CDF Operations,Physics and Analysis Plans

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Fermilab Institutional Review
June 6-9, 2011

U.S. DEPARTMENT OF ENERGY

Fermilab

The CDF Collaboration

North America

- 30 institutions

Europe

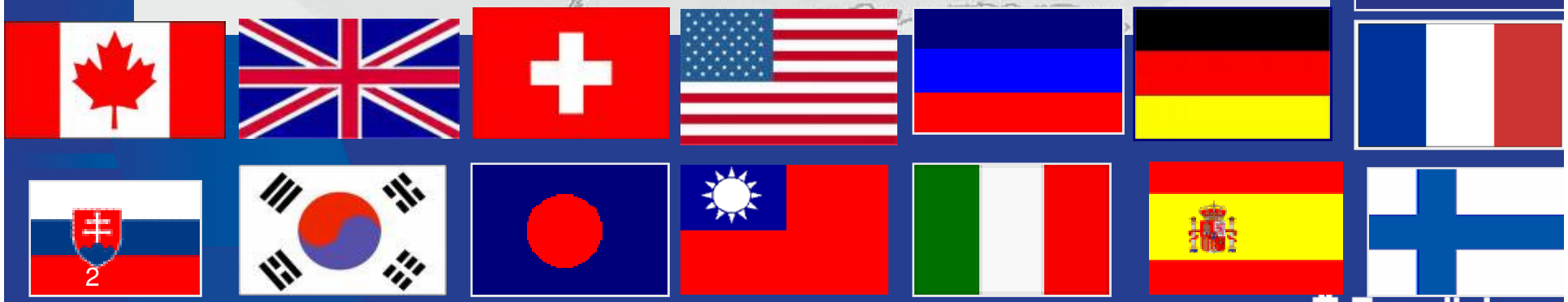
- 21 institutions

Asia

- 8 institutions

The CDF Collaboration

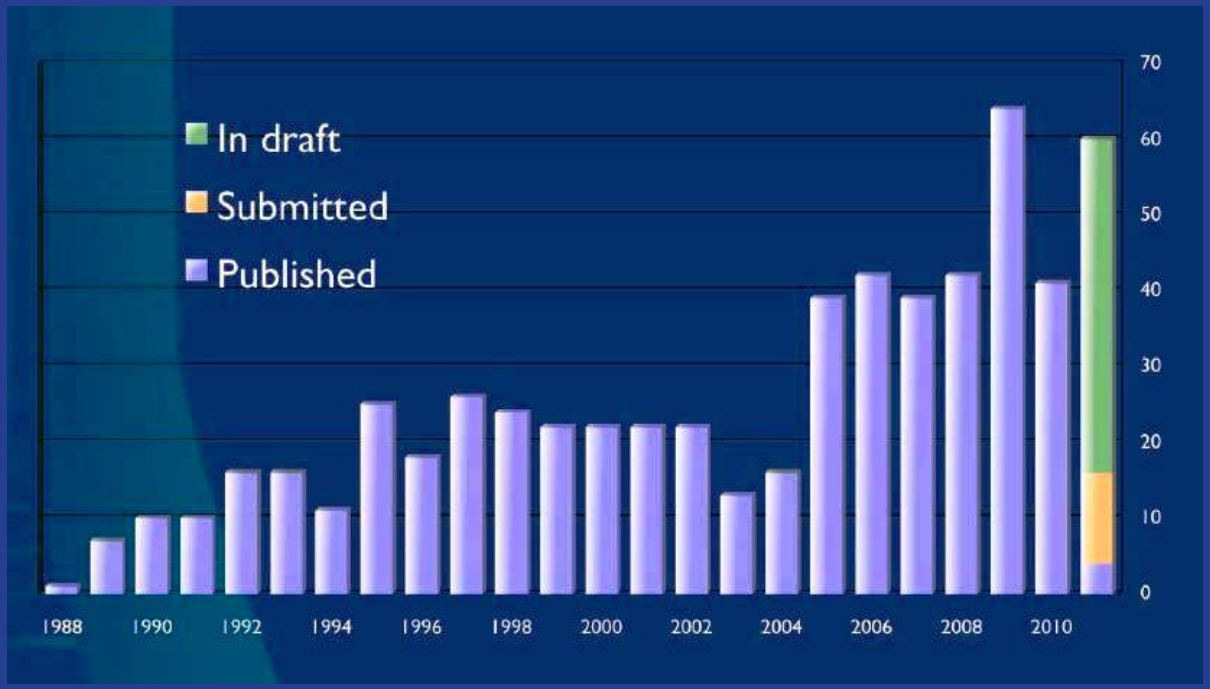
- 15 Countries
- 59 institutions
- 538 authors



CDF is Going Strong!

- Ph.D. Theses
  - ► 270 in Run II, 26 in CY10
  - ► 70 more expected

- Publications
  - ► 360 in Run II, 41 in CY10
  - ► 24 submitted in CY11 so far



Operations

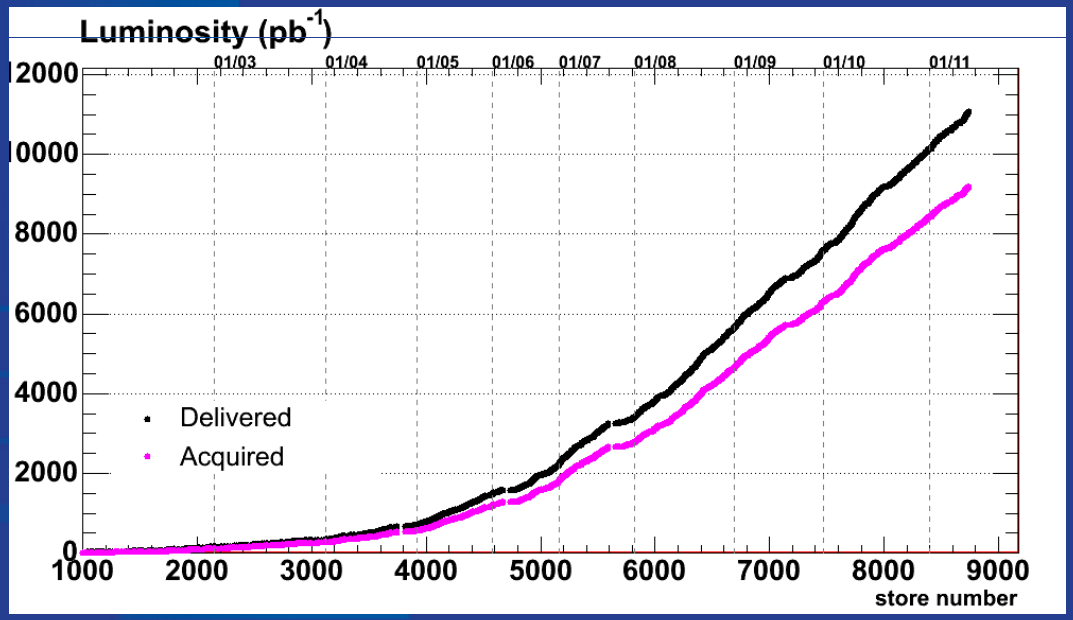
Total:

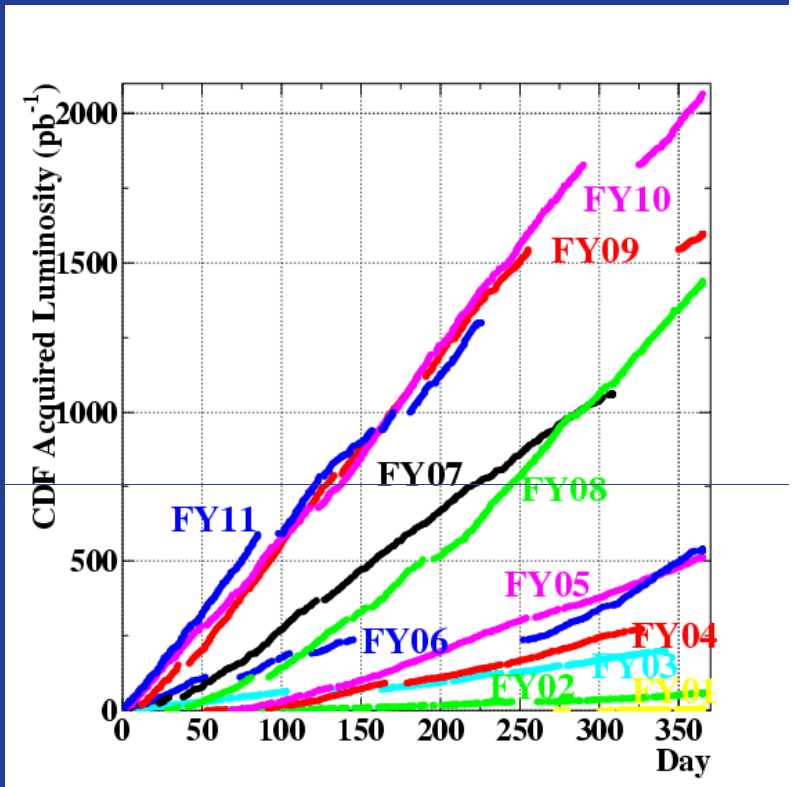
11.2 fb^{-1} delivered 9.2 fb^{-1} collected

Anticipated final dataset:

12 fb^{-1} delivered 10 fb^{-1} collected

Efficiency : similar to previous years

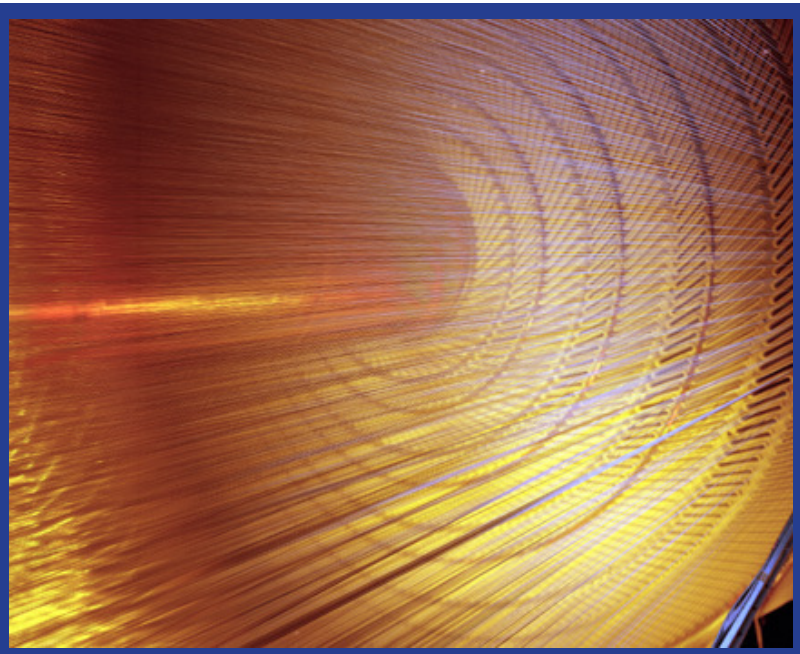




Operations

- Smooth running
  - ► broken COT wire, minimal data loss
  - ► replaced db machine

- Record luminosities
  - ► running at 405E30
  - ► no trips or other detector problems
  - ► deadtime high, but behaved as predicted
  - ► this is effective!



FNAL group participation:

Phil Schlabach: ops Co-Leader

Hahn, Schmidt, Lewis: Assoc Heads

Mukherjee, Wagner: COT leaders

Carron, Stancari: SVX leaders

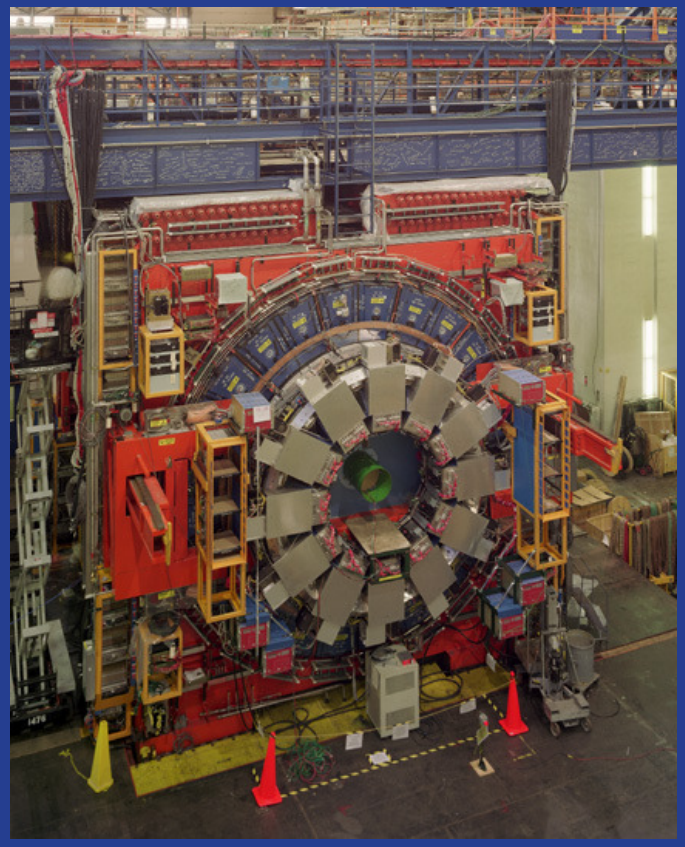
Lewis: DAQ leader, D&D

Murat: L3

Movilla-Fernandez: L2

Operators, pager carriers, studies…

Operations – End of Life



- Oct 1, 2011 – secure CDF
  - no cosmic runs
  - warm cryogenics
  - purge gas
  - drain water
  - re-purpose L3 computing
  - turn B0 over to D&D plan
- Construction of the Illinois Accelerator Research Center
  - utilities work, roads and holes
  - expect no interference with the B0 building, operations
  - good communication to minimize risk

Physics

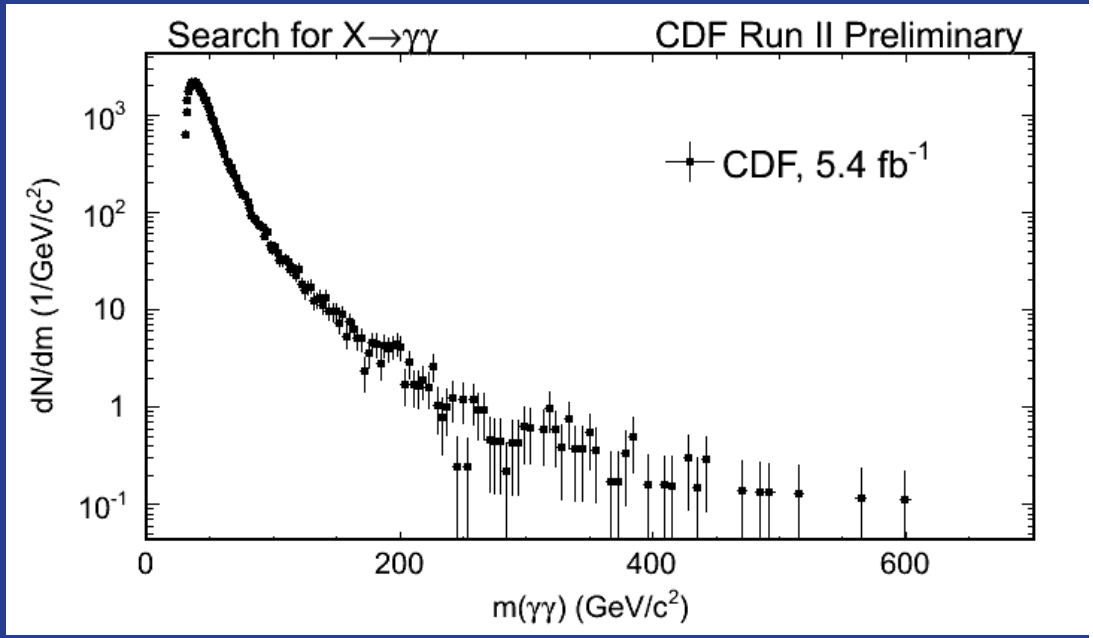
- Results
  - Exotics
  - Electroweak
  - QCD
  - Top
  - B Physics
  - Higgs
- Legacy
  - Searches
  - Higgs
  - Particle properties
  - Production
- Plans
  - FY12
  - FY13
- Finish Strong!
- Needs physicists

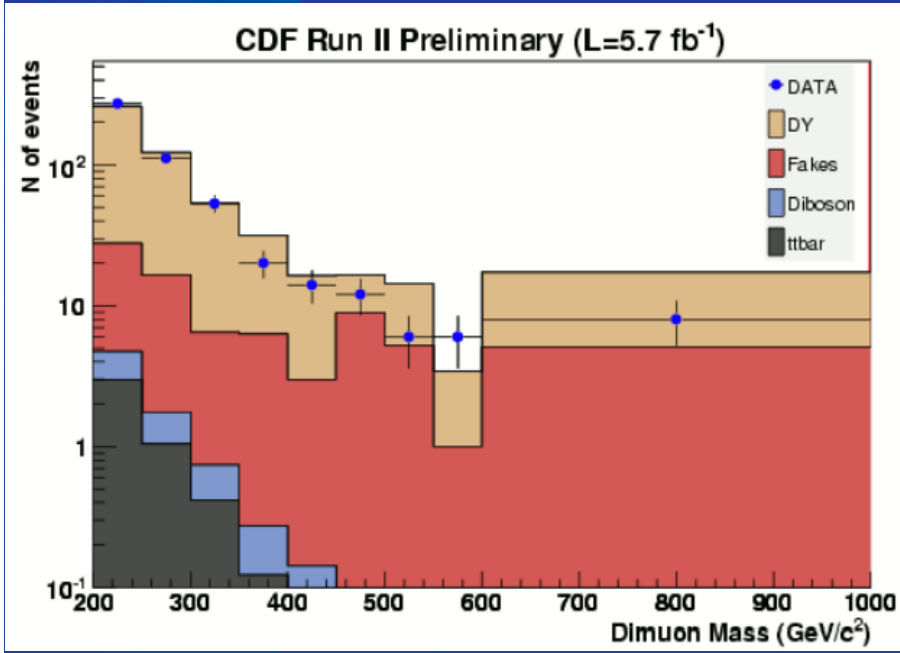
Exotics

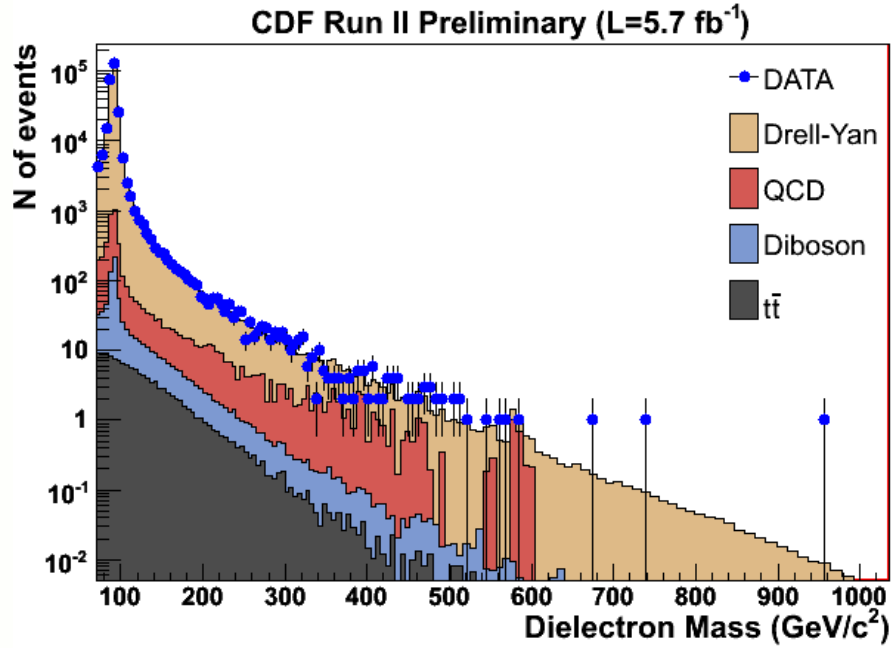
RLC, Yang

High mass Searches

- Sensitive to narrow peaks
- $\gamma\gamma$, e^+e^- and $\mu^+\mu^-$ spectra
- world's highest e^+e^- candidate so far…







RLC, Yang

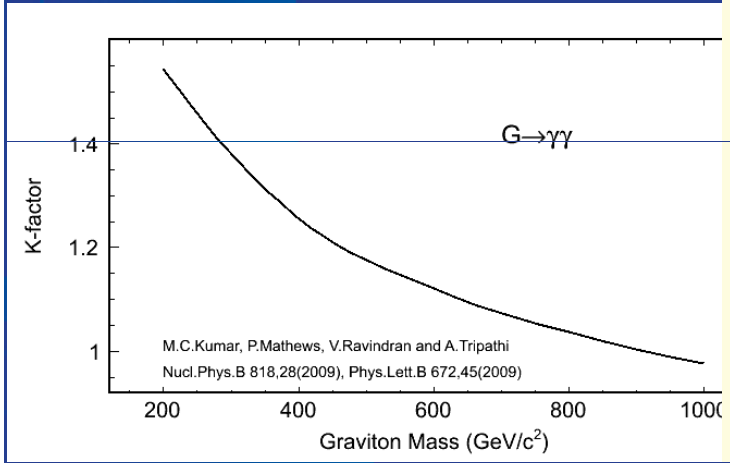
Limits on R-S Gravitons

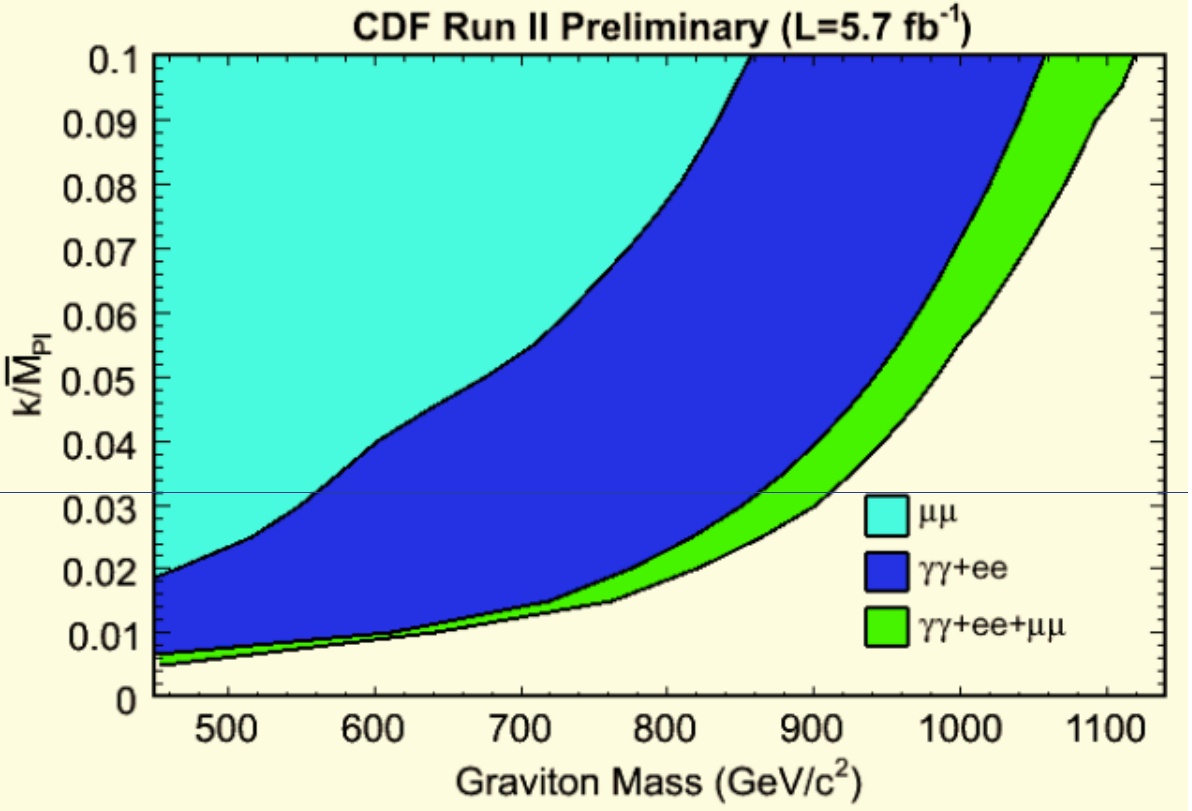
M>1119 GeV/c^2

for k/M_{pl}=0.1

and variable k-factor

World's best!





D0: 1050 GeV/c^2 with 5.4 pb^{-1} and k-factor=1.54 (P.R.L. 104 241802 (2010))

CMS: 1079 with 40 pb^{-1} dileptons and k-factor=1.6 (arxiv 1103.0981)

Atlas: 920 with 40 pb^{-1} diphotons and k-factor ? (ATLAS-CONF-2011-044)

Fermilab

Exotics Group Plans

- Severe case of LHC-itis
- wrap up current work and publish
- follow up on LHC discoveries!?

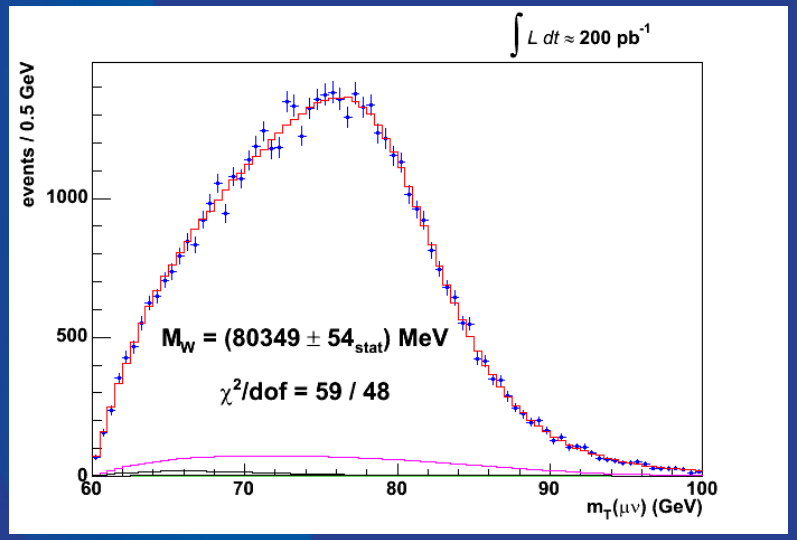
Electroweak

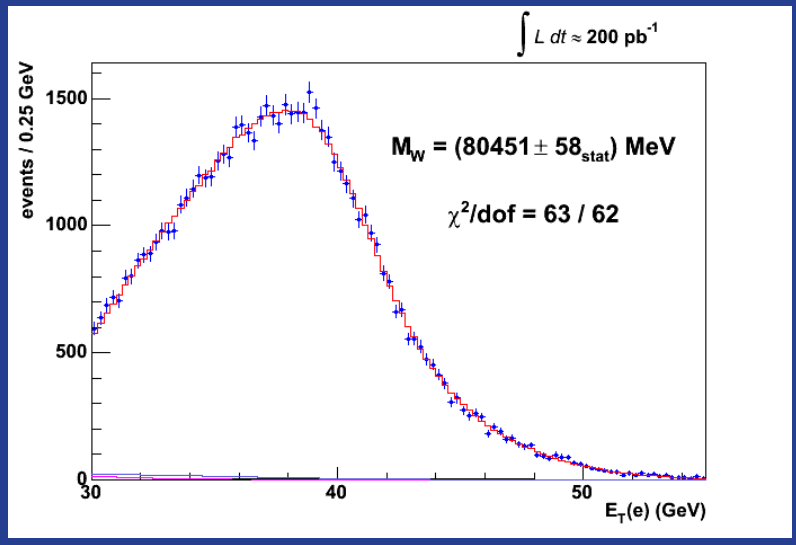
W mass

Efforts from 2000 to 2007…

- CDF 200pb^{-1} 80413 ±34$_{stat}$ ±34$_{syst}$ MeV = 80413±48 MeV
- Combined with DØ 1.2fb^{-1} 80420 ± 31 MeV

  more precise than LEP combined…

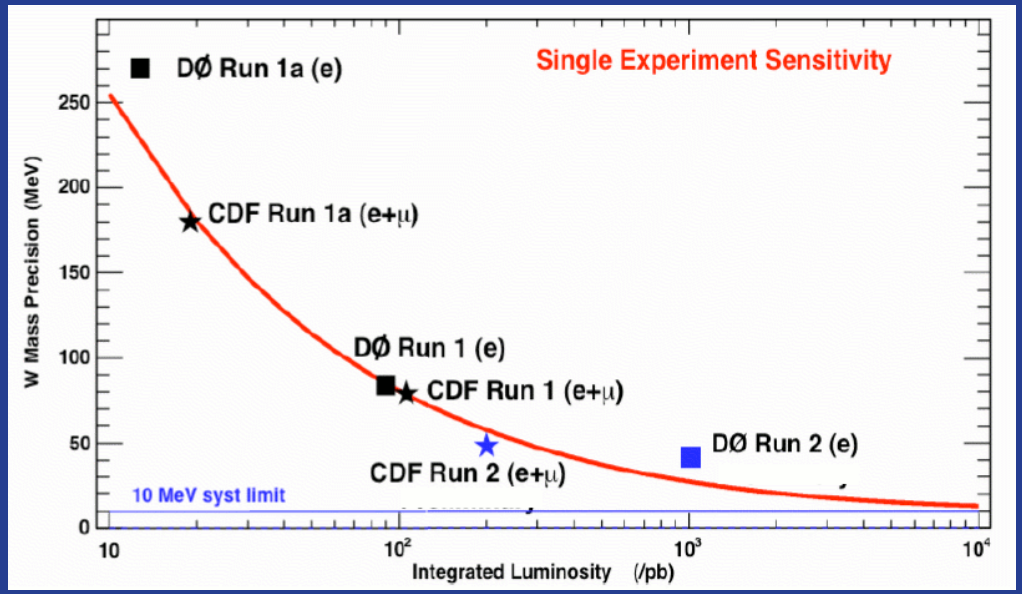




W mass

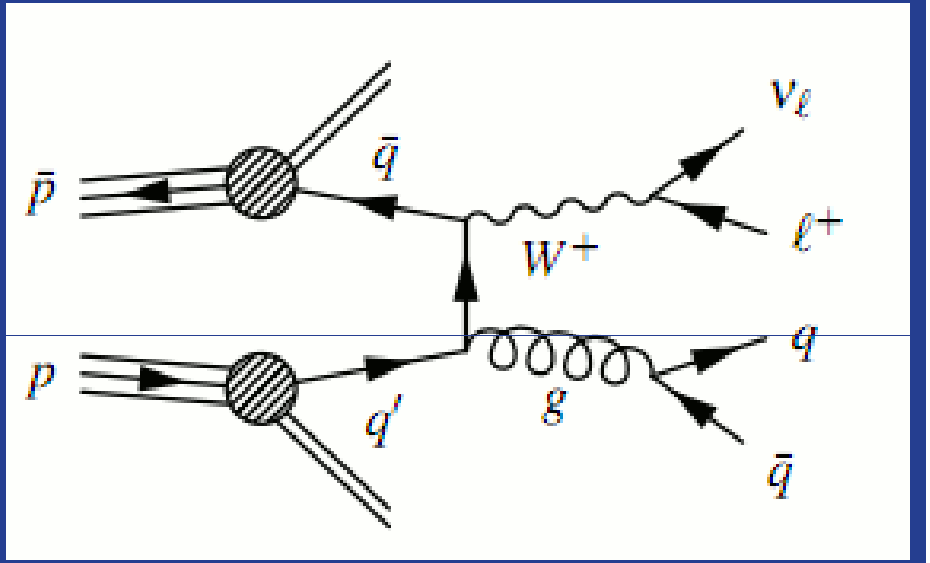
- leading systematics are statistical (green)
- improvements in QED models available
- improved W asymmetry would help PDF
- significant improvement in tracker and calorimeter understanding
- goals is $\delta M = 20$ MeV
- 2fb $^{-1}$ analysis is well underway
- interest in 10fb^{-1}

	electrons	*muons*	*common*
W statistics	48	54	0
Lepton energy scale	30	17	17
Lepton resolution	9	3	-3
Recoil energy scale	9	9	9
Recoil energy resolution	7	7	7
Selection bias	3	1	0
Lepton removal	8	5	5
Backgrounds	8	9	0
production dynamics	3	3	3
Parton dist. Functions	11	11	11
QED rad. Corrections	11	12	11
Total systematic	39	27	26
Total	62	60	



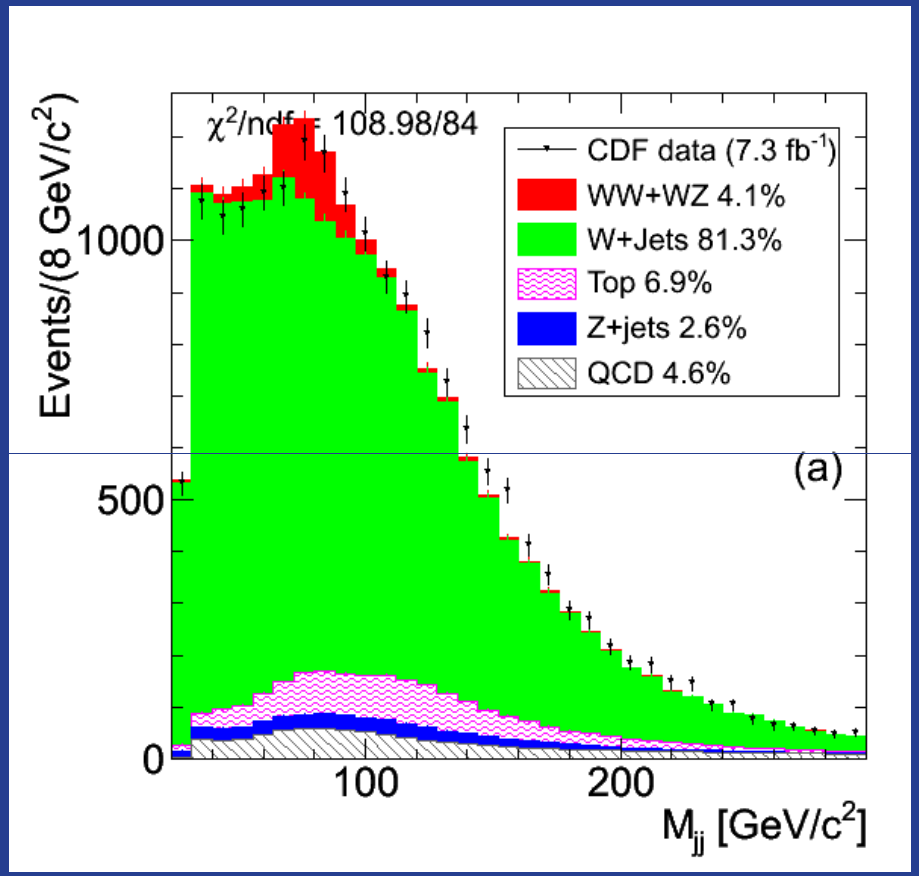
W +2jets

- Selection
  - 7.3 fb^{-1} *just updated!*
  - Isolated e or μ, E_T>20 GeV
  - missing E_T > 25 GeV
  - M_T>30 GeV
  - 2 cone 0.4 jets with E_T > 20 GeV
  - $P_T(jj)$ > 40 GeV



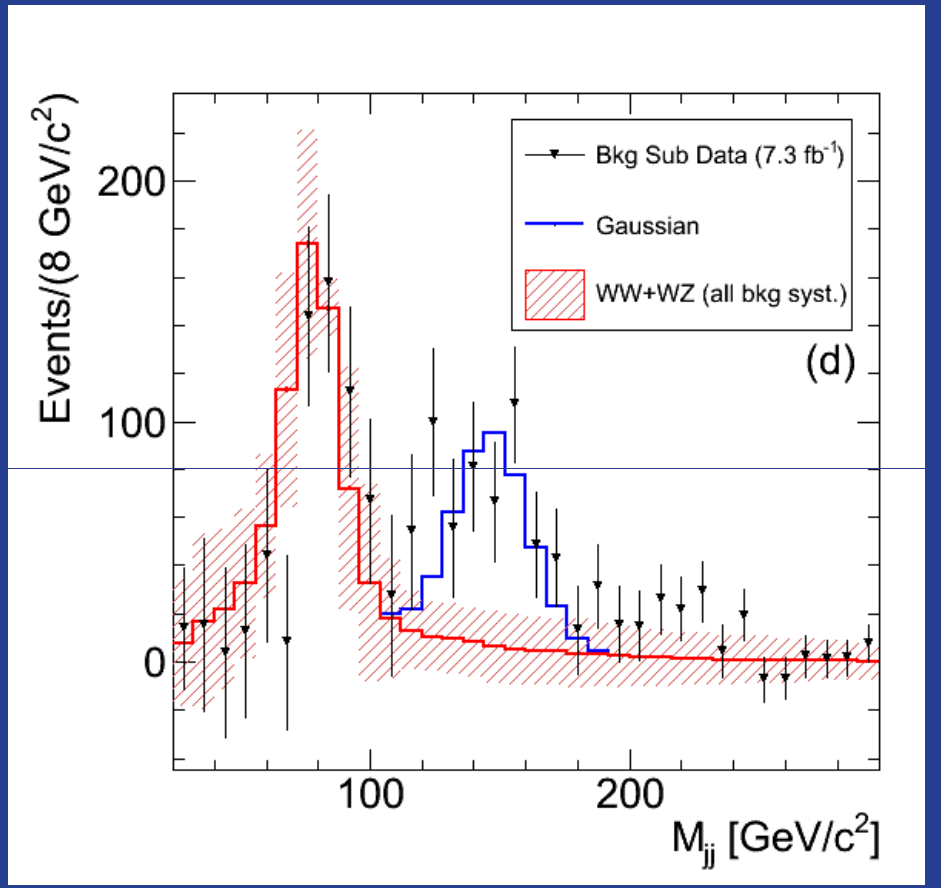
W +2jets

- Backgrounds
  - ► W+jets
    ALPGEN+PYTHIA
    MLM matching
  - ► Z+jets
    ALPGEN+PYTHIA
  - ► top from PYTHIA
  - ► QCD from anti-electron, norm to low missing E_T
  - ► WW/WZ from PYTHIA



W +2jets

- survives initial checks on QCD, W+jets backgrounds
- present in e and μ
- M=147±4
- width consistent with resolution
- not in Z+2j or W+bj
- 4.1 σ w/trials factor and syst
- higher with full lineshapes
- much to follow up on!



Electroweak Group Plans

- W mass 2fb^{-1} underway
- W mass 10 fb^{-1} under consideration
- planning sin θ_W from Z kinematics
- full dataset WW/WZ
- final W asymmetry

- investigations with W+2j excess

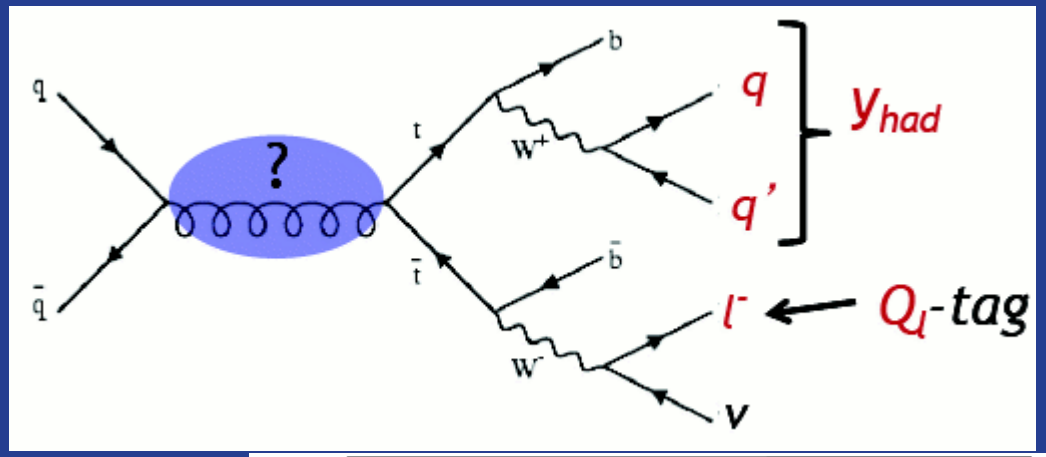
Top

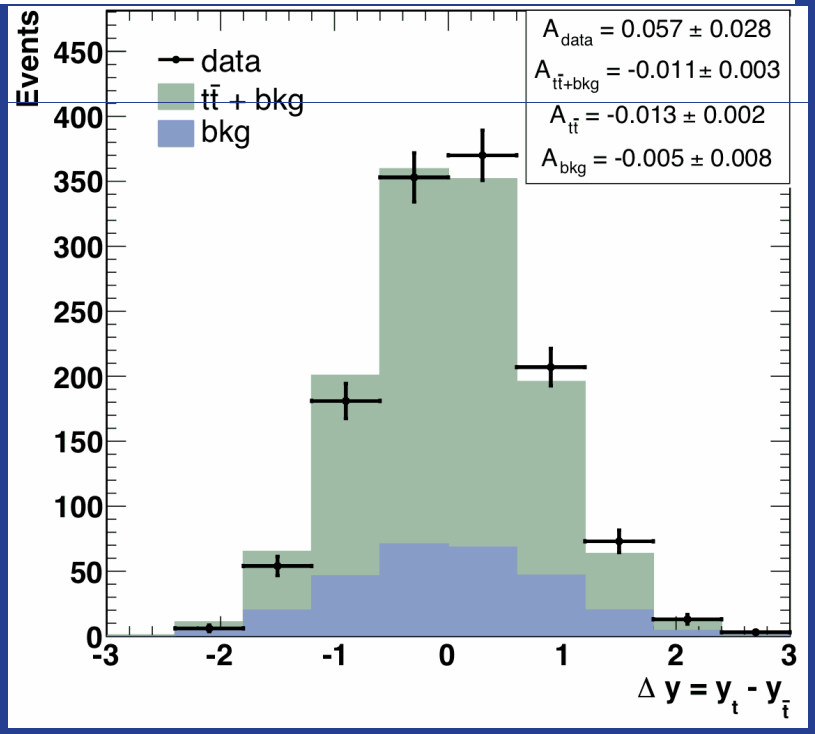
Top Charge Asymmetry

- an asymmetry could indicate a interference with new physics

- 5.3 fb^{-1}
- reconstructed tt in l+jets
- t and tbar consistent (CP)
- parton level, tt frame

Obs: 0.158 ± 0.075 (stat+sys)
QCD: 0.058 ± 0.009 (MCFM)





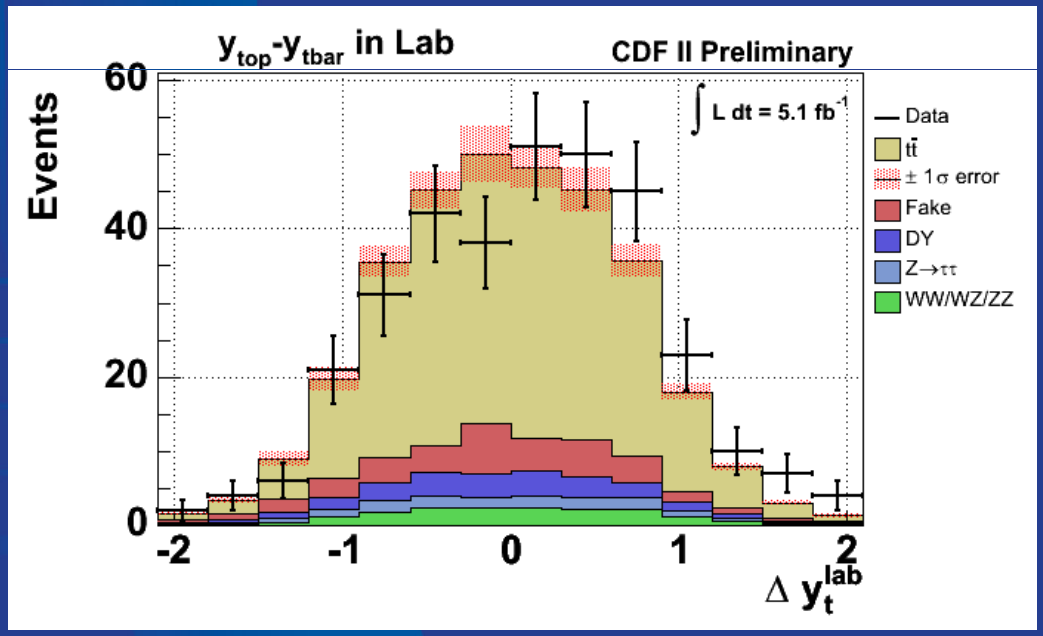
Top Charge Asymmetry

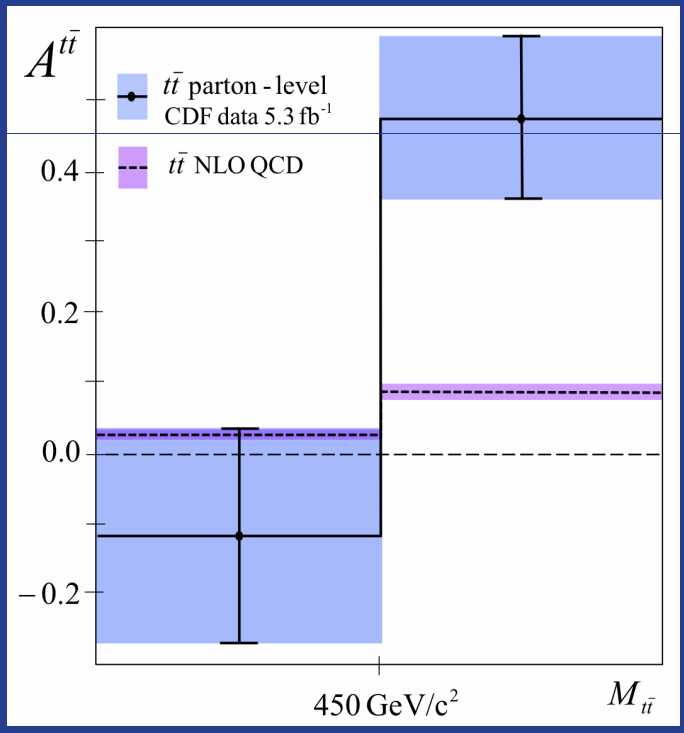
- dileptons are consistent (parton level, tt frame)

$A_{fb\ (corr)} = 0.42 \pm 0.15_{stat} \pm 0.05_{syst}$ $A_{fb\ (theory)} = 0.06 \pm 0.01$

- strongly enhanced for M(tt)>450 GeV

$A_{fb\ (corr)} = 0.475 \pm 0.114$ $A_{fb\ (theory)} = 0.088 \pm 0.013$

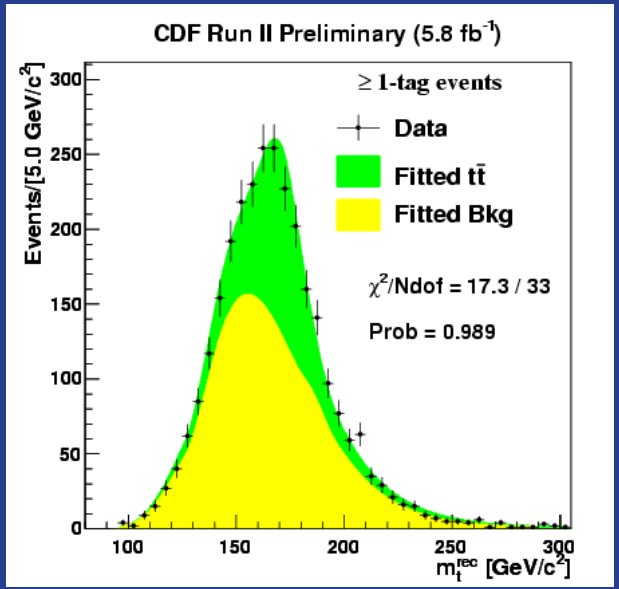


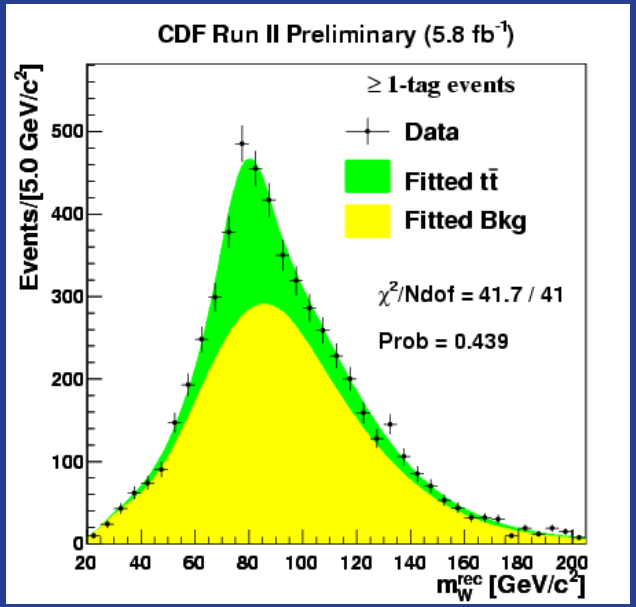


Top Mass in All Hadronic

- 5.8fb^{-1}
- 6,7,8 jets with E_T>15 GeV
- 1,2, or 3 b-tags
- NN kinematics selection
- data-driven background
- unbinned templates
- in situ JES from W peak

M_{top} = 172.5 ± 1.4 (stat) ± 1.0 (JES) ± 1.2 (syst) GeV/c^2 = 172.5 ± 2.0 (total) GeV/c^2

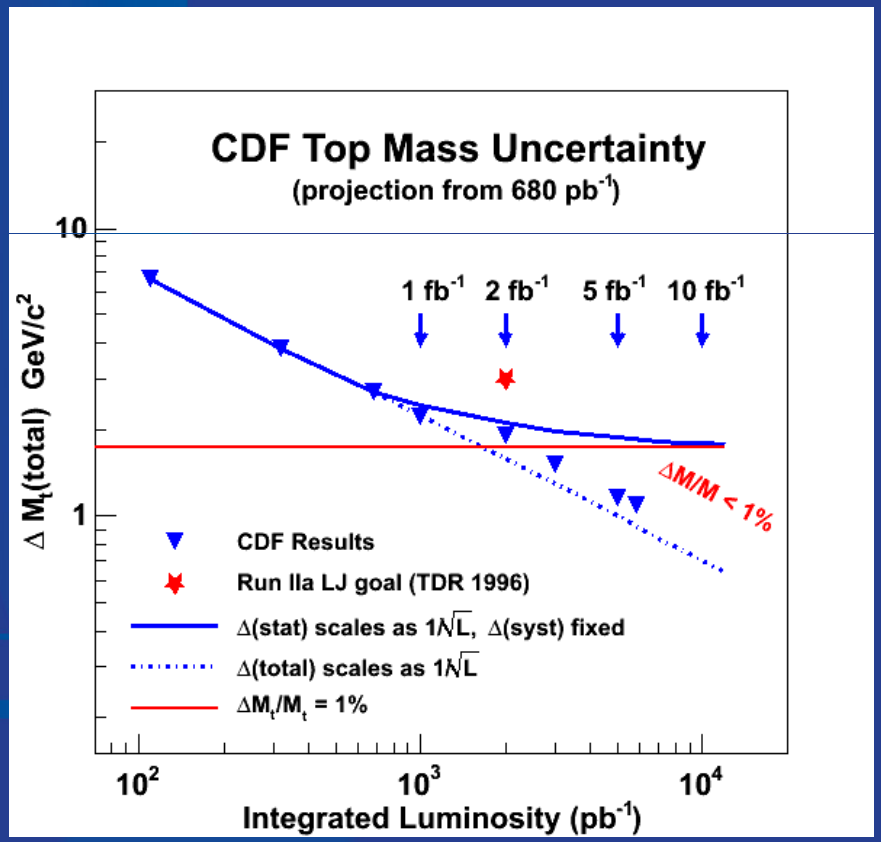


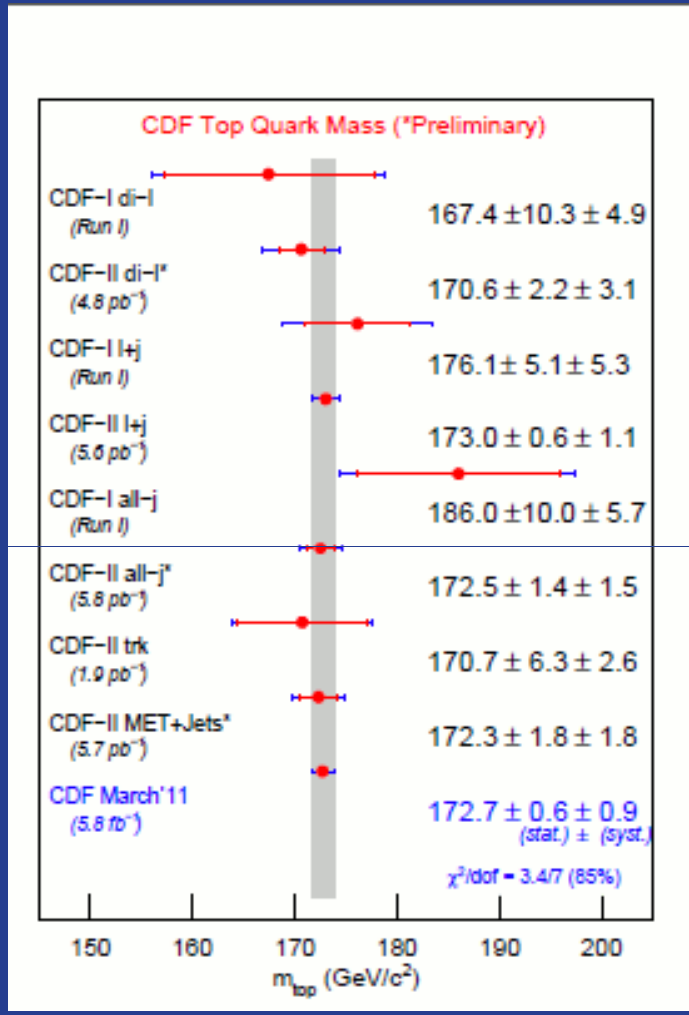


Top Mass

- Winter 2011 CDF combination

M_{top} = 172.70 ± 1.09 (total) GeV/c^2





Top Group Plans

- Completing the CDF top suite
  - single top (S+T channels)
    - this summer and final sample
  - final top mass measurement and combination
    - this summer and final sample?
  - kinematics of top events
  - measurements of spin correlations

- Investigating hints
  - top asymmetry
  - top polarization as a function of asymmetry
  - investigate top charge further

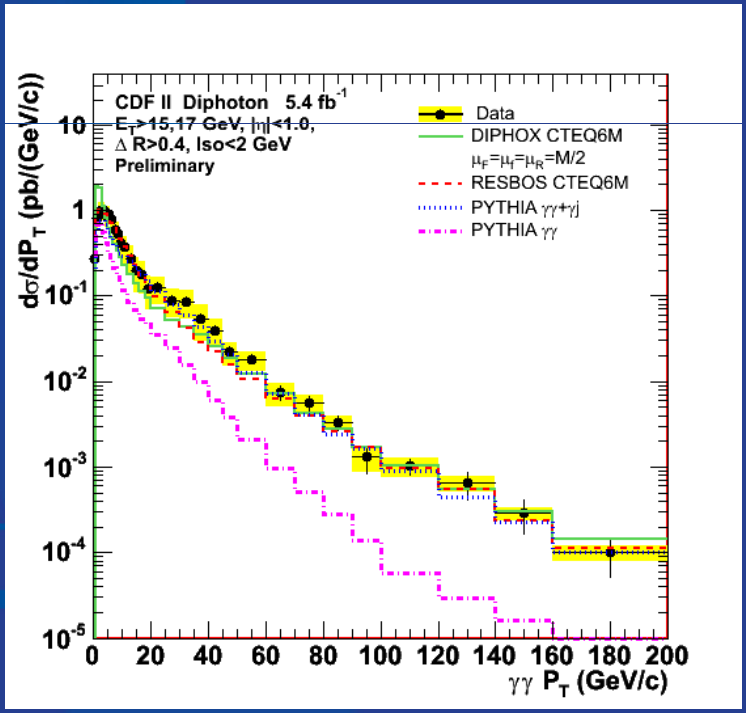
Convery, Pronko: co-convener

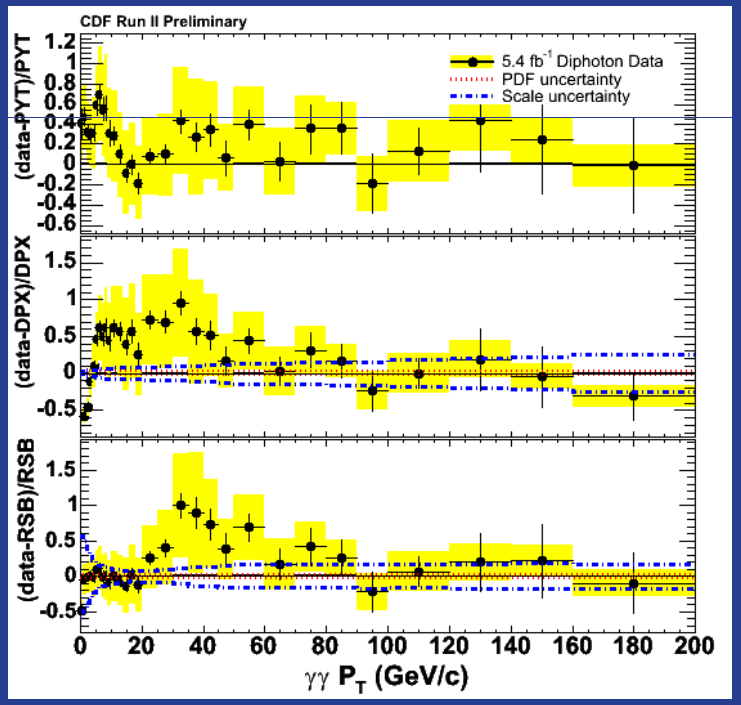
QCD

Diphoton Cross Section

- 5.4 fb-1
- 2 central, isolated photons
- BG subtraction via track iso

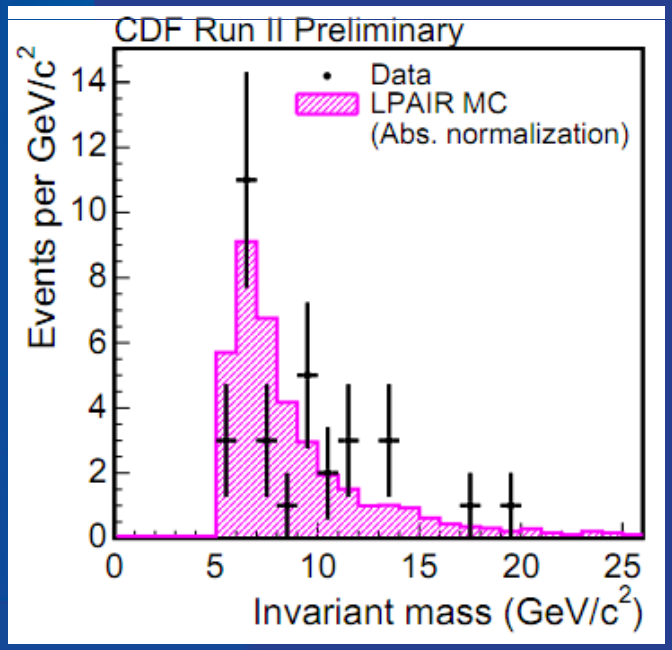
- PYTHIA $\gamma\gamma$
- PYTHIA $\gamma\gamma$ and γj + I/FSR
- DIPHOX N.L.O. w/brem
- RESBOS N.L.O. with resummed gluon emission

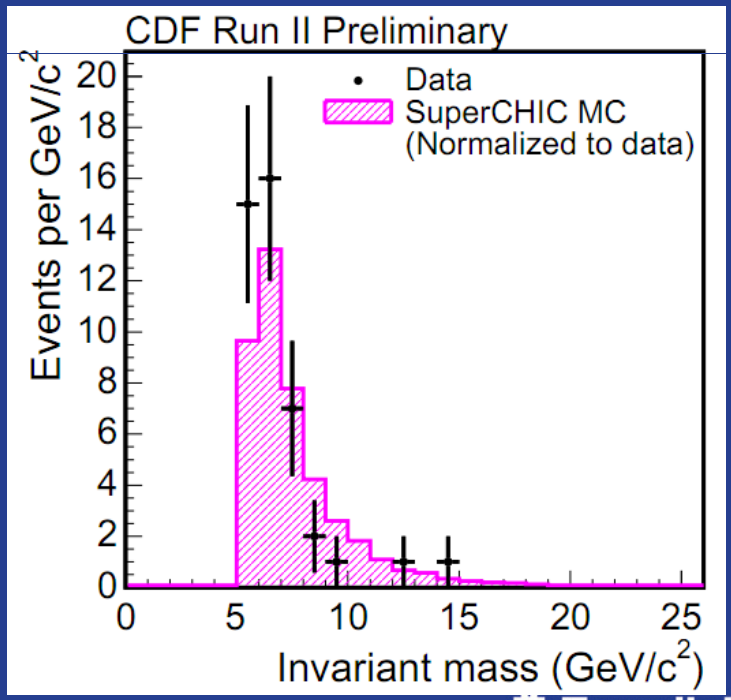




Exclusive Diphoton Production

- colorless exchange
- 1.1 fb^{-1}
- E_T > 2.5 GeV
- 32 exclusive e^+e^- events (a QED control sample)
- 43 exclusive $\gamma\gamma$ events, <16% di-π^0





QCD Group Plans

- most measurements are unique to the Tevatron, but …

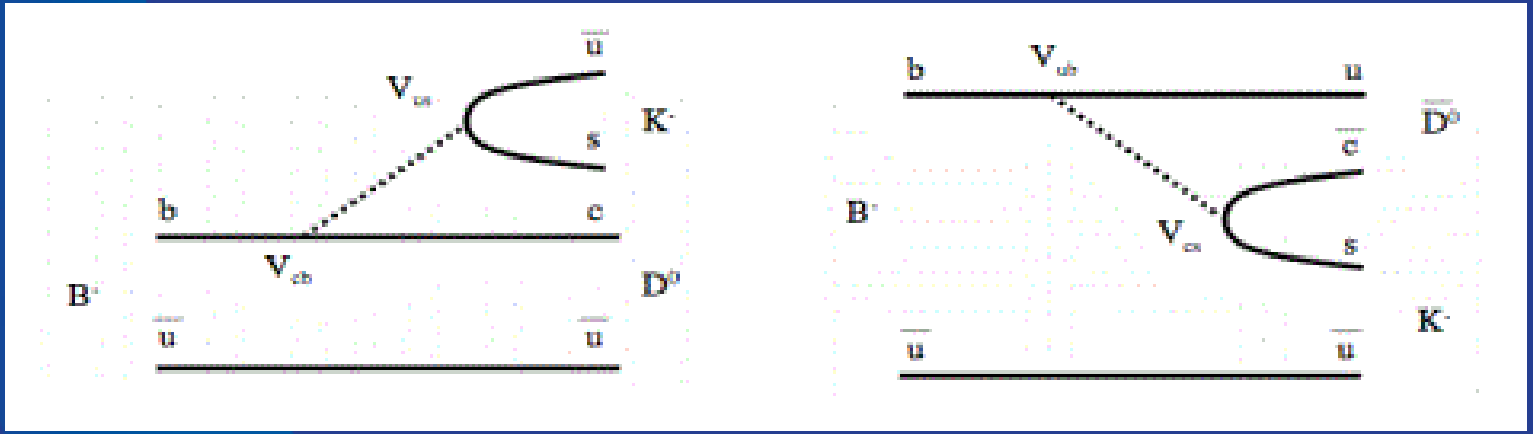
- fundamentals have been addressed
- many are systematics or theory limited

- limited personpower

B Physics

CP Violation in B →Dh

- Branching fractions and CP asymmetries of
  $B^{\pm} \rightarrow D^0 h^{\pm}$, $D^0 \rightarrow K^-\pi^+$ or $K^+\pi^-$ (CF and DCS decay)
- leads to a measurement of the γ angle
- clean method – no tagging or time-dependence
- first measurement at a hadron collider, "ADS" method
- uses the silicon impact parameter trigger (SVT)



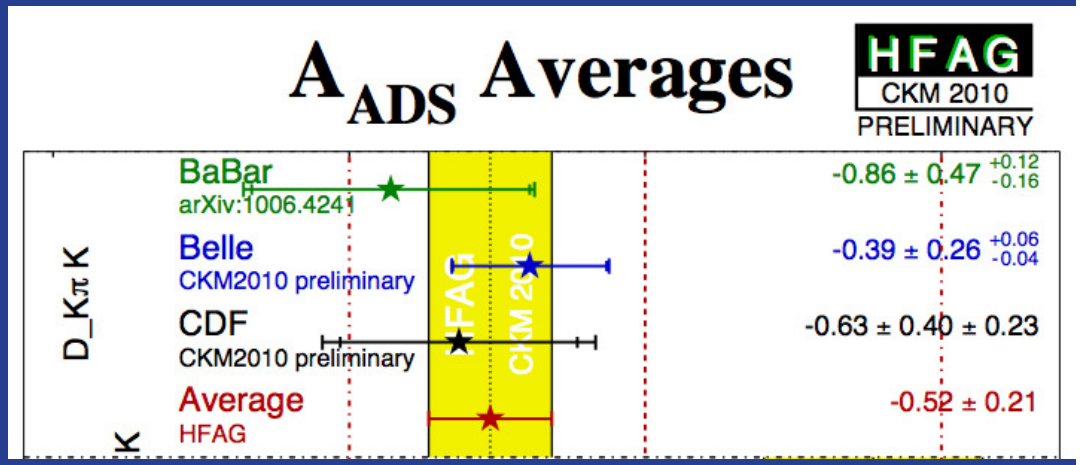
CPV in B →Dh

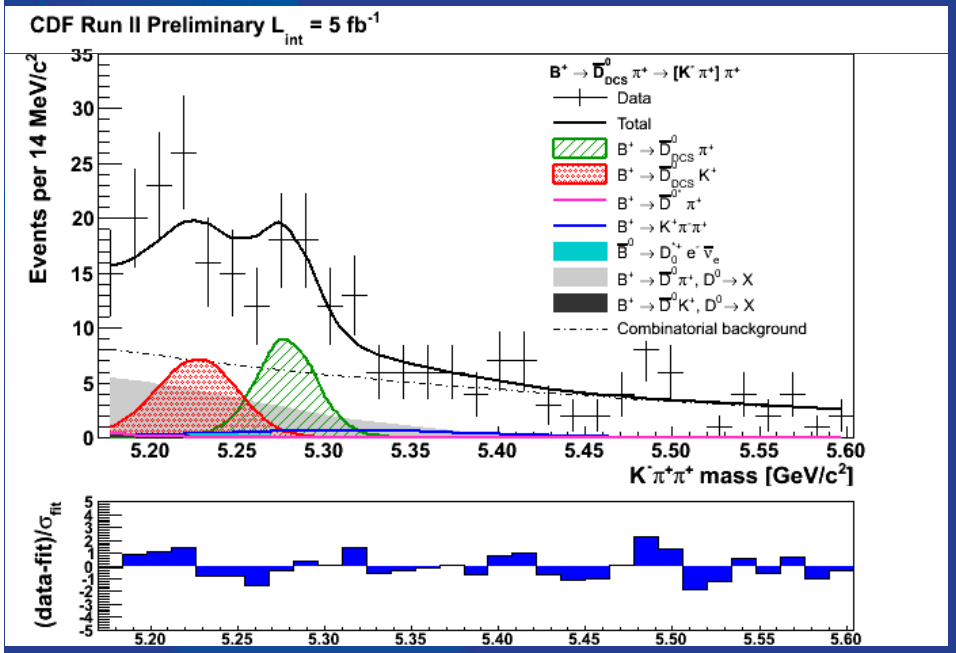
$$R_{ADS}(\pi) = (4.1 \pm 0.8(stat.) \pm 0.4(syst.)) \cdot 10^{-3}$$

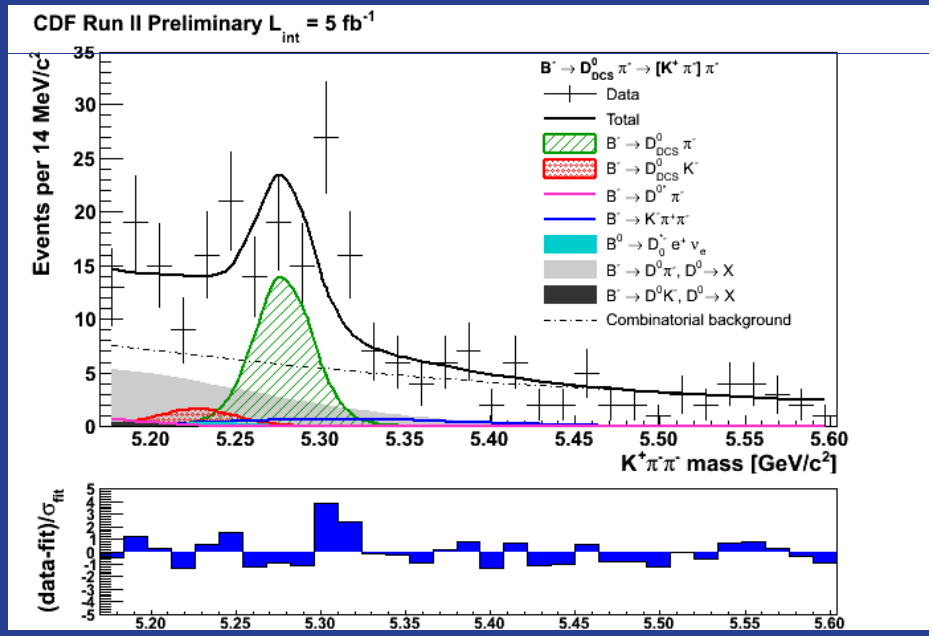
$$R_{ADS}(K) = (22.5 \pm 8.4(stat.) \pm 7.9(syst.)) \cdot 10^{-3}$$

$$A_{ADS}(\pi) = 0.22 \pm 0.18(stat.) \pm 0.06(syst.)$$

$$A_{ADS}(K) = -0.63 \pm 0.40(stat.) \pm 0.23(syst.)$$





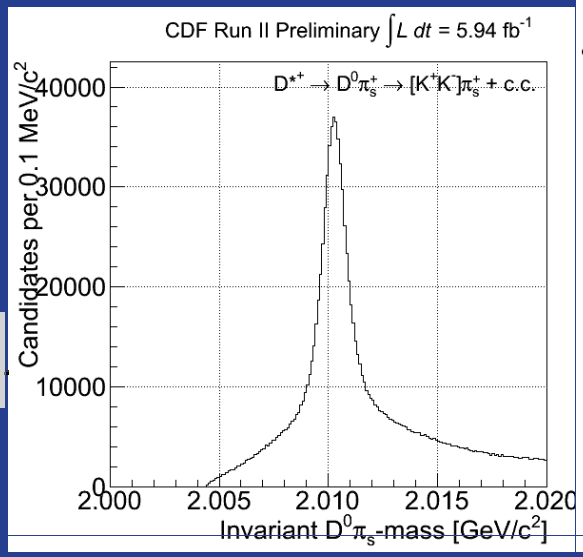


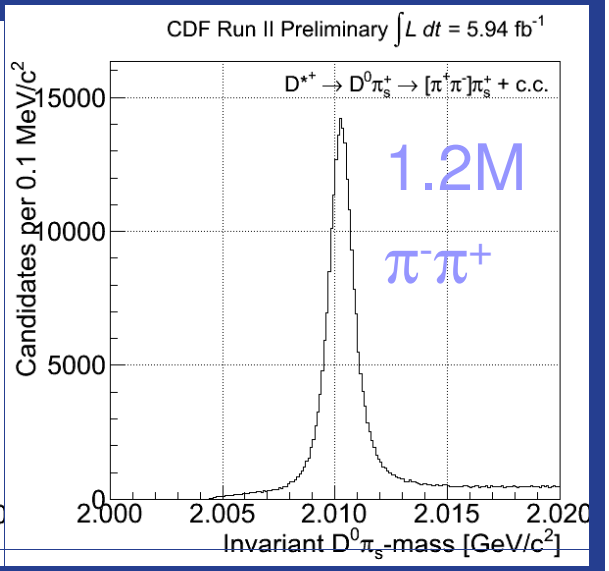
CP Violation in Charm Decays

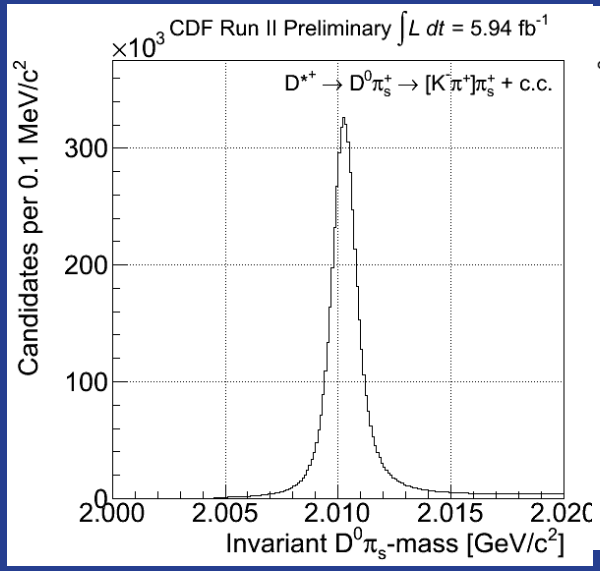
- CPV in charm would point to new physics
- Asymmetry

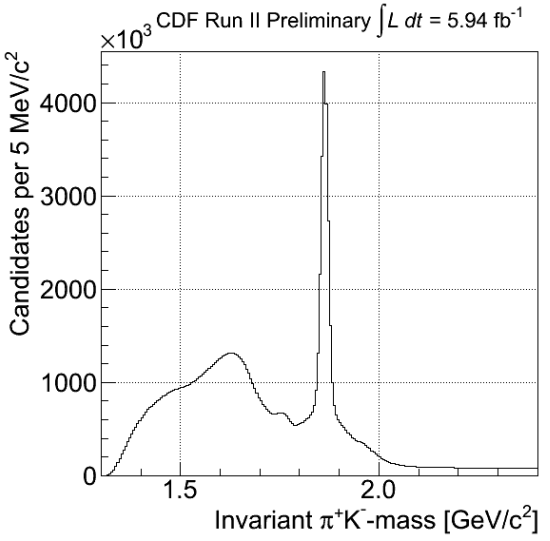
$$A_{CP}(h^+h^-) = \frac{\Gamma(D^0 \to h^+h^-) - \Gamma(\overline{D}^0 \to h^+h^-)}{\Gamma(D^0 \to h^+h^-) + \Gamma(\overline{D}^0 \to h^+h^-)}$$

- Negligible penguin contribution to charm decays in SM
- D* tag for charm or anti-charm
- Use data to correct for detector asymmetry



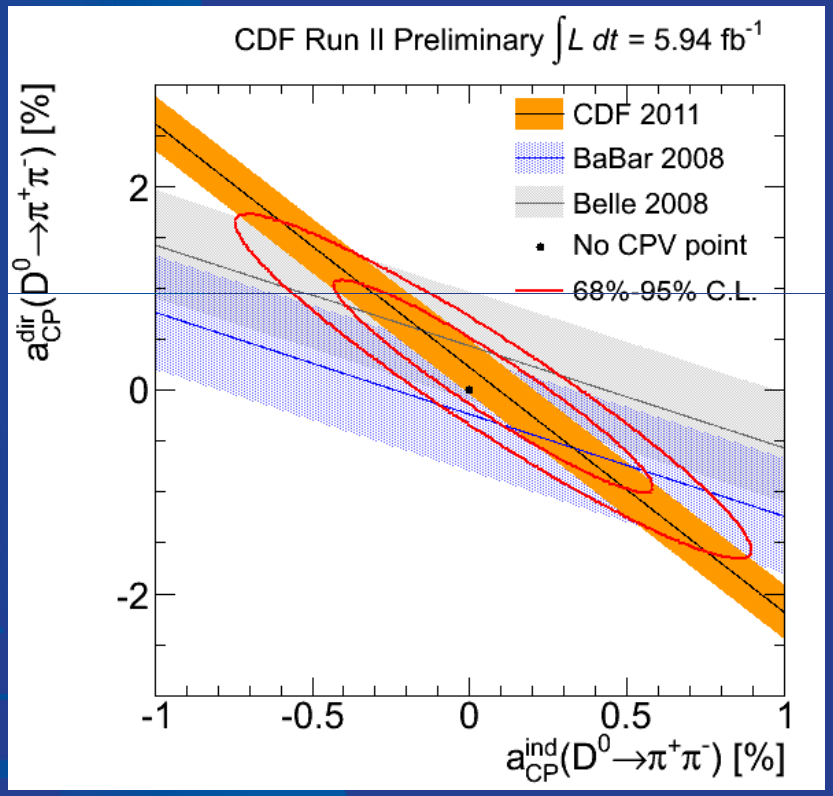


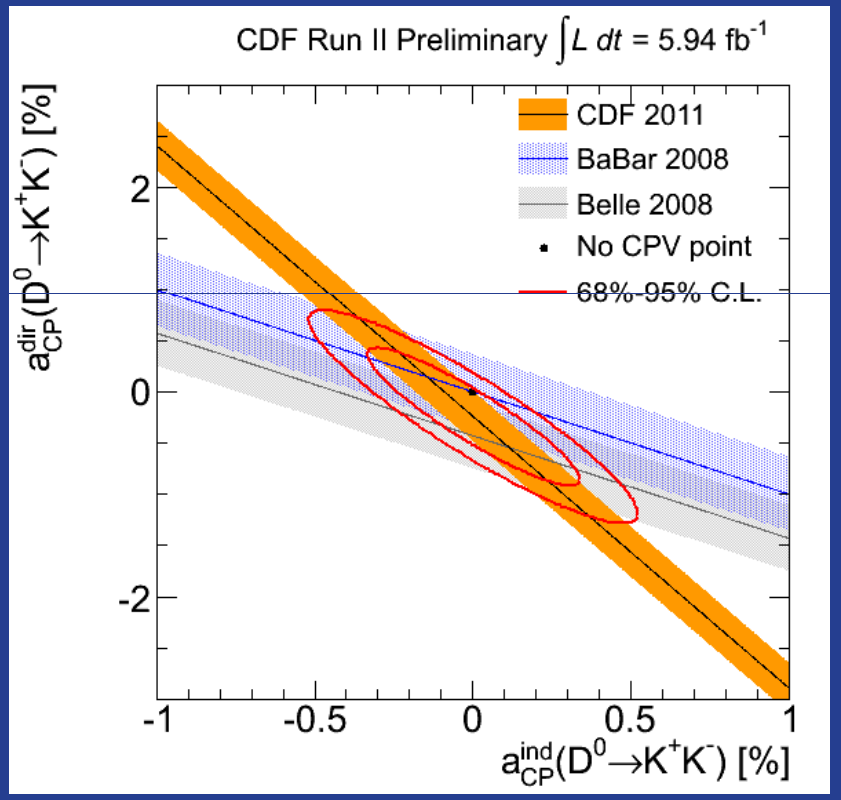




CP Violation in Charm decays

$$A_{CP}(D^0 \to \pi^+\pi^-) = [+0.22 \pm 0.24\ (\text{stat.}) \pm 0.11\ (\text{syst.})]\ \%$$
$$A_{CP}(D^0 \to K^+K^-) = [-0.24 \pm 0.22\ (\text{stat.}) \pm 0.10\ (\text{syst.})]\ \%.$$





- Expect to be world's best for several years!

B Physics Group Plans

Finishing shortly

- $B_{d/s} \rightarrow \mu\mu$
- sin 2(βs)
- $B_{d,s} \rightarrow hh$
- $B \rightarrow K(*)\mu\mu$
- D mixing

Mid term

- B_s $\Delta\Gamma$ from $B_s \rightarrow$ • D_sD_s,
- measurement of Υ polarization
- A_{SL} measurement in response to DØ

Unique in the long term

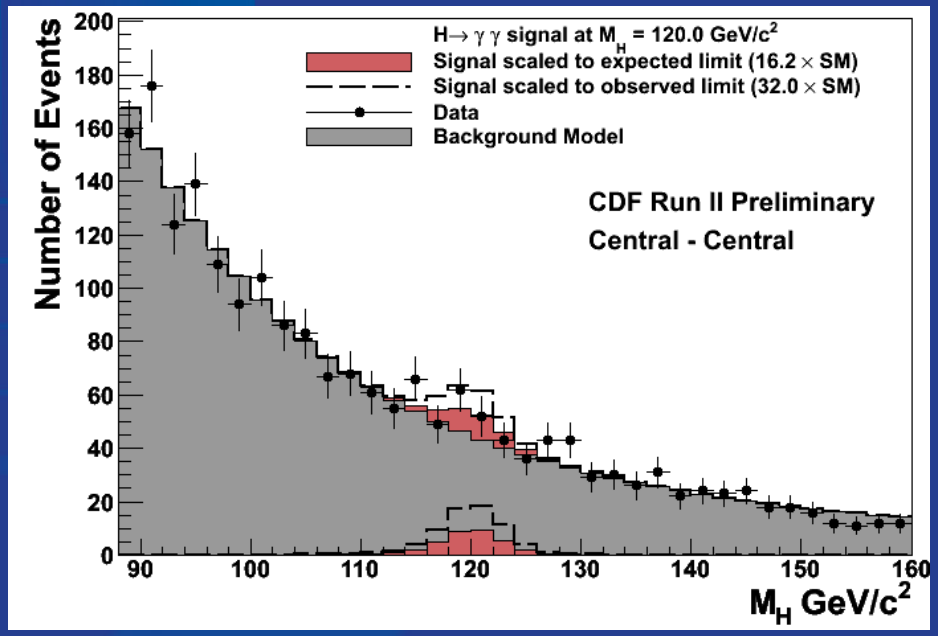
- production cross-sections, polarizations, etc...
- precise CPV where p-pbar collisions are crucial to ensure no CP-asymmetry is present at production

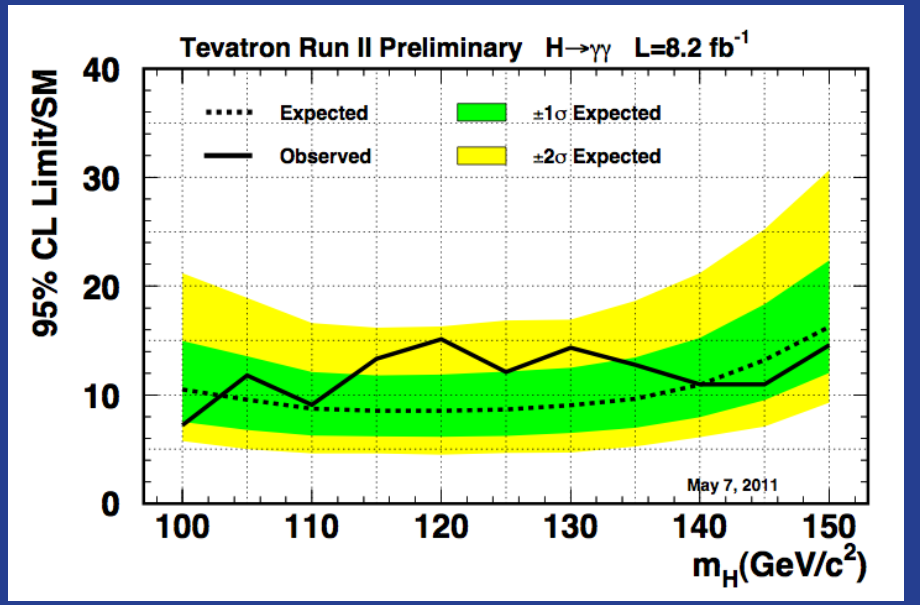
James, Kilminster: co-conveners

Higgs

SM $H \rightarrow \gamma\gamma$

- two photons+
- several firsts in techniques!
- CDF limits ~13xSM,
  combined with DØ's: ~8 xSM
- derived fermiophobic limit
  H> 114 GeV – world's best!



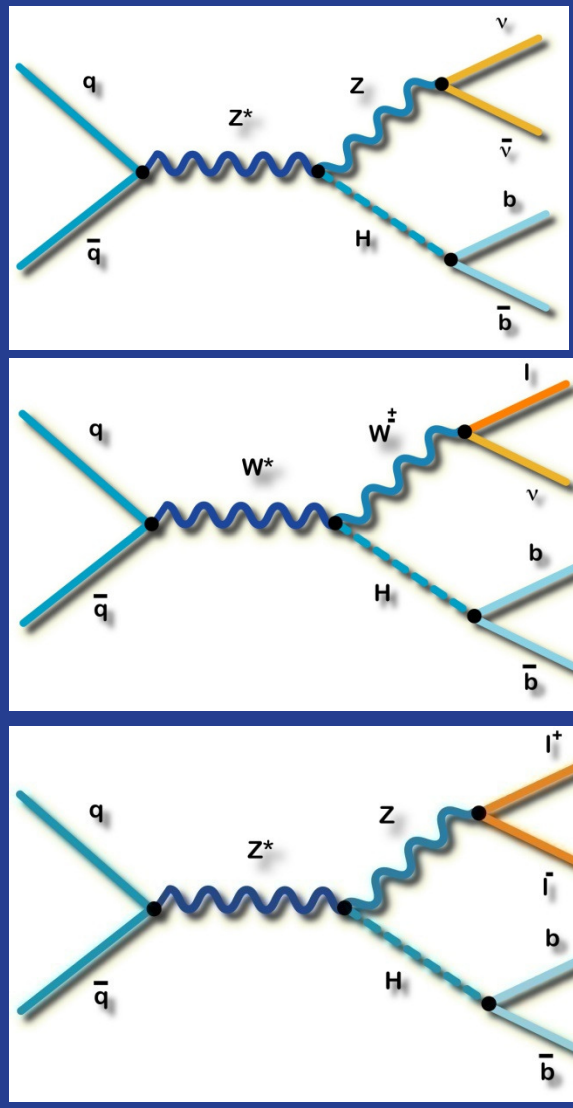


Fermilab

SM Higgs - Low-mass

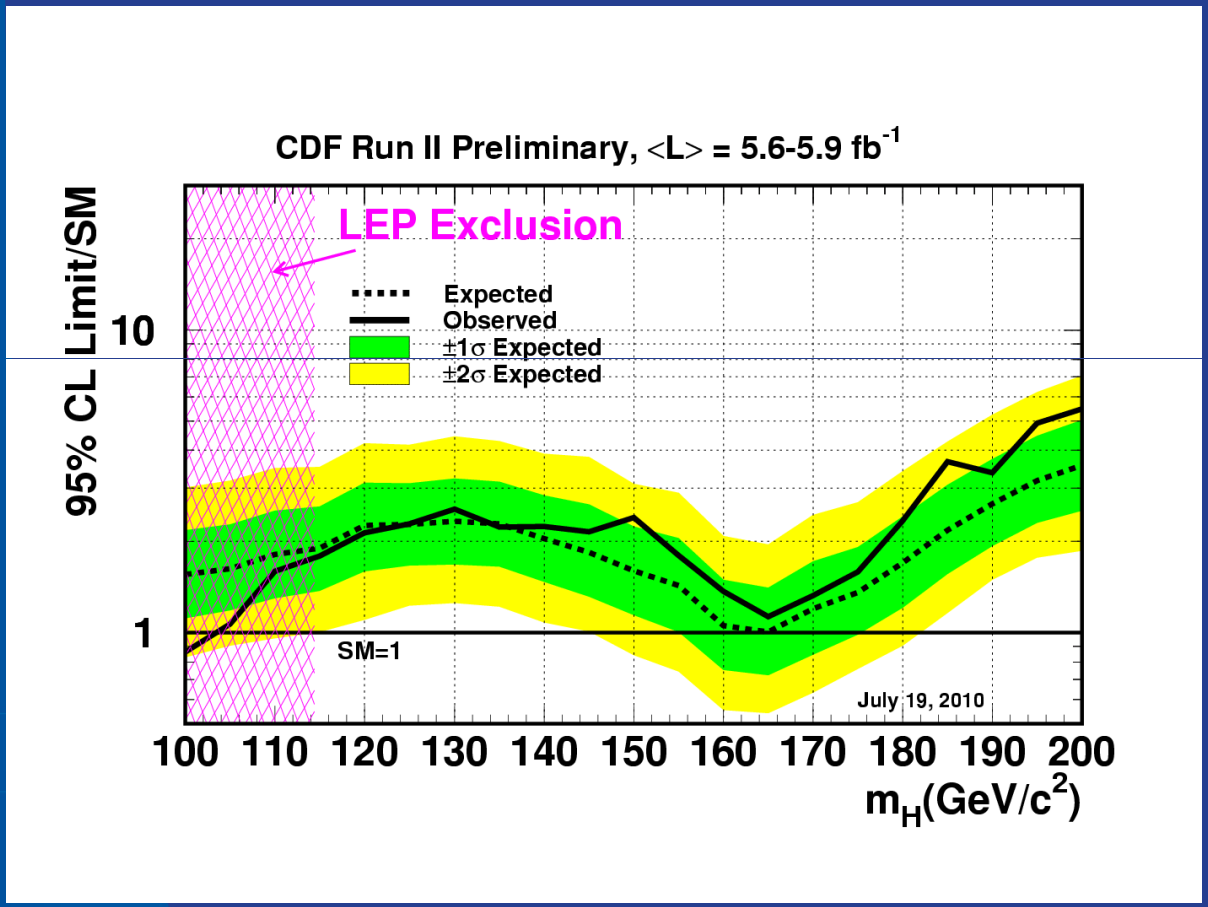
Kilminster, Freeman, Group, Rusu, Pronko, Junk

Channel	Luminosity (fb^{-1})	Sensitivity (xSM @115 GeV)
WH → lνbb (2j, neural networks)	5.7	3.48
WH → lνbb (3j, matrix element)	5.6	3.5
VH → MET bb	5.7	4
ZH → llbb	5.7	5.48
H→ ττ	2.3	24.5
VH → jjbb	4.0	17.8
H→ γγ	5.4	20.8
H → WW → lνlν	5.9	10.5

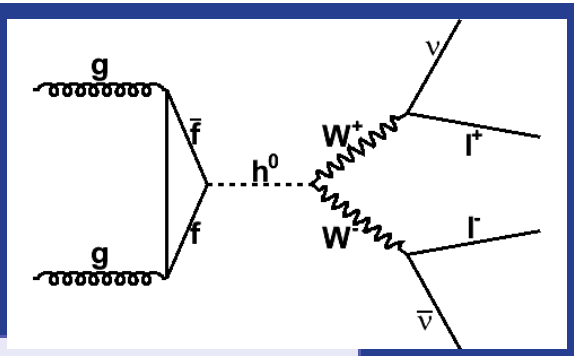


SM Higgs - Low-mass

SM Higgs limit, CDF-only, low and high mass analysis, 5.9 fb^{-1}



SM Higgs - High-mass



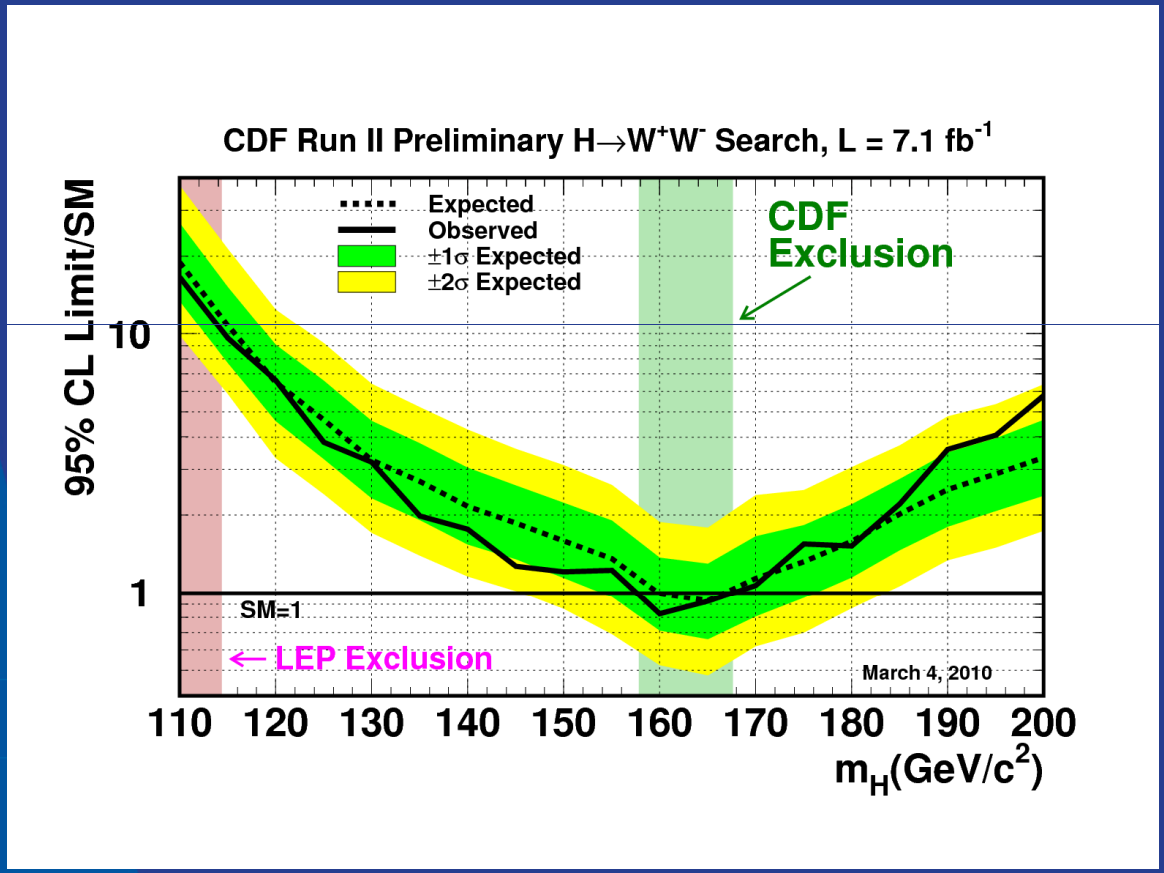
Channel	Main Signal	Main Background	Most Important kinematic variables
OS dileptons, 0 Jets	gg→H	WW	LR_{HWW}, ΔR_{ll}, H_T
OS dileptons, 1 Jet	gg→H	DY	ΔR_{ll}, $m_T(ll,E_T)$, $\not{E}_T$
OS dileptons, 2+ Jets	Mixture	t-tbar	H_T, ΔR_{ll}, M_{ll}
OS dileptons, low M_{ll}, 0 or 1 Jet	gg→H	W+γ	$p_T(l2)$, $p_T(l1)$, $E(l1)$
SS dileptons, 1+ Jet	WH→WWW	W+Jets	$\not{E}_T$, $\sum E_T^{jets}$, M_{ll}
Tri-leptons, no Z candidate	WH→WWW	WZ	$\not{E}_T$, ΔR_{ll}^{close}, Type(lll)
Tri-leptons, Z candidate, 1 Jet	ZH→ZWW	WZ	Jet E_T, ΔR_{lj}, $\not{E}_T$
Tri-leptons, Z candidate, 2+ Jets	ZH→ZWW	Z+Jets	M_{jj}, M_T^H, ΔR_{WW}
OS dilepton, electron + hadronic tau	gg→H	W+Jets	$\Delta R_{l\tau}$, τ id variables
OS dilepton, muon + hadronic tau	gg→H	W+Jets	$\Delta R_{l\tau}$, τ id variables

James, Jindariani, Junk

SM Higgs - High-mass

SM Higgs exclusion, CDF only, high-mass analysis only, 7.1fb^{-1}

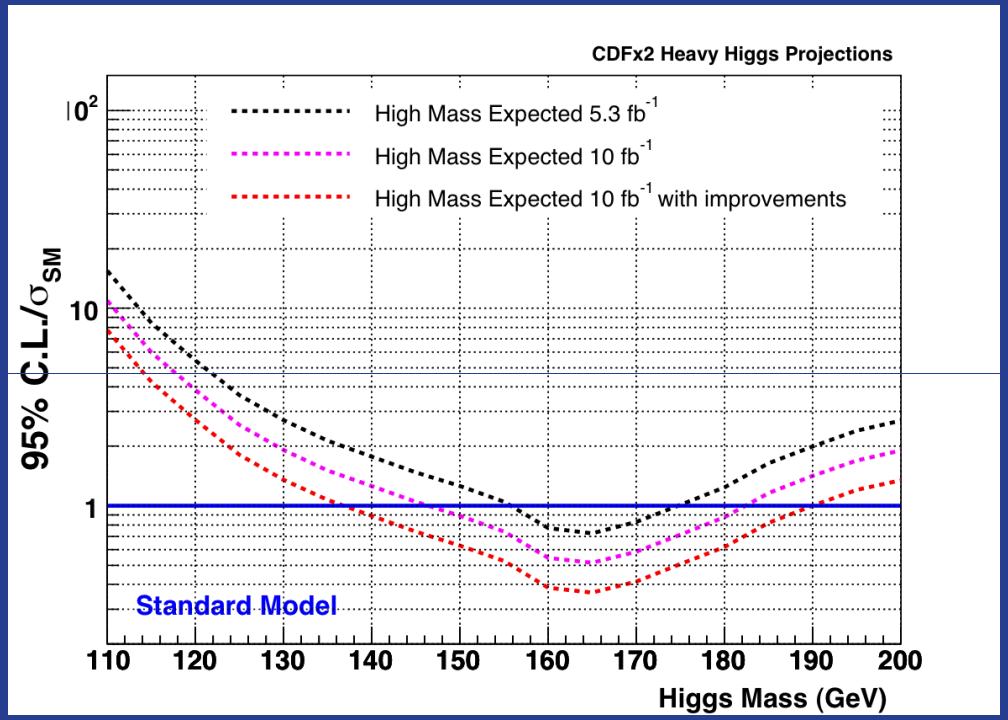
158-168 GeV



Combined with DØ 158-172 GeV

SM Higgs - High-mass plans

- New combination for summer 2011
  - ► lepton isolation overlaps
  - ► improved plug ID
  - ► new categories
- expect to achieve almost all projected improvements
- LHC expected to become competitive summer 2011



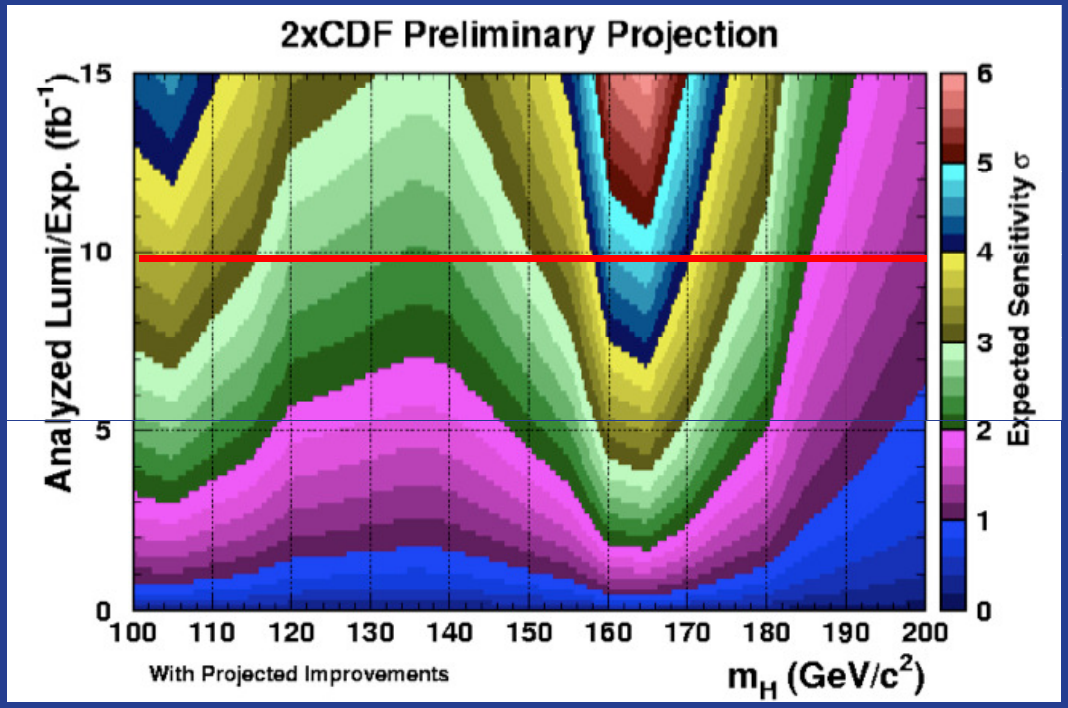
SM Higgs - Low-mass, Plans

- New combination for summer 2011 - not all improvements will be available or included in all channels
- In progress
  - ► lepton ID: advanced selection, using all that were triggered
  - ► mass resolution: incorporating particle flow ideas, optimized energy corrections, event techniques
  - ► B-tagging: Freeman, Junk, Kirby
    - o 10% improvement in 40% of data from reprocessing – done!
    - o 10+% additional from combined, re-optimized algorithms
- Final combination for winter 2012, or summer 2012 if necessary
- LHC competitive with $H \rightarrow \gamma\gamma$ with few fb^{-1}, WH with 30 fb^{-1}

SM Higgs Final Word

- Expect to collect 10 fb^{-1} by October
- Significant improvements for this summer
- More improvements for the final result in 2012

- We expect to be able to meet our most recent sensitivity projections



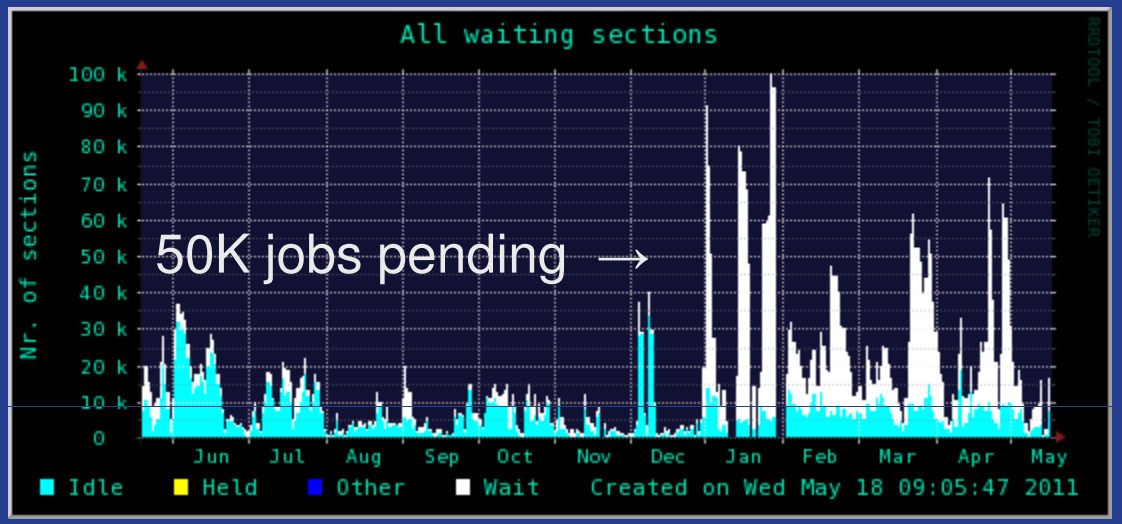
- with 90% of expected improvements
- 2xCDF

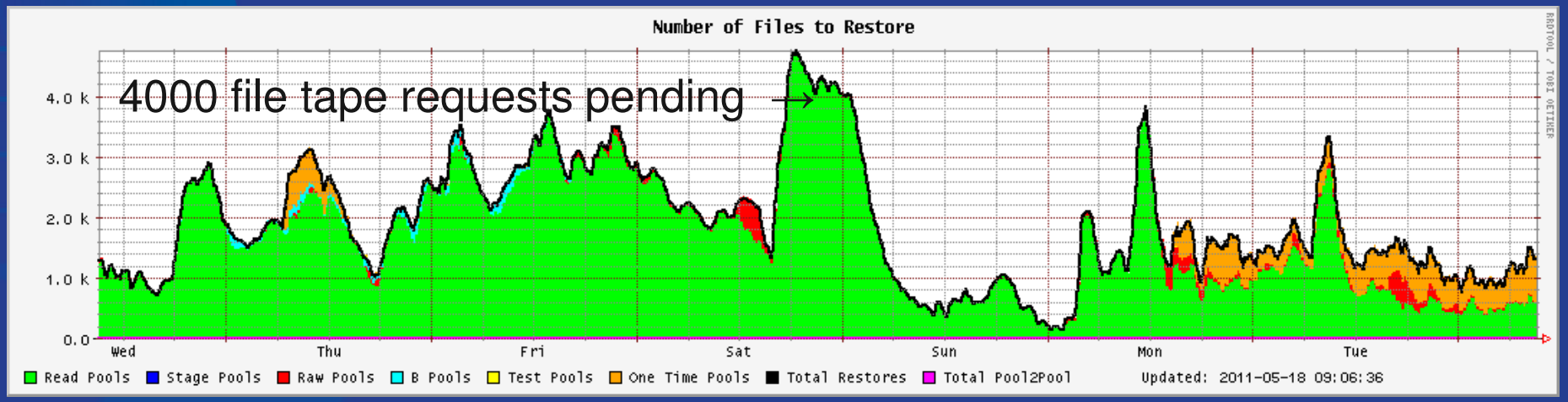
All the Rest

Computing Resources

- demand similar to previous years
- CPU at capacity
- tape drive capacity a notable annoyance
- major dCache upgrade
- deprecating diskpool

FNAL group participation:
RLC, G&V : Co-Leader
G&V: Operators, experts…





Computing Plans

- At capacity last year
- Expectation to continue at capacity in FY12
  - surge for final Higgs results
  - final data milestone legacy activity
  - scheduled special projects
  - small probability of a large reprocessing
- Anticipate a notable decrease in demand for FY13
- CD/CDF M&S Budgets:
  - current levels enable primary physics goals, but limit the pace and restrict options

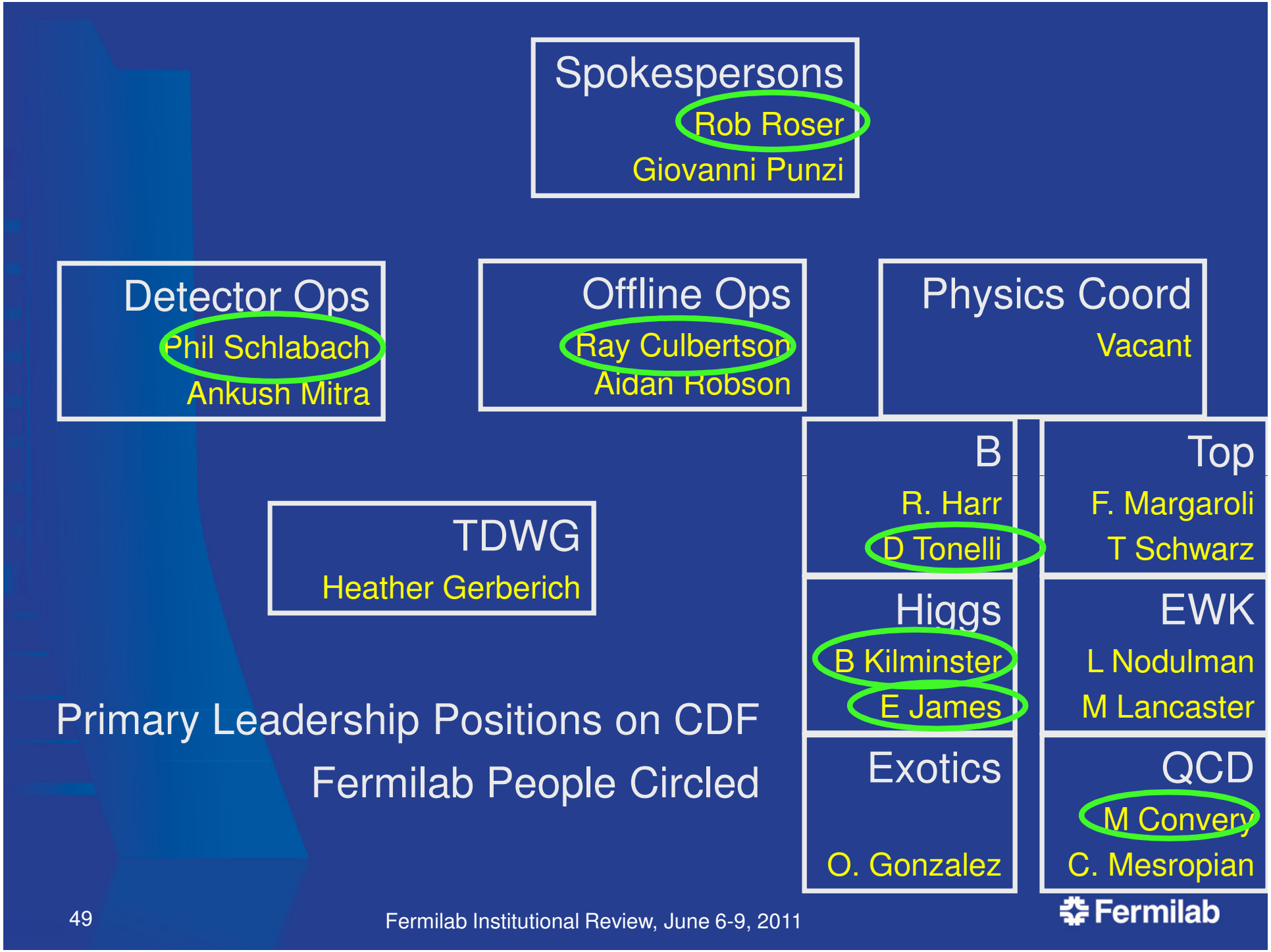
Data Preservation

- Continue full physics capability for 5y
  - ► requires:
    - farm and interactive CPU
    - access to all data
    - production and ntupling capability
    - full MC simulation, with standard generators
  - ► 1y full capacity (FY12), 1 reduced, 3 as negotiated
  - ► requires planning and funding (for ex. tape migration)
- Continuing past 5y
  - ► concepts under discussion
  - ► how will LHC discoveries overlap Tevatron data?
  - ► will require funding and attracting experts

Guests and Visitors

- Supports operations
  - operations co-leaders
  - operators and ops managers
- Supports computing
  - offline co-leaders
  - group leaders, operators
- Supports physics
  - physics leaders support

- FY12 request realizes savings from the end of operations, and asks continued offline and physics support
- shortfalls in FY12, 13 will put physics goals in greater risk
- with downsizing workforce and ambitious goals, we strive to maximize the effectiveness of each analyzer - traveling to and working at the lab is a huge help !


Spokespersons
Rob Roser
Giovanni Punzi
Detector Ops
Phil Schlabach
Ankush Mitra
Offline Ops
Ray Culbertson
Aidan Robson
Physics Coord
Vacant
B
R. Harr
D Tonelli
Top
F. Margaroli
T Schwarz
TDWG
Heather Gerberich
Higgs
B Kilminster
E James
EWK
L Nodulman
M Lancaster
Exotics
O. Gonzalez
QCD
M Convery
C. Mesropian
Primary Leadership Positions on CDF
Fermilab People Circled

Fermilab Group Research Associates

	Name	Start Date	Present Position
1.	J.Goldstein	1998	Rutherford Appleton Laboratory, Scientific Staff
2.	M.Bishai	1998	Brookhaven National Laboratory, Scientific Staff
3.	T.Nelson	1998	SLAC, Scientific Staff
4.	P.Gris	1999	Clermont-Ferrand, Faculty
5.	J.Dittman	1999	Baylor University, Faculty
6.	A.Meyer	1999	University of Aachen, Faculty
7.	R.Erbacher	1999	University of California, Davis, Faculty
8.	P.Merkel	2000	Purdue University, Associate Scientist
9.	A.-P.Colijn	2000	University of Amsterdam, Faculty
10.	M.Martinez	2001	University of Barcelona, Faculty
11.	C.-J.Lin	2001	Lawrence Berkeley National Laboratory, PDG Scientist
12.	N.Kuznetsova	2001	Hamilton College, Faculty (Astrophysics)
13.	J.Thom	2002	Cornell University, Faculty
14.	B.Reisert	2003	University of Munich, Faculty
15.	K.Anikeev	2004	IBM Analyst
16.	R.Eusebi	2005	Texas A&M University, Faculty
17.	E.Yu	2005	University of Taiwan , faculty
18.	K.Sato	2006	University of Tsukuba, faculty
19.	S.Burke	2007	APS Congressional Fellow
20.	A.Pranko	2005	UC Berkeley, Chamberlain Fellow
21.	C.Group	2007	University of Virginia, Faculty
22.	K Palencia	2007	CERN Fellow
23.	D. Tonelli	2007	Northwestern University
24.	S. Carrone	2009	SLAC Staff
25.	M. Morello	2010	INFN

22 of the 24 Run II RA's have tenure – track faculty level positions!

Current RA's

	Name	Start Date
1.	M.Datta	2005
2.	A.Golossanov	2005
3.	P. Movilla	2006
4.	S. Jindariani	2007
5.	J. Freeman	2007
6.	K. Knopfel	2010

Conclusions

- CDF had another banner year
  - ► maintained physics despite loss of personpower!
- For FY12, expect to need analysis resources at level of FY11
  - ► plan full Higgs combinations this summer and final combination for winter 2012, possibly summer 2012
    We expect significant improvements at each step!
  - ► other analysis will surge, triggered by the availability of the full dataset, then decrease over the year
- for FY13, expect a notable decrease in analysis activity
- Our greatest challenge in completing the CDF legacy is in maintaining the high level of analysis effort – people!
- Finish strong now - *Strike while the iron is hot!*

Fermilab Group Scientific Effort

Senior Scientists

M. Albrow*

R. Culbertson
D. Glenzinski*
E. James*

S. Lammel
J. Lewis
M. Lindgren*
T. Liu*
P. Lukens*
K. Maeshima*
R. Moore*
A. Mukherjee*
P. Murat
R. Roser
P. Schlabach
R. Snider
R. Tesarek*
G. Velev*
R. Wagner*
W. Wester*
S. Wolbers*

Associate Scientists

F. Canelli* (WF)(JA)
B. Kilminster*
V. Rusu (WF)
C. Group *(JA)

Application Physicists

S. Hahn
M. J. Kim*
E. J.J. Schmidt
J.-C. Yun*
Tom Junk
Michelle Stancari

Engineering Physicists

Halley Brown

Guest Scientists

G. Bellettini
M. Corbo (IF)
M. Casara
V. Cavaliere (IF)
N. Kuzhetskiy
J Vizan (IF)
P. Catastini
M. Mondragon (IF)
A. Di Canto (IF)
G. Punzi
L. Ristori
C. Vellidas (IF)
B. Di Ruzza (F)
P. Giromini
M. Trovato (IF)
P. Squillacioti

*Also contributes significant effort (>20%) to another thrust
WF – Wilson Fellow
IF – International Fellow
JA – Joint Appointment with the University of Chicago