DØ Experiment and BNL

presented by

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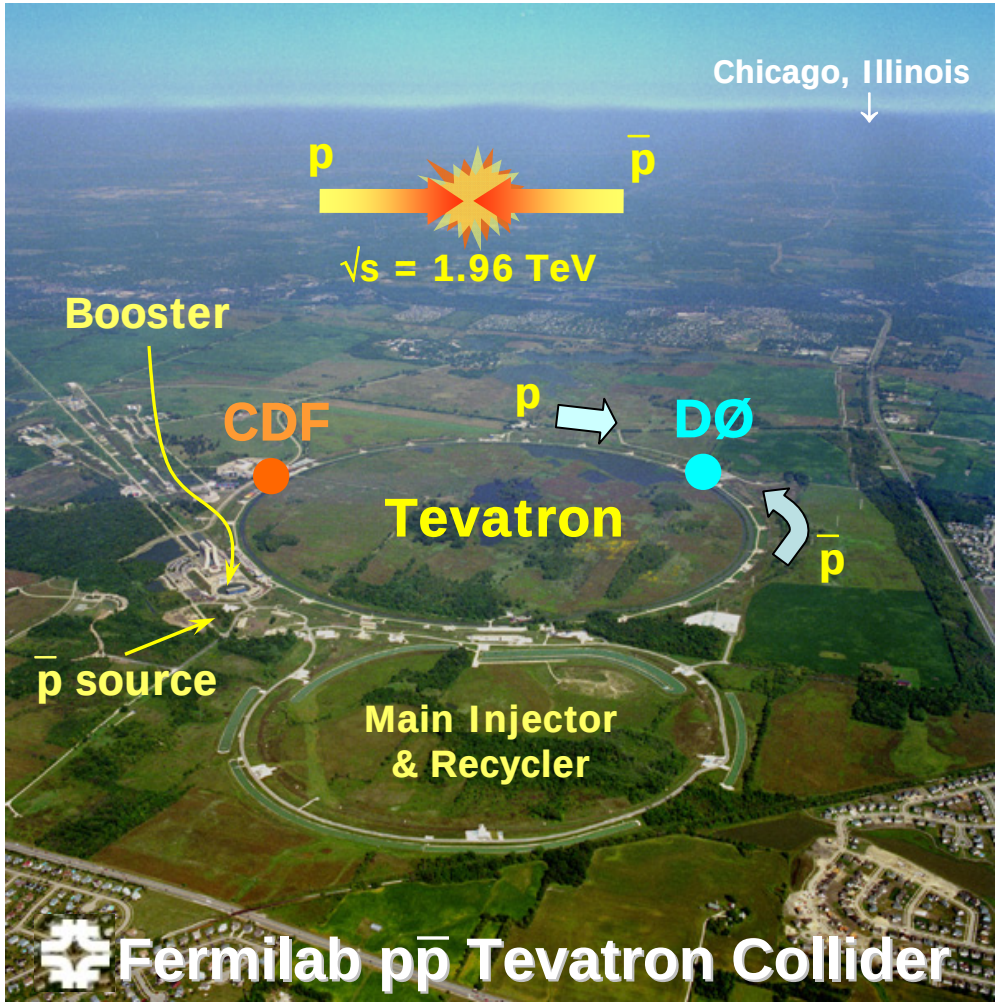
Department of Energy Review • April 17, 2007

BROOKHAVEN NATIONAL LABORATORY

Outline

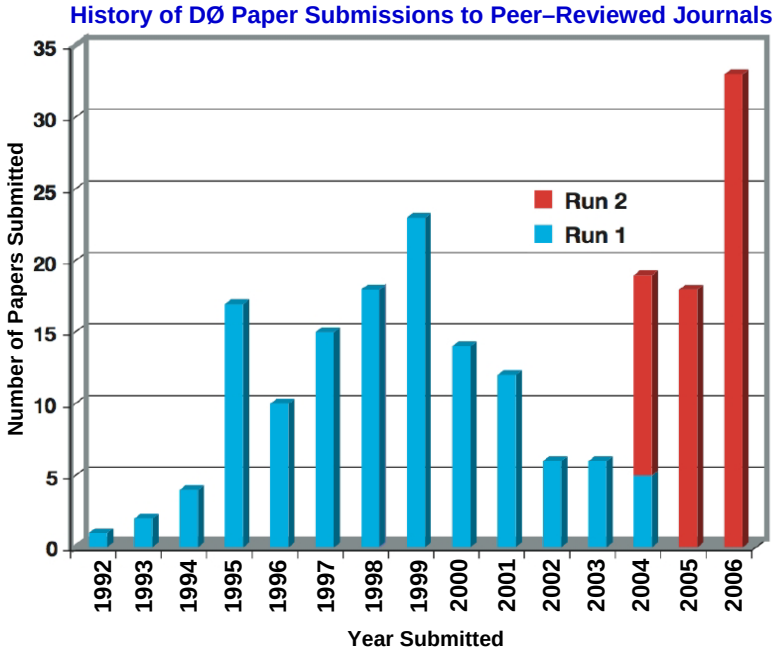
- Overview of the DØ Experiment
- BNL–DØ personnel
- Major BNL Contributions
- Present Status and Physics Results
- Summary



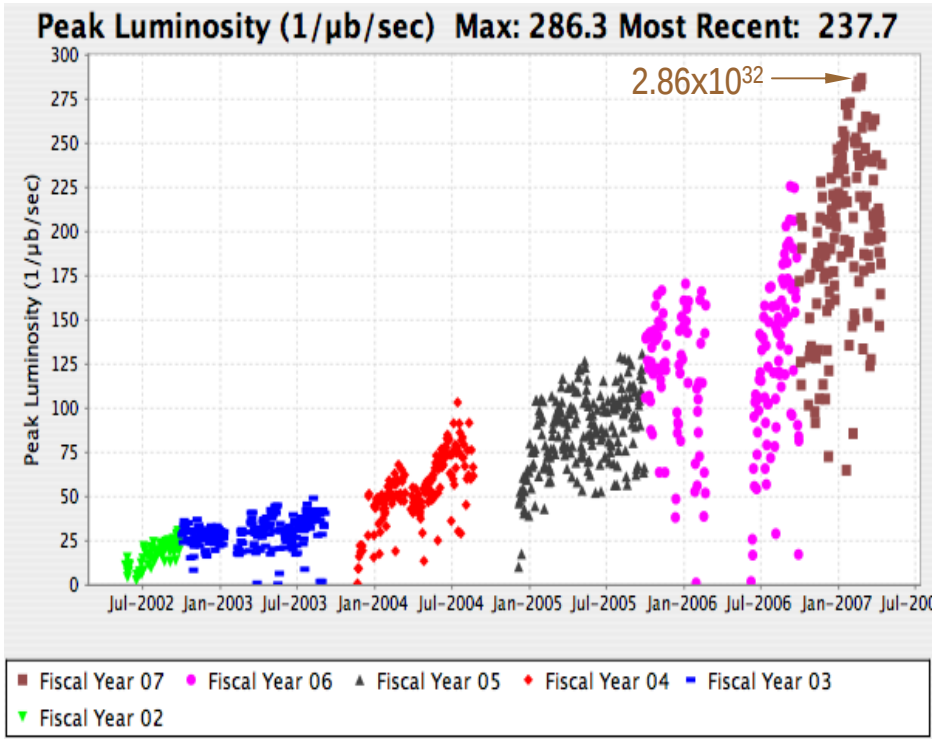
DØ Experiment

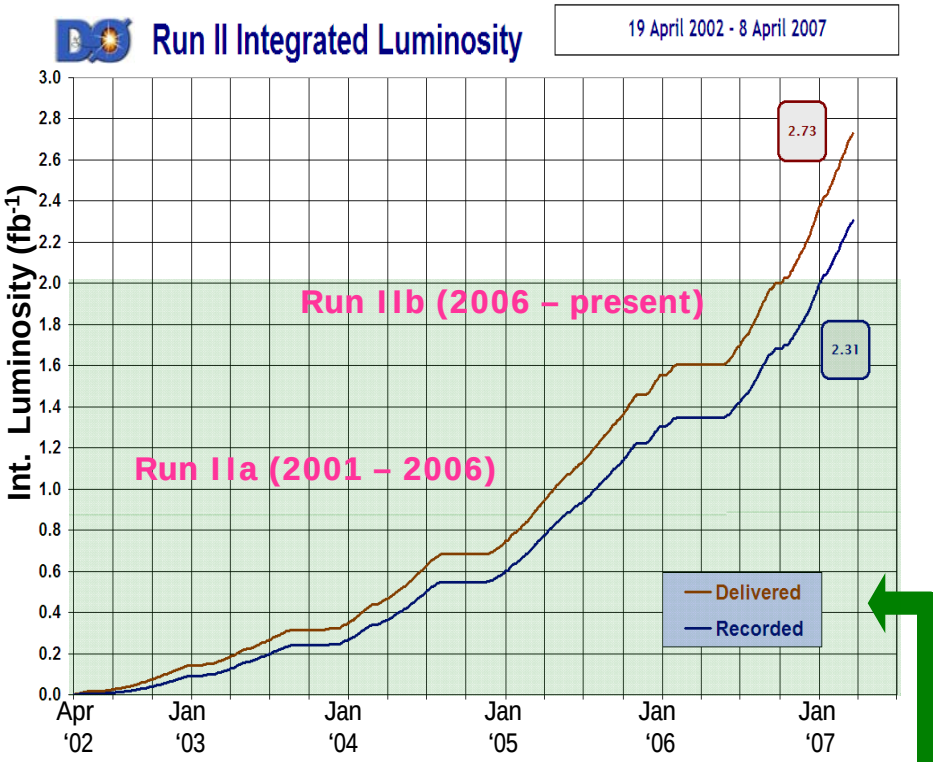
- **Composition**
  - **626 collaborators**
    - **185 graduate students**
    - **110 postdocs**
  - **82 institutions from 18 countries**
    - **39 US, 43 non-US**
  - **270+ Ph.D.'s awarded**
    - **116 Run II Ph.D.'s**

- **Run I (1992 – 1996) publications**
  - **132 publications**
- **Run II (2001 – present) publications**
  - **63 publications accepted, additional 9 submitted**
- **2006: best year ever for DØ submissions and publications**
  - **includes evidence of single top,** (accepted, hep-ex/0612052)



Tevatron Performance

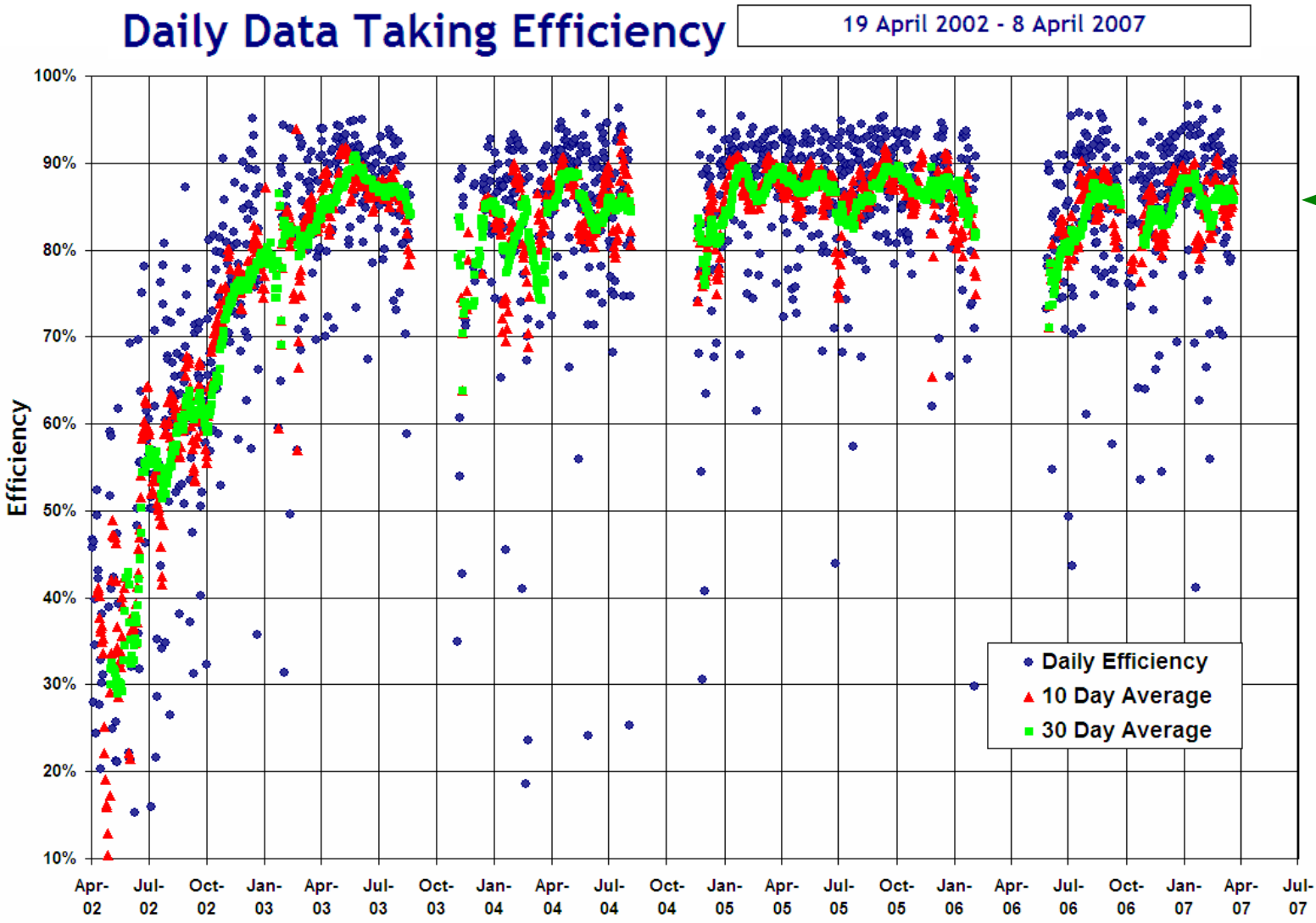




- **Tevatron Collider and DØ operating successfully in Run II**
- **Tevatron delivered $\int \mathcal{L}\, dt \rightarrow 2.8\ fb^{-1}$**
  - **DØ recorded $> 2.3\ fb^{-1}$**
  - **reached peak luminosities $> 2.8 \times 10^{32}\ cm^{-2}\ s^{-1}$**
  - **weekly integrated luminosity ~ $35\ pb^{-1}$/week**
- **Projections through end-FY09: expect to deliver 6 to 7 fb^{-1}**

– **Up to 2 fb^{-1}** *(Run IIa and RunIIb)* **dataset used in analyses reported thus far**

DØ Data Taking Efficiency



– **average data taking efficiency > 85% since January 2003**

BNL–DØ Group

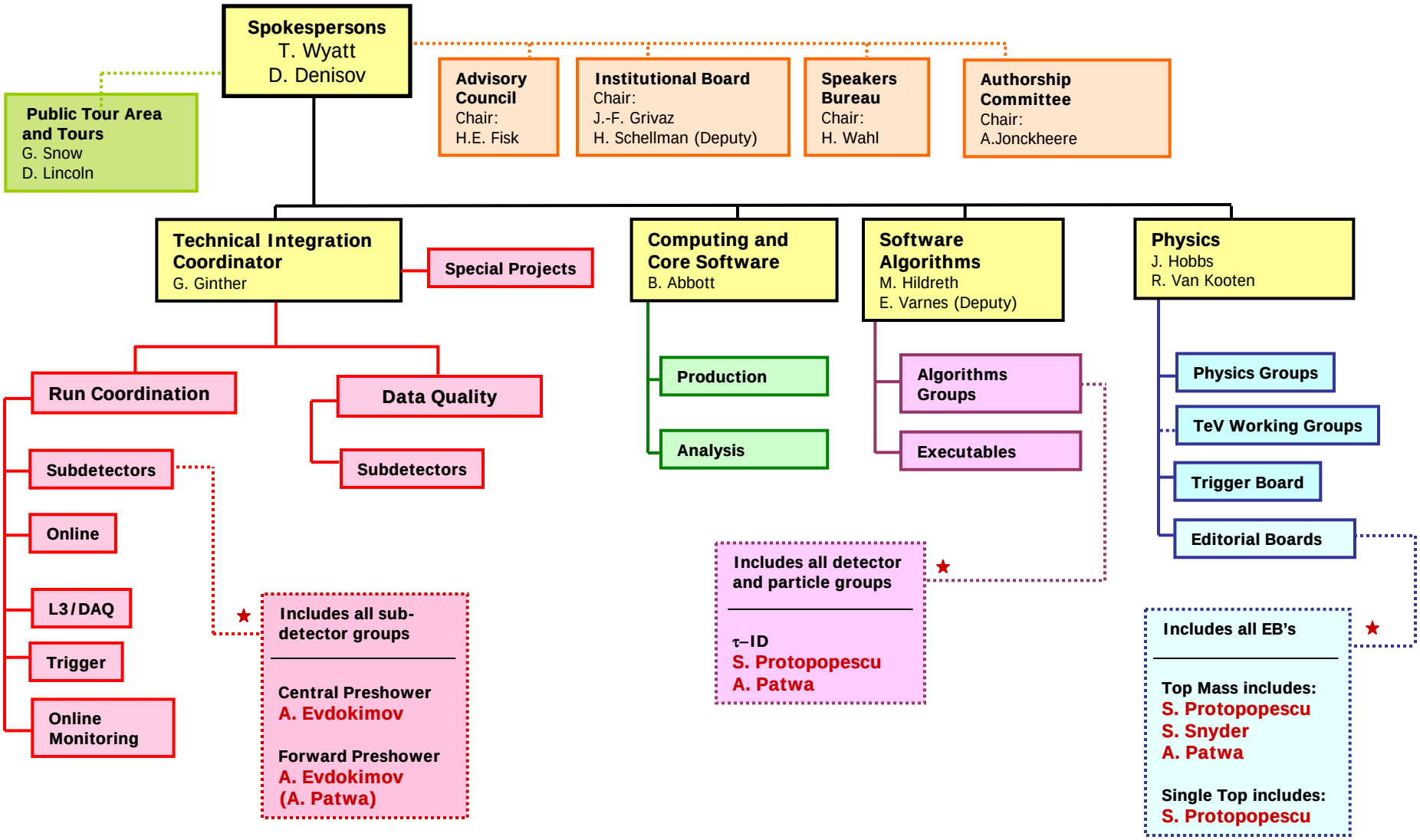
- **Current BNL–DØ members:**
  - S. Protopopescu (100%), A. Evdokimov (80%), A. Patwa (60%), S. Snyder (30%), K. Yip (30%, not in core program)
    - Total 3.0 FTE's (2.7 in core program)
  - 1 resident at FNAL (A. Evdokimov)

- **Major Service Contributions:**
  - Central and Forward Preshower (CPS, FPS) hardware and software maintenance — A. Evdokimov: CPS and FPS, A. Patwa: FPS
  - Online and Offline Software Maintenance — S. Snyder, S. Protopopescu
  - Data Processing — K. Yip
  - Model Independent Search for Beyond Standard Model (BSM) Signals at High-p_T — S. Protopopescu
  - τ–ID Algorithm Coordination — S. Protopopescu, A. Patwa
  - Shift Responsibilities — S. Snyder & A. Patwa *(Captains)*; A. Evdokimov *(Central Tracker and Preshowers)*; S. Protopopescu *(SAM database)*

BNL–DØ Group *(cont.)*

- **Physics Analysis:**
  - **Measurement of the Lifetime Difference in the B_s System**
    - **K. Yip**
  - **Studies of $Z \to \tau\tau$, $W \to \tau\nu$, $H \to \tau\tau$, and SUSY–τ channels**
    - **A. Evdokimov, A. Patwa, S. Protopopescu**
  - **Top Mass Editorial Board**
    - **S. Protopopescu** *(Chair)* **, S. Snyder** *(Member)* **, A. Patwa** *(Member)*
  - **Single Top Editorial Board**
    - **S. Protopopescu** *(Member)*

DØ Organization and BNL

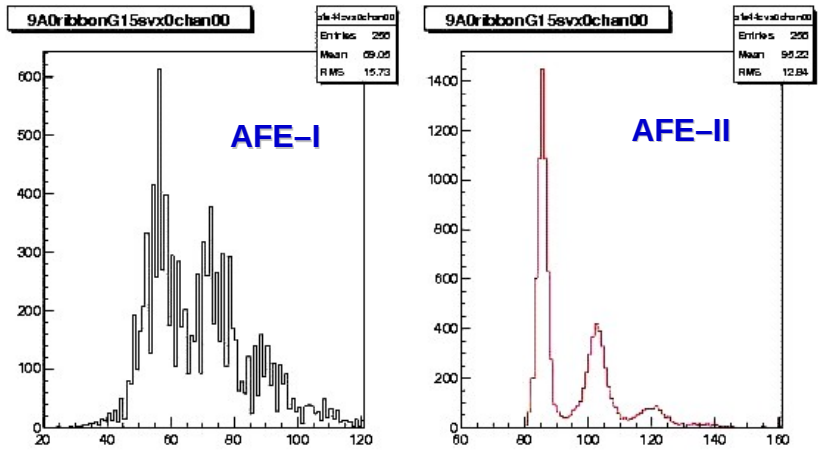


BNL plays prominent role in areas of detector operation, algorithm development and physics analysis

Preshowers: AFE-II Commissioning

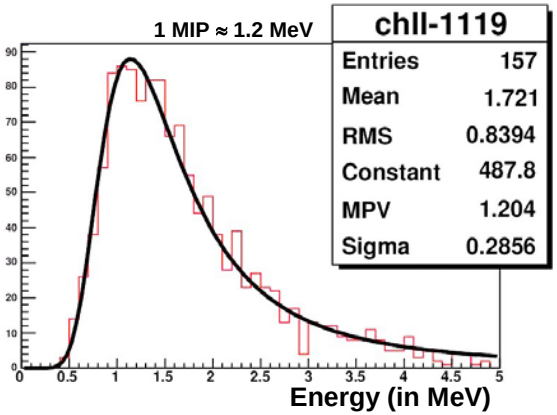
- **Upgraded Analog Front–End II (AFE–II) readout for Run IIb**
  - includes enhancements to make detector more robust
  - eliminate amplifier saturation at high instantaneous luminosities

LED Pulser Data: AFE–I *vs.* AFE–II

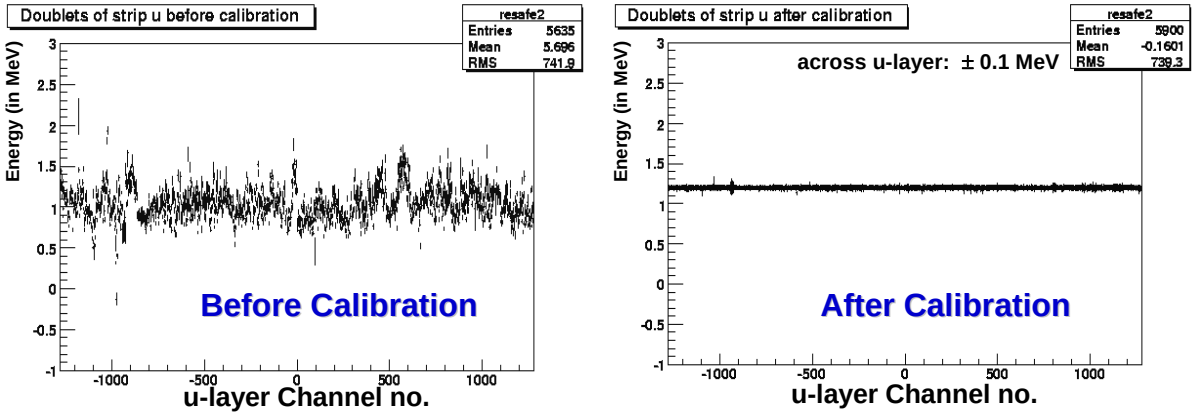


- **CPS fully instrumented**
  - 7,680 channels, 30 AFE–II boards
  - MIP and Discriminator thresholds calibration completed

CPS: Single channel MIP peak



Calibration Uniformity for u-stereo layer doublets (MIP): Before and After



- **Installation and commissioning of AFE–II's for FPS to follow**
  - 14,968 channels, 16 AFE–II boards

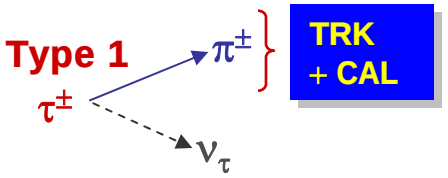
Physics with τ's

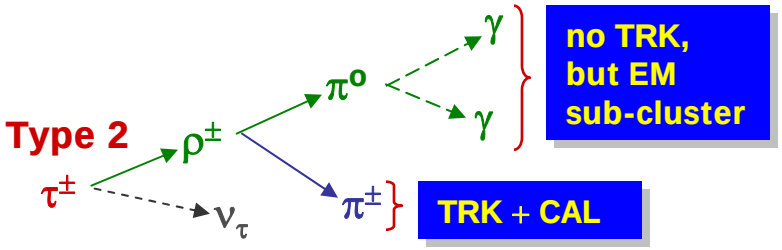
- **Begin by categorizing hadronic τ candidates into 3 types, based on their detector signature**

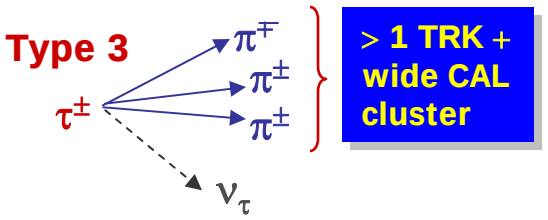
τ–type 1 (πν–like): one track + calorimeter cluster, no EM sub-clusters

τ–type 2 (ρν–like): one track + calorimeter cluster and > 0 EM sub-clusters

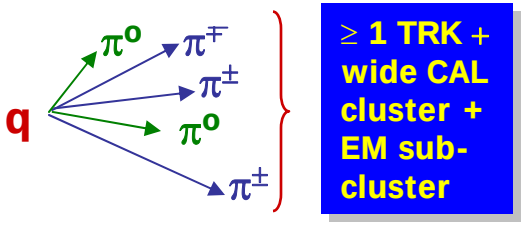
τ–type 3 (3–prong): > one track + calorimeter cluster and ≥ 0 EM sub-clusters







vs. **Jet–Background**



- **Discriminate backgrounds from τ's with Neural Network (NN) techniques ⇒ τ–ID**

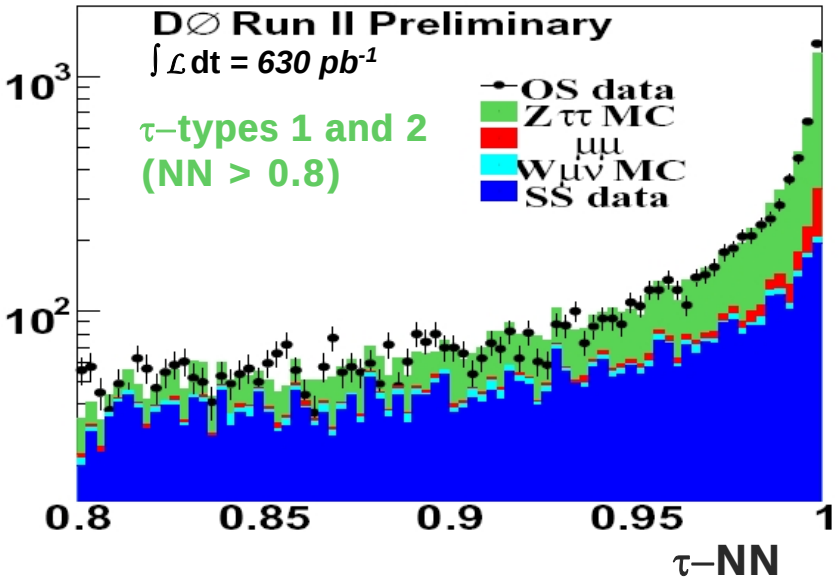
τ–NN and Z→ττ

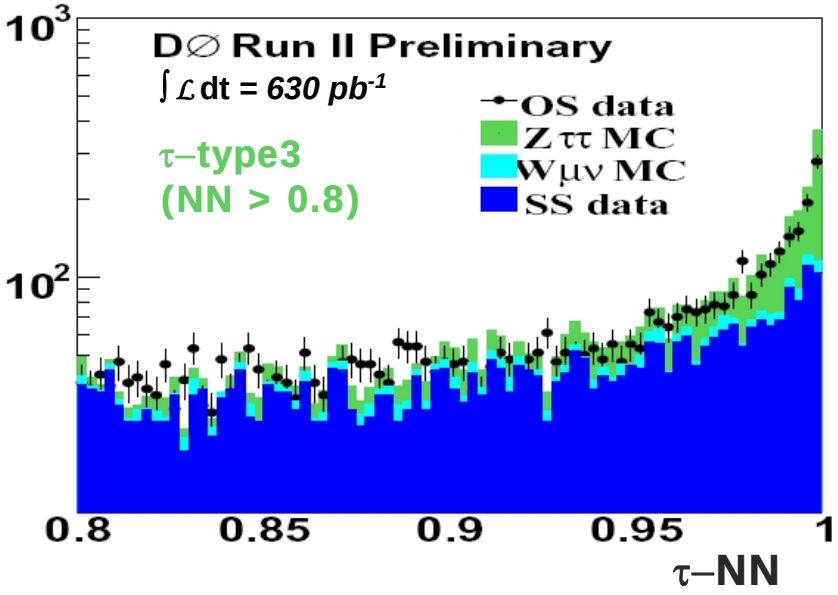
- **Published $Z \rightarrow \tau\tau$ Cross Section, $\tau_1 \rightarrow \mu$ and $\tau_2 \rightarrow$ had or e**
  - **PRD 71, 072004 (2005): 1st main τ result**
    - **benchmark study for testing and certifying τ–ID algorithm**
    - **extend developed method to other τ–physics channels**

- **Selections**
  - **$p_T^{\mu} > 12$ GeV, $|\eta_{\mu}| < 2.0$**
  - **$p_T^{\tau} > 10$ (5) GeV for τ–types 1, 3 (2), $|\eta_{\tau}| < 3.0$**
  - **opposite sign (OS) and back-to-back ($|\phi_{\mu} - \phi_{\tau}| > 2.5$) μτ pairs**

- **NN → 1 for signal, NN → 0 for background**

- **PRD: 225 pb^{-1} ⇒ ~1,400 τ's**
- **Since PRD: 630 pb^{-1} ⇒ ~5,000 τ's**



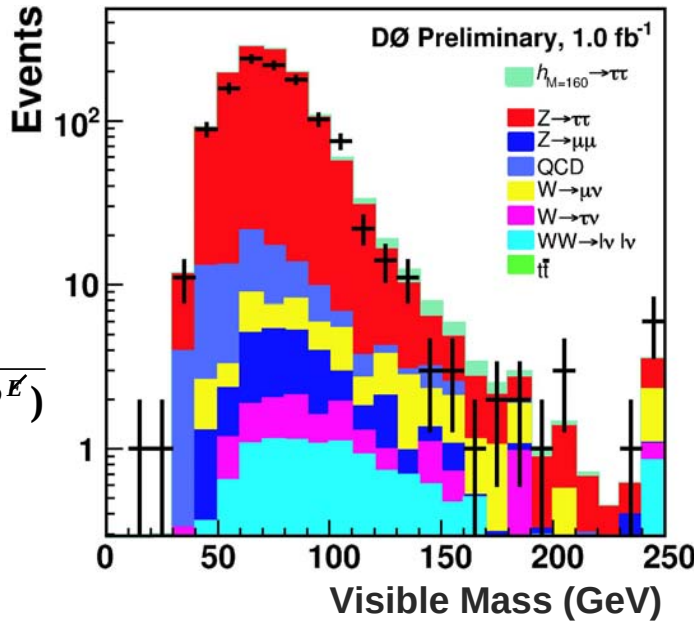


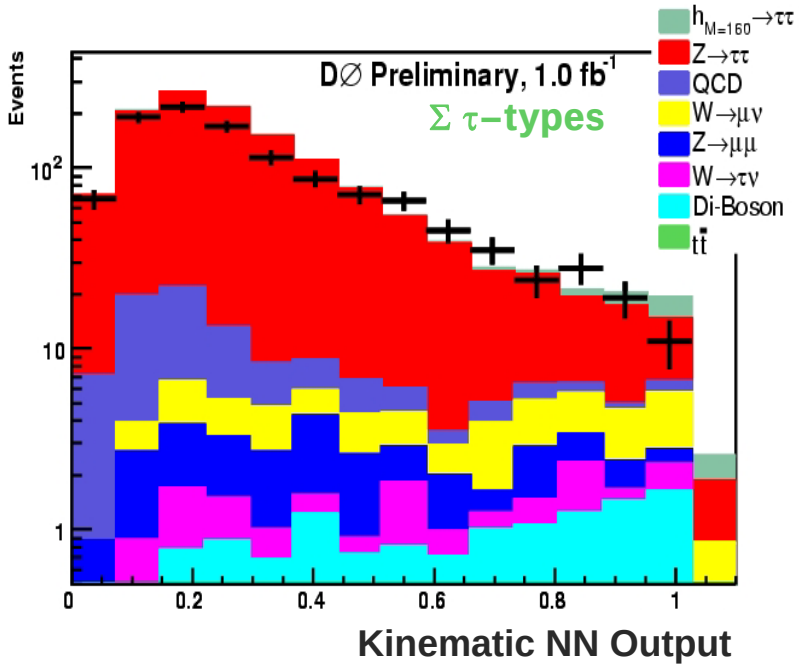
Neutral Higgs $\Phi \rightarrow \tau\tau$ Search

- Updated 1 fb^{-1} result considers $\Phi(\equiv h/H/A) \rightarrow \tau\tau$ with $\mu\tau_{had}$ decay
- Event selections
  - μ–ID: $p_T^{\mu} > 15$ GeV, isolated, opposite in sign with τ
  - τ–ID: $E_T^{\tau} > 15$ (20) GeV and τ–NN > 0.9 (0.95) for τ–type 1, 2 (3)
- Use kinematic NN (kNN) to improve separation of signal from background
  - exploit fact that signal resonates at masses higher than $Z \rightarrow \tau\tau$
  - variables: M_{vis}, p_T^{μ}, E_T^{τ}, $p_T^{\tau\text{–trk}}$, η_{μ}, η_{τ}
- Data consistent with backgrounds

$$M_{VIS} = \sqrt{(P^{\mu} + P^{\tau} + P^{\not E})}$$

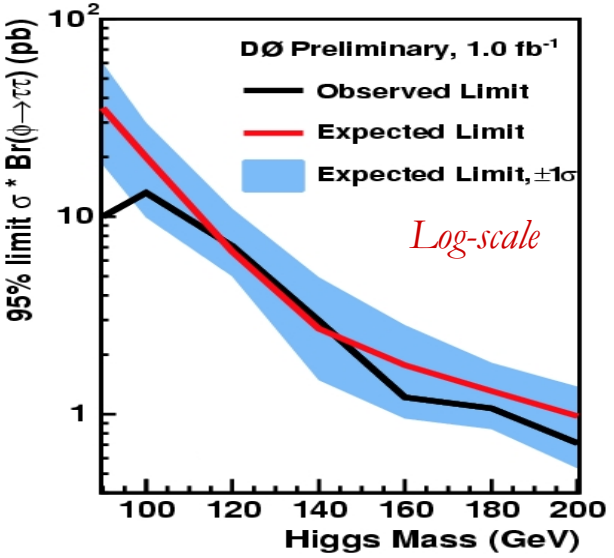
$$P^{\not E} = (\not E_T, \not E_x, \not E_y, 0)$$



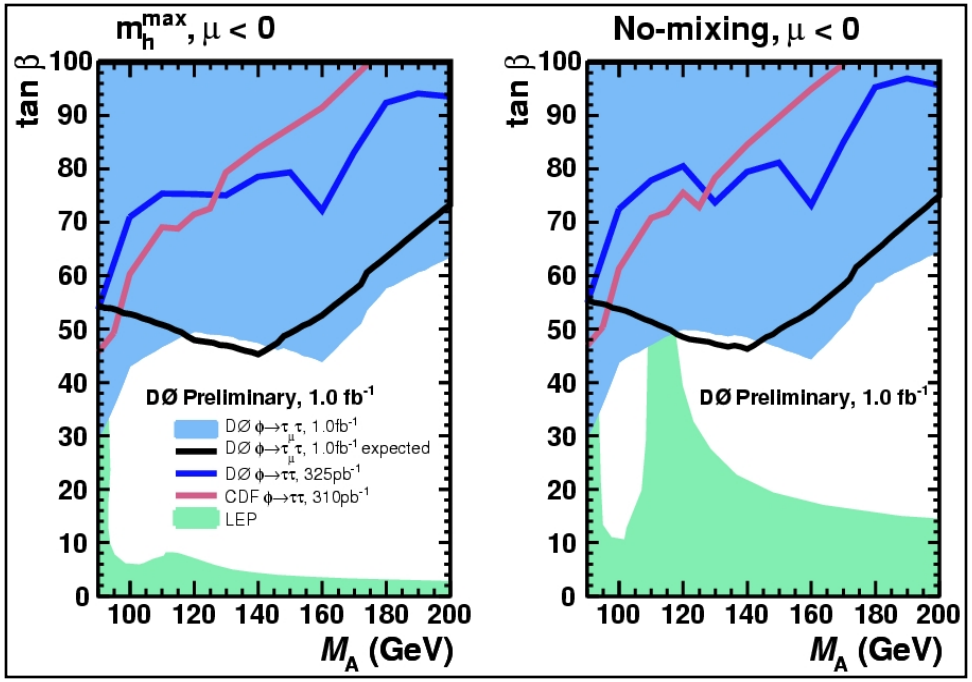


1 fb^{-1} $\Phi \rightarrow \tau\tau$ result *(cont.)*

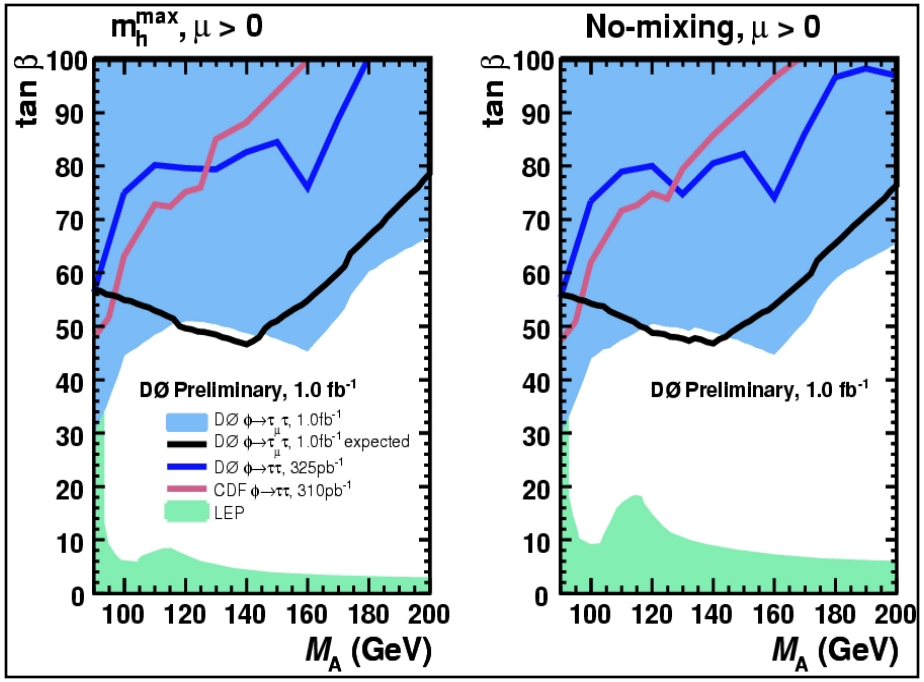
- kNN used in limit calculation $\Rightarrow$ better sensitivity
- Derive limits on $\sigma \times$BR at 95% CL
- Interpreted in MSSM $\Rightarrow$ 95% exclusion limits in (M_A, tanβ) plane
  - for m_h^{max} and no–mixing benchmark scenarios
  - $90 \leq M_A \leq 200$ GeV excludes tan$\beta \geq 40 \rightarrow 65$



for $\mu < 0$



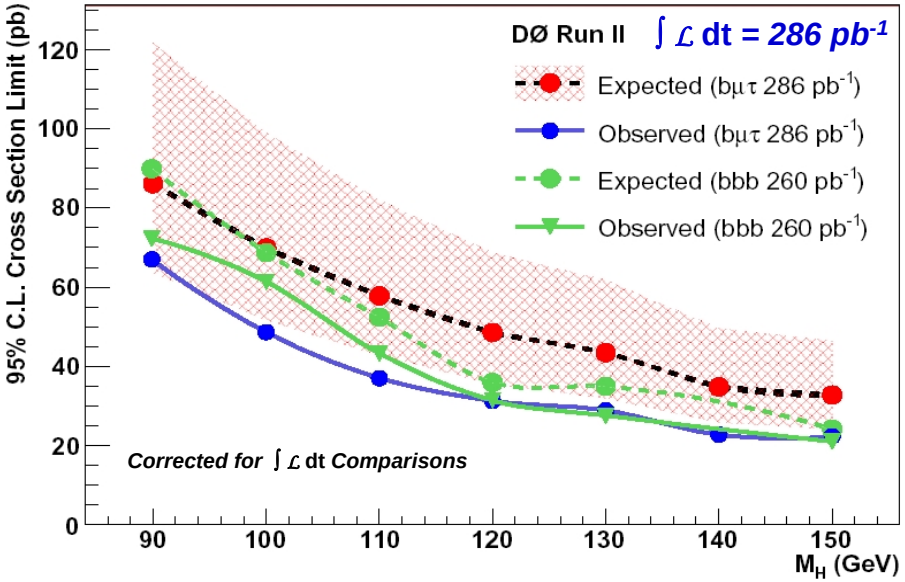
for $\mu > 0$



DØ: Most constraining limits from H→ττ decay channel to date

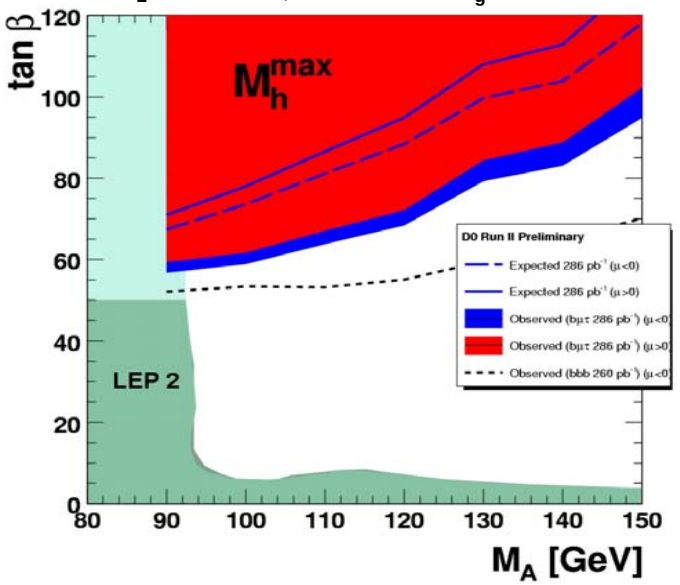
b(h/H/A) → bττ Search

- **Higgs production in association with b quark**
  - consider $bg \rightarrow b(h/H/A) \rightarrow b\tau\tau \rightarrow b\mu\tau_{had}$
  - analysis strategy built on $Z \rightarrow \tau\tau$, $\Phi \rightarrow \tau\tau$ results
- **Selections include b-tag and kNN**
  - no significant excess over backgrounds ⇒ 95% CL limits on $\sigma \times BR$

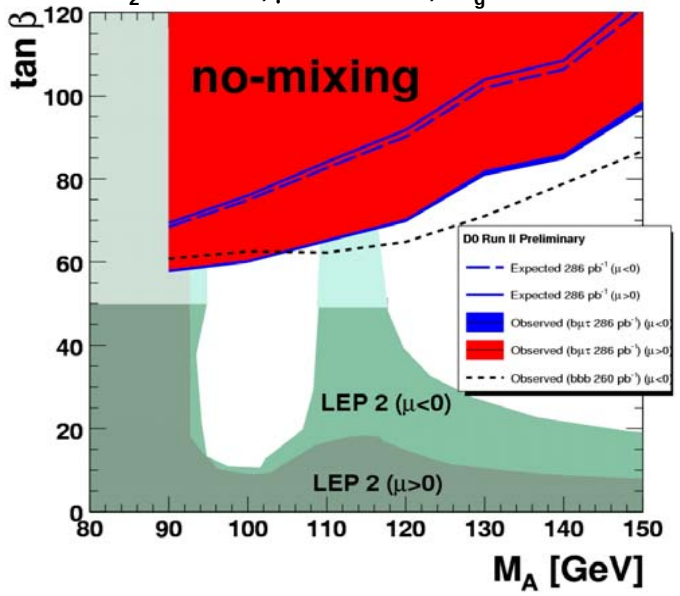


- **MSSM exclusion limits**
  - negative μ: ττ mode comparable to $b\bar{b}$
  - positive μ: ττ mode appears better than $b\bar{b}$, especially at lower masses despite 1:9 BR

M_h^{max}: M_{SUSY} = 1 TeV, X_t = 2 TeV, M_2 = 0.2 TeV, μ = ±0.2 TeV, $m_{\tilde{g}}$ = 0.8 TeV



no–mixing: M_{SUSY} = 2 TeV, X_t = 0, M_2 = 0.2 TeV, μ = ±0.2 TeV, $m_{\tilde{g}}$ = 1.6 TeV

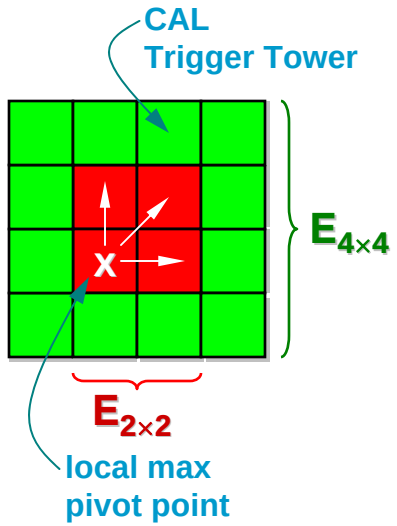


τ's at high luminosity: τ–triggers

- **RunIIa: start pre-scaling τ triggers at $L > 1.0 \times 10^{32}\ cm^{-2}\ s^{-1}$**
  - **L1 and L2: mainly jet triggers (CAL tower) with track match**
  - **L3: τ–NN to filter τ's**

- **RunIIb: implement L1Cal2b trigger upgrade**
  - **L1: τ's are "narrow jets"**
    - **pass E_T thresholds and CAL isolation ($\equiv E_{2\times2}/E_{4\times4}$)**

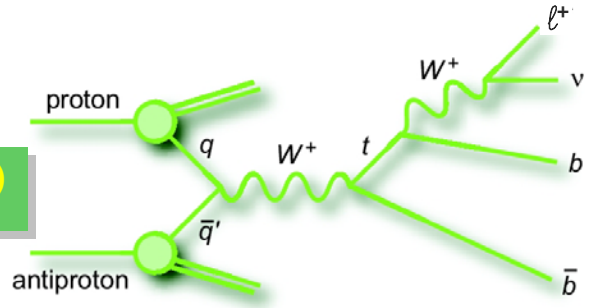
- **Suite of single–τ (*e.g.*, $W\rightarrow\tau\nu$) and di–τ ($\tau_{had}\tau_{had}$, e–τ, μ–τ)**
  - **L1: combinations of E_T thresholds ($10 \rightarrow 40$ GeV) with (loose, medium, tight) CAL isolation requirements**
    - **with or without central track requirement**
    - **μ–τ: L1 muon triggers with τ–NN filters at L3**

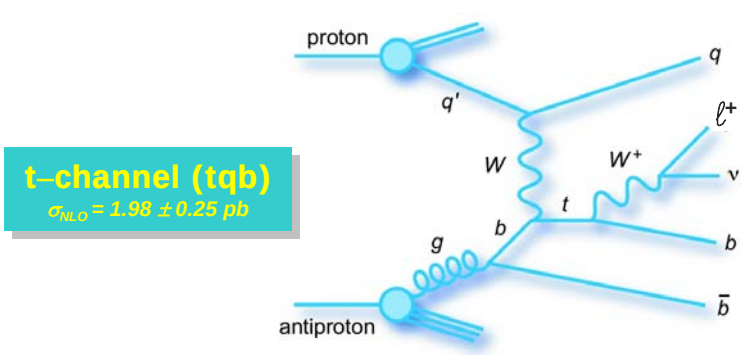


- **τ–triggers un-prescaled up to $L \sim 2.5 \times 10^{32}\ cm^{-2}\ s^{-1}$**
  - **L1CALTRK conditions allow running at higher luminosities**

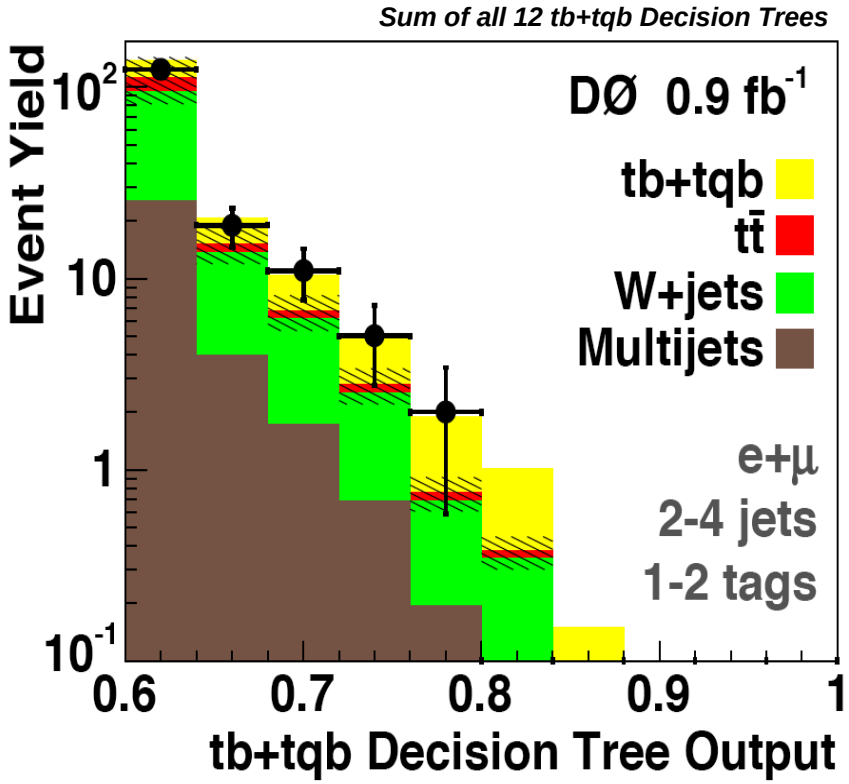
- **Triggers presently being commissioned**

Single Top Evidence and $|V_{tb}|$



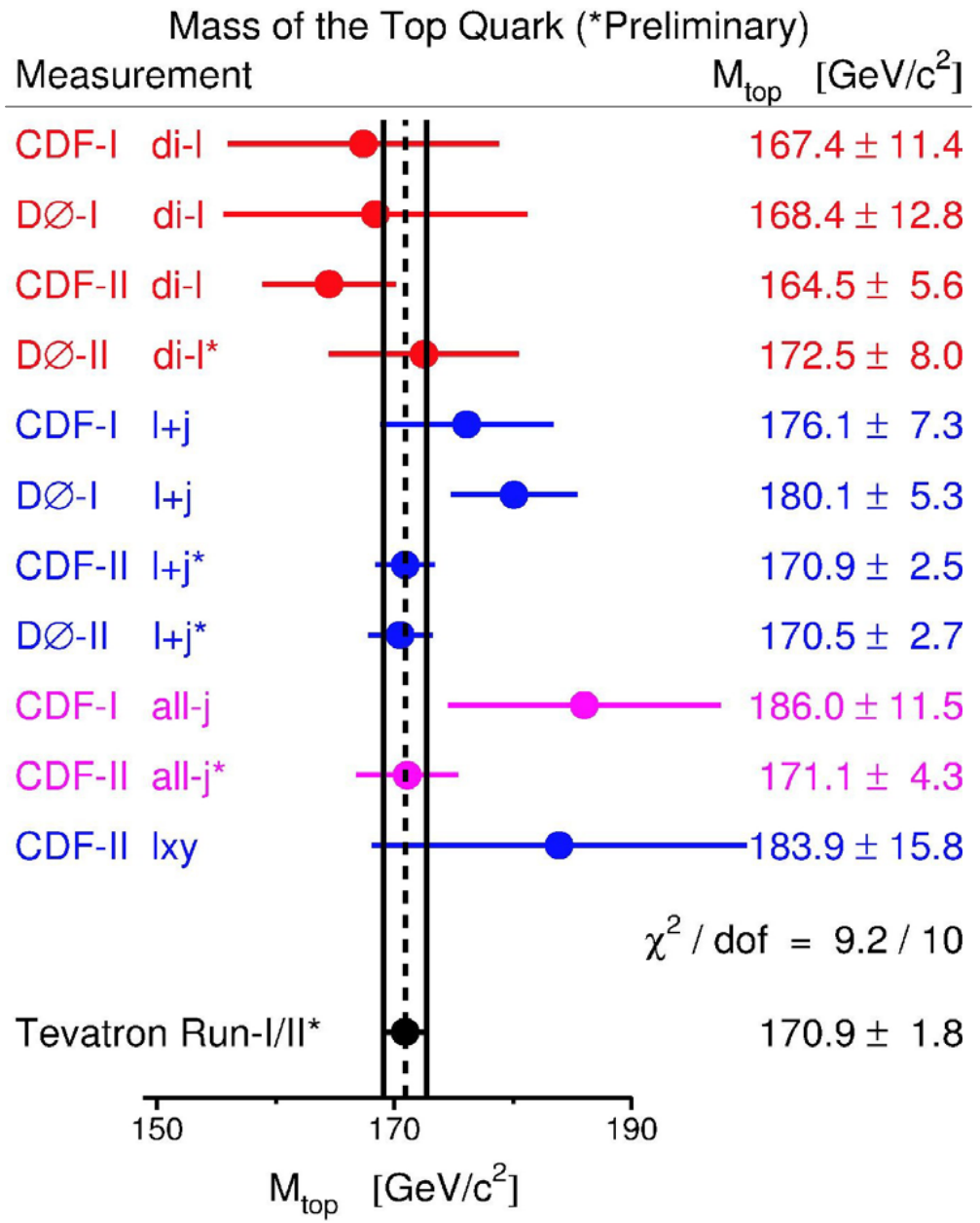


- Cross section for single top ~½ that of top pair production
  - and suffers from large backgrounds
- Event selections based on decision trees
  - categorized by final state: lepton flavor, jet multiplicity, and # of identified b-jets
- First evidence of single top and first direct measurement of $|V_{tb}|$
- $\sigma(p\bar{p} \rightarrow tb + X, tqb + X) = 4.9 \pm 1.4$ pb
  - excess has significance of 3.4 σ
- $0.68 < |V_{tb}| \leq 1$ at 95% CL
- Consistent with SM expectations



Top Mass with 1 fb^{-1}

- **Measurement of Top mass in lepton + jets using Matrix Element method, select exactly 4 jets**
- **Implement neural net b-tagging ⇒ increases purity**
- **M_{top} = 170.5 ± 2.4 (stat+JES) ± 1.2 (sys) GeV (900 pb^{-1} result)**
- **M_{top} = 170.3 $^{+4.1}_{-4.5}$ (stat+JES) GeV (PRD, 370 pb^{-1} result)**



Highlights and Recent Results

- **Other recent physics results with 1 fb^{-1} data, highlights from 2007 Winter Conferences**
  - **Search for trilepton decays from associated production of charginos and neutralinos**
  - **Search for new heavy charged Gauge Boson, $W' \rightarrow e\nu$**
  - **Measurement of $t\bar{t}$ cross section in dilepton and lepton + jets final states**
  - **Search for $(Z/\gamma^*)(Z/\gamma^*)$ boson production**
  - **Search for WH and ZH production**
  - **Combined limits for WH, ZH with $H \rightarrow b\bar{b}$ and $H \rightarrow WW$**
  - **Upper limit on BR for the rare decay: $B_s \rightarrow \mu^+\mu^-$ (2 fb^{-1})**

Several results with more than 2 fb^{-1} DØ dataset expected this Summer…

Closing Summary

- **Tevatron and DØ detector performing well**
  - **expect 3.0 fb^{-1} of recorded data by end-July 2007**
  - **CPS AFE–II readout commissioned, FPS will follow soon**

- **BNL currently active in**
  - **hardware maintenance**
  - **software development**
  - **τ–ID algorithm and τ–trigger performance**
  - **physics analyses with τ final states**

- **Strong focus on τ–physics analyses at DØ $\Rightarrow$ BNL will continue to play an important role in the measurements**

- **Group's transition to ATLAS in progress…**
  - **FY08: BNL plans to decrease resources provided to DØ to 2.3 FTE's**
  - **FY09: expect ~1 FTE on DØ**