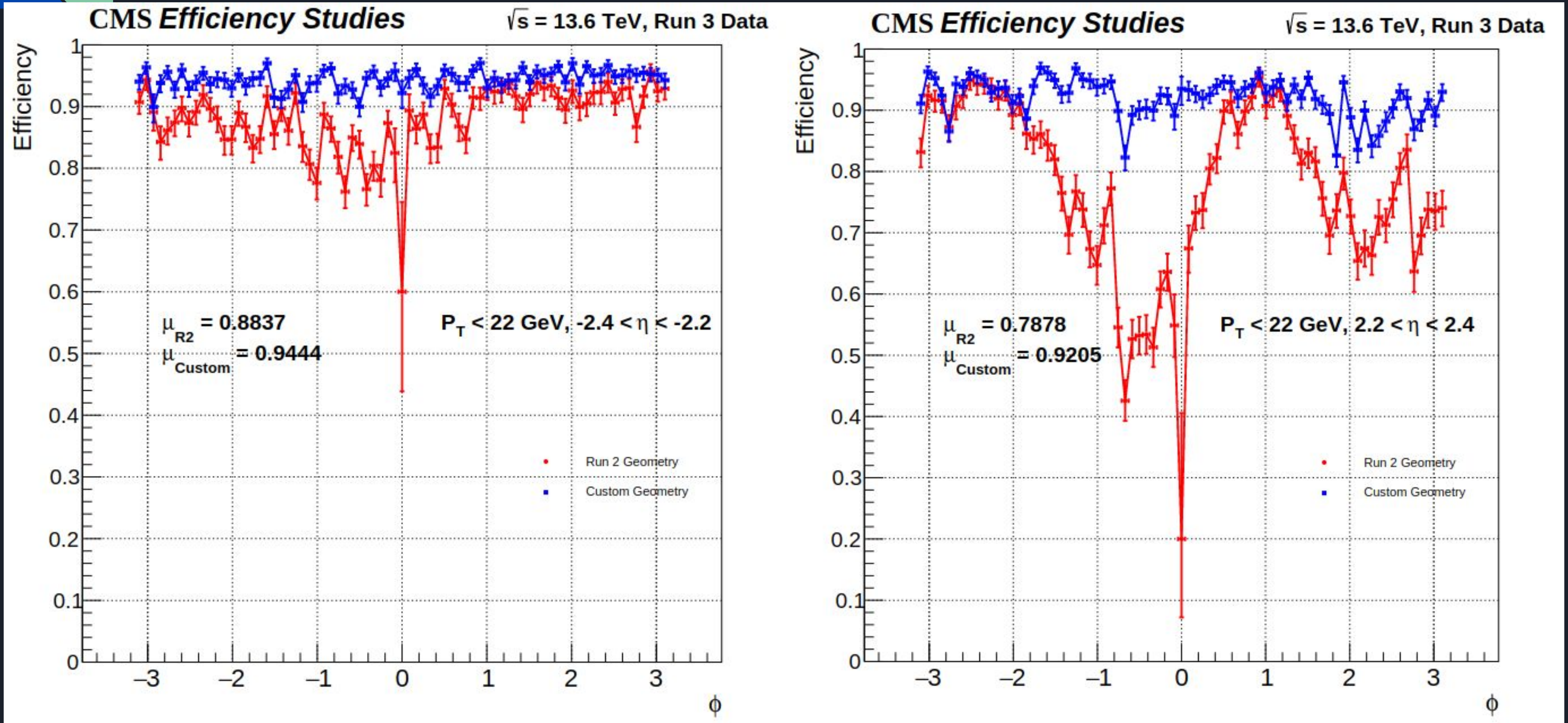
Sector 2 | Sector 5

R2 Geometry

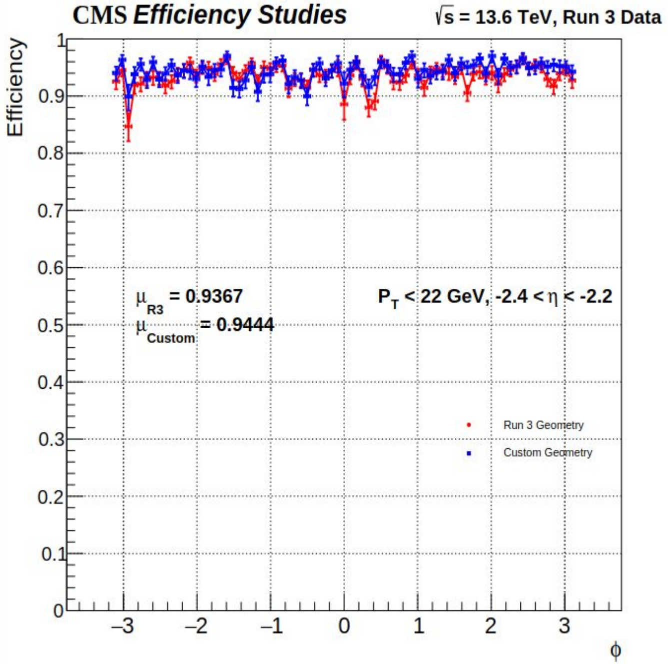
Custom Geometry

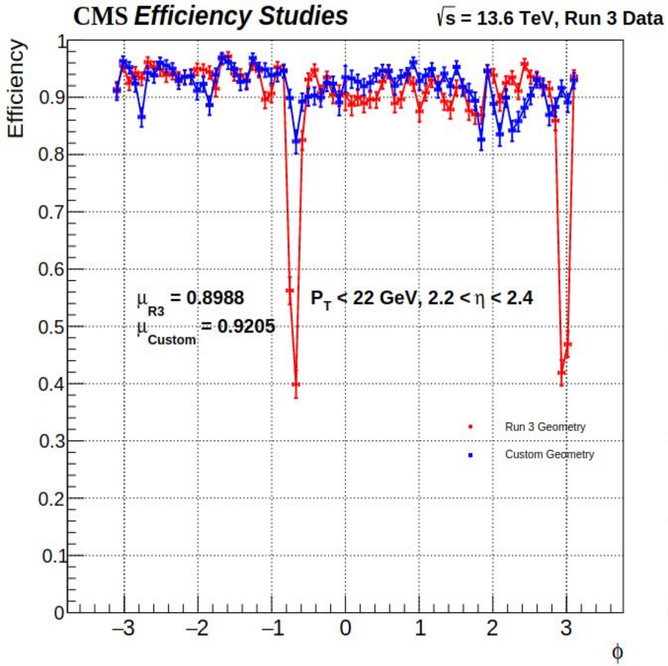


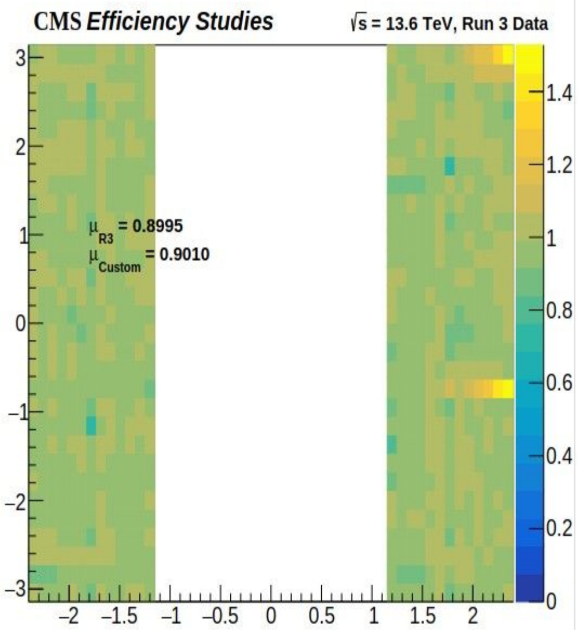
Custom Alignment: Run 2 Geometry Comparison



Custom Alignment: Run 3 Geometry Comparison





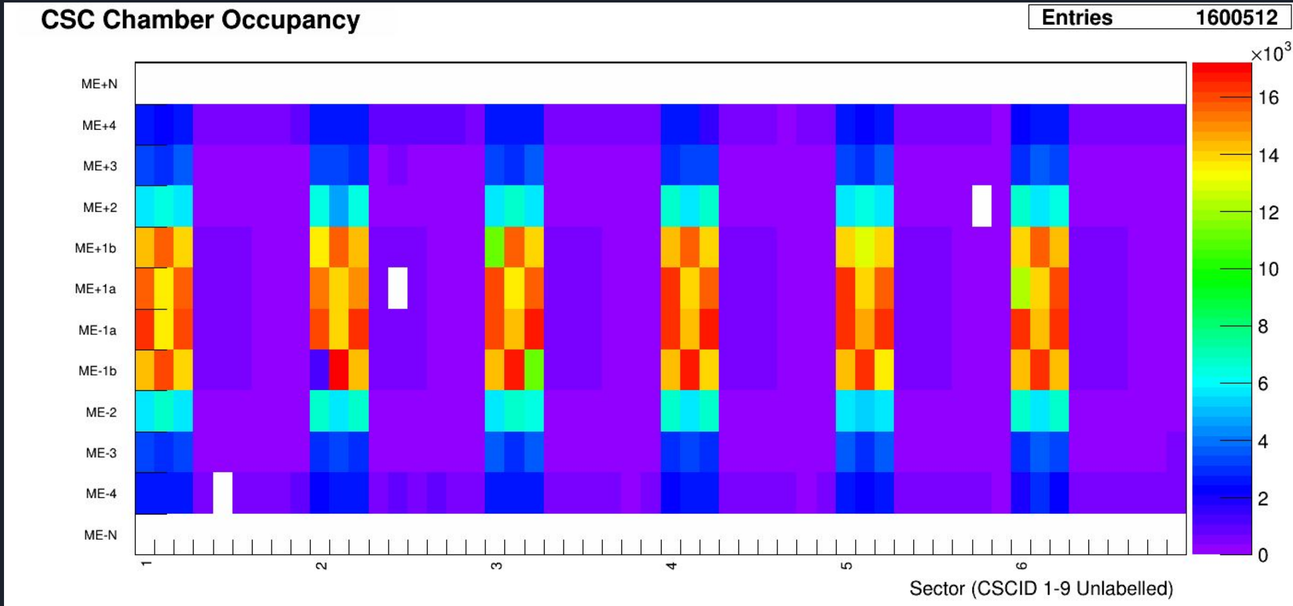


DQM Summary Web-tool

DQM: Data Quality Monitoring

- Detector data can be analyzed online or offline
- Tunnel into P5 to monitor CMS detector data online; accessible, up-to-date analysis
- Can also retrieve data offline, more time spent to detect inefficiencies and their possible causes
- The following plots utilize offline analysis of ROOT files stored in CMS's EOS

Online DQM plot

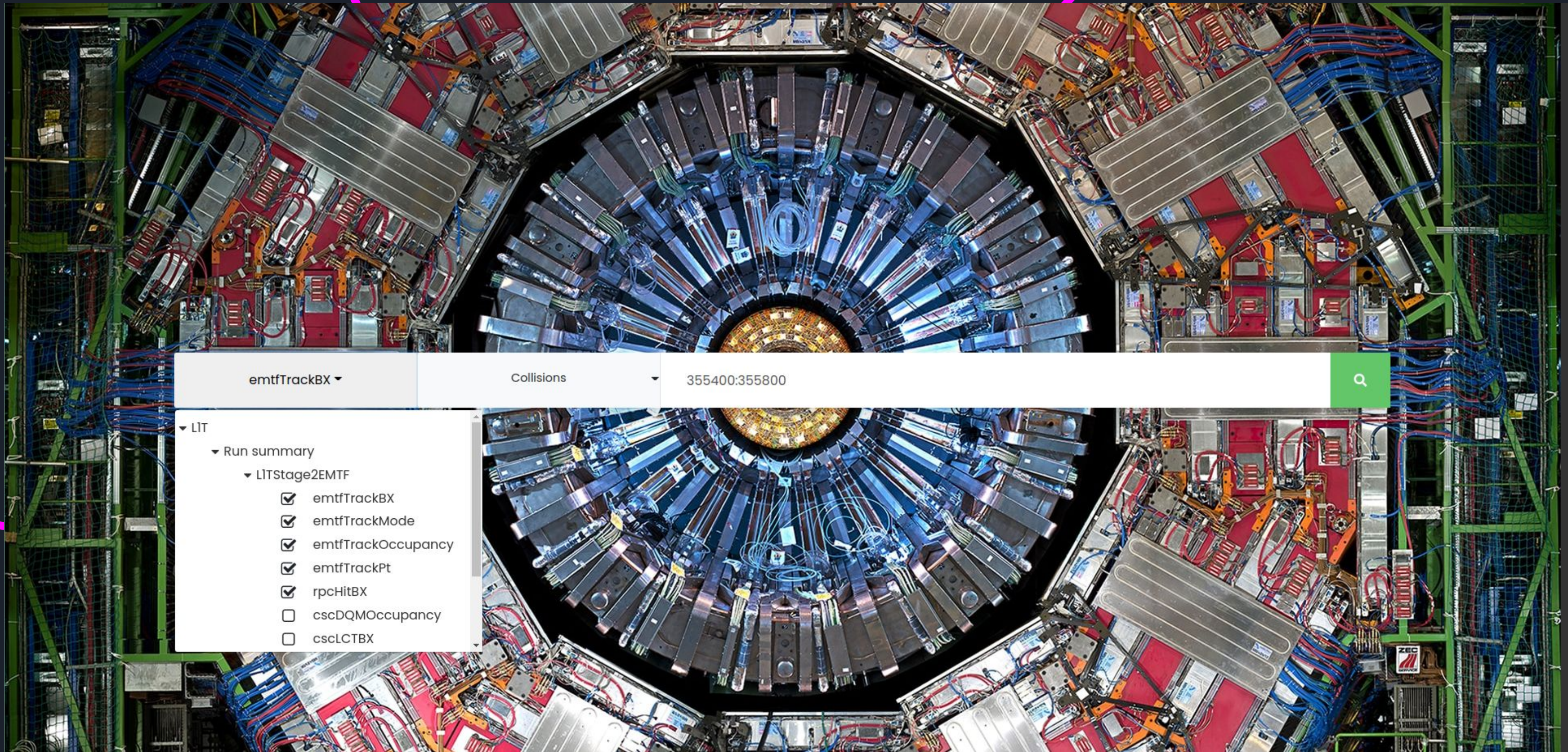


csctiming.cern.ch: Query Page

View **Collisions** or **Cosmics/Commissioning** Runs in given Run-Range

Give range of start_run:end_run. Give individual comma-separated runs

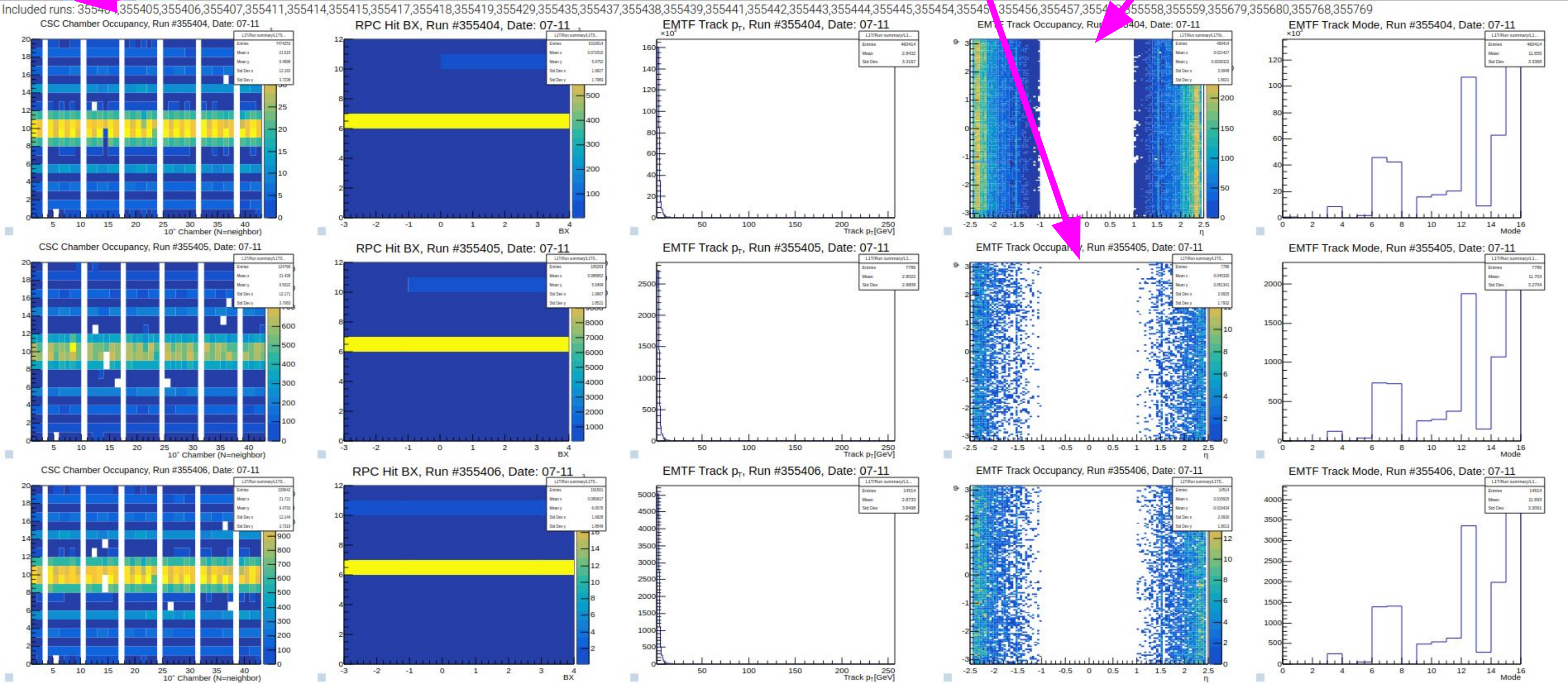
Select from variety of DQM Online plots



csctiming.cern.ch: Results Page (1)

List runs in the given range that return valid DQMIO files for Collisions or Cosmics/Commissioning

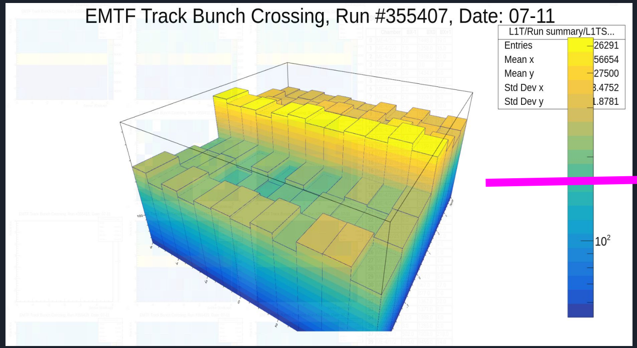
View selected plots side-by-side for qualitative trend analysis

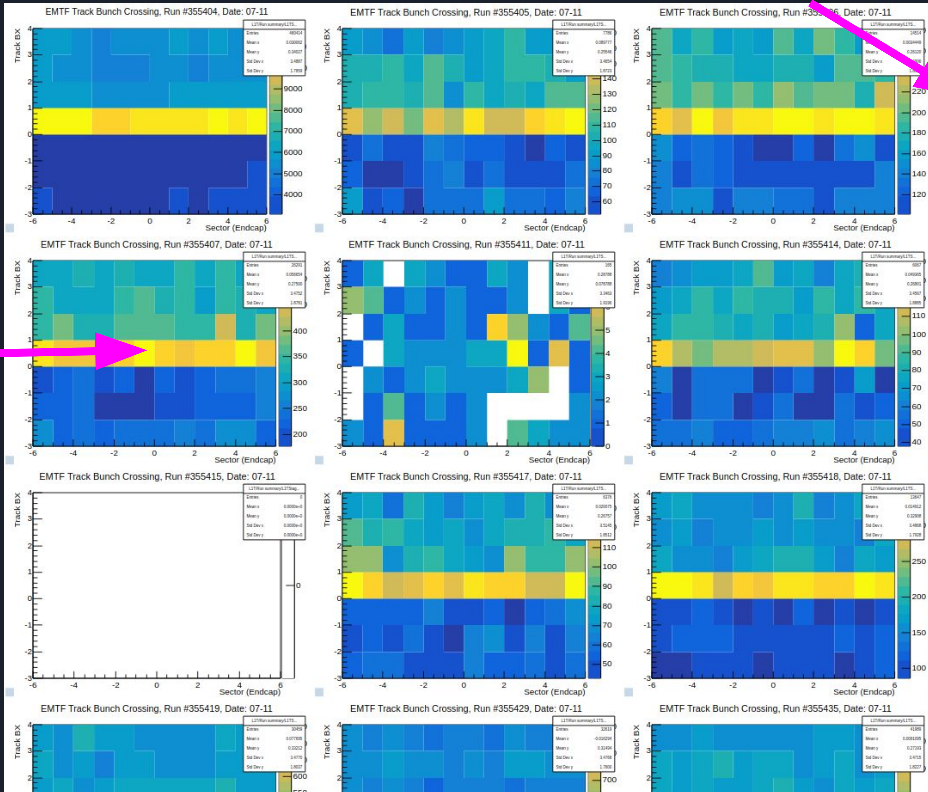


csctiming.cern.ch: Results Page (2)

Get Timing Distribution of CSC Chambers (Original Motivation for Tool)

Click on plots and they are fully interactive





CSC Timing Table

	Chamber	BX-1	BX0	BX+1
	ME-4/2/1	0.0	1448.0	19.0
1	ME-4/2/2	1.0	1258.0	15.0
2	ME-4/2/3	7.0	1318.0	21.0
3	ME-4/2/4	0.0	0.0	0.0
4	ME-4/2/5	3.0	1434.0	9.0
5	ME-4/2/6	5.0	1388.0	14.0
6	ME-4/2/7	2.0	1475.0	20.0
7	ME-4/2/8	2.0	1329.0	5.0
8	ME-4/2/9	8.0	1306.0	10.0
9	ME-4/2/10	0.0	1356.0	14.0
10	ME-4/2/11	1.0	1550.0	7.0
11	ME-4/2/12	11.0	1240.0	5.0
12	ME-4/2/13	5.0	1308.0	9.0
13	ME-4/2/14	2.0	1159.0	2.0
14	ME-4/2/15	5.0	1406.0	24.0
15	ME-4/2/16	5.0	1256.0	14.0
16	ME-4/2/17	6.0	1307.0	18.0
17	ME-4/2/18	6.0	1282.0	11.0
18	ME-4/2/19	1.0	762.0	27.0
19	ME-4/2/20	6.0	1379.0	14.0
20	ME-4/2/21	4.0	1321.0	13.0
21	ME-4/2/22	19.0	983.0	1.0
22	ME-4/2/23	9.0	1373.0	17.0
23	ME-4/2/24	1.0	1369.0	12.0
24	ME-4/2/25	1.0	1443.0	22.0
25	ME-4/2/26	1.0	1109.0	9.0
26	ME-4/2/27	6.0	628.0	2.0
27	ME-4/2/28	1.0	892.0	4.0
28	ME-4/2/29	3.0	871.0	1.0
29	ME-4/2/30	3.0	734.0	5.0
30	ME-4/2/31	2.0	867.0	27.0
31	ME-4/2/32	1.0	877.0	7.0
32	ME-4/2/33	0.0	1367.0	22.0
33	ME-4/2/34	1.0	1371.0	8.0
34	ME-4/2/35	12.0	1308.0	4.0
35	ME-4/2/36	3.0	1285.0	2.0
37	ME-4/1/1	502.0	7303.0	218.0
39	ME-4/1/2	175.0	9455.0	14.0
41	ME-4/1/3	275.0	9904.0	12.0

csctiming.cern.ch: Technologies

- **Backend:** Python Flask web-server hosted on OpenStack machine
- **Request-futures** with CERN Grid certificate to access DQMIO files
- **Runregistry** used to separate legitimate Collisions or Cosmics/Commisioning Runs
- **BeautifulSoup** used to parse web for valid DQMIO file-urls
- **Uproot** used to view ROOT byte-streams
- **Frontend:** Bootstrap5, with custom JQuery-based drop-down menu
- **JSROOT**: interactive web-based ROOT histogram viewer
- *Note: this website only works if you are on the CERN network*

Conclusion

- Last few months:
  - Validated Muon DPG's updated geometry
  - Investigated other methods of improving EMTF Alignment
  - Developed DQM Analysis Web-Tool csctiming.cern.ch
  - Not Mentioned:
    - Performed general DQM work investigating issues with GEM and hot RPC chambers
    - DOC duties updating EMTF configurations and monitoring data on DQM Online
    - **CSC-EMTF Laisson**: Presented EMTF updates to the CSC team, coordinate with them on DQM anomalies and csctiming tool
- Going Forward
  - Improve csctiming.cern.ch (**Please give me feedback!**)
  - Investigate GEM timing issues and strange EMTF behavior
  - Refine custom alignment script and LUTs
  - Document work for future co-ops on Github (https://github.com/nickh2000/EMTFAnalysis)