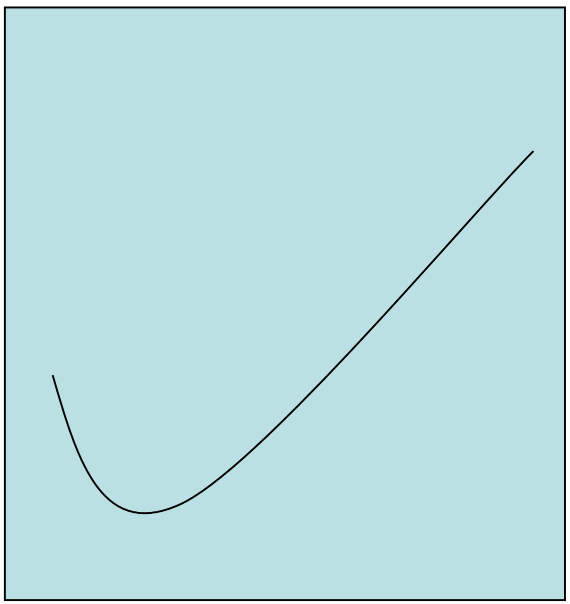
Total cross-sections: cross-talk between HERA, LHC and LC



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LCWS2004, Paris

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EPJC 2003, Phys. Rev. D 1999

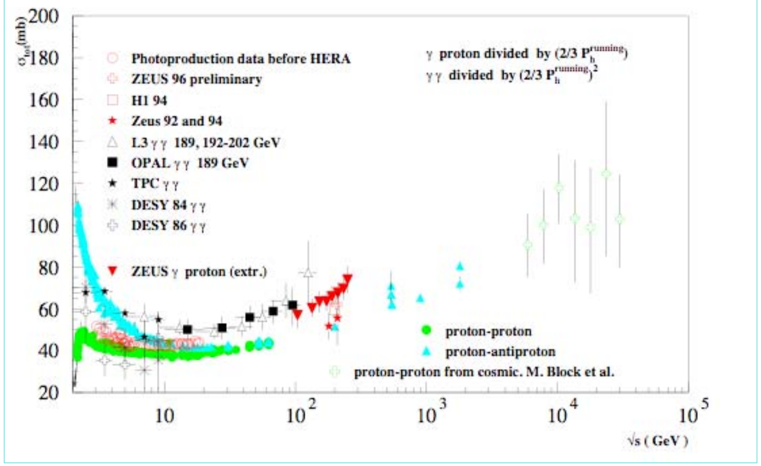
Comparing the energy dependence of pp, pγ, $\gamma\gamma$ total cross-sections

To compare them scale with

- quark content factor :
  2/3 to go
  from proton to photon

- Vector Meson Dominance factor

$$P_{VMD} = \Sigma_{V=\rho,\omega,\phi} \frac{4\pi\alpha}{f_V^2}$$



Some differences in
- Normalization
- Initial decrease
- Slope of rise with energy

Why and how do we study total cross-sections?

- To make realistic predictions for e^+e^- ⌫ hadrons at LC
- To understand the role played by QCD in the energy behaviour of total cross-sections

How?

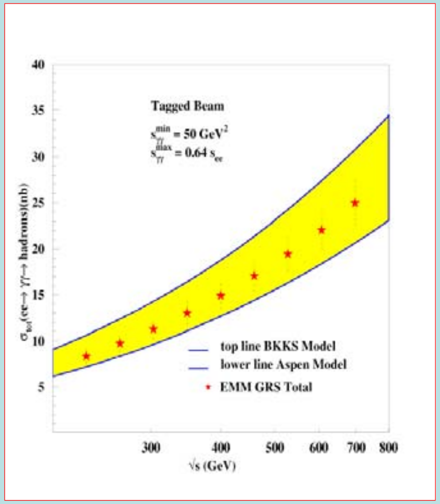
- **LHC** data for total cross-sections can restrict the range of QCD parameters in the **proton** behaviour

Form factors,overlap functions, Pomeron(s), minijets,...

- **HERA** data can do the the same for the **photon**
- Photon-photon cross-sections should then come out with a realistic error and so will **e^+e^-** ⌫ hadrons at **LC**

Realistic Predictions at LC?

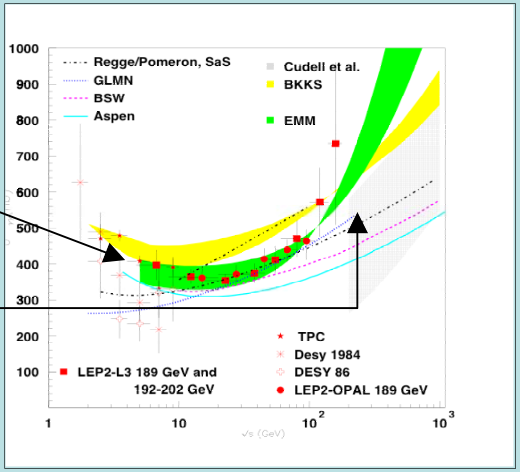
Predictions for e+e- at LC suffer from uncertainties in the $\gamma\gamma$ cross-section data present both in



- the low energy region, (normalization)

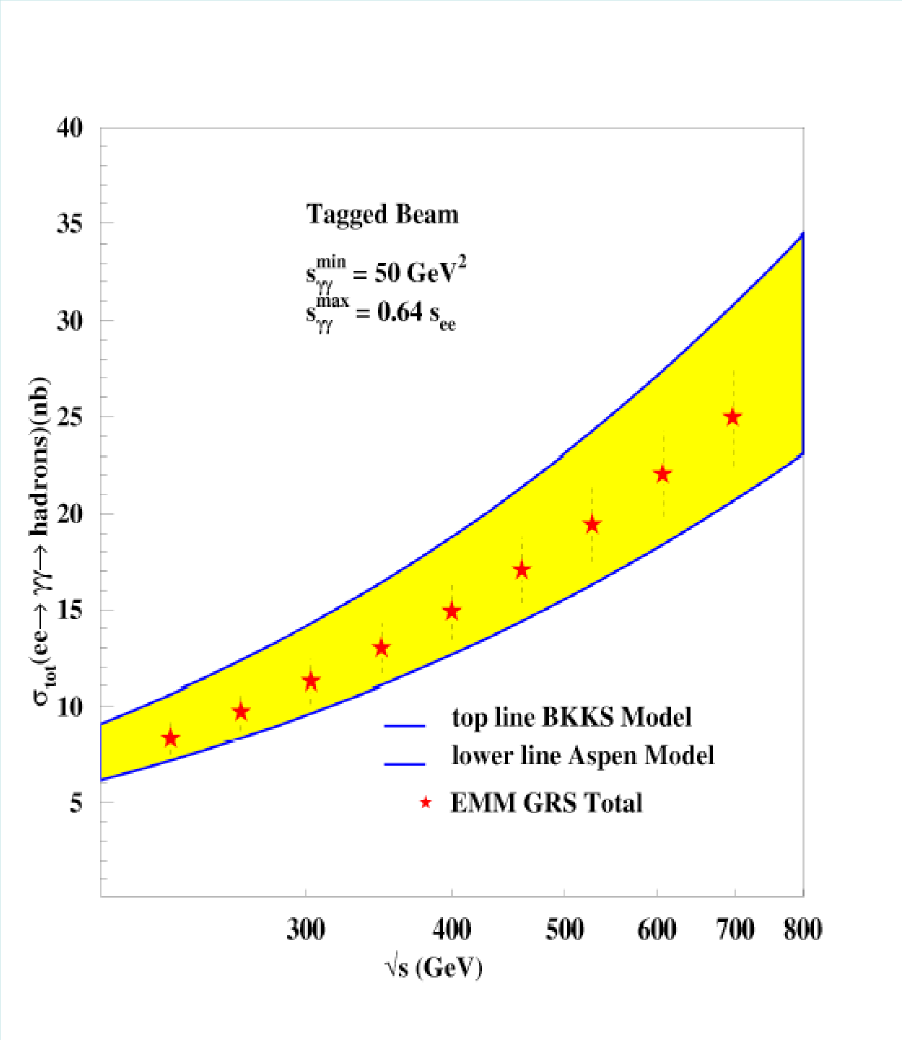
and

- the high energy, i.e. how much $\gamma\gamma$ will rise in the 100-200 GeV c.m.



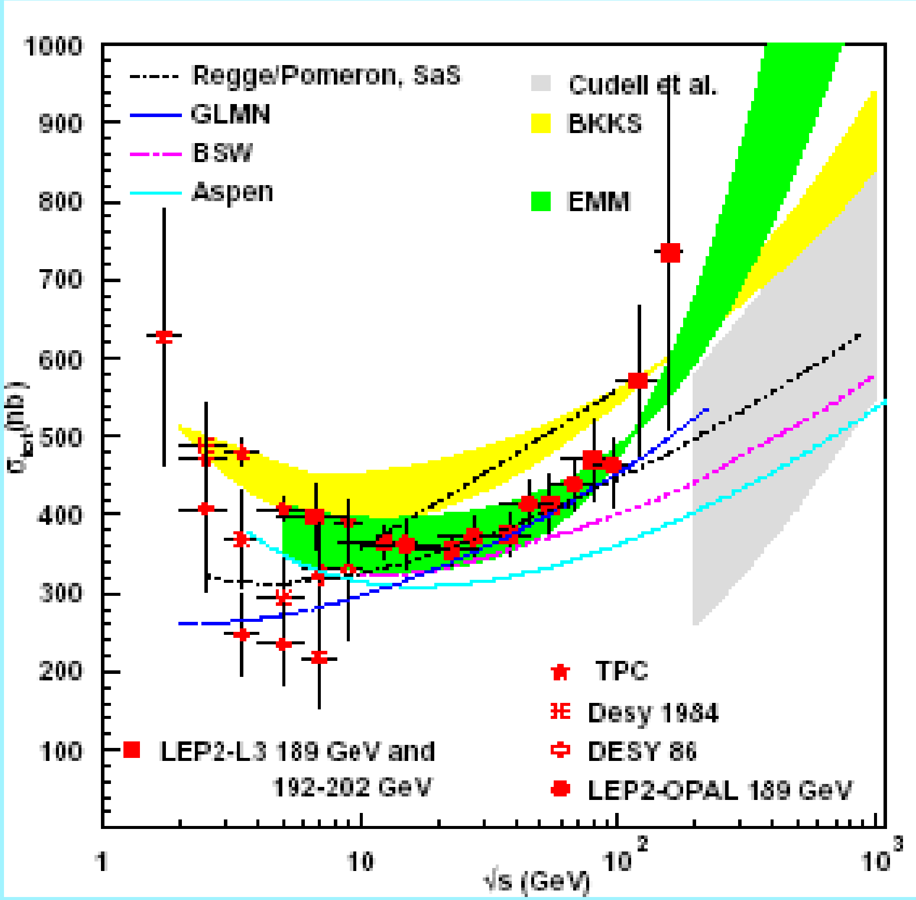
LC and $\gamma\gamma$ scattering

- Differences in predictions of total cross-sections in photon-photon collisions affect LC background studies



The photon-photon case

Already at √s=500 Gev
predictions
differ by a factor 5



Why such differences for photons ?

- Photon-photon cross-sections use input from proton data

- Uncertainties from proton cross-sections and lack of parameter free guidance from theoretical models lead to large variations

- Choice of model :QCD or Regge-Pomeron exchanges or factorization a' la Gribov ?

- And anyway which QCD model?

Some models for total cross-section

- Bounds from analiticity and unitarity
- Regge-Pomeron exchange
- Eikonal approximation
- Minijets from QCD
- Eikonal Minijet Model (EMM)
- Bloch-Nordsieck resummation for EMM

All the models have parameters, either for the soft (low energy part) or the high energy or both

Soft : one fits the data in pp with power laws and then extrapolates to gamma p

- Parameters for pp and pbar-p :
  - power exponents
  - normalization
- Parameters for gamma p : normalization (VMD+QPM)

High Energy : one can use power laws (Pomeron/s) and/or QCD jets or "QCD" inspired behaviour

- Power laws should not change from protons to photons
- In QCD cum eikonal, parameters like minimum jet transverse momentum should not change, while different parton densities and parton content may indicate that protons are different from photons

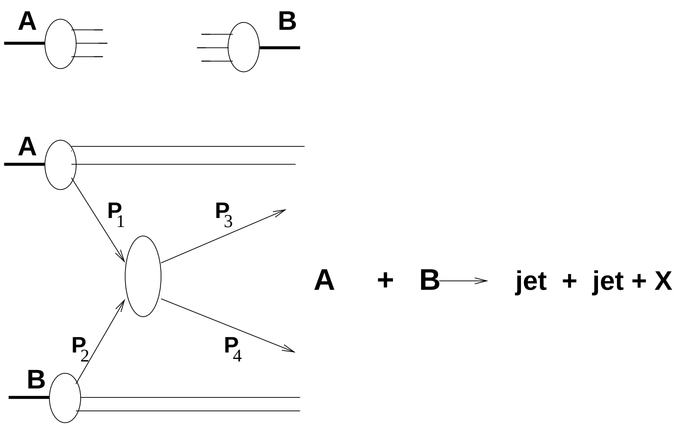
QCD : what it says about energy dependence in total cross-sections

- Perturbative QCD can be used when α_{strong}/π is small, practically for parton momenta around 1-2 GeV

- As the hadrons c.m. energy increases from 5 to 10^4 GeV in the c.m., the flux of perturbative partons of small x will increase=>the cross-section from such processes will increase

Perturbative QCD provides a natural mechanism for the increase of total cross-sections

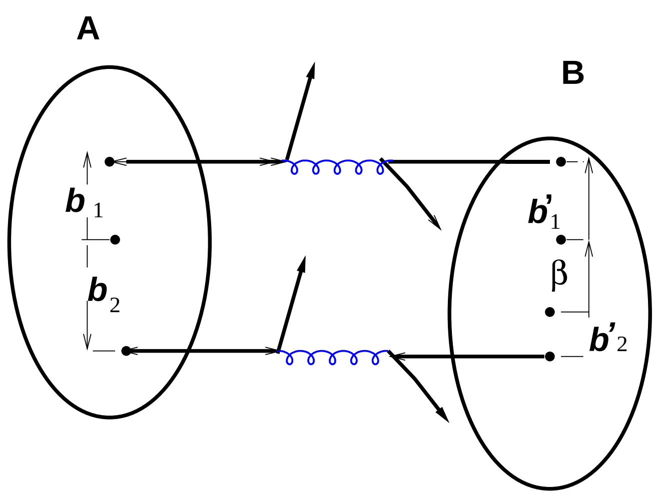
QCD model for total cross-sections : Minijets, eikonal formalism and and Bloch-Nordsieck resummation

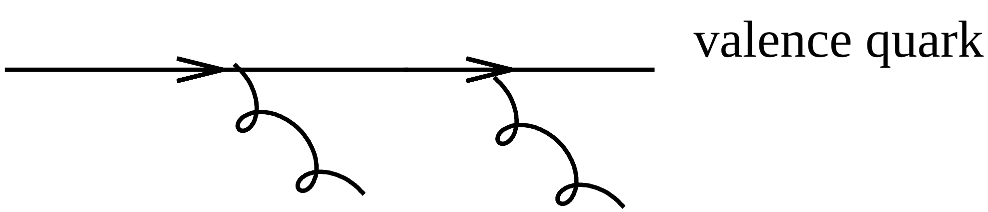


QCD Minjets drive the rise

Overlap in b-space and Eikonal Representation ensure unitarity

Soft gluon emission gives extra energy dependence





Transverse Overlap of the hadrons

The real question in any QCD approach to total cross-sections

- The real question in studying σ_{tot} with QCD is

$$\alpha_s (k_t \to 0) \ ?$$

- Why?
- Because of soft physics
  - At low energy of course
  - At high energy as well because high energy parton-parton scattering needs soft gluon effects, treated with resummation, which means to integrate (there are many such soft photons) from $k_t = 0$ (they are soft!) to some kinematically determined maximum value

Eikonal Minijet Model +Bloch-Nordsiek resummation

⇒ IEMM

Improved Eikonal Minijet Model

For protons

Low energy parameters

- Normalization
- Low energy impact parameter distribution (b-distribution)

High Energy parameters

- Minimum jet transverse momentum
- Parton densities
- Infrared behaviour of α_s for *soft* gluon emission resummation in k_t (linked to partonic b-distribution)

Work since Jeju Meeting

- Completed $\gamma\gamma$ and γp studies within the Eikonal minijet Model with Bloch-Nordsieck soft gluon resummation

for various photon densities

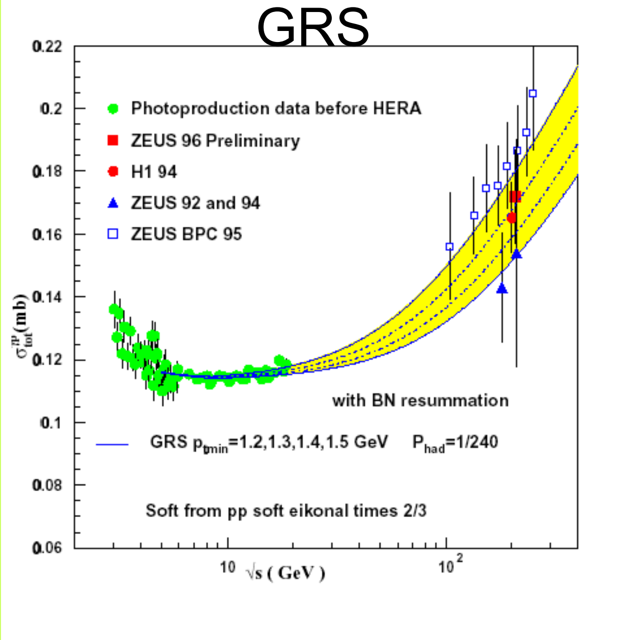
GRV	M.Gluck, E.Reya, and A.Vogt
GRS	M.Gluck, E.Reya and I.Schienbein
CJKL	F.Cornet, P. Jankowski, M.Krawczyk and A. Lorca

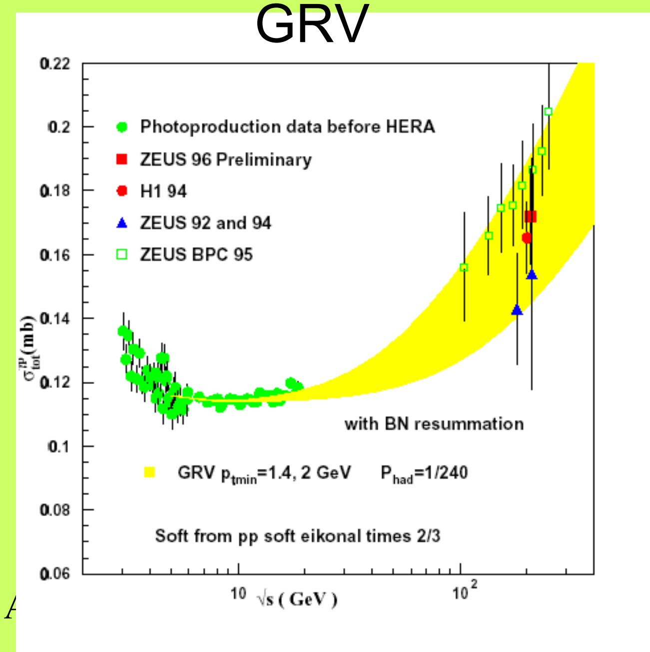
P_{tmin}=1.2 to 2 GeV

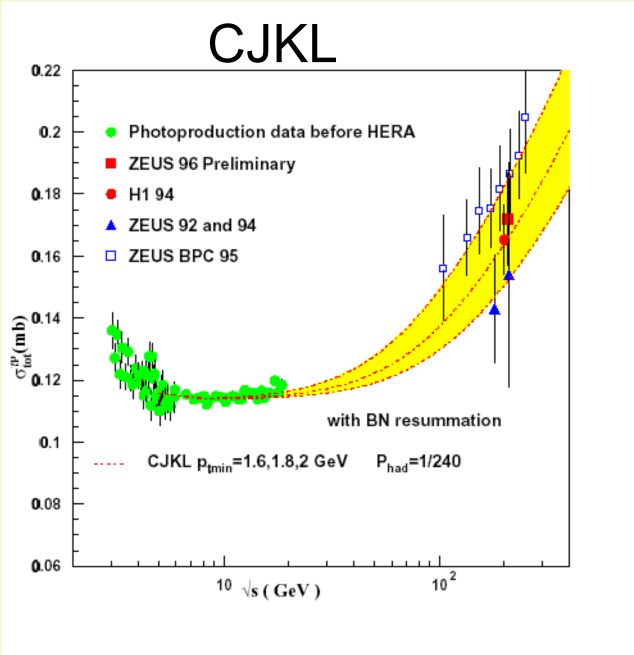
γp for various densities and p_{tmin}

GRV, GRS and CJKL Densities :

P_{tmin}=1.2 to 2 GeV



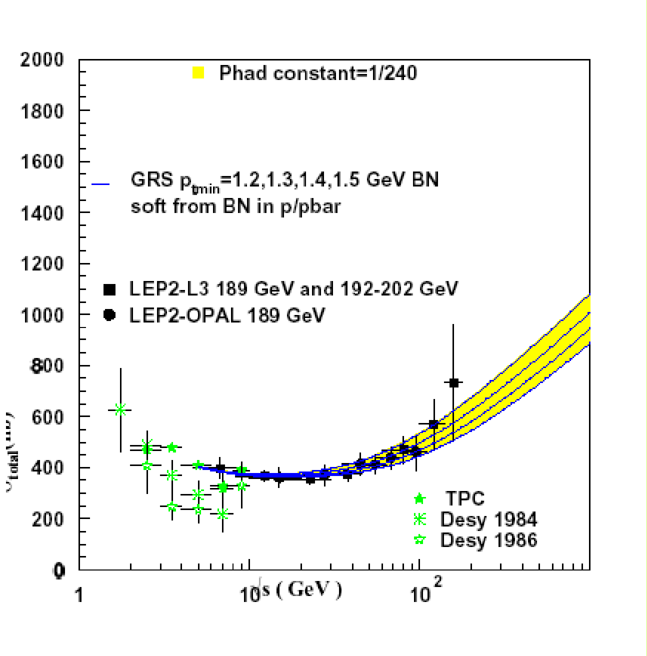




γγ for various densities and p_{tmin}

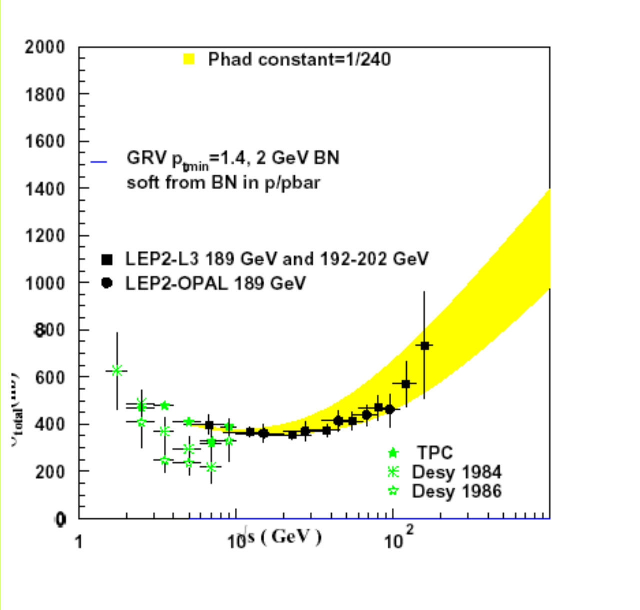
GRV, GRS and CJKL Densities :

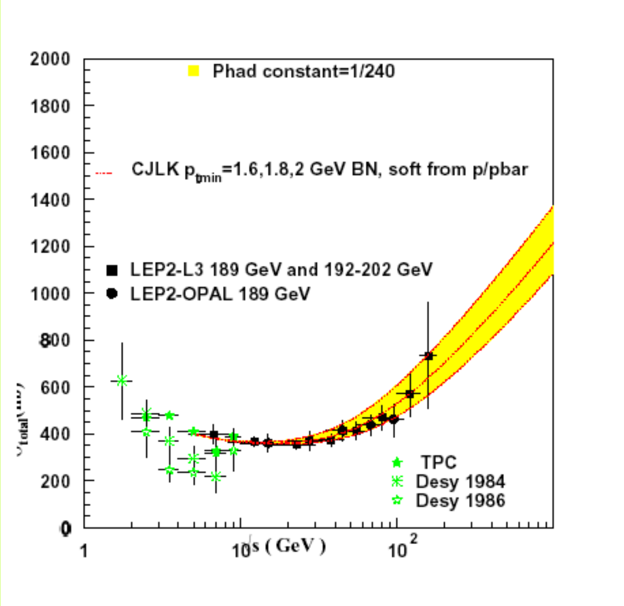
P_{tmin}=1.2 to 2 GeV



GRS

GRV

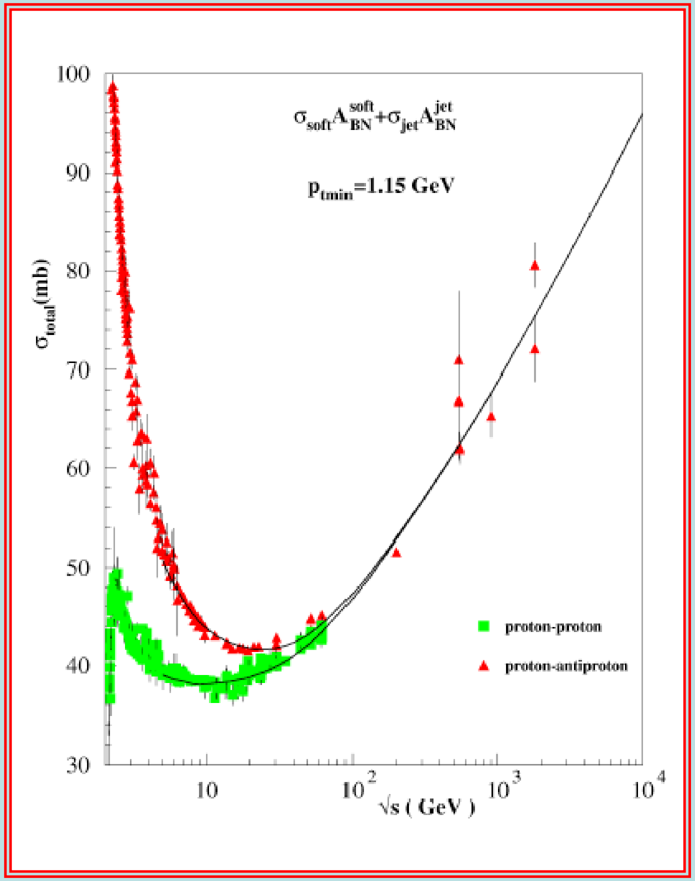




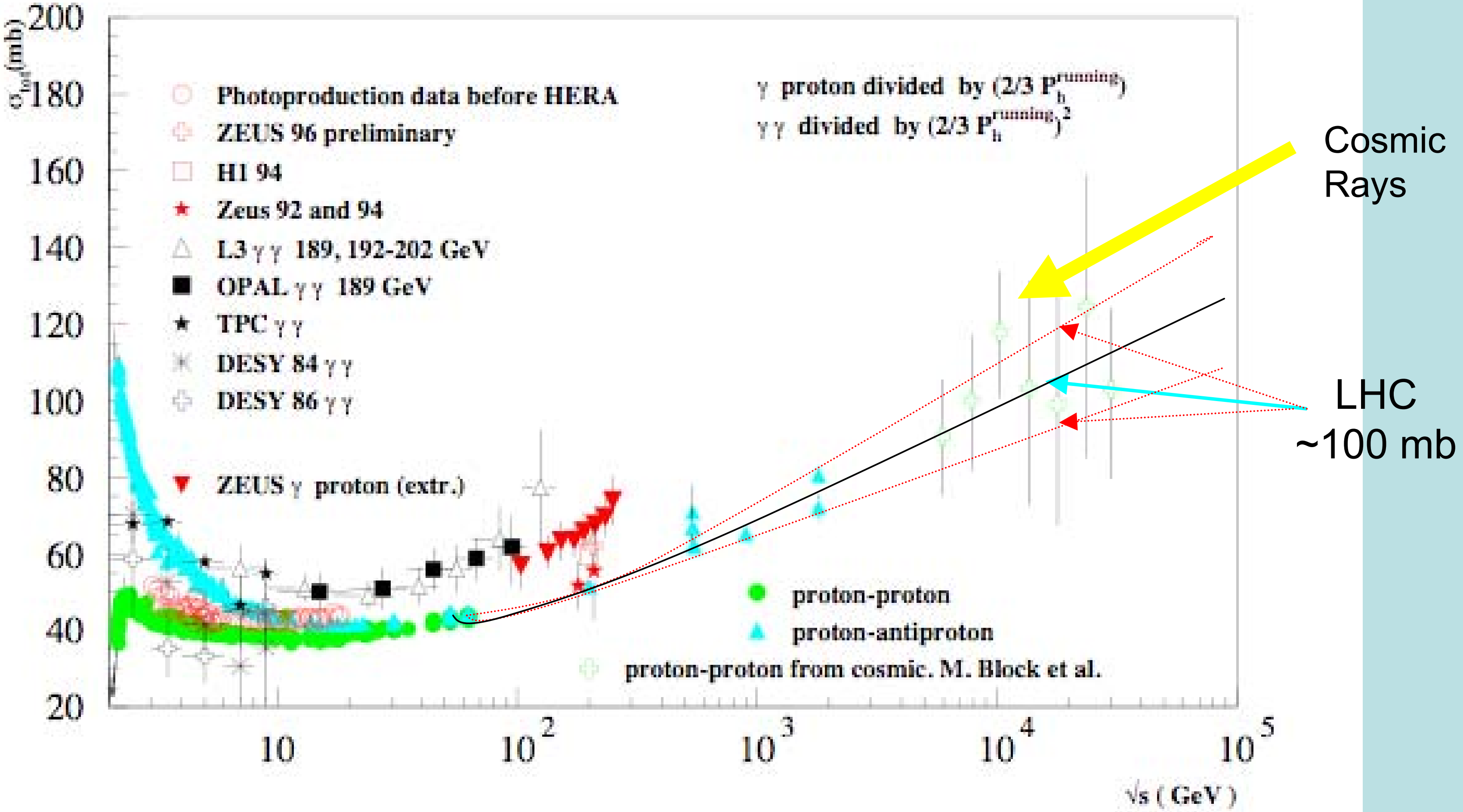
CJKL

The proton case

- Tevatron data allow for both log and $\log^2$ and more than simple Regge + 1 Pomeron
- The EMM + BN model predicts **98 mb** at LHC
- Range of model parameters, like p_{tmin} and soft IR behaviour, still needs to be determined



Cross-talk?



σ_{tot}(mb)
200
180
160
140
120
100
80
60
40
20
Photoproduction data before HERA
ZEUS 96 preliminary
H1 94
Zeus 92 and 94
L3 γ γ 189, 192-202 GeV
OPAL γ γ 189 GeV
TPC γ γ
DESY 84 γ γ
DESY 86 γ γ
ZEUS γ proton (extr.)
γ proton divided by (2/3 $P_h^{running}$)
γ γ divided by (2/3 $P_h^{running}$)^2
proton-proton
proton-antiproton
proton-proton from cosmic. M. Block et al.
10
10^2
10^3
10^4
10^5
√s (GeV)
Cosmic Rays
LHC
~100 mb

Learning from LHC for LC : From pp ⌫hadrons to e^+e^- ⌫ hadrons

- A work program to reach stable predictions for LC and learn about QCD contribution to σ_{total} needs LHC measurements and an understanding of how much parameters can vary.
- Predictions for e^+e^- ⌫ hadrons come from $\gamma\gamma$ ⌫ hadrons
- Model builders must prepare predictions for various parameter sets so as to constrain proton parameters from LHC as much as possible
- From proton to photons : HERA data are crucial in order to constrain the photon parameters
- From γp and pp : $\gamma\gamma$ should come out parameter free