Hadronic backgrounds due to two photon processes at e^+e^- colliders.

- $\diamondsuit$ Introduction.
- $\diamondsuit$ Data on $\sigma(\gamma\gamma \to \text{hadrons})$
- $\diamondsuit$ Status of model predictions for $\sigma(\gamma\gamma \to \text{hadrons})$
- $\diamondsuit$ Some predictions for $\sigma_{\gamma\gamma}^{\text{had}}$ upto CLIC energies.

Warning: More of a status survey and plan of action.

Some of the papers of interest:

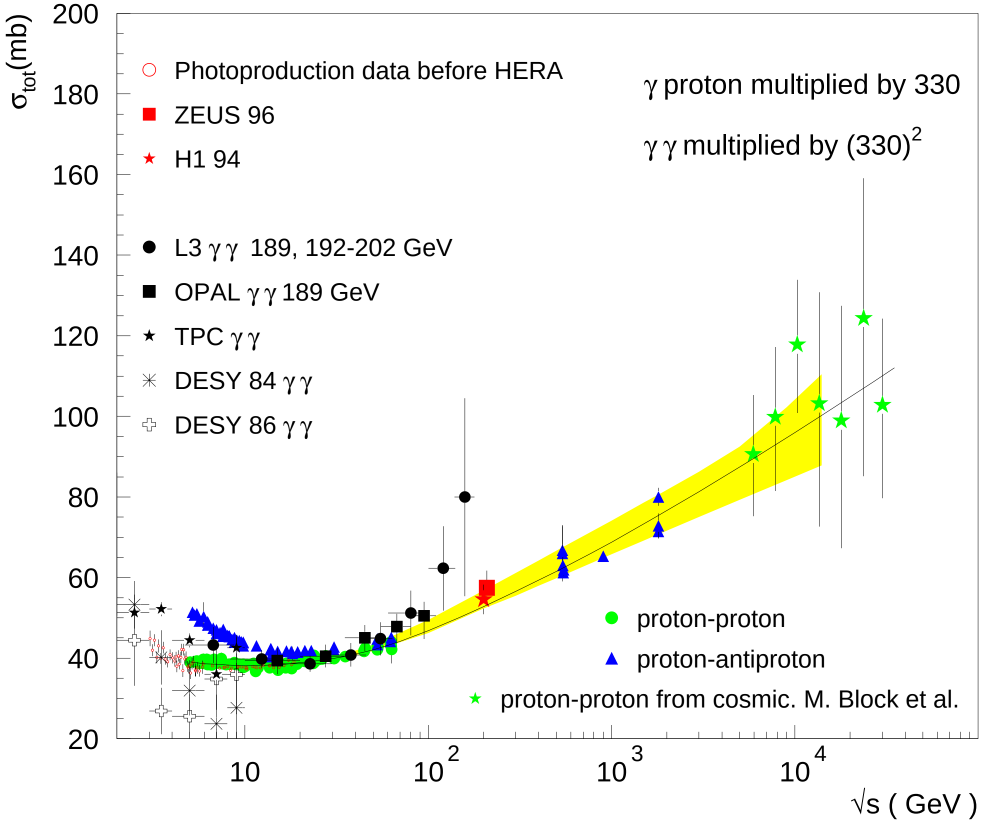
M. Drees, RG, Z. Phys. C59, 591-616 (1993),

P. Chen, T. L. Barklow, M. E. Peskin, PRD 49, 3209-3227 (1994),

RG, A. De Roeck, A. Grau and G. Pancheri JHEP **0306**, 061 (2003),

RG, A. Grau, G. Pancheri, Y. Srivastava, EPJC63 (2009) 69.

RG, Kirtimaan Mohan, Jakob Esberg, Marco Battaglia: Ongoing study.



All hadronic cross-section rise with energy. In plot all photon cross-sections are multiplied by a factor 1/330 ($(1/330)^2$) for γp ($\gamma\gamma$) case. Rise similar(?) for proton and photon induced processes. EPJC 63, 69-85 (2009).

The $\gamma\gamma \to$ hadrons can contribute to the hadron production in $e^+e^- \to e^+e^-\gamma\gamma \to X +$ hadrons.

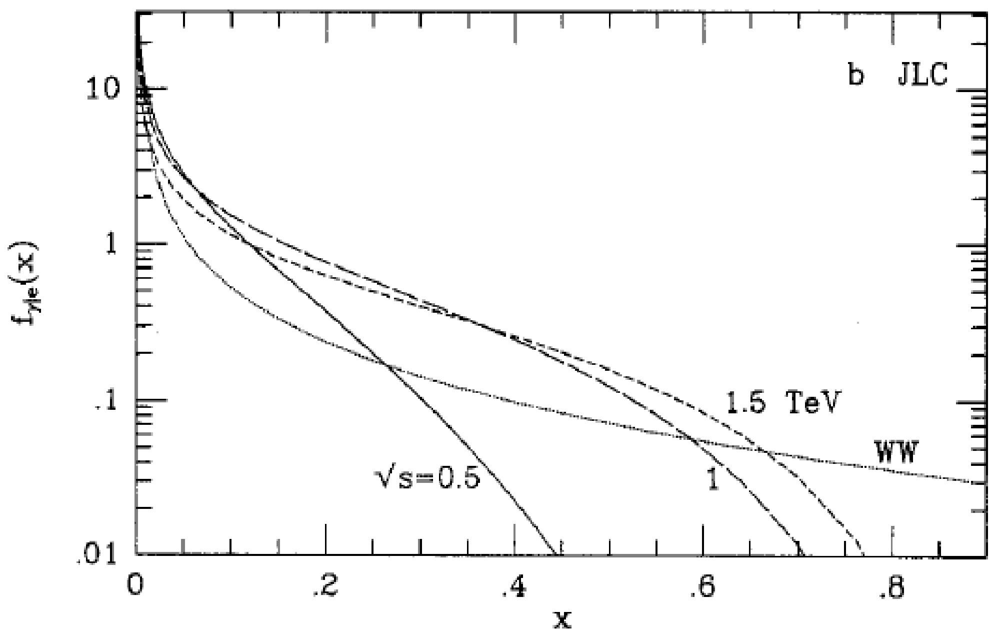
$\sigma^{\rm had}_{e^+e^-} = \int dz_1 \int dz_2 \; f_{\gamma/e}(z_1) f_{\gamma/e}(z_2) \sigma(\gamma\gamma \to \text{hadrons})$.

When measurements at LEP energies were not available we had estimated the hadron production in $\gamma\gamma$ collisions in terms of the photon structure function. Here we had used for the 'hard' part of the $\gamma\gamma$ cross-section an estimator for $\sigma(\gamma\gamma \to \text{hadrons})$, the quantity

$$\sigma^{jet}_{ptmin} = \int_{ptmin}^{\sqrt{s}} \frac{d\sigma(\gamma\gamma \to \text{jets})}{dp_t}$$

Collider	σ^{hard}(DG) [μb]	σ^{soft} [μb]	no. of events (DG)
T	0.016	0.041	0.004
D–D (nbb)	0.014	0.051	0.021
D–D (wbb)	0.041	0.20	0.20
P–F	0.042	0.072	0.46
P–G	0.48	0.51	24
JLC1	0.069	0.12	1.1
JLC2	0.41	0.19	24
JLC3	0.59	0.15	50
$\gamma\gamma$(500)	1.9	0.25	0.49 − 95
T(1000)	0.057	0.099	0.0036
T(2000)	0.21	0.15	0.013

semi-hard events per bunch collision or per 10^{-7} sec, whatever is bigger. Machines with larger Υ and hence more beamstrahlung photons , the number of expected semi-hard events can be large. ZPC 59 (1993) 591



WW : Bremstarhulng contribution Beamstrahlung depends on the Machine parameters and can enhance the number of photons.

Thus these backgrounds depend very much on the machine parameters. ZPC 59 (1993) 591

Chen, Barklow and Peskin:

Obviously our estimator overestimated the $\sigma(\gamma\gamma \to \text{hadrons})$. They proposed a simple model for *both* the soft and hard part of $\gamma\gamma$ cross-sections and studied the hadronic backgrounds coming from these processes using a Monte Carlo.

These depend critically on the beamstrahlung spectrum, which in turn depends on machine parameters

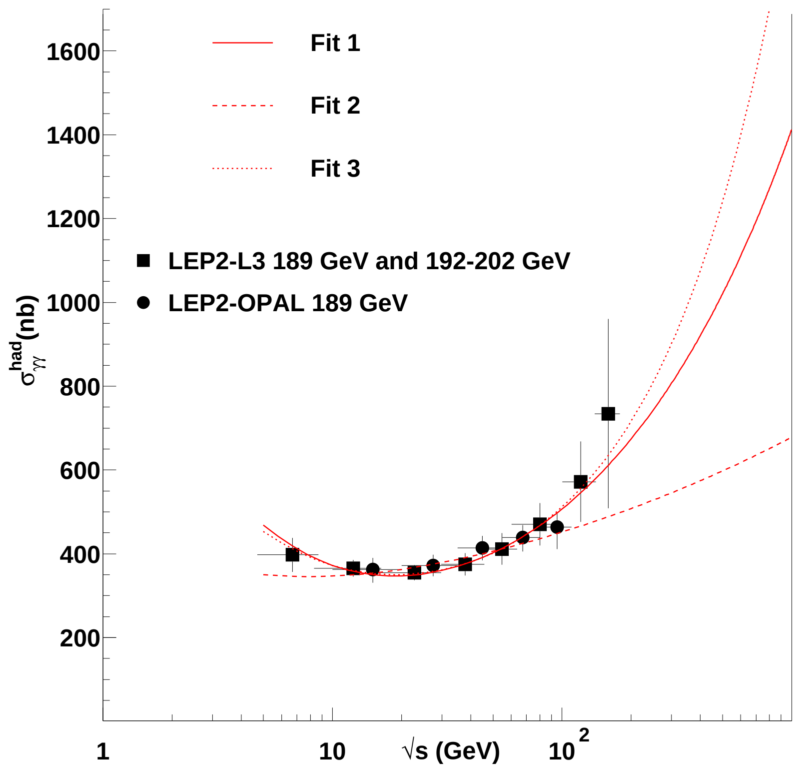
Their analysis showed how this background can be analysed and upto $\sqrt{s} = 1$ TeV or so, it is possible to have designs such that these hadronic backgrounds will be no threat.

But at CLIC story can be different.

Issue : estimate the theoretical uncertainties in these estimates.

Energy dependence of $\sigma(\gamma\gamma \to \text{hadrons})$?

What is the experimental information and what are the theoretical predictions?



L3 and OPAL data had some discrepancies.

Three different fits. Both the data sets require a rising component.

JHEP 0306 (2003) 061.

Results of fits to the OPAL and L3 total $\gamma\gamma$ cross sections, of the form $Bs^{-\eta} + As^{\epsilon} + Cs^{\epsilon_1}$.

Data	A (nb)	B (nb)	C (nb)	ϵ, ϵ_1	χ^2
L3	47 ± 14	1154 ± 158	–	$\epsilon = 0.250 \pm 0.033$	2.4
L3	187 ± 4	312 ± 95	–	$\epsilon = 0.093$,fixed	25
L3	98 ± 18	958 ± 162	5.3 ± 1.1	$\epsilon = 0.093$,fixed	
				$\epsilon_1 = 0.418$, fixed	1.3
L3+OPAL	51 ± 14	1132 ± 158	–	$\epsilon = 0.240 \pm 0.032$	4.0
L3+OPAL	187 ± 4	310 ± 91	–	$\epsilon = 0.093$ fixed	26
L3+OPAL	103 ± 18	934 ± 156	5.0 ± 1.0	$\epsilon = 0.093$,fixed	
				$\epsilon_1 = 0.418$, fixed	2.8

- Bounds from Analyticity and Unitarity.
- Regge Pomeron exchange.
- The Eikonal Minijet Model: EMM.
- Bloch-Nordsieck Resummation for the EMM.
- Want an unified description for $pp, \bar{p}p, \gamma p$ and $\gamma\gamma$.

The analyticty and unitarity implies Froissart Bound. $\sigma^{tot}(s)$ rises at most like $\ln(s)^2$.

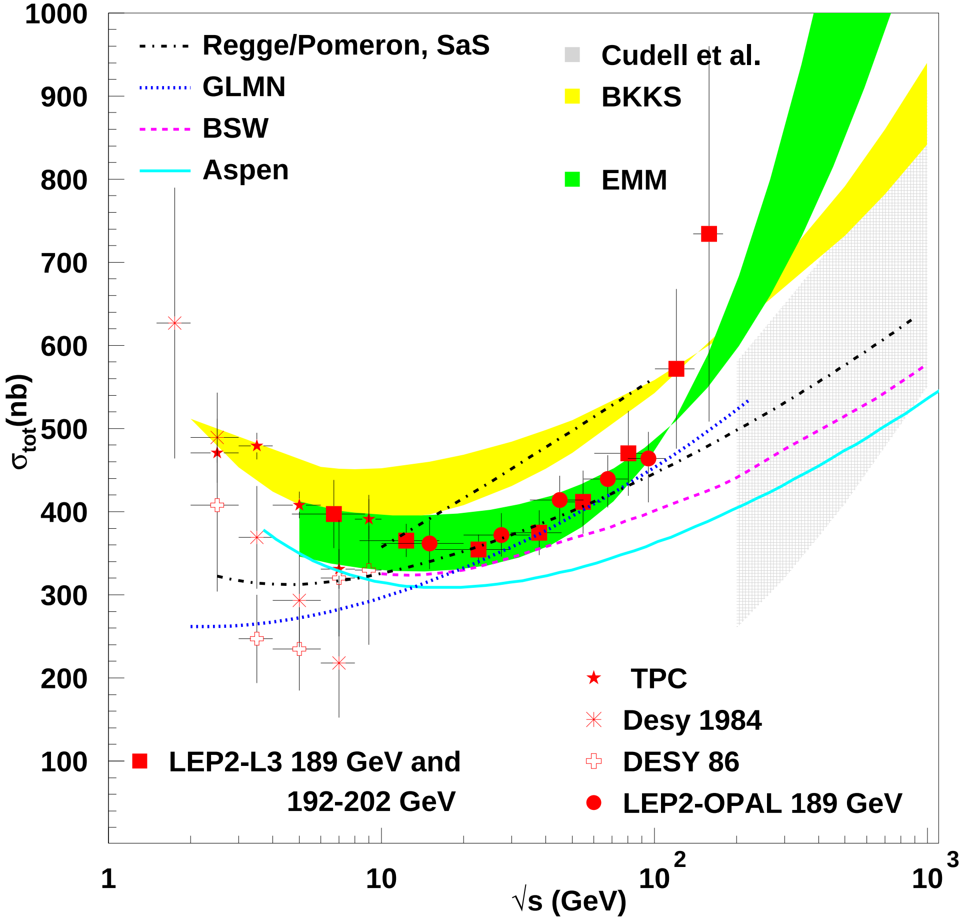
Regge-Pomeron exchange: (Donnachie and Landschoff)

$\sigma(s) = As^{-\eta} + Bs^{\epsilon}$

$\eta = 0.5, \epsilon = \alpha_P - 1 =$ small.

EMM: Unitarised minijet model. Rise of the cross-section with energy driven by rise in the number of gluons/partons and rise of the perturbative QCD cross-sections at low p_t.

Unitarisation by multi-parton interactions increasing with energy in a given hard collision.



JHEP 0306 (2003) 061.

This rise with energy is not tamed 'enough' for EMM.

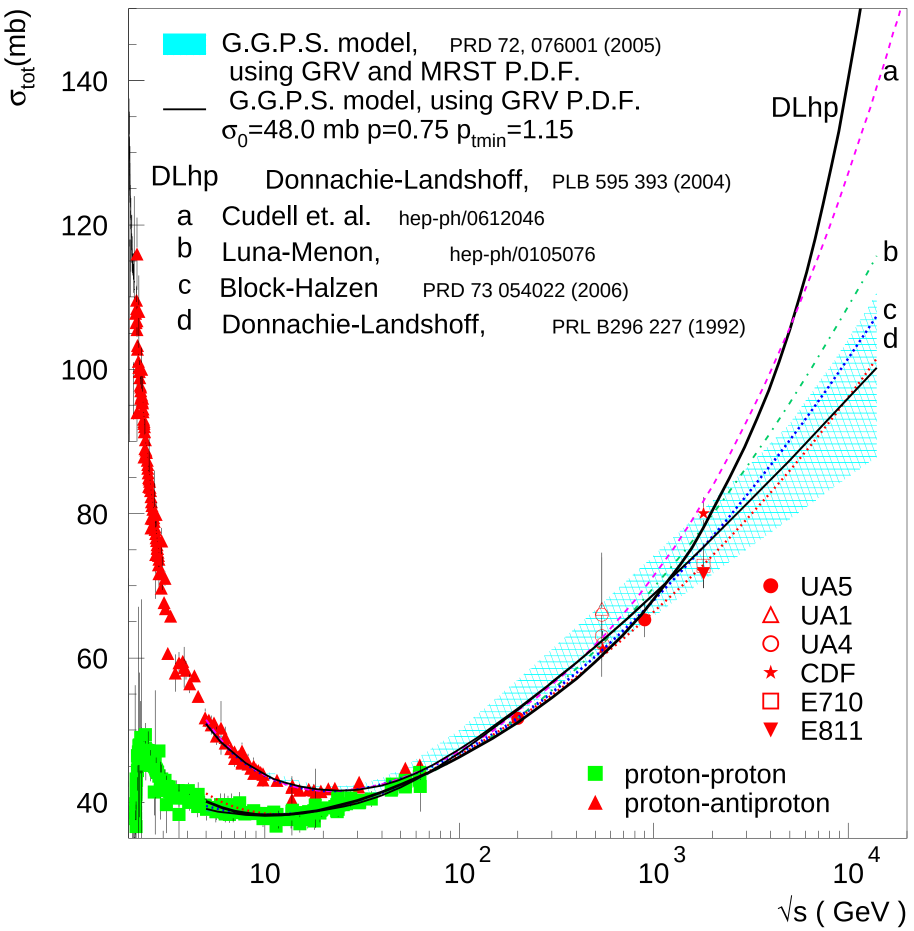
Remove the approximations in the EMM calculations.

Normally what is involved is the fourier transform of the transverse momentum distribution of the partons in the target

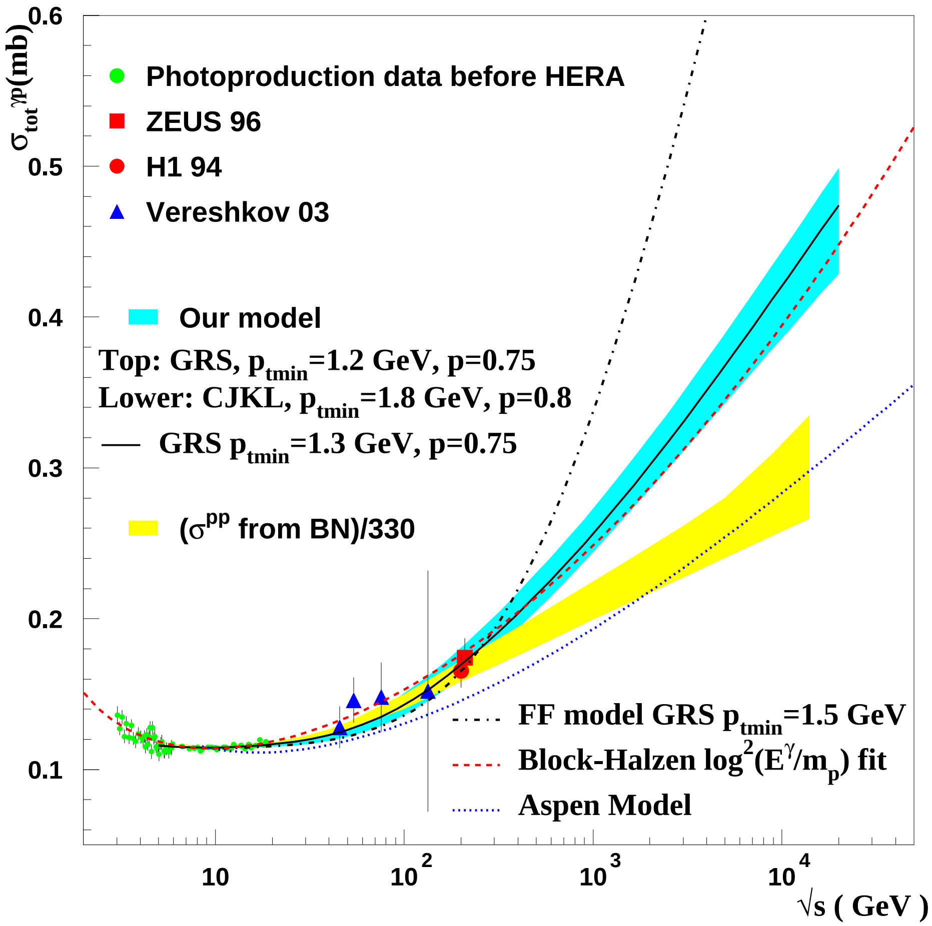
We developed a model where this was dervied in terms of soft gluon emissions.

We call it BN EMM

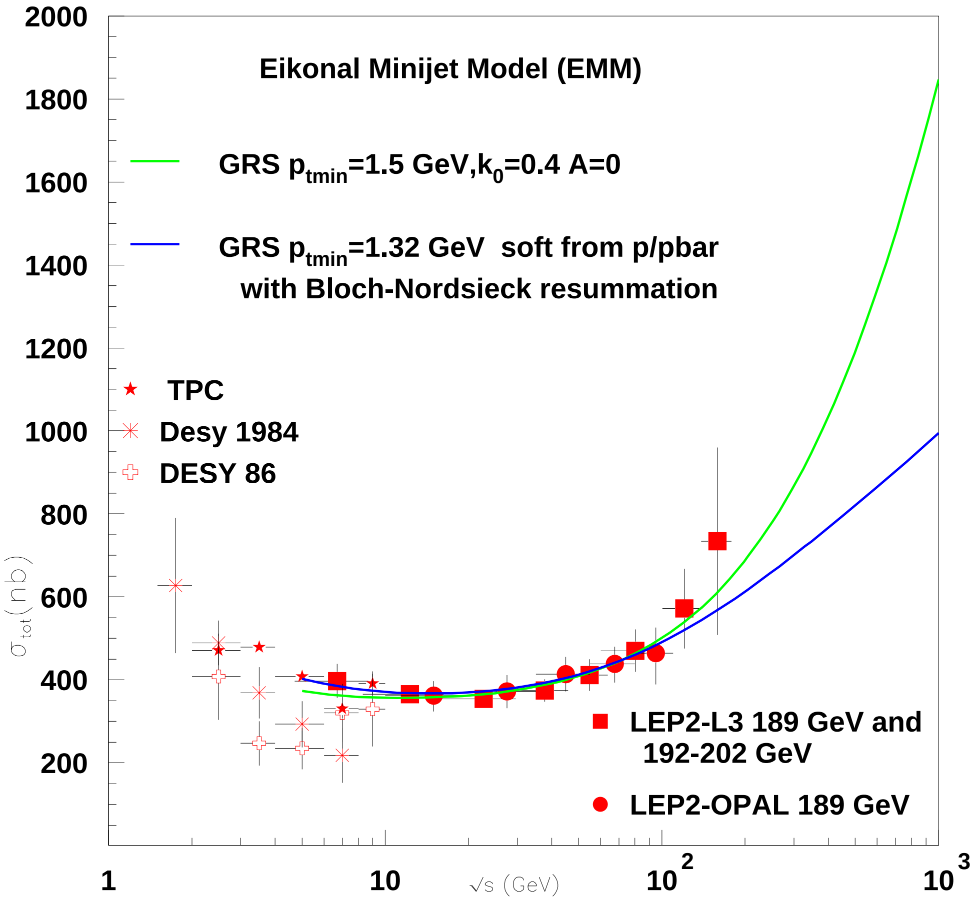
First applied it to protons. Interestingly we in fact get the Froissart bound 'naturally' (Pancheri, Grau, RG, Srivastava: PLB 2010)



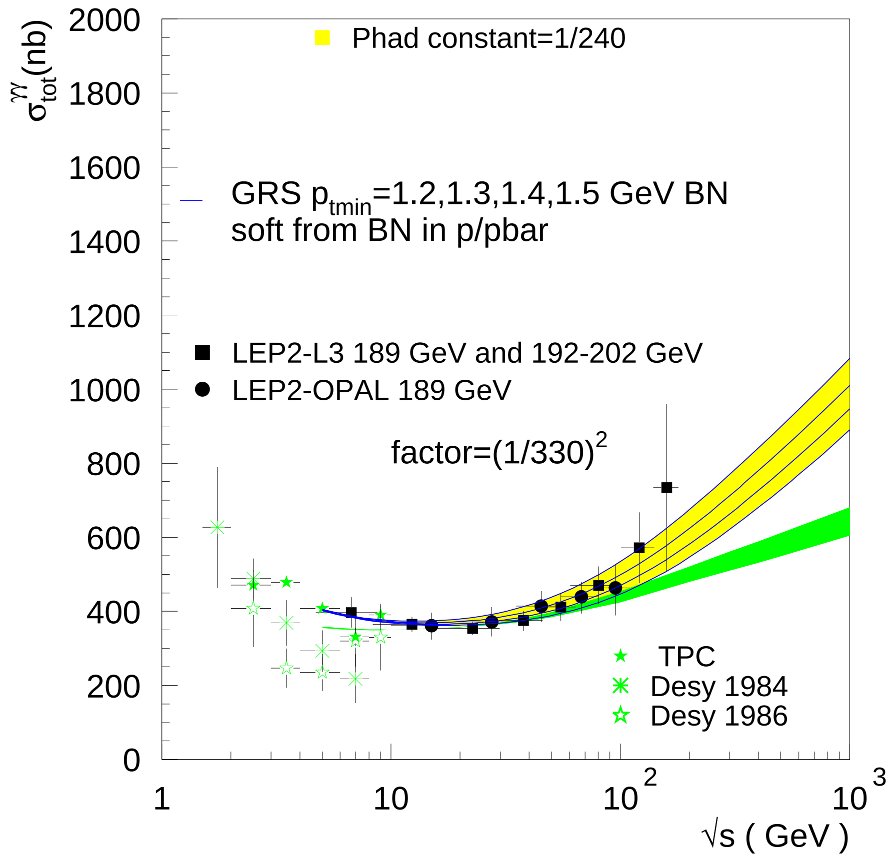
PLB659 (2008) 137



EPJC63 (2009) 69



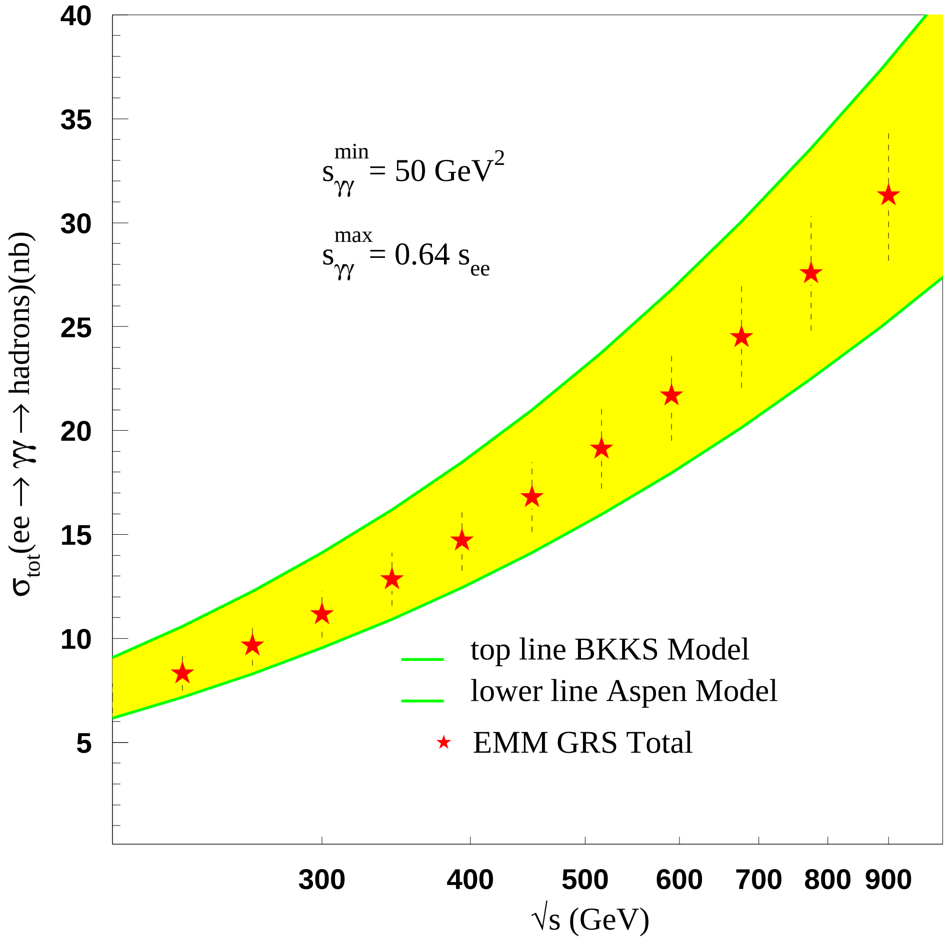
Early attempts: EMM and BN EMM.



Nucl.Phys.Proc.Suppl.184 (2008) 85; e-Print: arXiv:0802.3367

Were focussed on whether $\gamma\gamma$ processes can give information on the models of total cross-section.!

Since measuring photon photon cross-sections is more difficult we calculated hadron production in e^+e^- collisions

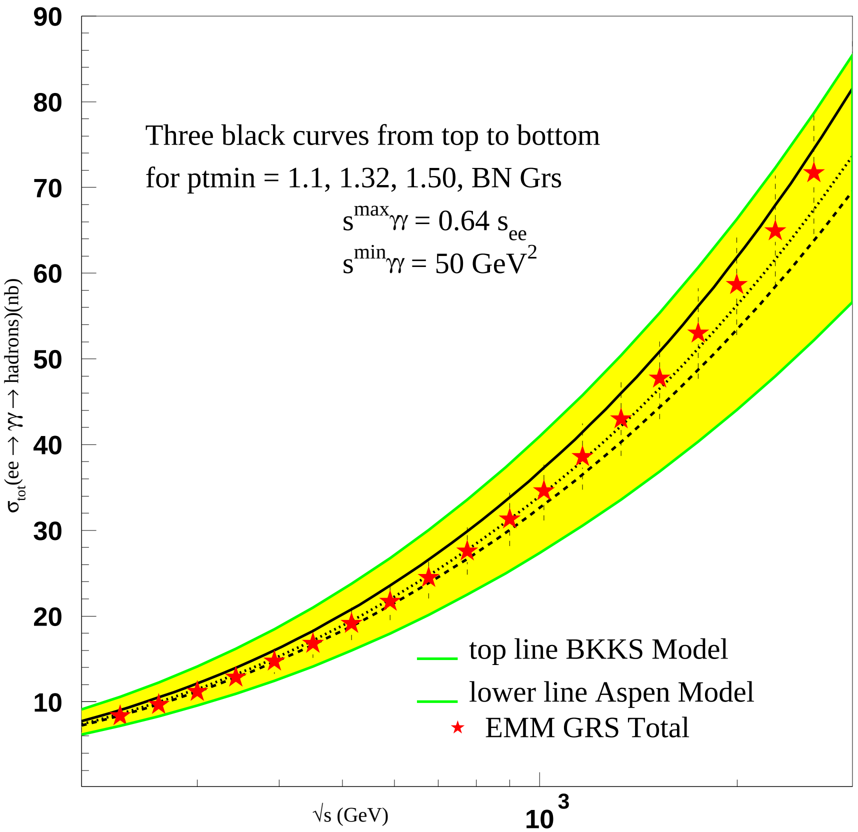


JHEP 0306 (2003) 061.

Notice that the hadron production dominated by behaviour of the c.section in the low $\sqrt{s}$ region.

What happens for higher energy? CLIC?

What is the effect of model uncertainties in the hadrnonic $\gamma\gamma$ cross-sections?



Of course at higher energies, Beamstrahlung contribution has to be included. **Still to be done.**