

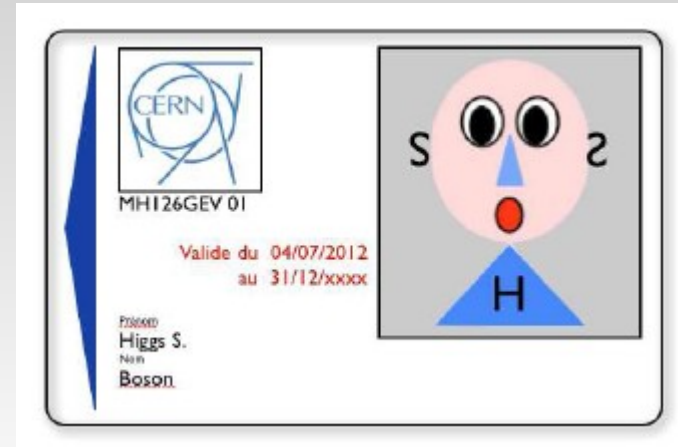
“New” and “Old” physics in Higgs sector

Workshop teaser

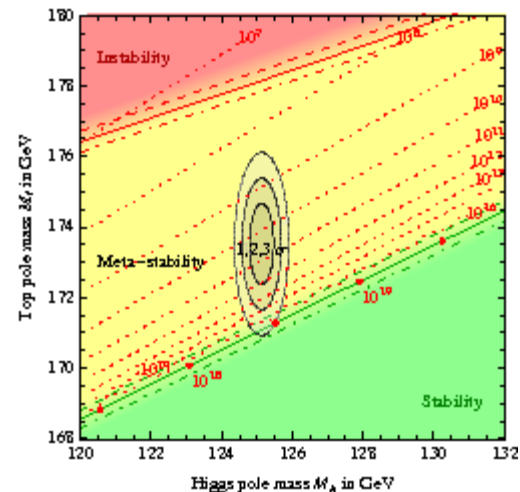
Just to say few words why you would not loose your time if you join the BSM workshop this afternoon

(Based a lot on Higgs Hunting talks 24-26 July 2017)

1.1) Higgs born 5 years ago



- The Higgs boson was discovered through its couplings to bosons.
- We obtained a theory with stable vacuum up to the Planck scale.



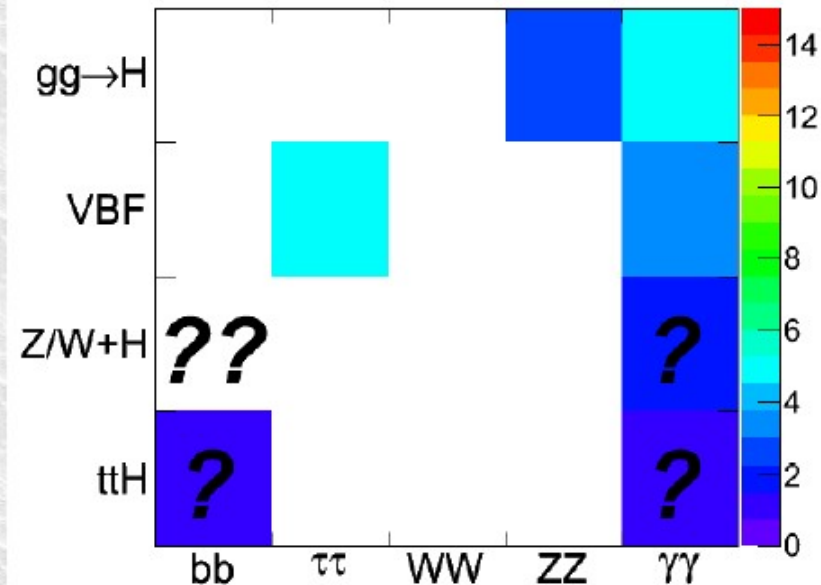
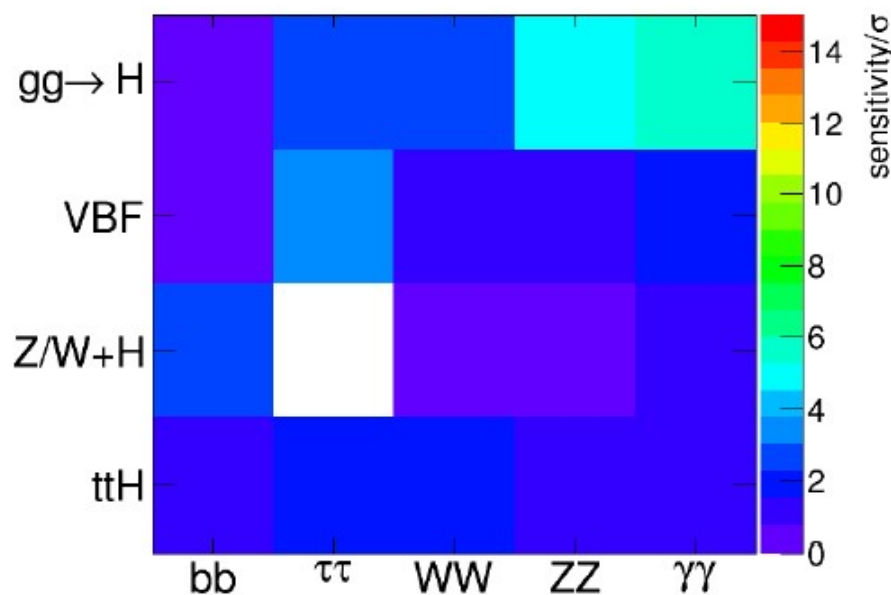
1.2) Higgs born 5 years ago

B.Murray

2017 reality

and

2009 estimate



- The Higgs mass offers a sweet spot: maximal number of channels/couplings available.

1.3) Higgs born 5 years ago

	Introduction to the Mini-Workshop on Latest Results and New Physics in the Higgs Sector	<i>Maxime Gouzevitch</i>
	<i>Room 1 (Auditorium, Main Session)</i>	08:30 - 08:55
09:00	BEH overview (ATLAS)	<i>Clara Jean May Nellist</i>
	<i>Room 1 (Auditorium, Main Session)</i>	08:55 - 09:25

Morning

Afternoon

	Higgs parameters measurement with CMS data	<i>Anna Kropivnitskaya</i>
	<i>Room 2</i>	09:30 - 10:00
10:00	Measurement of cross sections and couplings of the Higgs Boson in fermionic production and decay modes with the ATLAS detector	<i>Liaoshan Shi</i>
11:00	Measurements of the Higgs H(125) boson at CMS	<i>Valeria Botta</i>
	<i>Room 2</i>	11:00 - 11:30
	tH Coupling Measurement with the ATLAS Detector at the LHC	<i>Asma Hadeef et al.</i>
	<i>Room 2</i>	11:30 - 11:55
12:00	The Higgs and cosmology	<i>Prof. Oleg Lebedev</i>
	<i>Room 2</i>	11:55 - 12:25
	Search for rare and exotic Higgs Boson decay modes at CMS	<i>Junquan Tao</i>
	<i>Room 2</i>	12:25 - 12:55
13:00	Search for rare and exotic Higgs Boson decay modes and Higgs boson pair production with the ATLAS detector	<i>Suyog Shrestha</i>

15:00	Single Higgs production at LHC as a probe for anomalous Higgs self coupling	<i>Pier Paolo Giardino</i>
	<i>Room 2</i>	15:00 - 15:30
	Search for new physics in HH final state in CMS	<i>Konstantin Androsov</i>
	<i>Room 2</i>	15:30 - 16:00
	Search for neutral and charged BSM Higgs Bosons with the ATLAS detector	<i>Pawel Bruckman</i>
	<i>Room 2</i>	16:30 - 17:00
17:00	Phenomenological scenarios to fit a possible excess in the di-muon + jets channel	<i>Dr. Luca Panizzi</i>
	<i>Room 2</i>	17:00 - 17:30
	Measurement of $\sigma(Z \rightarrow b\bar{b})$ cross section and search for Higgs-like particle produced in association with b quarks at CDF	<i>Dr. Luigi Marchese</i>
18:00	Search for Anomalous Quartic Photon Coupling at the LHC	<i>Mr. Justin Andrew Williams</i>
	<i>Room 2</i>	18:00 - 18:30

2.1) 5 years later

MASS

- The only free parameter of SM where you really need to look “at the Higgs”: 125 GeV.

TOTAL WIDTH

- Expected: 4 MeV
- A very rough direct upper limit on the width ($H \rightarrow ZZ$):
Width < 1 GeV.
- A much more precise indirect limit from Higgs/continuum interference (model dependent): $\sim < 30$ MeV.

BEH overview (ATLAS)

Clara Jean May Nellist

Room 1 (Auditorium, Main Session)

08:55 - 09:25

Higgs parameters measurement with CMS data

Anna Kropivnitskaya



Room 2

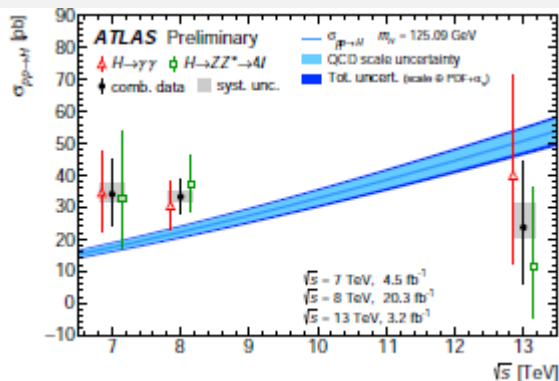
09:30 - 10:00

2.2) 5 years later

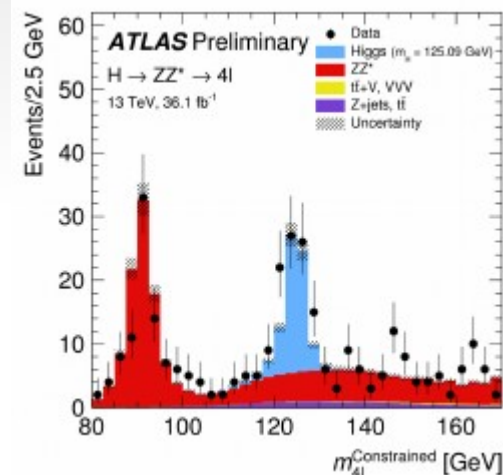
EWSB

$$\left(\frac{2m_W^2}{v} h W_\mu^+ W^{-\mu} + \frac{m_Z^2}{v} h Z_\mu Z^\mu \right)$$

- Rather precisely measured in Run I. EWSB mechanism is established there.
- In 2015 data (low stats): “We lost our Higgs”.



Panic



- In 2016 data: oufff we rediscovered it.

Measurements of the Higgs H(125) boson at CMS

Valeria Botta

Room 2

11:00 - 11:30

BEH overview (ATLAS)

Clara Jean May Nellist

Room 1 (Auditorium, Main Session)

08:55 - 09:25

2.3) 5 years later

H → ff

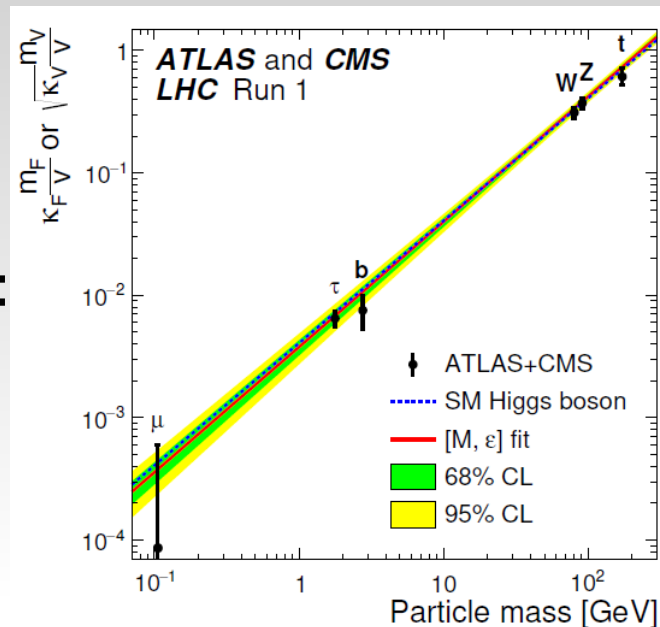
- Indirect constraints on top Yukawa through the coupling to massless bosons:

$$+c_g \frac{\alpha_s}{12\pi v} h G_{\mu\nu}^a G^{a\mu\nu} + c_\gamma \frac{\alpha}{8\pi v} h F_{\mu\nu} F^{\mu\nu} + c_{Z\gamma} \frac{\alpha}{8\pi v s_w} h F_{\mu\nu} Z^{\mu\nu}$$

- The most interesting news from 2016:

Couplings to fermions → $\sum_f \frac{m_f}{v} h \bar{f} f$ ✓ for bb , $t\bar{t}$, and $\tau\bar{\tau}$!

- Some thinking about how to tackle the 2nd generation.



Measurement of $\sigma(Z \rightarrow b\bar{b})$ cross section and search for Higgs-like particle produced in association with b quarks at CDF Dr. Luigi Marchese

Higgs parameters measurement with CMS data

Anna Kropivnitskaya

Room 2

09:30 - 10:00

Measurements of the Higgs H(125) boson at CMS

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$t\bar{t}H$ Coupling Measurement with the ATLAS Detector at the LHC

Asma Hadeef et al.

Room 2

11:30 - 11:55

2.4) The Higgs potential structure

- The choice of the minimal Higgs potential in SM is a postulate as well as its structure:

$$\mathcal{L}^h = \frac{1}{2}m_h^2 h^2 + \eta v h^3 + \frac{\eta}{4} h^4$$

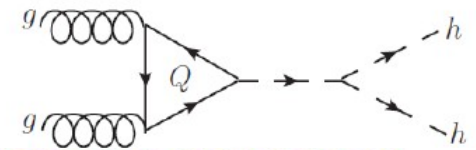
- Fully constrained within SM:

$$\lambda_{hhh} \equiv \eta = \frac{m_H^2}{2v^2}$$

$$v = 2^{-1/4} \cdot G_F^{-1/2} \approx 246 \text{ GeV}$$

$$\frac{\delta\lambda_{hhh}}{\lambda_{hhh}} \approx 2 \frac{\delta m_H}{m_H} \approx 0.4\%$$

- Higgs self-coupling provides a direct handle



Search for new physics in HH final state in CMS

Konstantin Androsov

Room 2

15:30 - 16:00

Search for rare and exotic Higgs Boson decay modes and Higgs boson pair production with the ATLAS detector

Suyog Shrestha

- High precision Higgs BF provides an indirect handle to λ .

Single Higgs production at LHC as a probe for anomalous Higgs self coupling

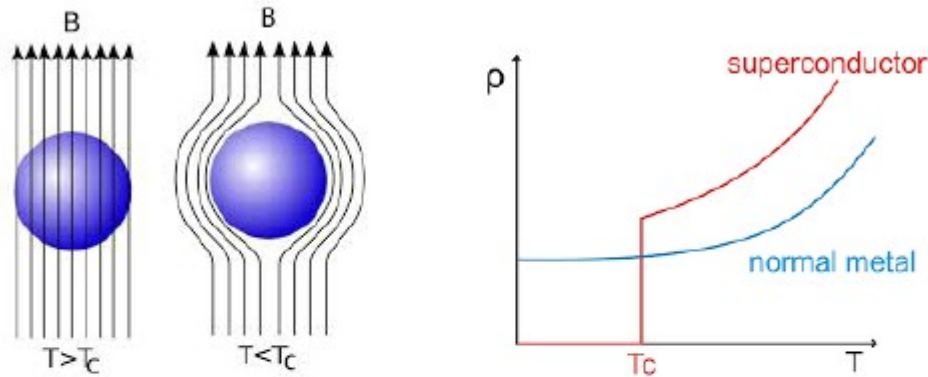
Pier Paolo Giardino

Room 2

15:00 - 15:30

2.5) The Higgs potential structure

One of the most beautiful examples is the superconductivity discovered in 1911:



Ginzburg-Landau theory from 1950 offered a macroscopic (ie effective) theory for conventional superconductivity,

$$V(\Psi) = \alpha(T)|\Psi|^2 + \beta(T)|\Psi|^4 \quad \alpha(T) \approx a^2(T - T_c) \quad \text{and} \quad \beta(T) \approx b^2$$

What is the microscopic origin of the Ginzburg-Landau potential for superconductivity?

Ian Low

Argonne/Northwestern/CERN

Higgs Hunting @ Paris, France
July 25th, 2017

2.5) The Higgs potential structure

In 1957 Bardeen, Cooper and Schrieffer provided the microscopic (fundamental) theory that allows one to

- 1) interpret $|\Psi|$ as the number density of Cooper pairs
- 2) calculate coefficients of $|\Psi|^2$ and $|\Psi|^4$ in the potential.

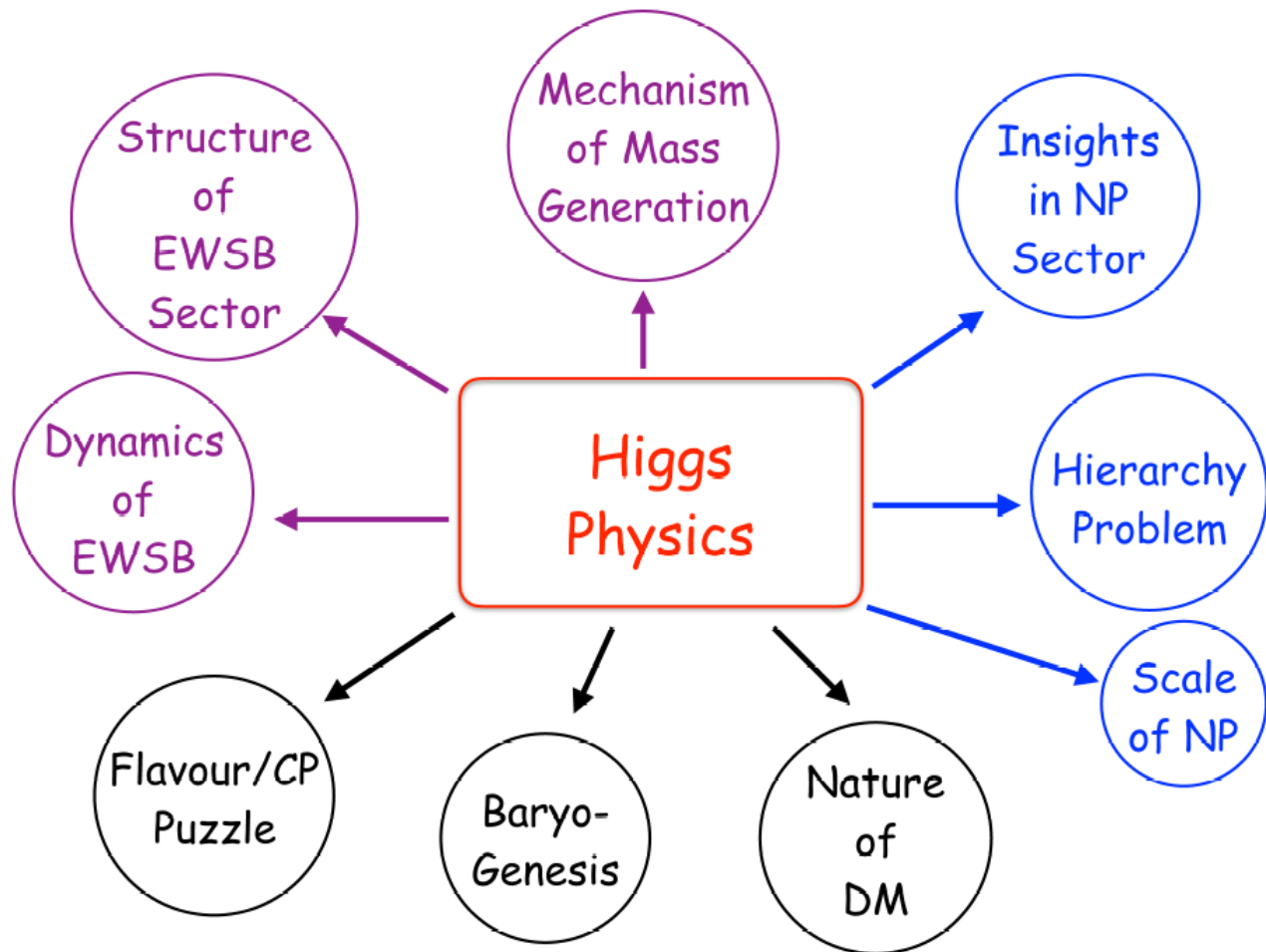
Our understanding of the electroweak symmetry breaking is far from the BCS level. In fact, we are not even at the level of Ginzburg-Landau!

Ian Low

Argonne/Northwestern/CERN

Higgs Hunting @ Paris, France
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3.1) Higgs portal to BIG questions



M.M.Mühlleitner, 24 July 2017, Higgs Hunting, Orsay

3.2) Higgs portal to BIG questions

Why the Higgs sector shall be minimal?

2Higgs-Doublet-Model
Multi-Higgs
CP-violating 2HDM
PortalHiggs
Next-2HDM
TwinHiggs
Singlet Extensions
LittlestHiggs
MSSM
Georgi-Machacek
3HDM
NMSSM
CompositeHiggs

Search for neutral and charged BSM Higgs Bosons with the ATLAS detector

Pawel Bruckman

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16:30 - 17:00

Search for rare and exotic Higgs Boson decay modes at CMS

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Search for rare and exotic Higgs Boson decay modes and Higgs boson pair production with the ATLAS detector

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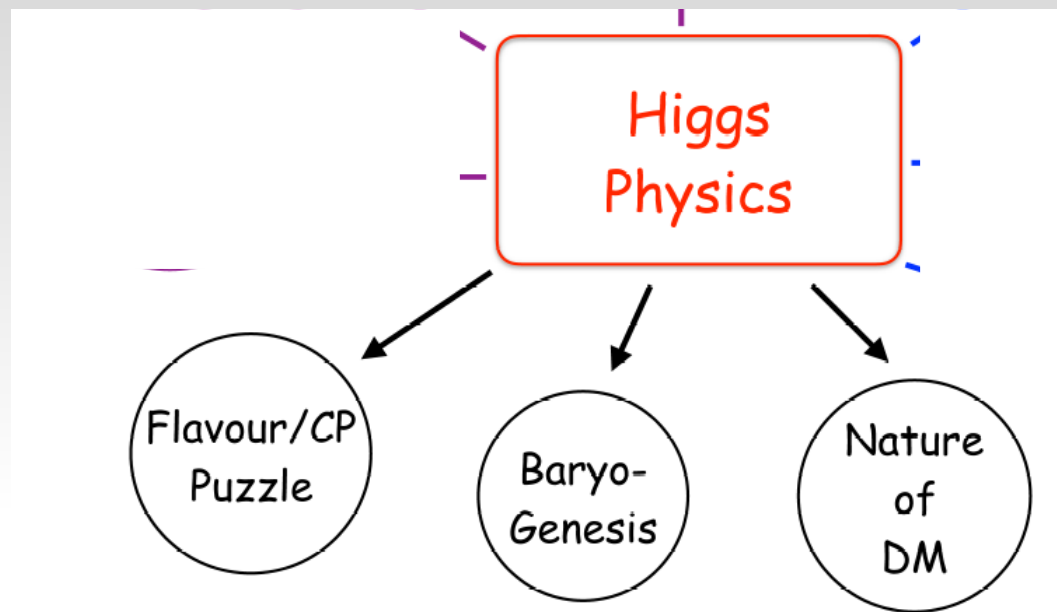
Search for Anomalous Quartic Photon Coupling at the LHC

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18:00 - 18:30

3.3) Higgs portal to BIG questions



12:00

The Higgs and cosmology

Prof. Oleg Lebedev



Room 2

11:55 - 12:25

Enjoy it

