

WORKSHOP ON DARK 2016 SECTORS

DMA



Electron beams Session Summary

J.Alexander, M.Battaglieri, E.Izaguirre, G.Krnjaic, M.Perelstein, R.Van de Water

Introduction
Experimental setup
Background
Experiment reach
Conclusions

The BDX experiment at Jefferson Laboratory

Andrea Celentano
INFN-Genova

DRIFT-BDX: A low-energy, low-background, directional search for LDMA

Dan Snowden-Ifft
Occidental College
Dark Sectors 2016, SLAC, CA
April 29, 2016

Conditions at a potential location of a beam dump experiment at LCLS-II

Clive Field, SLAC: 4/29/16

Searching for a Dark Photon with DarkLight

Ross Corliss
on behalf of the DARKLIGHT Collaboration



Dark Sectors
April 29, 2016



Massachusetts
Institute of
Technology

Searching for Light Dark Matter with Electron Missing Energy/Momentum



based on arXiv:1411.1404 and ongoing work
E. Izaguirre, G. Krnjaic, P. Schuster, N. Toro

NA64 Search for dark sector physics in missing energy experiments

Dipanwita Banerjee, Paolo Crivelli, Andre Rubbia
ETH, Zurich
On behalf of the NA64 collaboration

LDMX -- Light Dark Matter eXperiment

Owen Colegrove, Joe Incandela, Josh Hildbrand, Jeremiah Mans, Takashi Maruyama, Tim Nelson, Philip Schuster, Natalia Toro

Dark Photon Search in e+e- Annihilation

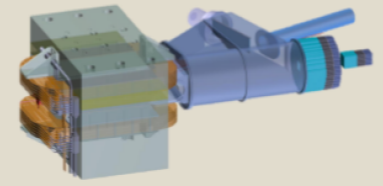
MMAPS = Missing Mass A-Prime Search

Cornell University J. Alexander, D. Cassel, M. Perelstein, D. Rubin, P. Wittich
University of Minnesota Y. Kubota, B. Wojtsekhowski

C. Cesarotti, E. Niklasson, B. Shin, Y. Wang Cornell undergraduate students
Katherine Ding, Josh Kurisko, Akshay Sawhney, Saquib Hassan,
J. Perrin, J. Park Cornell graduate student (accelerator physics)
Northwestern University undergrad

Dark Photon Search in e+e- Annihilation

The PADME experiment at LNF

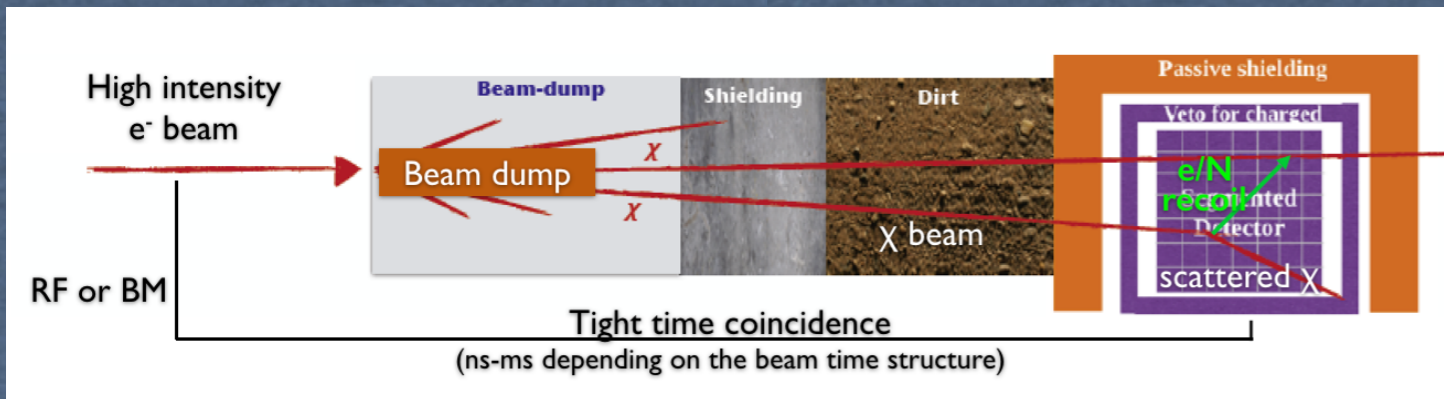


Mauro Raggi
INFN Laboratori Nazionali di Frascati
On behalf of the PADME collaboration

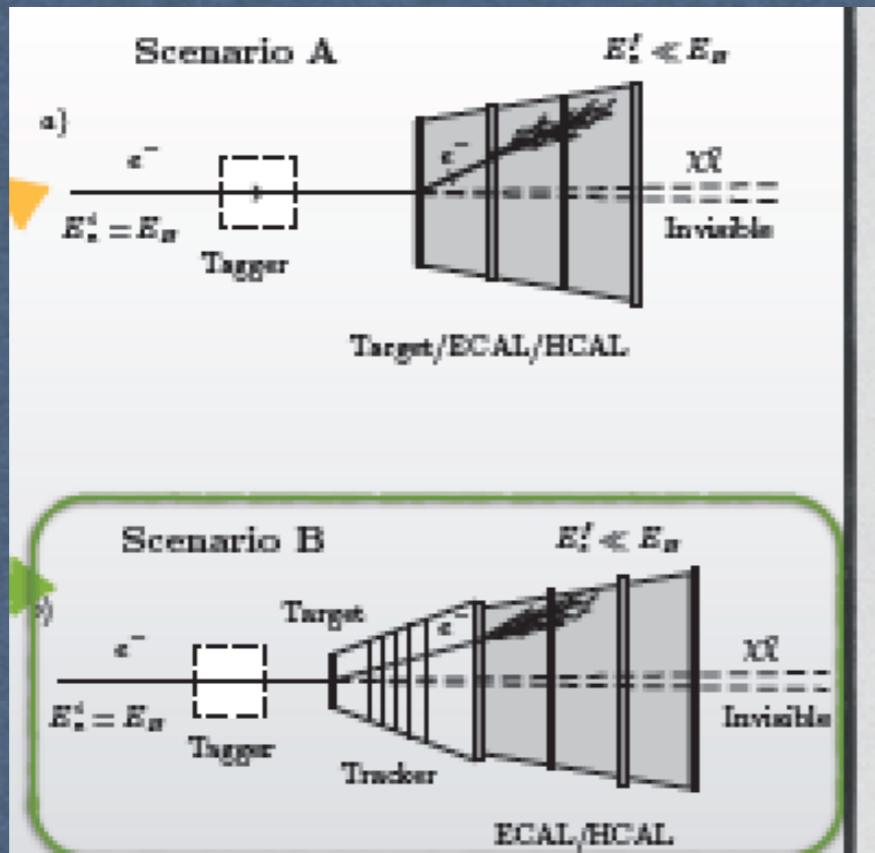
More on PADME at:
Proposal to Search for a Dark Photon in Positron on Target Collisions at DAΦNE Linac, Adv.HEP 2014 (2014) 959802
Indico PADME: <https://agenda.infn.it/category/Display.py?category=762>
Results and perspectives in dark photon physics, RIVISTA DEL NUOVO CIMENTO Vol. 38, N. 50, 2015

DMA/Visible joint session

Three different techniques in Invisible search

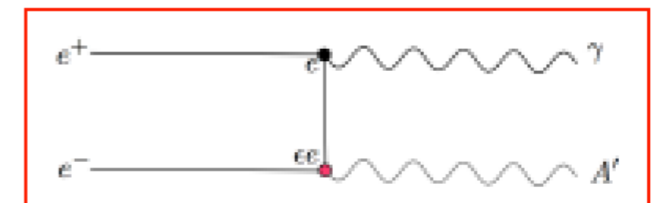


- Beam dump

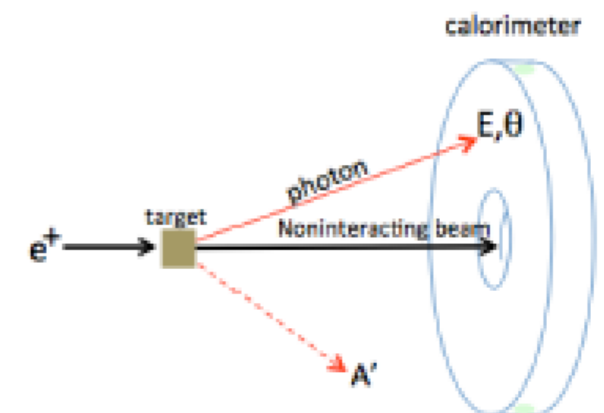


- Missing momentum

Process of interest:



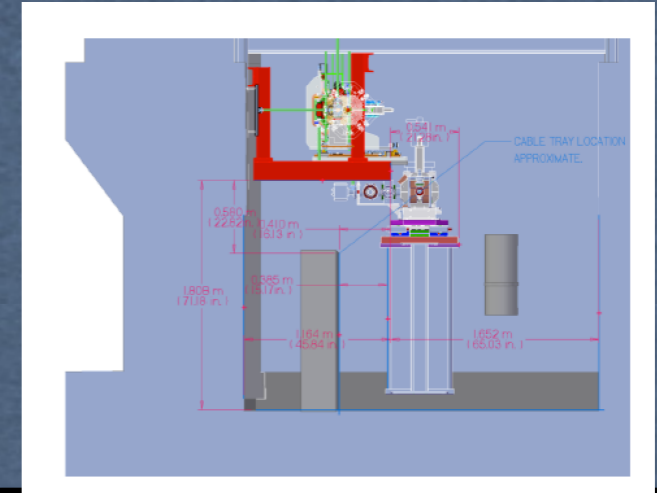
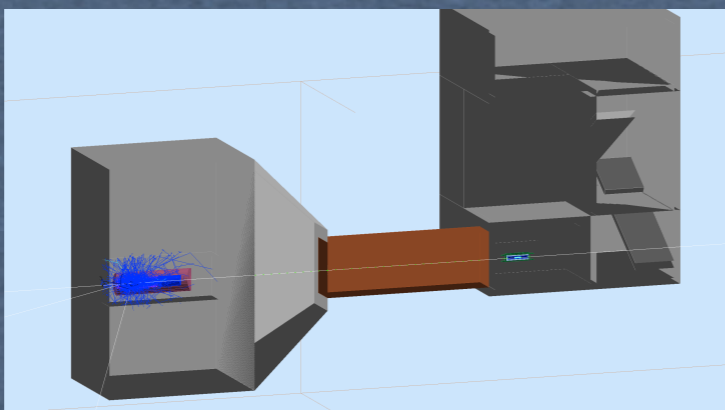
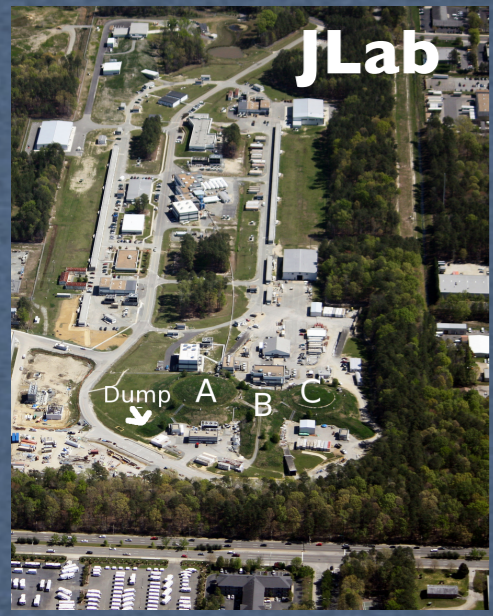
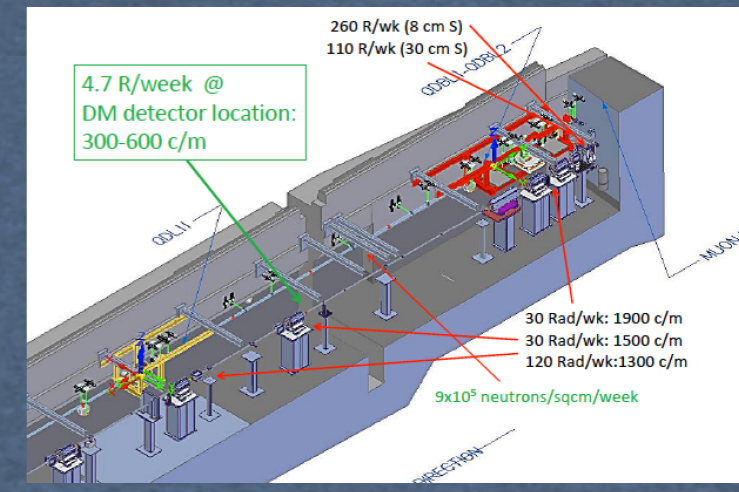
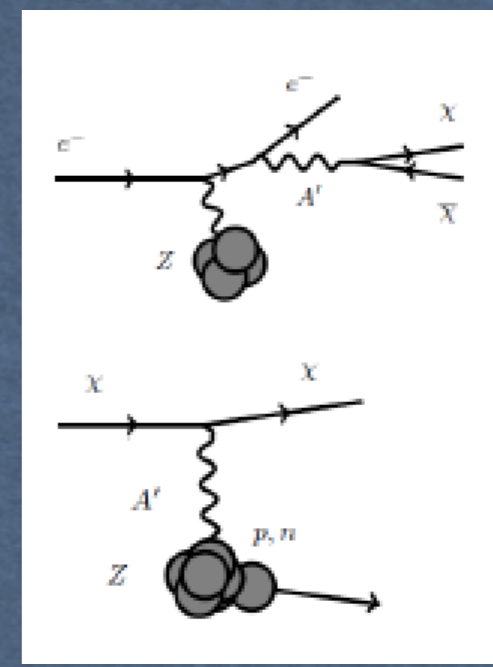
Hardware:



- Missing Mass

Beam dump

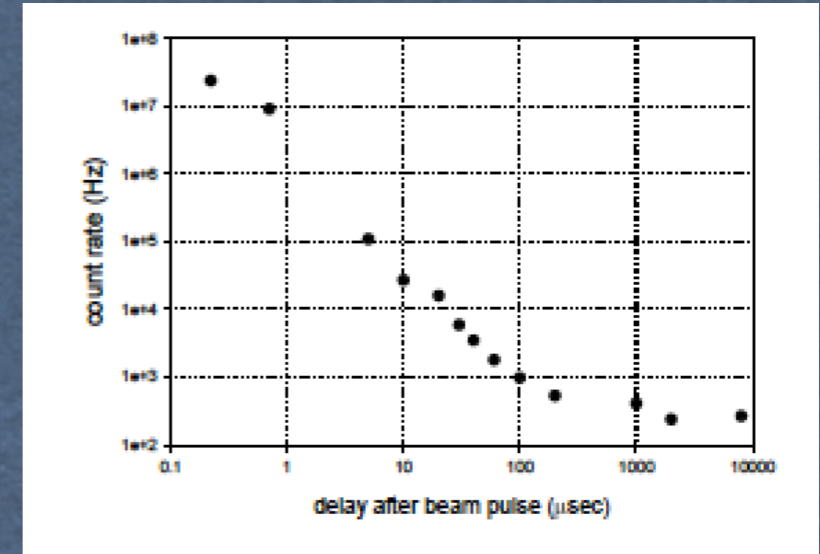
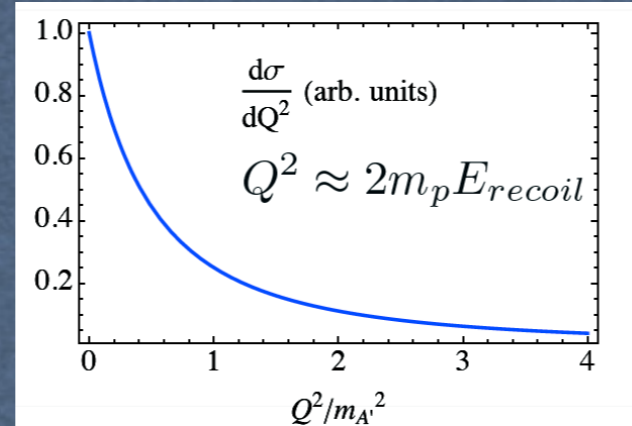
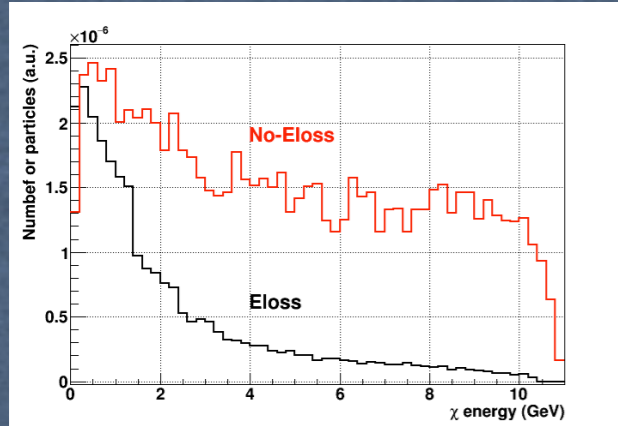
- ★ Sensitivity to nucleon ($T_n > 5 \text{ MeV}$) and electron scattering ($E_e > 500 \text{ MeV}$)
- ★ Calorimeter (reuse of existing crystals) + passive + active veto
- ★ Cosmic bg \rightarrow measurable but the ultimate limit for the sensitivity
 - CW (JLab) vs PULSED (SLAC)
 - Fast detector (how fast? costs?)?
 - Require real measurement
 - Shielding
- ★ Beam related bg \rightarrow reducible (?) but unmeasurable (??)
 - Full G4 simulations unrealistic \rightarrow alternative: FLUKA, MCNP
 - All processes included?
 - In-situ characterization
 - Bg shield staged to validate MC and demonstrate tha the experiment is bg-free



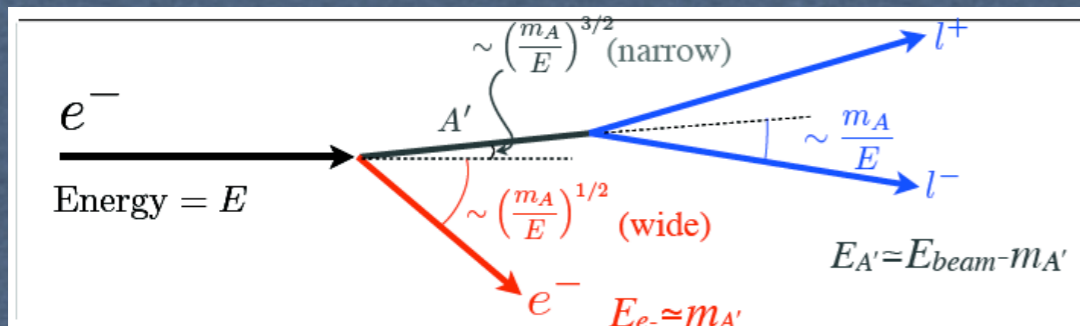
Beam dump

★ How to validate the BG model (cosmic and beam-related) to trust the measurement?

★ DM production and scattering are under control?

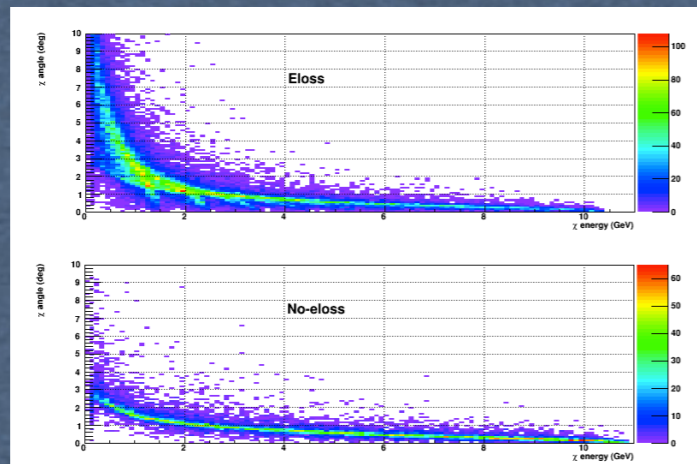


★ Is the collinear approximation valid?

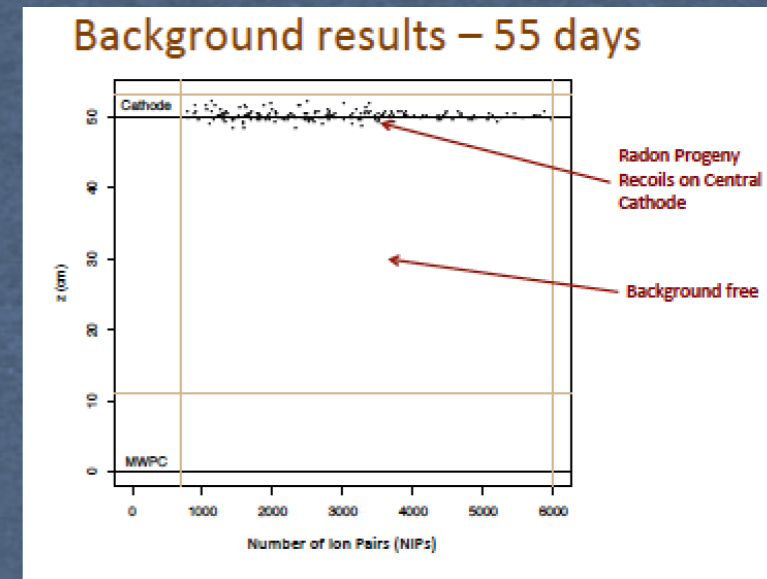


★ May we use different experimental techniques to optimise the reach and the cross check the results?

★ How it affects the procedures to assess systematics?

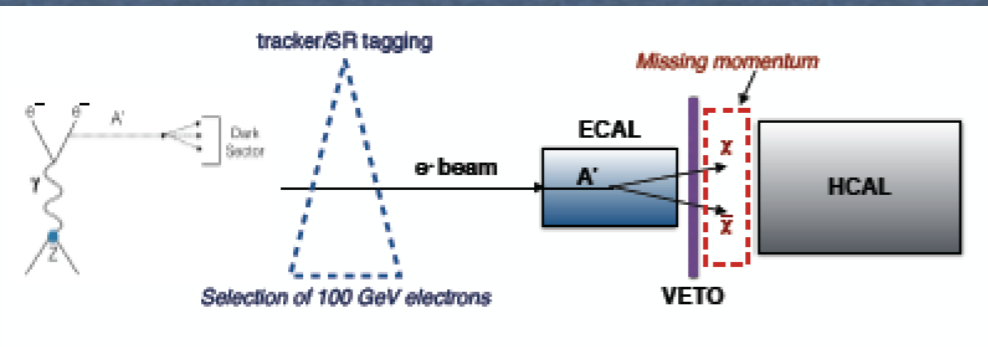


Eg: DRIFT-BDX: unconventional use of a DD detector for a beam dump experiment



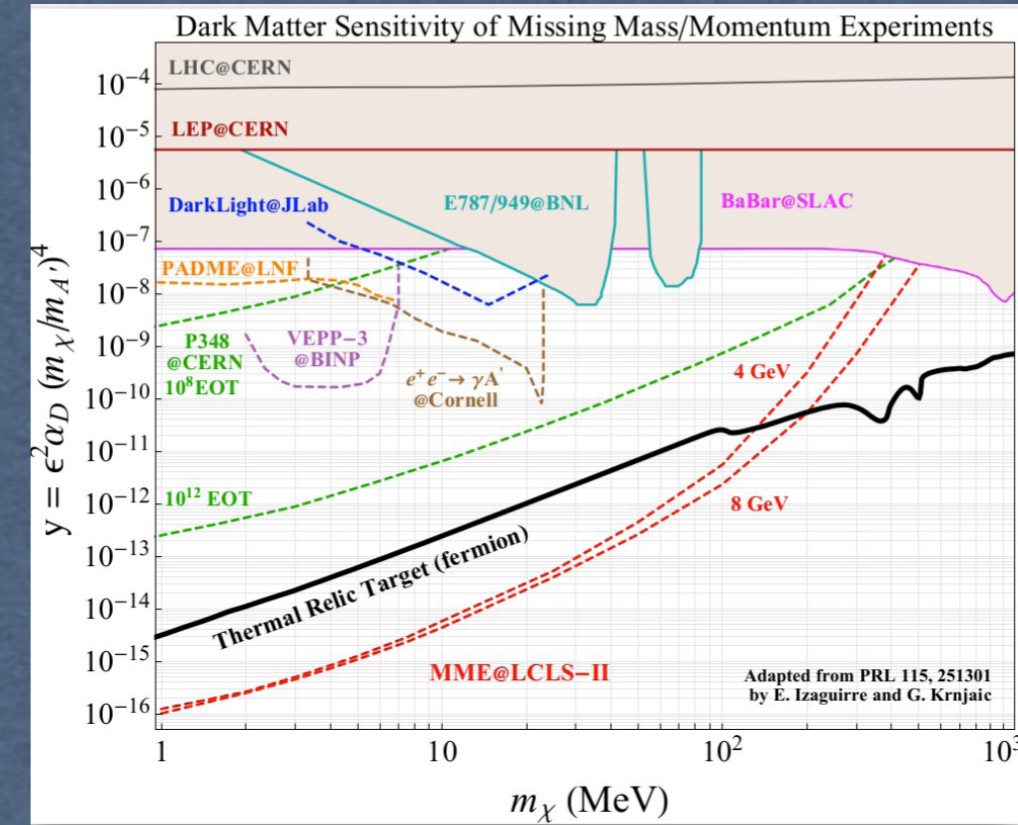
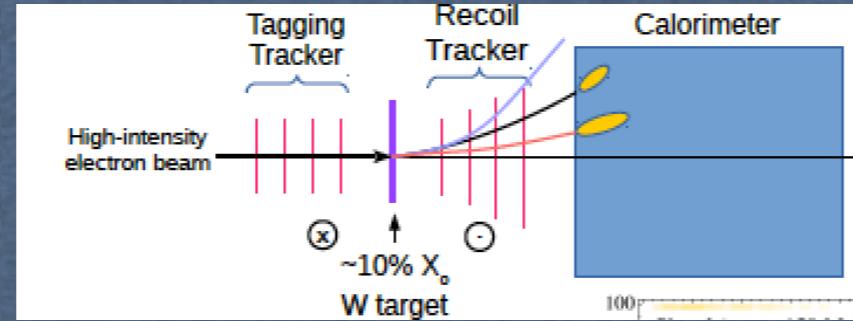
Missing momentum

★ Two options:



The detector is the target

Target/detector are different

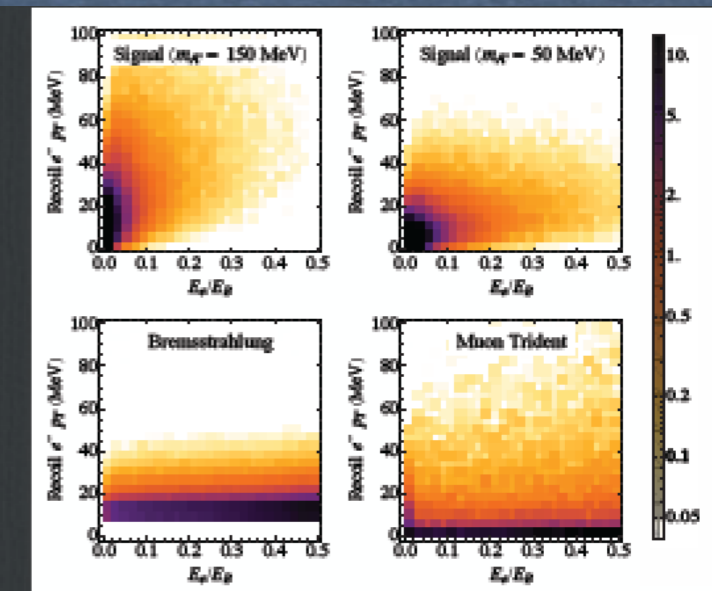
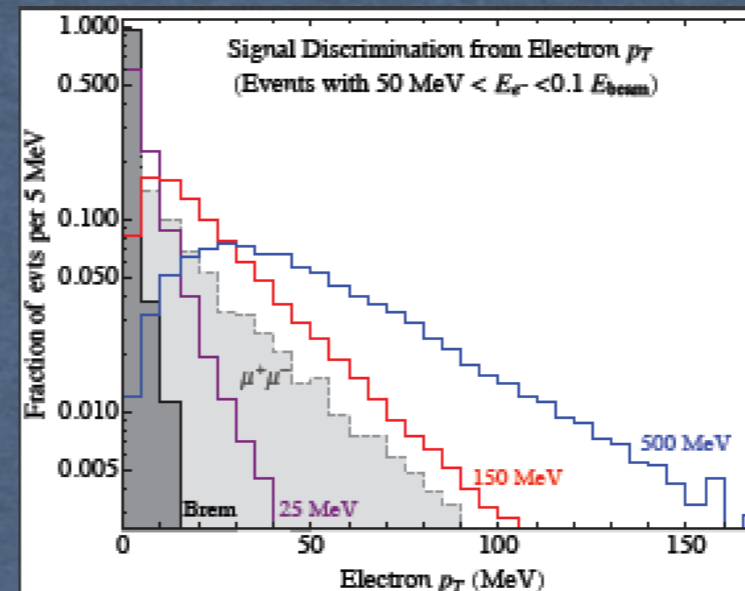


★ Best reach in a given time (no extra ϵ^2 to pay for detection!)

★ Is the MC parametrisation of “all possible” processes trustable?

★ Reaction kinematic allows to separate signal from BG (?)

★ Different kind of BG: physics (brem, neutron and K_L) and instrumental (pile-up)



Missing momentum

★ Technical challenges:

- How to control a low-current beam ($\sim 100\text{pA}$)?
- Is the $\sim 1\text{ GHz}$ detector-rate operation trustable at the required level?
- What is the time scale to reach 10^{16} EOT in 1y run?
- State-of-the art detector technology

★ What is the best energy regime to run the perfect LDMX?

- 100 GeV (CERN) vs 4 GeV (SLAC)
- Clean environment vs Calorimeter resolution

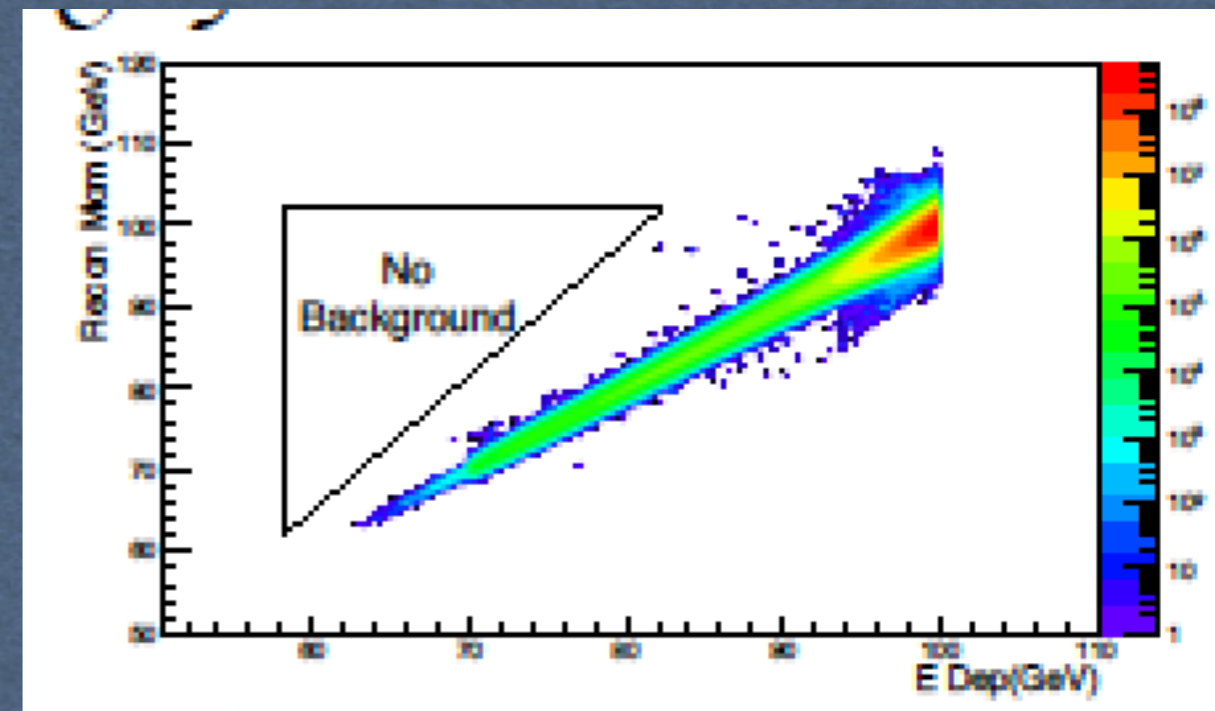
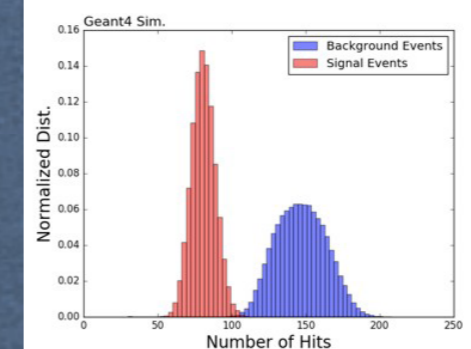
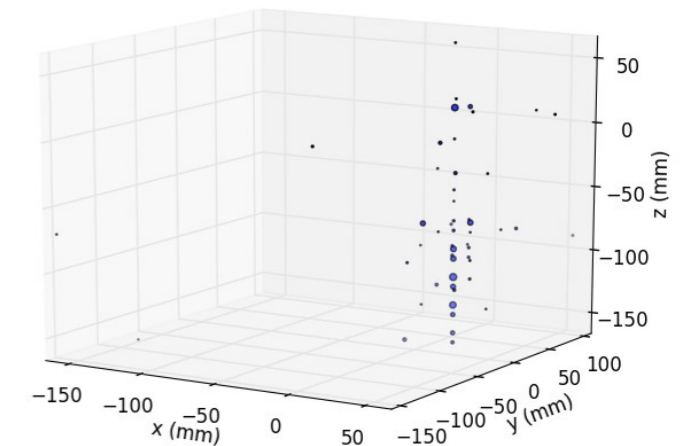
★ Missing momentum is a perfect exclusion experiment but what we need to convince ourselves in case of positive finding?

★ NA64 test results look promising

★ Eager to see results from the full run

Studies of Cluster Separation for LDMX

2000 MeV Photon



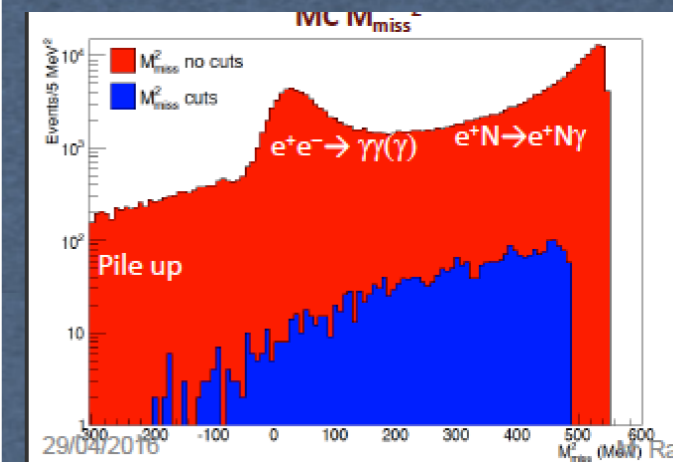
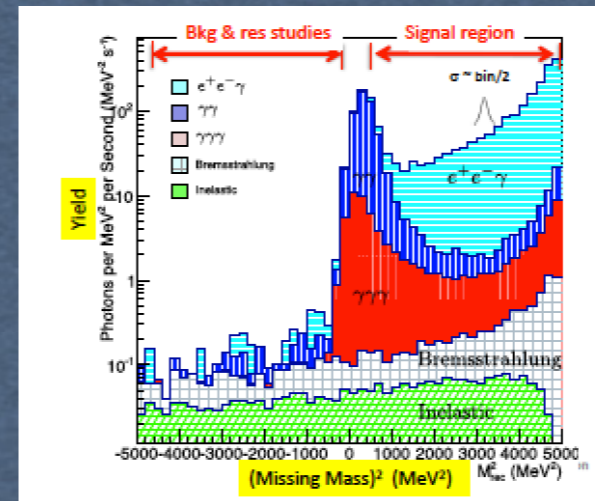
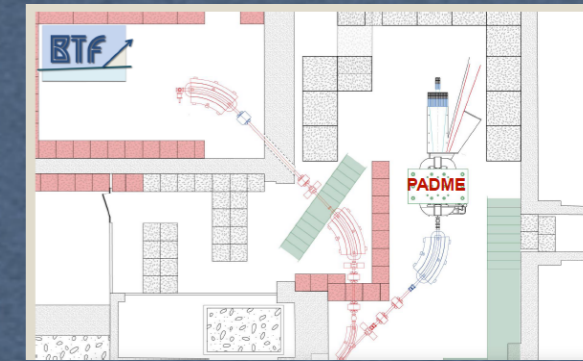
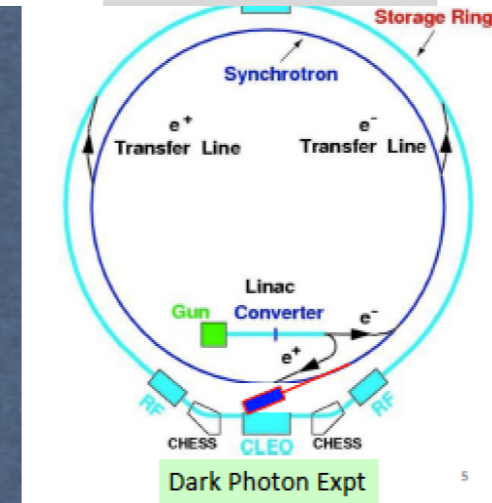
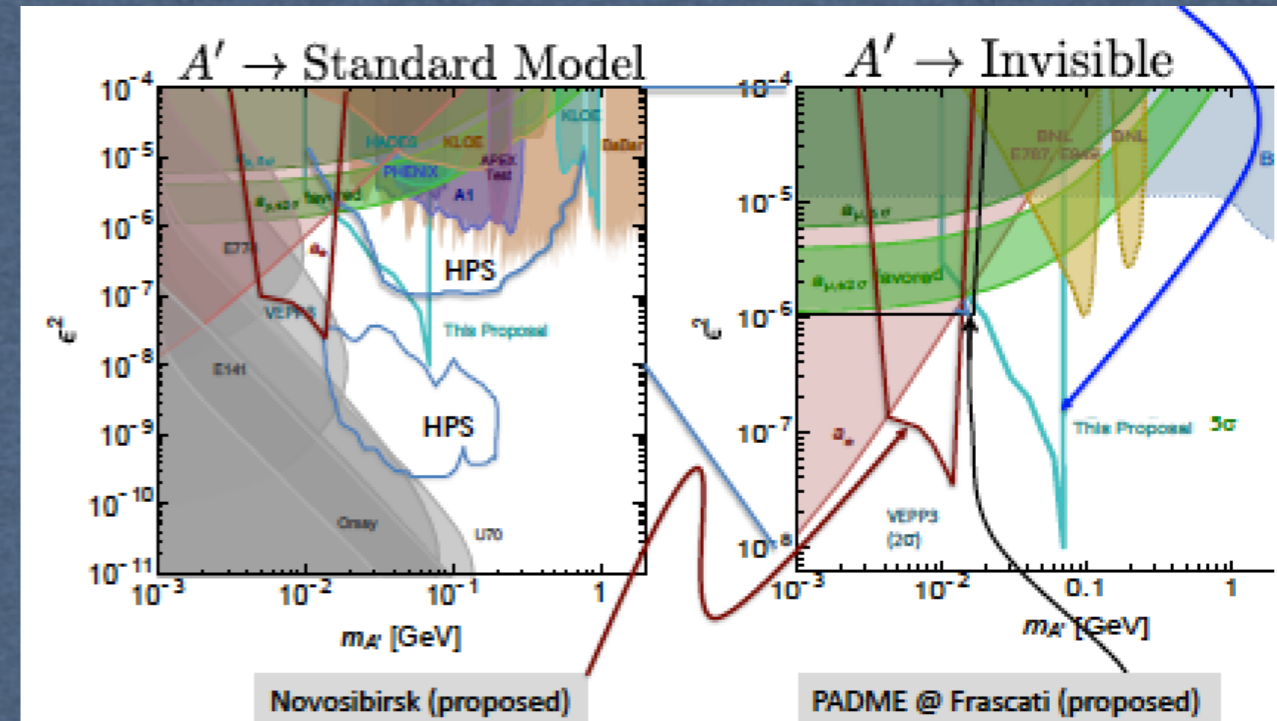
Missing mass

★ Advantages:

- Reduce the models dependence
- Provide a clear signature in case of positive result
- Reuse of many components (detector-wise)

★ (almost) on-shell experiments:
MMAPS@Cornell and PADME@Frascati

★ BG parametrization well controlled (based on many years of collider's experience)



Missing mass

- ★ Limited parameter space sensitivity
- ★ Difficult to scale to larger A' mass ($\sim\sqrt{E}$)
- ★ Costly infrastructure (see Cornell NSF proposal)
- ★ Both experiments require a supporting collaboration
- ★ A wider physics program would help

★ What is required to make the discovery trustable?

- Measure both ε^2 and the A' mass \Rightarrow Allow immediate cross check of the result
- Control of the background
 - PADME can run with electrons to get beam background from data sample
 - In electron runs any peak of annihilation production should disappear
 - Low energy beam allows few possible final state easy to simulate
 - Can profit by bunched beam to study beam-off background detector related
- Variable LINAC beam energy:
 - If any excess is observed we can enhance the cross section by setting the beam energy in the resonant production $M_{A'} = \sqrt{2m_e E_{\text{beam}}}$
 - Or we can reduce the beam energy below the production threshold peak should disappear!