New Run II Results from the DØ Experiment at the Tevatron Accelerator

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for the

DØ Collaboration

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- The DØ Experiment
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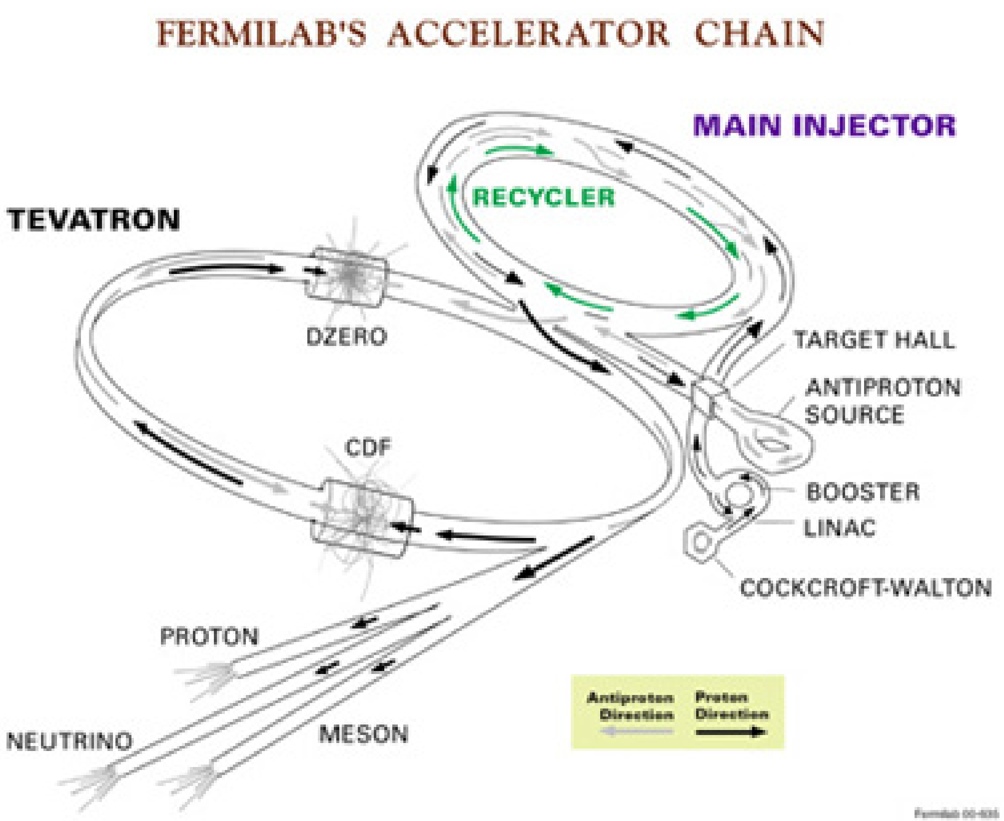
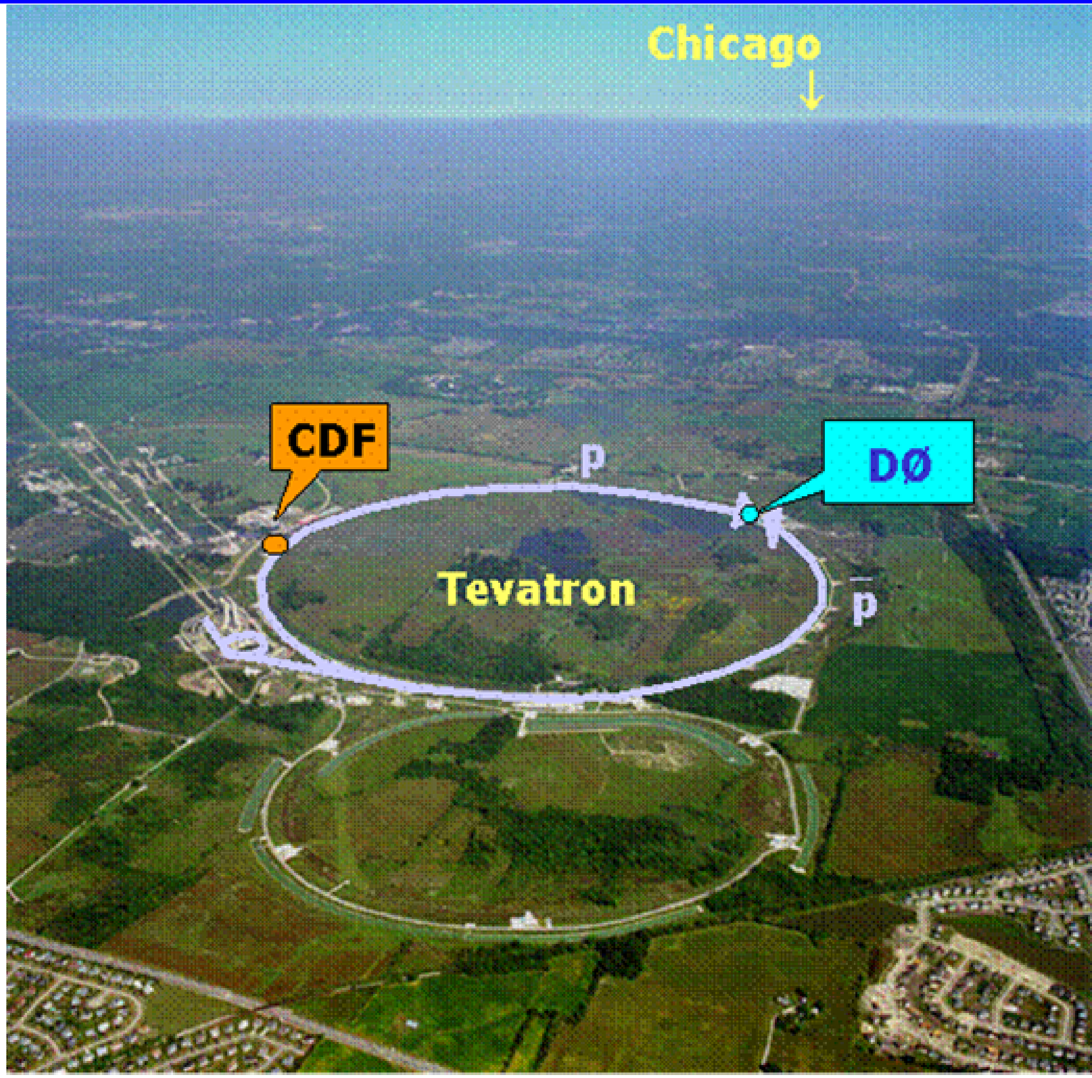
The Run II at the Tevatron

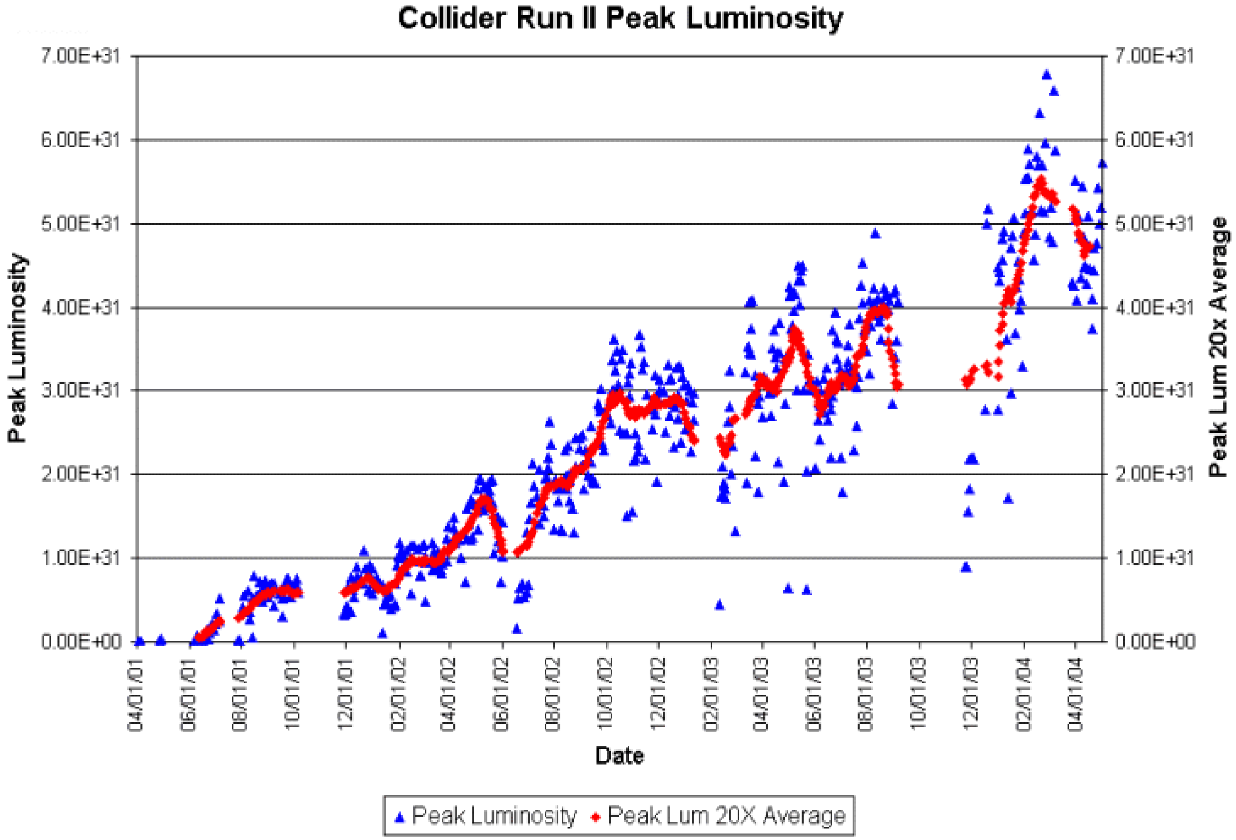


- New Main injector ring
- Tevatron: ~6km circumference
- Proton-Anti-Proton with ~1 TeV per beam (cms=1.96 TeV)
- 36 bunches per beam
- Collision rate: 7.5MHz
  396ns bunch distance
- Two experiments: CDF and DØ
- History:
  Built: 1984-92
  “Run I” @ 1.8TeV: 1992-96
  Upgrade: ’96 – 2001
- “Run II” started March 2001

Tevatron: Landscape



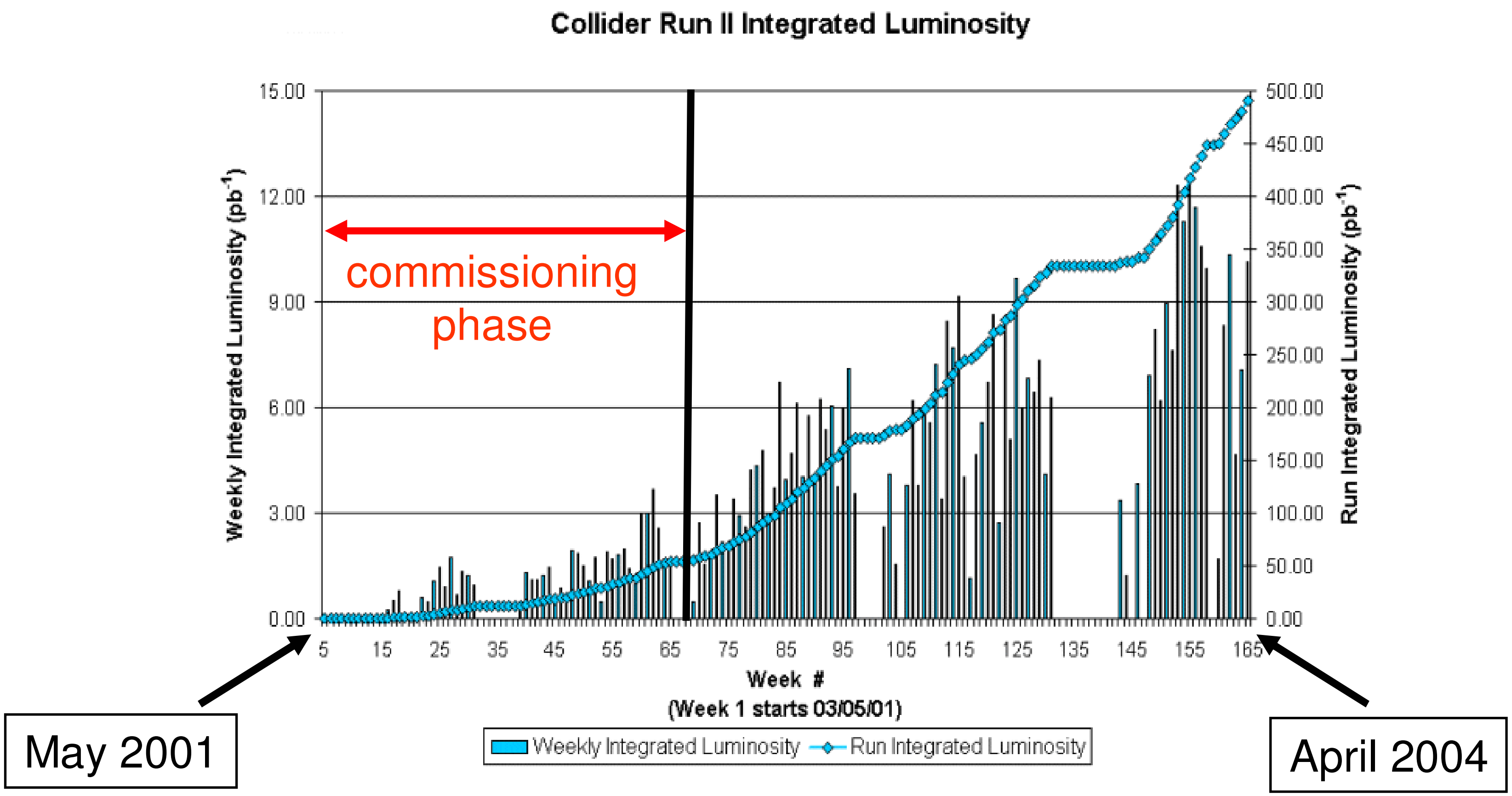
Tevatron: Performance



Luminosity: $$L = f \cdot \frac{n_1 n_2}{4\pi\sigma_1\sigma_2}$$

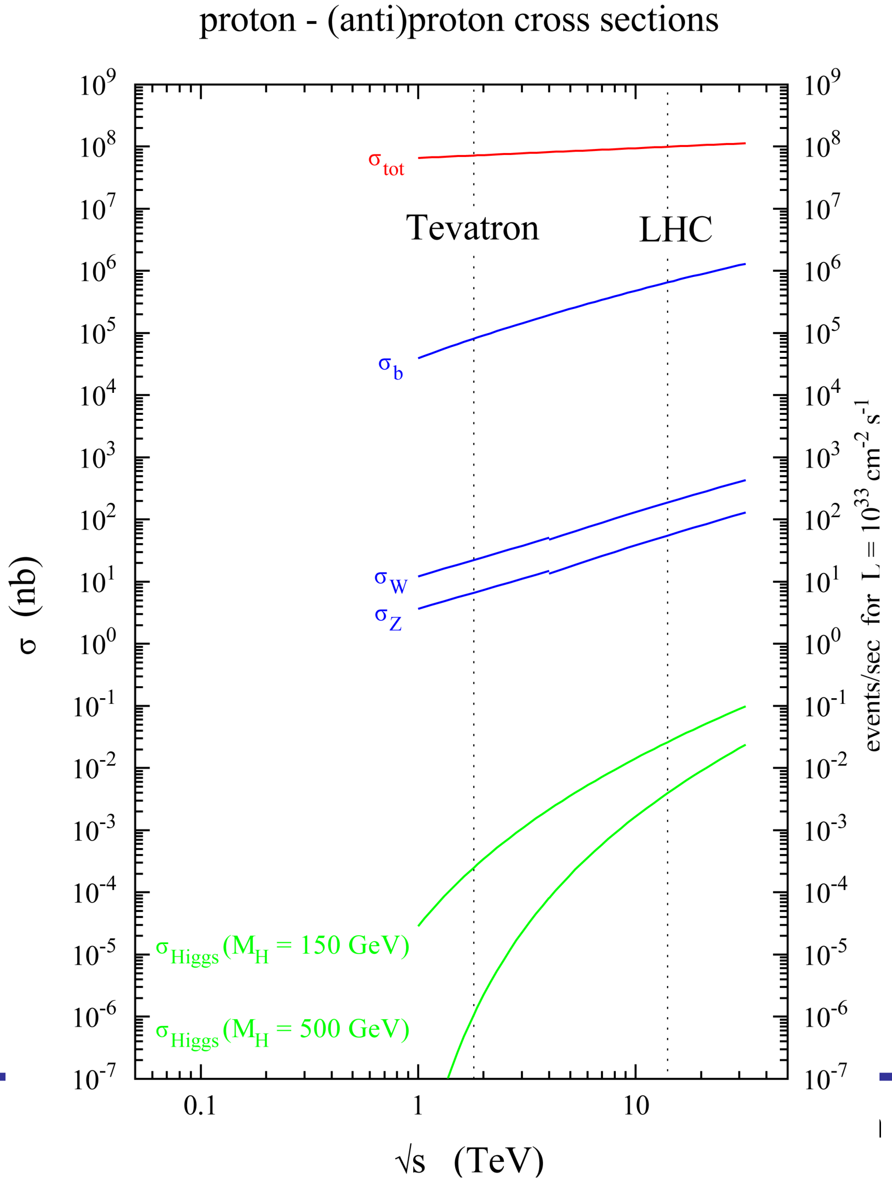
n_1 : number of protons per bunch
n_2 : number of anti-protons per bunch
σ_1 und σ_2: transverse bunch size
f : Frequency (average 7,5MHz)

Tevatron: Performance (2)



Delivered Luminosity: ~500pb^{-1}

Produktion Cross Section



→ $5 \cdot 10^{6}$ events/sec

→ $5 \cdot 10^{3}$ events/sec

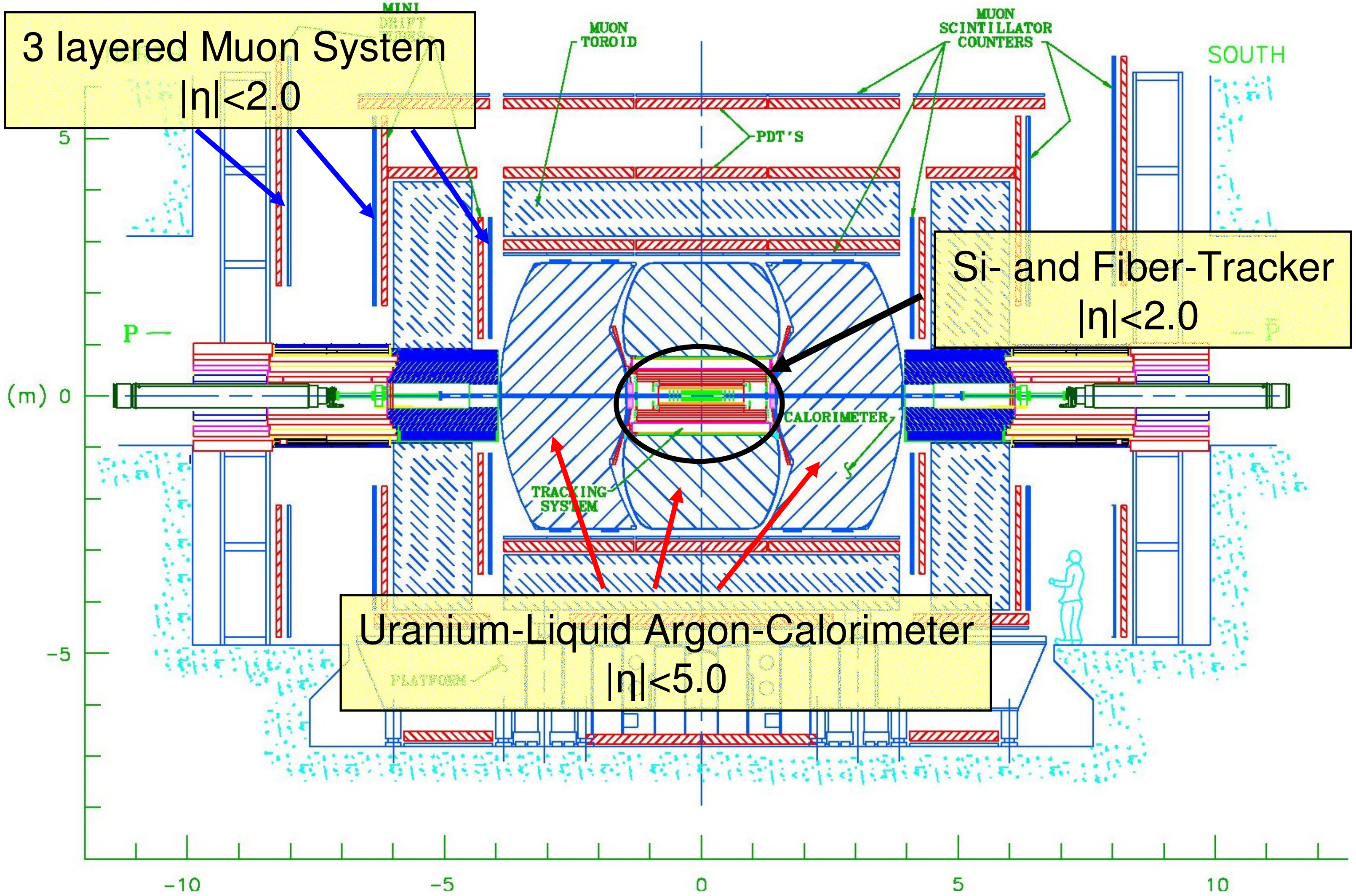
→ 5 events/sec

→ $5 \cdot 10^{-6}$ events/sec

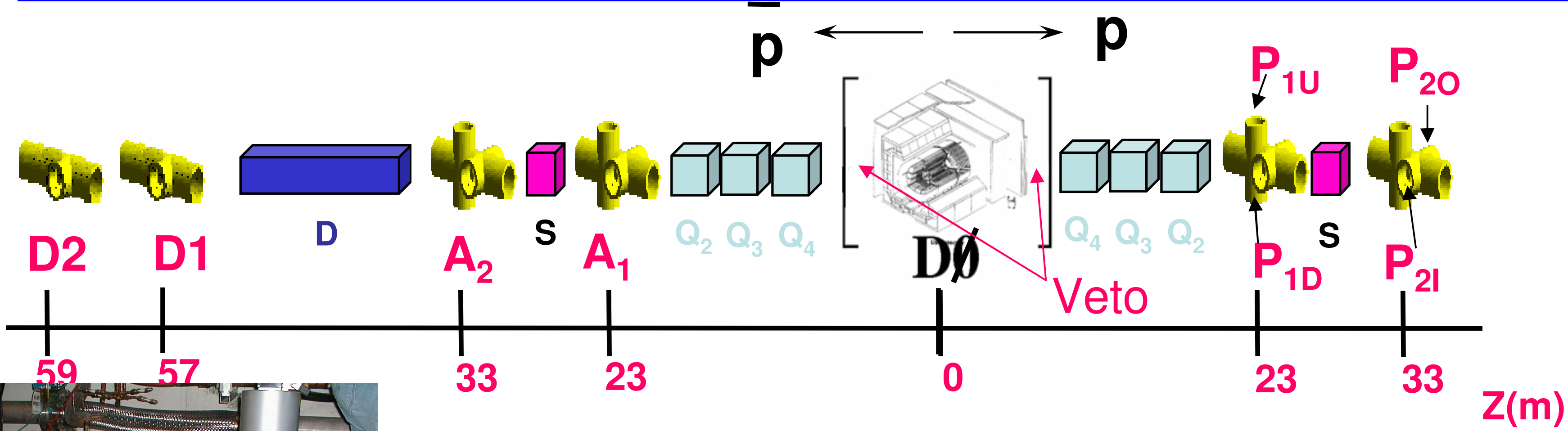
The DØ Experiment

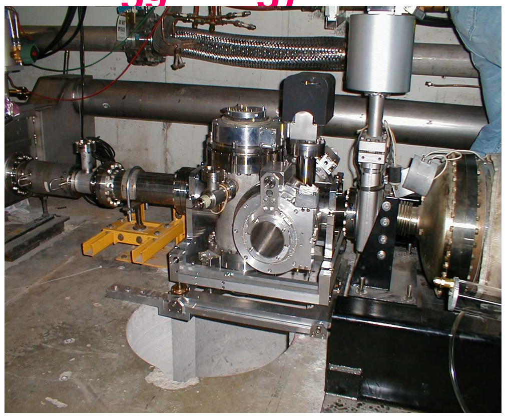
- 650 physicists from 19 nations
- For Run II an extensive upgrade of the detector
  - superconducting solonoid (2T)
  - scintillating fiber tracker
  - silicon vertex detector
  - new read out electronics
  - new data acquisition system

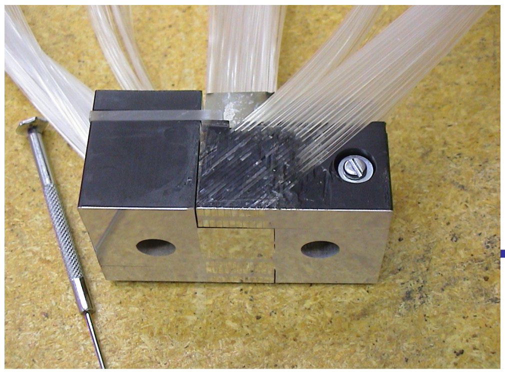
DØ Detector: Setup



DØ Forward Proton Detector



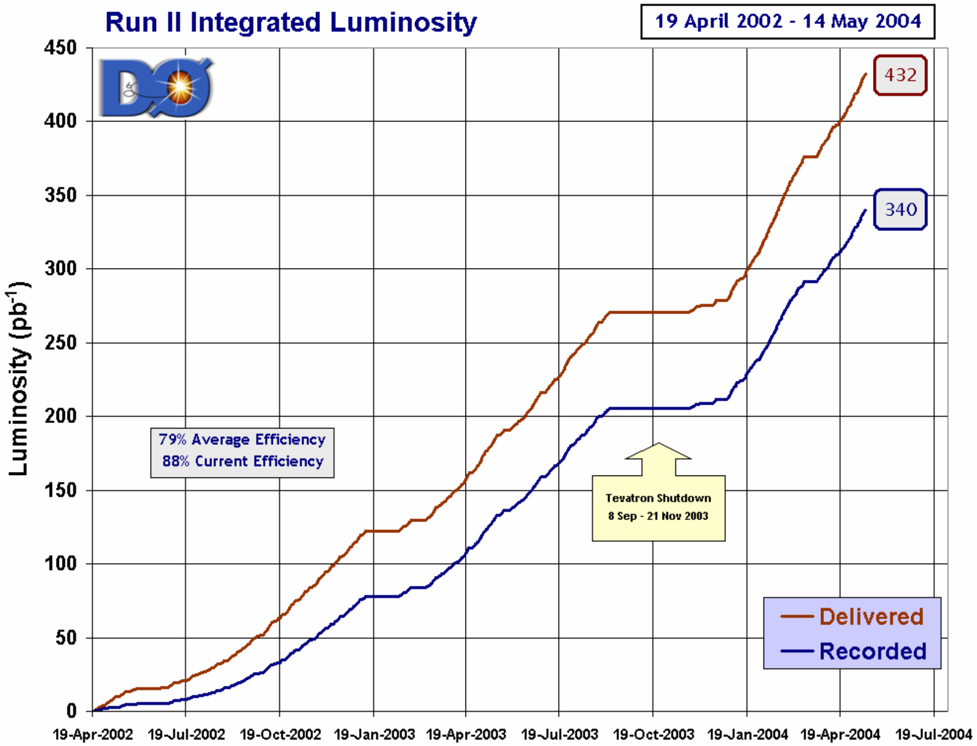




- 9 momentum spectrometers composed of 18 Roman Pots
- Protons and anti-proton are tracked utilizing scintillating fiber detectors
- Very close to beam line (down to ~6mm)
- Reconstructed track is used to calculate momentum fraction and scattering angle
- Used to measure elastic and diffractive events
- Covered t region: $0.6 < t < 4.5$ GeV^2
- Resolution substantially better than standard rapidity gap method

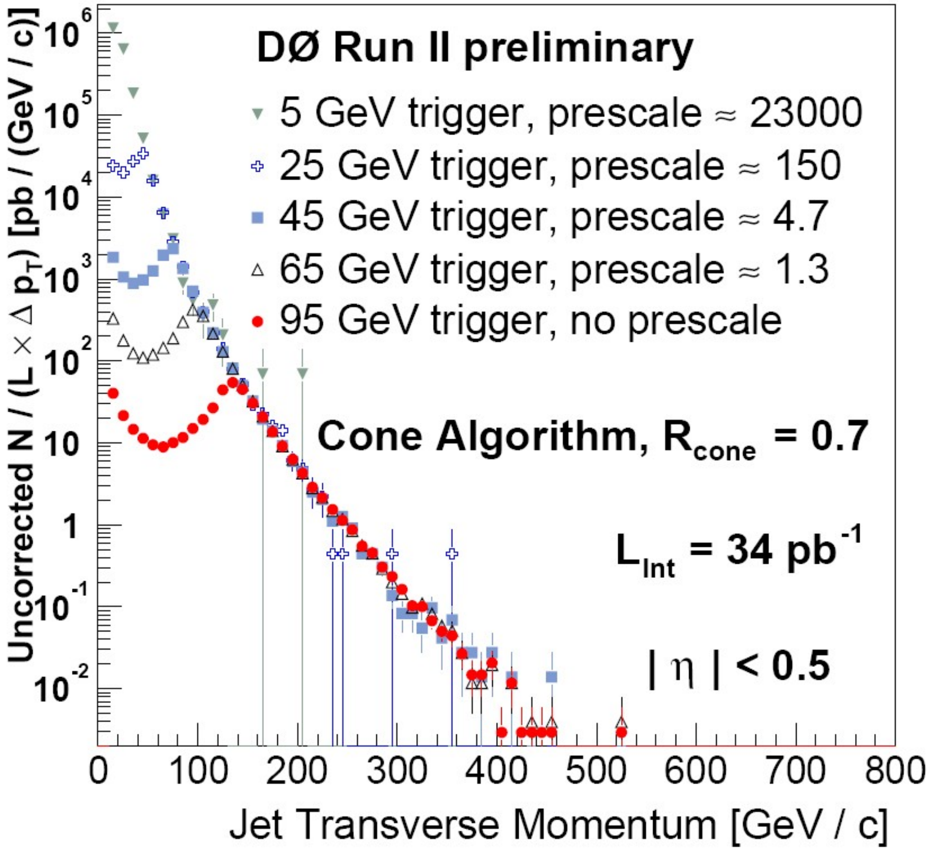
DØ: available data

- ~340 pb^{-1} on tape as of last week
- Not all data under optimal condidtions
  e.g. missing detector components
- Available for analysis: ~250pb^{-1}
- Most current results use between 140 and 200pb^{-1}



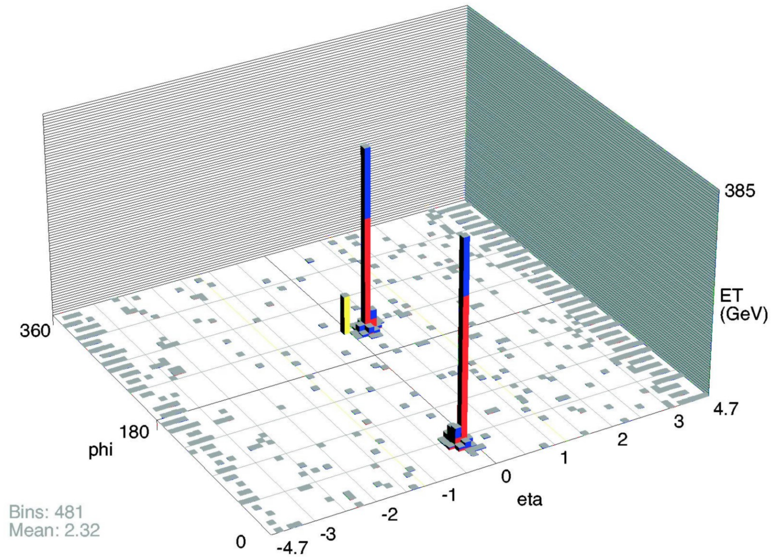
DØ: Triggering on Jets

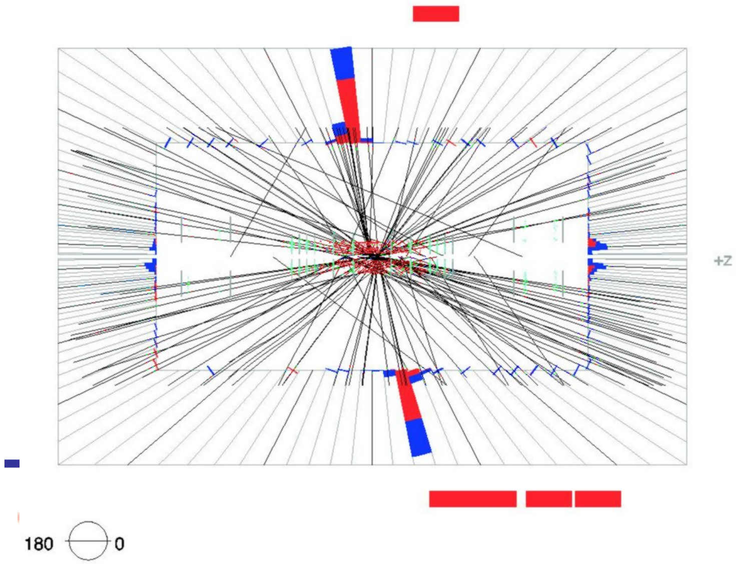
- Jet selection: Cone algorithm with radius R=0.7 in η and Φ
- Different p_T trigger thresholds
- Understanding of trigger turn-ons important
- Trigger acts on “raw” energies
- Jet *Energy Scale* corrections substancial !
- Error on *Energy Scale* still dominant systematic error !

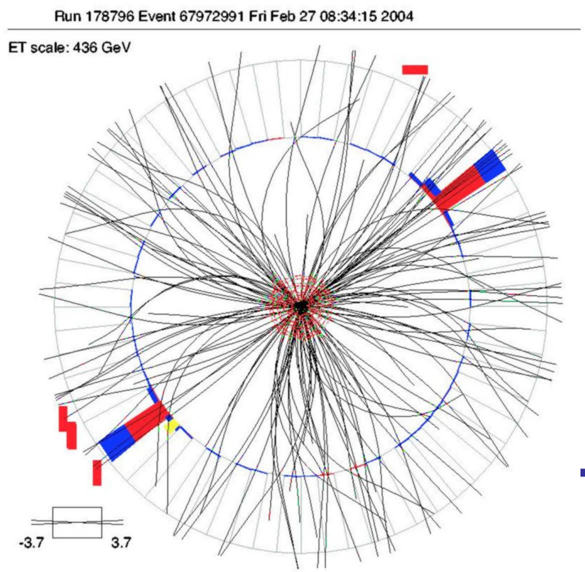


The *Biggest* Event

- Di-Jet Mass: M_{JJ}=1206 GeV/c^2
- Highest p_T Jet: p_T=616 GeV/c^2







mE_t: 72.1
phi_t: 223 deg

QCD: Inclusive Jet Cross-Section

- High p_T Jets and large M_{JJ} sensitive to:
  - Parton Density Functions
  - strong coupling constant α_S

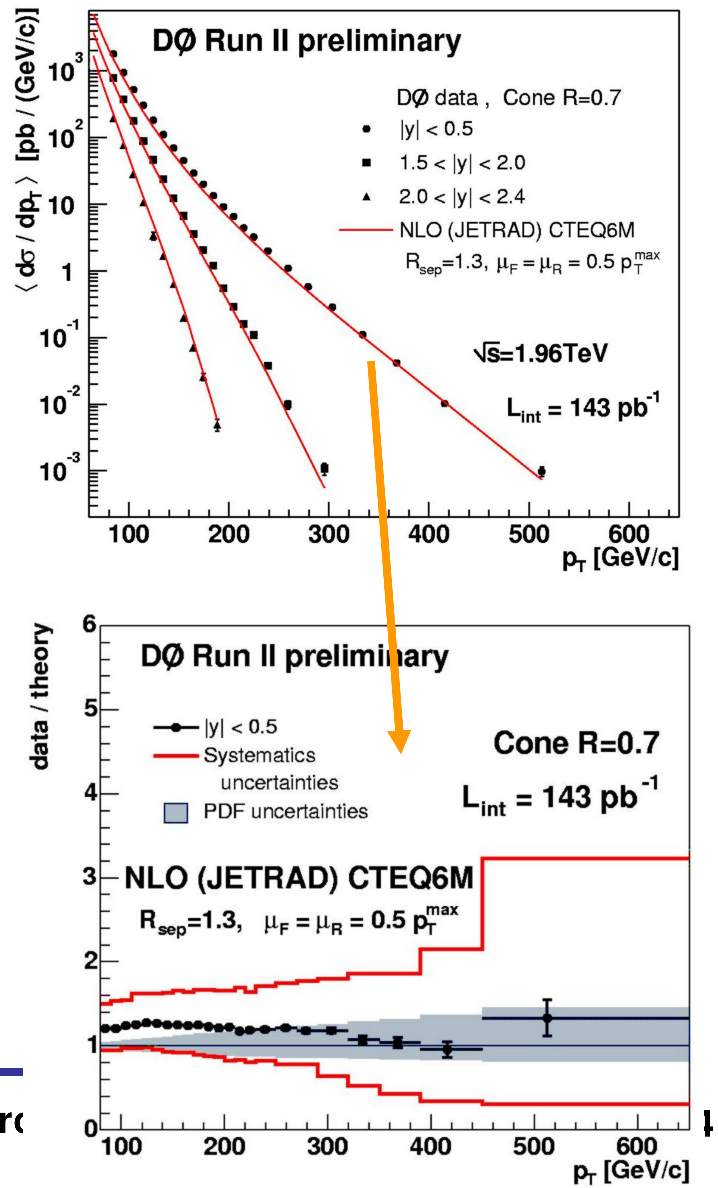
  Test of NLO perturbative QCD

- Deviations from predictions could indicate new physics

- Measurement in three different rapidity bins

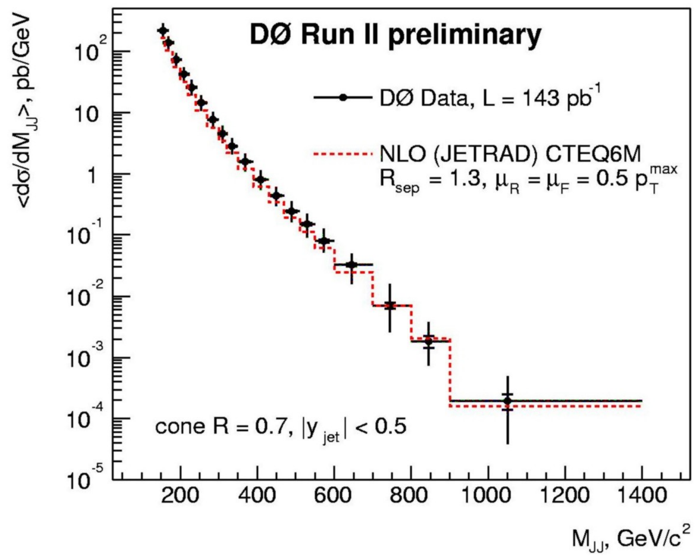
- Theoretical prediction:
  NLO pQCD calculation utilizing JETRAD and CTEQ6M PDFs

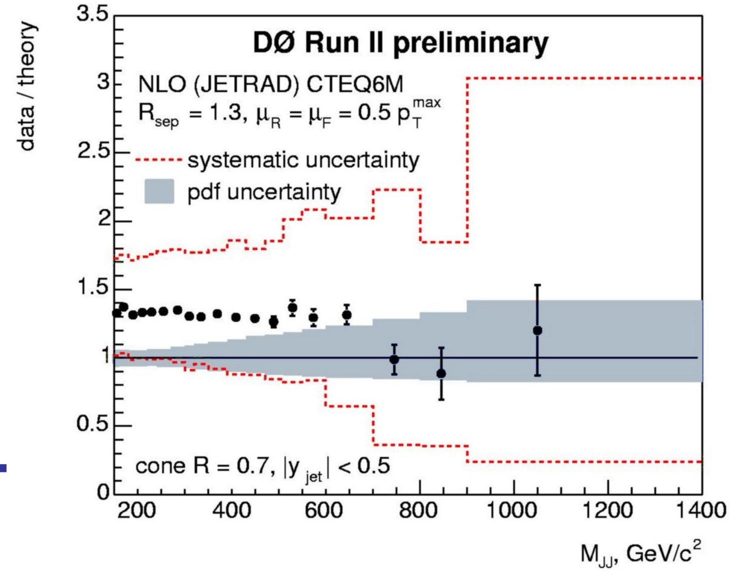
- Main systematic error source: jet energy scale



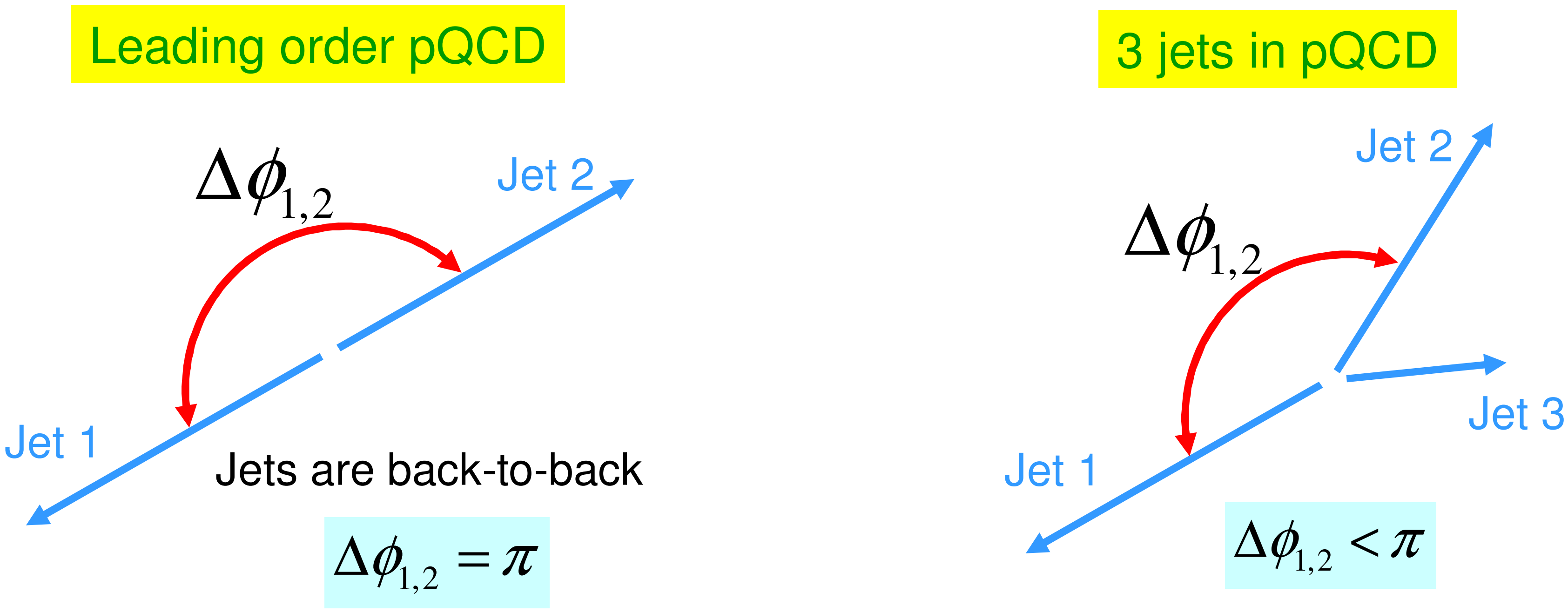
QCD: Di-Jet Cross-Section

- Jets selected in the central detector region $|\eta| < 0.5$
- Jets are merged if overlapping within R=0.7 cone with 50% of lower p_T jet in overlap region
- Current experimental systematic errors still dominating completely





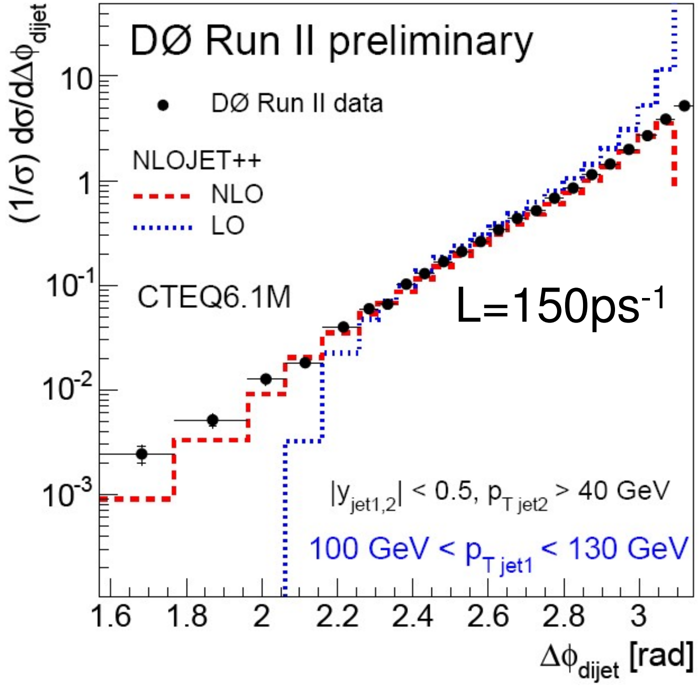
QCD: azimuthal decorrelation

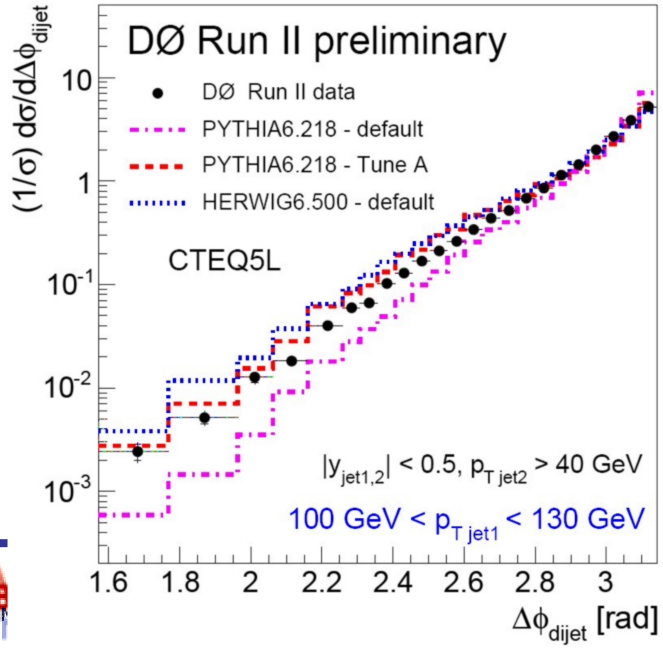


- Measure angle between leading and next-to-leading jet
- $\Delta\Phi$ is sensitive to jet formation without having to measure 3rd jet directly
- Sensitive to higher order QCD
- p_T of radiated gluon anti-correlated with $\Delta\Phi$ ($p_T=0 \rightarrow \Delta\Phi=\pi$)

QCD: azimuthal decorrelation (2)

- Jet selection:
  - $|\eta|<0.5$ (central detector region)
  - $p_T > 40$GeV/c
- As expected: LO pQCD does not describe the data
  - Pole at $\Delta\Phi = \pi$
  - max. $\Delta\Phi = 2\pi/3$
- Reasonable agreement with NLO pQCD

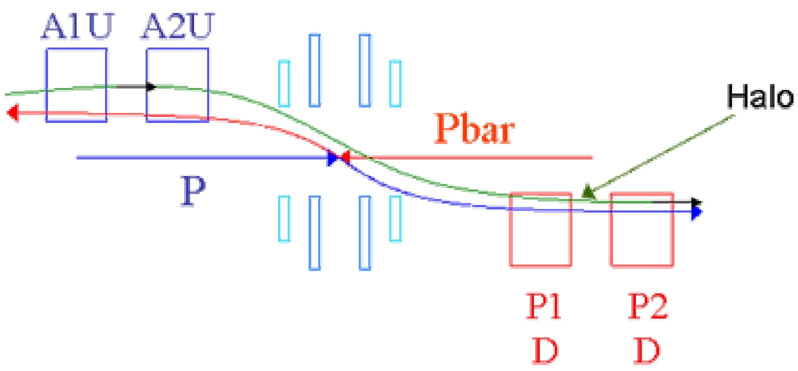


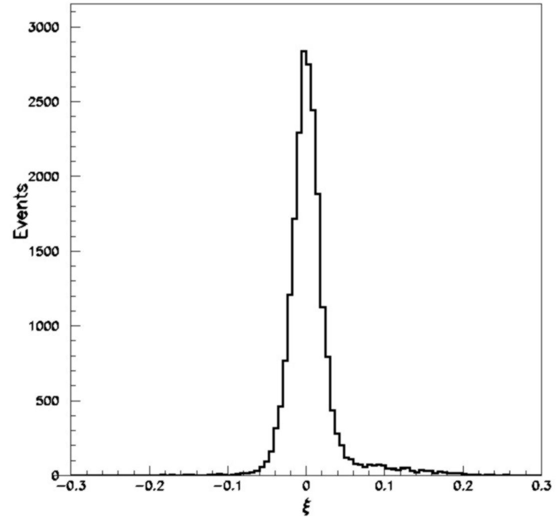


- Pythia tuning to other pp data fits well
- Pythia spectrum sensitive to amount of ISR

First Look at FPD Data

- Measure scattered proton and anti-proton in Forward-Proton-Spectrometer
- Determine momentum transfer t and $\xi=1-x_P$ (where x_P is the momentum fraction of the proton)
- Separate elastic and diffractive events
- Elastic events centered at $\xi=0$
  resolution 0.017
- Larger values correspond to diffractive events
  used cut at 0.03

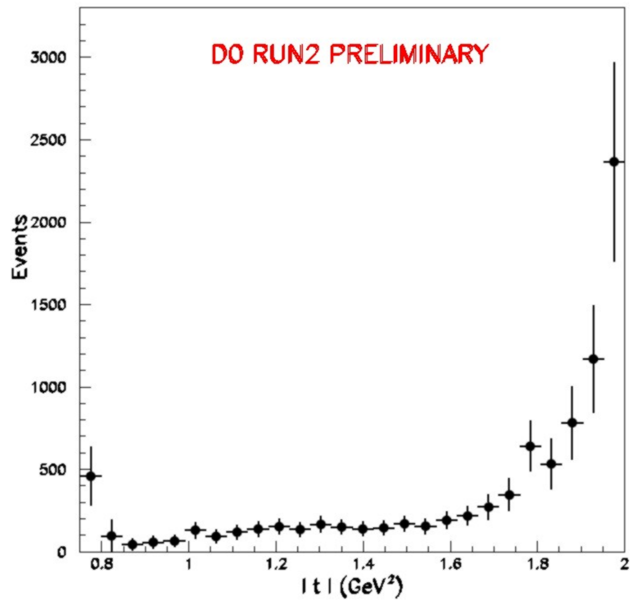




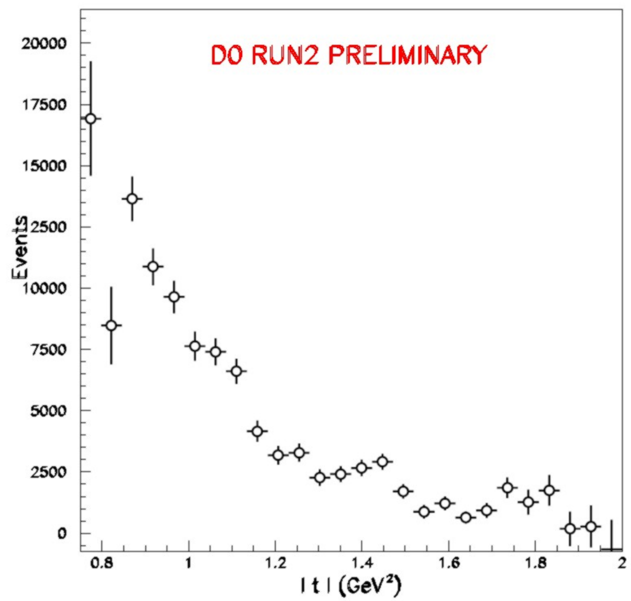
First FPD data (2)

Distributions of the momentum transfer |t|

Diffractive events

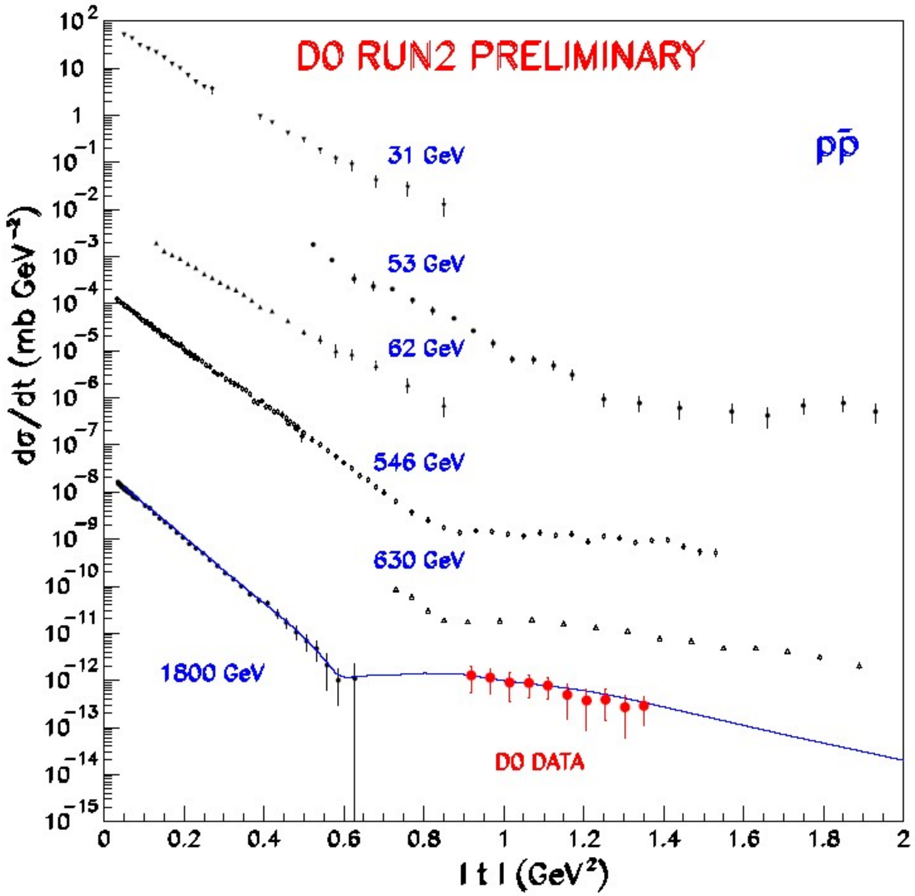


Elastic events



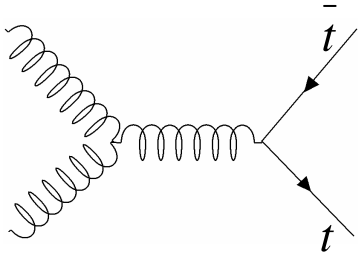
First FPD data (3)

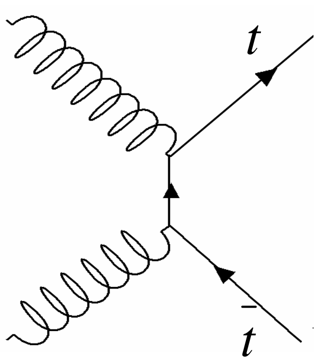
- Comparison of elastic proton anti-proton scattering at different $\sqrt{s}$
- Experiments: ISR, UA4 and E710
- DØ points normalized to E710 (1800 GeV)
- Model: M. Bloch Phys. Rev D41(1990) 978
- Lot more to come in the future!
  Diffractive W/Z production
  Diffractive jet production



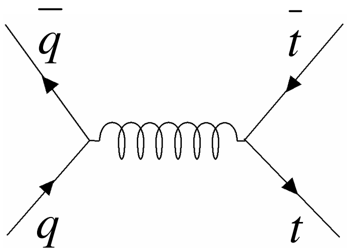
Scale factor between curves: 10^{-2}

Top Quark Physics





15% of $\sigma(tt)$

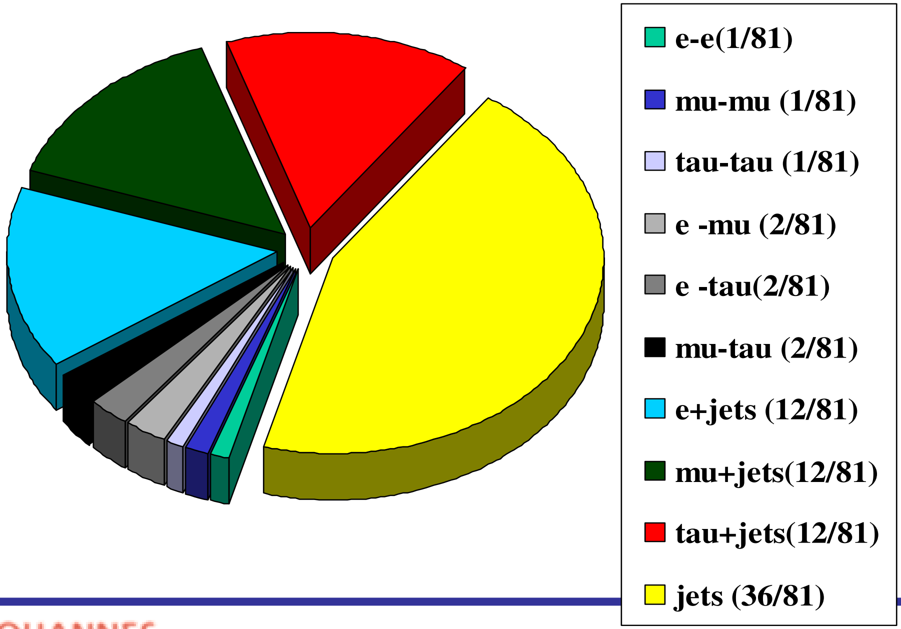


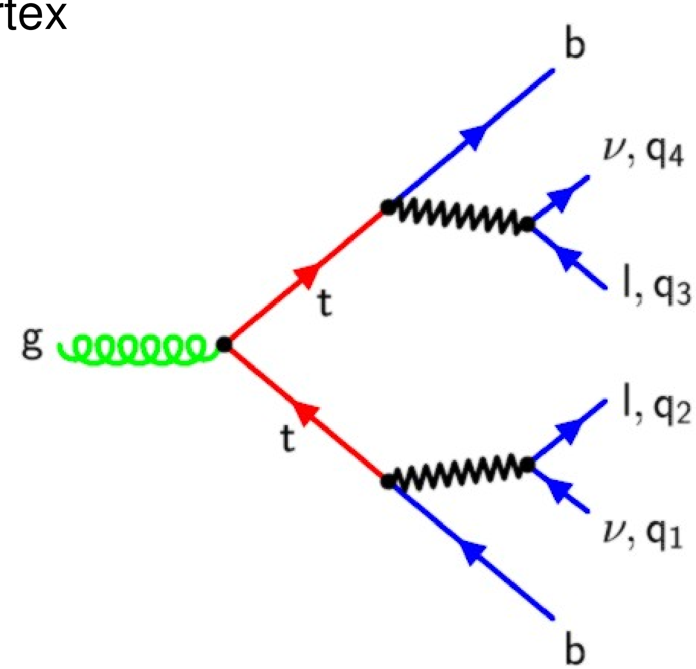
85% of $\sigma(tt)$

- Top cross-section and p_T distribution
  - Test of pQCD
- Top Quark mass
  - consistency of electro-weak model
  - Higgs mass constraints from loop corrections
- Top production from gluon splitting and quark-gluon fusion
- Theoretical production cross-section: ~6.7pb (Cacciari '03)

Top Decay Signature

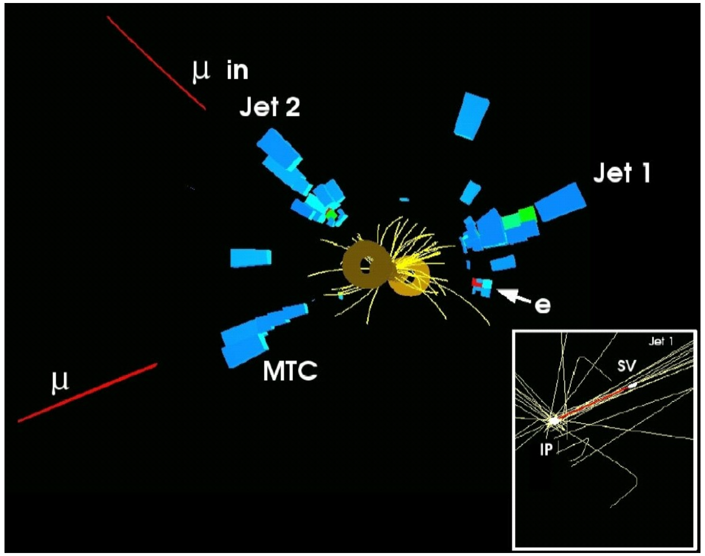
- Decay of top-quark into b-quarks + W
- Tagging of events: find secondary b-decay vertex
- 44% pure hadronic decays (difficult)
- 5% pure leptonic (e,µ) (very clean)

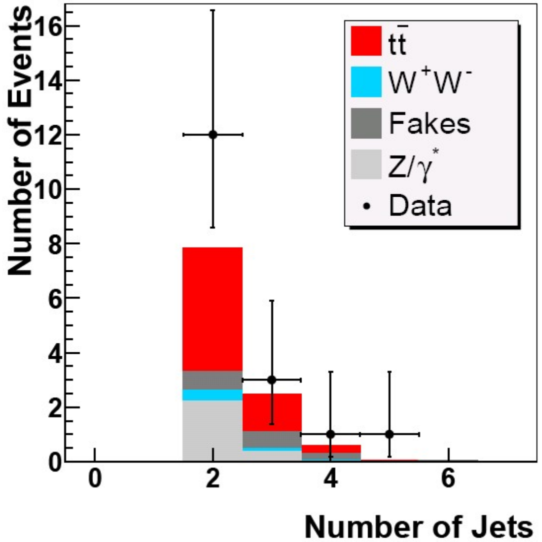




Top: Pure leptonic decay

- Select events with two leptons
  ee, μμ or eμ
- Two neutrinos lead to significant missing E_T
  missing E_T > 25GeV
- Expect two b-quark jets



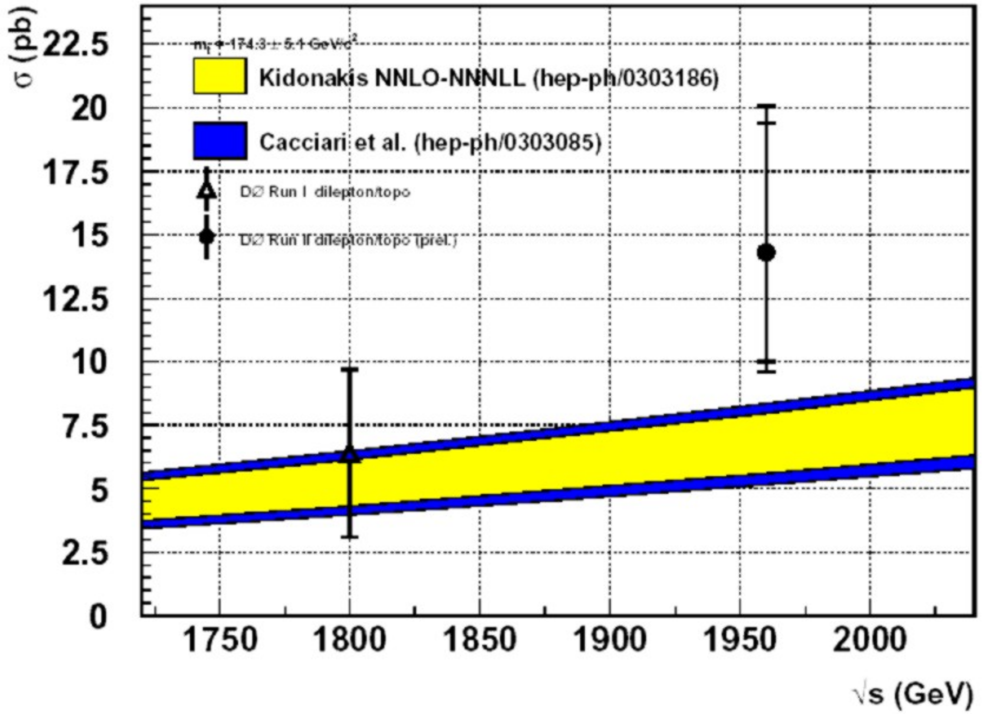


- Expected signal for 6.7pb: 6 events
- Expected background: 4.8 events
  mainly Z and fakes
- Observed (140-150pb^{-1}): 17 events

$$\sigma(t\bar{t}) = 14.3^{+5.1}_{-4.3}(stat)\,^{+2.6}_{-1.9}(syst) \pm 0.9(lumi)$$

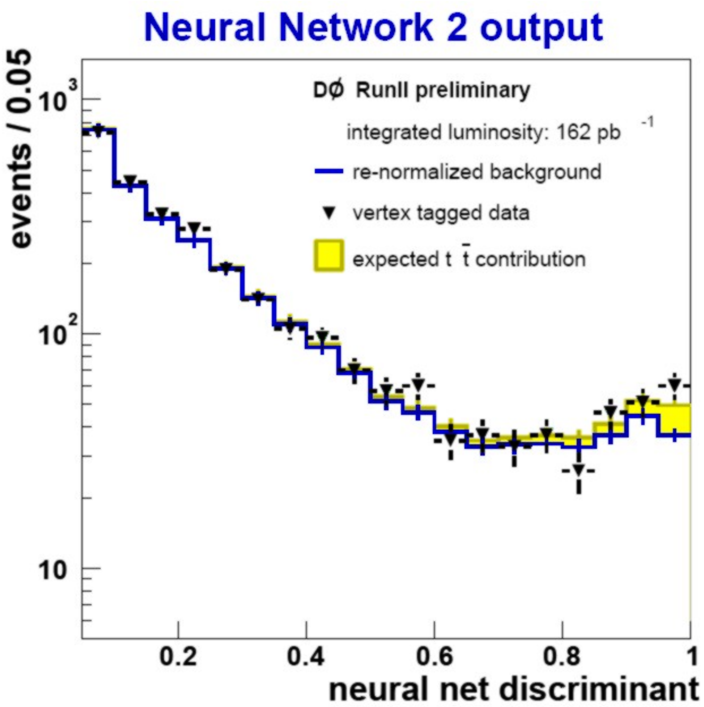
Top: pure leptonic decays (2)

- Evolution of cross section with √s
- Excess for Run II, but still consistent within errors
  Wait for more data!



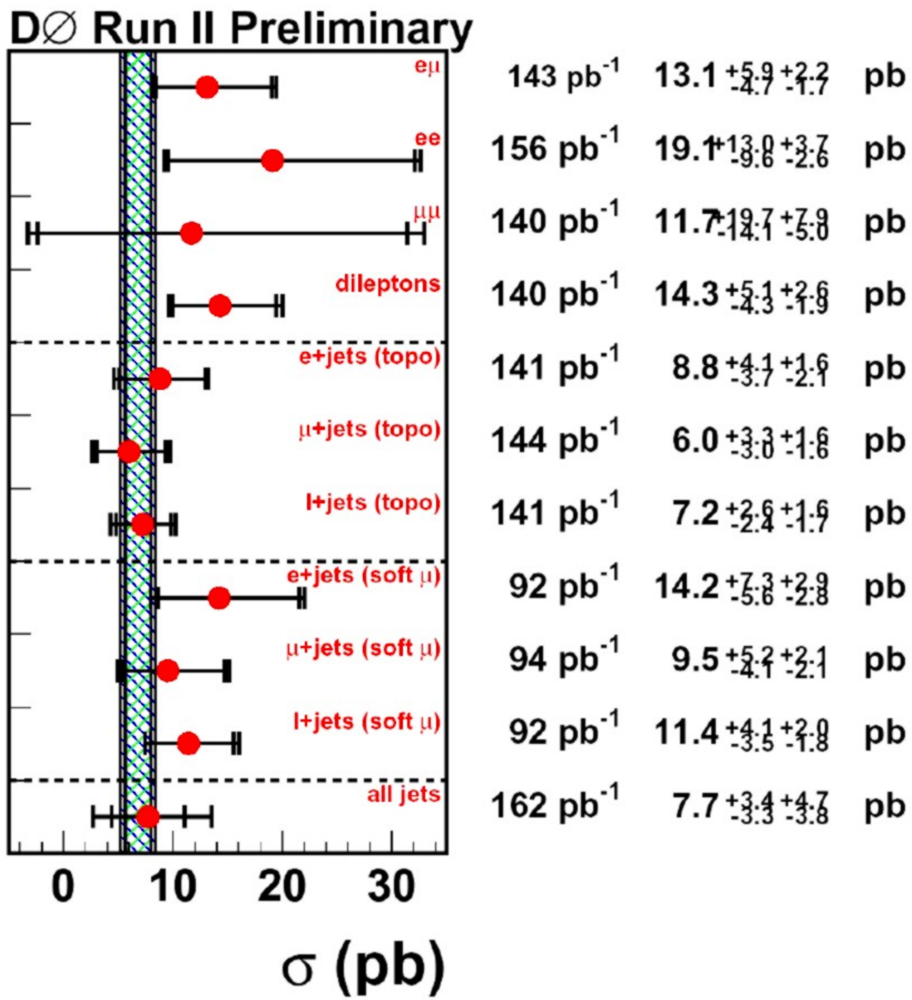
Top: Pure hadronic decay

- Background from QCD processes 3-4 orders of magnitude larger!!
- Tagging of b-quark decays via secondary vertex not sufficient
- Neural network analysis utilized to obtain reasonable signal/background ratio
- Data set: $162 pb^{-1}$
- Observed number of events: 220
- Expected background: 186±13
- Result: $\sigma(t\bar{t}) = 7.7^{+3.4}_{-3.3}(stat)\,^{+4.7}_{-3.8}(syst) \pm 0.5(lumi)$



Top Cross-Section

- More analyses: Lepton+Jets
- Results consistent with SM expectations
- Still statistically limited, but have to work very soon (and hard) on systematics
  - Jet Energy Scale
  - Jet identification
  - Top Mass
- Twice the statistics available: Expect new results this summer



Summary and Outlook

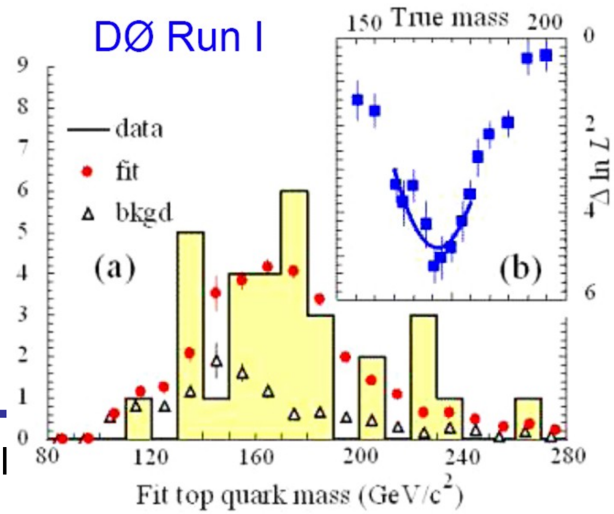
- First QCD results for Run II available
  - constistent with NLO calculations
  - still systematically limited
- top quark cross-section
  - results for all channels
  - consistent with SM prediction
  - still statistically limited
- top quark mass
  - re-analysis of Run I data lead to shift of Higgs mass prediction of electro-weak fit by 30GeV
  - expect first Run II results soon

- What will come for the summer conferences?
  - inclusive b-jet cross section
  - diffractive Z production
  - diffractive jet production
  - updated top cross section

THE END

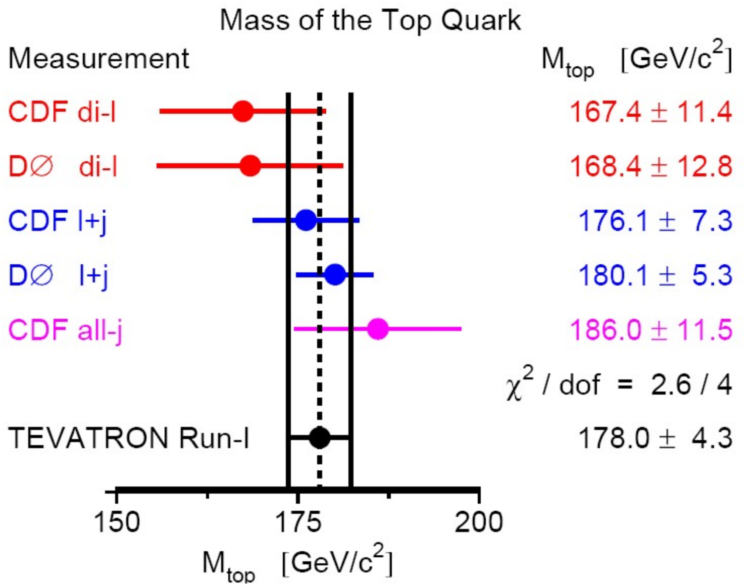
New Top Mass from Run I

- Run I data of lepton+jets events re-analysed with new method
  - event based weights derived from LO-Matrix element, PDFs and detector transfer function
  - background included into common likelihood function
- Old result from 1998: $M_{top} = 173.3 \pm 5.6_{stat} \pm 5.5_{syst}\ GeV/c^2$
- New result: $M_{top} = 180.1 \pm 3.6_{stat} \pm 4.0_{syst}\ GeV/c^2$
- Statistical error reduced by 36% !
- Main systematic errors:
  jet energy scale

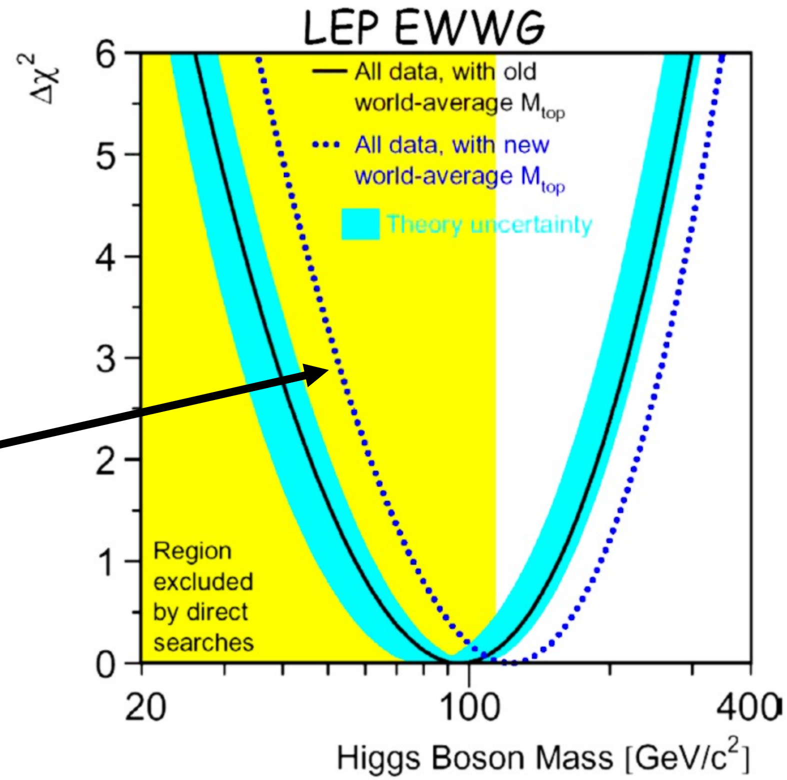


Top Mass: World average

- New averaged top quark mass including the new measurement



$M_{top} = 178.0 \pm 4.3\ \mathrm{GeV}/c^2$



- Shift of top mass by 1σ
  - ➡ Higgs mass from electro-weak fit increased by 30GeV/c^2

Cone Algorithm

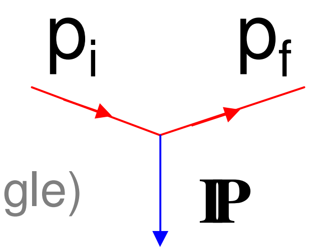
- Start from *particles* (calorimeter towers) as seeds for jets
- Create cone around each seed: $\Delta R = \sqrt{\eta^2 + \phi^2} < R_{cone}$
- Add all particles within given cone in η and Φ together (four-vectors)
- Iterate until stable solutions
- Use midpoints between solutions as additional seeds
- Re-iterate
- Reject jets below p_T cut

Diffractively produced W & Z

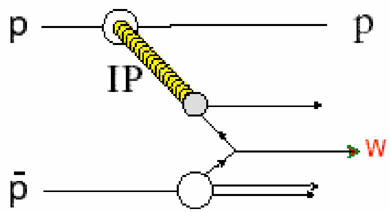
- Signature for diffractive events:
  Gap in η with (nearly) no energy
- Kinematics
  Four momentum transfer |t|

  $|t|=(p_f-p_i)^2$

  $|t| \sim \theta^2$ (scattering angle)

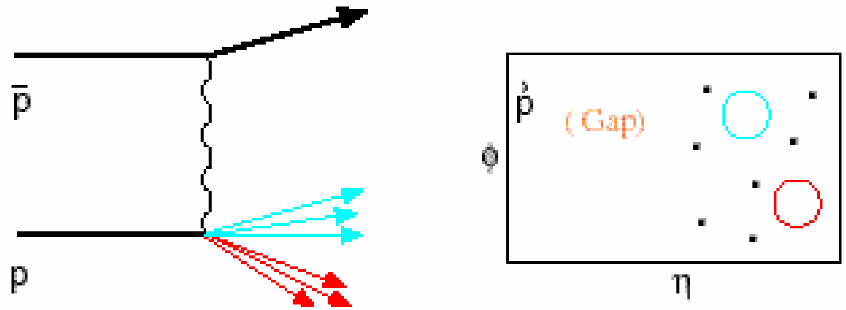


- LO diffractive production of W

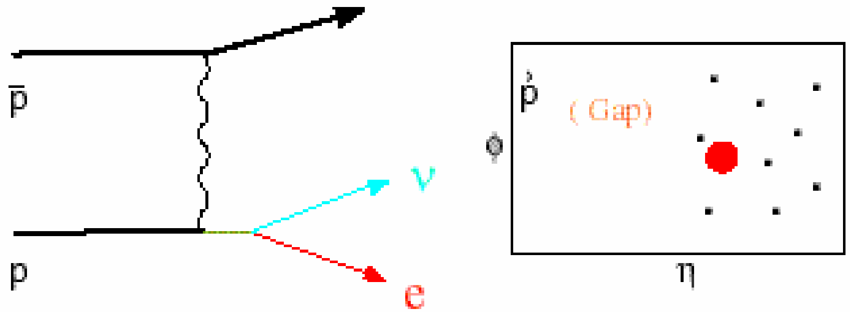


a) LO: $q\bar{q} \rightarrow W$

Hard diffractive jet production



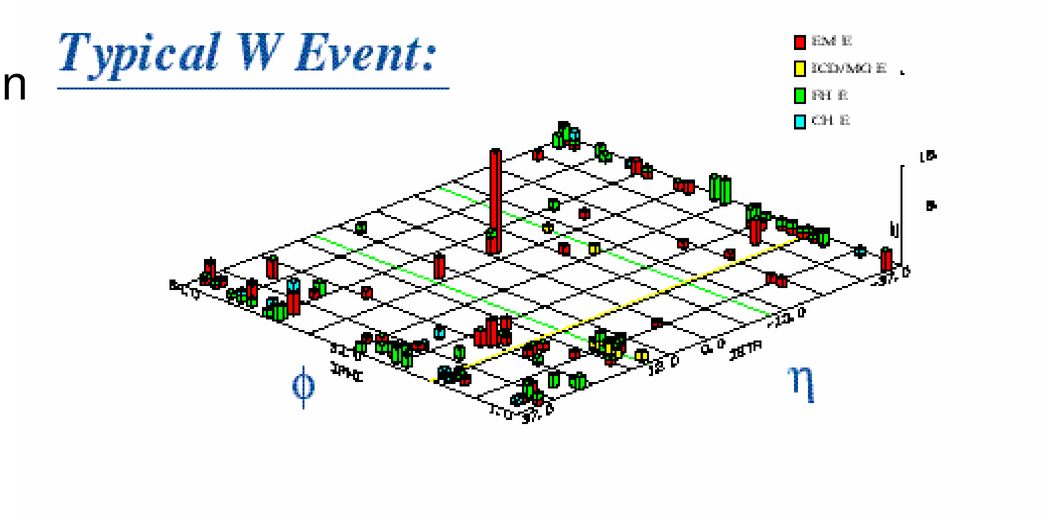
Hard diffractive W production

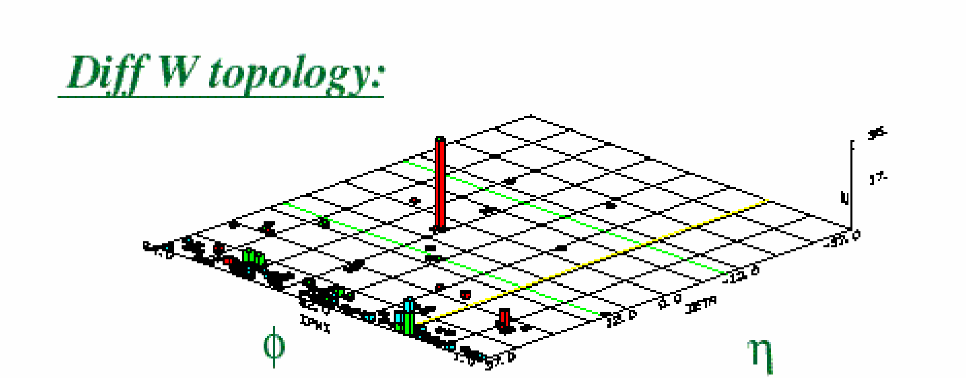


Diffractively produced W & Z (2)

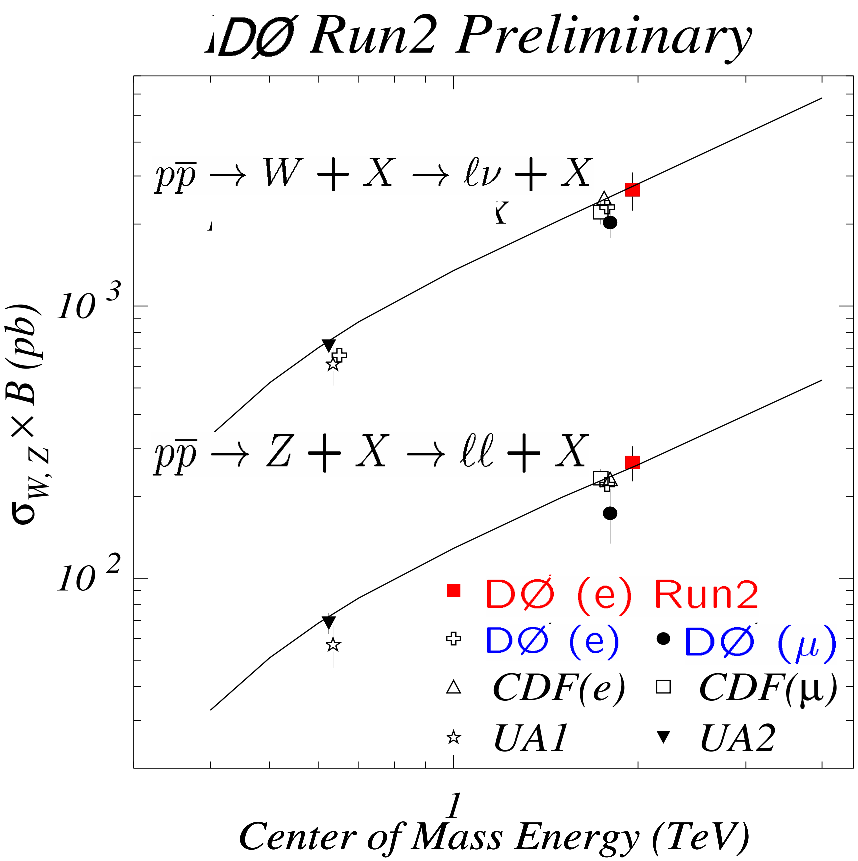
Diffractive W-production in Run I

- Event topology based on energy in the calorimeter
- Additional information from luminosity detector ($2.3<\eta<4.3$)





W/Z production cross section



X(3872) in J/Ψ $\pi^+\pi^-$