

THE MAGIX EXPERIMENT

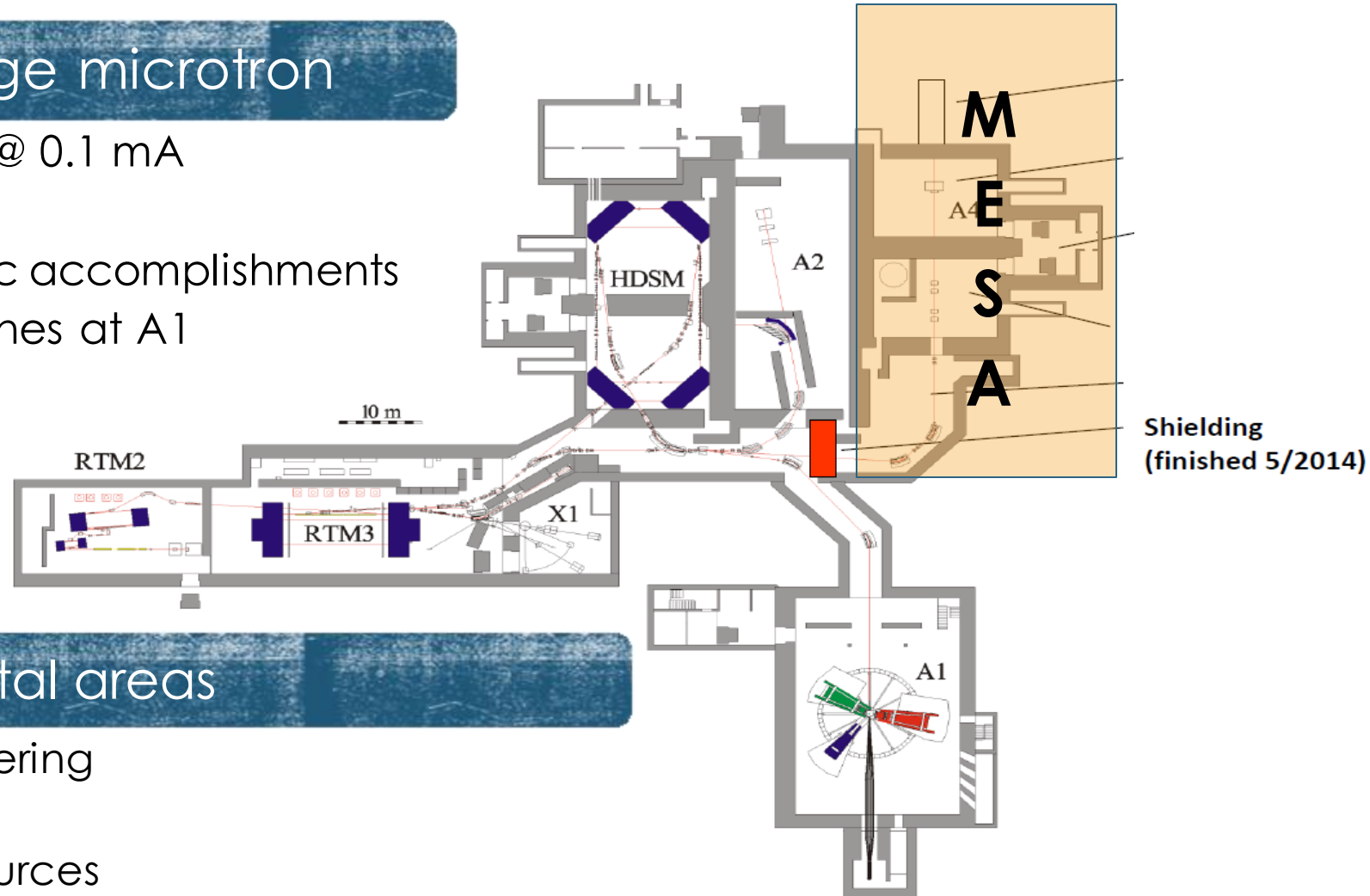
Not only Light Dark-Matter

S. Caiazza for the MAGIX collaboration
March 24 2017 – College Park (MD)
U.S. Cosmic Visions: New Ideas in Dark Matter



MAMI - Multi-stage microtron

- 1.5 GeV electrons @ 0.1 mA
- Active since 1979
- Long list of scientific accomplishments
- Dark photon searches at A1



Four experimental areas

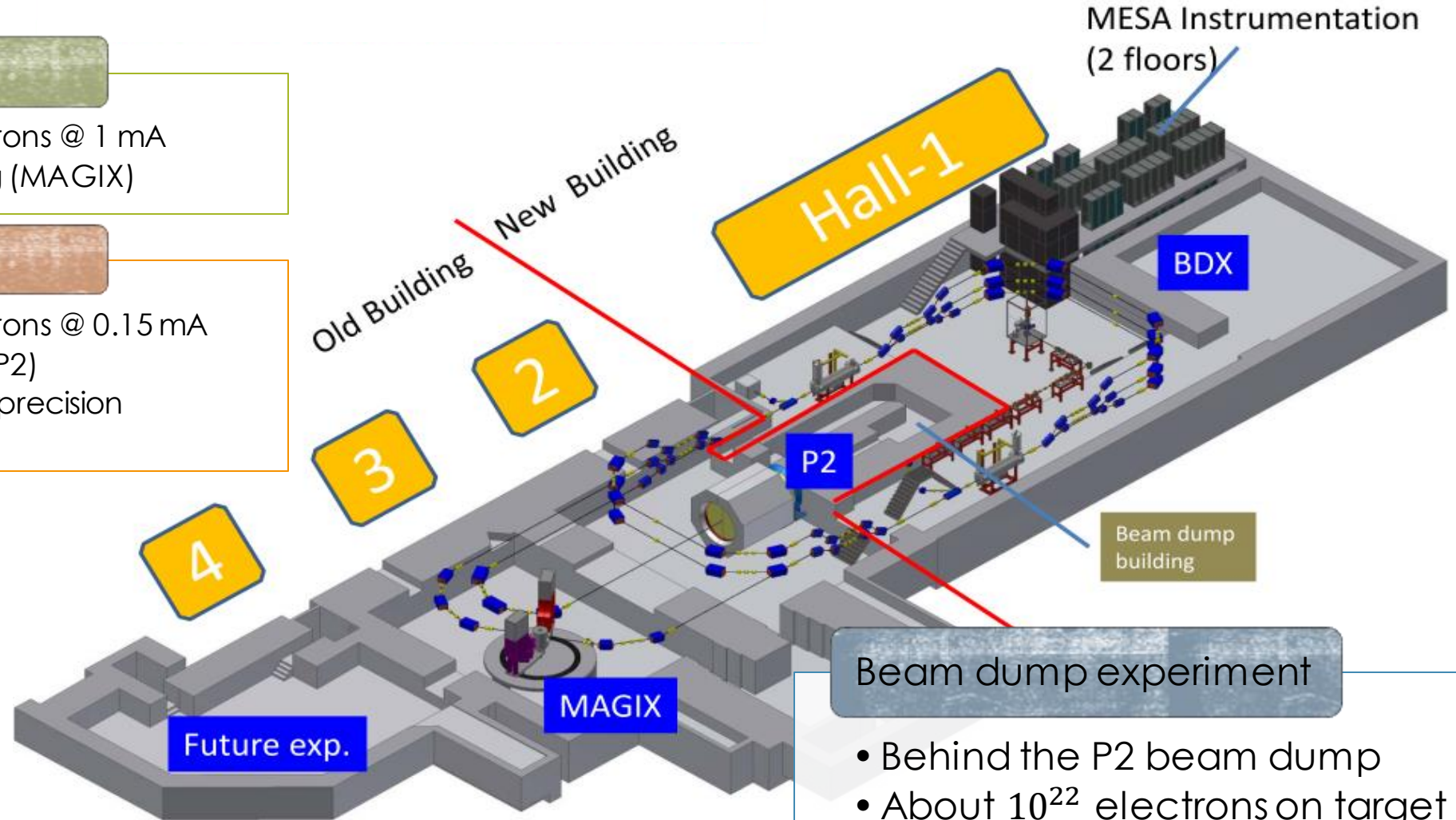
- A1: Electron scattering
- A2: Real photons
- X1: Hard X-Ray sources
- A4: Parity violation (Replaced by MESA)

ER branch

- 105 MeV polarized electrons @ 1 mA
- Internal target scattering (MAGIX)

Extracted beam

- 155 MeV polarized electrons @ 0.15 mA
- Dedicated experiment (P2)
- Electroweak asymmetry precision measurement



Beam dump experiment

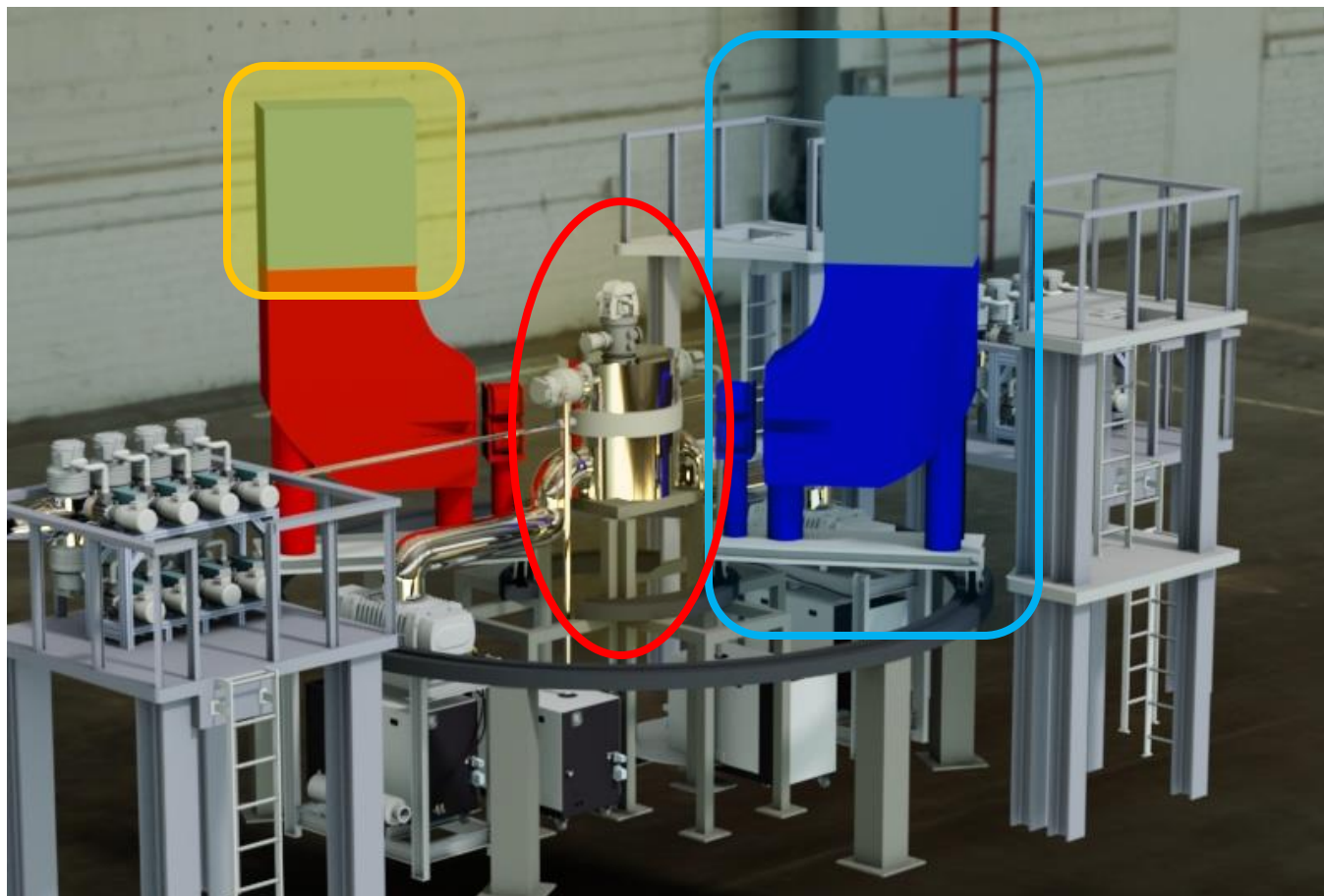
- Behind the P2 beam dump
- About 10^{22} electrons on target

A high-precision multi-purpose experimental setup

Internal Gas Target

Twin ARM
Dipole
Spectrometer

Focal Plane
Detectors



Limited material thickness

- Low energy electrons and recoil nuclei to measure
- Beam recapture after the interaction

High luminosity

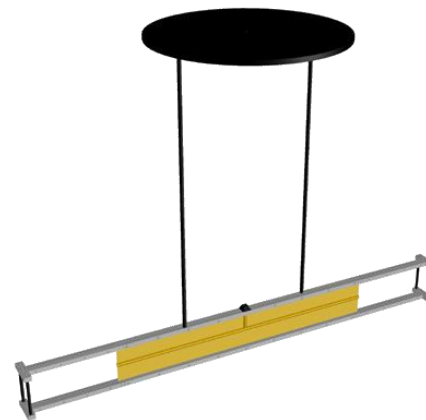
- Target luminosity $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$

Gas polarization

- Optional requirement for some process
- Not relevant for DM projects

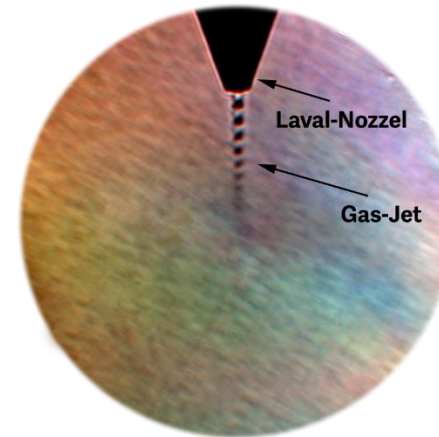
Polarized gas

- Molecular Flow inside a mylar tube



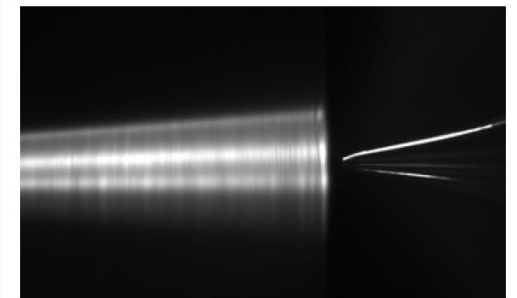
Supersonic jet

- 2 mm wide jet stream in vacuum
- $10^{19} \text{ atoms / cm}^2$



Cluster-Jet

- Molecular clustering @ 40K
- Increase self-confinement



Compact magnetic spectrometers

- Dipole + quadrupole design
- High momentum acceptance (~45%)

High resolution

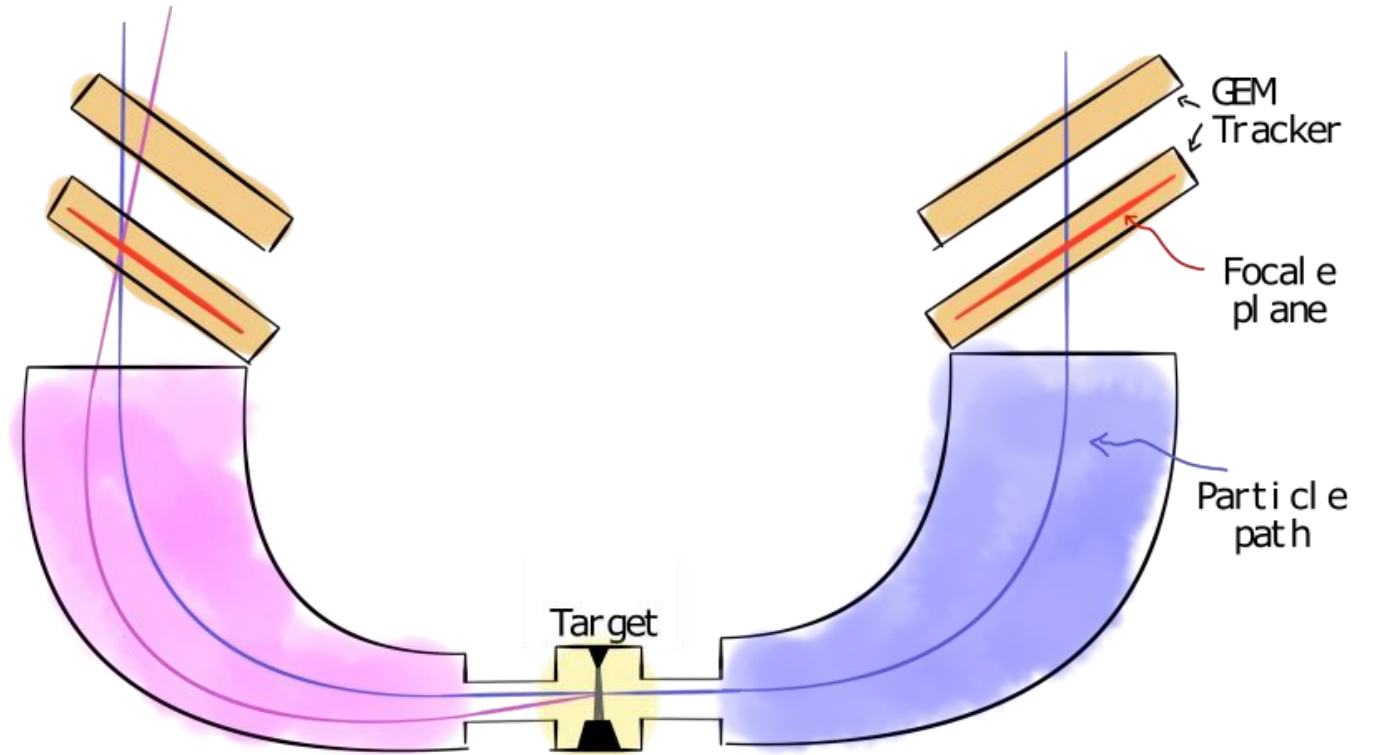
- $\frac{\Delta p}{p} \approx 10^{-4}$
- $\Delta\theta \cong 0.9 \text{ mrad}$

High rate capability

- With a CW operation rates up to $O(1 \text{ MHz})$
- Count rates of $O(100 \text{ KHz})$

Detectors

- GEM based focal planes (under development)
- Recoil detectors integrated in the scattering chamber (initial development)
- 0 degree detector (under study)
- Forward tagging (under study)



Hadronic structure

- Proton form factors (electric and magnetic)
- Nuclear polarizabilities
- Light nuclei form factors (Deuteron and helium)

Few-body physics

- Deuteron and ^3He breakup
- ^4He monopole transition factors
- Test of effective field theories
- Inclusive electron scattering

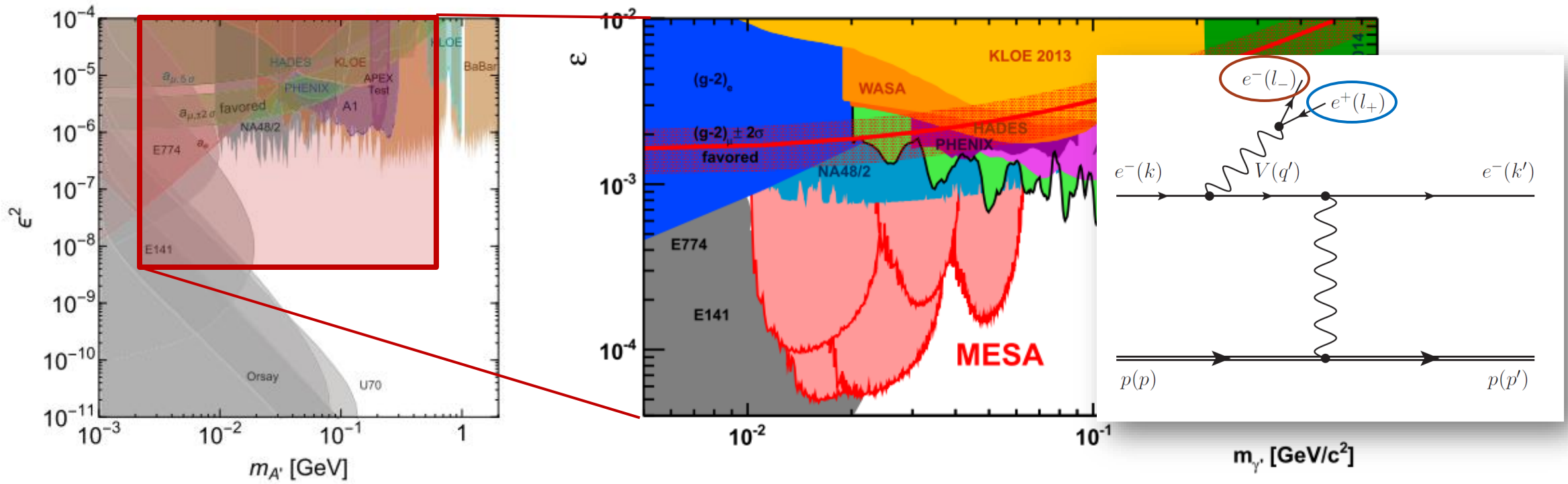
Precision cross-sections

- $^{16}\text{O}(e, e'a)^{12}\text{C}$ S-factor

Search for exotica

- Direct dark photon search
- Invisible decaying dark photon search
- Beam dump experiment (technically is not MAGIX but involves the same group)

DARK PHOTON VISIBLE DECAYS

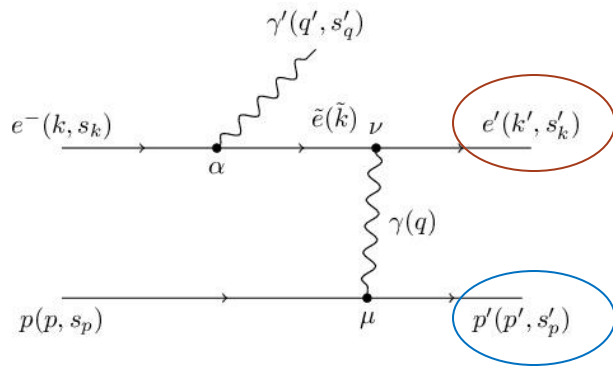


Measure the momenta of e^+e^- in coincidence

Bump hunting in the invariant mass distribution

Mass sensitivity: $10 - 60 \text{ MeV}$

Coupling down to about $\epsilon > 5 \cdot 10^{-5}$



Mass sensitivity
about 10-60
MeV

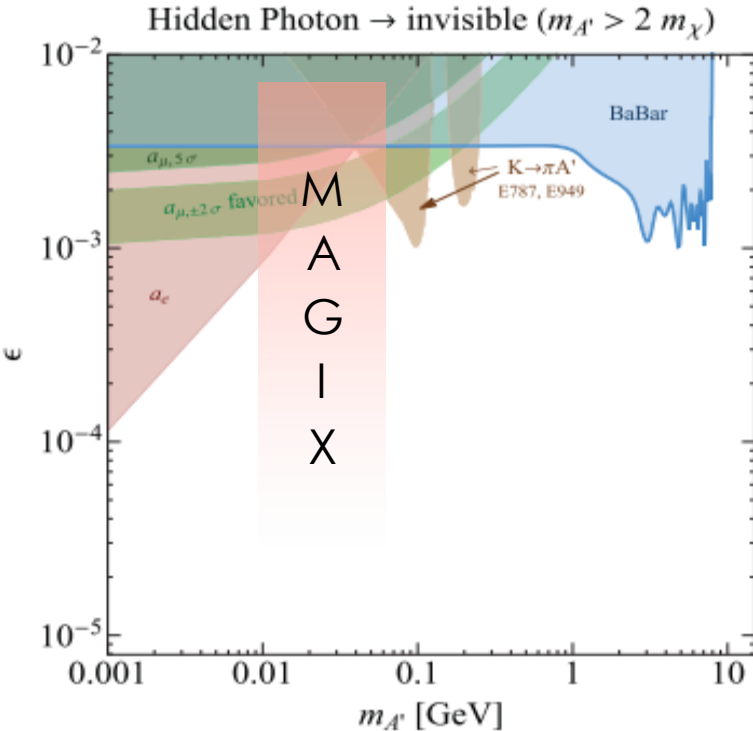
Coupling
sensitivity
unknown

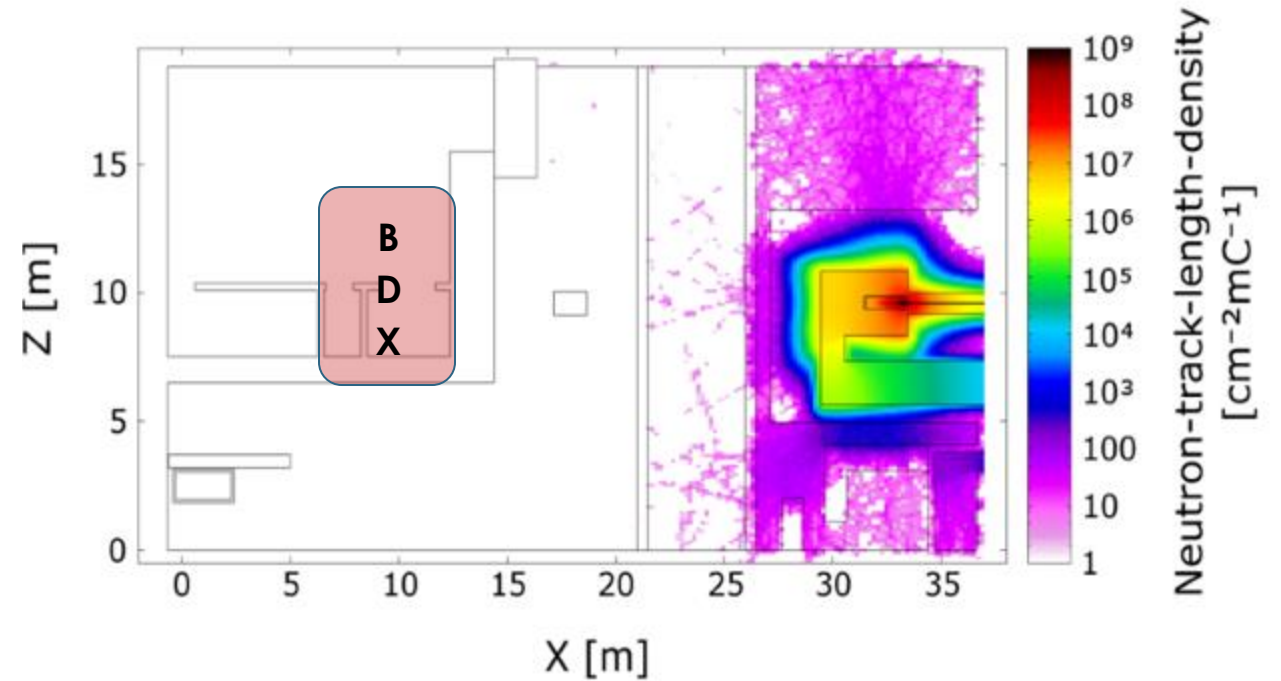
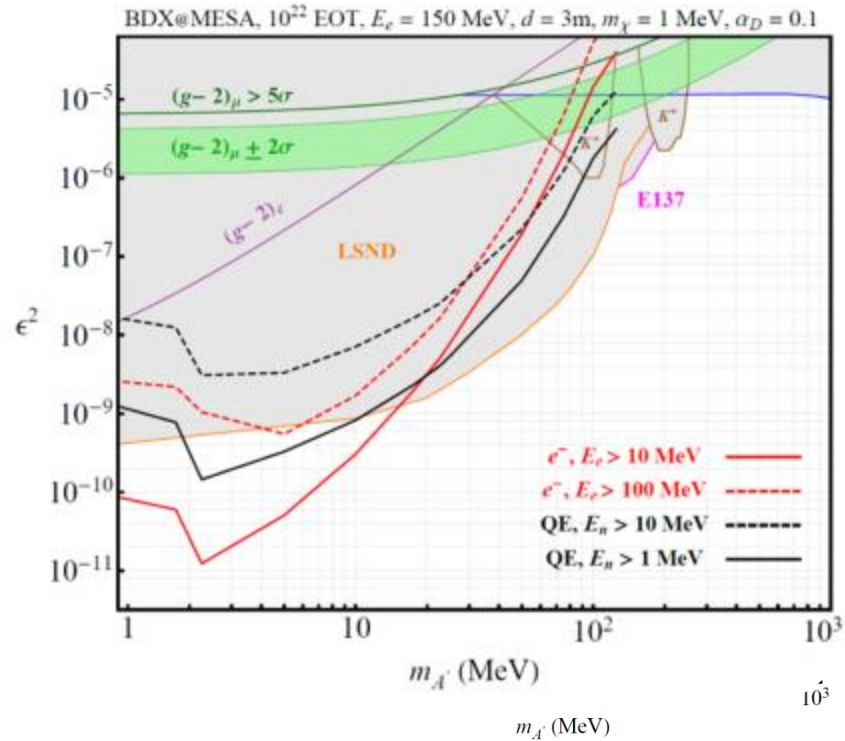
Full kinematic reconstruction

- Spectrometer for electron
- Second detector for the proton

Work in progress

- Spectrometer efficiency for proton detection
- Do we need a separate recoil detector?





Initial projections

- Done by G. Krnjaic assuming a BDX like setup
- Competitive below about 10 MeV
- New studies are starting

Background simulations

- Low beam energy \rightarrow only neutrons
- No beam backgrounds at the experiment location

Construction schedule

- Earliest availability of MESA: 2020
- First MAGIX operation: 2021-22

Design timeline

- R&D projects ongoing
- Physics book to be published in autumn
- TDR before the end of 2017

Financing

- Accelerator and experiments financed by the German science council and the PRISMA cluster of excellence
- PRISMA funded by the Rheinland-Pfalz state and by the Mainz university

MAGIX: a versatile experiment

- Experimental setup for high precision measurements
- Rich physics program under development

Dark matter searches

- Sensitive to Dark Photons with mass of about 10-60 MeV
- Sensitivity to couplings of the order of 10^{-4}
- Full simulations under development
- Beam dump experiment included in the program

Open and expanding collaboration

- Currently 4 institutes involved
- First collaboration meeting 15-17 February 2017
- Open to new physics proposals to make the project long-lasting
- Open to new collaborators to realize the Magix



THANK YOU FOR YOUR ATTENTION!

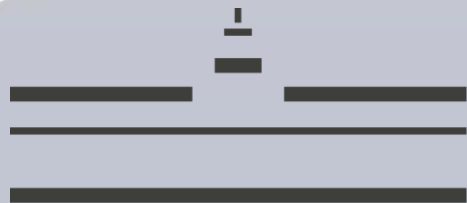
<http://magix.kph.uni-mainz.de>



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