JOINT MARCH MEETING AND APRIL MEETING
Global Physics Summit
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Semi-inclusive hadron+jet and inclusive jet measurements in O+O collisions at $\sqrt{s_{NN}}$ = 200 GeV

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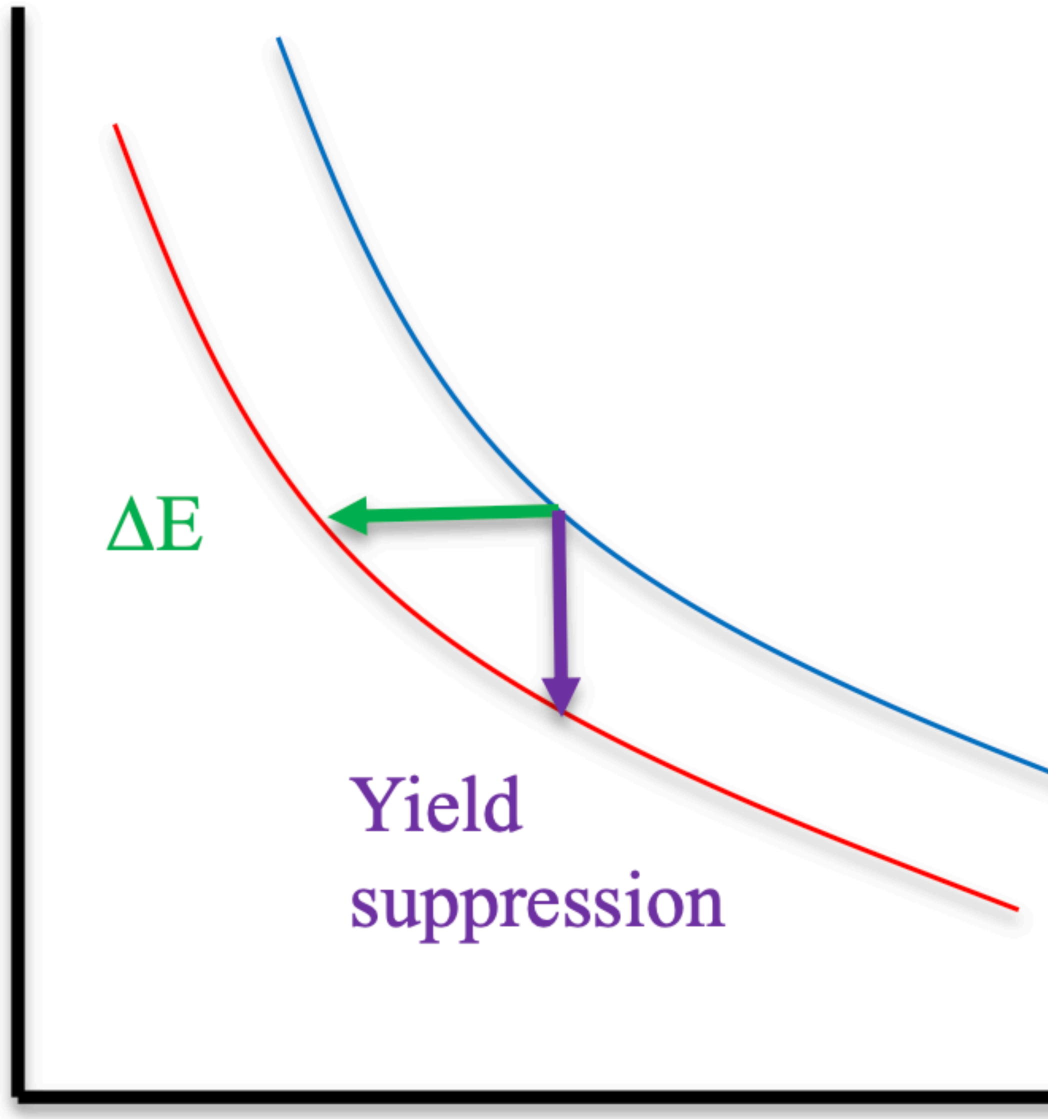
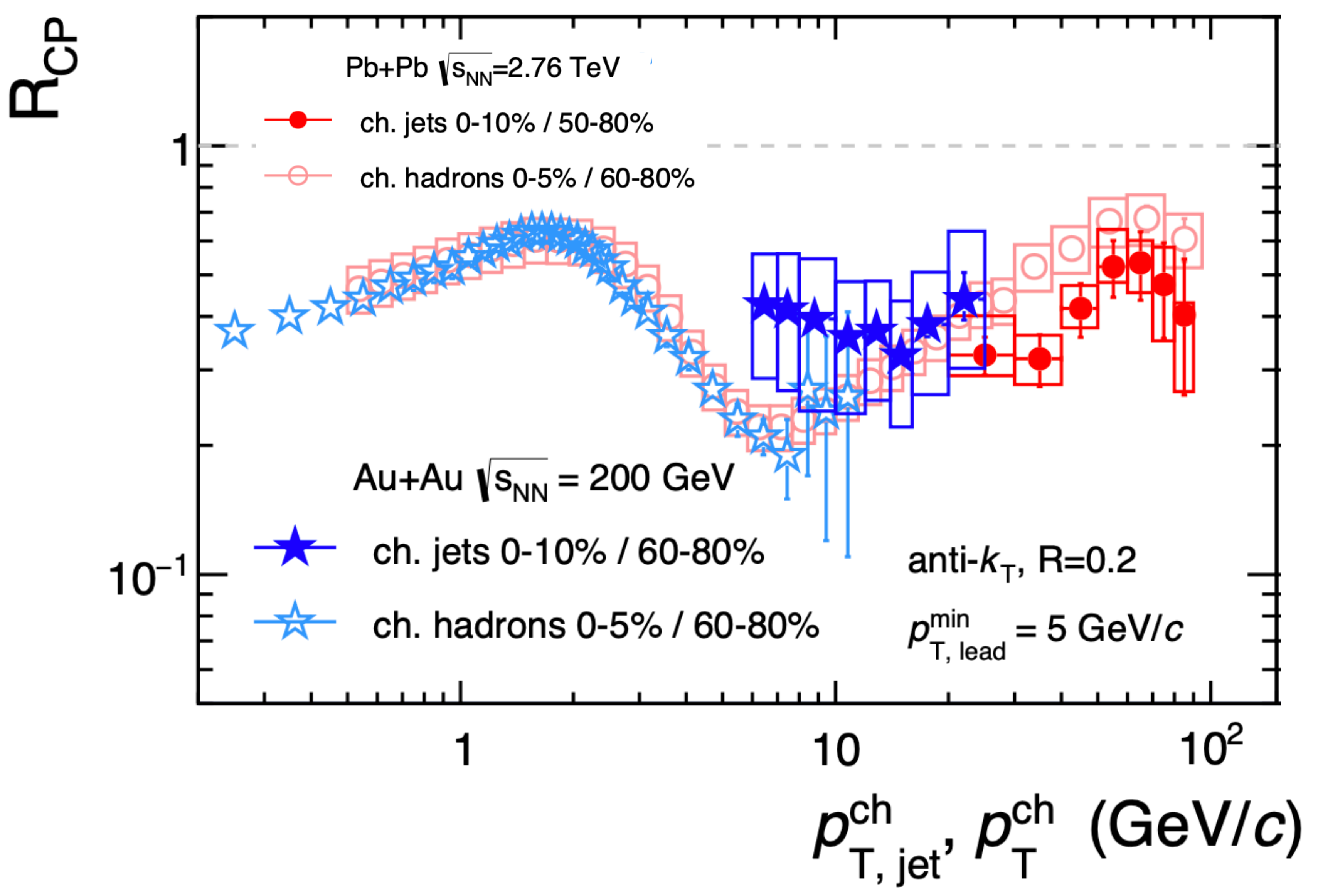
Jet quenching in large systems

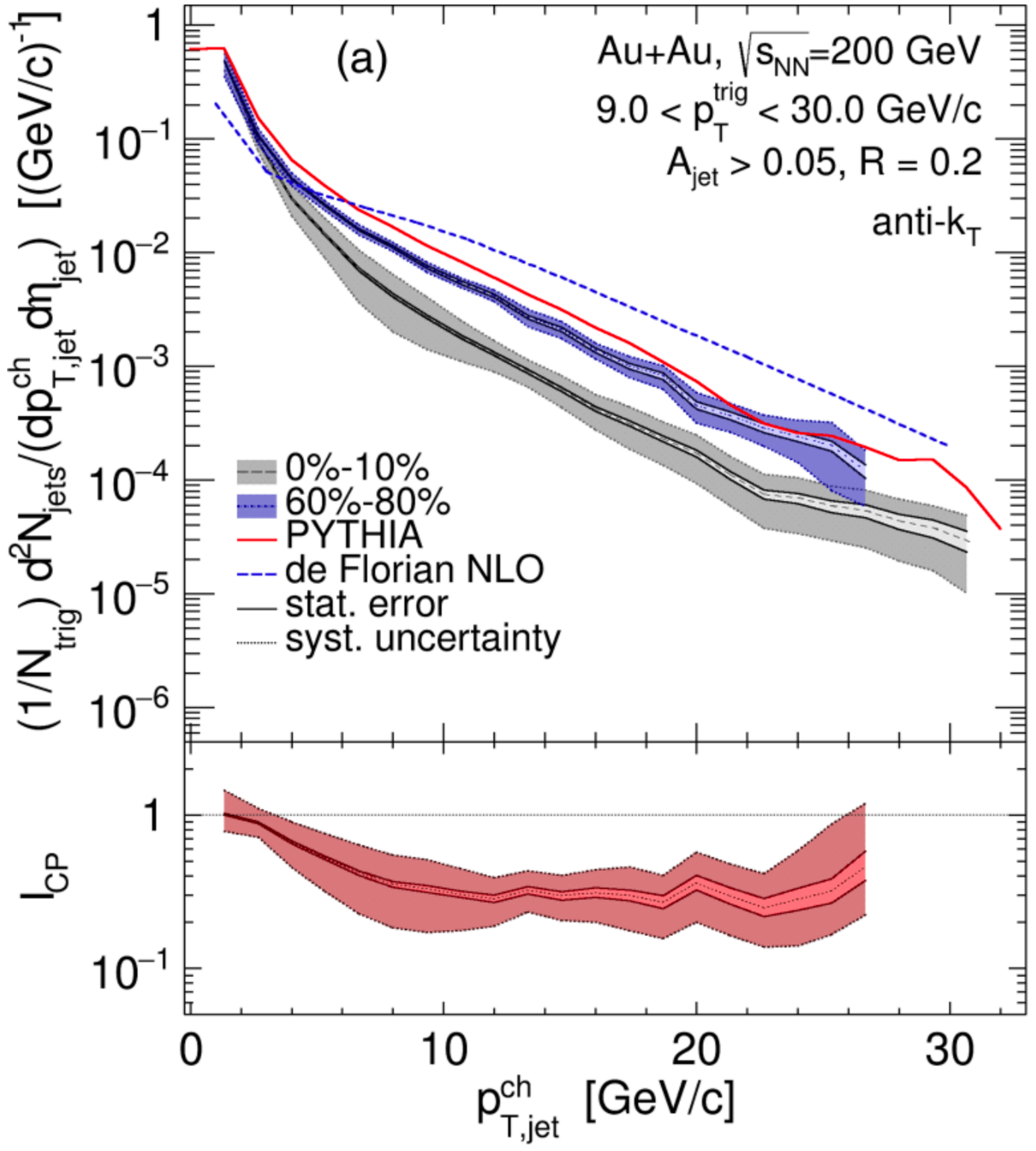
Jet quenching:
modifications to the energy and substructure of high-energy parton showers in QGP



power law falling distribution
yield suppression and shift in energy directly signal energy loss.



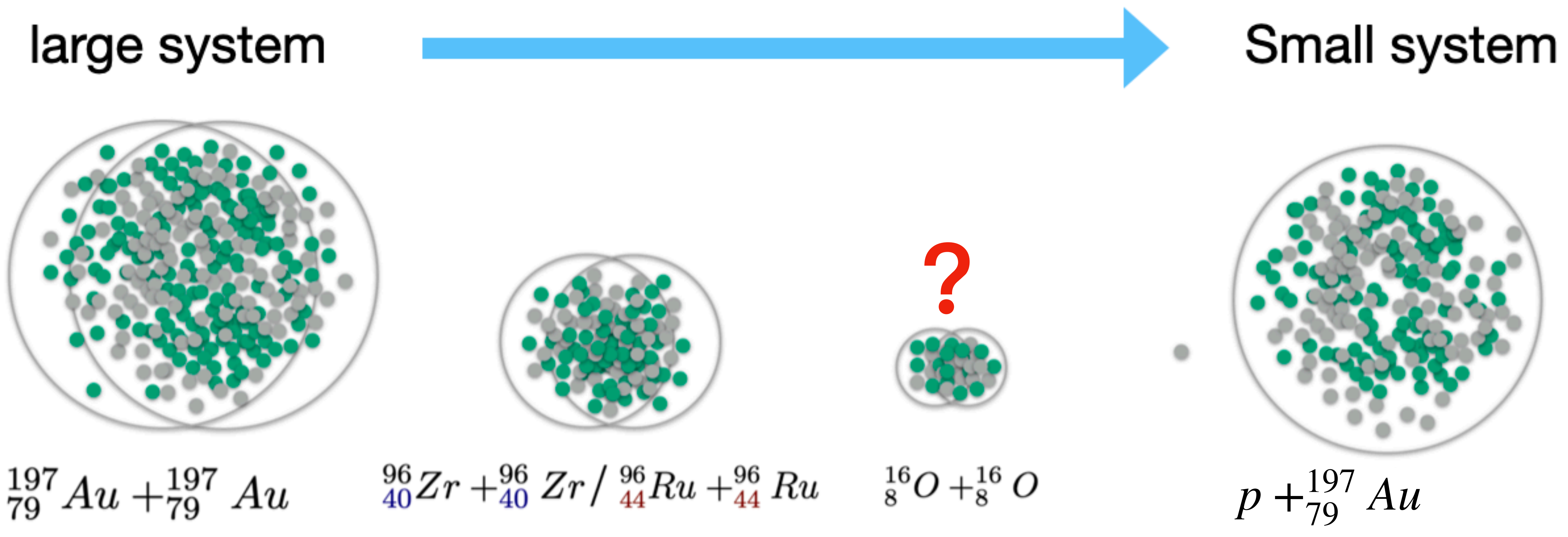
STAR, Phys. Rev. C102, (2020) 054913



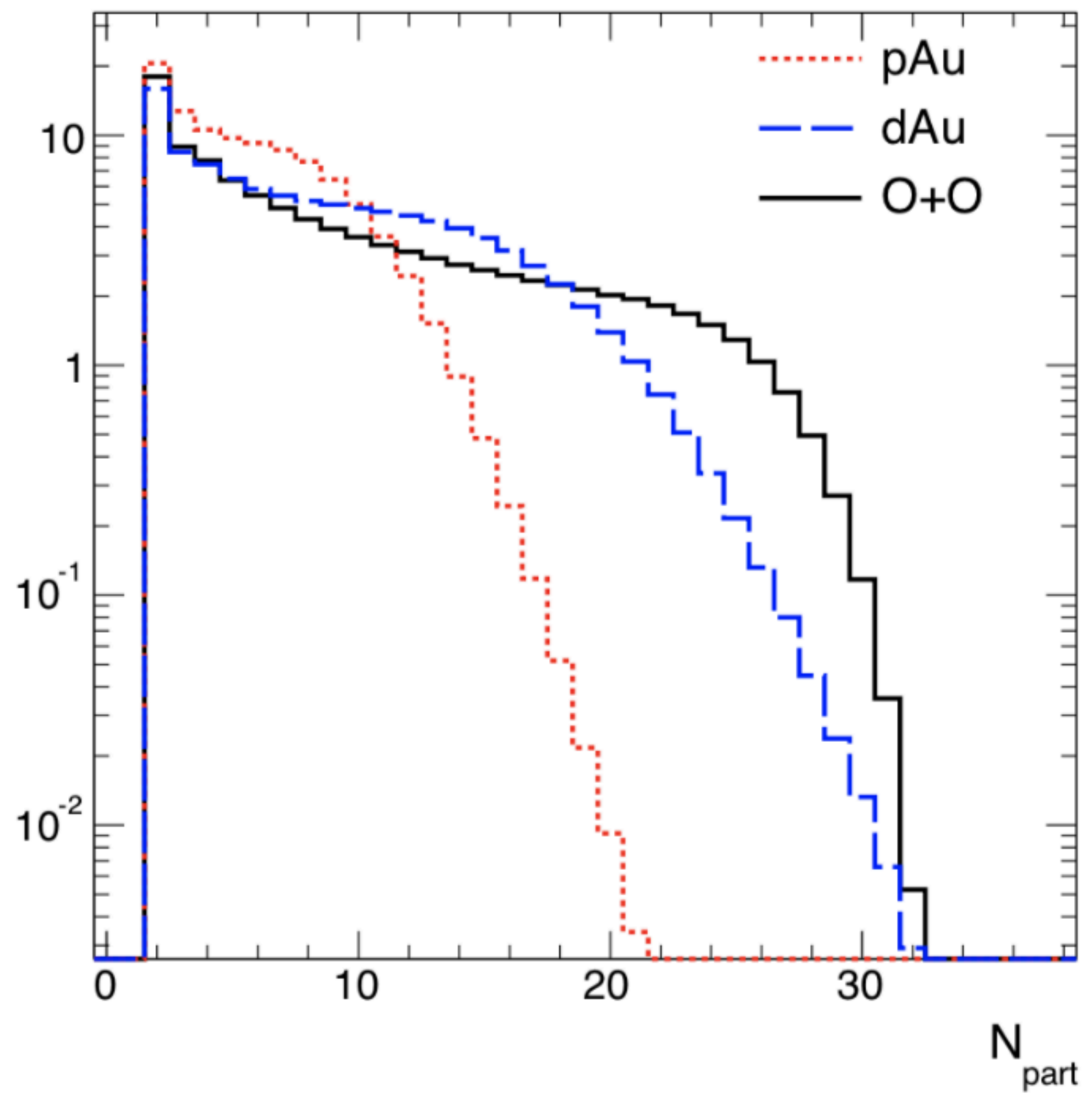
STAR, Phys. Rev. C 96, (2017) 024905

Jet quenching in Au+Au is studied with both inclusive and semi-inclusive jet production.

System size for jet quenching?



STAR BUR 2020



RHIC: 2021 at 200 GeV

LHC: 2025 at several TeV

O+O:

- Bridge the gap between these small and large systems.
- With an N_{part} close to that of p/d+Au collisions but with a larger geometrical transverse overlap that increases the in-medium path length and thus potentially quenching.

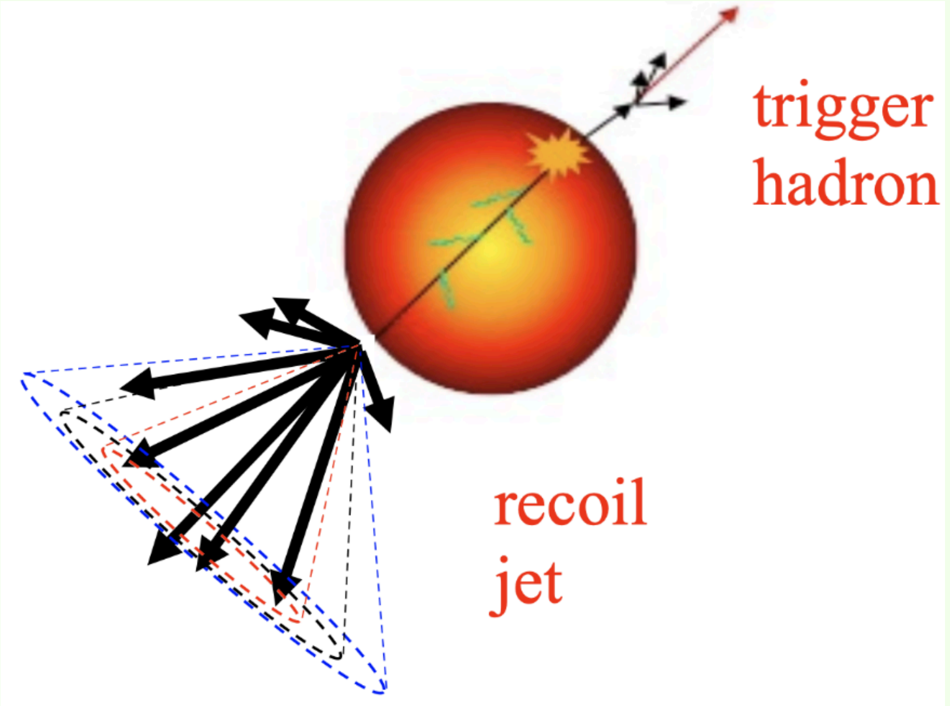
Jet quenching observables

- **Inclusive jets**

$$R_{AA} = \frac{Y_{AA}}{< N_{coll} > Y_{pp}} \qquad R_{cp} = \frac{< N_{coll}^{periphearal} > Y_{central}}{< N_{coll}^{central} > Y_{periphearal}}$$

Depend on N_{coll} from Glauber Model

- **Semi-inclusive h-jet**
  High-pT hadron triggered jet



$$I_{AA} = \frac{Y_{AA}}{Y_{pp}} \qquad I_{cp} = \frac{Y_{central}}{Y_{peripheral}}$$

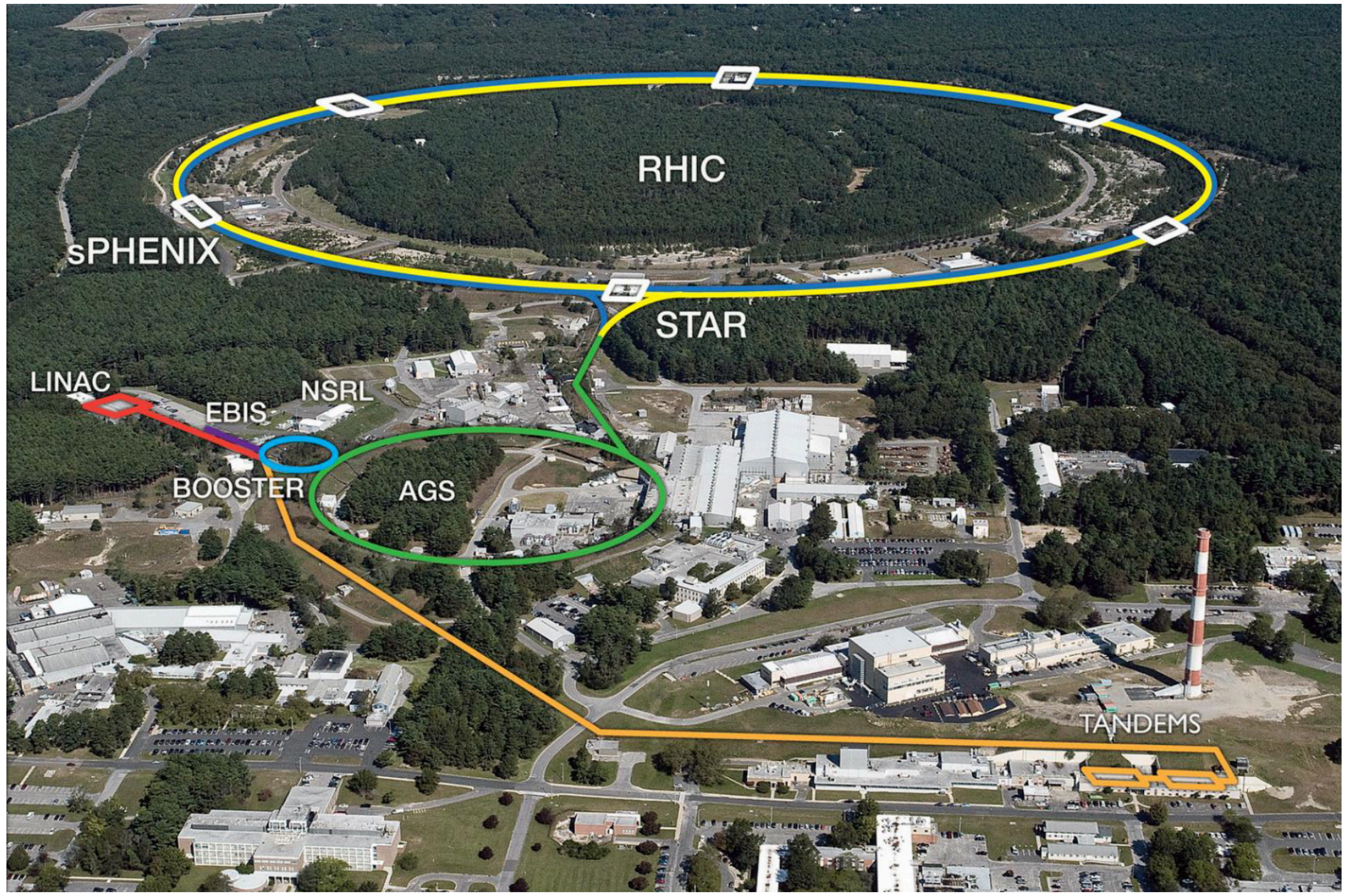
Self-normalize (per trigger)
Without model dependence

Dataset

2021 O+O $\sqrt{s_{NN}}$ = 200GeV

503M good events

Charged tracks with $0.2 < p_T < 30$ GeV/c



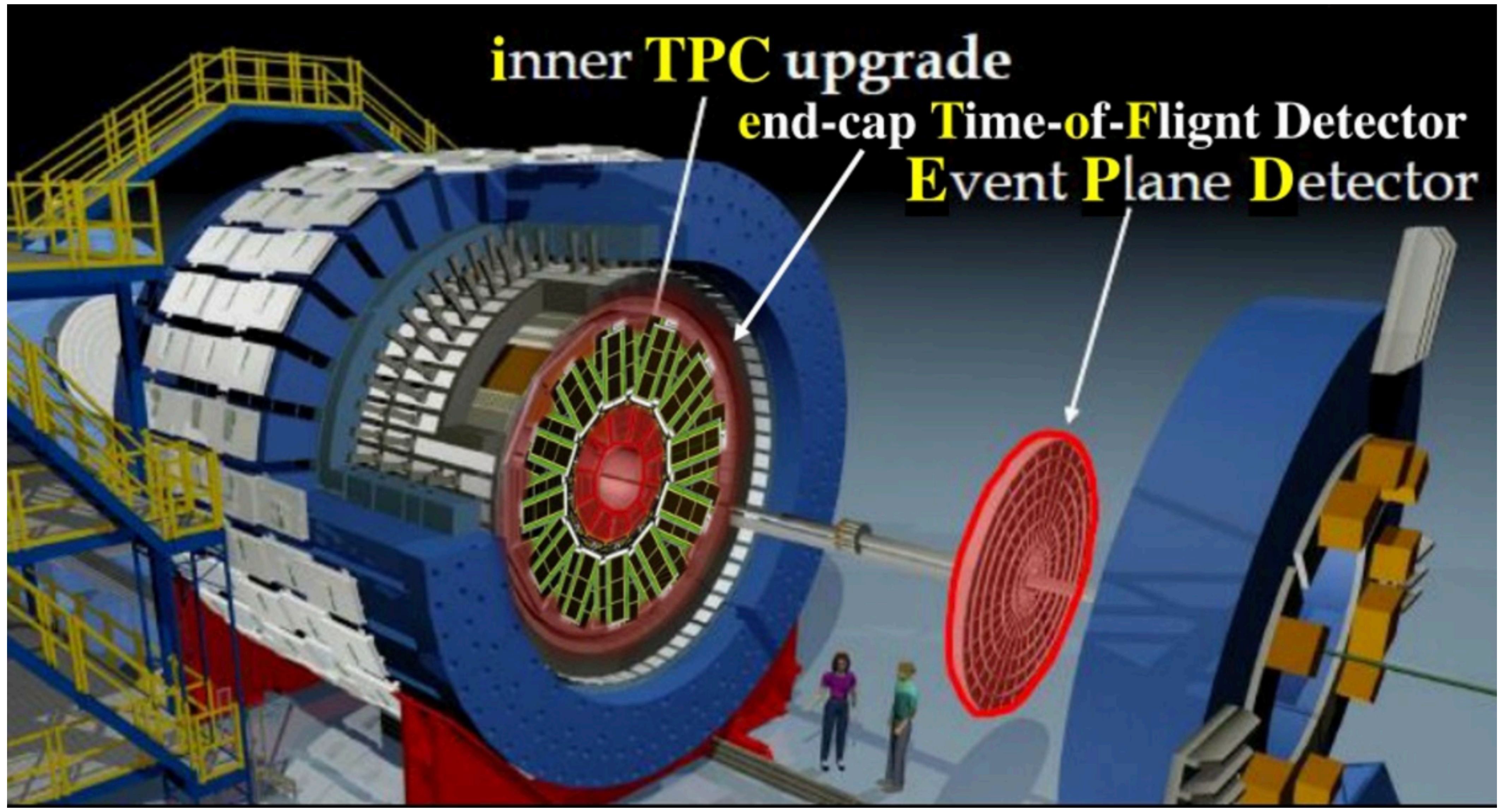
Solenoidal Tracker at RHIC (STAR)

- Time Projection Chamber (TPC)

  $|\eta| < 1.5$

- Event Plane Detector (EPD)

  $2.14 < |\eta| < 5.09$



Analysis procedure

Jet reconstruction
- h-jet
- Inclusive jet

→

Mixed event
Subtract uncorrelated background

→

Unfolding
Correct background fluctuations and detector effects

→

Observable
- I_{cp}
- R_{cp}

Jet reconstruction

Jet reconstruction
- h-jet
- Inclusive jet

→ **Mixed event** Subtract uncorrelated background → **Unfolding** Correct background fluctuations and detector effects → **Observable**
- I_{cp}
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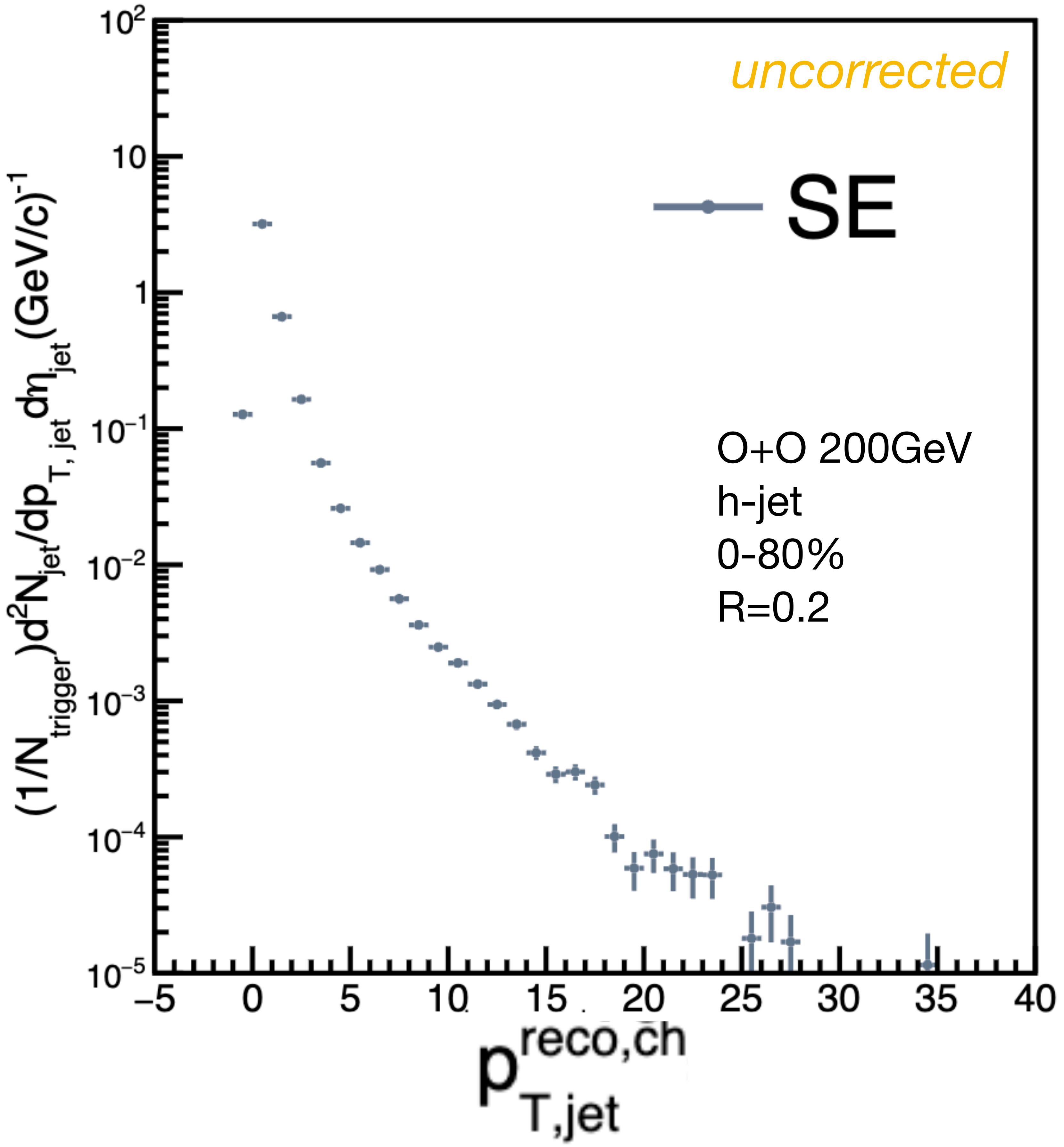

- Reconstruct jet from real event (same event, SE)
- Anti-k_T algorithm
- $|\eta_{jet}| = 1.5 - R_{jet}$
- $p_{T,jet}^{reco,ch} = p_{T,jet}^{raw,ch} - \rho' A (GeV/c)$

estimated background energy density :

$$\rho' = \underset{j \in \text{physical jets}}{\text{median}} \left\{ \frac{p_{Tj}}{A_j} \right\} \cdot C.$$

event occupancy C: the area $\sum_j A_j$ covered by physical jets divided by the total area A_{tot}

CMS, JHEP 2012,

Mixed event

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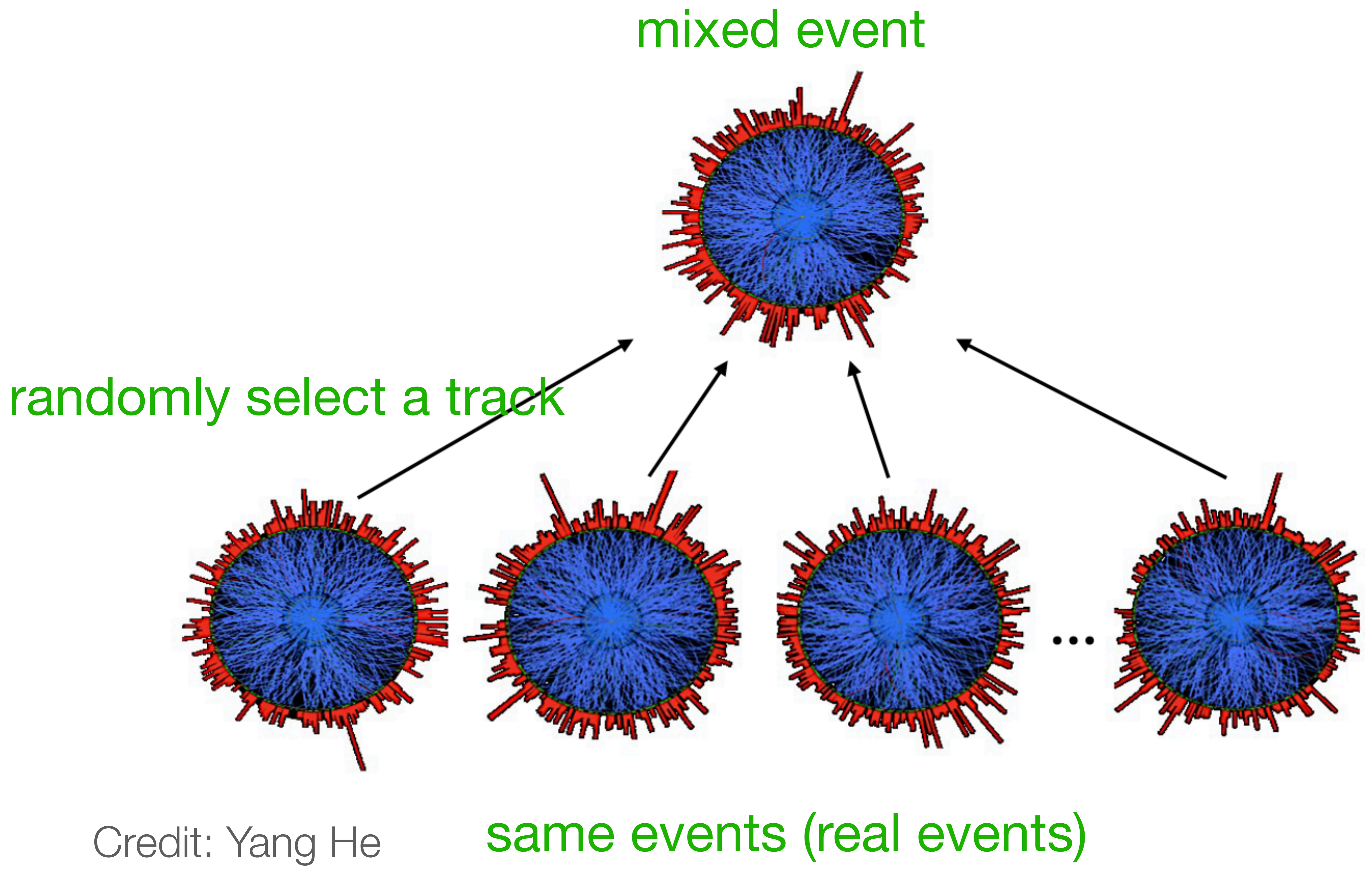

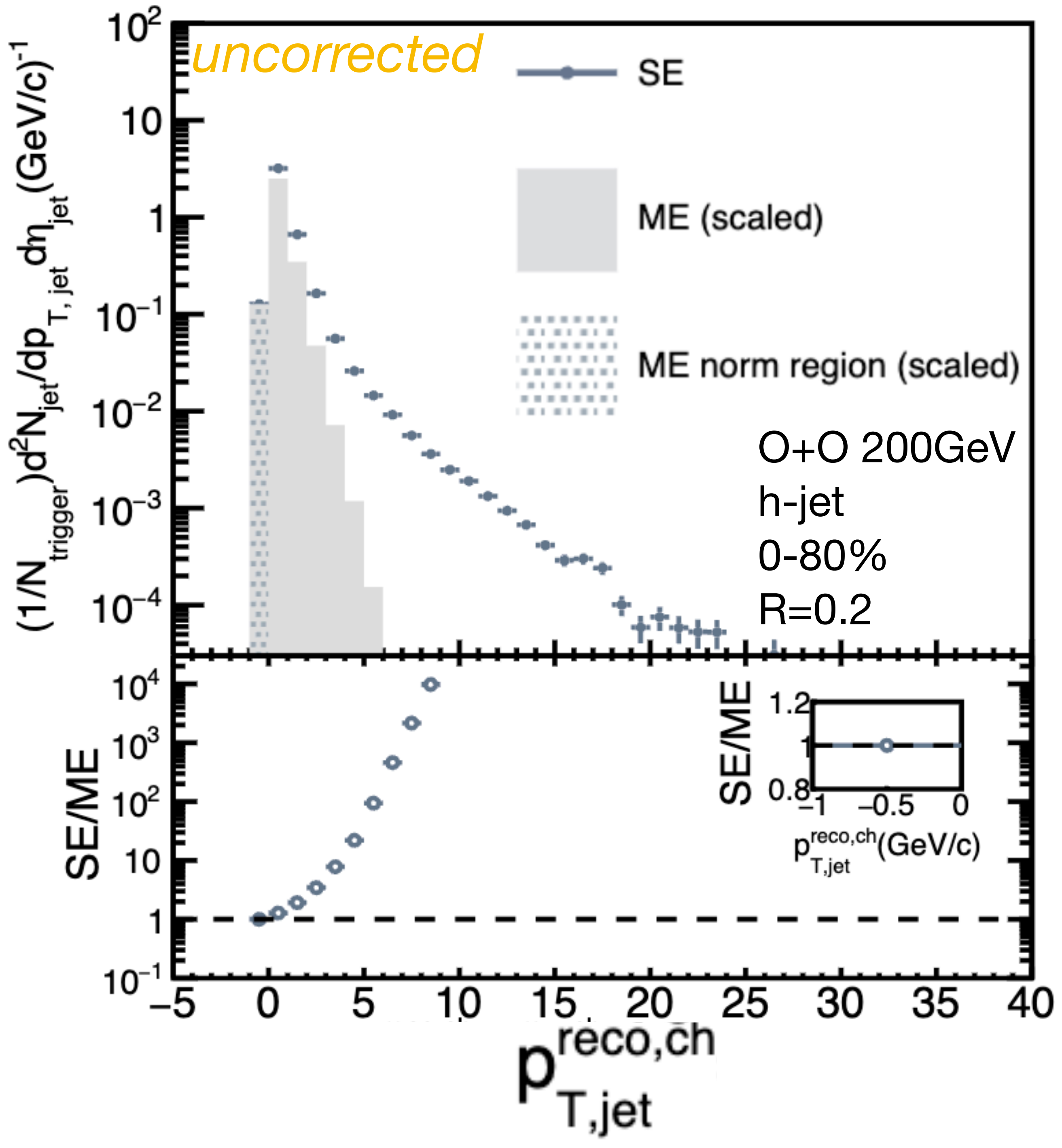

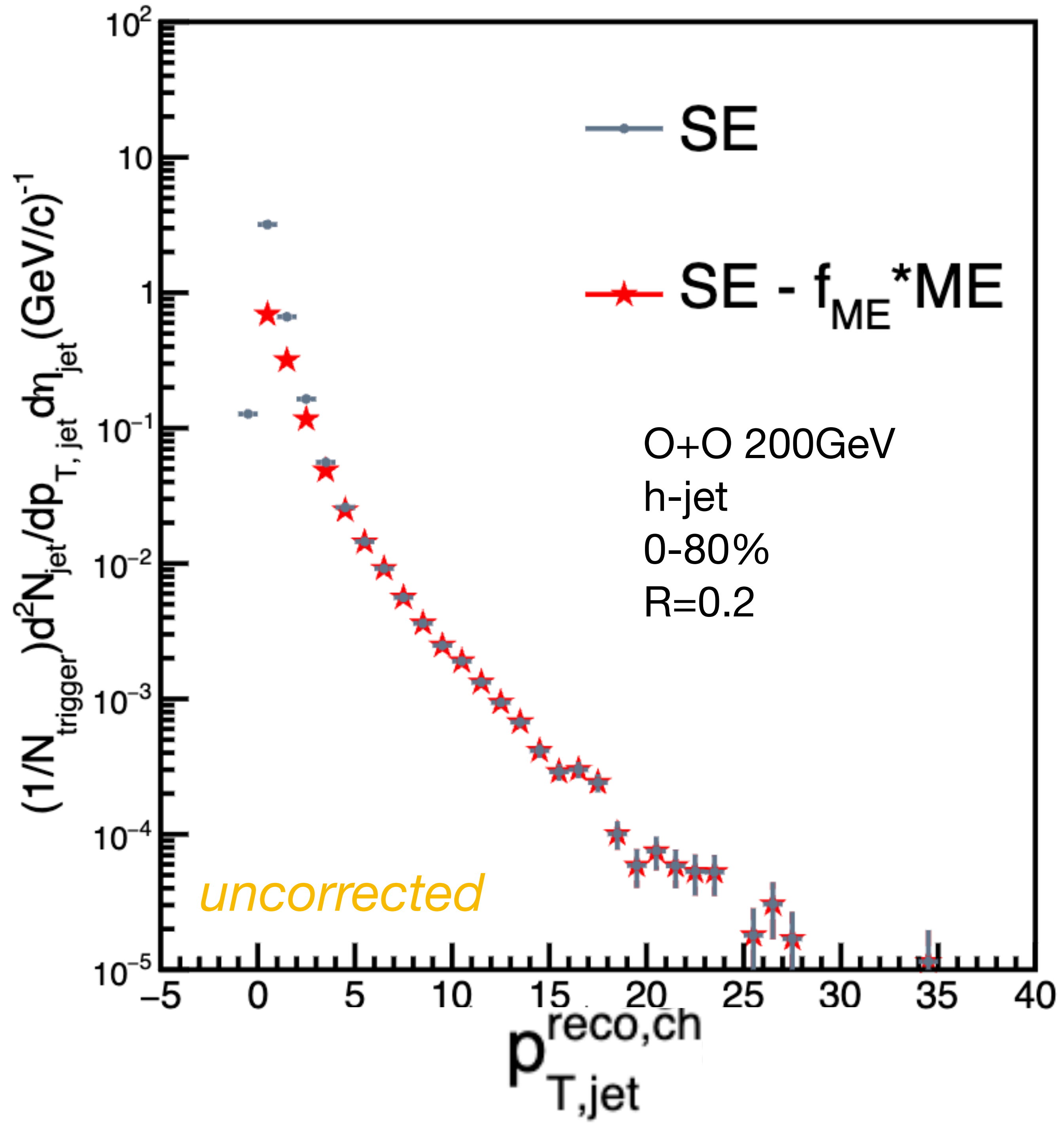

- f_{ME}: normalization parameter
- Combinatorial background is subtracted based on the event mixing technique

Semi-inclusive h-jet raw spectra

Jet reconstruction
- h-jet
- Inclusive jet

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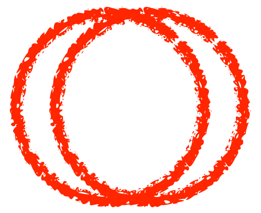
Subtract uncorrelated background

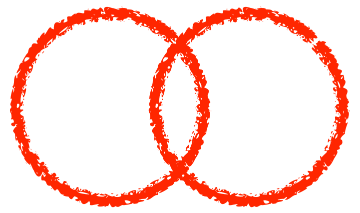
→ **Unfolding**
Correct background fluctuations and detector effects

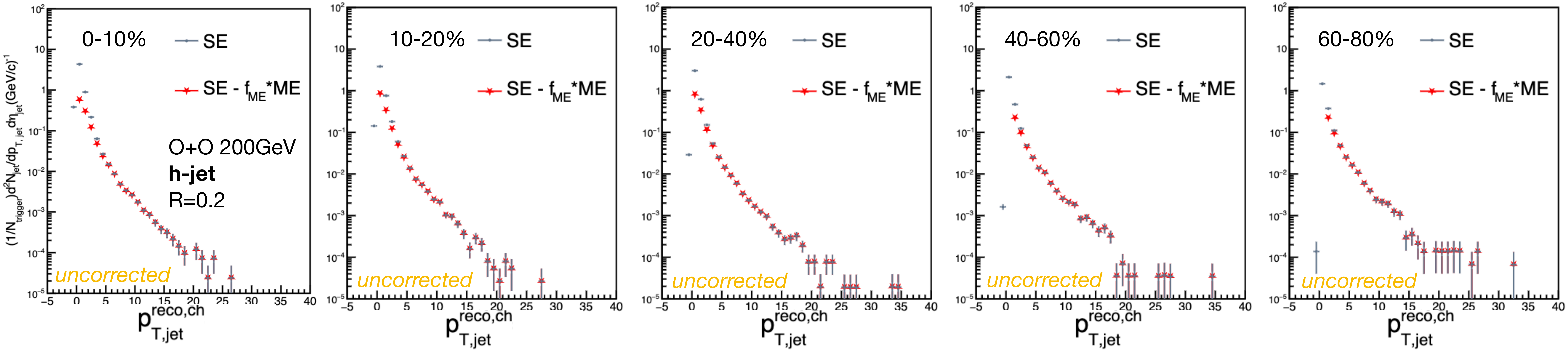
→ **Observable**
- I_{cp}
- R_{cp}

Central



Peripheral





- Obtain raw jet pT spectra of each centrality after uncorrelated background subtraction

Inclusive jet raw spectra

Jet reconstruction
- h-jet
- Inclusive jet

→ **Mixed event**
Subtract uncorrelated background

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- I_{cp}
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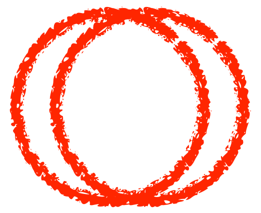
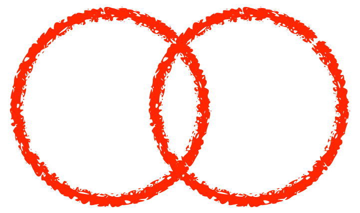
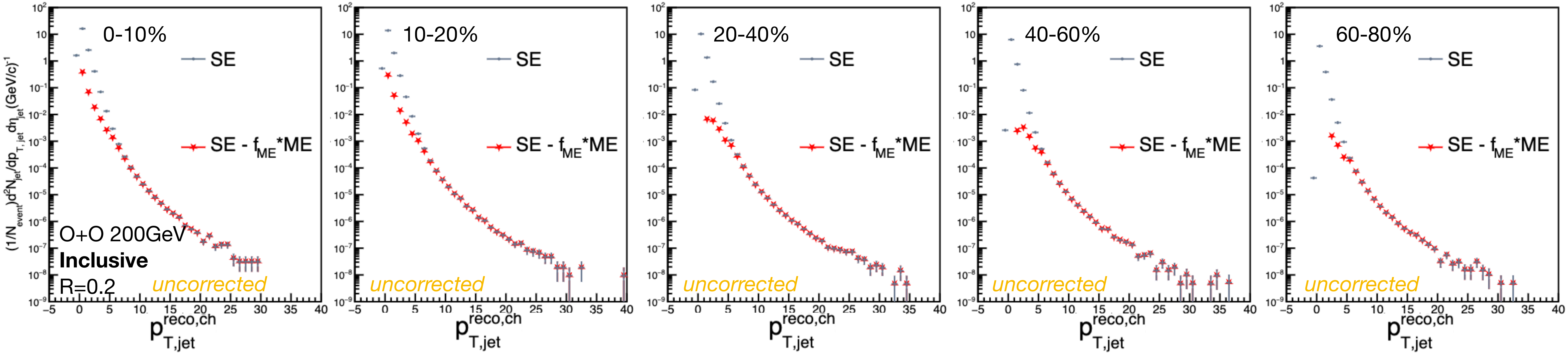


Peripheral





- Obtain raw jet pT spectra of each centrality after uncorrelated background subtraction

Unfolding procedure

Jet reconstruction
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- Inclusive jet

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Subtract uncorrelated background

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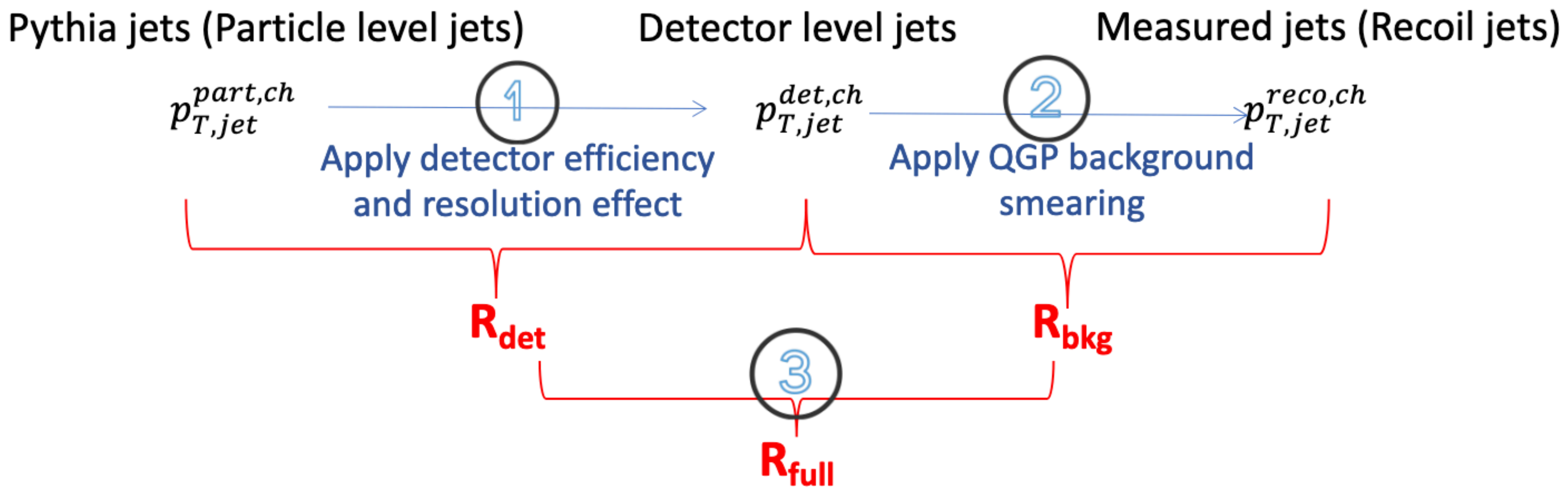
Correct background fluctuations and detector effects

→ **Observable**
- I_{cp}
- R_{cp}



- Obtain response matrix by fast simulation
- Background fluctuations and detector effects will be corrected by unfolding

Response matrix *(ongoing)*

Jet reconstruction
- h-jet
- Inclusive jet

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Subtract uncorrelated background

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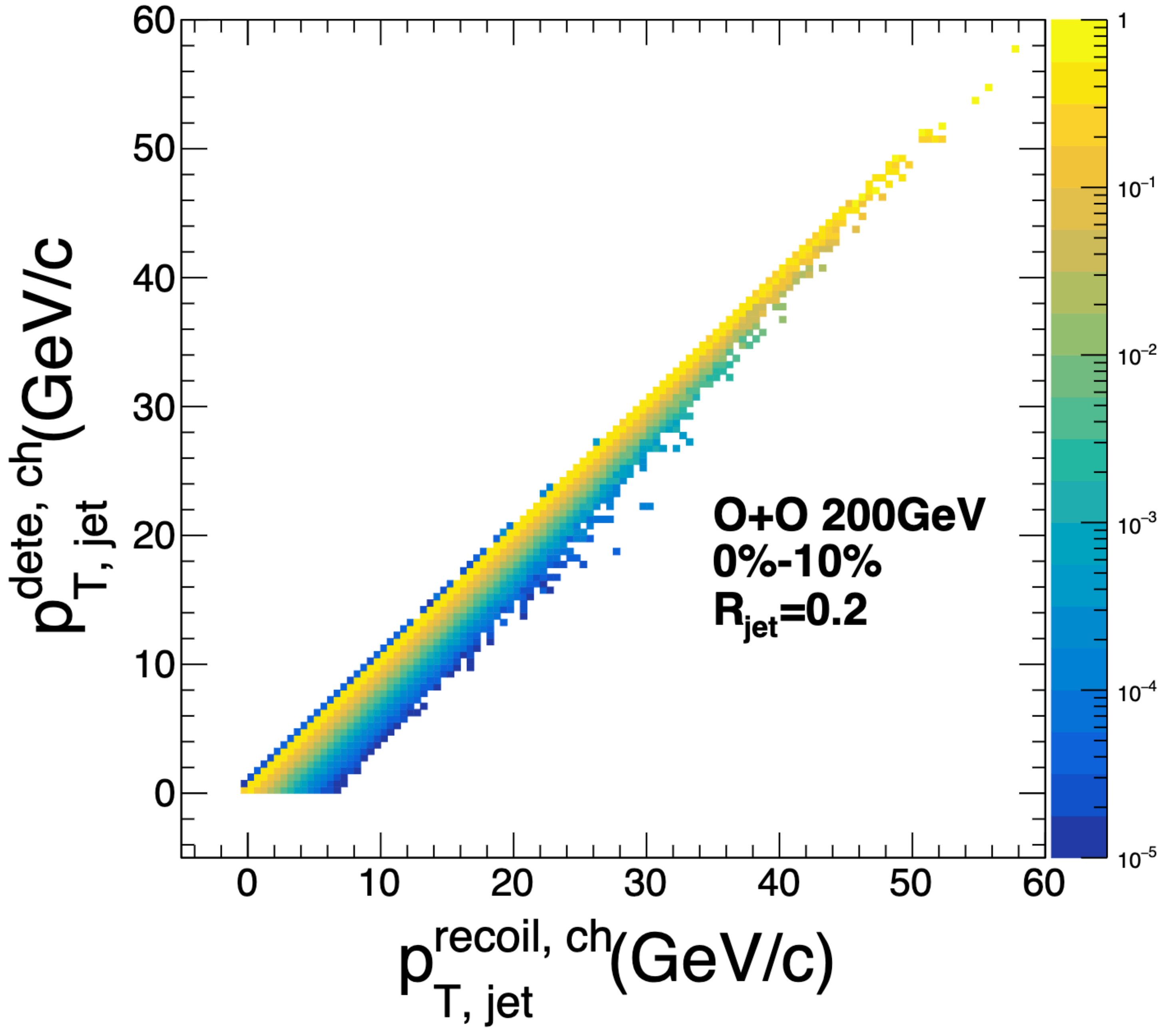
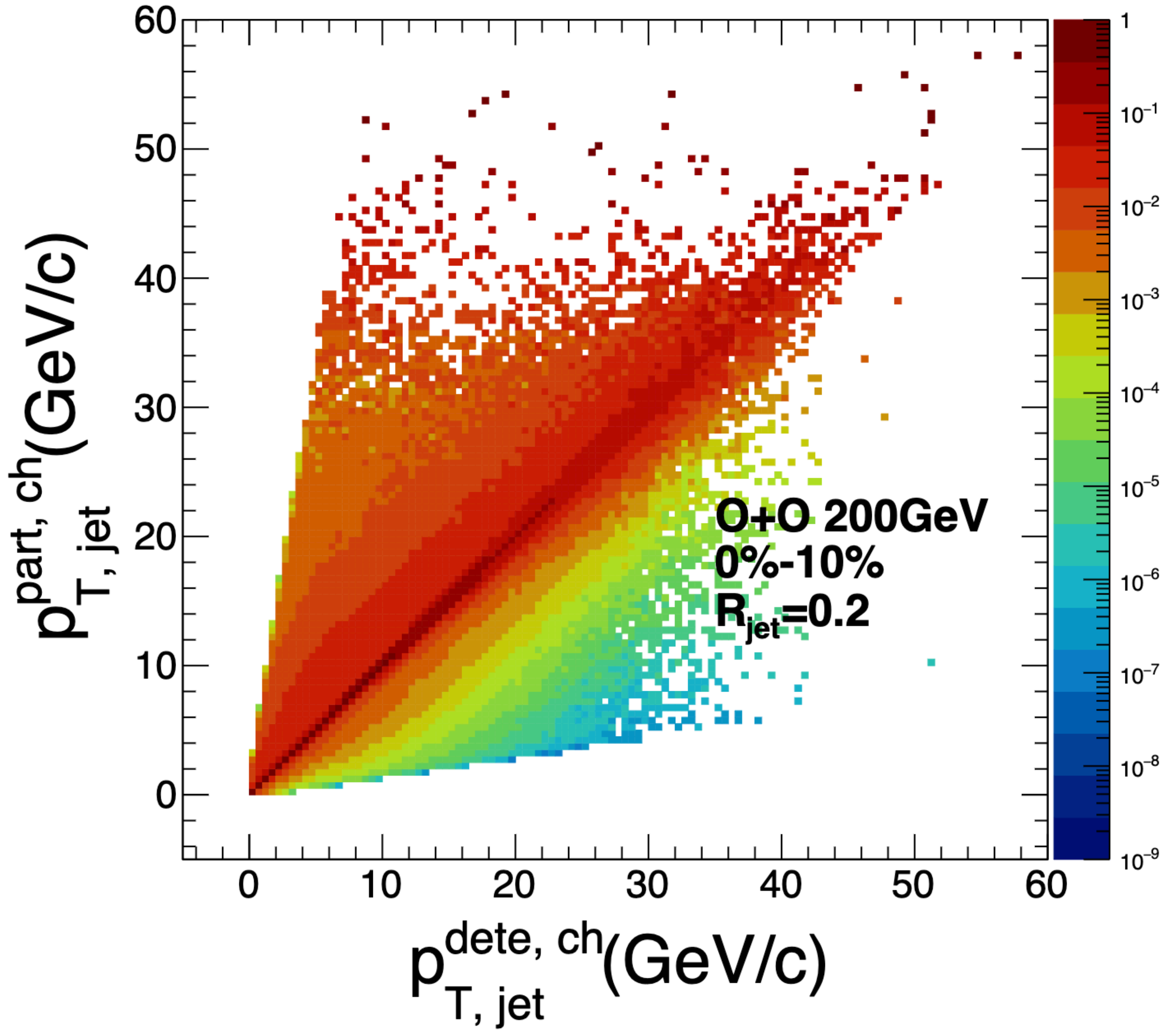
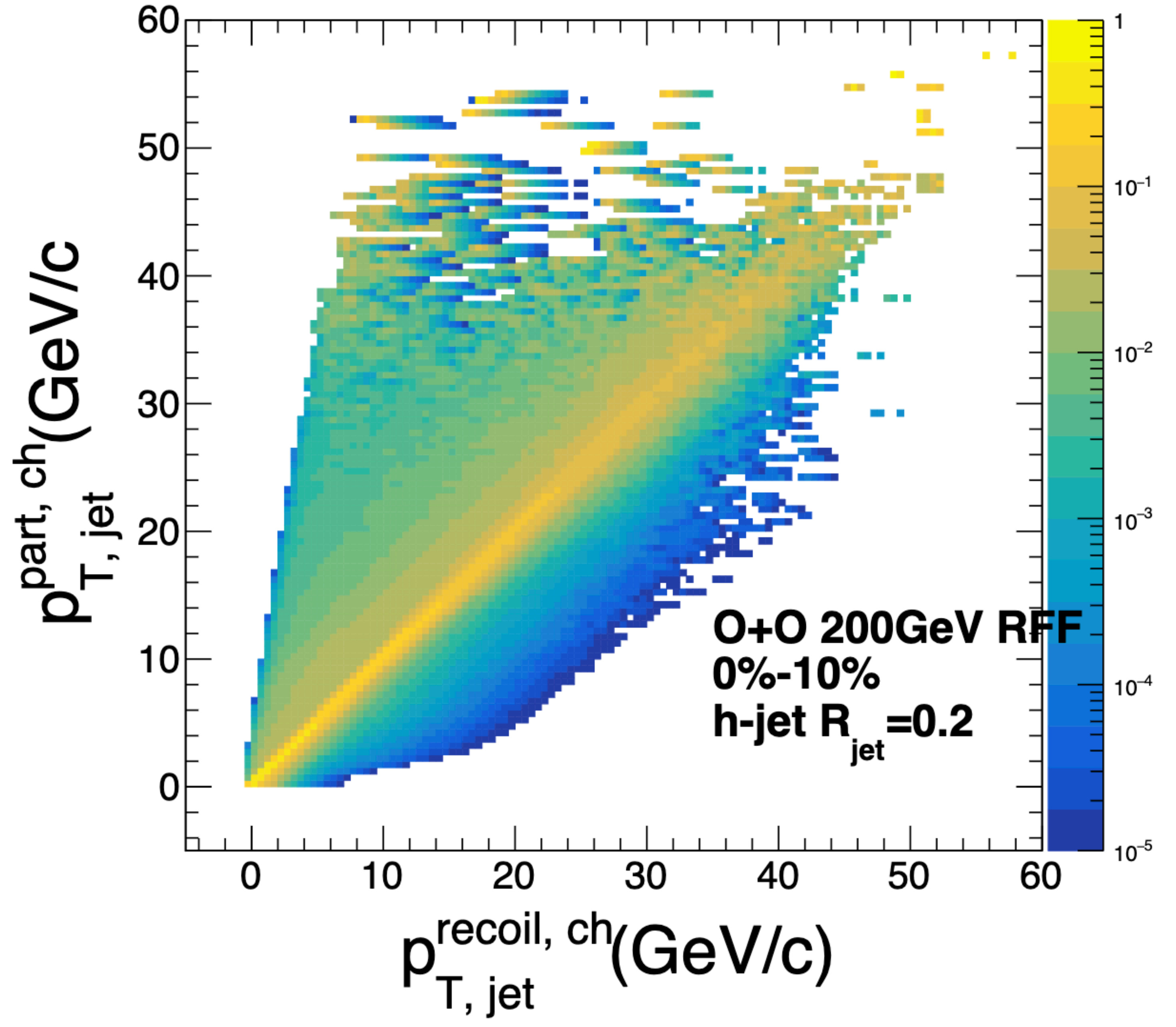
Correct background fluctuations and detector effects

→ **Observable**
- I_{cp}
- R_{cp}

R_{bkg} × R_{det} = R_{full}







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Summary

- A first look at h-jet and inclusive jet in O+O 200GeV.
- Raw jet pt spectra for each centrality class are obtained.

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Outlook

- Fully corrected spectra, R_{cp} and I_{cp}.
- Systematic uncertainty
- Compare to similar measurements in collision systems of various sizes.

Thank you!

Backup

Event cuts and track cuts

Event cuts	-30 < Vz < 30 cm Vr < 2 cm
Track cuts	pT > 0.2 GeV |eta| < 1.5 DCA < 1cm nHitsFit > 15 for TPC Sign DCA < 0.5(Pos), sign DCA > -0.5(Neg) nHitsFit/nHitPoss > 0.52

Background subtraction

- **Average background contribution**

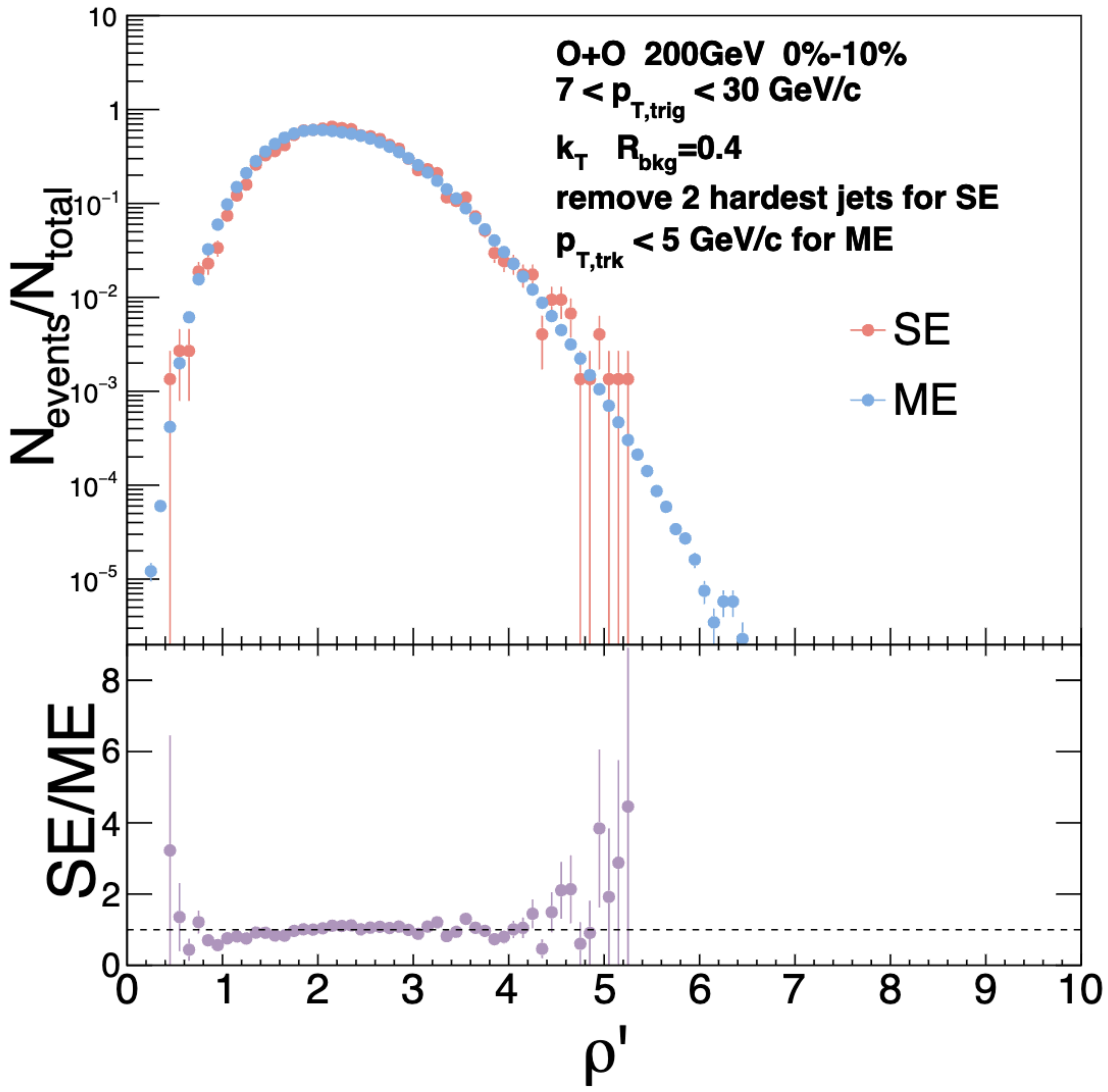
$$p_{\mathrm{T,jet}}^{\mathrm{reco,ch}} = p_{\mathrm{T,jet}}^{\mathrm{raw,ch}} - \rho \cdot A$$

ρ = estimated background energy density

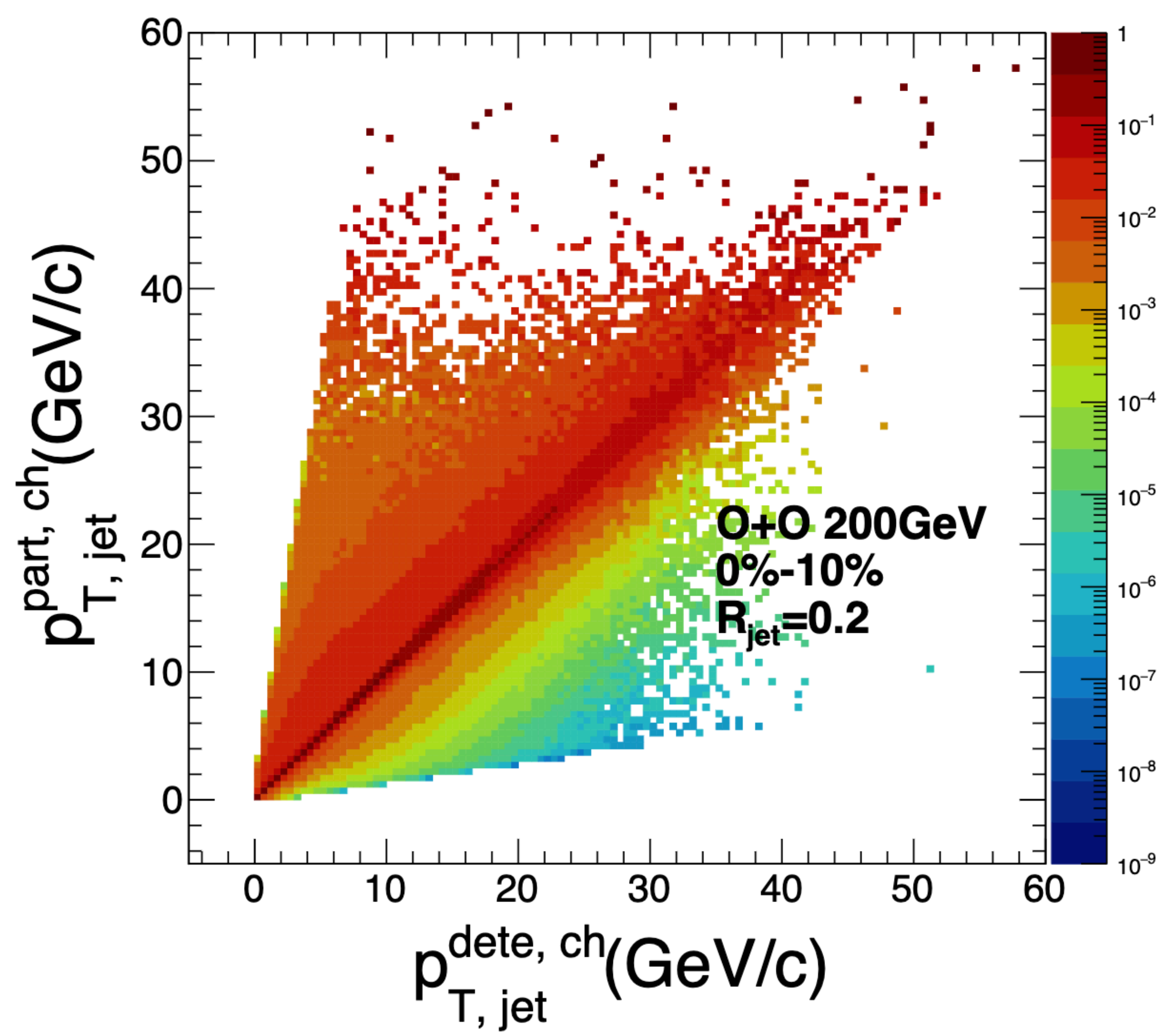
$$\rho' = \underset{j \in \text{physical jets}}{\text{median}} \left\{ \frac{p_{\mathrm{T}j}}{A_j} \right\} \cdot C.$$

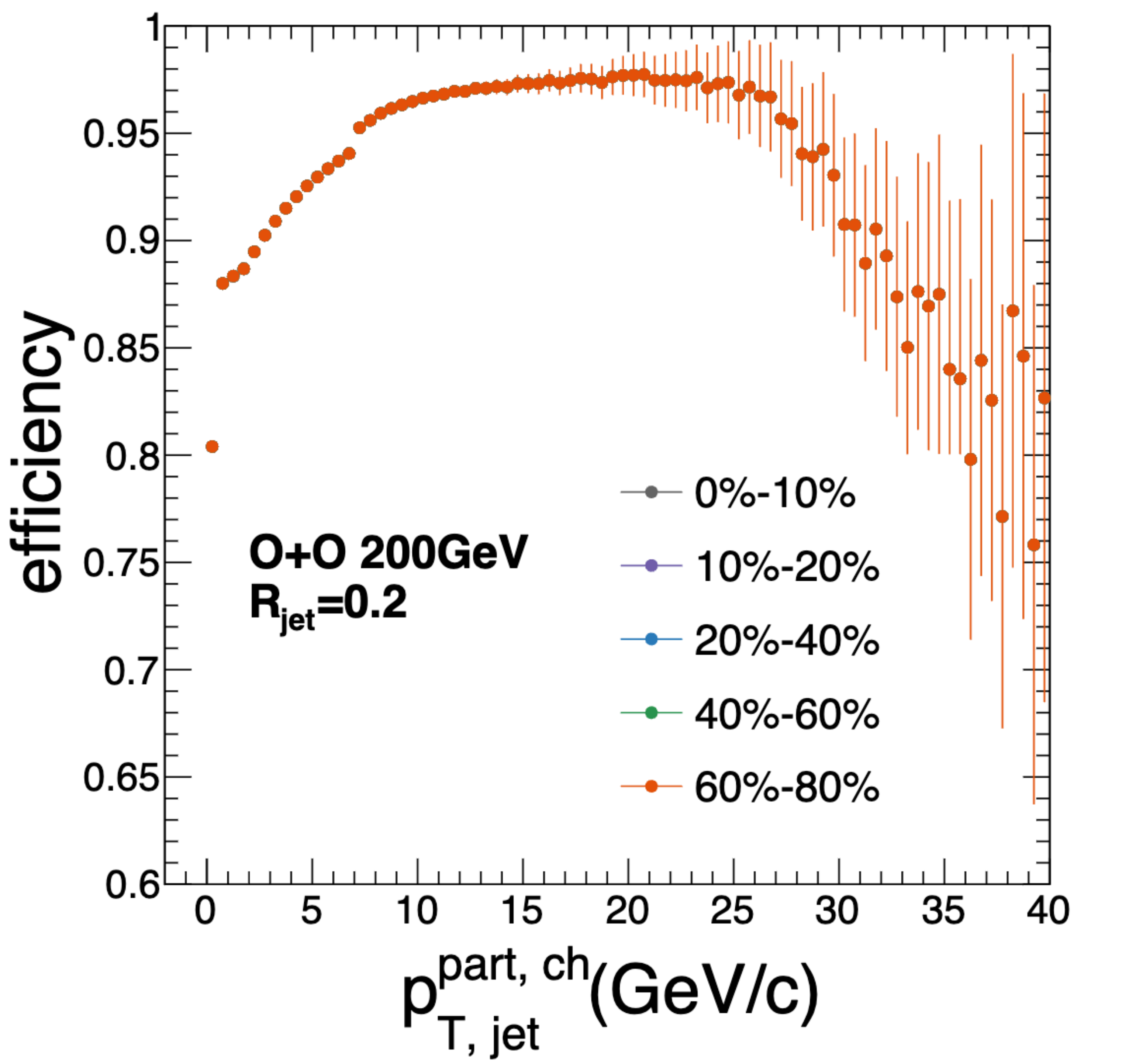
event occupancy C:
the area $\sum_j A_j$ covered by physical jets
divided by the total area A_{tot}

CMS, JHEP 2012, 130.



Detector matrix (R_{det})





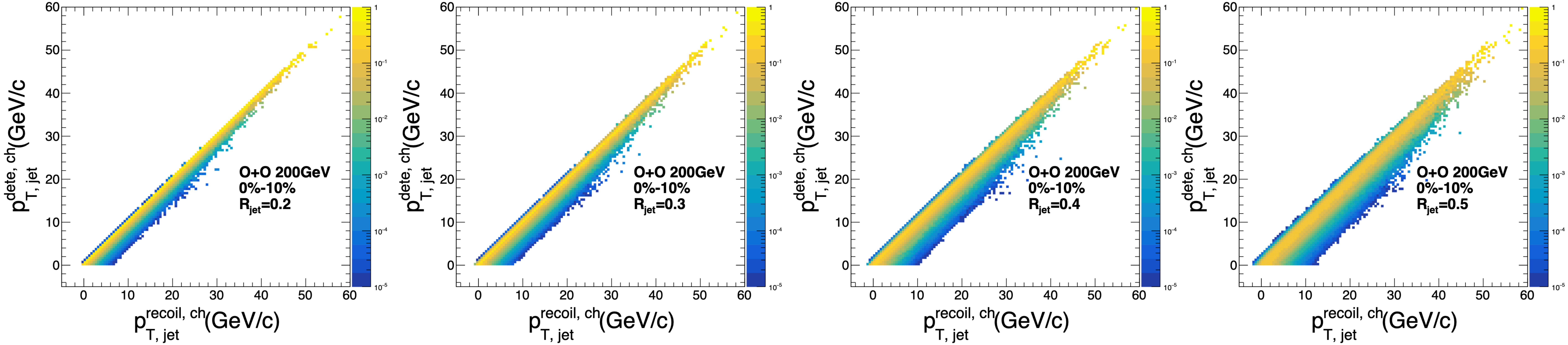
- jets at two levels are closest to each other.
- the distance between jets at the two levels is less than R_{jet}
- $\frac{p_{T,jet}^{dete}}{p_{T,jet}^{part}} > 0.15$ && $\frac{p_{T,jet}^{part}}{p_{T,jet}^{dete}} > 0.15$

$$jet\ match\ efficiency = \frac{matched\ particle\ jets}{all\ particle\ jets}$$

Background smearing

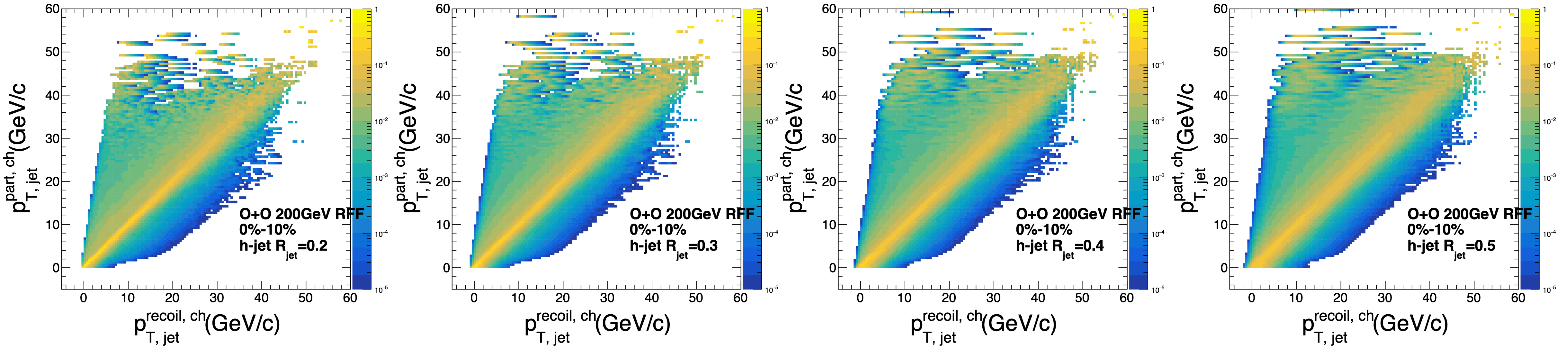
- Background fluctuations can influence the jet pt
- embed single particle to real O+O data
- $\delta p_T = p_{T,jet}^{reco,ch} - p_T^{embed}$

Background matrix (R_{bkg})



- apply delta pt to detector level jet

Multiplied matrix (R_{full})



$$R_{\text{full}}(p_{\text{T,jet}}^{\text{reco,ch}}, p_{\text{T,jet}}^{\text{part,ch}}) = R_{\text{bkg}}(p_{\text{T,jet}}^{\text{reco,ch}}, p_{\text{T,jet}}^{\text{det,ch}}) \times R_{\text{det}}(p_{\text{T,jet}}^{\text{det,ch}}, p_{\text{T,jet}}^{\text{part,ch}})$$