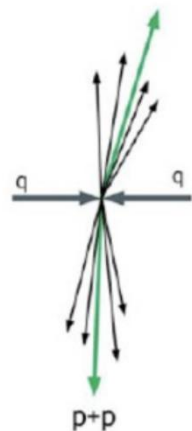


Di-jet Analysis Status with Data & MC

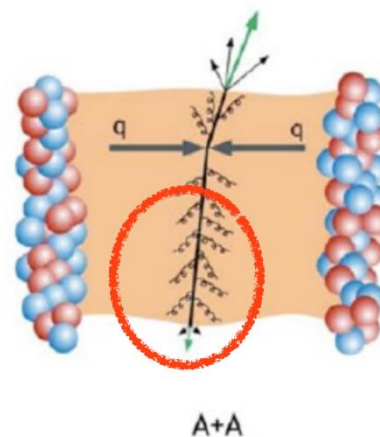
Beomgon Kim, Yongsun Kim (Korea University),
Samuel Steed Boren, Daniel Tapia Takaki (University of Kansas)

2nd Feb. 2017

- Jets
 - streams of particles collimated in a small cone around a given direction
- Jet quenching
 - The energy loss when partons passing through the medium
 - Information of the thermodynamic and transport properties of the medium by comparing pp & PbPb collisions



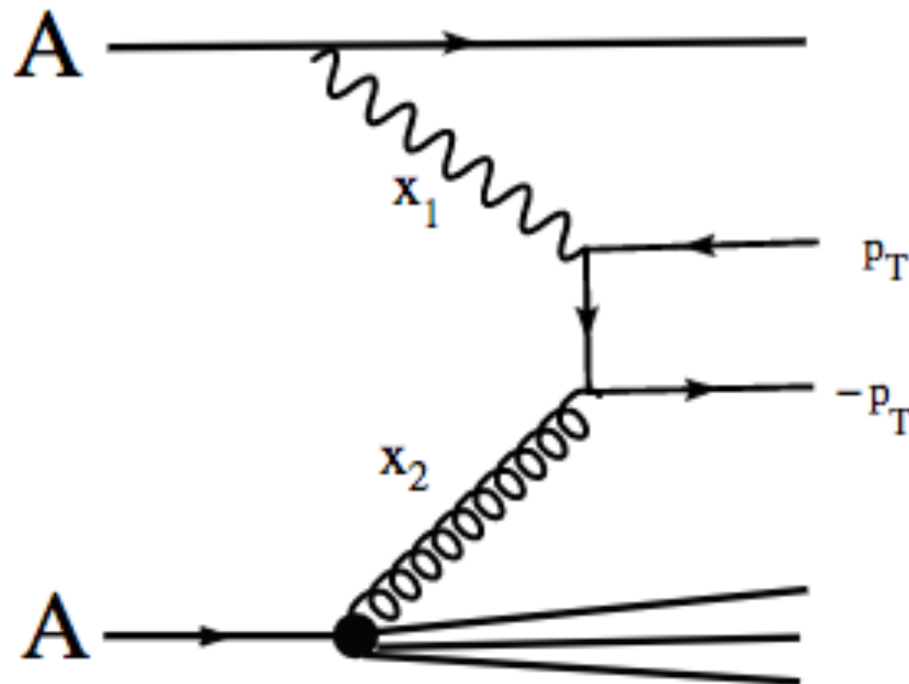
[QCD in vacuum]



medium induced radiation

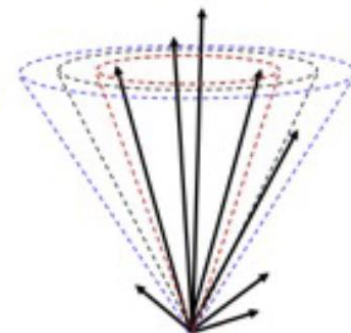
[QCD in medium]

- Photonuclear jet production
 - $\gamma + \text{Pb} \rightarrow \text{jet1} + \text{jet2} + X(+\text{Pb})$
- Observe photonuclear jets at the LHC for the 1st time.
- Study the energy dependence of photonuclear jets.
 - Do we observe jet quenching?

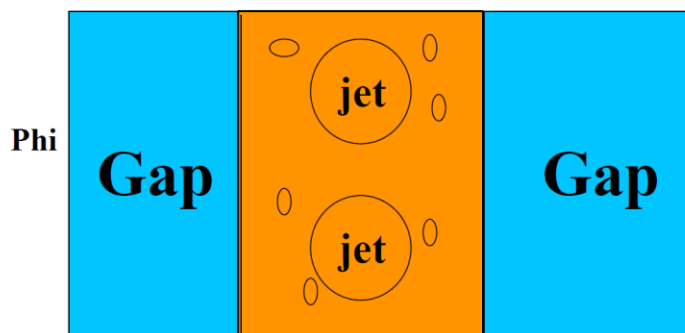
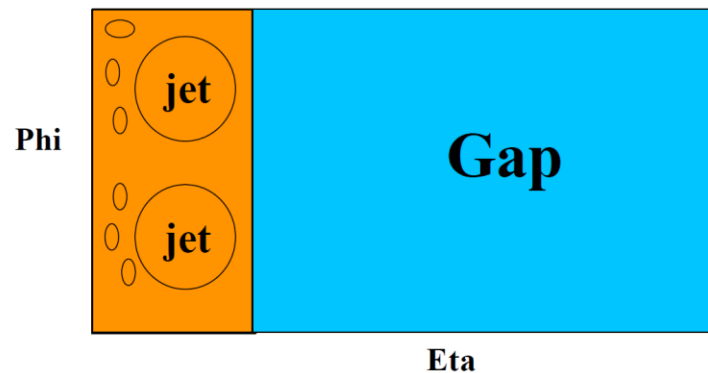
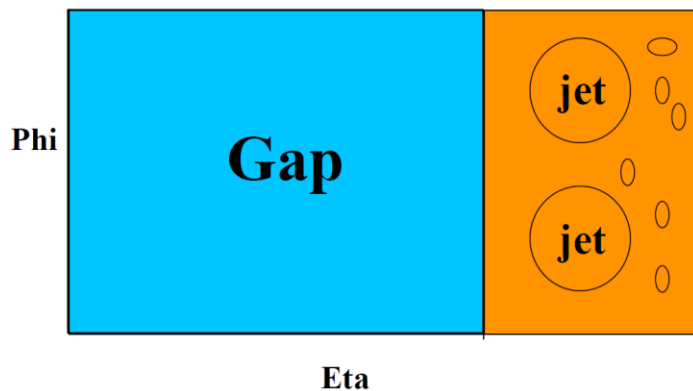


- ak5PF algorithm is used ($R = 0.5$)
- $|\eta_{track}| < 2.5$ and $|\eta_{jet}| < 2.4$
 - The range which CMS tracker can cover
 - The selection is being used at CMS High p_T group

Anti k_T Jet cone
 $R = 0.2, 0.3, 0.4$

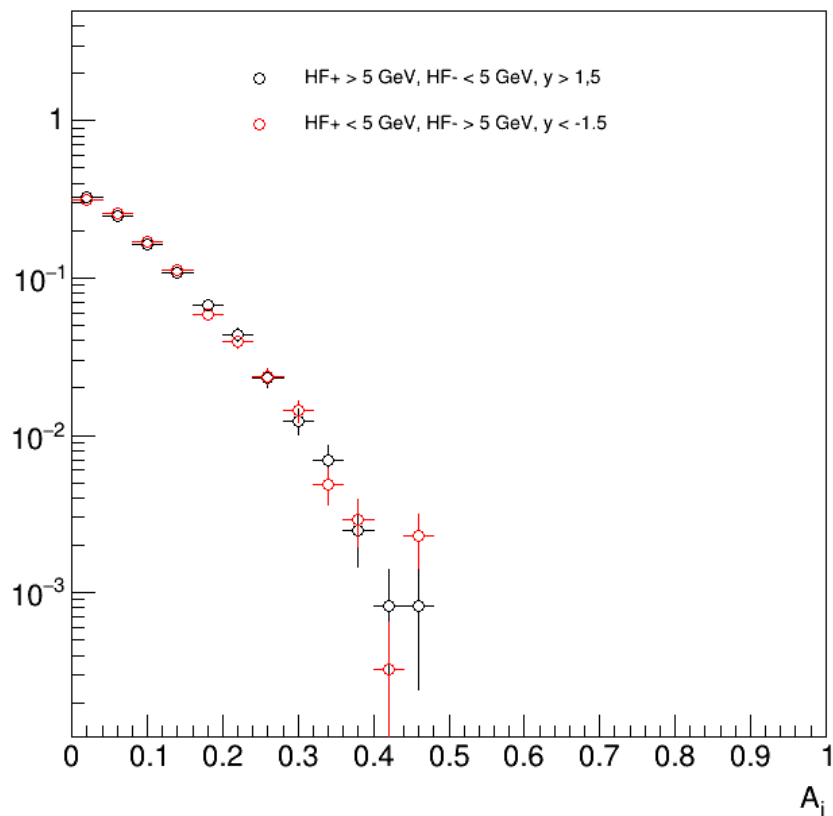


$$\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$$

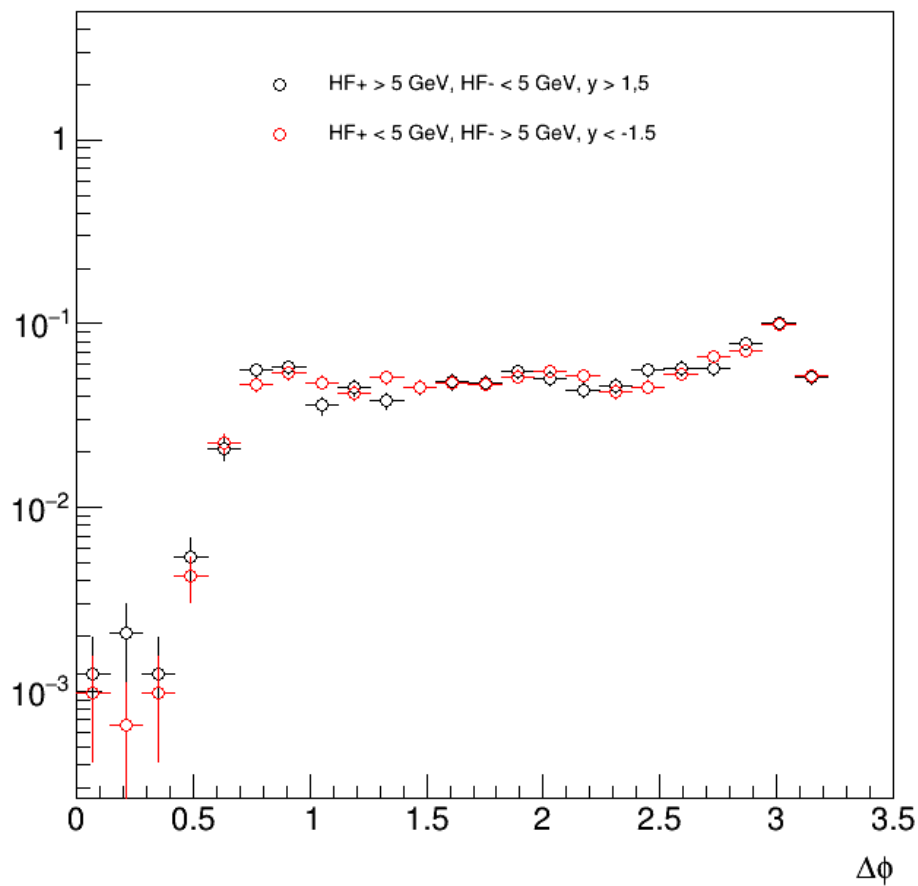


- Define the three different event topologies
- Check the distribution of di-jet events

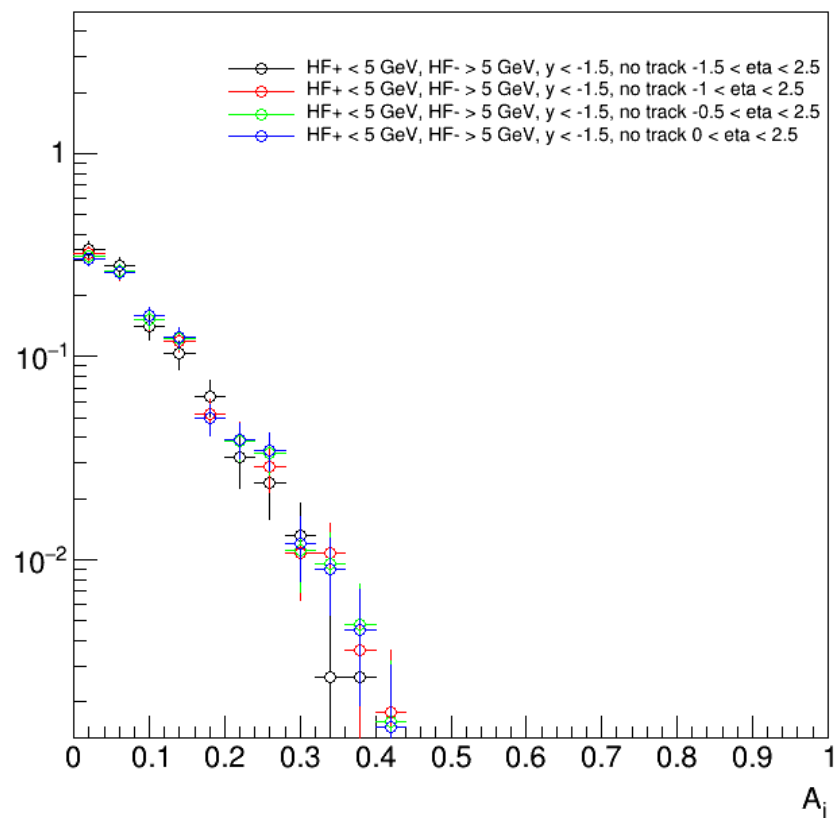
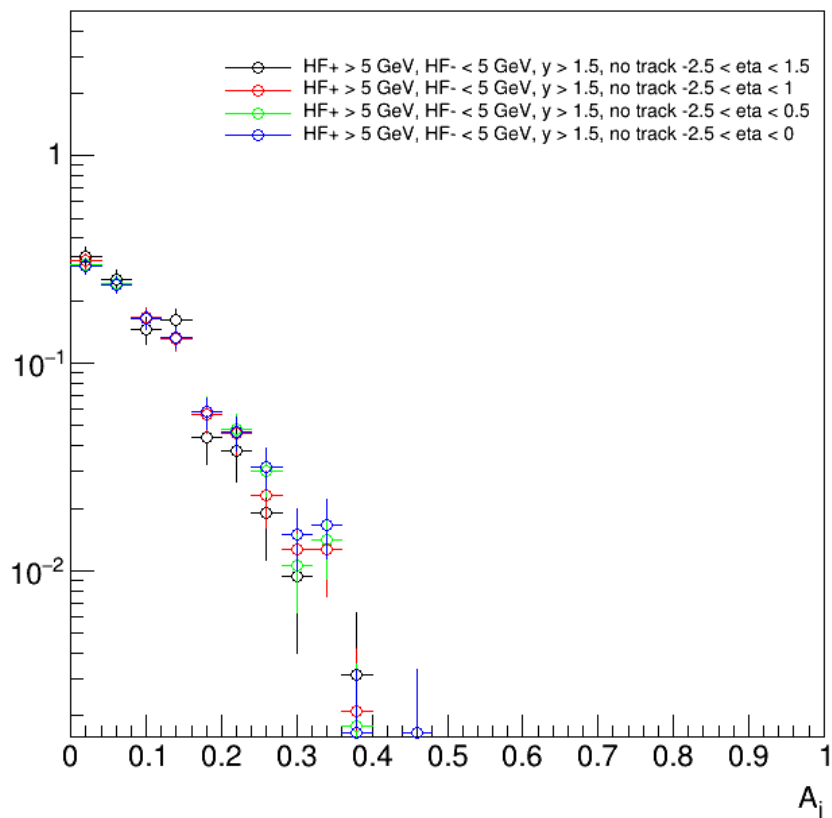
- $A_j = \frac{p_{T,1} - p_{T,2}}{p_{T,1} + p_{T,2}}$
 - Variable to check di-jet imbalance
- $p_{T,1} > 20 \text{ GeV}/c$ & $p_{T,2} > 20 \text{ GeV}/c$
- For every events which satisfy the cuts, $A_j < 0.5$.



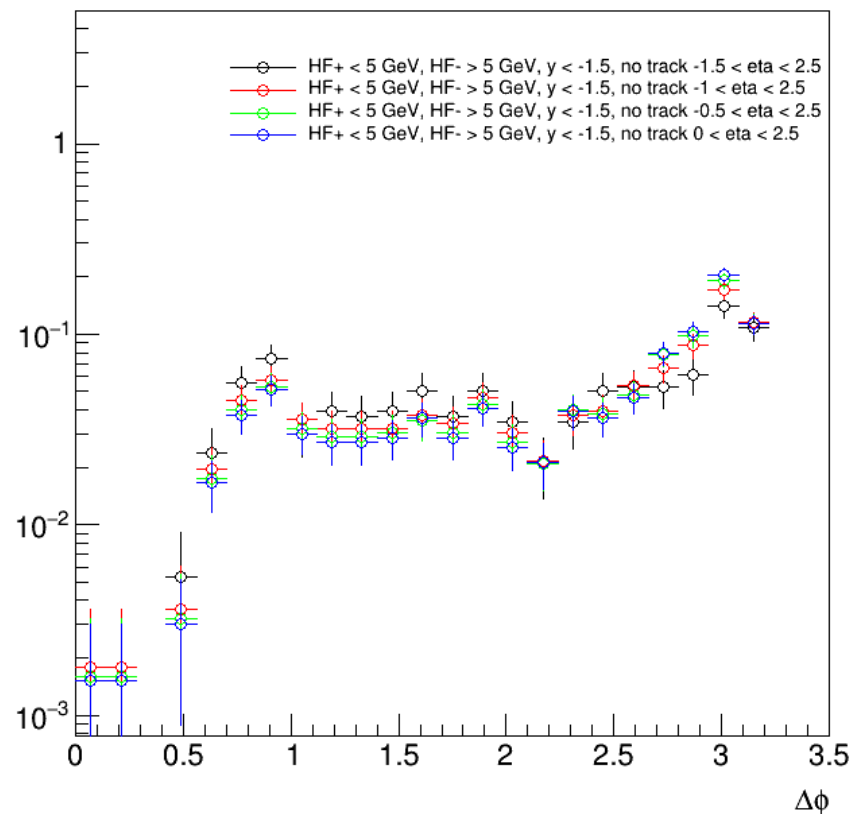
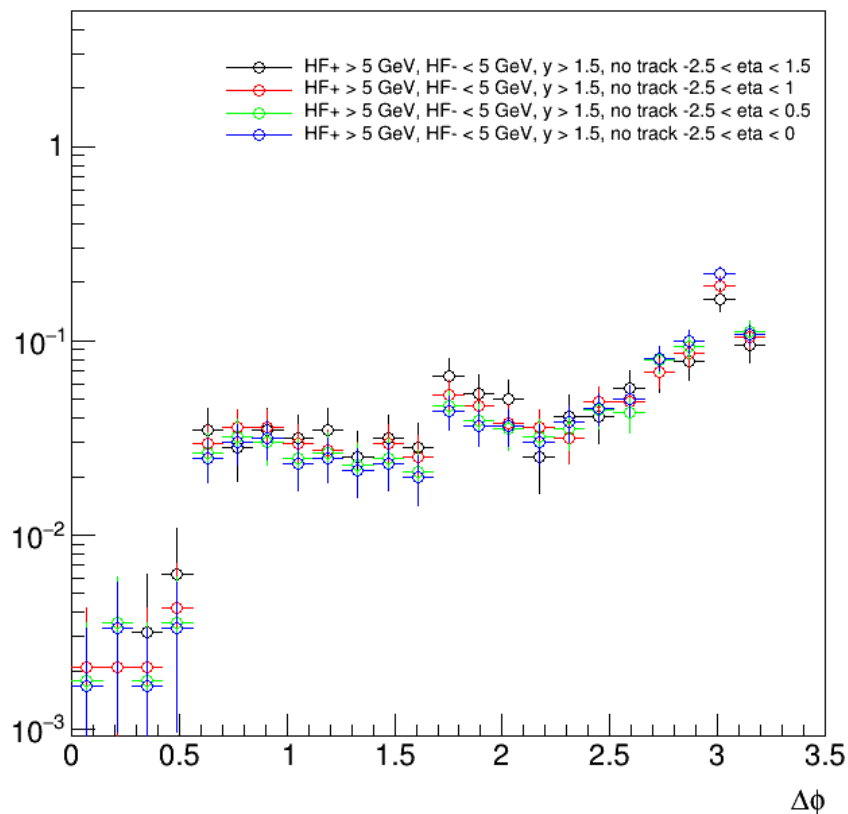
- For most of the events which satisfy the cuts, $\Delta\phi > 0.7$.



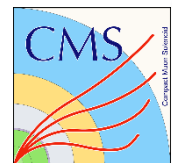
Di-jet Asymmetry Ratio Distribution



- $p_{T,1} > 20 \text{ GeV}/c$ & $p_{T,2} > 20 \text{ GeV}/c$



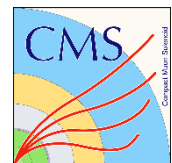
- Most of events which satisfy cuts have $\Delta\phi > 2$.



Next Step



- Checking the distributions at mid-rapidity region
- The distributions of A_j & $\Delta\phi$ with different jet cone size($R = 0.3 - 1.0$)
- PbPb MC production is almost done(by Samuel).
 - It will be able to compare MC with Data soon.

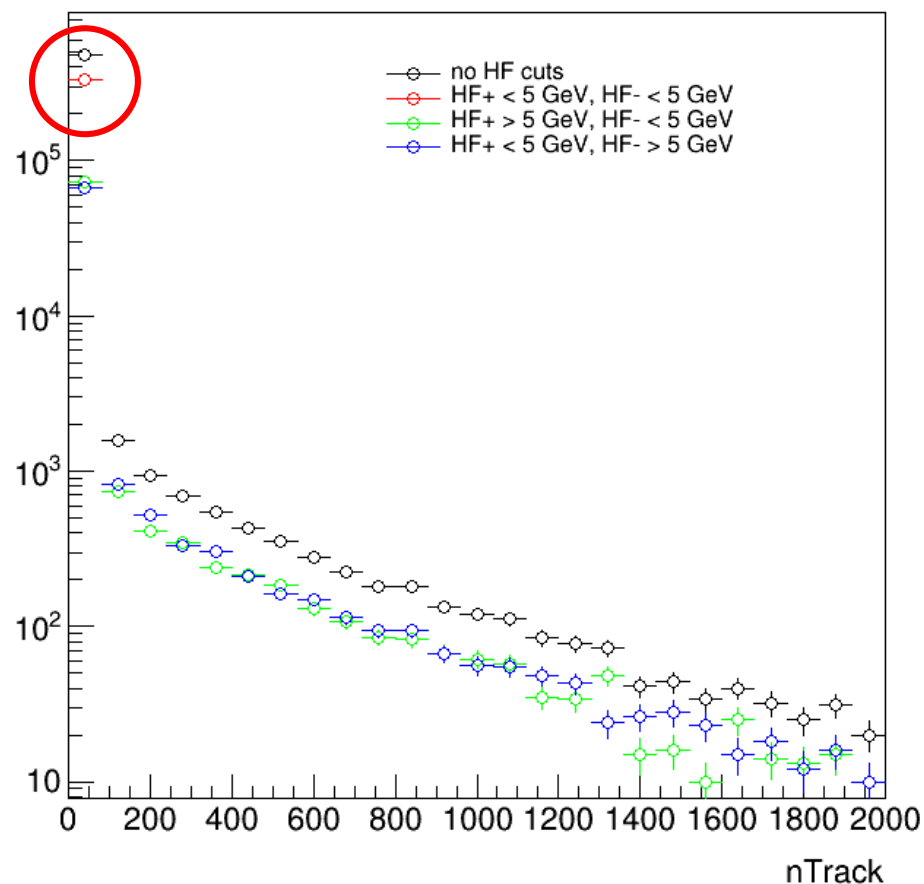


Back Up



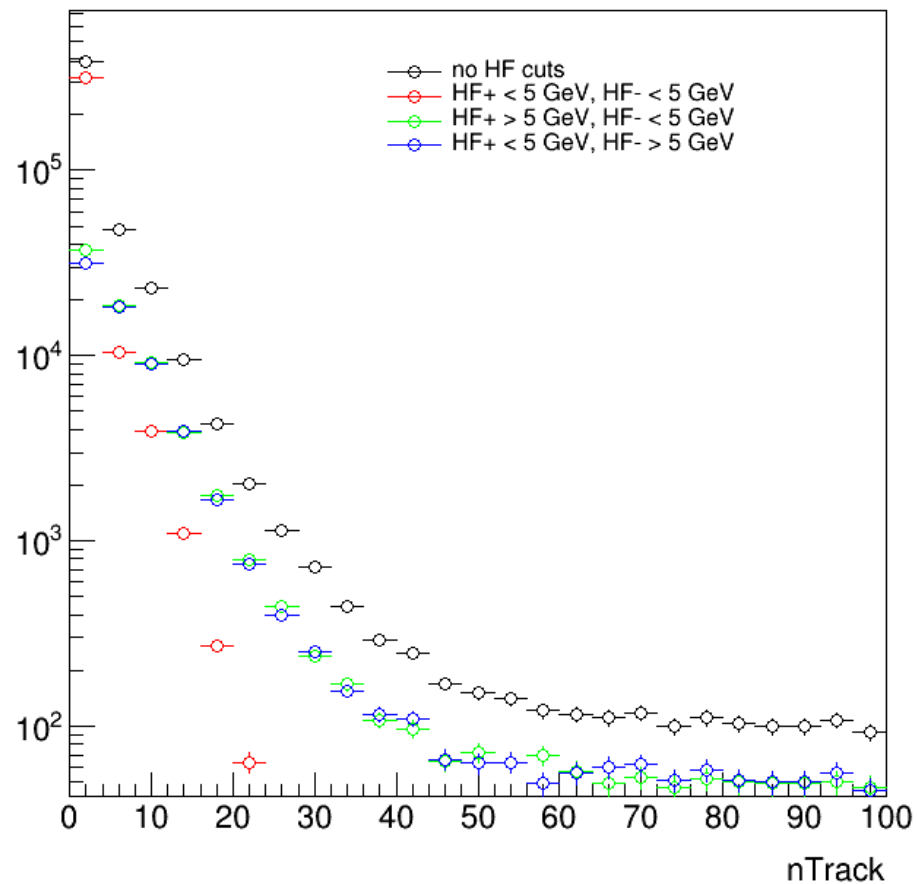
The Number of Tracks(0 to 2k)

- Normalized by the number of entries with "no HF cuts"
- The events satisfy "HF+ < 5 GeV & HF- < 5 GeV" seem to have the small number of tracks.



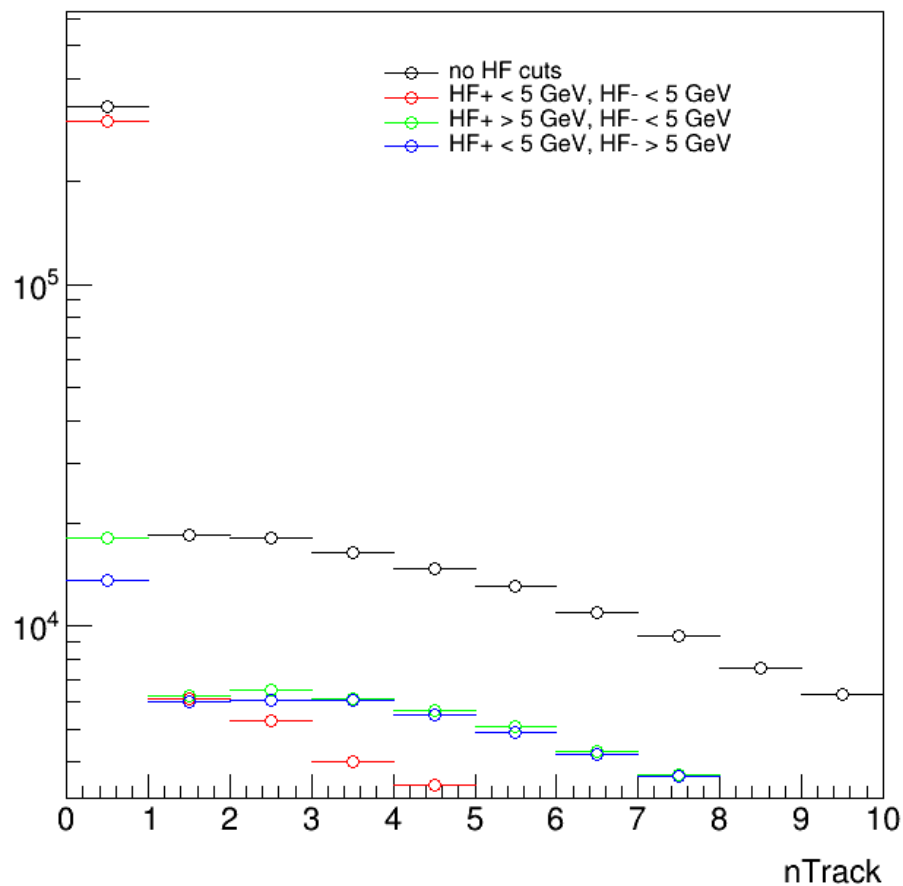
The Number of Tracks(0 to 100)

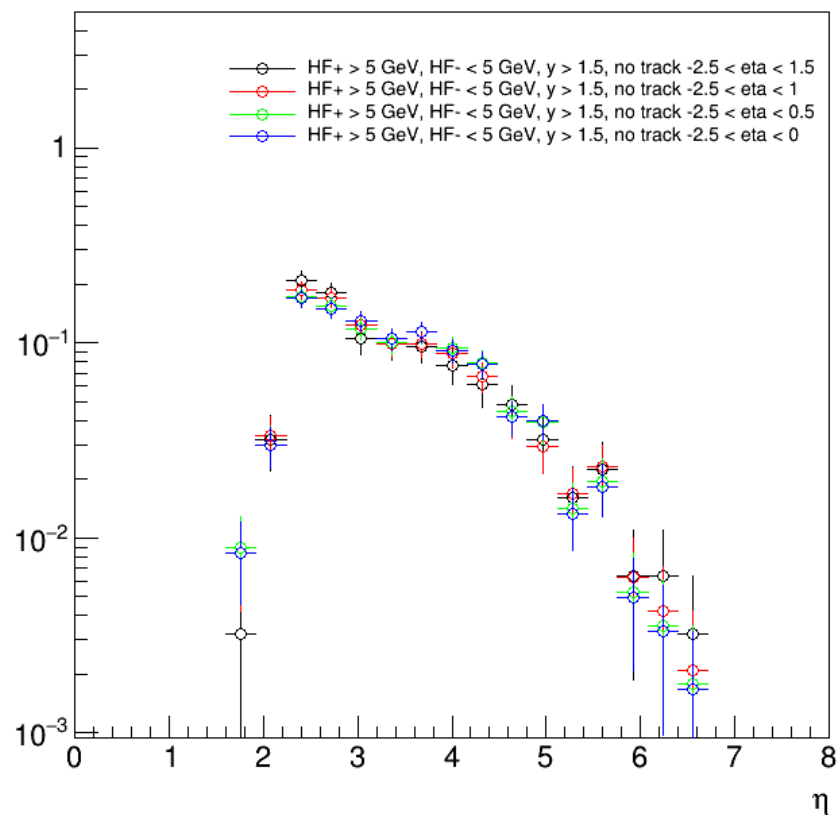
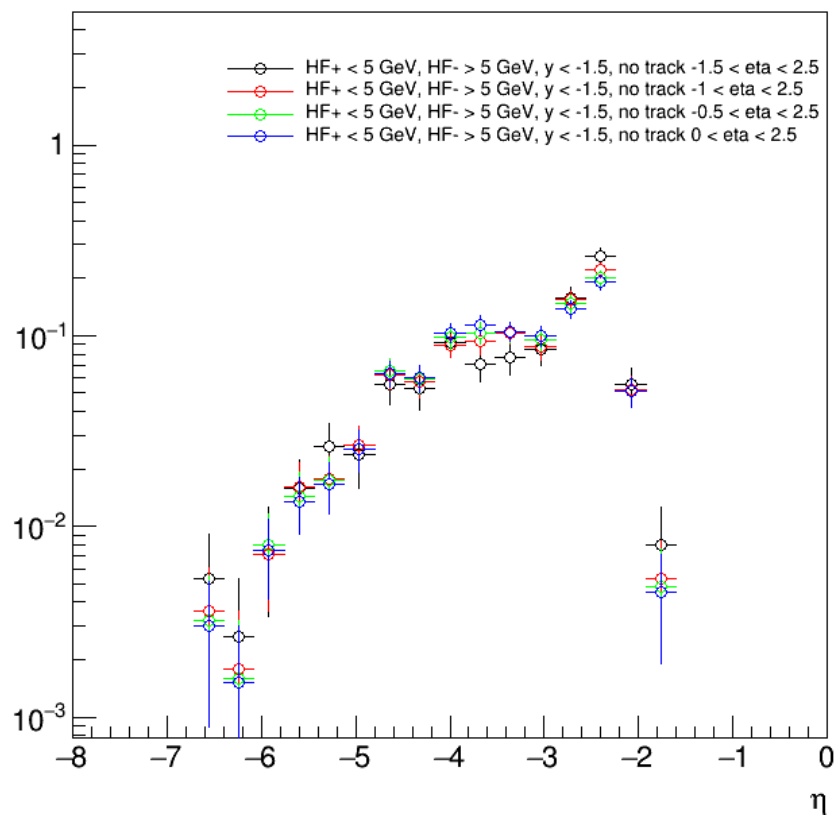
- Most of the events satisfy "HF+ < 5 GeV & HF- < 5 GeV" have the number of tracks < 25.



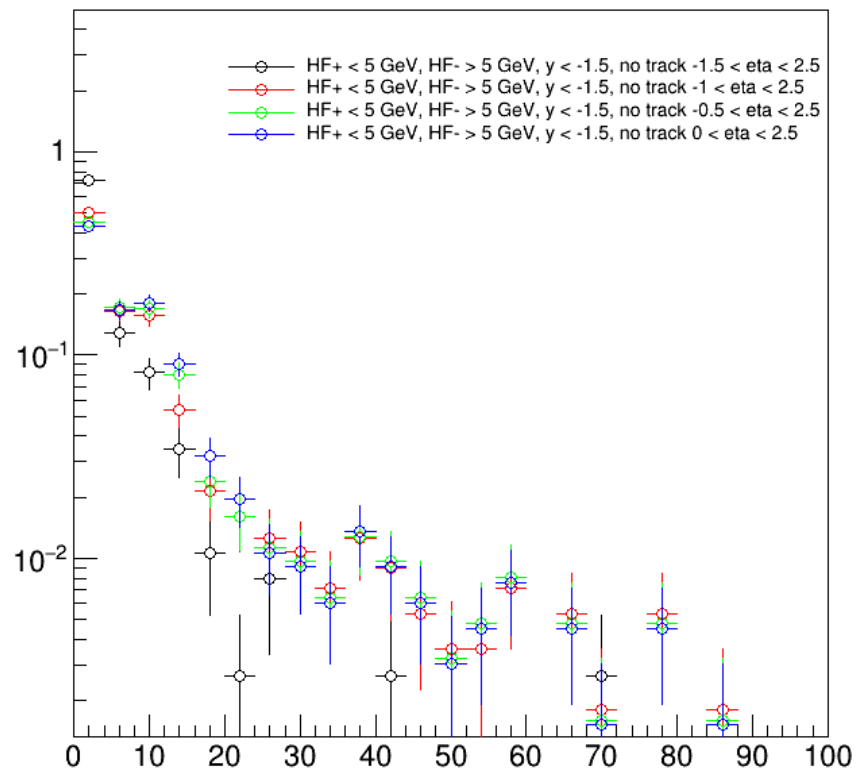
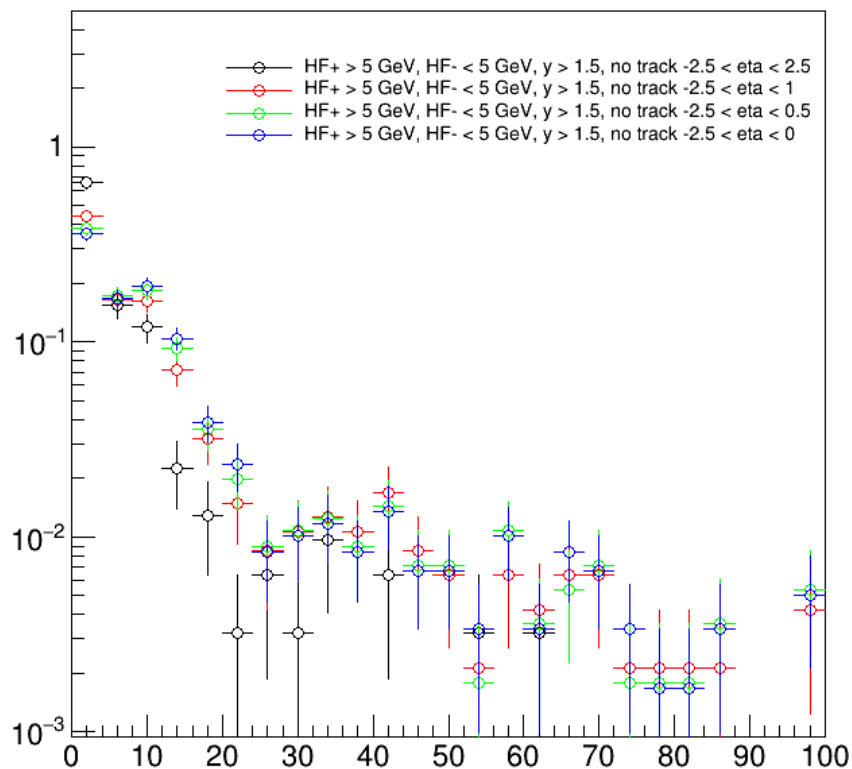
The Number of Tracks(0 to 10)

- For the events satisfy "HF+ < 5 GeV & HF- < 5 GeV", the rate of the events with the number of track=0 is relatively large.



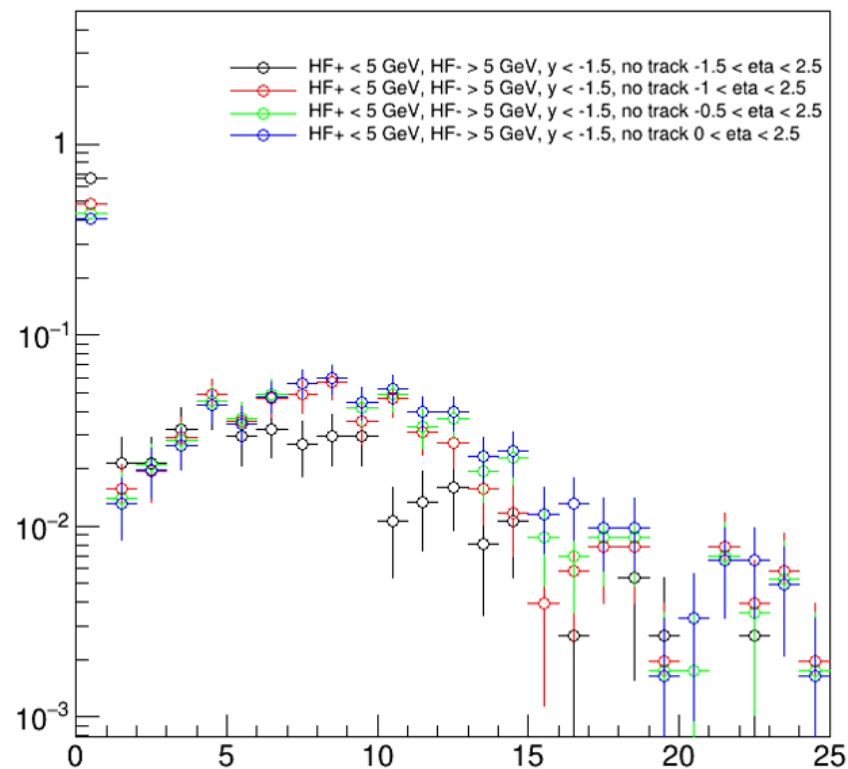
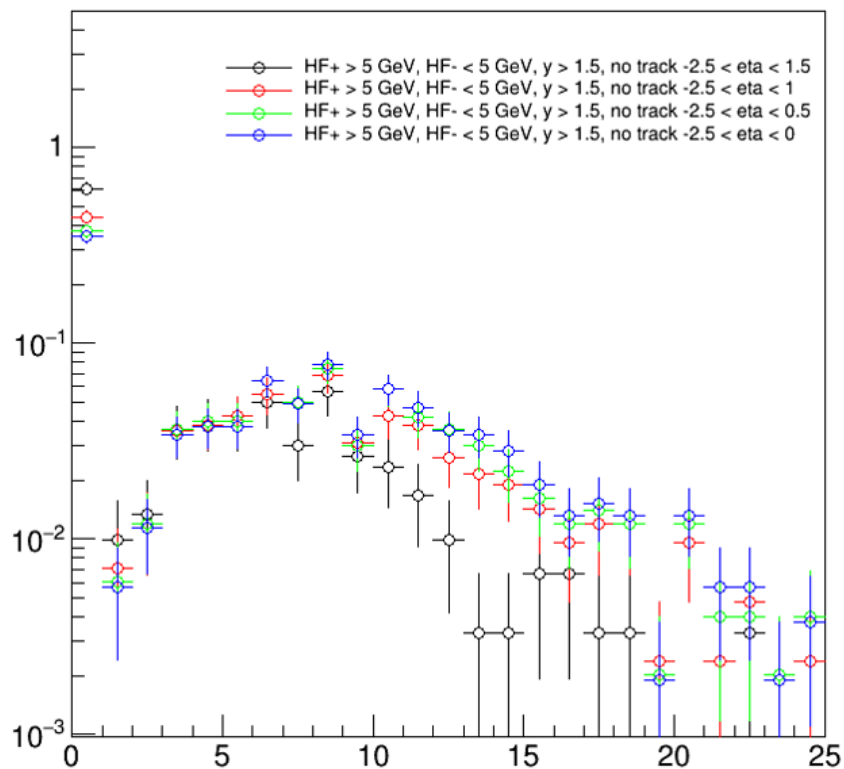


- Most of events which satisfy cuts have $2 < |\eta| < 5$.

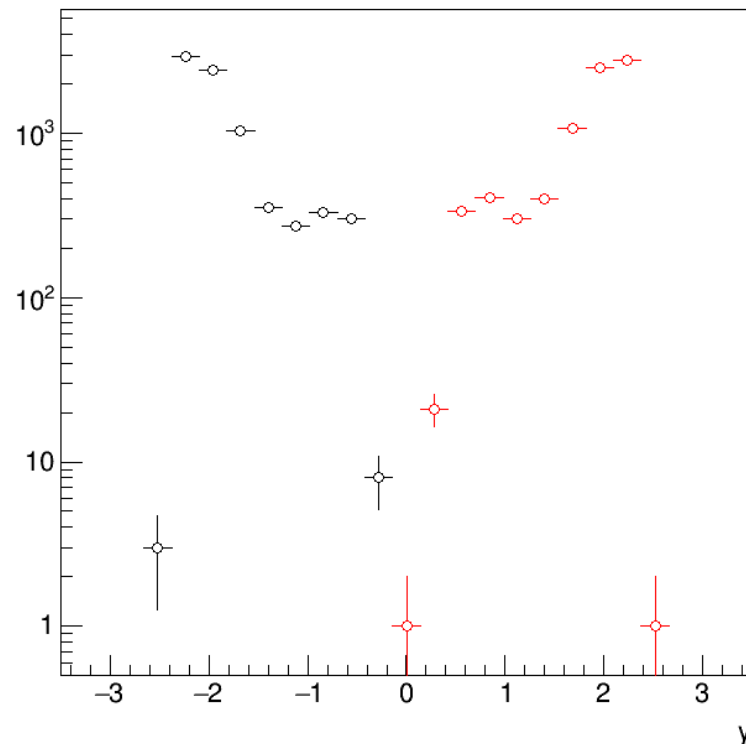


- For each selection, about 40-60 % of events have at least 1 track.

The Number of Tracks Distribution(0 to 25)

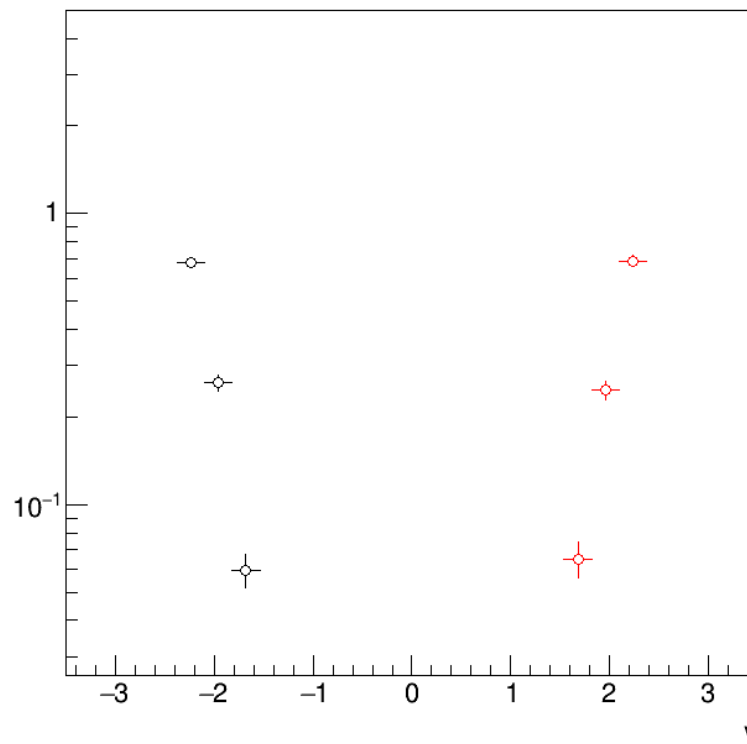


- About 7700 entries for both cases.



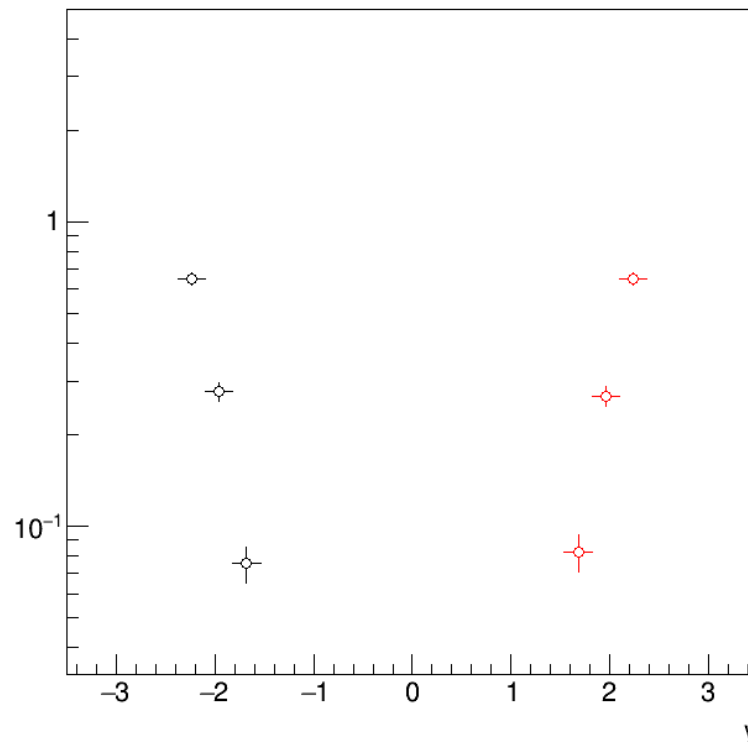
- Black:** $(\eta_1 > 1.5 \parallel \eta_1 < -1.5) \ \&\& \ (\eta_2 > 1.5 \parallel \eta_2 < -1.5) \ \&\& \ \eta_1 \cdot \eta_2 > 0 \ \&\& \ (h_{fplus} < 5 \ \&\& \ h_{fminus} > 5) \ \&\& \ y < 0 \ \&\& \ n_{Trk\eta_0p5to1} = 0 \ \&\& \ n_{Trk\eta_1to1p5} = 0$
- Red:** $(\eta_1 > 1.5 \parallel \eta_1 < -1.5) \ \&\& \ (\eta_2 > 1.5 \parallel \eta_2 < -1.5) \ \&\& \ \eta_1 \cdot \eta_2 > 0 \ \&\& \ (h_{fplus} > 5 \ \&\& \ h_{fminus} < 5) \ \&\& \ y > 0 \ \&\& \ n_{Trk\eta_0p5to1} = 0 \ \&\& \ n_{Trk\eta_1to1p5} = 0$

- About 850 entries for both cases.

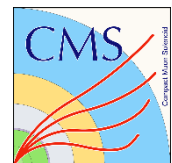


- Black:** $(\eta_1 > 1.5 \parallel \eta_1 < -1.5) \ \&\& \ (\eta_2 > 1.5 \parallel \eta_2 < -1.5) \ \&\& \ \eta_1 \cdot \eta_2 > 0 \ \&\& \ (h_{fplus} < 5 \ \&\& \ h_{fminus} > 5) \ \&\& \ y < 0 \ \&\& \ n_{Trketa0p5to1} = 0 \ \&\& \ n_{Trketa1to1p5} = 0 \ \&\& \ (pt_1 > 20 \ \&\& \ pt_2 > 20)$
- Red:** $(\eta_1 > 1.5 \parallel \eta_1 < -1.5) \ \&\& \ (\eta_2 > 1.5 \parallel \eta_2 < -1.5) \ \&\& \ \eta_1 \cdot \eta_2 > 0 \ \&\& \ (h_{fplus} > 5 \ \&\& \ h_{fminus} < 5) \ \&\& \ y > 0 \ \&\& \ n_{Trketam0p5to1} = 0 \ \&\& \ n_{Trketam1to1p5} = 0 \ \&\& \ (pt_1 > 20 \ \&\& \ pt_2 > 20)$

- About 650 entries for both cases.



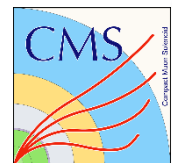
- Black:** $(\eta_1 > 1.5 \parallel \eta_1 < -1.5) \ \&\& \ (\eta_2 > 1.5 \parallel \eta_2 < -1.5) \ \&\& \ \eta_1 * \eta_2 > 0 \ \&\& \ (h_{fplus} < 5 \ \&\& \ h_{fminus} > 5) \ \&\& \ y < 0 \ \&\& \ n_{Trk\eta_0p5to1} = 0 \ \&\& \ n_{Trk\eta_1to1p5} = 0 \ \&\& \ (p_{t1} > 20 \ \&\& \ p_{t2} > 20) \ \&\& \ n_{Trk} > 0$
- Red:** $(\eta_1 > 1.5 \parallel \eta_1 < -1.5) \ \&\& \ (\eta_2 > 1.5 \parallel \eta_2 < -1.5) \ \&\& \ \eta_1 * \eta_2 > 0 \ \&\& \ (h_{fplus} > 5 \ \&\& \ h_{fminus} < 5) \ \&\& \ y > 0 \ \&\& \ n_{Trk\eta_0p5to1} = 0 \ \&\& \ n_{Trk\eta_1to1p5} = 0 \ \&\& \ (p_{t1} > 20 \ \&\& \ p_{t2} > 20) \ \&\& \ n_{Trk} > 0$



Motivation



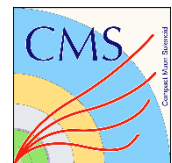
- For the UPC di-jet events, it is expected to be there are only 1 di-jet, and there is no other particle is generated.
- By check the number of tracks, we can make sure this is the UPC events.



New Skim with "nTrack"



- New skimmed files are uploaded.
 - `/afs/cern.ch/work/b/bekim/public/new_skim_170119`
- Each files are made by the same algorithm, but in different cone radius.
 - ak1PF, ak2PF, ak3PF, ak4PF, ak5PF
- New tree "Track" from "anaTrack" for the number of tracks is added.
- There are 11 leaves in the new Tree.
 - "nTrack" : the number of tracks
 - Ex.) "nTrketa0to0p5" : the tracks within the eta range, $0 \leq \eta < 0.5$
"nTrketam1to1p5" : the tracks within the eta range, $-1.5 \leq \eta < -1.0$

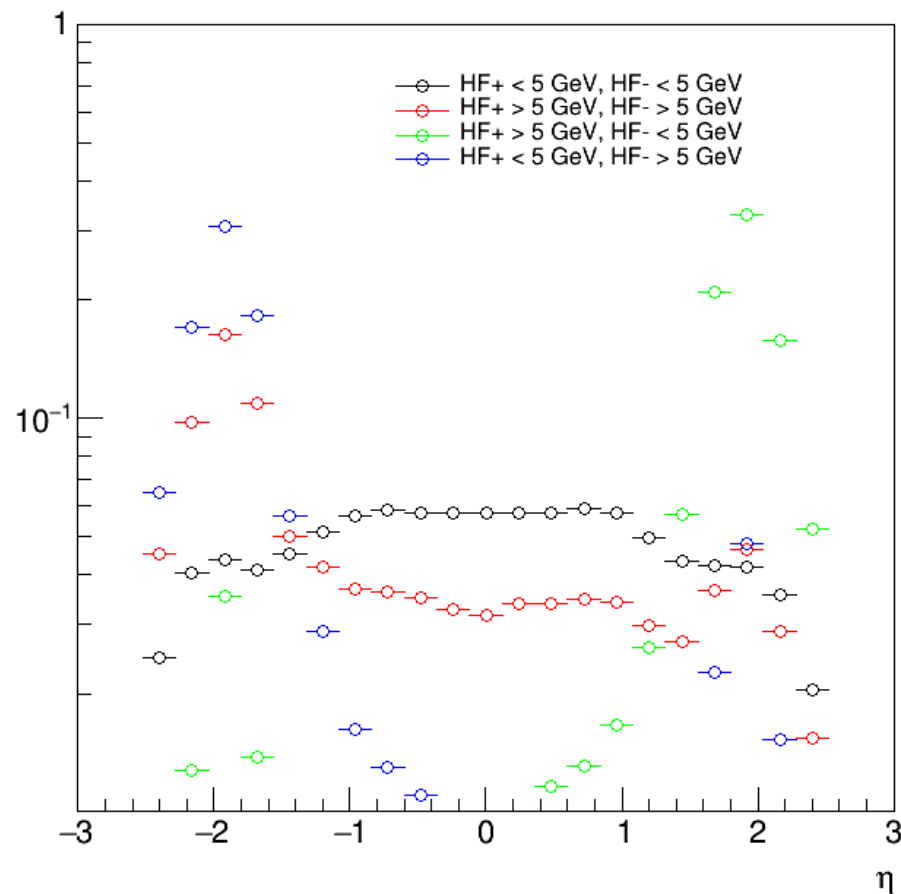


Plans of this week



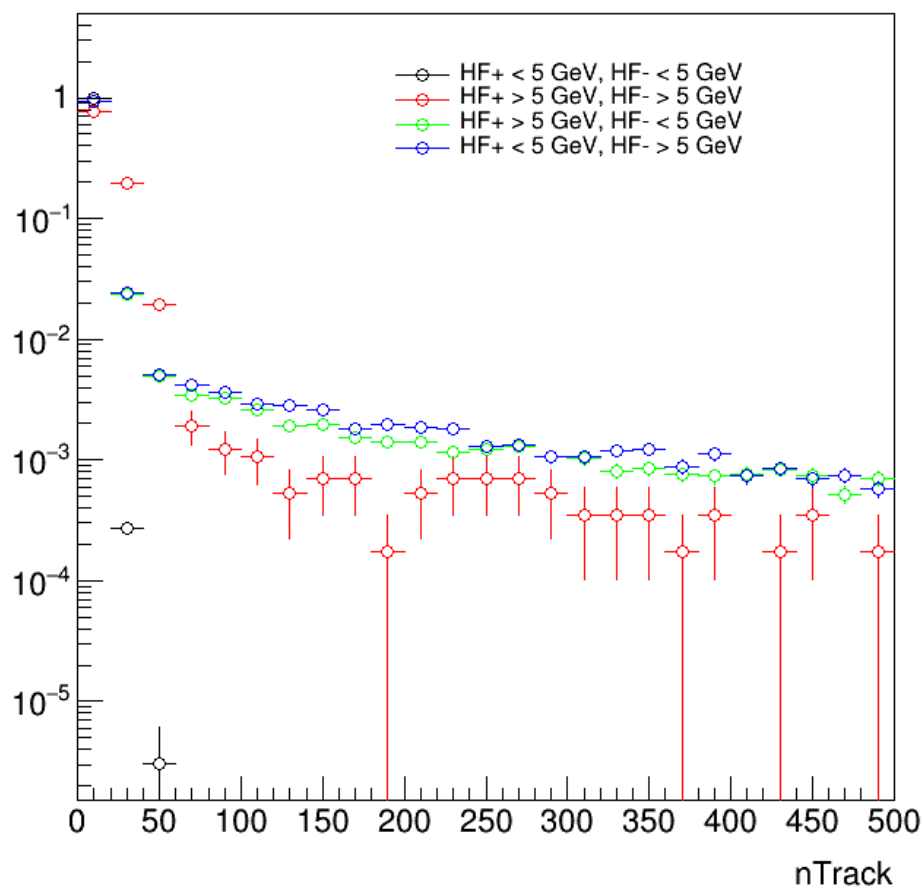
- Make new skim files which are more suitable for the analysis
- Check the distributions with the number of tracks

- "HF+ < 5 GeV & HF- > 5 GeV" and "HF+ > 5 GeV & HF- < 5 GeV" look have a good symmetric shapes.
- "HF+ < 5 GeV & HF- < 5 GeV" has a flat shape relatively.
- "HF+ > 5 GeV & HF- > 5 GeV" has a strange bump at $\eta_{track} \sim -2$



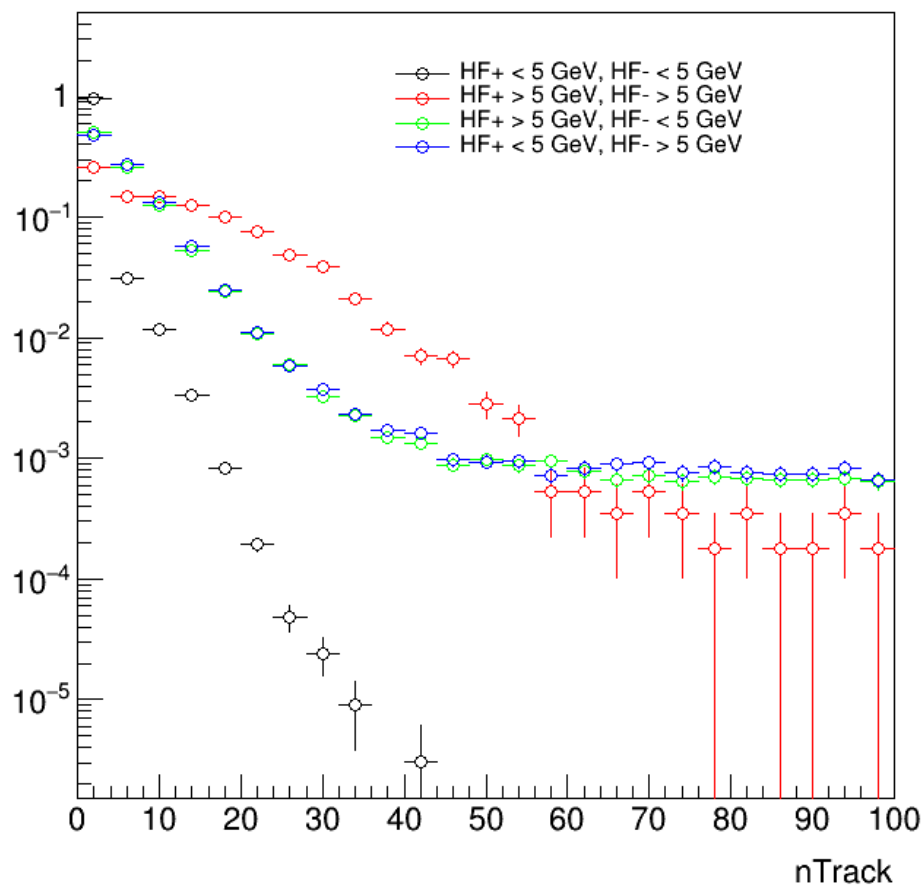
The Number of Tracks Distribution(0 to 500)

- "HF+ < 5 GeV & HF- > 5 GeV" and "HF+ > 5 GeV & HF- < 5 GeV" have similar shape like expected.



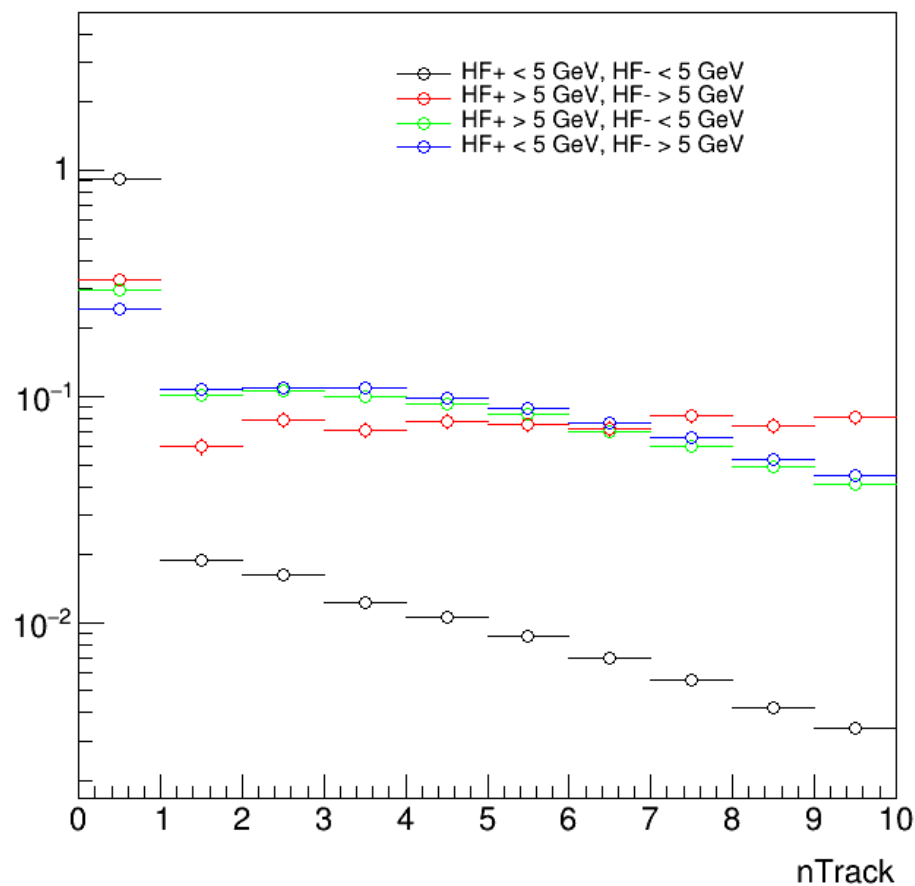
The Number of Tracks Distribution(0 to 100)

- For "HF+ < 5 GeV & HF- < 5 GeV", the number of tracks is under 45.

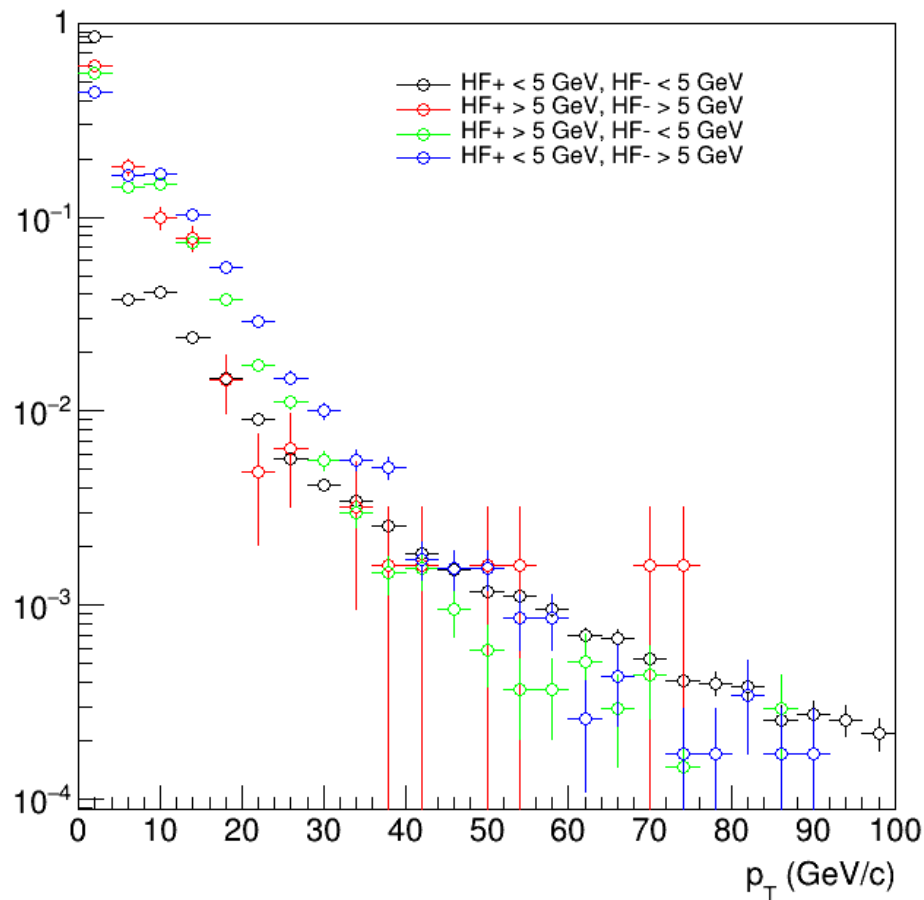


The Number of Tracks Distribution(0 to 10)

- Most of the events have 0 tracks, especially for "HF+ < 5 GeV & HF- < 5 GeV".

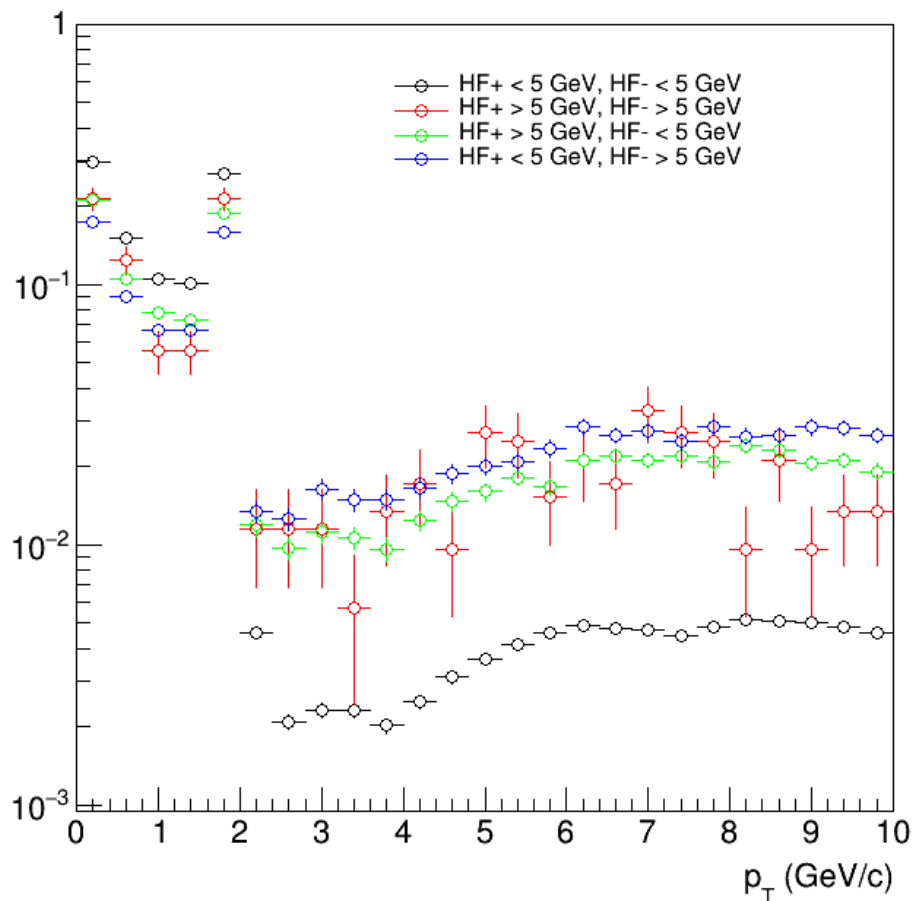


- $|\eta_{track,1}| < 1.5$ & $|\eta_{track,2}| < 1.5$
 - Only events which DO NOT have the tracks out of the mid-rapidity region are selected.
- $|\eta_{jet,1}| < 1.5$ & $|\eta_{jet,2}| < 1.5$
 - Only events which have two jets that are within the mid-rapidity region are selected.
- Most of events have a very low transverse momentum.

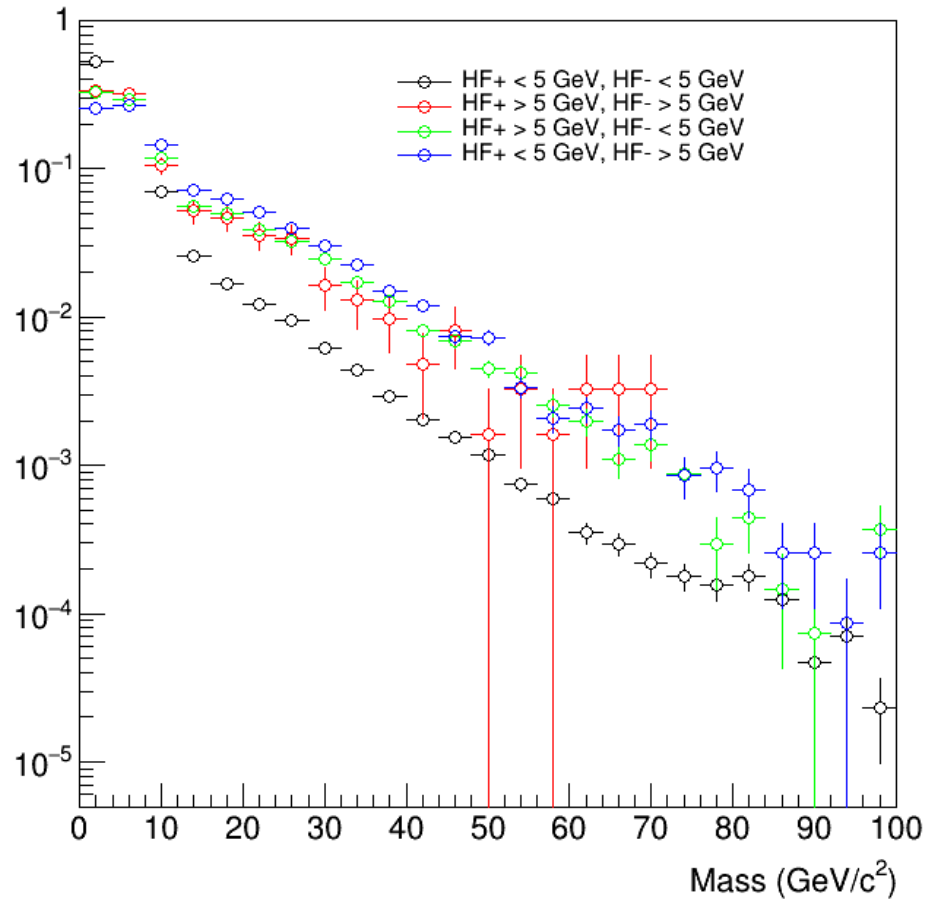


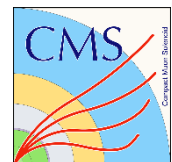
Di-jet p_T Distribution(0 GeV/c to 10 GeV/c)

- Most of events have $p_T < 2$ GeV/c
- Strange bump at about 1.5-2.0 GeV/c



- Most of events have Mass < 10 GeV/c

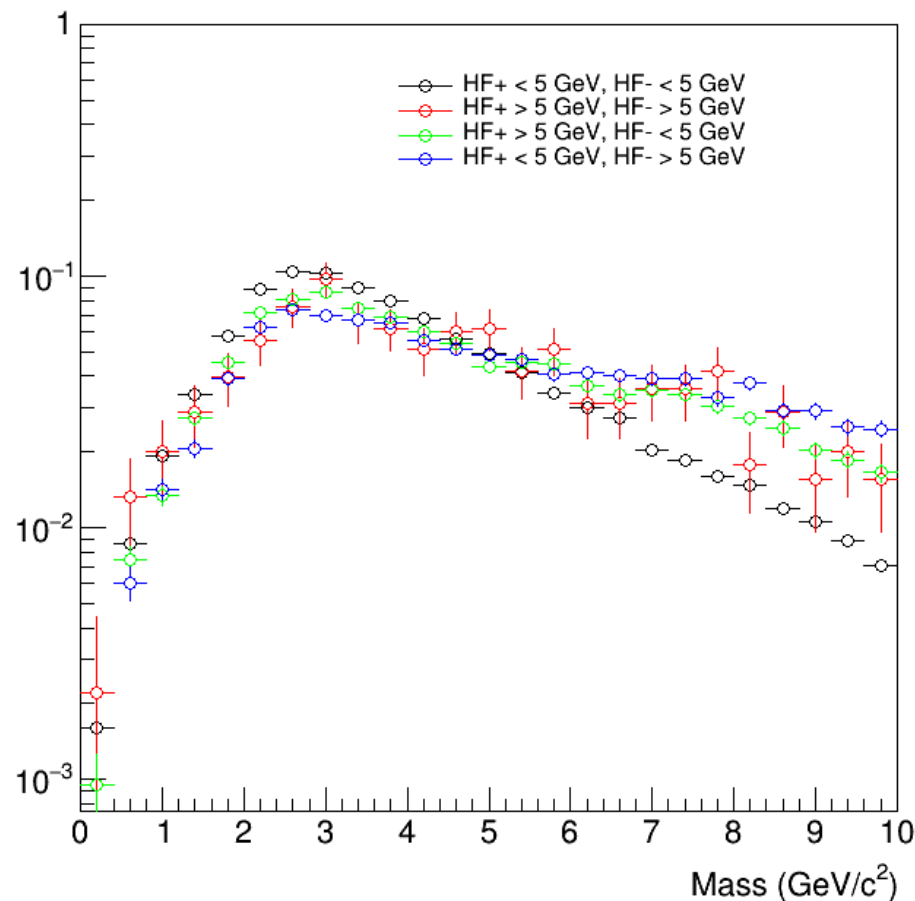




Di-jet Invariant Mass Distribution(0 to 10 GeV/c^2)

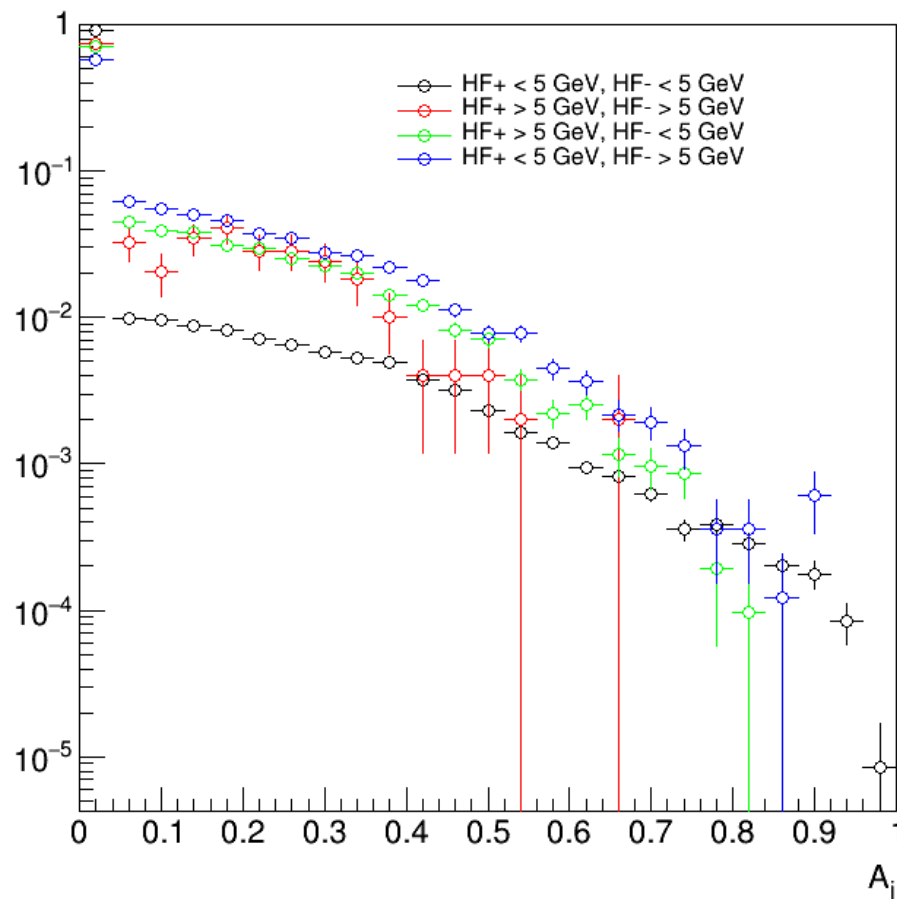


- There is a bump for every selections at about 3 GeV/c .



Di-jet Asymmetry Ratio Distribution

- Most of events have $A_j \sim 0$.
 - Most of events have same p_T .
 - It seems for most cases there is not jet quenching.



- Most of events are back-to-back ($\Delta\phi > 2$)

