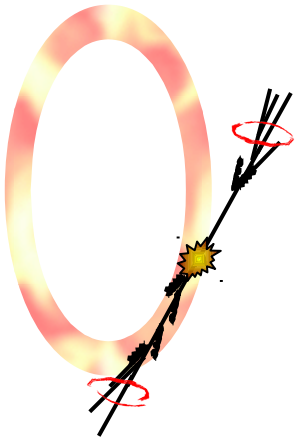
# Isolated photon measurements in pp and PbPb collisions with CMS

R. Alex Barbieri
MIT
For the CMS Collaboration

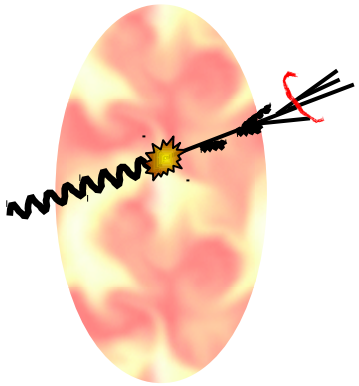
Hard Probes 2013
Stellenbosch Institute For Advanced Study
Stellenbosch, South Africa

# Strong probes have surface bias

- Colored probes (dijets) occur frequently
- Dijets have two drawbacks:
  - Surface bias of data sample
  - Loss of information about initial energy
- Solution: tag strong probe (jet) with EW probe (photon)



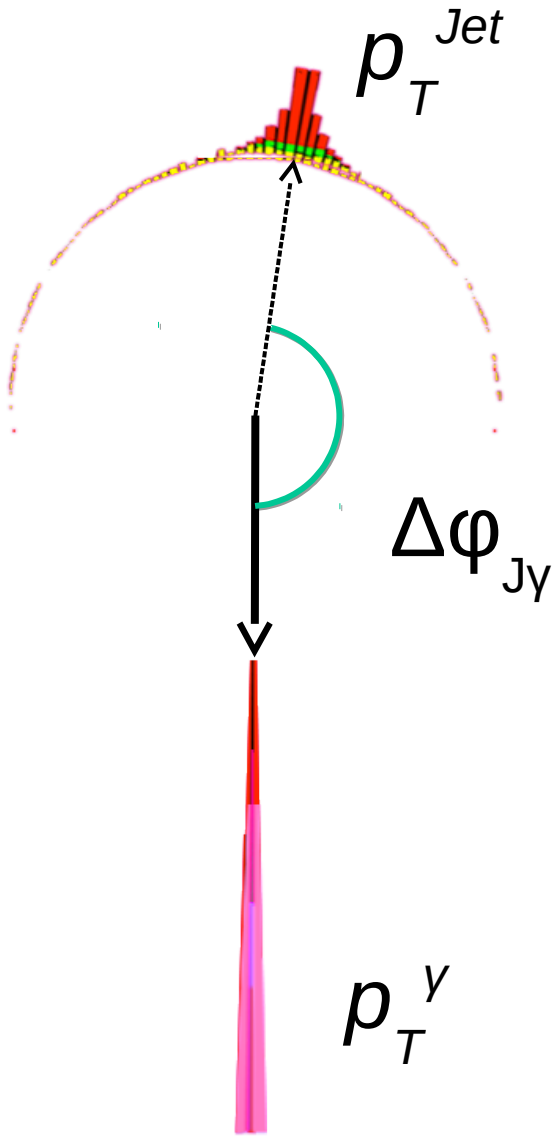
High statistics, with surface bias



Lower statistics, without surface bias

# Observables

- Azimuthal decorrelation: $\Delta\varphi_{Jy}$, and its parametrized width $\sigma(\Delta\varphi_{Jy})$
- Transverse momentum ratio: $x_{Jy}=p_T^{Jet}/p_T^{y}$, and its mean $\langle x_{Jy}\rangle$
- Fraction of photons with associated jets: $R_{jy}$
- Ratio of jet yield, Jet $I_{AA}$: number of jets in each $p_T^{y}$ and $p_T^{Jet}$ bin in PbPb over the number in pp.



# Analysis

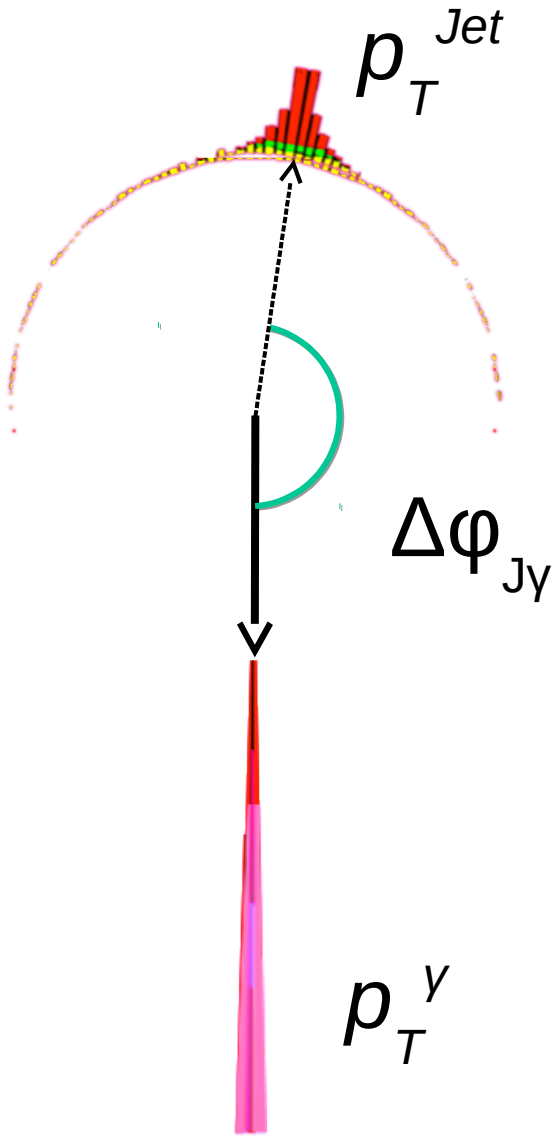
- Select leading isolated photon in event, correlate with all jets in event
- Apply background subtraction
  - Background from:
    - Decay/fragmentation photons ($\pi^0$, $\eta$)
    - Fake jets in underlying event
  - Rejected using
    - Isolation requirement (after a UE subtraction in PbPb)
    - Statistical subtraction of background photons based on purity
    - Subtraction of jets from mixed event

# Background subtraction

- UE subtraction of photon isolation in PbPb
  - Isolation calculated as energy in cone of R=0.4
  - Avg. energy in area containing cone but extending to full $2\pi$ is subtracted from isolation
- Subtraction of uncorrelated jets
  - Photons correlated with jets from a different hard scattering
  - Correlation from second hard scattering subtracted
- Statistical subtraction of decay photons
  - Photon purity calculated with template method in calorimeter shower-shape variable
  - Each observable subtracted using background-enriched sample from shower-shape sideband

# Kinematics

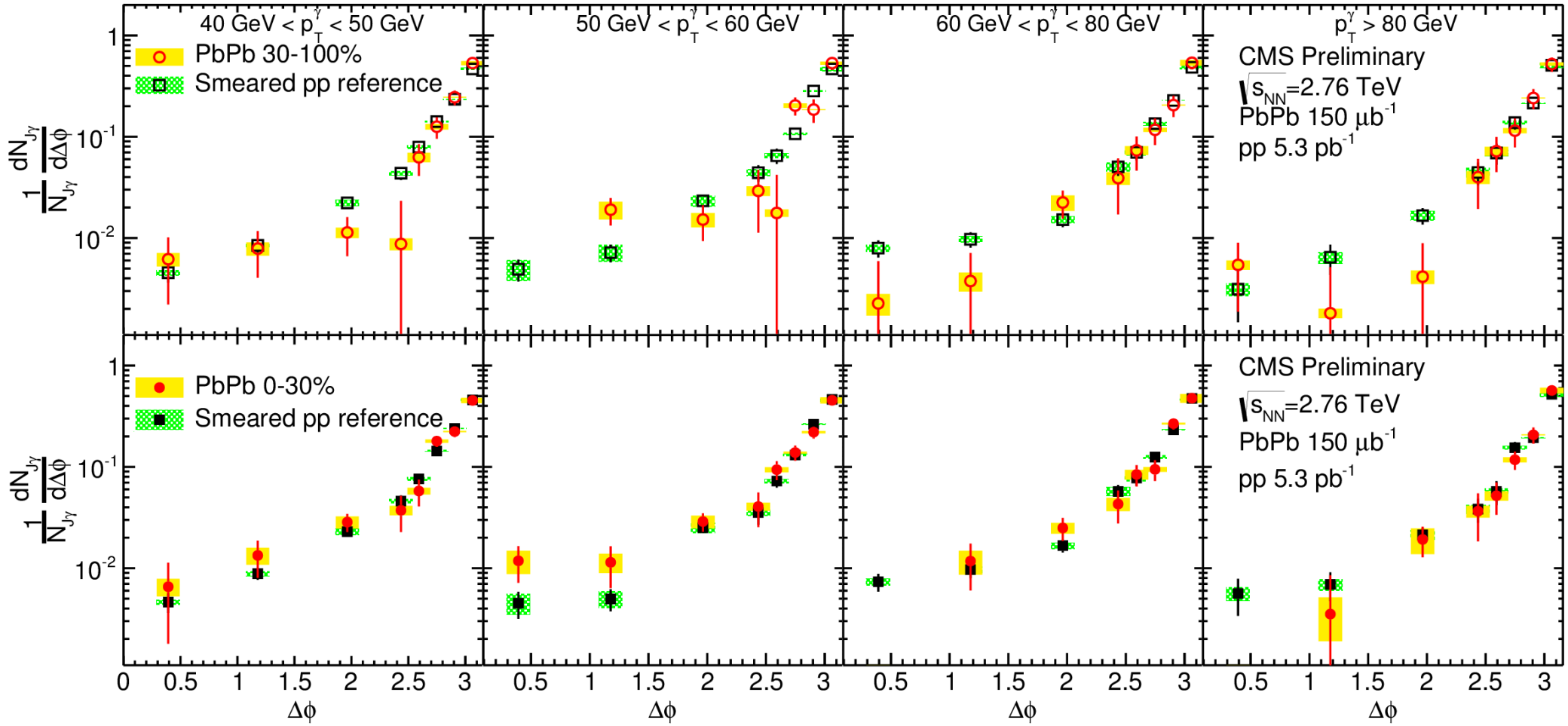
- Photons
  - $p_T^{\gamma} > 40$ GeV ( > 60 GeV for $p_t^{\gamma}$ inclusive plots)
  - $|\eta^{\gamma}| < 1.44$
  - $p_T^{\gamma}$ bins: [40-50], [50-60], [60-80], [80+] GeV
- Jets
  - Anti-$k_T$ particle-flow jets, R=0.3, UE subtracted
  - $p_T^{Jet} > 30$ GeV
  - $|\eta^{Jet}| < 1.6$
  - ALL jets in each event which meet criteria are included, not just leading.
- Photon-jet pairs
  - $\Delta\varphi > 7\pi/8$
  - Centrality bins: [100-50], [50-30], [30-10], [10-0]%



# Data samples and goals

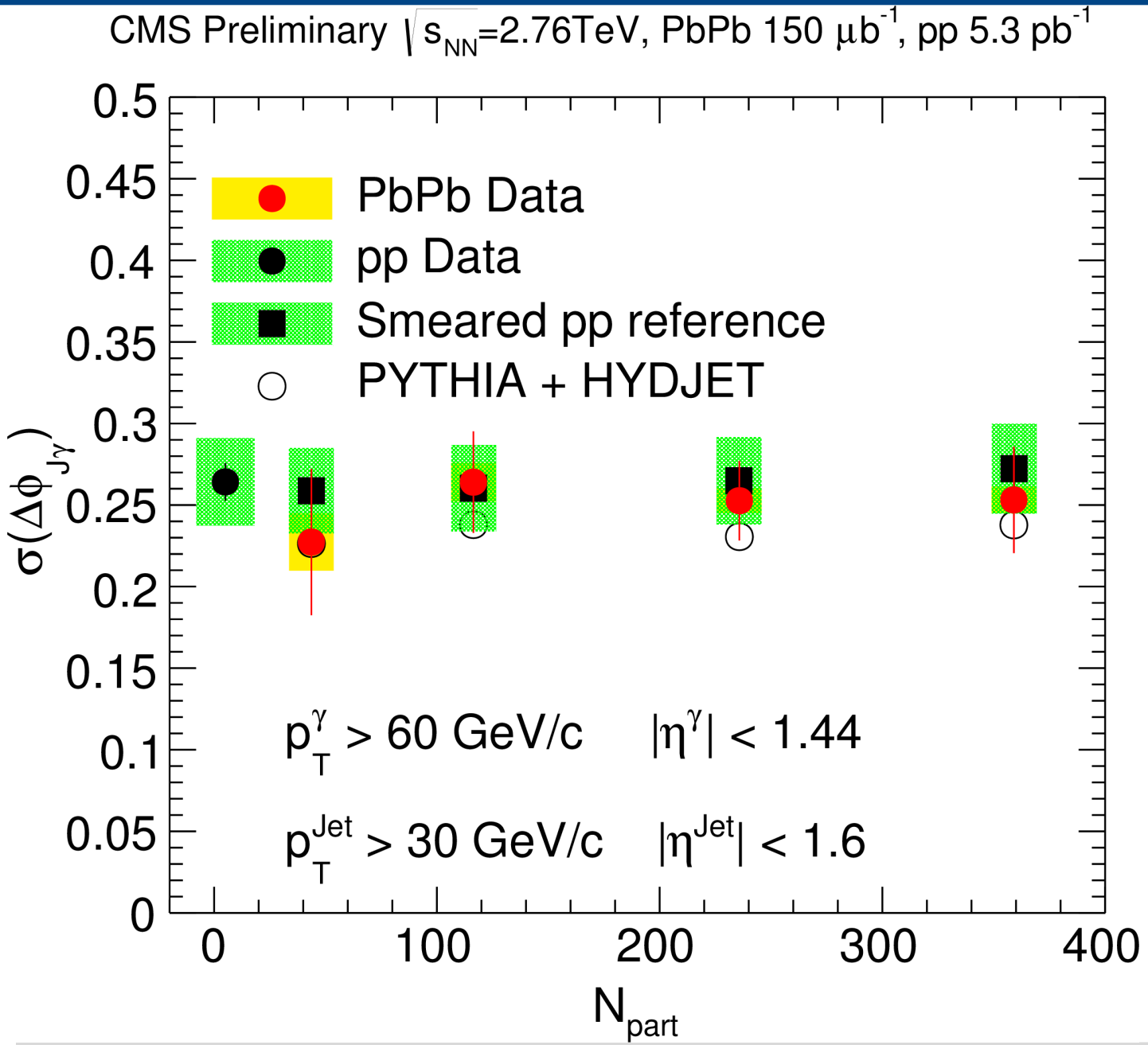
- Data used in this analysis:
  - 2011 PbPb data at 2.76 TeV, 150 $\mu b^{-1}$
  - 2013 pp data at 2.76 TeV, 5.3 $pb^{-1}$
  - 2013 pPb data at 5.02 TeV, 30.4 $nb^{-1}$
- Update of the previous CMS analysis, Phys. Lett. B 718 (2013) 773, with new pp data reference
- $p_T^y$ dependent analysis accesses energy loss as a function of initial parton momentum
- pPb offers insight into cold nuclear matter effects

# No jet deflection observed



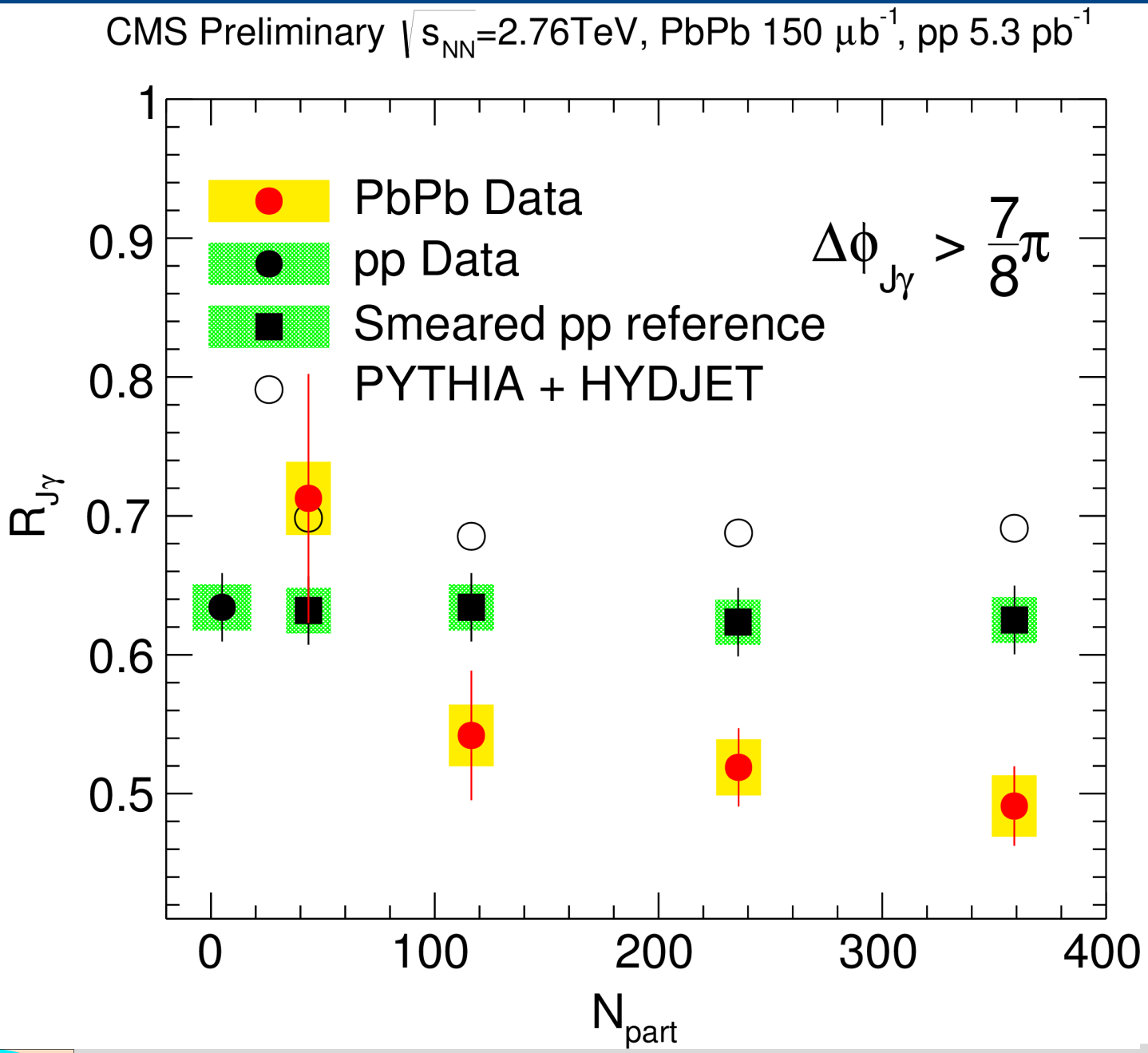

CMS-PAS-HIN-13-006

# No jet deflection observed




CMS-PAS-HIN-13-006

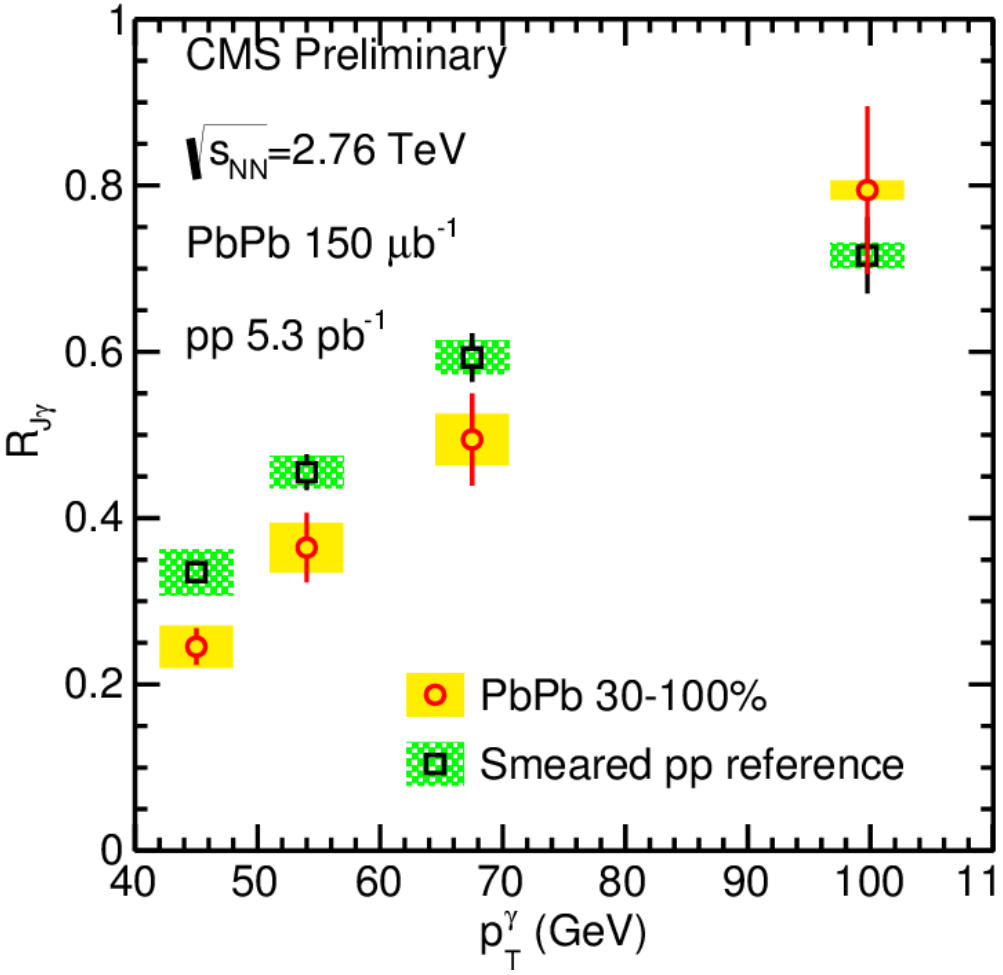
# Significant loss of jet partners with centrality

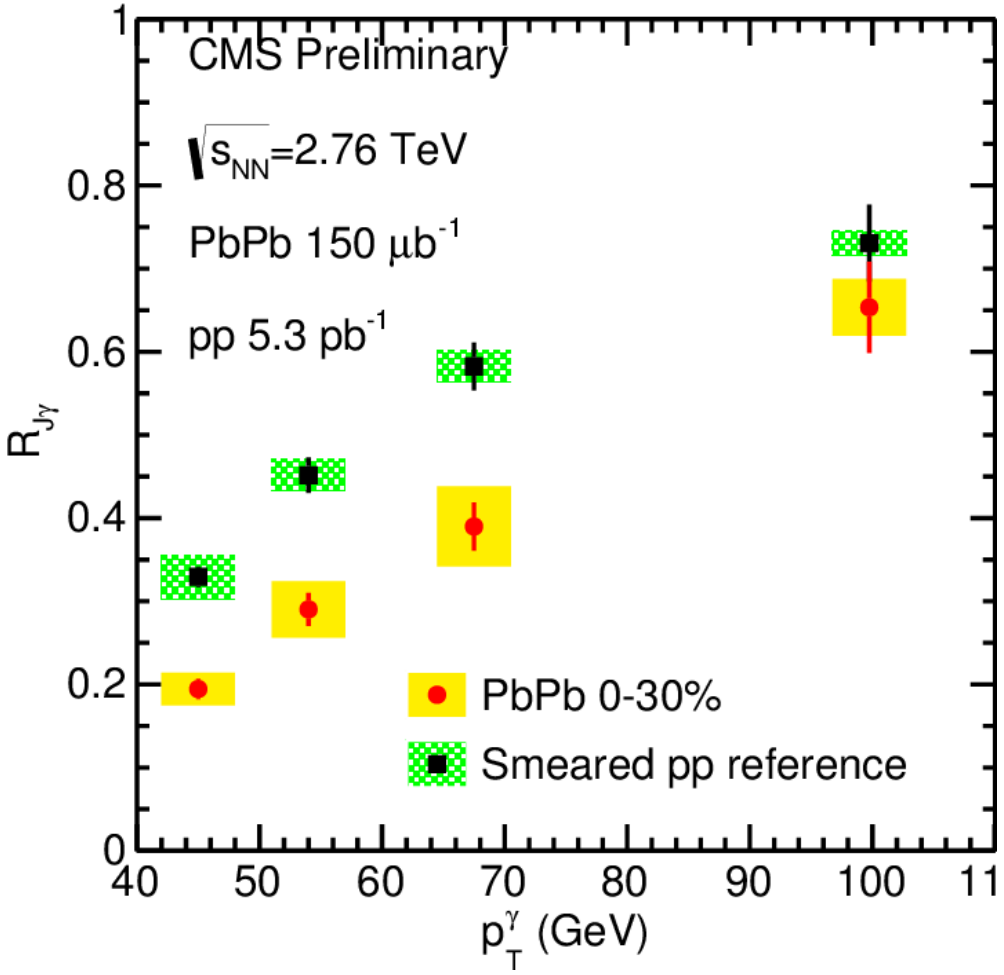



$R_{J\gamma}$ = Fraction of photons with jet partner

CMS-PAS-HIN-13-006

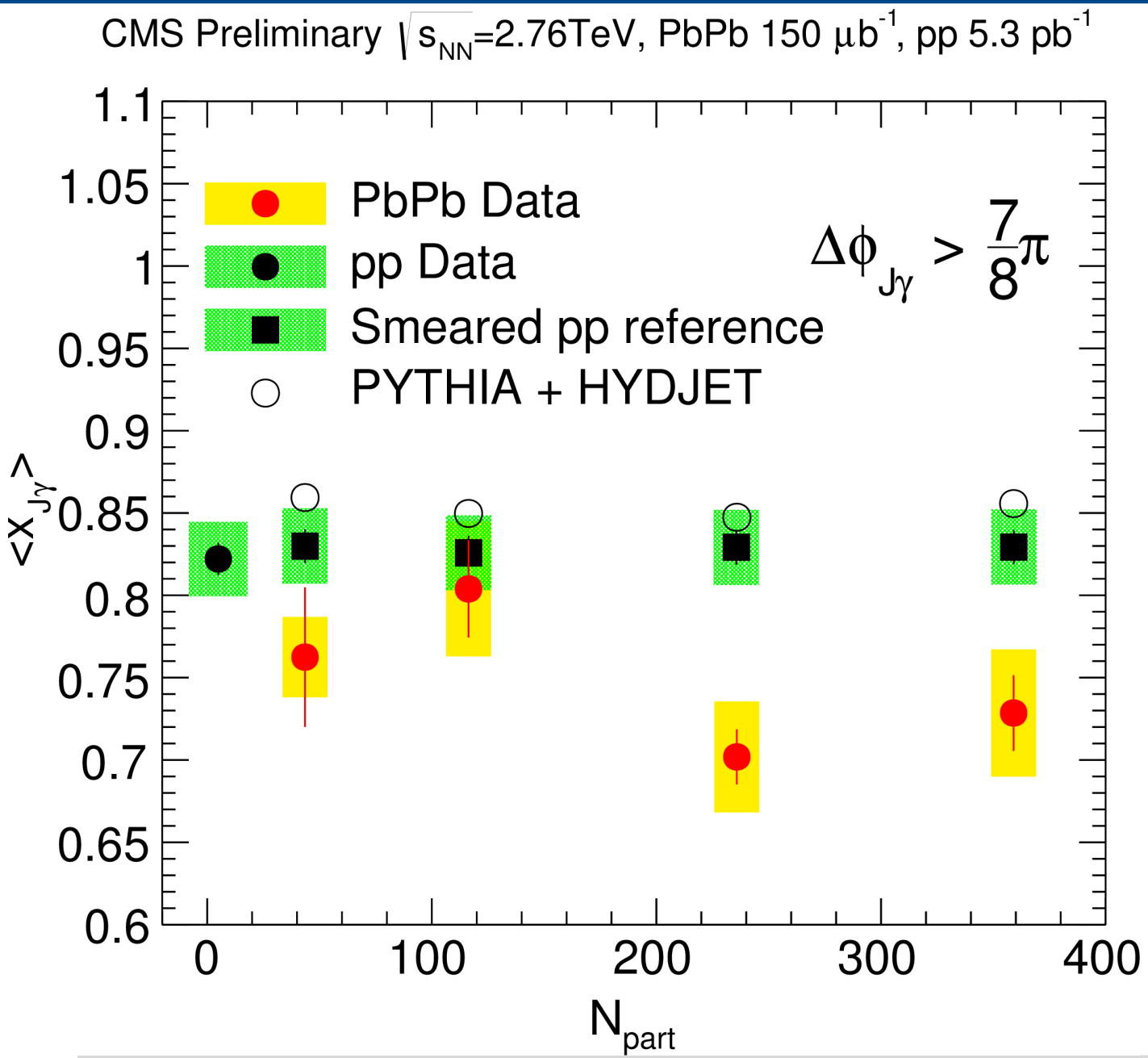
# Loss of jet partners constant over $p_T^{\gamma}$




CMS-PAS-HIN-13-006

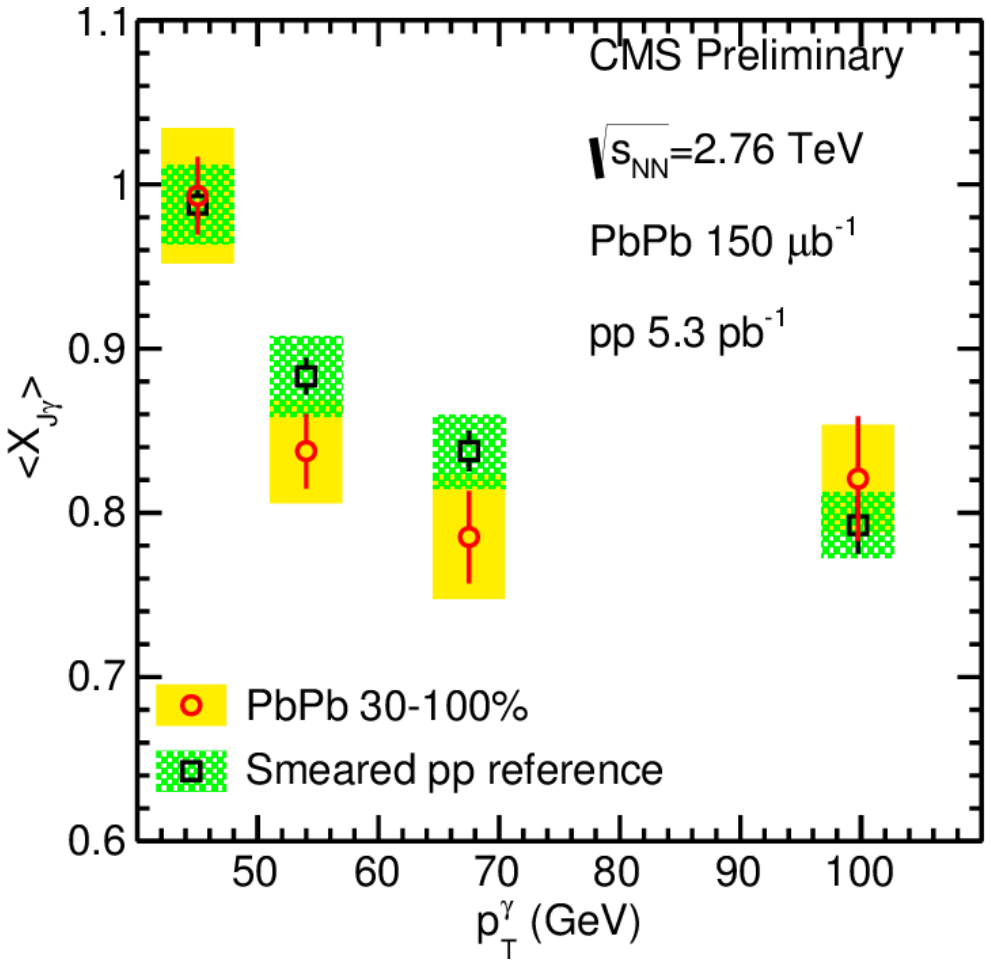
# Shift to lower $x_{J\gamma}$ with centrality

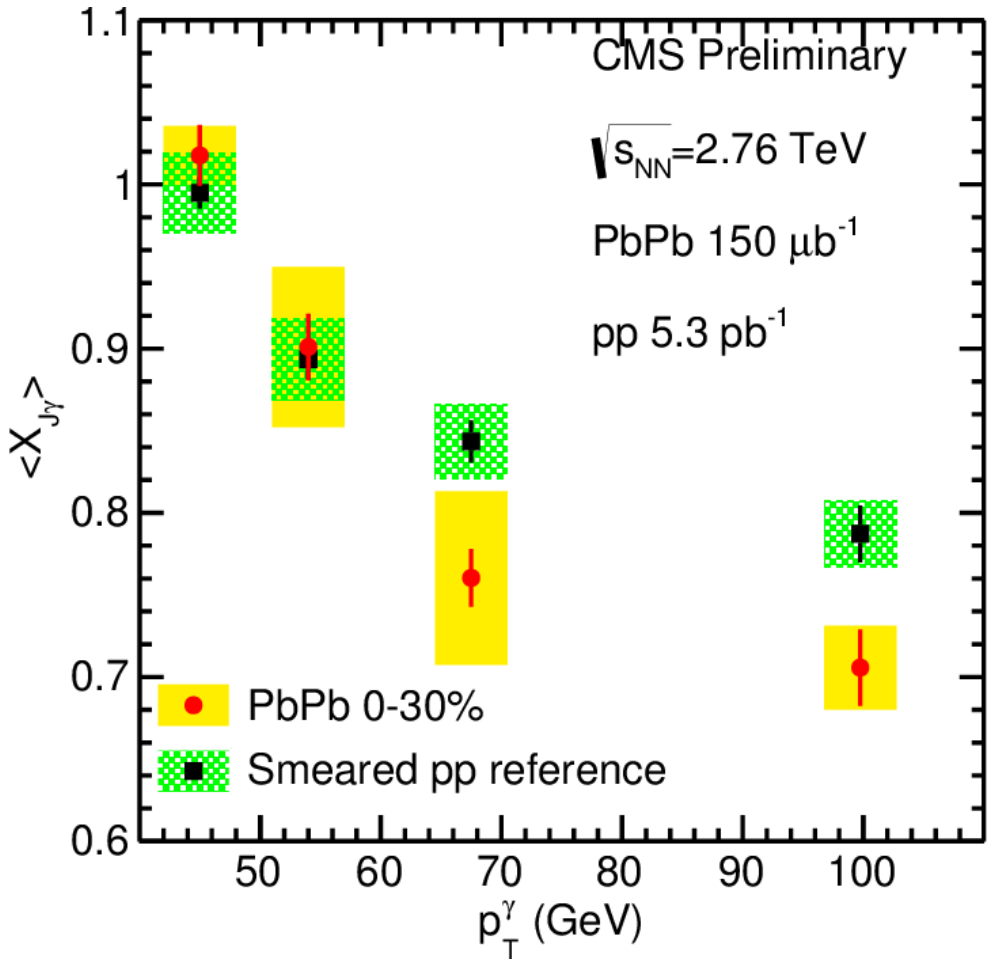



$$x_{J\gamma} = p_T^{Jet}/p_T^{\gamma}$$

CMS-PAS-HIN-13-006

# Shift to lower $x_{Jy}$ with $p_T^{\gamma}$ in central PbPb



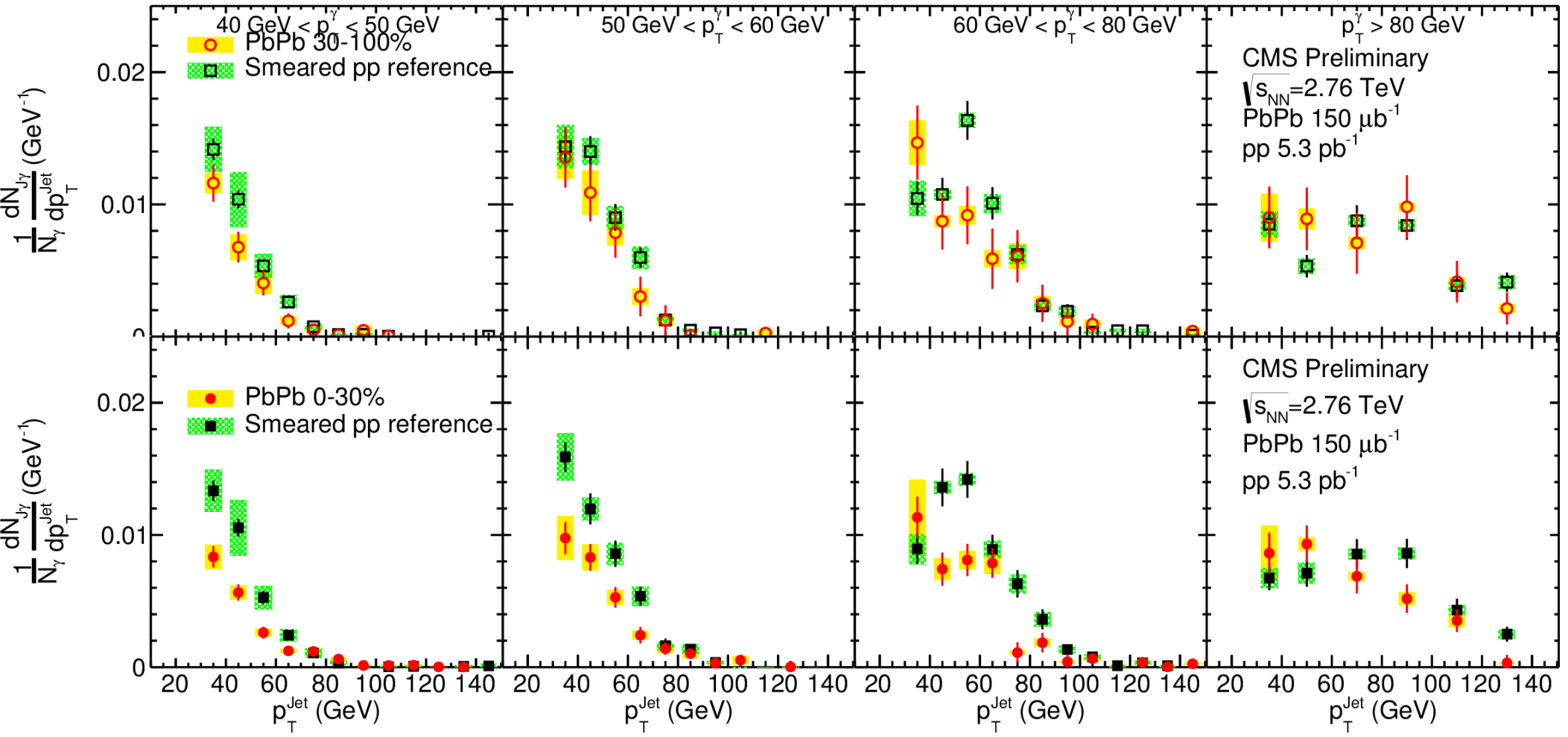




$$x_{Jy} = p_T^{Jet}/p_T^{\gamma}$$

CMS-PAS-HIN-13-006

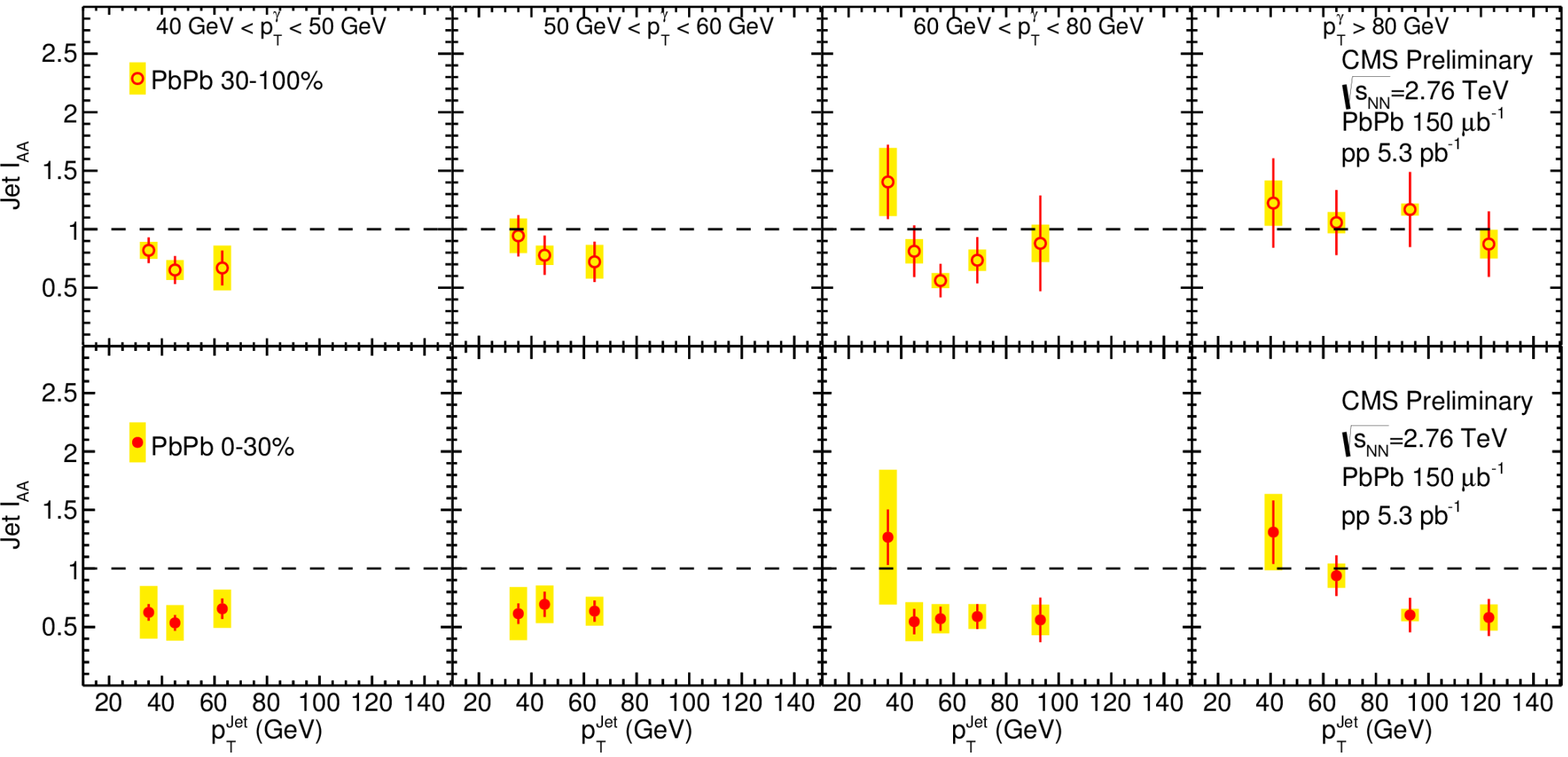
# Jet spectra heavily modified

CMS-PAS-HIN-13-006



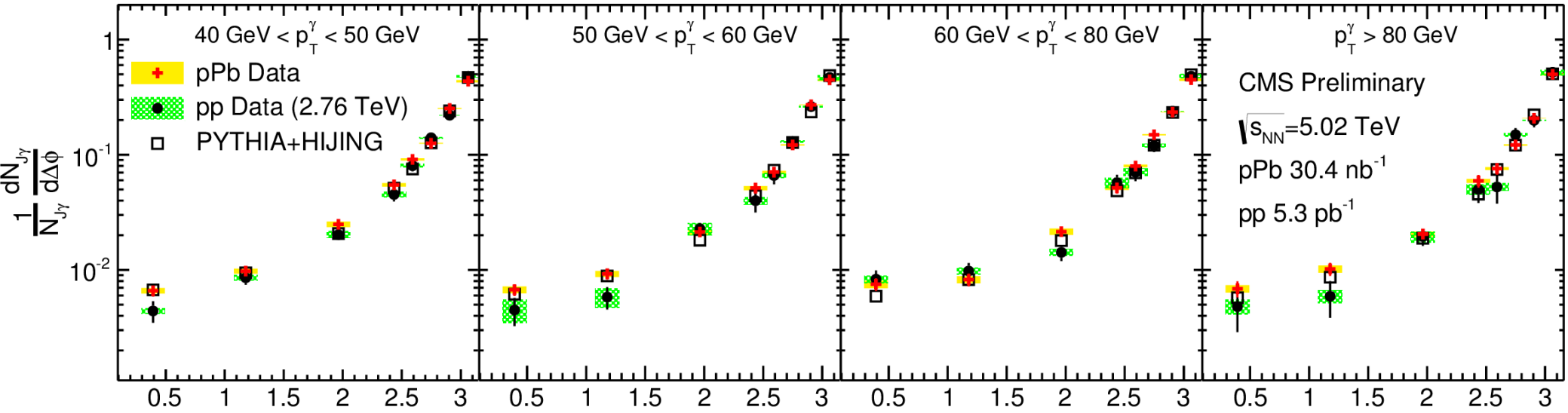
# Jet Yield shifted to lower $p_T^{Jet}$

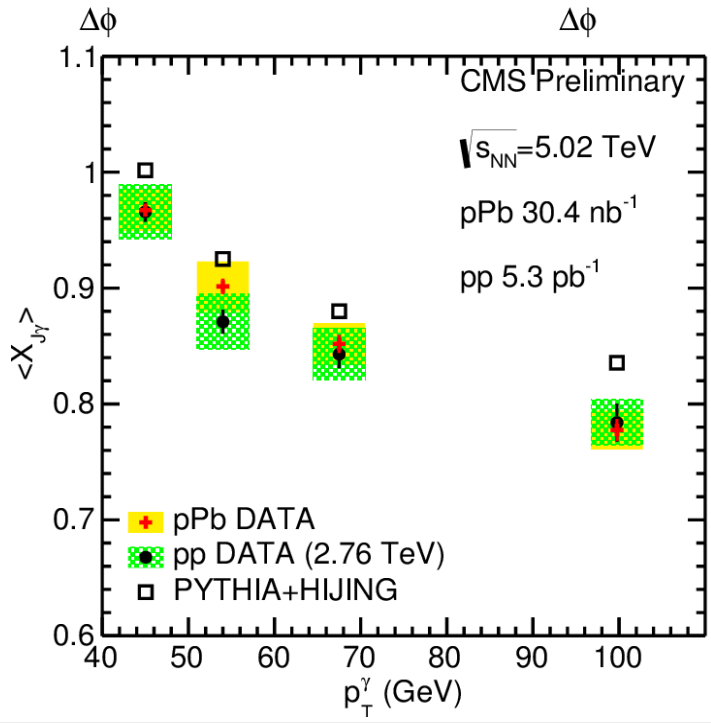
CMS-PAS-HIN-13-006

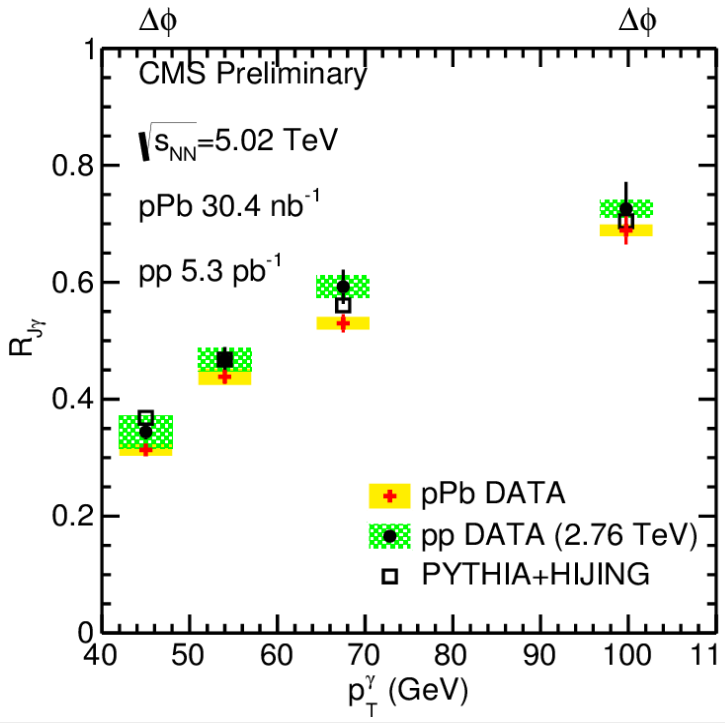



- Jet yield pushed to lower $p_T^{Jet}$ relative to $p_T^{\gamma}$

# pPb results difficult to interpret without proper reference



# Conclusion

- Update of pp reference agrees with previous conclusions from PLB 718 (2013) 773:
  - No deflection of jets
  - Decrease of $x_{Jy}$ with centrality
  - Decrease in number of partner jets with centrality
- $p_T^y$ – dependent results show:
  - Jet yields show a shift to lower $p_T^{Jet}$
  - Loss of jet partners roughly constant across $p_T^y$
- pPb shows no effects; needs proper reference

# Backup

# Signal definition

- Signal – isolated photons
- Background – suppressed by isolation requirement