Probing dark matter with ILC

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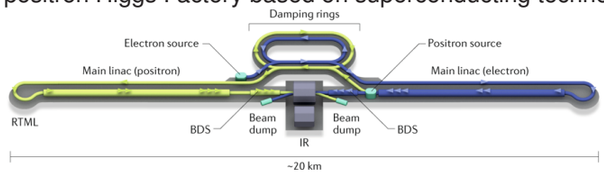
1. International Linear Collider

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.

See also "New physics searches with the ILD detector at the ILC" (poster ID #130)

2. Collider mode: Higgs portal scenarios

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

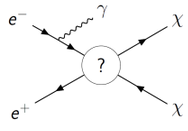
Recoil mass method:

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

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

See also dedicated posters on "Higgs invisible and rare decays at ILC" (ID #150) and "ILC Higgs Physics Potential" (ID #148)

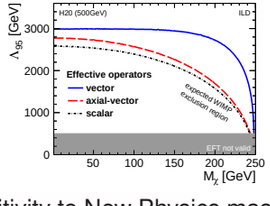
3. Collider mode: mono-photon signature



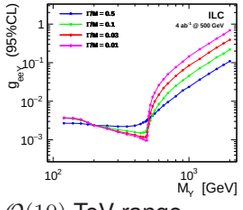
Mono-photon dark matter searches sensitive to many BSM scenarios

See also dedicated poster on "Sensitivity of future e^+e^- colliders to processes of dark matter production with light mediator exchange" (ID #52)

Heavy mediator mass limits for fixed couplings [3]



Mediator coupling limits for light mediator scenarios [4]

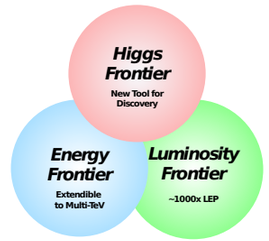


Sensitivity to New Physics mass scales in the $\mathcal{O}(10)$ TeV range

4. Probing dark matter

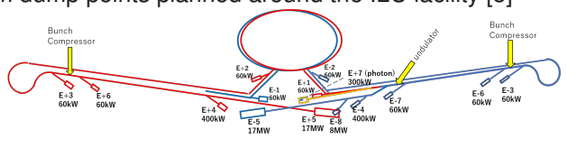
In addition to precision studies (Higgs Frontier) and direct searches (Energy Frontier) in e^+e^- collider mode, extreme beam intensities (Luminosity Frontier) open new options:

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

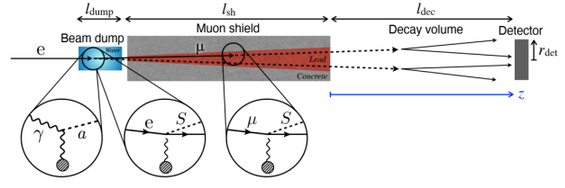


5. ILC beam dumps

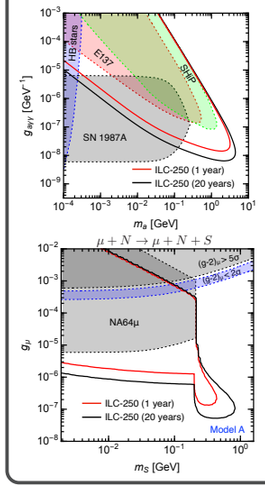
Many beam dump points planned around the ILC facility [5]



Concept of main beam dump experiments searching for axion-like particles, dark photons or new scalars [6]



6. 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]

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

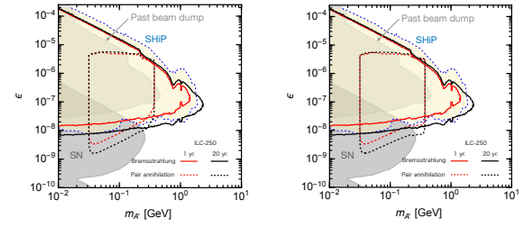
Sensitivity down to very small couplings

7. Beam dump experiments

Searching for Dark Photons (A') in visible decay channels [7]

$$\mathcal{L} \ni -\frac{1}{4} F'_{\mu\nu}F'^{\mu\nu} + \frac{1}{2} m^2_{A'} A'_\mu A'^\mu - \frac{\epsilon}{2} F'_{\mu\nu}F^{\mu\nu}$$

Sensitivity to Dark Photon production comparable with dedicated future experiments

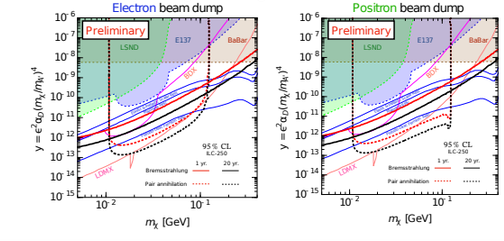


8. Beam dump experiments

Searching for invisible decays of Dark Photons (A') to DM (χ) [8]

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

Huge improvement in sensitivity for light A' / light DM scenarios



$m_{A'} = 3\, m_\chi$

References

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6. Y.Sakaki, D.Ueda, Search for new light particles at ILC main beam dump, Phys. Rev. D 103, 035024 (2021), arXiv:2009.13790
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8. D.Ueda, Fixed-target experiment using ILC main beam dump, Presented at ILCX'2021