LBNL CDF Program at the Tevatron

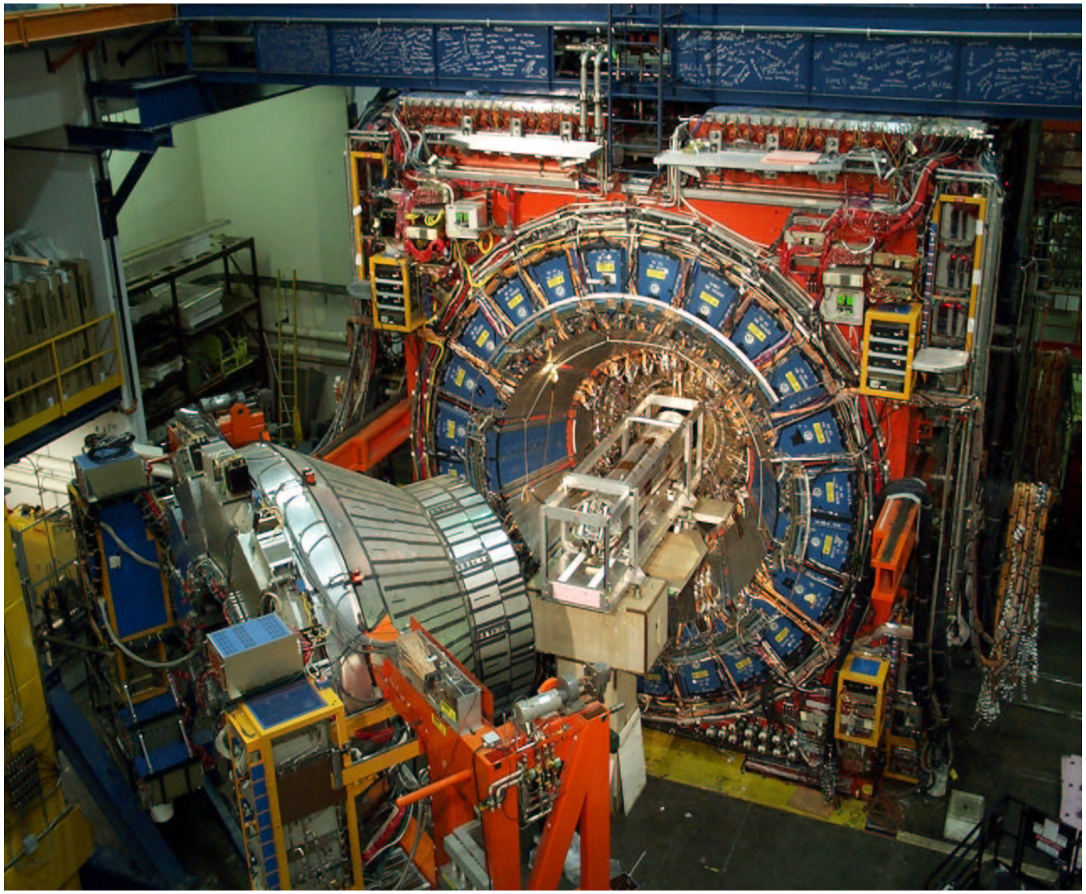
Angela Galtieri

LBNL Director Review
November 6−7, 2002

Outline

- Accelerator Status
- The CDF II Detector
- LBNL Group Responsibilities
- Silicon Detectors
  - Run IIa
  - Run IIb
- Current Activities
  - Silicon Tracking
  - b−tagging
- Physics Program
  - B Physics
  - EWK (W/Z/Top)
  - Higgs
  - New Physics
- Summary

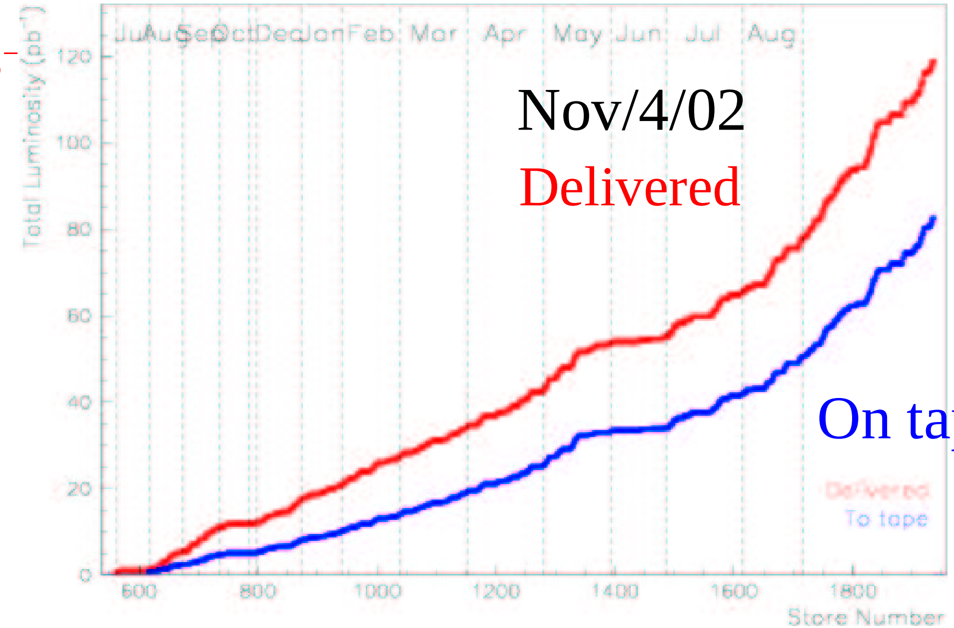
CDF Detector



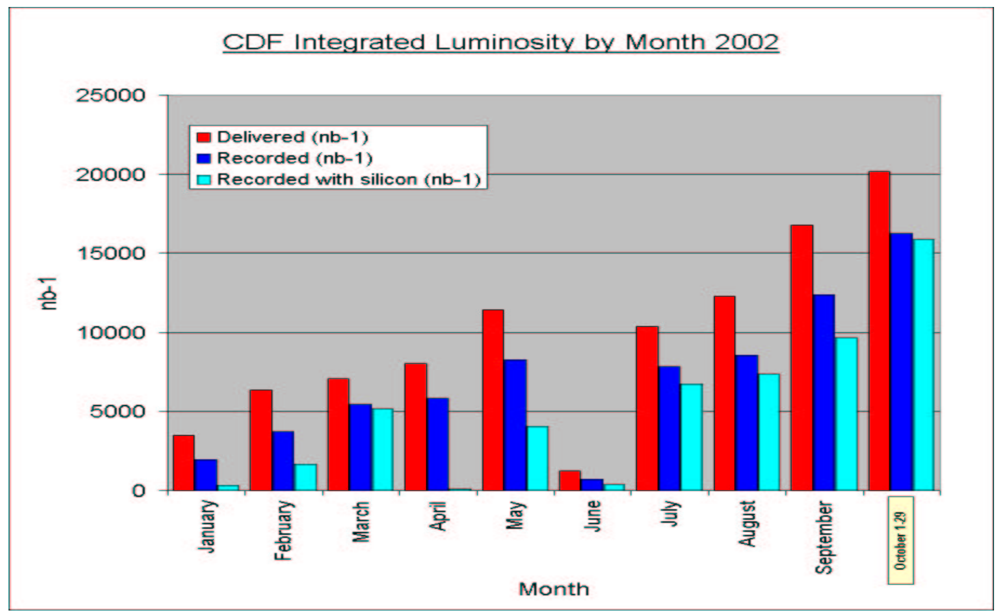
installing silicon tracker, prior to detector roll−in

Run II Accelerator Status

- Run II Upgrades: $5x10^{32}$ cm^{-2} s^{-1}
- Main Injector (2001)
- Recycler (2003):
  recover antiprotons
- Bunches
  baseline 36x36 at 396 ns
  ultimately 132 ns **(??)**
- $\sqrt{s}$ = 1.96 TeV



- Current performance
  3.6×10^{31} cm^{-2} s^{-1}
- Integrated luminosity
  120 pb^{-1} delivered
  CDF: 80 pb^{-1} on tape

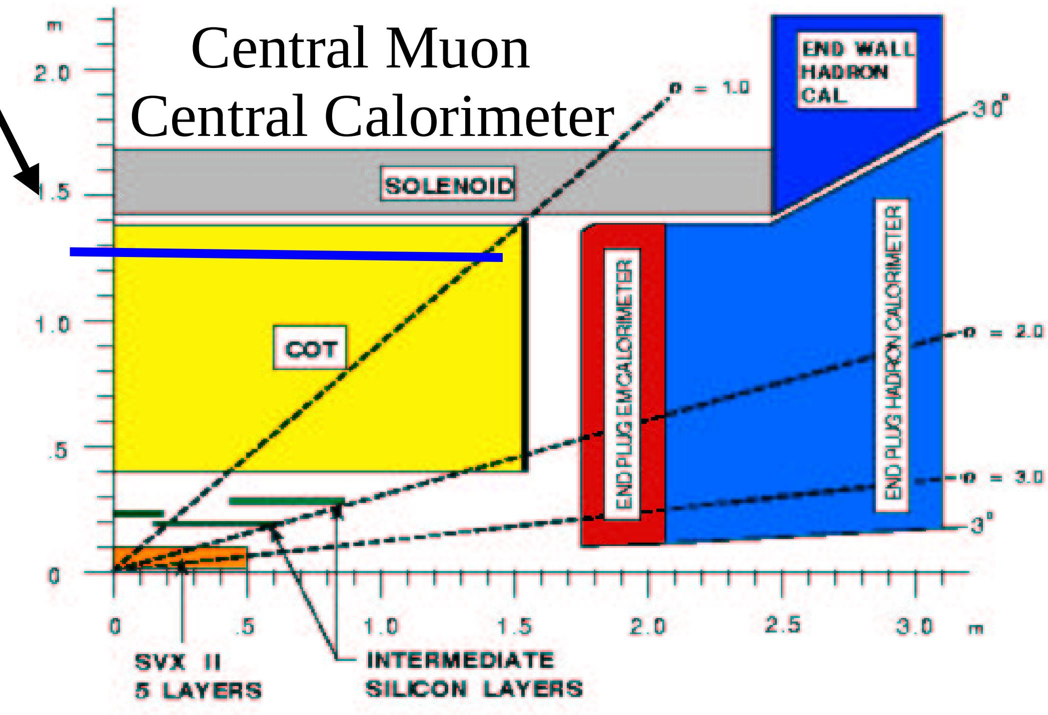


The CDF II Detector

Tracking system is all new, new Plug Calorimeter, improvements to all the other detectors

- New wire drift chamber,COT (96 layers)
- Time of flight system
- New silicon system:
  Double sided sensors,
  up to 7 layers
  Covers to $|\eta| = 2.0$
  L00, added later, close to beam pipe (1.35 cm) for improved impact parameter resolution
- Silicon vertex trigger (SVT)
- New scintillating tile plug calorimeter extends to $|\eta| = 3.6$
- Larger muon coverage

TOF



Detector Commissioned. Taking physics data

Members of the LBNL Group

Physicists−Staff (6.5 FTE)

P. Calafiura +
W. Carithers ++
R. Ely (retired)
A. Galtieri (Group leader)
M. Garcia−Sciveres*
C. Haber*
Y.K. Kim (UC Berkeley)
J. Lys *(retired)
R. Miquel**
M. Shapiro* (UC Berkeley)
J. Siegrist* (UC Berkeley)
W. Yao**

Physicists−Term (5.5 FTE)

A. Cerri
A. Dominguez
J. Nielsen
B. Orejudos
L. Vacavant
I. Volobouev

* ATLAS, ** PDG, + NERSC, ++ SNAP

Fellows (2 FTE)

C. Currat
M. Weber

Visitor (gone)

P. Maksimovic (JHU)

Grad. Students

T. Affolder ('96 Run II/I)
A. Connolly ('96 Run II/I)
G. Veramendi ('98)
H.C. Fang ('98)
E. Brubaker ('99)
H. Bachacou ('99)
A. Gibson ('00)
J. Muelmenstaedt ('02)
J. Freeman ('00)*

Undergrad. Students

L. Tompkins
B. Mishek (gone)

Engineers, Designers

B. Krieger
H. von−der−Lippe
J.P. Walder
E. Mandelli
B. Holmes

Leadership roles at CDF

- Marjorie Shapiro
  - **Offline Project Manager (March 98−October 2001)**
  - **Co−coordinator: CDF simulation group (since October 2001)**
  - **Co−coordinator: B physics group (since January 2002)**
- Young−Kee Kim
  - **Associate Head of CDF Operations Department (to Dec. 2001)**
    - **in charge of commissioning**
    - **setting milestones, schedule and priorities**
    - **daily operations**
  - **L3 Subgroup co−leader (now)**
- Bill Orejudos
  - **Co−coordinator of the COT group**
  - **CDFII Operation Manager (to June 02)**
- Alex Cerri
  - **Co−coordinator of the Semileptonic B physics group**
- Weiming Yao
  - **Co−coordinator : Higgs Physics group**
- Aaron Dominguez
  - **Co−coordinator: silicon performance**
  - **Co−coordinator: b−tagging group**
- Lina Galtieri
  - **Co−coordinator: Jet corrections group**
- Greg Veramendi
  - **Co−coordinator: High Pt Electrons gr.**

LBNL Contributions to CDFII

I. Construction

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

II. Commissioning

- Associated Project Manager (YK Kim)
- COT Commissioning (Orejudos)
- Silicon commissioning (Affolder, Dominguez, Nielsen)

III. Detector Operation (ongoing)

- CDF II Operation Manager (Orejudos)
- Online silicon monitoring (H. Bachacou)
- Offline Silicon calibration (Nielsen,pager)
- Online data monitoring (YMON) (Gibson)
- SVT operation (Cerri, pager)
- COT calibration (Orejudos, pager)

IV. Computing and software

- Project manager (M. Shapiro)
- Codgen for relational data bases
- Data handling software for early tests
- Muon reconstruction software

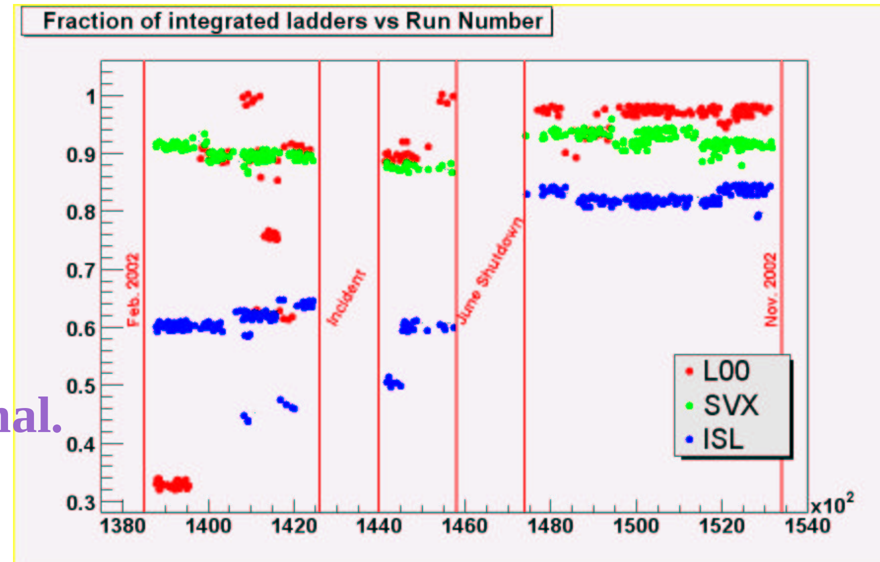
- Ongoing responsibilities
  - ➢ Simulation co−convener (M. Shapiro)
  - ➢ MC generators : ISAJET (L. Galtieri), HERWIG, Wbbgen (J. Lys)
  - ➢ Silicon Code librarian (A. Dominguez)
  - ➢ Silicon Tracking (W. Yao)
  - ➢ Secondary vertices code (W. Yao)
  - ➢ Passive material (L. Vacavant)

Status of Run IIa Si Operation

M. Garcia−Sciveres, J. Nielsen, H. Bachacou, I. Volobouev

Number of integrated modules(11/4/02)

L00	71/72	98.6%
SVX	332/360	92.5%
ISL	122/148	83.1%



L00 : noise pick up, read all channels

SVX: 1 wedge (5/360) has a missing control signal. Experienced failures in power connections within ladders (still at risk for more) in about 4% of channels

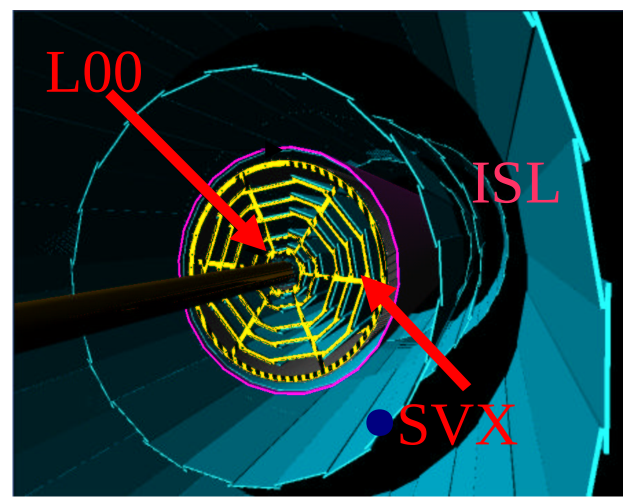
ISL : cooling lines blocked. Most fixed, two left to fix, need a week shutdown.

Many of the non−integrated modules can be fixed.

Details of SVX failures (see backup plot if interested)

- **13 analog power connections have failed: consistent with broken silver epoxy or jumper connection**
  - **5 happened over a period of time**
  - **6 happened during a beam accident**
  - **None have happened since.**

Silicon detector end view



Silicon operation (cont.)

Beam accident has been understood, protection system has been installed. Connection damage not reproduced at the FNAL booster with spare ladder exposed to x100 more radiation.

- 12 digital power connections have failed

A failure of this type disables the stereo side of the ladder, consistent with a broken jumper connection

- **task force has been studying these failures since September 30, 2002**
- **proposed cause is wirebond failures due to excitation of ~10KHz mechanical resonance by Lorentz forces (jumper connection at 90^{o} to B field).**
- **Test done in a magnetic field with video recording: wirebonding fails as they go into resonance mode at certain frequencies. More work needed.**

Is there something that can be done?

- **Can change chip operating parameter to reduce AC structure of digital current.**
- **Can reduce duration of AC transients by changing readout mode.**

Work in progress to understand further the problem and the solution.

Impact Parameter Trigger SVT

Contributor to SVT hardware: A. Cerri

SVT trigger simulation : A. Cerri

L1: COT track (XFT) with P_T > 1.5 GeV/c

L2: SVT combines COT track with Si hits

4/5 SVXII hits required (r−φ).

2 tracks P_T> 2 GeV/c and

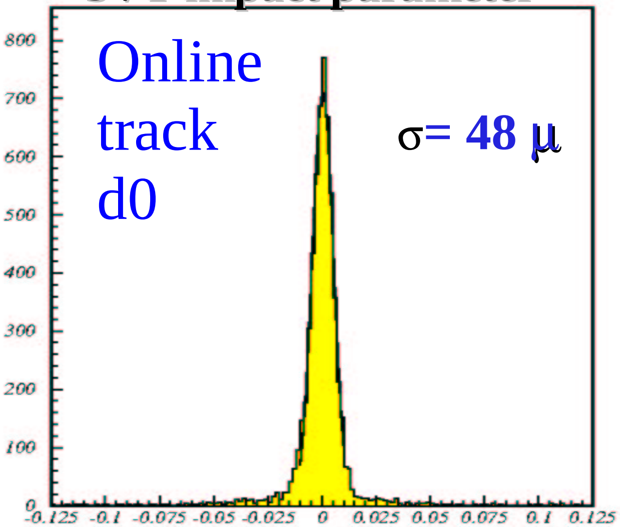
impact parameter > 100 μm

Missing SVT wedges (4/5 hits) reduce efficiency (9 out of 72 wedges are missing).

Some of the 9 wedges can be fixed.

σ= 48 μ m including beam spot spread of σ=33 μm

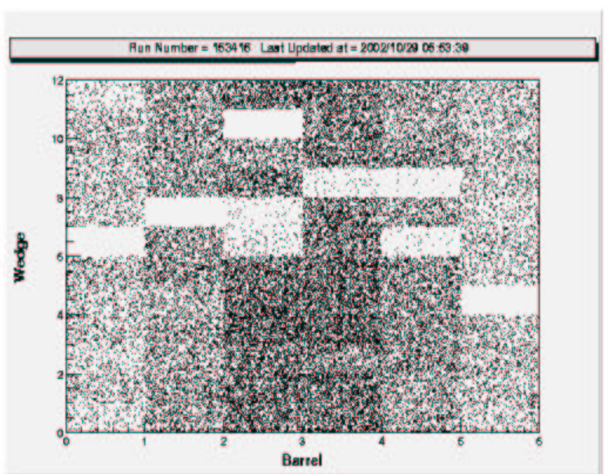
SVT impact parameter



(Cerri)

80% (August), now 90%

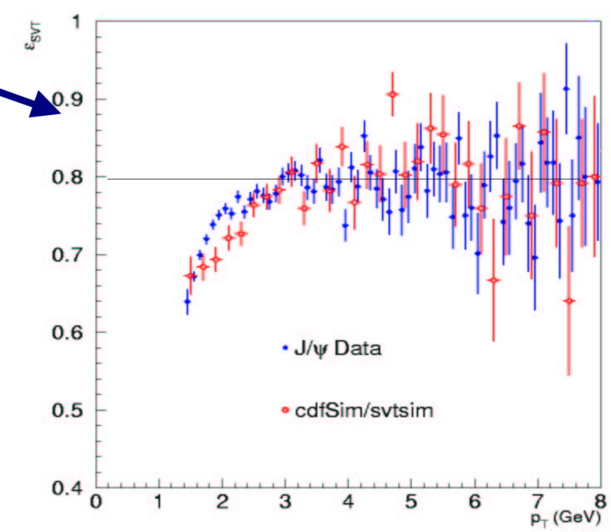
12 ladders in (r−φ)



SVX z: 6 half ladders

SVT Efficiency:

Good agreement J/ψ data (red) and trigger simulation (blue)

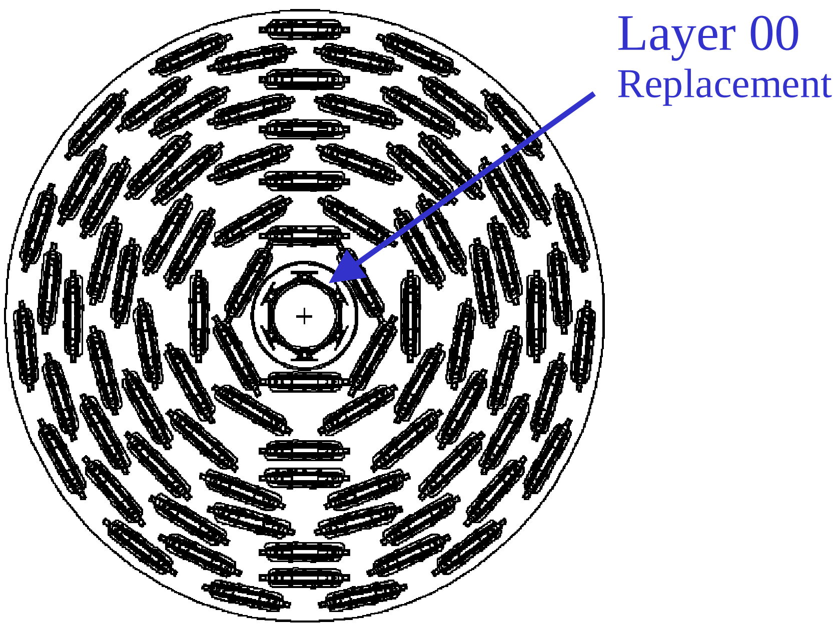


(Cerri)

Run II b Silicon Tracker Upgrade

M. Garcia−Sciveres, C. Haber, M. Weber, W. Yao, L. Galtieri (physicists),
A. Gibson, B. Mikesh (earlier students), J. Freeman (new student)

- **For high luminosity run much of silicon tracking will not survive.**
- **CDF plans a change over to new silicon in 2006 with minimal interruption of running**
- **Simplified construction and assembly. Single sided detectors.**
  - Most of tracker based on single "stave" design. All modules are the same, except for L0 (on the beam pipe)

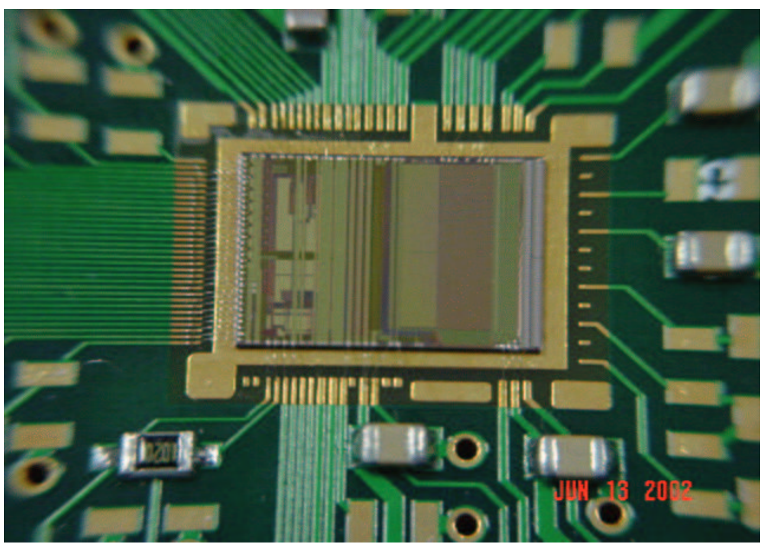


- LBNL group participation:
  - **LBNL−IC group leads SVX4 chip design (with FNAL and Padova). Chip to be used by both CDF and D0**
  - **SVX4 testing and irradiation**
  - **Design, prototyping of hybrid**
  - **On−stave bus cable: design, prototype and testing**
  - **Systematic studies of electrical performance of "stave" concept.**

Contributions to Run IIb Silicon

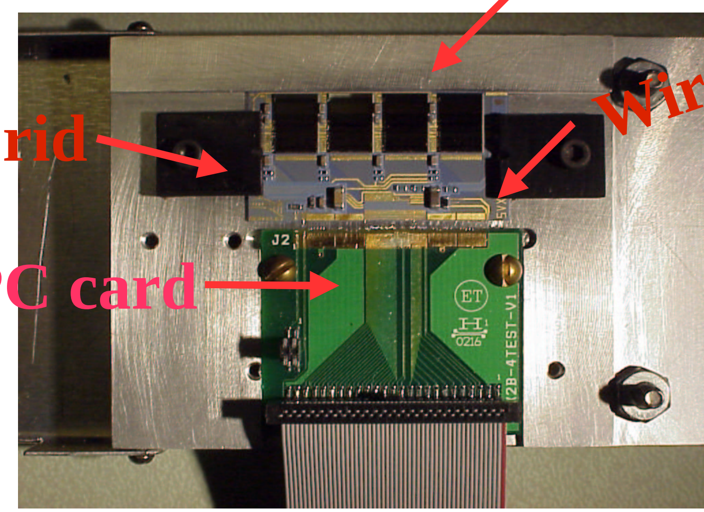
SVX4 chip

- **Complete simulation and verification of the SVX4 chip performed at LBL**
- **Full chip submitted (engineering run) on April 1, 2002, returned in June.**
- **Worked after 24 hours of arrival**
- **Extensive testing and radiation studies done. D0 physicist participated at LBNL**
- **Few modifications necessary. Expect new submission at end of January.**



Hybrids Prototyping

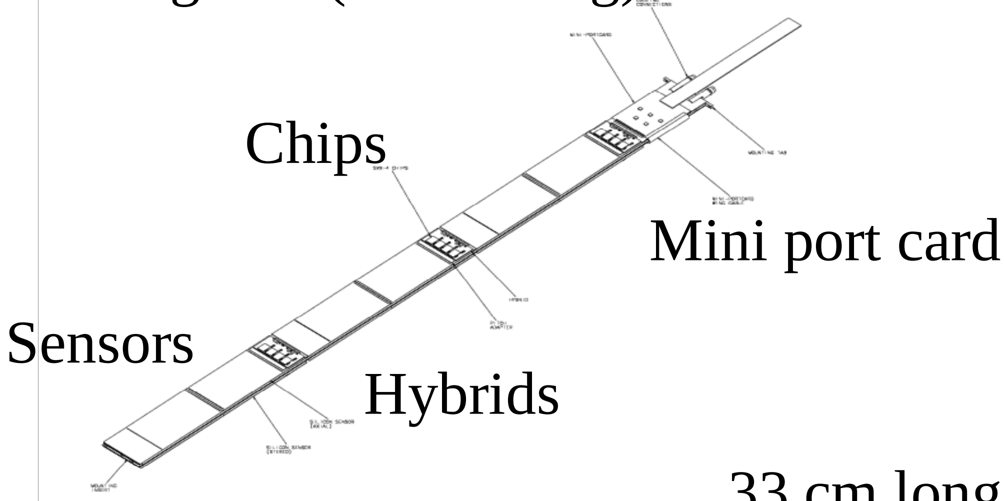
- **Based on technology used for L00 in Run IIa(BeO substrates): simple design, minimize components and assembly steps.**
- **Only two types of Hybrids (13 types in Run IIa)**
- **Prototypes built and tested, working as expected.**



Contributions Run IIb Silicon

LBNL "stave" concept

Highly integrated electrical, mechanical & cooling unit (66 cm long).



33 cm long

Stave Bus

- Stave contains integrated data+ power bus, serving all hybrids/sides.

  Prototype fabricated and tested at LBL

Status and plans:

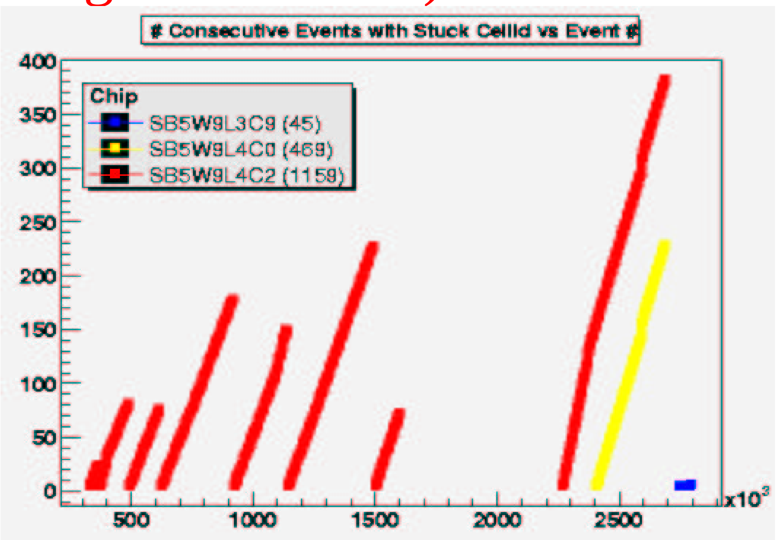
- SVX4 preproduction chip to be submitted early 2003.
  Initial testing at LBNL.
  Wafer probing at FNAL.
- Hybrid prototypes with SVX4 chip to be assembled and tested.
  Hybrid production being organized.
  Hybrid burn−in to be done at UC Davis.
- Stave Bus work at LBNL.
- Study of stave electrical performance to continue at LBNL.

Responsibilities: Silicon system

Online monitoring: I. Volobouev, H. Bachacou
Offline Calibration: I. Volobouev, J. Nielsen

The 722432 channels must be monitored and calibrated for each run.

- SVXMON is a very important tool to detect detector problems.
- Also used to RESET the silicon DAQ when front end chips loose pipeline syncronization. (see diagnostic below)



(Bachacou)

- 234M events with silicon data, to be used for physics analyses, have been processed so far
- 171 sets of constants have been provided. This system is setup so that most of the operations are automatic
- Pedestals very stable with time.

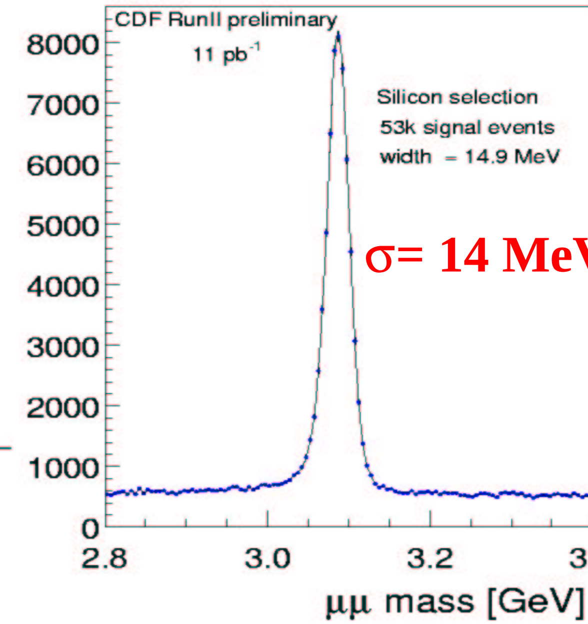
- Calibrated channels (11/4/02)

L00	13.6K/13.8K	98.1%
SVX	374.8K/405.5K	92.4%
ISL	251.9K/303.1K	83.1%

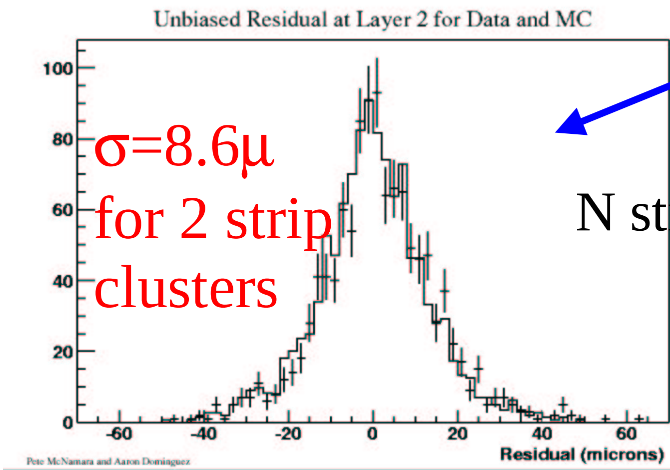
Responsibilities: Silicon Tracking

- Weiming Yao : outside−in track reconstruction (default CDF tracking)
  - Begin with COT tracks.
  - Add Silicon hits in r−ϕ and then z.

J/ψ mass



σ= 14 MeV



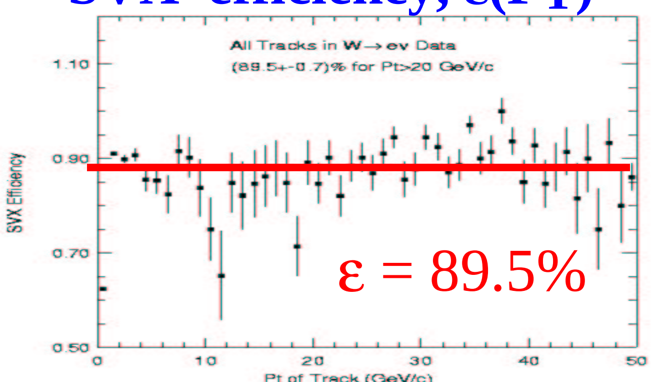
σ=8.6μ for 2 strip clusters

(A. Dominguez)

Unbiassed residuals

N strips	Data Resolution (μm)	MC Resolution (μm)
1	11.6 ± 0.7	12.7 ± 0.5
2	8.6 ± 0.2	8.6 ± 0.2
3	13.6 ± 0.5	13.8 ± 0.4
4	21.6 ± 1.8	20.0 ± 1.3

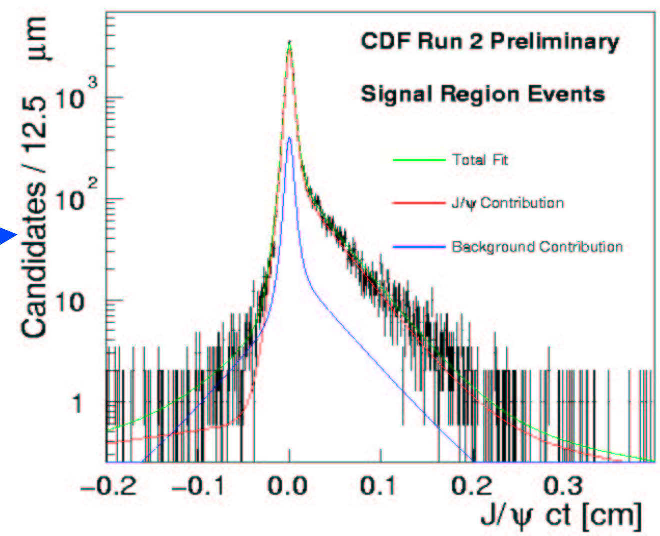
SVX efficiency, ε(PT)



ε = 89.5%

(Weiming Yao)

B lifetime in run II from J/ψ data . Tails well fit on both sides

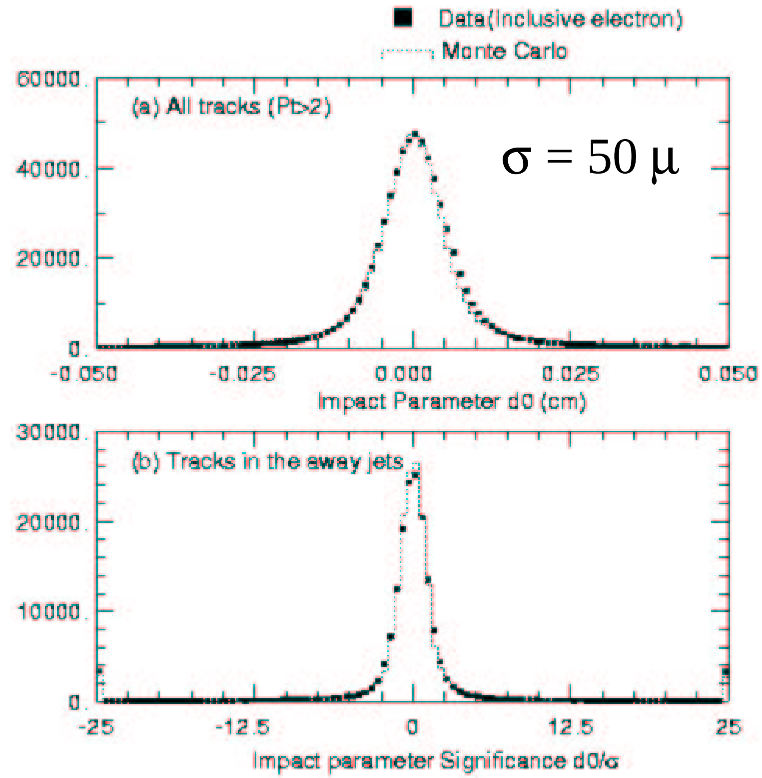


Responsibilties: b−tagging

A. Dominguez (co−cordinator of b−tag group), Yao, Bachacou

- Optimize the run I algorithm SECVTX (done by Weiming Yao)
- Data sets used: inclusive electrons trigger (P_T>9GeV), jet events.
- "Good run" selection done.
- Track quality cuts completed: COT requirements, SVX requirements.
- Studies of error assignment to track parameters.
- Tuning of Monte Carlo tracking efficiency and error matrix to data
- Realistic Monte Carlo: takes into account variation with time of detector components (i.e. SVX ladders)
- Compare impact parameter and its resolution to Monte Carlo

Hot off the presses:
Inpact parameter and its significance for electron sample.
Very good agreement with MC



(Weiming Yao)

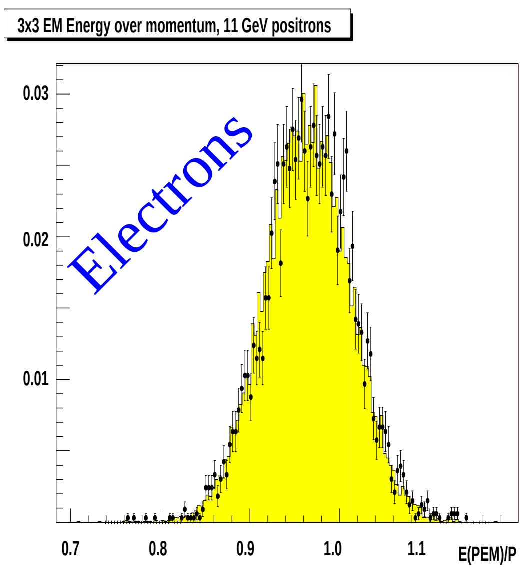
Calorimeter Simulation Tuning

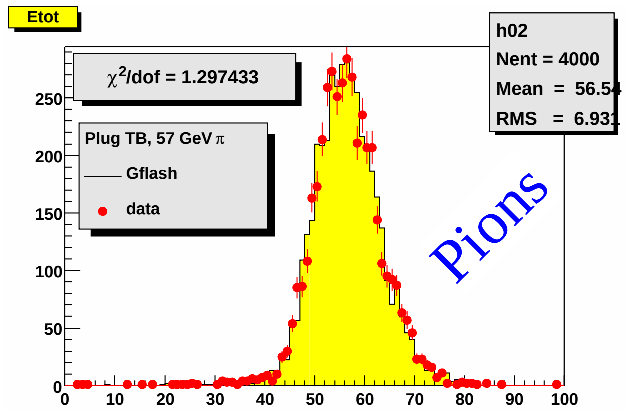
Charles Currat, Henri Bachacou, Erik Brubaker, Marjorie Shapiro

Tuning parameterized (fast) simulation – EM and hadronic calorimeter

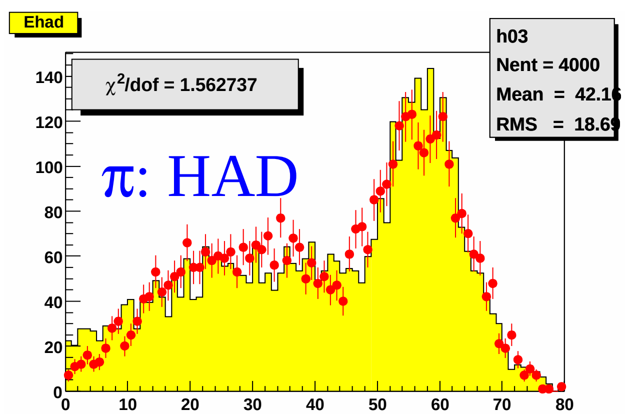
e.g. Electrons and $\pi^{\pm}$ responses : simulation vs test beam results (plug)

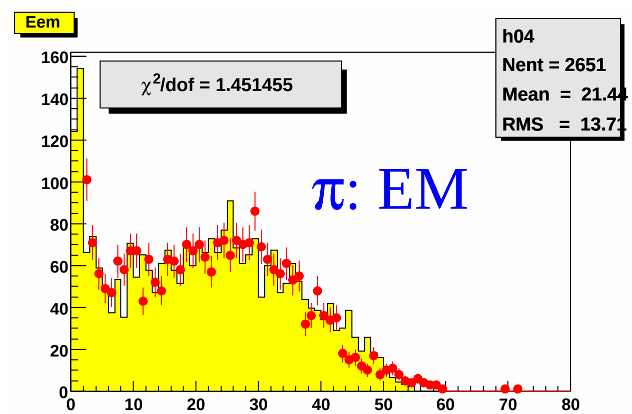
Very good agreement in 8−250 GeV range





For pions the EM and the HAD distributions are tuned separately





LBNL Group Physics Program

EWK/Top/Higgs Physics

- People : Bachacou, Brubaker, Currat, Dominguez, Garcia−Sciveres, Galtieri, Gibson, Kim, Lys, Nielsen, Orejudos, Siegrist, Veramendi, Volobouev, Yao
- Physics Interest :
  - M_{top}
    - The flagship analysis, to be done by the whole Top group.
  - Top : σ, ratio of σ's, spin correlation, and W couplings
  - σ(W) ,Z : A_{FB} at s > M_Z^2
  - Higgs Searches: SM and SUSY
  - New particle Searches

B Physics

- People : Cerri, Fang, Miquel, Muelmenstaedt, Shapiro, Vacavant

Physics Interests :

- V_{cb} and Semileptonic Decays

  Major LBL goal for Spring 2002

  Address timely issues in CKM mat.

  Can be used for B_s when more data

- B_s mixing

  Requires several 100 pb^{-1}

  Technique to be validated via B_d mixing measurements

Emphasis for spring 2002:

Optimization of tagger

B_s mass reconstruction

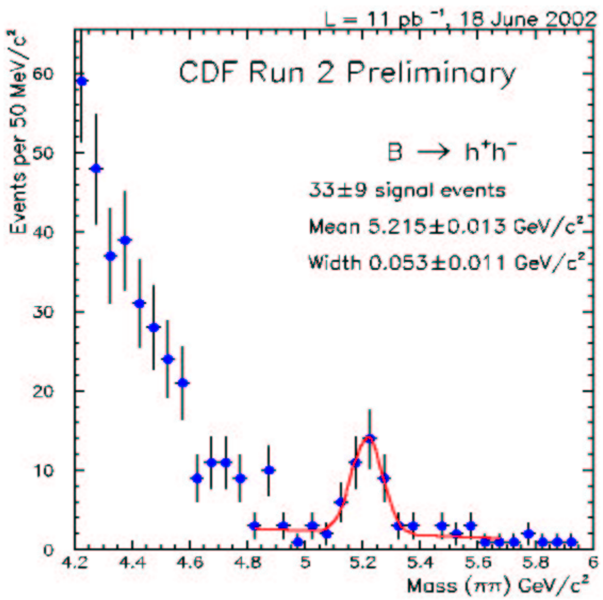
B Physics

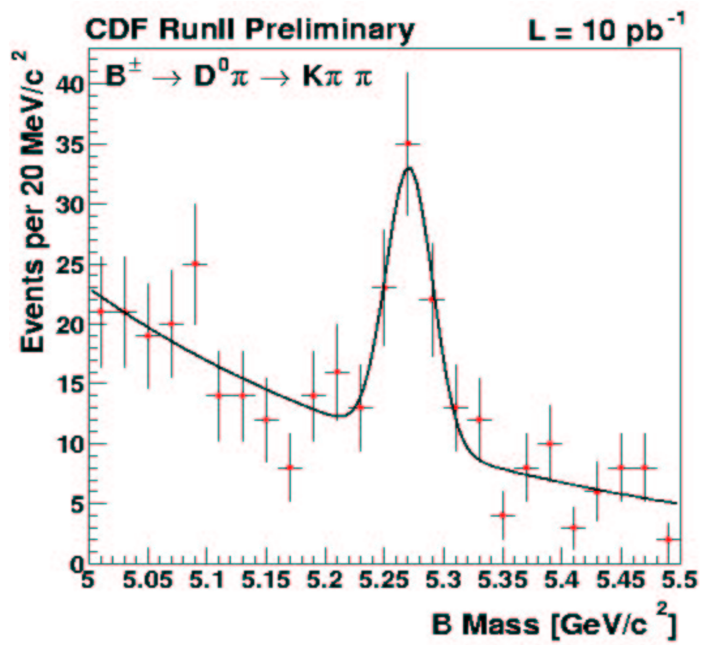
M. Shapiro, Cerri, Fang, Miquel, Muelmenstaedt, Vacavant

Silicon Vertex Trigger (SVT) revolutionizes B Physics at CDF
Essential for planned program including CP violation and B_s mixing

- SVT allows study of the hadronic decays $B \rightarrow hh$ and $B_s \rightarrow D_s \pi$
- B_s, Λ_B, B_c unique to the Tevatron
- Factor 3 improvement in semileptonic yields

- First full hadronic B signals
- Good signal to noise
- Yield low in first 10 pb^{-1} :partial Silicon coverage and SVT trigger non−optimized (expect x3).





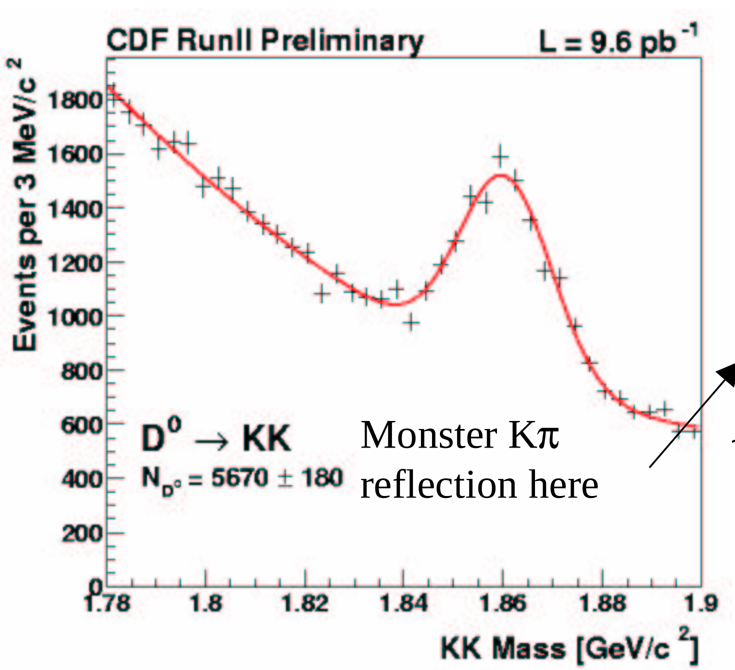
SVT Trigger: Charm Physics

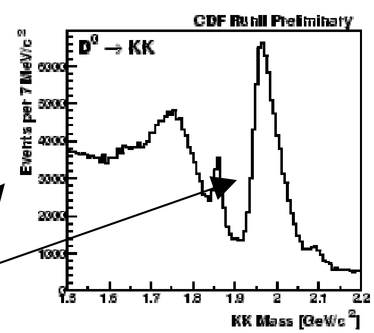
First CDF measurement of a charm decay branching ratio

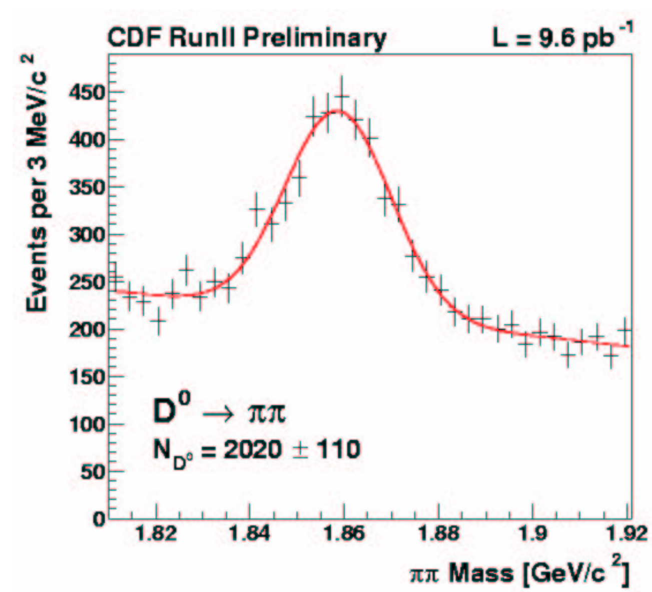
- $\Gamma(D \rightarrow KK)/\Gamma(D \rightarrow K\pi) = (11.18 \pm 0.48 \pm 0.98)\%$ (PDG: 10.83 ± 0.27)
- Main systematic (8%): background subtraction (work in progress).
- $\Gamma(D \rightarrow \pi\pi)/\Gamma(D \rightarrow K\pi) = (3.37 \pm 0.20 \pm 0.16)\%$ (PDG: 3.76 ± 0.17)
- several ~2% systematics

Already comparable!

- This charm measurement has pushed the state of the art on modeling SVT sculpting. Important simulation work for B physics program and high P_T b jet triggers.





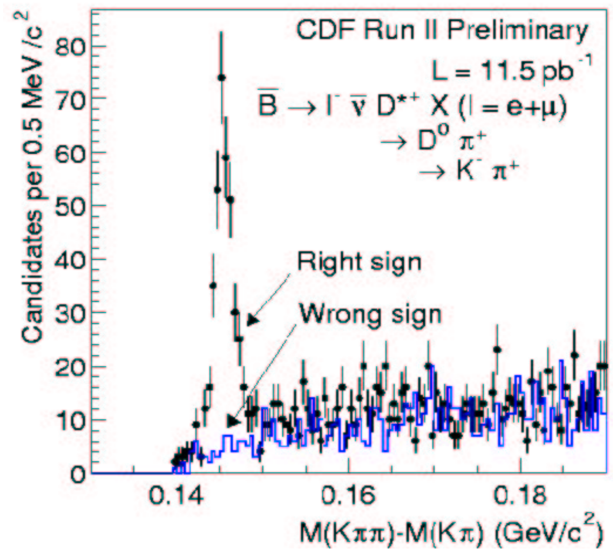


(Cerri with Rome group)

B Physics: current program

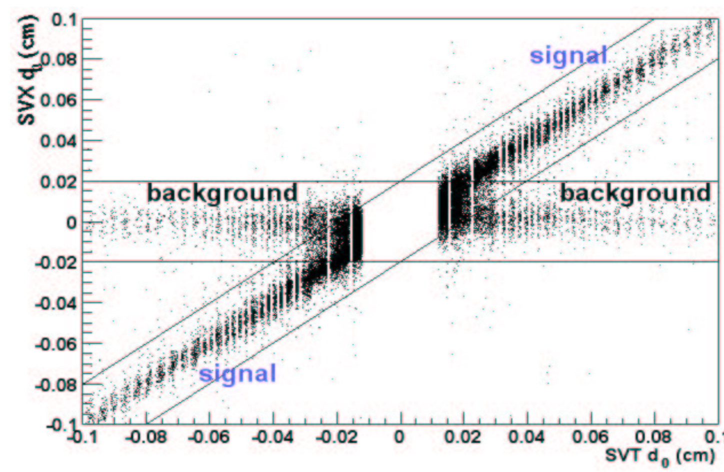
Current focus of LBNL B group: Semileptonic decays

- In 100 pb^{-1} (Spring Conference) expect:
  - 3 Million B→ lepton + track events with 90% purity
  - 20K B→ D^0 + l + X
  - 10K B→ D* + l + X
  - 1K B→ D_s + l + X



- ➢ Sample Selection and trigger modeling
- ➢ Study of D** production and measurement of hadronic mass moments
- ➢ Flavor tagging optimization
  - Use l + SVT track trigger (high statistics)
  - Measure B_d mixing
  - Amplitude of oscillations gives tagger quality (εD^2)
  - x_d measurement checks systematics on modeling of trigger and decays, as well as decay length reconstruction

Online (SVT)−vs−Offline(SVX) d0



(Fang)

B Physics: Moment Analysis

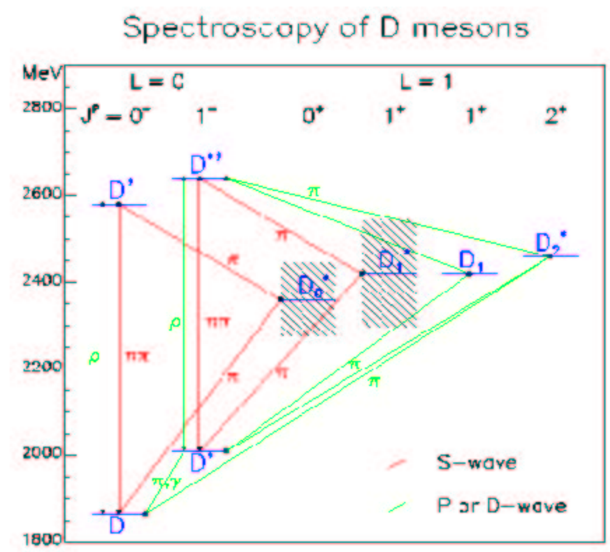
- Measurement of V_{cb} from inclusive semileptonic rate:

  OPE provides expansion in terms of α_s, Λ_{QCD}/m_b , ...
- To make a measurement to better than 5%, must understand effects of hadronic physics.
- Need comparison of theory and experiments for many quantities: build confidence in predictions by testing them
- Theory does not provide detailed knowledge of hadronic states, but make prediction for inclusive quantities, e.g.

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

  these are the "hadronic mass" moments

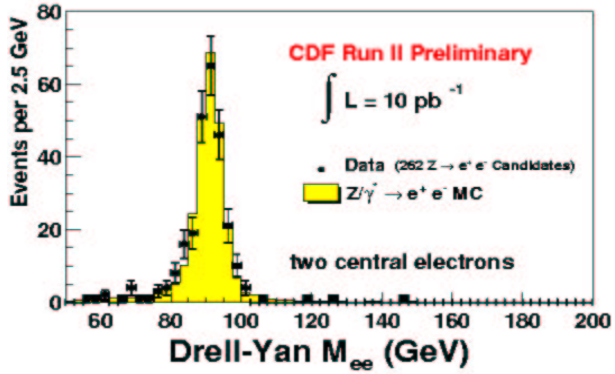
- To measure these moments, need to map out spectrum of hadronic decays.
- Also, must fit for non−resonant contributions.
- Goal: first CDF measurements by Spring 2003
- This measurement will help reduce systematics on B^+/B^0 lifetime measurement



High P_T Physics Activities

Bachacou, Brubaker, Currat, Dominguez, Garcia−Sciveres, Galtieri, Gibson, Kim, Lys, Nielsen, Orejudos, Siegrist, Veramendi, Volobouev, Yao

Transition from detector studies and tools development to physics analysis is occurring now.

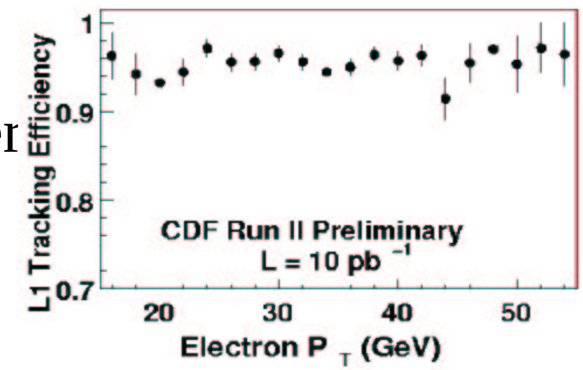


Plans for the Winter Conferences:

- W cross section, Z asymmetry
- Top cross section and mass measurement
- MSSM Higgs search
- Heavy long lived particles (CHAMP) search

Contributing to different areas:

- Electrons: data sample, ID criteria, E scale, trigger
- Tracking: track reconstruction code, Silicon performance and track efficiency optimization
- b tagging: optimization of secondary vertex finding in jets for top and Higgs physics
- Jet corrections: calorimeter E−scale to be kept stable within 1%
  $Z \to b$−bar for jet E−scale improvement.



(G. Veramendi)

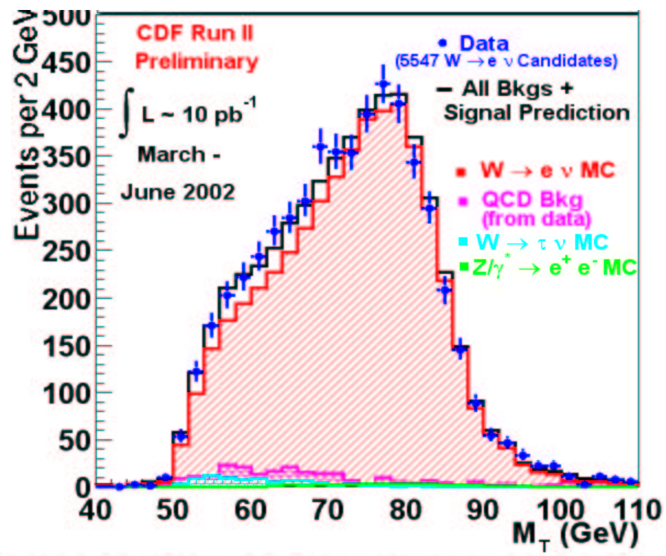
W → e ν cross section (ICHEP)

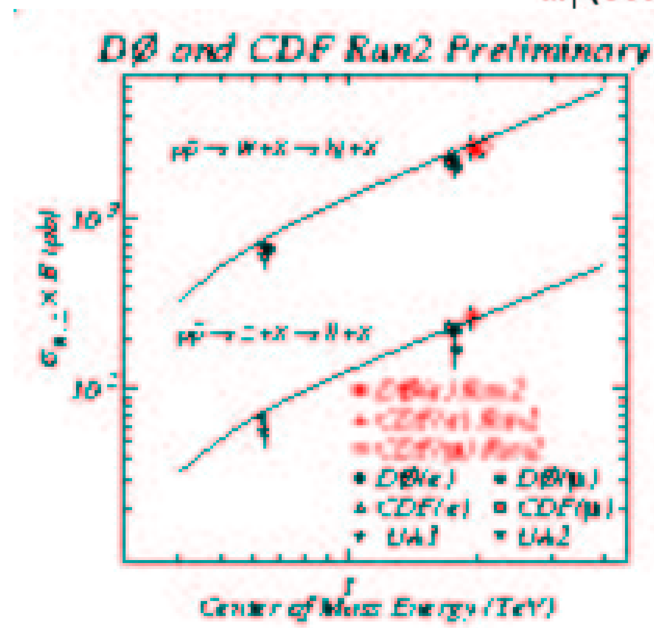
Y. K. Kim, Veramendi, Brubaker, Gibson, Tompkins and ETF group

- W cross section measurement

σ_W*BR(W}en) (nb) =
$2.60 \pm 0.07_{stat} \pm 0.11_{syst}$ $\pm 0.26_{lum}$

Consistent with Run I results, rescaled for the E=1.96 GeV.
(use Sterling et al. NNLO predictions



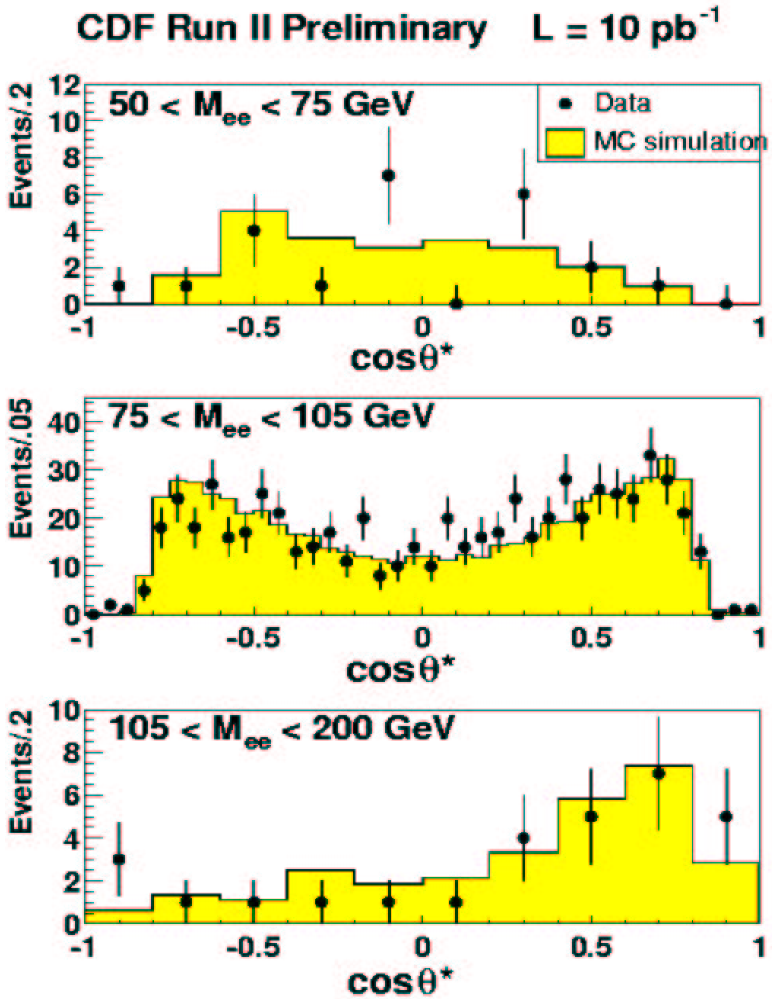


Candidate sample:
5547 events
Background (8%):
- **QCD:** 260 ± 34 ± 78
- **Z →ee:** 54 ± 2 ± 3
- **W→τν:** 95 ± 6 ± 1

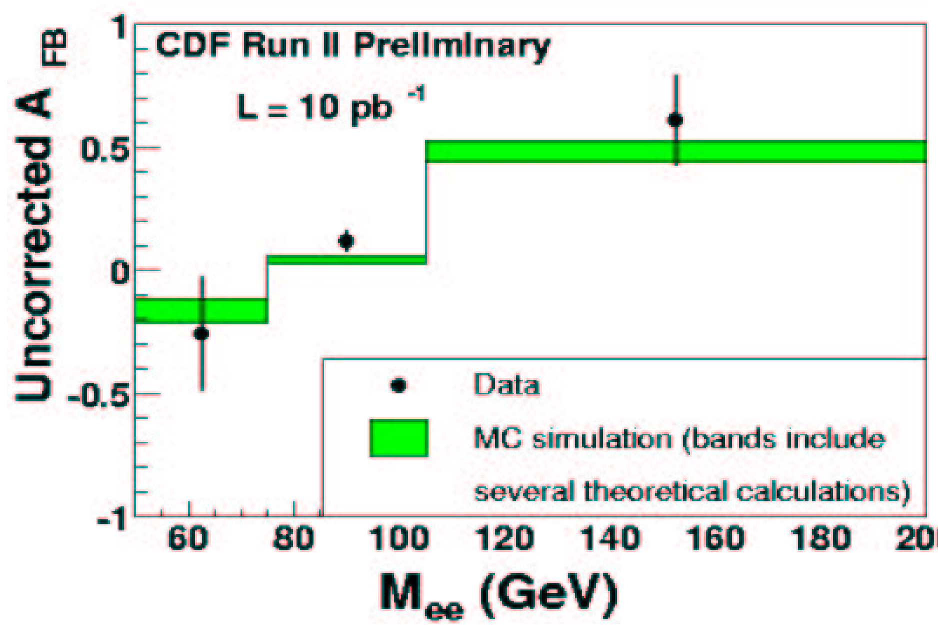
$Z \rightarrow e^+ e^-$ Asymmetry (ICHEP)

Y. K. Kim, Veramendi, Brubaker, Gibson, Tompkins

- Asymmetry of $Z \rightarrow e^+ e^-$ at the Tevatron is expected to agree with LEP measurement. the Standard Model predicts A_{FB} at all M(e+e−) .



Uncorrected $Z \rightarrow e^+ e^-$ shown at left
Measurements compared with PYTHIA/CTEQ5L below.



Top Quark property Measurements

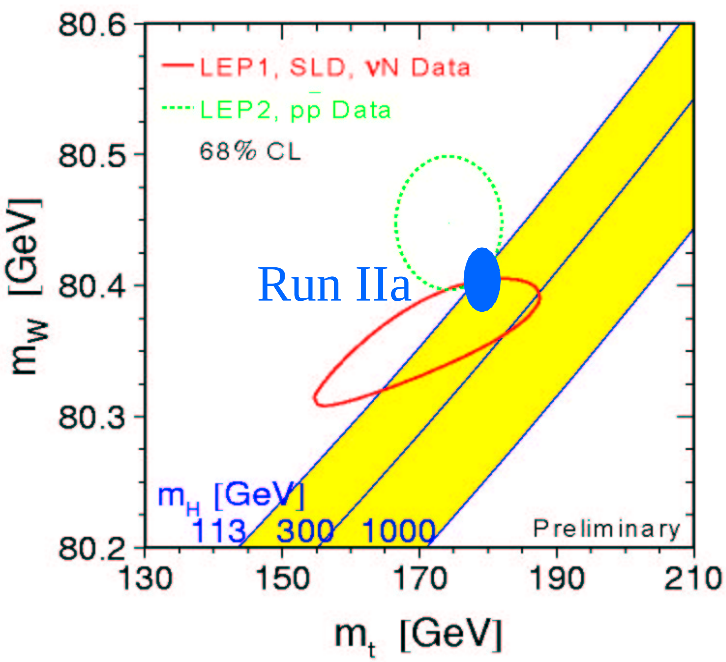
Bachacou, Brubaker, Galtieri, Gibson, Kim, Lys, Volobouev, Yao

Short term goal:

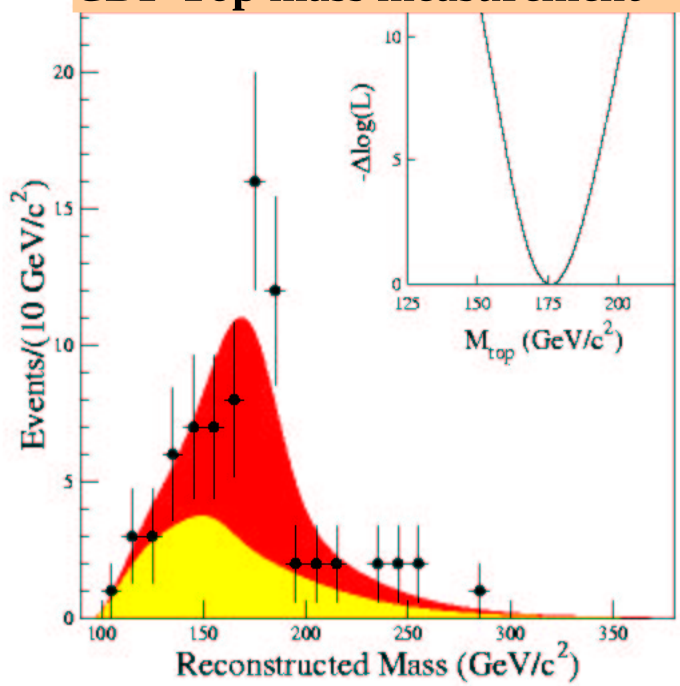
- Top cross section and mass measurement.
- The Standard Model predicts the Higgs mass, once the W and Top mass are measured with high precision.
- In Run II we need to improve on the systematic error, need to start work on this immediately.

M(top) = 174.3± 5.1 GeV CDF+D0 comb.

Electroweak Precision Measurements

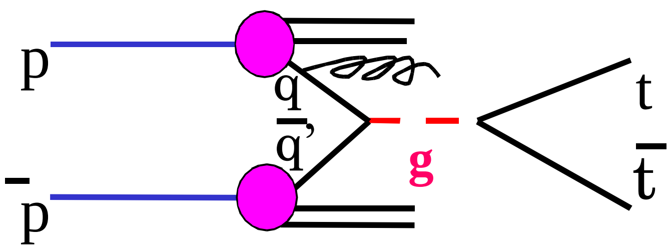


CDF Top mass measurement



Top Physics Studies

t tbar Production at the TeV:



t tbar→ W^+bW^-b

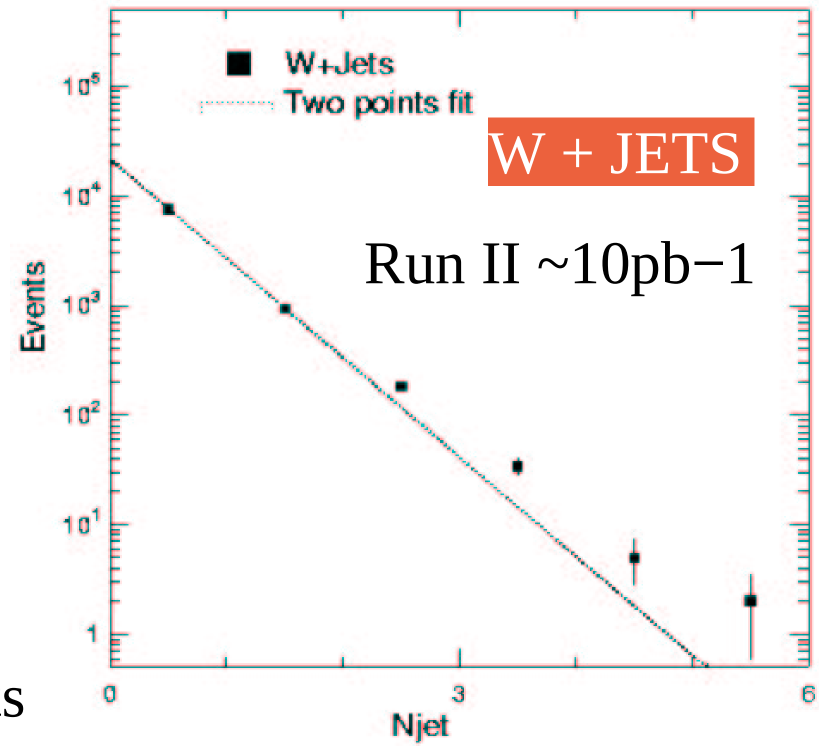
t

Final states (2 B−jets + Ws):
- − dilepton (2 W→ln)
- − lepton+jets (W→ln,W→qq)
- − all hadronic (2 W→qq)

Lepton + jets channel preferred:
statistics advantage over the dilepton,
less background then the all hadronic
2 (3) signatures: lepton and 1 (2) b jets

Sample is the same as W sample.
Top events are preferentially in
W+≥ 3 jets

Studies needed:
subtract background from lepton ID
b−tagging (to reduce background)
precision jet E−scale



Top Physics at CDF

First step is optimal event selection (W events)

Removal of:

conversion electrons, photon events , Z electrons

B−tagging in jets is a good signature

Use control samples to evaluate efficiency

Compare data and Monte Carlo to check that MC has predictive power for top events

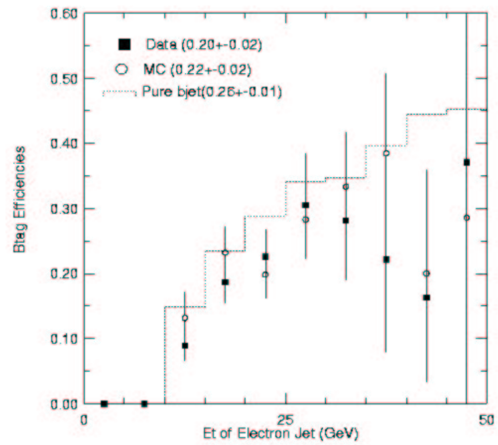
Jet energy scale systematics: major contribution to top mass uncertainty.

Working on:

Min bias events: determine calorimeter stability

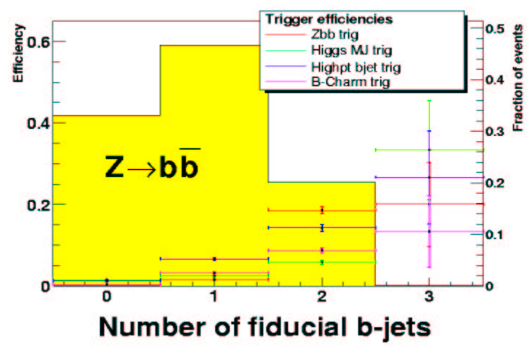
Jet events: determine Plug−Central relative correction

Z → bbar: improve absolute jet energy scale



(Weiming)

Preliminary trigger studies



(Brubaker)

Z → b−bbar (will provide a large sample of b jets):

Zbb trigger, requiring two tracks in opposite hemisphere.

B group two track trigger requires two tracks in same hemisphere

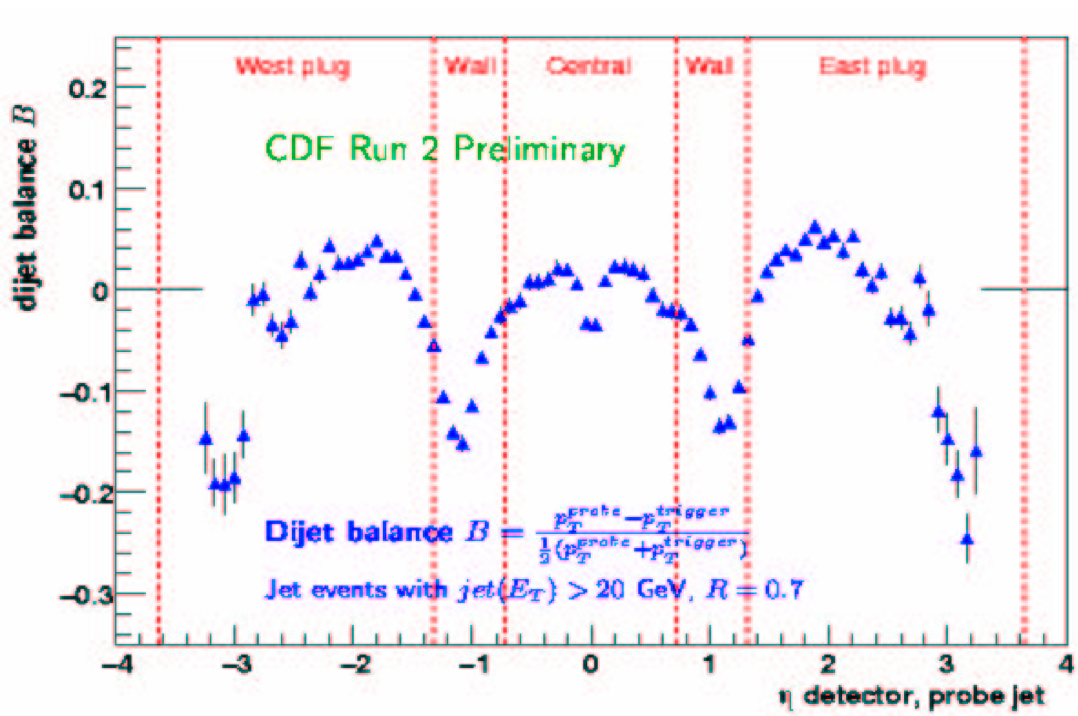
Jet E_T−Scale Studies

Galtieri (Co−convener jet correction group), Currat, Lys

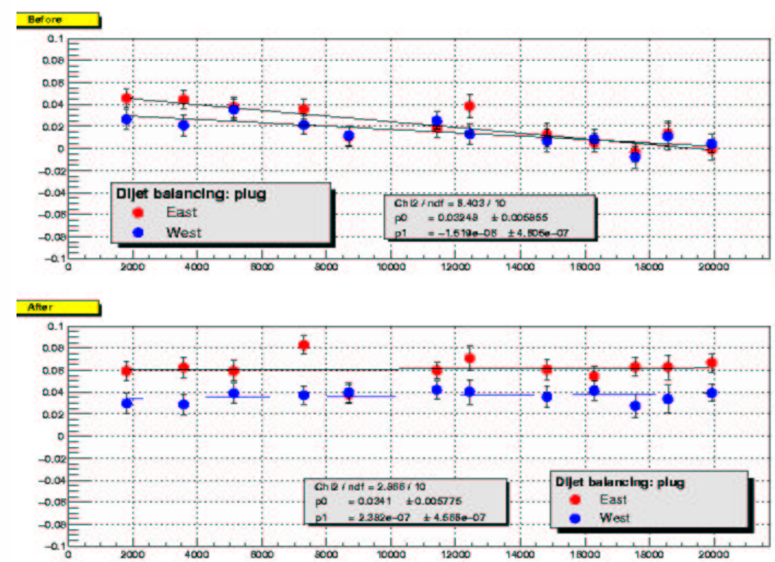
- Electron scale in central calorimeter CEM correct within 1% ($Z \to e\,e$)
- Hadronic scale now kept within 1% with Run I (MIP peak in $Z \to \mu\mu$, J/ψ)
- γ−jet balance can test **jet** scale, since EM scale is correct.
  MC studies needed to minimize QCD effects (K_T kick) (Jeremy Lys)

Preliminary result: absolute scale known within 6% in Central

Plug E−scale determined from jet−jet balance



Studying plug calorimeter gain changes at high eta.



Higgs search

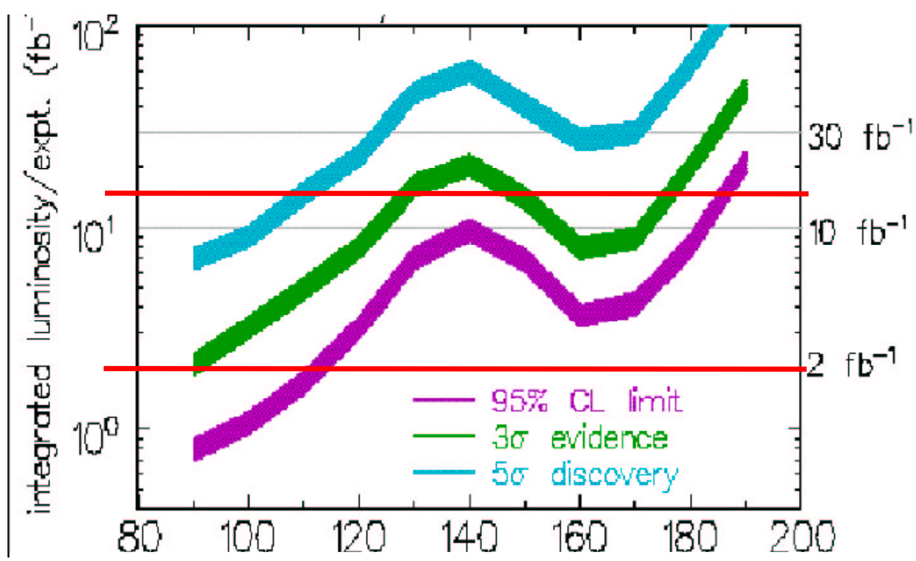
Yao (co−convener of the Higgs group), Dominguez, Nielsen

Standard Model Higgs needs large accumulated luminosity, improved jet resolution, understanding of backgrounds etc. Long range.

SUSY Higgs can have a large cross section for large values of tanβ. A modest luminosity can provide interesting limits.

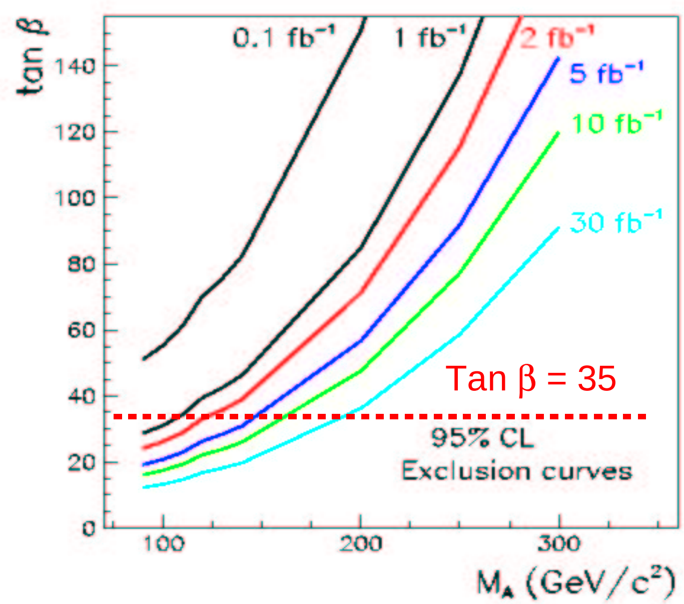
A/H → ττ, bb are the channels to study

LEP II Searches : M_{Higgs} > 113 GeV at 95%CL
LEP II Hint at Mh_{igg}= 115 GeV

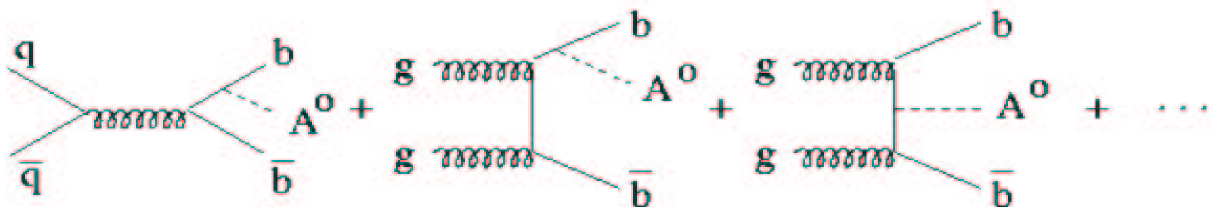


M_{higgs} (GeV)

SUSY Higgs Bb + (h/A) → 4b



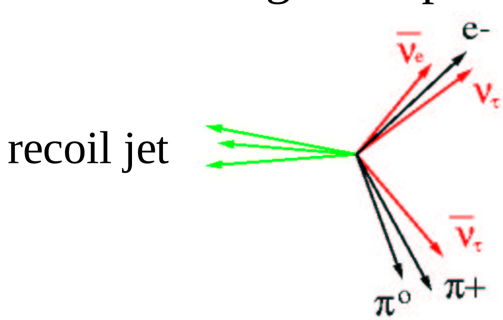
SUSY Higgs A/H in ττ, bb

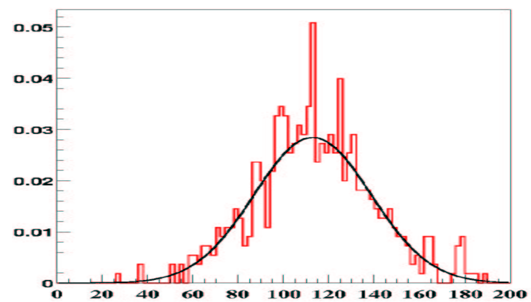


Run Ib Amy Connolly's PhD Thesis

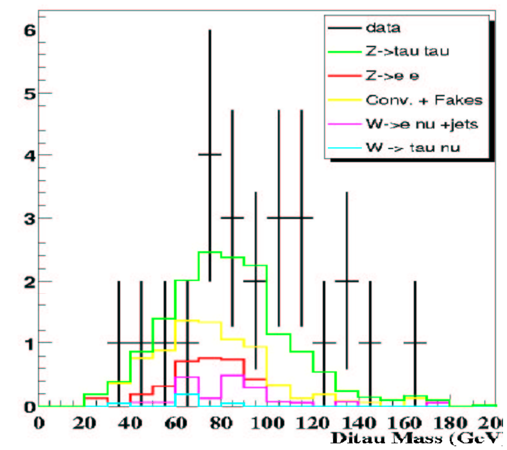
s(gg 0 A/H) = 25 pb for M(A) = 100 GeV tanβ = 30

Run Ib data : high Pt lepton triggers





Run Ib data

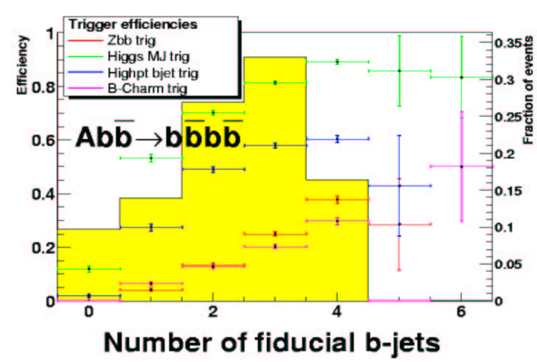


M(ττ) GeV

Results will be available soon

M(tt) will be an essential discriminant.

Run II : A. Dominguez, E. Brubaker

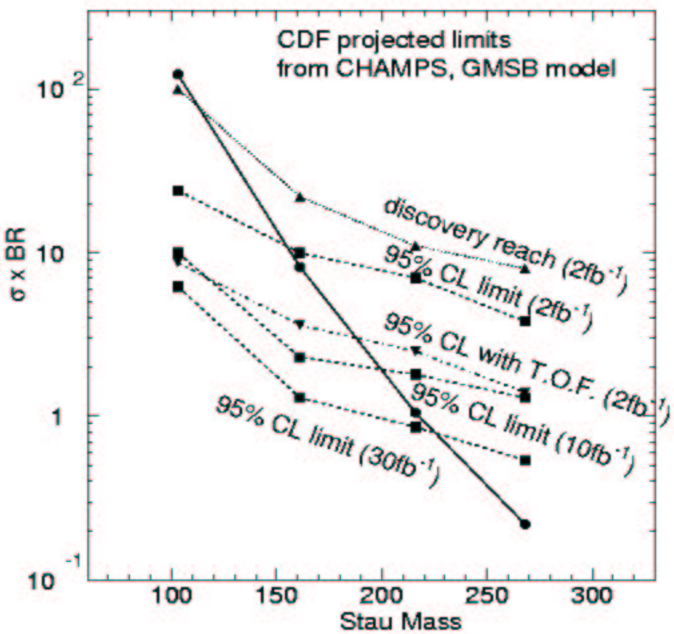


Use bbA/H final state. Trigger studies are being done. Many triggers contribute. Tools for analysis (b−tagging etc.) ready.

Charged Massive long−lived Particles

<u>Bill Orejudos (ICHEP)</u>

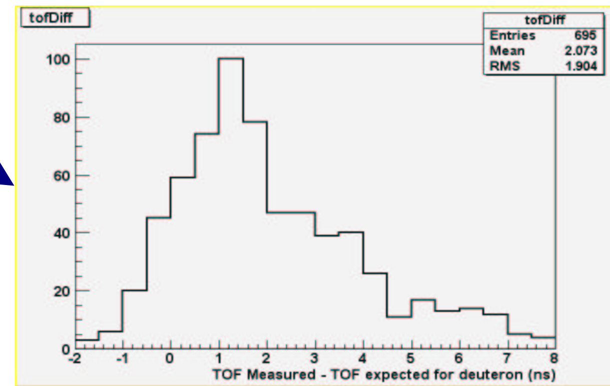
- CHAMP candidates
  SUSY: stable stau, stop



Stau mass

- 4^{th} generation quarks
- Implemented into MC
- **CHAMP property studies**
  - **Isolation, TOF, COT dE/dx**

- Trigger proposed: L1 2−tracks above 10 GeV/c
- Analysis based on flight time for massive particles
- TOF difference for a CHAMP of 200 GeV and a deuteron (MC)

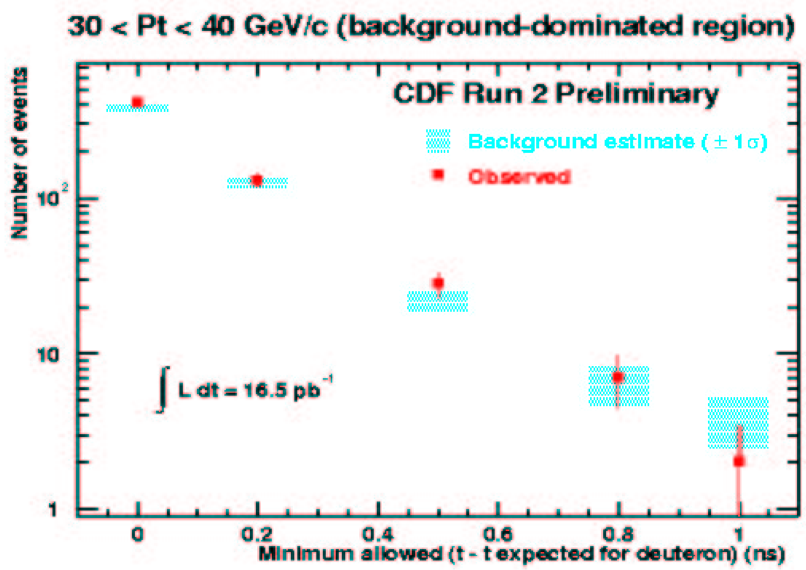


- Muon trigger used below: 16.5 pb^{-1} of data

Background region: P_T track=20−40 GeV

Require TOF difference
Δt>1 ns

Find:
2.2 ± 0.8
events



Summary

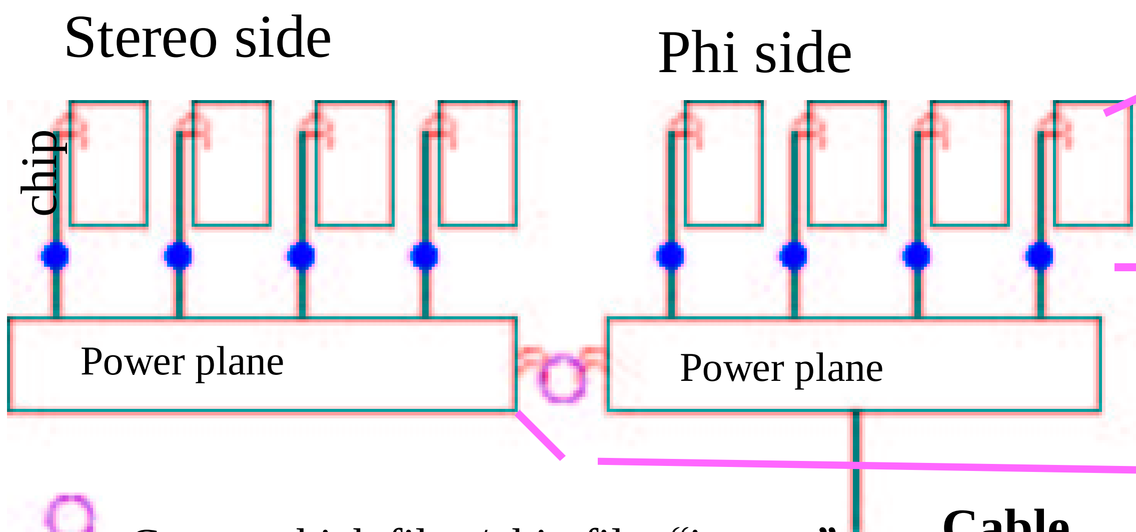
- Detector commissioning is almost completed. Performance optimization is still going on.

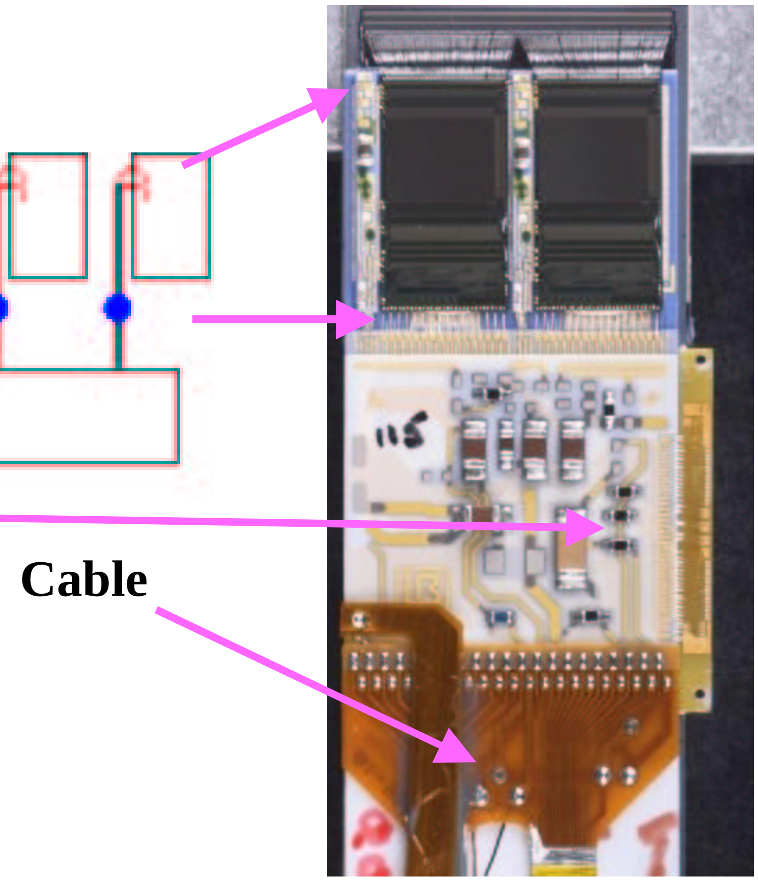
- Tools for physics analysis are now ready:
  tracking, exploitation of the SVT trigger, electron ID,
  jet corrections, b−tagging, simulation tuning etc.

- Now pursuing the physics. LBNL group plans to have results on the following analyses for the Winter Conferences (some with collaborators):
  - V_{cb} CKM matrix element
  - MSSM Higgs
  - W cross section , Z asymmetry
  - Long lived particle search
  - Top cross sections +mass measurement

- Run IIb silicon detector work proceeding well
  SVX4 chip: first submission of the chip worked!
  - Submit preproduction chip early next year
  - Hybrids prototypes worked first time. Stave prototype looks good.
  - Hybrid production being organized

SVX−II Ladder Power Distribution





- Custom thick film / thin film “jumper”
- Wirebond
- Silver epoxy connection only
- Applicable to analog power