

$x(g)$ with Heavy Flavours in ep & γp collisions at LHeC

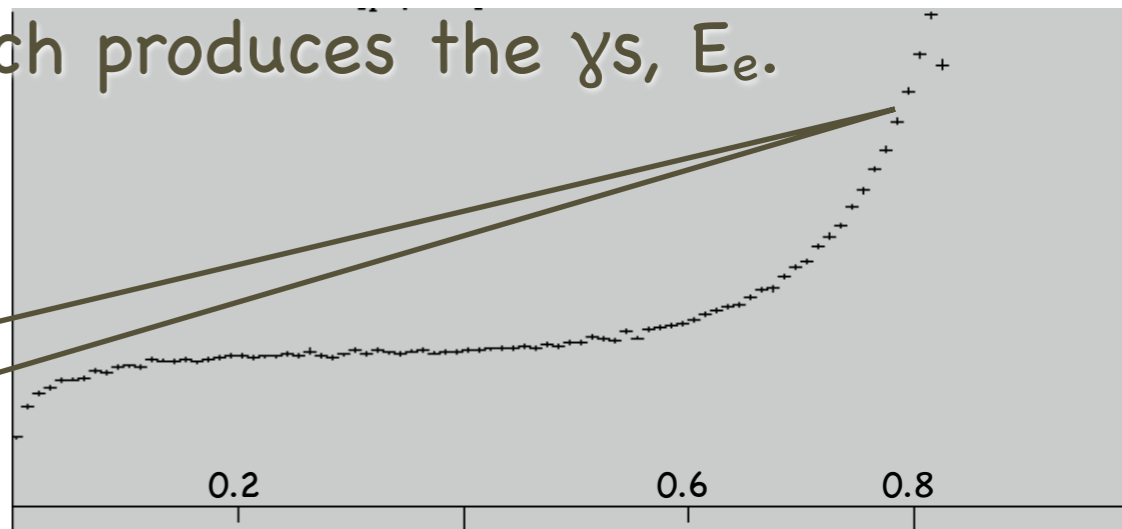
Gökhan Ünel / U.C. Irvine

1-3 September 2009
2nd LHeC workshop @Divonne

prologue

- This presentation is largely inspired from the work shown in a Thera meeting @ 19.10.2000 by L. Gladilin.
 - ➔ The results are cross checked against what was shown for ep and γp collisions at HERA and THERA.
- Assumed Parameters: LHC@ 7TeV, e^- beam@ 50 or 150 GeV
- Comphep 4.5.1/ Calchep 2.5.4 for cross section calculations, investigations of parameter dependence etc.
 - ➔ 10-15% difference between the two for the same(?) parameters.
- About the photon beam:
 - ➔ When beam E is written for the γ - p collider, it always means the energy of the mother electron beam which produces the γ s, E_e .
 - ➔ γ beam: using inverse compton spectrum

$(x \approx 4; x/x+1=0.8) E_\gamma^{\max} \approx 0.8E_e$



which process ?

1	.	e	u	->	W-	ne	c
2	.	e	d	->	W-	e	c
3	.	e	s	->	W-	e	c
4	.	e	c	->	e	c	H
5	.	e	c	->	Z	e	c
6	.	e	c	->	A	e	c
7	.	e	c	->	G	e	c
8	.	e	c	->	W-	ne	c
9	.	e	b	->	W-	e	c
10	.	e	G	->	e	c	<u>C</u>

3.3E+04pb

2.2E+05pb

Subprocesses							
1	.	e	u	->	ne	b	H
2	.	e	u	->	W+	e	b
3	.	e	u	->	Z	ne	b
4	.	e	u	->	A	ne	b
5	.	e	u	->	G	ne	b
6	.	e	d	->	W-	ne	b
7	.	e	s	->	W-	ne	b
8	.	e	c	->	ne	b	H
9	.	e	c	->	W+	e	b
10	.	e	c	->	Z	ne	b
11	.	e	c	->	A	ne	b
12	.	e	c	->	G	ne	b
13	.	e	b	->	e	b	H
14	.	e	b	->	Z	e	b
15	.	e	b	->	A	e	b
16	.	e	b	->	G	e	b
17	.	e	b	->	W-	ne	b
18	.	e	G	->	e	b	<u>B</u>
19	.	e	G	->	ne	T	b
20	.	e	G	->	ne	C	b
21	.	e	G	->	ne	U	b

8.2E-01pb

3.9E+03pb

● We care about $e/\gamma p \rightarrow c/b + X$

● We will focus on:

→ $e g \rightarrow e c \underline{c}$ OR $e b \underline{b}$

→ $\gamma g \rightarrow c \underline{c}$ OR $b \underline{b}$

PP notation: bar at the bottom.

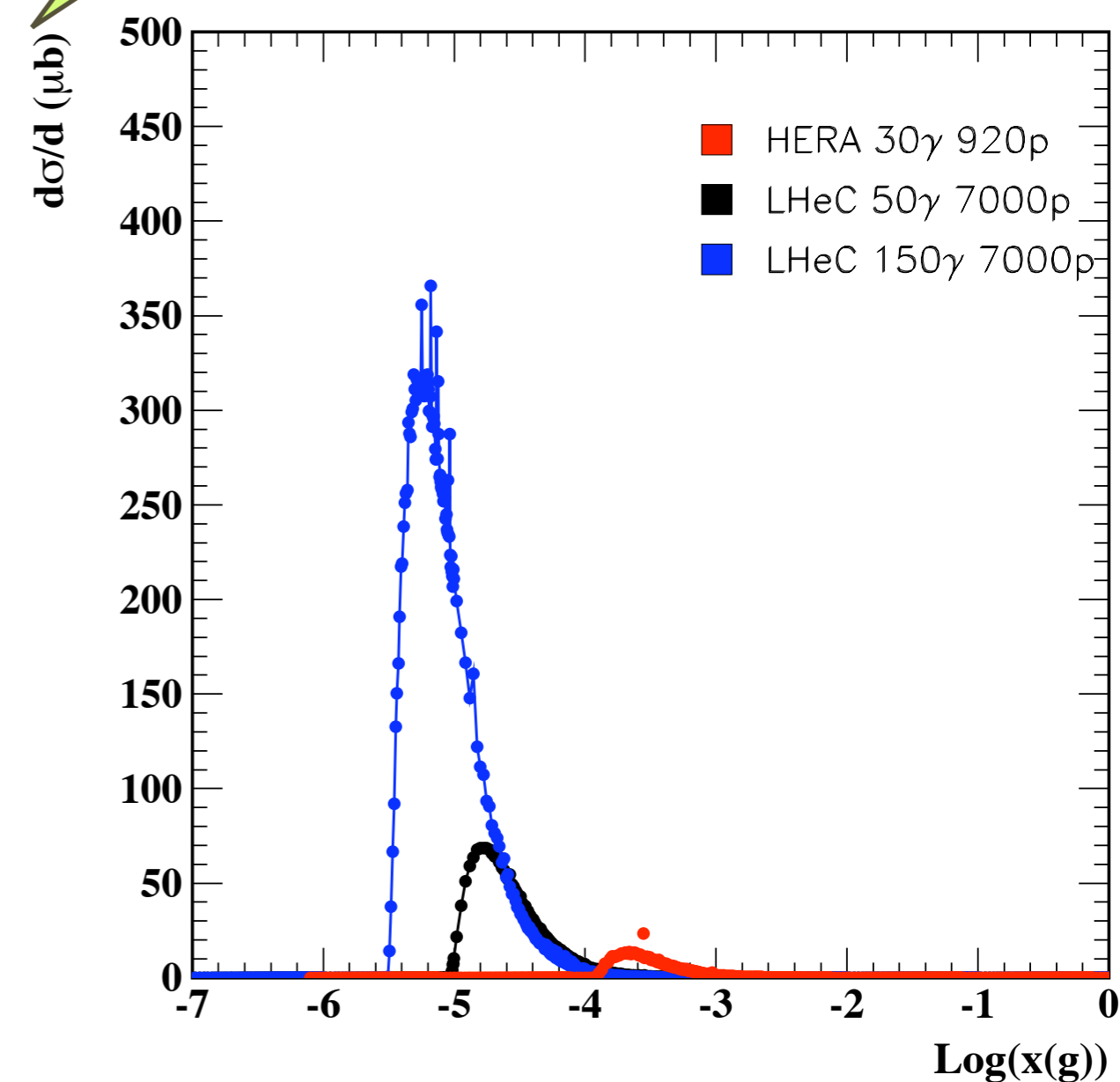
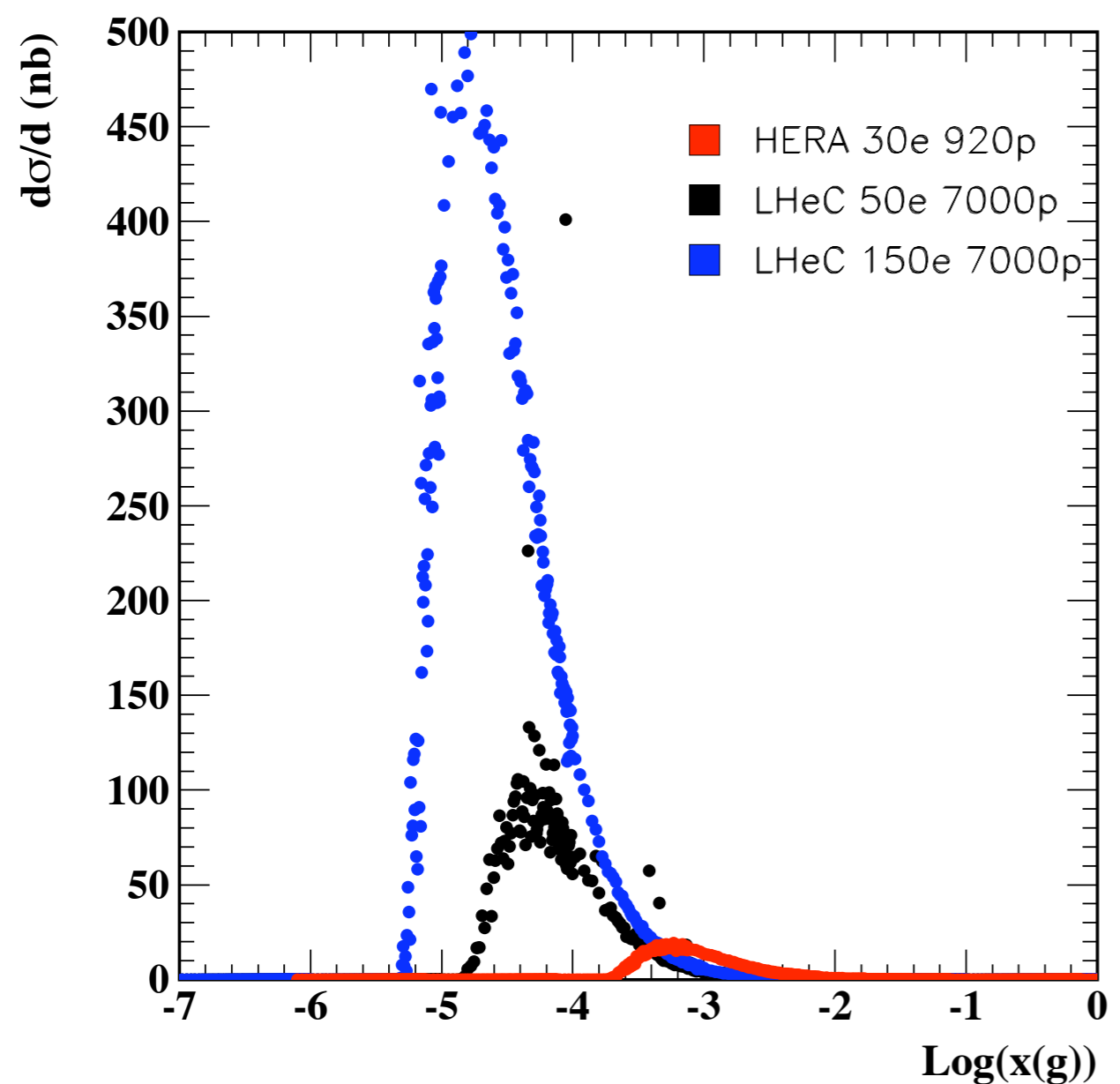
x(g) cc reach

● PDF=CTEQ 6L1 mc=1.65GeV

➔ eg→ecc

$\gamma g \rightarrow c\bar{c}$

~x700 gain in σ for the γ mode



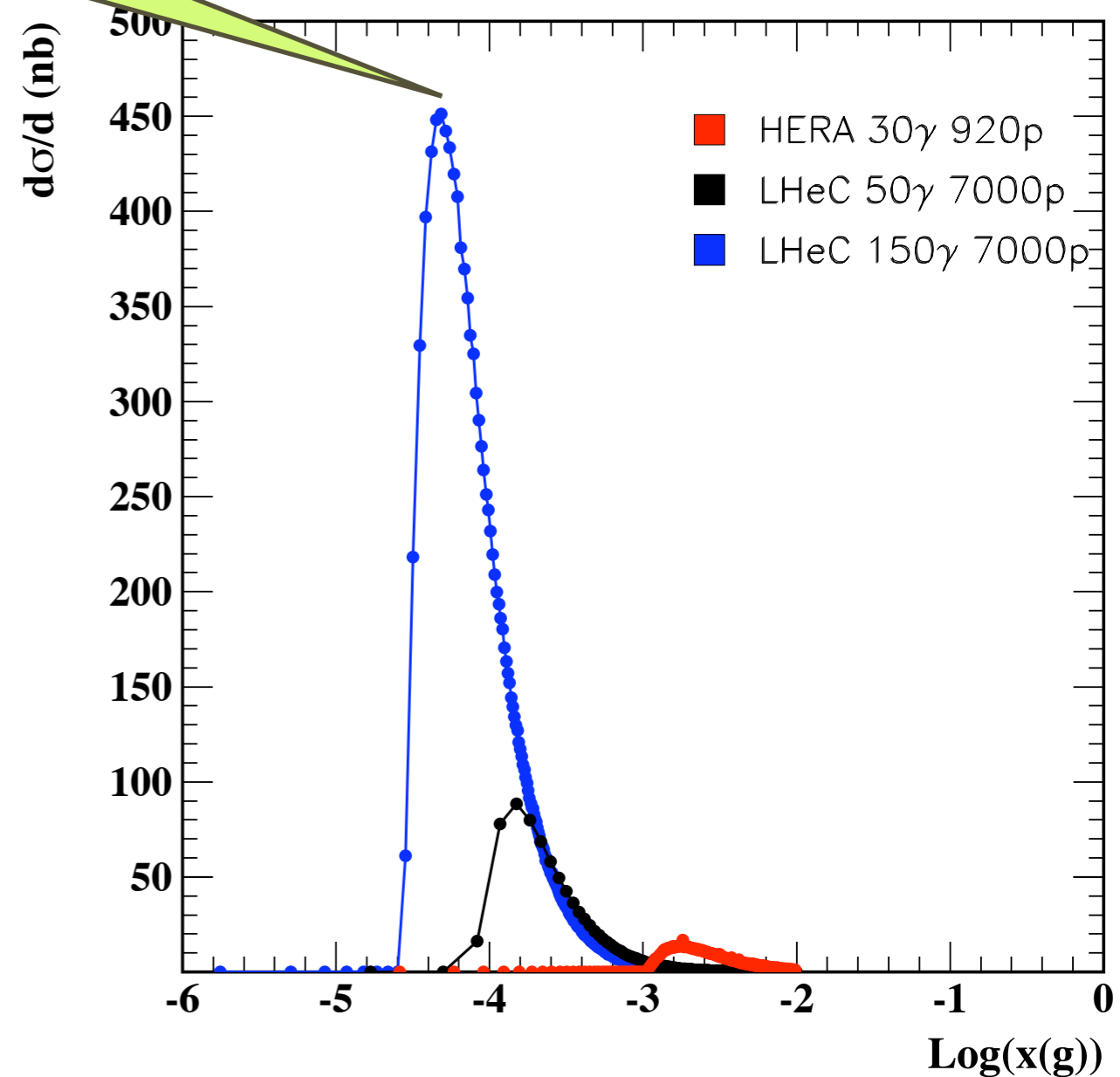
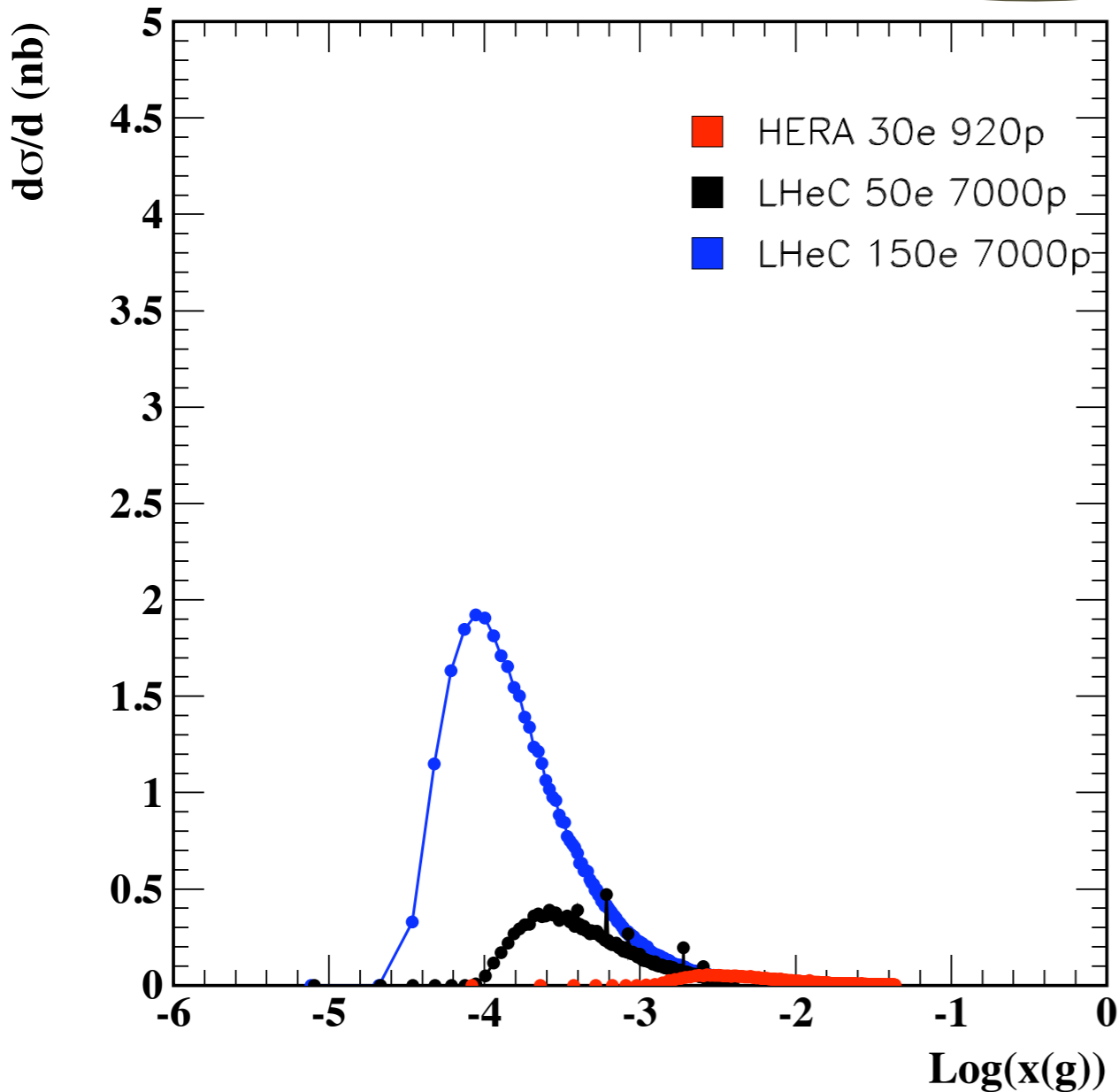
x(g) \underline{bb} reach

● PDF=CTEQ 6L1 mb=4.85GeV

➔ eg -> \underline{bb}

γ g -> \underline{bb}

**~x 200 gain in σ
for the γ mode**

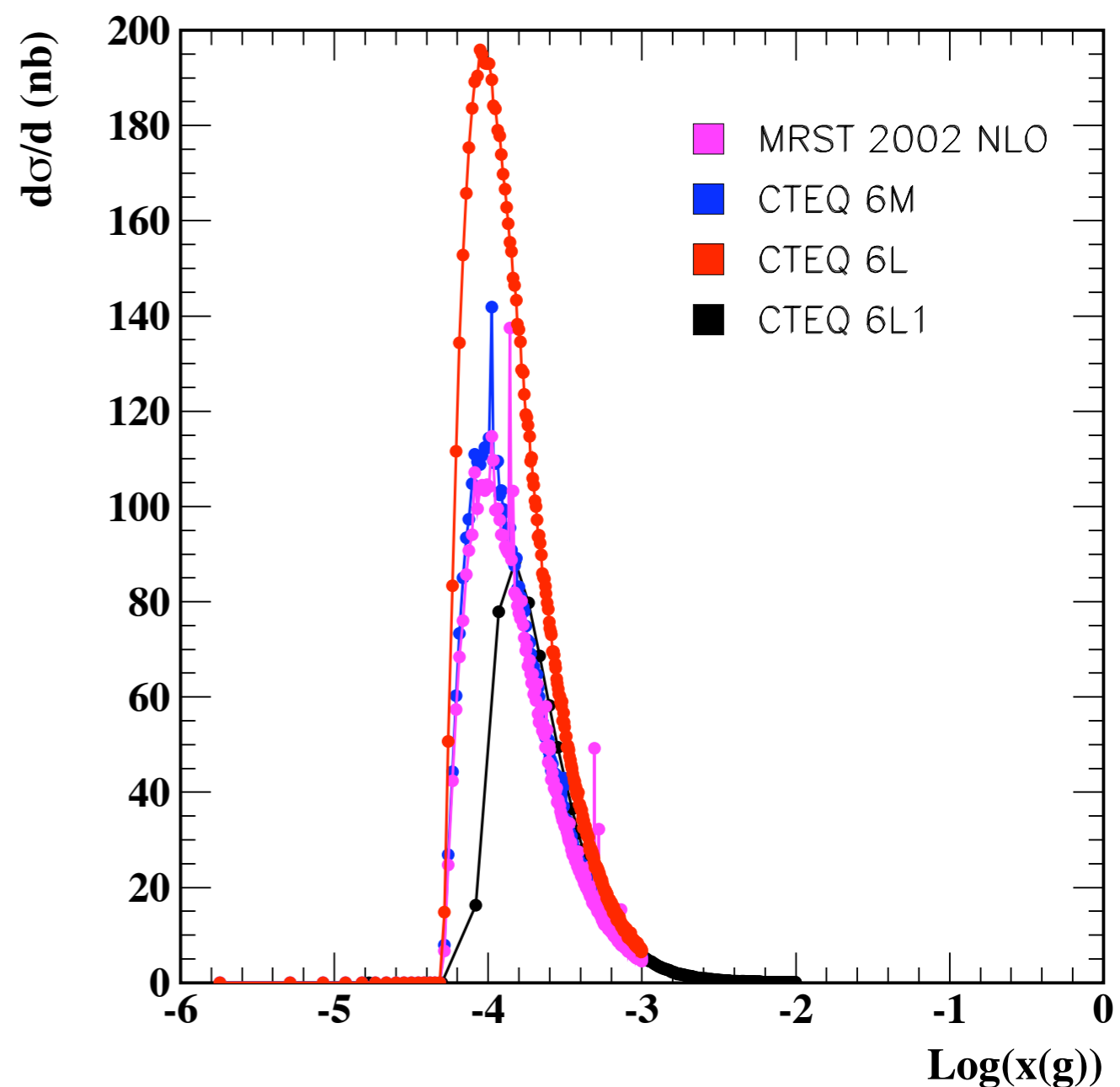
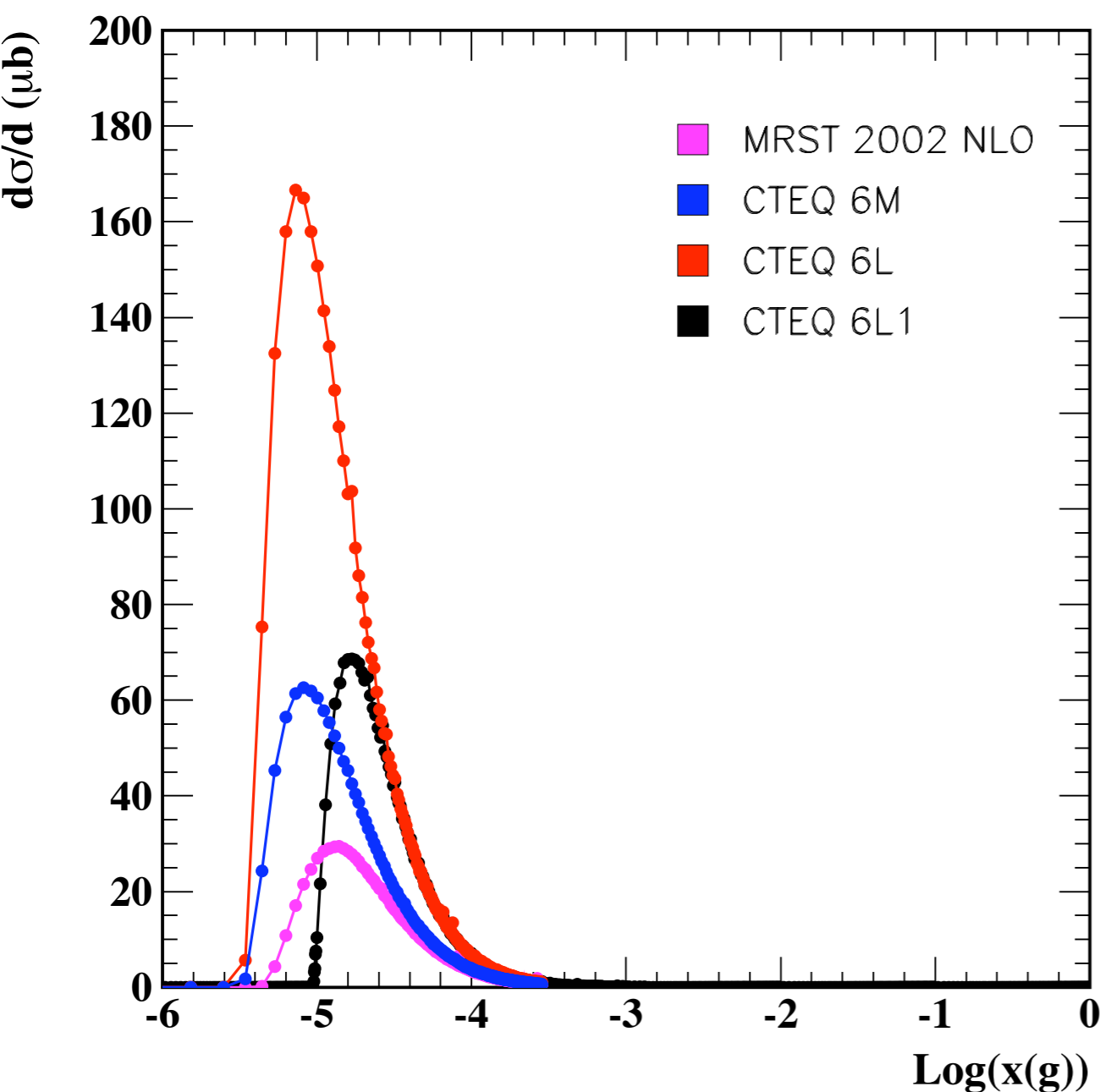


impact of different PDFs

● 50 GeV e & 7 TeV p , $m_c=1.65$ GeV, $m_b=4.85$ GeV

➔ $\gamma g \rightarrow c\bar{c}$

$\gamma g \rightarrow b\bar{b}$

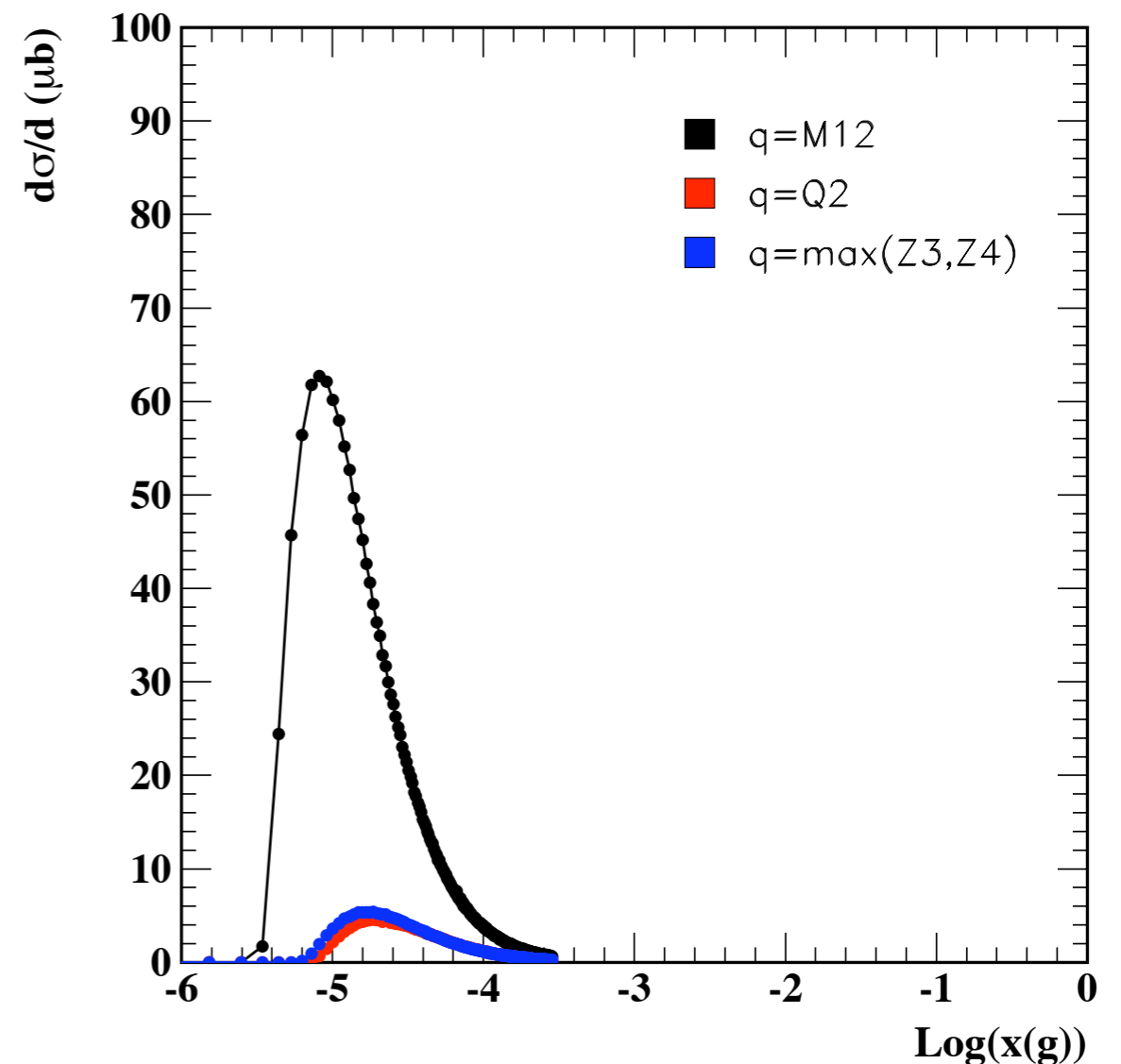
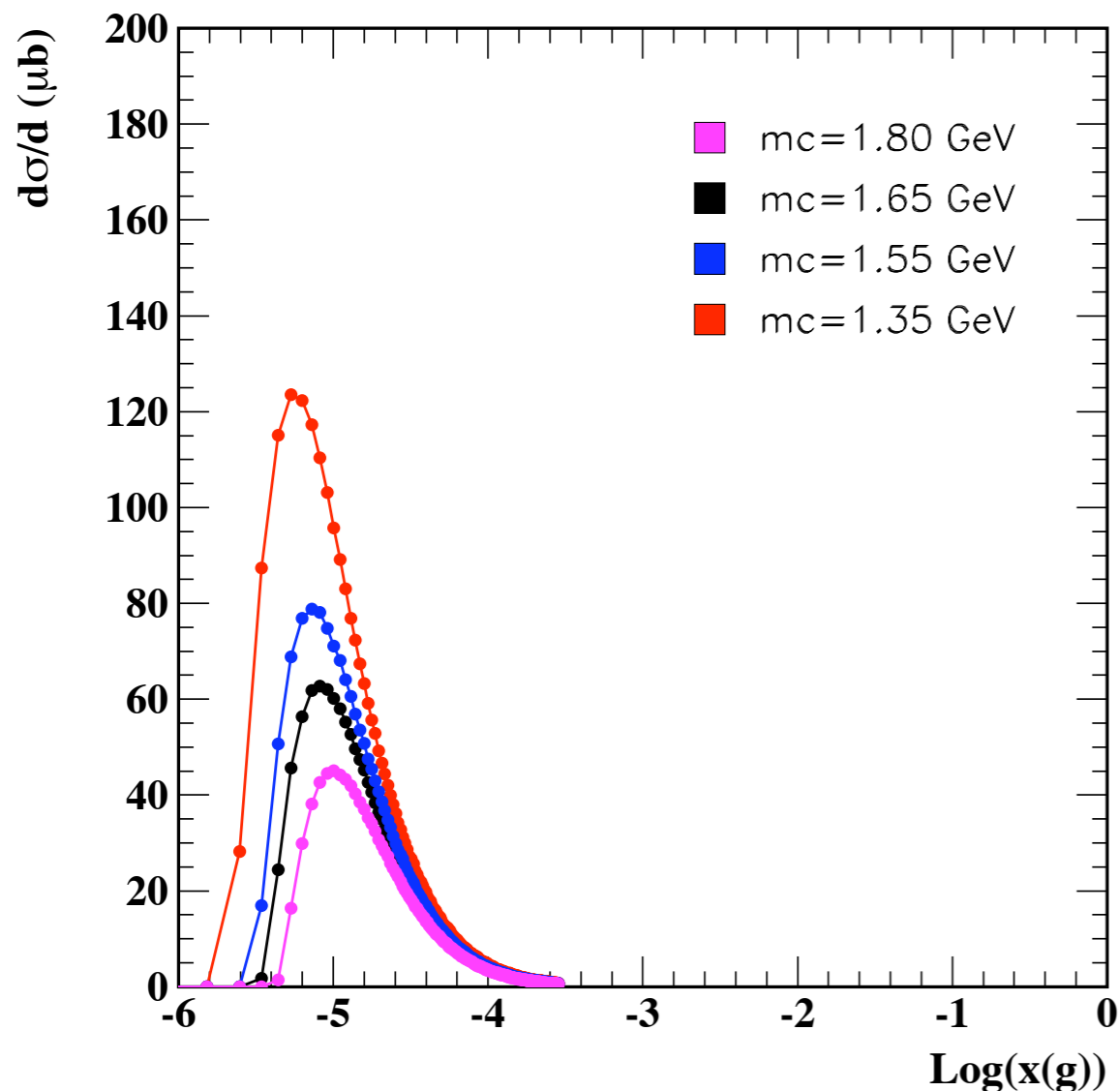


impact of masses & scales

● 50 GeV e & 7 TeV p, $\gamma g \rightarrow c\bar{c}$, PDF=CTEQ6M

➔ change c quark mass

change the QCD f/r scale



$$Q2 = 2*s*t*u / (s^2 + t^2 + u^2)$$

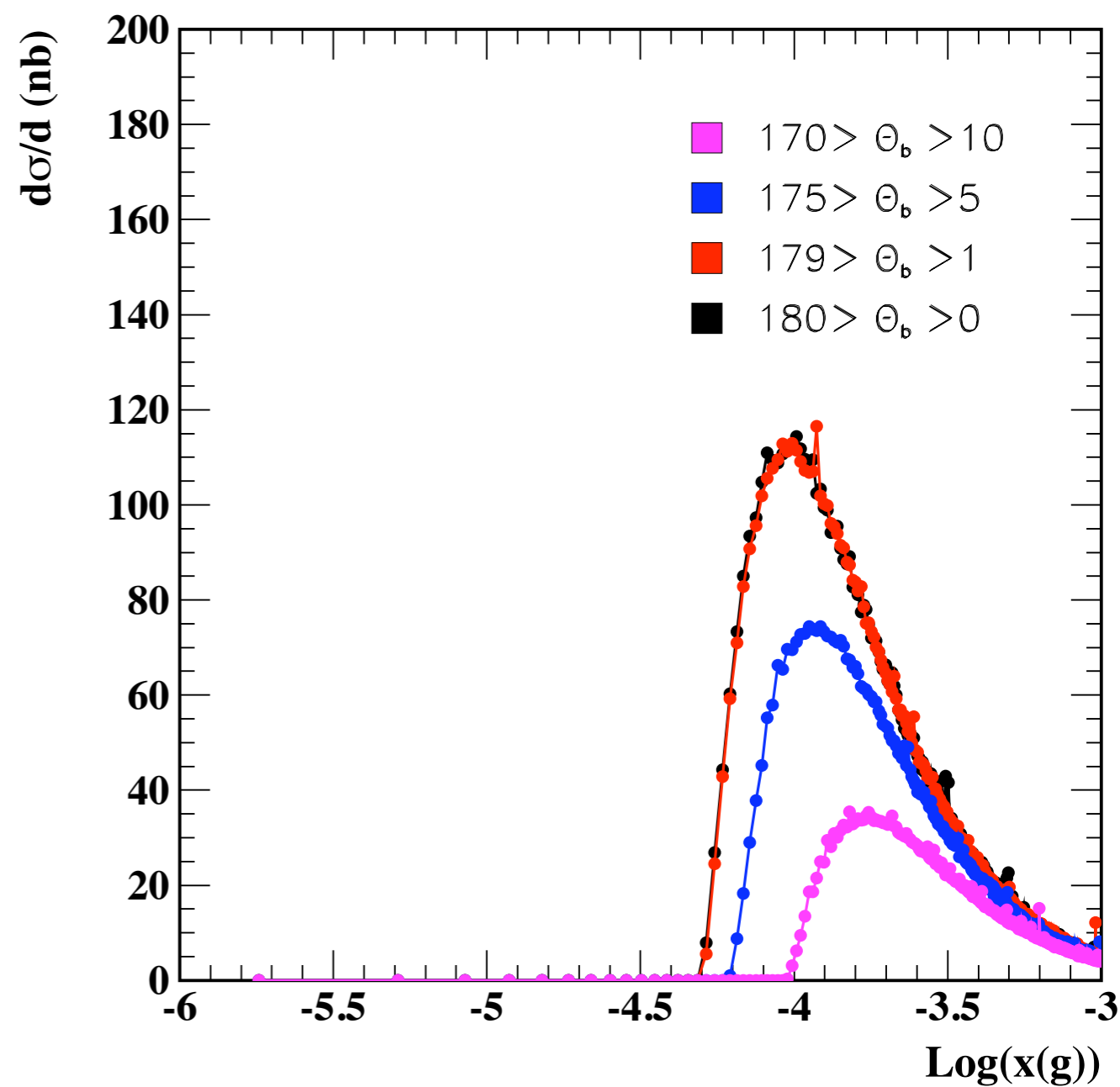
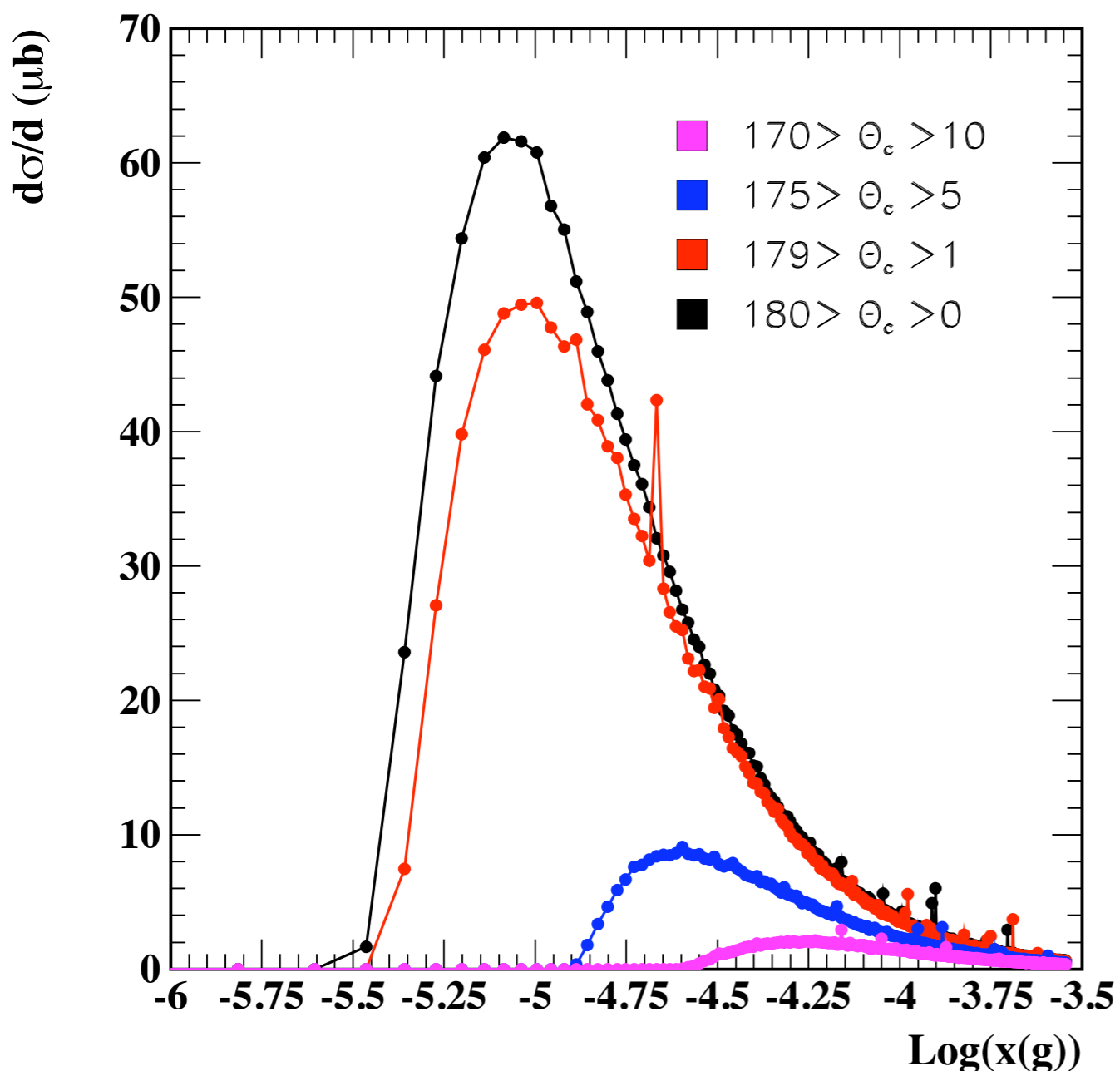
angular reach in γp

● 50 GeV e & 7 TeV p , $m_c=1.65$ GeV, $m_b=4.85$ GeV

➔ angular requirement on both quarks ($\underline{cc}/\underline{bb}$)

➔ $\gamma g \rightarrow \underline{cc}$

$\gamma g \rightarrow \underline{bb}$

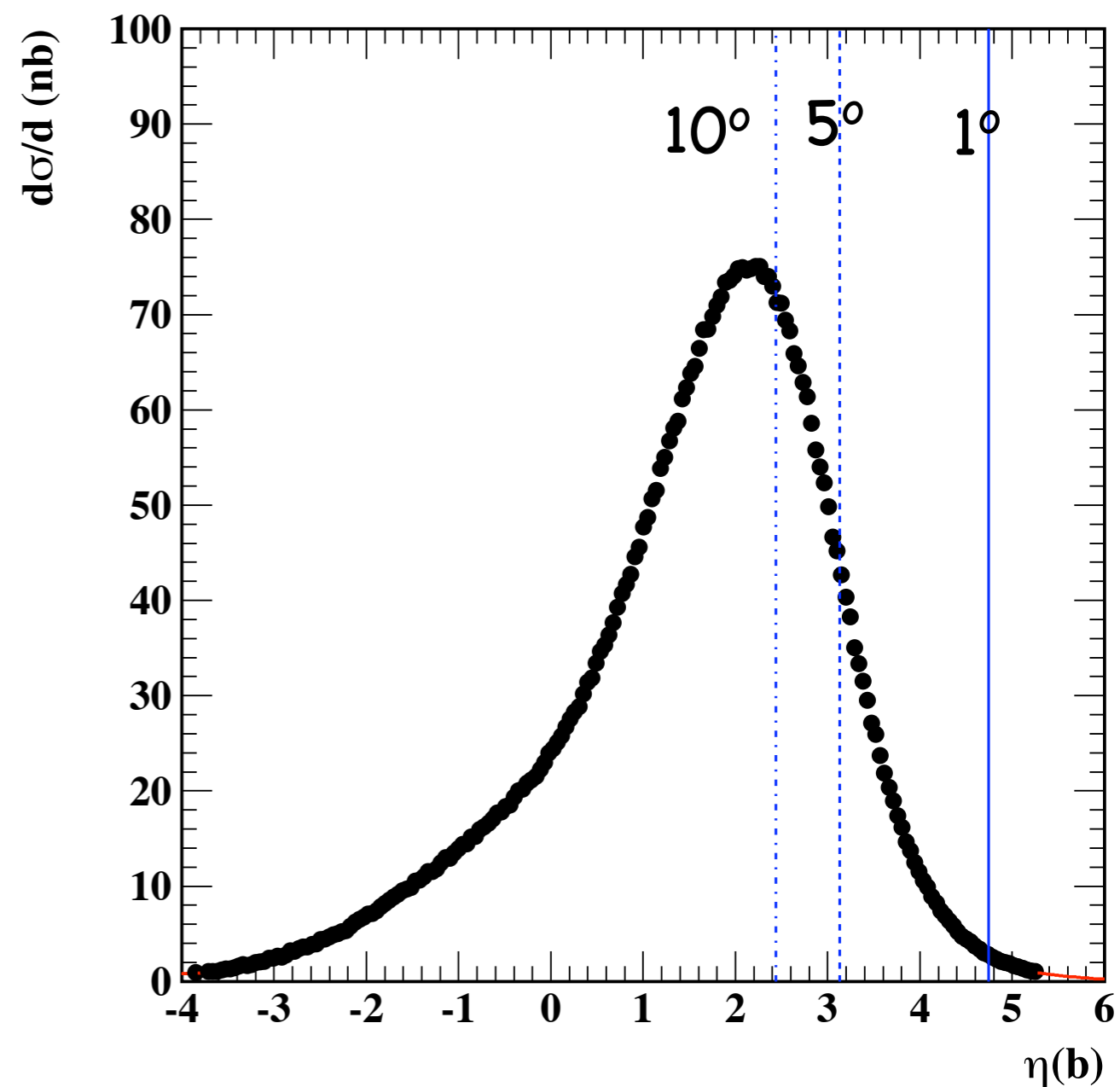
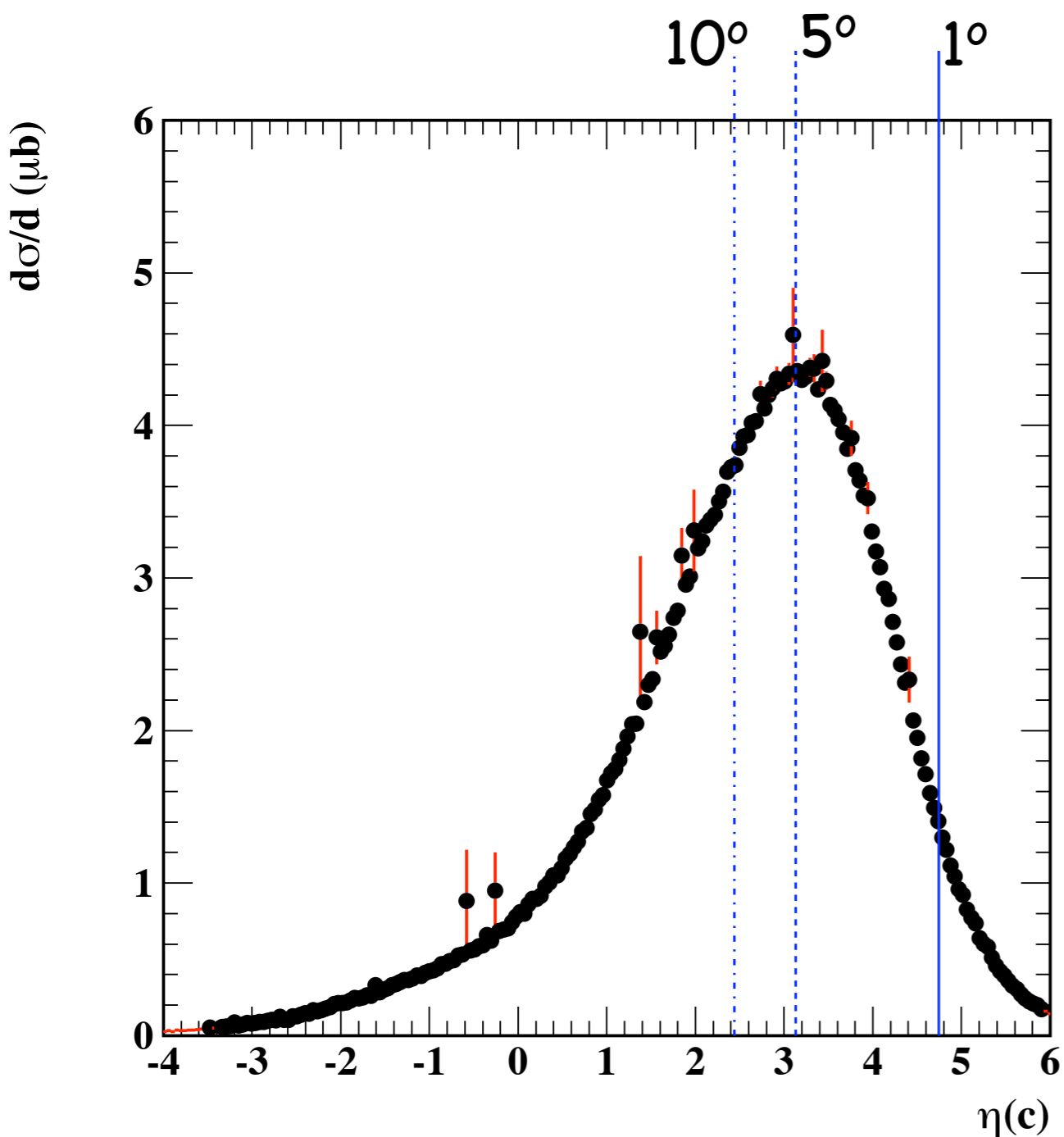


eta reach in γp

● 50 GeV e & 7 TeV p , $m_c=1.65\text{ GeV}$, $m_b=4.85\text{ GeV}$

➔ $\gamma g \rightarrow c\bar{c}$

$\gamma g \rightarrow b\bar{b}$



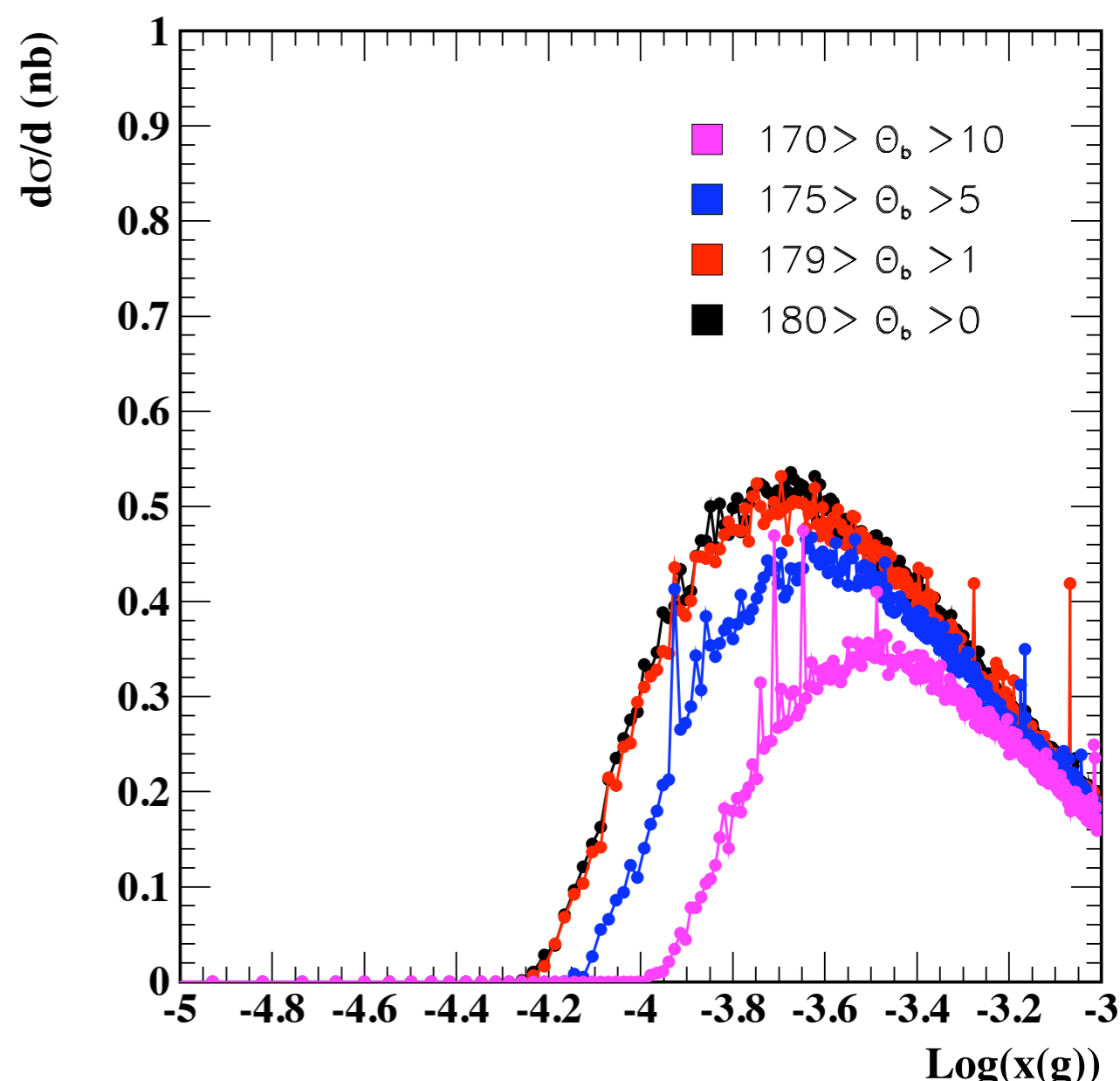
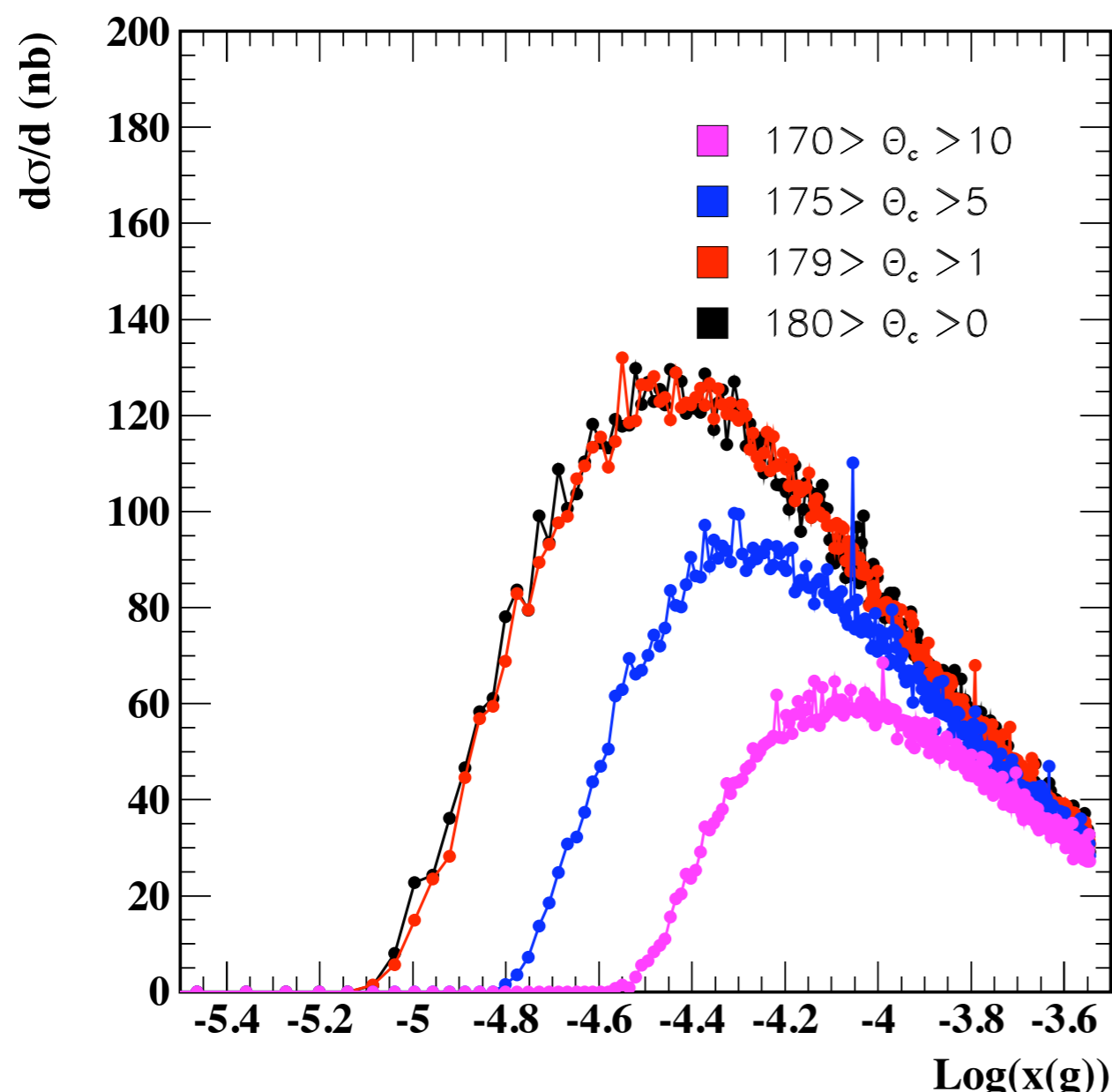
angular reach in ep

● 50 GeV e & 7 TeV p , $m_c=1.65$ GeV, $m_b=4.85$ GeV

➔ angular cut on both quarks ($\underline{c\bar{c}}$ / $\underline{b\bar{b}}$)

➔ $eg \rightarrow e\underline{c\bar{c}}$

$eg \rightarrow e\underline{b\bar{b}}$



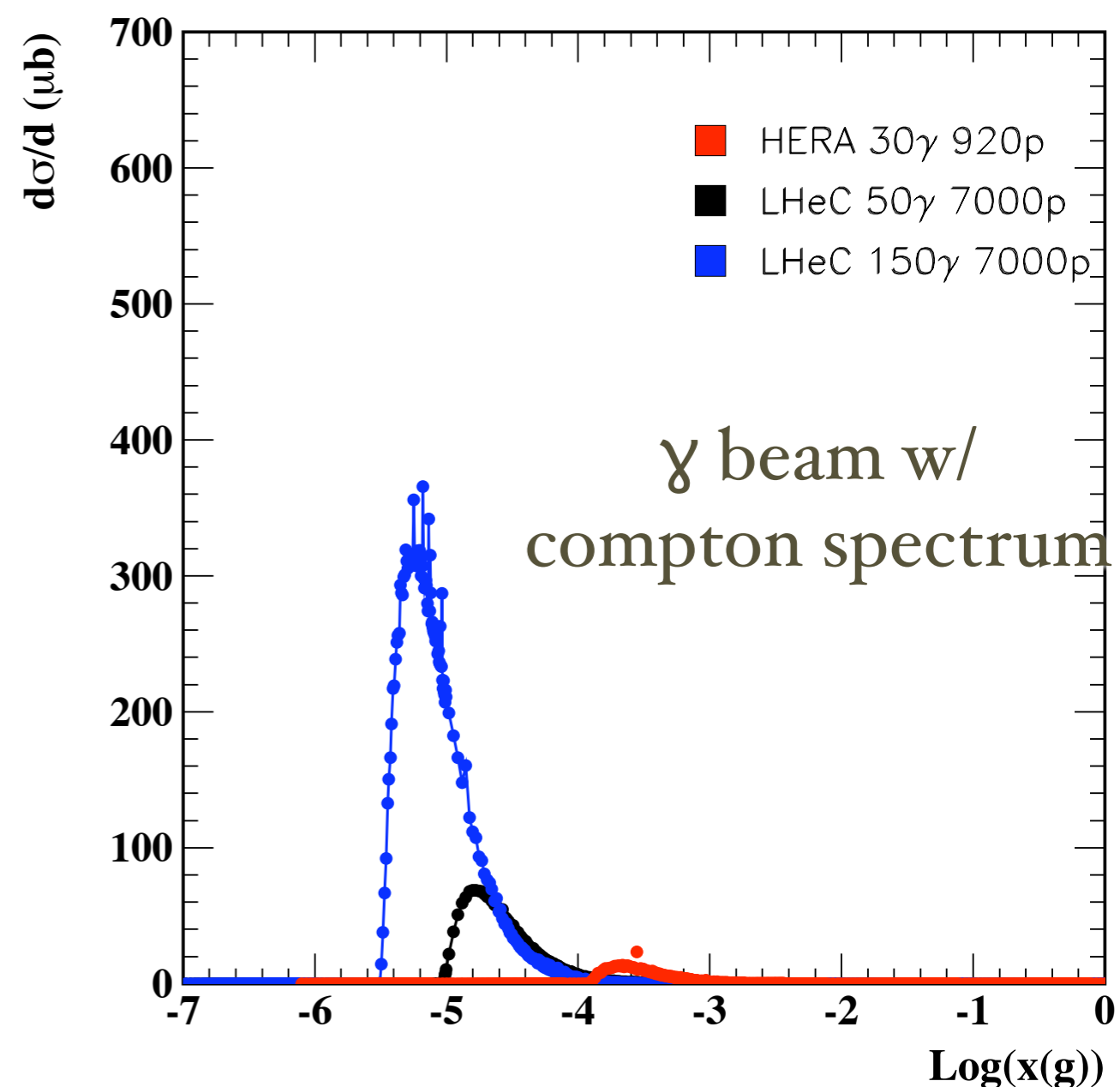
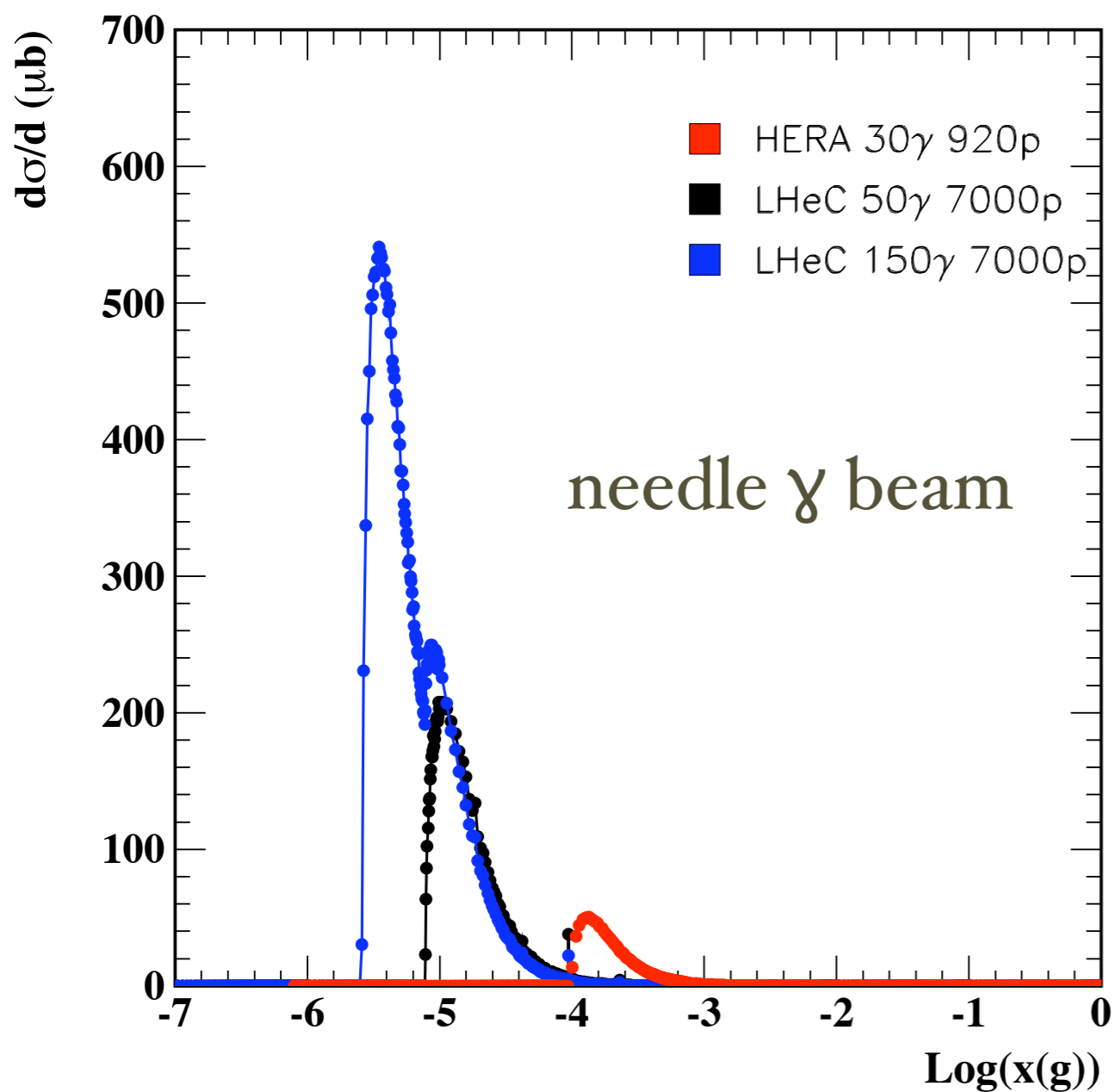
conclusions

- $\log(x(g))$ up to -5.5 seems to be reachable in γp collisions.
- γp collisions provide higher cross section and smaller $x(g)$ wrt the ep collisions with the same E_e (for the low $x(g)$ region):
 - ➔ the factor is ≈ 700 for $c\bar{c}$ and ≈ 200 for $b\bar{b}$.
 - ➔ even if the $\mathcal{L}_{\gamma p}$ is 10 times less than \mathcal{L}_{ep} the expected number of events would be 70 and 20 times higher for $c\bar{c}$ and $b\bar{b}$ respectively.
- The impact of PDFs, masses and scales can not be ignored/ should be worked on.
- The angular sensitivity is very important for smallest $x(g)$ reach
 - ➔ for either e or γ beams, coverage up to $\eta=5$ is ideal
- the same γp collisions could also be used to measure photon structure func.
 - ➔ work needed here.
- More work is in progress
 - ➔ Few other missing distros with high(er) statistics
 - ➔ Event production using RapGap.

thank you for listening

backup slides

- The effect of compton BS spectrum, $\gamma g \rightarrow c\bar{c}$ case
 - ➔ comparison wrt a needle beam



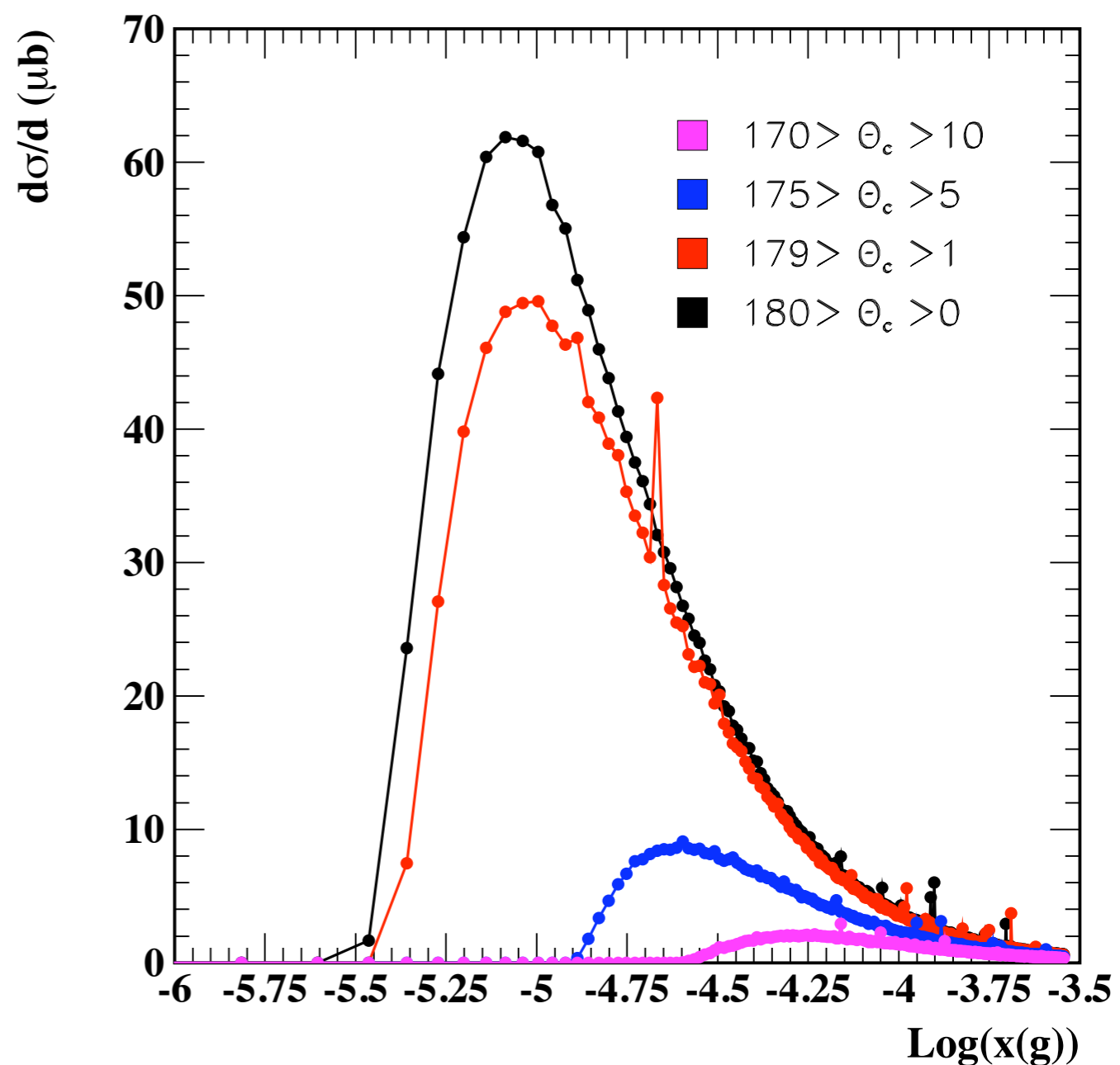
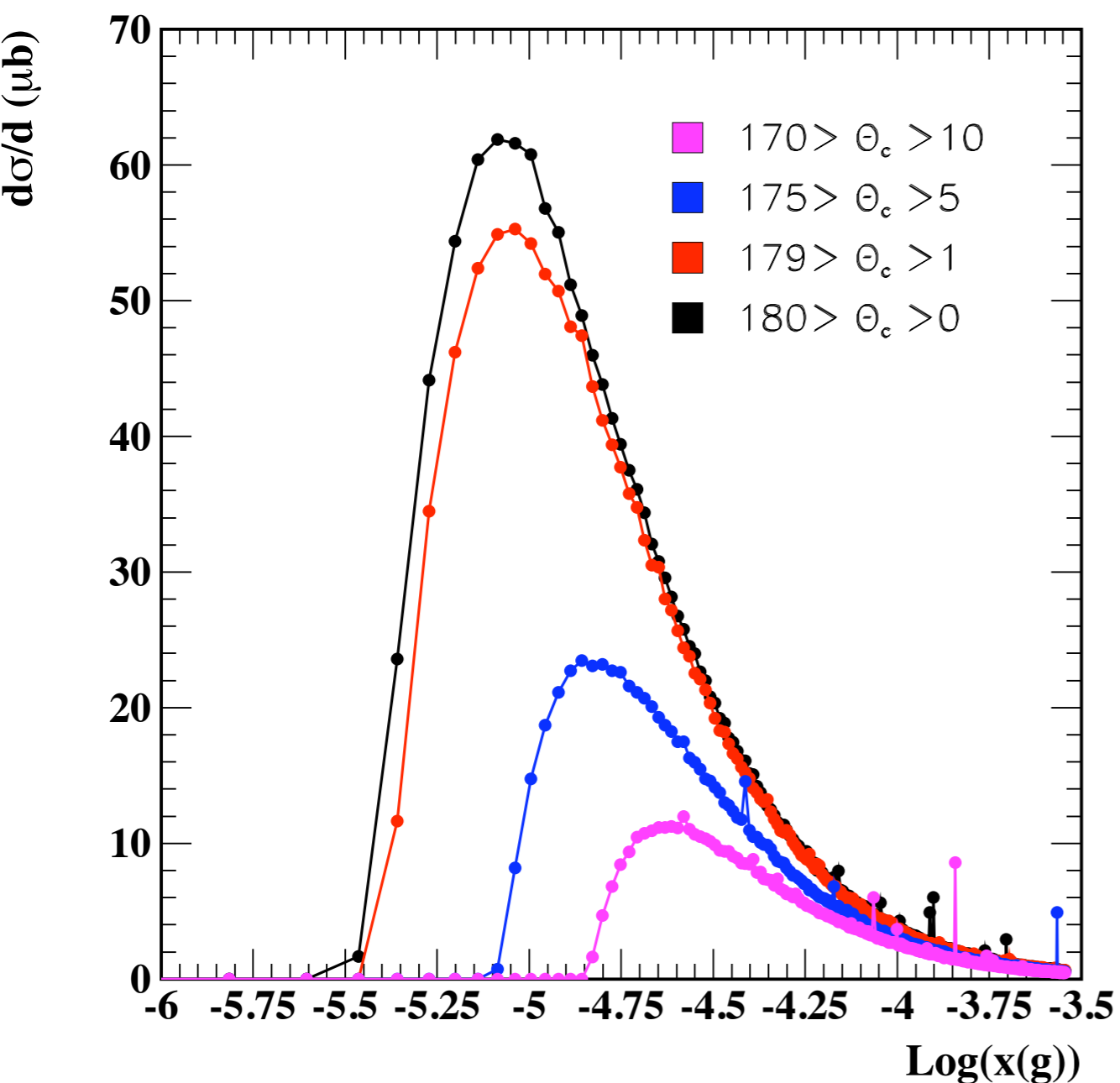
angular reach in γp

● 50 GeV e & 7 TeV p , $m_c=1.65$ GeV, $m_b=4.85$ GeV

➔ single versus both quarks

➔ $\gamma g \rightarrow c\bar{c}$ (cut on c)

$\gamma g \rightarrow c\bar{c}$ (cut on both)



total cross section summaries

	$50 \text{ GeV } e^-$	$150 \text{ GeV } e^-$
$ep \rightarrow e b \bar{b}$	3.80	7.38
$\gamma p \rightarrow b \bar{b}$	220	384
$ep \rightarrow e c \bar{c}$	218	389
$\gamma p \rightarrow c \bar{c}$	21900	30000

● cross sections in nb with CTEQ 6L1