Nov. 5 , 2015

BSM Discussion Session Introduction

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MEXT's ILC Review

MEXT = Japan's **M**inistry of **E**ducation, **C**ulture, **S**ports, **S**cience and **T**echnology

MEXT's ILC Review

Oct., 2013: Japanese HEP community filed a petition for the Japanese government to invite the ILC to Japan. → ILC became a project officially recognized by the government.

May 8, 2014: An Advisory Panel including external members under MEXT's ILC TF started the official review process!

MEXT's ILCTask Force

Established in May 2014

ILC Advisory Pannel (2014-5-1→2016-3-31: extensible if needed)

consisting of 13 academic experts from various fields

Research Contract on Survey of spin-off effects

Nomura Research Inst.

Particle and Nuclear Physics WG

Review ILC physics case, taking into account other HEP projects

15 from HEP(th/exp), nucl. phys., astronomy, CR research

Established in June 2014

TDR Validation WG

Evaluate ILC TDR from technical point of view (mostly on accelerator)

10 members, essentially all accelerator physicists

Established in June 2014

Particle and Nuclear Physics WG had 8 meetings and TDR validation WG had 6 meetings before producing their reports to the ILC Advisory Panel in March 2015. *The ILC advisory panel then published* ***an interim summary of discussions on Aug. 5, 2015***.

Summary of the ILC Advisory Panel's Discussions to Date

The ILC Advisory Panel

Official English version available from

http://www.mext.go.jp/component/b_menu/shingi/toushin/__icsFiles/afieldfile/2015/08/05/1360596_3.pdf

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3. Recommendations

Based on the investigations and reports by the working groups and discussions by the advisory panel, the panel recommends the following on the ILC project;

Recommendation 1: The ILC project requires huge investment that is so huge that a single country cannot cover, thus it is indispensable to share the cost internationally. From the viewpoint that the huge investments in new science projects must be weighed based upon the scientific merit of the project, a clear vision on the discovery potential of new particles as well as that of precision measurements of the Higgs boson and the top quark has to be shown so as to bring about novel development that goes beyond the Standard Model of the particle physics.

- The objective of the ILC project is to uncover physics beyond the Standard Model through the precision measurements of the Higgs boson and top quark and through searches for new particles. In case of new discoveries beyond the Standard Model, its scientific impact on elementary particle physics will be significant.
- As the ILC project requires huge investment, it is indispensable and essential prerequisite for the implementation to have a clear vision of participation and cost sharing by international partners including European countries and the United States while taking into account mid-term and long-term domestic economic and financial situations.
- From the viewpoint the huge investments in new science projects must be weighed based upon the scientific merit of the project, it is necessary to have a clear strategy of the discovery potential of new particles such as supersymmetry particles which are considered as a candidate of the dark matter, in addition to that of precision measurements of the Higgs boson and top quark, has to be shown so as to bring about novel development that goes beyond the Standard Model.
- It is appropriate to proceed discussion on a possible international cost sharing scheme of the ILC project by not only taking into account the scheme used by CERN but also taking into account the schemes of existing large scale international projects such as the International Thermonuclear Experimental Reactor (ITER) and International Space Station (ISS).

Recommendation 2: Since the specifications of the performance and the scientific achievements of the ILC are considered to be designed based on the results of LHC experiments, which are planned to be executed through the end of 2017, it is necessary to closely monitor, analyze and examine the development of LHC experiments . Furthermore, it is necessary to clarify how to solve technical issues and how to mitigate cost risk associated with the project.

- The specifications of the performance and the scientific achievements of the ILC project depend on the results of LHC experiments in the 13TeV run which is currently going on through the end of 2017. Especially whether new particle(s) can be found or not, and what their mass value(s) would be in case of the discovery, will provide important viewpoint for the judgement.
- It is important to show a clear outlook to address technical and cost issues pointed out at the working group discussions.
- It is recommended to further enhance the maximum efforts to incorporate technology development that can improve the accelerator performance.

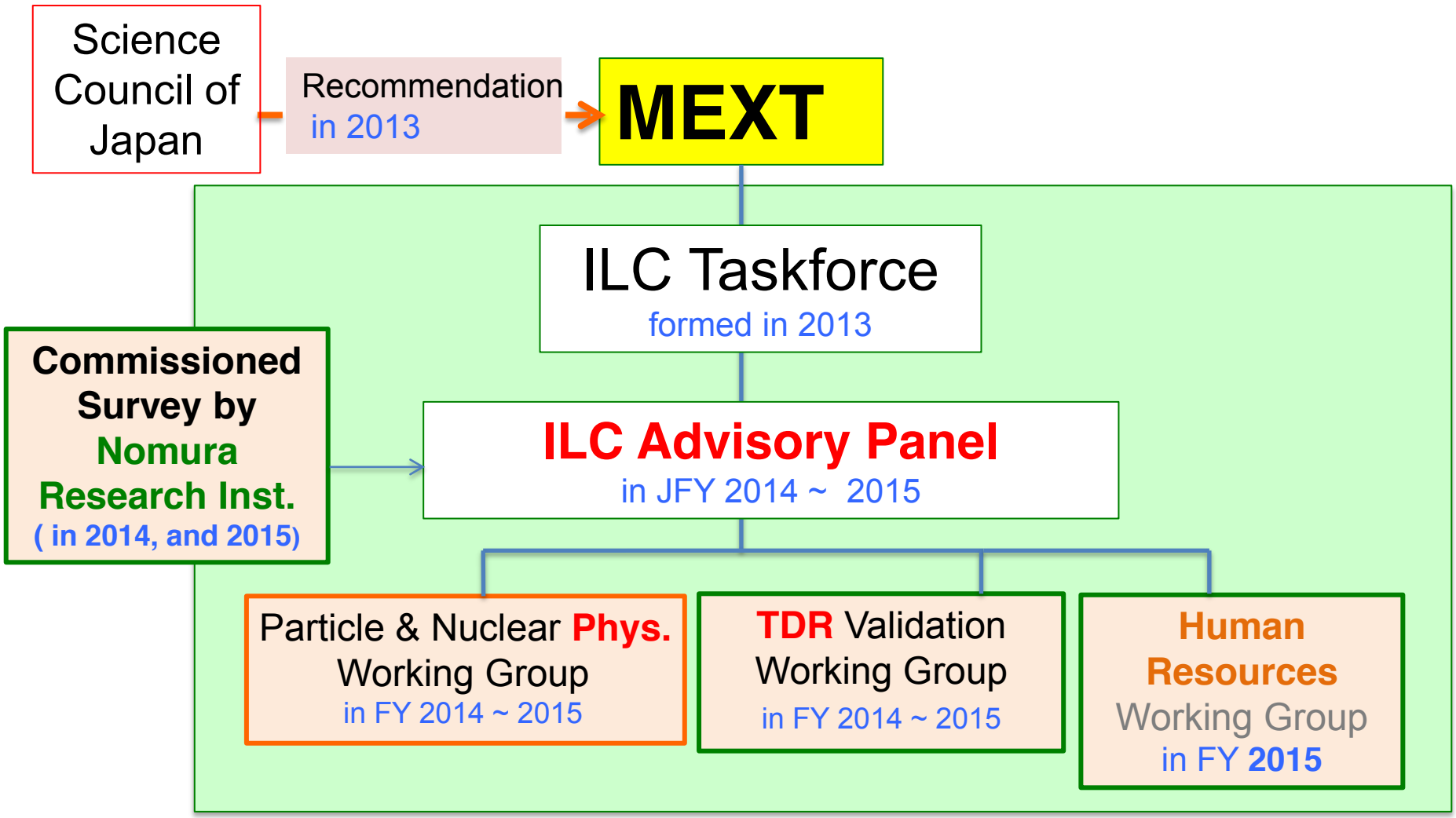
Recommendation 3: While presenting the total project plan, including not only the plan for the accelerator and related facilities but also the plan for other infrastructure as well as efforts pointed out in Recommendations 1 & 2, it is important to have general understanding on the project by the public and science communities.

5. Future prospects of the investigation

- We will set up another working group to investigate the issue of necessary human resources and their cultivation.
- We will commission another survey using an external research agency in order to understand the world trends in technology issues related to accelerator construction, and in approaches to reduce the production cost of accelerators.

The Position of MEXT and the Japanese Government towards the ILC

ILC being studied officially by the MEXT Japan



Actions to be taken

- LCB and ICFA agreed to send explanations on the following three points to the ILC Panel. Draft has been submitted from the Japanese community to LCB.
  - **… a clear vision on the discovery potential of new particles …**
  - **… It is appropriate to proceed discussion on a possible international cost sharing scheme of the ILC project …**
  - **… solve technical issues and how to mitigate cost risk associated with the project. …**
- **… it is necessary to closely monitor, analyze and examine the development of LHC experiments.**
  - Surely will do.
- **… general understanding on the project by the public and science communities.**
  - Public relation will be reinforced by KEK and AAA.
  - Discussions with scientists of the other fields have been undertaken.

Letter from ICFA to the ILC Advisory Panel of MEXT

Since the "Interim Summary" was translated in English for the international community, and there are so many open issues raised in this Summary, ICFA decided to write a letter to the Panel.

The Panel opened the Summary of their discussions but they did not ask anything to the international community, the purpose of the ICFA letter is just to clarify and to explain the issues raised in the Summary. KEK and Japanese ILC community is preparing the daft in cooperating with LCC and LCB.

Panel made recommendations to MEXT, not us!

0) Preface (based on request from KEK DG)

Appreciation of Panel's work

"First of all, we would like to express our profound gratitude to the members of the ILC Advisory Panel for seriously considering, in response to a request from the Japanese government, the various issues concerning the hosting of ILC in Japan, which is being promoted by the international community of elementary particle physicists. ….."

High-brow discussions on scope of our field beyond the Panel's Report

Social effects of fundamental science like ILC and the role of ICFA

Composition of this document

1） Science Significance and Potential for Discovering New Particles

(Follow the Panel's discussions ….. repeat positive paragraphs in their Report)

Particle Physics: Current Status, Issues, and Goals

Higgs boson and top quark

Potential for Discovering New Particles (three cases based on the Panel's Summary)

- No discoveries of new particles at LHC Experiments
- LHC experiments discover light new particles
- LHC experiments discover heavy new particles

Draft if now sent to LCC Physics WG for comments

2） Accelerator technology

General Response to Technical Recommendation

"It is necessary to clarify how to solve technical issues and how to mitigate cost risk associated with the project."

Comments to the issues presented at the "TDR Validation Working Group".

3） Comparison of Organizational Models of International Projects in vie of the ILC Application

Response to the following explicite paragraph in the "Recommendation 1"

"It is appropriate to proceed discussion on a possible international cost sharing scheme of the ILC project by not only taking into account the scheme used by CERN but also taking into account the schemes of existing large scale international projects such as the International Thermonuclear Experimental Reactor (ITER) and International Space Station (ISS)."

Comments from ICFA is based on "Project Implementation Planning"

Guideline

1. Start from the basic points made in the interim summary.
2. Reemphasize the importance of precision studies of the Higgs boson and the top quark.
3. Accept the questions asked by the MEXT panel as they were formulated:
   What if the LHC finds no new particles?
   What if the LHC finds relatively light new particles?
   What if the LHC finds heavy new particles?
4. Try to answer these questions as straightforwardly as possible.

Main Body

1. Particle Physics: Current Status, Issues, and Goals

2. The Higgs Boson and the Top Quark

3. Potential for Discovering New Particle

Difference between LHC and ILC

3-1) No discoveries of new particles at LHC Experiments

Dark matter
SUSY
Mechanism for EWSB (self-coupling)

3-2) LHC experiments discover relatively light new particles

SUSY
Dark matter / Mechanism for EWSB (self-coupling)

3-2) LHC experiments discover heavy new particles

SUSY
Composite Particles
Particles that mediate a new force
Dark matter / Mechanism for EWSB (self-coupling)

Draft if now with LCC Physics WG for comments

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Mid term Action Plan

A Report on

Prospects for New Particle Discovery Potential

Contents: Prospects for new particle discoveries at ILC
Target: MEXT Expert Panel (official name: MEXT ILC Advisory Panel)
Length: ??
Deadline: Summer 2016
Purpose: Backup the short report with updates taking into account LHC Run II development (as recommended by MEXT)

Plan

Report to be based on a ILC-LHC comparison table of discovery potential

Structure of the table

Typical discovery scenarios in Y-axis

- SUSY (subdivision such as Bino-, Wino-, Higgsino-LSP, as needed)
- Minimal Composite Higgs Models (subdivision as needed)
- Dark matter particles

Discovery channel/method in X-axis

- Precision Higgs measurements
- Precision top measurements
- Indirect searches (other than H and t)
- Direct searches

Each cell

Prospects at ILC (depending on 13TeV LHC results)

Key message to deliver

There are other important kinds of discovery than new particle discovery!

Classification of Parameter Space

(a) Both ILC and 13TeV LHC can access some new particle(s)
(b) Only 13TeV LHC can access some new particle(s)
(c) Ony ILC can access some new particle(s)
(d) Neither ILC nor 13TeV LHC can access any new particle

Need to decide we make a table for each of the 4 cases or combine some of the cases such as (a,b)(c,d) or (a,c)(b,d)

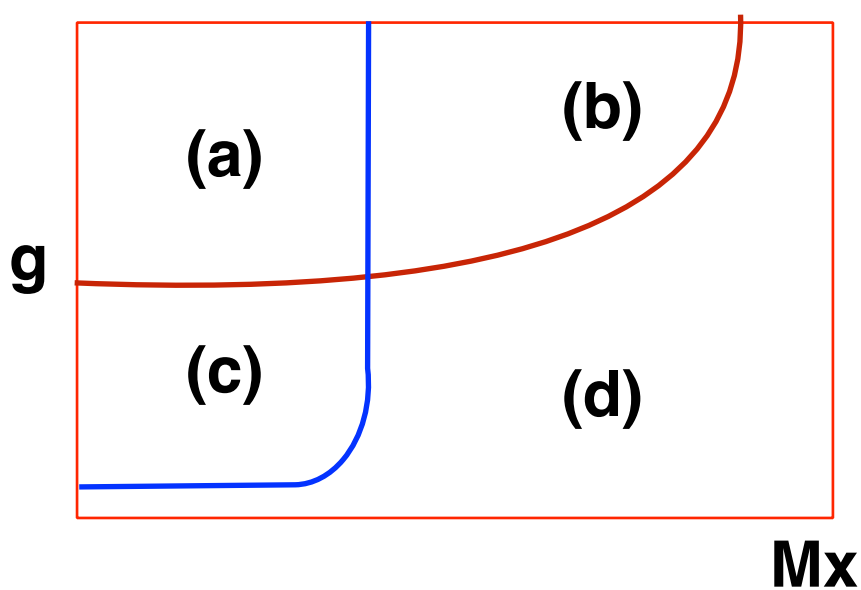
Key point:

- LHC-ILC synergy (in reconstructing Lagrangian in particular when some new particles are found)
- What will ILC's precision bring to us (even when the new particle is beyond the ILC's reach)

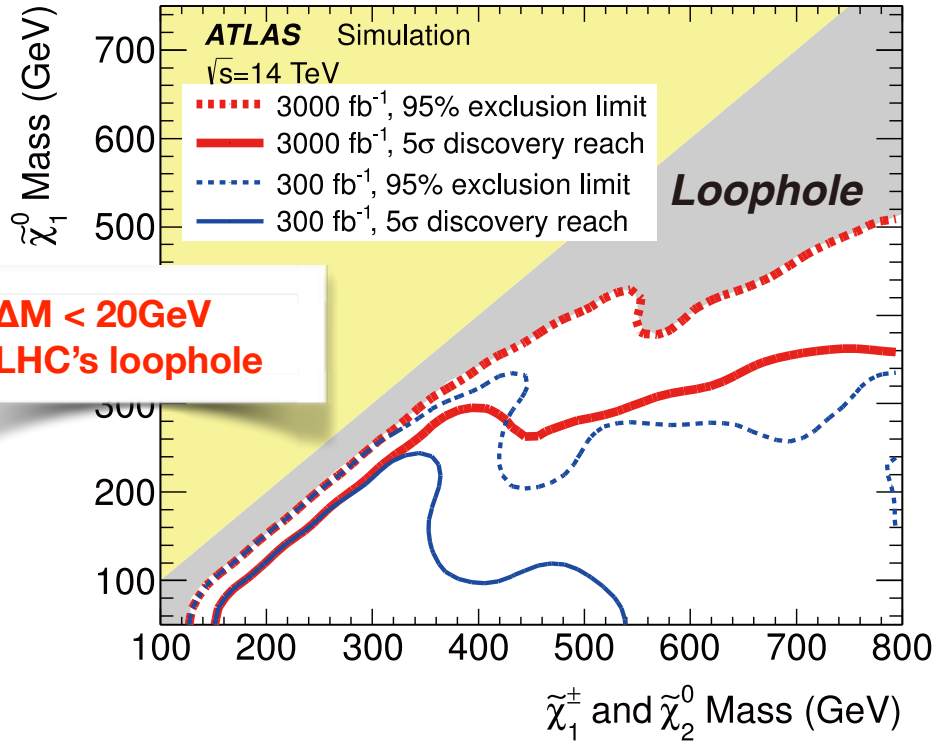
Visualization of Parameter Space

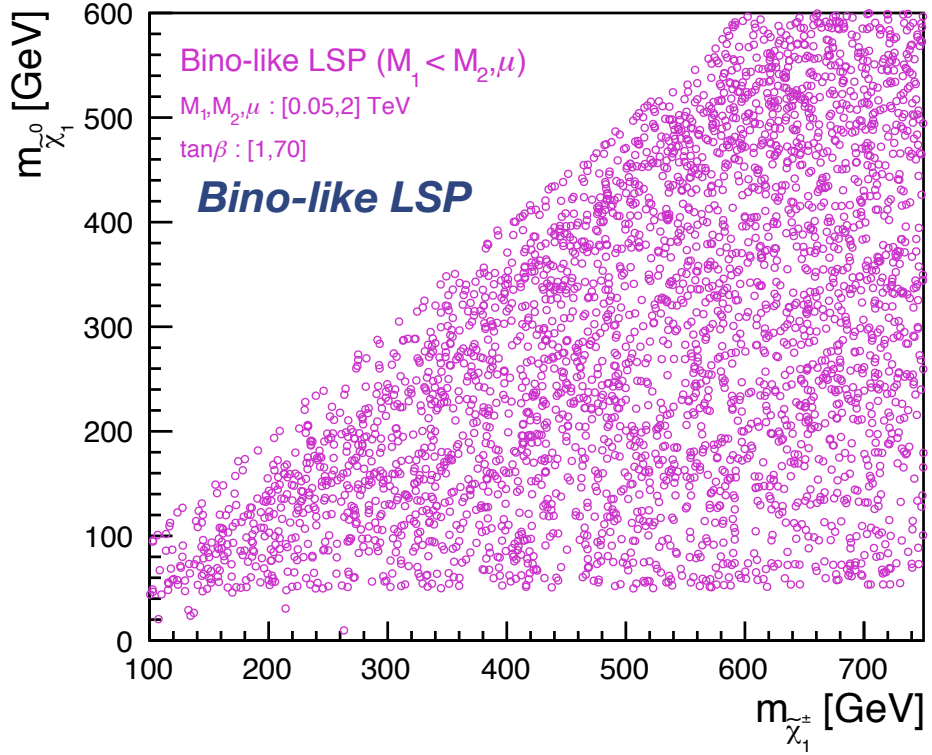
Although the measure in the parameter space is unknown a priori it may help show prospects.

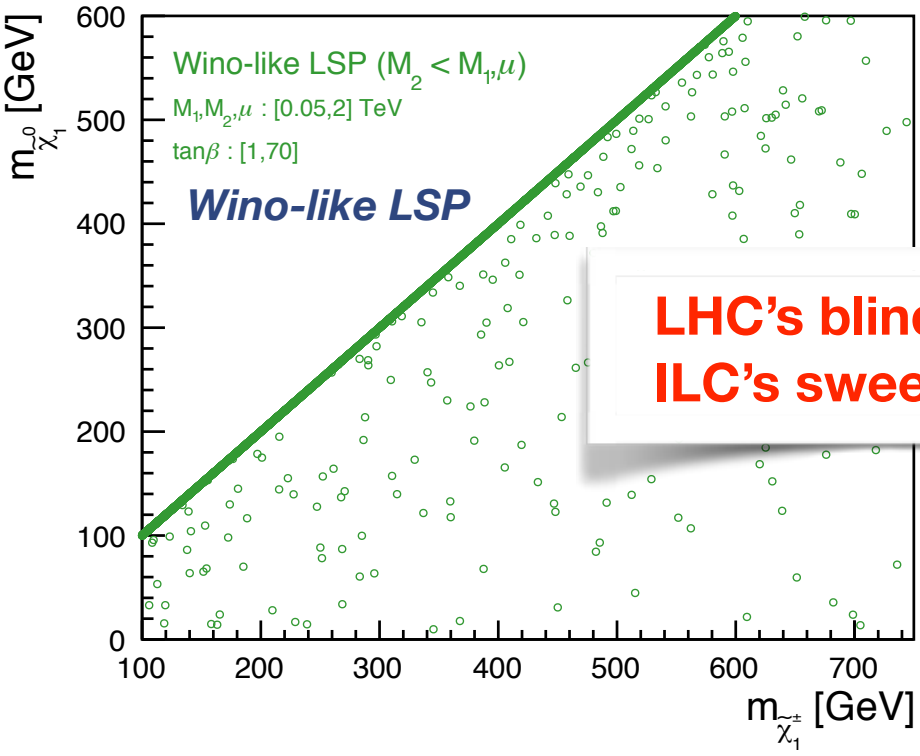
e.g.)



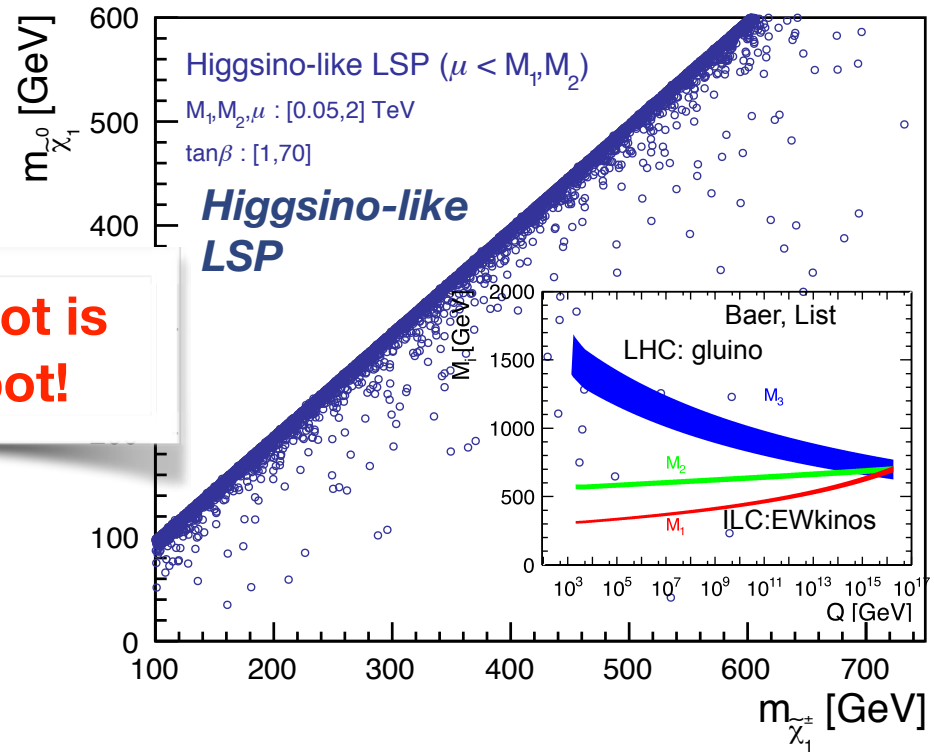
Chargino Search







LHC's blind spot is ILC's sweet spot!

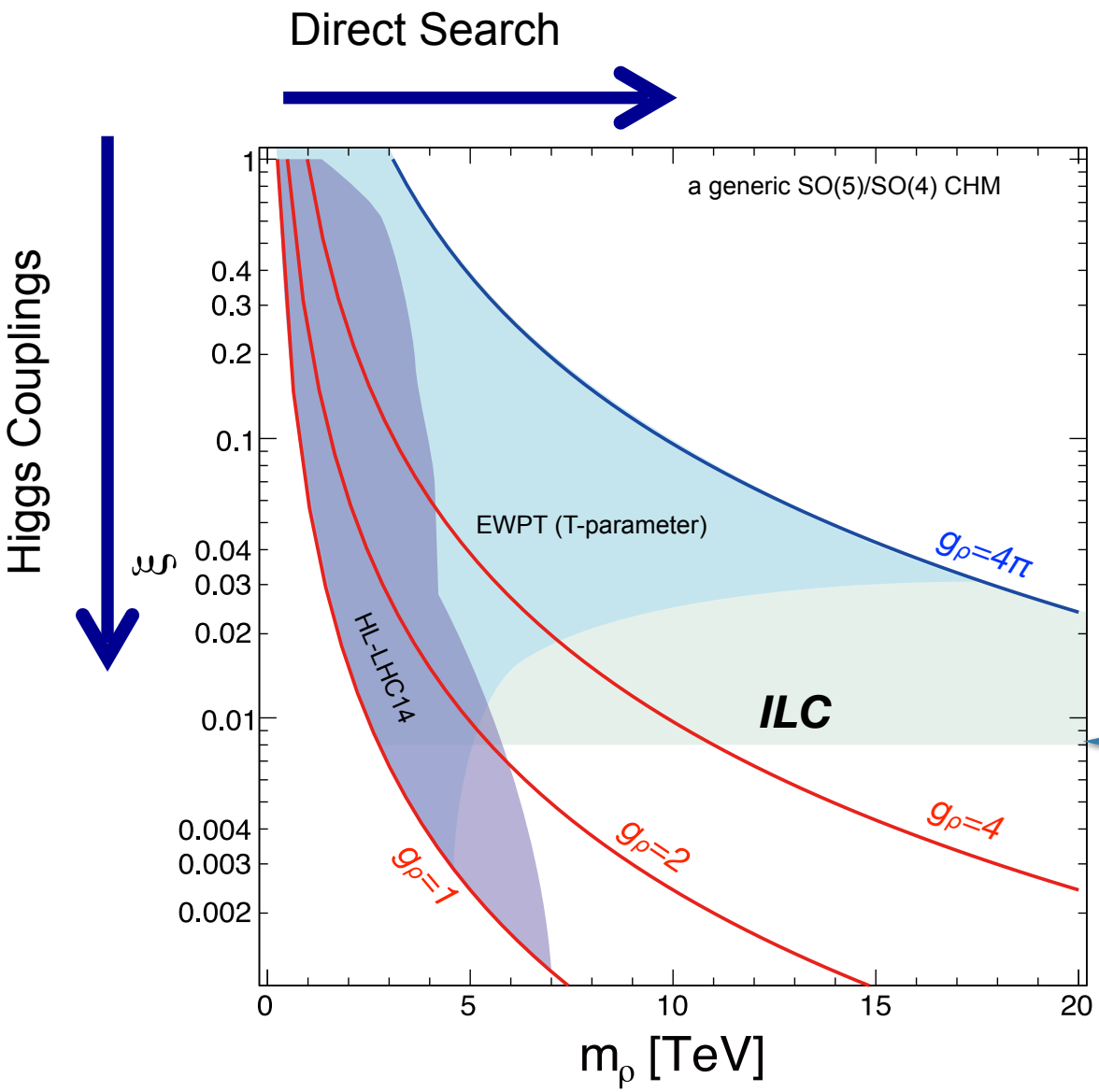


Composite Higgs: Reach

Complementary approaches to probe composite Higgs models

- Direct search for heavy resonances at the LHC
- Indirect search via Higgs couplings at the ILC

Comparison depends on the coupling strength (g_*)



Based on Contino, et al, JHEP 1402 (2014) 006
Torre, Thamm, Wulzer 2014
Grojean @ LCWS 2014

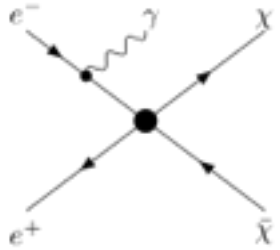
$$\xi = \frac{g_\rho^2}{m_\rho^2} v^2 = \frac{v^2}{f^2}$$

$$\frac{g_{hVV}}{g_{h_{\rm SM}VV}} = \sqrt{1-\xi}$$

ILC (250+500 LumiUP)

$$\Delta \frac{g_{hVV}}{g_{hVV}} = 0.4\%$$

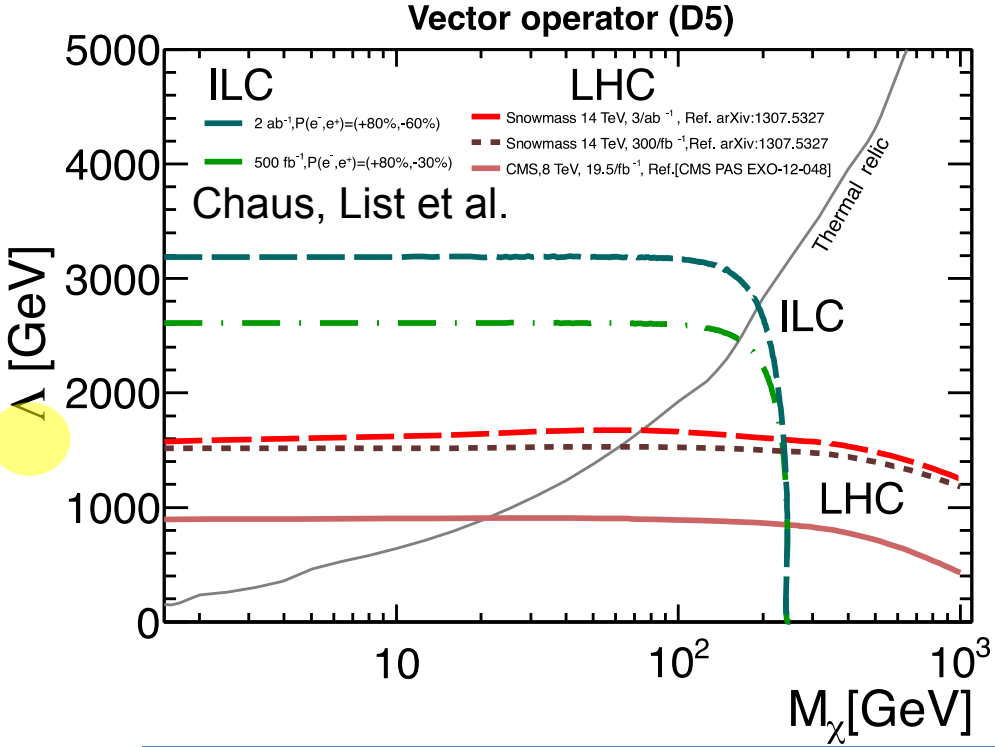
DM: Effective Operator Approach

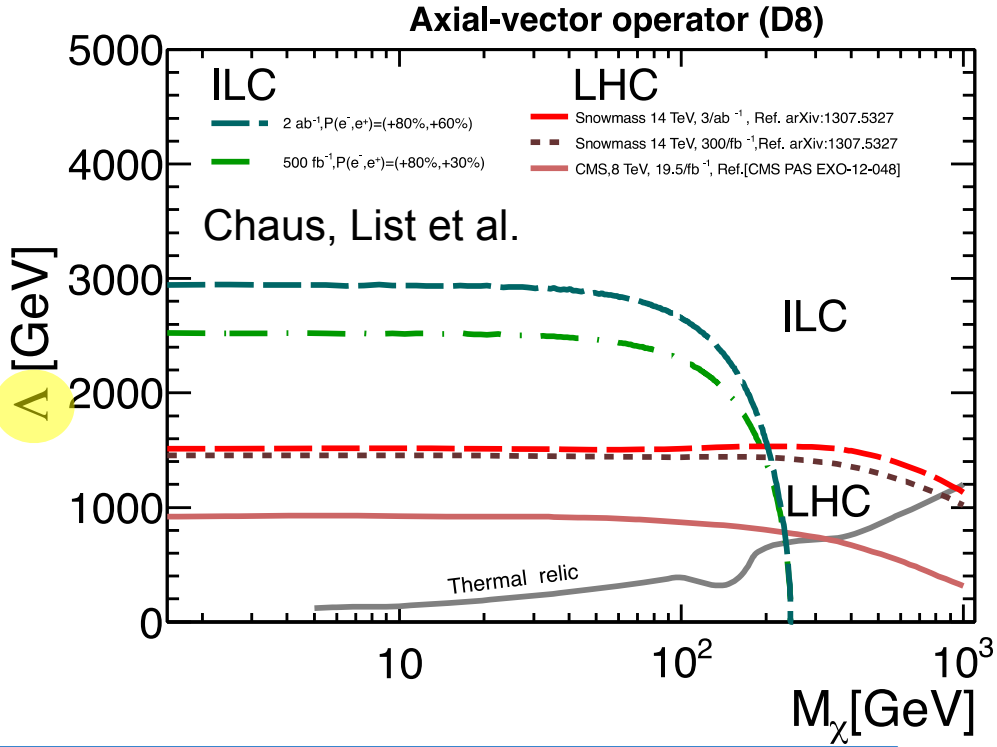


$$\mathcal{L}_{\rm int} = \frac{1}{\Lambda^2}\mathcal{O}_i$$

$$\mathcal{O}_V = (\overline{\chi}\gamma_\mu\chi)(\overline{\ell}\gamma^\mu\ell)$$

$$\mathcal{O}_A = (\overline{\chi}\gamma_\mu\gamma_5\chi)(\overline{\ell}\gamma^\mu\gamma^5\ell)$$





LHC sensitivity: Mediator mass up to Λ~1.5 TeV for **large DM mass**

ILC sensitivity: Mediator mass up to ***Λ~3 TeV*** for ***DM mass up to ~√s/2***

⇨ ***LHC-ILC synergy!***

If Some New Physics Signal Seen at 13 TeV LHC

	Precision Higgs	Precision Top	Other Indirect Methods	Direct Searches
SUSY				
Compositeness				
DM				
…				

If No New Physics Signal Seen at 13 TeV LHC

	Precision Higgs	Precision Top	Other Indirect Methods	Direct Searches
SUSY				
Compositeness				
DM				
…				

We need physics studies that backup the table

→ We need some more studies to make it fully convincing.

→ Form a team for each row (=discovery scenario)

Parameter space analysis, visualization, preparation of contents in each cell

→ DM study on going led by Shigeki Matsumoto

→ Contact phenomenologists working on LHC physics and ask if they can also investigate prospects at ILC.

→ A core team collect information and make the table.