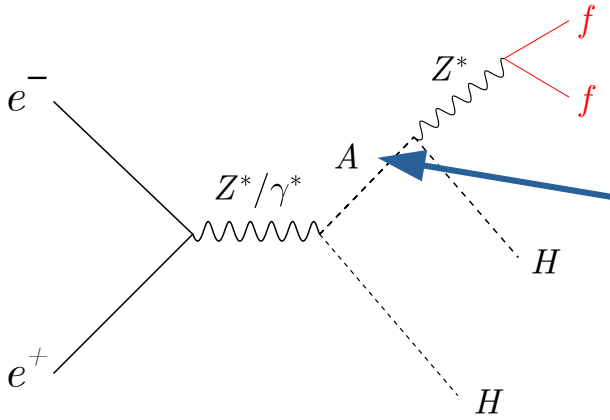
LLP searches with a gaseous tracker for a future Higgs factory

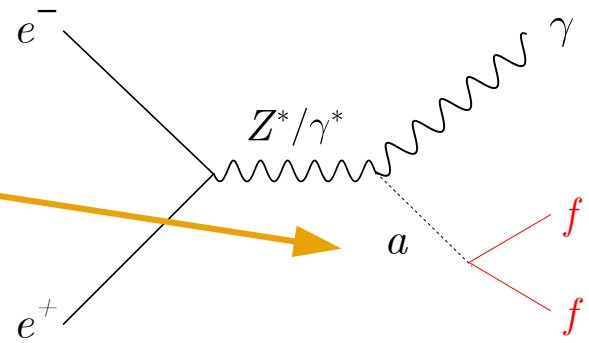
As a challenging case (small boost, low-pT final state) we considered:

→ heavy scalar LLP (A) and DM (H) pair-production with small mass splitting, $Z^* \to \mu\mu$



Long-lived, with $c\tau = 1\,\mathrm{m}$
$m_A = 75\,\mathrm{GeV}$
$m_A - m_H = 1, 2, 3, 5\,\mathrm{GeV}$

Long-lived, $c\tau = 10 \cdot m_a\,[\mathrm{mm}]$
$m_a = 0.3,\ 1,\ 3,\ 10\,\mathrm{GeV}$

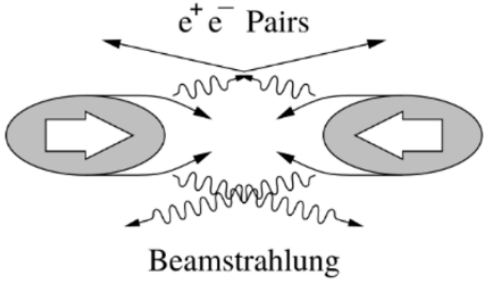


The opposite extreme case, (large boost, high-pT final state)

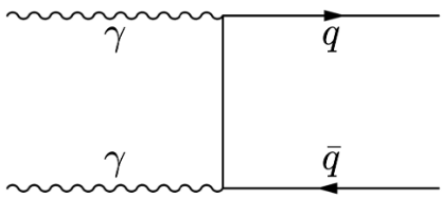
→ light pseudoscalar LLP $a \to \mu\mu$

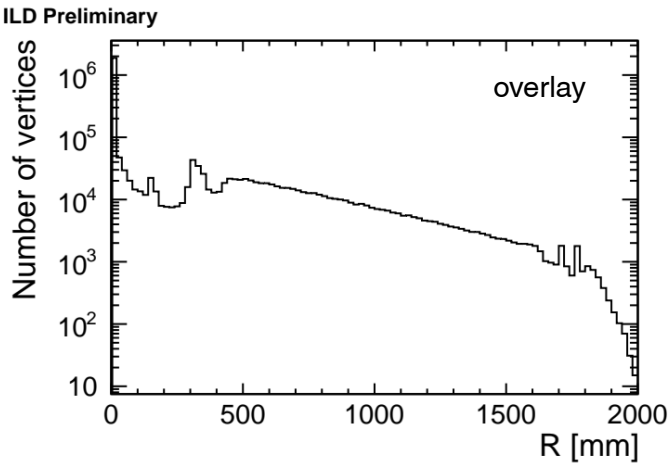
Very simple vertex finding (inside the TPC) based on a distance between track pairs

Overlay events as a significant background contribution



← linear →
← circular
collider





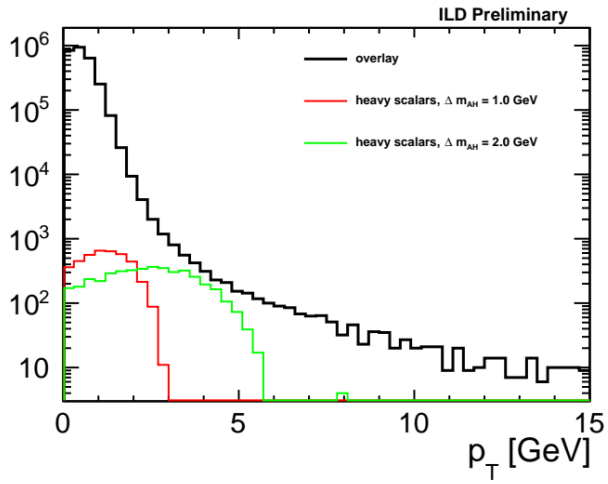
These events are soft, usually important as they **overlay** on physical events

...but appear in (almost) every bunch crossing (BX)

- ~10^{11} BXs per year at ILC → overwhelming number of overlay events
- Similar kinematics to the signal considered and can be busy

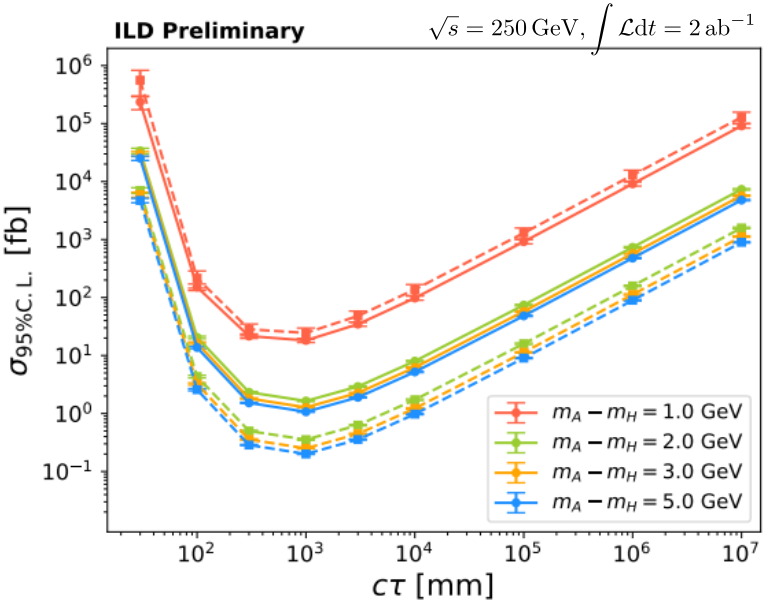
  → many **fake vertices** (random intersections)

  → also V^0s and photon conversions, interactions with detector material...

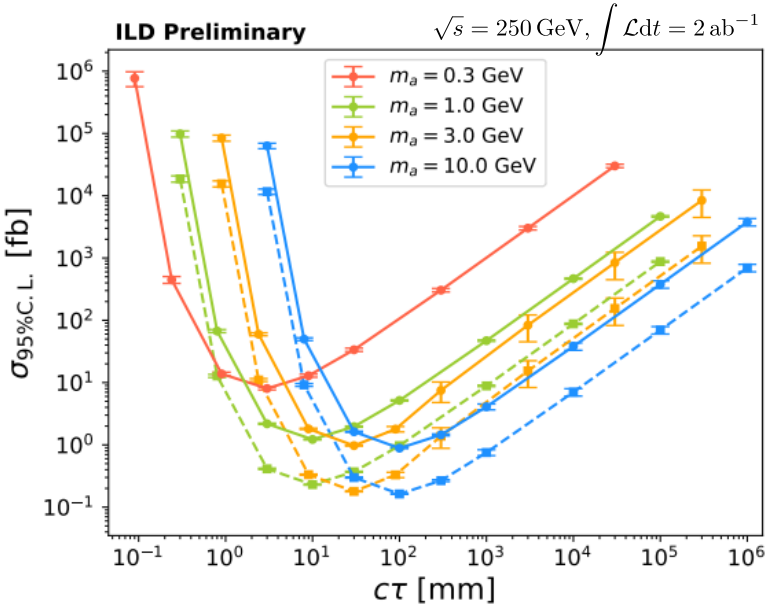


- Various effects **can** play a role (we want to look for **rare** processes!)
- Of course the importance depends on search inclusiveness, but full simulation may be crucial

Cross section limits



Heavy scalars



Light pseudoscalar

- Backgrounds from overlay and hard events taken into account
- Solid: "standard" selection, dashed: tight selection (less inclusive)
- Tight cuts reject $m_a = 300$ MeV scenario and worsens limit for $\Delta m_{AH} = 1$ GeV, but for the rest provides significant improvement

- More detailed slides with current results: **link**
- EPS-HEP'23 proceedings: **link**
- Final paper in preparation