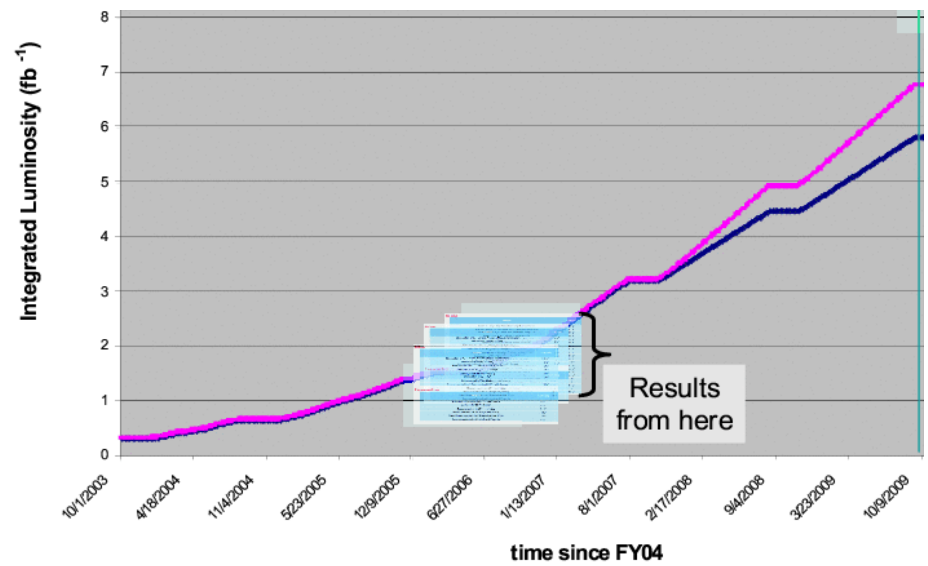
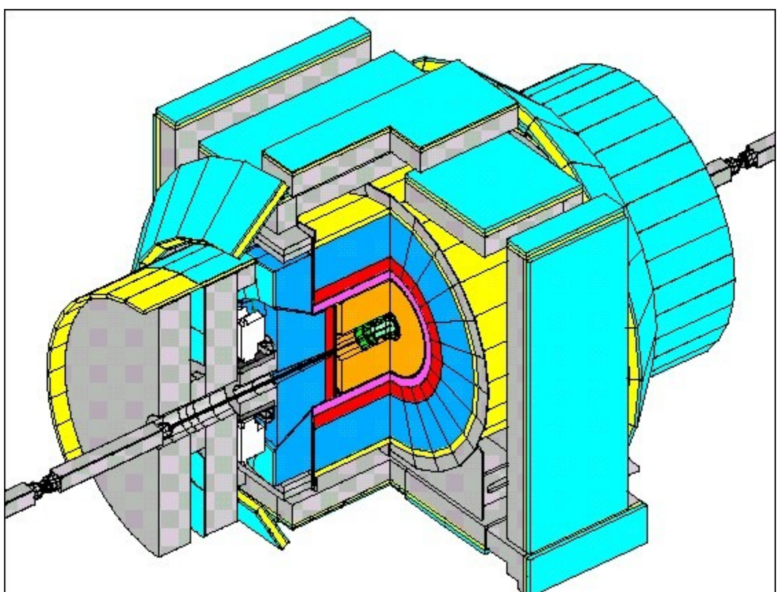
The CDF Group at LBNL

Expected Tev luminosity to FY'09



Outline

- Past Contributions
- Present members of the group
- Activities in B physics
- Activities in High PT physics
- Summary and Conclusions



CDFII Detector

LBNL contribution on:
silicon detector and
COT tracker

Contributions since 1981

Joined in 1981 (Bill Carithers)

Run 0: plug hadron calorimeter, DAQ electronics

Run I: Front end electronics for the silicon detector

This opened a new era in hadron collider physics

Very important for the top discovery.

LBL had major contributions to the software, data analysis and the writing of the top evidence and discovery papers

Several precision measurement of b hadron properties

Also: Major contributions to first CDF precision W mass measurement.

LBNL Contributions to CDF II (1)

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

IV. Computing and software

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

Silicon Detectors:LBNL Contributions

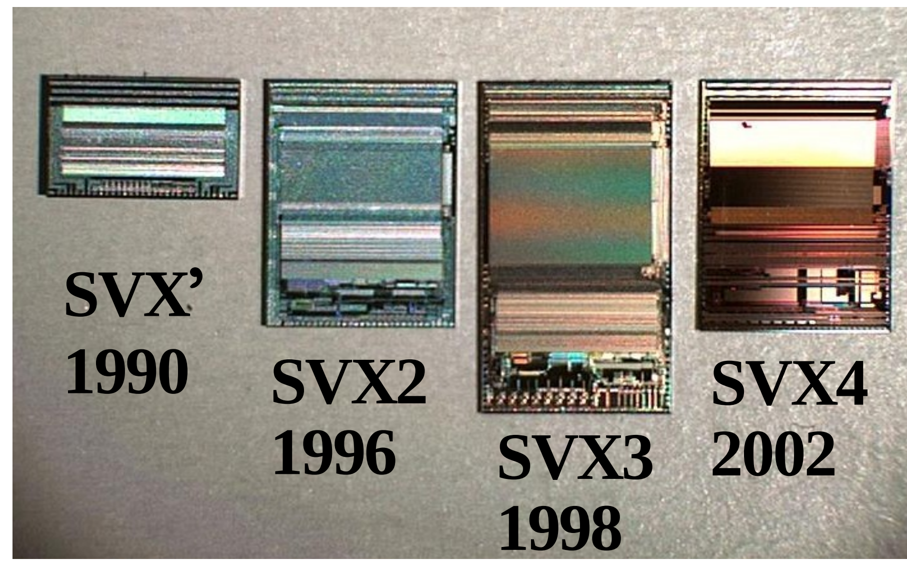
Silicon detectors transformed physics capabilities of CDF since early '90. LBNL is a major player in Vertex Detector technology. Long standing tradition, now extended to LHC.

- 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.
  Also 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 (2)

Detector Operation (MOU)

- Silicon good run list (P. Lujan)
- SCI-Co or CO shifts (everybody)

moved to other groups

- Online silicon monitoring
  (to John's Hopkins)
- Silicon calibration (Nielsen)
- Online data monitoring (YMON)
  (to Rochester)
- COT calibration (to FNAL)
- SVT data taking: pager (to Pisa)
- SVT online monitoring checks, SVT hardware support, upgrade code consultant (A. Cerri)
- DAQ shifts (3 months service)

Software Responsibilities (MOU)

- GFLASH tuning (P. Fernandez)
  (just ompleted)

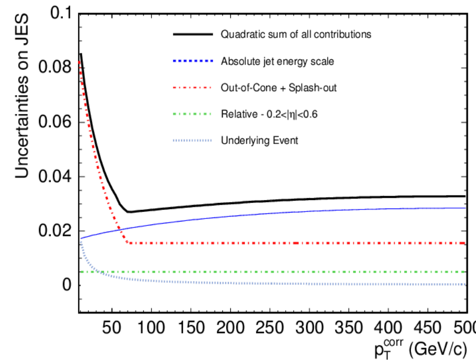
moved to other groups

- 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)
- SVT simulation (A. Cerri)
- MC: EVTGEN, B decays generator
  (J. Beringer)

Jet Corrections and systematics

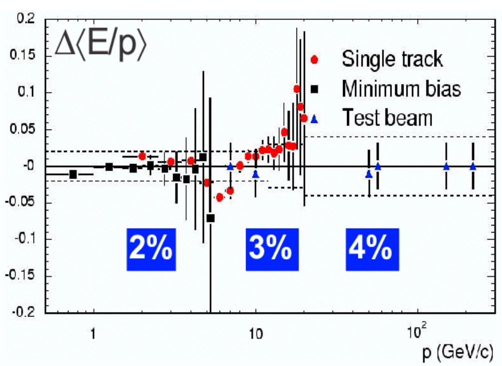
Pedro Fernandez, L. Galtieri + others

NIM **A566**, 375 (2006)

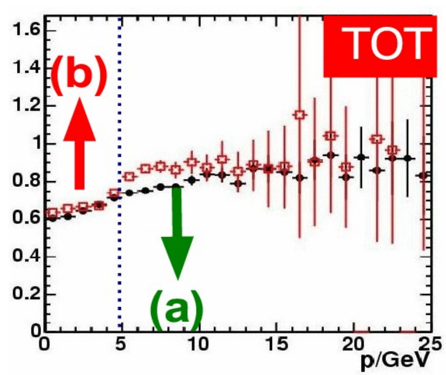


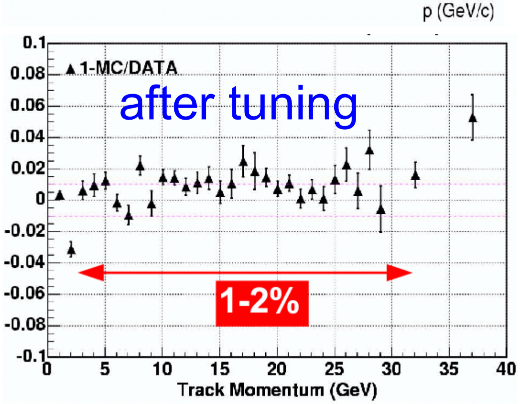
- Long standing expertise on jets in LBNL group
- Run2 systematic uncertainties (published in NIM) are now smaller than Run1.
- Recent calorimeter simulation tuning (P. Fernandez)

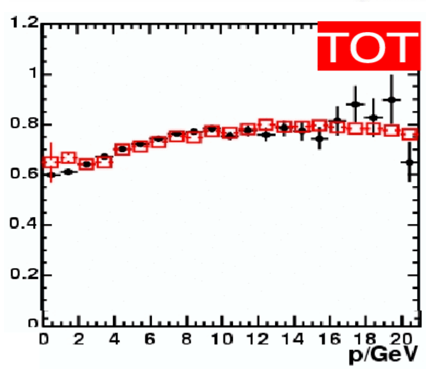
Central , before tuning



Plug , before tuning







- Special trigger provided large samples of isolated tracks to 40 GeV/c (from 5 GeV/c)
- Lateral and longitudinal tuning of central and plug calorimeters almost finished
- Plug tuning helped reduce W mass systematic uncertainty
- Expect to reduce jet energy systematics by at least 30%

Members of the LBNL Group

Physicists-Staff (1.8 FTE)

A. Galtieri
B. Heineman* (UC Berkeley)
J. Beringer**,*
C. Haber*
C-J Lin***,** (joined 9/'07)
J. Lys *
M. Shapiro* (UC Berkeley)
J. Siegrist* (UC Berkeley)
W. Yao**,*

Grad. Students(2.5FTE)

A. Deisher
H-C. Fang
P. Lujan
J. Freeman (FNAL,11/07)
J. Muelmenstaedt (UCSD, 1/08)

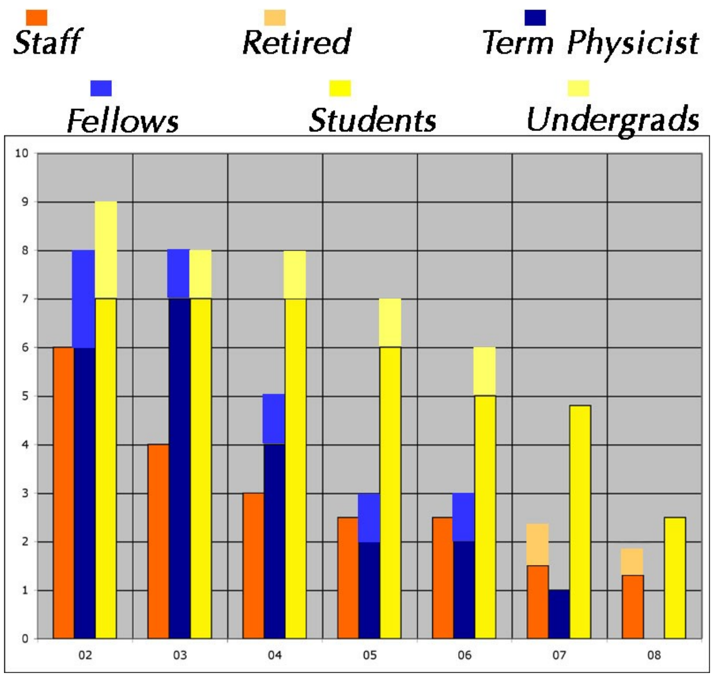
Guest

I. Volobouev (Texas Tech)
J. Nielsen (UCSC)

Physicists-Term (3 FTE)

P. M. Fernandez (FNAL, 11/07)

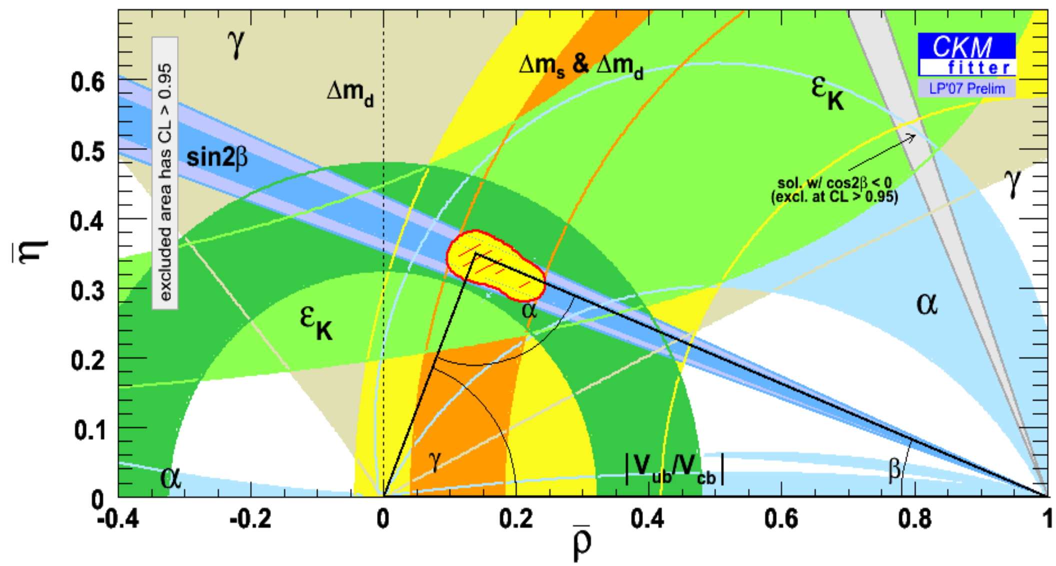
In 2003 DOE's directive was to move all the CDF effort into ATLAS. This is now almost accomplished



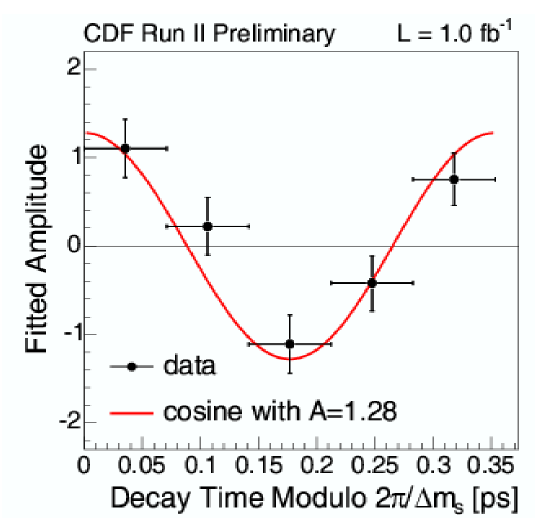
*ATLAS, ** PDG ***Daya Bay
FTE refer to FY08 (mostly part time staff physicists or students)

B physics recent contributions

Unitarity triangle as of LP'07



B_s mixing observed (CDF summer 2006)



Oscillations Period

Agrees with SM prediction:

no New Physics

Several LBNL contributions to the B_s mixing analysis.

Present work
(three PHD thesis):

- B_s lifetime
- Angle γ inputs: Cabibbo-suppressed modes
  - $B^- \rightarrow D^0 K^-$
  - $B_s \rightarrow D_s^- K^+$

The latter analysis is completed, paper is being written

Measurement of the B_s Lifetime

Amanda Deisher (PHD Thesis), with A. Cerri, H.-C. Fang, J. Muelmenstad, M. Shapiro

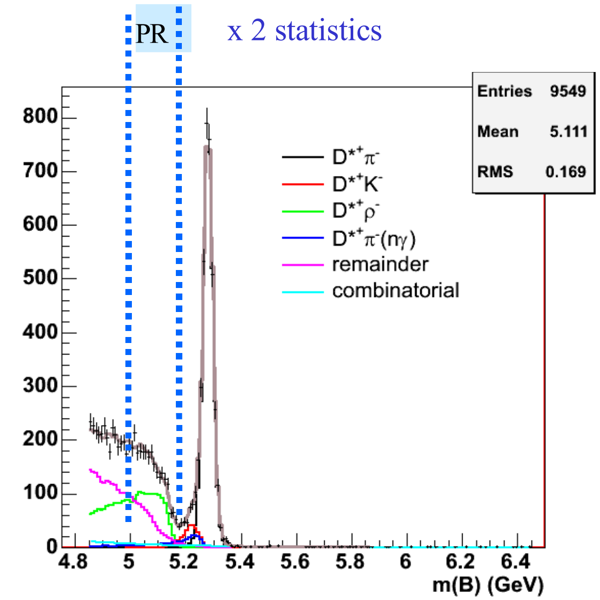
Motivation:

Reduce the experimental error on $\tau(B_s) / \tau(B^0)$

	$\tau(B^+)/\tau(B^0)$	$\tau(B_s)/\tau(B^0)$	$\tau(\Lambda_b)/\tau(B^0)$
Theory	1.06 ± 0.02	1.00 ± 0.01	$0.90 + 0.04$
Exp.	1.076 ± 0.008	0.914 ± 0.030	0.844 ± 0.043

PDG $\tau(B_s) = 1.466 \pm 0.059$ ps

CDF II Hadronic $\tau(B_s) = 1.60 \pm 0.10 \pm 0.02$ ps



Method (NEW!):

Use fully and partially reconstructed hadronic modes.

Results:

Preliminary results on B^0 control samples:

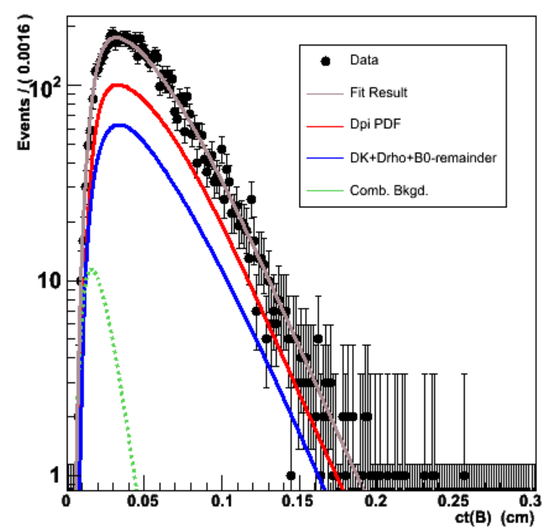
PDG

$$c\tau(B^0 \to D^-(K^+\pi^-\pi^-)\pi^+) = 456.9 \pm 3.8(stat)\mu m \qquad 458.7 \pm 2.7\mu m$$

$$c\tau(B^0 \to D^{*-}[\overline{D}^0(K^+\pi^-)\pi^-]\pi^+) = 457.3 \pm 8.7(stat)\mu m$$

$$c\tau(B^- \to D^0(K^-\pi^+)\pi^+) = 493.5 \pm 3.5(stat)\mu m \qquad 491.1 \pm 3.3\mu m$$

Control Sample: $B^0 \to D^{*-}\pi^+$



Will fit signal sample $B_s \to D_s(\ \ \pi)\ \pi$ soon!

Expected uncertainty ~ 0.05 ps

Cabibbo-suppressed $B^- \to D^0 K^-$

Hung-Chung Fang(PHD Thesis), with A. Cerri, A. D asher, J. Muelmenstad, M.D. Shapiro

- The Gronau-London-Wyler method* exploits the phase difference of $\delta+\gamma$ between the B^- amplitudes

$$A(B^- \to \overline{D}_f^0 K^-) \text{ and } A(B^- \to D_f^0 K^-)$$

to extract the CKM angle γ with measurements of

$$R_{CP\pm} \approx \frac{BR(B^- \to D^0_{CP\pm} K^-) / BR(B^- \to D^0_{CP\pm} \pi^-)}{BR(B^- \to D^0 K^-) / BR(B^- \to D^0 \pi^-)}$$

$$A_{CP\pm} \equiv \frac{BR(B^- \to D^0_{CP\pm} K^-) - BR(B^+ \to D^0_{CP\pm} K^+)}{BR(B^- \to D^0_{CP\pm} K^-) + BR(B^+ \to D^0_{CP\pm} K^+)}$$

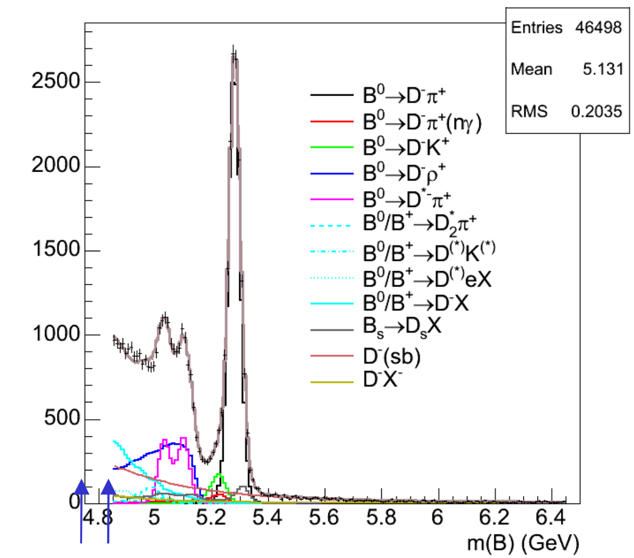
- We can measure R and A for flavor ($D^0 \to K^- \pi^+$) and CP+ ($D^0 \to K^- K^+ / \pi^- \pi^+$) modes
- Use maximum likelihood fit in mass and particle ID (dE/dx) to extract relative branching ratios
- Two control samples: $B^0 \to D^{*-} K^+$ and $B^0 \to D^- K^+$ (very preliminary)

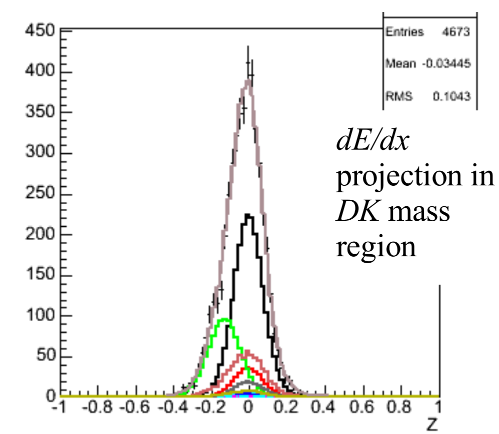
$$\frac{BR(B^0 \to D^{*-} K^+)}{BR(B^0 \to D^{*-} \pi^+)} = 8.4 \pm 0.8(stat.) \qquad \frac{BR(B^0 \to D^- K^+)}{BR(B^0 \to D^- \pi^+)} = 9.4 \pm 0.5(stat.) \pm 0.6(syst.)$$

$cp.$ BaBar (2006)** : $7.8 \pm 0.3(stat.) \pm 0.3(syst.)$ $cp.$ Belle (2001)*** : $6.8 \pm 1.5(stat.) \pm 0.7(syst.)$

- Expect approval from collaboration in ~2 months
- Use 1.3 fb^{-1} of integrated luminosity – statistics comparable to BaBar (2006)† and Belle (2006)‡

$B^0 \to D^- K^+$ control sample fit





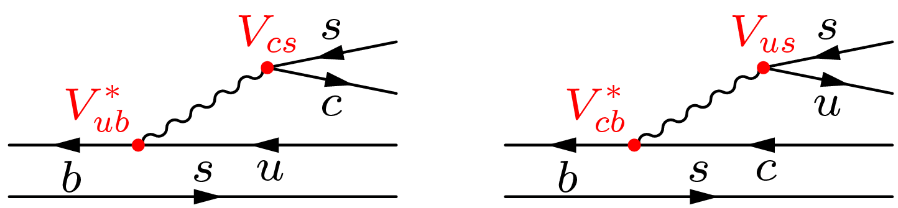
*PRD **58** 037301, **PRL **96** 011803, ***PRL **87** 111801, †PRD **73** 051105, ‡hep-ex/0601032

First measurement of $\mathcal{B}(B_s^0 \to D_s^\mp K^\pm)/\mathcal{B}(B_s^0 \to D_s^- \pi^+)$

A. Cerri, A. Deisher, H.-C. Fang, J. Mülmenstädt, M.D. Shapiro

1.2 fb^{-1} dataset

Motivation: a way* to measure the CKM angle γ



$B_s^0 \to D_s^+ K^-$ $\qquad$ $B_s^0 \to D_s^- K^+$

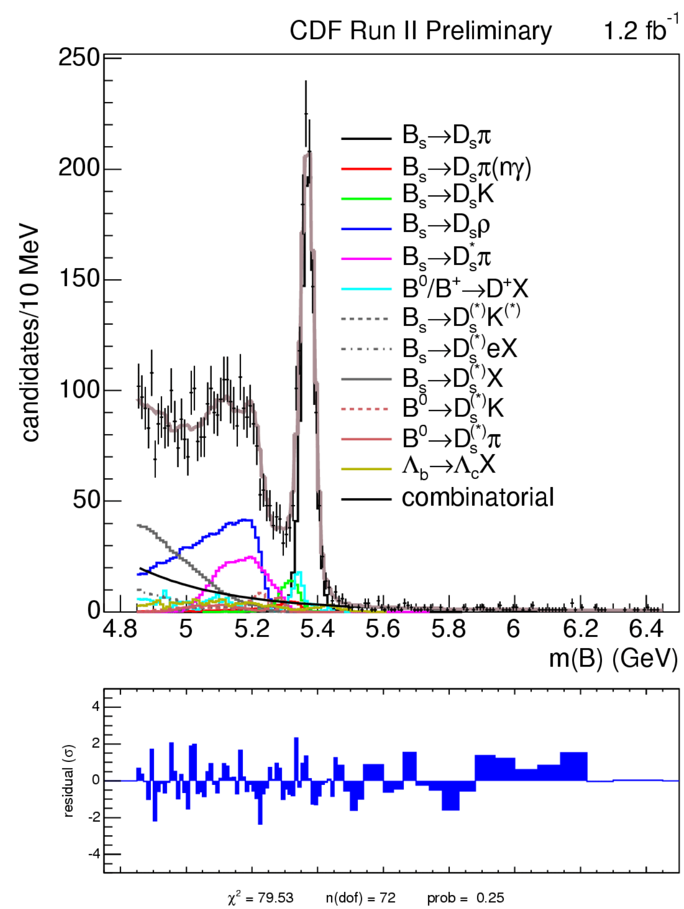
- $B_s^0 \to D_s^\mp K^\pm$ have relative phase γ, comparable amplitude
- Interference through mixing
- $\mathcal{B}(B_s^0 \to D_s^\mp K^\pm)/\mathcal{B}(B_s^0 \to D_s^- \pi^+)$ is first step towards γ measurement

Measurement:

- Unbinned likelihood fit using mass and dE/dx templates
- Control samples are $B^0 \to D^-(K^+\pi^-\pi^-)X$, $B^0 \to D^{*-}\left(\overline{D}^0(K^+\pi^-)\pi^-\right)X$
- Signal sample is $B_s^0 \to D_s^-(\phi\pi^-)X$
- Result: $\mathcal{B}(B_s^0 \to D_s^\mp K^\pm)\,/\,\mathcal{B}(B_s^0 \to D_s^- \pi^+) =$

  0.107±0.019(stat)±0.008(sys)

- Statistical significance of $B_s^0 \to D_s^\mp K^\pm$ signal: 7.90σ
- The answer could have been very different from $\mathcal{B}(B^0 \to D^- K^+)/\mathcal{B}(B^0 \to D^- \pi^+) = 0.068 \pm 0.017$



*R. Aleksan, I. Dunietz and B. Kayser, Z. Phys. C **54**, 653 (1992).

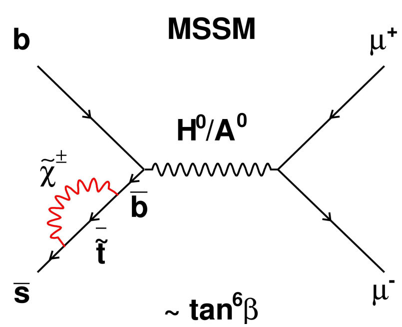
Rare B decays: $B_s \rightarrow \mu\mu$

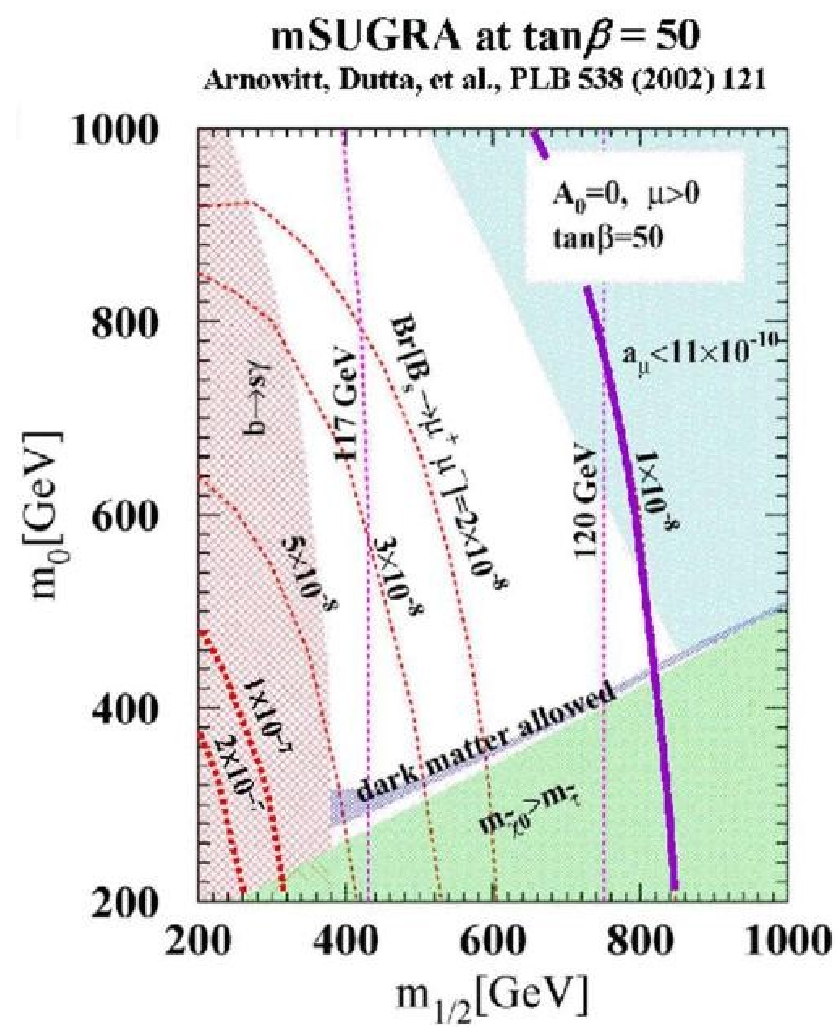
Cheng Ju Stephen Lin + others

$Br(B_s \rightarrow \mu\mu) < 5.8\times10^{-8}$ @ 95% CL
$Br(B_d \rightarrow \mu\mu) < 1.8\times10^{-8}$ @ 95%CL

SM prediction $\Rightarrow Br(B_s \rightarrow \mu^+\mu^-) \sim 3.42\times10^{-9}$

SUSY $\rightarrow$ big enhancement $\rightarrow (\sim \tan^6\beta)$





CDF analysis:

- Can distinguish Bs from Bd→μμ
- Using Neural Net to extract signal
- Improve sensitivity by including NN output and Mμμ in limit calculation

Find:

- B_s window → 3 events
- B_d window → 6 events
- No significant excess !

High P_T Physics

Present involvement:

SUSY Searches

Top mass precision measurement

Higgs Searches

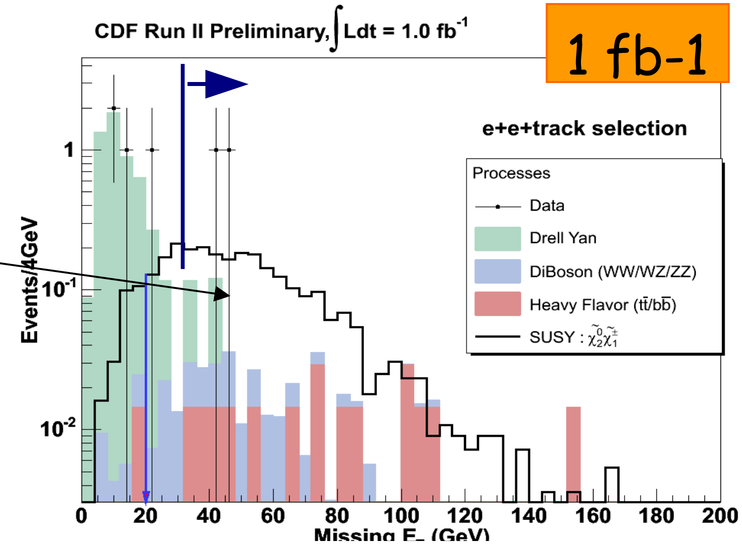
Several papers being prepared for publication

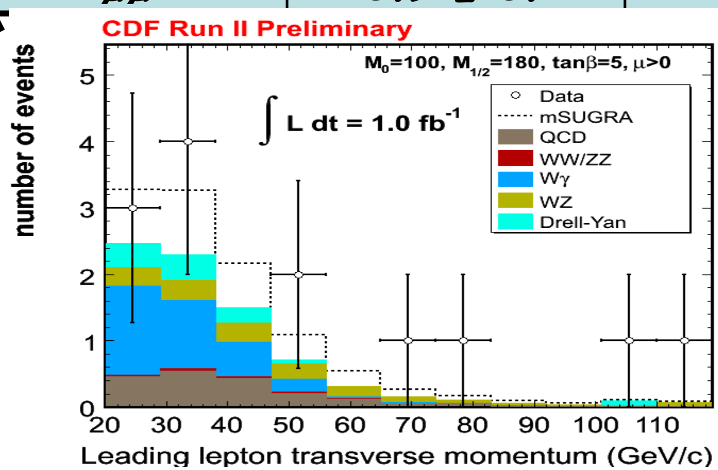
SUSY Searches: chargino-neutralino

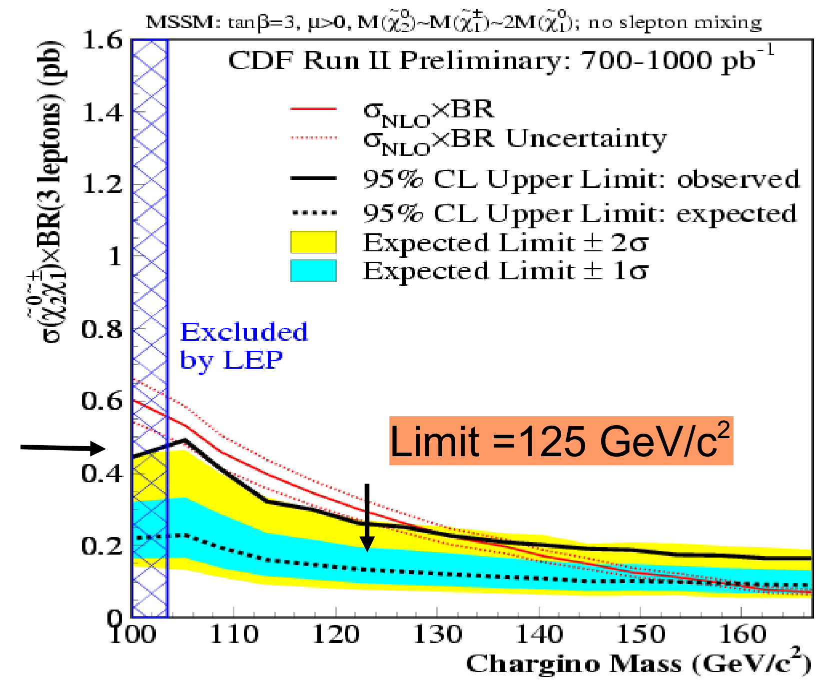
Beate Heinemann with others

trileptons	SM expect.	DATA
μμ+l (low pt)	0.4 ± 0.1	1
ee+ track	1.0 ± 0.3	3
μ+ll	1.2 ± 0.2	1
e+ll	0.8 ± 0.4	0

LS leptons	SM expect.	DATA
ee	2.9 ± 0.5	4
eμ	4.0 ± 0.6	8
μμ	0.9 ± 0.1	1







New top mass measurement

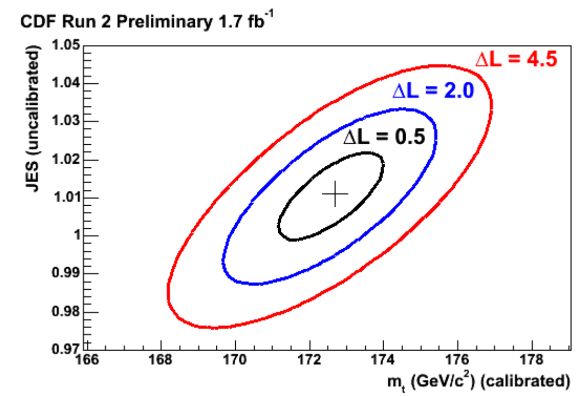
J. Freeman (PHD Thesis), L. Galtieri, P. Lujan, J. Lys, P. M. Fernandez (LBNL), J. Nielsen (UCSC), I. Volobouev (Texas Tech)

NEW

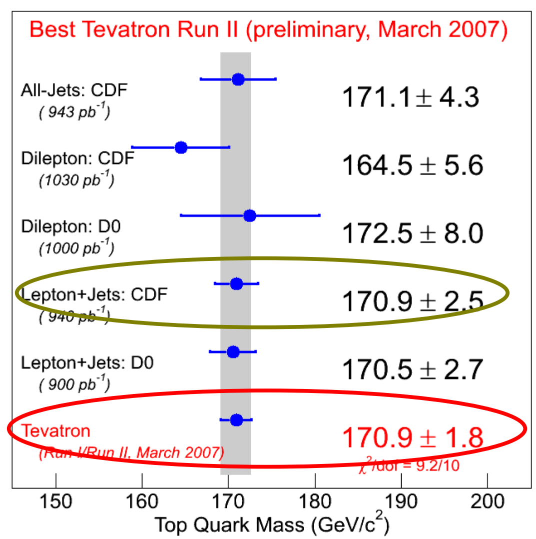
Measurement with 1.7 fb^{-1} (293 events passing all cuts):

$m_t = 172.7 \pm 2.1$ (stat. + syst.) GeV/c^2

Best individual top mass measurement to date!



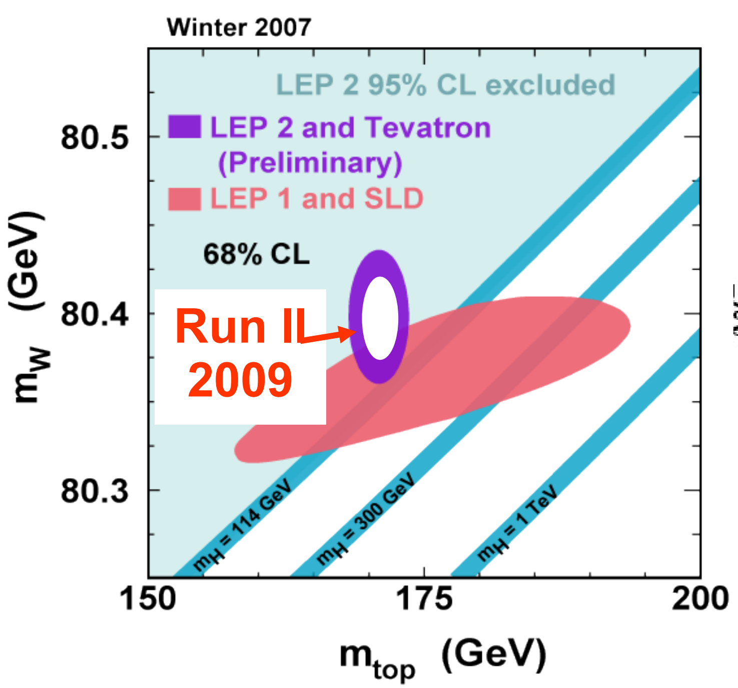
- The LBNLmethod uses a matrix element integration to calculate a 2-D likelihood as a function of top mass and jet energy scale (JES).
- It includes "effective propagators" which compensate for the assumptions we make in order to make our integration computationally tractable.
- It will reduce the uncertainty on the average top mass value and, and change the central value as well.

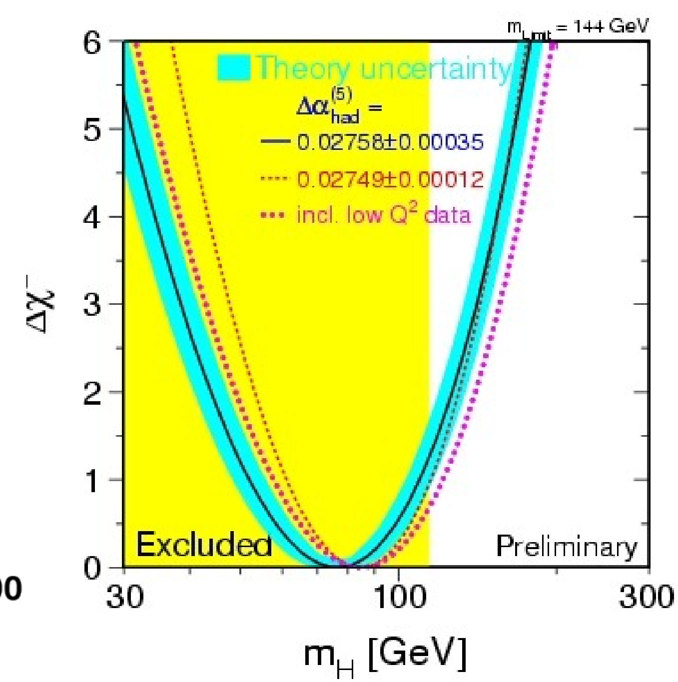


Top mass and Higgs in the SM

- 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 or $ln(M_H)$
- Winter 2007 World average:

M(top) = 170.9 ± 1.8 GeV/c^2 (CDF+D0 Run I+II)





July 2007 best Fit

$M_H = 76^{+33}_{-24}$ GeV/c^2

July '06:
$M_H = 85^{+39}_{-28}$ GeV/c^2

now
$M_H < 144$ GeV/c^2 at 95% CL

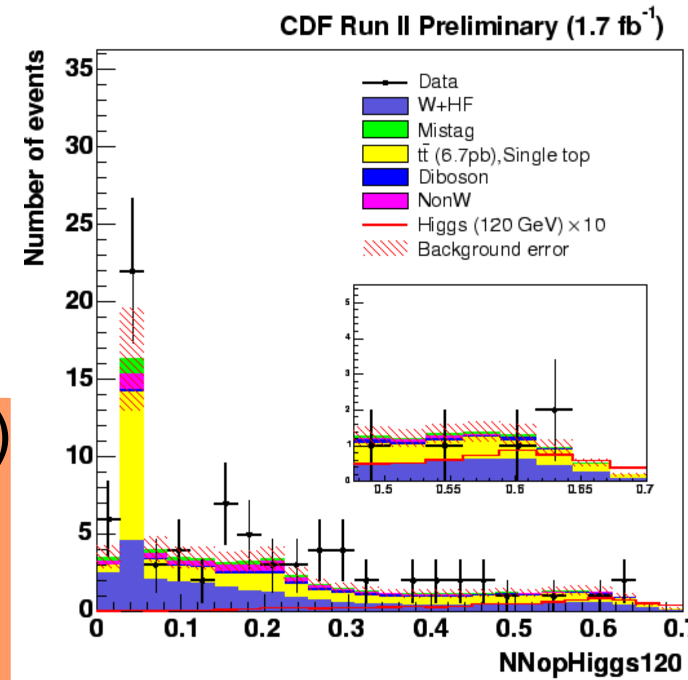
Direct limit:
$M_H > 114$ GeV/c^2 at 95% CL

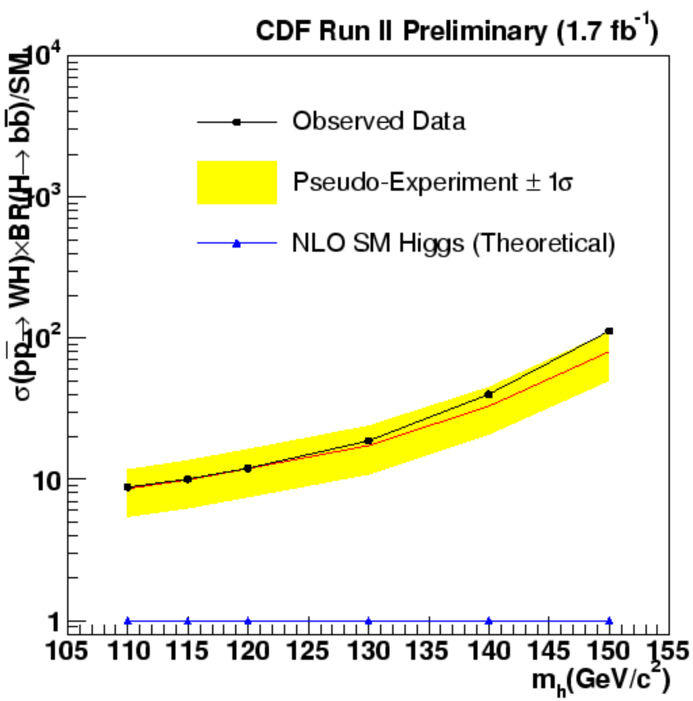
Direct Higgs search: $WH \rightarrow l\nu bb$

Weiming Yao, Tsukuba Students and others

- Sensitive channel for low mass Higgs
- Signature: *W* + 2 jets (both *b*-tagged)
- Dominant backgrounds: *W* + jets and top
- Search Strategy
  - Two tag categories: SECVTX + (SECVTX or JP)
  - Use kinematic information in neural network
  - Search for excess consistent with SM Higgs

Neural Network output





Limit (115 GeV)
- Obs: 1.31 pb (10.0xSM)
- Exp: 1.33 pb (10.1xSM)

New for this update

- Jet probability to increase double-tag acceptance   25% improvement
- Kinematic information in NN   10% improvement

Higgs Search in ZH, Z->l+l-, H->bb

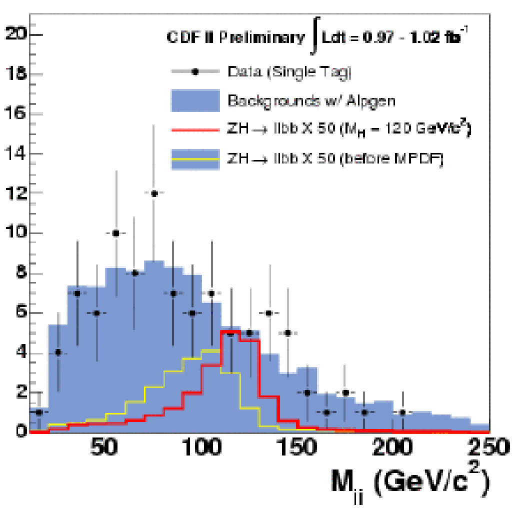
Beate Heinemann with others

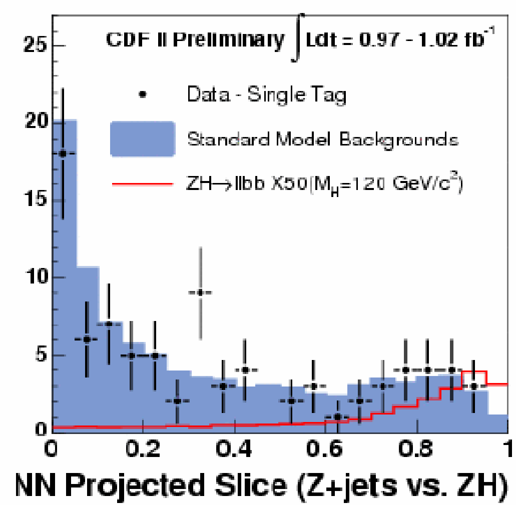
An Update of Summer Analysis with same 1 fb^{-1} Data Set

- Find Z + 2 >= jets with at least 1 b-tag
- 2D Neural Net Discriminant

Improvements from Summer

- Split data into 2 loose tags and 1 tight tag
- Use Missing E_T Dijet Fitter
  - Assigns Met of event onto jets
  - Improves Higgs dijet resolution from 16% to 10%
  - Allows more use of angular variables in NN

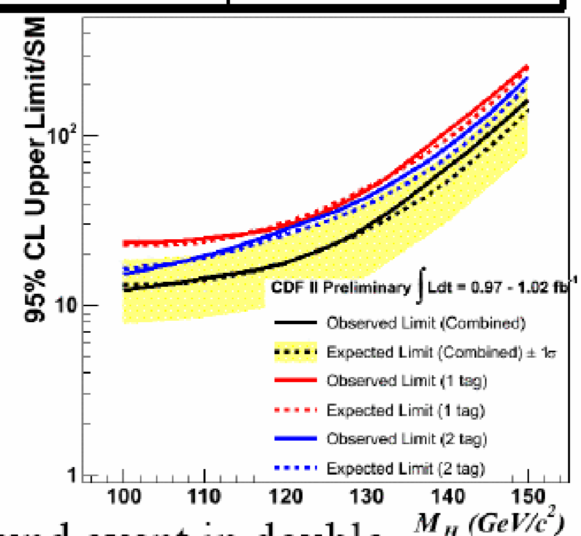




Summary:

- Improved result from summer (same 1 fb^{-1} data set): e.g. m_H=115 GeV/c^2 from 23 to 16 x SM (≈ to 2x Lum.)

ZH ->llbb	**16 (16 expected)**
ZH +WH ->vvbb	16 (15 expected)
WH ->lvbb	26 (17 expected)
D0 ZH->llbb	33 (34 expected)



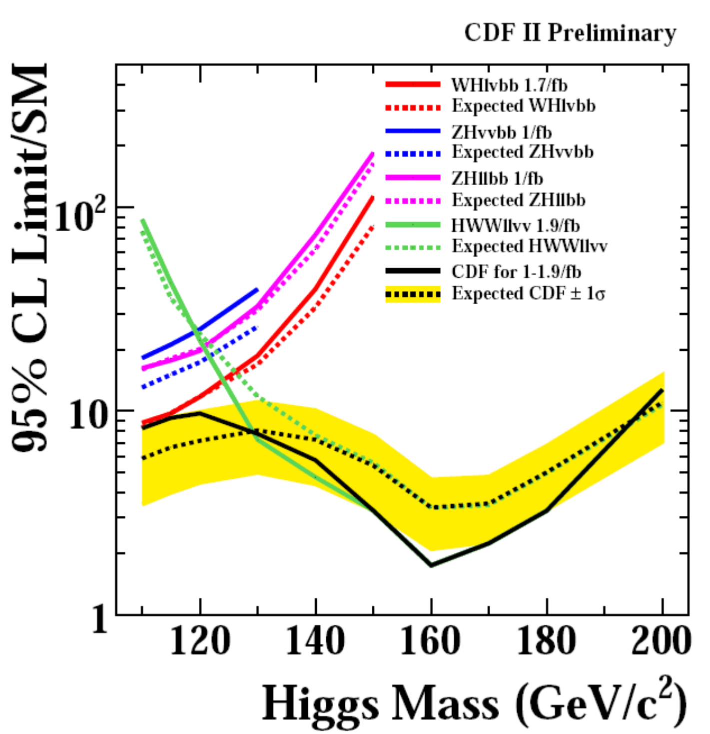
Found event in double tagged channel in Higgs corner S/B=1/4.2

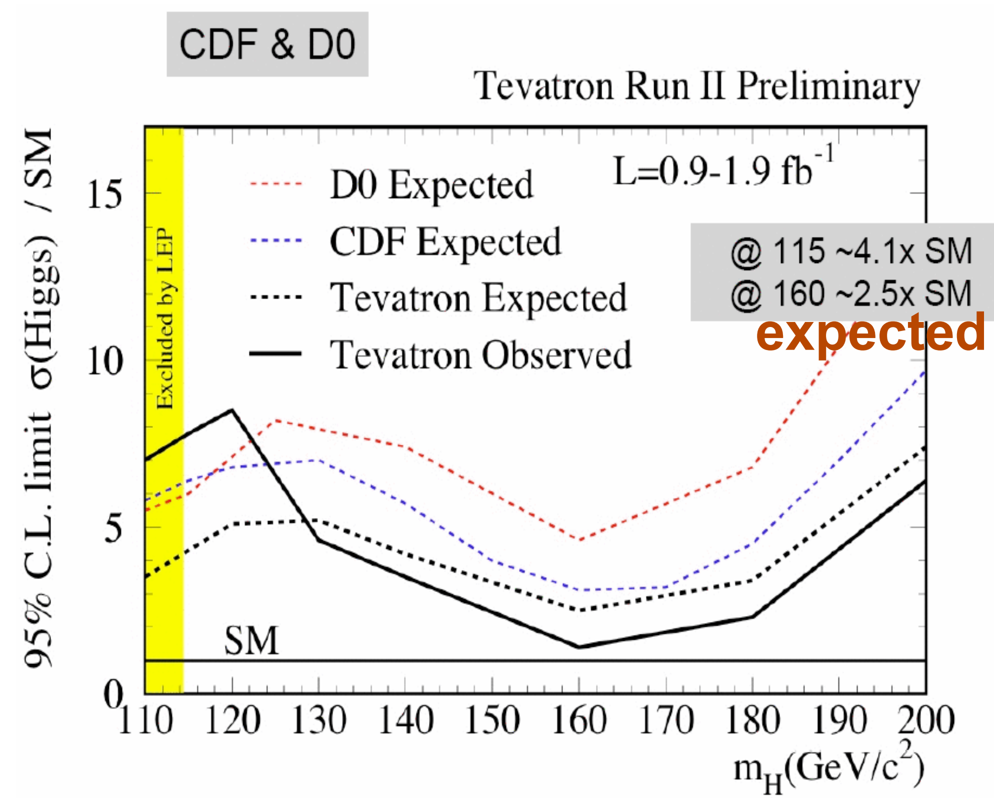
Tevatron Higgs results

Weiming Yao et al. : Higgs Tevatron averaging group
(all channels included)

Summer 2007 (Lepton-Photon)

CDF Combined Limit with 1-1.9/fb





CDF Higgs expectation

Beate Heinemann, co-chair
Higgs Trigger Task Force

mode	current acceptance	proposed acceptance
$WH \to e\nu_e bb$	45%	89%
$WH \to \mu\nu_m ub\bar{b}$	42%	88%
$ZH \to e^+e^- b\bar{b}$	71%	90%
$ZH \to \mu^+\mu^- b\bar{b}$	60%	96%
$ZH \to \nu\bar{\nu}b\bar{b}$	74%	96%
$H \to l\nu l\nu$	66%	82%

Existing Triggers "data in the bag"

trigger path	cross section (nb) at $3 \times 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
new ELECTRON_CENTRAL_18	100
new MET_PEM	20
MET45	80
new Z_NOTRACK	50
new MET28_JET24	120
new MUON_CMUP18	100
new MUON_CMX18	150
MUON_BMU_JET	40
total	< 660

More triggers being implemented

From existing triggers and new ones
Expected increase in Higgs events ~ x2

Other improvements

Factor 1.5 achievable from:
- 25% b-tagging (NN-based)
- 25% trigger acceptance (pre-existing triggers)
- 20% better analyses techn. and better usage of MET
- 10% Tau channels (hadronic)

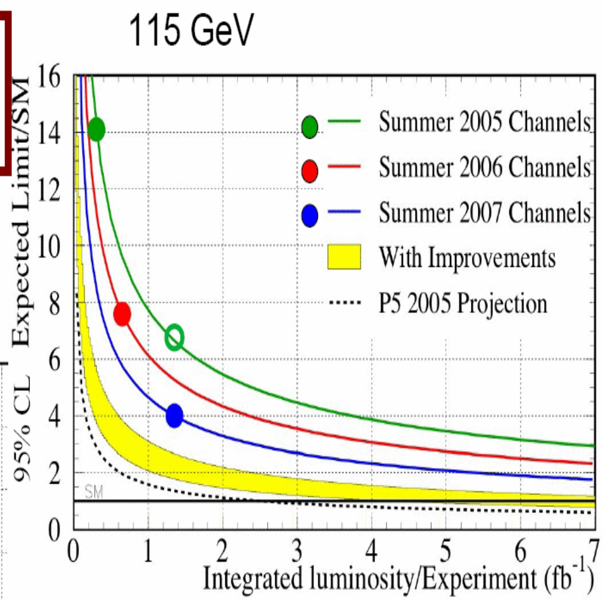
Other work in progress:
- Additional triggers (HTTF + L2 Cal upgrade)
- High P_T b-tagging triggers
- Better bb mass resolution
- Add forward Tracking

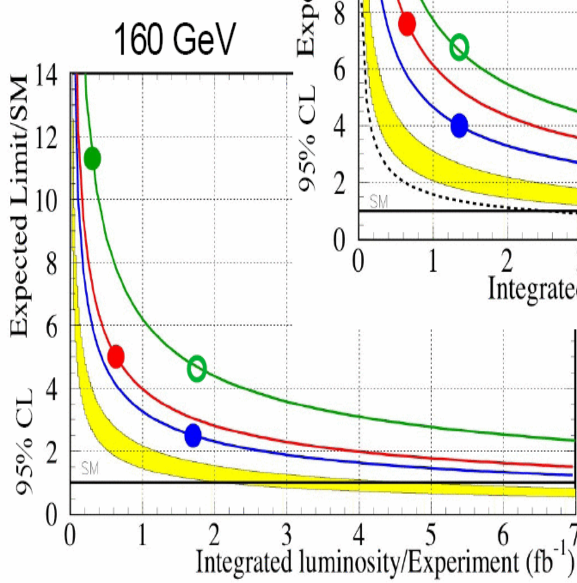
Higgs expectation (P5 presentation)

Contributions from B. Heinemann, W. Yao

CDF results+ expectation

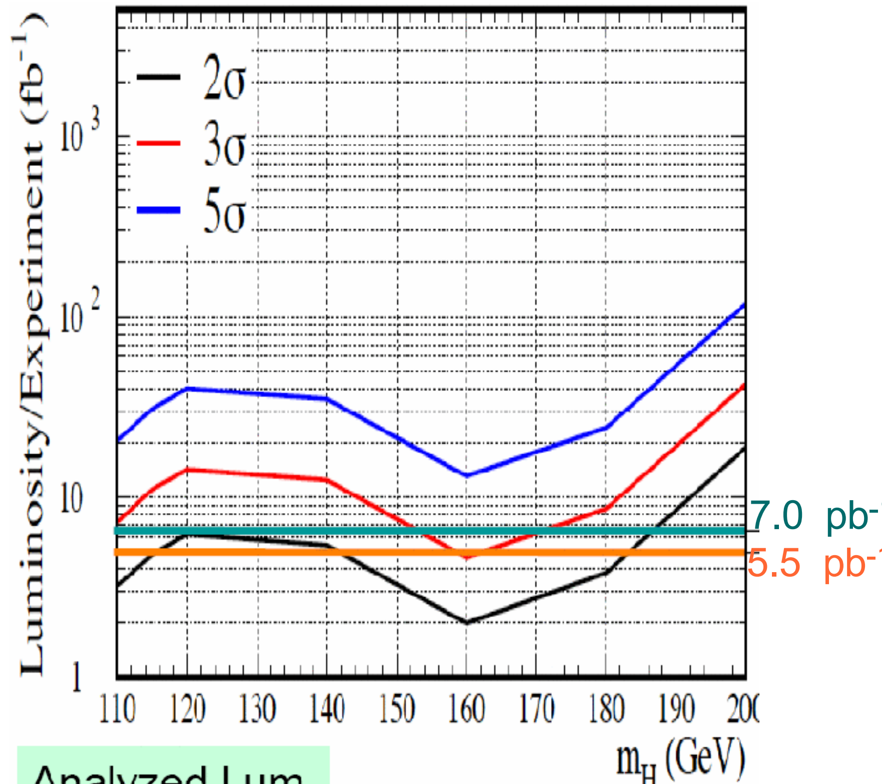
Significant progress from 2005 to 2007
- -At 115 = x1.8 in sensitivity
- -At 160 = x2.0 in sensitivity





2005 projections long lever arm
- large uncertainty -
2007 projections grounded in data

CDF+D0 combined



Analyzed Lum.

With 7 fb^{-1}
- exclude all masses !!! [except real mass]
- 3-sigma sensitivity 150:170 LHC's sweet spot

⬇

With 5.5 fb^{-1} tougher:
- Exclude 140:180 range
- 3-sigma in one point: 160

Summary and Conclusions

- Large contributions to hardware and physics over the last 25 years
  Trained 17 students (PHD theses), 21 postdocs.
  21 of these have faculty or lab staff positions.

- Contributed to top discovery, precision top and W mass measurements, particle searches, properties of B mesons, B_s mixing

- LBNL still contributing to Run II CDF physics results:

  - CKM Parameters
  - Top Physics
  - Higgs and new particle searches

- We will continue helping CDF with our expertise, especially the Higgs search.

- Our expertise and successes in CDF are the legacy we bring into ATLAS.

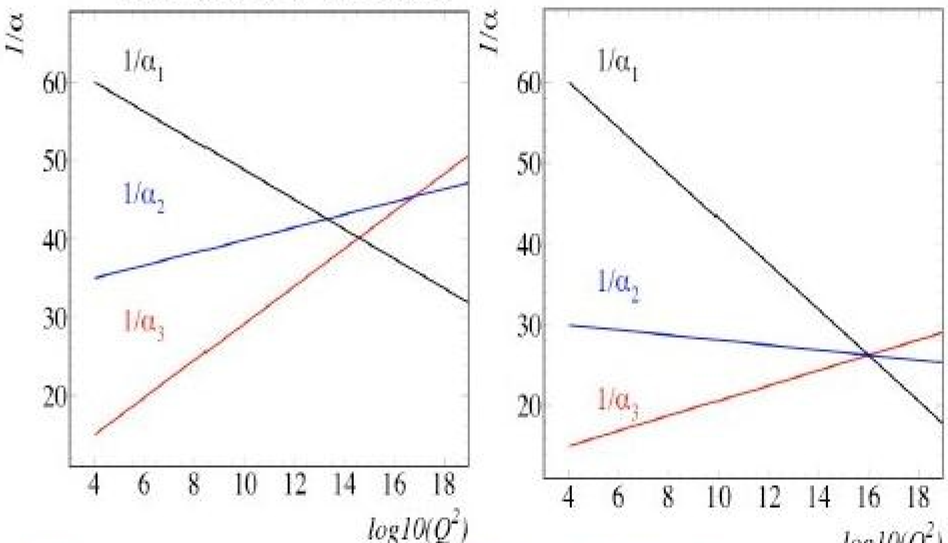
Back-up slides

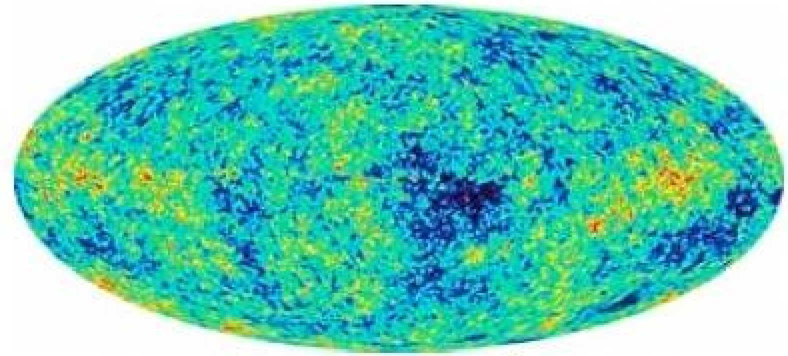
3

Supersymmetry: Motivation

- Solves **"hierarchy problem"**
- Allows **unification of the forces** at the 10^{16} GeV scale

Standard Model *SUSY*

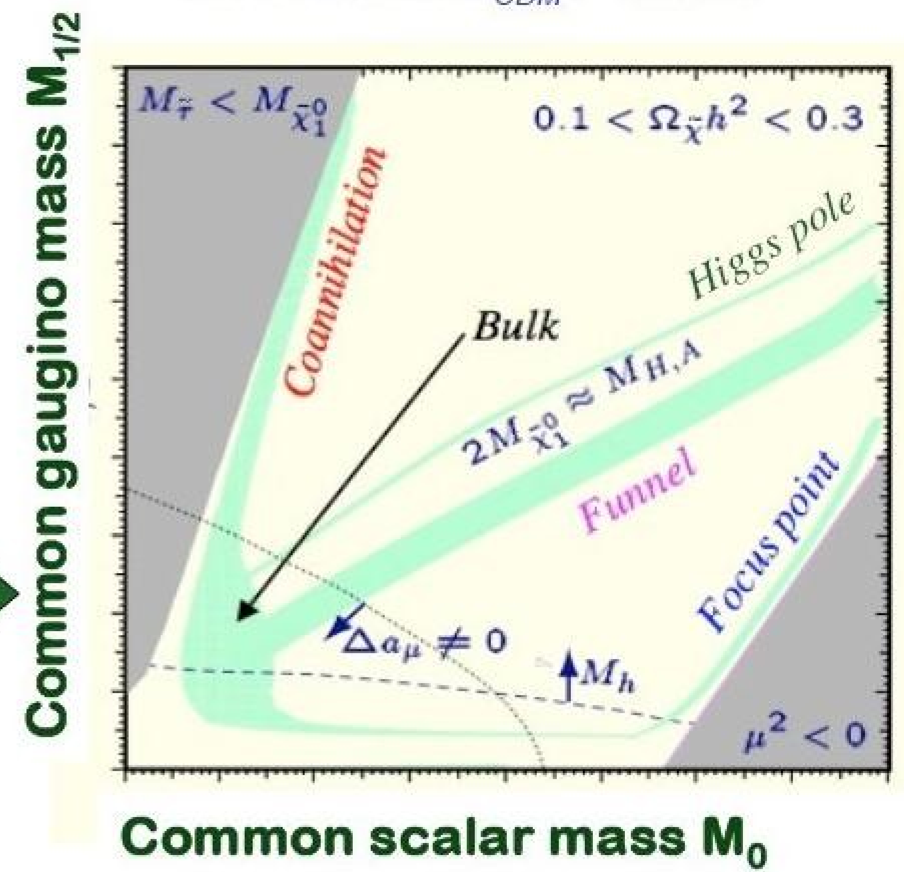




From WMAP: $\Omega_{CDM}h^2 \leq 0.113$

- Provides good **Dark Matter Candidate** (LSP)

-- 5 main regions where the LSP fulfills the relic density results (with constraints from other measurements)



- Consistent with results from **Precision Data fits**

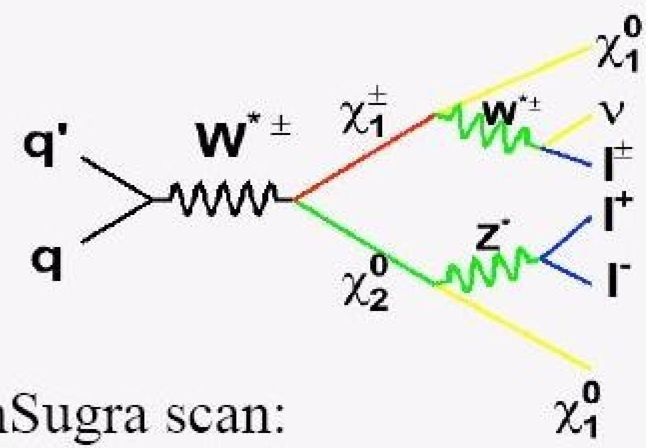
Giulia Manca, Paper Seminar, 12th July 2007

CDF SUSY Search

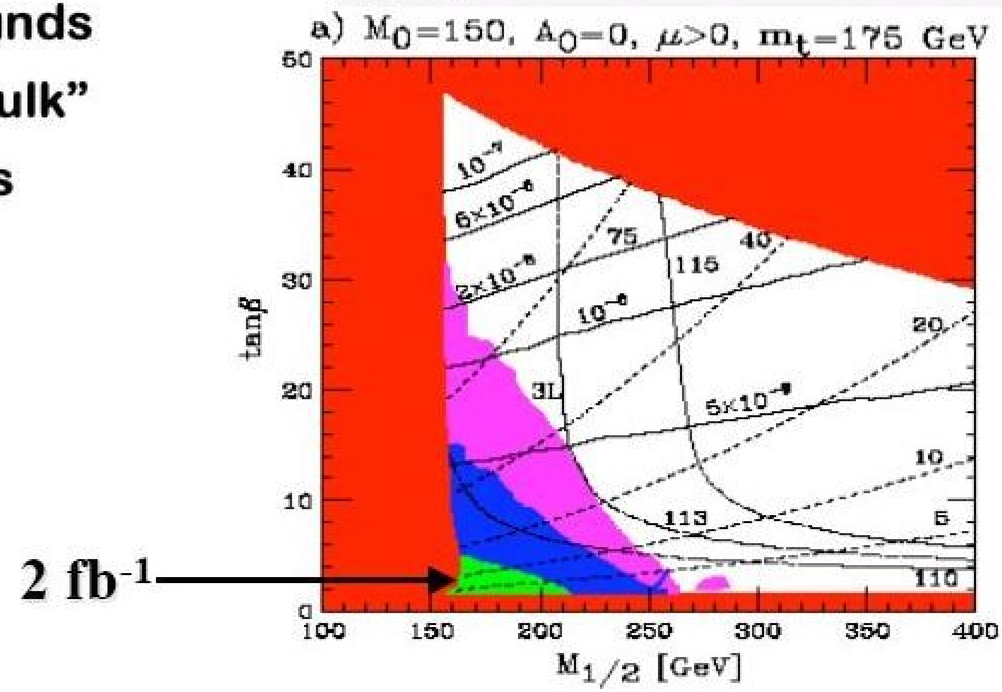
4

The Trilepton Channel

- **Chargino-neutralino production:**
  - 3 leptons + large MEt
- **Cross sections x BR small:**
  - 0.1-0.5 pb (largest at low tanβ)
- **Good discovery potential**
  - Clean, low SM backgrounds
  - Tevatron sensitive to “bulk” region of WMAP data fits
  - Complementary to e.g. Bs->μμ (high tanβ)



mSugra scan:



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