Multiple Parton Interactions in Sherpa

Multiple parton interactions @ the LHC”
Tel Aviv October 2012

Frank Krauss IPPP Durham

www.ippp.dur.ac.uk

Khoze-Martin-Ryskin model

- Eikonal as convolution of two" parton densities"

$$\Omega(\vec{b}_\perp) = \frac{1}{2\beta_0^2}\int \mathrm{d}^2 b_\perp^{(1)} \mathrm{d}^2 b_\perp^{(2)} \delta^2(\vec{b}_\perp - \vec{b}_\perp^{(1)} - \vec{b}_\perp^{(2)}) \cdot \Omega_{i(k)}(\vec{b}_\perp^{(1)}, \vec{b}_\perp^{(2)}, y)\Omega_{(i)k}(\vec{b}_\perp^{(1)}, \vec{b}_\perp^{(2)}, y)$$

- Two channel eikonal, with two evolution equations

$$\frac{\mathrm{d}\ln\Omega_{i(k)}(y)}{\mathrm{d}y} = +\exp\left\{-\frac{\lambda}{2}\left[\Omega_{i(k)}(y)+\Omega_{(i)k}(y)\right]\right\}\Delta$$

$$\frac{\mathrm{d}\ln\Omega_{(i)k}(y)}{\mathrm{d}y} = -\exp\left\{-\frac{\lambda}{2}\left[\Omega_{i(k)}(y)+\Omega_{(i)k}(y)\right]\right\}\Delta$$

Khoze-Martin-Ryskin model (cont'd)

- Boundary conditions involve form factors

$$\Omega_{i(k)}(\vec{b}_\perp^{(1)}, \vec{b}_\perp^{(2)}, -Y/2) = F_i(b_\perp(1)^2)$$

$$\Omega_{(i)k}(\vec{b}_\perp^{(1)}, \vec{b}_\perp^{(2)}, +Y/2) = F_k(b_\perp(2)^2)$$

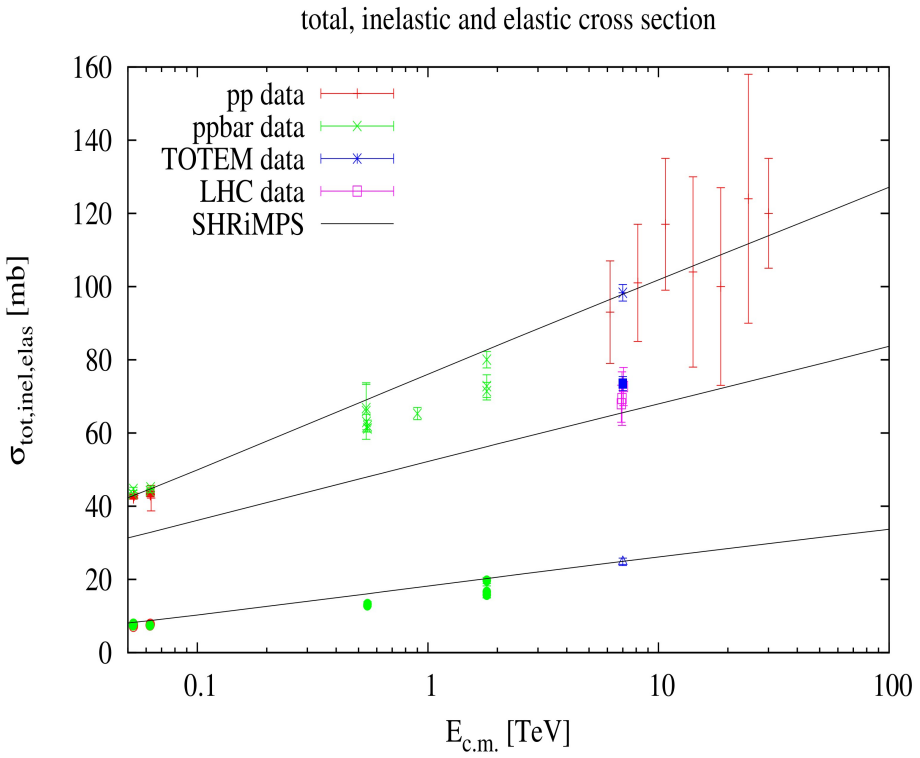
- Form factor as Fourier transforms of (dipole form with extra dampening)

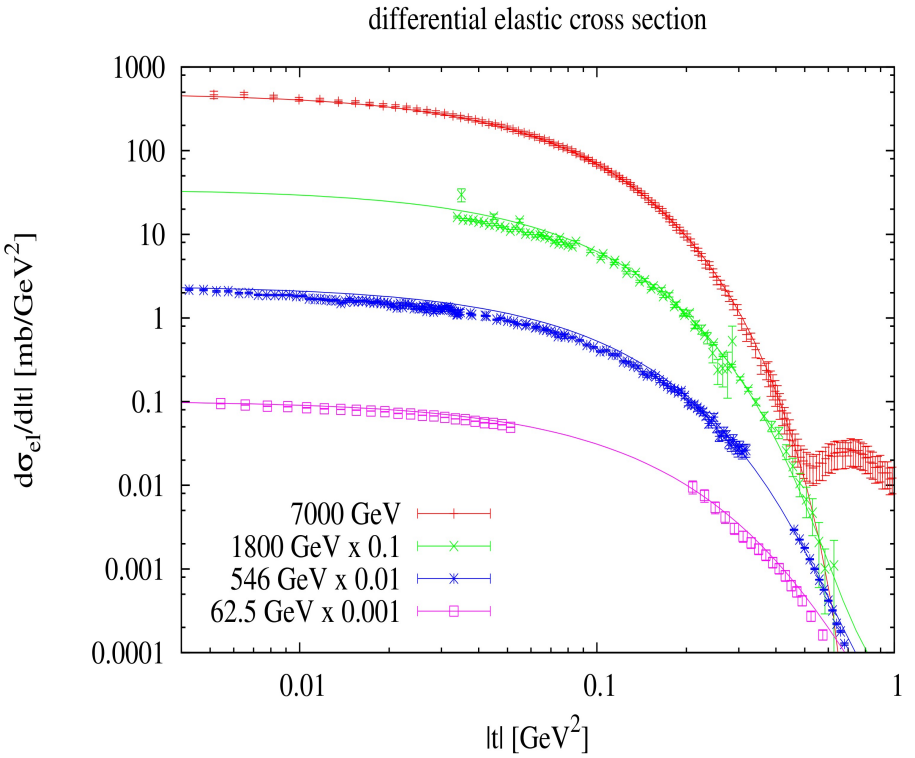
$$F_{1,2}(q_\perp) = \beta_0^2(1 \pm \kappa)\frac{\exp\left[-\frac{(1\pm\kappa)\xi q_\perp^2}{\Lambda^2}\right]}{\left[1 + \frac{(1\pm\kappa)q_\perp^2}{\Lambda^2}\right]^2}$$

- Parameters: $\Delta = 0.3$, $\lambda = 0.25$, $\beta_0^2 = 30$ mb, $\kappa = 0.5$, $\Lambda^2 = 1.5$ GeV^2, $\xi = 0.225$

Inclusive results

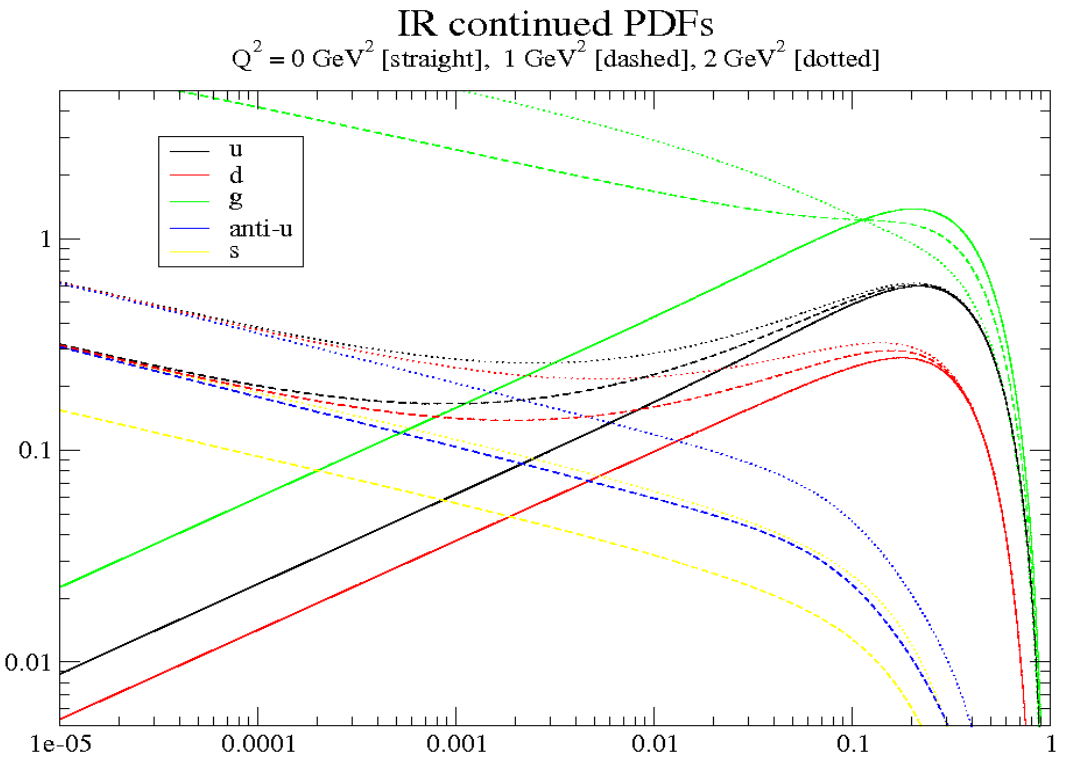
- Total and elastic cross sections vs. data at various energies





Initialising the (primary) ladders

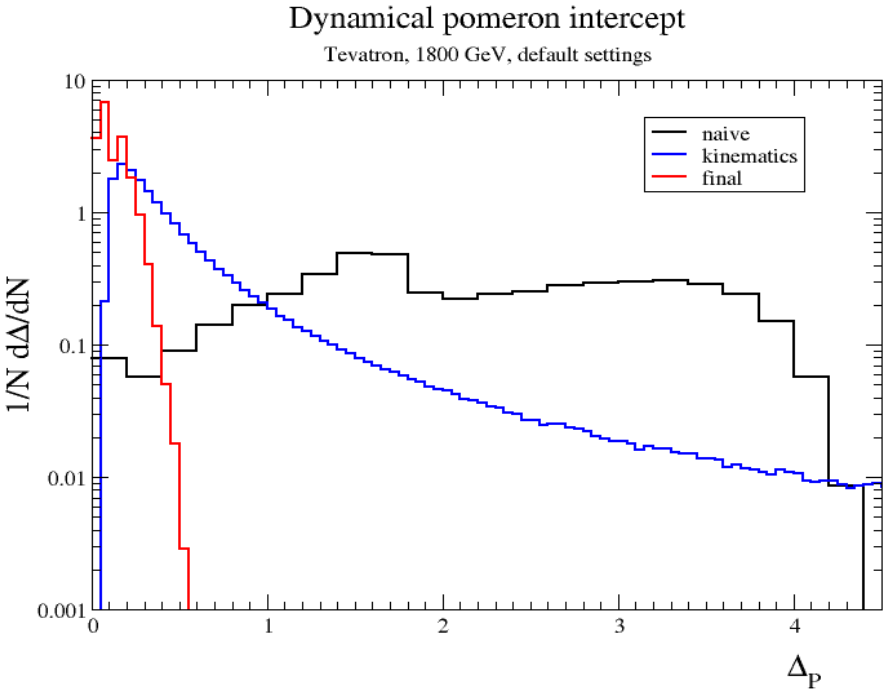
- Select flavours and (collinear) momenta according to IR-continued PDFs and Regge-motivated cross-section $(s/s_0)^{1+\eta}$, where
  - s_0 is fixed to reproduce inelastic cross section in this channel ik, $s>s_0$
  - Exponent $\eta = \Delta \exp[-\lambda/2(\Omega_{ik}(b,0)+\Omega_{ki}(b,0))]$ = "effective intercept"
- IR-continued PDFs:
  - assume f(x,0) = valence only
  - keep norm of valence quarks, renormalise "valence" gluons to satisfy momentum sum rule
  - switch off sea with Q
- Produce N_{ladders} pairs of incoming partons (one valence quark, rest will be gluons)
- Weight for each pair given by Regge expression times the PDFs



Filling the ladders

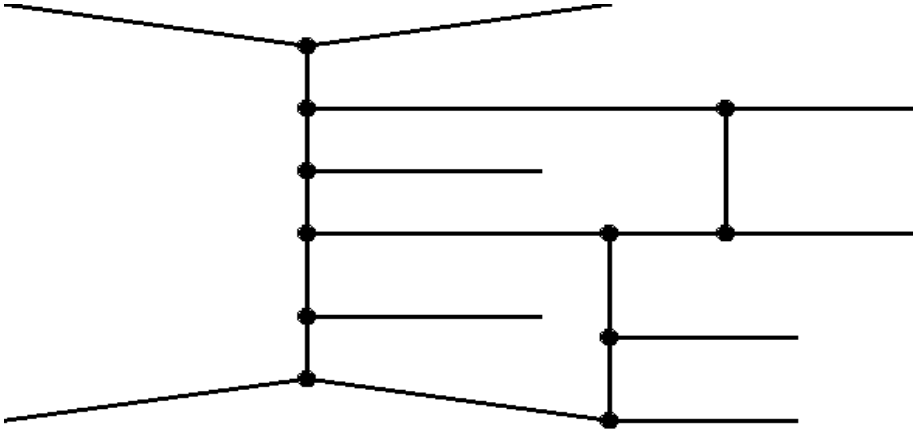
- Generate emissions in between, according to “Sudakov form factor”

$$\mathcal{S}(y_0, y_1) = \exp\left\{ -\int_{y_0}^{y_1} \mathrm{d}y \int \mathrm{d}k_\perp^2 \, \frac{\alpha_s(k_\perp^2 + K_0^2)}{(k_\perp^2 + K_0^2)} \right.$$
$$\times \left[\frac{K_0^2}{q^2 + K_0^2} \right]^{\frac{3\alpha_s(q^2+K_0^2)}{\pi}|y-y_0|}$$
$$\left. \times \exp\left[-\frac{\lambda}{2} \left(\Omega_{i(k)}(y) + \Omega_{(i)k}(y) \right) \right] \right\}$$



- dynamical pomeron intercept
- Reweight ladder with ME for hardest emission
- Note: At this point strictly t-channel, filling stops when either no more y can be “squeezed” in, or when “active” y-interval goes to singlet colour config.

Rescattering



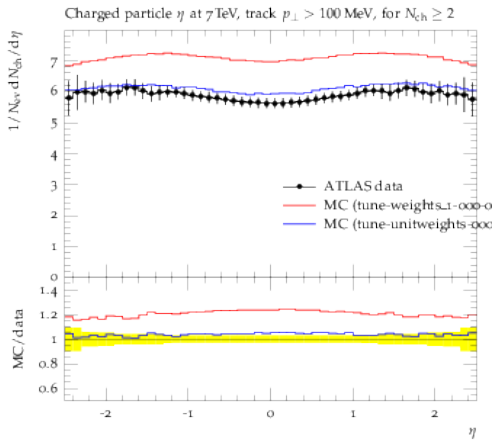
- Consider configurations like
- Partons from ladder may rescatter
- Additional feature (not shown):

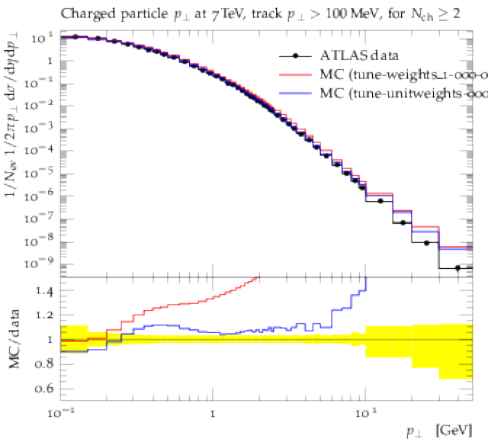
  FS parton shower attached to ladders …
- Question: How to decide if rescattering or not?
- Answer: Same as before
  - Iterate over all pairs of partons at some place in transverse plane
  - Construct rescattering probability for each pair as

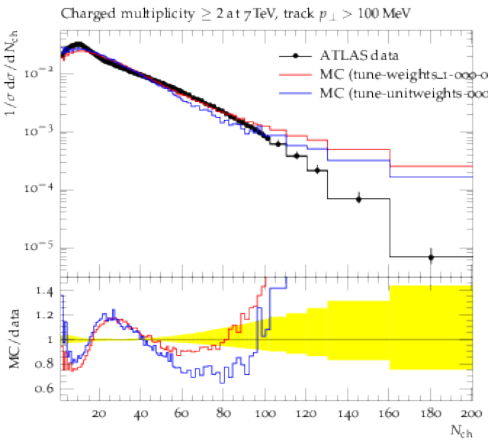
$$P_{\text{rescatter}} = 1-\exp\{-\lambda/2\ [\Omega(y_1)-\Omega(y_2))/(\Omega(y_1)]\}$$

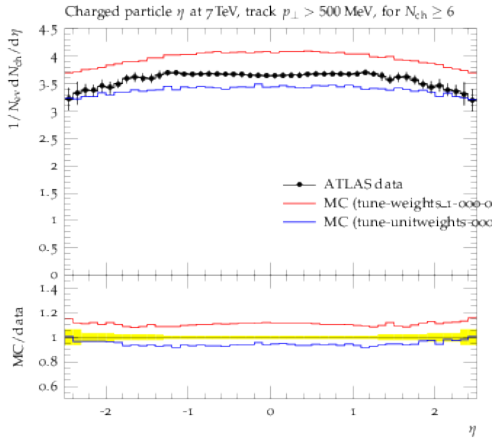
  - Check each pair (compare with random number)
- Open question: Is this consistent with AGK cutting rules? (Ryskin says yes)

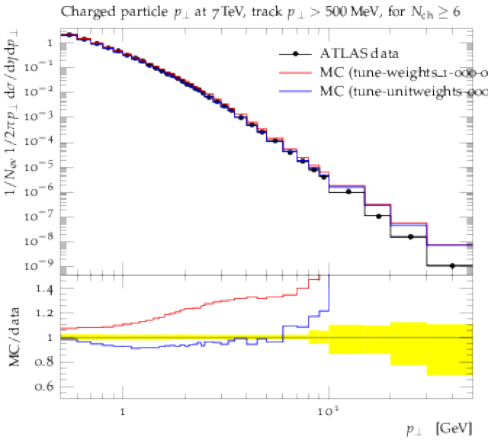
Some example results

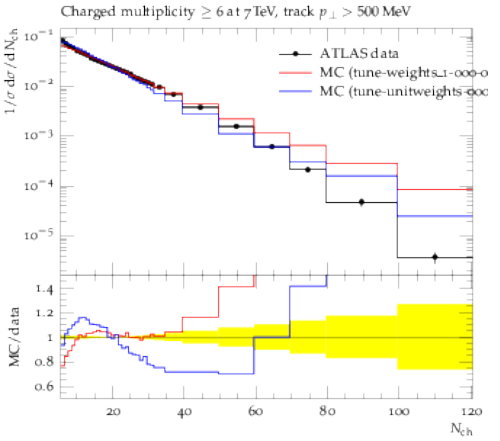




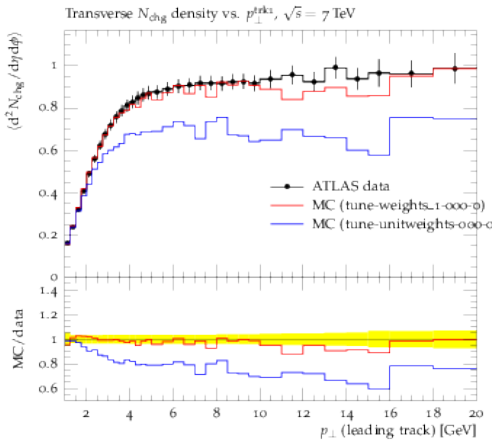


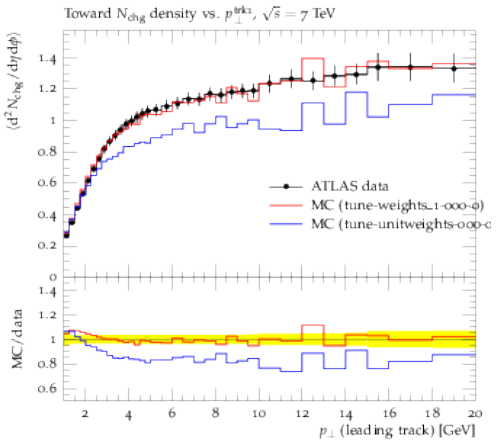


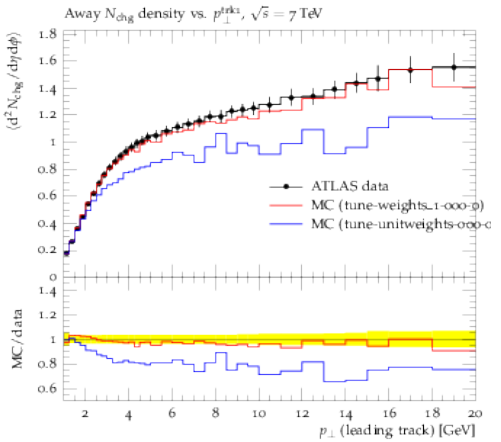


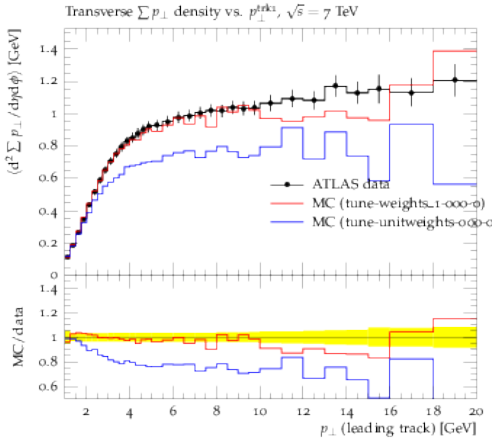


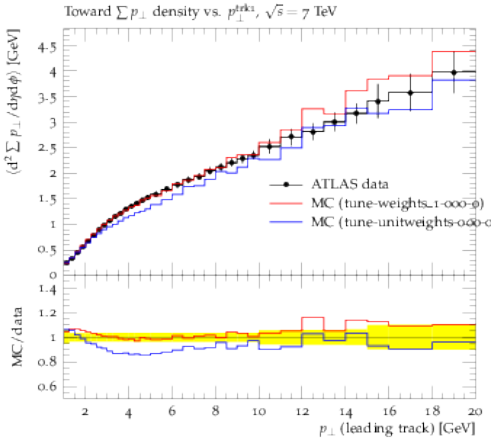
Some example results

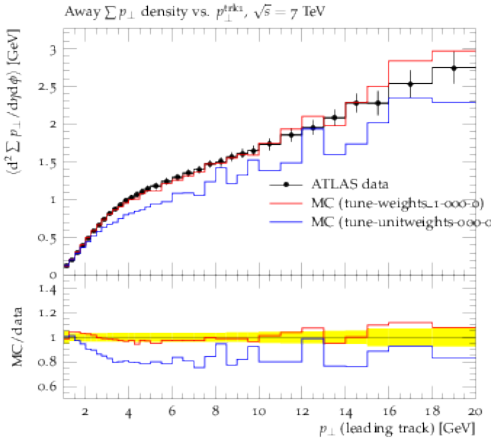




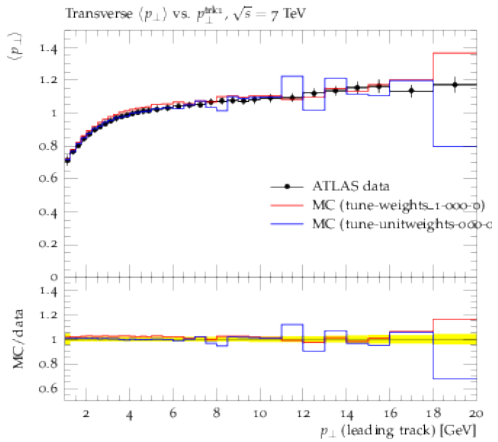


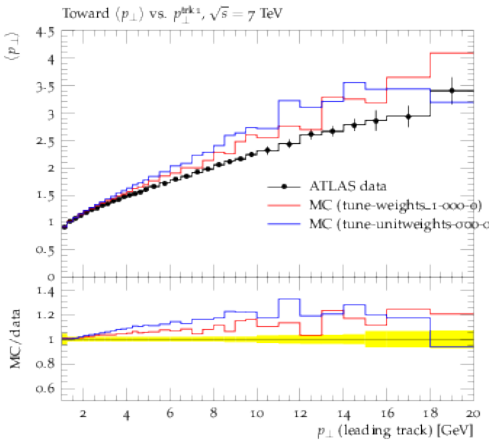


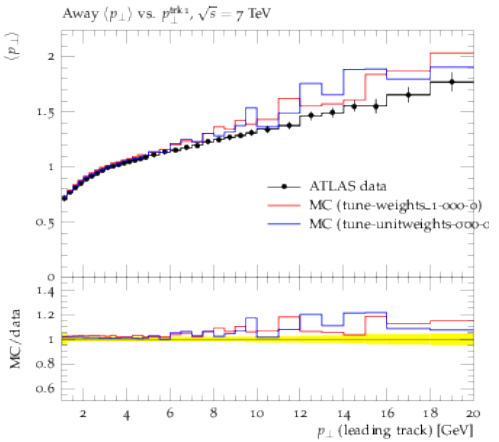


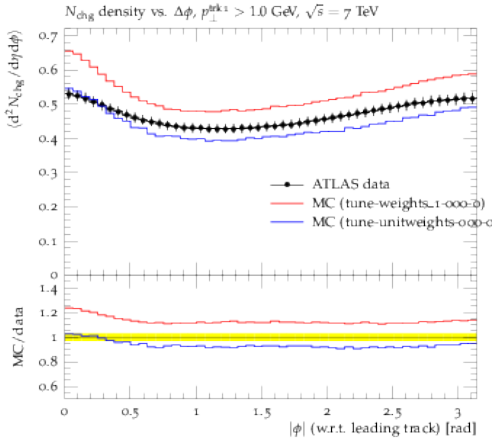


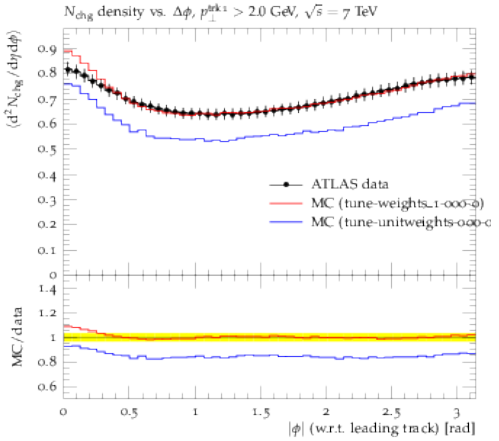
Some example results

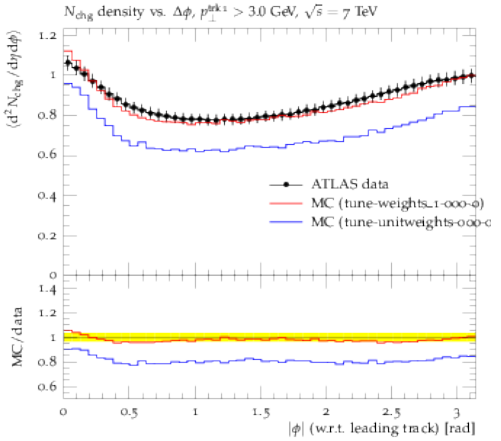




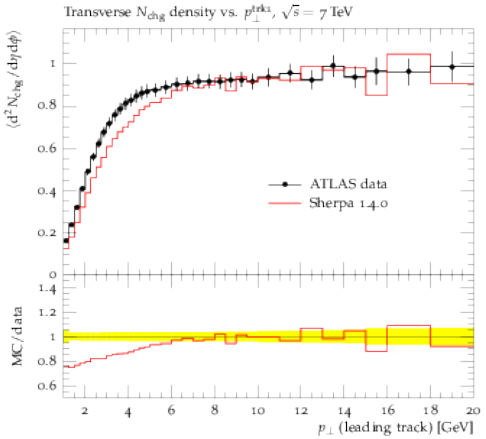


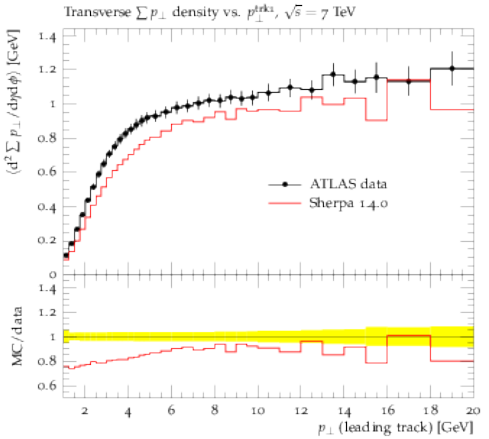


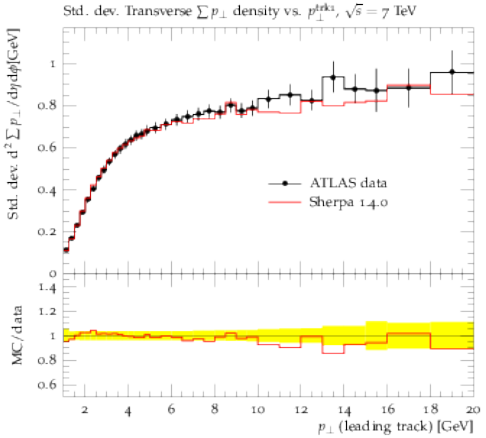


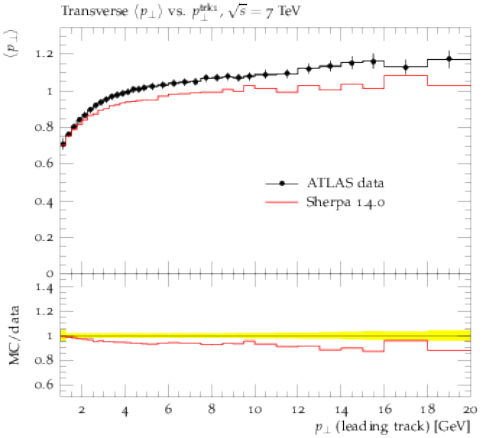


Sherpa's standard UE model

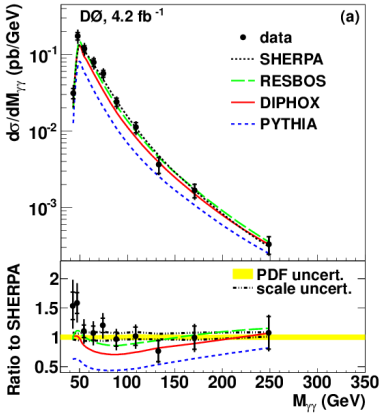


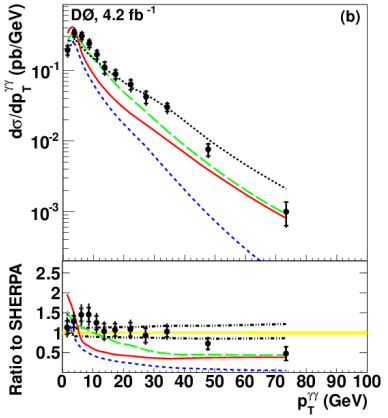


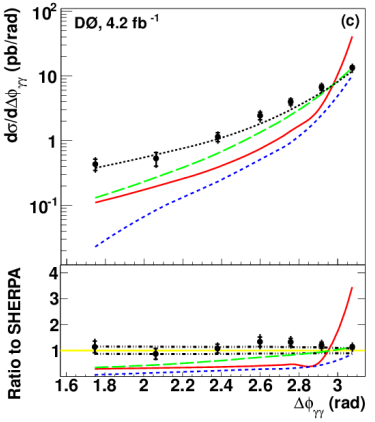


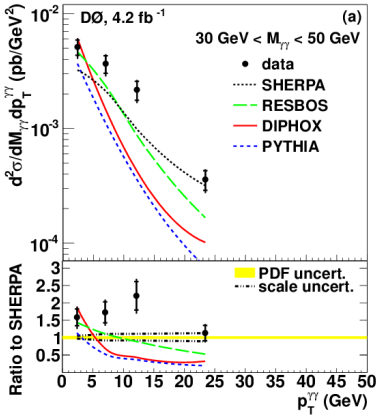


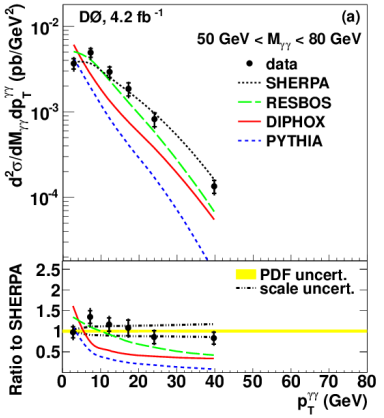
Sherpa's standard UE model

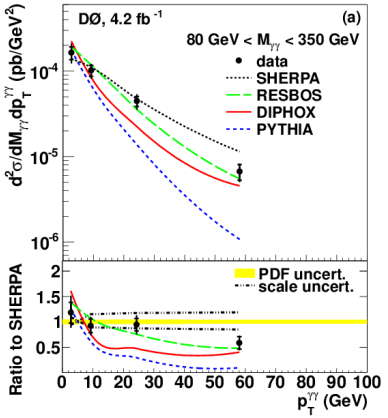












Summary

- In SHERPA's standard MPI/UE model: Include photons, etc.. This will happen in release Sherpa2.0, due end of November (together with many other features, mainly NLO)
- Also: A new model for soft interactions (SHRiMPS), together with Hendrik Hoeth, Valery Khoze, Alan Martin, Misha Ryskin, and Korinna Zapp.
- At the moment we iron out a few more features that we didn't like so much, will need retuning.
- Once done, we'll promote the soft model to a full UE model.