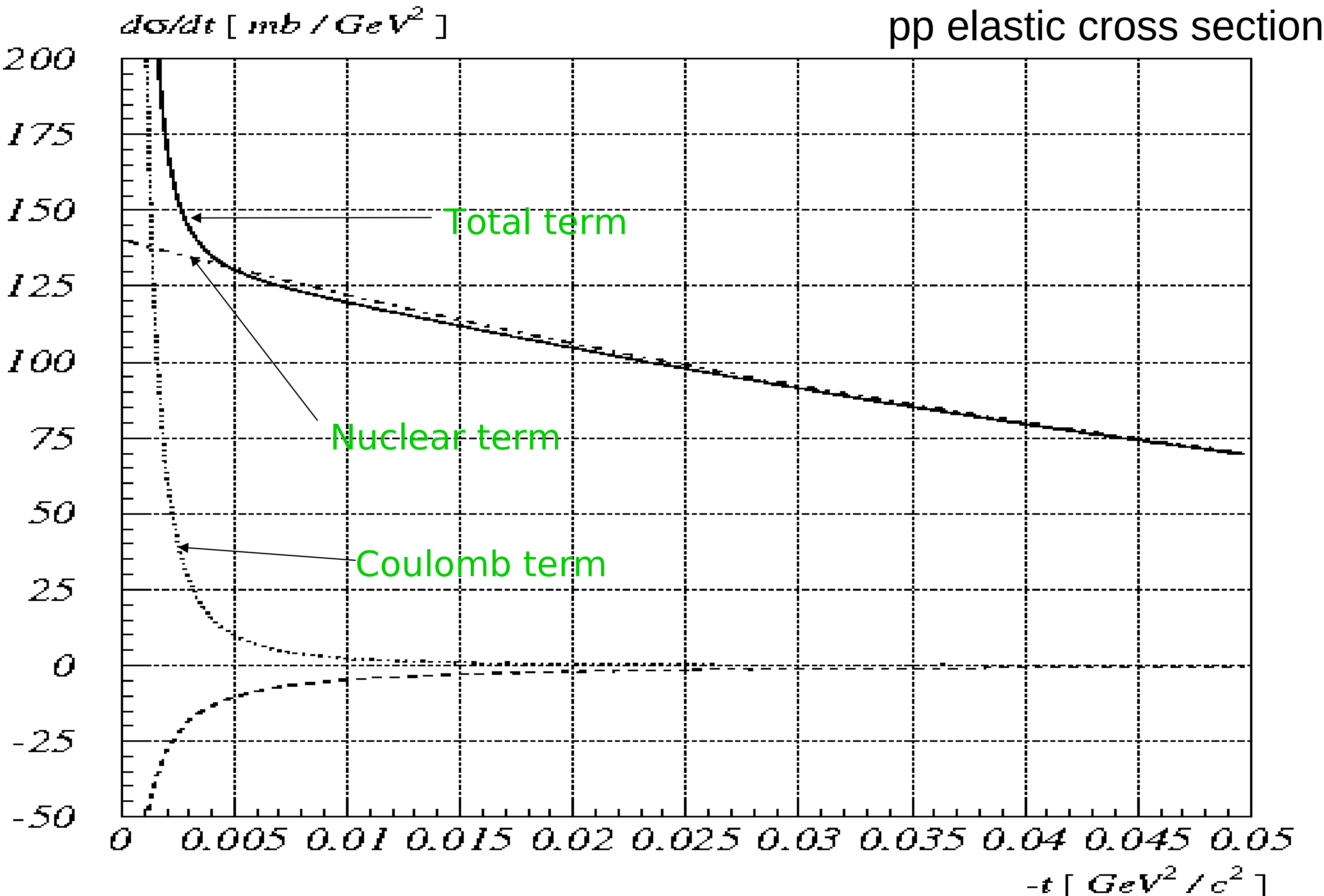
Running point 2013



Some equations

(from N. H. Buttimore et al. Phys.Rev. D59:114010, 1999)

Hadronic amplitudes

$$\sigma_{\text{tot}} = \frac{4\pi}{s}\,\mathrm{Im}(\phi_1(s,t)+\phi_3(s,t))|_{t=0} \qquad \phi_+ = \tfrac{1}{2}(\phi_1+\phi_3)$$

$$\frac{d\sigma}{dt} = \frac{2\pi}{s^2}\{|\phi_1|^2+|\phi_2|^2+|\phi_3|^2+|\phi_4|^2+4|\phi_5|^2\}$$

$$\mathrm{Im}\,\phi_+|_{t=0} = \frac{s\cdot\sigma_{\text{TOT}}}{8\cdot\pi} \qquad \frac{d\sigma}{dt}\approx\frac{4\cdot\pi}{s^2}\cdot|\phi_+^2| \qquad \mathrm{Re}\,\phi_+ = \rho\cdot\mathrm{Im}\,\phi_+$$

Coulomb amplitudes

$$\delta = \alpha\ln\frac{2}{q^2(B+8/\Lambda^2)} - \alpha\gamma$$ ~ 0.03 => mostly real

$$F_1 = \frac{G_E - G_M\,t/4m^2}{1-t/4m^2} \qquad G_E(q^2) = G_M(q^2)/\mu_p = (1+q^2/\Lambda^2)^{-2}$$

$$\phi_1^{\text{em}} = \phi_3^{\text{em}} = \frac{\alpha s}{t}{F_1}^2 \qquad F_1\approx 1 \qquad \phi_+^{\text{em}}\approx\frac{\alpha\cdot s}{t}$$

$$\frac{d\sigma}{dt}=\frac{4\pi\left(\alpha G_E^2\right)^2}{t^2}+\frac{\left(1+\rho^2\right)\sigma_{tot}^2 e^{bt}}{16\pi}+\frac{\left(\rho+\delta\right)\alpha G_E^2 \sigma_{tot} e^{\frac{bt}{2}}}{t}$$

Oversimplified at very small t (not the way to do real fit):

$$\frac{d\sigma}{dt}\approx\frac{4\pi\alpha^2}{t^2}+\frac{\sigma_{\mathrm{TOT}}^2}{16\pi}+\frac{\rho\alpha\sigma_{TOT}}{t}$$

Fit: $$\frac{d\sigma}{dt}=\frac{A}{t^2}+\frac{B}{t}+C$$

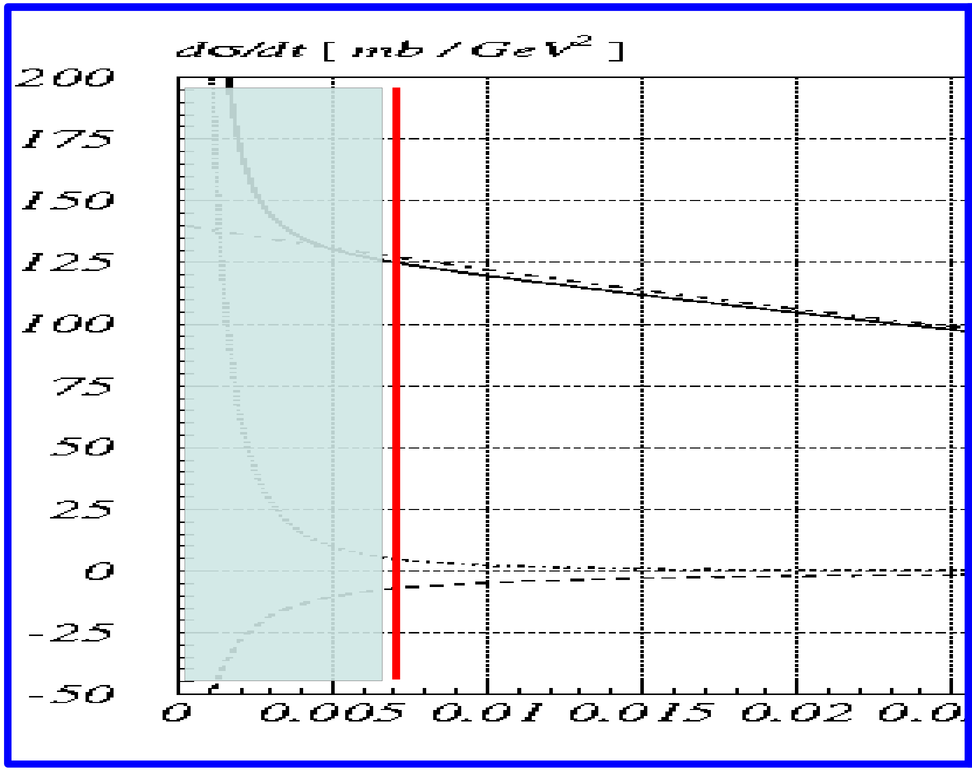
A is exactly calculable from QED – gives an **absolute** normalization (though it is not clear how good could be the fit)
B – interference term – a good way to measure ρ
C – total and elastic cross sections

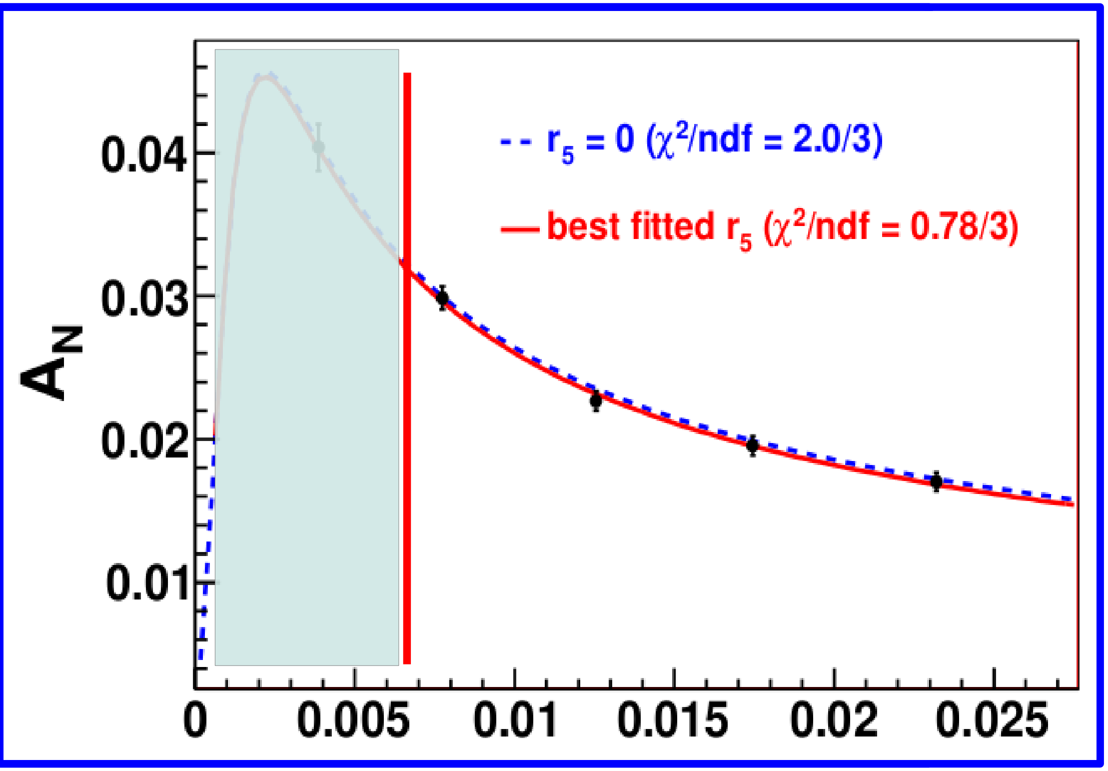
Upper Limit

- Maximum -t is defined by the worst of the two factors:
  1) Quad aperture (55 mm @ 35 m)
  2) Detector size (52 mm + 5 mm “best approach” @ Leff)
- (1) is critical unless Leff <~35m, $-t_{max}=0.15(GeV/c)^2$
- This is good enough:
  - 5 times Run2009
  - dσ/dt drops 8 times – see the slope
- Difficult to spoil, if even Leff=40m, only small change

Lower Limit

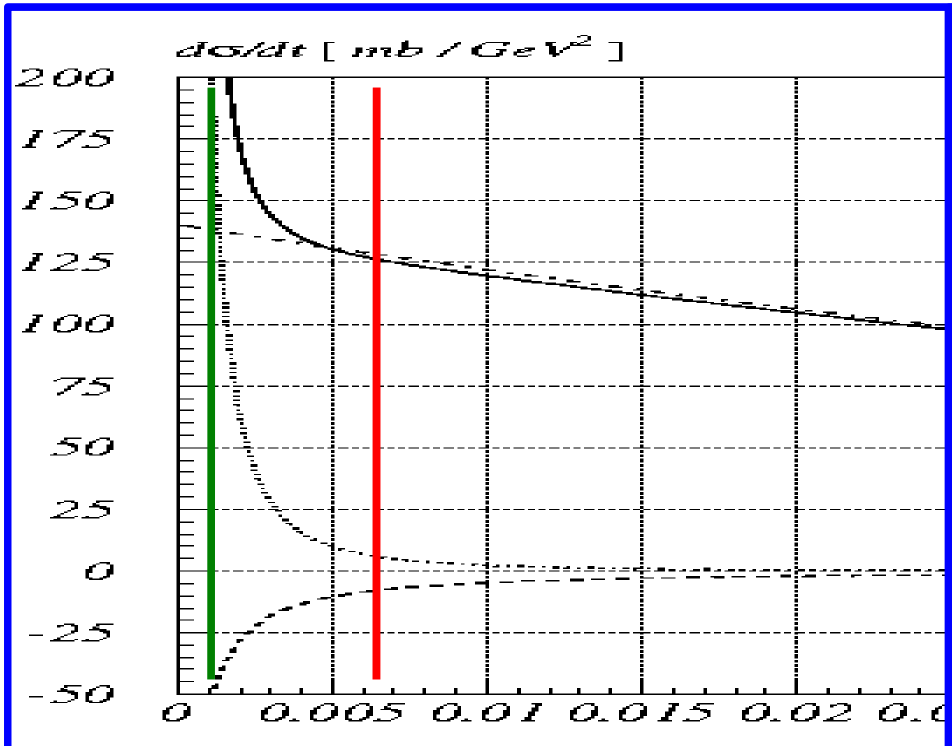
- β*=9m, the RP best approach 5mm (nσ=12σ)*, the worst Leff=16m, normalized emittance ε=10π
- Angular divergence at IP: $\sigma_{\dot{X}} = \sqrt{\frac{\varepsilon}{6\pi\gamma\beta^*}}$ =27 μrad
- Beam size at RP (one sigma) 0.44 mm
- Minimum -t: $\left(n\sigma_{\dot{X}}\, p\right)^2 = \frac{n^2 p\varepsilon}{6\pi\beta^*}$ =0.0065 (GeV/c)²

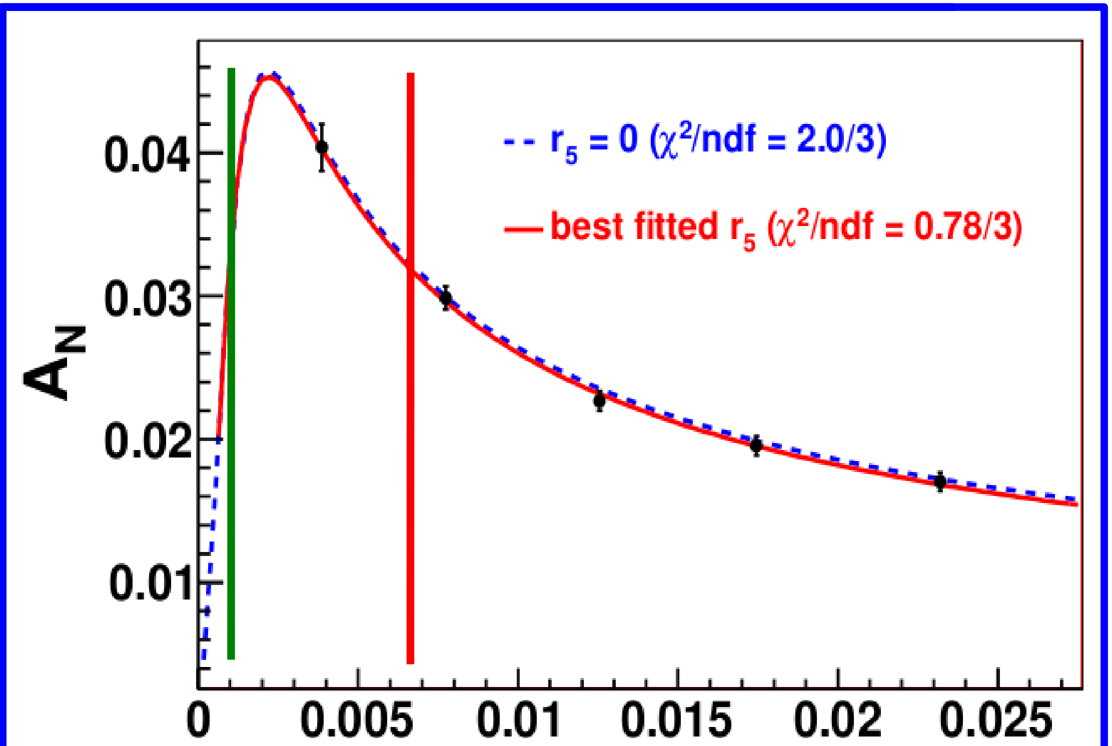




Lower Limit (cont'd)

- TOO BAD !!! (twice as bad as in RUN2009)
- Don't touch even interference region in cross-section
- Unable to get absolute calibration of cross-section
- Unable to sense ρ-parameter
- Useless to measure polarized effects
- CAN go as low as $0.001(\mathrm{GeV}/c)^2$ (in principle)



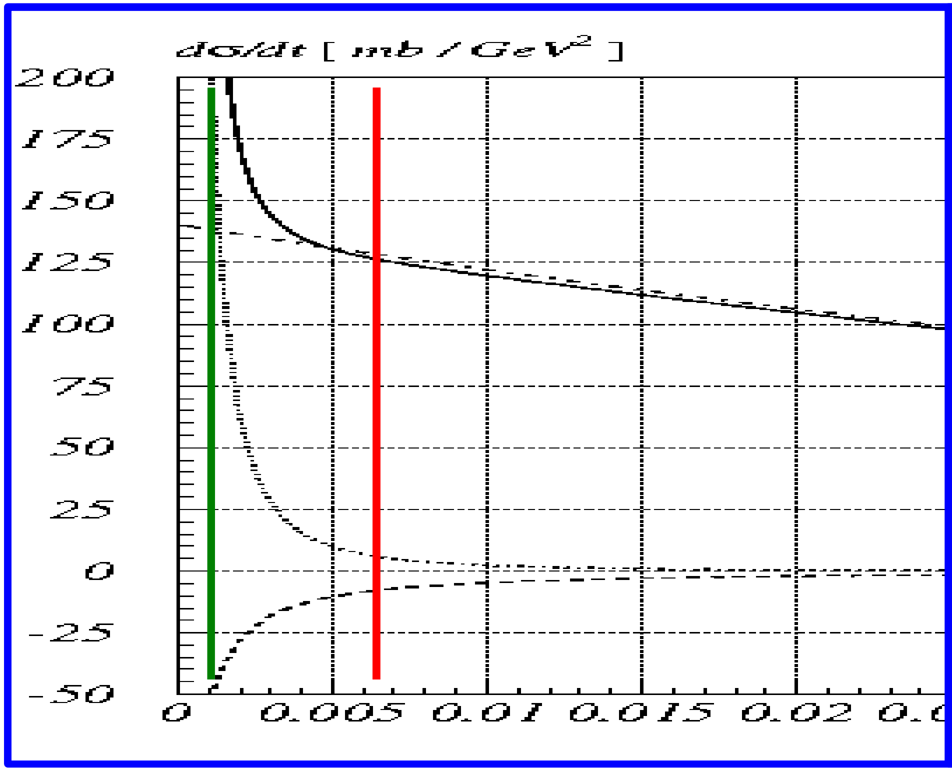


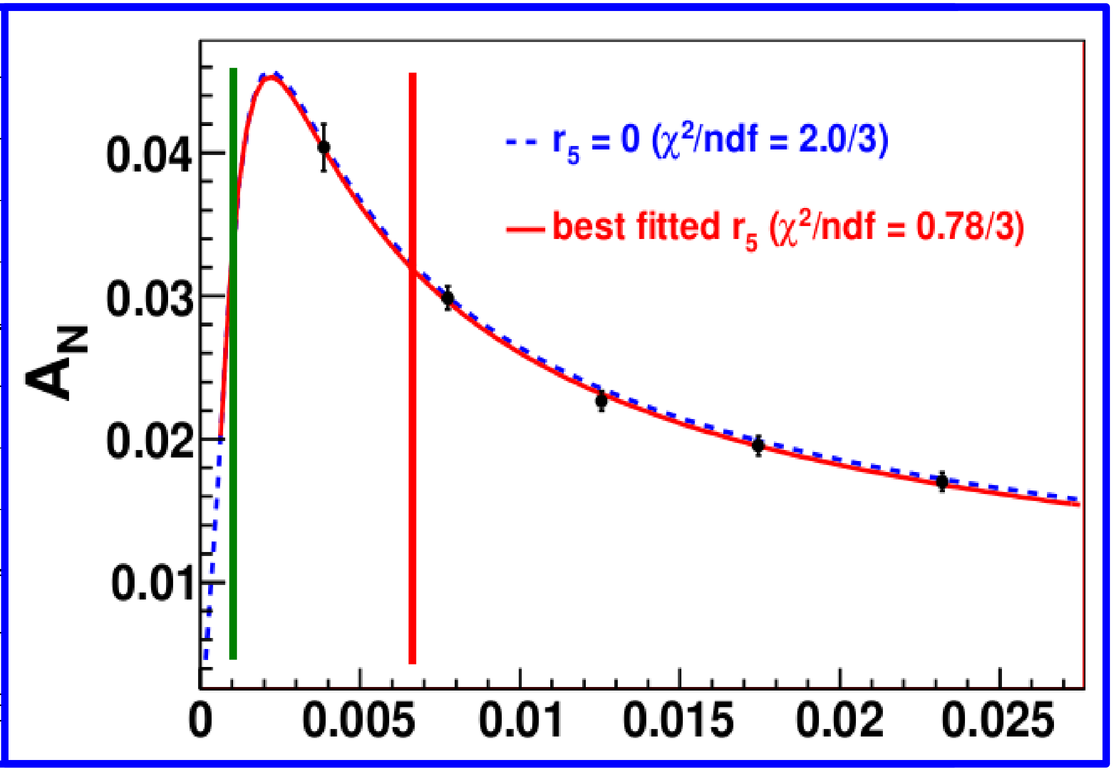
Lower Lower Limit – what needed

- Go down to 7-8σ*
- β*=20-25 m
- Large Leff (35-40 m) will help in terms of mm
- Real if: a) no collisions at Phenix;
  b) relax polarization

$$-t_{min} = \left(n\sigma_{\dot{X}}\, p\right)^2 = \frac{n^2\, p\varepsilon}{6\pi\beta^*}$$

*) Compare to TOTEM – the best approach **4.8σ**





Lower Lower Limit – advantages

- Reach area, where Column amplitude ≈ nuclear
- Total cross-section ≈ 2*nuclear
- Absolute calibration of the cross-section even without Veriner scan
- See the region of the very interference
- ρ-parameter measurement
- Measure A_N peak, if occasionally have polarization
- Set a record in lowest t for pp
- Setting the goal at $-t_{MIN}=0.002$ is nearly useless for unpolarized : Coulomb amplitude drops 2 times