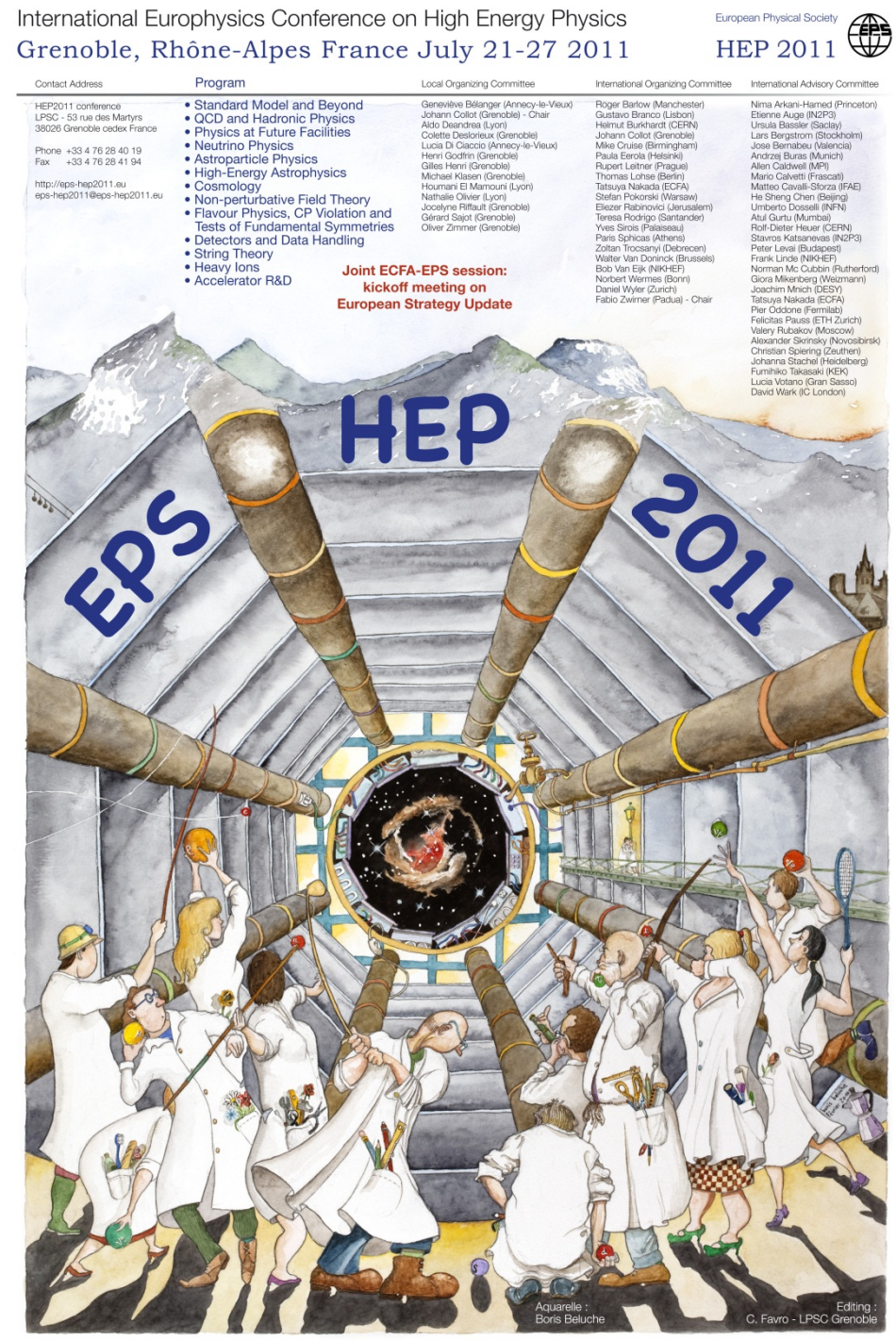


Legacy limits and hints of New Physics at the Tevatron

selection of results from the CDF and the DØ Collaborations

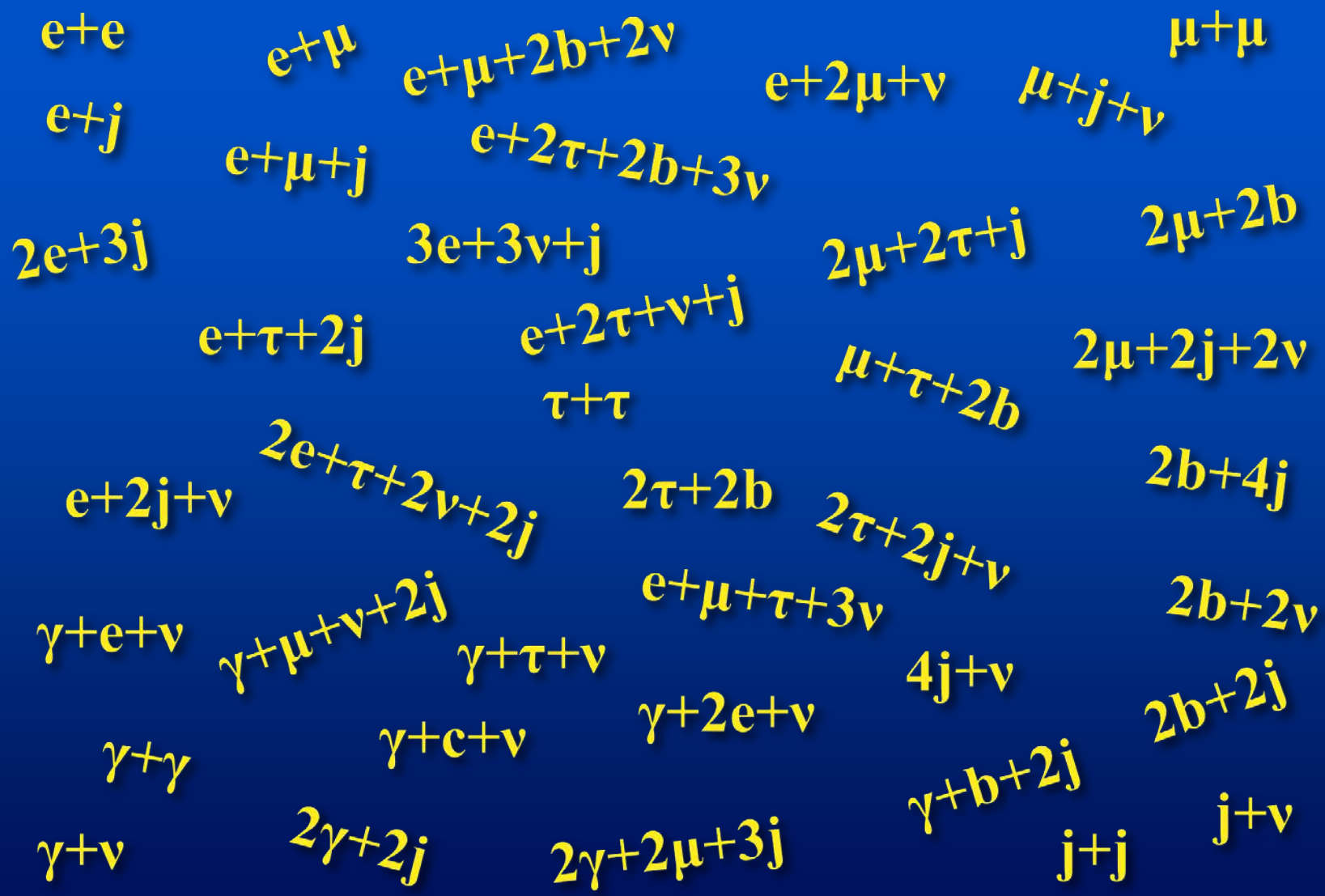
Arnaud Duperrin

Centre de Physique des Particules de Marseille

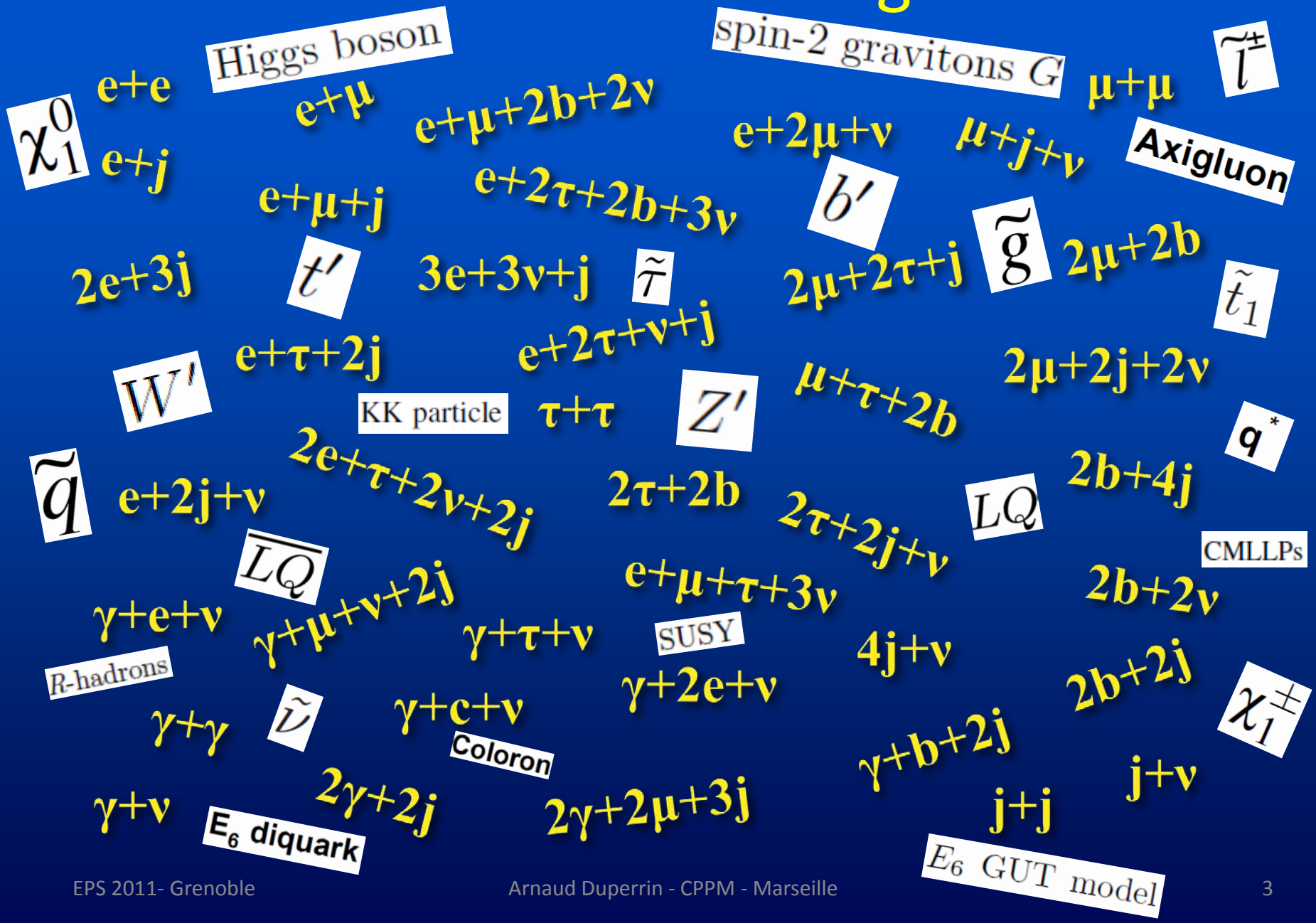
- New results for today include final states with:
  - dilepton
  - diboson
  - t-tbar

  + more exotic final states

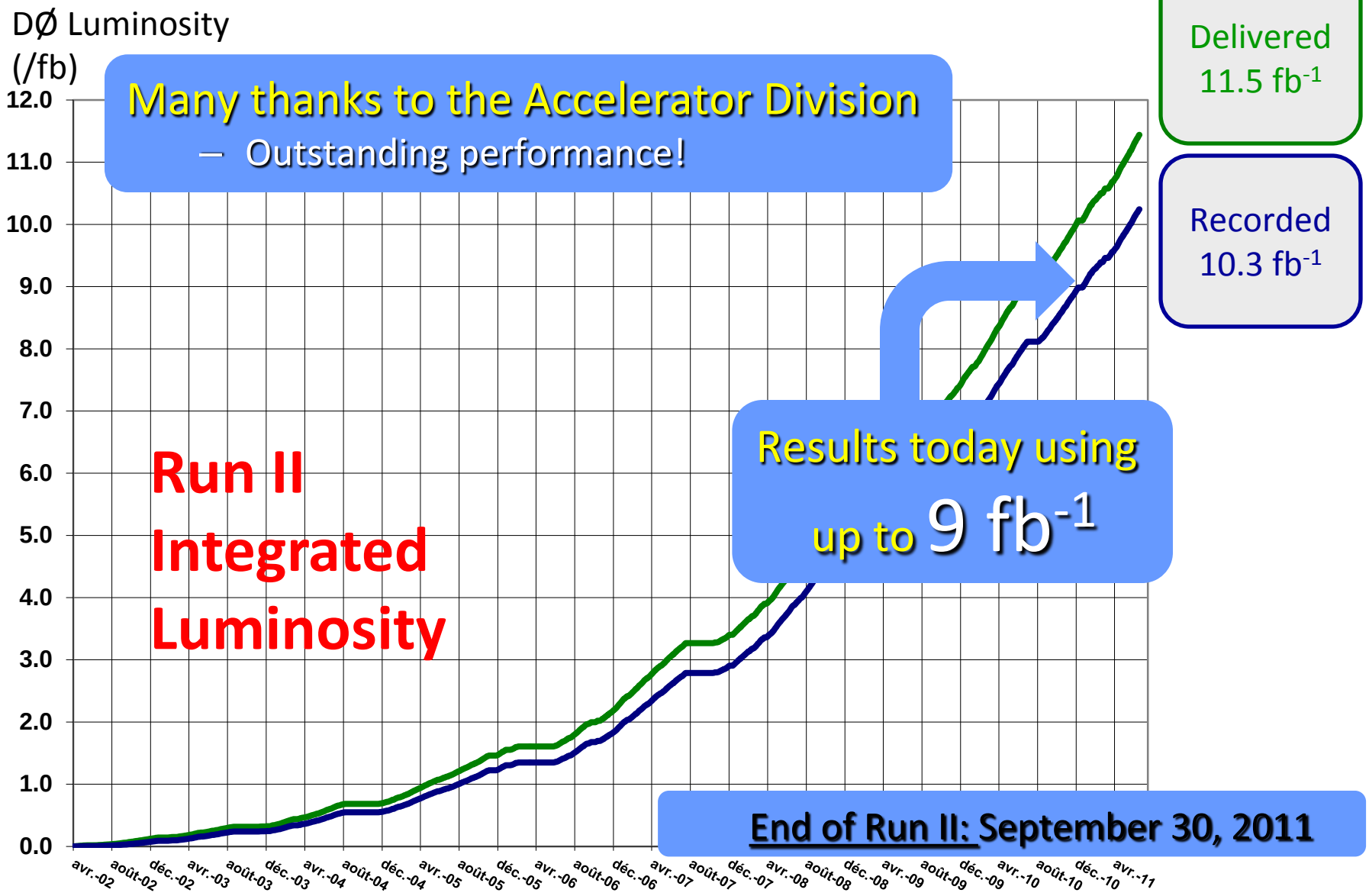
What are we looking for ?



What are we looking for ?

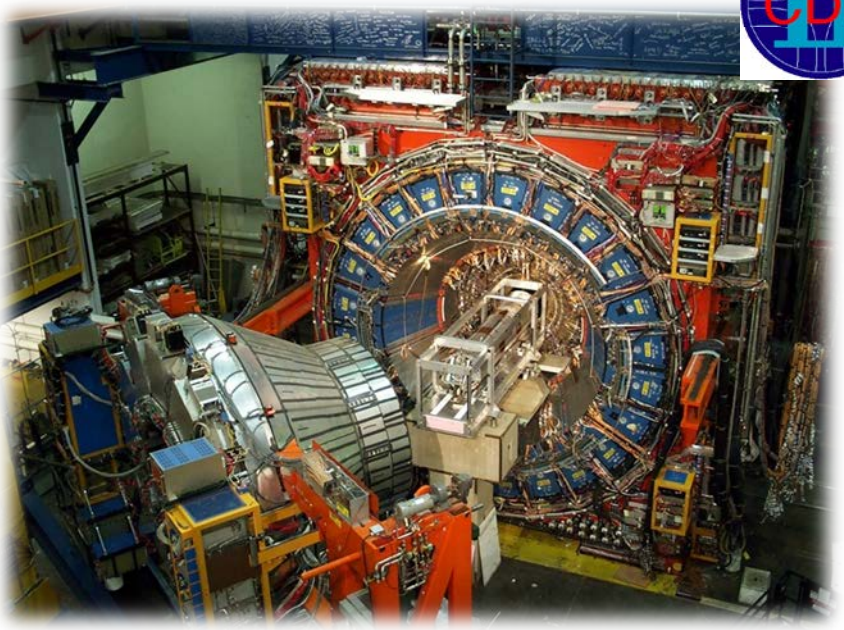


The Tevatron



The Detectors

Silicon Tracking, $|\eta|<3$
Scintillating Fiber Tracker
1.9 T B Field, $|\eta|<2$
LAr/U Calorimeter, $|\eta|<2.5$
Jet Energy Scale 1-2%
μ Drift/Scintillator Counters, $|\eta|<2$



Silicon Tracking, $|\eta|<2.5$
Open Drift Cell Tracker
1.4 T B Field, $|\eta|<1.1$
Pb/Cu/Scint Calorimeter, $|\eta|<3.2$
Jet Energy Scale 2-3%
μ Drift/Scintillator Counters, $|\eta|<1.4$

The data and the modeling

(differs from one analysis to another but this is a fair summary of what we are doing)

✓ Background Shapes:

- WW, WZ, ZZ
- single top
- t-tbar
- W+jets, Z+jets

→ Monte Carlo based

- QCD multijets

→ Data driven

✓ Background Normalization:

- WW, WZ, ZZ
- single top
- t-tbar
- Z+jets

→ Theory NLO or NNLO cross-sections

- W+jets
- QCD multijets

→ Fit to data

✓ Generators:

- WW/WZ/ZZ: PYTHIA (CDF & DØ)
- single top: PYTHIA (CDF), COMPHEP (DØ)
- t-tbar: PYTHIA (CDF), ALPGEN (DØ)
- W/Z+jets: ALPGEN (CDF & DØ)
- For signals: mostly PYTHIA (Z', RS Graviton, LQ, t', etc.) + appropriate k-factors for normalization (ex: PROSPINO)

✓ PDFs:

- CTEQ6L1 (DØ), CTEQ5L (CDF)

✓ + PYTHIA for showering.
✓ + GEANT3-based detector simulator

Getting the modeling of the SM right

✓ ALPGEN performs well but it is not the final answer
⇒ different generators have different predictions & uncertainty

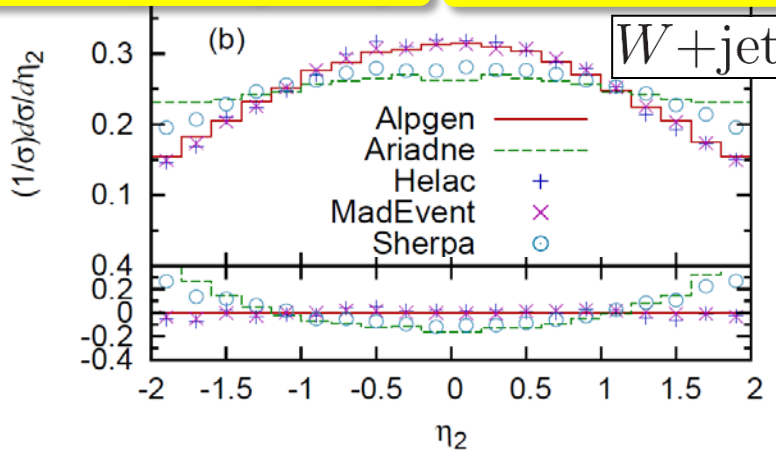
⇒ use parameterized functions to correct kinematic variables

EPJC 53, 473 (2008)

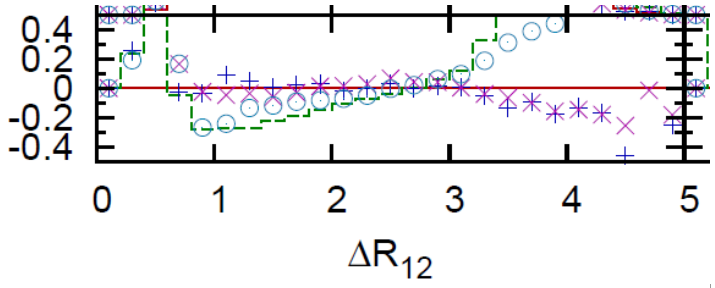
arXiv:0706.2569

W+jets

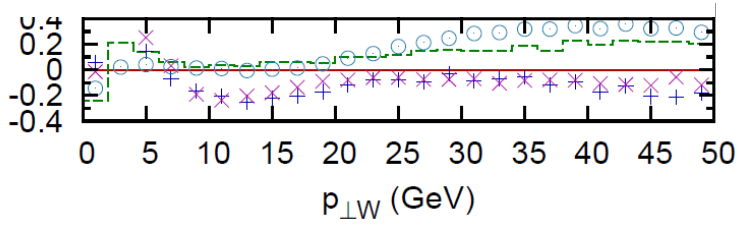
Jet η



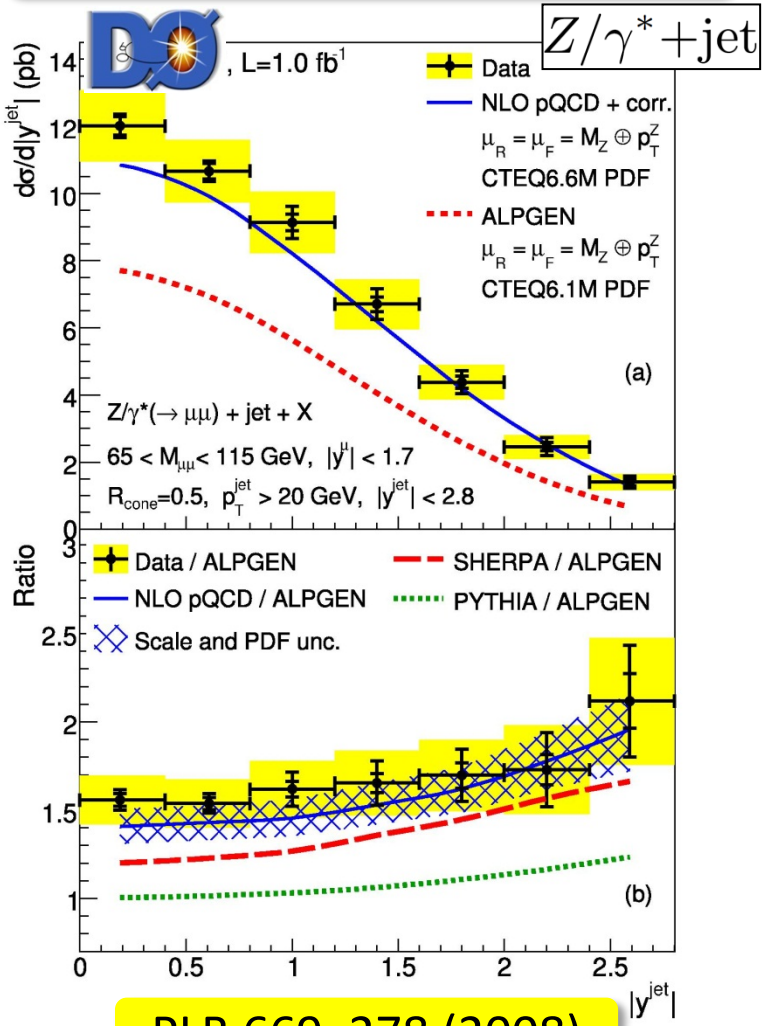
ΔR(jet1, jet2)



$p_T(W)$



Z/γ^*+jet



PLB 669, 278 (2008)

For more details, see talks in parallel sessions.

Name of speakers are given in the following slides.

My focus for today

Dilepton final states:

- Z'→ee, μμ
- RS Graviton → ee, μμ, (+γγ)

Diboson final states

- RS Graviton → WW, ZZ
- WX→Wjj

t-tbar final states:

- b'→tW
- t'→tW, qW, bW, tX
- Z'→ t-tbar

Leptoquark:

- LQLQ→eνjj

Other exotic final states:

- Charged long lived particles
- Signature-based searches

+ Other hints of new physics

Dilepton Final States

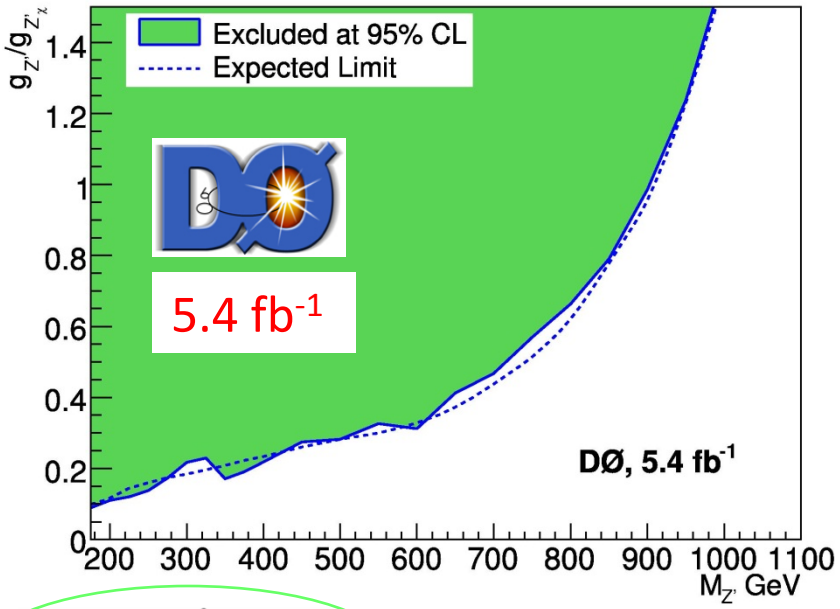
Z'→ee

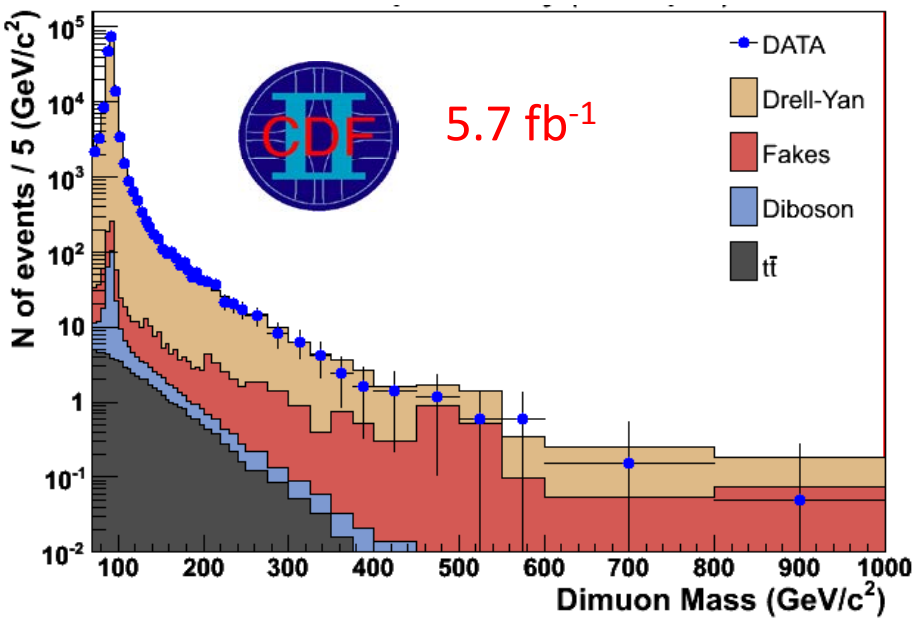
PLB 695, 88 (2011)

- ✓ Look for bump in dilepton mass spectrum

Z'→μμ

CDF public note 10165





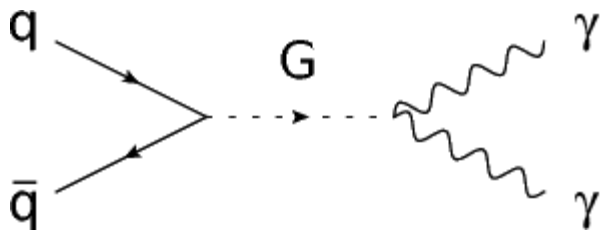
CMS preliminary, $\int$ Ldt = 1.1fb^{-1}

1940 GeV

Sequential V'

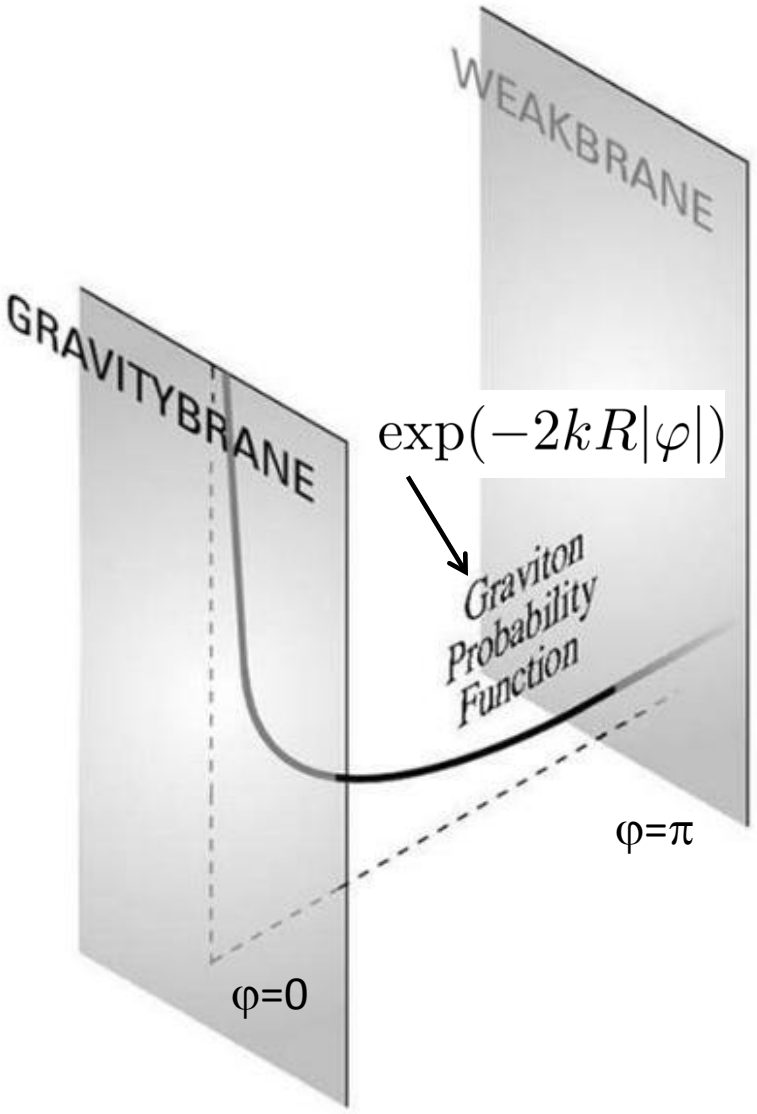
X→	eν	ee	μμ	eμ	ττ	qq	tt	tb	WZ
Limits (GeV)	1120	1023	1071	700	399	740	900	885	180-690

Extra Dimension



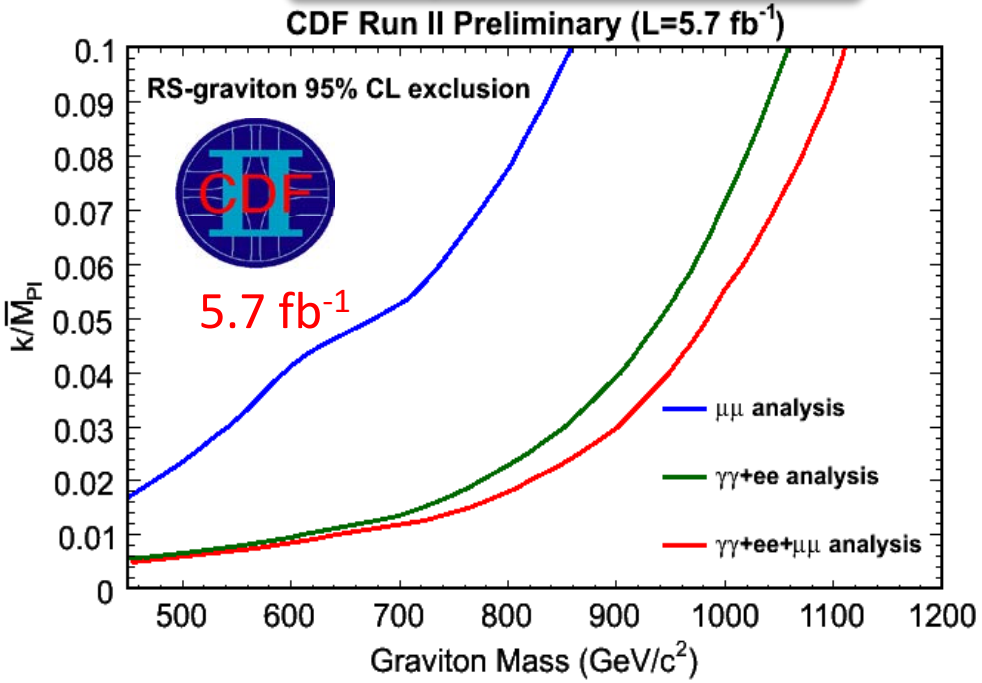
- ✓ Example: 5 dimensional warped geometry as in Randall and Sundrum model

- ✓ 2 experimental parameters:
  - First exited graviton mass
  - k/M_{PL} : coupling of the graviton to SM fields



Randall-Sundrum Gravitons $\rightarrow \mu\mu$ (+ee+$\gamma\gamma$)

CDF public note 10479

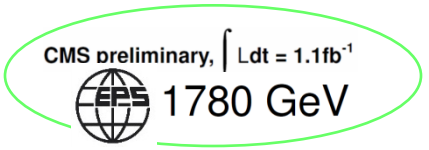


- ✓ Both CDF and DØ combine the ee and $\gamma\gamma$ searches
- ✓ CDF adds the $\mu\mu$ final state

- ✓ New: inclusion of $\mu\mu$ in the ee+$\gamma\gamma$ RS search

(results in a 33% increase in the rate of potentially produced signal).

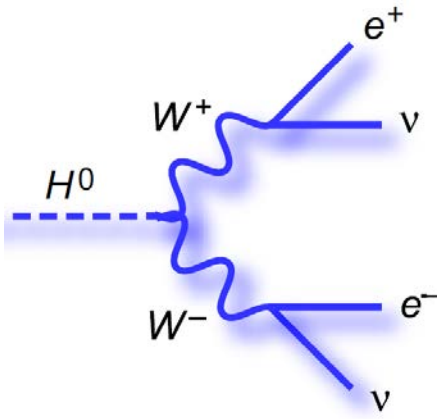
✓ strongest limits to date …before EPS



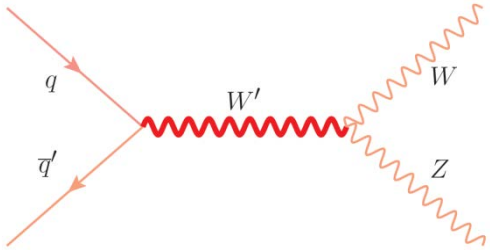
RS-G. k/M_{pl}=0.1

ee	$\gamma\gamma$	$\mu\mu$	ee+$\gamma\gamma$	$\mu\mu$+ee+$\gamma\gamma$	WW	ZZ
914	963	859	1058	1111	300-754	600

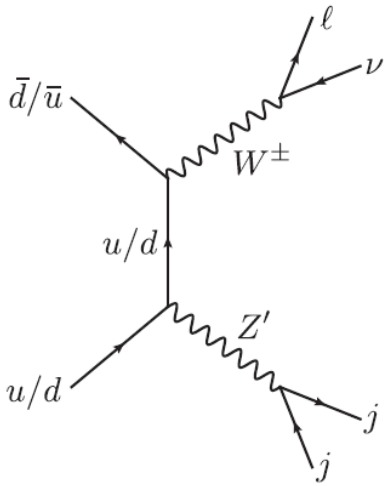
Diboson Final States



Higgs

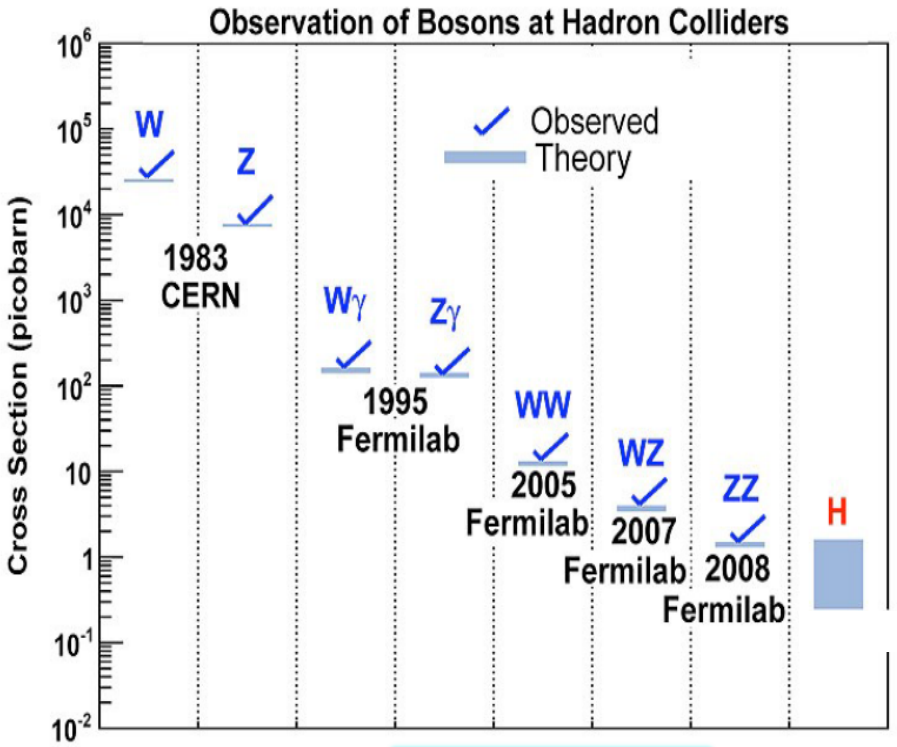


W'



Z'

- ✓ Some trends are repeating…
- ✓ Reality check for BSM searches



Ursula Bassler

WZ/ZZ with $Z \to b\bar{b}$

Thibault Guillemin

High-mass resonances decaying into Z boson pairs

CDF public note 10603

6 fb^{-1}

Aidan Robson

✓ Three final states are analysed:

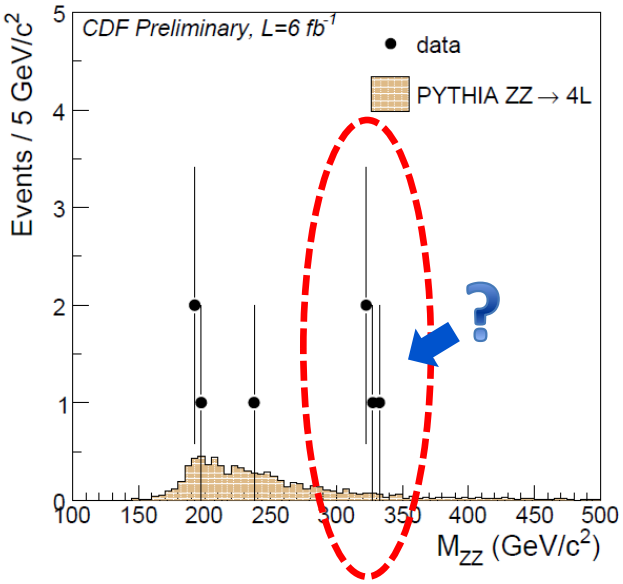
$ZZ \to \ell^+\ell^-\nu\nu$ ✓ OK

$ZZ \to \ell^+\ell^- jj$ ✓ OK

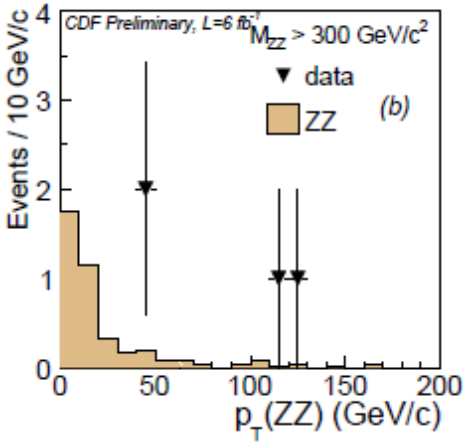
$ZZ \to \ell^+\ell^-\ell^+\ell^-$

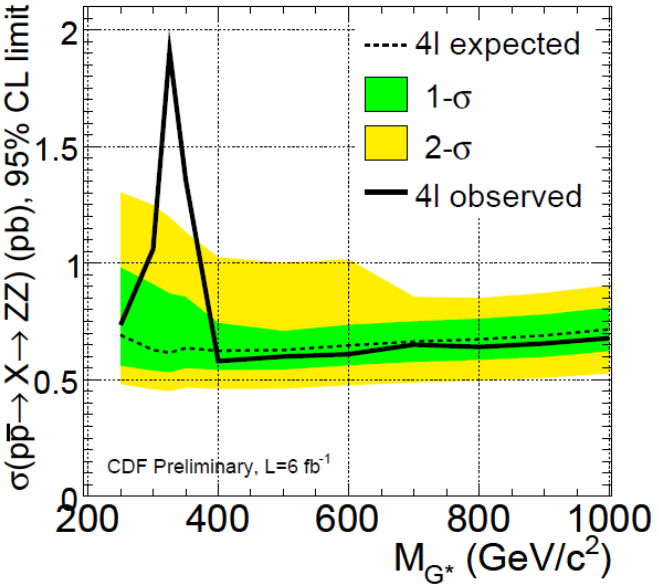
✓ Excess (4 events) ~ M_{ZZ}=325 GeV

$ZZ \to \ell^+\ell^-\ell^+\ell^-$ channel



have unexpected high values of p_T (ZZ)





RS-G. k/M_{pl}=0.1

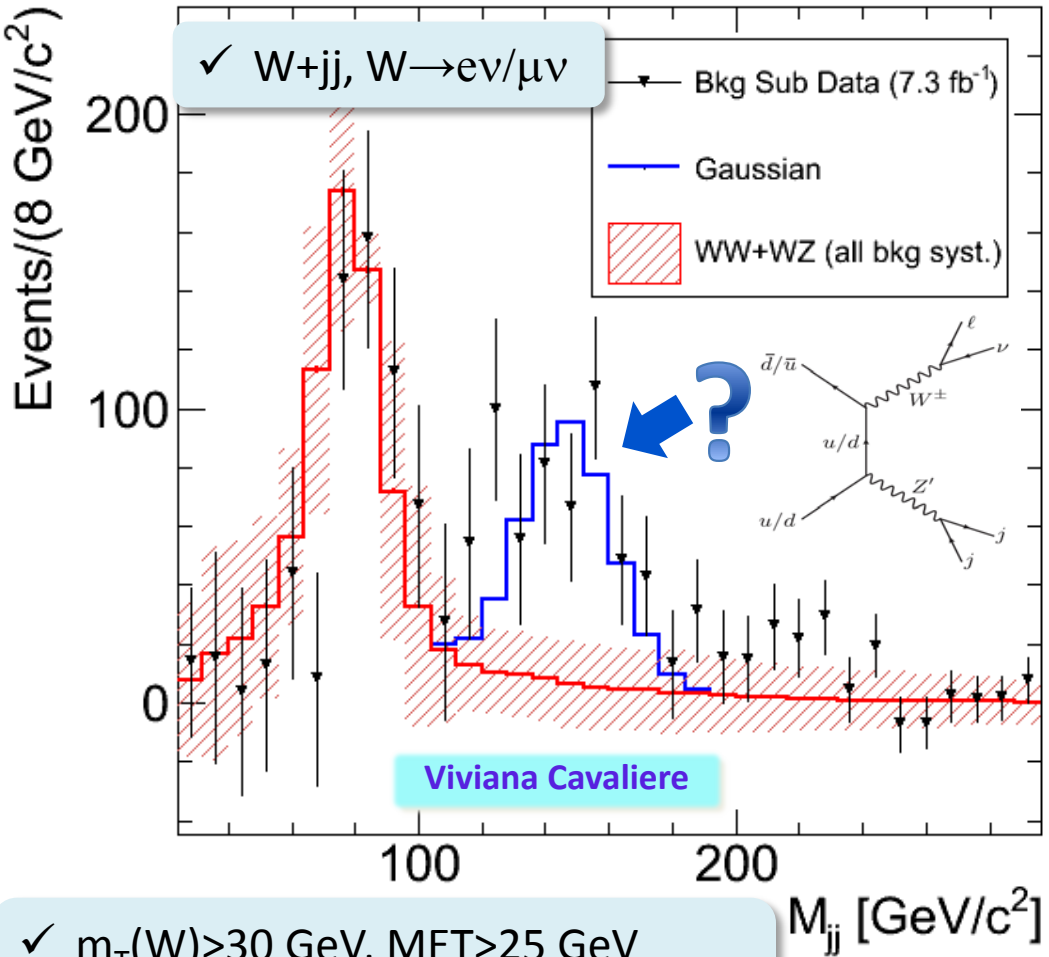
ee	γγ	μμ	ee+γγ	μμ+ee+γγ	WW	ZZ
914	963	859	1058	1111	300-754	~600

CDF: a bump in W+jets data

7.3 fb^{-1}

PRL 106, 171801 (2011)

7.3 fb^{-1} analysis is at: http://www-cdf.fnal.gov/physics/ewk/2011/wjj/7_3.html



- ✓ In the lνjj final state, CDF has reported an excess of events in the dijet mass spectrum around M_{jj}=150 GeV.

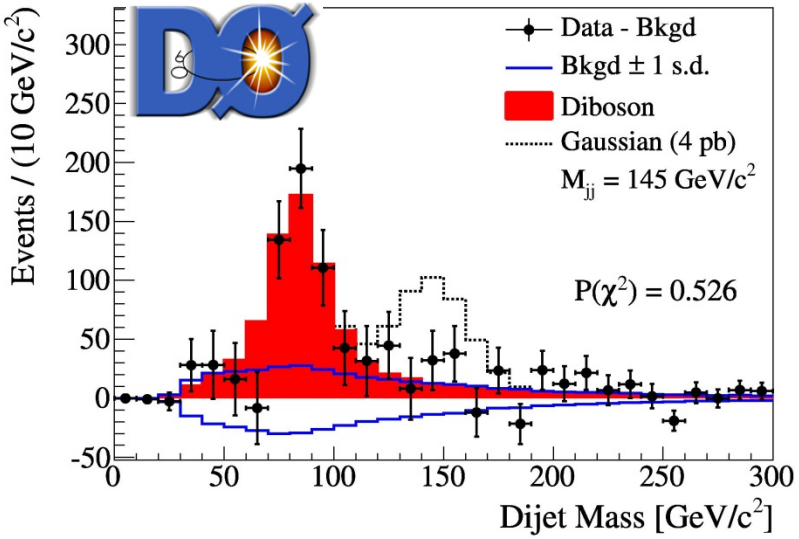
- ✓ Significance of excess now exceeds 4σ.
- ✓ σ(WX) ~ 4 pb
  - ✓ ± 2 pb (larges uncertainties).
  - ✓ no theory on the market supports 4 pb.

- ✓ m_T(W)>30 GeV, MET>25 GeV
- ✓ 2 jets p_T>30 GeV, p_T(jj)>40 GeV

See also ATLAS report on Thu. 21/7
ATLAS-CONF-2011-097

Perhaps no bump in the W+jets data

4.3 fb^{-1} PRL 107, 011804 (2011)

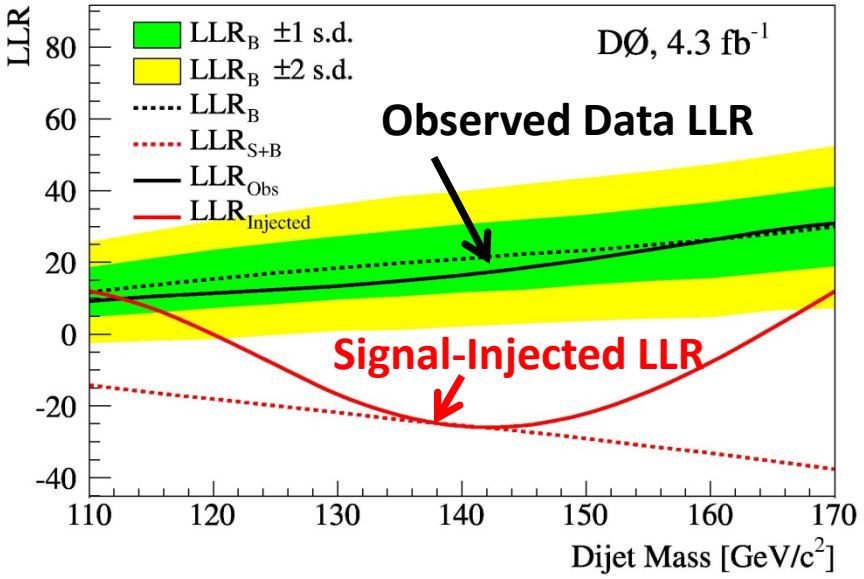


✓ DØ mirrors what was done in the CDF analysis.

✓ no evidence for such an excess, ruling out a particle with a σ=4 pb at the 4.3σ level.

✓ Could DØ have missed it?

✓ D0 clearly would have seen a 4 pb excess if it had been in the data.



Jadranka Sekaric

Getting the modeling of the SM right

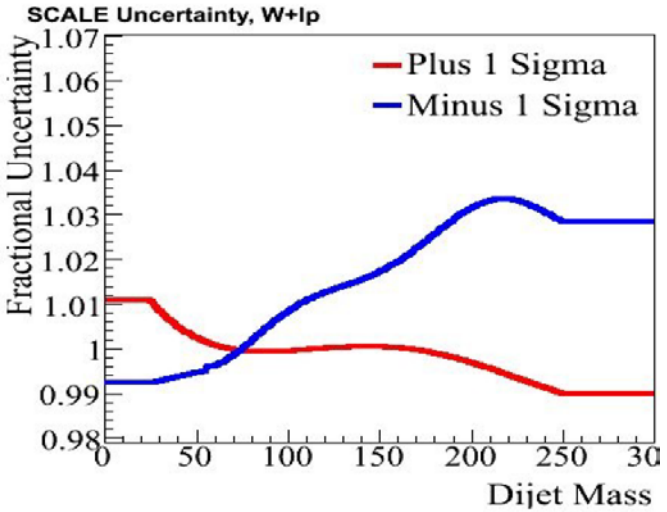
✓ The CDF analysis did not apply corrections to ALPGEN modeling

⇒ to parallel the CDF analysis, DØ performs the analysis without these corrections.

✓ CDF/DØ includes uncertainties on the modeling of these variables.

Ex for DØ :

- ALPGEN η and $\Delta R(jet1, jet2)$ corrections
- ALPGEN W p_T correction
- Re-weighting Diboson bias
- Renormalization and factorization scales
- ALPGEN parton-jet matching parameters



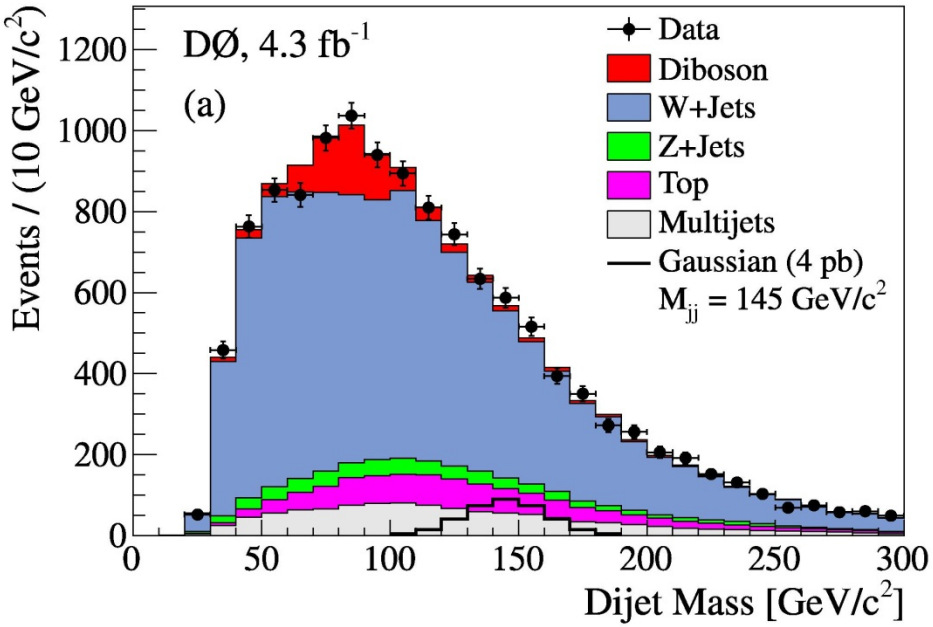
+ assigns uncertainties on ALPGEN parameters (parton-jet matching, parton shower model, renormalization/factorization scale), PDF etc..

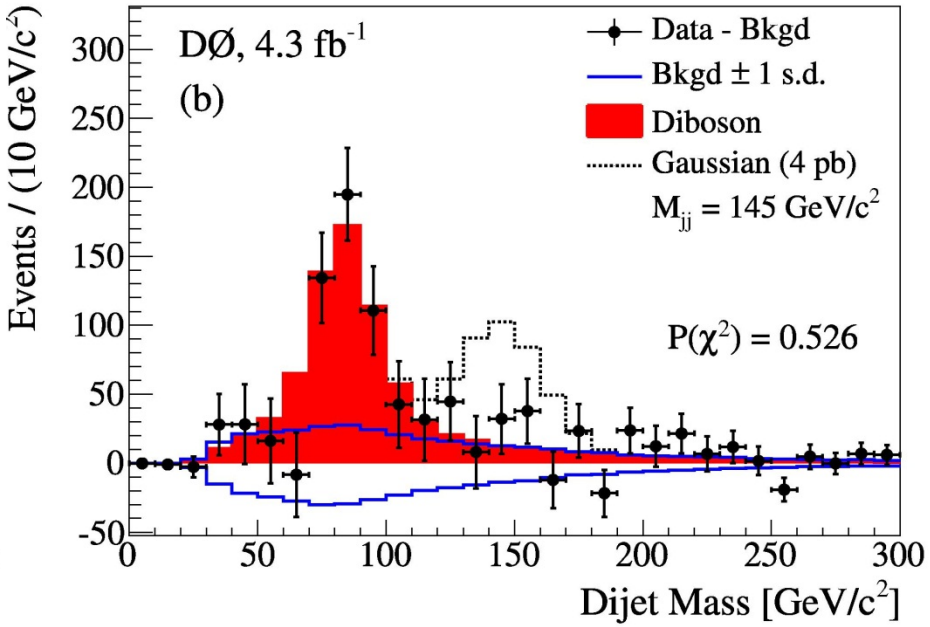
Getting the modeling of the SM right

✓ To show that these corrections would not alter the conclusion
⇒ DØ also present results with/without these corrections.

WITHOUT

kinematic corrections to the simulation





Getting the modeling of the SM right

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WITH

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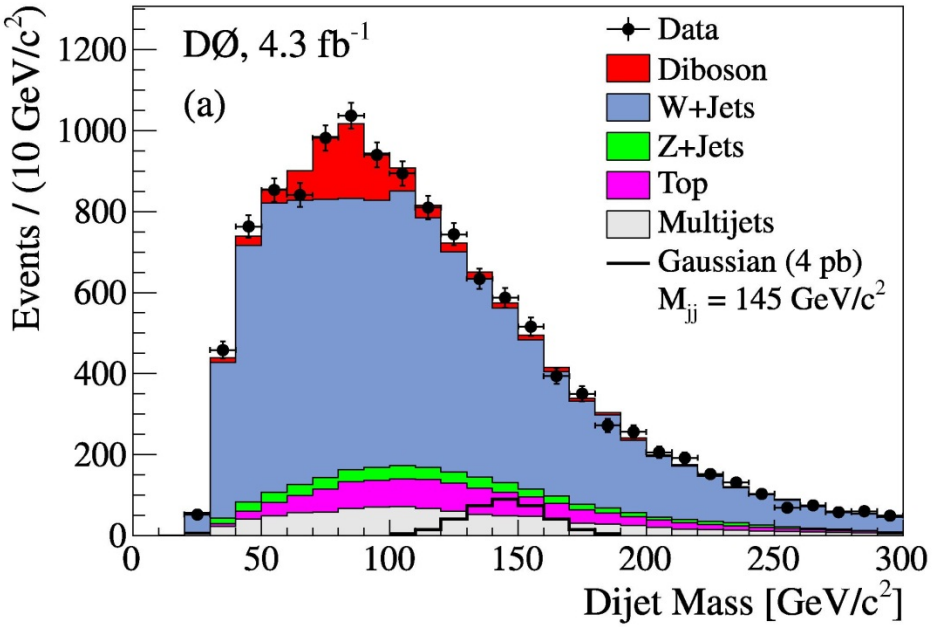
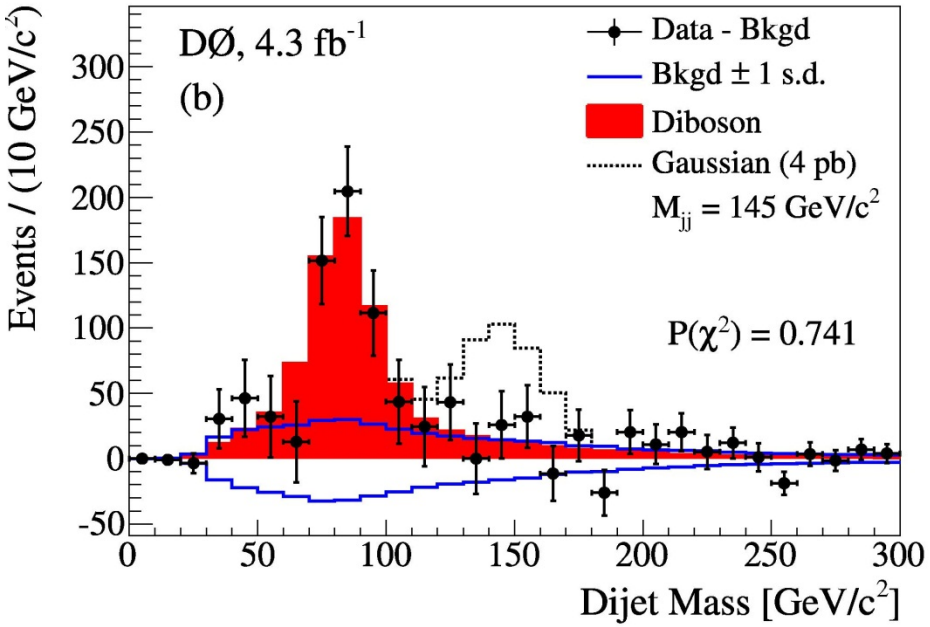


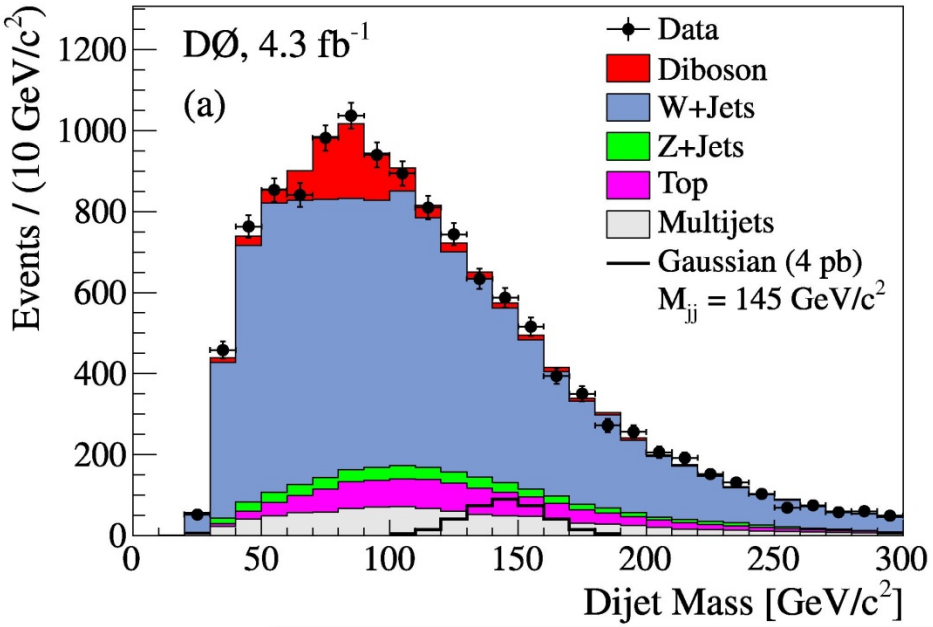


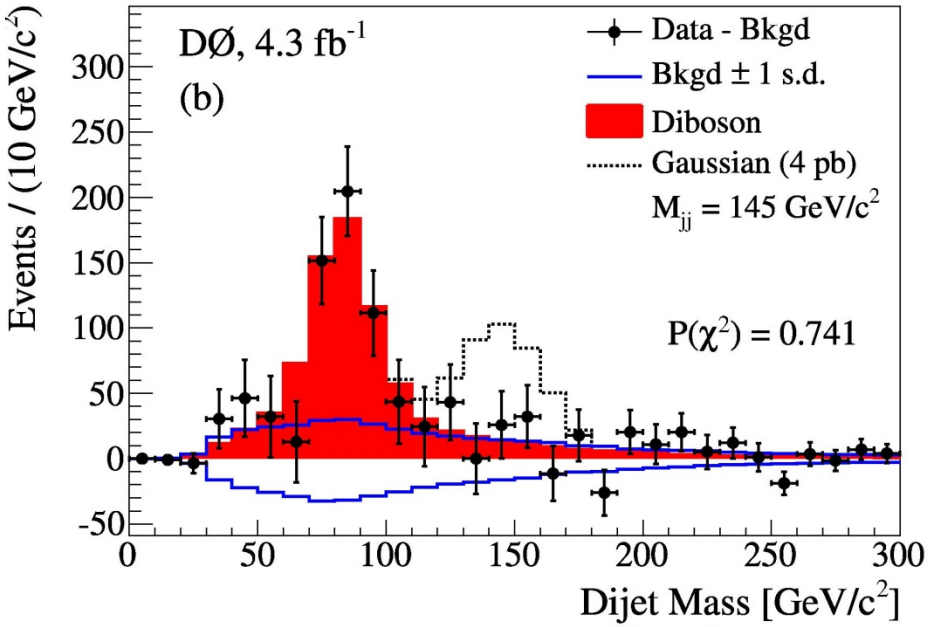
Getting the modeling of the SM right

✓ To show that these corrections would not alter the conclusion
⇒ DØ also present results with/without these corrections.

WITH

kinematic corrections to the simulation



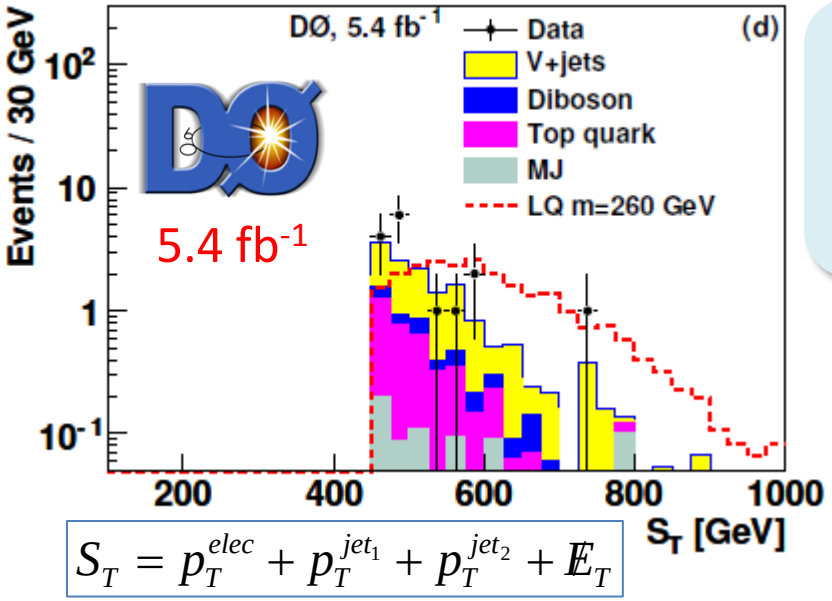


✓ No large change
✓ But improves the modeling (higher χ^2 probability)

$P(\chi^2) = 0.526 \rightarrow 0.741$

Leptoquarks

in the electron + missing energy + jets final state

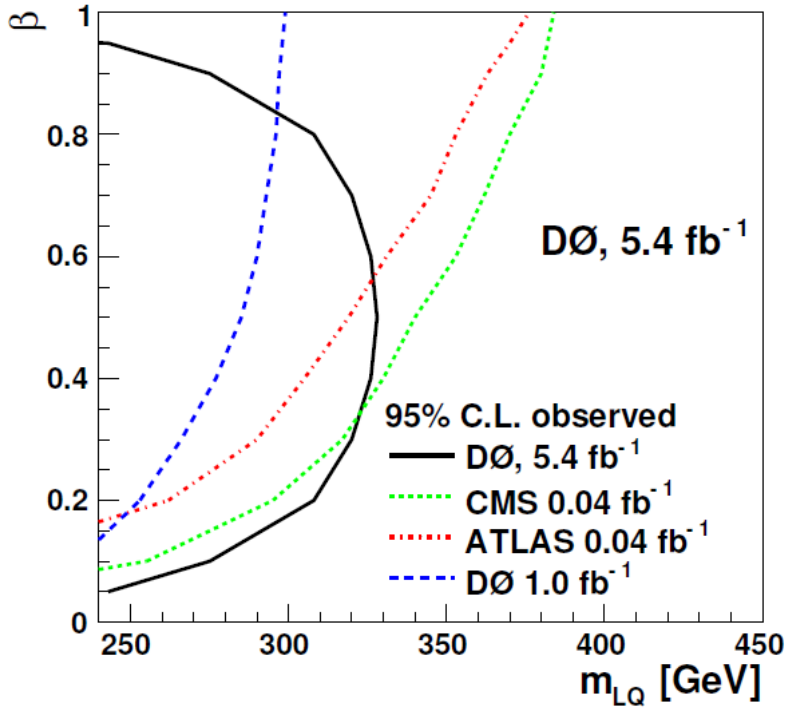


$$S_T = p_T^{elec} + p_T^{jet_1} + p_T^{jet_2} + \not{E}_T$$

✓ connecting the quarks and leptons is predicted by many extensions of the SM (SUSY, GUTs, string theory…)

β = BR(LQ → eq)

arXiv:1107.1849 (2011)



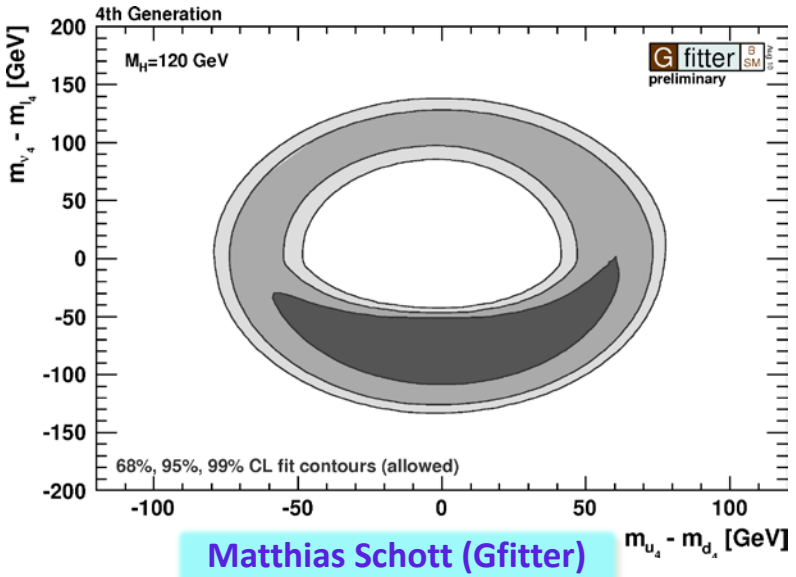
✓ M_{LQ} < 326 GeV for β=0.5

✓ Tevatron's 5.4 fb^{-1} set still slightly more stringent limits than LHC for β<0.35

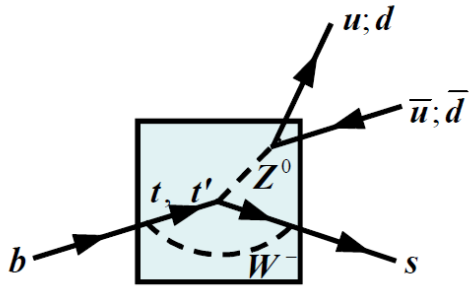
Top anti-Top Final States

✓ 4th family

With appropriate mass differences: 4th fermion model consistent with EW data



Matthias Schott (Gfitter)



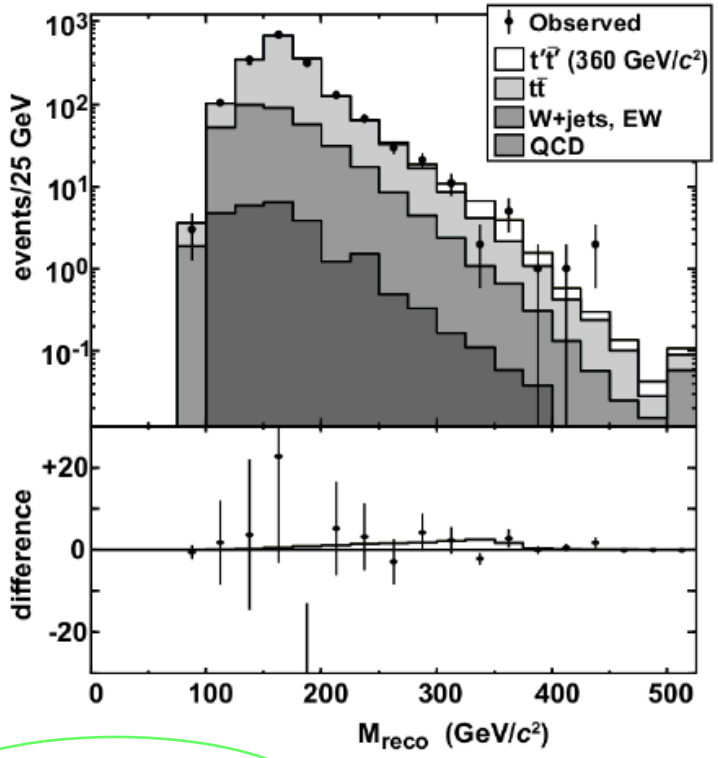
CKM 4x4 ⇒ New source of CPV

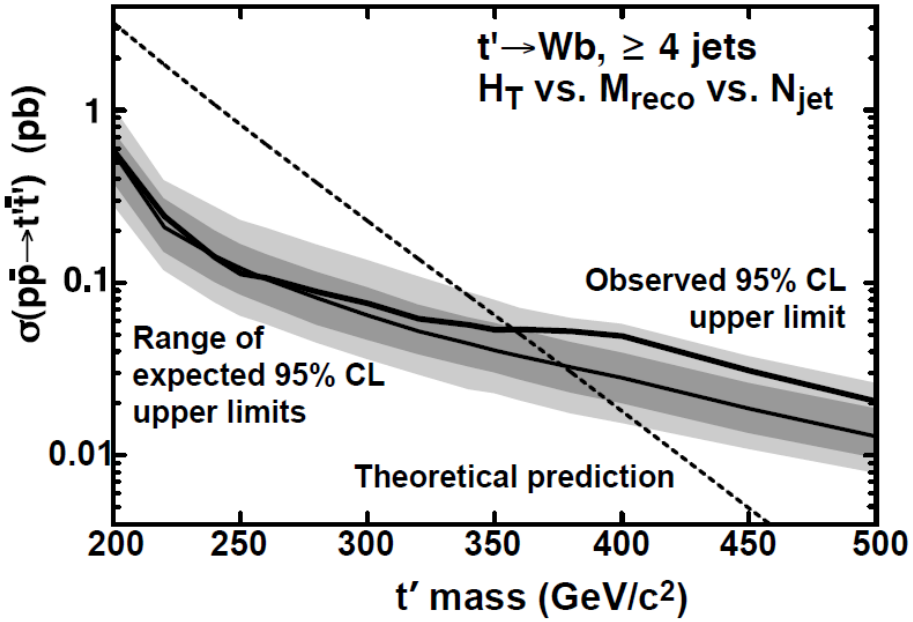
W. S. Hou, arXiv:0803.1234
"Source of CP Violation For Baryon Asymmetry of the Universe,"

t'→bW

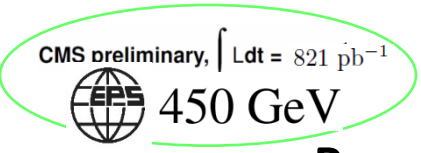
5.6 fb^{-1}

1107.3875 (2011)



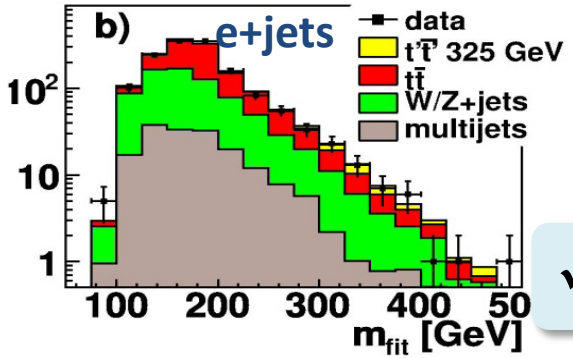


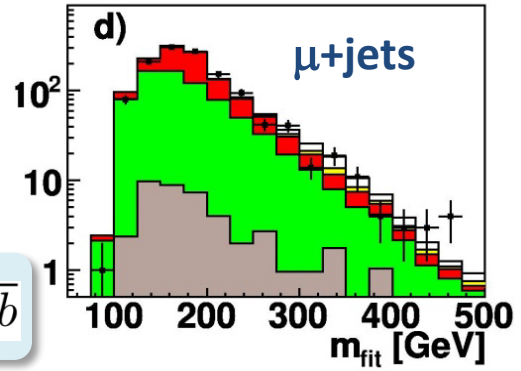
- ✓ assume that the new quark is heavier than the top (172.5 GeV).
- ✓ at least one tagged b-jet.
- ✓ a binned likelihood fit in both H_T and reconstructed t' mass.



Process	4th generation b'→tW	t'→qW	t'→bW	t'→tX	VQ qW	qZ
Limits (GeV)	372	340	358	360	693	551

$t' \rightarrow qW$

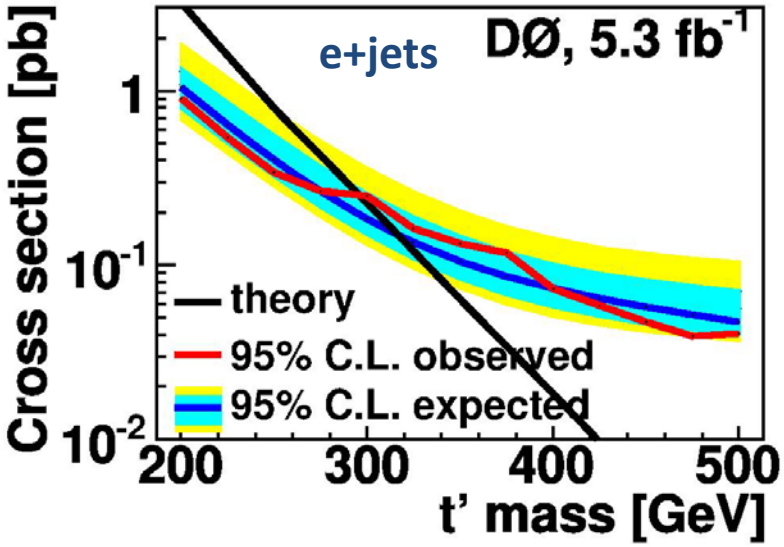


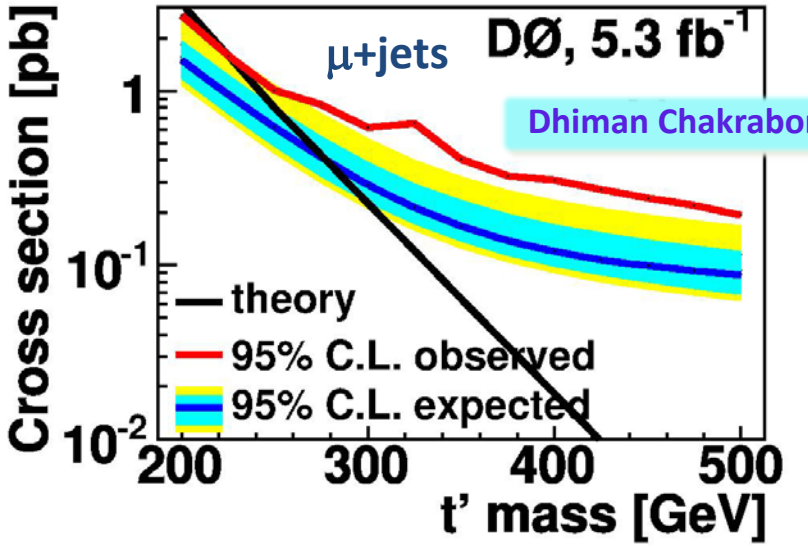


5.3 fb^{-1}

arXiv:1104.4522 (2011)

✓ A kinematic fit to $t'\bar{t}' \rightarrow \ell\nu bq\bar{q}'\bar{b}$





Dhiman Chakraborty

✓ small excess (2.5σ) in the μ+jets channel at ~325 GeV

✓ the expected limit is 320 GeV for e+μ combined

Process	b'→tW	t'→qW	t'→bW	t'→tX
Limits (GeV)	372	285	358	360

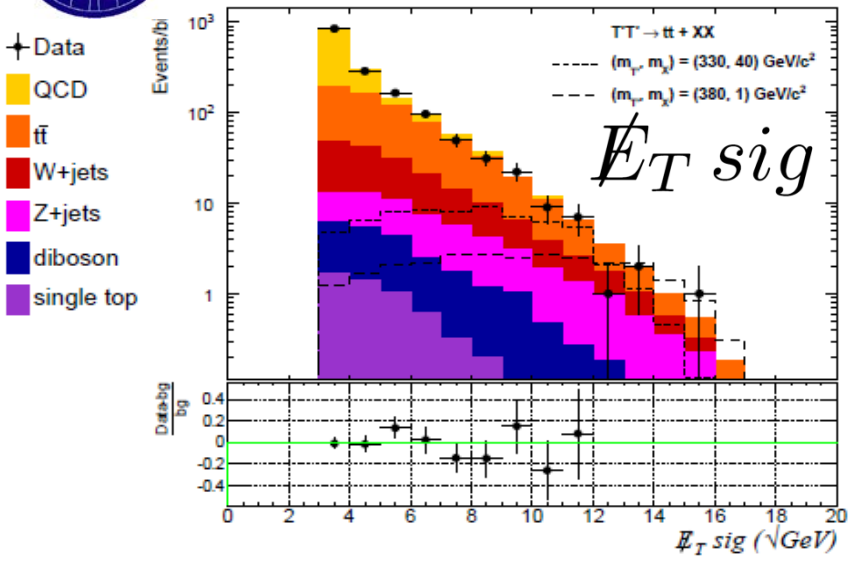
CDF: t'→qW
340

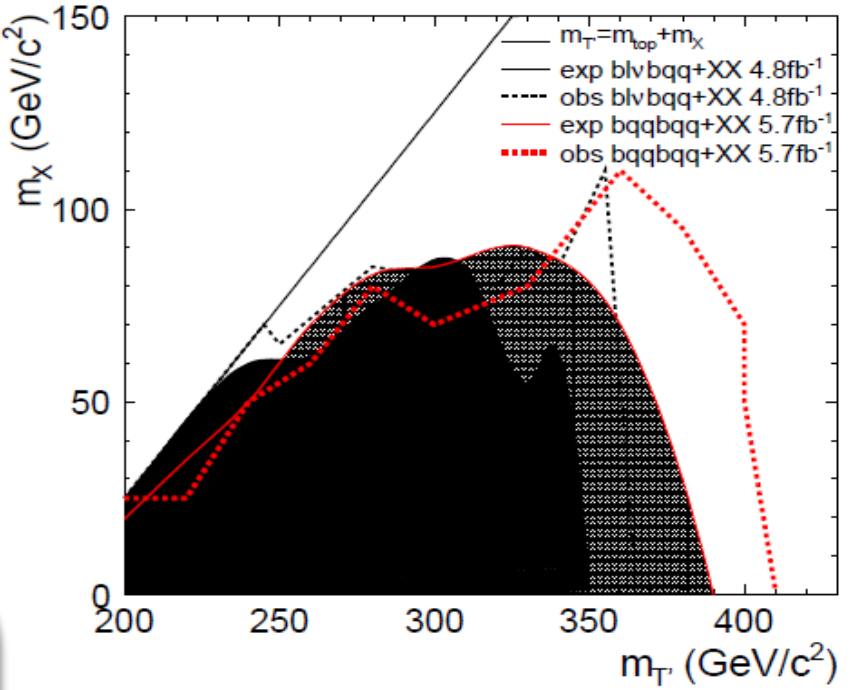
Top + Invisible

5.7 fb^{-1}

$p\bar{p} \to T'\bar{T}' \to t\bar{t} + X\bar{X}$

1107.3574 (Jul. 2011)





- ✓ 4th generation may be t' decaying via $t' \to t + X$
- ✓ *X* can be dark matter (i.e. invisible in the detector)
- ✓ in the all-hadronic t-tbar samples $\to bq\bar{q}\,\bar{b}q\bar{q} + X\bar{X}$

$5 \leq N_{jets} \leq 10$

No excess at large MET ⇒

- exclude t' below 400 GeV (for m_X<70 GeV).
- can also be interpreted as $\tilde{t} \to t + \chi^0$

Z'→t-tbar

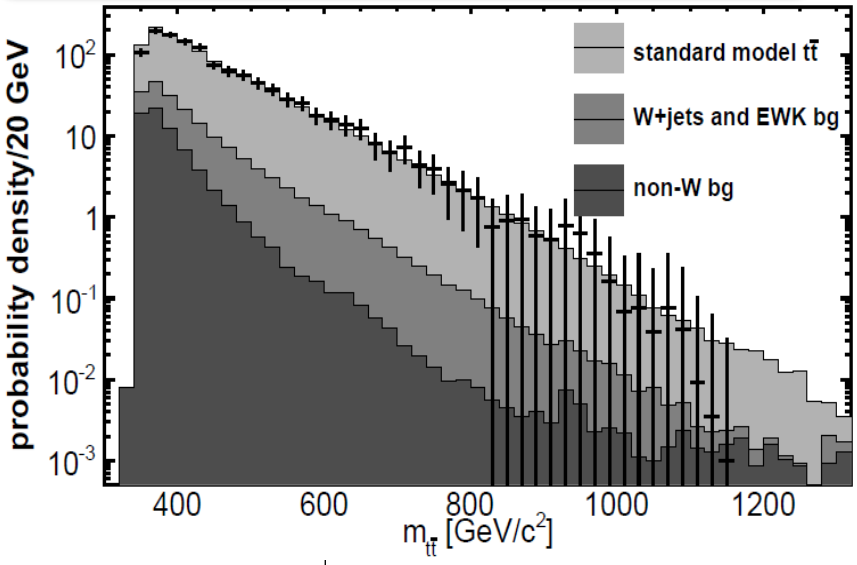
4.8 fb^{-1}

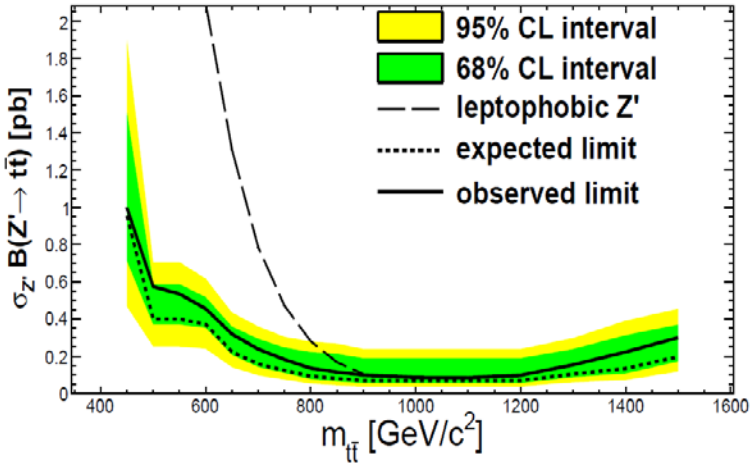
- ✓ Sensitive to Z', KK excitations, axigluons or strong dynamics to name a few.

- ✓ search for resonant production of t-tbar.
- ✓ lepton+jets samples.

CDF public note 10468

- ✓ Assume narrow resonance.





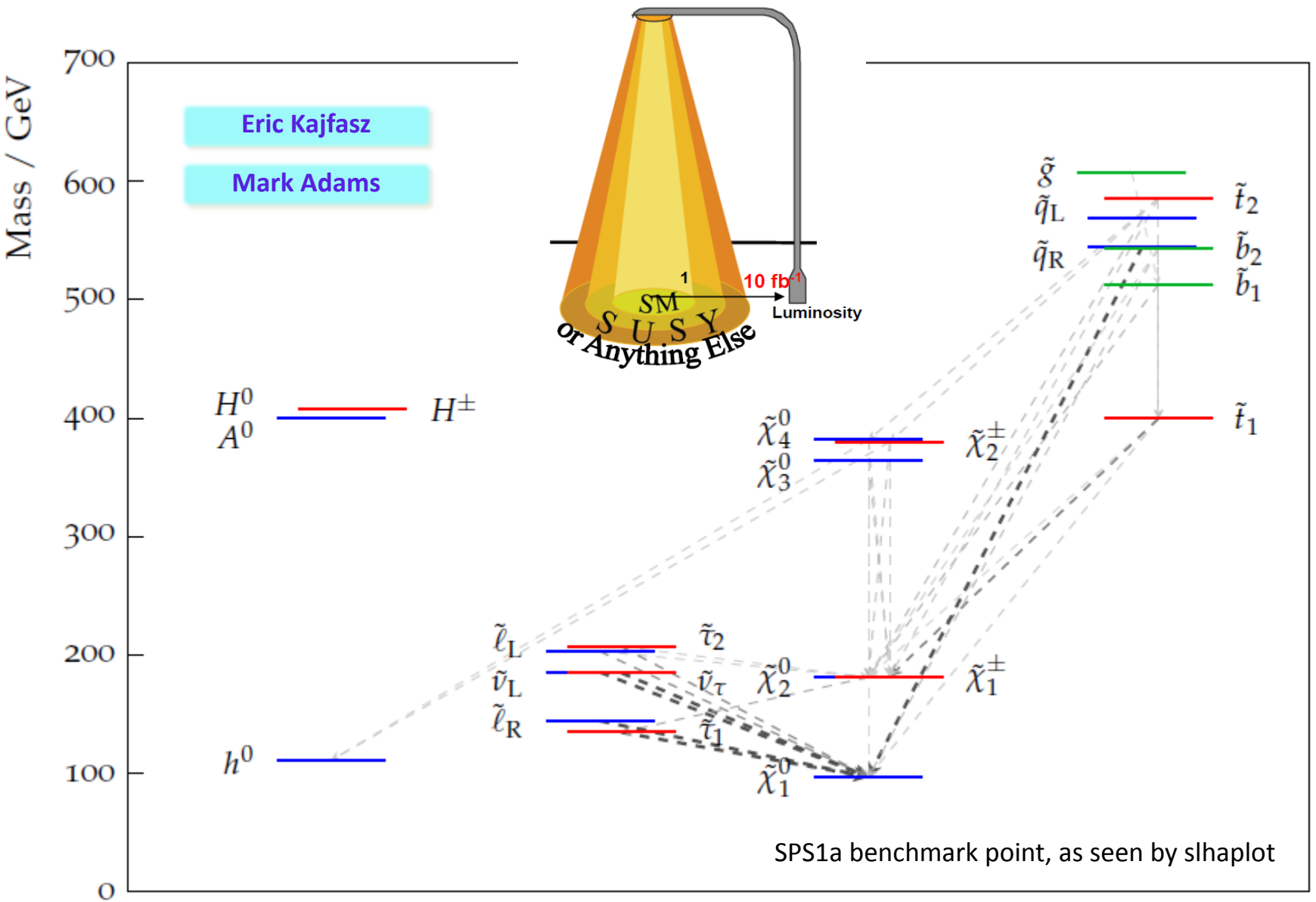
- ✓ strongest limits to date for leptophobic topcolour model.

X→	eν	ee	μμ	eμ	ττ	qq	tt	tb	WZ
Limits (GeV)	1120	1023	1071	700	399	740	900	885	180-690

No stone left unturned ?

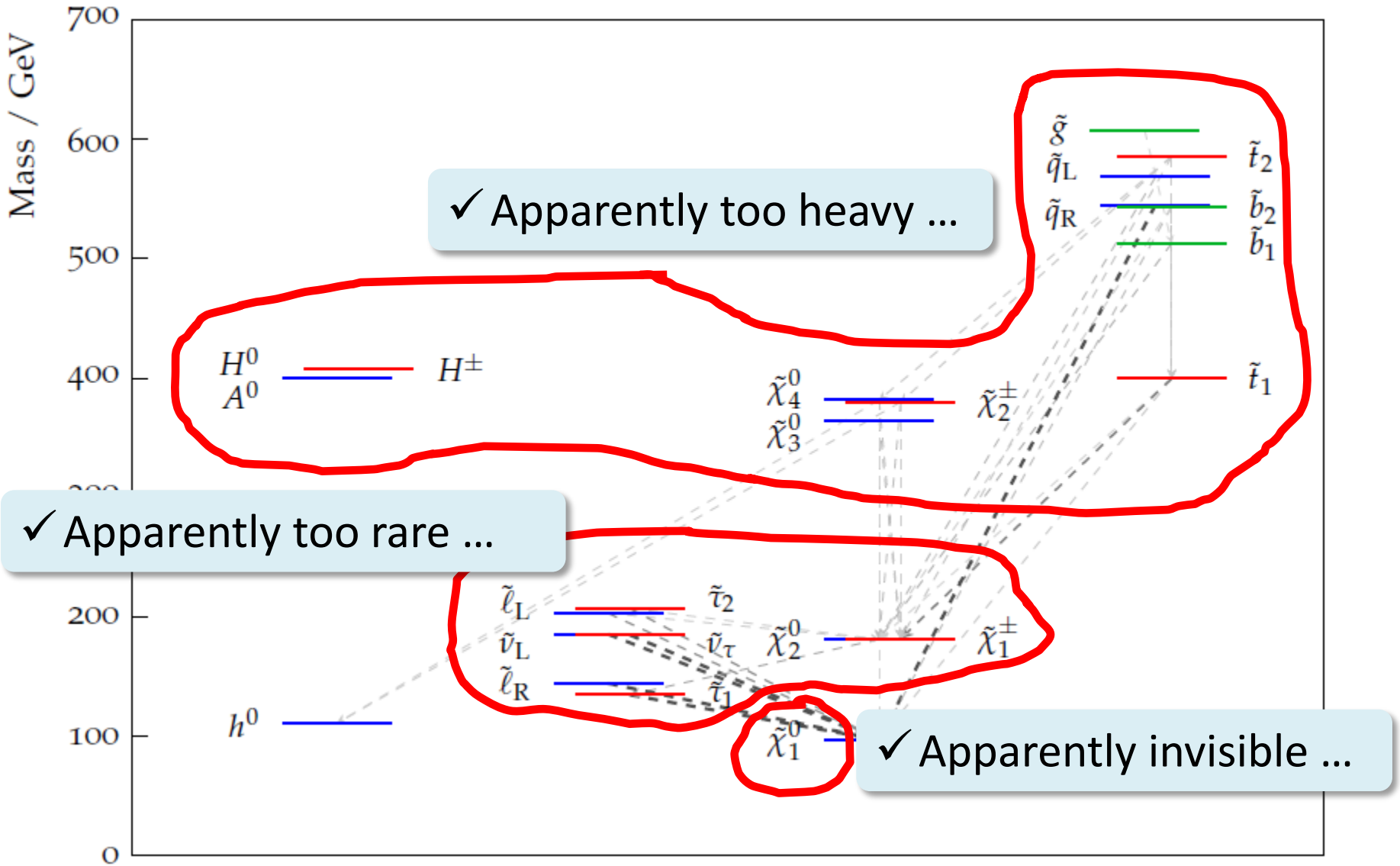
"New Phenomenists" at work in CDF and DØ

What about supersymmetry ?



SPS1a benchmark point, as seen by slhaplot

What about supersymmetry ?



✓ Try to concentrate on unusual decays:

Supersymmetry Long Lived

✓ several models predict long-lived particles:

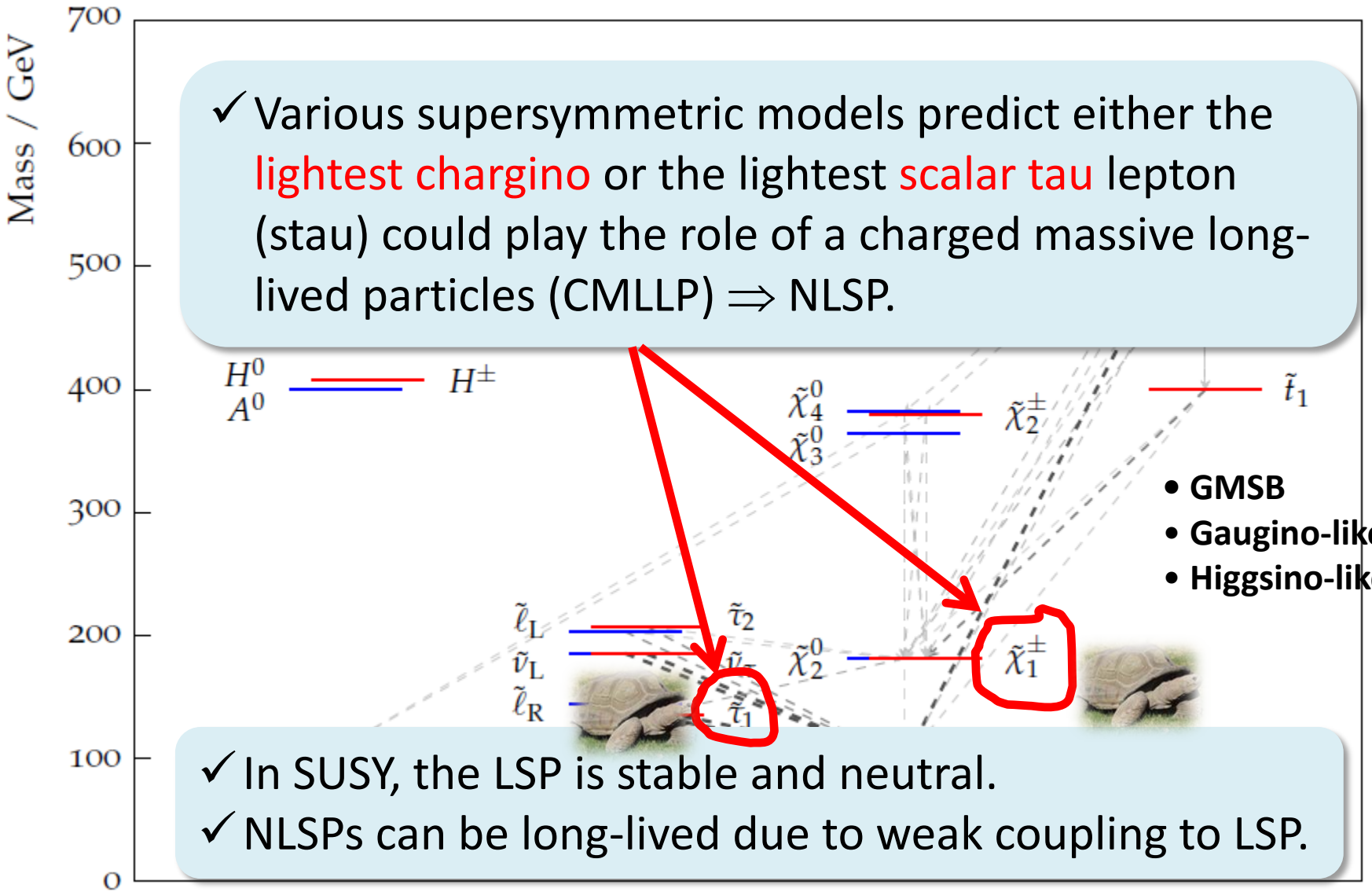
- charged or neutral
- decaying inside or outside detector

Can have implications on big bang nucleosynthesis

Scenario covered today

The Long-Lived Galápagos Tortoise particles (LLGTs)
also called the Charged massive long-lived particles (CMLLPs)

Supersymmetry Long Lived



✓ Various supersymmetric models predict either the lightest chargino or the lightest scalar tau lepton (stau) could play the role of a charged massive long-lived particles (CMLLP) ⇒ NLSP.

✓ In SUSY, the LSP is stable and neutral.

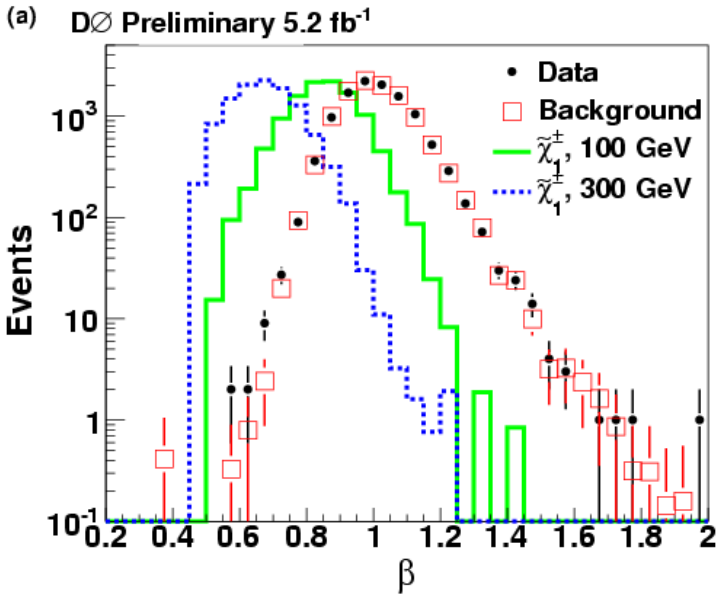
✓ NLSPs can be long-lived due to weak coupling to LSP.

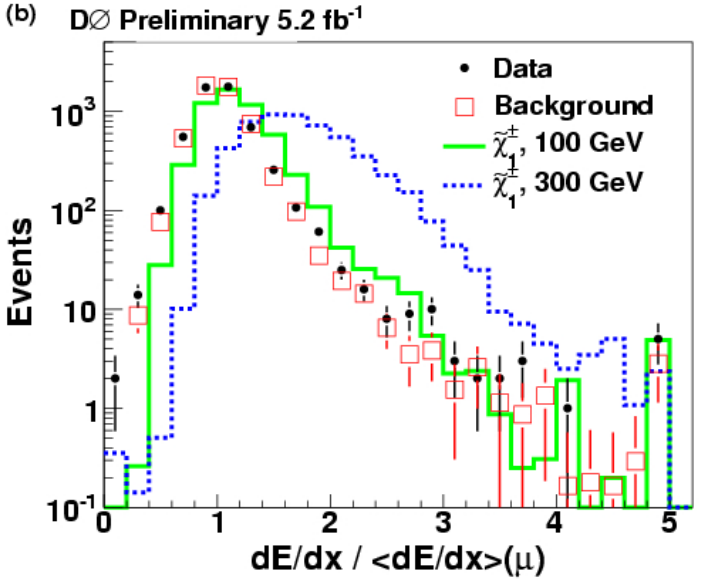
Long Lived

5.2 fb^{-1}

to be submitted soon

- ✓ Signal is like a heavy muon:
  p_T>60 GeV, β < 1, M_T > 200 GeV.
- ✓ Experimental characteristics:
  - β: slow speed (measured by muon scintillator counters).
  - high dE/dx (measured by silicon detector).
- ✓ Background is mostly W→μν:
  model defined as β > 1 and M_T < 200 GeV.





Limits on:

- ✓ GMSB
- ✓ AMSB
- ✓ stop

✓ Exclude higgsino-like (gaugino-like) charginos with m<230 (251) GeV.

Sudeshna Banerjee

No stone left unturned ?

Other Exotic Final States

"New Phenomenists" at work in CDF and DØ

Search for New Physics in ZZ+MET

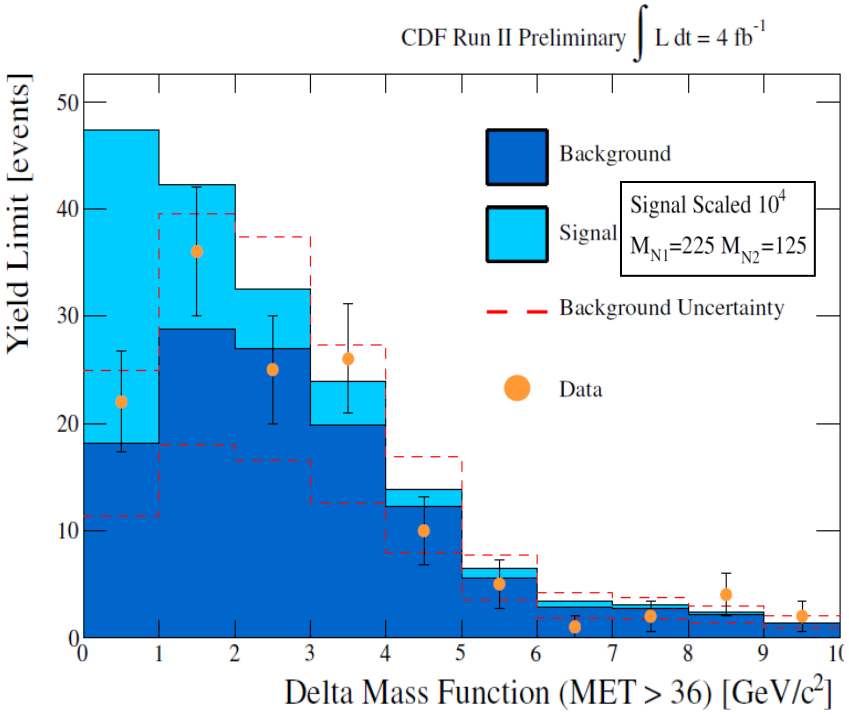
4 fb^{-1}

CDF public note 10539

- ✓ Search for 4th generation heavy neutrino N_1, N_2

$$p\bar{p} \rightarrow Z/\gamma^* \rightarrow N_2 N_2 \rightarrow N_1 Z N_1 Z$$

- ✓ 2 jets and 2 leptons from Z decays.



- ✓ Signal has peaks in both M_{ll} and M_{jj}:

$$\sqrt{\left(\frac{M_{ll}-91.6}{10}\right)^2 + \left(\frac{M_{jj}-85.3}{15}\right)^2}$$

Set limits on cross-section $\lesssim$ 300 fb

Same sign dilepton

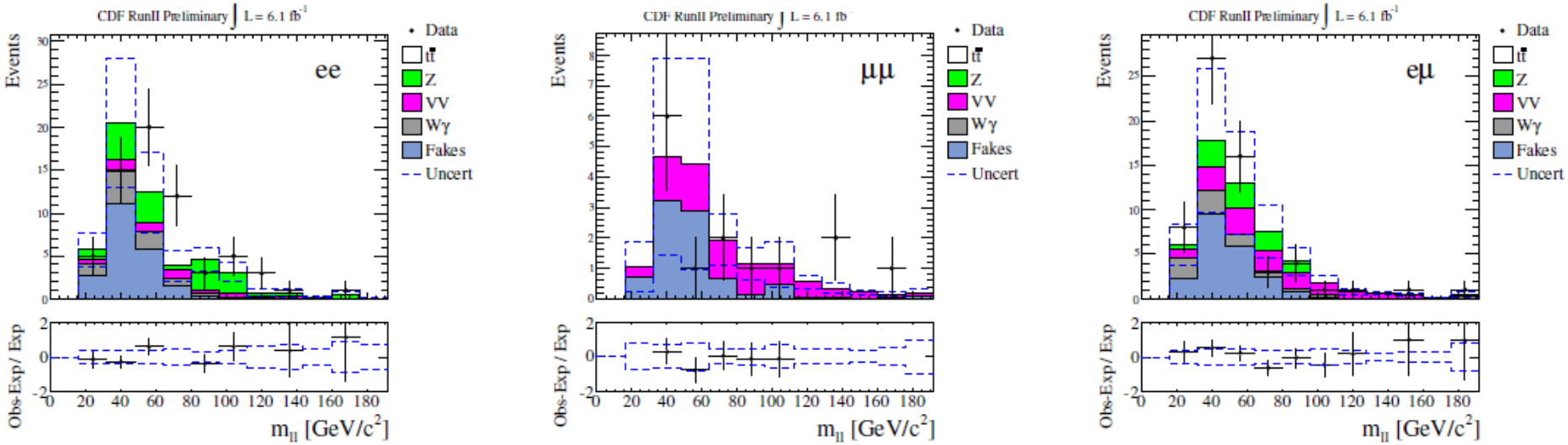
6.1 fb^{-1}

CDF public note 10464

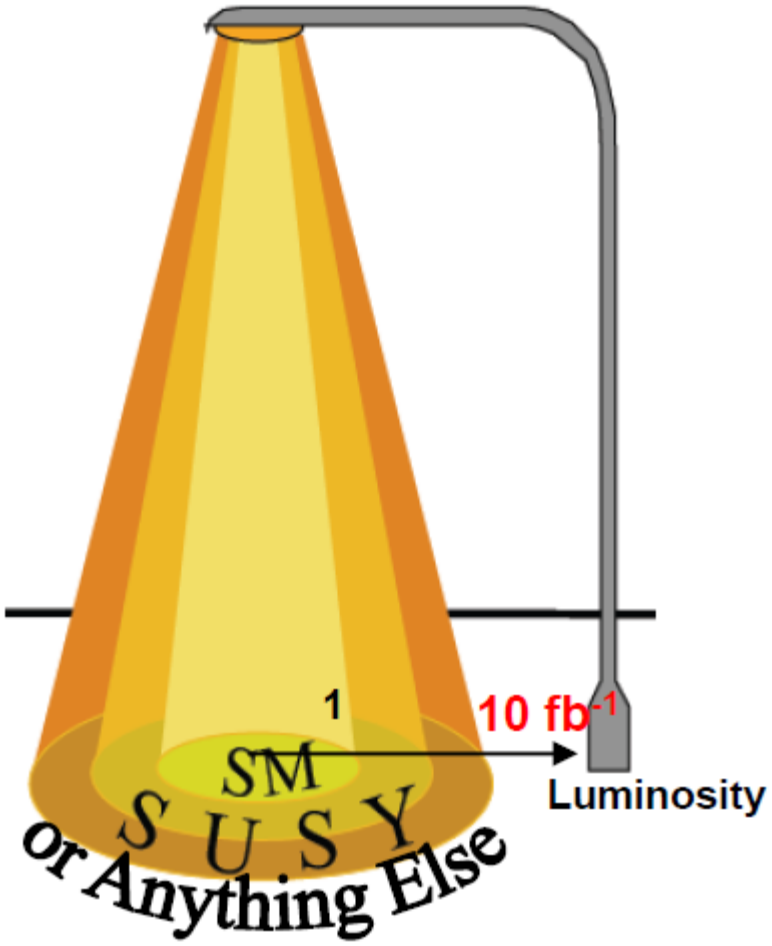
Consistent with SM

- ✓ Predicted in supersymmetry , heavy neutrinos , same-sign top quark, fourth-generation quarks, doubly-charged scalars…
- ✓ Very low background from Standard Model.
- ✓ e or μ with p_{t1}> 20 GeV and p_{t2}>10 GeV.
- ✓ Dominant background from “fake”-isolated lepton from HF semileptonic decays (obtained from data).

dilepton invariant mass $m_{\ell\ell}$



Any other hints of new physics?



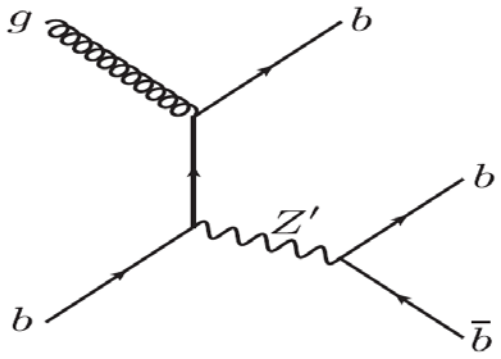
Multijet resonances in bbb

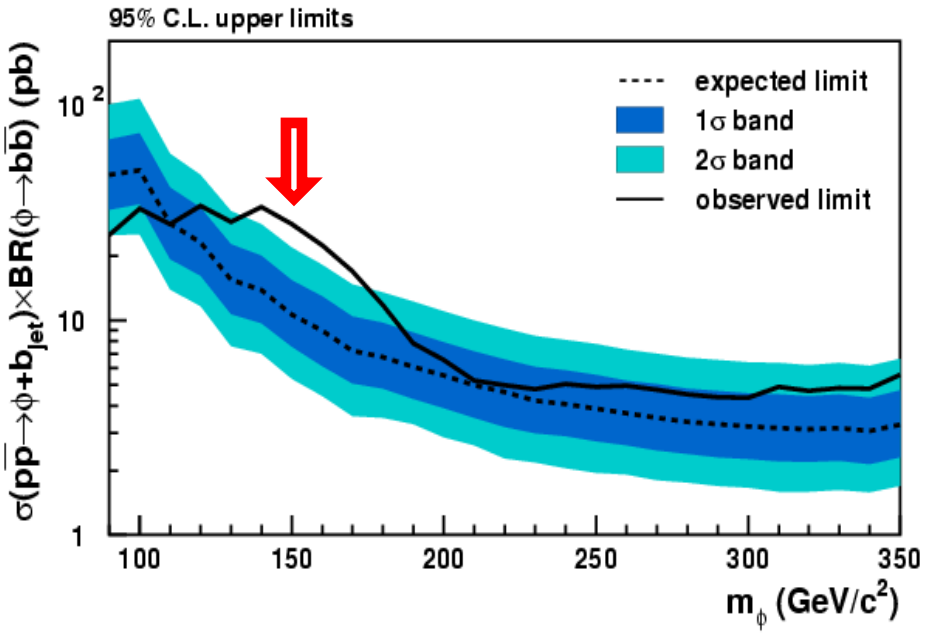
Fabrice Couderc

2.6 fb^{-1}

✓ Ex: search in triple tagged data

arXiv:1106.4782

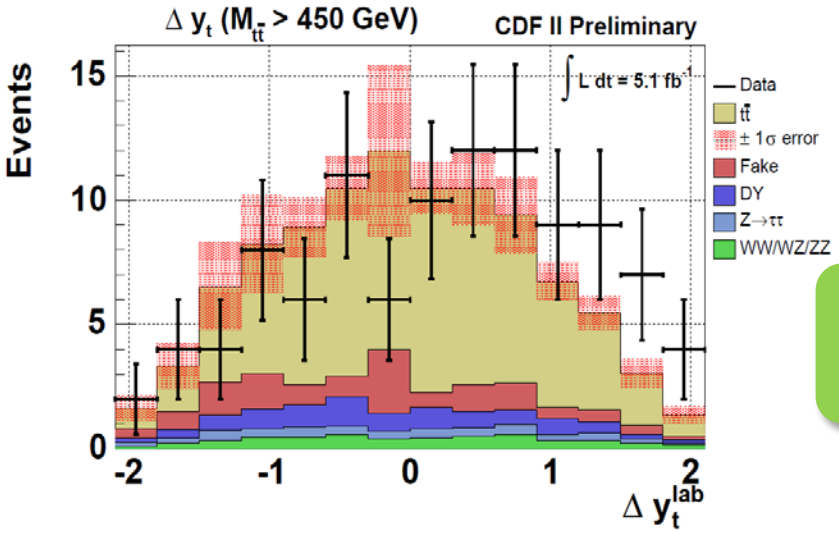




✓ $g_{bbZ'}$ ~ 0.7-0.9 could produce the observed excesses
(ex: PRD 83, 115013, 2011)

✓ 2.8σ at M_{bb}=150 GeV

Top anti-Top asymmetry



5.1 fb^{-1}

CDF public note 10436

$$A_{fb} = 0.42 \pm (0.15)^{stat} \pm (0.05)^{syst}$$

(dilepton final state)

- ✓ 2.3σ from the SM prediction.
- ✓ 3.4σ in the l+jets topology.

- ✓ axigluons, diquarks, new weak bosons, EDs etc..
- ✓ Or gluon radiations modeling at NLO?
- ✓ See Frederic Deliot's talk today!

new t-tbar asymmetry result

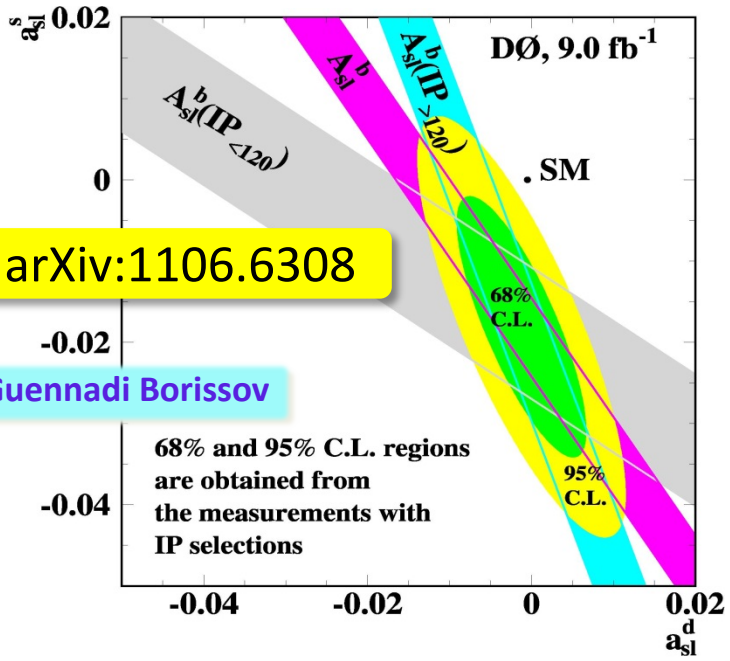
5.3 fb^{-1}

Dimuon Asymmetry

$B^0_s \to \mu^+\mu^-$

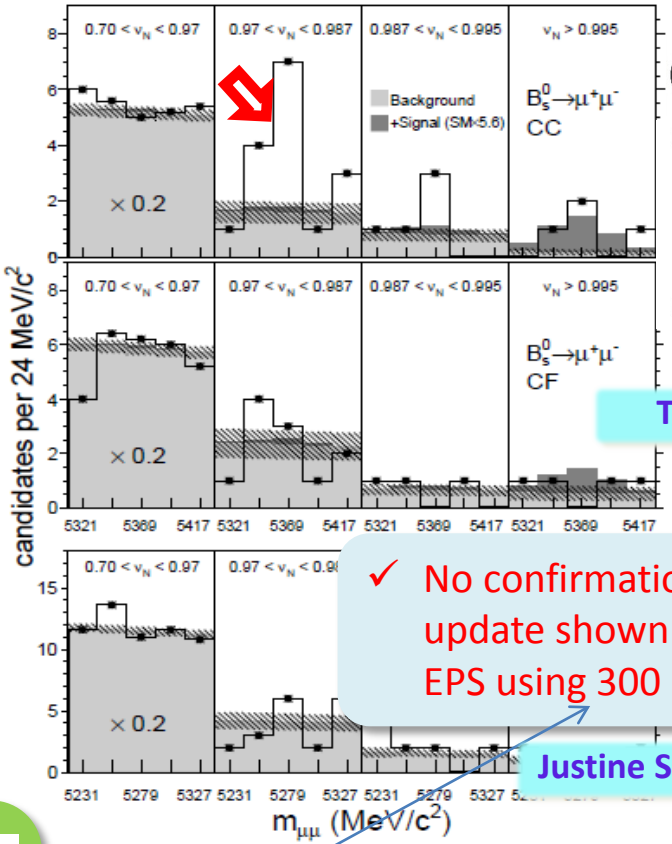
9 fb^{-1}

$$A^b_{sl} \equiv \frac{N^{++}_b - N^{--}_b}{N^{++}_b + N^{--}_b}$$

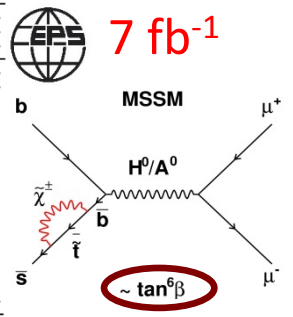


arXiv:1106.6308

Guennadi Borissov



7 fb^{-1}



Thomas Kuhr

✓ No confirmation from the update shown by LHCb at EPS using 300 pb^{-1}

Justine Serrano (LHCb)

$$A^b_{sl} = (-0.787 \pm 0.172\ (\text{stat}) \pm 0.093\ (\text{syst}))\%$$

✓ 3.9σ from SM ⇒ evidence for anomalously large CP violation

✓ Excess of B^0_s (~less than 3σ)

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = (1.8^{+1.1}_{-0.9}) \times 10^{-8}$$

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) < 4.0 \times 10^{-8} \text{ at } 95\%$$

✓ See Diego Tonelli's plenary talk on Wednesday

arXiv:1107.2304

Conclusion

- ✓ Huge number of signatures explored at the Tevatron.
- ✓ Up to 9 fb^{-1} of data analyzed so far.

- ✓ Few hints are being followed up on with the full dataset (11 fb^{-1}).
- ✓ Our goal ⇒ leave no stone unturned

Process		Lumi	signif.	Mass
ZZ→4 leptons	CDF	6.0 fb^{-1}	$3\sigma>$	325 GeV
t'→qW	DØ	5.3 fb^{-1}	2.5σ	325 GeV
W+jj	CDF	7.3 fb^{-1}	4.1σ	150 GeV
bbb	CDF	2.6 fb^{-1}	2.8σ	150 GeV
dimuon Asym.	DØ	9.0 fb^{-1}	3.9σ	
$B^0_s \to \mu^+\mu^-$	CDF	7.0 fb^{-1}	$3\sigma<$	
t-tbar Asym.	CDF	5.1 fb^{-1}	3.4σ	

- ✓ We are in a new era of large data samples both at the Tevatron and the LHC.

- ✓ Full set of results available at:

CDF: http://www-cdf.fnal.gov/physics/exotic/

DØ : http://www-d0.fnal.gov/

- ✓ We are living very special moment of particle physics!

Thanks for your attention!

and thanks to everyone in CDF, DØ, Tevatron and computing divisions, and our funding agencies for making all of this possible!

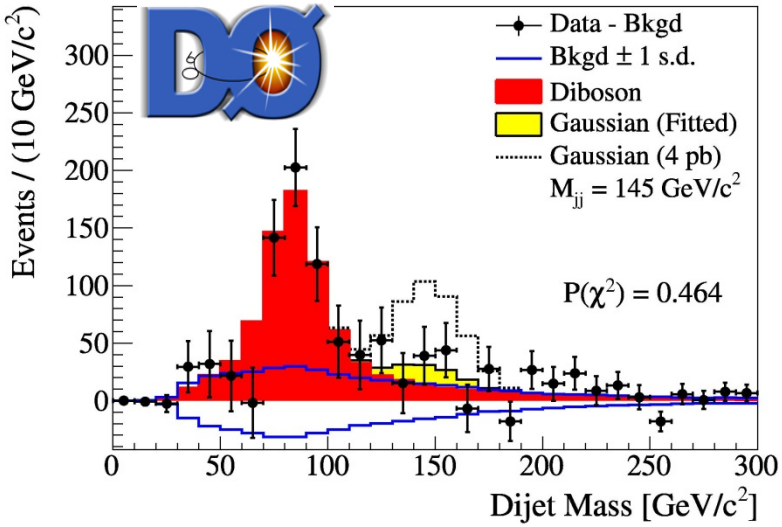
Thanks also to the Local Organizing Committee of EPS-HEP2011

Special thanks to CDF/DØ exotics/NP conveners:
Mike Eads (DØ), Oscar Gonzalez (CDF), Michel Jaffré (DØ)

BACKUP

Perhaps no bump in the W+jets data

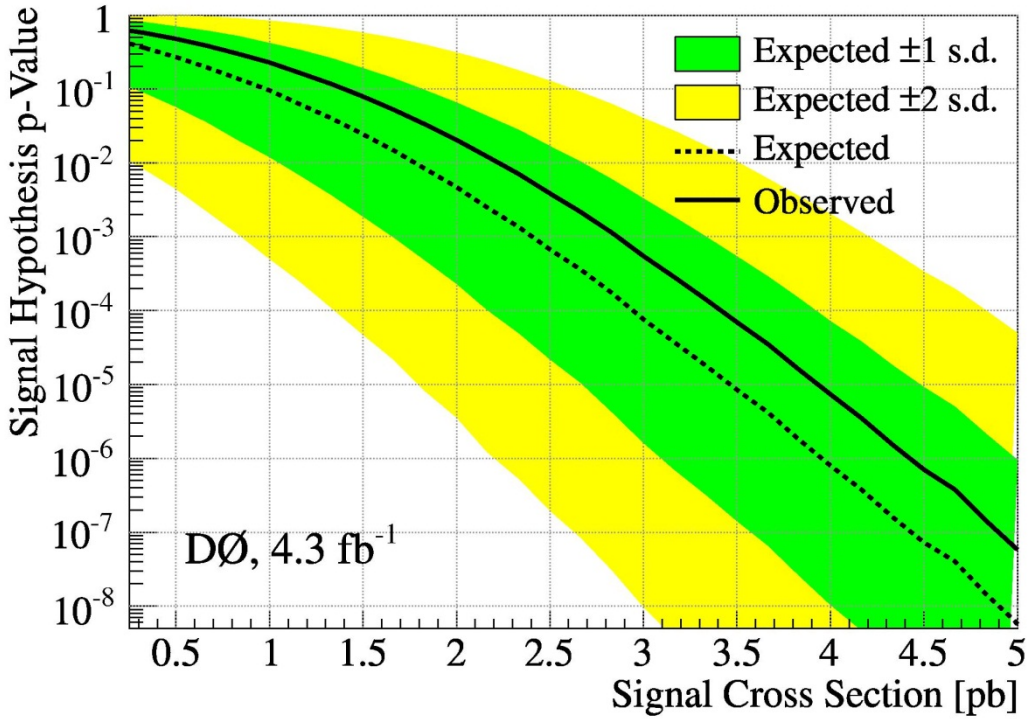
4.3 fb^{-1}



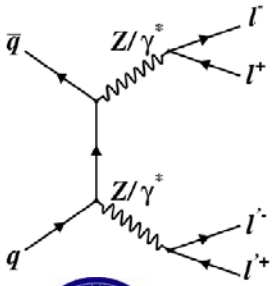
Jadranka Sekaric

PRL 107, 011804 (2011)

FIG. 4: (color online) Distribution of p-values for the signal+background hypothesis with a Gaussian signal with mean of $M_{jj} = 145$ GeV/c^2 as a function of hypothetical signal cross section (in pb). Shown are the p-values for the background prediction (dashed black) with regions corresponding to a 1 s.d. and 2 s.d. fluctuation of the backgrounds and the observed data (solid black).



ZZ→ 4 leptons



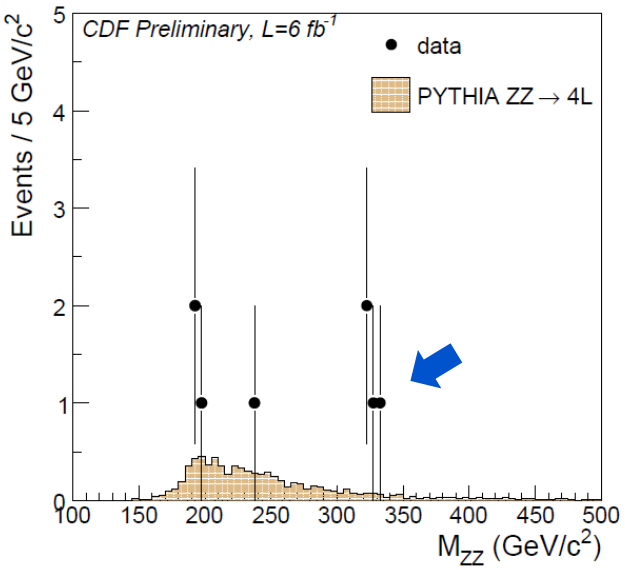
CDF public note 10603

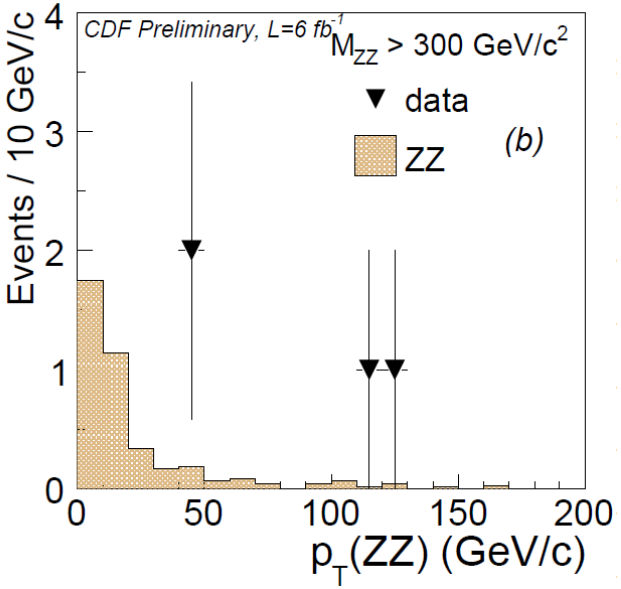
PRD 84, 011103(R) (2011)

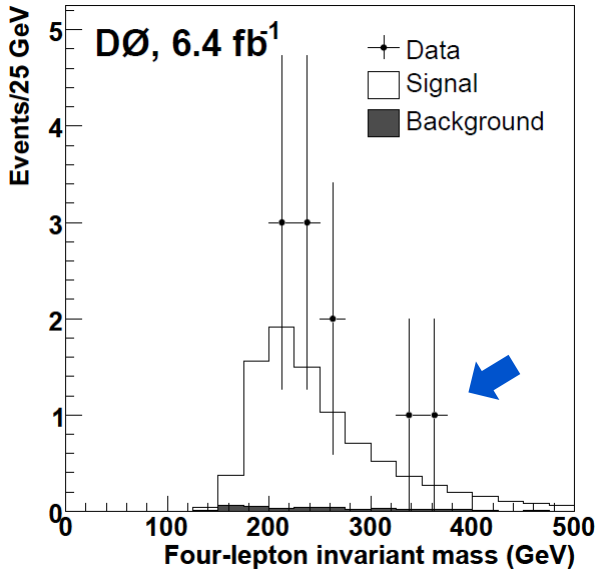
$$ZZ \to \ell^+\ell^-\ell'^+\ell'^-$$

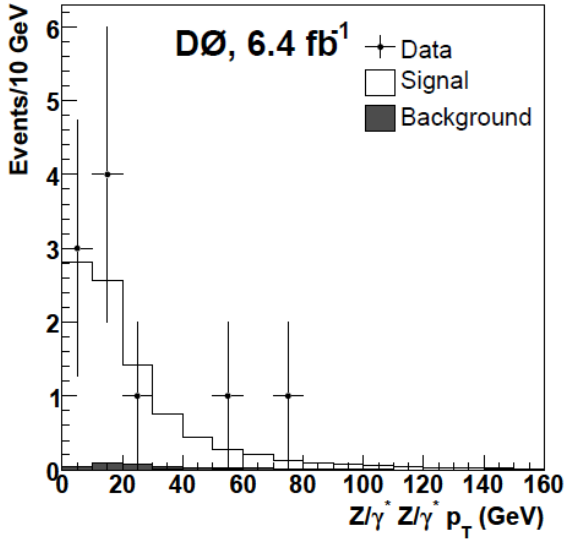
$$\sigma(p\bar{p} \to ZZ) = 1.24^{+0.47}_{-0.37}\ (\text{stat}) \pm 0.11\ (\text{syst}) \pm 0.08\ (\text{lumi})$$

in agreement with NLO QCD predictions.



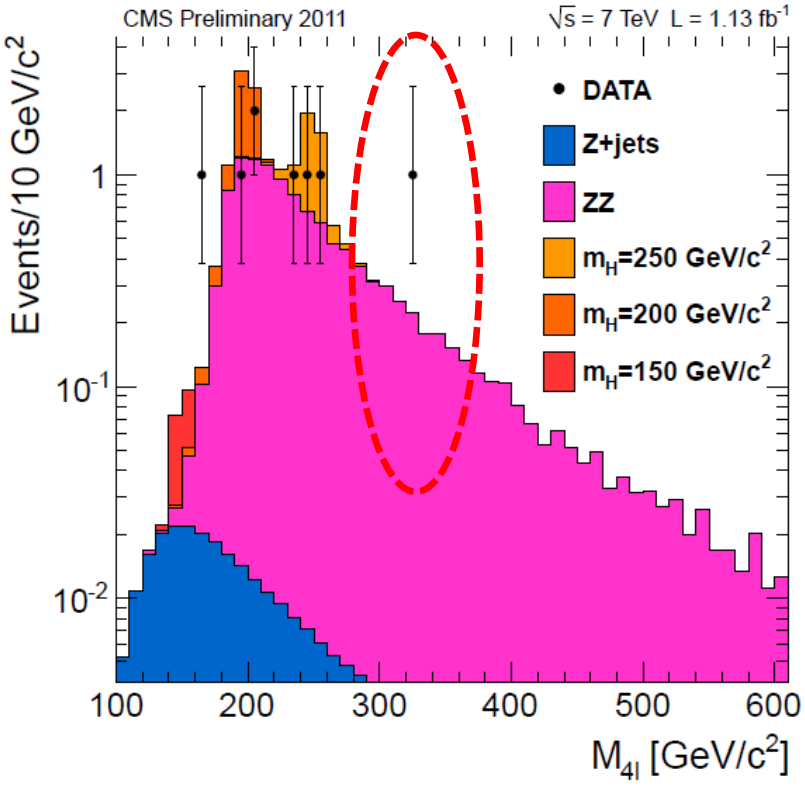






ZZ⟶ 4 leptons

CMS Preliminary 2011



$H \rightarrow ZZ^{(*)} \rightarrow 4l$

CMS PAS HIG-11-004

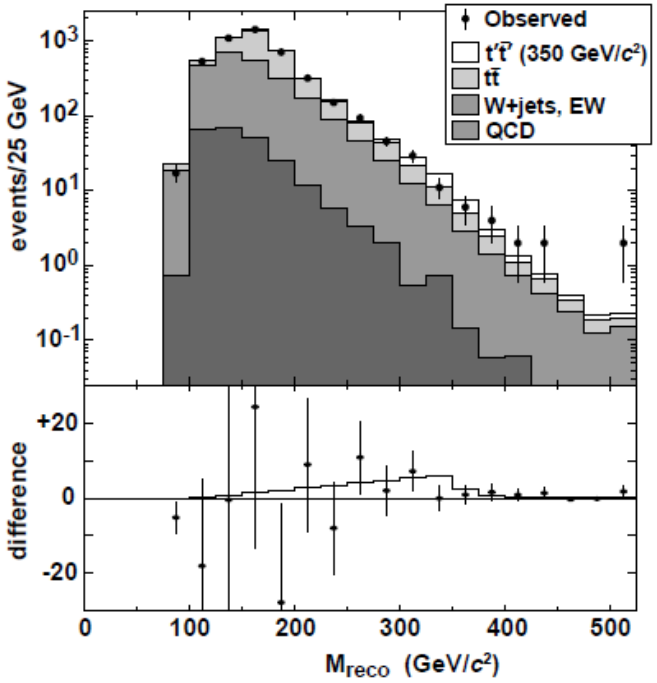
For fun…

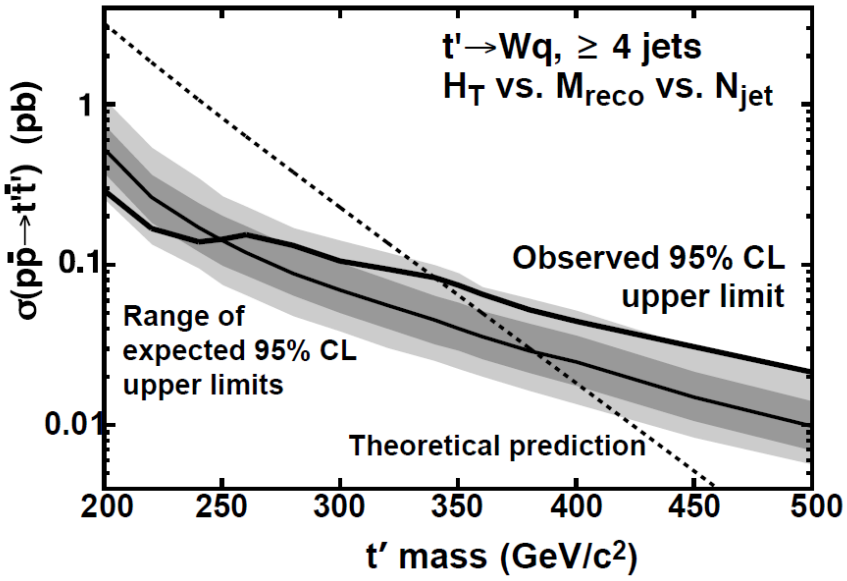
t'→qW

5.6 fb^{-1}

1107.3875 (2011)

Selection requirements by search	
$t' \to Wq$	$t' \to Wb$
lepton $p_T \geq 25$ GeV/c ≥ 4 jets with $E_T \geq 20$ GeV 2 jets with $E_T \geq 25$ GeV $\not\!\!E_T \geq 20$GeV $M_{T,W} > 20$ GeV/c^2 $\not\!\!E_{T,sig} > -0.05 \cdot M_{T,W} + 3.5$ Requirements on $\Delta\phi$ between lead jet E_T or lepton p_T and $\not\!\!E_T$	lepton $p_T \geq 20$ GeV/c ≥ 4 jets with $E_T \geq 20$ GeV $\not\!\!E_T \geq 20$GeV ≥ 1 jet identified as coming from a b-jet



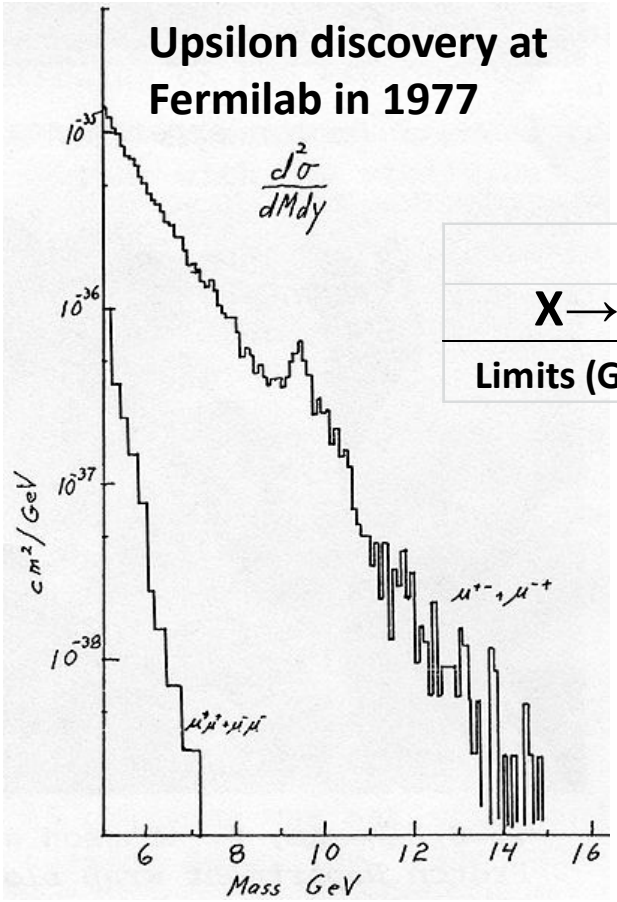


Process	4th generation b'→tW	t'→qW	t'→bW	t'→tX
Limits (GeV)	372	340	358	360

✓ Tevatron: strongest limits to date in b',t' (for tW, qW, tX)

Dilepton Final States

- ✓ Have historically been a source of major discoveries
- ✓ Most models predicts such high-mass states



- ✓ Look for bump in dilepton mass spectrum

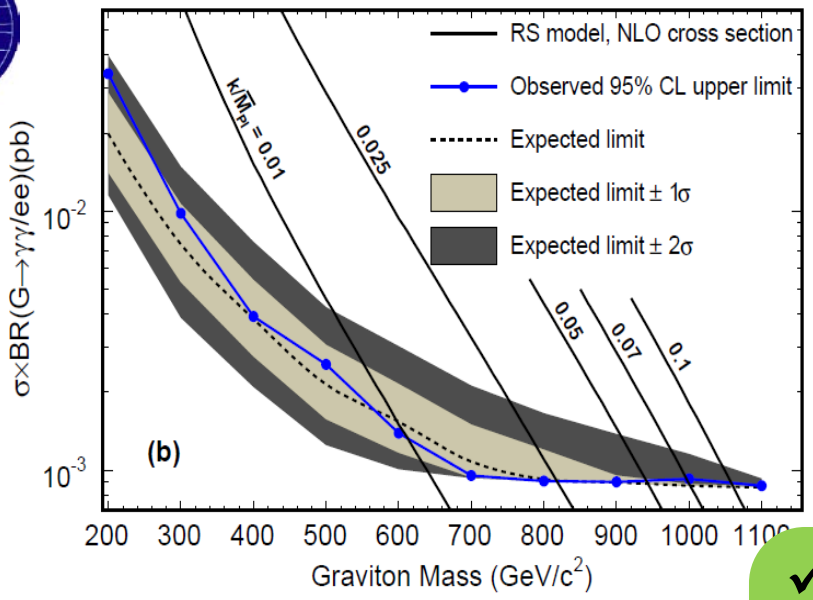
	Sequential V'								
X⟶	eν	ee	μμ	eμ	ττ	qq	tt	tb	WZ
Limits (GeV)	1120	1023	1071	700	399	740	900	885	180-690

RS-G. $k/M_{pl}=0.1$						
ee	γγ	μμ	ee+γγ	μμ+ee+γγ	WW	ZZ
914	963	859	1058	1111	300-754	491

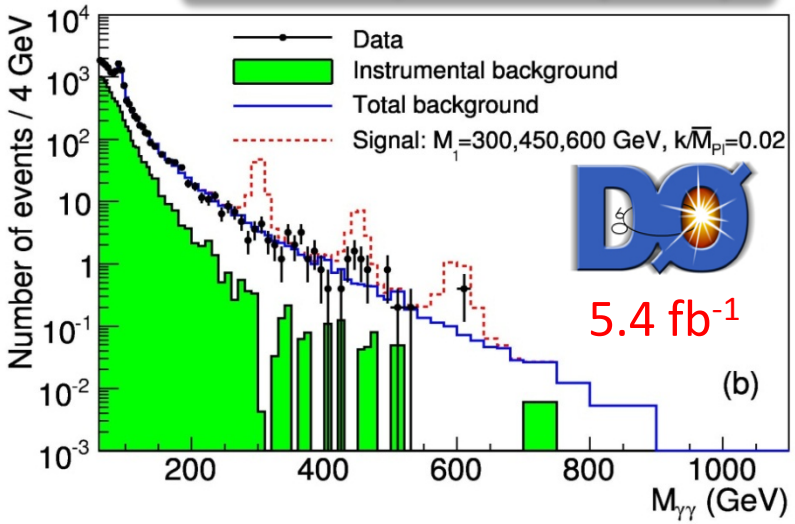
Randall-Sundrum Gravitons $\rightarrow$ee+$\gamma\gamma$

arXiv:1103.4650 (2011)

5.7 fb^{-1}



PRL 104, 241802 (2010)



✓ Both CDF and DØ combine the ee and $\gamma\gamma$ searches

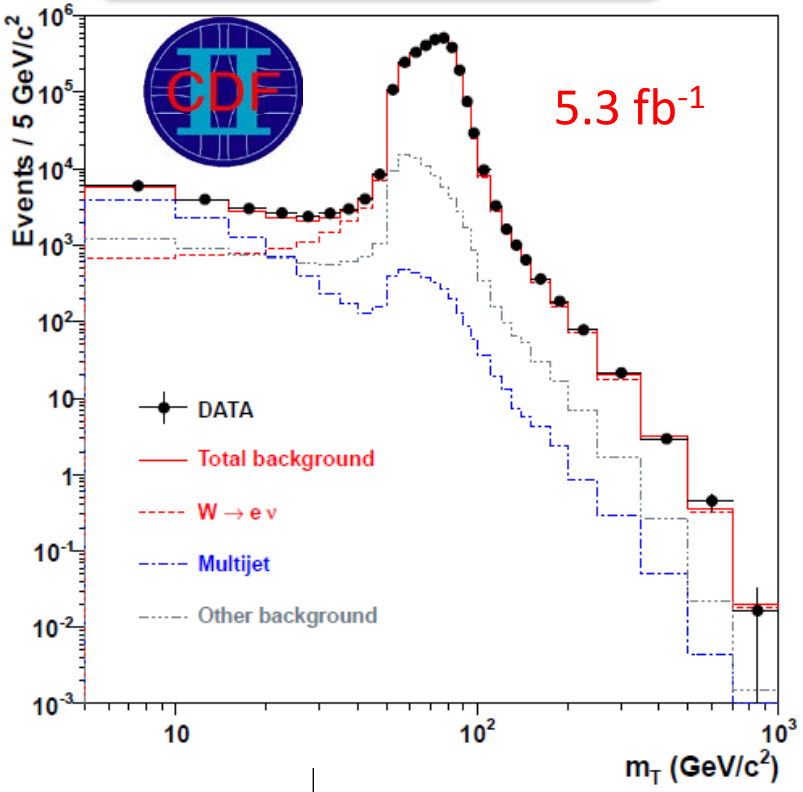
✓ The inclusion of ee in the $\gamma\gamma$ RS search results in a 50% increase in the rate of potentially produced signal.

RS-G. k/M$_{pl}$=0.1

ee	$\gamma\gamma$	$\mu\mu$	ee+$\gamma\gamma$	$\mu\mu$+ee+$\gamma\gamma$	WW	ZZ
914	963	859	1058	1111	300-754	491

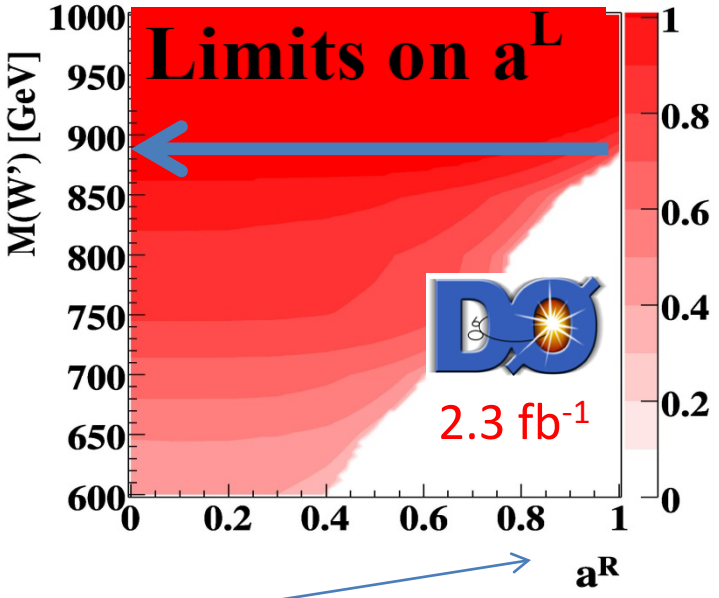
W'→eν

PRD 83, 031102 (2011)



W'→tb

PLB 699, 145 (2011)



$$\mathcal{L} = \frac{V_{ij} g_w}{2\sqrt{2}} \bar{f}_i \gamma_\mu \left(a_{ij}^R \left(1+\gamma^5\right) + a_{ij}^L \left(1-\gamma^5\right) \right) W'^\mu f_j + \text{h.c.},$$

Dhiman Chakraborty

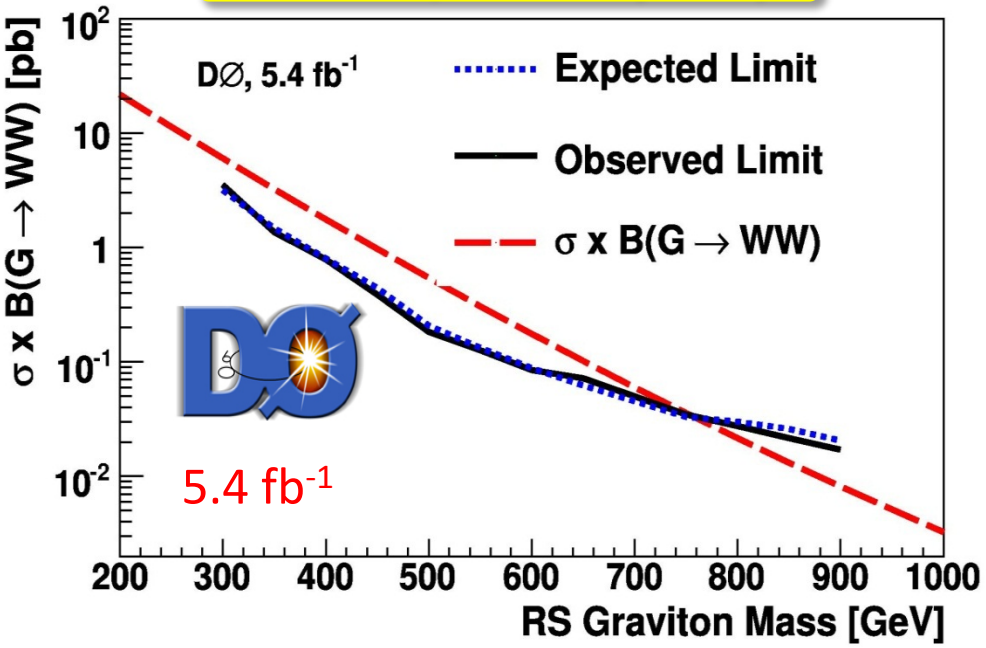
Sequential V'

X→	eν	ee	μμ	eμ	ττ	qq	tt	tb	WZ
Limits (GeV)	1120	1023	1071	700	399	740	900	885	180-690

Randall-Sundrum Gravitons ⟶ dibosons

PRL 107, 011801 (2011)

WW



✓ graviton decays to photons, leptons, and light jets can be suppressed, and dibosons become a discovery channel.

RS-G. $k/M_{pl}=0.1$

ee	γγ	μμ	ee+γγ	μμ+ee+γγ	WW	ZZ
914	963	859	1058	1111	300-754	600

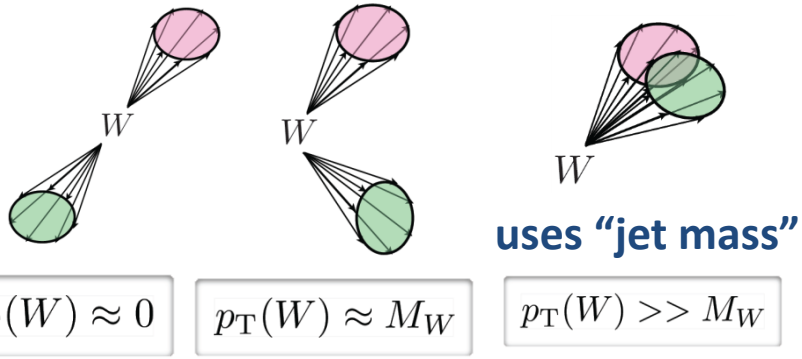
W'→WZ

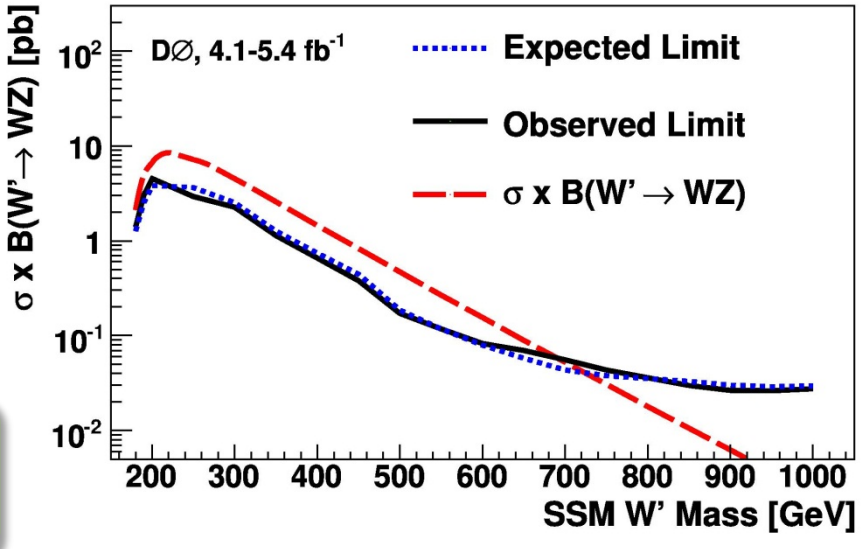
4.1-5.4 fb^{-1}

PRL 107, 011801 (2011)

✓ W and Z highly boosted:
⇒ e.g. W→jj→single jet

✓ combined result based on three independent searches:
⇒ 3 leptons + lνjj + lljj





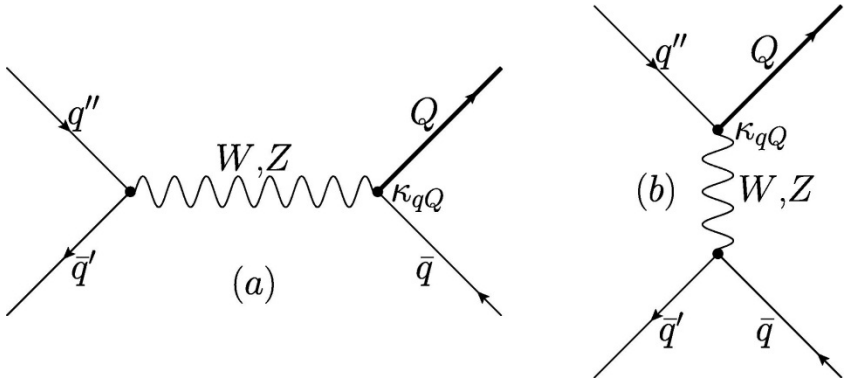
✓ reconstructed WZ transverse mass used to set limits

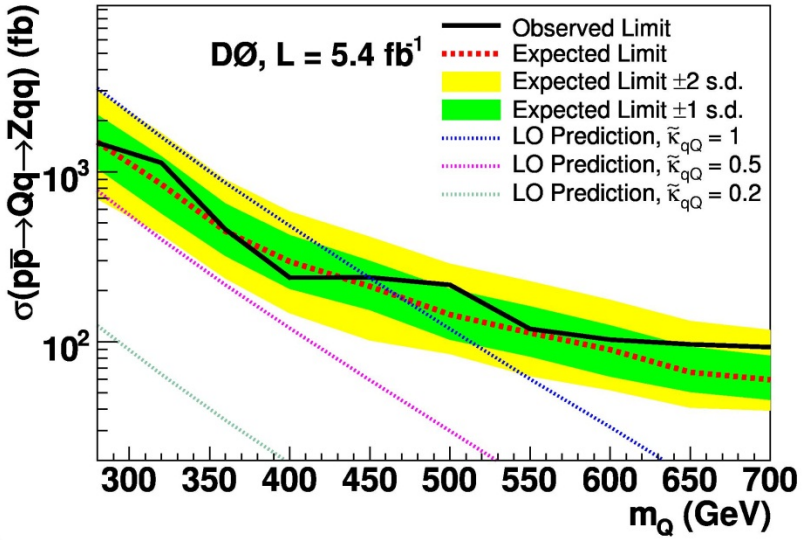
	Sequential V'								
X→	eν	ee	μμ	eμ	ττ	qq	tt	tb	WZ
Limits (GeV)	1120	1023	1071	700	399	740	900	885	180-690

Vector Quarks→Wq or Zq

5.4 fb^{-1}

PRL 106, 081801 (2011)





- ✓ Search for Wq and Zq resonances
- ✓ Use W/Z and at least 2 jets channels

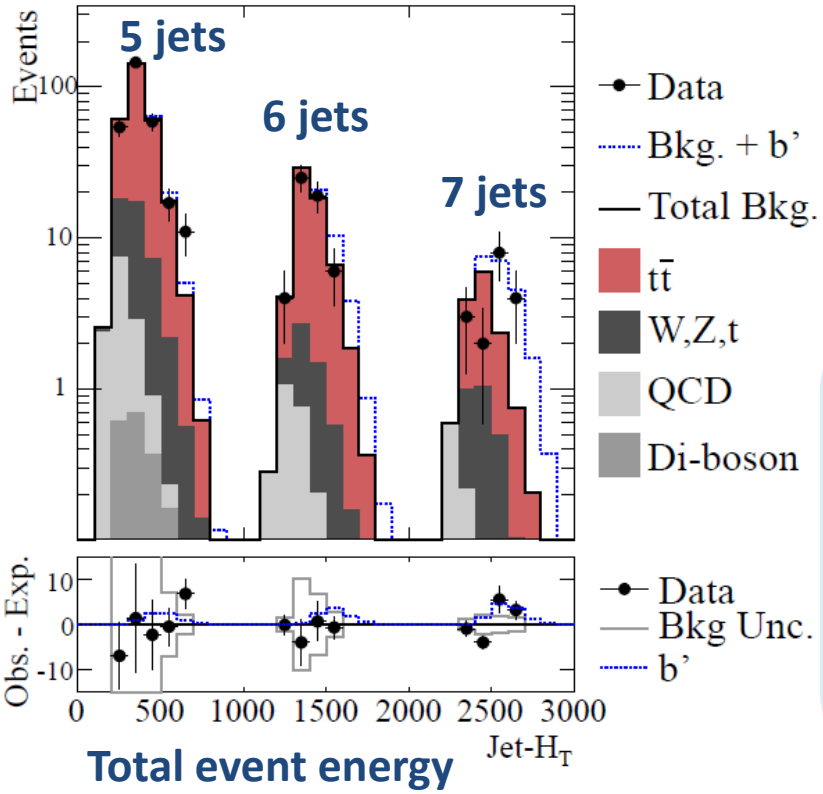
- ✓ benefit from the lower kinematic threshold compared to pair production

	4th generation				VQ	
Process	b'→tW	t'→qW	t'→bW	t'→tX	qW	qZ
Limits (GeV)	372	285	358	360	693	551

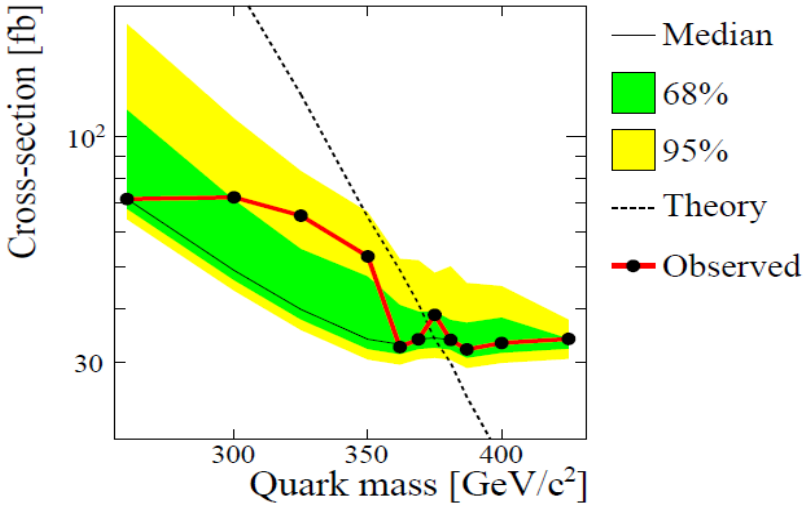
b'→tW

4.8 fb^{-1}

PRL 106, 141803 (2011)



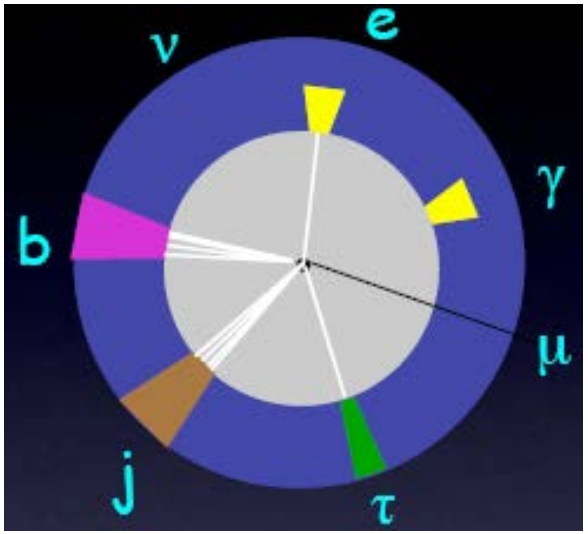
Total event energy

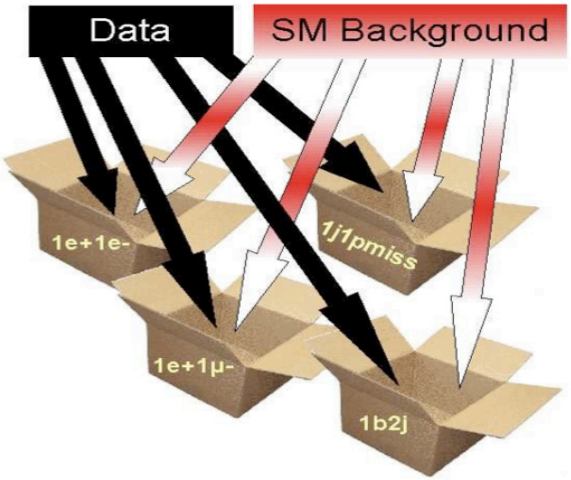


- ✓ pair production of 4th bottom-like chiral quarks
- ✓ e/μ and 5 jets
- ✓ dominant background (80%) is t-tbar

	4th generation				VQ	
Process	b'→tW	t'→qW	t'→bW	t'→tX	qW	qZ
Limits (GeV)	372	340	358	360	693	551

Signature-based searches
i.e. are observations consistent with SM expectation?





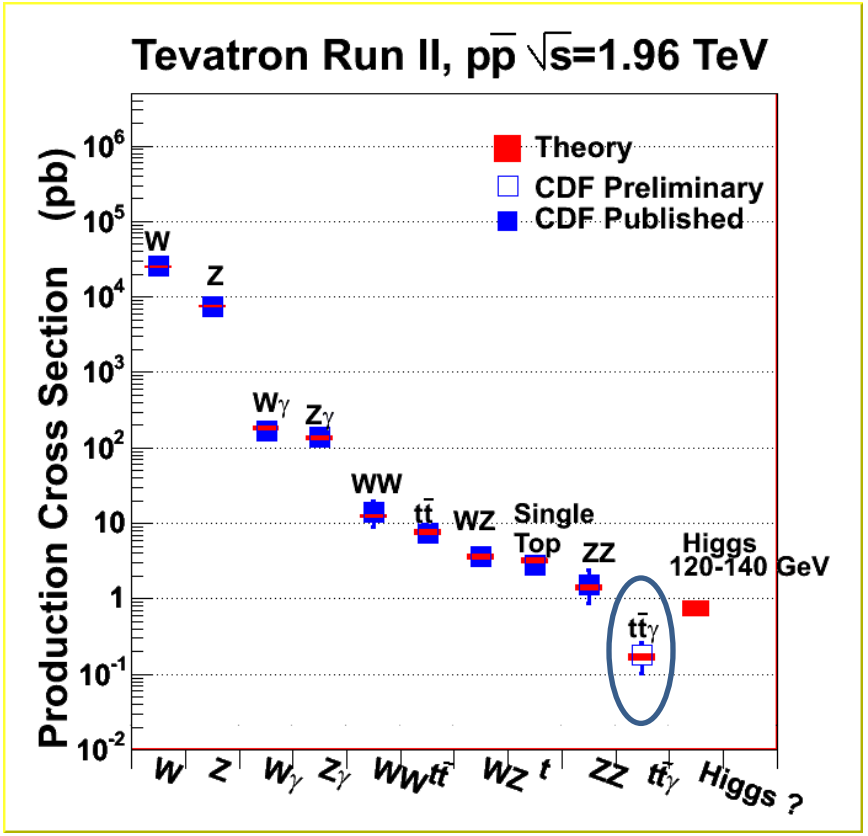
✓ These global analyses have revealed
✓ no new physics in 1-2 fb^{-1}

W+γ+b-jets+MET

CDF public note 10270

5.7 fb^{-1}

- ✓ $\ell\gamma \not\!\!E_T b$ signature is for instance possible in GMSB susy models.
- ✓ The SM $t\bar{t}\gamma$ process is one of the largest backgrounds



The probability, assuming no true t-tbar-γ Standard Model (SM) signal, for the background alone to produce at least as many events (30) as observed in data, is 0.03% (2.7 σ).

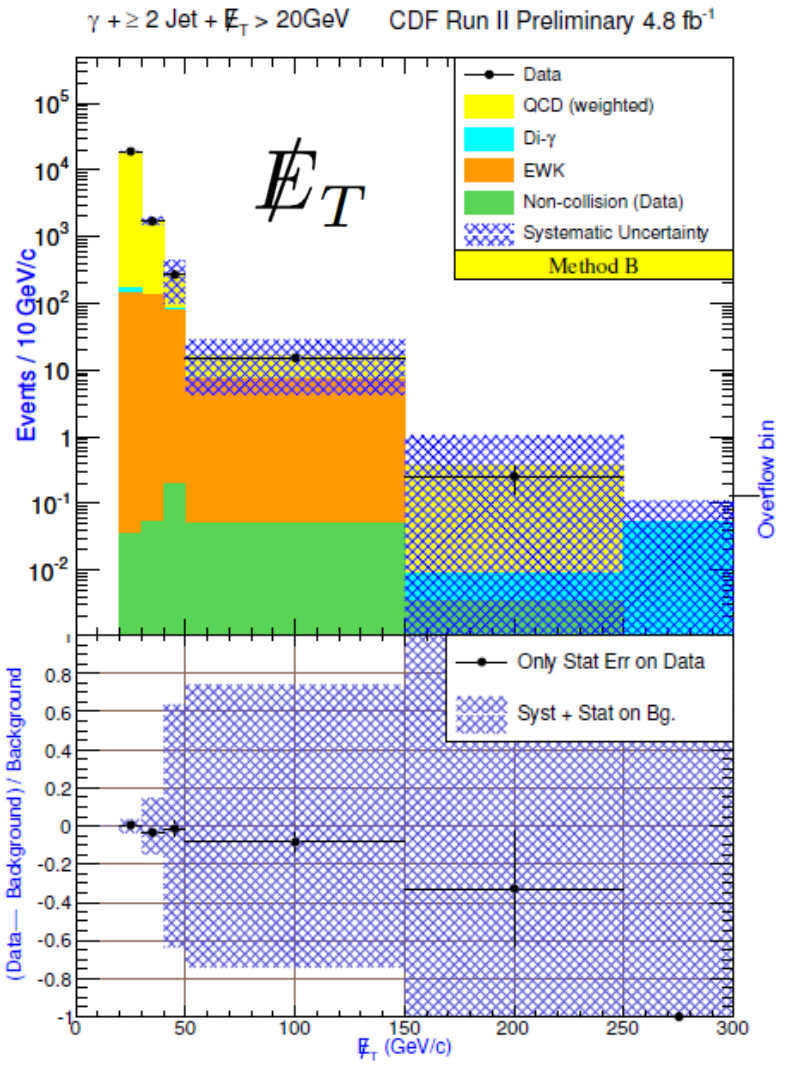
γ+Jets+MET

4.8 fb^{-1}

CDF public note 10355

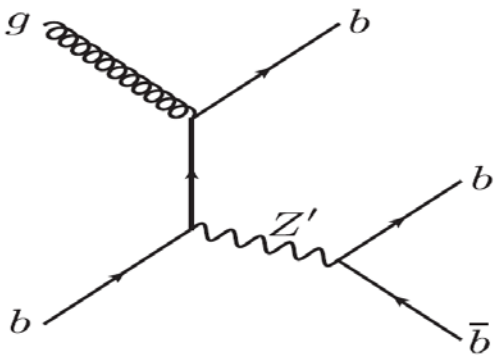
- ✓ signature possible in GMSB susy models ($\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$).
- ✓ prompt γ production, prompt γγ production, electroweak production of charged leptons that fake a prompt photon ⇒ PYTHIA
- ✓ QCD ⇒ data

in agreement with the Standard Model expectation



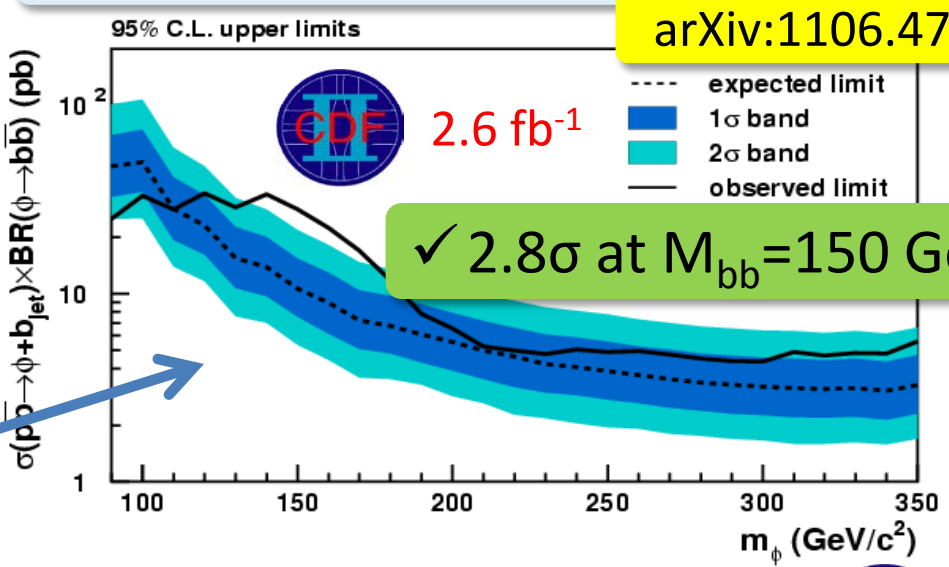
Multijet resonances (+bbb)

Fabrice Couderc



✓ Ex: search in triple tagged data

arXiv:1106.4782

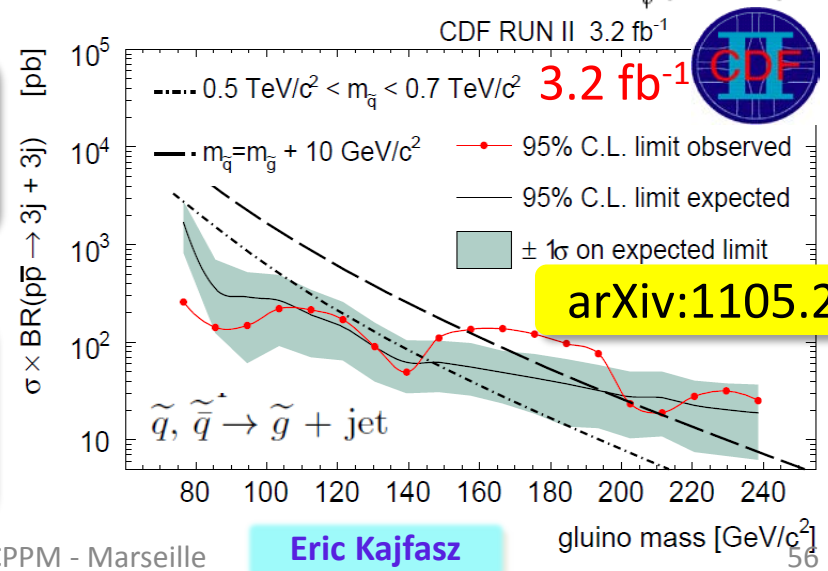


✓ 2.8σ at M_{bb}=150 GeV

✓ $g_{bbZ'}$ ~ 0.7-0.9 could produce the observed excesses (ex: PRD 83, 115013, 2011)

✓ or search in multijet (no b-tag)

⇒ $M_{(3\ jets)}$ resonance



arXiv:1105.2815

✓ 2σ near 175 GeV (~top quark)

✓ Set limit on RPV SUSY scenario:

$$\sigma(p\bar{p} \to XX') \times \mathrm{BR}(\tilde{g}\tilde{g} \to 3\ \mathrm{jet} + 3\ \mathrm{jet})$$

Eric Kajfasz

t-tbar asymmetry

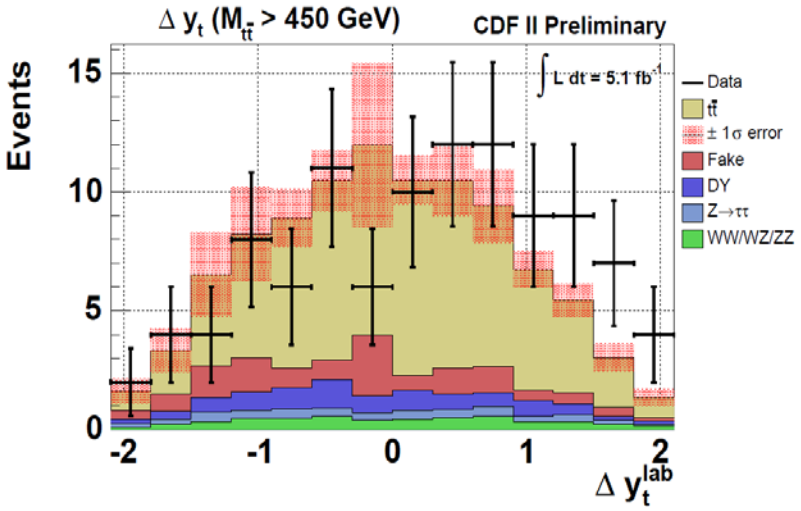
5.1 fb^{-1}

- ✓ The SM predicts small (6%) charge asymmetry between top and anti-top

CDF public note 10436

$$A_{fb} = 0.42 \pm (0.15)^{stat} \pm (0.05)^{syst}$$

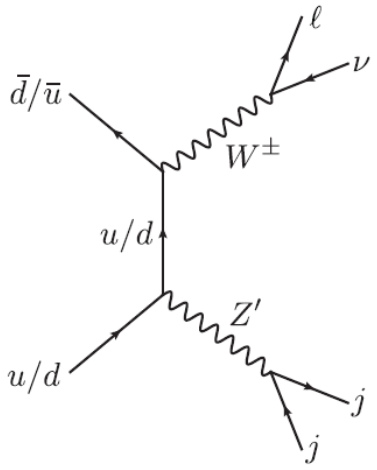
(dilepton final state)



- ✓ 2.3σ from the SM prediction
- ✓ M_{tt}>450 GeV:
  - 63 events in the positive side.
  - 41 events in the negative side.
- ✓ 3.4σ in the l+jets topology

- ✓ Numerous recent theoretical papers suggest interesting new physics mechanisms including axigluons, diquarks, new weak bosons, EDs etc..

A bump in W+jets data: what is it ?



✓ How about a Z' again ?

- ✓ Z'-fermion-fermion couplings as a free parameter ⇒ opens a wide range of Z' masses.
- ✓ A leptophobic Z' is constrain at both lepton and hadron colliders ($M_{Z'}$ <300 GeV ⇒ overwhelming multijet background at Tevatron).

Phys. Rev. D 83, 115013 (2011)

	$M_{Z'}$	$g_{qqZ'}$	$g_{bbZ'}$	$g_{utZ'}$
$W^{\pm}+jj$	140–150 GeV	0.1–0.3		
multi-b	130–160 GeV	$\ll 1$	0.7–0.9	
$t\bar{t}$ asymmetry	120–280 GeV			0.3–0.8

Matthew R. Buckley,[1], Dan Hooper[1,2], Joachim Kopp[3], and Ethan Neil[3]

- W+jets CDF bumps paper has ~70 citations ⇒ there are many other phenomenological explanations!
- Z' is just one (popular) example

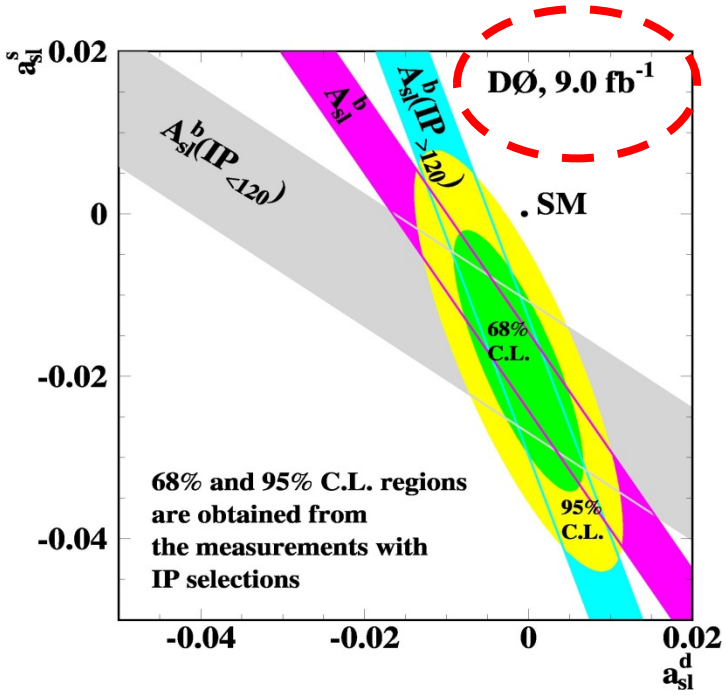
(see also Hewett and Rizzo, arXiv: 1106.0294v2)

✓ The three anomalies (3b, t-tbar asymmetry, W+jj) can be simultaneously explained by a Z' with an approximate mass of 140-150 GeV (and could have important implications for dark matter phenomenology).

9 fb^{-1}

Dimuon Asymmetry

arXiv:1106.6308v1



✓ DØ just released an updated measurement of the anomalous like-sign dimuon charge asymmetry A^b_{sl} for semileptonic neutral B decays

$$A^b_{sl} = (-0.787 \pm 0.172\ (\text{stat}) \pm 0.093\ (\text{syst}))\%$$

✓ 3.9σ from SM ⇒ evidence for anomalously large CP violation

✓ The dependence of the asymmetry on the muon impact parameter is consistent with the hypothesis that it originates from semileptonic b-hadron decays

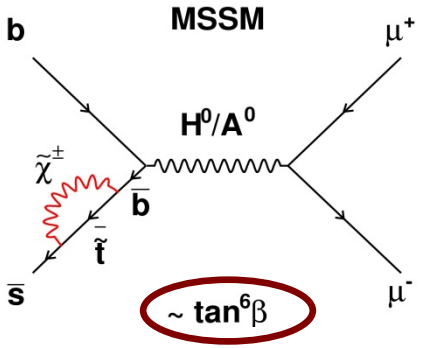
✓ See Diego Tonelli's plenary talk on Wednesday (also discussed by Guennadi Borissov in the Flavor Physics session last week)

$B^0_s \to \mu^+\mu^-$

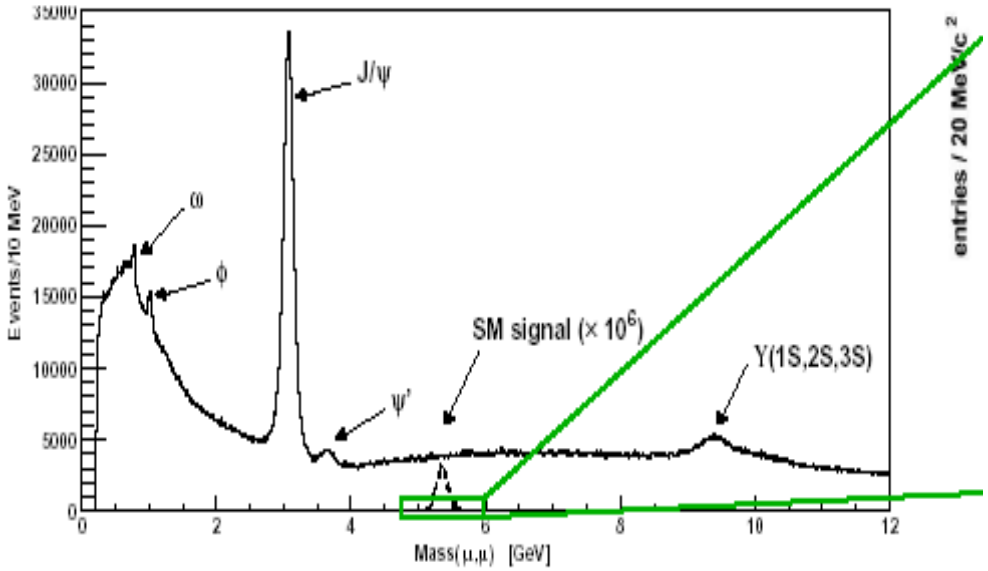
Thomas Kuhr

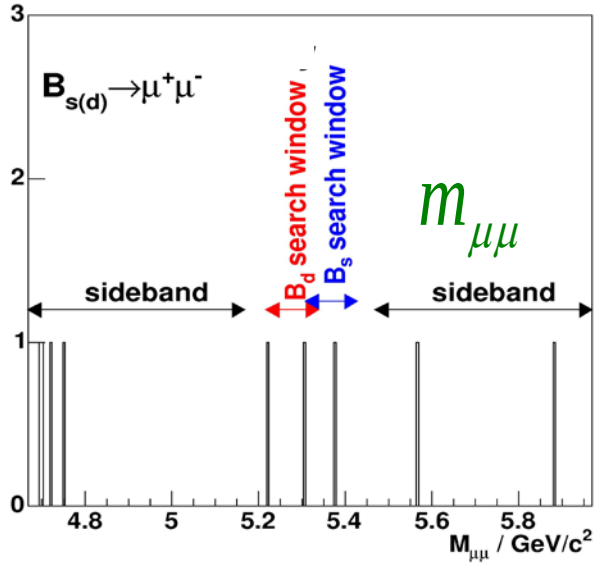
arXiv:1107.2304

7 fb^{-1}



✓ CDF just released a search based on $B^0_s \to \mu^+\mu^-$ and $B^0_d \to \mu^+\mu^-$





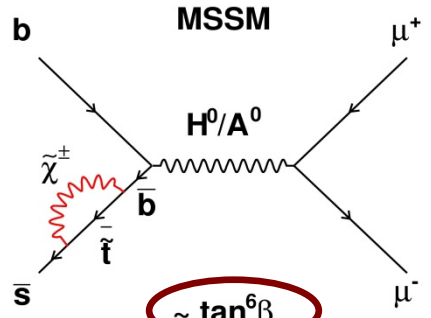
✓ In SM, tiny BR~3.2 10^{-9} (and 25 times smaller for B_d)

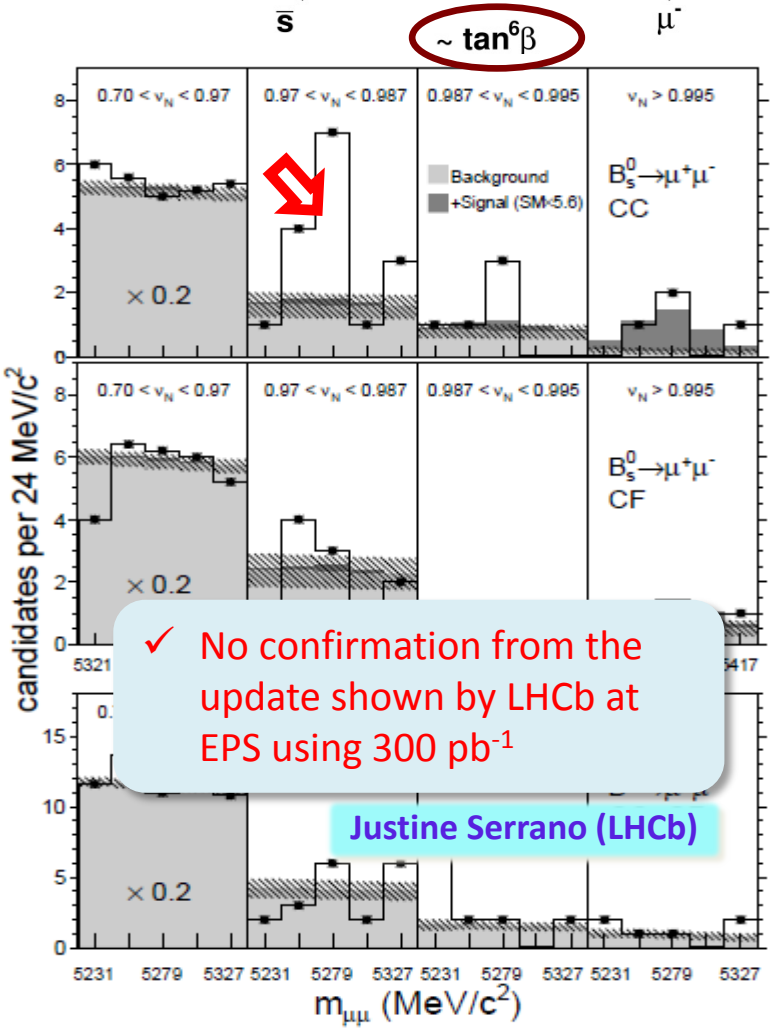
✓ But in SUSY, enhancement ~$(\tan\beta)^6$ factor

$B^0_s \to \mu^+\mu^-$

arXiv:1107.2304

7 fb^{-1}





Thomas Kuhr

- ✓ blind analysis using signal MC and side band data
- ✓ Normalize to the $B^+ \to J/\psi\, K^+$ mode
- ✓ Use a Likelihood ratio to discriminate from huge $\mu\mu$ background using:
  - Secondary vertex displacement
  - B pointing angle to Primary Vertex
  - B isolation,…
- ✓ Look inside a mass window

✓ No confirmation from the update shown by LHCb at EPS using 300 pb^{-1}

Justine Serrano (LHCb)

✓ Excess of B^0_s (~less than 3σ)

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (1.8^{+1.1}_{-0.9}) \times 10^{-8}$$

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) < 4.0 \times 10^{-8} \text{ at } 95\%$$

✓ See Diego Tonelli's plenary talk on Wednesday