

TAC-HEP Project Hough Transform

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- I'm a 3rd year at the University of Massachusetts, started TAC-HEP Summer 2023
- Mentors: Verena Ingrid Martinez Outschoorn (UMass), Guillermo Loustau De Linares (UMass), Michael Begel (BNL), Davide Cieri (MPI)

My TAC-HEP R&D project:

- Contributing to the LOMDT effort within the ATLAS Muon Spectrometer, specifically studying firmware design performance via simulations.
- Study the impact of inefficiencies within the detector and implement updates to the logic that can improve the robustness of the MS trigger.

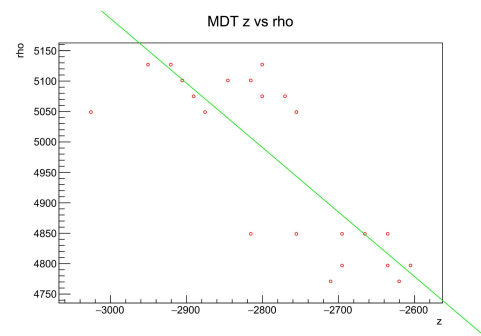
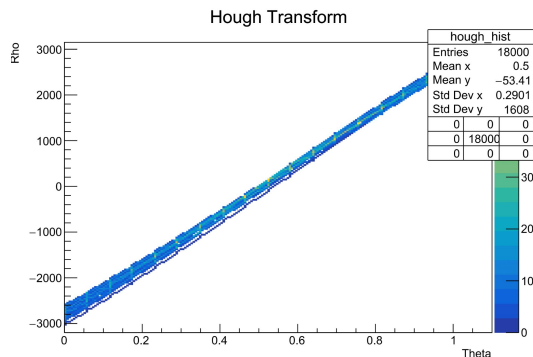
Courses: Software Engineering for Scientific Computing, GPU and FPGA training module, Systems for Data Science at UMass

Accomplishments:

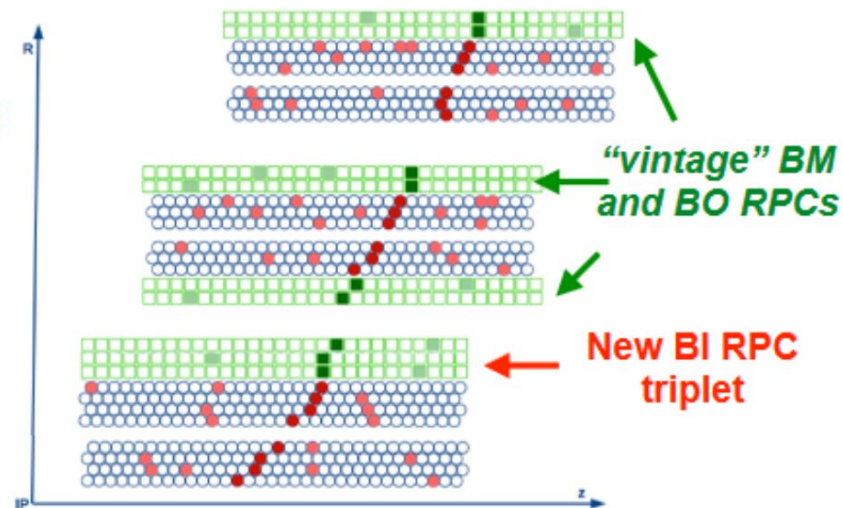
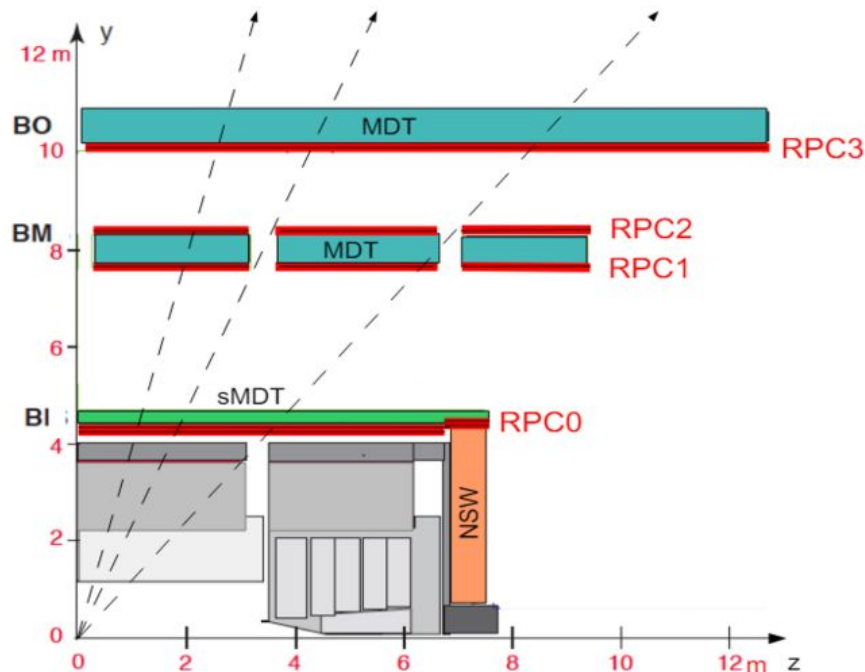
- Performance studies to understand effect of subdetector inefficiencies on MS trigger.
- Successful conversion of MDT hits into Hough Transform
- Currently using Hough transform to supplement for possible RPC inefficiencies

Next steps:

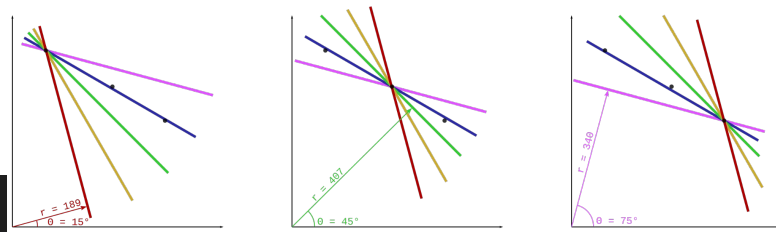
- Implement into MS segment construction
- Fine tune parameters
- Possible comparison with other models



Muon Spectrometer



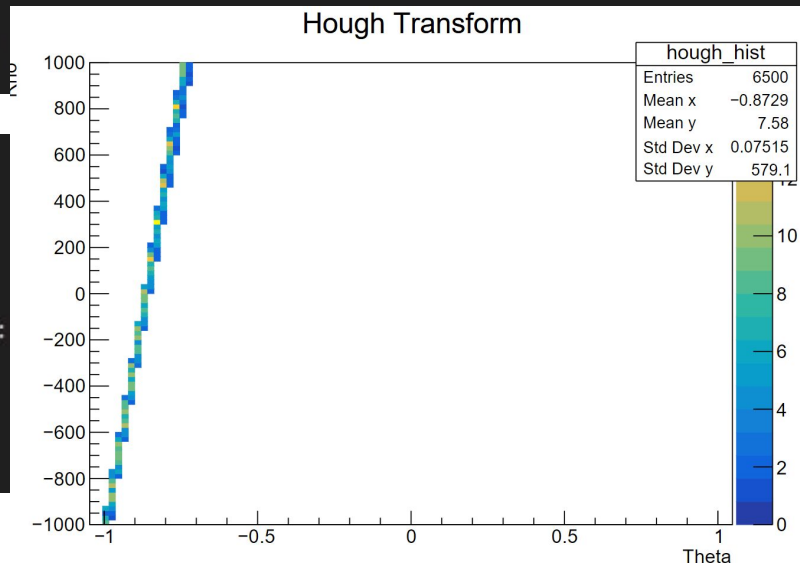
Hough Transform



```
theta_bins, rho_bins = 200, 200
theta_max = np.pi/4 # limit theta to force vertical line
rho_max = np.sqrt(max(mdt_z_list)**2 + max(mdt_perp_list)**2) # need to find better limit

hough_hist = ROOT.TH2F("hough_hist", "Hough Transform;Theta;Rho", theta_bins, -theta_max, theta_max, rho_bins, -rho_max, rho_max)
theta_range = np.linspace(-theta_max, theta_max, theta_bins)
for mdt_z, mdt_r in zip(mdt_z_array, mdt_perp_array): # loop over MDT hits
    for theta in theta_range: # loop over theta range
        rho = mdt_z*np.cos(theta) + mdt_r*np.sin(theta) # calculate rho
        hough_hist.Fill(theta, rho)
```

```
# If bin content is max, save rho and theta coordinates
rho_peak = []
theta_peak = []
for i in range(1, theta_bins):
    for j in range(1, rho_bins):
        if hough_hist.GetBinContent(i, j) == hough_hist.GetMaximum():
            rho_peak.append(hough_hist.GetYaxis().GetBinCenter(j))
            theta_peak.append(hough_hist.GetXaxis().GetBinCenter(i))
rho_peak_list_average = sum(rho_peak)/float(len(rho_peak))
theta_peak_list_average = sum(theta_peak)/float(len(theta_peak))
```



Making Lines

```
# Convert from rho, theta to z and r
line_list = []
z_max = 15000
for rho, theta in zip(rho_peak, theta_peak):
    r_min = (-np.cos(theta) / np.sin(theta)) * -z_max + (rho / np.sin(theta))
    r_max = (-np.cos(theta) / np.sin(theta)) * z_max + (rho / np.sin(theta))
    line = TLine(-z_max, r_min, z_max, r_max)
    line_list.append(line)
r_min = (-np.cos(theta_peak_list_average) / np.sin(theta_peak_list_average)) * -15000 + (rho_peak_list_average / np.sin(theta_peak_list_average))
r_max = (-np.cos(theta_peak_list_average) / np.sin(theta_peak_list_average)) * 15000 + (rho_peak_list_average / np.sin(theta_peak_list_average))
line_average = TLine(-15000, r_min, 15000, r_max)
line_average.SetLineColor(ROOT.kGreen)
```

1. If RPC is dead, use MDT Hough transform to trace back into the RPCs and simulate hits.
2. RPC and MDT hits are then used to create the MS segment.

