LBNL/CDF Group Report

Aaron Dominguez
LBNL

May 28, 2003

- Overview of LBNL/CDF physics program
- LBNL group responsibilities from May 2002-2003
- Current activities
- Physics results from May 2002-2003

Overview of LBNL/CDF Program

- LBNL played leading role in construction of important tracking devices (Si/COT) for RunI and RunII
- These detectors, especially the silicon detector, were key to discovery of top in RunI
- New RunII detectors will make precision top, EWK and B-physics possible, as well as Higgs searches
- LBNL has now transitioned from construction/commissioning to *using* these detectors for *physics*

Members of the LBNL Group in CDF

All are or will be authors

- Physicists-Staff
  - P. Calafiura[1,2]
  - R. Ely[1,3]
  - A. Galtieri
  - M. Garcia Sciveres[4]
  - C. Haber[4]
  - Y.K. Kim[5]
  - J. Lys[1,3]
  - R. Miquel[6]
  - M. Shapiro[4]
  - J. Siegrist[4]
  - W. Yao[6]
- Physicists-Term
  - A. Cerri
  - A. Dominguez
  - J. Nielsen
  - W. Orejudos
  - L. Vacavant
  - I. Volobouev
- Fellows
  - C. Currat
  - M. Weber
- Grad. Students
  - A. Affolder[7]
  - H. Bachacou
  - E. Brubaker
  - A. Connolly[8]
  - H.C. Fang
  - J. Freeman
  - A. Gibson
  - G. Veramendi[8]
- Undergrad. Students
  - L. Tompkins
- Engineers/Designers (RunIIb)
  - B. Krieger
  - H. von-der-Lippe
  - J.P. Walder
  - E. Mandelli
  - B. Holmes

[1] Moved to ATLAS [2] Part-time NERSC [3] Retired [4] Part-time ATLAS [5] Now at U Chicago [6] Part-time PDG
[7] Graduated, now at UCSB [8] Will graduate in 2003

LBNL Leadership in CDF

- Marjorie Shapiro
  - Co-chair Simulation Group
  - Co-chair B-Physics Group
- Young-Kee Kim[1]
  - L3 Subgroup co-leader[2]
  - Co-chair Top Mass Measurement Subgroup
- Lina Galtieri
  - Co-chair Jet Corrections Group[2]
- Weiming Yao
  - Co-chair Higgs Group
- Bill Orejudos
  - Co-chair COT group[2]
  - Operations manager[2]
- Igor Volobouev
  - Co-chair Top Mass Measurement Subgroup
- Jason Nielsen
  - Silicon Calibrations Working Group leader
- Alex Cerri
  - Co-chair Semileptonic B-Physics Group
- Greg Veramendi
  - Co-chair High-Pt Electron Group[2]
- Aaron Dominguez
  - Co-leader Silicon Tracking Group
  - Co-chair High-Pt B-Tagging Group

[1] Now at U Chicago [2] Until recently

Ongoing LBNL Responsibilities in CDF

Detector Ops

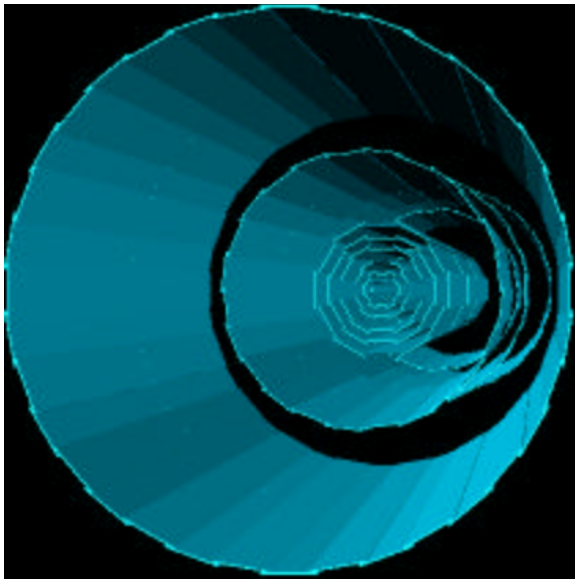
- Online Si Monitoring (Bachacou, Tompkins)
- Si Calibrations (Nielsen)
- On-call Si Expert (Nielsen)
- On-call SVT Expert (Cerri)
- COT calibrations (Orejudos)
- Online Detector Monitoring (Gibson)
- Silicon Problem Taskforce (Volobouev, Garcia Sciveres)

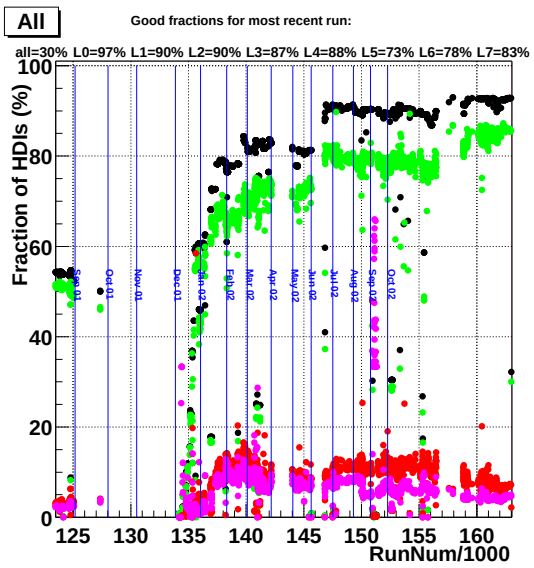
Offline Ops

- Simulation framework (Shapiro)
- Si Simulation (Dominguez)
- MC Generators: ISAJET (Galtieri), HERWIG & Wbbgen (Lys), ZGRAD (Gibson)
- Passive Material in MC (Vacavant)
- SVT Simulation (Cerri)
- Si Tracking (Yao)
- B-Tagging (Yao, Bachacou, Dominguez)
- L00 MC/Reco (Nielsen, Yao, Dominguez)
- Intrinsic Si Resolution (Dominguez)
- Jet Energy Corrections (Galtieri, Currat, Gibson)
- Plug Calorimetry Simulation (Currat)

Status of Silicon Detectors

Garcia Sciveres, Nielsen, Bachacou, Volobouev, Dominguez



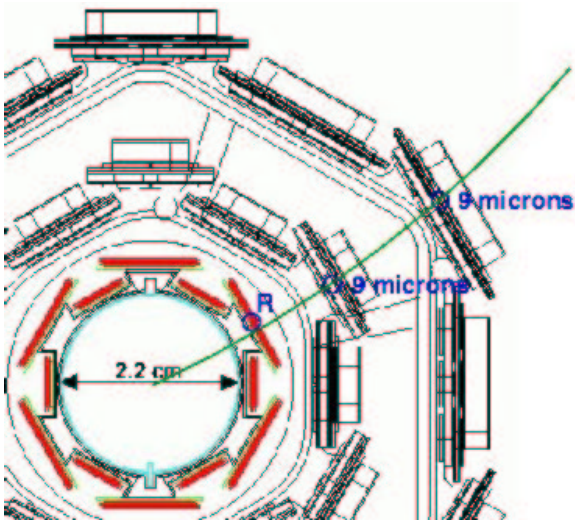


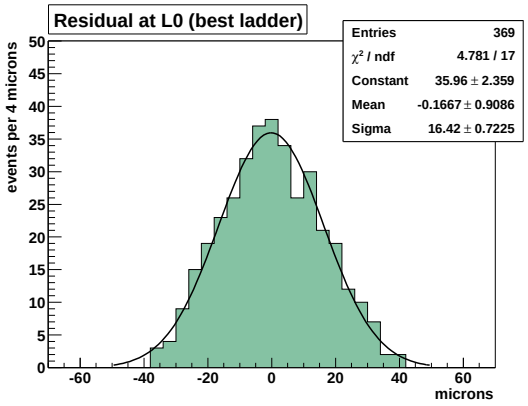
- Detector more stable
- Coverage increasing (ISL cooling lines unblocked)
- Developed workaround for L00 noise problems

- Safer operating procedure/monitoring for beam conditions
- SVX used in Winter '03 results, ISL will be in Summer '03 results
- L00 will be used in next Winter results

Silicon Tracking

Yao, Dominguez



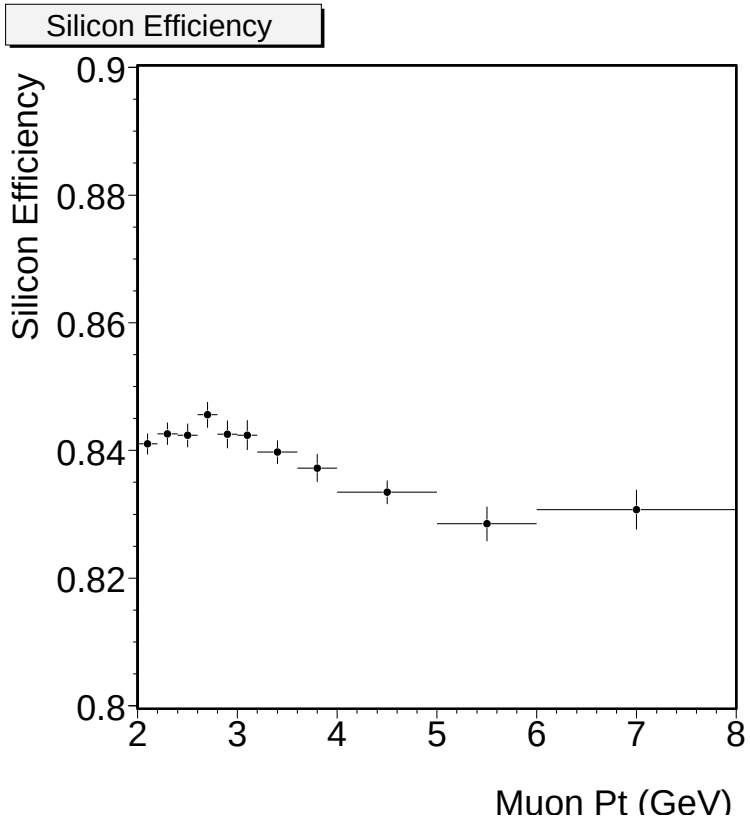


Cluster Width	Measured resolution in μm L00	SVX Axial L1-L5	SVX 90° L1,4
1 strip	18.4 ± 0.3	13.6 ± 0.3	29.5 ± 0.5
2 strips	10.1 ± 1.9	9.5 ± 0.1	23.0 ± 0.3
3 strips	17.2 ± 1.8	13.4 ± 0.2	34.3 ± 0.8
4+ strips	23.5 ± 2.8	18.7 ± 0.4	64.3 ± 1.8

L00 resolutions are new result & will improve with alignment/study

Silicon Tracking Performance

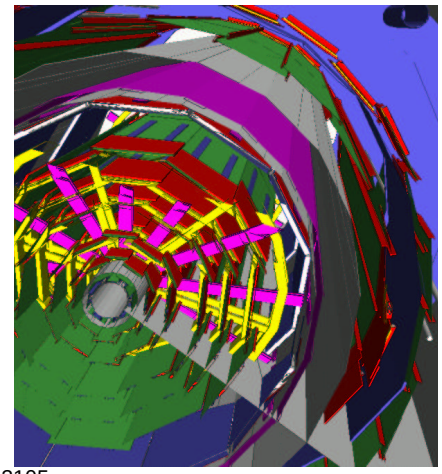
Yao[1]

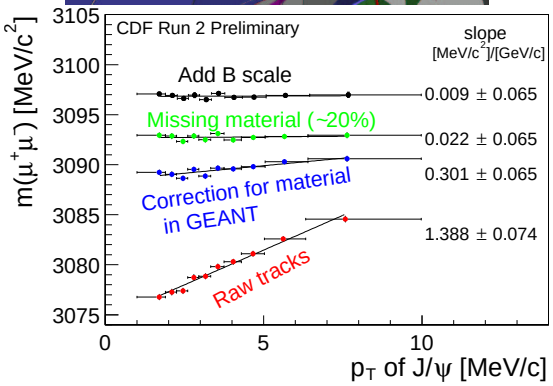


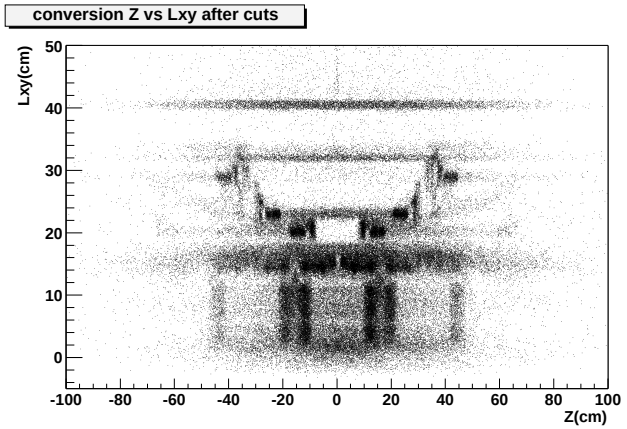
- Eff to attach $\frac{N-1}{N}$ $R\Phi$-Si hits to good COT tracks from $J/\psi \rightarrow \mu^+\mu^-$ events
- Eff averaged over most of RunIIa data taken so far (incl runs with parts not yet integrated)
- 5% dead wedges (have recovered some)
- 5% readout errors (have reduced some)
- 4% bad strips (irreducible)

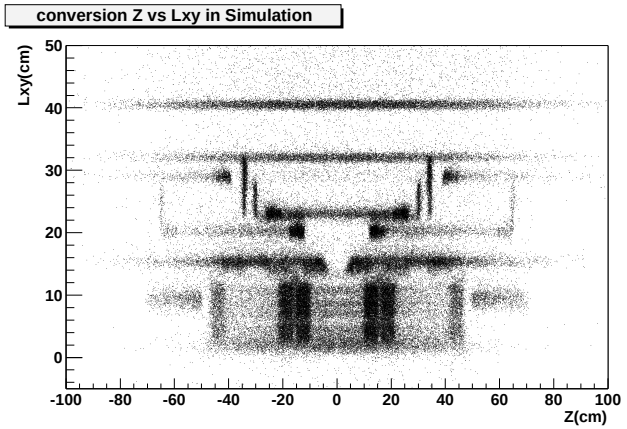
[1] Plot from Matt Herndon (Hopkins)

Silicon Material Map (Vacavant)





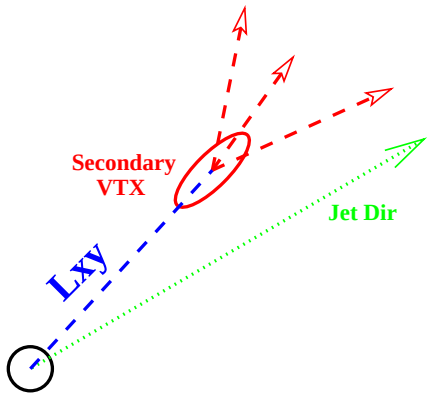




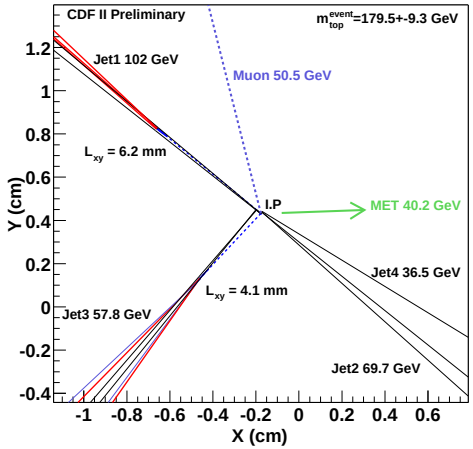
- Accounting for all material allows precise knowledge of energy loss and mass reconstruction (Plots from V. Tiwari (CMU), A. Korn (MIT))

High-P_t B-Tagging

Yao, Bachacou, Dominguez



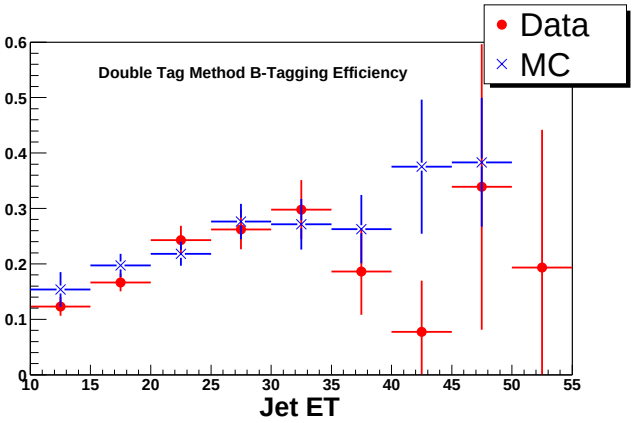
Reference VTX from beamline

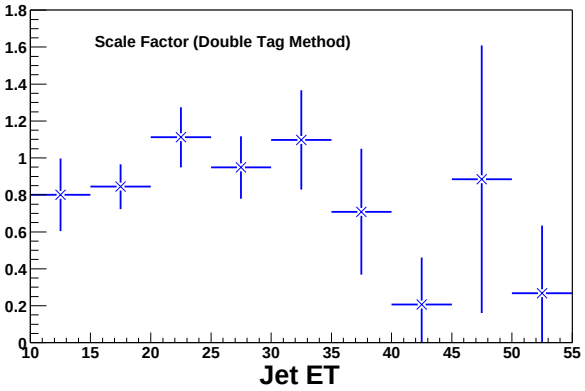


- Displaced vertexes: All combinations of at least 2 good tracks
- Jet is tagged as b-jet if $L_{xy}/\sigma_{xy} > 3$ (typical $\sigma_{xy} \sim 150\ \mu\mathrm{m}$)
- Performance/alignment/understanding of Si detectors crucial
- Measure eff and fake rate in incl lepton & generic jet data
- Tagger for high-Pt physics (top, Higgs...)

High-P_t B-Tagging Performance

Yao, Bachacou, Dominguez

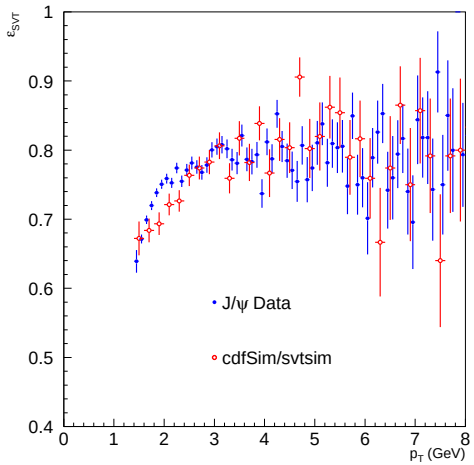


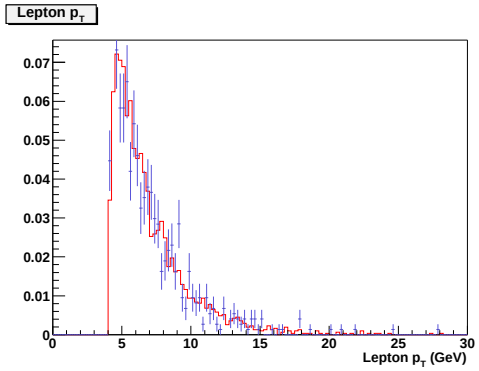


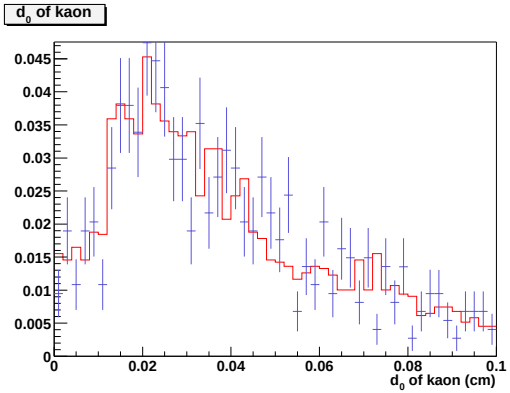
- Relative difference between data/MC $89\% \pm 9\%$
- Eff to tag a $t\bar{t}$ event $45\% \pm 1\% \pm 5\%$
- Prob. for fake jet-tag for top candidates $\lesssim 0.5\%$
- Expecting $\sim 15\% - 20\%$ improvement in jet-tag eff using event-by-event vtx & ISL

SVT Simulation

Cerri, Miquel, Vacavant



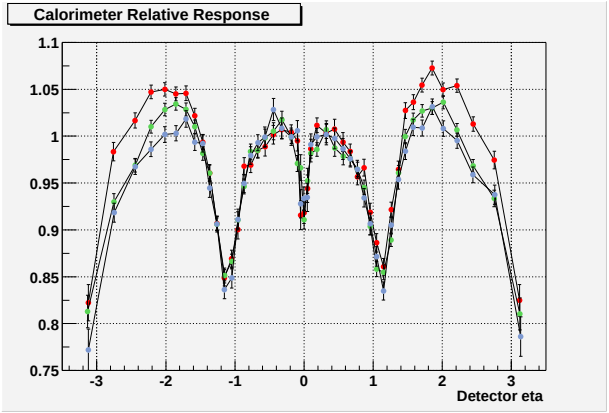




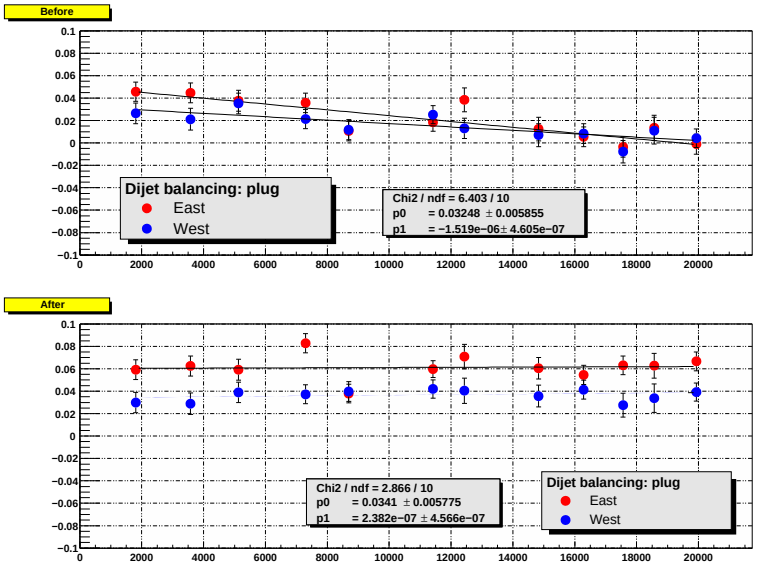
- Low level Silicon simulation and SVT trigger simulation in good agreement with actual detector
- Shown are data & MC
  1. SVT eff in di-muon events
  2. P_t of lepton in semilep B decays ($B \rightarrow D^* e\nu, D^* \rightarrow D^0\pi^+, D^0 \rightarrow K\pi$)
  3. Impact par of K in semilep B decays

Jet E_t: Corrections & Systematics

Galtieri, Currat, Gibson, Lys



- Relative energy scale vs η for 3 periods RunIIa
- Electron scale in central cal. correct to 1% ($Z \rightarrow e^+e^-$)
- Hadronic scale within 1% of RunI (MIP peak)
- $\gamma - \mathrm{jet}$ balance tests **jet** scale; EM scale known
- Plug scale changed over time
- Raw jet-energy scale known to 5%
- Extra material in RunII vs RunI may acct. for part of 5% syst. scale



- Used plug gain changes vs time for high η (see avg dijet balance vs run above)
- Tuned plug simulation
- Studied plug jets via dijet balancing
- Provided jet corrections & systematics for Winter Conf.

LBNL/CDF Group's Physics Program

Winter '03 results based on $\sim 60\ \mathrm{pb}^{-1}$, now have $2\times$ that on tape

Using key detectors that we helped build & maintain

EWK/Top/Higgs/Exotics Physics

- People:
  - Bachacou, Brubaker, Currat, Dominguez, Garcia-Sciveres, Galtieri, Gibson, Kim, Lys, Nielsen, Orejudos, Siegrist, Veramendi, Volobouev, Yao
- Physics Interest:
  - m_{t}: conventional & novel measurement methods
  - Top: σ, ratio of σ's, W-couplings
  - $\sigma(\mathrm{W},\mathrm{Z})$, A_{FB} at $\sqrt{s} > m_{\mathrm{Z}}$
  - Higgs search: MSSM and SM
  - CHAMP search

B Physics

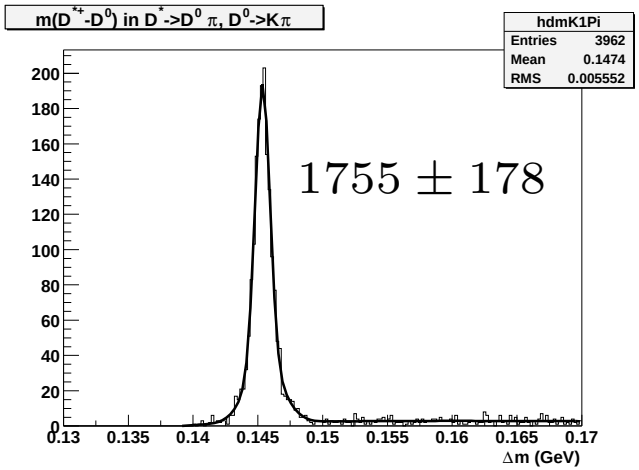
- People:
  - Cerri, Fang, Miquel, Shapiro, Vacavant
- Physics Interest:
  - V_{cb} and Semilep decays:
    - Goal for Summer '03
    - Addresses timely CKM-issues
  - B_{s} mixing
    - Requires several 100 pb^{-1}
    - Validate technique with B_{d} mixing
    - Continue optimization of tagger, $m_{B_{\mathrm{s}}}$ reconstruction
    - Semilep decays might be used with more data

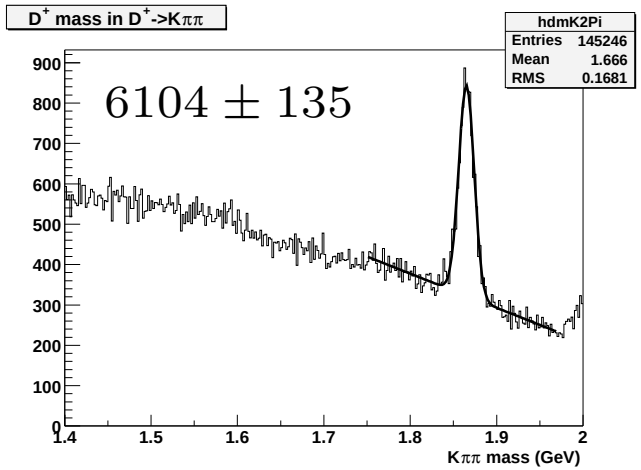
B-Physics: Hadronic Moments Analysis

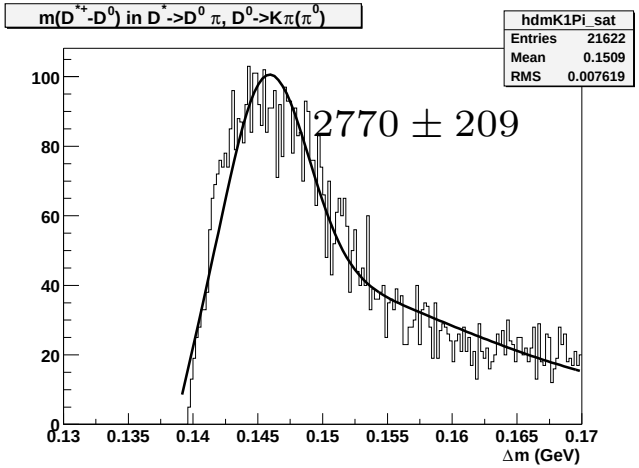
Cerri, Fang, Miquel, Shapiro, Vacavant

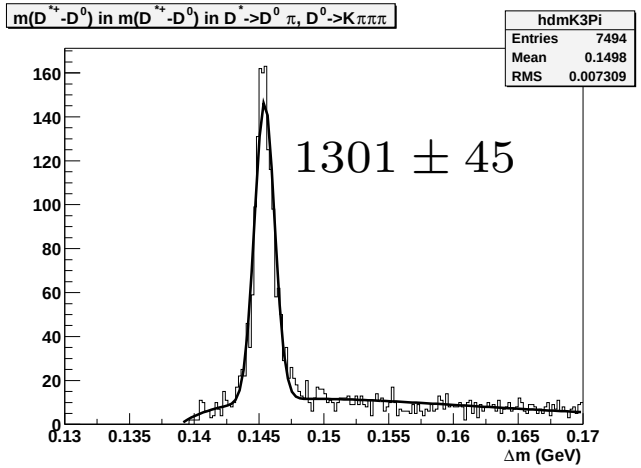
- **Goal:** measure quantities, from inclusive semileptonic B decays, that enter the determination of $|V_{\rm cb}|$
- **How:** measure first two moments (mean, RMS) of hadronic mass dist. in $B \to X_c \ell \nu_\ell$ (for $\ell = \mu, {\rm e}$)
- X_c: D, D^*, "D^{**}", where D^{**} stands for any charm state, resonant or not, with $m_{D^{**}} > m_{D^*}$
- ${\rm Br}(B \to D, D^*)$ and m_{D,D^*} well known, only need to measure $m_{D^{**}}$ distribution
- **Strategy:** look for secondary vertexes with $D^{(*)+}\pi^-\ell^-$ combinations

Moments: Lower resonances



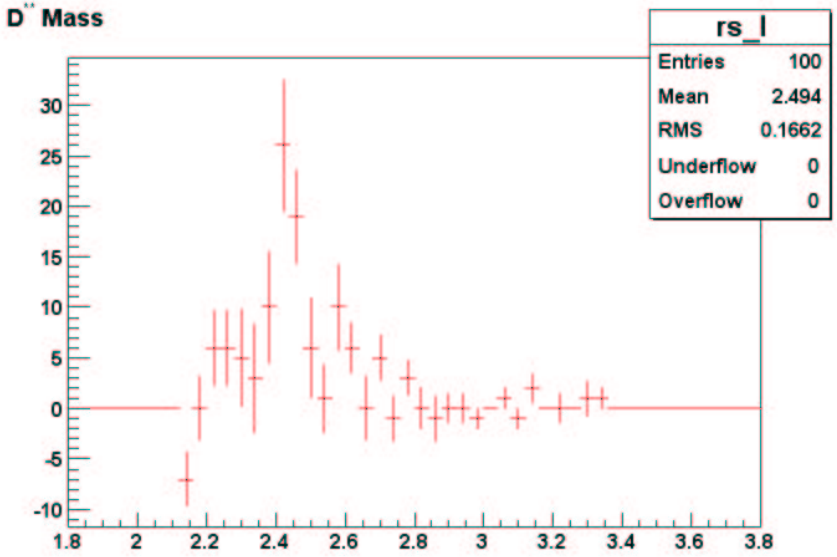






Mass plots used to select $D^{(*)+}\ell^-$ events

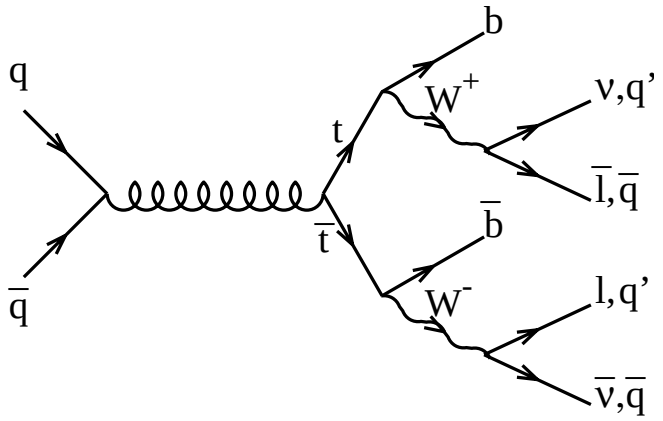
Moments: $m_{D^{**}}$



- Clear samples of lower order resonances
- First *very* preliminary results of $m_{D^{**}}$
- Shown above: $D^{*+}\pi^-$ mass dist. minus "wrong sign" $D^{*+}\pi^+$ dist.
- Expect $\sim 4\times$ stats when all channels incl
- First results in Summer '03 confs.

Top Physics Studies

Bachacou, Brubaker, Galtieri, Gibson, Lys, Nielsen, Siegrist, Volobouev, Yao



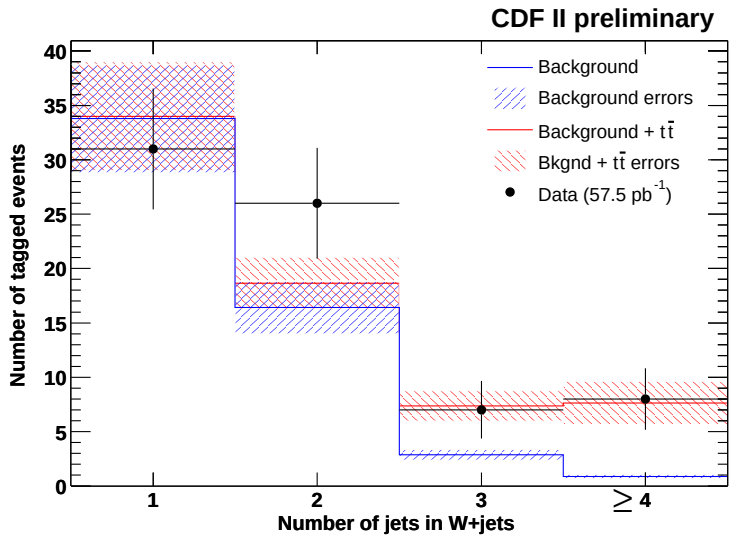
- Final states (2 B-jets & W's)
  - Dilepton (2 $\mathrm{W} \longrightarrow \mathrm{l}\nu$)
  - Lepton+jets ($\mathrm{W} \longrightarrow \mathrm{l}\nu$, $\mathrm{W} \longrightarrow \mathrm{q}\bar{\mathrm{q}}'$)
  - All hadronic (2 $\mathrm{W} \longrightarrow \mathrm{q}\bar{\mathrm{q}}'$)
- Lepton+jets preferred
  - Higher stats than dilepton chan
  - Less bkg than all hadronic chan

- Short term goal: Top cross section and mass measurement
- Long term goal: precision measurements, constrain SM. Must improve syst. error
- Both goals need: B-Tag, Jet E_t corrections & systematics, and understanding of heavy flav. content of W+jet events

Top: Lepton+Jets Cross Section

Bachacou, Nielsen, Yao

- Signature:
  - One high-P_t isolated lepton
  - Veto Z's, cosmics, conversions
  - Large missing E_t
  - At least 3 high E_t jets
  - At least 1 b-tag
- B-tag improves S/B from $1/6$ to $3/1$

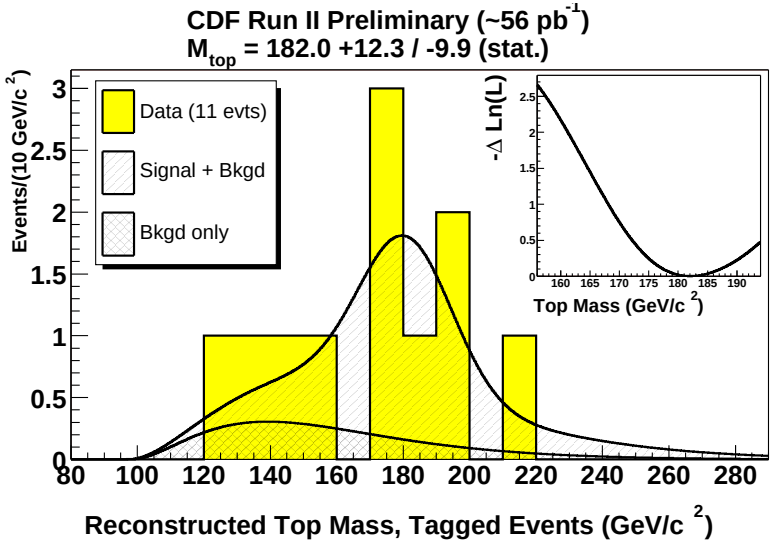


- Find 15 candidate events in 57.5 pb^{-1}
- Expect 3.8 ± 0.5 bkg events
- $\sigma_{t\bar{t}} = 5.3 \pm 1.9(\mathrm{stat}) \pm 0.8(\mathrm{syst})\mathrm{pb}$
- $\sigma_{t\bar{t}}(\mathrm{NLO}) = 6.7^{+0.71}_{-0.88}\mathrm{pb}$ (Mangano et al)

Top: Mass in B-Tagged Events

Brubaker, Volobouev

- Same sample as for cross section
- Require ≥ 4 jets
- ≥ 1 jets has b-tag
- Find 11 candidate events
- Expect 2.1 ± 1.0 bkg events
- Make 2C mass fit of each event
- Extract m_t using likelihood fit to simulated mass templates



$$m_t = 182.0^{+12.3}_{-9.9}(\text{stat}) \pm 7.9(\text{sys from E} - \text{scale}) \text{ GeV}$$ [1]

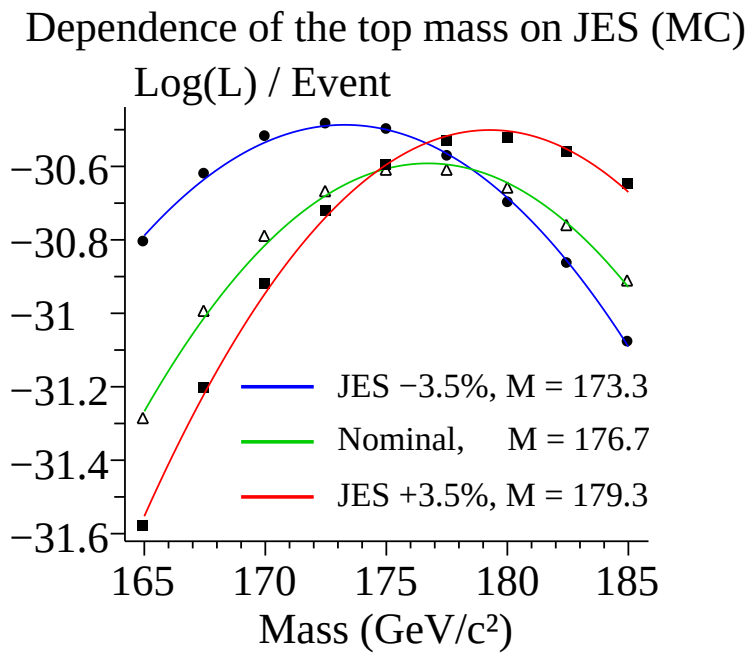
[1] This is the largest contribution to the as-yet unfinished systematic error

Top: Improving m_{t} Measurement

Volobouev

New ideas are being explored for reducing top mass systematic and statistical errors

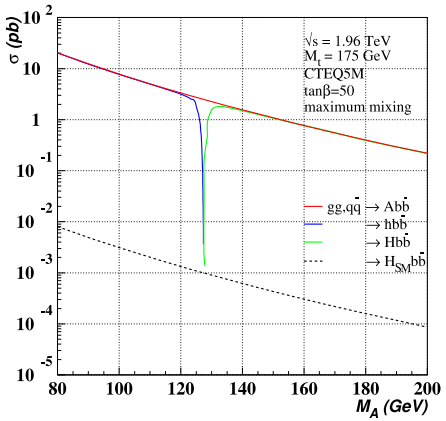
- Jet energy scale systematics: reduce by measuring W mass in the same event sample and adjusting the scale to get correct m_{W}
- Background systematics: explore statistical techniques less sensitive to distribution shape in the tails than maximum likelihood (M-estimates)
- Statistical uncertainty: improve permutation selection by using kinematical and dynamical information more efficiently (try event-by-event H_t in addition to χ^2 to choose best combo)



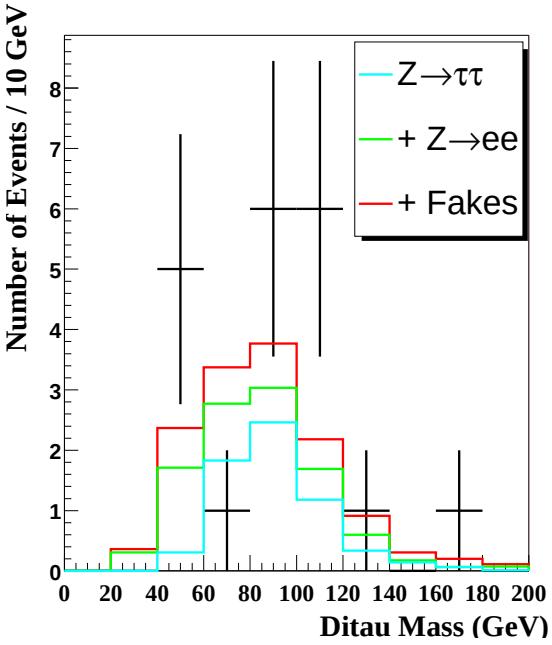
Looks like in this method the mass dependence on the absolute energy scale is about 30% smaller than in Run 1.

Higgs Searches

Connolly (thesis), Dominguez, Yao



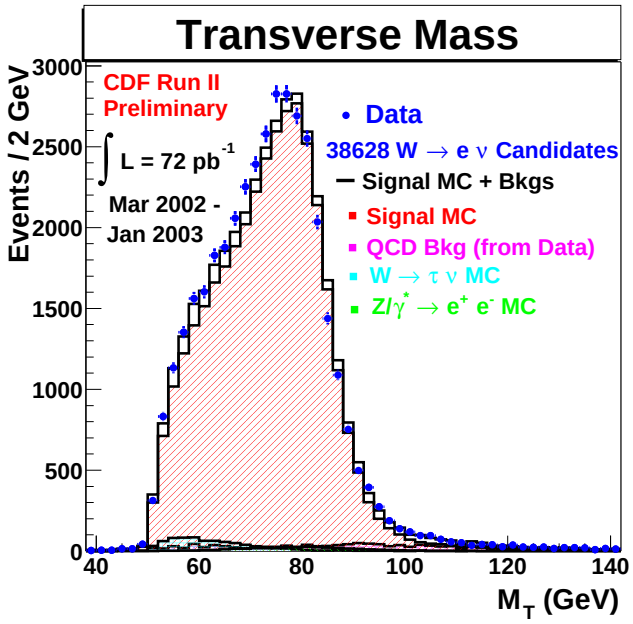
- MSSM Higgs can have large cross section for large values of $\tan(\beta)$
- Beginning analysis of $p\bar{p} \rightarrow b\bar{b}A \rightarrow b\bar{b}b\bar{b}$ using SVT trigger designed for this signature
- Re-evaluating SM Higgs reach with latest understanding of detector

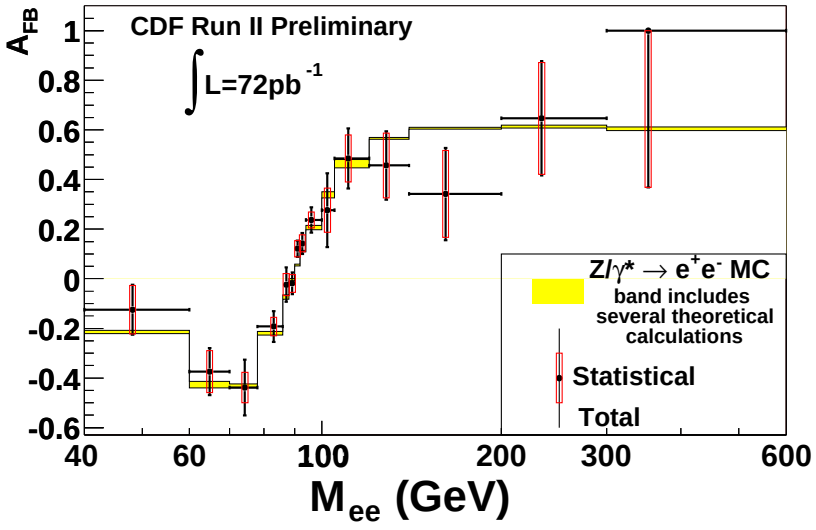


- A. Connolly currently finishing RunI analysis of $gg \rightarrow A \rightarrow \tau^+\tau^-$
- Uses high-P_t electron triggers
- Will be first published CDF analysis to see clear $Z \rightarrow \tau^+\tau^-$ signal

Electroweak

Brubaker, Gibson, Tompkins, Veramendi (thesis)



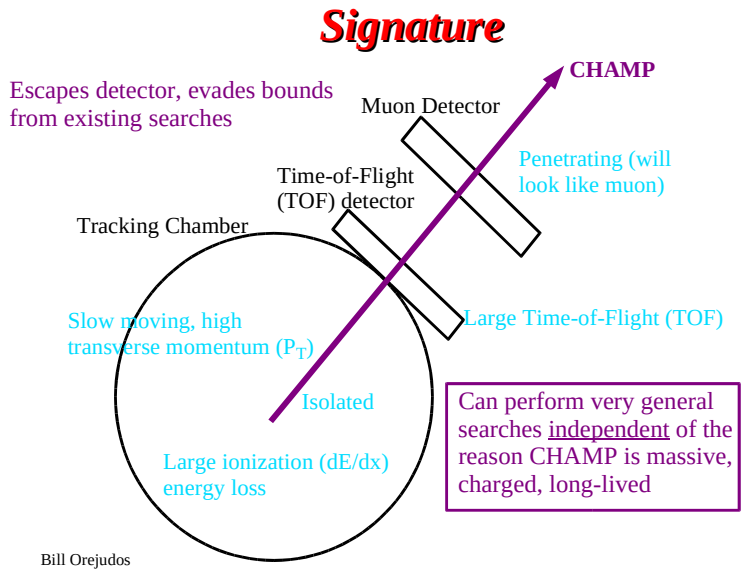


- $\mathrm{W} \to \mathrm{l}\nu$ clean signature (iso. lepton, miss E_t)
- High σ and S/B
- $\sigma(\mathrm{W} \to \mathrm{e}\nu) = 2.64 \pm 0.01_{\mathrm{st}} \pm 0.09_{\mathrm{sy}} \pm 0.16_{\mathrm{lum}}\,\mathrm{nb}$
- Consistent with RunI and NNLO SM results
- Consistent with other chans (μ, τ) and D0

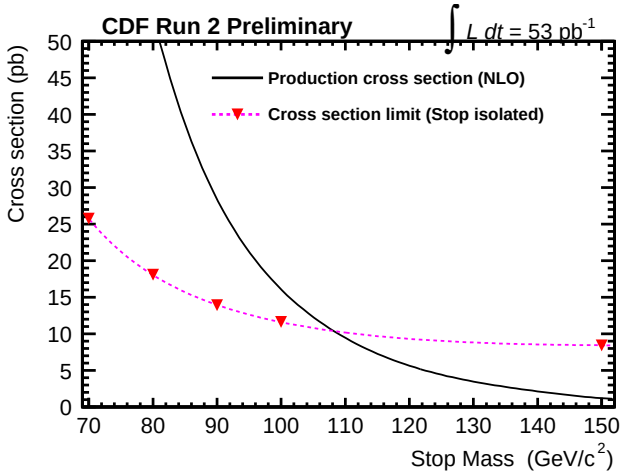
- A_{FB} of $\mathrm{Z} \to e^+e^-$ is probe of $\gamma\mathrm{Z}$ couplings (sensistive to new phys)
- Exploit forward coverage of electrons ($|\eta| < 3$)
- High mass reach unique to TeV
- So far results consistent with SM

CHAMPS (Charged Massive Stable Particles)

Orejudos



- Currently uses μ-trigger
- TOF used in analysis to find signal
- New specific trigger to be used in future



- Better than LEP stable stop limits (> 95 GeV at 95% CL, ALEPH)
- $m_{\mathrm{stop}} > 108$ GeV at 95% CL
- Can extend to other models
- More data coming

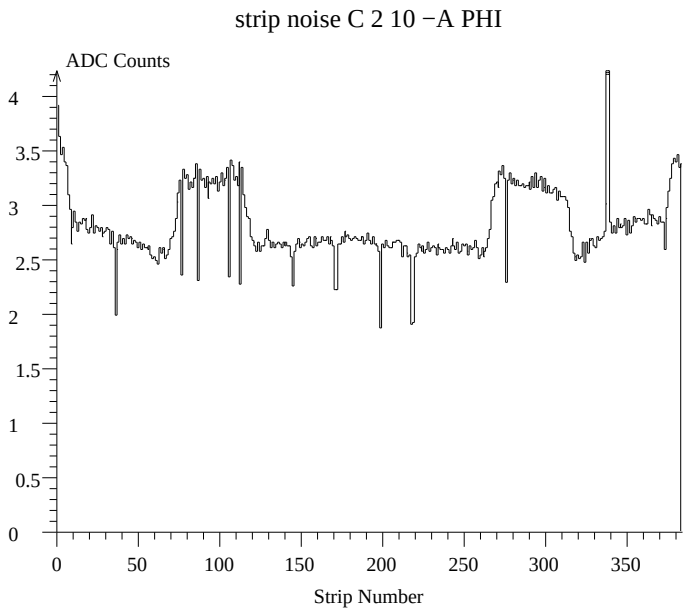
Summary

- Detector commissioning completed. Optimization nearly complete. LBNL delivering ongoing support to crucial detectors
- Tools for physics also in place: tracking, SVT, electron ID, jet corr, b-tag, MC
- Years of hard work on detectors now paying off—first physics results out the door!
- Looking forward to continue this physics program with higher int lum

Backup Slides follow

Silicon Calibrations

Nielsen, Volobouev

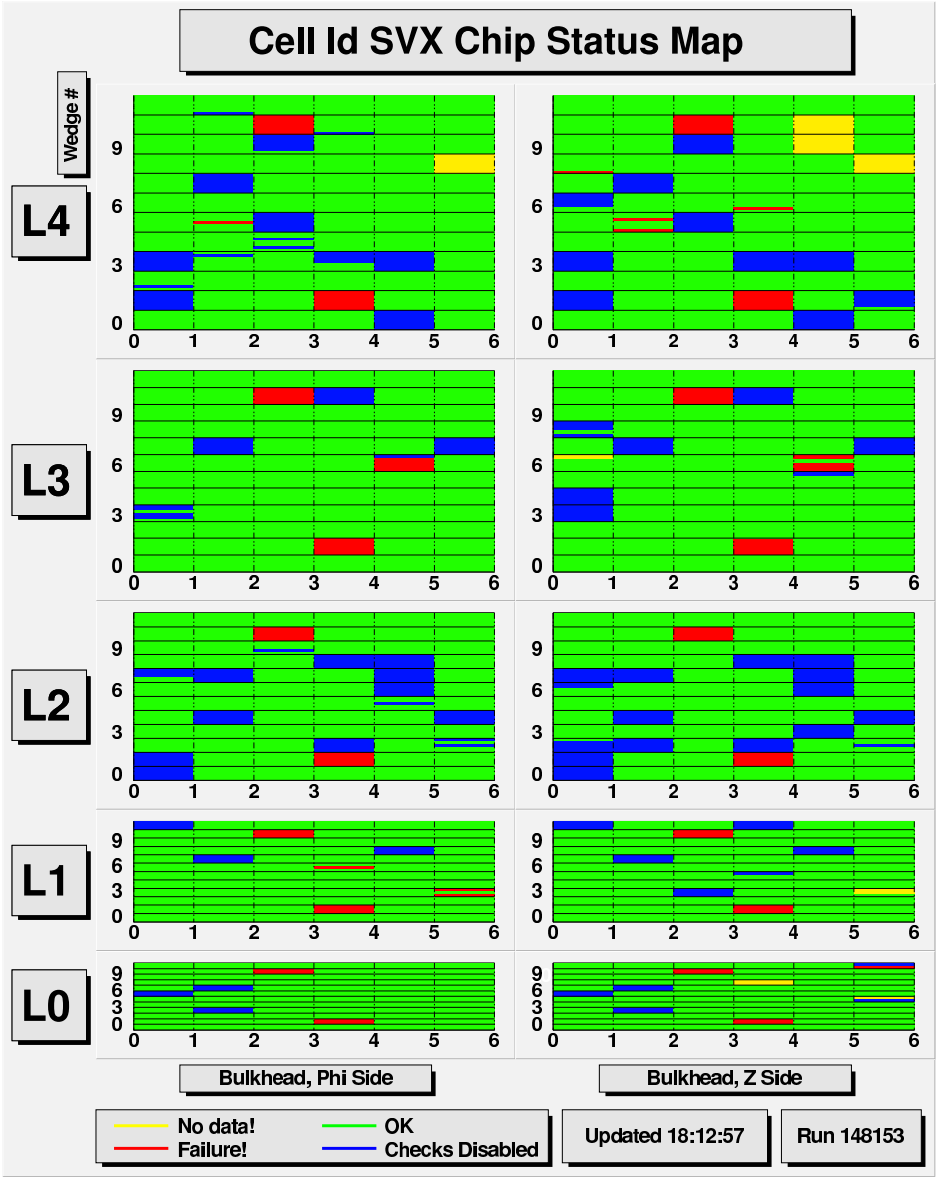


- Need valid calibrations for 722432 Si channels for $O(10^8)$ physics events

- Noise function of strip num (bad case shown at left)
- By calibrating each strip, maintains uniform fake-rate clustering accounting for known σ
- Can account for known bad strips
- Special treatment of L00 event-by-event ped fluctuations
- Regular/automatic calibrations. Will be key to following radiation damage (no meas damage so far)
- Allows for easy modeling of noise and dead regions in MC

SVXMon

Bachacou, Volobouev



- Online Si monitor follows status of each chip
- Can issue DAQ commands in case of dangerous conditions