Simulations for inclusive diffraction

Playing with SmearMatrixDetector_0_1_FF

Version corrected after fixing a bug in FF momentum smearing in SmearMatrixDetector_0_1_FF

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with
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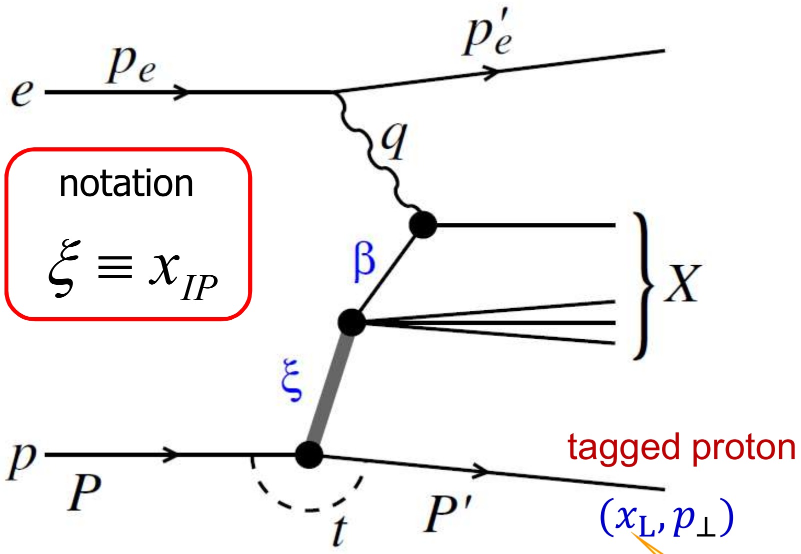
- Diffractive DIS sample from RAPGAP
- Smearing — including the far forward region

Diffraction and Tagging WG meeting 2020-09-10

Inclusive diffractive DIS



notation

$\xi \equiv x_{IP}$

$$x_L = \frac{P'_z}{P_z}$$

Lorentz invariants

$$\xi \equiv x_{IP} = \frac{(P-P')\cdot q}{P\cdot q} = \frac{Q^2 + M_X^2 - t}{Q^2 + W^2 - m_p^2}$$

$$\beta = \frac{Q^2}{2(P-P')\cdot q} = \frac{Q^2}{Q^2 + M_X^2 - t}$$

$$x = \xi\beta$$

Reconstruction of kinematic variables

Electron method

$$q = p_e - p'_e$$

$$Q^2 = -q^2$$

$$y = \frac{Pq}{Pp_e} = \frac{2Pq}{s}$$

$$x = Q^2/ys$$

Jacquet-Blondel

$$\bar{P} = \sum_{i\neq e'} p_i^{\text{out}} = P_X + P'$$

$$y = \frac{\bar{P}_-}{2E_e} = \frac{\bar{E} - \bar{P}_z}{2E_e}$$

$$Q^2 = \frac{\bar{P}_T^2}{1-y}$$

$$x = Q^2/ys$$

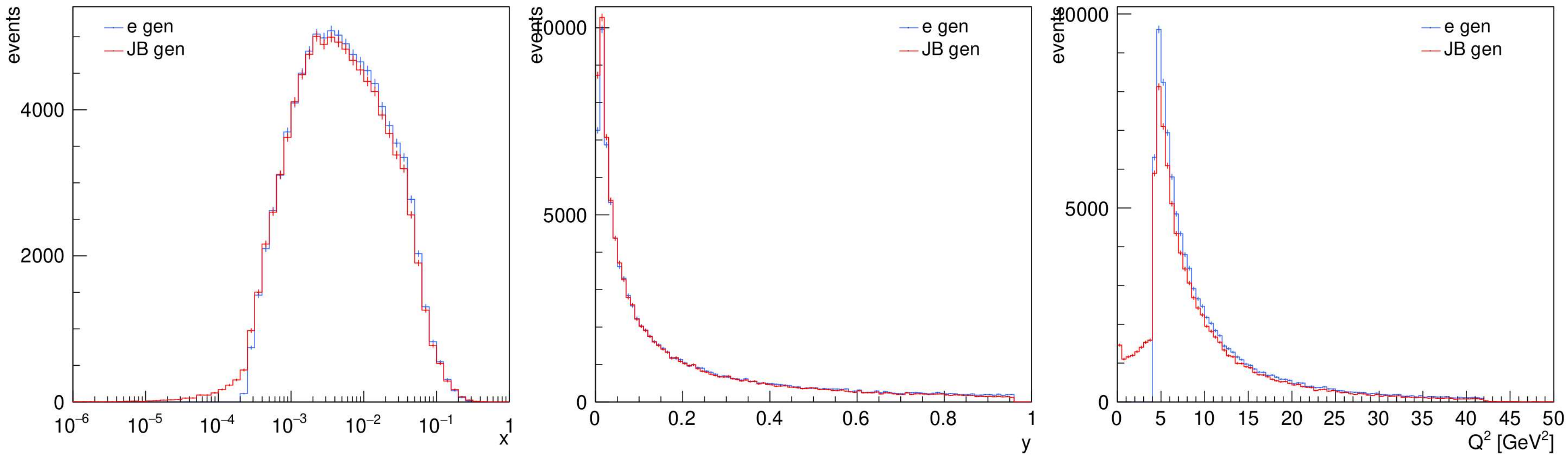
Monte Carlo sample for diffractive DIS

- **RAPGAP** generator used
  - 100 000 events generated
  - Pomeron & Reggeon contributions included
- Kinematic variables reconstructed using
  - Electron method — $q = p^e - p^{e\prime}$
  - Jacquet-Blondel method — $q = P_{out}^{had} - P_{in}^{tot}$

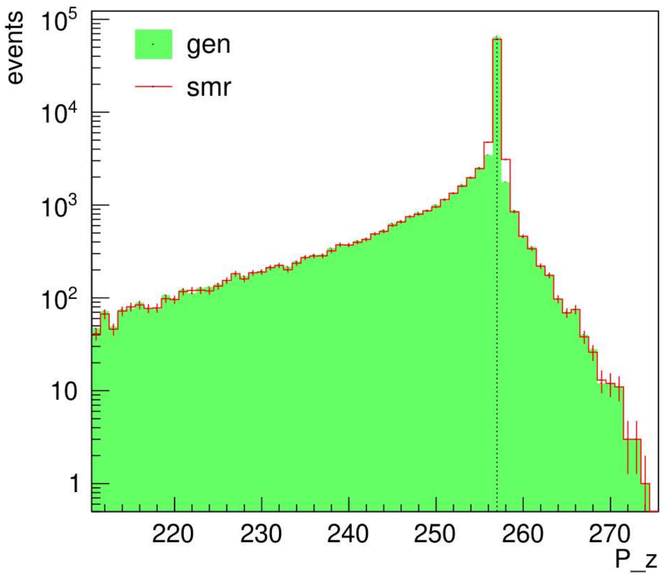
Kinematic bounds

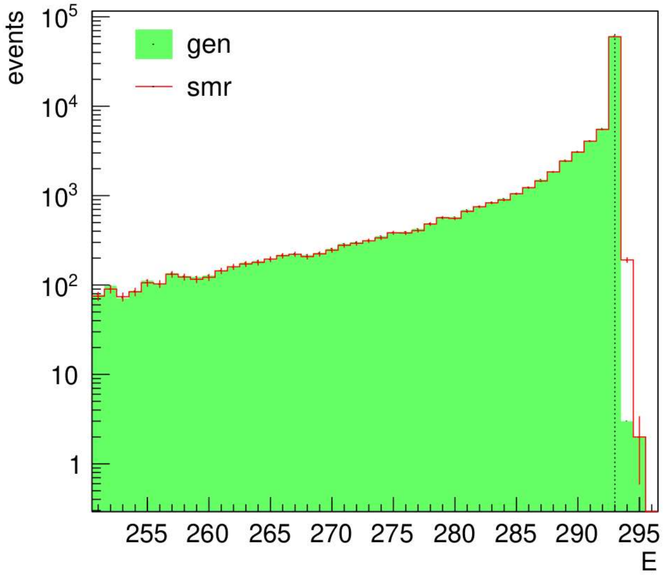
$x_L > 0.6$,
$-t < 5\ \mathrm{GeV}^2$,
$Q^2 \in [4.2, 42]\ \mathrm{GeV}^2$,
$y \in [0.005, 0.96]$,
$\theta_e \in [157°, 179°]$

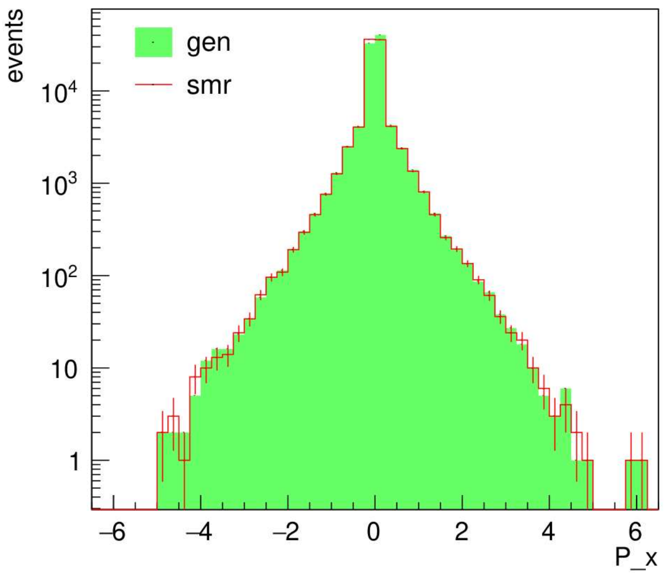
Even for the true (unsmeared) sample the (e) and (JB) methods give different results because of some nonconservation of the total 4-momentum.

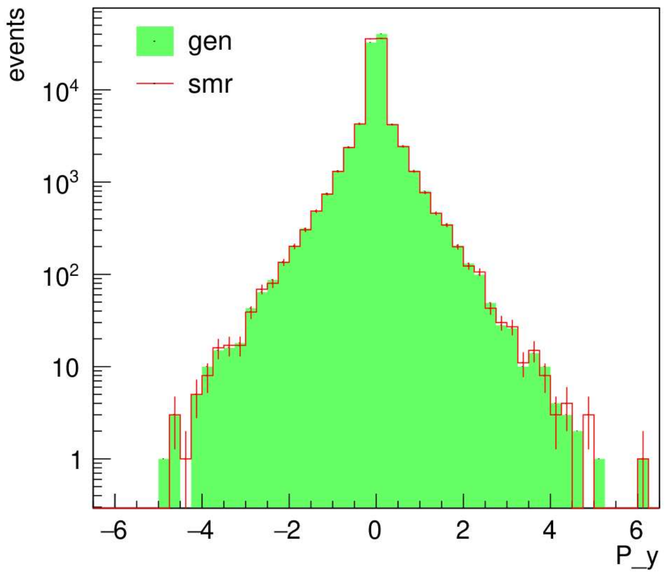


Total final momentum from RAPGAP









■	gen	generated
—	smr	smeared

Sizeable spread in the true (unsmeared) sample

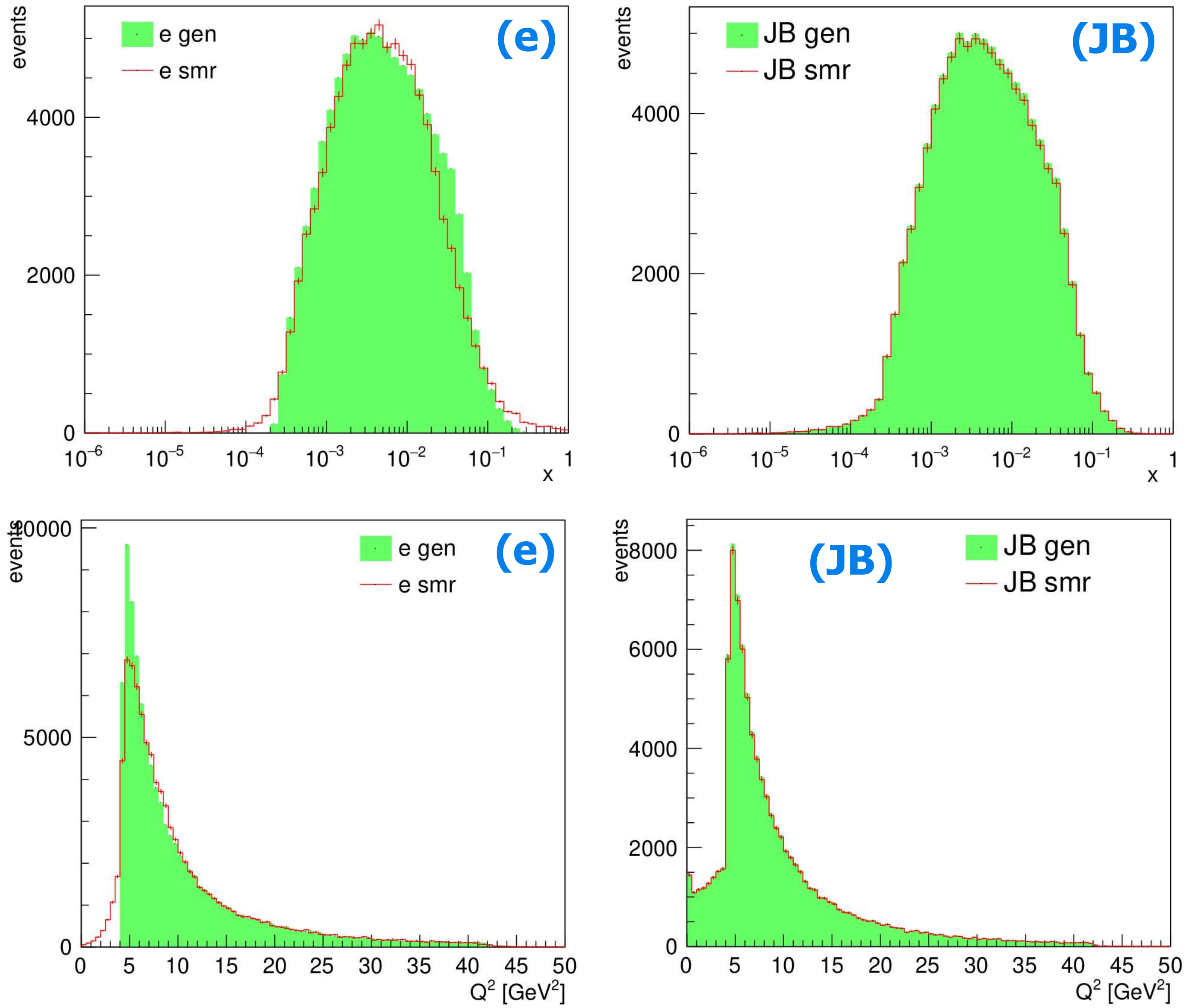
Under investigation with the RAPGAP author, Hannes Jung

Very good resolution

Smeared sample from SmearMatrixDetector_0_1_FF

- A “dead zone” between RP and B0: $\theta_p = 5 \div 6\ \mathrm{mrad}$
  - ca. 1.5% events with the final proton in the dead zone not accepted
- Energy or momentum not provided by some detector components
  - Reconstructed using measured θ and φ values and assuming mass = 0 or m_p for an identified final hadron

DIS variables: x, Q^2



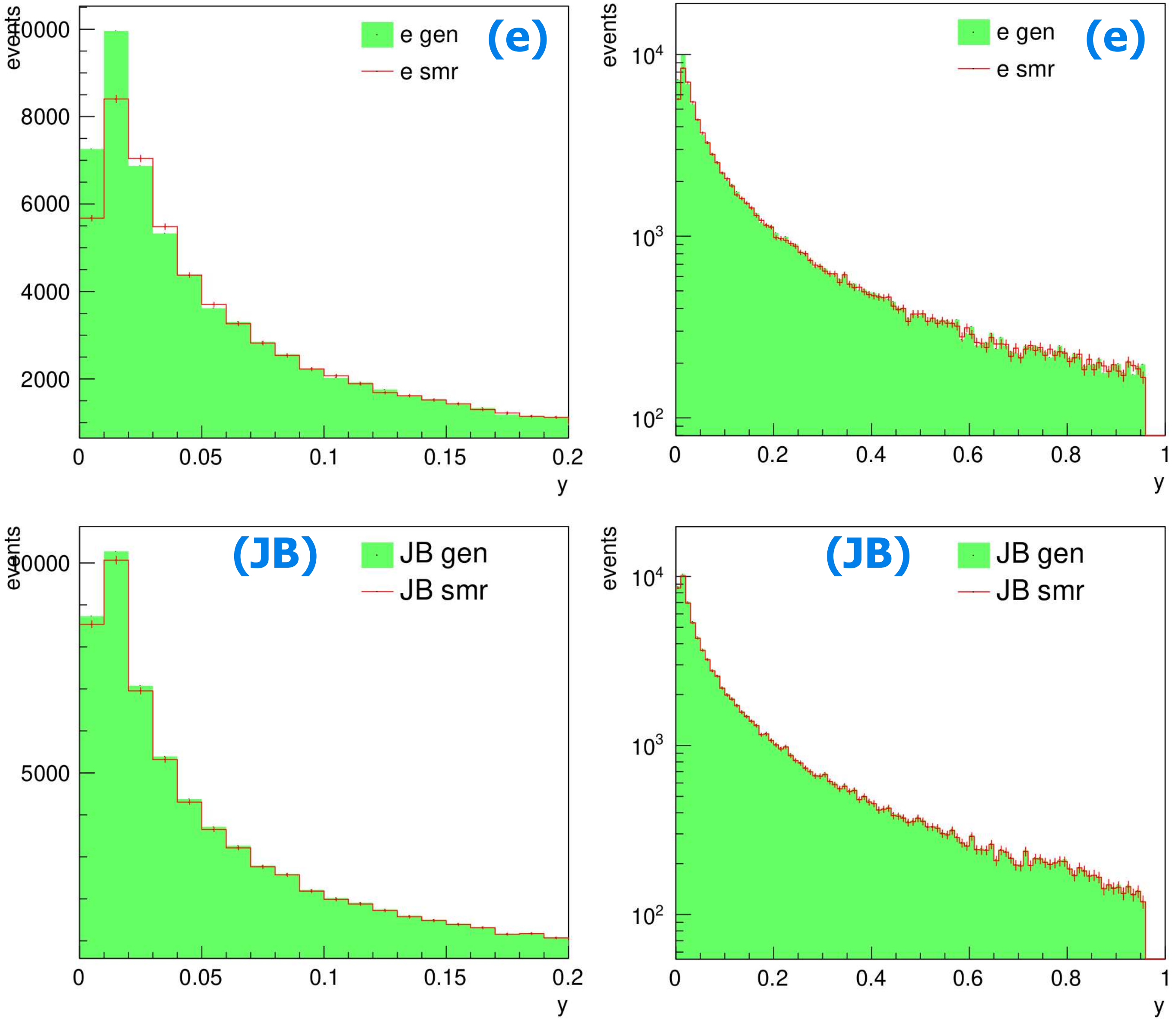
<u>Not accepted</u>

1.5% (1446) events
with final proton
in the dead zone
$\theta_p = 5 \div 6$ mrad

Very good
resolution
for (JB).

Worse for (e).

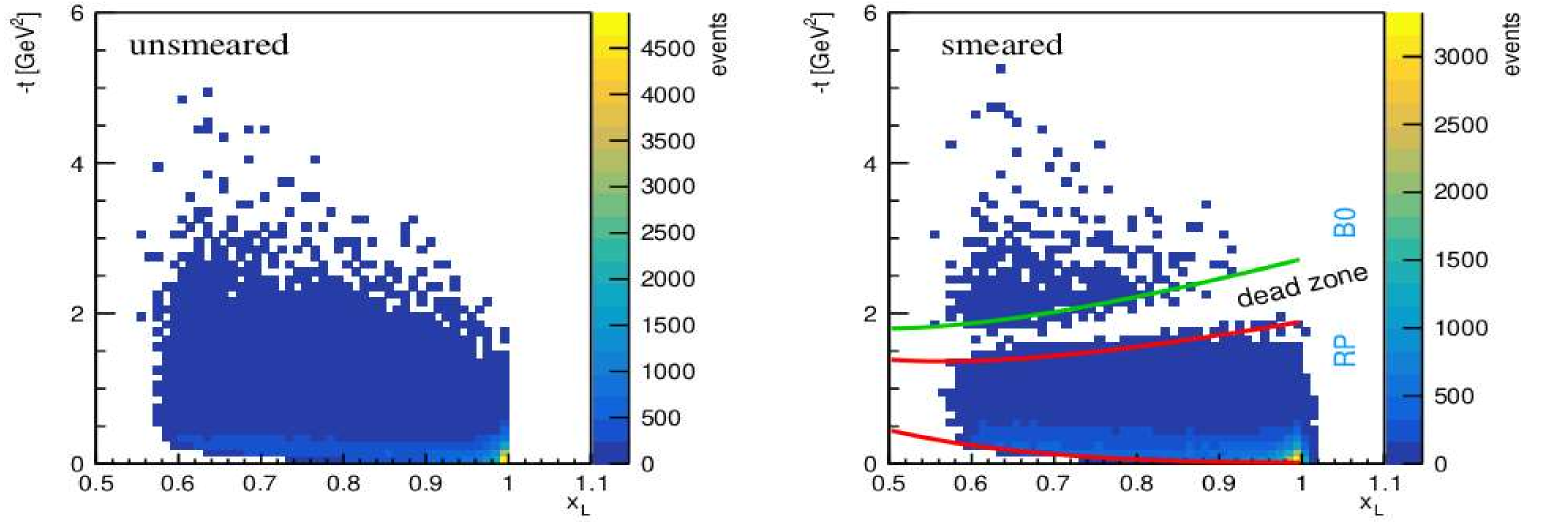
DIS variable y

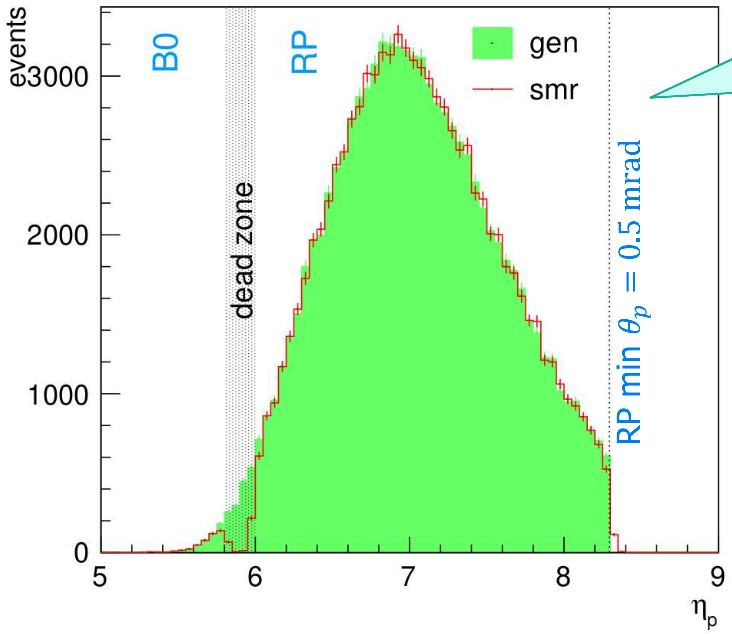


Very good resolution for (JB).

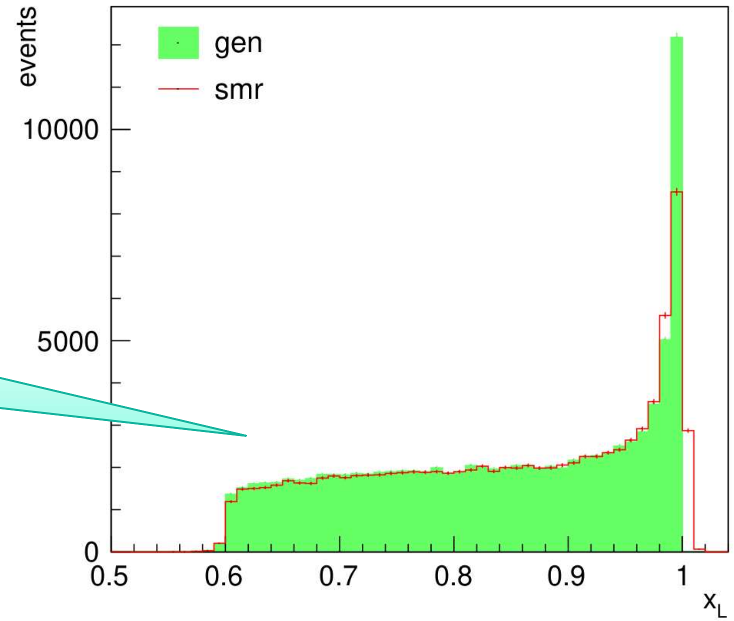
Worse for (e).

Tagged proton – η, x_L, t



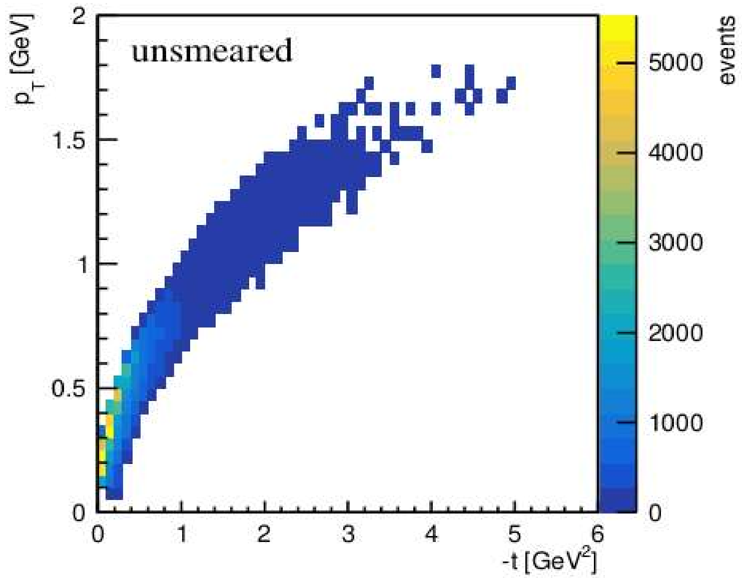


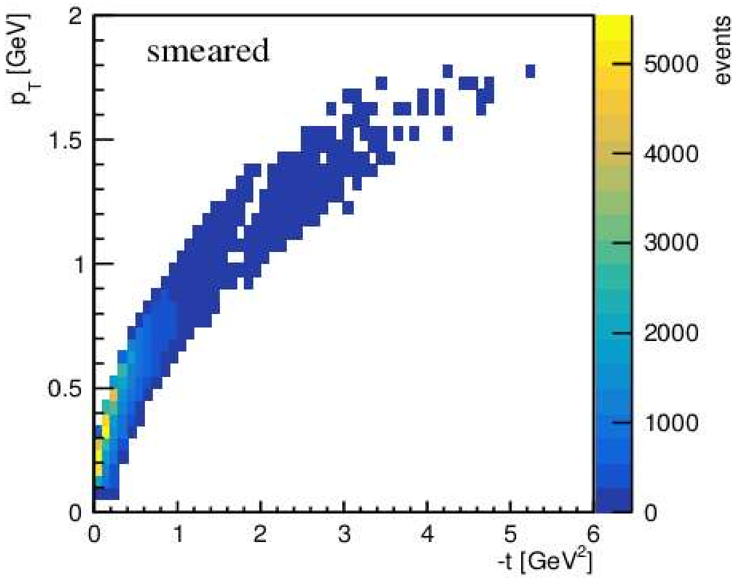
Very good resolution in η_p (θ_p)

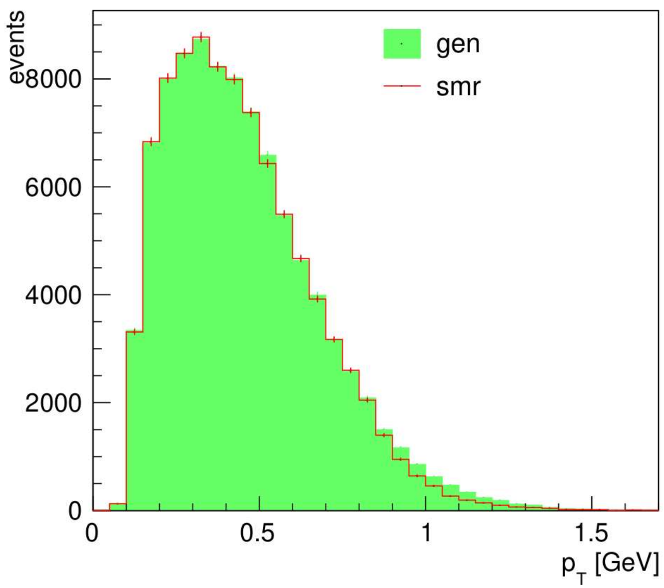


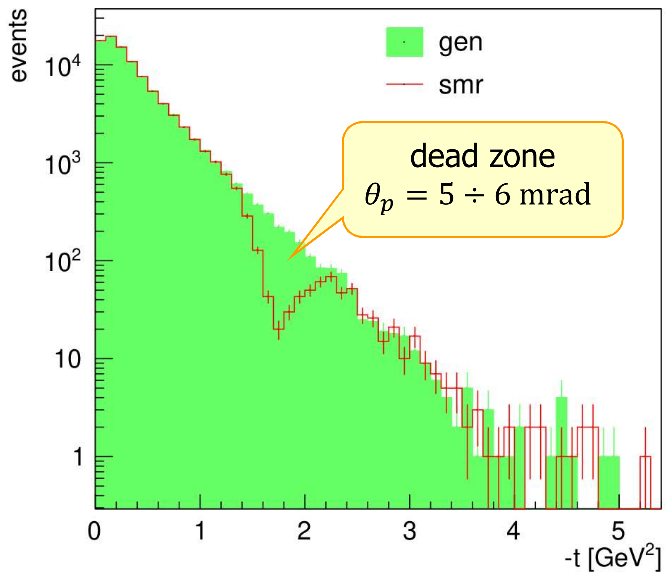
Good resolution in x_L

Tagged proton – t, pT







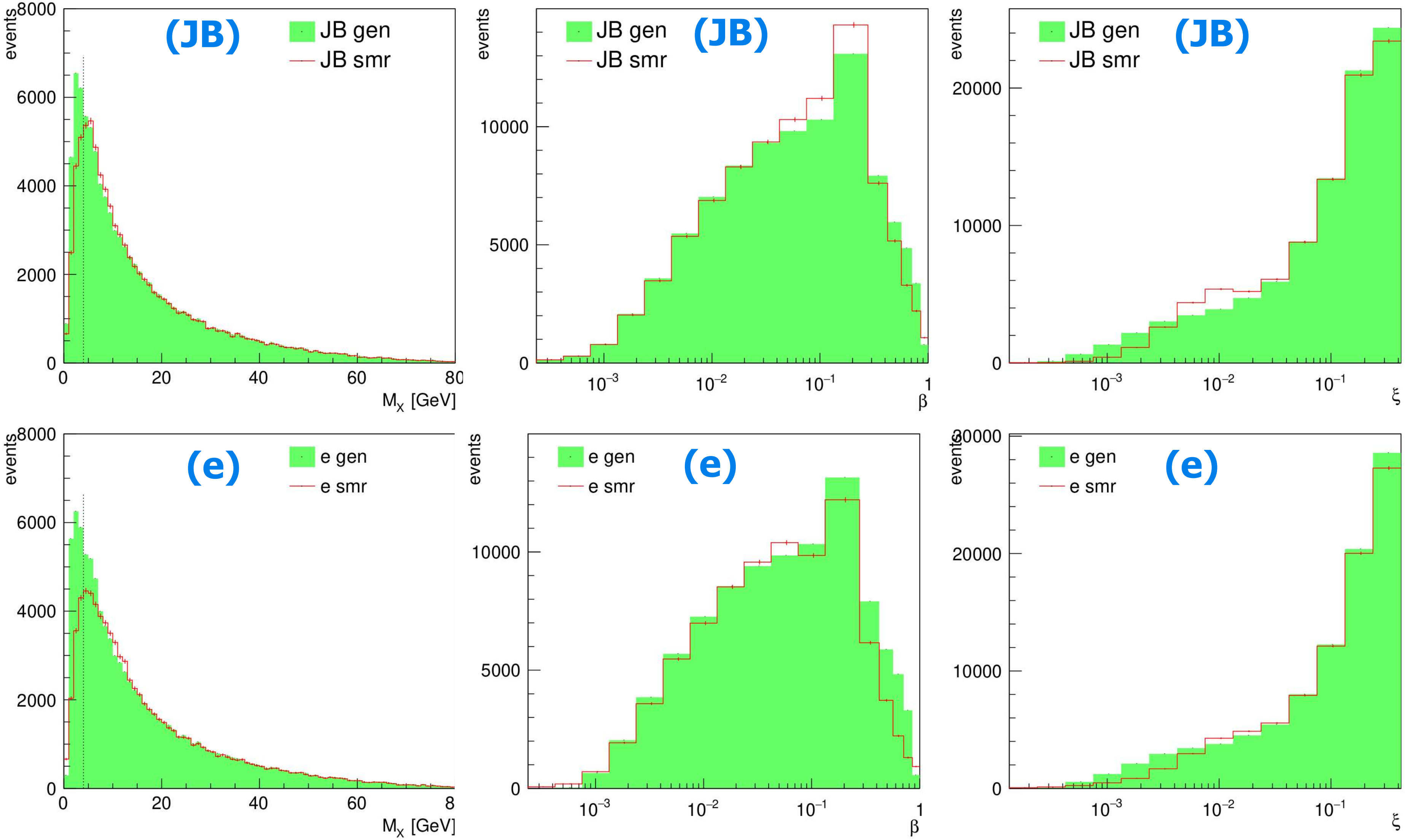


Very good resolution except for the *dead zone*

Diffraction specific variables: M_X, β, $\xi \equiv x_{IP}$

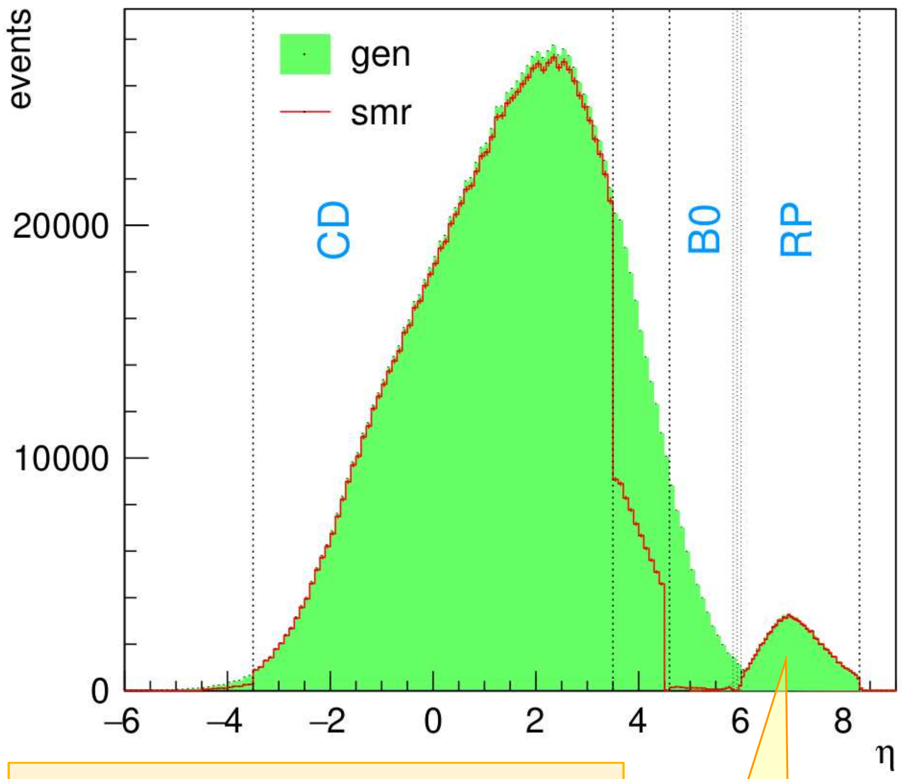
Good resolution only for M_X > 4 GeV

Moderate resolution for β and ξ



Discussion & Summary

Pseudorapidity distribution of all final particles excluding final lepton



Many particles lost for $\eta > 3.5$. This affects the M_X reconstruction.

Final proton

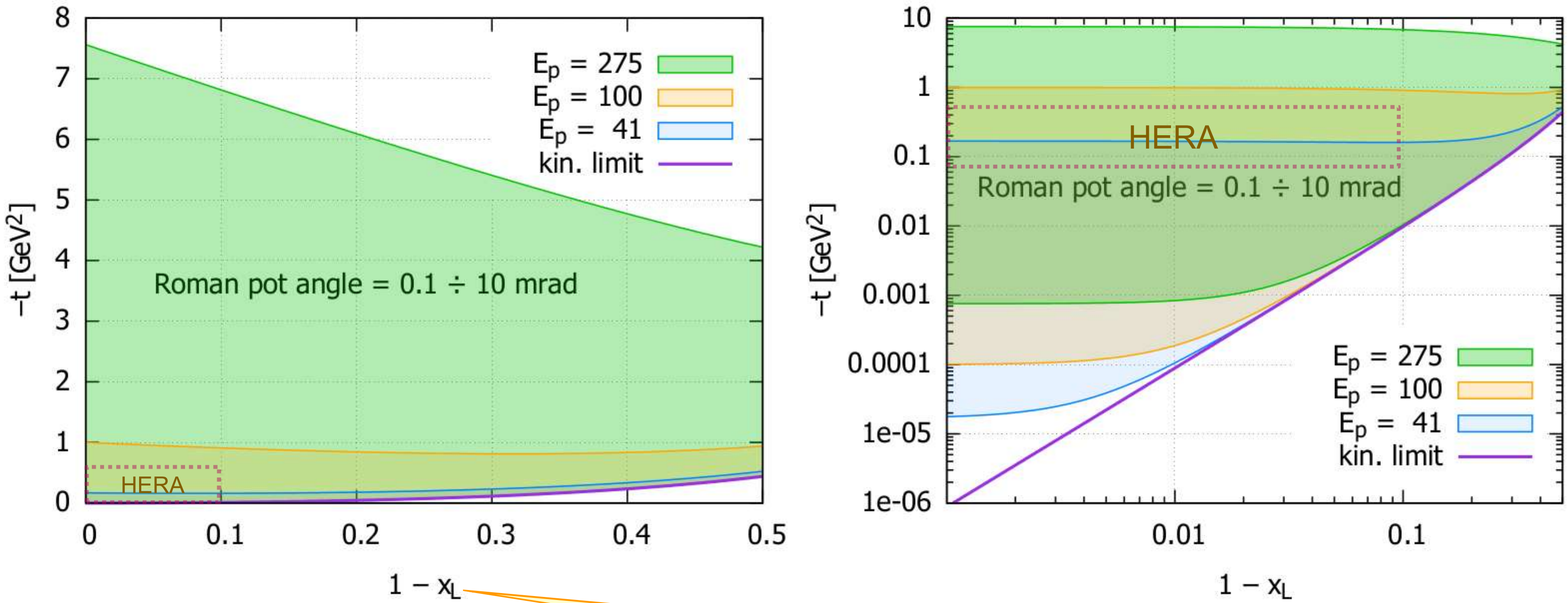
- Additional cuts for diffraction should be studied.
- We could also take the “dead zone” into account in the generated data

Summary

- Good resolution for: x, y, Q^2, t and p_T
- Reasonable resolution for: M_X, β, ξ
- Further studies required… – of course

EXTRAS

Final proton tagging — x_L, t range



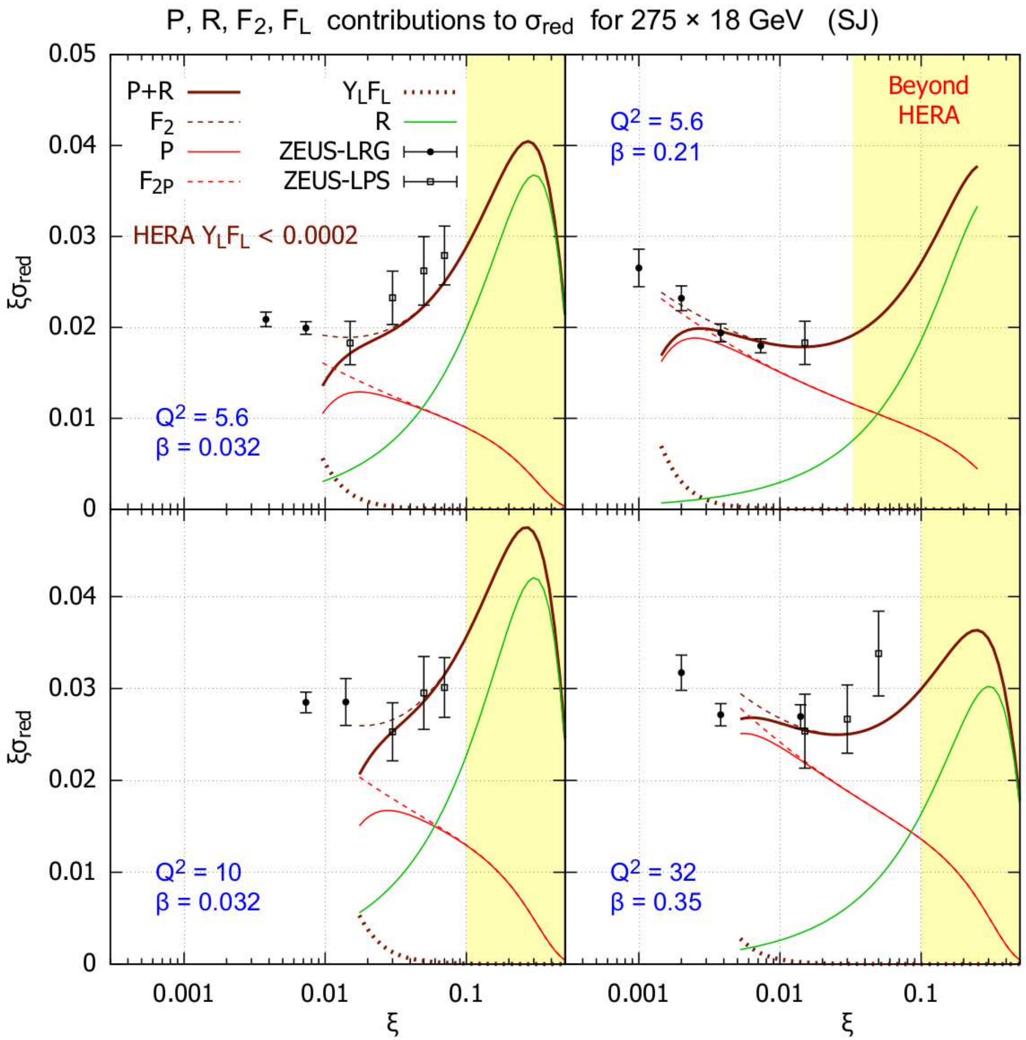
x_L measured in LAB = collinear (e,p) frame

$$t = -\frac{p_\perp^2}{x_L} - \frac{(1-x_L)^2\, m_p^2}{x_L}$$

HERA data taken at $0.08 < -t < 0.55\ \mathrm{GeV}^2$ and $0.9 < x_L < 1$

A better measurement of t-dependence possible

Pomeron, Reggeon, F_2, F_L components of σ_{red}



- $\mathbb{R}$ contribution dominates at high ξ
- Significant F_L component

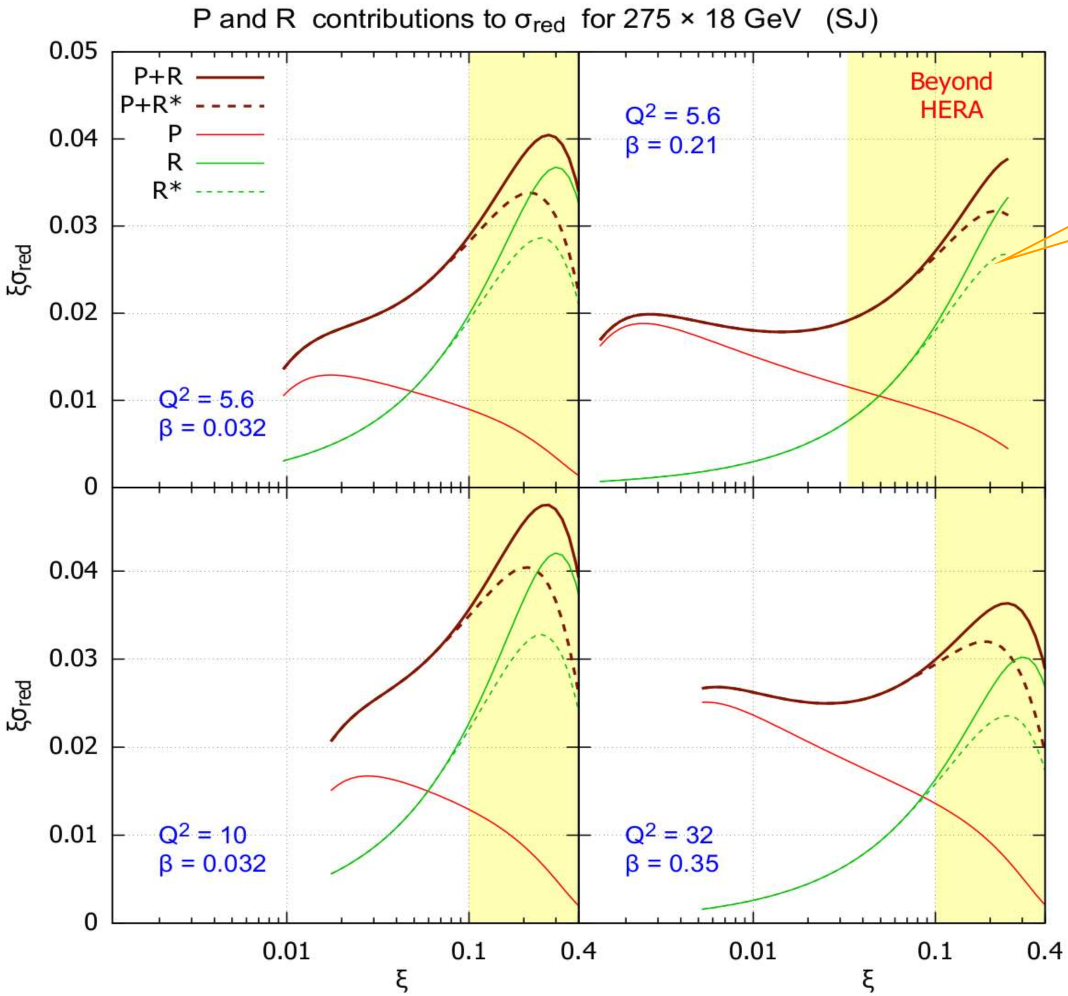
$$\sigma_{red} = F_2 - Y_L(y)\, F_L$$

$$Y_L(y) = \frac{y^2}{1 + (1 - y)^2}$$

At fixed (x, Q^2),
$Y_L(y)$ scales stronger than $\sim 1/s^2$,
e.g. $Y_L(0.9/5)/Y_L(0.9) = 0.024$

Some intermediate beam energy settings would improve F_L measurements.

Sensitivity to the Reggeon contribution to σ_{red}



1. Suppress Reggeon by a factor

$$\left(\frac{1-\xi}{1-\xi_0}\right)^p$$

   for $\xi > \xi_0 = 0.07$,

2. Generate pseudo-data with nominal and modified $\mathbb{R}$ contribution

3. Compare results of the fits

Fits to the unmodified $\mathbb{R}$ result in $\chi^2 \approx 1$, as expected.

Fits to $\mathbb{R}^*$ suppressed by ~10% give $\chi^2 \approx 1.2$

Reggeon flux $\varphi_R \sim \xi^{1-2\alpha_R}$ and α_R is a free fit parameter.
Hence the data can discriminate between two shapes in ξ.

THE END