## Mid Term Review

### Michele Boggia

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  - Lectures and conferences
  - The Singlet Higgs Model
  - Automation

## Present status





## 2003-2008

### High School Degree @ Liceo Scientifico Statale "G.Peano", Cuneo





Michele Boggia

# 2008-2011

### Bachelor of Science in Physics @ Universita' degli studi di Torino



Thesis title: Quantum information and computation



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Mid Term Review

2011-2014

### Master's Degree in Physics @ Universita' degli studi di Torino



Thesis: Singlet Extension of the Standard Model Supervisor: G. Passarino



Michele Boggia

# Summer 2012

### SLAC Summer Student @ SLAC National Accelerator Laboratory





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## The Project

# HT Project ESR5 Affiliation Albert-Ludwigs-Universität Freiburg Supervisors S. Dittmaier, M. Schumacher



# The Project

M2.2.1

Precision calculations for Vector Boson Scattering (VBS)



### Important process!

- Vector Boson Fusion (VBF), very important Higgs production channel, is included in VBS
- $3.6 \sigma$  evidence for  $W^{\pm}W^{\pm}jj$  EW production at 8 TeV [ATLAS Collaboration '14]
- promising channel for Runs 2 and 3
- sensitive to unitarization from Higgs sector (more on this later)



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# Recap of the last year Lectures and conferences

#### Attended courses

- Modern techniques of QCD (Priv. Doz. Dr. Christian Schwinn)
- Supersymmetry (Prof. Dr. Stefan Dittmaier)



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### Participation to conferences

- HiggsTools meetings:
  - First Young Researchers Meeting
  - First Annual Meeting (talk)
  - Annual School 2015
- Research Training Group 2044 Fall Workshop 2015 (poster)







### Recap of the last year The Singlet Higgs Model

SU(2) doublet  $\Phi$  + singlet  $\sigma$ 

the most general (renormalizable) scalar Lagrangian is

$$\mathcal{L}_{Higgs} = \mathcal{L}_{Higgs}^{SM} + \partial_{\mu}\sigma\partial^{\mu}\sigma - \eta_{12}\sigma\Phi^{\dagger}\Phi - \lambda_{12}\sigma^{2}\Phi^{\dagger}\Phi \\ -\xi_{1}\sigma + \mu_{1}^{2}\sigma^{2} - \eta_{1}\sigma^{3} - \lambda_{1}\sigma^{4}$$



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# Recap of the last year Automation

FeynRules Feynman rules generation [A. Alloul et al. '14] FeynArts diagram generation [T. Hahn '01] FormCalc algebraic simplification [T. Hahn, M. Perez-Victoria '99] LoopTools numerical evaluation [T. Hahn, M. Perez-Victoria '98]



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Cross sections for the scattering processes of weak gauge bosons:





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[A. Alboteanu, W. Kilian, J Reuter '08]







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- in the SM, the Higgs exchange unitarizes the cross sections
- differences may occur if the Higgs sector is not minimal
- contribution from the singlet can be evaluated
- inclusion of quantum corrections is required
- non-trivial because of the high number of external legs



Intermediate step: 1 loop corrections (EW + QCD) with the singlet to



- ... one of the most important Higgs decay modes @ LHC
  - matrix elements can be generated with the implemented model files (FeynArts)
  - four-body phase-space integration can be safely performed using the Monte Carlo generator Prophecy4F

[A.Bredenstein, A.Denner, S.Dittmaier, M.M.Weber '06-'07]



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### Future developments The Project

## $h \to WW \to 4f$

- SM limit check WRT Prophecy4f
- consistency checks for results in the Higgs Singlet Model (UV and IR finiteness)
- eventually, compare with an independent calculation
- $pp \rightarrow WW \rightarrow 4f + jj$ 
  - role of an additional Higgs boson in the unitarization

 $\rightarrow$  Constraints on the parameter space of the model



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### Future developments My Career

April-June 2016 Internship at Wolfram Research









May 2016 End of the current contract







May 2016 End of the current contract











May 2016 End of the current contract





2017 academic secondments at DFTTO and UDUR











2017 academic secondments at DFTTO and UDUR



2018 completion of thesis and award of PhD



Thank you for your attention

