

# Coordinators Report

Helmholtz Association

Brussels

20 October 2015

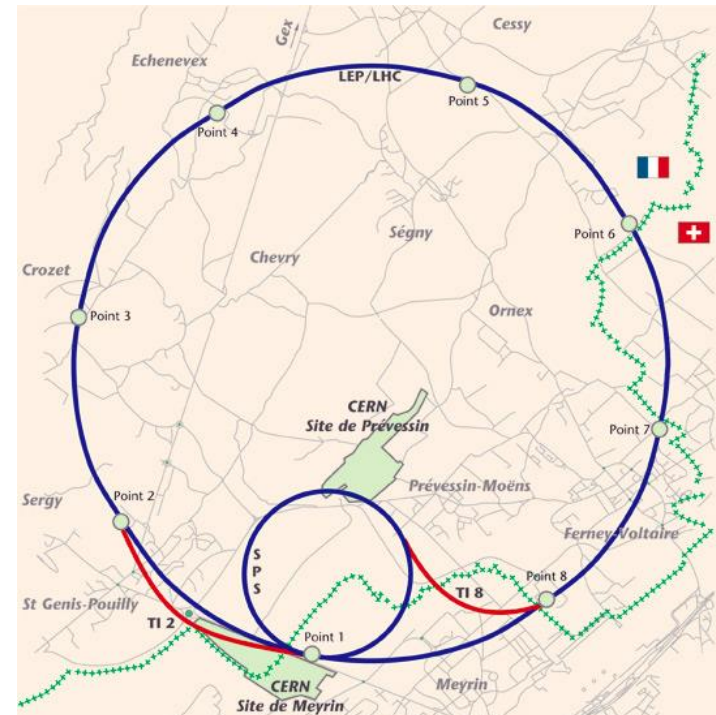
Nigel Glover

University of Durham



# The Higgs quest – exploring electroweak symmetry breaking at the LHC

- ✓ [www.higgstools.org](http://www.higgstools.org)
- ✓ Marie Curie Initial Training Network  
PITN-GA-2012-316704 (2014-2017)
- ✓ 10 Full Partners + 15 Associated Partners
  - (4 AP from private sector)
- ✓ 9+1 european countries



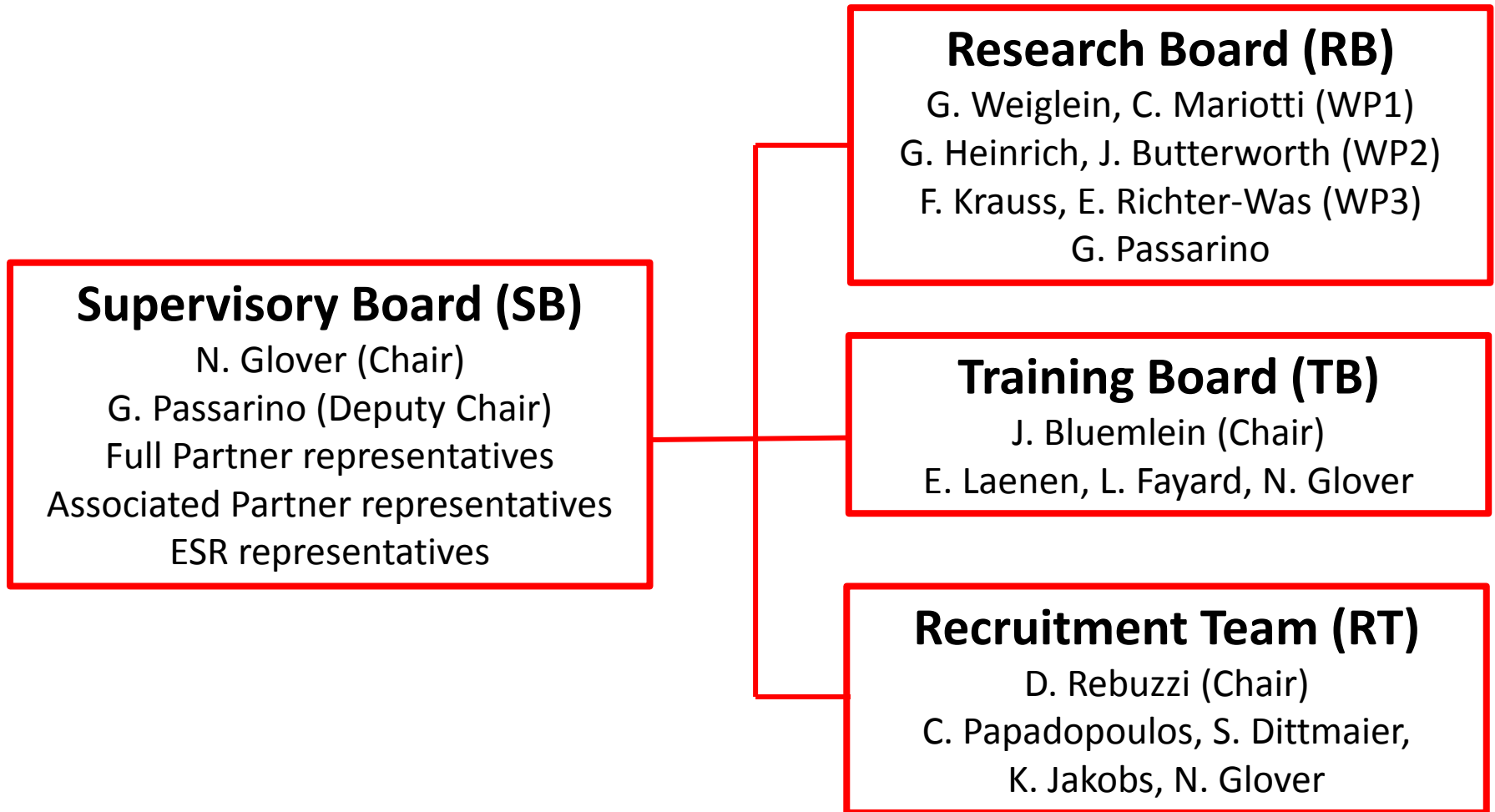


# Node Structure

	Full Partner	Associated Partner	Associated Partner
UK	UDUR	IC, UCL	CERN
D	ALU-FR	MPI	Brook Lapping
FR	CNRS		Maplesoft
D	DESY		Shell
IT	DFTTO	UNIMI	Wolfram Research
CH	ETH	UZH, PSI	Associated Partners provide additional opportunities for collaboration, training and secondments
NL	FOM	CP3	
PL	IFJ-PAN	UW	
GR	NCSR-D		
ES	UGR	IFIC, IFCA	



# Management Structure





## **Supervisory Board (SB)**

N. Glover (Chair)  
G. Passarino (Deputy Chair)  
Full Partner representatives  
Associated Partner representatives  
ESR representatives

## **Research Board (RB)**

G. Weiglein, C. Mariotti (WP1)  
G. Heinrich, J. Butterworth (WP2)  
F. Krauss, E. Richter-Was (WP3)  
G. Passarino

## **Training Board (TB)**

J. Bluemlein (Chair)  
E. Laenen, L. Fayard, N. Glover

## **Recruitment Team (RT)**

D. Rebuszi (Chair)  
C. Papadopoulos, S. Dittmaier,  
K. Jakobs, N. Glover

## **Young Researchers Assembly (YRA)**

All ESRs



## **Project Management Board (PMB)**

N. Glover, G. Passarino

## **Supervisory Board (SB)**

N. Glover (Chair)

G. Passarino (Deputy Chair)

Full Partner representatives

Associated Partner representatives

ESR representatives

## **Research Board (RB)**

G. Weiglein, C. Mariotti (WP1)

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## **Young Researchers Assembly**

**(YRA)**

All ESRs



# Coordinator Support Team in Durham



## ✓ Patricia Martin (secretarial)

- Record keeping (contracts, pdps)
- Meeting organisation (First Young Researchers Meeting, ...)

## ✓ Gary Mitchell (Finance)

- Communicates with Full Partners and will be signing off on Form C



# Recruitment

- ✓ apply online at [www.higgstools.org/Jobs](http://www.higgstools.org/Jobs)
- ✓ Procedure
  - ✓ Evaluation of applications by RT and supervisors
  - ✓ Skype interviews
- ✓ **First Call (closed 31/5/14)**
  - ✓ 108 applications (88M, 20F)
  - ✓ 25 interviews
  - ✓ 19 recruitments (14M, 5F)
- ✓ **Second Call (closed 28/2/15)**
  - ✓ 13 applications (12M, 1F)
  - ✓ 4 interviews
  - ✓ 2 recruitments (1M, 1F)



The screenshot displays the EURAXESS Researchers in Motion website. At the top, there is a navigation bar with links: A to Z, Services, About this site, Important legal notice, Analytics Disclaimer, Contact, Search on EUROPA, and English (en). Below this is the EURAXESS logo and the text "EURAXESS Researchers in Motion". A breadcrumb trail reads: European commission > Euraxess > MyEURAXESS > Job vacancies.

The main content area is titled "Preview" and "Early Stage Researchers in Particle Physics". It describes the Marie Curie Initial Training Network (ITN) HiggsTools, offering 21 Early Stage Researcher (ESR) positions across Europe. The partners include Germany, United Kingdom, France, Italy, Switzerland, the Netherlands, Poland, Greece, and Spain. The description states the main goal is to provide excellent initial training to young researchers in high energy particle physics, paving the way for new discoveries about the fundamental nature of the Universe.

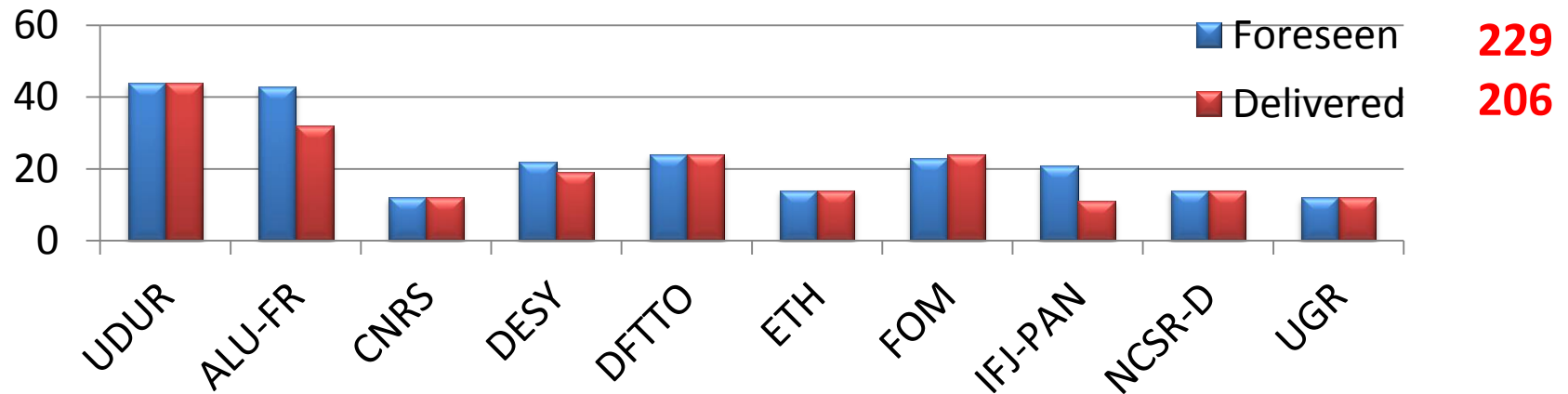
On the right, "Other job details" are listed: Job ID 33895567, Type of Contract Temporary, Status Full-time, Working Hours 40 hours per week or free text, Company/Institute HiggsTools, Country UNITED KINGDOM, City Durham, Postal Code DH1 3LE, and Street Physics Department, University of Durham.

Below this, the "EU Research Framework Programme" section states the job is funded through the FP7/People - Marie Curie Actions. It also lists the Project's Marie Curie Grant Agreement Number as 316704 and the Advert Number as 1.

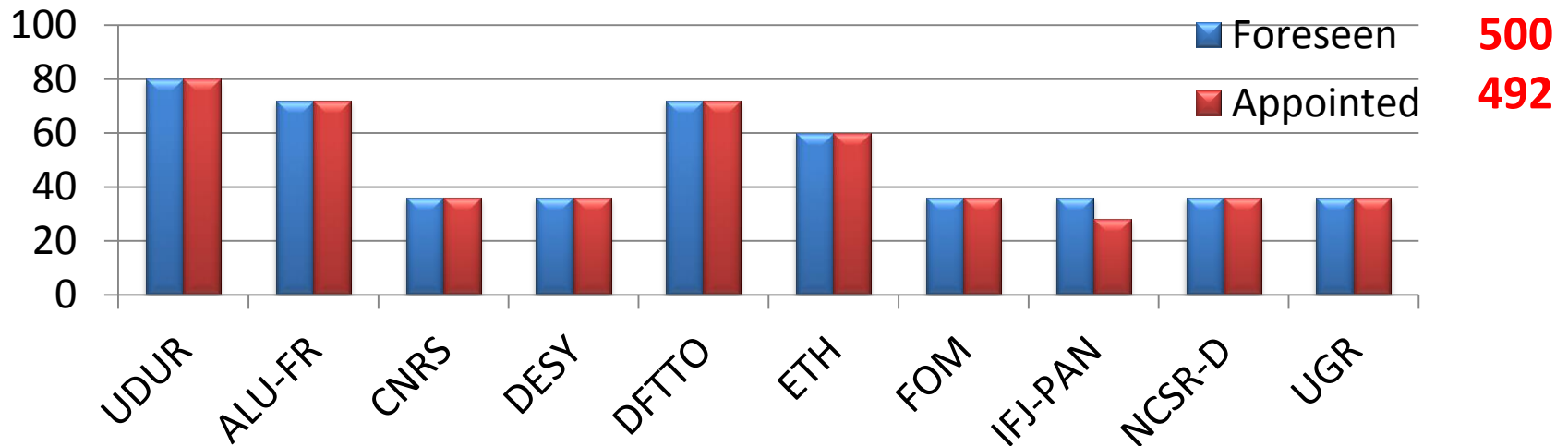
On the left side of the job details, there is a sidebar with links: Overview, Job vacancies (active), Fellowship Programmes, Search 4 CV, User management, Organisation's data, Account settings, Book: a name!, Logout, EURAXESS Public Website, and How to Publish Job Vacancies in 4 steps.



## Delivered versus foreseen ESR months (up to Sep 2015)

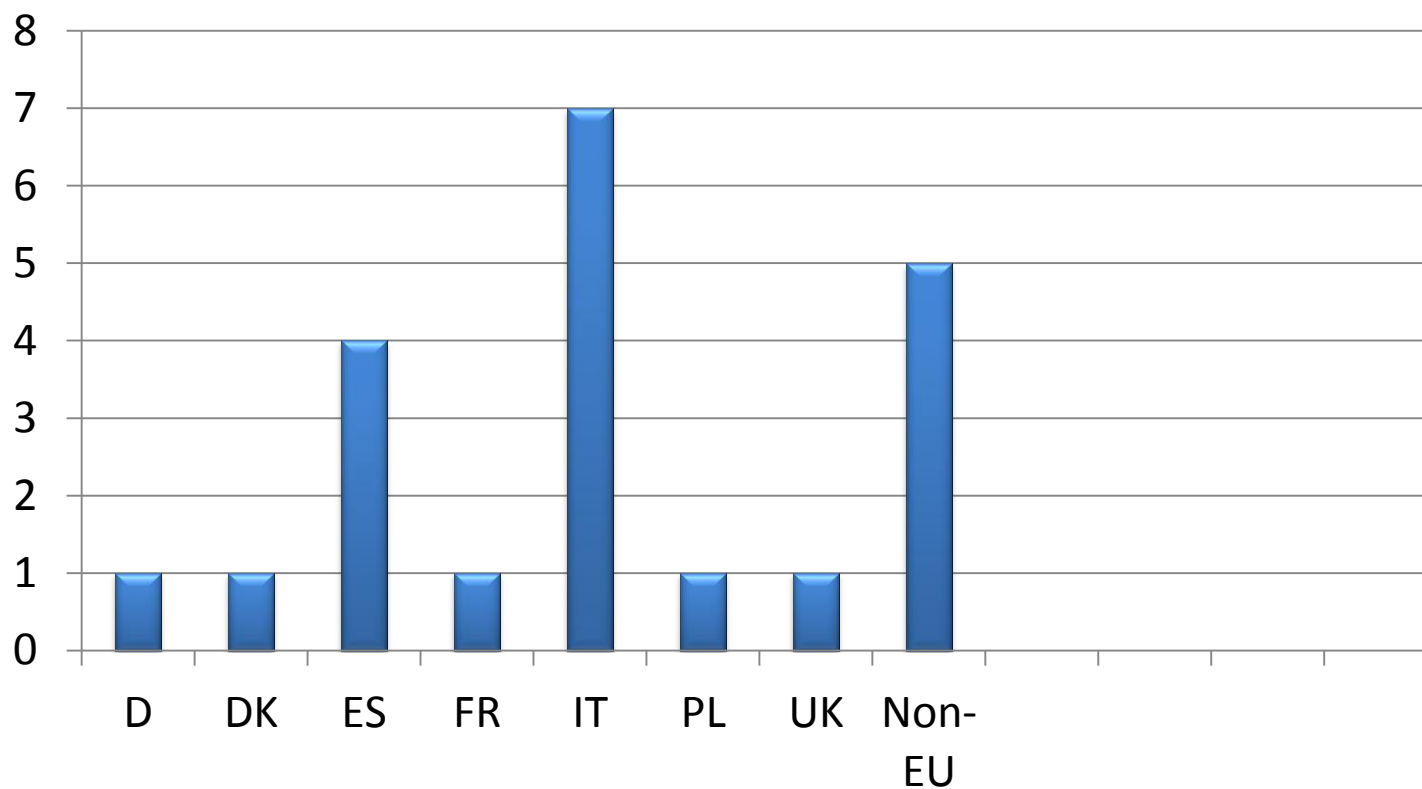


## Appointed versus foreseen ESR months (2014-2017)



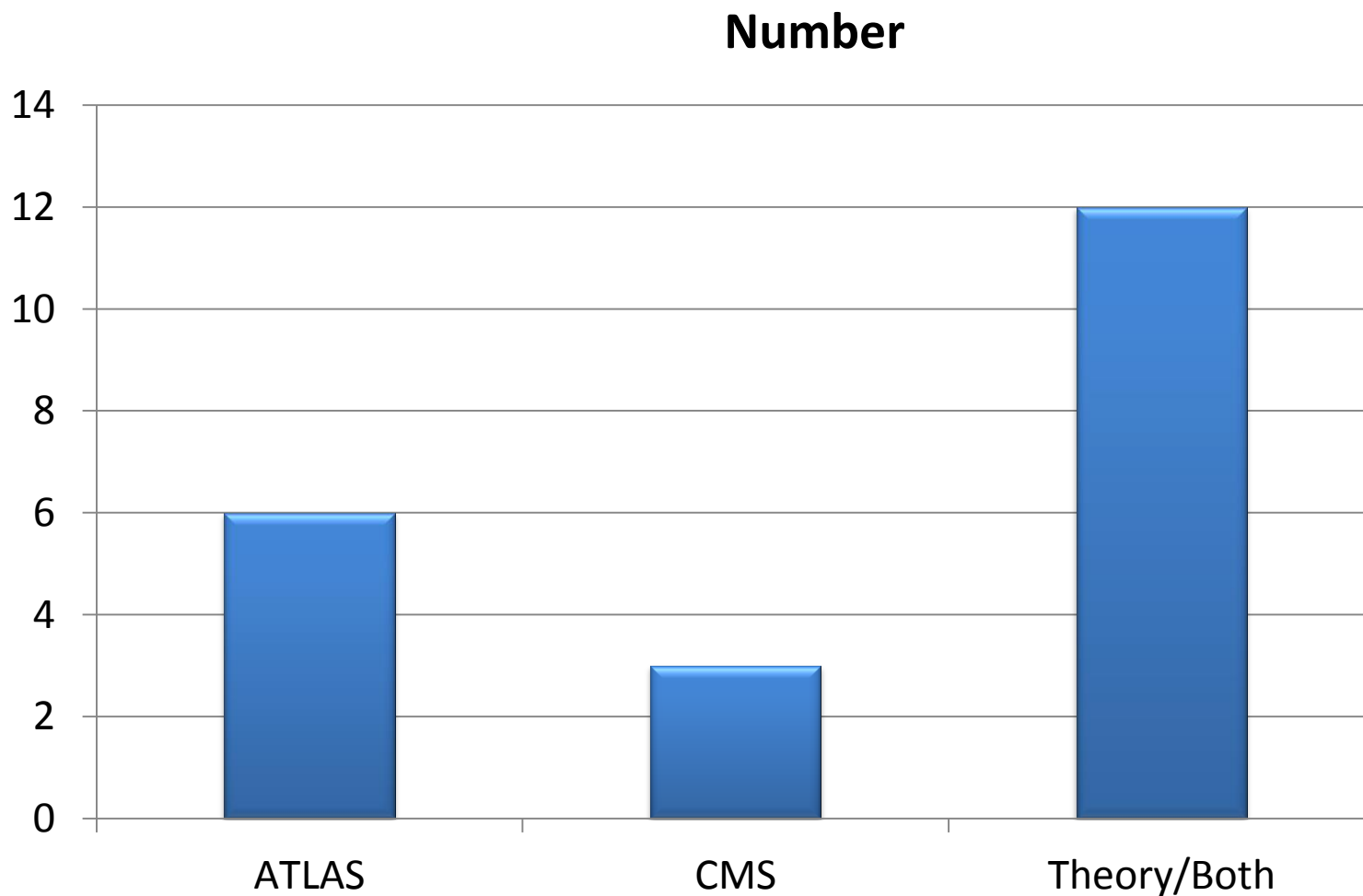


# ESR nationality





# Theory/Experiment Split





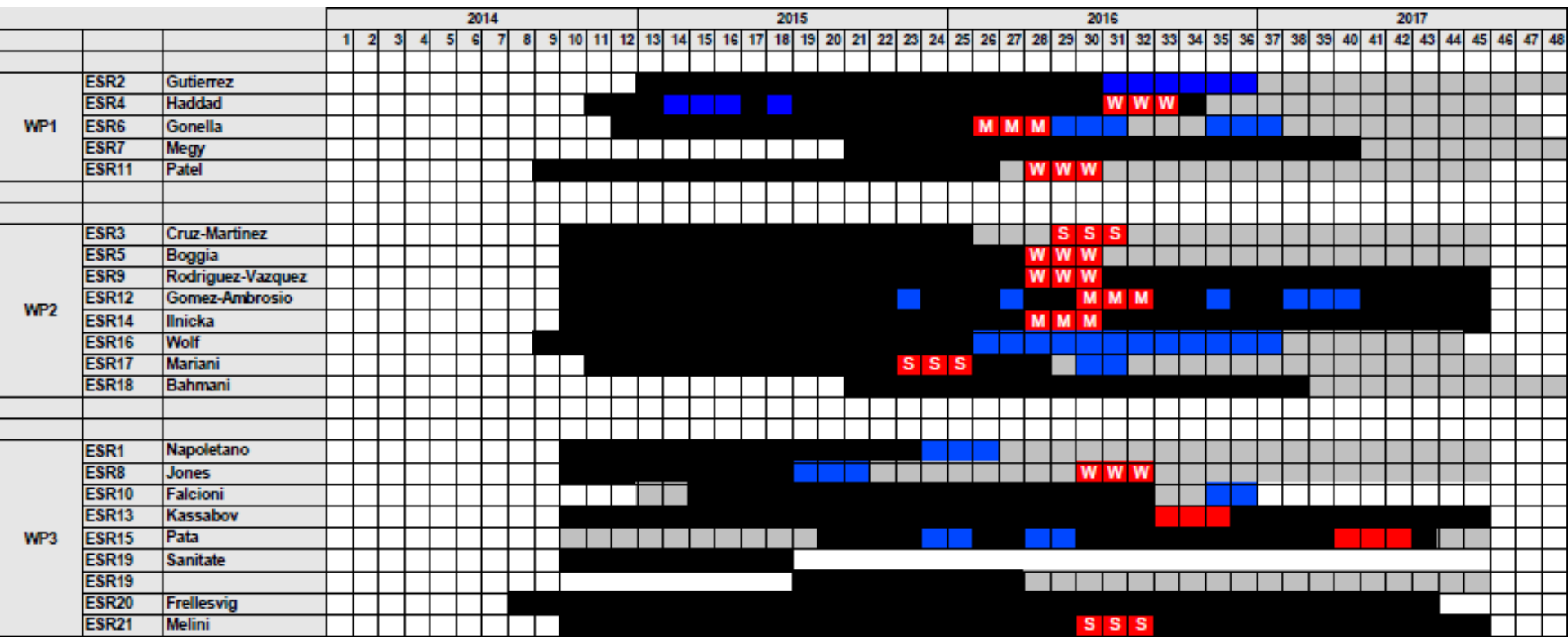
# PhDs awarded (so far)

ESR	Thesis Title	Awarding Institute	Month Awarded
Nicolas Gutierrez	Top-Tagging with Shower Deconstruction and Search for Single Production of Vector-Like Quarks at ATLAS	University of Glasgow	19
Yacine Haddad	A highly granular semi-digital hadron calorimeter for a future linear e+e- collider and a model independent Higgs boson measurement in the ZH to qq+X Channel	Ecole Polytechnique Paris	14
Stephen Jones	A Study of Exclusive Processes to NLO and Small-x PDFs from LHC Data	Liverpool University	18
Giulio Falcioni	The infrared structure of gauge theory scattering amplitudes	University of Torino	15
Hjalte Frellesvig	Generalized Unitarity Cuts and Integrand Reduction at Higher Loop Orders	Niels Bohr Institute	10



# ESRs in HiggsTools

- ✓ To fully benefit from the training of the network, all ESRs to be in network for 36 months
  - Many partly funded by EU ■ partly by local sources ■
  - Aim to build a cohort capable of collaborating comfortably across theory/experiment boundary





# Network Wide Events

- ✓ Aiming to build a strong cohort of ESRs that are all in the network for 36 months to fully benefit from training and collaborative opportunities
- ✓ Annual meetings to coordinate the network activities and assess research progress (Supervisory Board Meetings etc)
  - Priority to presentations by young researchers to enhance presentation skills in relaxed atmosphere
- ✓ Network Schools to complement local training
- ✓ Training in complementary skills (Young Researcher meetings)
- ✓ Journal Club run by ESRs
- ✓ Other scientific meetings organised by the network



## Kickoff Meeting

18 senior members of the network attended meeting plus representatives from **Maplesoft** and **Brook Lapping**

### Focus on

- ✓ Administrative aspects of the network
  - ✓ Including feedback from Coordinators meeting in Brussels
- ✓ Recruitment
  - ✓ Advertising of positions
  - ✓ Procedure for making appointments
  - ✓ ESR project booklet



**higgstools**



**higgstools**

## HiggsTools Kickoff Meeting

2-4 April 2014

University College London  
Department of Physics & Astronomy  
Gower Street  
London  
WC1E 6BT  
<http://www.higgstools.org/>









ESR Opportunities in the  
HiggsTools ITN





## First Young Researchers Meeting

- ✓ This was the first time that the ESR's met as a group
- ✓ All 19 attended the meeting plus 3 senior scientists

### Aims

- ✓ To develop a team spirit amongst the ESRs
- ✓ The programme for the first two days focussed on building a high performance network team that can collaborate and communicate in an effective manner
- ✓ The third day featured media training and was mostly hands on with cameras and simple editing (**Brook Lapping**).



**higgstools**



## First Young Researchers Meeting

Collaborative Teamwork and Communication

16 - 20 February 2015



Lumley Castle Hotel  
Chester le Street  
County Durham  
DH3 4NX

*"Coming together is a start.  
Staying together is progress.  
Working together is success."  
Henry Ford*

<http://www.higgstools.org/>







**Tuesday, 17 February 2015**

- 09:00 - 09:15 Welcome & Introductions 15'  
*Day 1 and Day 2 will be facilitated by Mr Stephen Hutchinson*
- 09:15 - 09:45 Learning Styles 30'
- 09:45 - 10:30 Ideal Researcher 45'  
*Participants in groups of 5 produce a poster of an ideal collaborative researcher*
- 10:30 - 10:45 Paired Reflection & Coaching 15'
- 10:45 - 11:00 Coffee ( Waterford Room )
- 11:00 - 12:00 Challenge Activity 1h0'  
*More details to follow*
- 12:00 - 12:25 Team Process Model 25'  
*Group Activity*
- 12:25 - 12:45 Understanding Self Within a Team 20'
- 12:45 - 13:45 Lunch ( Served in Waterford Room )
- 13:45 - 14:00 Theories of Teams 15'
- 14:00 - 15:00 Values 1h0'
- 15:00 - 15:15 Coffee
- 15:15 - 16:15 Game Theory 1h0'
- 16:15 - 17:15 Case Study for Overnight 1h0'  
*Introduction a d group work until 17:15*
- 17:15 - 17:30 Understanding Self Within the Team 15'
- 18:30 - 20:30 Dinner
- 20:30 - 23:30 Group Project Work 3h0'



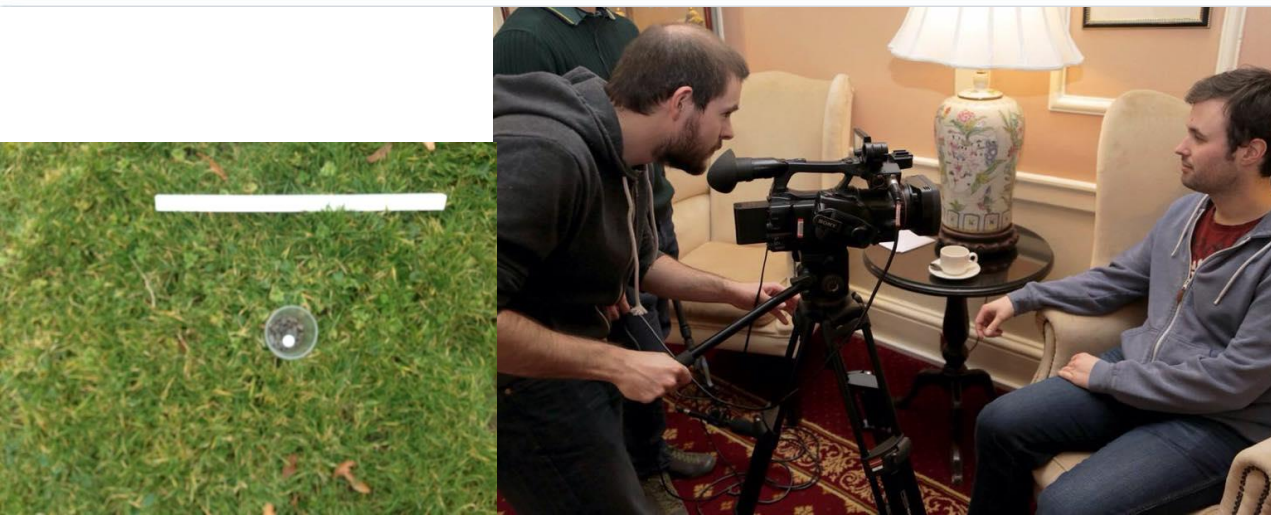
	1	2	3	4
ROUND 1	R -4	✓ -4	-4	Red -4
ROUND 2	R -8	✓ -8	-8	Red -8
NEG				
ROUND 3 (x2)	R 0	✓ -16	R 0	Red 0
ROUND 4	R -4	-20	R -4	Red -4
ROUND 5	R -8	✓ -24	R -8	Red -8
NEG				
ROUND 6 x3	R +4	✓ -12	R +4	Blue -20
TOTAL	+4	-12	+4	-20
HIGGS TOTAL		-24		





## Thursday, 19 February 2015

09:30 - 09:45	<b>Introduction 15'</b> ( Garter Suite ) <i>Day 3 will be lead by Stephen Wilkinson (Producer/Director) and Jim Franks (Trainer/Cameraman/Editor) from Brook Lapping. He will introduce the opportunities for the development of media materials to supporting the project with both internal communication and outreach</i>
09:45 - 10:15	<b>Planning a Production 30'</b> <i>The project plan that takes an idea from conception to the screen</i>
10:15 - 11:00	<b>The Idea 45'</b> <i>Brainstorming ideas that will form the basis of the hands-on productions in the afternoon session. How to produce a 3 min shooting script. This will also involve group work.</i>
11:00 - 11:15	<b>Coffee</b> ( served in the Waterford Room )
11:15 - 11:30	<b>Pitching Proposals 15'</b> <i>Facilitated by Stephen Wilkinson, Jim Franks and Nigel Glover</i>
11:30 - 12:30	<b>Introduction to Camera &amp; Sound 1h0'</b> <i>Explanation of how to capture pictures and sound. The ESRs will be shown techniques to improve "self generated" content and tips on how to achieve near broadcast quality sequences.</i>
12:30 - 13:00	<b>Lunch</b> ( served in the Waterford Room )
13:00 - 14:00	<b>Shooting the 3' Movie 1h0'</b> <i>The ESR groups will share responsibility across the five key tasks; director, cameraperson, sound, editor, writer/commentary.</i>
14:00 - 16:00	<b>Editing the Movie 2h0'</b>
16:00 - 17:00	<b>The Screening 1h0'</b> <i>The final films to be shown to the whole group, with Q&amp;A including both peers and trainers.</i>
17:00 - 17:30	<b>WRAP 30'</b>
18:30 - 20:30	<b>Dinner</b> ( To be served in The Scarborough Room )





## First Annual Meeting

59 participants including all ESRs and a number of external experts.

### Aims

- ✓ To review the state of the art with talks from the WP leaders and external experts
- ✓ For each ESR to give a first public talk about their research in a friendly environment
- ✓ For ESRs to learn about the possibilities of private sector secondments (**Maplesoft, Wolfram**)
- ✓ Meetings of Supervisory Board and YRA
- ✓ **Outreach** event with Rolf Heuer



**First Annual Meeting of HiggsTools**  
University of Freiburg, 15-17 April 2015  
<http://higgstools2015.uni-freiburg.de>

**Data**

**Predictions**

**Tools**

**International Organizing Committee**  
Jonathan Butterworth (London)  
Nigel Glover (Durham)  
Gudrun Heinrich (Munich)  
Frank Krauss (Durham)  
Chiara Mariotti (Torino)  
Giampiero Passarino (Torino)  
Elzbieta Richter-Was (Krakow)  
Georg Weiglein (Hamburg)

**Local Organizers**  
Susanne Bergmann (Secr.)  
Gislinde Bühler (Secr.)  
Christina Skorek (Secr.)  
Elias Coniavitis  
Stefan Dittmaier  
Karl Jakobs  
Karsten Köneke  
Markus Schumacher  
Christian Schwin





## Summer School 2015

29 students attended the school.

### Aims

- ✓ Immersion in Higgs Physics with 27 hours of lectures from experts within and outside of the network
- ✓ Meetings of the YRA
- ✓ Building the HiggsTools esprit de corps

## HiggsTools Summer School on Higgs Physics

June 28 – July 4 2015, Pallesieux, Italy

### Advisory Committee

J. Bluemlein, J. Butterworth, L. Fayard,  
N. Glover, G. Heinrich, F. Krauss,  
E. Laenen, C. Mariotti, G. Passarino  
E. Richter-Was, G. Weiglein

### Topics

Event Simulations  
Electroweak Physics  
Vector Boson Scattering  
Effective Field Theories for Higgs  
Higgs Coupling Measurements  
QCD at the LHC focussing on Higgs production

### Lecturers

A. David  
S. Dittmaier  
C. Duhr  
D. Froidevaux  
B. Jaeger  
F. Krauss  
F. Maltoni  
A. Manohar  
K. Nikolopoulos



higgstools

<http://conference.ippp.dur.ac.uk/e/HTSS2015>





## Second Young Researchers Meeting

Organised **entirely** by the ESR  
Focussing around three working group

1. Beyond the Standard Model
2. ttH Phenomenology
3. Monte Carlo, Vector Boson Scattering and PDF's

### Aims

- ✓ Develop organisational skills of the ESRs
- ✓ Develop common cutting edge research projects that could lead to collaborative research articles



**HiggsTools 2nd Young Researchers Meeting**  
21-23 October 2015, Universite Libre de Bruxelles, Belgium

Invited Speakers: Topics:

- M Spira
- F Maltoni
- F Krauss
- Beyond the Standard Model;
- ttH Phenomenology
- Monte Carlo, Vector Boson Scattering and PDFs

 <http://conference.ippp.dur.ac.uk/event/481/> 



# Meetings planned for 2016

## ✓ Second Annual Meeting

- Granada, 12-15 April
- will review progress in the field

## ✓ Second HiggsTools School – Exothiggs

- Zuoz, 14-20 August
- Combined with the famous biannual PSI school
- Will give a broader training in HEP

## ✓ Third Young Researchers Meeting

- Zeuthen, September
- will be open to young researchers outside the network



# Plus many other opportunities to present research e.g.

- ✓ **The 11th Workshop of the LHC Higgs Cross Section Working Group**
  - Jan 13-15, 2016, CERN, Switzerland
  - <http://indico.cern.ch/event/407347/>
  
- ✓ **Loops and Legs in Quantum Field Theory 2016**
  - April 24-29, Leipzig, Germany
  - <https://indico.desy.de/conferenceDisplay.py?ovw=True&confId=12010>
  
- ✓ **Higgs Hunting 2016**
  - August 31-September 3, 2016, Orsay, France
  - <http://higgshunting.fr/ttp://indico.cern.ch/event/407347/>





# Journal Club

Date	Title	Presenters
11/3/15	Constraining the Higgs via Vector-Boson-Fusion at LHC-II and LHC-III	Boggia Gonella
23/3/15	Search for invisible decays of the Higgs boson in VBF and associated ZH production modes Constraints on the Higgs boson width from off-shell production and decay to Z-boson pairs	Sanitate Gomez-Ambrosio
8/5/15	Measurements of the Total and Differential Higgs Boson Production Cross Sections in ATLAS Effective theories and measurements at colliders	Kassabov Melini
5/6/15	Lepton-flavour-violating decays of the higgs boson Neutrino masses and invisible decays at the LHC	Falcioni Pata
24/7/15	Testing the Higgs Boson Coupling to Gluons Search for a pseudoscalar boson decaying into a Z boson and the 125GeV Higgs boson in $l\bar{l}b\bar{b}$ final states	Wolf Mariani



# Interactions with private sector

- ✓ Presentations at network Meetings
  - Kickoff Meeting
    - Dave Hare (Maplesoft)
    - Stephen Wilkinson (Brook Lapping)
  - First Annual Meeting
    - Juergen Gerhard (Maplesoft)
    - Edoardo Serna (Wolfram)
- ✓ Participation in Supervisory Board Meetings
- ✓ Leading of training activities
  - First Young Researchers Meeting
    - Stephen Wilkinson, Jim Franks (Brook Lapping)
- ✓ Hosting ESRs via secondments



# Secondments to private sector partners



- |                                   |             |
|-----------------------------------|-------------|
| ✓ Giulia Gonella (ALU-FR)         | spring 2016 |
| ✓ Raquel Gomez-Ambrosio (DFTTO)   | summer 2016 |
| ✓ Agnieszka Ilnicka (ETH)         | summer 2016 |
| ✓ Joosep Pata (ETH)               | summer 2017 |
|                                   |             |
| ✓ Yacine Haddad (UDUR)            | summer 2016 |
| ✓ Michele Boggia (ALU-FR)         | summer 2016 |
| ✓ Stephen Jones (ALU-FR)          | summer 2016 |
| ✓ Zahari Kassabov (DFTTO)         | winter 2016 |
| ✓ Matias-Rodriguez-Vazquez (CNRS) | summer 2016 |
| ✓ Shruti Patel (DESY)             | summer 2016 |
|                                   |             |
| ✓ Juan Cruz-Martinez (UDUR)       | summer 2016 |
| ✓ Tim Wolf (FOM)                  | summer 2016 |
| ✓ Elisa Mariani (FOM)             | summer 2016 |
| ✓ Davide Melini (UGR)             | summer 2016 |





# Outreach

- ✓ Public Lecture by CERN DG Rolf Heuer during first annual meeting



- ✓ Local activities – open days, master classes, e.g. Exhibition for the general public “From Einstein to Higgs”, 15-21 June 2015, Bürgerhaus Seepark (2000 Visitors)





HiggsTools

Page Messages Notifications Insights Publishing Tools



**HiggsTools**  
Science Website

Create Call to Action Liked Message

Timeline About Photos Likes More

**HiggsTools**  
Published by Raquel Gmez [?] · 6 August ·

Hi all! Last week, some of us attended the HiggsHunting conference in Paris, which is one of the main conferences in our field. Among very good interventions, we had a very special historical talk given by the nobel laureate Martinus Veltman.

We will provide you a link to his talk as soon as it is available!

**HiggsTools**  
Published by YouTube [?] · 25 August ·

This is very nice short-movie about the Large Hadron Collider and the hunt for new physics. You can see beautiful images of CERN, LHC, both ATLAS and CMS detectors, and more ..  
Part of the sound track is made by the very talented Jolijn Goethals .



**The Large Hadron Collider Returns in the Hunt for New Physics**

The world's larger particle collider is back in action and colliding particles at greater energies than ever before. We visit the scientists hoping that the ...


YOUTUBE.COM

145 people reached

Boost Post

**HiggsTools via Women in Research**  
Published by Raquel Gmez [?] · 19 August ·

"Women driving the Large Hadron Collider forward - Part 2" by DiscovHer  
Did you know that among CERN's staff members only 2% of research physicists are women? #DiscovHER unveils a day in the life of Claire Antel, a Heidelberg PhD student in experimental particle physics working at the ATLAS Experiment.



**Women driving the Large Hadron Collider forward - Part 2**

DISCOV-HER.COM

Boost Post



# Research



# State of the Art

- ✓ During Run 1, the LHC discovered a resonance which is a candidate for the Higgs boson of the Standard Model (SM).
  - Nobel Prize in 2013 for Higgs and Englert
  - The spin-0 nature of the resonance is well established
  - There is no direct evidence for New Physics
  - The couplings of the resonance show compatibility with the Higgs boson of the SM.
- ✓ Main work
  - final analysis of data from Run 1
  - preparations for Run 2 (started June 2015)







**The Nobel Prize in Physics 2013 was awarded jointly to  
François Englert and Peter W. Higgs**

*for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider*

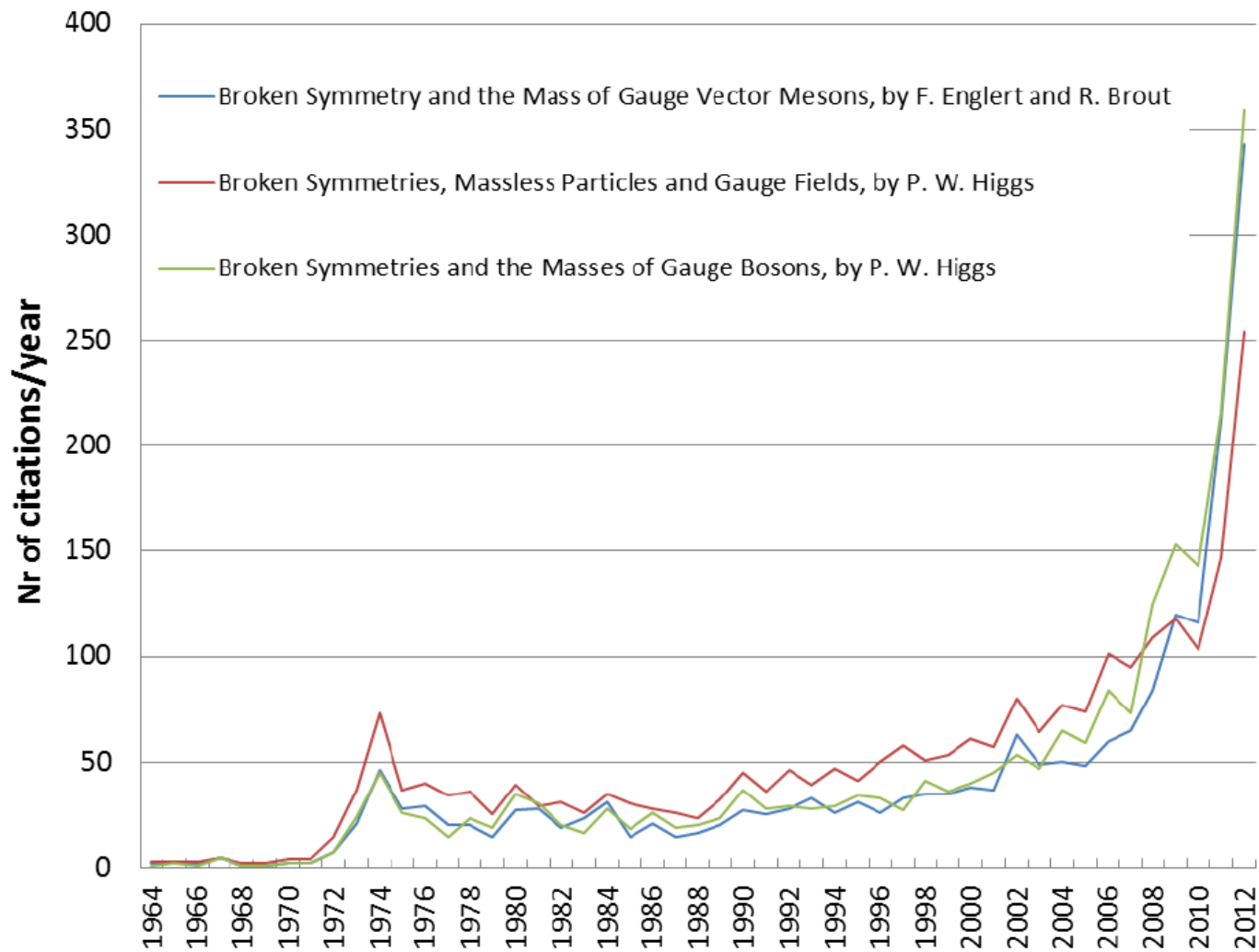


**higgstools**



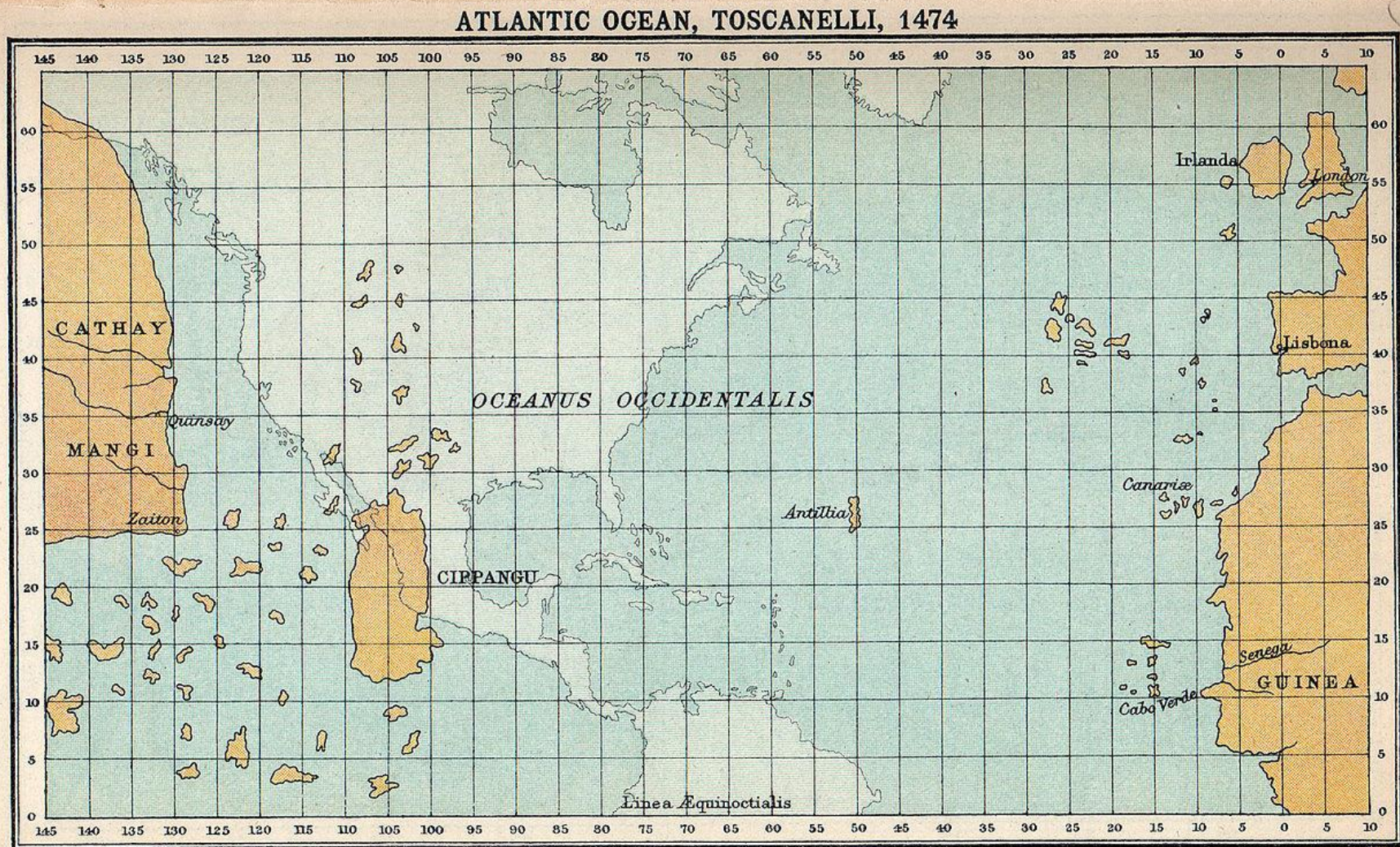


## Citation history of the papers behind the Nobel prize





# Is the story over?

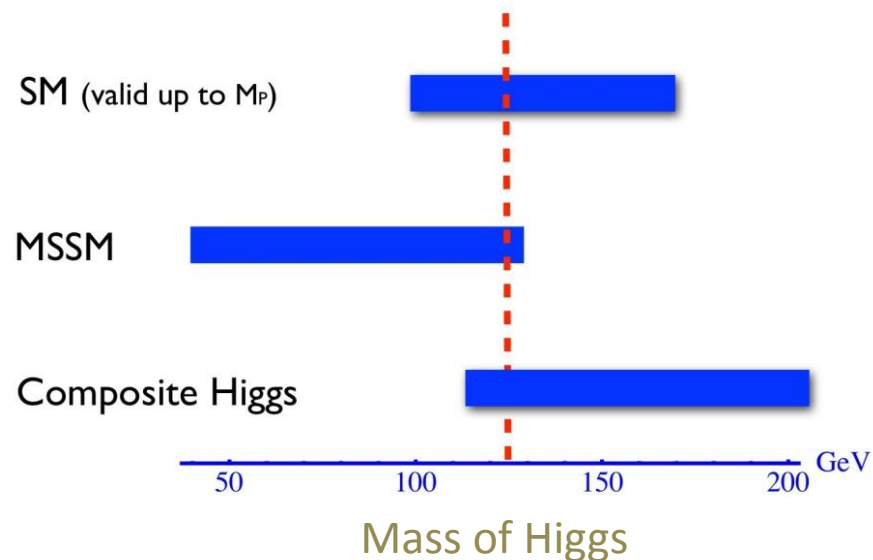
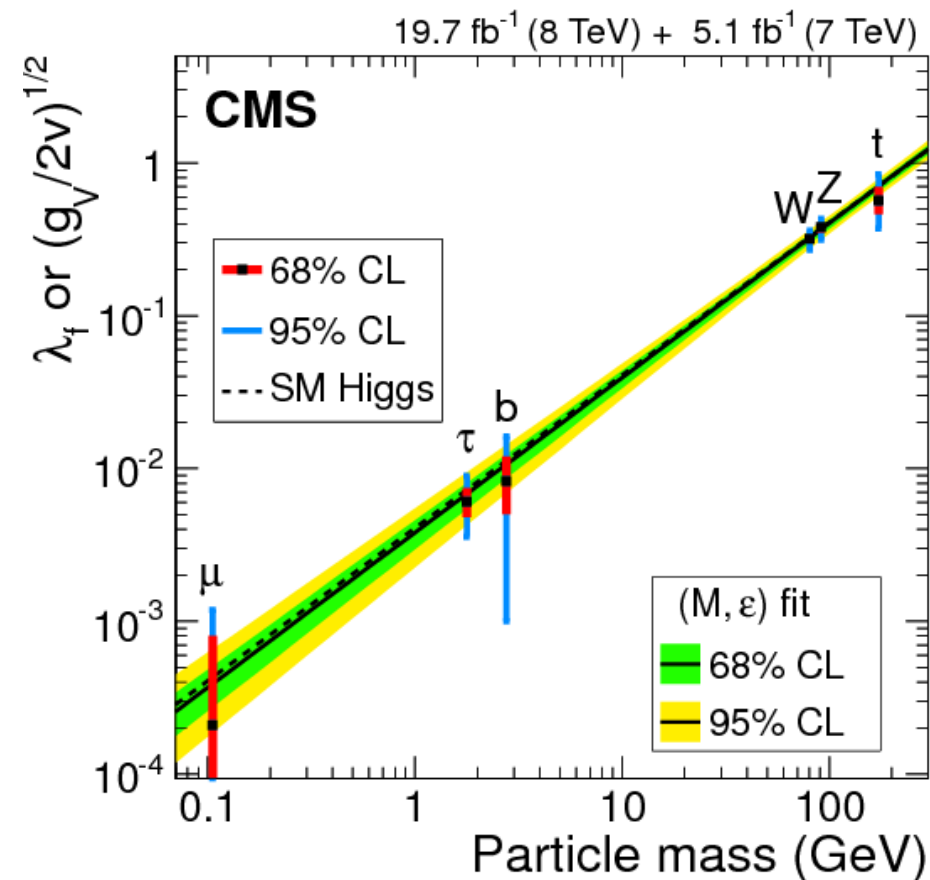


The Correct outline of North America is shown in light blue tint

John Bartholomew & Co., Edin.



# Many models have one or more 'Higgs'-like states



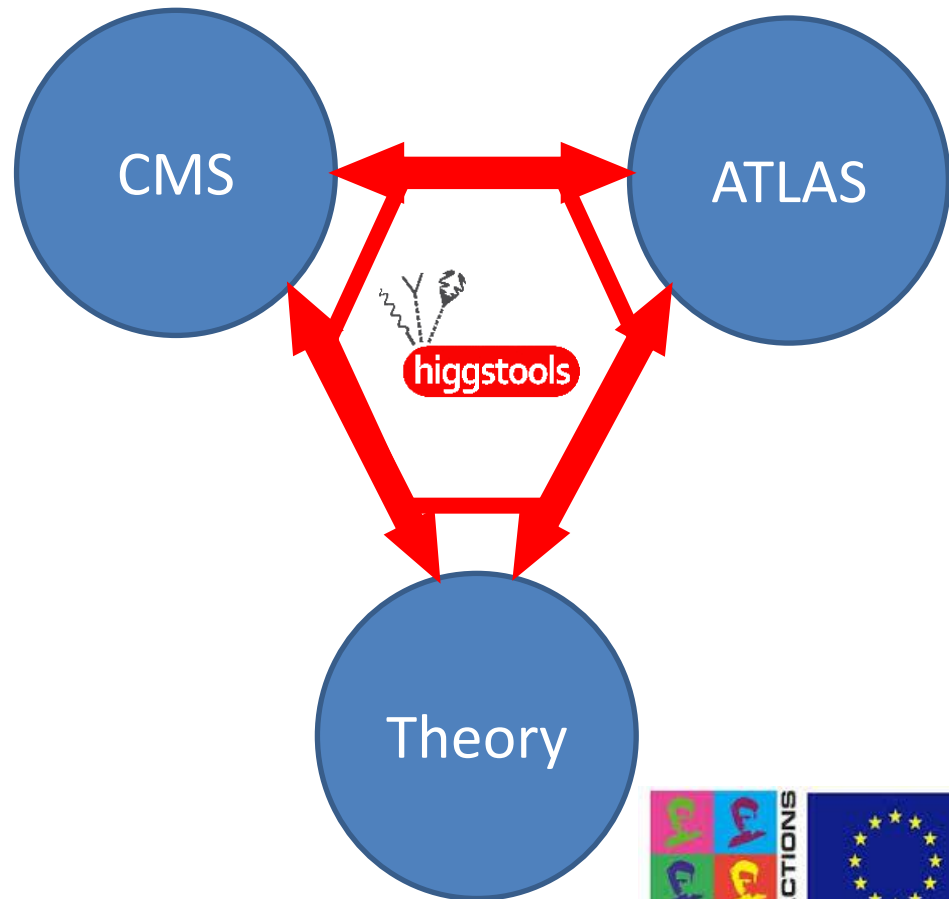
Looks promising, but other popular models such as supersymmetry (MSSM) or composite models where the higgs is made from other particles are not ruled out





# Work Packages

- ✓ **WP1: Interpretation of Data**
- ✓ **WP2: Predictions and simulations of signal and background**
- ✓ **WP3: Tools**





# WP1: Interpretation of Data

WP1 is centred on the interpretation of experimental results, compatibility with the SM, constraints on physics beyond the SM and the discrimination of different models

**WP leaders: Chiara Mariotti (DFTTO), Georg Weiglein (DESY)**

- ✓ **Task 1.1:** Extraction of model-independent results from data
- ✓ **Task 1.2:** Measurement of Higgs properties
- ✓ **Task 1.3:** Interpretation of experimental results in different models
- ✓ **Task 1.4:** Future European strategy for particle physics



# WP2: Predictions and simulations of signal and background

WP2 concentrates on the development of high-precision predictions for Higgs physics, including signal, background and their interference

**WP leaders: Jon Butterworth (UCL), Gudrun Heinrich (MPI)**

- ✓ **Task 2.1:** Improved predictions for Standard Model-like Higgs scenarios
- ✓ **Task 2.2:** Improved predictions for non-standard electroweak symmetry breaking scenarios
- ✓ **Task 2.3:** Backgrounds



# WP3: Tools

WP3 is dedicated to the development of tools relevant for Higgs phenomenology, specifically Monte Carlo tools and their automation and sets of parton distribution functions valid at NNLO.

**WP leaders: Frank Krauss (UDUR),  
Elzbieta Richter-Was(IFJ-PAN)**

- ✓ **Task 3.1:** Improved analysis tools
- ✓ **Task 3.2:** Development and automatization of general next-to-leading order tools
- ✓ **Task 3.3:** PDFs and PDF uncertainties



# WP1: Interpretation of Data

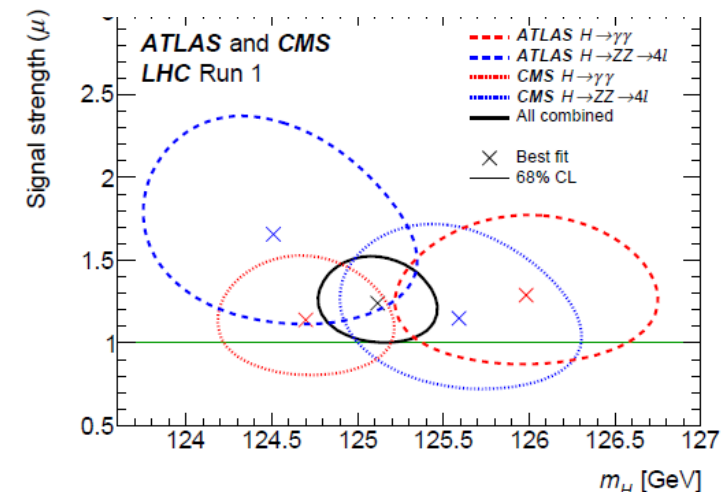
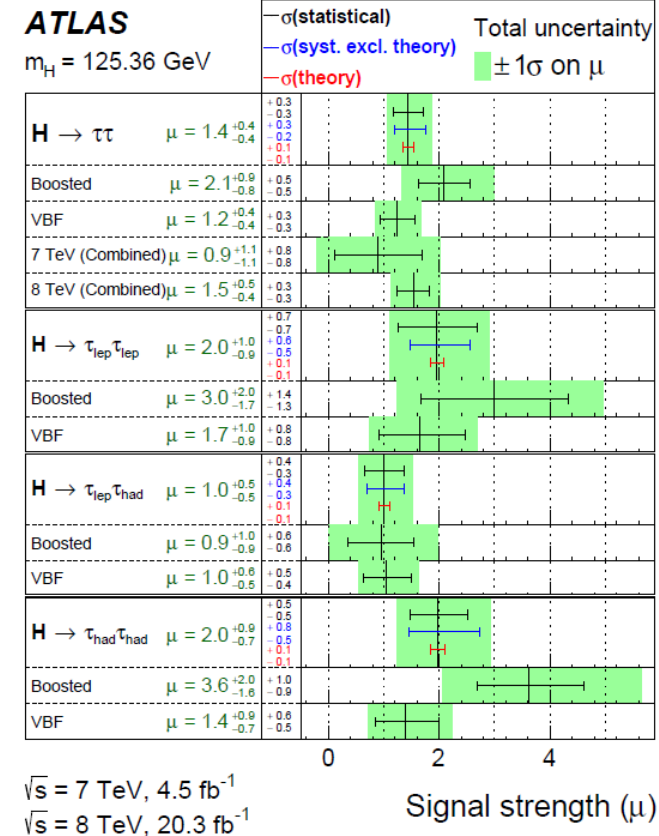
Task	Milestone		Papers
1.1	1.1.1	Extraction of model-independent results for cross sections times branching ratios in different Higgs search channels	12
	1.1.2	Extraction of model-independent results on the $V V \rightarrow V V$ cross section	1
	1.1.3	Extending the mass range and coupling range in different Higgs boson search channels	3
1.2	1.2.1	Extraction of constraints on Higgs couplings from fits to all available data; discussion of model dependence	5
	1.2.2	Extraction of information on Higgs spin and CP properties	1
1.3	1.3.1	Constraints on physics beyond the SM, distinction between different models	20
1.4	1.4.1	Review of the current state and future directions in Higgs boson physics	4



# WP1 Highlights

## 40 papers including

- ✓ more precise determinations of the couplings to standard model
- ✓ searches for the H to bb decay in ZH associated production
- ✓ constraints on the Higgs boson width, the spin-parity of the Higgs boson and anomalous HVV couplings
- ✓ ATLAS H to tau tau
- ✓ CMS ttH
- ✓ ATLAS and CMS combination
- ✓ Plus contributions from ESRs
  - Nicolas Gutierrez
  - Agnieszka Ilnicka
  - Raquel Gomez-Ambrosio





# WP2: Predictions and simulations of signal and background

Task	Milestone		Papers
2.1	2.1.1	Specialised codes for the SM-like Higgs boson scenario	10
	2.1.2	Better control of theoretical uncertainties for the SM-like Higgs boson scenario	13
2.2	2.2.1	Precision calculations for vector boson scattering	1
	2.2.2	Precision calculations of non-standard Higgs boson scenarios	
	2.2.3	Standardised description for non-standard Higgs boson interactions	12
	2.2.4	Interpretation of experimental data in the light of M2.2.3	3
2.3	2.3.1	Validation of key Higgs background processes and evaluation of uncertainties derived from extrapolating them to signal regions	3
	2.3.2	Better control of theoretical uncertainties	14
	2.3.3	Specialised codes for low multiplicity background processes	17



# WP2 Highlights

## 47 papers including

- ✓ Higgs production cross section via gluon fusion at N3LO
- ✓ top-quark pair production cross sections at approximate N3LO
- ✓ fully differential NNLO predictions for associated ZH production, Z+jet and Higgs+jet production
- ✓ NLO corrections to the H to Zgamma decay
- ✓ NLO predictions for the production of the Higgs boson plus multiple jets
- ✓ NLO predictions merged with a parton shower for tt + multijet and triple vector boson production
- ✓ first steps towards the automation of the NLO electroweak
- ✓ Improved resummation prescriptions and next-to-soft corrections
- ✓ predictions for the mass in the MRSSM
- ✓ data driven constraints on the parameter space of the NUHM2 model
- ✓ Higgs pair production in the NMSSM
- ✓ improved search strategies for the non-standard Higgs bosons.
- ✓ Plus contributions from ESR
  - Hjalte Frellesvig





# WP3: Tools

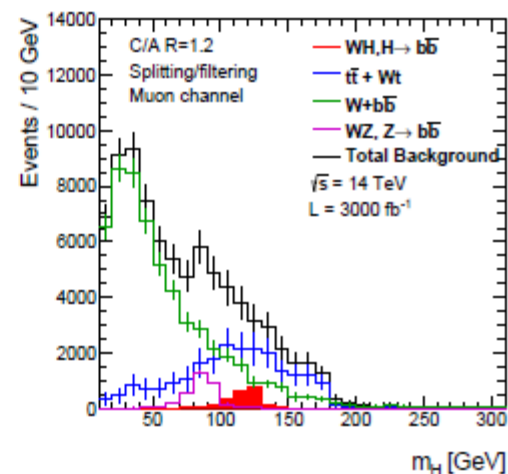
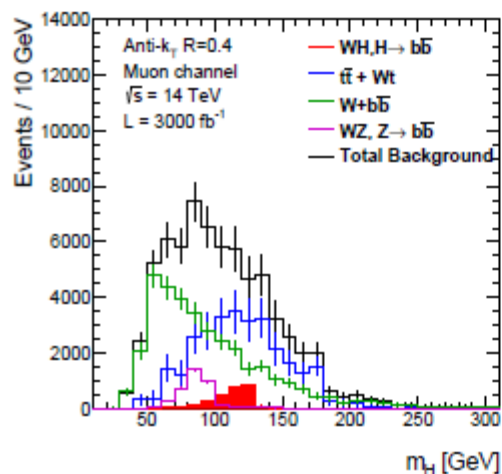
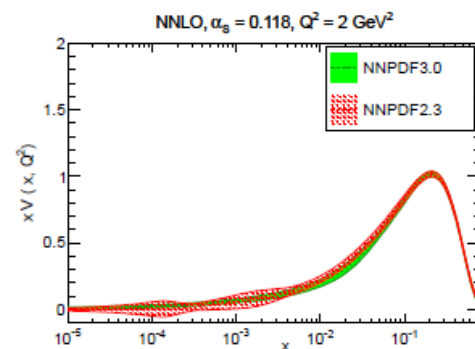
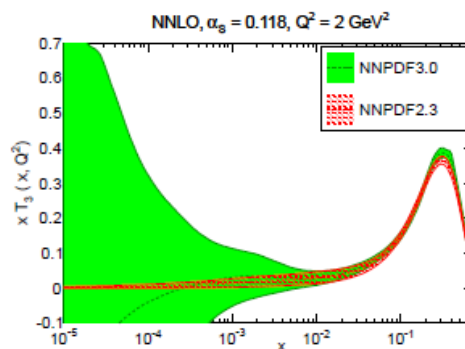
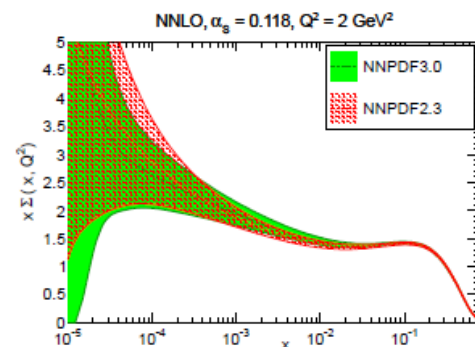
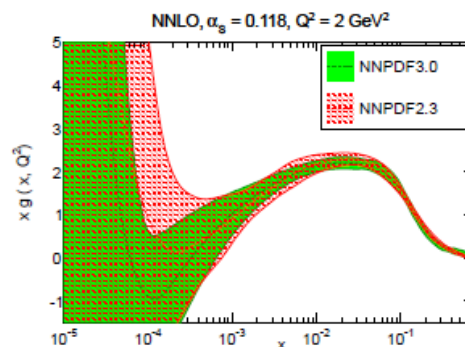
Task	Milestone		Papers
3.1	3.1.1	Tools for boosted objects & fat jets	1
	3.1.2	Fast simulation and reconstruction tools for the LHC	3
	3.1.3	Matrix element techniques for Higgs signals	
3.2	3.2.1	Automation of NLO calculations	3
	3.2.2	Automated matching of NLO codes to the parton shower	3
3.3	3.3.1	Improved parton shower with heavy initial states	
	3.3.2	Methods for PDF uncertainties in shower Monte Carlos	
	3.3.3	Improved PDFs using LHC data	7
	3.3.4	Consistent PDF fits at NNLO	19



# WP3 Highlights

## 28 papers including

- ✓ Development of a novel four-dimensional renormalization and regularization procedure (2-loop H decay)
- ✓ progress in automating NLO QCD and NLO electroweak corrections
- ✓ NNPDF3.0 parton distribution functions methodology now validated by closure test
- ✓ calculation of multi-loop diagrams, including massive 3-loop graphs, iterated binomial sums and their associated iterated integrals
- ✓ Study of HV production with H to bb decay in boosted Higgs events
- ✓ Plus contributions from ESRs
  - Stephen Jones
  - Davide Napoletano
  - Zahari Kassabov





# Interactions within Higgstools

- ✓ ATLAS involves 6 FP, 3 AP + CERN
- ✓ CMS involves 4 FP, 1 AP + CERN
- ✓ Theory involves all the FP and AP

Large well established collaborations  
High degree of cooperation

Increasing theory collaboration from 2014 to 2015

2014

	ALU-FR	CNRS	DESY	DFTTO	ETH	FOM	IFJ-PAN	NCSR-D	UGR
UDUR			42	14	8, 13, 40, 44, 61				42
ALU-FR									
CNRS									
DESY									10, 42, 55, 59, 65
DFTTO						53			
ETH									
FOM									
IFJ-PAN									
NCSR-D									

2015

	ALU-FR	CNRS	DESY	DFTTO	ETH	FOM	IFJ-PAN	NCSR-D	UGR
UDUR	46		34	49	39				
ALU-FR		13	13, 23				13		13, 23
CNRS			13				13		13
DESY						33	13		13, 19, 23, 36, 44
DFTTO					45				
ETH						22	25, 50		37
FOM									
IFJ-PAN									13
NCSR-D									



No.	Deliverable	Due	Comment
1	Scientific Publications	throughout	67 publications delivered in 2014 61 publications delivered in 2015
2	Annual Network Meetings	3, 15, 27, 39, 45	First meeting held in month 3, Second meeting held in month 16, Third meeting planned for month 28
3	Proceedings of final network conference	48	
4	Summer Schools	18, 30, 42	First School held in month 18, Second School planned for month 32
5	Young Researchers Meetings	12, 21, 33, 45	First meeting held in month 14, Second meeting planned for month 22
6	Outreach	throughout	
7	First Annual Report	12	First Progress Report month 17
8	Mid Term Report	21	Mid Term Report month 21
9	First Periodic Report	24	
10	3rd Annual Report	36	
11	Final Report	48	