Charged-particle jet trigger in Run 3

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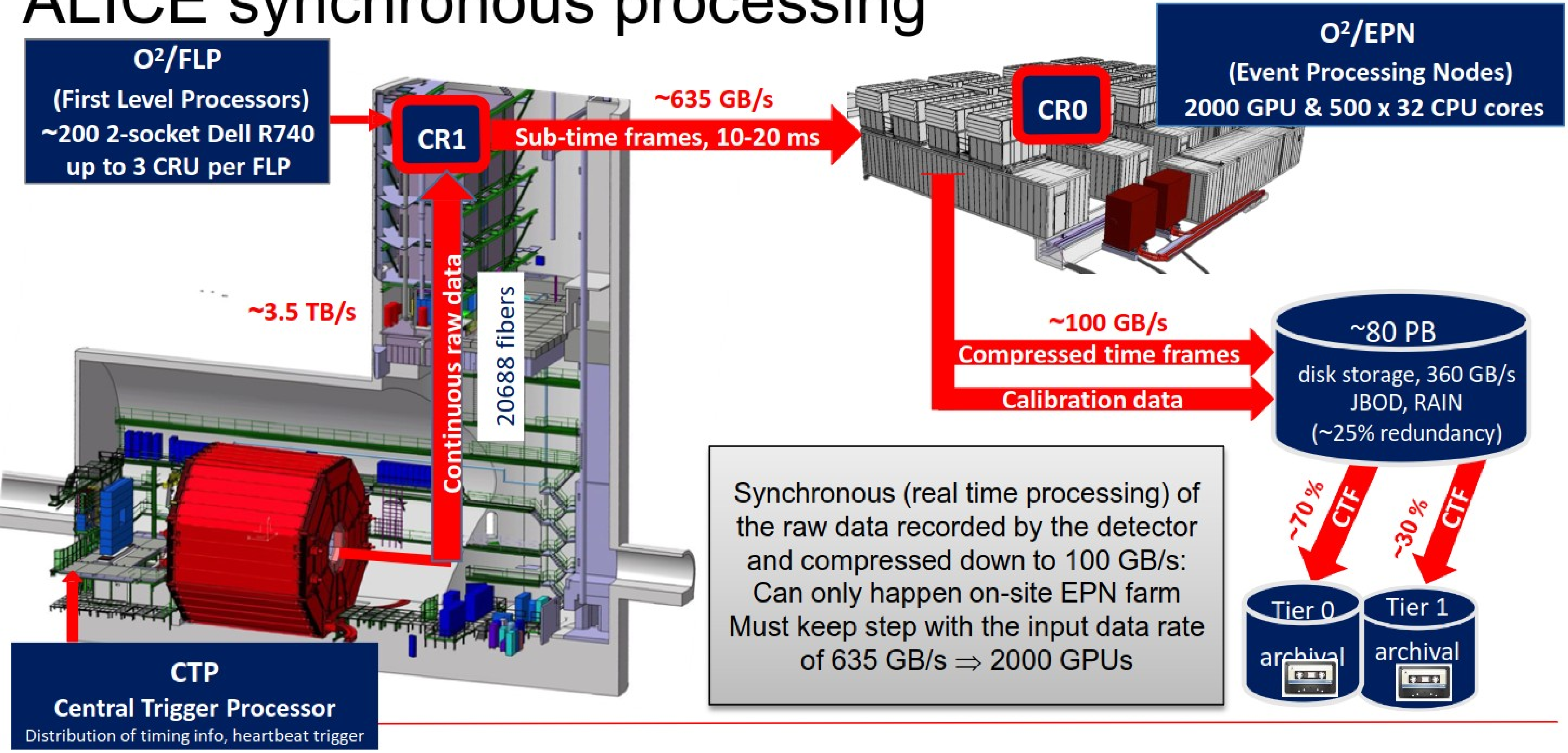
ÚJF AV ČR

3. Česko-slovenský ALICE workshop, Danišovce 2023

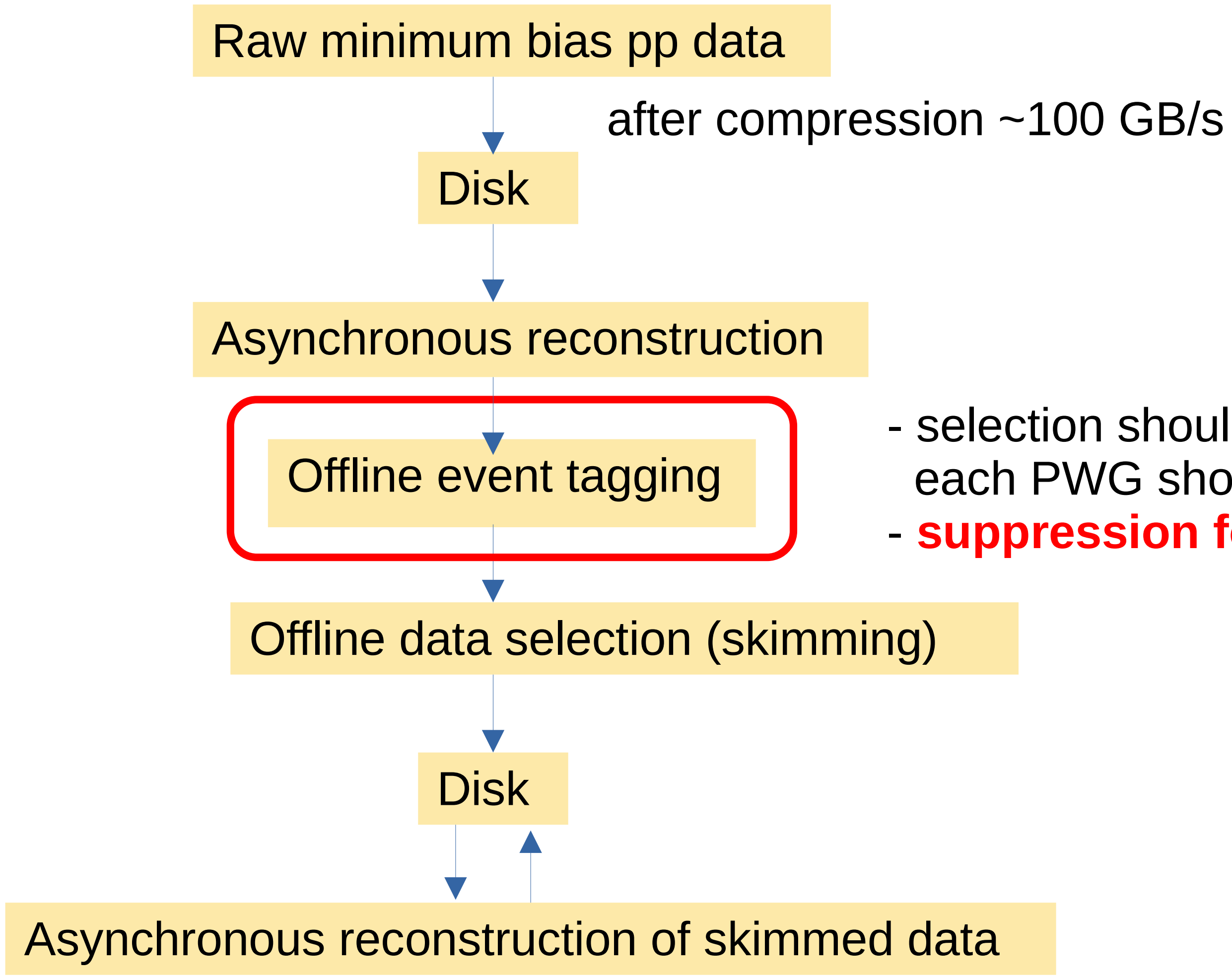
ALICE synchronous processing



Synchronous (real time processing) of the raw data recorded by the detector and compressed down to 100 GB/s:
Can only happen on-site EPN farm
Must keep step with the input data rate of 635 GB/s ⇒ 2000 GPUs

courtesy S. Piano

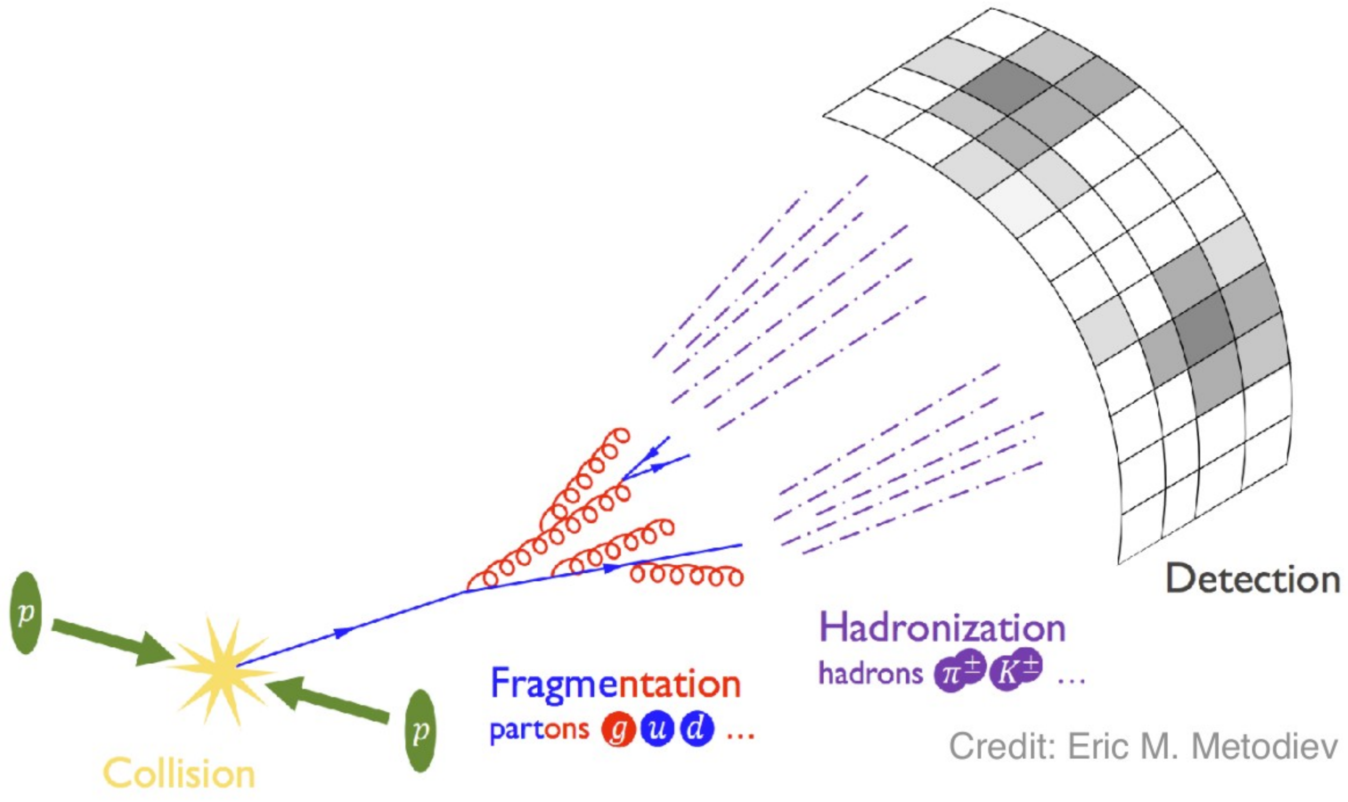
ALICE data selection strategy in Run 3



- selection should provide suppression 10^{-3} ⇒ each PWG should suppress by 10^{-4}
- **suppression for charge-jet triggers $2.5 \cdot 10^{-5}$**

Offline event tagging/skimming concerns just pp 13.6 TeV

$\mathrm{Jets} \equiv$ bunch of collimated particles $\approx$ hard partons



anti-k_T algorithm

1) For all particles *i*, *j* evaluate

$$d_{ij} = \min(p_{T,i}^{-2}, p_{T,j}^{-2}) \frac{\Delta_{ij}^2}{R^2}$$ and $$d_{iB} = p_{T,i}^{-2}$$

R ≈ cone radius

2) Find minimal d_{ij} , d_{iB}

3) If d_{ij} is the minimum ⟶ merge *i* + *j* and go to 1)

4) d_{iB} is the minimum ⟶ remove *i* from the list (final jet) and go to 1)

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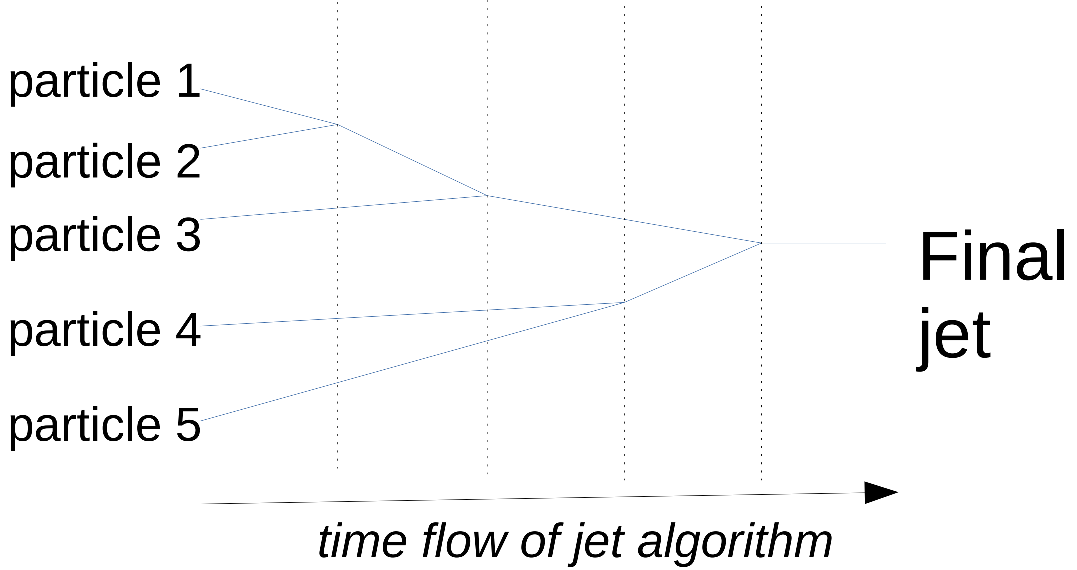
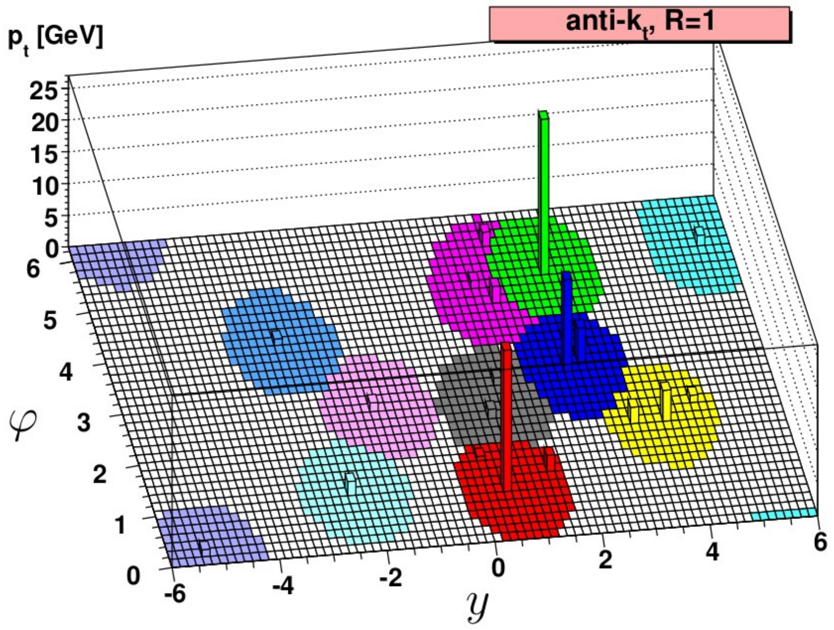




Considerations about the charged jet trigger

Observables:

- Inclusive jets (AKT jets $R = 0.4$ $|\eta_{jet}| < 0.5$, $R = 0.2$ $|\eta_{jet}| < 0.7$)
- jet substructure
- b jets, ...

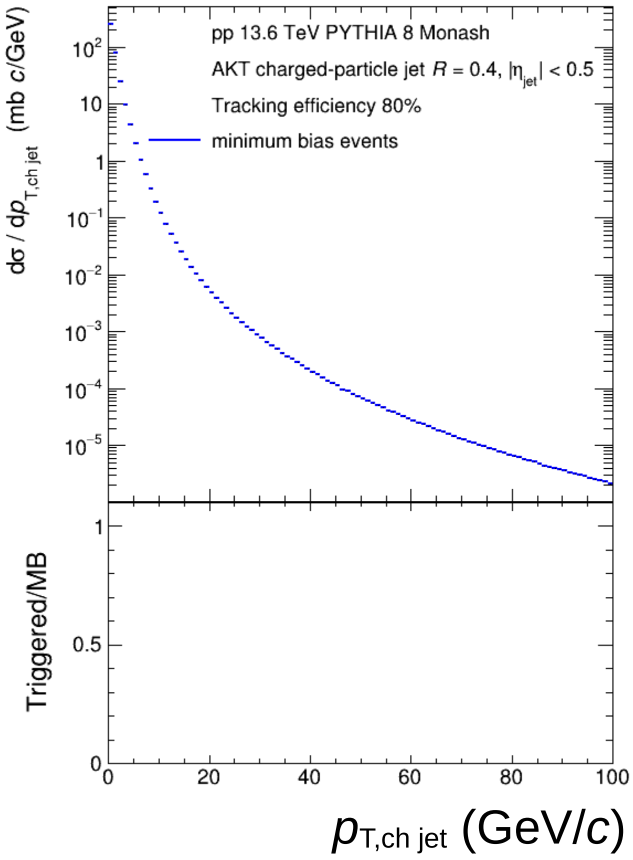
- Having a separate trigger for each of them does not seem optimal

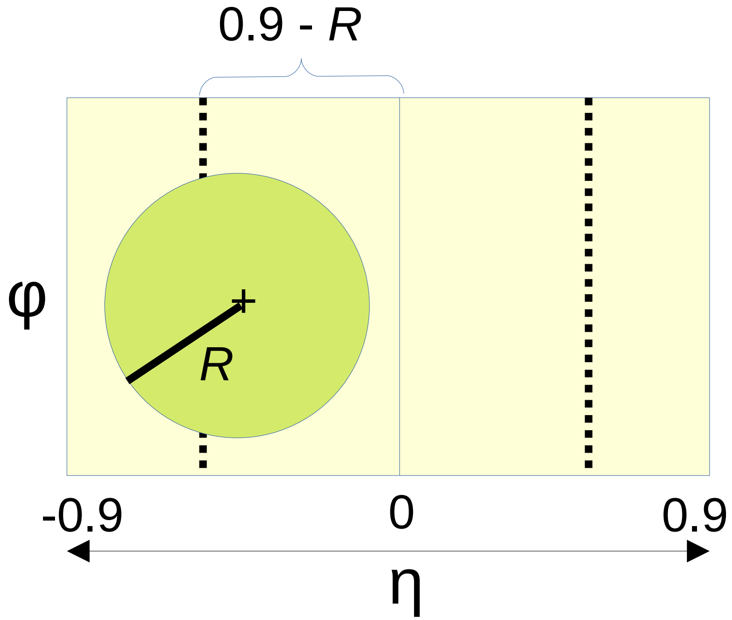
- Trigger on inclusive jets with $p_{T,jet}$ > threshold

- Use PYTHIA to test how different trigger designs affect spectra of jets

Example: Performance of the trigger
AKT jets R=0.4, $|\eta_{jet}|$ < 0.5 & $p_{T,jet}$> 30 GeV threshold

AKT jets R=0.4, $|\eta_{jet}|$ < 0.5





Example: Performance of the trigger
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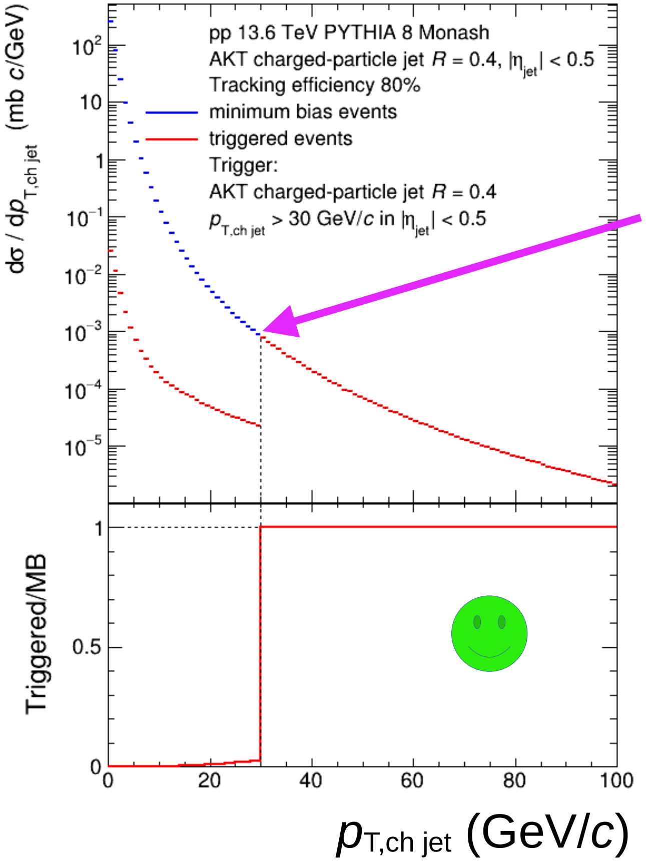
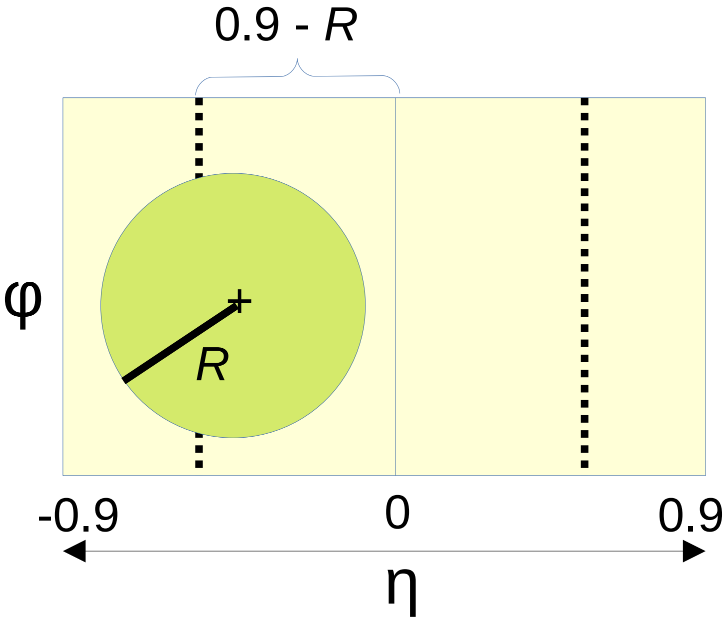


Trigger provides sharp turn on for AKT R = 0.4 jets



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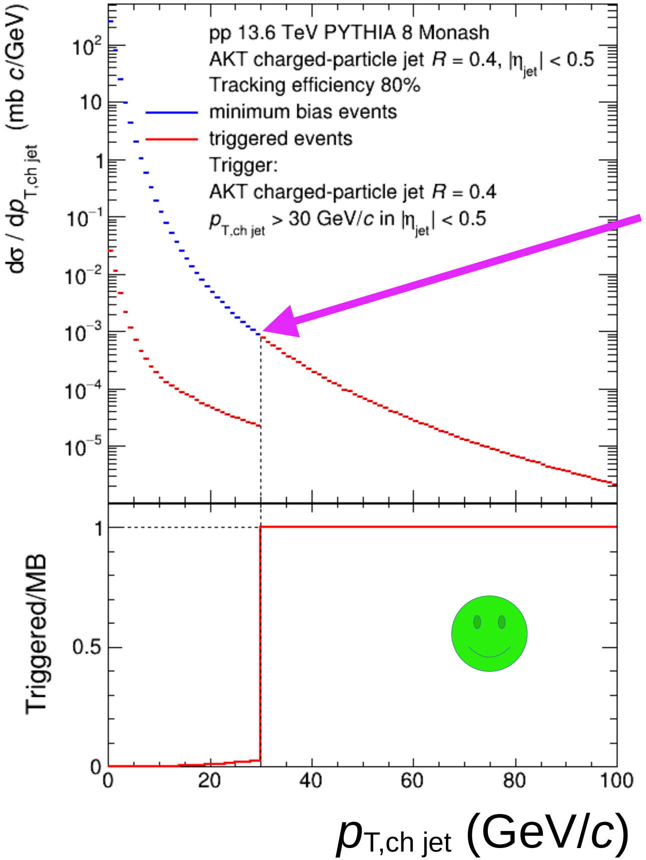
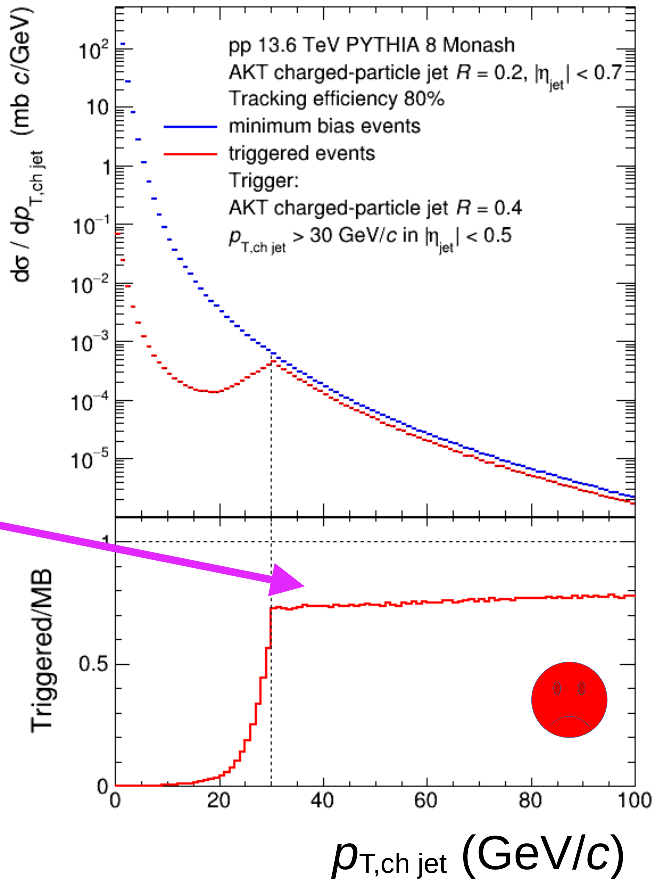
AKT jets R=0.4, $|\eta_{jet}| < 0.5$



Trigger provides sharp turn on for AKT R = 0.4 jets

AKT jets R=0.2, $|\eta_{jet}| < 0.7$



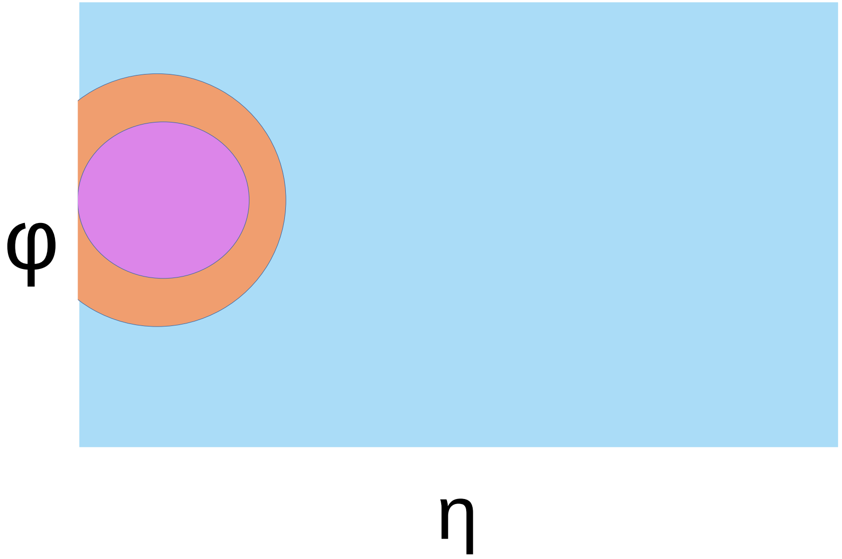
But is not fully efficient for AKT R = 0.2 jets in $|\eta_{jet}| < 0.7$ above threshold

Further thoughts about the charged jet trigger

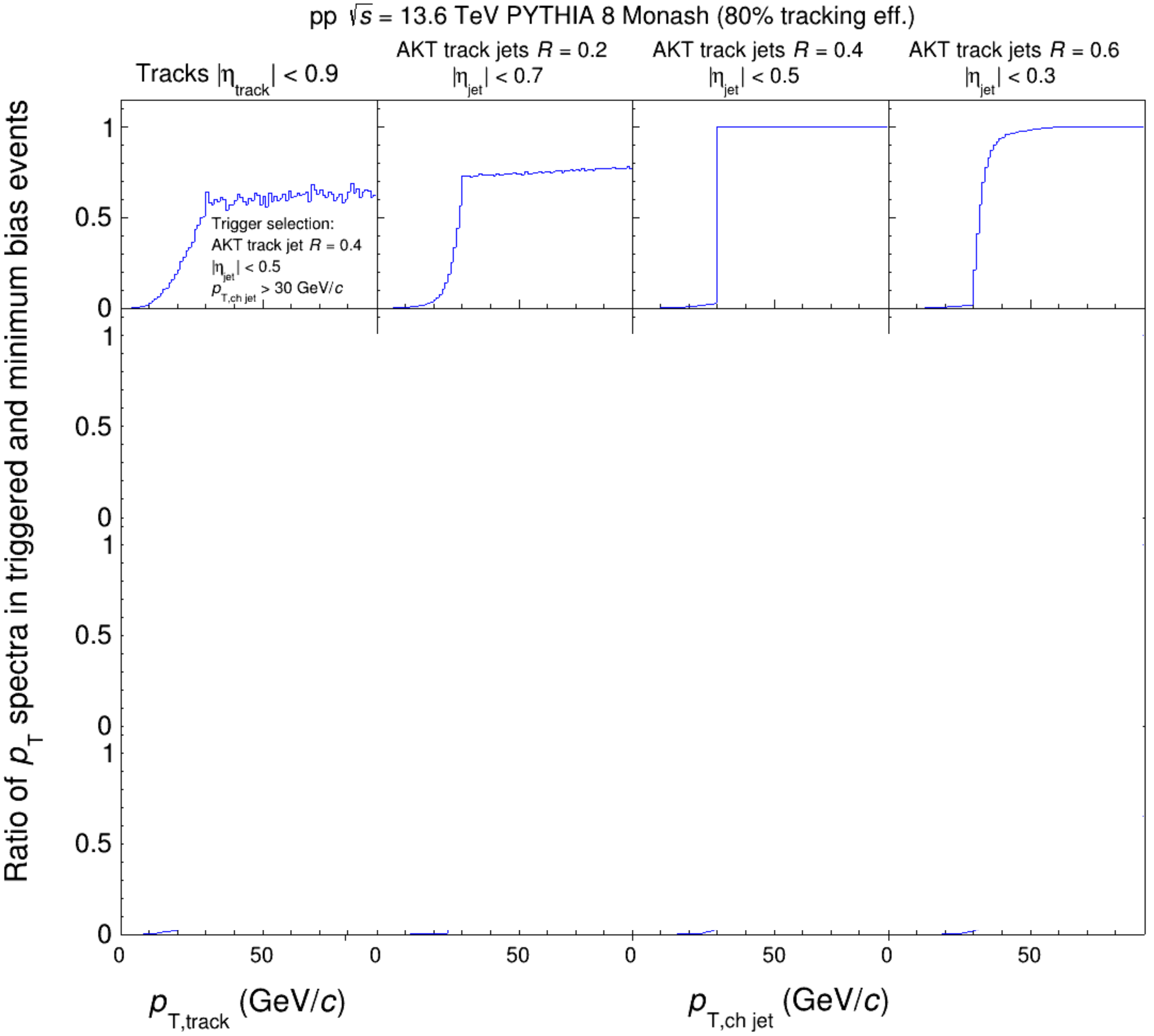
We want selection which provides unbiased jet sample for wide range of jet *R*

- *Large R jets contain small R jets in their core* ⇒
  Offline selection should decide based on large jet *R*

- *Small jets can be closer to acceptance boarder than large R jets* ⇒
  Application of the usual fiducial cut on jet should be avoided



Impact of different trigger conditions on spectra of tracks and jets



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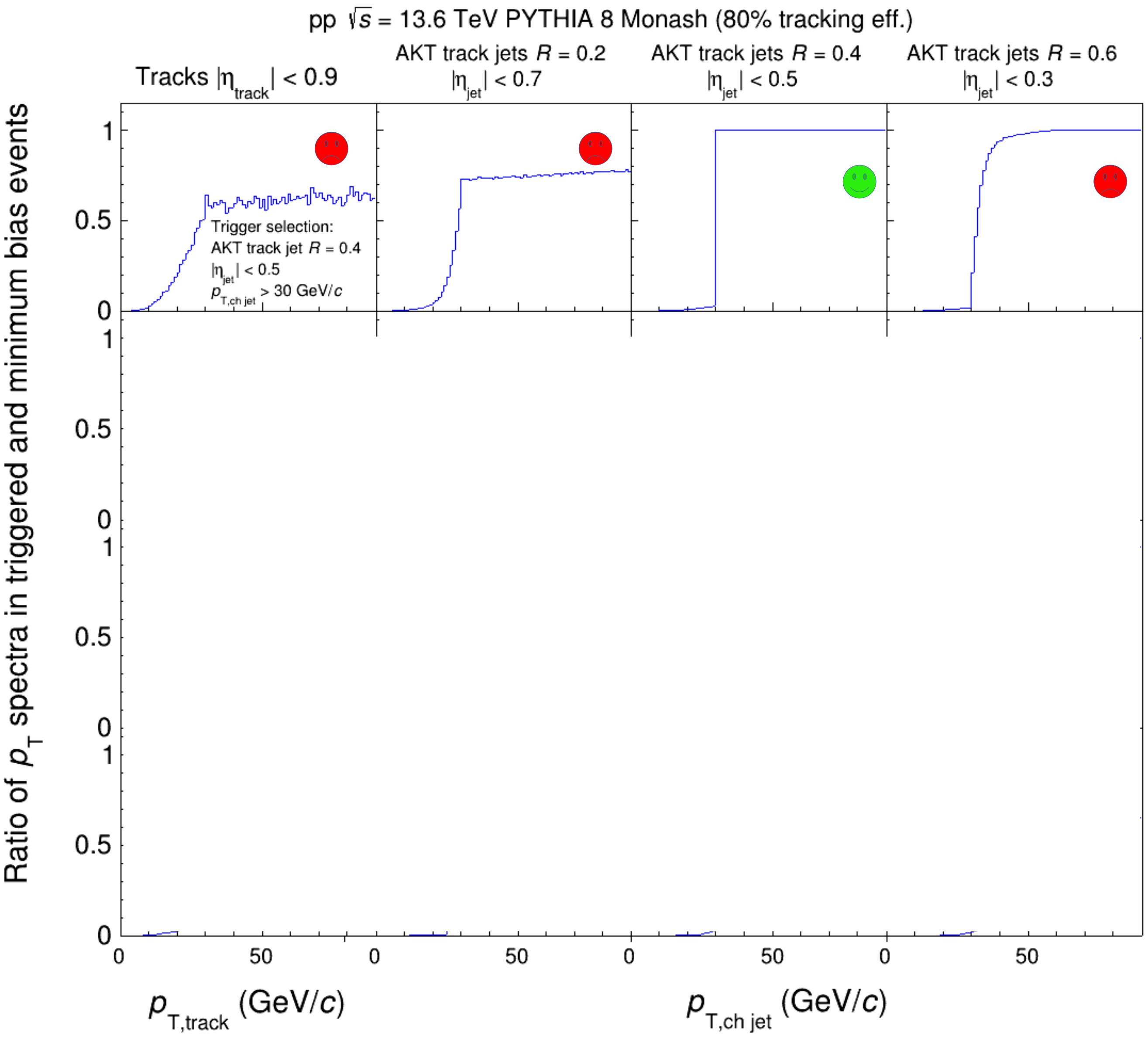

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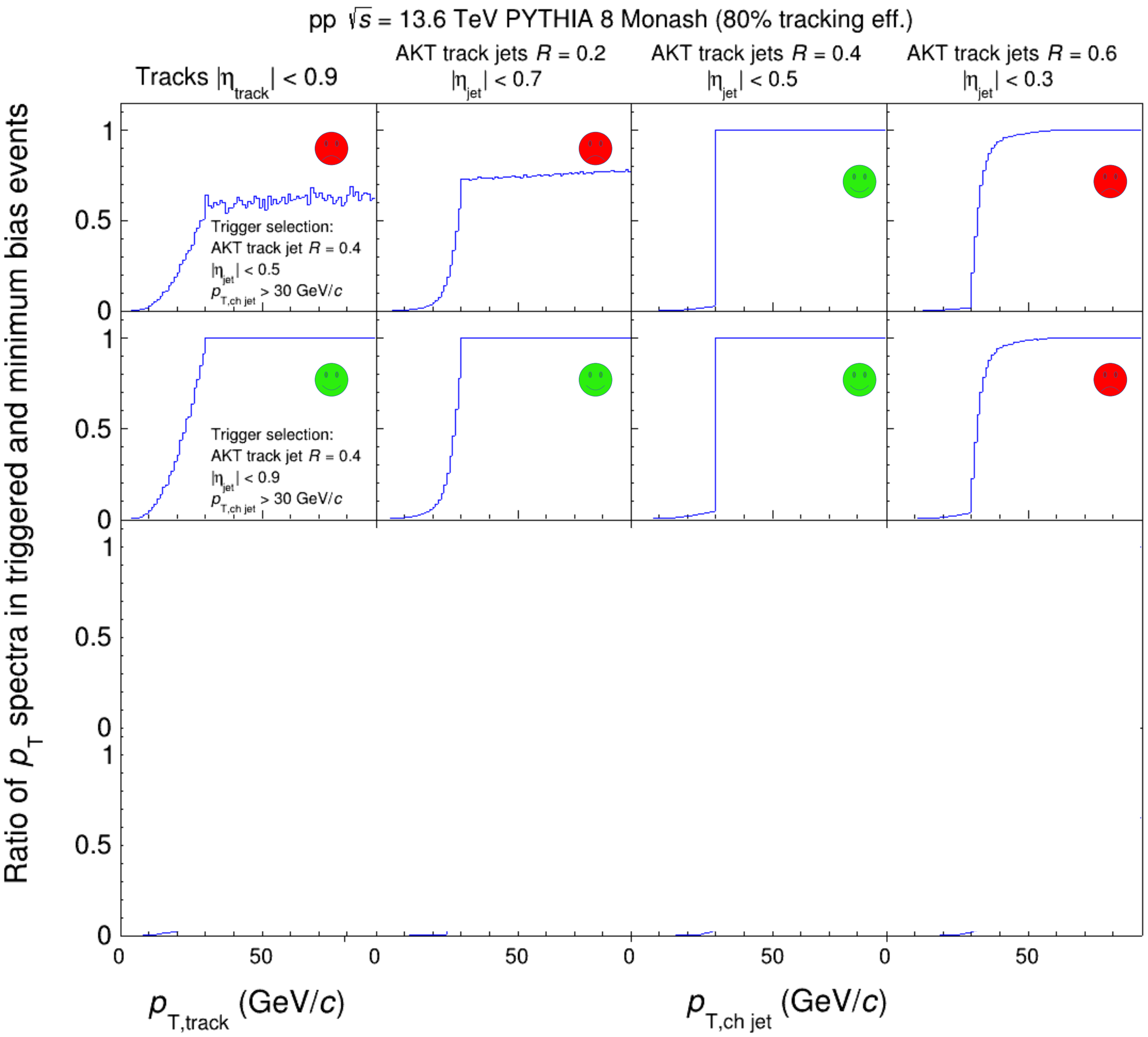

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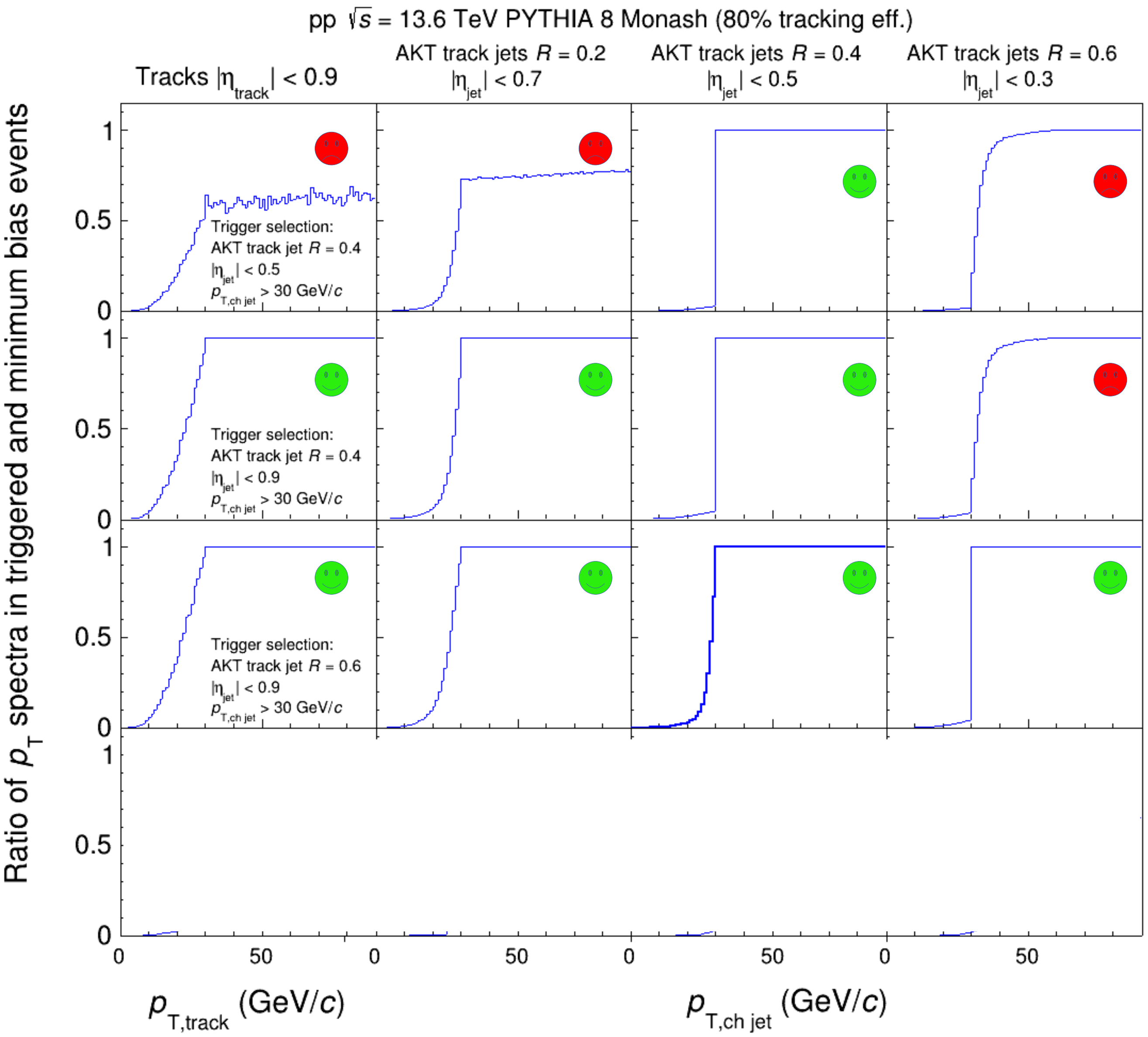
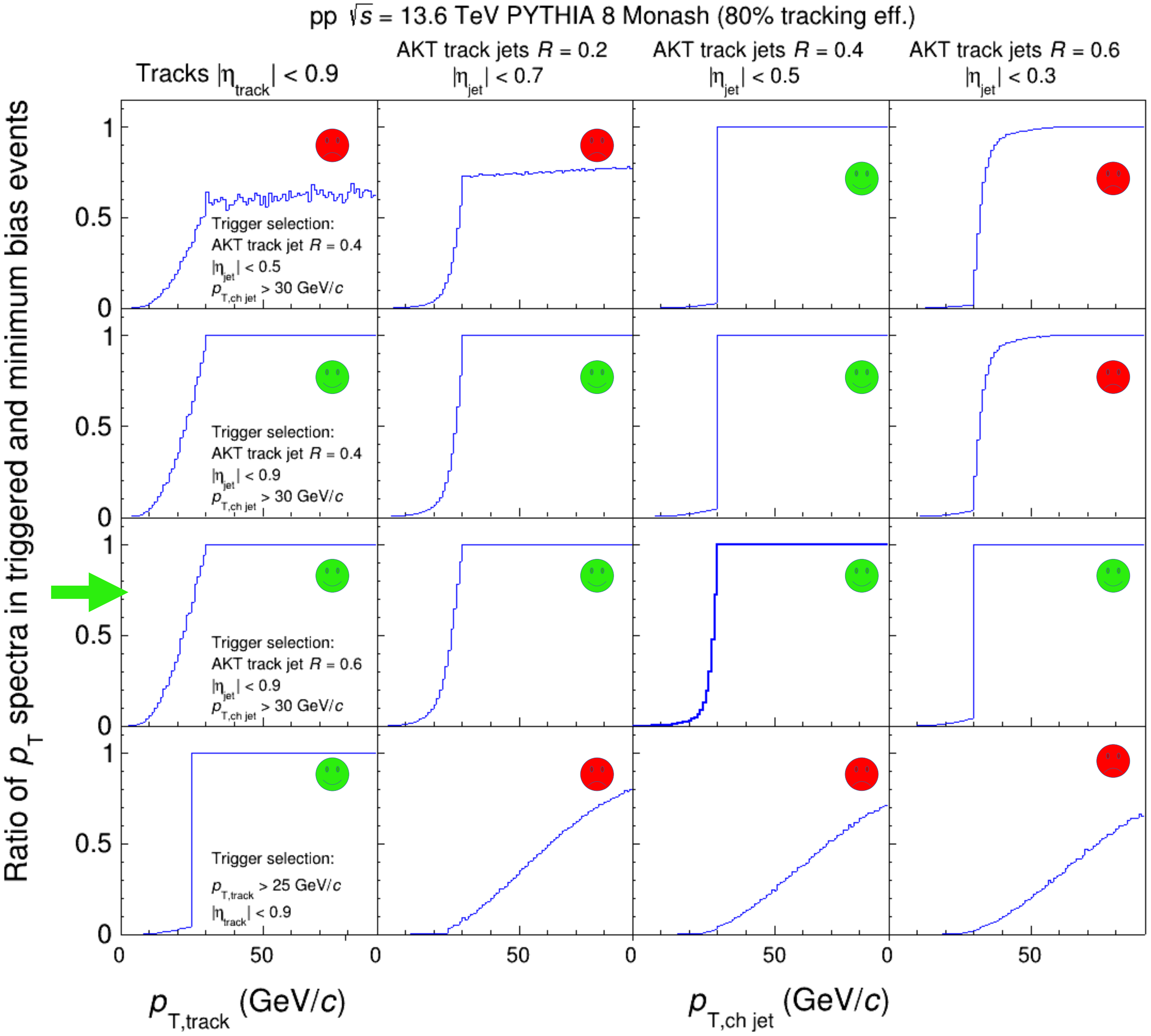
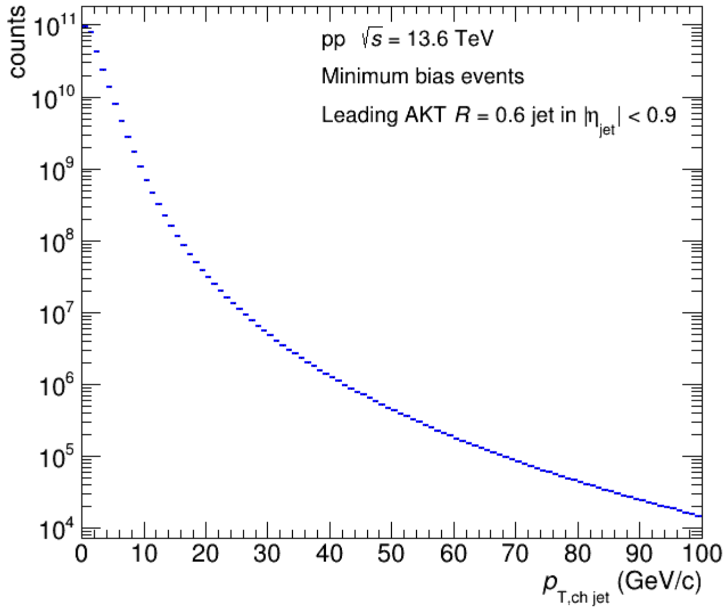


Impact of different trigger conditions on spectra of tracks and jets

Preferably trigger on:
AKT R = 0.6 jet
$|\eta_{jet}| < 0.9$
$p_{T,ch\ jet}$ > threshold



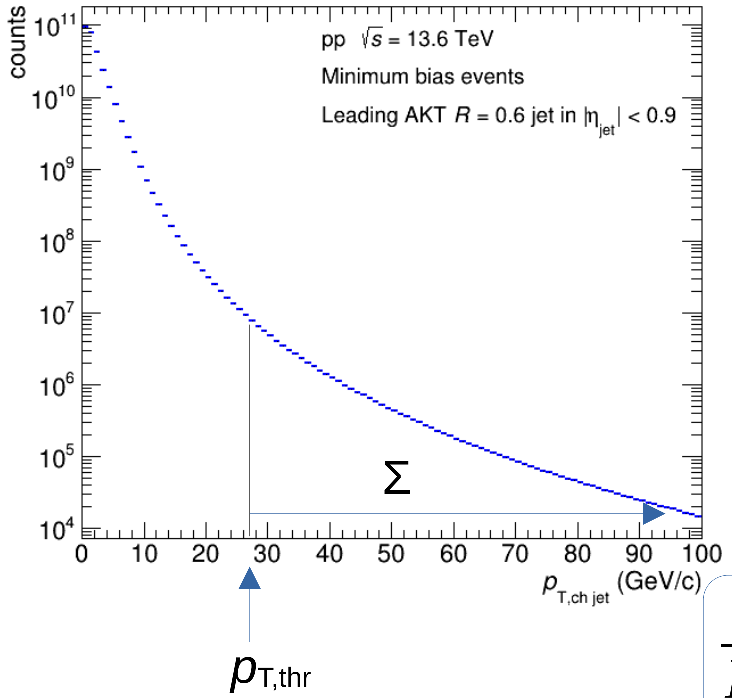
Selection of threshold



p_T spectrum of leading AKT R = 0.6 jets in $|\eta_{jet}|$ < 0.9

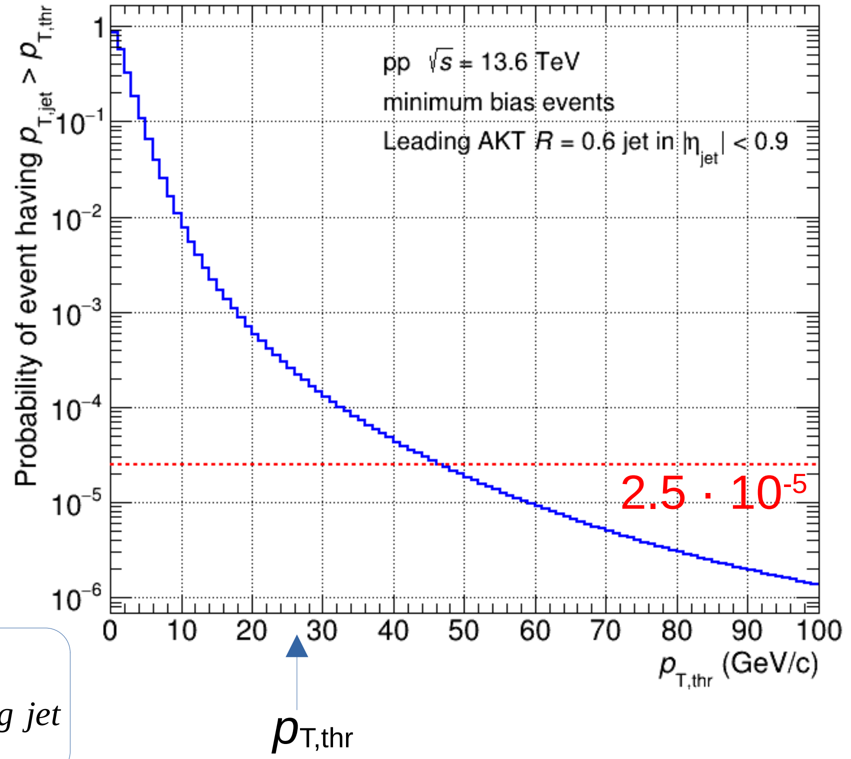
⇒ one entry in histogram per event

Selection of threshold

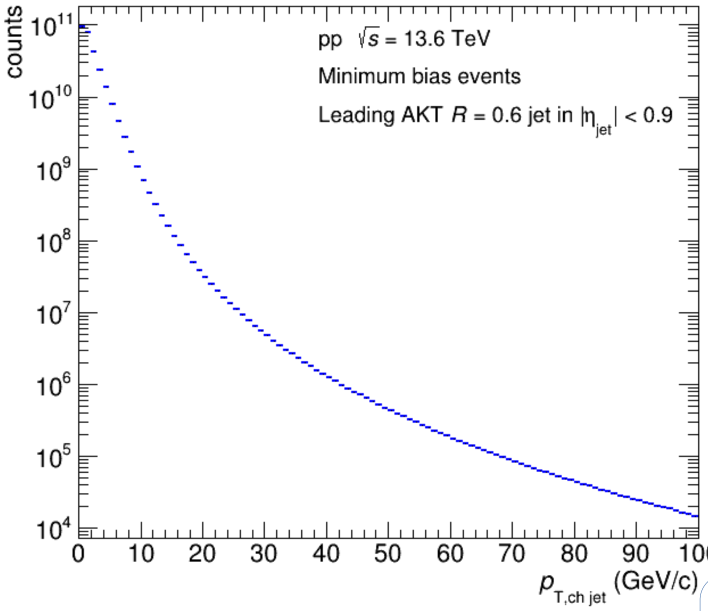


Convert the measured spectrum of leading AKT R = 0.6 jets to cummulative distribution

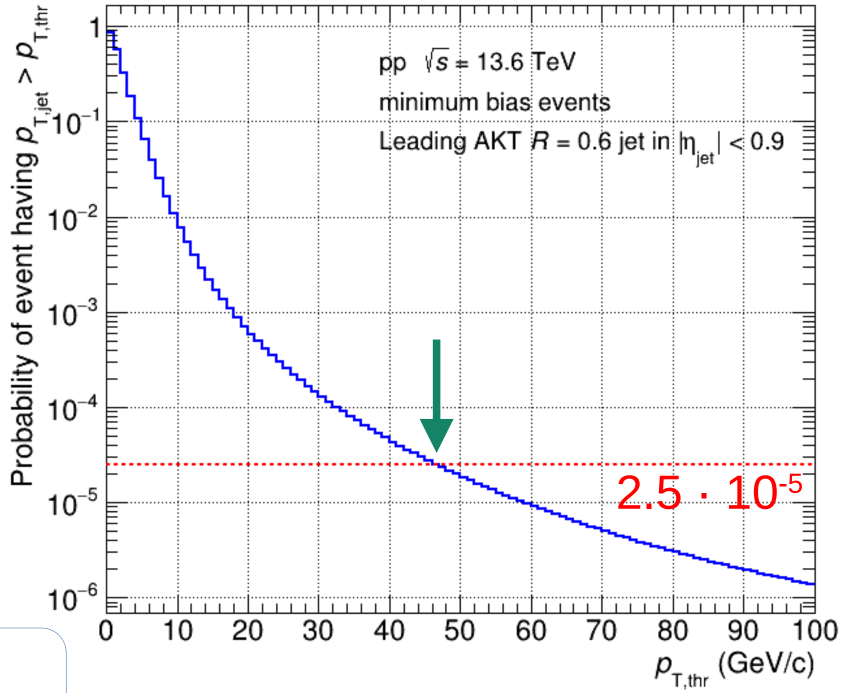
$$\frac{1}{N_{events}} \sum_{p_{T,ch\,jet} \geq p_{T,thr}}^{\infty} n_{leading\ jet}$$



Selection of threshold



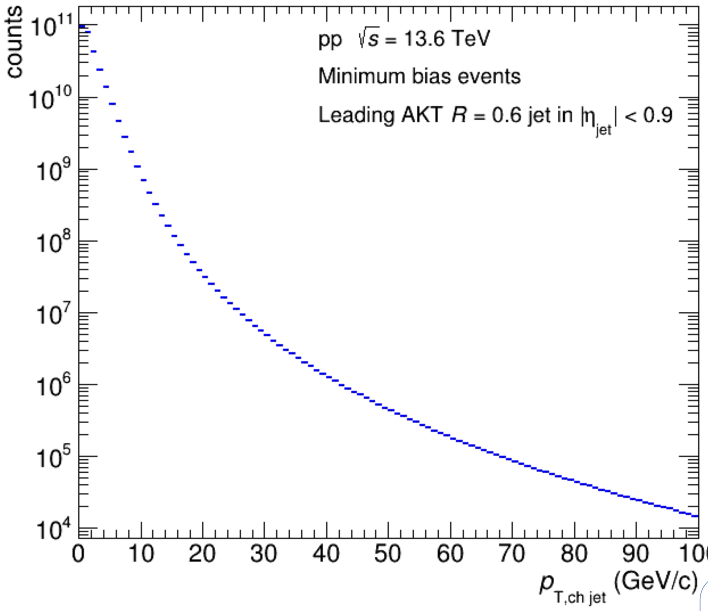
Convert the measured spectrum of leading AKT R = 0.6 jets to cummulative distribution



$$\frac{1}{N_{events}} \sum_{p_{T,ch\ jet} \geq p_{T,thr}}^{\infty} n_{leading\ jet}$$

- Selection of events with the jet $p_{\mathrm{T,ch\ jet}}$ > 47 GeV provides desired suppressesion ($2.5 \cdot 10^{-5}$)

Selection of threshold



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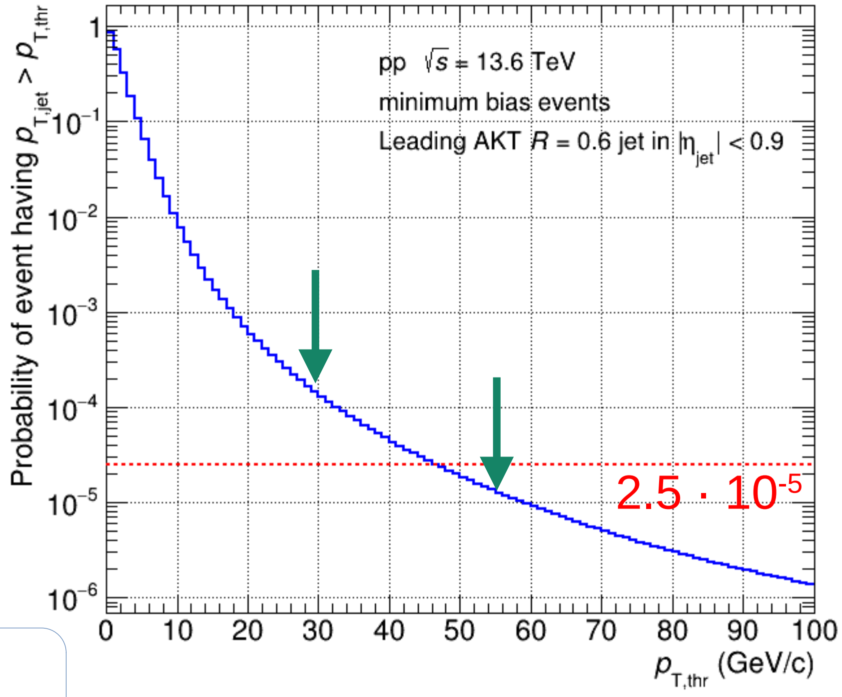


- Selection of events with the jet $p_{T,ch\ jet}$ > 47 GeV provides desired suppressesion ($2.5 \cdot 10^{-5}$)
- Two threshold scenario low p_T threshold ~ 30 GeV downscaled
  high p_T threshold ~ 55 GeV not downscaled

Downscaling of low trigger threshold

$$\frac{P_L}{D_L} + \frac{P_H}{D_H} = 2.5 \cdot 10^{-5}$$

$$D_L = \frac{P_L}{2.5 \cdot 10^{-5} - \frac{P_H}{D_H}}$$

P_L probability of event with AKT R = 0.6 jet above 30 GeV

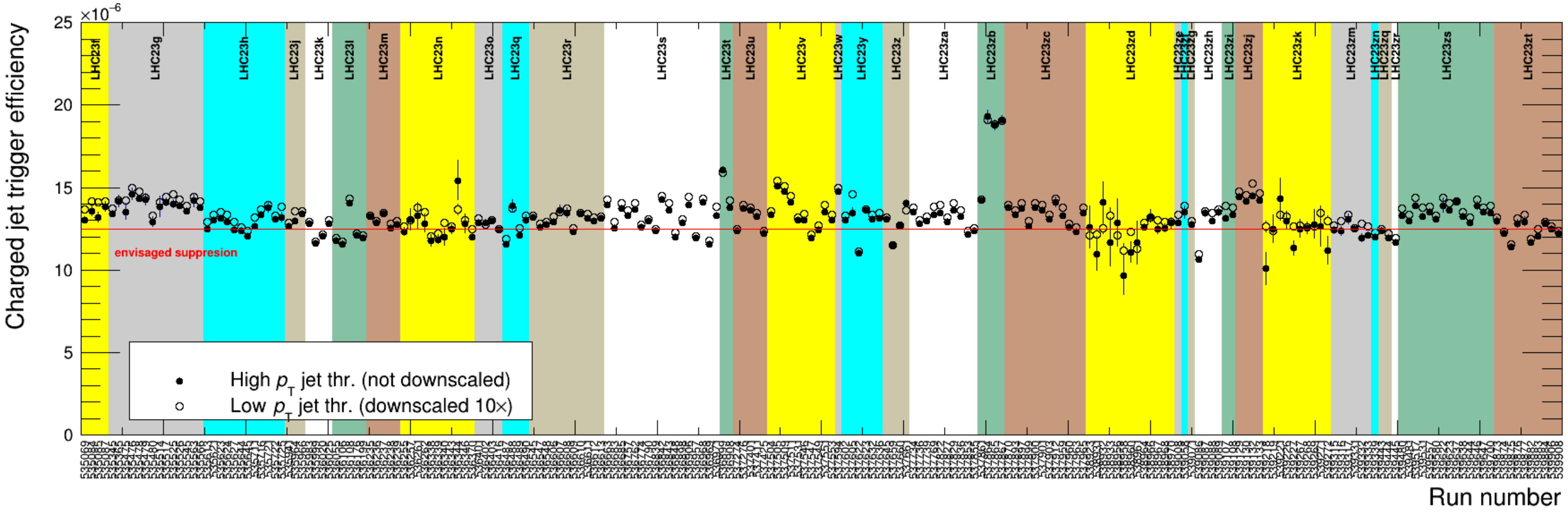
P_H probability of event with AKT R = 0.6 jet above 55 GeV

D_L, D_H corresponding downscaling factors

Trigger scenario for charged-particle jets in 2023

ch jet trhresh.	Probability	Downscaling
30 GeV	$1.28 \cdot 10^{-4}$	10
55 GeV	$1.26 \cdot 10^{-5}$	1

Performace for 2023



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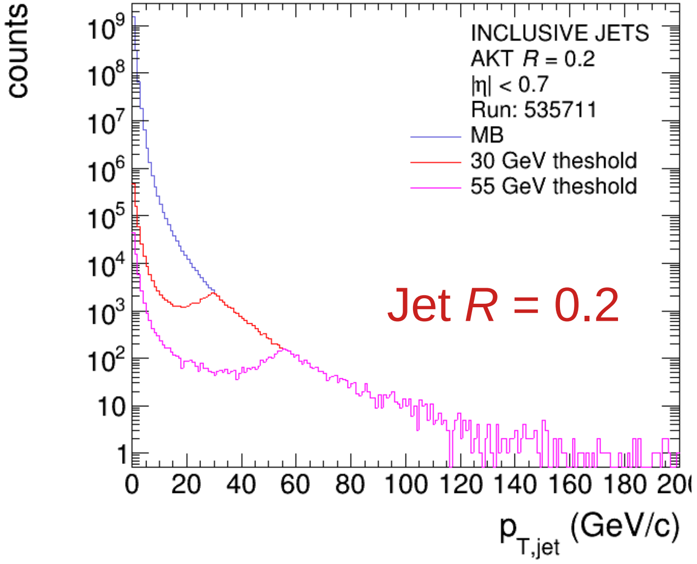
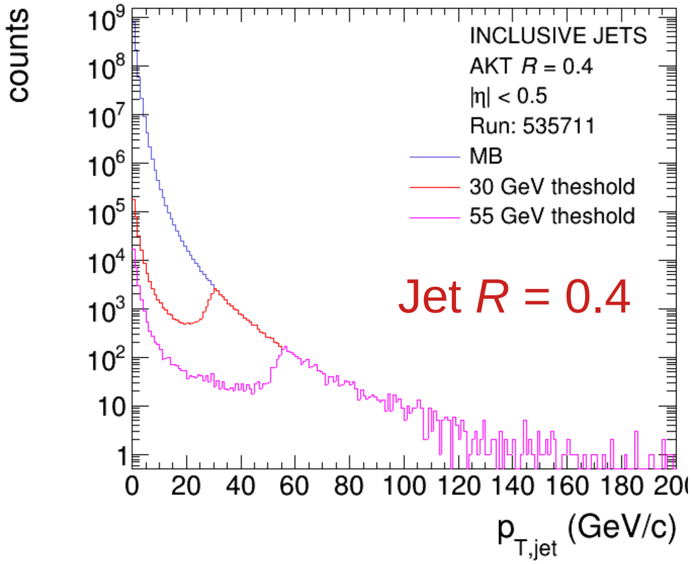
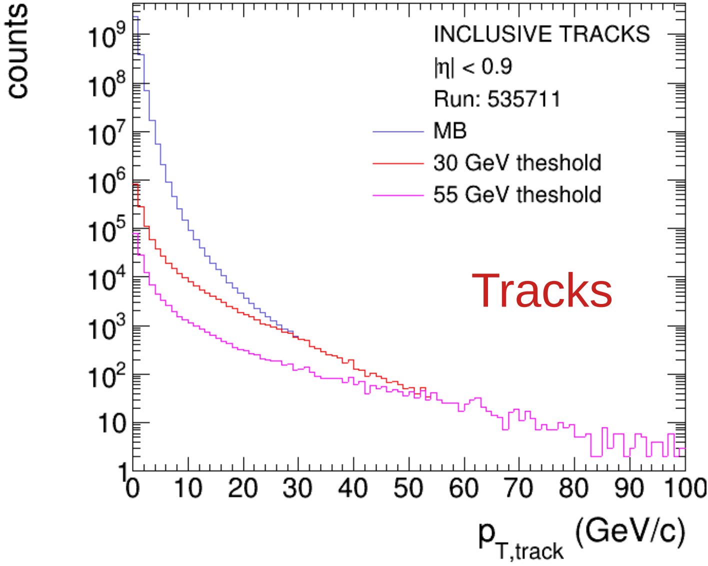
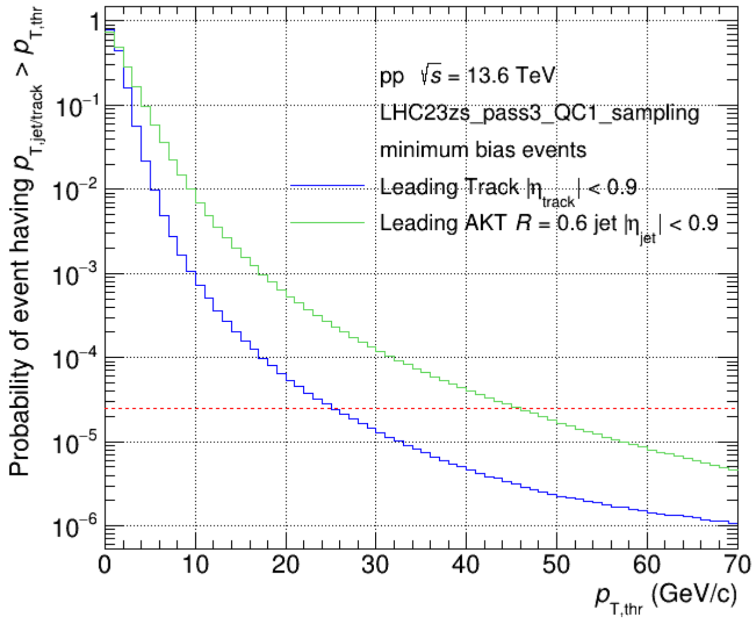






Spectra selected with the low p_T threshold will be downscaled by factor of 10 after the skimming

Trigger scenario for 2024



trigger	Probability of such event	Downscaling
leading jet p_T > 30 GeV	$1.28 \cdot 10^{-4}$	10
leading jet p_T > 55 GeV	$1.26 \cdot 10^{-5}$	not downscaled
leading track p_T > 25 GeV	2.41e-5	5
leading track p_T > 35 GeV	7.34e-6	not downscaled
minimum bias		333

Suppr. 2.5e-5

Suppr. 1.2e-5

Factor that convertes statistics of LHC23zs_pass3_QC1_sampling dataset to 2024 projection

$(L_{2024}/L_{2023})*(N_{2023}/N_{zs})$

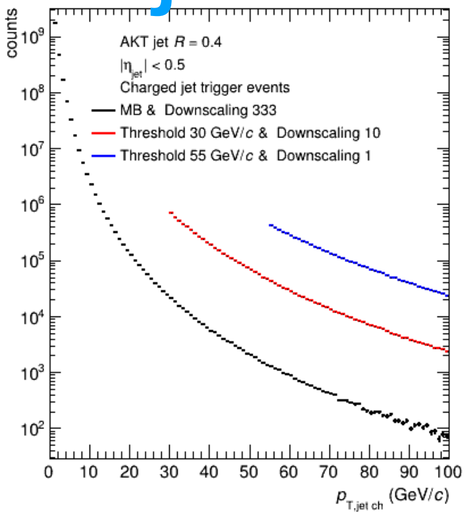
$N_{2023} = 3.14 \cdot 10^{11}$ number of events in 2023

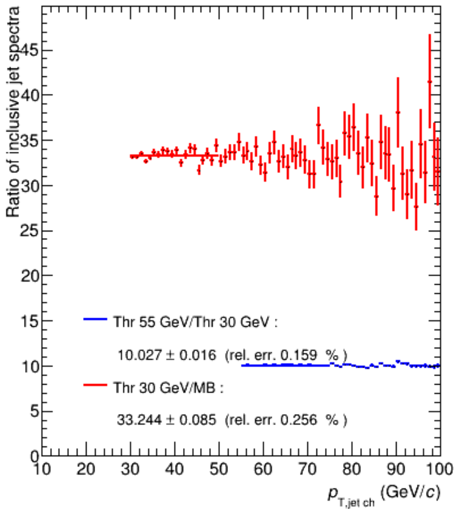
N_{zs} number of events in LHC23zs_pass3_QC1_samplig

L_{2023} = 9.7 pb^{-1} luminosity from 2023

L_{2024} = 30 pb^{-1} expected lumi for 2024

Projections for 2024





inclusive AKT R = 0.4 charged jets $|\eta_{jet}| < 0.5$:

Trigger \ p_T bin	15-20 GeV	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65
MB	1.3 M	423 k	170 k	79.8 k	40.6 k	22.5 k	13.6 k	8305	5373	3616
jet > 30 GeV				2.6 M	1.3 M	755 k	447 k	277 k	178 k	119 k
jet > 55 GeV									1.79 M	1.19 M

inclusive tracks $|\eta_{track}| < 0.9$:

Trigger \ p_T bin	15-20 GeV	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65
MB	315 k	89.3 k	33.4 k	15.9 k	8321	4160	2593	1246	1005	462
track >25 GeV			2.23 M	1.06 M	554 k	277 k	172 k	83 k	67 k	30.7 k
track >35 GeV					2.77 M	1.38 M	863 k	415 k	334 k	153 k

Concluding remarks

- Code location:

  O2Physics/EventFiltering/filterTables.h

  O2Physics/EventFiltering/PWGJE/jetFilter.cxx

- High p_T reconstruction ⇒ later improvements in p_T resolution will smear threshold