Predictions for $\gamma\gamma$ total cross-section in the TeV region : An Update.

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What has been updated?

- The Model, to get the initial decrease.
- Newer parton densities for the photon.
- The energy range: To include CLIC energies.

Based on:

R.M. Godbole, A. de Roeck, G. Pancheri, LC-TH-2001-030, hep-ph in preparation LC and CLIC predictions

M. Block, E. Gregores, F. Halzen and G. Pancheri, for the Aspen Model Phys.Rev.**D60** (1999) 054024 FACTORIZATION

R.M. Godbole and G. Pancheri, for the Eikonal Minijet Model PLB **435** (1998) 441, Eur.Phys.J.C19:129-136,2001 1/x in σ_{jet} drives the rise

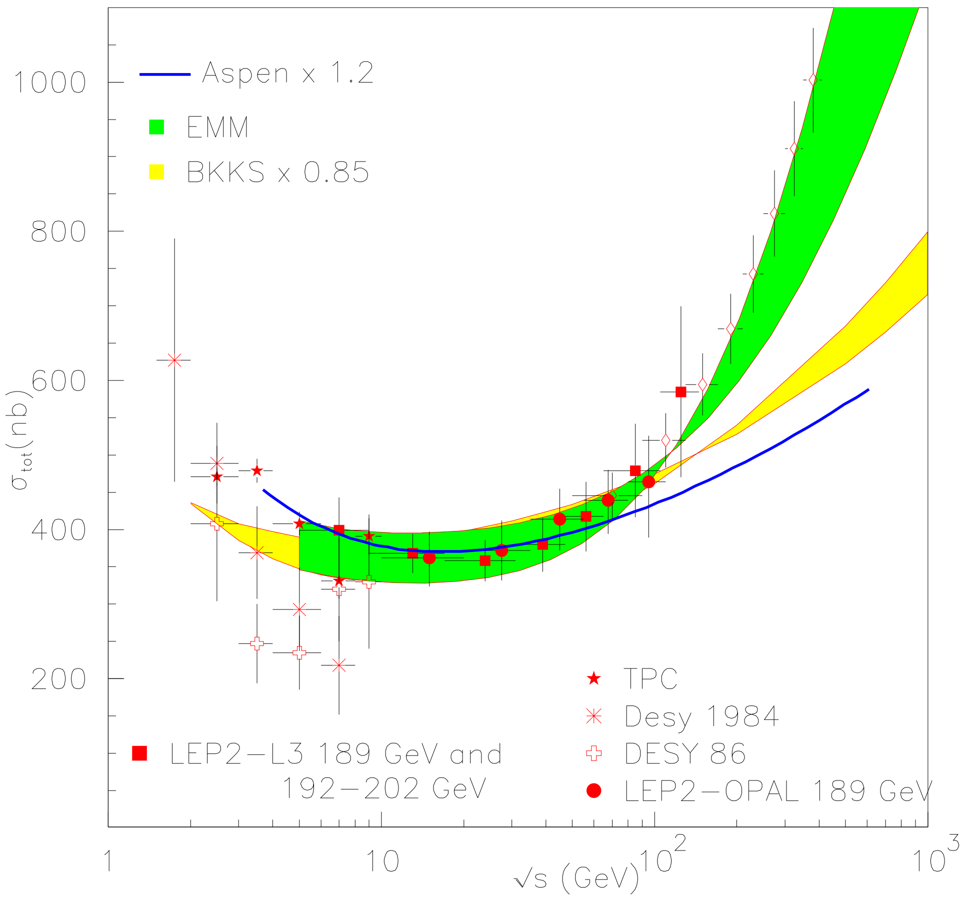
A. Grau,G. Pancheri, Y. N. Srivastava for the Bloch-Nordsieck Model PR **D60** (1999) 114020 $\alpha_s(k_t \to 0)$ tames the rise

A. Grau, R.M. Godbole, G. Pancheri and Y.N. Srivastava for Bloch-Nordsieck Model, in preparation to get the initial decrease with soft gluon emission.

Introduction

- $\gamma\gamma$ cross-sections knowledge important for estimation of hadronic backgrounds, particularly for $\gamma\gamma$ colliders and the high energies envisaged for CLIC.
- Theoretical computation of total/inelastic cross-sections for hadronic collisions is a challenging problem. QCD based descriptions invlove modelling of the non perturbative part.
- $\gamma\gamma/\gamma p$ cross-sections provide an addiitonal place for developement of these models.
- With LEP data the state of the data on $\sigma^{\gamma\gamma} \to hadrons$ has improved considerably. Helps the model developement.
- Knowledge of parton structure of the photon has firmed up and improved.

Summary of predictions for the LC (TESLA TDR):

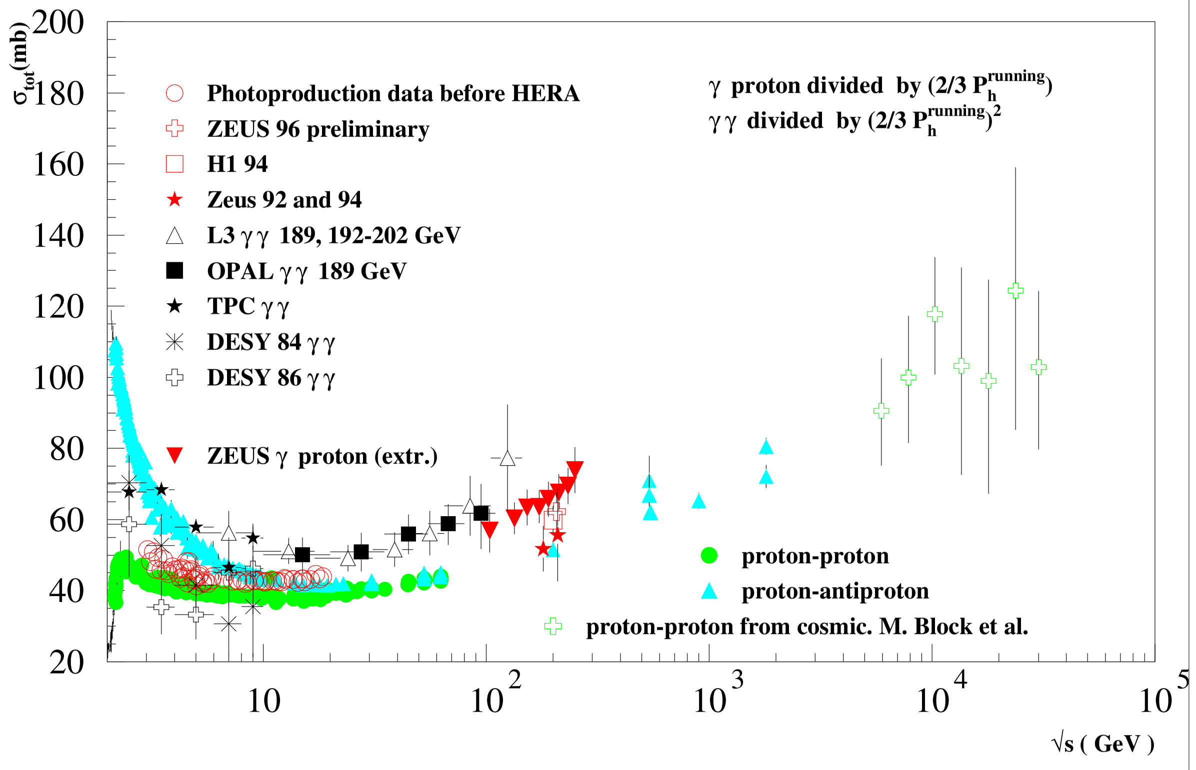


Predictions for $\gamma\gamma$ total yield at
TESLA or CLIC energies
can vary by factor 2 (and even more)
depending on the models,
which need to provide:

- normalization
- energy dependence

Normalization

Proton and photon total cross-sections can be put on the same scale using Quark Counting and VMD



γ *proton* total x-sections are divided by

- a factor $\frac{2}{3}$ for quark counting

and divided by

- a factor from VMD
  $$P_{had}^{running} = \sum_{\rho,\omega,\phi} \frac{4\pi\alpha_{QED}(\sqrt{s})}{f_V^2} = \frac{1}{240} \text{ at } \sqrt{s} = 200\ GeV$$

For $\gamma\gamma$, factors are **squared** FACTORIZATION

Energy dependence of σ_{total}

There are three main approaches to the task of describing the energy behaviour of total cross-sections

- A unified description a' la Regge-Pomeron

$$\sigma_{total} = X s^{\epsilon} + Y s^{-\eta} \tag{1}$$

- A factorization appproach with photons from protons
- A QCD approach with quarks and gluons

The rise alone can be obtained

- in the Regge model through s^{ϵ}
  but it does not seem that the same power ϵ fits protons and photons AdR hep-ph/0101076:
  $\epsilon_{pp} = 0.08, \epsilon_{\gamma\gamma} = 0.1 \div 0.2$ more power terms have been suggested to eq.(1) by Donnachie and Landshoff
- from factorization, but there remain the problem of getting the proton-proton xsection from first principles
- using the QCD calculable contribution from the parton-parton cross-section, whose total yield increases with energy
- Various model predicitions for $\sigma_{\gamma\gamma}$ can be fitted in the form of Eq. (1) yielding values of ϵ between $0.1 - 0.3$. R.M. Godbole, A.Grau, G. Pancheri and A. De Roeck, in hep-ph/0109166: K. Abe *et al.* [ACFA TDR].
- a combination of the above.

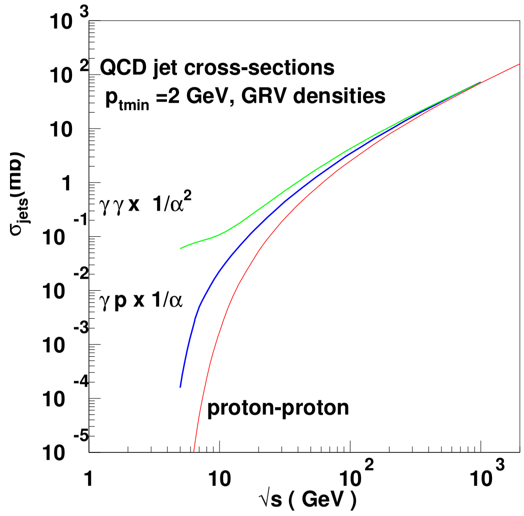
The LO QCD Contribution

The LO QCD Contribution to the rise can be calculated from

Integrated jet cross-sections

$$\sigma_{jet} = \int_{p_t min} \frac{d^2\sigma_{jet}}{d^2\vec{p}_t} d^2\vec{p}_t =$$

$$= \sum_{partons} \int_{p_t min} d^2\vec{p}_t \int f(x_1)dx_1 \int f(x_2)dx_2 \frac{d^2\sigma^{partons}}{d^2\vec{p}_t}$$



The minijet cross-sections depend on the densities and very dramatically on p_{tmin} the minimum transverse momentum cut-off

The Eikonal Minijet Model **EMM** *in LO QCD*

EMM

$\sigma^{\rm inel}_{pp(\bar{p})} = 2\int d^2\vec{b}[1 - e^{-n(b,s)}]$

Build n(b,s) for σ^{inel} and use it for

$$\sigma^{\rm tot}_{pp(\bar{p})} = 2\int d^2\vec{b}[1 - e^{-n(b,s)/2}cos(\chi_R)],\ \chi_R = 0 \text{ in EMM}$$

b is impact parameter $\Longrightarrow$ transverse momentum of partons in hadrons

In order to obtain n(b,s), one can
- factorize b vs. s behaviour

$\rightarrow n(b,s) \approx A(b)\sigma(s)$
- separate Non perturbative vs Perturbative behaviour

$\rightarrow n(b,s) = n_{NP}(b,s) + n_P(b,s)$

simplest model $n(b,s) = A(b)[\sigma_{soft} + \sigma_{jet}]$

$\Uparrow$

matter distribution

- A(b) dipole (proton) and monopole (photon) form factors
- σ_{soft} parametrized
- σ_{jet} LO QCD jet x-sections

$$\sigma^{\rm tot}_{pp(\bar{p})} = 2\int d^2\vec{b}[1 - e^{-n(b,s)/2}cos(\chi_R)],\ \chi_R = 0 \text{ in EMM}$$

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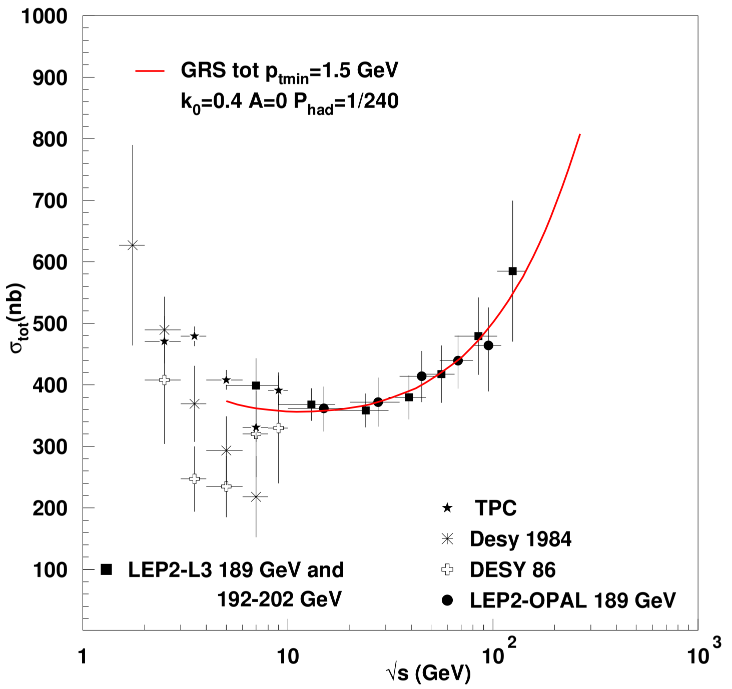
The Eikonal Minijet Model (EMM)for photons

- $\sigma^{\rm tot}_{\gamma\gamma} = 2P^{\gamma\gamma}_{had}\int d^2\vec{b}[1 - e^{-n(b,s)/2}]$
- $n(b,s) = 2/3 n^{\gamma p}_{soft} + A(b)_{FF}\sigma^{\gamma\gamma}_{jet}(s)/P^{\gamma\gamma}_{had}$
- $P^{\gamma\gamma}_{had} = [P^{\gamma p}_{had}]^2$

Then

- Using **EMM**, with VMD and Quark Counting at low energy, and same set of parameters which fit γp ,
- adjusting the overall normalization 10% upwards,

one gets a very good fit to the present data



$\Downarrow$

Data for $\gamma\gamma$ total x-sections show a very fast rise which can be reproduced with EMM

BUT

Is this rise realistic past LEP energies?

More about the rise

EMM needs further refinements,
including
full LLO resummation to tame the rise

$$n(b,s) = n_{soft}(b,s) + A_{PQCD}(b,s)\sigma_{jet}^{LO}$$

$$\Uparrow$$

Soft gluons can tame the rise

$A(b) \Longrightarrow$

$A(b,s) \simeq \int d^2\vec{K}_t e^{i\vec{K}_t\cdot\vec{b}}\Pi$ (K_t *from initial partons*)

Bloch Nordsieck
Resummation

$$A_{PQCD}(b,s) \equiv \frac{e^{-h(b,s)}}{\int d^2\vec{b}e^{-h(b,s)}}$$

- $h(b,s) = \int_{k_{min}}^{k_{max}} d^3 n_{gluons}(k)[1 - e^{ik_t\cdot b}]$
- $k_{max} \Longrightarrow$ *average over densities* $\Uparrow as\sqrt{s} \Uparrow$
- $k_{min} = 0$ in principle but one needs a model for

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

Bloch-Nordsieck Model for $p - p$ and $p - \bar{p}$

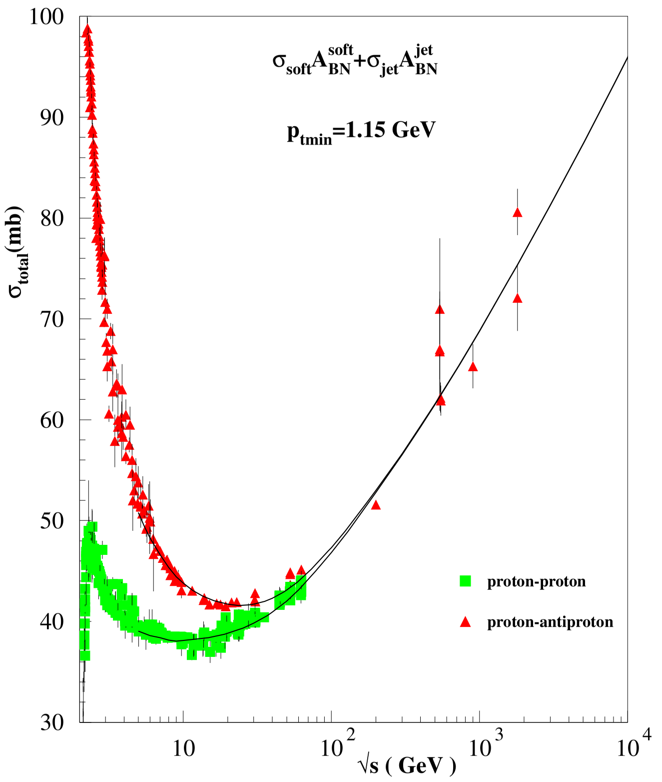
This is like EMM model with σ_{jet}^{QCD} driving the rise

$\boxed{\text{and in addition}}$

Soft Gluon Emission from Initial State Valence Quarks in k_t-space is used to give the impact parameter space distribution of colliding partons

This happens because

- as $\sqrt{s} \Uparrow$ the phase space available for soft gluon emission also $\Uparrow$
- the transverse momentum of the initial colliding pair due to soft gluon emission $\Uparrow$
- more straggling of initial partons $\Rightarrow$ less probability for the collision

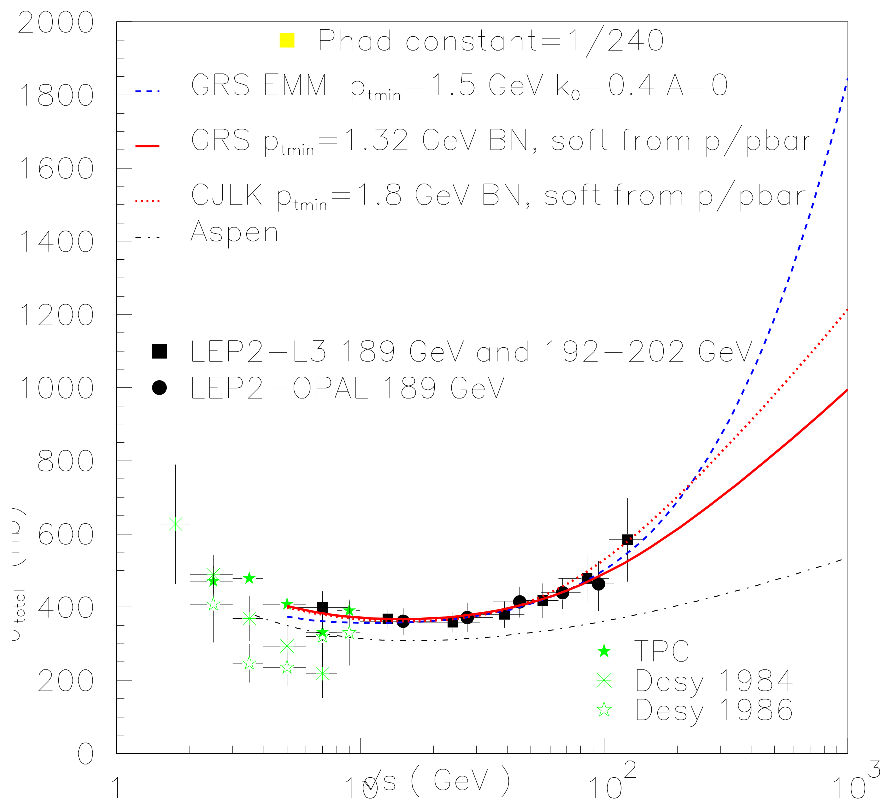


Present Update for $\gamma\gamma$

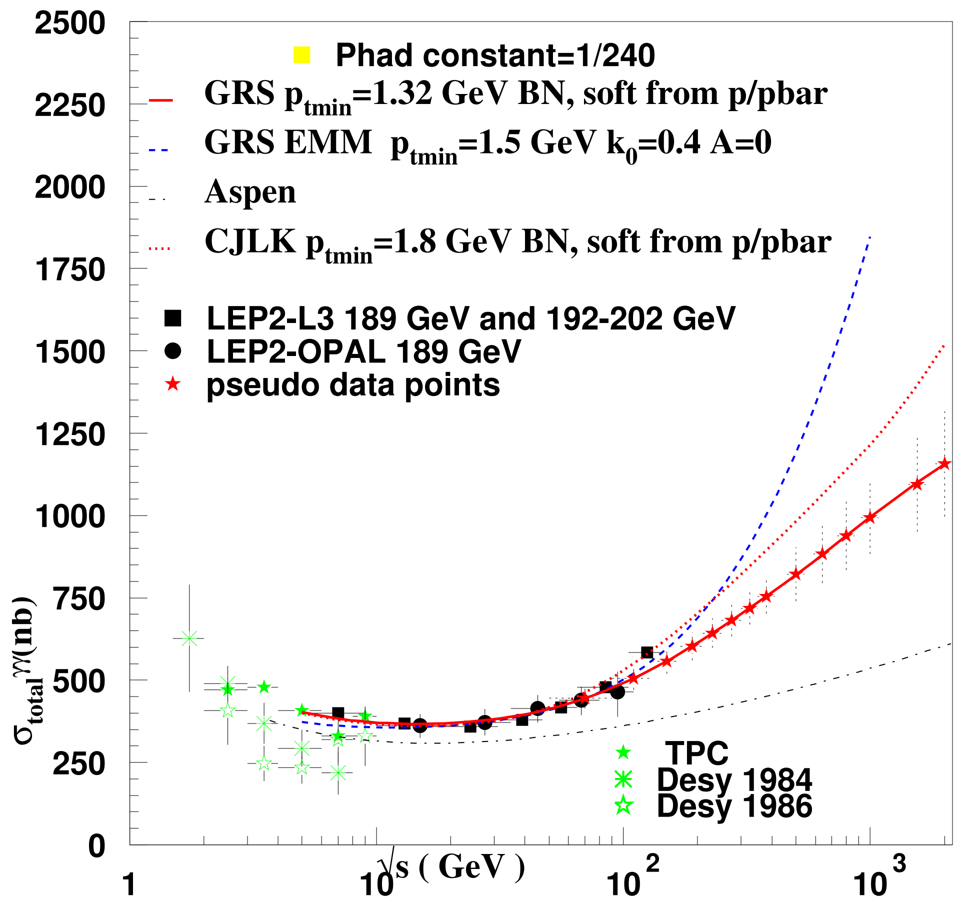
Present update is done using following improvements

1. Soft part of the eikonal $n(b,s)$ directly from proton and antiproton processes $\rightarrow n^{\gamma\gamma}_{soft}(b,s)$ given by $\frac{4}{9}\frac{n^{pp}_{soft}+n^{p\bar{p}}_{soft}}{2}$ using fit to protons,
2. soft resummation for hard scattering,
3. two types of densities

- GRS : Glück, Reya and Scheinbein, Phys. Rev. D 60, 054019,1999.
- CJLK: F. Cornet, P. Jankowski, A. Lorca and M. Krawczyk , hep-ph, in preparation.



Difference between models increases sharply at higher energies.



- The Block Nordsieck model does tame the rise at large $\sqrt{s}$.
- Soft gluon emission provides the initial decrease of the Cross-sections.
- Difference between different parton densities at higher energies upto 20%.