HELMHOLTZ

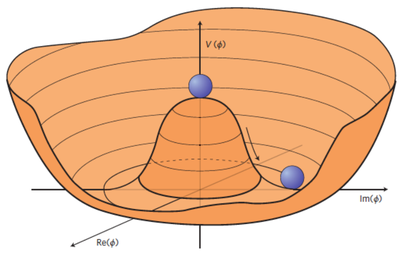
MATTER AND THE UNIVERSE MU

Topic: FPF

Probing the shape of the Higgs potential with the trilinear Higgs coupling and di-Higgs production

Johannes Braathen (DESY Theory)

Understanding the form of the Higgs potential



A realistic view of the Higgs potential in a Beyond-the-Standard-Model theory (here with 2 scalar states, as an example)

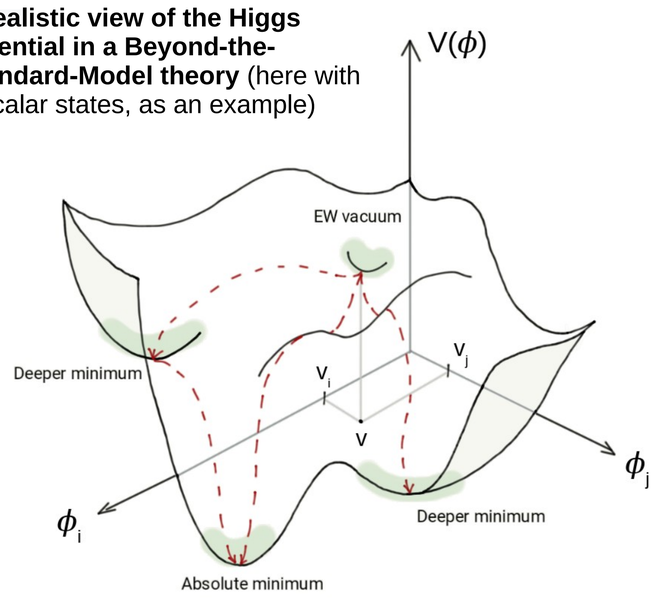


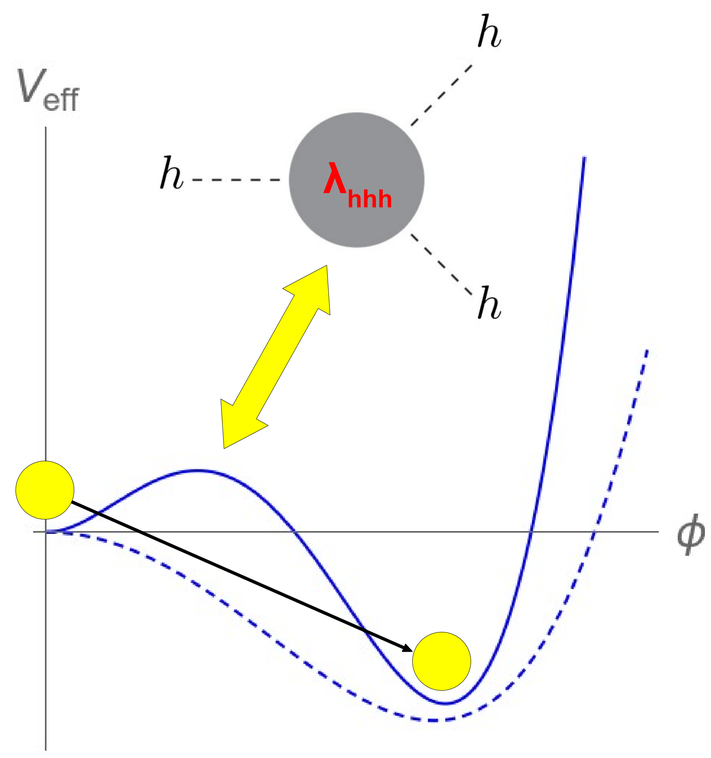
Figure by [K. Radchenko Serdula '24]

Trilinear Higgs coupling λ_{hhh}
crucial to understand the shape of the Higgs potential and the dynamics of the Electroweak Phase Transition

In general:

$$V^{(0)} = \frac{1}{2}m_h^2 h^2 + \frac{1}{3!}\overbrace{\kappa_\lambda \left(\frac{3m_h^2}{v}\right)}^{\equiv\lambda_{hhh}} h^3 + \frac{1}{4!}\kappa_{\lambda_4}\left(\frac{3m_h^2}{v^2}\right)h^4 + \cdots$$

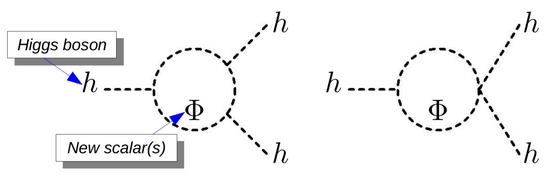
with $\kappa_\lambda \equiv \lambda_{hhh}/(\lambda_{hhh}^{(0)})^{\rm SM}$



Strong First-Order Electroweak Phase Transition, *needed to explain matter-antimatter asymmetry of Universe (via Electroweak Baryogenesis), typically requires a* ***large deviation of λ_{hhh} from SM***

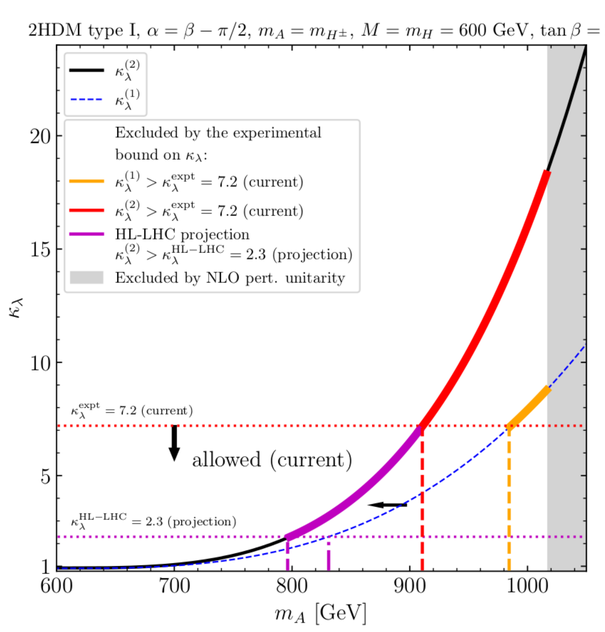
Constraining New Physics with the trilinear Higgs coupling λ_{hhh}

Large effects from New Physics possible in λ_{hhh} due to radiative corrections from extra scalars,
e.g. at leading order (one loop)

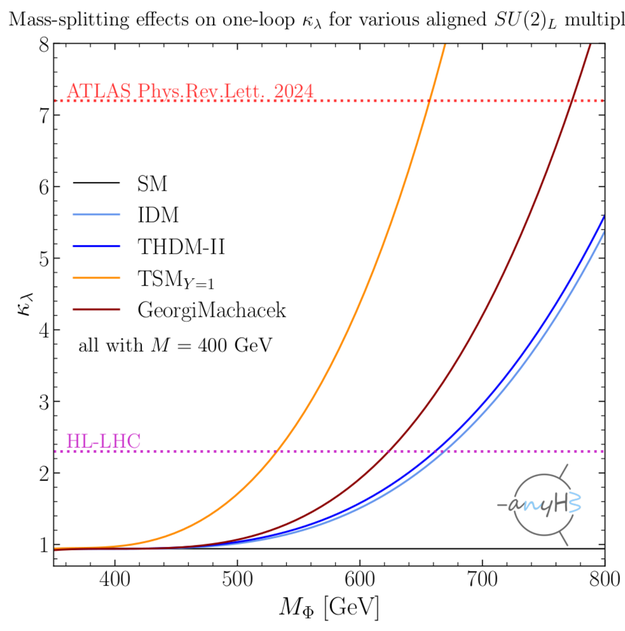


$$g_{hh\Phi\Phi} = -\frac{2(M^2 - m_\Phi^2)}{v^2}$$

m_Φ : *Physical mass of BSM state*
M : *BSM mass scale of the model*

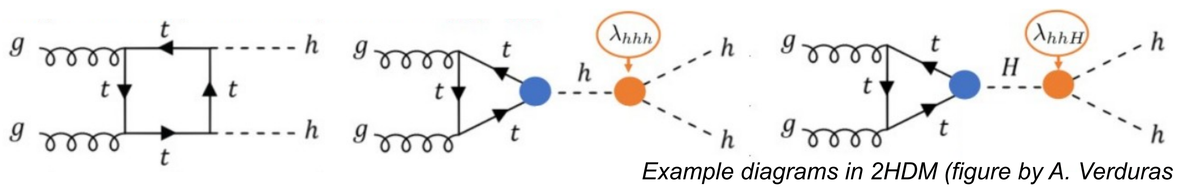


[Bahl, JB, Weiglein **Phys.Rev.Lett** '22]
(and [JB, Kanemura '19])



[Bahl, JB, Gabelmann, Weiglein '23]

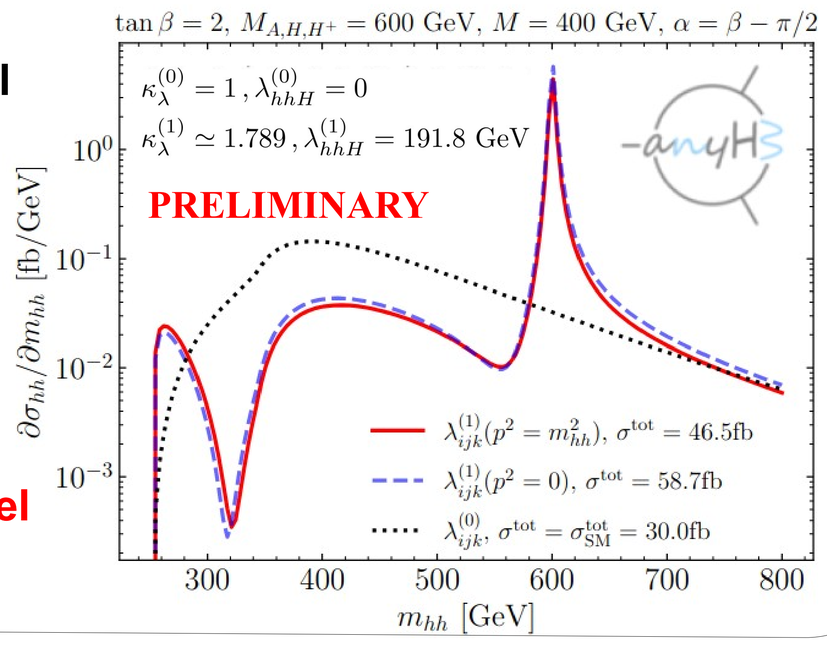
Calculating di-Higgs production at (HL-)LHC



Example diagrams in 2HDM (figure by A. Verduras Schaeidt)

anyHH: Total and differential cross-sections for gg→hh
including
- **1L corrections to λ_{ijk}**
(computed with `anyH3`)
and
- **BSM contributions in s-channel**
in **any renormalisable model**

[Bahl, JB, Gabelmann, Radchenko Serdula, Weiglein *WIP*]



About me

Junior staff member in the DESY Theory group and Emmy Noether research group leader

- *2015-2018*: Ph.D, LPTHE, Sorbonne University, Paris
- *2018-2020*: JSPS Postdoctoral Fellow, Osaka University
- *2020-2023*: DESY Fellow, DESY Hamburg
- *2023-*: Emmy Noether group leader, DESY Hamburg

Emmy Noether-Programm DFG Deutsche Forschungsgemeinschaft

-anyH3

DESY.