

### Introduction & Model

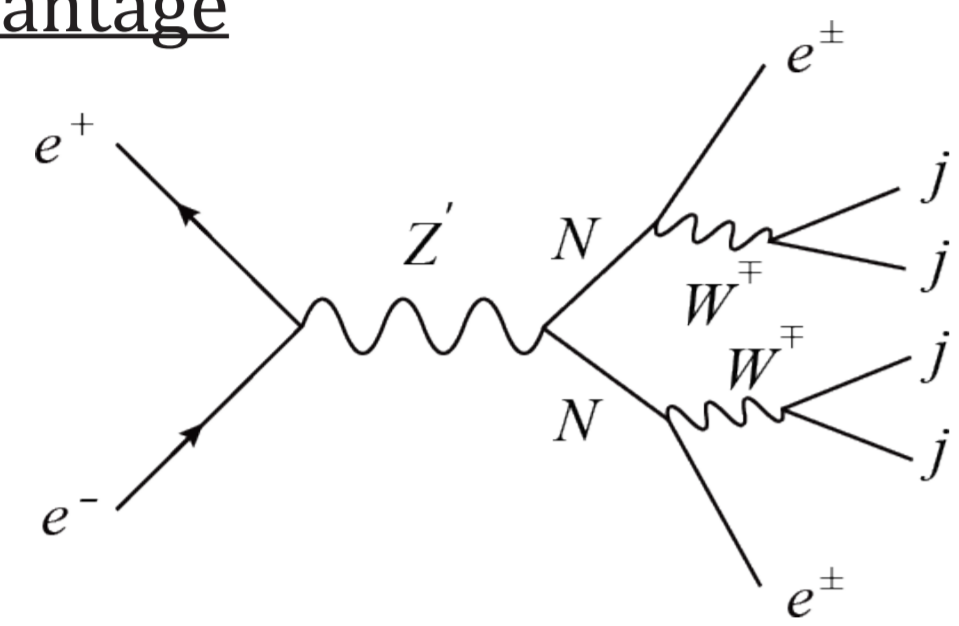
Extending SM with a minimal  $U(1)_{B-L}$  (Baryon - Lepton number) gauge symmetry:

$$G_{B-L} \equiv SU(3)_C \times SU(2)_L \times U(1)_Y \times U(1)_{B-L}$$

- three SM gauge singlet **Majorana Right Handed Neutrinos (RHNs)**
- gauge boson  $Z'$
- explain tiny neutrino mass and mixing

➔ We investigate RHN pair production at ILC 500

Advantage



Lepton number violation is possible

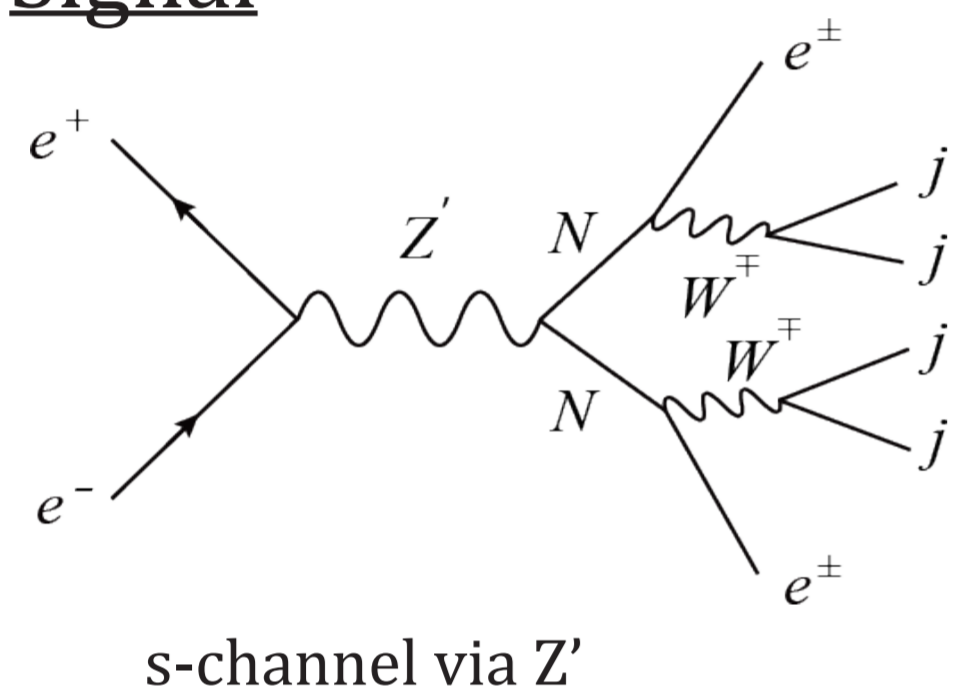
Same sign leptons are possible

very small SM backgrounds

### Signal & Background

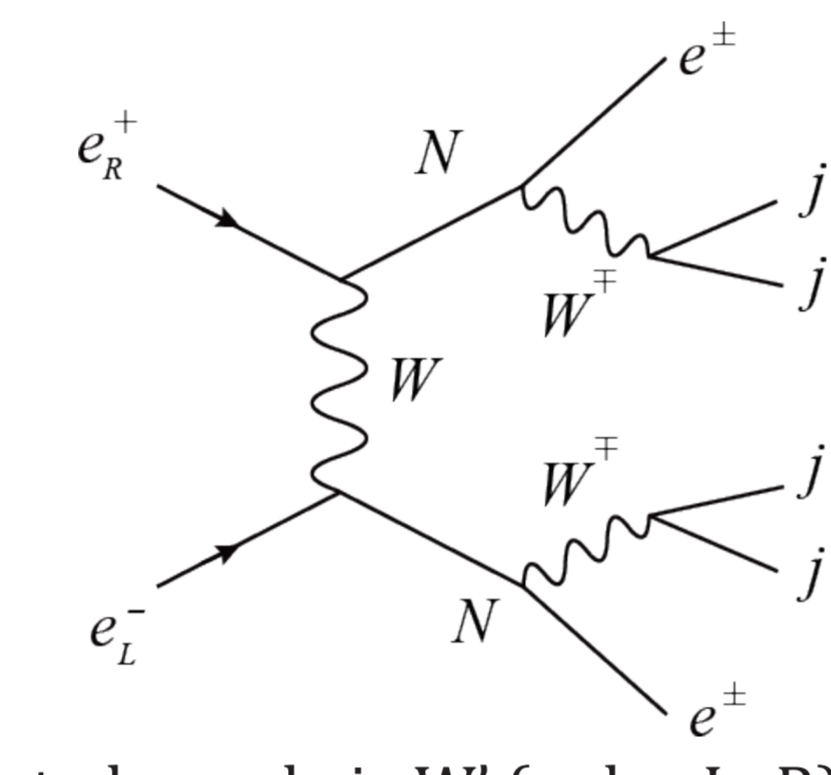
consider the decay of lightest  $N \rightarrow e^\pm W^\mp$ .

Signal



s-channel via  $Z'$

+ Destructive interference



t-channel via  $W$  (only eLpR)

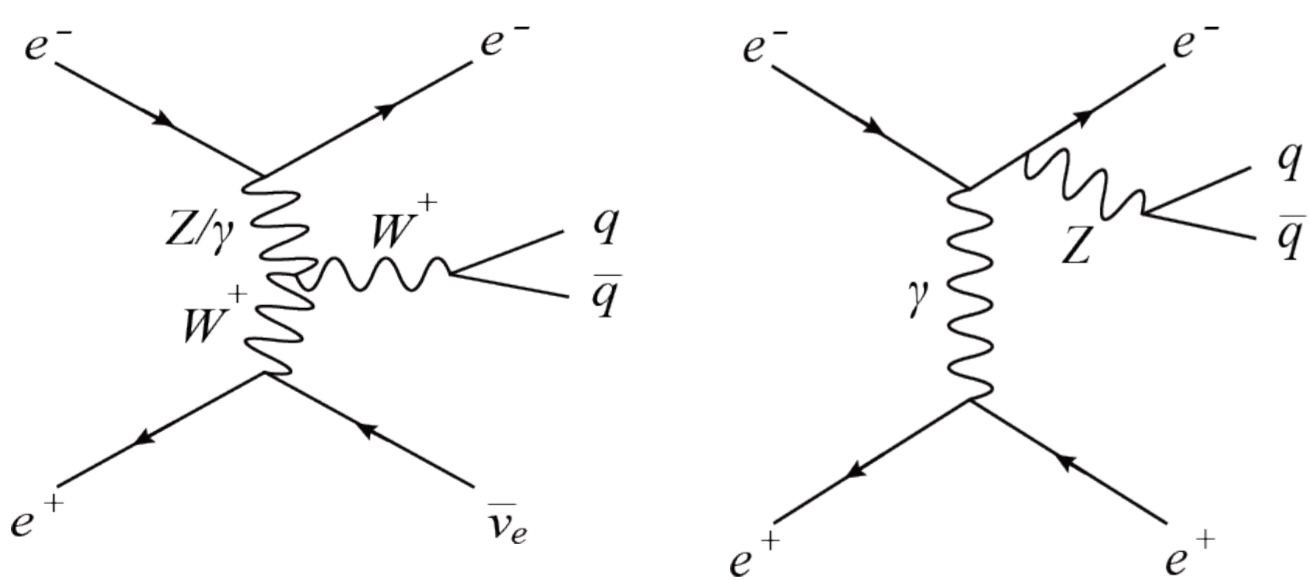
Benchmark points in this analysis

$M_N$ [GeV]	$M_{Z'}$ [GeV]	$g'_{B-L}$	$ V_{eN} $	$BR(N \rightarrow eW)$	$\sigma_{LR}$ [fb]	$\sigma_{RL}$ [fb]
100	7	1	0.03	0.44	0.55	0.71
150	7	1	0.03	0.33	0.36	0.45
200	7	1	0.03	0.30	0.14	0.16
225	7	1	0.03	0.29	0.046	0.0052

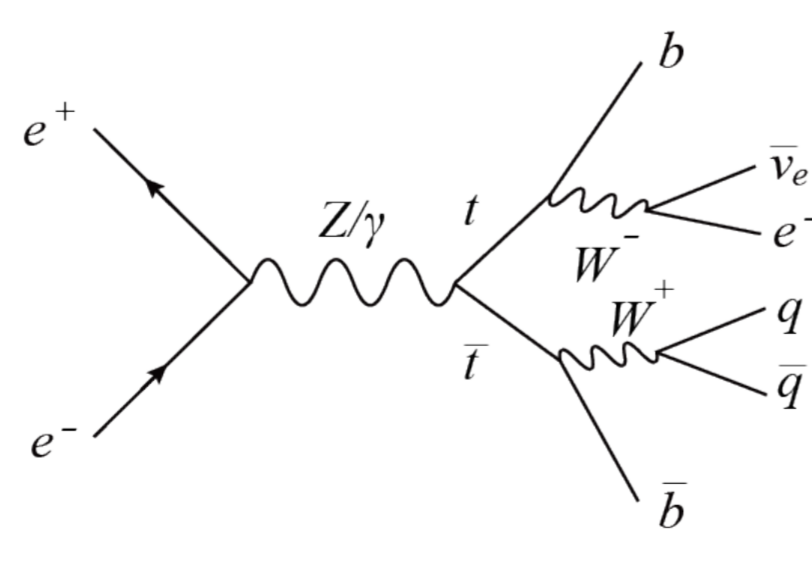
Consistent with LHC and HL-LHC bounds

Backgrounds

- 4-fermion:  $e^+e^- \rightarrow \nu e q \bar{q}$  and  $e^+e^- \rightarrow e^+e^- q \bar{q}$



- $e^+e^- \rightarrow t \bar{t}$

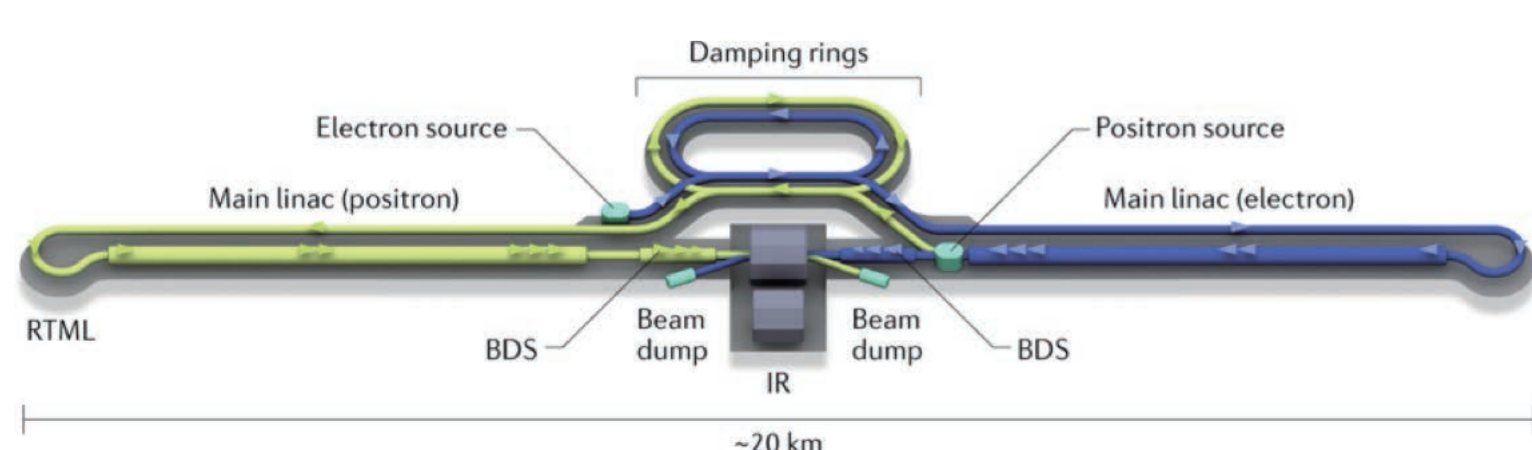


- 6-fermion:  $e^+e^- \rightarrow e^+e^- q \bar{q} q \bar{q}$

### Simulation Setup

**WHIZARD**  
Event generator

**ILD Full Simulation & Reconstruction**



- e+e- linear collider
- $\sqrt{s} = 250$  GeV (Extend to 500, 1000 GeV)
- Polarized beams  $e^-$ : 80%,  $e^+$ : 30%
- "eLpR" = ( $e^- -80, e^+ +30$ ) "eRpL" = ( $e^- +80, e^+ -30$ )

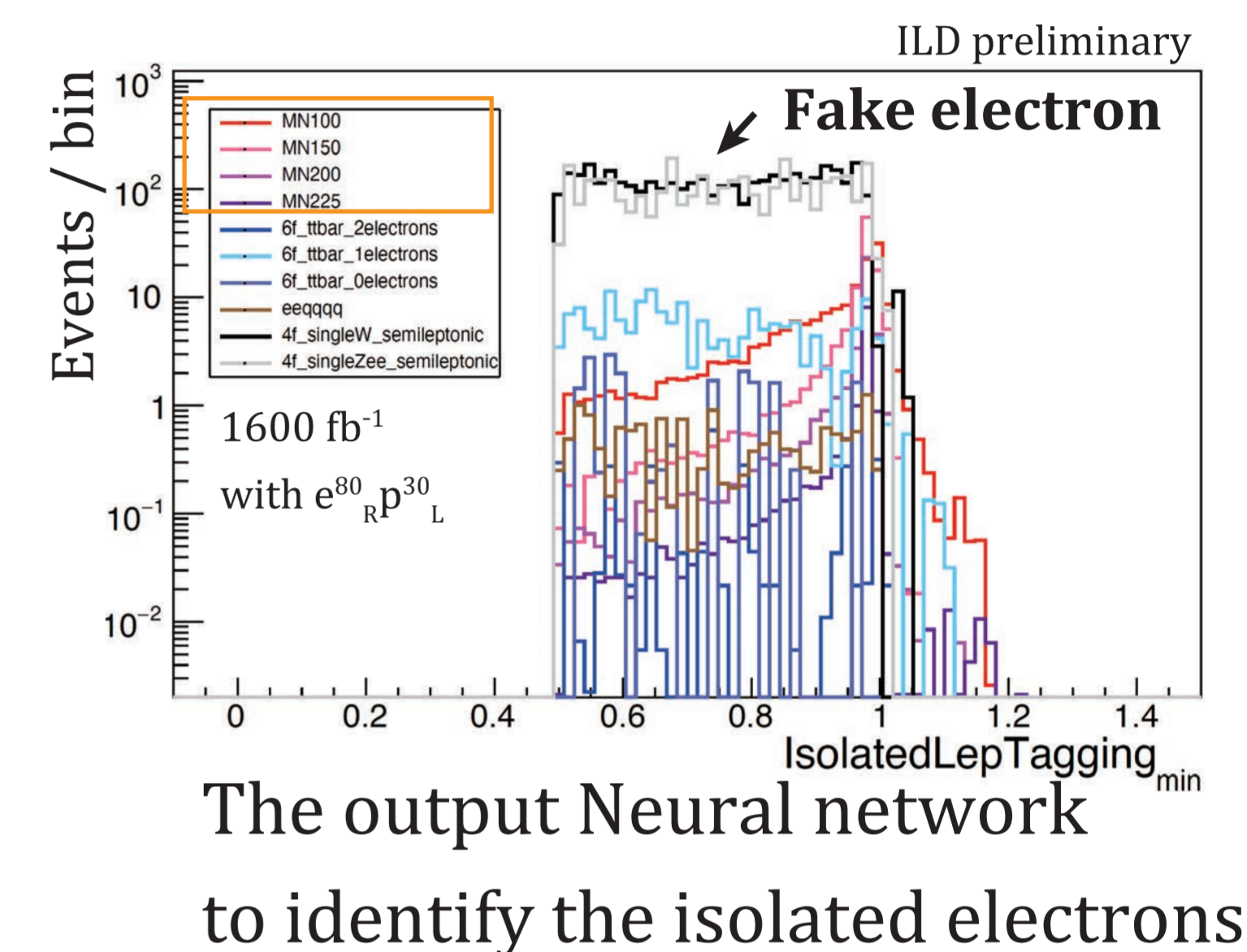
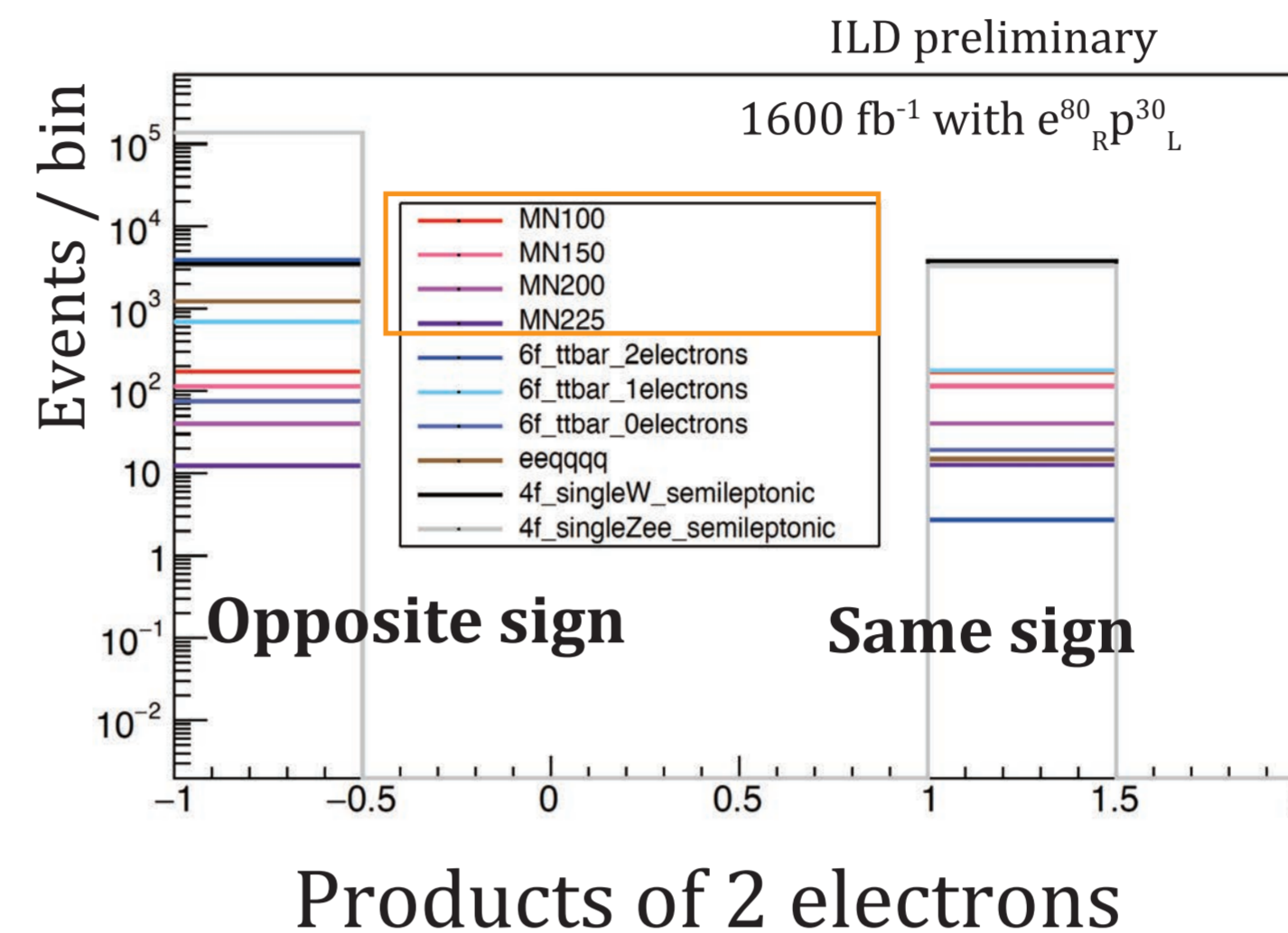


Detector for PFA

### Cut based Analysis

Cut conditions

- 2 same sign isolated electrons
- $E < 200$  GeV,  $|\cos\theta| < 0.95$
- IsolatedLepTagging(min) > 0.9
- Remove 2 Jet-like events
- Small missing momentum



Jet pairing  $\rightarrow$  RHN reconstruction

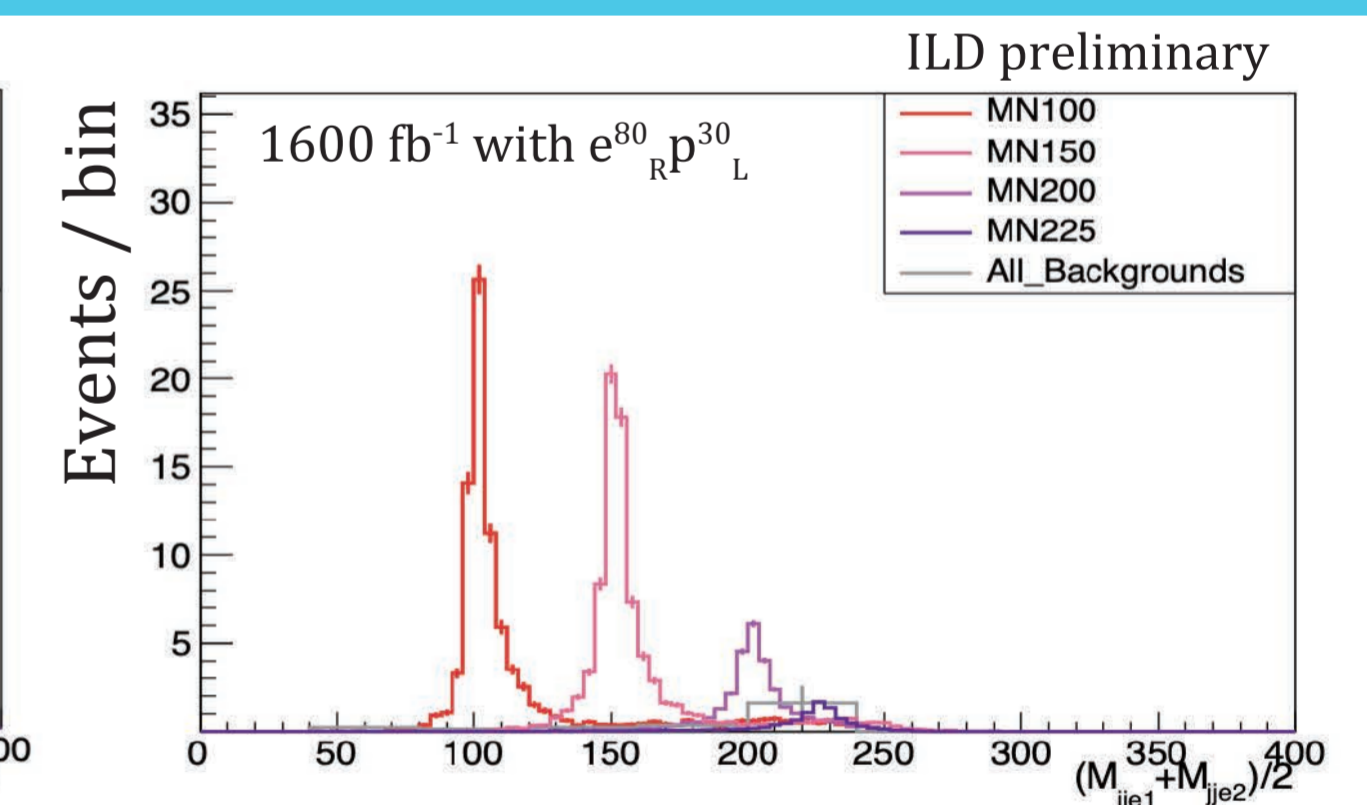
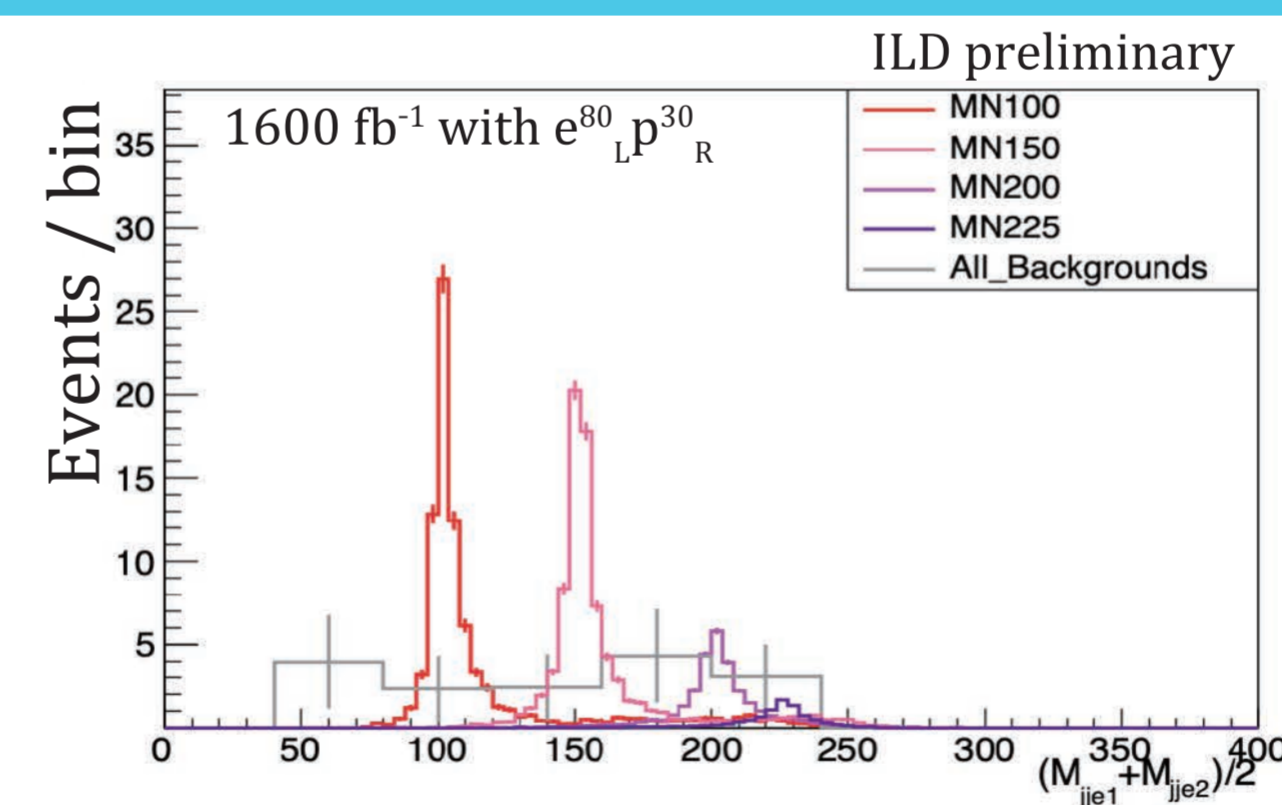
4 jets + 2 electrons in the final state

Choose combination most consistent with  $W$  mass and equal RHN masses

$$F_1 = (M_{jj1} - M_w)^2 + (M_{jj2} - M_w)^2$$

$$F_2 = (M_{jje1} - M_{jje2})^2$$

### Results



Signal efficiency  $\sim 20\%$

Remaining backgrounds  $\sim 150$  (eLpR), 20 (eRpL)

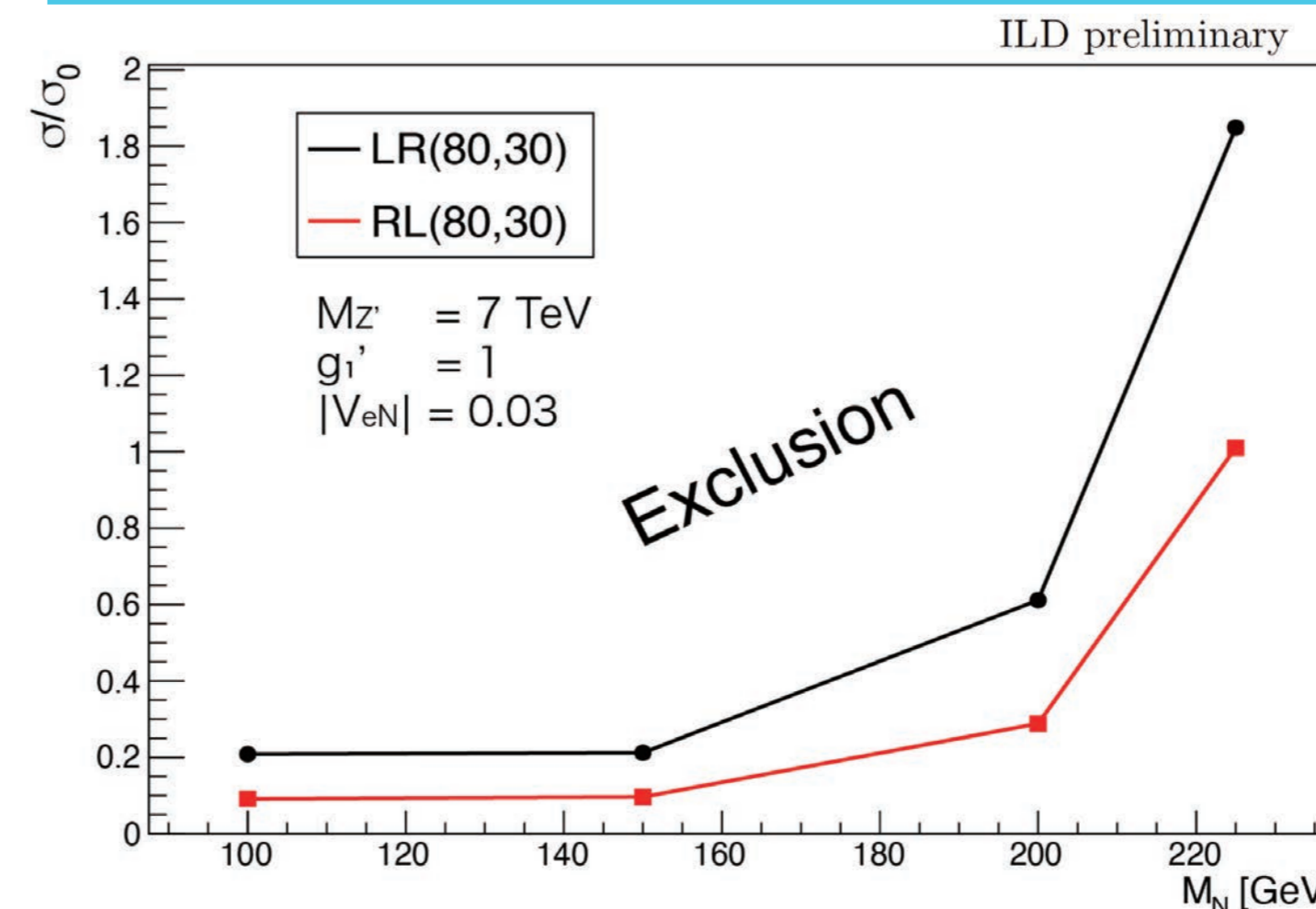
mass window around each true RHN mass ( $-10$  GeV /  $+15$  GeV)

Assume flat background distribution.

Signal efficiency  $\sim 20\%$

Remaining backgrounds  $\sim 20$  (eLpR), 3 (eRpL)

### Summary



Exclude benchmark points and cross-sections up to 10x smaller

Can use same sign lepton signature to set powerful limits on RHN at ILC!