Z' searches:

From Tevatron to LHC

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Outline

1. New physics
   - Competitors
   - Neutral gauge bosons

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4. Remarks

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Main candidates for BSM physics

- Supersymmetry
  - More than one neutral Higgses and a charged Higgs
  - Sfermions, gauginos
  - Neutralino $\longrightarrow$ Dark Matter
- Extra dimensions
  - String theory
  - $\longrightarrow$ Supergravity
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Q_{2f}	$-\sqrt{\frac{3}{4(1+x^2)}}z_f$	$\frac{3}{2\sqrt{7-2x+x^2}}z_f$	$-\frac{3}{2\sqrt{4+x+x^2}}z_f$	$\frac{3}{2\sqrt{1-x+x^2}}z_f$
$\tan\beta$	$\cdots$	0	$-\sqrt{\frac{3}{5}\frac{3+x}{1-x}}$	$\frac{\sqrt{3}(1-x)\mathrm{sign}(5-x)}{\sqrt{5-2x+5x^2}}$
$\tan\alpha$	$\cdots$	$\sqrt{\frac{3}{2}\frac{1+x}{x-4}}$	0	$2\sqrt{6}\frac{x}{5-x}$

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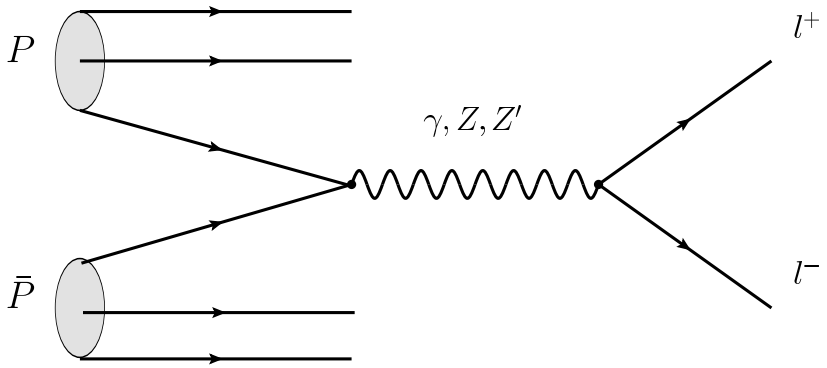
$\rightarrow$ $d - xu$ yields Z_I and Z_R if only SM fermions are considered!

Drell-Yan production at Tevatron



$$\frac{d\sigma}{dM^2}(p\bar{p} \to BX \to l^+l^-X)$$
$$= \frac{1}{N_c s}\int dz dx_1 \frac{1}{x_1 z}\theta\left(1 - \frac{1}{x_1 z r_z^2}\right)\sum_q \hat{\sigma}(q\bar{q} \longrightarrow l\bar{l})(M^2)$$
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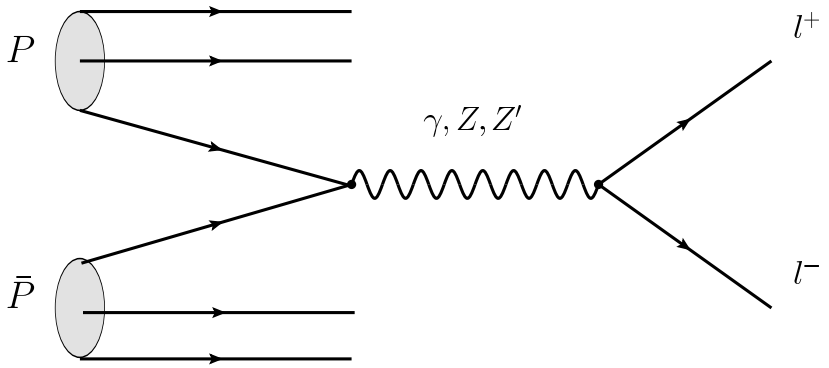

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\hat{\sigma}(M^2) &= \int_{-1}^{1} \frac{d\hat{\sigma}}{d\cos\theta^*} d\cos\theta^* \\
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CDF bounds

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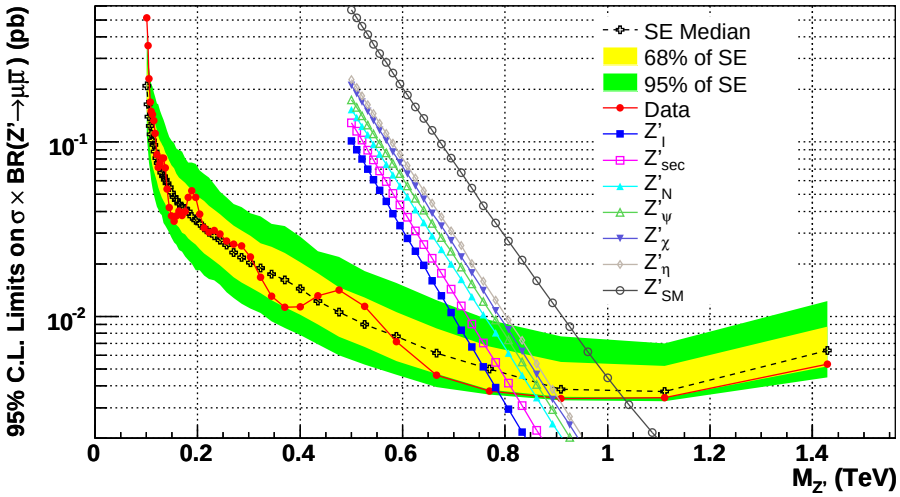
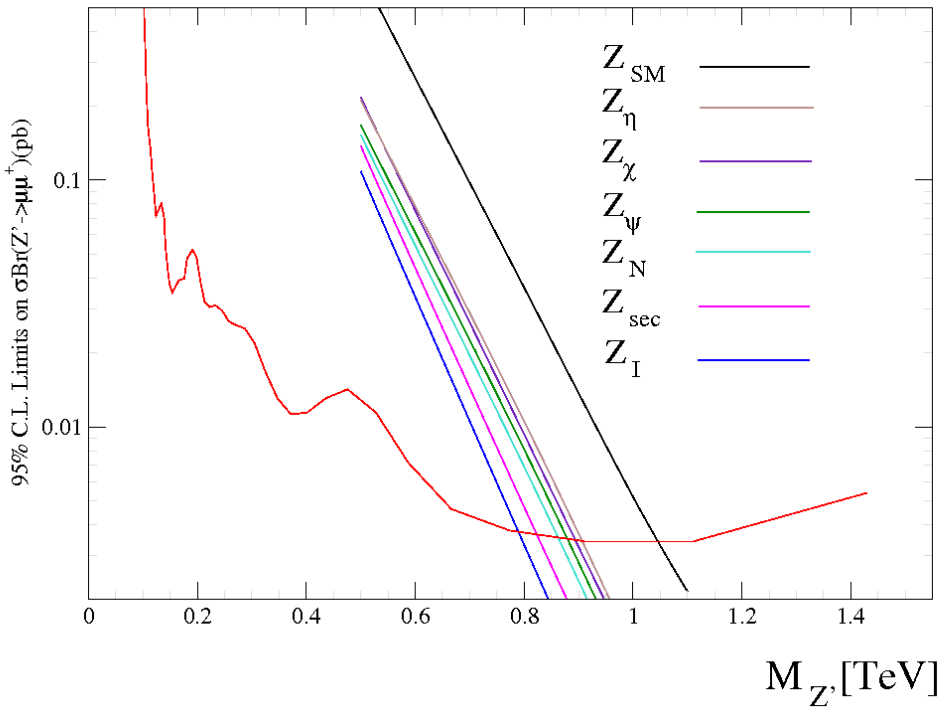


CDF collaboration (2009)



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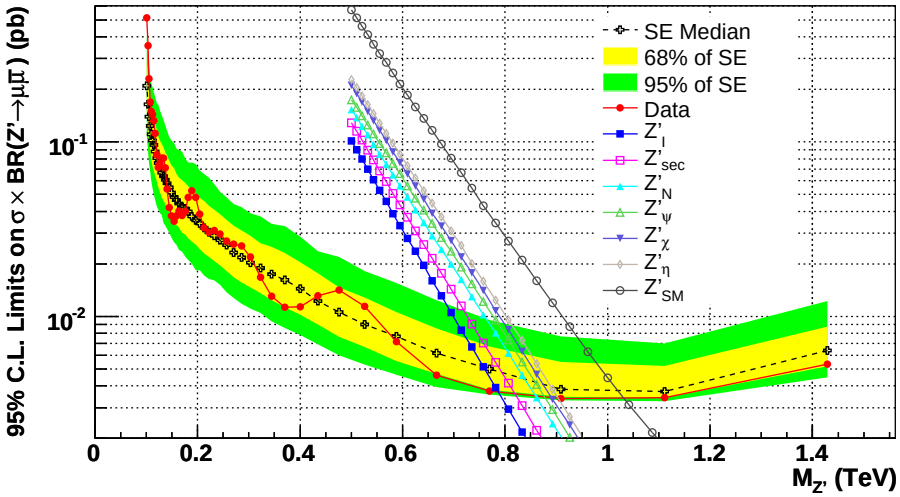

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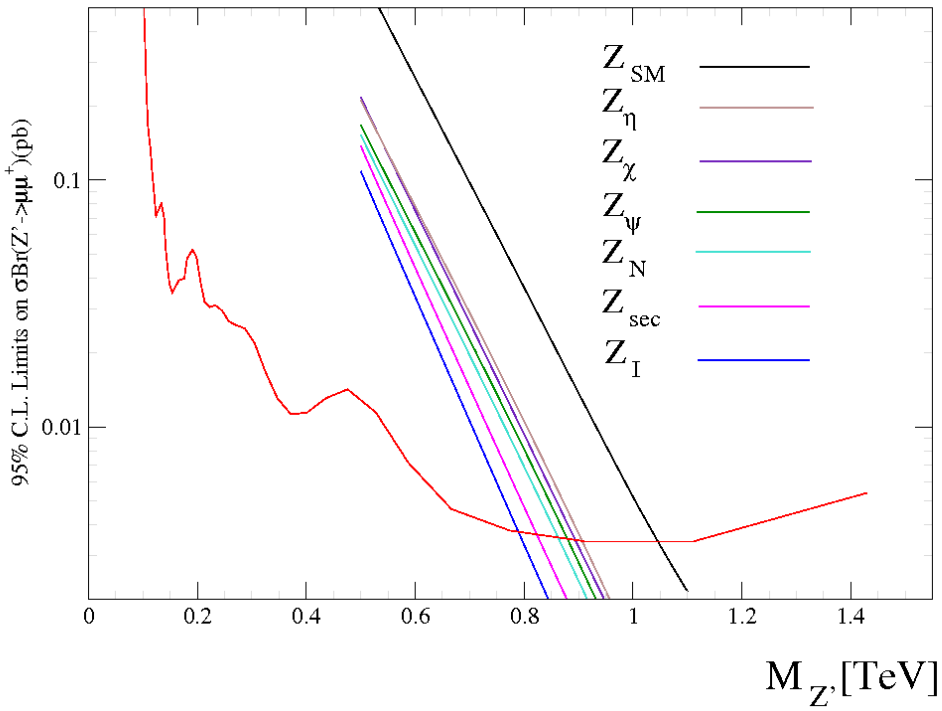

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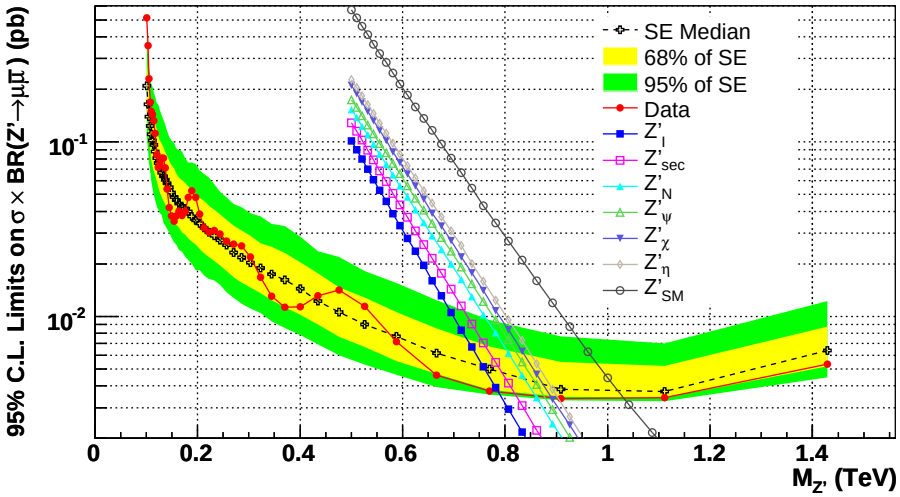

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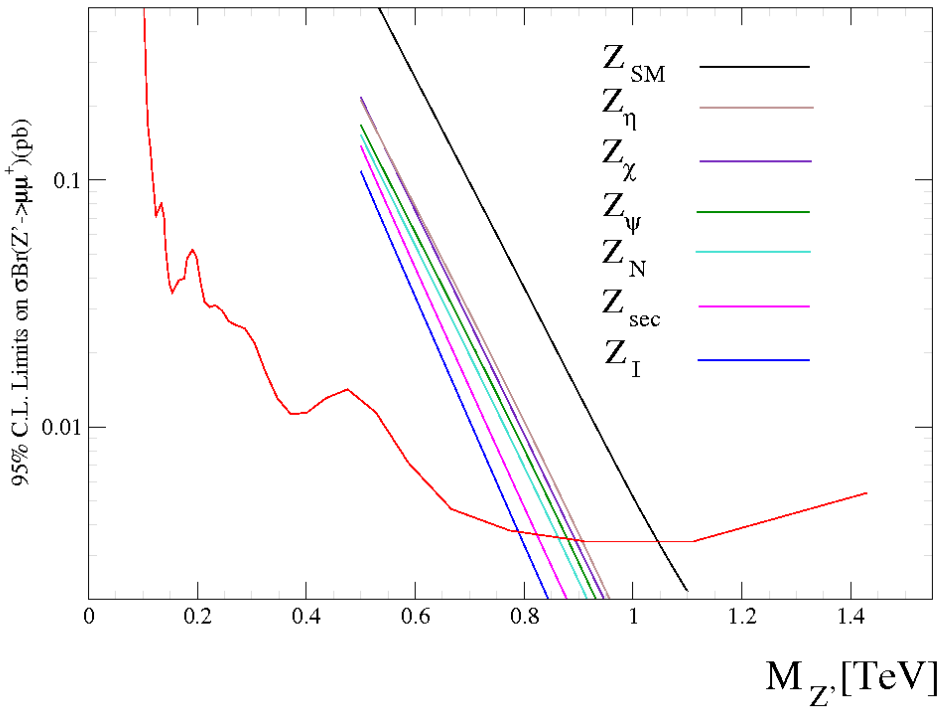

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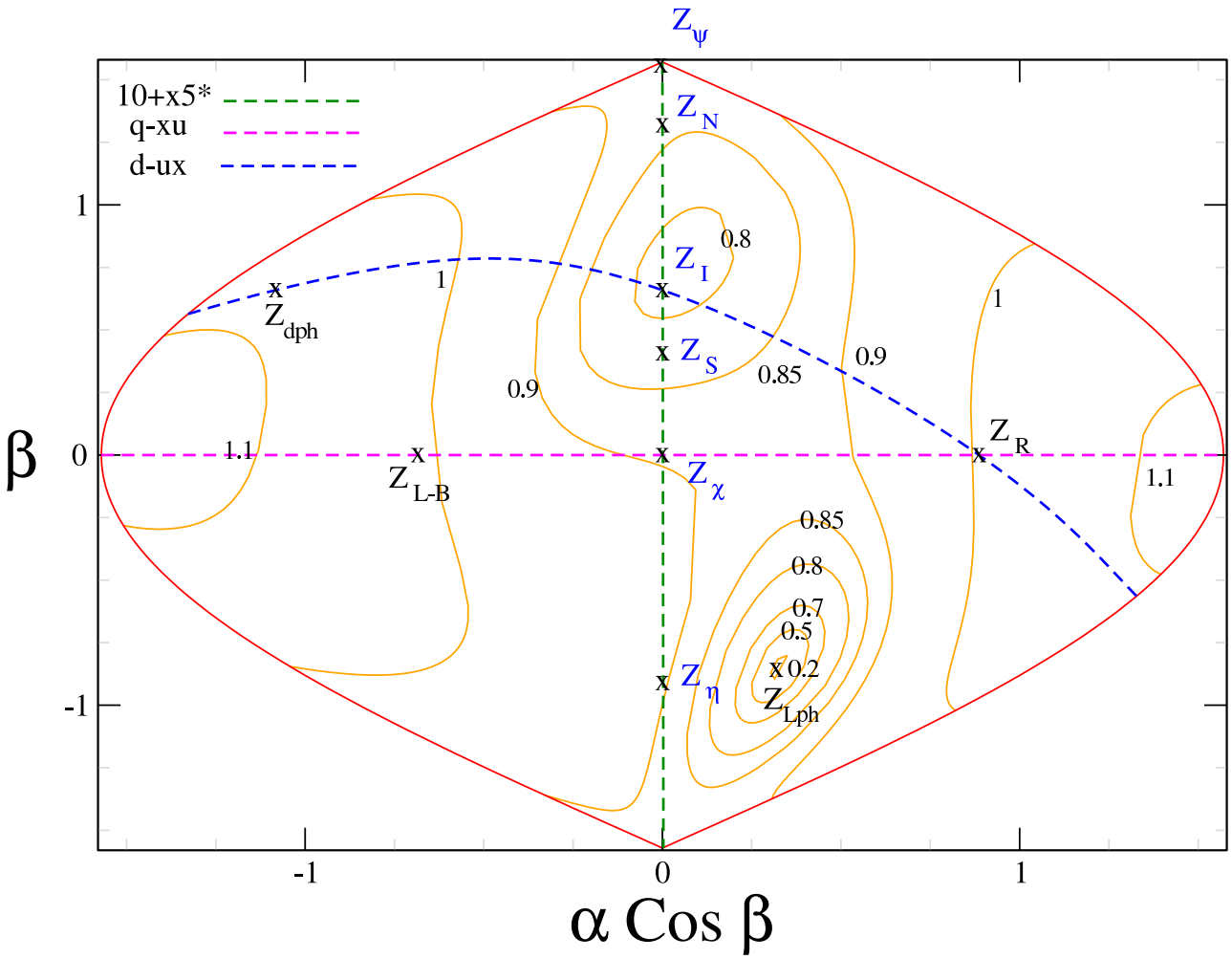
CDF mass bounds on E6 with kinetic mixing



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Model	$m_{Z'}^{lim}$ (GeV)	$m_{Z'}^{CDF}$ (GeV)	$m_{Z'}^{EW}$ (GeV)[1]	Projected for 8 fb^{-1} (GeV)
Z_χ	894.2	892	1141	1065.1
Z_ψ	879.8	878	147	1038.5
Z_η	907.1	904	427	1065.4
Z_N	862.6	861	623	1023.4
Z_S	823	821	1257	990
Z_I	789.2	789	1204	949.6
Z_{LR}	959		998	1158.1
Z_R	1006		442	1199.2
Z_{Lph}			(803)	
Z_{dph}	1073			
Z_{string}	707.3		1362	859.3
Z_{SM}	1034.3	1030	1403	1289.2

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[1] J Erler, PL, SM, ER (2009)

The log-likelihood method

- Expected number of events in a dimuon invariant mass bin at CDF

$$N = \mathcal{L} \int_{bin} dM_{\text{phys}} \text{ acceptance} \left\langle \text{efficiency} \times \frac{d\sigma}{dM} \right\rangle (M_{\text{phys}})$$

we use the data set for $\mathcal{L} = 2.3\text{fb}^{-1}$ [CDF collaboration (2009)]

- Inverse mass $\rightarrow$ constant resolution: $\sigma_{M^{-1}} = 0.17$ TeV^{-1}. Define

$$\left\langle \frac{d\sigma}{dM} \cdots \right\rangle (M_{\text{phys}}) = \int_{\frac{1}{2m_l}}^{\frac{1}{\sqrt{s}}} \frac{dM^{-1}}{\sqrt{2\pi\sigma_{M^{-1}}}} \exp \frac{(M_{\text{phys}}^{-1} - M^{-1})^2}{2\sigma_{M^{-1}}} \frac{d\sigma}{dM} \cdots$$

- Define log-likelihood ratio reproducing properties of the χ^2 function

$$LLR = -2 \ln \frac{\mathcal{L}(\vec{\mu'}|\vec{n})}{\mathcal{L}(\vec{\mu}|\vec{n})},$$

with $\quad \mathcal{L}(\vec{\mu}|\vec{n}) = \Pi_i^{N \text{ bins}} P(n_i|\mu_i); \quad P(n|\mu) = (\mu)^n \exp[-(\mu)]/n!$

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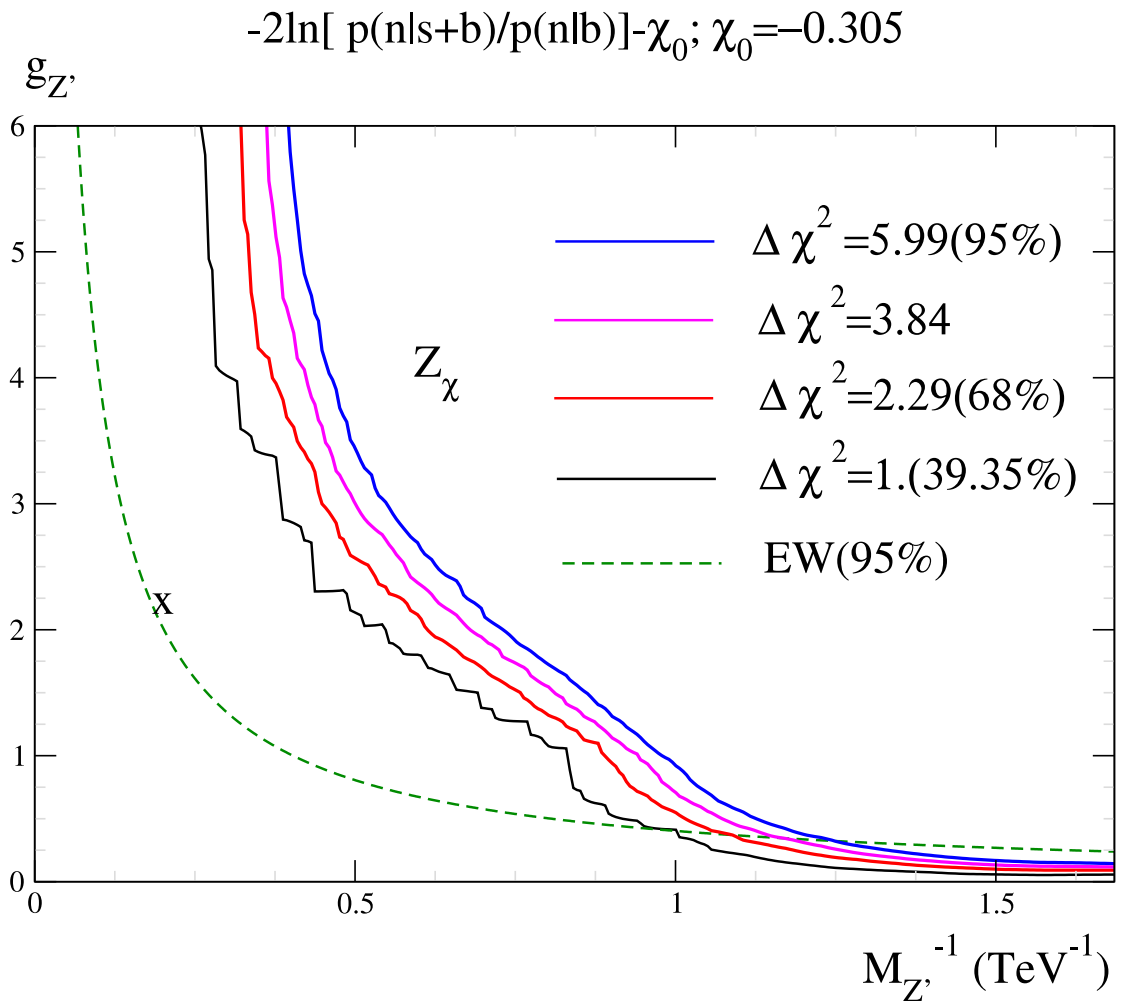
Limits using χ^2 minimization



J Erler, P Langacker, SM, E Rojas (work in progress)

Predictions for the LHC

$\mathcal{L}$ (fb^{-1})/$\sqrt{s}$ (TeV)	3.5	7	14	28
3	1.016	1.844	2.972	4.647
30	1.469	2.456	4.101	6.726
300	2.231	3.324	5.423	9.703
3000	3.923	5.548	7.911	12.154

Expected Z_χ limits from the LHC

$\mathcal{L}$ (fb^{-1})/$\sqrt{s}$ (TeV)	3.5	7	14	28
3	1.499	2.480	3.942	6.020
30	1.912	3.271	5.507	9.003
300	2.675	4.187	7.111	12.110
3000	4.654	6.569	9.511	15.517

LHC as a $p\bar{p}$ collider

J Erler, P Langacker, SM, E Rojas (work in progress)

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Conclusions and outlook

- We have been able to extend CDF lower bounds on the Z' mass to more general classes of models
- We carried out a detailed study of the various factors contributing to the production cross-section and thereby the mass limit
- Further improvement on the limits by constructing χ^2 function $\longrightarrow$ mass effects independent of the coupling constant effects
- Analysis can be easily performed for the LHC as soon as new data is released

MERCI!