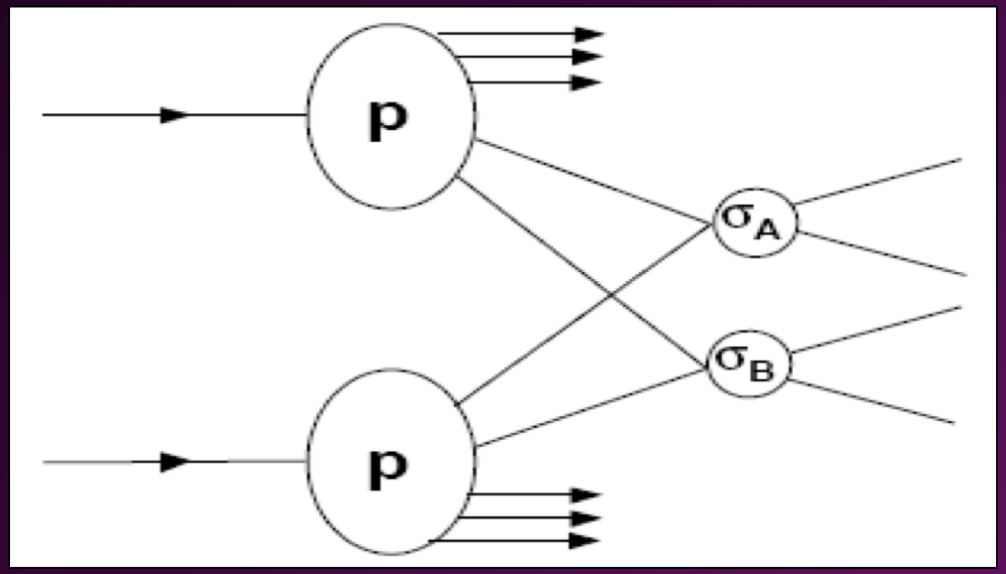
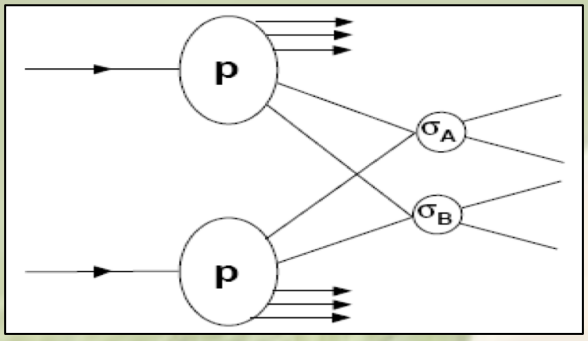
Multiparton interactions at the LHC



Ellie Dobson (CERN/UCL)
On behalf of the ATLAS and CMS collaborations

PIC 2012

Where can we see MPI?



W+W

Z+Z

W + hf

Z + hf

g + 3jet

bbjj

4-jets

W + di-jet

Z + di-jet

Double J/Ψ

Minimum bias

Jet+UE

W+UE

Z+UE

Scale of secondary scatter

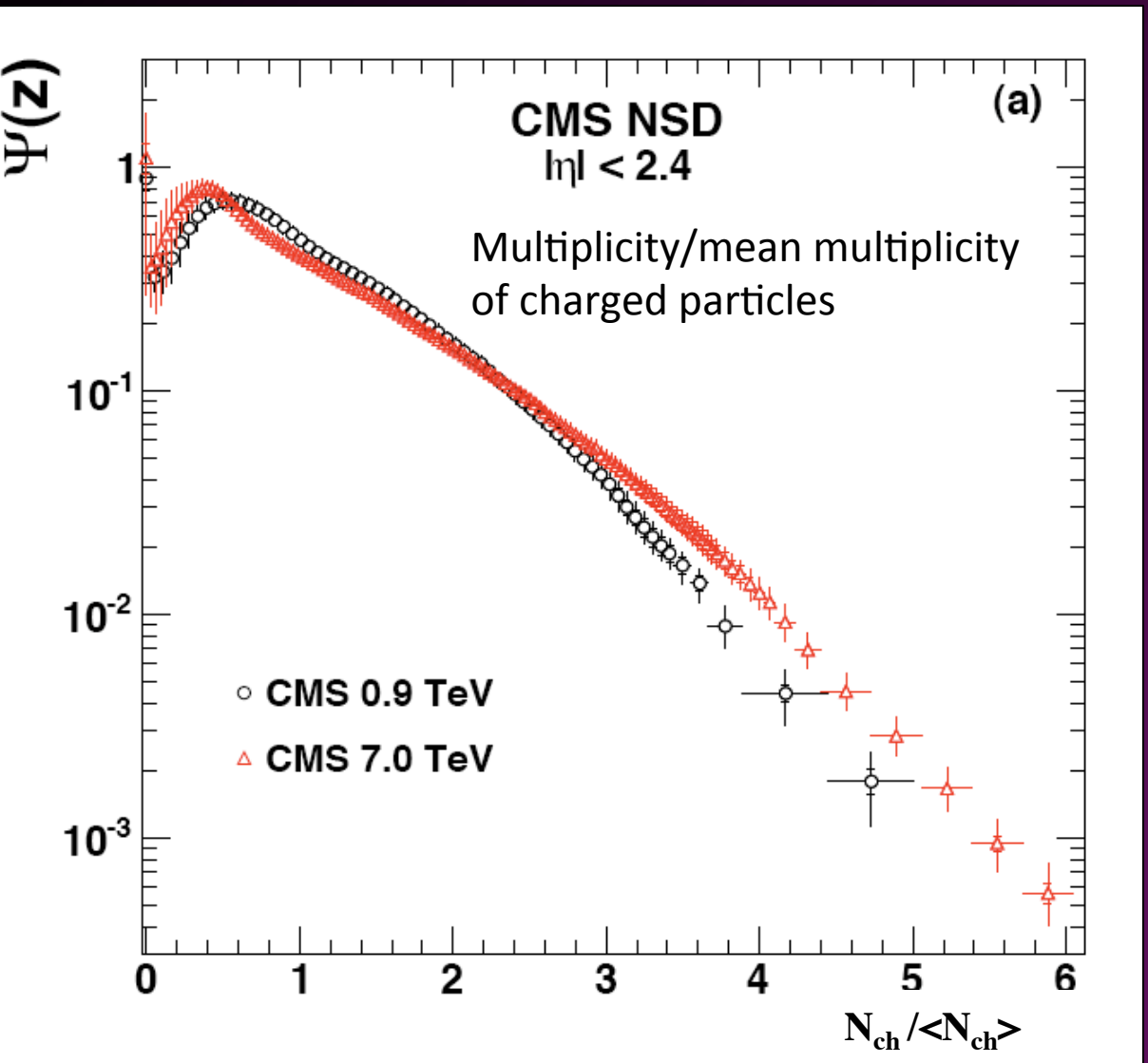
Scale of primary scatter

LHC measurements available

LHC measurements not yet available

Measurements performed at the Tevatron

MPI in Minimum Bias: scaling violations



CMS confirms previously observed violation of scaling with $\sqrt{s}$ for
- $|\eta| < 2.4$ (but not $|\eta| < 0.5$)
- high multiplicity

Violation of scaling related to presence of MPI

MPI in Minimum Bias: 'ridge effect'

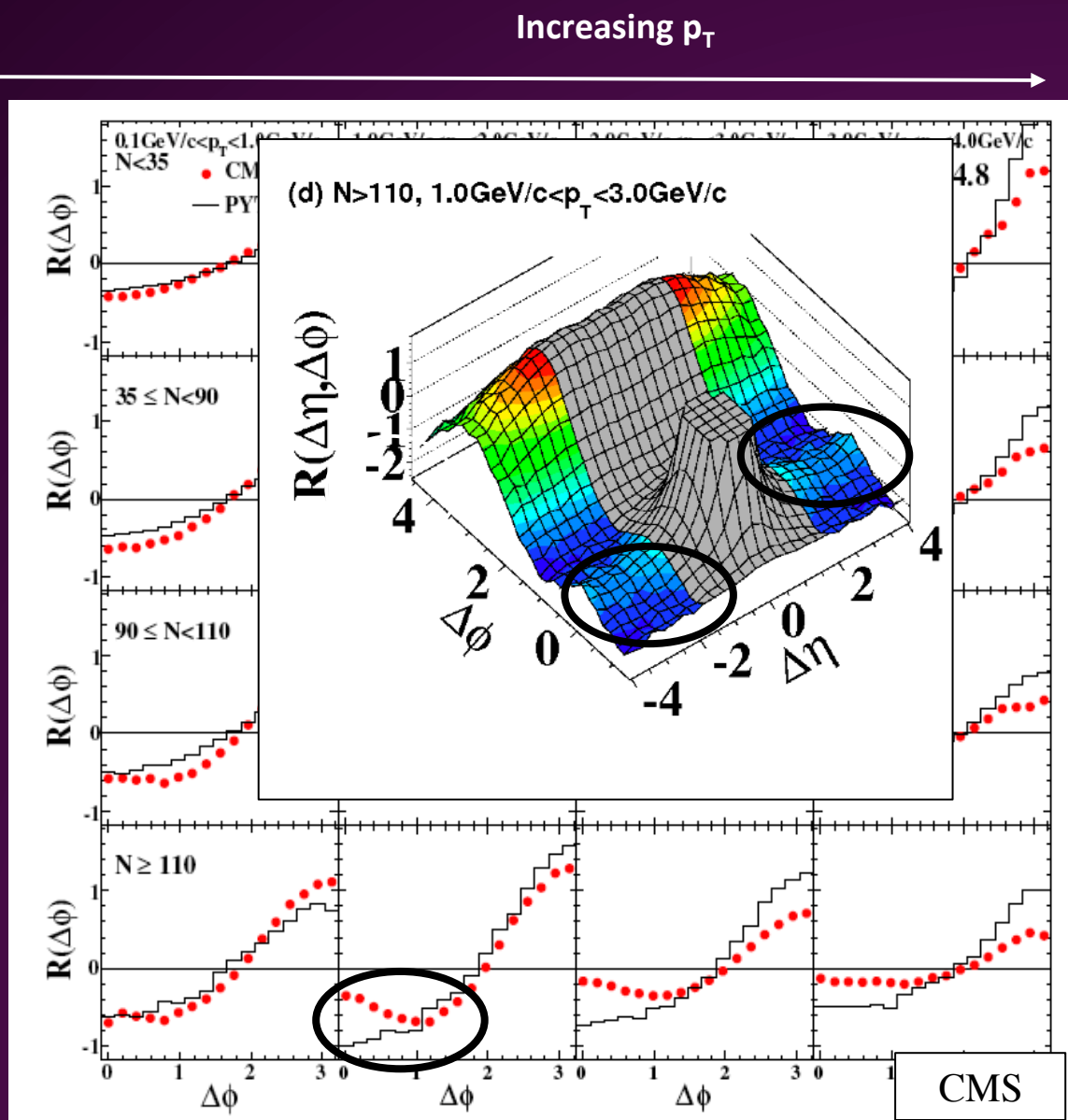
Study angular separation between charged particles

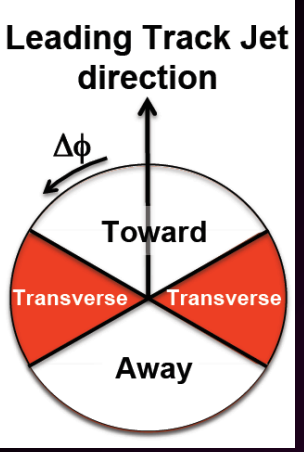
Ridge at $\Delta\phi \approx 0$ seen at
- high multiplicity
- moderate p_T

in both pp and HI collisions
→ not modelled in MC

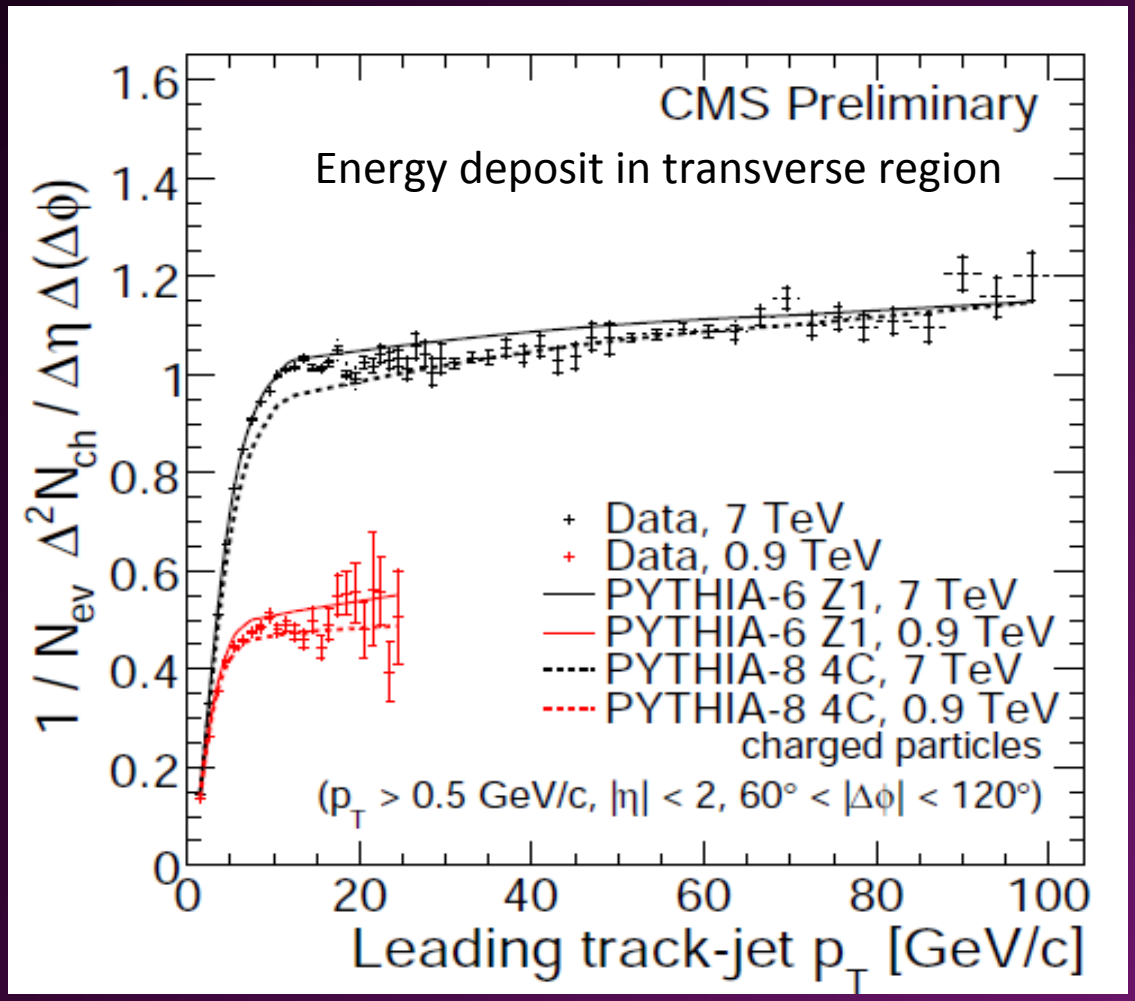
MPI explanations (amongst others) have been proposed to explain this effect

S. Alderweireldt, P.Mechelen
T. Lappi
MPI 2011



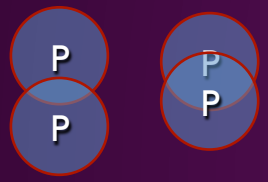


MPI in Jet+UE

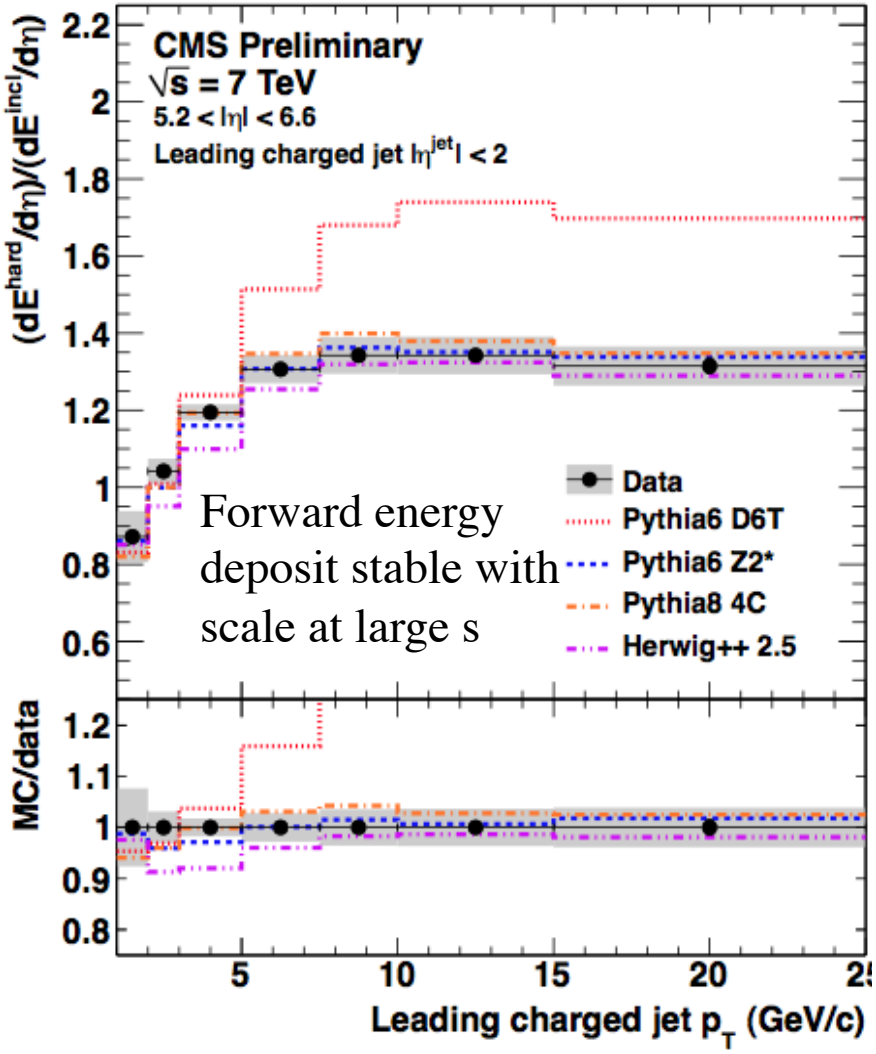


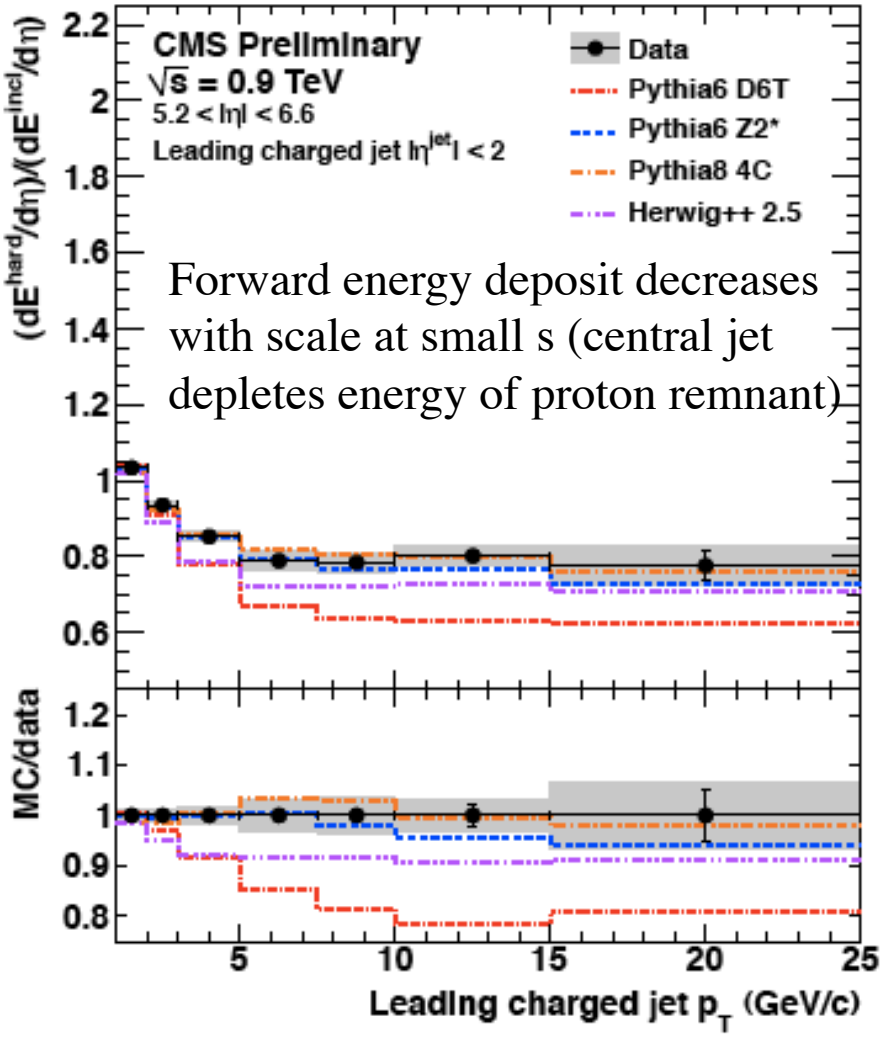
Sharp turn on
Increase of MPI wrt event centrality (and thus jet $P_{T)}$

Plateau
MPI saturation

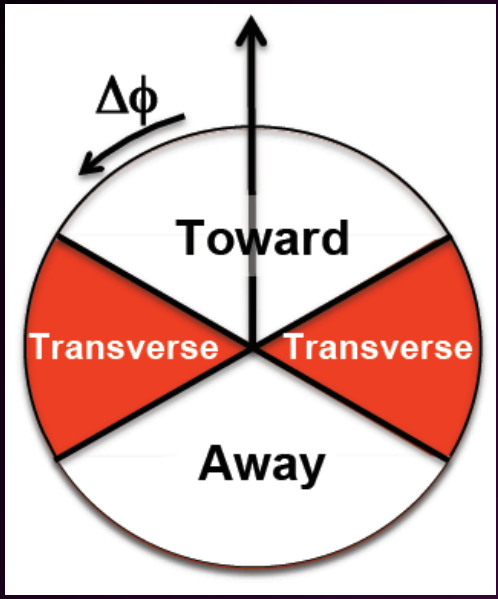


MPI in Jet+forward UE

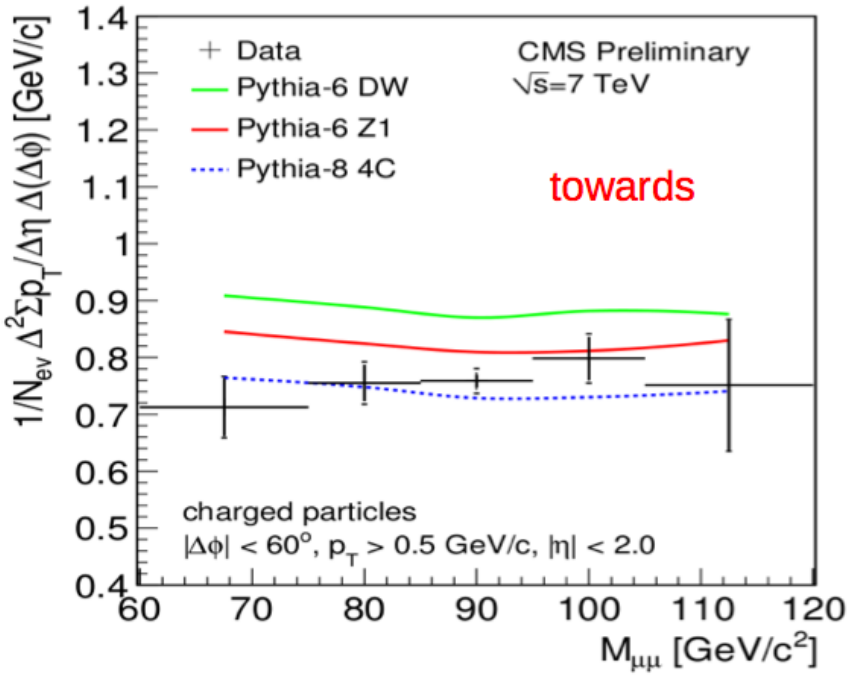




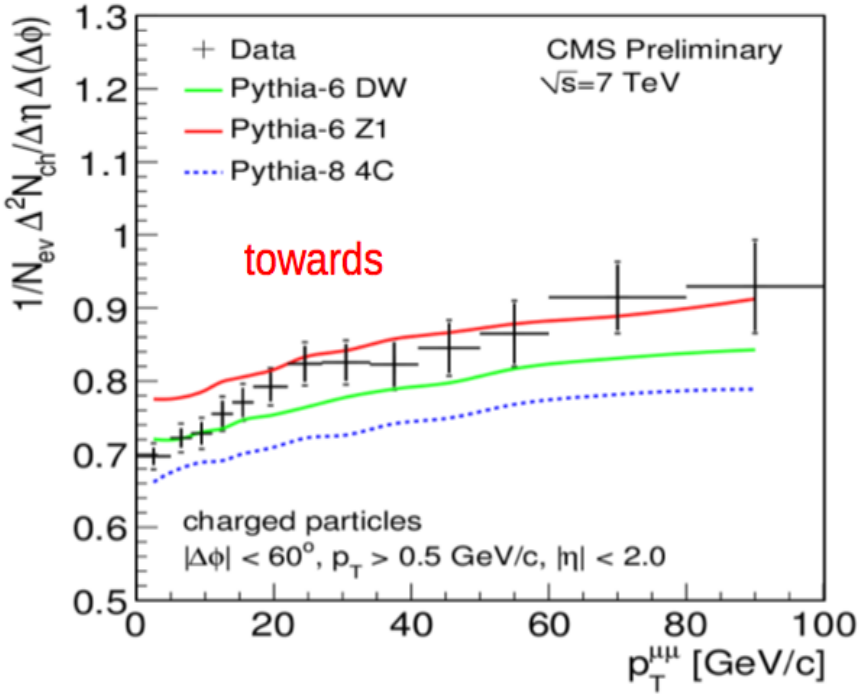
MPI in Z+UE



MPI saturated at high energy scale



$p_T^{\mu\mu}$ dependence gives radiation evolution

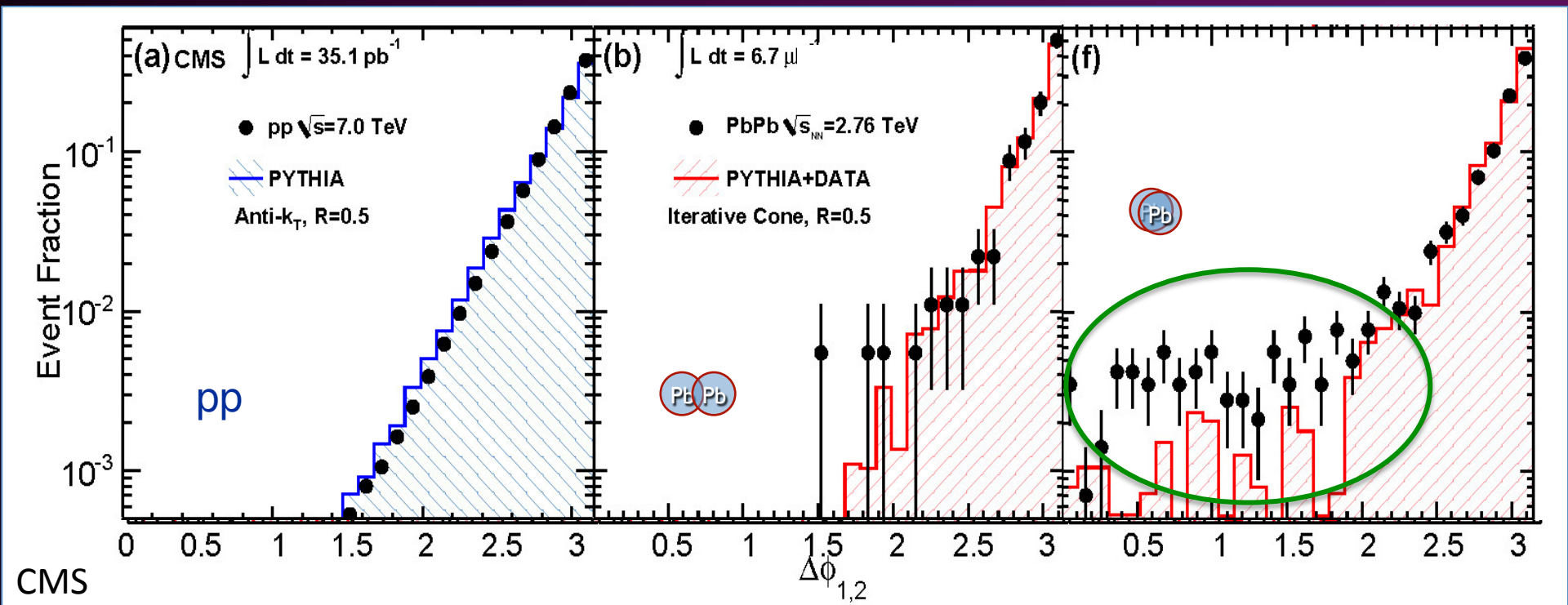


arXiv:1102.1957

MPI in PbPb

MC underestimates the momentum imbalance in dijets produced in highly central collisions (jet quenching)
- appears to arise from modelling of soft particles radiated at large angles

Effect thought to be related to presence of MPI



Increasing scale of secondary interaction MPI→DPI

- ? Hard DPI (double parton interactions) forms an irreducible BG to new physics searches and is not modelled well in MC generators
- ? Is DPI rate process independent?
- ? (How) does DPI rate depend on the collision energy?

$$\sigma_{eff} = \mathrm{m} \cdot \frac{\sigma(\mathrm{A}) \cdot \sigma(\mathrm{B})}{\sigma(\mathrm{A+B})}$$

m = ½ for identical interactions, m = 1 otherwise

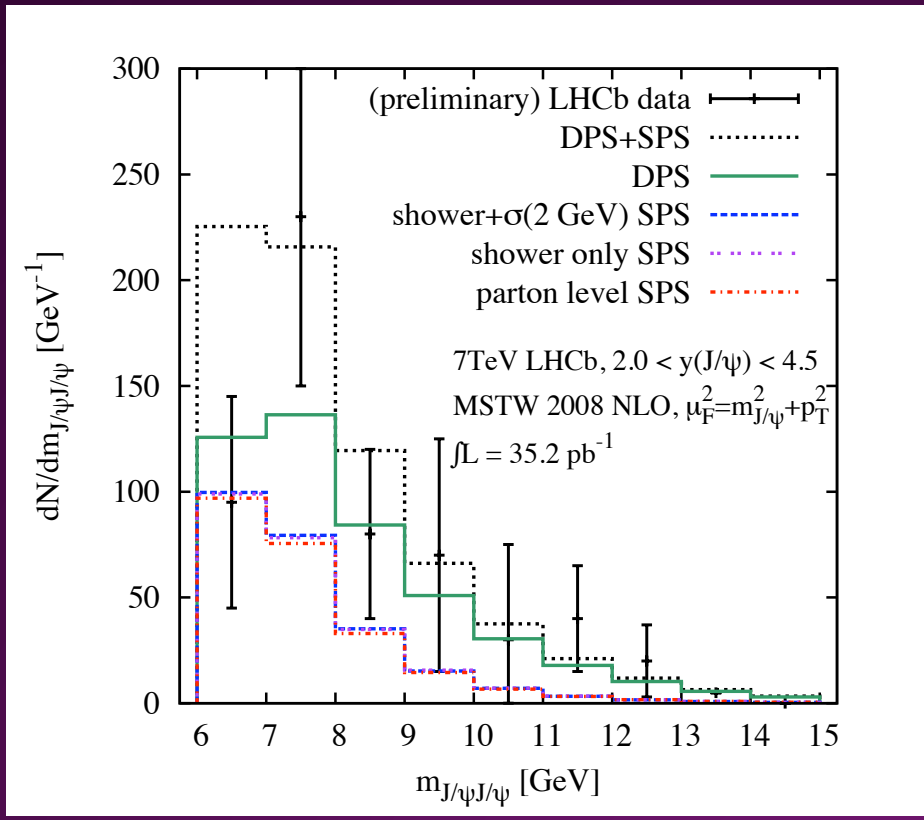
DPI in double J/Ψ

C.H. Kom, A. Kulesza, W.J. Stirling

Cross section measurement (LHCb)

$\sigma^{J/\psi J/\psi} = 5.1 \pm 1.0\ (stat) \pm 1.1\ (syst)\ nb$

Evidence for DPI in double J/ψ?



$$\sigma_{DPS}^{J/\psi J/\psi} = \frac{\sigma_{SPS}^{J/\psi}\sigma_{SPS}^{J/\psi}}{\sigma_{eff}} \cong 2.0nb$$

S.P. Baranov, A.M. Snigirev, N.P. Zotov

$$\sigma_{SPS}^{J/\psi J/\psi} = 4.15nb$$

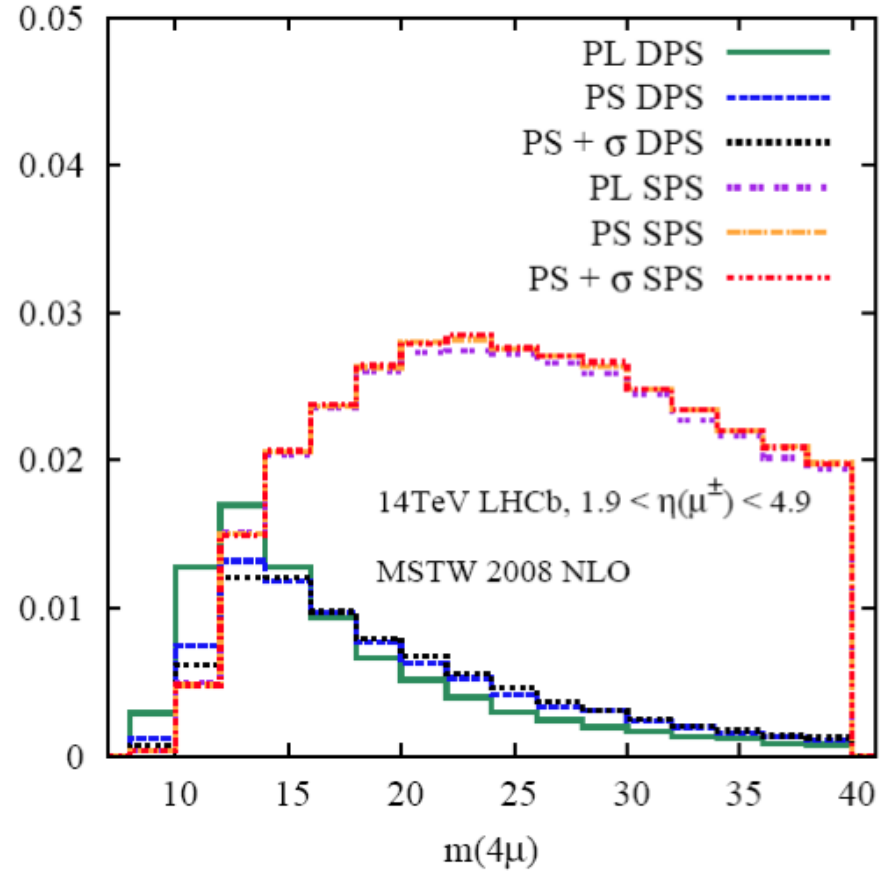
A.V. Luchnsky, A.A. Novoselov

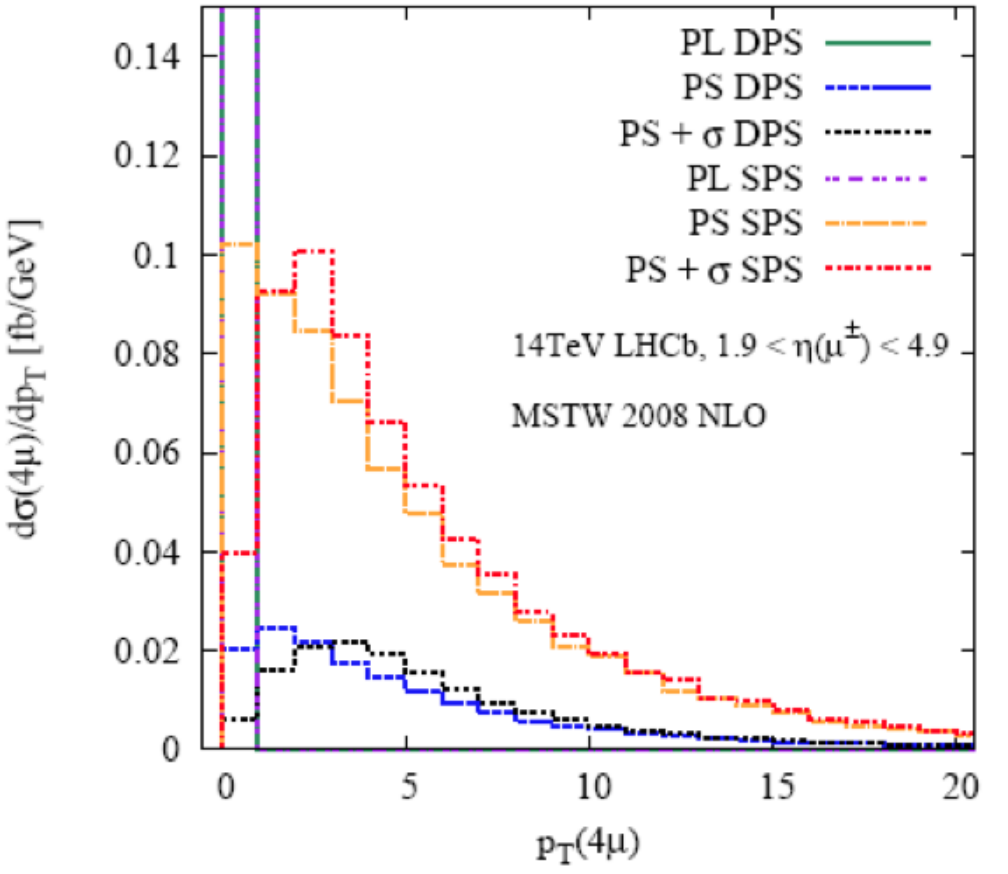
An eye to the future: Double Drell-Yan

An observation in the fully leptonic channel would be a ‘golden’ measurement - we are entering the luminosity regime where it may become possible

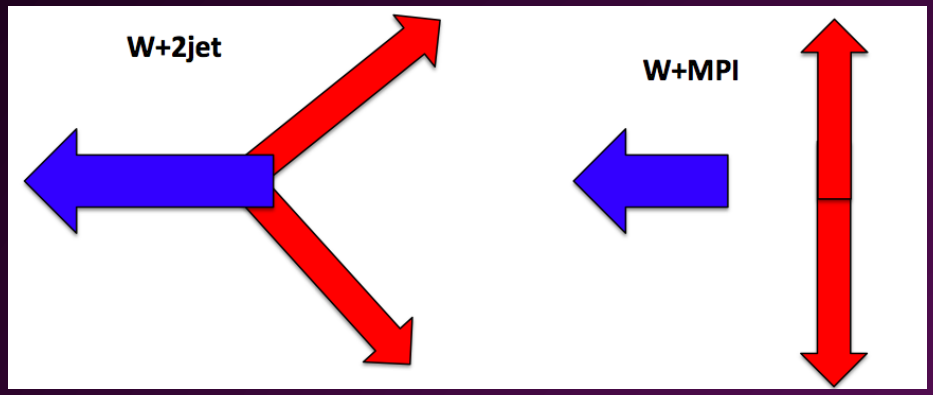
σ^{DPS}=0.08fb , σ^{SPS}=0.43fb

C.H. Kom, A. Kulesza, W.J. Stirling

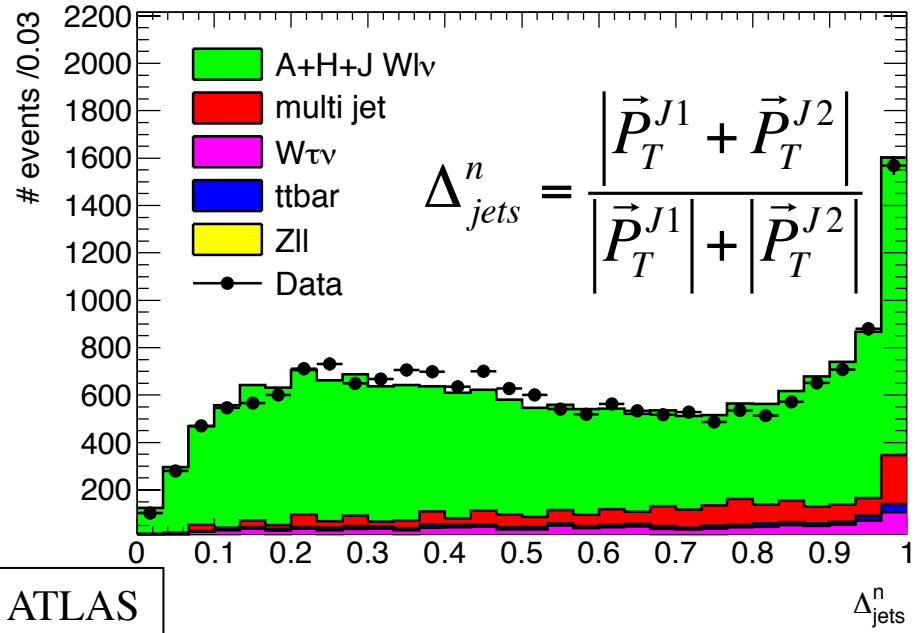


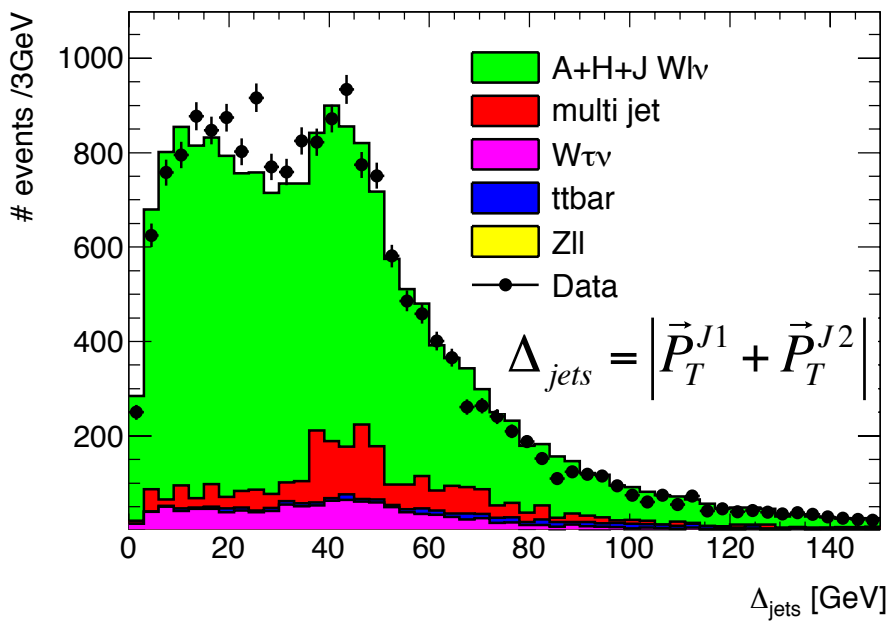


DPI in Wjj



Choose observable sensitive to DPI fraction…





ATLAS

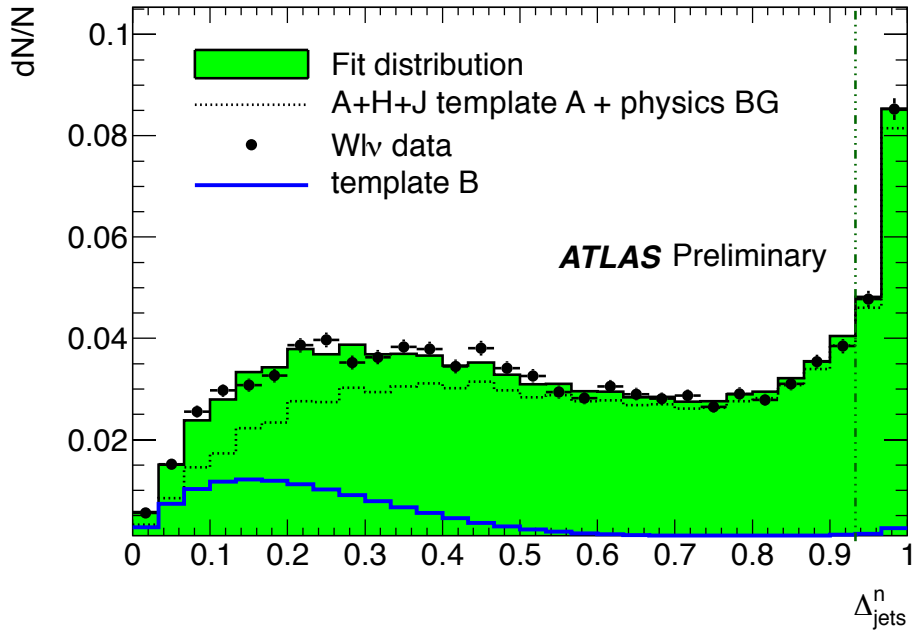
…and fit over this observable to extract the DPI rate

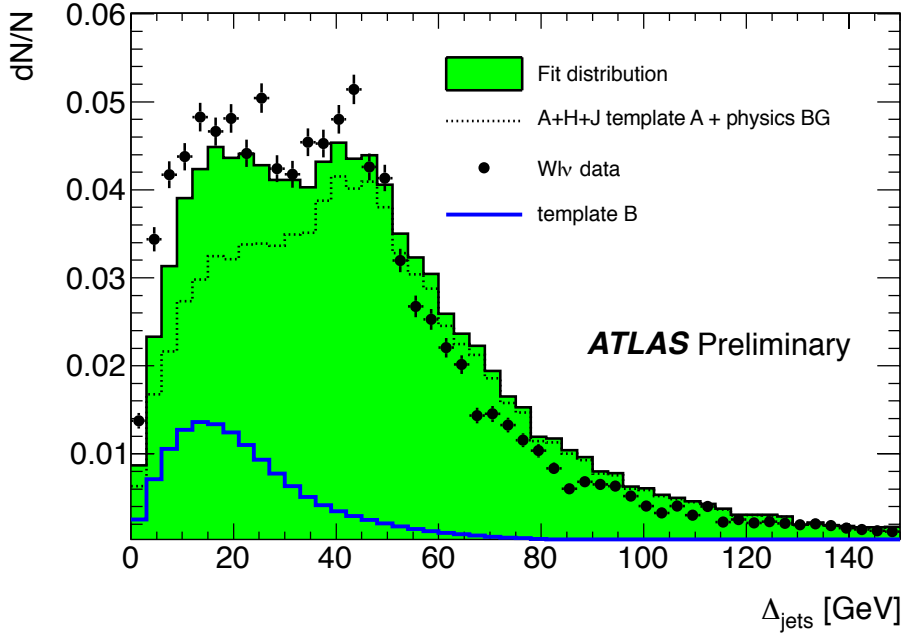
$$f_{DP}^{R} = \frac{N_{W_0+2\,j_{MPI}}}{N_{W+2\,j}}$$

W+2jet (no MPI) ↓ W+2jet (MPI) ↓

Overall distribution = $(1-f^{R}_{DP})$•Template A + f^{R}_{DP}•Template B

Monte Carlo → Wjj predicted kinematic
Dijet data → W+MPI predicted kinematic
- factorisation+correlation assumption)

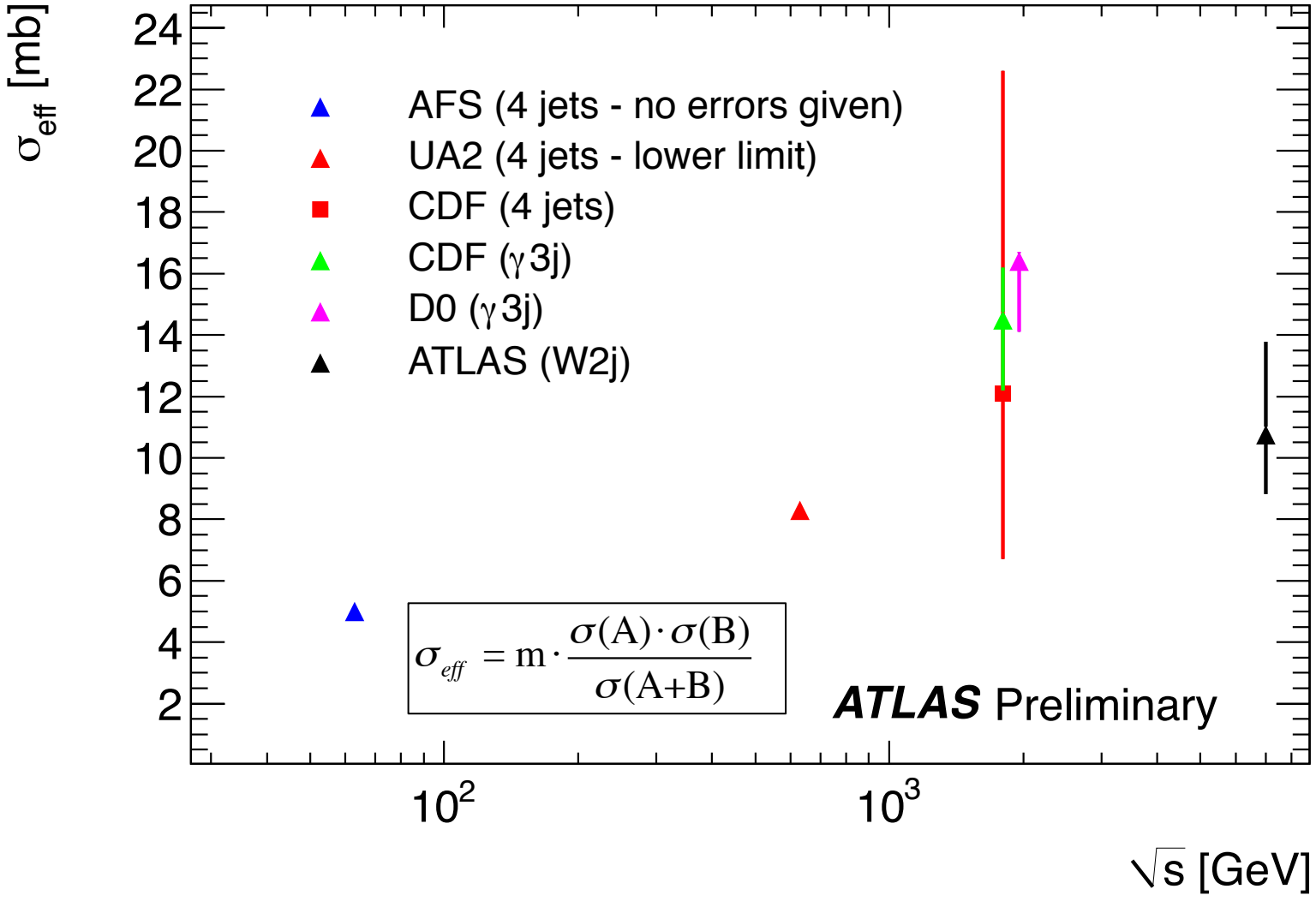




$f^{R}_{DP} \sim 0.15$ (hugely sensitive to selection and detector effects)

Can use extracted f^{R}_{DP} value to measure σ_{eff}

- which can be used to predict DPI rate for **any physics process**

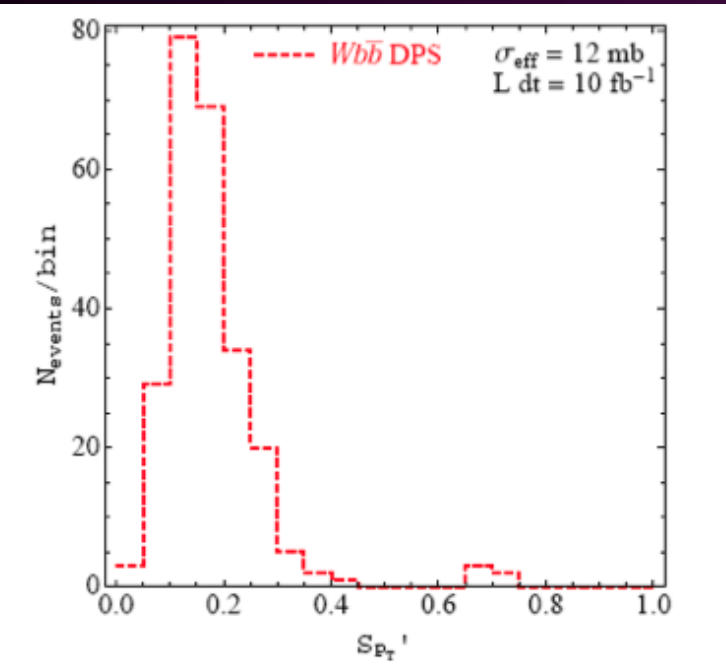


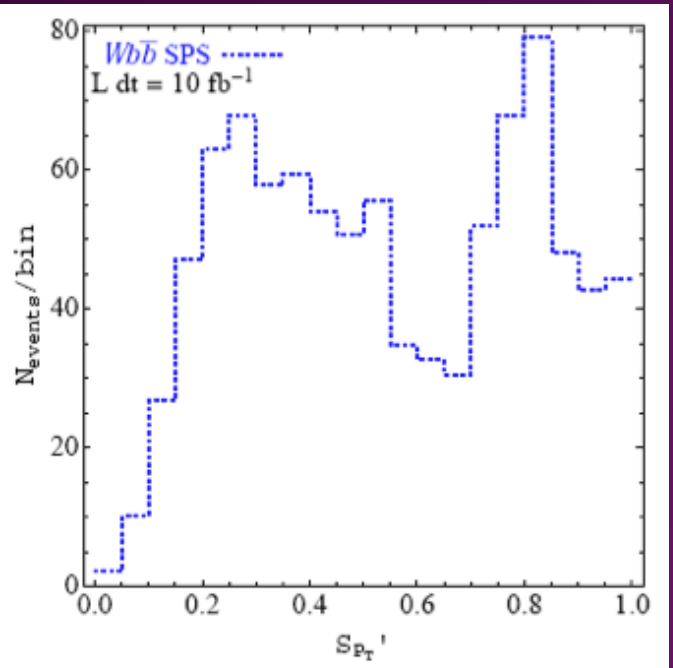
An eye to the future: Wbb

Wbb feasibility studies look promising

- understanding of this channel is crucial to many new physics searches

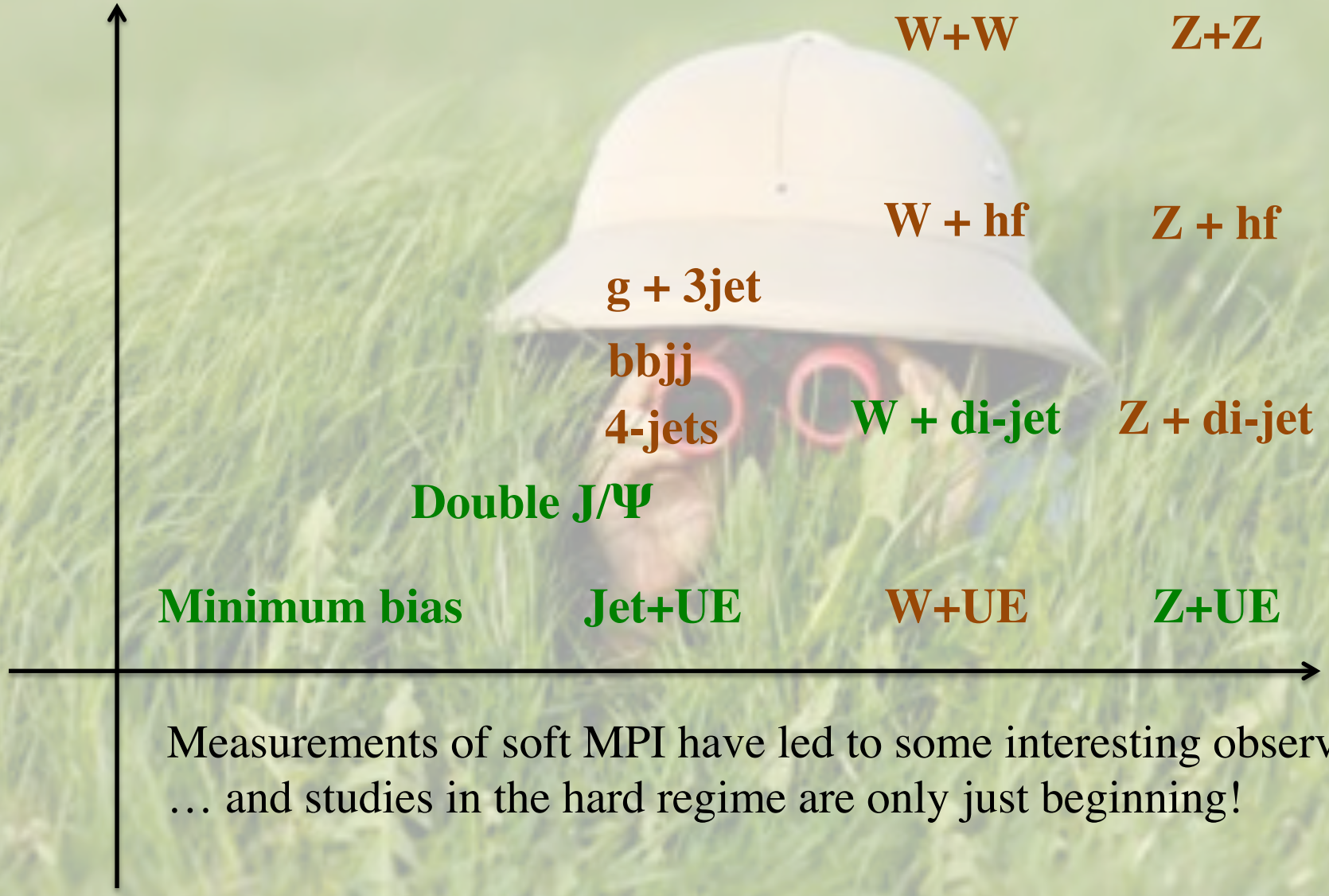
$$S_{PT} = \frac{1}{\sqrt{2}} \sqrt{\left(\frac{|p_T(b_1, b_2)|}{|p_T(b_1)| + |p_T(b_2)|} \right)^2 + \left(\frac{|p_T(l, \upsilon)|}{|p_T(l)| + |p_T(\upsilon)|} \right)^2}$$





E. Berger,
C. Jackson,
S. Quackenbush,
G. Shaughnessy

Conclusions



Measurements of soft MPI have led to some interesting observations … and studies in the hard regime are only just beginning!