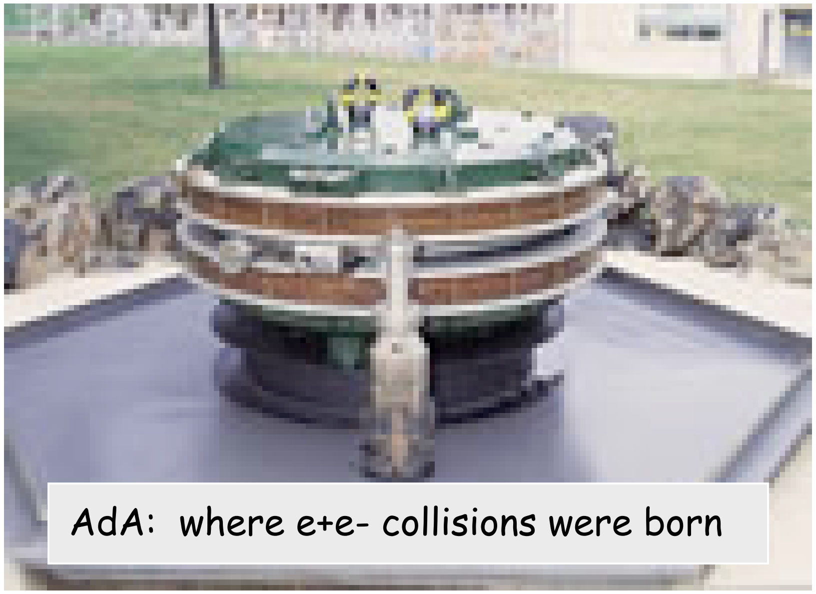
Total hadronic cross-sections: from LHC to ILC

[Giulia Pancheri - INFN-Frascati]

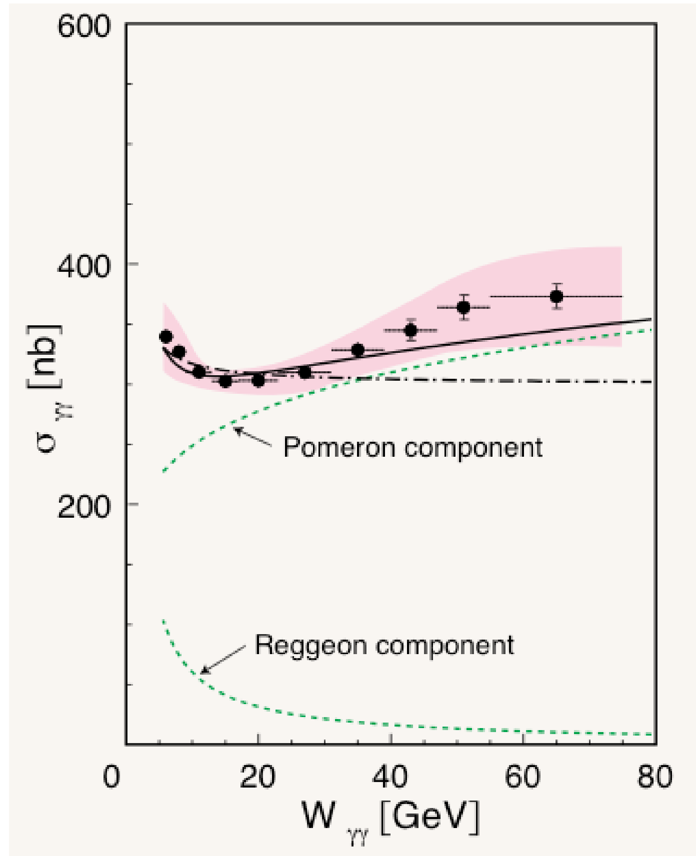
Presented by M. Krawczyk



AdA: where e+e- collisions were born

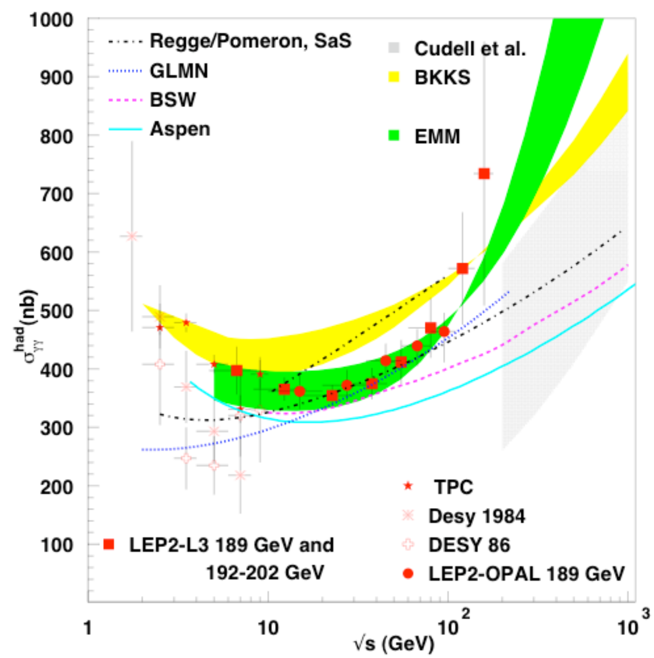
QCD tests

- Models for total cross-section



Models for total cross-section

- The interest lies in QCD role
- What is the Pomeron? The Reggeon?
- Are these concepts universal?
- Or do they just phenomenologically describe our ignorance?
- How can ILC help ?



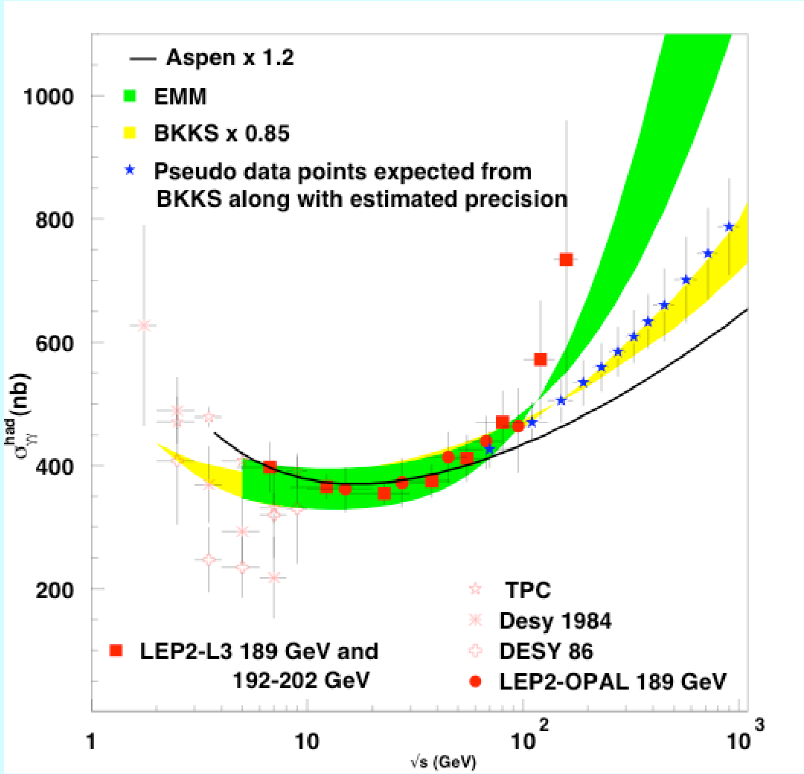
A.de Roeck, R. Godbole, A. Grau, G.Pancheri, JHEP 2003

S^{ε} : Should ε be the same for all hadronic cross-sections?

- Yes if the model
  - is based on Regge poles and a universal Pomeron pole exchange

    $\sigma = Bs^{-\eta} + As^{\varepsilon}$

- Not necessarily if
  - The model has some connection with QCD and parton densities play a role



A fit to LEP data shows that ε is not the same for proton and photon cross-sections

$\sigma = Bs^{-\eta} + As^{\varepsilon} + Cs^{\varepsilon_1}$

- Fit3

C≠ 0 $\varepsilon=0.093$

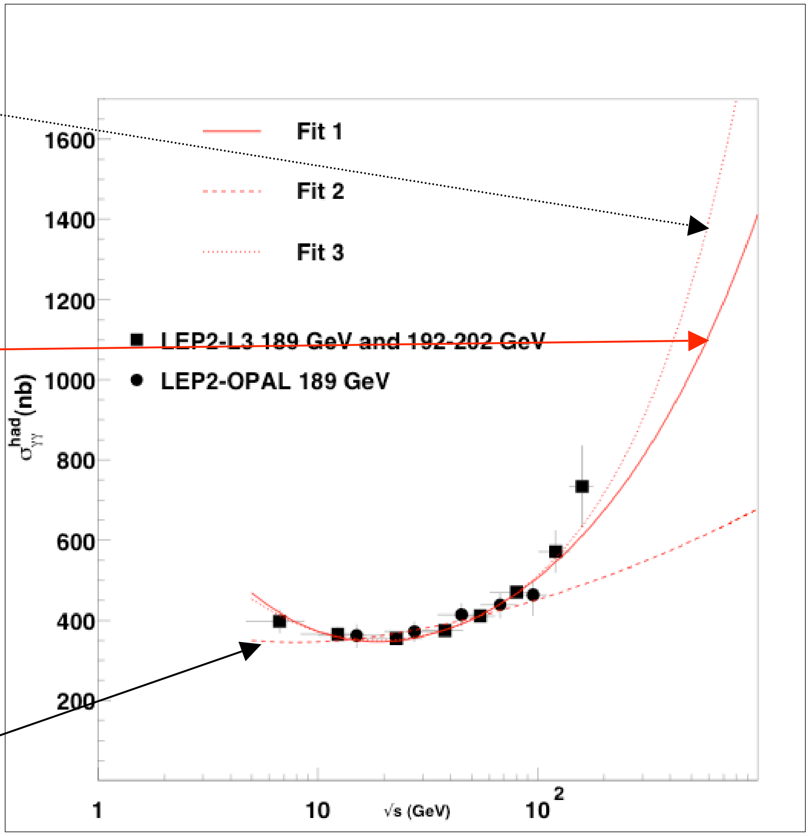
$\varepsilon_1=0.418$

- Fit 1

C=0 $\varepsilon=0.250$

- Fit2

C=0 $\varepsilon=0.093$ as in pp



A realistic QCD model should relate the fit to QCD phenomenological inputs quantities like densities etc.

The Bloch-Nordsiek Eikonal Minijet model includes k_t resummation

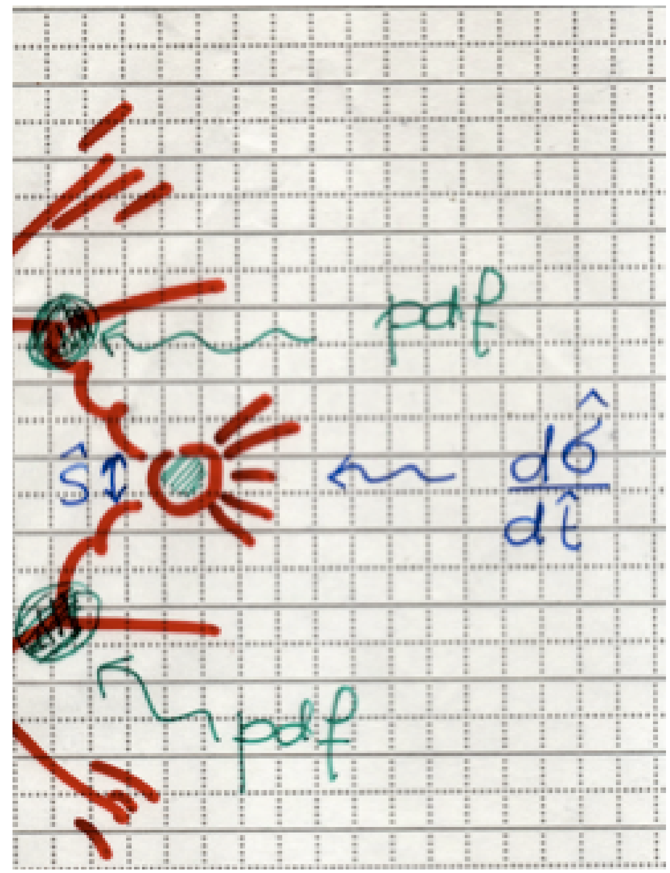
R.Godbole, A. Grau, G.Pancheri, Y.Srivastava PRD 2005
A. Corsetti, A. Grau, G.Pancheri, Y. Srivastava PLB 1996

1. Multiple parton interactions : optical theorem and eikonal representation for $T_{el}(s,t)$
2. Hard scattering to drive the rise due to 1/x
3. Soft gluons down to zero momentum to tame the rise

The hard cross-section

- Mini-jet cross-section

$\Sigma\int$ densities $\int dp_t \; d\hat{\sigma}/dp_t$



In all mini-jet models densities make all the difference between photon and proton processes

Proton-proton and proton-antiproton

Most commonly used densities

- GRV
- CTEQ
- MRST

γ–proton and $\gamma\gamma$

Most commonly used densities

- GRV
- GRS
- CJKL

Soft resummation

Probablity of total K_T from infinite # of soft gluons

$$\int d^2b\, e^{iK_T b} \exp\{-\int d^3n(k)[1-e^{-ik_t b}]\}$$

depends upon single gluon energy

- maximum : use Kinematics
- minimum : 0 from Bloch-Nordsieck theorem

Role of resummation

An infinite number of soft quanta

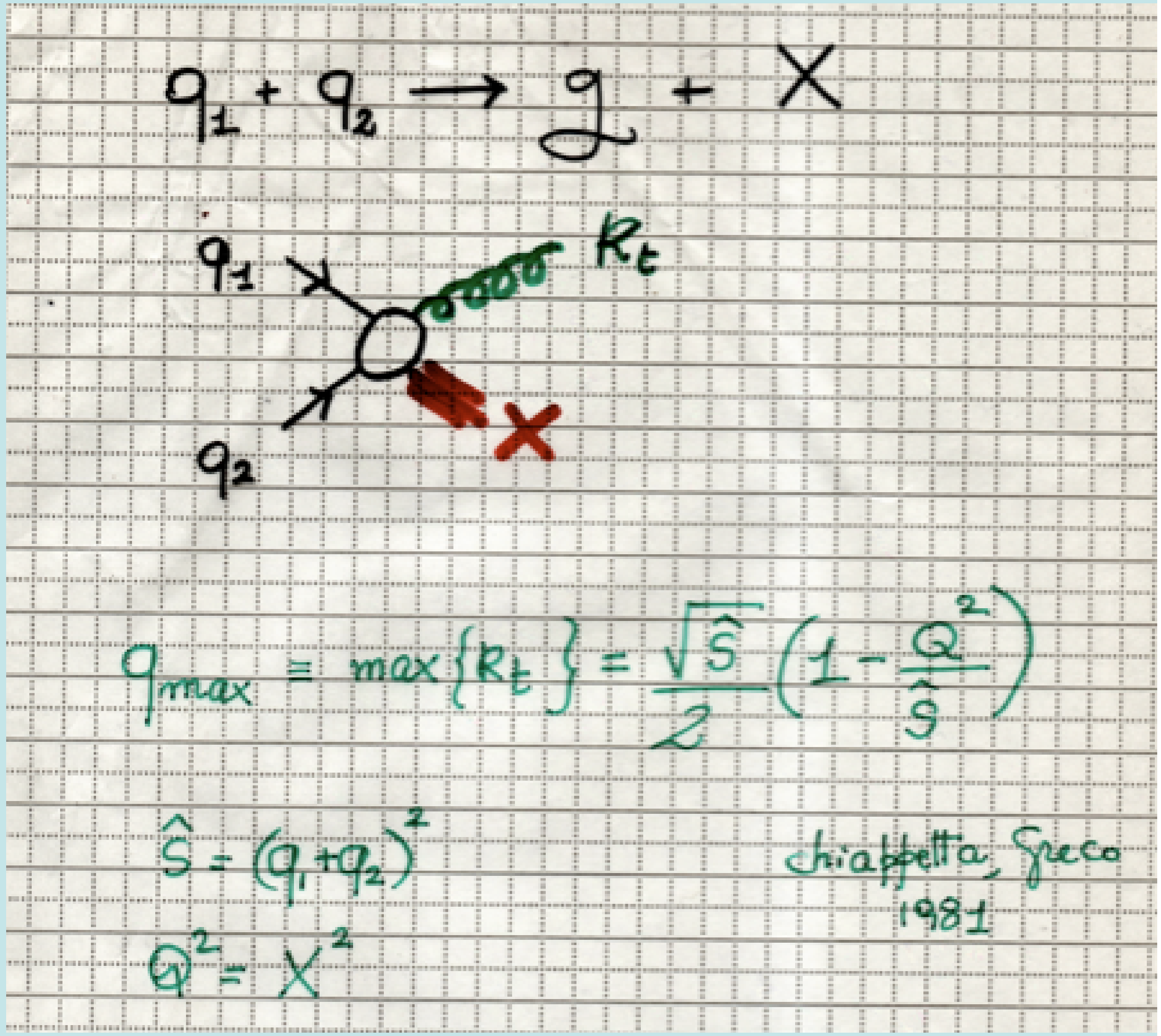
- down to zero momentum but how?

  next slides

- Up to an energy dependent limit q_{max}
  - Higher hadron energy ⟹ possibility of more small x partons with "high energy" (≈1-2 GeV) ⟹ higher q_{max}

Maximum soft gluon energy

- q_1 and q_2 : any two partons
- X : the 2-jet final state
- $Q^2 \geq 4\, p^2_{tmin}$
- q_{max} depends on x_1, x_2
- We average over densities



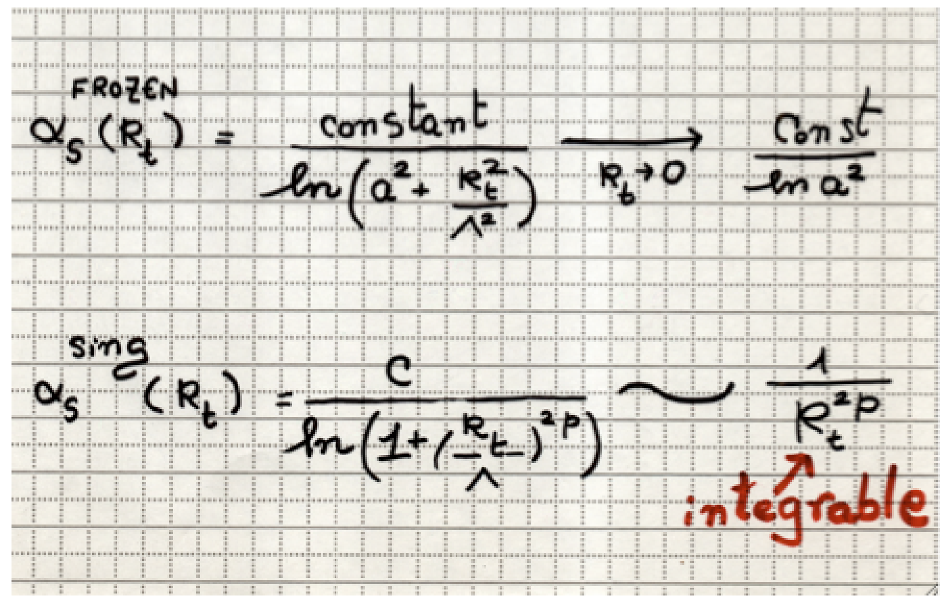
Zero momentum quanta

- Soft gluons need to be resummed if they are indeed soft $\approx 1/k$
- Resummation implies integration over dk_t

- What matters will be $\int \alpha_s(k_t)dk_t f(k_t)$

 and not $\alpha_s(0)$

Models for infrared behaviour



Soft gluons give b-distributions

In eikonal representation

$$\sigma_{tot} \approx 2\int d^2b\ [1-e^{-n(b,s)/2}]$$

- $n(b,s)$=average # of collisions at distance b, at energy $\sqrt{s}$
- b-distribution is needed

Our ansatz:

b-distribution =
Fourier transform of soft gluon K_t distribution

Resummation of soft gluons down to k_t=0

- Gluon emission in k_t changes the collinearity of initial partons
- And for same energy and p_{tmin}, acollinearity of initial partons will bring loss of luminosity of the parton beams and parton-parton cross-sections will decrease
- As the energy available for soft gluon emission increases, so does the acollinearity of the parton-parton collision
- The rate of rise of total cross-sections due to rising minijet cross-section is reduced (softened by) by soft gluon emissions.
- Softening effect more important the more singular α_s

We shall illustrate how the model works for the proton-proton case and then show its application to $\gamma\gamma$

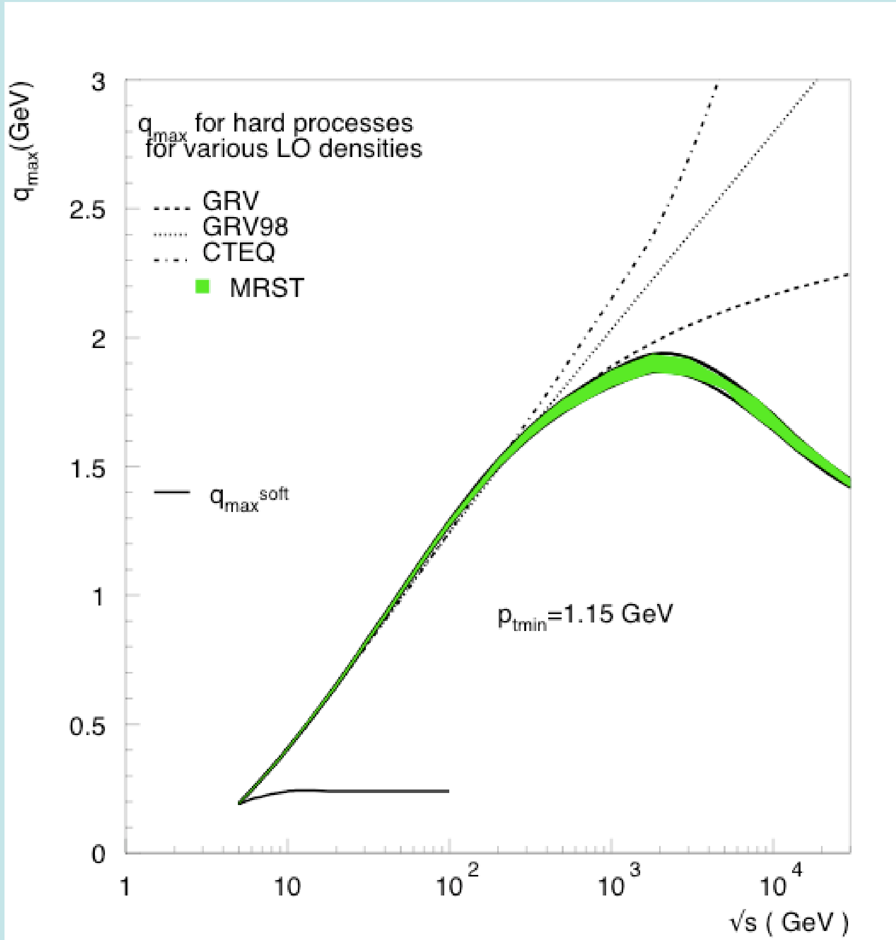
How the model works

- Choose p_{tmin} = 1÷2 GeV for mini-jets

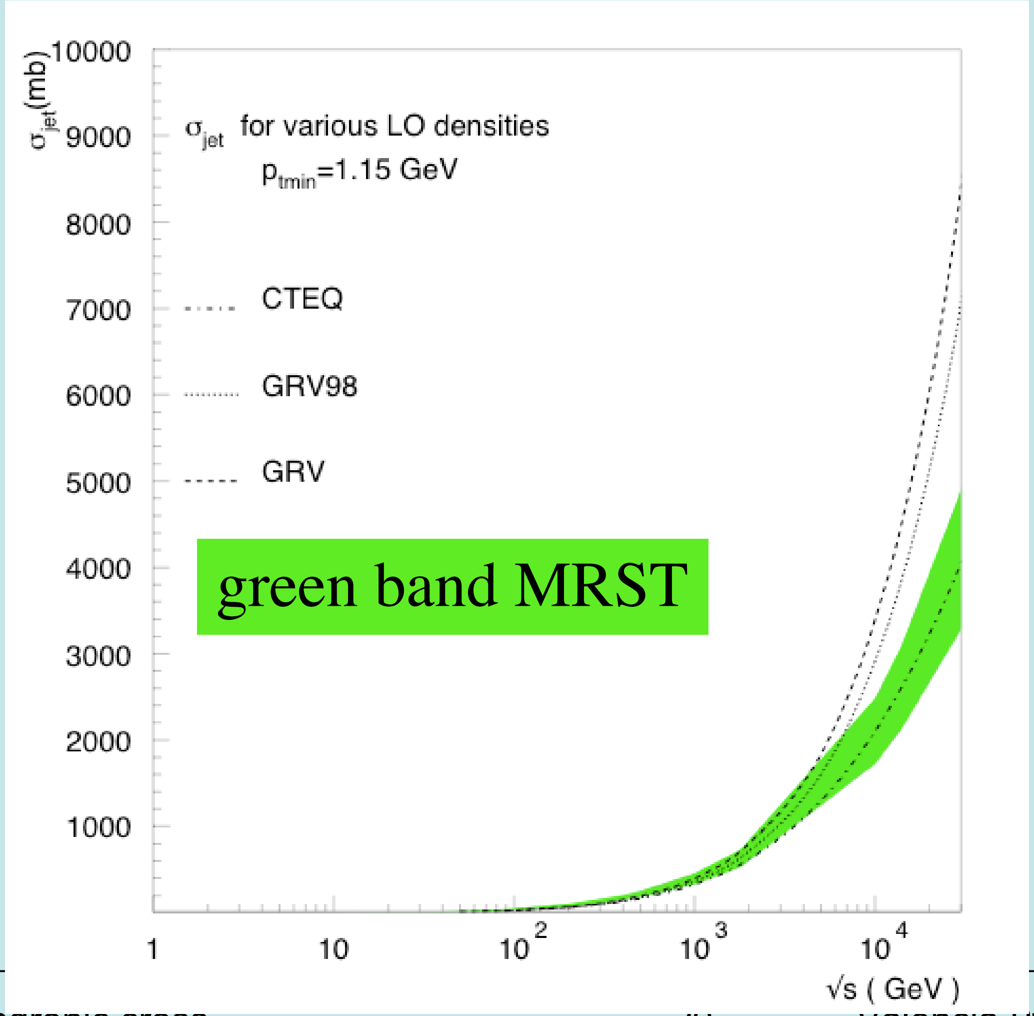
- Choose parton densities
- Calculate minijet x-section
- Calculate q_{max} for soft gluons
- Calculate A(b,s) for given q_{max}
- Calculate $n_{hard}(b,s)=A(b,s)\,\sigma_{jet}(p_{tmin},s)$
- Parametrize n_{soft}
- Evaluate $n(b,s)= n_{soft} + n_{hard}$

- Eikonalize $\sigma_{tot}\approx 2\int d^2b\,[1-e^{-n(b,s)/2}]$

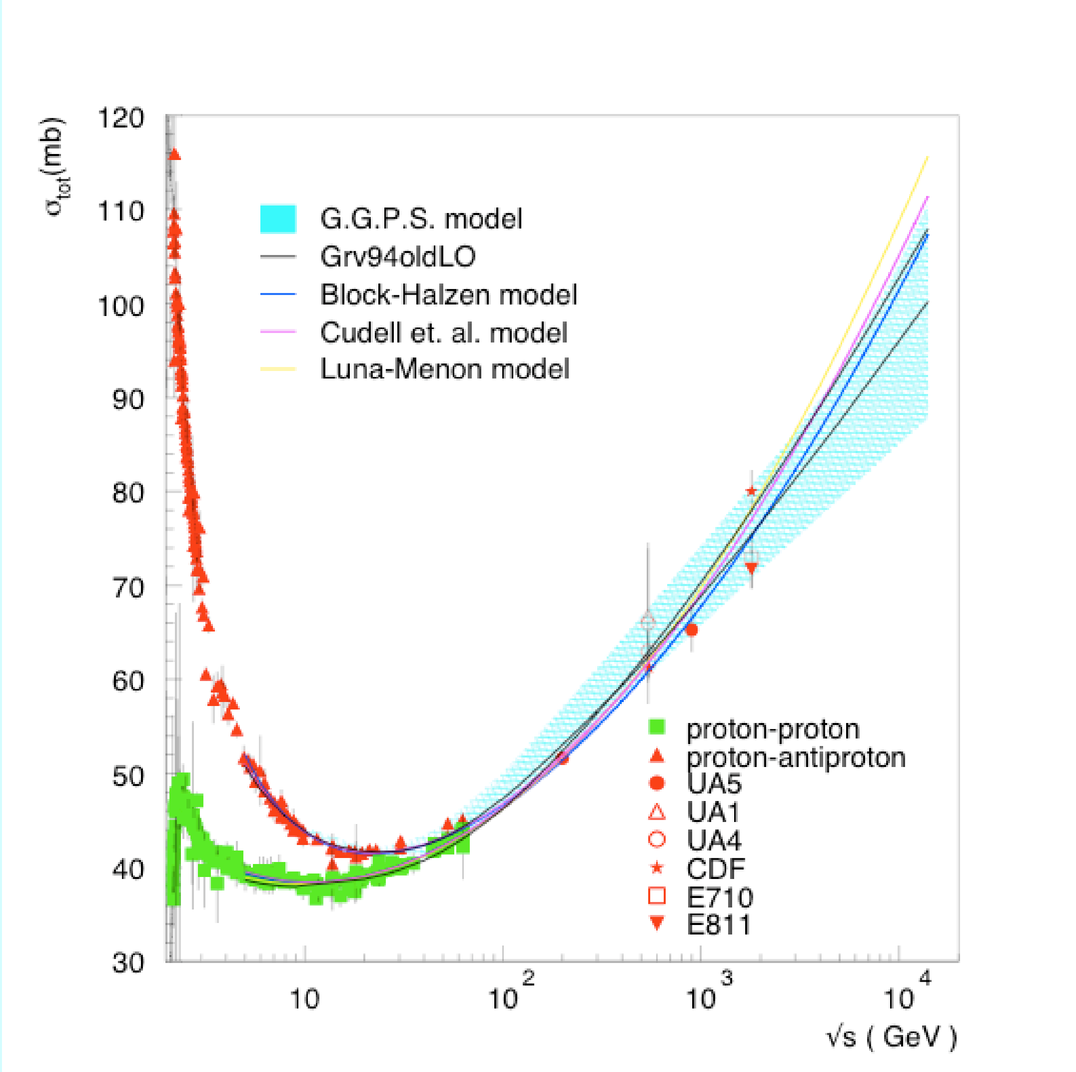
q_{max} for ptmin=1.15 geV



σ_{jet} for p_{tmin}=1.15 GeV



Comparison with proton data



R.Godbole,
A. Grau
R. Hedge
G. Pancheri
Y. Srivastava
Les Houches 2005
Pramana **67** (2006)

GGPS PRD **2005**

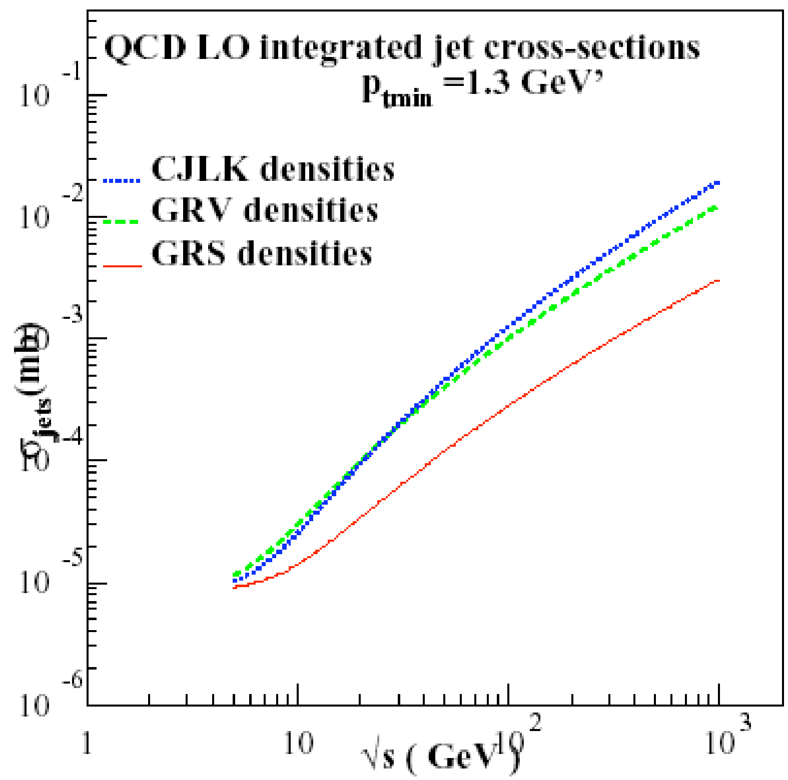
Now apply the model to $\gamma\gamma$

Choose p_{tmin} = 1÷2 GeV for mini-jets and parton densities

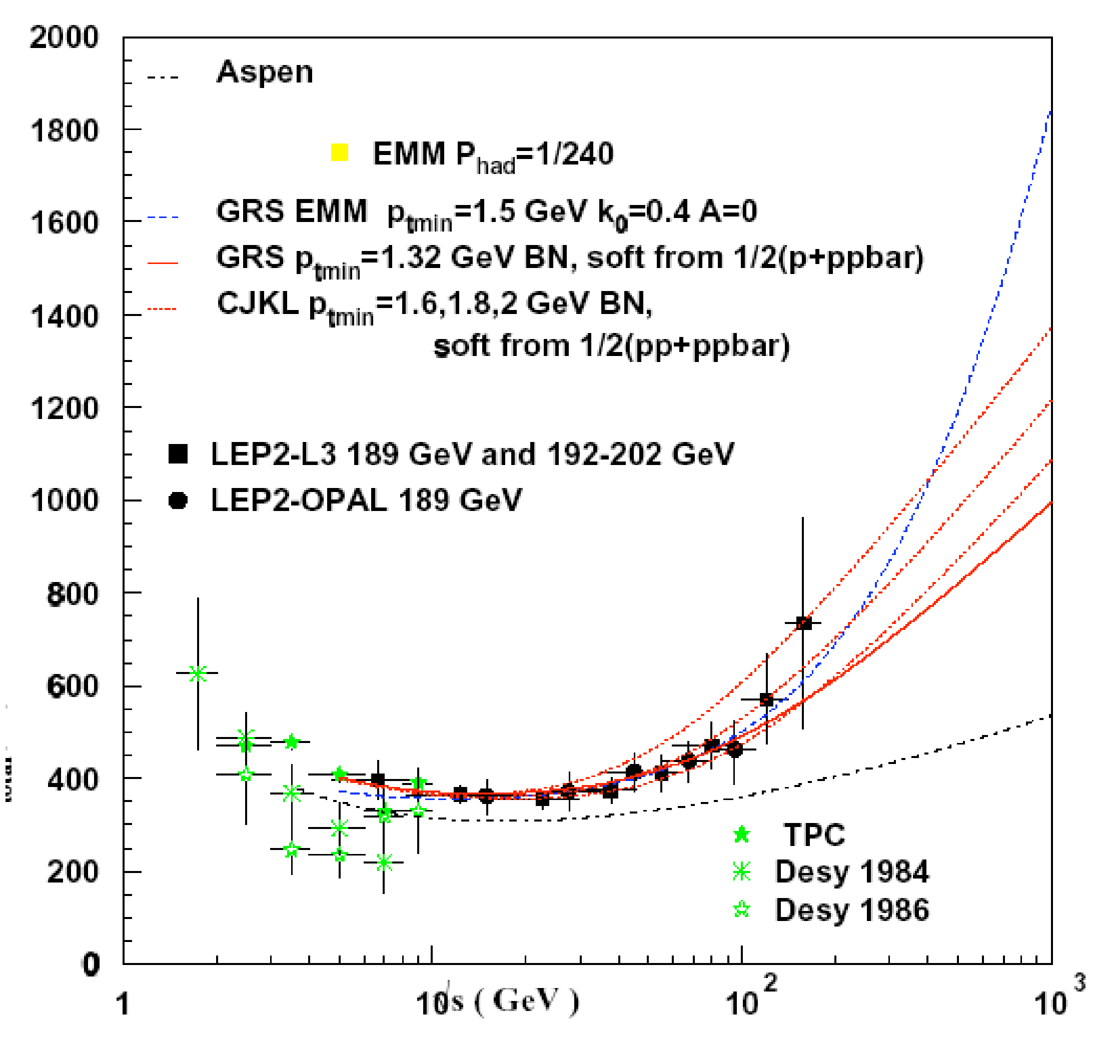
For photons, LEP data suggest

$p_{tmin} \sim 1.3 \div 1.8$ GeV

- Gluck Reya Vogt
- Gluck Reya Shielbein
- Cornet Jankowski Lorca Krawczyk



Eikonalize $\sigma_{tot} \approx 2P_{had} \int d^2b\, [1-e^{-n(b,s)/2}]$ and compare with data



P_{had} is a Phenomenological input describing the hadronic content of the photon in eikonal models

R.Fletcher, T.Gaisser. F.Halzen, 1993

Conclusions

- Predictions at ILC vary according to which densities better describe the behaviour at low x
- Total cross-sections measurements in Collider mode would allow clean information on $\gamma\gamma$ cross-sections, reducing the errors due to modelling of diffractive components
- Even in regular mode, difference in the model predictions are measurable and can give insights into the soft or non perturbative region of QCD.