Lohengrin

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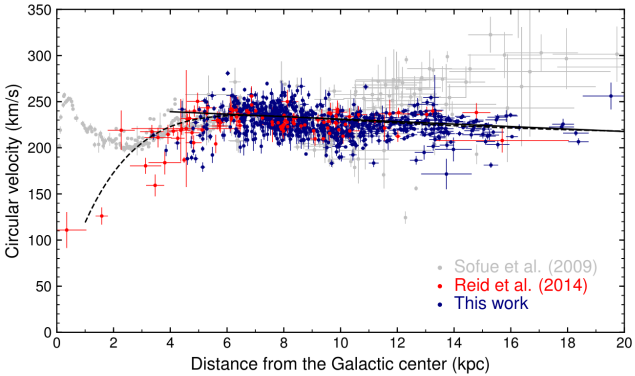
The Need for Dark Matter

Cosmology extremely successful→almost entire history of the universe on macroscopic scales



→ Gravitationally interacting form of matter, not observed directly

Mróz et al. 2019

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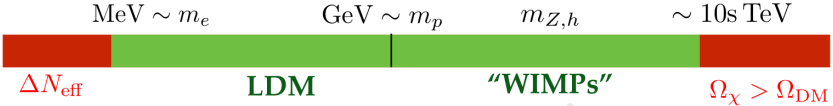
Light Dark Matter & Dark Photons



- Introduce dark photon A' and Dark Matter particle χ (in J_D^μ)
- Incorporate into SM Lagrangian $\mathcal{L}$:
  $\mathcal{L} \supset -\frac{1}{4}F'_{\mu\nu}F'^{\mu\nu} + \frac{1}{2}m^2_{A'}A'_\mu A'^\mu - \frac{\varepsilon}{2}F'_{\mu\nu}F^{\mu\nu} - g_D A'_\mu J_D^\mu$

Åkesson et al. 2018; Berlin et al. 2019

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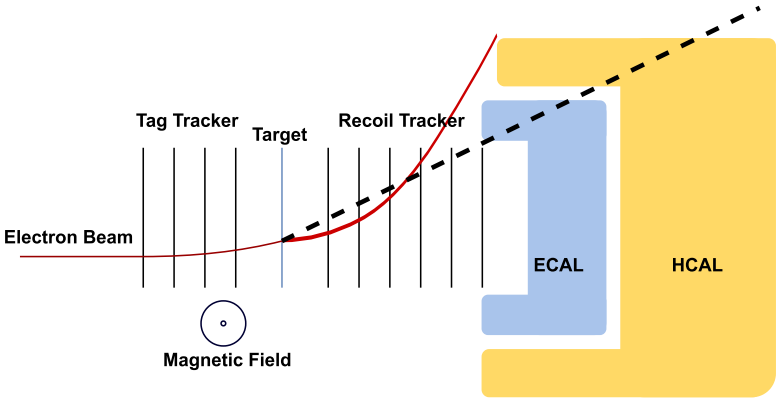
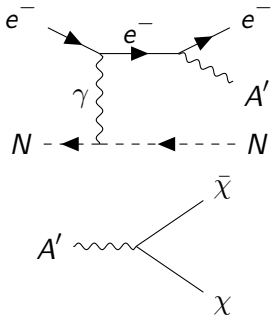
Experimental Idea

- Inspired by LDMX: Electron fixed target experiment (3.2 GeV beam energy)
- Measure dark bremsstrahlung with kinematics, missing energy and veto on ECal/HCal





Adapted from Åkesson et al. 2018

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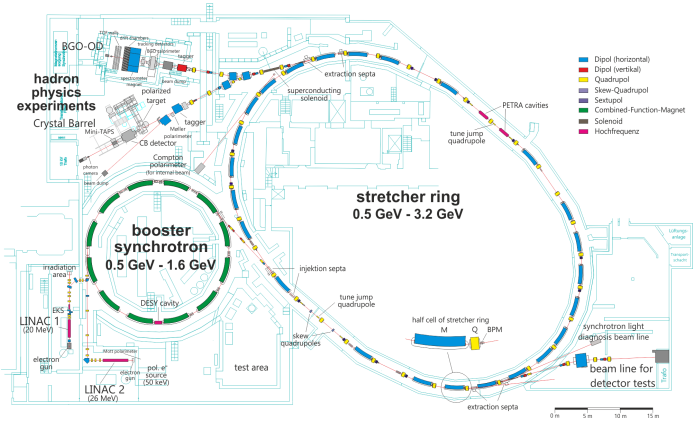
The Accelerator - ELSA

Electron Stretcher Accelerator (ELSA)



- Possibility for small bunches/single electrons at high frequency
- Very good energy resolution of 0.8 ‰
- Advantageous for precise tracking

Frommberger 2019

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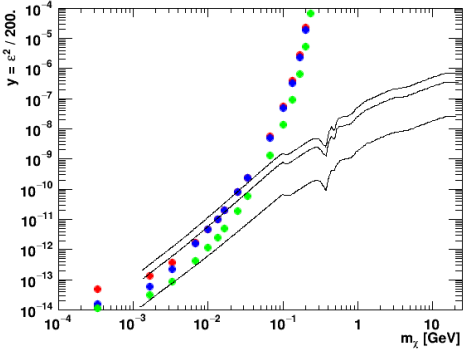
Physics Reach

- Very very rough estimate of physics reach
- Simple cut on energy in calorimeter and recoiling electron momentum
- Idea is in principle able to cover some fo the interesting parameter space
- Target is given by constraints from cosmology
- Lots of room for optimisation



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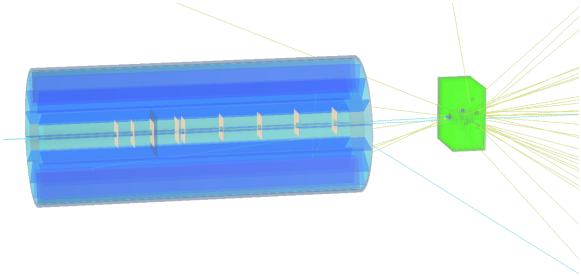
Tracker Requirements

- Telescope like with tagging and recoil tracker
- Thin to limit scattering and energy loss
  - Need a working GSF to account for energy loss
  - Own implementation with KF did not sufficiently account for this
- Focus on low momentum electrons ($<200\,\mathrm{MeV}$)



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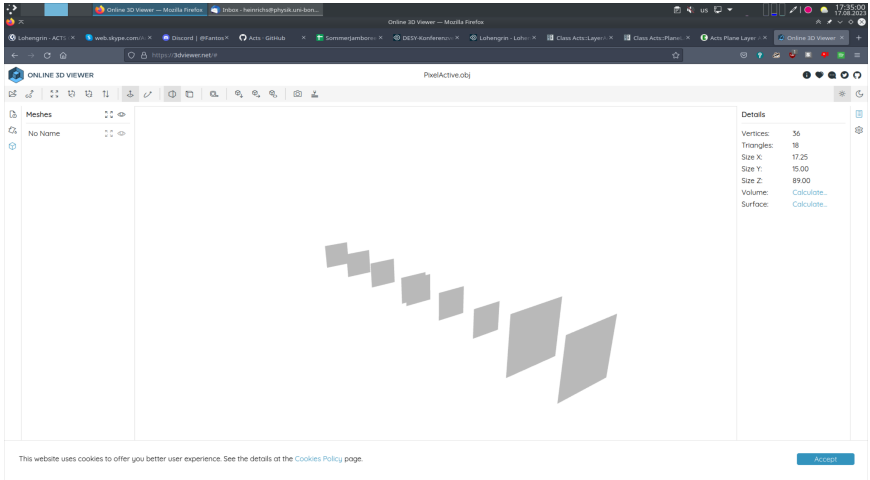
Experiences with Acts so far

- Extract only sensitive volumes → Hits are registered here
- Also allows for alignment on the fly



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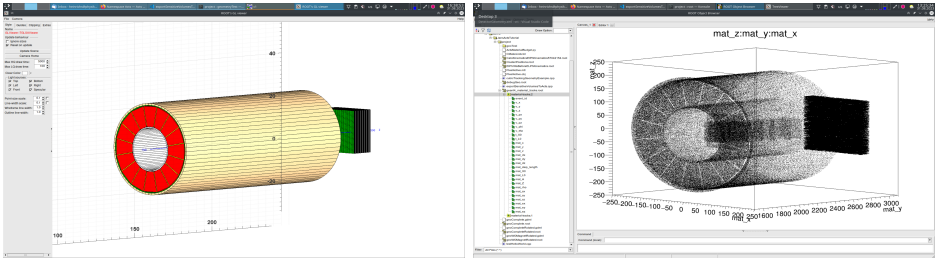
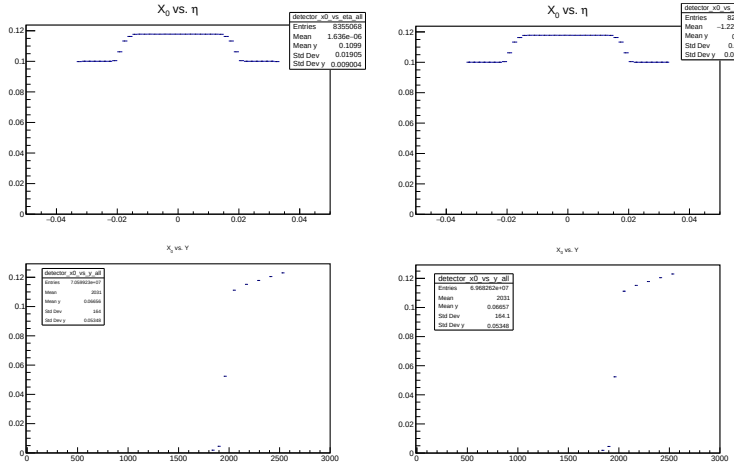
Generating the material budget



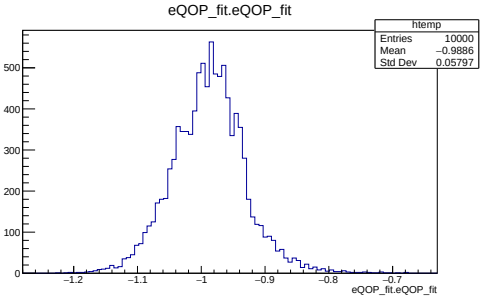
Comparing the Simplified Material Budget with Geant4 simulation

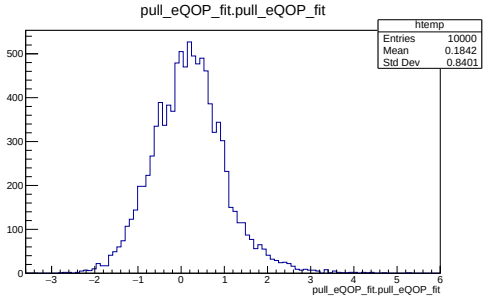
- Budget bound to tracking geometry (right) and budget simulated with Geant4 (left)



Finally: Running a GSF on a Telescope Detector Geometry

- Used custom tracking geometry and magnetic field with material map
- Just as test track 1 GeV muons
- Electrons currently not working with Fatras → Having some problems setting uo full Geant4 simulation
- Results look sensible





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Conclusion and Next Steps

- Implemented a working (first) Acts setup for a telescope geometry
- Some obstacles on the way:
  - GDML does not support all geometry types ROOT supports
  - Fatras not able to account for electron energy loss on thin surfaces
  - Coordinate system collider centric $\rightarrow$ Entire geometry needs to be rotated
- Some learnings which might be applicable to Acts as a whole
- Use this as test for applicability in wide range of scenarios
- Next: Get Geant4 for electrons working and get benchmark for possible tracking performance in interesting region

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- Åkesson, T. et al. (2018). *Light Dark Matter eXperiment (LDMX)*. arXiv: 1808.05219 [hep-ex].
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- Frommberger, F. (2019). *ELSA Homepage*. URL: https://www-elsa.physik.uni-bonn.de/index_en.html (visited on 26/02/2020).
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