

# ESR-Projects in the Southern German Node Freiburg, MPI Munich, Würzburg



Albert-Ludwigs-Universität Freiburg

Markus Schumacher

HiggsTools Kick Off Meeting  
UCL London, 2-4 April 2014



UNI  
FREIBURG



# ESR5

# General



UNI  
FREIBURG

**Host:** University of Freiburg

**Period:** October 2014 – September 2017

**Junior ESR** (PhD Position in Theoretical Physics )

First 20 month funded by HiggsTools, last 16 month by DFG/BMBF

**Work Package 2 Prediction and simulations of signal and background**

Task 2.1: Improved predictions for Standard Model-like Higgs scenarios

Task 2.3: Backgrounds

**Supervisor:** Stefan Dittmaier (Co-supervisor: Markus Schumacher)

**Secondments:** Torino, Durham

*The candidate will work on precision calculations for vector-boson scattering at the LHC in the channels of  $WW + 2$  jets production including QCD and electroweak corrections. Optimisation of analysis strategy: event selection, choice of observables.*



# ESR5

# Why?



UNI  
FREIBURG

- ◆ LHC running at 13 TeV starting in 2015 will produce many di-boson pairs allowing to study in detail vector-boson scattering and the structure of the quartic gauge-boson interaction
- ◆ W pairs, in particular with same sign leptons, are well suited to investigate vector-boson scattering in the SM and beyond
- ◆ Full exploration of the physics potential and interpretation of the LHC data require a precise prediction of the number of expected events and their kinematic distributions including QCD and electroweak corrections
- ◆ Optimisation of the experimental analysis strategy and the choice of sensitive observables require the implementation of the calculations in a MC event generator



# ESR5

# What?



UNI  
FREIBURG

QCD + electroweak NLO calculations for vector-boson scattering

- ◆ Techniques based on experience in similar calculations, e.g. for Higgs production and decay processes, or  $W$ -pair production
- ◆ Development of NLO MC tool for experimental studies, similar to MCs PROHECY4f and HAWK
- ◆ Development of optimised event selection at parton level
- ◆ Investigation of sensitivity of various observables in the measurement of quartic gauge couplings
- ◆ Implementation of calculations in the SHERPA event generator

## **Expected collaboration via secondments**

for event generation and modelling of jet distributions

- UDUR (F. Krauss) for implementation into SHERPA
- DFTTO (G. Passarino) for investigation of NLO effects on pseudo-observables



ESR6

General



UNI  
FREIBURG

**Host:** University of Freiburg

**Period:** October 2014 – September 2017

**Junior ESR** (PhD Position in Experimental Physics)

First 20 month funded by HiggsTools, last 16 month by DFG/BMBF

### **Work Package 1 Interpretation of Data**

Task 1.1: Extraction of model-independent results from data

**Supervisor:** Karl Jakobs (Co-supervisor: Stefan Dittmaier)

**Secondments:** Durham

*The candidate will work on development of an optimal analysis strategy for investigation of vector-boson scattering and measurement of cross sections and extraction of quartic gauge couplings and comparison to theoretical predictions in the Standard Model and its extensions.*



- ◆ LHC running at 13 TeV starting in 2015 will produce many di-boson pairs allowing to study in detail vector-boson scattering and the structure of the quartic gauge-boson interaction
- ◆ Vector-boson fusion (VBF), in particular, is well suited to investigate the structure of the Higgs-boson couplings to weak gauge bosons and the CP nature of the Higgs boson
- ◆ Interpretation of the experimental findings require a precise knowledge of the selection and acceptance efficiencies and their uncertainties for different coupling structures in the final states with different jet multiplicity / for different event categories

Based on previous investigations and measurement with ATLAS data of  $H \rightarrow WW$  decay in gluon fusion and VBF, di-boson production of WW

- ◆ optimise selection and analysis strategy for successive measurements of WW production, WW + 2 jet production and vector-boson scattering with ATLAS data collected at 13/14 TeV
- ◆ compare various (N)LO calculations and MC event generators in particular SHERPA w/ and w/o anomalous quartic gauge-boson couplings
- ◆ optimize algorithms for forward jet tagging and application of jet vetos w.r.t. experimental and theoretical uncertainties

### **Expected collaboration via secondments**

for event generation and modelling of jet distributions

- UDUR (F. Krauss) for validation of SHERPA and estimation of theoretical systematic uncertainties



# ESR7

# General



UNI  
FREIBURG

**Host:** University of Freiburg

**Period:** October 2014 – September 2017

**Junior ESR** (PhD Position in Experimental Physics) )

First 20 month funded by HiggsTools, last 16 month by DFG/BMBF

## **Work Package 1: Interpretation of Data**

Task 1.1: Extraction of model-independent results from data

Task 1.2: Measurement of Higgs properties

**Supervisor:** Markus Schumacher (Co-supervisor: Karl Jakobs)

**Secondments:** Durham (UDR), FOM-Louvain

*The candidate will work on the development of tools/prescriptions to estimate uncertainties for Higgs-boson selection efficiencies in several topologies in particular for vector-boson fusion and the application of this to the investigation of Higgs-boson couplings in ATLAS data.*



- ◆ LHC running at 13 TeV starting in 2015 will produce many Higgs bosons allowing to study the tensor structure of Higgs-boson couplings to other particles in an effective field theory approach
- ◆ Vector-boson fusion (VBF) in particular is well suited to investigate the structure of the Higgs boson couplings to weak gauge bosons and the CP nature of the Higgs boson
- ◆ Interpretation of the experimental findings require a precise knowledge of the selection and acceptance efficiencies and their uncertainties for different coupling structures in final states with different jet multiplicities / for different event categories



# ESR5

# What?



UNI  
FREIBURG

Based on previous LO studies of the coupling structure via VBF and contributions to LHC Higgs cross section working group

- ◆ compare predictions for jet multiplicities and jet kinematic distributions for SM coupling structure and anomalous coupling structure in various MC event generators
- ◆ develop recipe to derive central prediction and associated uncertainties
- ◆ validate algorithm with data, e.g., for Z + jets
- ◆ optimise analysis of ATLAS data: definition of event categories, choice of robust and sensitive observables to investigate coupling structure

### **Expected collaboration via secondments**

for event generation and modelling of jet distributions

- UDUR (F. Krauss) for validation of SHERPA
- FOM-Louvain (F. Maltoni) for validation of aMC@NLO/MADGRAPH