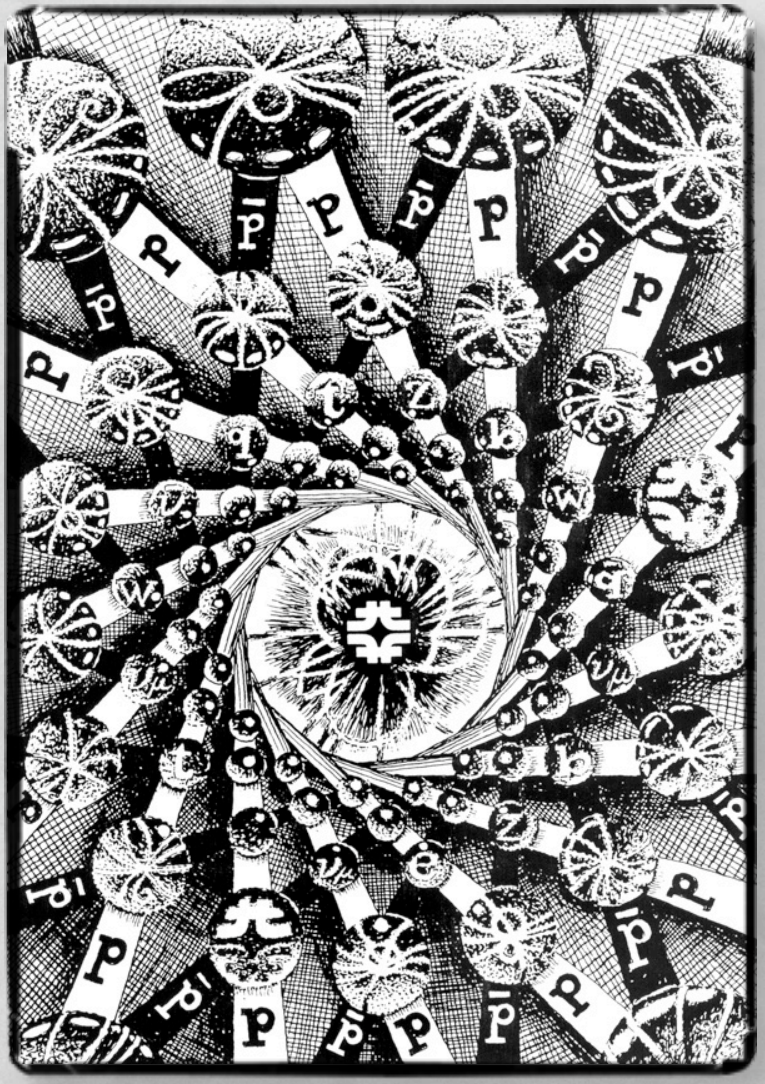
The LHC in the Tevatron era

La Thuile, 2010

Jacobo Konigsberg
U. of Florida
... a CDF perspective

Outline



- Landscape
- Possibilities
- What if

Landscape Tevatron

- The Tevatron program remains compelling
  - The program is at its peak
  - Have not exhausted the physics and the possibilities
  - Alone, it could go on producing quality physics for a very long time

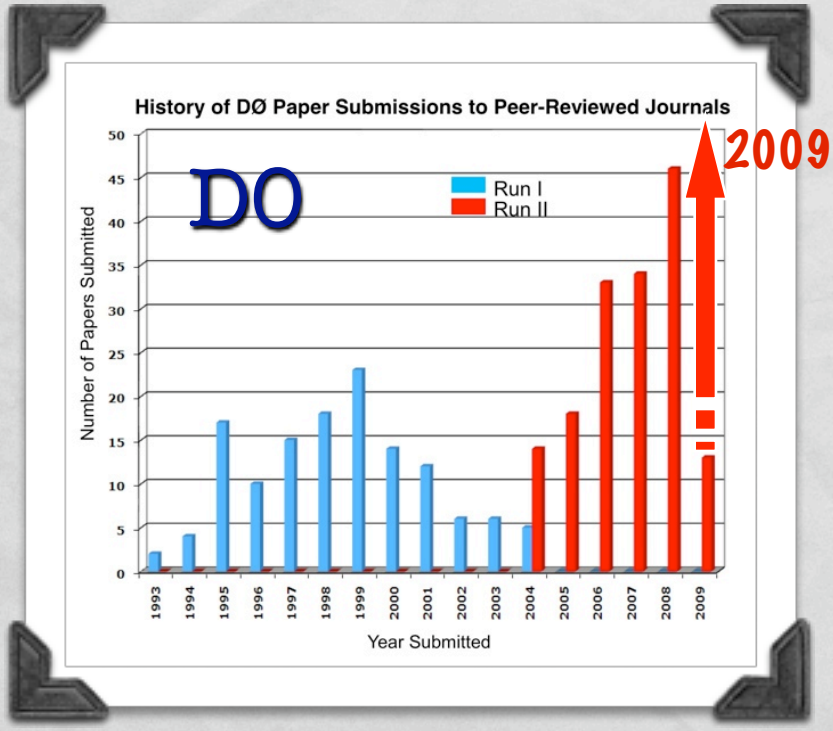
- Ideally its completion is defined on the basis of physics relevance alone
  - But two important modifiers:
    - The [continual] imminence of being overtaken by the LHC
      - and all the ramifications that have come from this
    - Compatibility with Fermilab's plans for the future

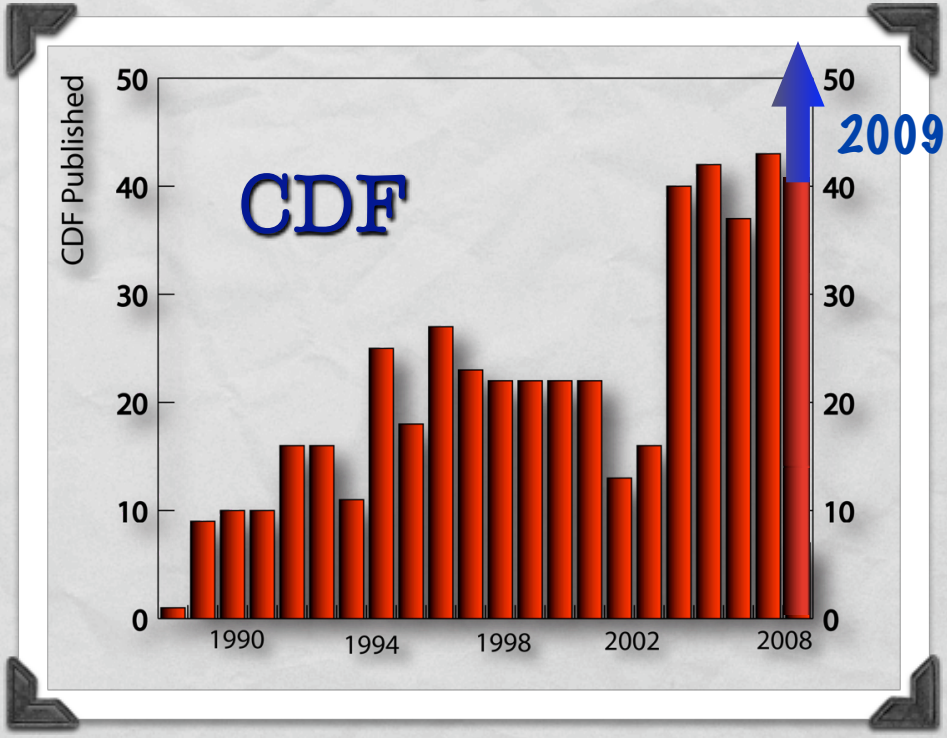
Landscape LHC

- The LHC initial program is now defined for 3-4 years...
  - 1 fb^{-1} @ 7 TeV by end of 2011 & down in 2012 for 1-1.5 yrs
  - A significant, and unfortunate, downgrade: in E and Lum
  - But hopefully a very solid first step towards design specs
- We all want and need this to succeed
- We also need to assess implications to the field
  - Q: Will this overtake the Tevatron ?
    - A: Possibly in some areas but not on the Higgs
    - A: Not necessarily in other important areas
  - Q: Should the baton be passed optimally ?
    - i.e. keep running until LHC results catch up
    - Could have results with 15 fb^{-1} if we run in 2012 & 2013

Tevatron Physics Output

A program at its peak

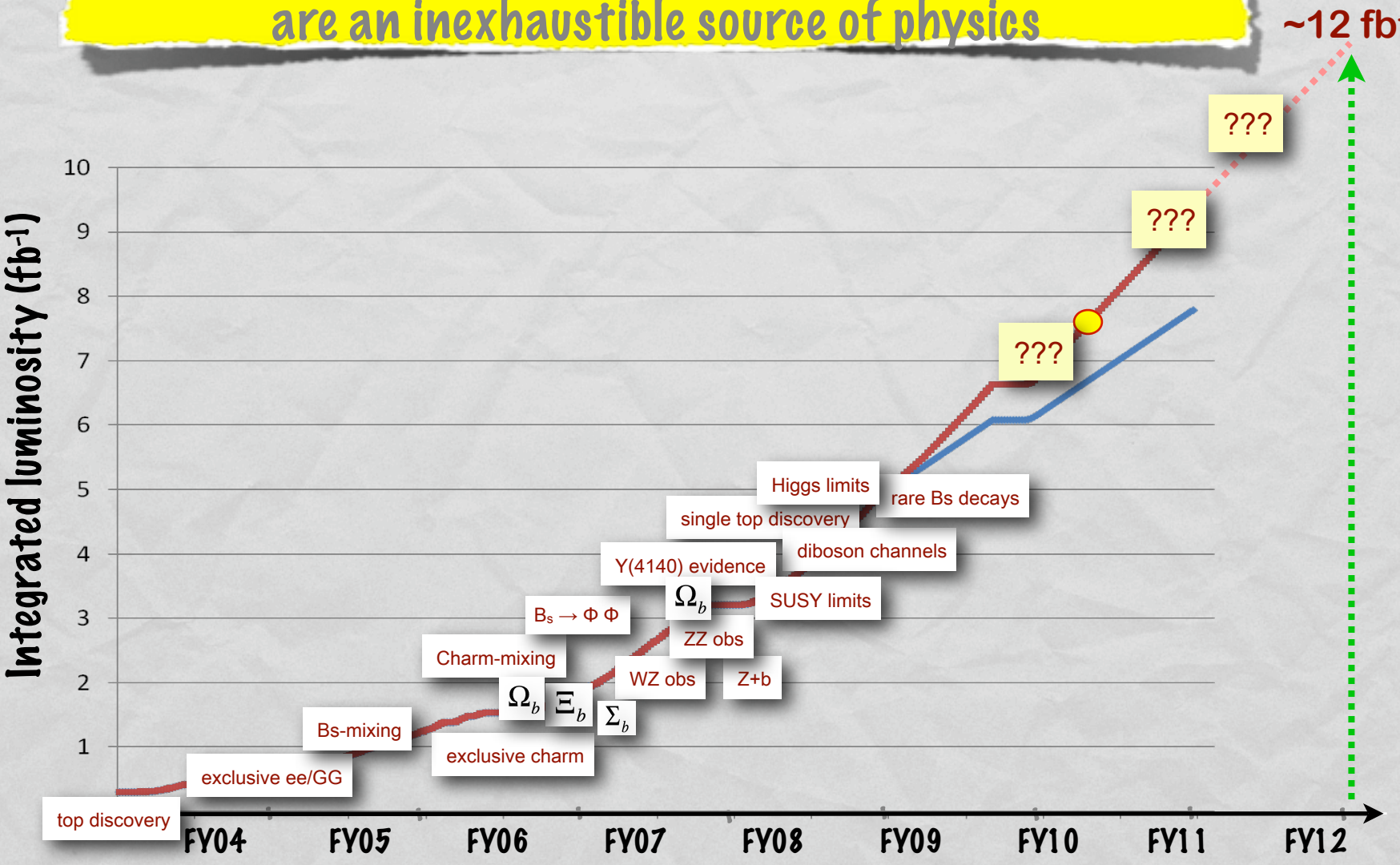




- Reached >50 journal publications/experiment/yr
- About 60 Ph.D.'s / year over the last few years
- 80 new results: Winter'09 => Summer'09 => Winter'10
- **Continually pushing boundaries**

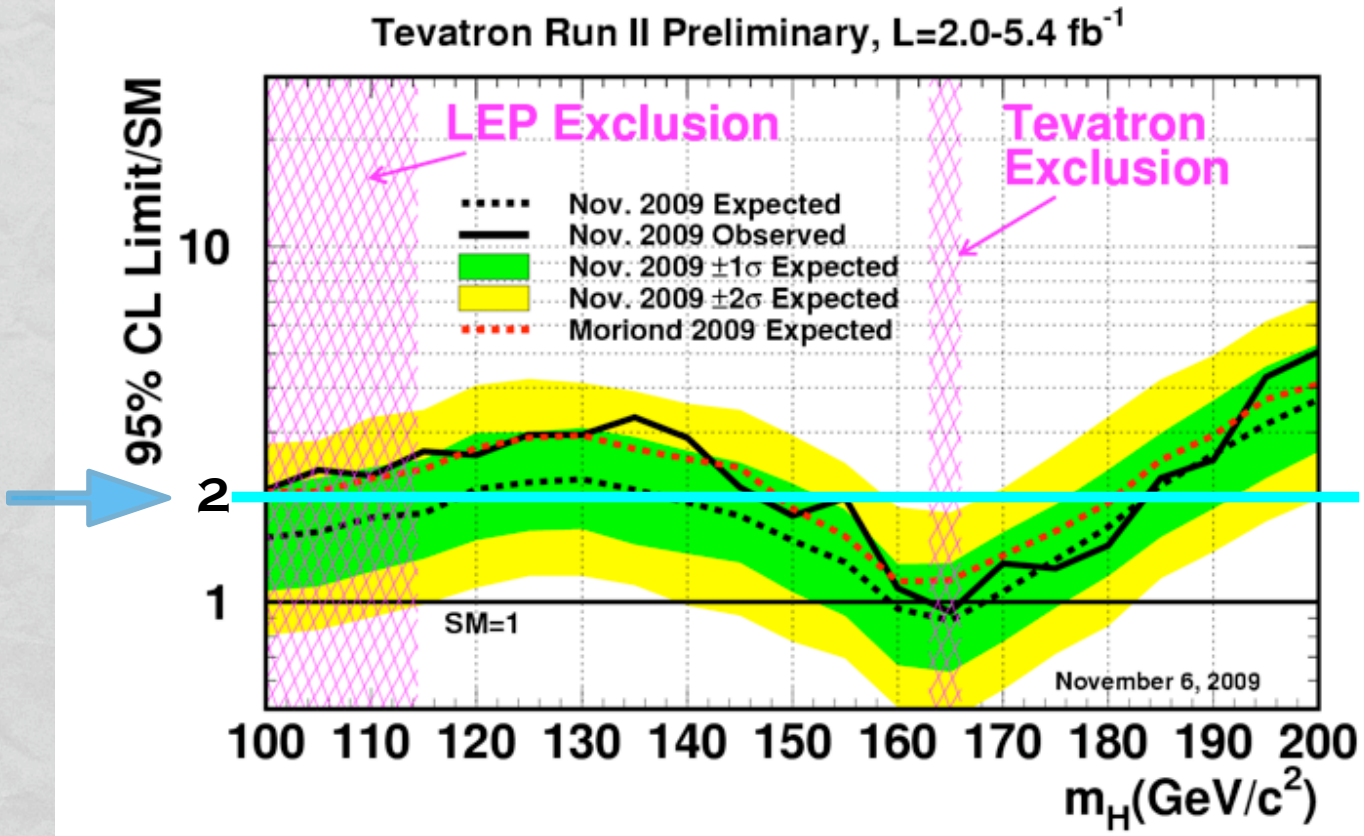
The Luminosity story

In many ways -even at fixed E - hadron colliders are an inexhaustible source of physics



Higgs

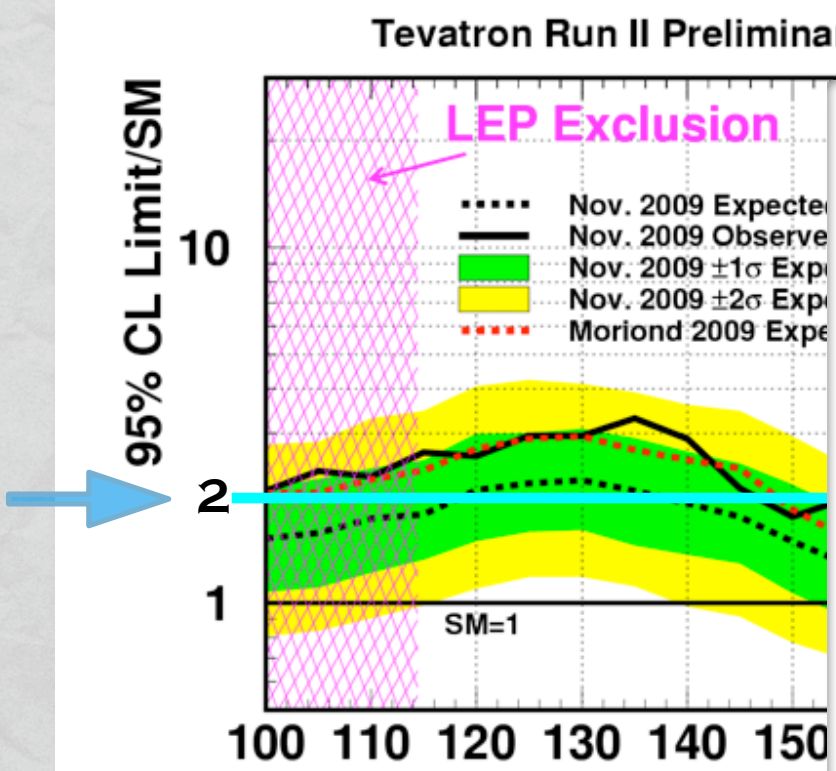
Most Recent Combination

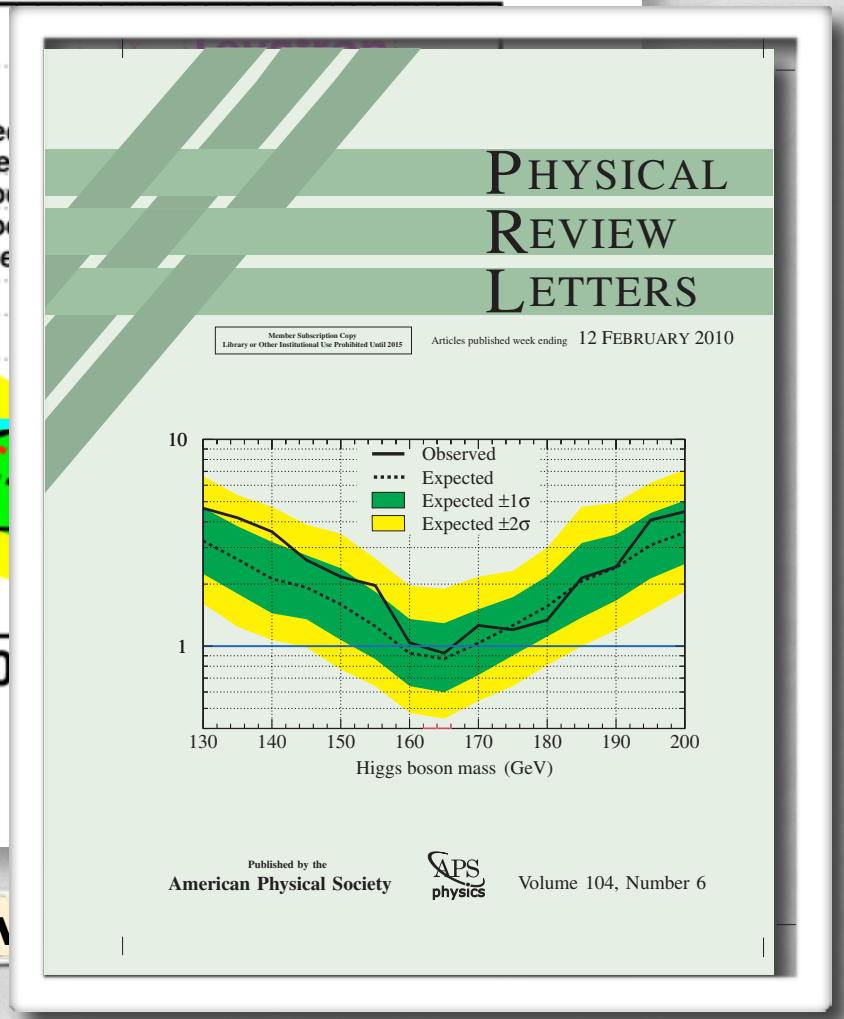


x 2 from SM across the whole mass range !

Higgs

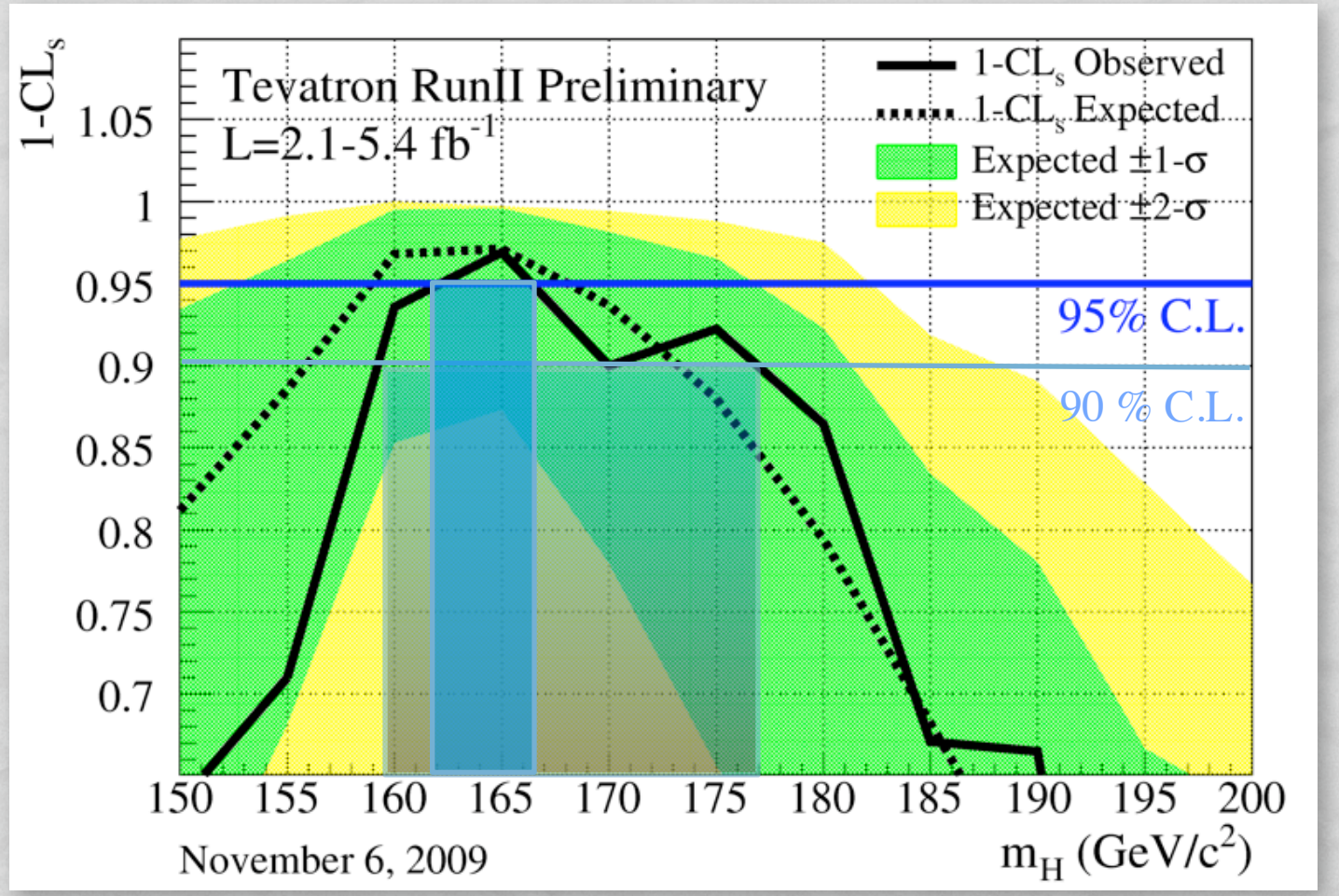
Most Recent Combination





x 2 from SM across the w

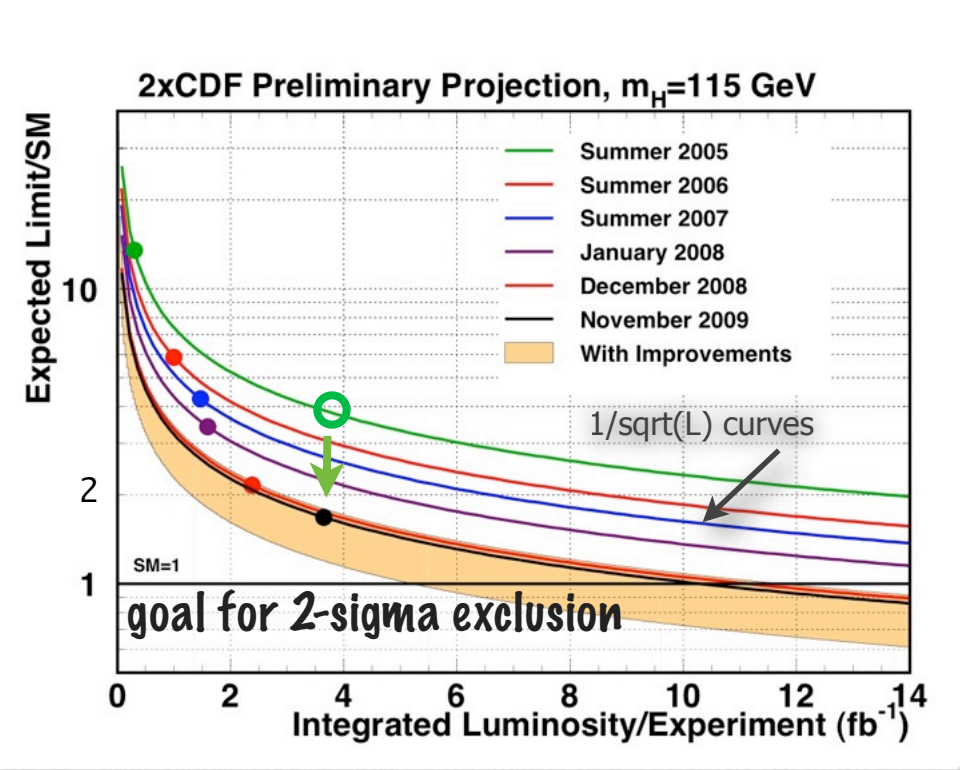
Higgs: exclusion probability vs mass

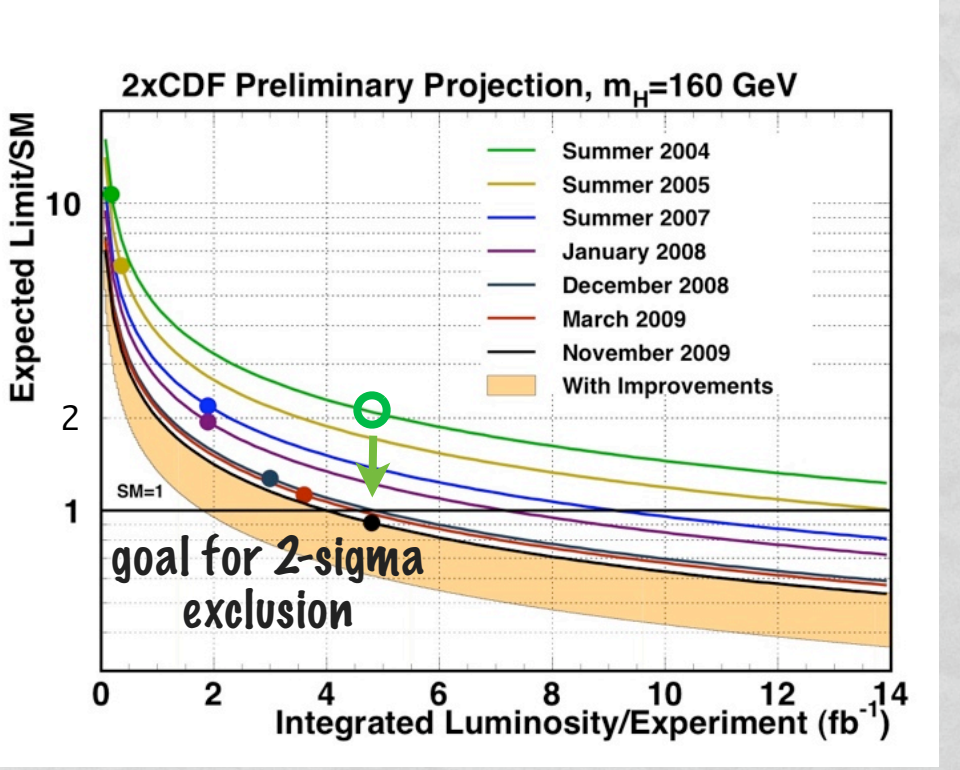


Nearing significant exclusion regions at high mass !

Higgs Search Progress

A huge effort and a long but exciting road

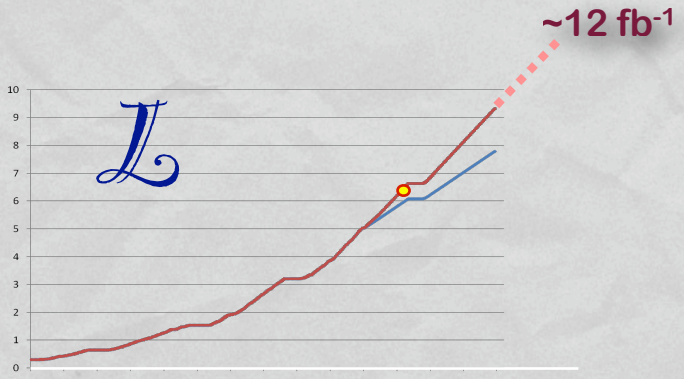




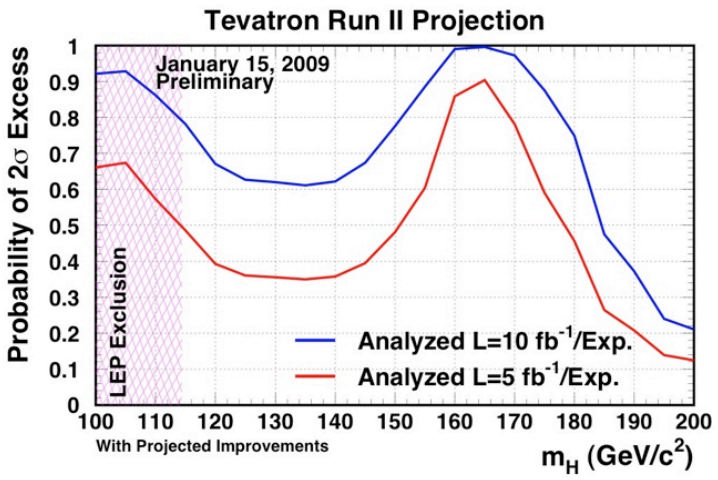
Orange band = expected improvement factors from 2007 analyses [x1.5 and x2.25]

Higgs Outlook

Higgs reach with FY11 running (10 fb^{-1} analyzed) and additional analysis improvement [bottom orange band]

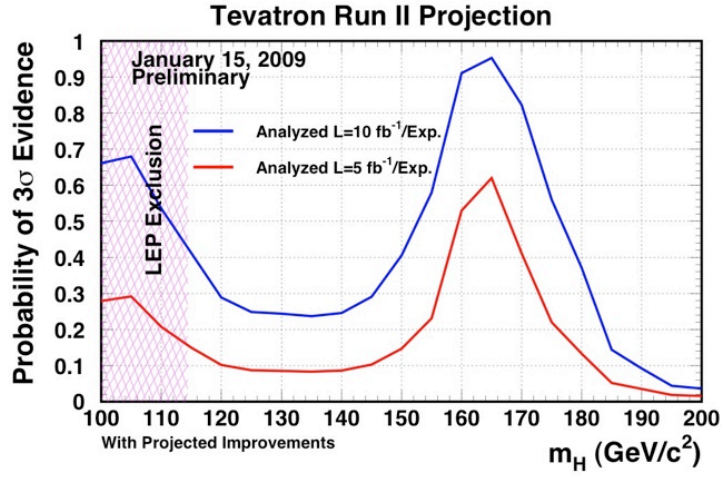


2-sigma

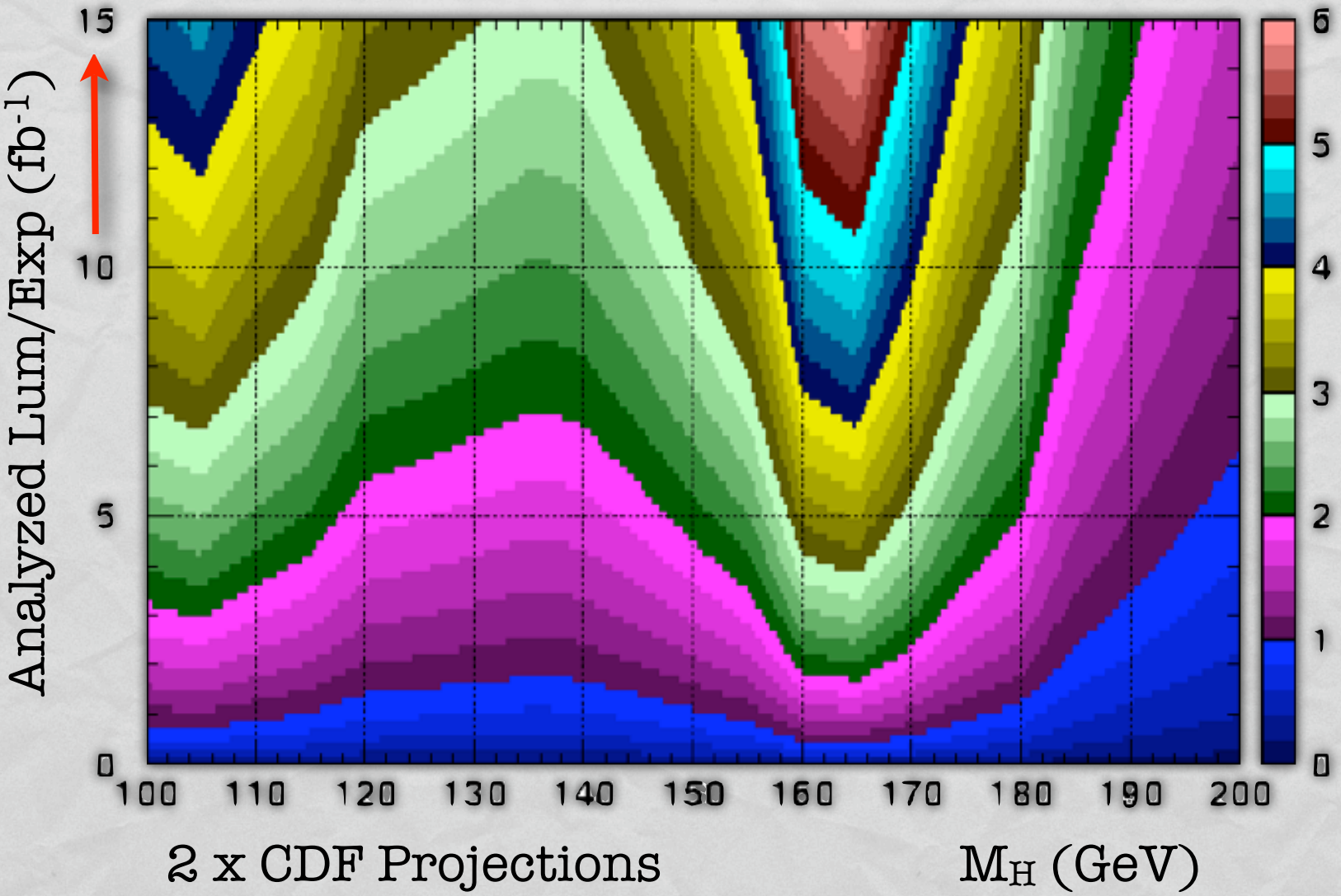


a-priori sensitivities

3-sigma



Higgs Reach

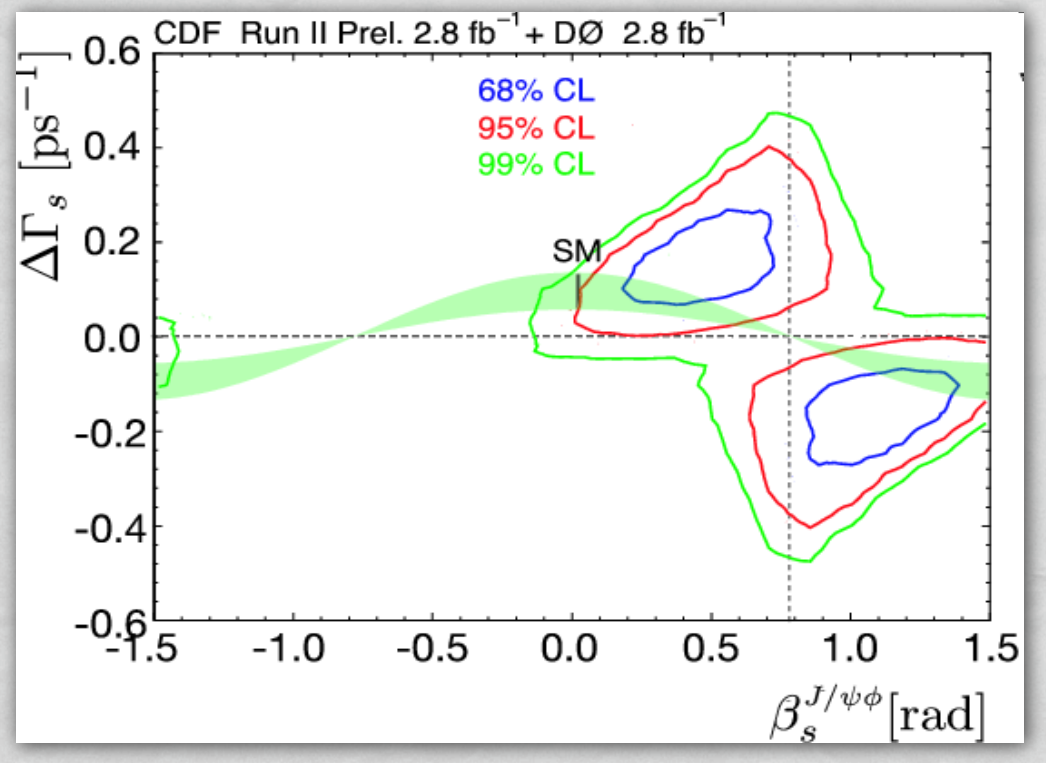


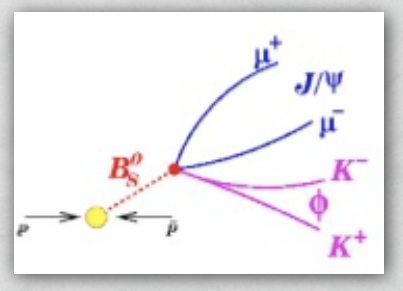
With projected improvements achieved

CPV in B_s

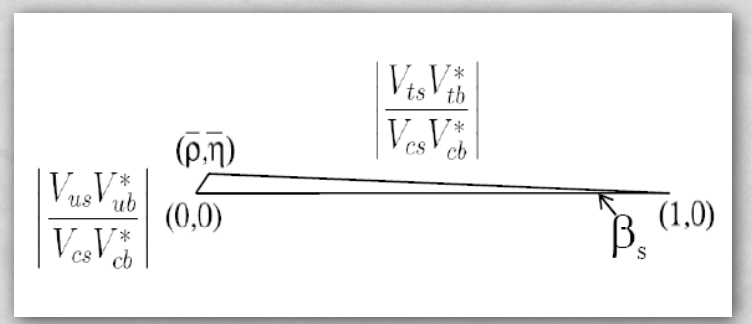
$$B_s \to J/\psi\,\varphi$$

Both CDF and DØ measured the CP violation parameter β_s in $B_s \to J/\Psi\Phi$ decays with 2.8 fb^{-1}





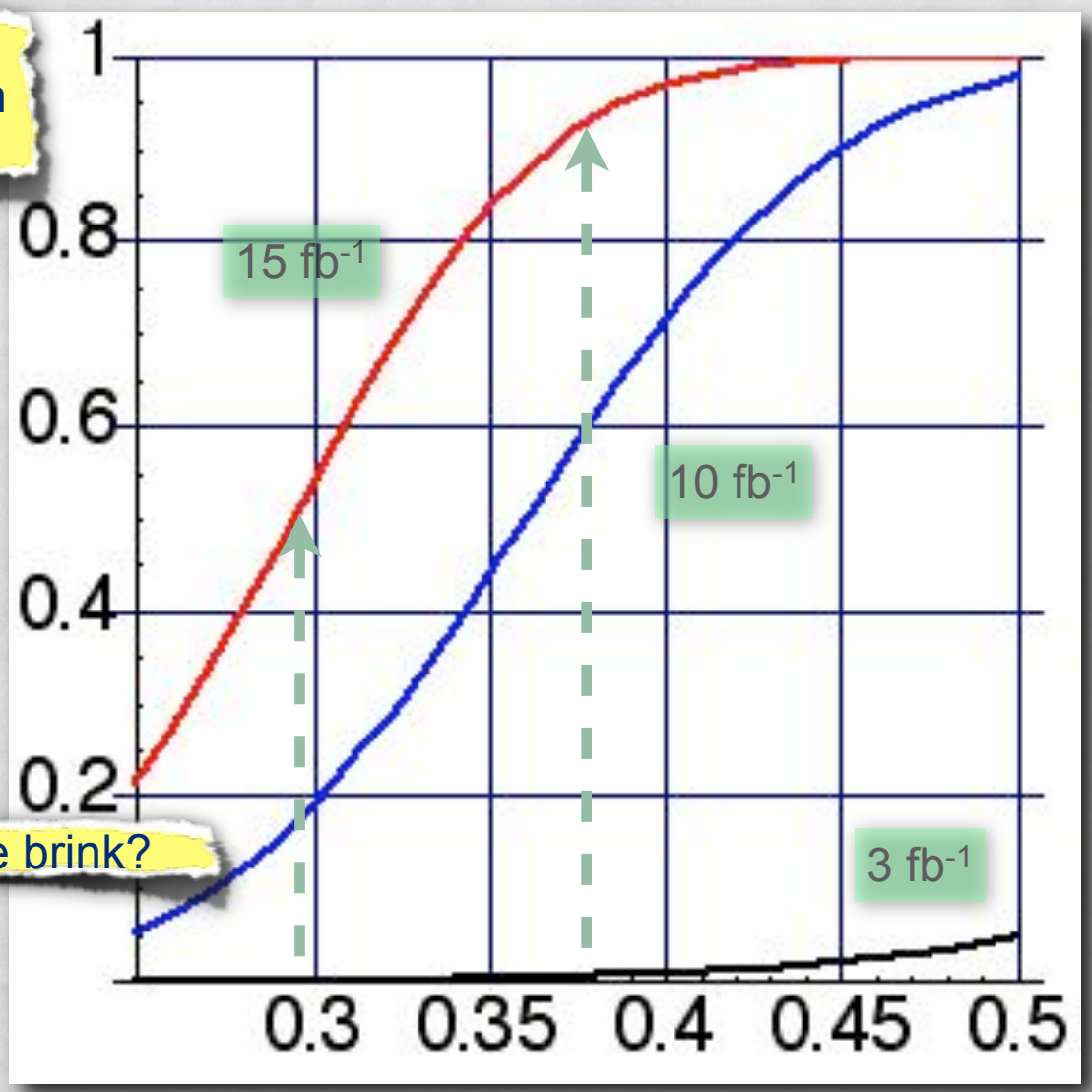
$$\beta_s \equiv \arg\left(-V_{ts}V_{tb}^*/V_{cs}V_{cb}^*\right)$$



2.1 sigma from SM predictions

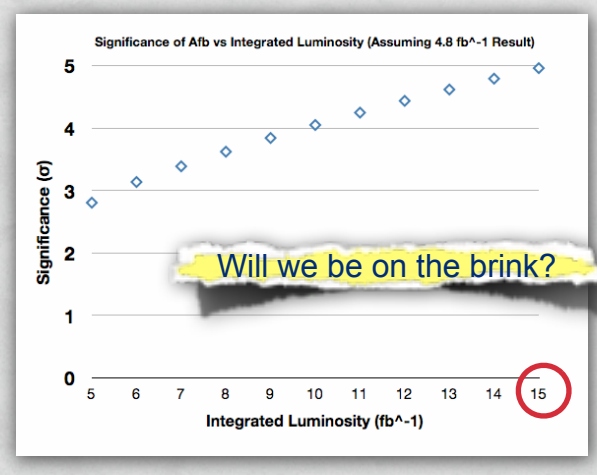
Reach in $B_s \to J/\psi\,\varphi$

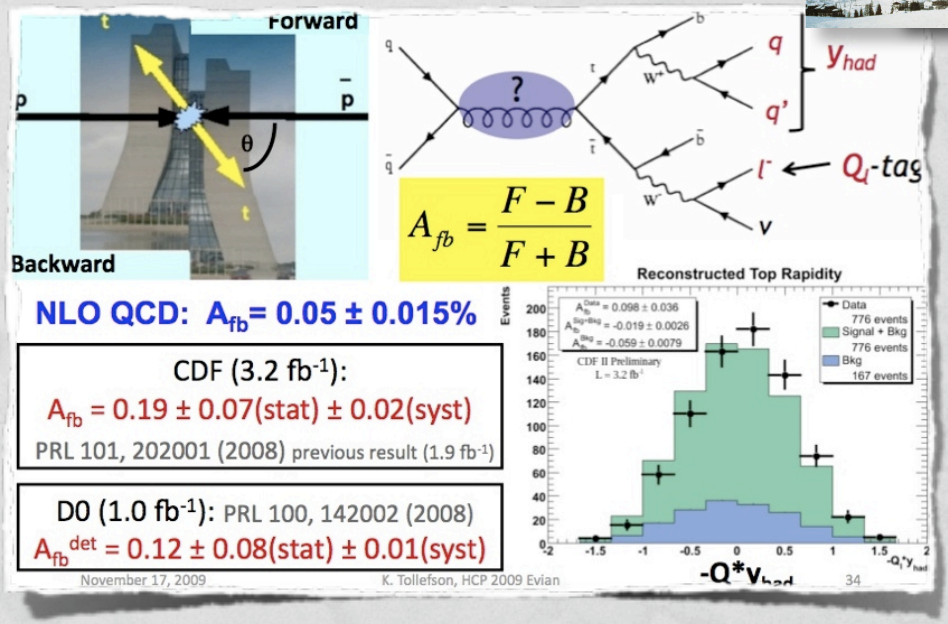
probability of
5-sigma observation
CDF + Dzero



Will we be on the brink?

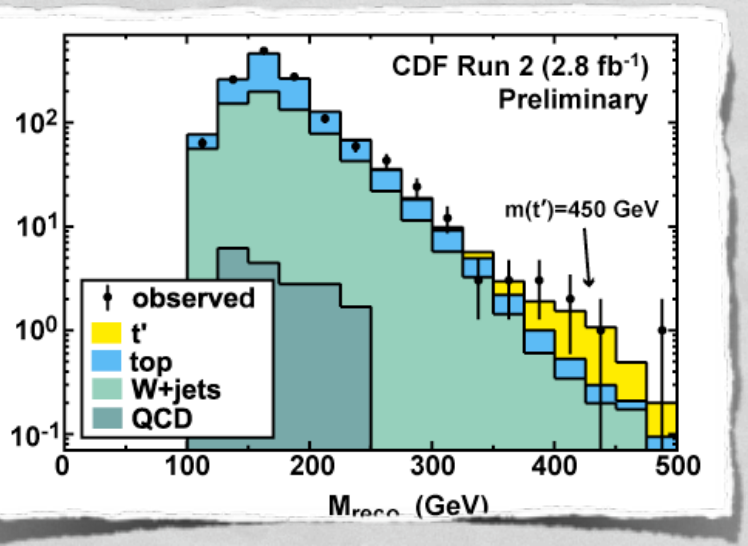
tt samples - other 2-sigmas

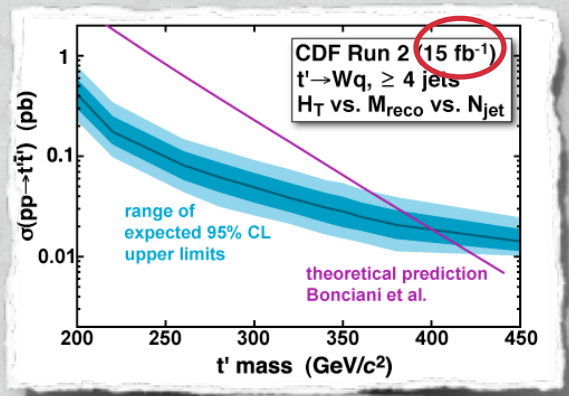




t-prime search

forward-backward asymmetry



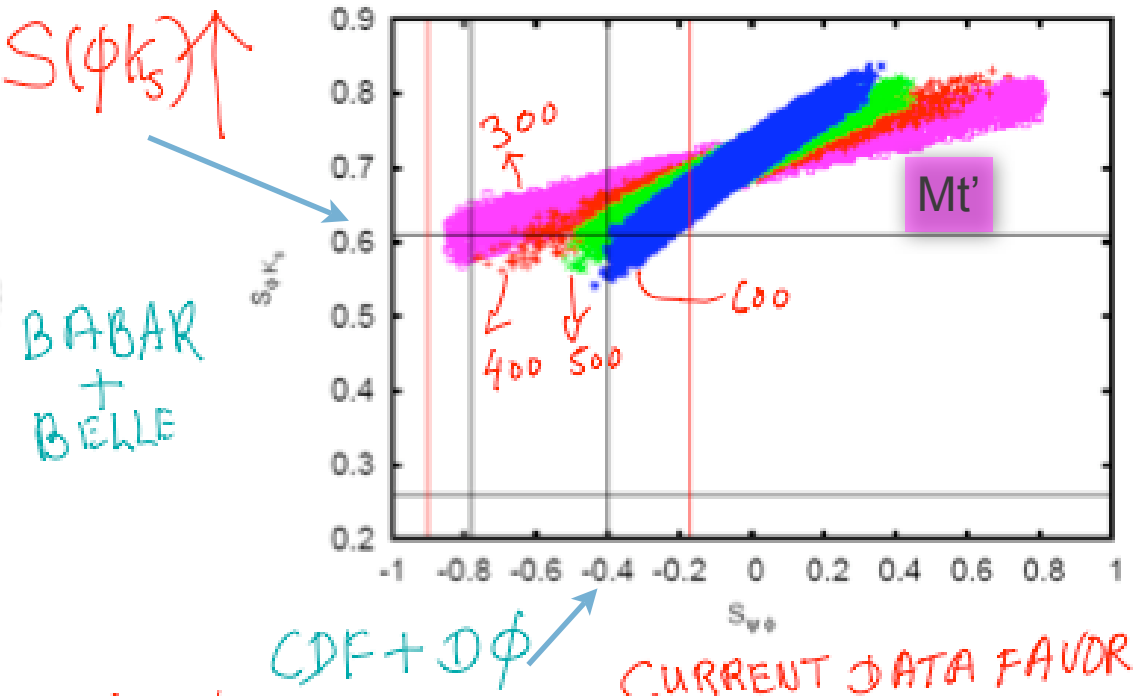


4th Gen (SM4) correlations

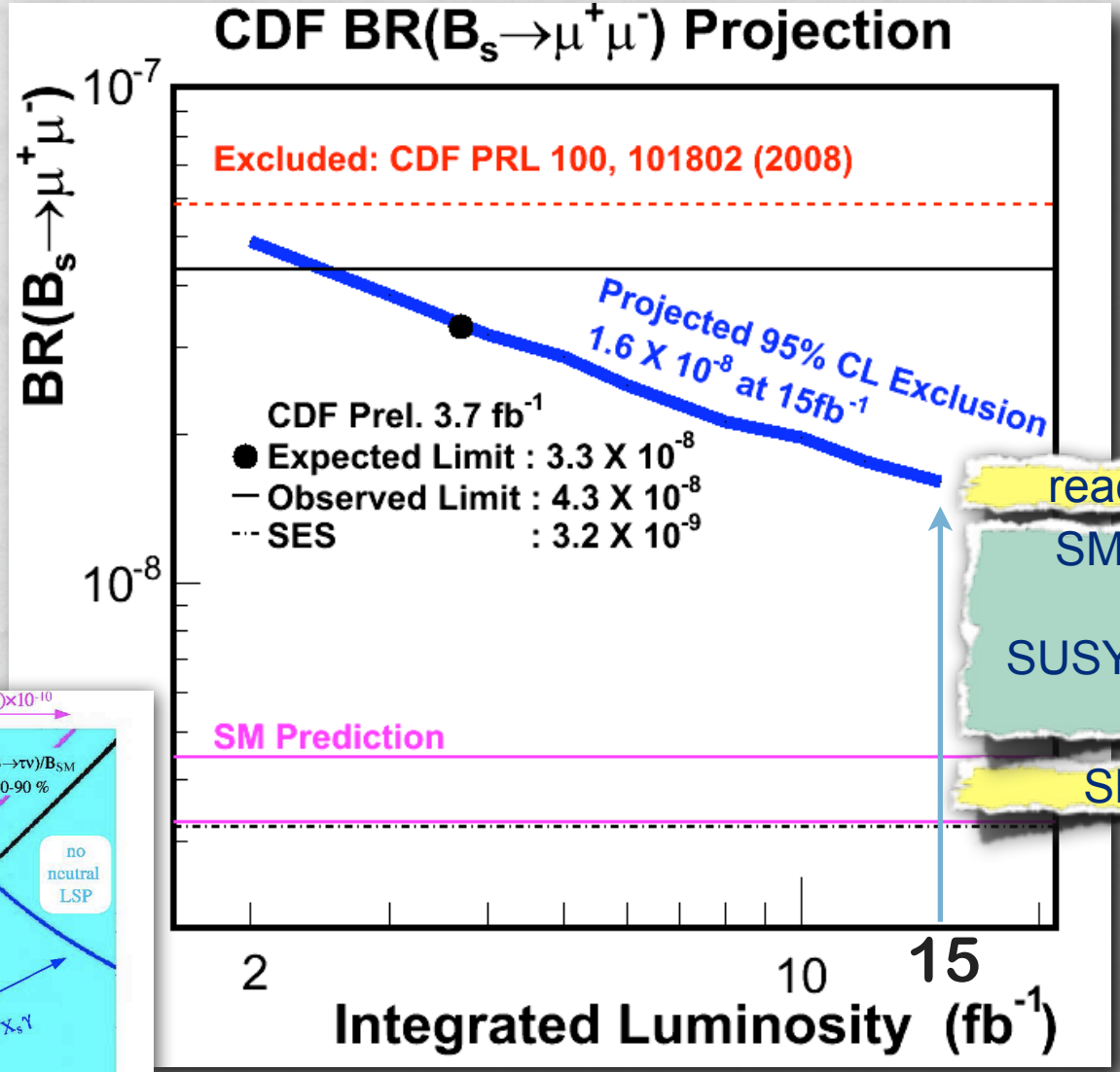
Tevatron t-prime & beta_s connection ?

Alok,Giri,Mohanta,Nandi+Soni

arXiv:0807.1971, 1002.0595



NP probe Bs ==> mu,mu

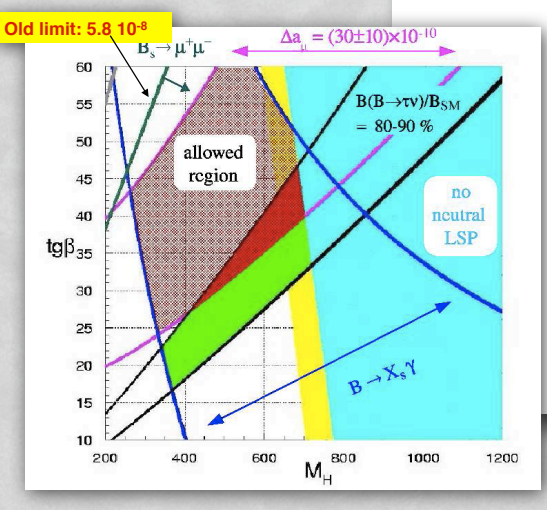


reach = 1.6 x 10^{-8}

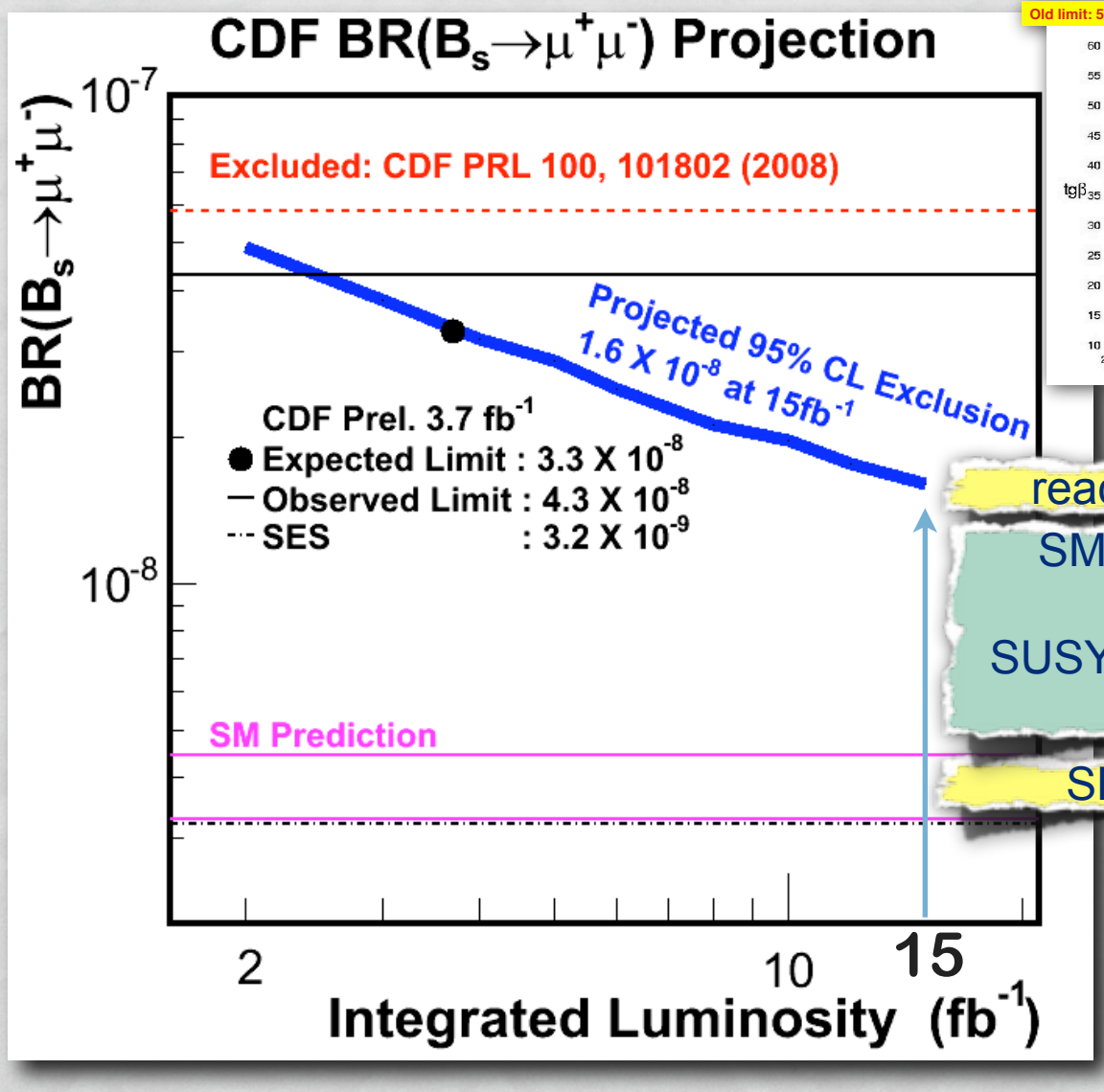
SM4 can change BR by x3

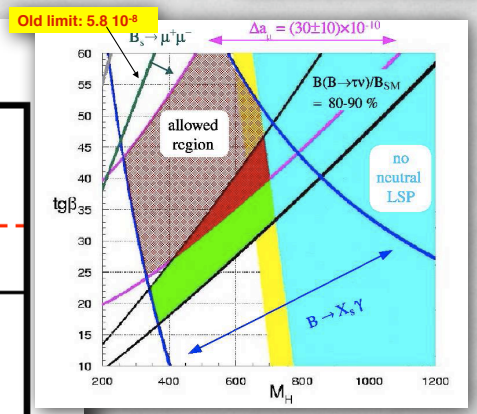
SUSY by much larger amounts

SM ~ 4 x 10^{-9}



NP probe Bs ==> mu,mu





reach = 1.6 x 10^{-8}

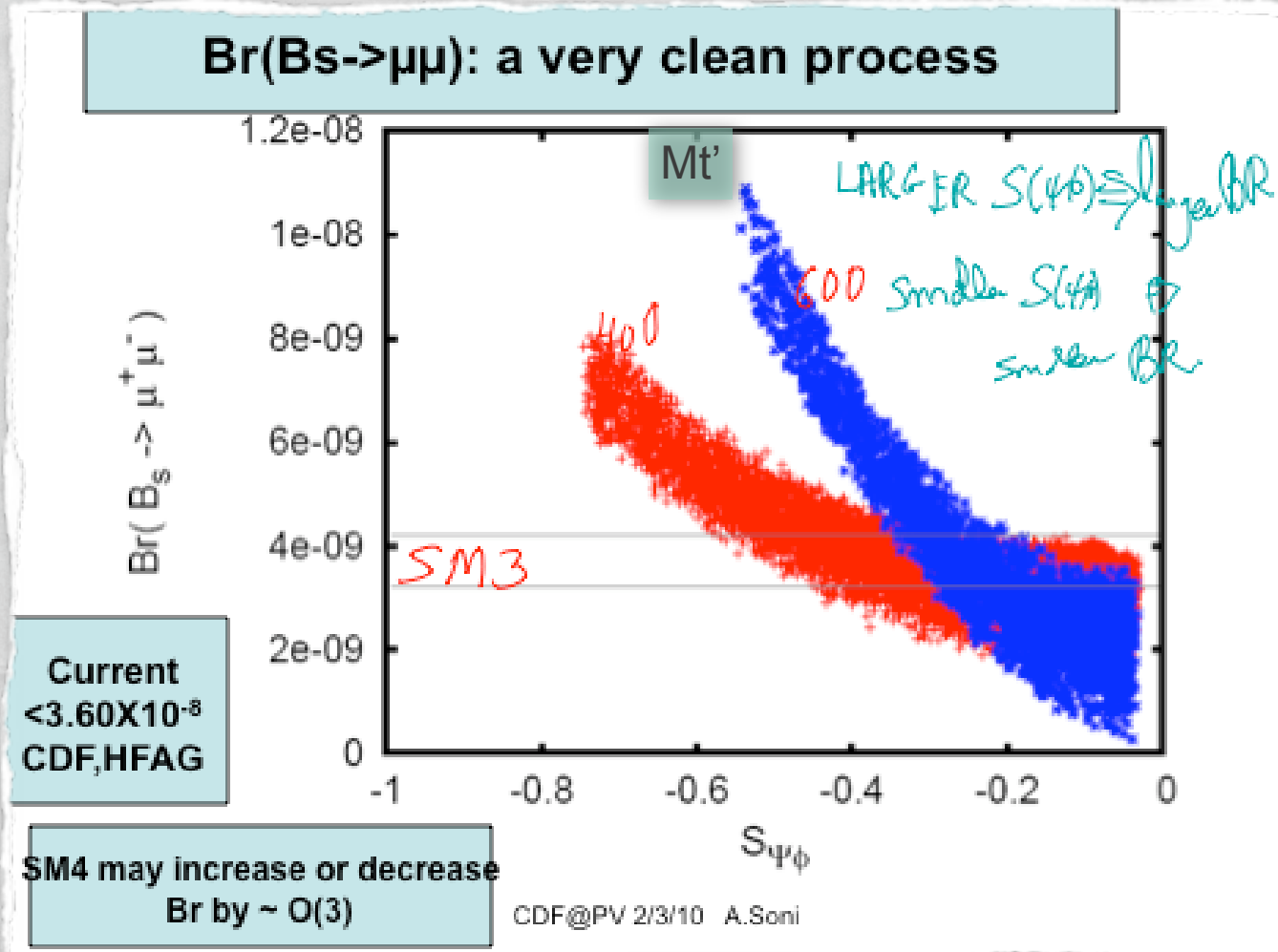
SM4 can change BR by x3

SUSY by much larger amounts

SM ~ 4 x 10^{-9}

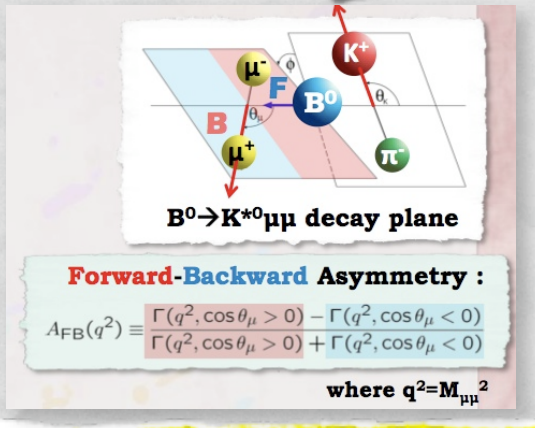
More Tevatron SM4 correlations

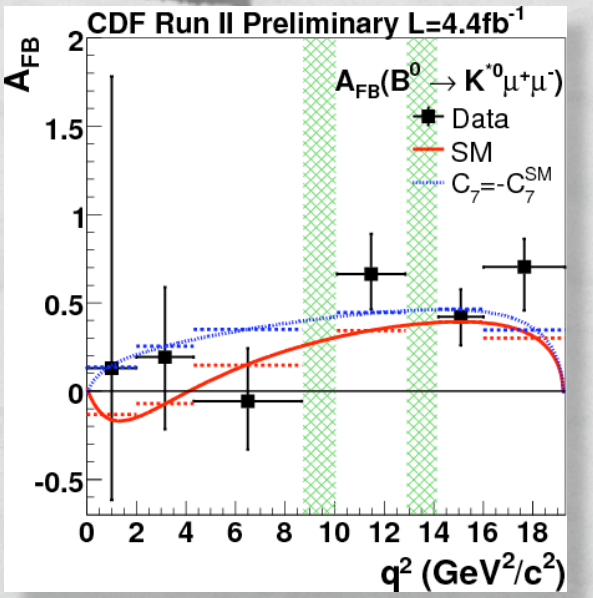
t-prime, beta_s & Bs--> mumu connection



More New Physics in HF

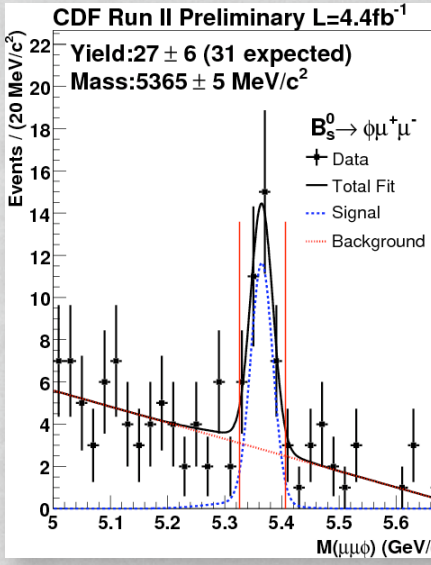
CDF's displaced track trigger: a unique window to flavor physics





1st measurement of B^0 => $K^*\mu\mu$ F/B asymmetry in hadron collisions -consistent w/ SM and BSM and Belle -

Factors of 3–4 more data can shed lots of light on these New Physics probes

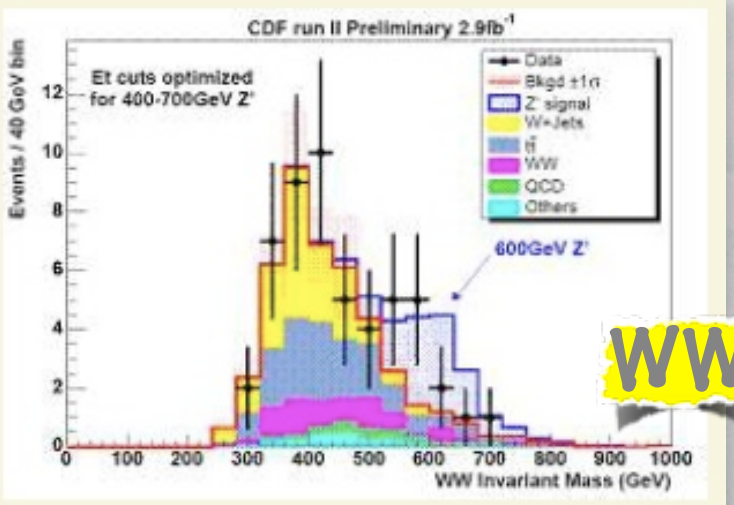


Bonus : first observation (6 σ) of B^0_s to φ μμ

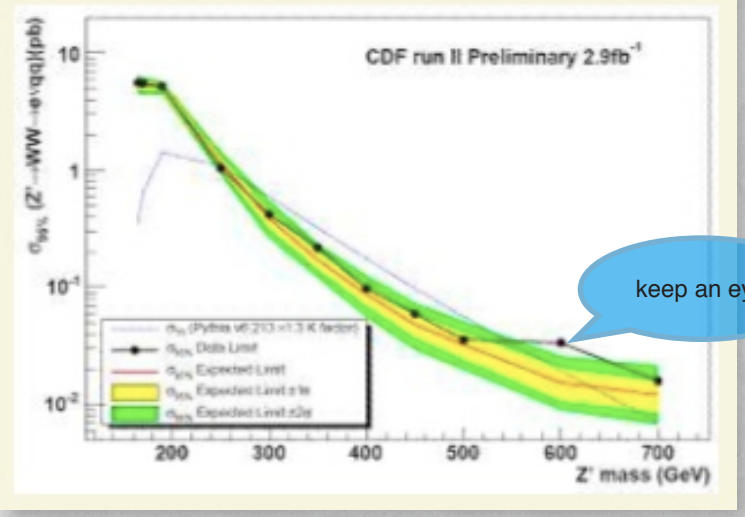
the rarest B^0_s decay so far: (1.44 ± 0.33 ± 0.46)10^{-6}
Brand new probe of new physics - also SM4

The more [stats] the better

A few tails have hints

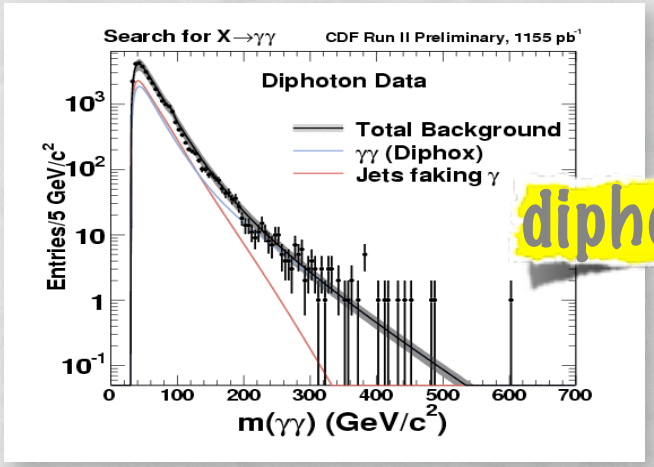


WW

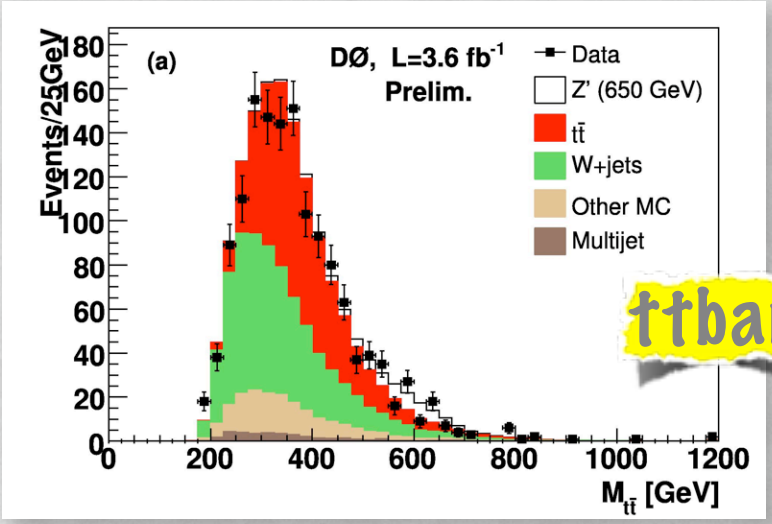


keep an eye

Many not [yet ?]

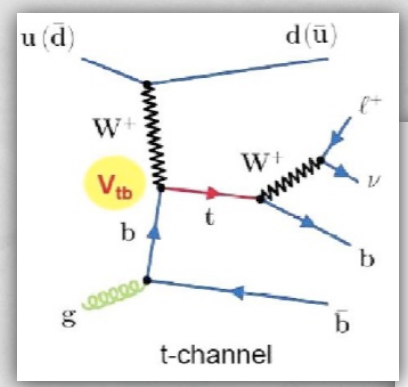


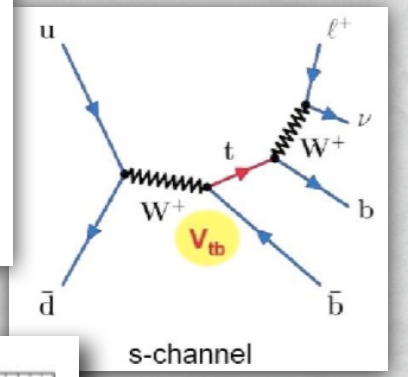
diphoton



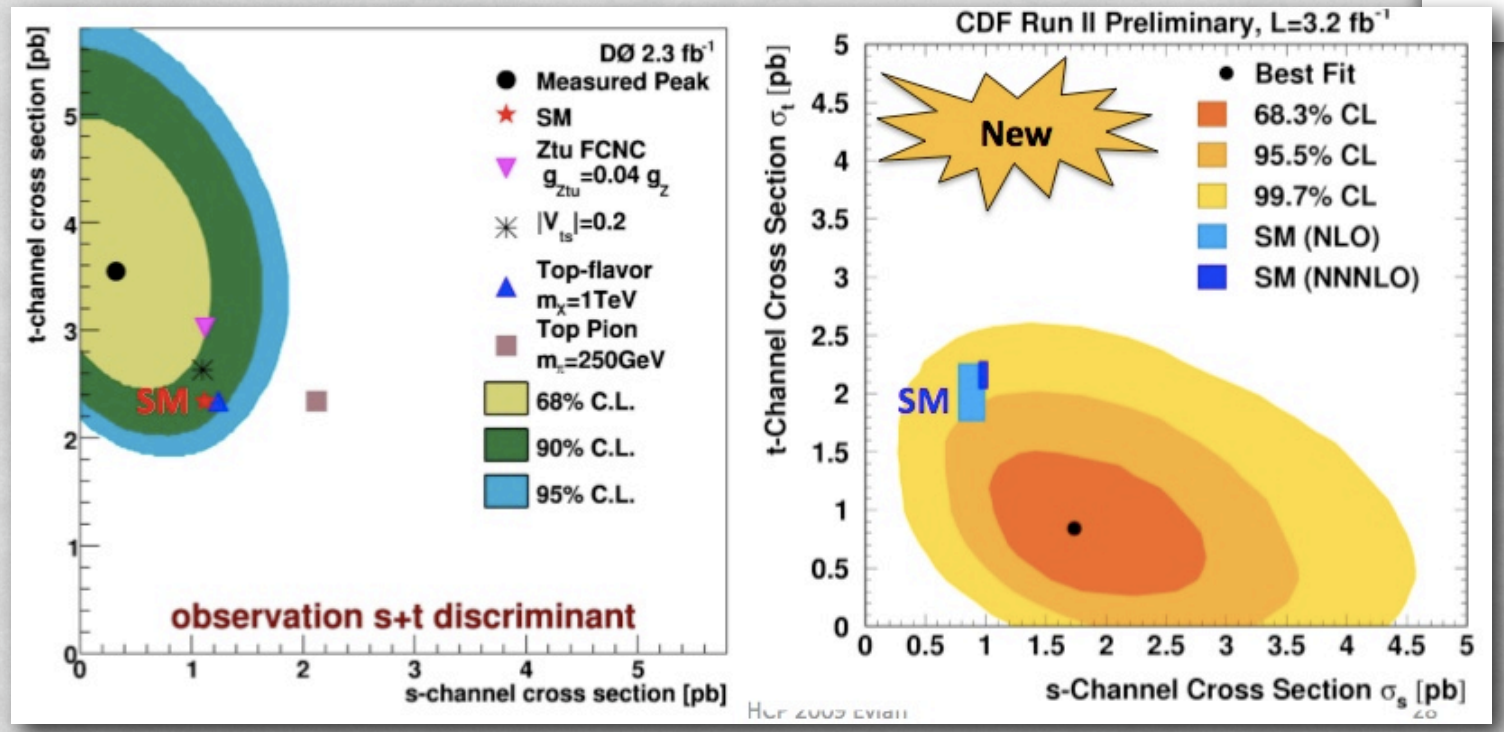
ttbar

Single top: only started @ 3 fb^{-1}





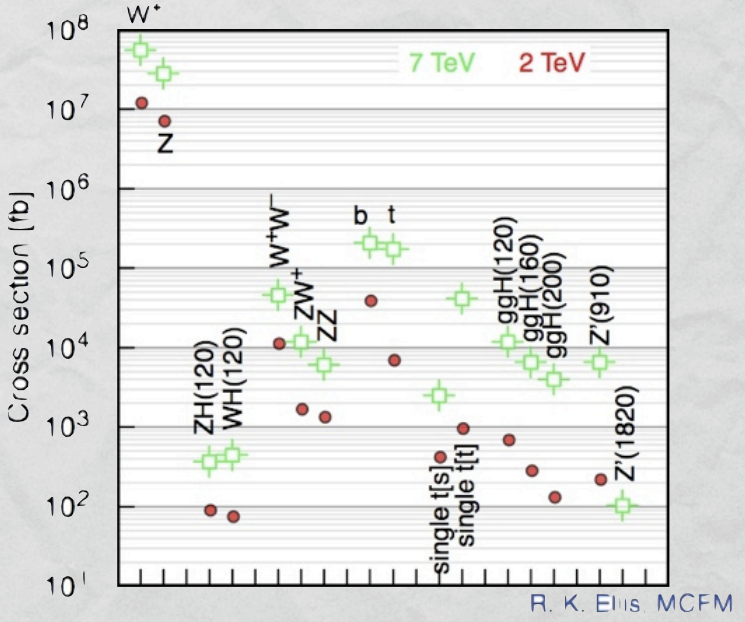
S vs T tension



measure it with max. luminosity

LHC vs Tevatron

- 1 fb^{-1} at LHC vs 15 fb^{-1} at Tevatron
  - Higgs
    - Tevatron gets there first at all masses
    - Sensitivity will depend on ultimate Lum
  - Top x~2 at LHC
  - Bs => mumu x~2 at LHCb
  - Z'(1 TeV) x~3 at LHC
  - > 1 TeV LHC wins but needs significant Lum
  - > 2 TeV @ LHC @ 1 fb^{-1} probably not accessible



- This assumes all delivered data goes into analyses and other few things we've worked hard at the Tevatron for years

What If

- We could really run the Tevatron through 2013?
  - **>15 fb^{-1} on tape**
  - Great reach on very important physics
  - May complete the program with a bang!
    - Strong evidence for Higgs/no-Higgs, BSMs in HF and/or top?
  - Remain competitive with LHC & no collider gaps in HEP
- Will the detectors hold [well enough]?
  - good question - need to asses this
- Will the community be there?
  - Another good question
  - With an ambitious and credible plan + Lab and support from funding agencies, we can probably make it happen
- How does it affect the future neutrino program?
  - can it run in parallel at all?

Furthermore

- What if the Tevatron had another mission once the LHC takes over?
  - NEED a compelling physics program
    - Interesting ideas for a charm CPV program at the Tevatron
  - Require better precision, upgraded, detectors
    - Upgrade detectors, while we run CDF & Dzero longer!?
  - This program could start when the Tevatron is done at the Energy Frontier
  - IMAGINE: the Tevatron at the intensity frontier !
    - A workshop to explore this might be a good next step

The Tevatron beyond the Higgs?

- It turns out the Tevatron might be the perfect machine for something other than that Higgs:
  - Search for NP effects in charm [i.e. Bigi at Extreme Beam Lectures @ FNAL, 9/22/09]

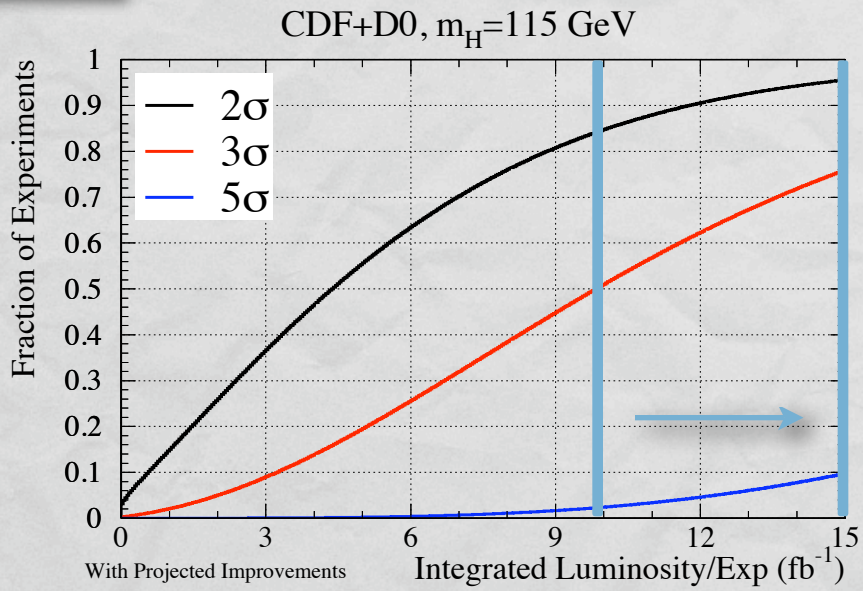
- Need very high statistics and precise control of systematics
  - High production rate: currently CDF collects fully reconstructed D0 at 10x Belle
    Tevatron + an optimized detector: 1 year = 4 year of SuperB (10^{36}) [$40ab^{-1}$]
  - CP-symmetric initial state, eta-symmetric detector, and availability of control samples: systematics can be controlled down to very precise level

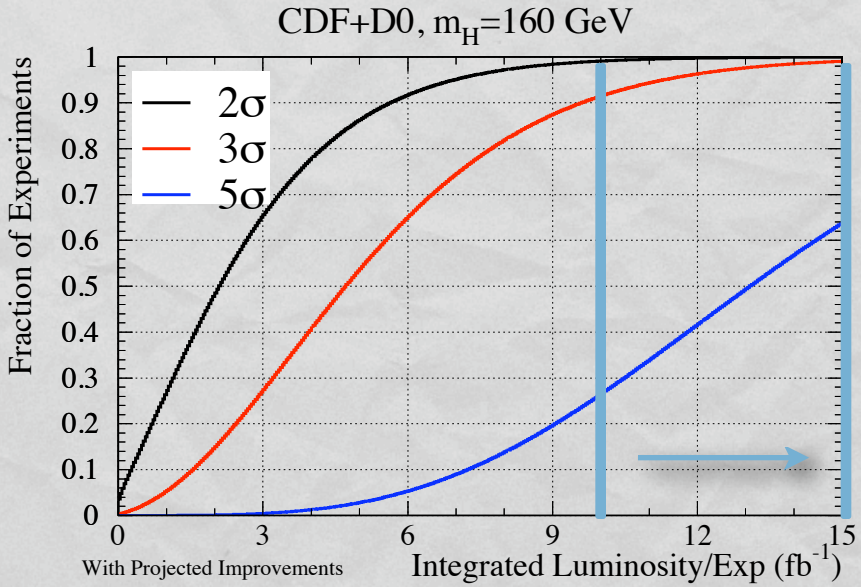
- This would be world-class physics that cannot be done anywhere else than at Tevatron in the foreseeable future.

- An upgraded new-generation detector, using state of the art technology optimized for a few specific goal would allow to fully exploit this potential:
  - High precision tracking + very high speed electronics for efficient triggering on heavy flavor up to highest possible luminosity (10^{33}?), providing enormous yields.

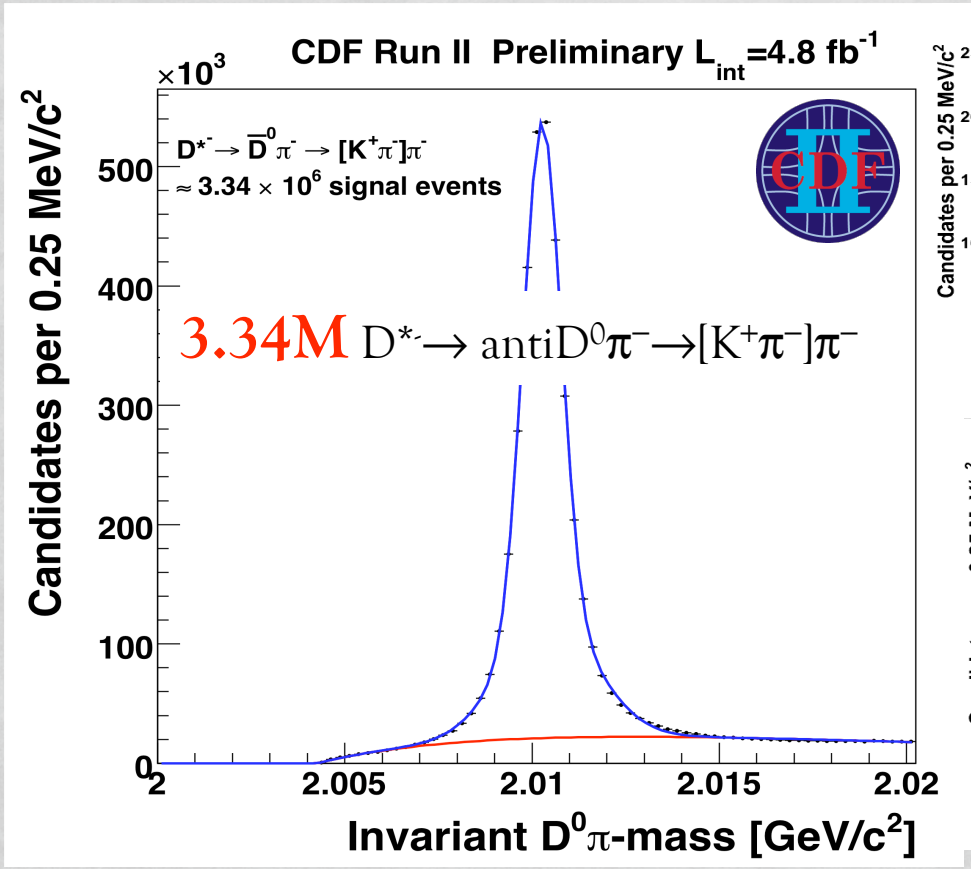
BACKUP

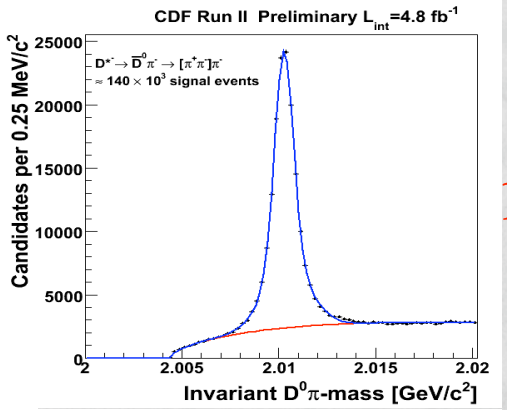
Probabilistic Insurance



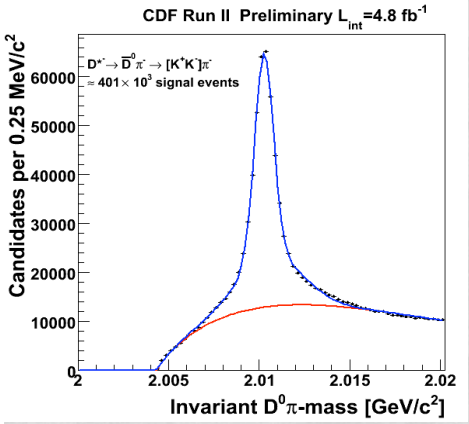


Today's largest D^0 samples come from Tevatron





140K $D^{*-} \to [\pi^+\pi^-]\pi^-$

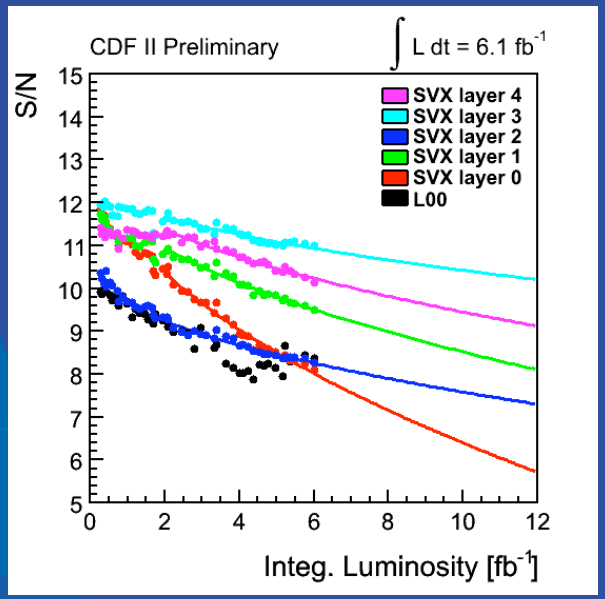


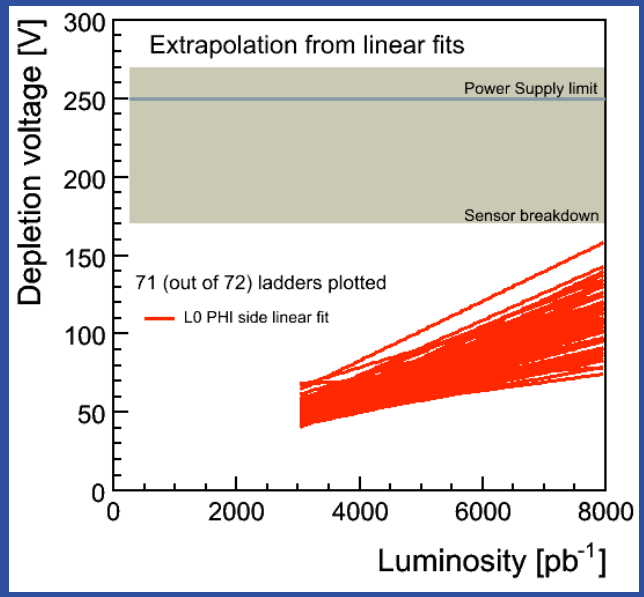
401K $D^{*-} \to [K^+K^-]\pi^-$

- Currently taking data at a rate **10x**Belle
- Expect a measurement of CPV(D0) much better than current WA
- Current trigger efficiency is LOW - can improve by x20 with upgraded detector

CDF detector status (I)

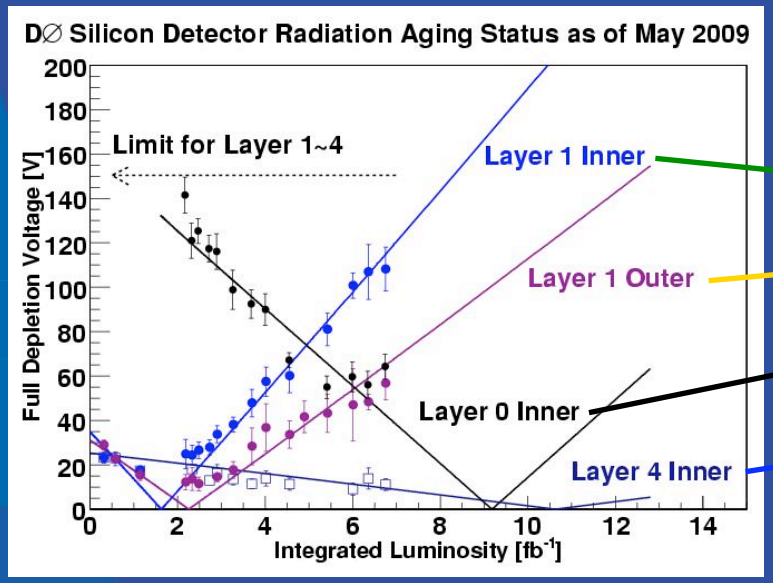
- Silicon detector:
  - ~90% of Si ladders are integrated in data taking (in 8 years 2-3% drop), ~80% return data with <1% error rate;
  - signal/noise projections: no tracking degradation expected;
  - cooling lines: check performed in October 2008 indicates that 2007 repairs are holding;
  - radiation aging: bulk of ladders will be fully depleted through 12 fb^{-1}.

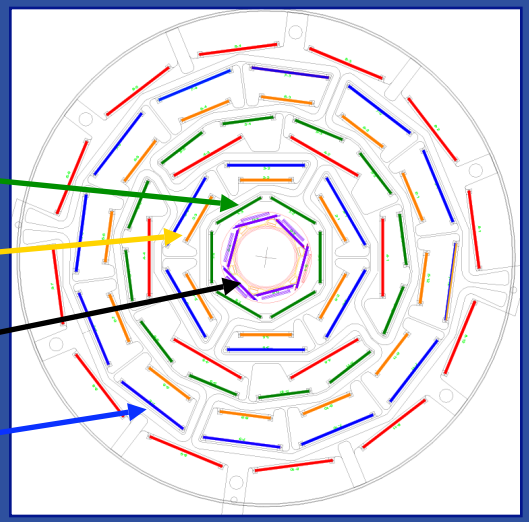




DØ detector status (I)

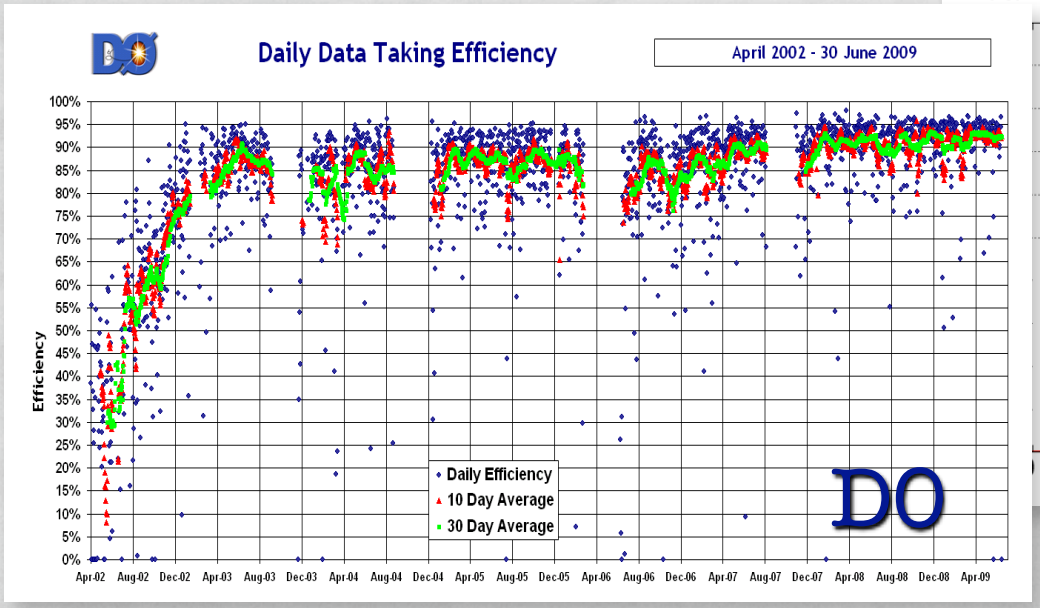
- Silicon detector:
  - used 2008 shutdown access time to recover ~5% channels which had been previously incapacitated;
  - optimized (and automated) high voltage ramping rate to minimize downtimes at begin and end of store;
  - optimizing operating bias voltages, pedestals and readout thresholds;
  - monitoring impact of radiation damage and adjusting bias voltages accordingly:
    - anticipate that the inner Layer 1 sensors may not be fully depleted beyond > 8 fb^{-1} delivered;
  - layer 0 was installed in 2006 to enhance impact parameter resolution and compensate for consequences of rad damage.

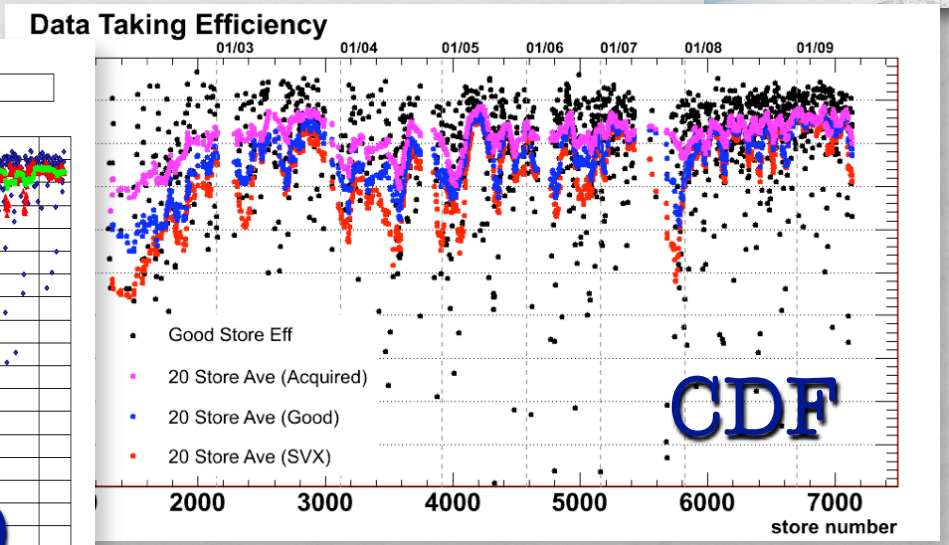




Fermilab

The Detectors Outlook





We record: 85-90 % of delivered luminosity

In analyses: 75-90 % of delivered luminosity

Expected to remain stable & operate well for another 2 yrs

A perfect week at the Tevatron