Scenarios for SUSY CDM and the ILC

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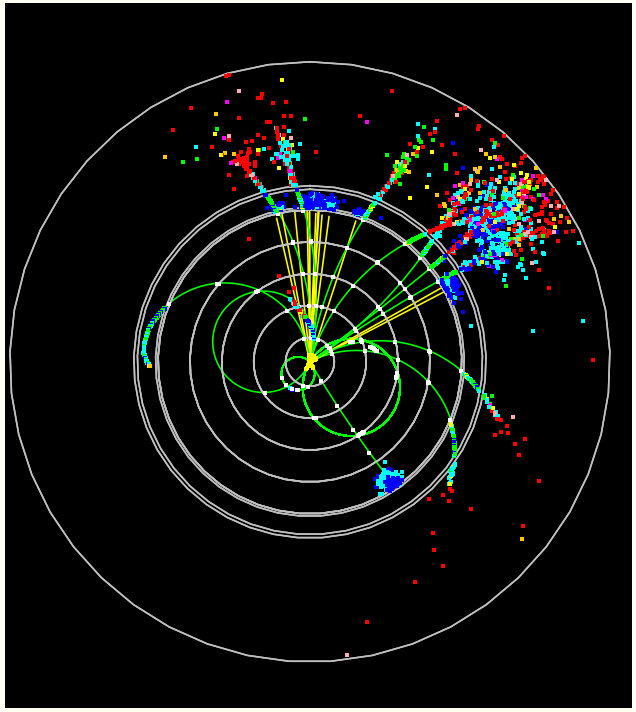
- ⋆ Non-universal gaugino masses
- ⋆ Motivation
- ⋆ Mixed wino dark matter (MWDM)
- ⋆ Bino-wino co-annihilation (BWCA) scenario
- ⋆ Consequences for LHC and ILC



Neutralino CDM in the mSUGRA model

- ⋆ mSUGRA model parameters
  - $m_0,\ m_{1/2},\ A_0,\ \tan\beta,\ sign(\mu)\ (m_t)$
- ⋆ Most of p-space is excluded by WMAP: $\Omega_{\widetilde{Z}_1} h^2 = 0.113 \pm 0.009$
- ⋆ Allowed regions
  - bulk region (low m_0, $m_{1/2}$)
  - stau co-ann. region ($m_{\tilde{\tau}_1} \sim m_{\widetilde{Z}_1}$)
  - HB/FP region (large $m_0 \sim 4 - 8$ TeV with small μ)
  - A-funel ($2m_{\widetilde{Z}_1} \sim m_A$ at large $\tan\beta \sim 45 - 55$)
  - h funnel
  - $\tilde{t}_1$ co-ann. (at particular A_0)

Non-universal gaugino masses

★ SUGRA models where GKF transforms non-trivially (Snowmass '96)

	M_{GUT}			M_Z		
F_h	M_3	M_2	M_1	M_3	M_2	M_1
1	1	1	1	~ 6	~ 2	~ 1
24	2	-3	-1	~ 12	~ -6	~ -1
75	1	3	-5	~ 6	~ 6	~ -5
200	1	2	10	~ 6	~ 4	~ 10

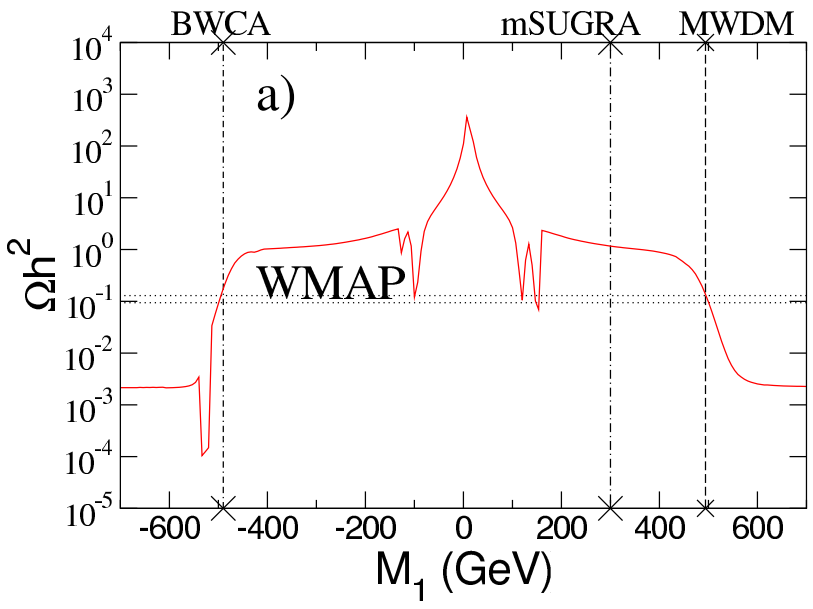
★ Heterotic superstring models with orbifold compactification: SUSY breaking dominated by the moduli field

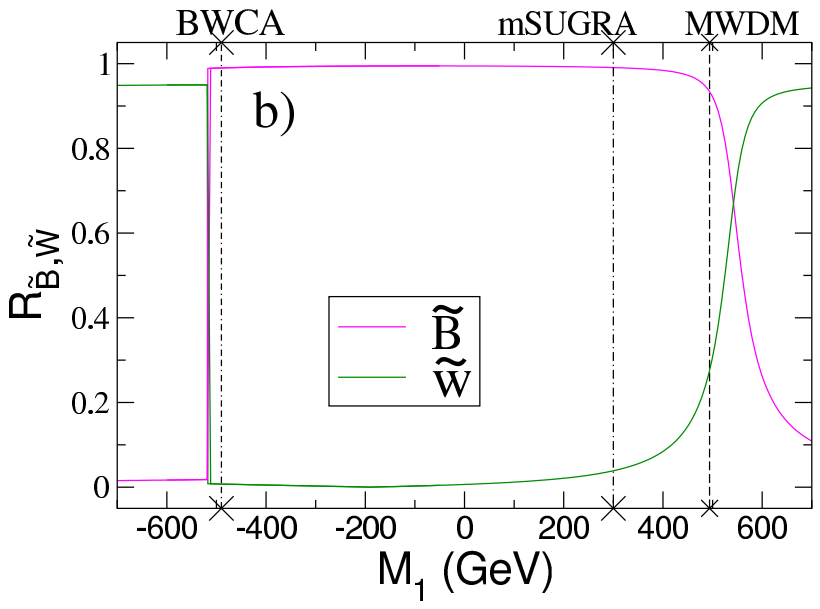
★ Extra-dimensional SUSY GUT models where SUSY breaking is communicated from the SUSY breaking brane to the visible brane via gaugino mediation (e.g. Dermisek-Mafi model)

- ...
- Here we adopt a phenomenological approach of independent M_1, M_2, M_3 but require consistency with WMAP
  - MWDM: HB, Mustafayev, Park, Profumo JHEP**0507**, 046 (2005)
  - BWCA DM: HB, Krupovnickas, Park, Profumo, Tata
- Large/small M_3 case, see Belanger et al. NPB706, 411 (2005)
- Related work: Corsetti and Nath; Birkedal-Hansen and Nelson; Bertin, Nezri and Orloff; Bottino, Donato, Fornengo, Scopel; Belanger, Boudjema, Cottrant, Pukhov, Semenov; Mambrini, Munoz and Cerdeno; Auto, HB, Belyaev, Krupovnickas; Masiero, Profumo, Ullio

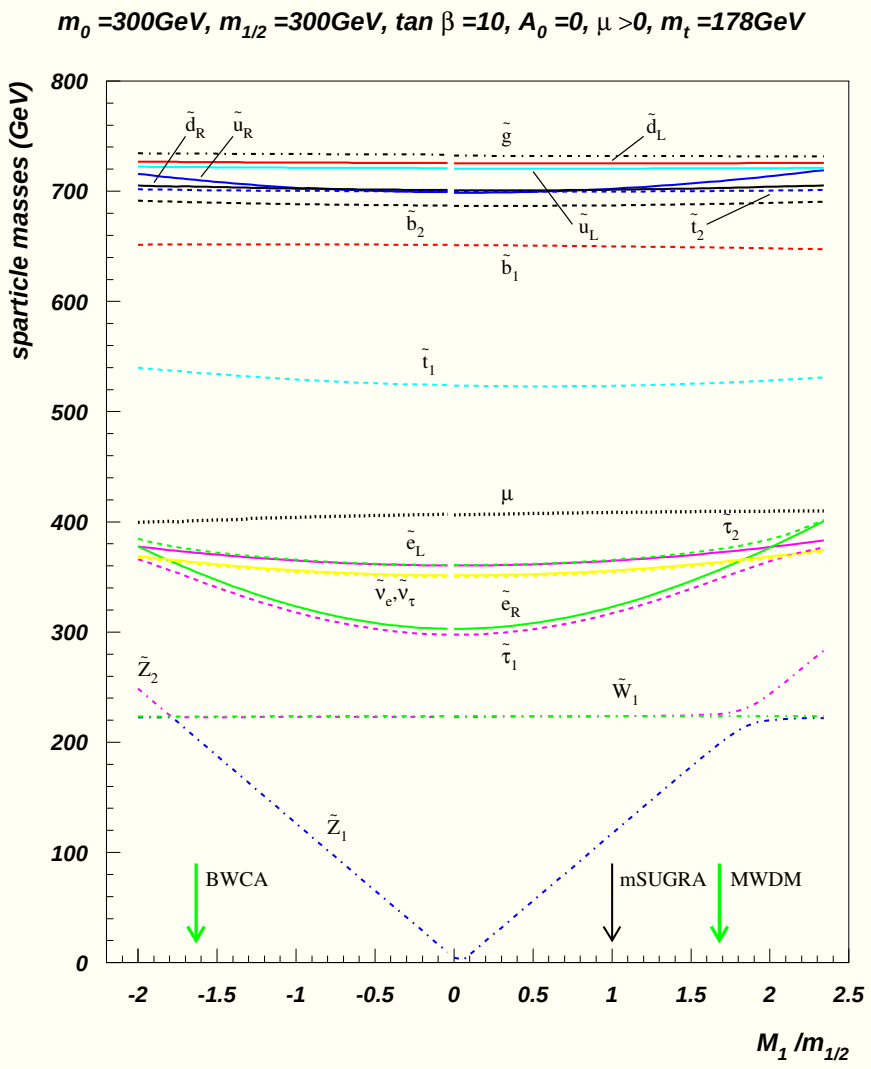
$\Omega_{\tilde{Z}_1} h^2$ vs. M_1

m_0=300 GeV, $m_{1/2}$=300 GeV, tanβ=10, A_0=0, μ>0, m_t=178 GeV

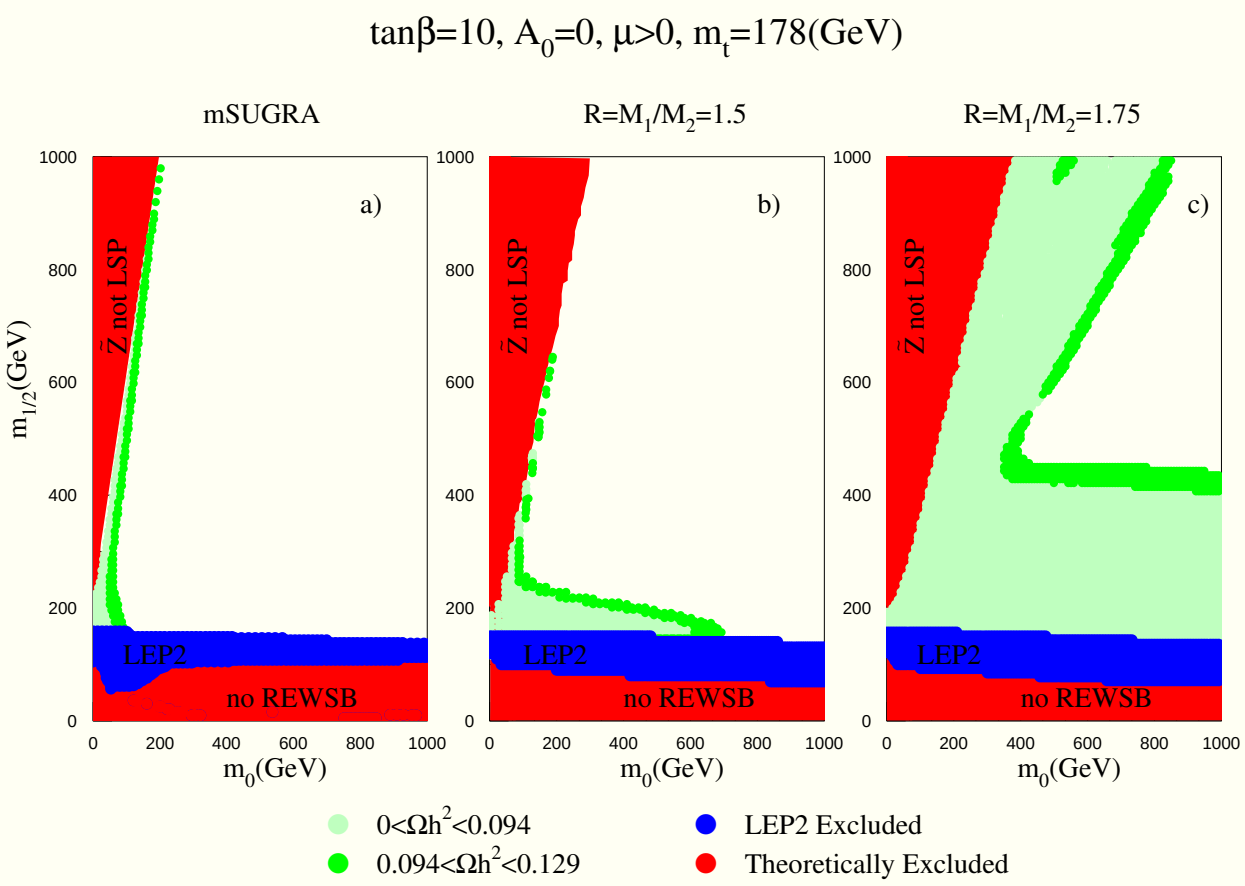




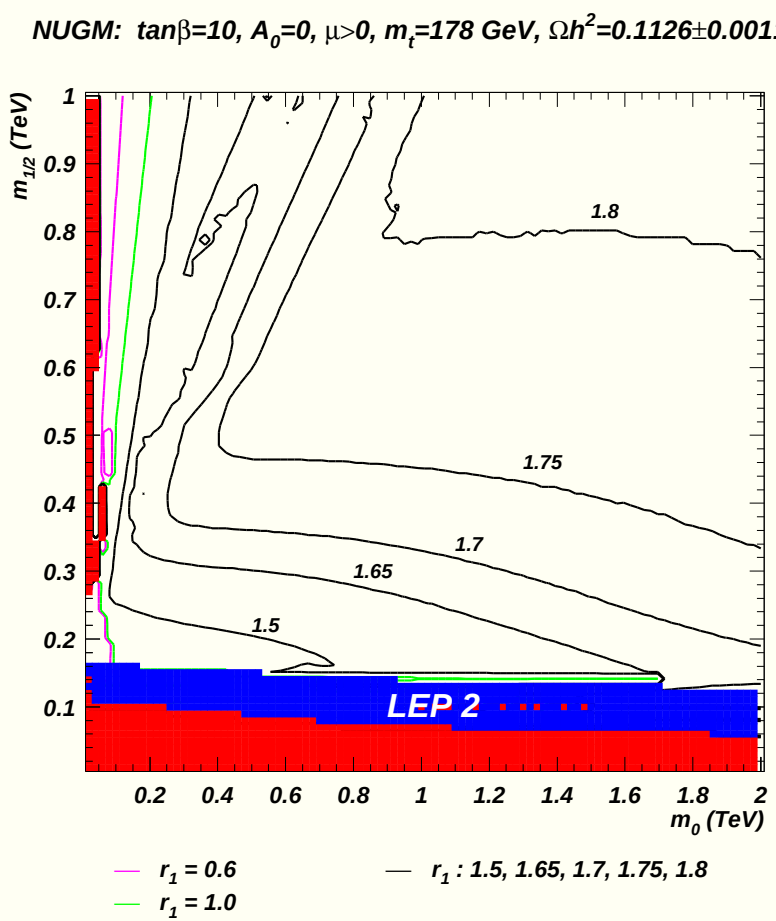
Sparticle mass spectra vs M_1



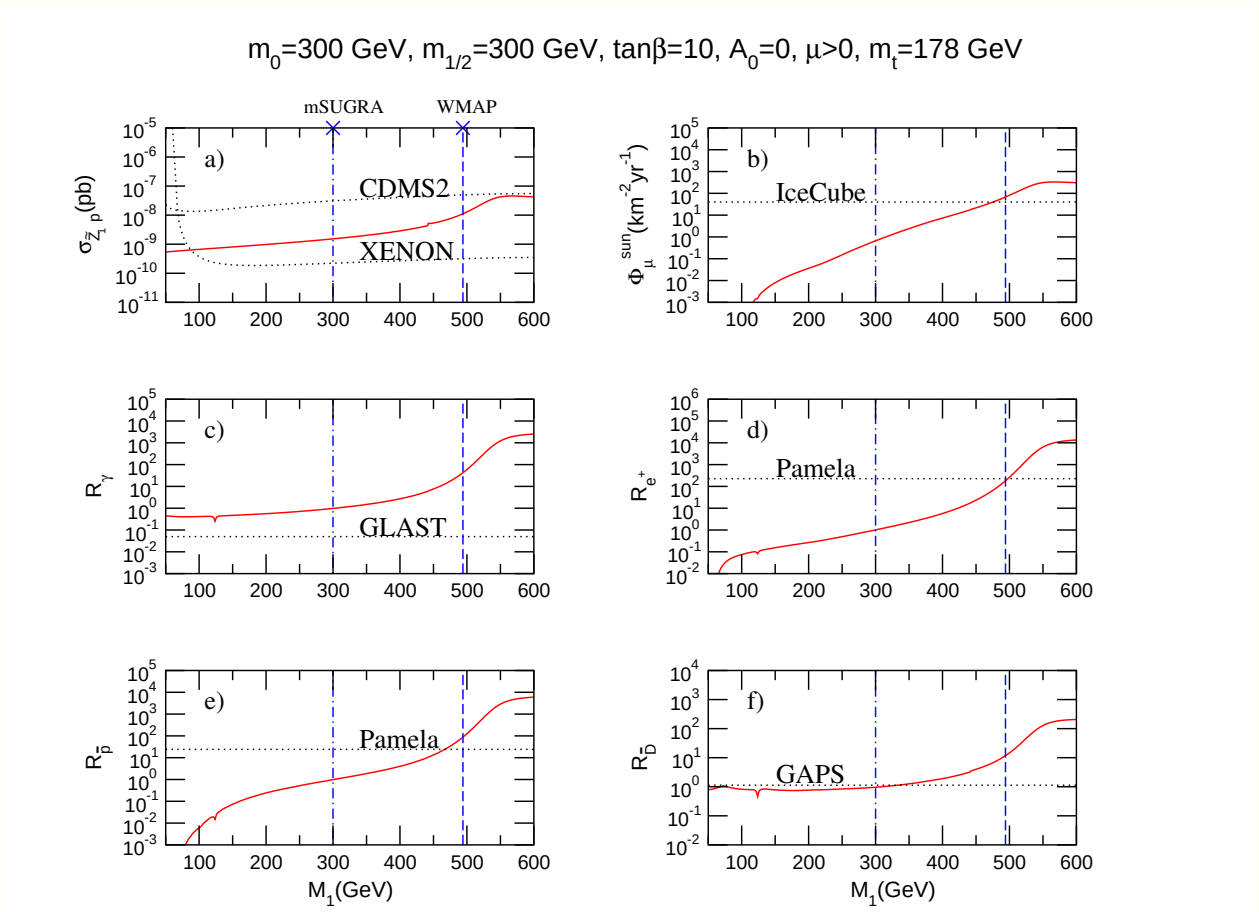
WMAP allowed regions for various M_1/M_2



MWDM: *Any* point in m_0-$m_{1/2}$ plane can be WMAP allowed

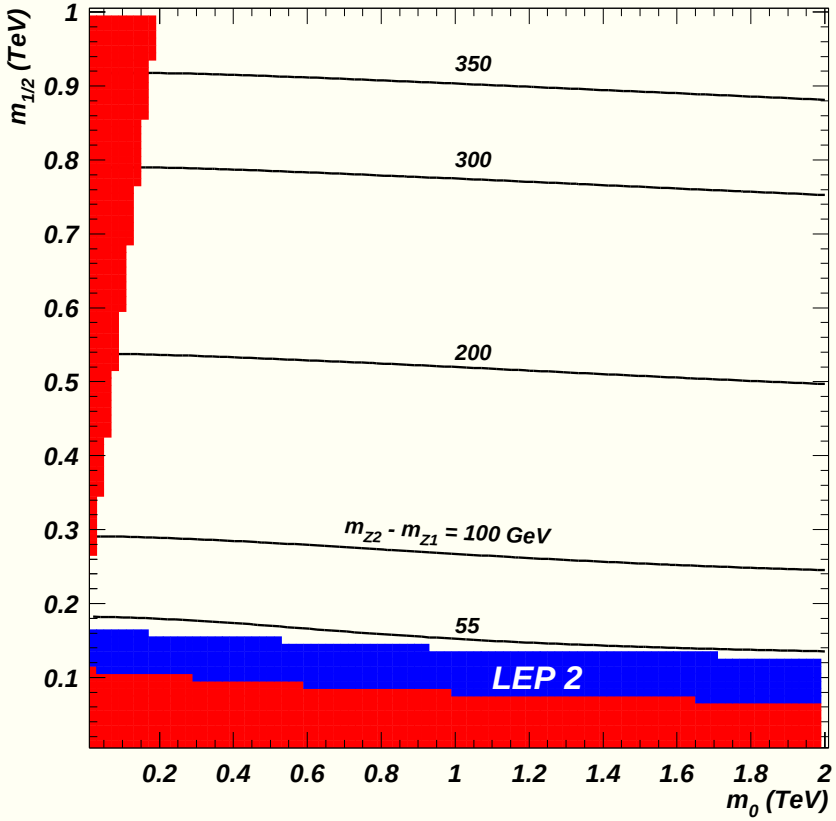


Neutralino DM search for MWDM: enhanced!

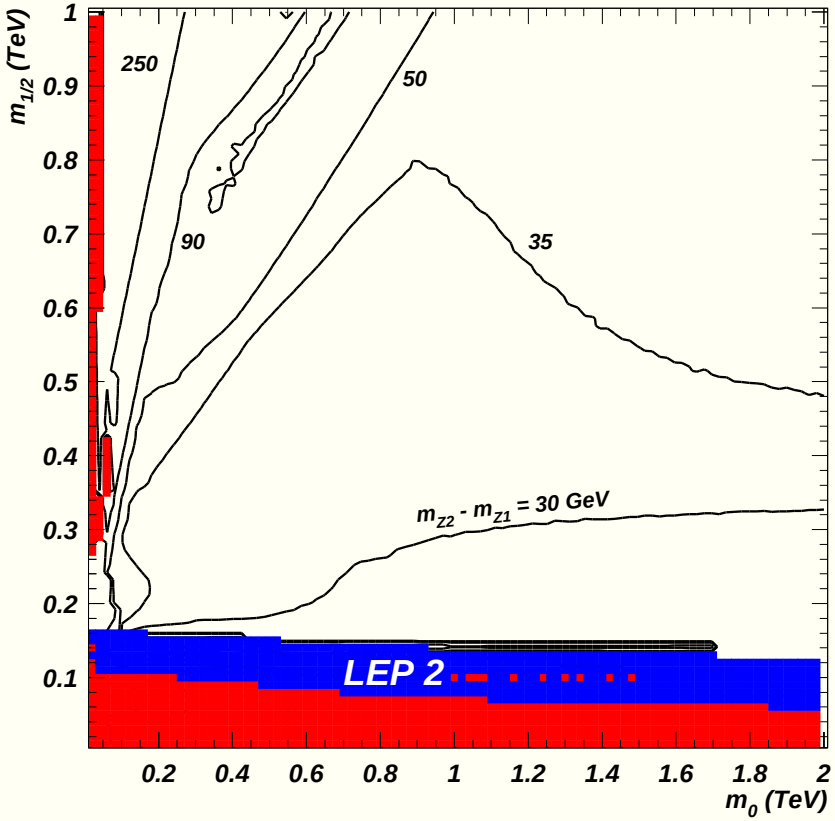


MWDM: small $\widetilde{Z}_2 - \widetilde{Z}_1$ mass gap

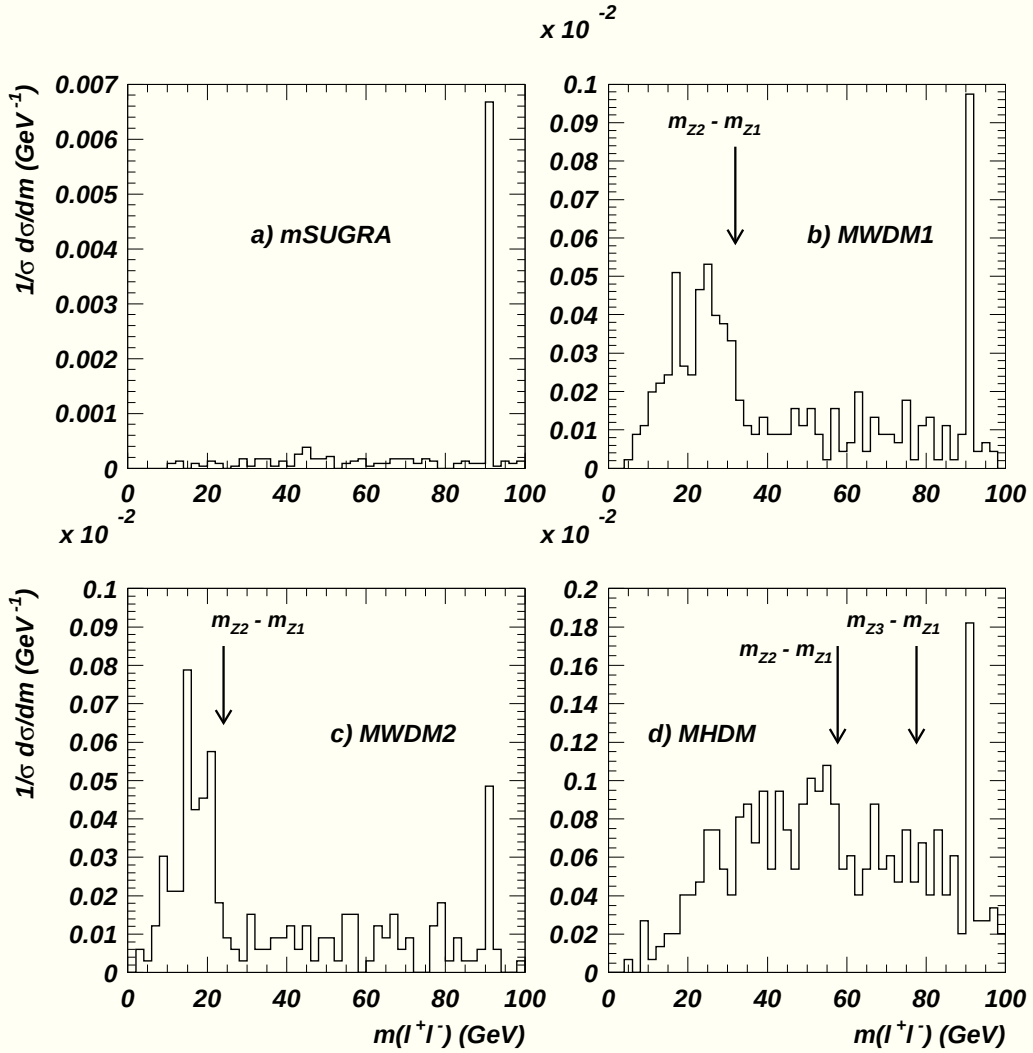
mSUGRA: tanβ=10, A_0 =0, μ >0, m_t =178 GeV



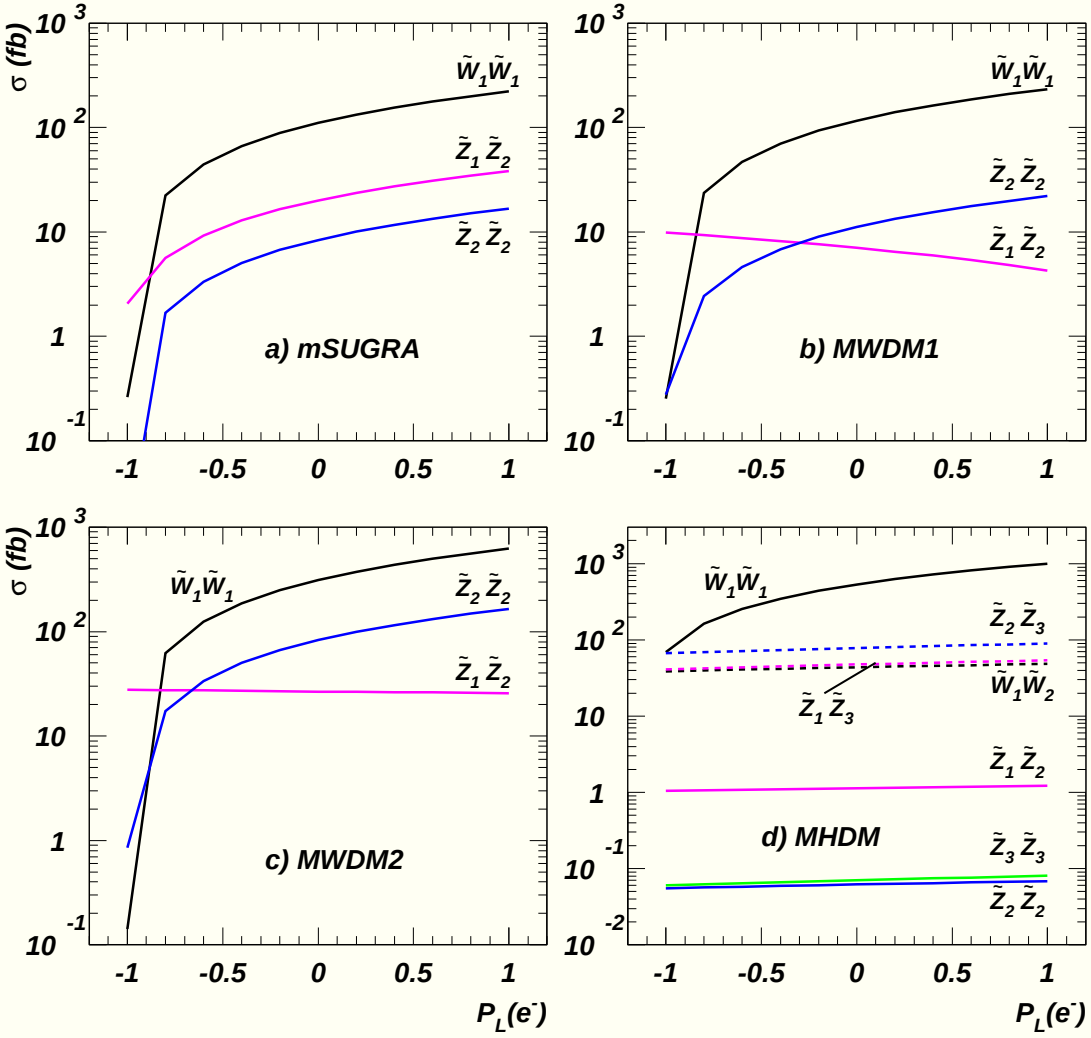
NUGM: $M_1 \neq m_{1/2}$, tanβ=10, A_0 =0, μ >0, m_t =178 GeV



$m(\ell^+\ell^-)$: mass gap observable at LHC for MWDM

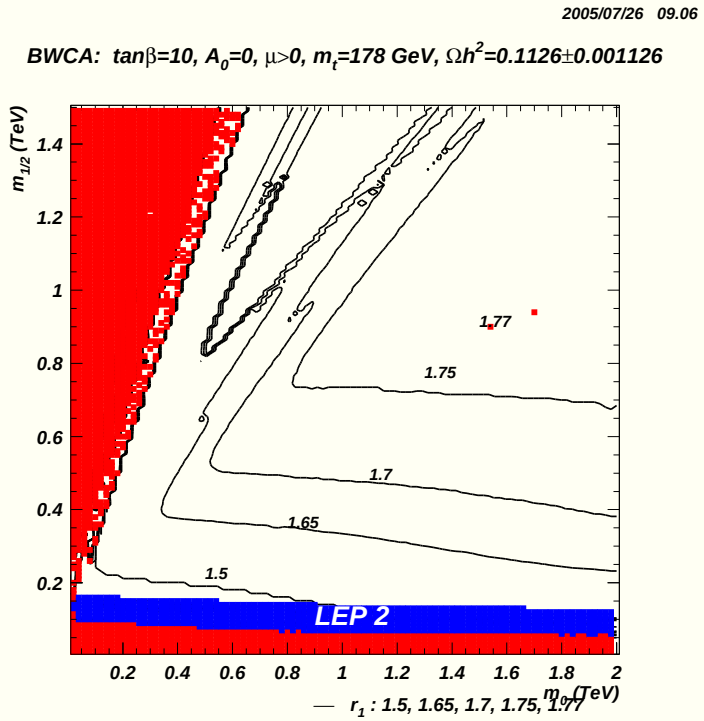


e^- beam polarization useful tool for MWDM at ILC

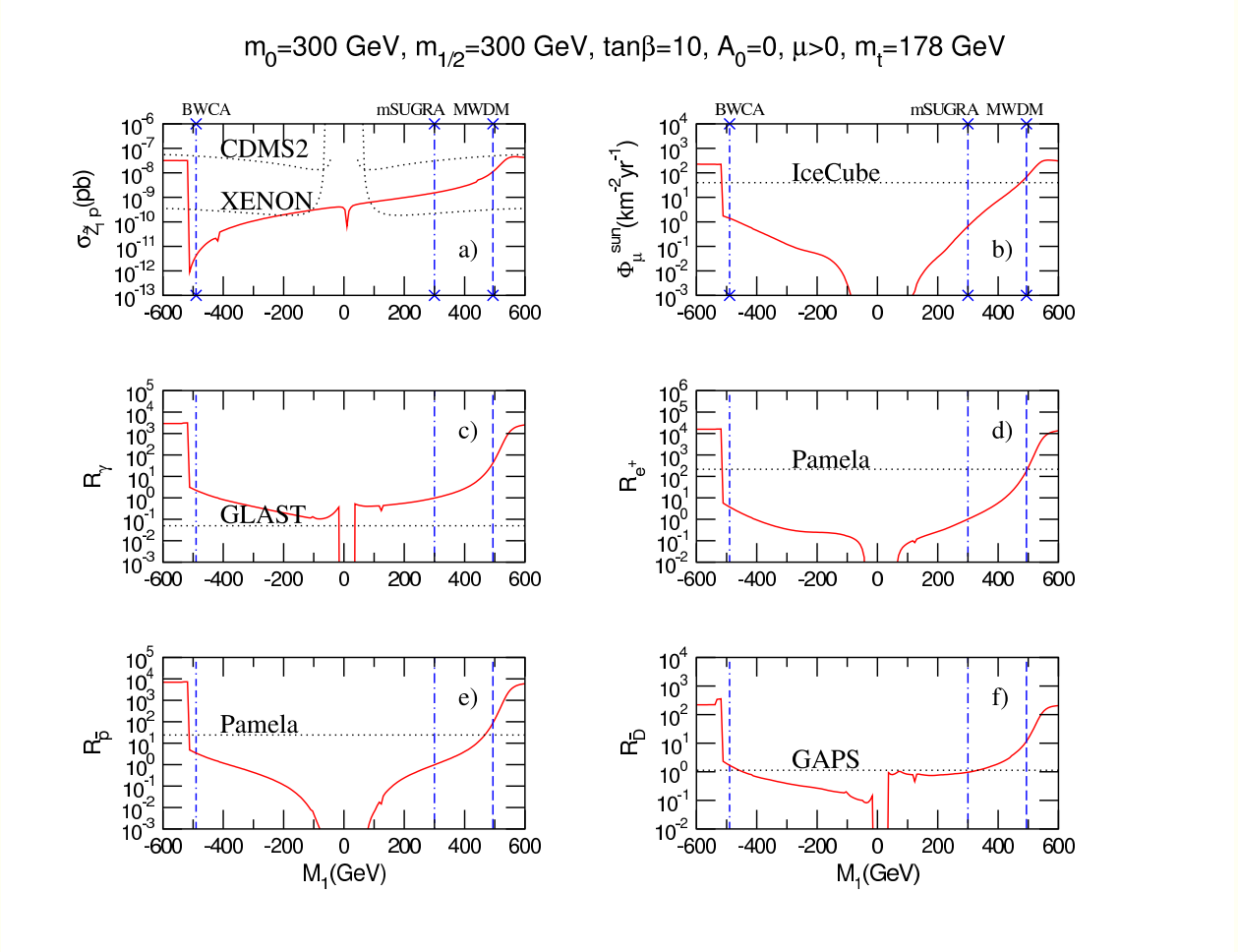


Bino-wino co-annihilation (BWCA) scenario

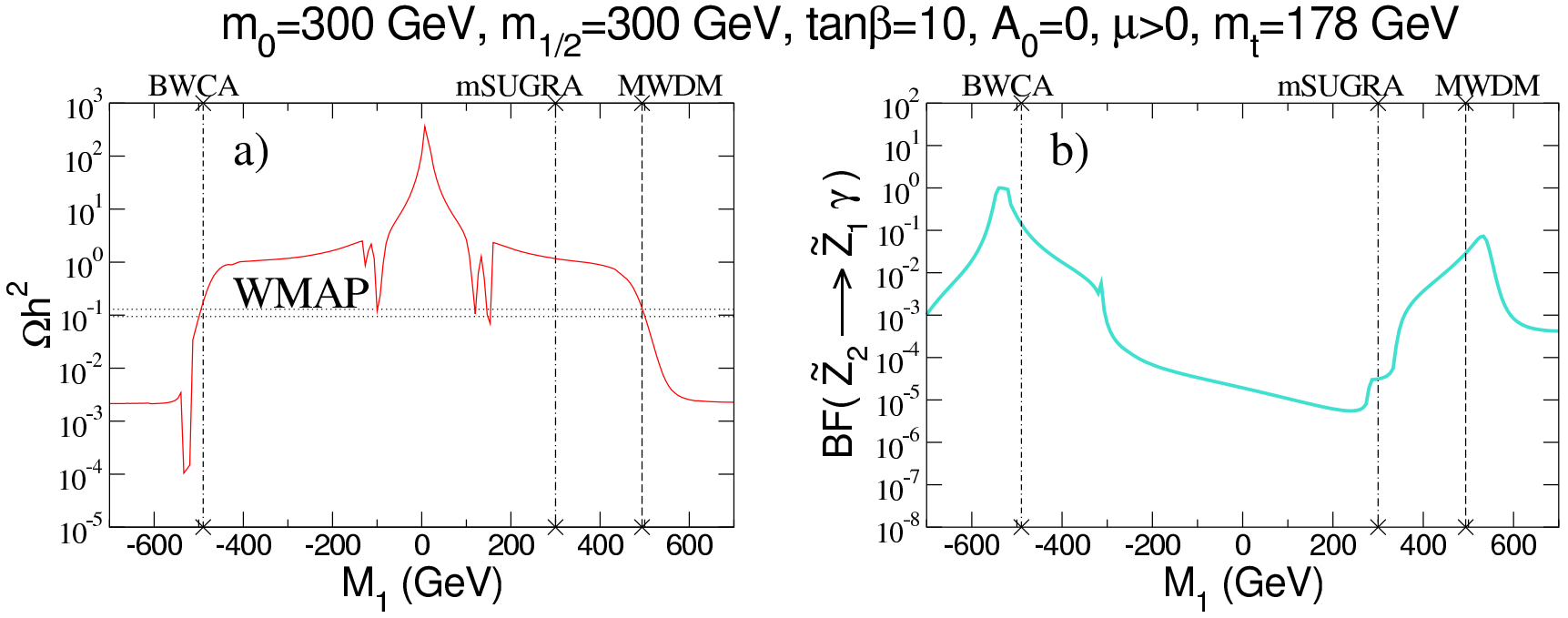
- If $M_1/M_2 < 0$, then no mixing between bino-wino
- Can only reduce relic density via bino-wino co-annihilation when $M_1 \simeq -M_2$ at $Q = M_{weak}$



Neutralino DM detection rates remain low

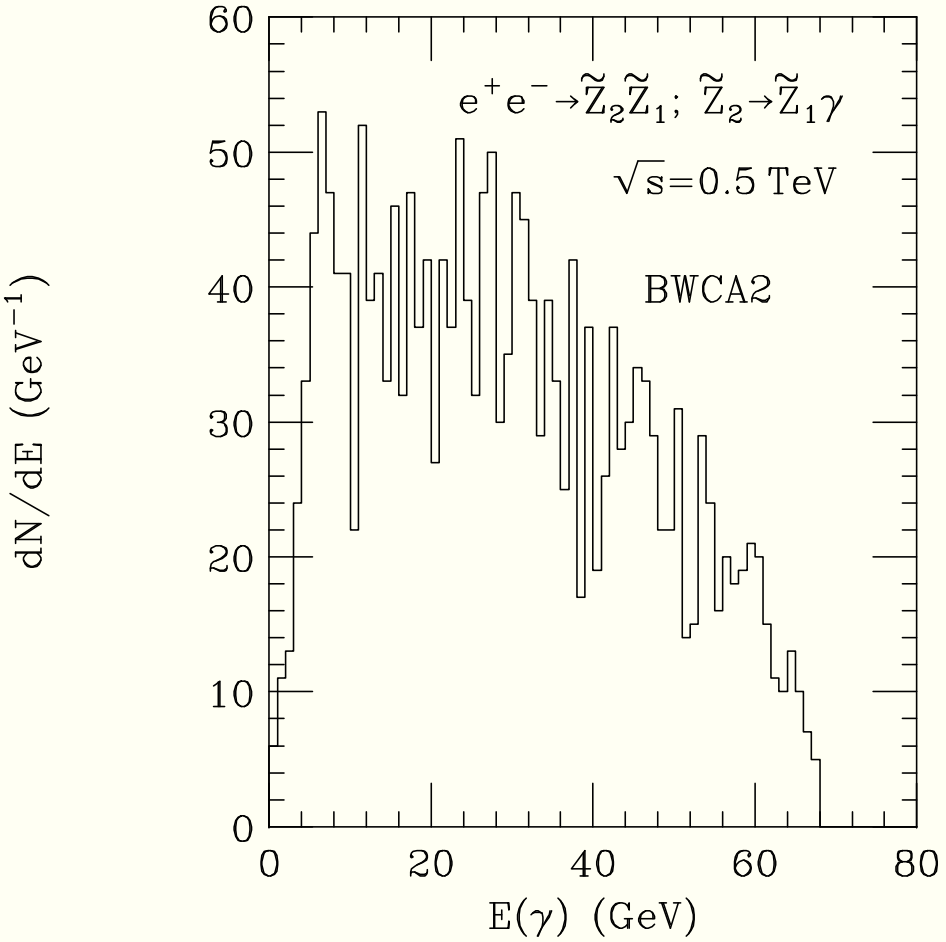


In BWCA at $m_0 \lesssim 500$ GeV, $BF(\widetilde{Z}_2 \to \widetilde{Z}_1\gamma)$ enhanced!

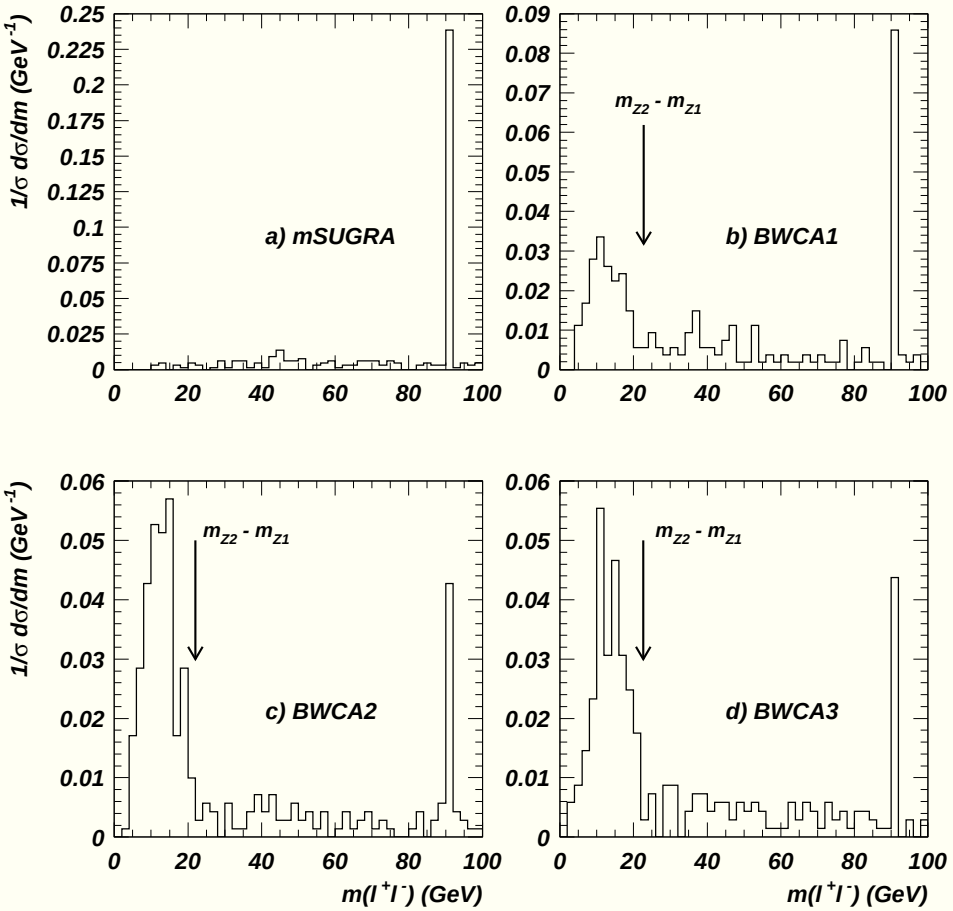


Haber+Wyler; Ambrosanio+Mele; Baer+Krupovnickas

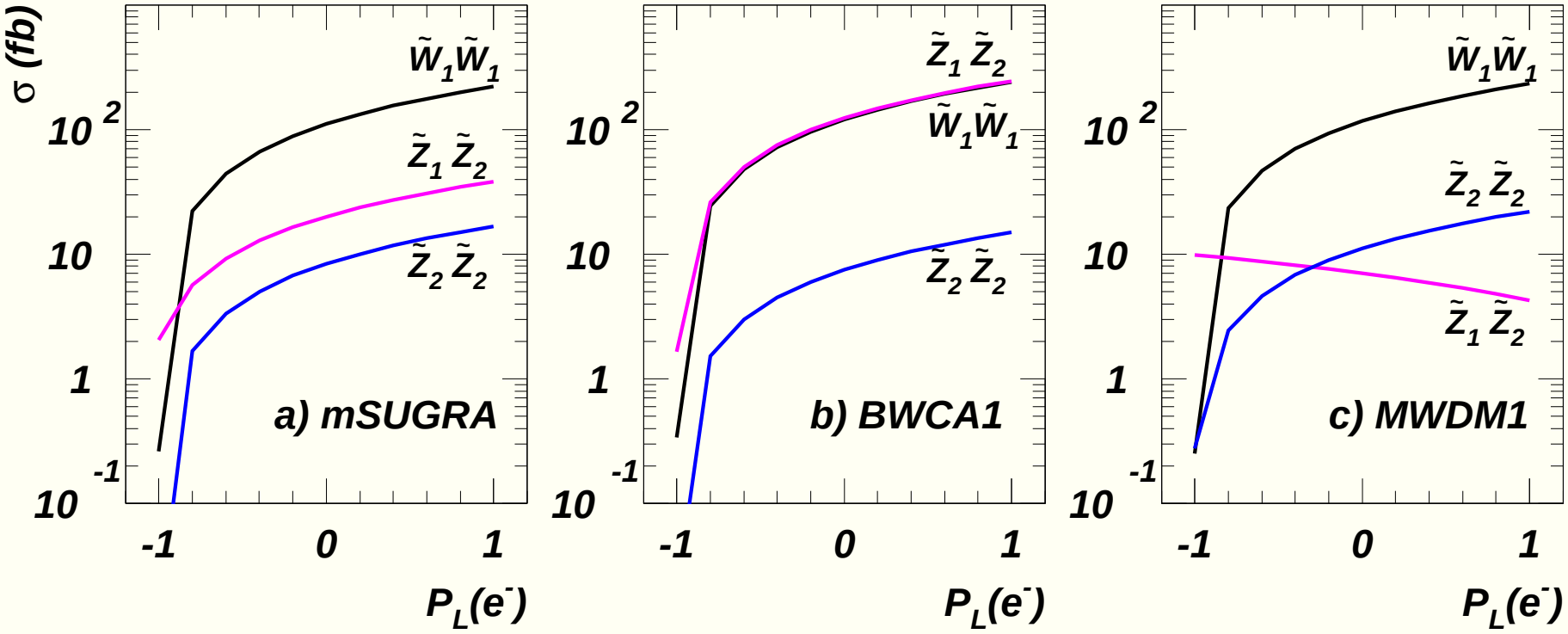
$$e^+e^- \to \widetilde{Z}_1\widetilde{Z}_2 \to \gamma + \not{E}_T$$



$m(\ell^+\ell^-)$ mass gap should be observable in BWCA DM



e^- beam polarization useful tool for BWCA DM at ILC



Conclusions

- ⋆ Non-universal gaugino masses possible in many models
- ⋆ Any point in m_0-$m_{1/2}$ plane WMAP allowed if MWDM or BWCA DM
- ⋆ MWDM: enhanced direct/indirect DM detection rates
- ⋆ BWCA DM: non-enhanced direct/indirect DM detection rates
- ⋆ MWDM and BWCA DM: small $\widetilde{Z}_2$-$\widetilde{Z}_1$ mass gap
- ⋆ e^- beam polarization useful for distinguishing MWDM and BWCA DM from MHDM, mSUGRA
- ⋆ Enhanced radiative $\widetilde{Z}_2$ decay in BWCA (MWDM) gives isolated photons