Min Bias and Underlying Event Models in HERWIG

Mike Seymour
Manchester

CERN MC4LHC

July 29th 2003

Underlying Event Models in HERWIG

1. Soft Underlying Event model (SUE)
2. ‘Hard’ Multiparton Scattering model (Jimmy)
3. Hard+Soft Multiparton Scattering model (Jimmy+Ivan)

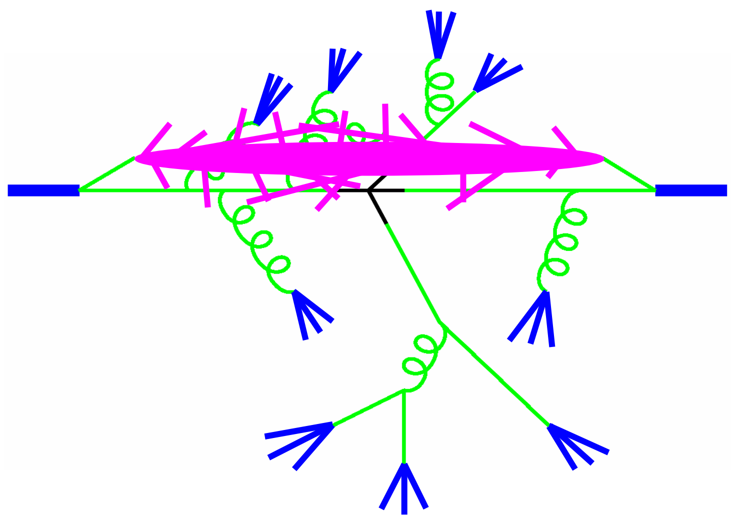
Underlying Event Models in HERWIG

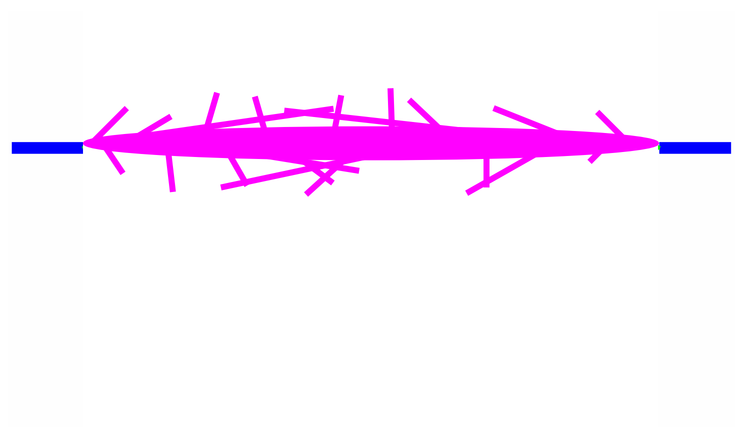
1. Soft Underlying Event model Fully supported
2. ‘Hard’ Multiparton Scattering model Partially supported
3. Hard+Soft Multiparton Scattering model Proof of concept

Soft Underlying Event model

G.Marchesini & B.R.Webber, PRD38(1988)3419

Compare underlying event with ‘minimum bias’ collision



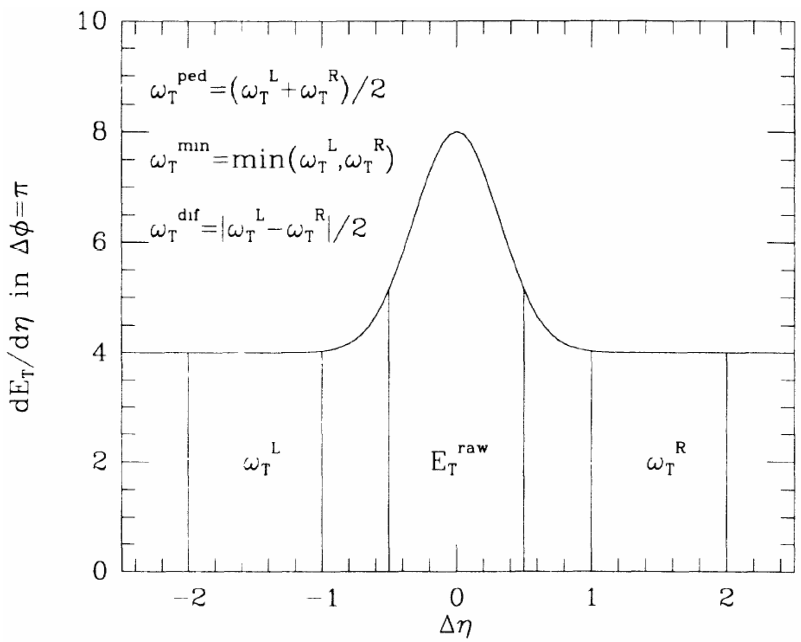


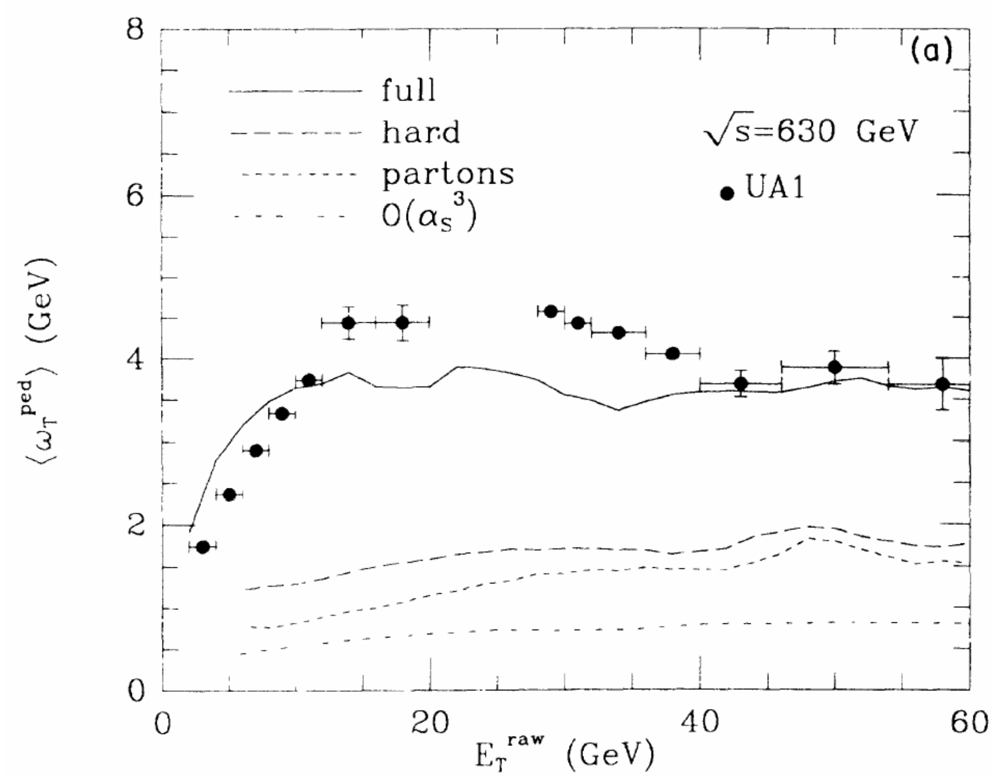
Parameterization of (UA5) data

+ model of energy-dependence

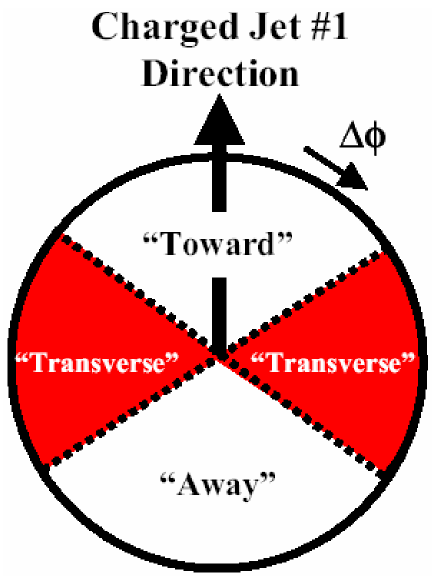
à Pedestal Effect

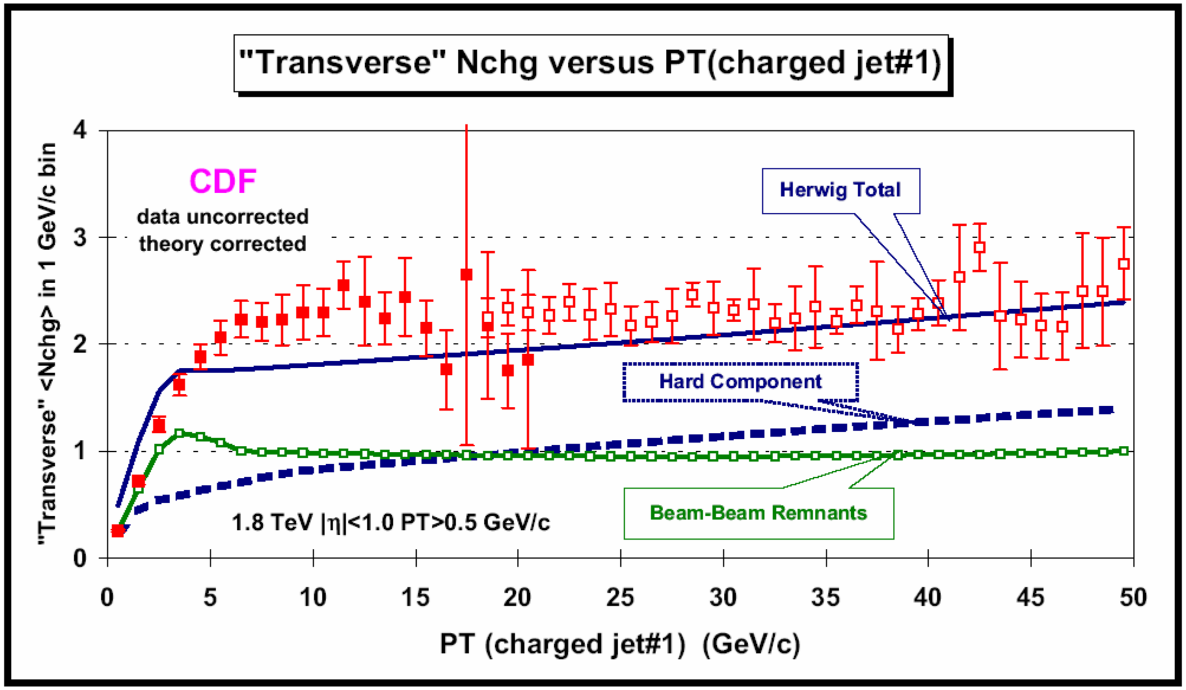
G.Marchesini & B.R.Webber, PRD38(1988)3419





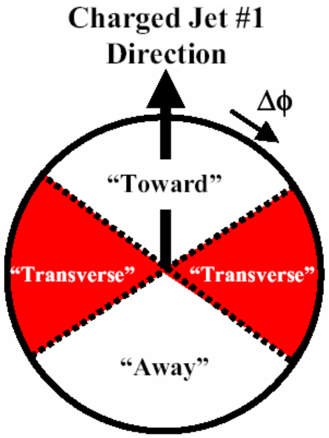
à Pedestal Effect

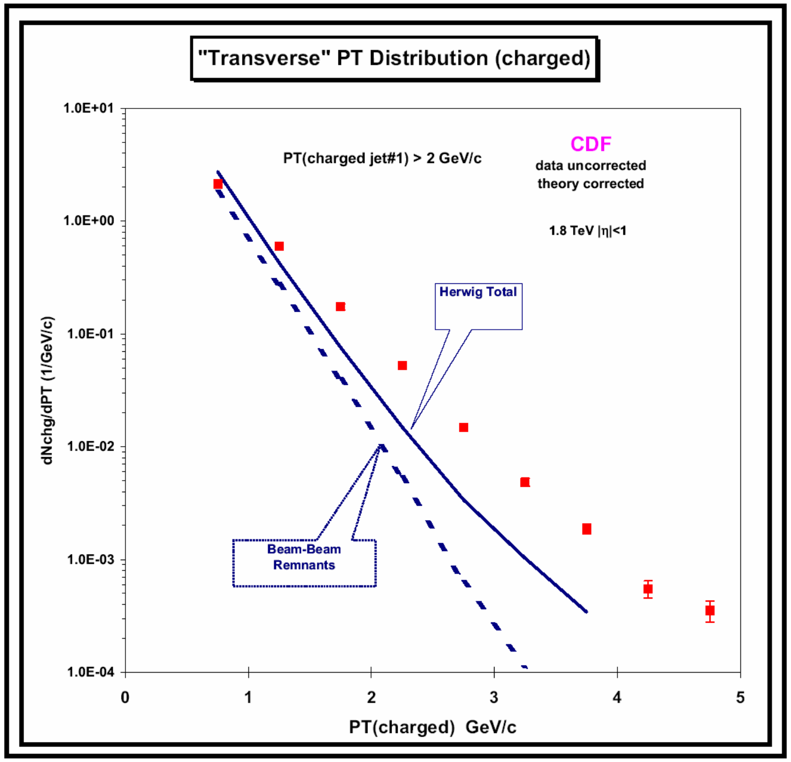




http://www.phys.ufl.edu/~rfield/cdf/chgjet/chgjet_intro.html

but suffers from lack of a hard component…

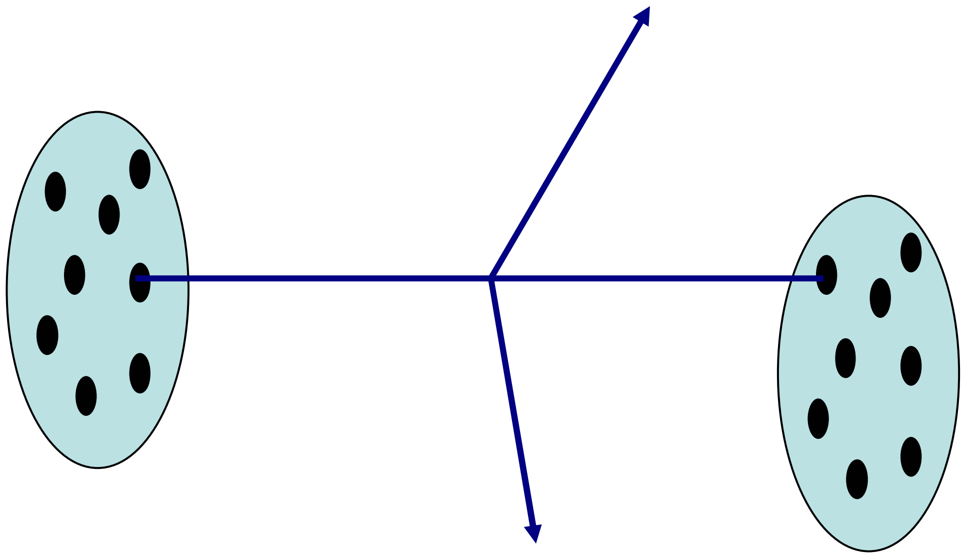




http://www.phys.ufl.edu/~rfield/cdf/chgjet/chgjet_intro.html

Jimmy – Multiparton Interactions in HERWIG

J.M.Butterworth, J.R.Forshaw & MHS, ZPC72(1996)637

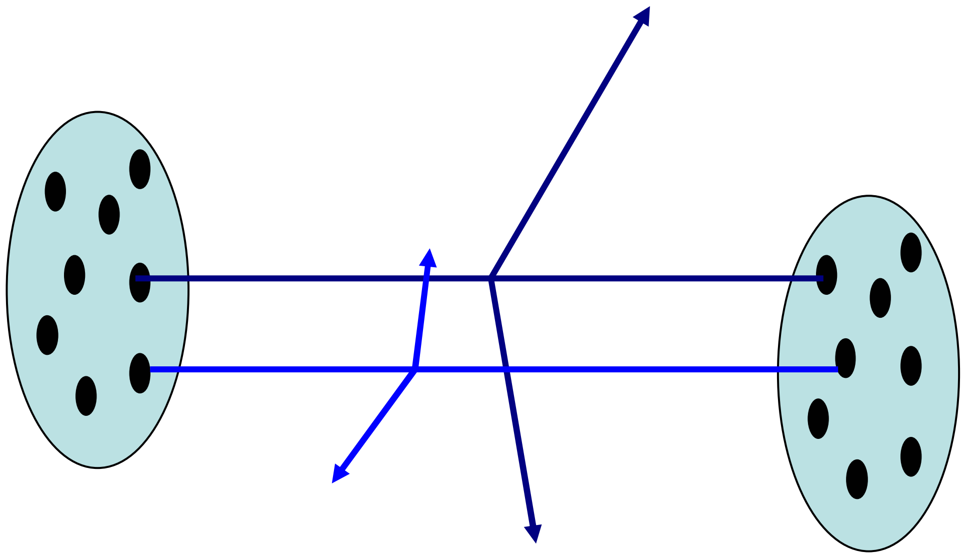


Starting point: $$\frac{dn_i}{d^2b\,dx} = f_i(x)G(b) \qquad \int d^2b\, G(b) = 1$$

eg (EM form factor) $$G_p(\mathbf{b}) = \int \frac{d^2\mathbf{k}}{(2\pi)^2} \frac{\exp(\mathbf{k}\cdot\mathbf{b})}{(1+\mathbf{k}^2/\mu^2)^2} \qquad \mu^2 = 0.71\ \mathrm{GeV}^2$$

$$\sigma^{inc}(s) = \int dx_1\, dx_2 \sum_{i,j} f_i(x_1)\, f_j(x_2)\, \hat{\sigma}_{ij}(x_1 x_2 s)$$

Multiparton Interactions



Assume: n-parton distributions uncorrelated:

$$\frac{dn_{i,j}}{d^2b_i\,dx_i\;d^2b_i\,dx_i} = f_i(x_i)G(b_i)\;f_j(x_j)G(b_j)$$

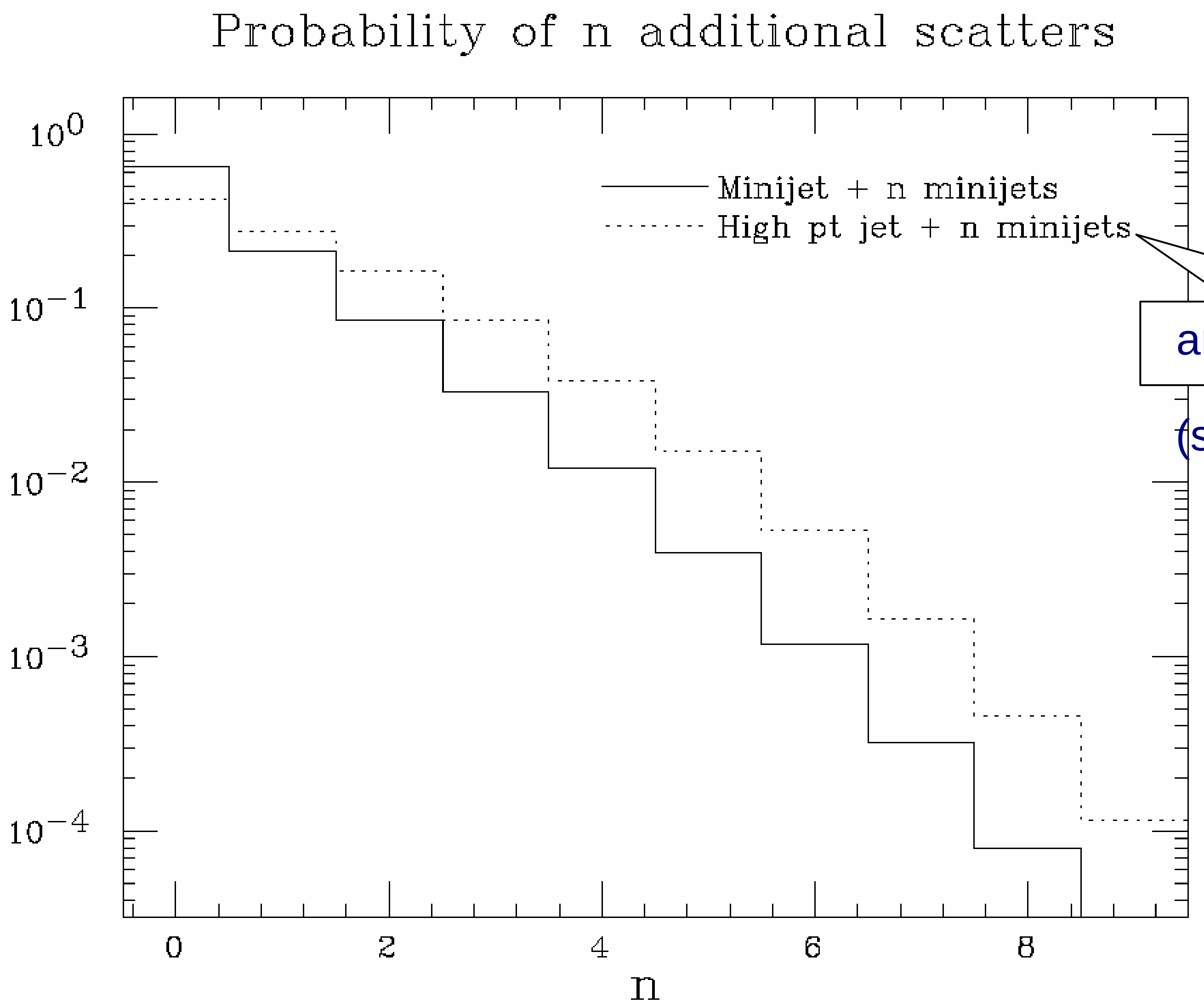
à Poisson distribution at fixed impact parameter

$$\sigma_n = \int d^2b\,\frac{(A(b)\sigma^{inc})^n}{n!}\exp(-A(b)\sigma^{inc})$$

$$A(b) = \int d^2b_1 G(b_1)\,d^2b_2 G(b_2)\,\delta(b - b_1 + b_2)$$

à Non-Poissonian Distribution

~ Geometric Distribution



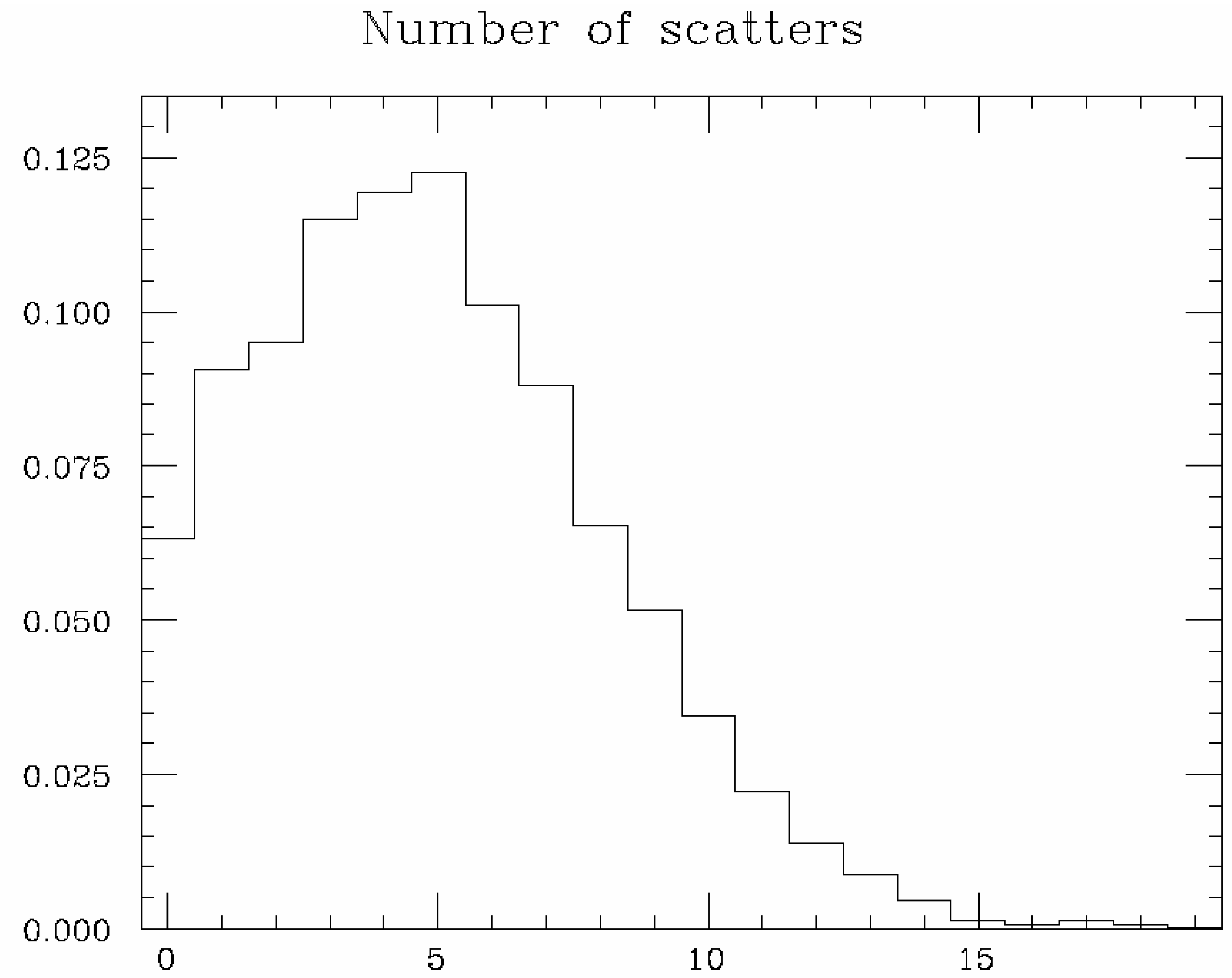
and b-space correlations

(saturates at pt~10 GeV)

Energy Conservation

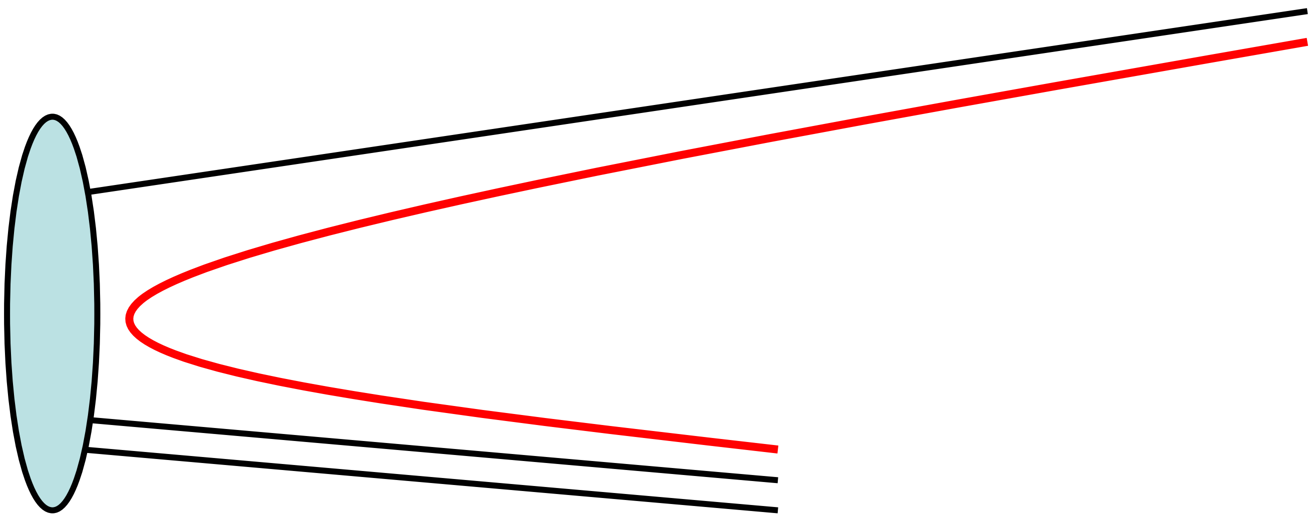
Narrows distribution.

Ask for infinite number of scatters. How many do you get?



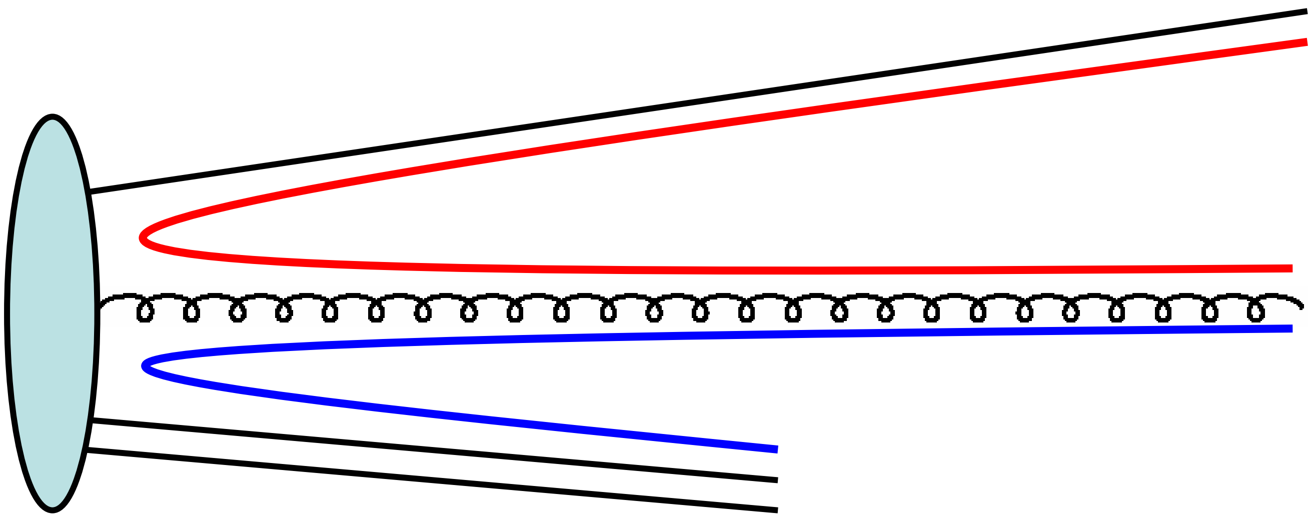
+ Many other choices…

- Scattering cross sections calculated with standard pdfs
- But initial state shower/remnant model gluon only
- Colour connections between scatters



+ Many other choices…

- Scattering cross sections calculated with standard pdfs
- But initial state shower/remnant model gluon only
- Colour connections between scatters

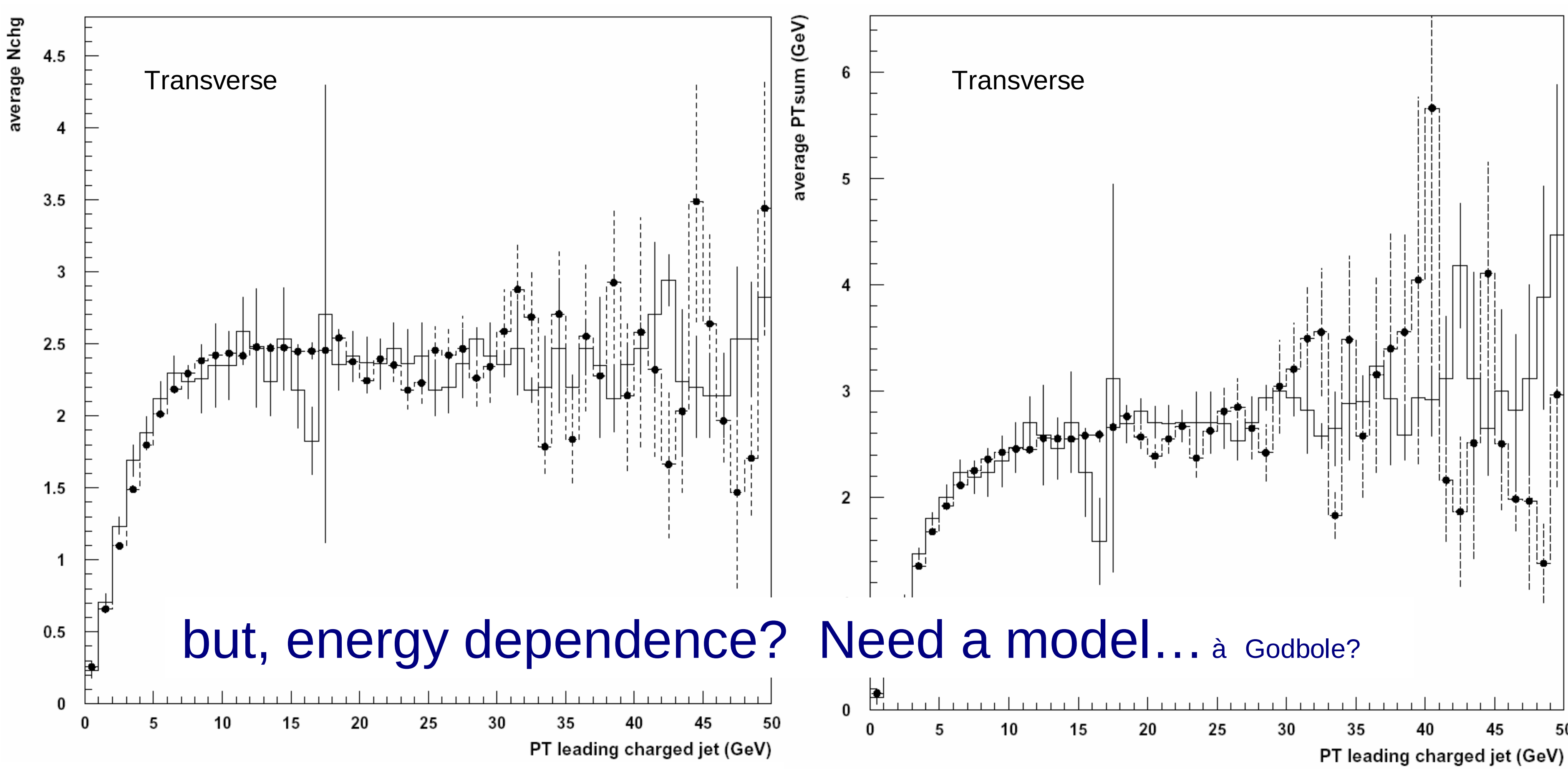


Proton Radius

I.Borozan, PhD thesis, unpublished

- Increasing μ^2 to 2 GeV^2 (i.e. decreasing proton radius by 40%) with ptmin=3 GeV gives

~ perfect description of Tevatron data…



but, energy dependence? Need a model… à Godbole?

Ivan – Multiple soft interactions in HERWIG

I.Borozan & MHS, JHEP0209(2002)015

- Partons still independent
- Soft scatters below PTMIN
- Gluon—gluon only: x g(x) = const
- 'Gaussian' distribution in pt
- Continuity at pt=PTMIN
- Take Eikonal seriously…

$$\sigma_{tot} = 2\pi \int_0^\infty db^2 [1 - e^{-\chi(b,s)}],$$

$$\sigma_{ela} = \pi \int_0^\infty db^2 \left| [1 - e^{-\chi(b,s)}] \right|^2,$$

$$\sigma_{inel} = \pi \int_0^\infty db^2 [1 - e^{-2\chi(b,s)}].$$

$$\chi_{total}(b,s) = \chi_{QCD}(b, s_{p\overline{p}}) + \chi_{soft}(b, s_{p\overline{p}}).$$

$$\chi_{QCD} = \frac{1}{2}\sigma_H^{inc}(s_{p\overline{p}})A(b),$$

$$\chi_{soft} = \frac{1}{2}\sigma_{SOFT}^{inc}(s_{p\overline{p}})A(b).$$

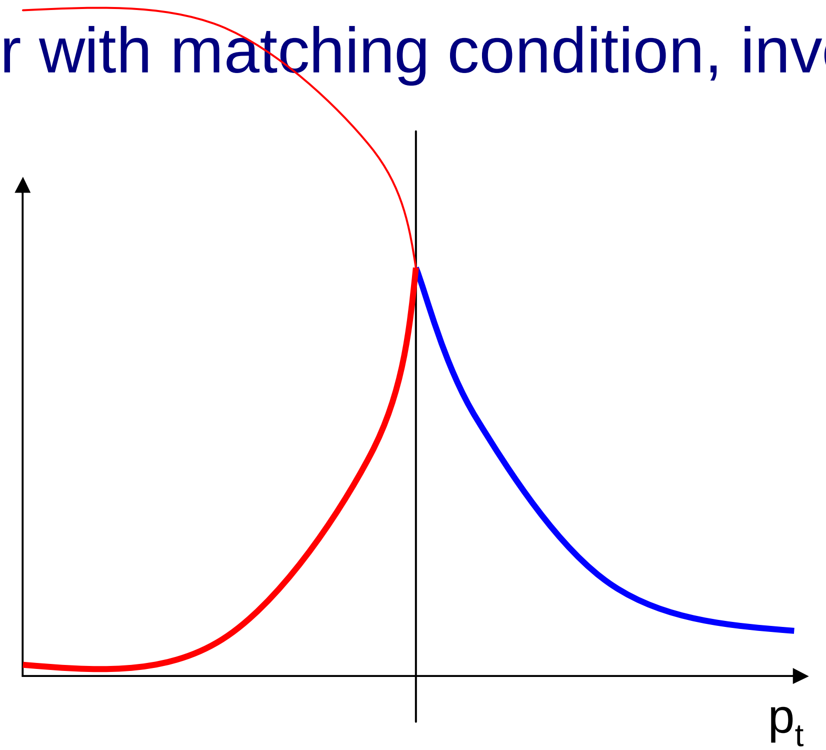
à No new free parameters!

Jimmy doesn't leave much room for Ivan!

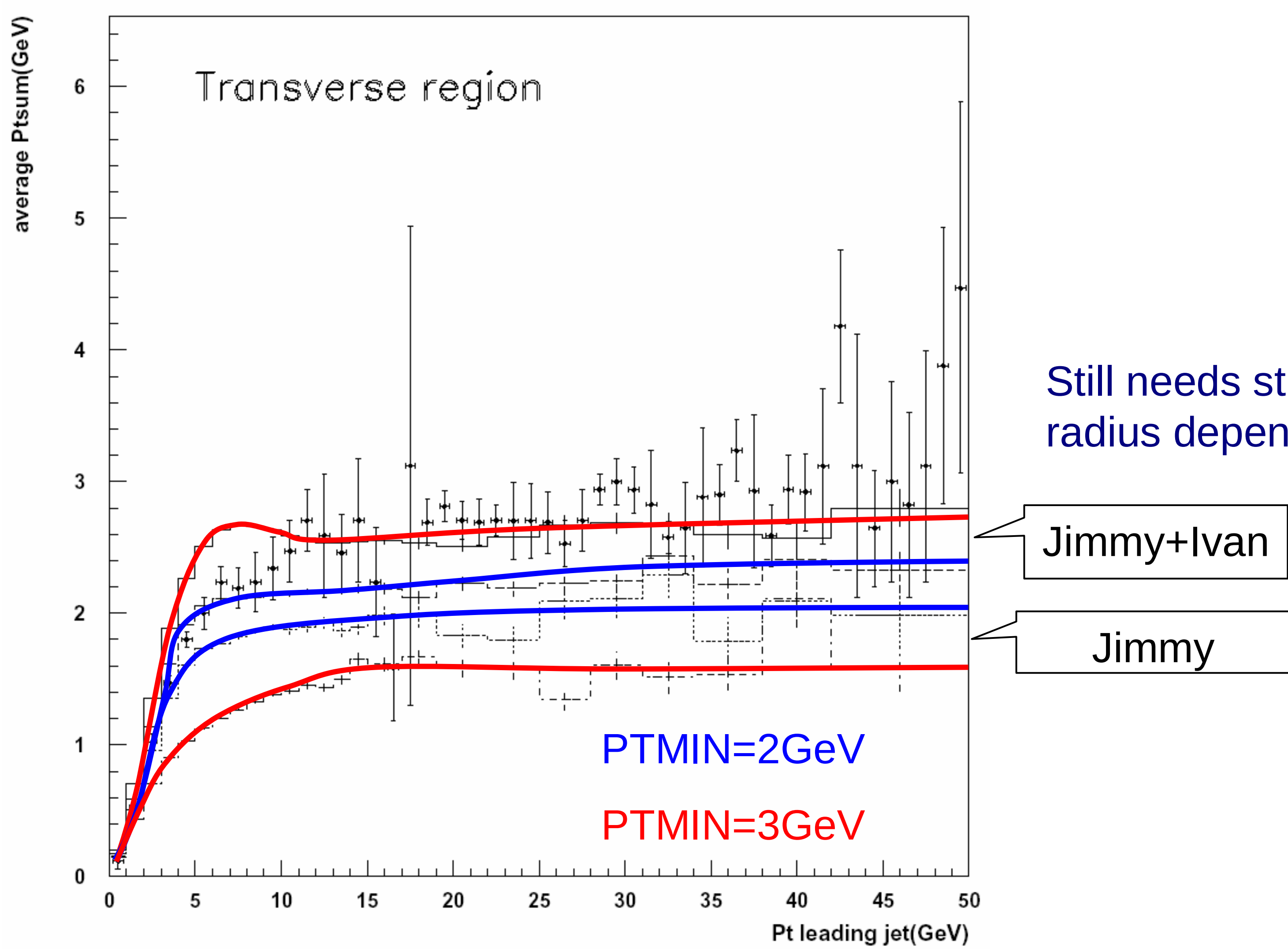
- For PTMIN<2 GeV, hard cross section saturates total…

p_{tmin}(GeV)	$\sigma^{inc}_{SOFT}(s_{p\bar{p}})$(mb)	$\sigma^{inc}_{H}(s_{p\bar{p}})$(mb)	$\langle n_{soft}\rangle$	$\langle n_{hard}\rangle$
2.0	39.7	99.2	0.7	1.7
2.5	85.6	51.3	1.5	0.9
3.0	109.7	28.7	1.9	0.5

- Together with matching condition, inverts Gaussian…



à Similar to Jimmy with low PTMIN, but smaller PTMIN dependence



Still needs study of radius dependence

To Do List

- Upgrade Jimmy to HERWIG6.5 This month
- PTMIN(HW) > PTMIN(Jimmy) Real soon now
- Robust distribution of Jimmy within HERWIG This year…?
- Robust distribution of Ivan within HERWIG++ …?