

WG3 Physics Potential and Opportunities Introduction and Plans

LCWS, 17 March 2021

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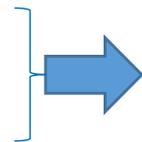
Physics Potential and Opportunities Group

Co-conveners Michael Peskin, Aidan Robson, Junping Tian
working closely with WG3 chair Hitoshi Murayama and deputies Jenny List, Claude Vallee

- ◆ Forum for development of the physics case, outside and across detector concepts, intended to build on all the work already done and:
 - have broad participation, supporting new involvement and increasing the active base of people contributing to ILC studies
 - provide a forum for collaboration and discussion between theorists and experimentalists
 - ensure connection to related initiatives
 - document the ILC physics potential

- ◆ Plans are well underway for:
 - **Topical Groups**
 - for open discussion of ILC physics issues
 - intended to be long-term
 - **Task Forces**
 - addressing specific issues needed for ILC design and Lol process
 - transversal; may reach across several groups in WG3 (and to WG2)

- ◆ WG3 will manage production of the **ILC Report to Snowmass** (due early 2022). We plan that the work of the Topical Groups and Task Forces will be documented in an **ILC Resource Book** assembled in 2024-25

 *intended for launch in April*

Vision for the Topical Groups



- ◆ The *Topical Groups* will be the forum for discussions of physics goals and requirements for e^+e^- experiments, and for advancing the necessary theory
- ◆ In the next year these groups will operate in parallel with the Snowmass study in the US and the ECFA Higgs Factory Study in Europe. We anticipate close cooperation among these study groups
- ◆ Since the goals of all proposed e^+e^- Higgs factories are closely aligned, we welcome participation from all members of the community interested in these accelerators – collaboration will advance the Higgs factory concept
- ◆ We expect the work of the Topical groups will assist the formulation of experimental proposals (Eols and Lols) for the ILC or any future e^+e^- collider
- ◆ Longer term, we expect the Topical Groups will remain active for discussions across the experimental collaborations and for linking the theory and experimental communities

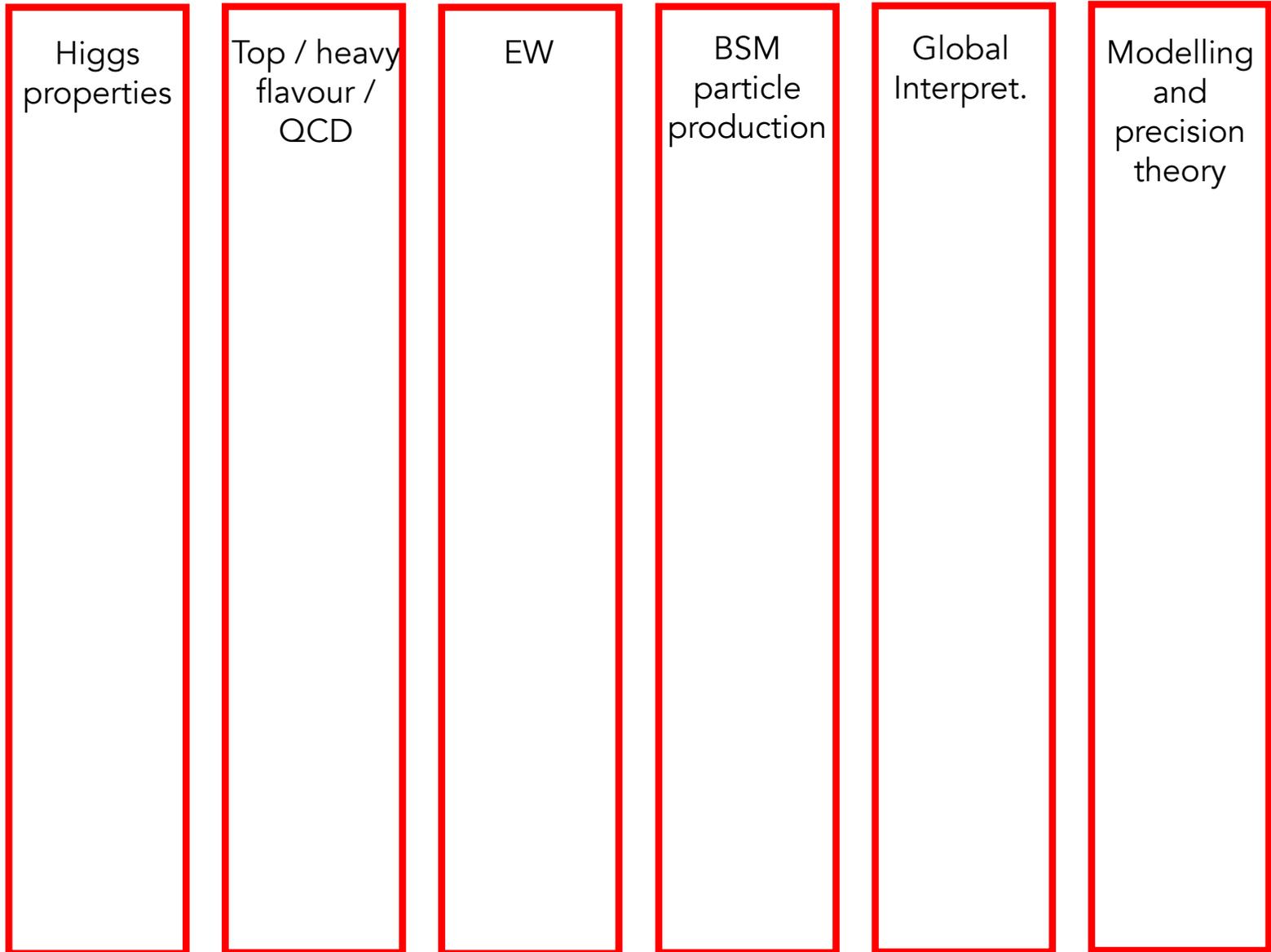
Vision for the Task Forces



- ◆ The *Task Forces* will specifically serve the ILC
- ◆ From time to time, reports will be needed on the physics implications of accelerator design choices, and physics input will be needed to set up the ILC LoI process
- ◆ The Task Forces will provide this input to the IDT and Pre-lab administration and to the accelerator design team, synthesizing the best information provided through the Topical Groups and other sources

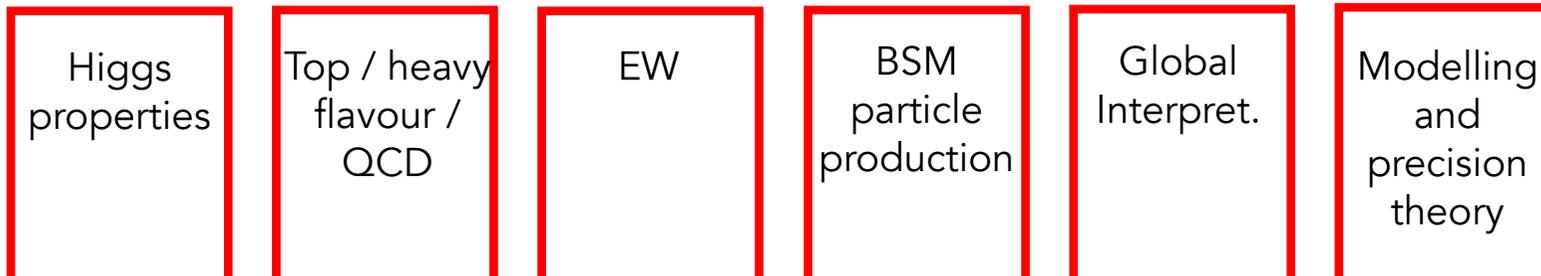
Topical Groups

-> broad scope



Topical Groups

-> broad scope



Task Forces

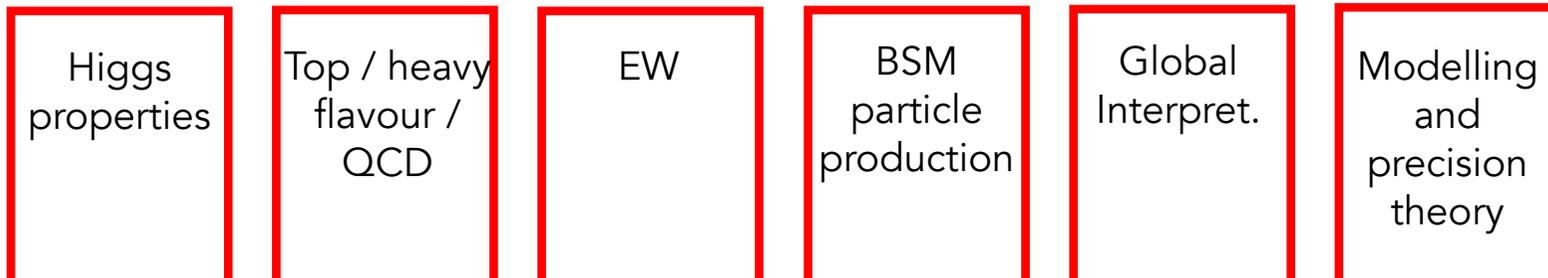
-> specific advice



Definition / discussion ongoing; may reach across WG3 groups; may include WG2;

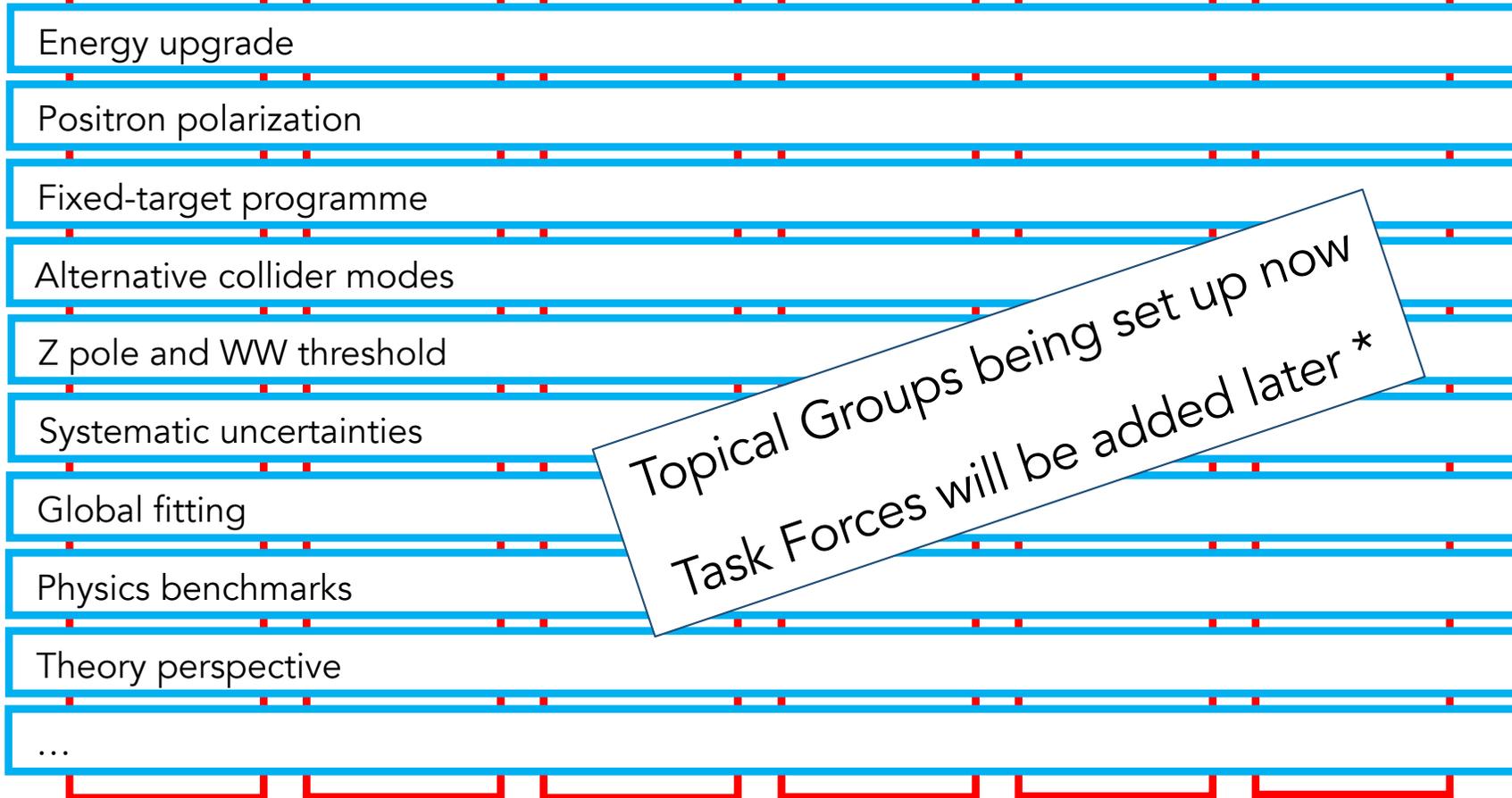
Topical Groups

-> broad scope



Task Forces

-> specific advice



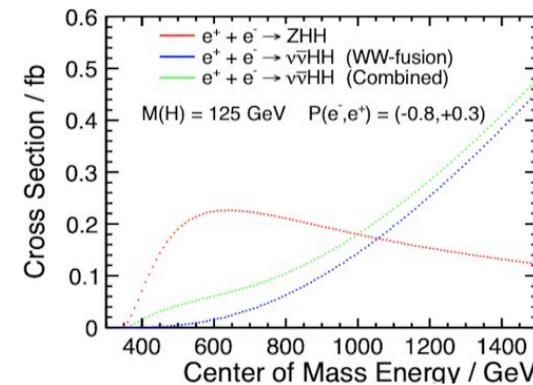
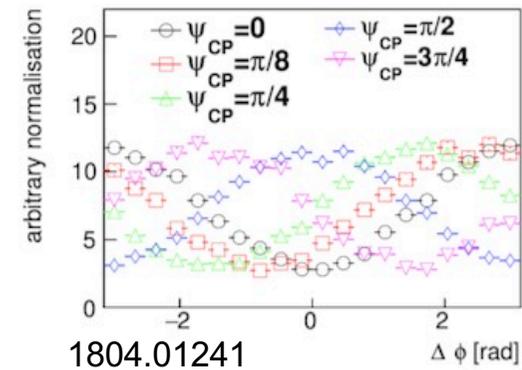
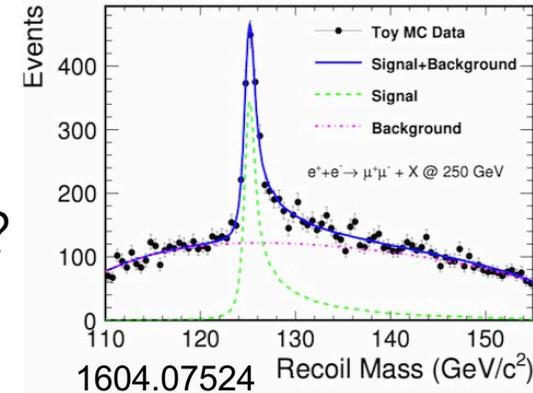
Topical Groups being set up now
Task Forces will be added later *

* Study Group on fixed-target / dark sector has started to meet

Topical Group: Higgs properties



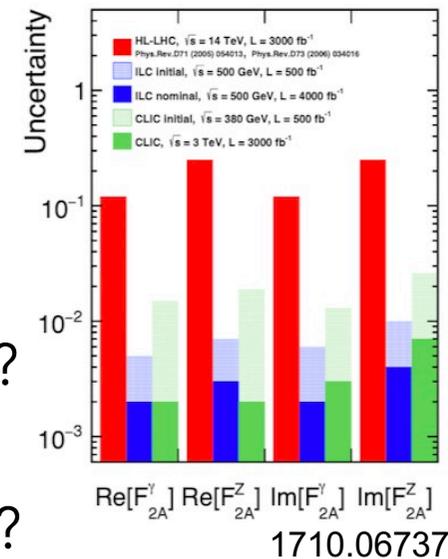
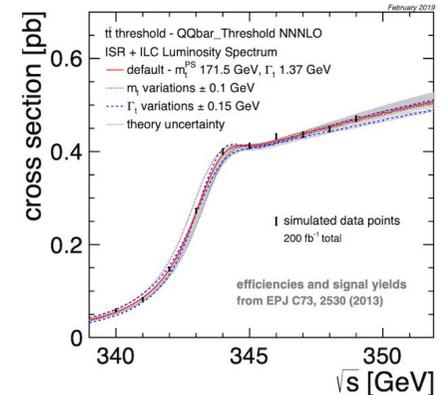
- ◆ High-precision measurement prospects for each channel
 - key observables? – required detector capabilities?
- ◆ BSM measurements expected to produce largest deviations?
- ◆ Mass measurement methods? Width?
- ◆ Prospects for 2nd and 1st generation couplings?
- ◆ Expected accuracy on possible CP-violating angles?
- ◆ Sensitivity to SM-forbidden decays?
- ◆ Strategies for self-coupling measurement?



Topical Group: Top / heavy flavour / QCD



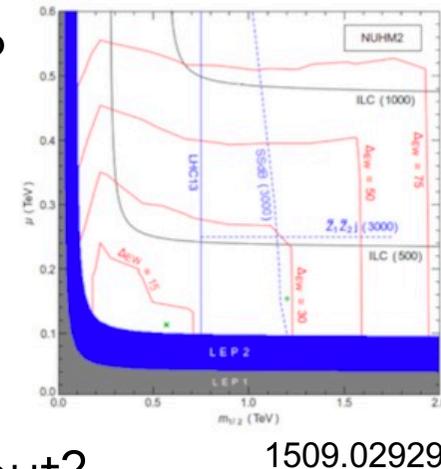
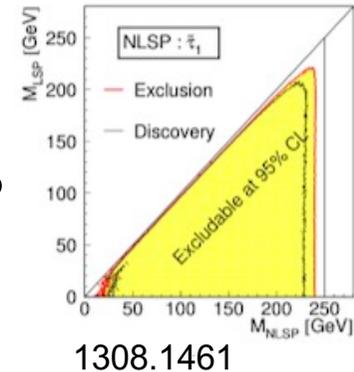
- ◆ Top-quark pair production at threshold and beyond:
 - key observables? – ultimate sensitivity on mass and width?
 - sensitivity to non-standard couplings/decays?
 - prospects for model-indep. polarized production amplitudes?
 - necessary QCD theory prediction accuracy? – optimal \sqrt{s} ?
- ◆ Single-top:
 - strengths w.r.t. pair production?
 - particular detector/beam requirements?
- ◆ Achievable accuracy on $t\bar{t}H$? How to interpret measurement?
- ◆ Relation of b , c , τ pair-production to top-quark studies?
 - requirements on flavour tagging? – interpretation framework?
- ◆ QCD programme
 - accuracy on α_s ? – key observables? – best use of multiple \sqrt{s} ?



Topical Group: BSM particle production



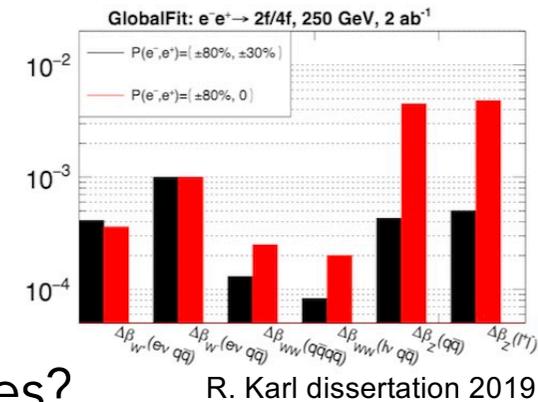
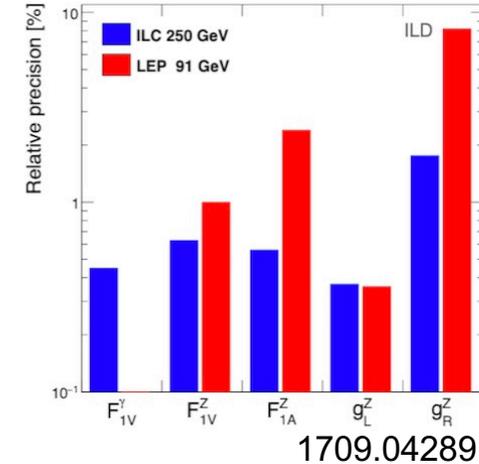
- ◆ Landscape of BSM particles relatively unconstrained by LHC?
- ◆ Scenarios for ILC discovery of:
 - additional Higgses? – SUSY particles? – massive colour-singlets?
 - dark matter particles? – long-lived particles?
 - in all cases where they are difficult for LHC
- ◆ What are the required detector requirements:
 - flavour-tagging performance? – missing energy performance?
 - forward detector performance?
 - opportunities opened with remote detectors?
 - how to discover particles with longer lifetime than ILC bunch length?
- ◆ Prospects for ILC beam-dump or fixed-target experiments?
 - comparison with planned experiments? – implications for layout?



Topical Group: Electroweak



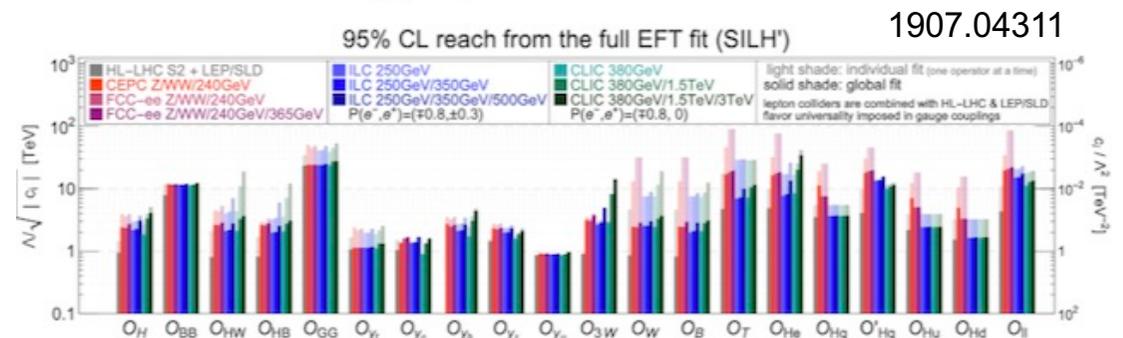
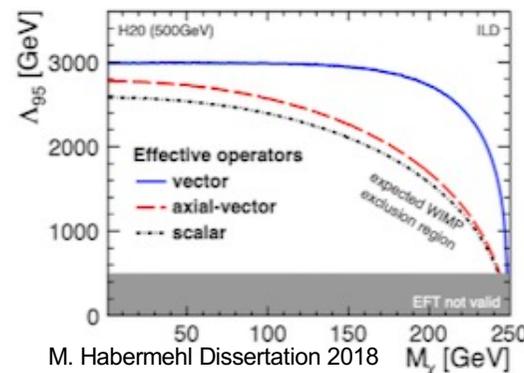
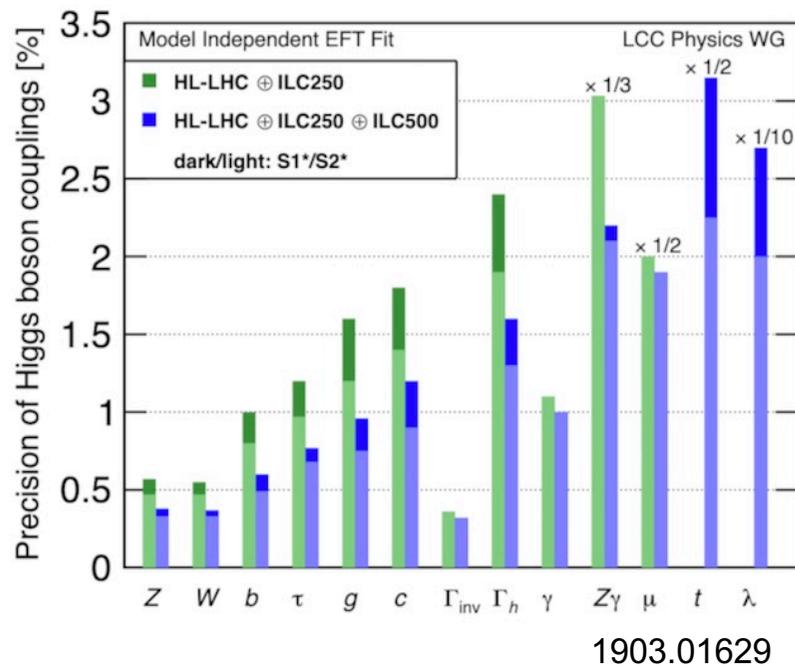
- ◆ Precision on Z-boson properties achievable with radiative return events?
- ◆ Potential for improvements with Z-pole run?
 - detector performance requirements?
- ◆ BSM models particularly affecting Z-boson couplings?
- ◆ W-boson mass methods and ultimate precision?
 - gain from WW threshold run?
- ◆ How to improve W-boson width precision?
- ◆ Ultimate precision in 2-fermion processes?
 - constraints on new physics?
- ◆ W-boson pair production
 - key observables?
 - prospects for model-indep. polarized production amplitudes?
 - sensitivity to non-standard couplings / rare decays?
 - necessary EWK theory prediction accuracy?
- ◆ Capabilities on other single and diboson processes?
 - how can these be analysed all together? – what special information offered?



Topical Group: Global Interpretations



- ◆ What is the best EFT framework for combining ILC measurements?
 - illustrative fits? – processes that need special attention?
- ◆ How are specific BSM models constrained?
 - To what extent are models distinguishable?
- ◆ Compare EFT and model-specific approaches, to identify problems



- ◆ Level of accuracy required in fixed-order and resummed QCD calculations?
 - plan for realization?
- ◆ Level of accuracy required in electroweak calculations?
 - plan for realization?
- ◆ How to generate and simulate e^+e^- events to preserve accuracy in calculation and give realistic final states?
 - unified QCD+EWK parton showers?
 - how best to incorporate vector boson couplings, EWK logs, loop effects?
- ◆ Develop MC generators for general processes and specific reactions
- ◆ Work with IDT WG3 (Software) to allow common MC sample production

Proposed Task Forces (1)



Some of these and/or additional Task Forces may be transversal across other WG3 groups and WG2 – discussion ongoing

- ◆ Energy upgrade
 - recommend specific energy for second stage
 - update reach for ZHH, $\nu\nu$ HH, ttH
- ◆ Positron polarization
 - quantify advantages
- ◆ Fixed-target programme
 - should a fixed-target / beam-dump / remote detector programme be included?
 - > Study group has already started within the ILC Snowmass effort
- ◆ Alternative collider modes
 - consider importance of e^-e^- and $\gamma\gamma$
 - reconsider ILC beam crossing angle

Proposed Task Forces (2)



- ◆ Z-pole and WW threshold operation
 - clarify motivation, benefit to other measurements, timeline
- ◆ Systematic uncertainties
 - recommend a uniform system for reporting systematic uncertainties in ILC Lols
- ◆ Global fitting
 - recommend a prescription for reporting global fits in ILC Lols and provide an appropriate software tool
- ◆ Physics benchmarks
 - define key physics benchmarks for ILC Lols
- ◆ Theory perspective
 - provide a sharp and up-to-date report on ILC goals in relation to the most important issues in particle physics
- ◆ ...

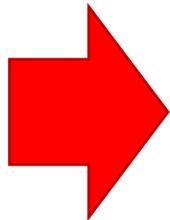
Current status and next steps



Now:

Topical Group conveners are being finalised
Initial group mandates will be finalised in discussion with conveners

April: Plan to launch full Physics Potential & Opportunities regular monthly meetings and Topical Group regular meetings



You can *already* pre-subscribe to the overall group and Topical Group mailing lists:

<https://agenda.linearcollider.org/event/9154/>

See presentation on ILC Snowmass Report from Michael Peskin in Thursday's LCWS Plenary

Looking forward to wide participation!