DØ Status and Prospects

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June 8 2007, P5 Meeting at Fermilab

Executive Summary

- DØ detector
  - Run IIb upgrade is a success
  - Smoothly collecting physics data – 2.5fb^{-1} recorded
  - No technical issues through 2009 expected
- Triggering and data reconstruction
  - Full high P_t trigger menu up to highest luminosities
  - Reconstruction is keeping pace with data collection
- The DØ physics program
  - 2006 is the best year in history for number of publications
  - Plenty of fundamental results over last year and more coming
- Experiment personpower
  - Resources required to operate the experiment in 2009 are well defined
  - MoUs provide predictions how personpower will evolve through 2009
- Success of the physics program in 2009 and beyond requires
  - Continuing commitment from the Collaborating groups
  - Strong support from the Laboratory
- Summary
  - The Collaboration looks forward to continuing data taking in 2009 and to exploiting the exciting potential of full Run II data set

The DØ Collaboration

DØ is an international collaboration of 610 physicists from 19 nations who have designed, built and operate the DØ detector at the Tevatron and perform data analysis

Institutions: 88 total, 38 US, 50 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….**

Fundamental questions

Quark sub-structure?

Origin of mass?

Matter-antimatter asymmetry?

What is cosmic dark matter? SUSY?

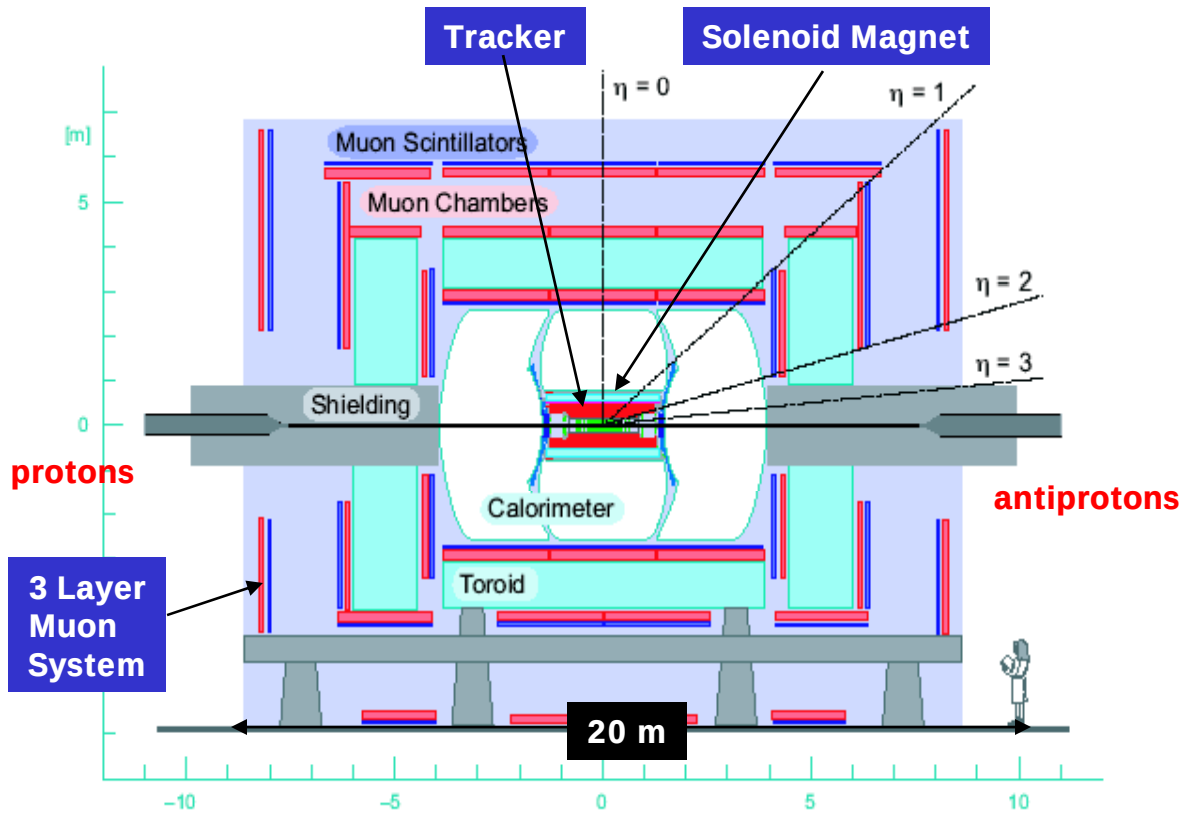
What is space-time structure? Extra dimensions?…

Driven by these goals, the detector emphasizes

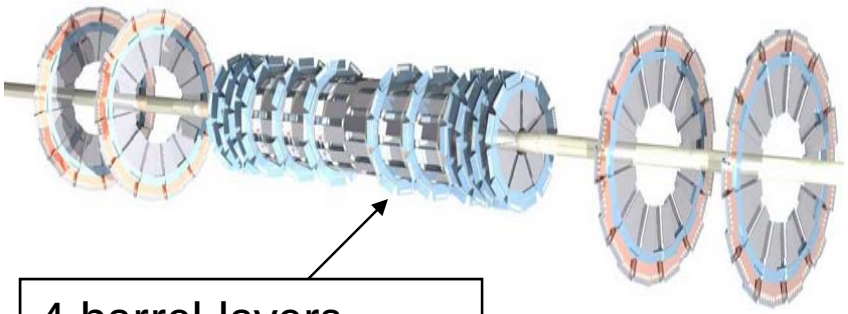
Electron, muon and **tau** identification

Jets and **missing transverse energy**

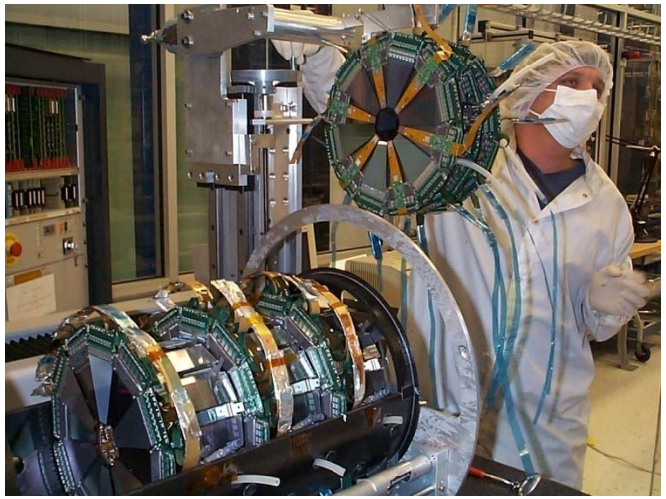
Flavor tagging through **displaced vertices** and **leptons**

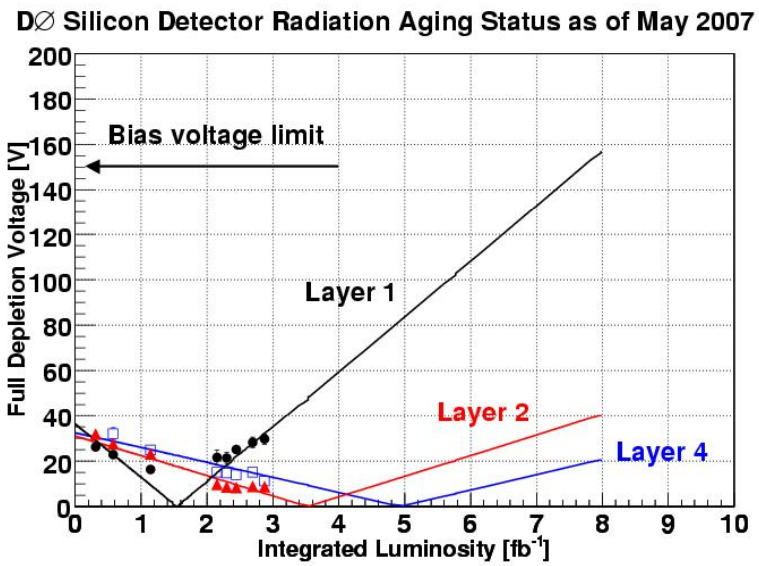


Silicon Microstrip Tracker

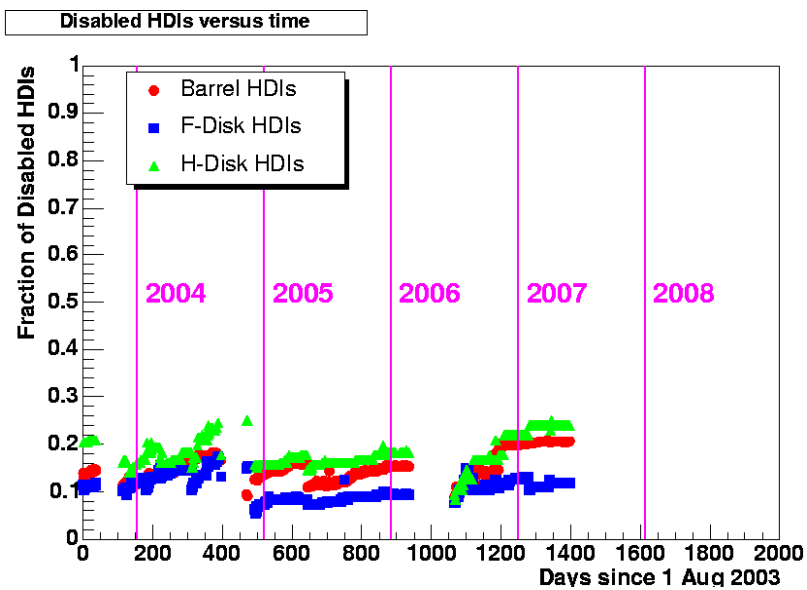


4 barrel layers
axial + stereo strips





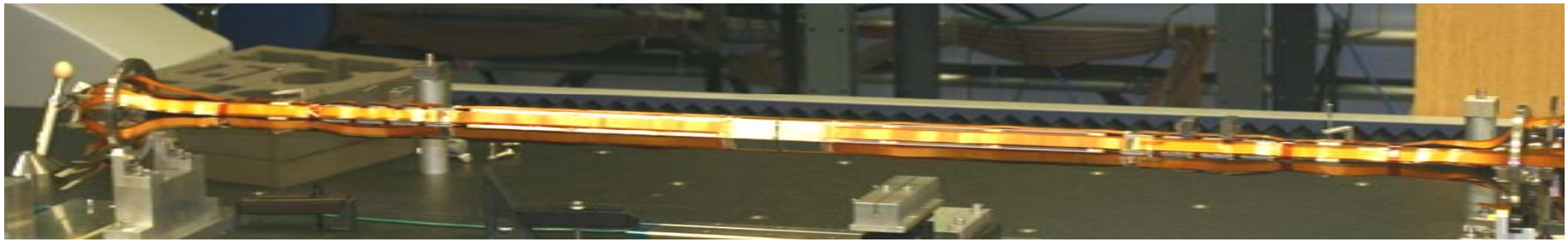
Detector is working well
Stable number of operating sensors

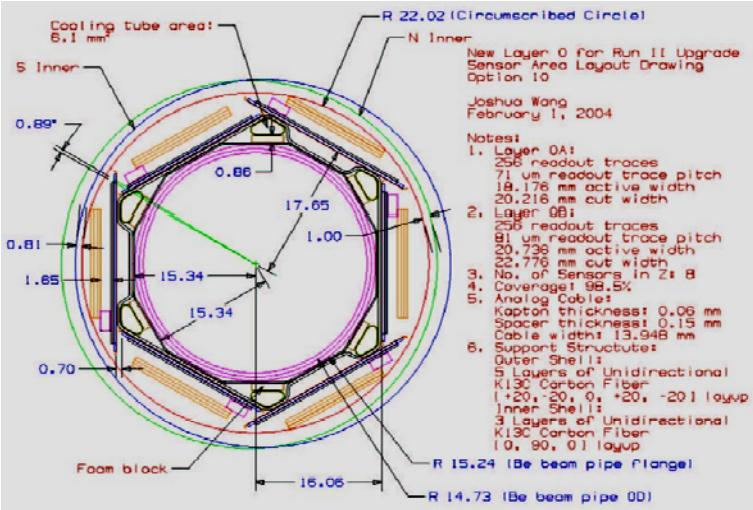


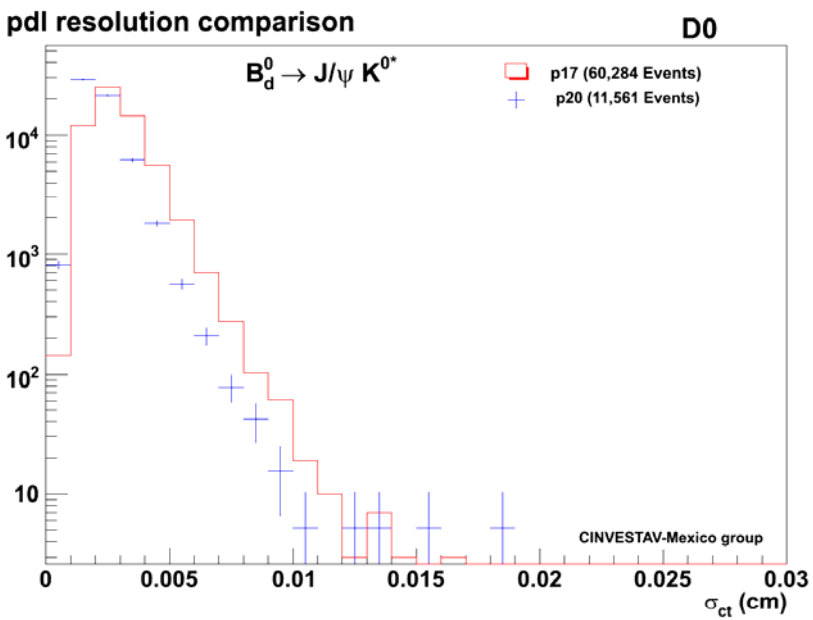
Radiation dose → no issues for running through 2009

Layer 0 Silicon Tracker

Additional layer of radiation hard silicon detectors designed
to fit inside the Run IIa Silicon Microstrip Tracker was successfully installed in 2006





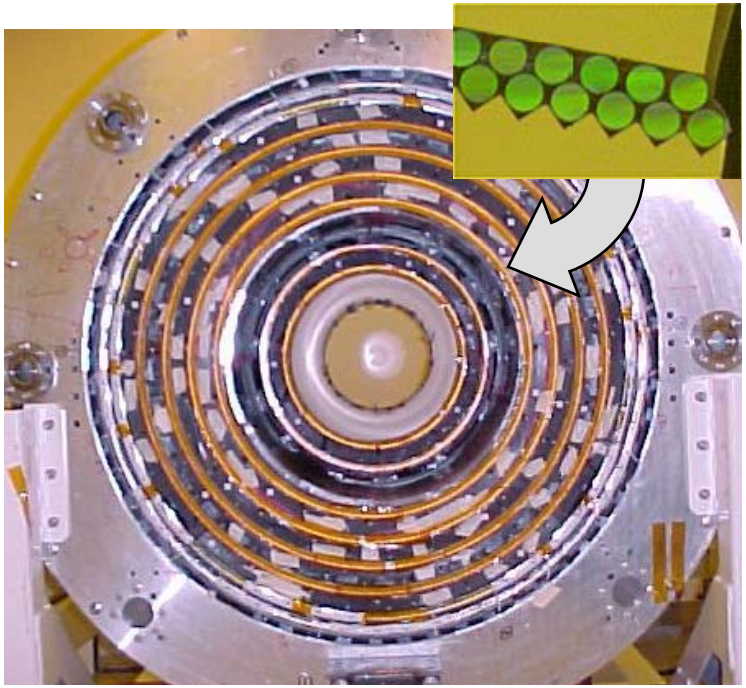


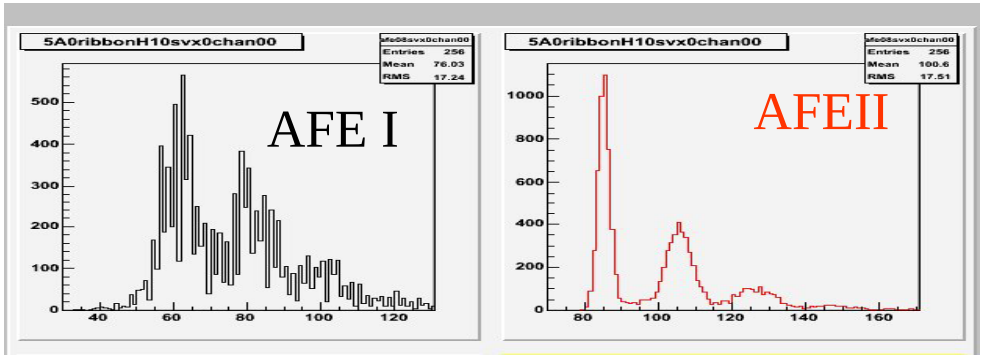
19 bad channels out of total of 12,288 channels

Provides major tracking precision improvements and already in use for first 2fb^{-1} results

Scintillating Fiber Tracker

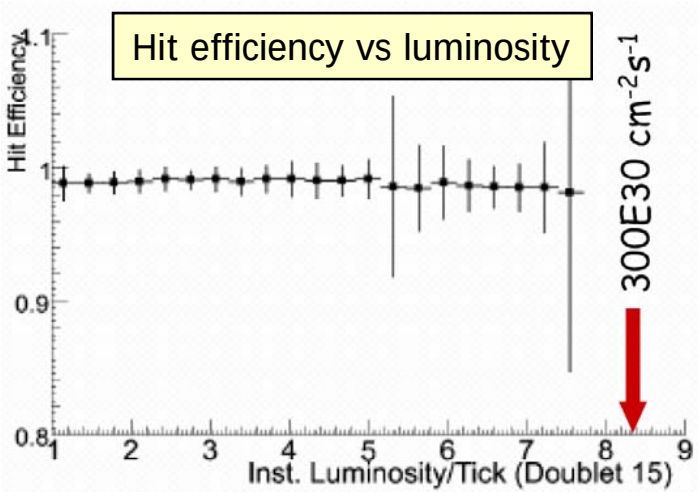
- 8 axial, 8 stereo fibers double layers
- Visible Light Photon Counters (VLPC) readout
- Performing well
  - Light yield of ~7 pe/mip
  - Number of operating channels > 98%
- Substantially improved readout electronics – AFEII boards - since late 2006
  - Excellent amplitude resolution and no saturation up to highest luminosity



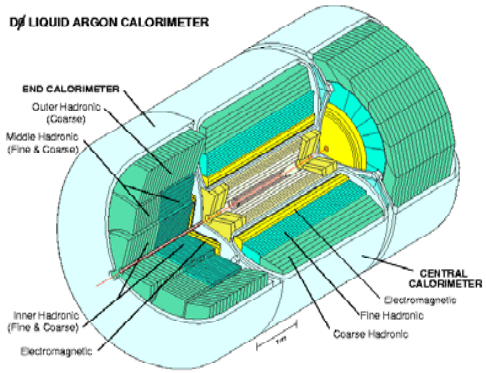


Single photo-electron peaks

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



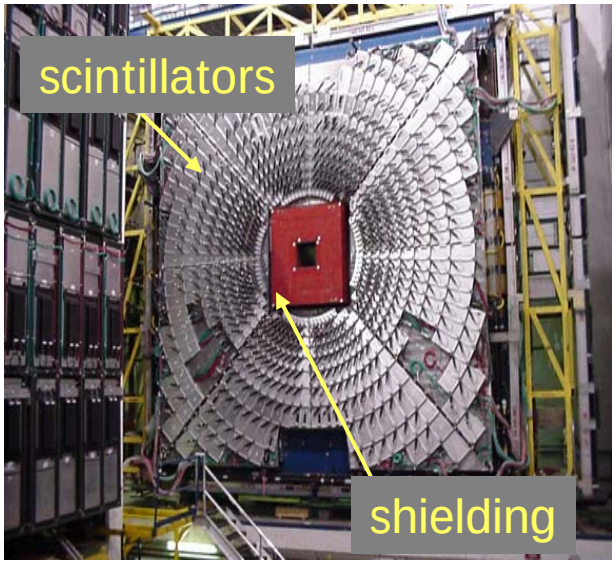
Calorimeter and Muon System



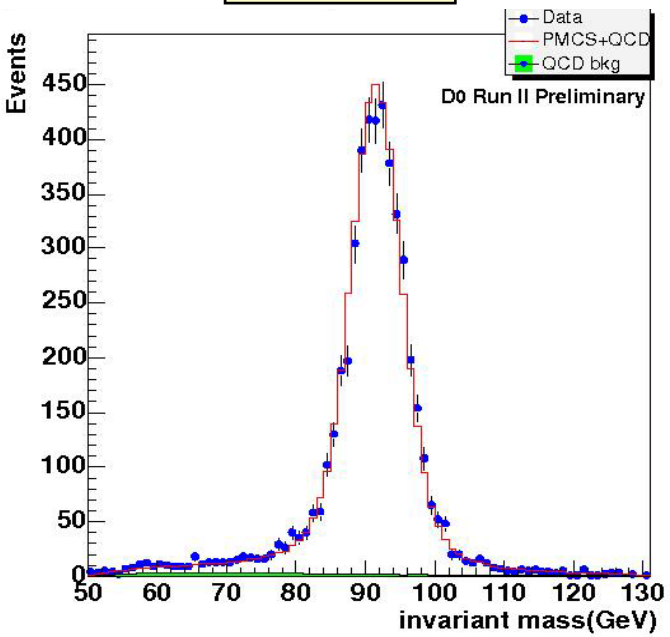
Uranium Liquid Argon calorimeter
Drift tubes and scintillation counters based muon system

Stable and reliable operation

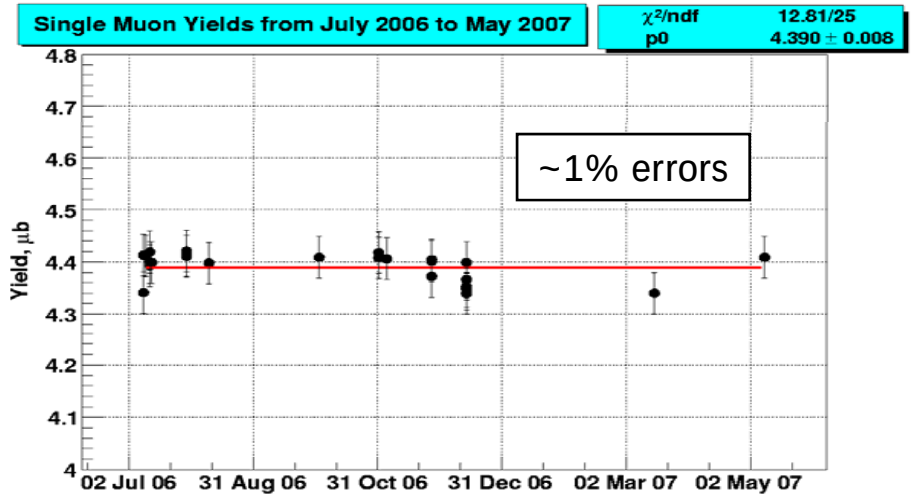
- Less than 0.1% of non-working channels in the calorimeter and 0.5% in the muon system
- No detectors radiation damage issues
- Stable operation since early Run II



$Z \rightarrow e^+e^-$



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



Trigger System

Trigger system selects ~100Hz of events to write to tape out of ~2 MHz interactions rate

~ 10^5 rejection!

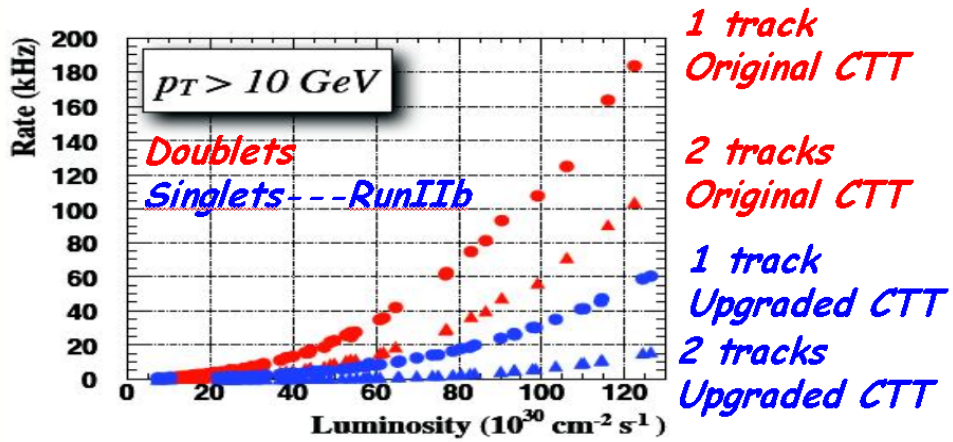
Current DØ capabilities

- **Level 1 trigger ~2kHz**
- **Level 2 trigger ~1kHz**
- **Level 3 trigger ~100Hz**

Substantial trigger upgrades installed during 2006 summer shutdown

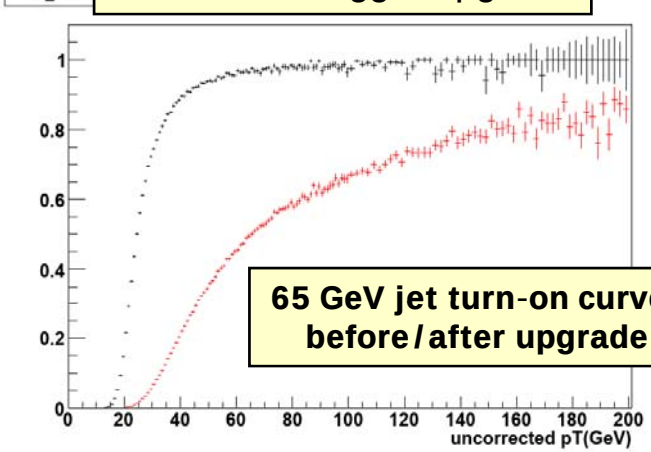
- Completely new calorimeter trigger
- New fiber tracker trigger elements
- New "caltrack" trigger provides matching between calorimeter objects and tracks

Fiber tracker trigger upgrade

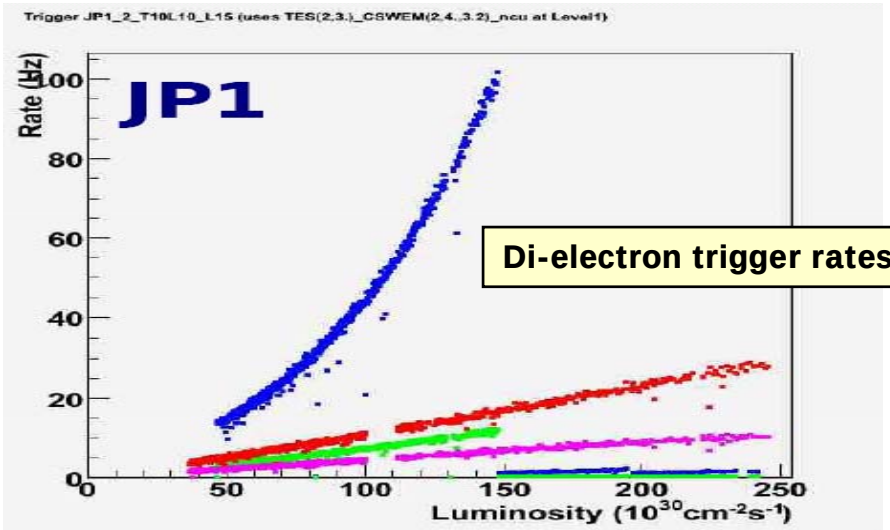


- **Level 1 and Level 2 trigger rates prior to "Caltrack"**
- **Level 1 and Level 2 trigger rates using "Caltrack"**

Calorimeter trigger upgrade



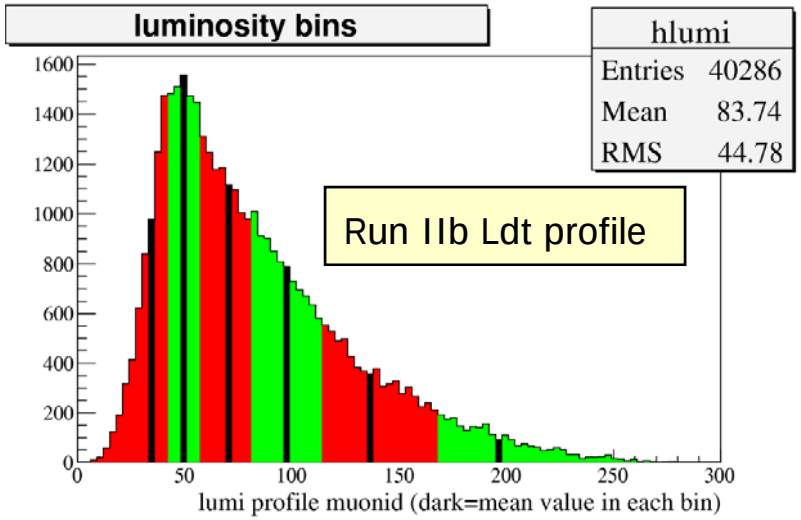
65 GeV jet turn-on curves before/after upgrade



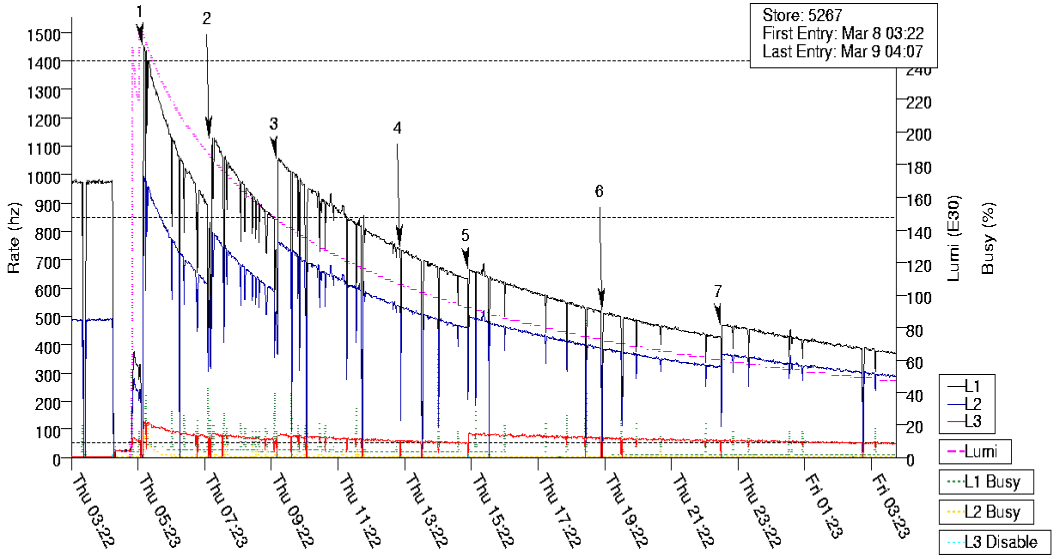
Di-electron trigger rates

Triggering at High Luminosities

- Run IIb trigger upgrades are essential for ensuring success of physics program at high luminosity
  - Successfully completed
- Trigger list with over 600 triggers is optimized on a trigger-by-trigger, final state-by-final state basis
- Running highly efficient high p_t trigger menu un-prescaled up to $300 \cdot 10^{30}$
- At lower luminosity trigger menu is extended to cover low p_t physics and calibrations



Level 1, 2 and 3 rates during typical Tevatron store



Working on optimizing triggering for luminosities above $300 \cdot 10^{30}$

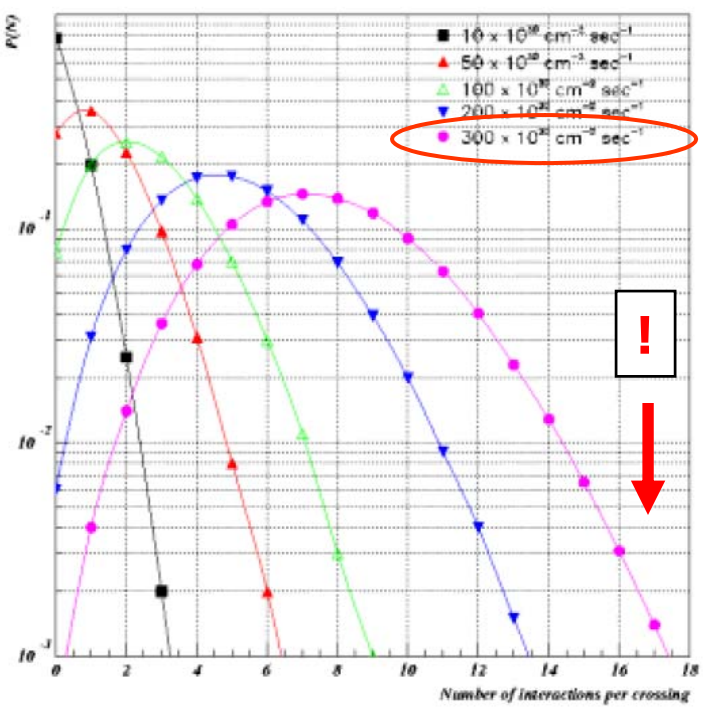
trigger algorithms

trigger list

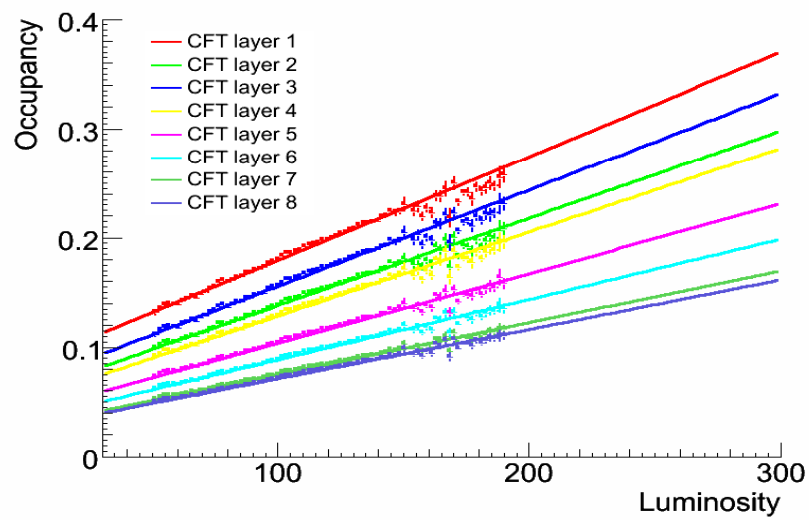
Other Challenges at High Luminosity

- Tevatron is already running with "LHC like" number of interactions per crossing
  - Efficiencies of reconstructed objects are decreasing
  - Number of "fake" reconstructed objects is going up
- Detector was originally designed to handle 1-2 interactions per crossing
  - Substantial collaboration resources are directed toward handling algorithms at high luminosity

Number of interactions per crossing



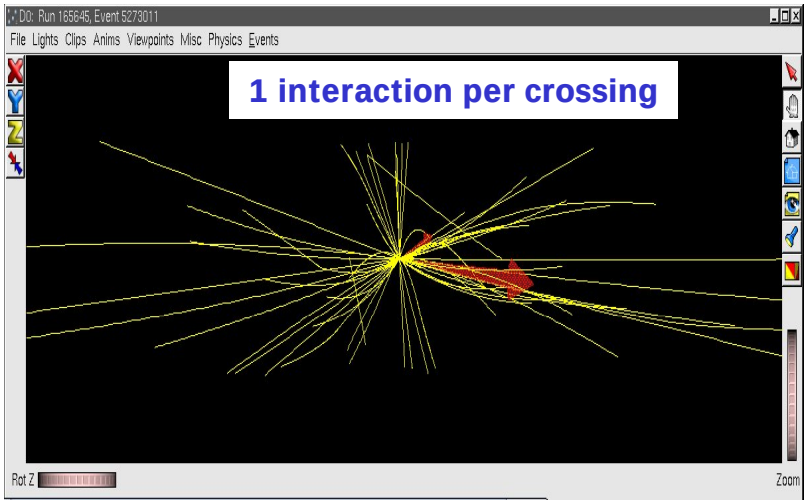
Most challenging issues are with tracking:
small central tracking volume and high occupancy "per fiber"

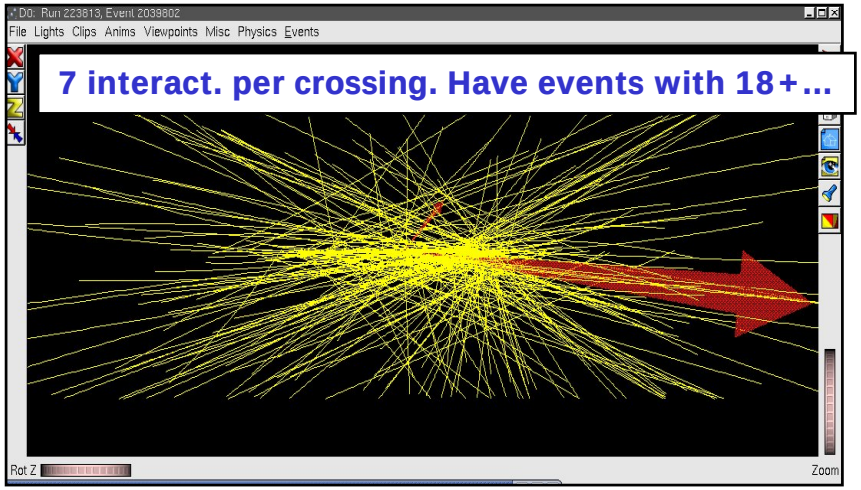


Above is mean occupancy in events selected by DØ physics trigger list. There are long tails in the multiplicity distributions.

Challenges at High Luminosity

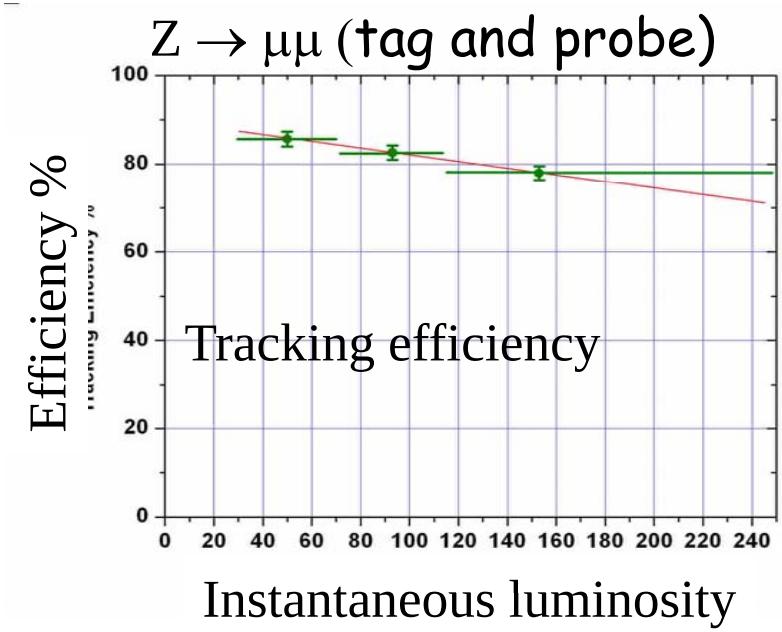
We are pushing detectors, triggers, algorithms well beyond original specifications





Z → ee events

Track reconstruction efficiency for Z → μμ events

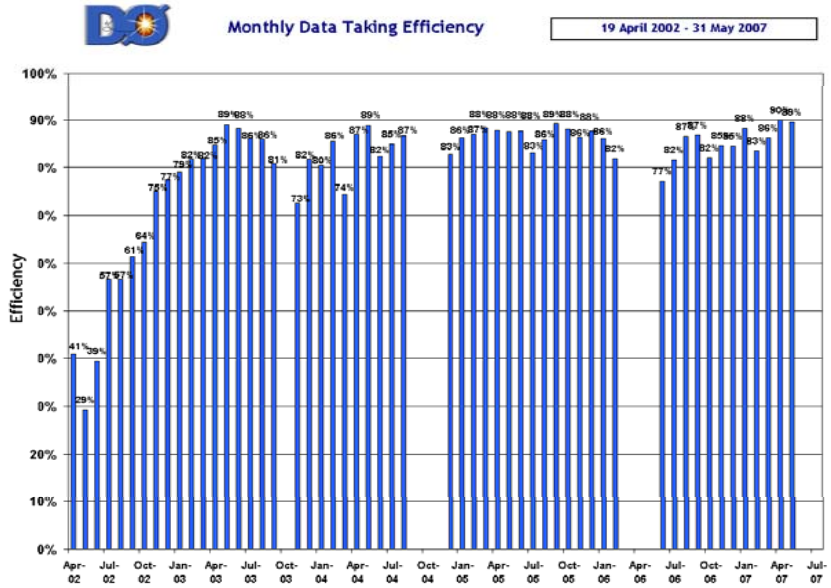


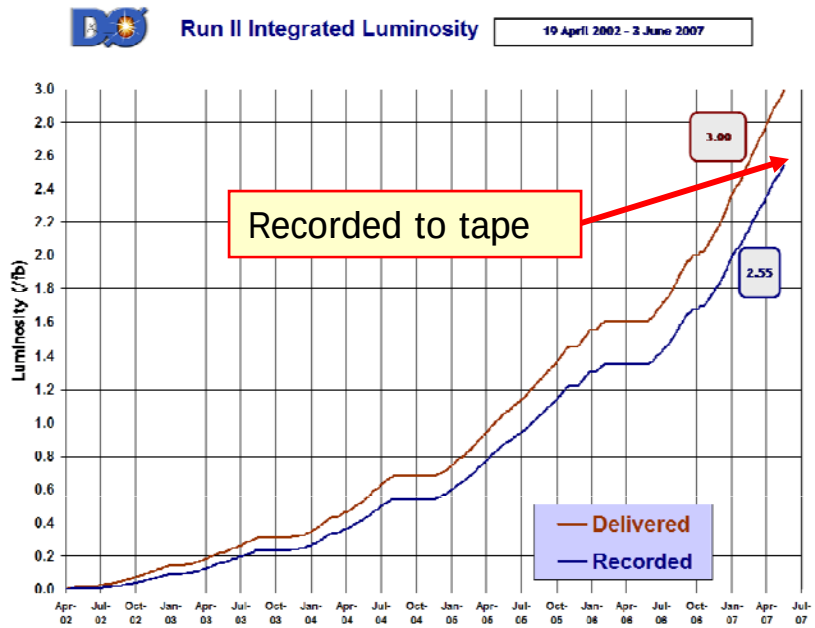
Observe measurable decreases in efficiencies with increase in luminosity (as expected)

Working on improvements to mitigate effects of high luminosity

- Triggering
- Algorithms
- Analysis

Operations





- The experiment is operating well and recording physics quality data
  - Typical "good" day 7 pb^{-1}
  - 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 ~2.5 fb^{-1} on tapes
  - All detectors functioning well
  - Already reported physics results from early 2007 data

All of the above is due to the dedicated team of experts and shifters

This week celebrating delivery of 3.0 fb^{-1} to the DØ experiment
Thanks to the Accelerator Division!

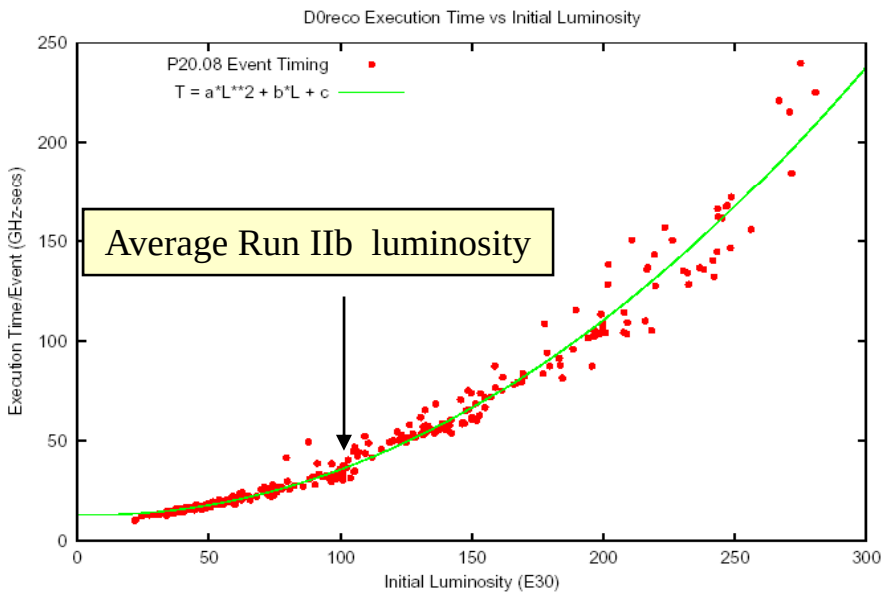
Data Processing

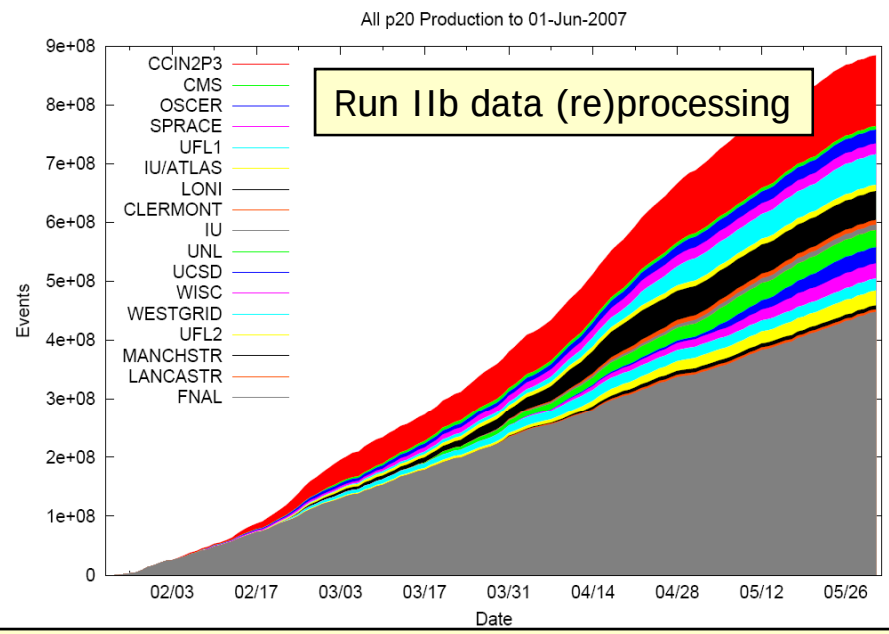
- DØ collected over $2 \cdot 10^9$ events in Run II
- Current reconstruction program (Version p20) is in use since summer 2006
  - New Run IIb detectors
  - Preliminary Run IIb calibration data
  - Faster and more robust

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

Was accomplished on the GRID in ~4 months

Have full Run IIb data set available for analysis





Reconstruction timing

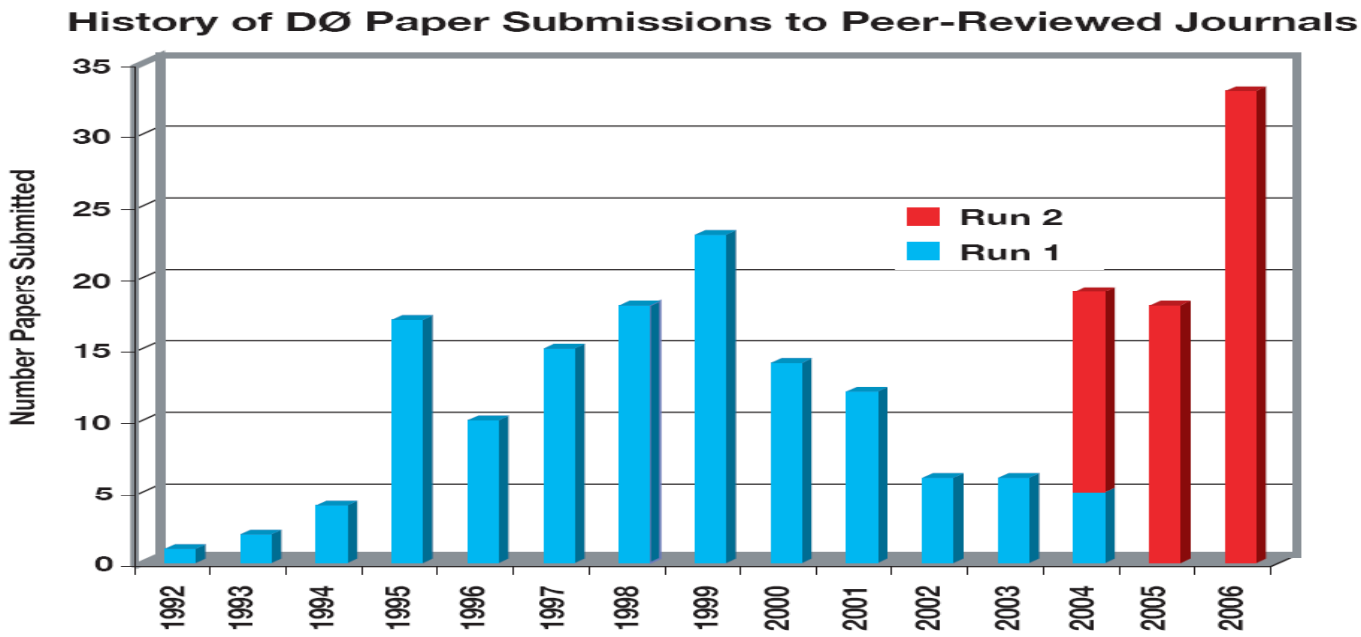
- Major time consuming process is tracking due to small number of tracking layers and high occupancies
- Currently reconstructing on the Fermilab's DØ farms ~5mln events per day and writing to tapes about the same number
- Within weeks extra computing resources will become available doubling available CPU
  - Will have "head room" and ready for even higher luminosity operation

DØ SAM based computing model and use of the GRID resources is a success!

Physics Analyses Progress

- 2006 was the best year in DØ history in terms of number of publications per year with 33 papers – one paper every 11 days
  - Including:
    - DØ B_s oscillations: PRL 97, 021802 (2006)
      - first 1 fb^{-1} paper from the Tevatron
      - the most cited HEP result of 2006
    - DØ single top quark production evidence: PRL 98, 181802 (2007)

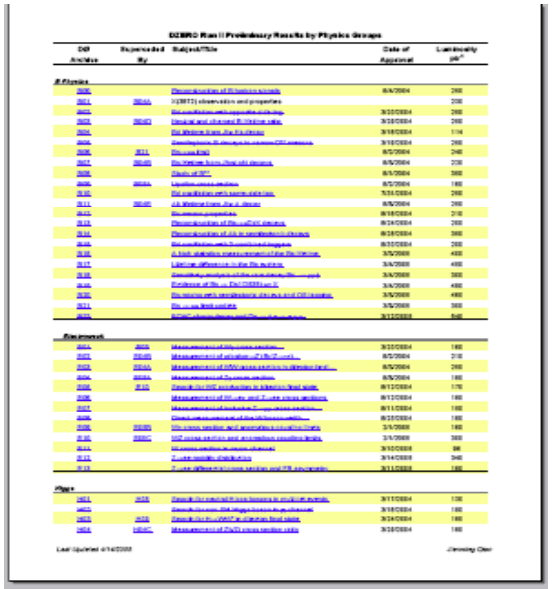
- Progressing well with publications in 2007
  - 14 papers in the first 5 months
  - On track to beat 2006 success
- DØ publication strategy
  - Finish 1fb^{-1}(Run IIa) publications
  - Concentrate on full Run II data set

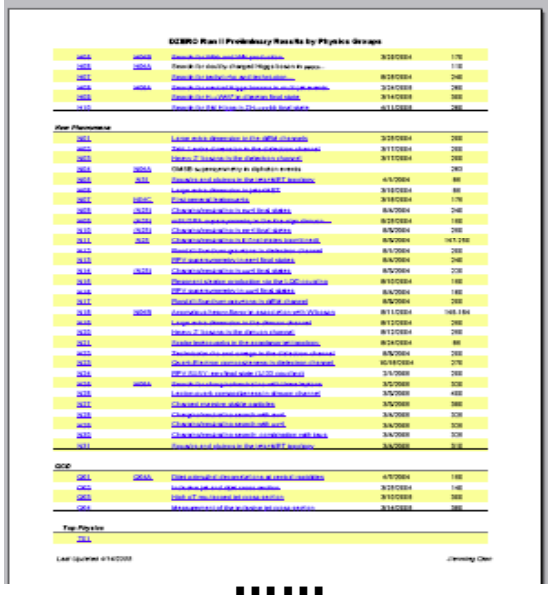


Summary of Results, Theses, Talks

- **62 new results approved for Conferences**
  - **Most will be published**
- **PhDs defended**
  - **35 in 2006**
    - **Wide range of topics, Universities and countries**
  - **Already 11 in 2007**
  - **DØ collaborators received**
    - **2007 URA best thesis award – Tim Scanlon (Imperial College, London)**
    - **2007 Tollestrup award – Yann Coadou (Simon Fraser, Canada)**
- **>250 invitations to Conferences per year**
  - **Invited talks at all major Conferences**

Too many to fit on 6 pages...





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For full list of DØ approved results and publications visit

http://www-d0.fnal.gov/Run2Physics/WWW/results.htm

including plain-English summaries

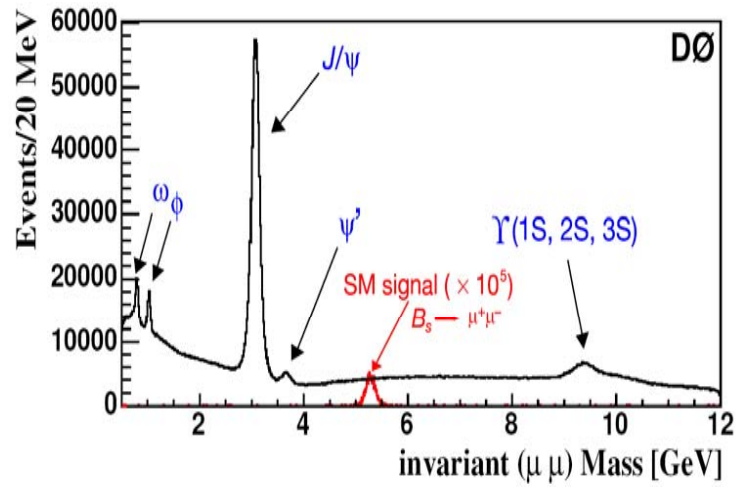
New Results for Winter 2007 Conferences

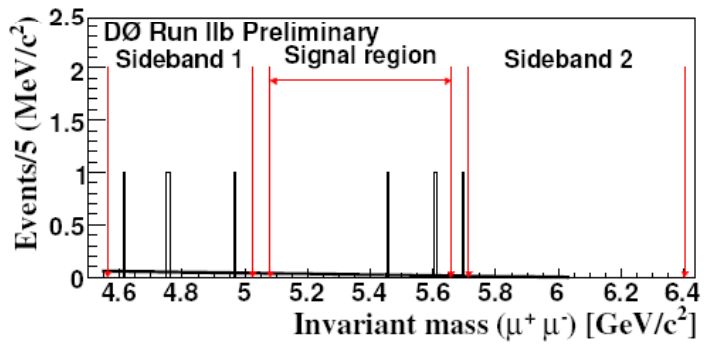
D0 (Figures)	Publication Reference	Superceded by	Conference Note Number	Subject/Title	Date of Approval	Luminosity pb-1
B Physics						
B45	B07D		5179-CONF	Measurement of the Lambda_B lifetime in the decay channel J/Psi(mumu)Lambda	08/18/06	1000
B46			5254-CONF	Measurement of B_s mixing in B_s -> D_s mu X, D_s -> K^0_S K channel	10/24/06	1200
B47			5263-CONF	Measurement of the Lambda_B lifetime semileptonic decay	10/27/06	1300(*)
B48			5344-CONF	A new upper limit for the rare decay Br(Bs->mu+mu-)	03/12/07	2000
Electroweak						
E19			5272-CONF	Measurement of the charge-signed rapidity difference in W-gamma events	10/27/06	900 (*)
E20			5345-CONF	Search for Z/gam* pair production decaying into four leptons	03/08/07	1000
Higgs						
H27			5275-CONF	Search for ZH(->llbb) ProductionÉ	10/30/06	840 - 920(*)
H28			5067-CONF	Search for Fermiophobic Higgs Bosons in 3-gamma+X Events	01/04/07	830
H29		H14	5331-CONF	Search for Neutral Higgs Bosons to tau(->mu) tau	02/02/07	1000
H30			5357-CONF	Search for WH production in 1 fb-1 (cut-based)	03/12/07	1000
H31			5365-CONF	Search for WH production using the Matrix Element technique in 900 pb-1	03/16/07	900
H32		H17	5350-CONF	A Search for the Standard Model Higgs Boson in ... ZH->vvbb E	04/06/07	1000
H33			5380-CONF	Combined Upper Limits on Standard-Model Higgs-Boson Production from the D¯	04/06/07	1000
New Phenomena						
N50			5312-CONF	Search for Squarks and Gluinos in Events with Jets and MET	01/05/07	960
N51			5349-CONF	Search for excited electrons in the e-e-gamma channel	03/08/07	1000
N52			5348-CONF	Search for Assoc. Prod. of Charginos & Neutralinos in 3-lepton final states	03/08/07	1100
N53			5370-CONF	Search for second generation leptoquarks in the mu-nu-jj final state	02/12/07	1050
QCD						
QJ07			5369-CONF	Measurement of triple differential photon+jet cross section	03/14/07	1100
Top						
T36			5257-CONF	Measurement of tt(bar) cross section in soft mu tagged l+jets events	10/26/06	835
T37	T07C		5262-CONF	Measurement of tt(bar) cross section in l+jets events using kinematicÉ	10/30/06	900(*)
T38			5234-CONF	Measurement of tt(bar) cross section in tau+jets channel	11/27/06	350
T39	T06J		W&C Talk	Evidence for single top quark production and meas. IV_tbl	12/10/06	1000
T40	T07D		5359-CONF	Measurement of tt(bar) cross section in electron+muon channel	03/06/07	1050
T41			5347-CONF	Measurement of m_top in the dilepton channel w/ neutrino weighting	03/07/07	1000
T42			5362-CONF	Measurement of m_top using matrix element method in l+jets	03/09/07	900
T43			5355-CONF	Measurement of tt(bar) xsec in the lepton+jets channel with lifetime tagging	03/11/07	900
T44			5342-CONF	Combining results from three single top xsec measurements	03/12/07	900
T45	T07D		5371-CONF	Measurement of tt(bar) xsec in the dilepton channel	03/13/07	1050
T46			5064	Combination of CDF and D0 Results on the Top-Quark Mass	03/16/07	1000

Six physics groups are working very productively in conjunction with trigger board, objects identification groups, analyses review boards and joint Tevatron combinations groups

First Tevatron 2fb^{-1} Result

- Study of rare decay B_s to $\mu\mu$
- Standard Model prediction for branching ratio is ~$3 \cdot 10^{-9}$
  - Beyond SM processes could increase this value – strong interest from theoretical community
- With data collected in December 2006
  - Result presented at Moriond in March 2007
  - Two months for reconstruction, analysis, analysis review and presentation of world best limit





Run IIb B meson detection

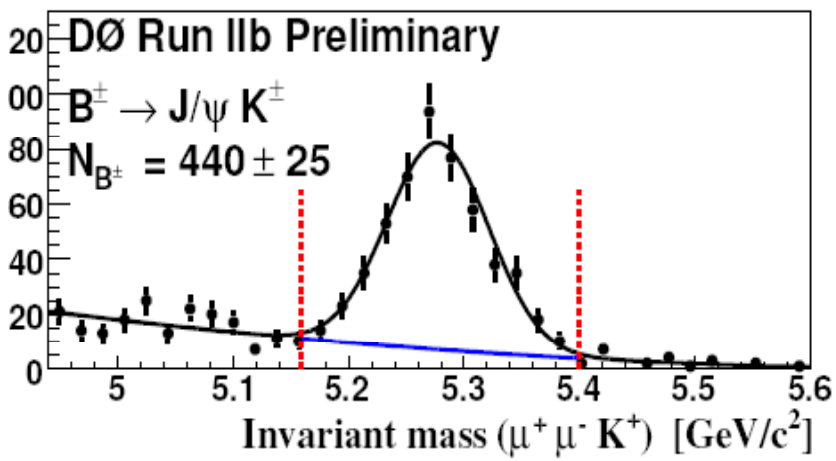
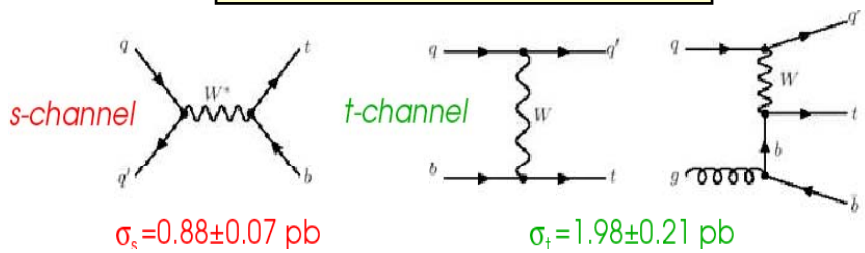


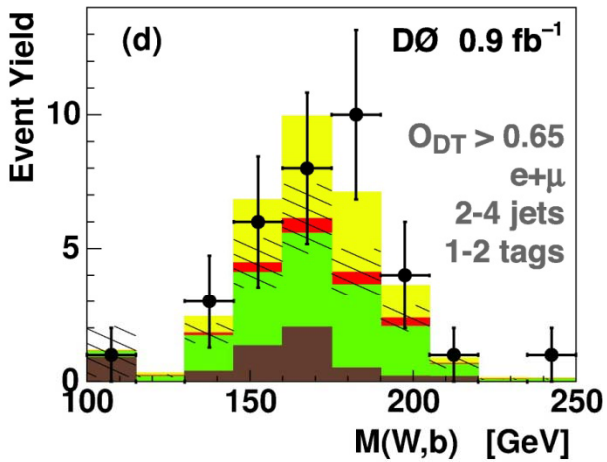
TABLE III: Summary information on the $B_s^0 \to \mu^+\mu^-$ analysis.

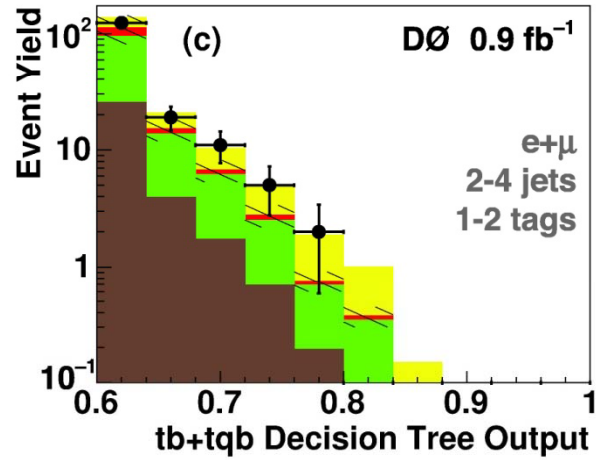
	Run IIa	Run IIb
$\frac{\epsilon^{B^\pm}_{\mu\mu K}}{\epsilon^{B^0_s}_{\mu\mu}}$	$0.173 \pm 0.005 \pm 0.009$	$0.136 \pm 0.003 \pm 0.019$
$N_{B^\pm}$	$1781 \pm 54 \pm 20$	$440 \pm 25 \pm 5$
N_{back}	0.8 ± 0.2	1.5 ± 0.5
N_{obs}	1	2
ses	2.2×10^{-8}	6.9×10^{-8}
limit 90% C.L.	7.9×10^{-8}	3.0×10^{-7}
limit 90% C.L.	7.5×10^{-8} (DØ comb.)	
limit 95% C.L.	9.5×10^{-8}	3.9×10^{-7}
limit 95% C.L.	9.3×10^{-8} (DØ comb.)	

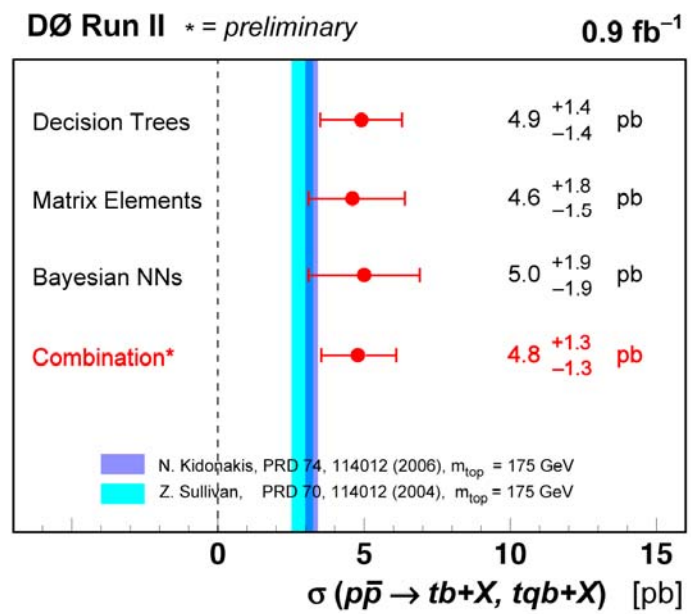
Single Top Quark Production

EW production of top quark
→ direct probe of $|V_{tb}|$
→ search for new physics







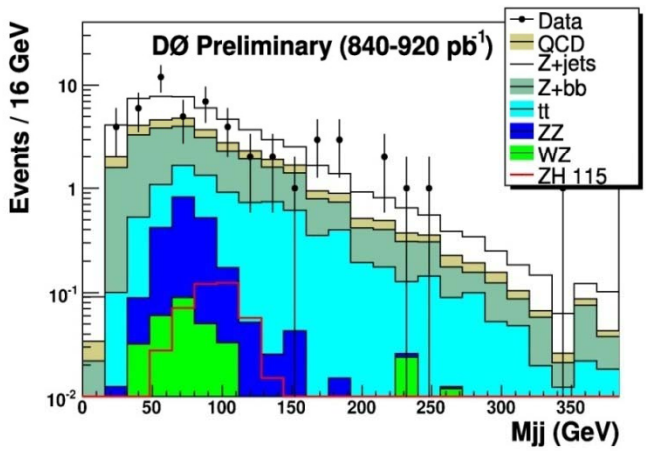


- **Consistent results obtained from three techniques**
  - **boosted decision trees, matrix elements, Bayesian NN**
- **Combined result:**
  - **4.8 ± 1.3 pb (3.5 σ significance)**
  - **Consistent with SM expectations**
- **First direct determination of $|V_{tb}|$**
  - **$0.68 < |V_{tb}| < 1$ at 95% CL**

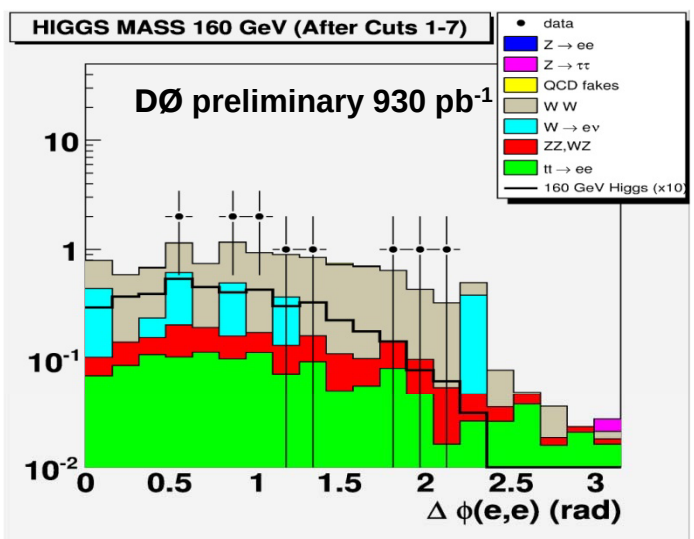
Developing advanced methods to separate signal events from substantial backgrounds

Standard Model Higgs Search

ZH → llbb



H → WW*



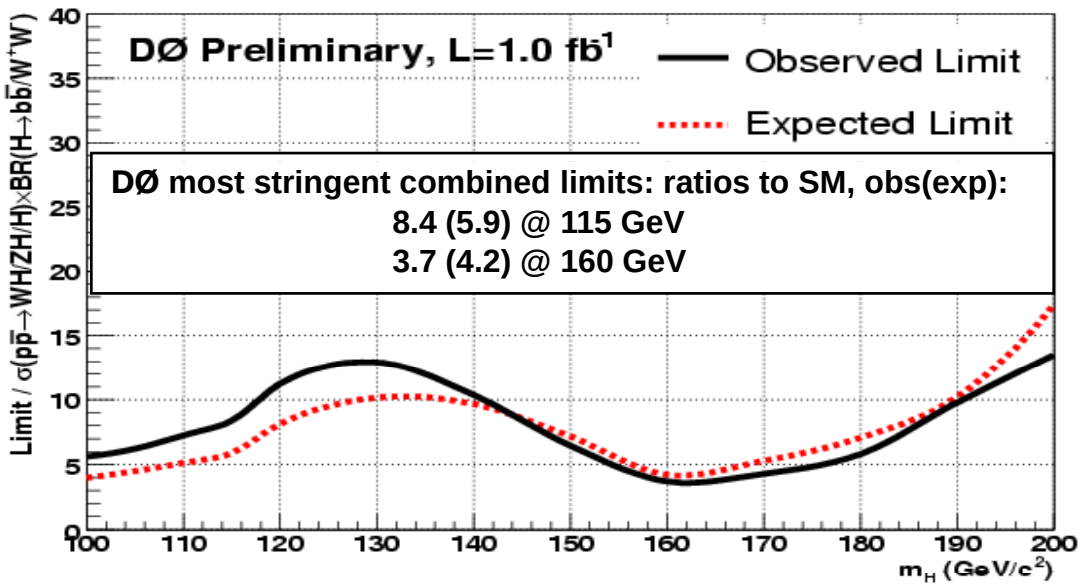
Search strategy:

M_H <130 GeV associated production and Higgs bb decay W(Z)H

Backgrounds: top, Wbb, Zbb…

M_H >130 GeV gg → H production with decay to WW*

Backgrounds: electroweak WW production…



DØ most stringent combined limits: ratios to SM, obs(exp):
8.4 (5.9) @ 115 GeV
3.7 (4.2) @ 160 GeV

Improvements to come:

- **larger datasets**
- **wider use of advanced analysis techniques**
- **additional channels: WH -> WWW, H->ZZ, hadronic H->WW, τ modes, …**
- **new silicon Layer 0: improves b-tagging**

Abe's Question

Abe: A specific issue to address in the manpower talks is the time for analyses to reach completion. What is it now for some important examples and what are expectations around end of 2009?

- Currently publish from three months to two years after data have been collected
- What are "ingredients" of publication
  - Data are on tapes
  - Data are reconstructed with "final" reconstruction program
  - Data quality determined
  - Trigger and object ID efficiencies determined
  - MC samples are available
  - Analysis is performed
  - Paper is written
  - Paper is internally reviewed and approved
  - Paper is submitted
- Examples
  - B_s oscillations analysis
    - ~ three month between data collection finished and publication
    - Mainly tracking based analysis (no precision calorimeter calibration, etc.)
  - Single top quark production evidence analysis
    - ~ 9 months between data collection finished and publication
    - Analysis requires deep understanding of: calorimeter, muons, tracking and analysis methods
- After data taking is finished
  - Many results could be published between a few months and about a year later
  - Some interesting analyses might take longer
    - Best Run I Tevatron top mass measurement was published in 2004
  - Critical: stability of detector, data taking conditions, reconstruction algorithms
    - Working hard on minimizing changes while benefiting from improvements

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

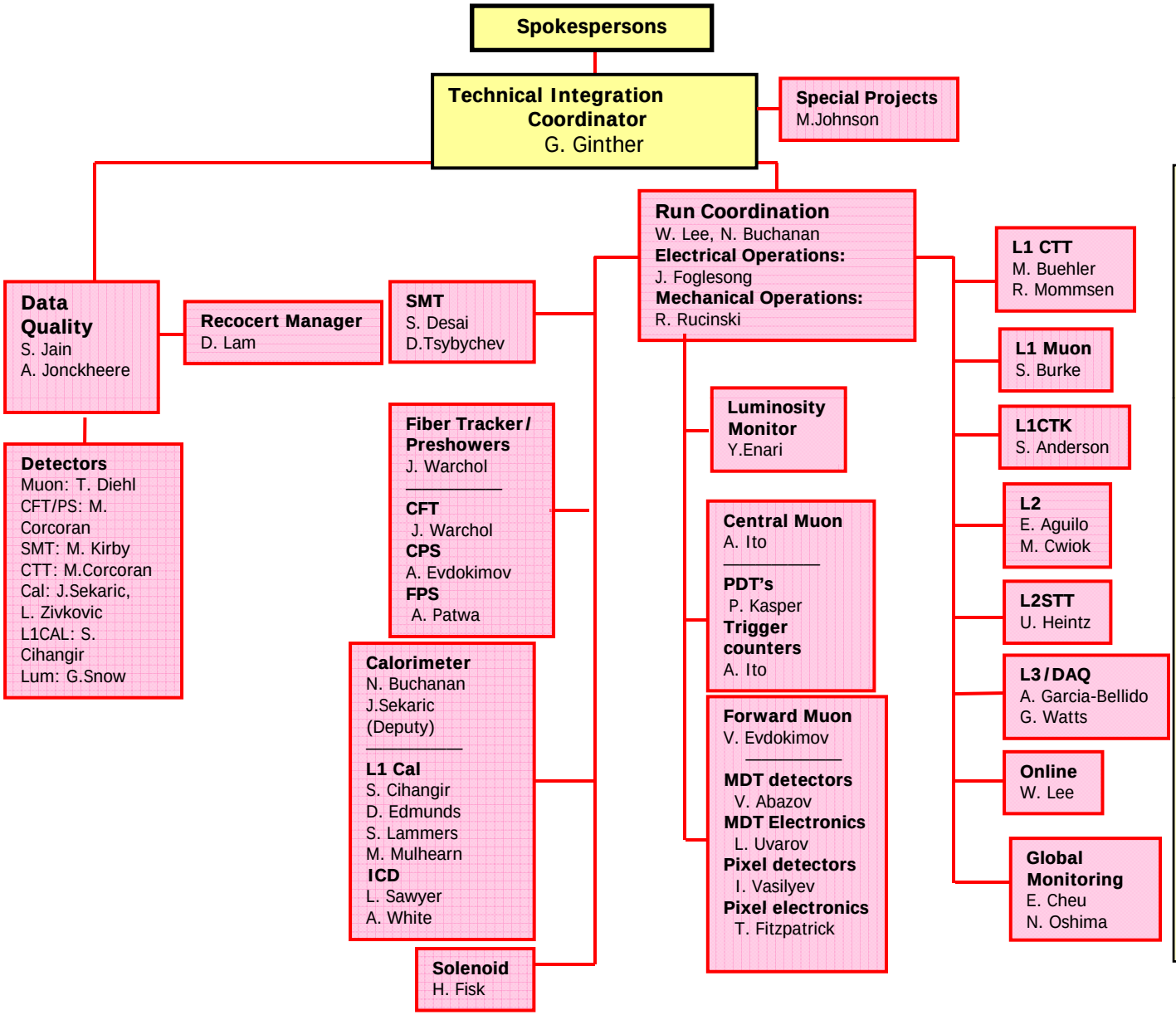
- Overall manpower decrease
- Total number of FTE vs experts in specific areas
- Substantial efforts required to optimize triggering and algorithms at high luminosity
- Unexpected challenges

Tevatron Task Force in early 2006 devoted considerable effort to estimate resources needed to run the experiment and analyze data – report is available.
Recently we re-evaluated Tevatron Task Force numbers and concluded that estimates 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 significantly less than 1 FTE

- Uncertanties... not easy to estimate
  - Most important is to use "the same currency" in all estimates
    - Checked via comparing Efforts Reports and MoUs (see below): ~10%

Future Personpower Estimates



Experiment has well defined organization

Operations - example Computing Algorithms (Physics)

Each group provided estimates of resources required

Experiment management carefully reviewed and verified resources required

Final numbers are presented on the next page

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	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

Memorandum of Understanding

- We know past efforts needed to run the experiment
  - Efforts Reports
- We estimated future resource needs to operate the experiment
  - Bottom up and top down
- Next step is to reliably predict future personpower contributions to 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
  - Overlap in 2007

Example of MoU

Example of MoU with Manchester University.

Similar MoUs exist with all other groups and provide opportunity to make reliable future manpower estimates.

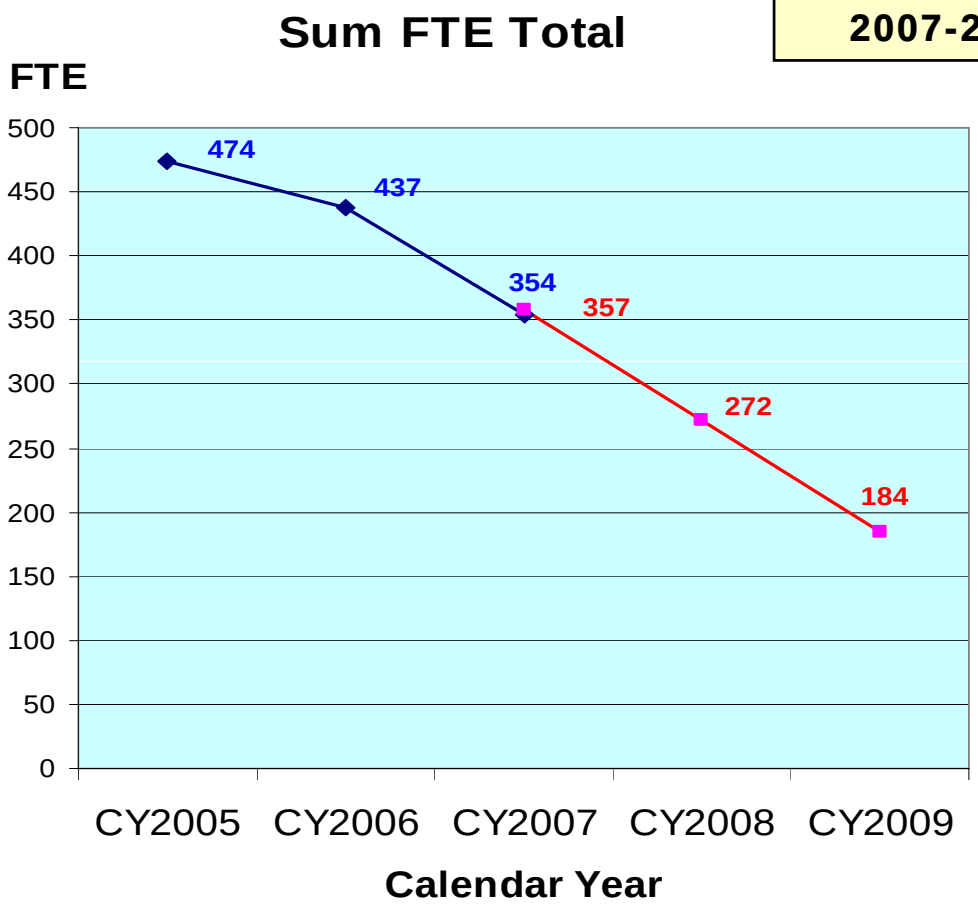
	A	B	C	D	E	F	G	H	I
1									
2	1	**Institution:**	**University of Manchester**						
3		**Contact Person:**	**Stefan Soldner-Rembold**						
4		**Funding agency(ies)**	**PPARC**						
5									
6									
7									
8	2	**Estimated fraction of FTE for each person working on DØ**							
9									
10			**Total FTE on DØ**			**Service FTE on DØ**			**Description of Service Contribution for EACH individual**
11		**Faculty**	CY2007	CY2008	CY2009	CY20072	CY20082	CY20092	Column1
12		Terry Wyatt	0.9	0.6	0.4	0.8	0.1	0.1	Spokesperson (2007)/Supervision of service work (2008/2009)
13		Stefan Soldner-Rembold	0.4	0.4	0.2	0.1	0.1	0.0	Tau Identification/Group Management/Supervision of service work
14		Christian Schwanenberg	0.5	0.2	0.1	0.2	0.0	0.0	Electron Identification
18		**Sums**	1.8	1.2	0.7	1.1	0.2	0.1	
19		**FTE at Fermilab**	0.5	0.1	0.0	0.5	0.0	0.0	
20									
21		**Research Scientists and Engineers**	CY2007	CY2008	CY2009	CY2007	CY2008	CY2009	
22		Kristian Harder	0.2	0.2	0.1	0.1	0.1	0.0	SMT operations
28		**Sums**	0.2	0.2	0.1	0.1	0.1	0.0	
29		**FTE at Fermilab**	0.0	0.0	0.0	0.0	0.0	0.0	
30									
31		**Postdocs**	CY2007	CY2008	CY2009	CY2007	CY2008	CY2009	
32		Matthew Ford	0.3	0.0	0.0	0.3	0.0	0.0	Data Quality Convener
33		Krisztian Peters	1.0	1.0	1.0	0.5	0.5	0.5	Calorimetry Convener
34		Remigius Mommsen	1.0	1.0	0.8	0.5	0.5	0.4	Central Track Trigger Convener
38		**Sums**	2.3	2.0	1.8	1.3	1.0	0.9	
39		**FTE at Fermilab**	2.3	2.0	1.8	1.2	1.0	0.9	
40									
41		**Graduate students**	CY2007	CY2008	CY2009	CY2007	CY2008	CY2009	
42		Mark Owen	1.0	0.8	0.0	0.1	0.0	0.0	Tau Identification/Muon Identification
43		Philip Rich	1.0	1.0	0.8	0.2	0.1	0.0	Tau Trigger Commissioning
44		Wan-Ching Yang	1.0	1.0	0.0	0.5	0.1	0.0	to be determined
45		N.N.	0.2	1.0	1.0	0.1	0.5	0.0	to be determined
48		**Sums**	3.2	3.8	1.8	0.9	0.7	0.0	
49		**FTE at Fermilab**	1.0	1.0	1.0	0.5	0.5	0.0	
50									
51		**Institute sum FTE effo**	7.45	7.15	4.35	3.35	2	1	
52		**Sum FTE at Fermilab**	3.8	3.1	2.8	2.2	1.5	0.9	
53		**Degree of certainty**	DC	DC	DC				

Sums / Aachen / Bonn / Buenos_Aires / Canada / CBPF_LAFEX / Cinvestav / Clermont / Delhi / Dublin / Ecuador / Freiburg / Grenoble / Holland / IC / IHEP / ITEP / JINR / Korea / LAL / Lancaster / Lyon / Mainz / **Manchester**

Ready

Total FTE Personpower of the Experiment

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

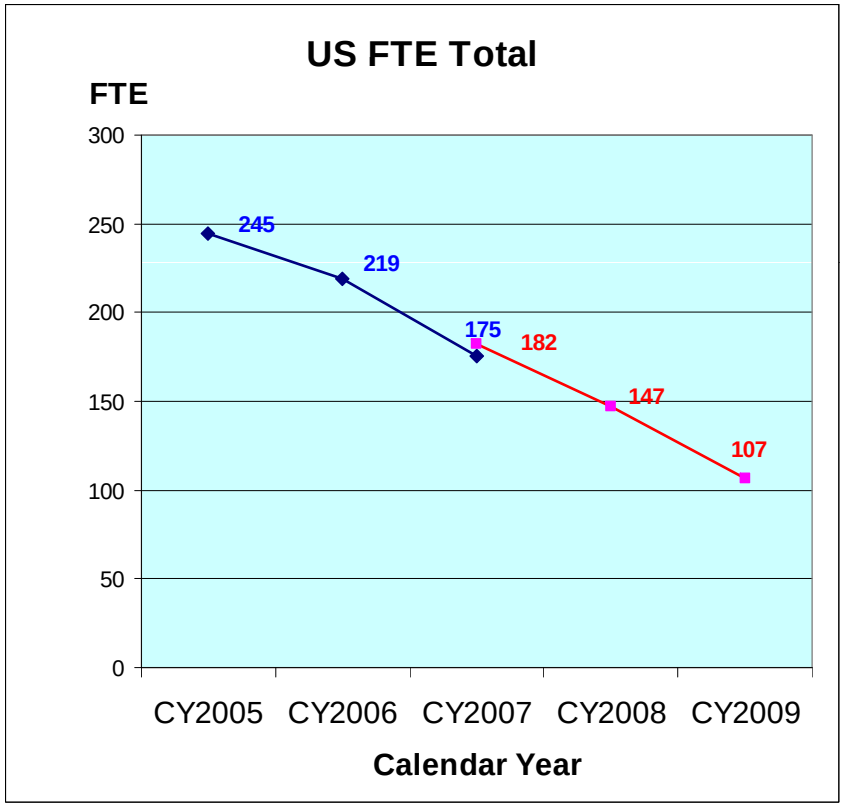


Good agreement between MoUs prepared in 2005 and 2007 for year 2007

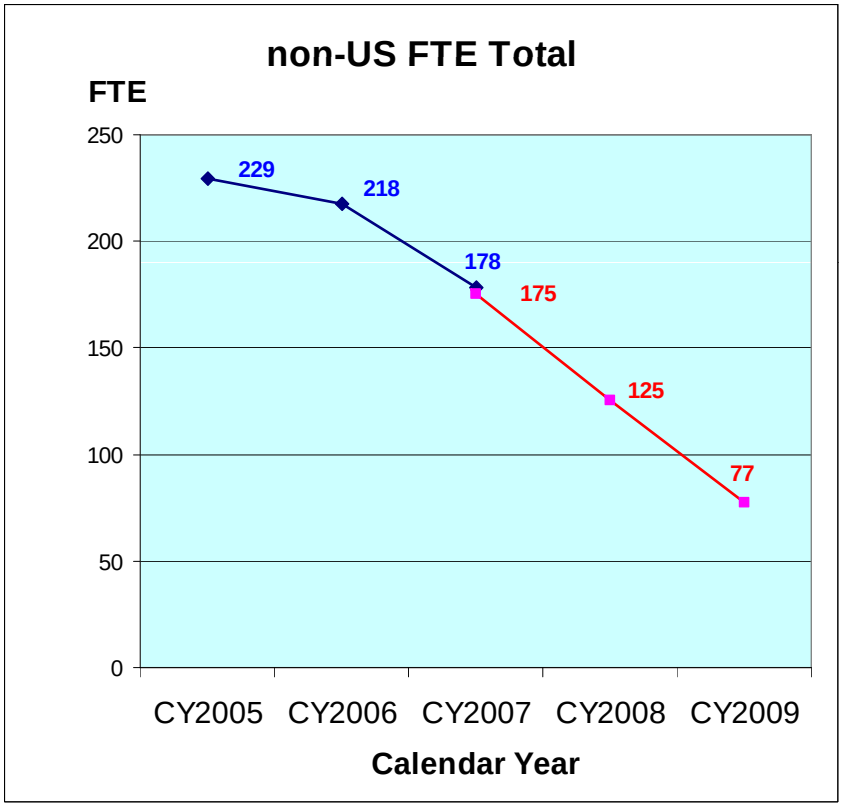
This plot permits cross-check using 2006 Efforts Reports.
Total FTE reported in Efforts Reports in 2006 is 407 FTE – match within errors.
MoUs do(!) have predictive power.

Total FTE Personpower of the Experiment

US FTE Total



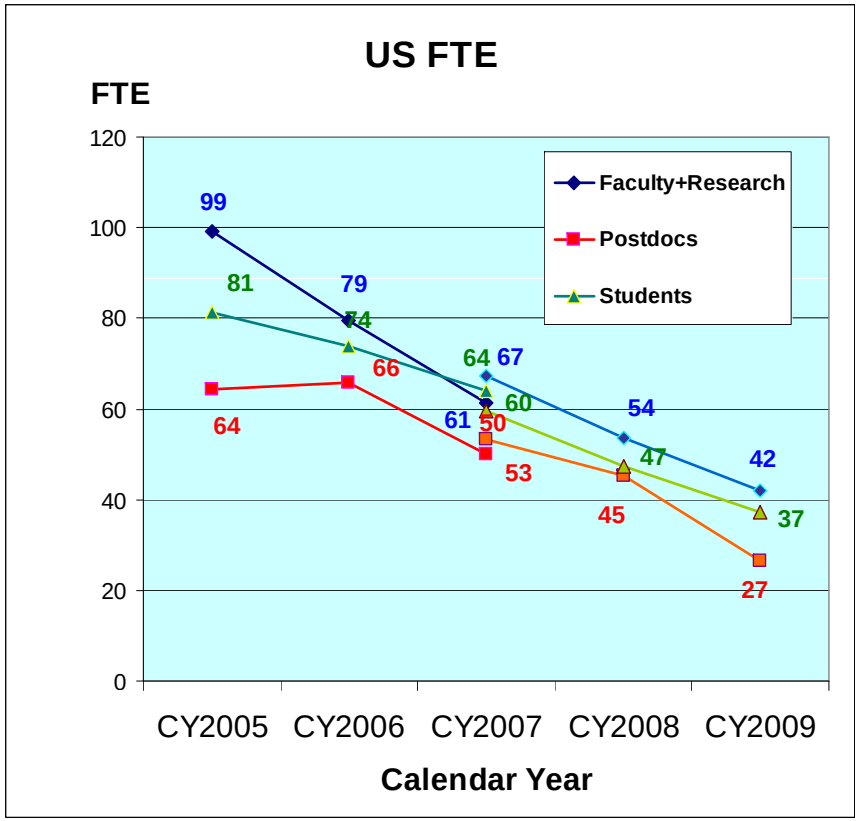
Non-US FTE Total



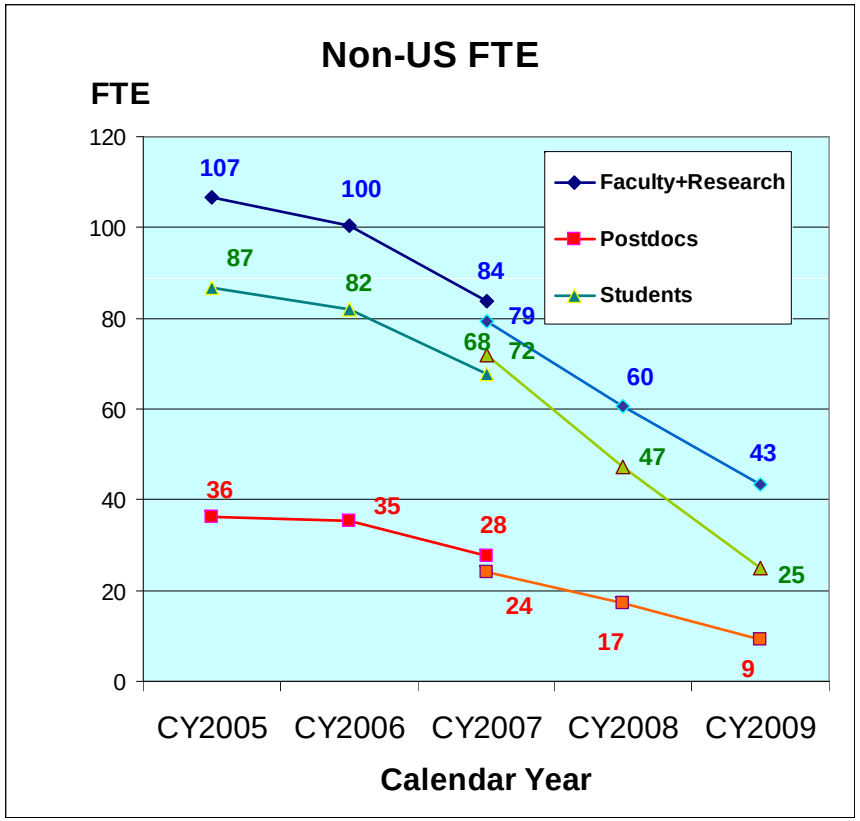
Both are declining with "LHC in Europe" effect clearly seen

FTE Manpower on DØ for Different Positions

US FTE

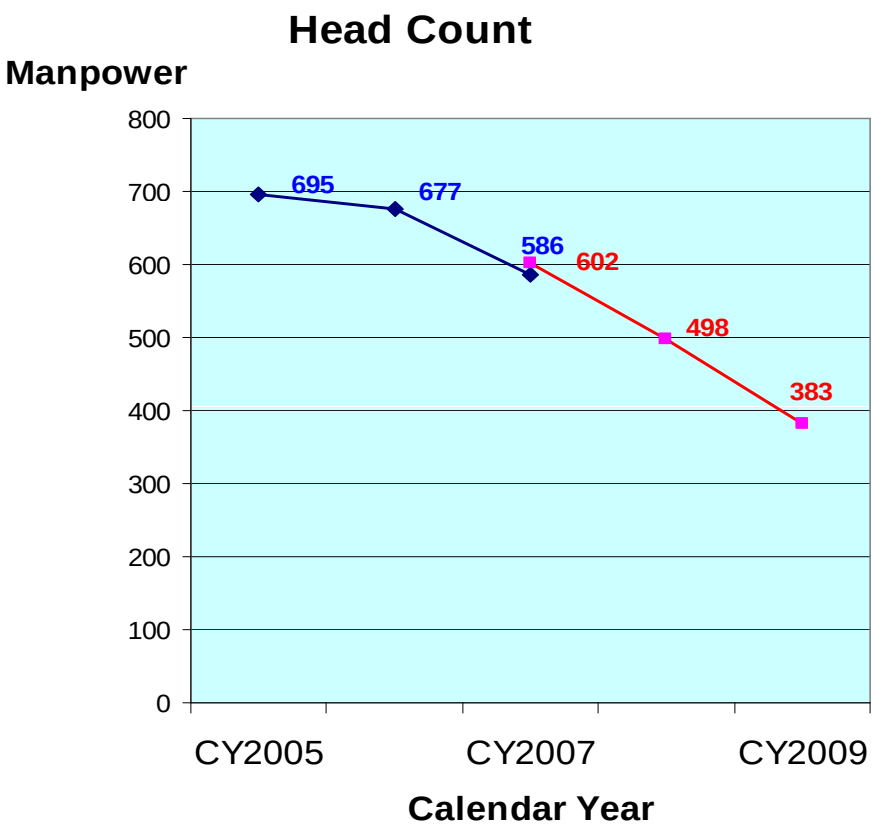


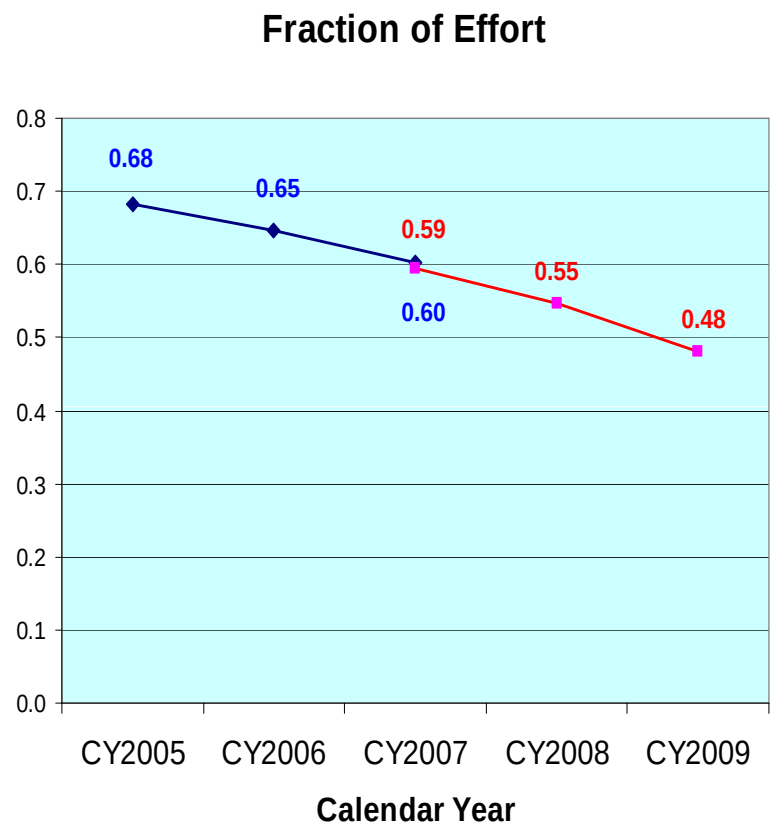
Non-US FTE



Good match between 2005 and 2007 MoUs in 2007.
Substantial drop in number of non-US postdocs and students in 2009.

"Head Count" and "DØ Fraction"





Total number of collaborators decreases, but slower than FTE.

Average fraction of time collaborator spends on DØ.
Decrease in number of students and postdocs (~1.0 FTE) explains steady decline.

Service Fraction

- Service fraction

  – Ratio of FTE needed to run the experiment to total FTE available

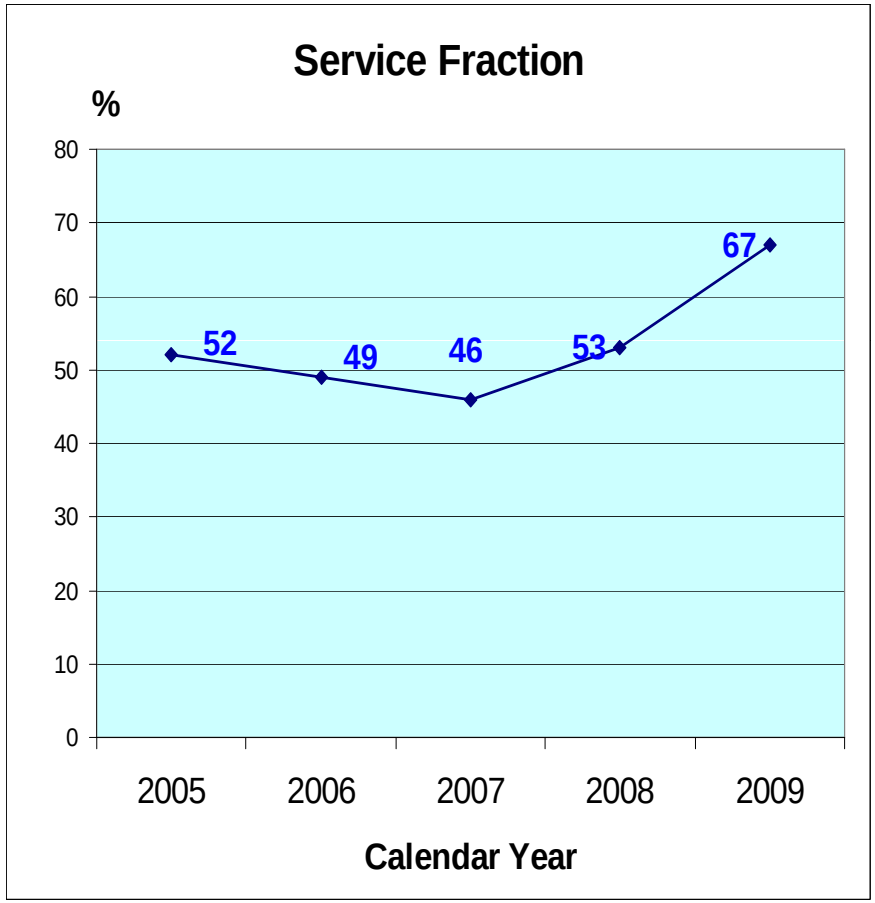
  – For 2005-2006 based on efforts reports

    - Service efforts (everything, except physics analysis) divided by total number of FTE reported

  – For 2007 and 2009

    - Expected service needs from Tevatron Task Force report divided by total number of FTE according to MoUs

- For 2007 and 2008 fraction is stable, while for 2009 it is increasing substantially



Reducing Personpower Requirements

With knowledge of the present and future resources and needs one of the major goals in managing Collaboration is to reduce service load while maintaining high efficiency operation and to increase total Collaboration manpower:

to increase resources devoted to physics analysis.

- **Reducing resource needs in every area of the experiment**
  - **Control room shifts**
    - **Down to 4 shifters from June 1, 2007**
  - **Streamlining operations**
    - **Automation**
    - **Experts cross training**
    - **Minimizing changes**
      - Changes at the data taking stage propagate all the way to the analysis
  - **Remote computing shifts**
    - **Support data processing and analysis**
    - **Remote collaborators active participation**
  - **Stability of reconstruction algorithms**
    - **Run IIb improvements integrated**
    - **High luminosity improvements to be finished soon**
  - **Continuing efforts with Computing Division on automation of**
    - **GRID based processing**
    - **Skimming and datasets creation**

Reducing Personpower Requirements

- Each new project (operations, computing, analysis)
  - Careful analysis of "cost/benefits"
  - Don't want to loose opportunities or stretch resources too thin
- Long term commitments
  - Most positions with substantial responsibilities are for at least a year
    - Reduces training time, increases efficiency
- Reduction in efforts needs for analysis
  - Joint object identification groups for all physics groups
  - Joint "final states" groups
    - V+jets
    - Multijets
    - Multileptons
  - 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
  - Few "holes" in detector, algorithms, computing areas

Specific Expertise in Critical Areas

- Specific features of the DØ Collaboration to take into account for personpower analysis
  - Large number of relatively small groups
    - Less flexibility for groups to redirect resources
  - Detectors designed/built in '80s
    - Require substantial support

- **While there are people who can sing Puccini operas… not every FTE can sing like Pavarotti**

- **There are quite a few specialized areas in the experiment where long term individuals experience/commitments are important**
  - **Experiment was not designed/built/documented so that a "generic physicist" could run it without major training/commitments**

- **Long term institutional commitments are also very important**
  - **MoUs helps identify areas needed attention in advance**
  - **Most DØ groups are strongly committed to the experiment**

- **Fermilab support is important in critical areas**
  - **One of the main Tevatron Task Force recommendations**
  - **Working closely with Laboratory and PPD/CD on addressing specific needs, for example**
    - Run coordinator - accomplished
    - Level 1 muon and caltrack triggers support – in progress
    - Tracking algorithms
    - On-line controls
    - Fiber tracker operation
    - Level 3 trigger coordination
    - Muon detector operations

Attracting Collaborators and Resources

- **Interest and excitement are keeping the Collaboration together**
  - **Collaboration has (almost) no money**
  - **400 FTEs cost about $30Mln per year**
- Important to keep every and each collaborator interested and actively engaged

- Interesting physics
  - Mutli-purpose detector, wide range of physics topics
  - High quality data available
  - Hunt for
    - New SM states/objects
      - WZ, single top, 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
- Leadership positions
  - 5 excellent candidates run for Spokesperson position in April 2007
- Talks, seminars, conferences
  - NBC news, press releases, lectures

International Fellowships, Visitors Fund

- **Fermilab International Fellowships started in 2006**
  - **Two candidates accepted in 2006 (UK and Canada)**
    - **Both are already primary authors of interesting physics results**
  - **8 excellent candidates for two new positions in 2007**
- **Natural way to attract new talents**
  - **Looking forward for increase in number of fellowships**

- **Fermilab's PPD guests and visitors budget**
  - **$940k in FY07**
    - **Able to attract ~40 FTEs**
      - Excellent investment!
    - **Provides opportunity to come to Fermilab and get full time involved**
    - **Used for**
      - Teaching buyouts
      - Foreign visitors support
  - **Tevatron Task Force recommended doubling guests and visitors budget**
    - **Extra funds will help greatly with increase in collaboration resources**

Using every option to attract more collaborators!

Collaboration Resources

- The Collaboration is tracking personpower closely
  - Efforts Reports
  - MoUs
  - Future resource needs
    - Includes operations, computing, algorithms and management
    - ~124 FTEs required to run the experiment in 2009
- For 2007 and 2008 DØ FTE availability is well above needed to run the experiment
  - Have enough manpower for many analyses
- Current expectations for 2009 DØ resource availability is ~184 FTEs
  - Working actively attracting more collaborators
  - Reducing personpower needed to run the experiment
- Continuing commitments from the Laboratory and funding agencies are critical to assure adequate staffing of the experiment
  - Support of Universities groups
  - Fermilab's staff continuing involvement in the experiment
  - Increase in Guests and Visitors budget
  - New openings to address specific operational and scientific resource needs
- Together we expect to face personpower challenges successfully

Conclusions

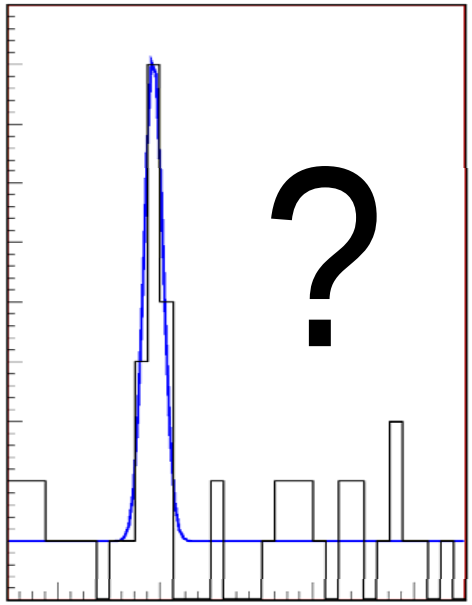
- The DØ detector is working well with high data taking efficiency
  - Currently 2.5 fb^{-1} on tapes
  - No major technical issues to continue data collection up to and above 8 fb^{-1}
- Data processing is keeping pace with data collection, MC production is steady

Physics program is flourishing: Top Quark studies, QCD, Electroweak, B physics, Beyond SM searches

SM Higgs is within our reach

There are challenges which we are actively working on

- Technical: triggering, algorithms at high luminosity
- Manpower: support from Fermilab, DoE/NSF and foreign groups/agencies is critical



The Collaboration is looking forward to continue data taking in 2009 and perform analysis for another several years

This decision was endorsed by the DØ Institutional Board on March 8, 2007

Exploration of energy frontier continues - stay tuned!

Backup Slides

PhD Theses

Late 2006 Theses List

Marine Michaut	DAPNIA/SPP, SACLAY	Search for Supersymmetric Higgs Bosons at Large tan(beta) at the D0 Detector	October, 2006
Tim Scanlon	Imperial College	b-Tagging and the Search for Neutral Supersymmetric Higgs Bosons at D0	October, 2006
Aurélien Mendes	Centre de Physique des Particules de Marseille	Recherche du partenaire supersymétrique du quark top dans le canal stop1 -> b+snu+e(mu) au sein de l'expérience D0 auprès du Tevatron. Calibration du calorimètre électromagnétique de D0.	October, 2006
Daniela Kaefer	RWTH Aachen	Search for R-Parity Violating Supersymmetry in Multilepton Final States	November, 2006
Jeff Temple	University of Arizona	Measurement of the Top Mass via Neutrino Weighting in the Dilepton Decay Channels	November, 2006
James Heinmiller	University of Illinois, Chicago	Search for the Higgs Boson in the ZH Channel	November, 2006
Avdhesh Chandra	Tata Institute of Fundamental Research	Lifetime Difference in the B0s System from Untagged B0s -> J/psi phi Decay at sqrt(s)=1.96 TeV	November, 2006
Cano Ay	University of Mainz	Messung der B_s Oszillation mit dem semileptonischen Zerfall B0_s -> D-_s(phi pi-) mu+ neutrino	November, 2006
Lydia Lobo	Imperial College London	Jet Energy Scale Studies and the Search for the Standard Model Higgs Boson in the Channel ZH -> nbar nu bbar b at DØ	November, 2006
Susan Burke	University of Arizona	Measurement of the Top-antitop Production Cross Section in the Dimuon Final State	December, 2006
Lars Sonnenschein	University of Paris VI	Habilitation thesis on STT and Higgs searches in WH production(in French)	December, 2006
Christian Autermann	RWTH Aachen	Resonant Second Generation Slepton Production at the Tevatron	December, 2006

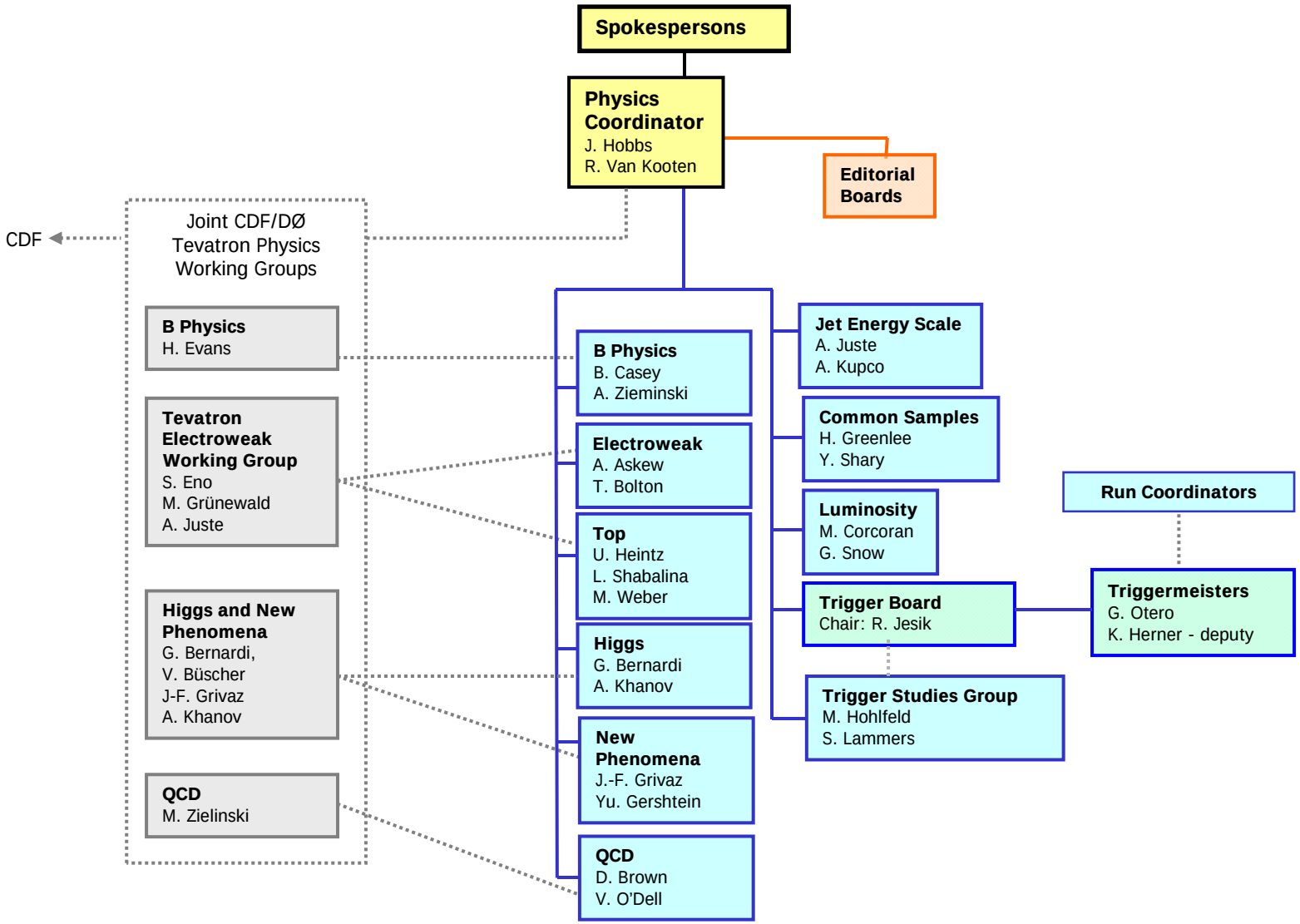
2007 Theses List

Robert Harrington	Northeastern University	Measurement of the Top Quark Mass in Lepton+Jets Events with Secondary-Vertex Tagging	February, 2007
Lei Wang	Univ. of Maryland	Measurement of Z Boson Transverse Momentum In Proton-Antiproton Collisions	February, 2007
Daniel Krop	Indiana University	A Search For Bs0 Oscillations at the Tevatron Collider	March, 2007
Ming Yan	Univ. of Maryland	Measurement of 1/sigma dsigma/dy for Z/gamma* to e+e-	March, 2007
Isaac Hall	University of Oklahoma	Observation and Properties of X(3872) at D0	April, 2007
Thomas Gadfort	University of Washington	Evidence For Electroweak Top Quark Production In Proton-Antiproton Collisions	April, 2007
James Degenhardt	University of Michigan	Evidence for WZ Production and a Measurement of the WZ Production Cross Section	May, 2007
Bryan Gmyrek	University of Arizona	Search for Right-handed W Bosons in Top Quark Decays	May, 2007
Florent Chevallier	Universite de Grenoble	Mesure de la section efficace de production de quarks top en paires dans le canal lepton+jets à D0 et à ATLAS et interprétation en terme de Higgs chargé dans ATLAS	May, 2007
Thomas Millet	Institut de Physique Nucleaire de Lyon	Search for gluino pairs in the b-jets+mET topology	May, 2007
Amitabha Das	Boston University	Search for Randall-Sundrum Gravitons in Dilepton and Diphoton Final States with 1 fb-1 of Data	May, 2007

Wide range of topics, Universities and countries

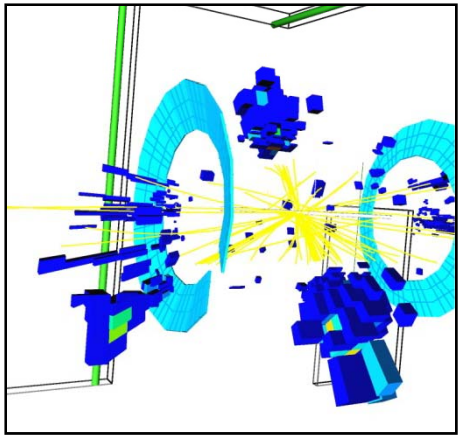
Physics Organization

Six physics groups are working well together, and in conjunction with trigger board, objects identification, analyses review boards and joint Tevatron groups



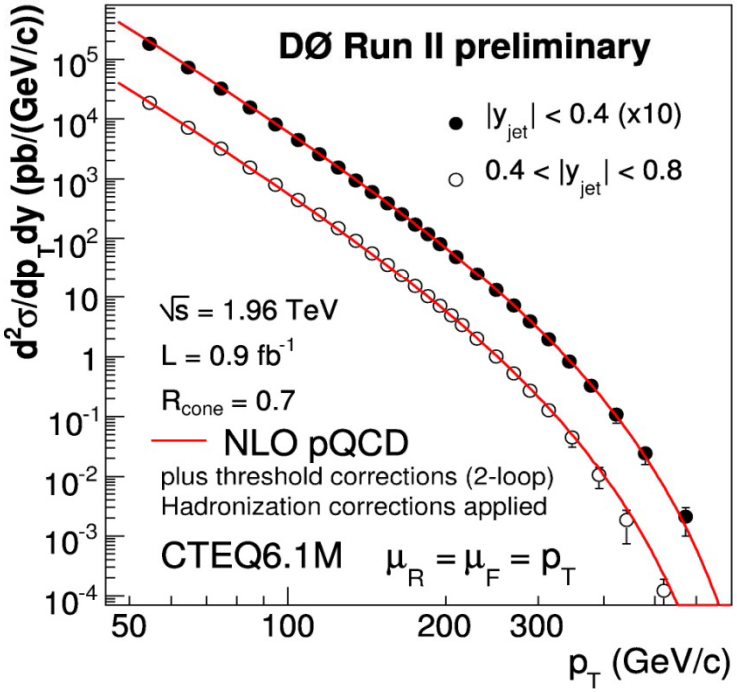
QCD Studies

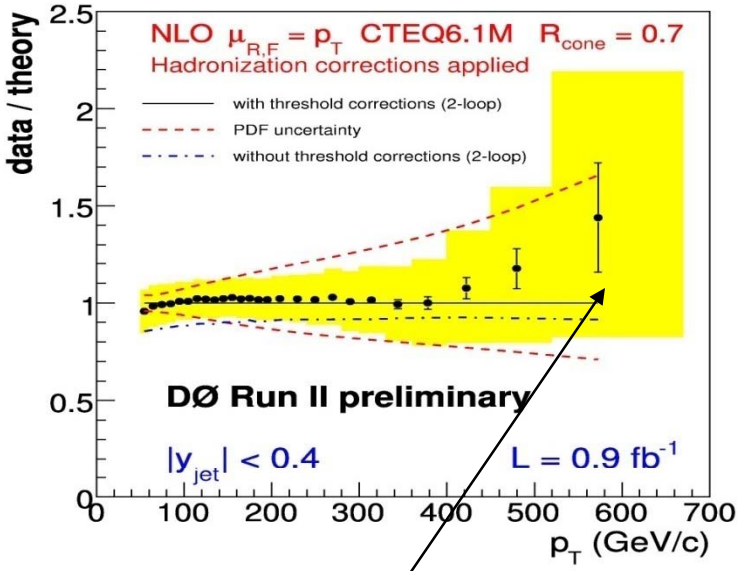
1TeV Et!



Use high energy jets production to measure proton structure
→ quarks sub-structure?
Resolve some outstanding puzzles
→ e.g. heavy flavor production
Understand the backgrounds to physics beyond SM
Study diffractive production, new objects such as X(3872)

Inclusive jets cross sections





9 orders of magnitude σ changes!

Jet energy scale (JES) uncertainty is starting to be comparable with PDF errors

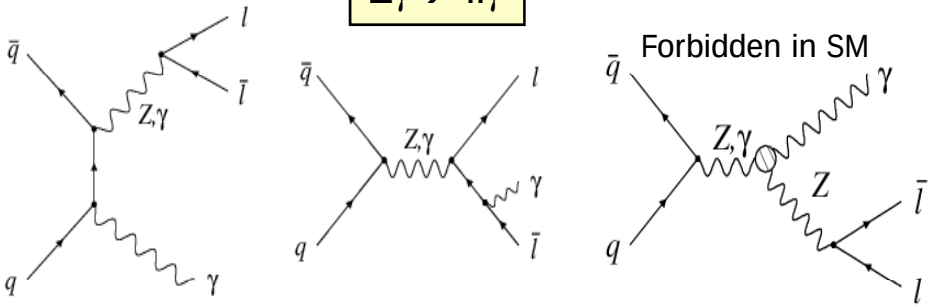
No surprises… for now

Diboson Production

WW, WZ, ZZ, Wγ, Zγ production test SM and tell us about boson self-coupling
Background to many interesting searches, such as H→WW*

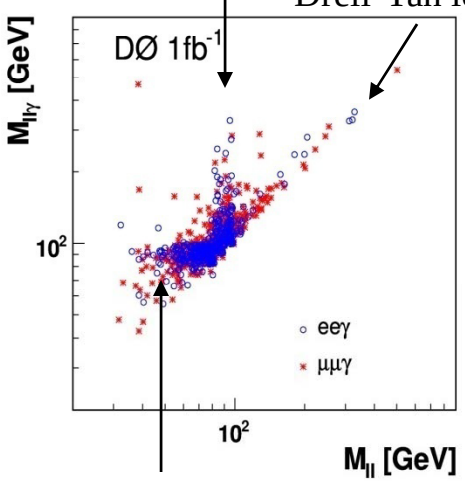
Evidence for radiation amplitude zero in Wg production

Zγ→ llγ



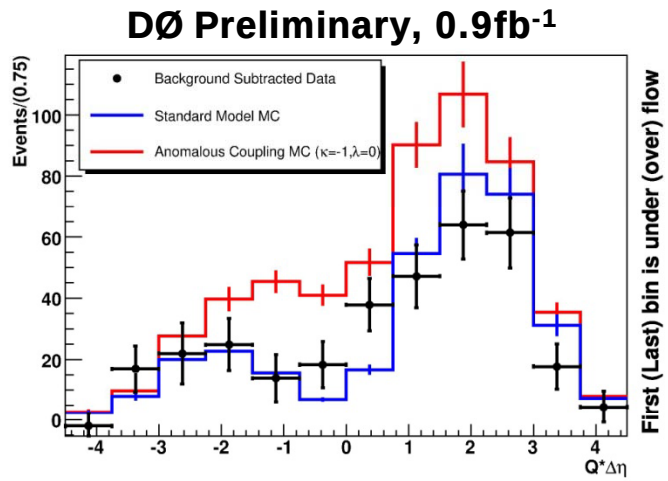
Initial State Radiation

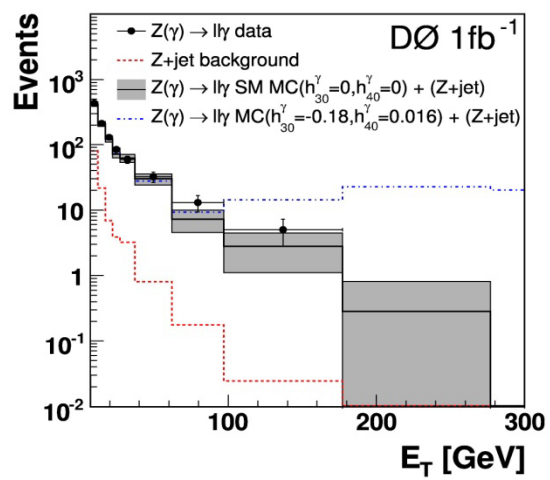
Drell-Yan leptons

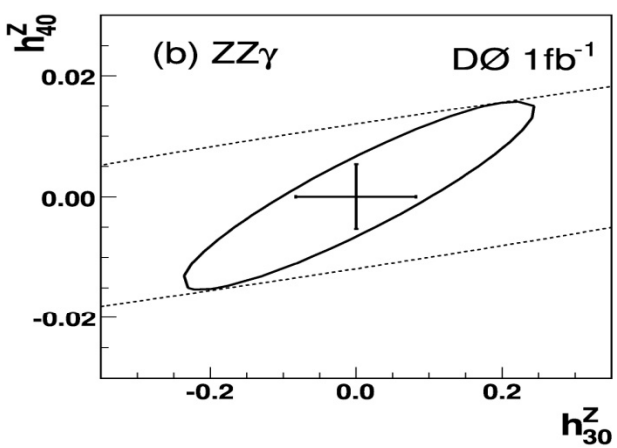


Final State Radiation

Limits on Anomalous Couplings set: world most stringent for h_{40}







Search for New Phenomena

One of the most natural studies is to look for New Phenomena at energy frontier machine: SUSY, leptoquarks, Technicolor, new exotic particles, extra dimensions…

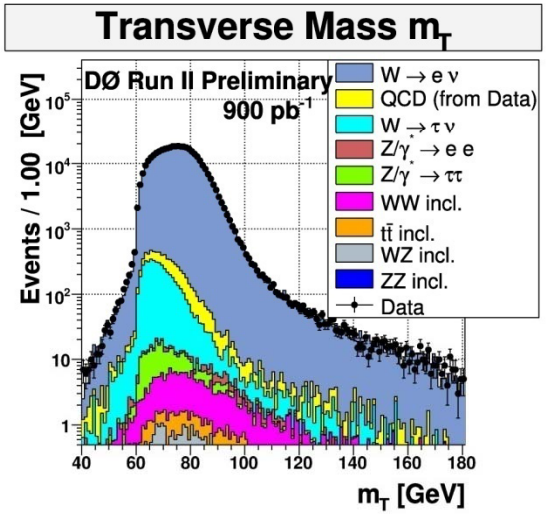
Recipe: search for irregularities in effective mass spectra or other kinematic parameters to study events not described by the SM

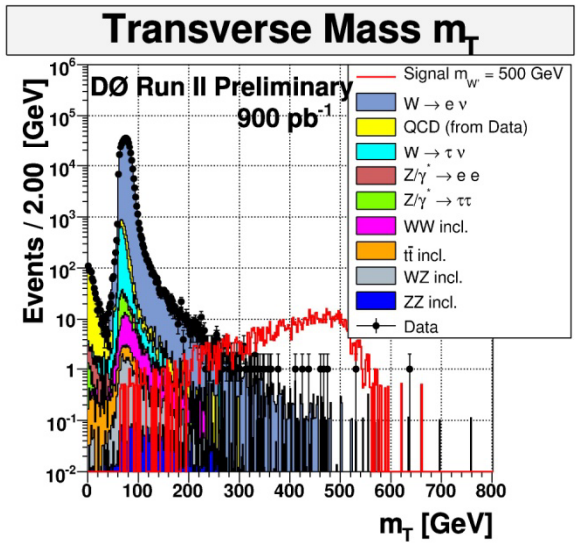
Example: Search for heavy W' decaying to eν

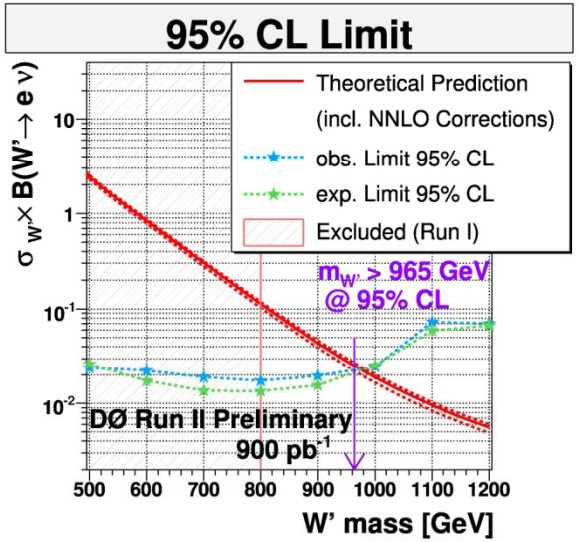
First check prediction of SM processes in low mass region

Then look into high mass region

If no excess found, set limits





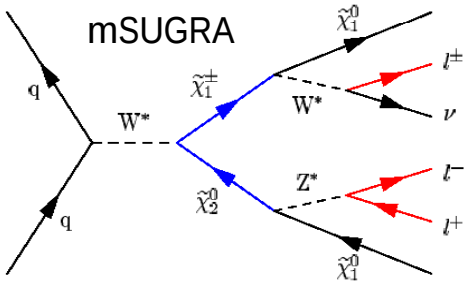


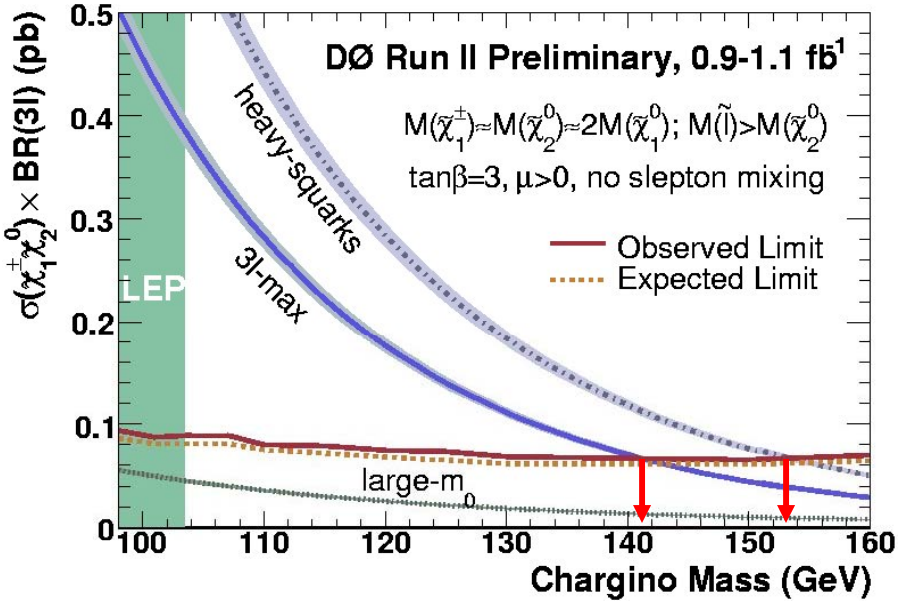
Reaching masses up to ~1TeV – ½ of Tevatron center of mass energy!

Search for SUSY

SUSY solves "Hierarchy Problem", provides Grand Unification at the 10^{16} GeV scale, and is potential Dark Matter Candidate (LSP)…

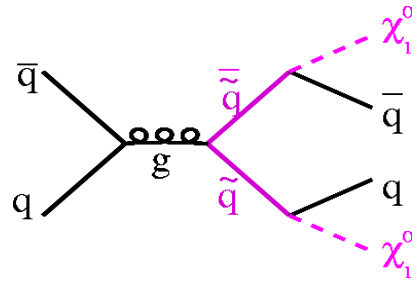
Chargino/Neutralino production in 3l+$\not{E}_T$

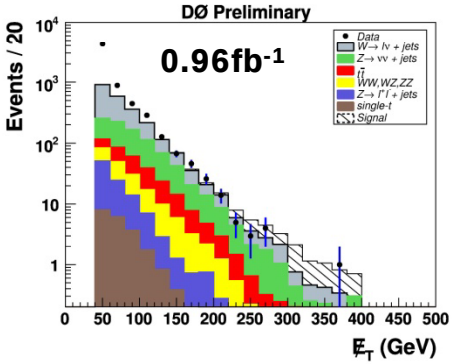


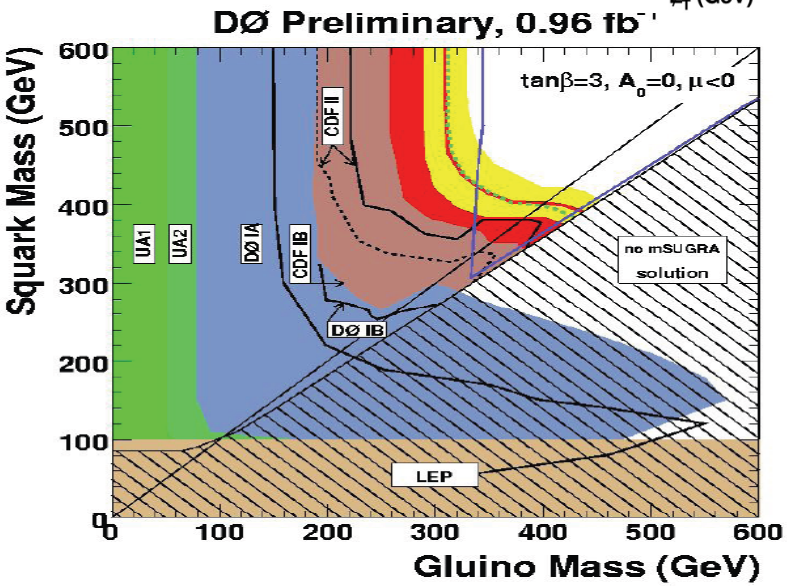


Much better than previous results

Squarks and Gluinos in jets+$\not{E}_T$



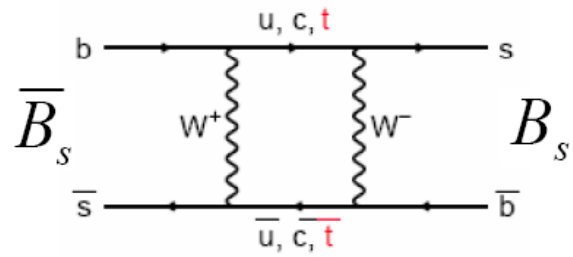




~50 GeV higher then previous limits

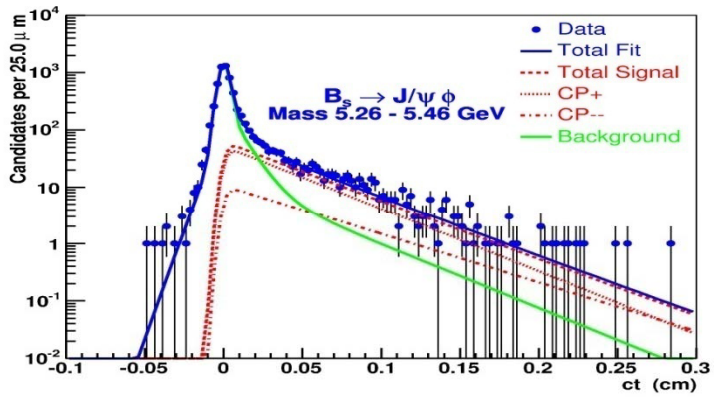
Studies of B_s System

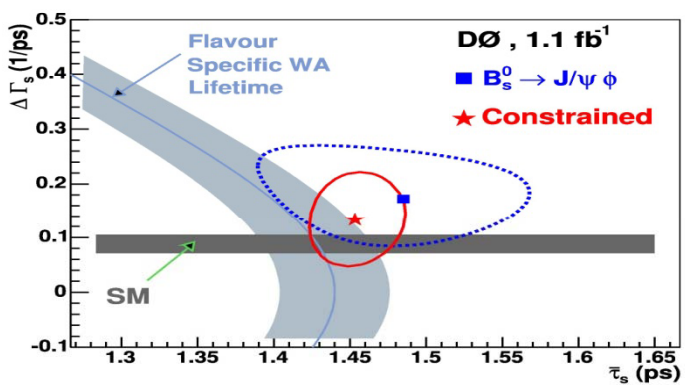
- **Tevatron is an excellent place to study B_s system**
  - **Mass difference Δm_s**
  - **Lifetime Γ and lifetime difference $\Delta\Gamma$**
  - **CP-violating phase ϕ_s**

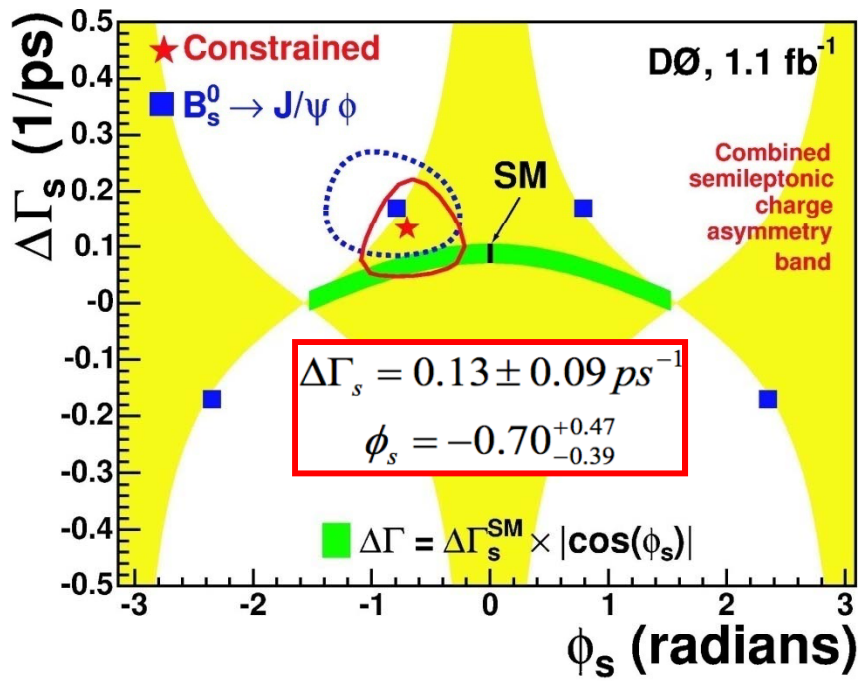


Using $B_s \rightarrow J/\psi\phi$ decay (CP- and CP+ final states) measure Γ, $\Delta\Gamma$ and ϕ_s

With sizable lifetime difference there is sensitivity to CP-violating phase: first direct sensitivity to this parameter!

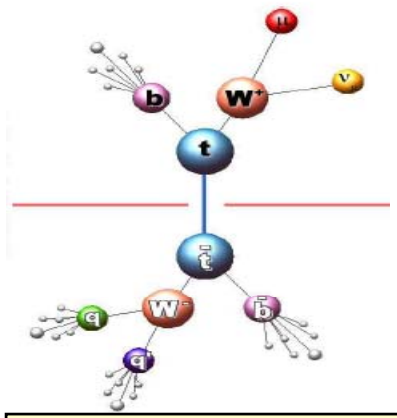






Twice more data on tapes, analysis improvements

Top Quark Studies



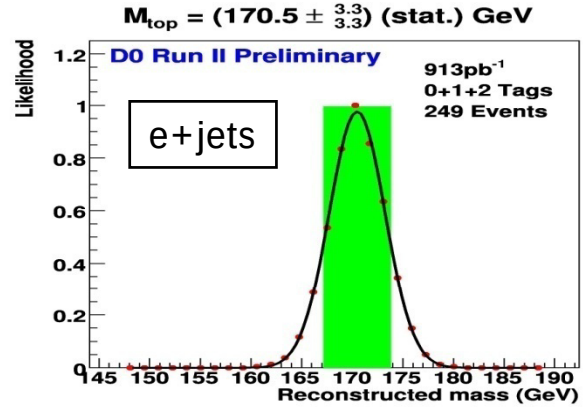
In triggering and analysis select events with

→ high P_t leptons

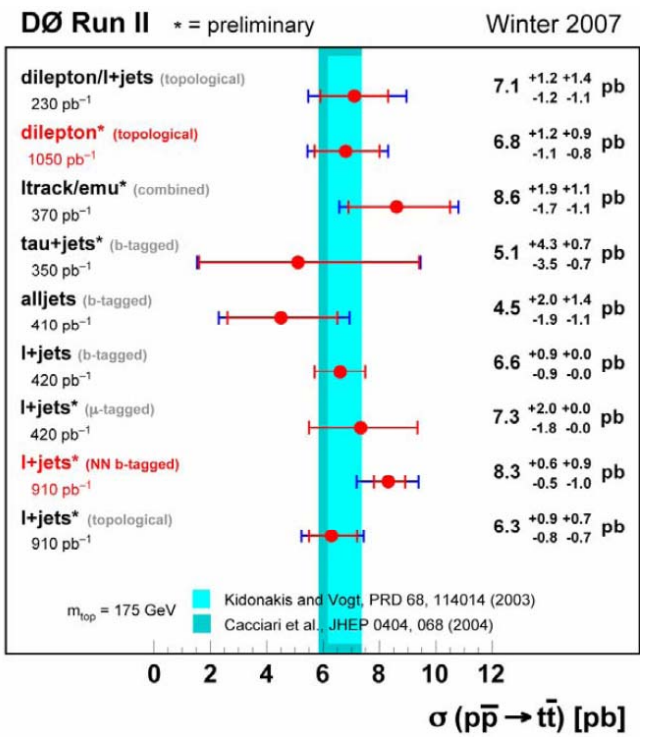
→ multiple high E_t jets

→ large missing E_t (ν)

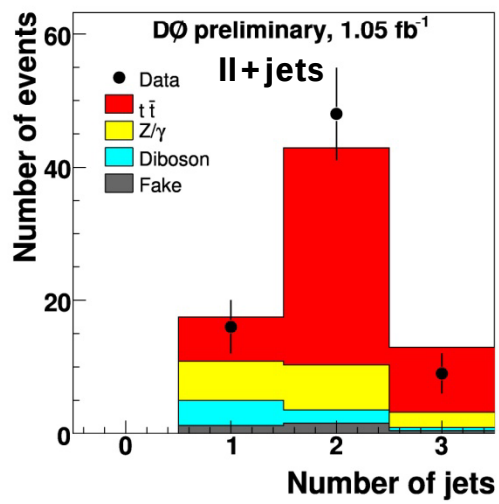
→ displaced vertex for b-jets

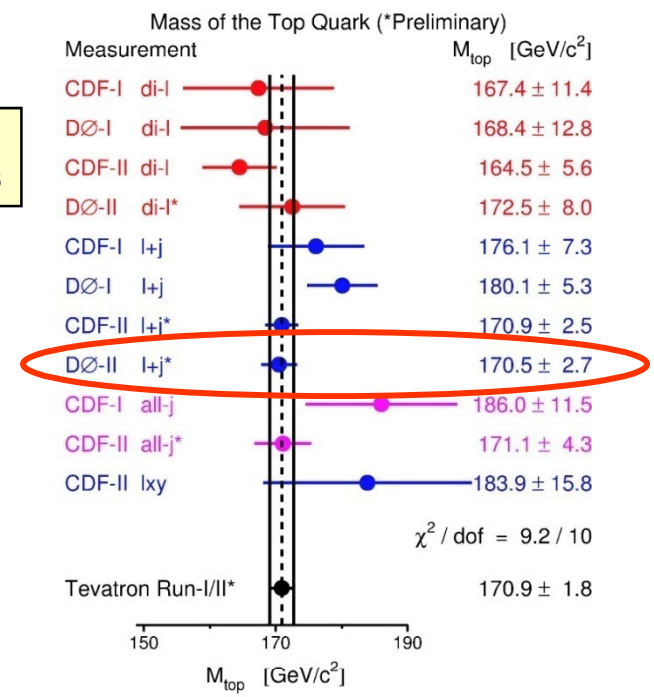


Cross sections are consistent with SM and demonstrate success of multiple top quark detection techniques



Large and pure samples of top quark events





Down to 1% combined top mass measurement precision – best among quarks

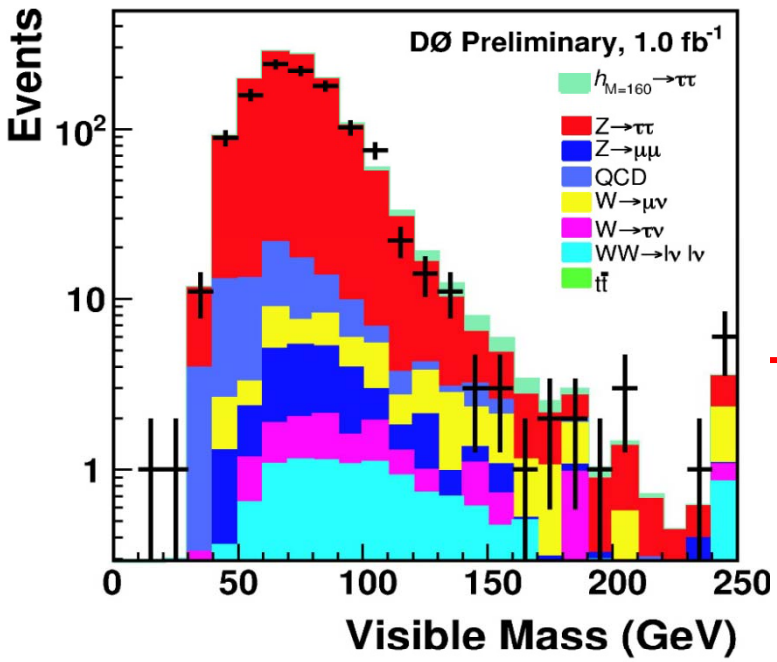
MSSM Higgs Search

MSSM predicts larger Higgs cross sections for some values of parameter space than SM

Using NLO cross section calculations and assuming no difference between A and h/H DØ performs search for MSSM Higgs

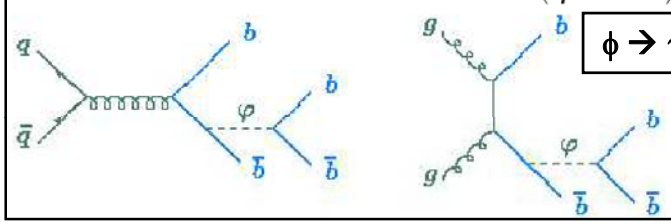
→multi b-jets

→ di-τ events with extra b-jets

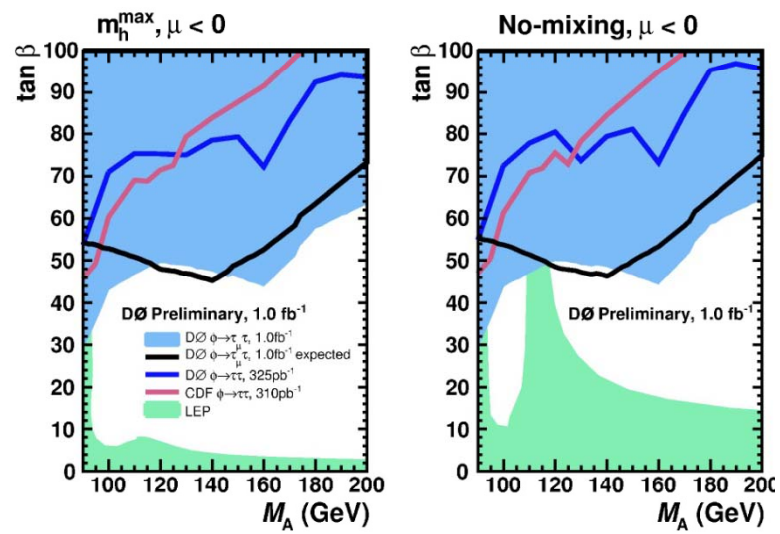


Two Higgs Doublets $\mathcal{H}_1$, $\mathcal{H}_2$ and 5 physical states

2 CP-even neutral Higgses	h^0, H^0	$m_h < m_H$
1 CP-odd neutral Higgs	A^0	
2 charged Higgses	$H^\pm$	
Free parameters:	$\tan\beta = v_2/v_1$	(VEV ratio)
	α	(mixing angle of h, H)
	μ	Higgs mass parameter
	A_0	common trilinear Higgs-sfermion coupling
tree level:	$m_h < m_Z < m_H$	
rad.corrected:	$m_h < 130$ GeV	$Br(\phi \to b\bar{b}) \sim 90\,\%$



$\phi \to \tau\tau \sim 10\,\%$



Also fermiophobic Higgs, doubly charged Higgs …

World's most stringent limit

Standard Model Higgs Search

Improvements to come:
- analysing larger datasets
- wider use of advanced analysis techniques
- additional channels: WH -> WWW, H->ZZ, hadronic H->WW, τ modes, ...
- new Layer 0: improves b-tagging

Xsec Factor = (95% C.L. limit)/(SM cross section)

Ingredient	Equiv Lumi Gain	Xsec Factor MH=115 GeV	Xsec Factor MH=160 GeV
Today with 1fb^{-1}	-	5.9	4.2
Lumi = 2 fb^{-1}	2	4.2	3.0
b-Tag (Shape + LayerØ)	1.5	3.4	3.0
Multivariate Techniques	1.7	2.6	2.3
Improved mass resolution	1.5	2.1	2.3
New Channels	1.3/1.5	1.9	1.9
Reduced systematics	1.2	1.7	1.7

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

All of the above will benefit from larger integrated luminosity