Top Physics at DØ

First Data and Future Prospects in RunII

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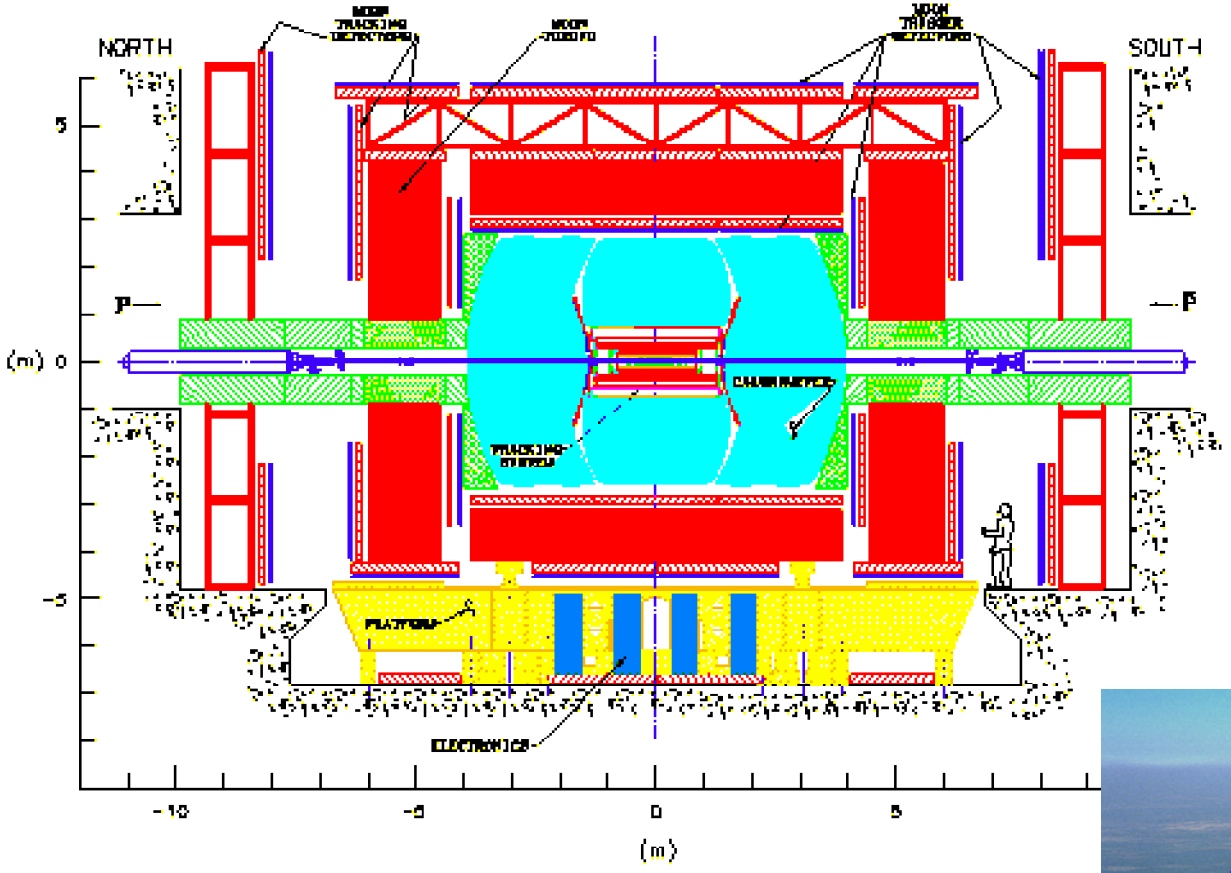
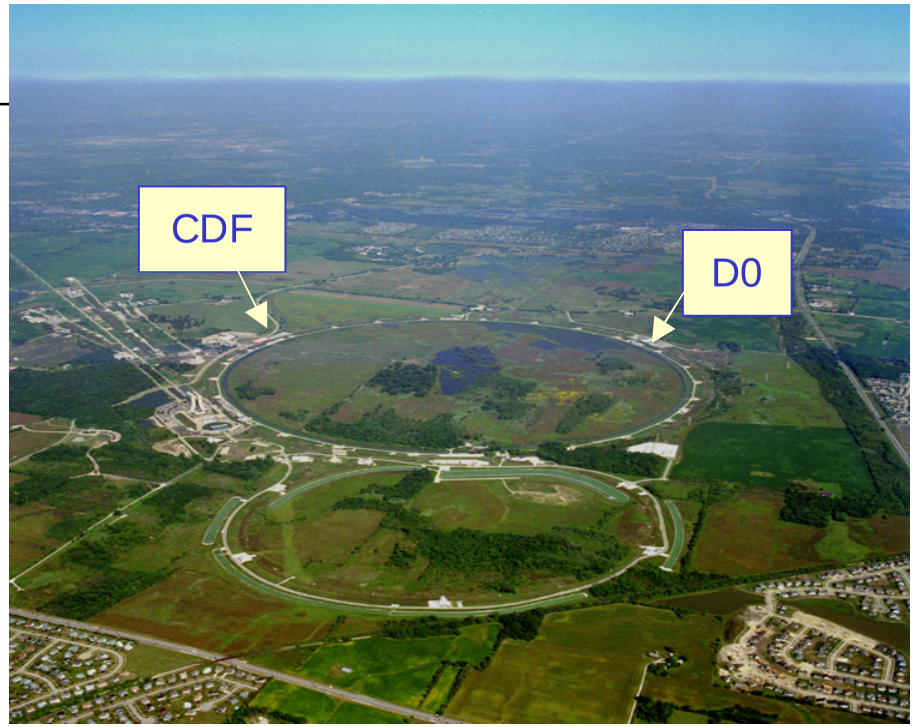
- **Top Physics Menu**
- **Improved DØ Experiment**
- **First Physics Results from RunIIa**
- **Outlook**

DØ at the Tevatron



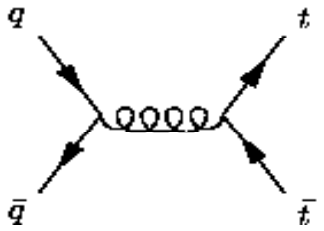


a multipurpose detector:

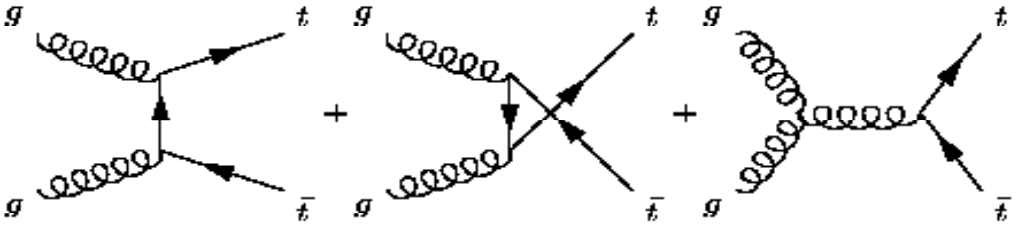
- Tracking
- Calorimetry
- Muon
- Pipelined 3–level trigger

Top Production at the Tevatron

- strong production
  - **quark annihilation** and gluon fusion



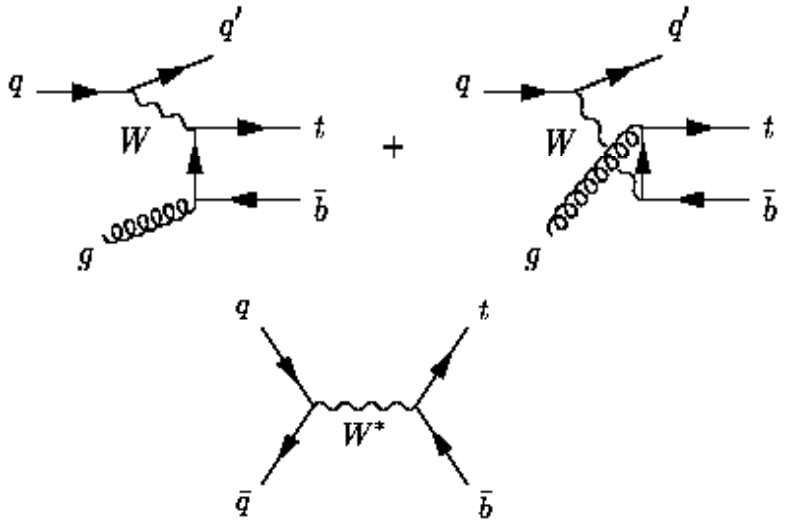
90% @ 1.8 TeV
85% @ 1.96 TeV



  - DØ: $\sigma = 5.7 \pm 1.2 \pm 1.0$ pb @ 1.8 TeV (PRL 79,1203 (1997))
- are there $t\bar{t}$ resonances?
  - search for non–SM production

Electroweak Top Production

- leading diagrams:



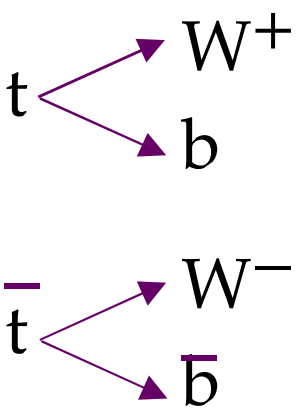
~70%

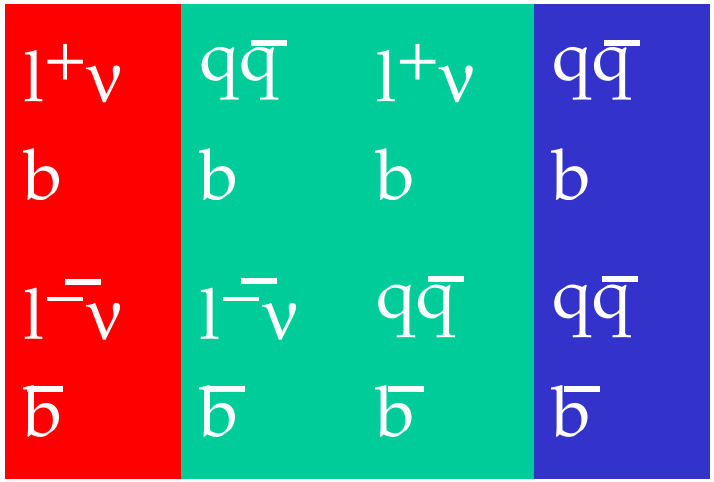
~30%

- direct measure of $|V_{tb}|$
- top quarks polarized
- DØ: σ < 17 pb (s–chan.), < 22 pb (t–chan.) (PRD 63, 031101 (2001))
  - theory: 0.8 pb and 1.5 pb, resp.

Top Decays

- expect
  - BR(t → Wb) ~ 100%
  - BR(W → *ff′*) ~ 1/9 each
  - b decays

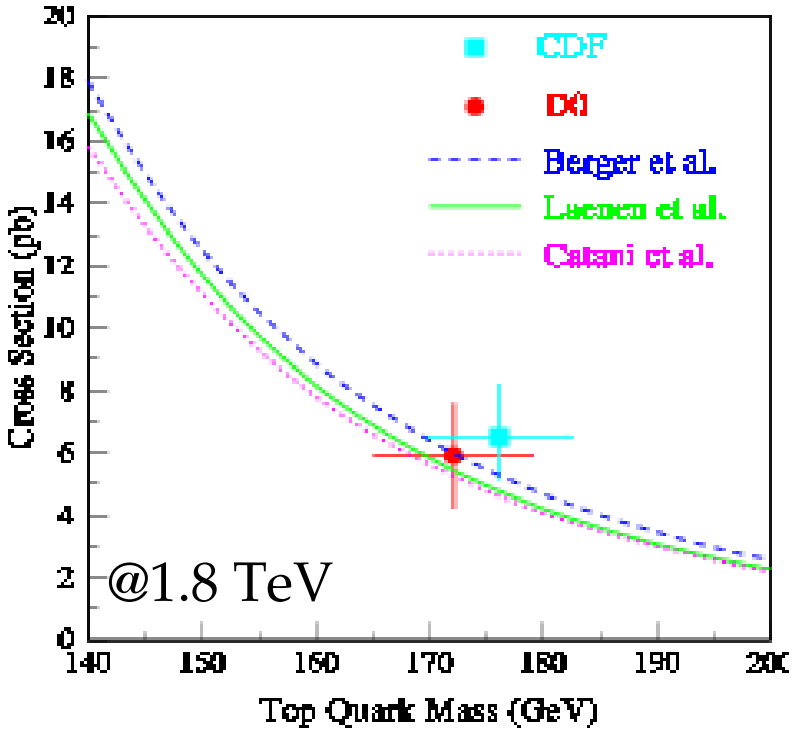


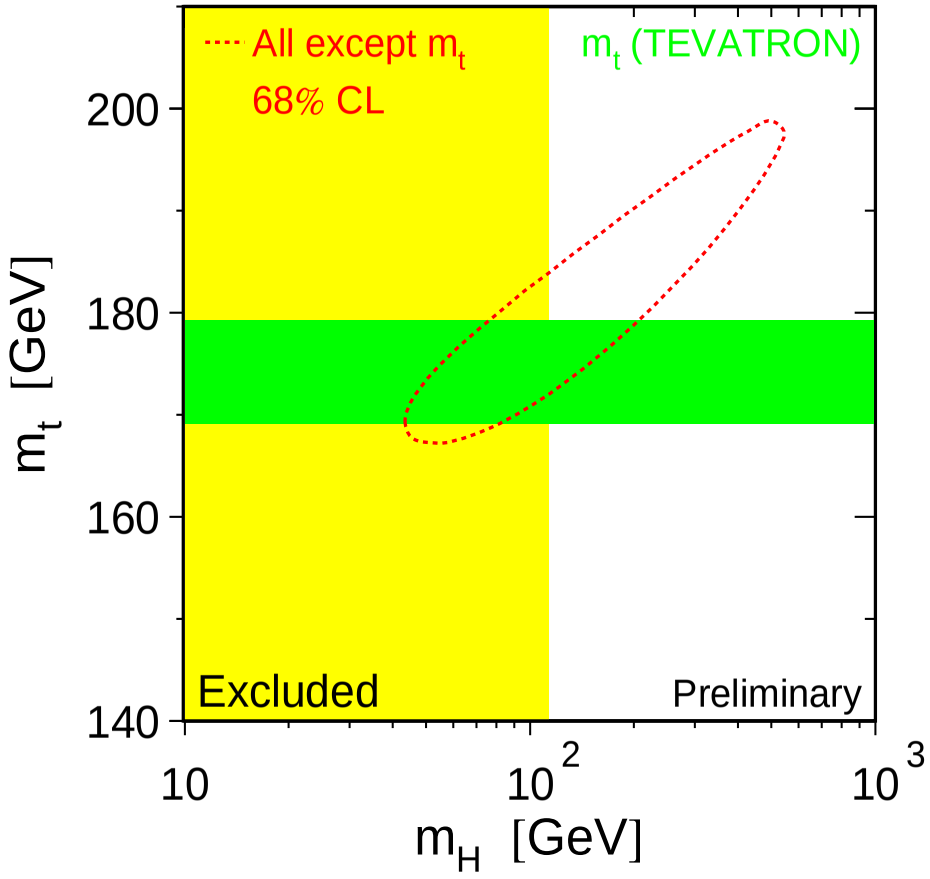


  - dilepton events: (ee,eμ,μμ) 5% total
  - e+jets, μ+jets: 15% each
  - all jets 45% total
- deviations from SM → new physics
  - eg. H^+b search (PRL 82, 4975 (1999))
    - significant branching ratio region excluded

Top Mass

- in SM, m_t helps constrain m_{H^0}
- Run1 m_t measurement:

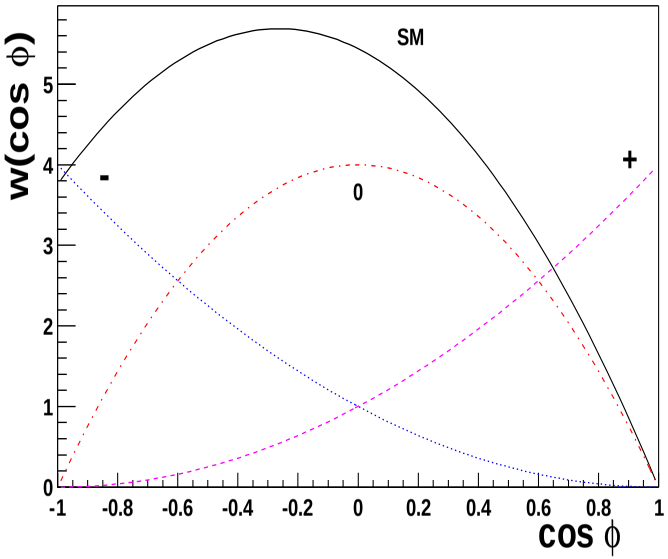




- DØ: $m_t = 172.1 \pm 5.2 \pm 4.9$ GeV (PRD 58, 052001 (1998))
- best measured mass of all quarks: 174.3 ± 5.1 (DØ+CDF)

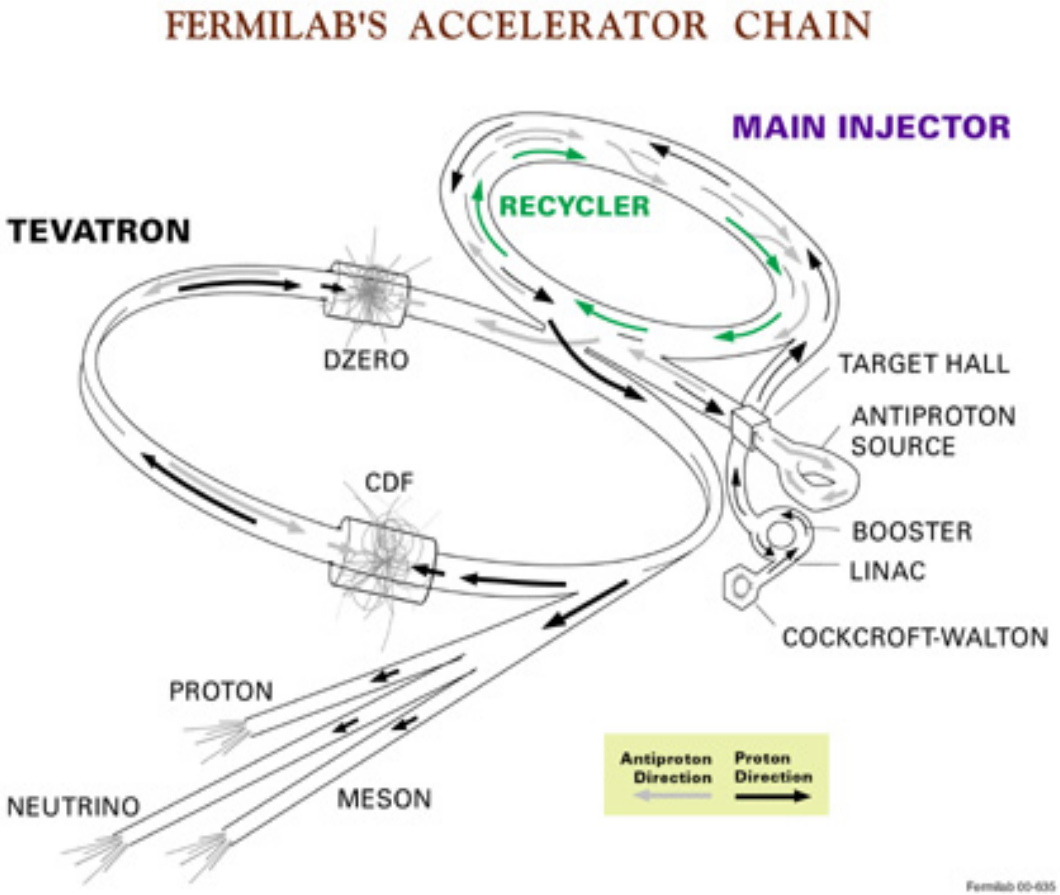
Spin and Helicity

- top can be studied as bare quark
- W helicity from top quark decays
  - W's never right–handed in SM
    - ~70% longitudinal
    - ~30% left–handed
  - can measure with lepton p_T and M_{eb}
- spin correlation in $t\bar{t}$ production
  - top expected to be unpolarized
  - spins of t and $\bar{t}$ correlated
  - DØ: $\kappa > -0.25$ @ 68% c.l. (dilepton channel – PRL 85, 256 (2000))



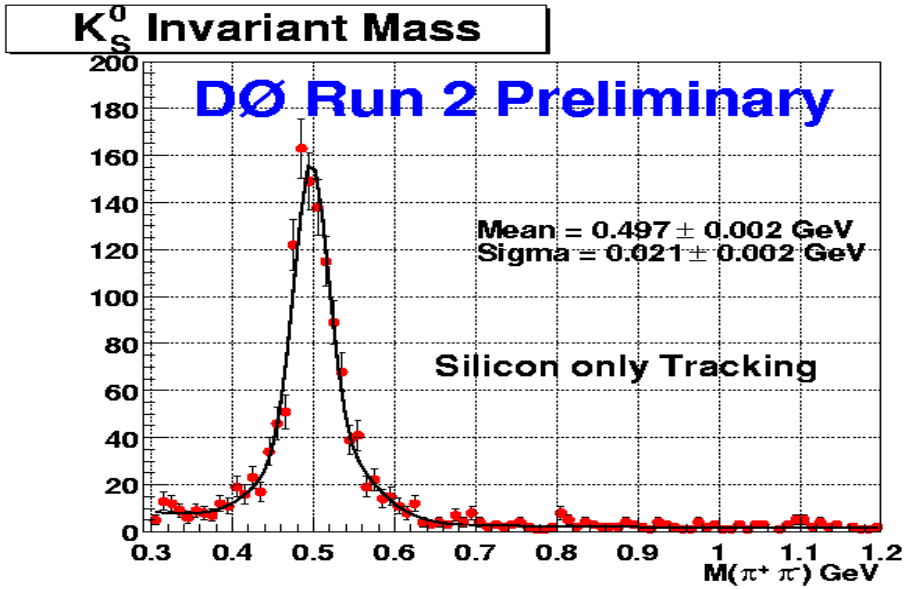
Tevatron Improvements

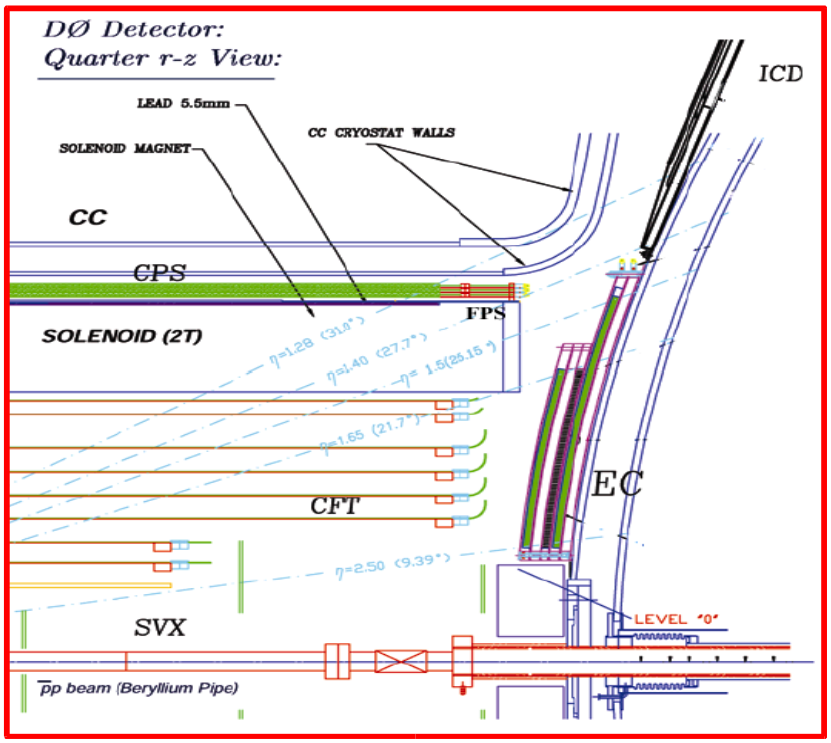
- Main Injector
  - much higher luminosity
    - eventually to 5×10^{32}
  - $2\ fb^{-1}$ thru 2004
  - $15\ fb^{-1}$ thru 2007
- Energy increase to 1.96 TeV
- first collisions April 2001
- current luminosities ~ 10^{31}



New Tracking for DØ

- Silicon Microstrip Tracker (SMT)
  - 840k channels
  - 4 layer barrels – 3D tracking
  - detached vertex detection
    - b–tagging
    - triggering
  - fully commissioned

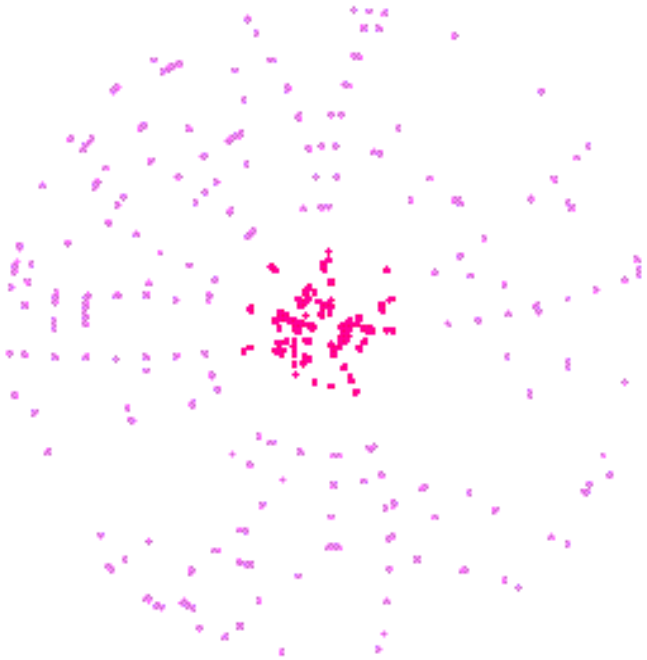




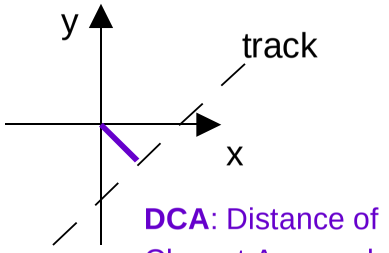
2T superconducting solenoid

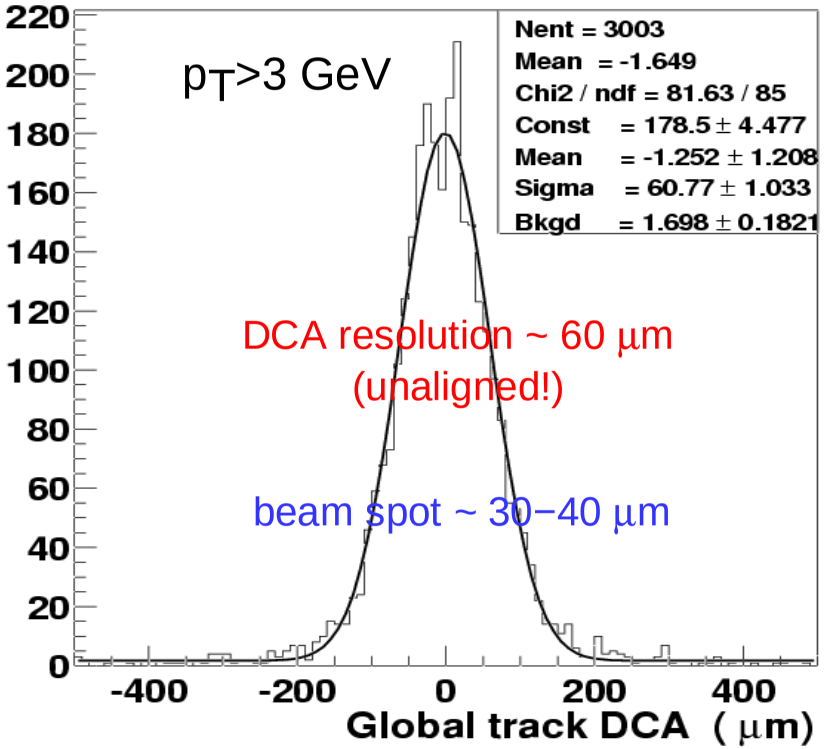
momentum, charge

New Tracking for DØ: CFT



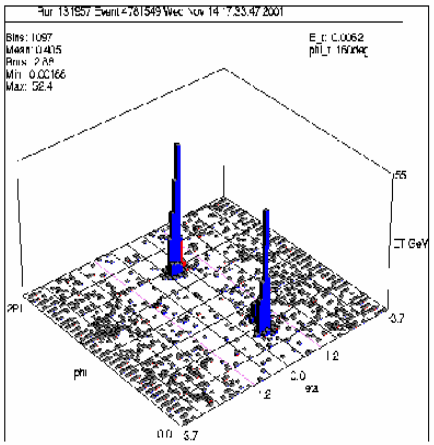
- Central Fiber Tracker
- 77k channels with VLPC readout
  - first sci–fi/VLPC tracker at collider
  - VLPC's
    - 9K operating temp.
    - 85% QE, excellent S/N
- 8 layers fiber doublets
- tracking trigger
- fully operational
- E/p measurement
  - improved calibration





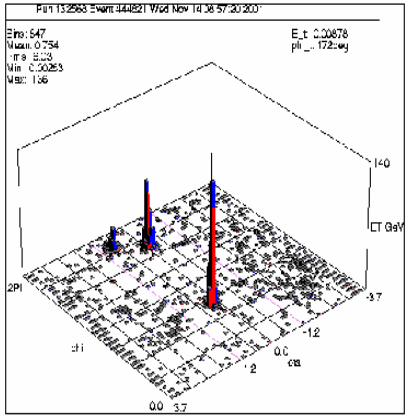
Calorimetry

- U/LAr calorimeter
  - uniform, hermetic, full coverage ($|\eta| < 4.2$)
  - compensating ($e/\pi \sim 1$)
  - good energy resolution
  - faster readout while
    - preserving performance
  - fully operational
- preshowers
  - for electron ID, energy resolution
  - only forward electronics remain to finish
- new inter−cryostat detector



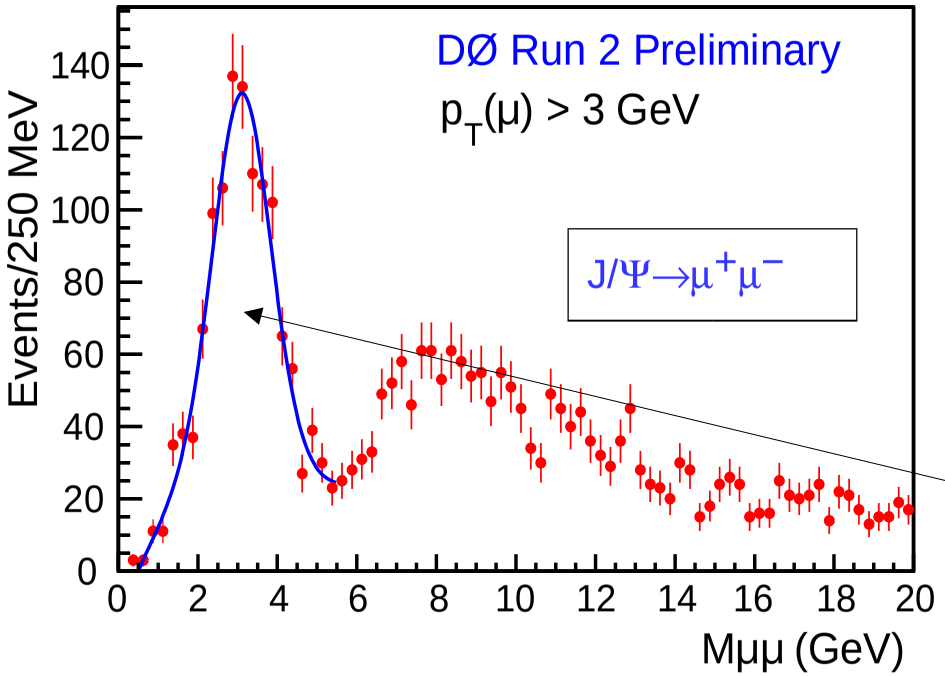
2- jet event
- E_T^{jet1}~230GeV
- E_T^{jet2}~190GeV

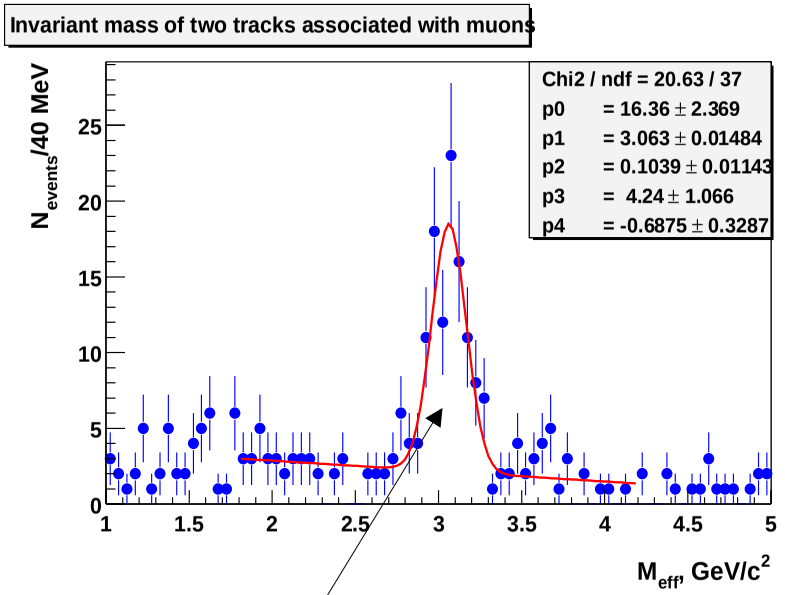
3- jet event
- E_T^{jet1}~310GeV
- E_T^{jet2}~240GeV
- E_T^{jet3}~110GeV
- E_T~8GeV



Muon

- coverage to $|\eta| < 2$
- good muon ID at trigger level
- new forward MDTs working well
- fully commissioned





Muon+CFT

From muon triggers (central+forward)
Muon System–only tracking

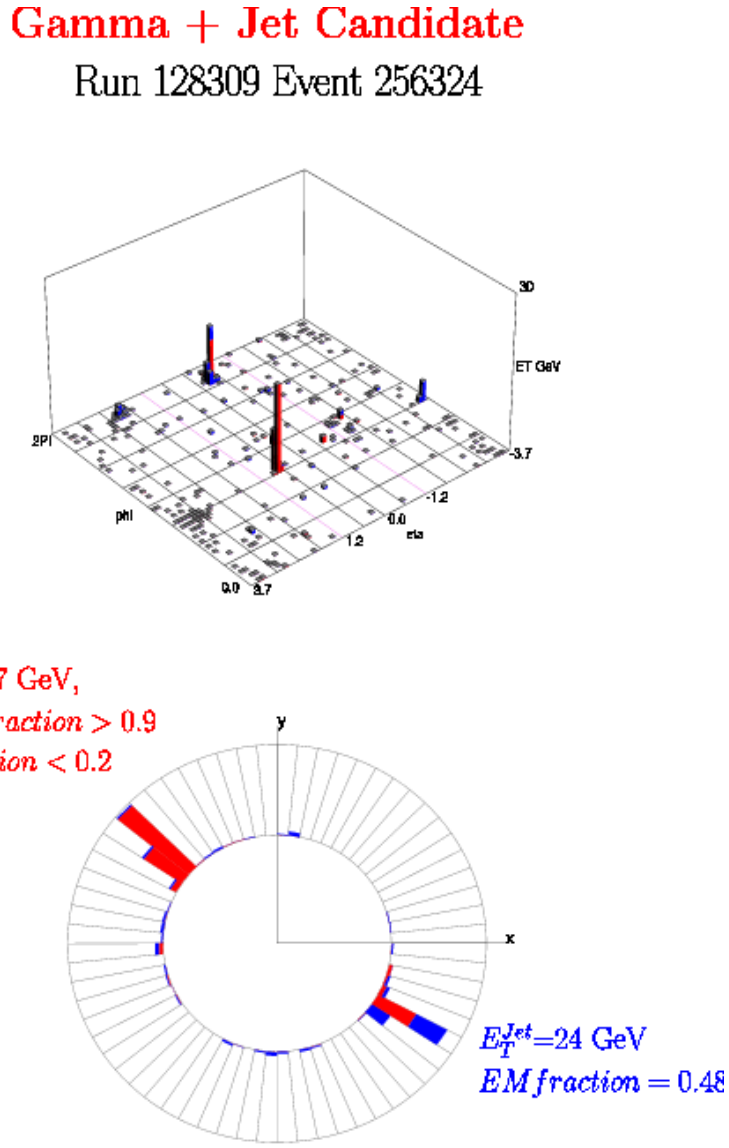
Run II Prospects: More Events!

- 20x increase in luminosity in RunIIa
- cross sections 40% larger
- for example:
  - expect ~160 dilepton events
    - 6 seen in Run1
    - will make mass measurement competitive with *l*+jets

	Run1–*ll*	RunIIa–*ll*	RunIIa–*l*+jets
stat.(GeV)	12.3	2.4	1.7
sys.(")	3.6	1.4	2.1
TOTAL(")	12.8	2.8	2.7

Run II Prospects: Smaller Systematics

- lower background
  - via detached vertex b–tag
- smaller systematics
  - more background statistics
  - eg. jet energy scale
    - strong emphasis early in run
    - significant problem for
      - m_t, σ_{tt}
    - tracking, more statistics
    - 2x to 3x smaller error

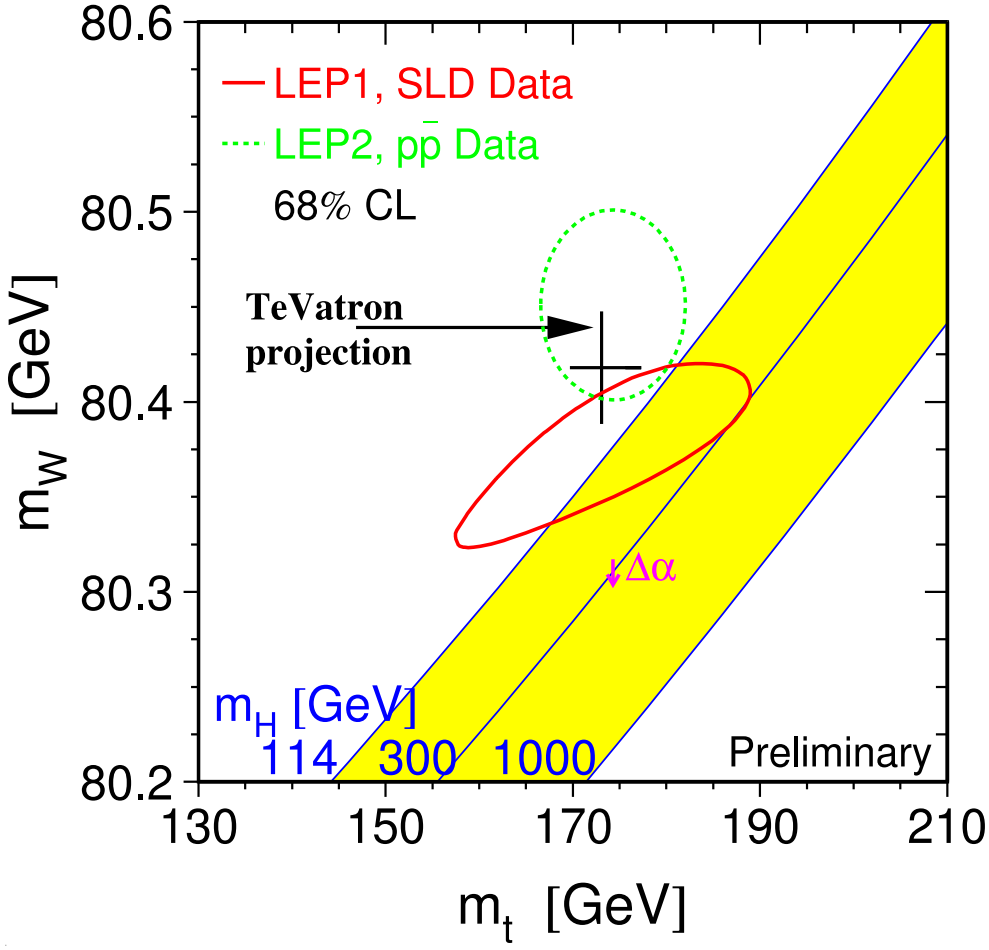


Run II Prospects: How We Should Do

about 3x smaller error for mass or cross section

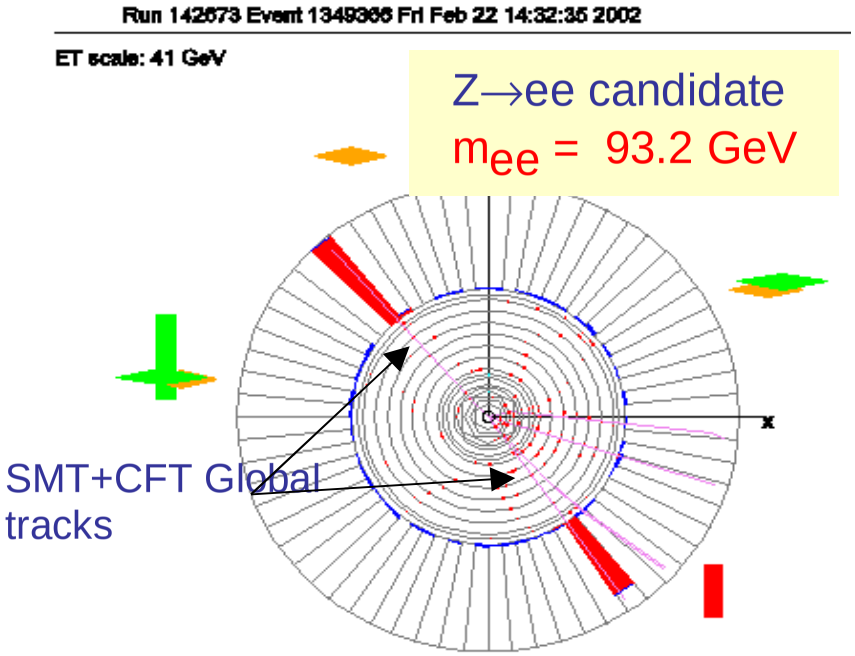
- δm_t 2–3 GeV
- $\delta\sigma/\sigma$ 8%
- $t\bar{t}$ spin 2σ
- $\delta|V_{tb}|$ 15%
  - measure σ_t to ~30%

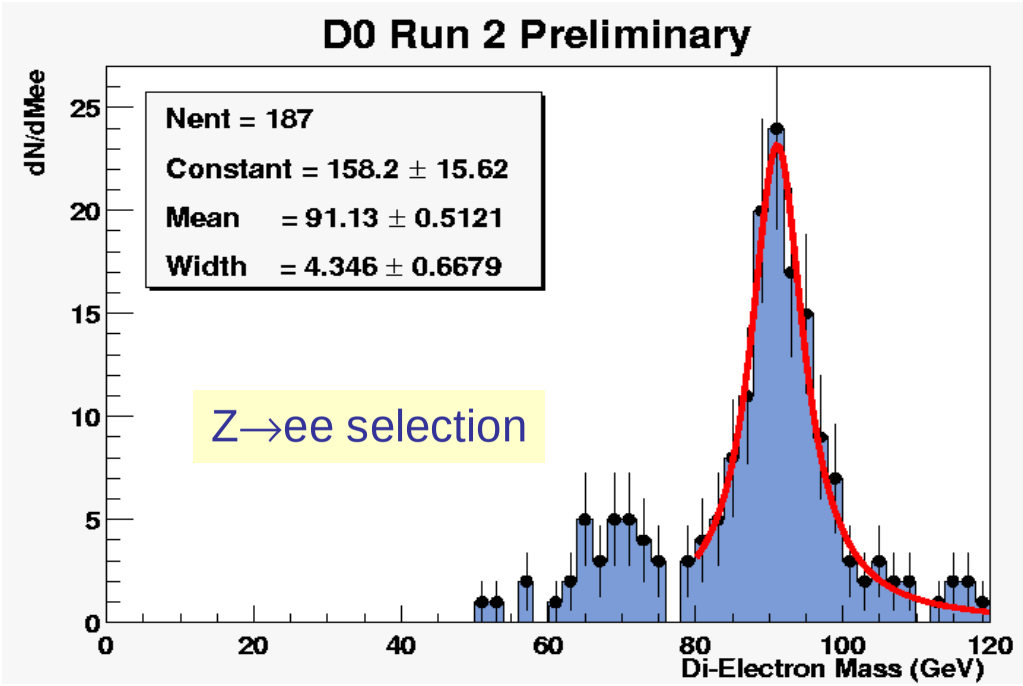
- m_W vs. m_t
  - dramatically reduce region allowed for SM Higgs

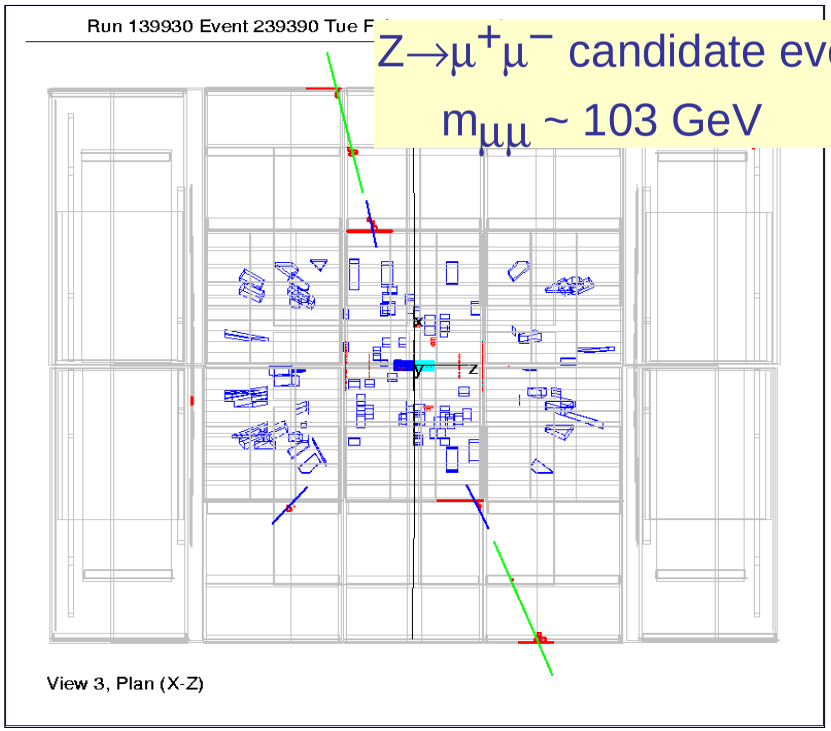


First Data: Z events

- significant as a top dilepton background
- Z→ee crucial sample for calibration studies

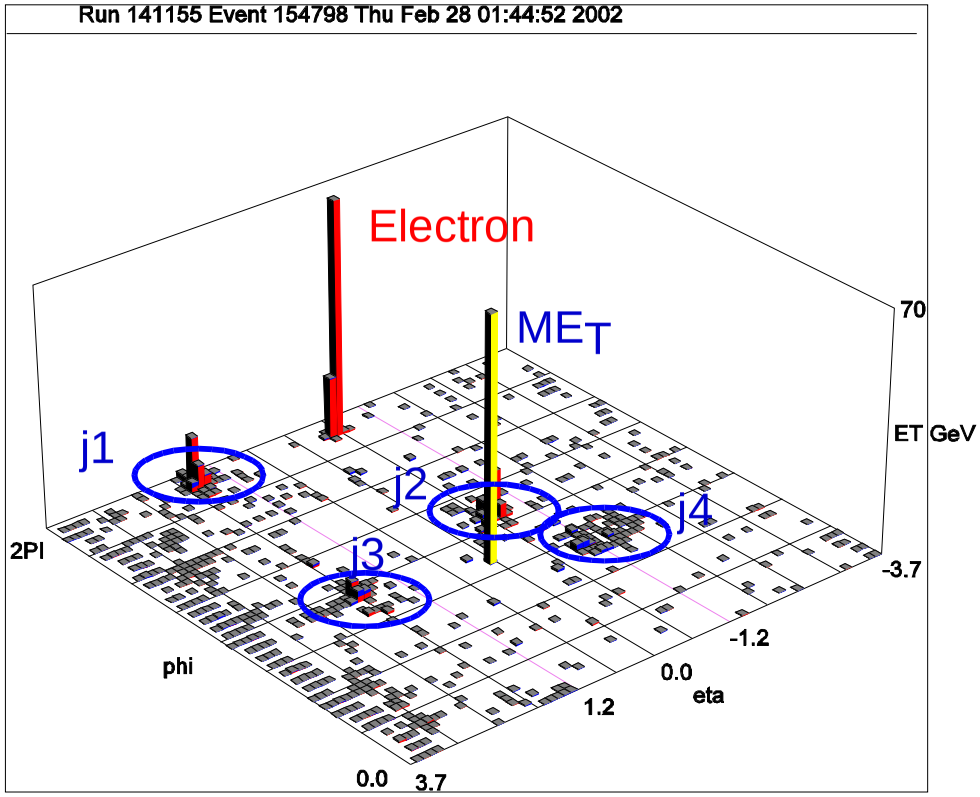


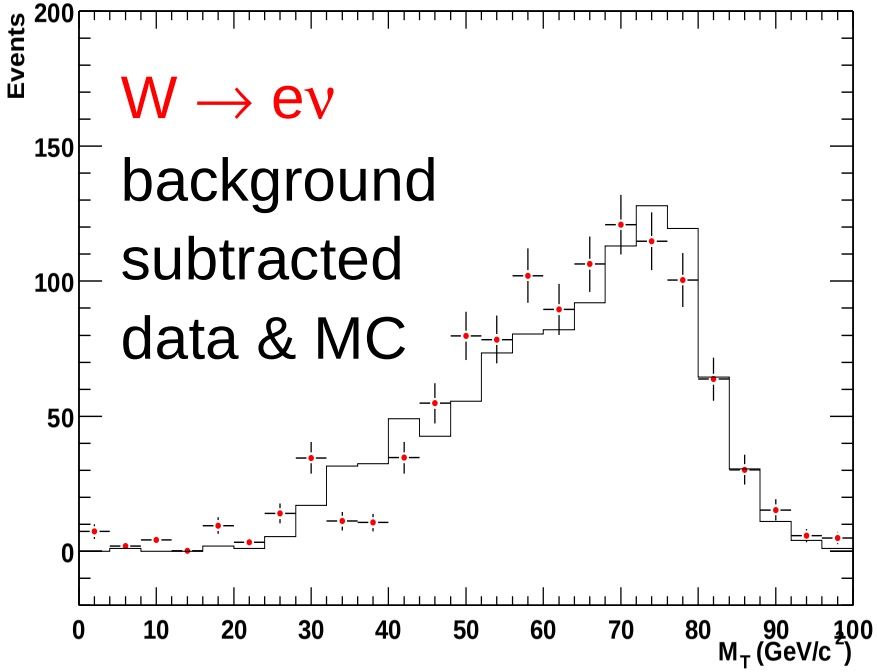


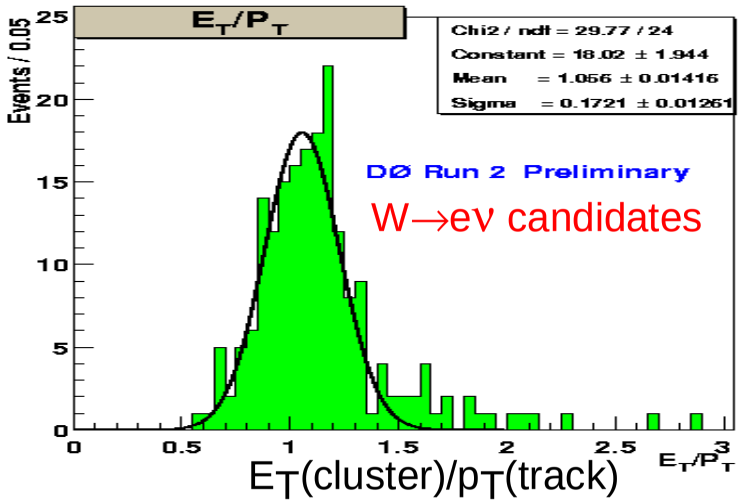


First Data: W events

- main l+jets background
- W→eν important test of $\not\!\!E_T$
- W+4jets: top candidate sample







Outlook

- major upgrade complete
  - all new tracking, forward muon
  - mostly new trigger/DAQ, alot of new electronics
- RunII will be rich environment
  - measurements will be vastly improved over Run1
  - top mass will verge on precision measurement
  - single top and $t\bar{t}$ production
    - single top should be observed
  - studies of top decay modes
  - spin and helicity studies
  - excellent laboratory for to look for new physics
    - several ways to probe SM