DØ on Running Beyond 2009

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November 2 2007, Fermilab PAC Meeting

Executive Summary

- **Running beyond 2009 discussion started early 2007**
  - **Excellent Tevatron performance: 1.7 fb^{-1} delivered in Run IIb**
  - **Large number of discoveries and excellent results from the experiments**
  - **Delays in the LHC schedule**
- **Major elements to be considered during the decision process**
  - **Physics potential - in this talk**
  - **Manpower - in this talk**
  - **Detector longevity – in this talk**
  - **Fermilab resources**
  - **LHC progress**
- **2010 physics program**
  - **Exciting opportunities in all areas of physics studies**
  - **Chance for three-sigma evidence for SM Higgs over almost entire mass range**
- **Manpower**
  - **Resources available to run through 2009**
  - **MoUs for 2009-2011 to be collected early 2008 to assist for longer term planning**
- **DØ detector**
  - **No technical issues through 8 fb^{-1} expected**
- **Summary**
  - **The Collaboration looks forward to continuing data taking in 2008, 2009 and 2010 to exploit the exciting potential of full Run II data set**

The DØ Collaboration

DØ is an international collaboration of 600 physicists from 18 nations who have designed, built and operate the DØ detector at the Tevatron and perform data analysis

Institutions: 82 total, 38 US, 44 non-US

Collaborators:
~ 50% from non-US institutions
(note strong European involvement)
~ 100 postdocs, 140 graduate students

Physics Goals

Precision tests of the Standard Model
- **Weak bosons, top quark, QCD, B-physics**

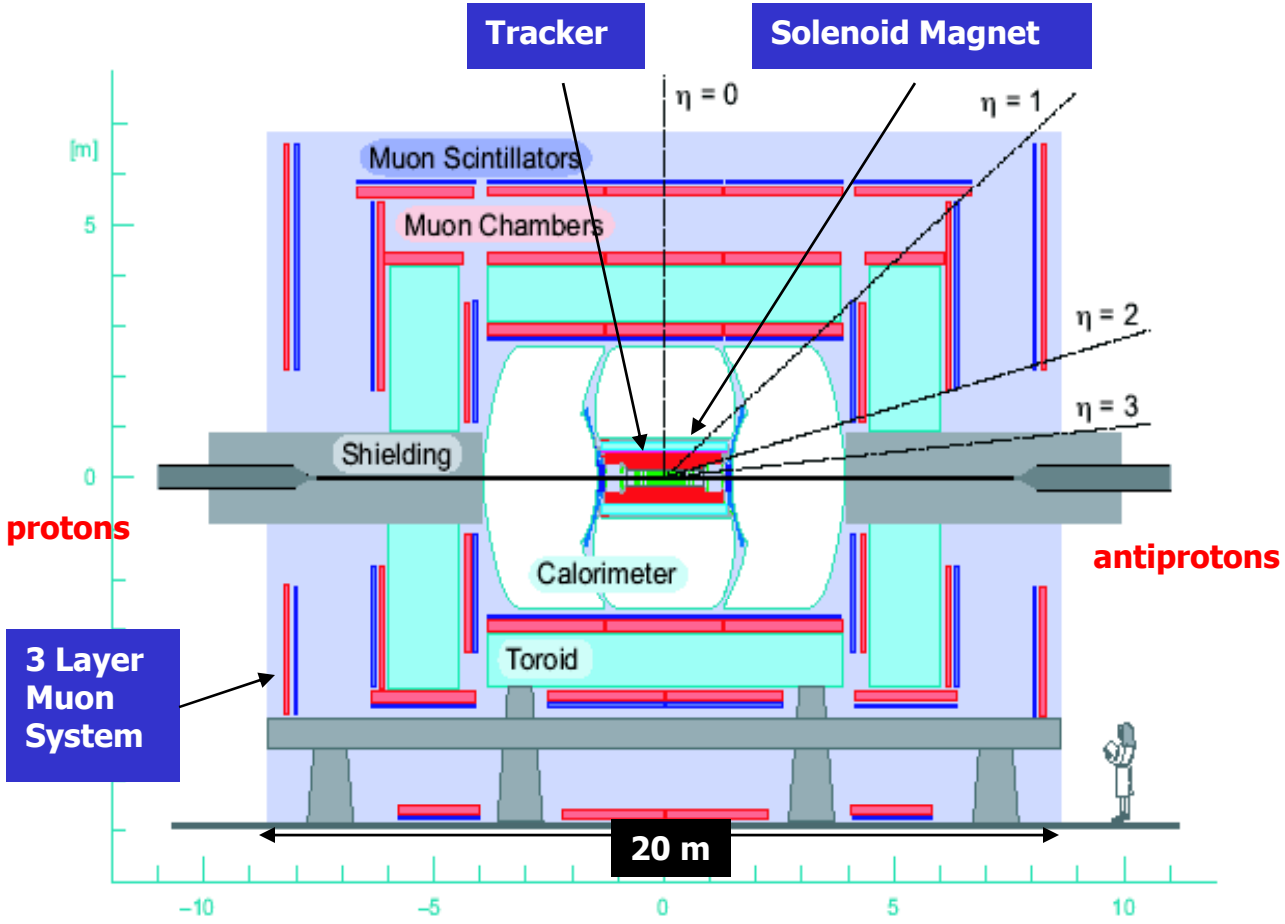
Search for particles and forces beyond those known
- **Higgs, supersymmetry, extra dimensions….**

Driven by these goals, the detector emphasizes

Electron and muon identification

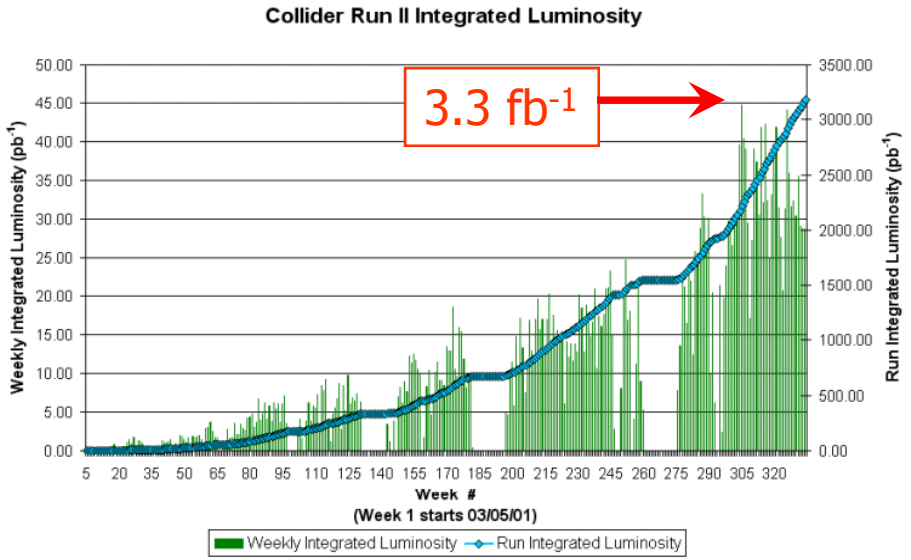
Jets and **missing transverse energy**

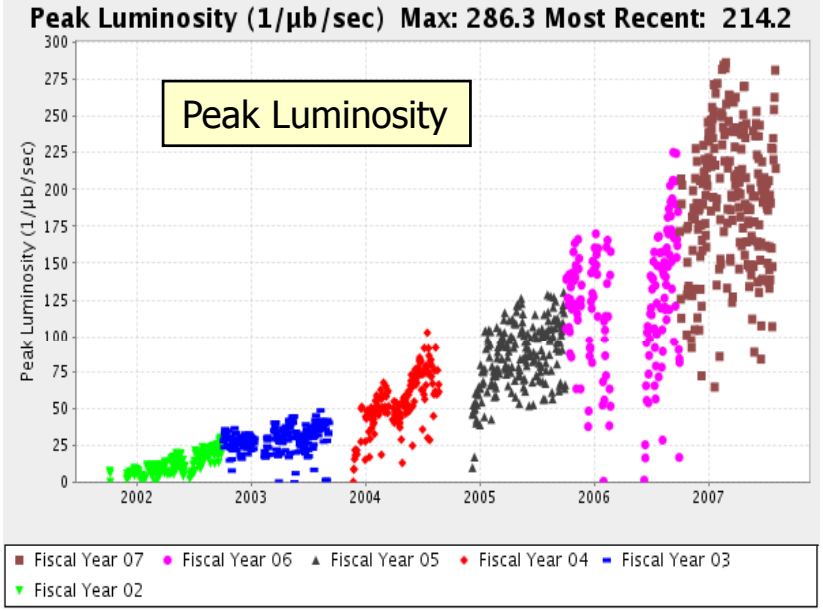
Flavor tagging through **displaced vertices** and **leptons**

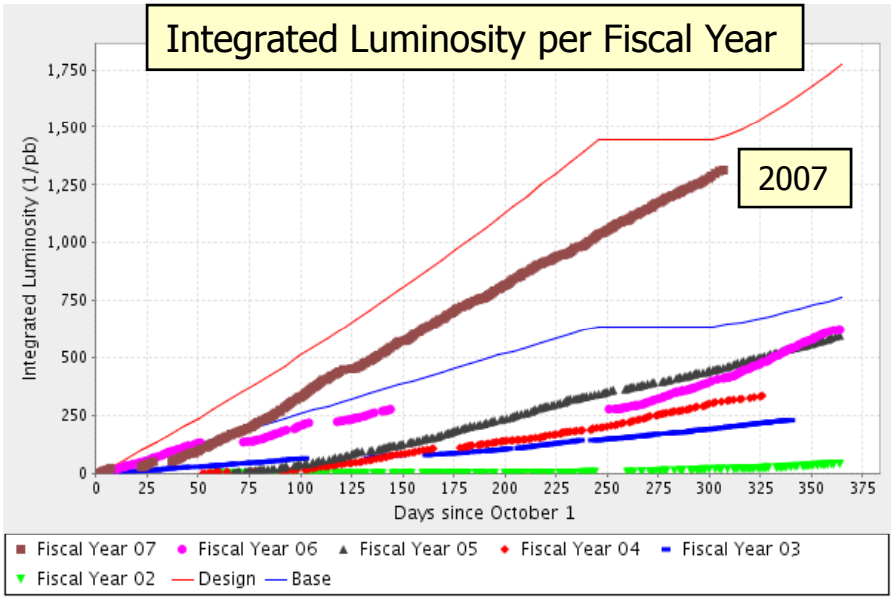


Tevatron Run II Performance

- Peak luminosity is above $2.9 \cdot 10^{32}$ $cm^{-2}sec^{-1}$
- Reliable operation of very complex machine
  - in stores ~120 hours/week
- Total 3.3 fb^{-1} delivered in Run II
  - as planned

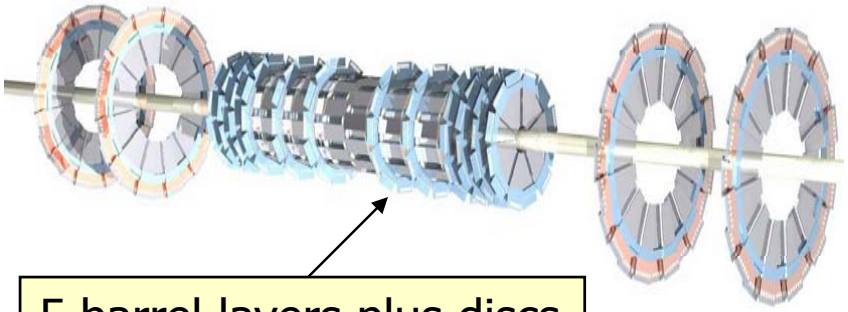




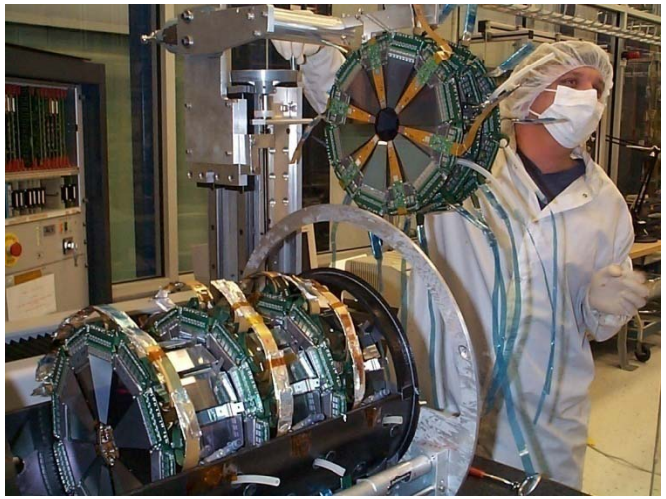


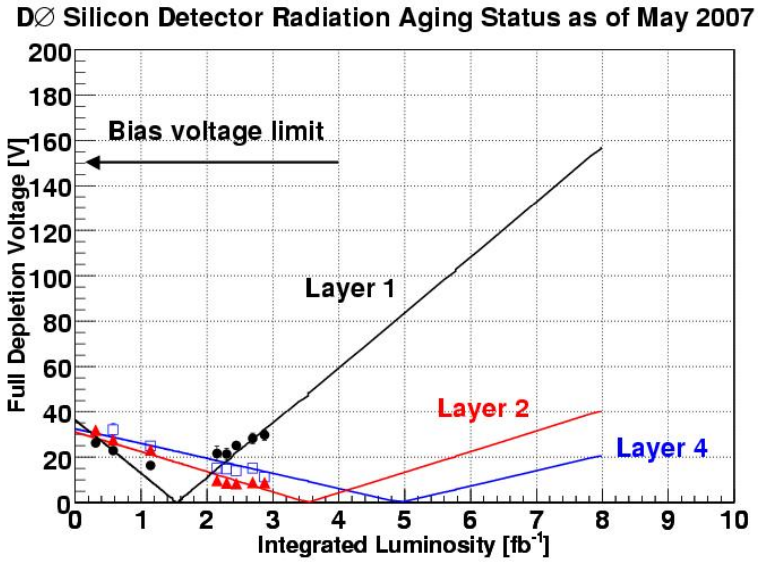
Excellent performance!

Silicon Microstrip Tracker

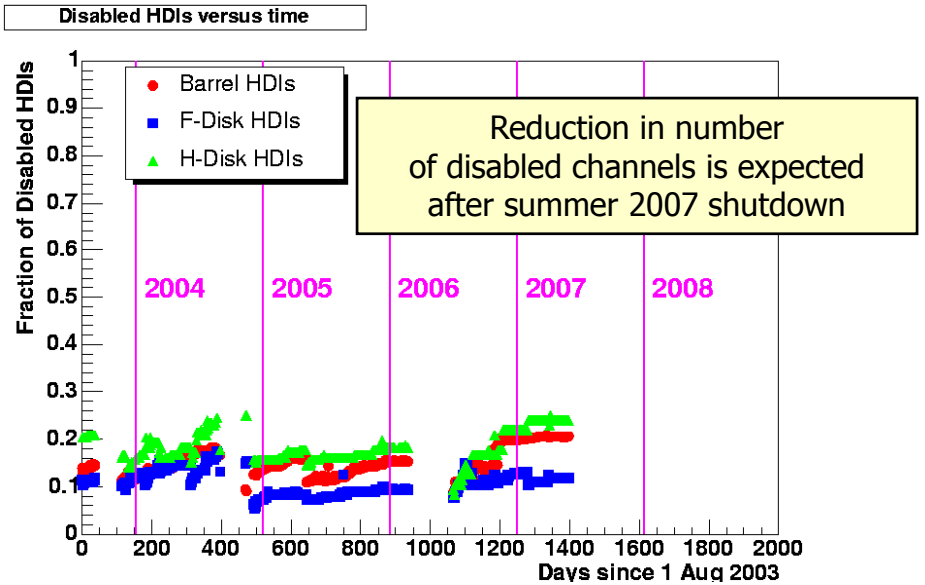


5 barrel layers plus discs





Detector is working well
Stable number of operating sensors

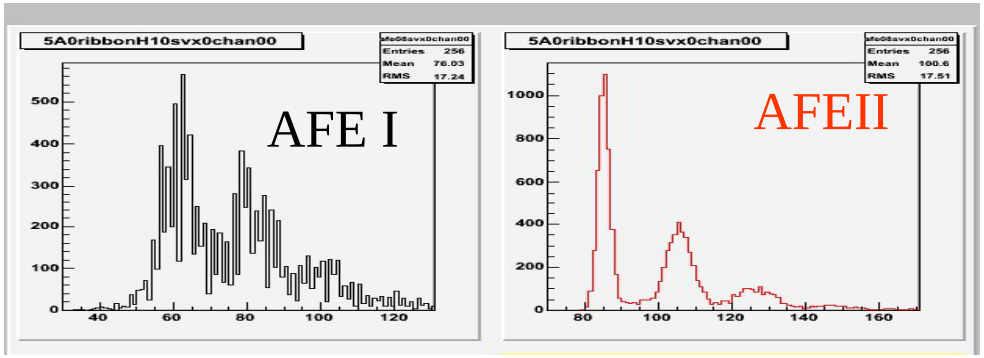


Reduction in number
of disabled channels is expected
after summer 2007 shutdown

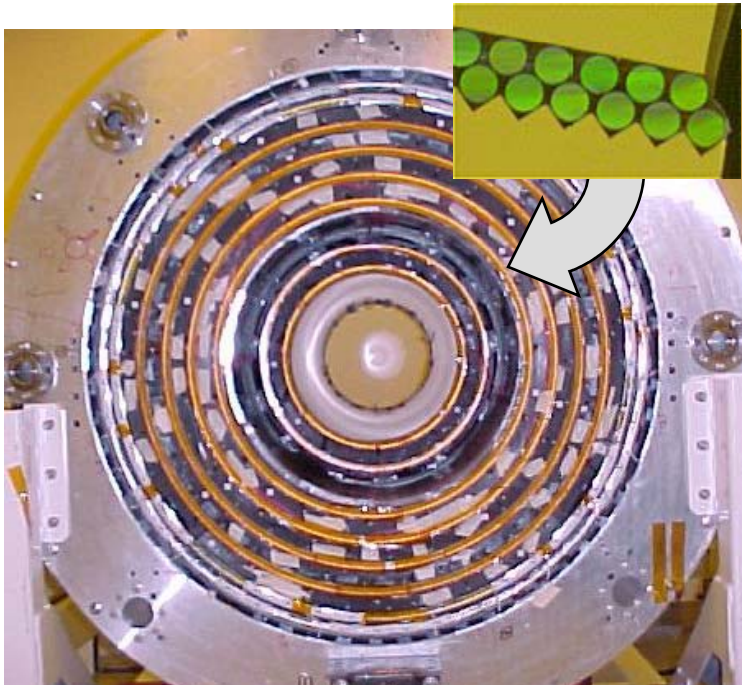
Radiation dose → no issues for running
up to 8 fb^{-1} of delivered luminosity

Scintillating Fiber Tracker

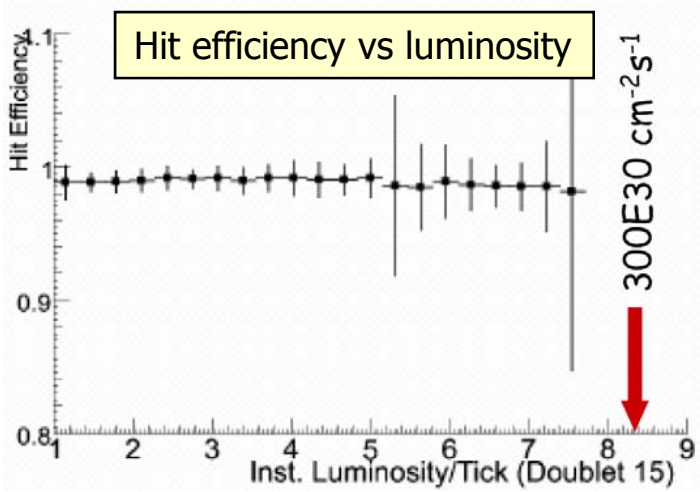
- 8 axial and 8 stereo fibers double layers
- Performing well
  - Light yield of ~7 pe/mip
  - Number of operating channels > 98%
- Substantially improved readout electronics – AFEII boards - since late 2006
  - Excellent amplitude resolution and no saturation up to highest luminosity
  - Provide hits longitudinal coordinate measurement capability



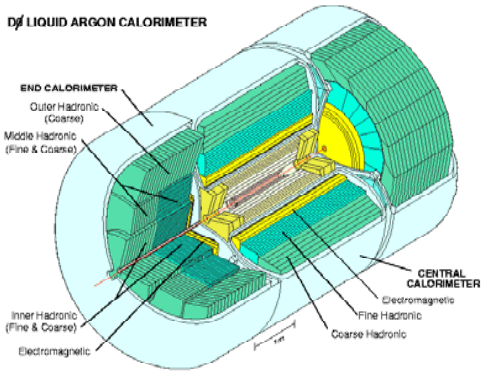
Single photo-electron peaks



Fiber tracker and silicon detector are running in 1.9T magnetic field created by superconducting solenoid
- ~5% field reduction to prevent quenches in 2004
- Stable operation over last 3 years
  - Closely monitoring operational parameters

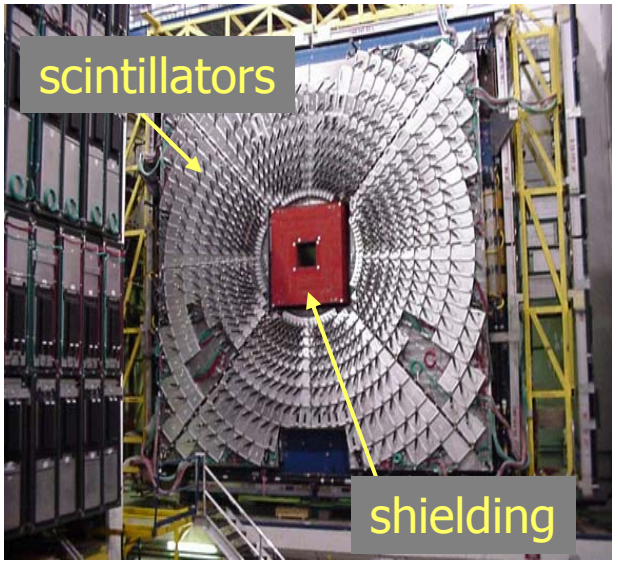


Calorimeter and Muon System

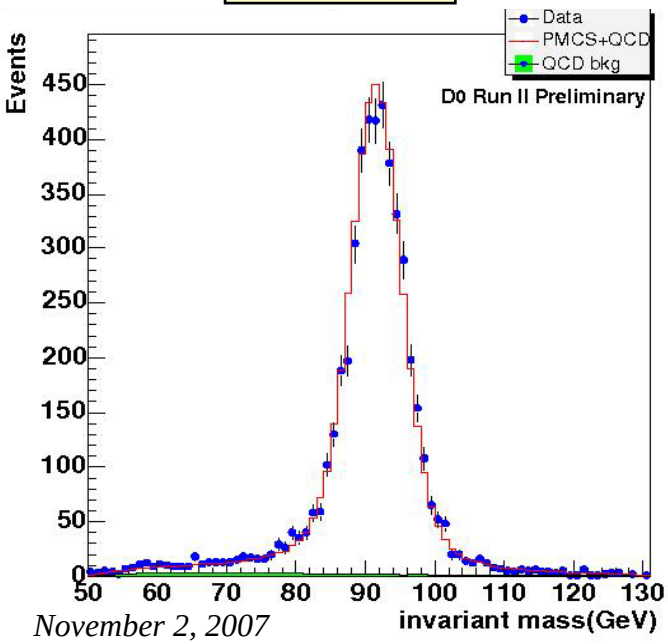


Uranium Liquid Argon calorimeter
Drift tubes and scintillation counters based muon system

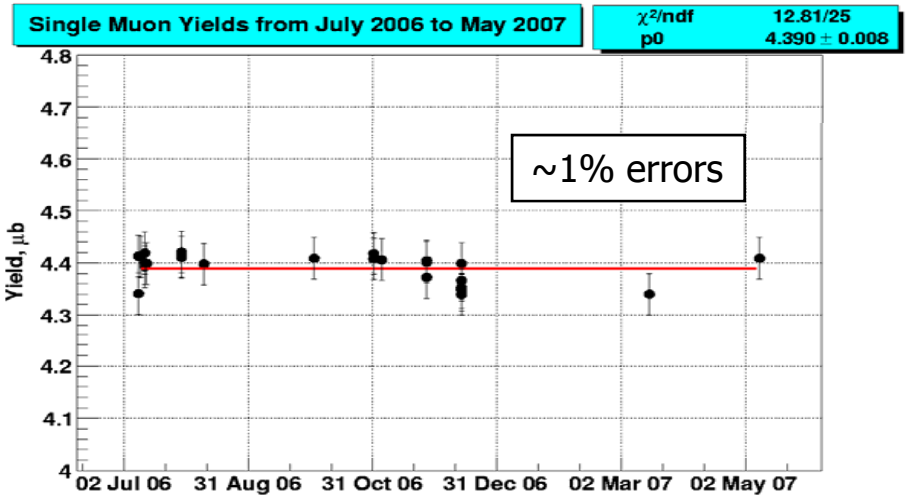
Stable and reliable operation
- Less than 0.1% of non-working channels in the calorimeter and 0.5% in the muon system
- No detectors radiation damage issues
- Stable operation since early Run II



$Z \rightarrow e^+e^-$



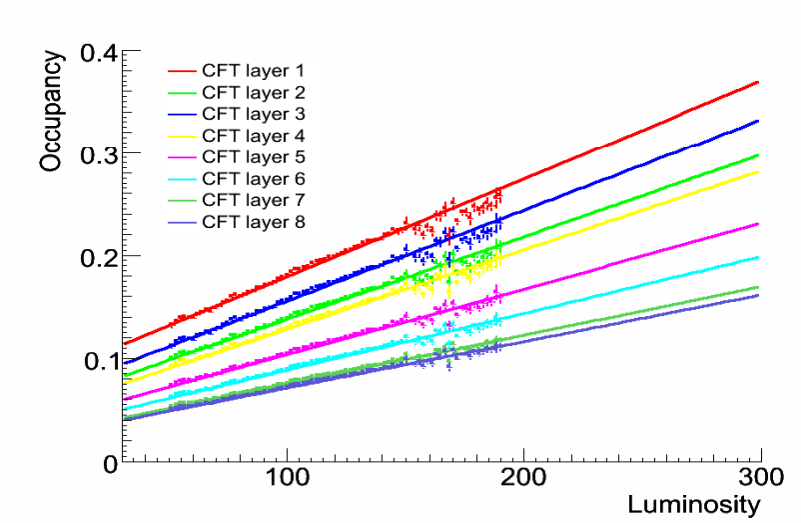
Monitoring of muon system stability using inclusive muon production. ~1% stability over many years of operation.



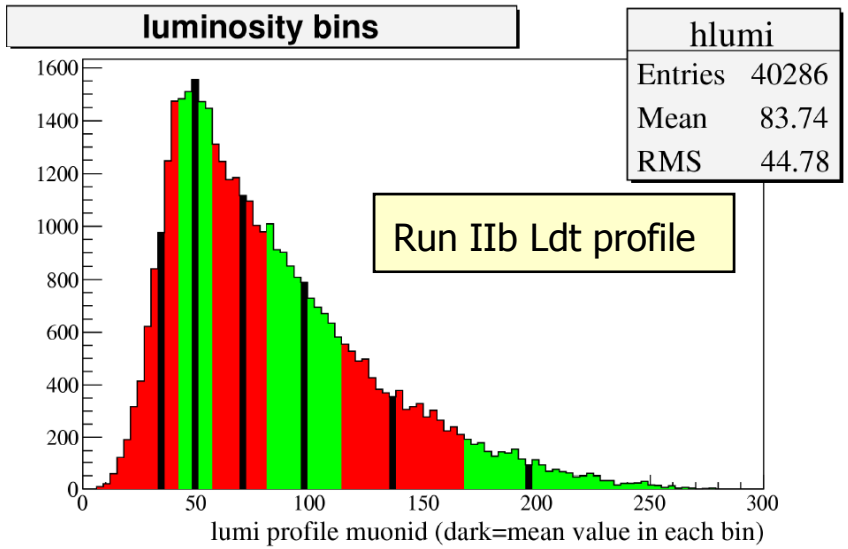
Running at High Luminosities

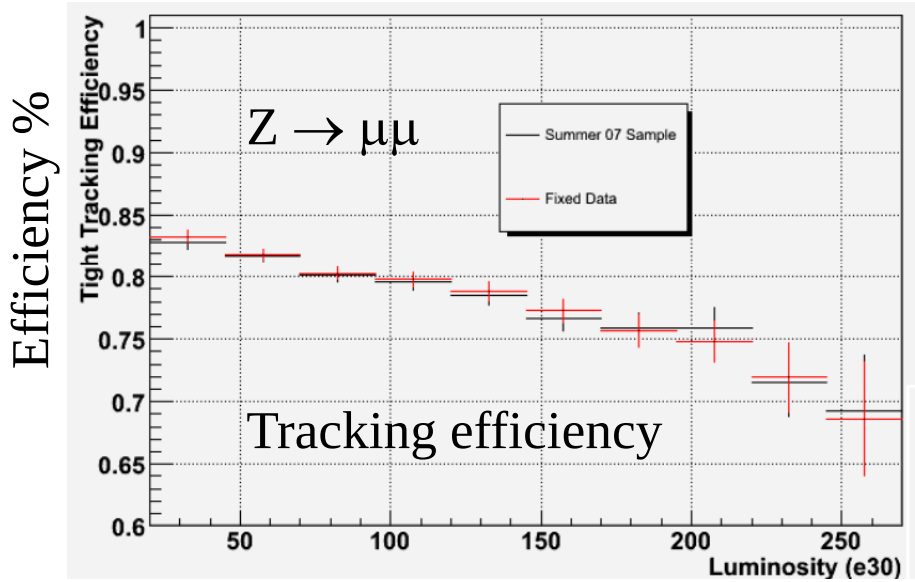
- Run IIb trigger upgrades were essential for ensuring success of physics program at high luminosity
  - Successfully completed
- Running highly efficient high p_t trigger menu un-prescaled up to $300 \cdot 10^{30}$

Most challenging issues are with tracking: small central tracking volume and high occupancy "per channel"



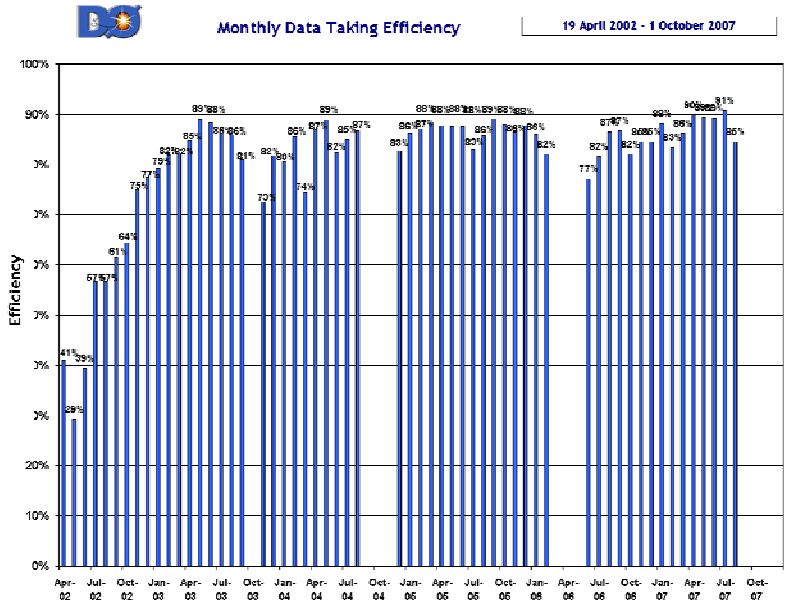
Continue work on improvements to further reduce effects of high luminosity
- Triggering, algorithms, analysis
- No substantial loss in sensitivities for Run IIb data

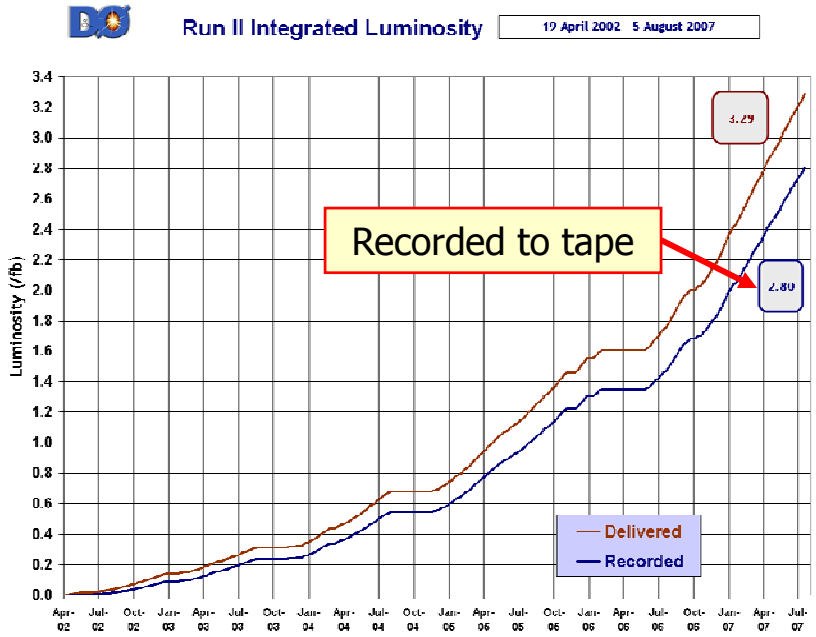




Instantaneous luminosity

Operations





- The experiment is operating well and recording physics quality data
  - Typical "good" week 40 pb^{-1}
    - Run I top quark discovery in a week!
- On average 85% data taking efficiency
  - 5% are trigger/readout system disables
  - 10% are begin/end stores, failures
- As of today DØ has ~2.8 fb^{-1} on tapes
  - All detectors functioning well
  - Already reported physics results from summer 2007 data
- First post-summer 2007 shutdown week started very smoothly
  - ~90% efficient physics data taking!

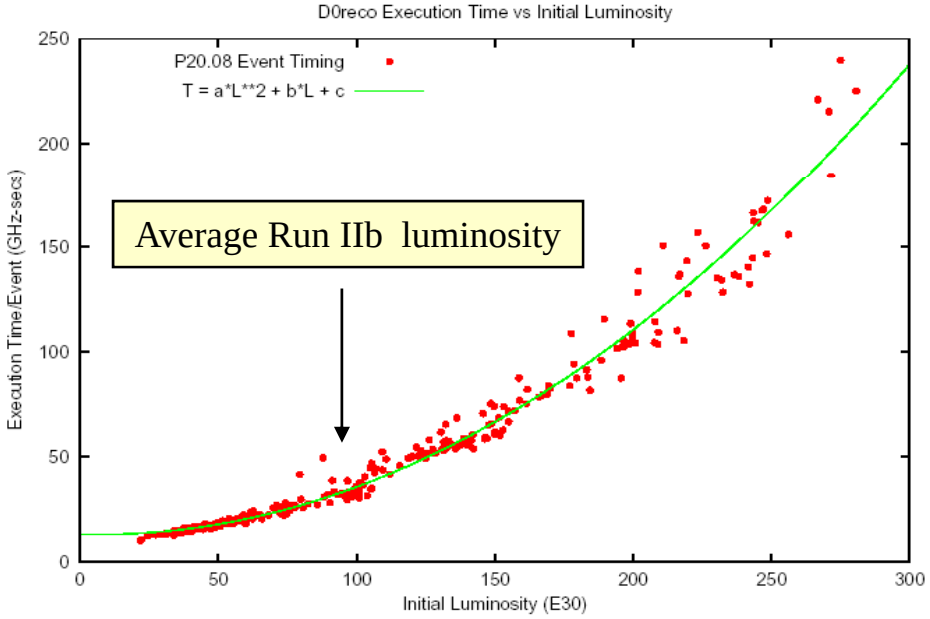
Data Processing

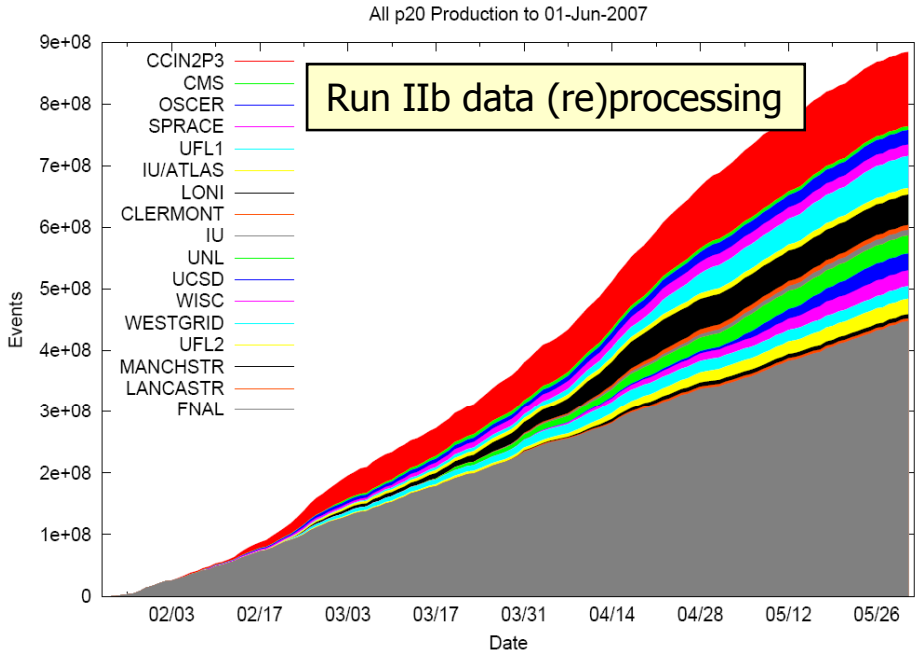
- DØ collected over $2 \cdot 10^9$ events in Run II
- Current reconstruction program (Version p20) is in use since summer 2006
  - New Run IIb detectors
  - Updated calibration data
  - Faster and more robust

For uniform and better quality data set reprocessed Run IIb data collected before January 2007

Was accomplished on the GRID in ~4 months

Have full Run II data set available for analysis!





Reconstruction timing

- **Major time consuming process is tracking due to small number of tracking layers and high occupancies**
  - **Reconstructing ~5mln events per day and writing to tapes about the same number**
- **Extra computing resources will become available in about a month**
  - **Will have "head room" and ready for even higher luminosities operation**

The Experiment Personpower

We expect(!) decline in experiment manpower: startup of the LHC, approaching the end of the Tevatron program, out-flux to other experiments

The challenge is how to fully utilize Tevatron and the experiment potential over next several years

Issues

- Overall manpower decrease
- Experts in specific areas
- Efforts required to optimize triggering and algorithms at high luminosity
- Unexpected challenges

Tevatron Task Force in early 2006 devoted considerable effort to estimate resources needed to run the experiment and analyze data – the report is available

We re-evaluated Tevatron Task Force numbers and concluded that estimates for 2009 hold

Unit of manpower measure is "FTE" or Full Time Equivalent

One person spending full time on DØ is "1 FTE"

Person with teaching duties is less than 1 FTE

Efforts Reports and Future Resource Needs

Every year in December each Collaboration group reports past year efforts
This is actual effort spent by the Collaboration
Could be compared with resource needs

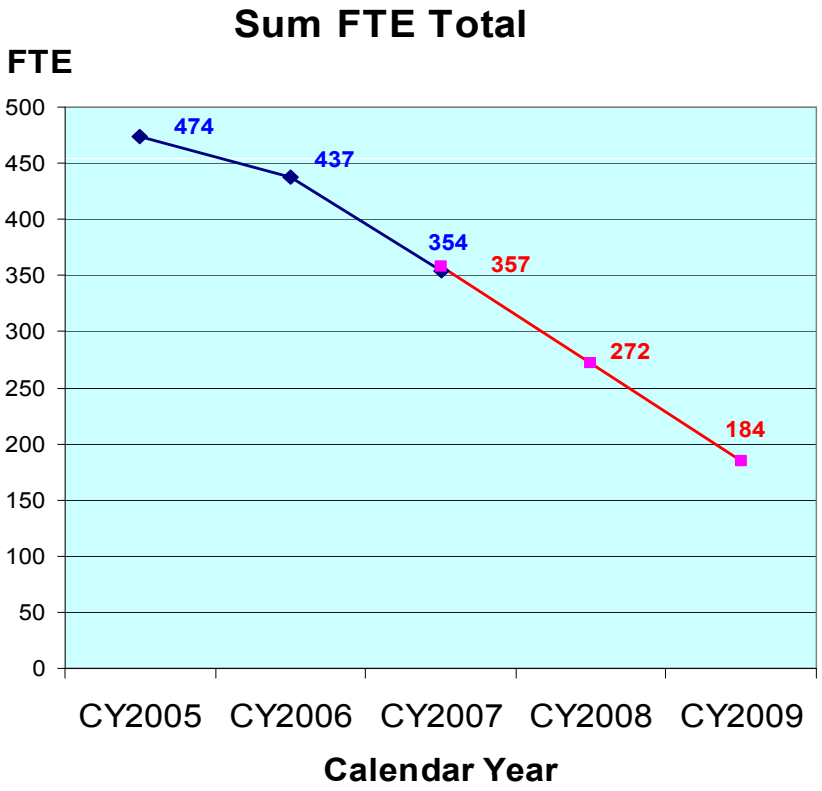
Total future FTE required as service contributions

	Effort Report "FTE"		Resource Needs "FTE"	
	2005	**2006**	**2007**	**2009**
Operations and Run IIb upgrade	**107**	**91**	**68**	**68**
Computing	**35**	**30**	**32**	**25**
Algorithms	**74**	**65**	**55**	**21**
Management	**14**	**14**	**10**	**10**
Total service contributions	**230**	**200**	**165**	**124**

Based on the above table to operate the experiment, reconstruct data and perform object (jets, muons, etc.) identification studies 124 FTEs will be required in 2009

Personpower of the Experiment

- To estimate future experiment resources each DØ group periodically (once every ~2 years) provides expected manpower contributions in the form of
  - MoU – Memorandum of Understanding
- In January-February 2007 all groups provided their MoUs for 2007-2009
- Previous MoUs completed in 2005 covered 2005-2007



Total experiment personpower based on MoUs
2005-2007 – blue (MoU data collected in 2005)
2007-2009 – red (MoU data collected in 2007)

- Current expectations for 2009 DØ resource availability is 184 FTEs
  - About 124 FTEs required to run the experiment in 2009
  - Will be able to continue efficient data taking and perform physics analysis
  - Working actively attracting more collaborators
  - Reducing personpower needed to run the experiment

Reducing Personpower Requirements

- Reducing resource needs in every area of the experiment
  - Control room shifts
    - Down to 4 shifters from June 1, 2007
  - Streamlining operations
    - Automation
    - Minimizing changes
  - Stability of reconstruction and algorithms
    - Run IIb improvements integrated
    - High luminosity improvements to be finished soon
  - Continuing efforts with Computing Division on automation
    - Processing and datasets creation
- Reduction in efforts needs for analysis
  - Joint object identification groups for all physics groups
  - Joint "final states" groups
  - Common MC samples production

- Streamlining in all areas of the experiment already bearing fruits
  - Stable and highly efficient data taking
  - Smooth and stable reconstruction
  - Fast analyses publications

Attracting Collaborators and Resources

- Interest and excitement are keeping the Collaboration together
  - Important to keep each and every collaborator interested and actively engaged!

- Interesting physics
  - Multi-purpose detector, wide range of physics topics
  - High quality data available
  - Hunt for
    - New SM states/objects
      - single top, ZZ, SM Higgs
    - New Phenomena
    - High precision measurements
  - Many graduate students who become primary authors in their first year!
- Challenging projects
  - Detectors
  - Algorithms
  - Computing
- Training for younger scientists
  - 25 PhD dissertations in 2007 and counting!
  - Excellent jobs opportunities
- Leadership positions
  - Operations, detector, physics and algorithm groups
- Talks, seminars, conferences
  - High profile talks: Lepton-Photon, ICHEP, EPS, APS…
  - NBC news, press releases, lectures

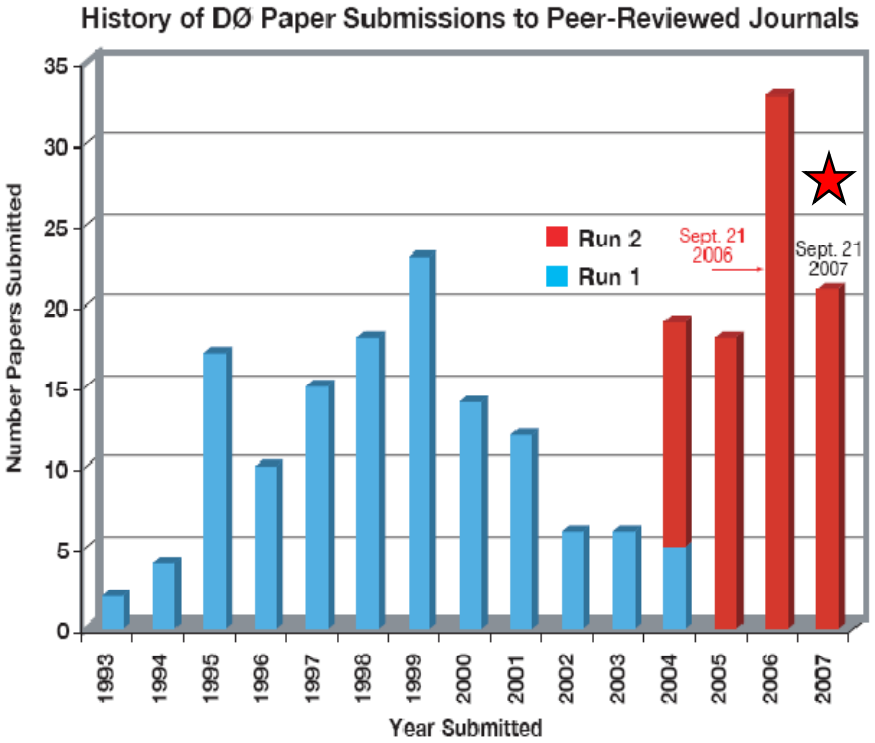
Collaboration Resources

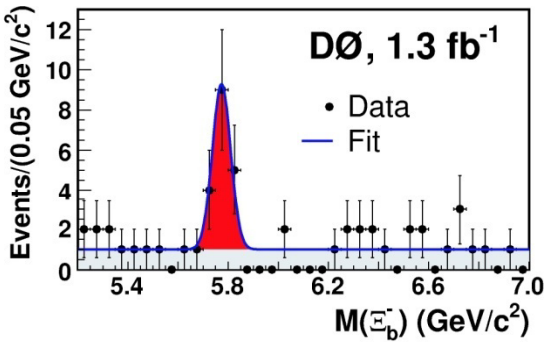
- Plan to estimate 2010 experiment manpower
  - Needs: based on experience and future expectations
  - Availability: new set of MoUs for 2009-2011
- Both will be completed by early spring 2008
  - as agreed by the DØ Institutional Board in September 2007
- Early endorsement of 2010 run will help with attracting more collaborators
  - Grants
  - Students/Postdocs time scales
  - Long term commitments

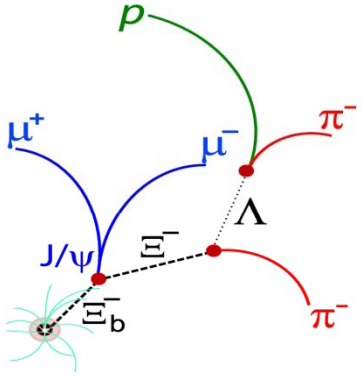
- October 29th DØ 2007 International Finance Committee meeting
  - Representatives from many international funding agencies
  - Proposal to run in 2010 resonated well
  - Many DØ groups are planning to re-apply for funding in 2008 for 2009 and beyond
  - Funding agencies are ready to consider funding requests
- Clear statements on the 2010 run by the Laboratory and the experiment are already paying off

Tally of New DØ Results

- More than 30 new results presented at 2007 Summer conferences
  - EPS and Lepton-Photon
- New from all physics areas: B physics, Electroweak, New Phenomena Searches, QCD, Top Quark Physics, Higgs Searches
- Some have improved techniques, some with increased luminosity
  - and some a combination of these
- Some completely new topics now explored due to larger samples and/or new theoretical developments



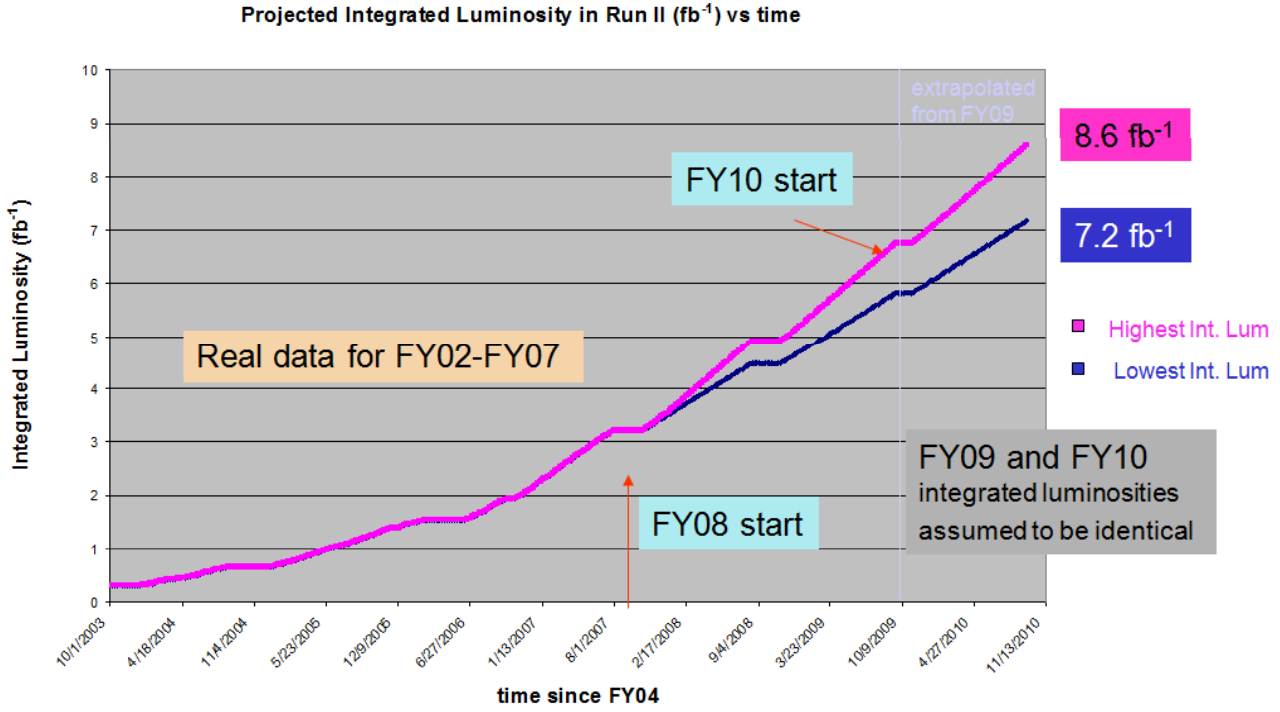




- Publications
  - 21 as of September 2007
    - 27 as of today - ★!
  - On track to beat 2006 peak
  - 200th DØ publication submitted this summer

2010 Running: Parameters

- Based on estimates from Fermilab accelerator division we anticipate
  - ~ 6.8 fb^{-1} delivered by end of FY09
  - ~ 8.6 fb^{-1} delivered by end of FY10 with a 2010 run
- We estimate about 80% of this delivered luminosity will finally be used in analyses
  - 5.5 fb^{-1} by end of FY09
  - 6.8 fb^{-1} by end of FY10 (=25% increase over FY09)
- We will use "analyzed luminosity" for remaining projections so the projected results can be compared easily with existing results



Rich Physics Program Ahead

- Limit on the B_s to $\mu\mu$ branching ratio
- CP violation studies in B_s system
  - Mass difference Δm_s
  - Lifetime Γ and lifetime difference $\Delta\Gamma$
  - CP-violating phase ϕ_s
- High precision measurement of W boson mass
- High precision measurement of the top quark mass
- Studies of the top quark production and properties
- Precision measurements of the top quark production cross sections
- Search for SM Higgs boson
- Search for non-SM Higgs boson(s)
- Search for SUSY in many modes
- Search for high mass resonances (Z', extra dimensions, etc.)
- Highest energy QCD jets studies
- Di-boson production and studies of anomalous couplings
- And many, many more exciting studies

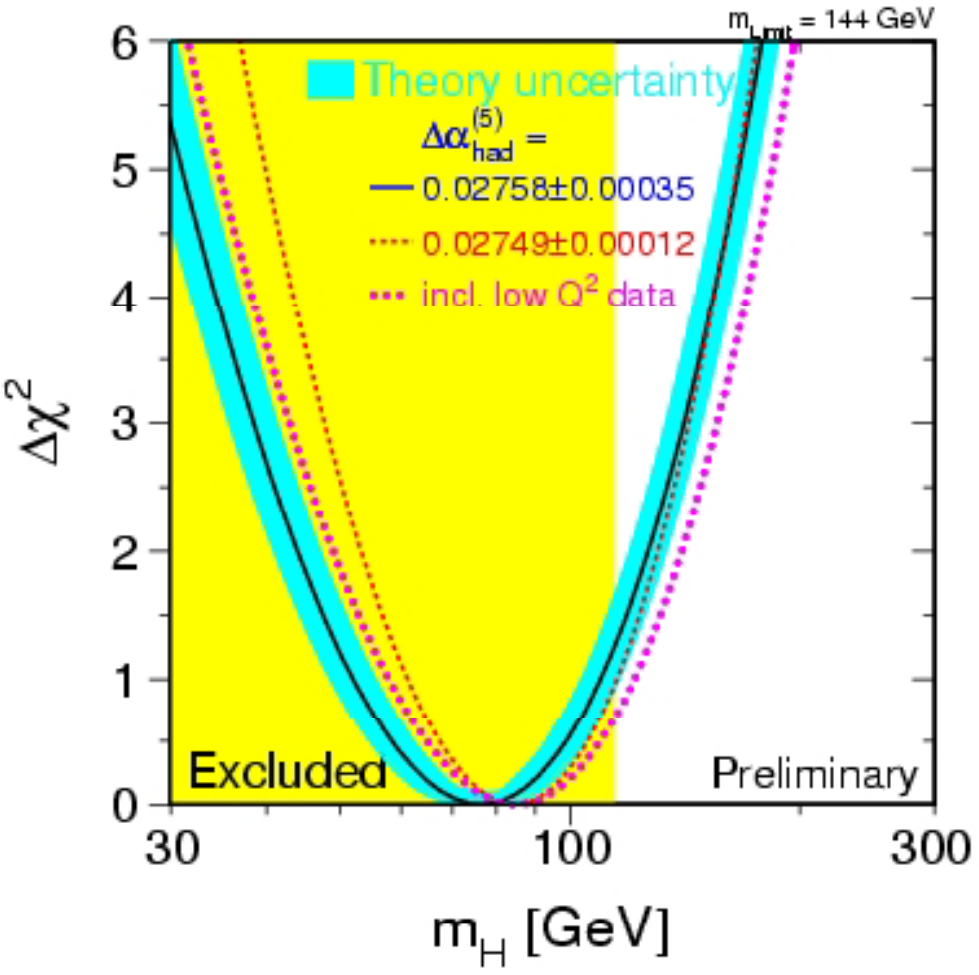
Many projections for M_t, M_W, SUSY Higgs search and others vs Ldt already been shown to PAC
Legacy measurements from the Tevatron will be best for many years

Physics Projection: SM Higgs search

- Indirect constraints, including Tevatron measurements of the top mass and W boson mass, indicate that the Higgs should be fairly light
  - It could be in reach of the Tevatron!

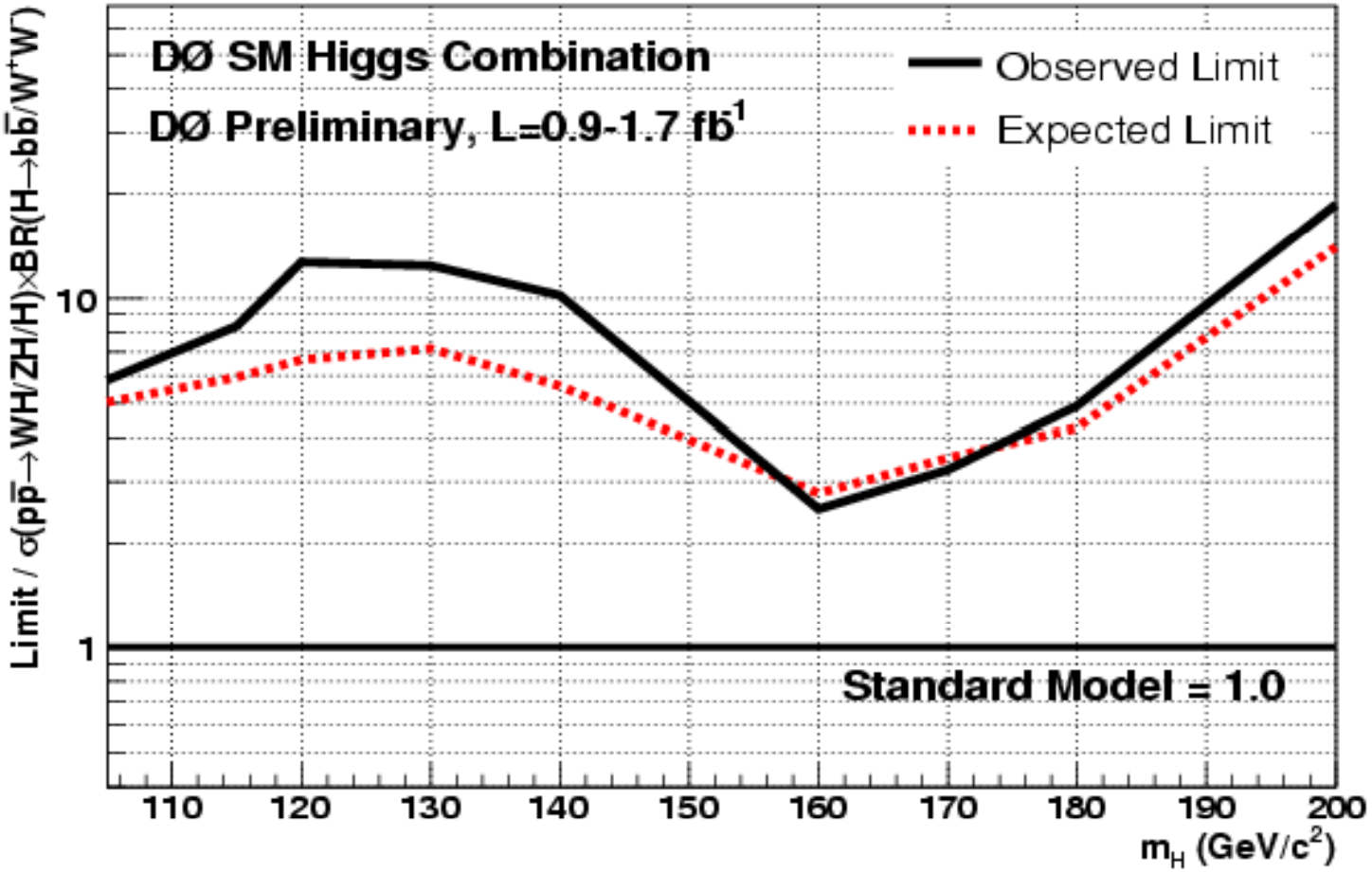
m_H<144 GeV (w/o direct exclusion)

m_H<182 GeV (w/ direct exclusion)



Current DØ SM Higgs Limits

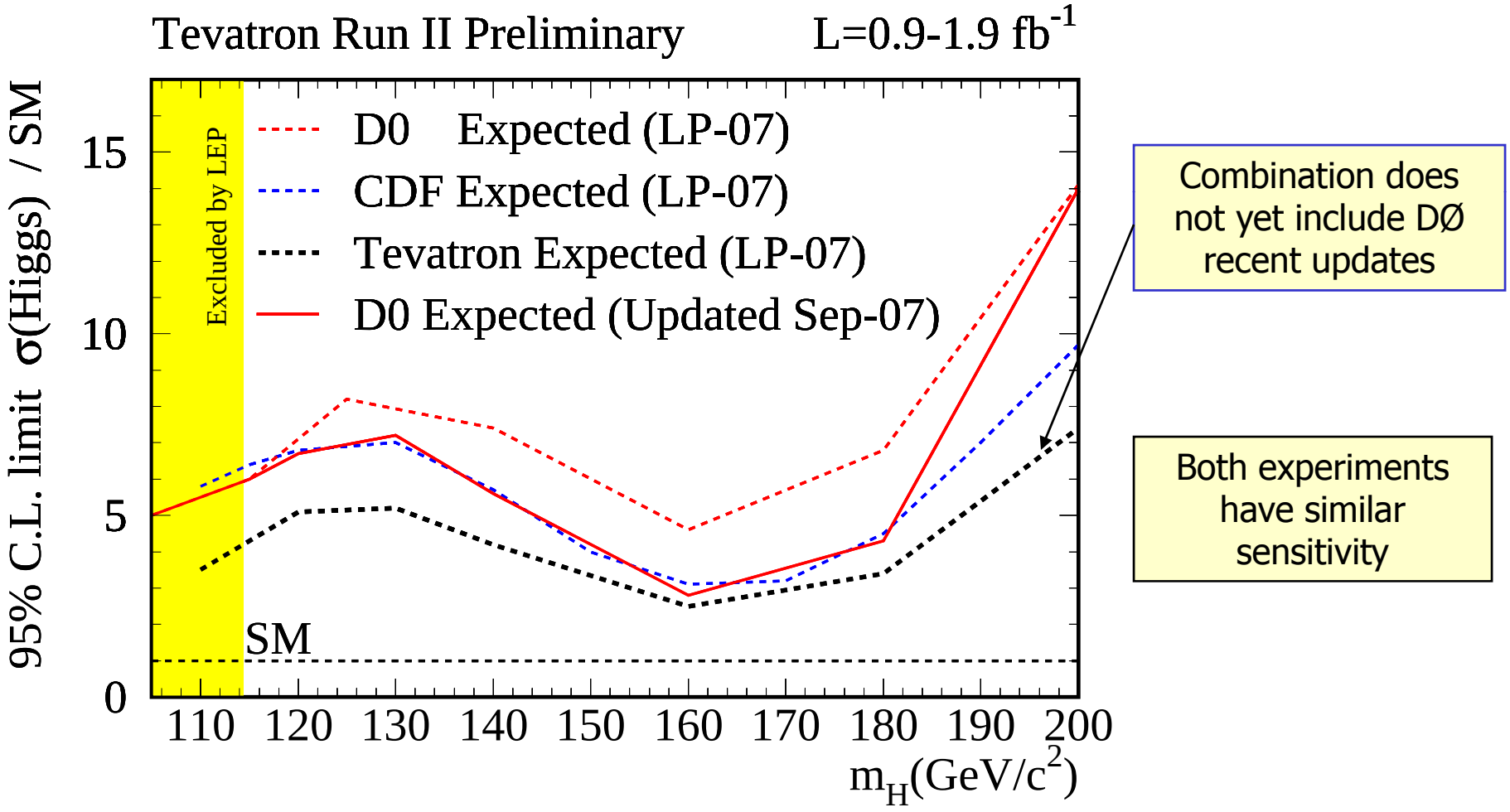
- For m_H=115 GeV, expected (observed) 95% CL relative to σ_{SM} = 6.0 (8.3)
- For m_H=160 GeV, expected (observed) 95% CL relative to σ_{SM} = 2.8 (2.5)



New results added since Lepton Photon 2007 already

Current Tevatron Limits

- For m_H=115 GeV, expected (observed) 95% CL relative to σ_{SM} = 4.3 (7.8)
- For m_H=160 GeV, expected (observed) 95% CL relative to σ_{SM} = 2.5 (1.4)



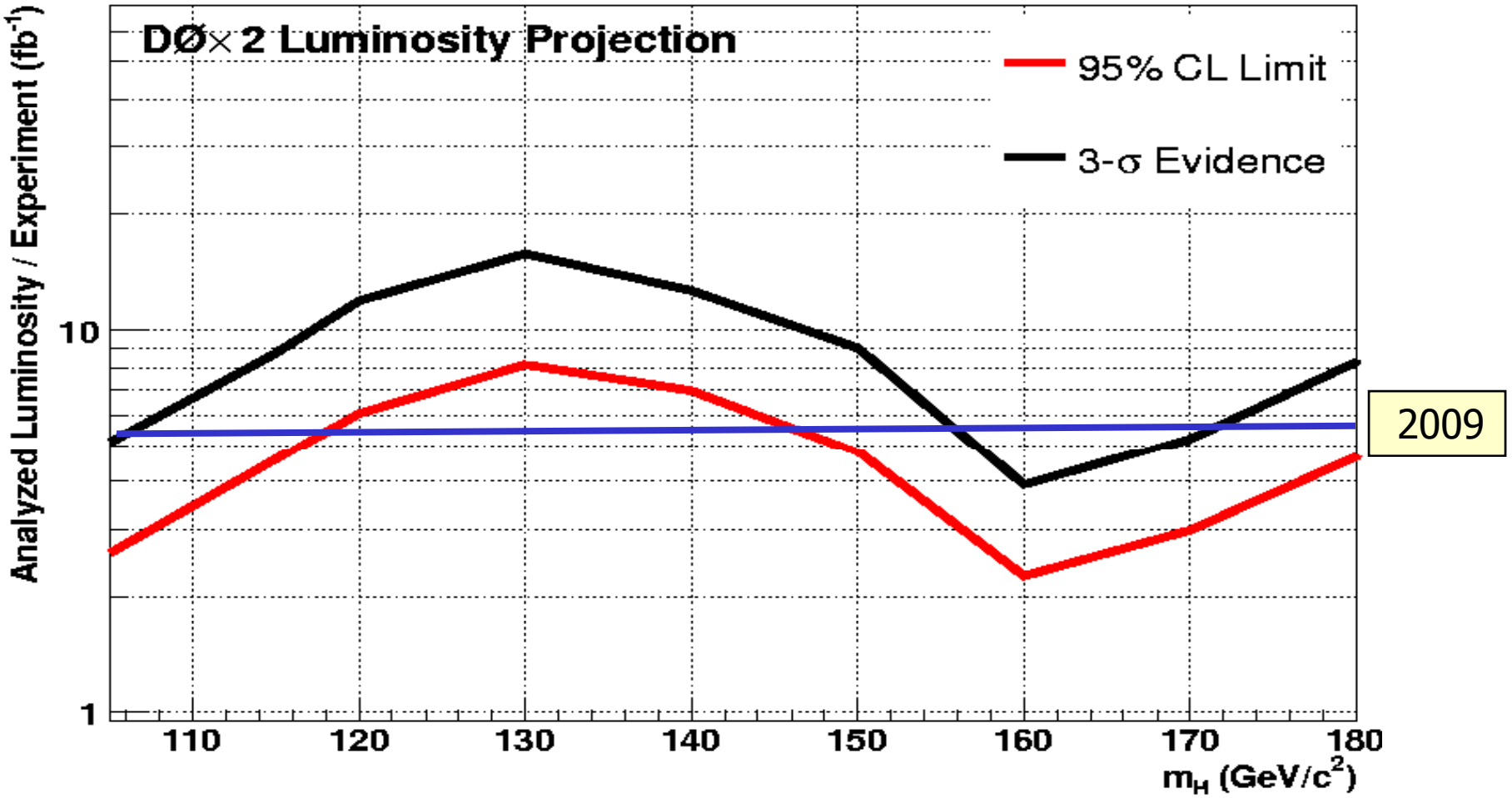
Combination does not yet include DØ recent updates

Both experiments have similar sensitivity

Projecting Higgs Reach to 2010

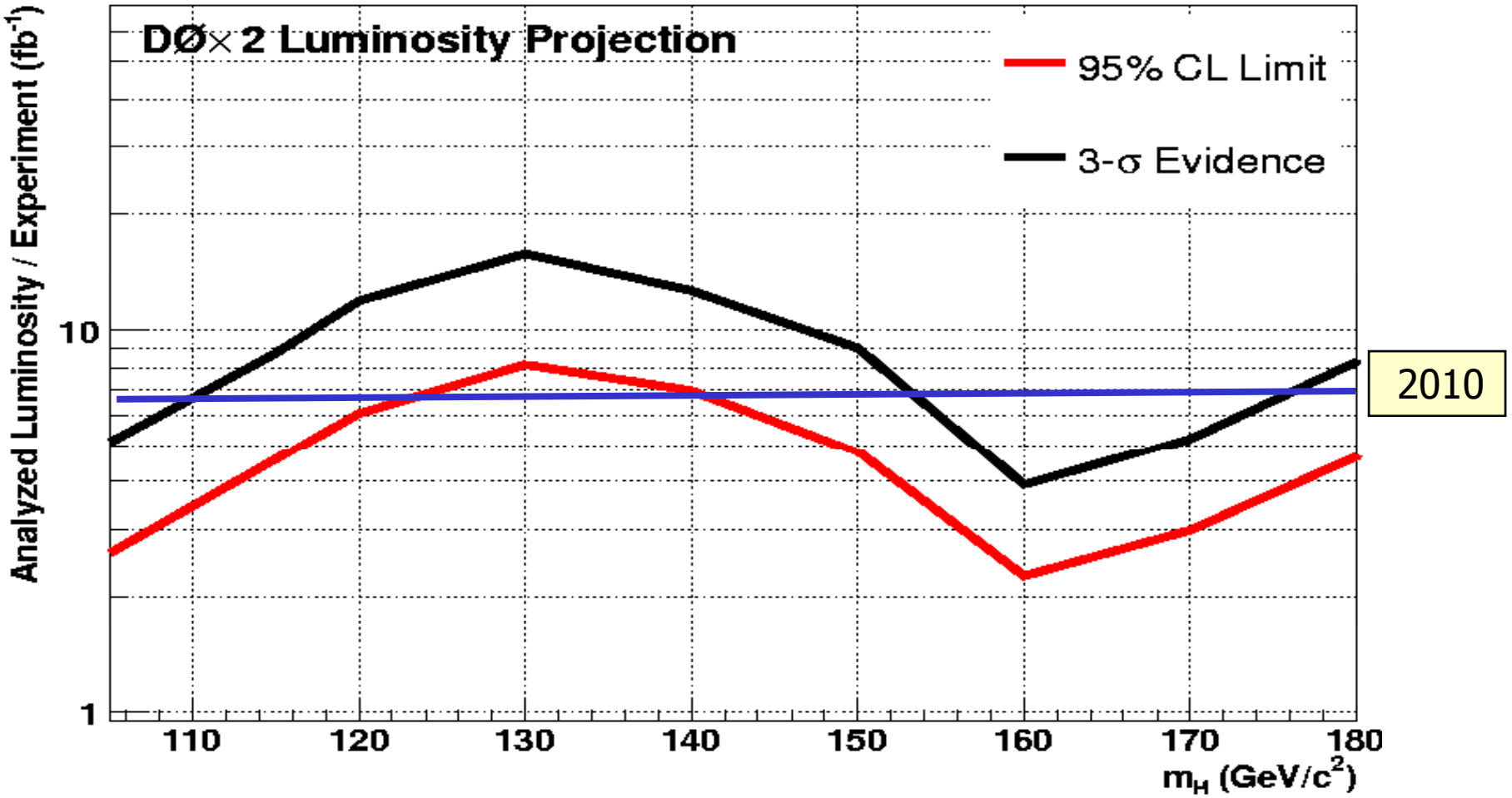
- For the first time expected limits extrapolation is based on actually observed limits with
  - Extrapolation in ∫Ldt by a factor of 3-6
  - Taking into account expected improvements in analysis
- For background dominated searches, one generally expects the cross section limit to improve with integrated luminosity in proportion to sqrt(∫Ldt)
  - so far in Run II, limits have improved approximately in proportion to ∫Ldt itself due to substantial improvements in analysis
- Higgs sensitivity expected improvements
  - Well-predicted improvements (not yet implemented) – expected gains known with good precision
    - update ZH→νν̄bb̄ with Neural Net
    - add single-b-tag channel to ZH→νν̄bb̄
    - include forward electrons in WH
    - scaling of systematic uncertainties as a function of luminosity
    - Run IIb H→WW optimized to match Run IIa performance…
  - Improvements in progress – gain factors estimated
    - Di-jet mass resolution (18% to 15% in σ(m)/m)
    - increased lepton efficiency (10% per lepton)
    - multivariate analyses (~20% in sensitivity)…
  - Additional improvements not yet included in projection
    - inclusion of tau channels
    - optimizing H→WW at low mass…

Median Expected Higgs Sensitivity



Assumes two experiments

Median Expected Higgs Sensitivity



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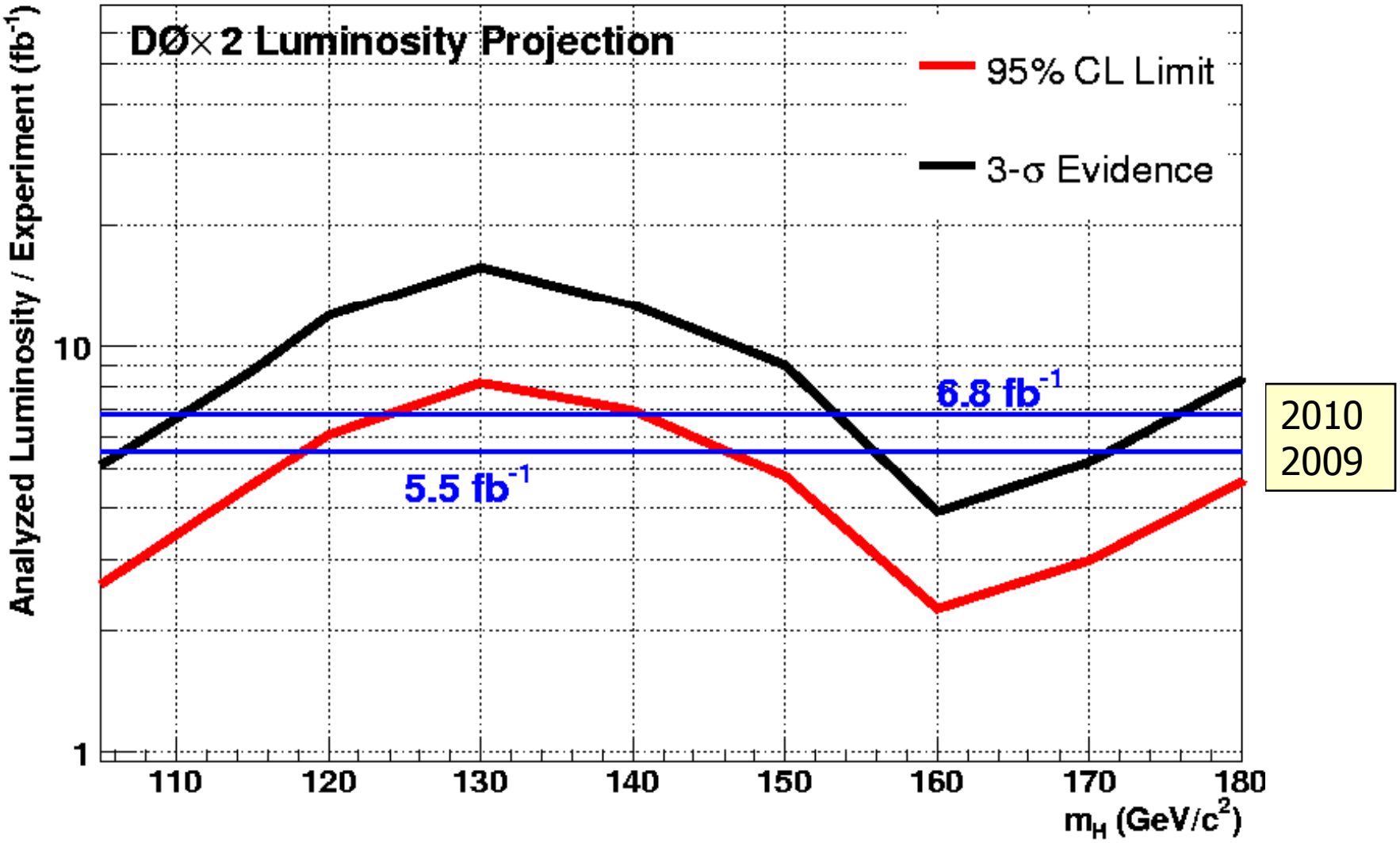
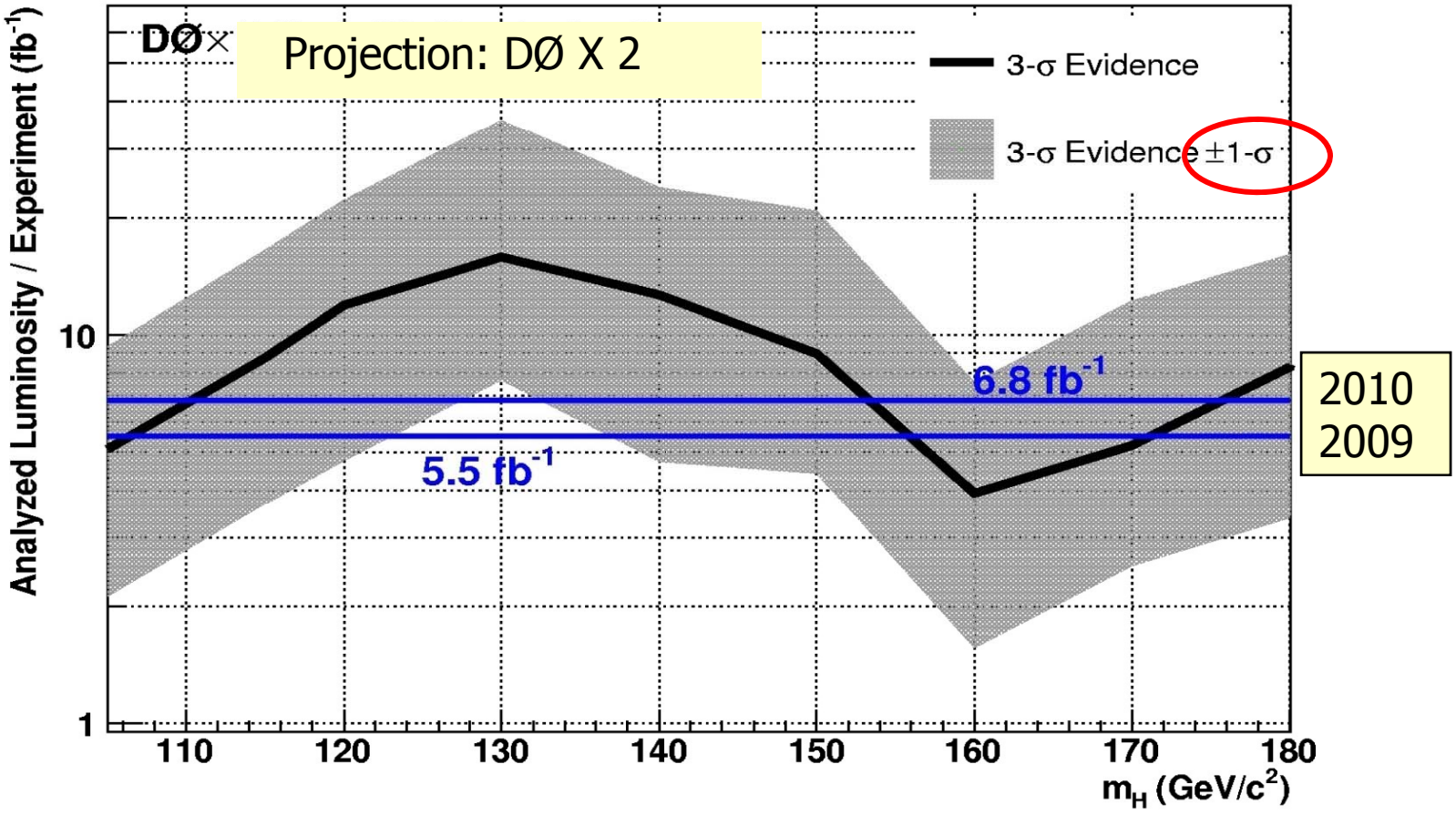


Higgs sensitivity, 3-σ evidence



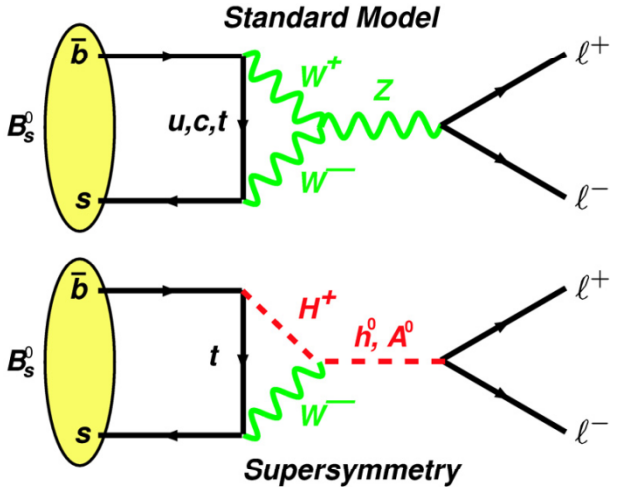
Assumes two experiments

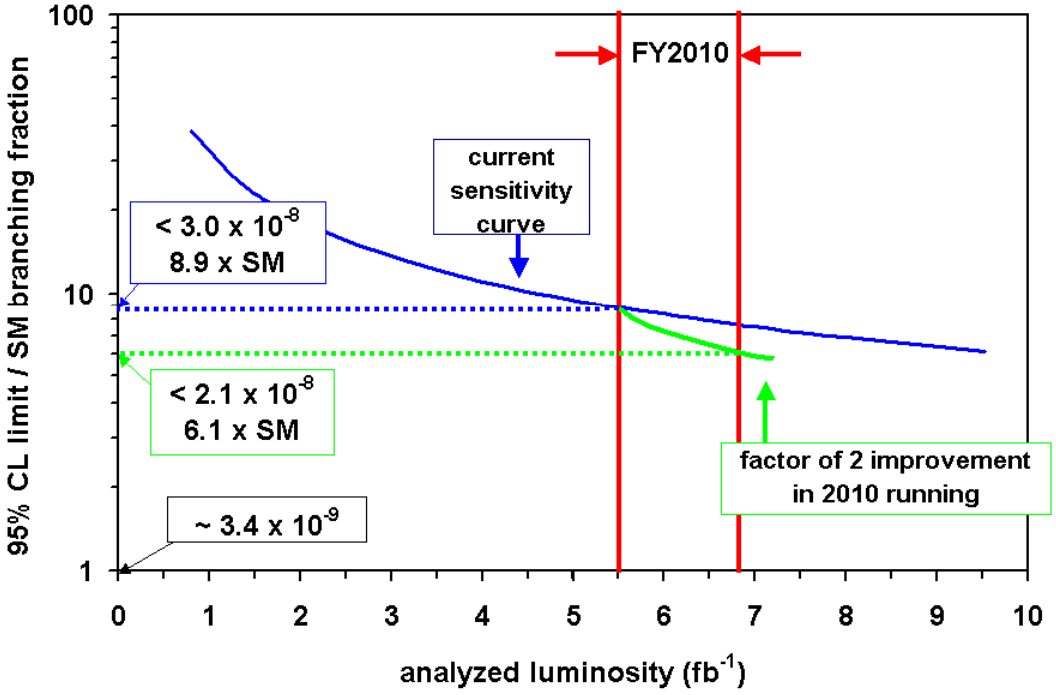
SM Higgs Prospects – Executive Summary

- With data accumulated by the end of 2010, we will be able to explore much of the SM Higgs mass region allowed by the constraints from precision measurements and LEP direct exclusion
  - Expect 95% CL exclusion over whole allowed range
    - assuming the Higgs does not exist at these masses
  - Three-sigma evidence for a Higgs possible over almost entire range, and probable for the low end and high end
- Work is underway to achieve and exceed these levels of sensitivity
  - Extremely exciting!

2010 projection: $B_s \rightarrow \mu\mu$

- Clean rare decay channel
  - SM: BR($B_s \rightarrow \mu\mu$)=(3.5±0.5)x10^{-9}
- BR can be enhanced significantly in new physics models
  - e.g. MSSM enhanced by $\tan^6\beta$
  - BR predictions as large as 10-10,000 times the SM prediction
- Trigger can be adjusted to give higher efficiency for low-mass muon pairs
  - Can have higher sensitivity in the future data
    - single muon triggering
    - looser di-muon trigger





Breadth

- These cases (SM Higgs, $B_s \rightarrow \mu\mu$) are part of a much broader physics program
  - Top quark studies, QCD, B physics, New Phenomena searches, electroweak measurements
- Many interesting measurements will still be statistics limited in 2009
  - 25% increase in statistics would give valuable improvements
- More time provides opportunity to react to experimental and theoretical developments
  - Adjust triggering
    - Could gain substantially more than factor of 25%
  - Adjust analysis
    - Detector/algorithms are well understood
      - Quick reaction to new developments

Conclusions

The DØ detector is running well with high data taking efficiency

- **No technical issues to continue data collection up to and above 8 fb^{-1}**

Data processing is keeping pace with data collection, MC production is steady

Physics program is flourishing

- **Top Quark studies, QCD, Electroweak, B physics, Beyond SM searches**

SM Higgs is within Tevatron reach!

Evaluation of available manpower for 2010 run

- **In spring of 2008**
- **New set of MoUs for 2009-2011**

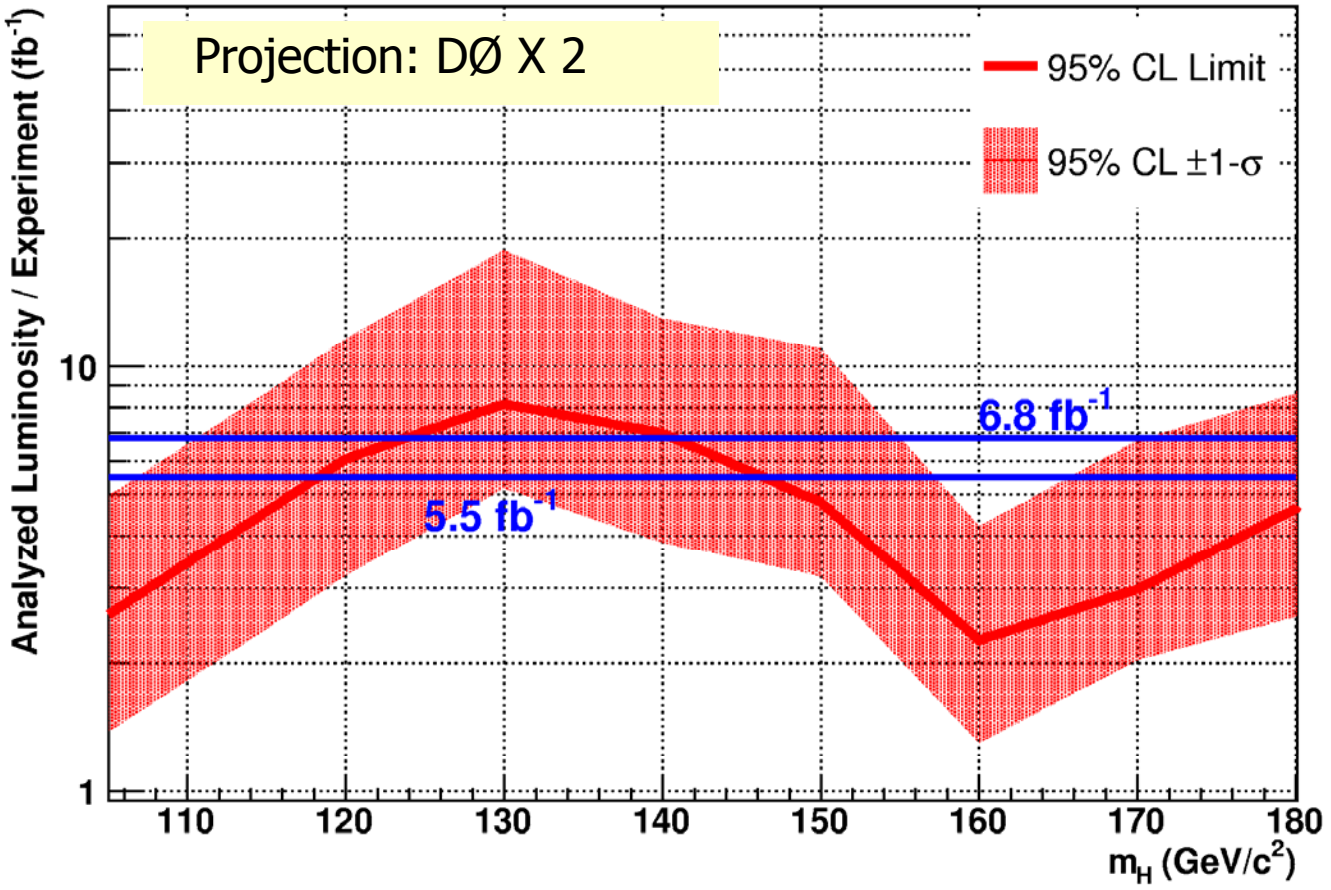
Early endorsement on 2010 run will help greatly to keep collaborators able to participate

The DØ collaboration will take data in 2009 and exploring 2010 run with great enthusiasm

Let's keep the 2010 opportunity open and move forward!

Backup Slides

Higgs sensitivity, 95% CL



Assumes two experiments