

Another collaboration:

The SHIFt project

(Solving the Higgs Finetuning problem with Top partners)

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*Knut och Alice
Wallenbergs
Stiftelse*



CHALMERS
UNIVERSITY OF TECHNOLOGY



UPPSALA
UNIVERSITET



**Stockholms
universitet**

The problem

$$V = -\mu^2 \Phi^\dagger \Phi + \lambda (\Phi^\dagger \Phi)^2$$



What is this?

There's a mass scale μ^2 in the Higgs sector, it's the only mass in the SM, and moreover

$$\mu^2 \ll m_{\text{Pl}}^2$$

Why is $-\mu^2 < 0$?

- Because then EW symmetry is broken

Why is EW symmetry broken?

- Because $-\mu^2 < 0$.

Higgs finetuning problem?

- You can buy the hierarchy problem, or not
- But regardless, there is a question of what μ^2 is and where it comes from
- It's the only super-renormalizable / relevant operator in the SM (and it's small)
- The Higgs is so far the only scalar in the theory



- Is there a dynamical explanation for EWSB?
- What role does the top have, with its large coupling to the Higgs, and are there top partners?

Approaches with top partners

- **Composite Higgs**
Higgses are pseudo-Nambu-Goldstone bosons
Vectorlike quarks as top partners
- **SUSY**
Stops as top partners

The project has three "tracks":



The SHIFT Project

- Collaboration between theorists and experimentalists at Swedish universities:
 - Chalmers University of Technology, Gothenburg
 - Stockholm University
 - Uppsala University
- Grant from Knut & Alice Wallenberg Foundation (KAW) (major private foundation in Sweden)
- 35 MSEK (3.3 M euro). PI is Sara Strandberg (Stockholm)
 - Use to fund postdocs and PhD students and partial salaries for senior staff + travel, invite collaborators

The SHIFT Collaboration

Faculty:

- Elin Bergeaas Kuutmann Uppsala (ATLAS)
- Rikard Enberg Uppsala (theory)
- Gabriele Ferretti Chalmers (theory)
- David Milstead Stockholm (ATLAS)
- Jörgen Sjölin Stockholm (ATLAS)
- Sara Strandberg Stockholm (ATLAS; PI)

Postdocs:

- Laura Barranco Navarro Stockholm (ATLAS)
- Diogo Buarque Franzosi Chalmers (theory)
- Venugopal Ellajosyula Uppsala (ATLAS)
- Alex Kastanas Stockholm (ATLAS)
- Luca Panizzi Uppsala (theory)

Plus **5 PhD students** and a bunch of **master students**

Associated theory collaborators (including some RISE people)

Rachid Benbrik (Cadi Ayyad, Marrakesh)

Yao-Bei Liu (Heinan IST & Southampton)

Tanumoy Mandal (New Delhi → Uppsala)

Stefano Moretti (Southampton)

... (your name here?)

Organization and Objectives

- So far, no signs of SUSY or compositeness at the LHC; Minimal models with light top partners constrained
- Main objective of the SHIFT project:
Widen searches for BSM physics with top partners
- Three different complementary tracks:
 - Direct searches for scalar top squarks in SUSY
 - Direct searches for vectorlike top quarks in compositeness
 - Indirect searches for top partners not kinematically accessible at LHC energies.
- Strengthen collaboration between experimental and theoretical particle physicists in Sweden

Compositeness/Vectorlike Quarks

- Current ATLAS and CMS searches have focused on VLQ \rightarrow SM particles.
- Look at VLQ \rightarrow BSM scalars.
- Model building: which models are viable?
- Which models are detectable at the LHC?
- ATLAS searches for the most promising models

[My talk on Friday is about VLQ \rightarrow BSM]

SUSY

- RPC SUSY: Stop searches in single-lepton final state
- RPV SUSY: Searches for long-lived particles in DV+jets and DV+MET final states
(*DV=displaced vertices*)
- Non-minimal SUSY models
- Review stop coverage in RPV SUSY and let that steer future searches
- Look further into new RPC models e.g. GMSB-type models with massive LSPs and (extended) NMSSM models

Indirect / EFT

- Analysis of the $ttW(j)$ process in same-sign final state
- Construct optimal observables for indirect searches for top partners.
- Quantify the sensitivity of the optimal observables to top-partner models.
- Consistent MVA fitting framework for EFT operators
- Include more final states such that the complete top EFT basis is covered.

Future

Since **NonMinimalHiggs** ends soon, it's good to find new possibilities for networks/grants ...

KAW grants is one possibility, but can only pay people working in Sweden

However, ample travel money is possible

We will also as part of the project organize a 3-week workshop at **NORDITA** in Stockholm in 2020:

Is Nature Natural?

(Dates will be announced soon)



NORDITA

The Nordic Institute for Theoretical Physics