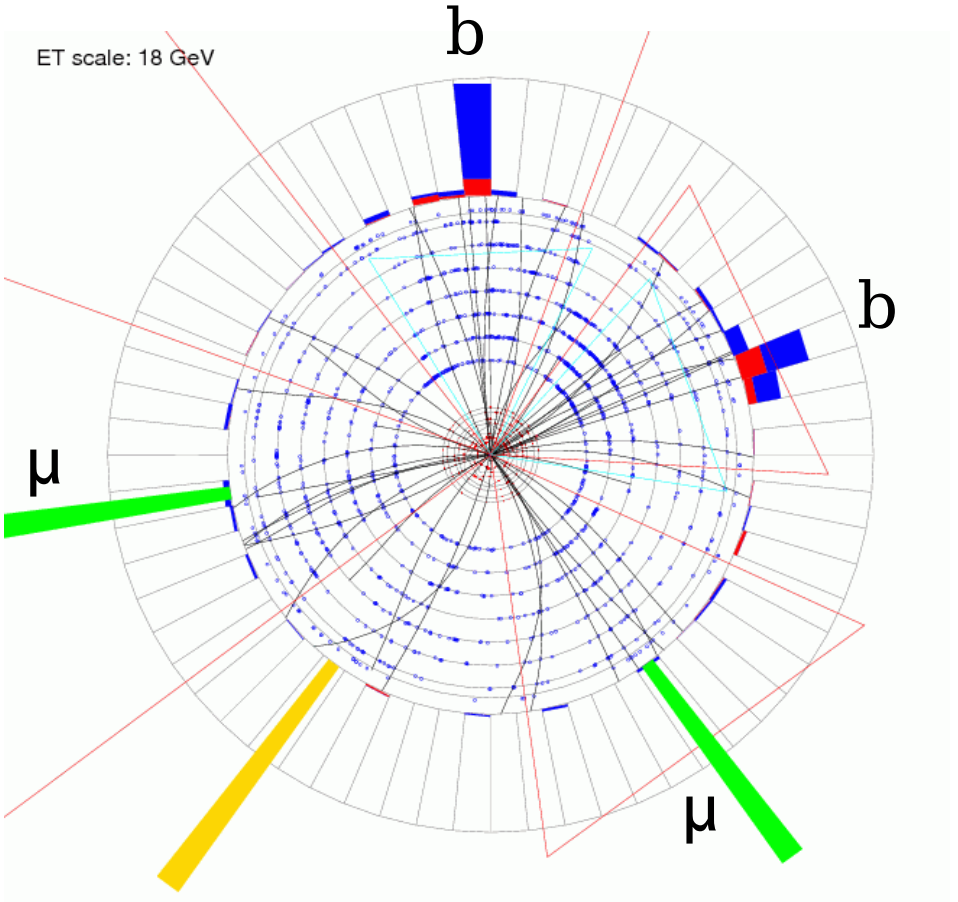
Higgs Group Status and Plans

Andy Haas
Sasha Khanov, Gavin Davies

D0 Collaboration Meeting
September 28, 2007

**Thanks Gregorio*
for years of leadership!



COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Introduction

- MSSM Higgs
- Exotic Higgs
- SM Higgs
  - Low mass
  - High mass

- Other activities
  - W/Z+jets,Wbb, Zb/Zj, Z->bb, VBF,...

Being updated...
Call for person-power.

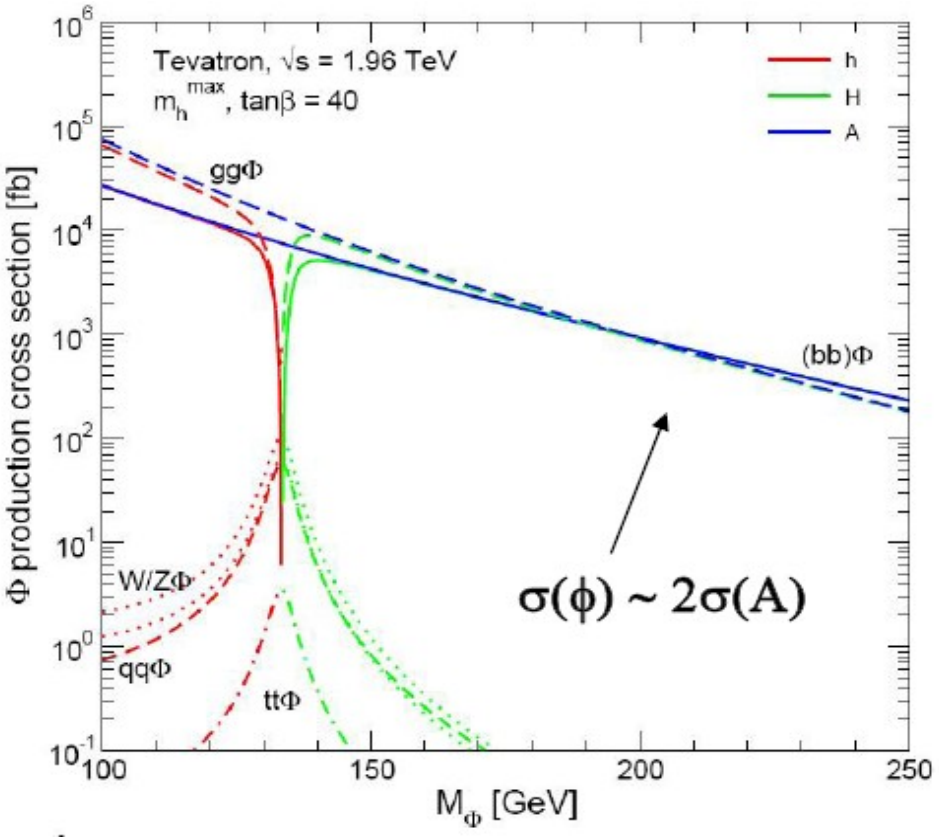
Subgroups	Tasks	People	Results/Plans
V+jets	Zb/Zj	Ashish Kumar	
	W+bb	Alan Magerkurth	
	VBF (WW->munujj)	Sabine Lammers	
	W/Z+jets	Gavin Hesketh / Henrik Nielsen	
	ZH->llbb	p17: Haas (mu), Fu (e) p20: Kirby+Lucian (mu), Tania+Md (e) Mulhearn (ME)	p17 w/NN Prelim. Summer'07 - to publish p17+p20 w/NN+ME for Moriond'08
	WH->lnubb	Alan, Dale Johnston, Thomas, Chun, Jonas	Include ME (in NN) for Moriond'08
		Venkat, Jeremie Lellouche, Gregorio, Yuji, Michel Sanders	Prelim. Summer'07 p17+p20 NN - to publish p17 w/ NN
Multilepton	h→γγ	p17: Alex Melnitchouk, Yuri Gershtein, Oleksiy Atramentov p20: Xuebing Bu, Yanwen Liu	p17: prelim. Summer'07, towards publication
	H->WW (->ll)	p17: Maxim (ee,emu), Harald (mumu) p20: Ralf, Bjoern Penning, Harald ME: Thomas	p17+p20 w/ NN for P5'07 Include ME (in NN) for Moriond'08 (?)
	h->WW (->lnujj)	mu: Marc Buehler, Bob Hirosky, Shannon Zelitch e: Lidija	
	WH→WWW	p17: Sasha Khanov p20: Stefan Gruenendahl	p17: prelim. Summer'07
	H++→4μ	Taejeong Kim	Prelim. Summer'07, towards publication
Multijet	bh->bbb	p17: Fabrice, Boris, Gavin, Per, Stephen Robinson, Tim Scanlon p20: Prolay, Per	p17: towards publication p20: ?
	CPV Higgs	student or post-doc needed	
	ZH→vbb	Theo, Remi, Krisztian, Christophe	p17+p20 NN for Moriond'08
	W/Z+H→jjbb	Justace Clutter	
	Z→bb	Chad Johnson	
Tau	bbh→bbττ	p17: Peter Svoisky p20: Ken Herner	
	WH->τnubb	Phil Rich	
	ZH→ττbb	Yuan Hu	
	h→ττ	p17: Stefan Soldner, Mark Owen p20: Maxim + student or post-doc needed	
	H->WW->e+tau	student or post-doc needed	
	H->WW->mu+tau	Bjoern Penning	
	h->4tau	student or post-doc needed	
Combination	SM	Wade, Gregorio	
	SUSY	Mark Owen	

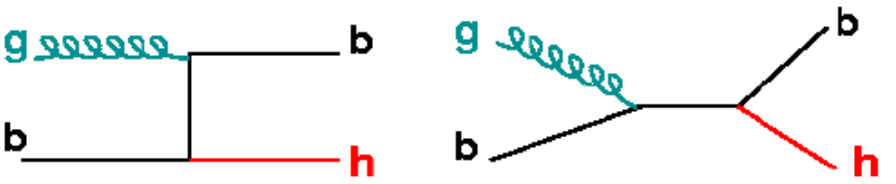
MSSM Higgs (H/A) @ High TanB

- 3 neutral Higgses
  - h, H/A
- Enhanced cross section
  - tanB^2
  - ~10pb @ mA=120 GeV
- H->bb=90%,H->tautau=10%

- H->tautau
- bH-> b tautau
- bH-> b bb

- 3 analyses have similar sensitivity
  - Will be combined





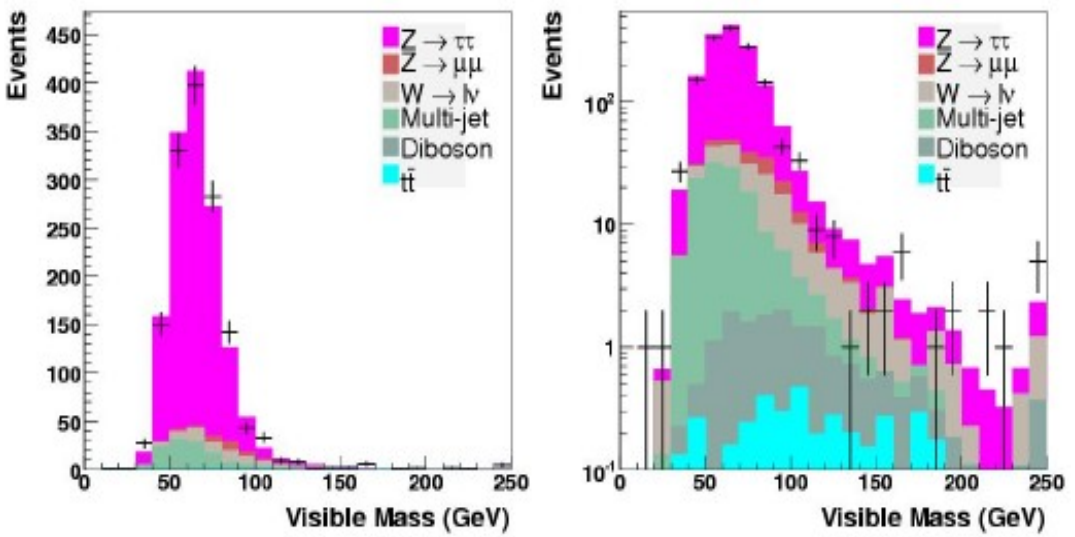
H-> tau tau

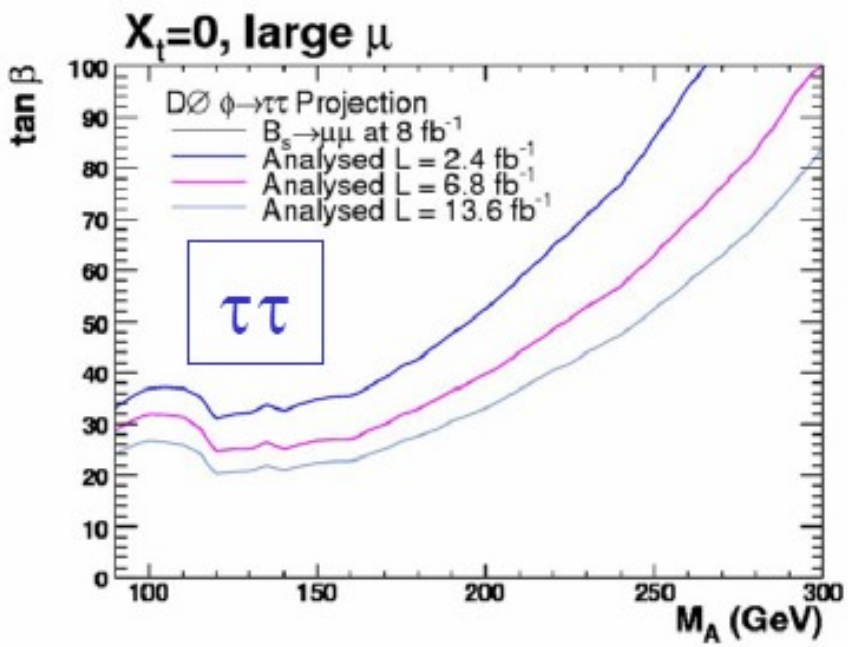
- mu+tau channel preliminary for Moriond '07
- Updates: triggers, z-vertex profile, lum. reweighting
- Much better data/MC agreement

- e+tau, mu+e also ready
- Focusing on a combined p17 publication

- Projection for P5
  - Discovery down to tanB=30 for mH<200 GeV

- *bH-> b tau tau efforts also underway in p17+p20*

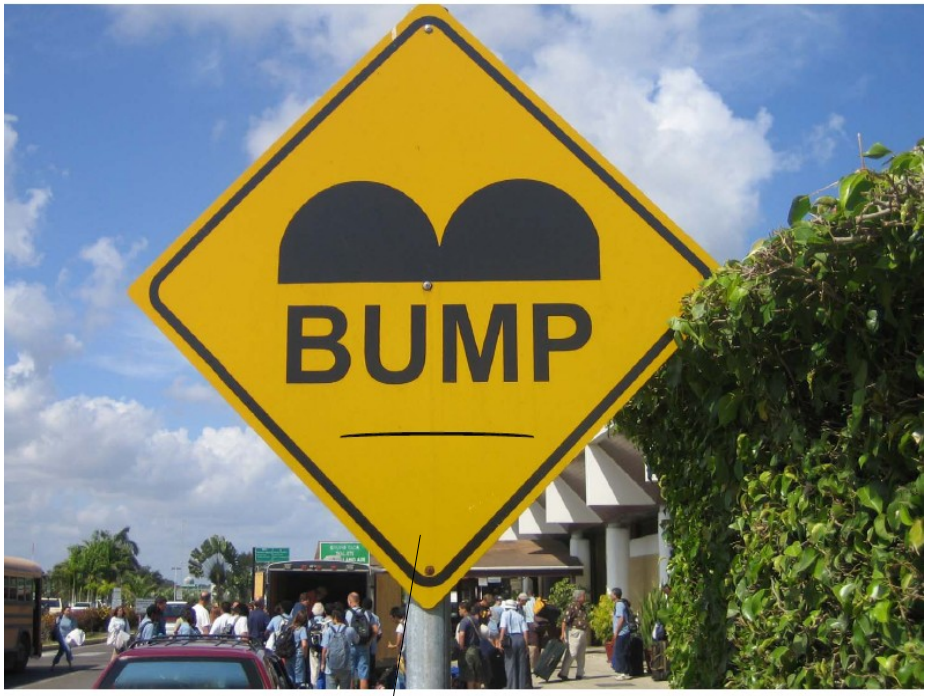


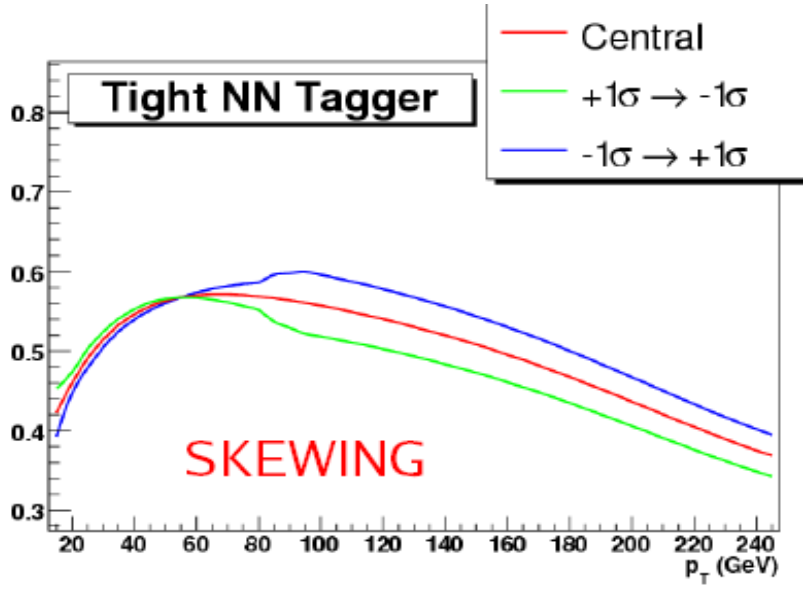


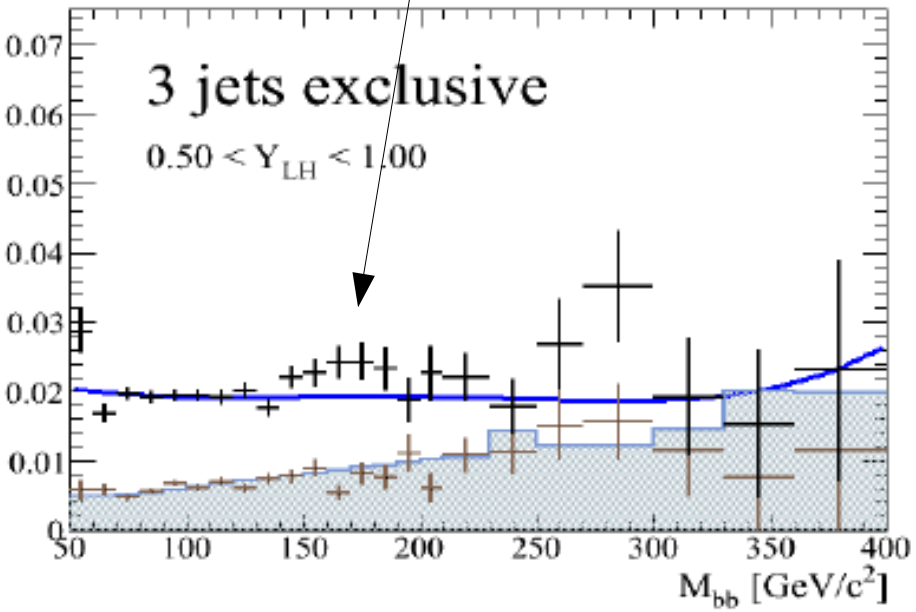
bH->bbb

- Bump at mH=180
- bbb x-check group: likely due to a systematic in background
- Analysis group is studying additional systematics

- Updated note in October
- p17 result by Moriond '08
  - Combine with p20 analysis







Exotic Higgs

- H^{++} -> $mu^{+}mu^{+}$, extended SUSY
- h->$\gamma\gamma$, Fermiophobic Higgs

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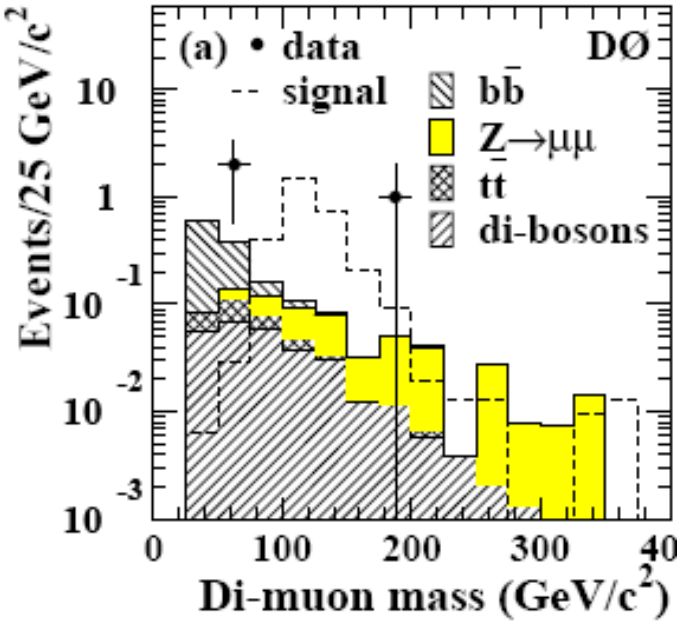


FIRST RUN II PAPER

113/pb

Data=3

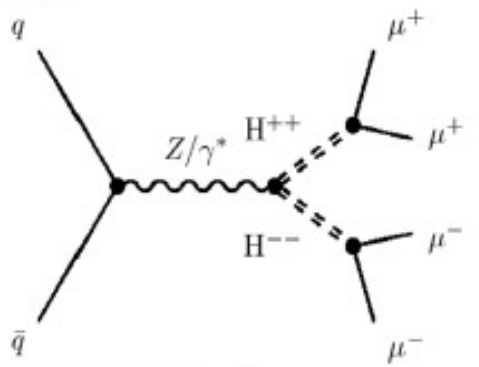
Background= 1.5+-0.4

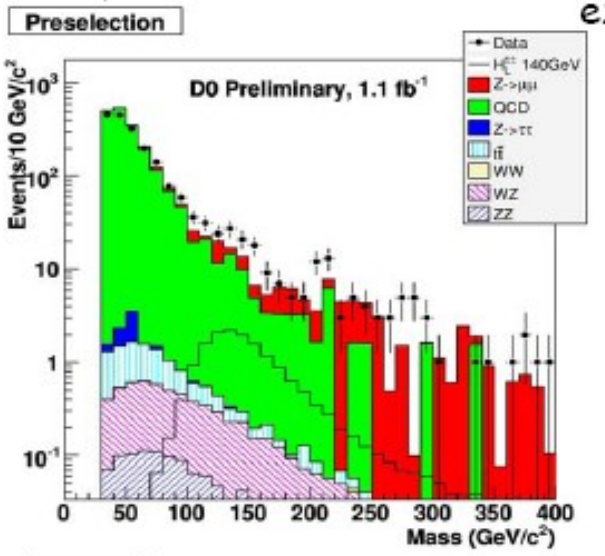
$$M(H_L^{\pm\pm}) > 118.4\ \mathrm{GeV}/c^2 \text{ and } M(H_R^{\pm\pm}) > 98.2\ \mathrm{GeV}/c^2$$

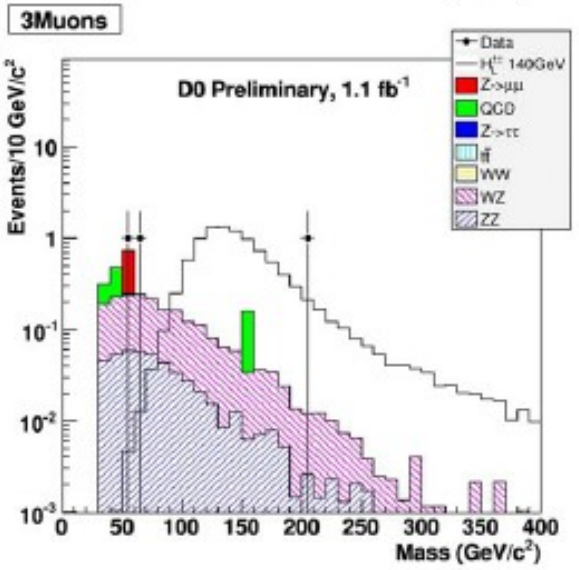
1.1 fb-1

Doubly Charged Higgs

exotic extensions of Higgs sector
with higher isospin multiplets







- 2 like-sign muons
  - $p_T > 15$ GeV
  - $|\eta| < 2$
  - isolated
  - $\Delta\varphi_{\mu\mu} < 2.5$
  - $M_{\mu\mu} > 30$ GeV
- A third muon

⬇

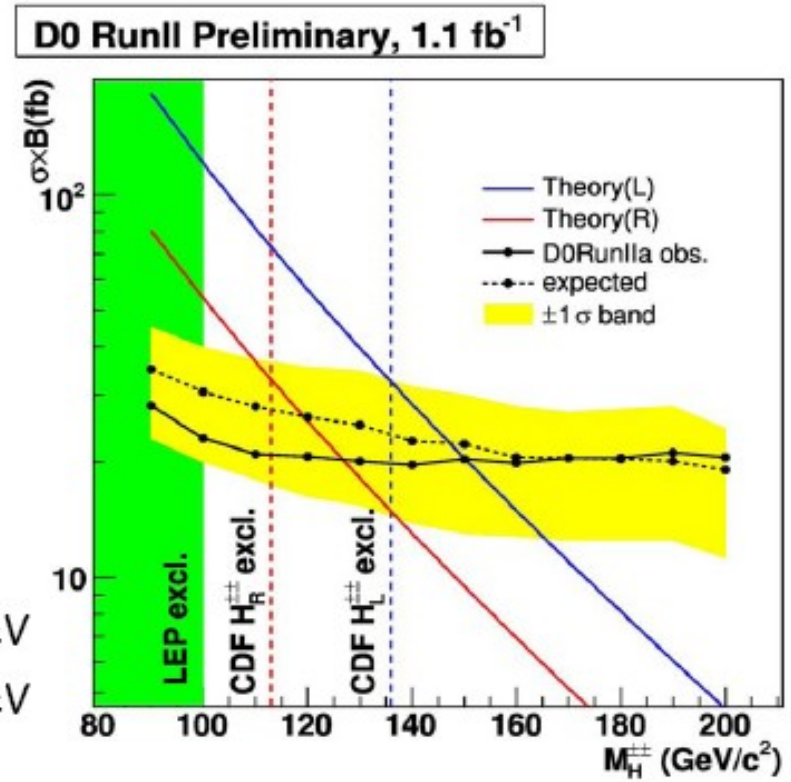
3 events

$(SM: 3.1 \pm 0.5)$

⬇

$M(H_L^{\pm\pm}) > 150$ GeV

$M(H_R^{\pm\pm}) > 126$ GeV



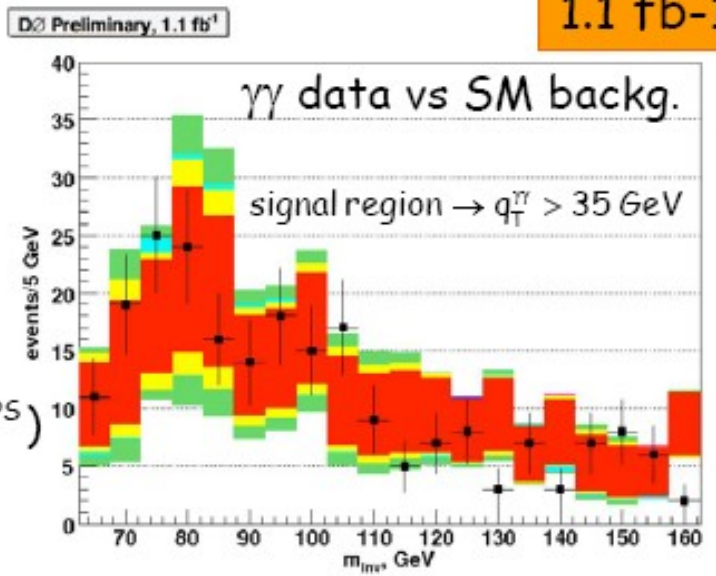
Fermiophobic Higgs in 2γ+X

1.1 fb-1

$$p\bar{p} \to VV \to h_f \to \gamma\gamma + X$$
$$p\bar{p} \to h_f W^{\pm}(Z) \to \gamma\gamma + X$$

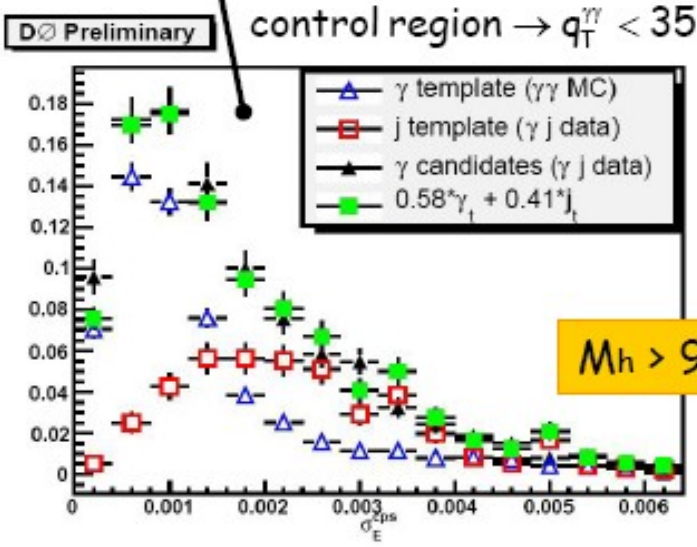
2 photons ($p_T^{\gamma} > 25$ GeV, $|\eta^{\gamma}| < 1.1$)

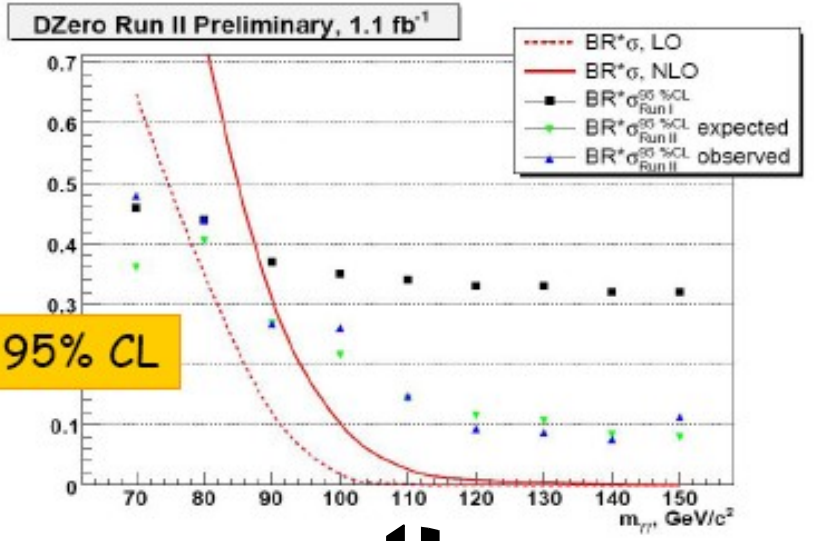
background from $\gamma\gamma$, γ + jet and jet + jet



2D fits to templates of EM shower profiles (σ_E^{CPS})

(separation between photons and jets)



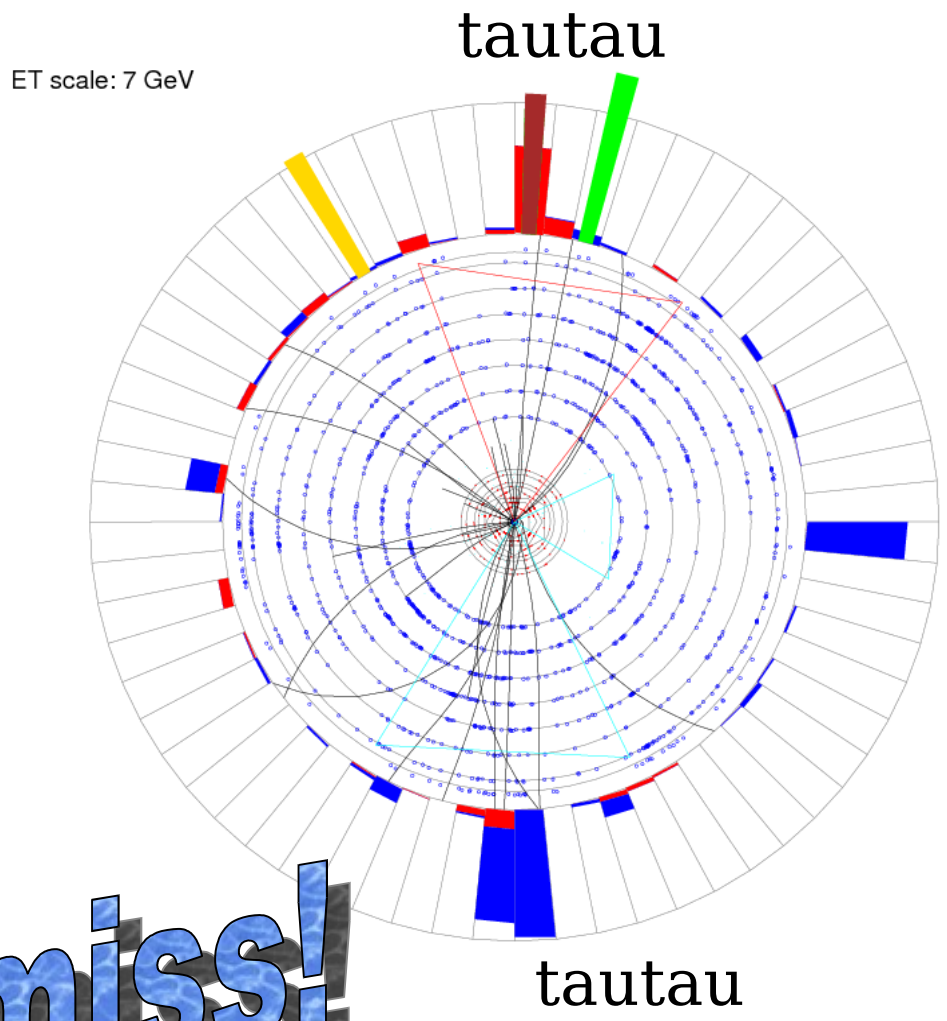


$M_h > 92$ GeV @ 95% CL

Continue in p20

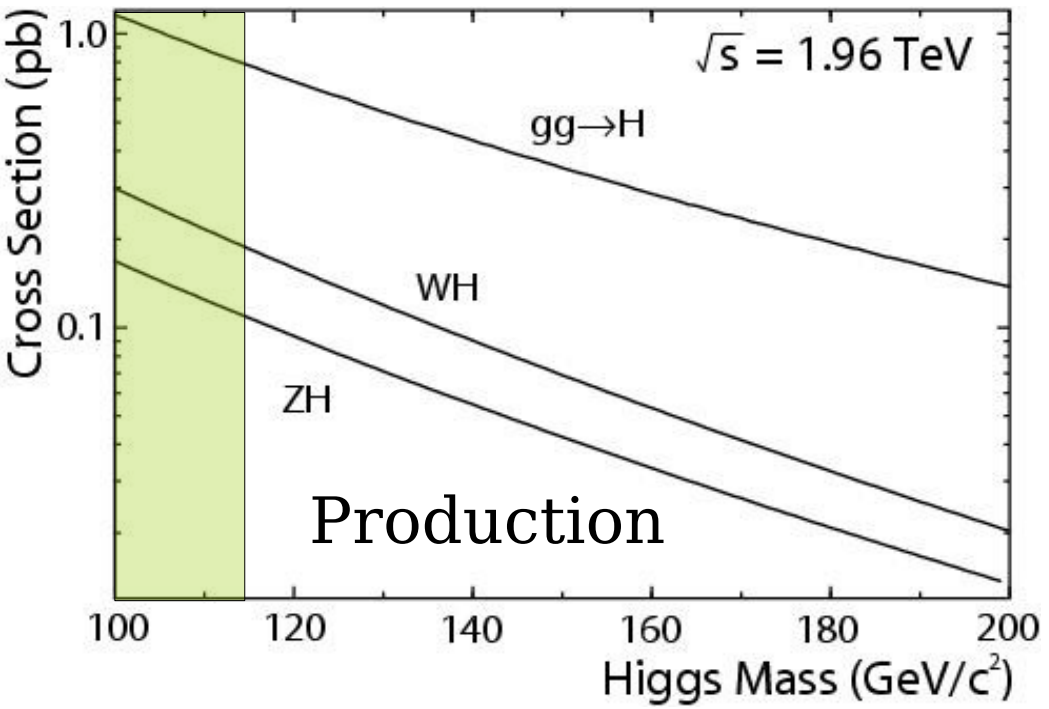
Other Possible Searches

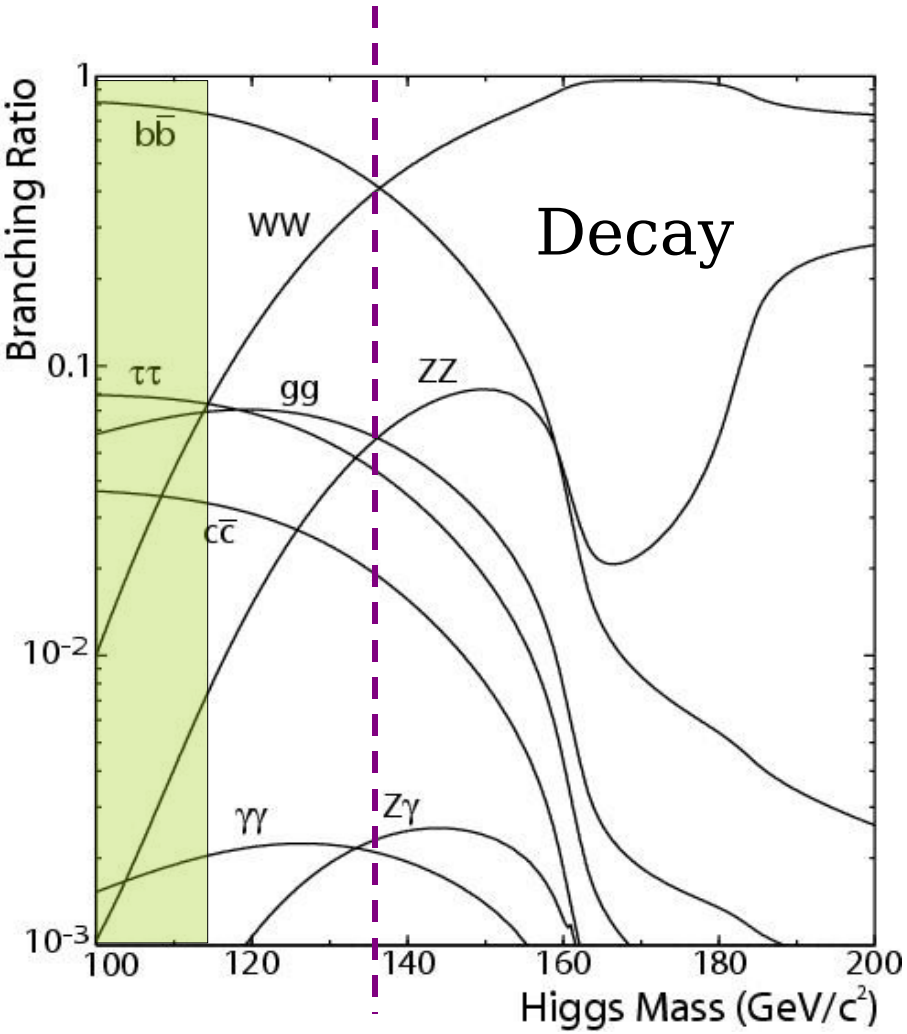
- CP-violating MSSM Higgs
  - mH=50 GeV?
- Invisible Higgs
  - Zh -> Z +
  - Studies underway
- *N*MSSM Higgs
  - h -> aa -> tautau tautau
- H^{++} -> $mu^{+}mu^{+}$, p20
- …

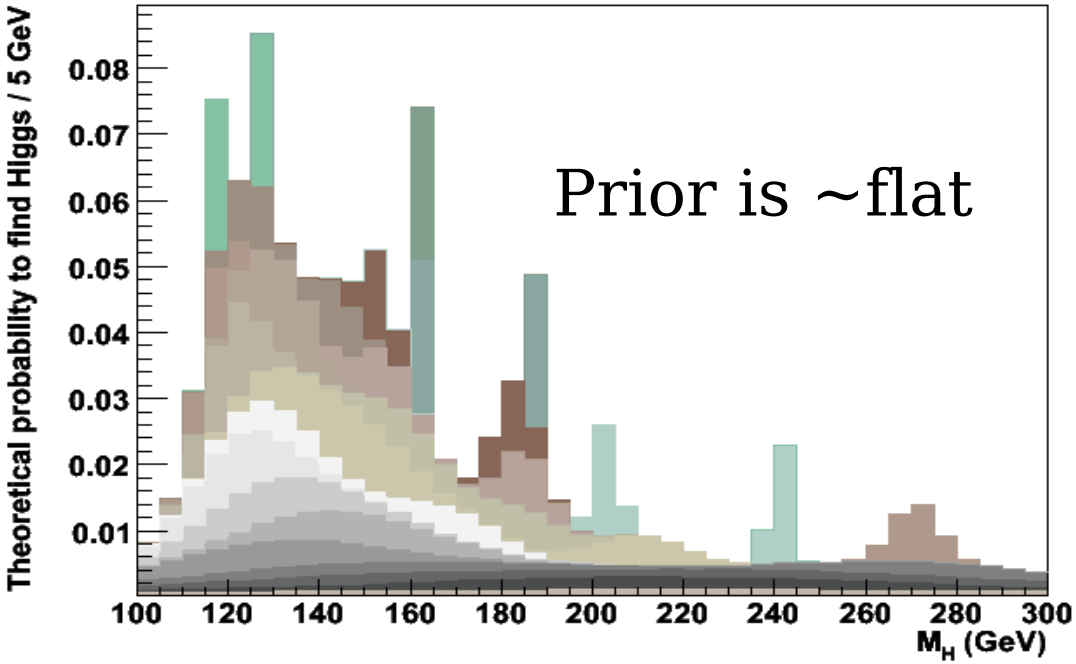


A shame to miss!

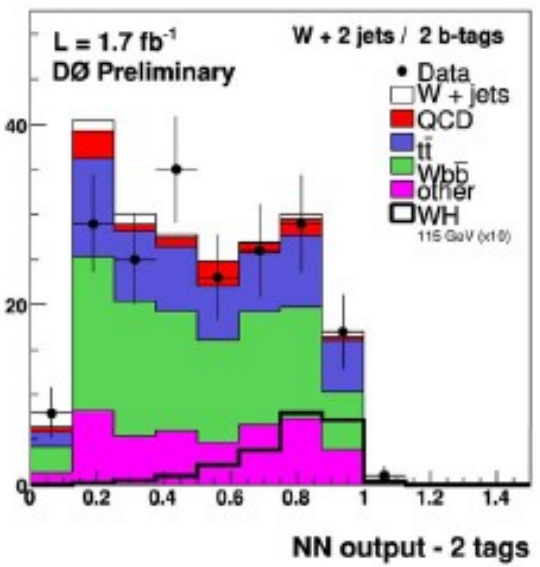
Introduction to SM Higgs



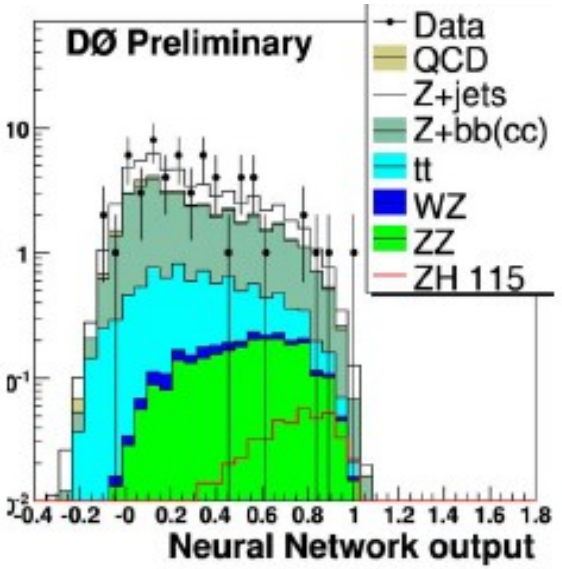




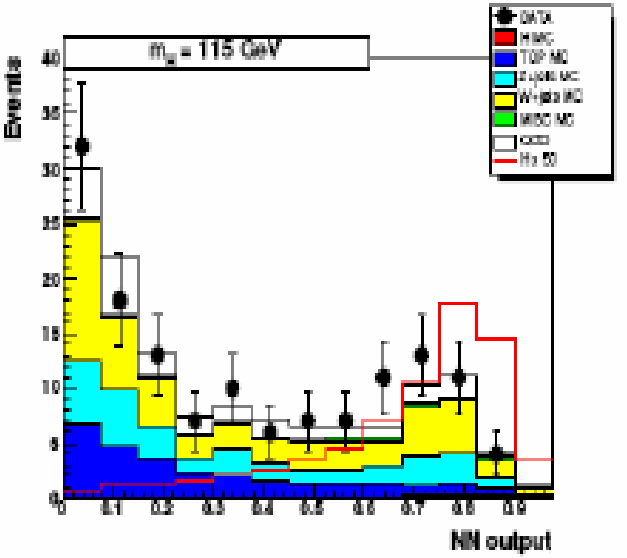
Analyses



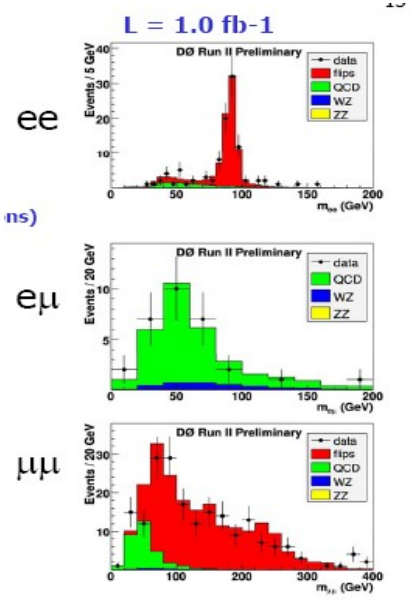
WH->lnubb 1.7/fb



ZH->llbb 1.1/fb

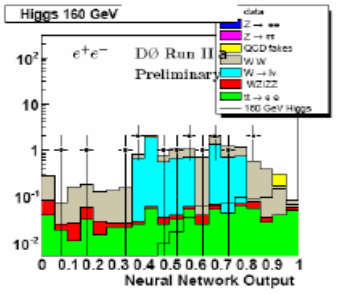


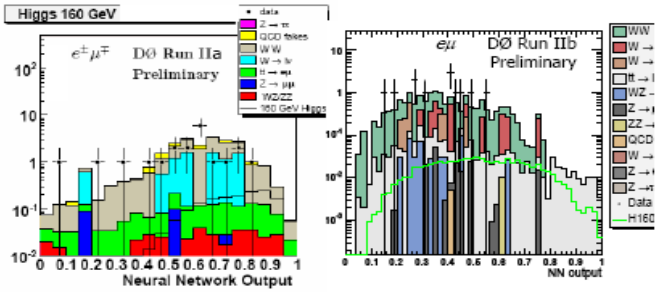
ZH->nunubb 0.9/fb

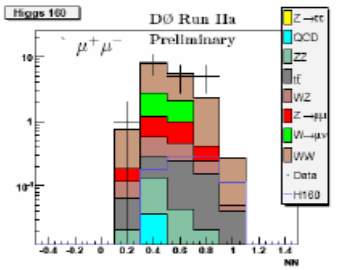


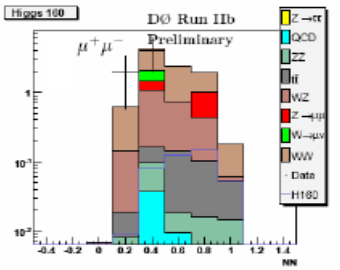
WWW->
like-sign ll
1.1/fb

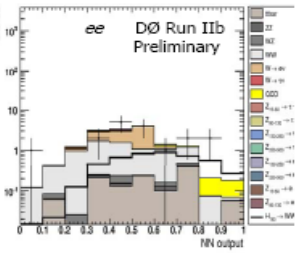
WW->ll
1.7/fb



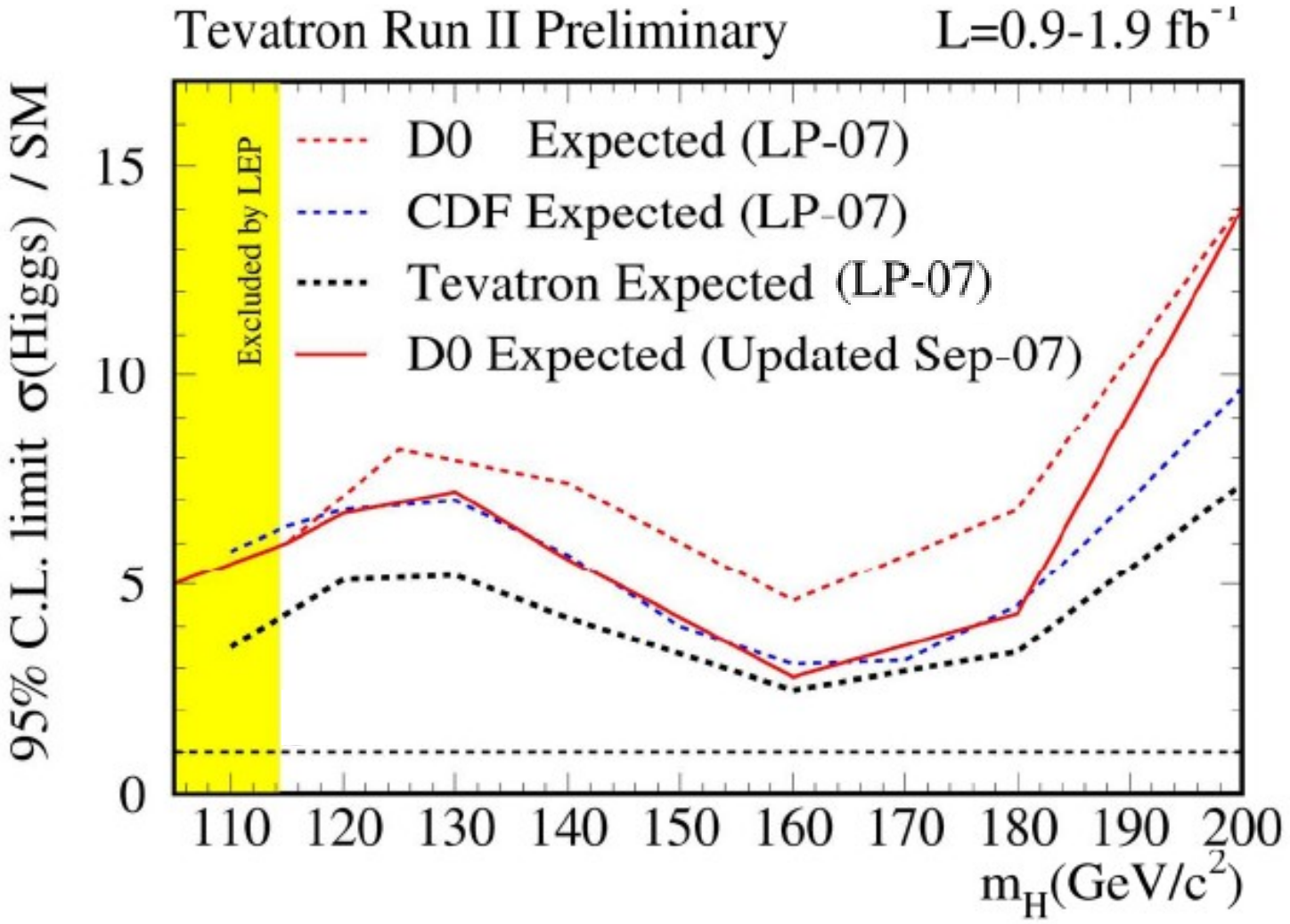








Where We Are Now



* See Gregorio's talk from Wed. for details!

Moriond '08 Goals

- Known improvements to ZH->nunubb and WH->lnubb
  - (Single tag, EC electrons, 3jet bin, etc.)
- Solidify all p20 analyses
  - p20 MC, p20 b-tagging, “certified ID's”, etc.
- Update to full 2.6/fb data set
- Work in common groups
  - V+jets, Trigger Studies Group, ...
- Start early: Mini-workshop Oct. 17+18th
- *And include as many of the “further improvements”*

Further Improvements “In Hand”

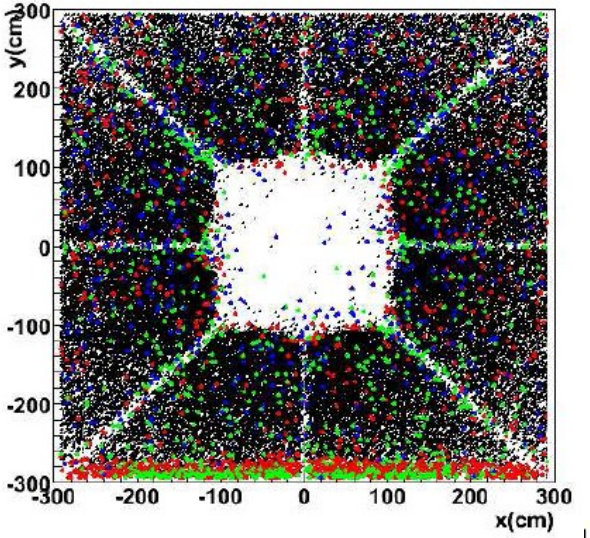
- Lepton ID
  - 10% efficiency per lepton
- *Improved* multivariate S vs. B separation
  - Better NN's, combined with *ME's*
  - 20% improvement in sensitivity
- B-tagging
  - Layer0 in tagging (8% per jet)
  - Semi-leptonic tagging (5% per jet)
- bbbar mass resolution, 18->15%
  - 20% improvement in sensitivity

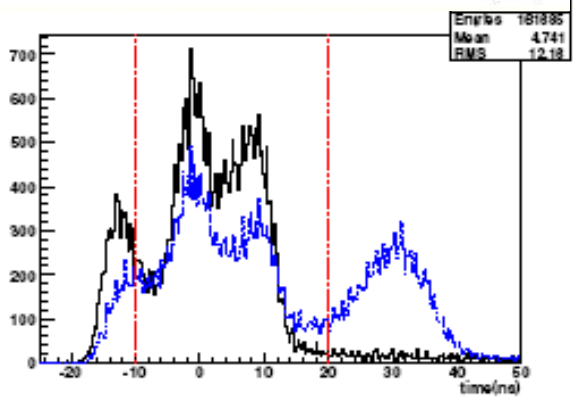
Meant to be *realistic* estimates!

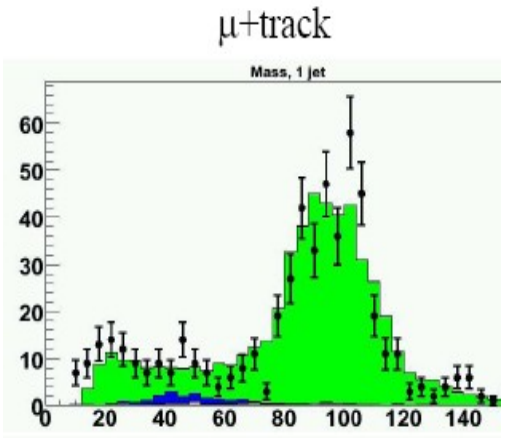
Serious efforts are already underway in all these areas...

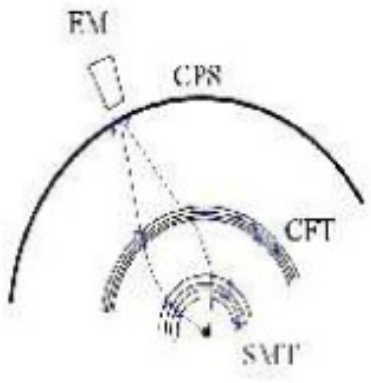
Lepton ID

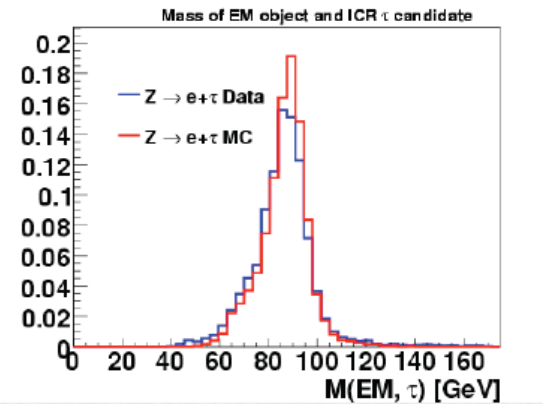
- Very useful Lepton-ID workshop
- *Many* ways to improve / use lepton ID
  - Looser muons (hits, timing, ...)
  - Smarter Cal isolation
    (#pv, lepton quality dependencies)
  - Hits on the road
  - EC electron track matching
  - ICR electrons
  - *Tracking at high luminosity*
  - "lepton-track":
    Good lepton & No track || No lepton && good track
- Must make tools available for all analyses

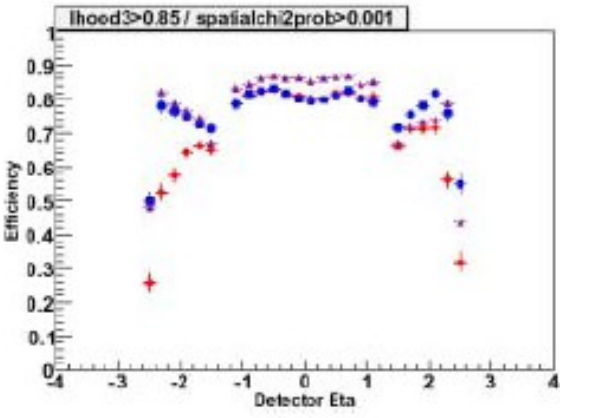








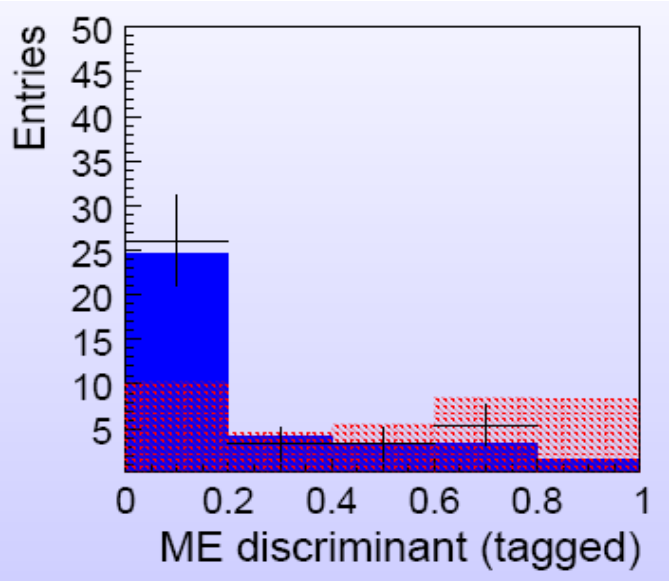


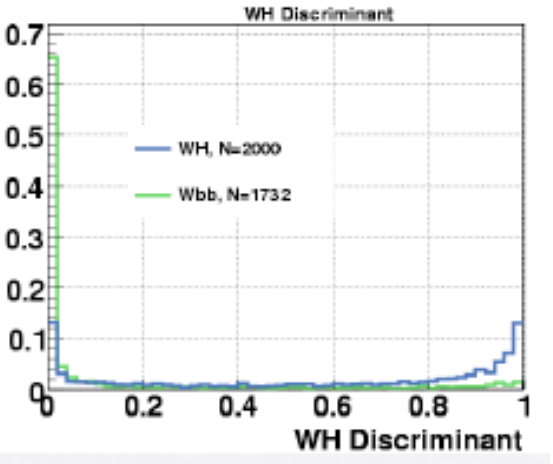


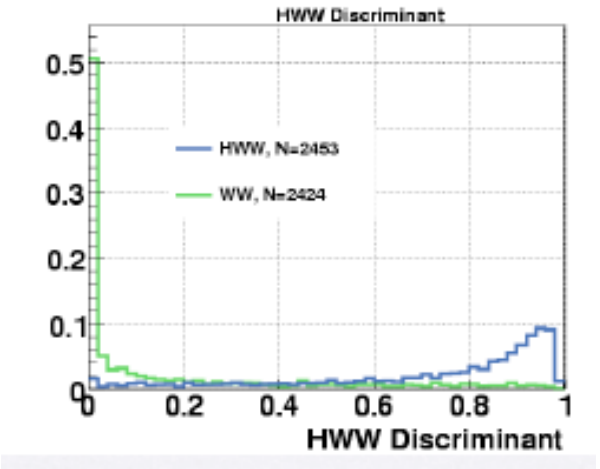
Improved Multivariate Methods

- Working on Matrix Elements for
  - WH->lnubb
  - ZH->llbb
  - WW->ll
- Will be combined with NN's
- Formed new D0 ME group
  - Join with top group

- *Plenty to gain here!*



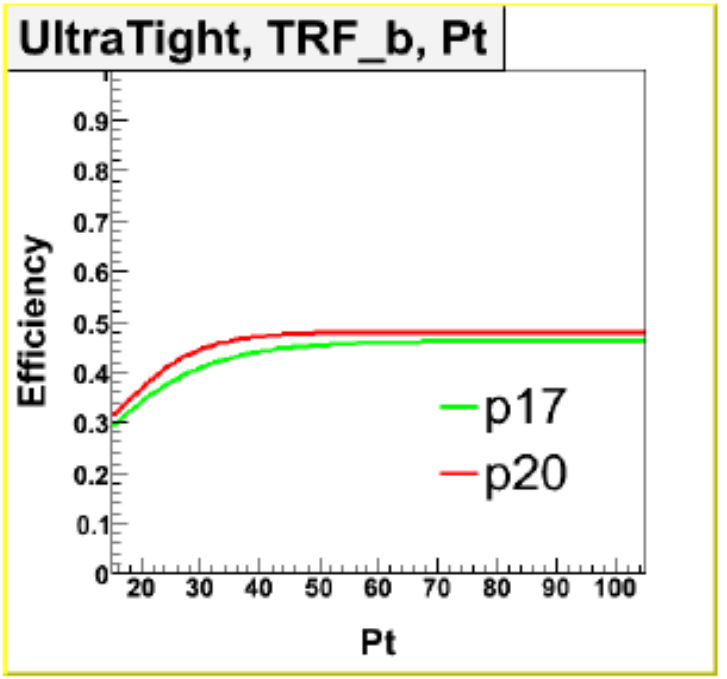


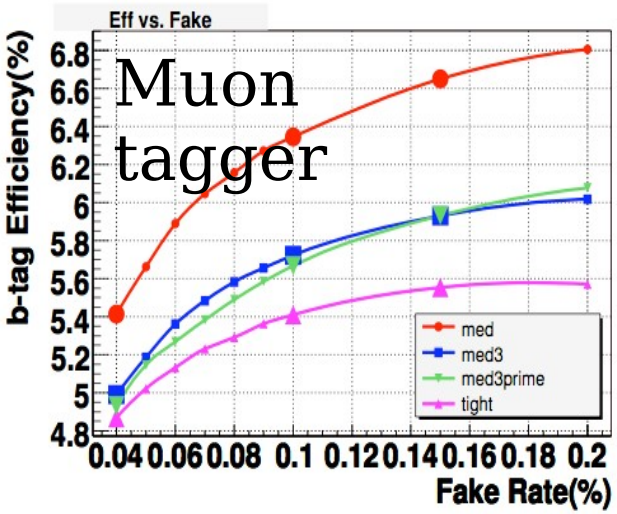


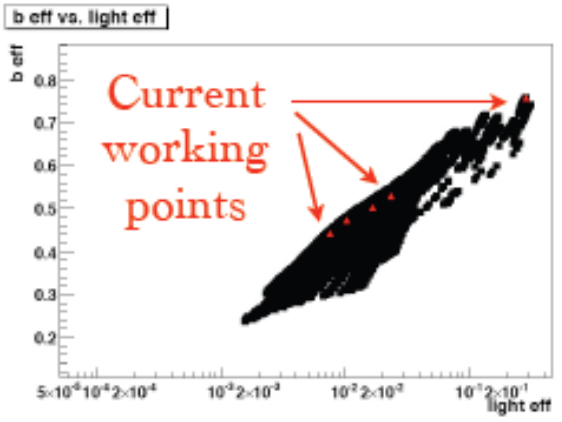
Thanks to Mike Mulhearn for leading the effort!

B-tagging

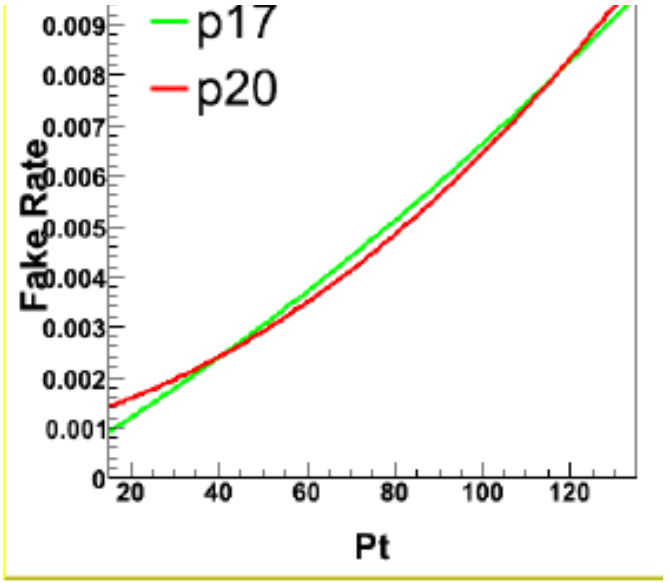
- p20 NN b-ID is almost ready
  - Already improvement over p17
  - Performance with L0 and at high luminosity not yet optimized
- NN muon-tagger almost ready
  - Needs to be continued in p20!
- Several other improvements already being studied
  - But *more help* needed here!







SVT optimization



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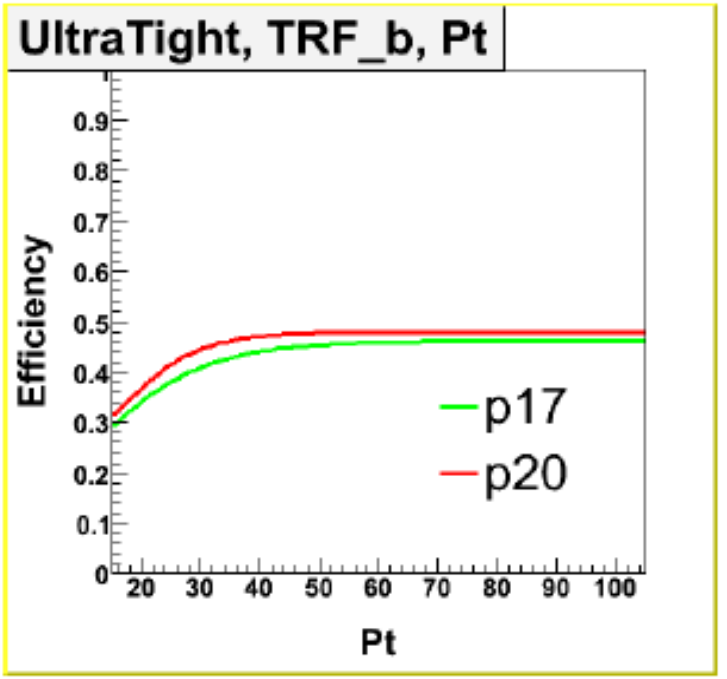
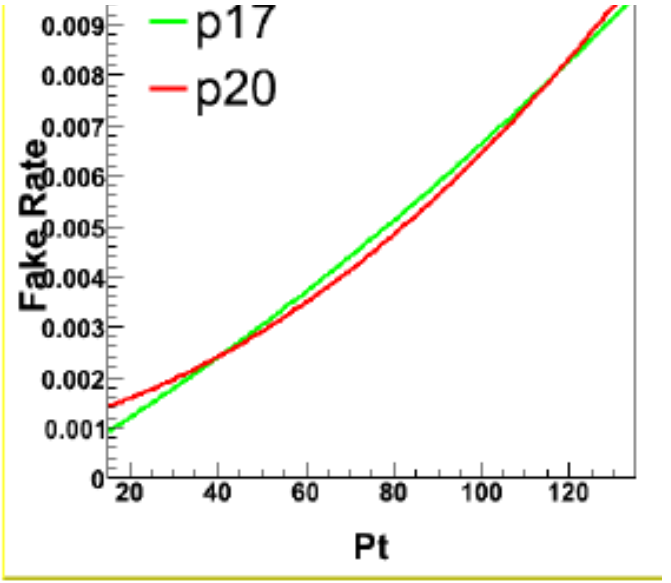
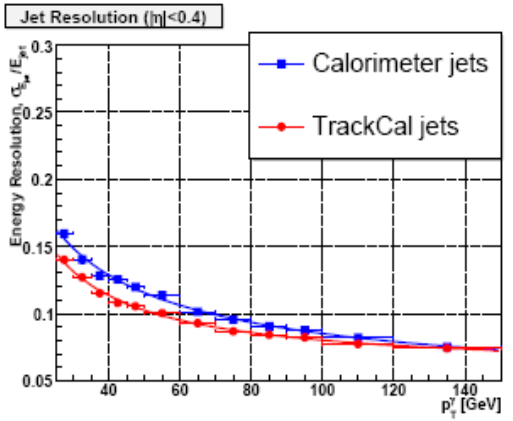
- Several other improvements already being studied
  - But *more help* needed here!
- Optimize b-tagging / tracking at higher luminosities
- b/c separation
- g->bb vs. b separation
- Soft-electron tagging
- Continuous b-ID NN output

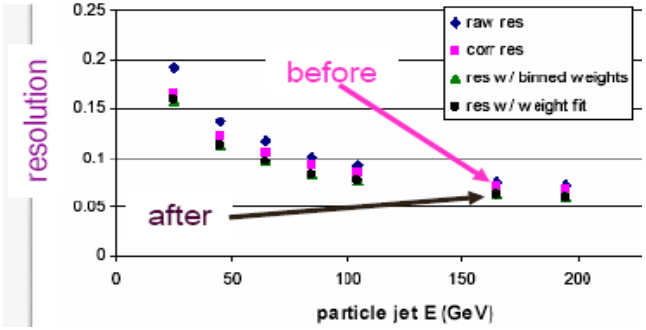


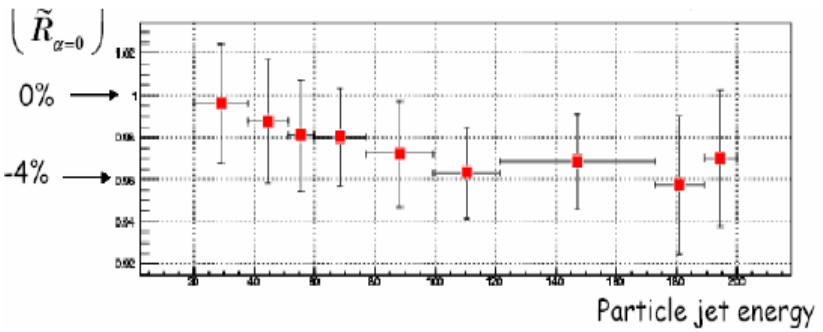


Jet Energy Resolution Group (JERG?)

- Critical to our low-mass SM Higgs
- Aim for 20% improvement by summer '08, some by Moriond
- *Many ways* to improve
  - Energy flow / track-jet algorithms
  - Cell-weighting (software compensation)
  - CPS info
  - Semi-leptonic corrections
  - FSR corrections
  - Response corrections (#PV, jet width, ...)
  - Revisit basics: 0-suppression, T42, jet algorithms, split/merge, ...
- Strong effort – but needs *more help*

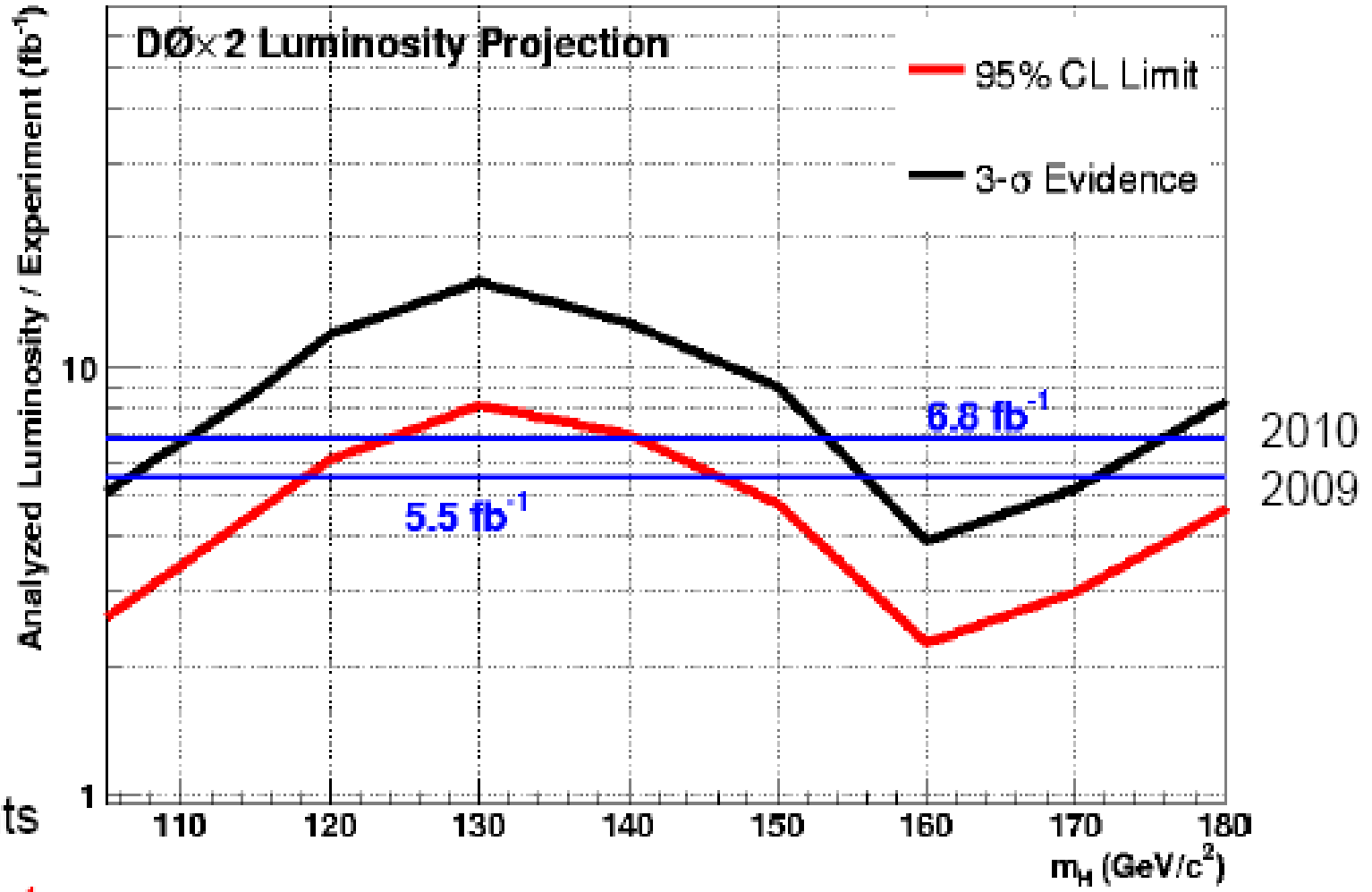






Thanks to Brendan for leading effort!

The Future "In Hand"



Assumes

2 experiments

Needs 4.5 fb^{-1} for 115 GeV

Needs 3 fb^{-1} for 160 GeV

We Will Do Better

- Top discovery
  - nothing, one nice event, BOOM!
- Bs mixing
  - maybe, will take a lot of work, BOOM!
- Single-top
  - Looks tough, gonna take a while, BOOM!

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  - *Looks really tough, might have a chance in 2010, BOOM?*

- **People get excited when they can “smell it” !**

- Thrill of discovery -> expanded, dedicated effort -> new ideas, Dr. Pepper -> some late nights -> ???

Excitement / New Ideas are Starting

Improving b-jet energy resolution

Paul Grannis

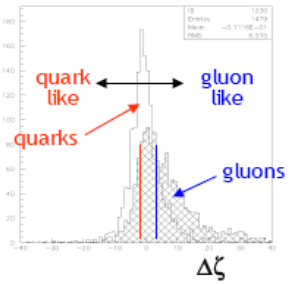
Improving b-jet energy resolution and raising the di-b jet tag efficiency could substantially improve the Higgs search sensitivity.

I comment here on old work† that might be of use ir energy resolution.

† http://sbhep1.physics.sunysb.edu/~grannis/talks.html
Notes 1 (estimating B hadron momentum)
2 (distinguishing quark and gluon jets)
9 (merging b jet FSR)

What variables might be used to predict E_b?

A separate OPAL study sought to distinguish quark and gluon jets using energy (and multiplicity) in a set of 10 annular cones around the jet axis. The H matrix chisquares, ζ_g and ζ_q, for conforming to gluon or quark hypotheses were formed and the difference, $\Delta\zeta$ (Fisher discriminant), obtained.

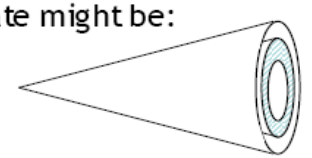


Keeping only subsample of events to left of red line or right of blue line could give ~65% quark/gluon purity with ~60% efficiency. Not great, but enhanced samples.

But the variables used do seem to have some discrimination power. b-jets are perhaps more different from light quarks than gluons!

A potential set of variables for b-jet energy estimate might be:

- Visible jet energy
- Energy profile (energy into annular subcones)
- Jet mass
- Nearby lepton energy, $p_T$rel
- Info on nearest jet ΔR and E jet (to account for FSR gluon radiation) (I tried once to improve Higgs di-b resolution by merging jets near a b-jet if low invariant mass ... no success!)



...

Ideas, study and optimization clearly needed.

Other Possible Improvements

- Loosen / optimize triggers
- Reduce systematics further
- Tau channels (some are almost ready now…)
- New channels (H->ZZ? Hadronic states?)
- Further lepton ID
  - tracks for electrons which Brem?
- (*Insert your idea here…*)

Conclusions

- SM Higgs is within our reach, but it won't be easy
  - Complete improvements “in hand”
  - Good detector performance, integrated luminosity
  - CDF
  - Luck
  - SM to be right

- It's up to you...
  - Get involved in an analysis
  - Work on improvements
    -> *we depend upon the success of the ID, JERG groups!*
  - Be creative!
    -> new channels? new corrections?
    new ways to separate S vs. B?

Discovery is 50% inspiration and 50% perspiration!