Tevatron Operations and Physics

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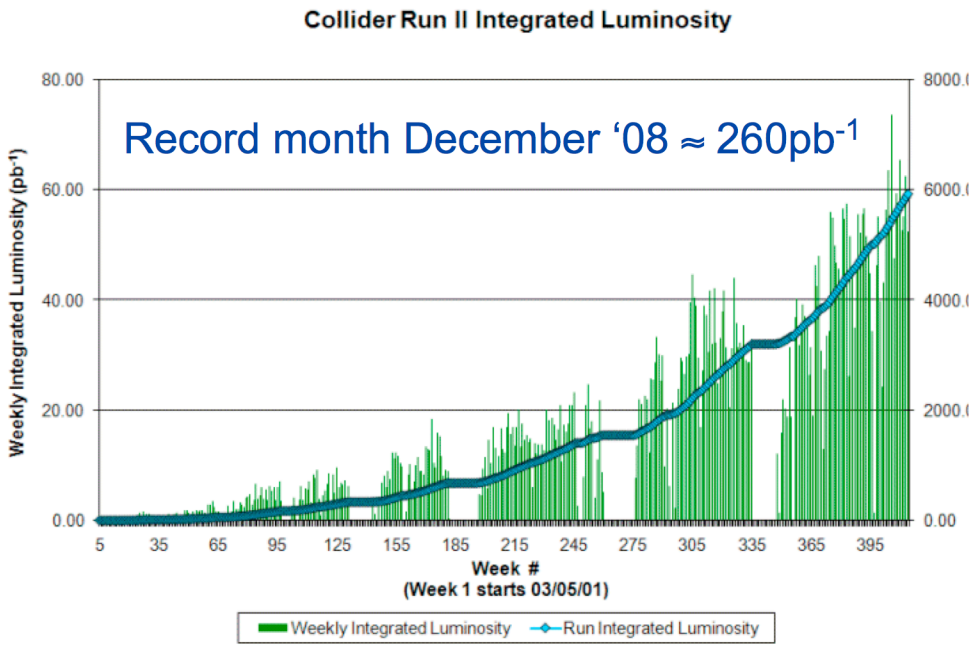
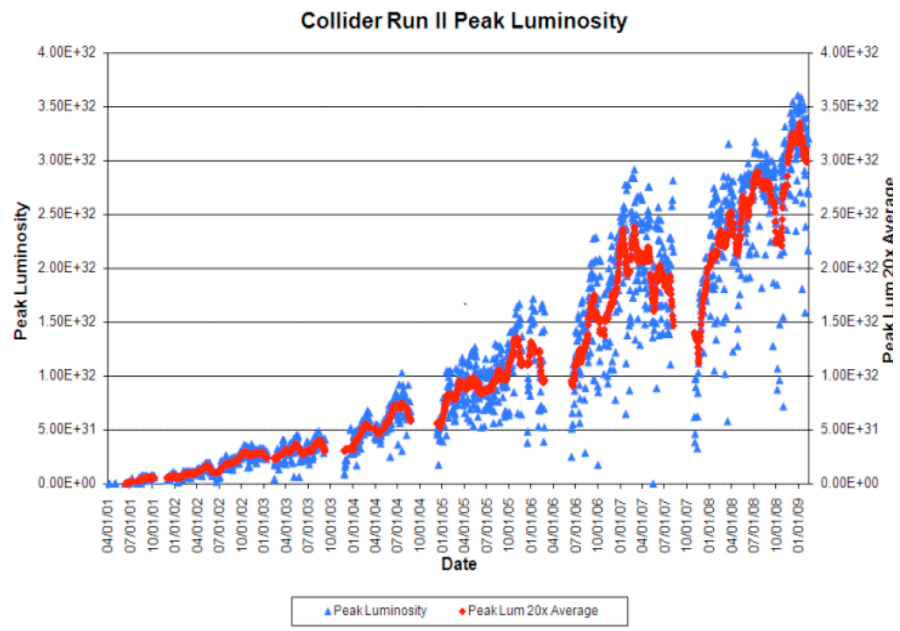
Fermilab - PPD

Tevatron Status



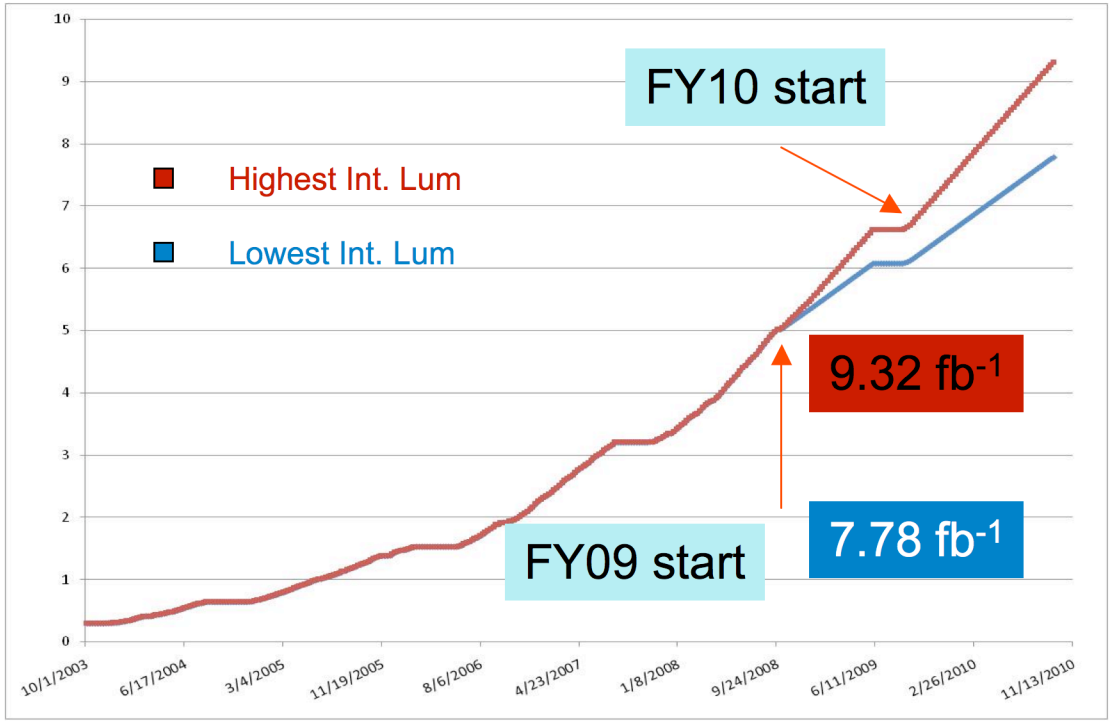


- Improved stacking rate
  - 28.6×10^{10}/hour December 2008
- Faster transfers to Recycler
  - More time stacking
- Improved reliability
  - Store-hours/week: 110 (100 in 2004)

- Exceptional performing machine
  - Luminosity >60pb^{-1} / week
  - > 2fb^{-1} /year
  - >350 E30 cm^{-2}s^{-1} instantaneous luminosity
  - ~6.1 fb^{-1} delivered so far

Tevatron projections

- Using data for FY02-FY08
- ~2 months shutdown this year
- Then, 12 months until end of FY10: +2.5fb^{-1} = 9.3fb^{-1}
- If running all of FY11: +2.5fb^{-1} = 11.7fb^{-1} …or more

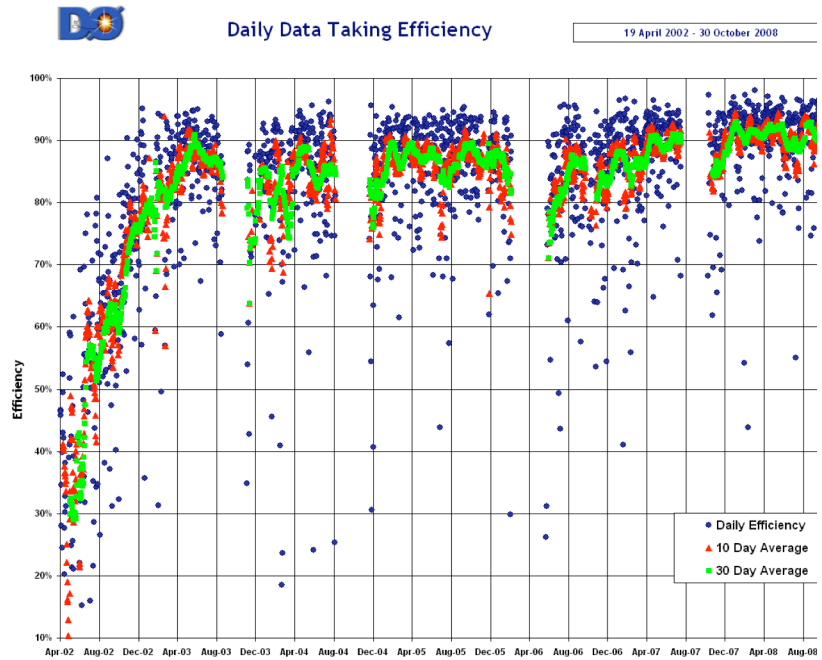


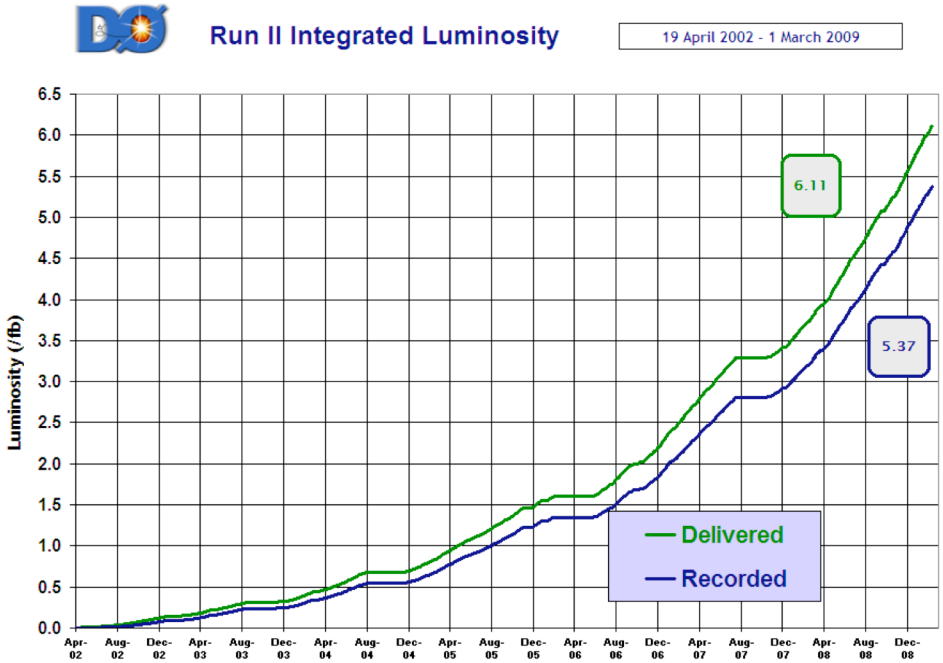
Estimated delivered Luminosity at end of FY1

Expect at least doubled delivered luminosity by the end of FY11

Detector status DØ

- Stable operation
- ~90% efficiency
- 5.4 fb^{-1} collected so far

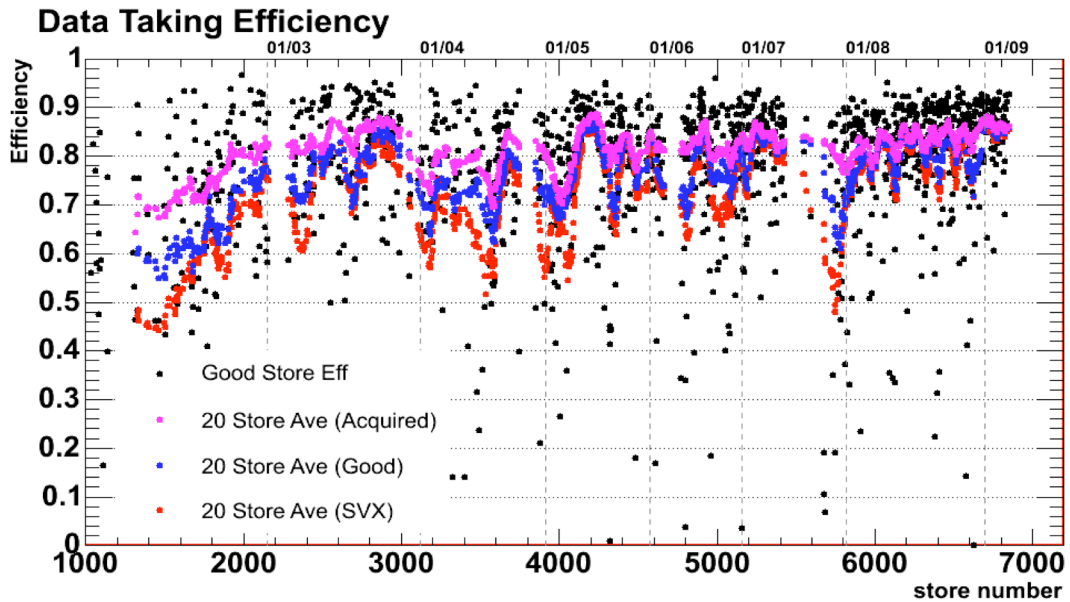


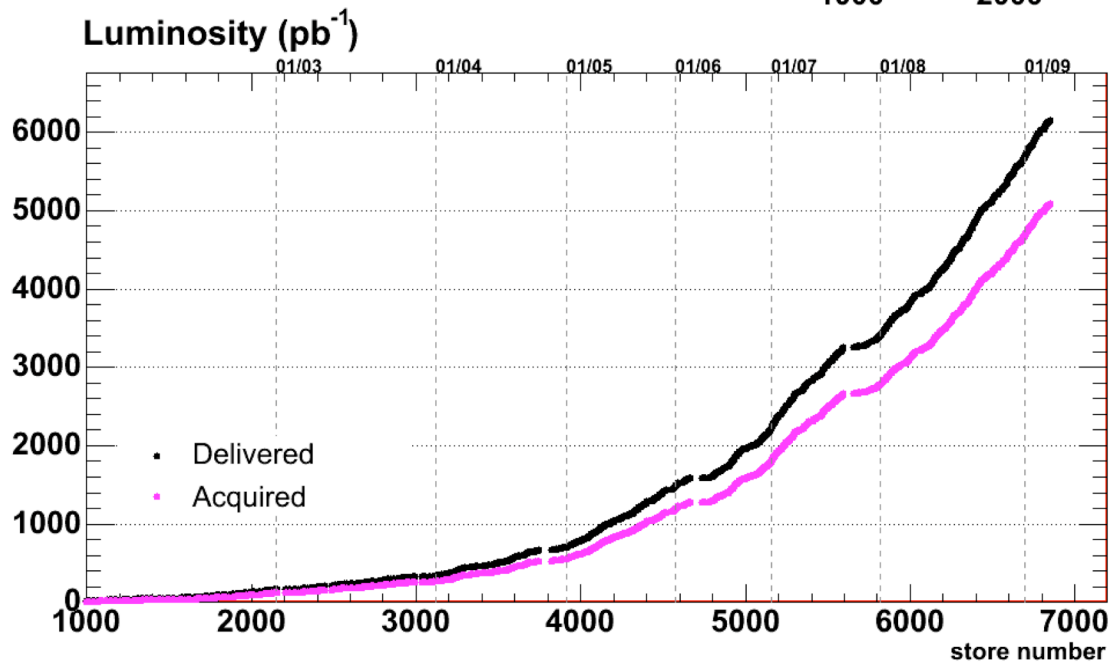


Up to 5 fb^{-1} analyses are planned to be presented at Moriond 2009

Detector Status CDF

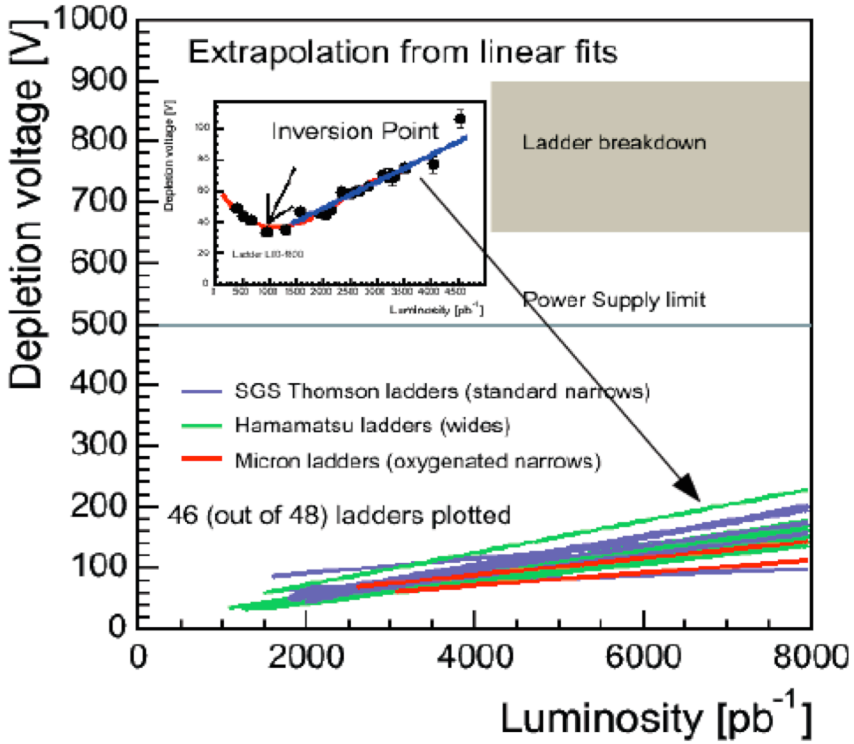
- Stable operation
- 5.1fb^{-1} collected so far
- ~85% efficiency

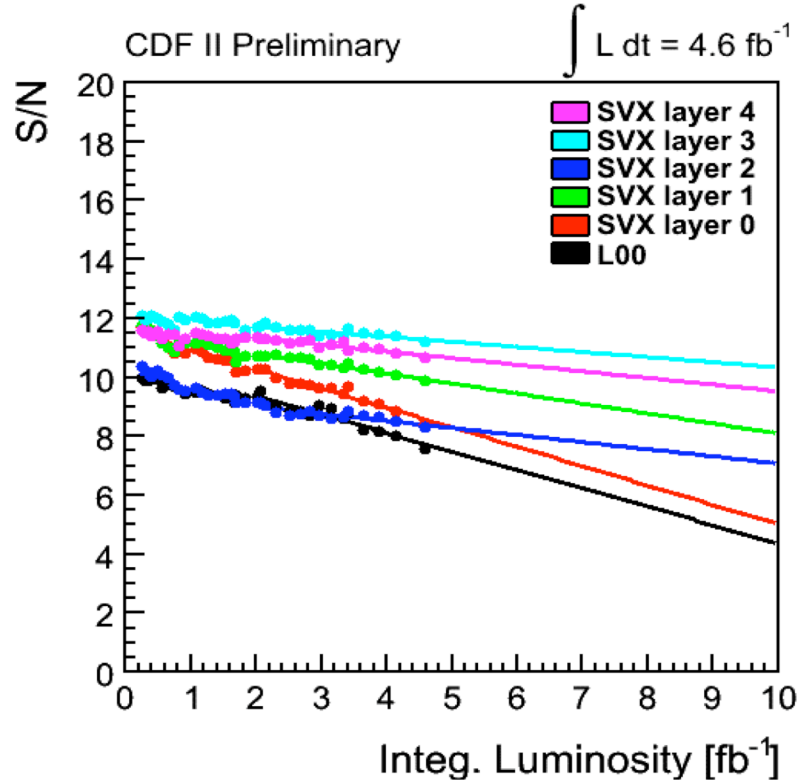




~4 fb^{-1} analyses are planned to be presented at Moriond 2009

CDF SVX Radiation Aging Projections

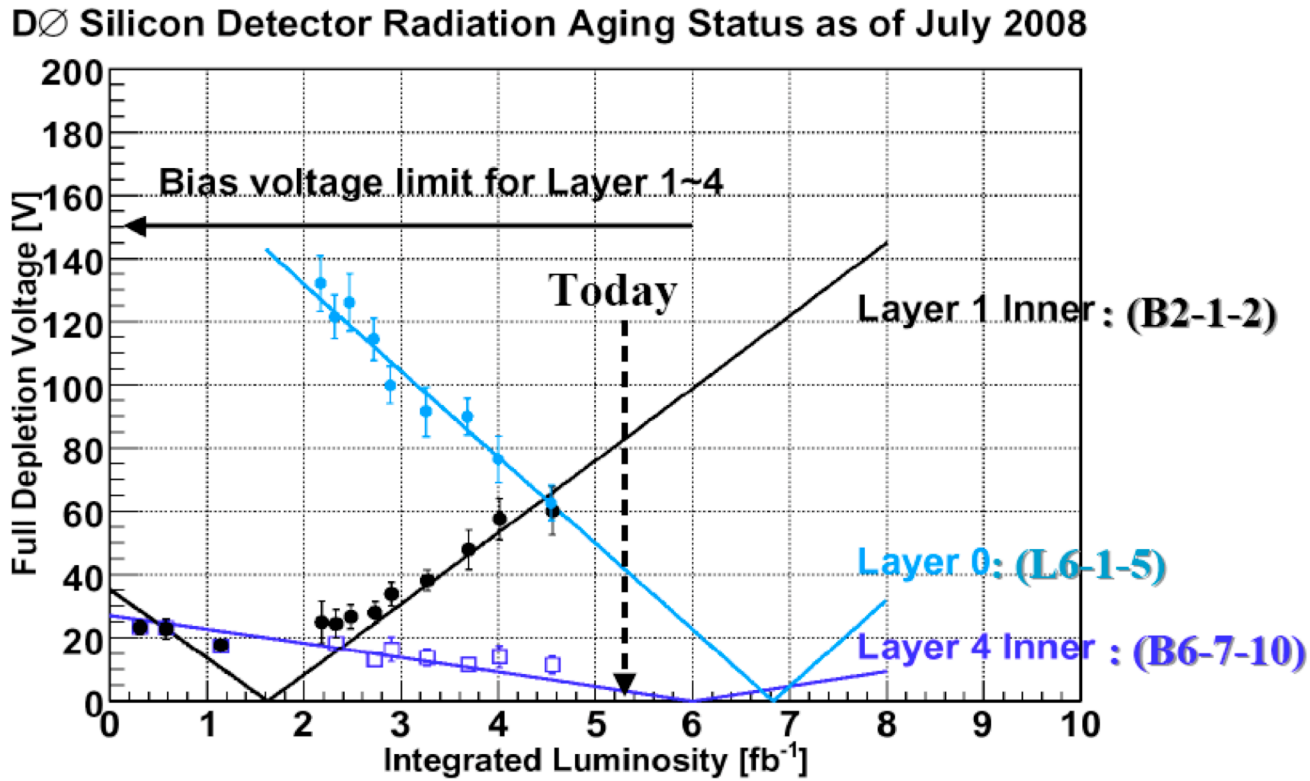




- Is radiation damage going to limit the operational lifetime of SVX?
  - Study performed recently and answer: NO
- ~ 5-6 (S/N) good for physics
- ~ 3 (S/N) Run I able to do high P_T b-tagging

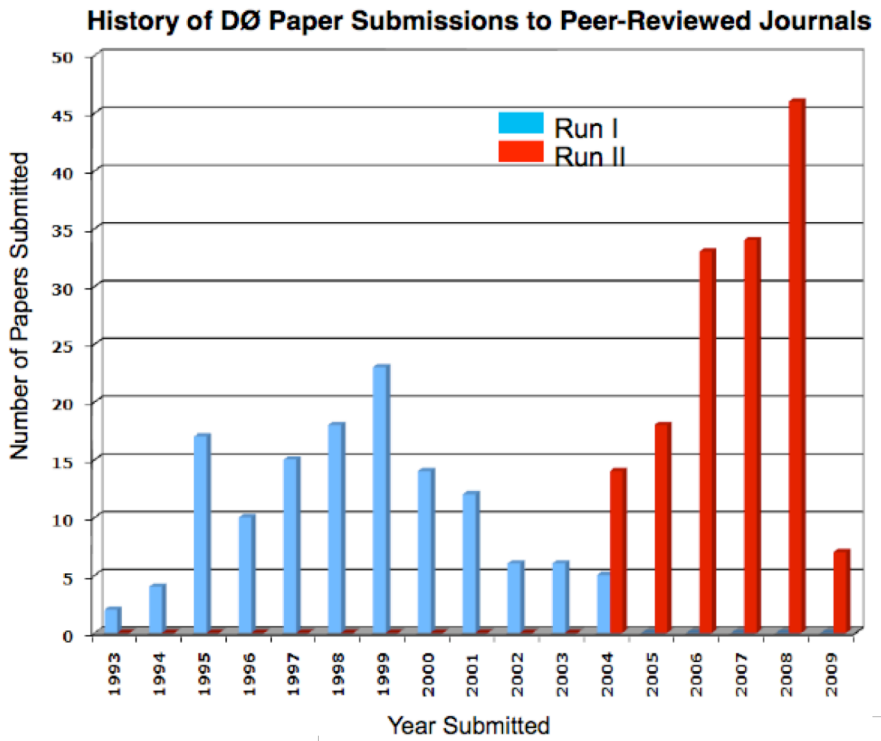
SVX will be operational to 12fb^{-1} or more

D0 SMT Radiation Aging Projections

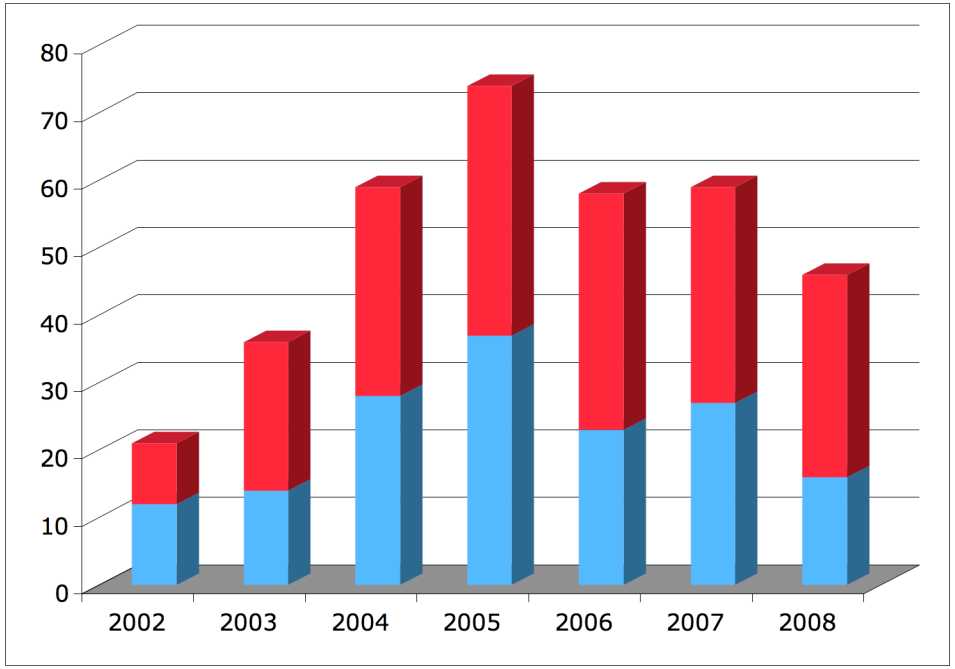


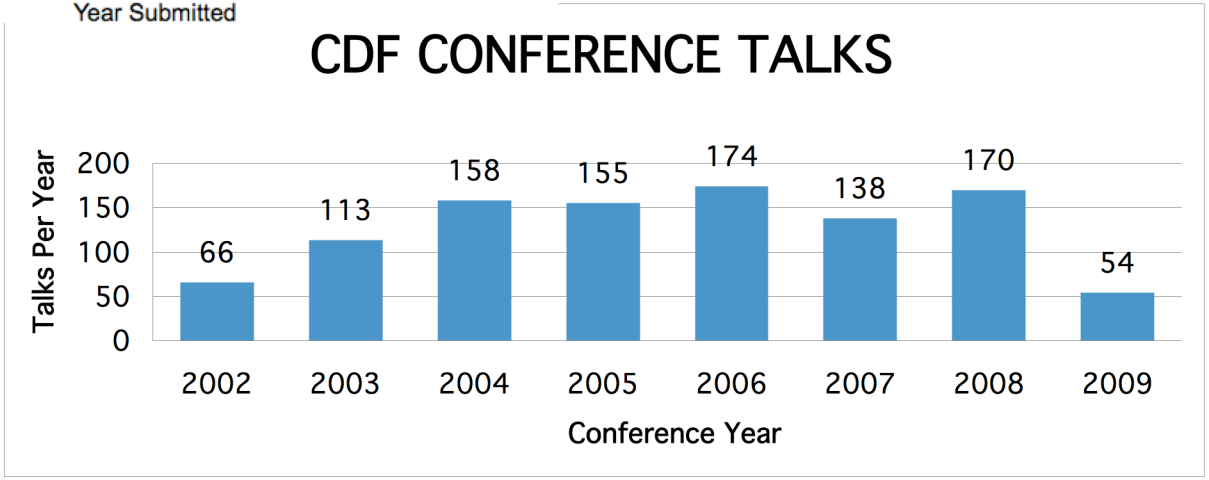
- Layer 0 and outer layers will be fine through the end of Run II
- A few sensors in Layer 1 might reach the bias voltage limit
  - Layer 0 was added to compensate for this possibility
- Continue to monitor the impact of radiation on the silicon detector
  - Adjust bias voltages as necessary

A Center for Physics Excellence

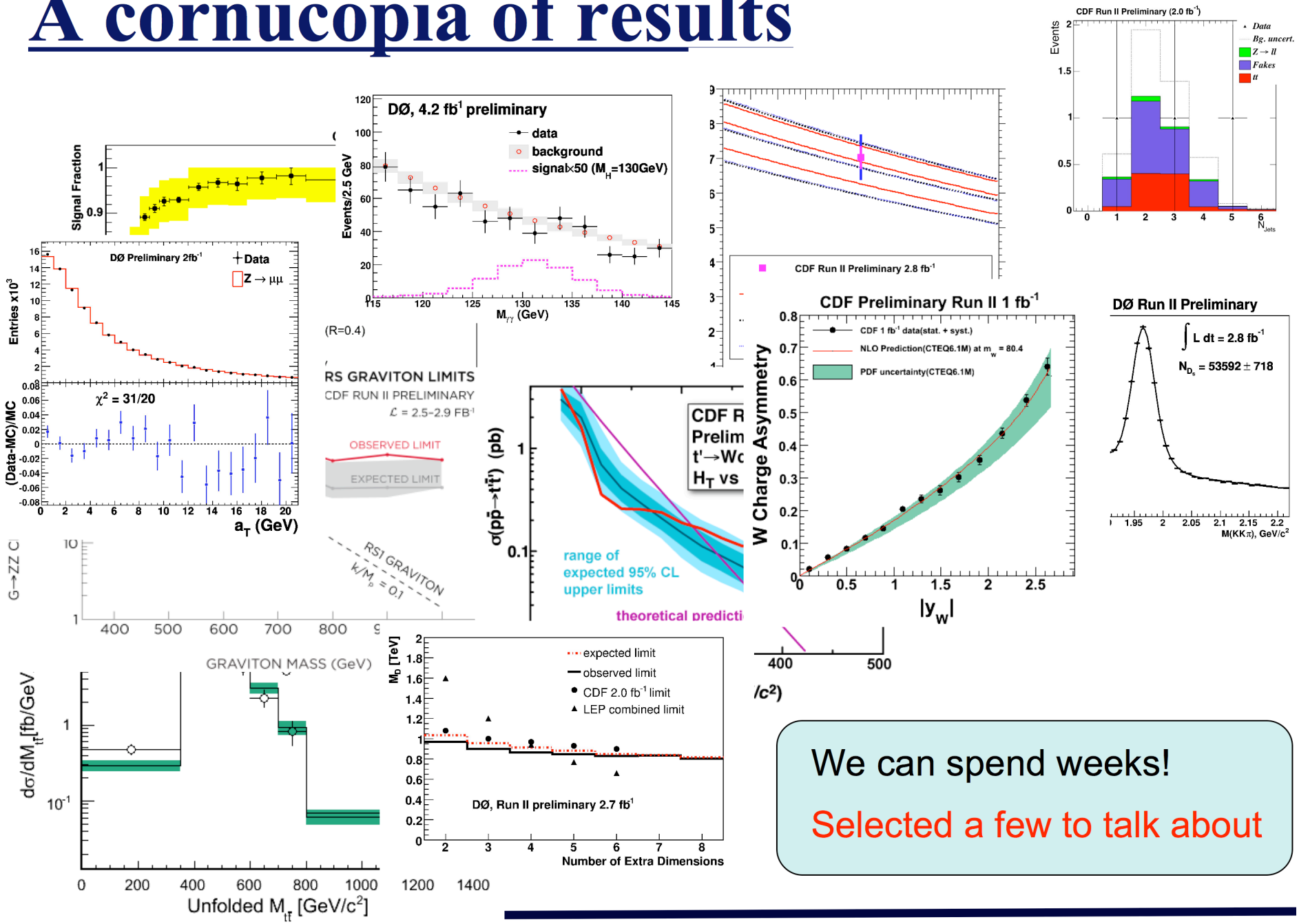


Awarded CDF and D0 theses





A cornucopia of results



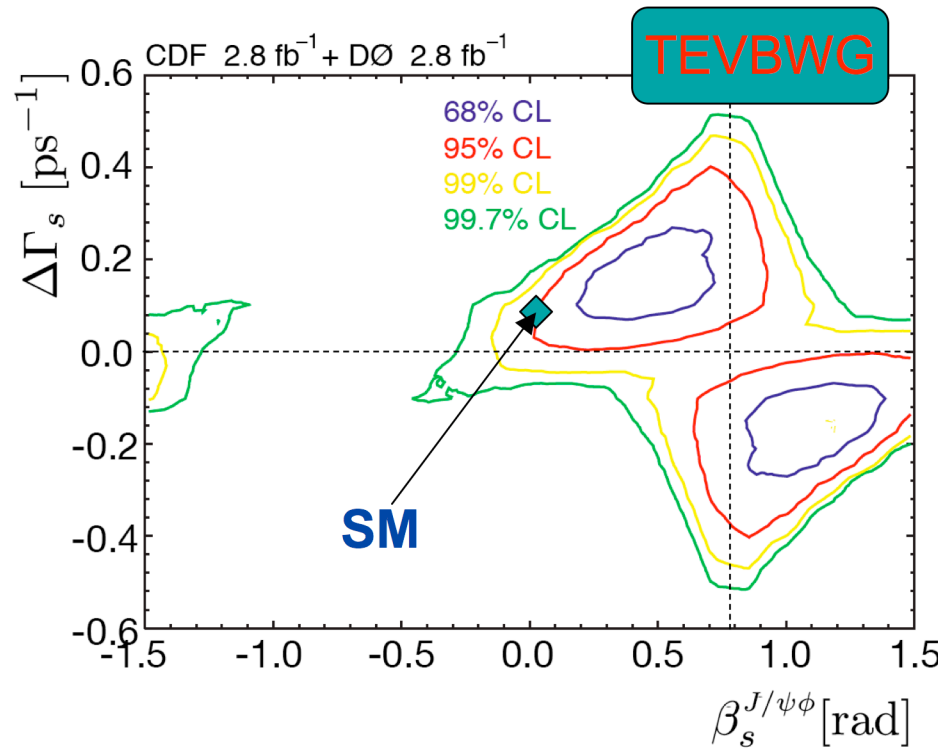
We can spend weeks!

Selected a few to talk about

B Physics

$$B_s \to J/\psi\,\phi,\ J/\psi \to \mu^+\mu^-,\ \phi \to K^+K^-$$

- Final state is a mixture of even and odd CP eigenstates
- Use mass, tagging information, proper decay time and angular distributions
- Extract $\Delta\Gamma$ and β_S

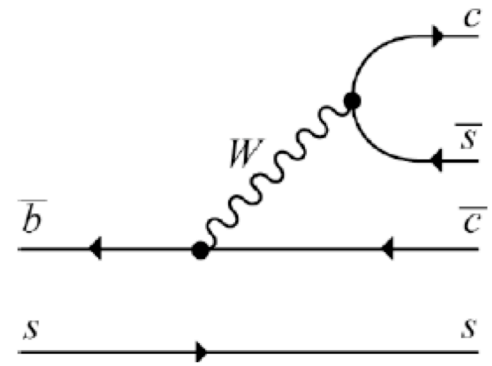


Both results are compatible with SM at 1.8σ (CDF) and 1.7σ (D0)

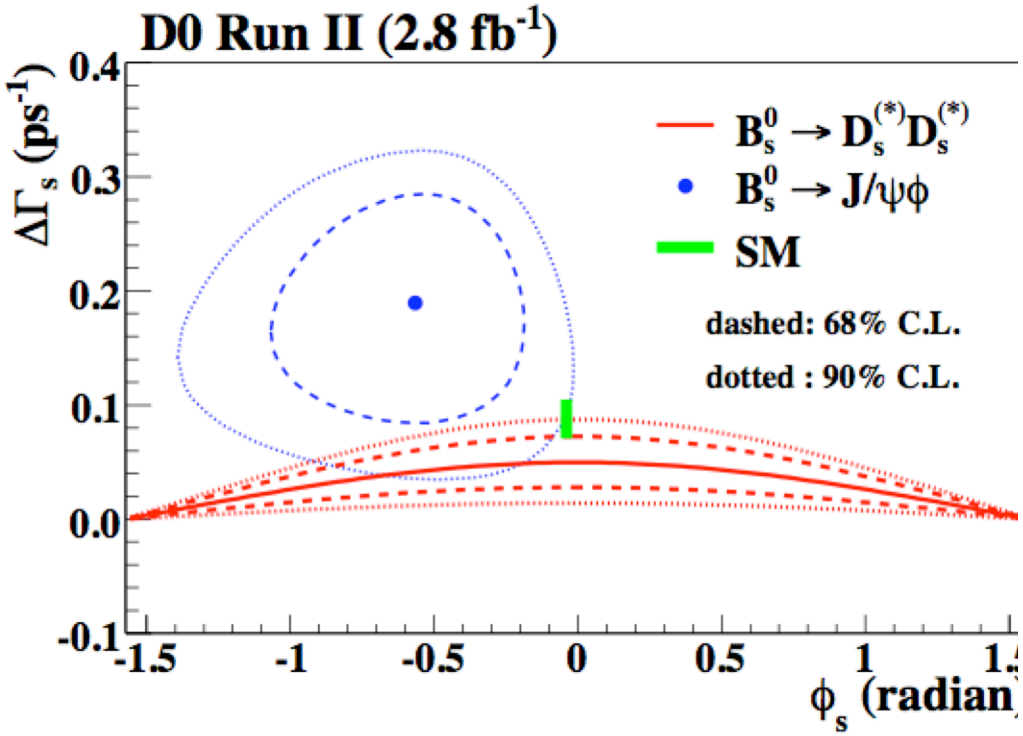
Both results show same tendency

Combined they are 2.2σ away from the SM prediction

$B_s \rightarrow D_s^{(*)} D_s^{(*)}$



- $D_s D_s$ final state CP even
- Measure BR ≈ $\Delta\Gamma_{CP}/\Gamma$
- No flavor tagging required

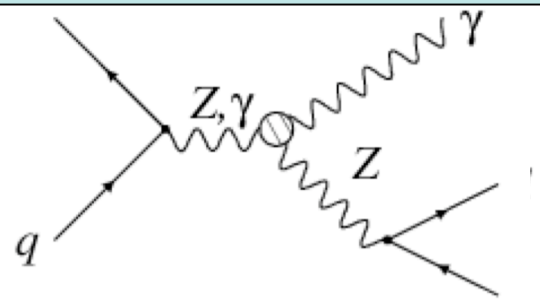


$$\Delta\Gamma_s^{CP}/\Gamma_s = 0.072 \pm 0.021(stat) \pm 0.022(syst)$$

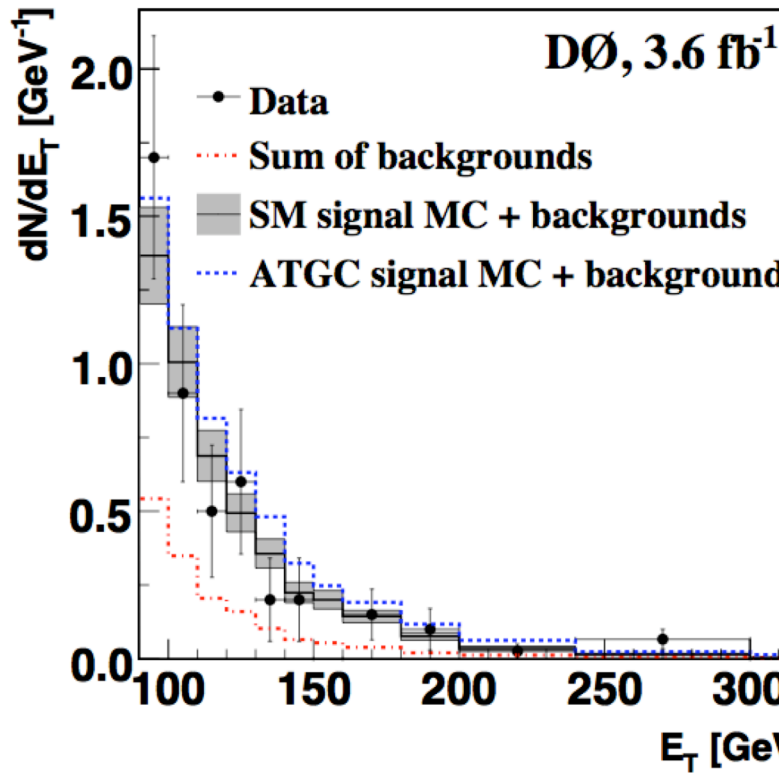
First single measurement that demonstrates non zero lifetime difference between CP eigenstates in the B_s system

Dibosons

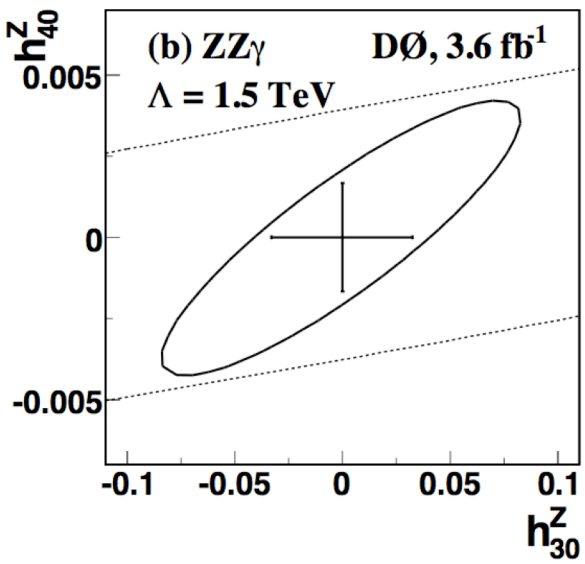
ZZγ and Zγγ are zero in SM
- 10^{-4} QED corr.



Photon+MET



The most stringent bound on h_{30} and h_{40}
(low energy approx. of the couplings)

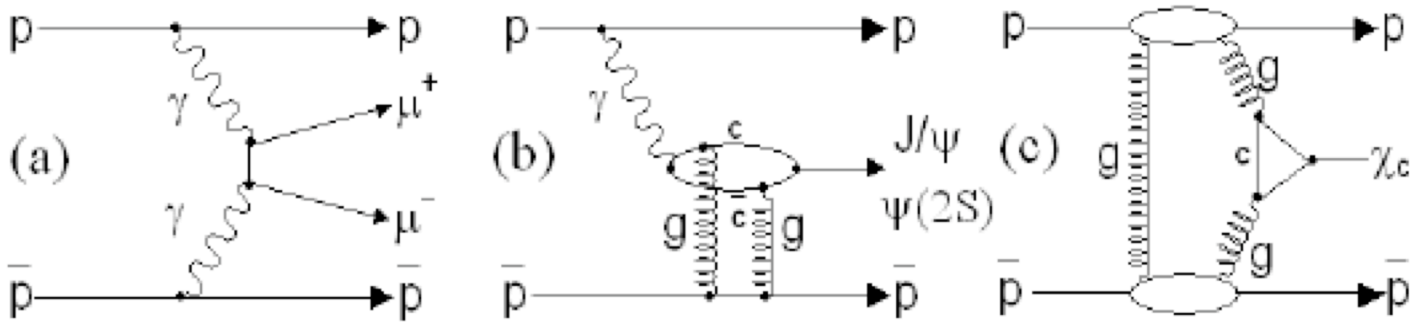


E_T^{photon}>90GeV

σ=32±9(stat.+syst.)±2(lumi.) fb

First observation of Z(νν)+γ at hadron colliders

QCD

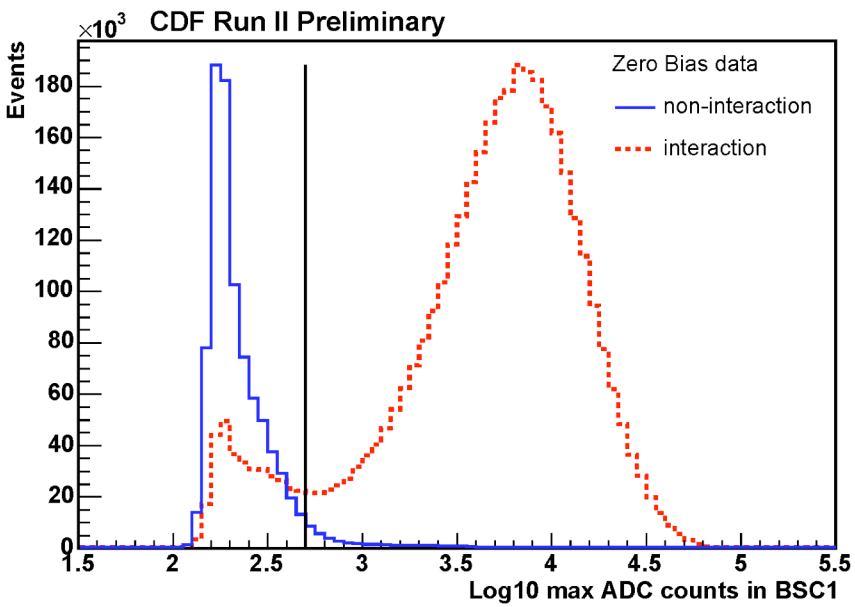


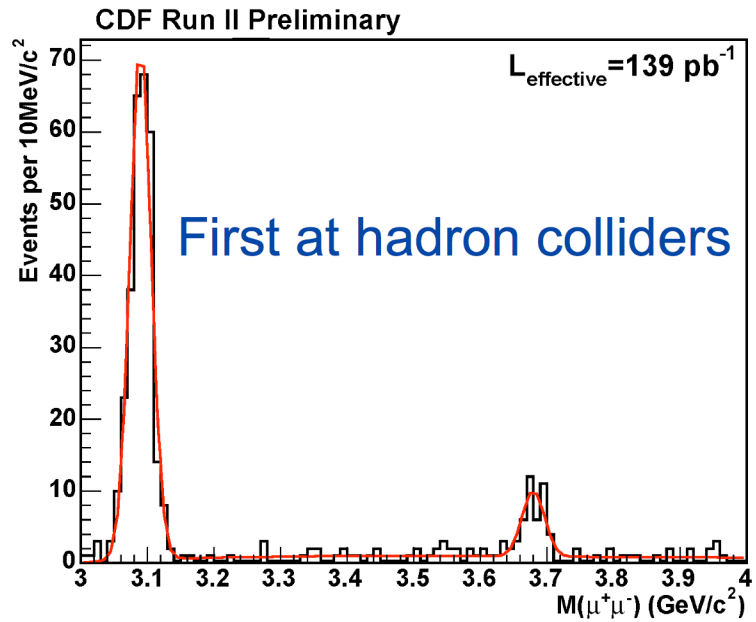
Exclusive charmonium production

$\sigma_{J/\Psi}$= 3.92±0.62 nb

$\sigma_{\Psi 2s}$ = 0.53±0.14 nb

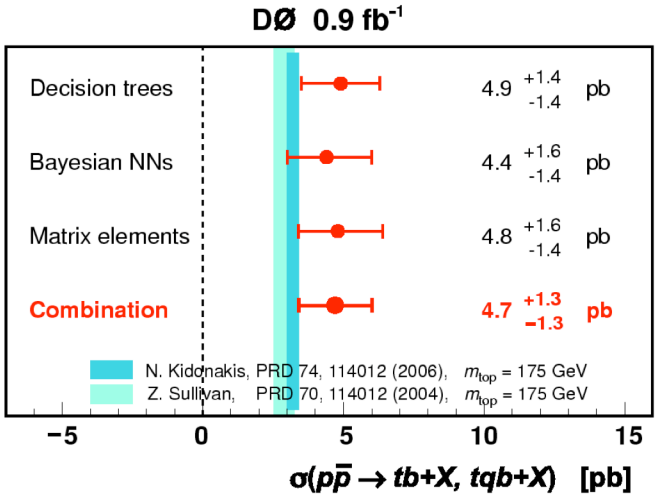
$\sigma_{\chi c}$ = 75±14 nb



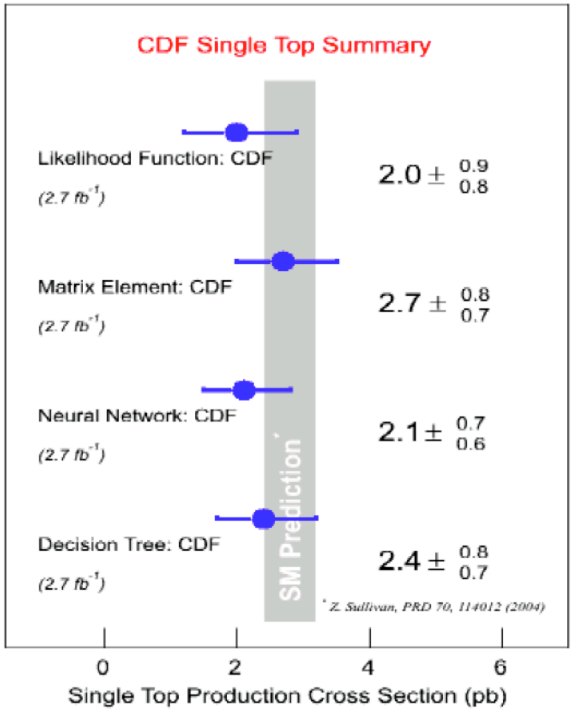


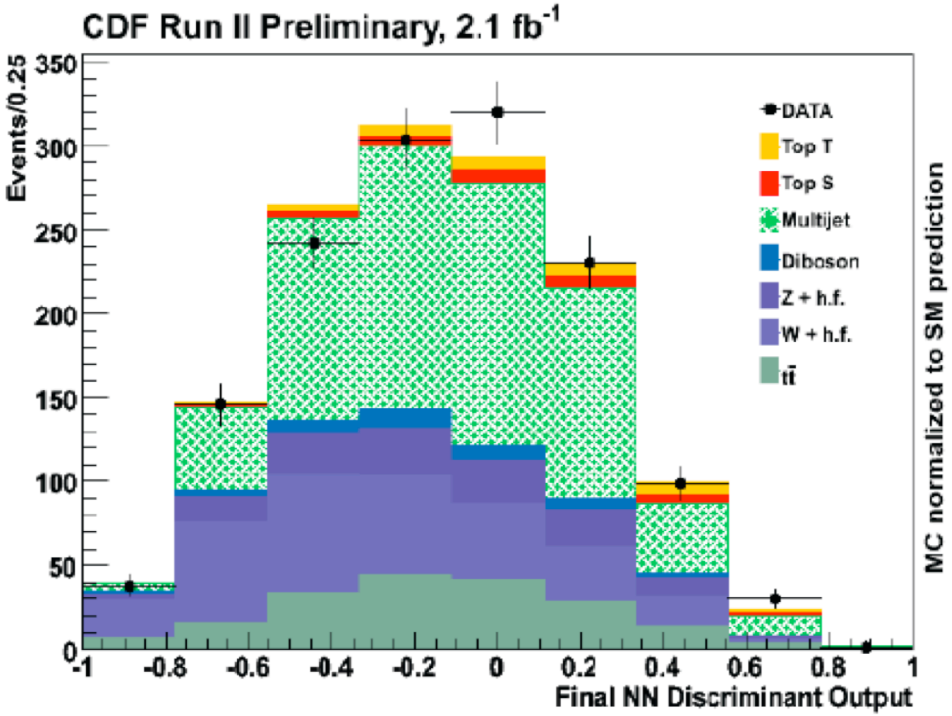
Similar to diffractive Higgs

Single top



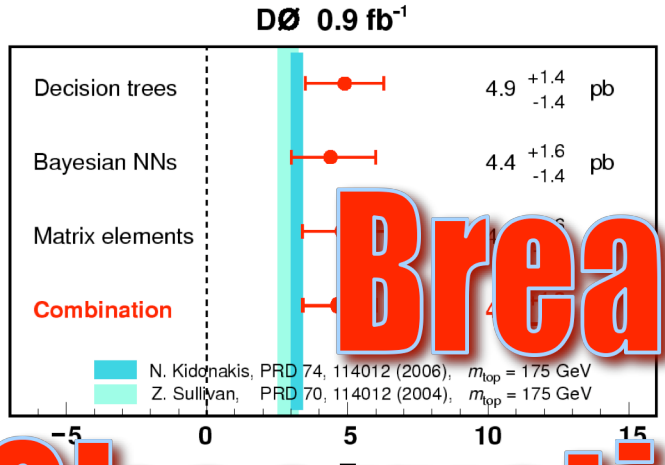
- Usually require the lepton from W
- New CDF MET+2j
  - τ decays or missed e/μ
  - σ=4.5±2.5±2.1pb





Similar to WH: Good training ground

Single top

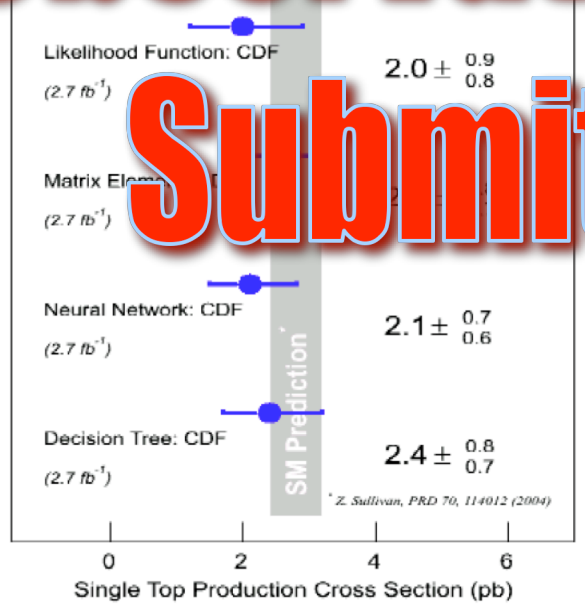


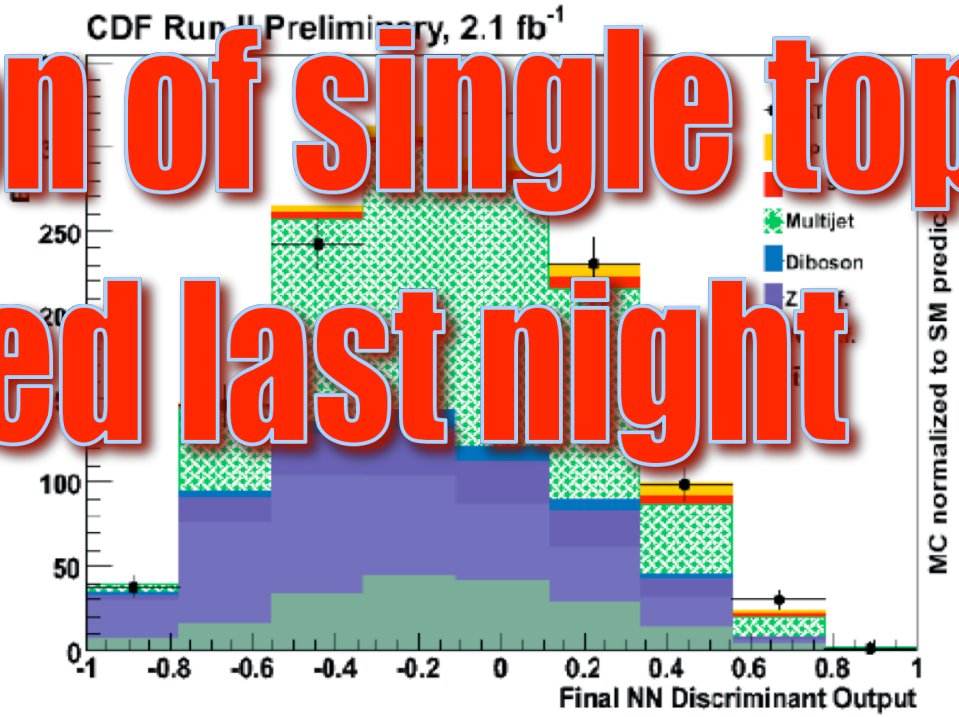
- Usually require the lepton from W
- New CDF MET+2j

Breaking News:

Observation of single top

Submitted last night

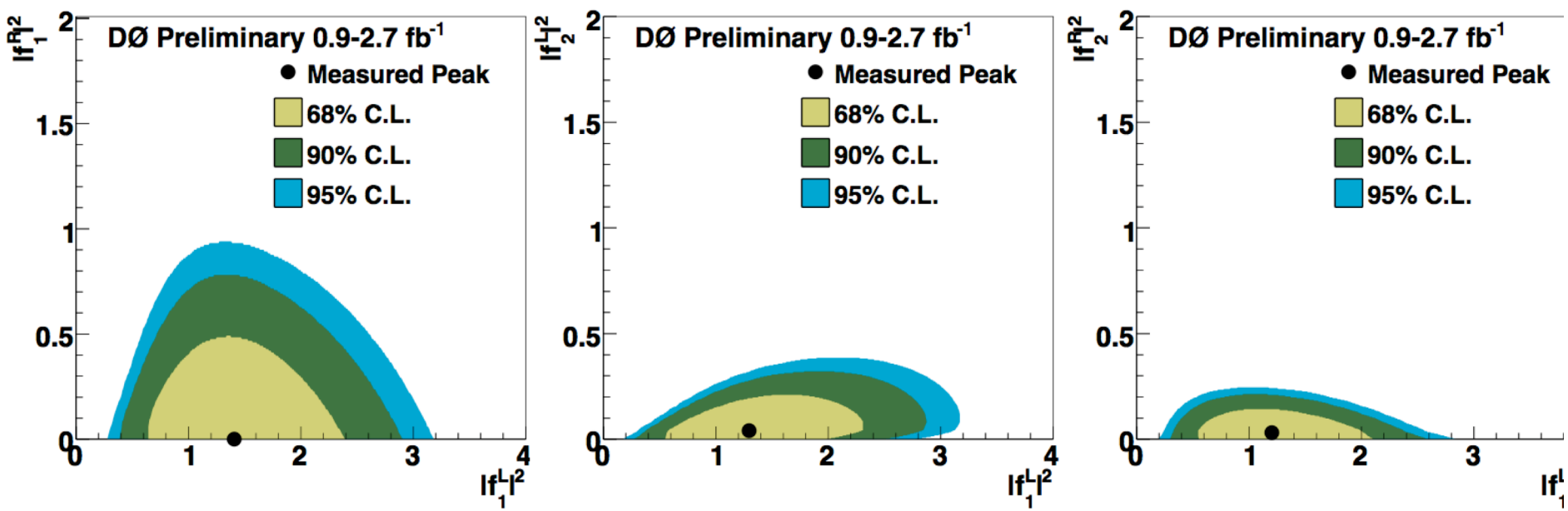




Similar to WH: Good training ground

Anomalous top couplings

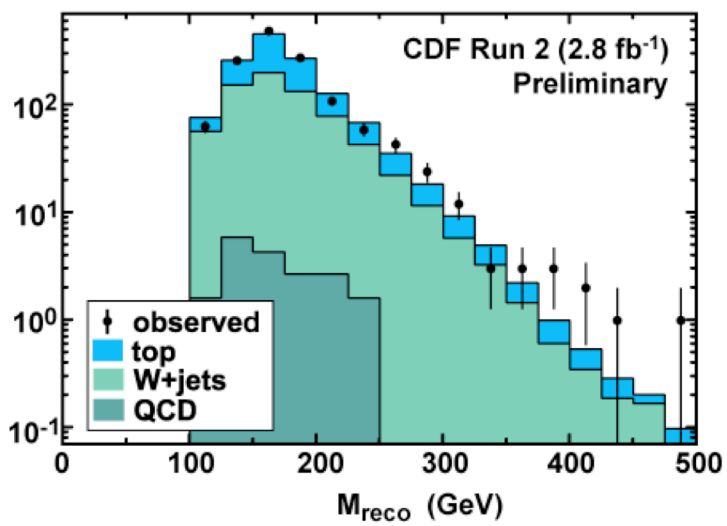
- Top is the heaviest SM particle
  - May play interesting role in EWSB
  - May have modified couplings to gauge bosons
- Combine single top and W helicity measurement
- Express result in left/right vector/tensor tbW couplings
  - SM: $f^1_L=1$, $f^1_R=0$, $f^2_L=0$, $f^2_R=0$

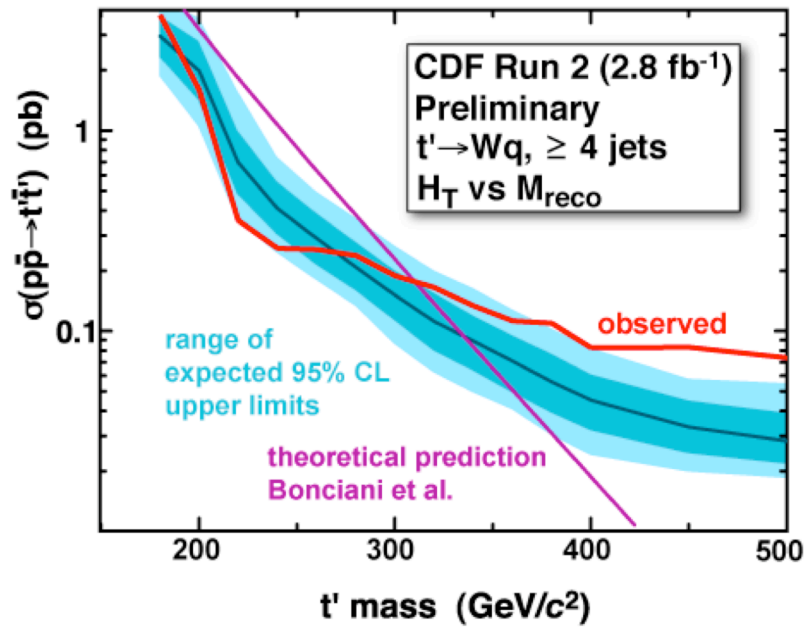


Most stringent limit on anomalous top couplings

Heavy top

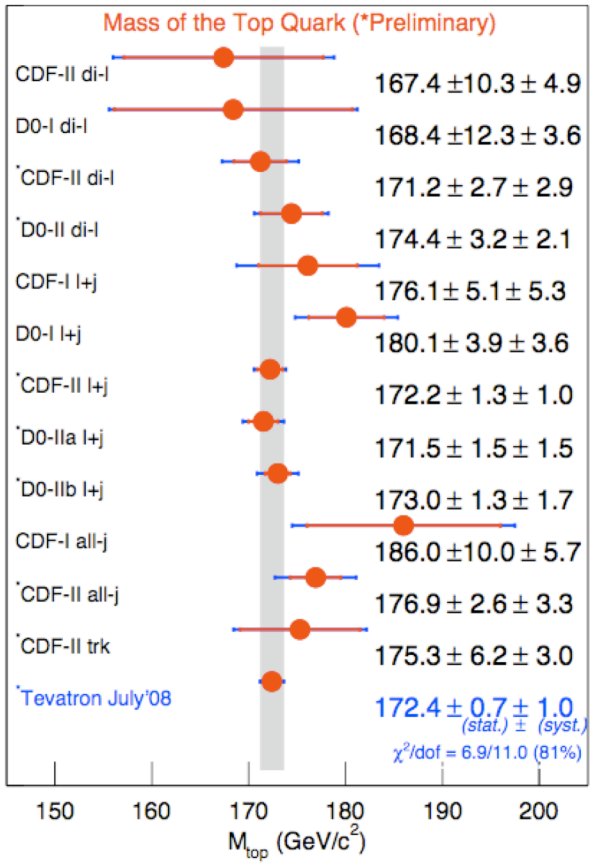
- Tevatron has now a large sample of top quarks
  - Small deviations can show up
- First question: is top really top?
- Exclusion limits on heavy t' models
- Only 1% consistency with SM in the tail





Stay on top of the unexpected - more data to be added

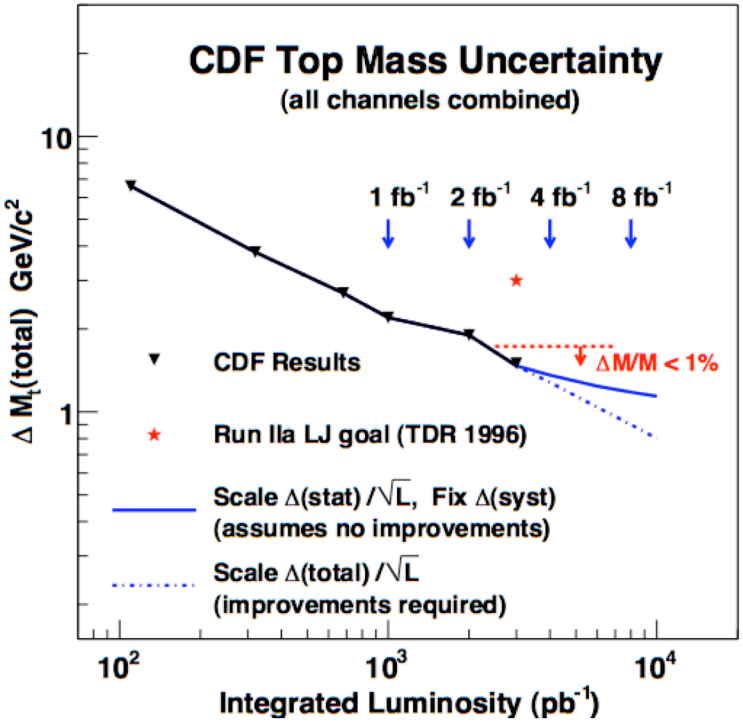
Top Mass



Up to 3.2fb-1

March 2009 CDF combined
Below 1% uncertainty

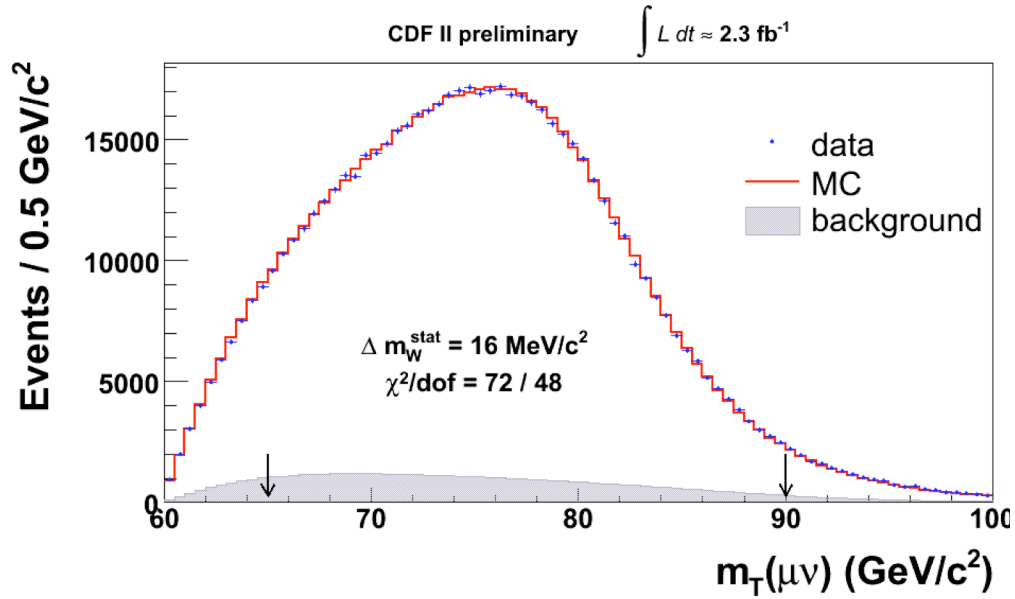
m_t = 172.6 ± 0.9 (stat.) ± 1.2 (syst.)

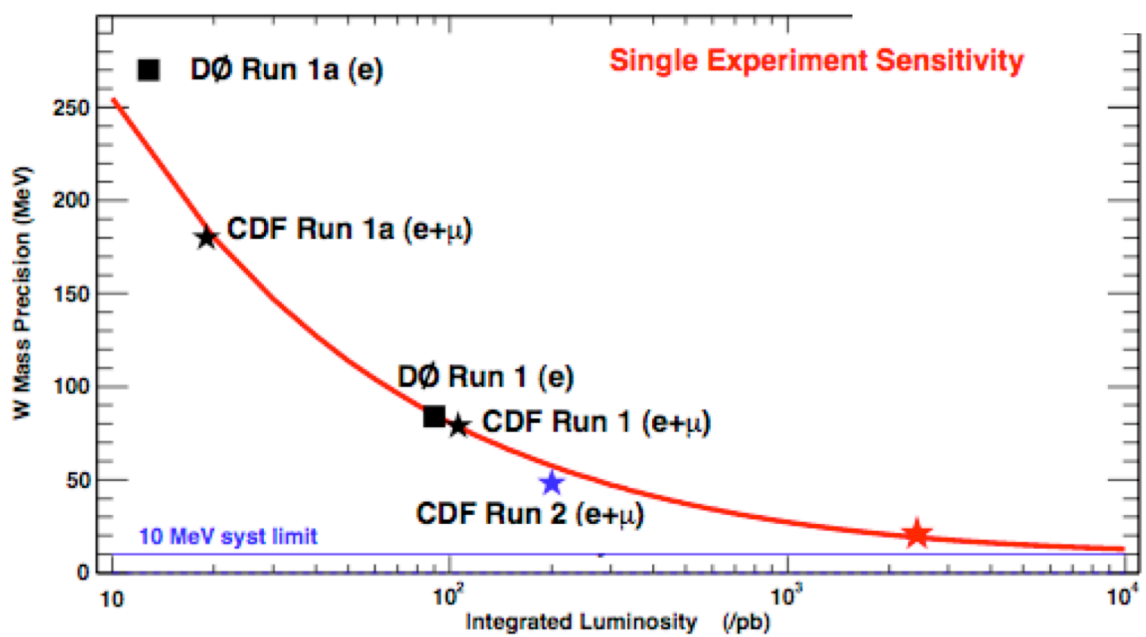


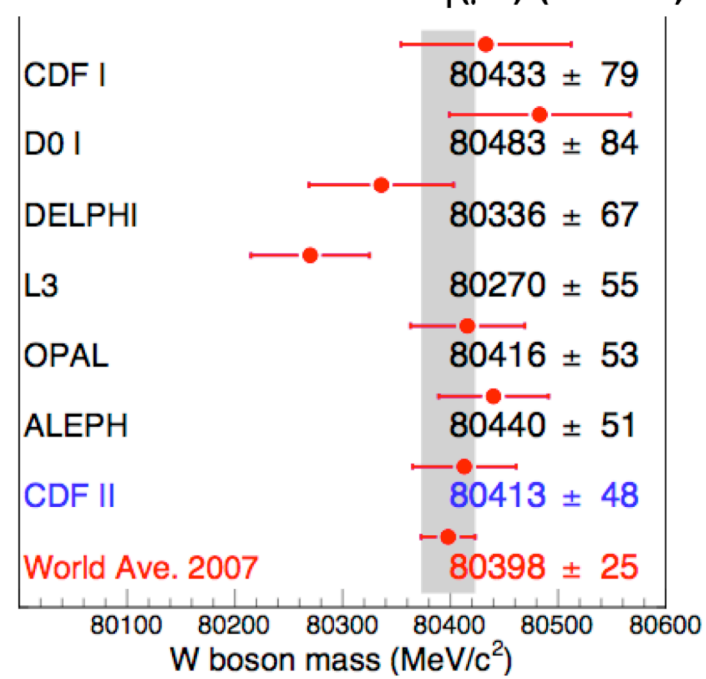
8fb^{-1} top mass uncertainty is expected below 1GeV

W mass

- Last result: 200pb^{-1}
  - m_W = 80413±48 MeV
- Target uncertainty 25 MeV



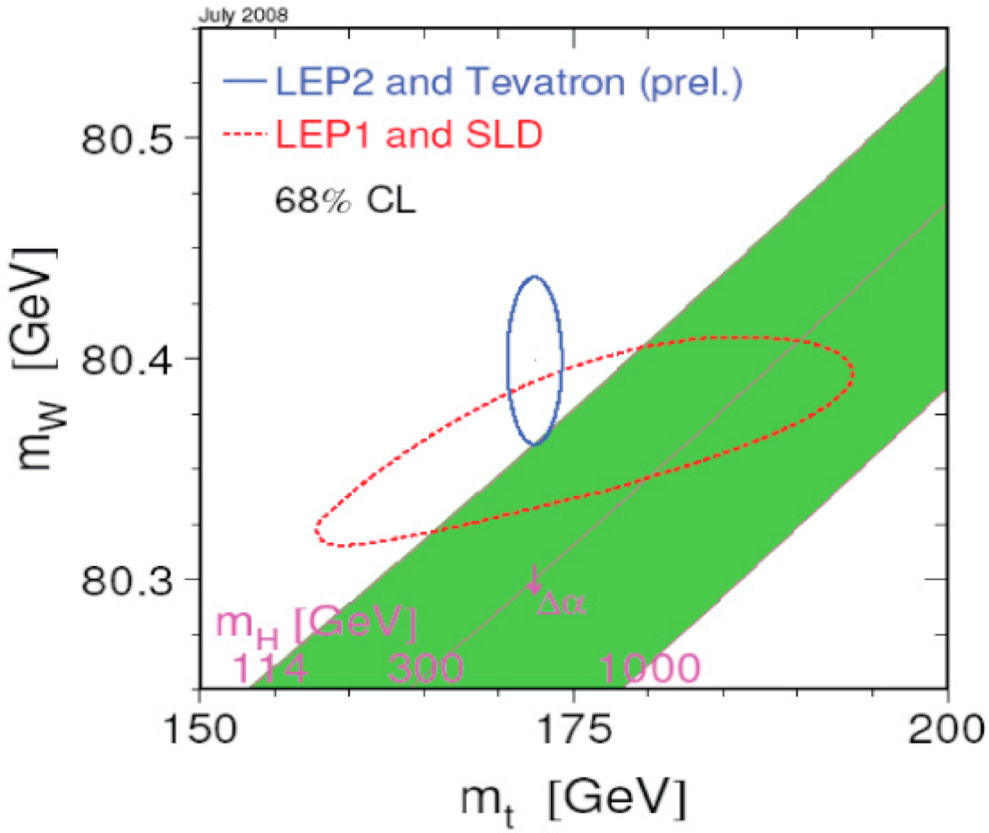




The W mass results will be in textbooks for a long time to come

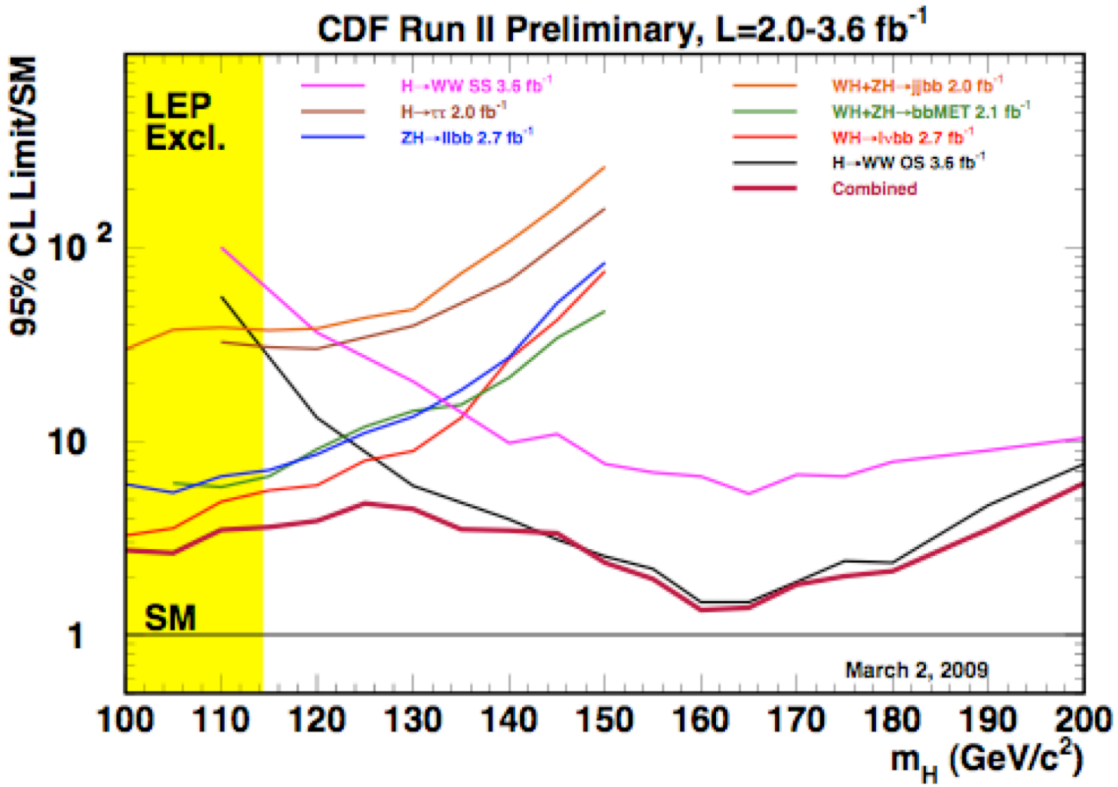
Cornering the Higgs

- Higgs quantum corrections to the EWK observables
- m_t and m_W constrain m_H



When Higgs discovered this will be good consistency check on SM

Direct Higgs searches

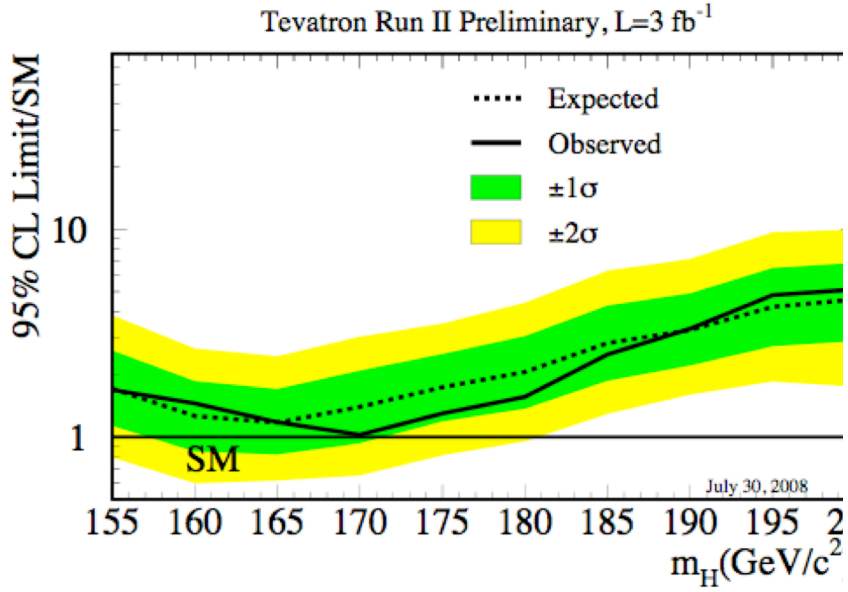


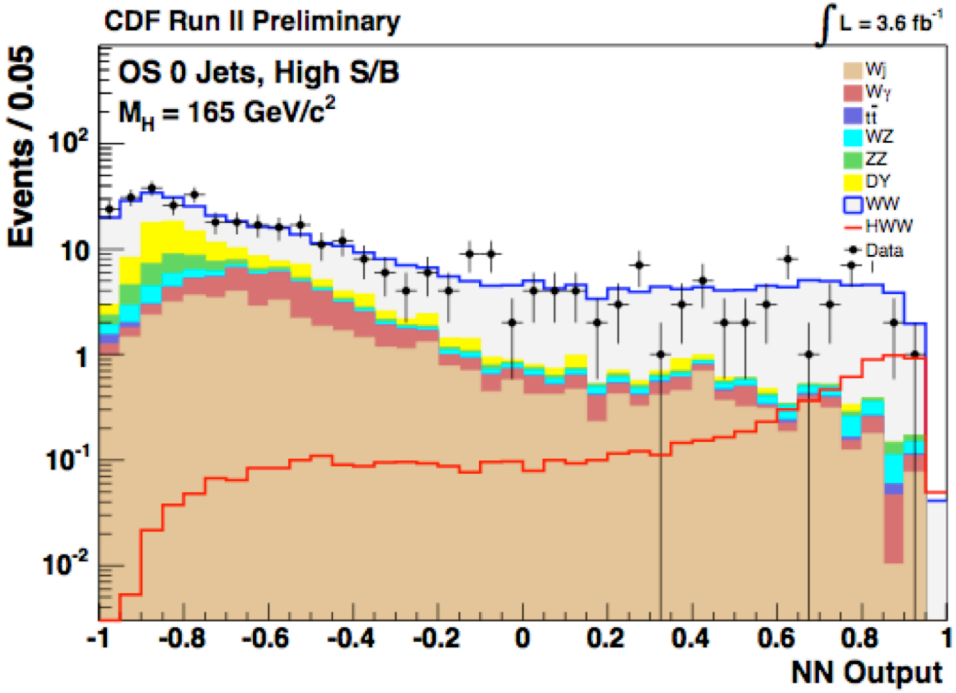
m_H<130GeV
VH - associated prod.
Background: V+jets

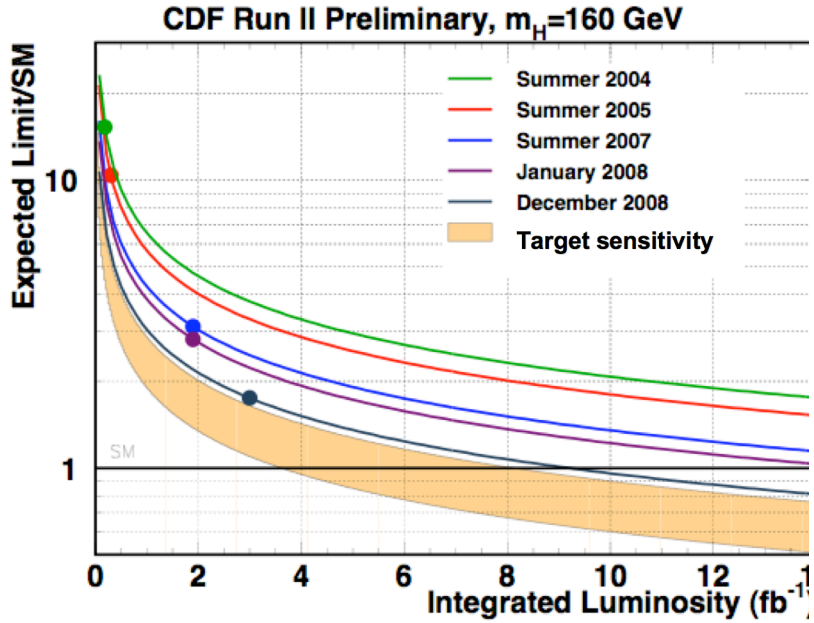
m_H>130GeV
H→WW
Background: WW SM

High Mass

- H→WW
- Angular correlation of leptons (0 spin)
  - NN selection
- Also combine with HW→WWW (SS leptons)



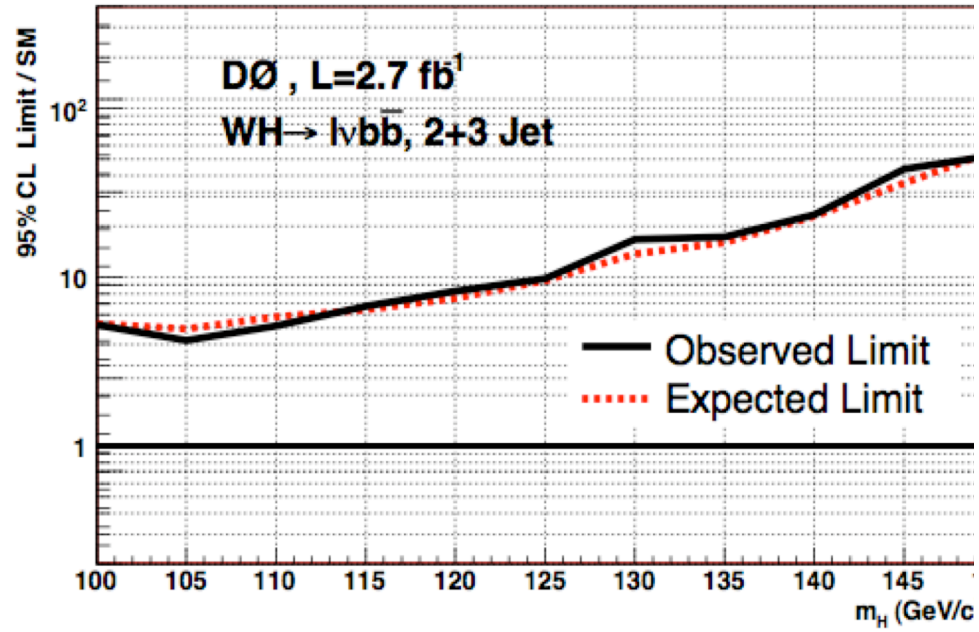


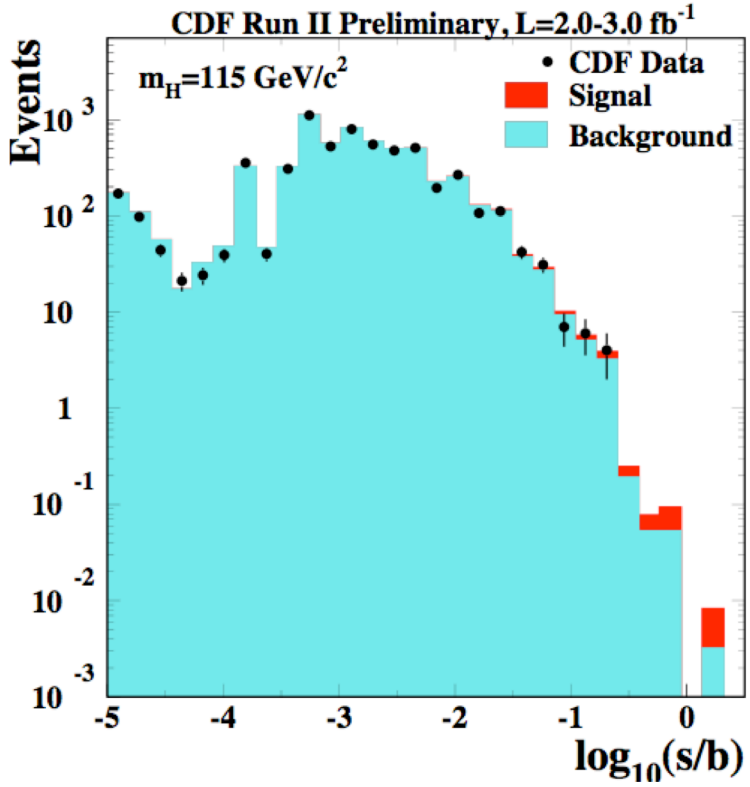


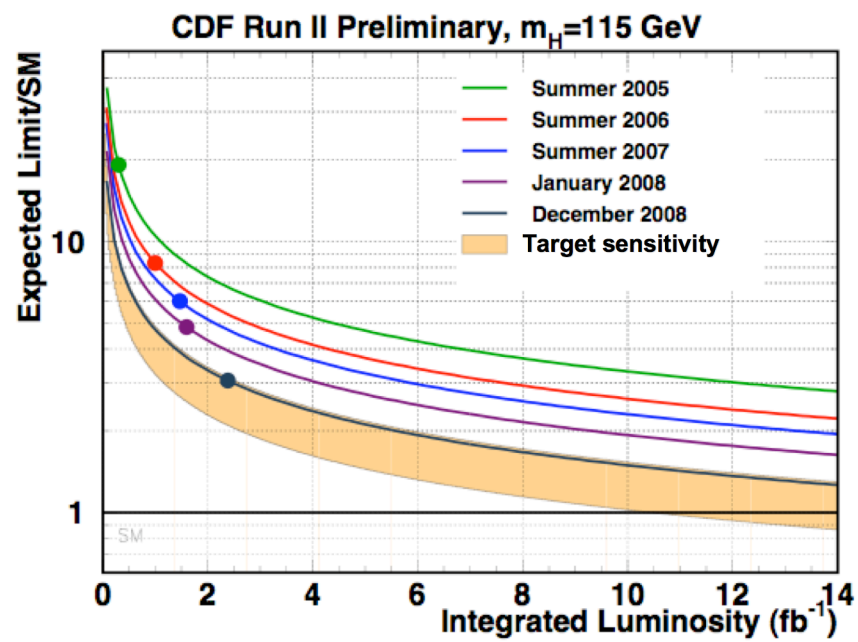
Tevatron is sensitive to SM Higgs!

Low Mass

- VH
  - H→bb ; V→ll
- Fully reconstructed H
  - Dijet mass
  - Multivariate technique for selection



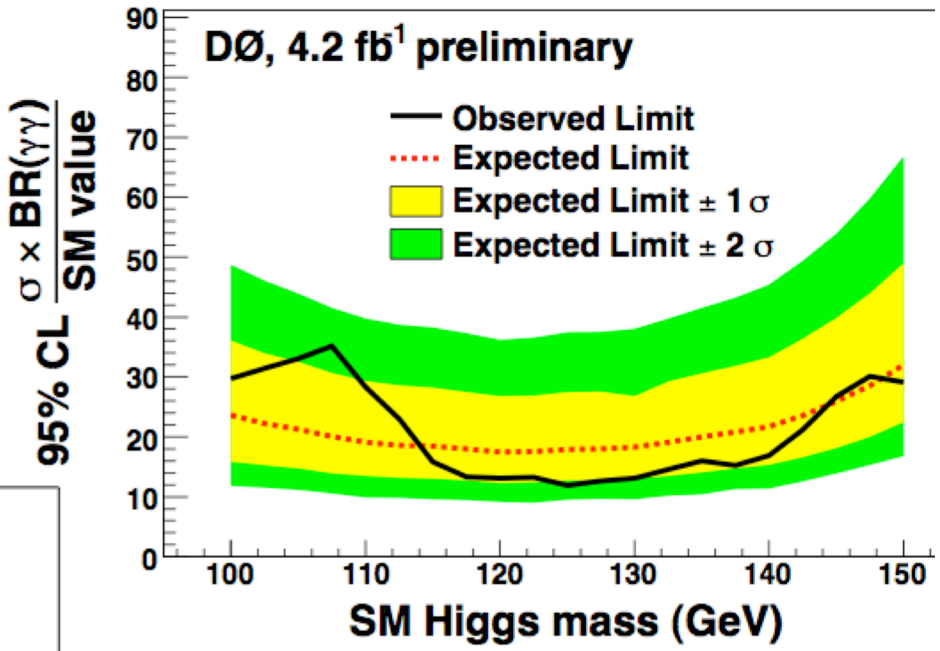


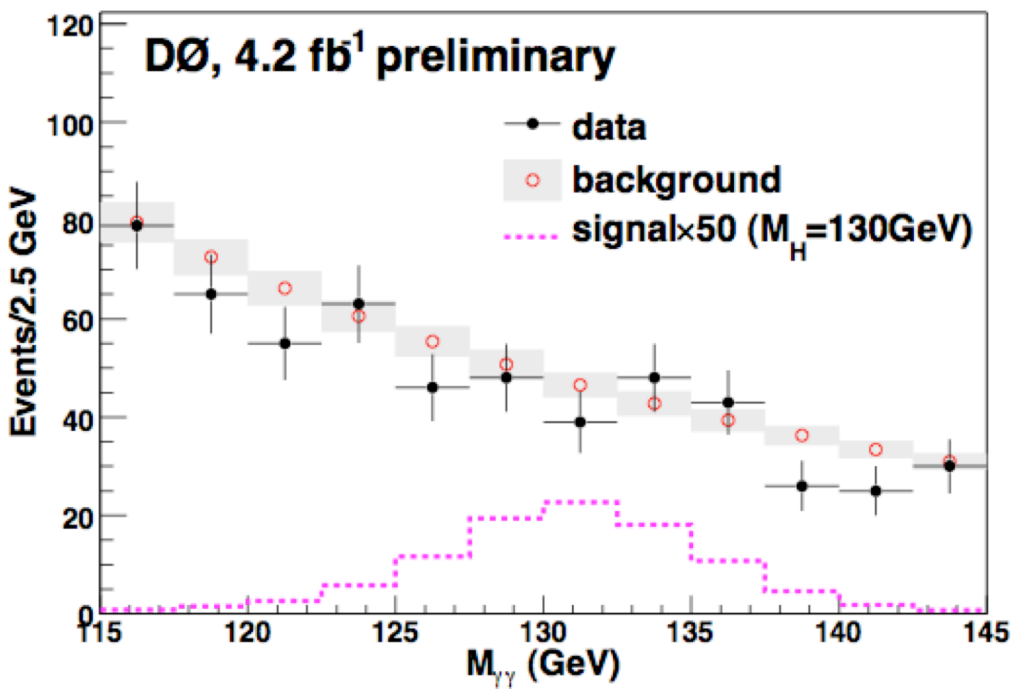


Getting interesting and more data helps

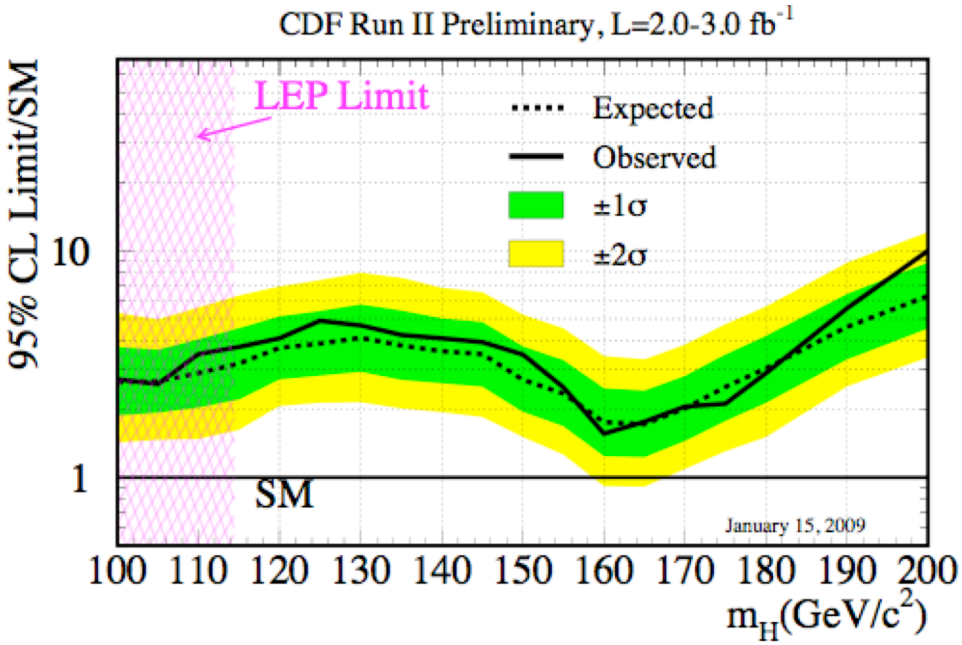
Pushing the limits

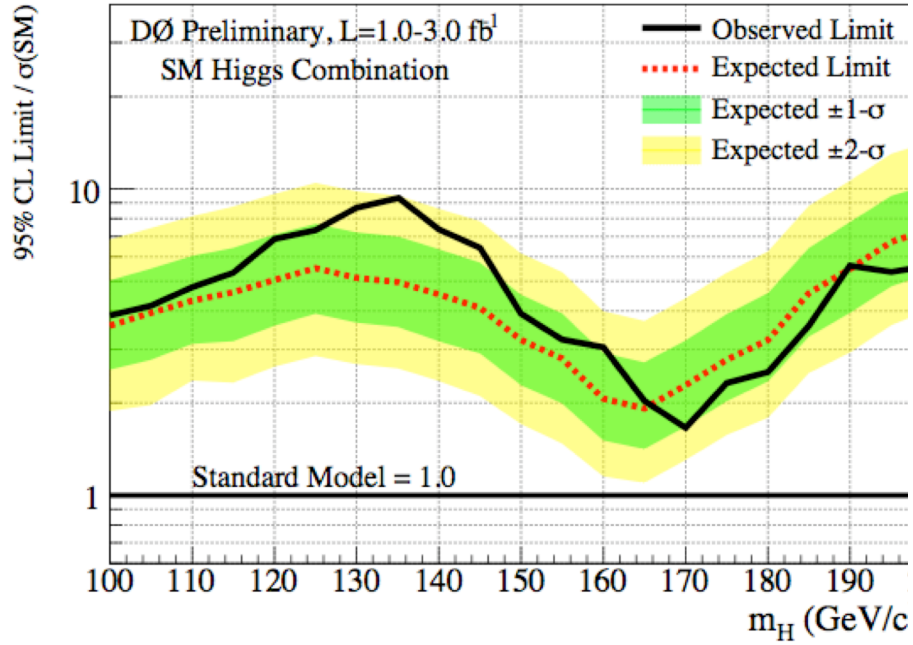
- $H \rightarrow \gamma\gamma$
  - Pro: good mass resolution
  - Con: tiny SM cross section
- Large enhancement in fermiophobic models

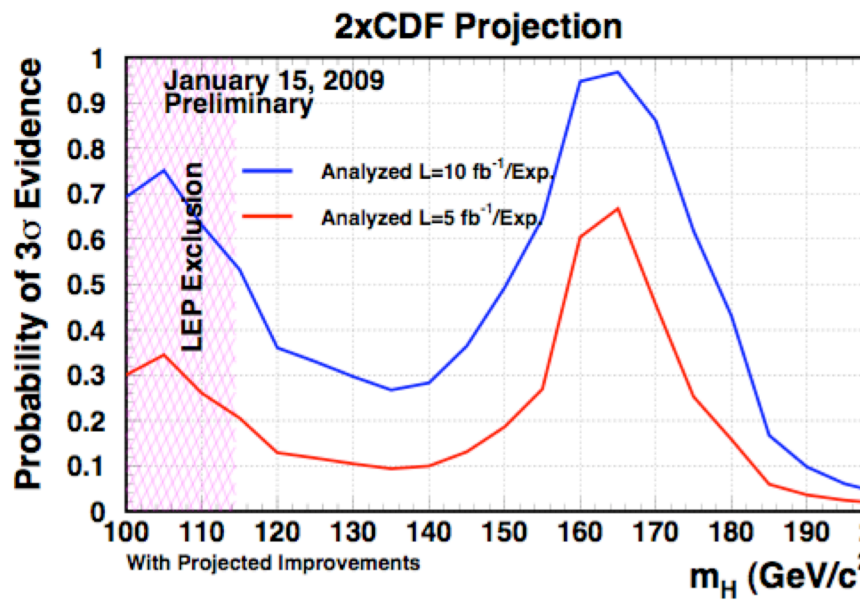




Overall picture



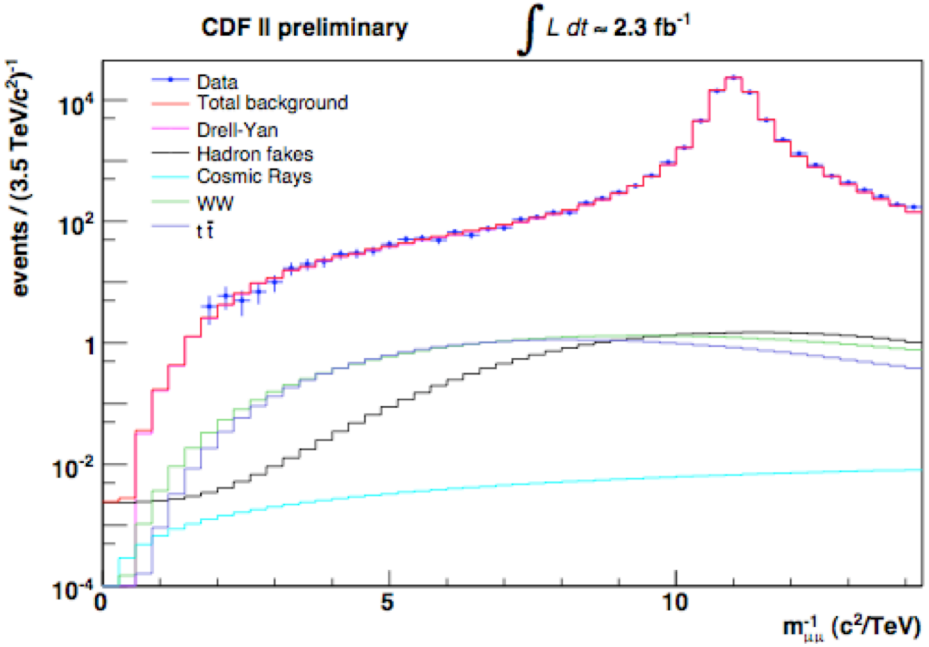




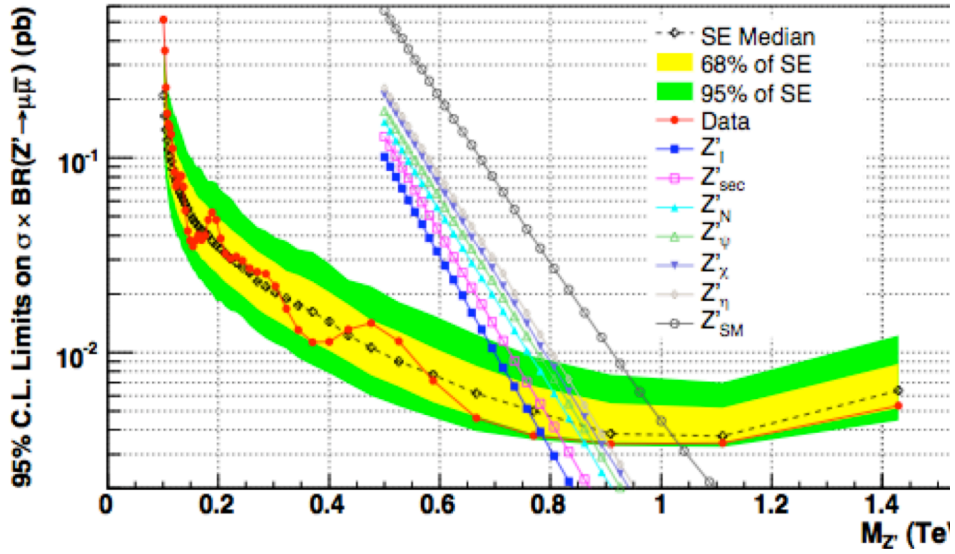
- ~70 channels from the two experiments get combined into a single limit
  - Coming soon
- Correlated systematics across channels

Tevatron will have a lot more to say about Higgs over the next few years

Searching for the unknown

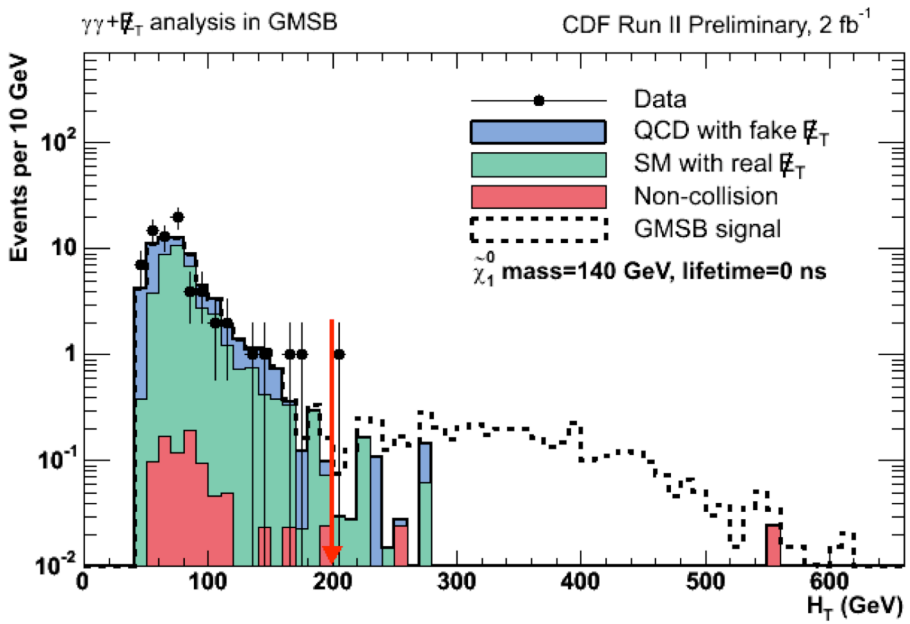


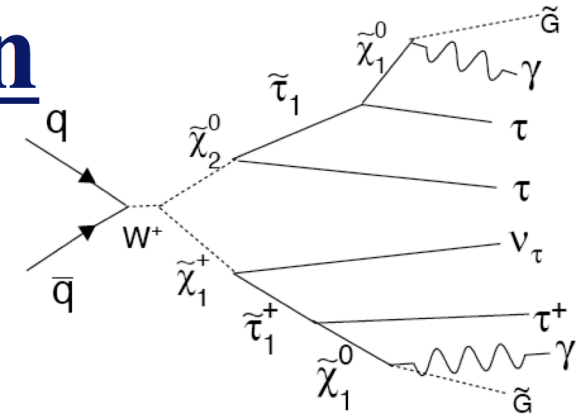
- $Z' \rightarrow \mu\mu$
  - Looking for bumps on a smooth background
  - Mass exclusion depends on production mechanisms
    - Acceptance
  - Z'_{SM} - high mass Z like object

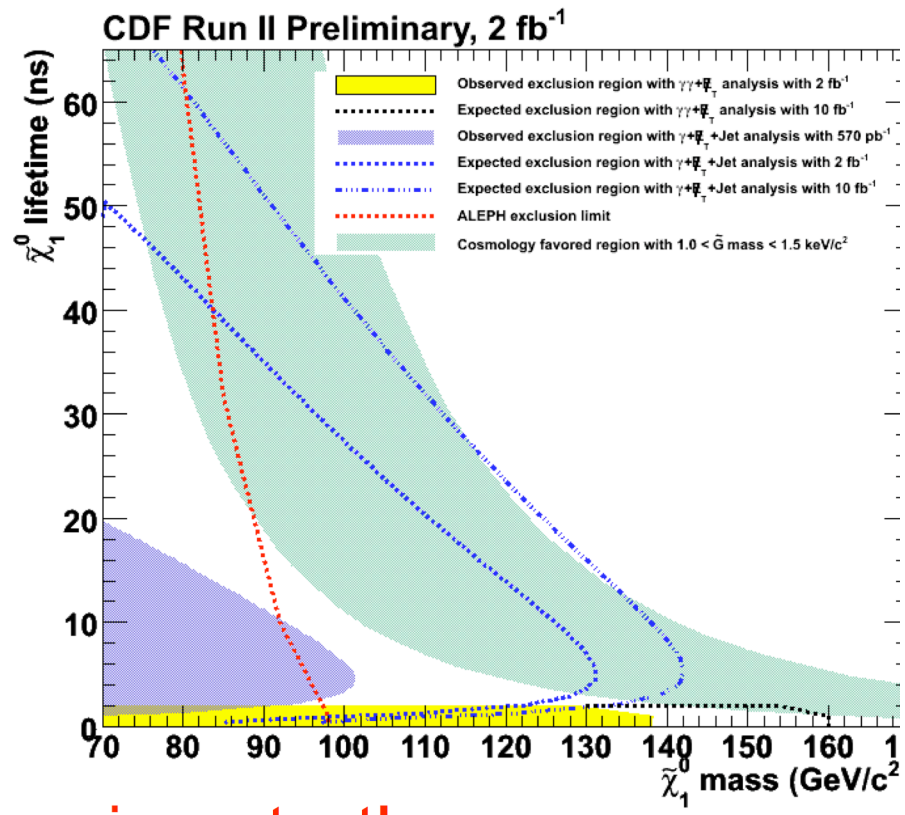


Tevatron breaks into TeV region!

Searching for the unknown



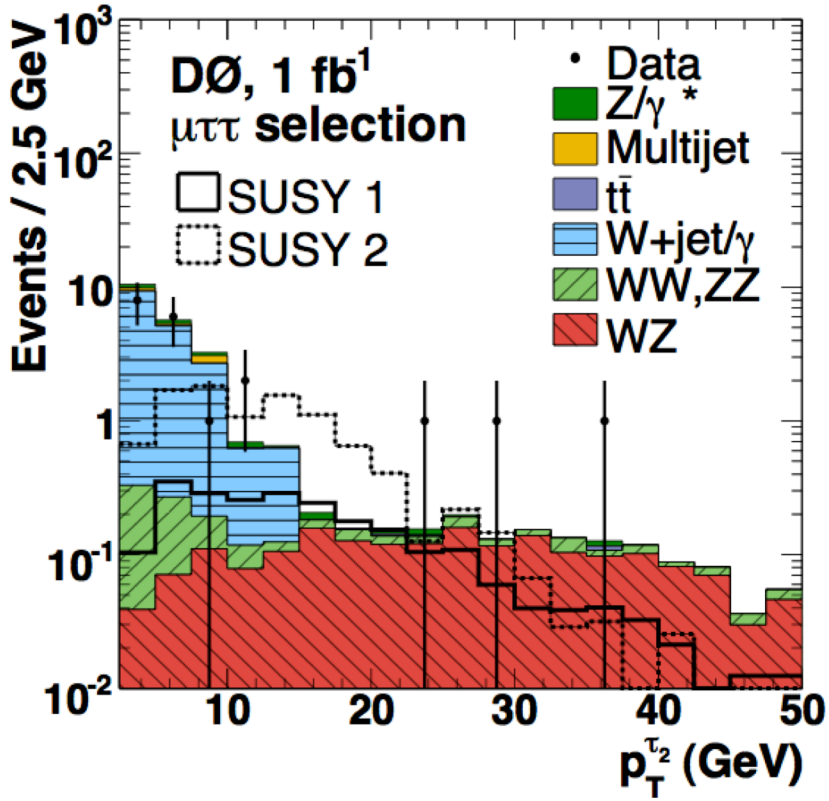




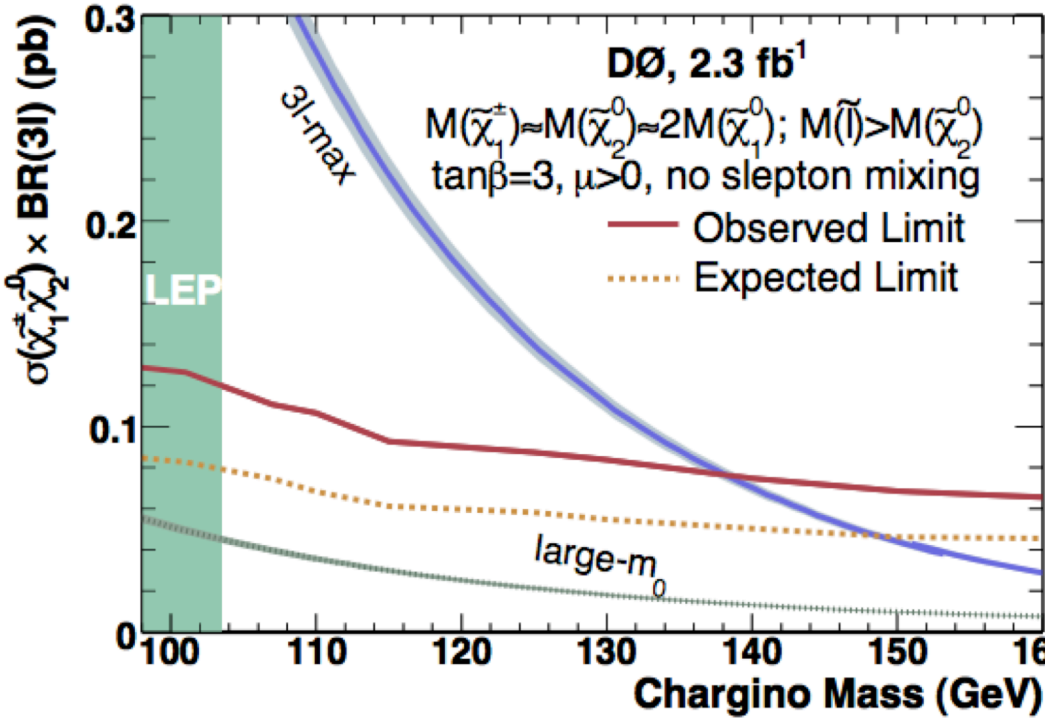
- Two photons + MET
- Gravitino LSP
  - Delayed photons from $\chi^1{}_0$

Increasing dataset is very important!

Searching for the unknown



Excluding up to 140GeV chargino mass



- Chargino-Neutralino production
- 3 lepton final state
- Multiple 3-lepton combinations

Conclusions

- The accelerator and the detectors are performing extraordinarily well
- Many exciting discoveries and measurements are coming from the Tevatron experiments
  - ~2 papers/week
- Large datasets will allow us to access new realms of interesting physics
  - The new results are usually better than sqrt(L)
- Look forward to double the dataset

BACKUP

Multimuon Analysis

- An analysis of a di-muon data set
- Motivated by 3 long-standing discrepancies dating back to Run 1
  - $\sigma(pp \rightarrow bbX)$ is larger than expected from NLO QCD
  - Time integrated mixing parameter (chi-bar) is larger at the Tev than at LEP
  - Low mass dilepton spectrum inconsistent with expectation from Heavy Flavor
- First, re-measured b-bbar XS in Run II. Now in excellent agreement with theory by making very tight cuts on di-muon selection
- Then loosened selection cuts on di-muons and allow them to originate outside the beam-pipe.
- Observations with this looser cut.
  - Many more events than we expected (whimsically referred to as “ghosts”)
  - Unexpected ghosts events explain the previous discrepancies
  - The muons in these ghost events have a large impact parameter tails and many more companion tracks and muons than expected
- To date, unable to completely account for these ghost events either in terms of detector effects or a known SM backgrounds

CDF's Statement on Multi Muons

- Do not fully understand the source of the source of "interesting events" presented in the paper
- Have not ruled out that what we see comes from instrumental effects or not-understood background
- We are not making a claim that this is new physics
- Regardless of the source, these events have not been quantified before and offer a plausible explanation for several long-standing discrepancies
- We reached a plateau in our understanding and decided to publish what we know.
- Work continues on improving our understanding