The CDF Group at LBNL

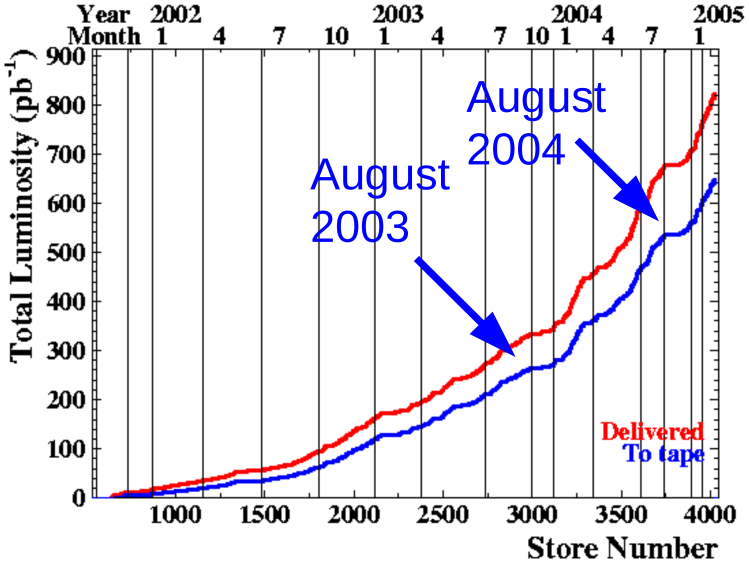
Angela Galtieri

LBNL DOE Review, March 16-17, 2005

Outline

- LBNL Group
- CDFII Detector
- Contributions to CDFII
  - hardware
  - operation
- Roles (last 3 years)
- Recent Contributions
- Physics Program
  - B physics
  - Top Physics
  - New Phenomena
- Summary and Conclusions
- Prospects for the Future

Tevatron Luminosity

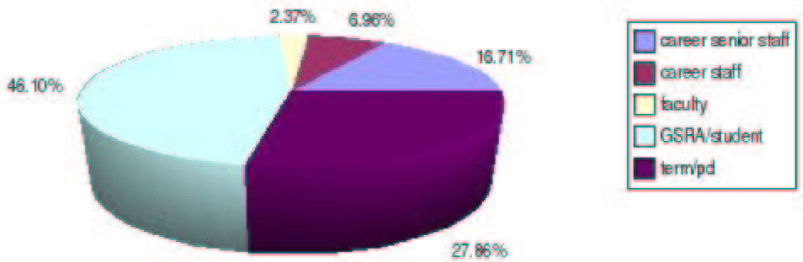


Integrated Luminosity (fb^{-1})				
	Design Projection		Base Projection	
	per year	Accum-ulated	per year	Accum-ulated
FY03	0.22	0.30	0.20	0.28
FY04	0.38	0.68	0.31	0.59
FY05	0.67	1.36	0.39	0.98
FY06	0.89	2.24	0.50	1.48
FY07	1.53	3.78	0.63	2.11
FY08	2.37	6.15	1.14	3.25
FY09	2.42	8.57	1.16	4.41

CDF Personnel

category	name	level_of_effort
GSRA/student	Bachacou,Henri	47
career staff	Beringer,Juerg	25
term/pd	Cerri,Alessandro	100
GSRA/student	Deisher,Amanda J	48
GSRA/student	Fang,Hung-Chung	47
GSRA/student	Freeman,John Christian	47
career senior staff	Galtieri,Angela B	100
GSRA/student	Gibson,Adam	47
career senior staff	Haber,Carl H	20
GSRA/student	Lujan,Paul	47
GSRA/student	Muelmenstaedt,Johannes	48
term/pd	Nielsen,Jason	100
faculty	Shapiro,Marjorie D	17
career staff	Yao,Wei-Ming	25

Distribution of FTE



Sum of level_of_effort	
category	Total
career senior staff	120
career staff	50
faculty	17
GSRA/student	331
term/pd	200
Grand Total	718

Members of the LBNL Group

Physicists-Staff (3.2 FTE)
- A. Galtieri
- J, Beringer** (joined '04)
- M. Garcia-Sciveres*
- C. Haber*
- J. Lys *
- R. Miquel** (now SNAP)
- M. Shapiro* (UC Berkeley)
- J. Siegrist* (UC Berkeley)
- W. Yao**

Physicists-Term (2 FTE)
- A. Cerri
- A. Dominguez (now Nebraska)
- J. Nielsen
- B. Orejudos (now industry)
- L. Vacavant* (now Marseille)
- I. Volobouev (now SLAC)

Fellows (1 FTE)
- M. Weber (nowRutherford)
- P. M. Fernandez (July '03)

Grad. Students(6.5FTE)
- A. Connolly++ (now UCLA)
- G. Veramendi++ (now Illinois)
- E. Brubaker ++ (now Chicago)
- H. Bachacou++ (soon CERN)
- **H. C. Fang**
- **A. Gibson**
- **J, Freeman**
- **A. Deisher**
- **J. Muelmenstaed**
- **P. Lujan**

Undergrad. Students (1FTE)
- E. Feng (to ATLAS)
- L. Tompkins (Fullbright,Orsay)
- M. McFarlane +

Visitors (gone)
- F. Zetti (Pisa) (to ATLAS)
- M. Tavi (to Finland)

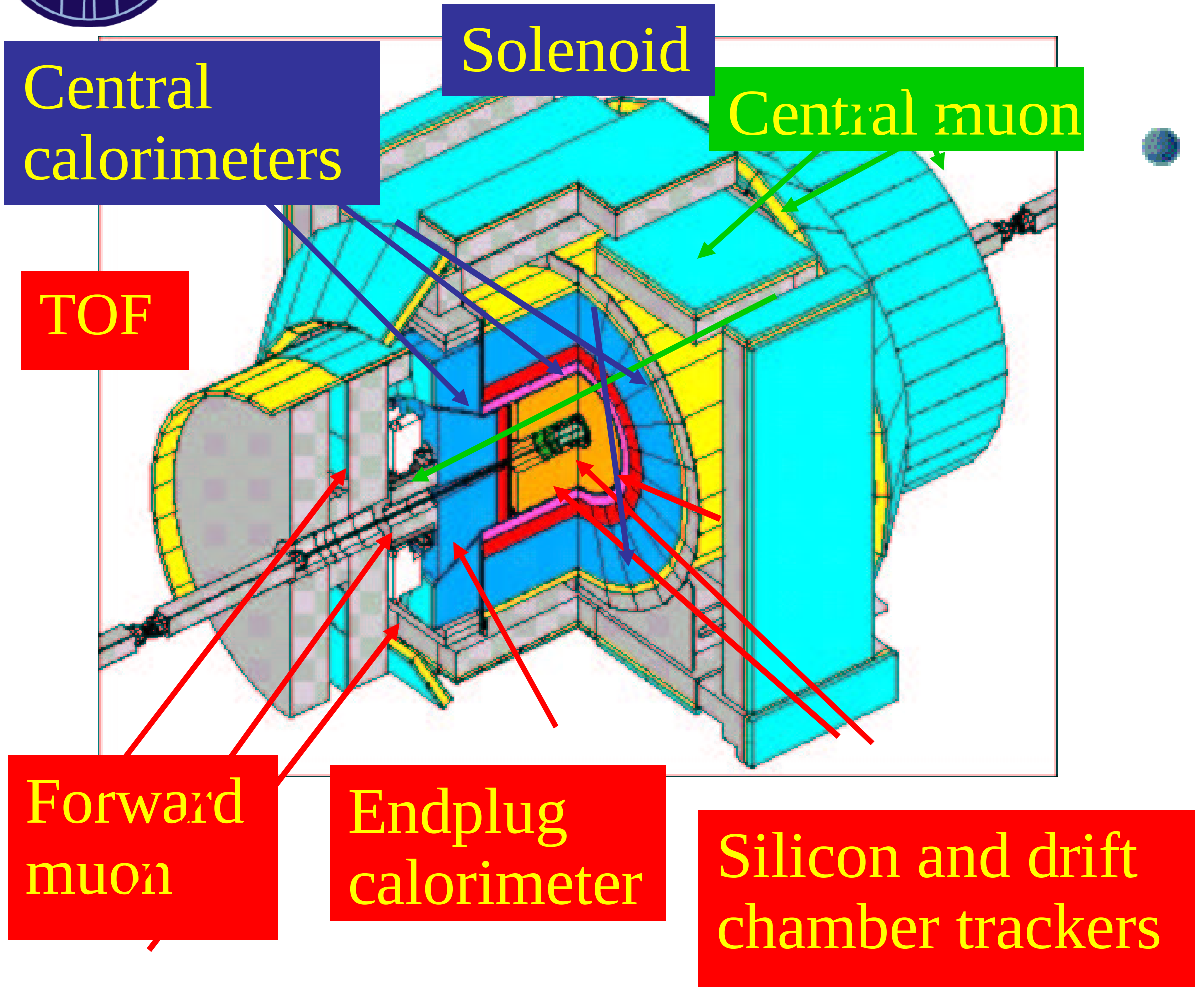
Engineers, Designers*#
- B. Krieger
- H. von-der-Lippe
- J.P. Walder
- E. Mandelli
- B. Holmes

*****ATLAS, ** PDG
FTE refer to FY05

+ Start on CDF on '05
++ Thesis completed

Silicon Upgrade Project
SVX4 chip completed.

CDFII Detector



- CDF recent upgrades
  - Improved photon detection
    - EM calorimeter: timing readout added
    - Central preshower: wire chambers replaced with scintillation tiles
  - DAQ upgrade
    - To match the trigger: 20MB/sec -> 60 MB/sec
  - Trigger Upgrade
    30KHz(L1), 1KHz(L2) 100Hz(L3)

LBNL Contributions : Silicon detectors, COT, TOF

Commissioning, Operation, Software

Silicon Detectors: LBNL contributions

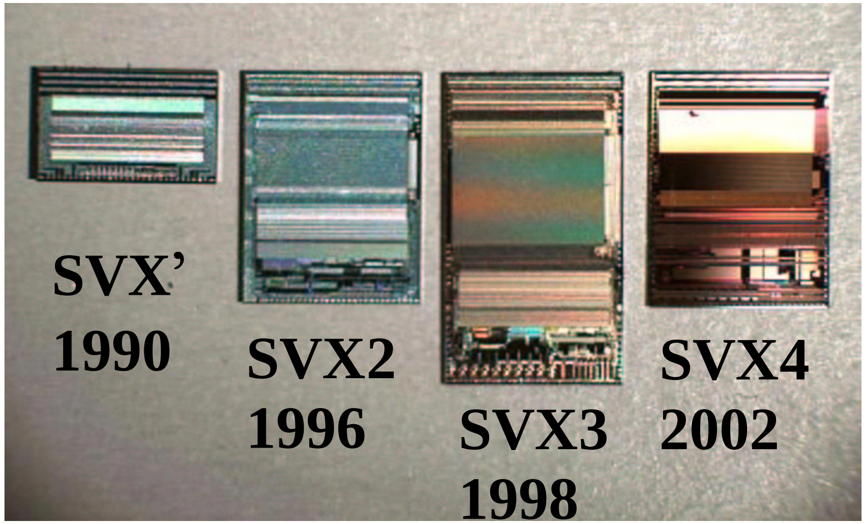
Silicon detectors transformed physics capabilities of CDF since early '90. LBNL is a major player in Vertex Detector technology. Long standing tradition, now applied to LHC.

- LBNL designed SVX, SVX'.
- Joint designs with FNAL since.
- SVX3 used in CDFII

RUN 2b R&D and prototyping

- SVX4: developed for Run 2b
  Project canceled due to budget cut.
  Chip used by D0, Phenix at BNL
- Conversion to .25 micron CMOS technology proposed by LBNL.
  Later used by ATLAS pixel chip
- Hybrids and "stave" (new detector concept : integrated electrical, mechanical and cooling unit) being evaluated by ATLAS

Rad hard chips for Silicon Detectors



SVT, displaced vertex trigger
Extended B physics capability

LBNL Contributions to CDF II

I. Construction

- Silicon detectors
  - ➢ SVX3 chip (co-design with FNAL), test, probe
  - ➢ hybrids for L00, SVXII, ISL
  - ➢ associated electronics
- Drift Chamber (COT)
  - ➢ inner cylinder, field sheets
  - ➢ Conceptual design of alignment
  - ➢ Time calibration system
- TOF
  - ➢ Study laser calibration system
  - ➢ Install fibers, online monitoring

II. Commissioning

- ➢ COT Associate Project Manager
- ➢ COT Commissioning
- ➢ Silicon commissioning

III. Operation

- ➢ CDF II Operation Manager
- ➢ SVT operation
- ➢ Silicon Operation (ongoing, see later)

IV. Computing and software

- ➢ Project manager
- ➢ Codegen for relational data bases
- ➢ Data handling software for early tests
- ➢ Silicon Code librarians

LBNL Contributions to CDFII

Detector Operation (MOU)

- Silicon calibration (Nielsen)
- Silicon good run list (P. Lujan)
- SVT online monitoring checks, SVT hardware support, upgrade code consultant (A. Cerri)
- DAQ shifts (3 months service) (FY04-05: 3 students, one fellow)
- SCI-Co or CO shifts (everybody

moved to other groups

- Online silicon monitoring (to John's Hopkins)
- Online data monitoring (YMON) (to Rochester))
- COT calibration (to FNAL)
- SVT data taking: pager (to Pisa)

Software Responsibilities (MOU)

- MC: EVTGEN, B decays generator (Juerg Bensinger)
- GFLASH tuning (P. Fernandez)
- SVT simulation (A. Cerri)

moved to other groups

- MC generators : ISAJET(Galtieri),
- HERWIG, Wbbgen (Lys), ZGRAD (Gibson)
- Silicon geometry (A. Dominguez)
- Passive material (L. Vacavant)
- Silicon Tracking (W. Yao)
- Secondary vertices code (W. Yao, A. Dominguez)

Leadership Roles (last 3 years)

- Marjorie Shapiro
  - Co-coordinator: CDF simulation group (10/ 2001-10/ 2003).
  Co-convener: B physics group (2002-2004)
- Young-Kee Kim (left Jan.03)
  Associate Head of CDF Operations Department (to January 2002)
- Bill Orejudos (left '04)
  Co-coordinator of the COT group
  CDFII Operation Manager (to June 02)
- Lina Galtieri
  - Co-convener: Jet corrections (to 5/03)
- Alex Cerri
  - Co-convener: Semilep. B group (to 1/04)
  - CDF representative at HFAC (B semi)
- Aaron Dominguez (left '04)
  - Co-convener : b-tagging (to 9/03)
  - Co-convener: silicon studies (to 5/03)
  Co-convener: Higgs group (to 8/04)
- JasonNielsen
  Silicon calibration
  Co-convener: W+jets Top group
- Greg Veramendi (graduated '04)
  Co-convener: High Pt Electrons (to 2/03)
- Weiming Yao
  Co-convener : Higgs group (to 9/03)

Recent Contributions to Analysis Tools

Exploit group expertise to optimize data taking and detector performance.

Develop reliable tools to perform physics analysis.

Essential for precision measurements.

- EVTGEN (improve B decays simulation)
- Realistic Monte Carlo (improve data-MC agreement)

- Trigger efficiency for electrons (all High P_T physics groups)
- Improved offline code, Gen5, and data validation for top group analysis

- Trigger studies for B physics (improve B_s mixing measurement)
- Silicon b tagging high P_T (efficiency and scale factor)
- Improved impact parameter resolution (better B_s mixing sensitivity)
- Jet corrections and systematics (smaller systematics on top mass)

Trigger studies for B physics

Deisher, Muelmenstaed, Beringer, Cerri, Shapiro

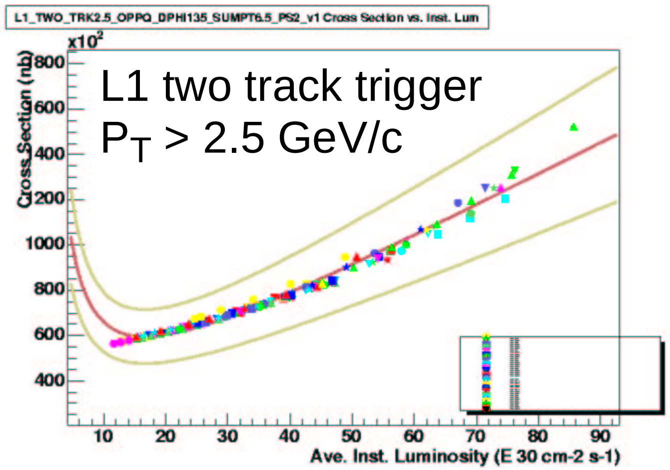
Trigger Upgrade: 30KHz(L1), 1KHz(L2) 100Hz(L3)

- B cross section is very large
- The "trigger cross section" increases with luminosity as L^2
- Need new trigger strategies to keep collecting hadron B decays (essential for B_s mixing) at high luminosity
- Reduce event rate without rejecting taggable candidates

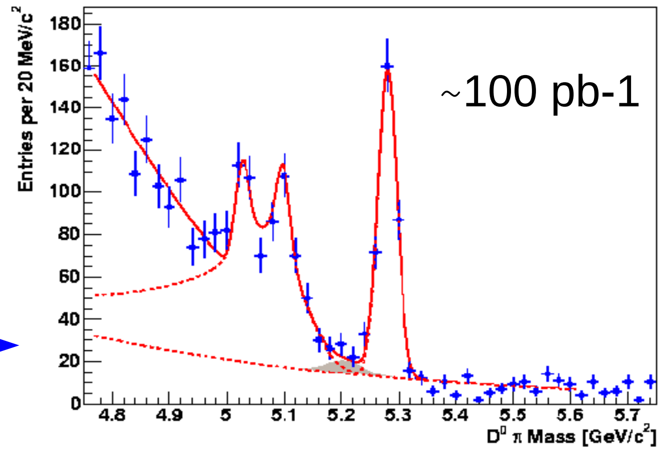
Solution:

- Require b tag at trigger level, i.e, require a muon trigger with the 2 tracks at L1.
- Keep the SVT cut of 120 μ for the impact parameter at L2
- This will give us b events enriched in b-tags (the muon). Found

$\varepsilon D^2 = (5.2 \pm 2.6)\%$

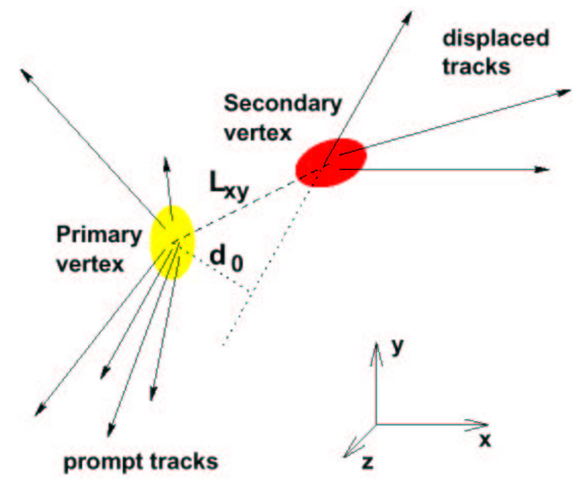


μTT trigger test



Displaced vertex b-tagging (SECVTX)

H. Bachacou, P. Lujan, J. Nielsen, W-M Yao

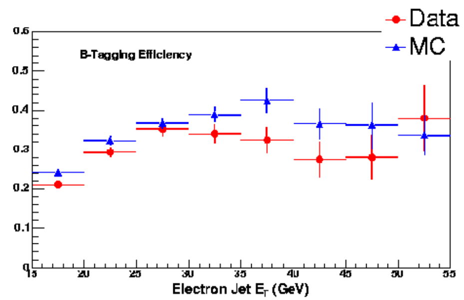


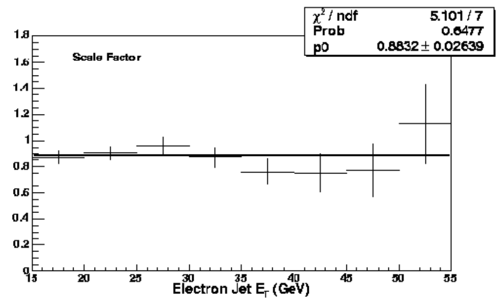
Displaced vertex algorithm allows detection of b quarks, important for B physics, top, and Higgs

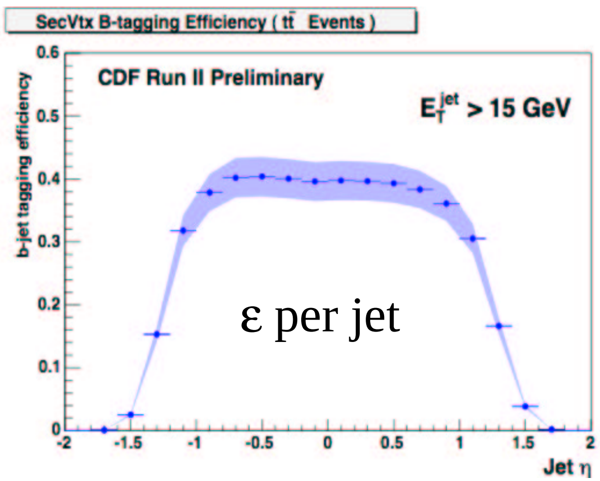
- Use e+jets (b enriched)
- Reconstruct secondary vertex with $\geq$ 2 tracks
- Require $L_{xy}/\sigma_{xy} > 3$

  $\sigma_{xy} \sim 150\ \mu$

Performance, alignment of Si detector crucial







- $t\bar{t}$ event efficiency =(55±5)%, **now (60±3)%**
- Efficiency for a second tag in top events (24.0±1.7)% , **now (25±2)%**
- Efficiency ratio between data and MC (86 ± 7)%, **now (91± 6)%**

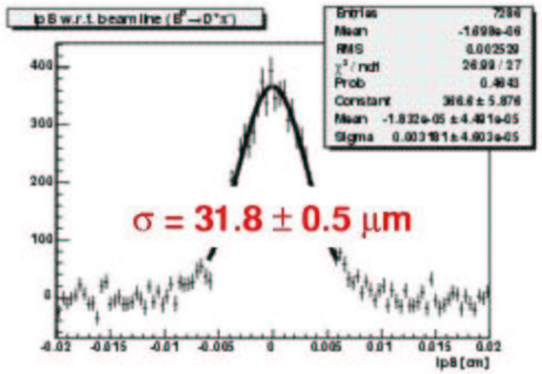
ct Resolution improvement

Beringer, Cerri, Deisher, Muelmenstaedt, Shapiro

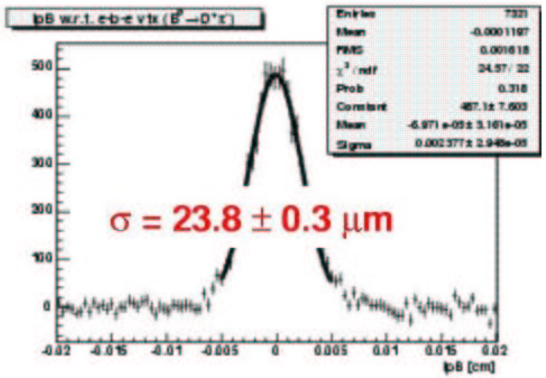
Use L00 of the silicon system and perform event by event primary vertex reconstruction to improve the ct resolution in B_s mixing studies

σ_d in $B \rightarrow D^0\pi \rightarrow [K\pi]\pi$ sample

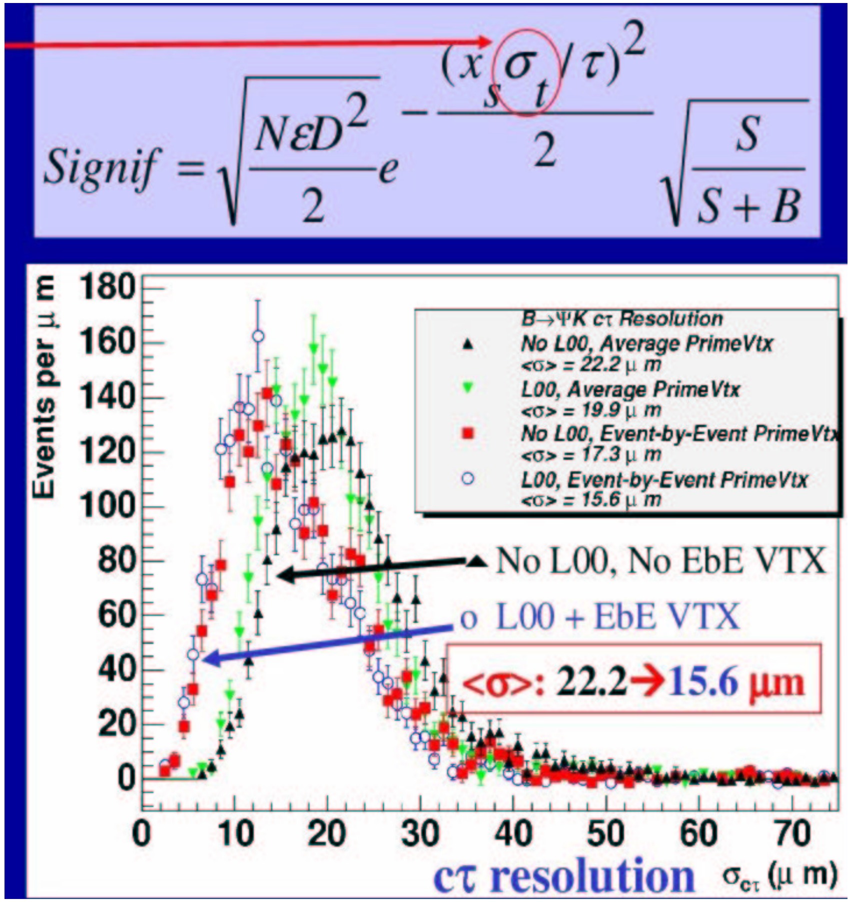
Uses the Beamline



uses the event by event PV



d/σ_d

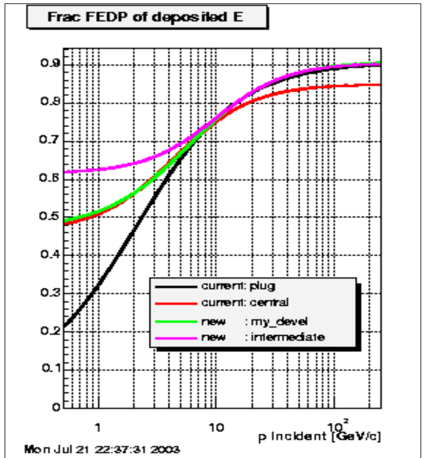


Jet Corrections and systematics

L. Galtieri, A. Gibson, P. Lujan, J. Lys. C. Currat (left end '03)

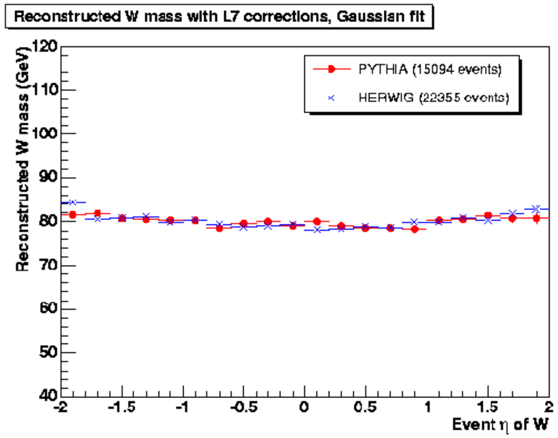
- Longstanding expertise on jets in LBNL group (since 1986).
- Our suggestion, changing the energy deposition (EDEP) form in the MC simulation, implemented . Helped reduce systematics in E- scale.
- Run2 systemat 1

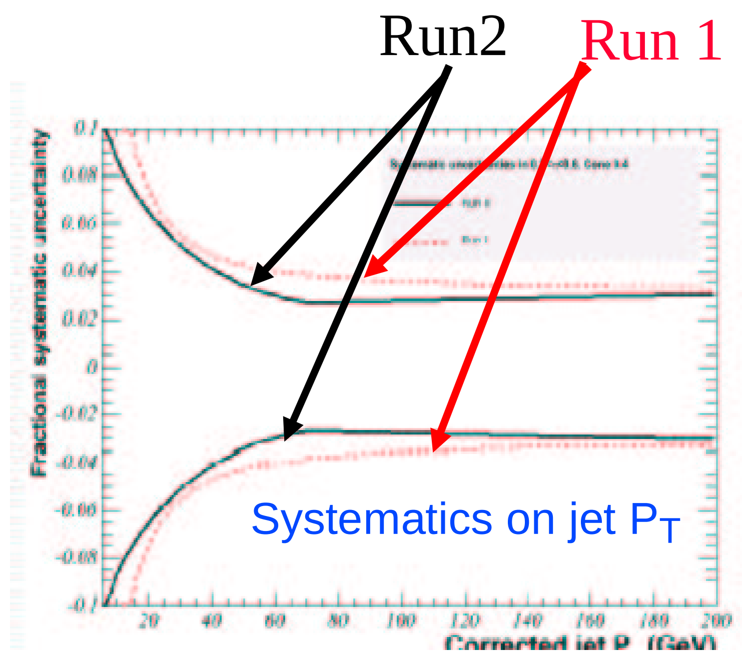
Improved ΔM_{top} from jets by factor ~2



Magenta Curve for EDEP improved data-MC agreement

Testing corrections in tt $\rightarrow$ WbWb W mass reconstruction





Achievements 2004-2005

- Papers submitted for publication
  - ttbar Production Cross Section with Secondary Vertex b-tagging (accepted)
  - Moments of Hadronic Inv. Mass Distribution in Semileptonic Decays (accepted
  - F-B Charge Asymmetry in e+e- pairs (Veramendi PHD Thesis)
  - Combined limit for Higgs Production (Run I)
  - B_s/B^0 Ratio of Branching Fractions
  - b-bbar correlations (A. Affolder PHD thesis, Run I)
  - Partial Widths and Search for Direct CPV in D0 Decays to K^+K^- and $\pi\pi$
- Papers with Drafts Circulating in Collaboration
  - Inclusive cross sections of pp --> W and Z
  - MSSM Higgs, H/A into tau-tau (A. Connolly PHD thesis, Run I)
- Papers being reviewed by godparents committee
  - Top Mass in Lepton+Jet Channel using a Template Method (Brubaker PHD thesis)
  - Search for Particles Decaying into bb with associated W Production
  - Top Mass in Lepton+Jet Channel Using a Multivarient Method

Will highlight only a few of these analyses here

Conference Papers in Proceedings ('04)

J. Nielsen : “ CDF Top cross section and mass”, Lake Luise 2/04
I. Volobouev : “ Top cross section and mass at CDF”. HCP 6/04
R. Miquel : “ Hadronic mass moments in B semileptonic decays”, BEACH 7/04
P. Fernandez : “ Top mass measurements at CDF”, BEACH 7/04
W-M. Yao : “ H iggs searches at the Tevatron” , ICHEP 8/04
A. Cerri : “ Charm production at CDF”, ICHEP 8/04
J. Freeman: “ Top Mass measurement with Mutivariate Templates “ , DPF 8/04
H-C Fang : “ Moments of B hadronic mass distributions”, DPF 8/04
H. Bachacou: “ CDF top cross section measurements with B-tagging”, DPF 8/04
P. Lujan : “ Run 2B silicon detector performance in prototype”, DPF 8/04
M. Weber: “ Run 2B Silicon detector: electrical performance”, IEEE 9/04
J. Nielsen : “ Performance of the Run II silicon detector”, Vertex 04 Como , 9/04

Technical Papers Published in 2004

“The CDF Central Open Tracker (COT)” , NIM A526, 249 (2004)

“Silicon Vertex Tracker (SVT)” , NIM A518,532 (2004)

“Shielding and Electrical Performance of Silicon Detector Supermodules”, submitted to IEEE Trans. Nucl. Science (10/04)

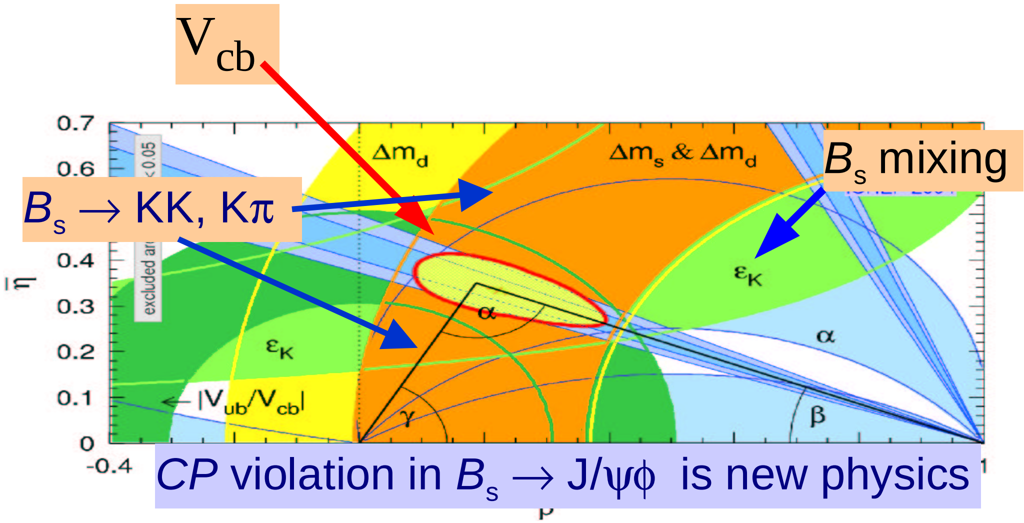
“CDF Run 2B Silicon Detector: Stave Design and Testing”, IEEE Trans. Nucl. Science, 51, 2209 (2004)

“SVX4: A new Deep Submicron Readout IC for the Tevatron Collider”, IEEE Trans. Nucl. Science, 51, 1968 (2004)

“The CDF Run 2B Silicon Detector”, NIM A518, 270 (2004)

B Physics: where are we?

CP violation in the B system constrains the unitary triangle.
SM requires $\alpha+\beta+\gamma=\pi$
Sin2β measured with high precision at the B factories.



- B_s physics can only be done at the Tevatron
- SVT (Silicon Vertex trigger) allows study of the hadronic decays
  B hh and B_s D_s π
- **It opens whole new chapter that can lead to new physics**

- B_s mixing requires fully reconstructed decays to reach high values of x_s and eventually will lead to measurements of the angle γ
- Initially B_s semileptonic decays , high statistics, can be used
- LBNL Group working on two sides of the triangle: B_s mixing and V_{cb}

B Physics: Moments Analysis

A. Cerri, H-C Fang, R. Miquel, M. Shapiro, L. Vacavant

- Measurement of V_{cb} from inclusive semileptonic rate:

  OPE provides expansion in terms of α_S, Λ_{QCD}/m_b, ...

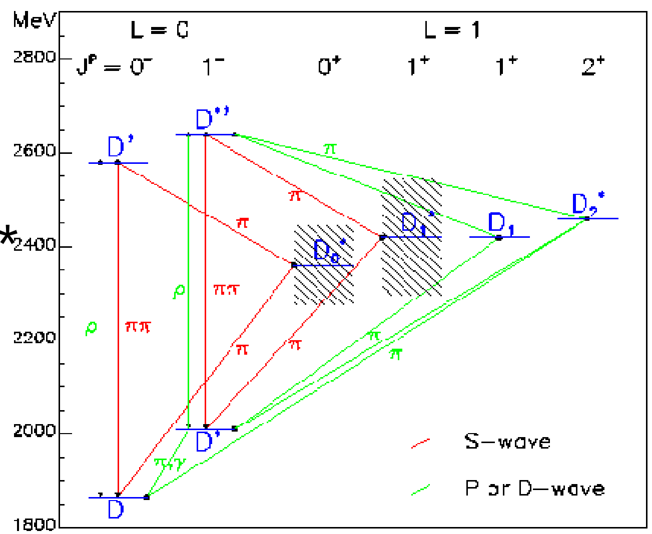
- Need comparison of theory and experiments for many quantities to test the model.
- Theory does not provide detailed knowledge of hadronic states, but makes prediction for inclusive quantities, e.g.

  $\langle M_{hadronic} \rangle$, $\langle M^2_{hadronic} \rangle$,....

  these are the "hadronic recoil mass

  $B \rightarrow X_C \, l\nu_l$

Spectroscopy of D mesons



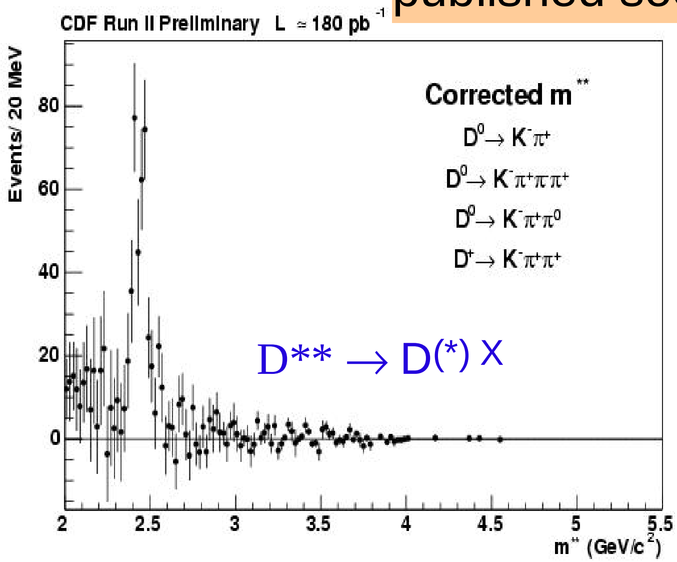
- X_C is D, D*, D** . Measurements for D and D* already known. Here we measure the D** contribution
- D** is any charm state, resonant or not with $M_{D^{**}} > M_{D^*}$
- Use known info for BR(B lνD,D*) and M for D and D*
- Measurement completed: accepted for publication

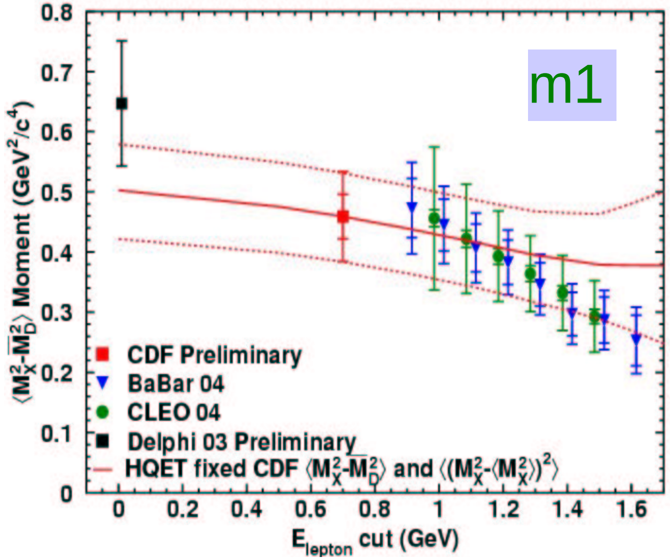
Moments Analysis Results

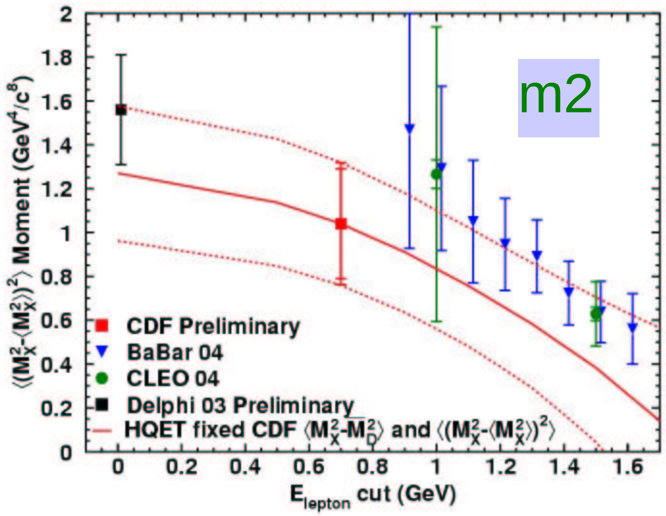
Cerri, Fang, Miquel, Shapiro, Vacavant

- Correct M** distribution to fixed lepton p*

published soon

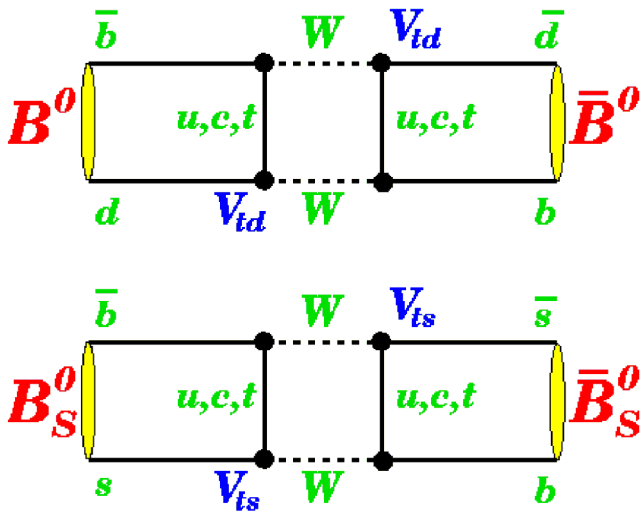






- Combine with D and D*
- Extract QCD parameters Λ, λ_1
- Theory predicts evolution with p*

B_S Physics at CDF



- To measure CPV in the B_S system we need to measure Δm_s from B_S-$\bar{B}_S$ oscillations. $A_{mix} \sim D * \cos(\Delta m_s t)$

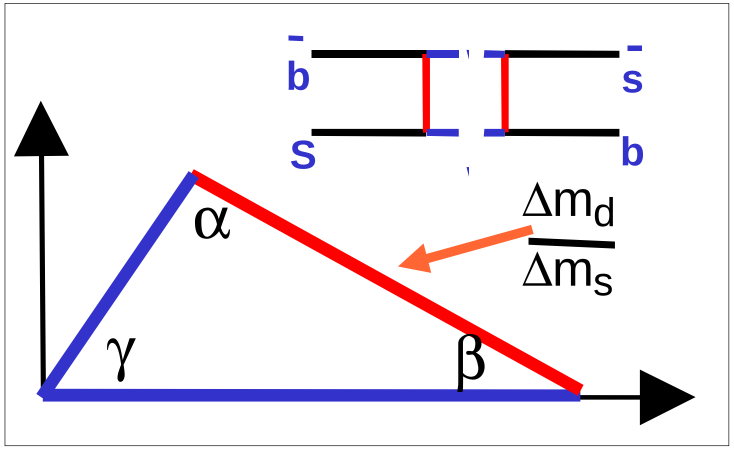
  Δm_s expected to be large due to coupling to top quark
- B_S fully mixes in < 0.15 lifetimes !!

$$\frac{|V_{td}|}{|V_{ts}|} = 1.01\xi\sqrt{\frac{\Delta m_d}{\Delta m_s}}$$

from LATTICE

ξ accurate at ~ 5%

SM Fit: $\Delta m_s = 18.3 \pm 1.6\ ps^{-1}$



unitary triangle

- B_s mixing World Average @95% C.L.

  Δm_s 14.5 ps^{-1-}

  Uses data from LEP and SLD

B_s Mixing Strategy

Beringer, Cerri, Deisher, Muelmenstaedt, Shapiro

$$Signif = \sqrt{\frac{N\varepsilon D^2}{2}} e^{-\frac{(x_s \sigma_t / \tau)^2}{2}} \sqrt{\frac{S}{S+B}}$$

- Optimize yield of B_s : S/(S+B)
  - Use many modes
  - Cuts to give best signal significance (done)
  - Improvements in trigger (μ done, e in progress)
- Optimize vertex resolution (σ_t)
  - Primary Vertex determined event-by-event (done)
  - Best possible silicon tracking
- Optimize Tagging (efficiency(ε), and Dilution(D))
  - Combine many tags

LBNL activities in areas marked in red completed

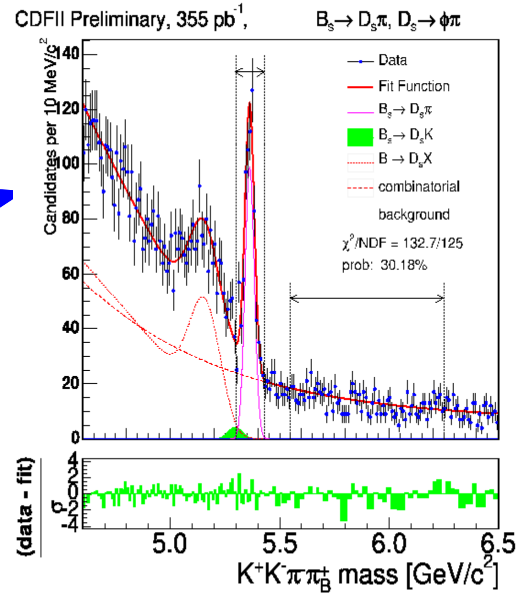
B_S: fully hadronic channels

- B_S mixing signals in 355 pb^{-1}:
  - B_S –> D_S π, D_S 3π
    - $D_S \to \phi\pi$, KK , 3π
  - Highest ct resolution
  - ~ 900 fully reconstructed events
- Preliminary limit

$\Delta m_s > 0.4\ ps^{-1}$ @95% C.L.

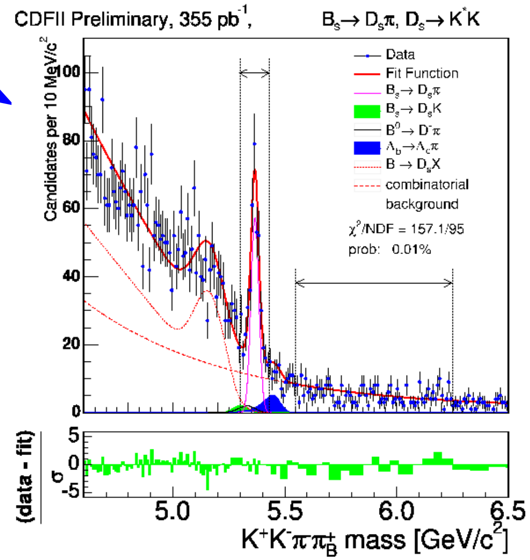
$B_s \to D_s\pi$

$D_s \to \phi\pi$



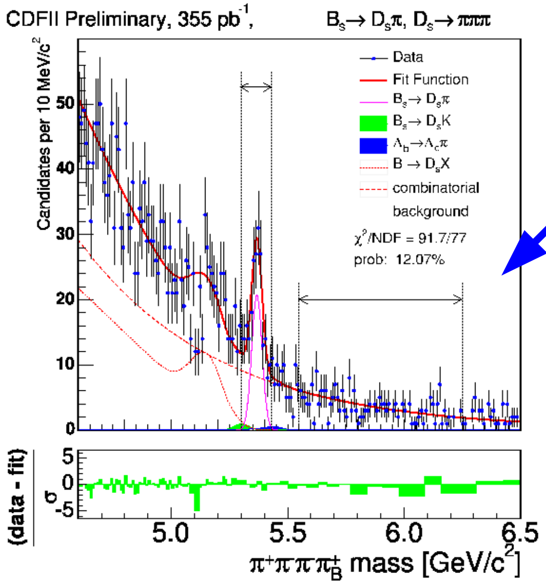
$B_s \to D_s\pi$

$D_s \to K^*K$



$B_s \to D_s\pi$

$D_s \to \pi\pi\pi$



$\epsilon D^2 = (1.12 \pm .18)\%$

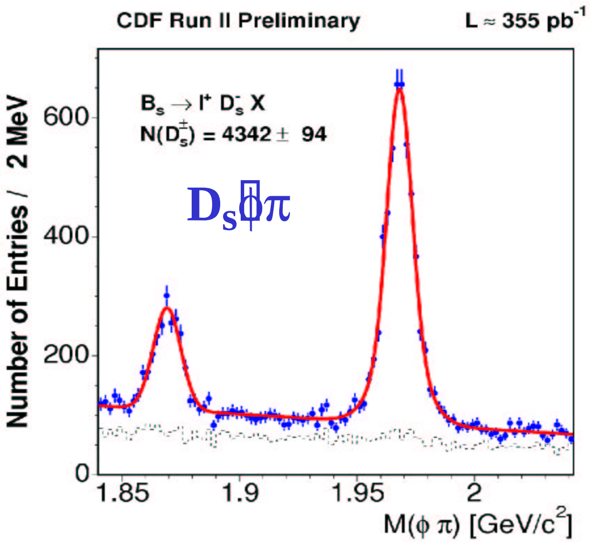
B_s Mixing Results

Semileptonic: Lower c   resolution than hadronic.... but very large statistics: ~7.5K events

Basic: $B_s \rightarrow \nu D_s$

- $D_s \rightarrow \phi\pi, K^{*}K^{-}, 3\pi$

$\varepsilon D^2 = (1.43 \pm .09)\%$



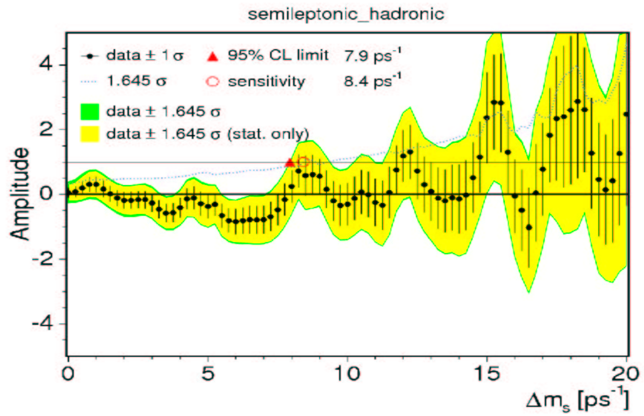
$\Delta m_s > 7.7\ ps^{-1}$ @95% C.L.

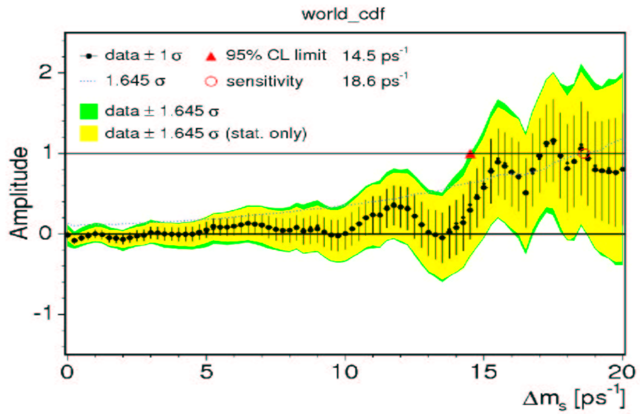
Combined results:

- 7.9 ps^{-1} @95% CL limit
- Sensitivity: 8.4 ps^{-1} ⇒⇒

➤ Effect on World Average:

- Limit: 14.5 -> 14.5 ps^{-1} ⇒⇒
- Sensitivity: 18.2 -> 18.6 ps^{-1}





Prospects for High P_T physics at CDF

Measure top quark properties

Mass to 3 GeV, Top cross section to 10%

Verify SM decay properties

Any non SM processes hide in top events?

Higgs production

SM Higgs: it is a big challenge, but try

SUSY: tanβ=50 5σ discovery possible of H/A with M=175 GeV (5 fb^{-1})

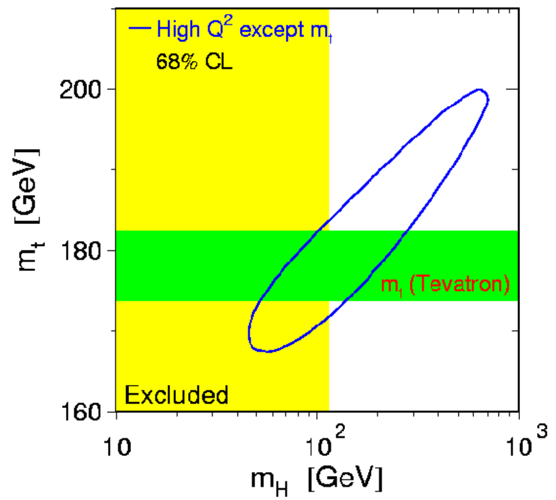
SUSY:

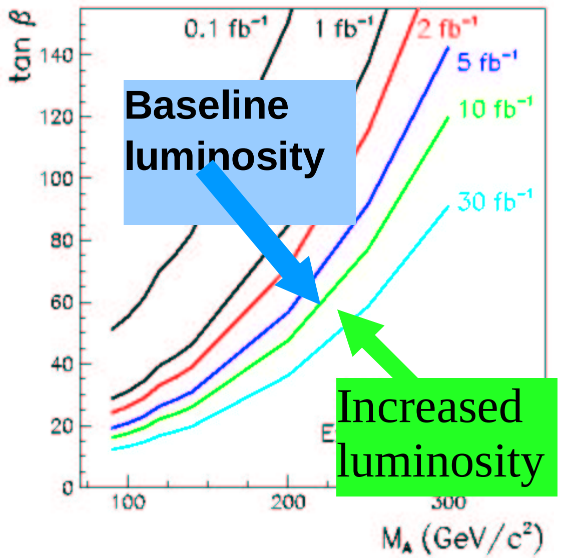
Some of the parameter space for squarks and gluinos can be explored.

Long lived stable particles , trileptons, etc. Many ways to search

Many other searches: W'. Z', leptoquarks , technicolor, extra dimensions etc.

Electroweak Precision Measurements



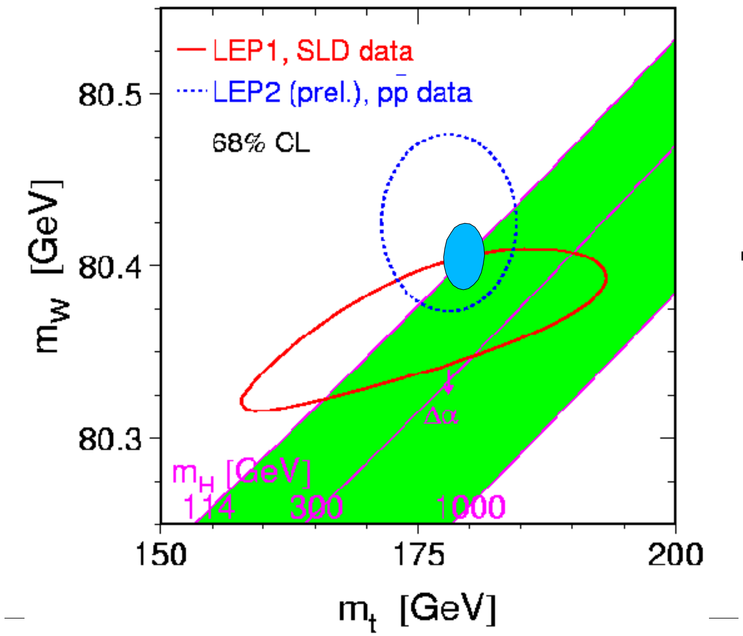


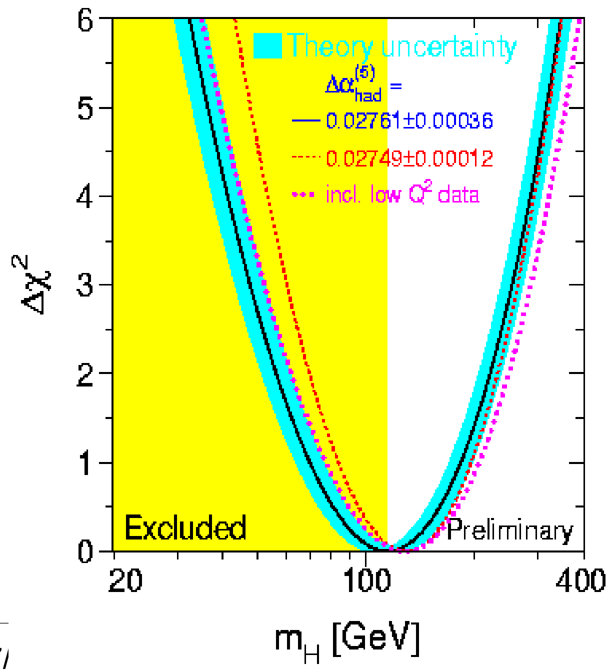
Top Quark Property Measurements

Bachacou, Fernandez, Freeman, Galtieri, Gibson, Lujan, Lys, McFarlane, Nielsen, Yao

- The Standard Model predicts the Higgs mass, once the W and Top mass are measured with high precision.
- Loop corrections to M_W proportional to M_t^2 and M_H

Run I: M(top) = 178.0± 4.3 GeV CDF+D0 comb.





Feb. 2005 best Fit

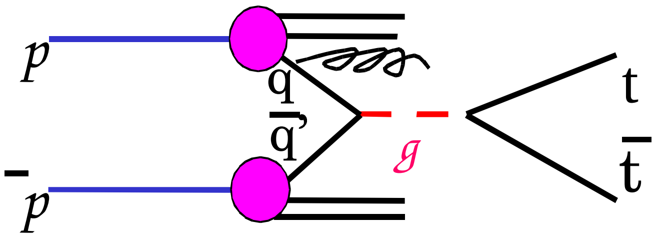
M_H= 126 $^{+73}_{-48}$GeV

M_H< 280 GeV at 95% CL

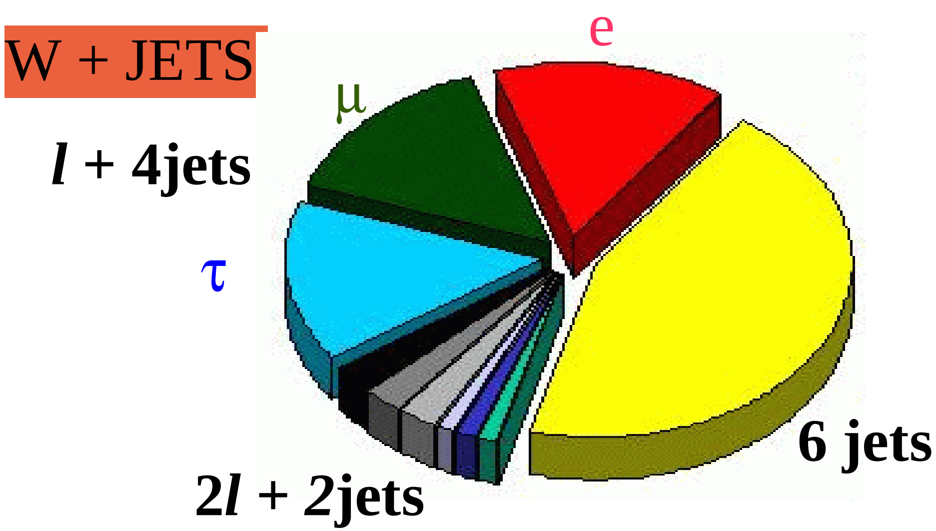
Direct limit:
M_H > 114 GeV at 95% CL

Top Physics Studies

$t\bar{t}$ Production at the TeV:



$t\bar{t} \rightarrow W^{+} b\, W^{-} \bar{b}$



Top events preferentially W+≥ 3 jets

Top quark is heavy: decays very fast!

Γ(t -> Wb) ~ 1.5 GeV, t=4x10^{-25}sec

Λ_{QCD} = 100 Mev, Λ^{-1} = 10^{-23} sec

No hadronization: no top mesons or baryons

LBNL group present plan:

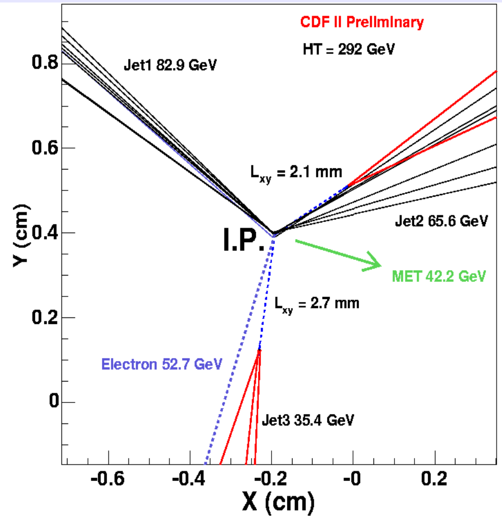
- Understand the top candidate sample: b-tagging, backgrounds, agreement between data and Monte Carlo etc.
- Optimize tools for above measurements
- Look for deviation from SM in top sample

Top Cross Section Measurement

Bachacou, Lujan, McFarlane, Nielsen, Yao+ others

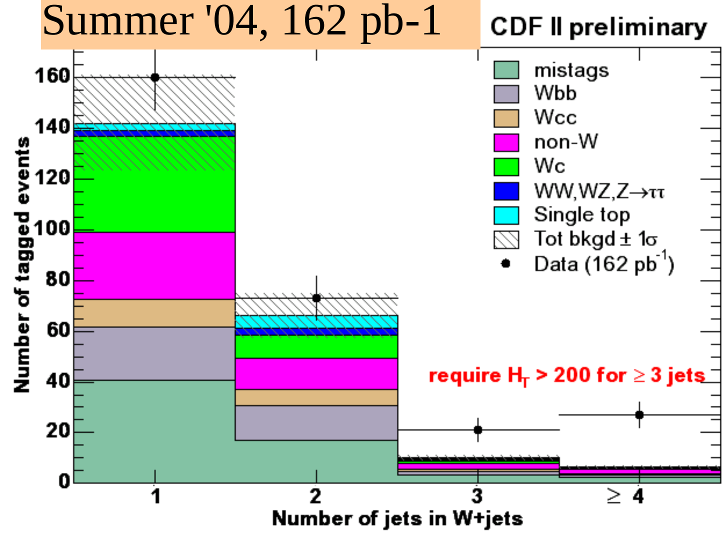
- Understanding top candidates sample, to be used for all other top studies
- LBNL: use lepton+jets channel, b-tagging to reduce background.
- Sample selection:
  - Isolated lepton, $P_T > 20$ GeV
  - MET > 20 GeV (neutrino)
  - N (jets) ≥ 3 jets
  - 1 b-tag by the SVX algorithm

Double tagged top event



- Background : use N(jet) = 1,2 to check background calculations
  - Mistag
  - non-W QCD
  - Physics background: Wbb, Wcc
  - Single top, WW, WZ etc.

Summer '04, 162 pb-1



Top Cross Section (cont.)

Require, H_T (total transverse energy) > 200 GeV

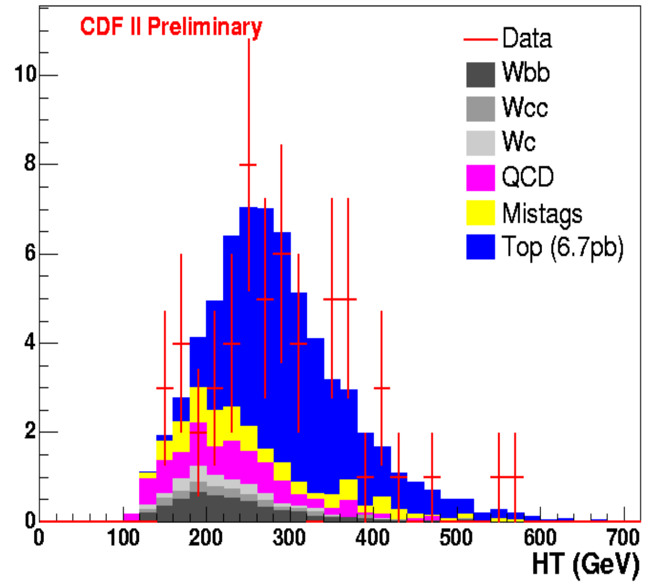
$$\sigma_{t\bar{t}} = \frac{N_{obs} - N_{bkg}}{\epsilon_{t\bar{t}} \times \mathcal{L}}$$

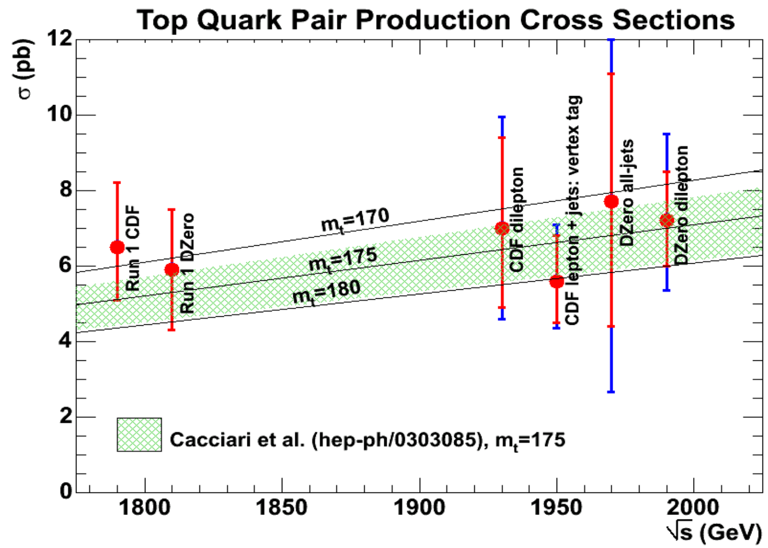
$$\sigma_{t\bar{t}} = 5.6\ ^{+1.2}_{-1.1}(\text{stat.})\ ^{+0.9}_{-0.6}(\text{syst.})\ \text{pb}$$

N(jets)	W + 3 Jets	W +≥4 jets
Pretag	179 **366**	91 **189**
Background	13.5 ± 1.8 **34.4 ± 3.9**	
b-tagged	21 **66**	27 **80**

Summer '04,162 pb^{-1} Published

Bold refer to 320 pb^{-1}





Top mass: Summer '04 method

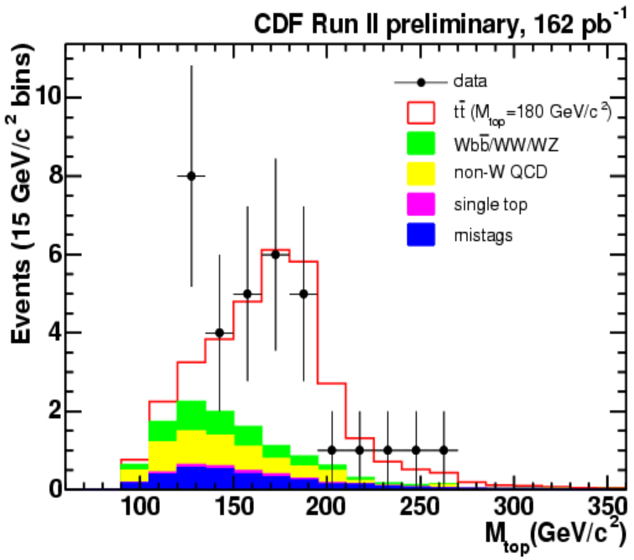
Volobouev, Fernandez, Freeman (PHD thesis), Galtieri, Lys

Fits events to $t\bar{t} \rightarrow W^{+} b W^{-} \bar{b}$

- Jet E-scale (JES) allowed to vary within a gaussian shape in W mass fit, to balance statistical and systematic uncertainties.
- Separate templates for correct and incorrect permutations.
- Probability of correct choice determined from the χ^2 value of all permutations.
- Two-dimensional templates: mass and E_{T4} (sum of the 4 jets).
- Increase discrimination between background as well as other top masses.

Measure simultaneously mass and background fraction.

Summer '04 result



$M = 179.1^{+6.4}_{-6.3}$ (stat) +6.8 (syst)

33 b-tagged events
34% background

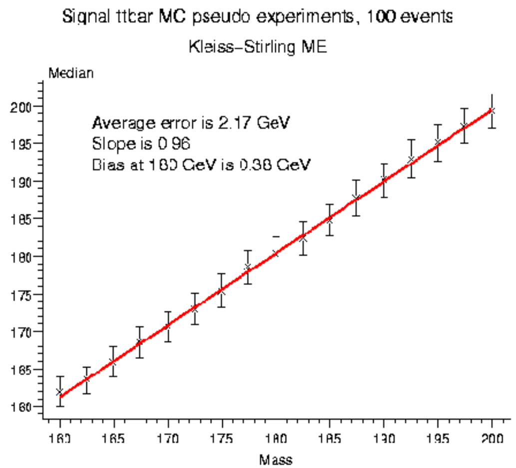
Top Mass: new LBNL method

Volobouev,Bachacou, Fernandez, Freeman (thesis), Galtieri, Lujan, Lys, Nielsen

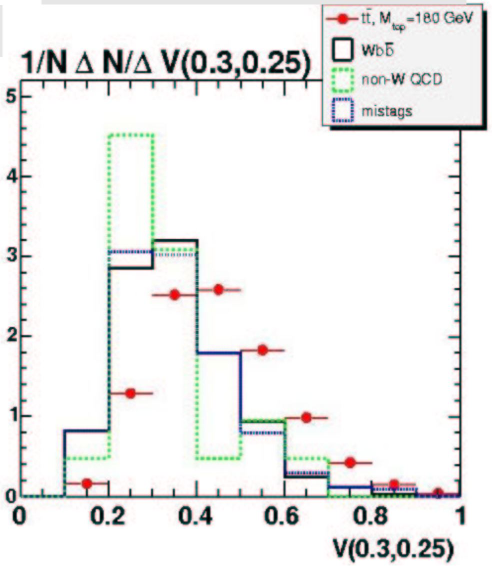
- Major systematic uncertainty in top mass measurement comes from jet energy uncertainties. We use jet transfer functions to improve resolution and the JES parameter to transfer systematic to statistical uncertainties.
- We integrate over phase space and Matrix Element for top production and decay, after a transformation into measured variables (similar to the method D0 has used for recent Run I result).
- See Kondo (JPhys. Soc. 57,1988), Dalitz&Goldstein(Proc. R. Soc. Lond., A445,1999).

- Integration being done over four variables + jet energy scale (JES). W mass constraint not imposed (2C fit, 4d).
- Use multivariate method for background separation: kinematic discriminant.
- New data sample will have about 60 tagged events.

Uses TF and ME integration



kinematic discriminant



Other LBNL Top mass measurements

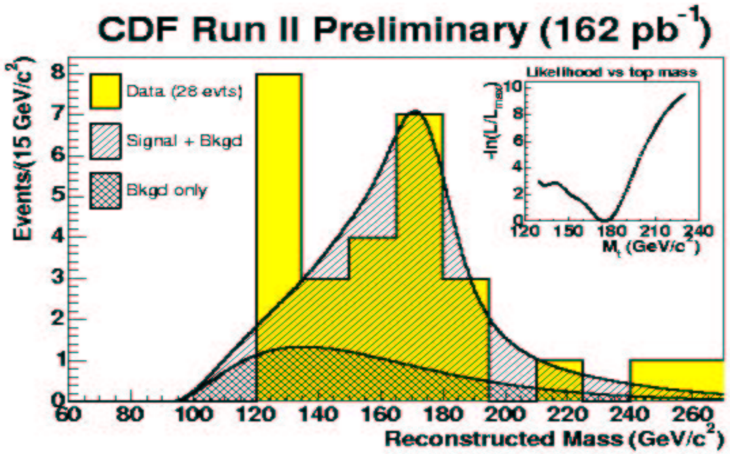
Brubaker(PHD) , Gibson+others

Analysis follows run I methodology

- 28 Lepton+jets b-tagged events
- 6.8±1.2 estimated background
- Kinematic constraints (χ^2)
- Compare reconstructed mass to MC Top +background templates

$M = 174.9^{+7.1}_{-7.7}(stat) \pm 6.5(syst)$ GeV

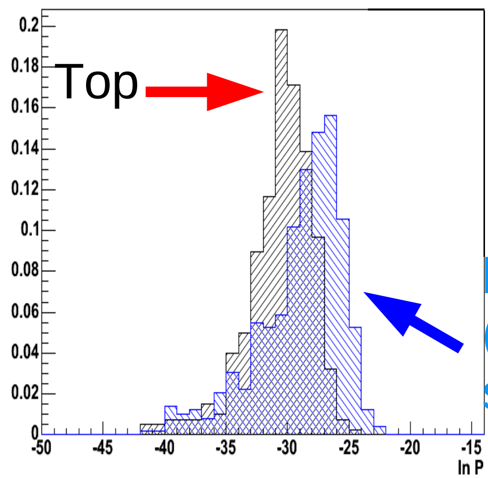
Updates result (320 pb^{-1}) to be published



A. Gibson(PHD thesis), and others

- Another variation of the ME approach to top mass measurement. Uses transfer functions for jets.
- Uses matrix elements for top production and decay in likelihood. Integrates over 3 variables. Narrow width approximation for the W's.

HERWIG, VECBOS MC



Use matrix element for background as well

background (after detector simulation)

Search for new signals in W bb events

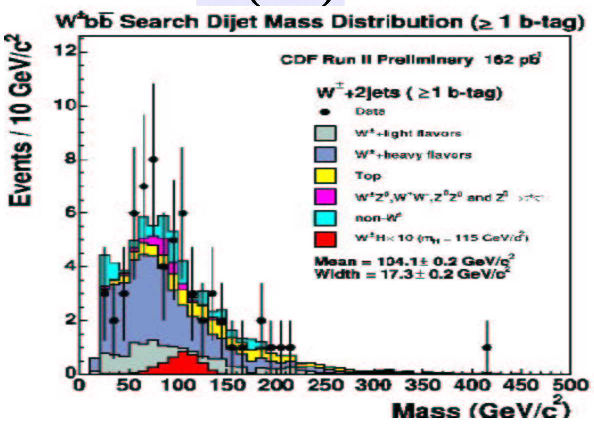
W-M Yao, Tsukuba student

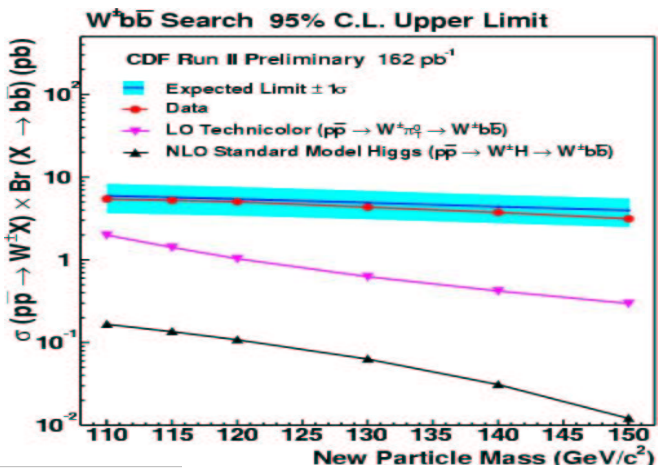
Techniques developed in Top analyses can be used for other searches
Production of new particles in association with W

- Higgs $\rightarrow b\bar{b}$, SM cross section too small for observation in current data
- Models such as technicolor can predict larger σ

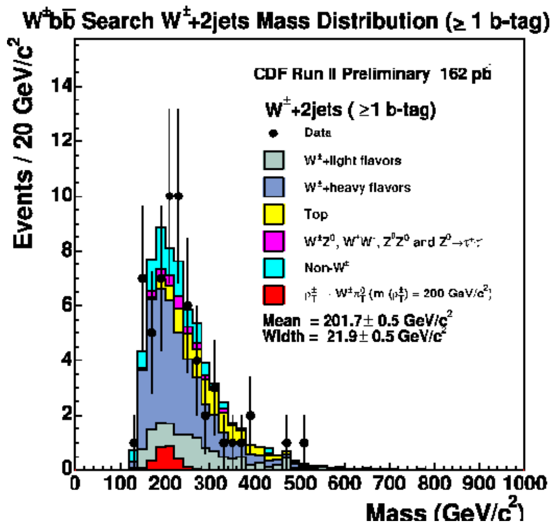
Use events with a W and 2 jets (at least one tagged jet).
Observe 62 events, with a background of 66.5±9.0 events expected.
Limit for SM Higgs $\rightarrow b\bar{b}$ and for technirho $\rho_T \rightarrow W\pi_T$, $\pi_T \rightarrow b\bar{b}$

M(bb)





M(W bb)



Summary and Conclusions

- Large contributions to hardware and physics over the last 23 years
  Contributed 12 PHD thesis, 18 postdocs.
  19 of these have faculty or lab staff positions.

- Contributed to top discovery, precision top and W mass measurements, properties of B mesons, Higgs studies etc.

- LBNL still contributing to Run II CDF physics results:
  - B_s Mixing
  - Top Physics
  - New particle searches

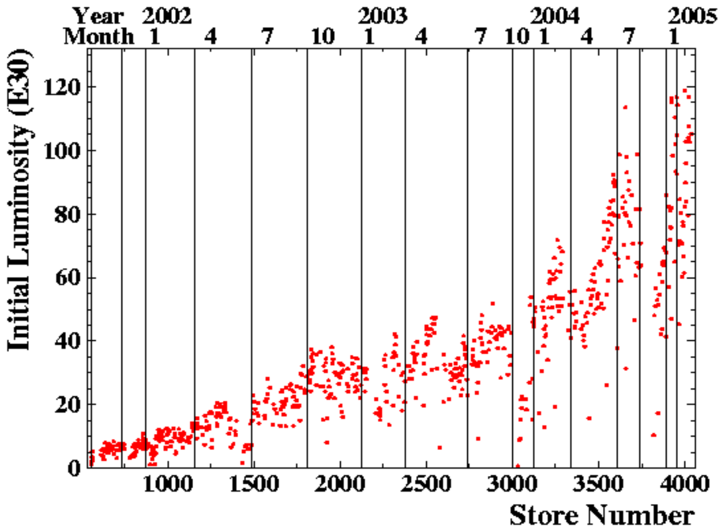
- Very enthusiastic about pursuing this physics.

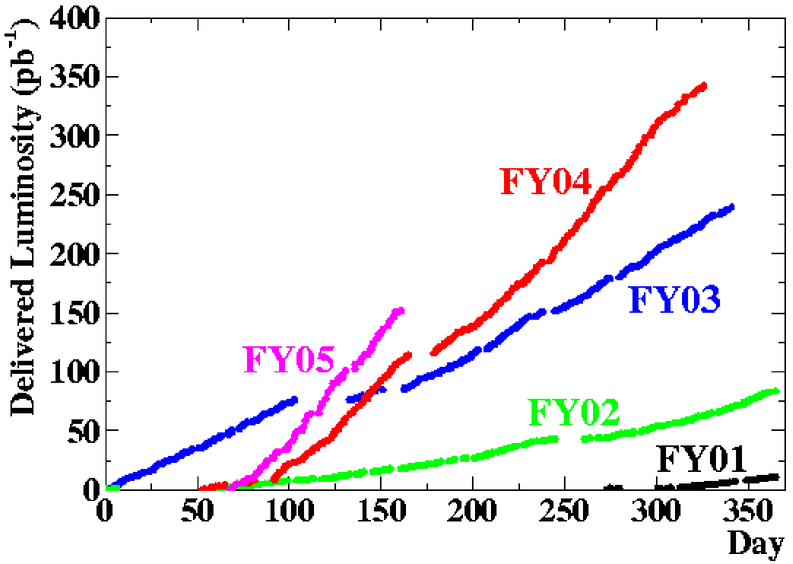
- Data sample expected to be ~ 30 times the Run I data by end FY07.
- Window of opportunity for high P_T physics before the LHC!!
- Great way to prepare for the challenges of LHC physics.

Backup Slides

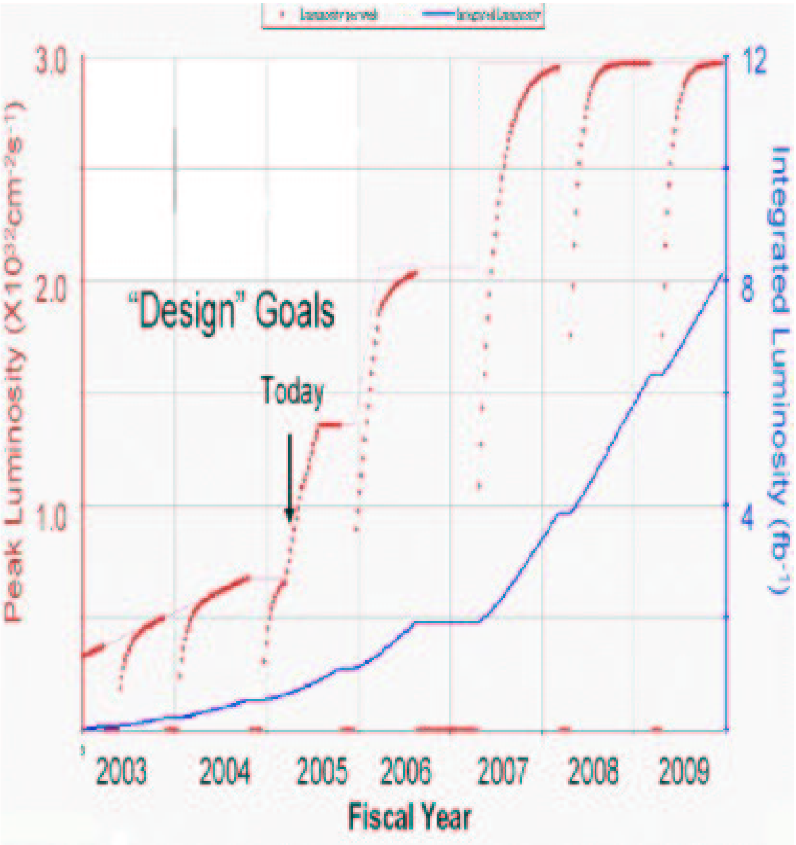
Tevatron performance and expectation

Delivered luminosity surpassed 800 pb^{-1}

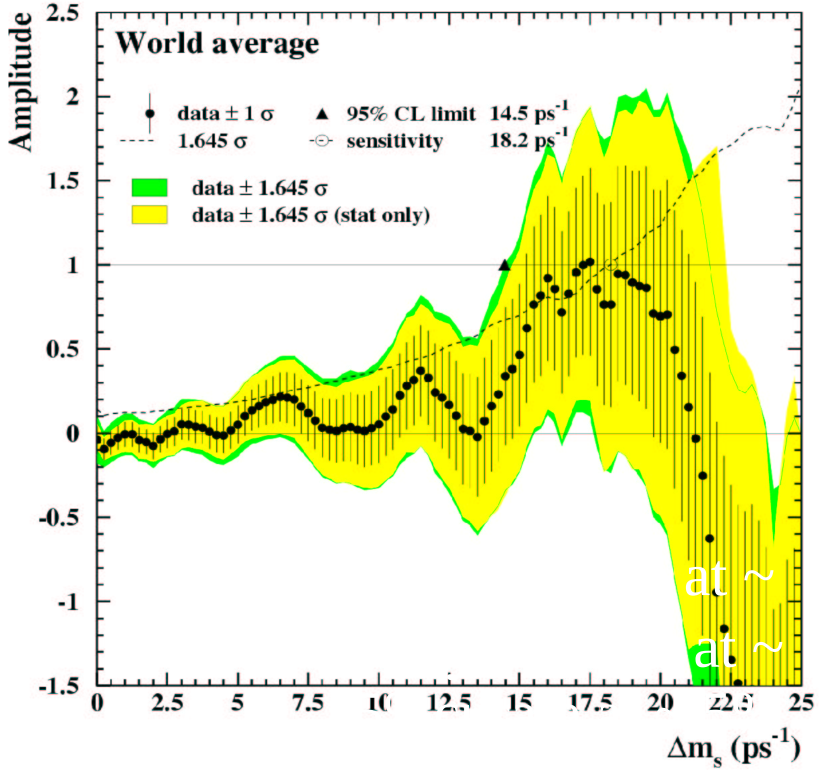




Plan for FY 2005: Integrate 470pb^{-1} in 34 weeks (~14pb^{-1}/week)



B_s world Average (ICHEP 04)



- B_s mixing World Average @95%

C.L. Δm_s 14.5 ps^{-1}-

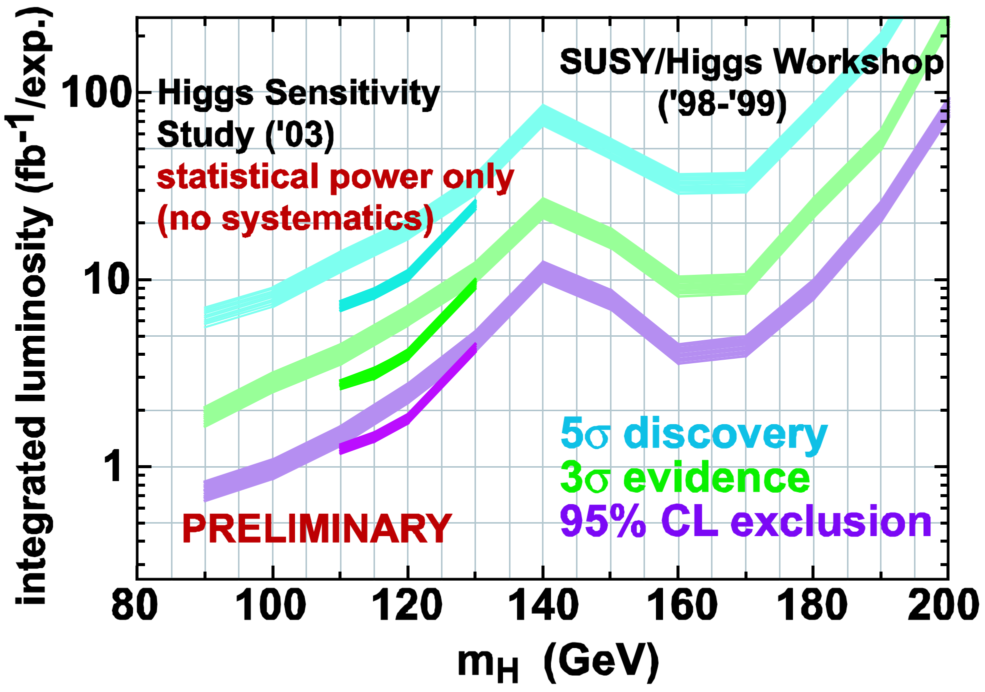
Uses data from LEP and SLD

Standard Higgs Expectation

Standard Model Higgs needs large integrated luminosity

SUSY Higgs can have a large cross section for large values of tanβ.

Study the A/H → ττ, bb channels



LEP m_H>114.4 GeV @95% CL