$\gamma^*\gamma^*$ cross-sections at CLIC and LC

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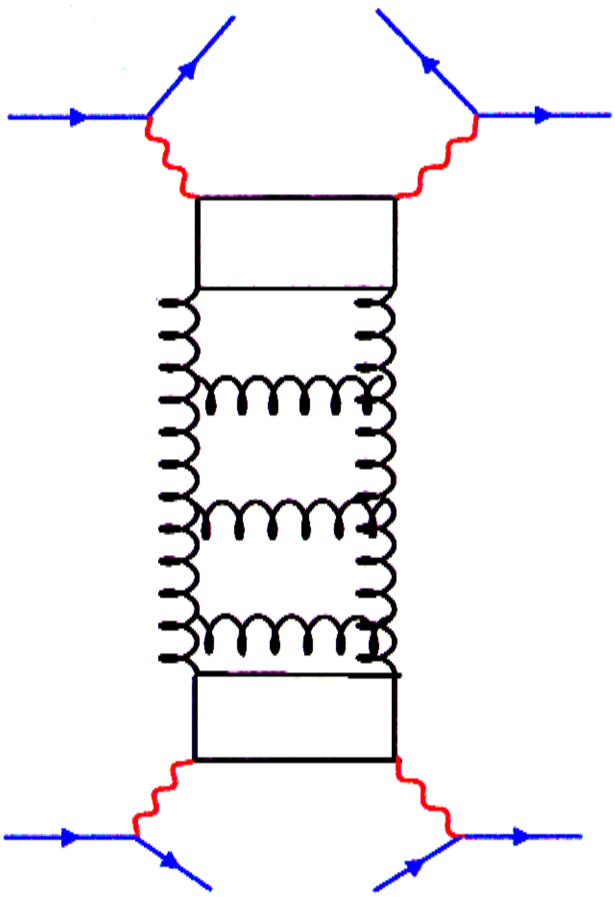
- Introduction and fit of L3 data
- 2-gluon and BFKL cross-sections
- Energy and angle dependence at CLIC, LC

Work done in collaboration with M.Boonekamp, A.De Roeck, S.Wallon

$\gamma^*\gamma^*$ cross-section



DGLAP

$\Sigma_n(\alpha_S \log Q^2)^n$

k_T ordering, $...k_{i+2}^2 \ll k_{i+1}^2 \ll k_i^2...$

BFKL

$\Sigma_n(\alpha_S \log 1/x)^n$

x_i ordering, $...x_{i+2} \gg x_{i+1} \gg x_i...$

IDEA: $Q_1^2 \sim Q_2^2$ BFKL$\gg$DGLAP

Higher-order corrections to BFKL equation

Higher order corrections done phenomenologically:

[inspired by the L3 $\gamma^*\gamma^*$ fit and by Nucl.Phys.B555 (1999) 540]

$$\sigma_{BFKL} \sim exp\left(\frac{4\alpha_S N_C}{\pi} Y \ln 2\right) \text{ where } Y = \frac{s y_1 y_2}{\sqrt{Q_1^2 Q_2^2}}$$

α_S taken constant at LO

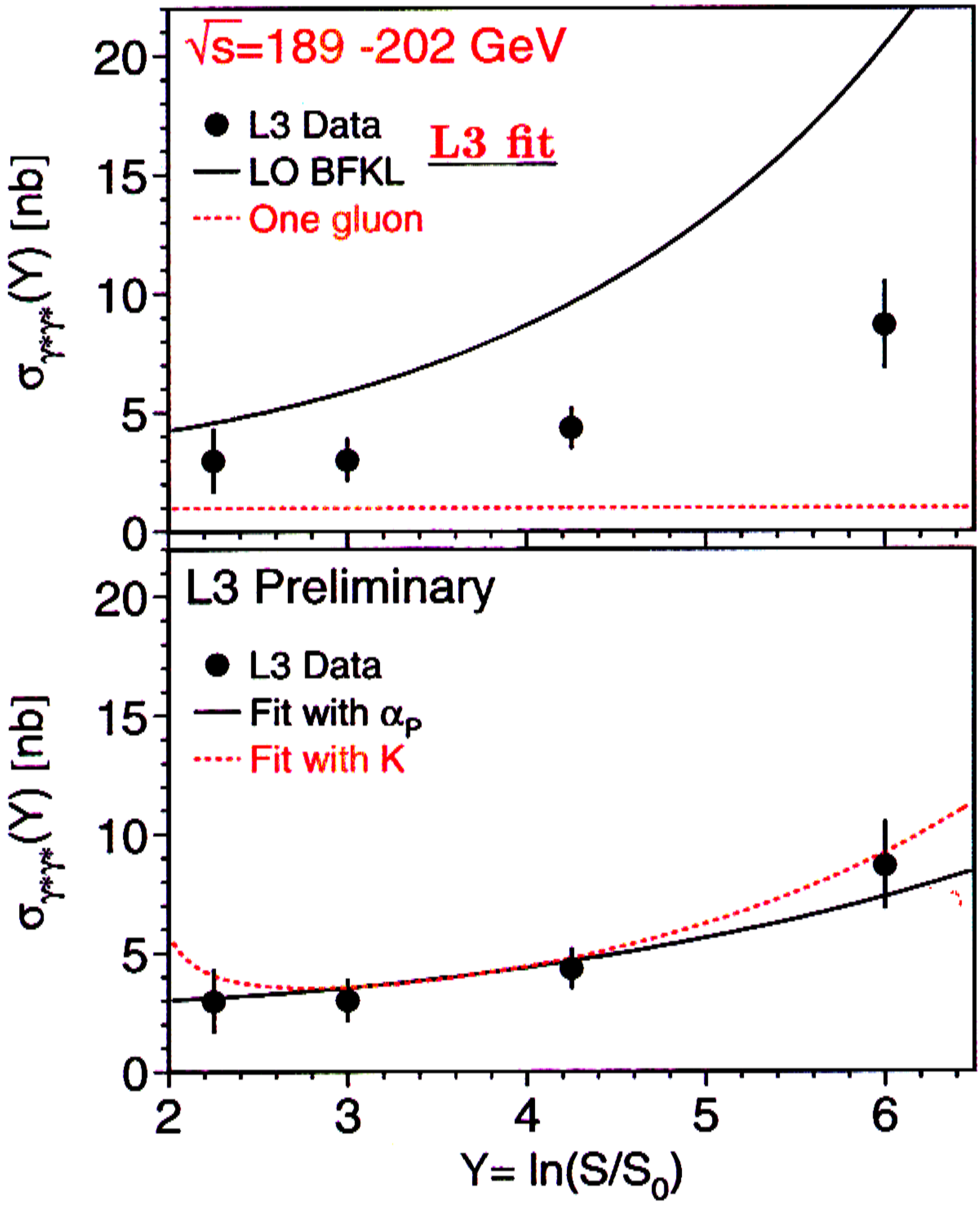
LO: $\alpha_S(\mu^2)$ where $\mu^2 = exp(-\frac{5}{3})\sqrt{Q_1^2 Q_2^2}$

(Brodsky et al.)

higher order: rescale $\alpha_S(\mu^2)$ such that

$\alpha_S(Q_1^2 = Q_2^2 = 15\ \text{GeV}^2) \sim 0.136$ [L3 fit]

Cross-section very much reduced

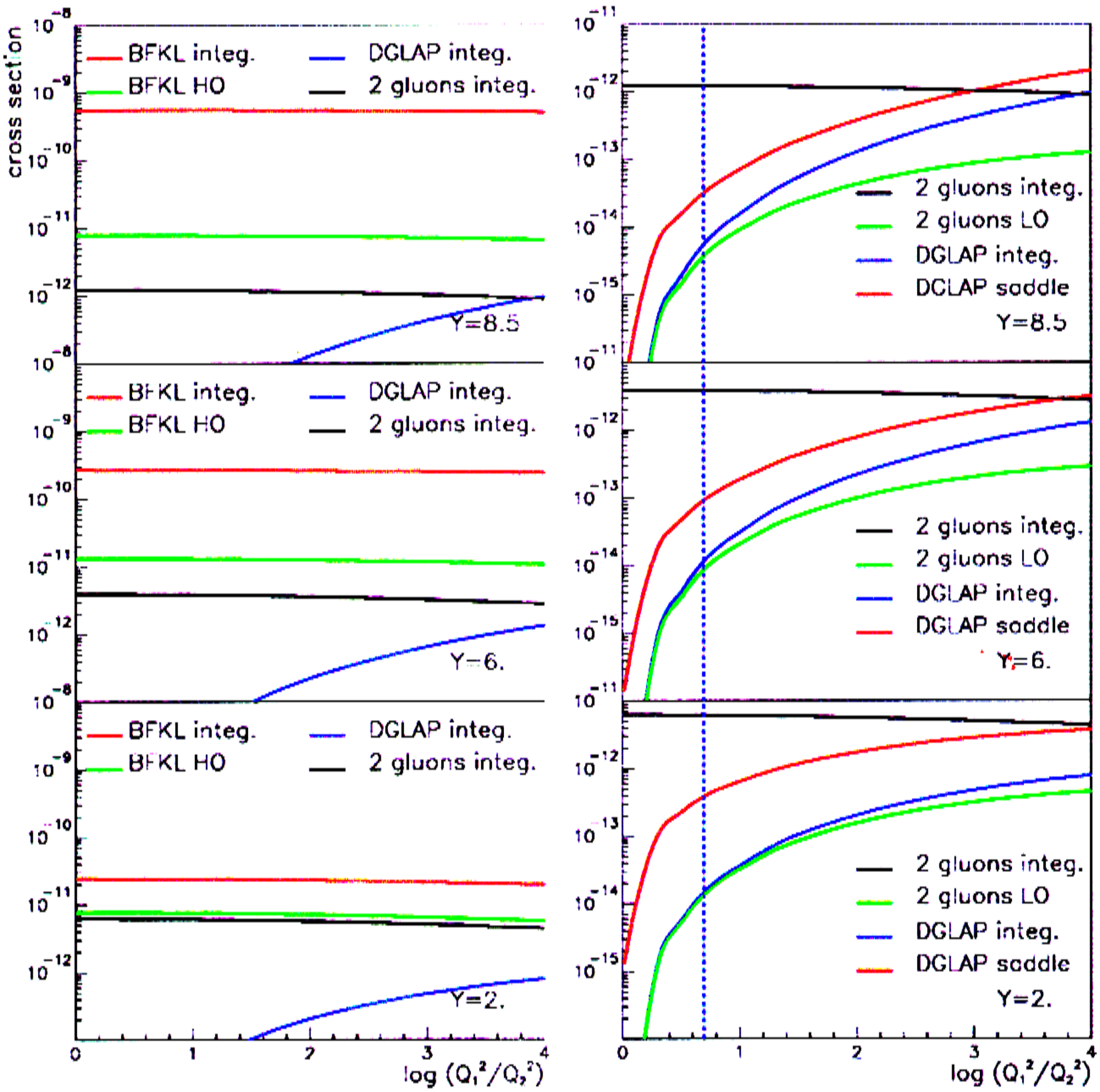

√s=189 -202 GeV
L3 Data
LO BFKL
One gluon
L3 fit
L3 Preliminary
L3 Data
Fit with α_P
Fit with K
$\sigma_{\gamma^*\gamma^*}(Y)$ [nb]
$\sigma_{\gamma^*\gamma^*}(Y)$ [nb]
Y= ln(S/S$_0$)

Differential cross-section

- Study of the differential cross-section in Y bins as a function of $\log(Q_1^2/Q_2^2)$
  Y total rapidity of the $\gamma^*\gamma^*$ process
  $Y = \ln \frac{\hat{s}}{\sqrt{Q_1^2/Q_2^2}}$, $(\hat{s} = s y_1 y_2)$
  we compare: BFKL-LO, BFKL-HO, DGLAP (double leading log. approximation), 2-gluon cross-sections

- Results
  - $Q_1^2 \sim Q_2^2$ 2 gluons LO $\sim$ DGLAP-DLL
    2-gluon cross-section at NNNLO (exact) will dominate the DGLAP background in the phase space studied $\frac{1}{2} \leq \frac{Q_1^2}{Q_2^2} \leq 2$
  - BFKL LO $\gg$ 2 gluons especially at high Y
  - Huge higher order corrections

Differential cross-section



Kinematical cuts

- **CLIC**
  E_{beam} =1.5 TeV, 2.5 TeV e tagged between 100 GeV and E_{beam}
  $\theta \geq 40$ mrad

- **LC**
  E_{beam} =250 GeV, e tagged between 50 and 250 GeV
  $\theta \geq 40$ mrad

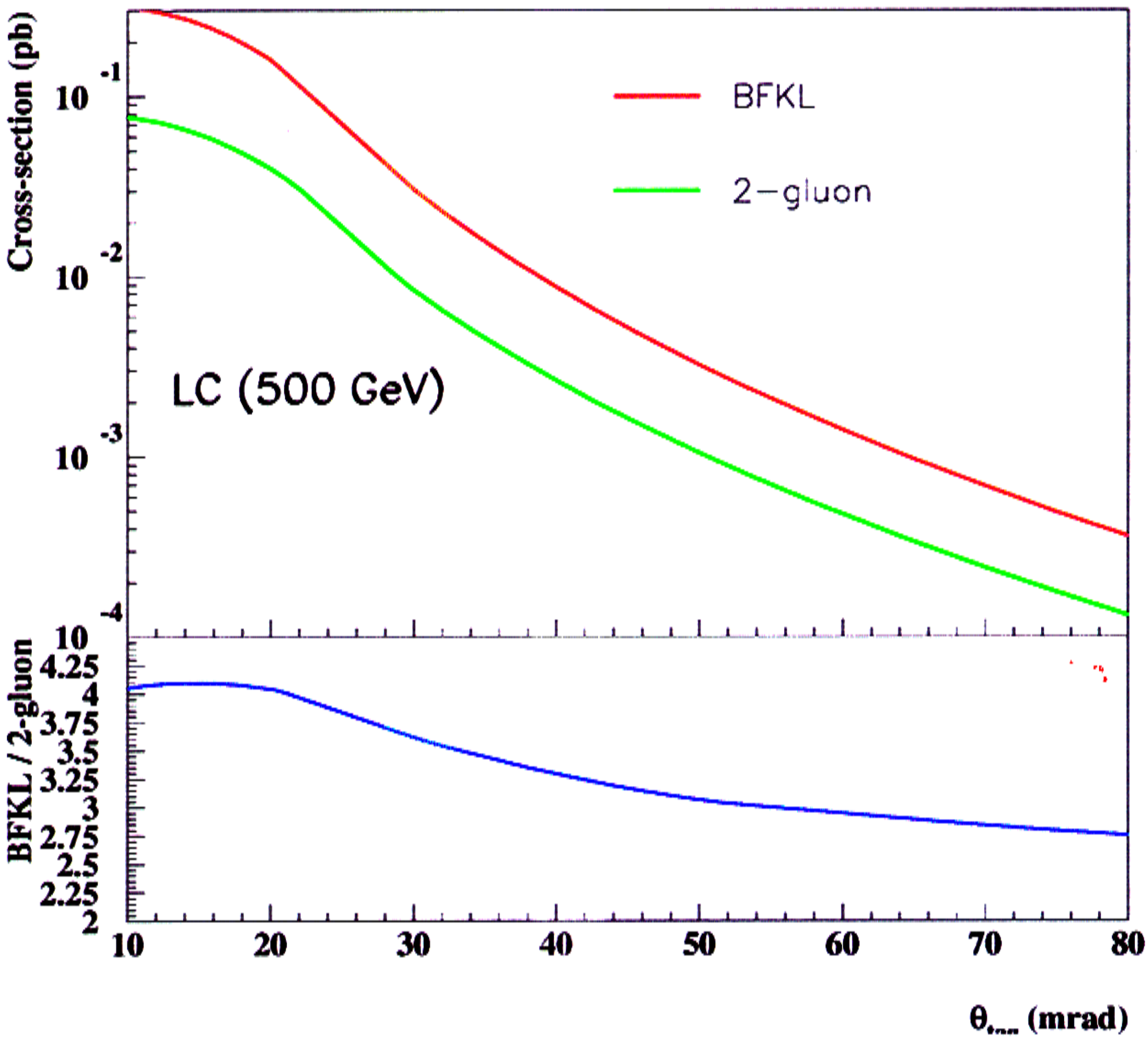
Constraints for the validity of perturbative calculations

- $\alpha_S(\mu^2)$ small enough $\mu^2 = exp\left(-\frac{5}{3}\right)\sqrt{Q_1^2 Q_2^2}$
  BLM scheme, $\mu^2 \geq 3$ GeV^2

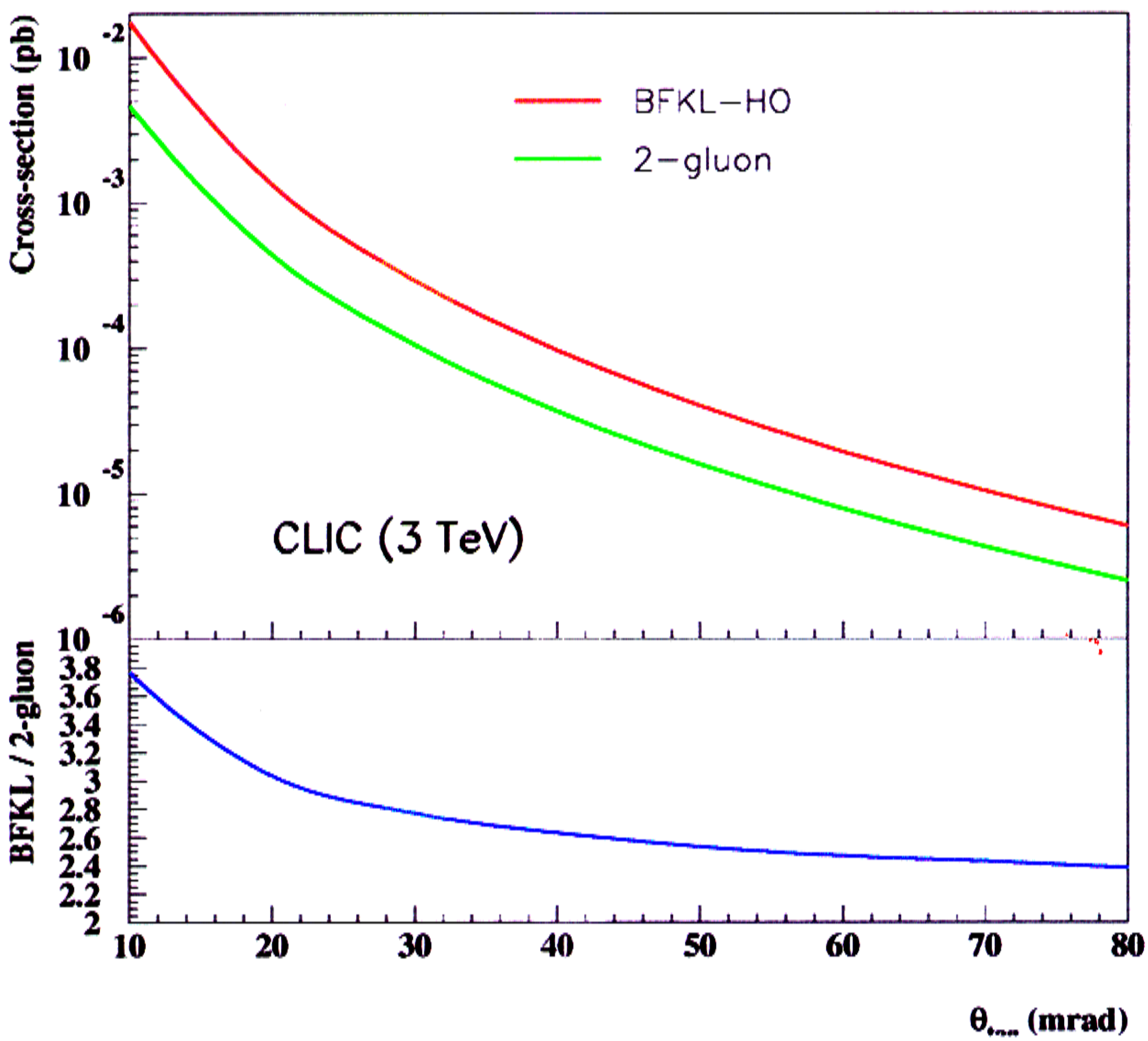
- Y large enough (BFKL calculations to be valid) $Y \geq \ln 100$

- Q_1^2 close to Q_2^2 $\frac{1}{2} \leq \frac{Q_1^2}{Q_2^2} \leq 2$

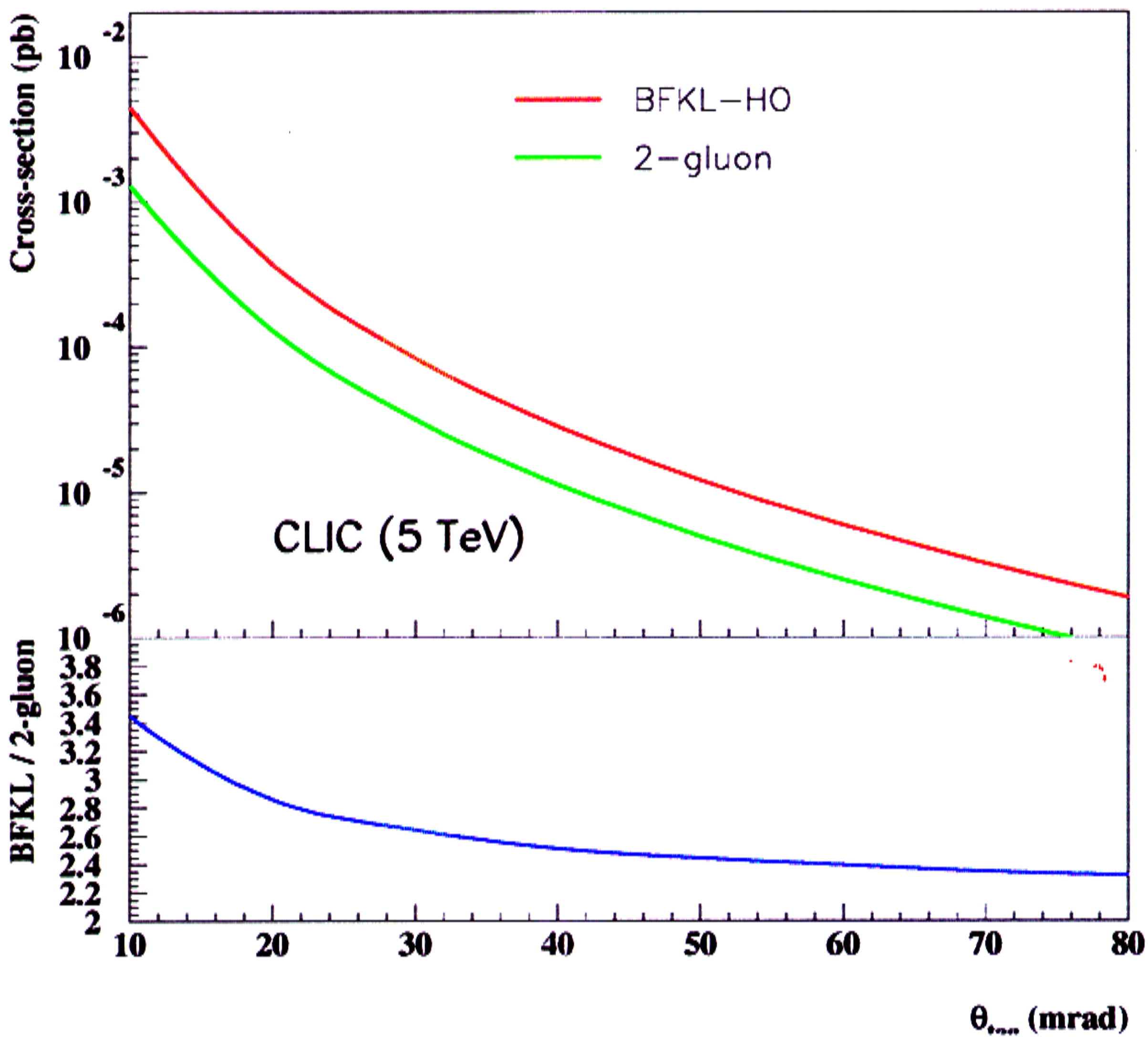
Theta dependence



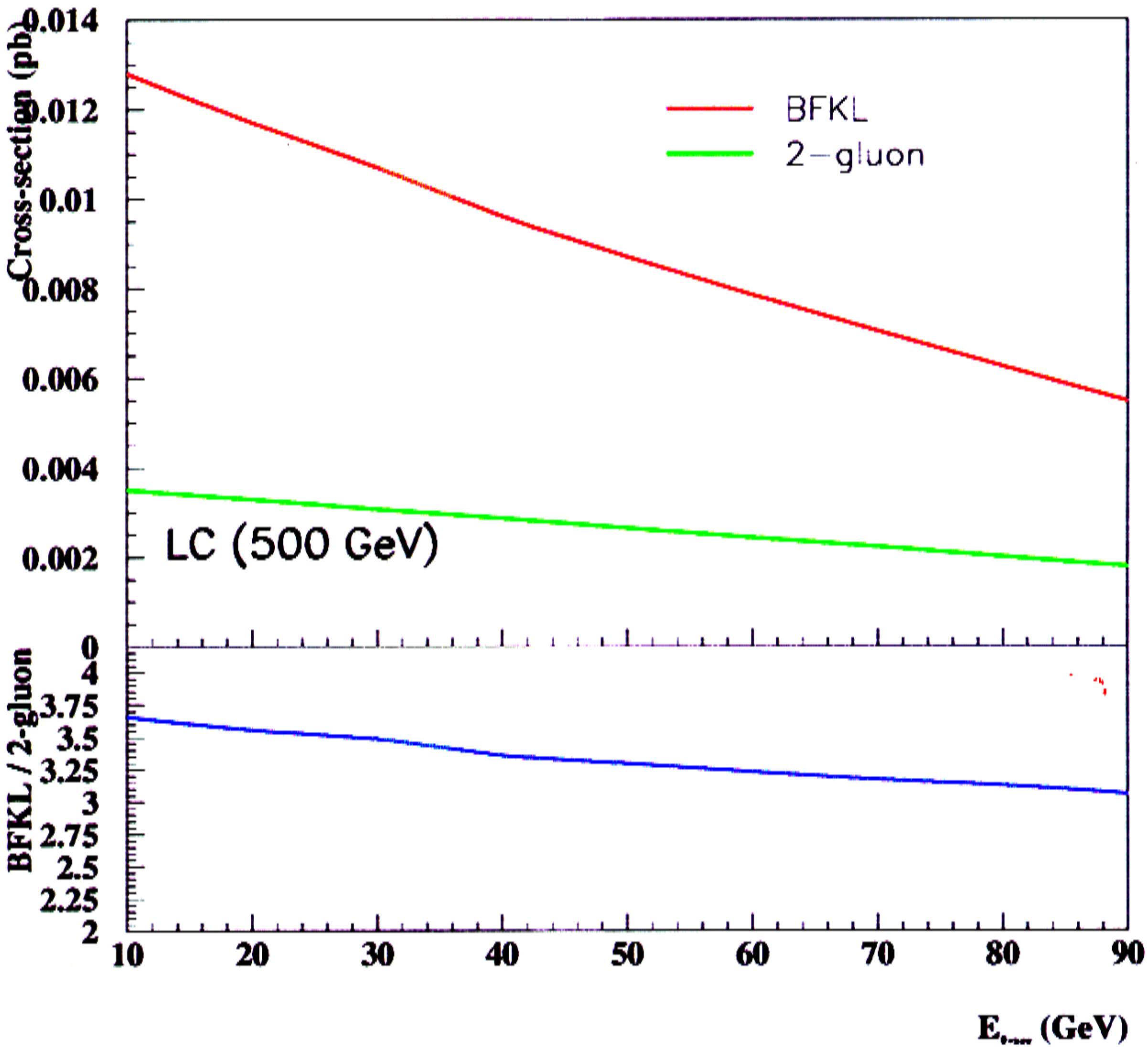
Theta dependence



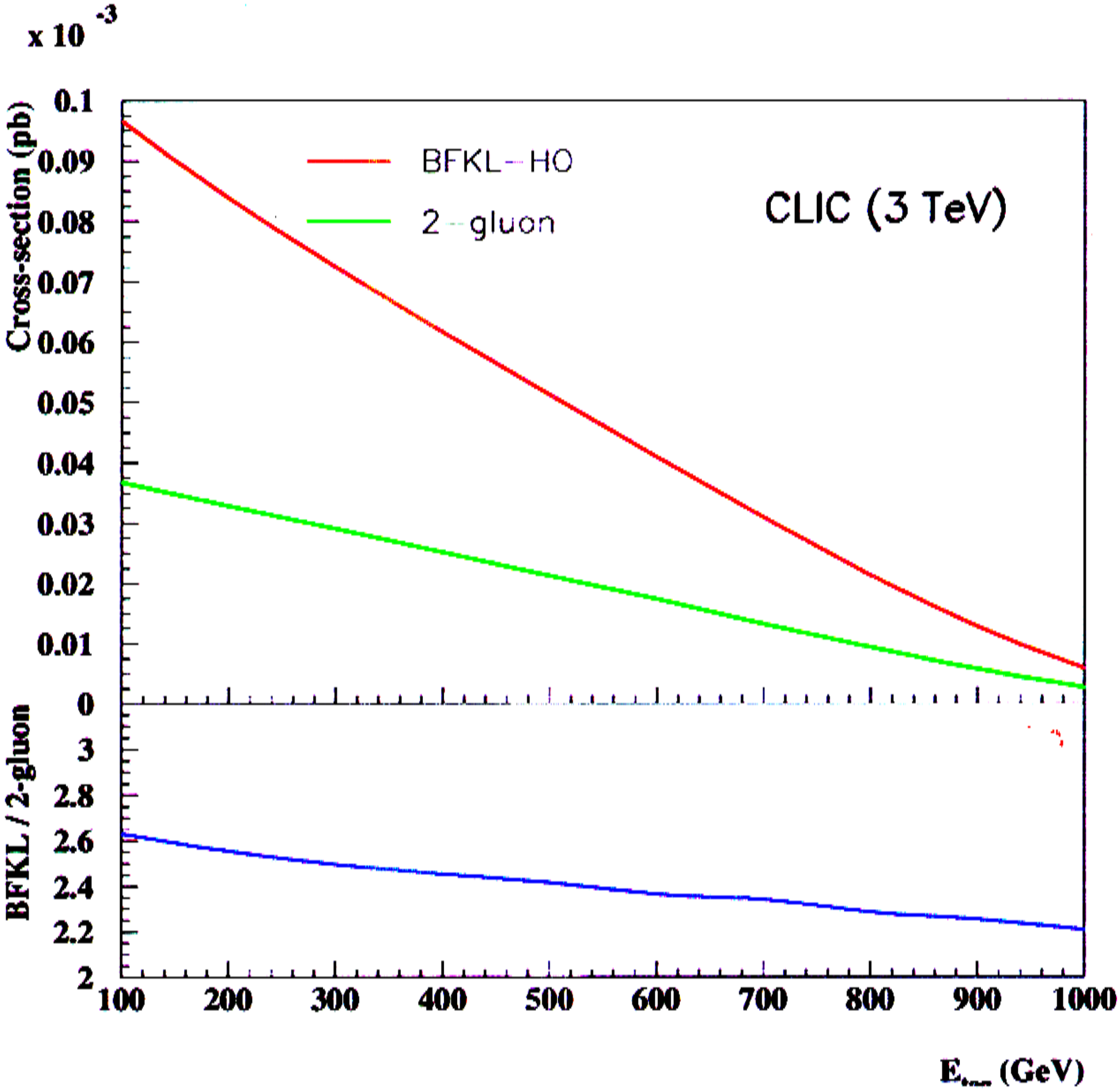
Theta dependence



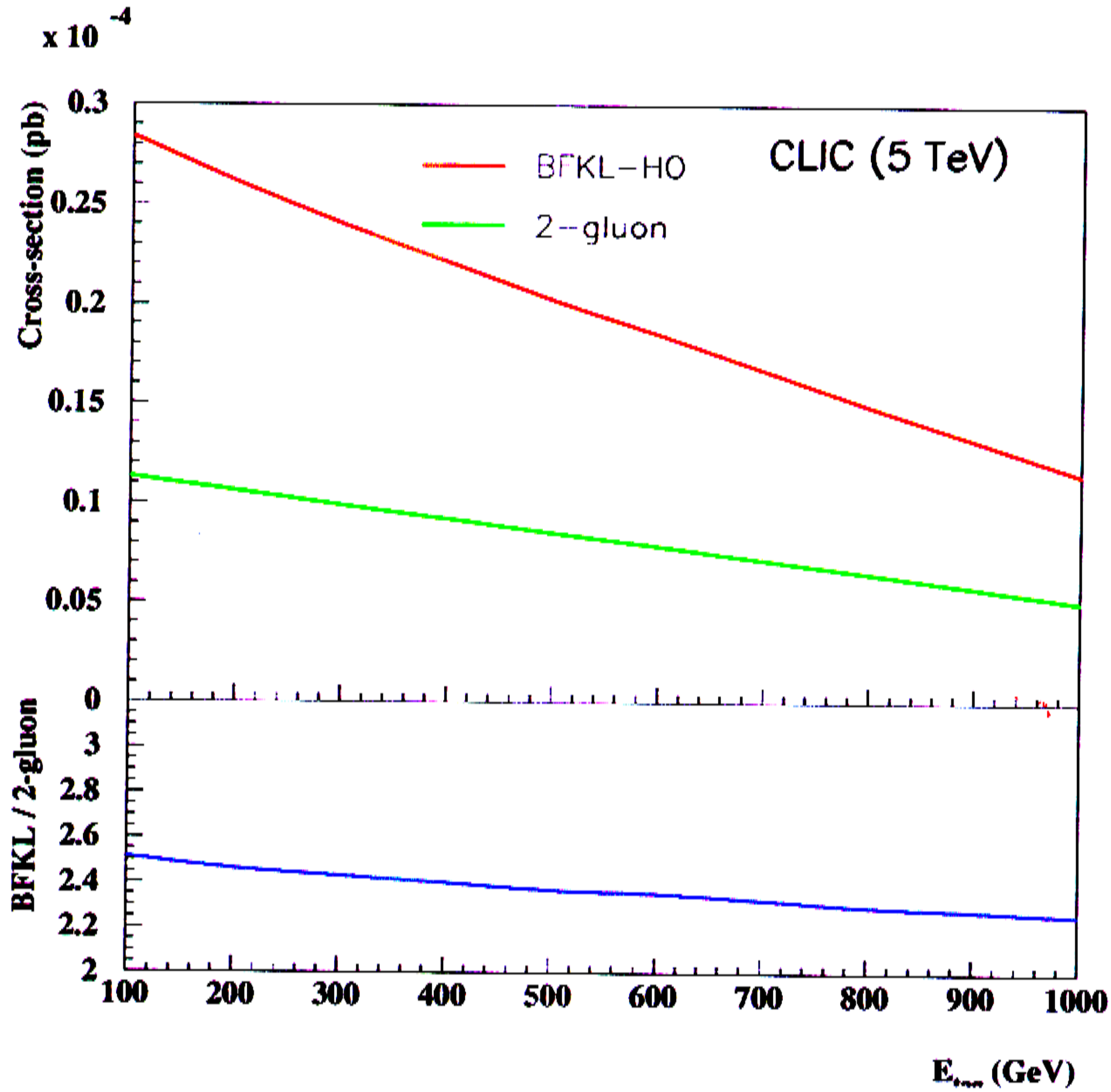
Energy dependence



Energy dependence



Energy dependence



Cross-sections results (CLIC and LC)

- CLIC

  $\sigma_{BFKL-HO} \sim 9.7 10^{-2}$ fb (3 TeV), about 97 events per year

  $2.8 10^{-2}$ fb (5 TeV), about 28 events per year

  RATIO BFKL/2 gluons : 2.5-2.6

- LC

  $\sigma_{BFKL-HO} \sim 0.009$ pb, $\sigma_{2gluons} \sim 0.003$ pb

  RATIO BFKL/2 gluons: 3.3

Y-dependence of cross-section (CLIC)

- Possibility to cut on Y to enhance BFKL cross-section with respect to 2-gluon one

- 3 TeV center-of-mass energy $Y > 9$ (resp. 8): σ_{BFKL}= 1.9 10^{-6} pb, ratio= 6.2 (σ_{BFKL}= 7.8 10^{-6} pb, ratio= 4.8)

- 5 TeV center-of-mass energy $Y > 9$ (resp. 8): σ_{BFKL}= 9.3 10^{-7} pb, ratio= 5.7 (σ_{BFKL}= 2.8 10^{-6} pb, ratio= 4.5)

- $Y > 9$, and $\theta > 25$ mrad,
  σ_{BFKL} (3 TeV) =3.3 10^{-5} pb, ratio= 7.5
  σ_{BFKL} (5 TeV) =1.1 10^{-5} pb, ratio= 6.2

Conclusion

- $\gamma^*\gamma^*$ cross-section: pure perturbative way to test BFKL dynamics
  Ratio BFKL/2 gluon cross-section $\sim$ 2.5-3.3 for LC and CLIC

- Study in Y bins
  possible at LC because of high luminosity
  ratio BFKL/2 gluon cross-sections $\sim$ 7 at high Y
  Necessity to go at small tagging angles

- Final state studies charm production, J/Ψ production...