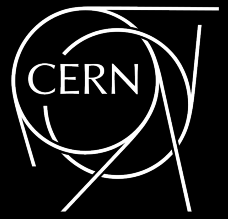
ECFA $H \rightarrow ss$ Focus Group
- Open meeting -

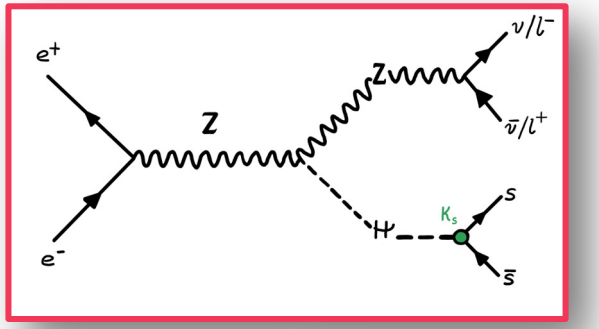
Valentina Maria Martina Cairo

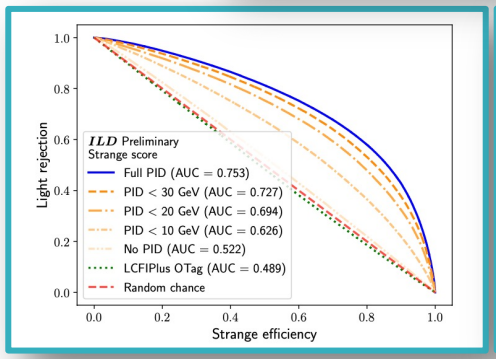


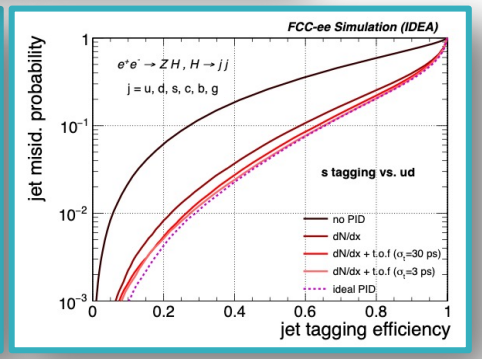
WHAT WE DO AND WHO WE ARE

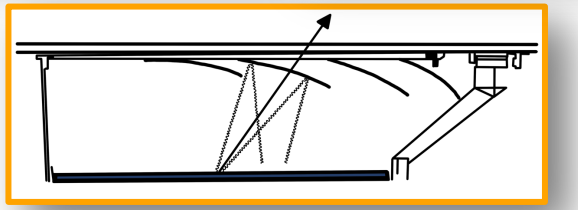
Within ECFA, we focus on studying the interactions of the Higgs boson with the strange quark at future e^+e^- colliders

The topic has been gathering increasing interest and crosses all three ECFA working groups: prospective **physics sensitivity**, **algorithm development**, and **detector design optimization**.









Expert team:
John Alison, Matt Basso, Valentina Cairo (coordinator), Valerio Dao, Loukas Gouskos, Karsten Köneke (HTE convener), Yotam Soreq, Taikan Suehara, Caterina Vernieri

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Subscription link: http://simba3.web.cern.ch/simba3/SelfSubscription.aspx?groupName=ecfa-whf-ft-HtoSS

GOALS

Our objectives were summarized in an ECFA note available at 2401.07564

ECFA **HtoSS** expert team has identified possible directions, which are listed below.

Theoretical, phenomenological and MC generator targets

Expanding the BSM interpretations of the studies that have already been performed or developing new simulation-based analyses targeting specific BSM scenarios would enlarge the physics case for strange tagging at future colliders. In particular, we welcome studies in the following areas:

- Detailed understanding of how to extract the Higgs-strange coupling strength from a BR($h \to s\bar{s}$) measurement, given contributions from Dalitz decays, e.g, $h \to g^*(\to s\bar{s})g$ or $h \to \gamma^*(\to s\bar{s})\gamma$.
- BSM models predicting deviations in $h \to s\bar{s}$, e.g., SUSY or composite Higgs — see Refs. [36, 37];
- BSM models predicting, for example, charged Higgs bosons with large branching ratios in final states including strange quarks, e.g., 2HDM $H^+ \to cs$ BR $\approx 50\%$;
- $s\bar{s}$ vs. $b\bar{b}$ in BSM models: gain from $s\bar{s}$;
- BSM flavour structure and $h \to s\bar{s}$ signal.

Target physics observables

Several physics quantities will be investigated:

- $e^+e^- \to Zh$ with $h \to ss$ ($Z \to$ anything) at $\sqrt{s} = 240/250$ GeV (this has been the only target so far, but it will be relevant to explore also higher centre-of-mass energies, which, in turn, enable different Higgs production modes);
- projected precision on the branching fraction and the differential cross-section in $\cos\theta_s$;
- flavour-changing decays are very rare in the SM, for example, BR($h \to bs$) $\simeq 10^{-7}$. New physics models, which can be encapsulated by an EFT, allow larger values.

Target analysis techniques

The performed proof-of-concept studies [49, 51] showed that to improve the results there will be a large need for more powerful background rejection techniques as well as a potentially more global approach in the extraction of the Higgs couplings. Two areas of particular interest will be:

- diboson background suppression;
- signal extraction (fit discriminant variables, counting experiments, etc.).

Target methods to be developed

In collaboration with the Reconstruction and Detector groups, the impact from the following features will have to be evaluated when estimating the analysis sensitivity reach, including:

- control of strange-tagging related systematic uncertainties;
- reconstruction of in-flight decays, e.g., $K^0_S \to \pi^+\pi^-$;
- strangeness-tagging with ML techniques and compared with anti-b-tagging techniques;
- s vs $\bar{s}$ separation;
- complementarity of particle identification (ID) techniques for charged hadrons in momentum reach (from dN/dx, dE/dx, ToF, RICH);
- understanding the contribution from $g \to s\bar{s}$ (from single jets) to strange-tagging performance and analysis sensitivity.

Target detector performance aspects

The obtained results will inform the community on two crucial aspects:

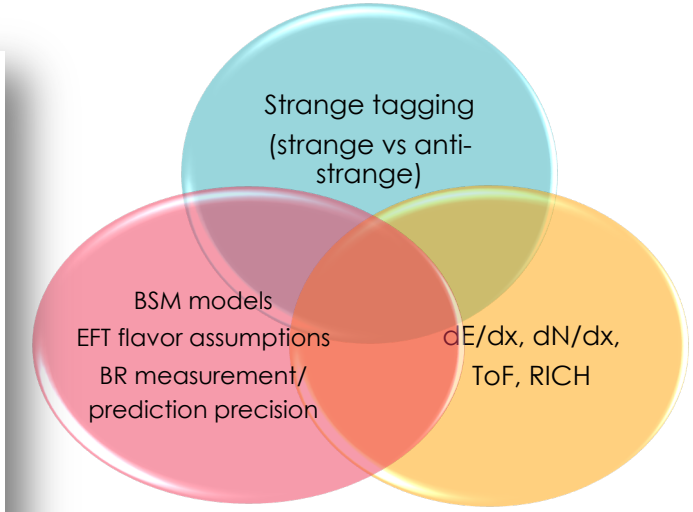
- dependence of the precision on physics observables on particle ID, strange-tagging, and reconstruction capabilities;
- technology benchmarks for sub-detectors.

Generation and Simulation needs

Full simulation samples will be needed to perform the studies listed above. Samples for $e^+e^- \to f\bar{f}h$ at $\sqrt{s} = 240/250$ GeV and $350/380/550$ GeV are available as indicated in the general samples listed in the motivation. In the years to come, it will be important to iterate with simulation experts on $s\bar{s}$ correlations and fragmentation uncertainties in order to account for more realistic systematic uncertainties.

Existing tools / examples

There are several existing tools and analysis codes available. At the time of writing, this includes examples for ILC and FCC-ee. However, due to ongoing developments, in case you would like to get actively engaged, please contact us directly (see below), such that we can point you to the up-to-date tools and code repositories.



TODAY'S AGENDA

We will review existing studies and open challenges to bring the community up to speed and plan for inputs to next year's Update of the European Strategy for Particle Physics

15:10 → 15:15	**Timelines** **Speaker**: Jenny List (Deutsches Elektronen-Synchrotron (DE))	5m	
15:25 → 15:35	**Theory introduction: Higgs and light flavours** **Speaker**: Yotam Soreq (Technion- Israel Institute of Technology (IL))	10m	
15:40 → 15:55	**The challenge of fragmentation modelling** **Speaker**: Peter Skands (Monash University (AU))	15m	
16:00 → 16:10	**The first step in your studies: where to find the samples [documentation contribution]**	10m	
16:15 → 16:30	**Quick review of existing studies** **Speaker**: Matthew Basso (TRIUMF (CA))	15m	
16:35 → 16:45	**PID reconstruction** **Speaker**: Ulrich Einhaus	10m	
16:50 → 17:00	**Detector design** **Speaker**: Roger Forty (CERN)	10m	

THANK YOU!