Physics of Options

Hitoshi Yamamoto

BDS Kickoff meeting

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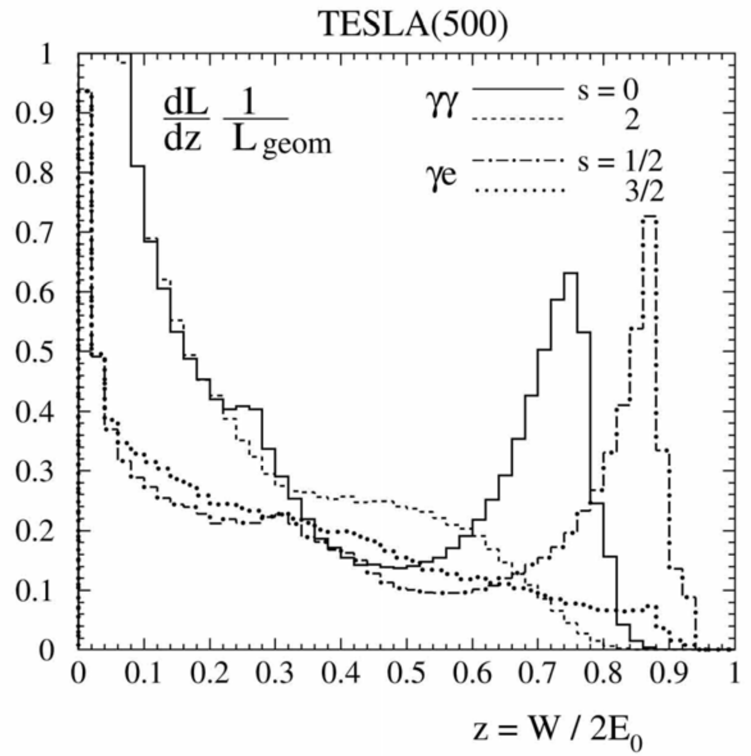
Gamma-Gamma Collider

Luminosity spectrum



Use e^-e^- for smaller bkg and e- beam polarization (e^-e^-, $e^-\gamma$ comes with it)

Crossing angle > 25 mrad for safe extraction of disrupted beams.

Lumiosity$_{\gamma\gamma}$ peaks at ~ z=0.7. Close to the ee CM energy.

Luminosity usually quoted is for $z>0.8z_{max}$

SM Higgs: $\gamma\gamma$

- Produced by $\gamma\gamma$ fusion.
  - S-channel production
  - Polarization can reduce backgrounds

- Precise determination of Γ(Higgs$\rightarrow \gamma\gamma$)
  - ~2% precision
  - Ecm = 210 GeV
  - MH = 120 GeV
  - 410 fb^{-1}

Higgs Total Width

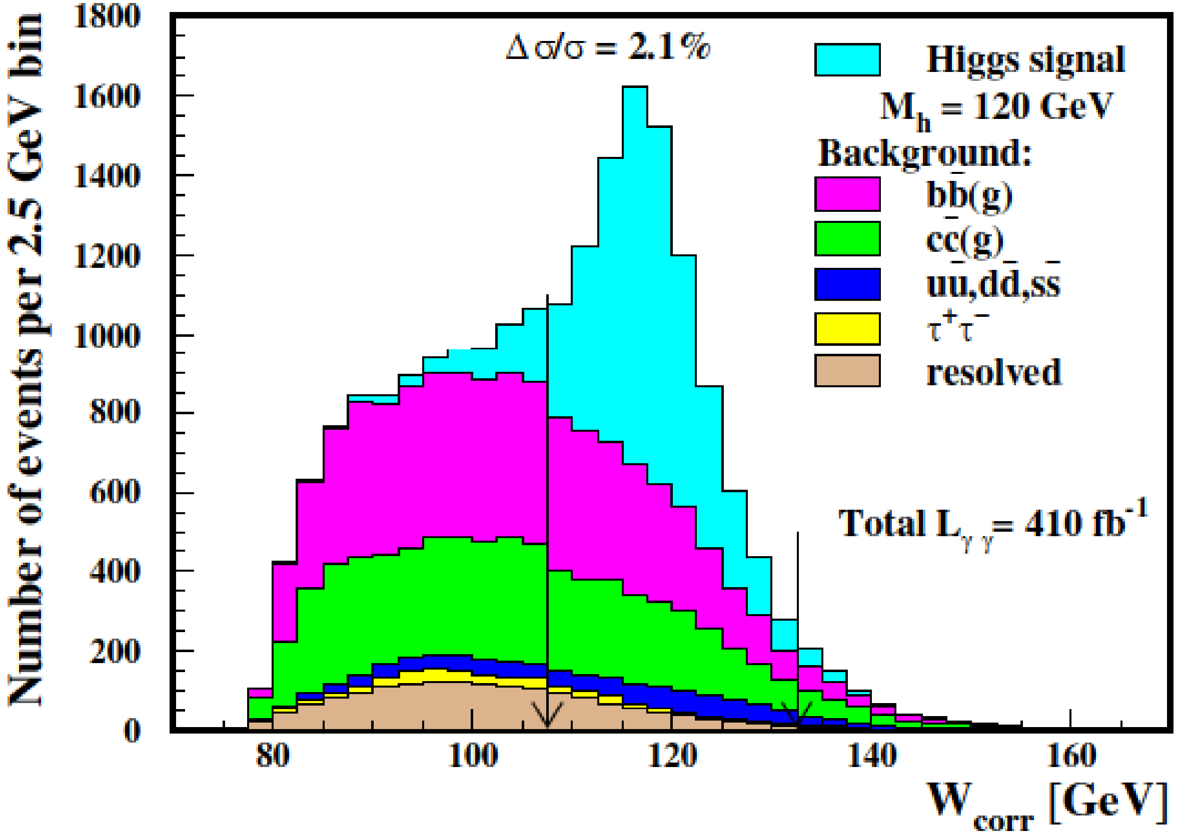
- Combine $\Gamma(H\rightarrow\gamma\gamma)$ measured at $\gamma-\gamma$ collider with $Br(H\rightarrow\gamma\gamma)$ to obtain Higgs total width
    - ~ □error on Γ_H
  - Complimentary to the method on e+e-

- Similar to the error obtained by e+e-
  - **Br(H→WW*)** & **Γ(H→ WW*)** calculated by HWW coupling in the WW fusion production of Higgs.

SM Higgs: $\gamma\gamma$

H→bb

Zarnecki



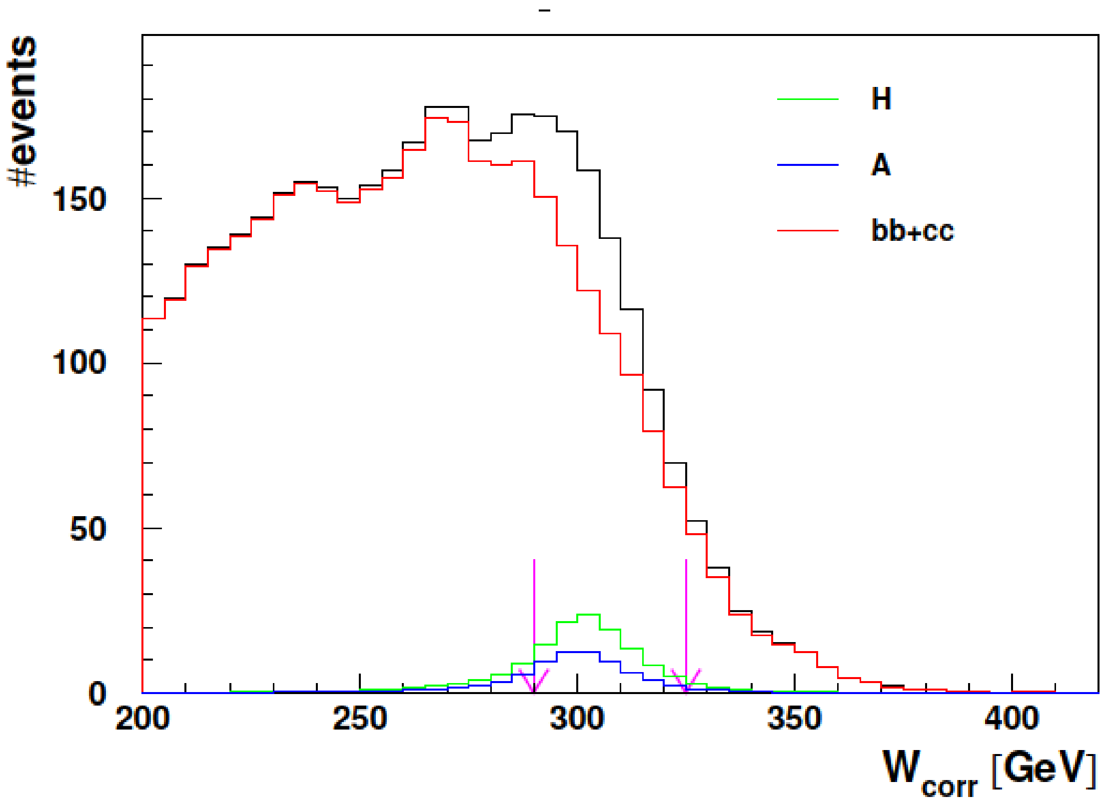
MSSM Higgs: $\gamma\gamma$

- In SUSY in general, there are 5 Higgs:
  - Neutral: h, H, A
  - Charged: H+-
- h is like the SM Higgs
- H, A are pair produced in e+e-
  - For Ecm=500 GeV,
  - M_{Amax} ~ 250 GeV for e+e-
  - M_{Amax} ~ 400 GeV for $\gamma\gamma$
- H(CP+), A(CP-) :
  - Can be distinguished by linear polarization

MSSM H or A? : $\gamma\gamma$

Linear polarization

Zarnecki



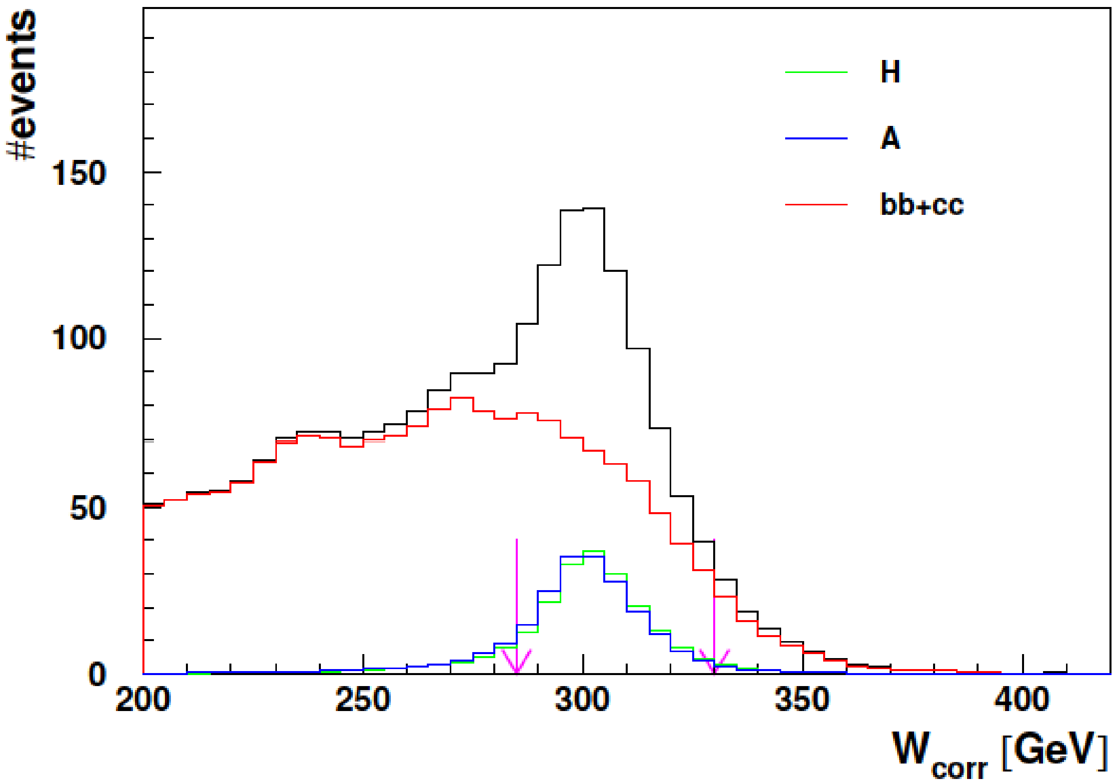
808 fb^{-1}

4 sigma separation of H and A

MSSM H or A? : $\gamma\gamma$

Circular Polarization

Zarnecki



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One may first find signal this way.

Triple gauge couplings

$\gamma\gamma$ and e γ colliders can add to e+e-

$\gamma\gamma$ WW (W exchange)

- e γ νW (W exchange)

- Both measure WWγ coupling.
- No ambiguity from WWZ coupling.
  - **e+e- case: interference of WWZ and WWγ.**
- Large cross sections.
  - **Coupling sensitivities are similar to e+e-**

e-e- collider

- Doubly charged particles in s-channel
  - Appears in some GUT theories
- Sensitive to majorana neutrino
  - $e^-e^- \rightarrow W^-W^-$
  - t-channel exchange of a majorana neutrino
- Selectron quantum numbers
  - $e^-e^- \rightarrow e_{L,R}e_{L,R}$
  - t- channel neutralino only (unlike e^+e^-)
  - Use beam polarizations to specify e_R and e_L
  - Change E_{CM}.
  - Excitation curve gives spin.

Giga-Z option

- Run ILC on Z^0. Collect ~ 1 Giga Z^0 in a few months.

- Advantage : beam polarization + b tagging
  - **Require very high accuracy of beam polarization and energy measurements.**
  - **E_{cm} to 1 MeV required (relative to Z peak)**

- Particularly important if no Higgs (or anything new) is observed at LHC and first running of ILC.

Giga-Z option

	LEP/SLC/Tevatron	Giga-Z
$\sin^2\theta(A_{LR})$	0.23146 ± 0.00017	±0.000013
M_Z	91.875 ± 0.0021 GeV	±0.0021 GeV
$\alpha_s(M_Z)$	0.1183 ± 0.0027	±0.0009
$\Delta\rho$	0.0055 ± 0.0010	±0.0005
N_ν	2.984 ± 0.008	±0.0004
A_b	0.898 ± 0.015	±0.001
R_b	0.21653 ± 0.00069	±0.00014

WW Threshold Run

- W mass measurement
  - **Run at Ecm ~ 160 GeV**
  - **M_W: 6 MeV error in 1 year**

    (Not many other physics, though)

WW resonances?

If no Higgs found at LHC or 1st ILC,

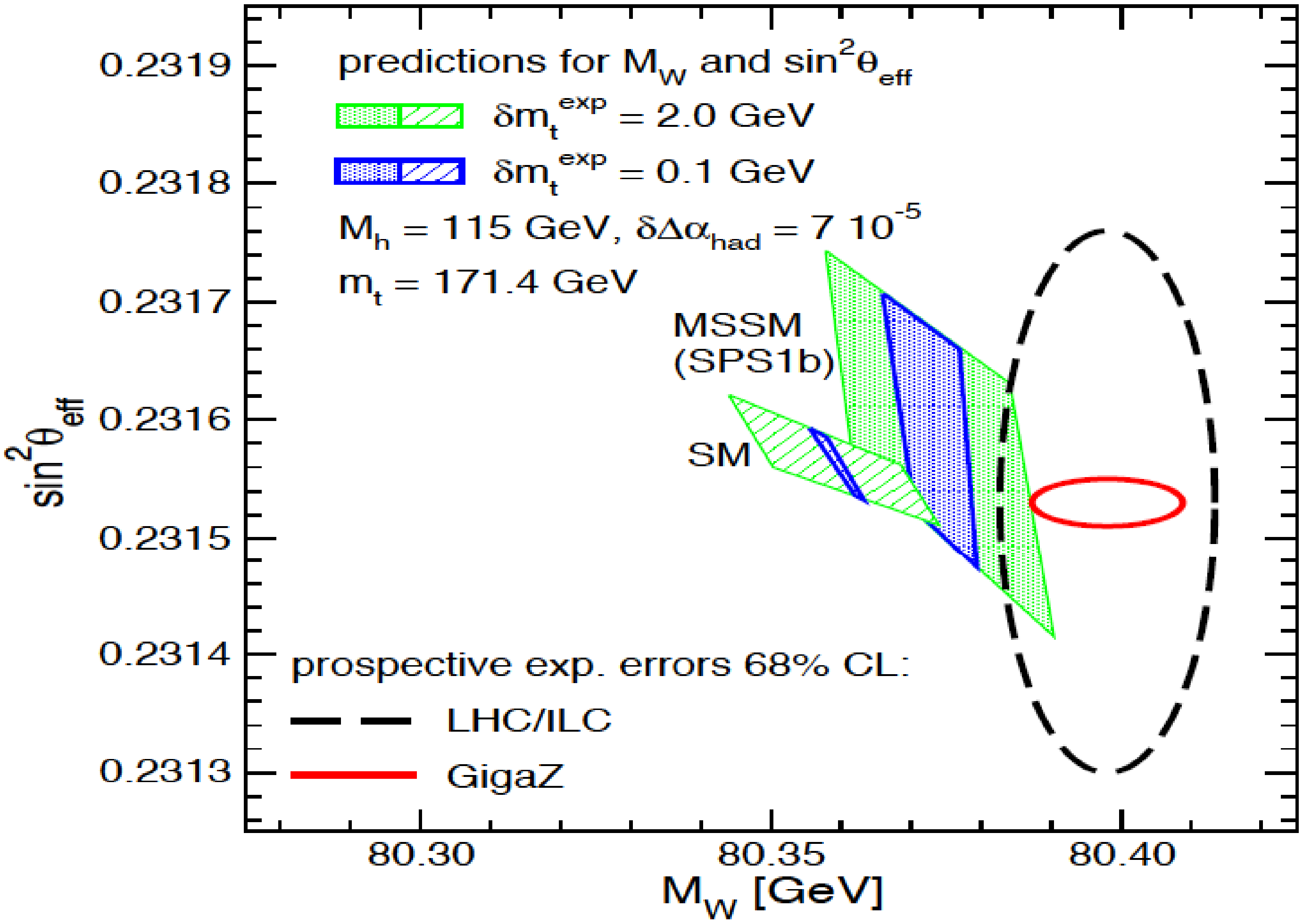
Higgs may be very heavy

Strong W-H coupling

WW bound state

May show effects at WW threshold

Precision measurements of Z, W



Dark Matter Candidates

- Needs to be consistent with the DM relic density:

  $\Omega_{DM}\ h^2 = 0.111 +\!- \ 0.006$

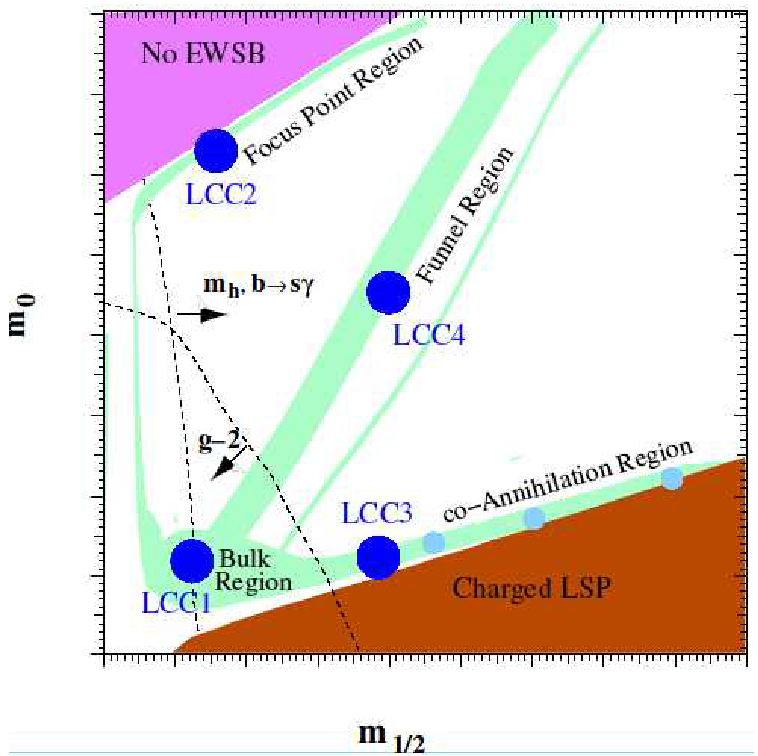
  (h: Hubble constant in 100km/s/Mpc ~ 0.7, h^2~ 1/2)
- DM has to be stable (cosmic timescale)
- DM has to be massive
- Right annihilation rate: Relic density ~ $1/\sigma_{annihilation}$

- SUSY LSP (lightest super particle): most likely?
- KK (Kaluza-Klein) excitations in large extra dimension models, Little Higgs models, …
- Axinos …

4 regions of mSUGRA for DM

Need mechanism to enhance LSP annihilation
(too much DM relic density otherwise)

- Bulk region: mostly excluded
  - **Small m_0, $m_{1/2}$ (LCC1)**
- Focus point region
  - **$m_0 >> m_{1/2}$: LSP~Higgsino (LCC2)**
- Co-annihilation region
  - **m(NLSP) ~ m(LSP)**
  - **NLSP annihilation also (LCC3)**
- Funnel region
  - **m(A) ~ 2 m(LSP) : pole enhancement (LCC4)**



Coannihilation Region DM

e+e- → stau stau

stau → tau + neutralino

Stau and neutralino nearly degenerate

Tau pairs are very soft ~ a few GeV

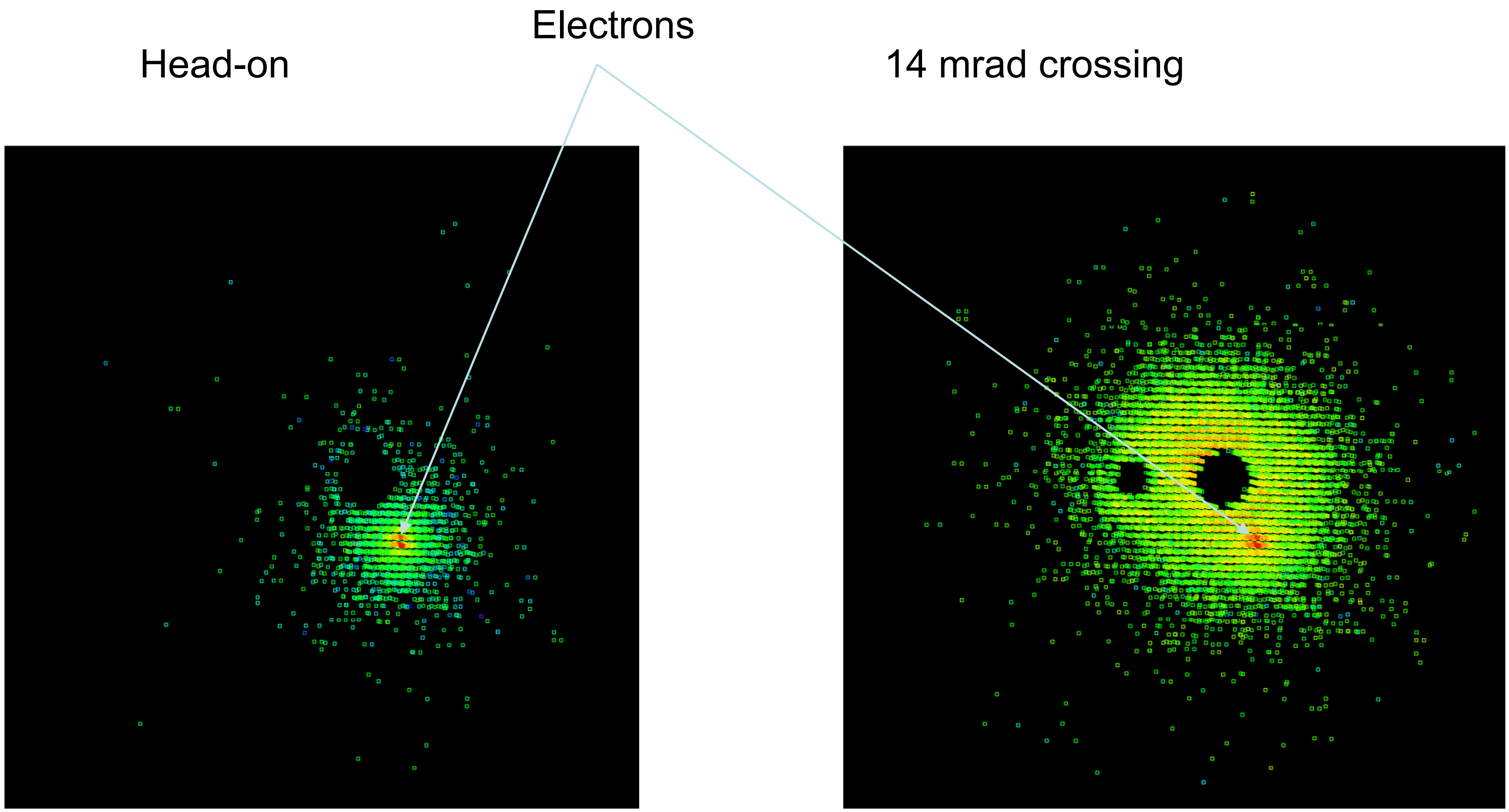
Large two photon background

e+e- → e+e- tau+ tau-

Need to find the high energy e+e- near beam direction

Use Beamcal.

Two-photon Background



U. Nauenberg

Stau search

- 14 mrad crossing requires two holes in Beamcal.
- Head-on or 2mrad crossing require only one hole.
- Loss of two-photon tagging efficiency result in effective luminosity loss of ~40% for two holes.
- Applies to other potentially important modes with a few soft charged tracks with nothing else.

Backgrounds

- Very naively,
  - **Background on a given event (assuming bunch id)**
    - determined by hits per bunch crossing
  - **So, if pairs ∝ luminosity,**
    - Background hits ∝ bunch luminosity
    - E.g. Low-P background ≈ 2× nominal background
    - '2×' applies to all backgrounds proportional to luminosity
      - Two-photon, radiative Bhabha, debris ...
- For pairs, effects can be more than ×2
  - **Pt of the pairs ∝ E field on the surface of bunch**
    - Pt is ~1.5 times larger for Low-P than nominal
    - More pairs hits the detector

Summary

- Options can add substantial physics outputs with modest investments.

- Some of the options come together.

  γ.γe-□..e-e-

- The values of given option depends on what is found at LHC and 1st ILC

- We should keep the options open, and do minimal preparations.

  (Sorry not to cover fixed target option - due only to my ignorance)