LCC Physics and Detector

Hitoshi Yamamoto
LCWS2013, Tokyo
November 11, 2013

1

Goals of the LCC Physics&Detector

- Ultimate goal is the same as that of LCC
  - Realization of an LC
  - Synergy of ILC and CLIC

    Synergy (Oxford dictionary):
    - The interaction or cooperation of two or more organizations. substances, or other agents to produce a combined effect greater than the sum of their separate efforts.

- Currently, the most likely scenario is the ILC

But, be flexible!

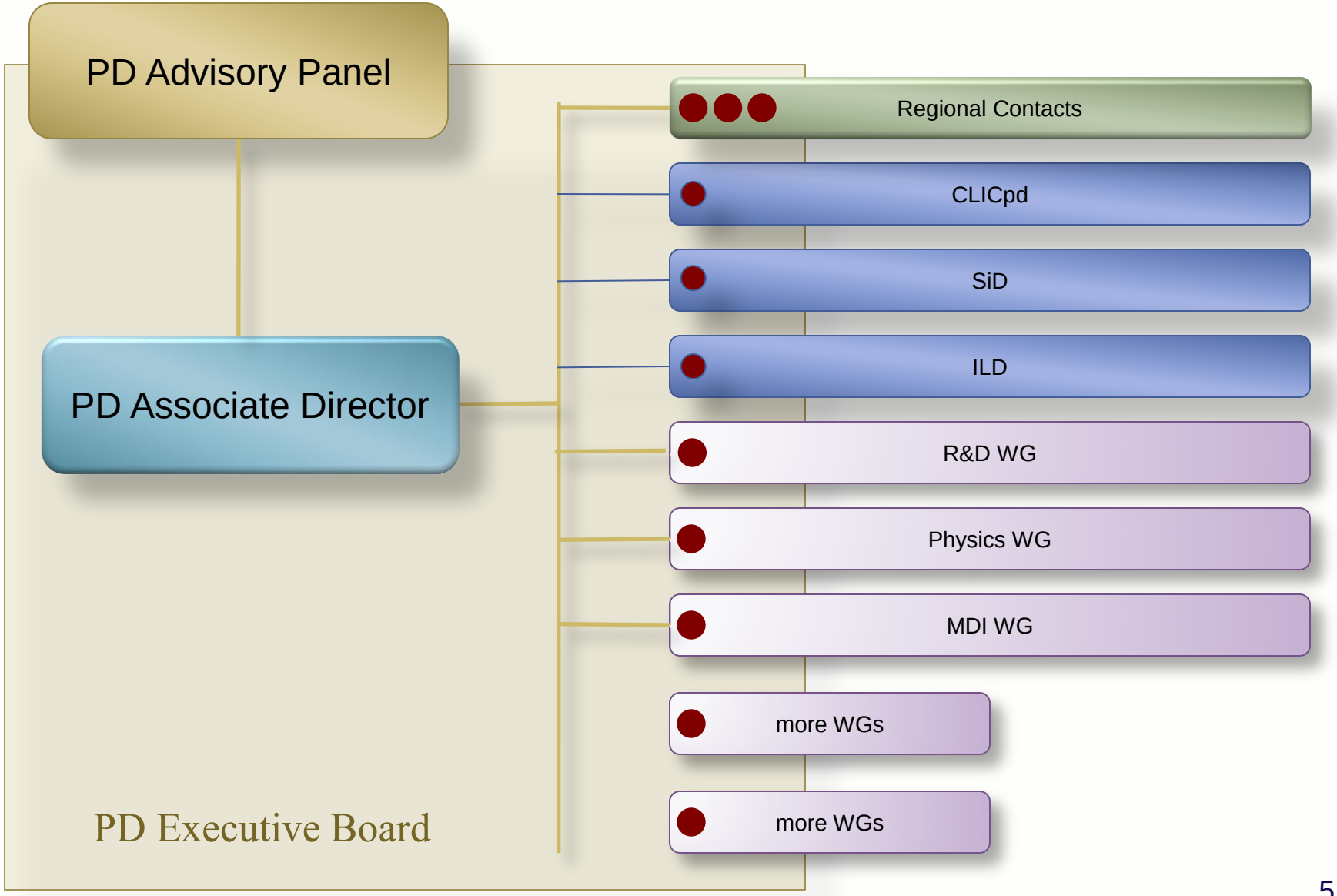
Objectives of LCC Physics/Detector Box (Under the current conditions)

- Complete remaining detector R&Ds and move toward realistic engineering designs based on DBD, and prepare for realization of the ILC.
- Coordinate the collaborative phys./det. efforts of the ILC and the CLIC. Promote the CLIC physics&detector studies.
- Coordinate physics studies for LC, and work closely with the deputy director (HM) to advance the physics case in the wider community.
- Encourage participation of new researchers in LC, and prepare an effective framework toward collaboration formation.
- Globally promote generic detector R&Ds relevant to LC.

Time scale

- Assume an optimistic scenario:
  - International agreement reached in 2~3 years
  - Then, the real LC lab will be established
- Detector fabrication&assembly:
  - Takes about the same time as the machine
- Construction-ready design:
  - Should be completed not too much later than the establishment of the lab

LCC PD Structure



PD Advisory Panel

- Advises the associate director in executing his/her mandate
  - Should be independent of the executive board
  - The PDAP chair is nominated by the AD, and reports to the AD
  - Its membership is chosen by the PDAP chair in consultation with the AD

- A reviewing body for the progress of concept groups toward real collaborations

Concept Groups

- Integrated into the decision making process
  - Representatives of concept groups on the EB
- CLICdp, SiD, ILD are now moving toward more formal organizations
  - Well-defined membership
  - Organization structures defined clearer

LCC Physics and Detectors

EB members

- SiD representative : Marcel Stanitzki
- ILD representative : Ties Behnke (Interim)
- CLICdp representative : Mark Thomson (Interim)

- European regional contact : Juan Fuster
- North American contact : Dmitri Denisov
- Asian contact : filled in by HY

Plus WG conveners

Weekly EB meetings have been initiated

WGs are being formed now.

MDI Working Group

- Charge (tentative)
  - The MDI working group coordinates the activities related to the machine-detector interface. The relevant activities include design of the detector hall, integration of detectors, alignment of detectors and beamlines near the interaction point. It liaise with related groups of accelerator activities.

- Convener
  - Karsten Buesser

MDI Working Group

- Coordination with the accelerator side
  - Exact form is under discussion
    - Joint MDI working group
    - Separate MDI working groups
    - The physics and detector MDI ⇔ BDS
- Site-specific issues
  - Detector assembly scheme will depend on specific site – vertical vs sloped access

Physics Working Group

- Charge (tentative)
  - The physics working group is the central body in formulating the physics case for the linear colliders. It coordinates relevant experimental analyses and motivates new theoretical studies in coordination with the detector studies. The membership consists of experimentalists and theorists, and should be closely connected with the physic analysis activities of CLIC and ILC. The deputy LCC director sits in the physics working group as an observer.

Physics Working Group

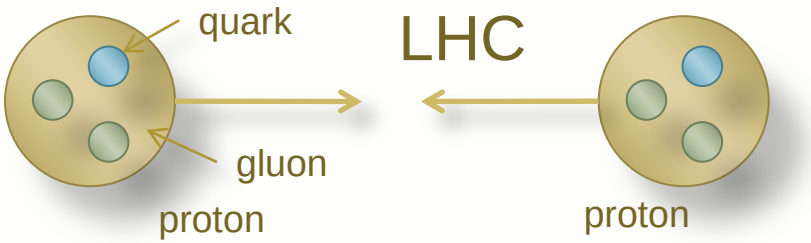
- Europe
  - inputs to the European strategy was successful
- North America
  - P5 deliberation has begun
    - We have made a good case for LC at Snowmass
    - P5 deliberation will focus more on scheduling/funding/political issues
    - Physics WG may not be in time for the P5 town hall meeting
- LC physics case needs to be continuously updated

LC features : cleanliness

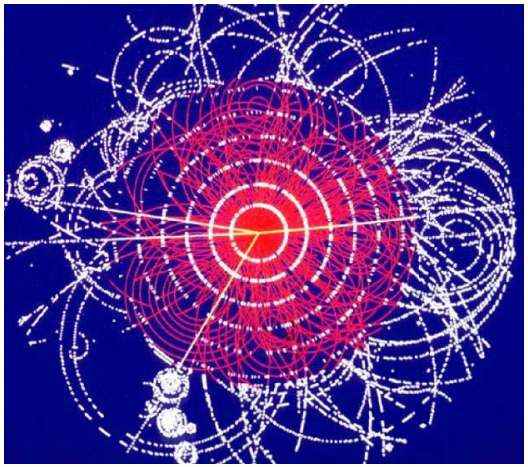
- Collision of two elementary particles

  → Trigger-less data taking

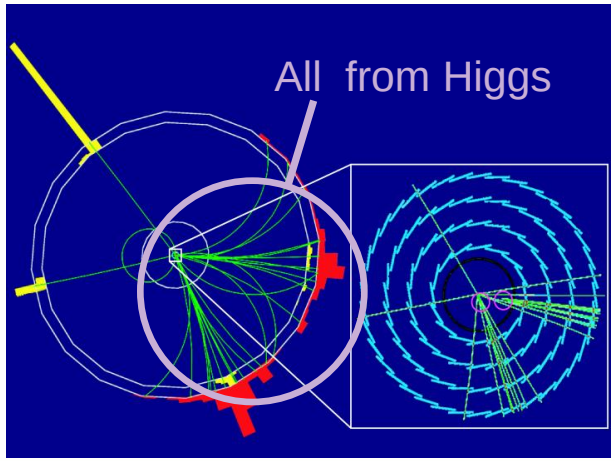
  → Theoretically clean
  (less theoretical uncertainties)



LHC



LC



LC features : control

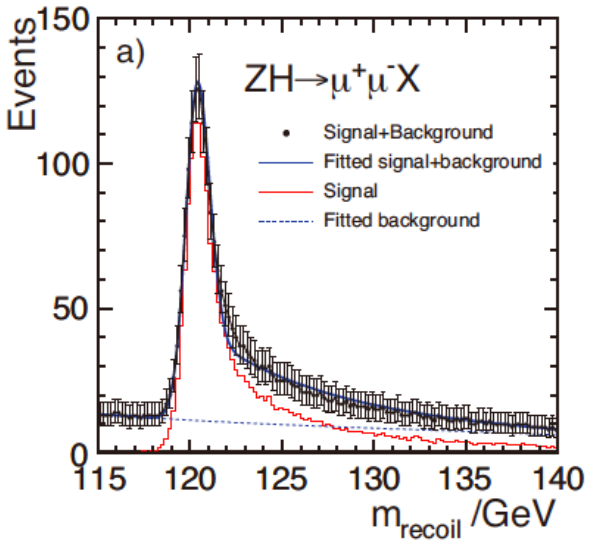
- Initial state of electron-positron interaction :
  - Energy-momentum 4-vector is specified
  - Electron polarization (80%~90%) is specified
    - Positron polarization (60%) is optional (30% comes for free)

Energy-momentum 4-vector

→ e.g. recoil mass analysis: tagged Higgs

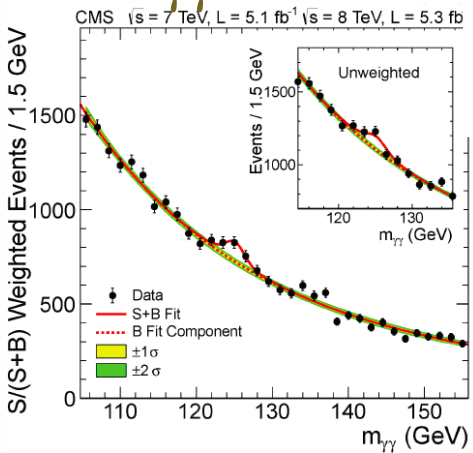
Higgs to ALL (including invisible final state)

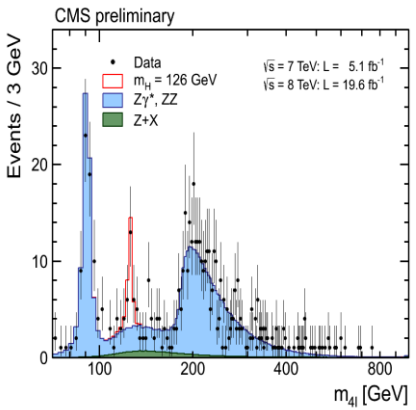
ILC



LHC

$H \to \gamma\gamma$





$H \to ZZ$

ILC Upgrade Options

- 250 GeV CM (Higgs factory)
  - x4 luminosity @ 3E34/cm^{2}s
  - x2 Nbunch, x2 rep rate; 120 → 200 MW wall plug
- 500 GeV CM
  - x2 luminosity @3.6E34/cm^{2}s
  - x2 Nbunch; 160 → 200 MW wall plug
- 1 TeV CM
  - x1.4 luminosity @5E34/cm^{2}s
  - Aggressive beam params;
    Same wall plug power

Additional ~x2 luminosity by polarizations
for Ecm ~1 TeV (W-fusion)

Measurement errors of Higgs Couplings
(Snowmass study – Higgs WG)

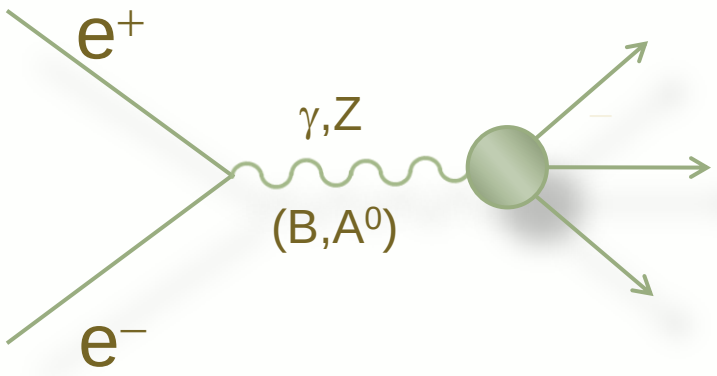
Facility	LHC	HL-LHC	ILC500	ILC500-up	ILC1000	ILC1000-up
$\sqrt{s}$ (GeV)	14,000	14,000	250/500	250/500	250/500/1000	250/500/1000
$\int \mathcal{L}dt$ (fb^{-1})	300/expt	3000/expt	250+500	1150+1600	250+500+1000	1150+1600+2500
κ_γ	$5-7\%$	$2-5\%$	8.3%	4.4%	3.8%	2.3%
κ_g	$6-8\%$	$3-5\%$	2.0%	1.1%	1.1%	0.67%
κ_W	$4-6\%$	$2-5\%$	0.39%	0.21%	0.21%	0.2%
κ_Z	$4-6\%$	$2-4\%$	0.49%	0.24%	0.50%	0.3%
κ_ℓ	$6-8\%$	$2-5\%$	1.9%	0.98%	1.3%	0.72%
$\kappa_d = \kappa_b$	$10-13\%$	$4-7\%$	0.93%	0.60%	0.51%	0.4%
$\kappa_u = \kappa_t$	$14-15\%$	$7-10\%$	2.5%	1.3%	1.3%	0.9%

- Fit assumes generation universality, no BSM.
- Apart from γ, ILC1000 is 1/3 ~ 1/10 of HL-LHC
- With luminosity upgrade, additional ~1/2
- ILC can measure model-independently w/o assumptions above.

Electron polarization

Specify the intermediate state

- Right-handed e- turns off A^0
  - Information on the gauge structure of the final state



SUSY Lagrangian Determination (MSSM: an old analysis)

- Chargino: mixture of Wino and Higgsino

$$(\tilde{W}^+, \tilde{H}^+)\begin{pmatrix} M_2 & \sqrt{2}m_W \cos\beta \\ \sqrt{2}m_W \sin\beta & \mu \end{pmatrix}\begin{pmatrix} \tilde{W}^- \\ \tilde{H}^- \end{pmatrix}$$

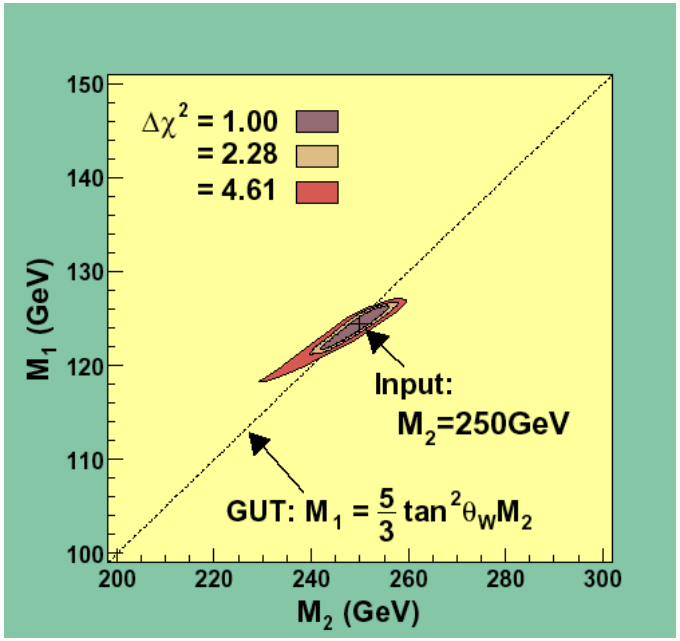
- Use polarized electron (e^-_R: iso-singlet)
  - Can turn off specific isospin interaction
  - Higgsino component contributes to Chargino pair creation
  - Right-handed selectron pair creation depends on Bino

- $(M_1, \tan\beta, M_2, \mu)$ can be extracted from

$$\sigma(e^+e^-_R \to \tilde{e}^+_R\tilde{e}^-_R) \qquad \sigma(e^+e^-_R \to \tilde{\chi}^+_1\tilde{\chi}^-_1)$$

$$m(\tilde{\chi}^+_1) \qquad m(\tilde{\chi}^0_1)$$

SUSY: probe underlying physics



- E_{cm} = 500 GeV, 50 fb^{-1}
- Probe GUT relation (or any other theoretical structures)

Such studies need to be updated with LHC constraints.
Model-independent analysis desired.

Detector R&D Working Group

- Charge (tentative)
  - The detector R&D working group promotes detector R&D efforts relevant to linear colliders including those currently not directly adopted by the detector groups and ensure good communications with and among detector R&D efforts.

- ILC-CLIC synergy
  - Productive in the past, should be promoted more

Detector R&D Working Group

- Issues:
  - There are many forms of detector R&Ds relevant to LC
    - ‘Large collaborations’ such as CALICE, LCTPC, FCAL…
    - Collection of many efforts such as the vertexing R&Ds
    - Individual mall efforts
    - Efforts currently not directly included in the concept groups, but may become important for LC in future
  - How to make sure that they are appropriately represented in the decision making process
  - How to support them in obtaining funds

Software&Computation Working Group

- Charge (tentative)
  - The software and computing working group coordinates efforts to develop common software tools among the detector concept groups so that duplications are avoided and overall progresses are promoted. The relevant software includes event generators, data formats, and reconstruction programs. When needed, it coordinates large-scale MC productions. It also evaluates computing needs from now up to the real experiments.

- ILC-CLIC synergy
  - Another productive area

Coordination with Accelerator

- In the effort to realize an LC, well-coordinated efforts between the physics/detector and accelerator is essential.
  - Physics case and baseline design
  - Building support for LC in the wide phys/det and accelerator communities
  - Well-integrated design of detector and accelerator
- Three levels
  - LCC management
  - MDI working group
    - Machine hardware meets detector hardware
  - Machine specific parameter working group
    - A la ‘SB2009’ working group (ILC)

Summary

- LCC Physics and Detector Organization is starting to function
  - EB has been active for ~ 1 month
  - Working groups are being formed
  - Coordination with accelerator is being defined