Pileup jet suppression in ATLAS

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Pileup jet suppression in ATLAS

- **Pileup is one of the main challenges for jets** (and missing ET) at the LHC

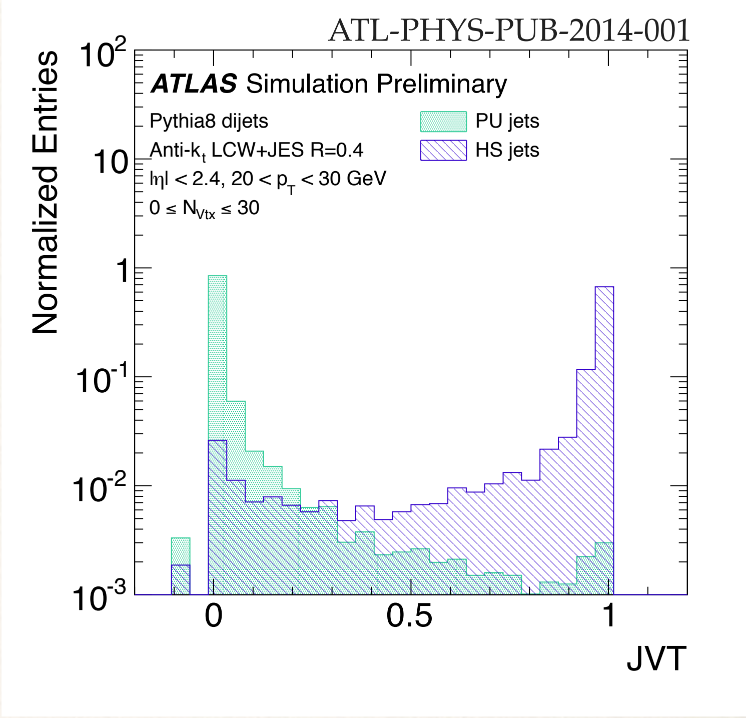
- Pileup adds additional energy (offset) and degrades the jet energy resolution

- Pileup has a large effect on jet shapes and jet mass

- Pileup can give rise to **pileup jets**

- ATLAS-CONF-2013-085: Pile-up subtraction for jet shapes
- ATLAS-CONF-2013-083: Pile-up subtraction and suppression for jets
- ATLAS-CONF-2012-066: Impact and mitigation of pile-up on large-R and groomed jets
- Approved plots: Exhaustive studies of pileup effects in jetETmiss up to <μ>=200

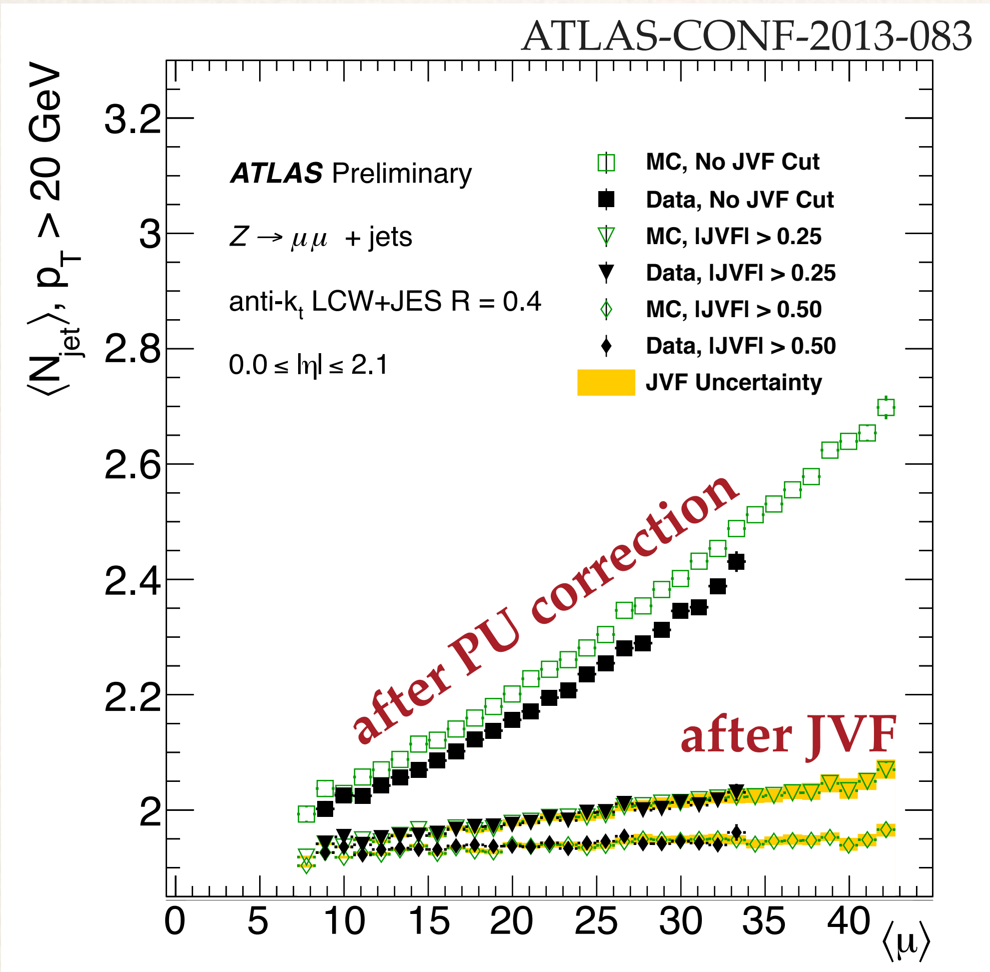
- Today's new results: ATL-PHYS-PUB-2014-001
  - Track-based pileup jet suppression
  - Track-assisted grooming of large-R jets



Track-based pileup jet suppression

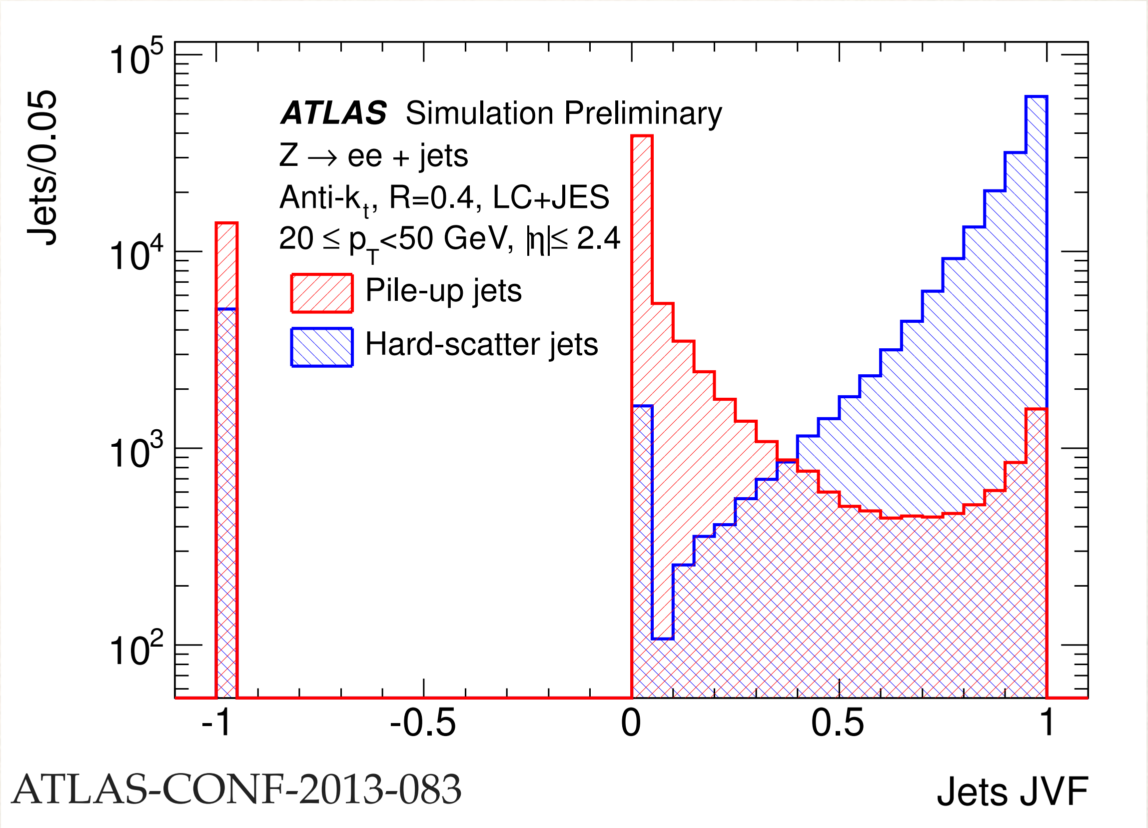
The need for pileup jet suppression

- Pileup effect on jets are mitigated by applying the jet-area pileup correction
  - based on event-by-event pileup p_T density
- *Local* fluctuations in the event-by-event pileup activity can give rise to **pileup jets**



- Track-based pileup jet suppression:
  - associate tracks to jets with |η|<2.5
  - calculate the jet-vertex-fraction (**JVF**)

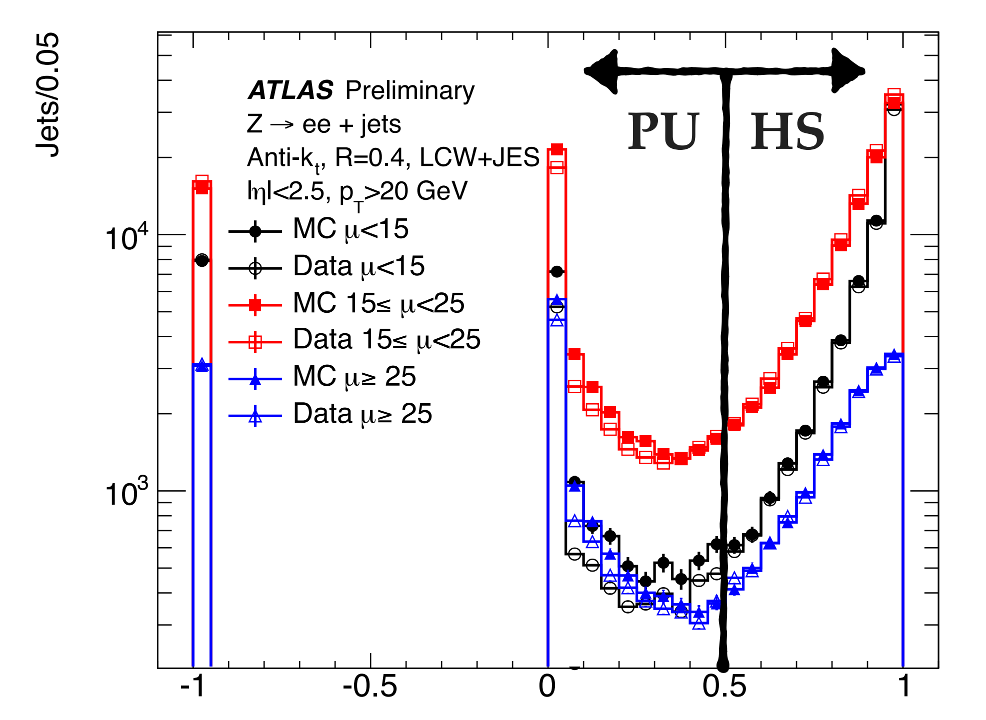
$$\mathrm{JVF} = \frac{\sum_i p_{T,i}^{\mathrm{trk,HS}}}{\sum_i p_{T,i}^{\mathrm{trk,HS}} + \sum_j p_{T,j}^{\mathrm{trk,PU}}}$$



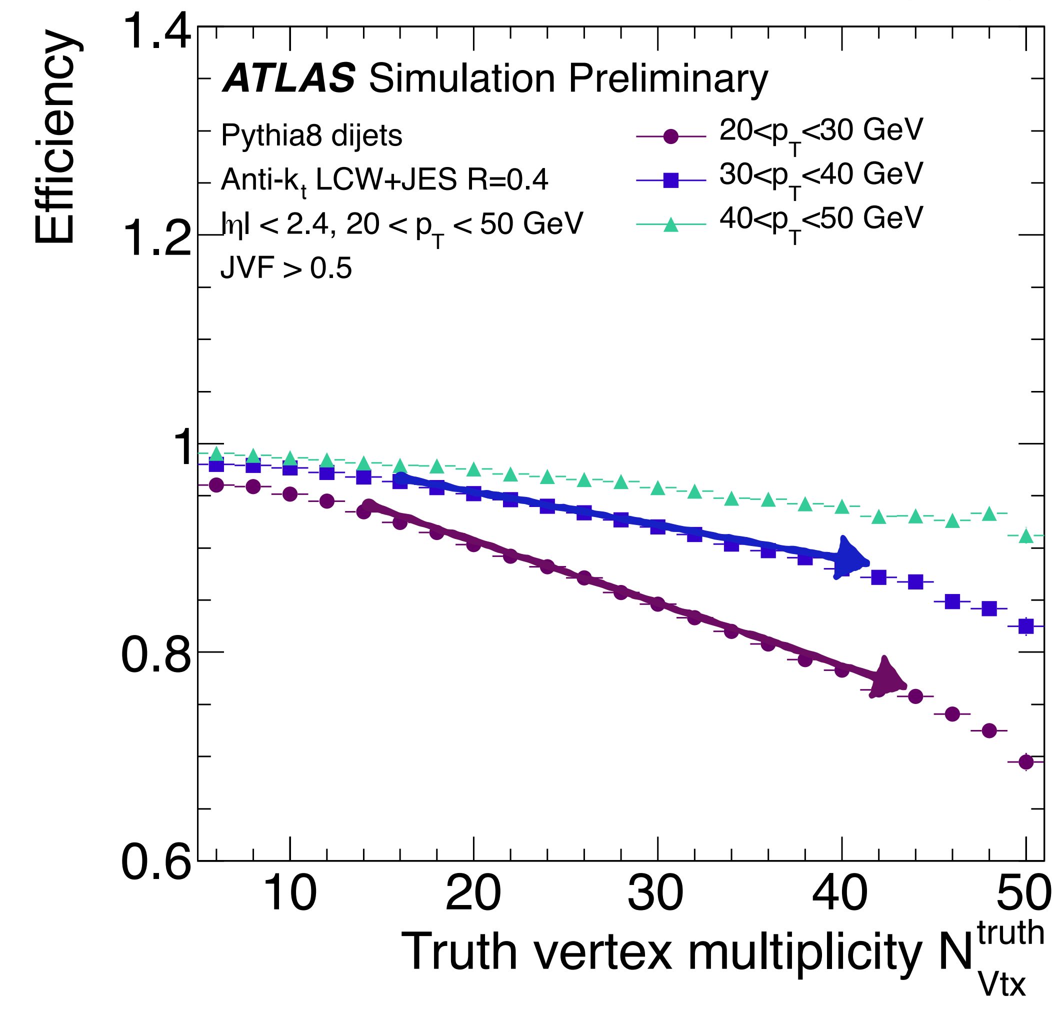
JVF based PU jet suppression

- **JVF is a measure of the fraction of track p_T from the HS PV**
  - **naturally decreases with N_{Vtx}**

$$\mathrm{JVF} = \frac{\sum_i p_{T,i}^{trk,HS}}{\sum_i p_{T,i}^{trk,HS} + \sum_j p_{T,j}^{trk,PU}}$$



ATLAS-CONF-2013-083



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- The explicit pileup dependence of JVF leads to N_{Vtx} dependent hard-scatter jet efficiencies

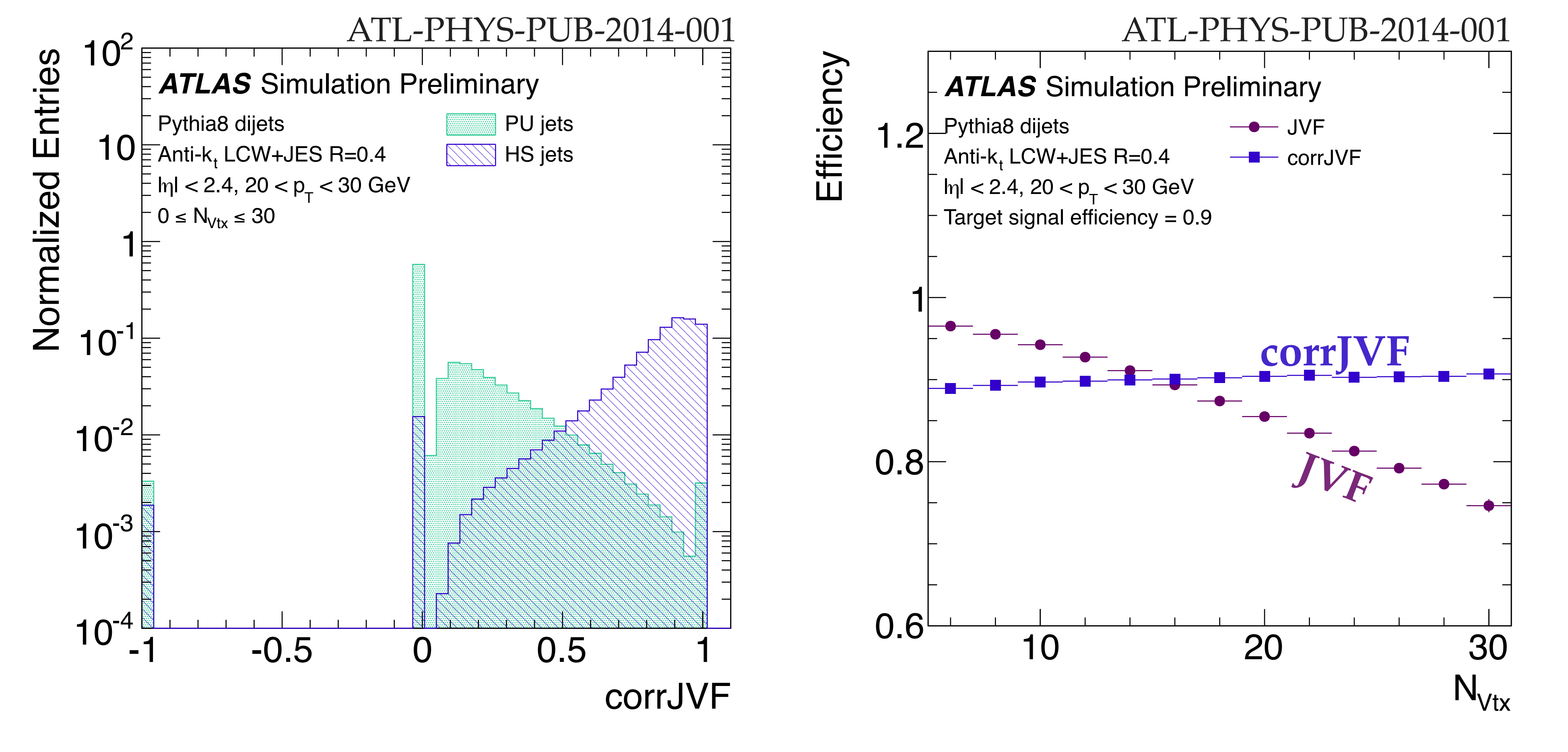
- A key element of this talk:
  - **new track-based variables to suppress pileup jets with N_{Vtx} insensitive jet efficiencies**

new variables for PU jet suppression

- Correcting JVF for its explicit pileup dependence

$$\mathrm{JVF} = \frac{\sum_i p_{T,i}^{trk,HS}}{\sum_i p_{T,i}^{trk,HS} + \sum_j p_{T,j}^{trk,PU}} \longrightarrow \mathrm{corrJVF} = \frac{\sum_i p_{T,i}^{trk,HS}}{\sum_i p_{T,i}^{trk,HS} + \sum_j p_{T,j}^{trk,PU}/(k N_{trk}^{PU})}, \quad k = 0.01$$

mean p_T from PU trk increases linearly with N_{trk}^{PU}



- N_{trk}^{PU}= total number of pileup tracks in the event

HS jet efficiency as a function of N_{Vtx}

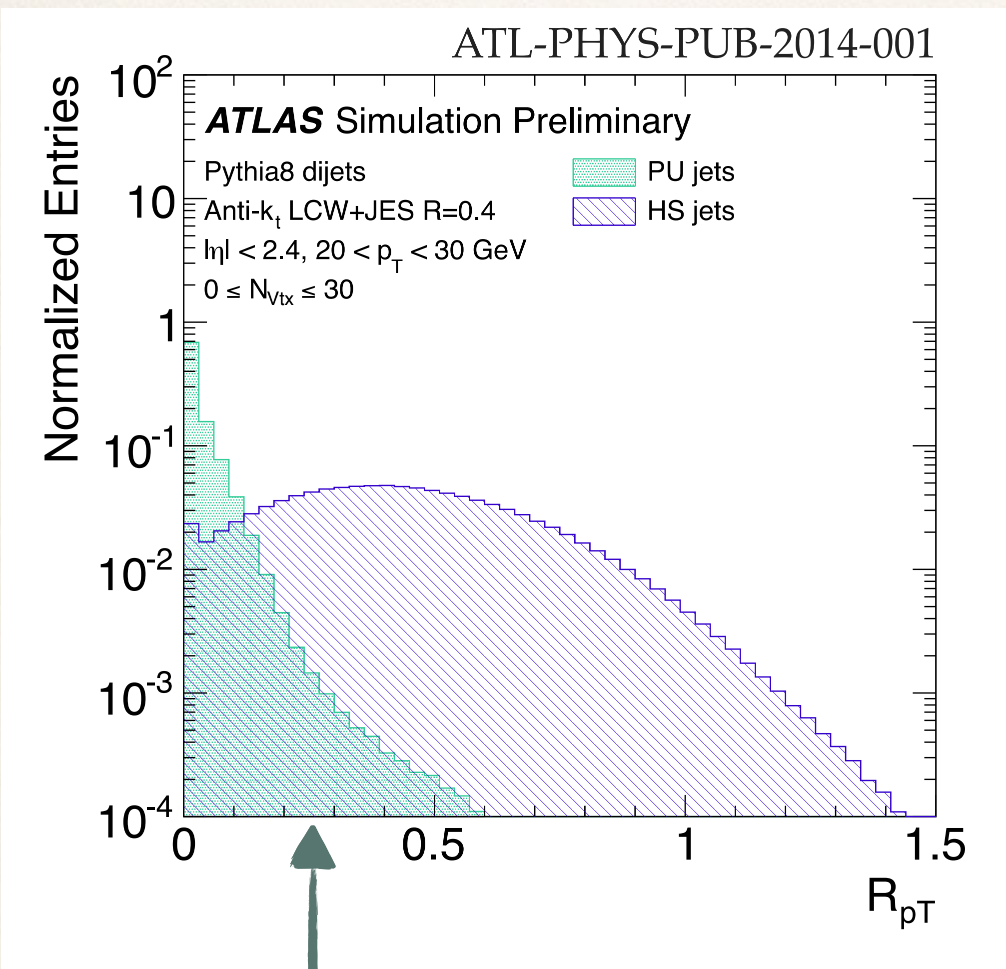
- JVF degrades by 20%
- corrJVF stable at 90±1%

new variables for PU jet suppression

- Another variable with large separation power:

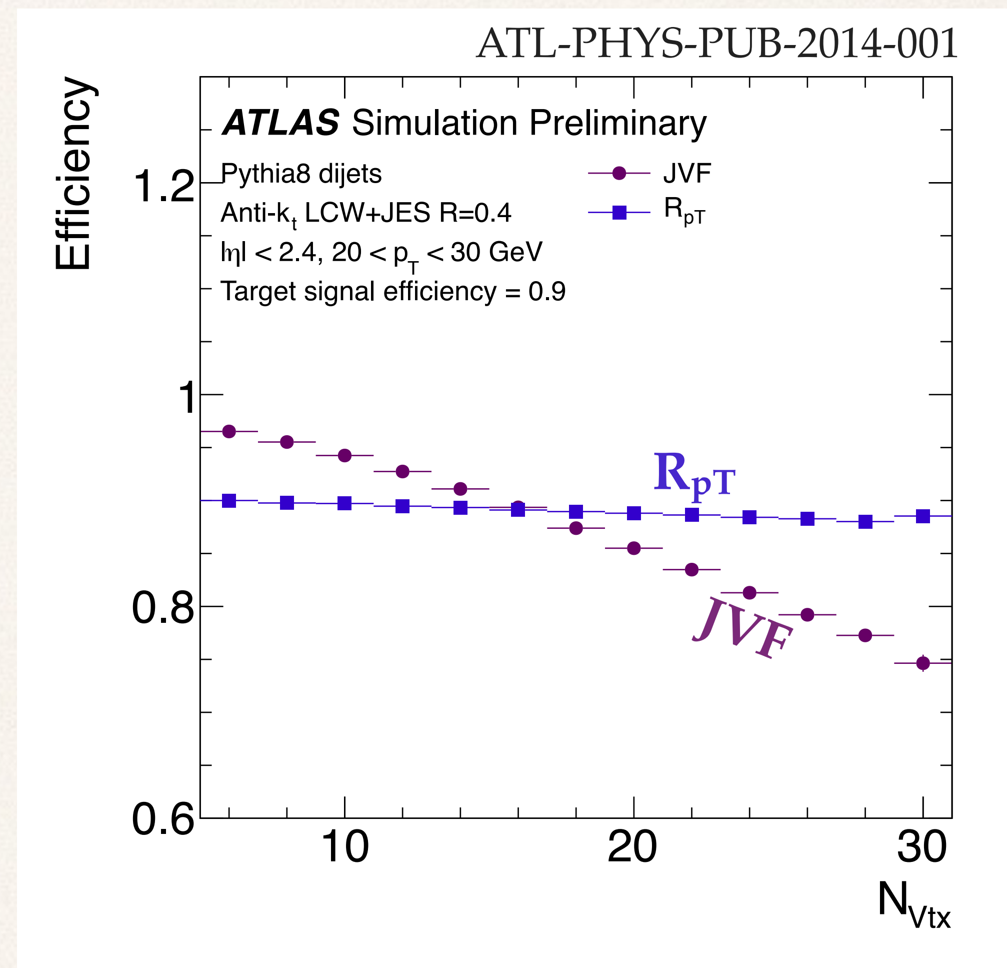
  $R_{pT} = [\sum_j p_{T,j}^{trk,HS}]/p_T^{jet}$

  - R_{pT} ~ charged fraction of a jet



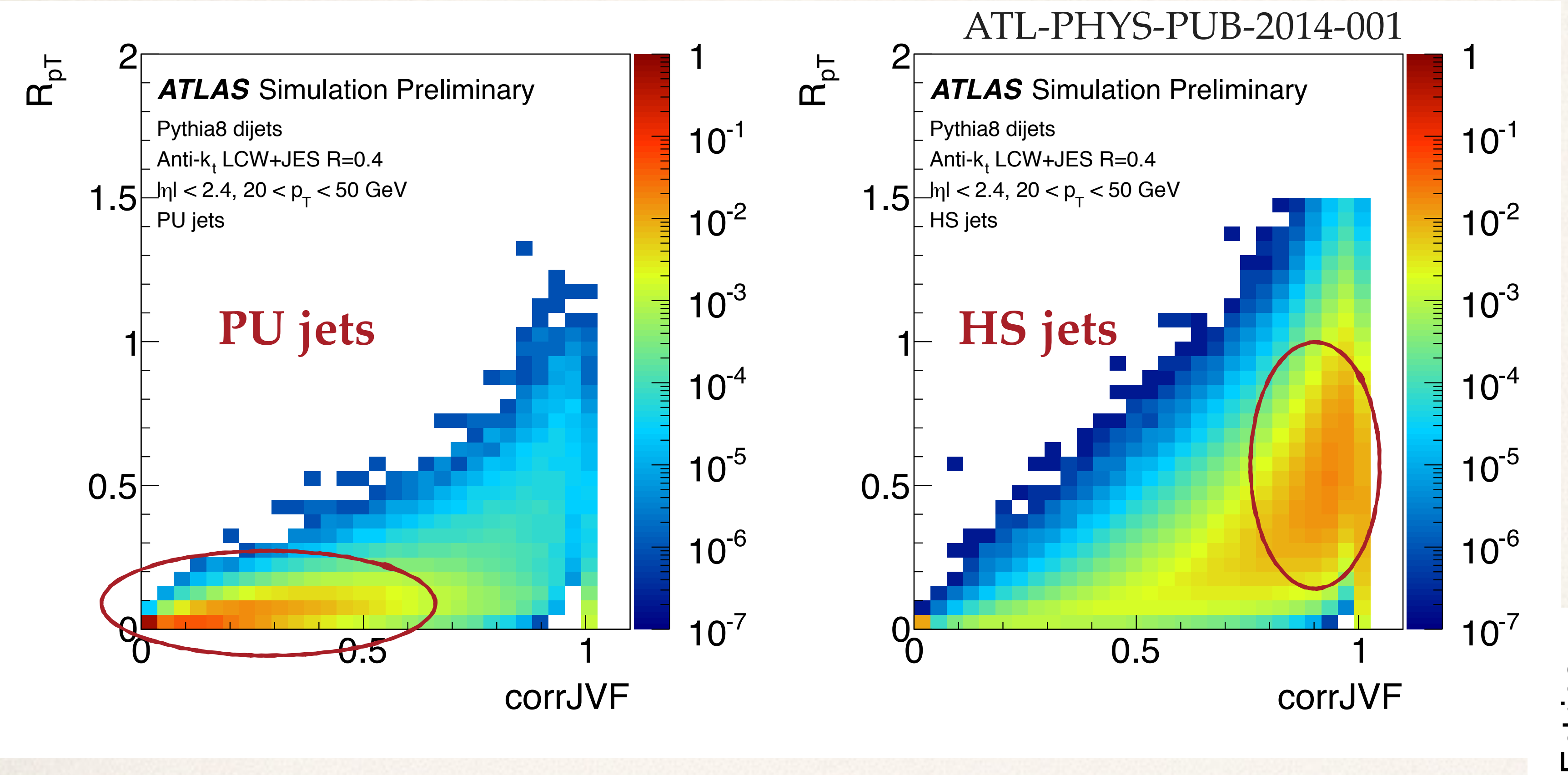
PU jets have no or only little p_T from pileup tracks

- R_{pT} only uses pileup insensitive variables
  - tracks from the HS PV
  - fully-calibrated (pileup corrected) jet p_T



for R_{pT}: HS efficiency is stable with N_{Vtx}

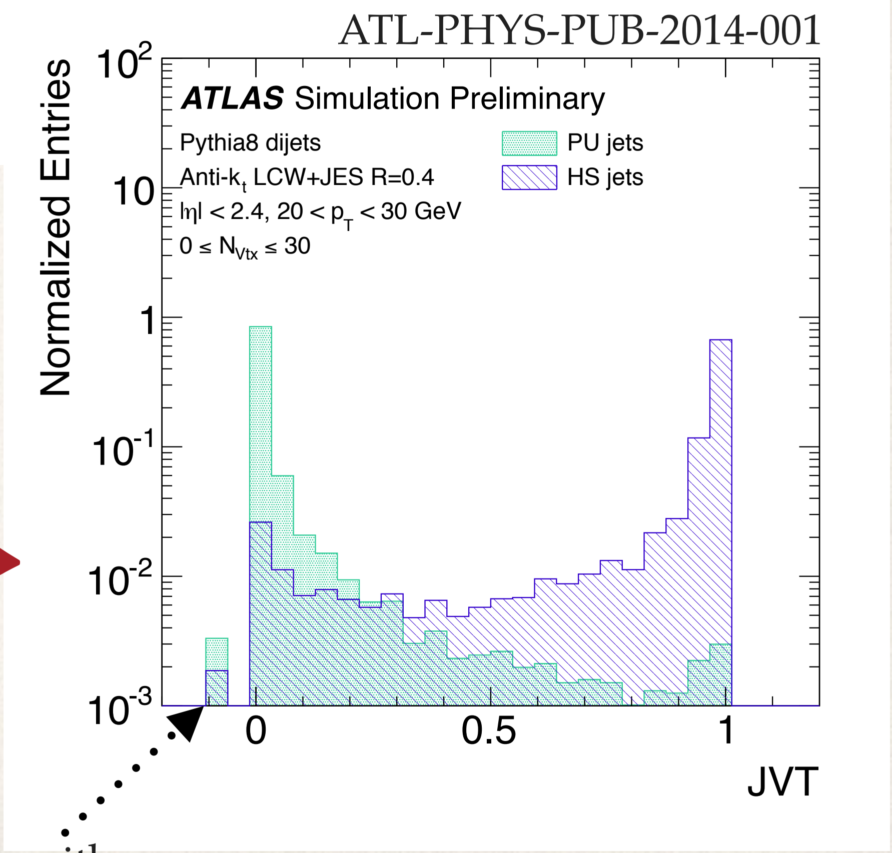
corrJVF vs. R_{pT} correlation



- **PU jets** populate **low R_{pT} - low corrJVF** region
- **HS jets** are mostly in **moderate R_{pT} - large corrJVF** region

- **Exploit corrJVF - R_{pT} correlation to gain discrimination power**

- Construct a **discriminator** based on **full 2D likelihood** using a nearest neighbor algorithm
  - **jet-vertex-tagger JVT**



jets with
no tracks

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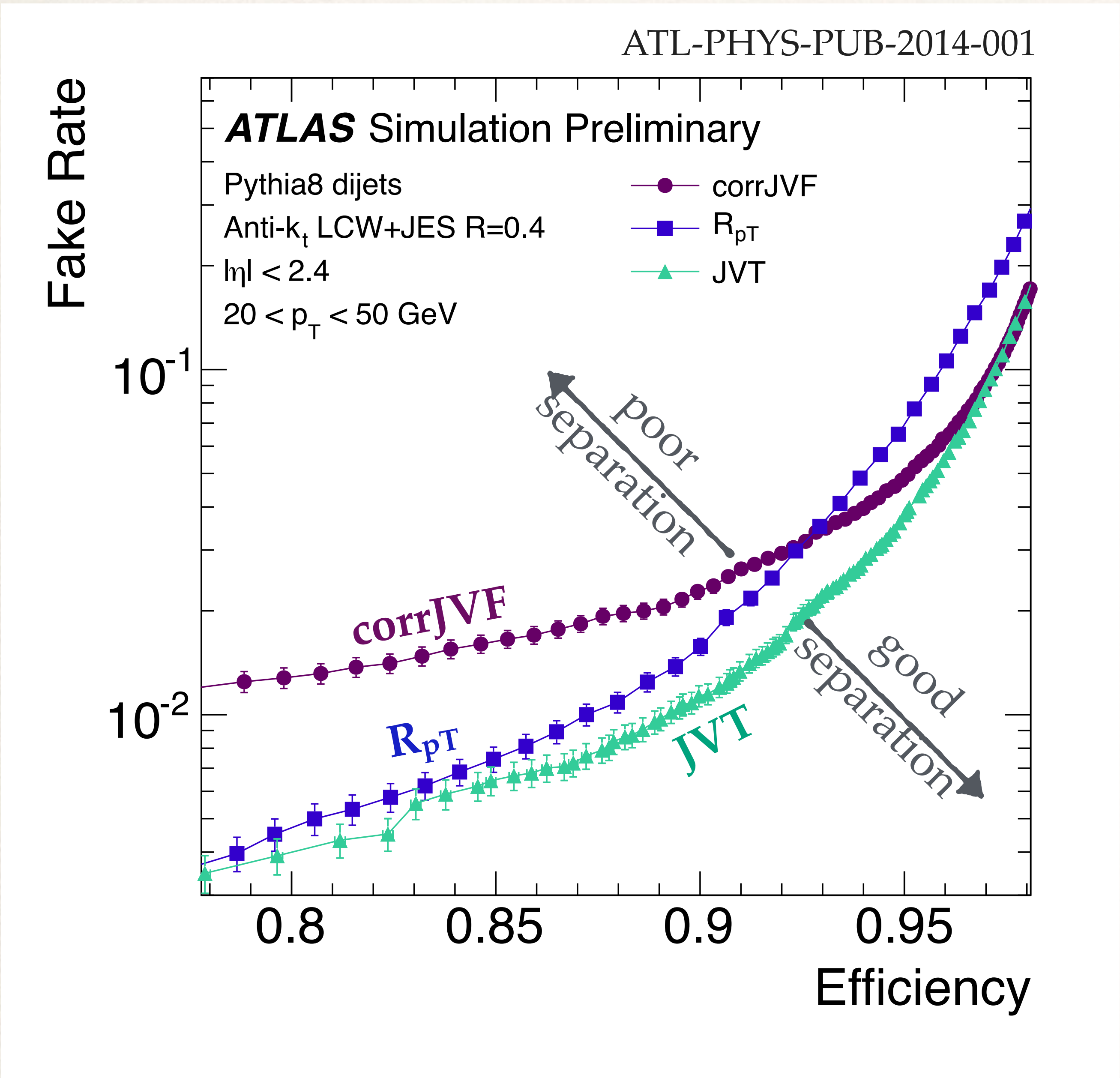
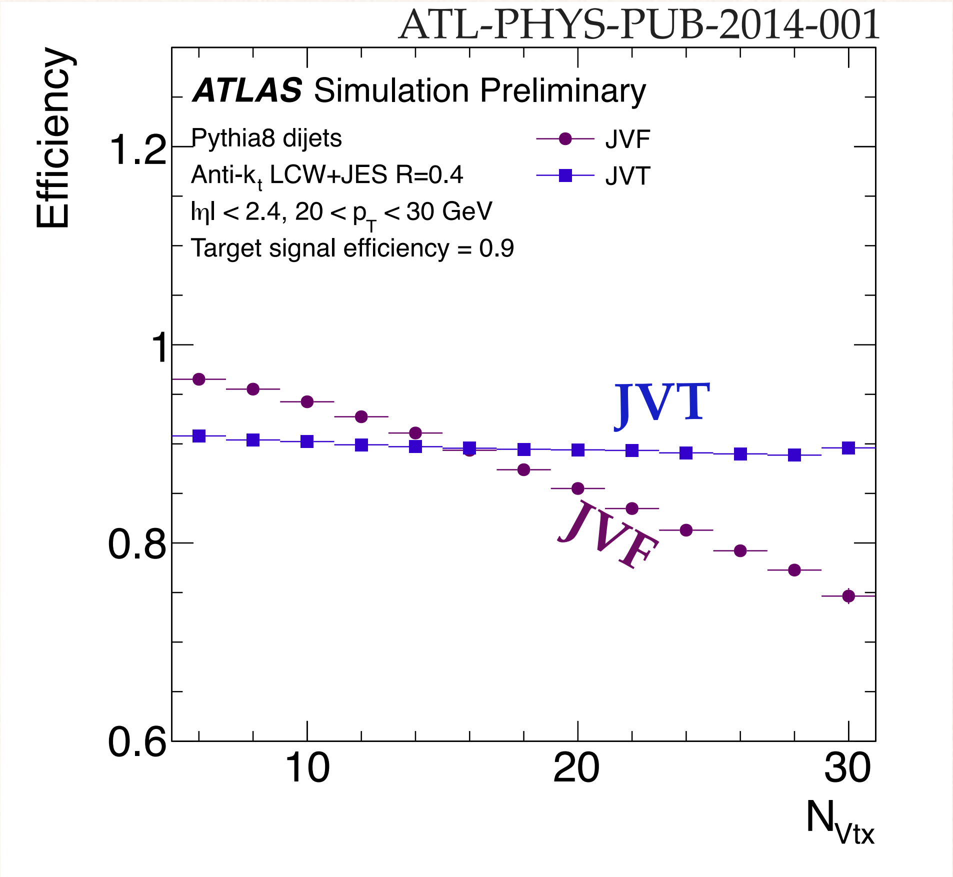
JVT performance



- Cutting on JVT gives N_{Vtx} insensitive HS jet efficiencies



- Hard-scatter vs. pileup discrimination with JVT
  - **fake rate of 0.4% for signal efficiency of 80%**
  - **fake rate of 1.0% for signal efficiency of 90%**
  - **fake rate of 4.0% for signal efficiency of 95%**

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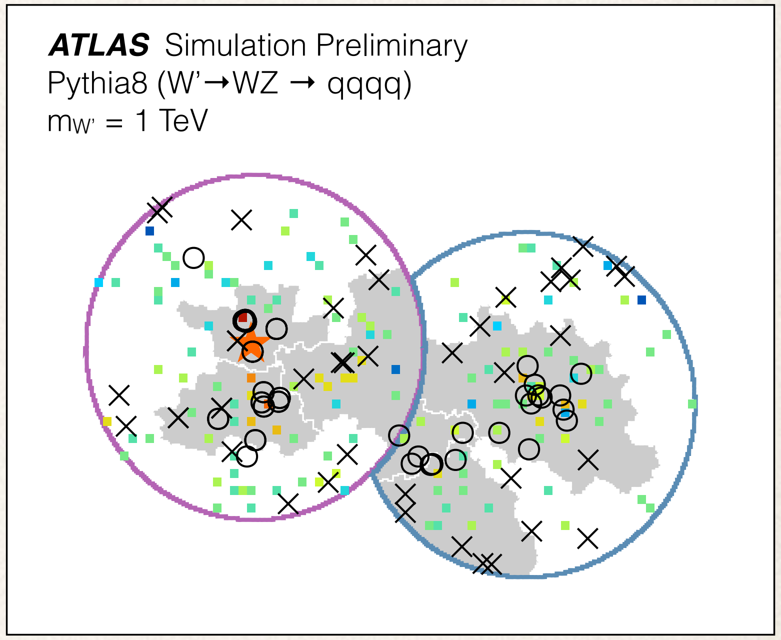
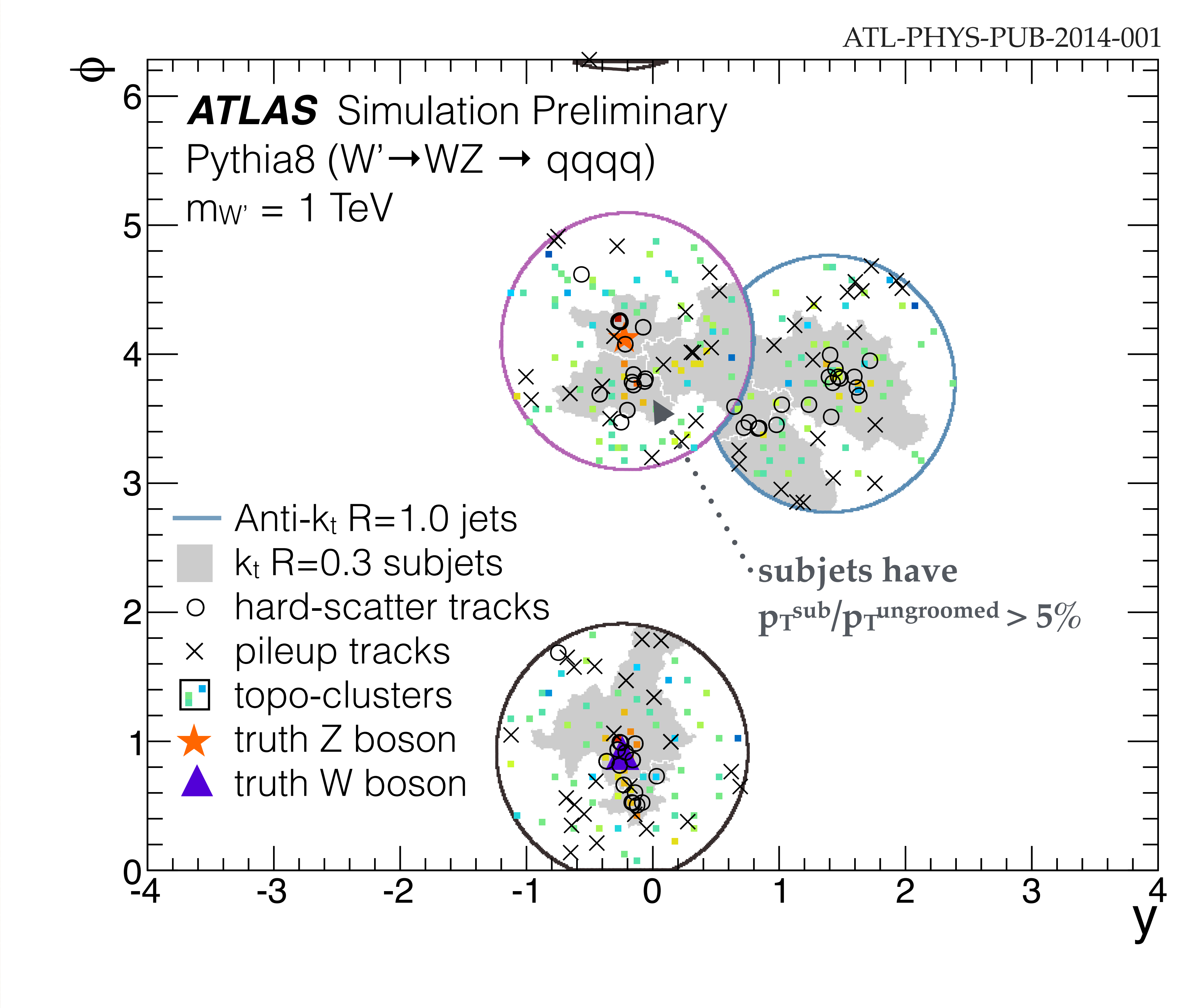


Track-based grooming of large-R jets

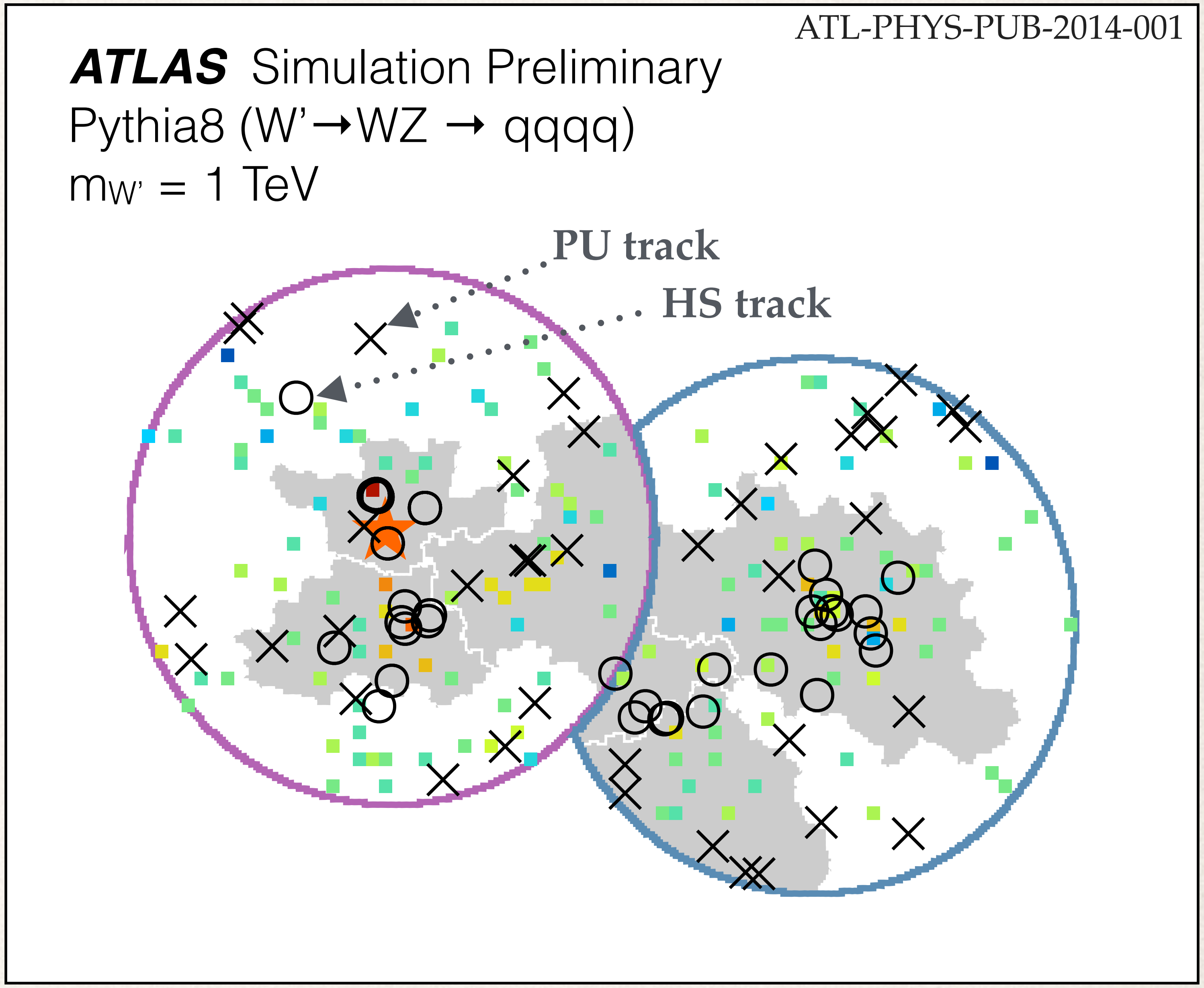
Can we improve the grooming of large-R jets by exploiting tracking information?

track-based trimming of large-R jets



track-based trimming of large-R jets

- The pink large-R jet is **matched to the truth Z boson**
  - 3 subjets with $p_T^{sub} / p_T^{ungroomed} > 5\%$
  - **only two subjets have associated tracks from the HS PV**



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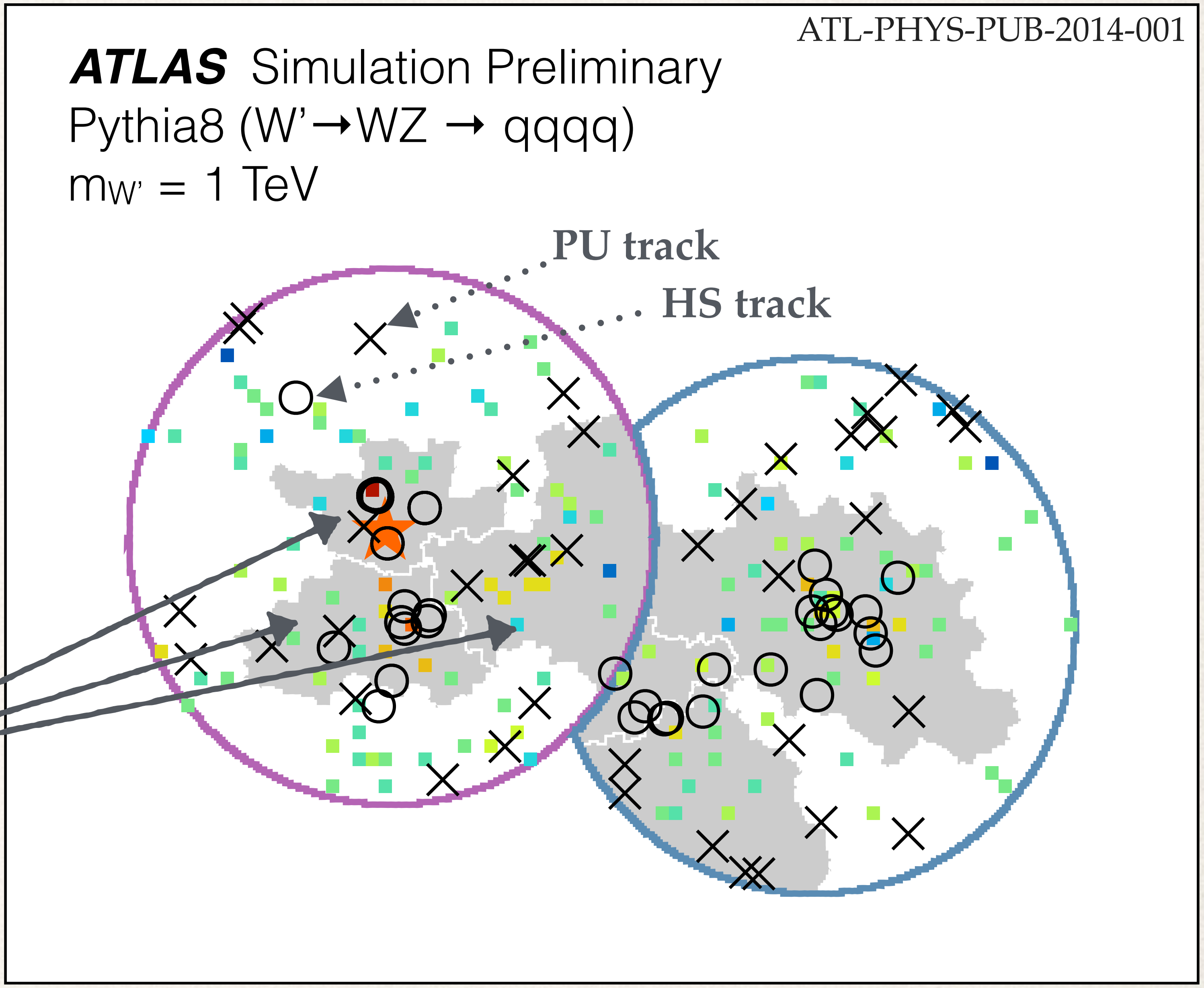

$m_j = 119$ GeV

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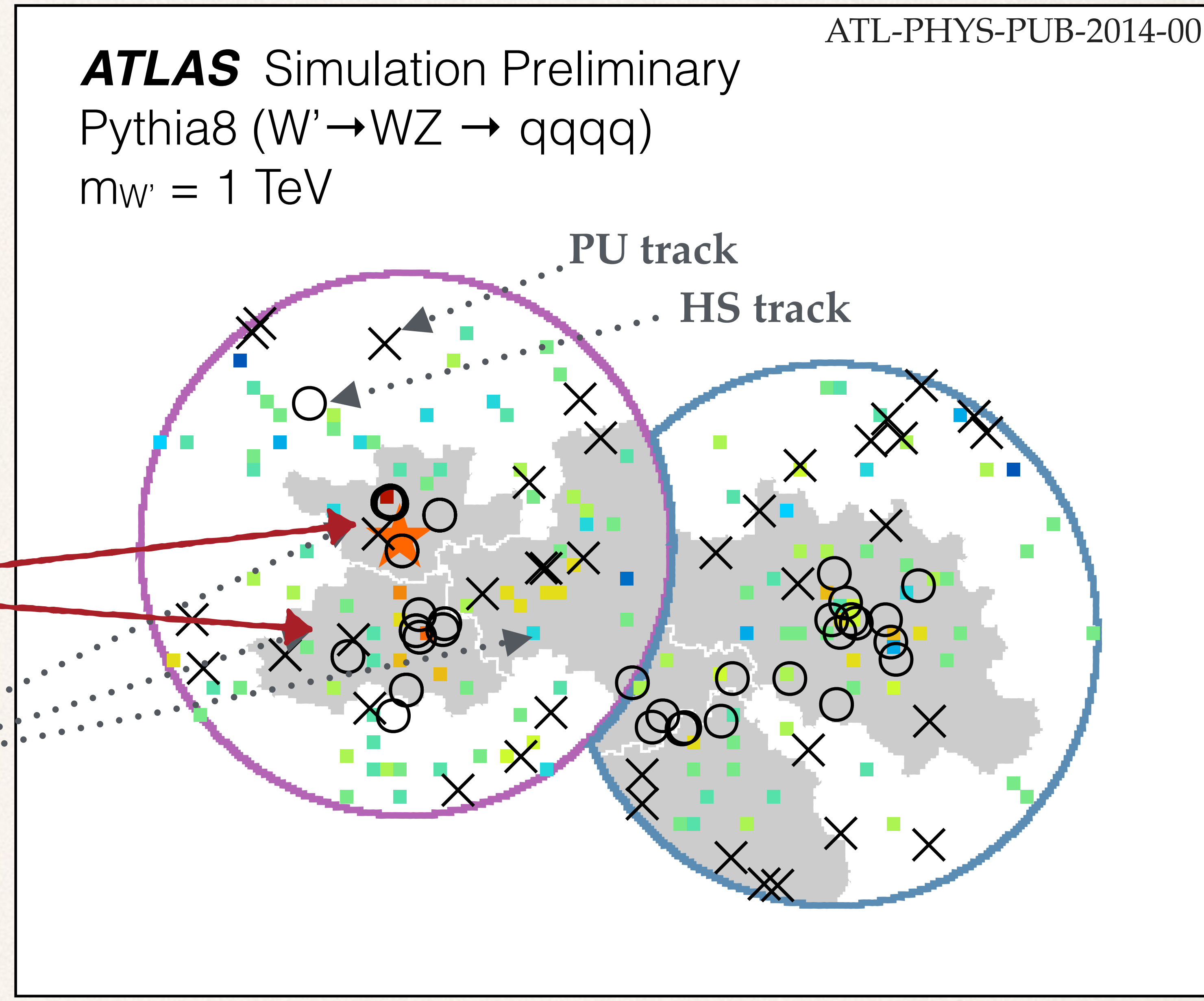

$m_j = 88.7$ GeV

$m_j = 119$ GeV

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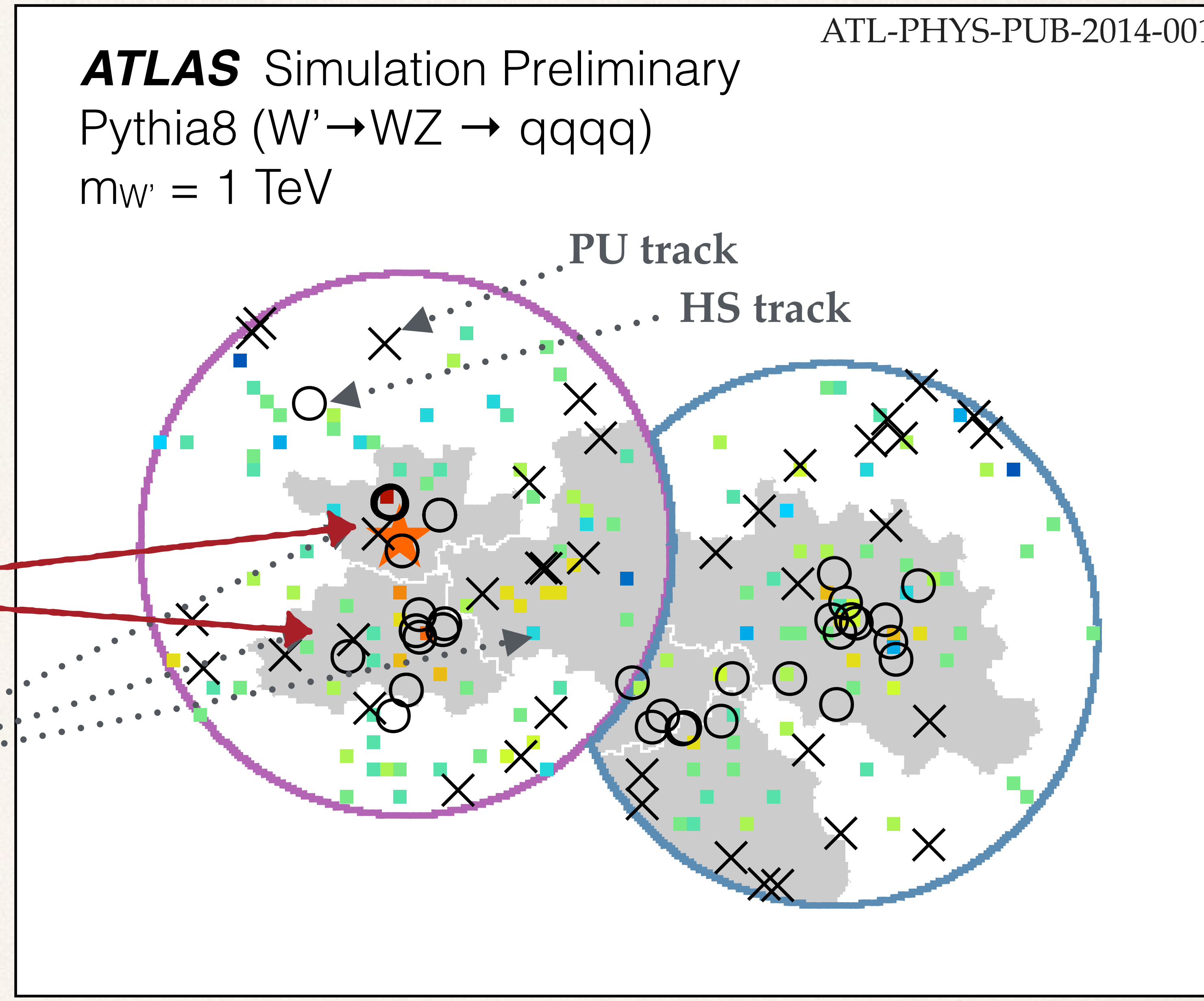

m_j =88.7 GeV

m_j =119 GeV

- **using tracking information to remove pileup subjets may improve the jet mass resolution**

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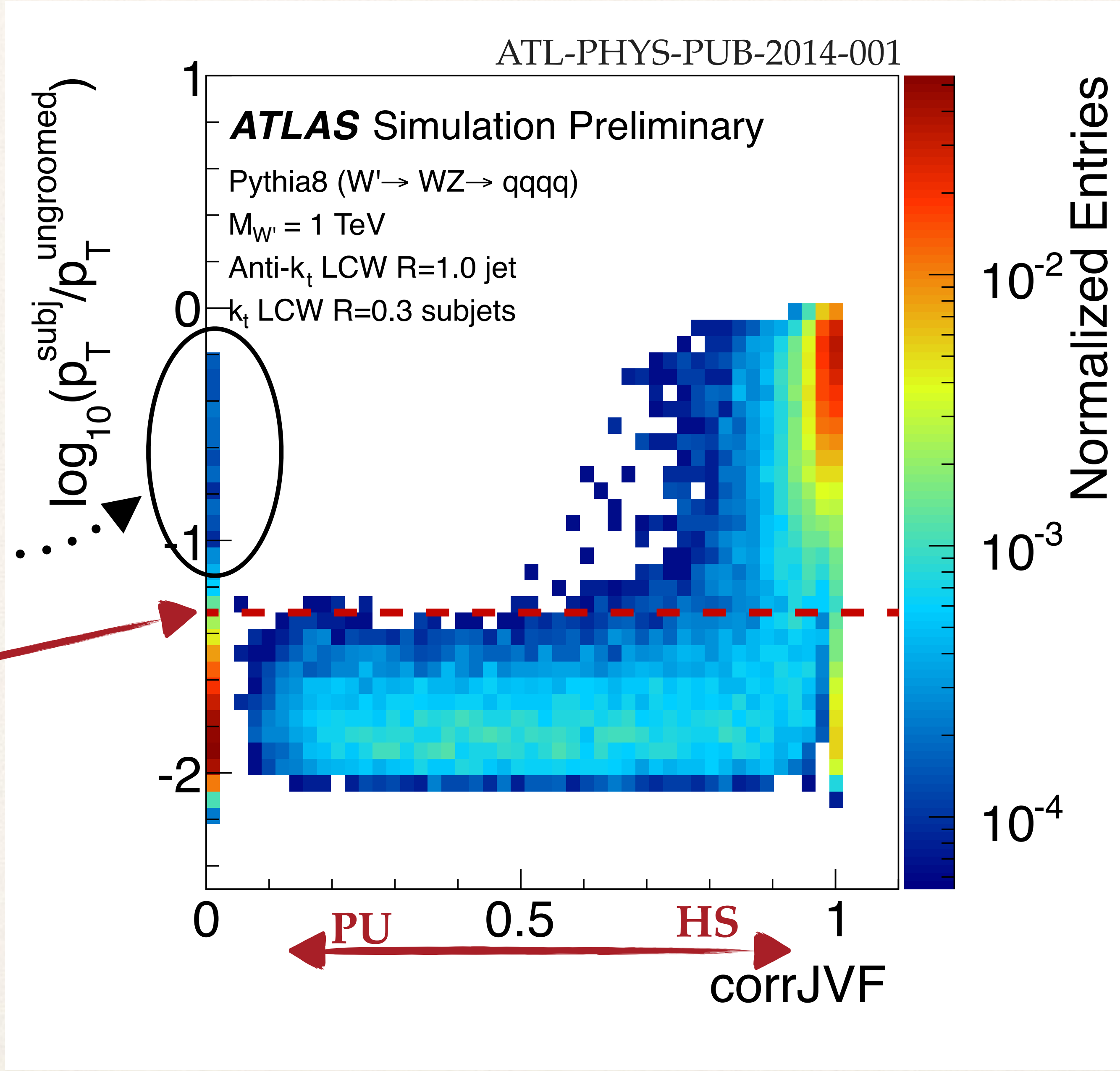
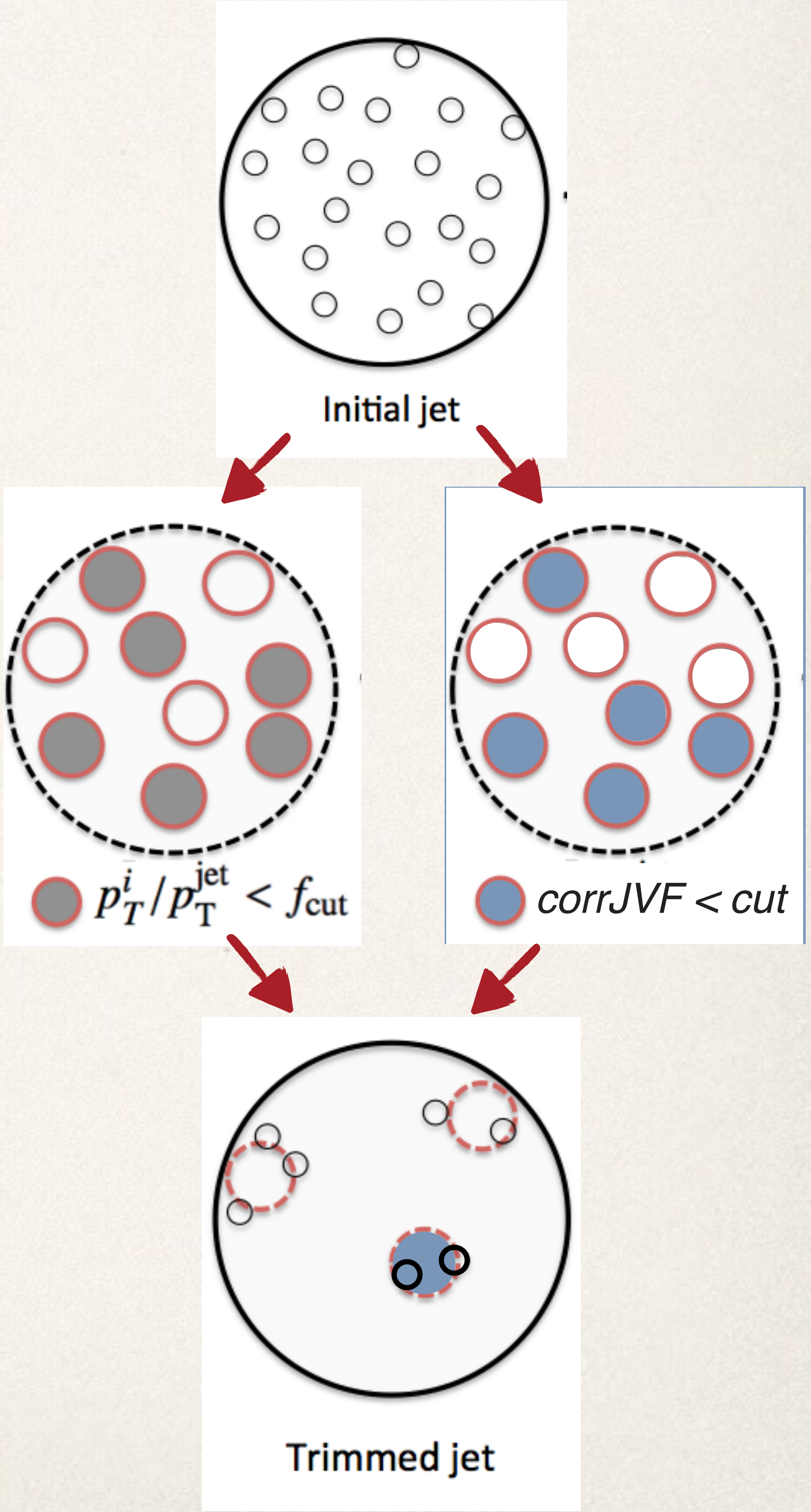
corrJVF-based trimming

- **subjet corrJVF vs. $p_T^{subj}/p_T^{ungroomed}$ in W′->WZ->qqqq events**
  - ungroomed jet $p_T > 300$ GeV

- "high" p_T pileup jets

- $f_{cut} = 5\%$ line





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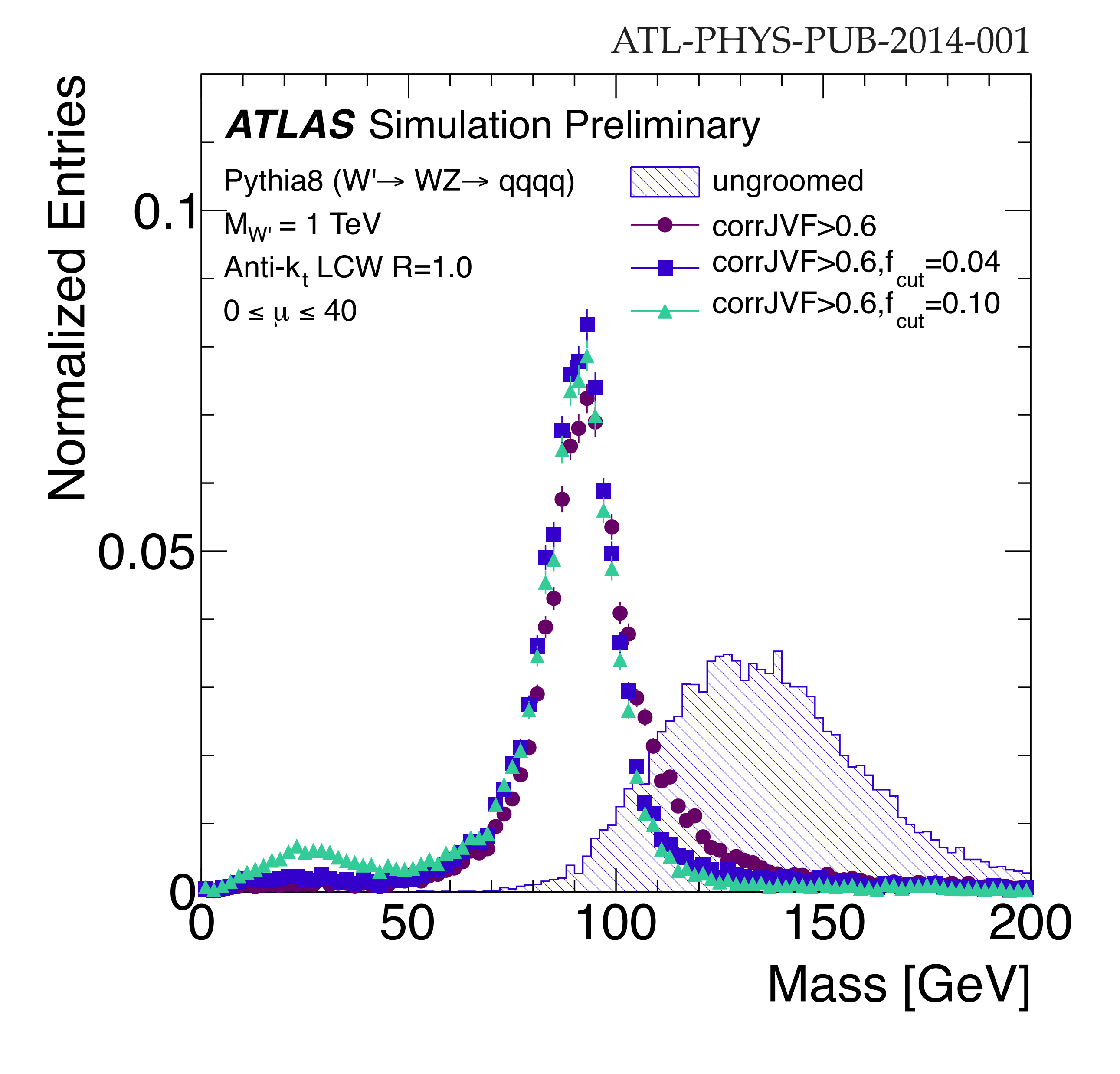
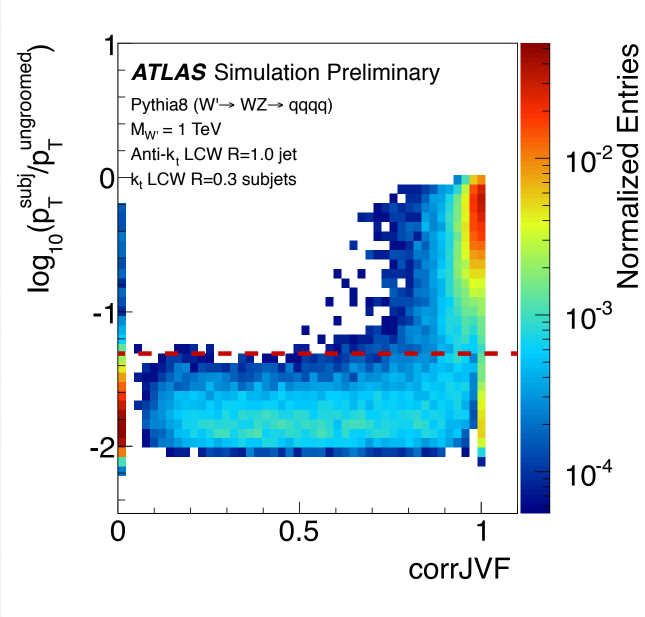
corrJVF-based trimming

- subjet p_T based trimming in combination with corrJVF
  - **which f_{cut} is optimal?**



- looking at large-R jets matched to the truth Z boson
  - jet $p_T > 300$ GeV



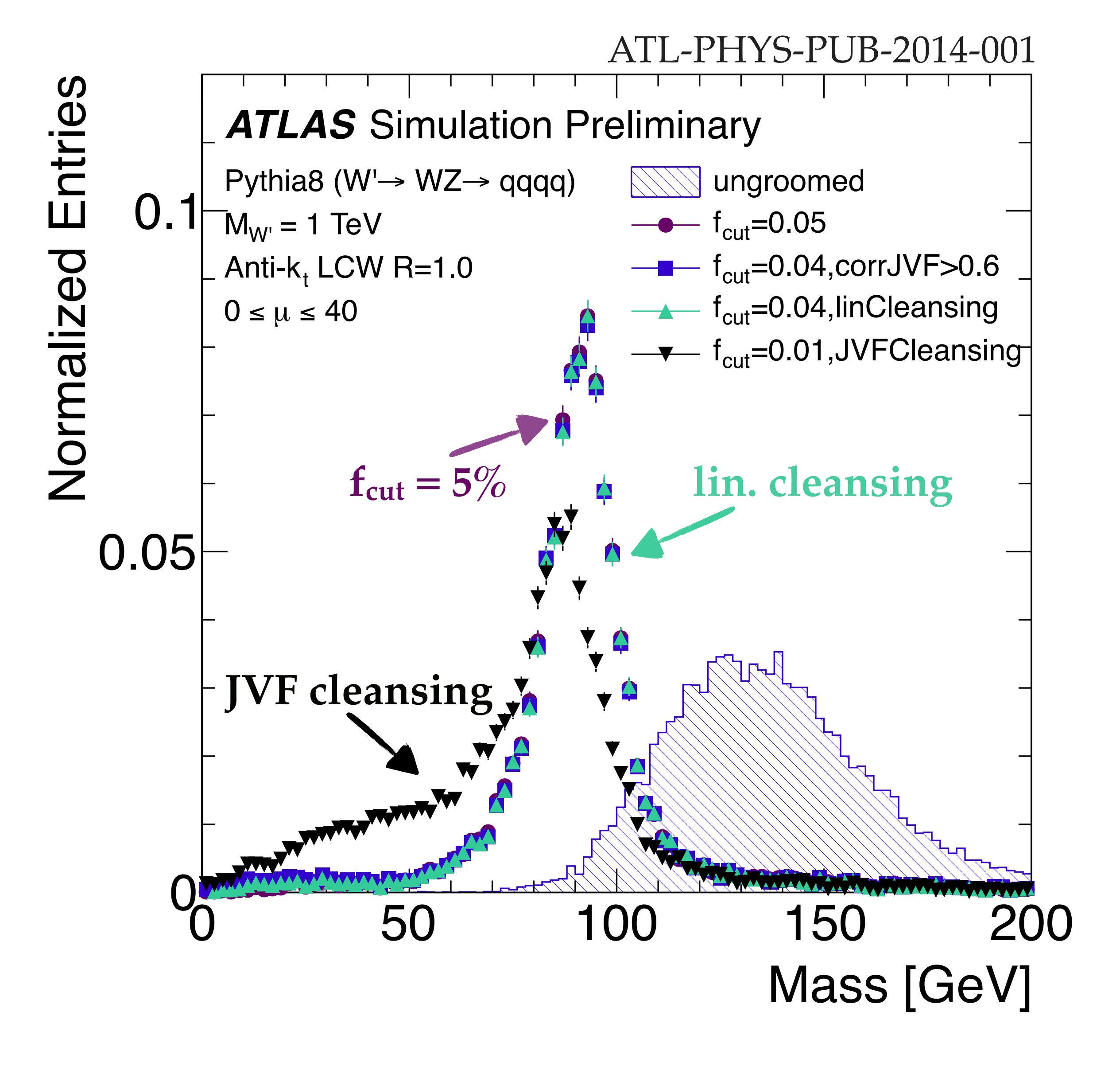
- **calculating the trimmed jet mass from subjets passing:**
  - **corrJVF & f_{cut} = 10%**

  → too aggressive
  - **corrJVF only:**

  → already quite good, but slightly too loose
  - **corrJVF & f_{cut}= 4%**

  → best mass resolution for this signal

Pileup removal with jet cleansing



- **comparing corrJVF-based grooming with jet cleansing (arXiv:1309.4777)** [see dedicated talk by Matthew Low]
  - linear jet cleansing
  - JVF jet cleansing

jet cleansing aims to approximate the subjet p from the HS PV:

- **JVF cleansing:**
  - scale 4-momentum by JVF
- **linear cleansing:**
  - scale subjet 4-momentum based on the assumption that $p_T^{charged}$ / p_T^{total} from pileup is 0.55

- In **2012 pileup** conditions, performance (in terms of mass resolution) of track-based procedures are **similar to a calorimeter-only based** $f_{cut} = 5\%$.

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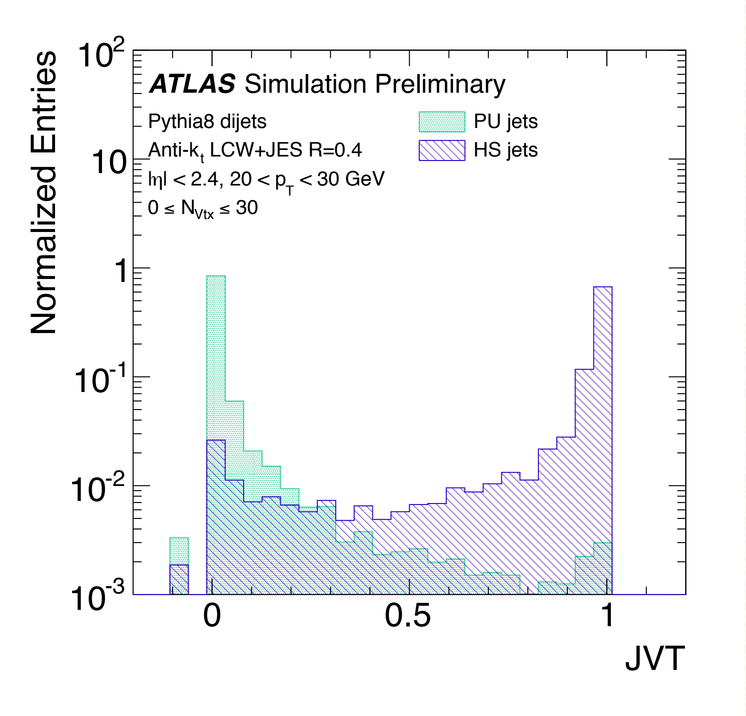
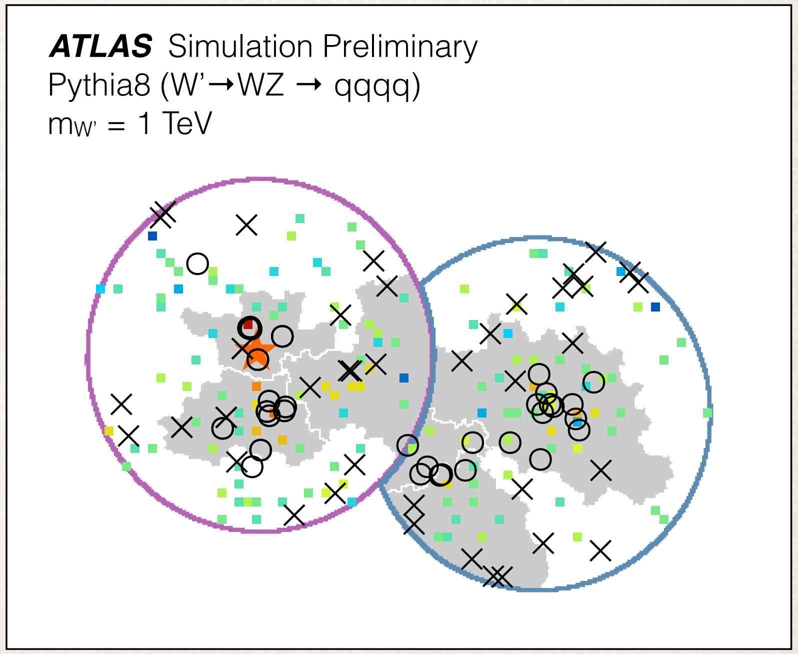
Conclusions



- Pileup mitigation was important for many 8 TeV analyses, and will be event more so for future LHC runs.

- Presented new results on pileup jet suppression:
- new 2D likelihood-based discriminant …
  - shows excellent pileup vs. hard-scatter discrimination power
  - results in hard-scatter jet efficiency that is flat with N_{Vtx}

- First ATLAS results on track-assisted grooming procedures
  - more studies ongoing



- The results presented here are published in **ATL-PHYS-PUB-2014-001**
- A CONF note with more details is in preparation … stay tuned.

Additional Material

HS jet efficiency in data

- Hard scatter jet efficiency for various JVF cuts in Z->ll events for **data and MC**