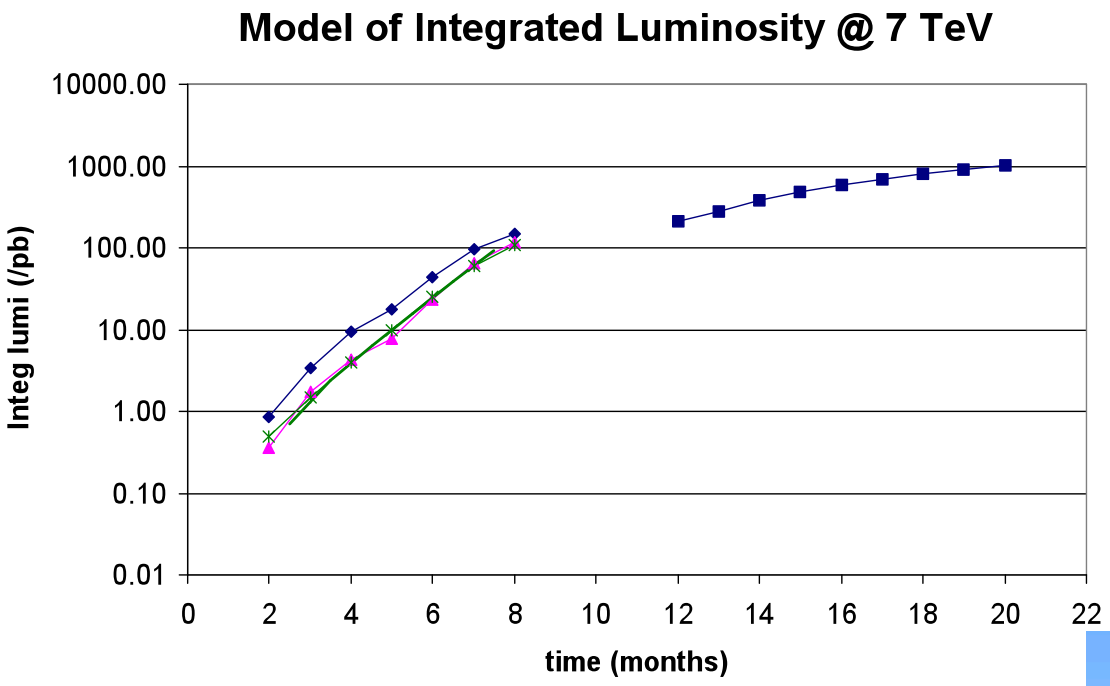
The LHC Higgs Cross Section WG: now and the future

Freiburg 12-13 April 2010

Stefan Dittmaier, Chiara Mariotti,
Giampiero Passarino, Reisaburo Tanaka

LHC schedule

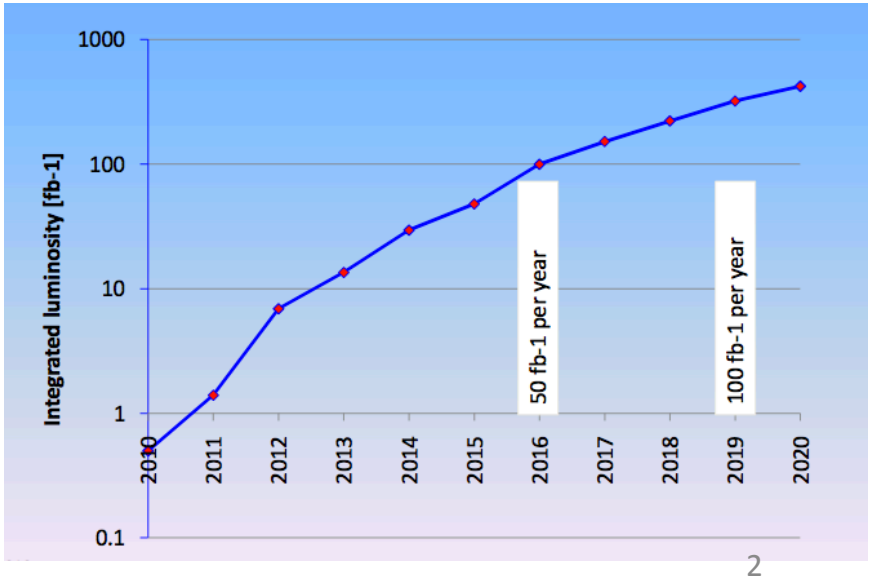


Assumptions used for planning:

~1-10pb^{-1} for ICHEP;

~100pb^{-1} at the end of 2010;

~1fb^{-1} at the end of 2011.



Then: long shutdown to replace the splices.
Restart in ~2013 aiming at 14 TeV

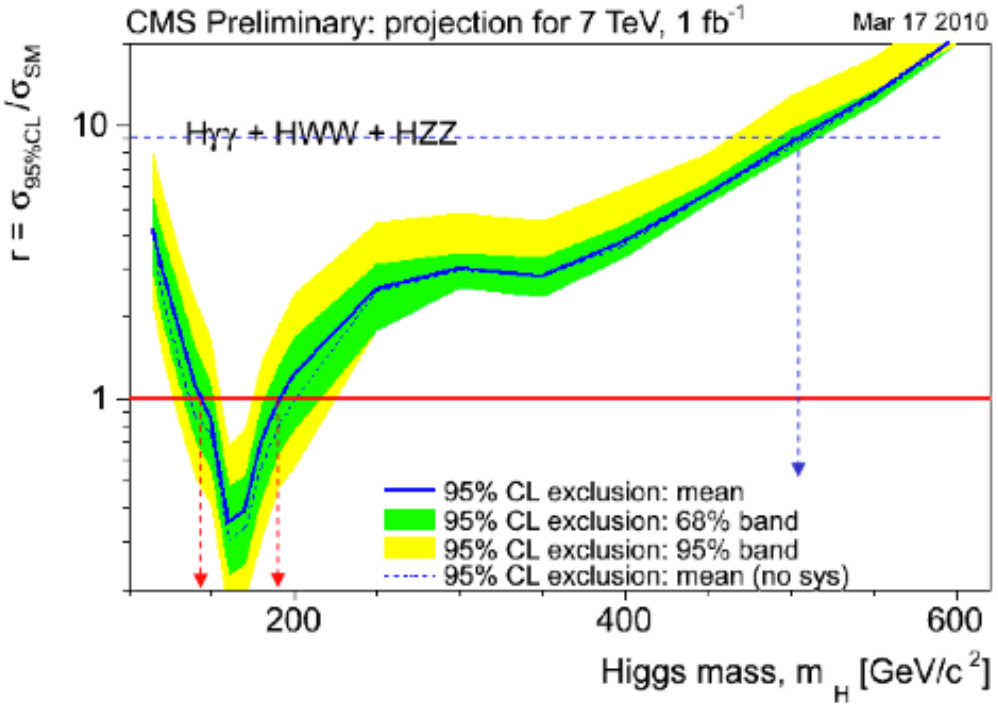
3000 fb^{-1} on tape by the end of the life of the LHC!

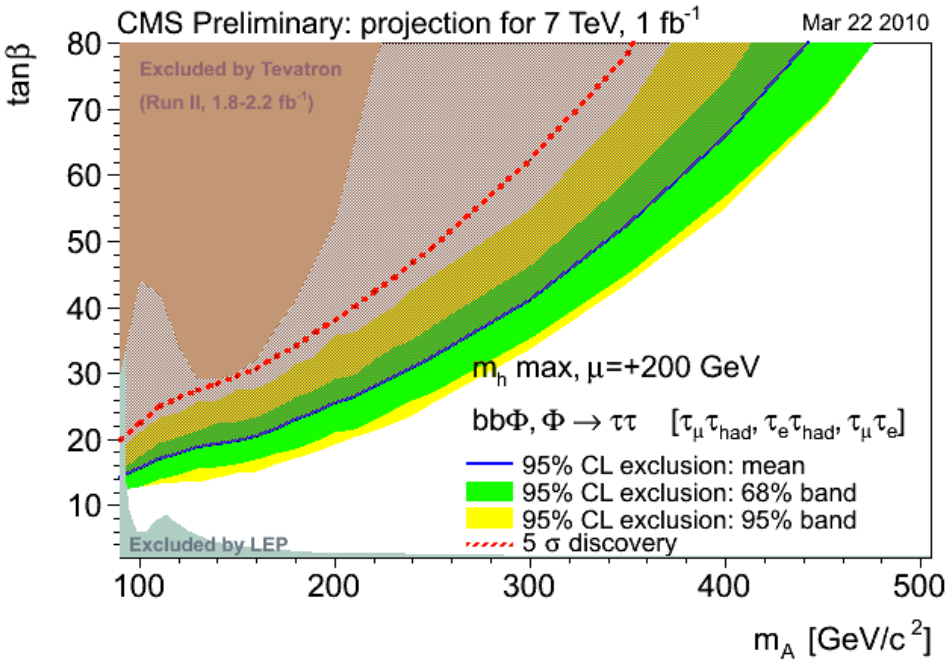
250-300 fb^{-1} /year in the second half of the LHC life…

Why?

- By the end of the 7 TeV run, the luminosity collected will hopefully allow us to probe some Higgs-mass value

(exclusion, evidence - see Guillelmo talk)





The tasks

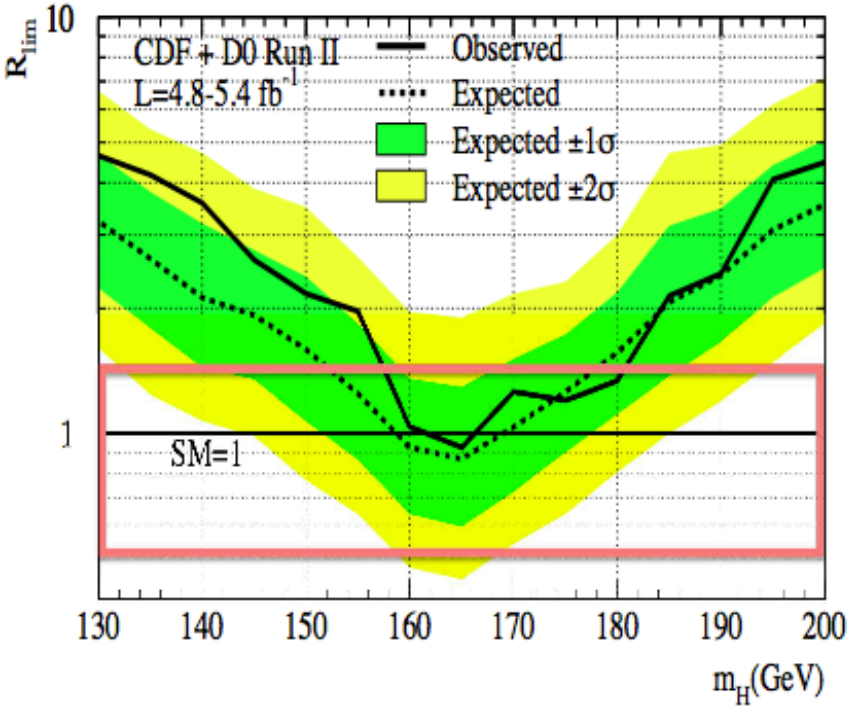
- For SM and MSSM Higgs analyses, it means:
  - Compute and agree on cross sections and branching ratios
    ALL THE GROUPS ARE ACTIVE !
  - use the same input parameters
  - strategy on uncertainties (α_s, PDF, scale etc.) ← with PDF4LHC
  - MonteCarlo at NLO for the Signal
  - define pseudo-observables DIFFICULT BUT ONGOING
  - cross sections of background processes ←
  - Prepare to compare and combine Hopefully for the following

….and a correct citation policy

We want to do it correctly!

6. Conclusion

- **Performed "state of the art" update of Higgs cross sections at Tevatron.**
- **Investigated all sources of theoretical errors for the two main channels.**
  - $M_H \lesssim 150$ GeV : $q\bar{q} \to HV$:
    only a $\approx 10\%$ error but a factor of two larger than what is used.
  - $M_H \gtrsim 150$ GeV : $gg \to H$:
    a large, $\approx \pm 40\%$, uncertainty, mainly from scale and PDF+α_s
  - $\sigma^{NNLO}_{gg\to H}$ **could be a factor of two lower than what is assumed by CDF/D0 analysis for** $p\bar{p} \to H \to W^{(*)}W^{(*)} \to \ell\ell\nu\nu$



- **Need to reconsider 95% CL CDF/D0 exclusion limit $162 \lesssim M_H \lesssim 166$ GeV.**

What we need before the end of 7 TeV run

- We want to have the TH Higgs cross sections with the uncertainty from
  - SM input parameter
  - PDF and α_s
  - QCD Scale

- We will see presentation today on the work done and the short term plans:
  - The cross sections have been computed with common SM inputs and with a “temporary prescription” for PDF and α_s values and variation.

MC at NLO: Signal and Bckgd

- This year and the next – with the 7 TeV run - we will have enough luminosity to properly measure SM processes. A good control of the background is mandatory to properly exclude certain mass regions (if…!)

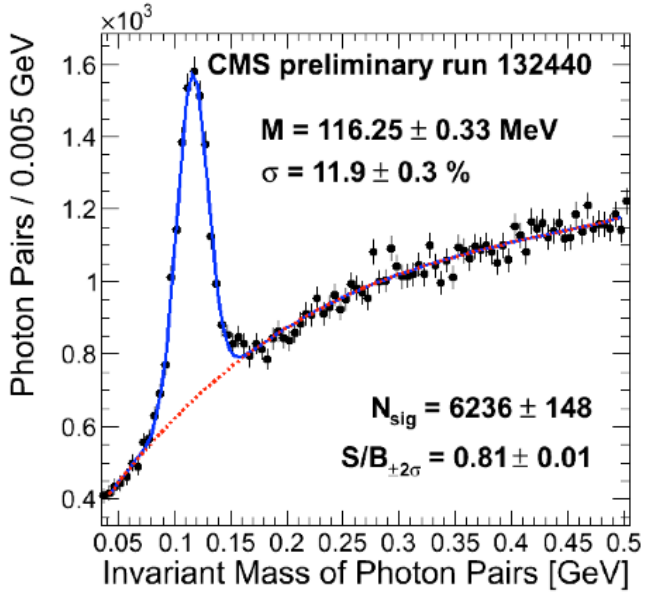
- The other groups (EW, MC gen etc) will provide the best description to the SM processes, but we should contribute by measuring with the first data the particular regions in the parameters space where the Higgs signal is enhanced, and check if they are as well described by the NLO-MC. i.e. we should work out if the "tails" of the distributions are well understood.

- thus not only **Higgs @ NLO MC and PS interface**,
  but also measurement of the background from data and
  validation of the MC in the "tails"
  in collaboration with SM and MC groups

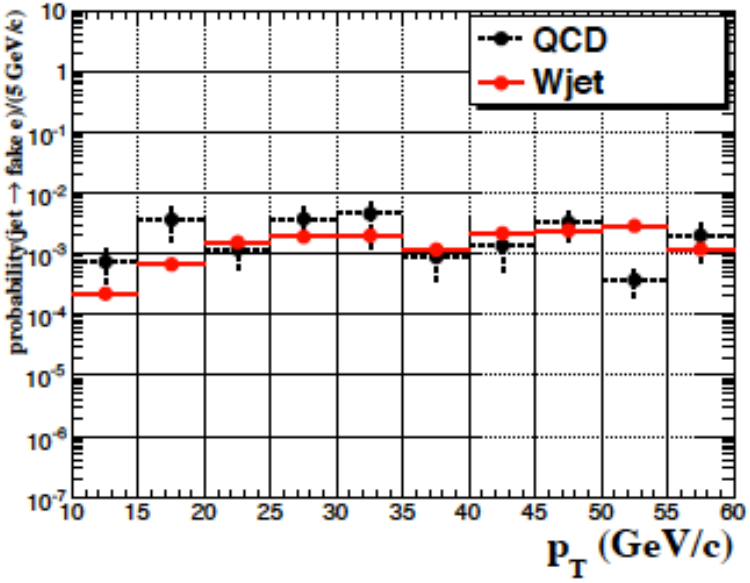
Background: an example

- The M(γγ) can be studied from day 0.
  - Already after 10 pb-1 -> study of the high M(γγ) spectrum values
  - The resolution can be studied with Z→ee events.

π→γγ at √s=7 TeV

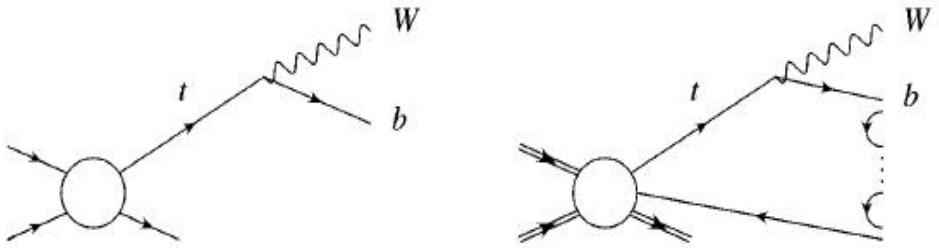


- Fakes in HWW analysis
  - From QCD events the rate of the fakes can be measured
- ttbar has to be under control
- di-boson production



Pseudo Observables

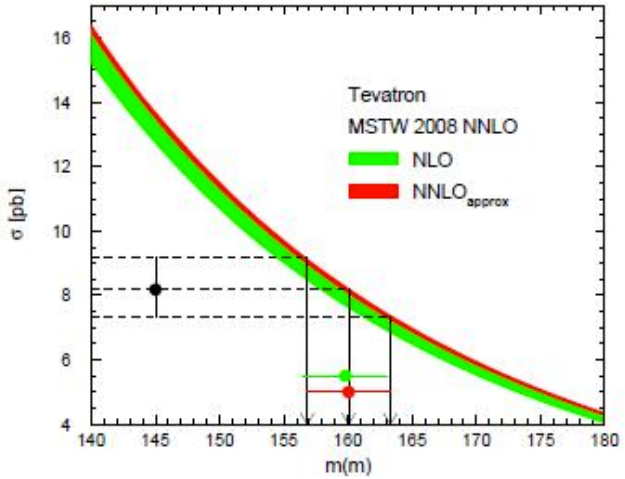
- We need to have a correct definition of the Mass and of the Partial Widths
- An easy example before the talk tomorrow:



Because of NLO, the Wb invariant mass from the reconstructed final state is NOT equal to the pole mass

By measuring the "running mass" from the cross section value, the result is:

M_{top} $(M_{top})_{\overline{MS}}$ = 160.0 ±3.3 GeV

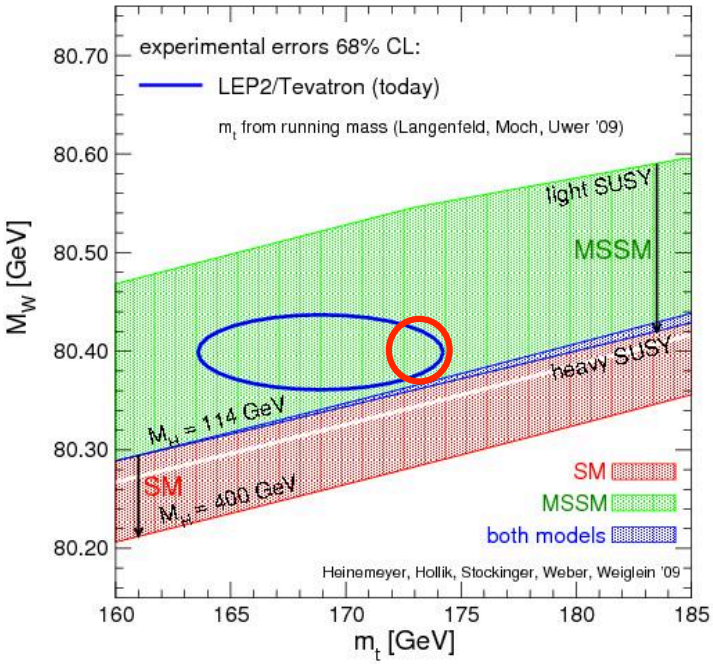


U.Langfeld, S.Moch, P.Uwer, arXiv:0906.5273

That translates into a pole mass of 168.2±3.6 GeV

While the measured mass is:

173.1 ± 1.3



What we ALSO need for the end of 7 TeV run

- We need to think on the next step.

→ We would like to compare ATLAS and CMS results and **combine** the results

- Thus: TH Cross sections, uncertainties, Pseudo Observables and all that …+
- We will have real data, so we have also to think on a prescription for the estimation of ALL the systematic uncertainties (luminosity, detector resolution, physics inputs etc…) with correlation matrix (-> we would like to end this meeting with a first "List of Syst. Uncertainties")
- A common policy on what to publish (i.e. the likelihood functions for all the channels…?)

Compare and Combine

- We propose to do an exercise on published material with RooStat

  (in this way all the details will be sorted out well in advance!)

- We have to think on the best way to present the results (plots + tables + likelihood function ?) in order to properly show not only the experimental error but also the theoretical error

  → communication with the Statistical Groups

"From our understanding, good testbeds for exercising this process are near-term searches, such as SUSY, and Monte Carlo studies on longer term efforts like the Higgs search in the context of the joint ATLAS-CMS cooperation…"

Tom Le Compte and Gigi Rolandi 9-Apr-2010

Future

- We are having a very smooth and constructive start-up
- We should continue! The first meaningful results has to be ready already next year!
  Maybe already for the winter conferences…
- If we combine we gain a factor of 2 in Lumi!

Next meeting : at CERN 5-6 July?

The agenda for this workshop

- Prospect for early Higgs boson discovery at LHC
  Guillelmo Gomez-Ceballos
- ggH
- VBF
- WH/ZH
- ttH
- Neutral MSSM
- Charged MSSM
- PDF
- BR
- NLO MC
- Pseudo Observables
- Discussion

The structure of the group

Group	ATLAS	CMS	LHCb	THEORY	
1. ggF	Jianming Qian (Michigan)	Fabian Stöckli (CERN)		Massimiliano Grazzini (Firenze)	Frank Petriello (Wisconsin)
2. VBF	Daniela Rebuzzi (Pavia) Sinead Farrington (Oxford)	Christoph Hackstein (Karlsruhe)		Ansgar Denner (PSI)	Carlo Oleari (Milano-Bicocca)
3. WH/ZH	Giacinto Piacquadio (CERN)	Jim Olsen (Princeton)	Clara Matteuzzi (Milano-Bicocca)	Stefan Dittmaier (Freiburg)	Robert Harlander (Wuppertal)
4. ttH	Simon Dean (UCL)	Chris Neu (Virginia)		Laura Reina (Florida)	Michael Spira (PSI)
5. MSSM neutral	Markus Warsinsky (Freiburg)	Monica Vazquez Acosta (IC)		Michael Spira (PSI)	Georg Weiglein (DESY)
6. MSSM charged	Martin Flechl (Freiburg)	Sami Lehti (Helsinki)		Michael Krämer (Aachen)	Tilman Plehn (Heidelberg)
7. PDF	Joey Huston (Michigan State)	Kajari Mazumdar (TIFR)		Stefano Forte (Milano)	Robert Thorne (UCL)
8. Branching ratios	Daniela Rebuzzi (Pavia)	Ivica Puljak (Split)		Ansgar Denner (PSI)	Sven Heinemeyer (IFCA)
9. NLO MC	Jae Yu (Texas)	Marta Felcini (UCD)		Fabio Maltoni (Louvain)	Paolo Nason (Milano-Bicocca)
10. Pseudo-observables	Michael Dührssen (CERN)	Martin Grünewald (Ghent)		Sven Heinemeyer (IFCA)	Giampiero Passarino (Torino)

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CrossSections

Sharepoint, e-mail, twiki page, indico…

Web Pages of similar groups

- LEP Higgs
  http://lephiggs.web.cern.ch/LEPHIGGS/www/Welcome.html
- LEP EWK
  http://lepewwg.web.cern.ch/
- LEP Susy
  http://lepsusy.web.cern.ch/lepsusy/
- LEP Exotica
  http://lepexotica.web.cern.ch/LEPEXOTICA/

- Tevatron New Phenomena & Higgs
  http://tevnphwg.fnal.gov/
- Tevatron EWK:
  http://tevewwg.fnal.gov/