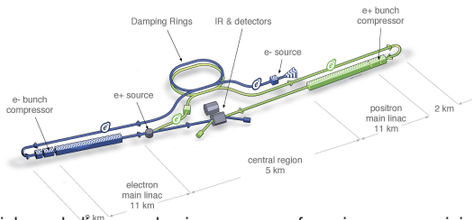
Probing dark matter with ILC

Aleksander Filip Żarnecki (filip.zarnecki@fuw.edu.pl) on behalf of the ILC International Development Team Physics and Detector Working Group

1. International Linear Collider

Electron-positron Higgs Factory based on superconducting technology



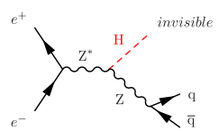
250–500 GeV (baseline)
1 TeV upgrade possible

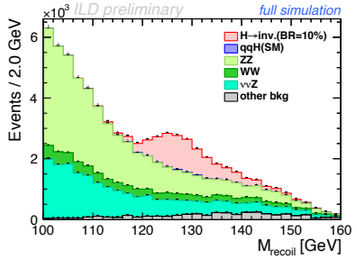
polarisation for both e^- and e^+

Rich and diverse physics program focusing on precision Higgs measurements, top quark physics, as well as indirect and direct searches for Beyond the Standard Model (BSM) phenomena, also including many dark matter scenarios.

2. Collider mode: Higgs portal scenarios

Model independent search for invisible Higgs/new scalar decays [1,2]



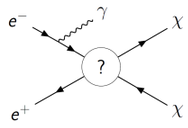


Recoil mass method:

$$M^2_{Recoil} = s + m_Z^2 - 2E_Z\sqrt{s}$$

Expected limit: BR($H \rightarrow$inv) = 0.23% (0.65 %) for $\sqrt{s} = 250$ GeV (500 GeV)
ILC 10 times more sensitive than HL-LHC

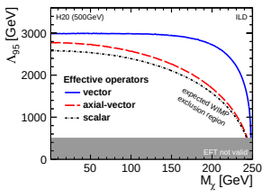
3. Collider mode: mono-photon signature



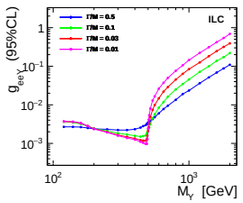
Mono-photon dark matter searches sensitive to many BSM scenarios

See also dedicated poster on “Dark matter searches with mono-photon signature at future e^+e^- colliders” (ID #205)

Heavy mediator mass limits for fixed couplings [3]



Mediator coupling limits for light mediator scenarios [4]

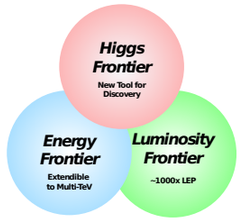


Sensitivity to New Physics mass scales in the 0(10) TeV range

4. Probing dark matter

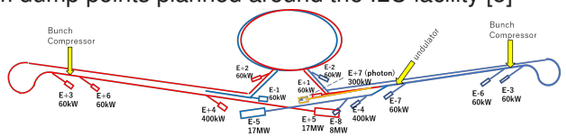
In addition to e^+e^- collider mode, Dark Matter searches possible in:

- main dump experiments
- extracted beam exp.
- off-beam (far) detectors

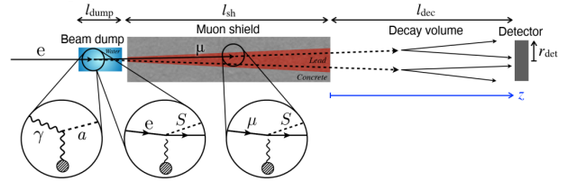


5. ILC beam dumps

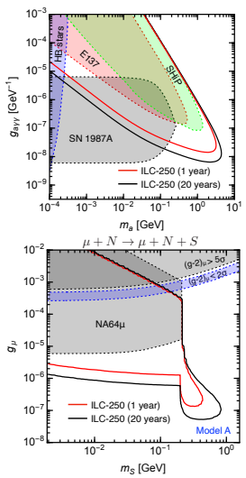
Many beam dump points planned around the ILC facility [5]



Concept of main beam dump experiments searching for axion-like particles and new scalars [6]



6. Main beam dump experiments



Axion-like particle model [6]

$$\mathcal{L} \ni -\frac{1}{4} g_{a\gamma\gamma} a F_{\mu\nu}\tilde{F}^{\mu\nu} + \frac{1}{2}(\partial_\mu a)^2 - \frac{1}{2} m_a^2 a^2$$

An order of magnitude better sensitivity than other experiments

Light scalar coupled to charged leptons [6]

$$\mathcal{L} \ni \frac{1}{2}(\partial_\mu S)^2 - \frac{1}{2} m_S^2 S^2 - \sum_{l=e,\mu,\tau} g_l S\bar{l}l$$

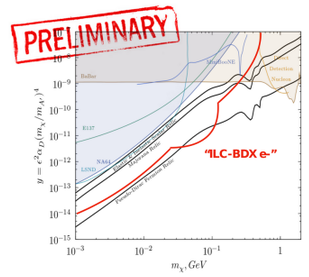
Sensitivity down to very small couplings

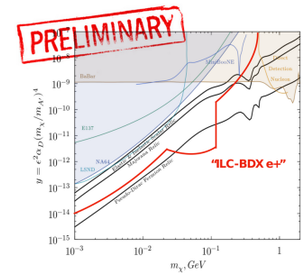
7. Main beam dump experiments

Searching for Dark Photons (A’) with Dirac fermion DM (χ) [7]

$$\mathcal{L} \ni -\frac{1}{4} F'_{\mu\nu}F'^{\mu\nu} + \frac{1}{2} m_{A'}^2 A'_\mu A'^\mu - \frac{\epsilon}{2} F'_{\mu\nu}F^{\mu\nu} + \bar{\chi}(\imath\not{D} - m_\chi)\chi$$

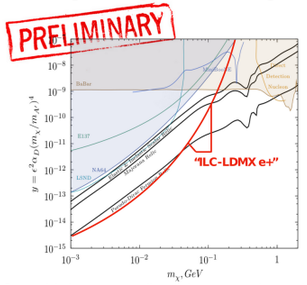
Huge improvement in sensitivity for $m_{A'} \lesssim 1$ GeV thanks to much higher statistics

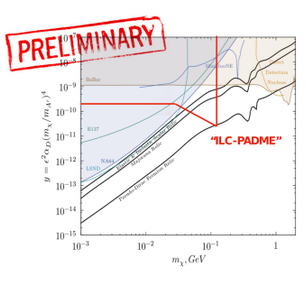




8. Experiments with extracted beams

Searching for Dark Photons [7] with extracted beams
Missing energy or missing mass reconstrution in dedicated detectors





Sensitivity extending down to the minimum couplings allowed by relic density measurements.

References

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3. M.Habermehl, M.Berggren, J.List, WIMP Dark Matter at the International Linear Collider, Phys. Rev. D. 101, 075053, arXiv:2001.03011
4. J.Kalinowski et al., Sensitivity of future e^+e^- colliders to processes of dark matter production with light mediator exchange, arXiv:2107.11194
5. K.Yokoya, ILC Tour for Fixed-Target Options, Presented at LCWS’2021
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7. M.Perelstein, Opportunities for Fixed Target Experiments with ILC Beams, Presented at LCWS’2021