URA Visiting Committee Meeting
May 8-9, 2006, Fermilab

# DØ Research Program

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Fermilab

**OUTLINE**

- Status of DØ detector and operations
- Status of Run IIb upgrade
- Overview of DØ physics program
- Plans for the future
- Contributions of FNAL/DØ group
- Summary and conclusions

# The DØ Collaboration


- Institutions:
  - 39 (US) + 53 (non-US) = 92 total
- Collaborators:
  - ~671 total
  - ~50% from non-US institutions (note strong European participation)
  - ~100 post-docs
  - ~140 graduate students

# Physics Goals

- Experimentation at the Tevatron collider is directed towards helping answer truly fundamental questions:

DISCOVERING THE QUANTUM UNIVERSE

THE ROLE OF PARTICLE COLLIDERS

DOE / NSF

HIGH ENERGY PHYSICS ADVISORY PANEL

EINSTEIN'S DREAM OF UNIFIED FORCES

1

ARE THERE UNDISCOVERED PRINCIPLES OF NATURE : NEW SYMMETRIES, NEW PHYSICAL LAWS?

2

HOW CAN WE SOLVE THE MYSTERY OF DARK ENERGY?

3

ARE THERE EXTRA DIMENSIONS OF SPACE?

4

DO ALL THE FORCES BECOME ONE?

THE PARTICLE WORLD

5

WHY ARE THERE SO MANY KINDS OF PARTICLES?

6

WHAT IS DARK MATTER? HOW CAN WE MAKE IT IN THE LABORATORY?

7

WHAT ARE NEUTRINOS TELLING US?

THE BIRTH OF THE UNIVERSE

8

HOW DID THE UNIVERSE COME TO BE?

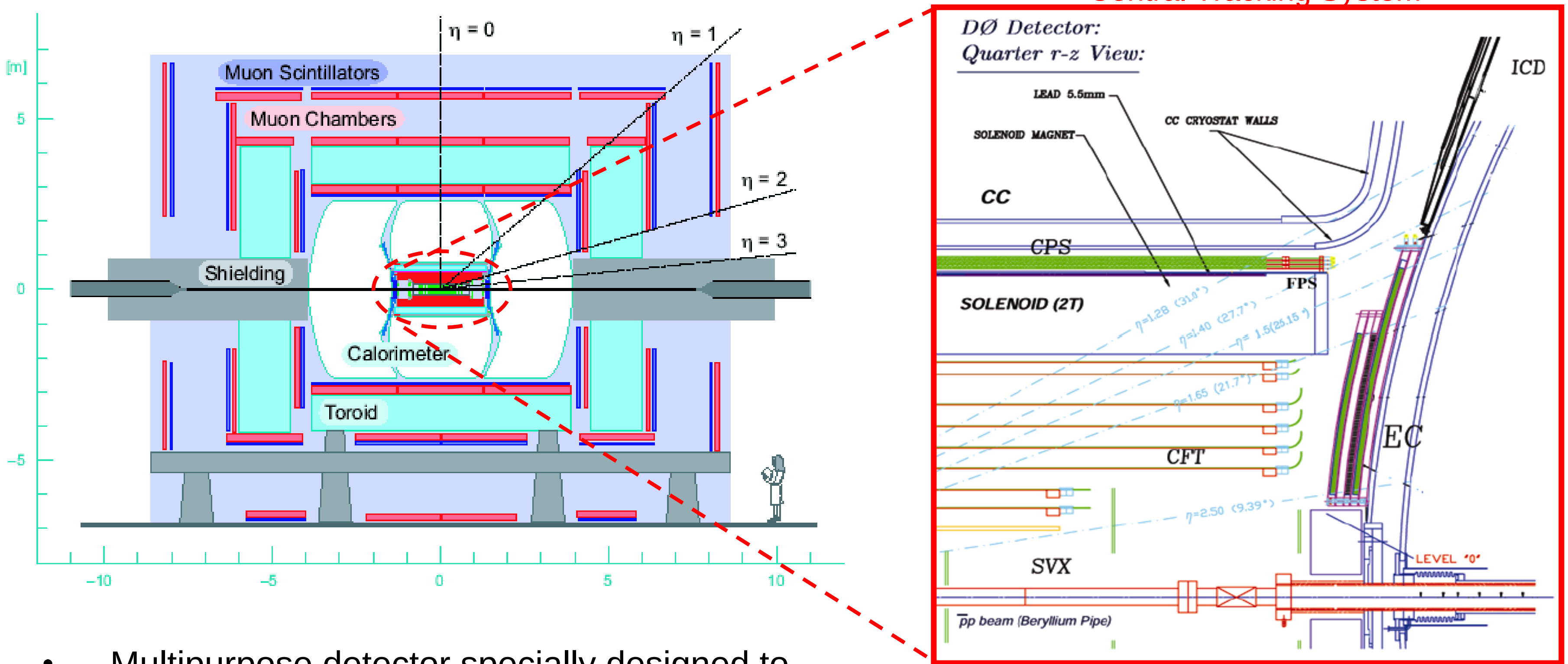
9

WHAT HAPPENED TO THE ANTIMATTER?

- The large expected integrated luminosity during Run II and the excellent performance of the CDF and DØ detectors, better understood than ever before, point to a very promising and exciting future.

# The DØ Detector

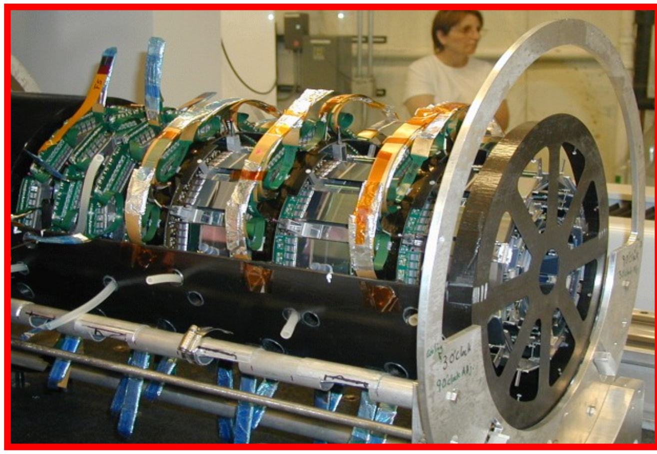
Central Tracking System

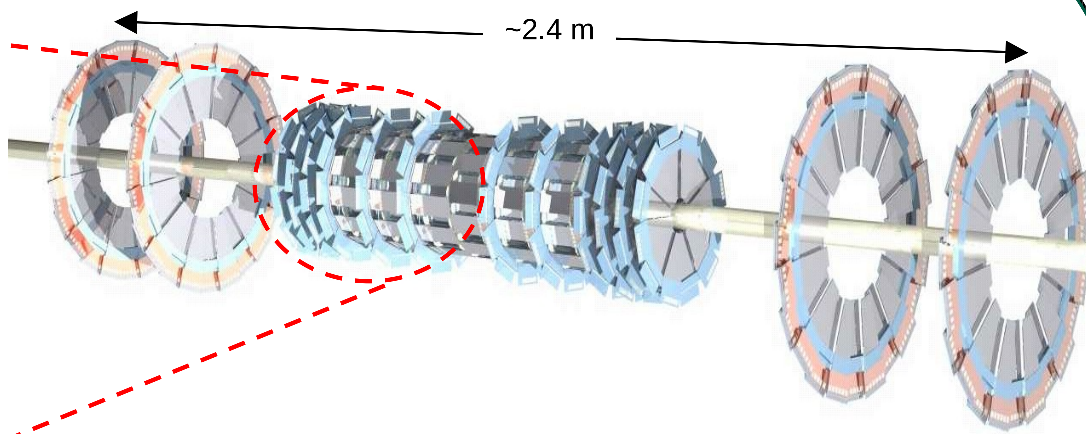



- Multipurpose detector specially designed to address the previous fundamental questions:
  - Lepton (e, μ, τ) identification
  - Jets and missing transverse energy reconstruction
  - Jet flavor identification via displaced tracks and soft-leptons
- Detector upgrades well underway to provide further enhanced performance.

- Features:
  - Central tracking system embedded in a 2 T solenoidal field:
    - Silicon Tracker (|η|<3)
    - Scintillating Fiber Tracker (|η|<1.5)
  - Central and forward preshowers
  - LAr/U calorimetry (|η|<4.2)
  - Muon system (3 layers, (|η|<2.0)

# Silicon Microstrip Tracker (SMT)



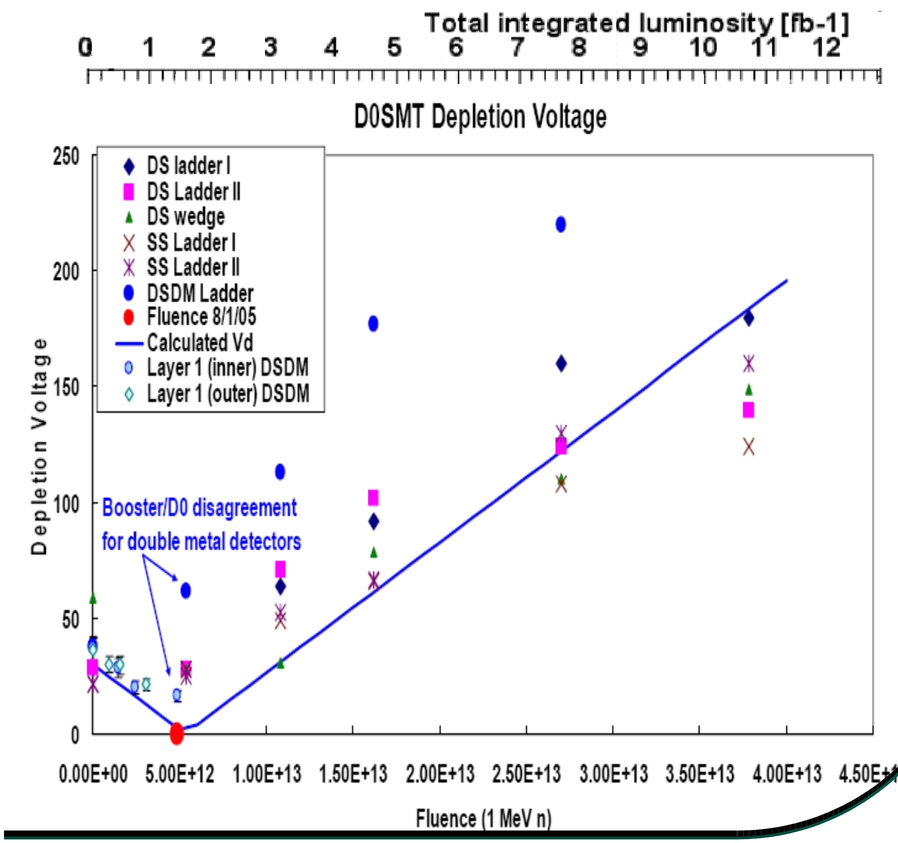



- ~793k readout channels
- 6 barrels (4 layers) and disks (wedges) for forward tracking ($|\eta|<3.0$)
- Single- (axial) and double-sided (axial+stereo) detectors

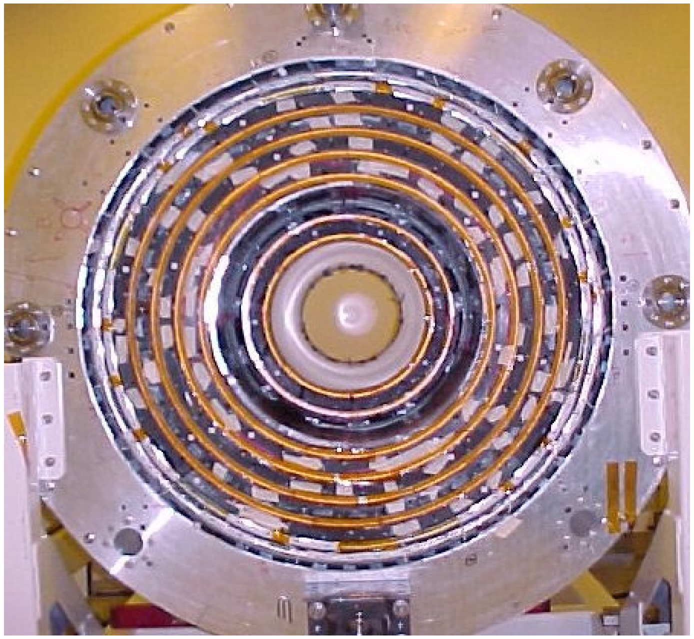
- Good and stable detector performance
- S/N>10 in all devices
- >97% cluster reconstruction efficiency
- Mortality <15%, not growing; no fiducial loss
- Radiation hardness: studied in the booster and in situ with HV scans of noise and efficiency.

Evolving as expected.

Inner layer: $V_{depl}$~$V_{max}$=150 V @ 5-7 $fb^{-1}$



# Central Fiber Tracker (CFT)



- 20 cm < r < 51 cm
- 8 layers of axial and stereo 830 $\mu$m $\varnothing$ scintillating fibers, mounted on carbon fiber cilinders
- ~12m long clear wave-guide to Visible Light Photon Counters (operating at 8K)
- ~77k readout channels
- Fast pick-off for trigger

- Performing well:
  - Good light yield (~7 pe/mip)
  - >98% per layer efficiency
  - Occupancy matches expectations (although concerns for very high instantaneous luminosity)

- ~1% of VLPC channels not functional after November'03 shutdown (was 0.1% before).
- Attributed to cryostat warm up / contamination
- Attempted to fix problem in 2005 shutdown:
  - Warmed up 1 (of 2) cryostats
  - Pumped out 0.5l of water
  - Upon cool down same loss rate BUT different channels
- Does not seriously degrade performance (affecting mainly trigger rates) but requires vigilance. Not warming up!

# Calorimeter

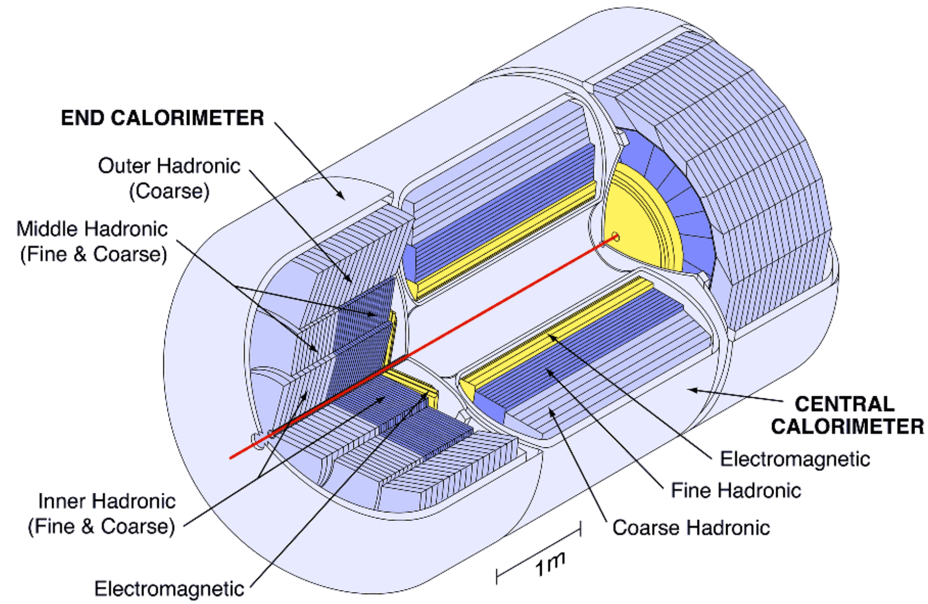
- LAr sampling, U absorber (Cu/Steel for coarse hadronic)
- ~55k readout channels
- Uniform, hermetic, full coverage ($|\eta|<4.2$)
- Good energy resolution

- Stable and reliable operation
- >99.9% channels operational

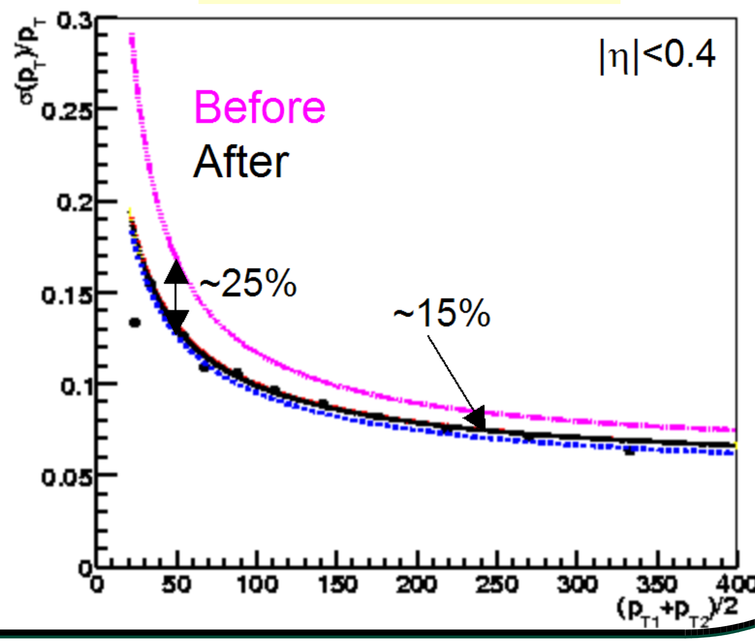
- Episodic noise problems (pick-up from crane/welding, muon toroids, etc), affecting ~1% of the data.

  Better detector grounding during '04 shutdown lead to some improvements. Aggressive program to reduce noise continues.

- Recently completed in-situ cell-by-cell calibration of EM and HAD calorimeters, leading to significant improvements:
  - $Z \rightarrow ee$: $\Delta M_Z$=3.35 $\rightarrow$2.93 GeV (~15% improvement)
  - Jet energy resolution (~15-25% improvement)




Jet energy resolution



# Muon System

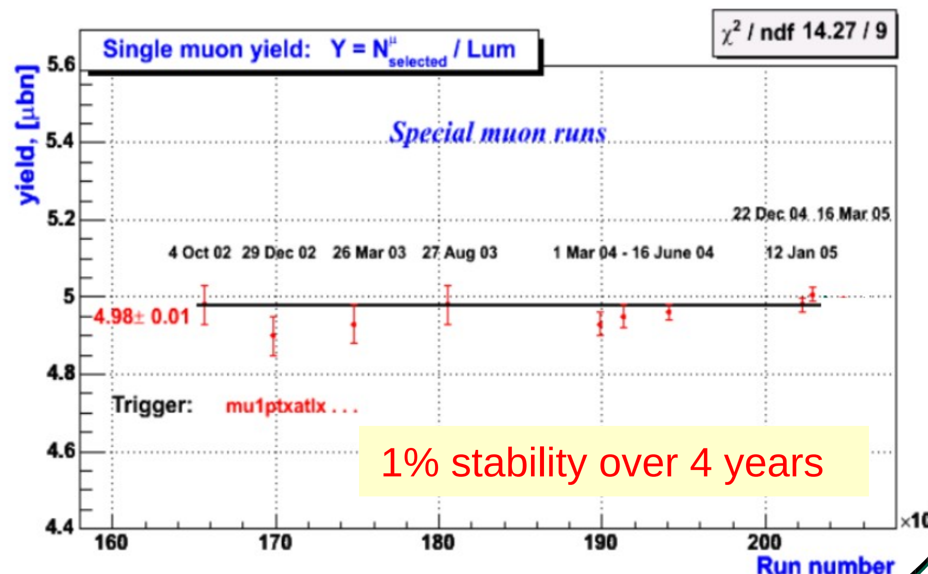
- Three layers of scintillator planes/drift tubes for triggering/tracking.

- Central:
  - Scintillator: 99.8% of 630 counters active
  - PDTs: 98.6% of 8k tubes active
- Forward:
  - Scintillator: 99.9% of 4608 counters active
  - MDTs: 99.7% of 50k wires active

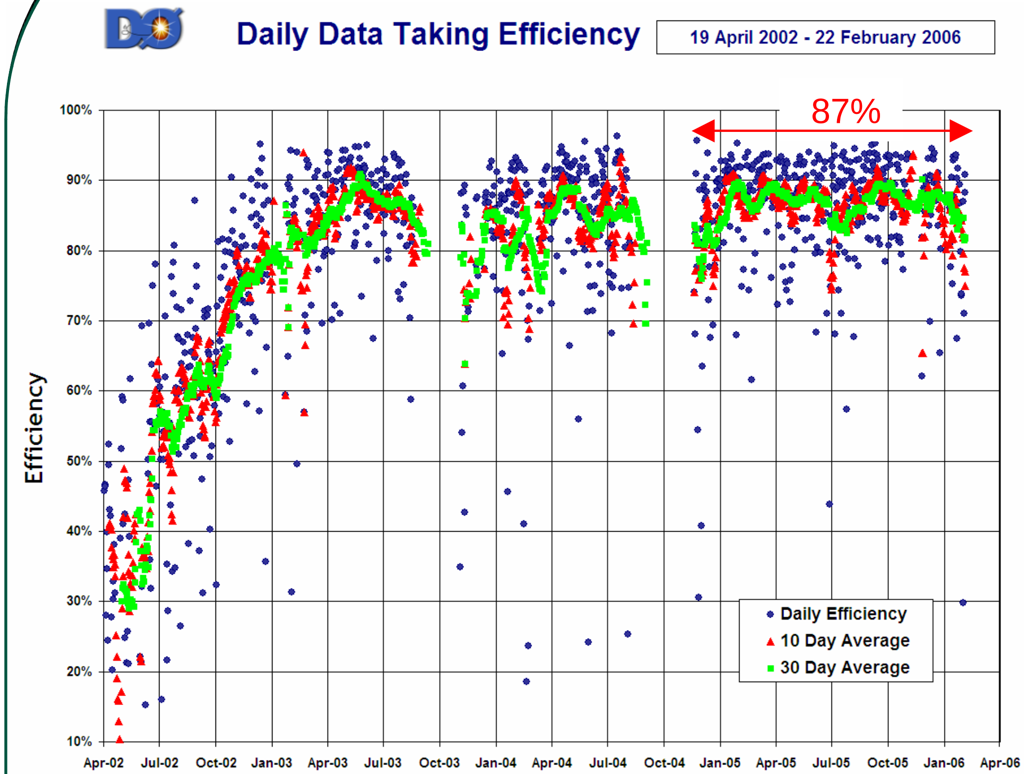
  Expect ~10% degradation (mainly in phototube) at 15 $fb^{-1}$

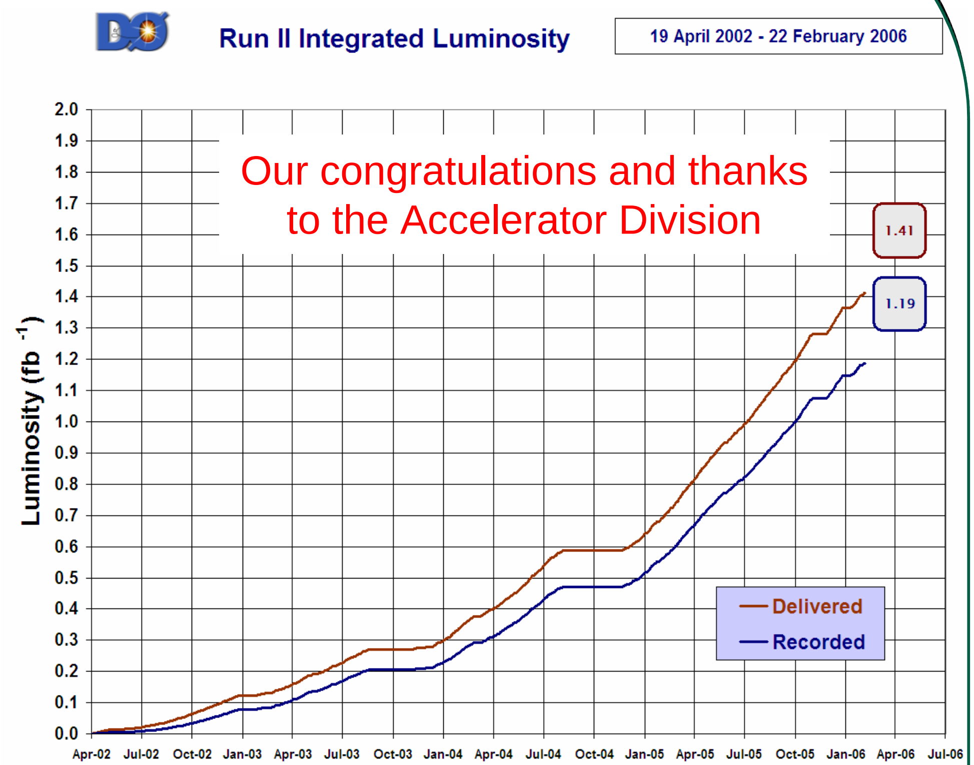
- Very stable
- Coverage up to $|\eta|<2.0$.
- High and uniform efficiency (average ~94%)

⇒One of the strengths of DØ!



# DØ Detector Operations




- The detector is operating well, collecting physics quality data with ~90% efficiency.
- Main sources of inefficiency:
  - ~5%: trigger system disables
  - ~5%: being/end stores, failures
- Have run efficiently at the higher luminosities:

  e.g. ~87% during record store on 1/6/06 of initial luminosity ~$1.73 \times 10^{32}$ $cm^{-2}s^{-1}$

- Since April 19, 2002:
  - 1.41 $fb^{-1}$ Delivered,
  - 1.19 $fb^{-1}$ Recorded

$\Rightarrow$ average efficiency over whole Run IIa with full detector readout: ~84.4%

# Computing

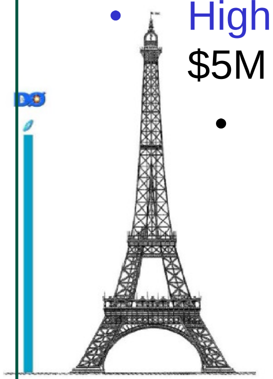
- DØ's computing and Computing Model continue to be a success.
- FNAL facilities and infrastructure for data storage, farm production and user analysis
  - 1.6 petabytes of data on tape
  - Sequential Access via Metadata (SAM) delivers over 6 B events/week to users .


- Highly successful SAMGrid activities supplied $5M in computing value to DØ
  - Reprocessing 1B events from raw data in 6 six months (March-Nov 2005) at 12 sites.

    ⇒ largest HEP activity on the Grid ever

    ⇒ apply uniform improved reconstruction version to full Run IIa dataset.
  - Re-fixing 1.4 B events in 5 weeks—at 7 "sites" including interoperating with LCG and OSG

    ⇒ apply improvements/correction after cut of production release (e.g. CAL calibration)

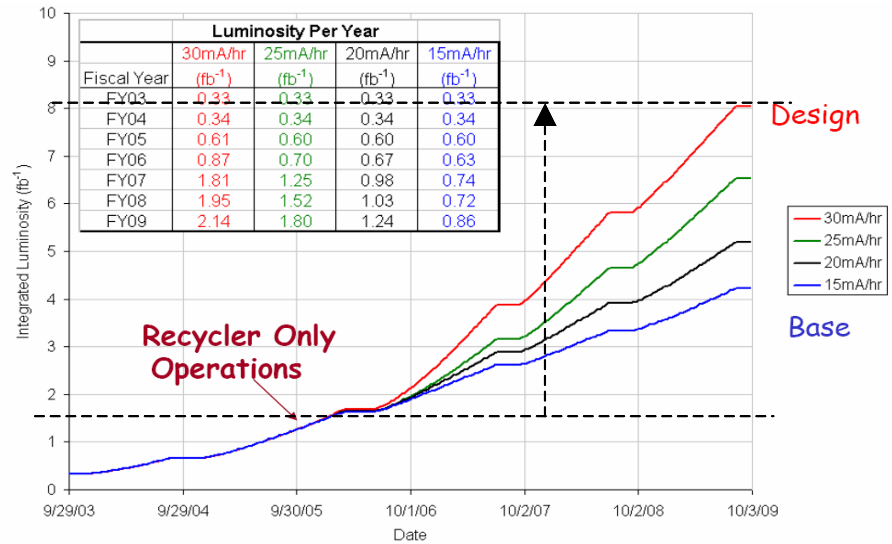


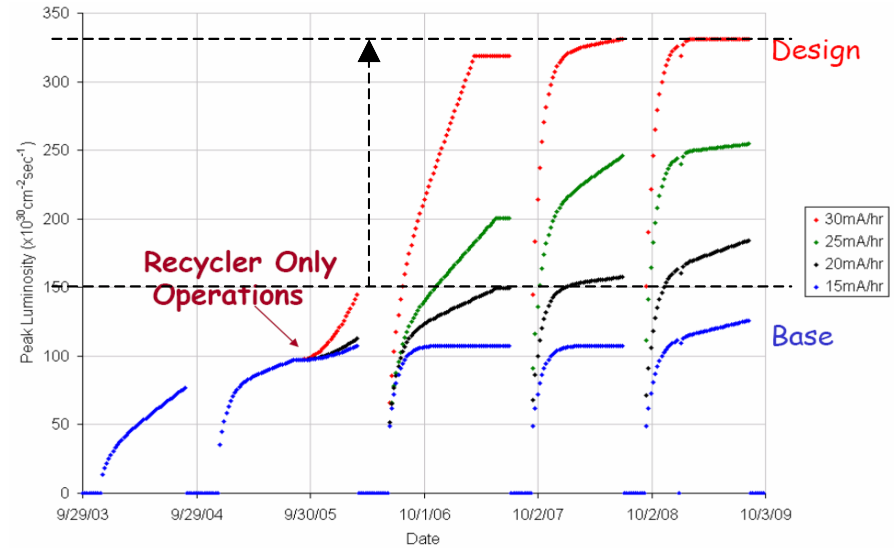
- Monte Carlo significantly increased production as ramp up SAMGrid usage (~150M events since Oct 2005)
- Centralized event streaming (a.k.a. "skimming") based on reconstructed physics objects.
- Common root-based Analysis Format (CAF) introduced last year.

  ⇒ maximize development of common tools and analysis code sharing

# Detector Upgrade

- The DØ Run IIb Upgrade Project is a suite of upgrades designed to prepare the DØ detector to effectively handle larger integrated (x3-6) and instantaneous (x2) luminosities:



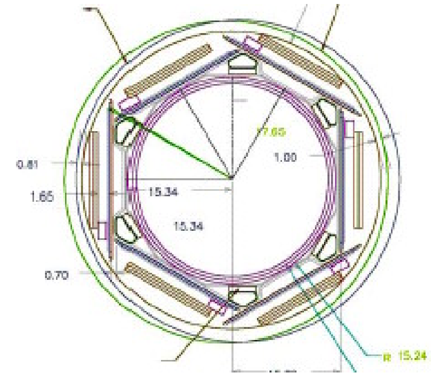



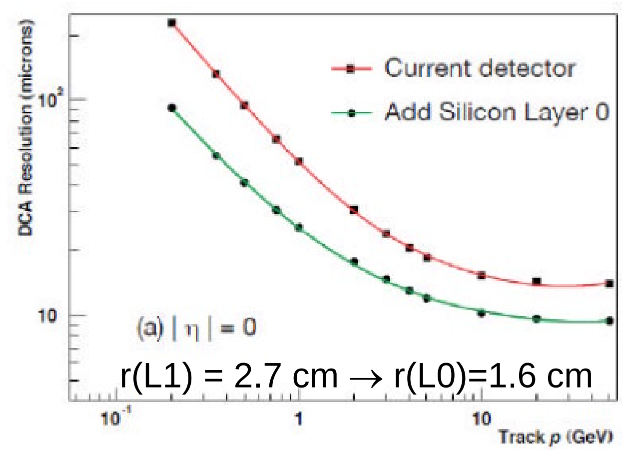

  - Tracking Upgrades
    - Layer 0 Silicon Detector
    - Enhanced front-end boards (AFE II) for CFT: a relatively recent increase in scope.
  - Trigger Upgrades to keep trigger rates under control
    - Level 1: Central Track Trigger, Calorimeter Trigger, Cal Track Match
    - Level 2: Silicon Track Trigger, Processor Upgrades
  - DAQ/Online System Upgrades to handle data rates

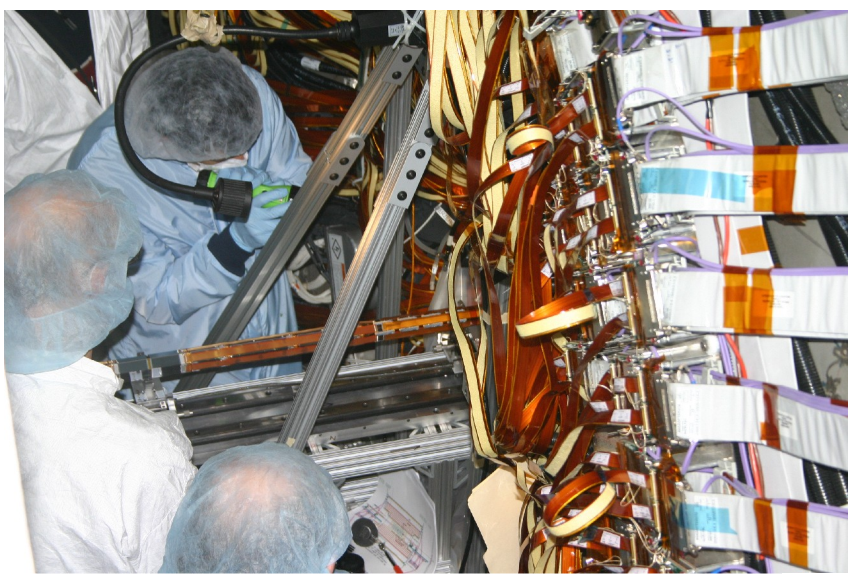
- In great shape: all hardware is available, tested, and installation is in progress during the ongoing shutdown (14 weeks duration, started on Feb 23, 2006).
- AFE II boards in production. Full complement expected by Oct. 2006. Installation during short accesses in Summer/Fall 2006.

# Tracking Upgrade: Layer 0

- Additional layer of silicon detectors designed to fit inside the current SMT:
  - Mitigate potential tracking losses due to radiation damage and detector aging
  - More robust tracking and pattern recognition at high instantaneous luminosity
  - Improved impact parameter resolution (~x2).
- 48 sensors mounted on six-sided carbon fiber support structure; SVX4 readout chips.
- Significant attention devoted to suppressing noise.
- Installation challenging due to extremely tight clearances (~1mm) involved.



- Current status:
  - Detector has been successfully installed, fully biased and read out.
  - Noise performance is exceptional, with no significant coherent noise component.

# Trigger Upgrade

## Level 1

- Calorimeter Trigger: complete replacement. Sliding windows algorithm for CAL object finding (higher efficiency, sharper turn-on curves, topological triggers)
  Status: cabling and in-situ verification of functionality in progress.
- Central Track Trigger: replacement of track finding modules. Larger FPGAs allowing singlet equations (higher efficiency, sharper turn-on curves)
  Status: cabling complete; in-situ verification of functionality in progress.
- Cal-Track Trigger: new system to match calorimeter objects and tracks. Improved rejection and tau trigger capabilities.
  Status: hardware and firmware in place and successfully tested. Trigger latency measured.
  [We will return to operation with old latency and then move the whole detector to the new one.]

## Level 2

- Upgraded/additional processors
  Status: already running at DØ.
- Silicon Track Trigger: incorporation of new Layer 0 inputs
  Status: cabling and in-situ verification of functionality in progress.

Specification (rate @ $3\times10^{32}$ $cm^{-2}s^{-1}$):

- Level 1: 1600 Hz
- Level 2: 900 Hz
- Level 3: 55 Hz DC

Significant progress on Run IIb trigger list design:

- Level 1: almost complete (1680 Hz)
- Level 2: almost complete (950 Hz)
- Level 3: underway. Improved functionality of tools and new filters.

# DØ Physics Program

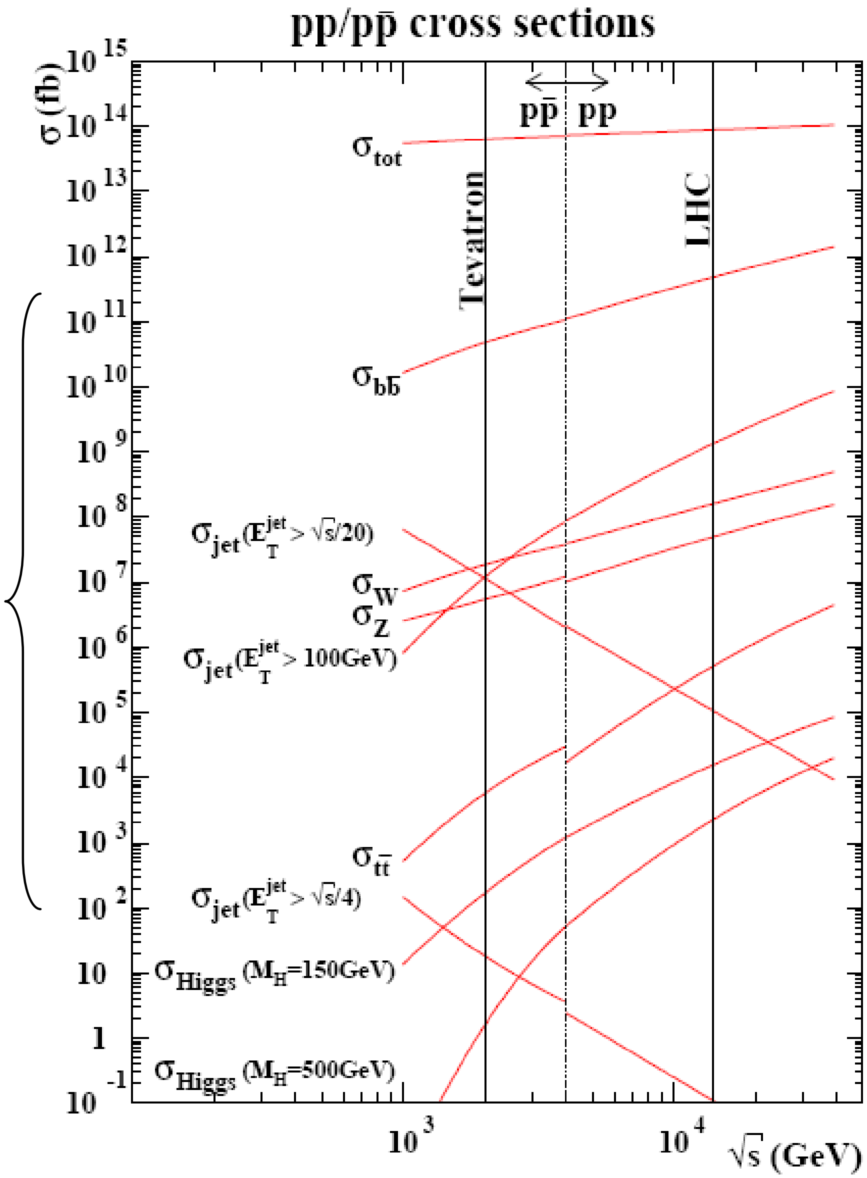
- During the last decade the Standard Model has been confirmed experimentally beyond reproach. However, it is believed to provide only an incomplete description of the world.

- Confront the Standard Model via precision measurements in
  - Bottom quark,
  - QCD,
  - Electroweak and
  - Top quark sectors.

  9 orders of magnitude in production rate

- Direct search for particles and forces beyond those known:
  - quark substructure,
  - Higgs,
  - Supersymmetry,
  - Extra Dimensions, etc.

- Here just giving an brief overview of recent measurements.

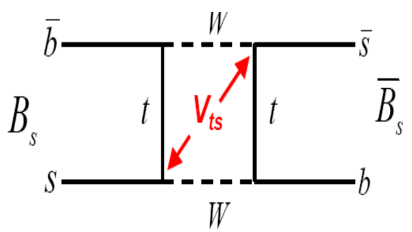


# B Physics

- Measure particle production and decay properties.
- Confront the unitarity triangle in ways that complement measurements at $e^+e^-$ B-factories, e.g. throught the $B_s^0$ system.
- DØ benefits greatly from large muon acceptance and forward tracking coverage.
- Ten new ~$1fb^{-1}$ analysis approved for Moriond. Most are WORLD'S FIRST or WORLD'S BEST.

## $B^0_d$/ $B^0_s$ Mixing

- In the SM B-mixing is explained by box diagrams:

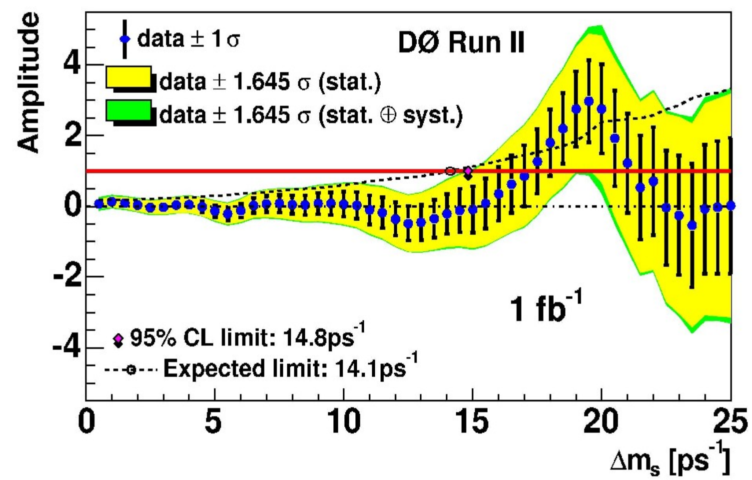


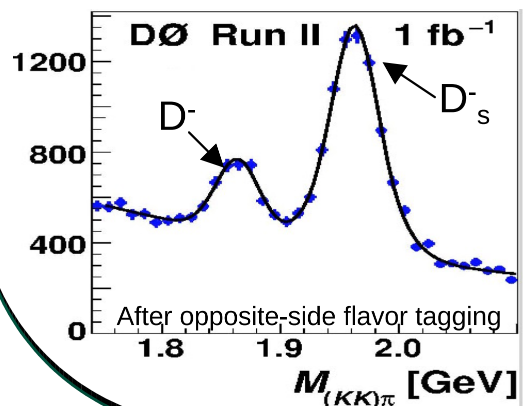

$$\begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix}$$

⇒ constrains $V_{td}$ and $V_{ts}$ elements of the CKM matrix

⇒ sensitive to new New Physics

⇒ $\Delta m_s/\Delta m_d$ free from many theoretical uncertainties

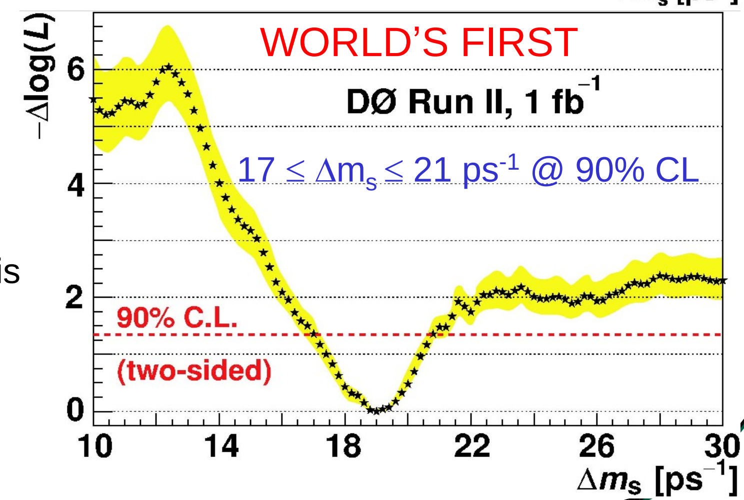



Exploiting semileptonic decay:

$B^0_s \rightarrow \mu^+ D^-_s X$, $D^-_s \rightarrow \phi\pi^-$, $\phi \rightarrow K^+K^-$

Further improvements to the analysis underway (flavor tagging, adding channels, etc).
Layer 0 will significantly improve performance.



# B Physics

- $B^*_{s2}$ observation WORLD'S FIRST
- Studies of excited B mesons WORLD'S FIRST
- Lifetime difference in $B^0_s$ WORLD'S BEST

  $\Delta\Gamma = 0.15 \pm 0.10$ (stat) $\pm 0.04$ (syst) $ps^{-1}$

- $Br(B_s \to D_s^{(*)} D_s^{(*)})$ measurement WORLD'S BEST

  $Br(B_s \to D_s^{(*)} D_s^{(*)}) = 0.071 \pm 0.32$ (stat) $+0.029\ -0.025$ (syst)

- $Br(B_s \to \mu\nu D_s^{**})$ measurement WORLD'S FIRST
- Limit on FCNC charm decay WORLD'S BEST

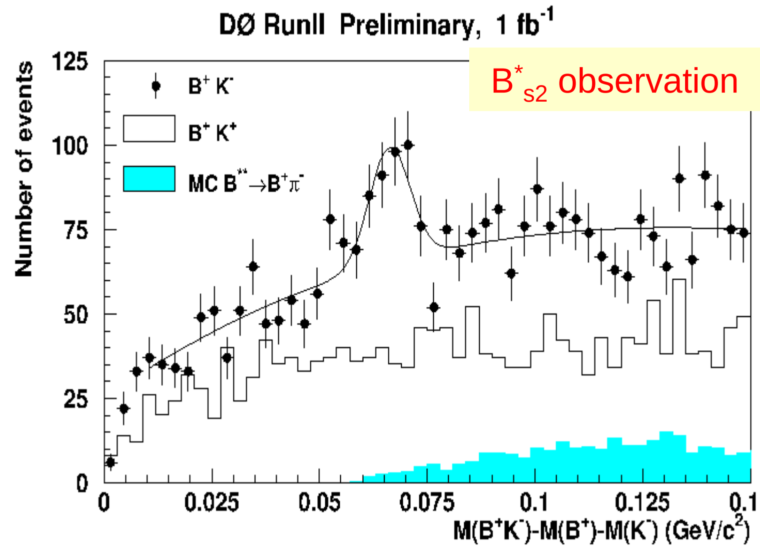
  $Br(D^+ \to \pi^+\mu^+\mu^-) < 4.7 \times 10^{-6}$ @ 90% CL

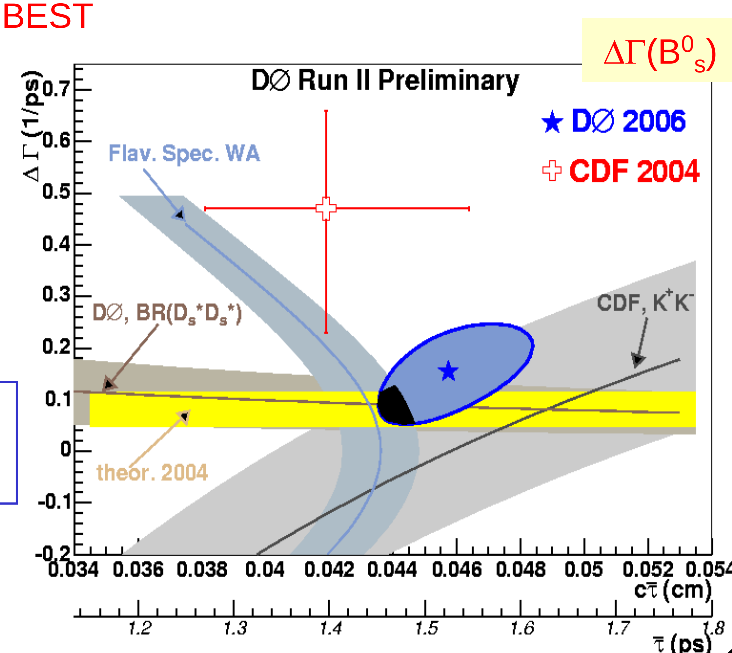
- Limit on CP violation in $B^0$ mixing and decay WORLD'S BEST

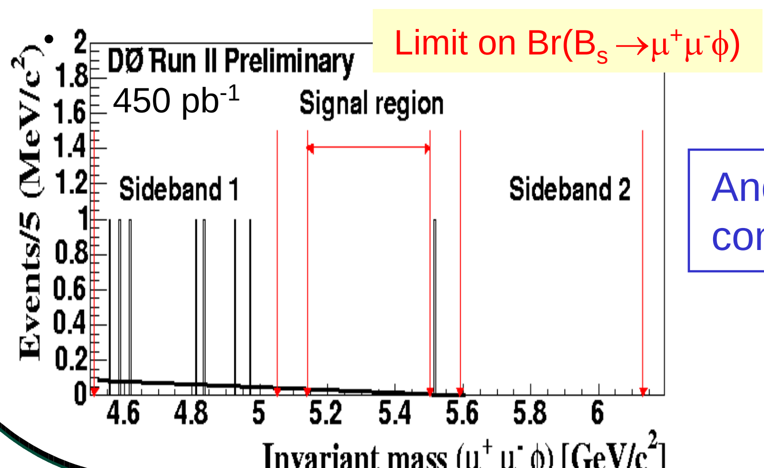
  $Re(\varepsilon_{B0})/[1-|\varepsilon_{B0}|^2] = -0.0011 \pm 0.0010$ (stat) $\pm 0.0007$ (syst)

- Limit on $Br(B_s \to \mu^+\mu^-\phi)$ WORLD'S BEST

  $Br(B_s \to \mu^+\mu^-\phi) < 4.1 \times 10^{-6}$ @ 95% CL



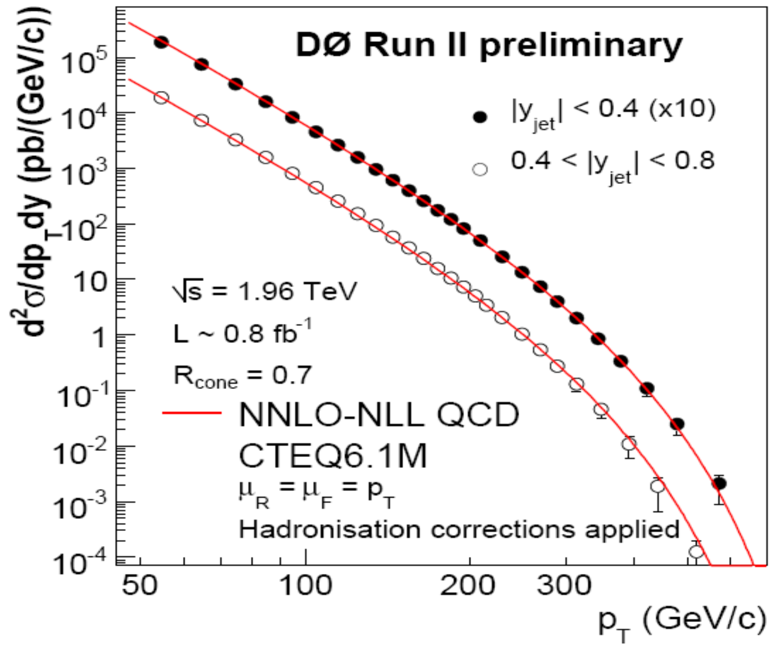




And many more to come by the summer!

# QCD Physics

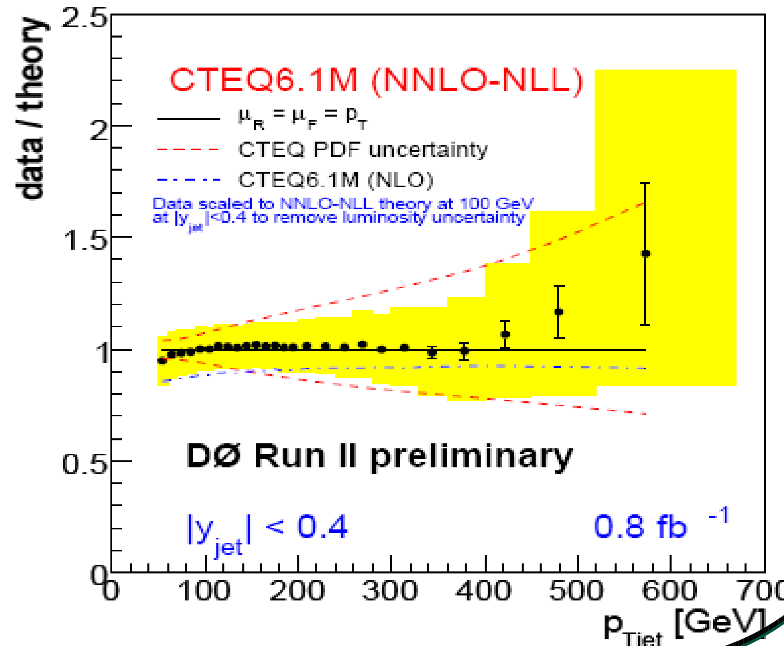
- Use well understood physics processes to:
  - measure the proton structure (e.g. constrain gluon parton distribution function)
  - probe for quark compositeness
  - advance our understanding (both theoretical and experimental) of dominant background to most physics analyses
  - …

Inclusive Jet Cross Section

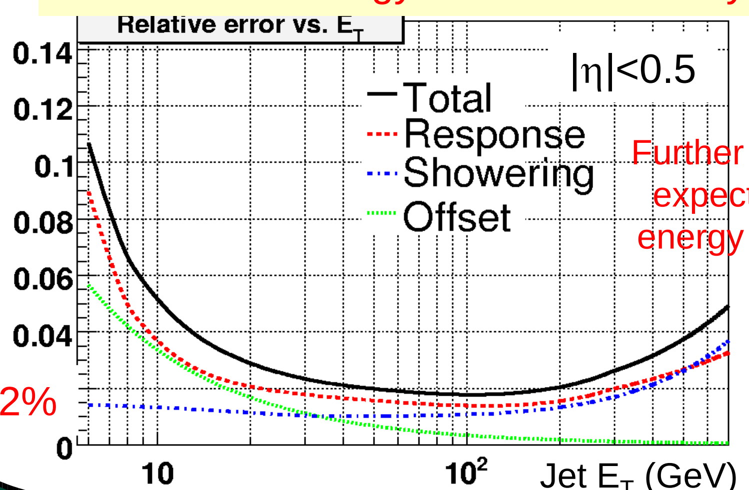



8 orders of magnitude!

- Dominant systematic uncertainty is jet energy scale. New version has allowed to reduce systematic uncertainties by x2.




Relative Jet Energy Scale Uncertainty

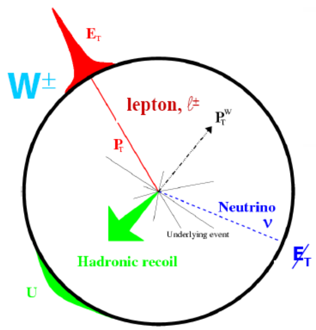


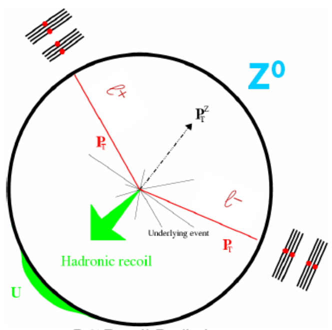

2%

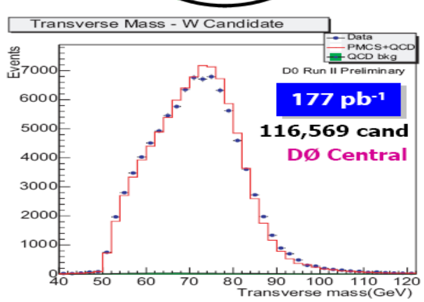
Further improvements expected in new jet energy scale version!

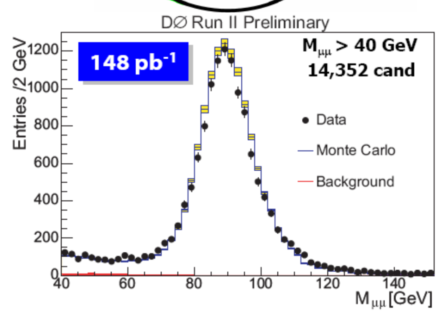
# Electroweak Physics

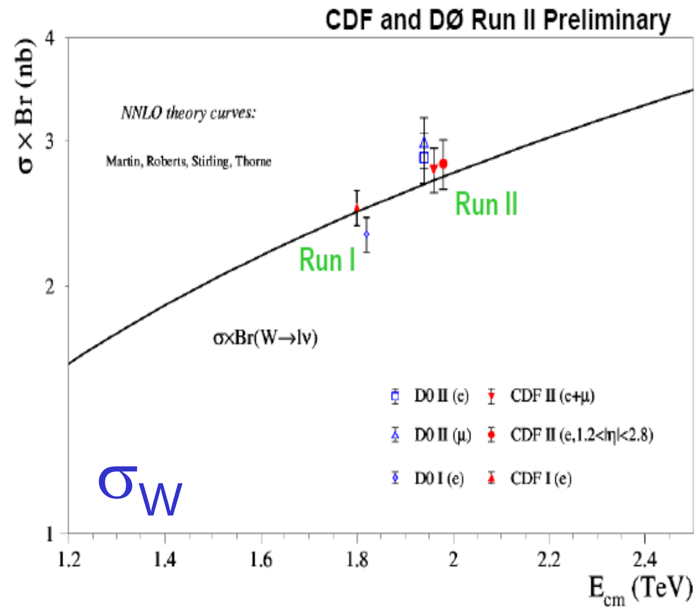
- Indirectly constrain New Physics through precision measurements of electroweak parameters, especially $m_W$.
- Measurements of W/Z+jets, multi-boson production, charge (forward-backward) asymmetry in W(Z) production.
- W/Z production provides a clean/abundant source of high $p_T$ leptons, extremely useful as calibration samples.

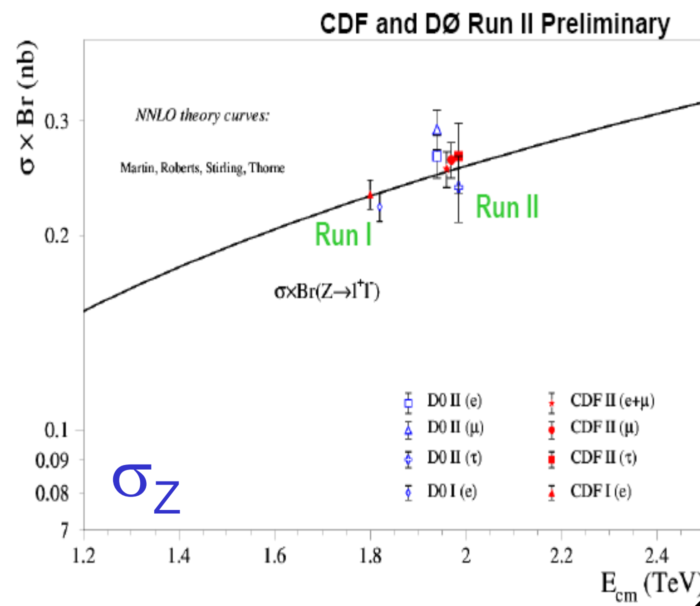


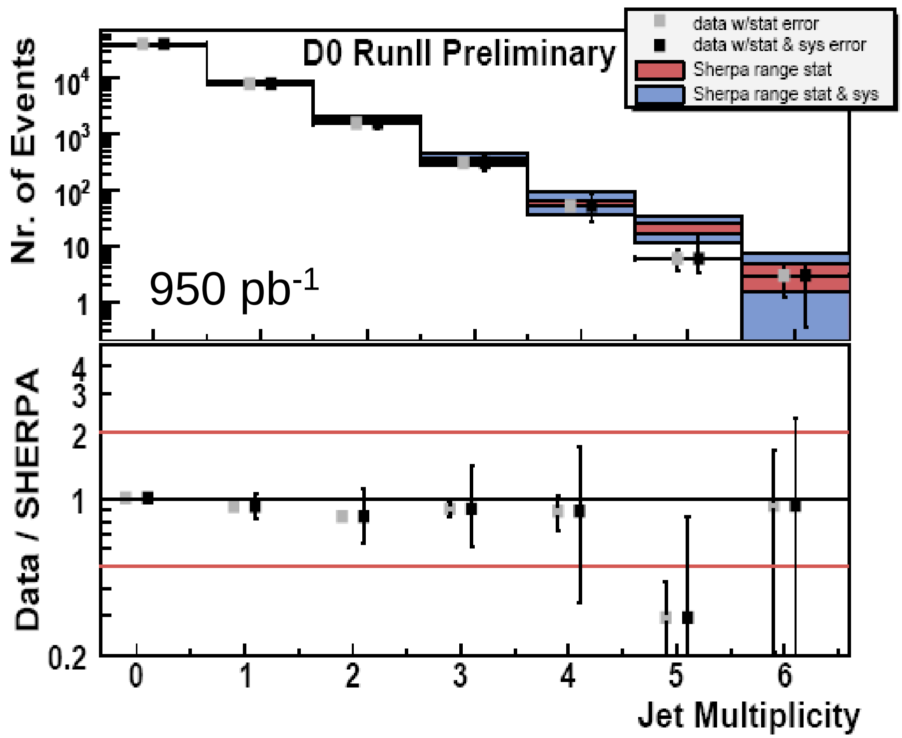

Inclusive W/Z Cross Section

- Measurement in good agreement with NNLO theory. Could eventually be used as luminosity monitor.

# Electroweak Physics

## Z+jets production

- Large available dataset allows to start making precise comparisons between data and simulation for Z+jets up to high jet multiplicities. Accurate modeling crucial for many measurements.




- SHERPA (matrix element+parton shower) MC describes reasonably well high jet multiplicity rate and kinematics.

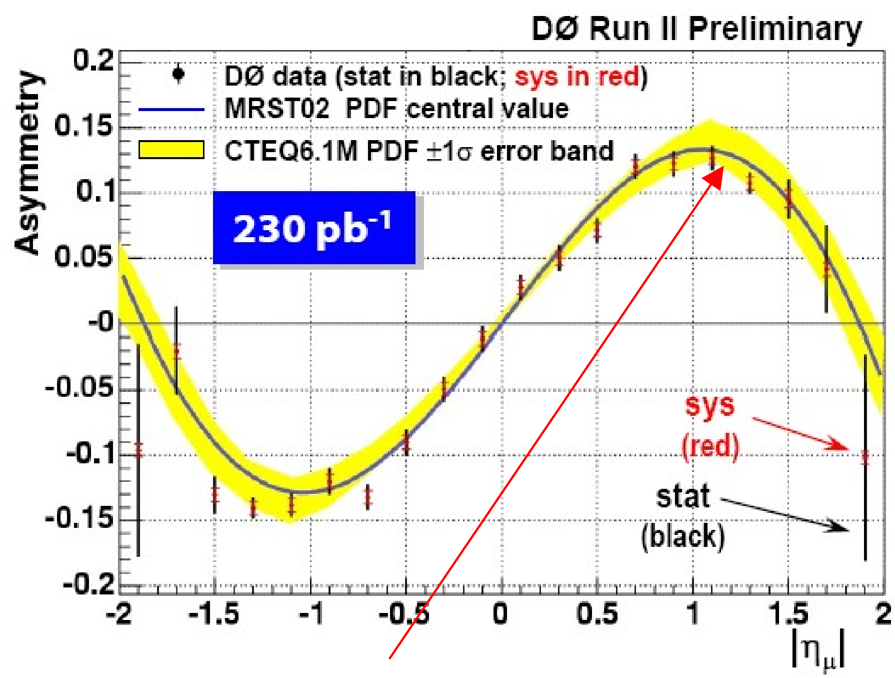
## W(→μν) charge asymmetry

- Provides constraint on parton distribution functions

$$A(\eta_\ell) = \frac{d\sigma(\ell^+)/d\eta - d\sigma(\ell^-)/d\eta}{d\sigma(\ell^+)/d\eta + d\sigma(\ell^-)/d\eta} \approx \frac{d(x)}{u(x)}$$

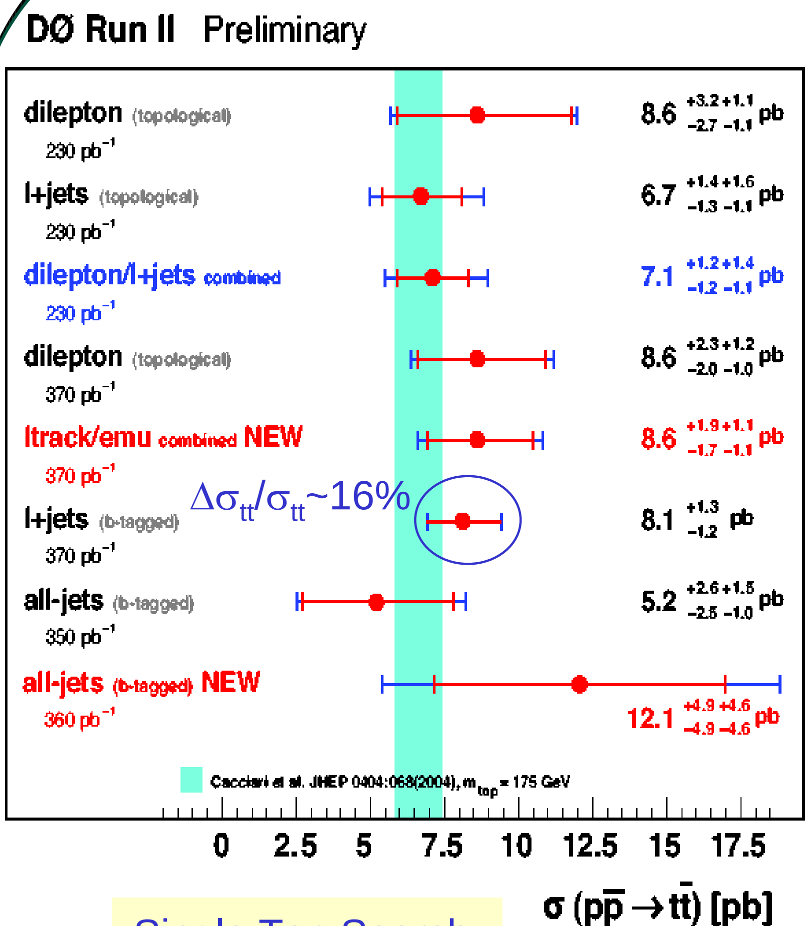
- Widest |η| possible coverage desirable (both muon identification and tracking)

  ⇒ one of DØ's strengths!




Note size of PDF uncertainties (yellow band) compared to experimental measurement

# Top Quark Physics




- Till the LHC, the Tevatron is the world's only source of top quarks.
- Large top quark mass suggests the top quark may shed light on the mechanism of EWSB and mass generation.
- Precision measurements of top quark properties are crucial in order to unveil its true nature.

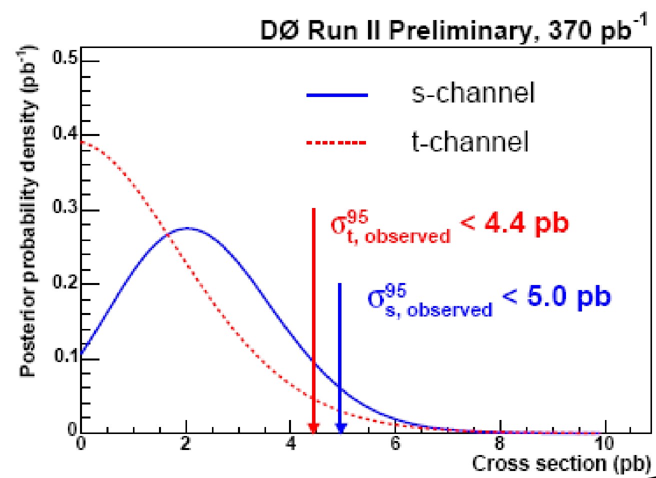
Comprehensive program of measurements underway.

## Top Pair Production Cross-Section

- Measurements in many different channels self-consistent and so far in agreement with the SM prediction. Combination of channels underway.
- As precision continues to increase, comparison among channels will become sensitive to New Physics effects.

## Single Top Search

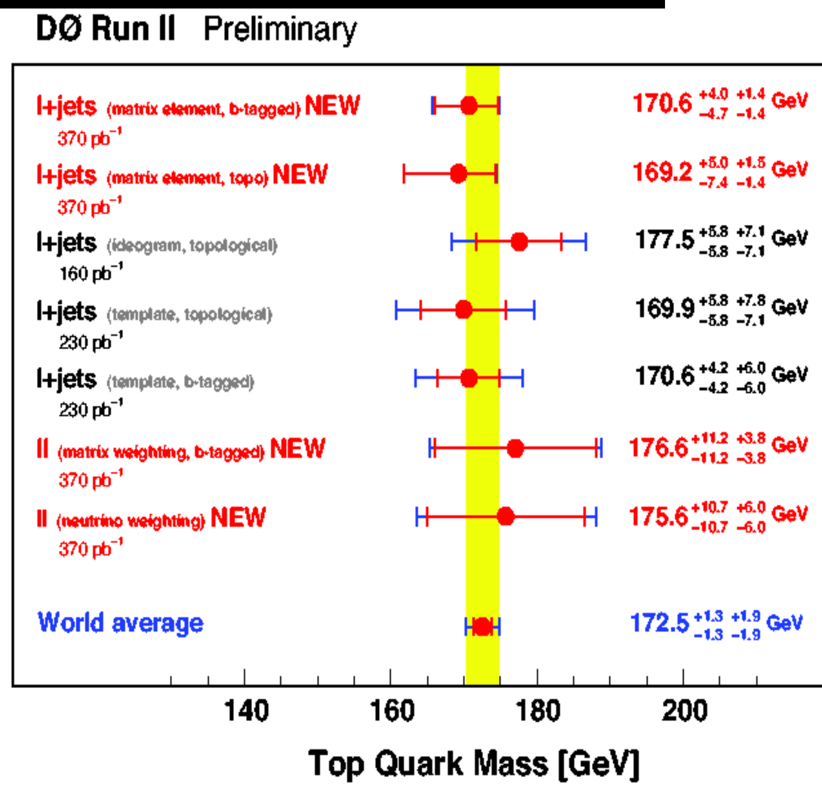
- Search for single top quark production underway with improved algorithms, larger dataset and increasingly more sophisticated analysis techniques.
- Directly sensitive to New Physics in W-t-b vertex. Possibility of a surprise around the corner. If SM-like, 3σ evidence could happen this year!



# Top Quark Physics

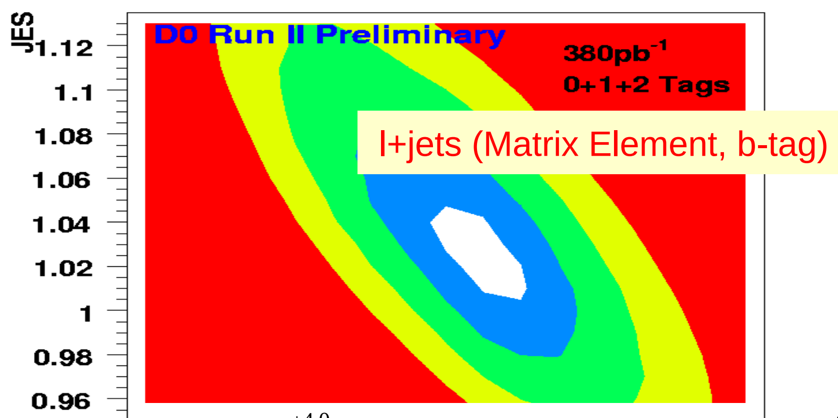
## Top Quark Mass

- Fundamental parameter of the SM.
- Important ingredient for electroweak precision analyses at the quantum level (e.g. constrain SM Higgs boson mass).
- Increasingly more sophisticated analyses (e.g. matrix-element based, $W \rightarrow jj$ mass to constrain jet energy scale uncertainty, etc). Expectation: $\Delta m_t$(DØ)~2 GeV for 2 $fb^{-1}$ (TDR 1996: 3 GeV)




## Other Properties

- Top quark charge: $Q_t$=-4/3 excluded @ 94% CL
  WORLD'S BEST
- W helicity in top quark decays (probes W-t-b vertex):
  $$F_+ = 0.08 \pm 0.08(stat) \pm 0.05(syst); \quad (SM: F_+ = 3.6 \times 10^{-4})$$
  WORLD'S BEST
- $R=B(t \rightarrow Wb)/B(t \rightarrow Wq)$
  $$R = 1.03^{+0.19}_{-0.17}(stat+syst); \; (SM: R \approx 1)$$
  WORLD'S BEST
- …

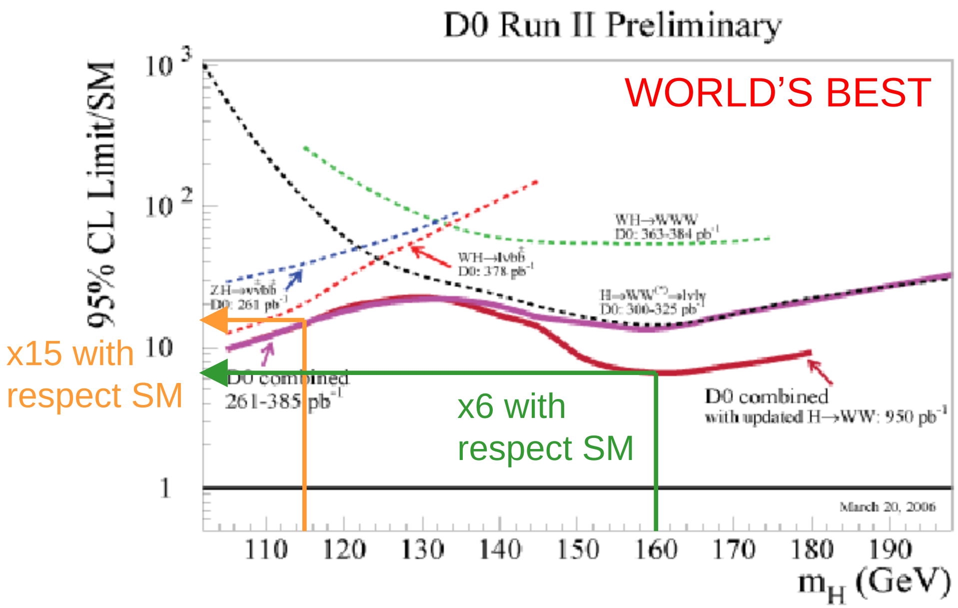


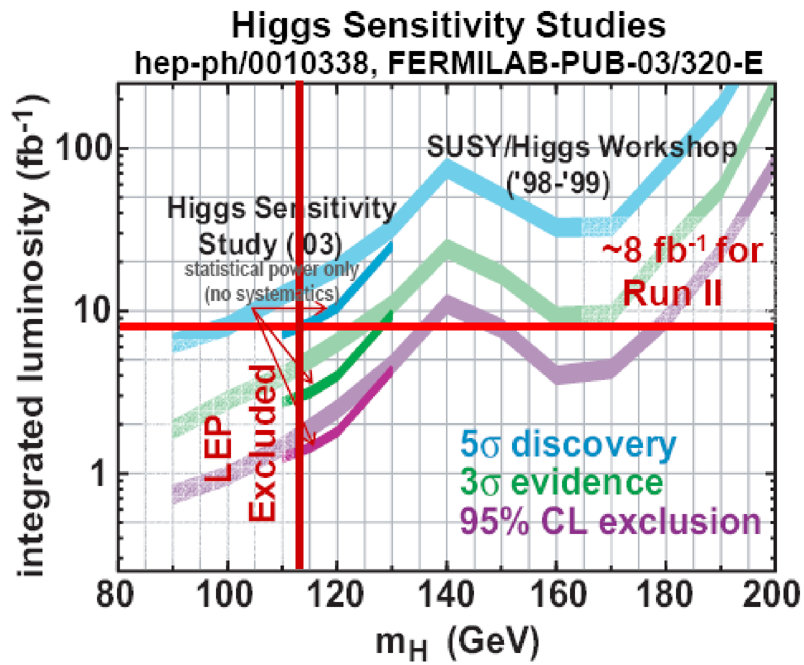

$$m_t = 170.6^{+4.0}_{-4.7}(stat+JES) \pm 1.4(syst) \text{ GeV}$$

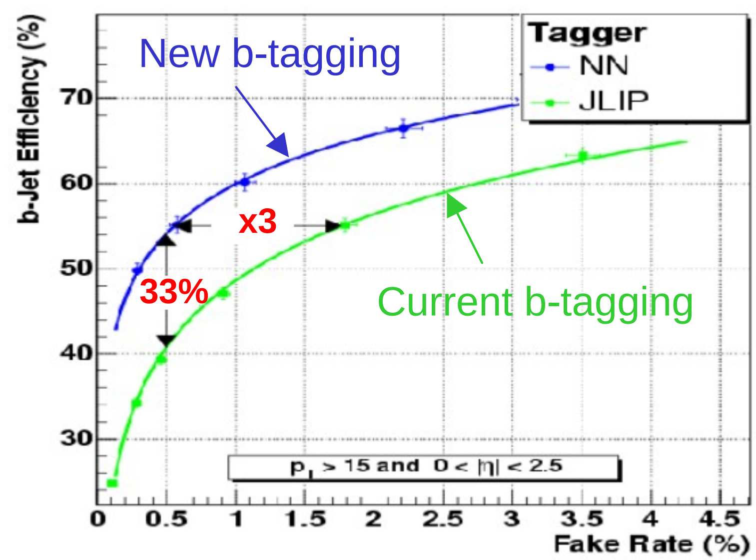
# Higgs Boson Search

Standard Model Higgs

- With 8 $fb^{-1}$, CDF+DØ could see a 3σ evidence up to $M_H \leq 125$ GeV or exclude at 95% CL most of the $M_H \leq 180$ GeV region.
- $M_H < 135$ GeV: H→bb (di-bjet mass)
  - WH →lνbb, ZH →ννbb,llbb
- $M_H > 135$ GeV: H→WW (di-lepton)
  - gg → H → WW →lνlν, WH →WWW → lνlνX
- **Up to 14 analyses recently combined!!**



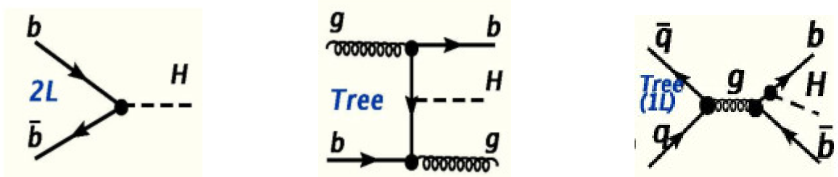




- Expect to reach projected sensitivity through planned improvements (NN-tagger, additional channels, reduced systematics, etc).

# Higgs Boson Search

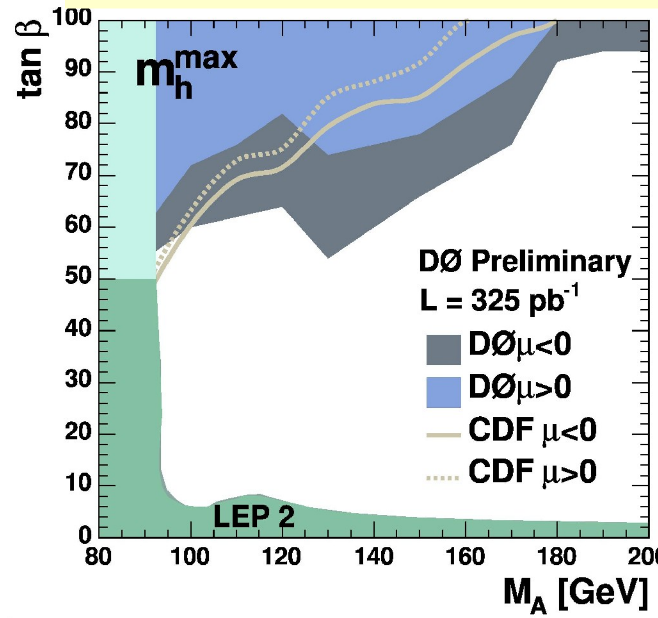
## Beyond Standard Model Higgs

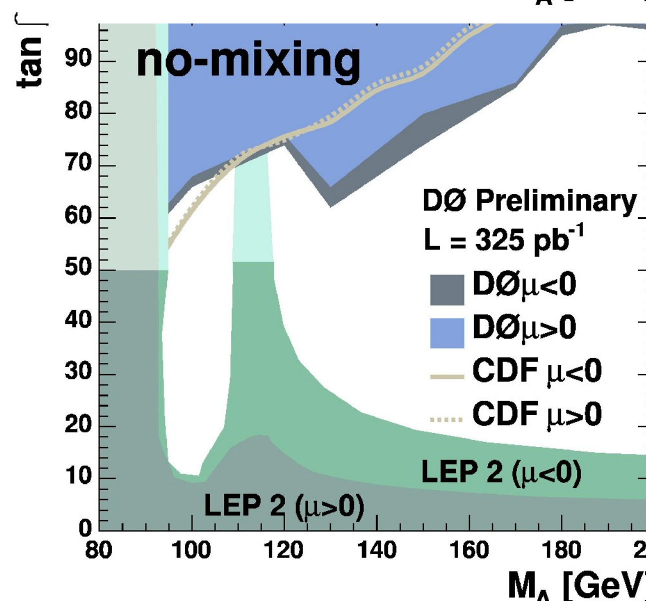
- Many extensions of the SM include two Higgs doublets. EWSB produces five Higgs bosons: $h^0$, $H^0$, $A^0$ and $H^{\pm}$.
- b-b-h coupling $\propto \tan\beta$; large enhancements in cross-section over SM possible (several orders of magnitude).



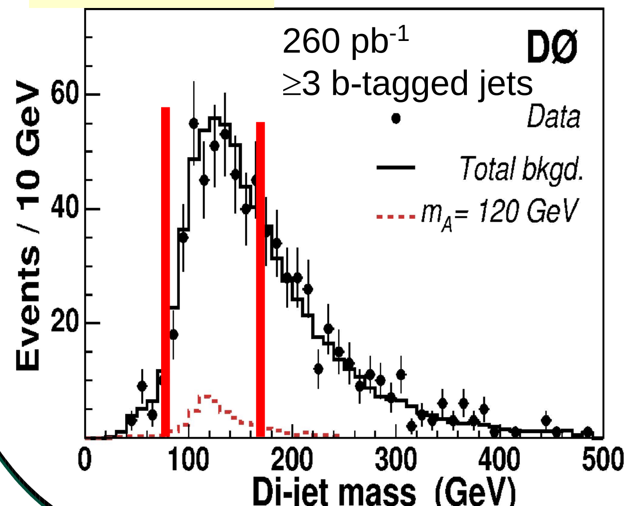

- At high $\tan\beta$, A almost degenerate with $h^0$, $H^0$
  - $B(\Phi \to bb)$~90%, $B(\Phi \to \tau\tau)$~10%

Combined hb(b) and h→ττ searches

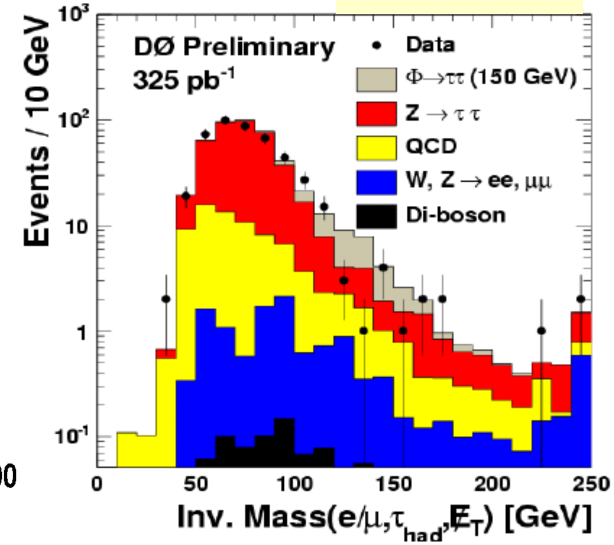



hb(b) Search



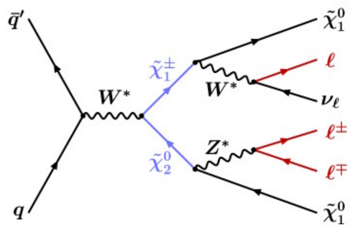

h→ττ Search

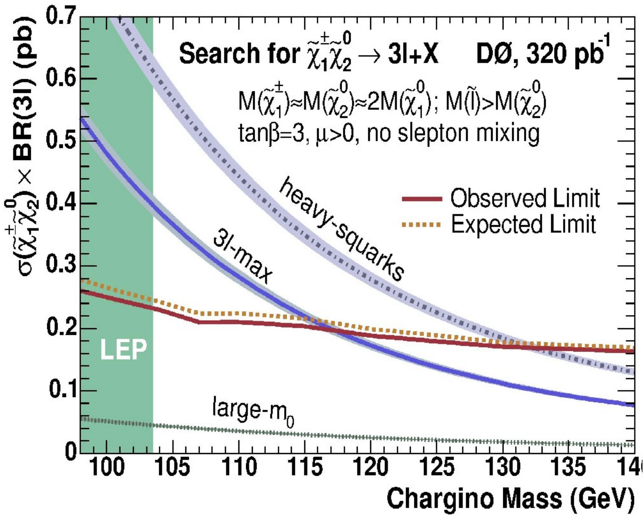


# Searches for SuperSymmetry

- SUSY: solves "Hierarchy Problem", provides coupling unification at the GUT scale, a dark-matter candidate (LSP),.. Different SUSY breaking scenarios (mSUGRA, GMSB, AMSB, etc) predict different phenomenology.

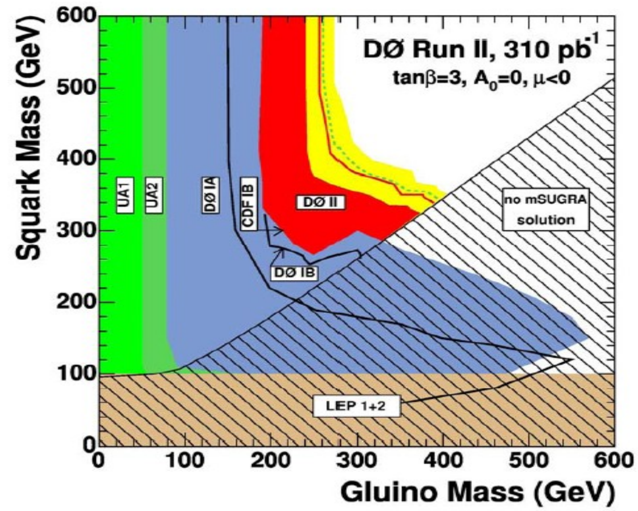
Chargino/Neutralino in 3l+MET



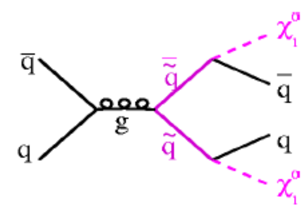



Small cross-section
Small background

WORLD'S BEST



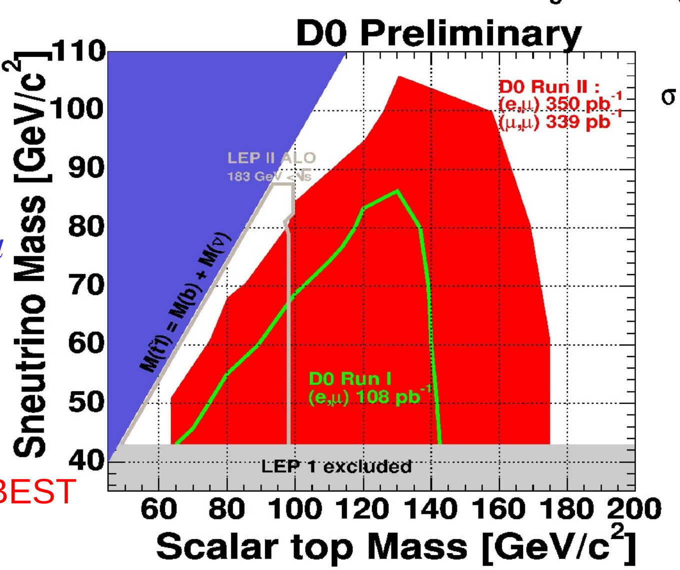

Squark/gluino in multijets+MET



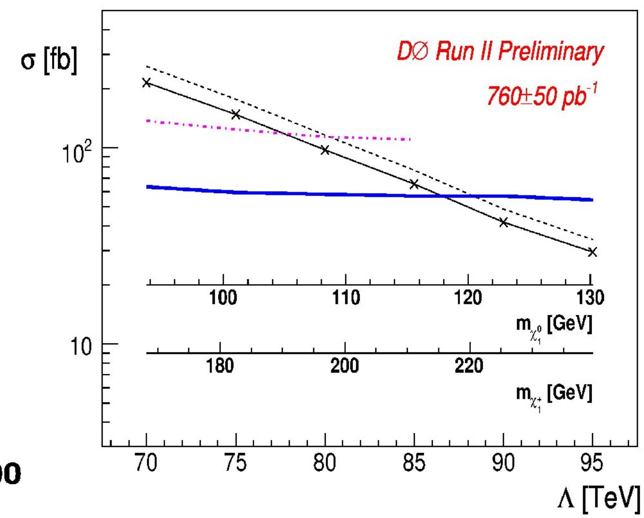
Cross-section ~ pb
Large background
WORLD'S BEST

Stop pairs in 2l+2j+MET

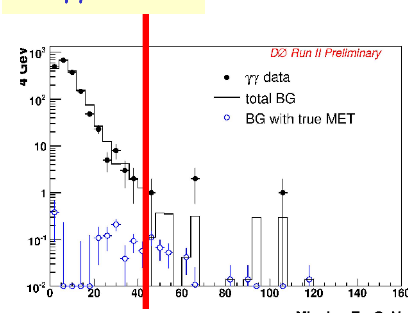
$\tilde t \to bl\nu\tilde\chi^0, l = e,\mu$




WORLD'S BEST



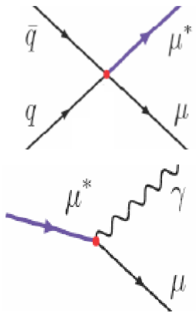

GMSB in γγ+MET

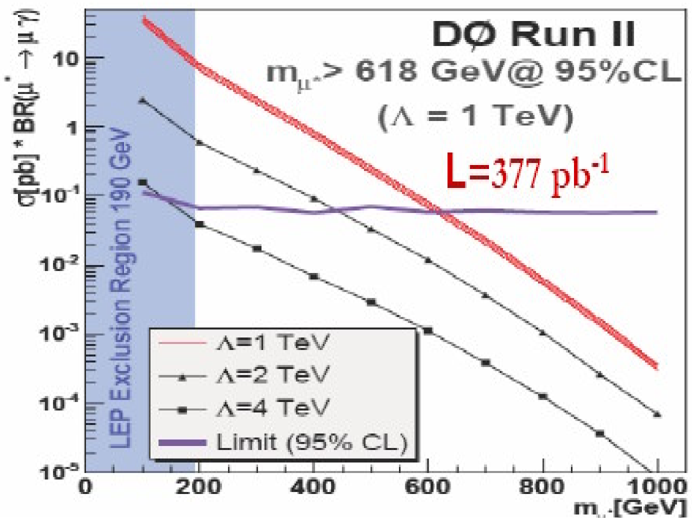


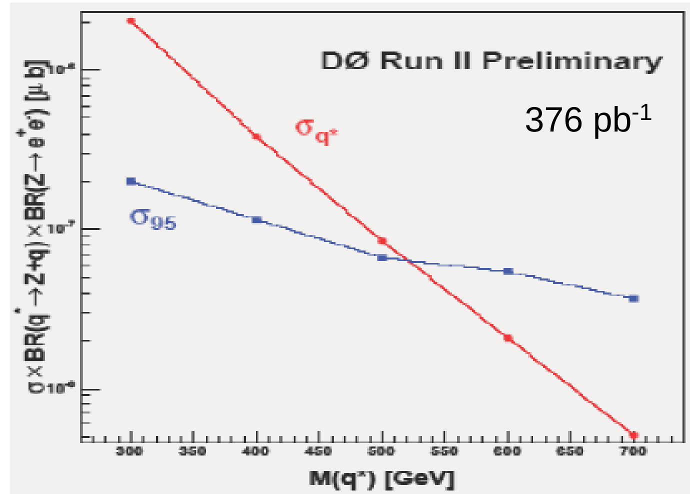

WORLD'S BEST

# Other New Phenomena Searches

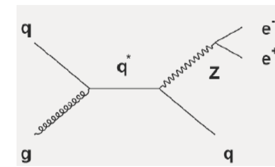
Excited muon ($\mu^*$) in $\mu\mu\gamma$





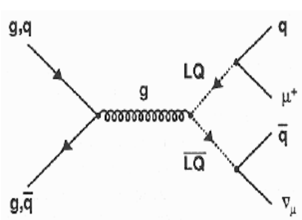



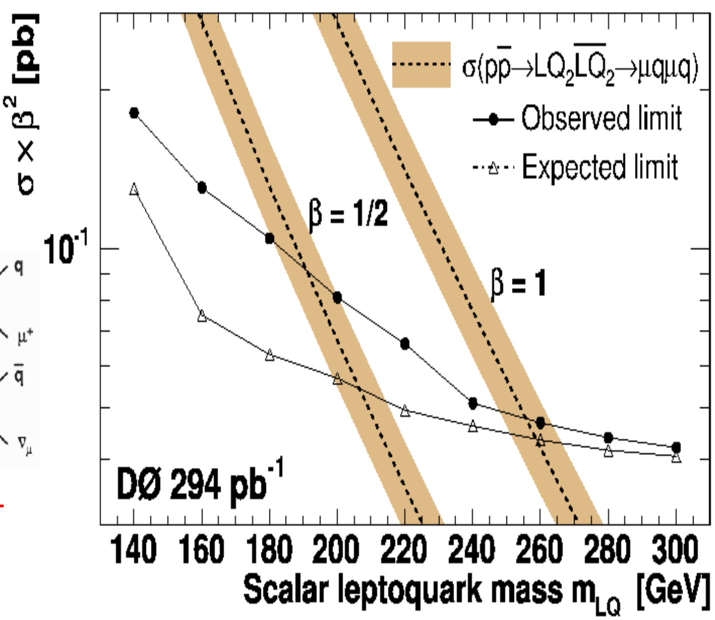

Excited quark ($q^*$) in Z(→ee)+jet



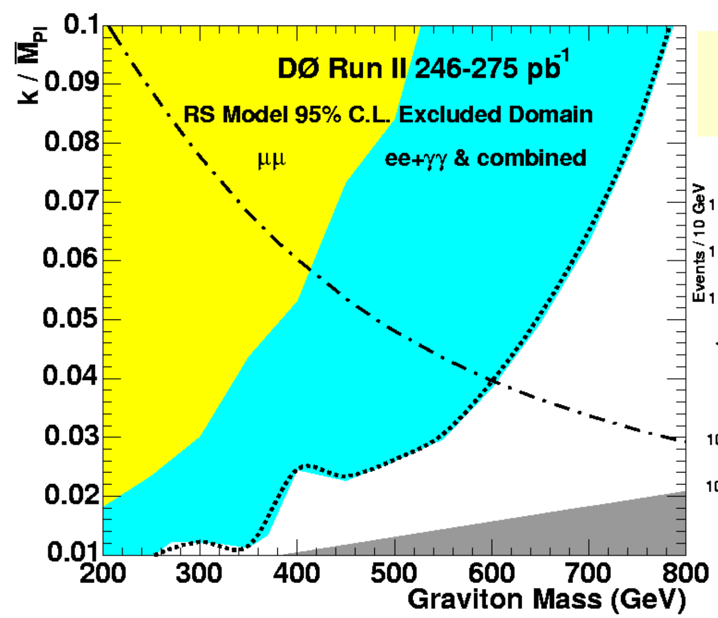
TEVATRON'S FIRST

$2^{nd}$ Generation Lepto-quark in $\mu\mu jj$

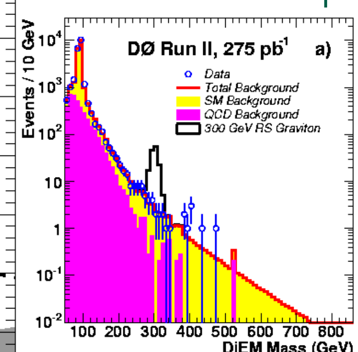





WORLD'S BEST (for β=1)




RS Graviton in ee,γγ and μμ




WORLD'S BEST

A very exhaustive program of searches for New Physics.

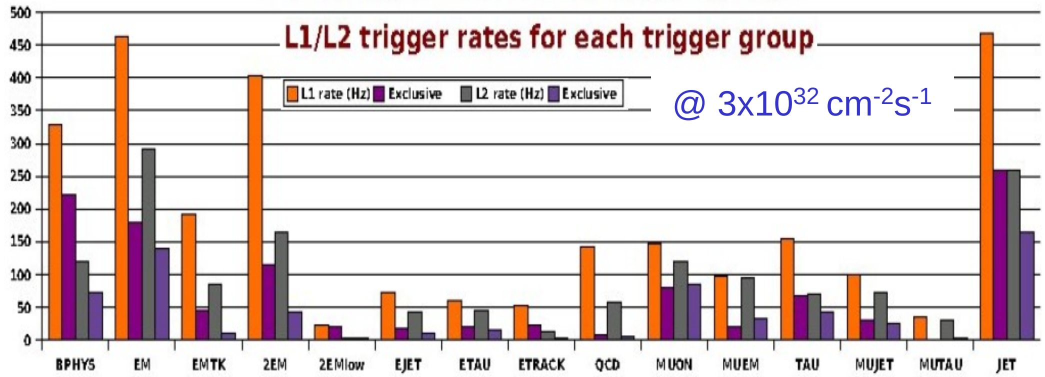
# Physics Summary

- DØ's physics production in full swing.
- 41 publications (accepted or submitted)
  - 2004: 2
  - 2005: 29
  - 2006: 10 (and many more in internal review)
- ~60 new preliminary results presented at Summer'05 (~30) and Winter'06 (~30) conferences. Many will turn into publications during 2006.
- 12 preliminary ~1$fb^{-1}$ analyses presented at Winter'06 conferences, 8 of which are WORLD'S FIRST or WORLD'S BEST. Many more expected for Summer'06 conferences.
- >250 invitations to conferences per year
  - Invited talks to all major conferences
- For full list of DØ preliminary and published results (including Plain English Summaries):

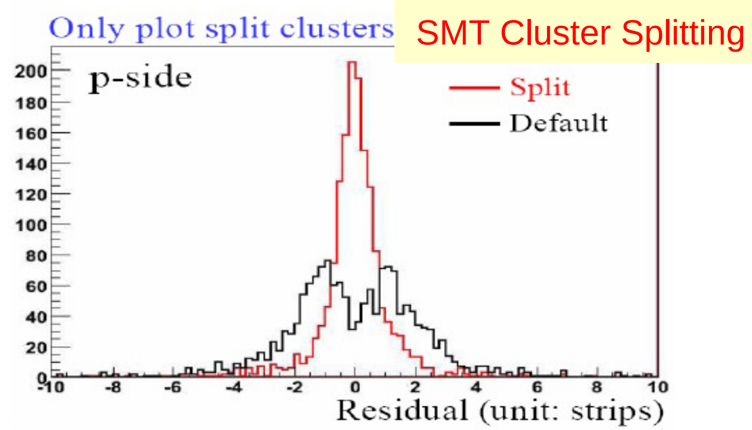
  http://www-d0.fnal.gov/Run2Physics/WWW/results.htm

# Getting Ready for High Luminosity

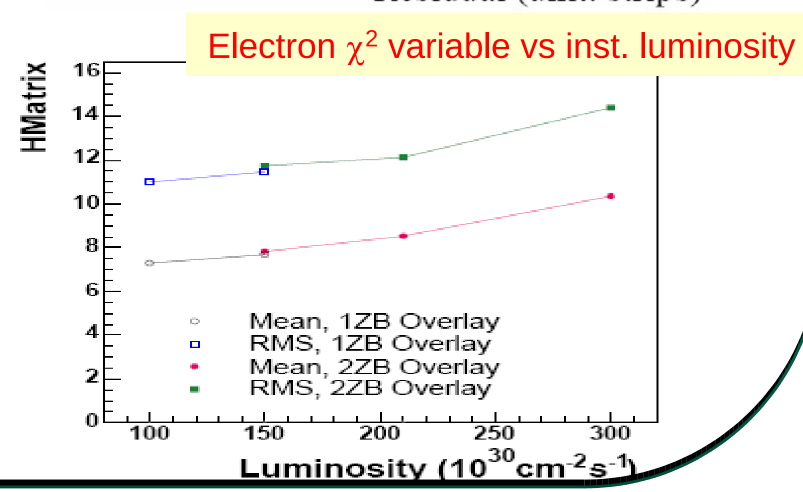
- Physics at high luminosity is challenging:
  - reduced efficiencies (trigger, object ID),
  - increased bckg (trigger rates, fakes),
  - increased event reconstruction time (at Level 3, offline).
- A number of developments/studies underway to maintain physics capabilities at Run II design instantaneous luminosities. Some examples:




- Run IIb trigger upgrade: trigger list able to operate at $3\times10^{32}$ $cm^{-2}s^{-1}$ almost in place. Developments at Level3:
  - Tracking: x2 faster
  - Secondary vertex: x2 lower mistag rate
  - Electron using longitudinal+transverse shower shape information: ~100% efficient now.
  - …




- Offline reconstruction (new version for Run IIb):
  - Improved cluster position resolution in SMT via cluster-splitting algorithm.
  - Tracking: 10-20% faster, x2 lower fake rate, BUT some efficiency loss at low $p_T$ (<1.5 GeV) related to SMT cluster-splitting. Under investigation.
  - Electron ID cut optimization studies.
  - Jet confirmation using tracking, …



# Status of MOUs

- Surveyed FTE[(1)] effort dedicated to DØ
  - For each year 2005-2009[(2)]
  - Named individuals in following categories: faculty, scientist, postdoc, student
- Requested details of institutional commitments to “service”.

Notes:

(1) FTE ≡ fraction of total working week.
NOT fraction of research time;
NOT fraction of 40 hour week

(2) 2008-2009 “optional” - not part of MOU

- At first sight, total FTEs look adequate:

| Year | 2005 | 2006 | 2007 |
|---|---|---|---|
| US FTE totals | 240 | 210 | 170 |
| non-US FTE totals | 228 | 214 | 175 |
| All | 468 | 424 | 345 |

but detailed analysis leads to some concerns:

- lack of expertise and institutional commitments in some critical areas of operations and algorithms,
- iteration with individual institutes continuing.

- Very useful information in managing the collaboration.

- Plan to sign formally all MOUs by June collaboration meeting.

# Tevatron Collider Experiment Task Force

- HEPAP survey suggested a big gap between needs and availability
- CDF and DØ Fermilab groups have lost 15-20 FTEs per experiment over past 3 years

⇒ Task force appointed by Pier Oddone to:
  - analyze needed/available manpower through FY09 and
  - recommend strategies to improve balance.
- Subgroups to analyze effort; list of tasks created and detailed bottom-up estimate of FTE's required to operate.
- Report delivered on January 2006. Focus was a detailed analysis of needs/availabilities for the year 2007. Estimates for 2008-2009 less certain and based on availability for 2007; scaled down by reduction factor extracted from HEPAP numbers.

- Needed effort:
  - "Service": rather well defined and categorized
  - "Physics": less well defined what "needed" means. Three different measures:

  1) "core" physics program:

     Precision measurements: $m_t$, $V_{tb}$, $M_W$, $B_s$ mixing, $B_s$ lifetime

     Searches: SM and MSSM Higgs, SUSY searches, Z', $B_s \rightarrow \mu\mu$

     [Wouldn't/couldn't restrict to such narrow program!]

  2) "= service" physics program: assume ~50% service fraction

  3) "available" physics program: = MOU availability – "service" needs

# Tevatron Collider Experiment Task Force

| FTEs | 2007 | 2009 (*) |
|---|---|---|
| Operations+offline+management | 110 | 103 |
| Algorithms | 55 | 21 |
| Total service needs | 165 | 124 |
| Physics needs (1 / 2 / 3) | 86 / 165 / 180 | 66 / 124 / 76 |
| Total needs (1 / 2 / 3) | 251 / 330 / 345 | 190 / 248 / 200 |
| Available (MOU) | 345 | 200 |
| Needs – Available (2) | +15 | -48 |

1) "core" physics program
2) "= service" physics program
3) "available" physics program

(*) Extrapolated numbers using HEPAP-based scaling

- A number of recommendations made to the experiments and Fermilab to reduce needed effort and increase availability. Some real progress in a number of fronts already.
- Extrapolating manpower needs & availability from where we are now to 2007:
  - subject to large uncertainties,
  - just looking at total FTEs can hide many problems (detailed analysis required of "service" needs versus commitments),

  but provisional conclusion is that problem is solvable.
- Extrapolating from what we know now to 2008-2009 is largely guess work until:
  - 2007 manpower needs and availability demonstrated to be realistic,
  - progress on antiproton accumulation for Tevatron,
  - experiments demonstrate timely publication of 1-2 $fb^{-1}$ dataset,
  - believable schedule for LHC accelerator announced,

  but working towards ensuring 2008 and 2009 are a reality for DØ.

# FNAL/DØ: Overview

- All of the above would not be possible without the hard work of hundreds of DØ Collaborators and the FNAL/DØ group.

- FNAL/DØ group: ~54 members ⇒ ~8% of the collaboration – largest DØ group
  - Particle Physics Division: 44 (includes 6 Post-Docs, 2 Wilson Fellows, 1 Lederman Fellow)
  - Computing Division: 7 (includes 1 Post-Doc)
  - Accelerator Division: 1
  - Technical Division: 1
  - Visitors: 1

*Current 7 Post-Docs just a historical low.*
*We are recruiting to reach a total of 10.*

- Members of the FNAL/DØ group provide strong contributions to the experiment in a variety of areas, including:
  - Responsible for major detector parts
  - DØ upgrade
  - Computing and software development
  - Active participation in all stages of physics analyses

# FNAL/DØ: Leadership

- During the last 12 months, members of the FNAL/DØ group have helped DØ in many key leadership positions:
  - Operations: 12 out of 39 leadership positions (~31%)
  - Upgrade: 19 out of 30 leadership positions (~63%)
  - Computing: 6 out of 14 leadership positions (~43%)
  - Software/Algorithms: 3 out of 22 leadership positions (~14%)
  - Physics: 5 of 13 leadership positions (~38%)

- In the past 3 years, the FNAL/DØ group has provided leaders in most upper management positions:
  - spokesperson,
  - run coordinator,
  - computing and core software leader,
  - software algorithms leader.

- Many senior members of the group provide leadership by example rather than by title.

# FNAL/DØ Physics

- Of the 54 members of the FNAL/DØ group:
  - ~22 involved in reviewing physics analyses in the 36 active Editorial Boards (5 EB chairs).
  - ~12 are actively involved with current physics analyses (in all 6 physics groups)
- Of the 41 (accepted or submitted) publications, members of the FNAL/DØ group have significantly contributed (i.e. are internally listed as authors) to ~10 (i.e. ~24%).
- Recently (last 12 months) accepted or submitted:
  - *Measurement of semileptonic branching fractions of B mesons to narrow D** states (PRL)*
  - *First direct two-sided bound on the $B_s^0$ oscillation frequency (PRL)* WORLD'S FIRST
  - *Search for the rare decay $B_s^0 \rightarrow \phi\mu^+\mu^-$ (PRL)* WORLD'S BEST
  - *WZ production and anomalous coupling limits (PRL)* WORLD'S BEST
  - *Measurement of $B(t\rightarrow Wb)/B(t\rightarrow Wq)$ (PRL)* WORLD'S BEST
  - *Measurement of ttbar cross section using l+jets events with lifetime b-tagging (PLB)*
- Expected publications within next 12 months:
  - *Top quark mass in lepton+jets final state (Ideogram and Matrix Element methods)*
  - *Search for the Standard Model Higgs boson in the $ZH\rightarrow\nu\nu bb$ Channel*
  - *Search for quark-lepton compositeness in dileptons*
  - *Inclusive jet cross section (1 $fb^{-1}$)*
  - *$B_s$ mixing in semileptonic $B_s$ decays using the $D_s\rightarrow\phi\pi$ decay mode (1 $fb^{-1}$)*
  - *$B_d$ mixing measurement using opposite-side flavor tagging (1 $fb^{-1}$)*
  - *$W\gamma$ anomalous couplings and radiation zero*
  - *Measurement of $WW\gamma$ anomalous couplings*
  - …

  and many preliminary results for Summer'06 conferences using the full Run IIa dataset!!
- 14 invitations to speak at international conferences over the last 12 months (many have published proceedings).

# FNAL/DØ Personnel Projections

- Projected FNAL/DØ group activities for 2006-2007:
  - 2006-2007: based on a poll in Summer'05
  - 2008-2009: estimate not requested.

⇒ The FNAL/DØ group is expected to remain strong till the end of Run II, and the continued success of DØ depends critically on maintaining a strong and active FNAL group!!

| FTE | 2006 | 2007 |
|---|---|---|
| Post-Doc | 8.6 | 8.6 |
| Scientist | 27.8 | 22.6 |
| Total FNAL/ DØ | 36.4 | 31.2 |
| Total DØ | 424 | 345 |
| Fraction | 8.6% | 9.0% |

- Effort breakdown for 2006:

| FNAL/DØ 2006 | FTE |
|---|---|
| Software/Algorithms | ~1.2 |
| Computing | ~3.0 |
| Operations | ~10.8 |
| Upgrade | ~3.8 |
| Physics | ~9.8 |
| Miscellaneous | ~4.6 |
| Not yet determined | ~3.2 |
| Total | ~36.4 |

- "Miscellaneous": DØ upper management, student supervision, Tevatron working groups, etc.
- "Not yet determined": applies essentially to Post-Docs (certain freedom to choose among a list of available projects).

⇒ Continued strong involvement in key areas of the experiment, especially operations, physics and upgrade.

# FNAL/DØ Budget

- Direct costs for PPD scientists on DØ:

| | FY05 | FY06 | FY07 | FY08 | FY09 |
|---|---|---|---|---|---|
| SWF+M&S | 2.8M | 3.0M | 3.1M | 3.1M | 3.3M |

- SWF: salaries
- M&S:
  - Includes support for scientific research of PPD scientists: travel, office support, computer/software maintenance, video-conferencing, etc.
  - Accounts for ~8-11% of the total.

- Constant budget till the end of Run II.

# Summary and Conclusions

- The DØ collaboration has many reasons to be excited…
  - the detector is collecting data with high efficiency and showing an excellent performance,
  - detector upgrades close to successful completion (enhanced physics capabilities after the summer),
  - many ~1 $fb^{-1}$ analyses already available,
    - many are World First or World Best,  and many more to come in the next months,
  - physics with multi-$fb^{-1}$ within the next few years,
    - getting ready to fully exploit Tevatron's rich physics potential,

  … but is also aware of the challenges ahead and planning accordingly:
  - physics at high instantaneous luminosities,
  - availability of resources, etc.

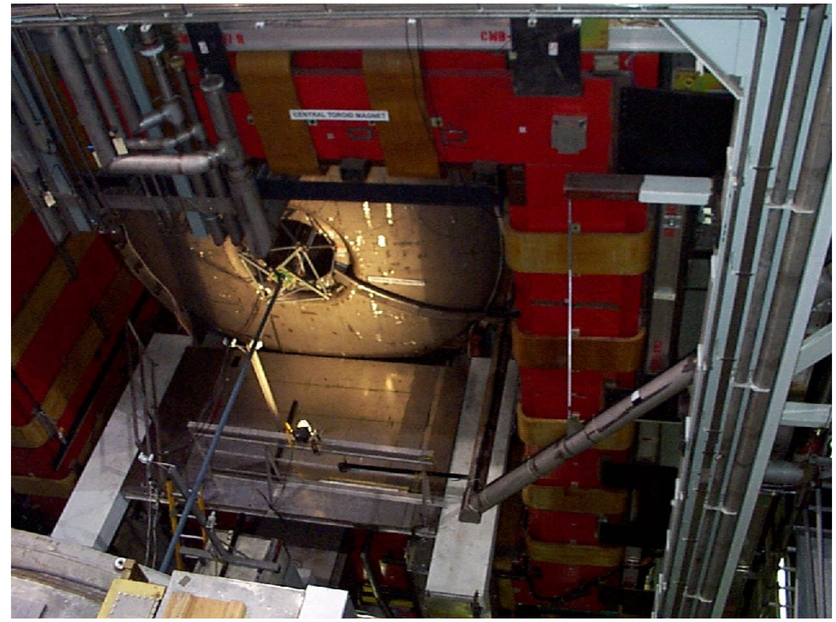
- The FNAL/DØ group has been and will continue to be instrumental in this success with very strong contributions and leadership in all areas of the experiment.

The very best of Tevatron Physics is yet to come!
A very exciting time ahead! Stay tuned!

# Backup Slides

# Solenoid

- Coming out of the FY04 shutdown, while attempting to ramp to full current, the solenoid quenched.
- Problem:
  - A solder joint in the coil has degraded (become more resistive than it should).
  - Resistive heating raises the local superconductor temperature above the point at which it can sustain 4750 A and 2.0 Tesla field.
  - The degradation is correlated to thermal cycling of the magnet.
- Prescription:
  - Minimize future thermal disturbances.
  - Limit power cycles.
  - Upgraded cryogenics plant to provide additional operating margin.
- Carefully monitored coil resistance and support temperature since beginning of FY05 run and show no further signs of degradation.
- Have run stably at 4550 A (rather than 4750 A) for about a year.

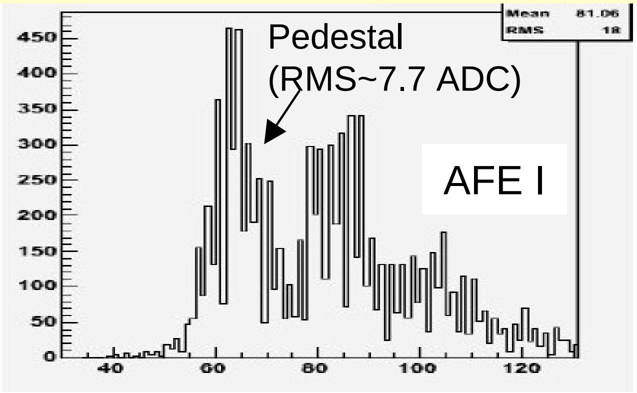


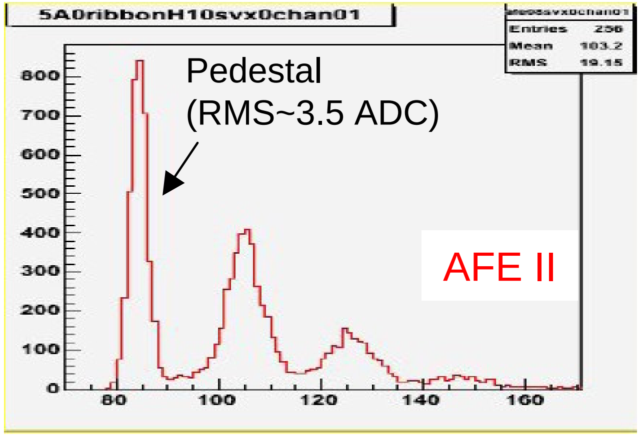
| | |
|---|---|
| Central Field | 2.0 T (now 1.92 T) |
| Operating Current | 4750 A (now 4550 A) |
| Cryostat Warm Bore | 1.067 m |
| Cryostat Length | 2.729 m |
| Integrated Field Homogeneity | +/- 0.005 |
| Stored Energy | 5.6 MJ |
| Inductance | 0.48 H |
| Conductor | High Purity Al Stabilized |
| Cooling | Indirect, 2-phase forced flow helium |
| Cold Mass | 1500 kg approx |
| Transparency | 0.9 Xo |

# Tracking Upgrade: CFT Readout

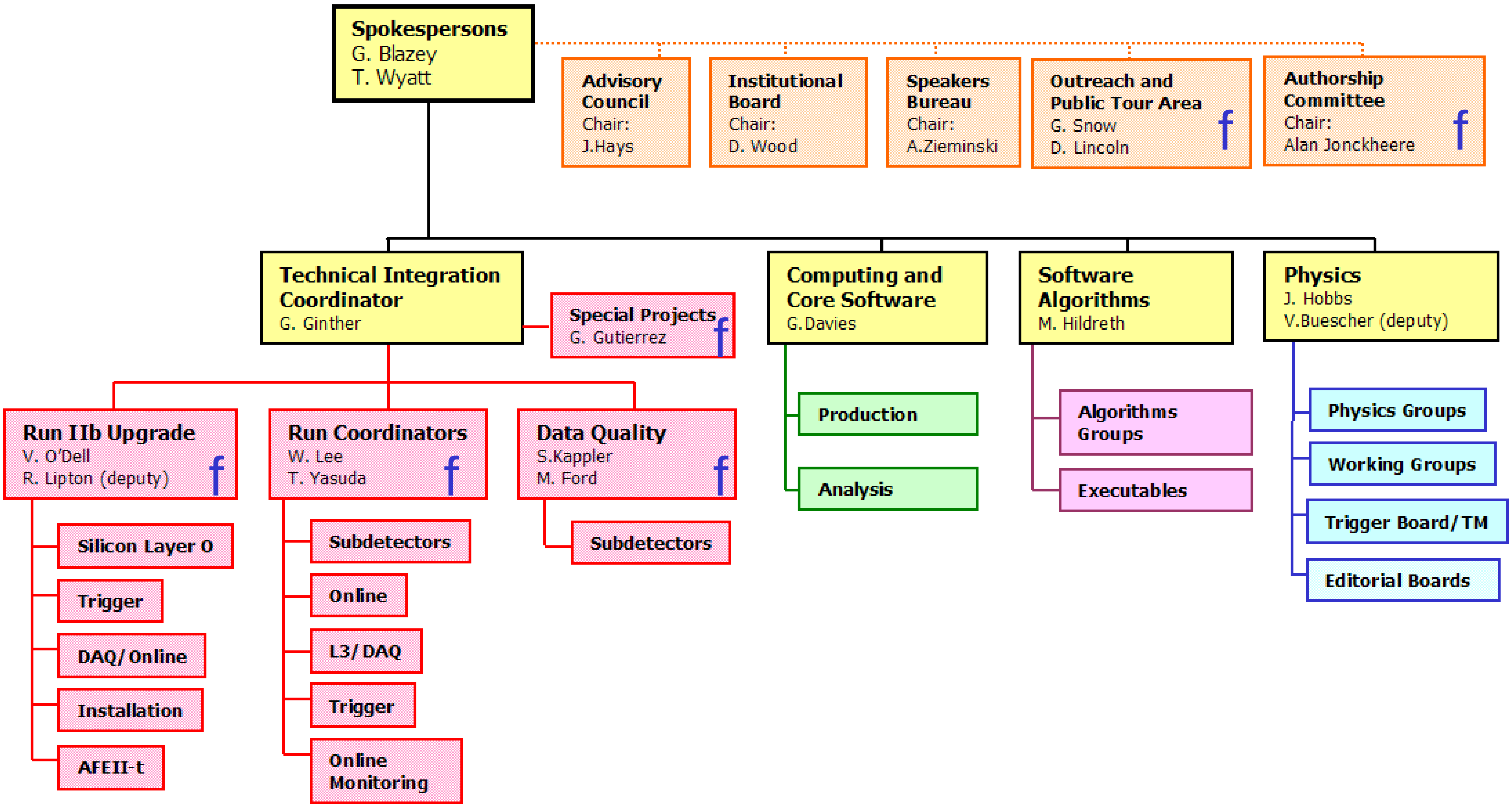
- Occupancies on inner layers of Central Fiber Tracker grow to significant levels as luminosity increases.
- Goal:
  - Address limitations of current readout electronics (will become increasingly important as luminosity increases): saturation of SVX2 chip, tick-to-tick variations, discriminator cross-talk.
  - Provide enhanced capabilities (timing measurement).
  - A (relatively) recent scope increase.
- AFE II addresses these shortcomings via custom ASIC (Trip-t) and commercial ADCs.
- Status:
  - Trip-t testing complete
  - Pre-production boards tested on platform inside collision hall
  - AFE II bare boards in production; full complement of tested production boards expected by October 2006
- Plans:
  - Installation during summer/fall 2006
  - Designed to be plug compatible with current AFE to allow adiabatic installation (preferred) during brief accesses (~200 boards to be installed)

LED spectra from single crossing



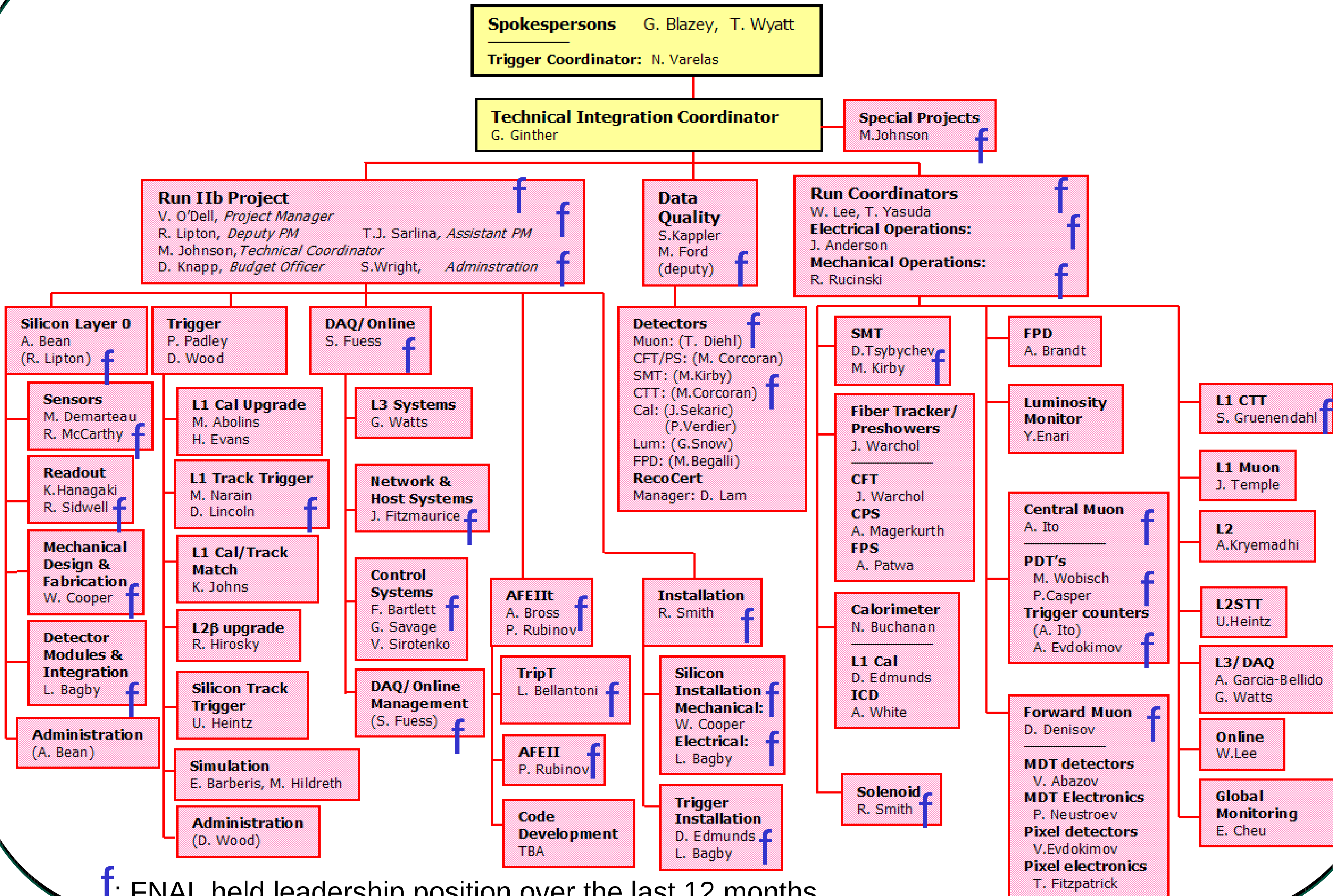



# DØ Organization



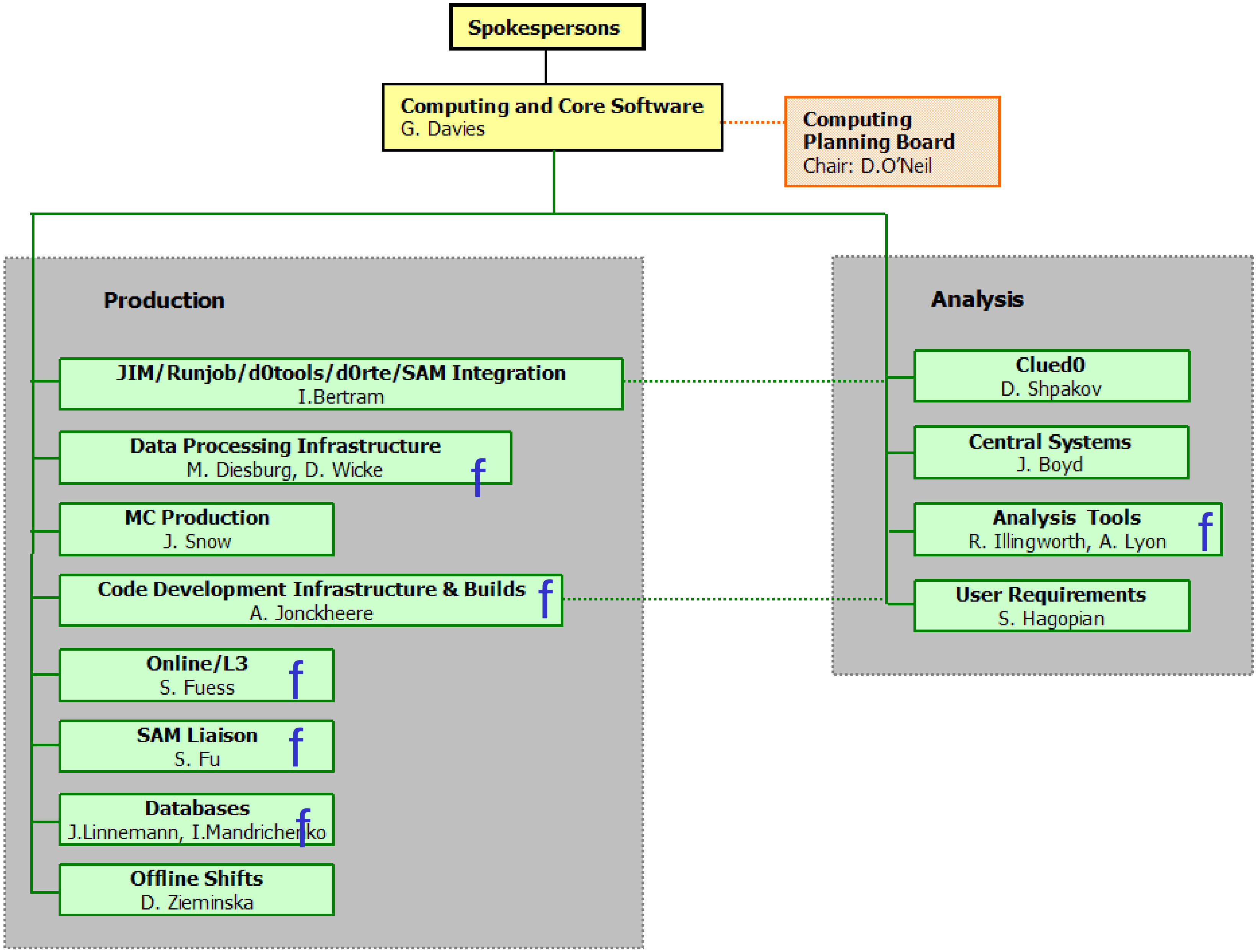

f: FNAL held leadership position over the last 12 months

# Technical Organization



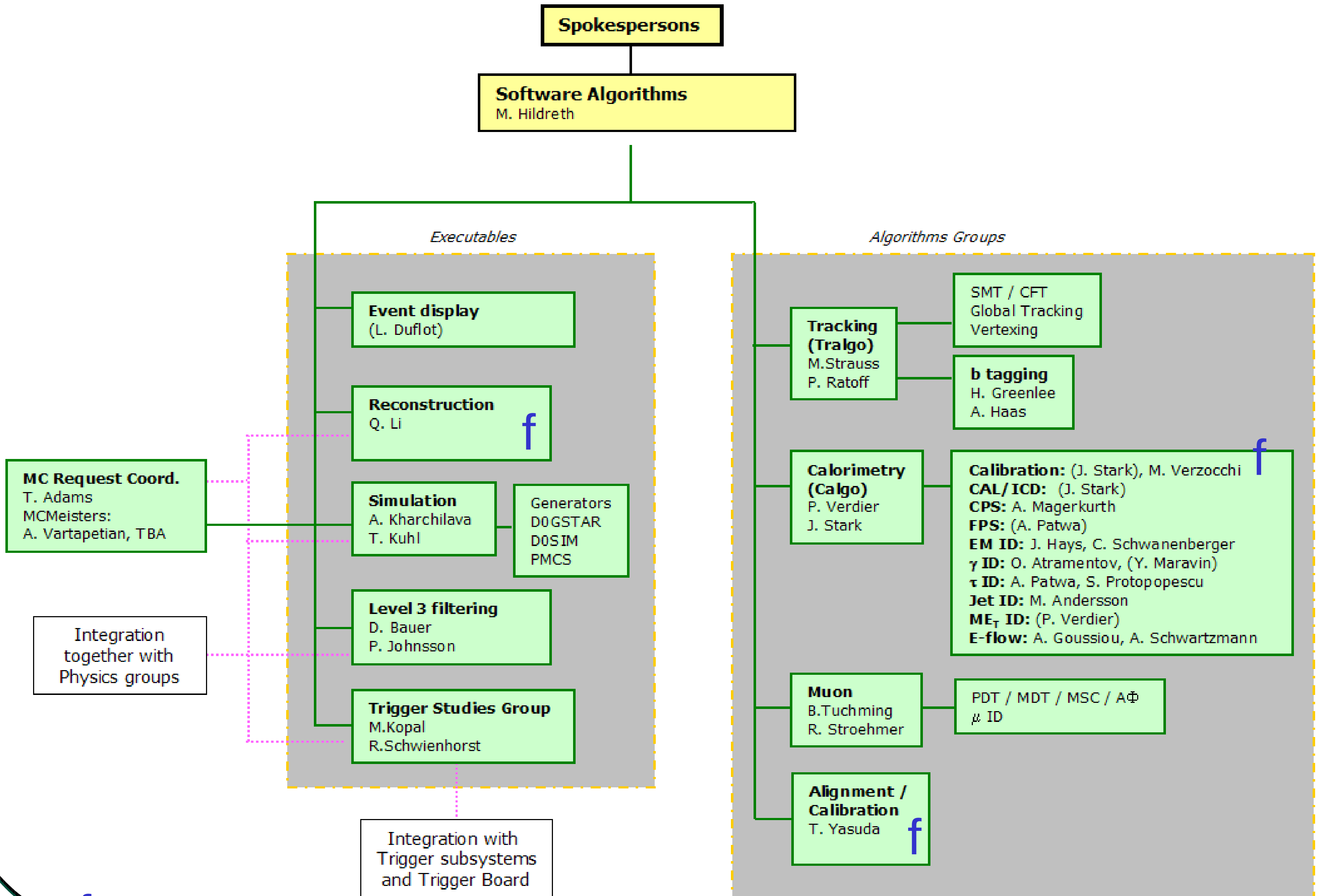

f: FNAL held leadership position over the last 12 months

# Computing and Core Software



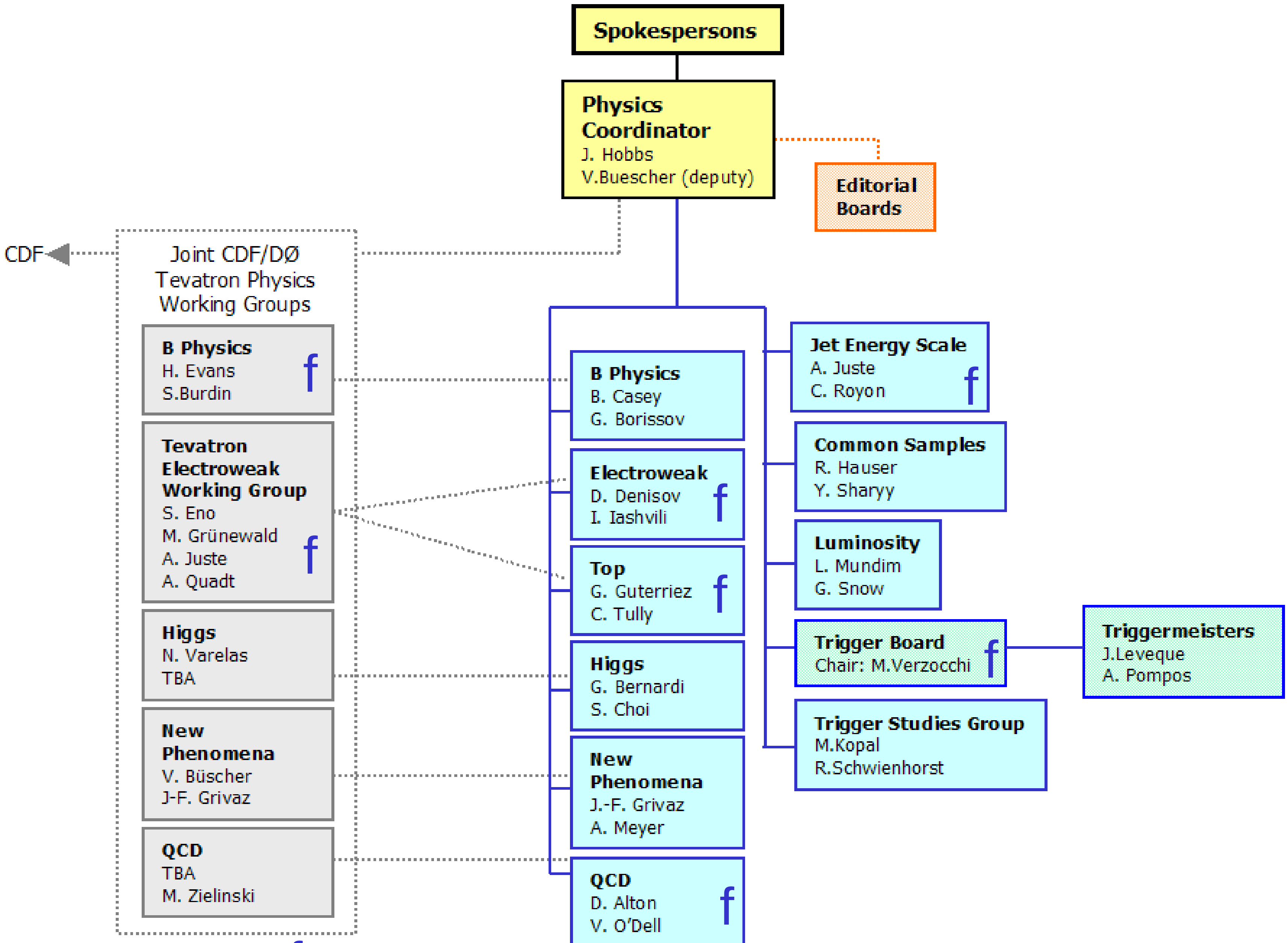

f: FNAL held leadership position over the last 12 months

# Software Algorithms




f: FNAL held leadership position over the last 12 months

# Physics Organization




f: FNAL held leadership position over the last 12 months