
Searches at CDF

Ray Culbertson, FNAL August 4, 2004

Status of CDF Detector

New plug Calorimeter

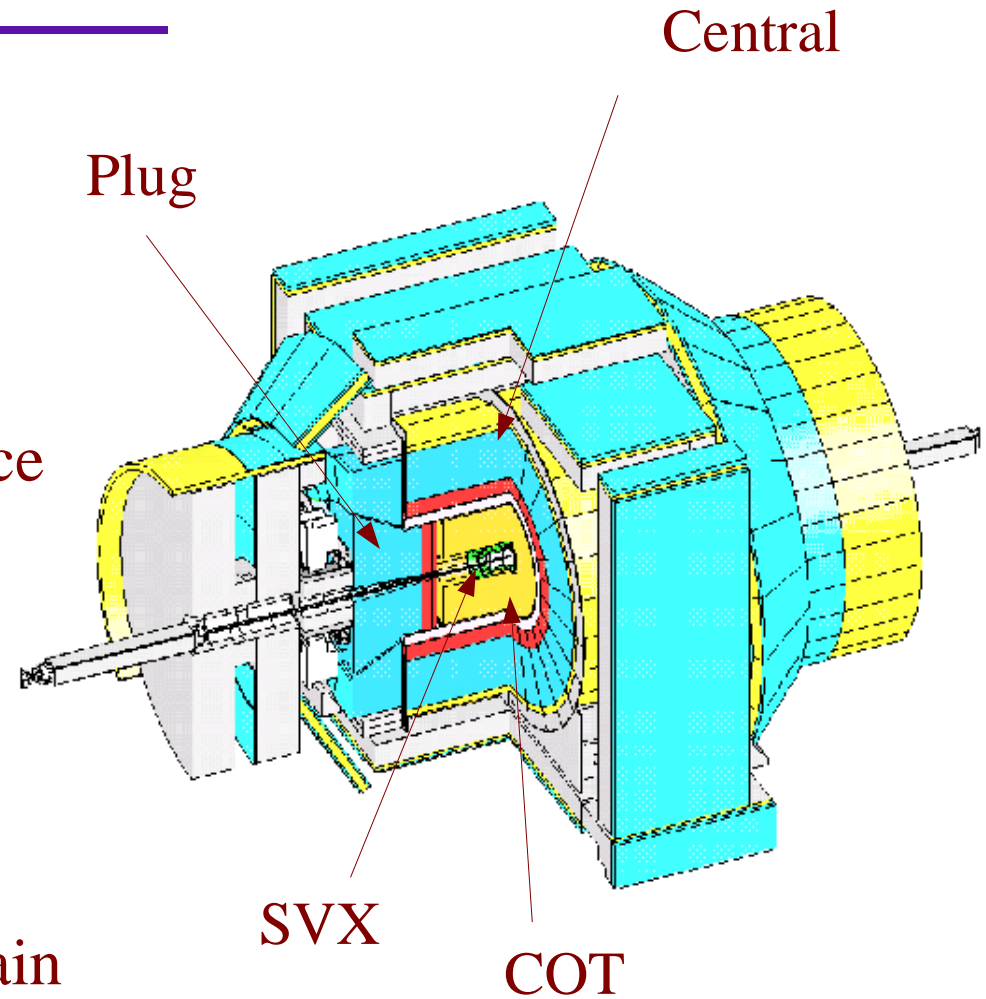
- working well

New SVX detector

- on about 90% of the time
- 5/12% loss radiation, resonance
- L00 is being used right now
- Has to last until LHC (OK)
- SVT working well

New COT tracker

- working well in general
- showed some aging, loss of gain
- inner layers off for a period
- back on, higher flow, O₂
- Recovery looks good



Most analysis now: 200pb
This Fall: 500pb

Trigger Scale at CDF

Most searches:

- Inclusive central e at 18 GeV
- Inclusive central μ at 18 GeV
- e+e, $\mu+\mu$, or e+ μ at 4GeV
- Inclusive γ at 25 GeV
- Diphoton at 12 GeV
- Central b-jet at 2x20 GeV
- Inclusive single jet at 100 GeV
- 3 jets at 10GeV, SumEt>100
- Missing Et at 45 GeV
- τ +Missing Et at 10/20 GeV
- e/ μ +track at 8/5 GeV

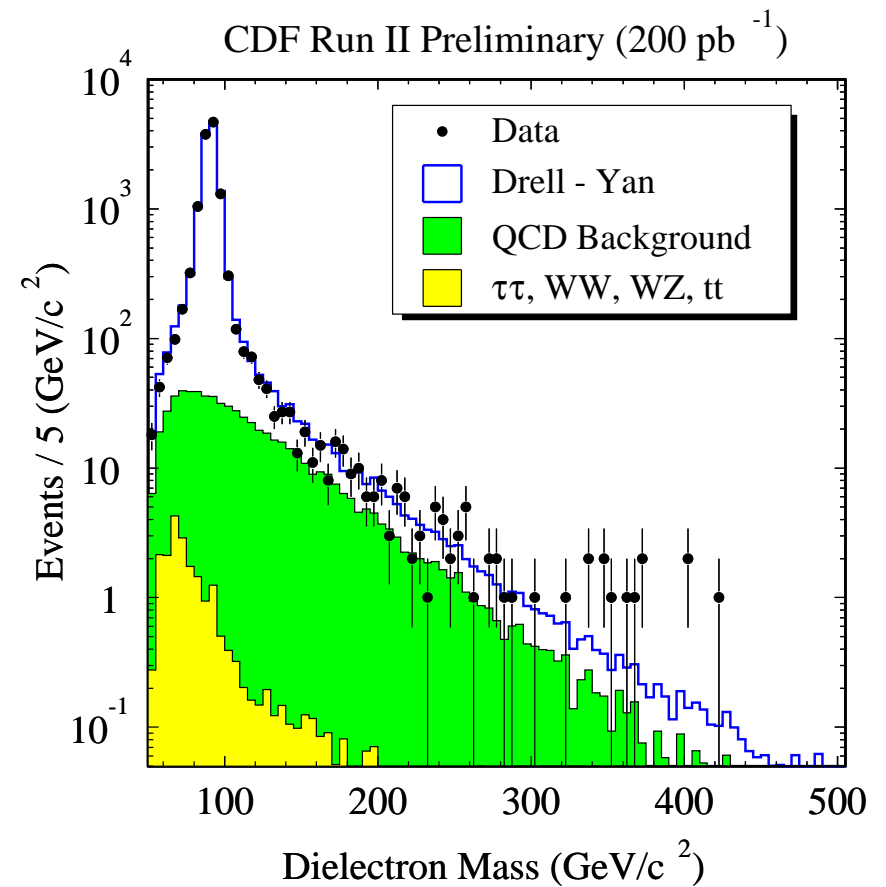
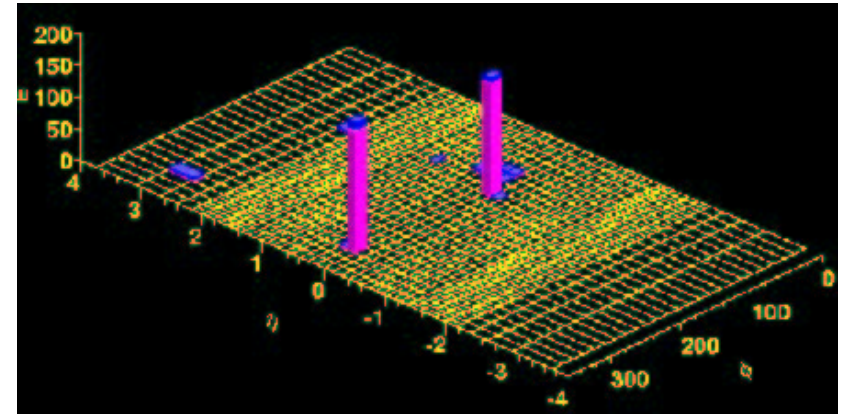
Also:

- $\mu\mu$ J/ ψ at 1.5GeV
- All 6-track
- e/ μ +track+SVT
- diffractive
 - some prescale...
- ee J/ Ψ at 1.5GeV
- 2 tracks with SVT, Pt>2.5

Search for $Z' \rightarrow e e$

Sample

- Based on high-Et electron triggers
- Loose cuts for good S/N sample
 - Iso Et/Et < 0.2
 - Pt > 15 GeV
- Add Plug
 - Iso Et/Et < 0.1
 - No track requirement
- Backgrounds
 - jet \rightarrow e - est. from data iso dist. shape from loose cuts
 - Drell-Yan MC, incl $\tau\tau$
 - Electroweak MC



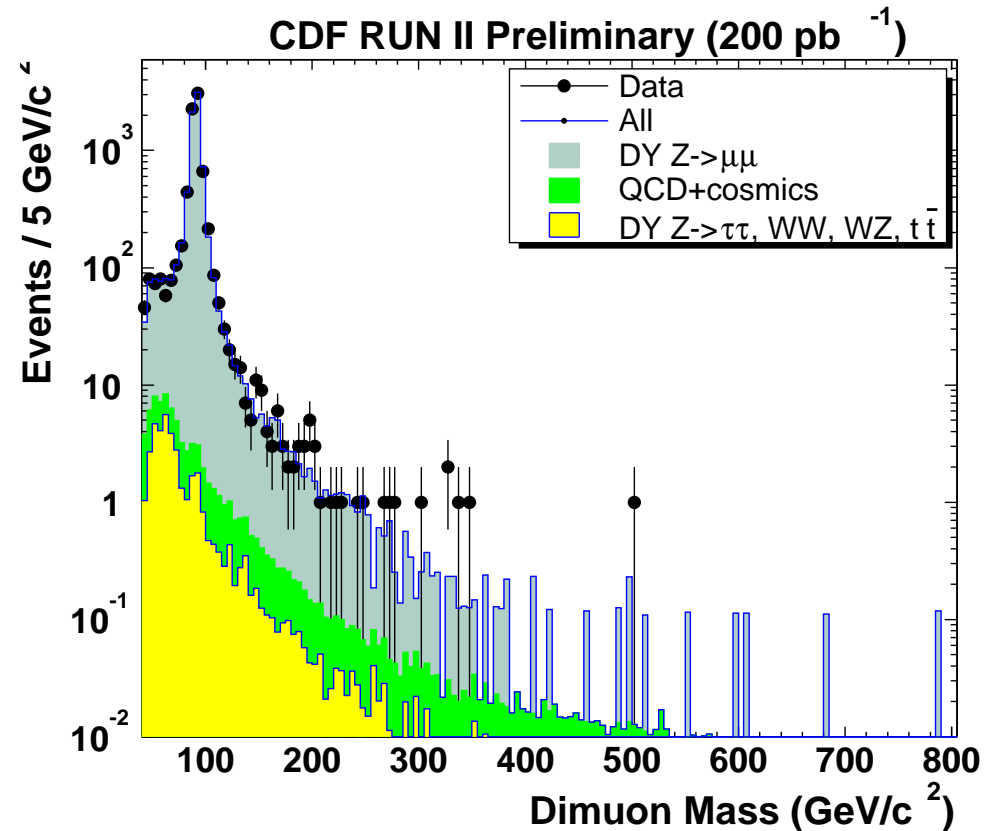
Search for $Z' \rightarrow \mu\mu$

Selection

- 2 muons
 - central or no-stub (2nd)
- isolated
- reject cosmic rays
 - examining COT fit,
 - looking for exiting trk
 - matching i.p. and z

Background

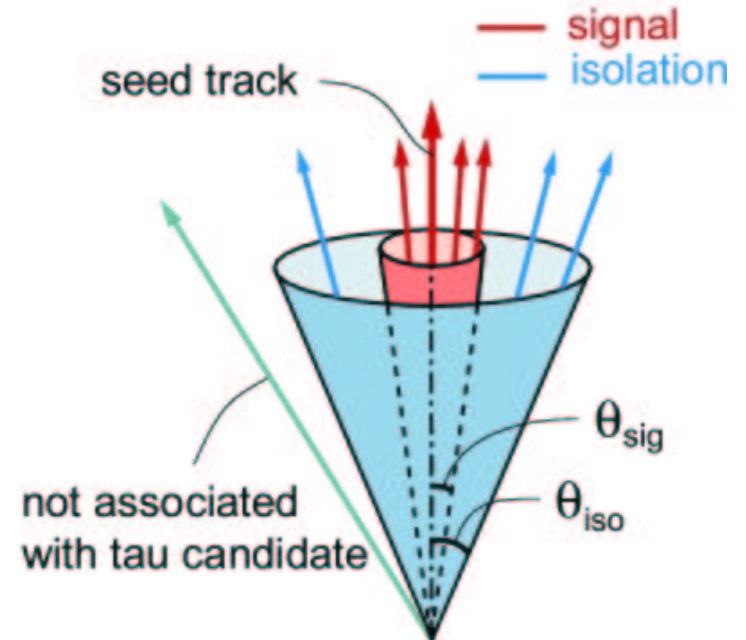
- Above 200 GeV in Mass
 - 18.7 ± 0.9 Drell Yan from MC
 - 2.2 ± 0.5 fakes (from same sign)
- Observed: 18



Search for $Z' \rightarrow \tau\tau$

Tau Selection- hadronic decays

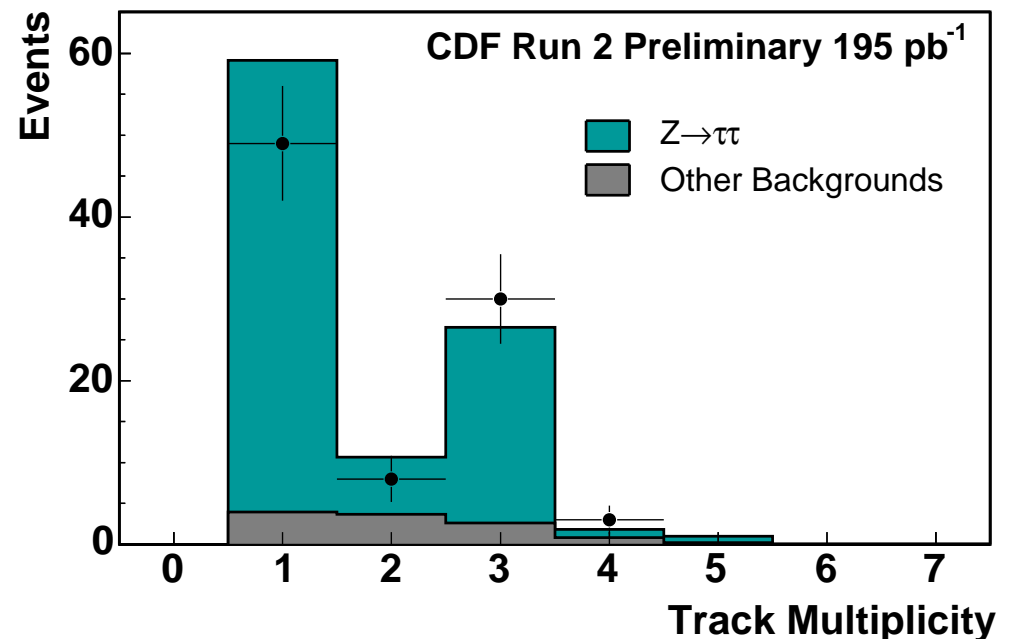
- Narrow jet of tracks/energy
- isolated from nearby tracks/energy (shrinks for high E_t)
- reconstruct π^0 's in shower max
- τ mass < 1.8 GeV



Z' Selection

- Require $e + \tau$, $\mu + \tau$, or $\tau\tau$ (trigger on same)
- $M_{Et} > 15$ GeV
- M_{Et} along lepton (2 ν 's)
- Z' Mass from l , τ and M_{Et}

$\tau\tau$ Control Sample, Tau Signature



Search for $Z' \rightarrow \tau\tau$

Backgrounds

- jets fake τ 's at level of 1%
create fake rates from jets,
multiply e/μ + jet sample
- Use Z as a control sample check
- Mass > 120 GeV is signal region

Results

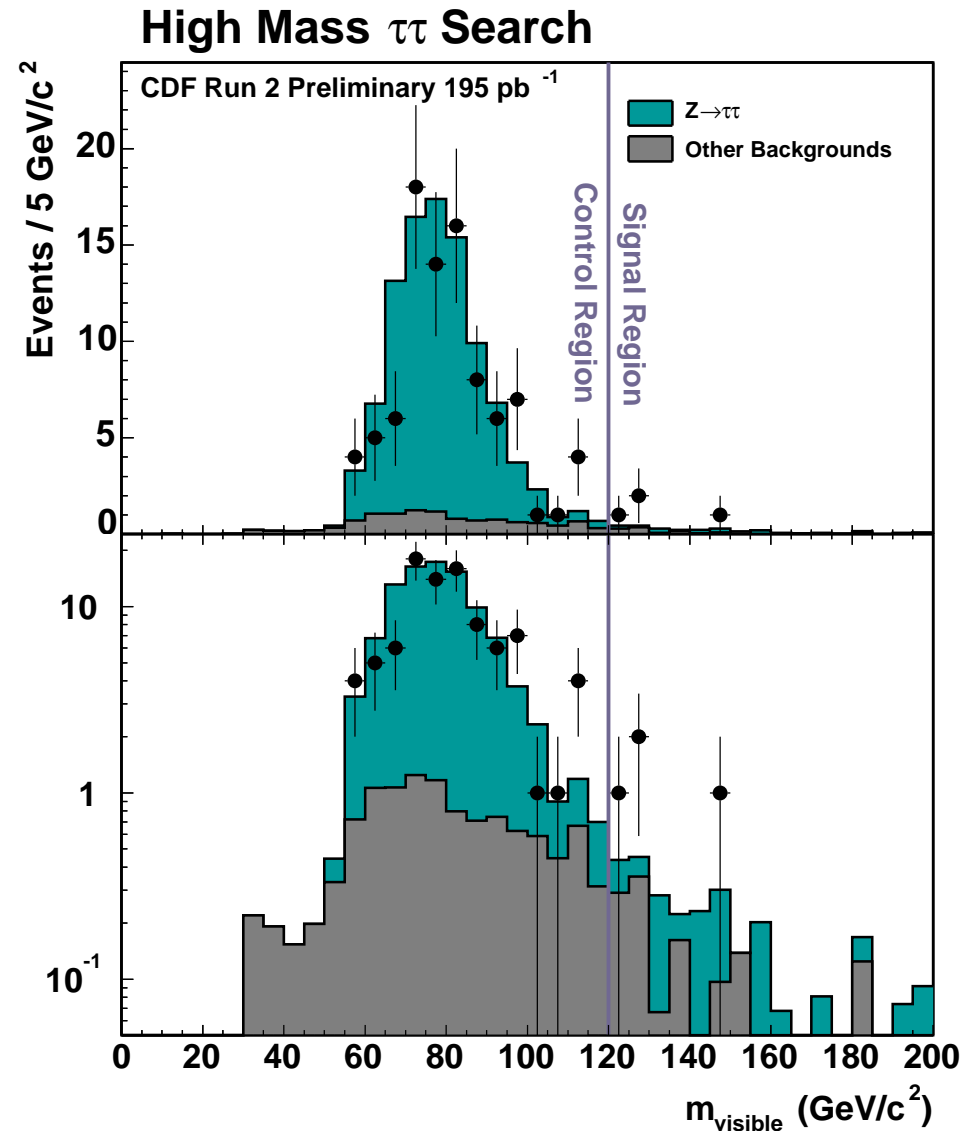
D.Y. 2.08 ± 0.33

Fakes 0.75 ± 0.19

Total 2.83 ± 0.38

Observed: 4

- signal acceptance*efficiency = 3%



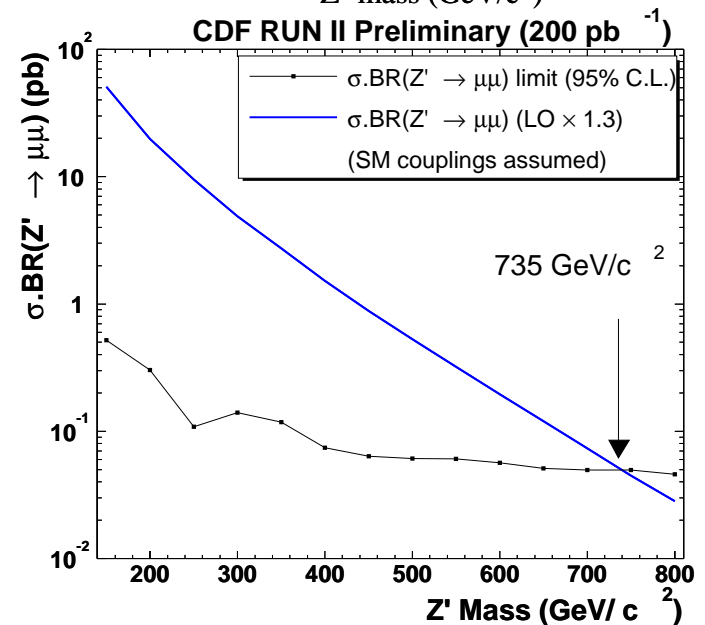
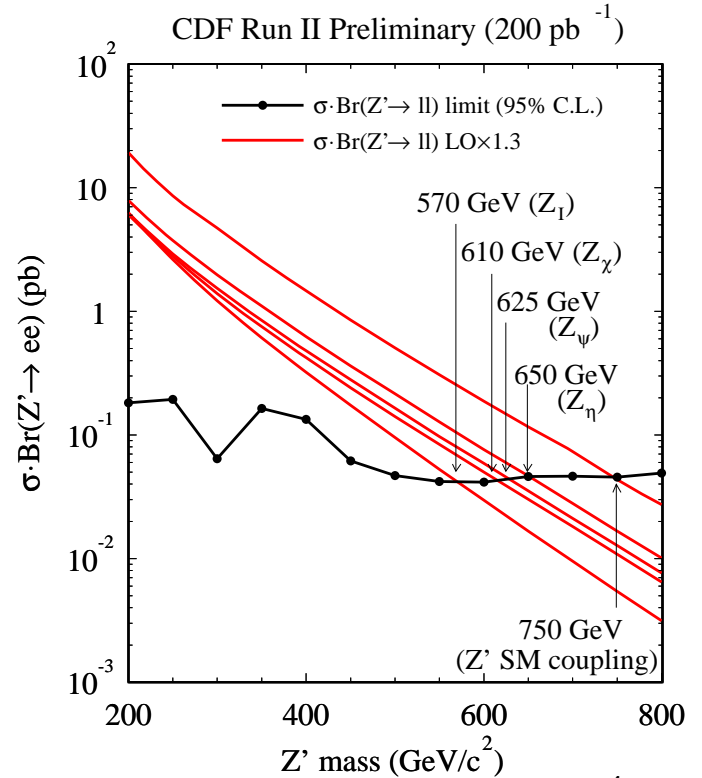
Z' Limits

Models

- SM, E6, Littlest Higgs, Technicolor

	ee	$\mu\mu$	
Z'	750	735	
Z'_Ψ	625	600	
Z'_χ	610	580	
Z'_η	650	635	
Z'_I	570	530	
RPV ν	660	665	$\lambda^2 BR=0.01$
Z_H	~ 800	775	$\cot\theta=0.9$
ρ_T, ω_T	no limit		

$Z' \rightarrow \tau\tau$ alone: $\sim 400\text{GeV}$



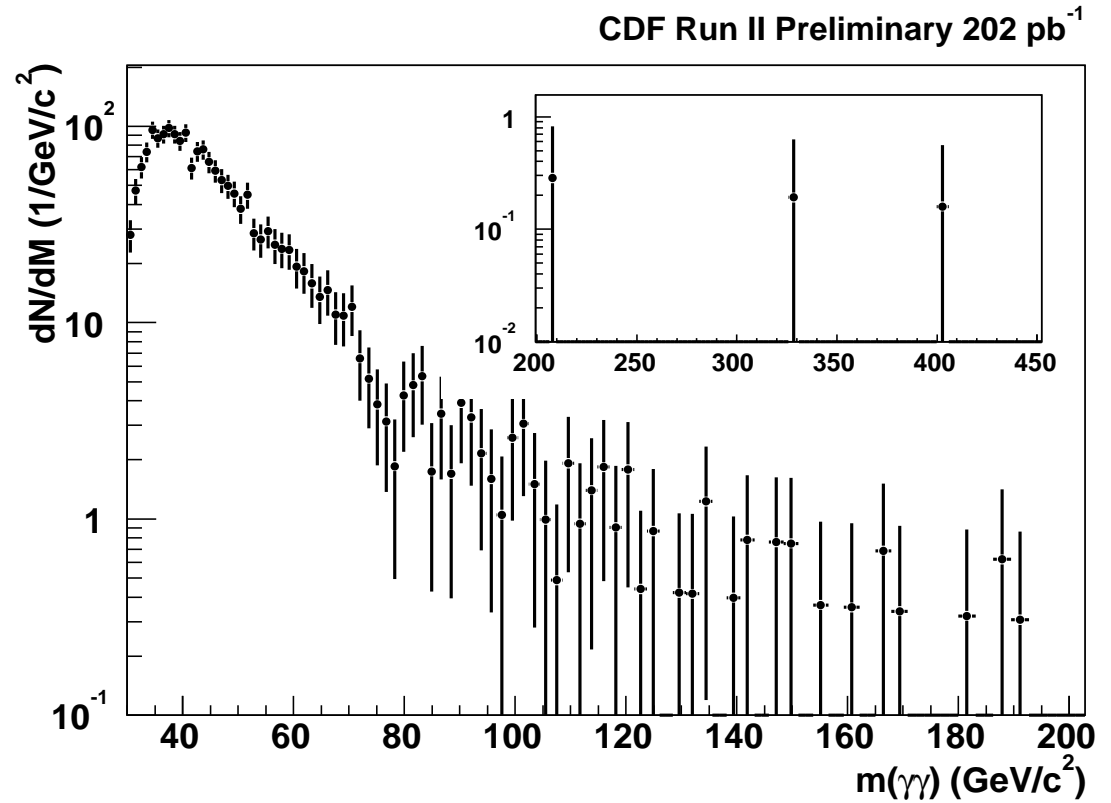
Search for Diphoton Peaks

Sample

- diphoton triggers
- checked with backup high-Et trigger

Analysis

- Selection similar to electrons but with track rejection
- losing 6% per leg to conversions!
- could be combined with electrons, plug added



$\gamma\gamma$ Mass in bins of 1σ mass resolution

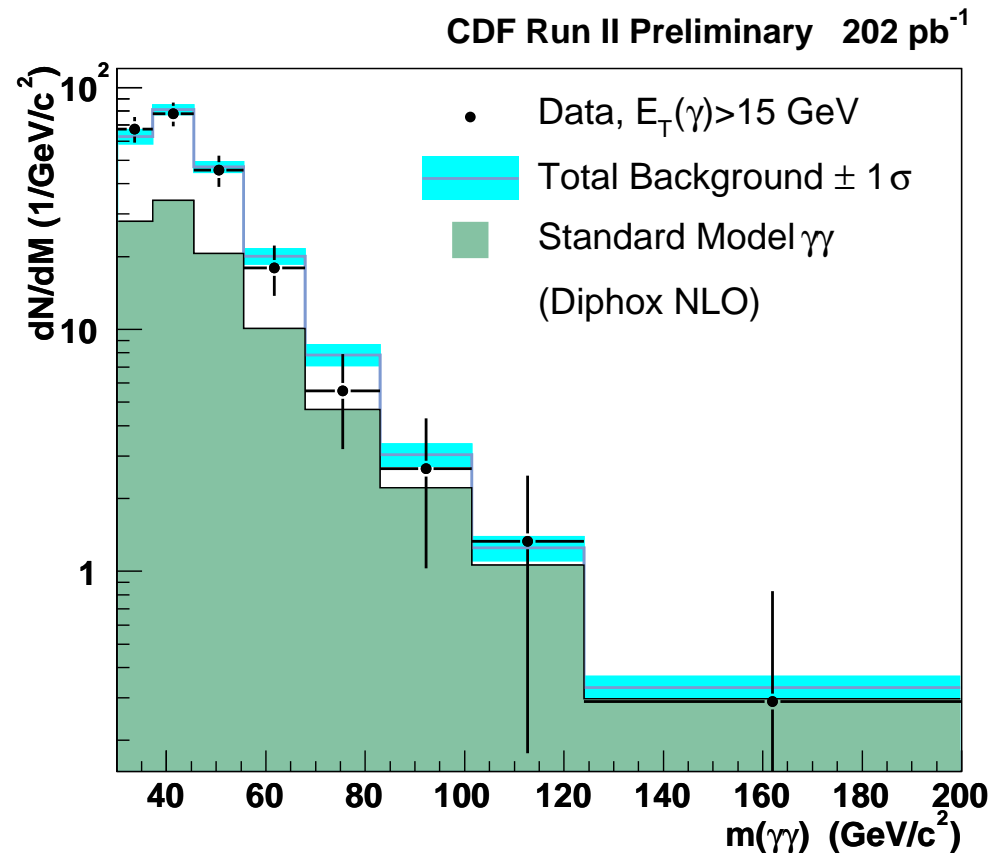
Search for Diphoton Peaks

SM background

- NLO Diphox calculation
- normalized to \mathcal{L}

Jets Faking Photons

- Usually a high-Et π^0
- extremes of fragmentation usually from q, not g
- shape from a sample of loose photons
- normalize to low Mass



- Variable bins for statistical comparison to BG prediction

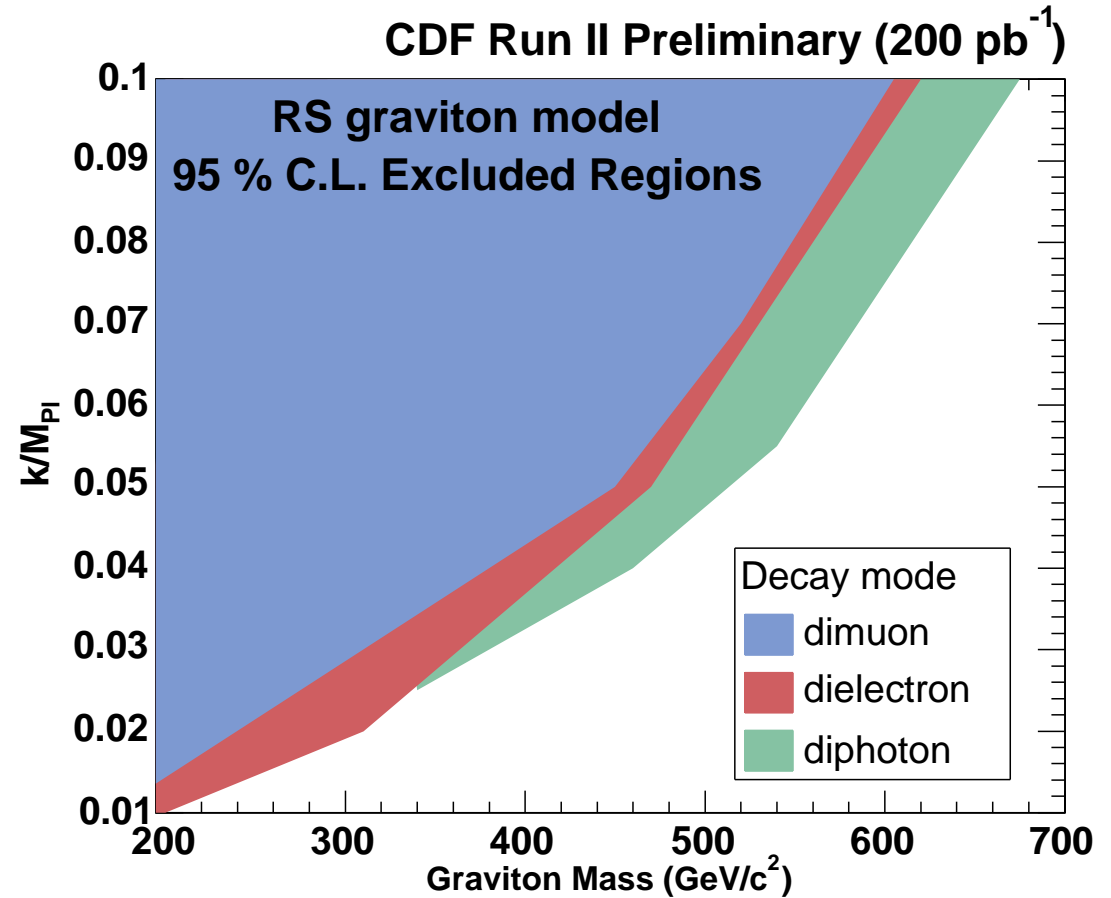
Randall-Sundrum Graviton Limits

Model

- S-channel Graviton
- Warp factor is curvature in extra dimension
- small warp values predict narrow peaks

Limits

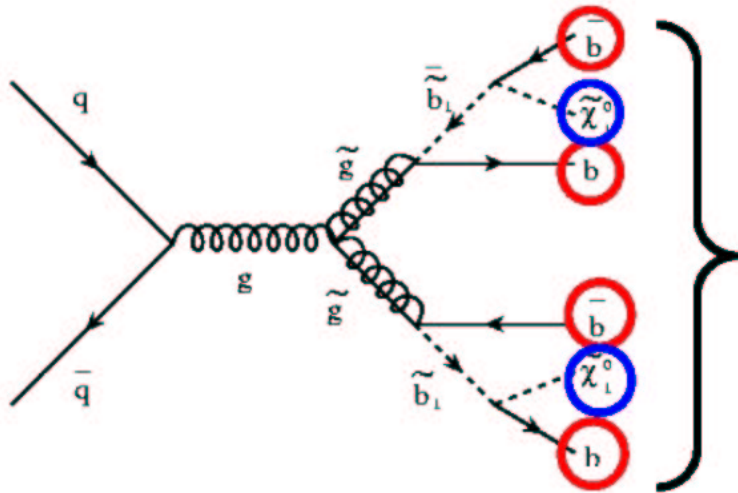
- $e\bar{e}$, $\mu\bar{\mu}$ and $\gamma\gamma$
- All about 200pb
- $\gamma\gamma$ has larger BR
- $\gamma\gamma$ spin factors improve acceptance



"Very Exotic" Searches

- Z' $ee, \mu\mu, \tau\tau, jj, bb, tt$
- W' $e\nu, \mu\nu, \tau\nu, jj, tb$
- RS Graviton, $ee, \mu\mu, \tau\tau, \gamma\gamma, ZZ, WW, jj$
- ADD Graviton $ee, \mu\mu, \tau\tau, \gamma\gamma, ZZ, WW, j\nu, \gamma\nu$
- Axion - $jj, \gamma\gamma$
- Excited l/q $e\gamma, \mu\gamma, \tau\gamma, qg, b\gamma, jj, bZ, t\gamma$
- LQ 1, 2, 3 gen
- Monopoles
- CHAMPS
- Technicolor $\rho_T \rightarrow W bb$
- b' long-lived $Z, b\gamma$
- t' high-mass $t, t\gamma$
- Technicolor $Wb, \gamma bb$

Search for SBottom



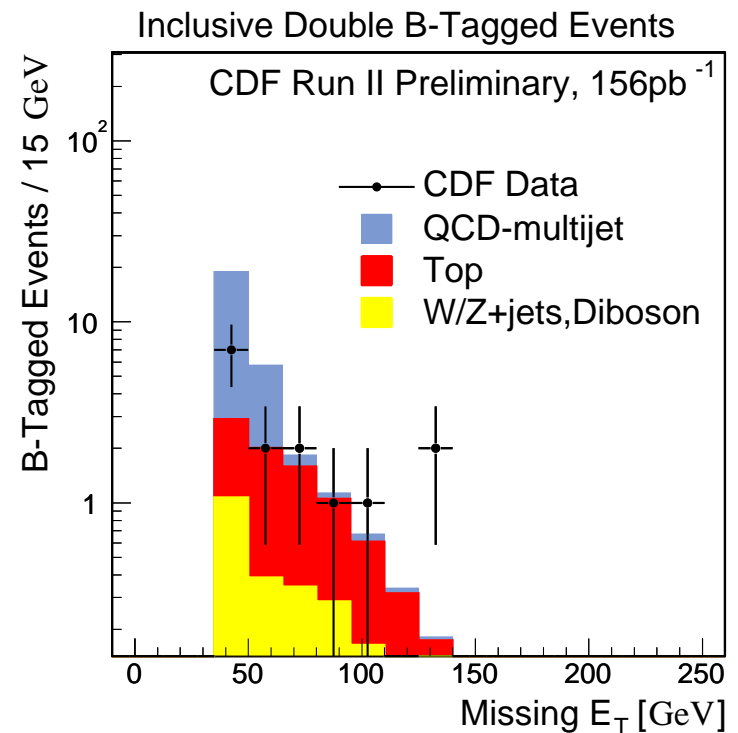
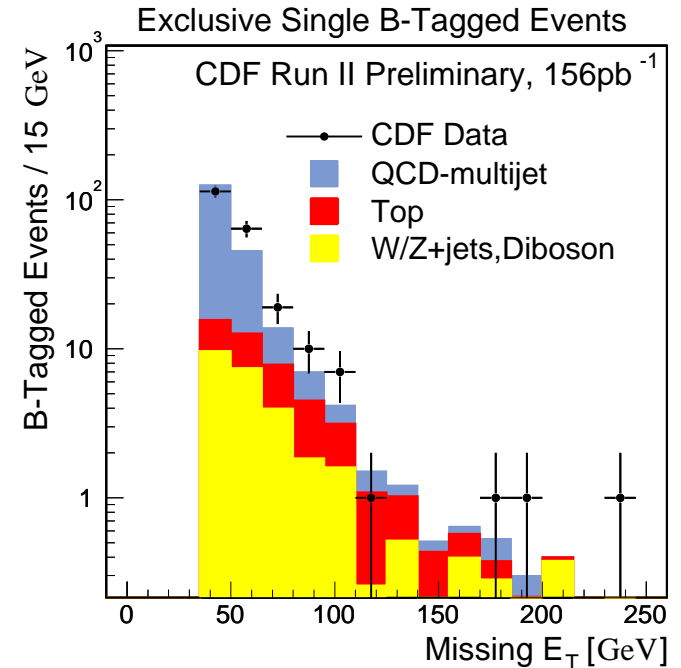
- 4 high-Et b's
- Missing Et

B-tagging

- SVX tracks in jets, w/large i.p.
- cluster into vertices
- eff ~40% per b jet
(~55% → ~65%+ per top event)

Selection

- MEt not along jets, no leptons
- 3 jets+1 or 2 tags
- Optimized MEt > 80 GeV



Search for SBottom

Backgrounds

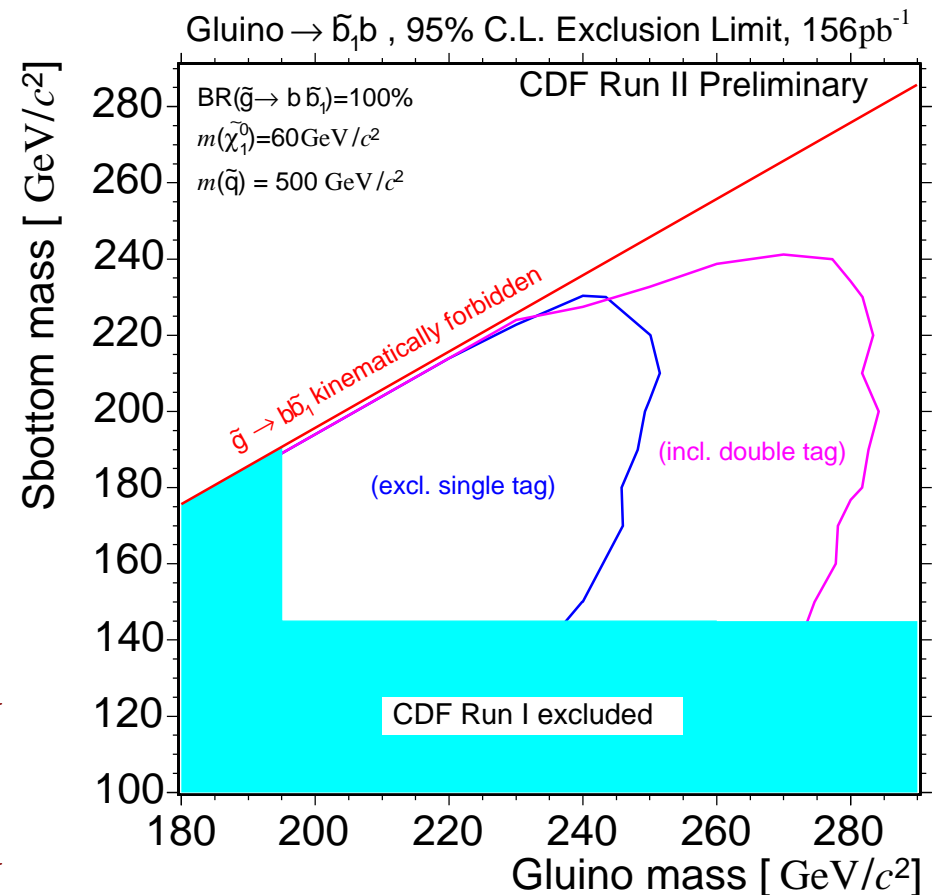
- QCD light-q jets, fake tags
use non-tagged jets X fake rate
- QCD heavy flavor
Monte Carlo, norm to low MET
- W/Z ..., t t - Monte Carlo
- Several checks in control regions

One tag

16.4 ± 3.7 expected 21 observed

Two tags

2.6 ± 0.7 expected 4 observed



SUSY Searches

MSSM

- squark: jj MET
- stop: cc MET, lbb MET, $lbbjj$ MET, $jjjjbb$ MET, stable
- sbottom: bb MET, $bbbb$ MET
- stau: stable
- chargino-neutralino: ll MET, $\tau\tau$ MET
- gluino: bbb MET, $jjjj$ MET, LS ll
- indirect: $B_s \rightarrow \mu\mu$

Other Scenarios

- RPV sneutrino: dilepton modes
- RPV stop: τbb , bb MET, t MET
- RPV chargino-neutralino: $llll$
- RPV squark: $lljj$, ljj MET, qq MET
- GMSB: $\gamma\gamma$
- GMSB stop: γjj , $W\gamma$, Wb
- GMSB stau: $\tau\tau\nu$

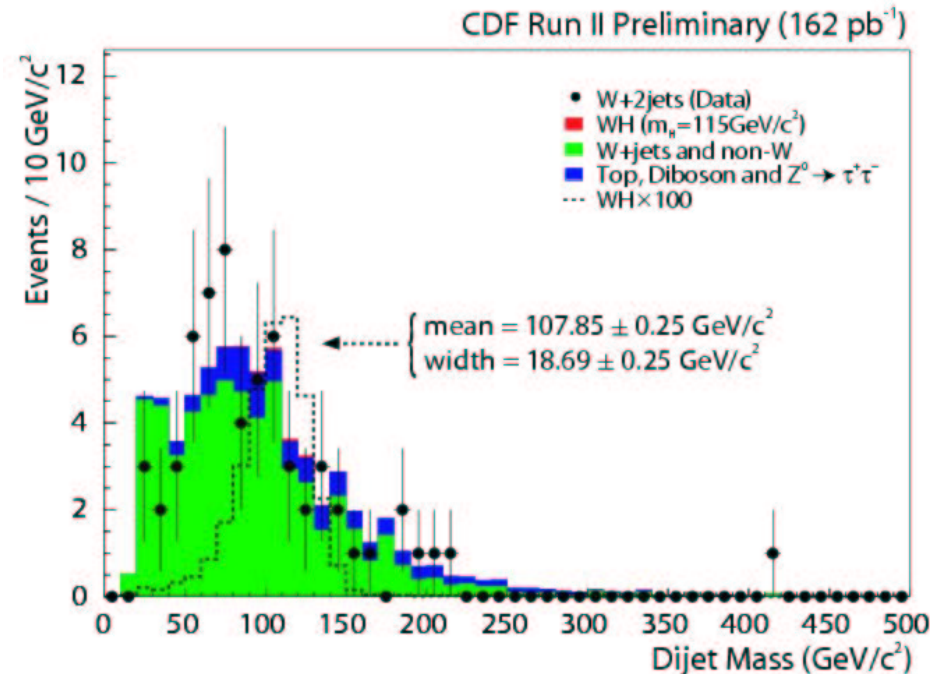
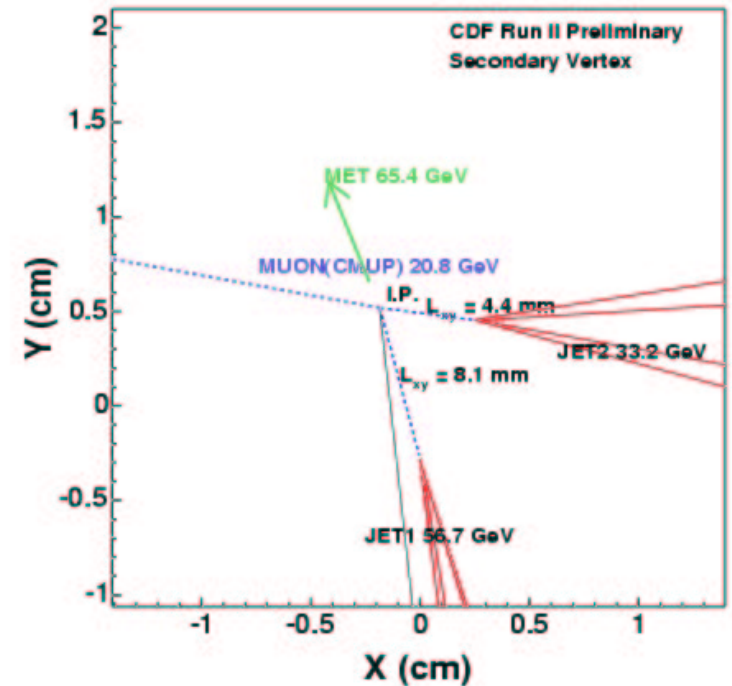
SM Higgs \rightarrow Wbb

Selection

- central e or μ with $P_t > 20$ GeV
- $M_{Et} > 20$ GeV
- 2 jets with $E_t > 15$ GeV, $|\eta| < 2$
(optimized)
- 1 SVX b-tag
- veto events with extra jets
- veto loose second lepton
- total eff $\sim 1.8\%$
(including W BR)

Mass Resolution

- 17% here
- 10% possible, in progress



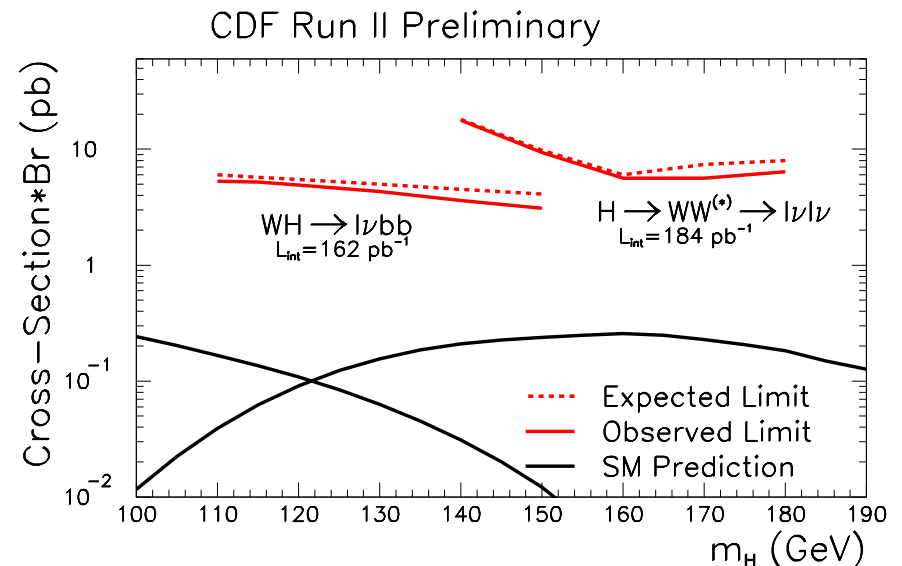
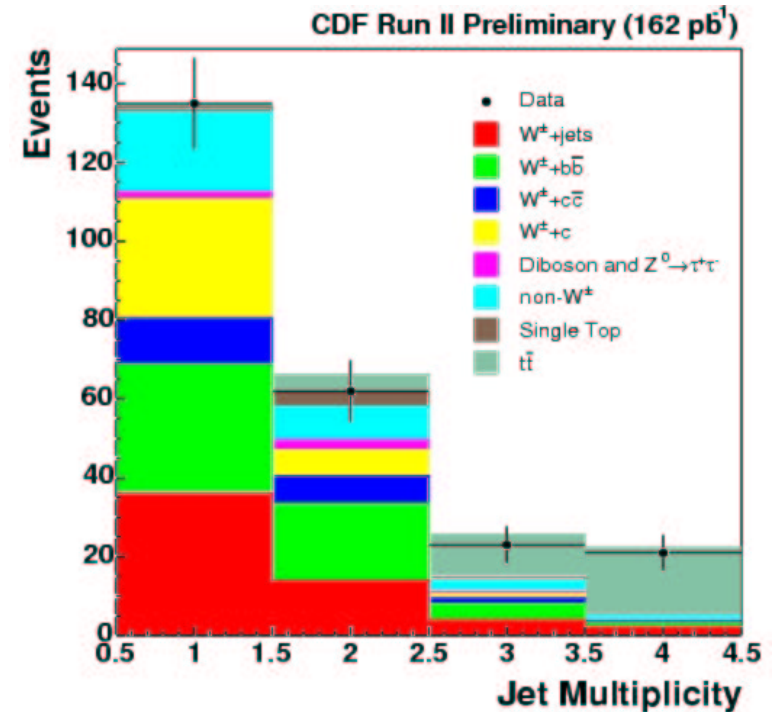
Search for SM Higgs

Background

- Fakes from mistag matrix
- Wbb from Data/MC
- Fake lepton from MET vs Iso
- DiBoson, tt, t from MC

Background Totals

Fake b-tags	14 ± 2.6
Wbb	33 ± 6.4
DiBoson	2.5 ± 0.6
Fake lepton	8.5 ± 1.2
tt	4.3 ± 1.4
single t	3.8 ± 0.5
<hr/> total	<hr/> 66 ± 9
Observed Events:	62



Notes on Higgs

Available Searches

- SM Wbb
plug leptons, better mass meas
other taggers, high- η tagging
- SM $h \rightarrow WW \rightarrow ll\nu\nu$
- H^{++} , including long-lived

Ongoing Searches

- most modes of Wh, Zh
- most modes of $h \rightarrow WW, ZZ$
- hbb at high $\tan\beta$
- $A \rightarrow \tau\tau$
- H^+ direct and indirect
- several more

Future

For probable 95% exclusions on <120 GeV SM Higgs - need 2fb

For probable 3σ evidence - need ~ 5 fb

Restricting SUSY Higgs using Vbb : starting 1-2 fb

Setting limits on SUSY at high $\tan\beta$ now

Thoughts on Searches

Historically Model-based

- One student, one model, one publication
- Models expire or are excluded - shouldn't change search results
- How do we select models? No limit = not interesting?
- We are too focused on models - inefficient, creates blinders
- The good part is that it is precise, optimized, and tells a story

Increasingly (?)

- Models treated as nominal examples, benchmarks
- Several searches published without a model
- Trying to spend more time investigating data
- Publish more variations on data selection
- Investigate virtually every signature
 - (we covered essentially all primary signatures in Run I!)
- Automated searches - DØ Sleuth proponents moved to CDF
- Trying to preserve results to apply to new models

Run I CDF Anomaly Scorecard

Effect	Run II Status
- high-mass dijet excess	accomodated by PDF
- top dilepton event kinematics	pattern not reinforced, need more definitive statement
- μ - γ event excess	excess at this level is excluded in Run II
- $e e \gamma \gamma$ MET candidate	no event yet (note $D \not{\exists} e \gamma \gamma E_T$)
- Wbb superjets	no result yet, tools need more development

Where are the Run II anomalies?

Last Slide

Operations

- COT back in full operations
- Biggest problem is tuning trigger table to high luminosity!

Searches

- We are hemorrhaging results! More for ICHEP..
- Will comment on SM/SUSY Higgs by LHC era
- Still plenty of time for even bigger discovery
- Always looking for new ideas