Status of BSM Study Group

ILD Software and Analysis Meeting
July 13, 2016

Jacqueline Yan (KEK)

On behalf of the ILC BSM study group

Goal of BSM Study Group

Provide a clear vision on the discovery potential of new physics at the ILC

Without overlap with Higgs and Top groups

- **Direct search for new particles** *complementary to the LHC*
- **indirect search through precision measurements of SM physics (Higgs boson and top quark couplings, 2-fermion processes)**

BSM Study Group Organization

- Recently held ILD physics convener's meeting to categorize various studies
  Details coming up

<Mailing list>

(1) **Mailing list for BSM sub-group**

- anyone can ask to be included by sending "SUBSCRIBE ild-physics-bsm firstname lastname" to sympa@desy.de
- wait for OK from administrators (Mikael, Jackie)
- list to be used by people actually working on ILD BSM analyses (and supervisors)

(2) **mailing list of ILD physics WG conveners + physics coordinator and deputy**
ild-physics-conveners@desy.de

- For communication among conveners
- Please send talk requests to this mailing list

Ongoing studies in this group

Manpower welcome in both untouched and ongoing studies

analysis main person		topic	sqrt(s) [GeV]	detector sim	Status/ comments
Hale Sert, Yorgos Voutsinas	DESY	Light Higgsinos, dM <= 1 GeV	500	SGV/ FullSim	Paper published (Hale Sert) Eur.Phys.J. C73 (2013) no.12, 2660 Yorgos working on reconstruction of low momentum particles
Jacqueline Yan Tomohiko Tanabe	Tokyo/ KEK	Radiative Natural SUSY dM = 15-20 GeV	500	FullSim	Ongoing Input for Suvi's theoretical studies
Tomohiko Tanabe/ Moritz Habermehl	Tokyo/ DESY	WIMPs	350 / 500	FullSim	Ongoing Include systematics
Mikael Berggren	DESY	Sleptons, reco and disc. reach	500/ ...	SGV	Paper published in Eur.Phys.J. C76 (2016) no.4, 183 Moving towards FullSim and other channels than sleptons
Madalina Chera	DESY	SUSY Point 5 chi->Z/ W->qq	500	FullSim & SGV	ongoing
needed		fermion pair production	500	Full Sim	

Domestic movements: **plan to submit a document to the MEXT (ILC Advisory Panel) to demonstrate the potential for new physics discovery at the ILC**

Follow up to the ICFA letter

A Report on

Prospects for New Particle Discovery Potential

From slides of K. Fujii

by the end of this summer

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

From slides of K. Fujii

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!

New Physics Discovery at LHC ?
Prepare for both scenarios (yes and no)

If Some New Physics Signal Seen at 13 TeV LHC

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

Completion of this table is the near future goal

If new physics signals seen / not seen at 13 TeV LHC

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

Active participation in many of these cells

However much remains to be done (analysis, software, theoretic studies)

We need to start working here

We need physics studies that backup the table and make it fully convincing.

- **Form a team for each row (=discovery scenario)**
- **Prepare contents in each cell**
- **Combined (global) analyses of Higgs/Top/New Physics**
- **Involve theorists**

Additional Materials

BSM Search Strategy at ILC

Focus on three cases based on the results of the (HL)-LHC:

Case 1: No discovery at LHC

- SUSY: Discovery anticipated for light SUSY particles (e.g. Higgsino)
- Dark Matter: Discovery anticipated for DM that can be seen at the ILC
- Precision measurements might give first discovery of new BSM interactions

Case 2: LHC discovers light new particles (can be seen at the ILC)

- SUSY: ILC will probe the new particles in detail; may discover more.
- Dark Matter: ILC will address the question of whether any of the new discovered particles is DM
- Precision measurements sensitive to heavy particles beyond LHC reach.

Case 3: LHC discovers heavy new particles

- SUSY: It is probable that ILC will discover new light particles.
- Dark Matter: Same as in Case 2, via measurements of the new light particles.
- Precision measurements test if there are additional heavy particles beyond the LHC reach.

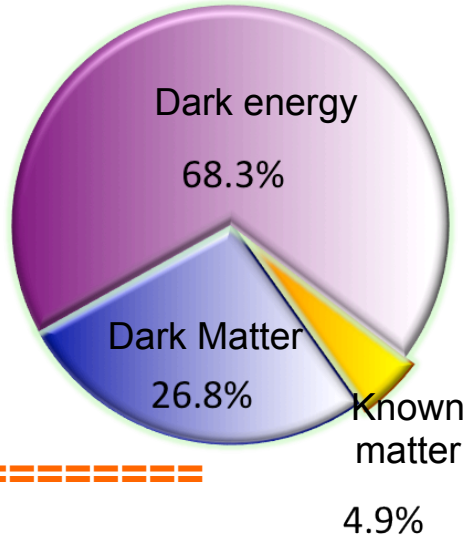
From slides of T. Tanabe

Dark Matter Search at the ILC

Production, discovery, and detailed study of DM (WIMP) is anticipated at the ILC

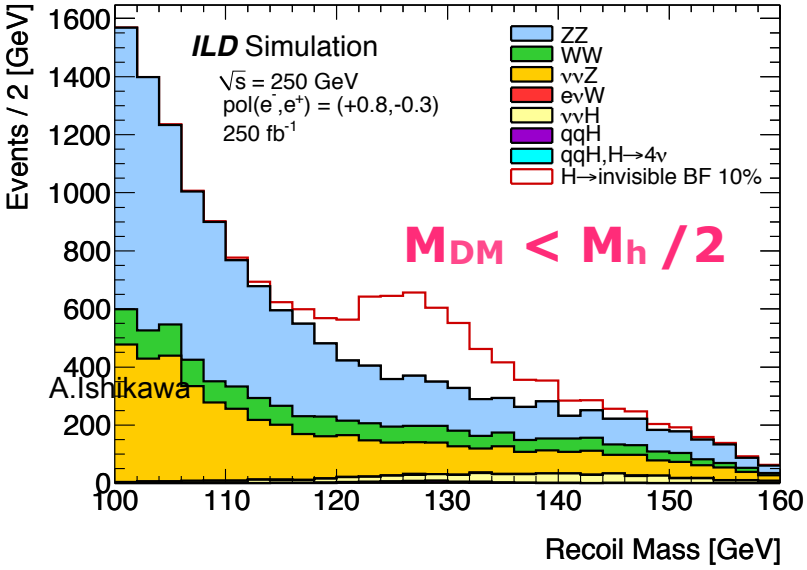
at ILC energy lightest SUSY particle is strong DM candidate

➔focus on SUSY signals (light Higgsinos, light stau)



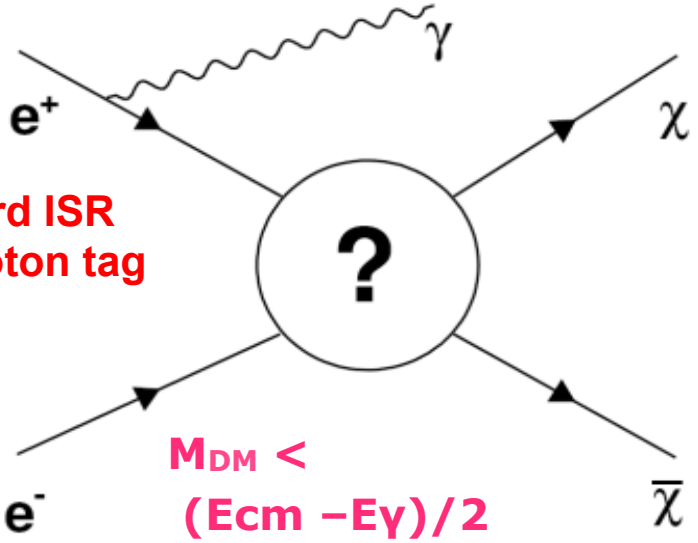
========== *Activities by Asian groups* ==========

Higgs Invisible Decay



A. Ishikawa, J. Tian et al

Monophoton Search

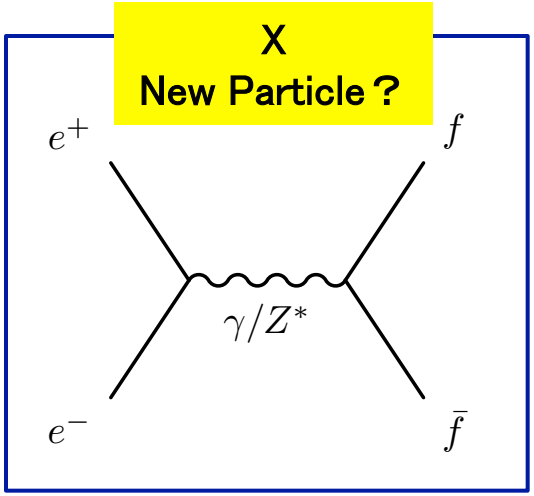


If BR(H->invis) deviate from SM →BSM

BR(H→invis.) < 0.4% at 250 GeV, 1150 fb^{-1}

T. Tanabe et al

Search for new interaction forces : 2–fermion processes and top precision measurements



Measure the effect of new forces on SM physics

e.g. heavy gauge boson Z'

LHC: direct search

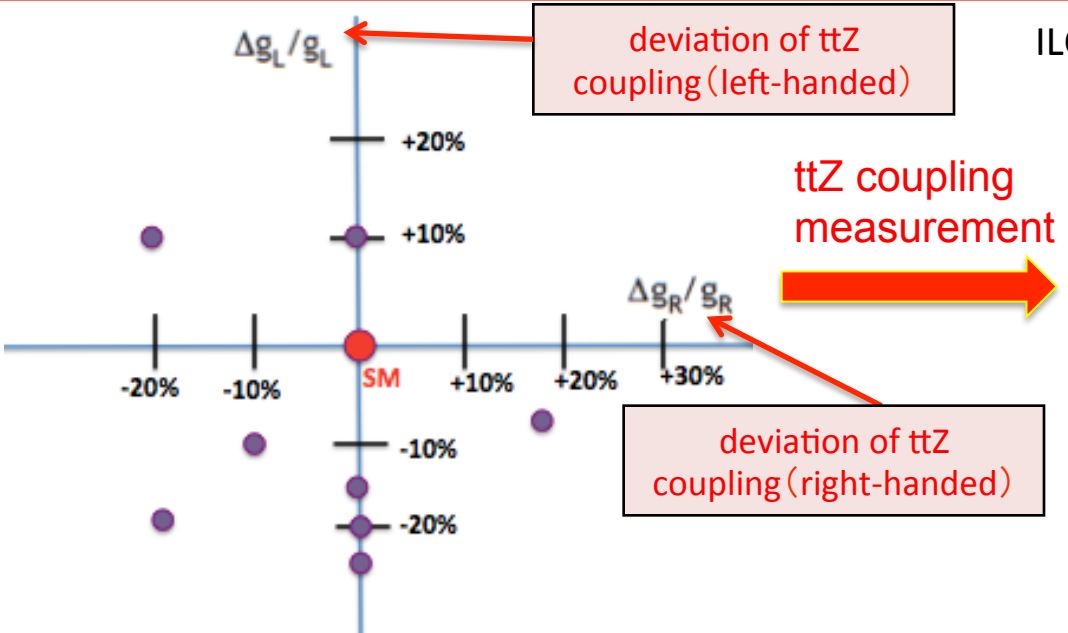
ILC: determine new physics model using precise coupling measurements

f = top quark, leptons, etc..
X = Z', KK graviton, etc…

example) **deviation of top quark coupling from SM signifies new physics**

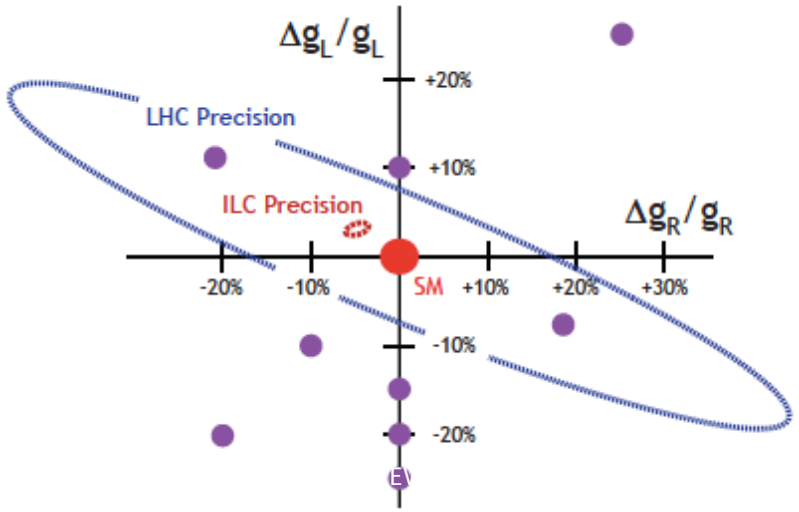
Top coupling anomalies for various new physics models （energy～1 TeV）

Beam polarization is a MUST

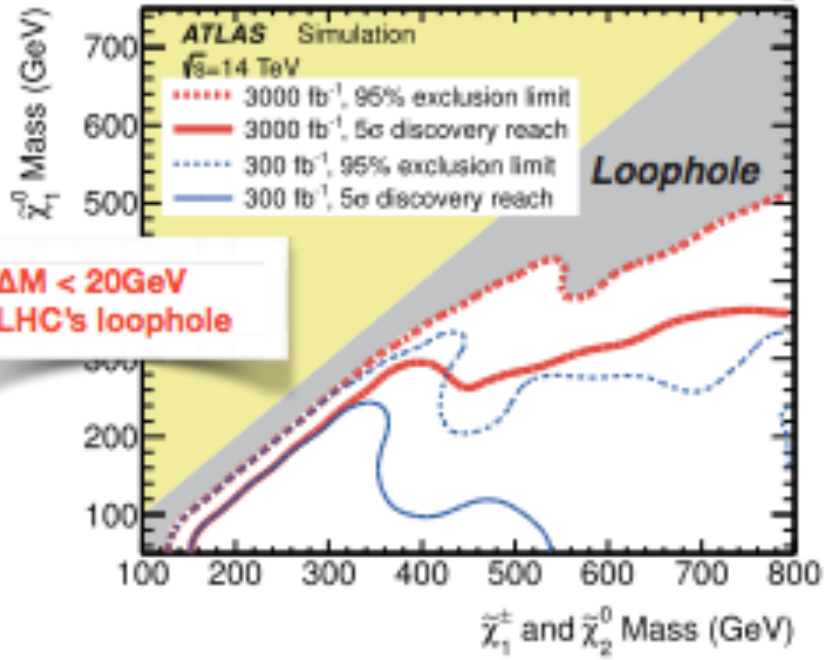


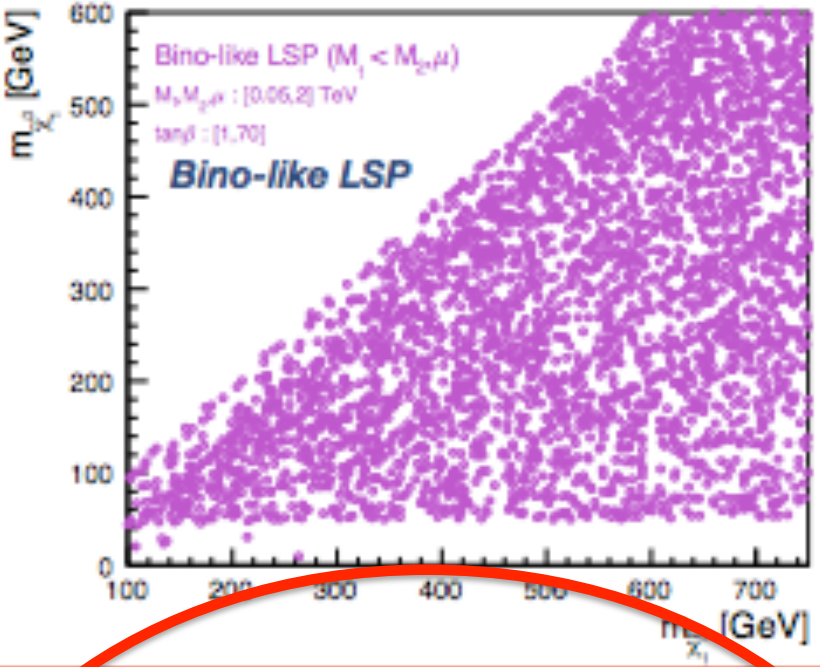
ttZ coupling measurement

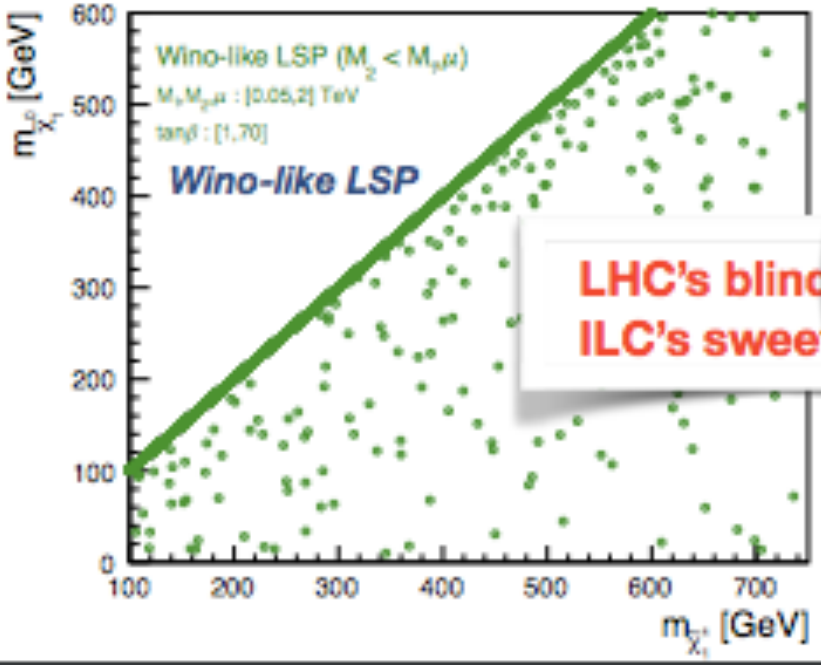
ILC can exclude more models than LHC (68% CL)



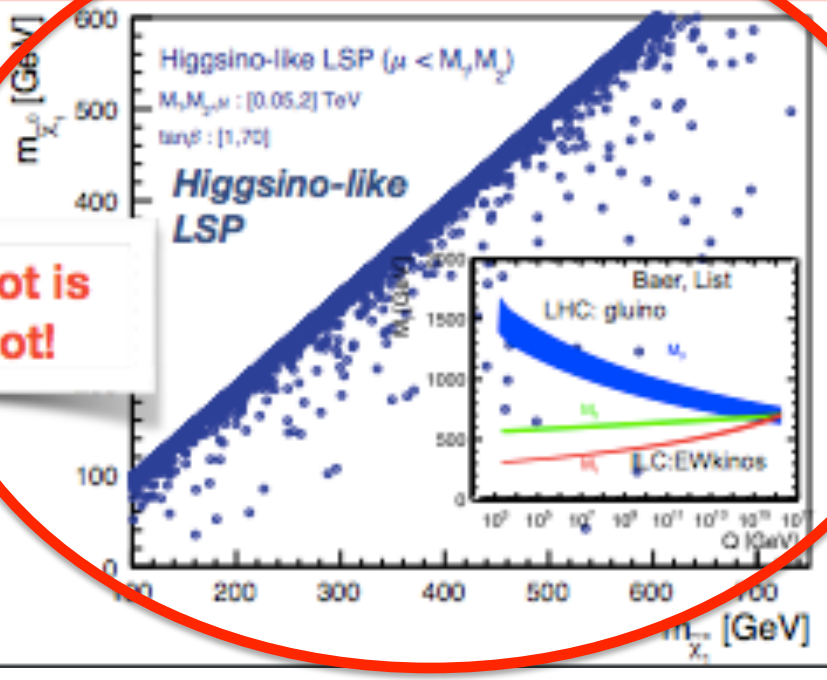
Chargino Search



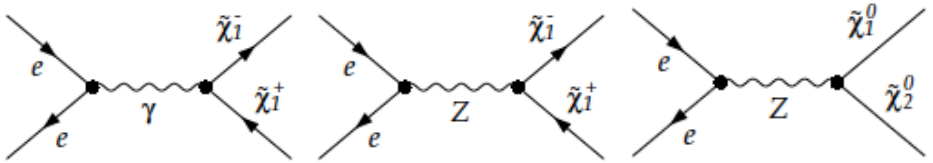




LHC's blind spot is
ILC's sweet spot!



Goal of Light Higgsino Study



Demonstrate measurement precision of Higgsino masses and production cross sections

Masses and cross sections as input

Determine SUSY parameters
e.g. **M_1, M_2, μ, tanβ**

Why?

- **To get info about unobserved sparticles**
- **To test GUT-scale models**

How?

- **Global χ^2 fit of to observables**

- **Study dependence of cross section on beam polarization**
  → **Determine mixing ratio**
  Higgsino vs. Bino vs. Wino

Study input parameters and required precision for parameter extraction; interplay with Higgs precision measurements

Existing studies

(1) "Tackling light higgsinos at the ILC", M. Berggren et al. [arXiv:1307.3566]
- √s= 500 GeV, ΔM ～1 GeV → use ISR tag, , Based on full ILD simulation

(2) "Physics at a Higgsino Factory", H. Baer et al. [arXiv:1404.7510]
- √s= 250 (340) GeV for ILC1 (ILC2), ΔM = 10-20 GeV, detector effects based on resolution formula

Ongoing studies

Asian group

Light Higgsinos with ΔM= 10 – 20 GeV , J. Yan, T. Tanabe et al
√s= 500 GeV, ΔM ～10-20 GeV , Based on full ILD simulation