Search for Light Dark Matter using a Primary Electron Beam

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Partikeldagarna 2020

Why dark matter?
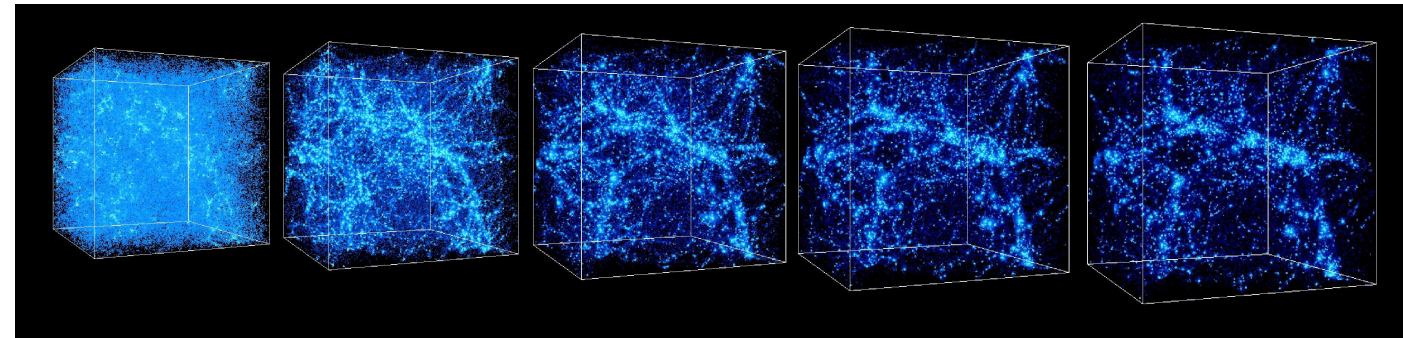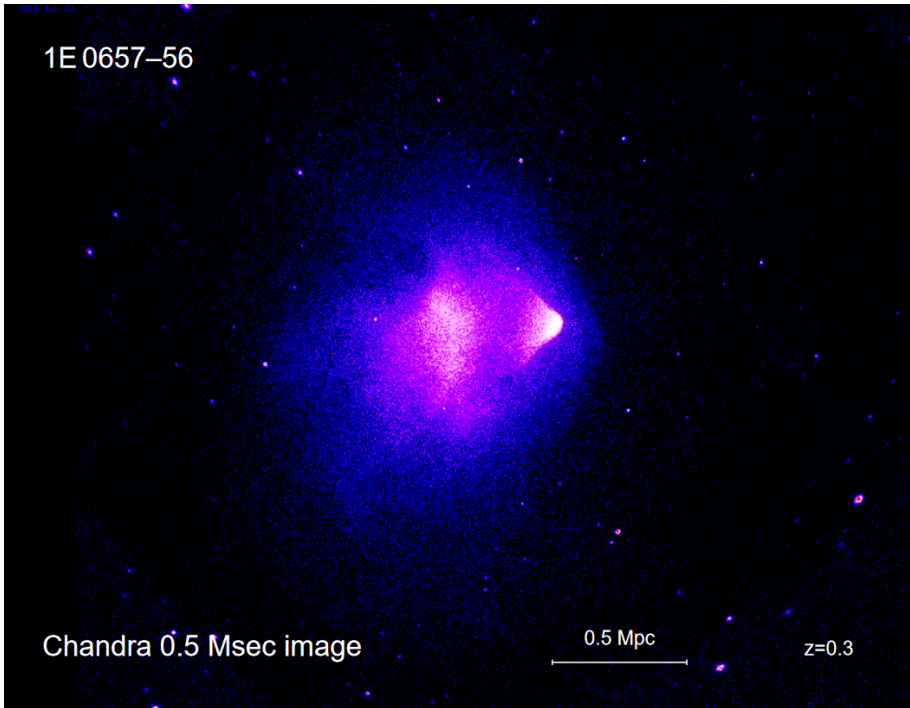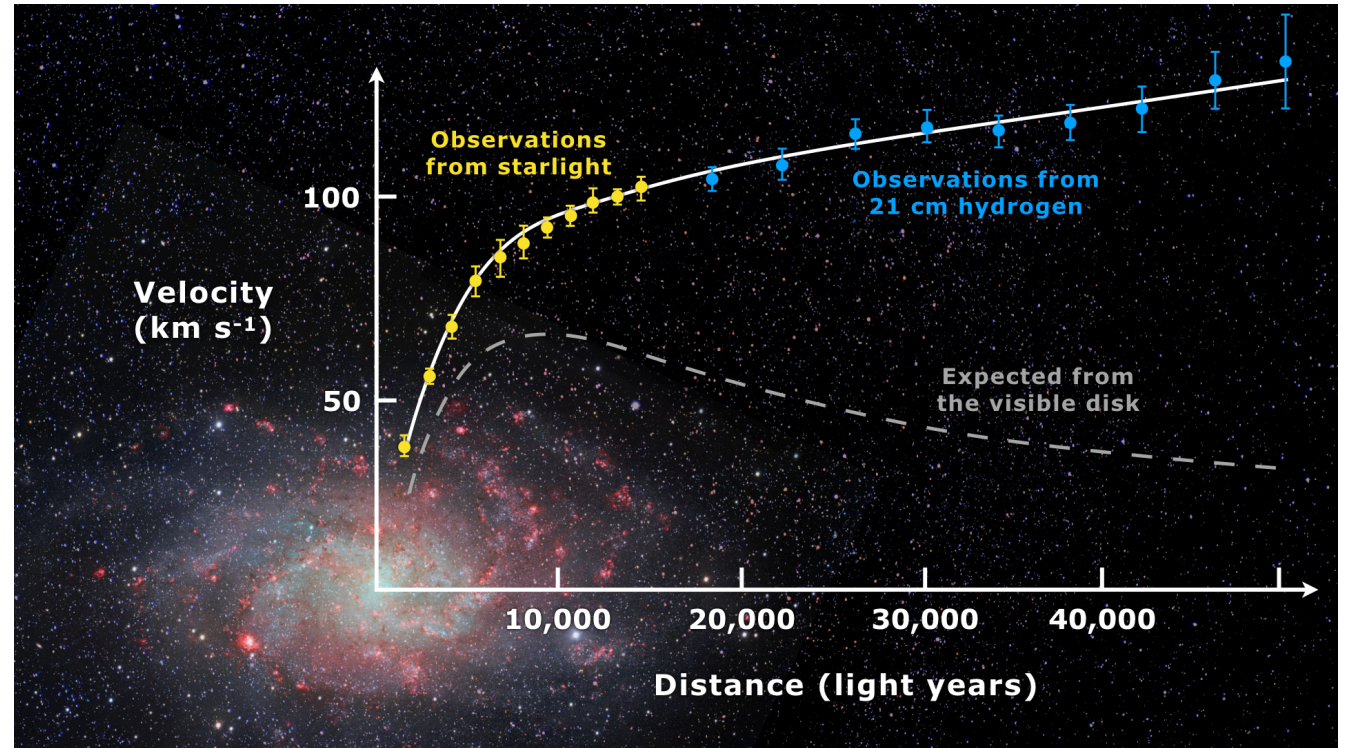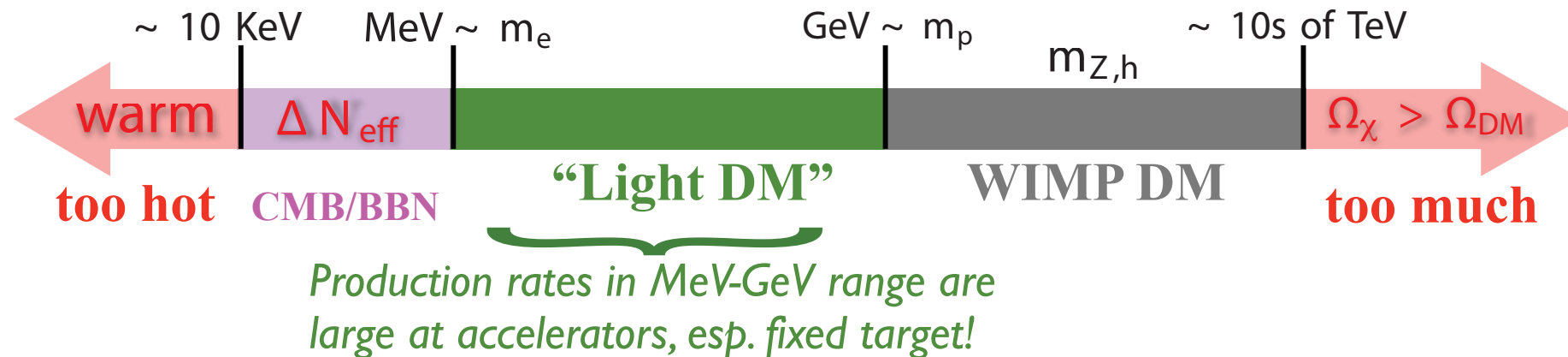
- Cosmological observations
  - Galactic rotation curves
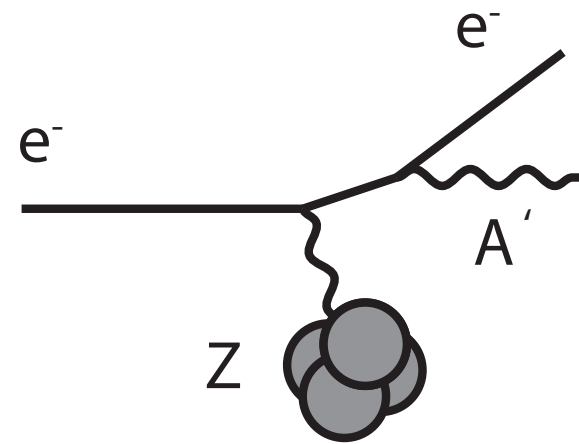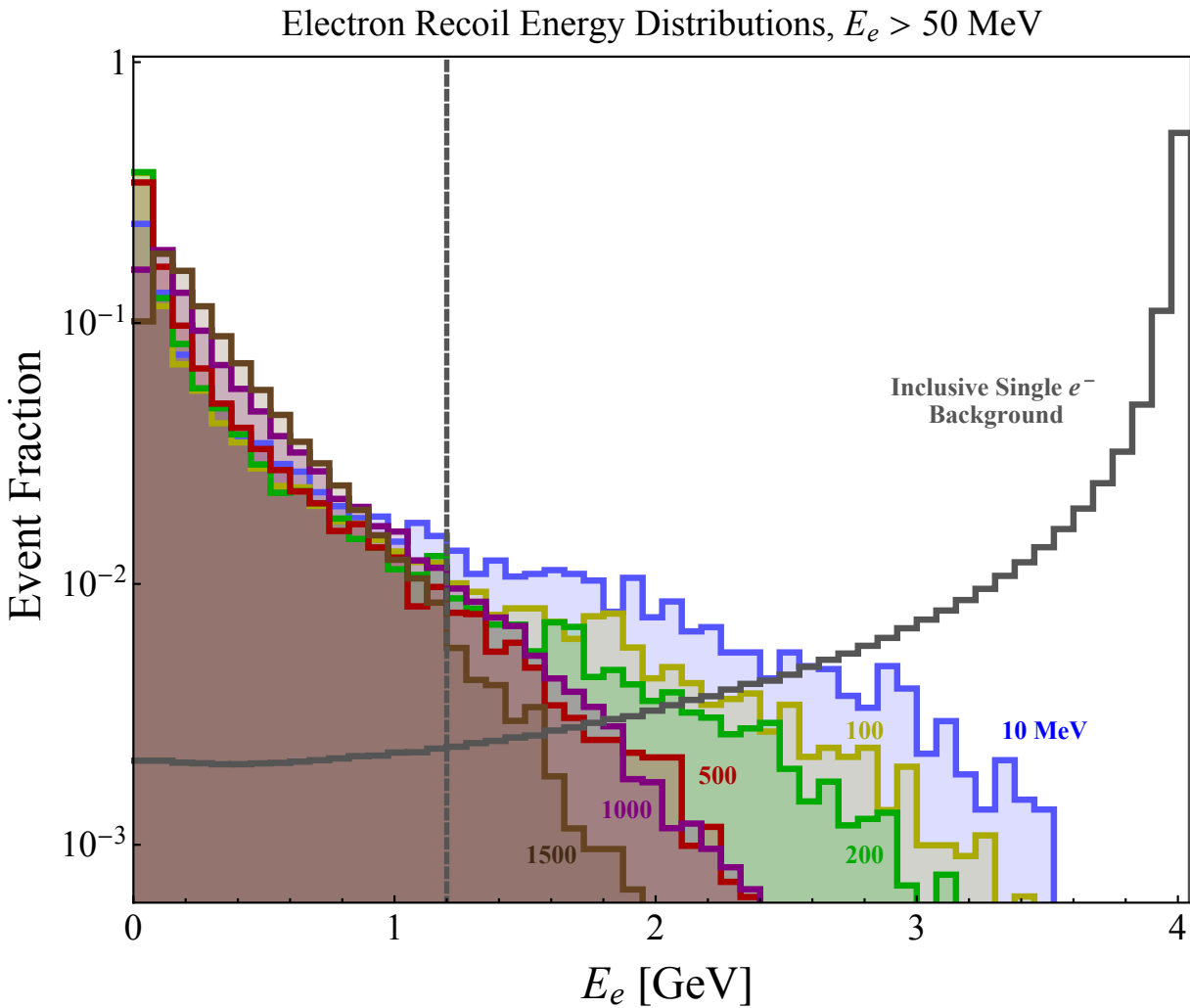 - Large scale structures
  - Bullet cluster

Dark Matter with an e⁻ beam, Why?

- Cosmological observation, constrains Dark Matter and sets limits for masses of both DM and mediators

- Extensive search program in the WIMP sector already but not of the Light DM sector

- In a Light DM scenario, thermal relic DM requires light mediators for thermal freeze out.

~ 10 KeV   MeV ~ m_e GeV ~ m_p ~ 10s of TeV

$m_{Z,h}$

warm ΔN_{eff} "Light DM"   WIMP DM $\Omega_\chi > \Omega_{DM}$

too hot   CMB/BBN   WIMP DM   too much

Production rates in MeV-GeV range are large at accelerators, esp. fixed target!

Fundamental idea

Electron Recoil Energy Distributions, $E_e > 50$ MeV

Inclusive Single e^- Background

10 MeV

100

500

1000

1500

200

Event Fraction

E_e [GeV]

- Dark matter could have such properties that it could be produced via Dark Photons (Or a similar process)

- Candidate events will leave only so much energy in the detector

- Any other event would be caught thanks to energy deposits

e^-

e^-

A'

Z

LUND UNIVERSITY
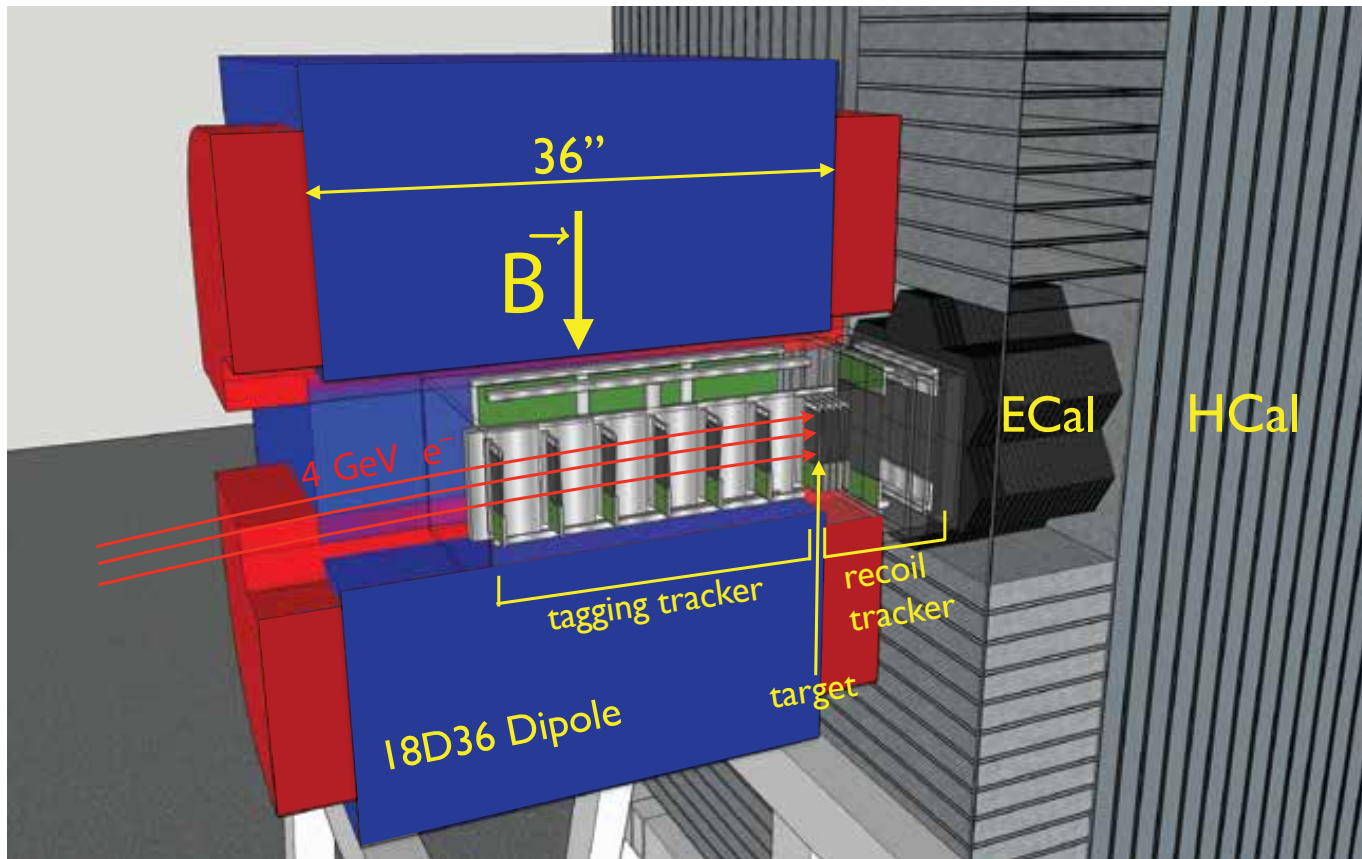
LDMX

The Light Dark Matter Experiment (LDMX)

- Collaboration between several US institutes and Lund U.

- [Making use of the e⁻ beam from the Linac Coherent Light Source (LCLS) X-Ray laser at SLAC](#)

- 4/8 GeV beam

- Using proven technology in order to minimise detector R&D costs
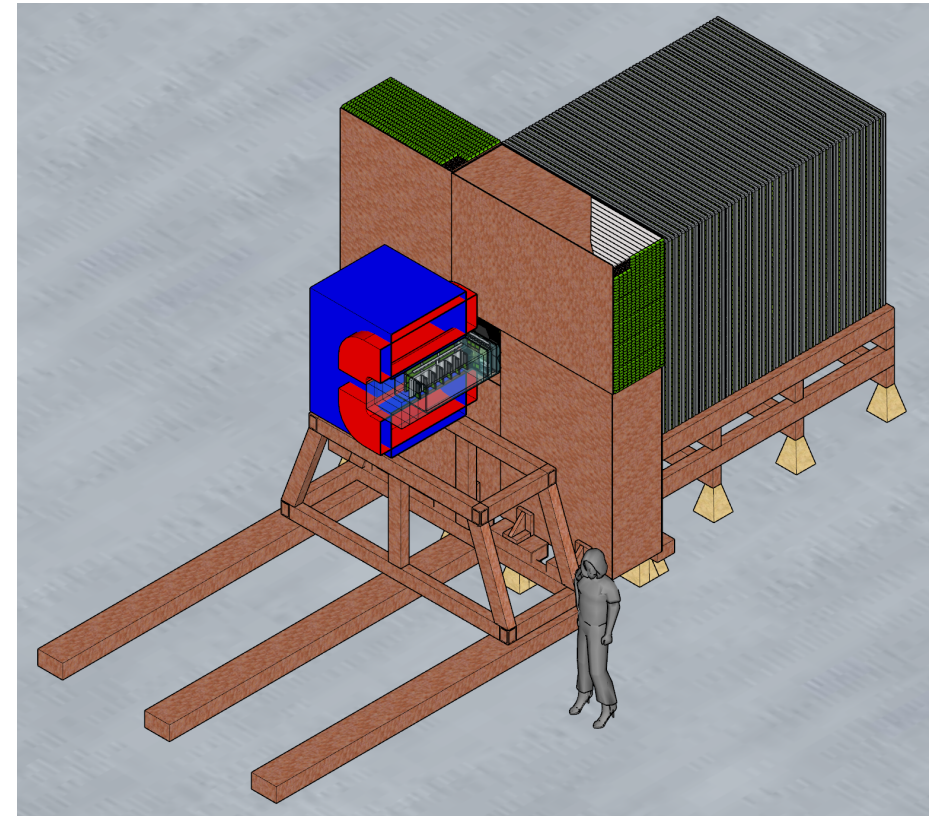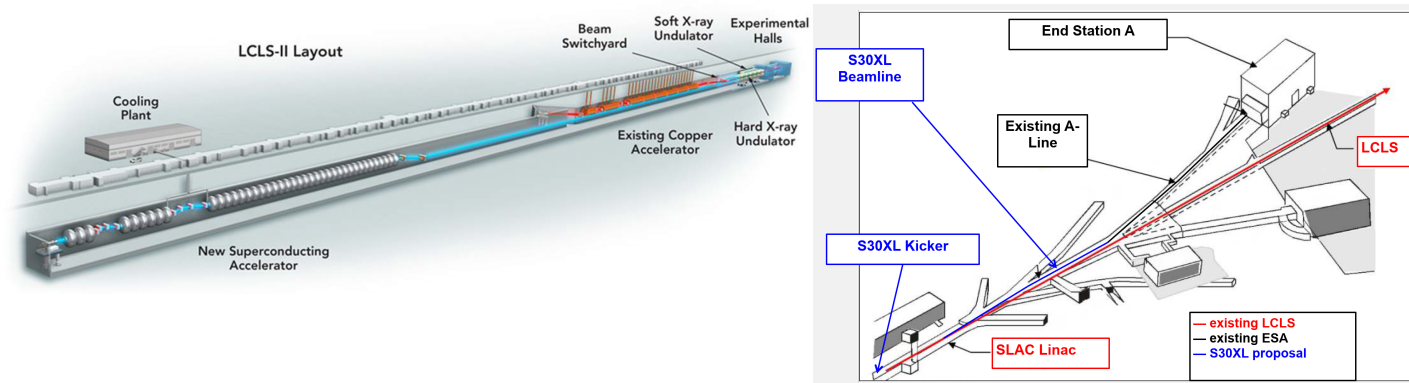
https://arxiv.org/abs/1808.05219
https://link.springer.com/article/10.1007/JHEP04(2020)003

LDMX Detector

- Tagging tracker (HPS)
  - Identify incoming electrons
- Recoil tracker (HPS)
  - Identify outgoing products of the interaction with the target
- Trigger Scintillator
  - Electron counting for triggering purpose
- Electromagnetic Calorimeter (CMS)
  - Catching and tracking products of the interaction with the target
- Hadronic calorimeter (Mu2e)
  - Catching and identifying any nuclear products produced during any of the interactions
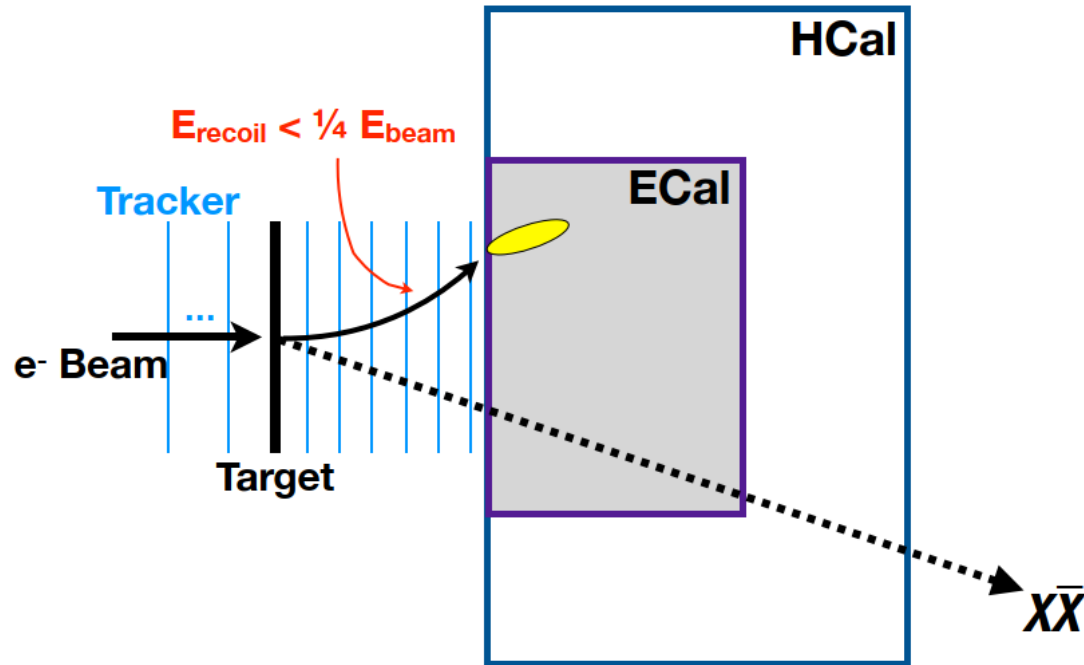
Hadronic Calorimeter
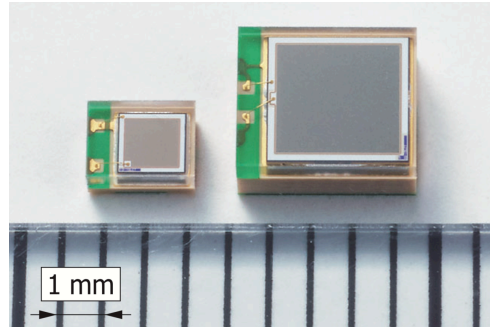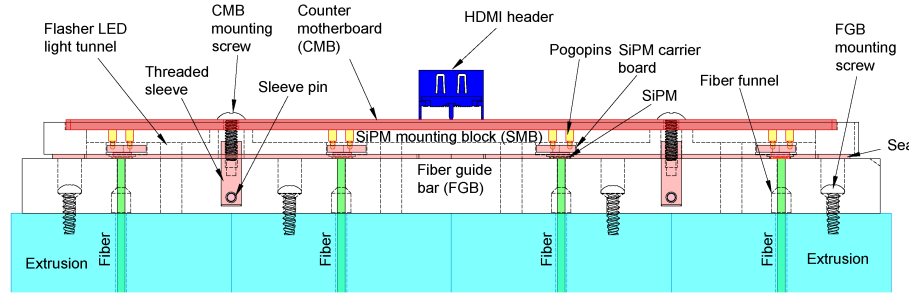
- Scintillator bars with wavelength shifting fibers read out with Silicon Photomultipliers (SiPMs)
- Mu2e based electronics
- Front End boards designed by Lund based on the same readout chip as the ECal
- Test setup being build at Lund for prototyping
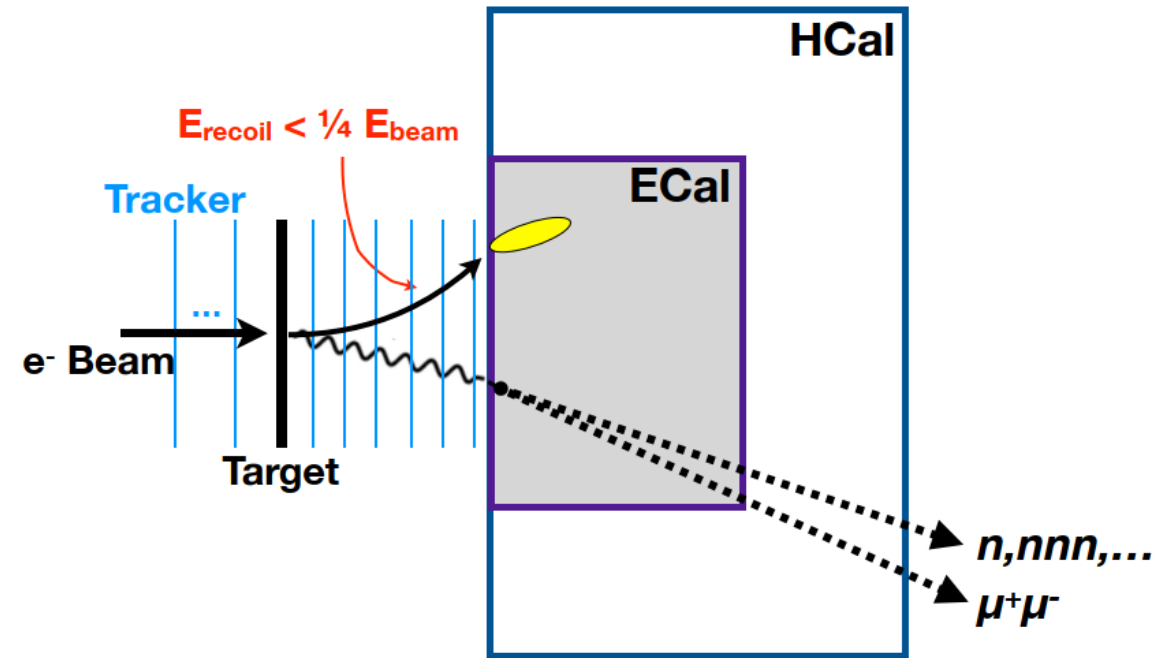- Test Beam expected end of next year
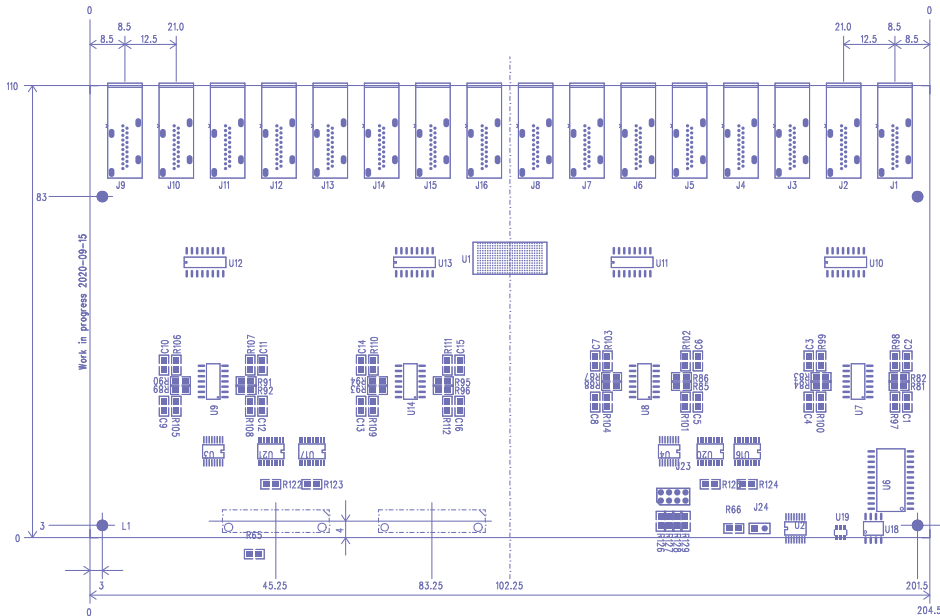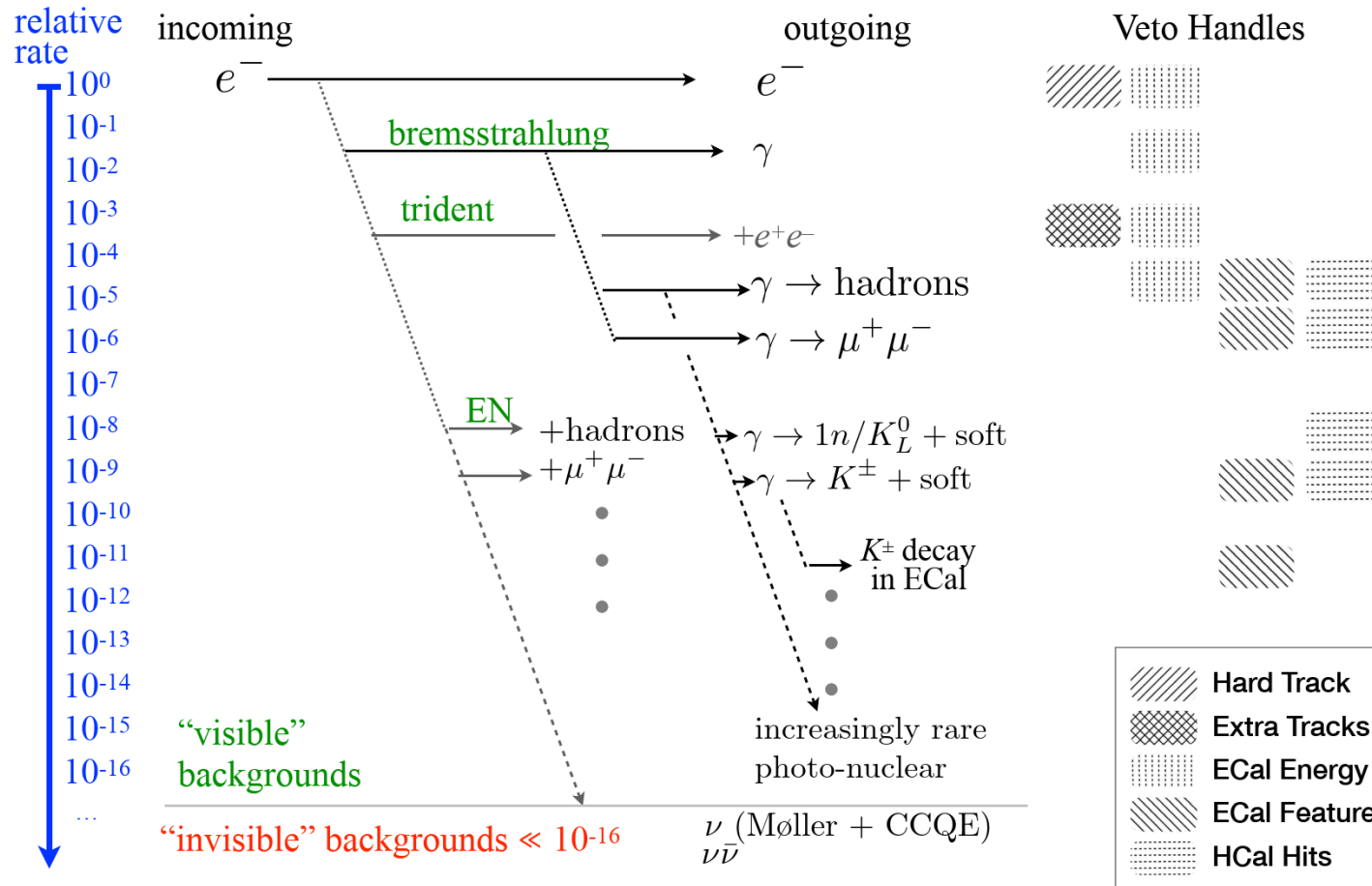
Getting back to the Physics

Signal

Backgrounds

Backgrounds


- In our sensitivity context every single rare background is challenging

- We do have handle with MC but modeling is an important element

- All of these are important not only for design of LDMX but also for the physics reach of the experiment

- Any work at improving the understanding of any of those backgrounds is directly impacting LDMX results but also has applications outside of LDMX

Initiative for dark matter research

Combinaison of experimentalist and theorists from different universities to tackle those challenging questions.
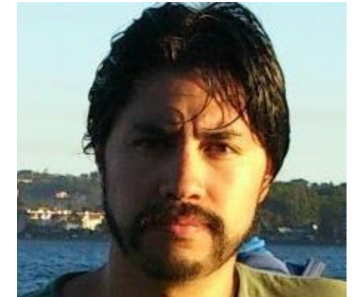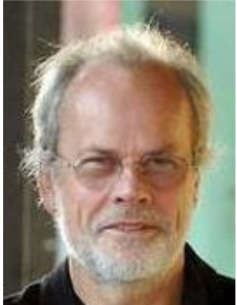
Torsten Akesson
Particle Physics, LU

Riccardo Catena
Theoretical Physics, Chalmers

Jan Conrad
Astroparticle Physics, SU

**Caterina Doglioni**
Particle Physics, LU

Stefan Prestel
Theoretical Physics, LU

Ruth Pöttgen
Particle Physics, LU

Luis Sarmiento
Nuclear Physics, LU

- WP1 The Light Dark Matter eXperiment, Lund Particle physics 100% in LDMX
- WP2 Simulation: Signal exploration & integration in PYTHIA, PYTHIA- GEANT4 integration, strengthening the nuclear physics modeling in GEANT4. Chalmers, Lund (Theory, Particle, Nuclear)
  Experience will tell relevance for and interaction with LDMX
- WP3 Data interpretation: Statistical inference & global fits. Lund Particle Physics, Chalmers, Stockholm Astroparticle, LDMX stakes: see WP2
- WP4 Detector material evaluation for direct detection: Use lessons to prepare for future direct detection experiments. Chalmers and Stockholm
  100% outside LDMX

Current development WP2
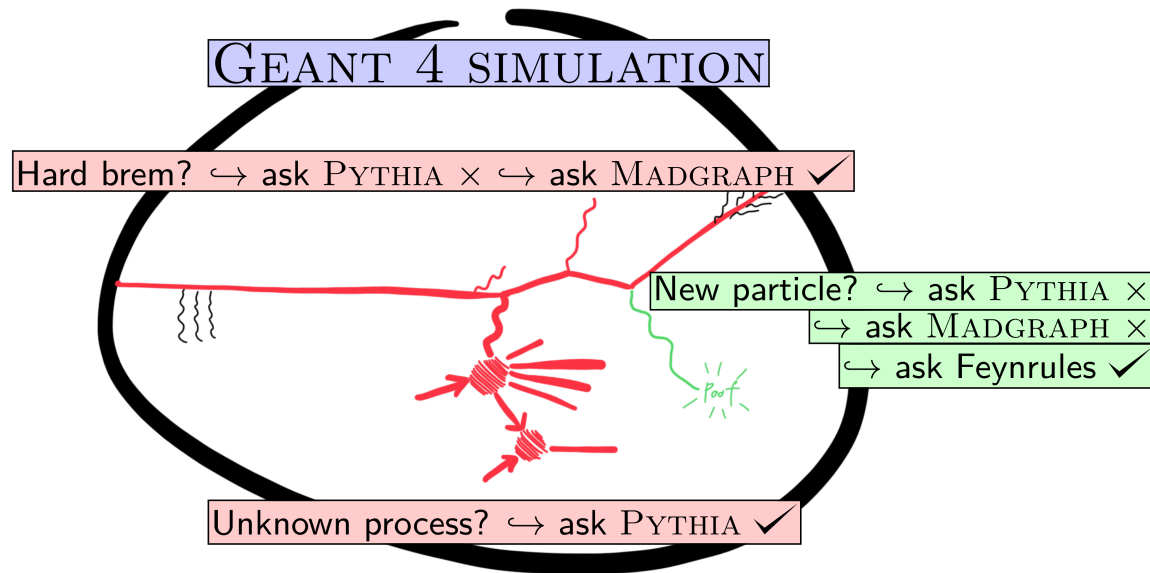
- Basic idea:
  - When in doubt, ask a friend
- Integration of Pythia and Madgraph in Geant4 Simulation for signal generation
- Allows to be much more precise on challenging processes

In Summary

- LDMX is an electron fixed target experiment that aims to fully exploit the missing momentum technique with sensitivity to various asymmetric, thermal scalar elastic, Majorana, and inelastic/Pseudo-Dirac scenarios

- Strong Swedish involvement in LDMX via Lund

- There is in Sweden a broader involvement in the Dark Matter sector

- In this context Sweden has a particular program that has reach beyond LDMX
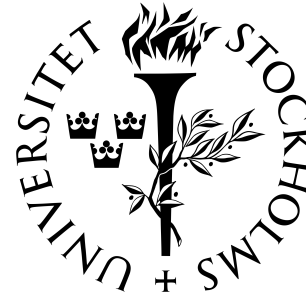
Thank you for your attention!