LOI Short Talk: Feasibility Study on Probing the Seesaw Mechanism with full detector simulation for 250 GeV ILC

Nobuchika Okada

University of Alabama

In collaboration with

Satomi Okada (U. of Alabama)

Shu Shimomura (Tohoku U.)

Ryo Yonamine (Tohoku U.)

Snowmass EF08: BSM meeting, Oct. 15, 2020

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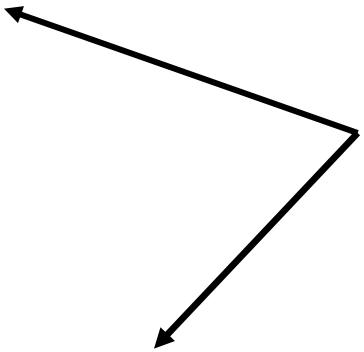

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HEP Ex

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Gauged B-L extended Standard Model

Well-motivated extension to supplement the SM with neutrino masses & flavor mixings

- B-L is the unique anomaly-free global symmetry in the SM
- Gauging the global B-L symmetry may be natural
- Anomaly-free requirement → 3 right-handed neutrinos
- B-L symmetry breaking → Massive Z' & Majorana RHNs
- Seesaw Mechanism for tiny neutrino mass generation

Two cases for B-L charge assignment

Anomaly-free in both cases

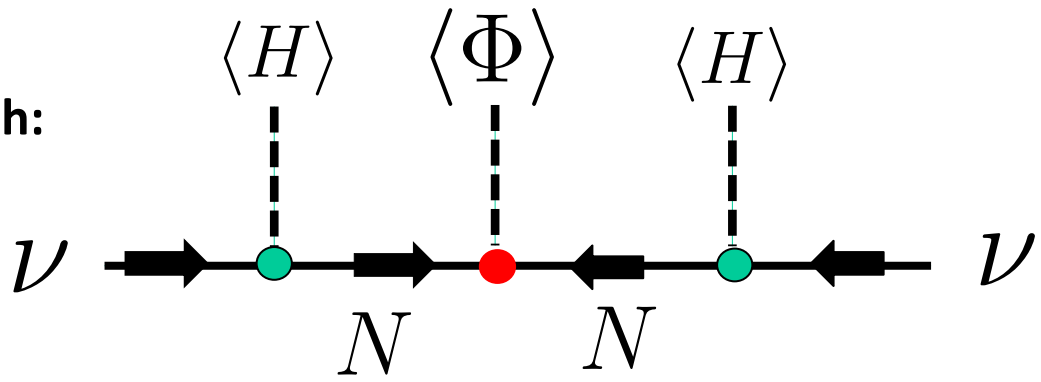
``Standard''

	$\mathrm{U}(1)_{B-L}$
N_R^1	-1
N_R^2	-1
N_R^3	-1

``Alternative''

	$\mathrm{U}(1)_{B-L}$
N_R^1	-4
N_R^2	-4
N_R^3	$+5$

Seesaw Mech:

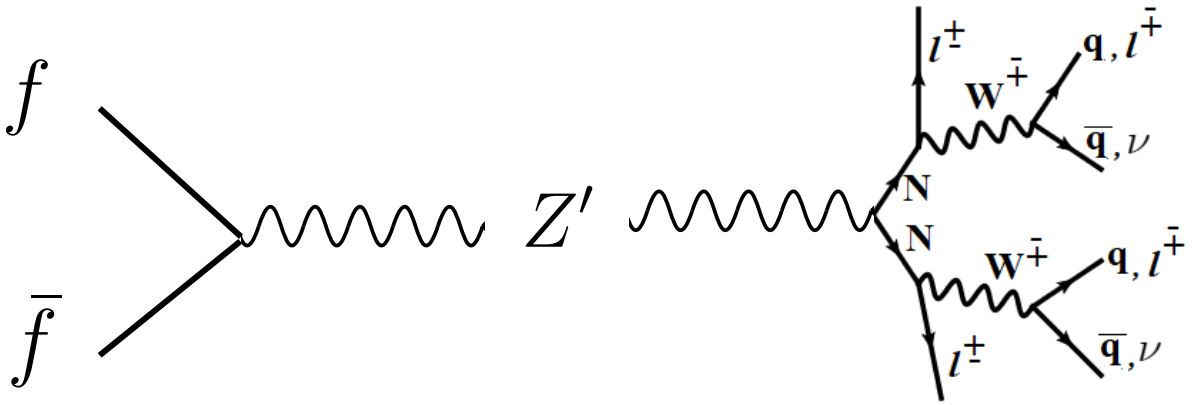


* In the alternative case, the minimal seesaw + Dark Matter
Ref: NO, S. Okada & D. Raut, PRD 100 (2019) 3, 035022

How to probe the Seesaw Mechanism at Colliders?

- RHNs production via Z' boson (B-L gauge interaction)
- ``Smoking-gun signature of the RHNs' Majorana nature

Same sign dilepton+jets



- Hadron Collider: f=q, Z' resonance & decay
- Lepton Collider: f=e, off-shell Z' boson

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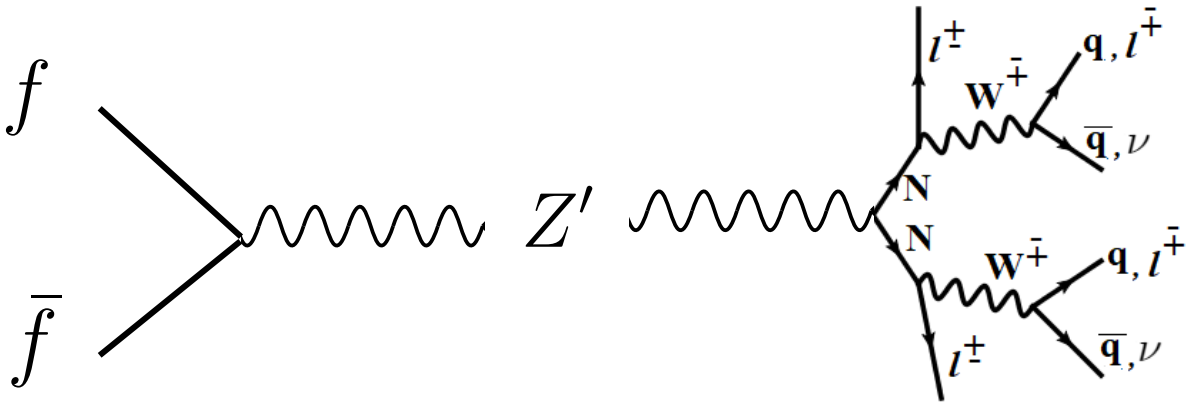
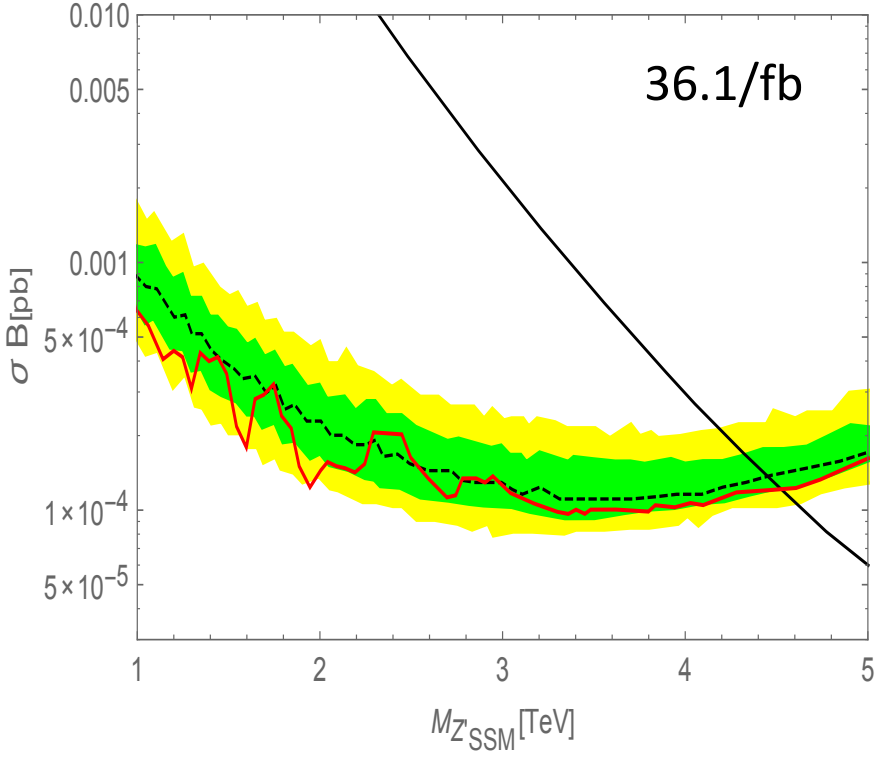


- Hadron Collider: f=q, Z' resonance & decay
- Lepton Collider: f=e, off-shell Z' boson ←This LOI 250 GeV ILC

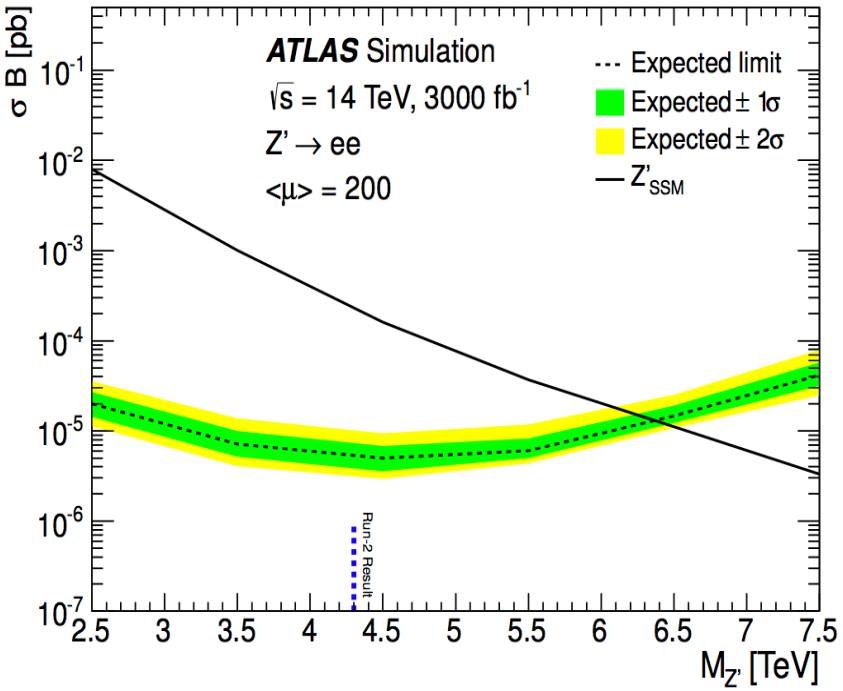
Current Status: LHC constraints

Search for a narrow resonances with dilepton final states
Z' boson constraints from LHC are already very severe

LHC Run-2 (ATLAS)



HL-LHC prospects

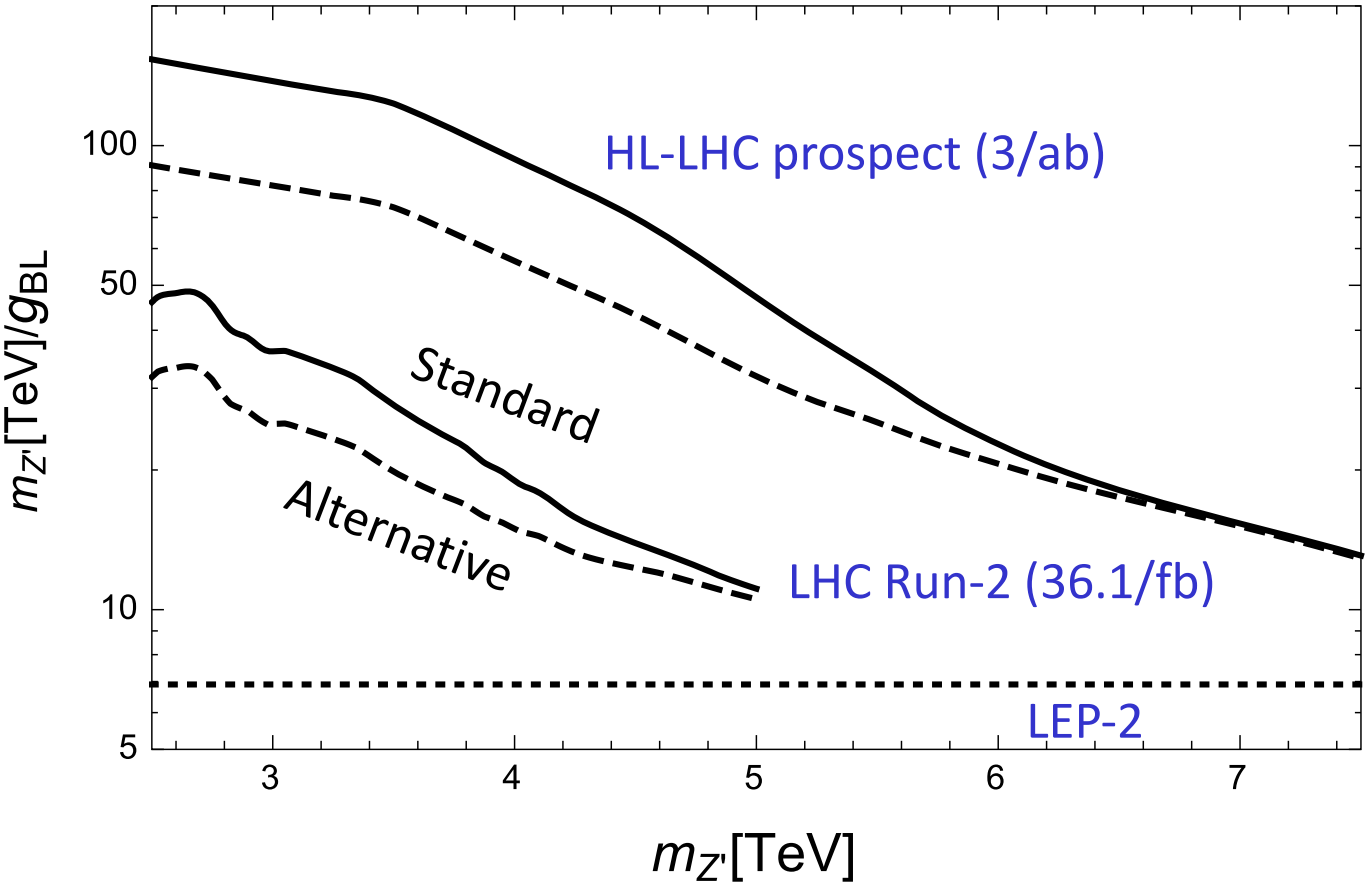


* ATLAS & CMS constraints are consistent

Interpretation of the LHC bounds

Lower bound on B-L VEV

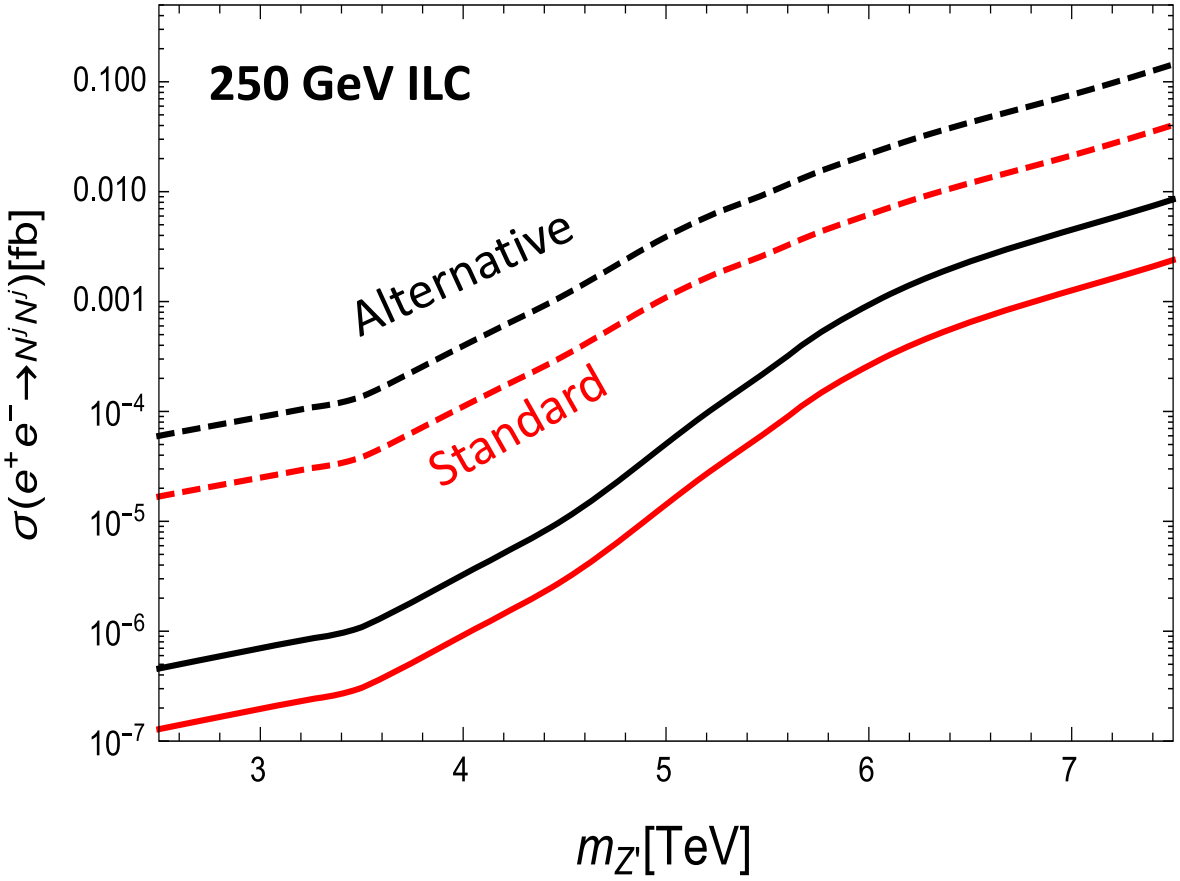
A. Das, NO, S.Okada & D. Raut, PLB 797 (2019) 134849



As Z' boson becomes heavier, the LHC bounds get weaker

If Z' boson is very heavy, the LHC bounds are not severe.
In fact, we can obtain sizable RHN-production cross sections at 250 GeV ILC, while satisfying HL-LHC prospective bound

A. Das, NO, S.Okada & D. Raut, PLB 797 (2019) 134849



RHN mass:
50 GeV

100 GeV

ILC 250 GeV:
2000/fb
goal luminosity

Plan for full detector simulation of 250GeV ILC

We will basically rely on the software framework developed by the ILD collaboration.
This topic may also be interesting for SiD colleagues.

1) Event generation (Signal)

We have worked on ***Physsim*** (https://www-jlc.kek.jp/subg/offl/physsim/) to generate the signal event (RHN pair production), but we encountered a technical problem with tau decays.
—> Fortunately, the latest ***Whizard*** generator (https://whizard.hepforge.org/) can generate Majorana particles and thus we are considering to restart with the ***Whizard***.

※ The ILD collaboration has already generated the SM processes. We could use these samples as our background

2) Full detector simulation, reconstruction, and analyses

ILCSoft (https://ilcsoft.desy.de/portal) provides a full chain of these processes.

- Geant4 based detector simulation
- Realistic event reconstruction, which can be used in the real experiment
  - Isolated lepton finding
  - Charge identification
  - Jet clustering
  - Vertex finding

Currently we have two master students who are interested in this study:
Our plan : One for “same sign leptons” search, another for “displaced vertex” search.