Bormio Conference

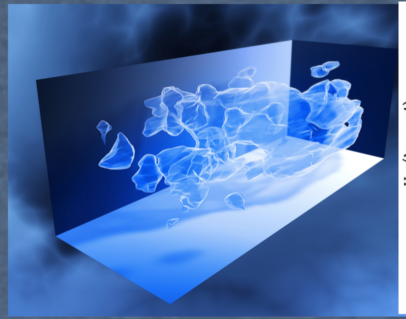
27–31 Jan 2025
Bormio, Italy
Europe/Berlin timezone

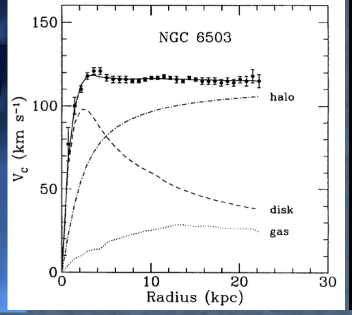
61st International Winter Meeting on Nuclear Physics

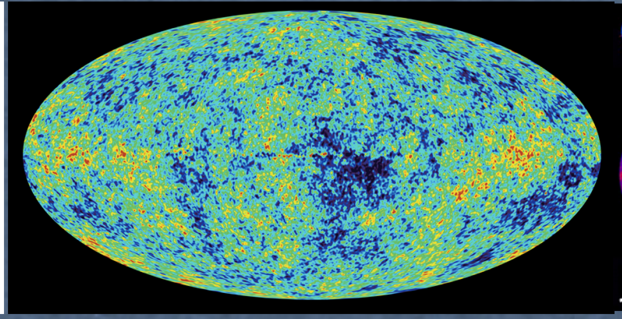
27 - 31 January 2025
Bormio, Italy

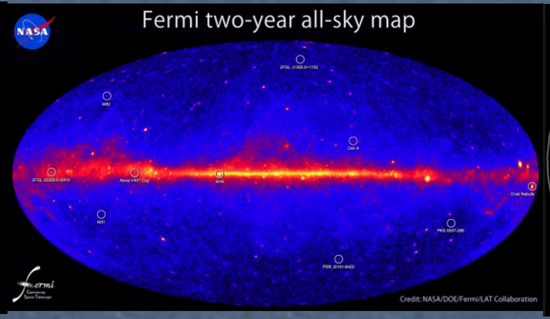
Light Dark Matter searches

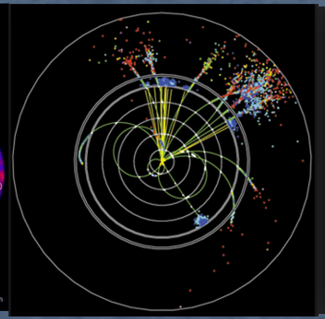
M.Battaglieri (INFN)

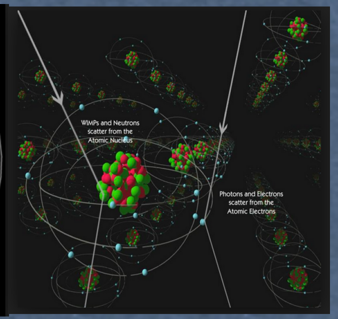




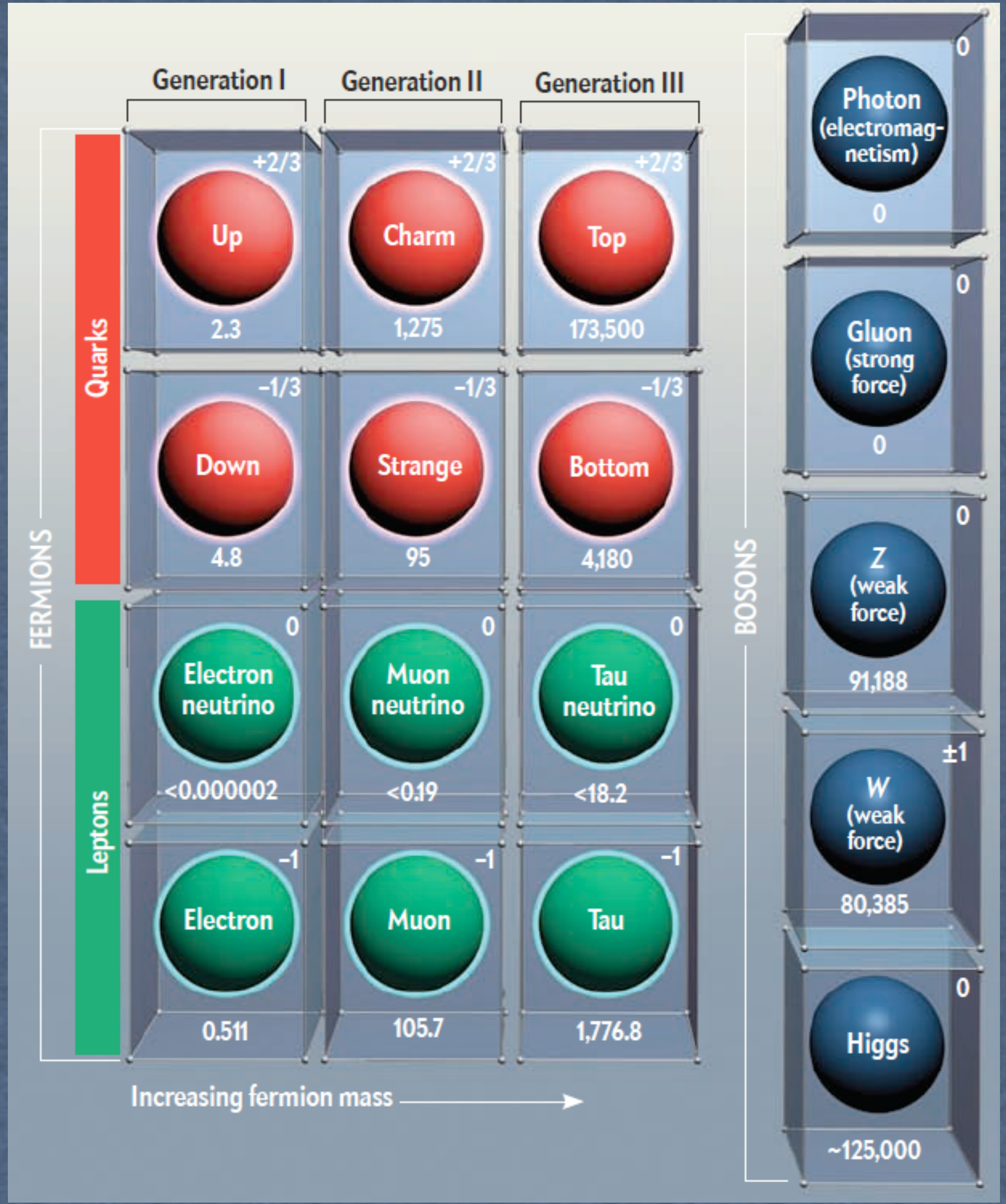






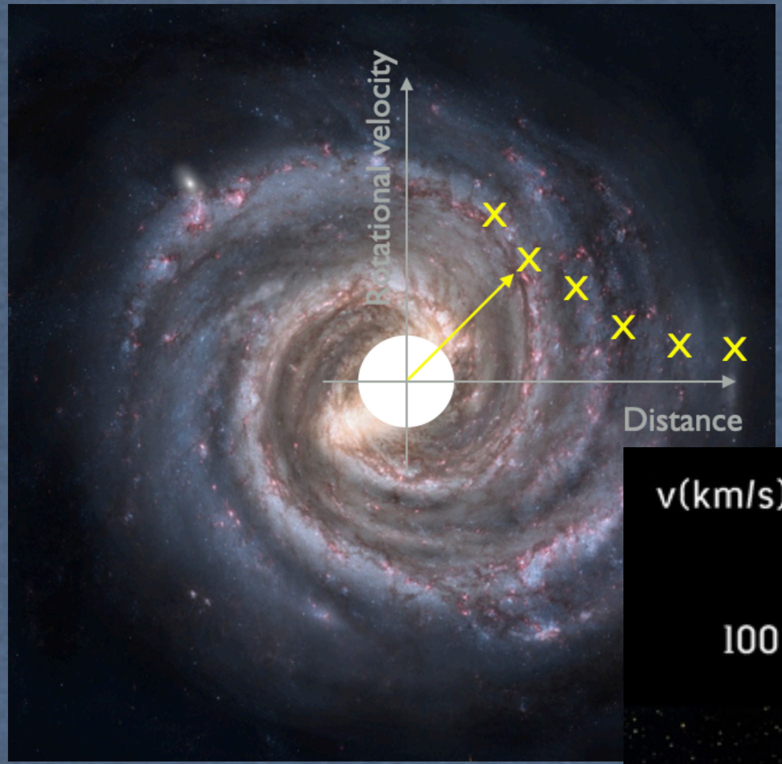


Standard Model of particles and interaction

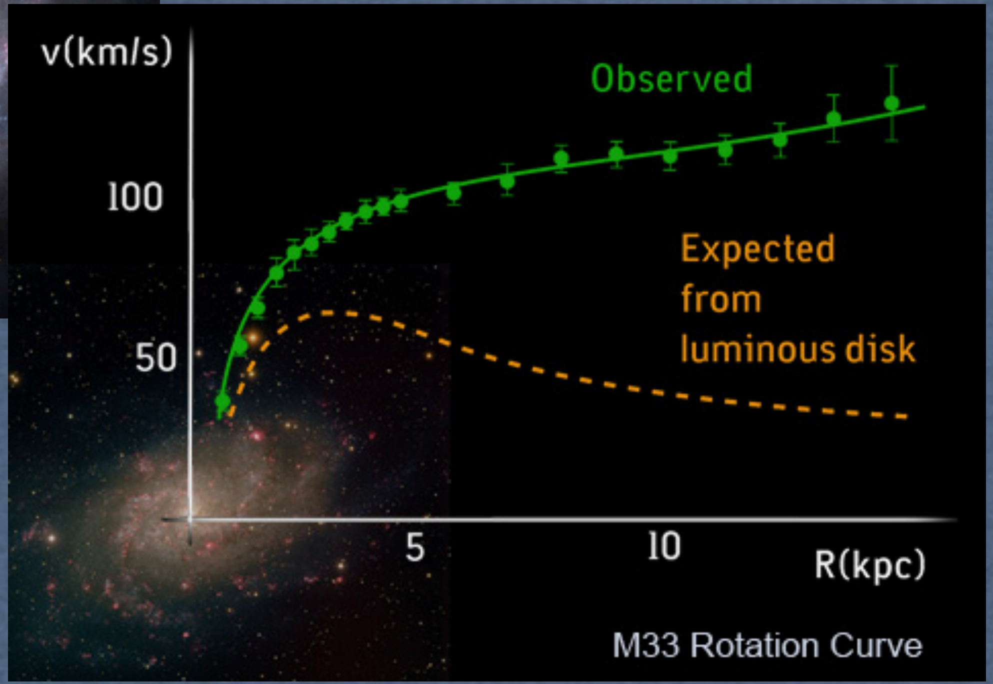


some anomalies ...

1935: Zwicky, Coma and Dark Matter
The gravity of the Stars is not enough to hold clusters together



1970s: Rubin and Flat Rotation Curves



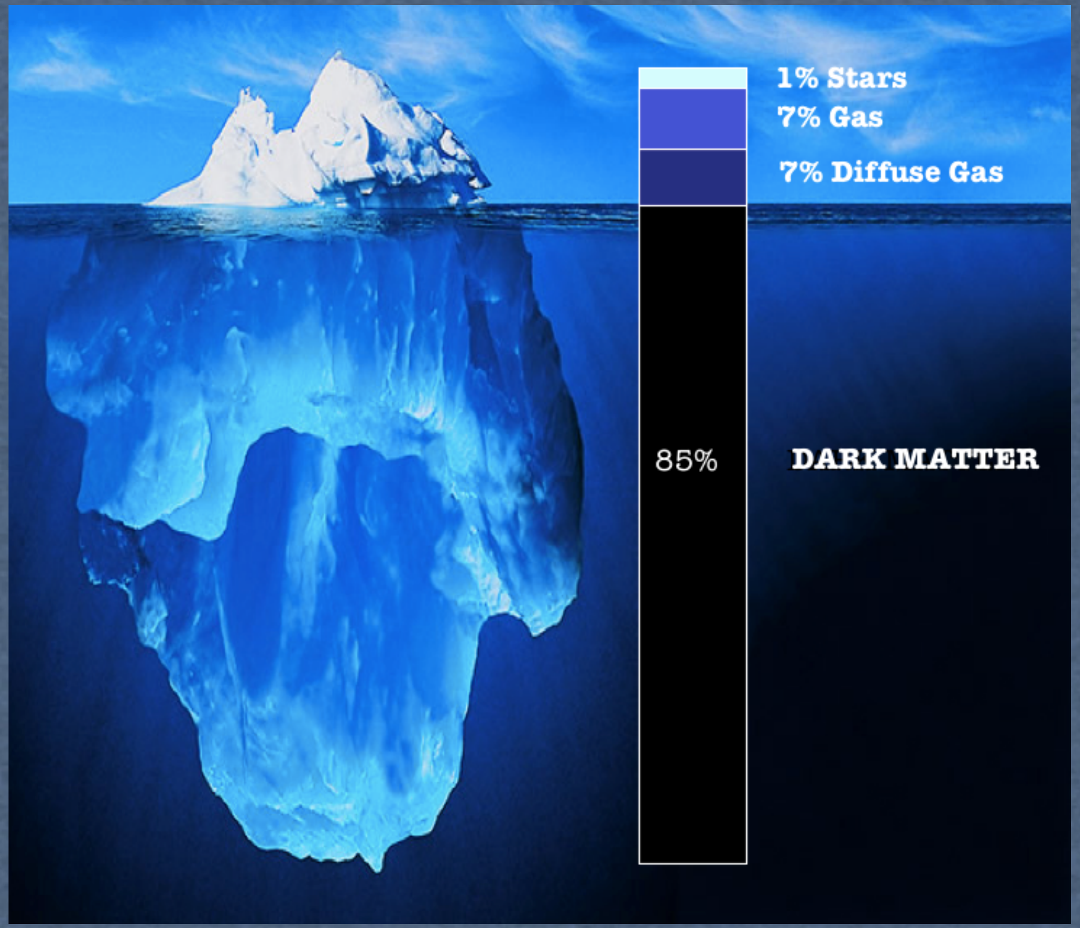
beside visible matter there should be something else
➨ DARK MATTER

- ★ Gravitational lensing
- ★ Mass balance
- ★ CMB
- ★ Clusters of galaxies
- ★ Cluster collisions
- ★ …

Compelling astrophysical indications about DM existence

Dark Matter (DM) vs Baryonic Matter (BM)

★ How much DM w.r.t. BM?



★ Does DM participate to non-gravitational interactions?
★ Is DM a new particle?

★ Constraint on DM mass and interactions

- should be '*dark*' (no em interaction)
- should weakly interact with SM particles
- should provide the correct relic abundance
- should be compatible with CMB power spectrum

… assuming that the gravity is not modified and DM undergoes to other interactions

★ We can use what we know about standard model particles to build a DM theory

Use the SM as an example: $SM = U(1)_{EM} \times SU(2)_{Weak} \times SU(3)_{Strong}$

Particles, interactions and symmetries

Known particles & new force-carriers

Particles:
quarks, leptons

Force-carriers:
gluons, γ, W, Z, graviton (?), Higgs, ...

Two options:

★ New matter interacting trough the same forces
★ New matter interacting through new forces

Any guess about the DM mass and interaction?

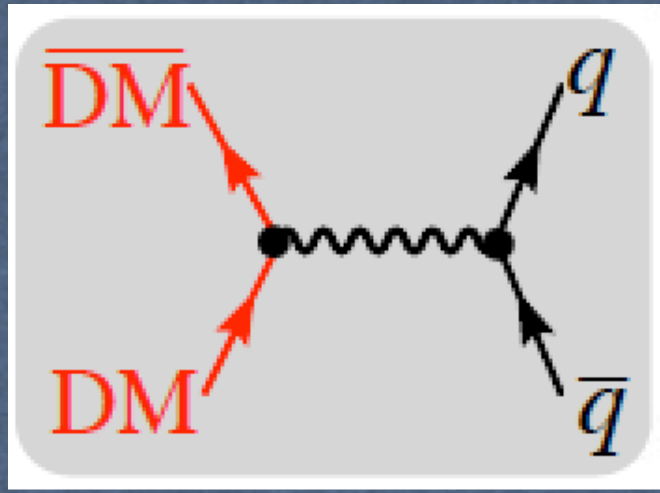
Yes, if we do a couple of assumptions:

★ DM thermal origin

in the early Universe DM was in thermal equilibrium with regular matter (via annihilation)

★ DM as thermal relic from the hot early Universe

Minimal DM abundance is left over to the present day

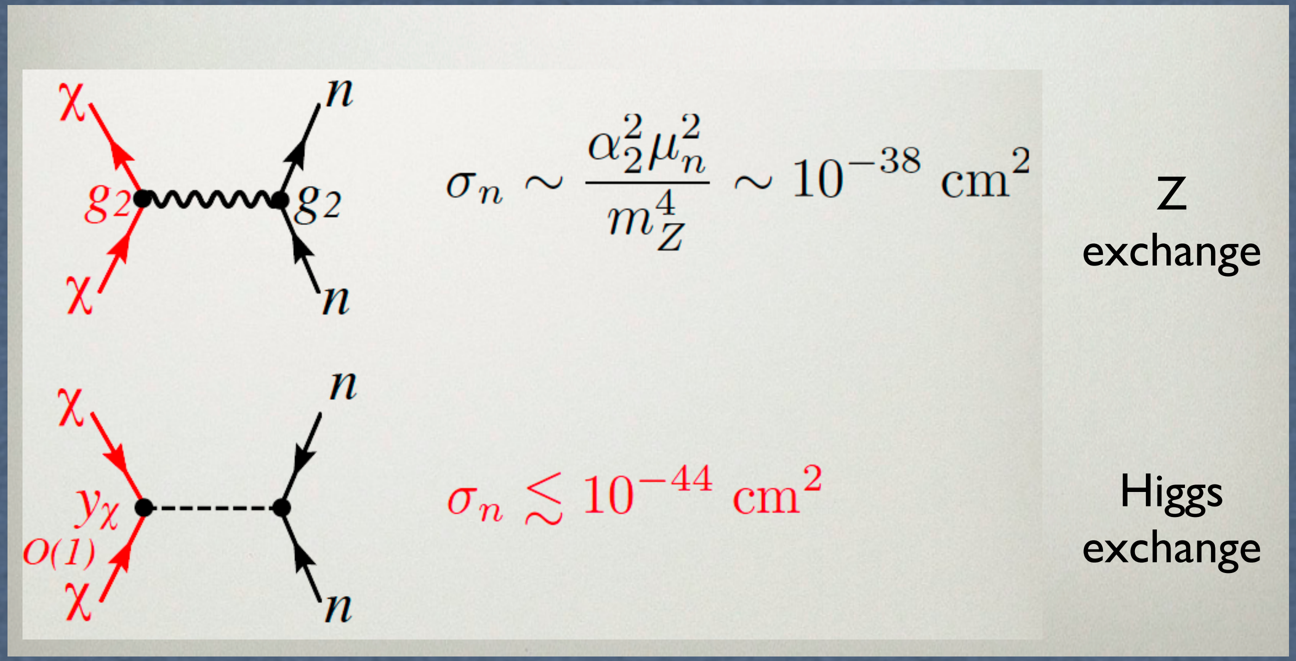


$\langle\sigma v\rangle \sim M^2_{DM}/M^4_{mediator}$

Correct DM density for an annihilation xsec: $\langle\sigma v\rangle \sim 3\times10^{-26}\ \mathrm{cm}^3/\mathrm{s} \sim 1/(20\ \mathrm{TeV})^2$

WIMPs (Weakly Interacting Massive Particles)

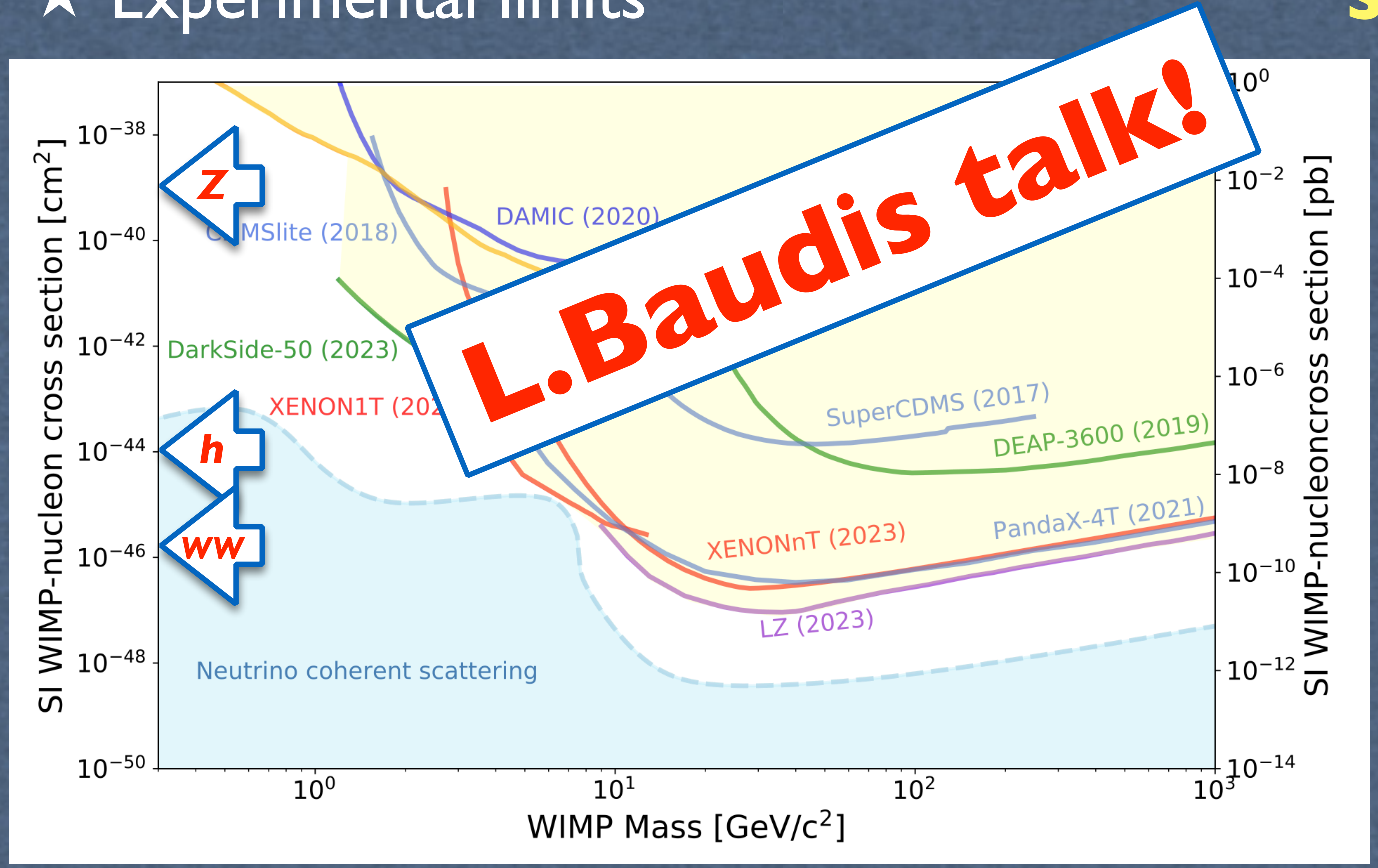
- Massive DM with massive mediator
- For ~100 GeV DM mass, weak-scale mediators provide reasonable annihilation rate and range of DM-scattering rates



Thermal origin suggests DM interactions and mass in the vicinity of the weak-scale

Exploring the WIMP's option

★ Experimental limits



Slow-moving cosmological weakly interacting massive particles

- DM detection by measuring the (heavy) nucleus recoil
- Constraints on the interaction strength from the DM Direct Detection limits
  - Scattering through Z boson ($\sigma \sim 10^{-39}$cm^2): ruled out
  - Approaching limits for scattering through the Higgs ($\sigma \sim 10^{-45}$cm^2)
  - Close to irreducible neutrino background

✳ No signal observed in Direct Detection

✳ Experiments have reduced sensitivity to (light) DM (<1 GeV)

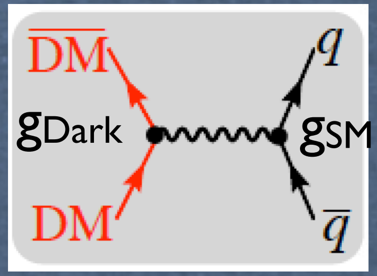
Direct Detection

1 MeV — 1 GeV — Mz — 10 TeV

WIMPs

WIMPs paradigm is not the only option (keeping the DM thermal origin)

$\langle \sigma v \rangle \sim g^2_{Dark}\, g^2_{SM}\, M^2_{DM}/M^4_{mediator}$



Light Dark Matter

Light Dark Matter (<TeV) naturally introduces light mediators

New interaction

Introducing a new force in nature

✳Hidden sector (HS)
present in string theory and super-symmetries

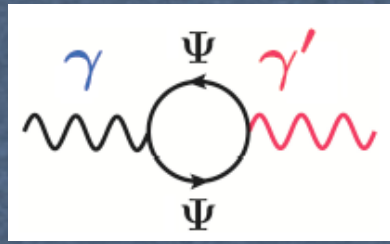
✳HS not charged under SM gauge groups (and v.v.)
no direct interaction between HS and SM
HS-SM connection via messenger particles

A simple way to go beyond the SM (not yet excluded!):

$SU(3)_C$ x $SU(2)_L$ x $U(1)_Y$ **x extra U(1)**

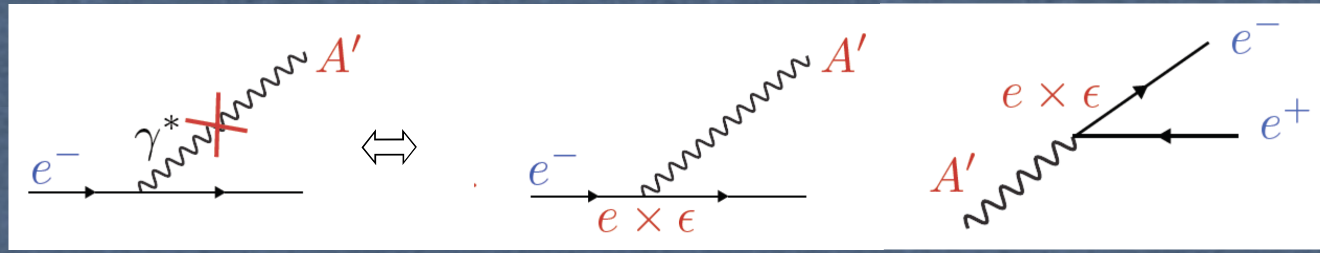
Color Electroweak Hypercharge Hidden sector

$$\mathcal{L}_{\rm eff} = \mathcal{L}_{\rm SM} - \frac{1}{4} X_{\mu\nu} X^{\mu\nu} - \frac{\chi}{2} \overset{\text{Hidden}}{X_{\mu\nu}} \underset{\text{Visible}}{F^{\mu\nu}} + \frac{m^2_{\gamma'}}{2} X_\mu X^\mu$$

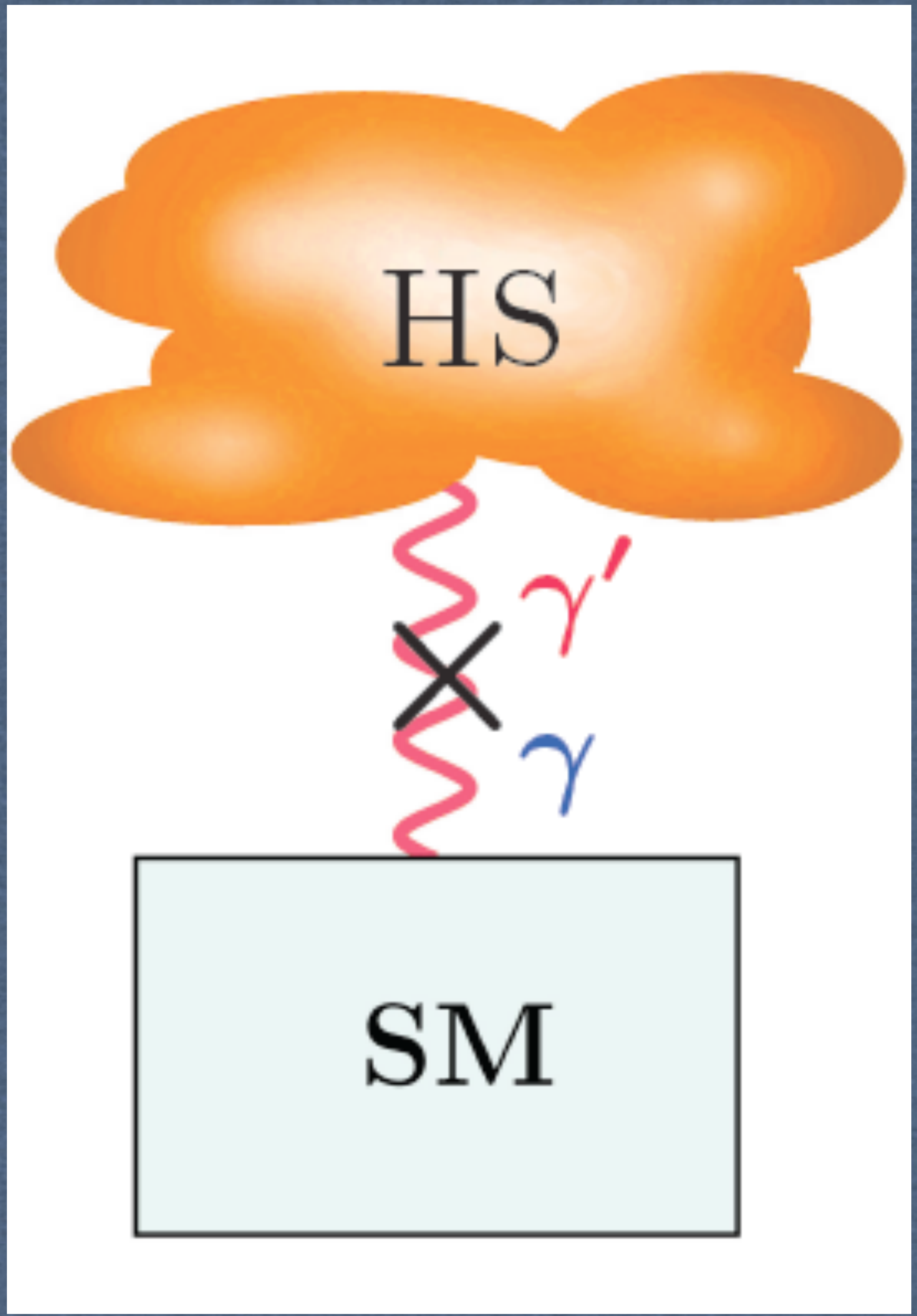


γ'/A' couples to SM via electromagnetic current (kinetic mixing)

➜ $A_\mu \rightarrow A_\mu + \varepsilon a_\mu$ $\chi=\varepsilon \sim 10^{-6}$-$10^{-2}$ ($\alpha^{DarkProton} = \varepsilon^2 \alpha_\mu$)



Ψ can be a huge mass scale particle
(M_Ψ~1EeV) coupling to both SM and HS



A lesson from history

An historical example of a ‘Standard Model’ and ‘hidden sector’

★ Back in the ’30 the Standard Model of the elementary particles was: photon, electron and nucleons

★ Beta decay: Continuous spectrum!

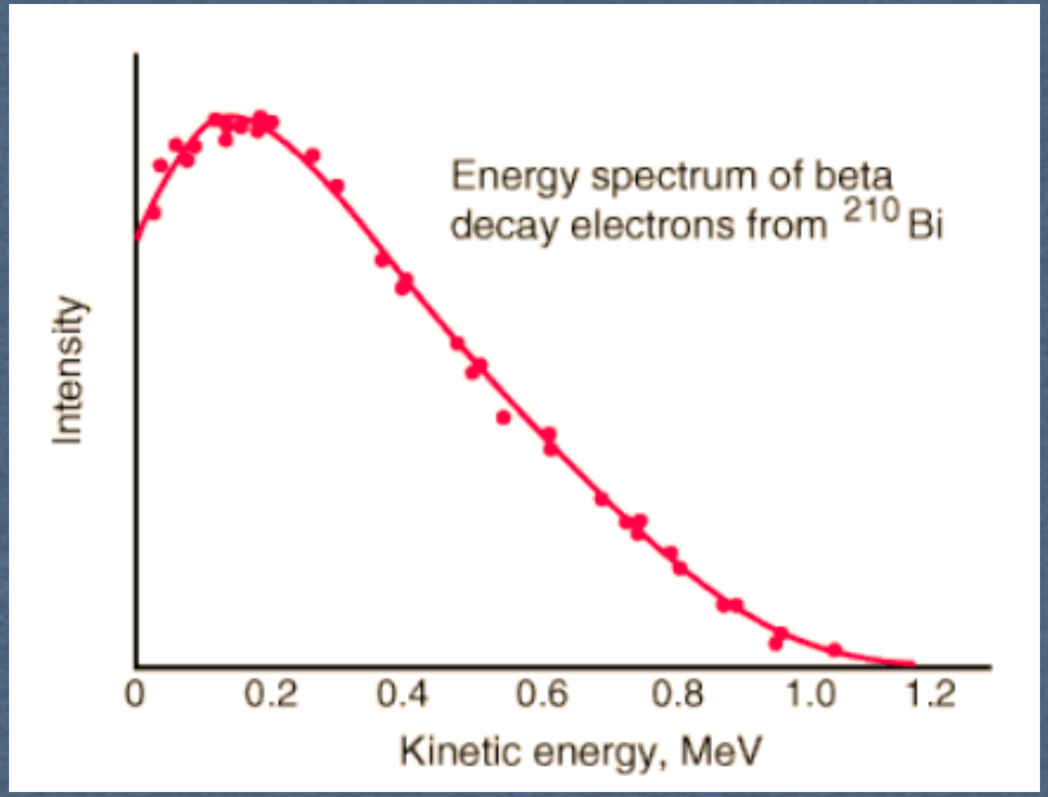
$$n \rightarrow p + e^-$$

★ Pauli proposes a radical solution - the neutrino!

$$n \rightarrow p + e^- + \bar{\nu}$$

★ Perfect example of a hidden sector!

- neutrino is electrically neutral
- very weakly interacting and light
- interacts with “Standard Model” through “portal” - $(p\gamma^\mu n)(e\gamma^\mu\nu)$

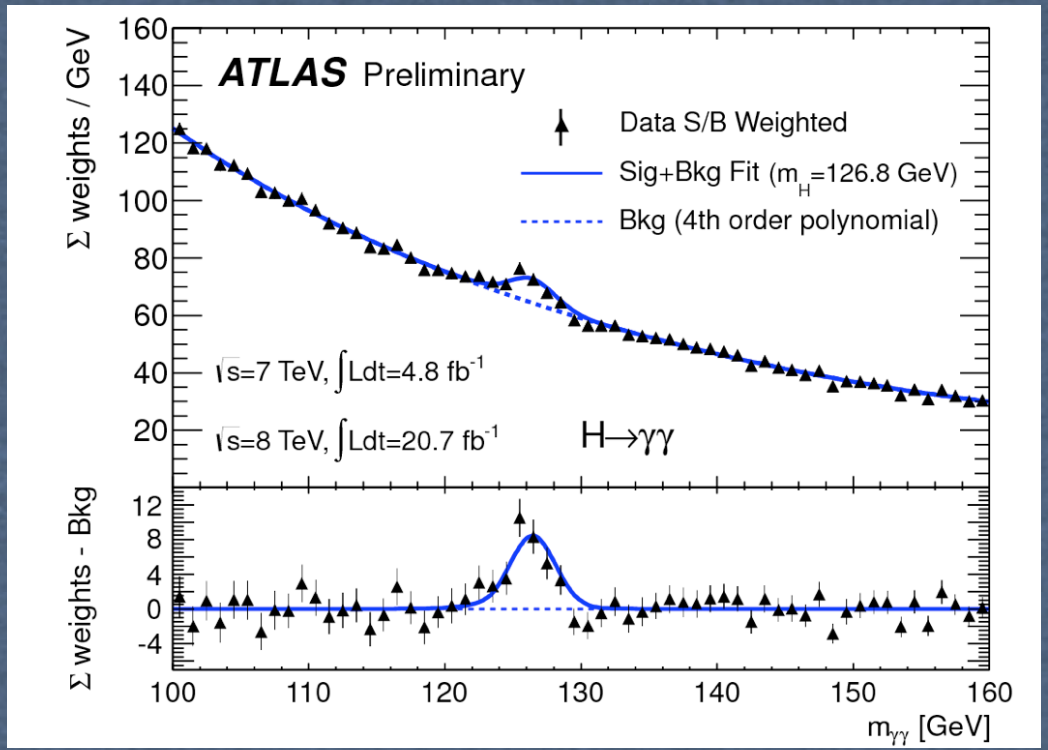


Today?

★ Higgs discovery represent the triumph of SM

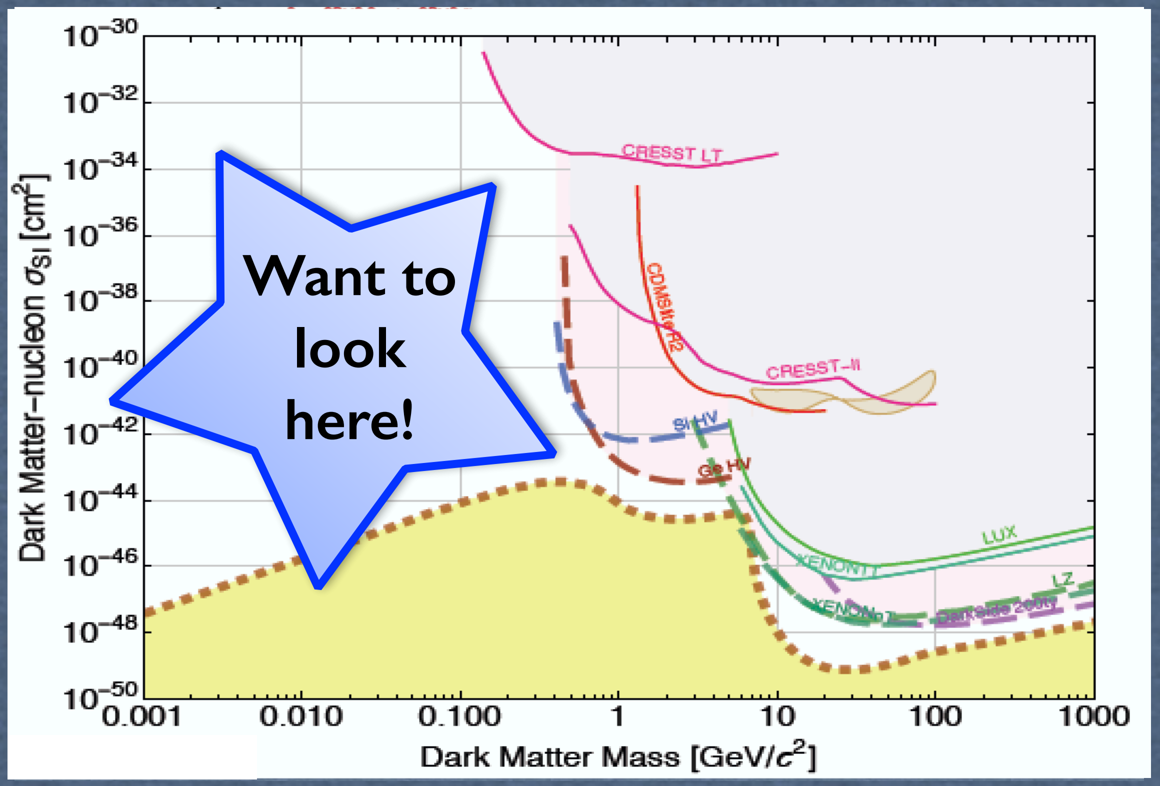
★ but there are still some missing pieces: Dark Matter, baryon asymmetry, neutrino oscillations …

★ No guarantee of discoveries but exciting times to look for new physics!



Light Dark Matter

★ Experimental limits



Light Dark Matter with a (almost) weak interaction (new force!)

- Direct Detection is difficult
  - Low mass elastic scattering on heavy nuclei produces small recoil
  - eV-range recoil requires a different detection technology
  - Directionality may help to go behind existing limits at large masses

Accelerators-based DM search

covers an unexplored mass region extending the reach outside the classical DM hunting territory

- **High intensity**
- **Moderate energy**

Light Dark Matter | Direct Detection

1 MeV — 1 GeV — Mz — 10 TeV

WIMPs

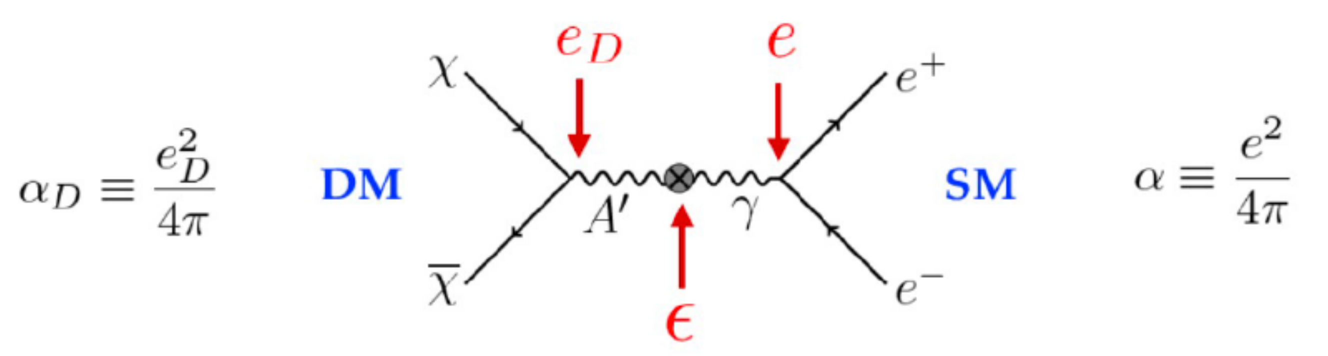
Dark Sector or Hidden Sector (DM not directly charged under SM interactions)

Can be explored at accelerators!

Dark Photon Signatures

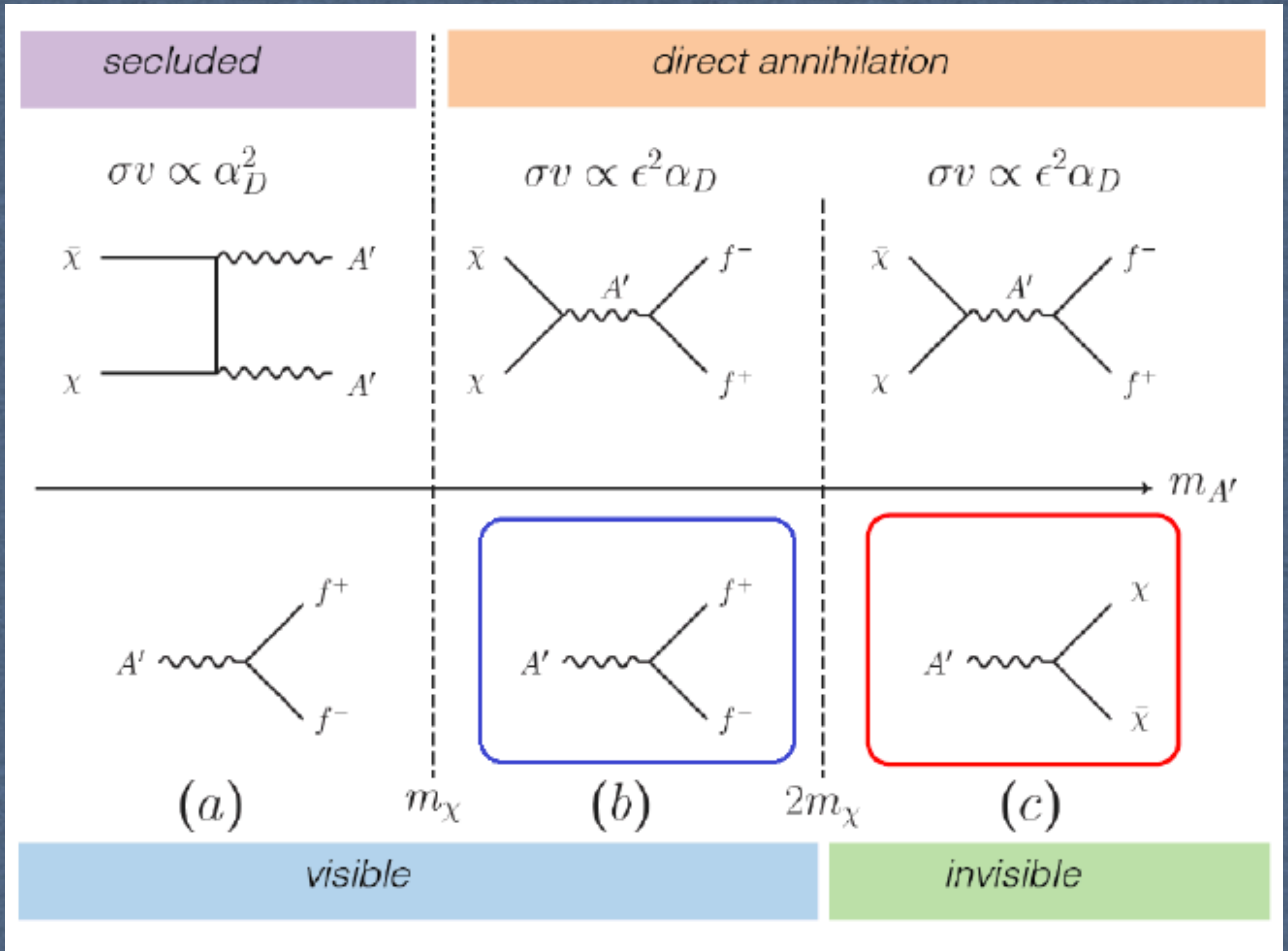
Vector mediated Light Dark Matter

- Vector-Portal: DM-SM interaction mediated by U(1) gauge-boson (dark photon or A') couples to electric charge

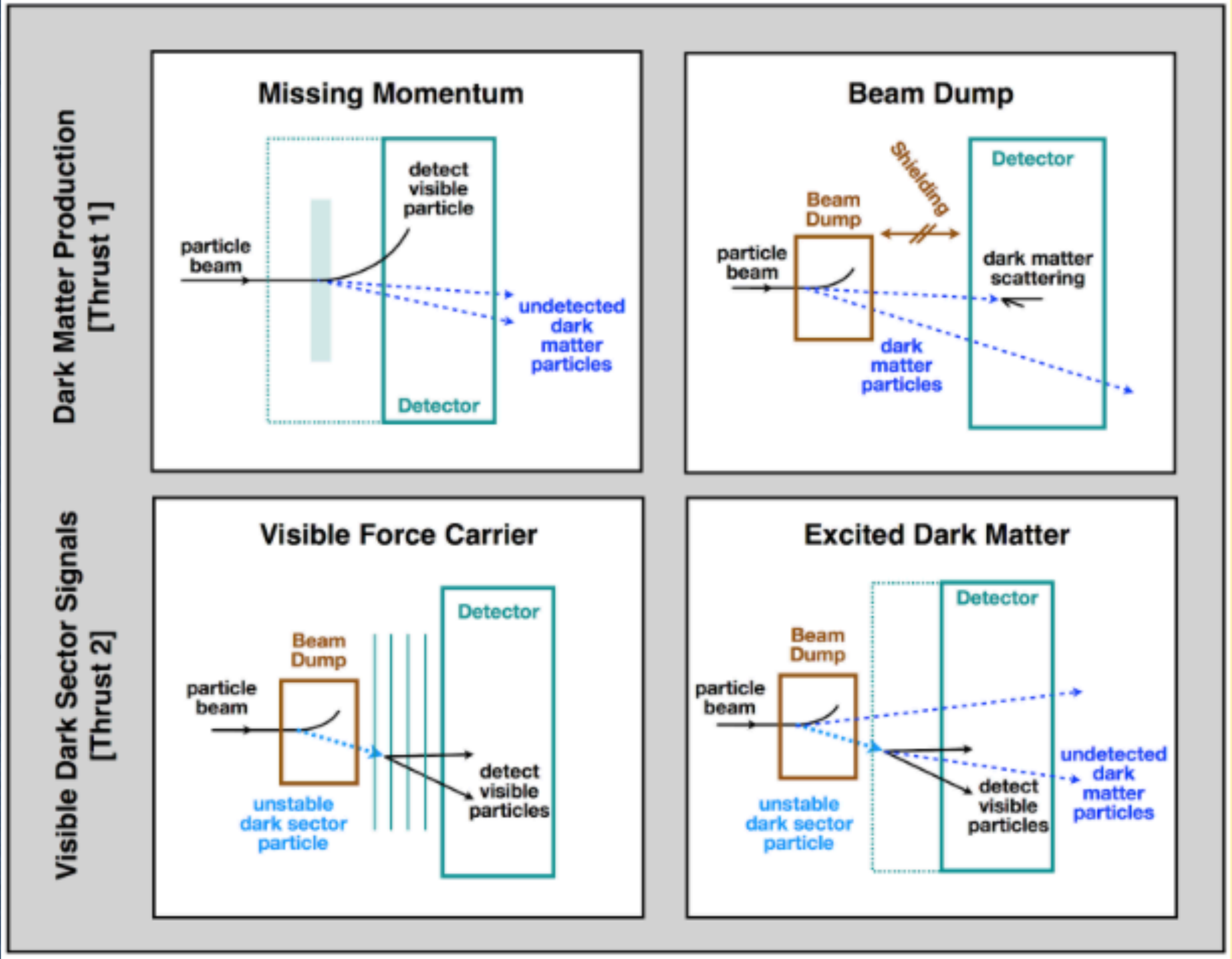


A' interaction scenarios

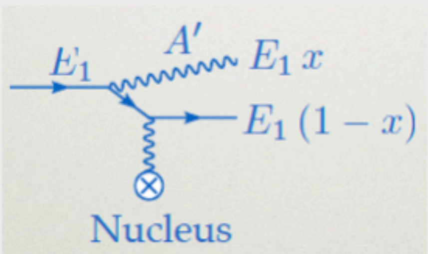
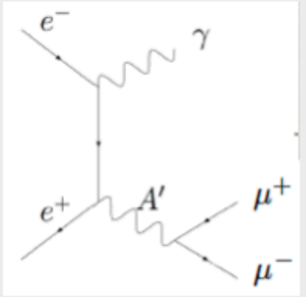
- **Secluded**: no constraints by cosmology for accelerator based experiments. Any ε allowed
- **Visible decay**: final state contains SM particles
- **Invisible decay**: A' decays to Dark Sector invisible particles



Experimental techniques



Fixed target vs. collider

	Fixed Target	e+e- colliders
Process		
Luminosity	10^{11} e- ; $\sim 10^{23}$ atoms in target	10^{11} e- ; 10^{11} e+
Cross-Section	$\sigma \sim \frac{\alpha^3 Z^2 \epsilon^2}{m^2} \sim O(10\ pb)$	$\sigma \sim \frac{\alpha^2 \epsilon^2}{E^2} \sim O(10\ fb)$

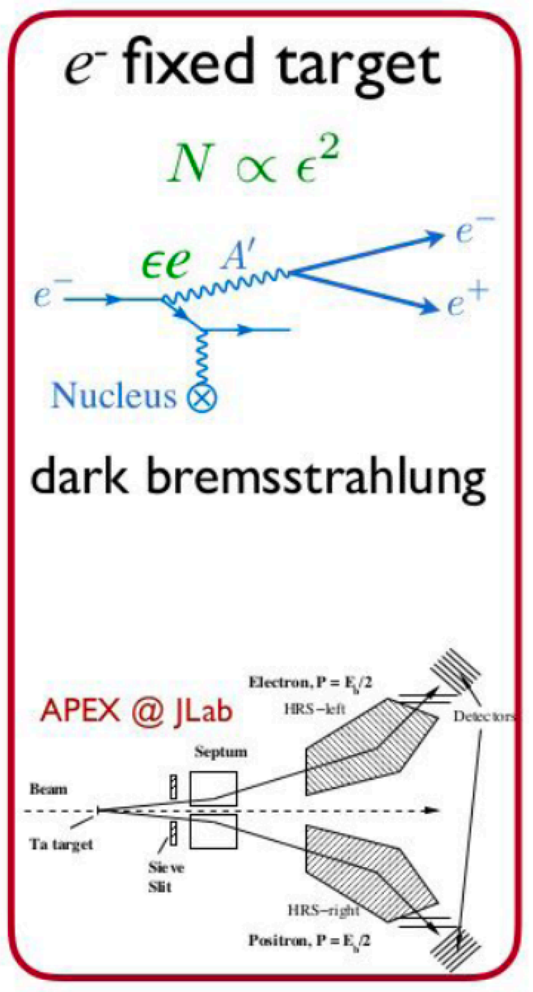
Fixed Target:
- high backgrounds
- limited A' mass

e+e- colliders:
- low backgrounds
- higher A' mass

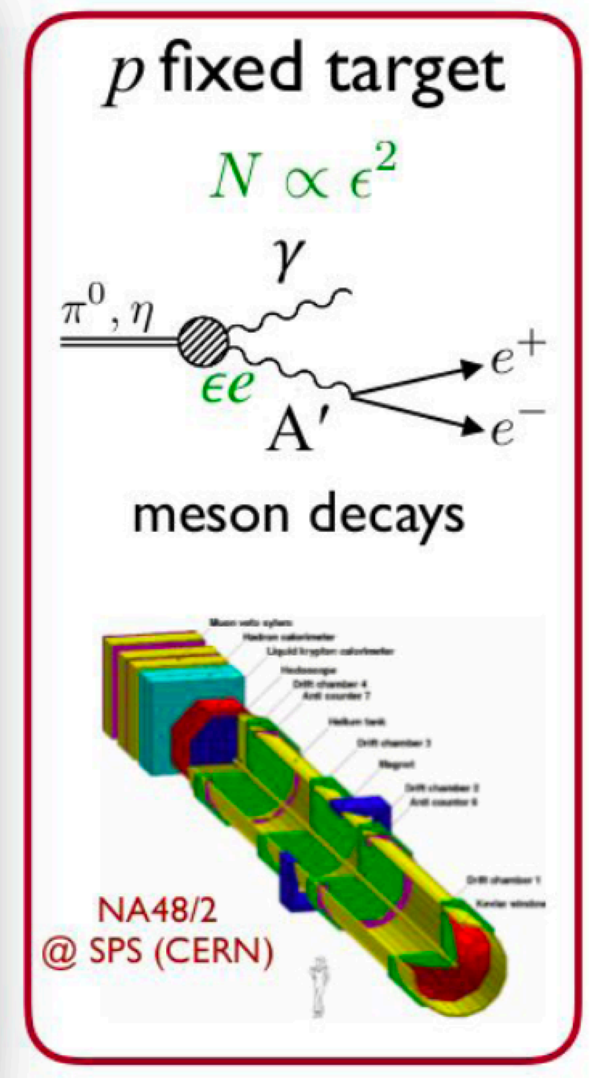
✳ $1/M_{A'}$ .vs. $1/E_{beam}$

✳ Coherent scattering from Nucleus ($\sim Z^2$)

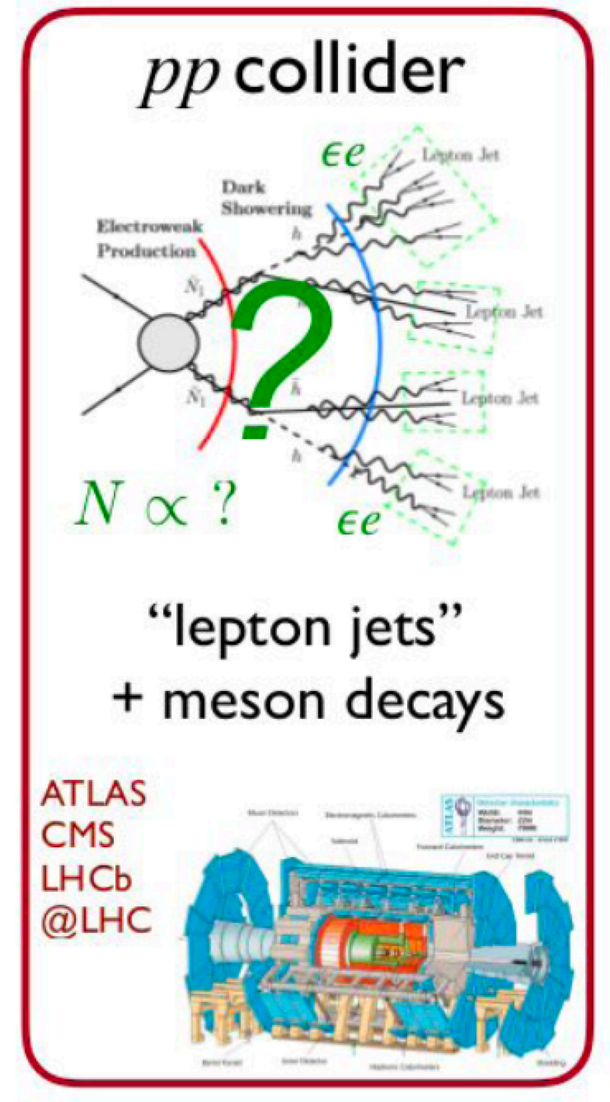
A' visible and invisible decay at accelerators



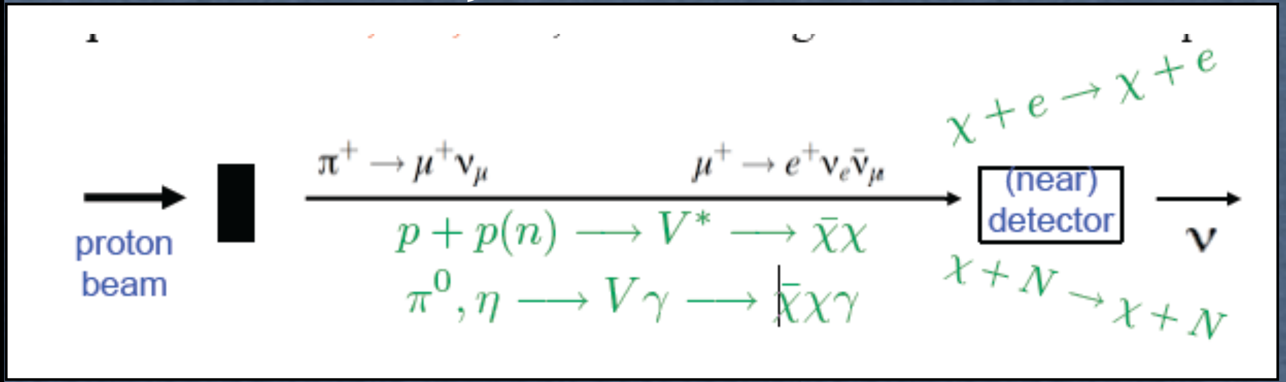
Fixed target:
e N →N γ'→ N Lepton Lepton+
→ JLAB, MAINZ



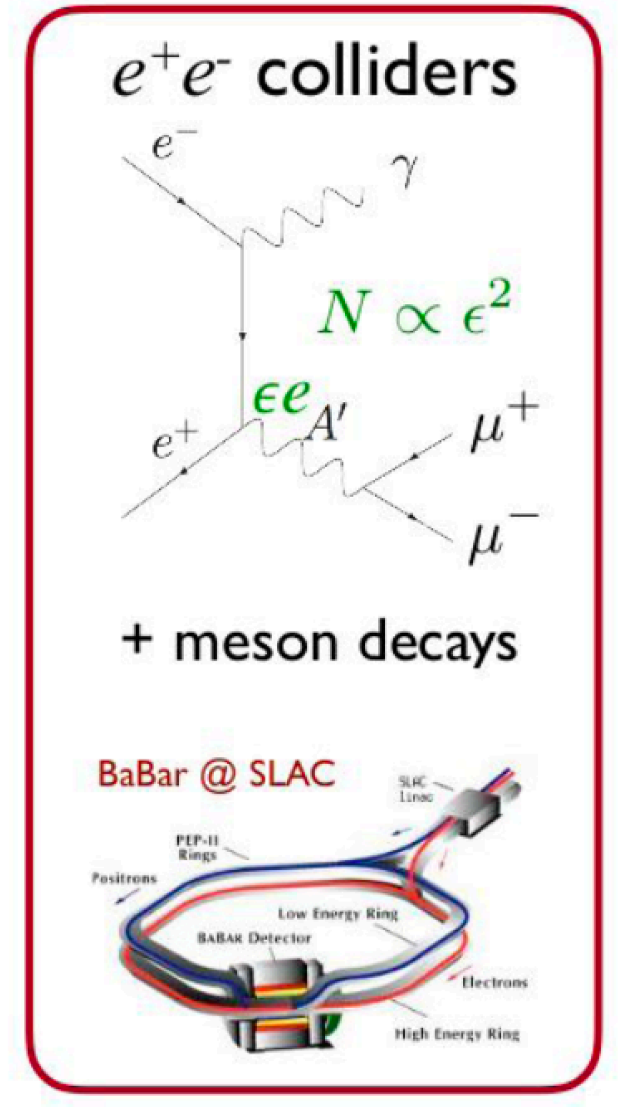
High Energy
Hadron Colliders:
pp → lepton jets
→ ATLAS, CMS, CDF&D0



Fixed target:
p N →N γ'→ p Lepton Lepton+
→ FERMILAB, SERPUKHOV

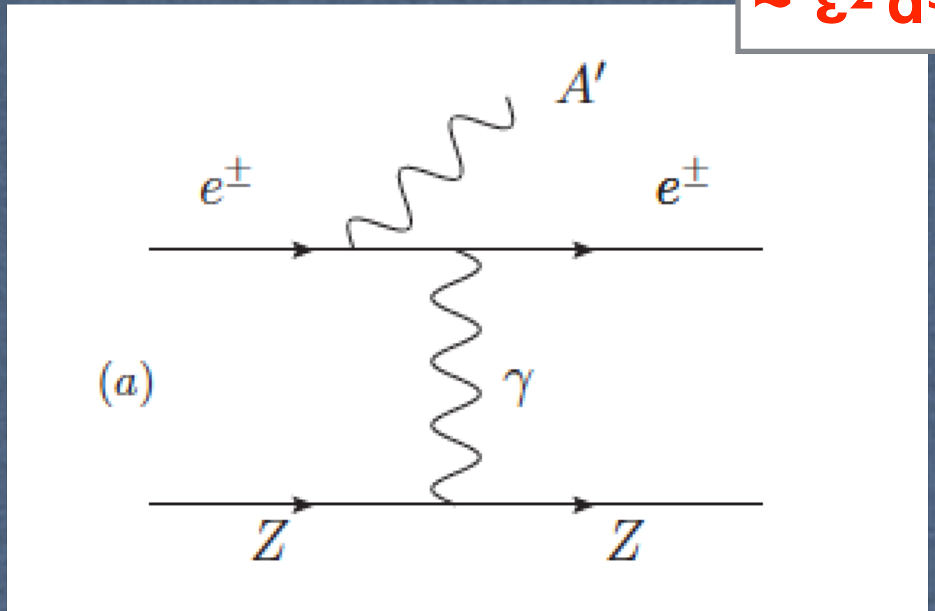


Meson decays:
π0, η, η', ω,' → γ' γ (M)
→Lepton Lepton + γ (M)
→ KLOE, BES3, WASA-COSY, PHENIX



Annihilation:
e+e- → γ' γ → μμ γ
→ BABAR, BELLE-II, KLOE, CLEO

A’ Production mechanisms - $e^{\pm}$

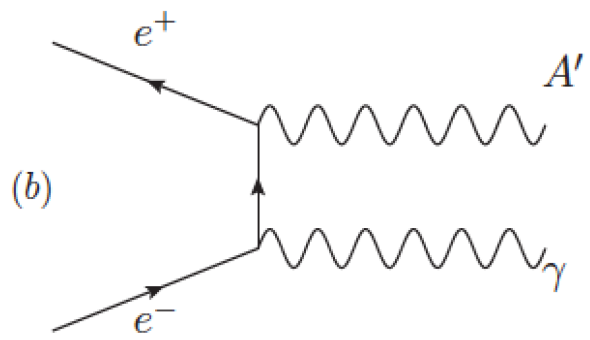


~ $\varepsilon^2 \alpha^3$

The Weizsacker-Williams approximation (*A’-strahlung*)

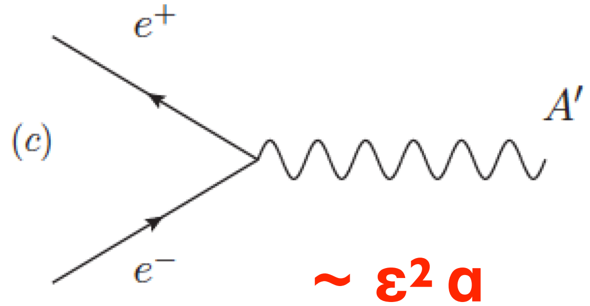
- The incoming electron ‘see’ a fast-moving cloud of effective photons to scatter from
- Photons are almost on-shell (low Q2) → transverse photons ~ $e^- \gamma_{Real}$ scattering
- Same treatment as the regular *bremstrahlung*
- Regularisations occurs in the case of interest $M_{A'} >> M_{e-}$
- Effective photon flux χ is critical, accounting for nuclear effect using FF

A’ Production - positrons



~ $\varepsilon^2 \alpha^2$

- **NON-RESONANT annihilation**
  - **A’ along (e^+e^-) direction**

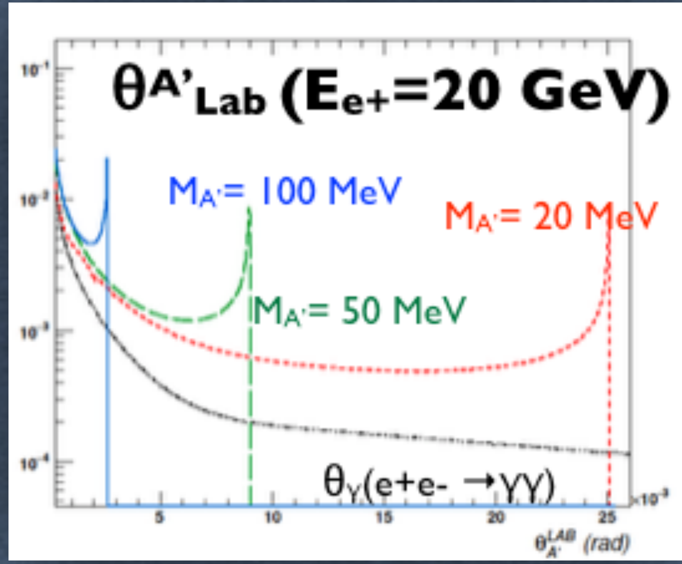


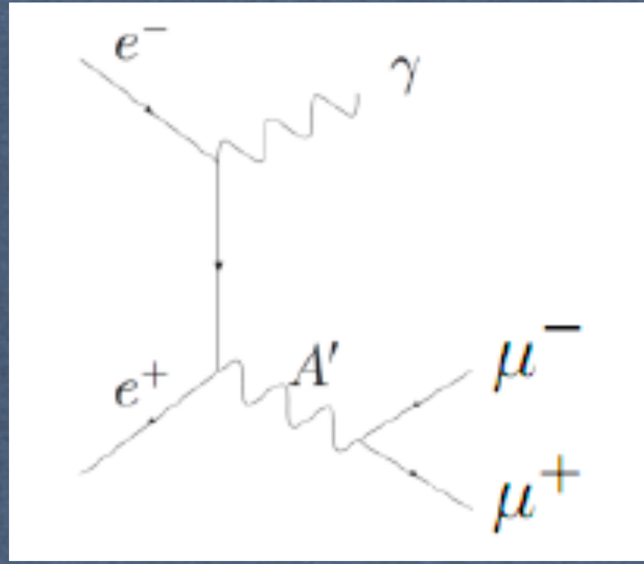
~ $\varepsilon^2 \alpha$

- **RESONANT annihilation**

$$\sigma_r = \sigma_{\rm peak} \frac{\Gamma_{A'}^2/4}{(\sqrt{s} - m_{A'})^2 + \Gamma_{A'}^2/4},$$

- **Two-body process**
- **A’ forward-peaked along e^+ direction**
- **$E_{A'} = E_R = m^2_{A'}/2m_e$**

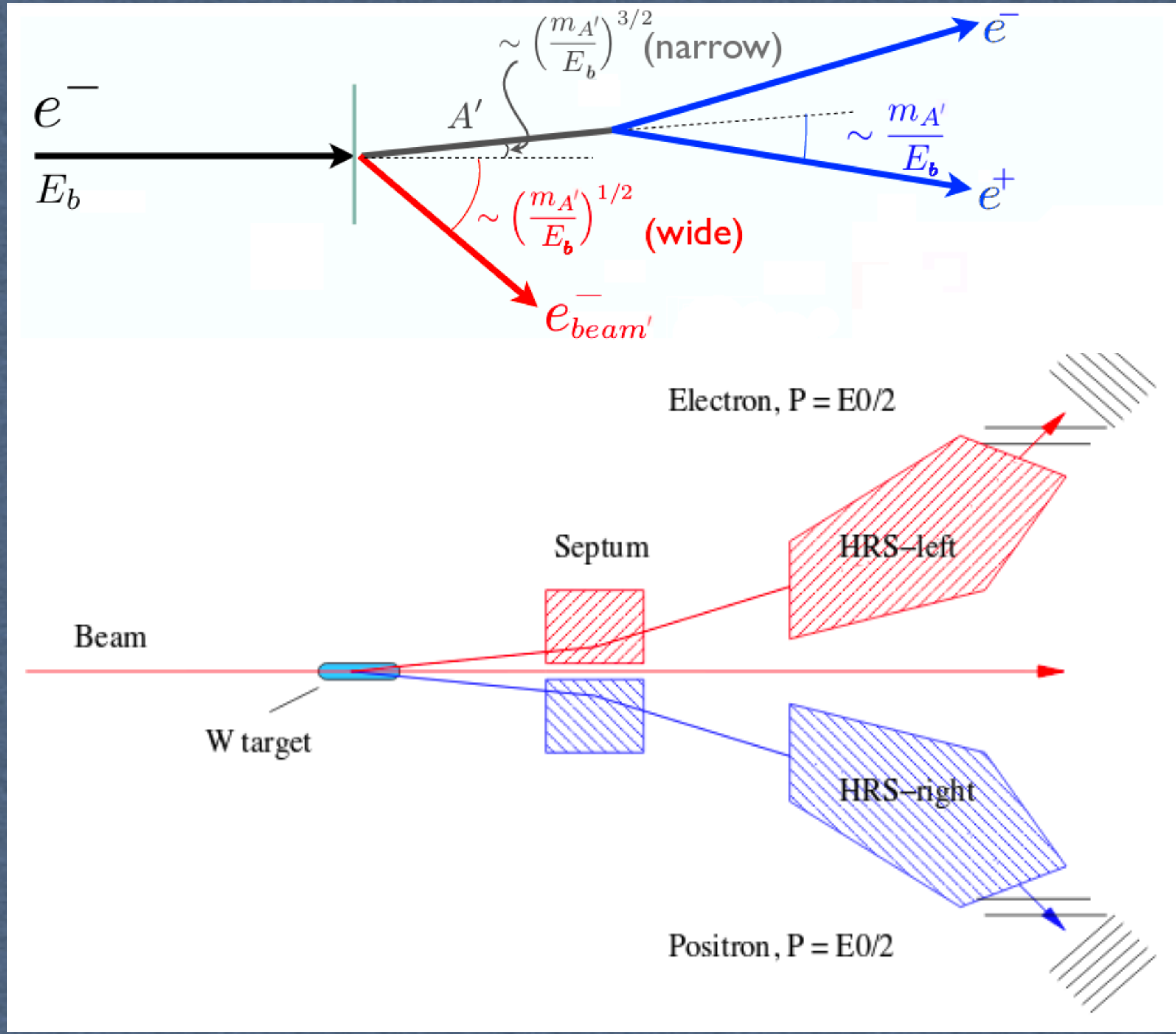


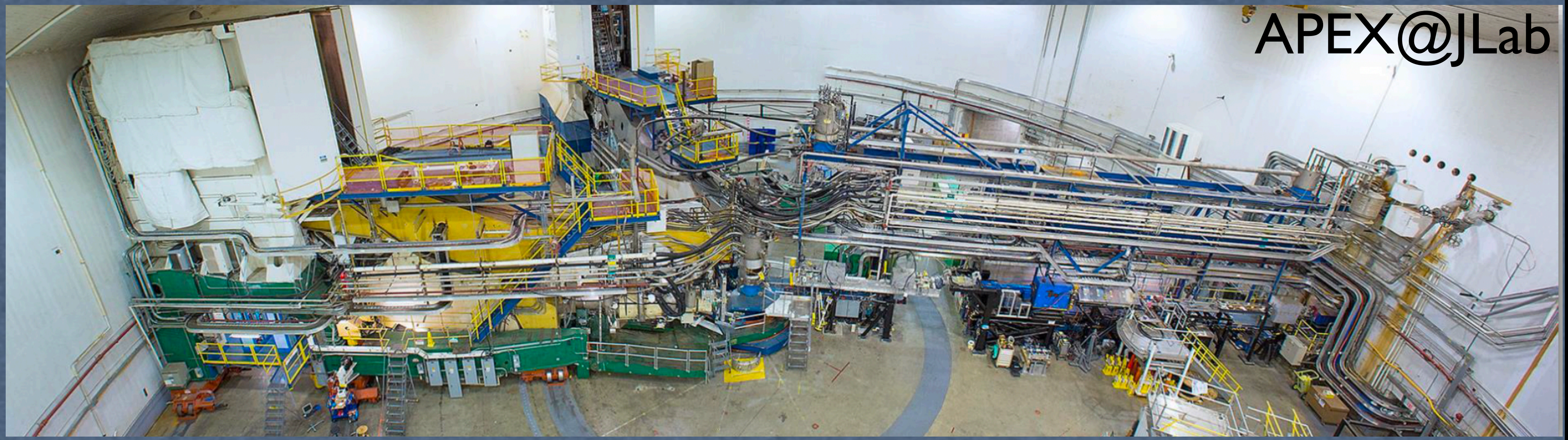


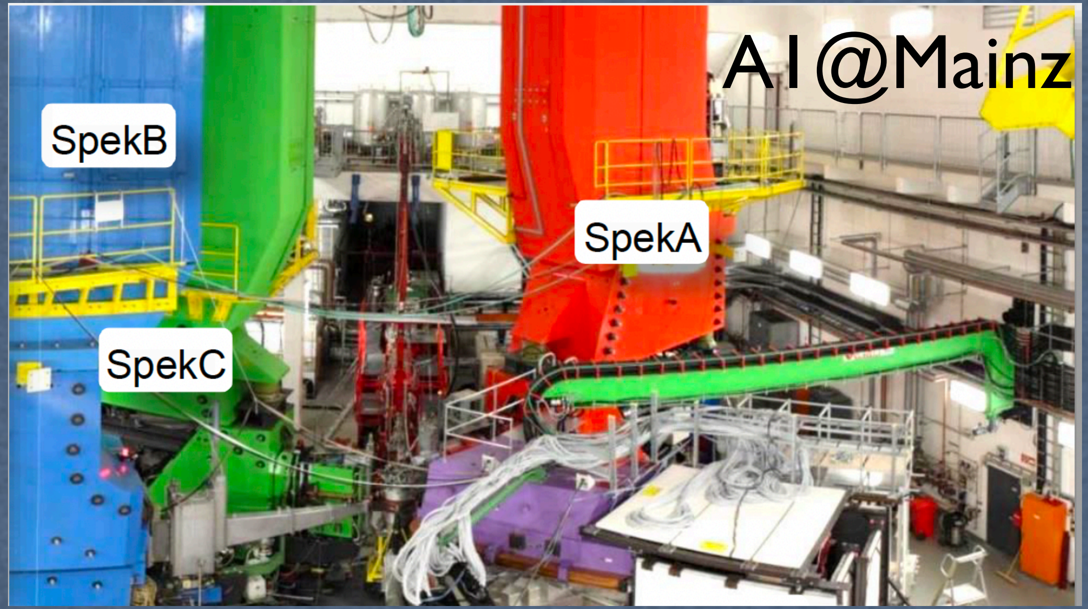
- Known and used
- Collider (missing mass experiments)
- Thin target experiments (visible decay)

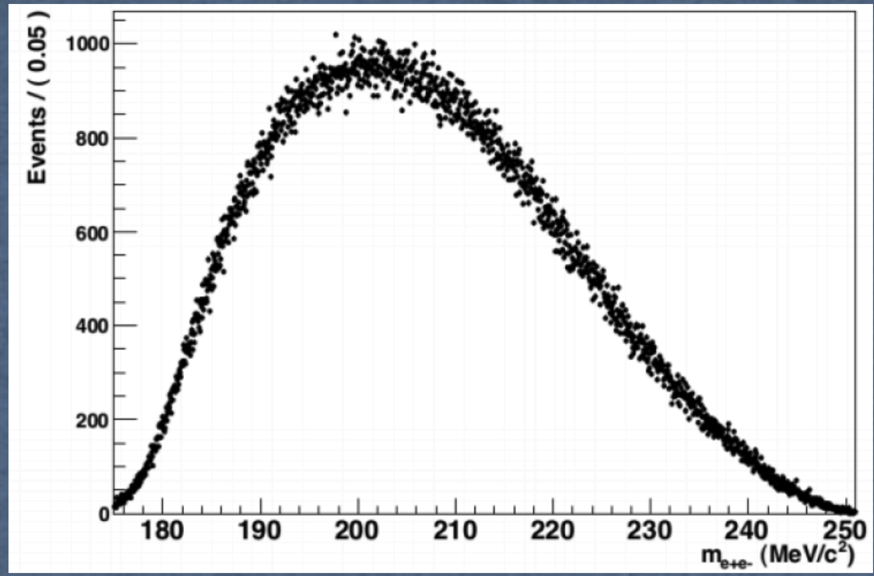
e+e- → γ’ γ → μμ γ
➜ BABAR, BELLE, KLOE, CLEO

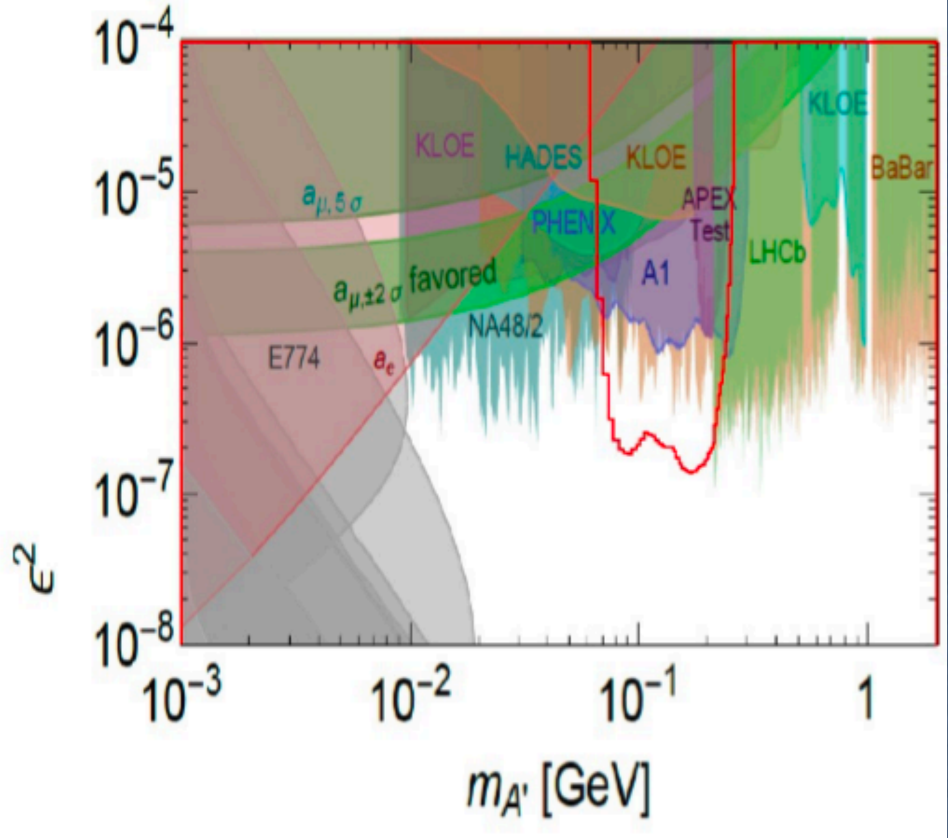
APEX@JLab and A1@Mainz





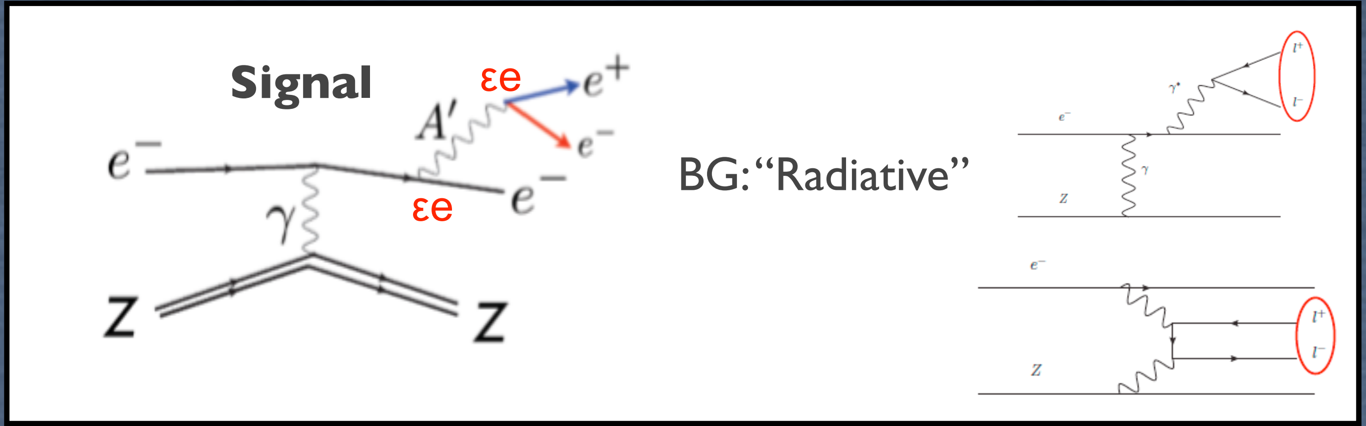


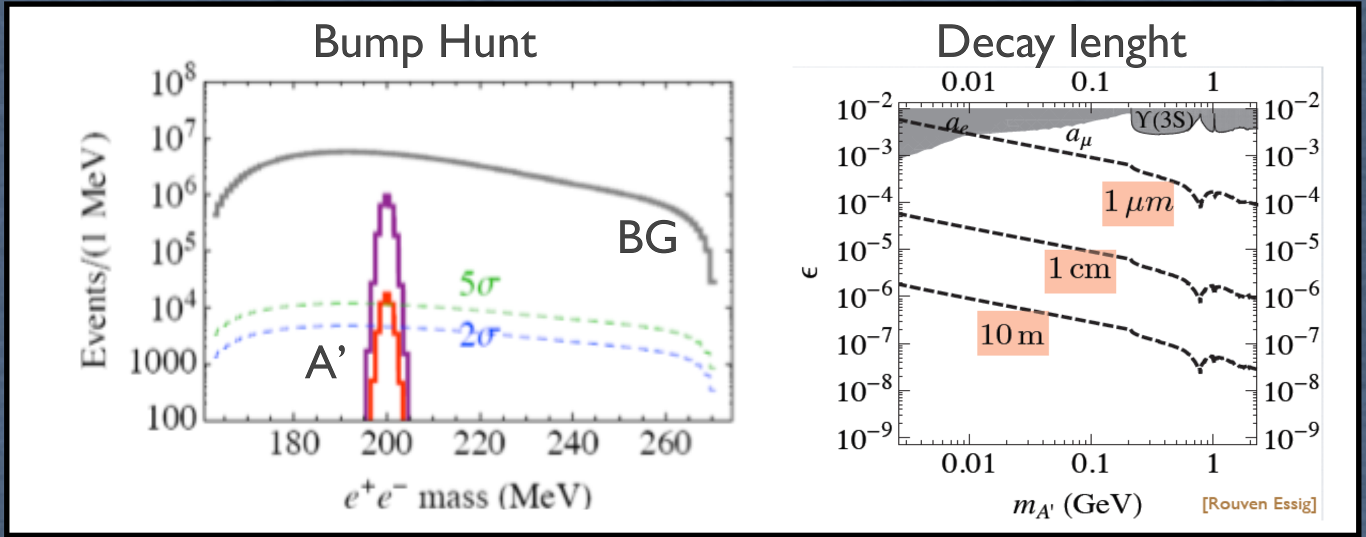


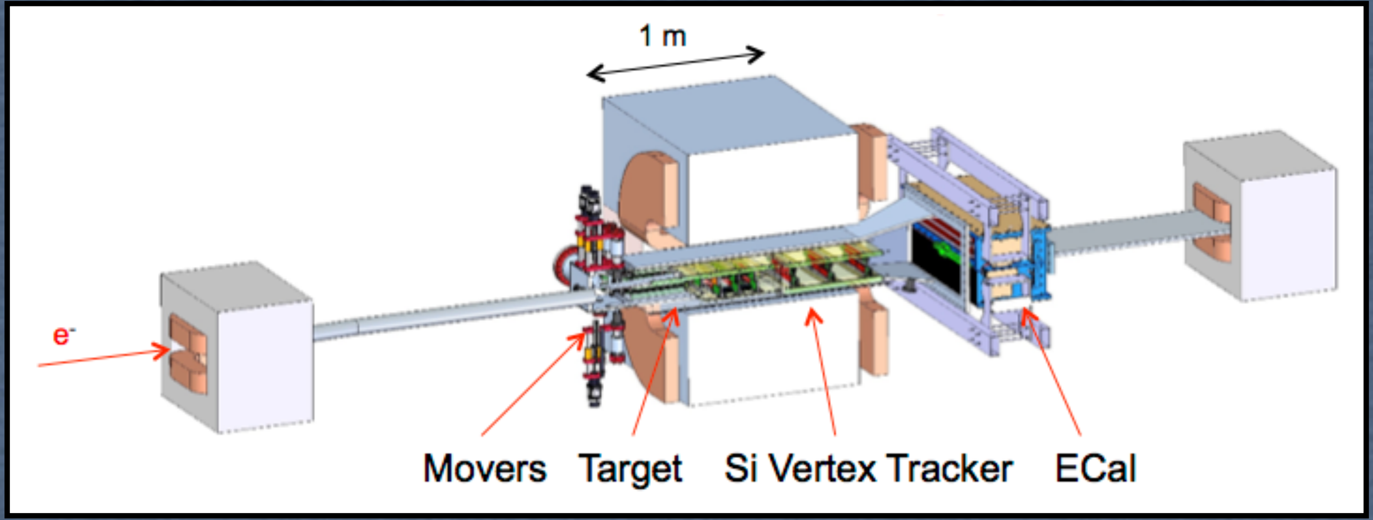


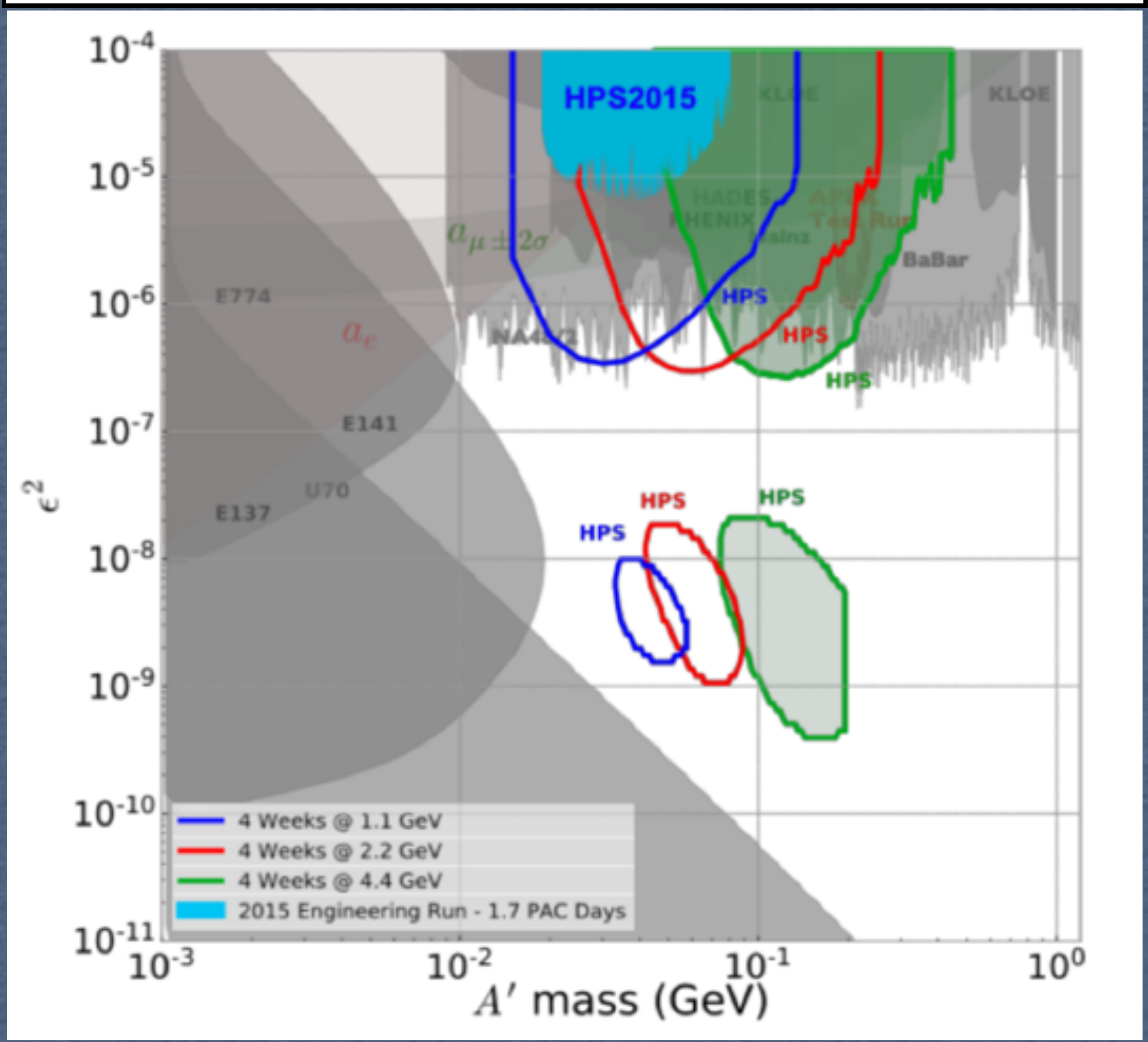
- Dark photon searched as a narrow resonance in e+e- mass over a smooth QED background
- Two High Resolution Spectrometers (HRSs) in coincidence to measure events with an e- in one arm and e+ in the other

Heavy Photon Search @n JLab
visible decay









1) Bump Hunting (BH)
Narrow e+e-resonance over a QED background
➥ good mass resolution: $\sigma_{A'mass}$~1 MeV

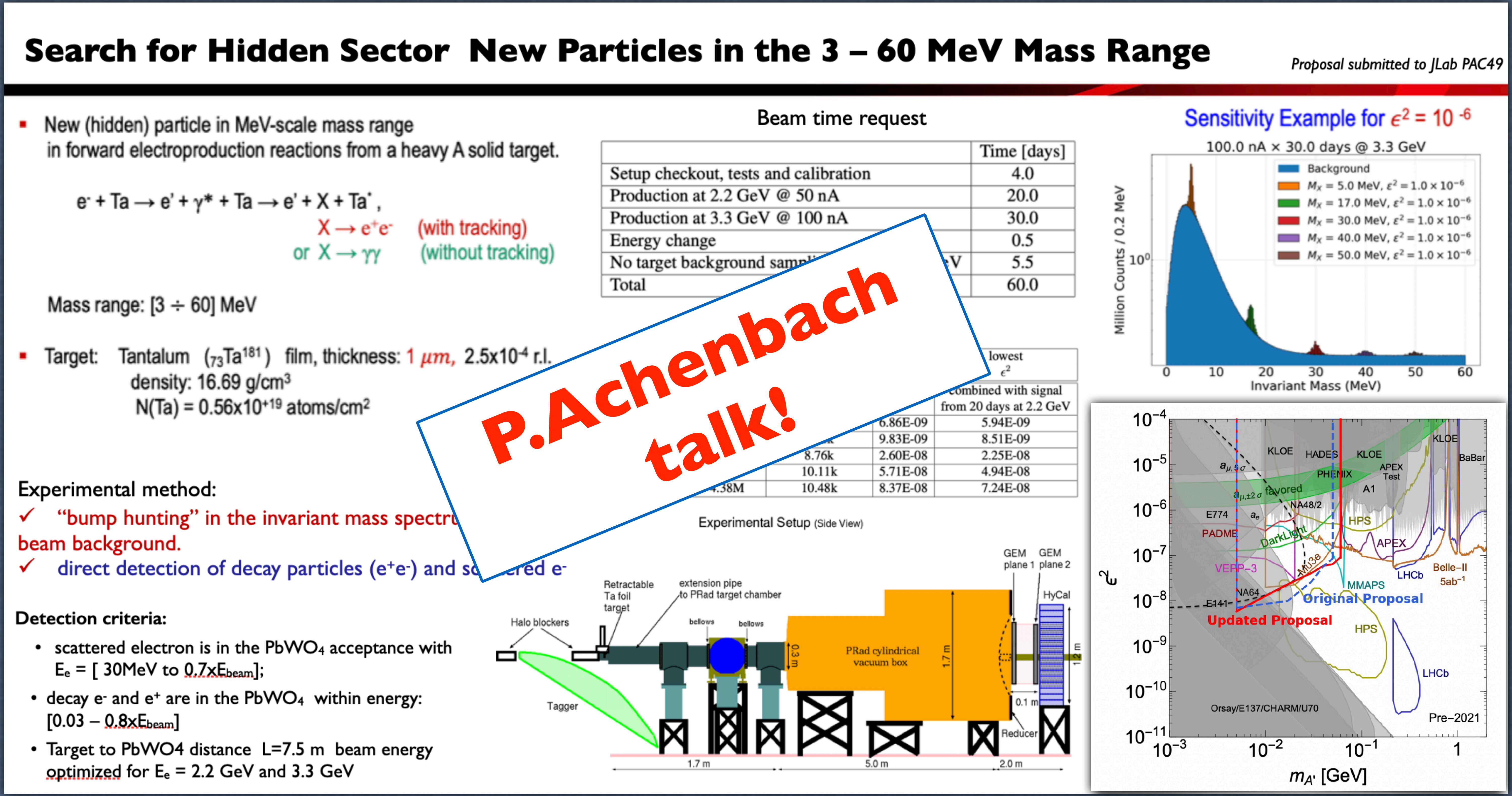
2) Secondary decay vertex (vertexing)
Detached vertex from few mm to tens cm
➥ good spacial resolution: σ_{vertex}~1mm

Heavy photon signatures in HPS

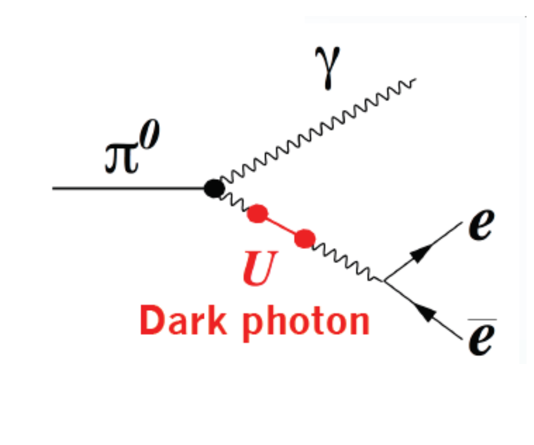
BH + Vertexing = enhanced experimental reach

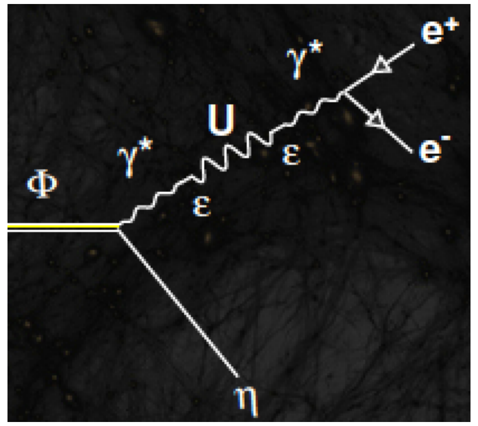
X17 search at JLab

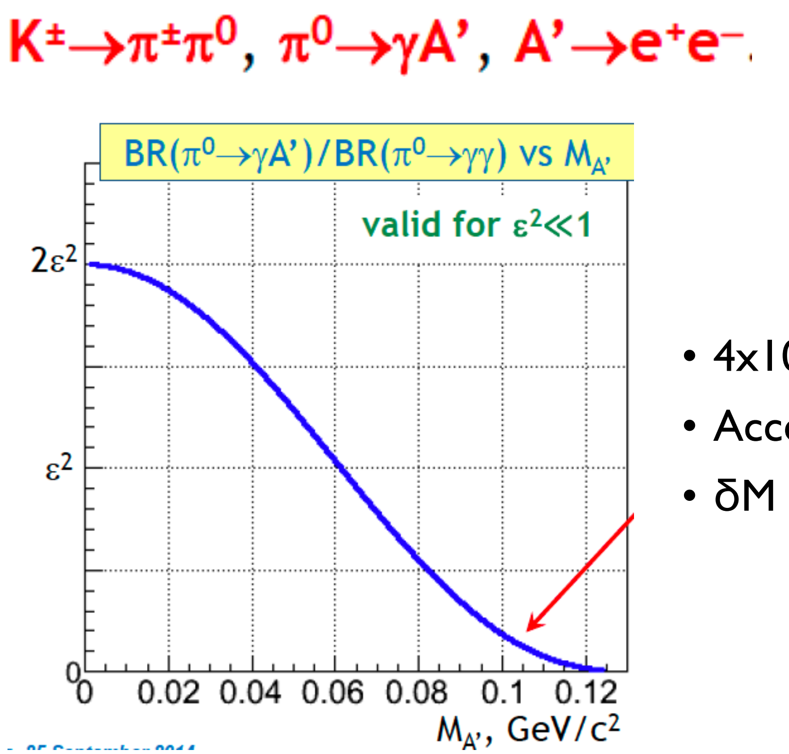
- Search for the X17 in e+e- invariant mass
- Presented to JLab PAC 49 in Aug 21 and granted a C2 approval
- Presented to JLab PAC 50 in Aug 2022 and granted A rate (full approval)
- Scheduled to run soon



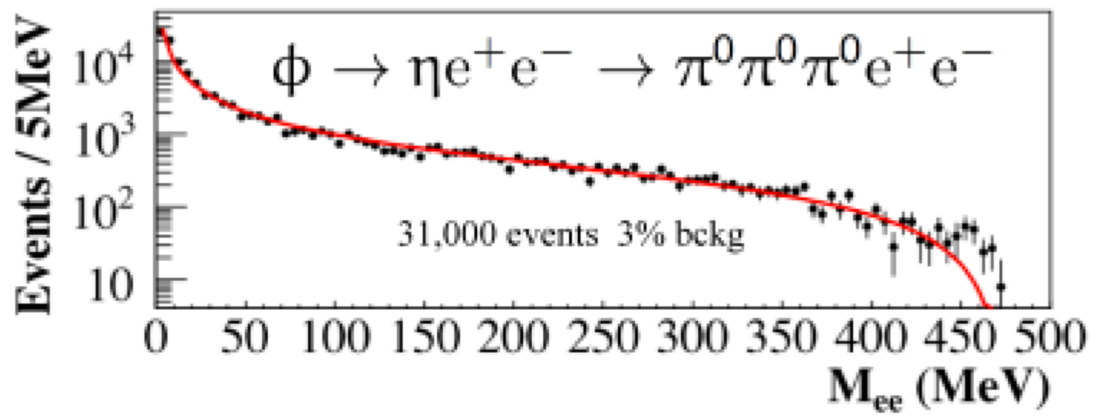
Meson Decay
- visible -

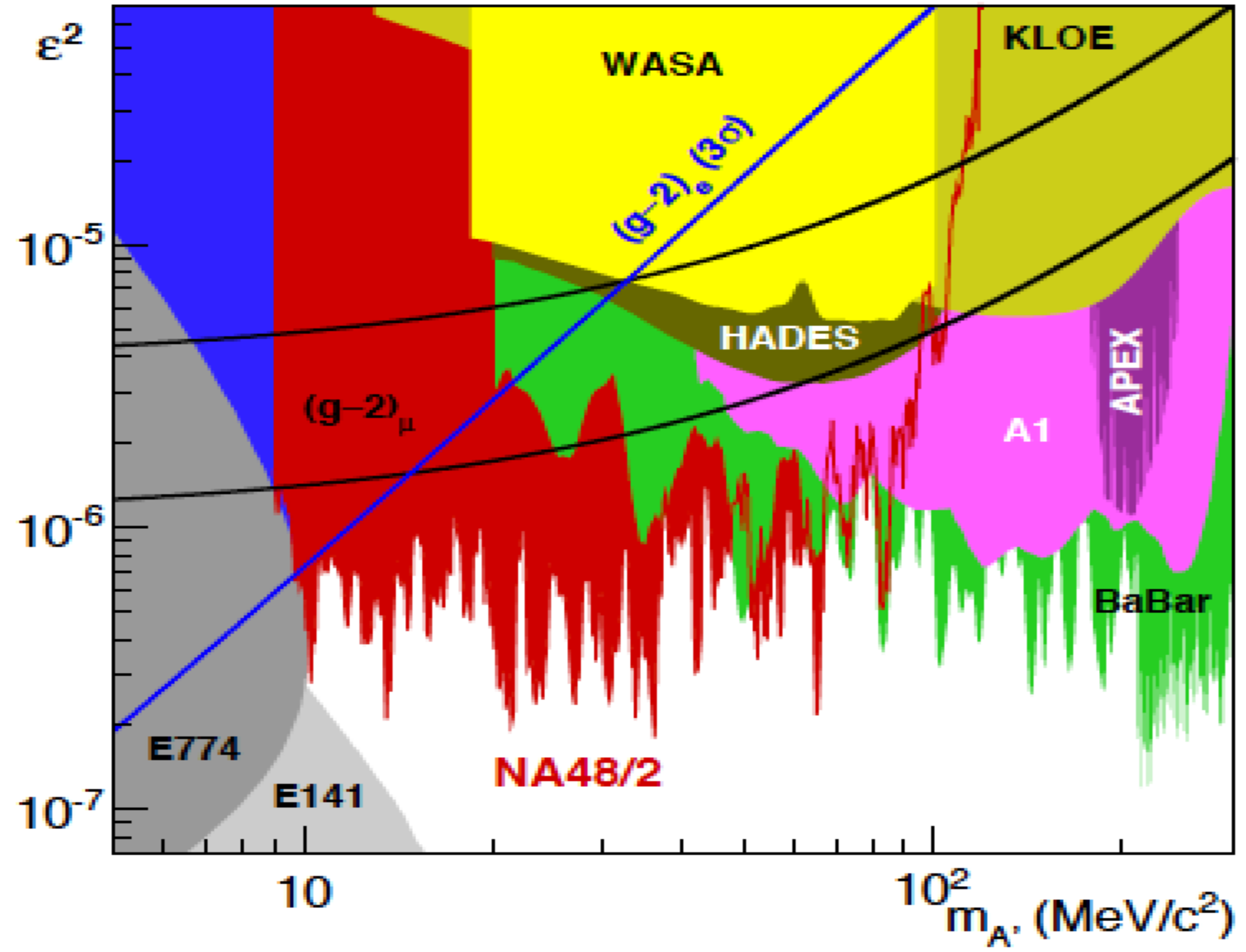






- 4×10^{10} π^0
- Acceptance ~ 2.5%
- δM ~ 1% Mee





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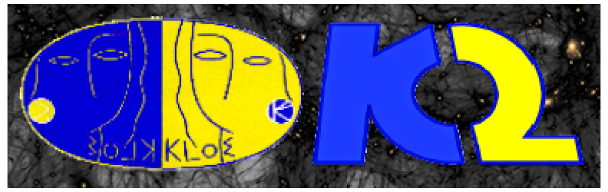
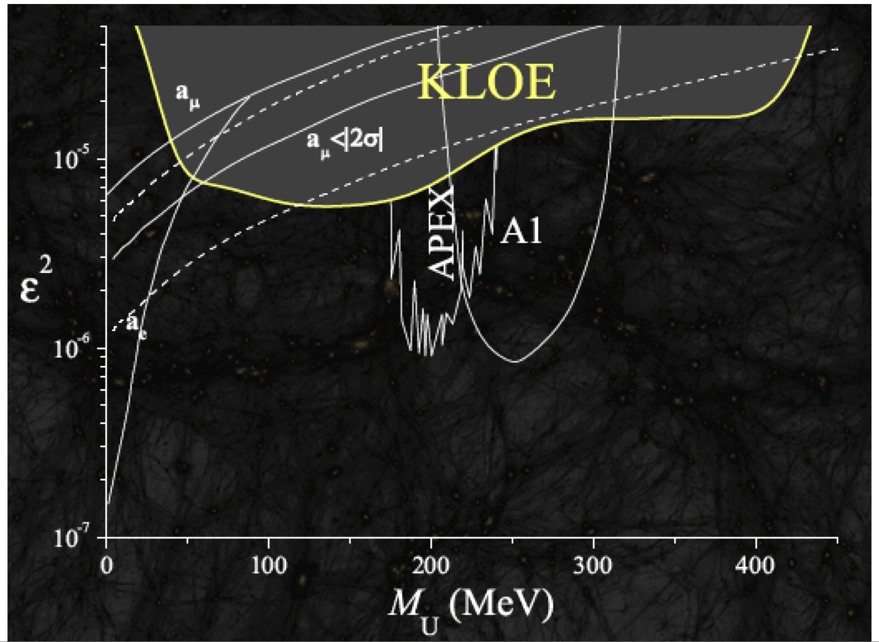
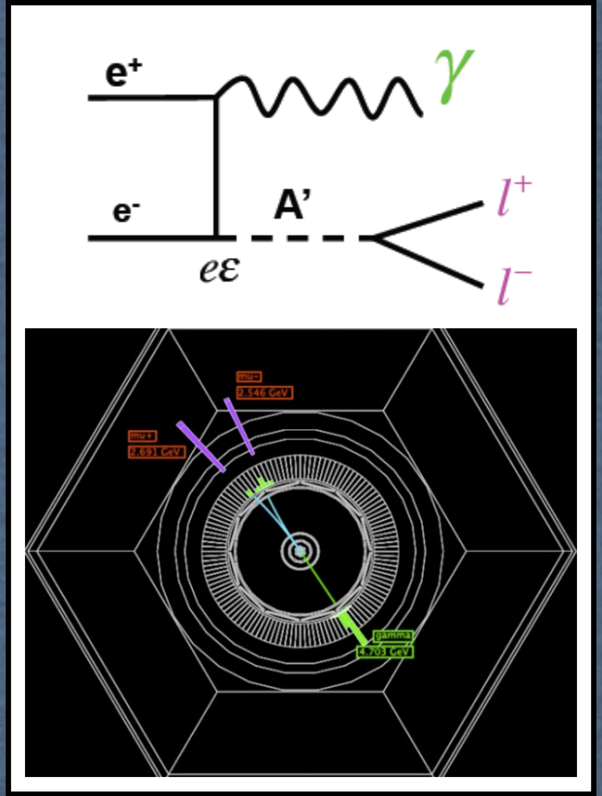
J.R.Batley et al.
Arxiv: 1504.00607



Phys. Lett. B 706 (2012) 251
Phys. Lett. B720 (2013) 111



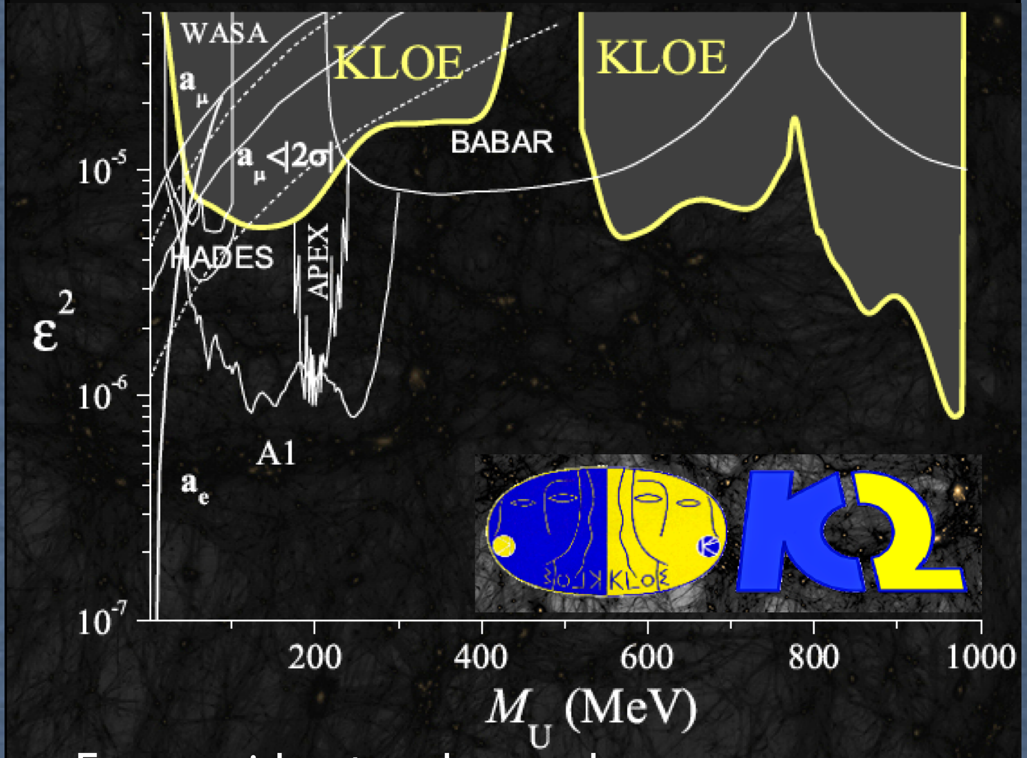
e+e- Colliders
- visible -



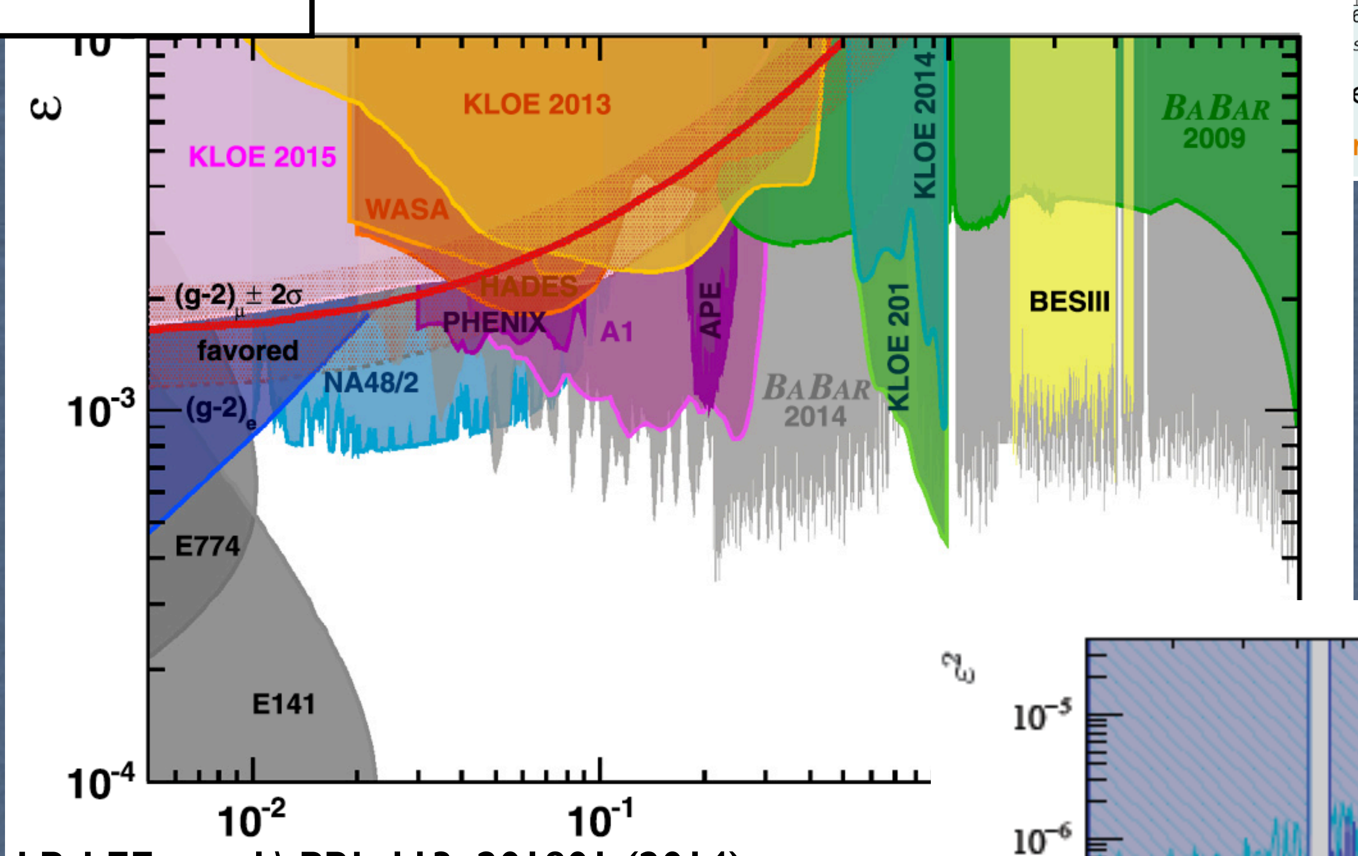
BABAR

- 1gamma + 2 opposite leptons
- Di-lepton mass fit to a bg
- Mass resolution: 1.5 MeV - 8 MeV
- Int (L) = 514 fb^{-1}

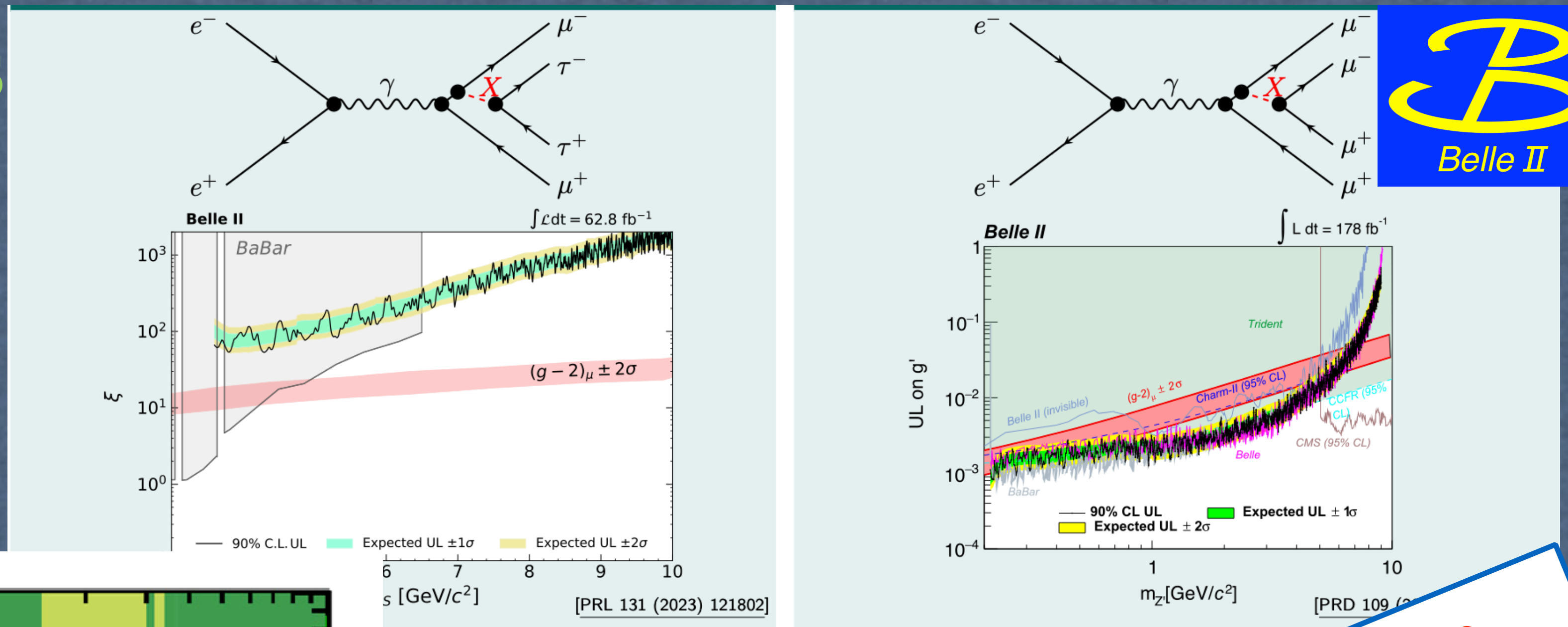
Phys. Lett. B 736 (2014) 459



- Events with μ+μ- detected
- L~ 240 pb^{-1}



J.P. LEEs et al.\ PRL 113, 201801 (2014)



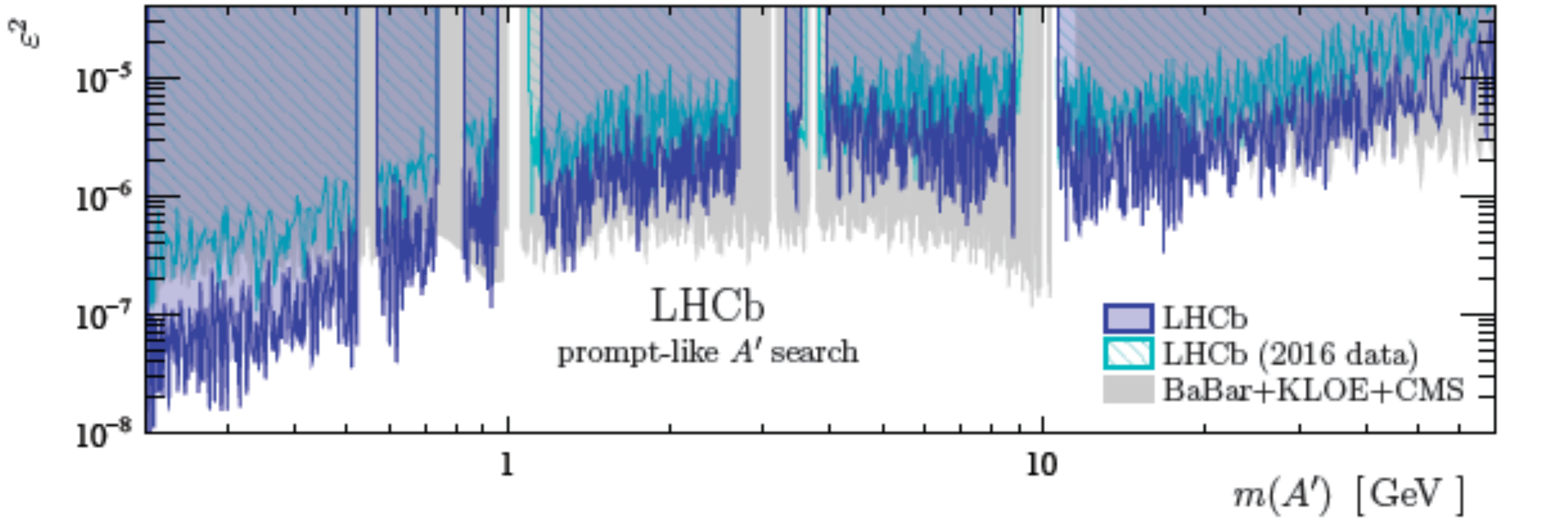
ed above 6.5 GeV/c^2

r ALPs

- Exclude Z' and muophilic scalar
- $(g-2)_\mu$ over wide mass

Belle II

S.Wallner talk!

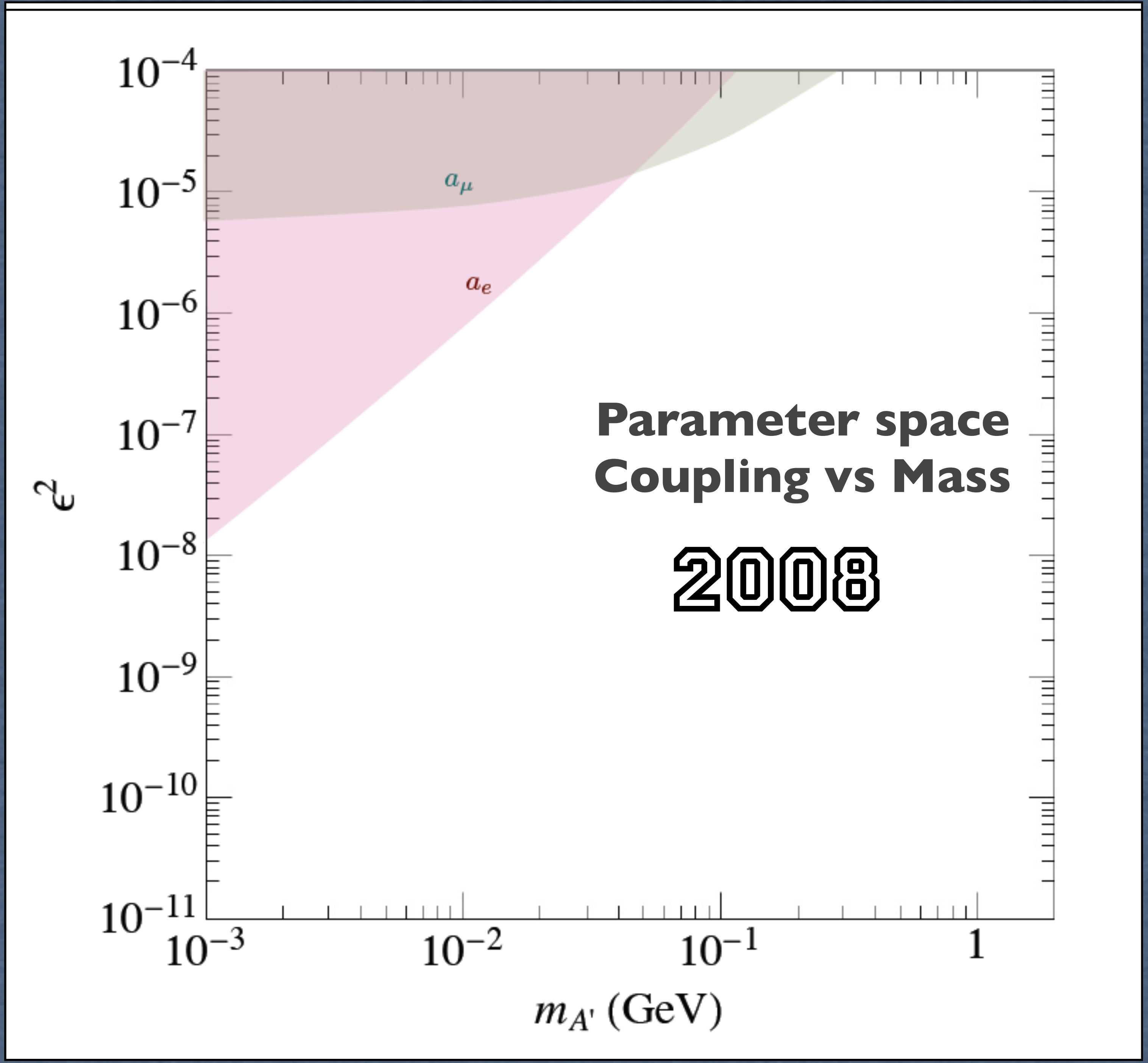


BESIII

Hunting for A' at accelerators
visible decay

Fixed target: e N →N γ'→ N Lepton⁻ Lepton⁺
→ **JLAB, MAINZ**
Fixed target: p N →N γ'→ p Lepton⁻ Lepton⁺
→ **FERMILAB, SERPUKHOV**
Annihilation: e+e- → γ' γ → μμ γ
→ **BABAR,BELLE,KLOE**
Meson decays: π^0, η, η', ω,' → γ' γ → Lepton⁻ Lepton⁺ γ
→ **KLOE, BES3, NA48, HC**

coupling vs mass



Hunting for A' at accelerators
visible decay

Fixed target: e N →N γ'→ N Lepton⁻ Lepton⁺
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Fixed target: p N →N γ'→ p Lepton⁻ Lepton⁺
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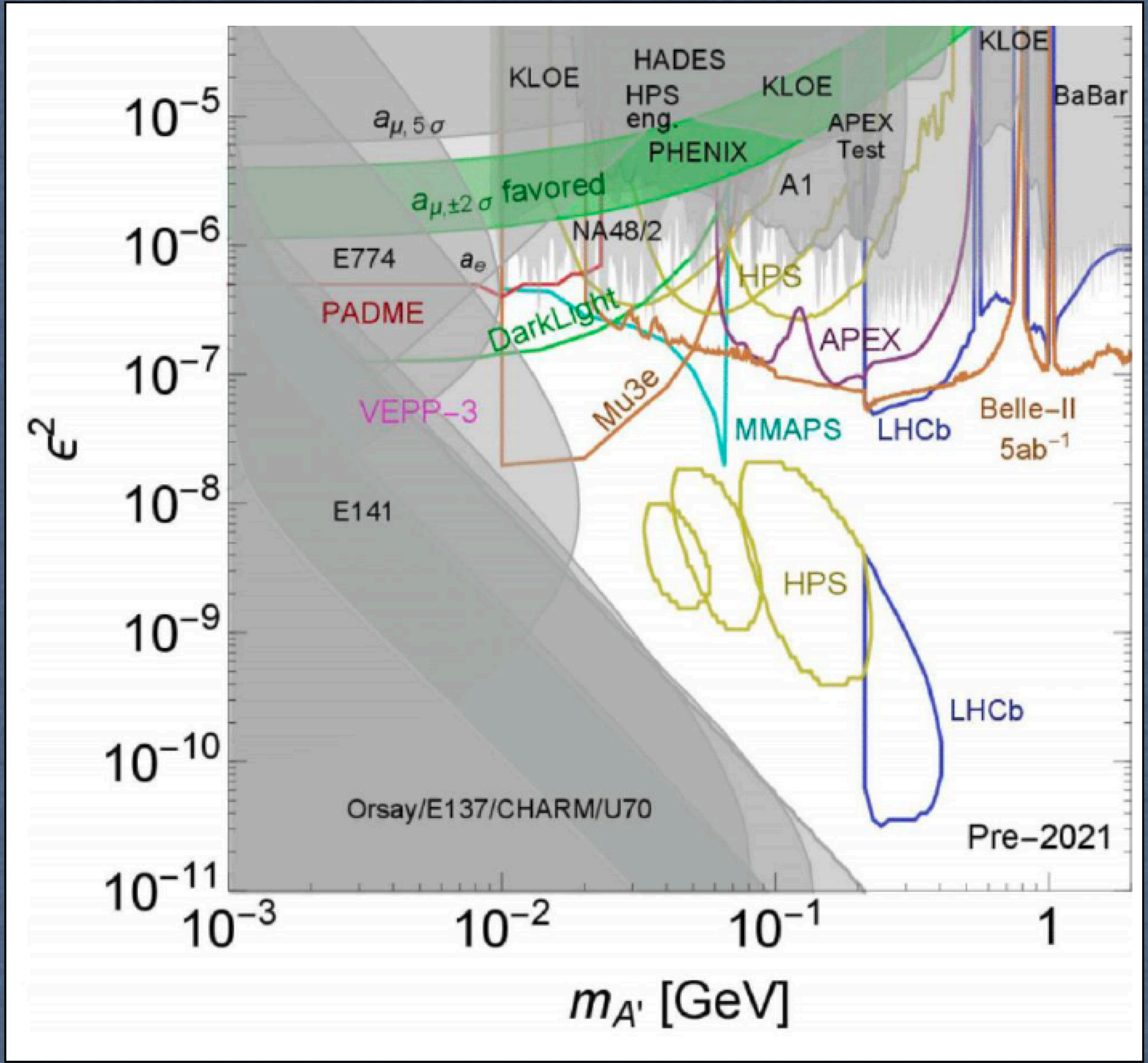
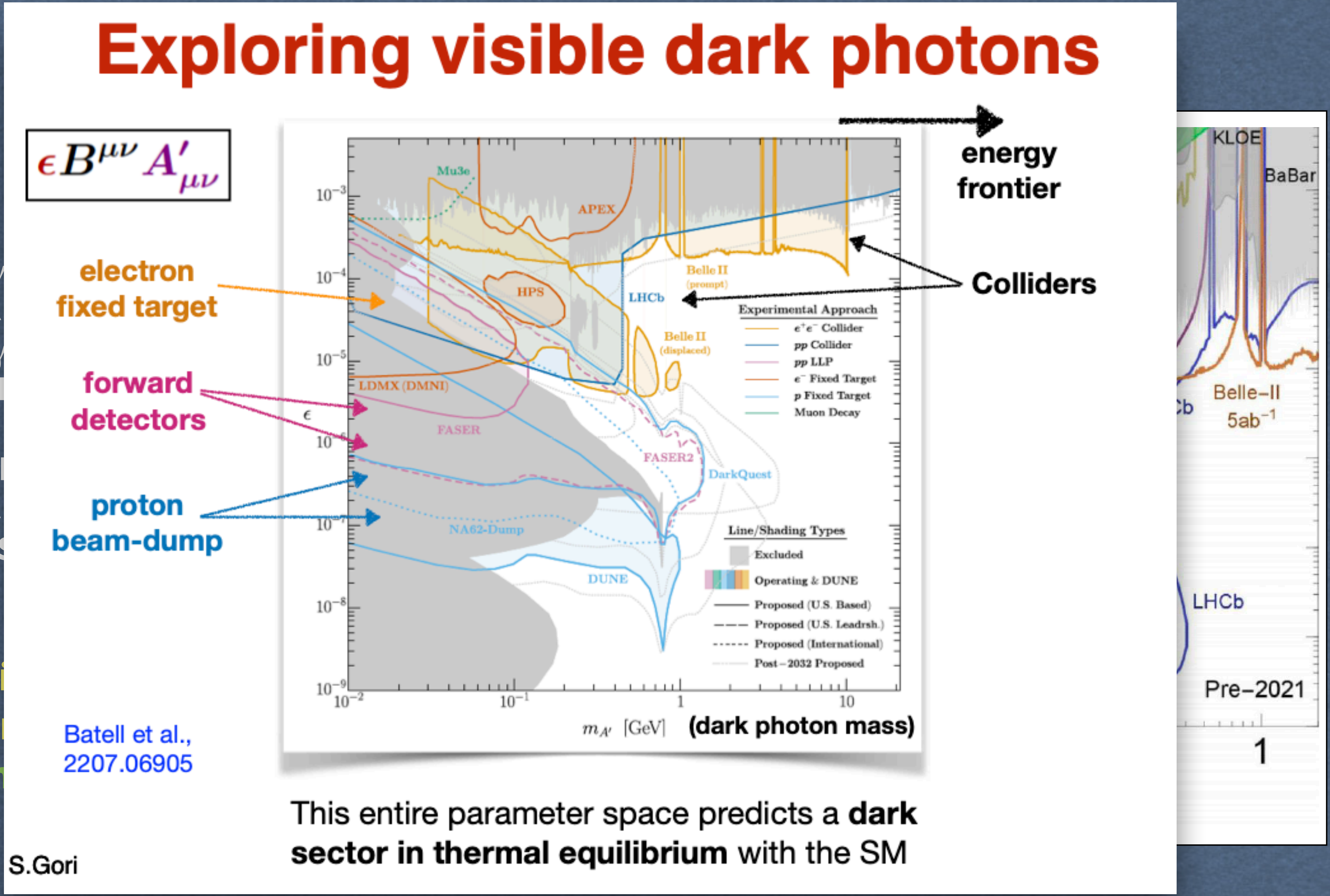
Annihilation: e+e- → γ' γ → μμ γ
→ **BABAR,BELLE,KLOE**
Meson decays: π^0, η, η', ω,' → γ' γ → Lepton⁻ Lepton⁺ γ
→ **KLOE, BES3, NA48, HC**



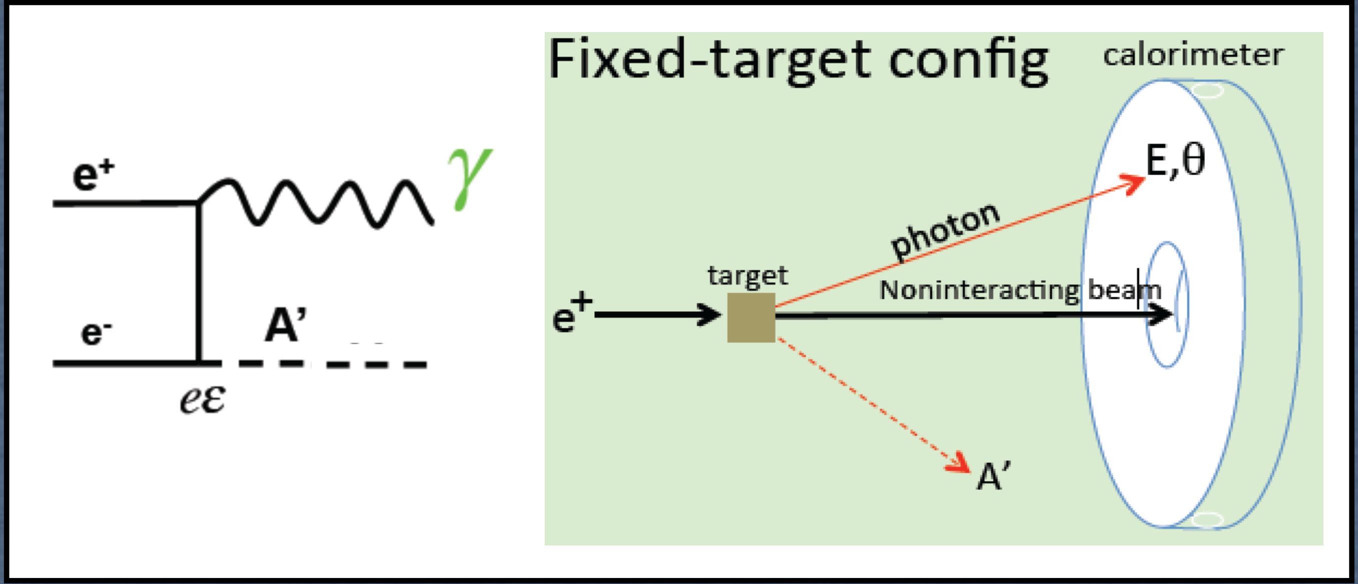
No positive signal (so far) but limits in parameter space
coupling vs mass

Fixed target: e N →N γ
→ JLAB, MA
Fixed target: p N →N γ
→ FERMILA
Annihilation: e+e- → γ'
→ BABAR,BE
Meson decays: π^0, η, η',
→ KLOE, BES

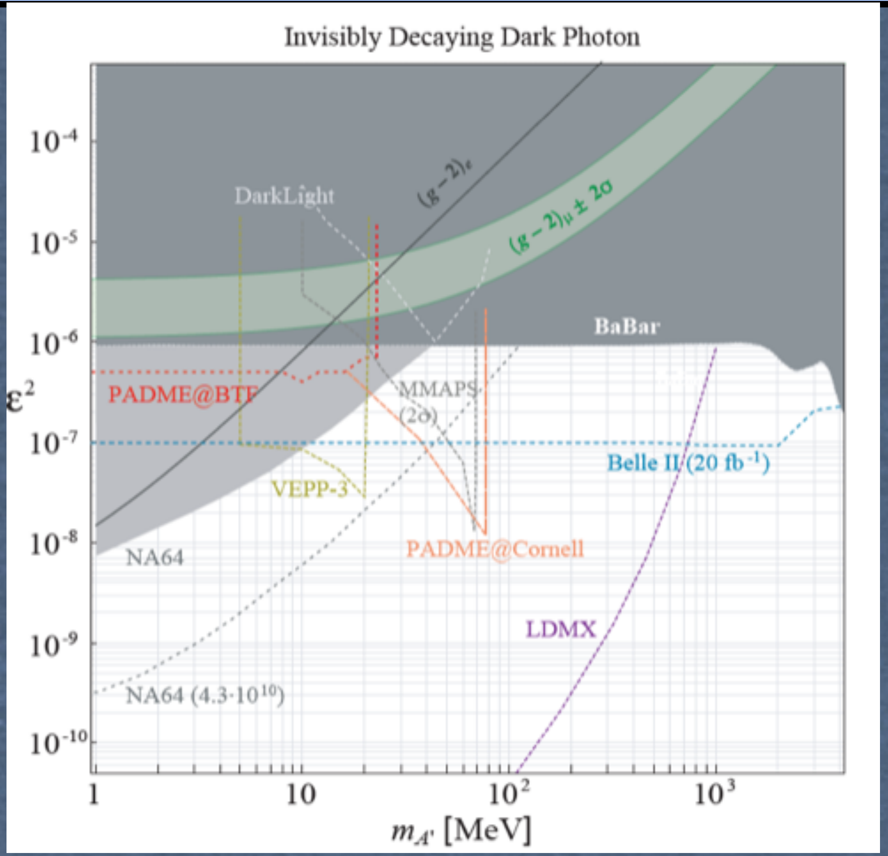


No positive si
limits in par
couplin

e+ annihilation on fixed (thin) target - invisible -

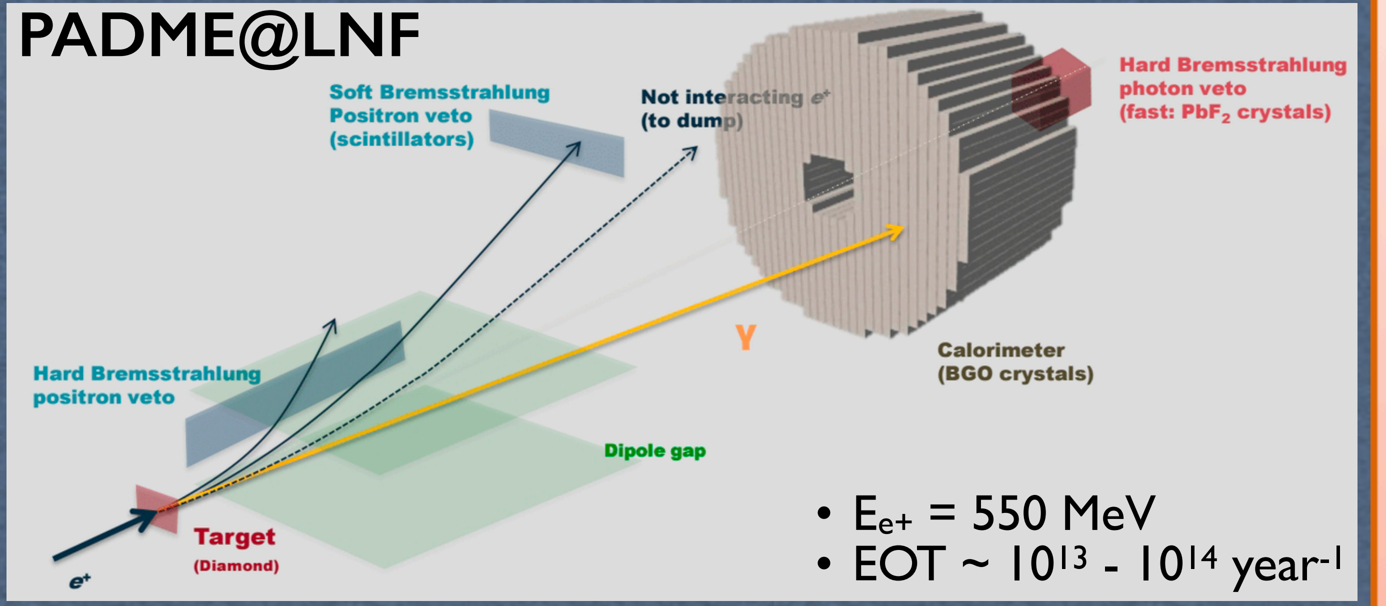


Missing mass search:
- Independent of A' decay mechanism
- Bump hunt (monophoton@collider)
- Need a positron beam
- Limited $M_{A'}$ accessible
  - 1 GeV beam: $M_{A'} < 31$ MeV
  - 5 GeV beam: $M_{A'} < 71$ MeV
  - 11GeV beam: $M_{A'} < 106$ MeV



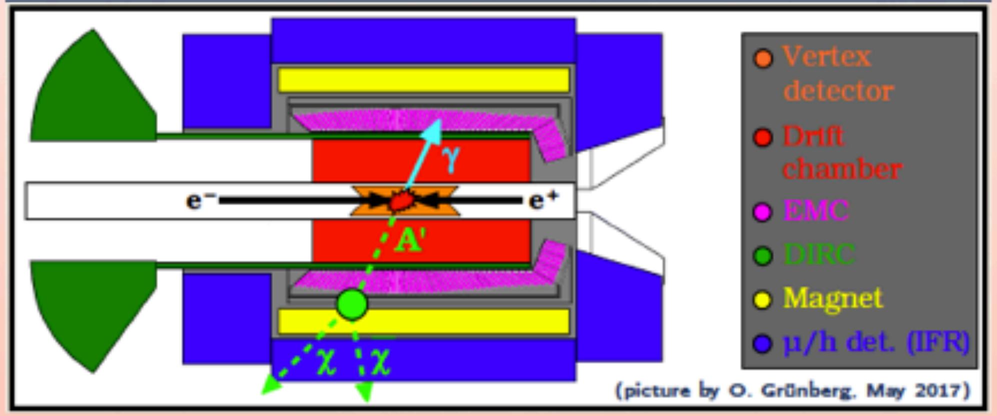
- **Novosibirsk**
- **LNF**
- **Cornell**
- **Jefferson Lab**

PADME@LNF

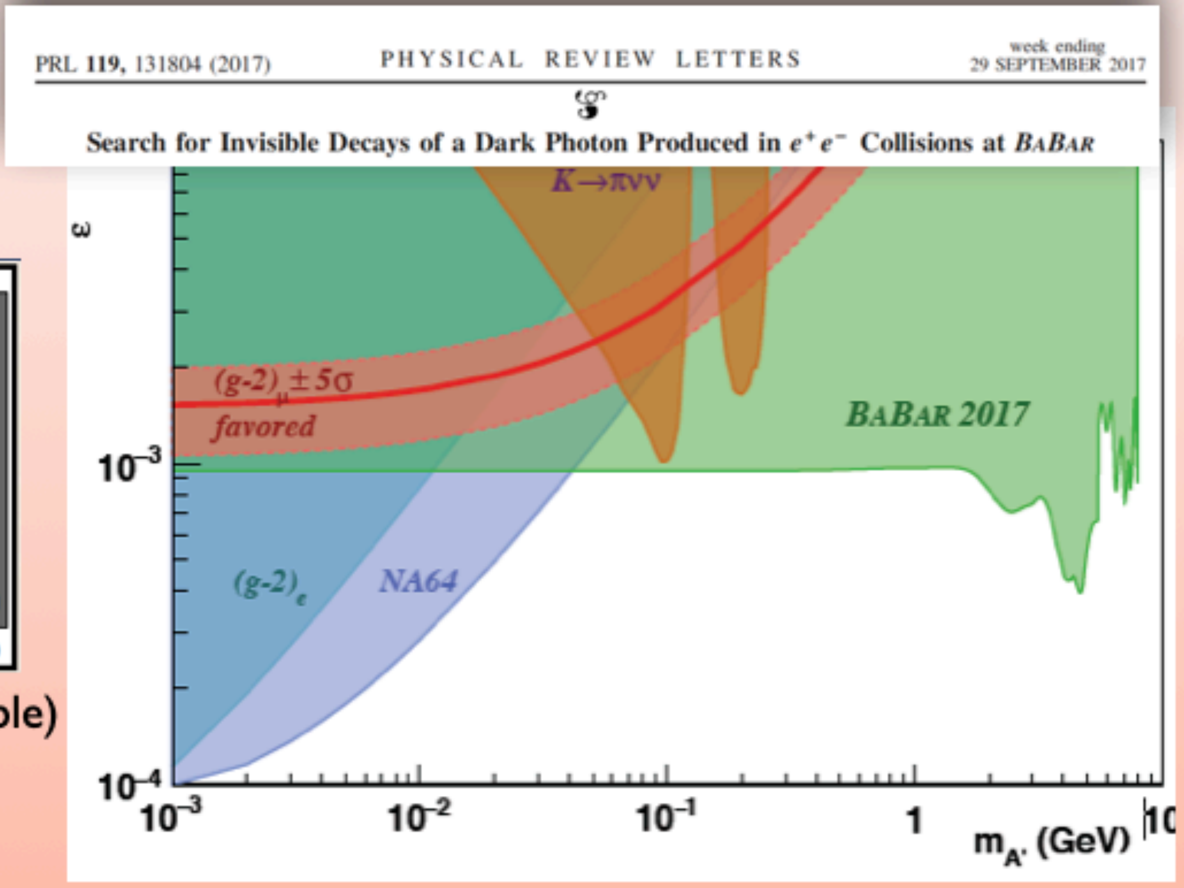


- E_{e+} = 550 MeV
- EOT ~ 10^{13} - 10^{14} year^{-1}

Similar techniques at e+e- colliders
BaBar @ SLAC



- Missing mass exp (e- e+ → γ A' with A' → invisible)
- Mono-photon trigger
- Exclusion plots based on ~50 fb^{-1}



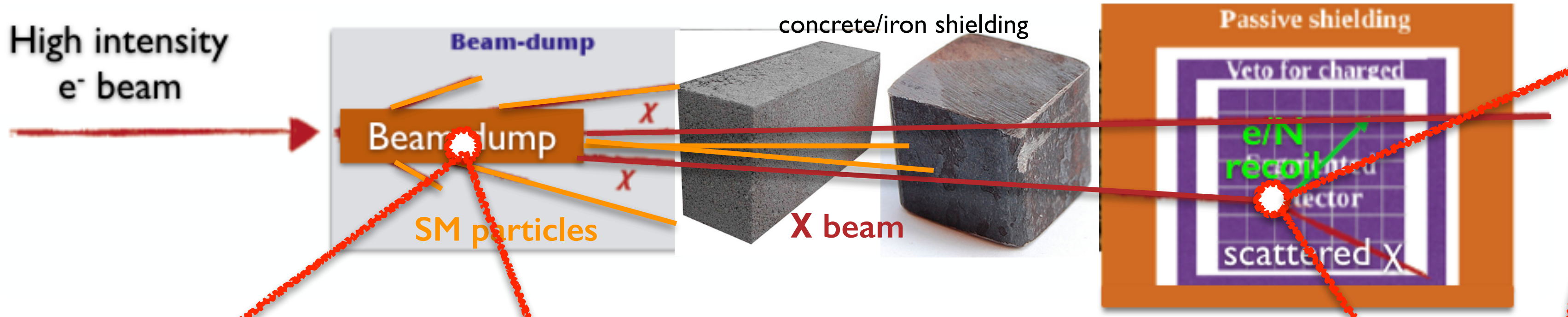
The BDX experiment

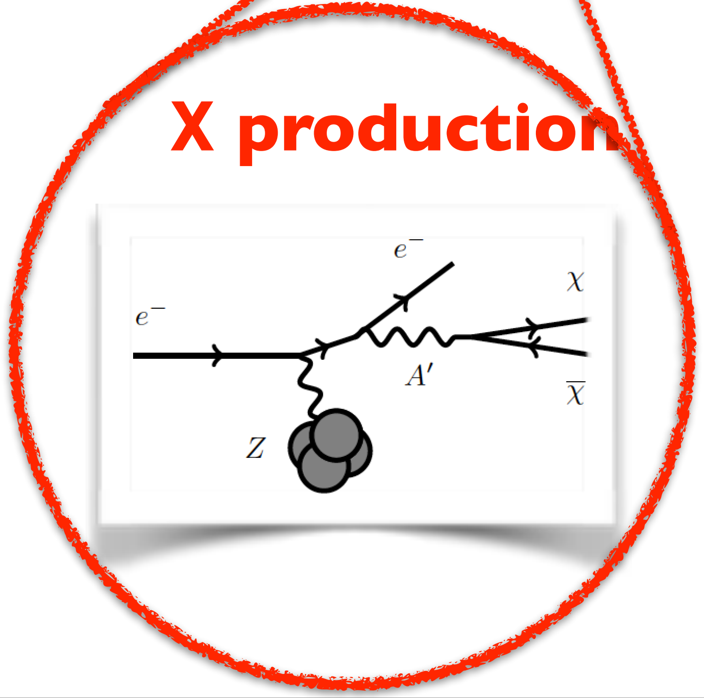
Two step process

I) An electron radiates an A' and the A' promptly decays to a χ (DM) pair

II) The χ (in-)elastically scatters on a e-/nucleon in the detector producing a visible recoil (GeV)

PhysRevD.88.114015 E.Izaguirre,G.Krnjaic, P.Schuster, N.Toro



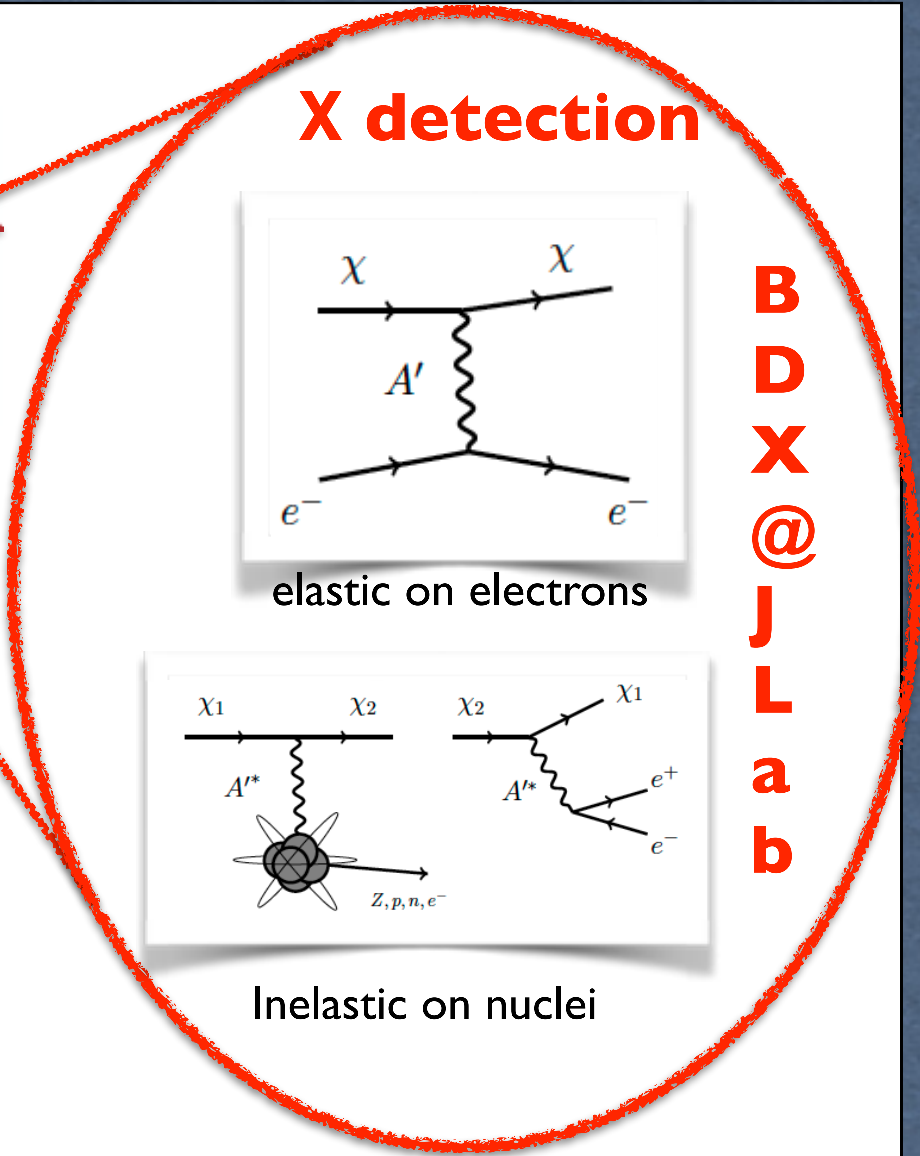


A' yield: $N_{A'} \propto \frac{\varepsilon^2}{m^2_{A'}}$

χ cross-section: $\sigma_{\chi e} \propto \frac{\alpha_D \varepsilon^2}{m^2_{A'}}$

Number of events: $N_\chi \propto \frac{\alpha_D \varepsilon^4}{m^4_{A'}}$

- **Intense electron beam**
- **~ few GeV range energy**



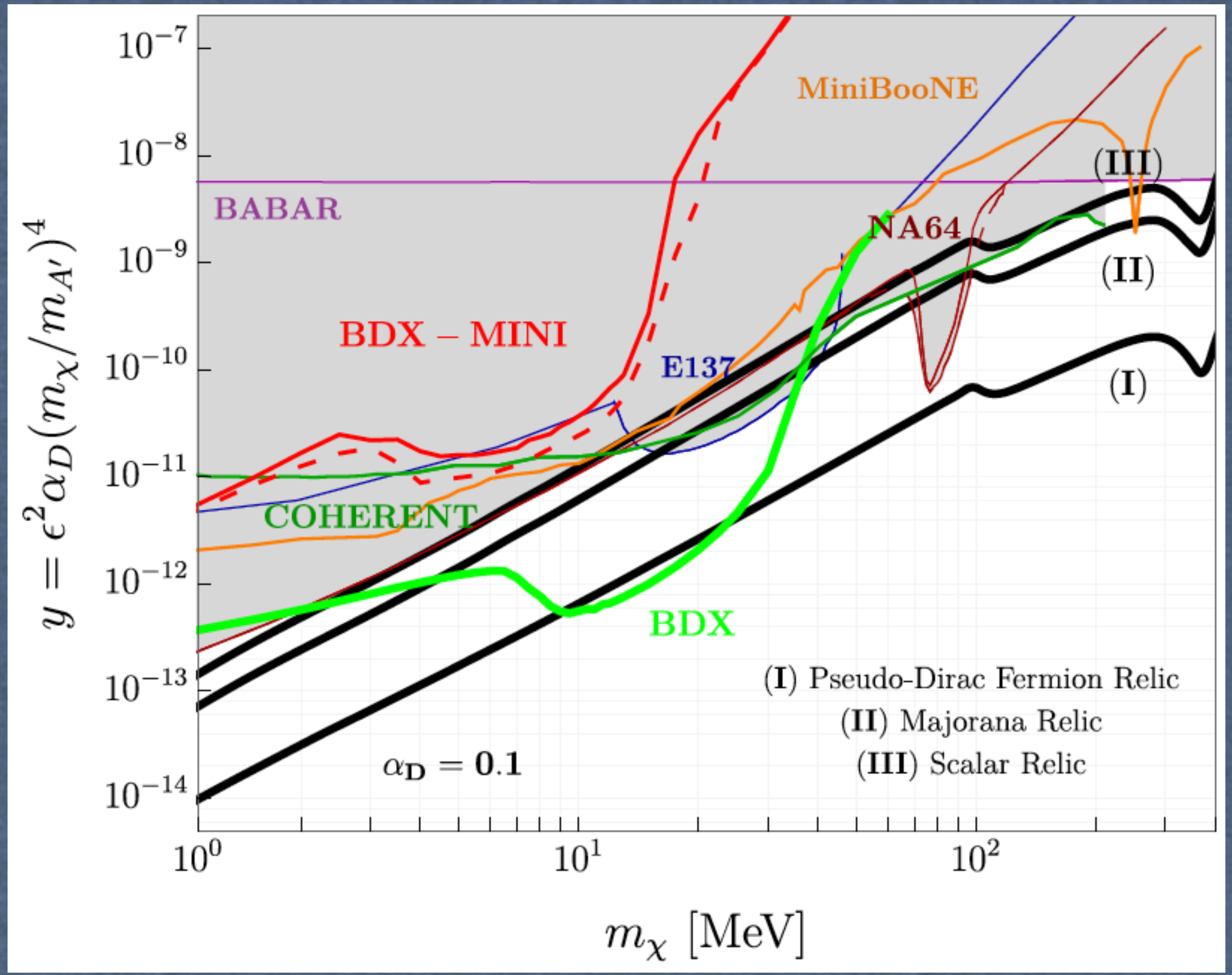
B D X @ J L a b

Experimental signature in the detector: **X-electron → EM shower ~GeV energy**

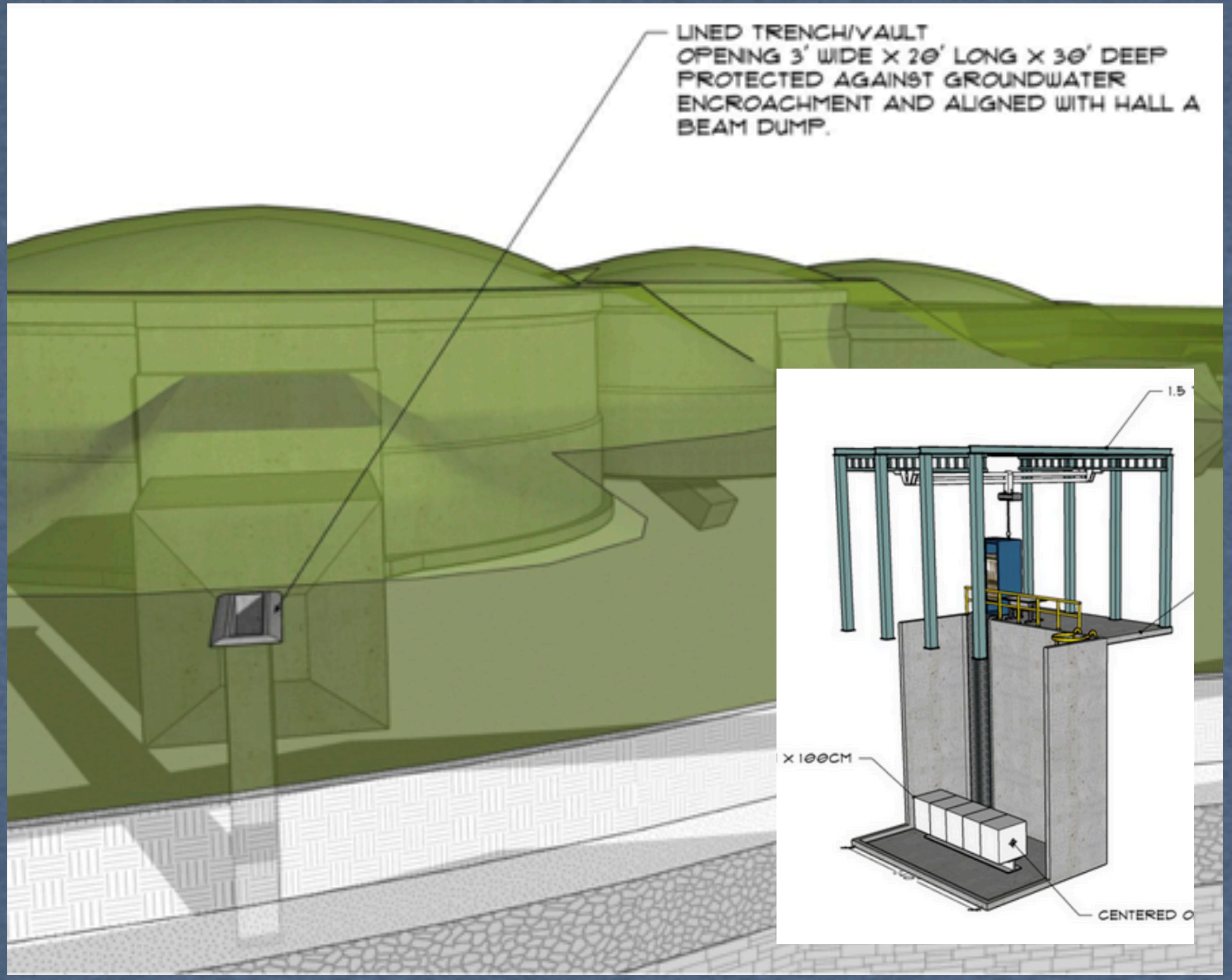
BDX @ JLab

Approved by JLab 2018 PAC with max rate (A)

Waiting to be scheduled



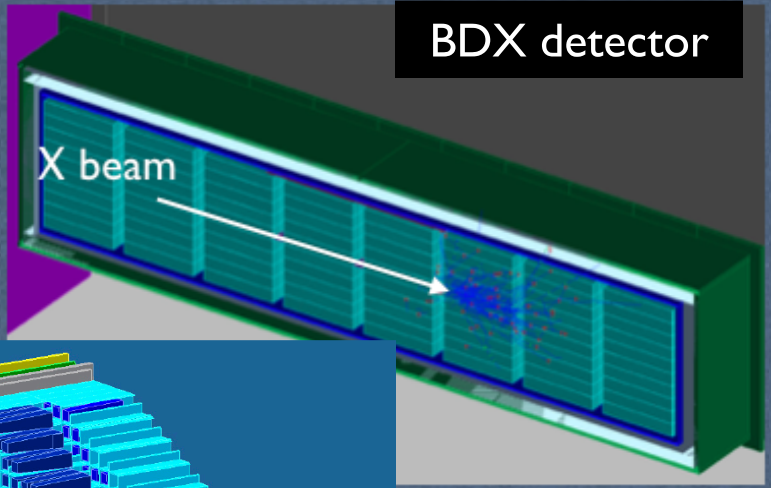
- High energy beam available: 11 GeV
- The highest available electron beam current: ~65 uA
- The highest integrated charge: 10^{22} EOT (41 weeks)
- Drilled shaft downstream of Hall-A BD
- BDX detector (recycling BaBar CsI and/or PANDA PbWO4 crystals)
- Expected to run in parallel to the Moeller experiment (2027-2030)



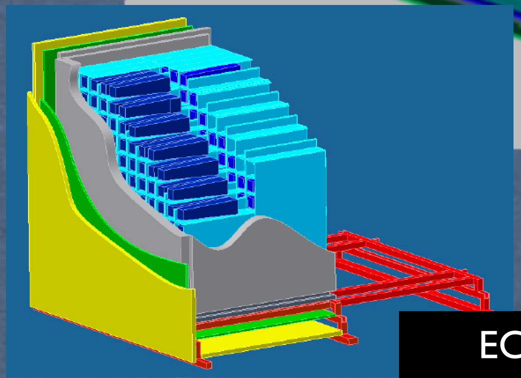
Accumulating 10^{22} EOT in ~2y BDX sensitivity is 10-100 times better than existing limits on LDM

BDX detector:
EMCalorimeter + Veto

- 4 modules 2x(20x20)crystals each
- 3200 PbWO4 crystals (repurposed)
- 1200 crystal from PRAD-II/JLab
- Negotiating with PANDA to loan ~3k ECal PbWO crystals
- 6x6 mm² Hamamatsu SiPM
- Veto: Plastic scintillator + WLS fibres



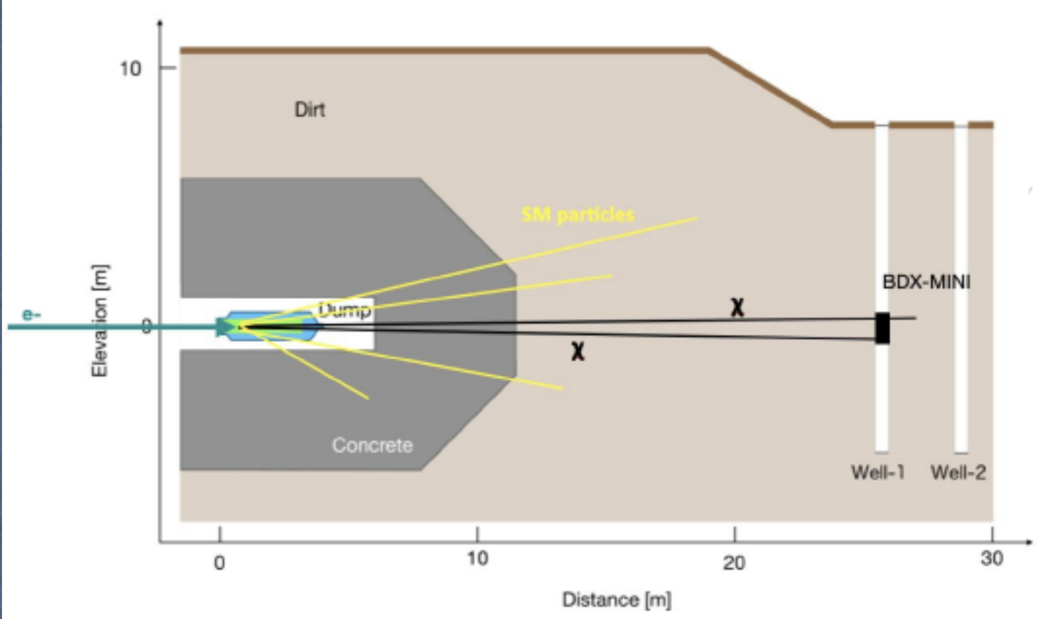
BDX detector


ECal module


BDX prototype to asses cosmic bg

BDX-MINI @JLab

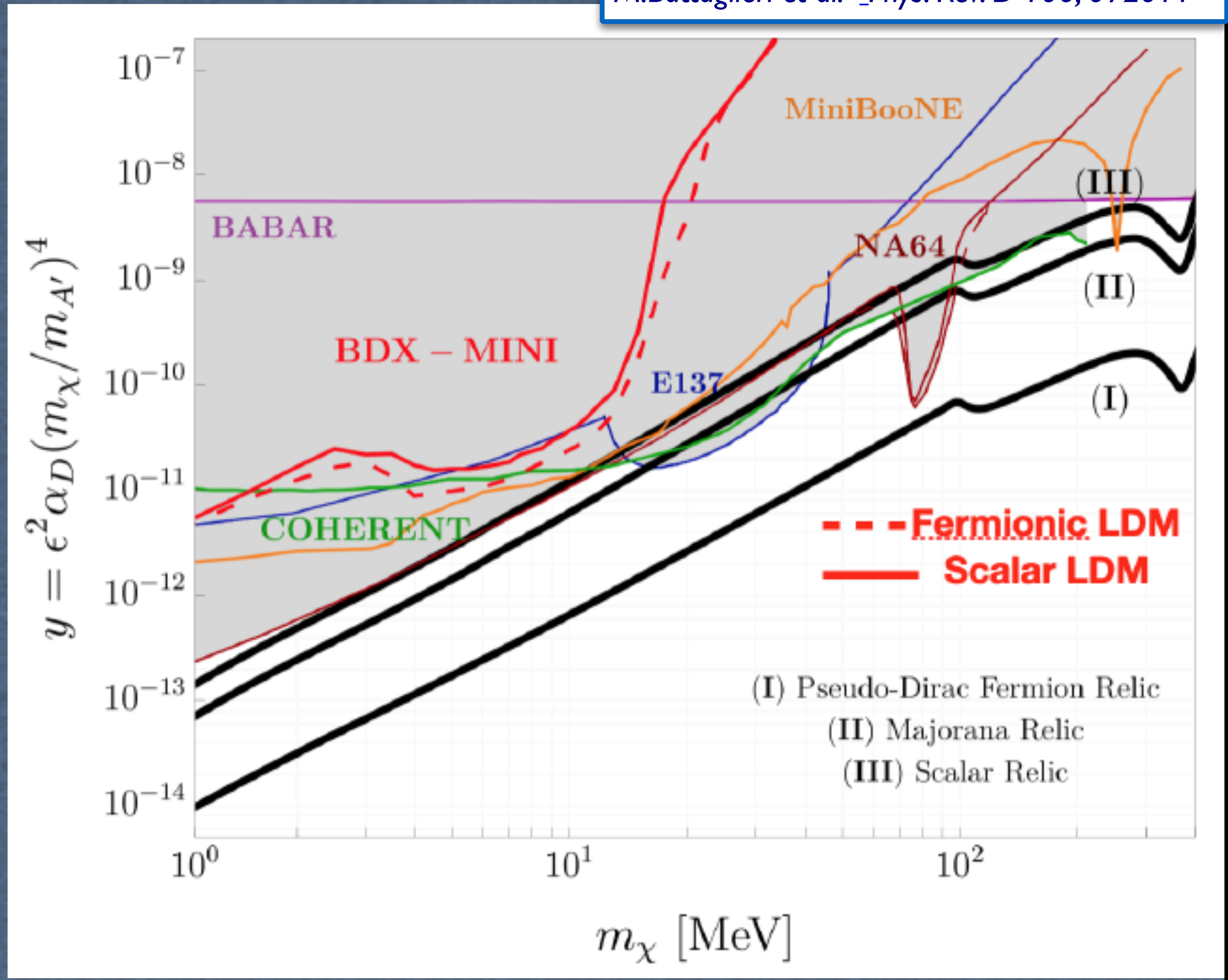
BDX-MINI: pilot experiment to prove the validity and feasibility of the BDX experiment



- Installed in March 2019
- Run form Dec 2019 to Aug 2020
- Collected 4e21 EOT (40% BDX!) in ~4 months (+ cosmics)
- Good detector performance with high duty factor

- Two wells dug for bg muon tests
- E_{beam}=2.2 GeV, no muons
- Limited reach but first physics result!

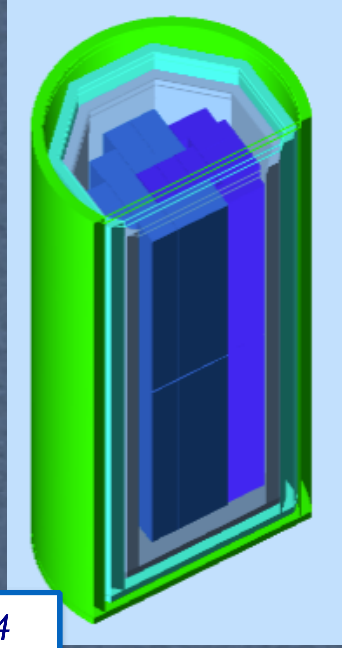
M.Battaglieri et al. Phys. Rev. D 106, 072011

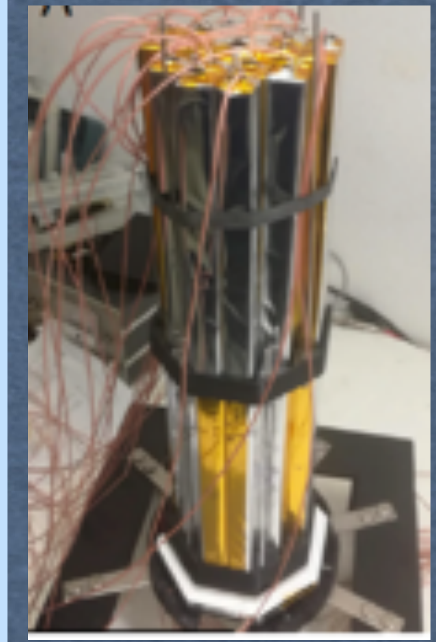


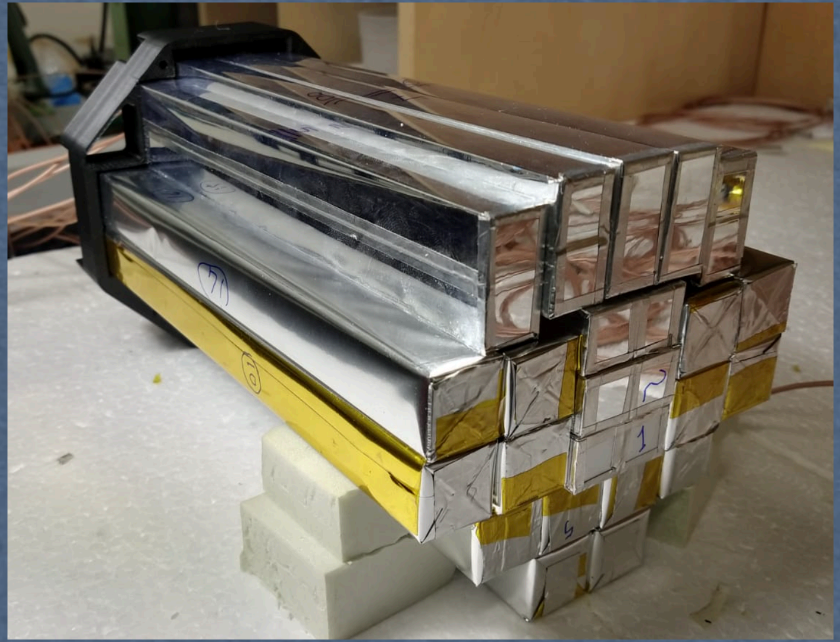
- Data-taking completed, analysis completed
- Results provide exclusion limits similar to the best existing experimnts (E137, NA64, BaBar, …)

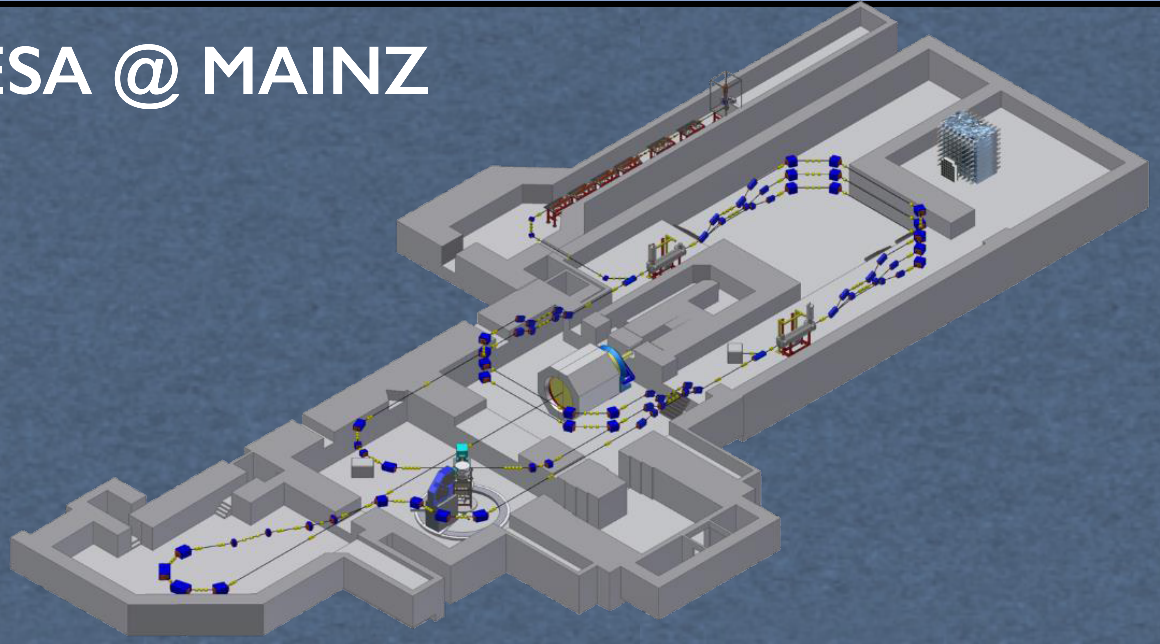
- 44 PbWO4 PANDA/FT-Cal crystals (~1% BDX active volume)
- 6x6 mm2 SiPM readout
- 2 active plastic scintillator vetos: cylindrical and octagonal (8 sipm each) + 2x lids + Passive W shielding

M.Battaglieri et al. EPJC (2021) 81: 164



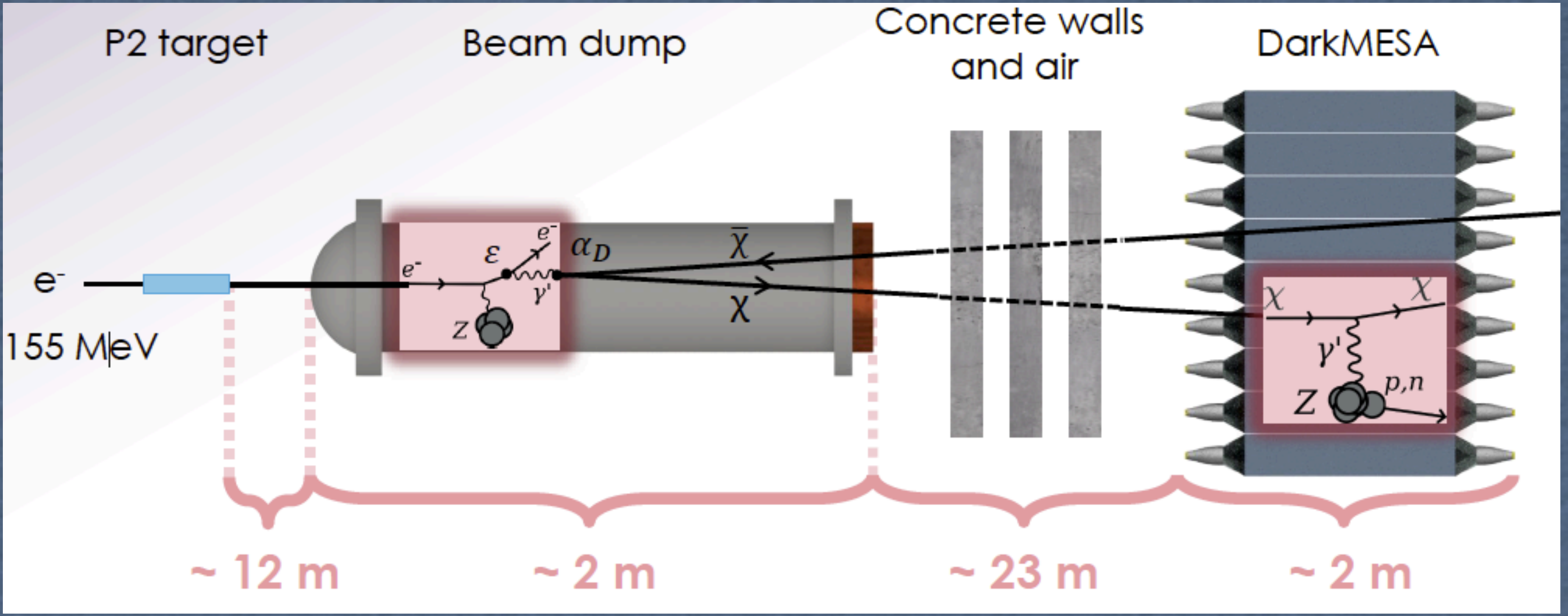


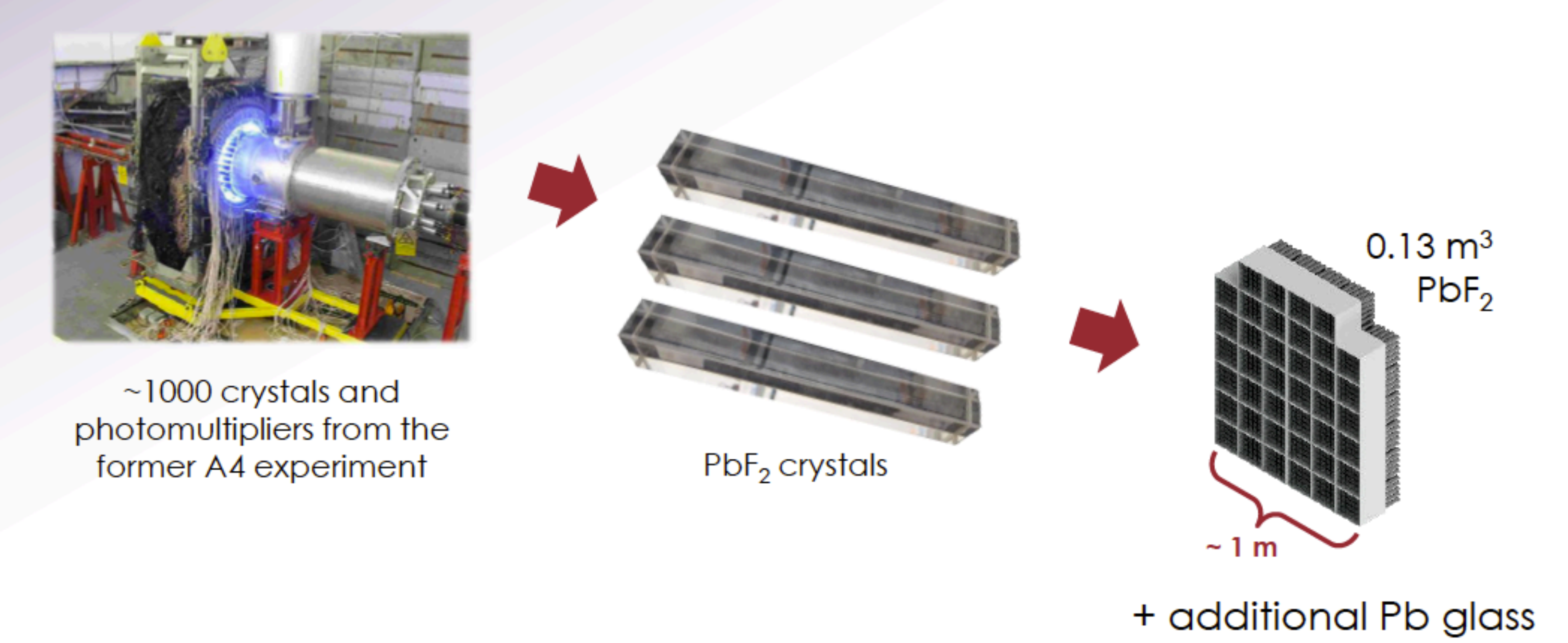


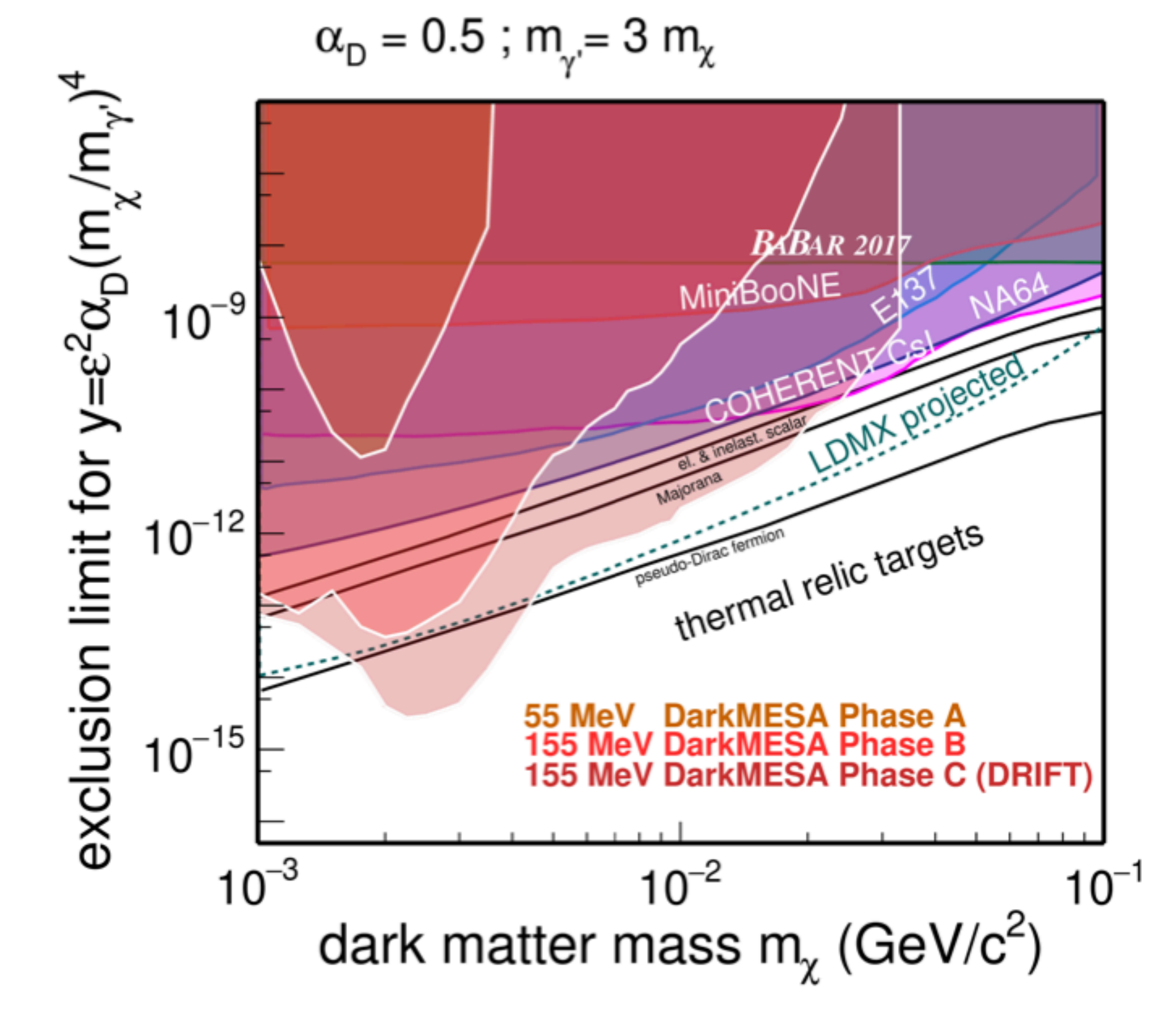


BeamDump@MAINZ: DARKMESA

MESA @ MAINZ



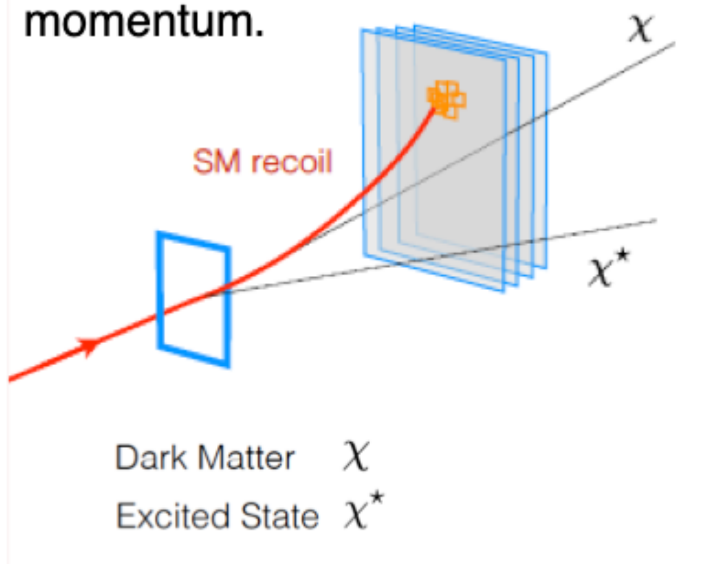


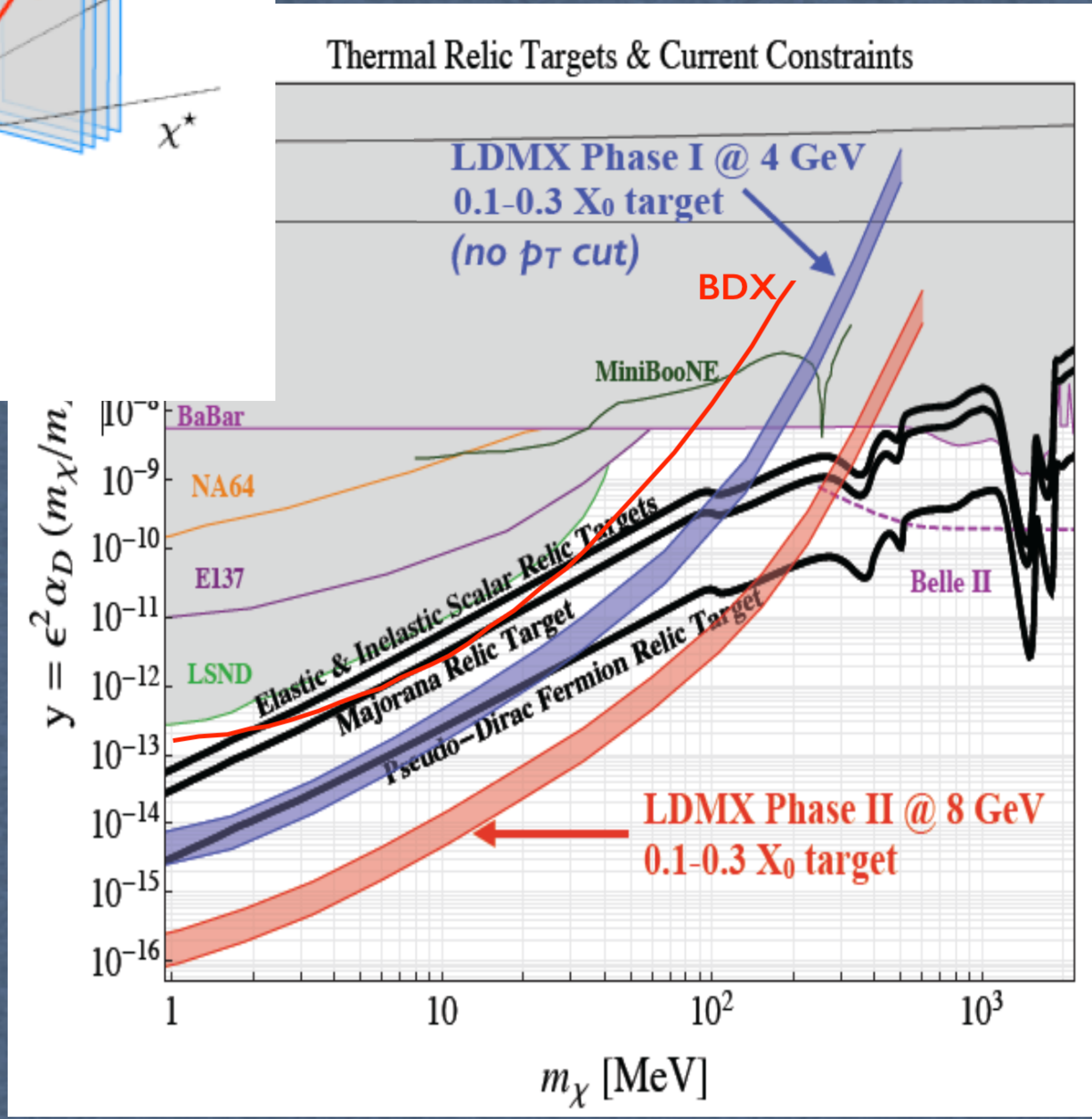


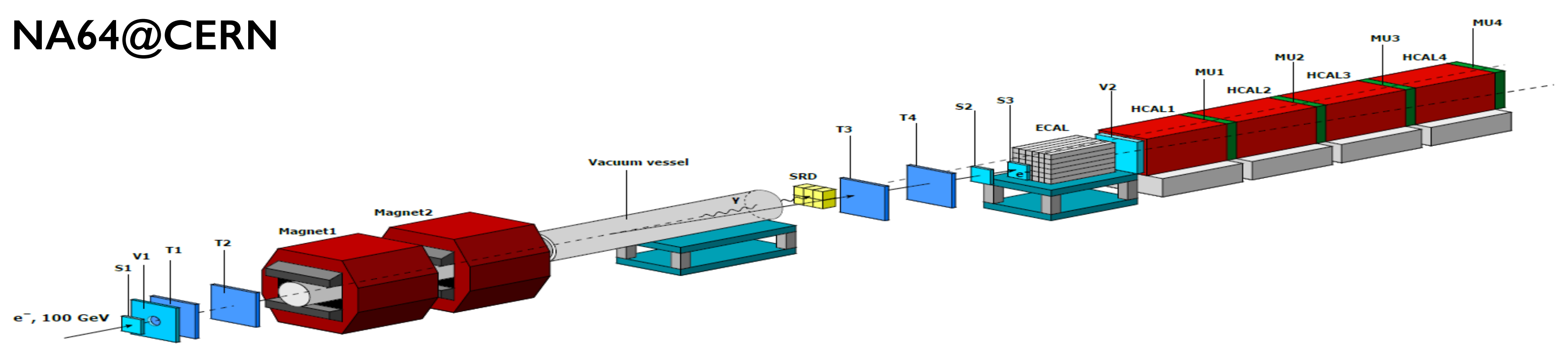
- αD=0.5and $m\gamma'=3\cdot m\chi$
- $3\cdot 10^{22}$ EOT
- Energy detection threshold 14 MeV
- Detector efficiency 90%
- No backgrounds

Missing energy/momentum BD experiments

"Disappearance" of a sizable fraction of the beam energy/ momentum.



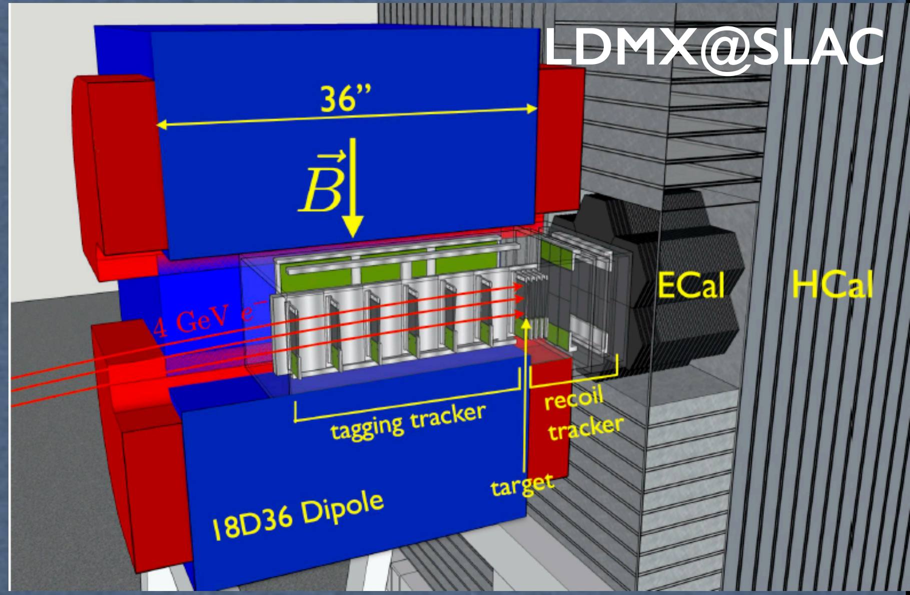




- *Active* beam-dump experiment
- Missing energy exp (e Z → e Z' A' with A' → invisible)
- 100 GeV SPS electron beam at SPS
- Active target (calorimeter)
- Exclusion plots based on 3×10^9 EOT

… and future BD experiments

- LDMX: missing momentum exp proposed at SLAC-LCLS-II 4 GeV e- beam, (*Active* beam-dump)



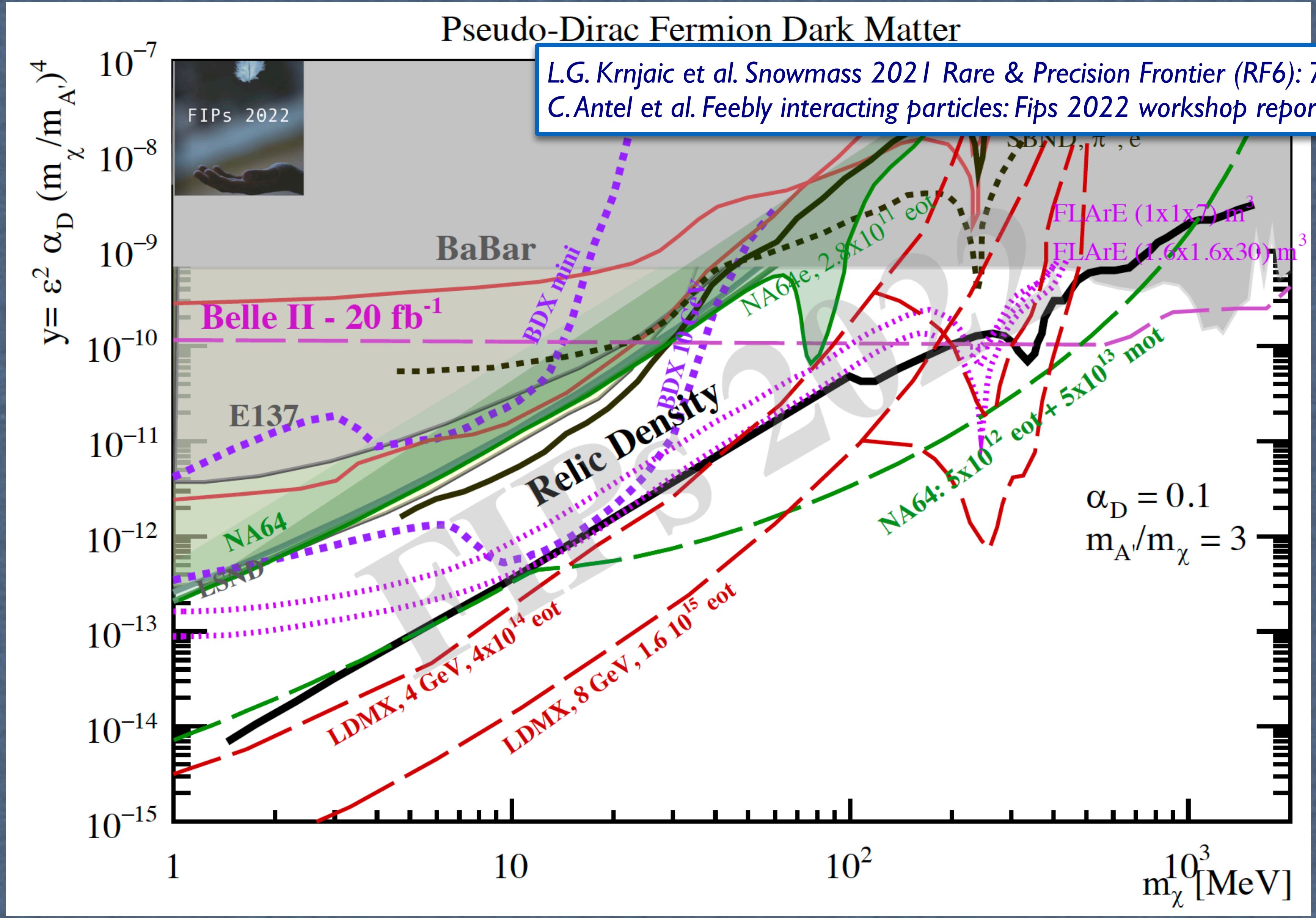
MissingMomentum vs BeamDump (*disappearance* vs *appearance*)

… **more sensitive** in the exclusion plots but **less reliable/convincing** in case of positive finding!

The two experimental approaches are complementary

LDM searches status

Experiment	lab	beam	particle yield/$\mathcal{L}$	technique	portals	timescale
current						
ATLAS [1382]	CERN	pp, 13-14 TeV	up to 3 ab^{-1}	visible, invis.	(1,2,3,4)	2042
Belle II [1219]	KEK	e^+e^-, 11 GeV	up to 50 ab^{-1}	visible, invis.	(1,2,3,4)	2035
CMS [1383]	CERN	pp, 13-14 TeV	up to 3 ab^{-1}	visible, invis.	(1,2,3,4)	2042
Dark(Spin)Quest [1256]	FNAL	p, 120 GeV	$10^{18} \rightarrow 10^{20}$	visible	(1,2,3,4)	2024
FASER [1052]	CERN	pp, 14 TeV	150 fb^{-1}	visible	(1,2,3,4)	2025
LHCb [1384]	LHC	pp, 13-14 TeV	up to 300 fb^{-1}	visible	(1,2,3,4)	2042
MicroBooNE [1385]	FNAL	p, 120 GeV (NuMi)	$\sim 7 \times 10^{20}$ pot	visible	(2,4)	2015-2021
NA62 [1174]	CERN	K^+, 75 GeV	a few 10^{13} K decays	visible, invis.	(1,2,3,4)	2025
NA62-dump [1386]	CERN	p, 400 GeV	$\sim 10^{18}$ pot	visible	(1,2,3,4)	2025
NA64$_e$ [1387]	CERN	e^-/e^+, 100 GeV	up to $1 \cdot 10^{13}$ e^-/e^+	$\not{E}$, visible	(1,3)	< 2032
PADME [1300]	LNF	e^+, 550 MeV	$5 \cdot 10^{12}$ e^+ot	missing mass	(1)	< 2023
T2K-ND280 [1388]	JPARC	p, 30 GeV	10^{21} pot	visible	(4)	running
proposed						
BDX [1389]	JLAB	e^-, 11 GeV	$\sim 10^{22}$ eot/year	recoil e	(1,3)	2024-2025
CODEX-b [1030]	CERN	pp, 14 TeV	300 fb^{-1}	visible	(1,2,3,4)	2042
Dark MESA [1390]	Mainz	e^-, 155 MeV	150 μA	visible	(1)	< 2030
FASER2 [1068]	CERN	pp, 14 TeV	3 ab^{-1}	visible	(1,2,3,4)	2042
FLaRE [1068]	CERN	pp, 14 TeV	3 ab^{-1}	visible, recoil	(1)	2042
FORMOSA [1068]	CERN	pp, 14 TeV	3 ab^{-1}	visible	(1)	2042
Gamma Factory [1391]	CERN	photons	up to 10^{25} γ/year	visible	(1,3)	2035-2038?
HIKE-dump [1392, 1191]	CERN	p, 400 GeV	$5 \cdot 10^{19}$ pot	visible	(1,2,3,4)	<2038
HIKE-K+ [1392, 1191]	CERN	K^+, 75 GeV	10^{14} K decays	visible, inv.	(1,2,3,4)	<2038
HIKE-K$_L$ [1392, 1191]	CERN	K_L, 40 GeV	10^{14} K decays	visible, inv.	(1,2,3,4)	<2042
LBND (DUNE) [1393]	FNAL	p, 120 GeV	$\sim 10^{21}$ pot	recoil e, N	(1,2,3,4)	< 2040
LDMX [1271]	SLAC	e^-, 4,8 GeV	$2 \cdot 10^{16}$ eot	$\not{p}$, visible	(1)	< 2030
M^3 [1394]	FNAL	μ, 15 GeV	10^{10} (10^{13}) mot	$\not{p}$	(1)	proposed
MATHUSLA [1395]	CERN	pp, 14 TeV	3 ab^{-1}	visible	(1,2,3,4)	2042
milliQan [1070]	CERN	pp, 14 TeV	0.3-3 ab^{-1}	visible	(1)	< 2032
MoeDAL/MAPP [1396]	CERN	pp, 14 TeV	30 fb^{-1}	visible	(4)	< 2032
Mu3e [1397]	PSI	29 MeV	$10^8 \rightarrow 10^{10}$ μ/s	visible	(1)	< 2038?
NA64$_\mu$ [1398]	CERN	μ, 160 GeV	up to 2×10^{13} mot	$\not{p}$	(1)	< 2032
PIONEER [1399]	PSI	55-70 MeV, π^+	$0.3 \cdot 10^6 \pi$/s	visible	(4)	phase I approved
SBND [1400]	FNAL	p, 8 GeV	$6 \cdot 10^{20}$ pot	recoil Ar	(1)	< 2030
SHADOWS [1401]	CERN	p, 400 GeV	$5 \cdot 10^{19}$ pot	visible	(2,3,4)	<2038
SHiP [1402]	CERN	p, 400 GeV	$2 \cdot 10^{20}$ pot	visible, recoil	(1,2,3,4)	<2038



L.G. Krnjaic et al. Snowmass 2021 Rare & Precision Frontier (RF6): 7 2022
C.Antel et al. Feebly interacting particles: Fips 2022 workshop report, 2023

From CERN-FIPs workshop report, (SNOWMASS22): several experiments planned/proposed (LHC, SLAC, Mainz, FNAL, KEK, PSI, LPARC) with a variety of beams (proton, leptons, photons), energies (from 150 MeV to 14 TeV) and experimental techniques (visible, invisible, recoil, ..) with a timeline that reaches ~2042

Conclusions

✴ Existence of Dark Matter is a compelling reason to investigate new forces and matter over a broad range of mass

✴ Accelerator-based (Light)DM search provides unique feature of distinguish DM signal from any other cosmic anomalies or effects

✴ Extensive experimental plans at high intensity e-facility: JLab, LNF, Cornell, Mainz, SLAC (+ p beam at FNAL and CERN)

✴ A new generation of dedicated and optimised experiments at high intensity frontier will test the relic (light) dark matter scenario

✴ Jefferson Lab is the world-leader facility for present and near-future LDM searches: APEX, HPS, DarkLight, BDX (and possibly e+ annihilation and LDMX)

✴ Significant interests from funding agencies (DOE/NSF) and labs (CERN and JLab) to run small scale experiments with a great discovery potential

✴ Discovery or decisive tests of simplest scenarios will possible in the next ~5-8 years!