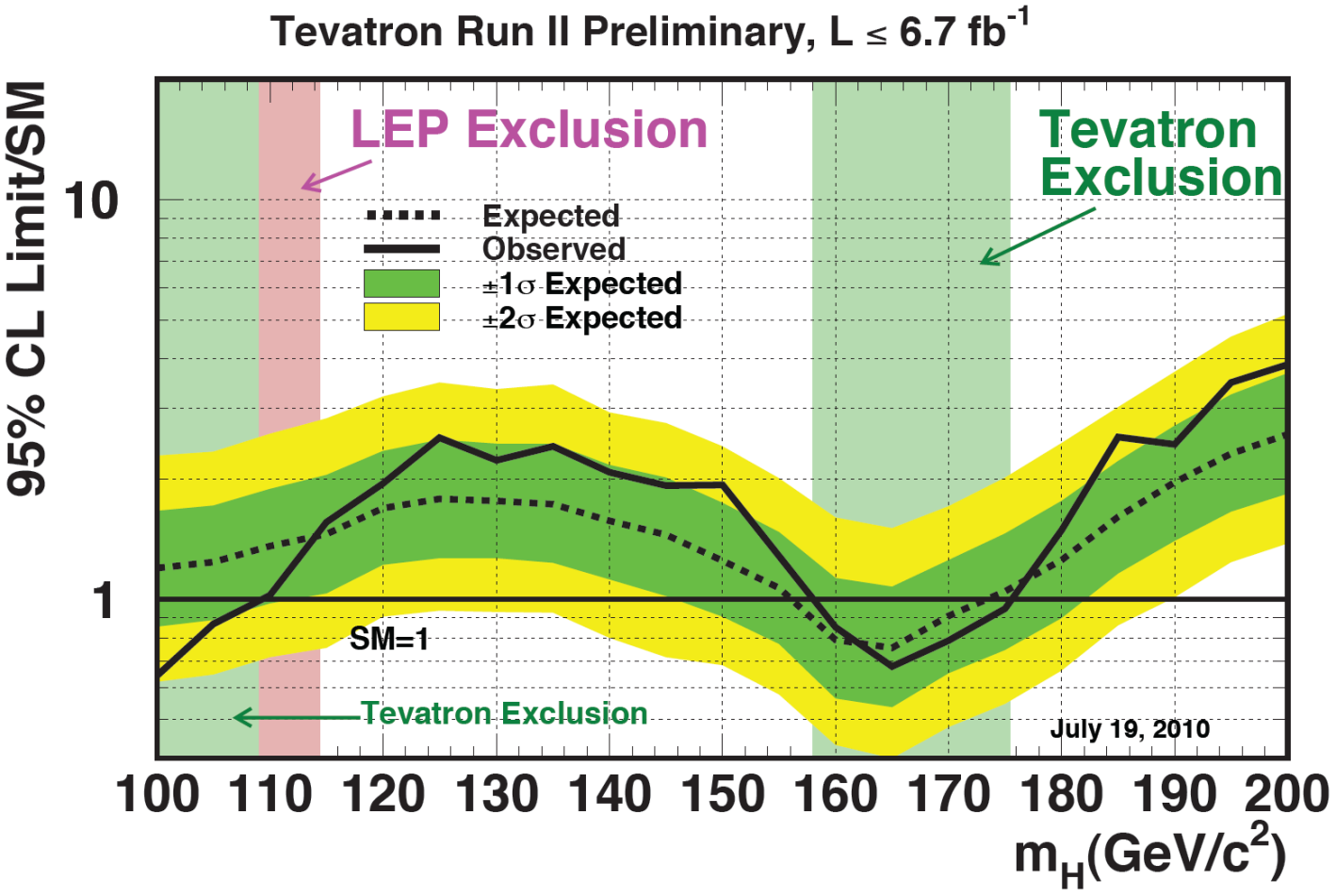
Summer plans and prospects on Higgs searches at DZero

Yuji Enari

2011. 5.30

D0 France meeting

Tevatron combination on SM Higgs



Low mass : avg Lumi = 5.8 fb^{-1}

WH→lνbb, ZH→llbb, ZH→ννbb

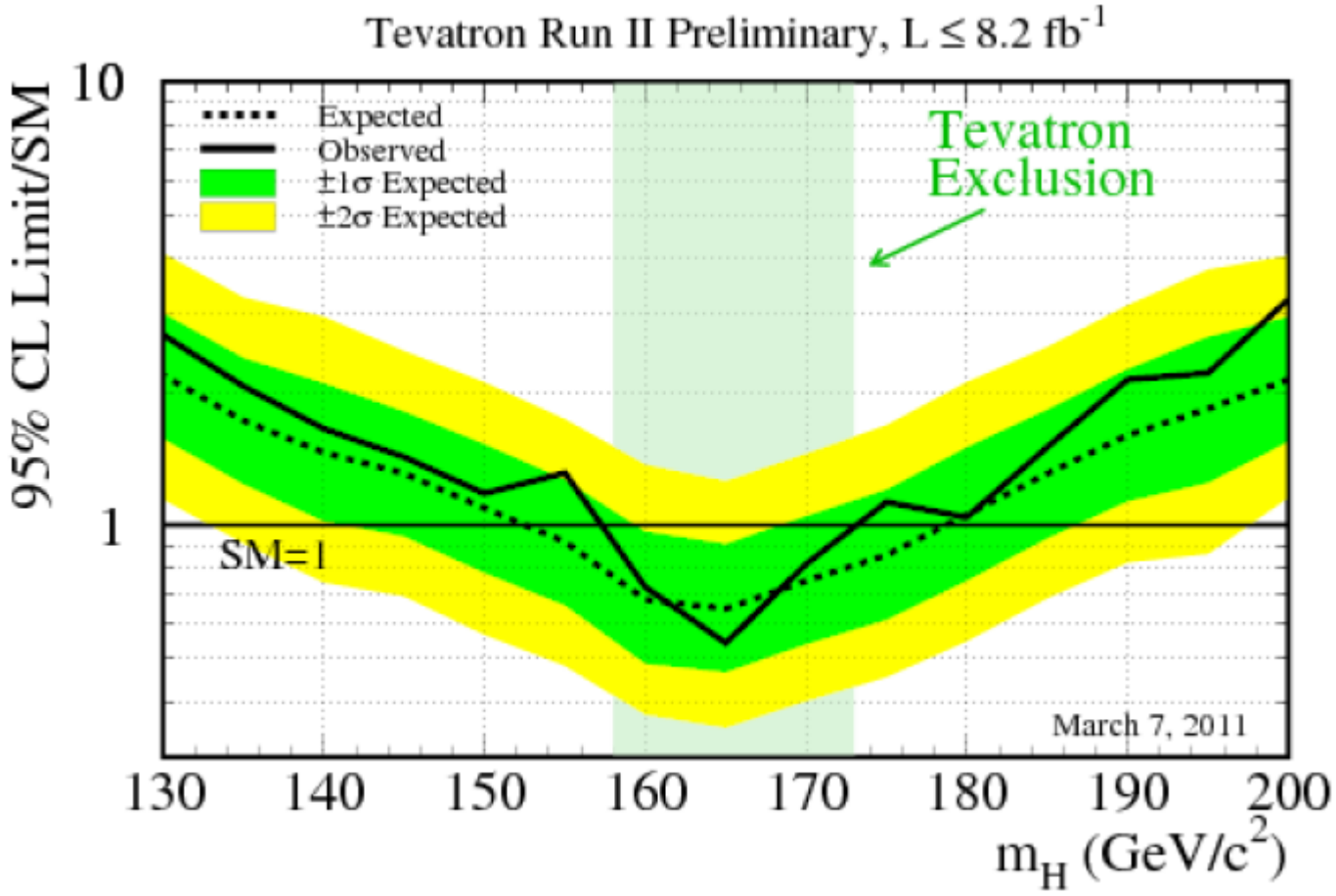
- Limit/SM : Exp: 1.45 obs : 1.56
- Excluded: 0.95 (1.24) x SM @ 105 GeV

High mass: avg Lumi = 6.0 fb^{-1}

H→WW→lνlν. (ee,μμ,eμ,eτ,eτ)

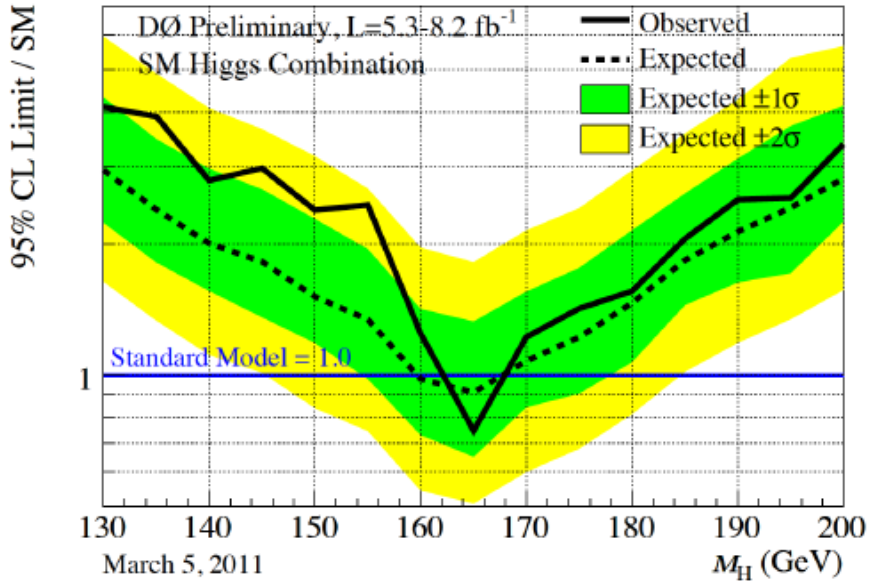
- High mass exclusion : 4 times wider
- 156 < MH < 175 GeV in expected

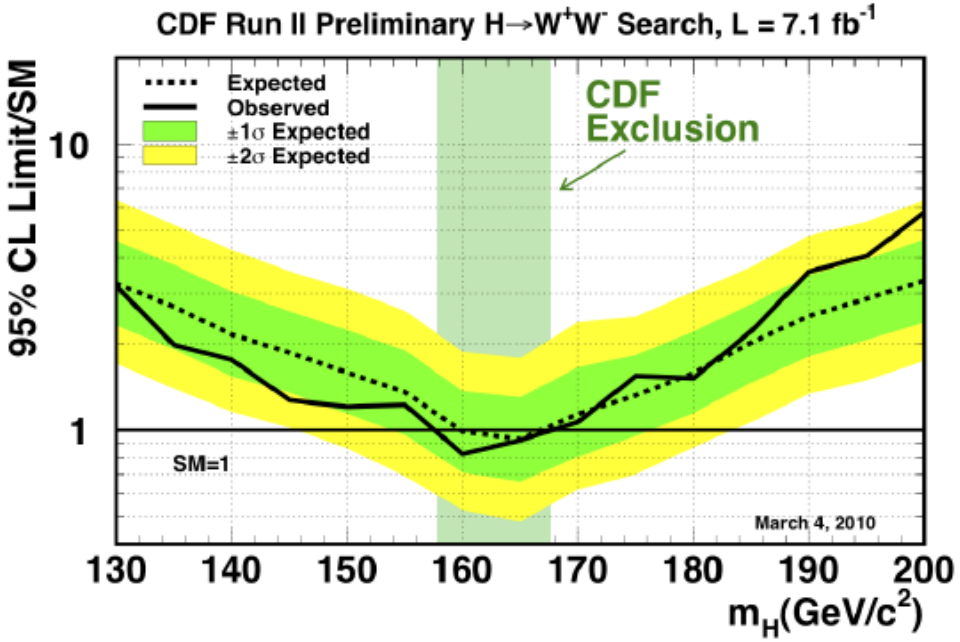
Latest High mass combination



- SM Higgs excluded at 95% CL for **158 < mH< 173 GeV**
- Expected exclusion at 95%CL **153 < mH< 179 GeV**
  - (Summer 2010 expected exclusion: 156 < mH< 173 GeV)

CDF & D0 exclusion



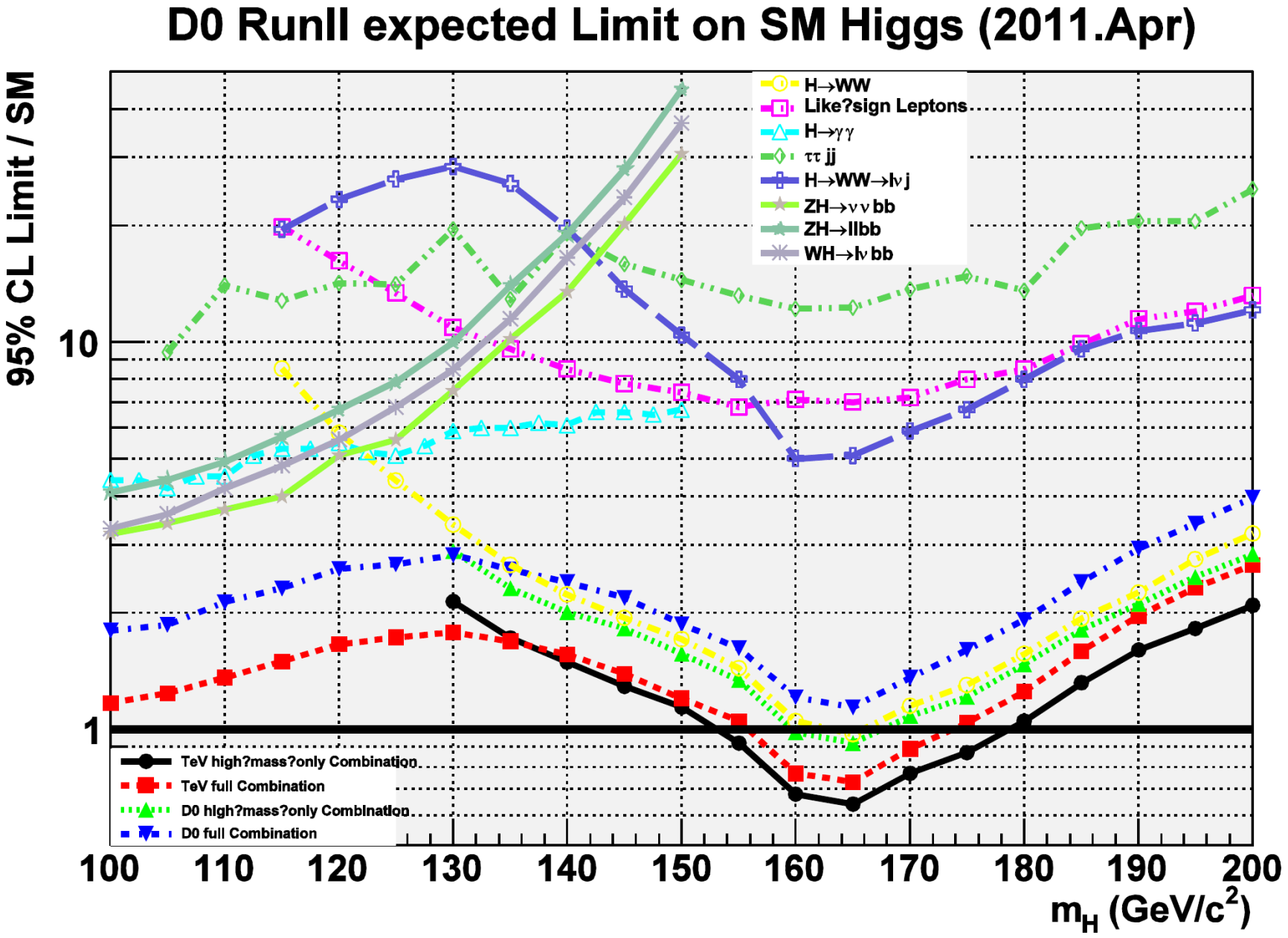


163<M_H<168 @95% C.L
(160<M_H< 168 expected)

158<M_H<168 @95% C.L
(160<M_H< 167 expected)

First exclusion by single experiment!

Individual input to Combination

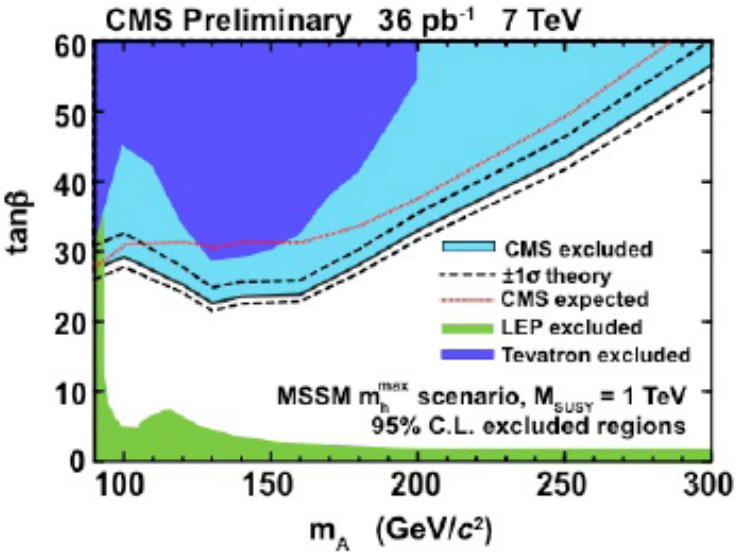


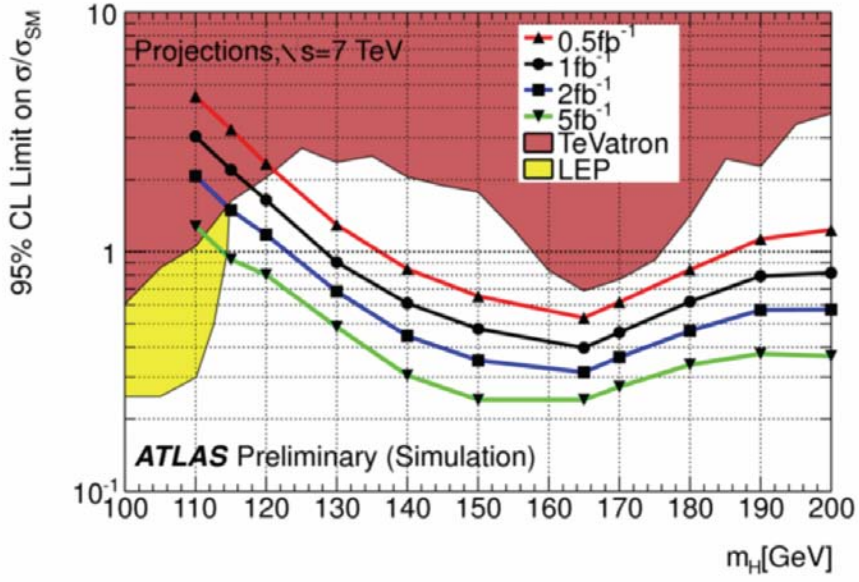
2011 Summer results

- CDF/D0 set target as EPS conference
  - Full Tevatron combination
- Strategy depends also LHC operation
  - ATLAS/CMS would have 0.4-0.5 fb-1
  - Their sensitivity for BSM Higgs and high mass Higgs would exceed Tevatron's sensitivity

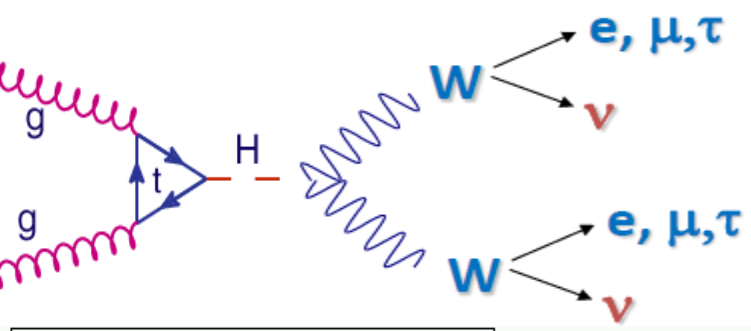
Many discussion at PAC/P5 for run extension based on assumption of 16 fb^{-1} @ TeV vs 1 fb^{-1} @ LHC.

→ This summer would be 8 fb^{-1} @ TeV vs 0.5 fb^{-1} @LHC

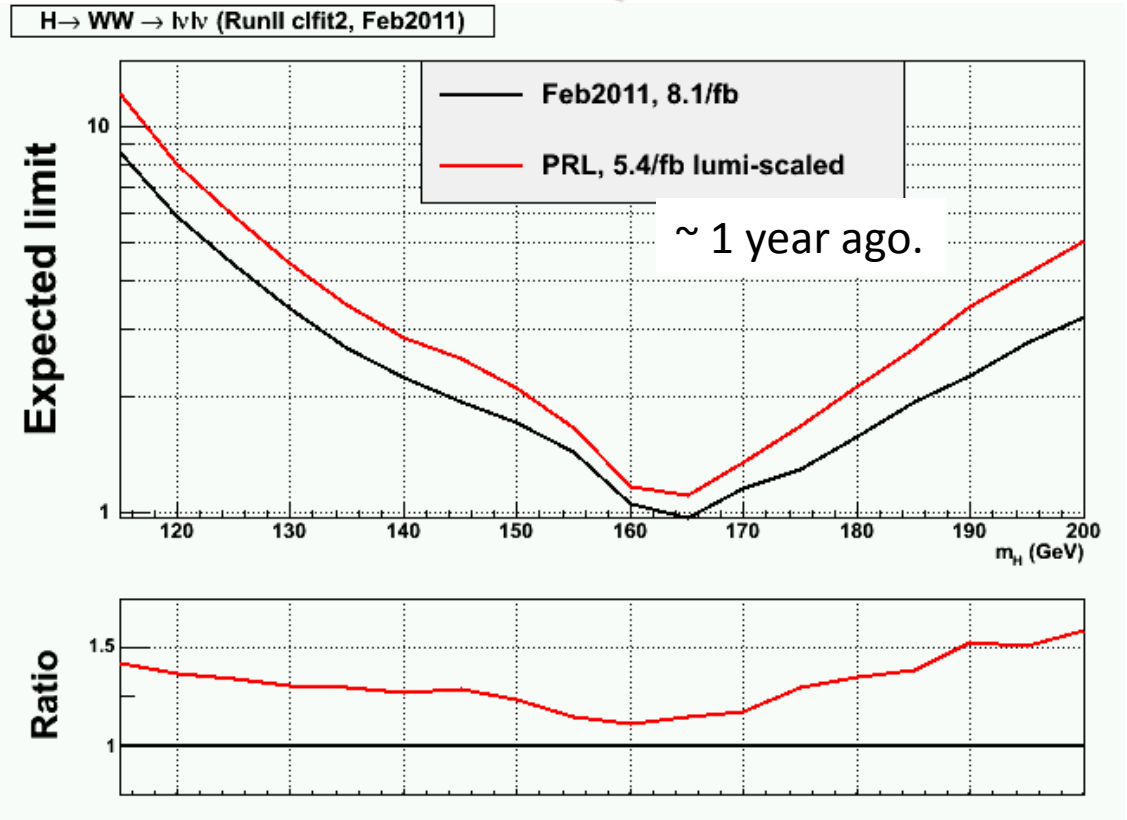




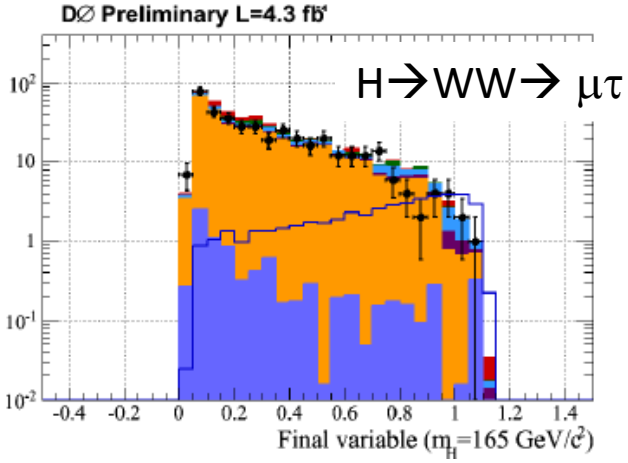
High Mass Search: lvlv



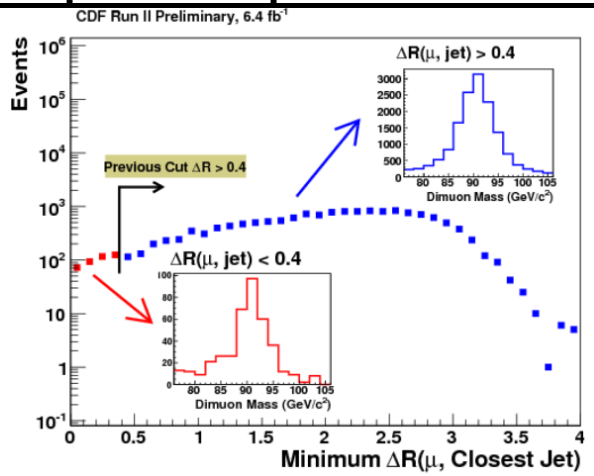
IPNL: P. Verdier
CEA : B. Tuchming, E. Chapon, C. Royon
Z. Hubacek, F. Couderc, R. Madar



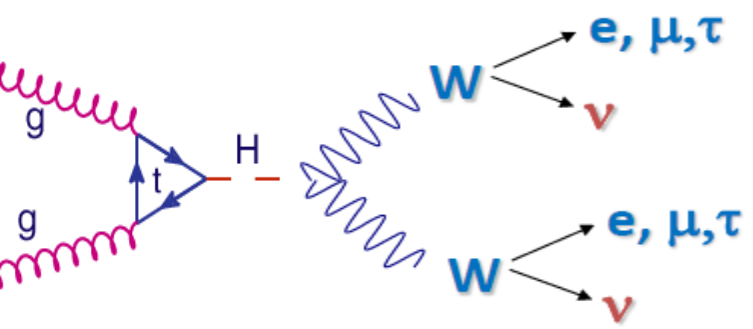
Major Update -1: new channel



Major Update-2: update muon criteria



High Mass Search: lvlv



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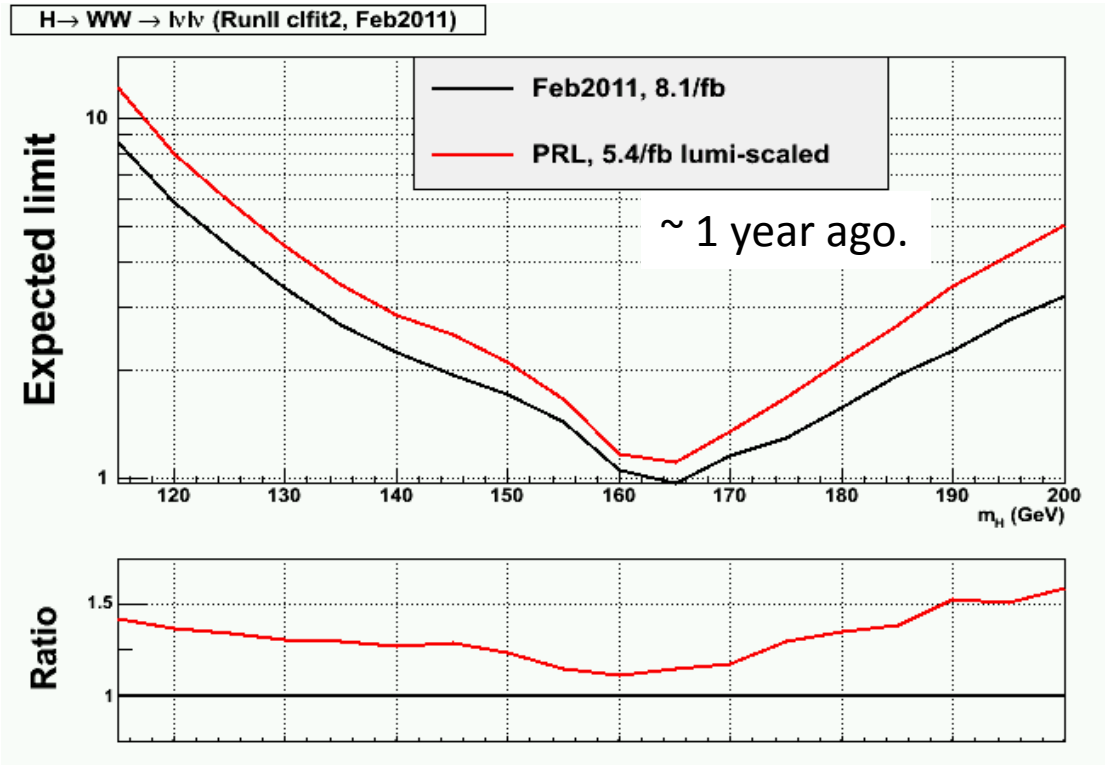
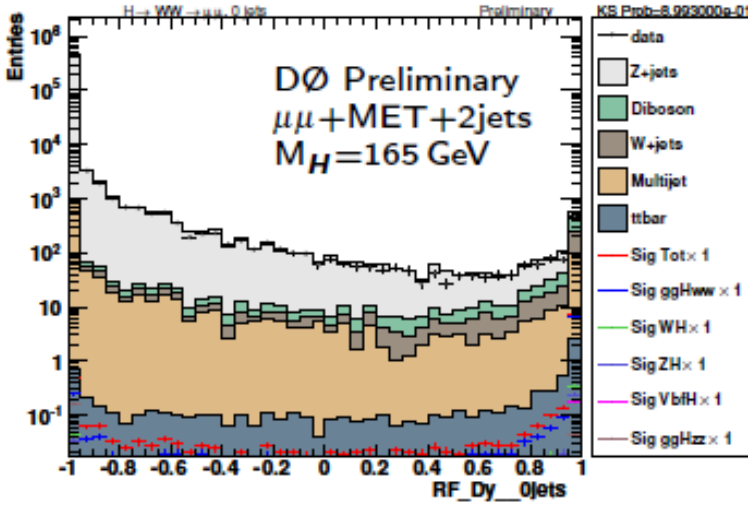




Major update-3: MVA

- 2 step, 1st: reduce particular BG, 2nd : final discriminant.)
- Splitting sample, i.e. Jet multiplicity improved expected limit by 30% @ 130 GeV and 15% @ 160 GeV.

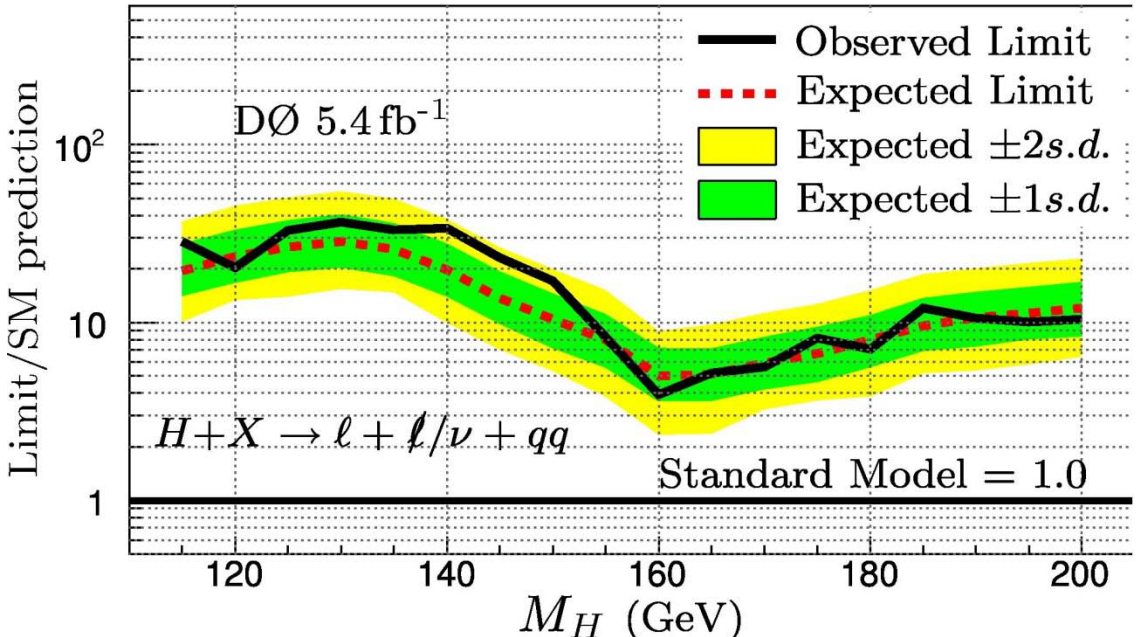
Summer 2011: Current main focus is to publish this result.
Also working on adding new data set (+0.4 fb-1)

High Mass Search: lvjj

- H→WW→lvjj
  - Large number of expected signal yield, but large W+Jet background.
- Published 5.4 fb^{-1} as the first result at the TeV.
- Plan to update with 8.x fb^{-1}.
  - Work closely with WH → lvbb analysis.

Expected improvements
- Looser Electron, Muon ID
- Inclusive trigger on Muon

→Enlarge signal acceptance
More than 30%.



Higgs in 4th generation Model

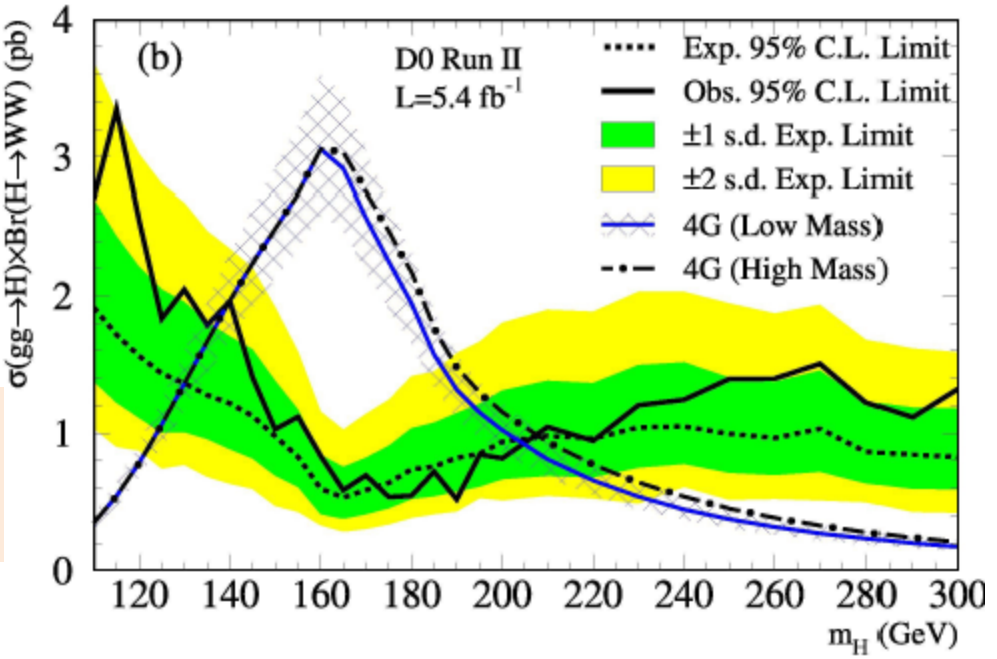
- Additional quarks enhance ggH coupling by 3.
  - $\sigma(gg \rightarrow H)$ enhanced by ~9 for MH=100-300 GeV
  - No enhancement on VH and VBF.
- Published result on 5.4 fb-1 TeV combination.
  - Excluded130<MH<210 GeV
- Updated result with recent input
  - Larger data
  - Additional channes.

    H+X→taus

    H→WW→lvjj,

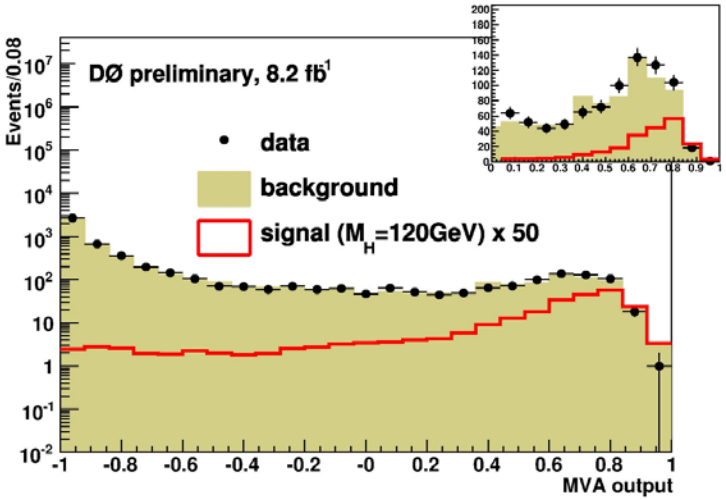
    H→ZZ→lljj…

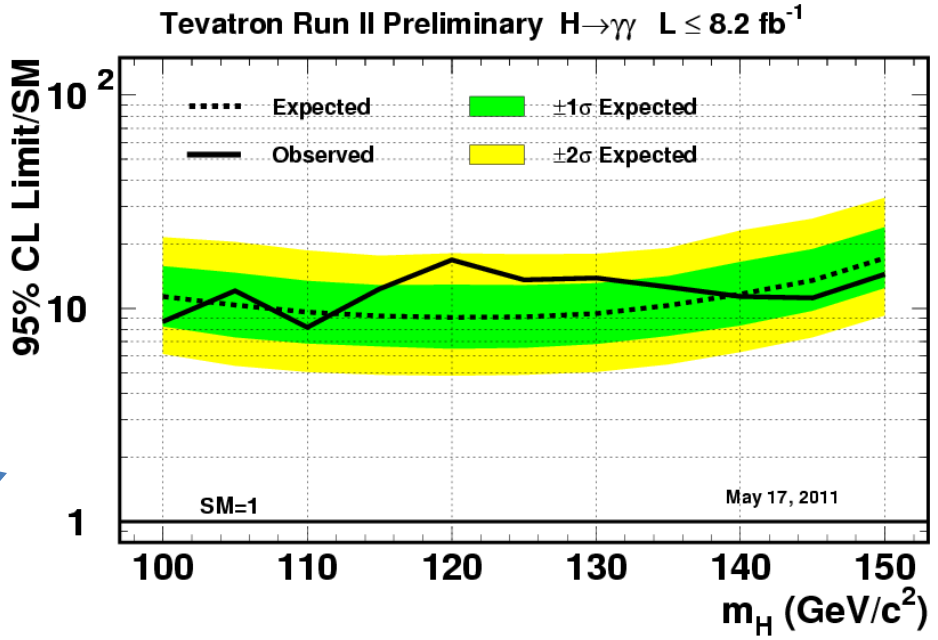
LHC will exceed TeV sensitivity
Plan to have publication.

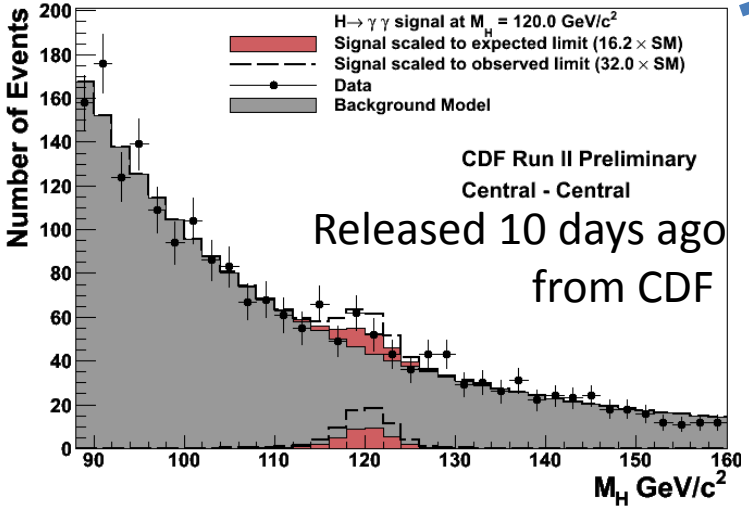


Medium Mass Search: γγ

- H→γγ contribution is not small, especially medium mass range.







Released 10 days ago from CDF

@ MH=120 GeV
Exp : 9.1 xSM. Obs: 16.9 xSM

Target is publication for Dzero, and TeVatron combination as soon as possible.
Fermiophobic interpretation.

Low mass Higgs searches

- H→bb with W/Z associated production

  ZH→llbb

  CPPM: E. Nagy, M-C. Cousinou, (B. Calpas)

  WH→lvbb

  LPNHE: G. Bernardi, J. Brown, D. Brown, Y. Enari, D. Li, M. Boulenger

  IPHC: S. Greder, F. Miconi, I. Ripp-Baudot

  VH→vvbb

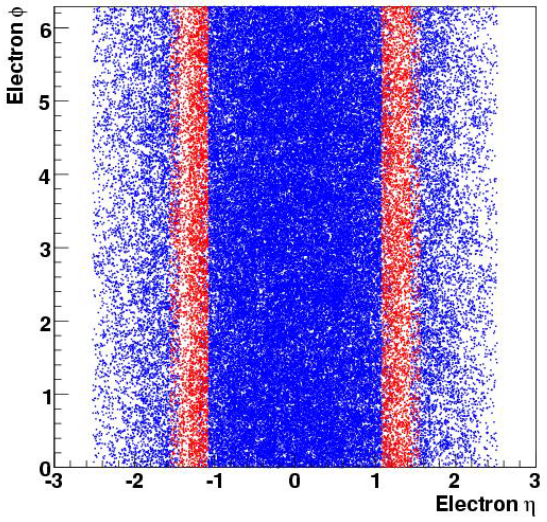
  LAL: J-F. Grivaz, T. Guillemin, (M. Rangel)

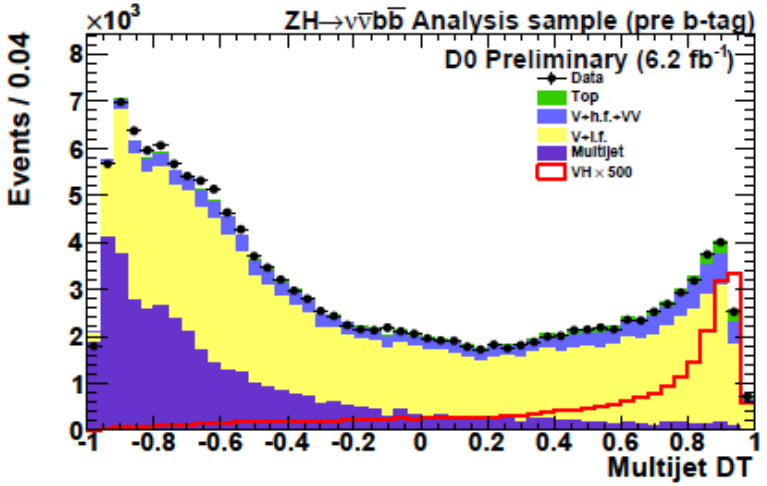
  CPPM: A. Duperrin, (D. Jamin), N. Osman

- Large D0 France contribution into low mass Higgs analyses.

Low mass Higgs Search

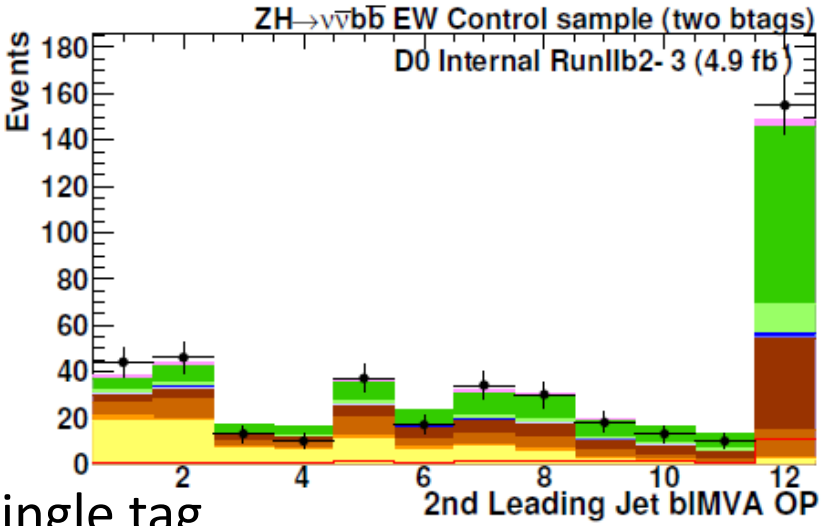
- Strategy for improvement:
  Use Looser ID, apply MVA
  Lepton
  - Include GAP region
  - Loosening isolation
    - LVBB could gain ~15%
  - Muon Trigger: go to inclusive.
    - SingleMU → Inclusive gain ~ 20%
  - Optimize selection
    - Lowering MET, etc..
  - Use MVA to suppress Multi-jet BG





Low mass Higgs Search

- Strategy for improvement:
  Use Looser ID, apply MVA bID usage



Event category

Old style: Loose double tag + tight single tag

New style: use Loosest OP and include bID MVA output into training of final MVA.

→ vvbb analysis observe 14 % improvement.

For EPS, use this approach for all three channels.

Note:

Can not judge any more just looking at S/B in final sample.

→ Final MVA is trained with bID discriminant.

Be careful to make a comparison from dijet mass to MVA result.

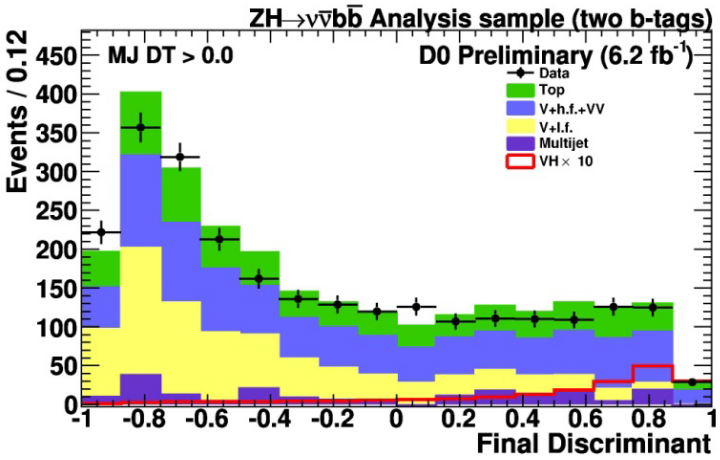
→ old style: Dijet / MVA is ~ 20%

→ new style: Dijet / MVA is ~ 50%

Low mass Higgs Search

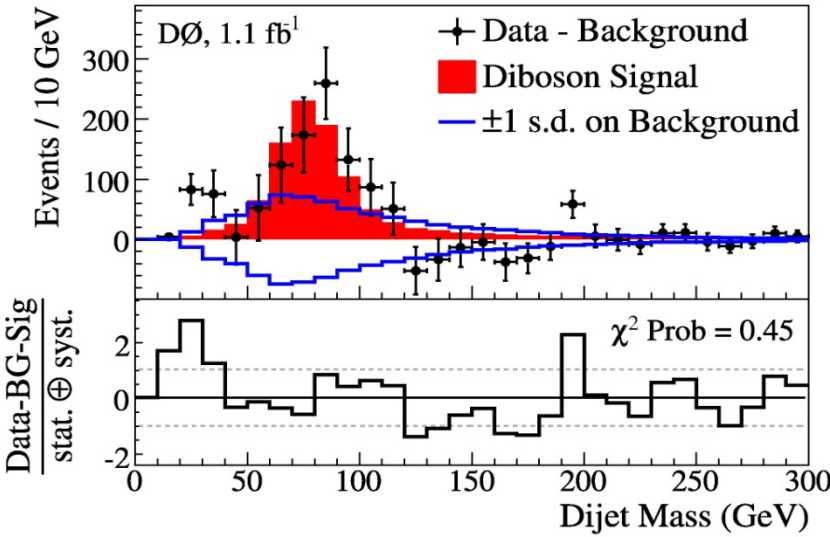
Channel	LLBB	LVBB	VVBB
Latest result	L=6.2 fb^{-1} Exp: 4.8 x SM Obs: 8.0 x SM	L=5.3 fb^{-1} Exp: 4.8 x SM Obs: 4.1 x SM	L=6.2 fb^{-1} Exp: 4.0 x SM Obs: 3.4 x SM
bID usage	MVA tagger Normal tag	NN tagger Normal tag	MVA tagger L6-Continous tag
Final MVA	TMVA RF	SPR RF	TMVA BDT
Lumi @ EPS	L6-contineous MVA tagger with L>=8.2 fb^{-1}		

- Aim to exclude LEP result at low mass! Let's see!



Diboson measurement

- lepton + Jets final state (LLJJ, LVJJ, VVJJ) from Diboson is a good bench mark for low mass Higgs search.
  - Understanding preselection.
  - Dijet mass resolution
  - Multivariate Analysis

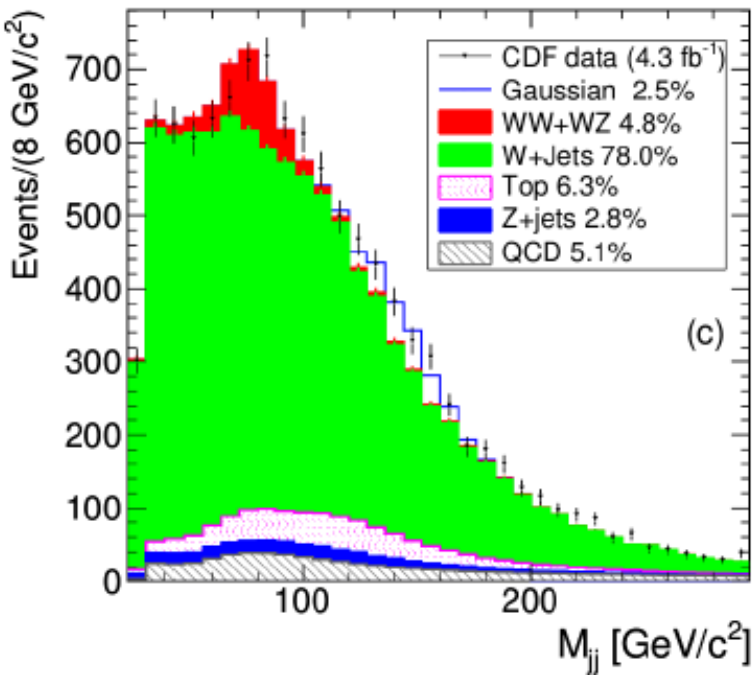


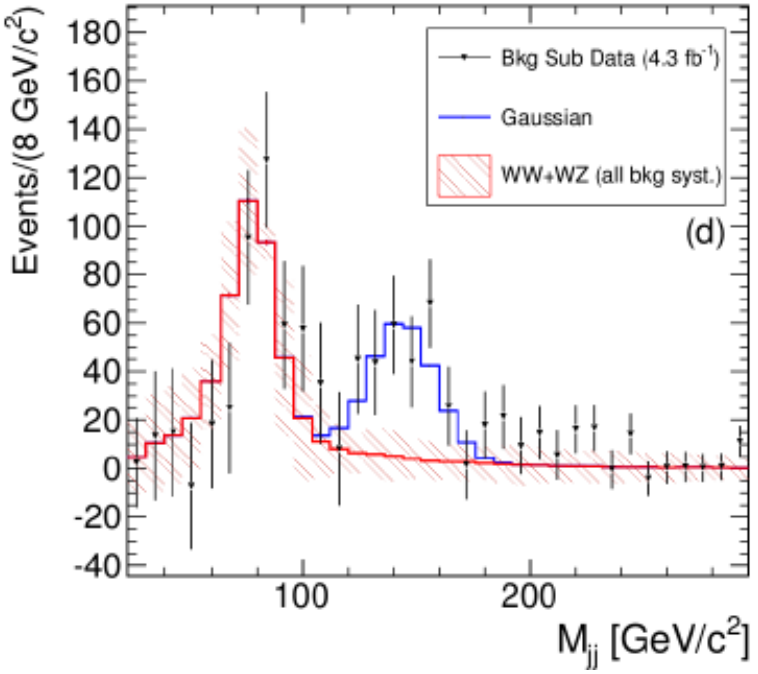
- For EPS result
  - Obtain limit/cross section measurement with
    - Exact same treatment with Higgs search.
    - 1tag+2tag with WZ and ZZ production as signal
    - WW is one of Background.

    → Will obtain TeVatoron Combined result.

Bump search on Dijet in W+jets

- CDF reported a 3.2 s excess at Mjj~ 144 GeV in W+2jets sample.
- Diboson lvjj analysis (by WJJ, Wade, Jadranka, Joe) for cross check on this bump is now under collaboration review.
- Will be submitted to PRL by June 10th and be reported at Wine & Cheese seminar (if it is approved).





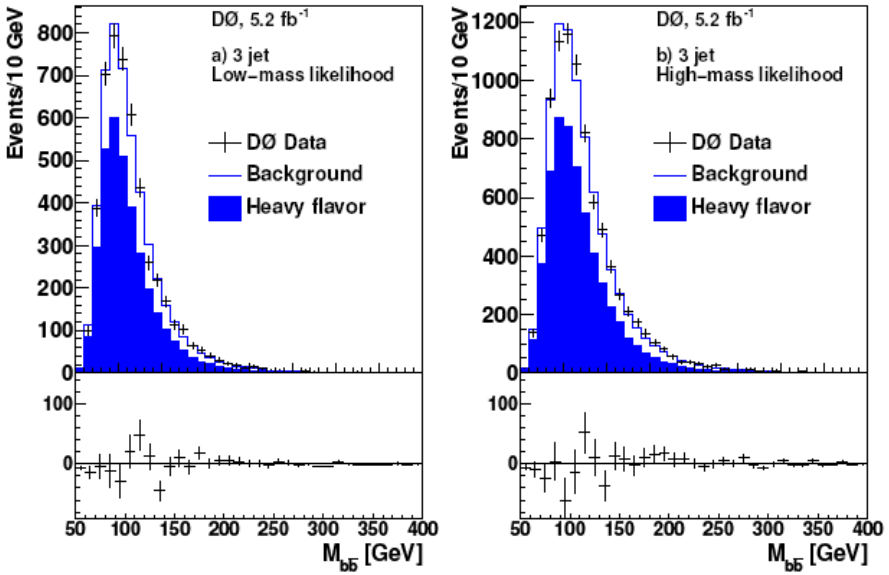
MSSM Higgs

- 2 Higgs doublets
  5 Higgs bosons
  - 2 Charged (H+)
  - 3 neutral (ϕ = h, H. A)

  Coupling $\phi \rightarrow \beta$ enhanced by $\tan^2\beta$
  $\phi \rightarrow bb$~90%, $\phi \rightarrow \tau\tau$ ~ 10%

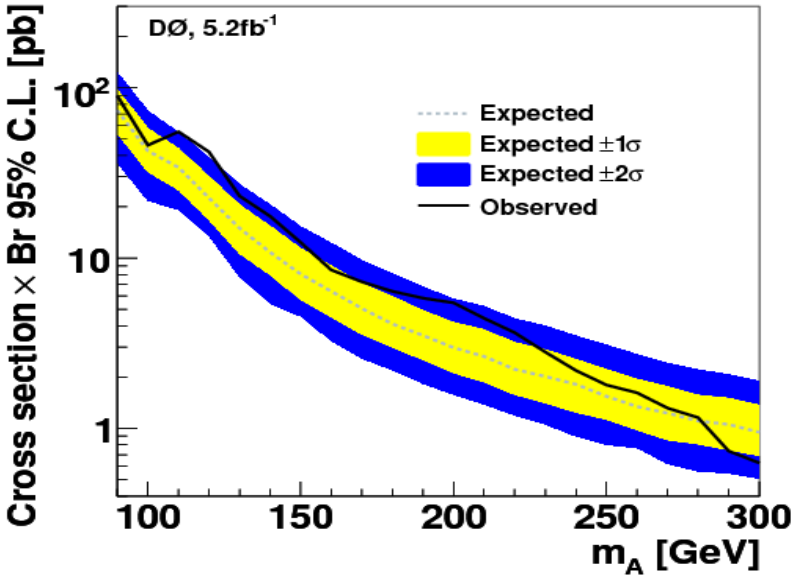
Searches on

$b\phi \rightarrow bbb$, $b\phi \rightarrow b\tau\tau$, $\phi \rightarrow \tau\tau$



CEA:

B. Tuchming, F. Couderc



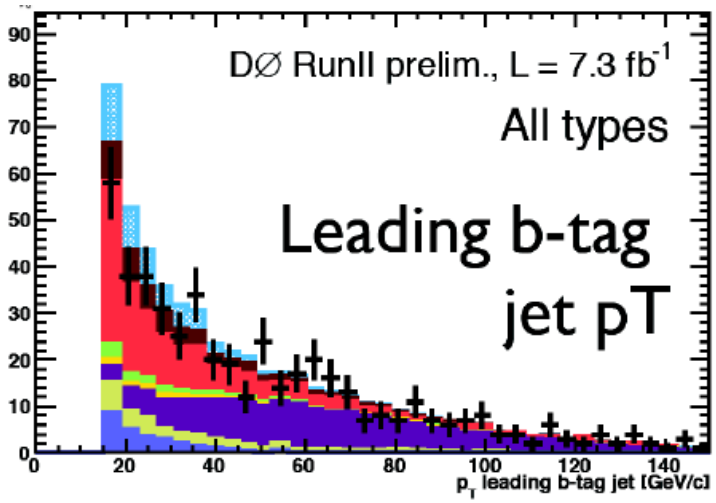
Update with 7.2 fb-1
- latest b-tagger
- jet pairing with MVA

Stay tuned on excess at 140 GeV.

MSSM Higgs (2)

bϕ→bττ

CEA: F. Couderc

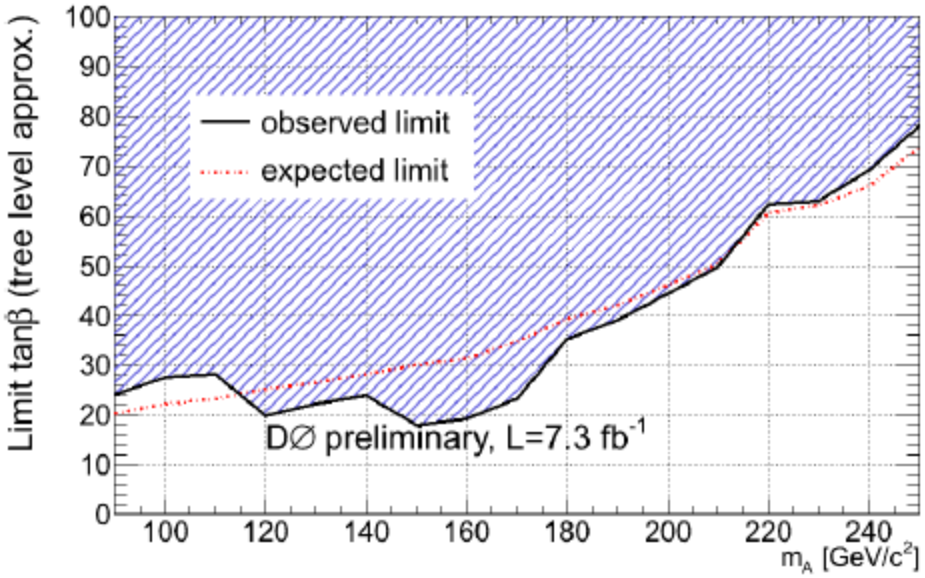


Updated result with 7.3 fb^{-1}

- make big progress on understanding on τ_{had}
  - Introduce inclusive trigger approach
  - reducing Z +jet BG
  - MVA optimization

→ 70% improvement in cross section limit.

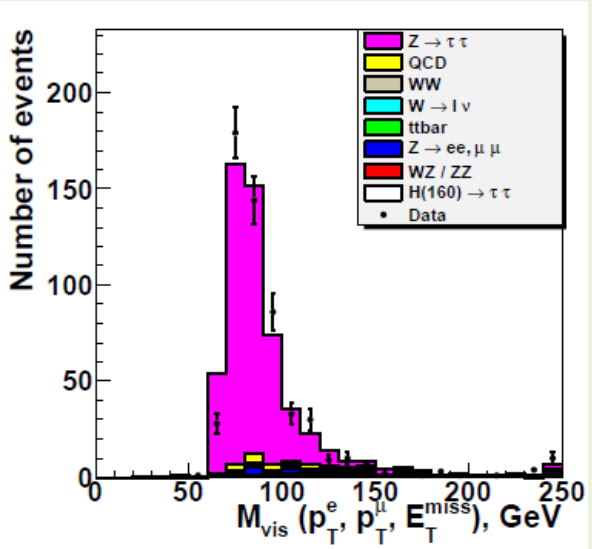
Will publish very soon.



ϕ→ττ→eμ

Will publish with 5.4 fb-1

CEA: S. Shary, M. Titov



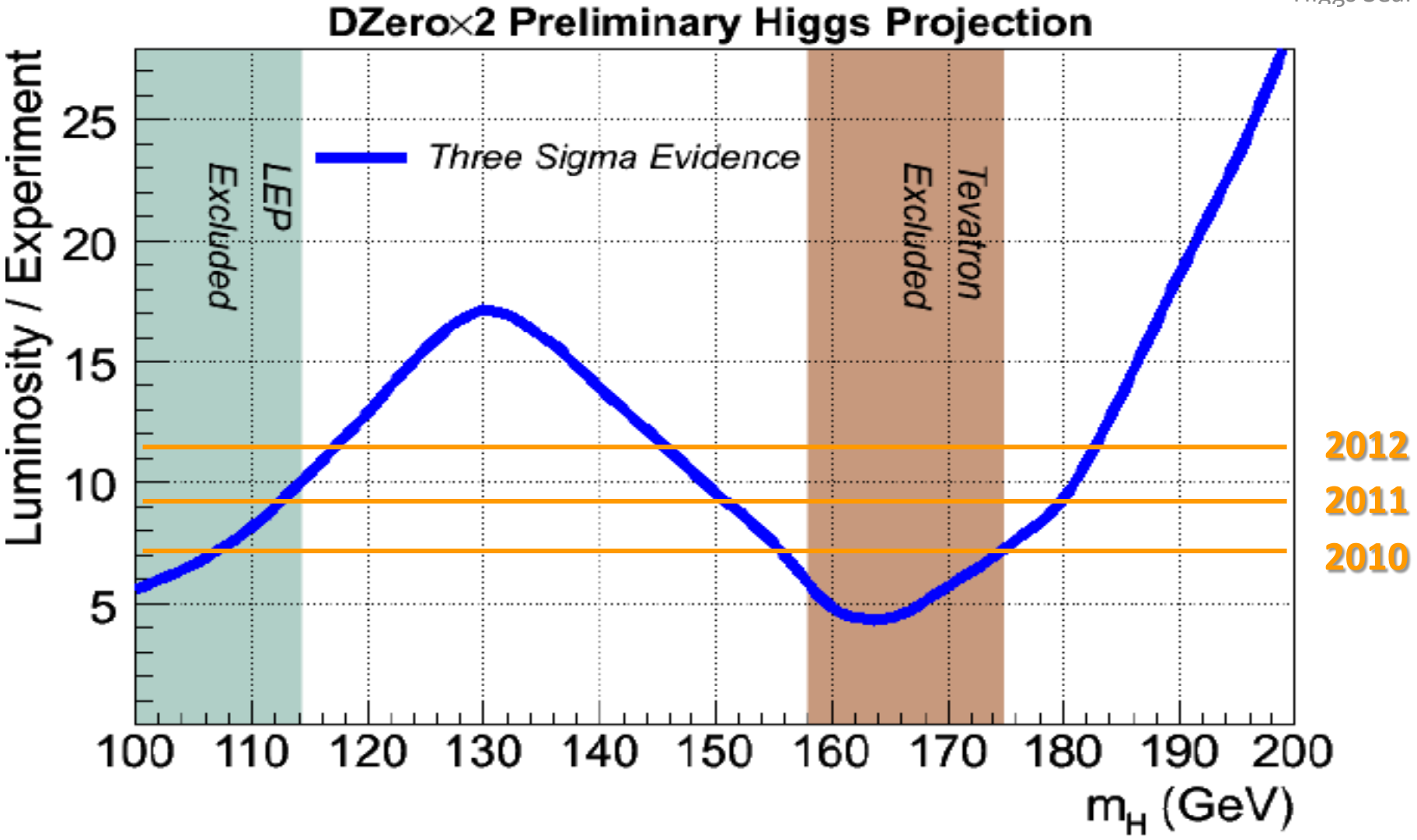
Summary

- D0 France involves deeply, provides solid results.
- Very strong program on Higgs search is going.
  - SM Higgs

    High mass Higgs search:
    - D0/CDF individual result start to exclude high mass region
    - Combination will enlarge exclusion region

    Low mass Higgs search:
    - Full update results will be released from main 3 analyses
    - Aim to exclude 115 GeV on TeV combination!
    - Diboson measurement will be also release as a additional mass point.
  - MSSM
    - Getting sensitive, now 2.5 sigma in $b\phi \rightarrow bbb$ analysis.
    - Similar behavior in $b\phi \rightarrow b\tau\tau$?
- Serious competition has been started with LHC experiments.
  - Most of MSSM higgs search will be exceeded by LHC results.
  - Sensitivity on High mass SM Higgs search will be comparable at EPS time scale
  - Low mass search with $H \rightarrow bb$ stay be competitive ~ a year.

2 × Dzero on 3σ observation



- Required lumi. to make 3σ observation including improvements.
- Should be able to exclude almost full range with 95% C.L.

Other channel

- SM Higgs
  - HX → tautau + jets
    - Publish with 5.4 fb^{-1}.
  - VH→VWW
    - Trilepton analysis → new channel
    - Same sign dilepton → will publish soon with 5.4 fb^{-1}.
  - H→ZZ→lljj
    - Will publish with 4.3 fb^{-1}.
- BSM
  - H++ H-- → 2mu 2 tau, 4 tau
    - Will publish soon with 7.0 fb^{-1}.

Backups

Improvements

Type	Projected Improvement	WH→lνbb	ZH→llbb	ZH→ννbb	H→WW	Other Channels
Lepton ID	MVA Electron ID	1%	5%	-1%	3%	3%
	Improved MuonID/tracking	4%	3%	-2%	0%	3%
	Add Isolated Tracks	2%	0%	-1%	3%	2%
	Add ICR Electrons	2%	0%	-1%	3%	2%
	Add EC Electrons	0%	0%	0%	0%	2%
	Improved energy scale	1%	2%	0%	2%	5%
Trigger/Reco	Trigger/Reconstruction Efficiency	5%	3%	0%	0%	5%
Jet Selection	Dijet Mass Resolution	10%	10%	10%	0%	0%
	MVA B-ID	5%	5%	5%	0%	0%
	MVA Bottom vs Charm	4%	4%	4%	0%	0%
MVA Analysis	Enhanced Techniques	10%	10%	10%	10%	10%
	New signal separation variables	5%	5%	5%	5%	5%
	MVA QCD Rejection	3%	1%	0%	3%	3%
	Matrix Element Discriminants	5%	5%	5%	5%	3%
	Kinematic Fitting	5%	0%	0%	0%	3%
Optimization	Track Variables	5%	3%	0%	5%	5%
	Optimized B-ID Usage	3%	3%	3%	0%	0%
	Optimized Jet Treatment	3%	8%	0%	0%	0%
New Channels	HWWetau	0%	0%	0%	0%	5%
	Vhetaujj	0%	0%	0%	0%	3%
	HZZ	0%	0%	0%	0%	3%
	VH->trileptons	0%	0%	0%	0%	3%
	Additional Decay Modes	5%	5%	0%	5%	5%
	Existing Improvements:	57%	70%	29%	41%	
	Planned Improvements:	36%	27%	23%	12%	
	Total:	113%	116%	59%	58%	

Improvements

D0 France is deeply involved!

Type	Projected Improvement	WH→lν			
Lepton ID	MVA Electron ID	1%	5%	-1%	3%
	Improved MuonID/tracking				3%
	Add Isolated Tracks				2%
	Add ICR Electrons				2%
	Add EC Electrons				2%
	Improved energy scale				5%
Trigger/Reco	Trigger/Reconstruction Efficiency				5%
Jet Selection	Dijet Mass Resolution	10%			0%
	MVA B-ID	5%			0%
	MVA Bottom vs Charm	4%			0%
MVA Analysis	Enhanced Techniques	10%			10%
	New signal separation variables	5%			5%
	MVA QCD Rejection	3%			3%
	Matrix Element Discriminants	5%			3%
	Kinematic Fitting	5%			3%
Optimization	Track Variables	5%	3%	0%	
	Optimized B-ID Usage	3%	3%	3%	
	Optimized Jet Treatment	3%	8%	0%	
New Channels	HWWetau	0%	0%	0%	
	Vhetaujj	0%	0%	0%	
	HZZ	0%	0%	0%	
	VH->trileptons	0%	0%	0%	
	Additional Decay Modes	5%	5%	0%	
Existing Improvements:		57%	70%	29%	41%
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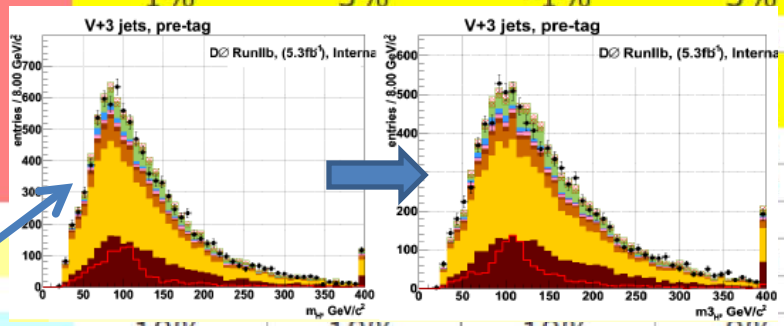
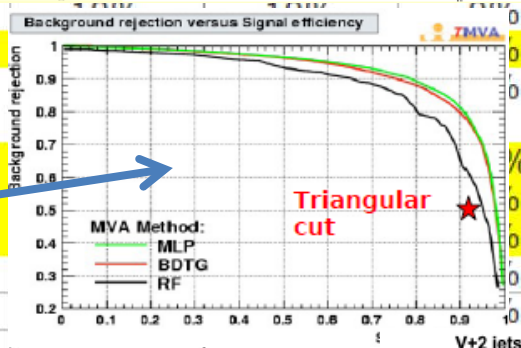
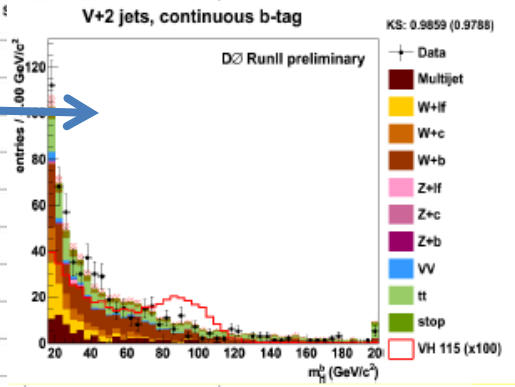
CEA





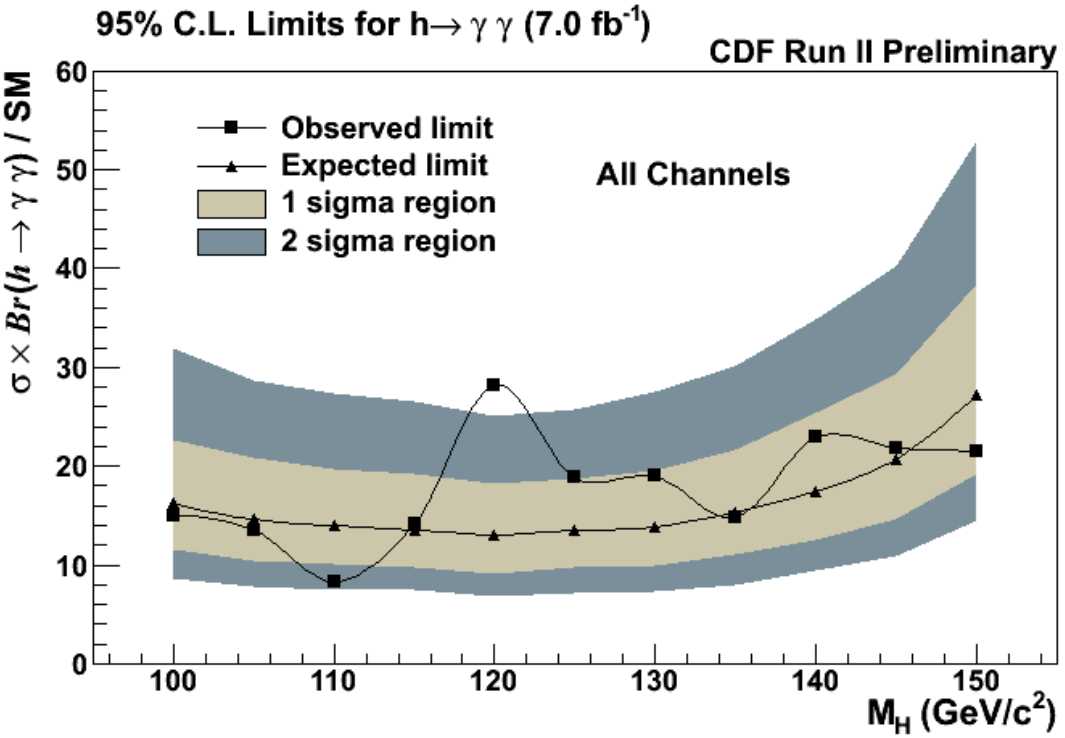


CDF H→γγ result

- 12 GeV/c^2 signal region for each test mass used to set upper limits set on σ×Br relative to SM prediction
- Expected limit of 13.0xSM @ 120 GeV
- An improvement of ~33% on last result!
- Observed limit outside 2σ band @ 120 GeV, but reduced to < 2σ after trial factor taken into account

CDF Run II Preliminary $\int \mathcal{L} = 7.0$ fb^{-1}

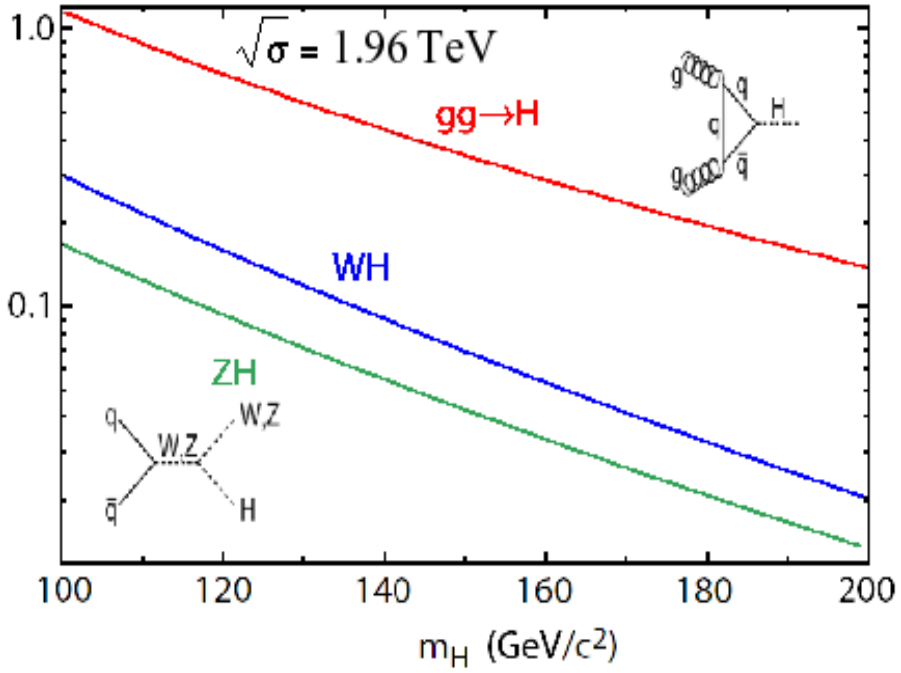
M_H (GeV/c^2)	95% C.L. Limit/σ(SM)×$B(h \to \gamma\gamma)$					
	-2σ	-1σ	Median Exp	+1σ	+2σ	Observed
100	8.7	11.6	16.2	22.7	32.0	14.9
105	7.9	10.5	14.6	20.8	28.6	13.5
110	7.5	10.1	14.0	19.7	27.3	8.3
115	7.5	9.8	13.5	19.2	26.6	14.1
120	6.8	9.2	13.0	18.3	25.1	28.2
125	7.2	9.7	13.5	18.7	25.7	18.8
130	7.4	10.0	13.9	19.6	27.5	19.0
135	8.0	11.0	15.3	21.7	30.1	14.8
140	9.4	12.5	17.5	25.4	34.9	22.9
145	11.0	14.7	20.7	29.3	40.2	21.9
150	14.5	19.2	27.2	38.5	52.9	21.5

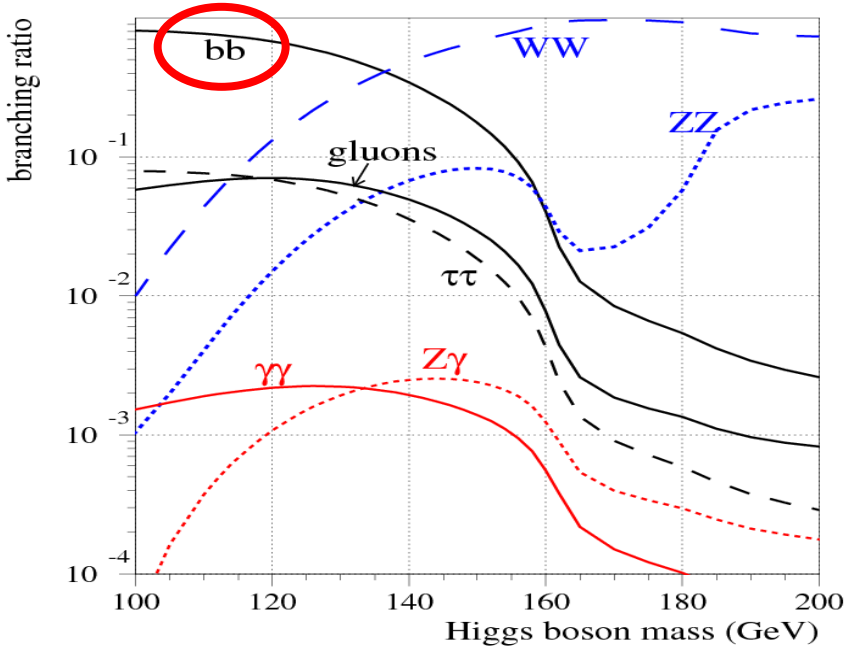


New Limits on $H \to \gamma\gamma$ at CDF using 7.0/fb

Will be added to SM Higgs Tevatron combination this summer

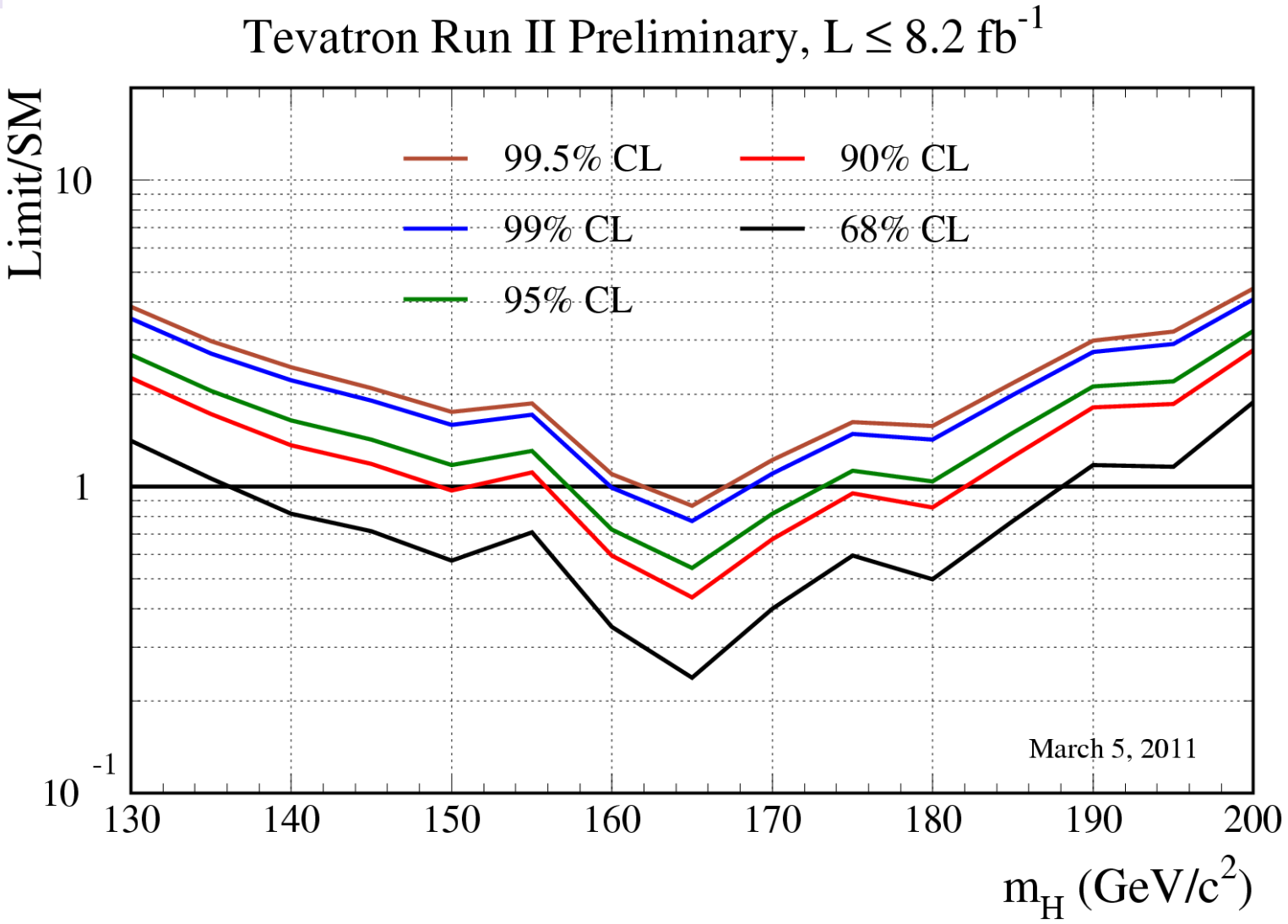
SM Higgs Production and Decay





- Highest cross section: gg→H
  - H decays into $b\bar{b}$ at low mass region
    → Due to high multi-jet BG, almost impossible
- W or Z associated production
  - High pT lepton with H→bb decay.

TeV Exclusion limit



SM Higgs excluded at 99.5% CL for **162 < mh< 166 GeV**

Improvements for low mass (2)

- Improving ID performance
- Change usage

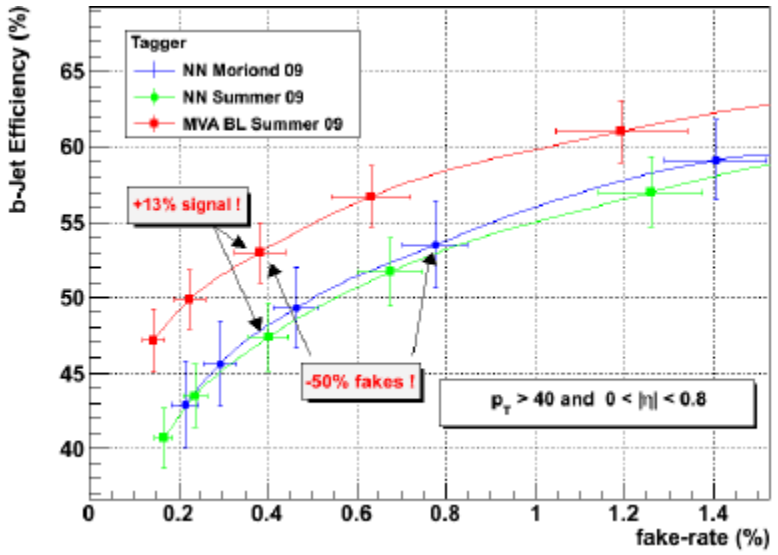
  Before: use optimal operating poing

  Recent: apply loosest operating point

  Put bID discriminant to final MVA.

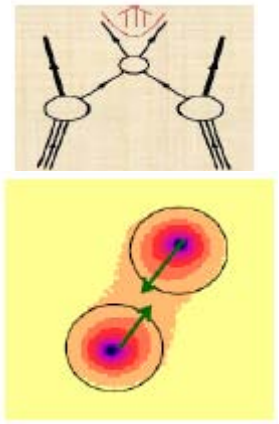
  → 5-10% improvement.

- Introduce new variables

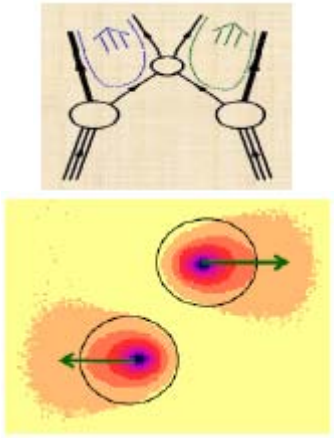


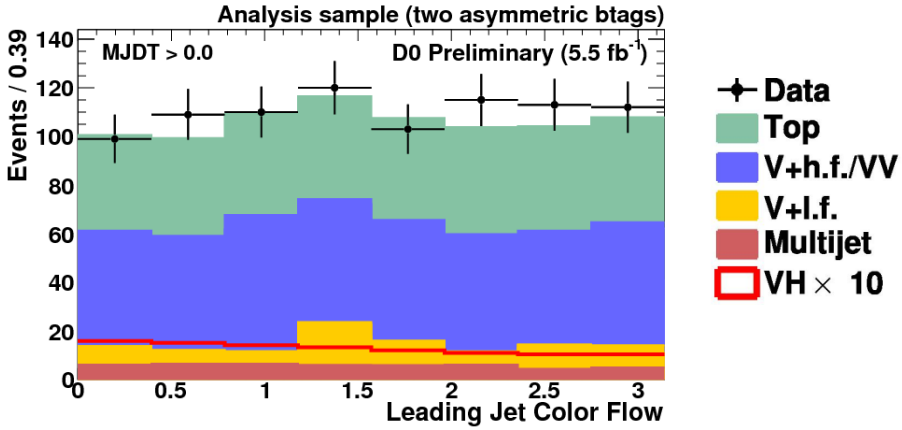
Ex. Color flow variables

Signal
color singlet



W+jets
color octet.

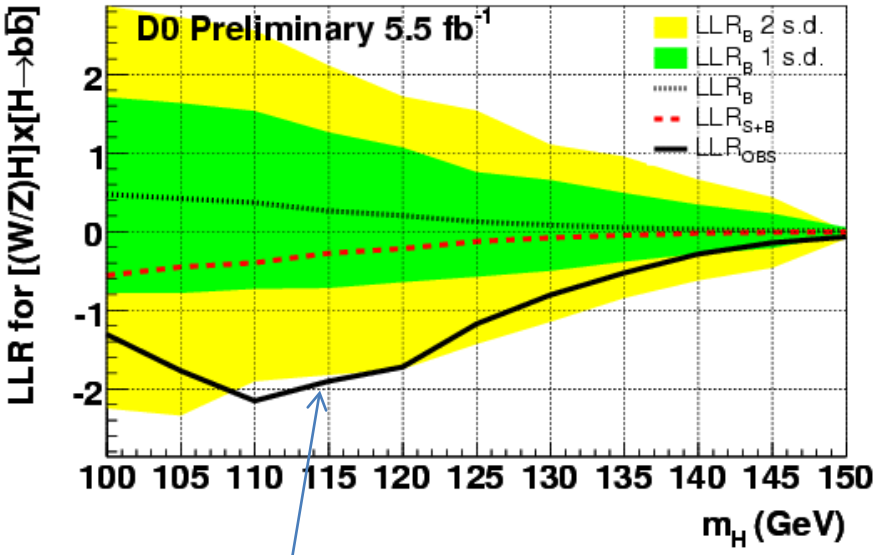




ZH→vvbb analysis
improved 15% in total.

Check on the excess: signal injection

- Inject expected signal event of MH=115 GeV and check how limit curve look like.
- With current luminosity, we suppose to have ~ 1 sigma excess in wide range due to mass resolution.
- Looks consistent what we observe in MH~ 130 GeV.



Injected signal of this plot:
ZH→vvbb with scale factor of 4.2

LLR for Tevatron combination at ICHEP 2010

The Log-Likelihood Ratio:

Basic test statistic of the Frequentist statistical method used here.

Arise from the ratio of Poisson likelihoods for TEST & NULL hypotheses.

Distances between Points behave like model $\Delta\chi^2$s