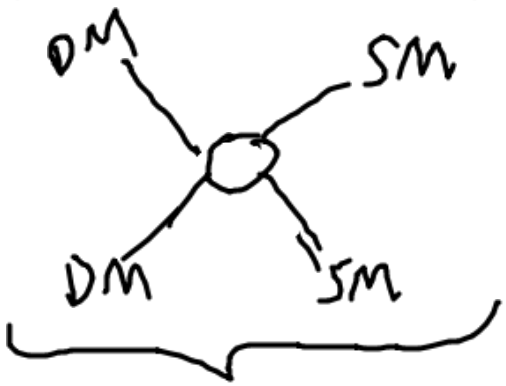
Light Dark Matter (LDM)
LDMX and DASEL

- Motivation & LDM
- Summary of LDMX
- " " DASEL

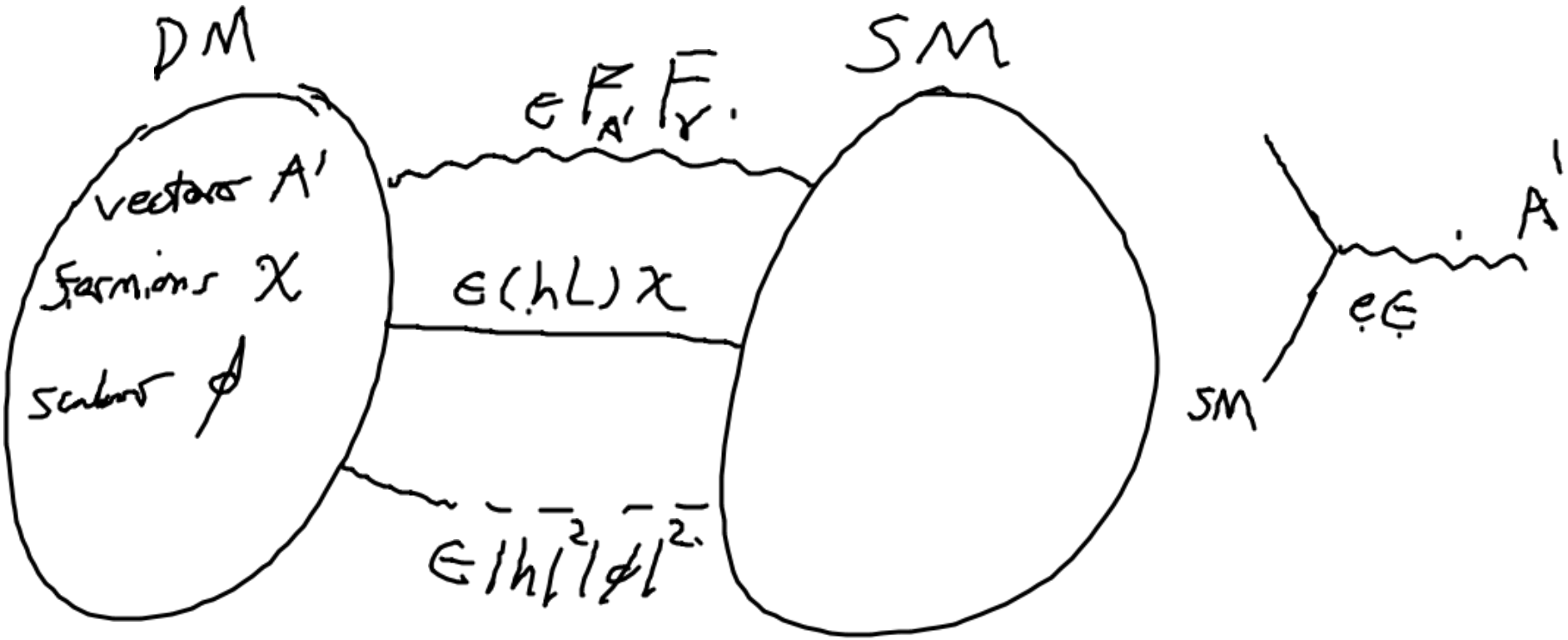
Philip Schuster (SLAC)

Prime Target: Thermal DM

- Simple.
- Predictive



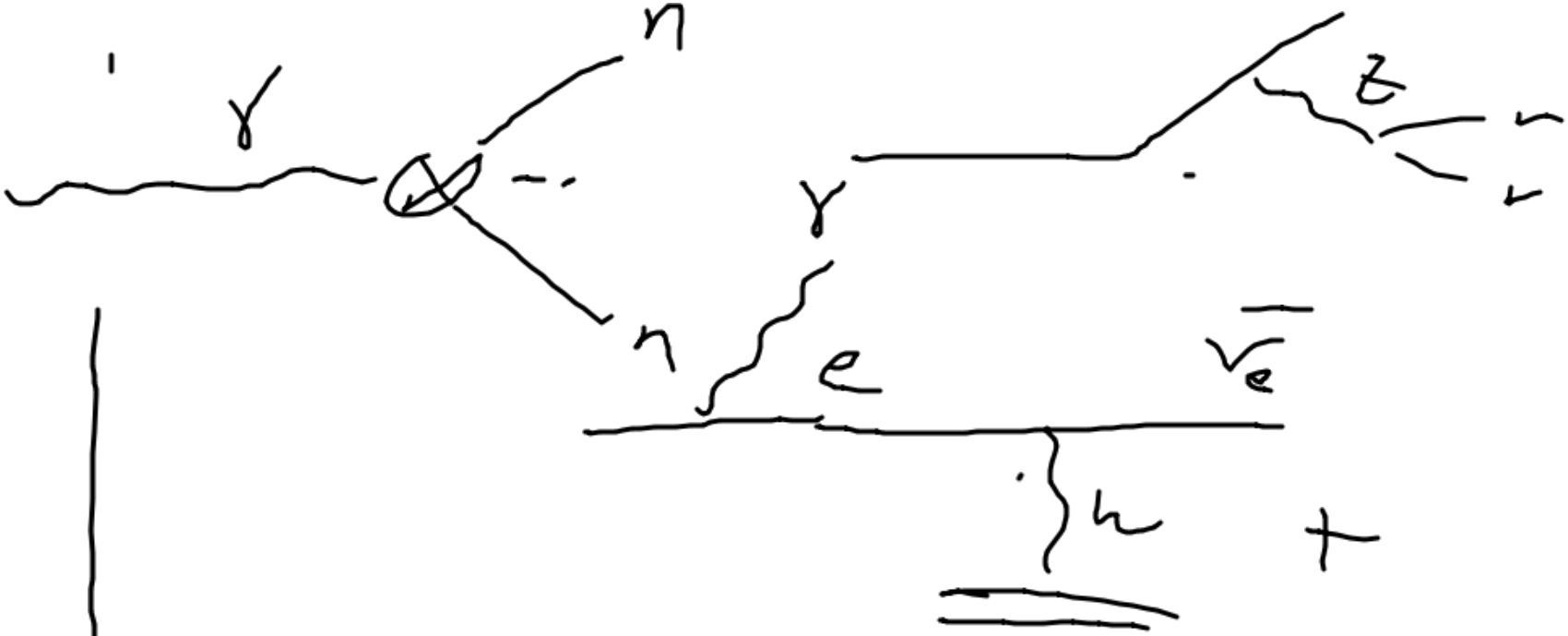
$$\sigma_{DM-SM} \longleftrightarrow \rho_{DM}$$

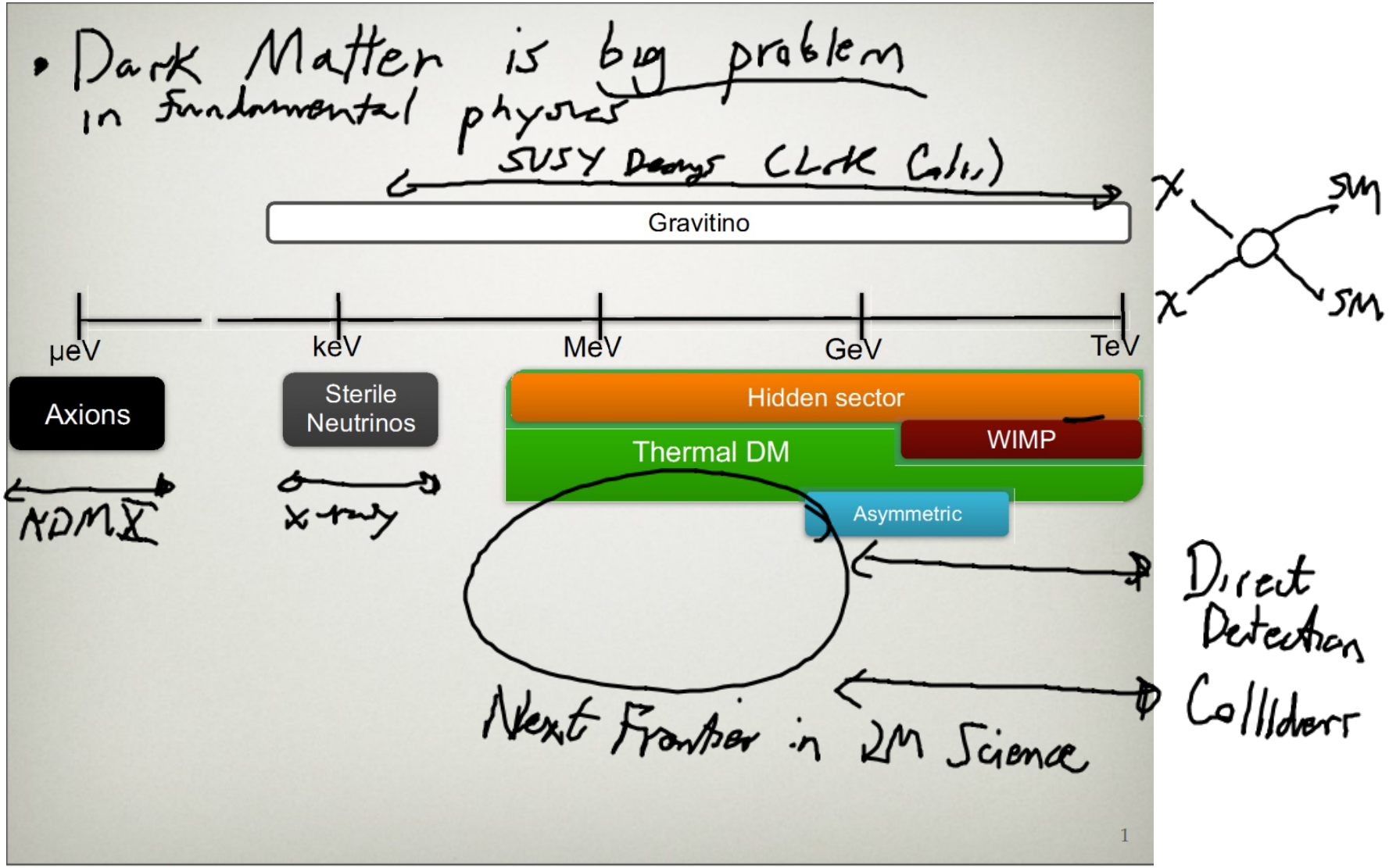

DM
vectors A'
fermions χ
scalars φ
SM
εF_A' F_γ
ε(hL)χ
ε|h|²|φ|²
SM
εe
A'

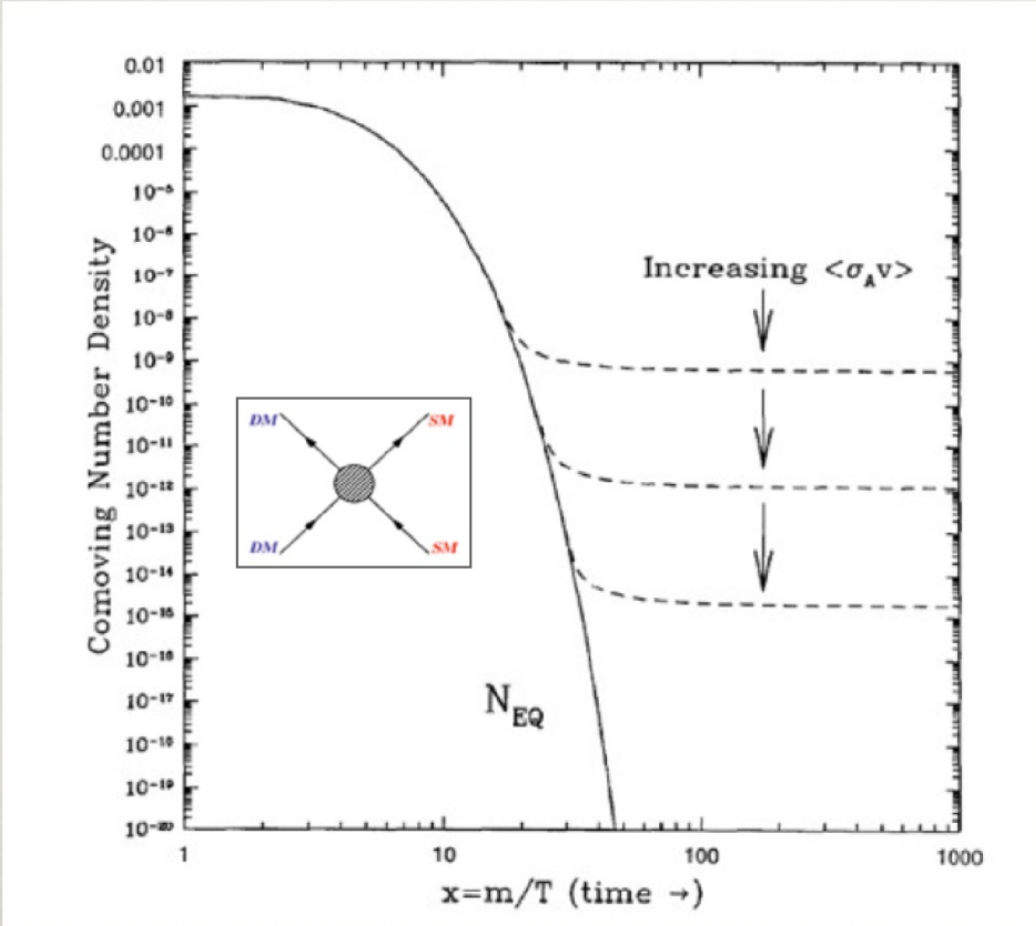
$$\sigma v \sim \left[\alpha_D \, \epsilon^2 \alpha \, \frac{m_\chi^2}{m_{A'}^4} \, m_\chi^2 \right] \frac{1}{m_\chi^2}$$

$$\mathcal{L}_{DM} = g_0 A'_\mu \bar{\chi} \gamma^\mu \chi + m_\chi \bar{\chi}\chi + \frac{1}{2} m_{A'}^2 A'^2 + \text{KT}$$

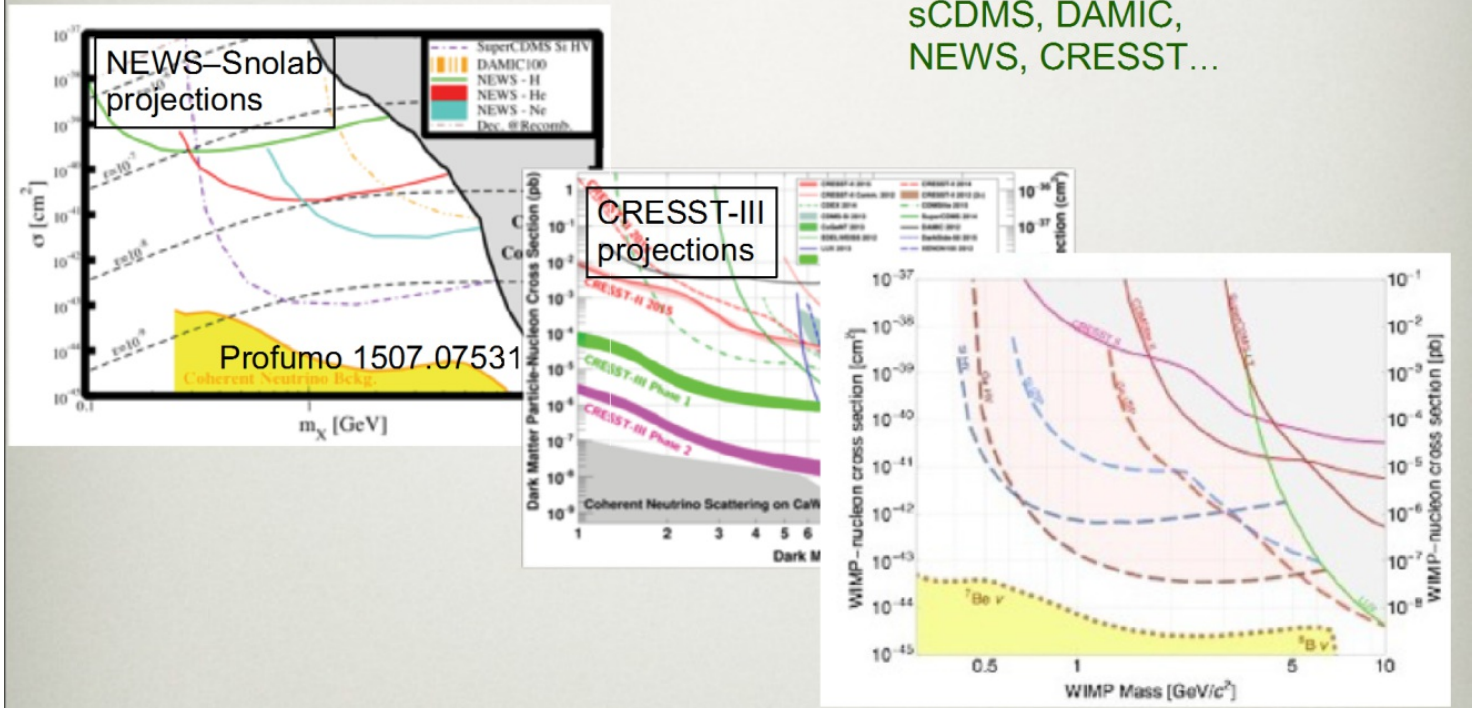
$\sim 10^{-3}$



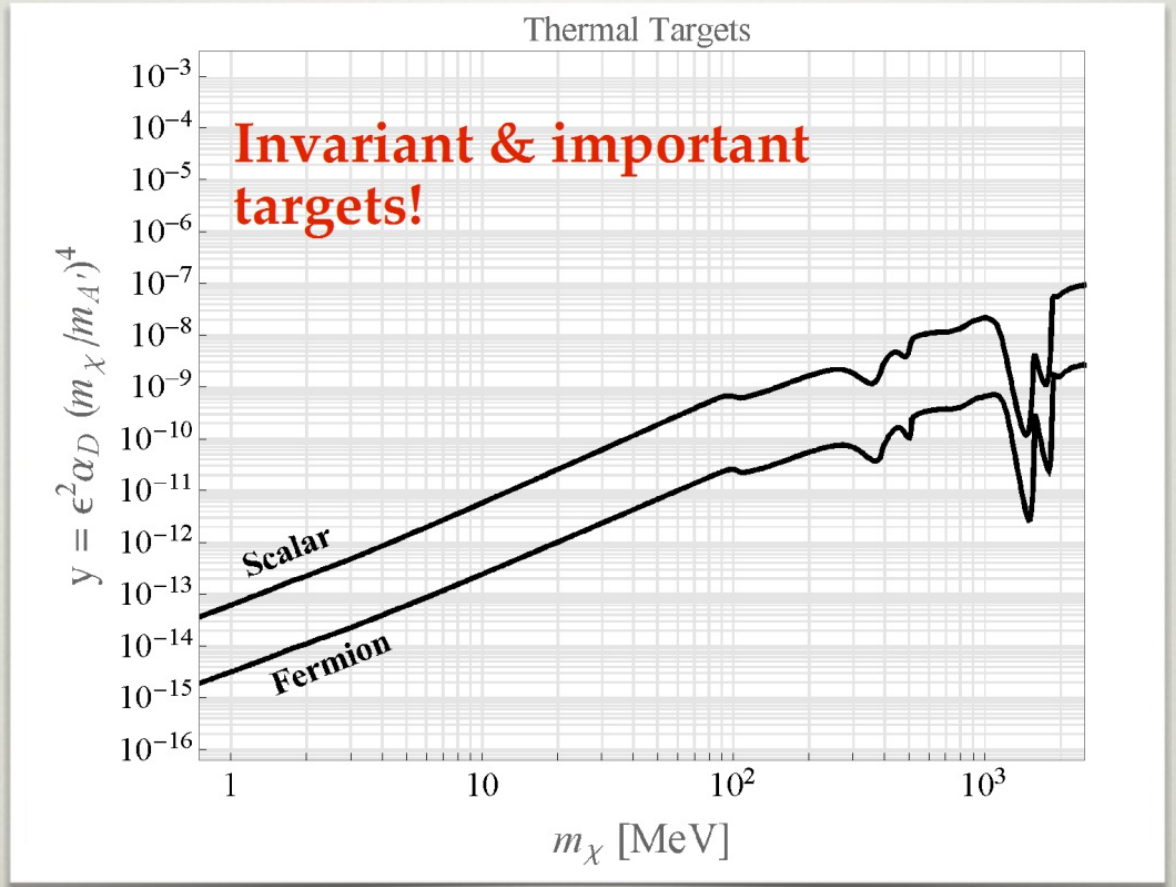

• Dark Matter is big problem in fundamental physics
SUSY Decays (LHC Colls)
Gravitino
μeV
keV
MeV
GeV
TeV
Axions
Sterile Neutrinos
Hidden sector
Thermal DM
WIMP
Asymmetric
NDMX
x-ray
Direct Detection
Colliders
Next Frontier in DM Science
χ
χ
SM
SM
1

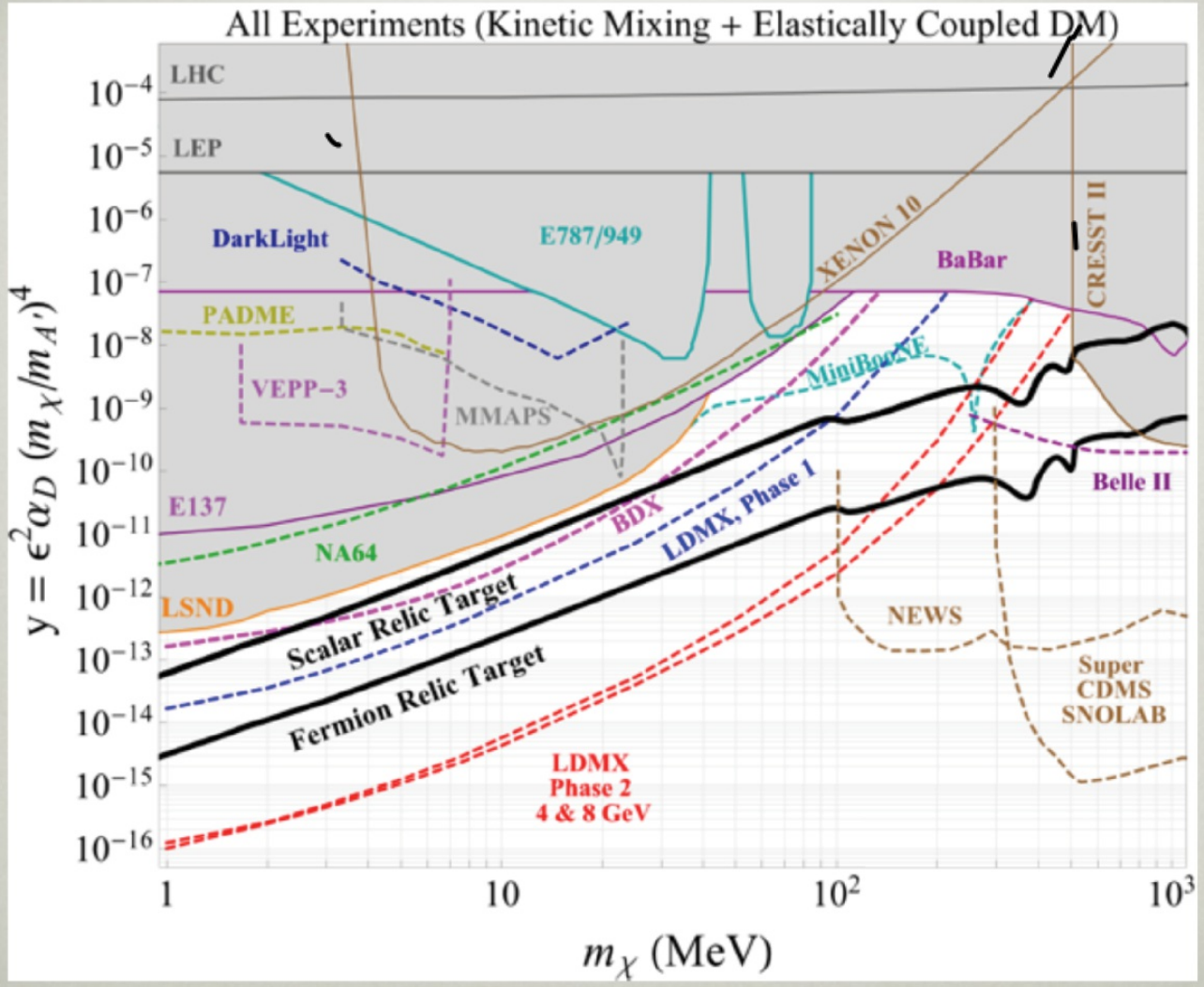

Comoving Number Density
0.01
0.001
0.0001
1
10
100
1000
x=m/T (time →)
Increasing <σ_A v>
N_EQ
DM
SM
DM
SM

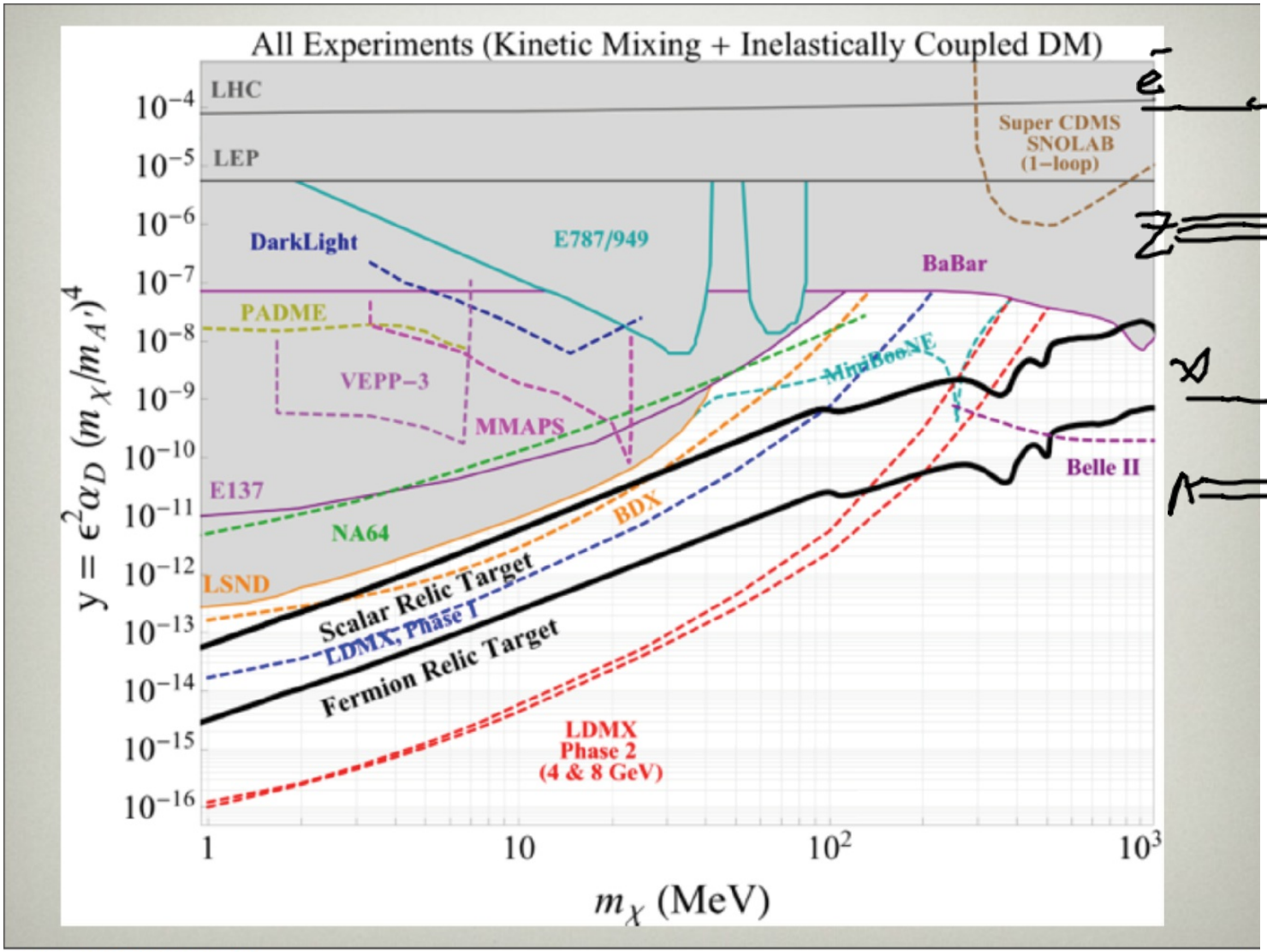
sCDMS, DAMIC,
NEWS, CRESST…

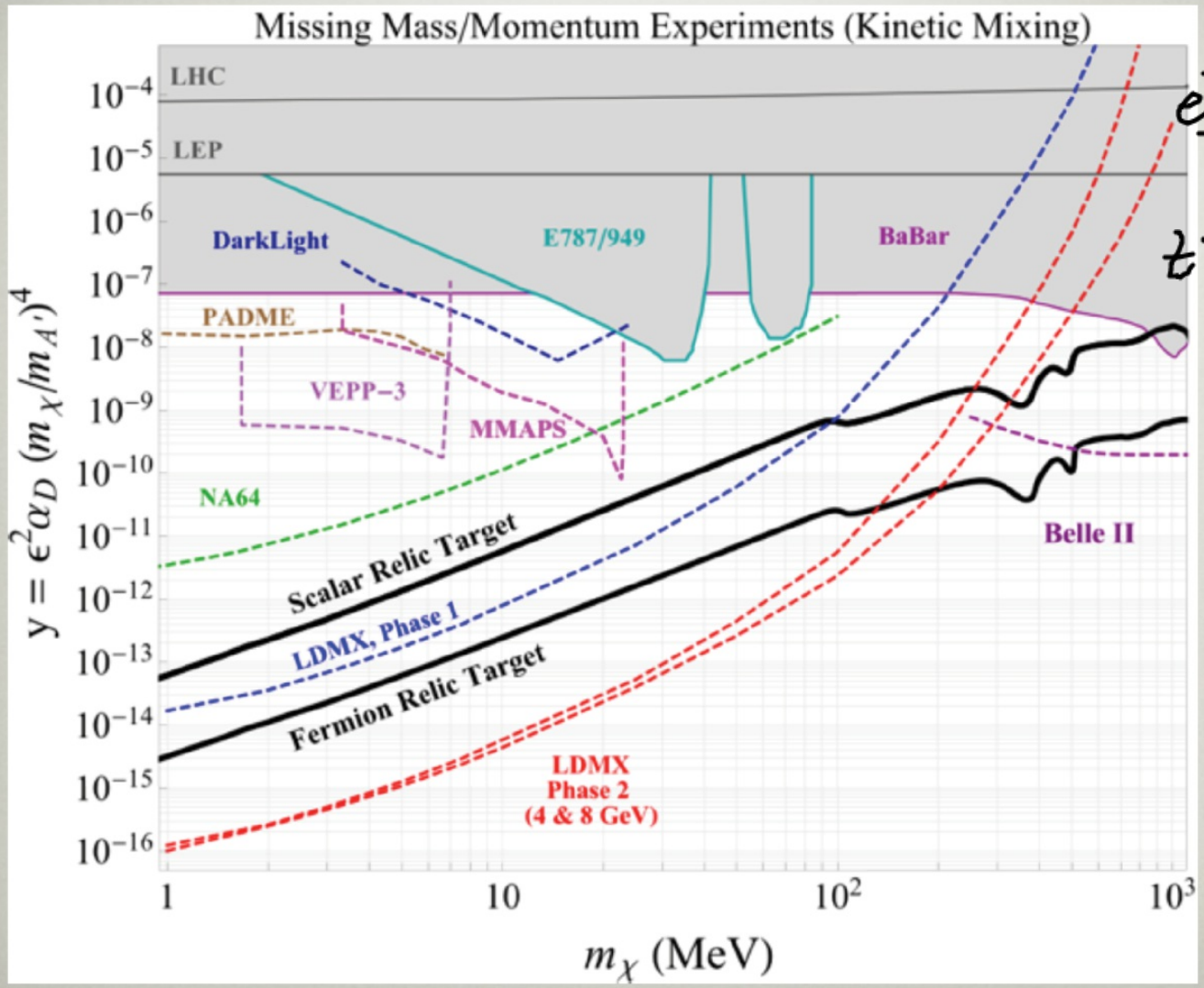


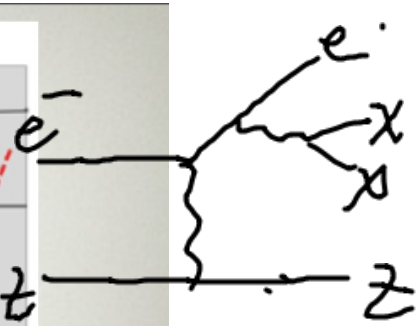
Dark Sectors Program

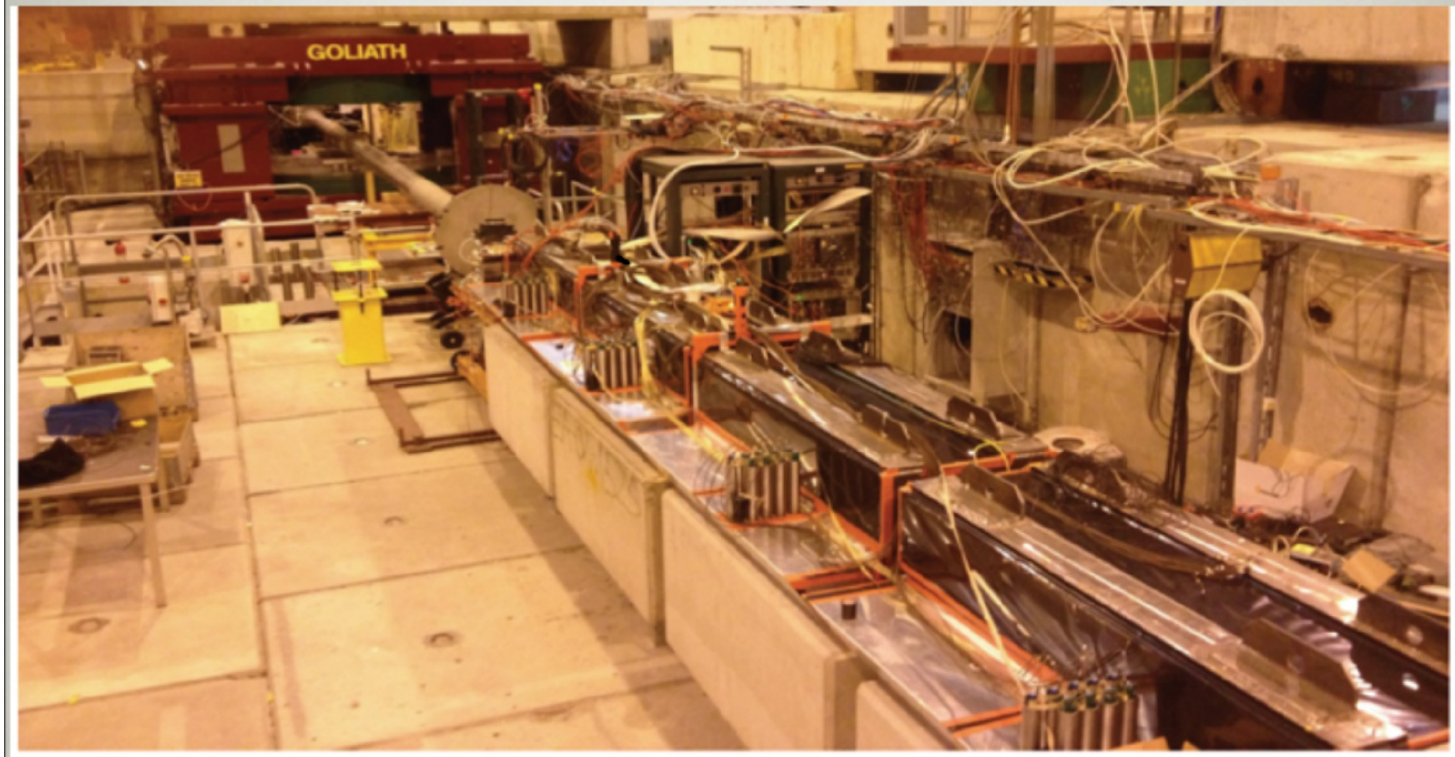

Thermal Targets
Invariant & important targets!
$y = \epsilon^2 \alpha_D (m_\chi / m_{A'})^4$
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{-16}
Scalar
Fermion
1
10
10^2
10^3
m_χ [MeV]


All Experiments (Kinetic Mixing + Elastically Coupled DM)
LHC
LEP
DarkLight
E787/949
XENON 10
BaBar
CRESST II
PADME
VEPP−3
MMAPS
MiniBooNE
E137
NA64
BDX
LDMX, Phase 1
Belle II
LSND
Scalar Relic Target
Fermion Relic Target
NEWS
Super CDMS SNOLAB
LDMX Phase 2 4 & 8 GeV
$y = \epsilon^2 \alpha_D (m_\chi / m_{A'})^4$
m_χ (MeV)


All Experiments (Kinetic Mixing + Inelastically Coupled DM)
LHC
LEP
Super CDMS
SNOLAB
(1−loop)
DarkLight
E787/949
BaBar
PADME
VEPP−3
MMAPS
MiniBooNE
E137
NA64
BDX
Belle II
LSND
Scalar Relic Target
LDMX, Phase I
Fermion Relic Target
LDMX
Phase 2
(4 & 8 GeV)
$y = \epsilon^2 \alpha_D (m_\chi/m_{A'})^4$
m_χ (MeV)


Missing Mass/Momentum Experiments (Kinetic Mixing)
LHC
LEP
DarkLight
E787/949
BaBar
PADME
VEPP−3
MMAPS
NA64
Scalar Relic Target
LDMX, Phase 1
Fermion Relic Target
Belle II
LDMX
Phase 2
(4 & 8 GeV)
$y = \epsilon^2 \alpha_D (m_\chi/m_{A'})^4$
m_χ (MeV)

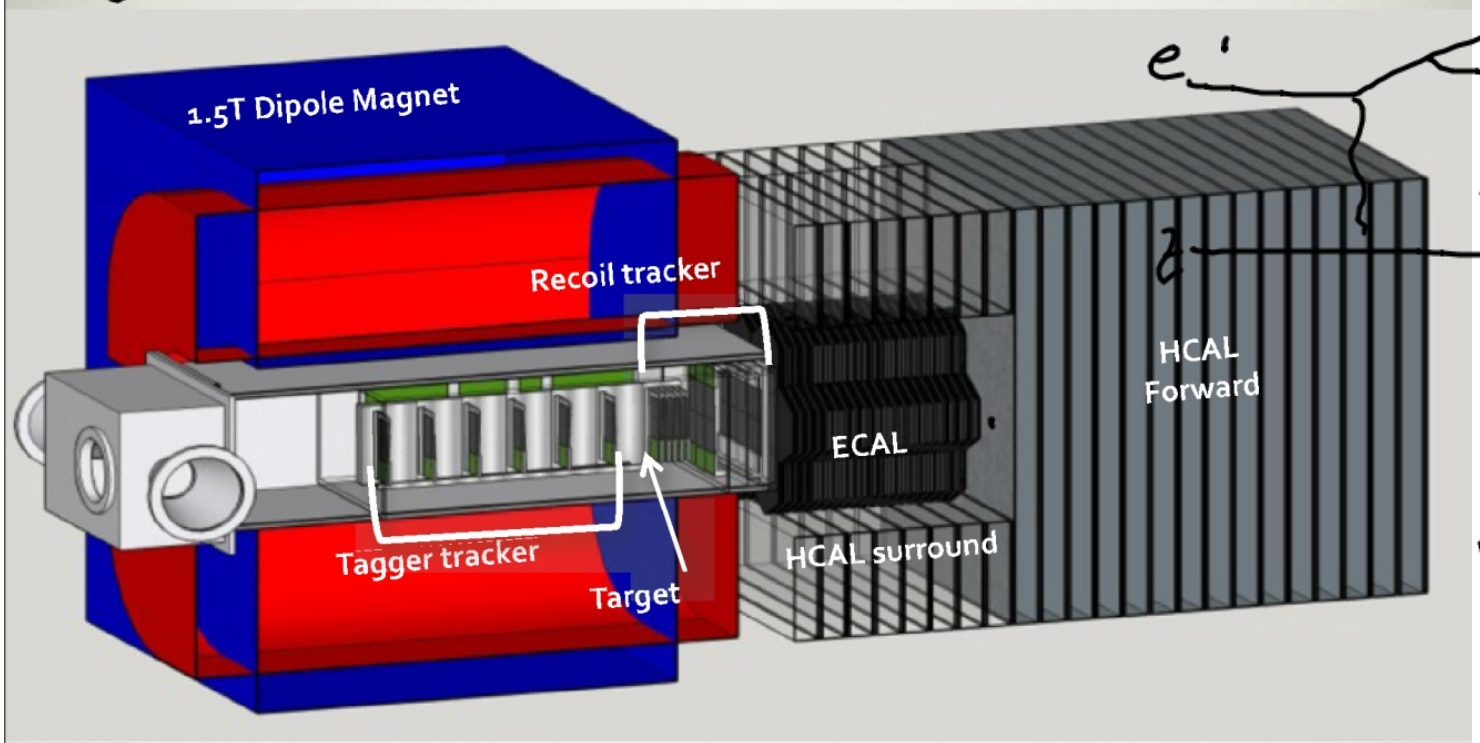

e⁻
e⁻
χ
χ
Z
Z

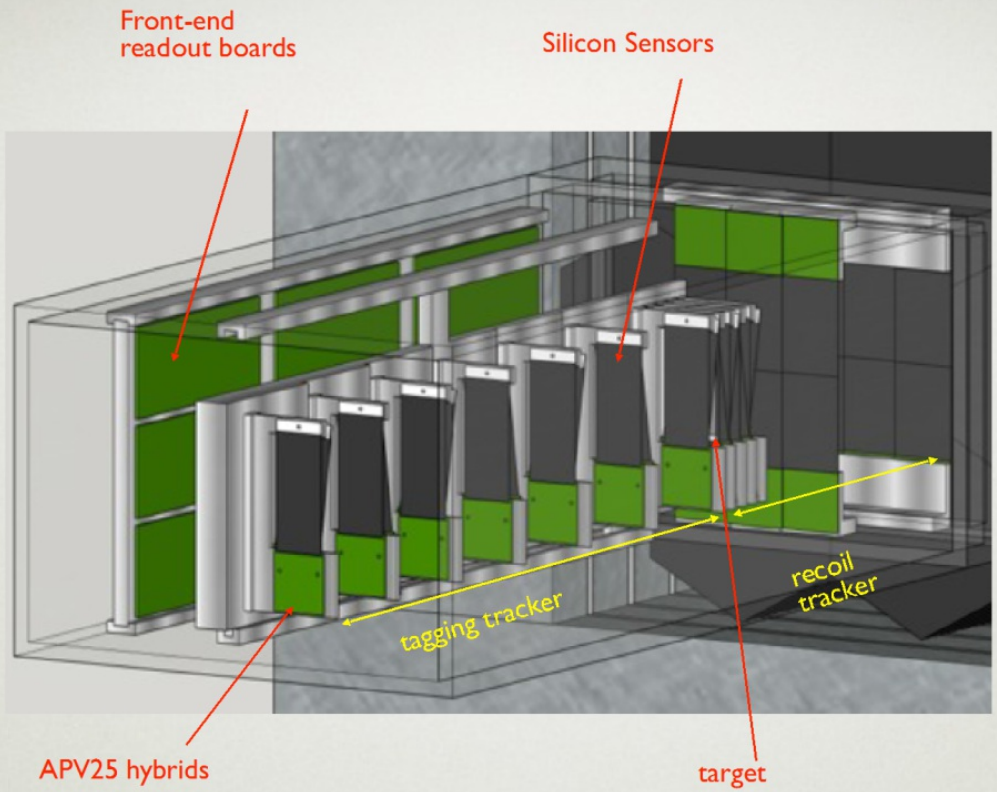


S.N. Gninenko(INR) – CERN, Feb. 5, 2016 – Search for dark sector physics

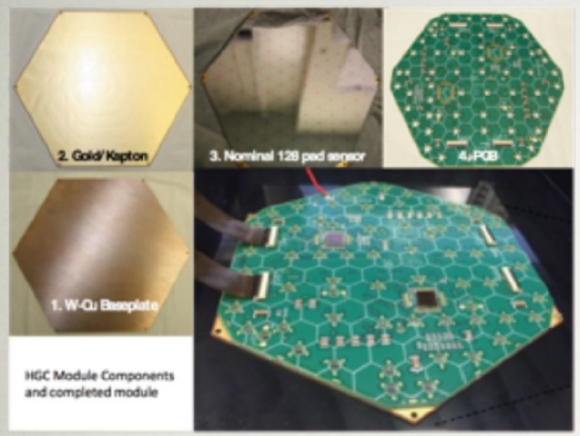
~40 MHz

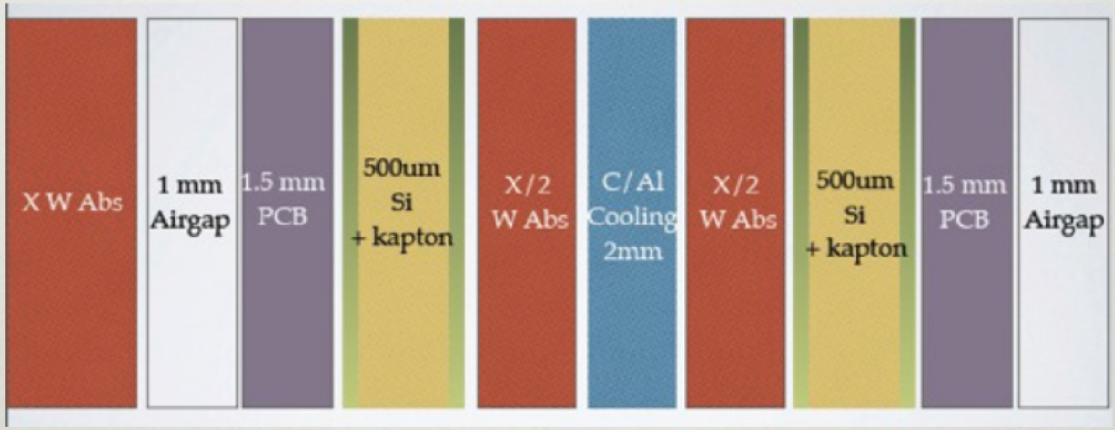
Light Dark Matter eXperiment (LDMX)



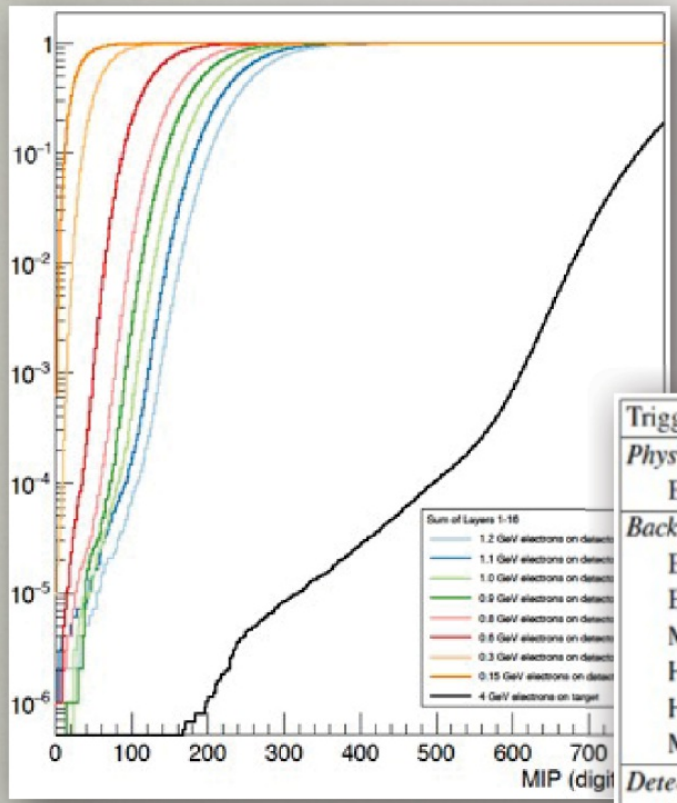

Front-end
readout boards
Silicon Sensors
tagging tracker
recoil
tracker
APV25 hybrids
target

~145mm

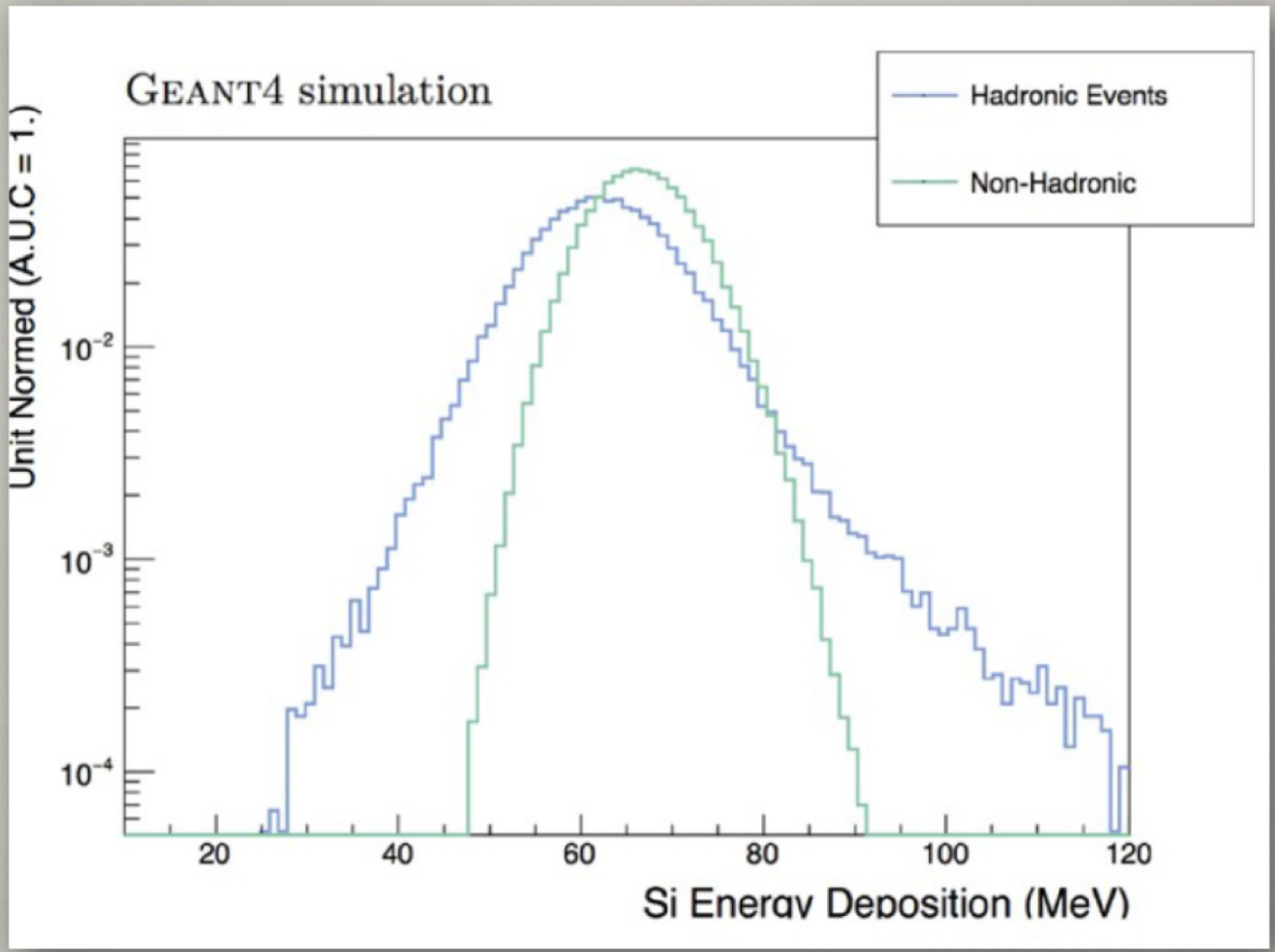




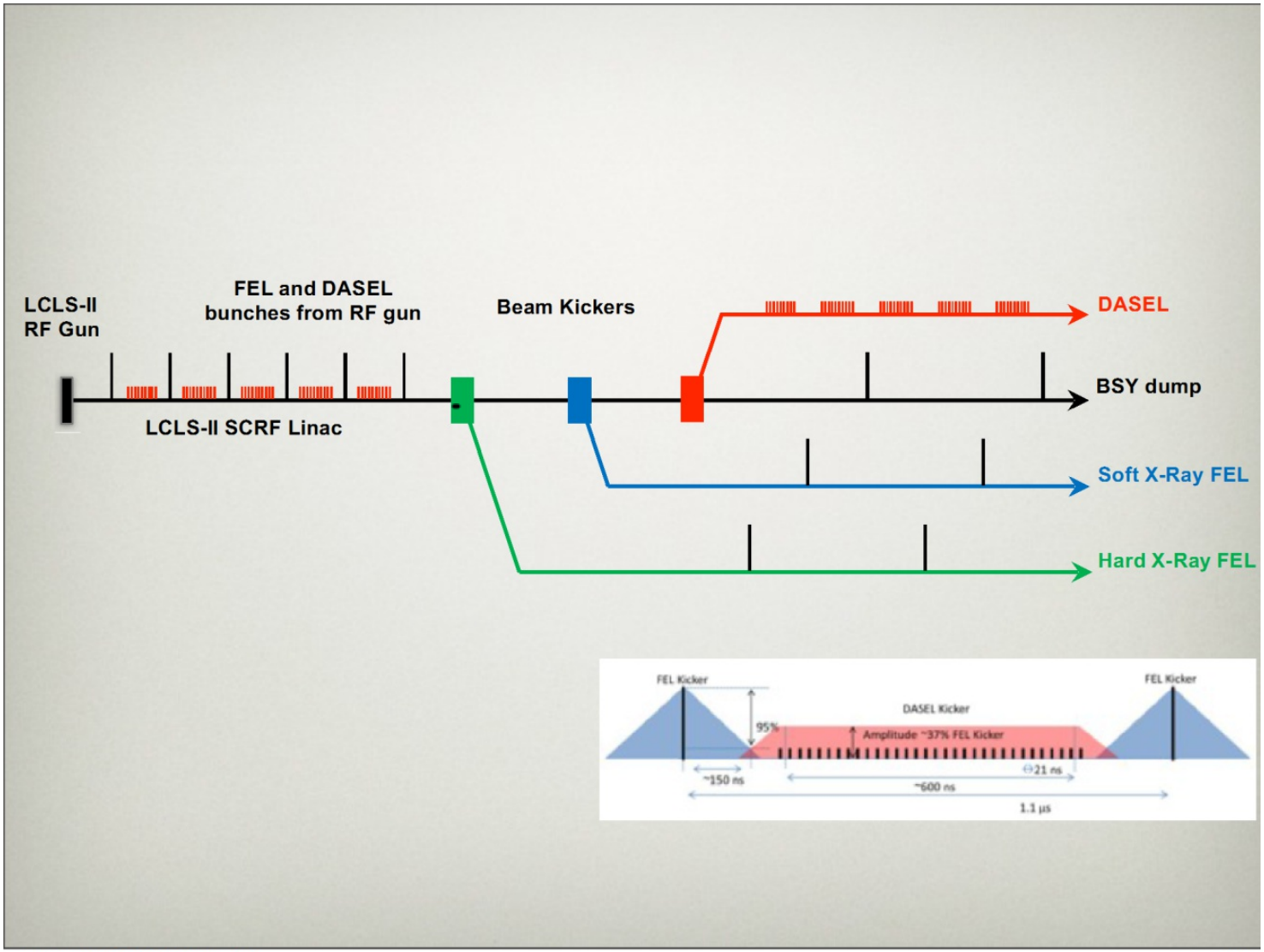
Studying different ECAL material configurations in GEANT...

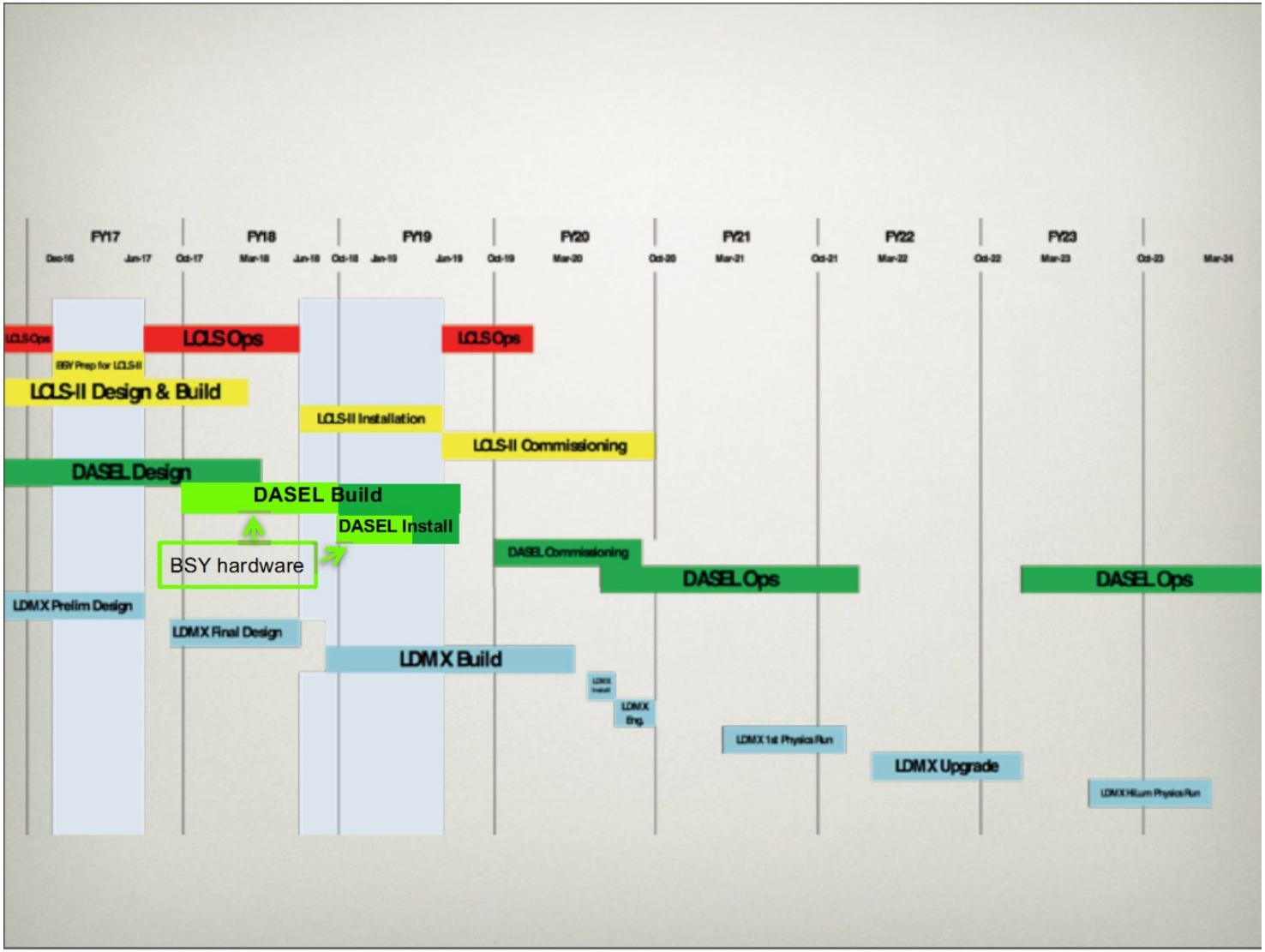


Trigger	Prescale factor	Rate (Hz)
Physics Trigger		*4000*
E(ECAL) < 1.8 GeV	1	4000
Background-Measurement Triggers		*600*
E(ECAL) > 3 GeV	3000	100
E(ECAL) > 2 GeV	25	100
Multi-MIP event in trigger scintillator		100
HCAL single layer-hit trigger	2500	100
HCAL multilayer trigger	75	100
Multi-electron trigger (E(ECAL) > 6 GeV)	100	100
Detector-Monitoring Triggers		*400*
Beam-arrival (trigger scintillator)	2.3×10^5	200
Empty-detector (trigger scintillator veto)		200
Total Trigger Budget		5000

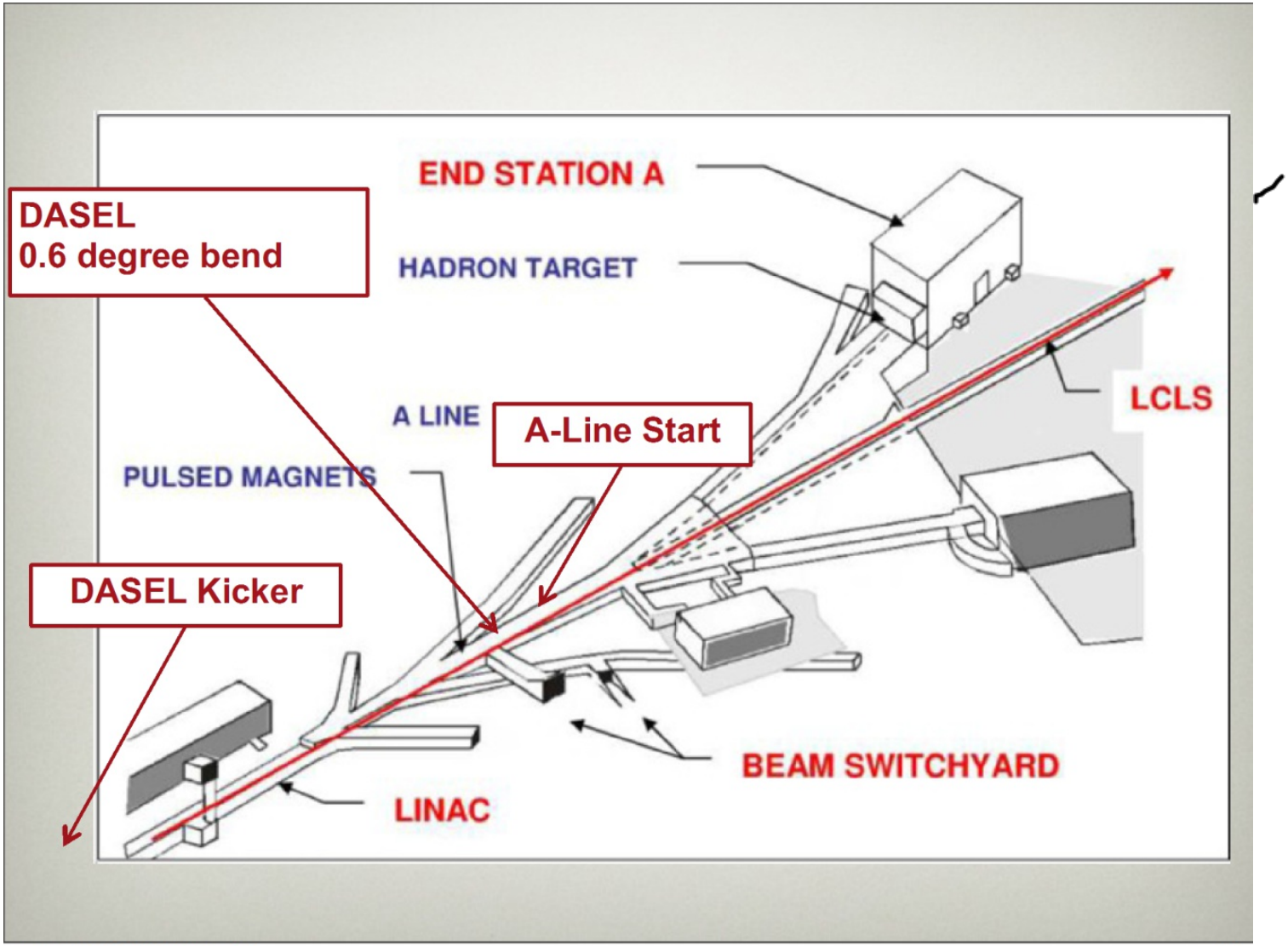

GEANT4 simulation
Hadronic Events
Non-Hadronic
Unit Normed (A.U.C = 1.)
10^{-2}
10^{-3}
10^{-4}
20
40
60
80
100
120
Si Energy Deposition (MeV)

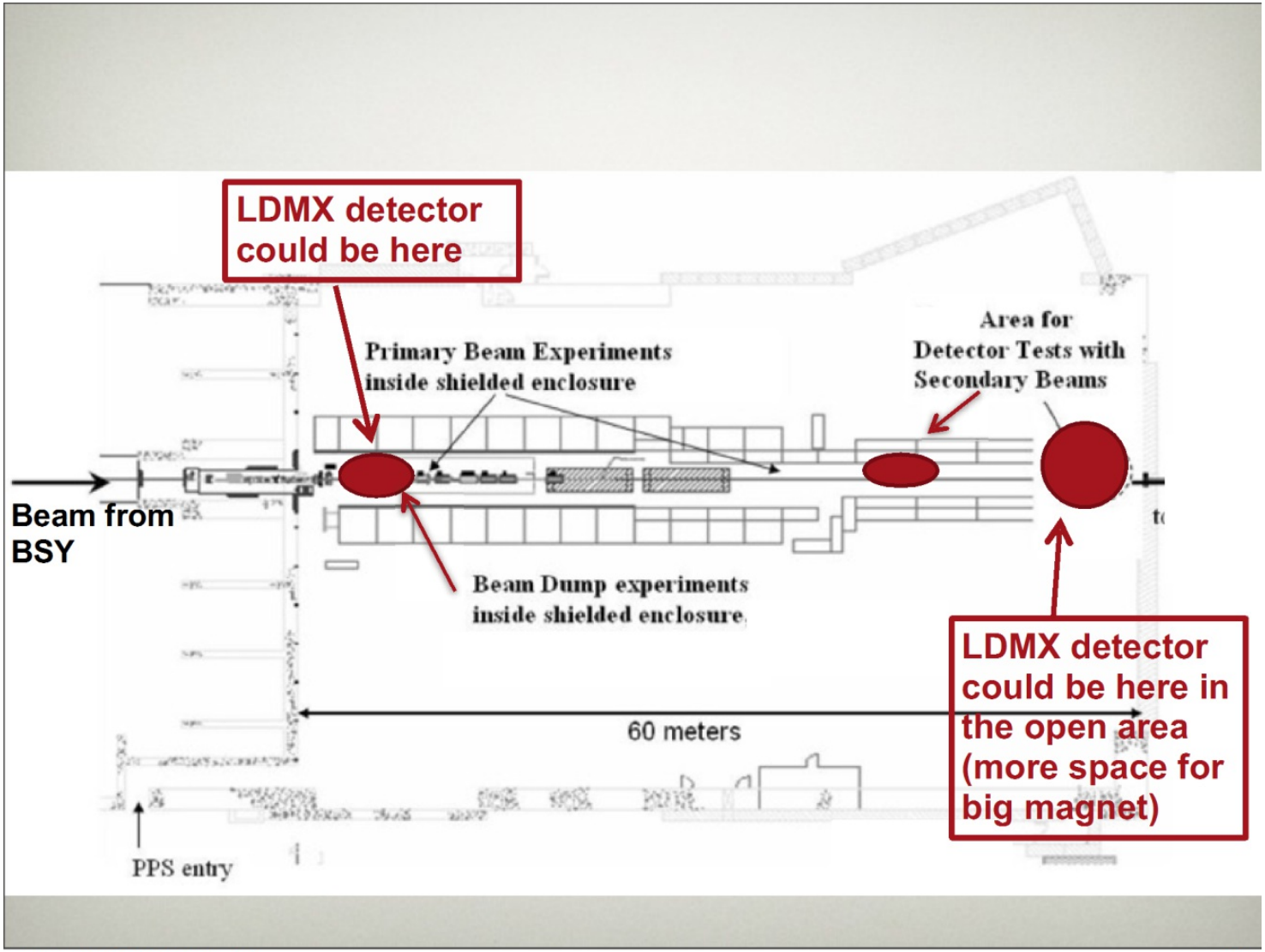
LCLS-II Linac
SCRF
4 GeV
proposed
FACET-II
Sec. 11-20
LCLS-I Linac
2.5-15 GeV
Sec. 21-30
0.2-1.3 keV (1 MHz)
SXU
HXU
1-25 keV (120 Hz)
1-5 keV (1 MHz)
1 km
2 km
1 km


LCLS-II
RF Gun
FEL and DASEL
bunches from RF gun
Beam Kickers
DASEL
BSY dump
LCLS-II SCRF Linac
Soft X-Ray FEL
Hard X-Ray FEL
FEL Kicker
FEL Kicker
DASEL Kicker
95%
Amplitude ~37% FEL Kicker
~150 ns
~21 ns
~600 ns
1.1 µs


FY17
FY18
FY19
FY20
FY21
FY22
FY23
Dec-16
Jun-17
Oct-17
Mar-18
Jun-18
Oct-18
Jan-19
Jun-19
Oct-19
Mar-20
Oct-20
Mar-21
Oct-21
Mar-22
Oct-22
Mar-23
Oct-23
Mar-24
LCLS Ops
BSY Prep for LCLS-II
LCLS Ops
LCLS Ops
LCLS-II Design & Build
LCLS-II Installation
LCLS-II Commissioning
DASEL Design
DASEL Build
DASEL Install
BSY hardware
DASEL Commissioning
DASEL Ops
DASEL Ops
LDMX Prelim Design
LDMX Final Design
LDMX Build
LDMX Eng.
LDMX 1st Physics Run
LDMX Upgrade
LDMX HiLum Physics Run

Experiment Parameters	LDMX experiment (~2020)	Super-HPS-style upgrade (~2025)
Energy	4.0 GeV (possible to upgrade to 8.0 GeV)	4.0 GeV (possible to upgrade to 8.0 GeV)
Bunch spacing	21.5 ns	5.4 ns
Bunch charge	0.05 – 20 e-	70,000 e- (10 fC)
Macro pulse beam current	0.1 – 150 pA	2 uA
Duty cycle	55% (600 ns out of 1.1 us)	55% (600 ns out of 1.1 us)
Beam norm. emittance (rms)	~100 um; < 1000 um	~1 um
Bunch energy spread	<1%	<1%
IP spot size	4 cm x 4 cm (rastering at 40 MHz could be used)	<250 um including jitter
Max beam power	0.6 W	5 kW
ESA Spoiler Parameters		
Charge reduction	0 – 99.99%	N/A
Emittance increase	1 - 1000x	N/A
Max beam power	55 W	N/A
Spoiler thickness	0 – 0.5 r.l.	N/A
Accelerator Parameters		
Macro pulse beam current	0 – 25 nA	2 uA
Beam norm. emittance (rms)	~1um; < 25 um	~1um; < 25 um
Beam admittance (edge)	<50 nm; defined by LCLS-II collimators	<50 nm; defined by LCLS-II collimators
Bunch energy spread (FWHM)	<2% ; defined by LCLS-II collimators	<2%; defined by LCLS-II collimators
Bunch length (rms)	<1 cm	<1 cm
Max beam power	55 W	5 kW


END STATION A
DASEL
0.6 degree bend
HADRON TARGET
LCLS
A LINE
A-Line Start
PULSED MAGNETS
DASEL Kicker
BEAM SWITCHYARD
LINAC


LDMX detector could be here
Primary Beam Experiments inside shielded enclosure
Area for Detector Tests with Secondary Beams
Beam from BSY
Beam Dump experiments inside shielded enclosure
LDMX detector could be here in the open area (more space for big magnet)
60 meters
PPS entry

ESA can support LDMX