Searches for Heavy Vector Bosons at CDF

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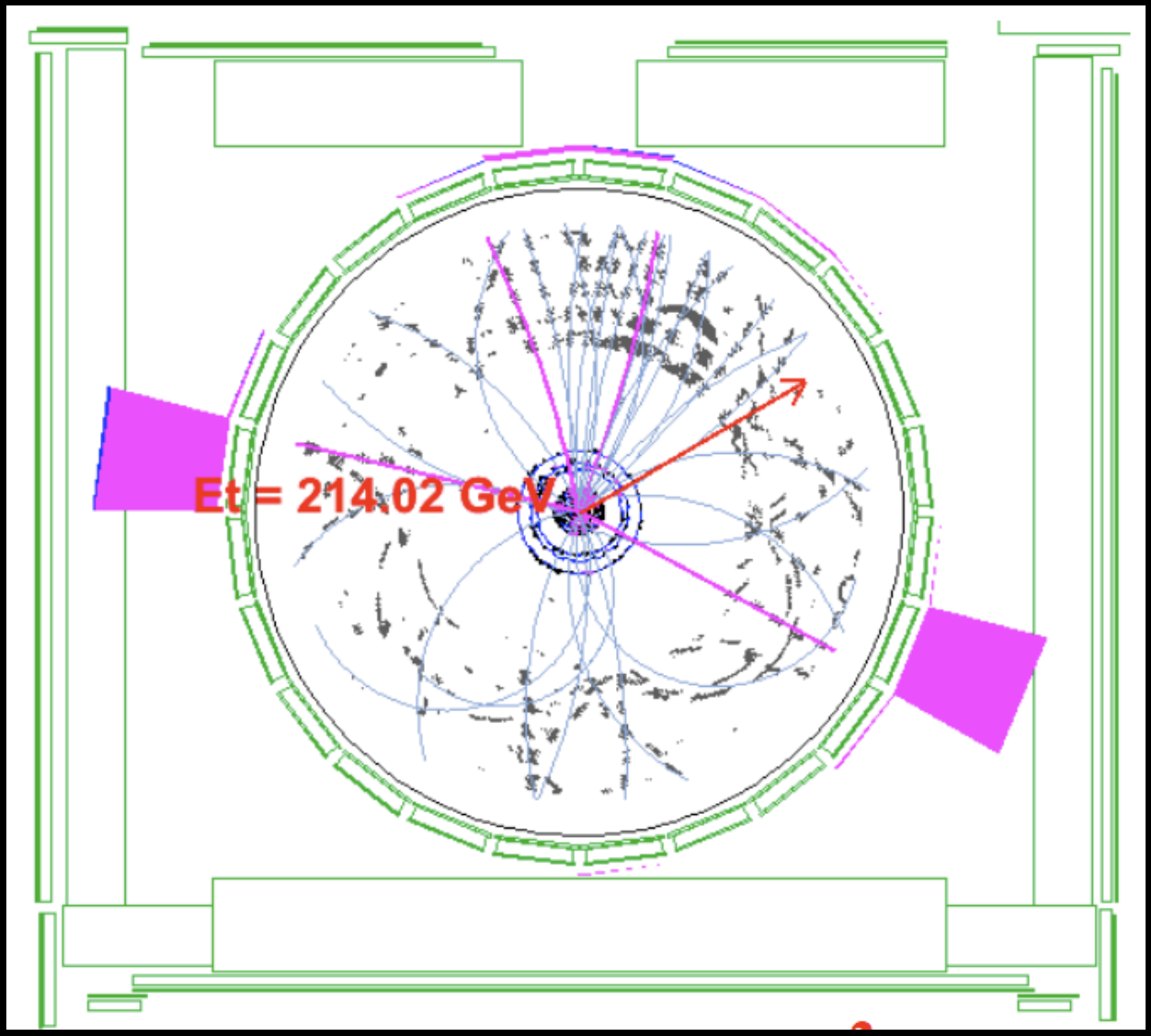
Why Look for Heavy Vector Bosons?

Z′ arise naturally in many extensions of SM:
GUTS (E6,S0(10),...), extra dimensions, little Higgs...

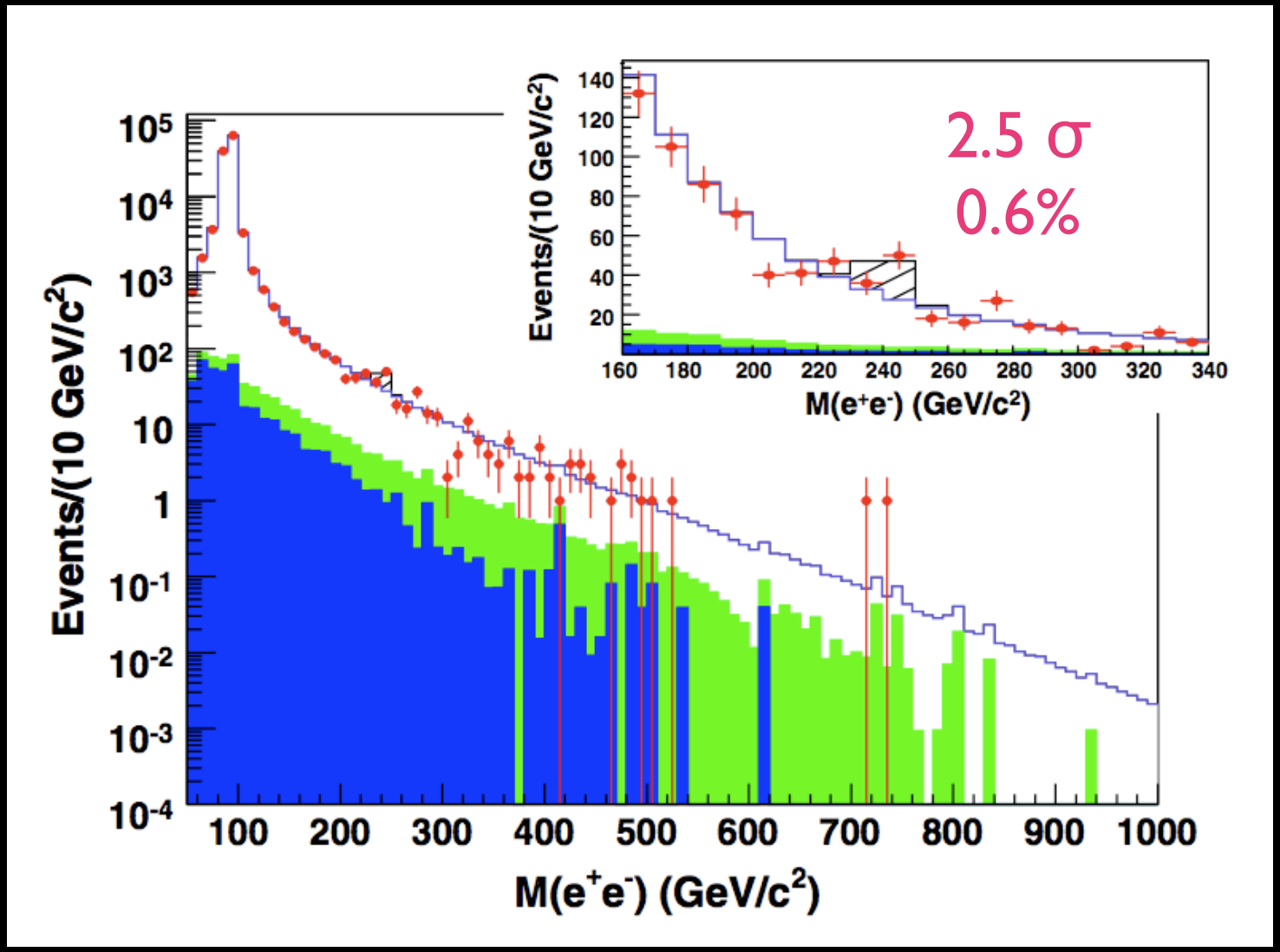
W′ GUT, LR symmetric (W_R, ν_R), etc.
see Z. Sullivan Phys.Rev.D66:0750111,2002

Dramatic Signatures! e.g. 470 Gev M(e^+e^-)



electron pair mass 2.5 fb^{-1}

PRL 102, 031801 (2009)



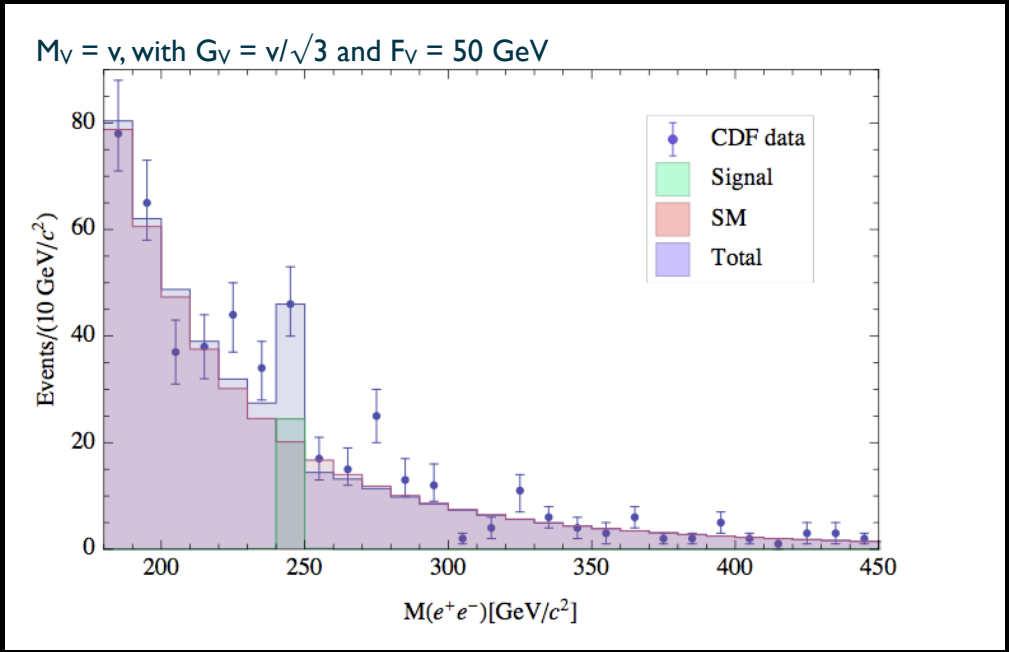
Drell-Yan Υ*,Z*

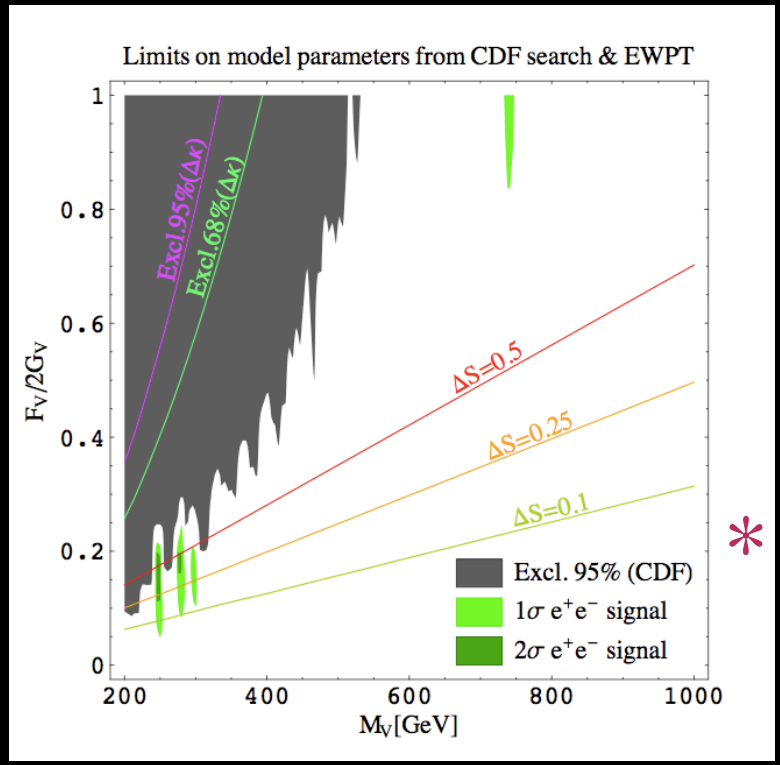
QCD
dijets, W+jets

other SM
ττ,top
WW,WZ,WΥ,ΥΥ

Heavy Vectors in Higgsless Models
new strong dynamics
new spin-1 instead of H

Cata, Isidori, Kamenik arXiv:0905.0490v1



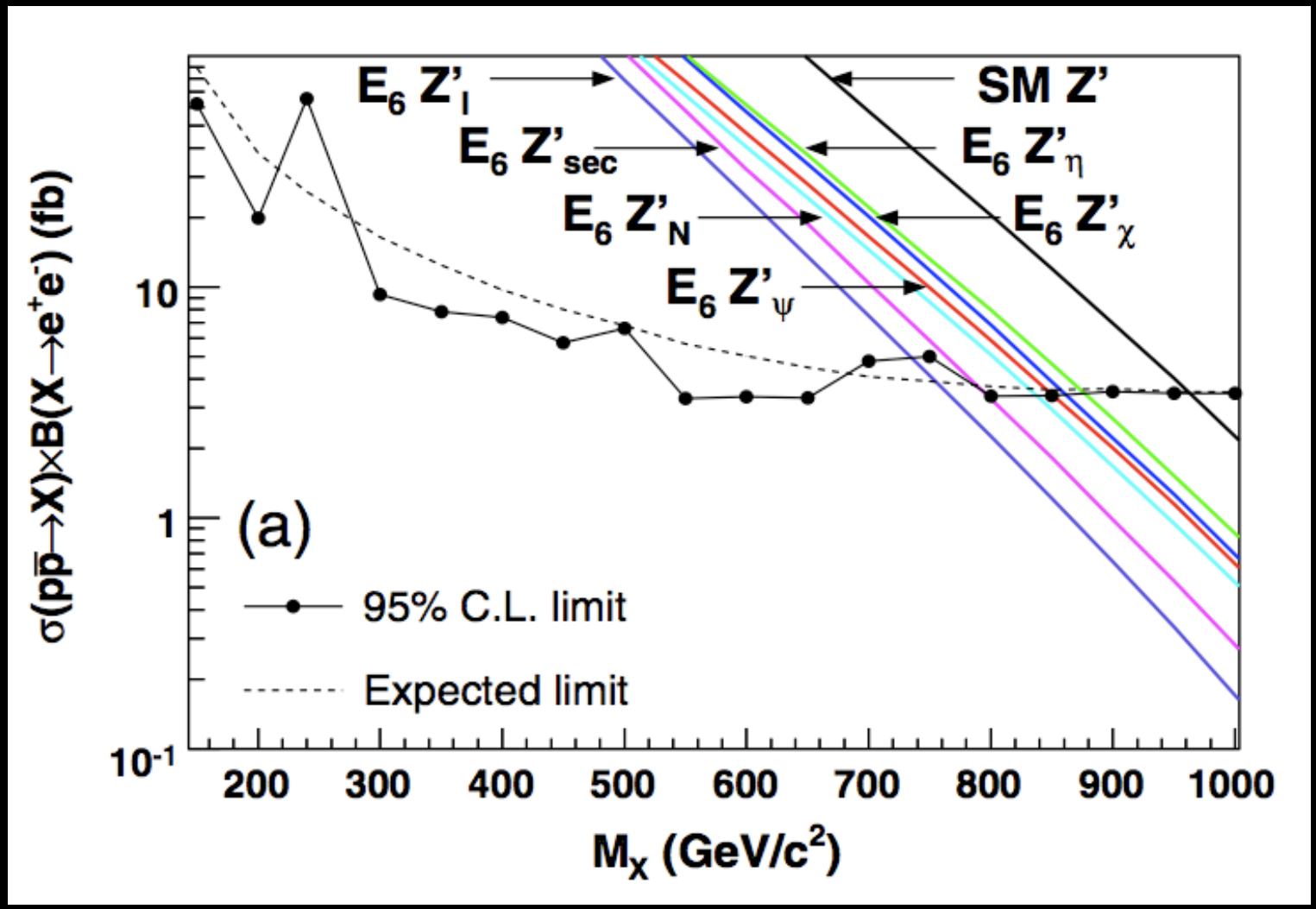


effective couplings

consistent w/ EW precision

$$V \to f\bar{f} \propto F_V^2 \quad V \to WW \propto G_V^2$$

*[3] An even more stringent prediction is the appearance of an excess similar to the one in Fig. 4 in the $p\bar{p} \to \mu^+\mu^-$ spectrum. The absence of significant deviations from the SM in the latter [17] reinforce the explanation of Fig. 4 in terms of statistical fluctuations only.

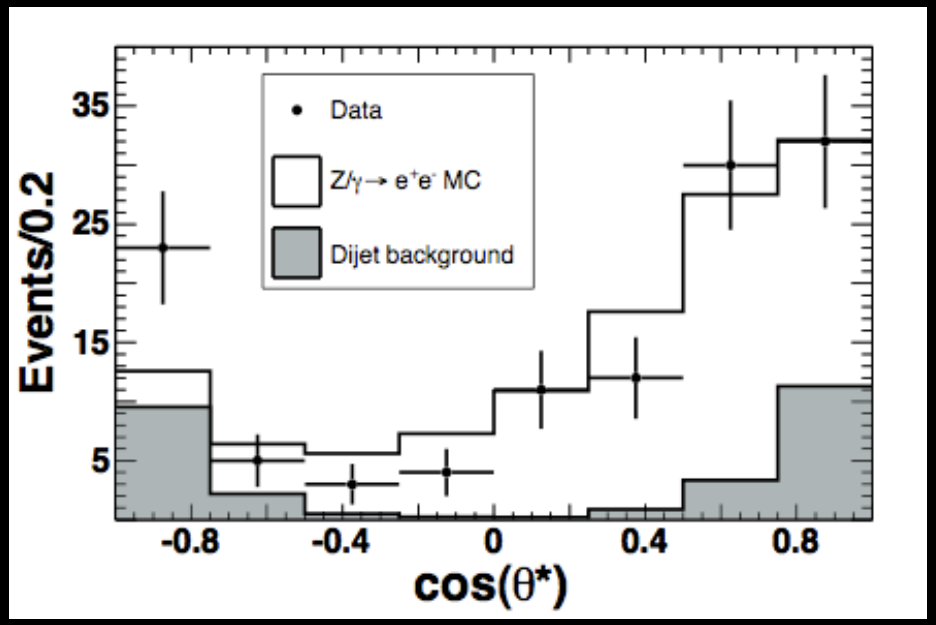

E6 Z'I
E6 Z'sec
E6 Z'N
E6 Z'ψ
SM Z'
E6 Z'η
E6 Z'χ
(a)
95% C.L. limit
Expected limit
σ(pp̄→X)×B(X→e+e-) (fb)
Mx (GeV/c2)
10
1
10-1
200
300
400
500
600
700
800
900
1000

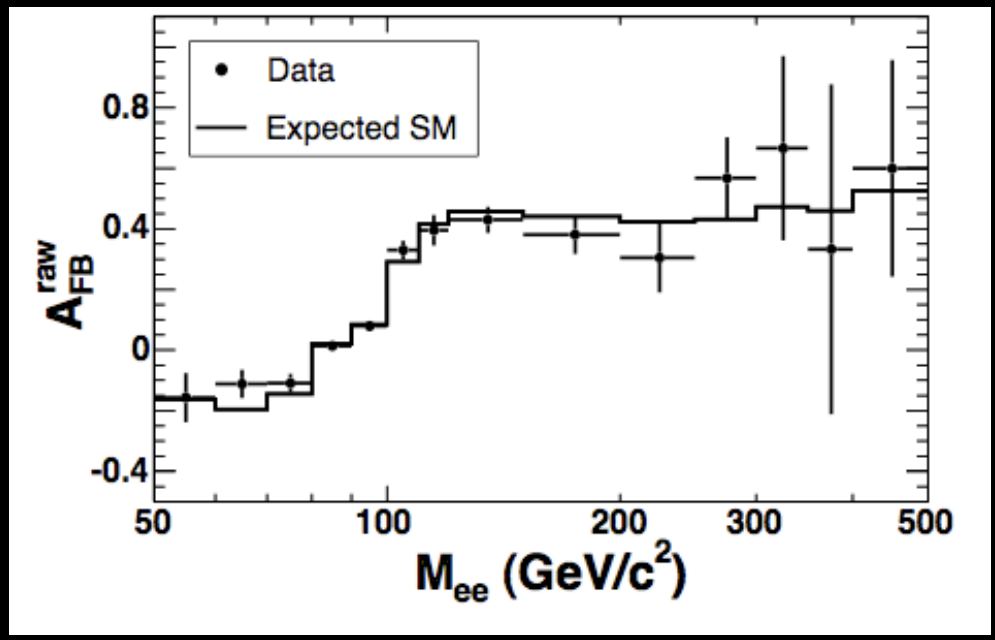
M^{SM}<963 GeV

electron pair angular distribution 0.45 fb^{-1}

suggested by Rosner 1996

PRL 96 211801,2006





set limits in generic models

Carena, Daleo, Dobrescu, Tait PRD70-093009 2004

M_{SM}<850 GeV

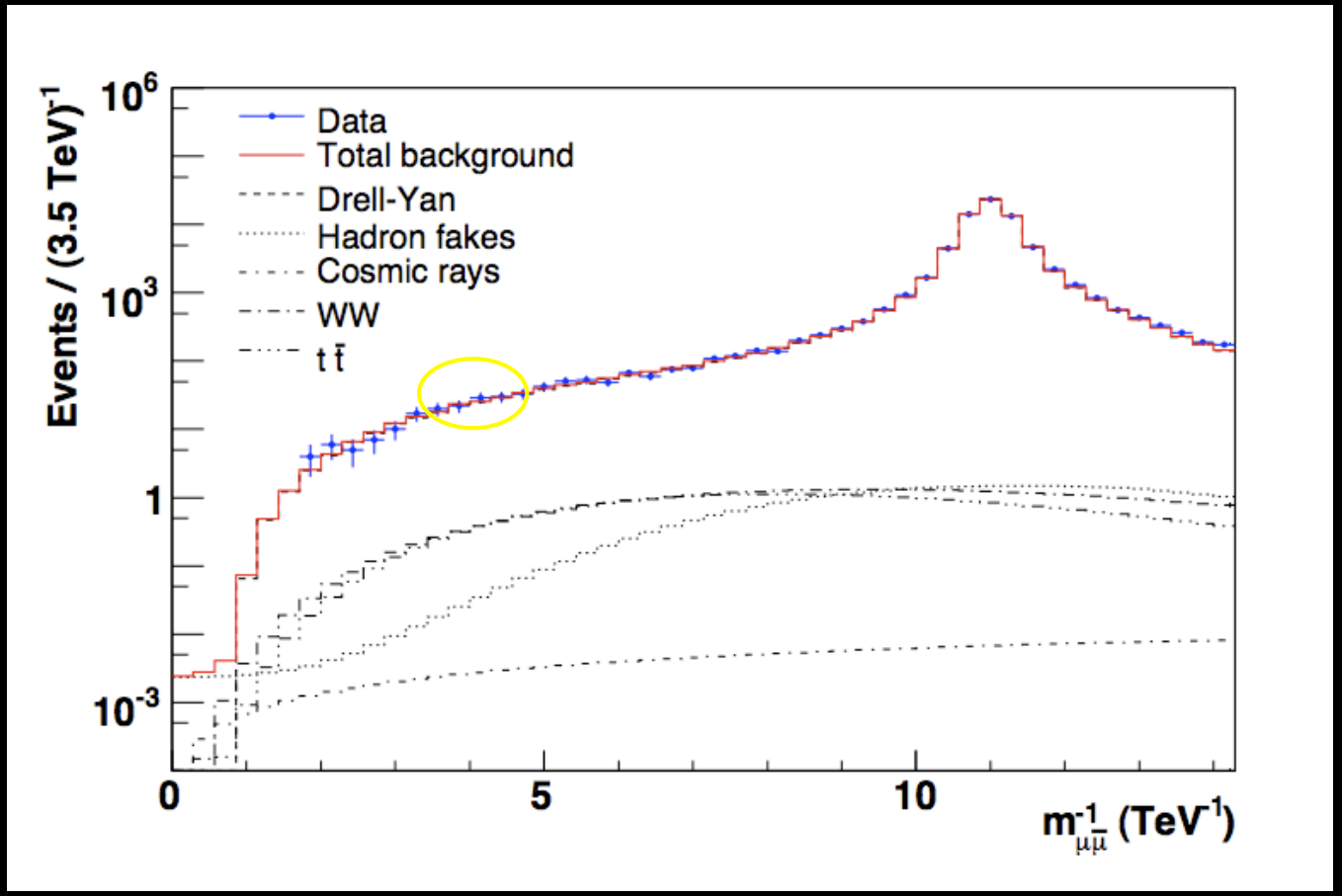
A_{FB} at LHC Rizzo

arXiv:0904.2534

Interaction	LL	LR	RL	RR	VV	AA
Λ_{qe}^{+} limit (TeV/c^2)	3.7	4.7	4.5	3.9	5.6	7.8
Λ_{qe}^{-} limit (TeV/c^2)	5.9	5.5	5.8	5.6	8.7	7.8

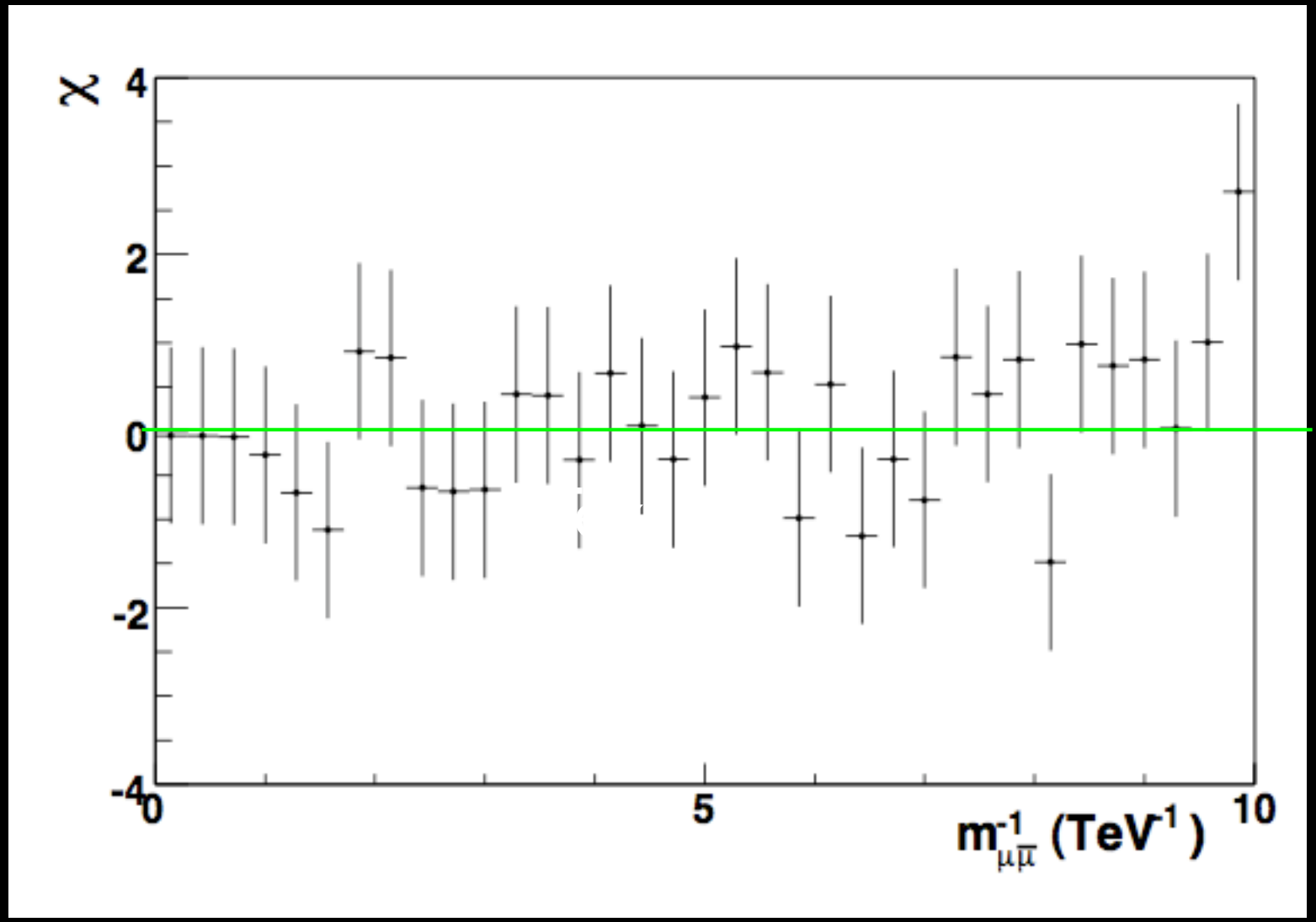
muon pairs 2.3 fb^{-1}

PRL 102, 091805 (2009)

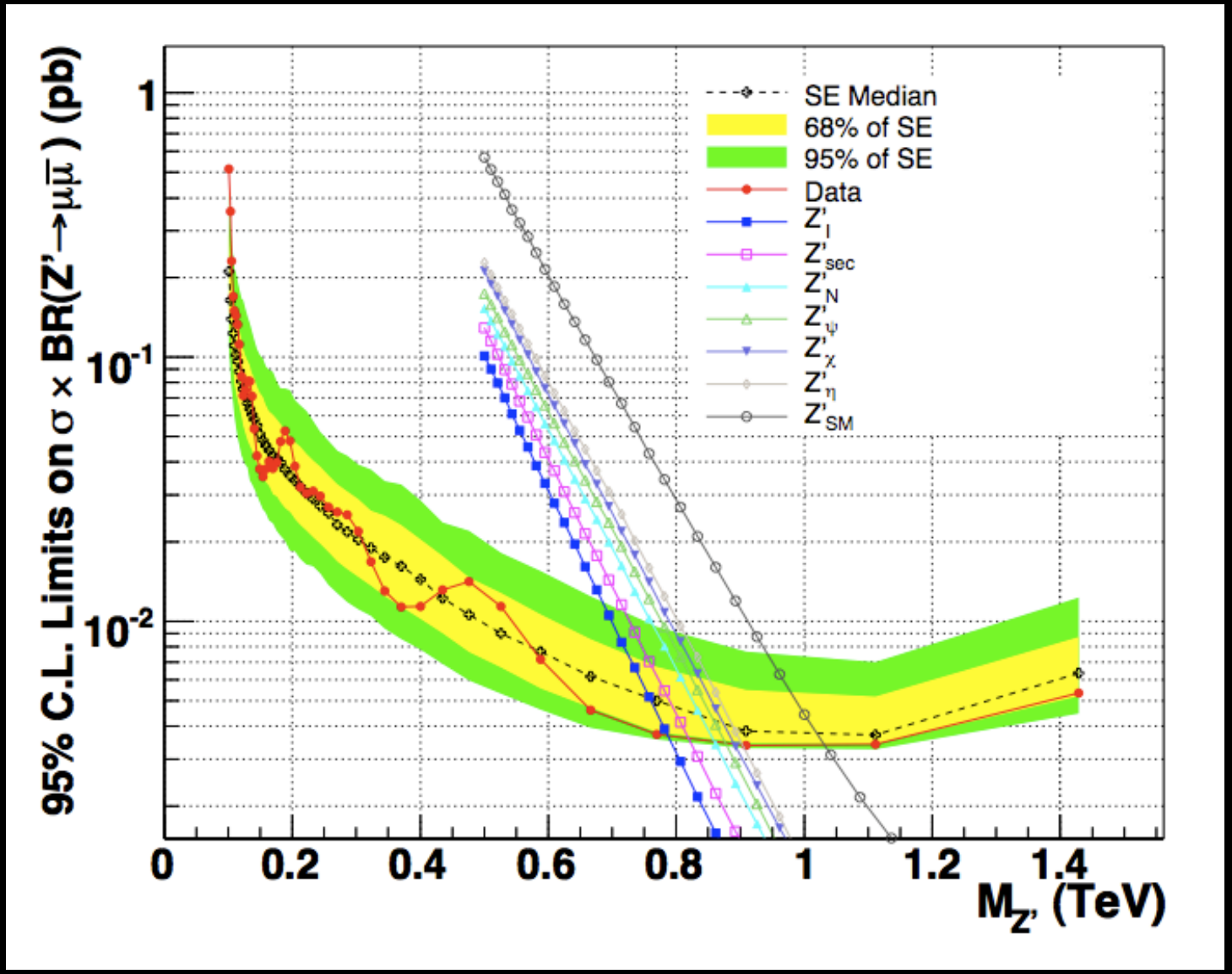


resolution ≈ constant $\delta M^{-1}_{\mu\mu} \approx 0.17\ \mathrm{TeV}^{-1}$

excellent agreement of di-muon data & background



di-muon limit 2.3 fb^{-1} M^{SM} <1030 GeV

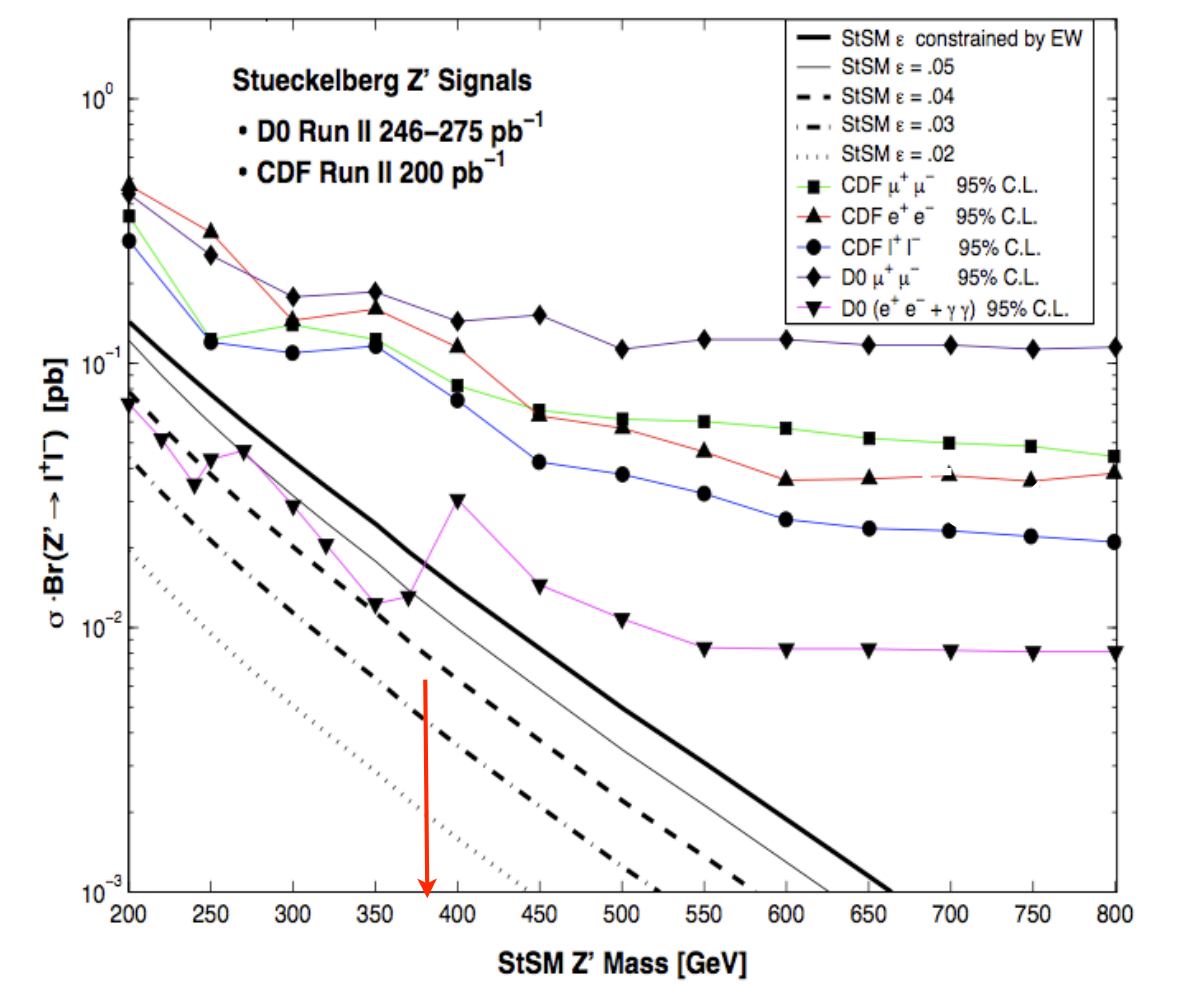


note: di-tau M^{SM} < 600 GeV 0.2 fb^{-1} PRL 95,131801 (2005)

very narrow (Γ<60 MeV) Z′ StSM

$M_{Z'}$ from St to 0$^-$

Nath et al.
PRL 97:021801,2006

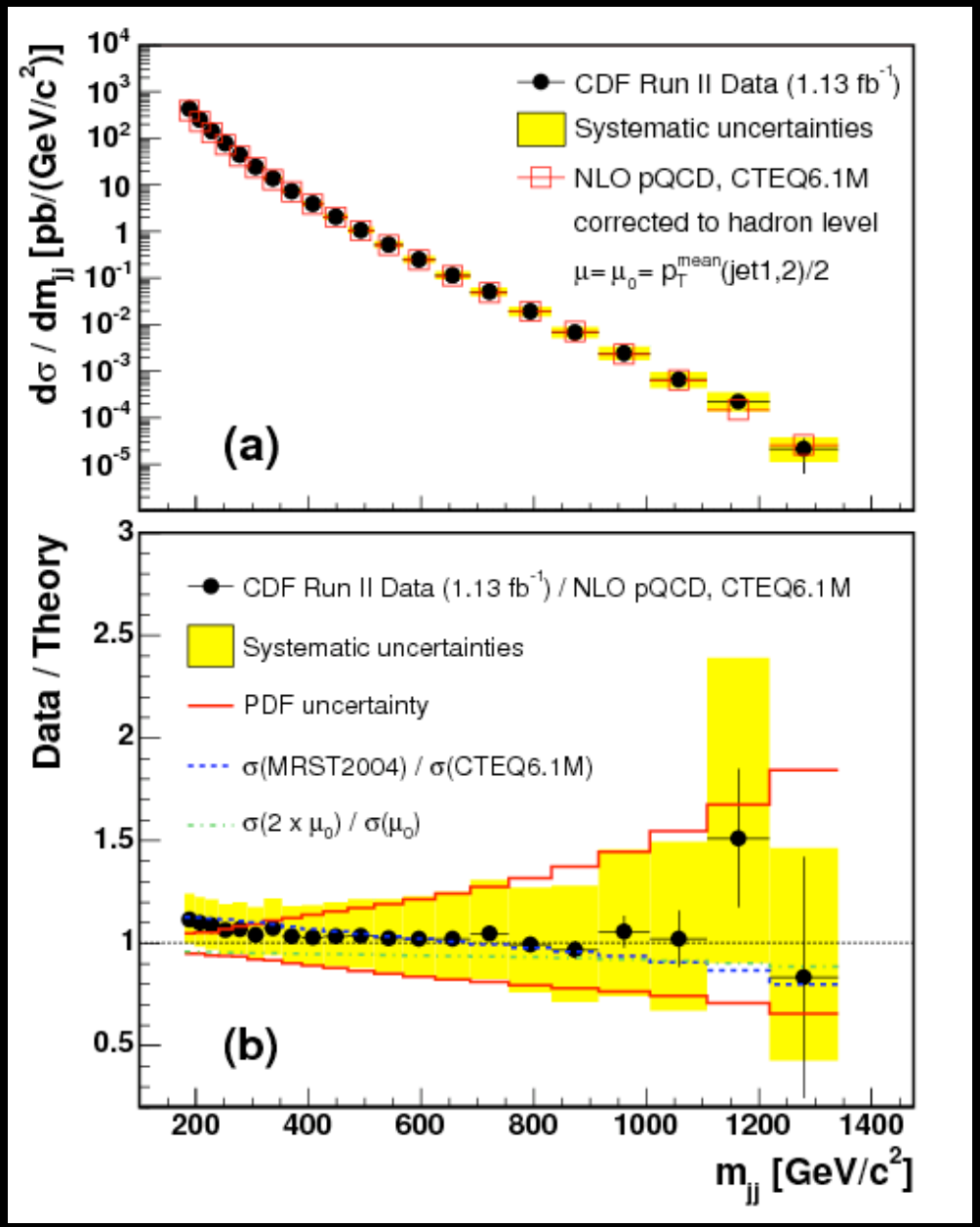


ε=0 →SM
ε~.05 EWK consistent

CDF(*ll*) 0.20 fb-1
D0(ee+γγ) 0.26 fb-1

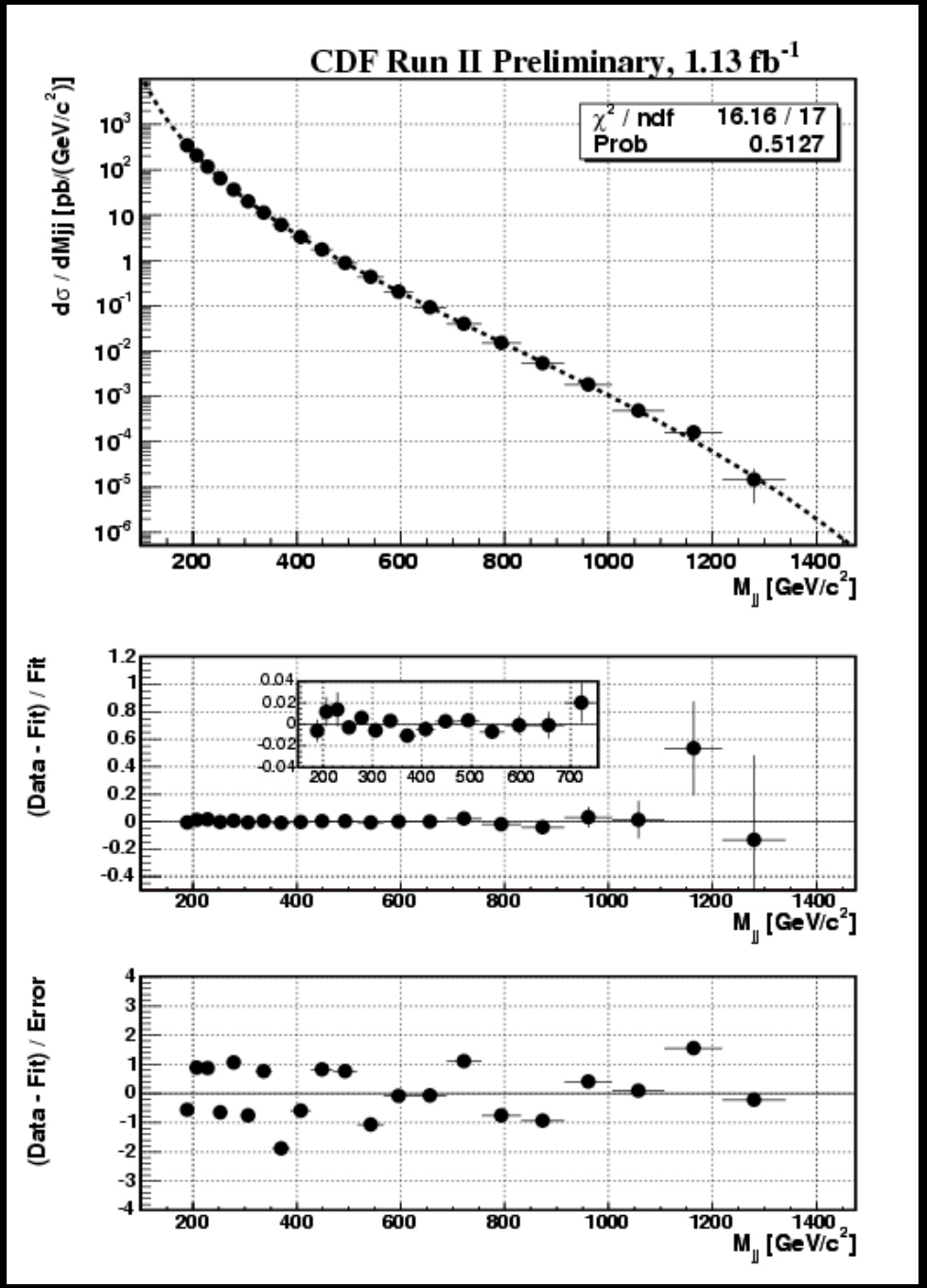
discovery to 600 GeV
w/ 8 fb^{-1}

Search for di-jet mass resonances 1.1 fb^{-1}

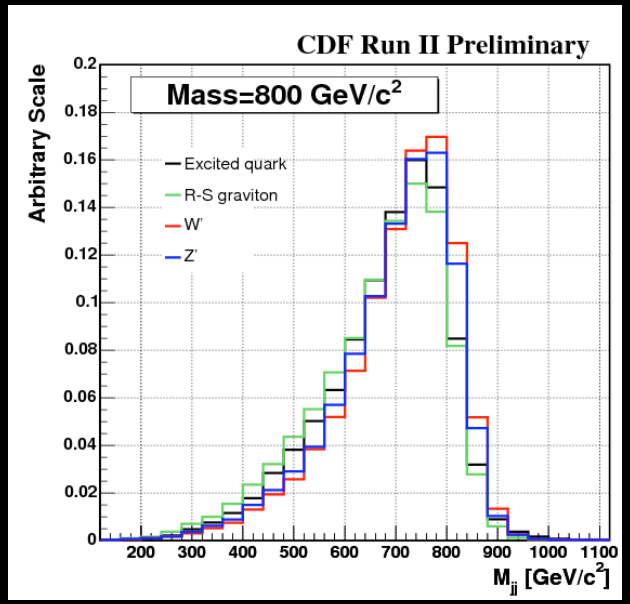


central dijets
corrected for resolution
and efficiency

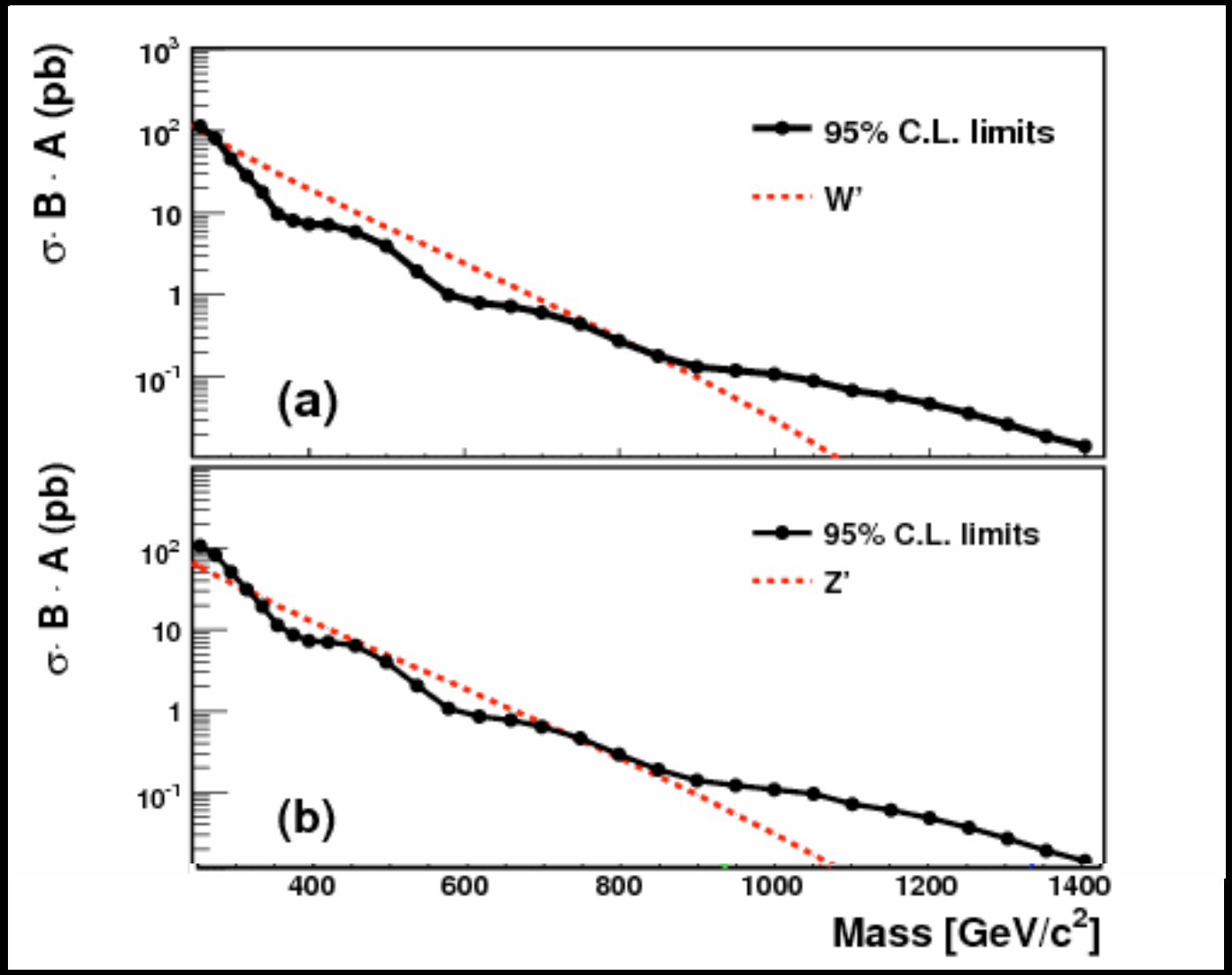
exp. systematics:
energy scale, resolution,
unfolding (and lumi)



fit to parameterized smooth curve for limits



limits from di-jet resonance search

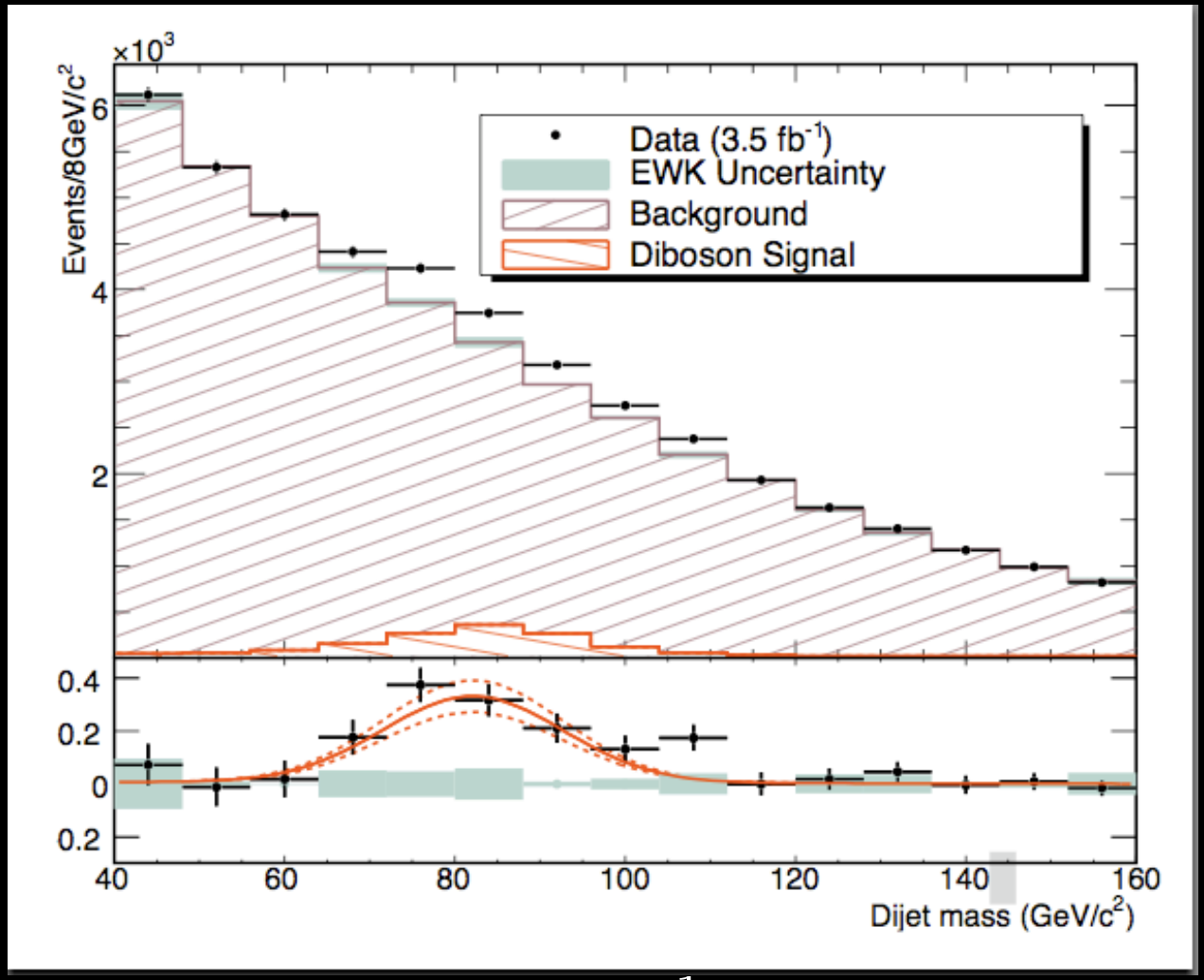


280-840 GeV
SM couplings

320-740 GeV
SM couplings

DI-BOSONS

"First Observation of Vector Boson Pairs in a Hadronic Final State at the Tevatron Collider"



$\ell\nu jj$

$1516 \pm 239 \pm 144$ in 3.5 fb^{-1}

May, 2009 arXiv:0905.4714

WW/WZ eνjj resonance search 2.9 fb^{-1}

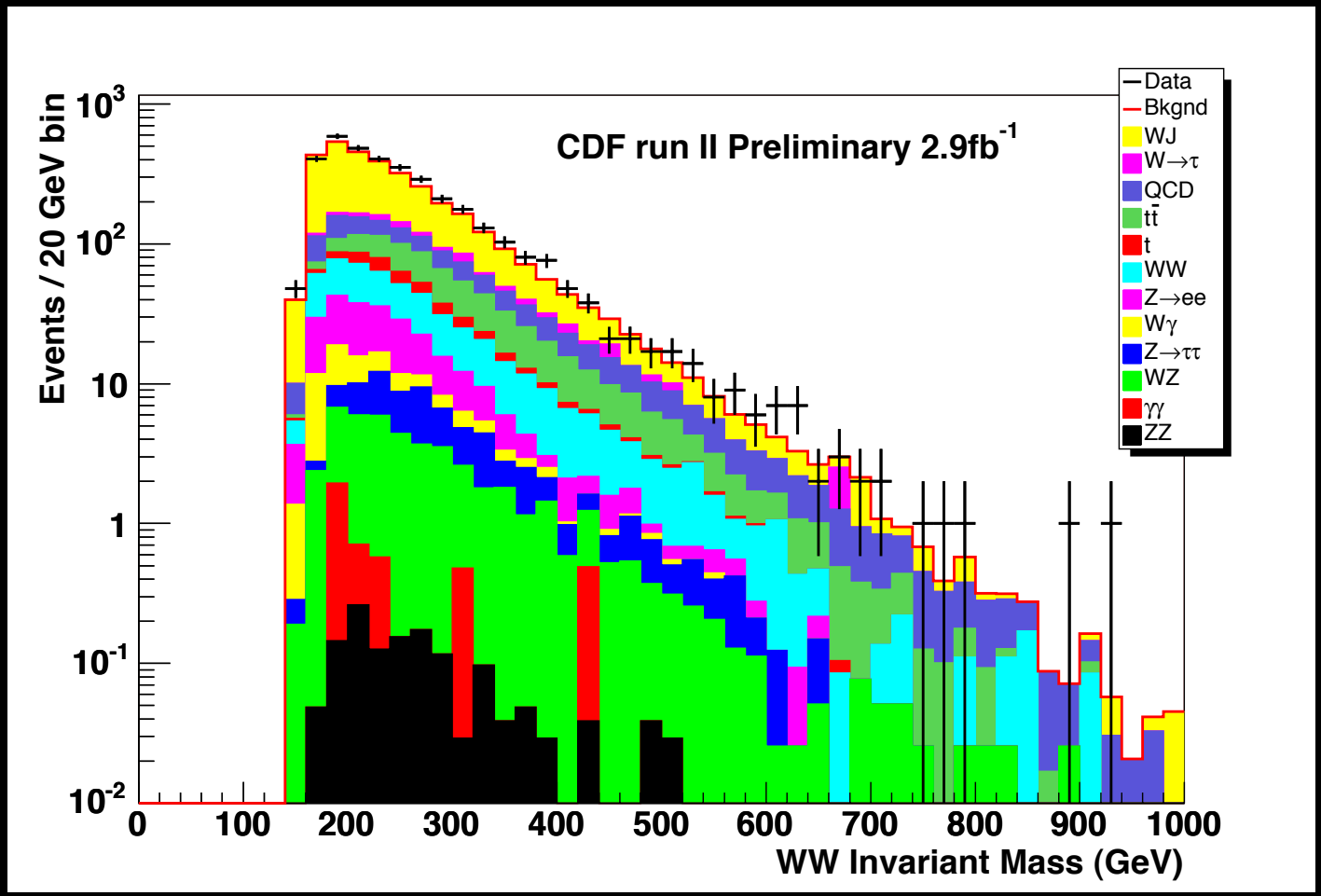
65 < M(jj) < 95 GeV

1 central e Et > 30 GeV

$\not\!\!E_t$ > 30 GeV

2 or 3 jets, Et > 30 GeV

H_T > 150 GeV.



BG(%)

WJ: 58.5

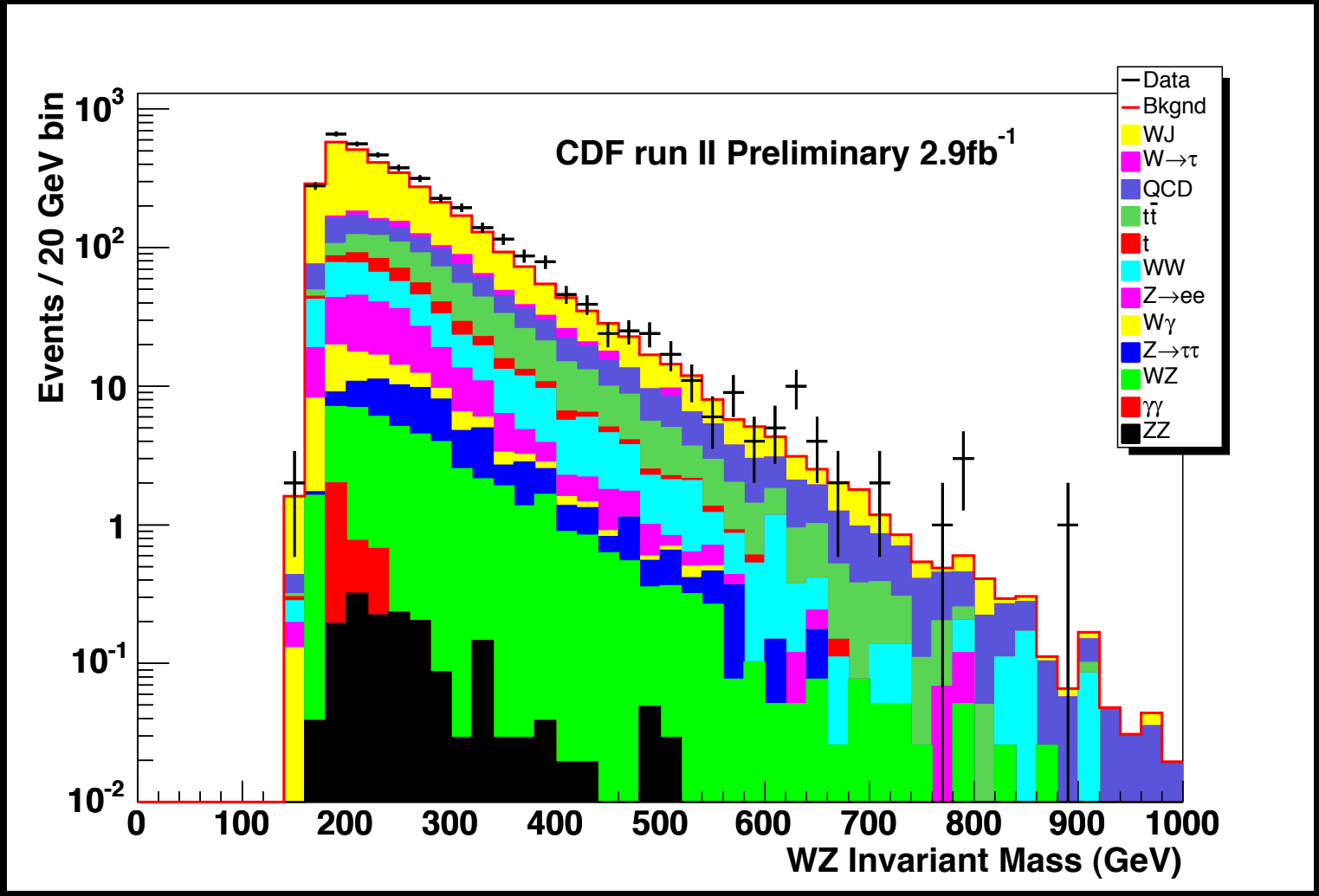
QCD:10.7

$t\bar{t}$: 9.5

WW: 7.8

WW/WZ evjj resonance search 2.9 fb^{-1}

75 < M(jj) < 105 GeV



BG(%)

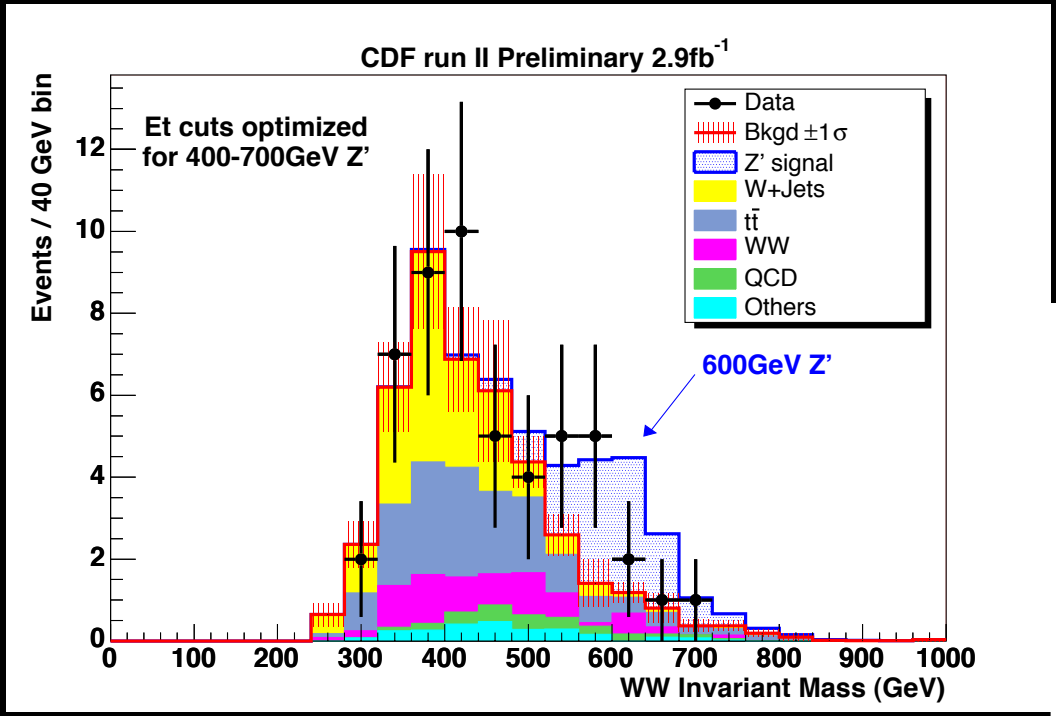
WJ: 59.0

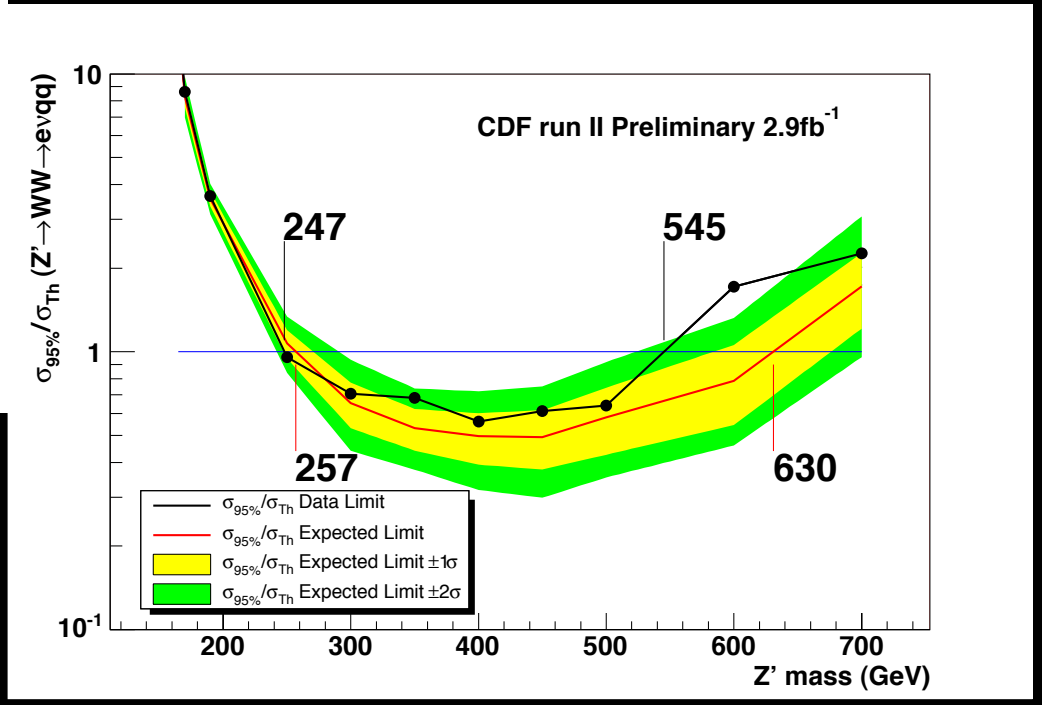
QCD:10.8

$t\bar{t}$: 9.8

WW: 6.7

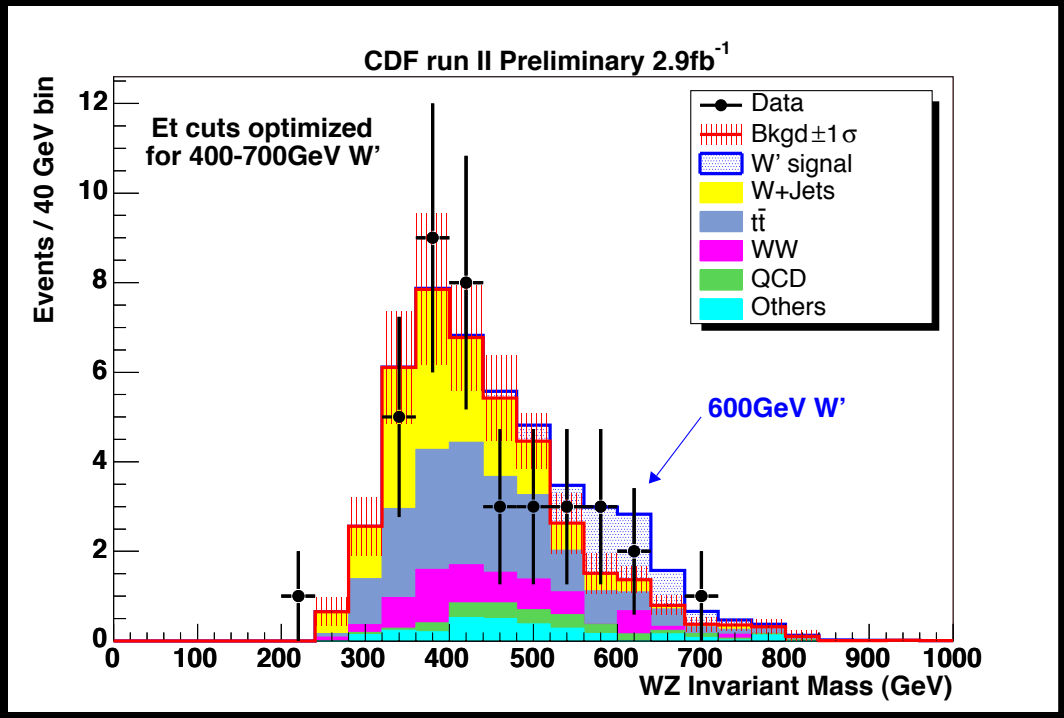
E_T cuts optimized for different masses



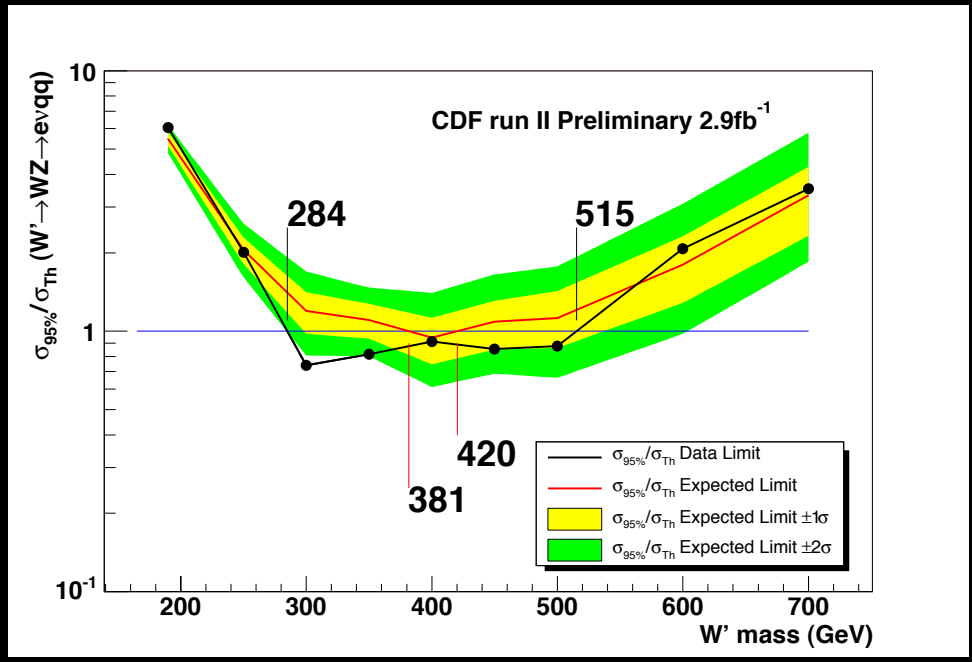


E_T^4>60 cut

E_T cuts optimized for different masses



E_T^4>60 cut



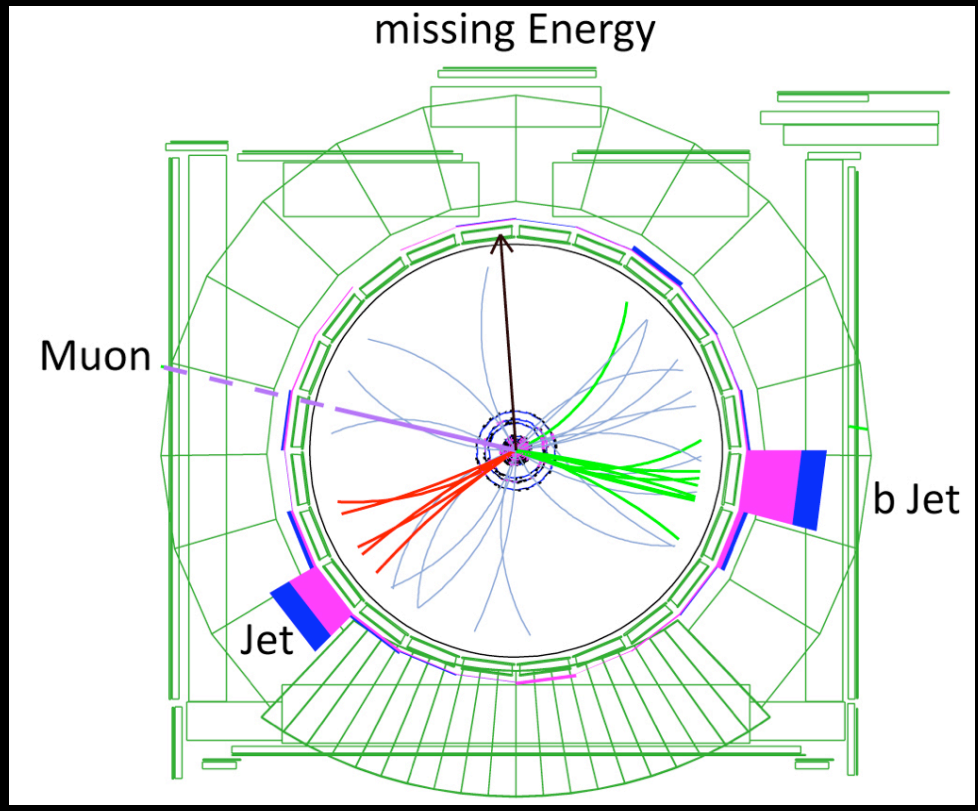
W′ in single top events

Br(W′→ tb) ~ 0.25 @ 500 GeV

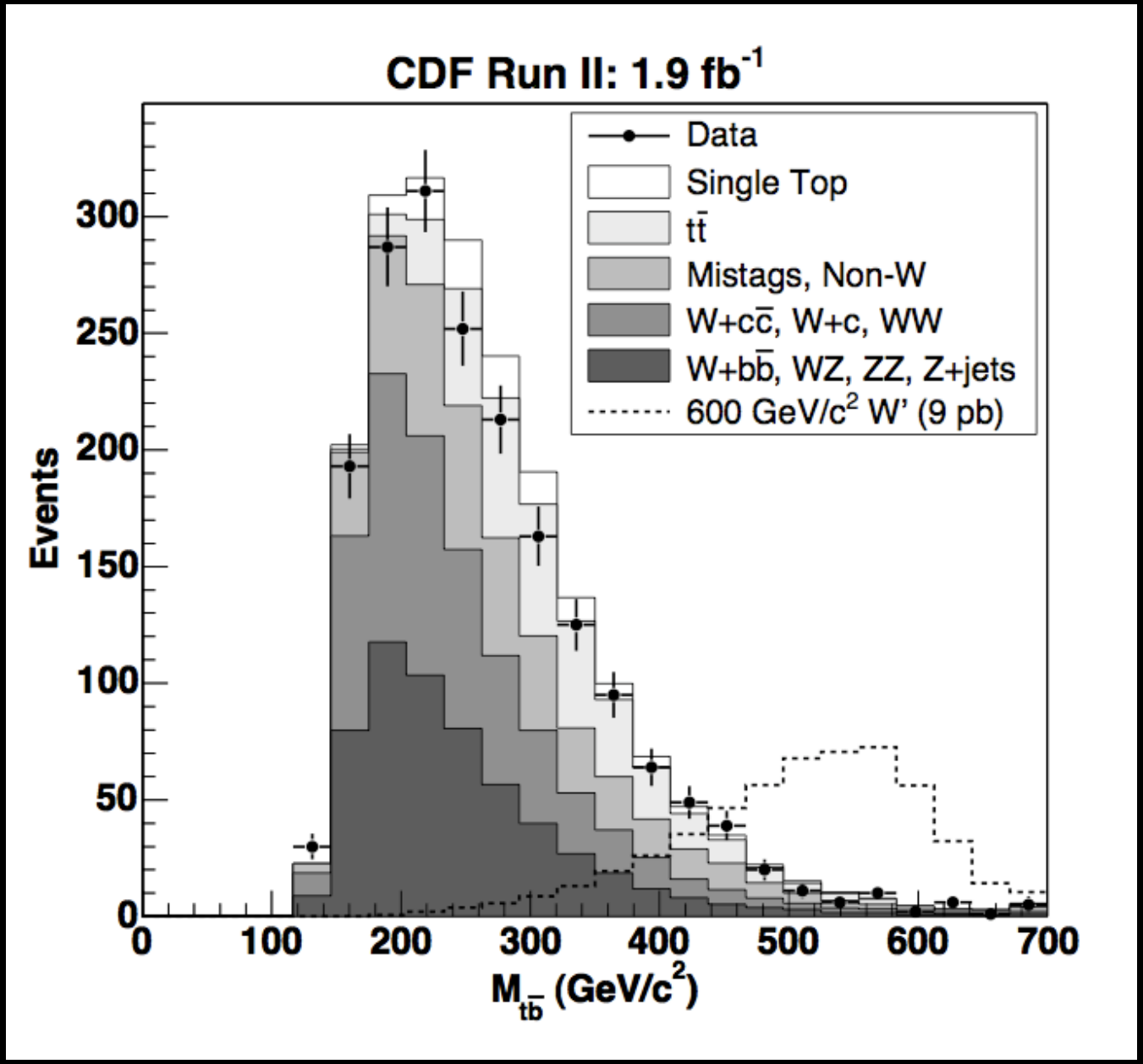
contribution to single top

single top 5σ observation
3.2 fb^{-1} arXiv:0903.0885

$$\sigma_{\rm exp} = 2.3^{+0.6}_{-0.5}\ {\rm pb}$$
$$\sigma_{\rm th} \sim 2.9\ {\rm pb}$$



tb candidate event
3.2 fb^{-1}
arXiv:0903.0885



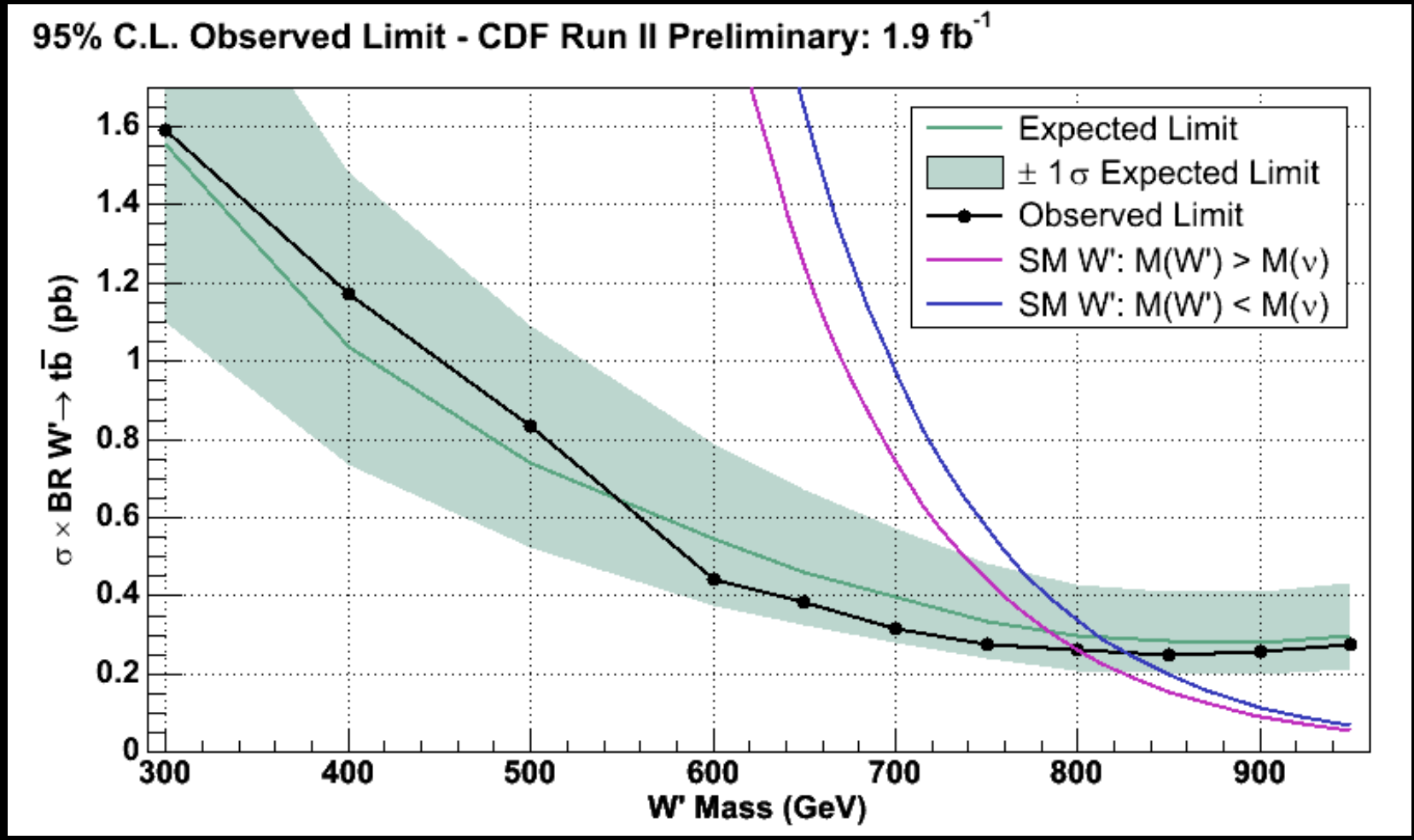
$\ell\nu bj(j)$

JJ: 1362
(1444 ∓ 255)

JJJ: 617
(682 ∓ 83)

$$\sigma(p\bar{p} \to W' \to t\bar{b} + \bar{t}b)_{600} \approx 2\ pb$$

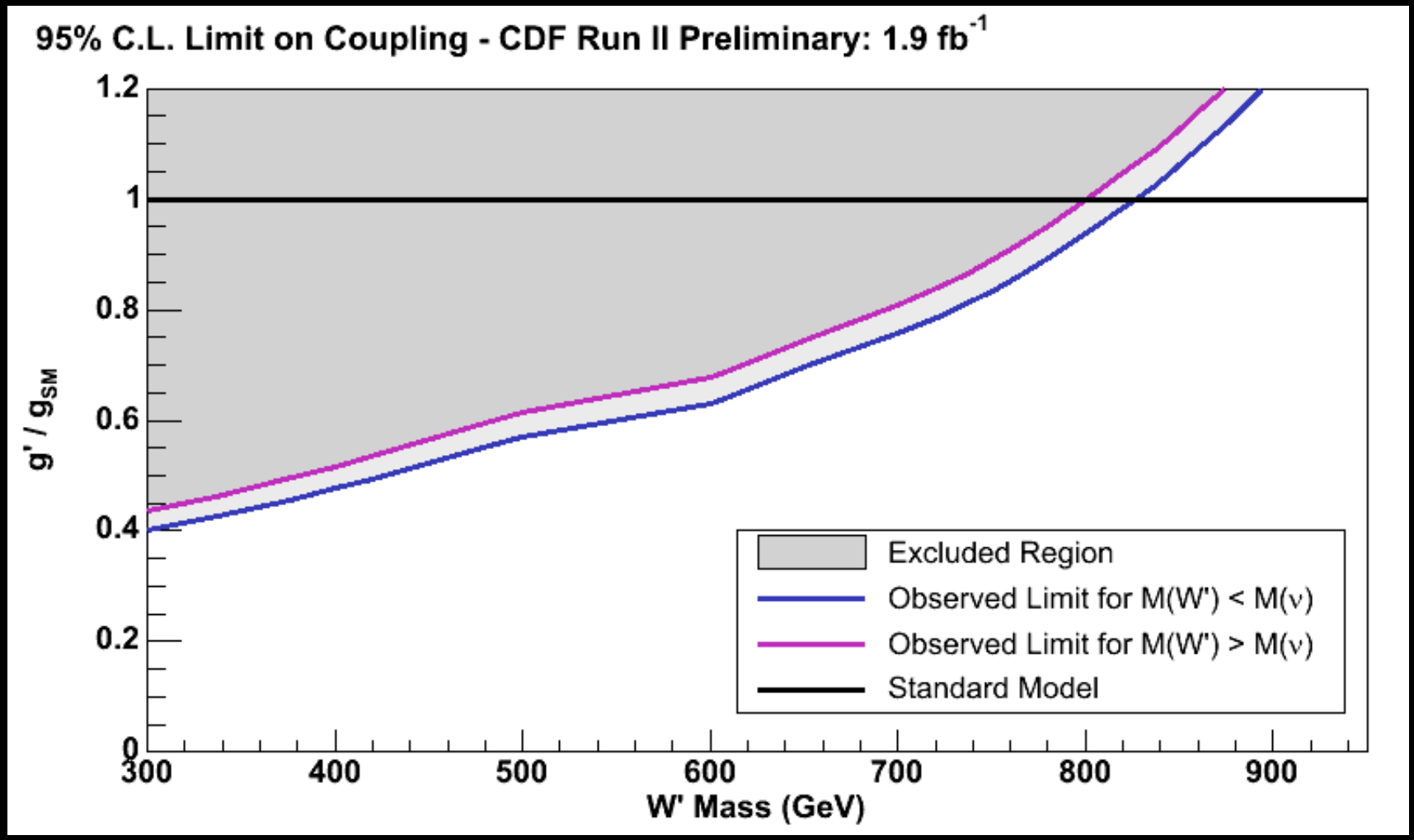
M. Gold for CDF SUSY-09 June 2009



$M_{W'} > 800$ GeV $(M_{W'} > M_{\nu_R})$

$M_{W'} > 825$ GeV $(M_{W'} < M_{\nu_R})$ ~~leptonic decays~~

limit in coupling-mass



also,

$M_T(e,\nu)$ 0.2 fb^{-1}: M < 788 GeV PRD 75 091101 (2007)

Summary of CDF Heavy Boson Searches

$mode$	$\mathcal{L}(\mathrm{fb}^{-1})$	$\mathrm{M}_{Z'}^{SM}$	$\mathrm{M}_{W'}^{SM}$
ee	2.5	$150 - 963$	
$\mu\mu$	2.3	$100 - 1030$	
$\tau\tau$	0.2	$120 - 399$	
jj	1.1	$320 - 740$	$280 - 840$
WW, WZ	2.9	$247 - 545$	$284 - 515$
tb	1.9		$300 - 950$

SM mostly near kinematic limit of Tevatron
signficantly weaker limits in particular models

STILL MORE DATA AND INTERESTING SEARCHES

lepto-phobic Z′ in top events-- see talk by Shulamit Moed