Herbi (born 1962) - Michael (born 1956)
1987-2023 A long (and beyond) physics relation

M.Dittmar (retired (from ETHZ) since 2021)

- Some background (dates) .. and a problem (not only) for Herbi
- Early discussions.. (spin and spinning) exchanging ideas about physics and the world
- Combining experimental and theoretical thoughts and transforming ideas into a new publication(s)?
- A great (well almost) result: (August 14, 1996)
  How to find a Higgs with a mass between 155-180 GeV at the LHC
- Subsequent work, (des)illusions and other activities.
- Instead of a summary: future spinning activities!?

We are an old "couple" since 36 years..

- Cargese 1987 summer school in Corsica:

  Starting our friendship, discussing physics and the problems of the world, hiking and etc
  Herbi: visiting CERN 2-3 times per year and staying with me/us in Thoiry.
  Michael: visiting Herbi's varying locations Wisconsin, Hamburg, Zurich, Oxford, Bonn
  and meeting at several workshops conferences .

- Founding a family: Marriage and 2 children all around the same time.

- Retirement .. well after all, I am almost 7 years older but:
  Since 2019, spinning on/with the bike over many days and long distances at least with 100 km/day and for 7-10 days per year.

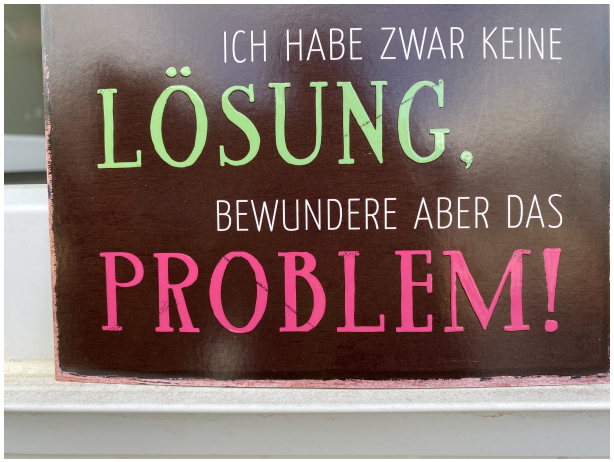
Talking about physics and world problems with theorists .. and a problem (not only) for Herbi

- Interactions with theorists and experimentalists?
  A theorist friend from Greece liked to provoke me (around 1987) with:
  "What can be measured? Results from Theory!" Einstein to Heisenberg
  (creating a "cognitive dissonance" for me!)

- *in an ideal and non existing real world:*
  Experimentalist learn from theorists about new and foggy areas (the SM and beyond);
  Theorists learn from experimentalists what, how and when something can measured!

- *Sometimes this works well and can result even in publications!*
  (not always appreciated by experimental and theoretical colleagues!)

- *With Herbi (and a few other theorists) this worked out very well!*
  (and not only in physics!)

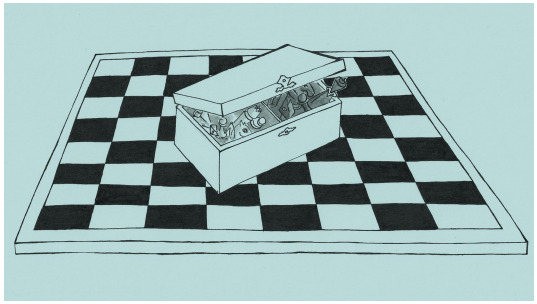


Talking about physics and world problems with theorists ..

- Real (unsolvable?) world problems (everything is "Gaussian"!?), the Limits of Growth, evolution theory, environmental problems, peace and war and on and on.

- Herbi (reading, reading and reading and sometimes watching football) gave me some books to read. One book created more "cognitive dissonances" for me: **"Galapagos" from Kurt Vonnegut.**
  (I read most of the other Vonnegut books afterwards!)

- A useless problem (not only for Herbi) and for the rest of my talk:
  How many knights (Springer) can one put on a chess board, such that they can neither defend or attack each other?



Combining experimental and theoretical thoughts and transforming ideas into new publications

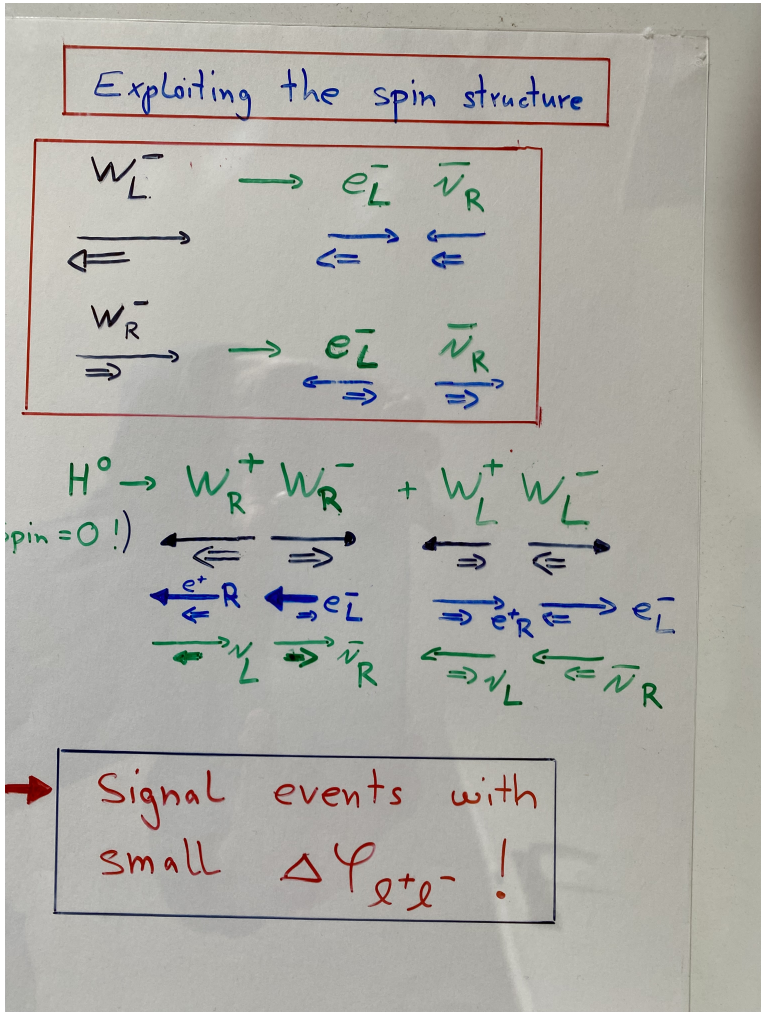
- Coffees, tea's and well (beer and wine): don't be afraid to ask a theorist! Herbi (and some others!) always open to discuss and answer my questions: Many ideas were naive, wrong and stupid but some were interesting! Sometimes, with the combined experimental and theoretical efforts publications became possible.

- SM Physics and beyond: Lepton universality and questions related to beauty (quarks) , parity violation and the V-A interactions and Spin(ning) phenomena. finding and testing the limits of experimental knowledge.

- We both liked especially to work on non crowded topics: e.g. "the beauty" of some neglected publishable and measurable topics.
  1) "Testing locality at colliders via Bell's inequality?" (1992)
  "We consider a measurement of correlated spins at LEP and show that it does not constitute a general test of local-realistic theories via Bell's inequality. "
  2) How to find a Higgs with a mass between 155-180 GeV at the LHC (1996)

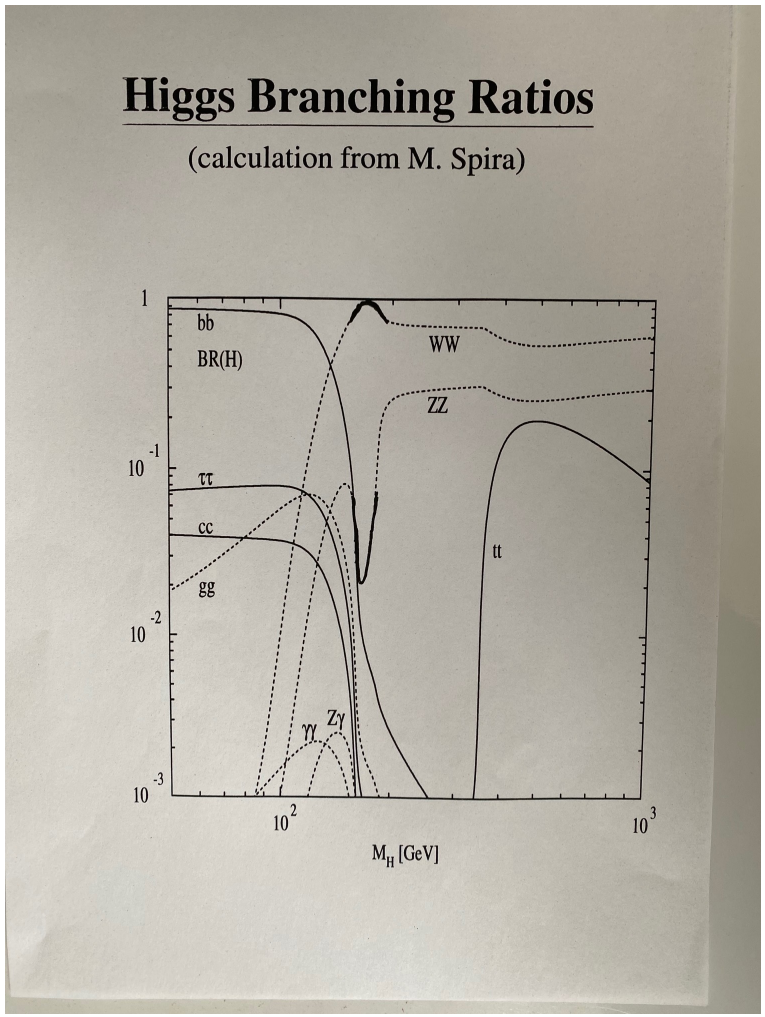
A great (well almost) result (I)
A coffee and tea in the CERN cafeteria some time around 1994

while both of us working at ETHZ (Herbi came often to CERN)
Asking Herbi: *"does this makes sense to you"?* *"Yes, but there was something with transverse and longitudinal W's in the Higgs decay. Will have a look"*



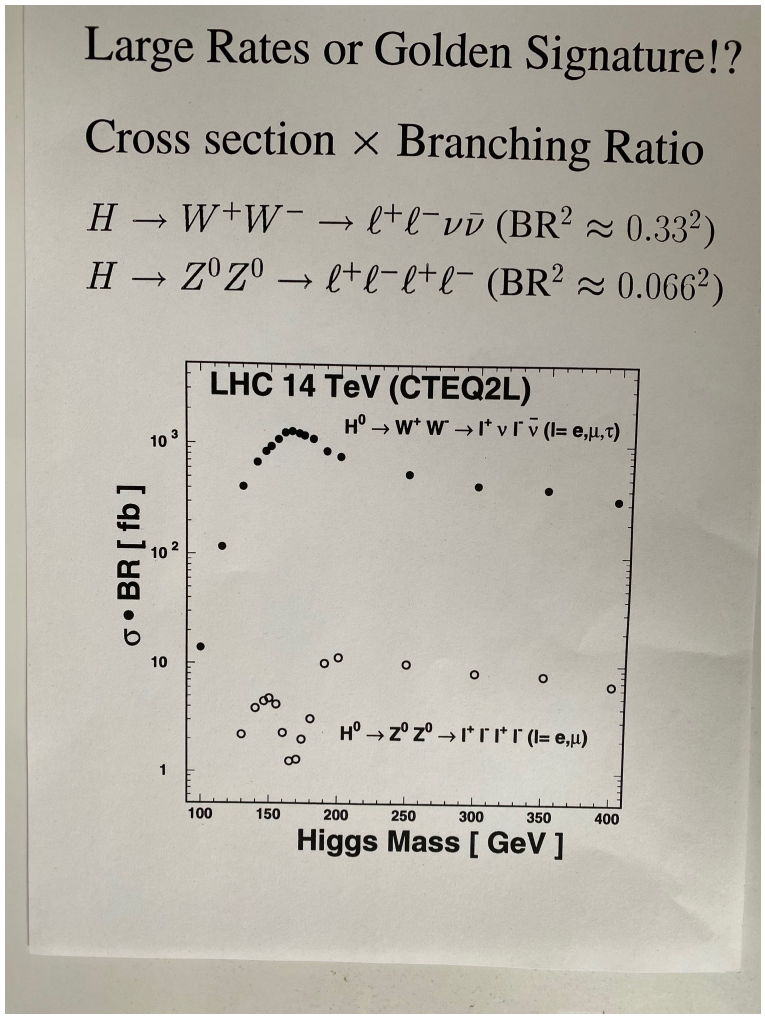
A great (well almost) result (II)
A few weeks later

Getting hooked and reading papers:
"Higgs search at the LHC with H $\rightarrow$ WW" few inconclusive experimental results found! *"That is good, lets try it together!"*



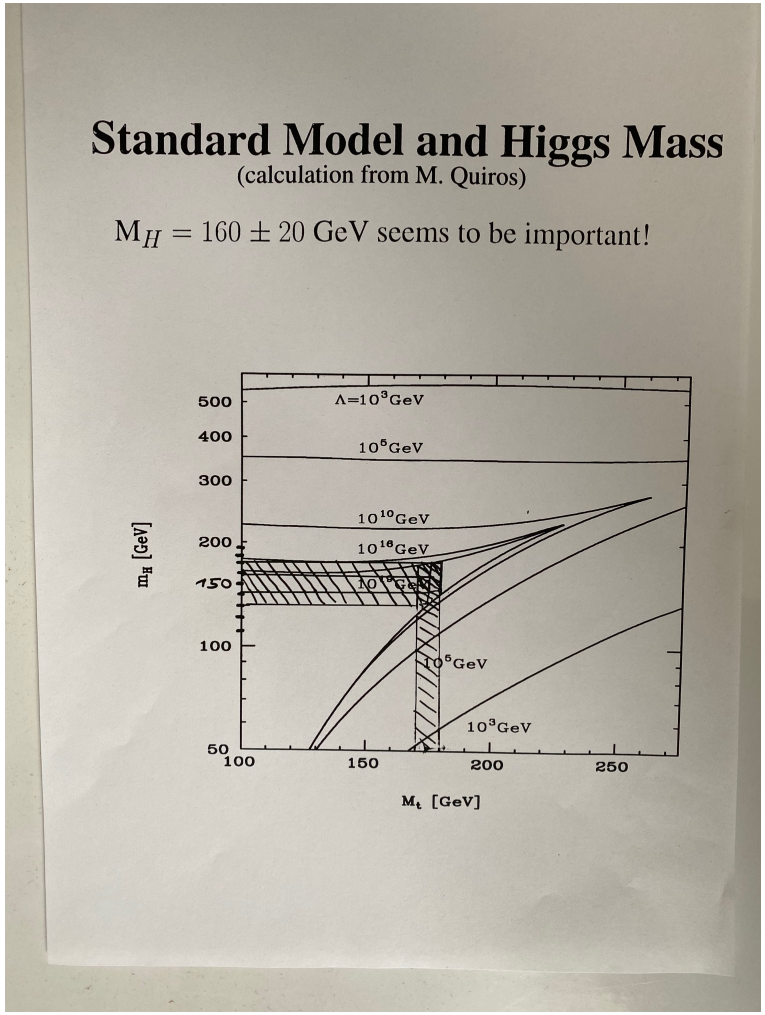
A great (well almost) result (III)
A few weeks later

How and what to study:
"Higgs search at the LHC with H $\rightarrow$ WW" *"Goal of our work: investigate for a Higgs mass between 100-700 GeV!"*



A great (well almost) result (IV)
A few months later

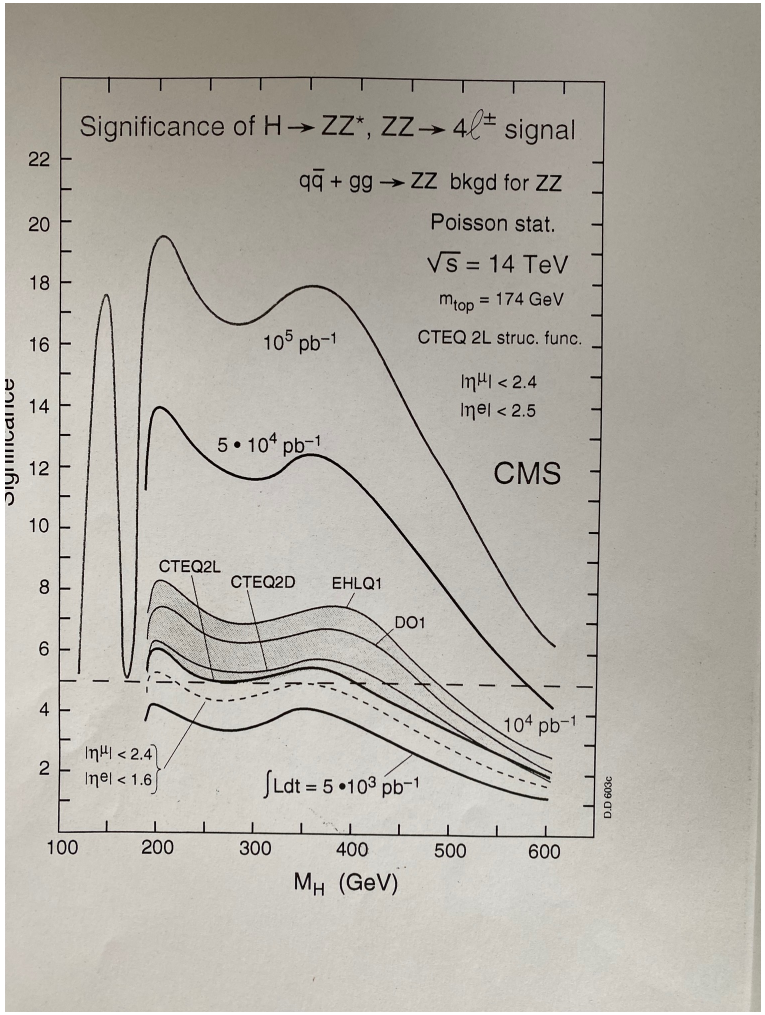
(probably after a good dinner and with a bottle of wine at home in Thoiry)
(M to H): "bad news first: tried everything can't find a detectable signal for masses greater than 200 GeV and less than 140 GeV"
(H to M): "What are the good news"?
(M to H): "Great signal for 155-180 GeV at least! But what now?"
(H to M): "Well, somebody showed recently a plot about about the Higgs Mass"
the next day we found the plot and yes thats it!



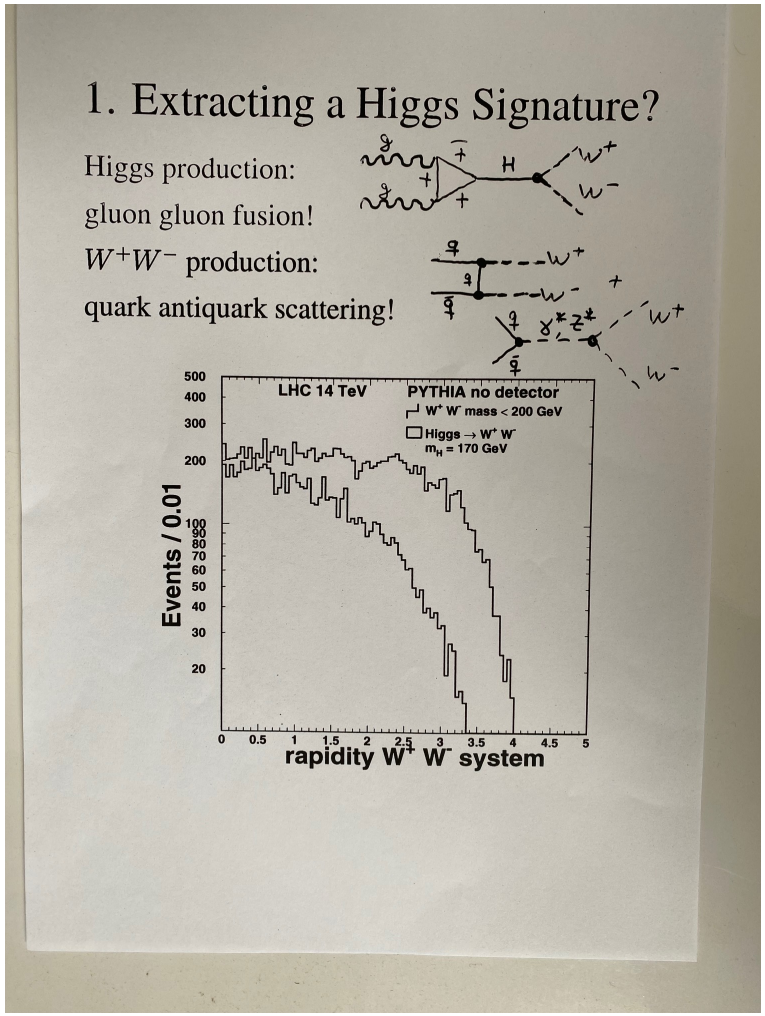
A great (well almost) result (V) some days later

(M to H): "Unglaublich, look: for the SM forever Higgs mass
.. So far the most difficult region at the LHC, and we resolve it with H $\rightarrow$ WW" !!!!

"Herbi you start writing the paper and I finish the study for the mass range 155-180 GeV and no words to nobody!"



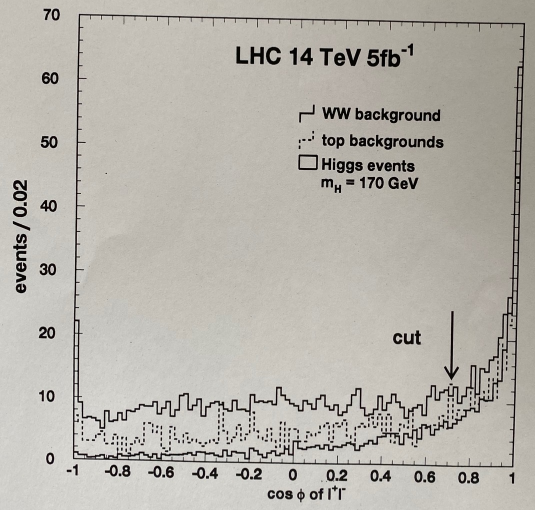
A great (well almost) result (VI)
A few weeks later.. the paper is taking shape



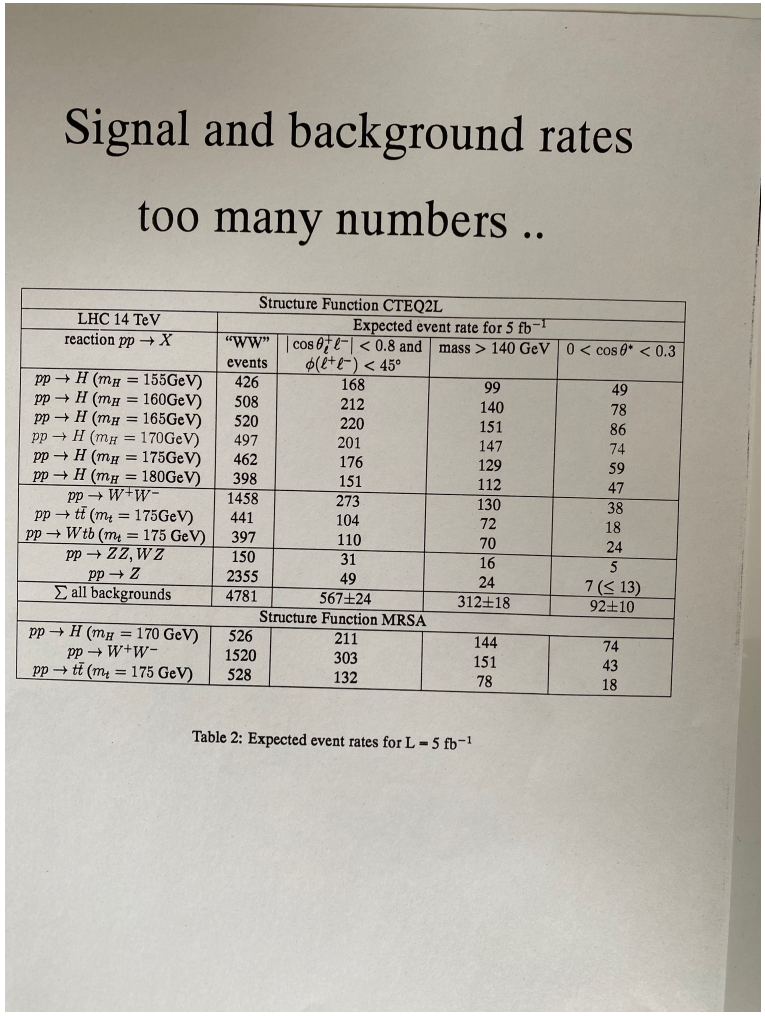
A great (well almost) result (VII)
A few weeks later.. the paper is taking shape

2. W^+W^- Spin correlations!

small ℓ^+ and ℓ^- opening angle:
$\cos\phi_{plane} > 0.71 (\phi_{plane} = 10° - 45°)$



A great (well almost) result (VIII)
A few weeks later.. August 14, 1996 the paper is ready



Signal and background rates

too many numbers ..

LHC 14 TeV	Structure Function CTEQ2L			
reaction $pp \to X$	Expected event rate for 5 fb^{-1}			
	"WW" events	$\lvert\cos\theta^{+}_{\ell}\ell^{-}\rvert < 0.8$ and $\phi(\ell^{+}\ell^{-}) < 45°$	mass > 140 GeV	$0 < \cos\theta^{*} < 0.3$
$pp \to H\,(m_H = 155\text{GeV})$	426	168	99	49
$pp \to H\,(m_H = 160\text{GeV})$	508	212	140	78
$pp \to H\,(m_H = 165\text{GeV})$	520	220	151	86
$pp \to H\,(m_H = 170\text{GeV})$	497	201	147	74
$pp \to H\,(m_H = 175\text{GeV})$	462	176	129	59
$pp \to H\,(m_H = 180\text{GeV})$	398	151	112	47
$pp \to W^{+}W^{-}$	1458	273	130	38
$pp \to t\bar{t}\,(m_t = 175\text{GeV})$	441	104	72	18
$pp \to Wtb\,(m_t = 175\text{ GeV})$	397	110	70	24
$pp \to ZZ, WZ$	150	31	16	5
$pp \to Z$	2355	49	24	7 ($\leq$ 13)
$\sum$ all backgrounds	4781	567$\pm$24	312$\pm$18	92$\pm$10
Structure Function MRSA				
$pp \to H\,(m_H = 170\text{ GeV})$	526	211	144	74
$pp \to W^{+}W^{-}$	1520	303	151	43
$pp \to t\bar{t}\,(m_t = 175\text{ GeV})$	528	132	78	18

Table 2: Expected event rates for L = 5 fb^{-1}

A great (well almost) result (IX)
The next years.. the paper was published in January 1997 (Phys Rev Letters)

Presenting and defending the results in many places (1996– 2000.) further experimental work with PhD students at ETH on higher order QCD cross section corrections and more and more sophisticated CMS simulations.

Some colleagues (worked on Higgs searches at the SSC), at a 1997 CMS meeting in Madison, congratulated us for the result and told me after the presentation:
"We tried to use the WW spin correlations signature, but gave up as we could not get anything significantly. The problem was likely that we used a Monte Carlo Simulation which did not simulate the spin correlations."

$\rightarrow$ *It was essential to work together with a friend like Herbi*
(1) to keep working with confidence, and
(2) to have theoretical skills to double check if the spin correlations were correctly simulated in PYTHIA.

Perspectives of SM Higgs measurements at the LHC

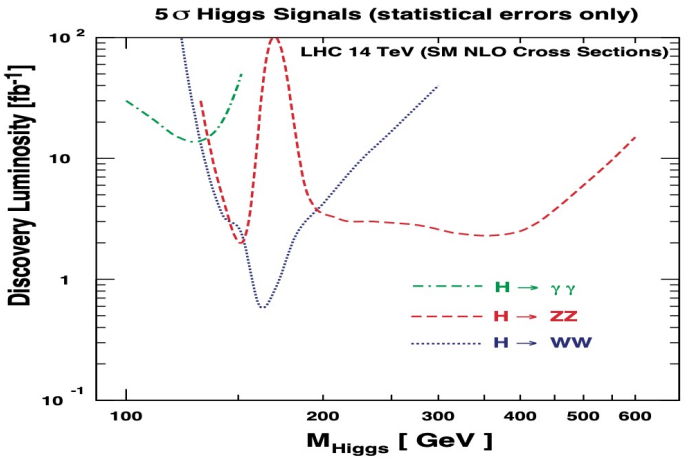


Figure 8. Required luminosity to discover the Standard Model Higgs with a statistical significance of five standard deviations in the mass range between 100–700 GeV at the LHC.

A great (well almost) result (X)
1996 – 2000 (un)expected (negative) reactions

From experimental and theoretical colleagues like:

"nothing special with your result, mass peaks are required to make discoveries" *(from a theorist who happily talked about hypothetical SUSY signals (events with missing energy)) or*

"The result is ok, but not interesting! The SM electroweak data show that the Higgs mass is around 100 GeV." *or*

"The result is not interesting because we know the SM is wrong, SUSY is correct and in any case the Higgs mass is smaller than 125 GeV"

"The result is ok, but you should not have published it! Keep it secret until the LHC works" *An Experimental colleague around 1998.*

After 2000, the LHC experimental "community" repeated and the result was accepted (and now more than 300 citations)
(but ... sometimes colleagues needed to be reminded about referencing our work)

Almost a "great" result (year 2000 onwards): "Dark clouds approaching" (I)

"SM forever and a Higgs mass of 160± 20 GeV"
"Perhaps for a short moment we believed that this would be great but..."

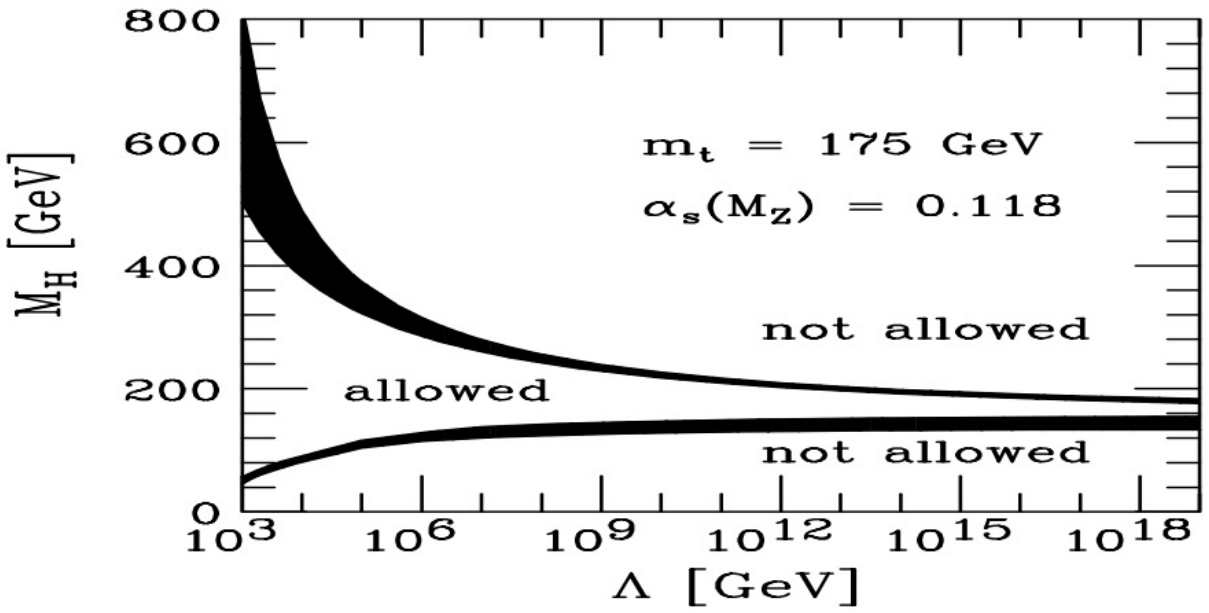


Figure 1. The area between the two black curves shows the allowed Higgs mass range assuming the validity of the Standard Model up to a scale Λ [3].

Almost a "great" result (year 2000 onwards): "Dark clouds approaching" (II)

Perhaps provoking/hoping too much??? (the Higgs mass is 168 GeV, my size in cm)
I was happy with the draft and gave it to my student Dario. The next day he told me:
"Very nice, but there is one mistake!" (Dario is even taller than Herbi)

$\rightarrow$ the idea is nice, but the Higgs will not have the right mass!
(and Herbi is also much taller than me!)

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Perspectives of SM Higgs measurements at the LHC

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Abstract. The latest unsuccesful Higgs searches at LEP have pushed its mass well into the domain where significant signals can be expected from the LHC experiments. The most sensitive LHC Higgs signatures are reviewed and the discovery year is estimated as a function of the Higgs mass. Finally, we give some ideas about: 'What might be known about the production and decays of a SM Higgs boson' after 10 years of LHC?

Keywords. Large hadron collider; Higgs.

PACS No. 12.80.Bn

1. Introduction

The Standard Model (SM) of particle physics has survived [1] not only the Y2K millennium bug, but also many years of precision electroweak physics at high energies.

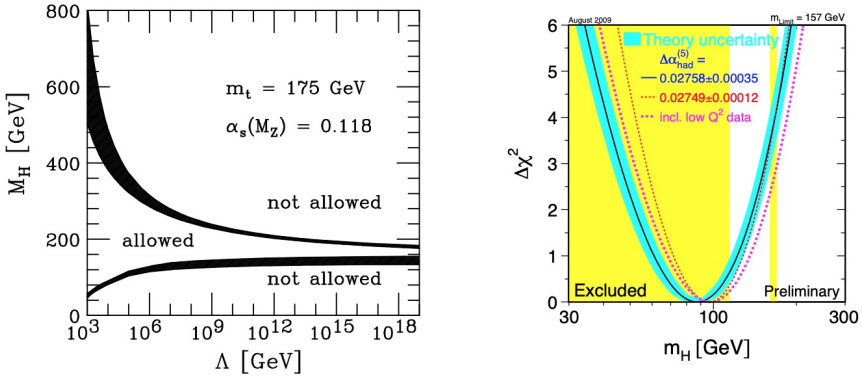
With the observation of the top quark, with a mass of $\approx 175 \pm 5$ GeV, and within the SM, the Higgs boson became the 'last' undiscovered particle. Assuming that the Higgs boson is the only missing particle up to very high energy scales Λ, the mass of the SM Higgs can be constrained from a phenomenological approach [3], as shown in figure 1. Assuming that the SM is valid up to the Planck scale, one finds that the Higgs mass should be $\approx 160 \pm 20$ GeV [4].

[3] T Hambye and K Riesselmann, *Phys. Rev.* **D55**, 7255 (1997) and hep-ph/9708416
[4] Surprisingly this estimate corresponds to the body size [in cm] of an expected standard reader

Almost a "great" result (year 2005-2010) (III) "From my last long particle physics talk at DESY (2010)"

The SM Higgs mass or the nothing else "nightmare scenario?"

- If SM and nothing else $\rightarrow M_H \approx 150 - 180$ GeV or "the SM could be an effective theory up to very high scales!"
- Direct searches from LEP II: $M_H > 114$ GeV
  Jan 2010 Tevatron exclusion claims: 162-166 GeV (more later)
- from electroweak parameters ("bad fit" more later): $M_H < 157$ GeV
  (for more precise numbers stay tuned for the latest changes)!

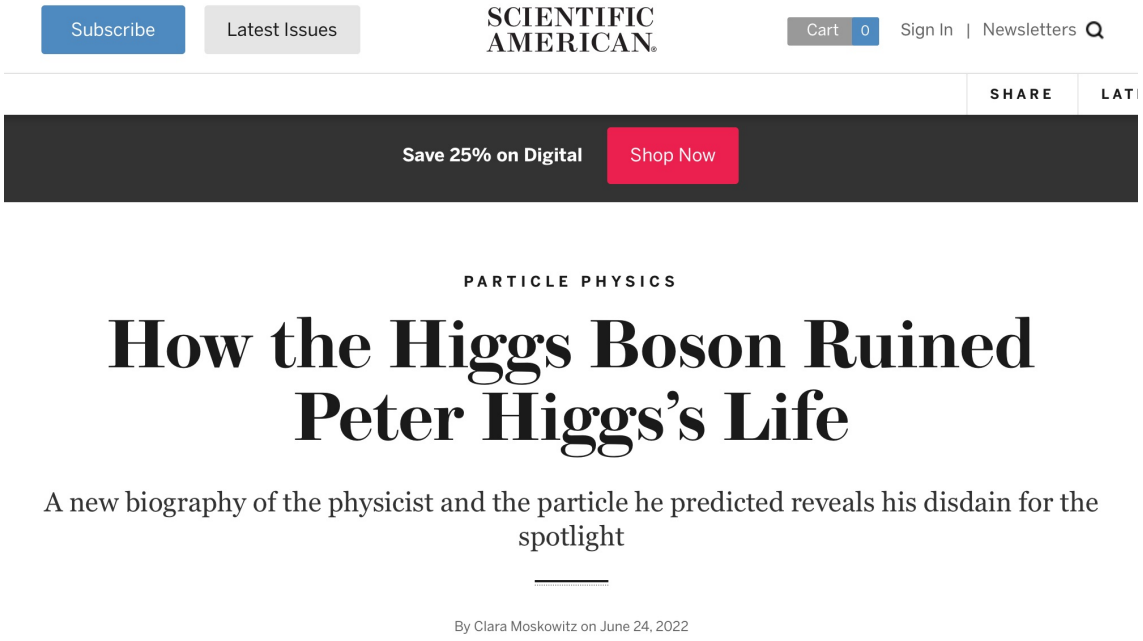


source: T. Hambye and K. Riesselmann, PRD 55, 7255 (1997) and
http://lepewwg.web.cern.ch/LEPEWWG/plots/summer2009/s09_blueband.eps

The LHC and the "rain" started (I do not like biking in the rain!):
The analysis sector in CMS (and ATLAS) was taken over by
a new generation of young, clever and faster physicists and
all this combined with neural networks and artificial intelligence!
Thus: We moved to other areas of interest and problems:
like Herbi's Physik Show
and me lecturing on "Energy and the Environment in the 21st century" and publishing "Nuclear Fusion Illusions", "Energy Resource limits" and "Unsustainabillity".

Almost a "great" result (year 2005-2010) (IV)

The Higgs was discovered at 125 GeV (July 4 2012)



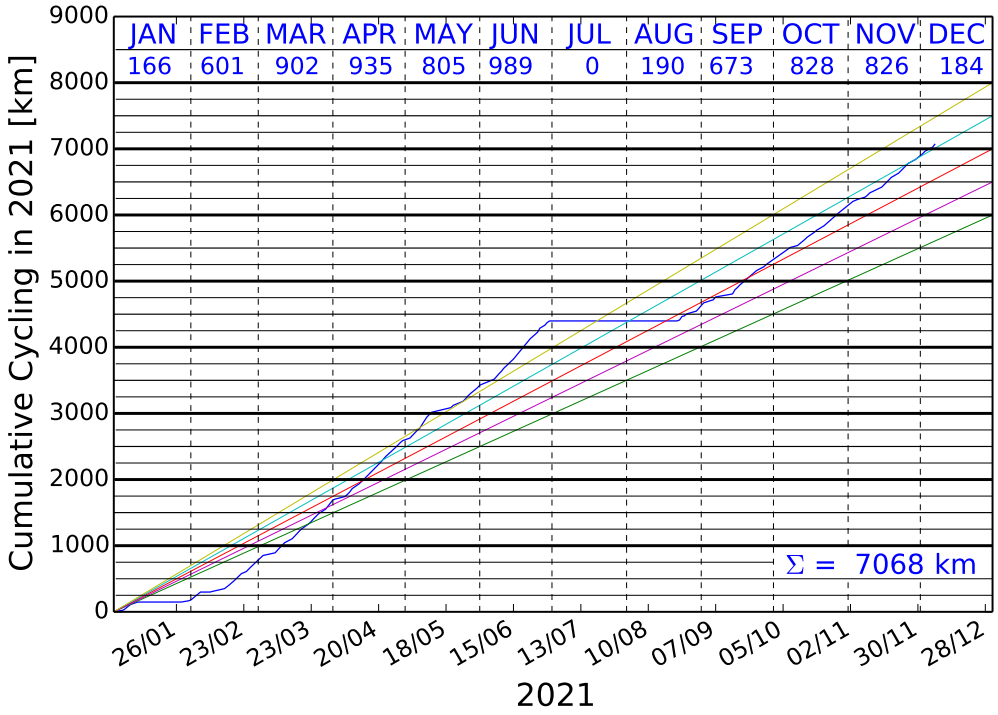
"Science promised us truth, or at least a knowledge of such relations as our intelligence can seize. It never promised us peace or happiness"
Gustave Le Bon `http://en.wikipedia.org/wiki/Gustave_Le_Bon`

Almost the end of Herbi's and my spinning story: challenges remain:
preparing for retirement and living actively our retirement!

There is a way spinning forward (I)

First my challenge:
How many knights (Springer) can one put on a chess board, such that they can neither defend or attack each other?

Herbi's most difficult challenge for me:
His yearly biking distance (not only daily biking to work!) is impressive!
Can I do the same?



There is a spinning way forward (II)

(Hard) Working and biking with the LHC:

This is not a way to compete spinning with Herbi..

A worker cycles along the beam line of the LHC in a tunnel at Cern. Photo: Valentin Flauraud/AFP/Getty

There is a spinning way forward (III)

Biking long distances together: the way to progress with Herbi..

There is a spinning way forward (IV)

Biking long distances together: the way to progress with Herbi..

There is a spinning way forward (V) and for many more years to come!

Biking long distances together: the way progress with Herbi..