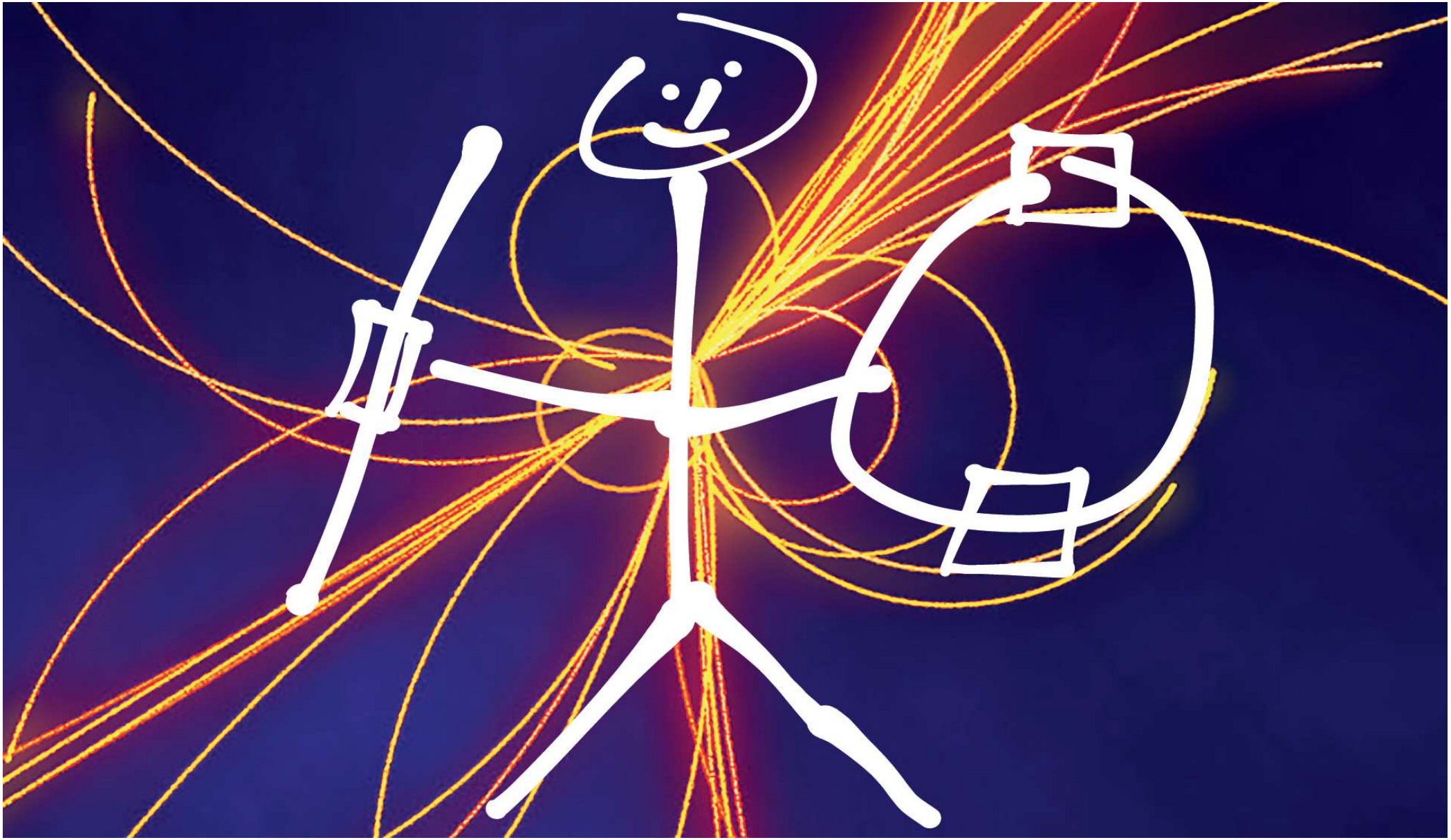


Summary of Physics

Sven Heinemeyer, IFT (CSIC, Madrid)

KEK/Tsukuba, 11/2026

Summary of Physics

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Big words . . .

Summary of Physics

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Big words . . .

What is "Physics"?

Summary of Physics

Sven Heinemeyer, IFT (CSIC, Madrid)

KEK/Tsukuba, 11/2026

Big words . . .

What is "Physics"?

Physics = experimental/phenomenological analyses
$\oplus$ theory predictions

Why is "Physics" important?

LCWS26: 37/36 plenary talks/parallel sessions - 2/11 on "physics"

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Physics: that's it what it is (in the end) all about!

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This is why we want

- a new e^+e^- experiment
- with higher energy
- with higher luminosity
- with polarized beams (if possible)
- with high-resolution/precision detectors
- ... $\Rightarrow$ motivational talks by Roman and Hitoshi on Monday

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Erkennen, was die Welt im Innersten zusammenhält.

[*J. W. v. Goethe, 1808*]

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$\Rightarrow$ despite the fact that the collider and the detectors are in the focus,
11/36 constitutes an indispensable minimum

Parallel sessions on:

- top, flavor, QCD
- Higgs/EW
- BSM physics
- Global analyses

Parallel sessions on:

- top, flavor, QCD I: CPV, entanglement
- Higgs/EW
- BSM physics
- Global analyses

	Probing CP violation in (e^+e^- \to t\bar tH) at a 550 GeV Linear Collider with Machine-learned Observable *Yuyang Zhang* *Bld.3-1F-Seminar hall, KEK* 14:30 - 15:00
15:00	**Disentangling new physics with quantum entanglement in top-pair production at future lepton colliders** *Prof. Kentarou Mawatari*
	Experimental prospects for quantum decoherence measurements at colliders *Guillermo Garcia Mir* *Bld.3-1F-Seminar hall, KEK* 15:30 - 16:00

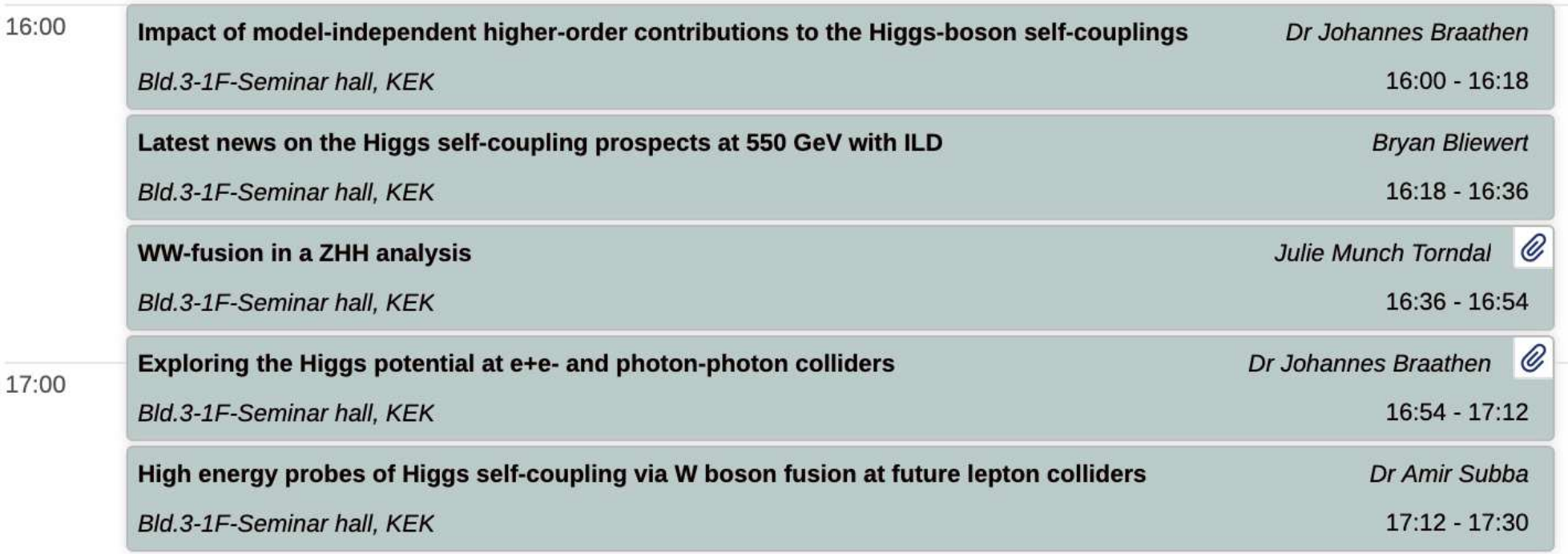
Parallel sessions on:

- top, flavor, QCD II: HNL, toponium
- Higgs/EW
- BSM physics
- Global analyses

11:00	**Heavy Neutral Leptons at Beam Dump Experiments of Future Lepton Colliders**	*Douglas Tuckler*
	Bld.2-1F-Big meeting room, KEK	11:00 - 11:30
	Top quark rare processes at future linear colliders	*Dr Adil Jueid*
	Bld.2-1F-Big meeting room, KEK	11:30 - 12:00
12:00	**Toponium at the ILC revisited**	*Yajuan Zheng*
	Bld.2-1F-Big meeting room, KEK	12:00 - 12:30

Parallel sessions on:

- top, flavor, QCD
- Higgs/EW I: triple Higgs couplings (THC), Higgs potential
- BSM physics
- Global analyses



Parallel sessions on:

- top, flavor, QCD
- Higgs/EW II: THCs, Higgs decays
- BSM physics
- Global analyses

11:00	**Precision Higgs Physics and Higgs Self-Coupling Measurements at the XFEL Compton Collider**	*Umar Qureshi*	
	Bld.3-1F-Seminar hall, KEK	11:00 - 11:18	
	Study of the H to bs search at the ILC	*Kanako Watanabe*	
	Bld.3-1F-Seminar hall, KEK	11:18 - 11:36	
	Probing Extended Higgs Sectors through Zh Production	*Juhi Dutta*	
	Bld.3-1F-Seminar hall, KEK	11:36 - 11:54	
12:00	**One-loop corrections to the discovered Higgs boson decays in the real Higgs triplet model**	*Kodai Sakurai*	
	Bld.3-1F-Seminar hall, KEK	11:54 - 12:12	
	Evaluation of the measurement accuracy of Higgs boson coupling constants via $e^+e^- \to ZH(jj)$ processes at the Int...		
	Takumi Seino		

Parallel sessions on:

- top, flavor, QCD
- Higgs/EW III: $H \to$ inv., MC
- BSM physics
- Global analyses

16:00	**Event Reconstruction and Higgs-to-Invisible Analysis with ILD Detector Models for FCC-ee** *Bld.3-1F-Seminar hall, KEK*	*Victor Schwan* 16:00 - 16:18
	Higgs Precision Calculations and New Developments toward Version 4 *Bld.3-1F-Seminar hall, KEK*	*Kei Yagyu* 16:18 - 16:36
	The Whizard Monte Carlo generator *Bld.3-1F-Seminar hall, KEK*	*Wolfgang Kilian* 16:36 - 16:54
17:00	**Quark Electroweak Couplings at Future e+e- Colliders** *Bld.3-1F-Seminar hall, KEK*	*Krzysztof Mekala* 16:54 - 17:12
	The bottom quark mass at high scale *Bld.3-1F-Seminar hall, KEK*	*Juan Ramírez Alfaro* 17:12 - 17:30

Parallel sessions on:

- top, flavor, QCD
- Higgs/EW
- BSM physics I: DM, BSM Higgs, LZ event
- Global analyses

Dark Matter Searches as Probes of Reheating at Future Linear Colliders — *Abhik Sarkar*
Bld.3-1F-Meeting room, KEK 16:30 - 16:45

17:00

Decay-mode independent searches for new light scalars at future Higgs factories — *Maria Teresa Nunez Pardo De Vera*
Bld.3-1F-Meeting room, KEK 16:48 - 17:03

Searches for light exotic scalars in the $S\rightarrow b\bar{b}$ decay channel at future Higgs factories
Bartłomiej Brudnowski

Prospects for light exotic scalar measurements in di-tau decay channel at future Higgs factories
Aleksander Filip Zarnecki

A DM candidate indicated at Fermi-LAT and LZ ? Connection with LHC and LC perspectives — *Francois Richard*
Bld.3-1F-Meeting room, KEK 17:42 - 17:57

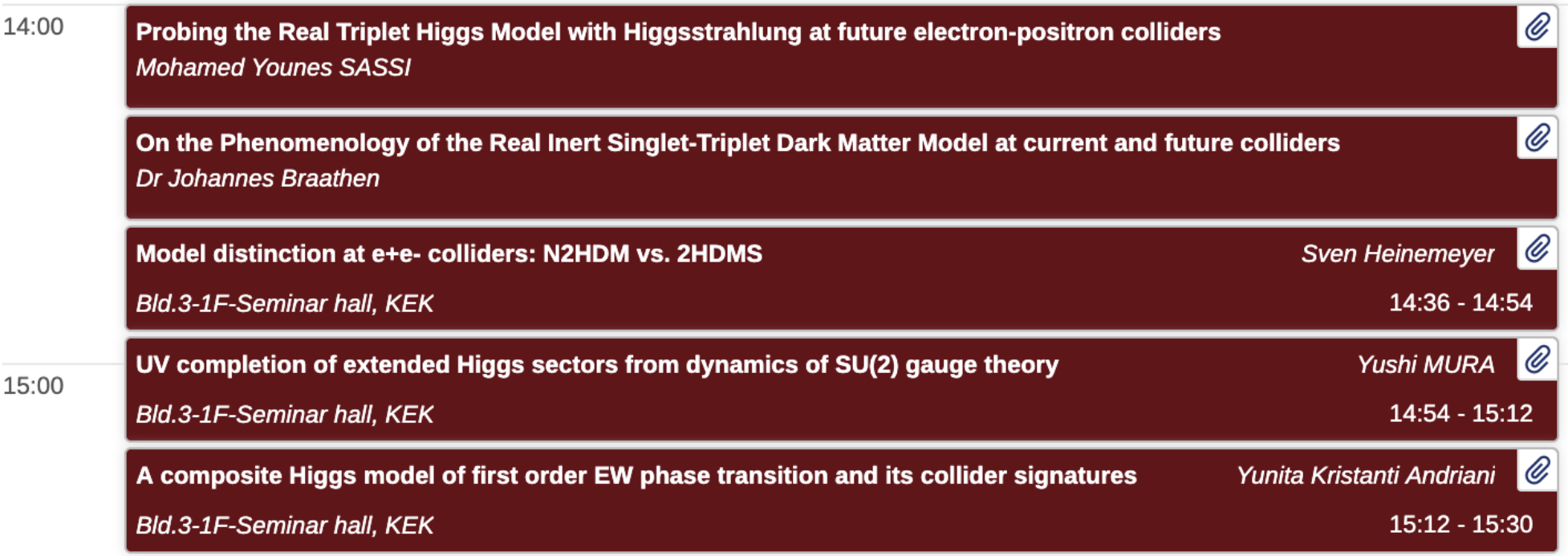
Parallel sessions on:

- top, flavor, QCD
- Higgs/EW
- BSM physics II: DM, CPV Higgs sectors, EWPT
- Global analyses

11:00	**Shedding light on Dark Matter Using Extended Higgs Sectors**	*Juhi Dutta*	
	Bld.3-1F-Meeting room, KEK	11:00 - 11:15	
	Dark Matter Determination at future e+e- Colliders	*Gudrid Moortgat-Pick*	
	Bld.3-1F-Meeting room, KEK	11:20 - 11:35	
	CP-violation in the complex 2HDM	*Jayita Lahiri*	
	Bld.3-1F-Meeting room, KEK	11:40 - 11:55	
12:00	**Phase Transitions in the THDMS**	*Juhi Dutta*	
	Bld.3-1F-Meeting room, KEK	12:00 - 12:15	

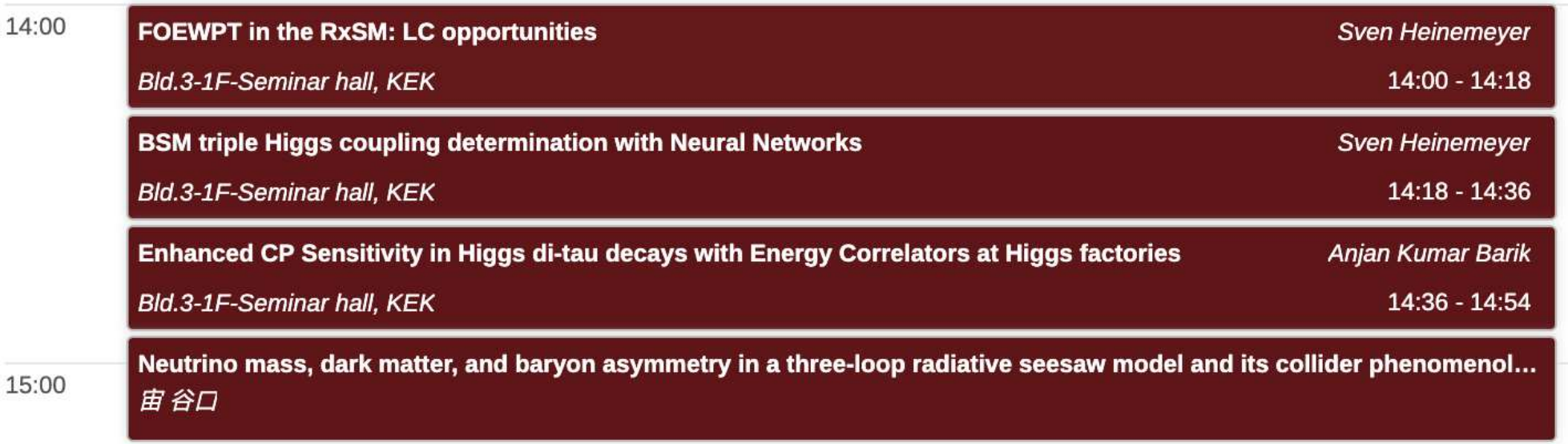
Parallel sessions on:

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- BSM physics I: Extended Higgs sectors, EWPT
- Global analyses



Parallel sessions on:

- top, flavor, QCD
- Higgs/EW
- BSM physics II: EWPT, BSM THCs with NN, CPV Higgs
- Global analyses



Parallel sessions on:

- top, flavor, QCD
- Higgs/EW
- BSM physics
- Global analyses: Polarimetry, THCs, SMEFT, recoil mass

	ILC, FCC-ee Precision Polarimetry with Difermion and Vector Boson Event Fits	*Brendon Madison*
	Bld.3-1F-Seminar hall, KEK	16:30 - 16:48
	Assessing uncertainties in the determination of the trilinear Higgs self-coupling from single-Higgs observables	
17:00	*Murillo Rebuzzi Ardións Vellasco*	
	Probing SMEFT Effects in VBS Vh Production at TeV-Scale Lepton Colliders	*Hiroyuki Furusato*
	Bld.3-1F-Seminar hall, KEK	17:06 - 17:24
	Triple Gauge Couplings: Using Optimal Observables at the Detector Level	*Leonhard Reichenbach*
	Bld.3-1F-Seminar hall, KEK	17:24 - 17:42
	Recoil Mass -- Version 2	*Junping Tian*
	Bld.3-1F-Seminar hall, KEK	17:42 - 18:00

Often two (or even three) sessions in parallel

$\Rightarrow$ split of (my) wave function

timetable shown just to give an impression of the richness of the program

$\Rightarrow$ obviously not possible and not sensible to give an overview

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$\Rightarrow$ results for $\sqrt{s} \gtrsim 500$ GeV not (or hardly) shown
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$\Rightarrow$ to give you a flavor, I picked 1-2 presentations from each session to highlight the relevance of $\sqrt{s} \gtrsim 500$ GeV

Top, flavor, QCD:

Probing CP violation in $e^+e^- \to t\bar{t}H$ at a 550 GeV LC with machine learned observables

talk by: Yuyang Zhang

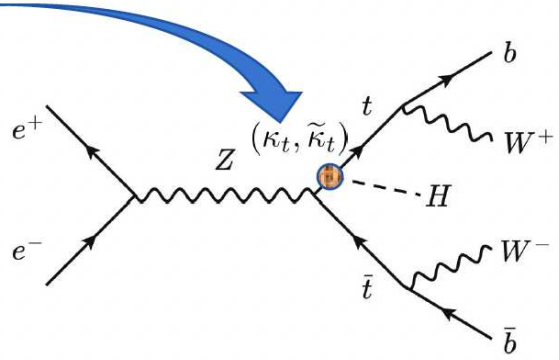
The main idea:

Parameterisation of the top-Higgs Yukawa coupling with CPV source

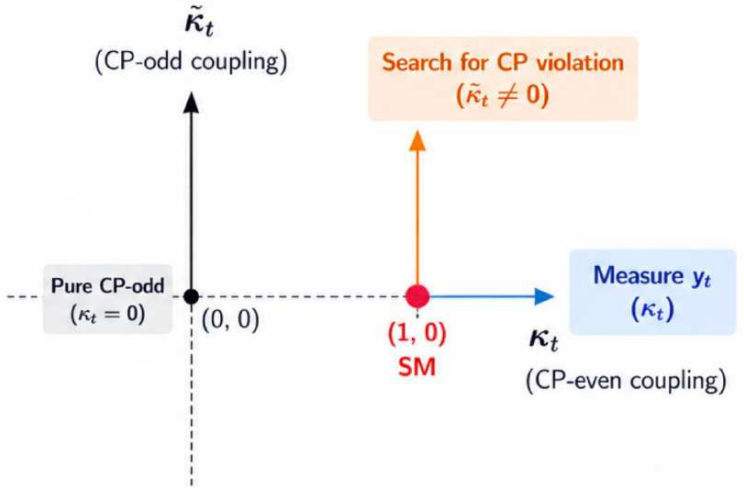
scalar coupling

$$\mathcal{L}_{t\bar{t}H} = -\frac{m_t}{v} H\,\bar{t}\,(\kappa_t + i\tilde{\kappa}_t\gamma_5)\,t$$

pseudoscalar coupling



The $(\kappa_t, \tilde{\kappa}_t)$ plane

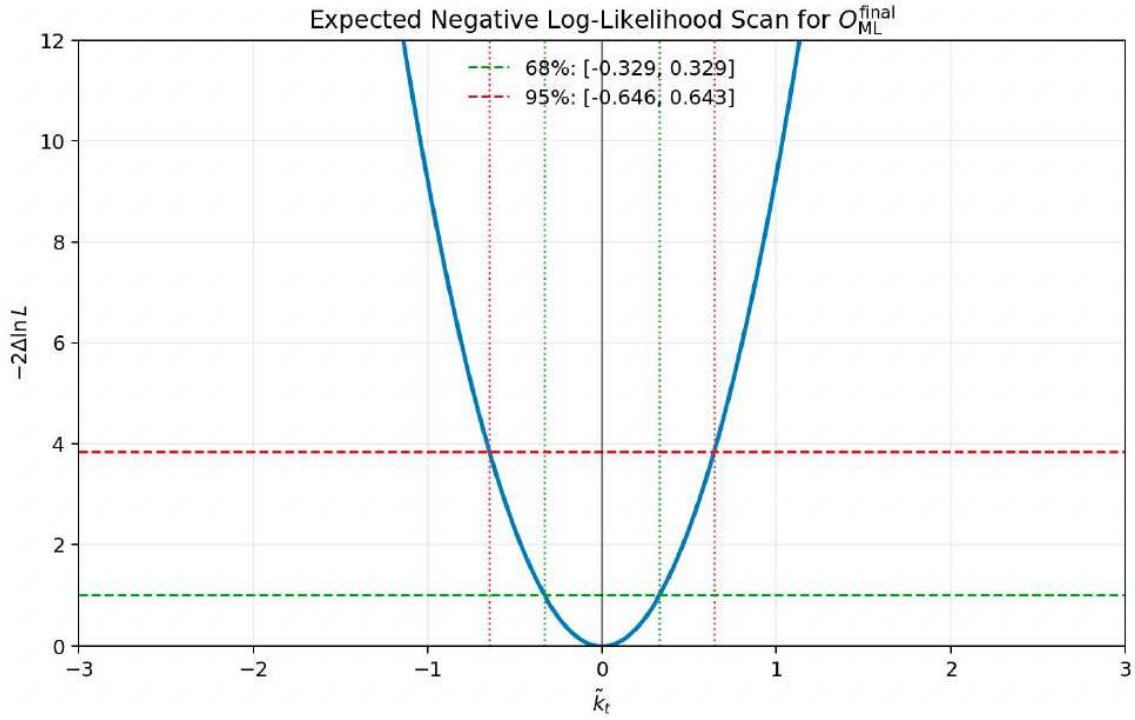


Top, flavor, QCD:

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The results:



Translate to other paramters

$$\mathcal{L}_{t\bar{t}H} = -\frac{m_t}{v} H\,\bar{t}\,(\kappa_t + i\widetilde{\kappa}_t\gamma_5)\,t$$

- CP-mixing angle $\kappa_t = \kappa\cos\alpha = 1, \widetilde{\kappa}_t = \kappa\sin\alpha$

  α≤ 0.10π at 68%, α≤0.18π at 95%,

- SMEFT $\kappa\cos\alpha = 1 - \frac{v^3}{\sqrt{2}\,m_t}\frac{C_{t\varphi}}{\Lambda^2}, \quad \kappa\sin\alpha = -\frac{v^3}{\sqrt{2}\,m_t}\frac{C^I_{t\varphi}}{\Lambda^2}.$

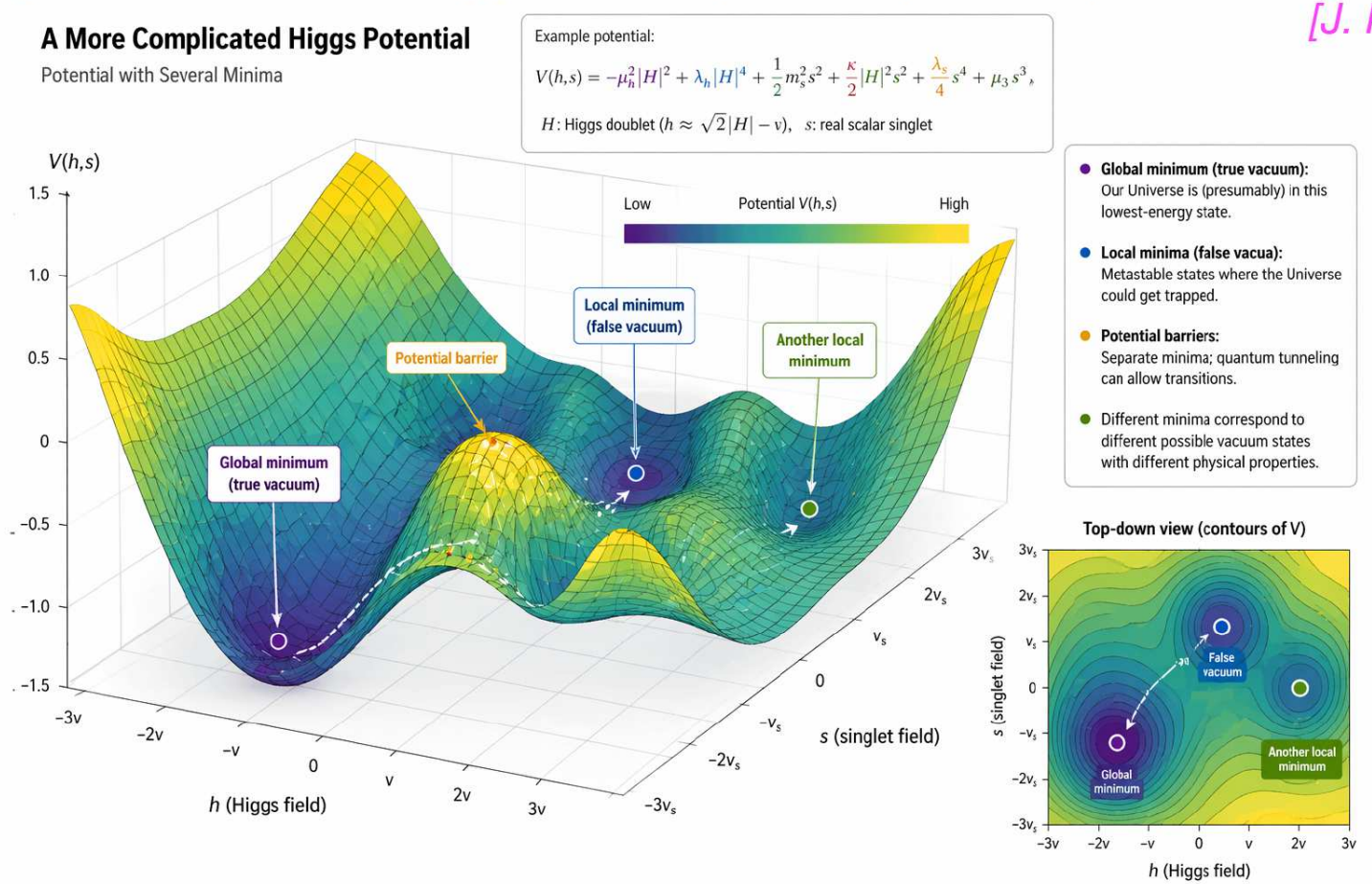
  $\left|\frac{C^I_{t\phi}}{\Lambda^2}\right| \le 5.39\ \text{TeV}^{-2}$ at 68% $\left|\frac{C^I_{t\phi}}{\Lambda^2}\right| \le 10.64\ \text{TeV}^{-2}$ at 95%

Higgs/EW:

Exploring the Higgs potential at e^+e^- and $\gamma\gamma$ colliders
talk by: Johannes Braathen, Georg Weiglein

Example of extended Higgs sector (artist's AI view):

[J. Reuter '26]



Shape can drastically differ from single field case, rich structure of minima, requirement of vacuum stability yields important constraints

Higgs/EW:

Exploring the Higgs potential at e^+e^- and $\gamma\gamma$ colliders

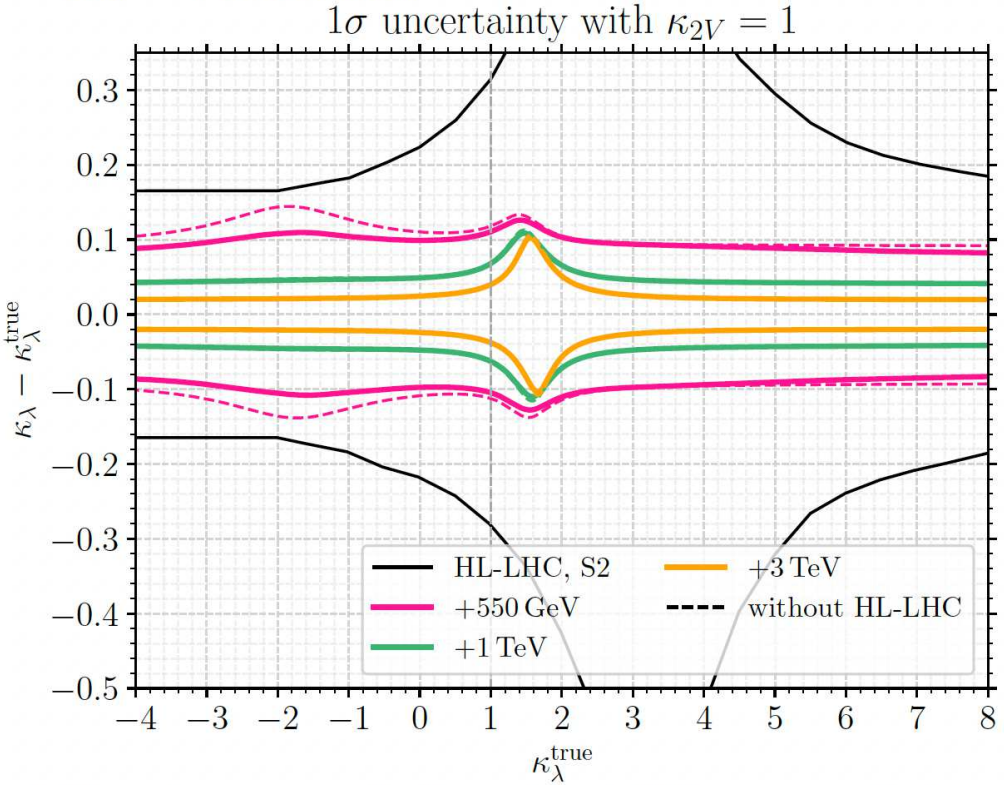
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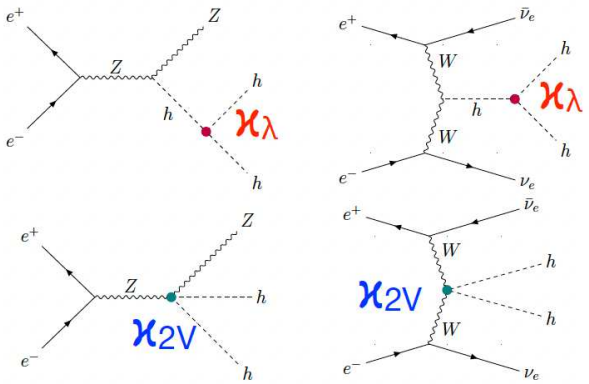
e⁺e⁻ Linear Collider (LC) with 550 GeV (or higher)

[F. Arco, G. W. '26]

Here and for results above:

$\kappa_{2V} = 1$ assumed





⇒ Good prospects for e⁺e⁻ LC for $\kappa_{2V} = 1$, large improvement over HL-LHC, input from HL-LHC plays minor role for LC results

18

Higgs/EW:

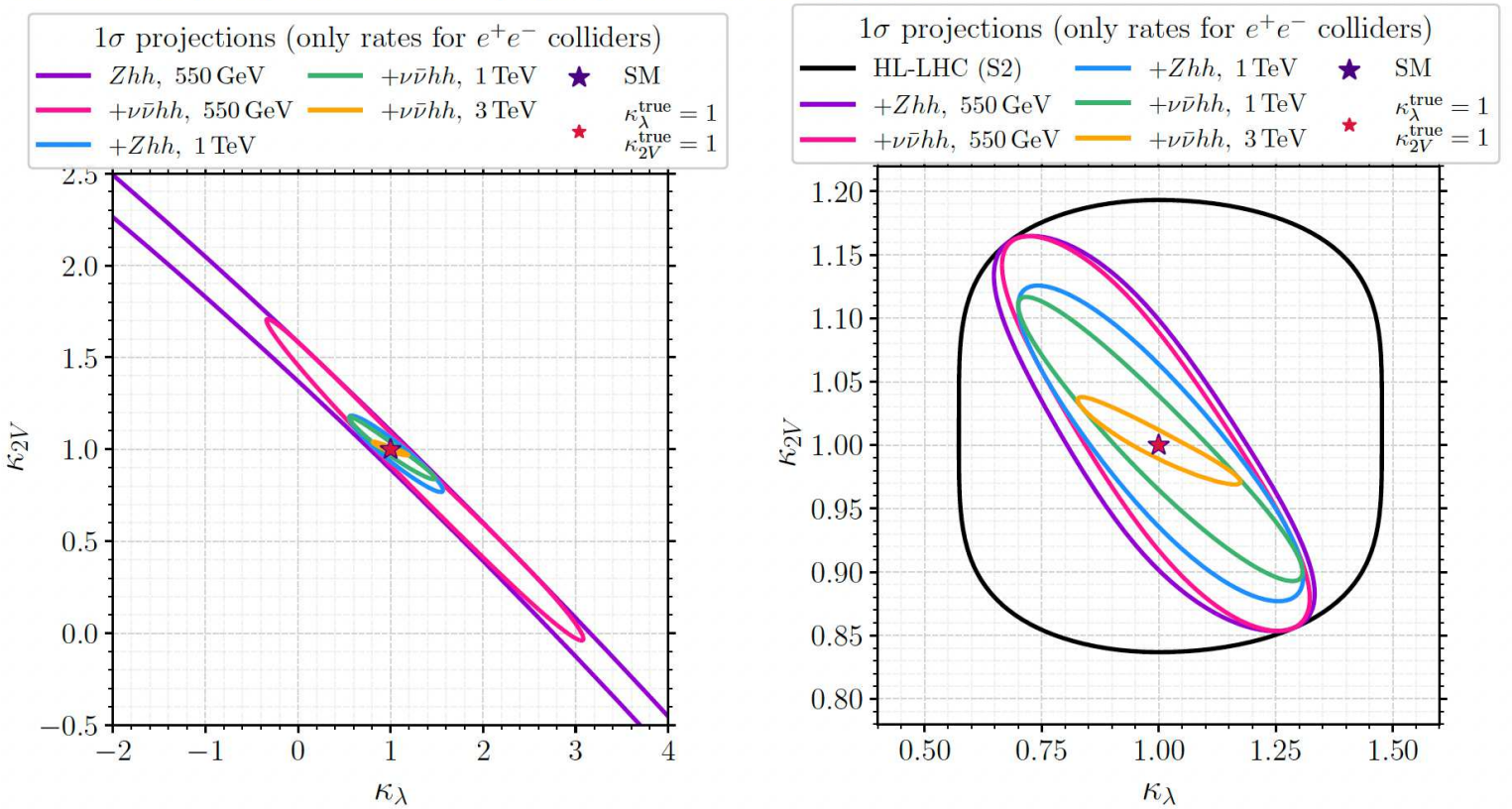
Exploring the Higgs potential at e^+e^- and $\gamma\gamma$ colliders

talk by: Johannes Braathen, Georg Weiglein

e⁺e⁻ LC: impact of varying κ_{2V}

Without (left) and with (right) HL-LHC input:

[F. Arco, G. W. '26]



⇒ Accuracy on κ_λ significantly reduced, HL-LHC input is crucial for LC550 results (here: ``pessimistic" HL-LHC projection, see below)

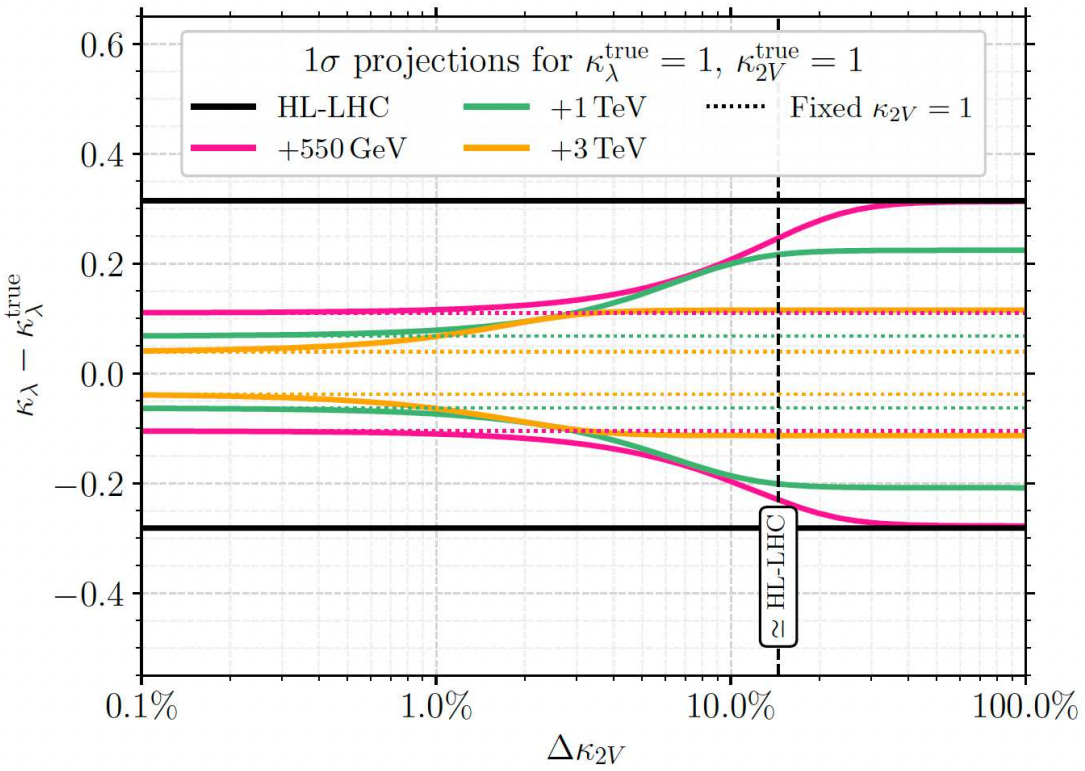
19

Higgs/EW:

Exploring the Higgs potential at e^+e^- and $\gamma\gamma$ colliders

talk by: Johannes Braathen, Georg Weiglein

e⁺e⁻ LC: accuracy for κ_λ depending on HL-LHC input for κ_{2V}



[F. Arco, G. W. '26]

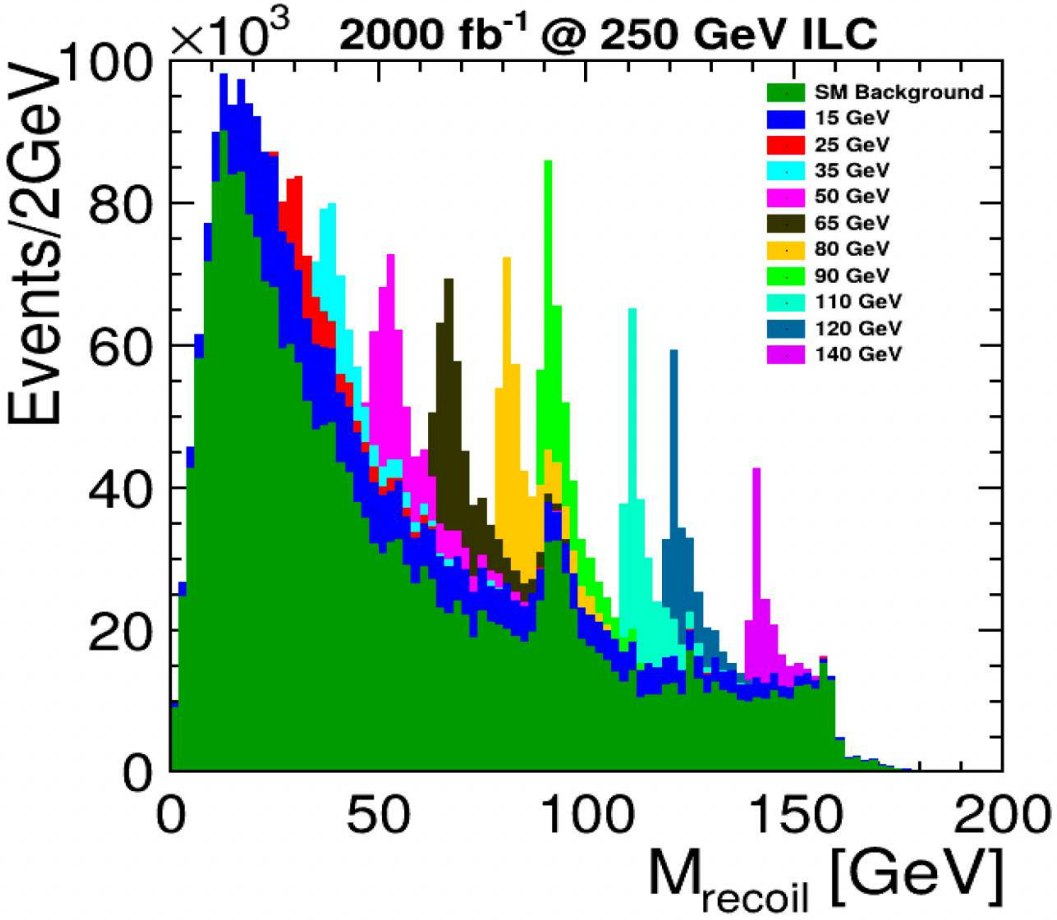
⇒ Improvement in accuracy on κ_{2V} (e.g. factor 2-3) w.r.t. (pessimistic) HL-LHC projection (based on only one channel, does not include latest analysis improvements) will significantly improve LC determination of κ_{λ}

BSM:

Decay-mode independent searches for new light scalars at future Higgs Factories

talk by: Maria Teresa Nuñez Pardo De Vera

The old results:



$e^+e^- \rightarrow ZS^0 \rightarrow \mu^+\mu^- S^0$

Before cuts on the MVA output

$$M^2_{rec} = (\sqrt{s} - E_{ll})^2 - \left|\vec{P}_{ll}\right|^2$$

BSM:

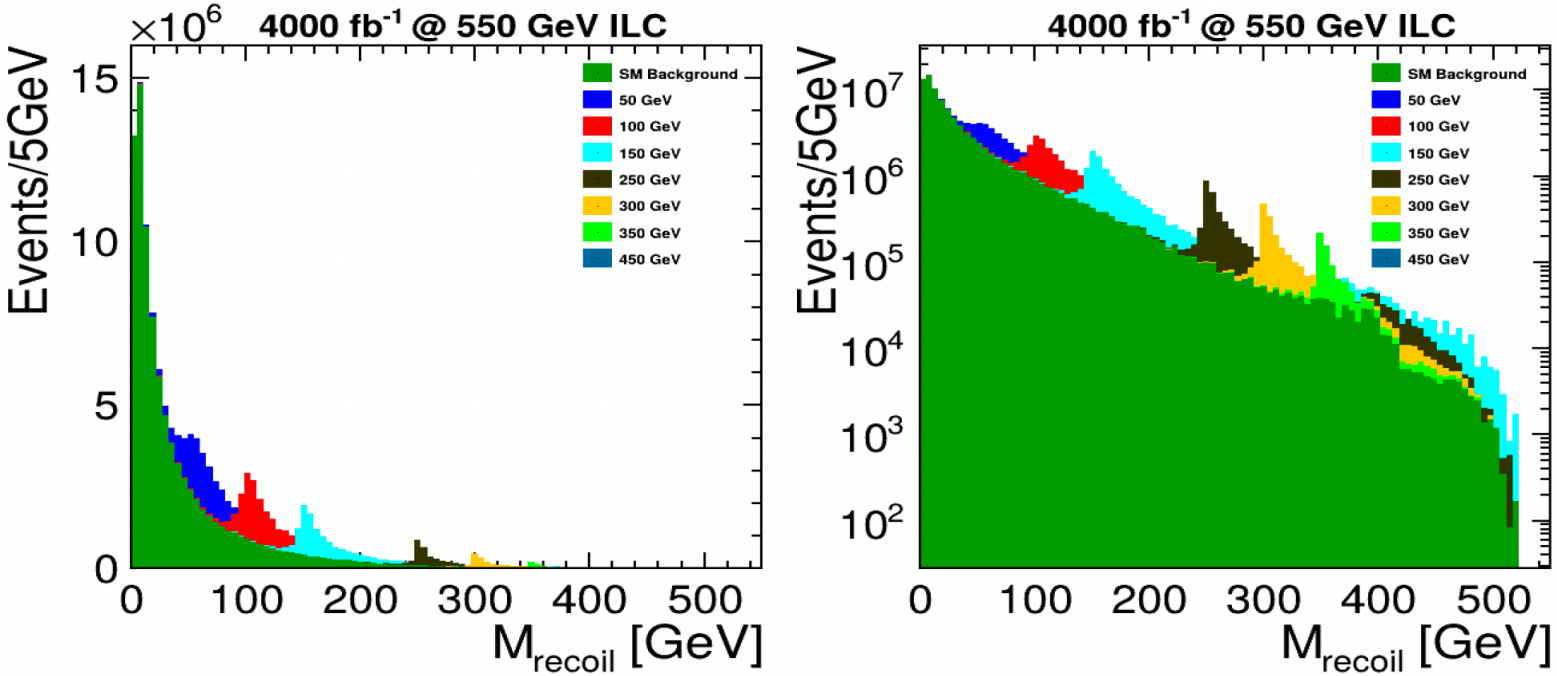
Decay-mode independent searches for new light scalars at future Higgs Factories

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The new results:

Recoil mass distributions selecting ZZ fusion events

Before MVA cuts

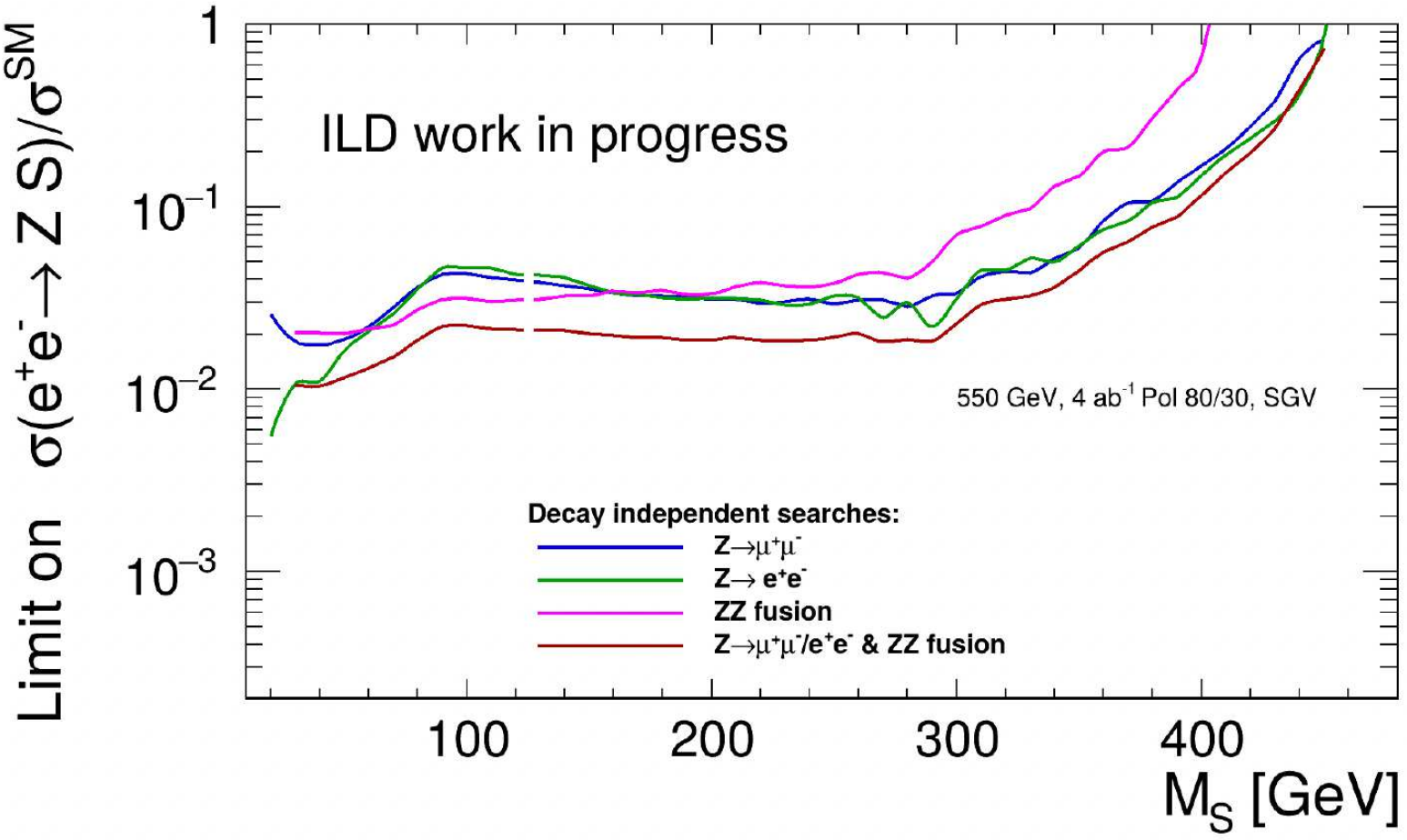


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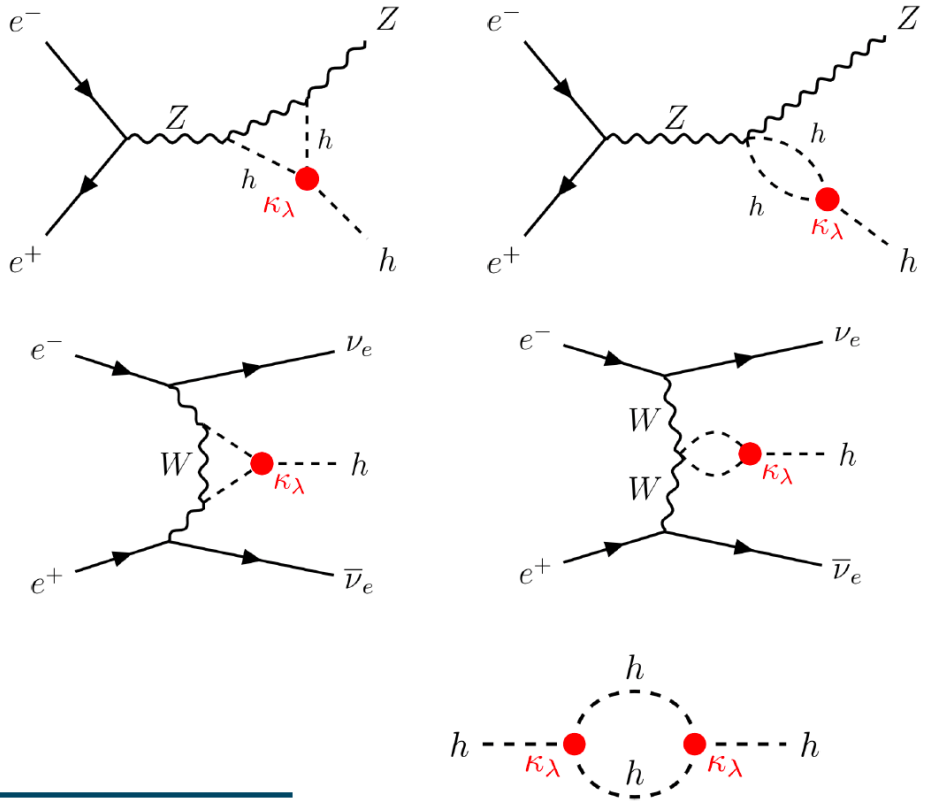
Global:

Uncertainties in the Determination of trilinear Higgs couplings from Single-Higgs Observables

talk by: Murillo Vellasco

- Alternative: precision measurements of **single h** observables

- κ_λ only present at **loop-level**
  - Need **high precision!**
- **Profits greatly** from measurements at **different $\sqrt{s}$**
  - **Disentangle** κ_λ from other couplings
- **"Indirect"** or **loop-level** sensitivity
  - **Circular** e^+e^- colliders
  - Studied by several groups [McCullough '13, deBlas '25, ter Hoeve et al. '25, Maura et al. '25]
- **Caveat**: sensitivity depends on the BSM theoretical framework, i.e.:
  - BSM particles in the loop
  - Theoretical assumptions

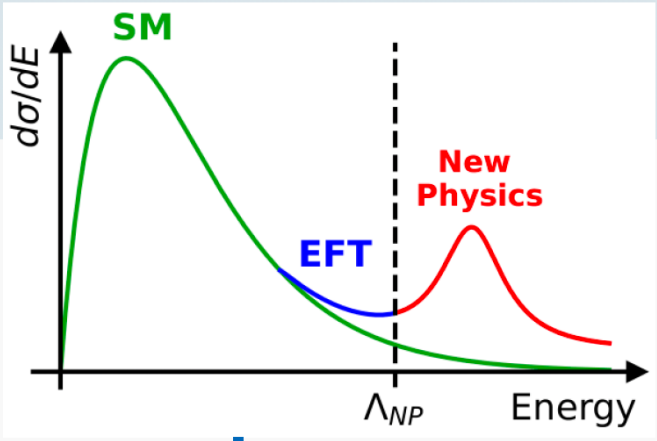


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The SMEFT



Standard Model Effective Field Theory (SMEFT)

- Assume **New Physics** has a typical **energy scale** Λ_{NP}
- SMEFT can **parametrize** BSM physics at energies $\ll \Lambda_{NP}$

$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}}^{(4)} + \frac{1}{\Lambda_{\text{NP}}} \sum_k C_k^{(5)} O_k^{(5)} + \frac{1}{\Lambda_{\text{NP}}^2} \sum_k C_k^{(6)} O_k^{(6)} + \mathcal{O}\left(\frac{1}{\Lambda_{\text{NP}}^3}\right)$$

- Includes **all** possible **(non-renormalizable) operators** consistent with Poincaré and SM gauge symmetries
- The C_k are called **Wilson Coefficients** (WC) → **Dimensionless**!
- Current setup for **indirect** constraints: **dimension-6 SMEFT** $(\sim \mathcal{O}(1/\Lambda_{\text{NP}}^2))$

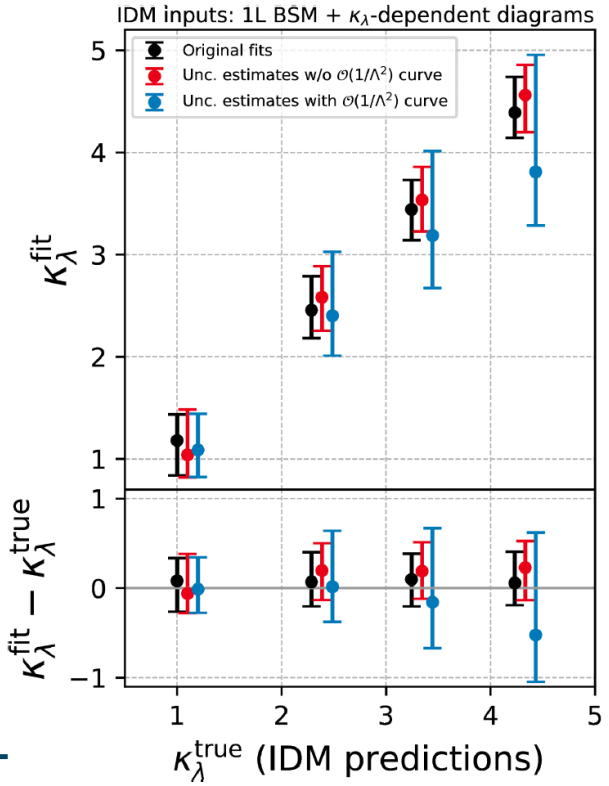
Global:

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talk by: Murillo Vellasco

Incorporate these uncertainties as new nuisance parameters (NPs) in the global SMEFT fits

- Fits **without new nuisance parameters:**
  - Fit able to **determine "true" κ_λ**
  - Important **cross-check**
- Estimates **without** the $\mathcal{O}(1/\Lambda^2)$ SMEFT curve
  - **Little effect** on κ_λ **uncertainty**
- Estimates **including** the $\mathcal{O}(1/\Lambda^2)$ **SMEFT curve**
  - **Larger κ_λ uncertainty!**



Result: better go to 500 GeV with $e^+e^- \to Zhh$

What to conclude?

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Overview and highlights demonstrate that

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- many new studies are produced
- it is very important to have $\sqrt{s} \gtrsim 500$ GeV

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New LC-Vision document:

Linear Collider Vision



Brainstorming document on candidate BSM scenarios for Discovery Stories

Sven Heinemeyer[*], Jenny List[†], Roman Pöschl[‡], Jürgen Reuter[†], Aidan Robson[§], Gudrid Moortgat-Pick[¶], Please add your name here if you'd like to contribute :)[¶]

On behalf of the LCVision Team

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Physics: that's it what it is (in the end) all about!


Further Questions?