LDMX — Progress and Plans

PBC annual workshop

16 January 2019

Ruth Pöttgen, on behalf of LDMX

LUNDS UNIVERSITET

Introduction

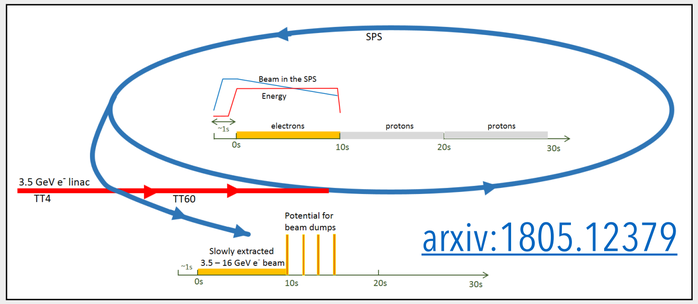
electron-beam,

fixed-target,

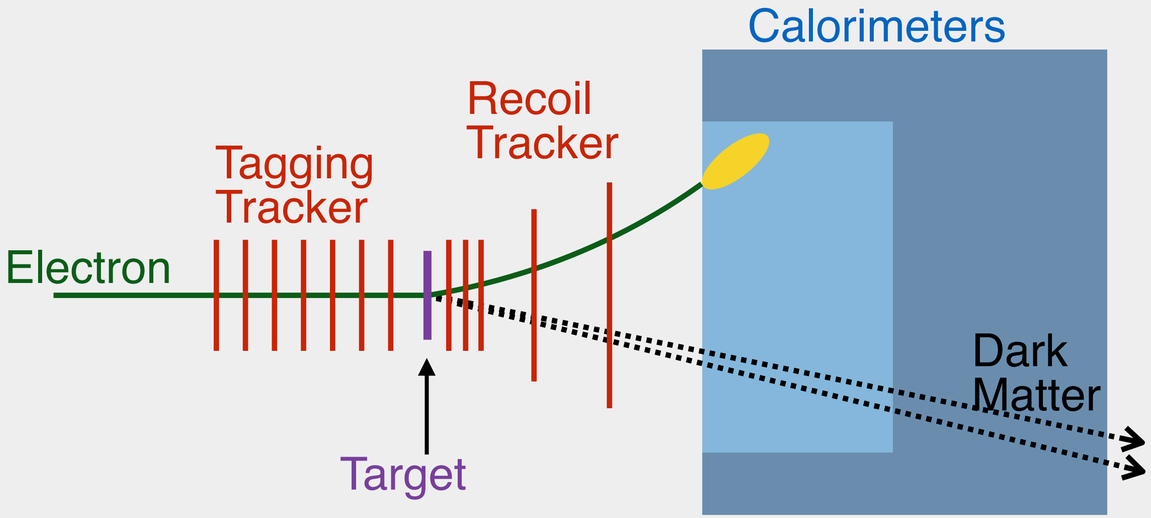
missing-momentum

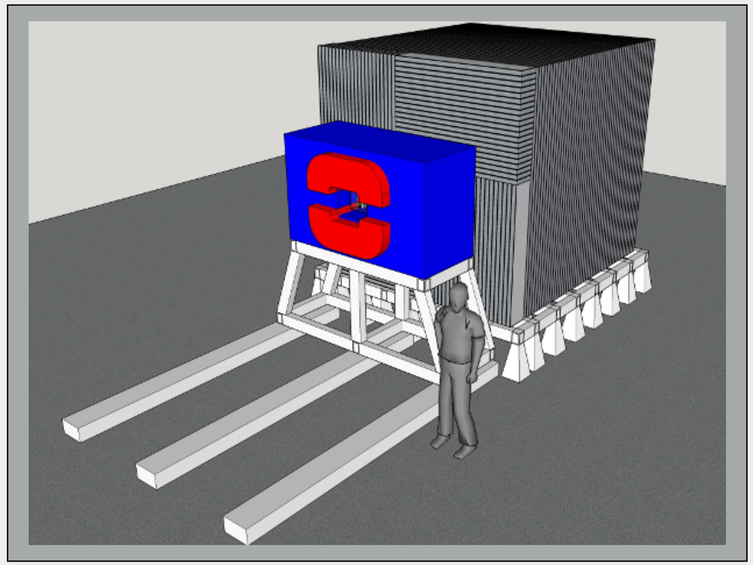
experiment

→ eSPS, see talk by Steinar tomorrow



arxiv:1805.12379



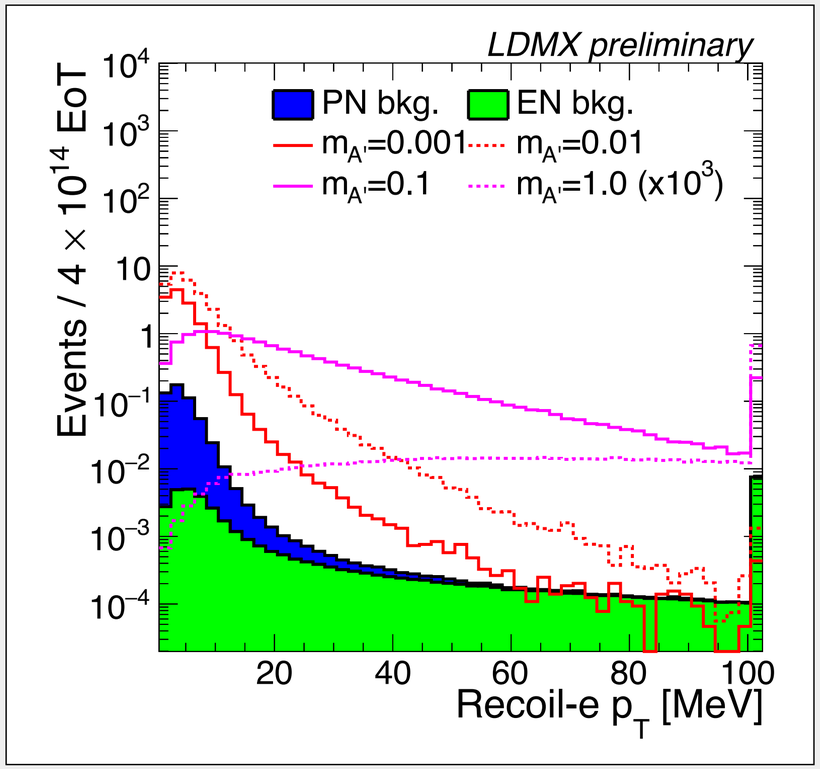


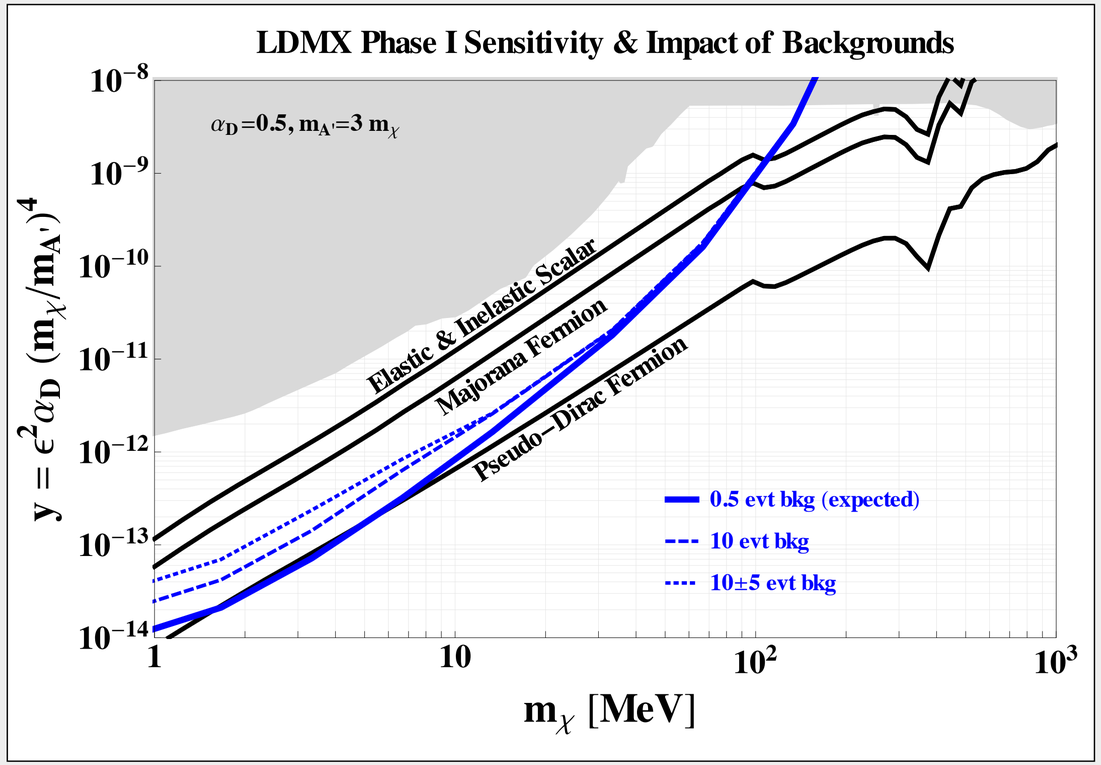
Caltech Fermilab SLAC NATIONAL ACCELERATOR LABORATORY UCSB UNIVERSITY OF CALIFORNIA SANTA BARBARA UNIVERSITY OF MINNESOTA LUNDS UNIVERSITET

White Paper

major milestone last year: comprehensive summary of design status arxiv:1808.05219

- detailed simulation studies of relevant background processes and their rejection
  - expect <1 background events for 4 x 10^{14} EOT (4 GeV beam energy)





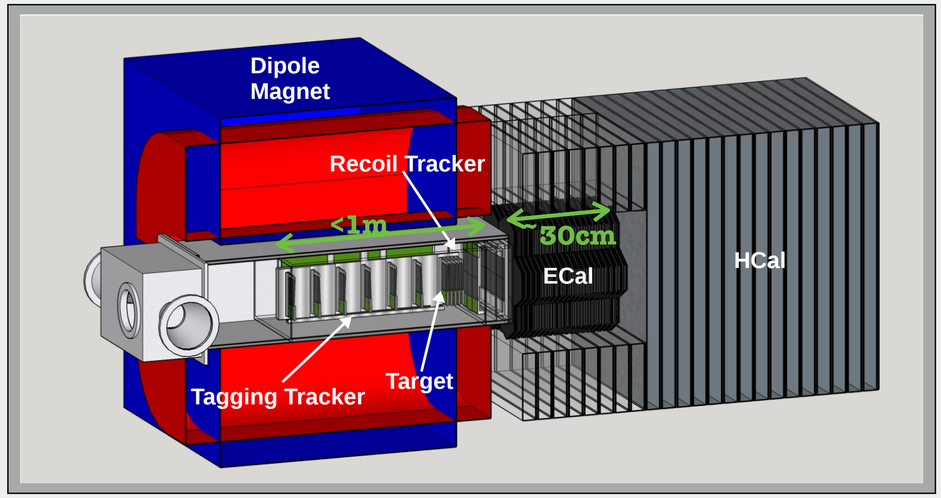
in the following: (some of the) important pieces that went into this

Detector & Simulation

Draw from existing designs/systems

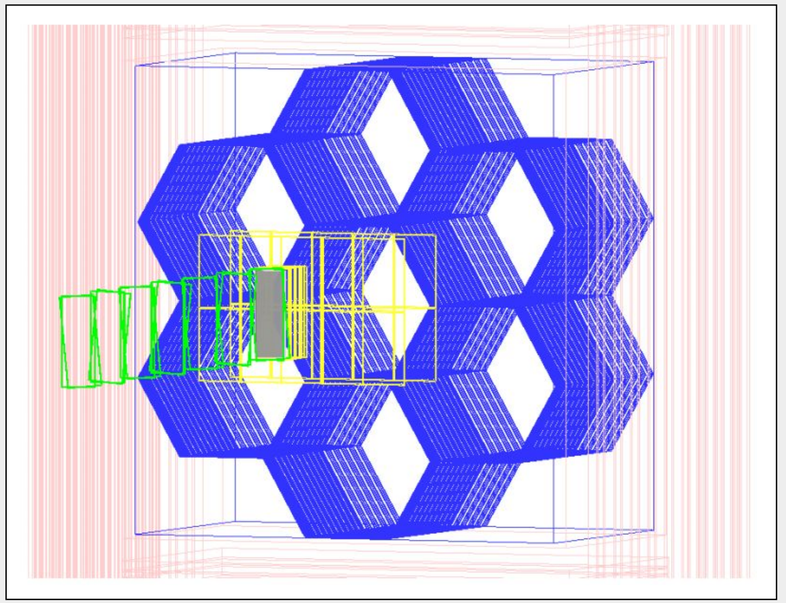
- magnet: e.g. 18D36 in storage at SLAC
- tracking: Silicon Vertex Tracker of HPS experiment
- electromagnetic calorimeter: CMS high-granularity calorimeter
- hadronic calorimeter: scintillator/steel, inspiration from Minos/ Mu2e/CMS

—> moderate R&D needs



Configurable **simulation**

- based on customised Geant4 version (more later)
- all detectors described in GDML files
  - studied >10 different detectors
- filtering/biasing tools to efficiently simulate specific processes
- event displays



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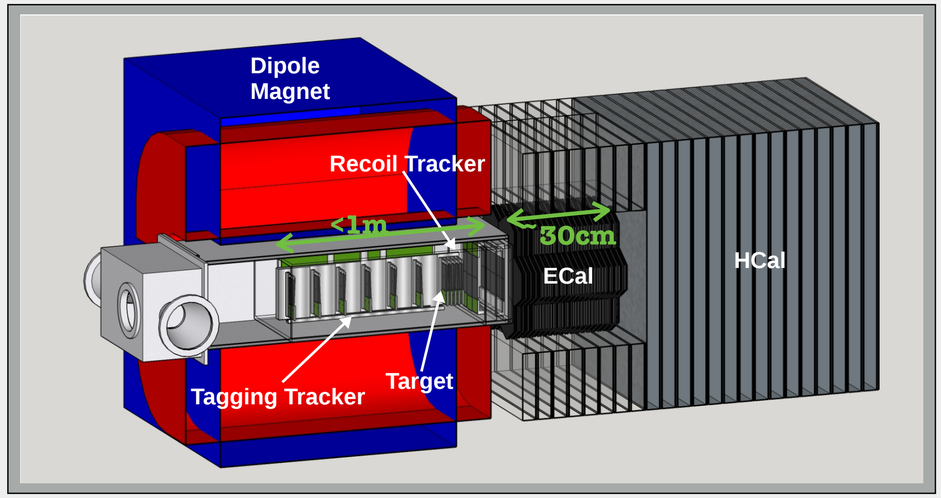

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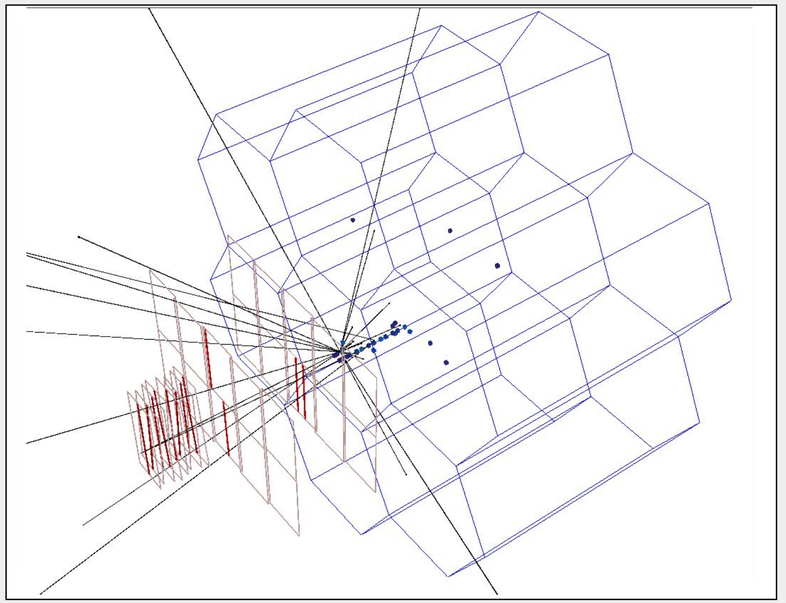
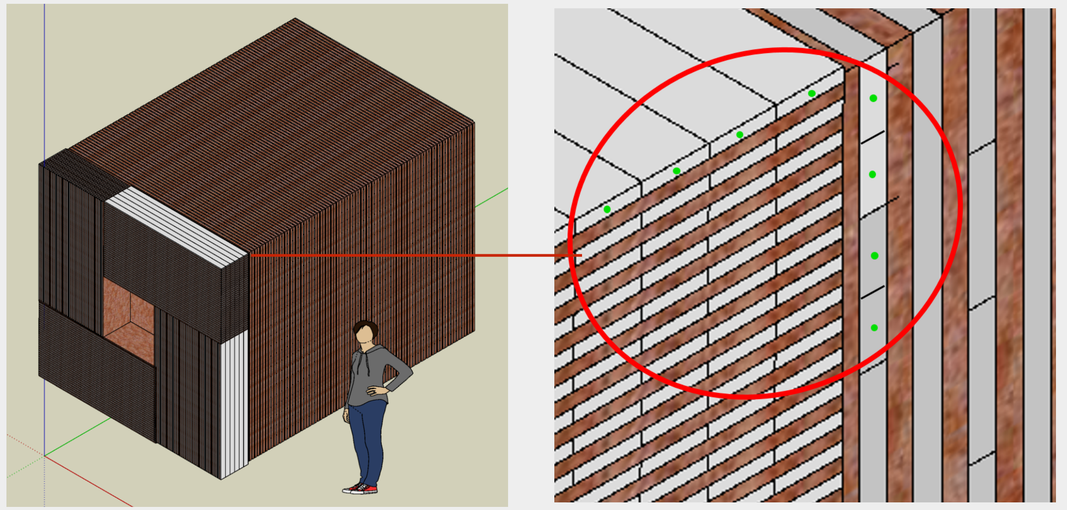


Hadronic Calorimeter (White Paper)

Veto instrument for Dark Matter search, but also important for displaced signatures, electro-nuclear cross-section measurements + triggering

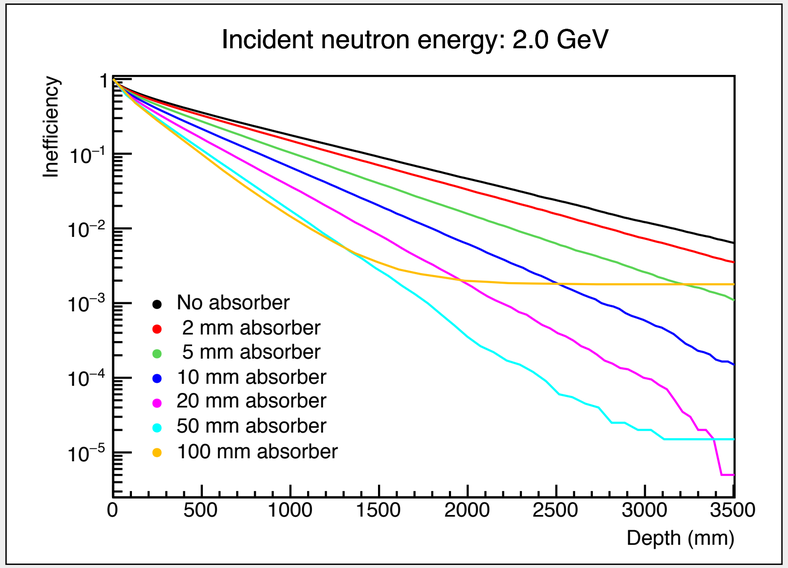
Originally least defined subdetector

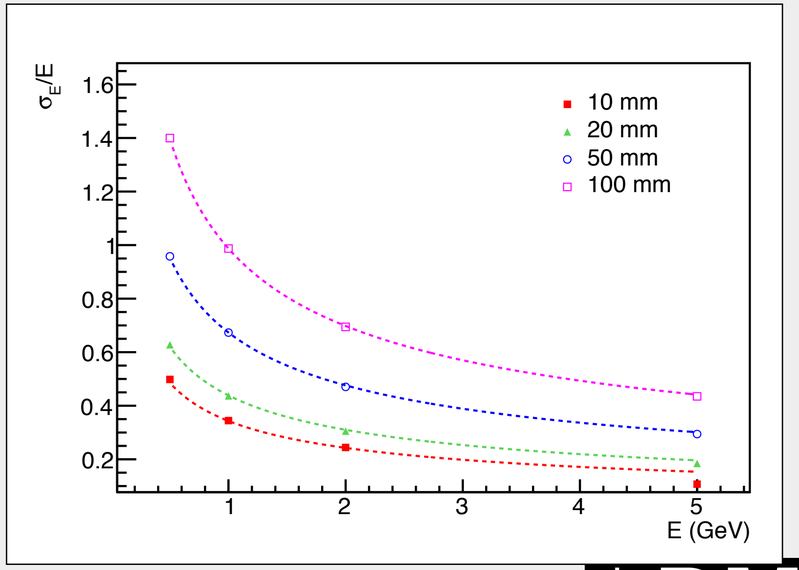
- extensive studies past ~year led to 'conceptual design'
- plastic scintillator bars + WLS fibres (200 x 5 x 2 cm^3)
- steel absorber (50 mm)
- back (13λ) + side (~5λ) HCal, 2-3m in each direction



Preliminary simulation studies show potential to get close to 0 background in phase 1,

while retaining decent energy resolution

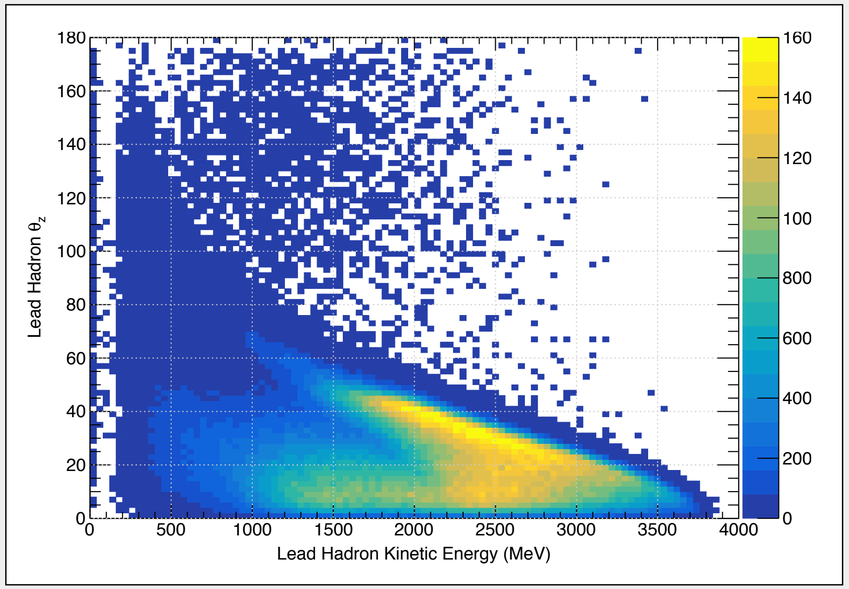




Improved Background Simulation

Observed unphysical photo-nuclear events with hard, backward going hadrons

Related to details of Bertini Cascade model in Geant4

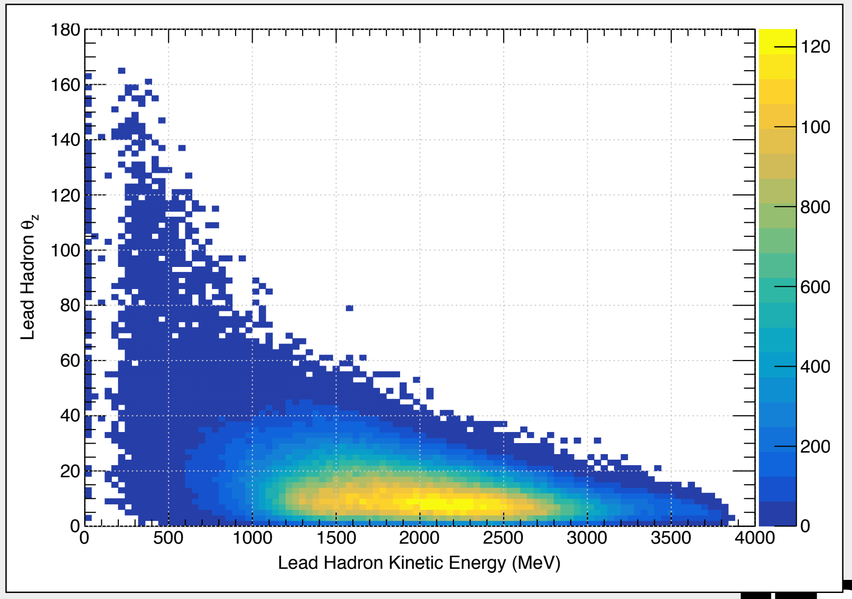


Modifications in LDMX version of Geant4 eliminate these events

(for white paper handled via reweighting)

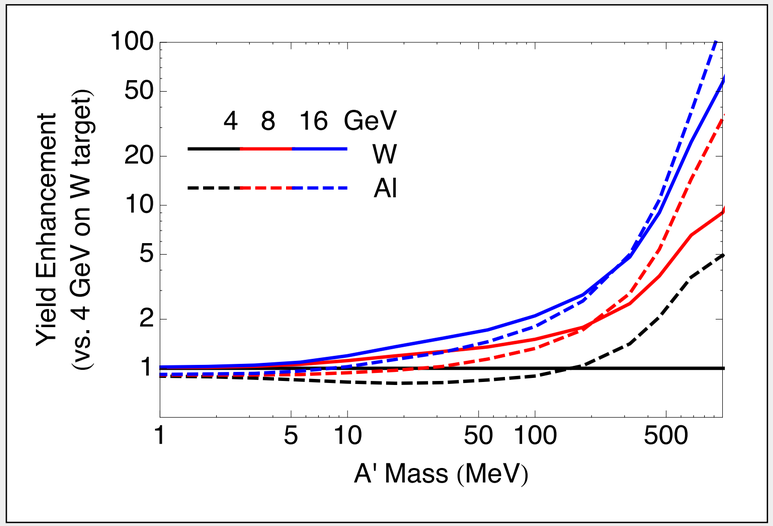
—> Background estimate will be redone

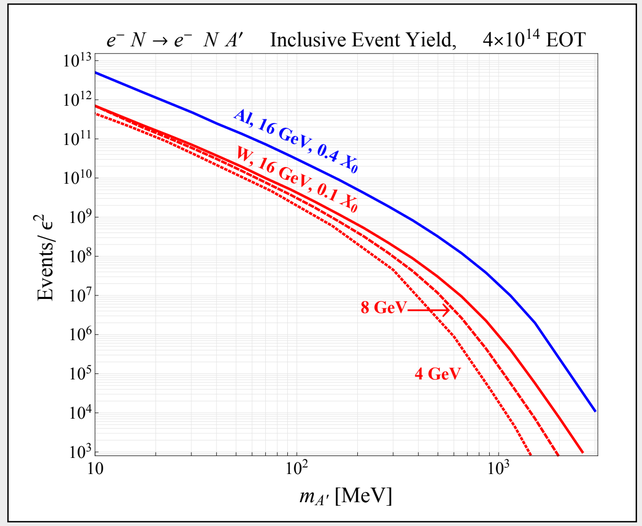
In contact with Geant4 developers to update official version as well



Extending LDMX

Design studies focused on
4 GeV,
~1 electron per bunch every 20ns,
W target of 0.1 X_0
to reach 4 x 10^{14} EOT in ~1 year





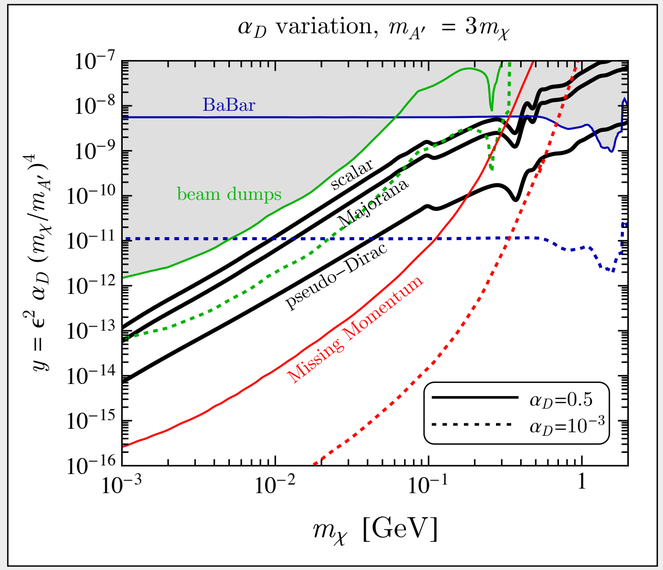
Varying these parameters allows in principle
to increase luminosity to reach pseudo-Dirac
target up to few hundred MeV

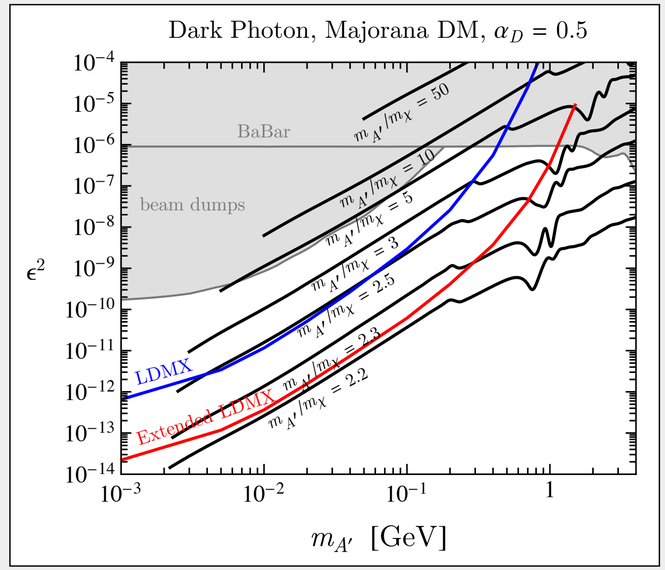
Mass Range [MeV]	Factor needed		E_e [GeV]	E_e Factor	Target $[X_0]$	Target Factor	μ_e	Years running	Factor achieved
$0.01 \leq M_\chi < 20$	2		4	1	0.15 W	1.5	1.5	1	~2
			4	1	0.1 W	1	1.5	1.5	
			4	1	0.15 W	1.5	1	1.5	
$20 \leq M_\chi < 75$	6		8	2	0.1 W	1	2	1.5	~6
			8	2	0.15 W	1.5	1	2	
			4	1	0.15 W	1.5	2	2	
$75 \leq M_\chi < 150$	80		8	4	0.4 W	4	2	3	~ 80
			8	4	0.4 Al	6	2	2	
			16	8	0.4 W	4	1.5	1.5	
			16	8	0.4 Al	4	1	2	
$150 \leq M_\chi < 300$	6×10^3	*	8	8	0.4 Al	13	2	4	$\sim 8 \times 10^2$
			16	45	0.4 W	4	2	4	$\sim 1 \times 10^3$
			16	45	0.4 Al	8	5	4	$\sim 7 \times 10^3$
			16	45	0.4 Al	8	10	2	$\sim 7 \times 10^3$

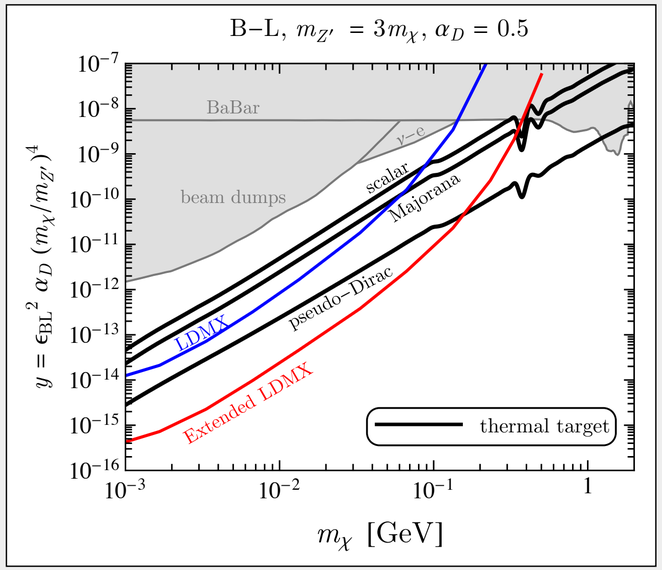
Sensitivity

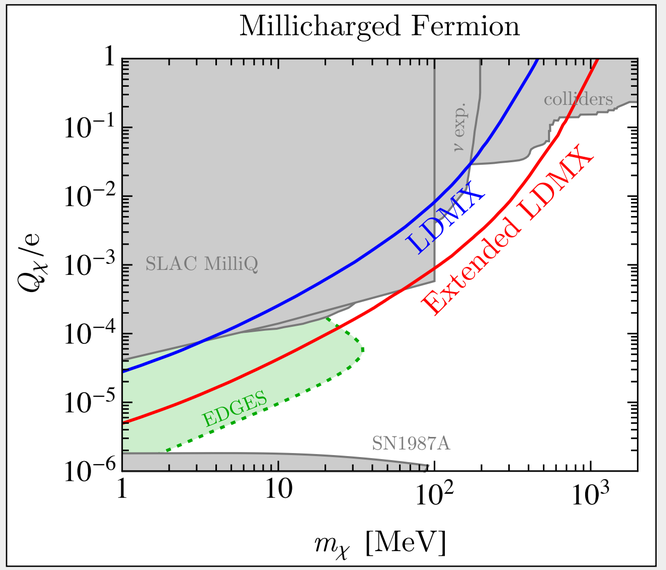
What happens when deviating from benchmark parameters?

Dark Photon "golden channel", but sensitivity to much broader range of new physics, collected also in arxiv:1807.01730





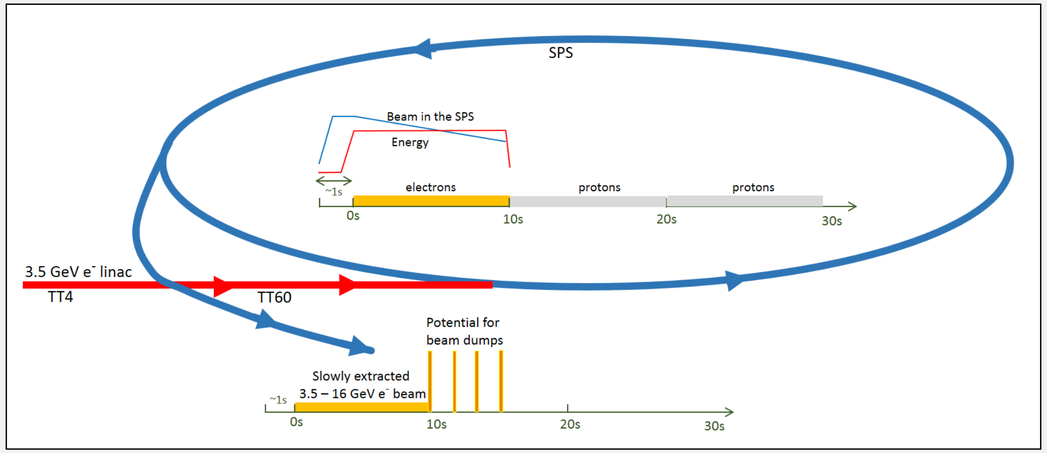




LDMX@CERN — eSPS

Requirements for an experiment like LDMX

- multi-GeV (ideally ~15 GeV)
- low current (resolve individual particles)
- large beam spot (separation of particles)
- high repetition rate (high integrated number of EoT)



Triggered idea of having a **new Linac into SPS**,
quickly became active field of study arxiv:1805.12379

Expression of interest to SPSC in October 2018
https://cds.cern.ch/record/2640784

Submission to European Strategy Update

flexible parameters:

- energy: 3.5 - 16 GeV
- electrons per bunch: 1 - 40
- bunch spacing: multiples of 5 ns
- adjustable beam size

Details in Steinar's talk tomorrow

Recent Developments: Detector

Internal review last week

- baseline designs, R&D needs, resources, costs…
- “practicalities" (TDAQ, integration, software/computing…)

Refining **HCal** design

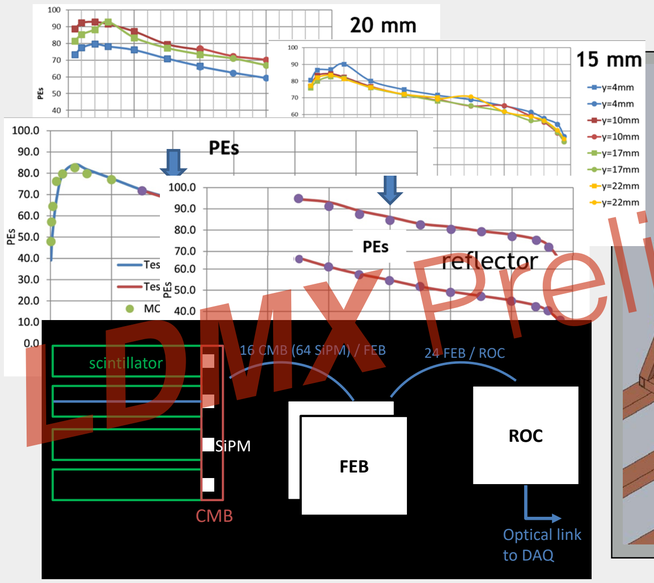
- performance tests on scintillator bars/fibres
- baseline for read-out system (with trigger capabilities)
- geometry optimisation ongoing

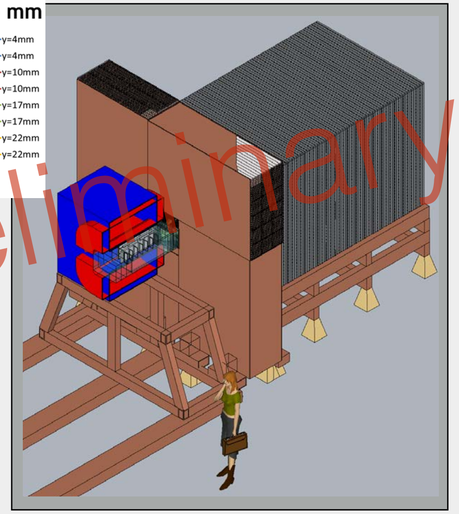
Trigger & DAQ considerations

- trigger menu, rates/bandwidths/latencies
- subdetector inputs/interfaces
- clock and controls

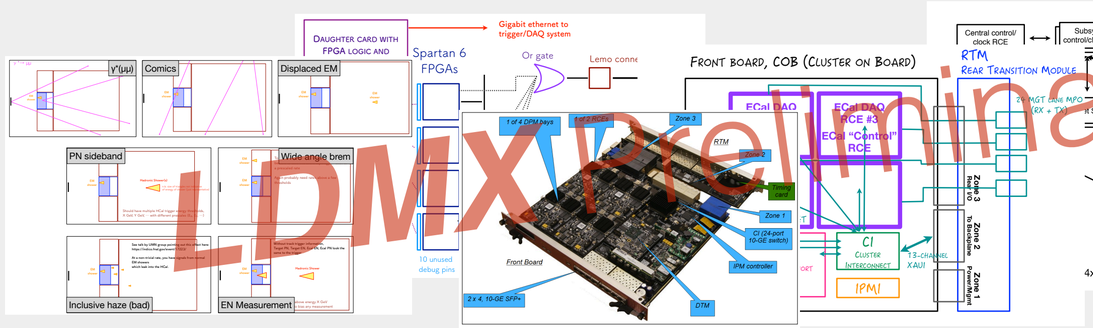
ECal

- CMS module testing ongoing
- higher granularity (CMS) modules underway

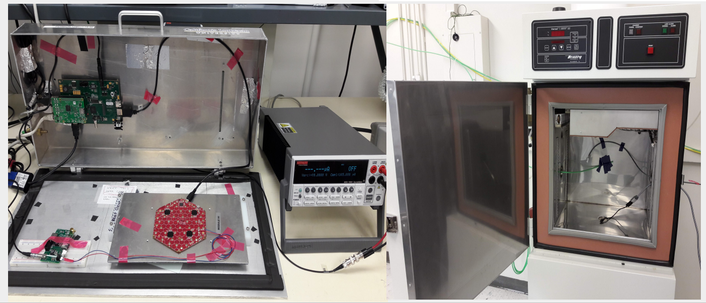




LDMX Preliminary



LDMX Preliminary

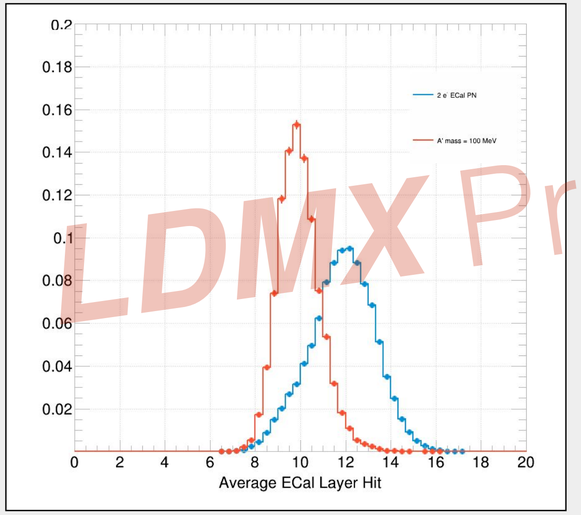


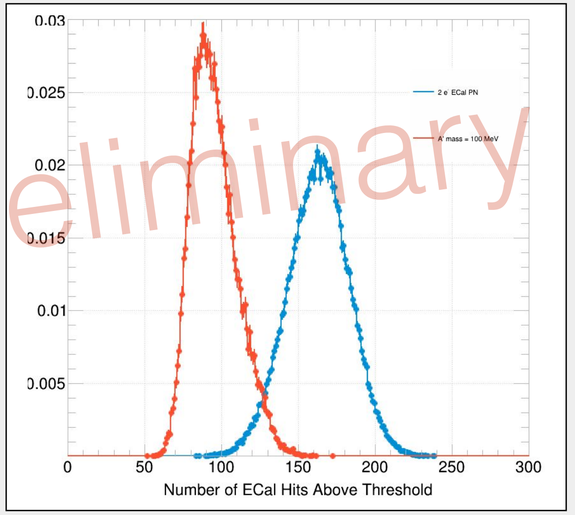
Recent Developments: Physics

Photo-nuclear background simulation being re-done with **Geant4 patch**

- will feed into further HCal/ECal studies

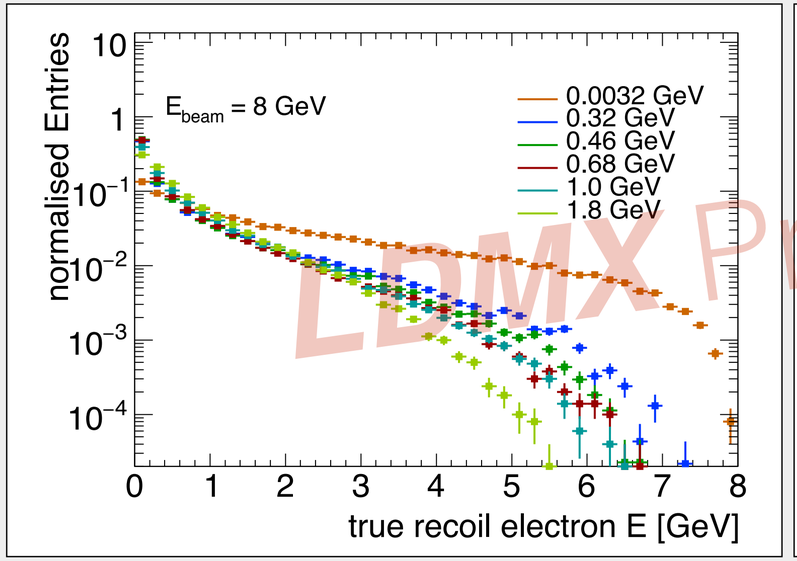
Began study of **2-electron events**

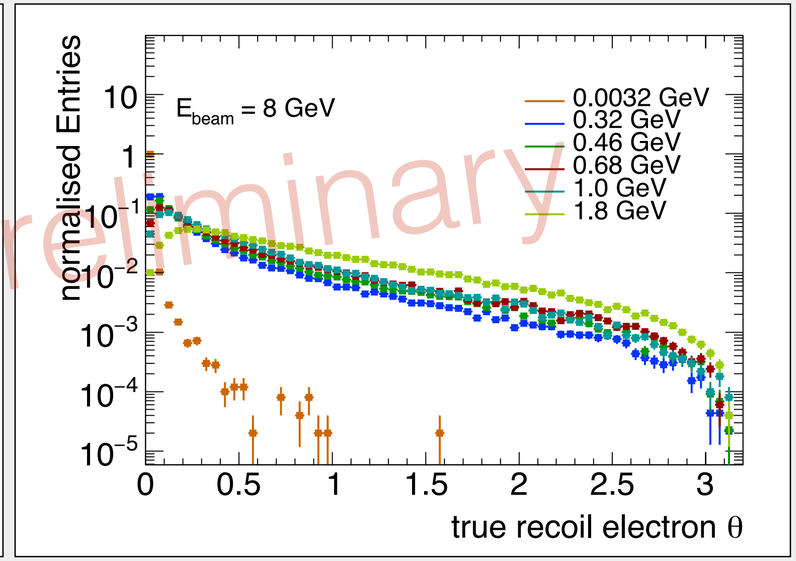




LDMX Preliminary

Began study of **higher energies** (8 GeV)





LDMX Preliminary

Plans for the next year

towards a CDR…

Studies on **multi-electron** & **higher-energy** scenarios

- background rejection, triggering…

Further develop detector simulation/reconstruction

Refine detector design

- HCal geometry/performance (simulation studies, prototype+beam test 2020)
- feasibility of higher-granularity modules (PCBs) for central ECal
- TDAQ system
- …

seek funding for and do design/engineering of various components

Summary

Concrete design ideas for all detector components

- details to be finalised

Detailed background/sensitivity estimates for phase 1

Developing more concrete ideas for phase 2

next stop: funding for R&D, CDR

Additional Material

Plans per system

beamline/magnet:

understand better status of magnet and how to operate it at experimental site + shielding requirements

tracking:

sharpen conceptual design into something ready for engineering + tracking in fringe field

target area:

R&D for baseline design, answer open questions beyond baseline (passive/active, geometry…)

ECal:

investigate higher granularity, understand readout specifics/performance, get ready for engineering

HCal:

finalise design studies, build prototype and test in beam, get ready for engineering

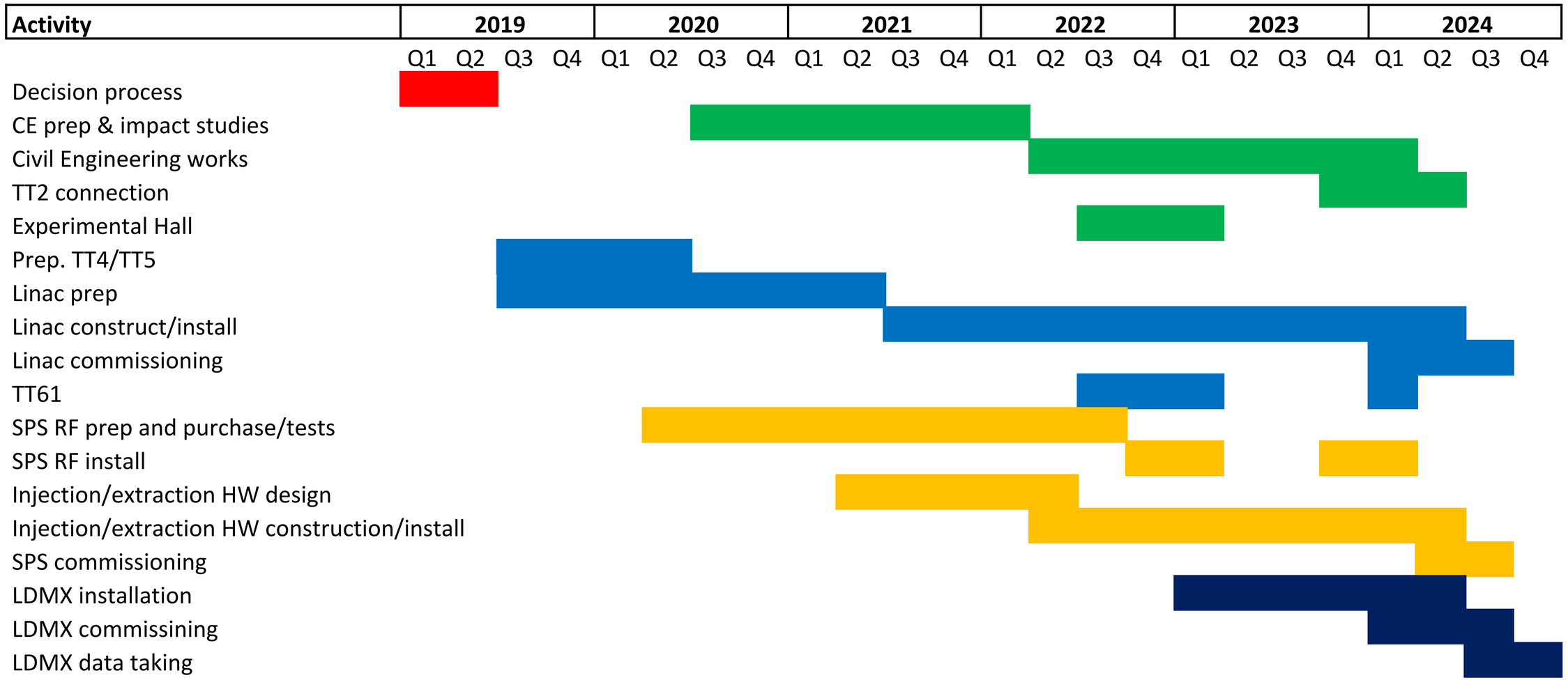
TDAQ:

understand interfaces to subsystems + integration, refine trigger menu

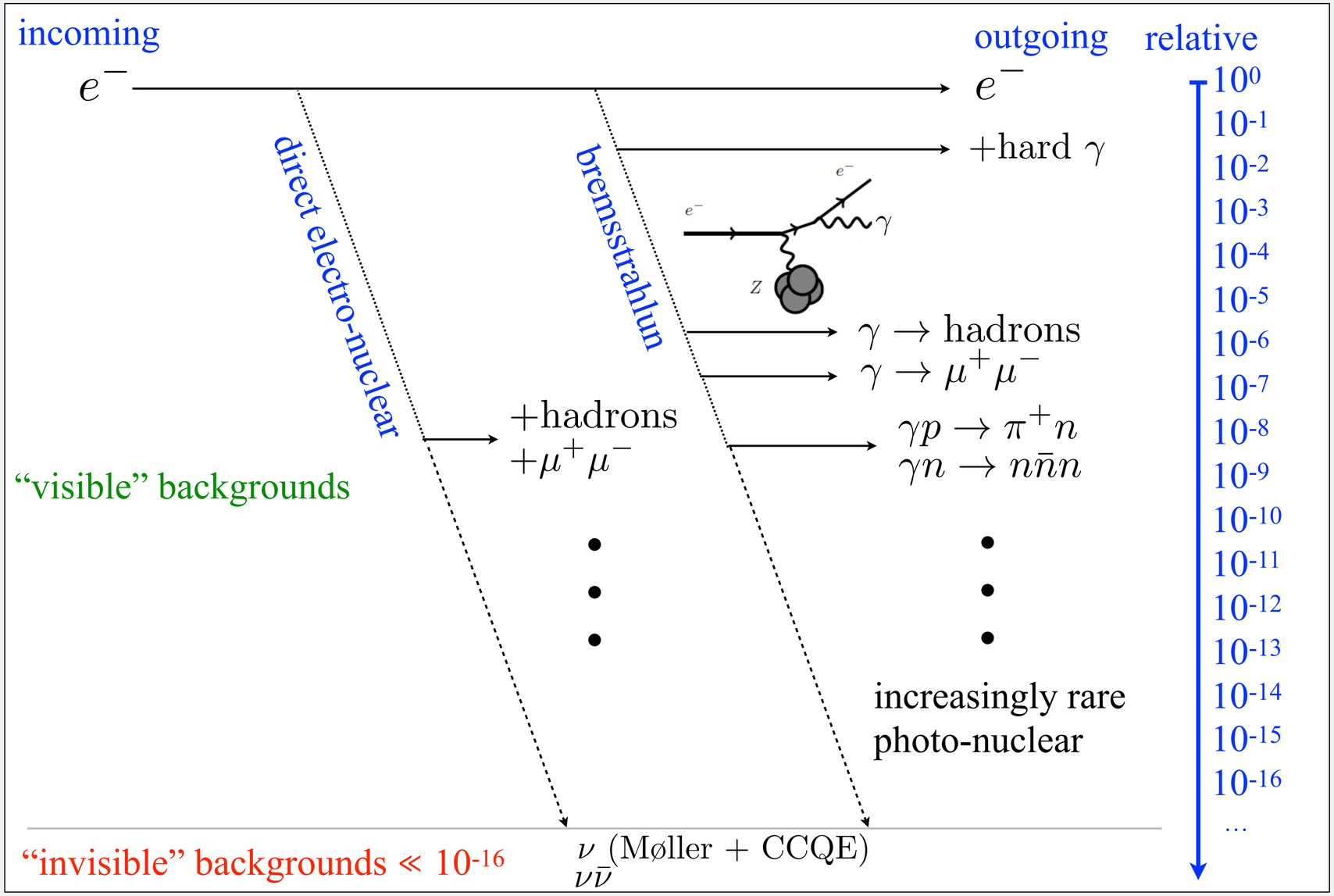
Computing/software:

improve biasing/filtering, digitisation simulation, Geant4 modelling + develop comprehensive computing model

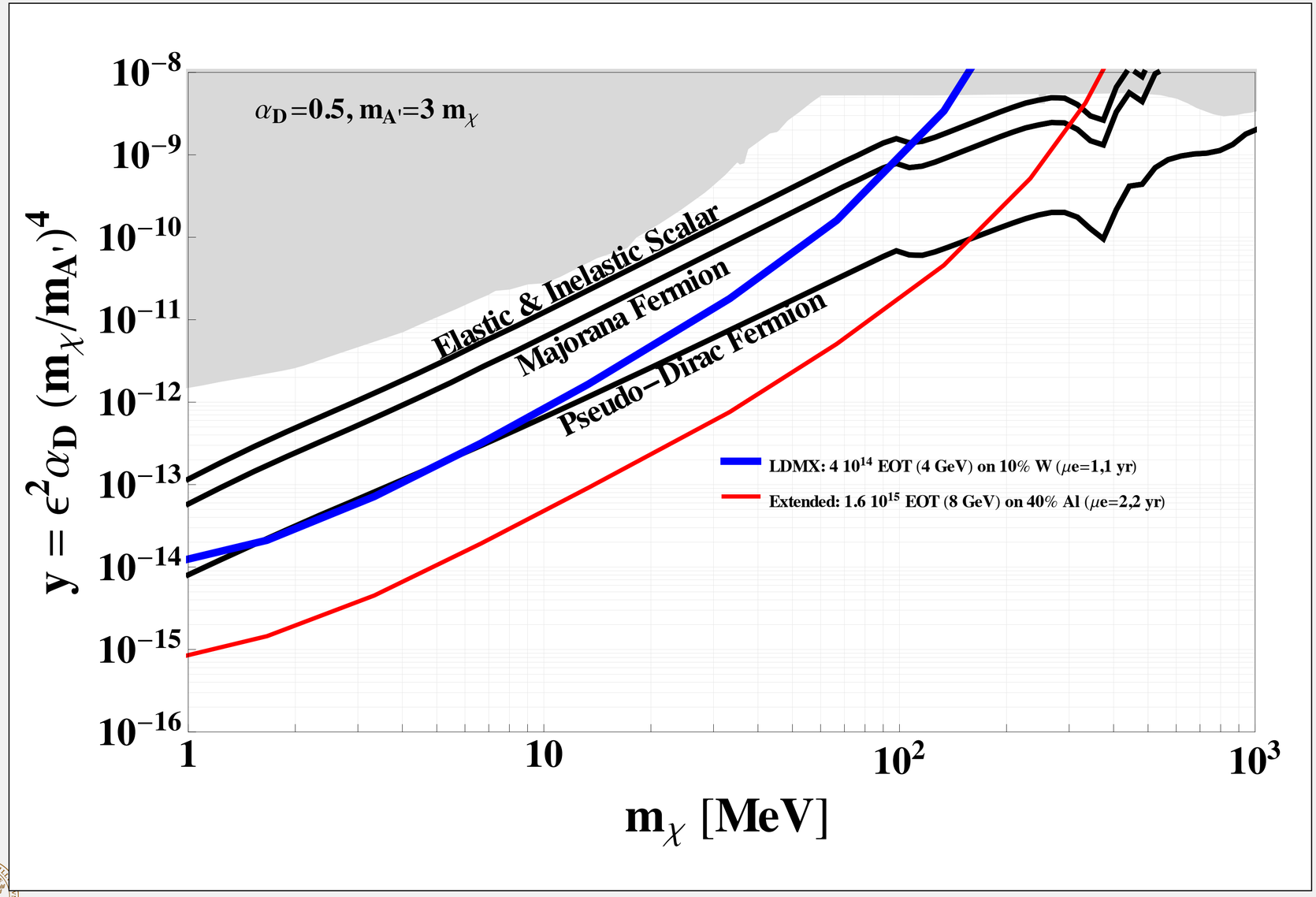
Possible eSPS Timeline



Backgrounds



Projected Sensitivity



LDMX can explore a lot of new parameter space

sensitive to various thermal targets already with phase 1

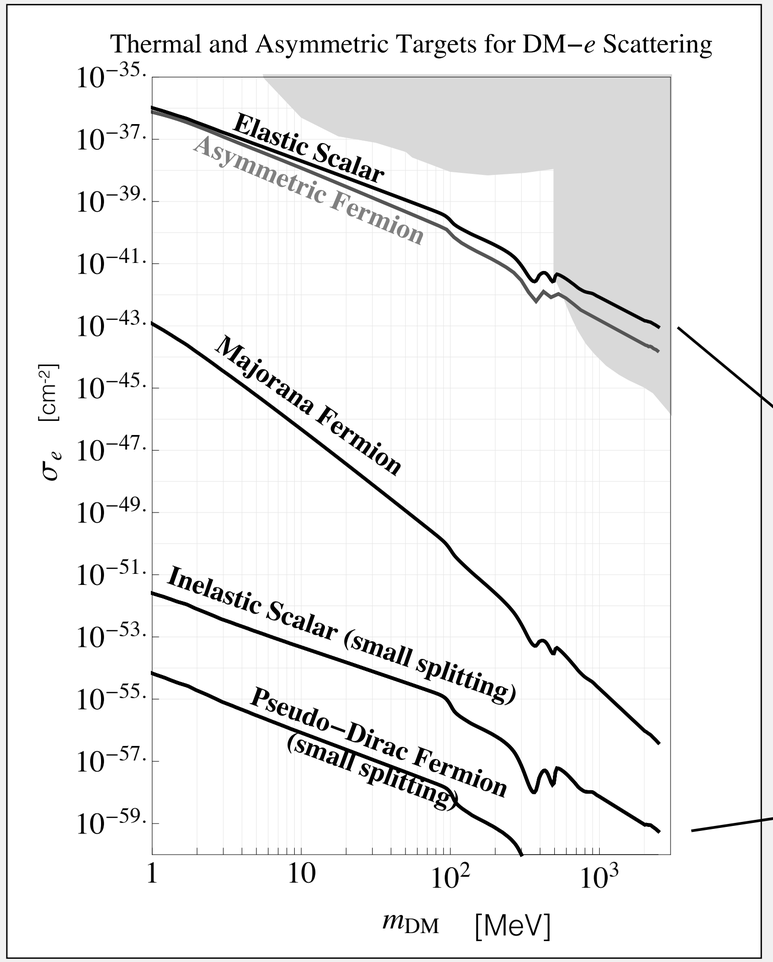
ultimately potential to probe all thermal targets up to O(100) GeV

timescale: few years

Why not just direct detection?

direct detection:

strong spin/velocity dependency



at accelerators: relativistic production

—> spin/velocity dependency reduced

all thermal targets in reach!