

TYL/FJPPL 2021 application: HEP\_13

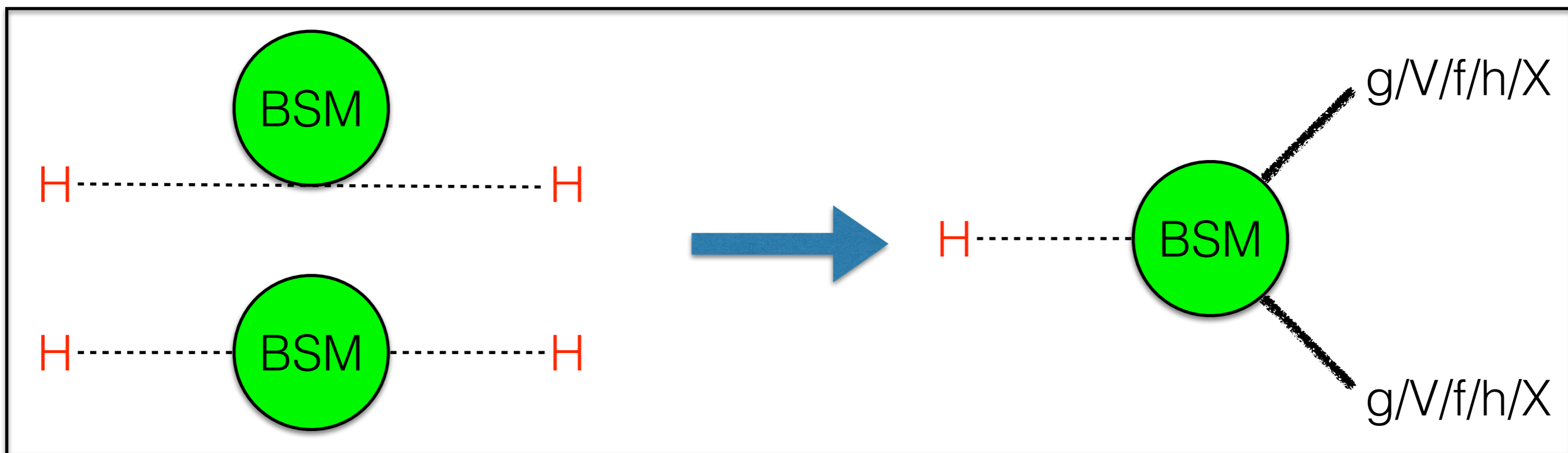
## **Higgs Physics at the ILC**

---

PIs & main members      Jean-Claude Brient (LLR)<sup>a</sup>, Junping Tian (U. Tokyo)<sup>b</sup>,  
Daniel Jeans (KEK), Jonas Knuth (LLR)  
(a) brient@llr.in2p3.fr; (b) tian@icepp.s.u-tokyo.ac.jp

# Higgs provides a unique window for BSM

- so far the only fundamental scalar particle
- may connect to many of the outstanding questions in HEP:  
Origin of EWSB? Naturalness? Matter anti-matter asymmetry?  
Nature of dark matter?

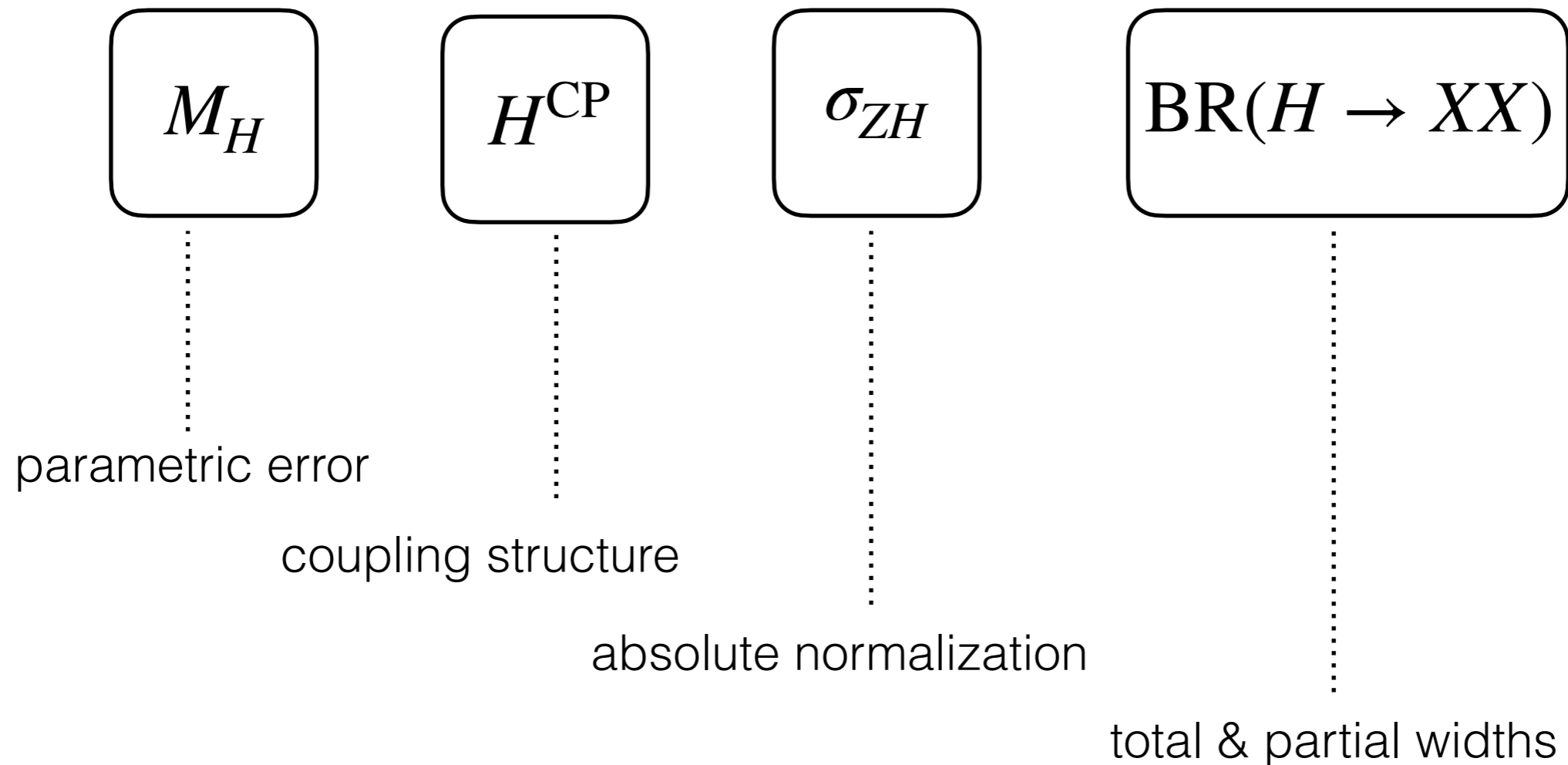


looking precisely at Higgs properties

= opportunity to discover the new physics

# HEP\_13: overview of topics in this application

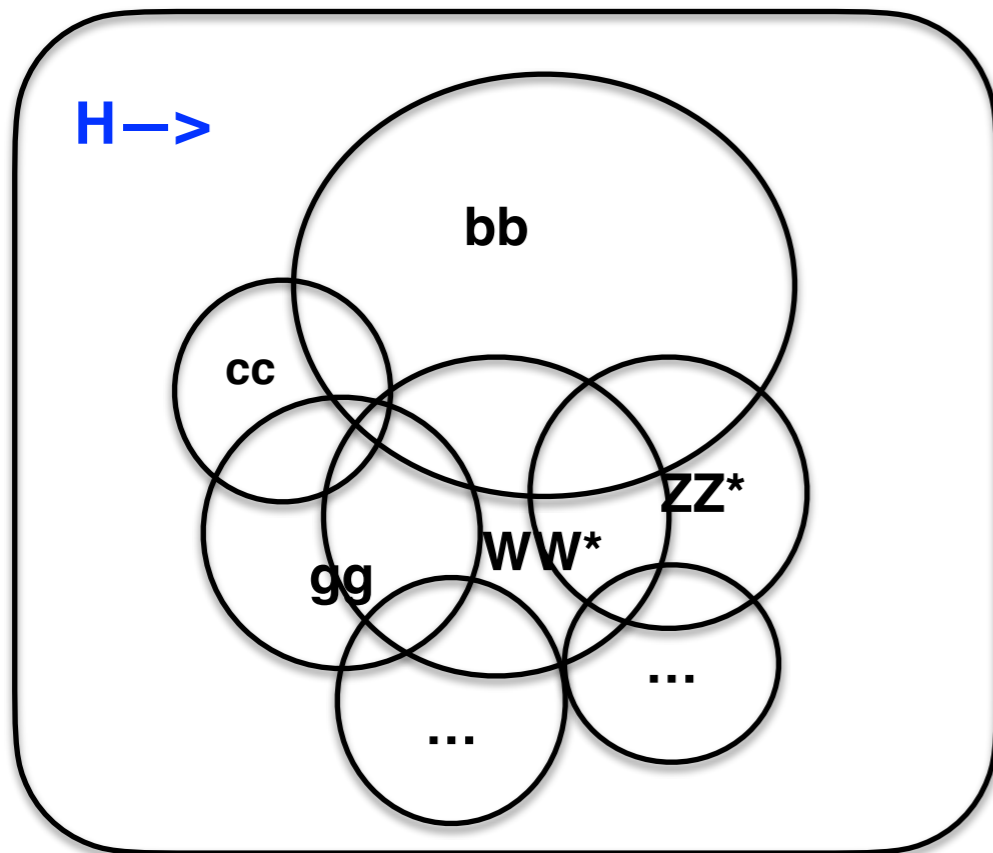
to improve measurements of various Higgs properties



all essential for globally determining Higgs couplings

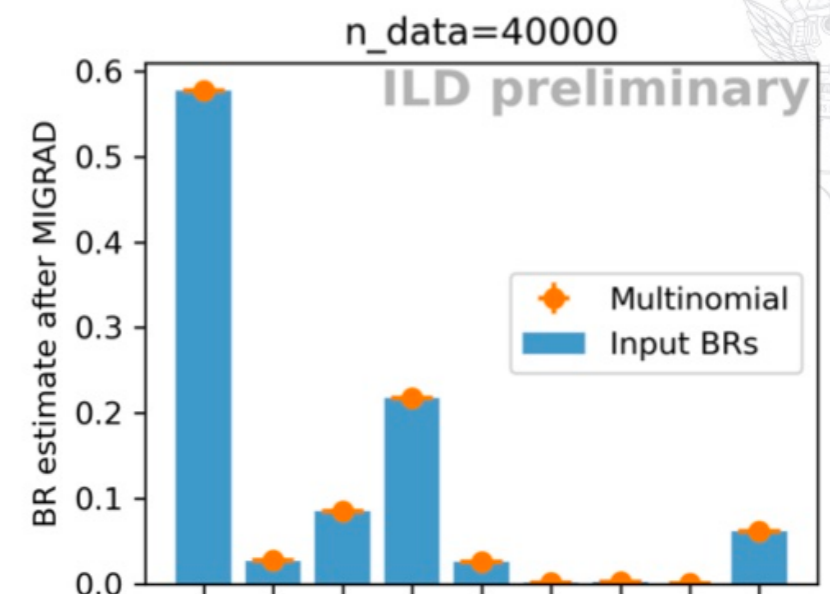
# BR(H->XX) measurement: a new method from old ideas

✓ what's new:



- selected signal events for a particular decay mode inevitably contain contributions from other modes; assumed to be perfectly known in past studies
- how can we realistically determine those overlapped events?
- ▶ a combined fit to all BRs

- ▶ unbiased Higgs sample with all modes
- ▶ categorization for various modes
- ▶ model-independent; multinomial uncertainty
- ▶ analysis ongoing —> Jonas @ LCWS2021

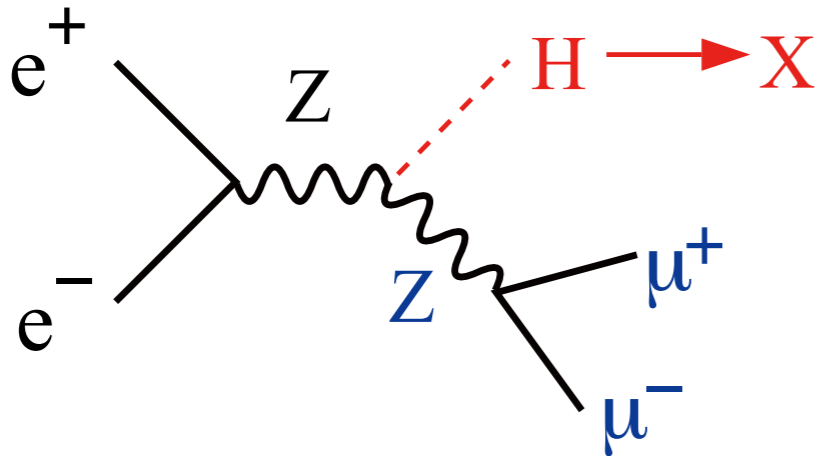


[1] ALEPH, Phys.Rept.421:191-284,2005

[2] SLC, Michael Peskin, private comm.

# new method for inclusive $\sigma_{ZH}$ measurement

✓ what's new:



○ recoil mass analysis is a flagship meas. at  $e^+e^-$ , providing model-independent meas. of  $\sigma_{ZH}$

○ only leptonic ( $e/\mu$ ) and hadronic channels were studied

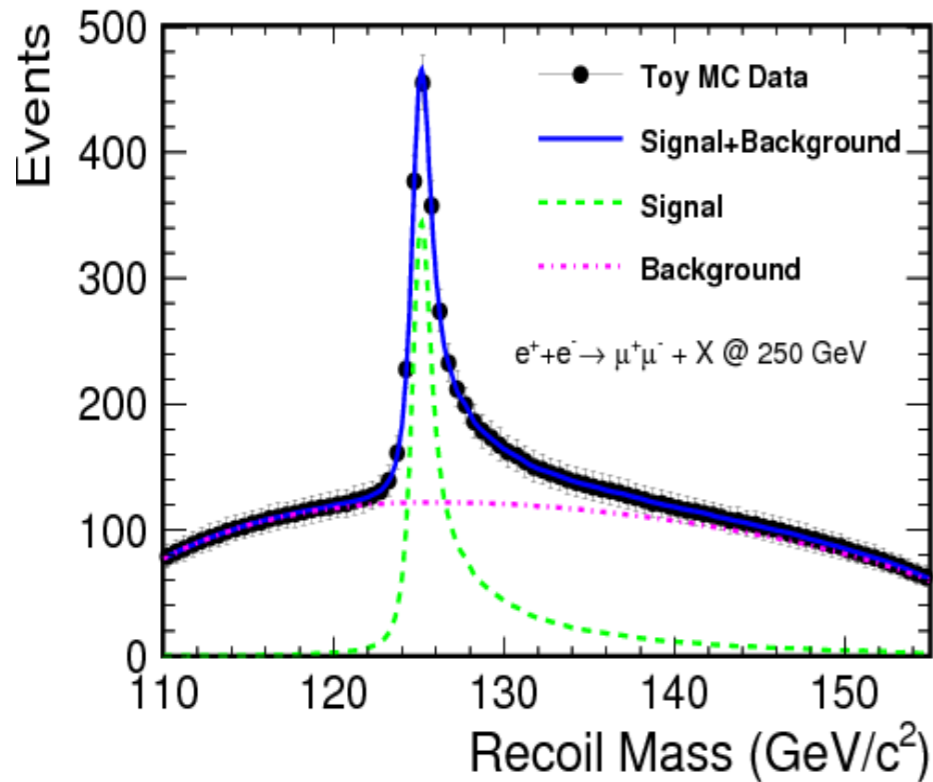
○ Can we use  $H \rightarrow \nu\nu / \tau\tau$  channels?

$$M_X^2 = (p_{CM} - (p_{\mu^+} + p_{\mu^-}))^2$$

- ▶ build a reference sample employing  $Z \rightarrow ee / \mu\mu$  channels
- ▶ construct variables depending on Z-only and Higgs-only
- ▶ select Higgs events from counting samples in  $Z \rightarrow \nu\nu / \tau\tau$
- ▶ selection efficiency for Z-variable from MC; for H-variable from the reference sample
- ▶ generator level, improvement as equiv. x2 luminosity
- ▶ ongoing, Jonas, Jean-Claude, LCWS2019

# new method for Higgs mass measurement

✓ what's new:



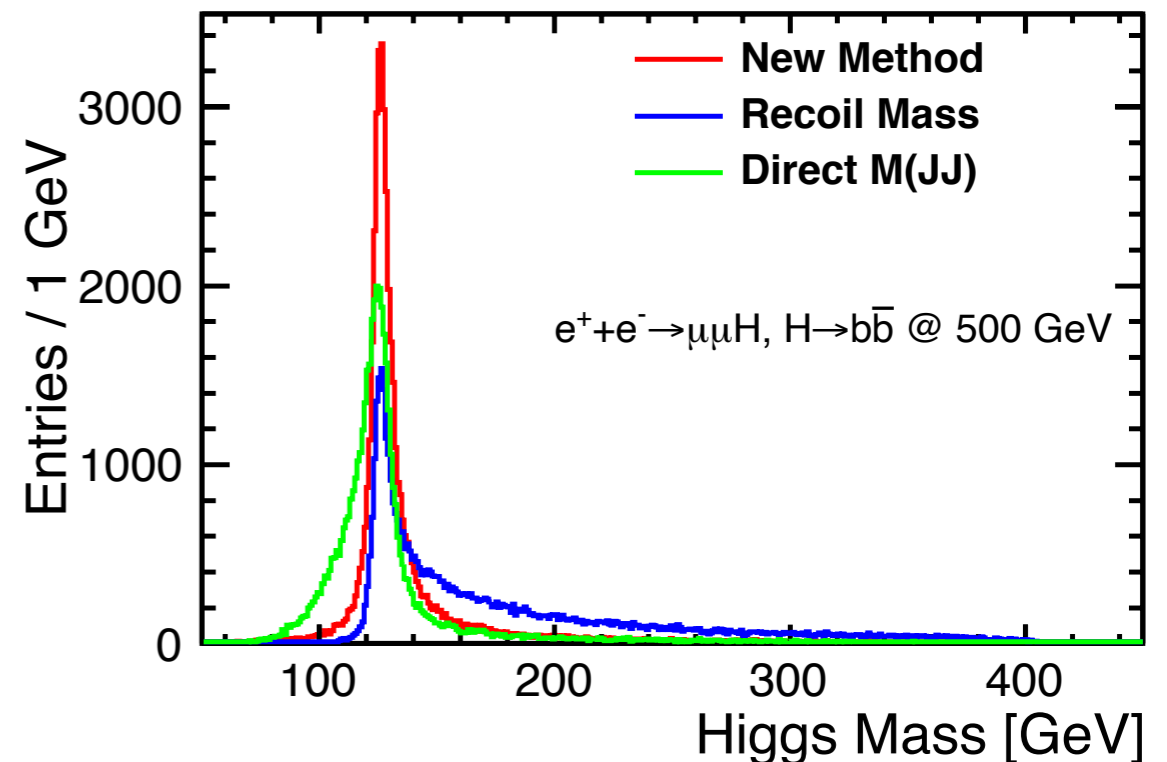
○  $\delta m_H$  may become one main source of systematic errors

$$\delta g_{HWW} = 6.9 \cdot \delta M_H \quad \delta g_{HZZ} = 7.7 \cdot \delta M_H$$

○ traditionally we have to rely on  $Z \rightarrow \mu\mu$  recoil mass

▶ can we use direct reconstruction?

- ▶ resolution is relatively worse if directly using  $H \rightarrow 2\text{-jet}$
- ▶ use jet directions only; impose transverse momentum conservation
- ▶ proved in  $H \rightarrow b\bar{b}$ ; to explore  $H \rightarrow \tau\tau$

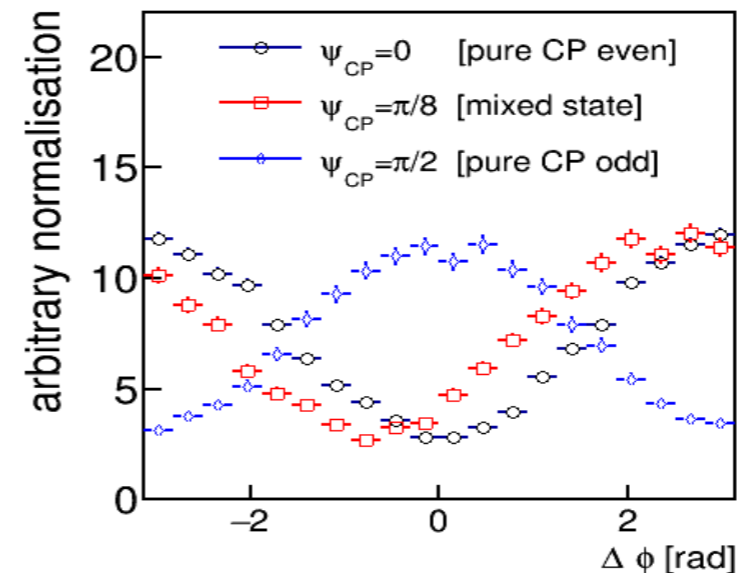
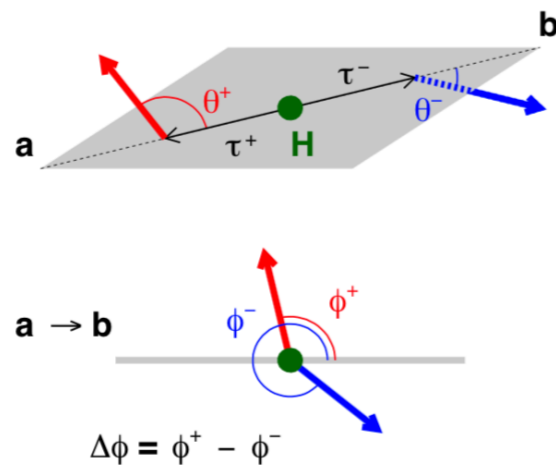




# new method for Higgs CP measurement

✓ what's new:

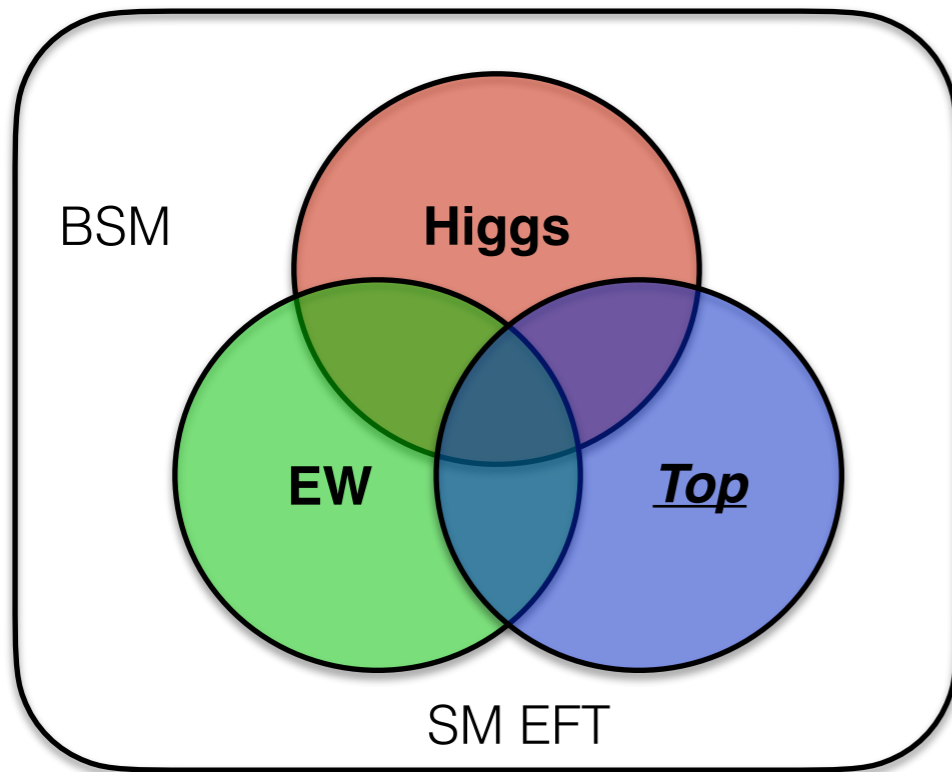
$$L_{Hff} = -\frac{m_f}{v} H \bar{f} (\cos \Phi_{CP} + \underline{i\gamma^5 \sin \Phi_{CP}}) f$$



- $H \rightarrow \tau\tau$  channel is ideal to measure Higgs CP
- a novel method was developed by reconstructing  $\tau$ -polarimeter using impact parameters; efficiency is limited
- ▶ can we reconstruct  $v'$  4-momenta w/o impact parameters?
- ▶  $\tau$  hadronic channels, 2 neutrinos, 6 unknown: employ 4-momentum conservation + 2  $\tau$ -mass constraints; +Higgs mass if ISR
- ▶ ongoing, Daniel & K.Yumino @ LCWS2021

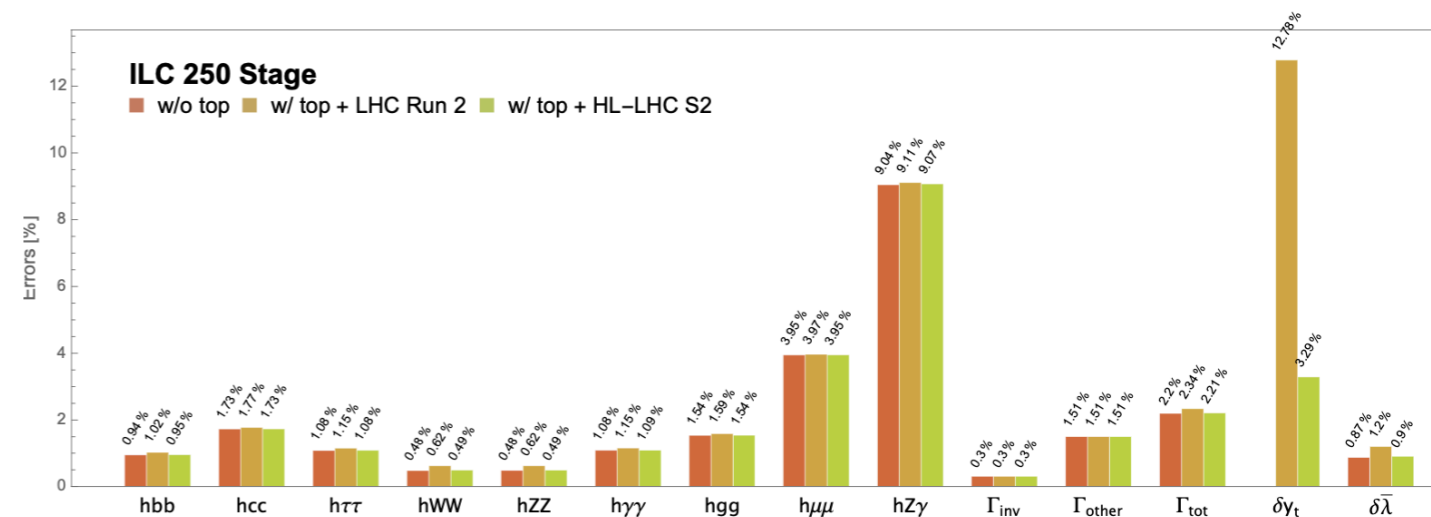
# new studies on global interpretation

✓ what's new:



- Higgs is not alone in looking for new physics
- ▶ need global interpretation of all measurements in Higgs / EW / Top / 2-fermion / new particles
- ▶ ongoing global SMEFT fit

- ▶ role of Z-pole measurements
- ▶ role of top-quark measurements
- ▶ role of beam polarizations



[Jung, Tian, et al, Phys. Rev. D 97, 053004 (2018); arXv: 2006.14631]



# HEP\_13: **Higgs Physics at the ILC**

---

PIs & main members      Jean-Claude Brient (LLR)<sup>a</sup>, Junping Tian (U. Tokyo)<sup>b</sup>,  
Daniel Jeans (KEK), Jonas Knuth (LLR)  
(a) brient@llr.in2p3.fr; (b) tian@icepp.s.u-tokyo.ac.jp

---

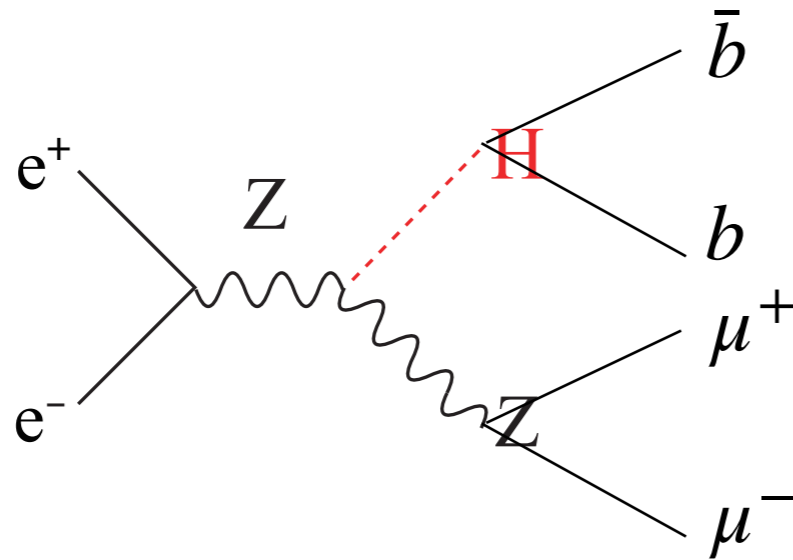
we share the common interest on Higgs physics, complement with each other in expertise about  $\tau$ -reconstruction, detector simulation and physics interpretation. The scope is somewhat ambitious, but supports from TYL/FJPPL 2021 will definitely help us make progress.

Thank you very much for the attention!

backup

## global perspective for precision meas. @ future e+e-

- different new physics effects can appear in a same observable  
e.g. suppose we discover a deviation in rate meas.  $\sigma \times \text{Br}$



- hbb coupling?
- hZZ coupling?
- $Z\mu\mu$  coupling?
- Zee coupling?
- new diagrams?

- same new physics effect can appear in different observables

$$i \frac{c_{HL}}{v^2} (\Phi^\dagger \overleftrightarrow{D}^\mu \Phi) (\bar{L} \gamma_\mu L)$$

