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

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

Warning: Mainly a status survey and partial results.

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.

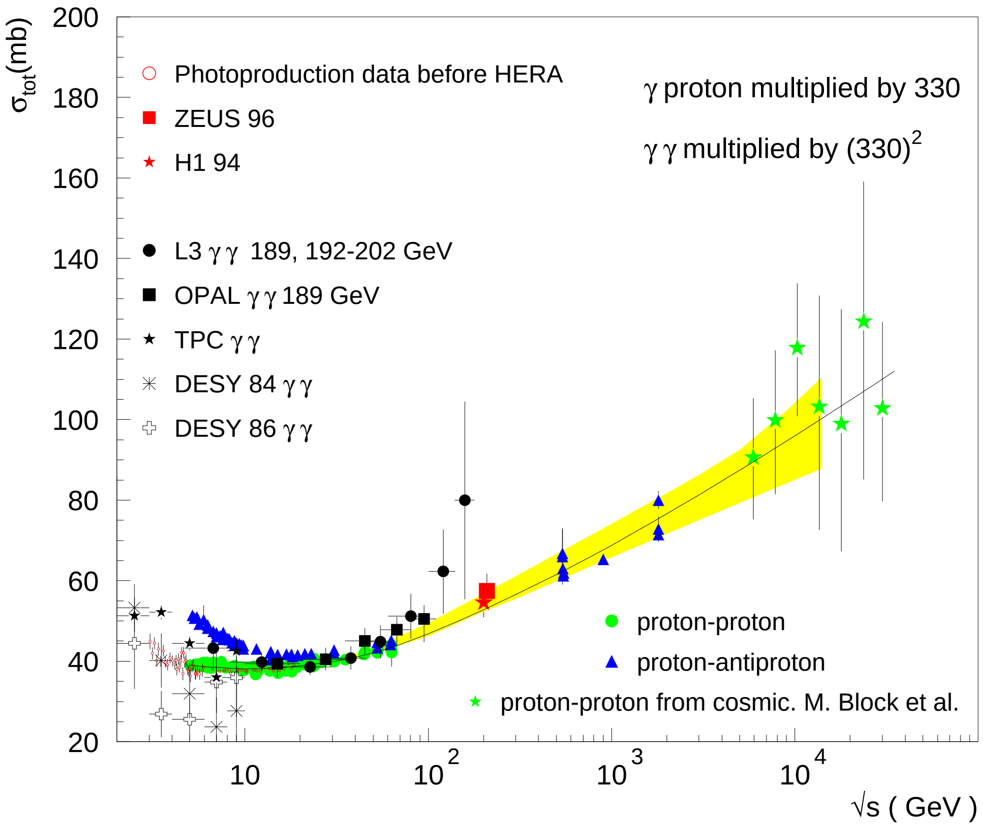
M. Battaglia, Jakob Esberg, RG, Kirtimaan Mohan, G. Pancheri: Ongoing study.

The clean environment of the linear colliders is a great positive point for new physics searches.

At high energy linear colliders $\gamma\gamma \rightarrow$ hadrons can threaten to destroy this clean environment M. Drees and RG, Phys. Rev. Lett. **67**, 1189 (1991).

For ILC beamstrahlung spectra controlled such that these backgrounds are under control.

Evaluate these backgrounds for CLIC



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.

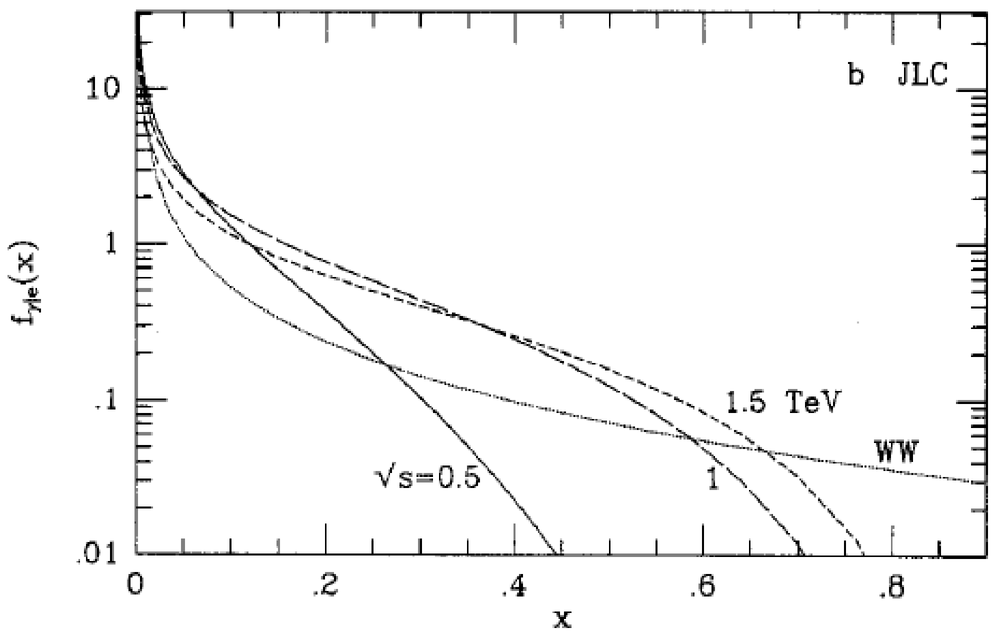
$\sigma^{\text{had}}_{e^+e^-} = \int dz_1 \int dz_2 \; f_{\gamma/e}(z_1) f_{\gamma/e}(z_2) \sigma(\gamma\gamma \to \text{hadrons})$.

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.

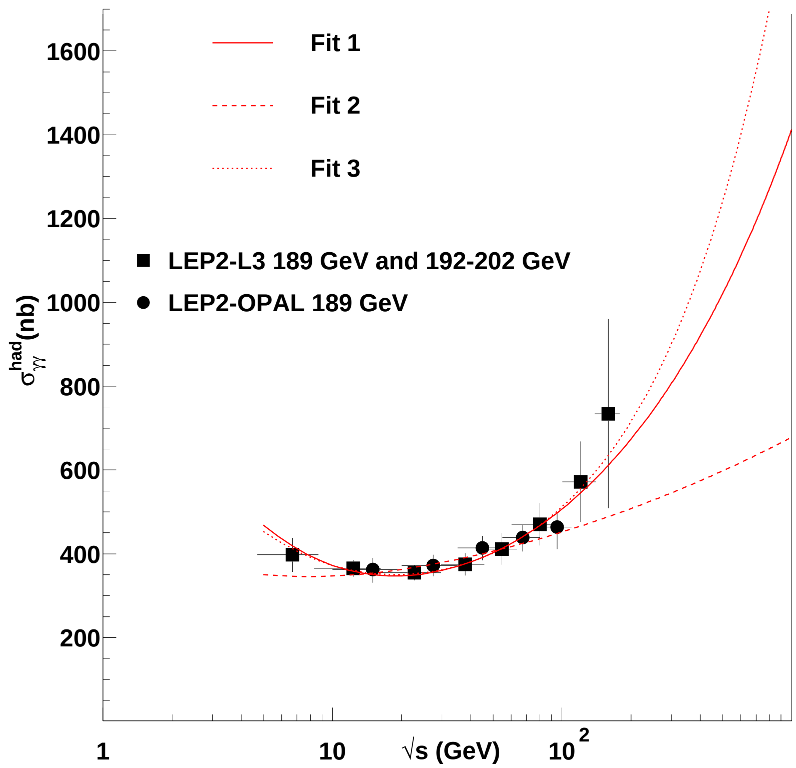
Their analysis showed how this background can be analysed and upto $\sqrt{s} = 1$ TeV or so, it is possible to have designs such that these hadronic backgrounds will be no threat.

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

$A(nb)$	$B(nb)$	$C(nb)$	ϵ, ϵ_1	χ^2
51 ± 14	1132 ± 158	-	$\epsilon = 0.24 \pm 0.032$	4.0
147 ± 4	310 ± 91	-	$\epsilon = 0.093$	26
103 ± 18	934 ± 156	5.0 ± 1.0	$\epsilon = 0.093,\ \epsilon_1 = 0.418$	2.8

Values used.

- 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 $\ln(s)^2$.

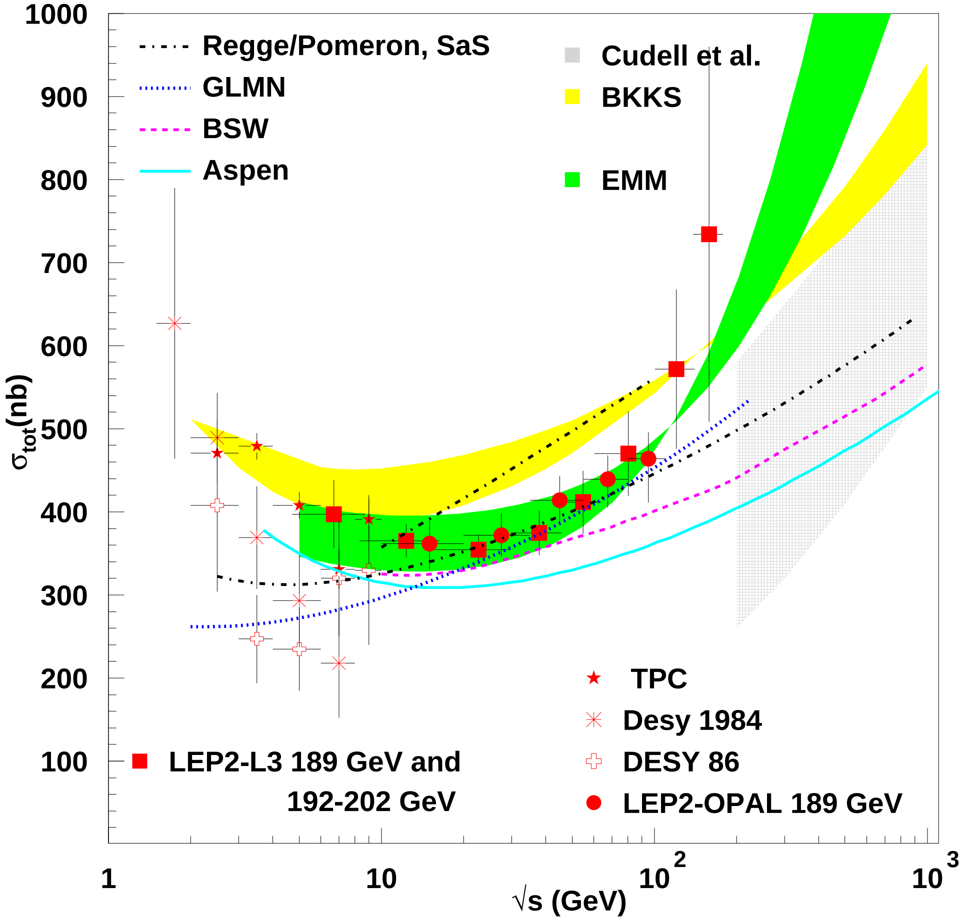
Regge-Pomeron exchange: (Donnachie and Landschoff)

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

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

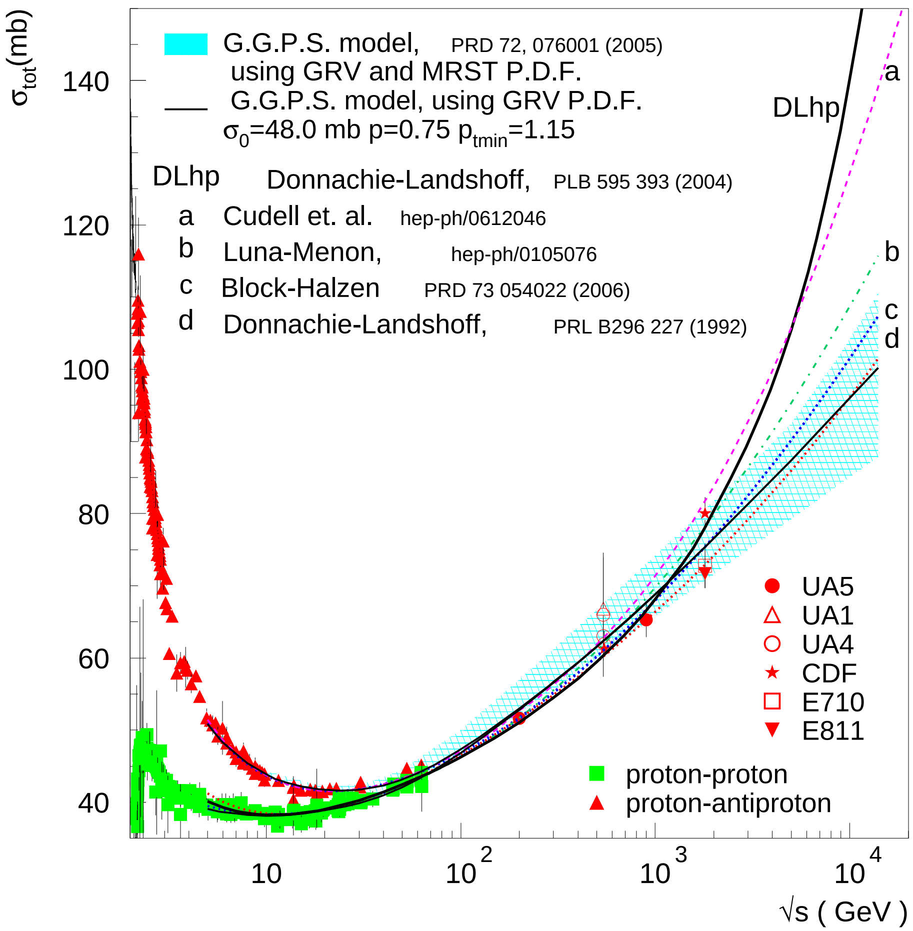
Remove the approximations in the EMM calculations.

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

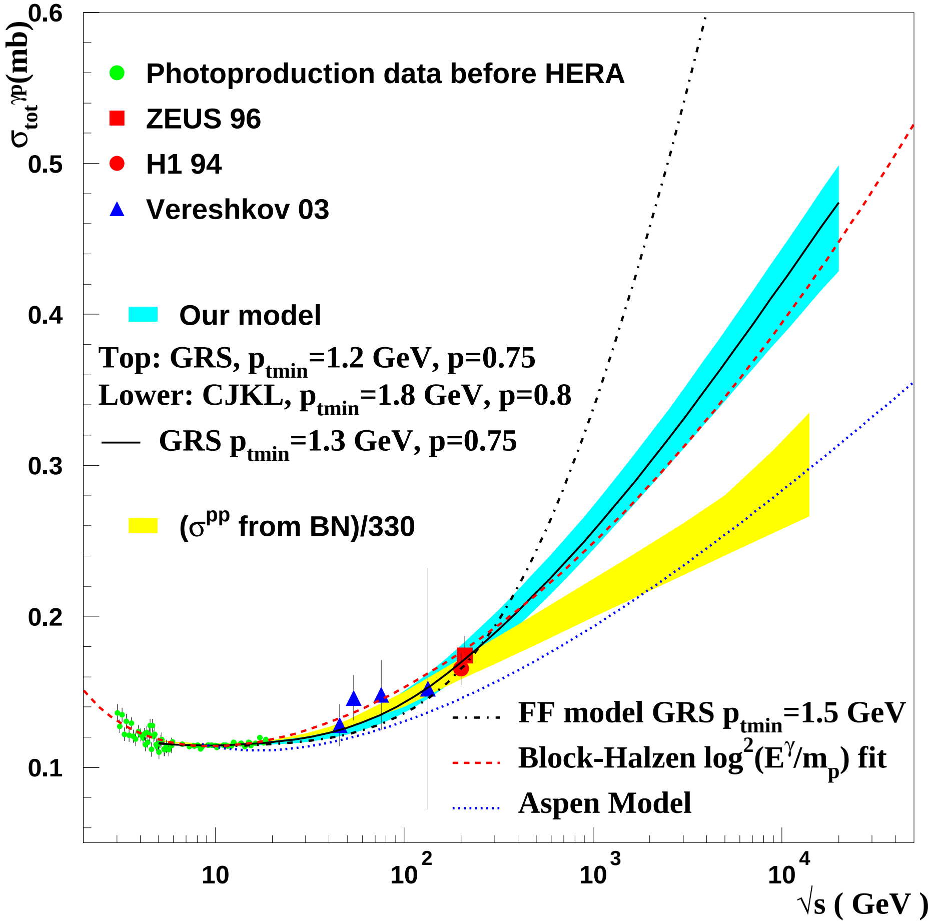
We developed a model where this was dervied in terms of soft gluon emissions.

We call it BN EMM.

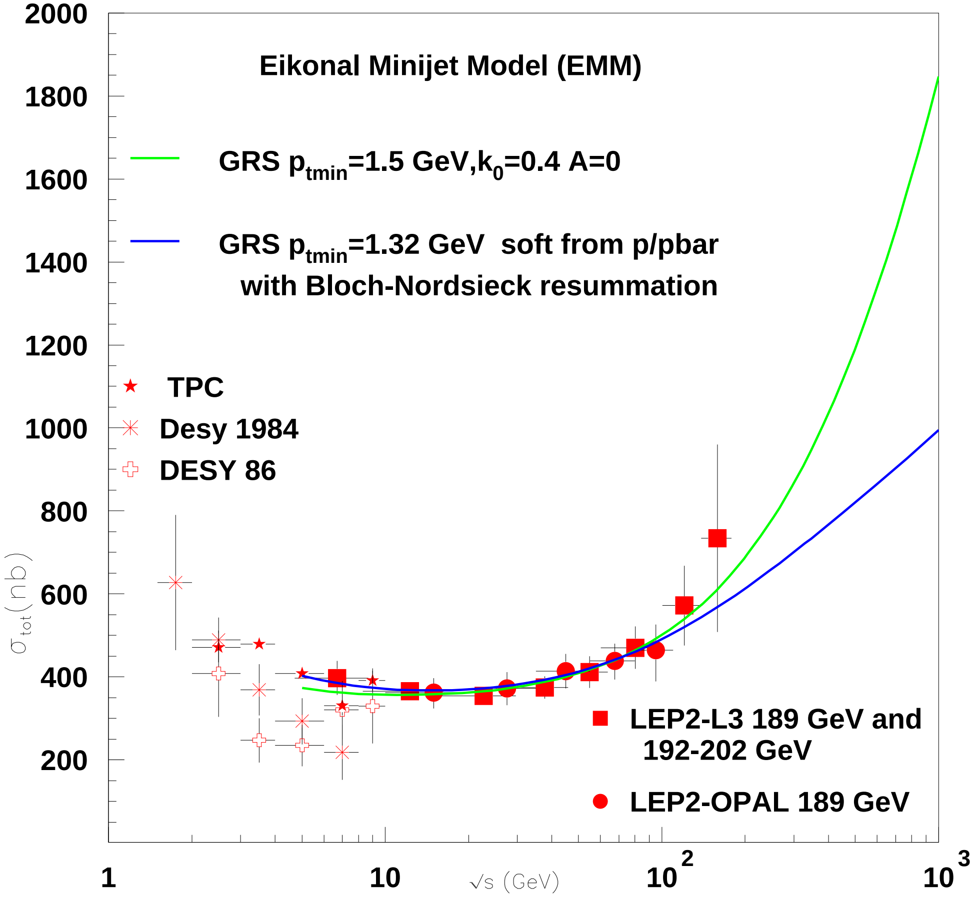
First applied it to protons. Interestingly we in fact get the Froissart bound 'naturally' (Pancheri, Grau, RG, Srivastava: PLB 2010).



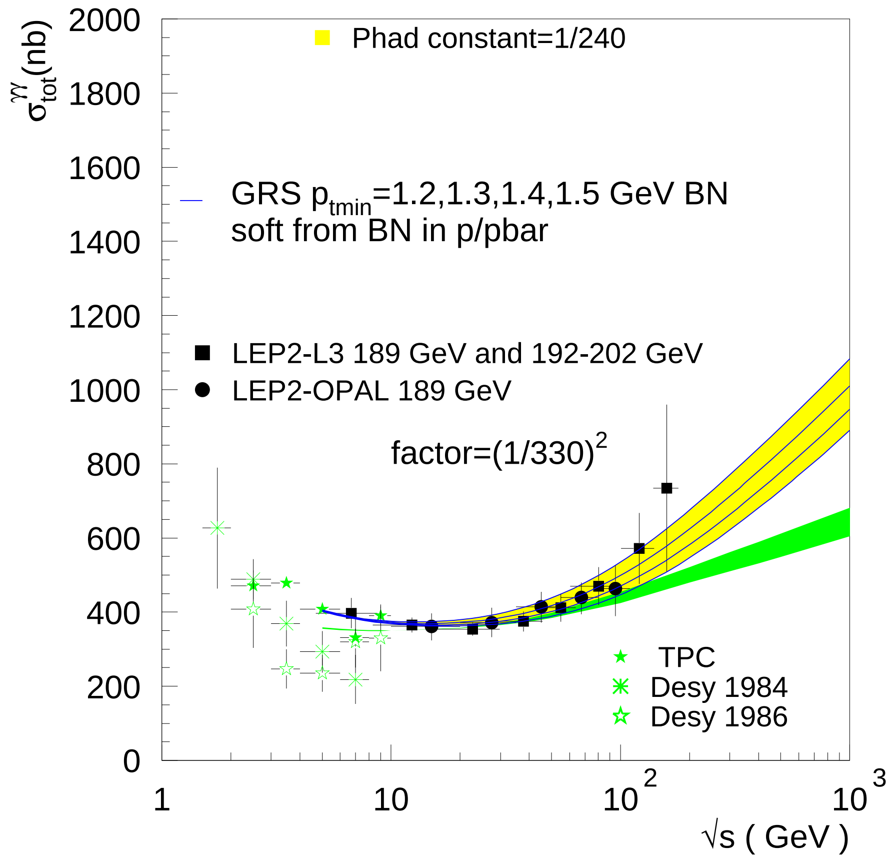
PLB659 (2008) 137



EPJC63 (2009) 69



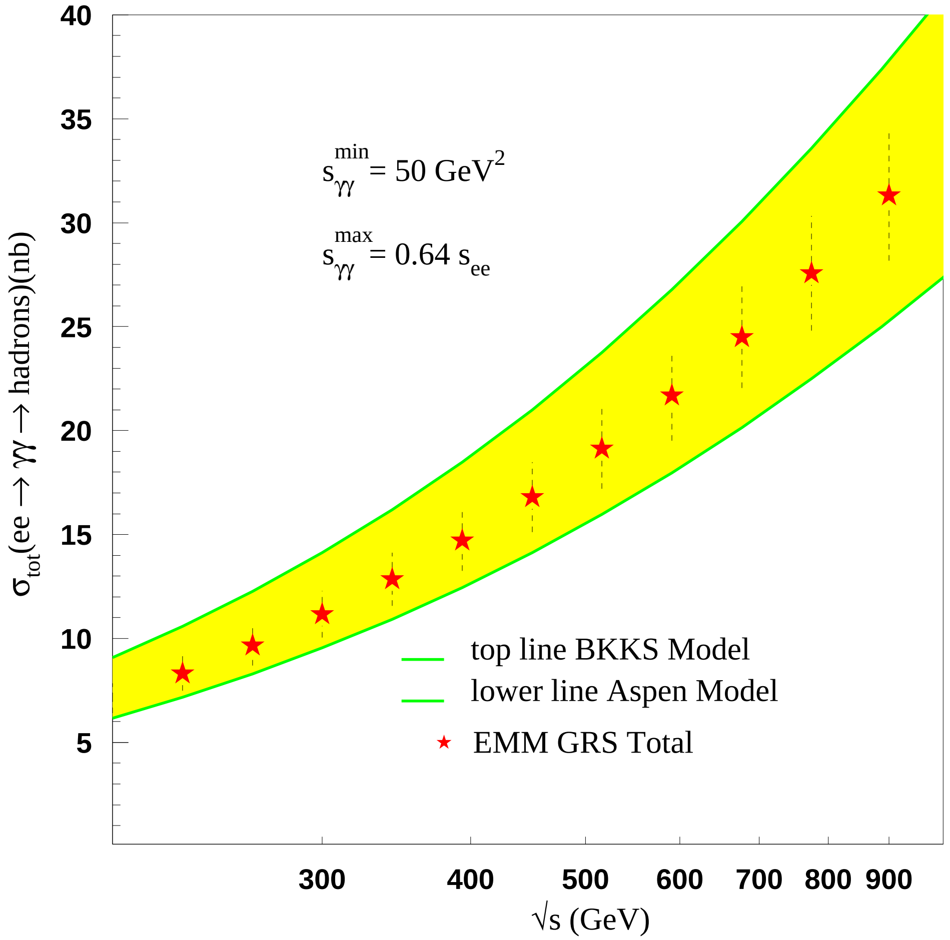
Early attempts: EMM and BN EMM.



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.

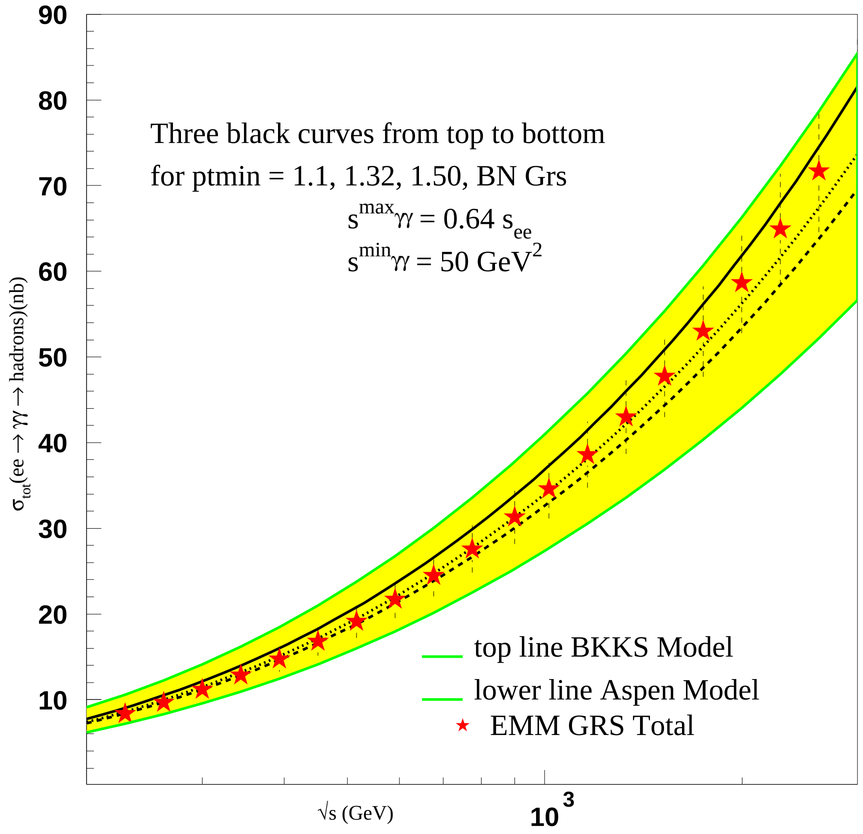


JHEP 0306 (2003) 061.

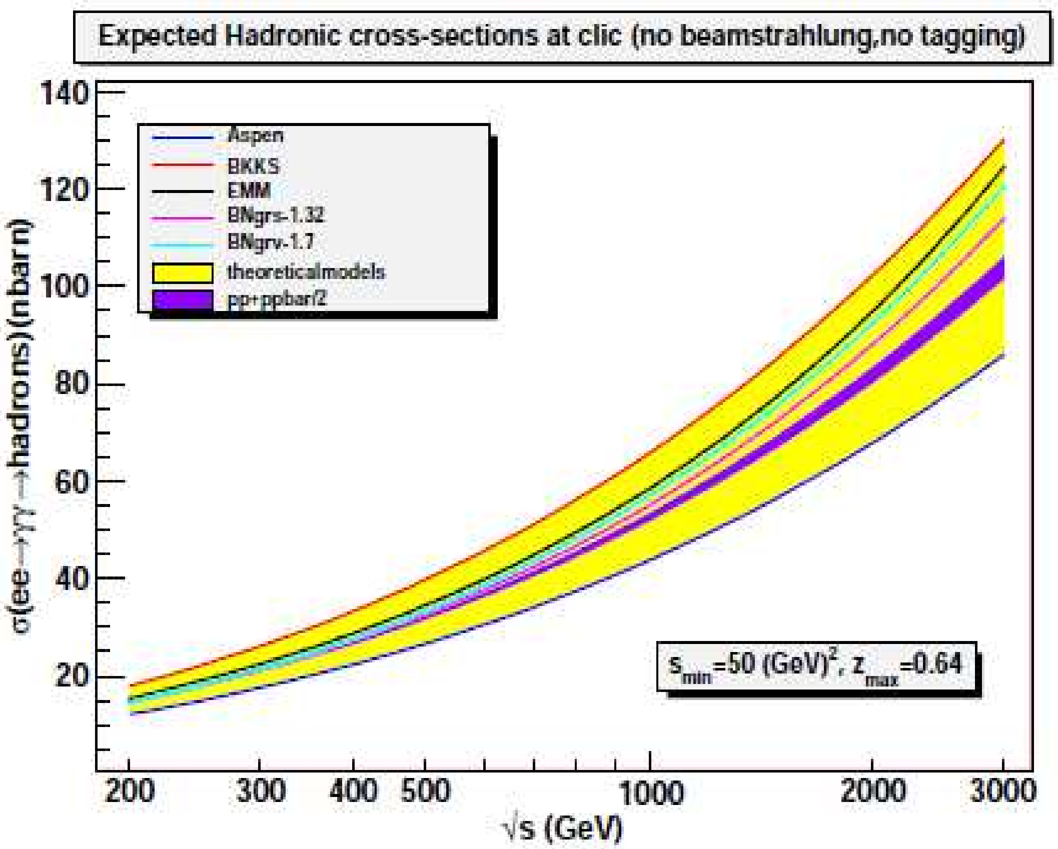
Notice that the hadron production dominated by behaviour of the c.section in the low $\sqrt{s}$ region.

What happens for higher energy? CLIC?

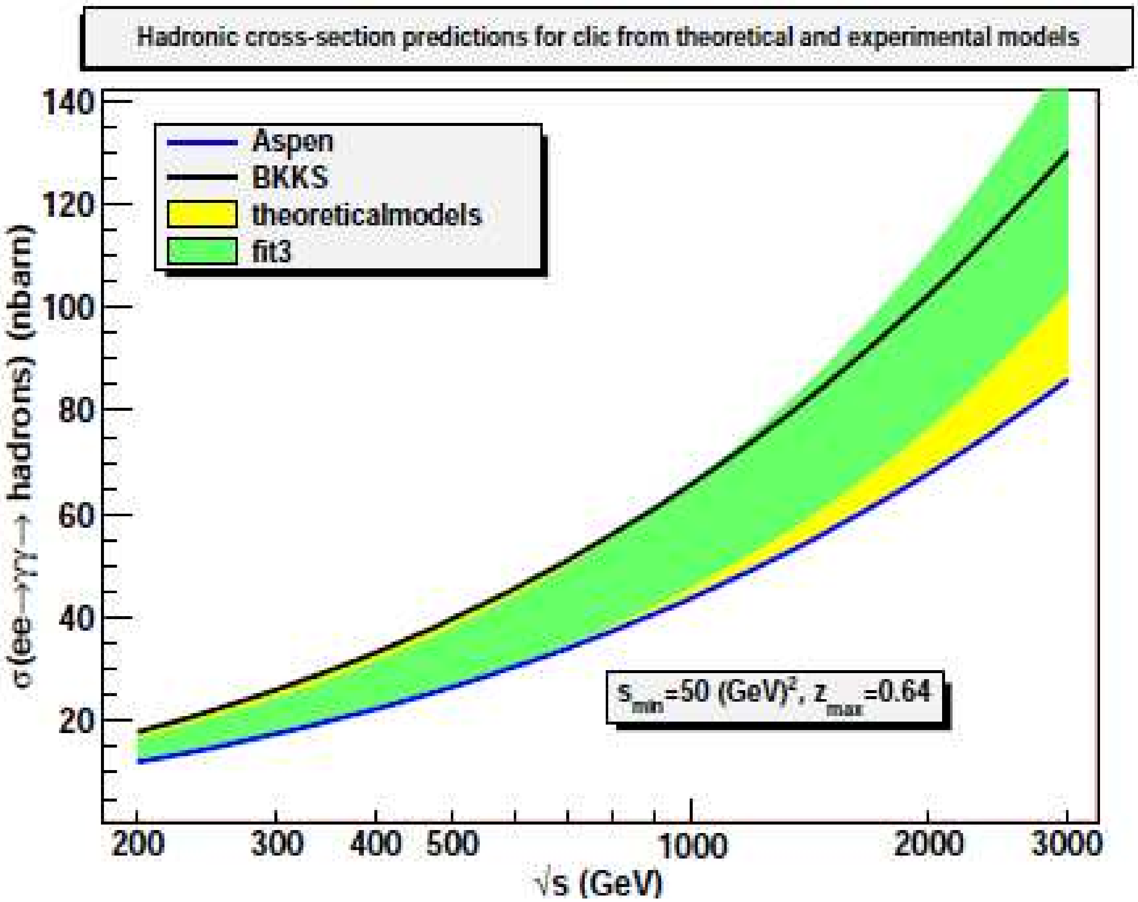
What is the effect of model uncertainties in the hadrnonic $\gamma\gamma$ cross-sections?



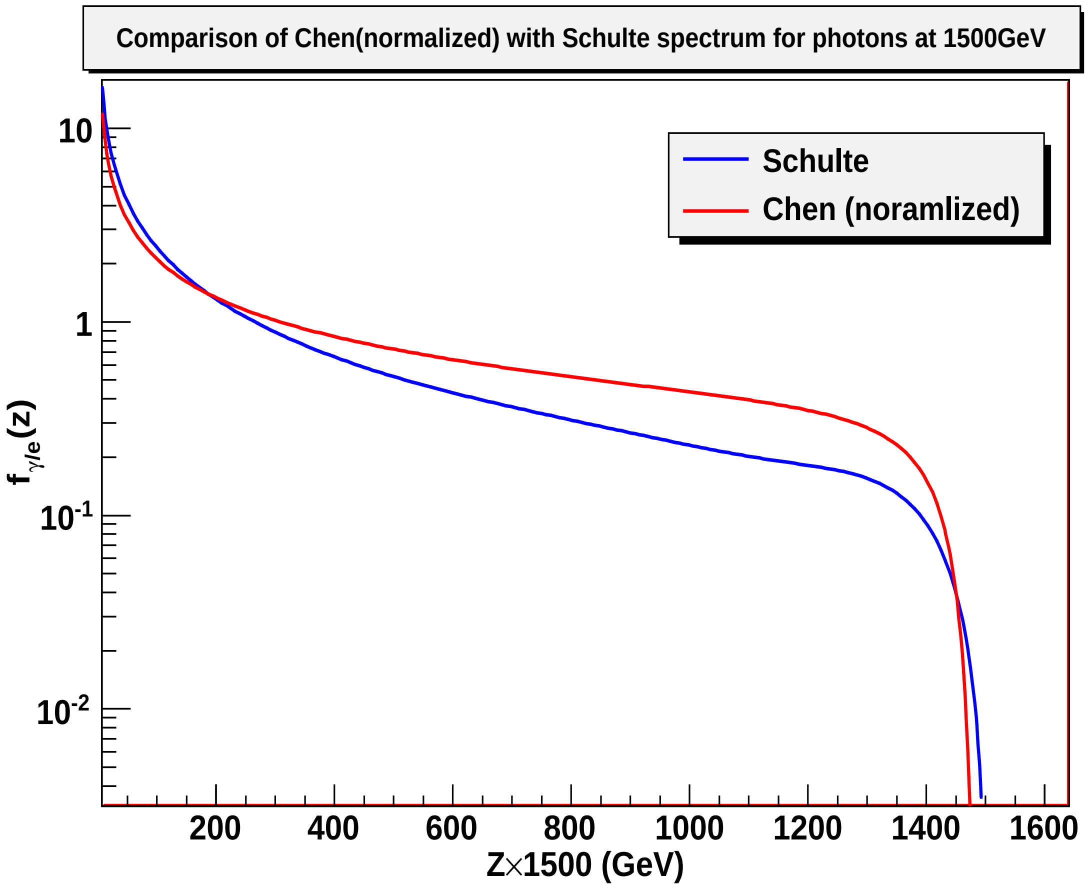
90
80
70
60
50
40
30
20
10
Three black curves from top to bottom
for ptmin = 1.1, 1.32, 1.50, BN Grs
$s^{max}_{\gamma\gamma}$ = 0.64 s_{ee}
$s^{min}_{\gamma\gamma}$ = 50 GeV^2
$\sigma_{tot}(ee \to \gamma\gamma \to hadrons)(nb)$
top line BKKS Model
lower line Aspen Model
EMM GRS Total
√s (GeV)
10^3



Expected Hadronic cross-sections at clic (no beamstrahlung,no tagging)
Aspen
BKKS
EMM
BNgrs-1.32
BNgrv-1.7
theoreticalmodels
pp+ppbar/2
s_min=50 (GeV)^2, z_max=0.64
σ(ee→γγ→hadrons)(nbarn)
√s (GeV)
140
120
100
80
60
40
20
200
300
400
500
1000
2000
3000



Of course for CLIC need to take into account beamstrahlung.


Comparison of Chen(normalized) with Schulte spectrum for photons at 1500GeV
Schulte
Chen (noramlized)
$f_{\gamma/e}(z)$
10
1
10^{-1}
10^{-2}
200
400
600
800
1000
1200
1400
1600
Z×1500 (GeV)

Model	Chen	Schulte	No Beamstrahlung
EMM(BN) grs-1.32	356.61(1.77)	1004.51(4.98)	113.972(0.56)
EMM(BN) grv-1.7	385.33 (1.91)	1090.35(5.4)	120.54(0.60)
EMM	403.63(2.0)	1135.00 (5.62)	124.54(0.62)
Aspen	254.57 (1.26)	710.67(3.52)	86.04(0.43)
BKKS	387.76 (1.92)	1085.02 (5.37)	130.10(0.64)
$\frac{pp+p\bar{p}}{2}$lo	299.22(1.48)	835.26(4.14)	101.52(0.5)
$\frac{pp+p\bar{p}}{2}$hi	317.09(1.57)	887.96(4.4)	106.17(0.52)

Beamstrahlung increases the number of events per b.c. substantially.

Low energy part of the spectrum dominates.

Region where data are available.

See the spread in values as we look at three fits and varying smin.

smin(GeV)	fit1	fit2	fit3
5	514.67 (2.55)	318.50(1.58)	552.0 (2.73)
25	419.57 (2.08)	266.20(1.32)	462.41 (2.29)
50	390.07 (1.93)	246.49(1.22)	433.57 (2.15)

With the analytical spectrum from Chen et al.

smin(GeV)	fit1	fit2	fit3
5	1359.15 (6.73)	840.348(4.16)	1466.74 (7.27)
25	1164.66 (5.77)	733.142(3.63)	1283.39(6.36)
50	1100.6 (5.45)	690.336 (3.42)	1220.7 (6.05)

For the sepctrum from Gunieapig (from Daniel Schulte)

The beamstrahlung induced hadronic backgrounds are large at CLIC.

Dominated by the values of $\gamma\gamma$ cross-sections where data are available.

The spread in the model predictions in fact less than the spread among the three fits to the data themselves.

Work is in progress to include this range of predictions on the analyses of new physics.