

**Parasitic particle physics at the high intensity frontier:
Searching for sub-GeV scale hidden-sector particles
exploiting FLASH or XFEL electron beams**

Andreas Ringwald

in collaboration with

**Sarah Andreas, Philip Bechtle, Erika Garutti,
Axel Lindner, Javier Redondo (Munich)**



**Beschleuniger-Ideenmarkt
June 16-17, 2010, DESY, HH, Germany**

Introduction

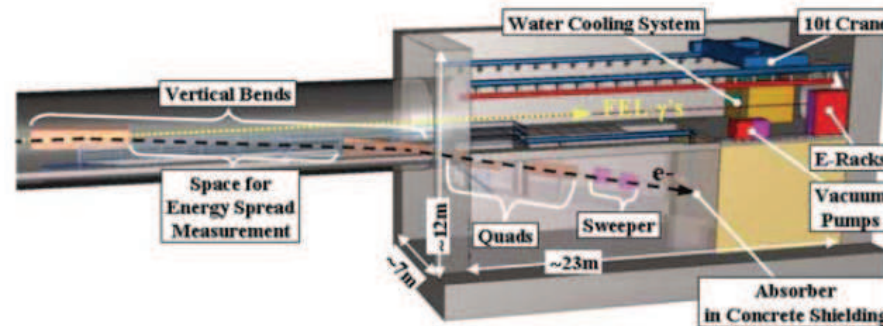
- Since the shutdown of HERA, there are no active particle physics experiments exploiting the accelerators at DESY, apart from
 - detector tests exploiting test beam lines at DESY II
 - the upcoming OLYMPUS experiment exploiting DORIS
 - accelerator tests exploiting the FLASH linac
- Unique intense electron beams of **FLASH** (**XFEL**) just dumped



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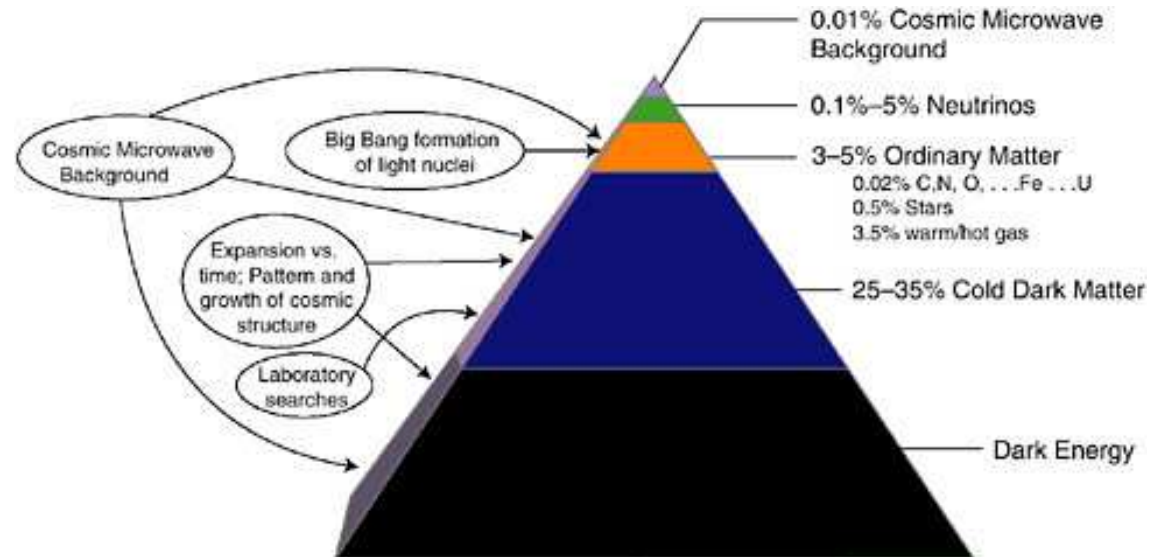
- **Missing unique parasitic particle physics opportunities!**

- **Parasitic particle physics opportunities exploiting electron beams:**
 - **Search for hidden-sector particles in $e^\pm$ nucleus collisions**
 - ⇒ cheap, small-size experiments
 - **Tests of QCD**
 - ⇒ expensive, large spectrometer experiments
 - **Particle physics detector tests**

Search for hidden-sector particles in $e^\pm$ nucleus collisions

- **Physics case for light hidden-sector particles:**

- Standard Model (SM) describes only $\sim 5\%$ of the universe:

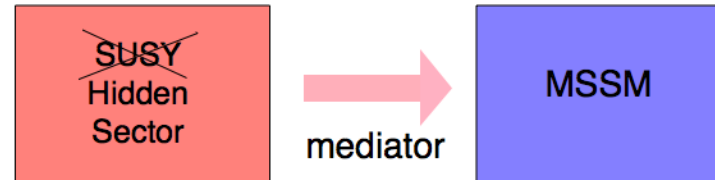


⇒ There are dark matter particles beyond the SM

– Searching for sub-GeV scale hidden-sector particles ... –

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– Dark matter particles χ may reside in the hidden sector

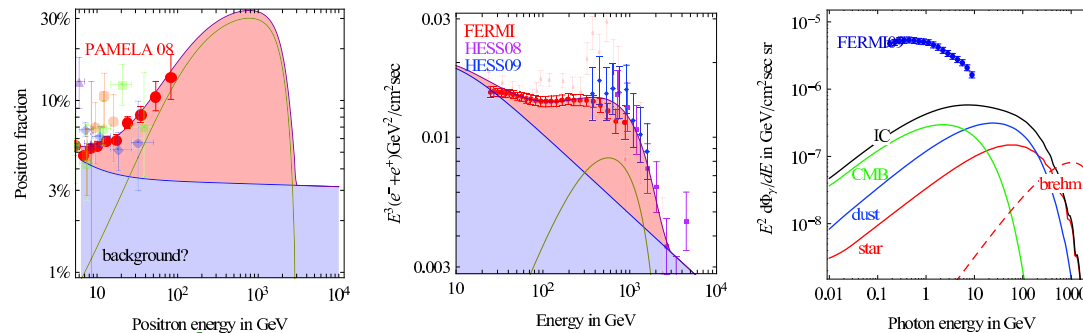


– χ may be charged under hidden sector U(1)

!!! Sub-GeV scale hidden-sector U(1) dark gauge boson γ'

* may explain cosmic ray electron and/or positron excesses observed by PAMELA, FERMI, ... in terms of annihilation $\chi + \chi \rightarrow \gamma' + \gamma' \rightarrow 4\mu$

DM with $M = 3$ TeV that annihilates into 4μ with $\sigma v = 8.8 \times 10^{-23} \text{ cm}^3/\text{s}$



[Arkani-Hamed, Finkbeiner, Slatyer, Weiner '08; ...; Meade, Papucci, Strumia, Volansky '09]

* predicted in asymmetric dark matter models

[An, Chen, Mohapatra, Zhang '09]

– Searching for sub-GeV scale hidden-sector particles ... –

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- Search for sub-GeV hidden photon γ' very hot topic:

Dark Forces Workshop

SEARCHES FOR NEW FORCES AT THE GeV-SCALE

[Home](#)
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[Program](#)
[Organizers](#)
[Participant List](#)
[Accommodations](#)
[General Information](#)
[Travel and Directions](#)
[Visa Information](#)
[Contact](#)



Dark Forces Workshop

Credit: source images used courtesy of CERN and V. Springel et al./Millennium Simulation

REGISTRATION

This meeting is free to registered participants. Registration is necessary to participate in the workshop.

[» Register](#)

ACCOMMODATIONS

Please reserve your room early at Stanford Guest House.

[» More Information](#)

Searches for New Forces at the GeV-scale

Date/Time: September 24th to 26th, 2009.
– Thu : from 8:30am to 6:00pm
– Fri : from 9:00am to 6:00pm
– Sat : from 9:00am to 5:00pm
Location
Building: 48 ROB A/B/C/D
SLAC National Accelerator Laboratory
Menlo Park, California

Theoretical models related to dark matter have proposed that there are long-range forces mediated by new gauge bosons with masses in the MeV to GeV range and very weak coupling to ordinary matter. The experimental constraints on the existence of these new gauge bosons are quite weak. This workshop will bring together theorists and experimentalists to stimulate progress in searching for these "dark forces" in three arenas:

1. new fixed-target experiments at electron and proton accelerators such as JLab, SLAC, and Fermilab;
2. searches at high-luminosity e^+e^- experiments, including BaBar, BELLE, CLEO-c, KLOE, and BES-III;
3. searches at the Tevatron experiments.

– Searching for sub-GeV scale hidden-sector particles ... –

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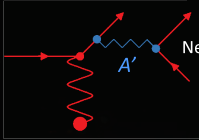
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Workshop

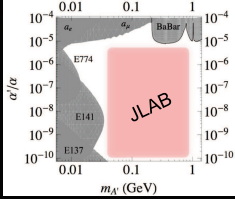
SEARCHING FOR A NEW GAUGE BOSON AT JLAB

Experimental search for a dark force carrier at GeV scales

September 20-21, 2010
Jefferson Lab
Newport News, VA, USA



Organizing Committee:
Andrei Afanasev (Hampton U/JLab)
Rouven Essig (SLAC)
Peter Fisher (MIT)
John Jaros (SLAC)
Stepan Stepanian (JLab)
Bogdan Wojtsekhowski (JLab, Chair)



Jefferson Lab

Jefferson Science Associates, LLC

Meeting webpage:
<http://conferences.jlab.org/boson2010/>

A. Ringwald (DESY)

DESY, June 2010

- **Attacking Dark Forces with New Fixed-Target Experiments**

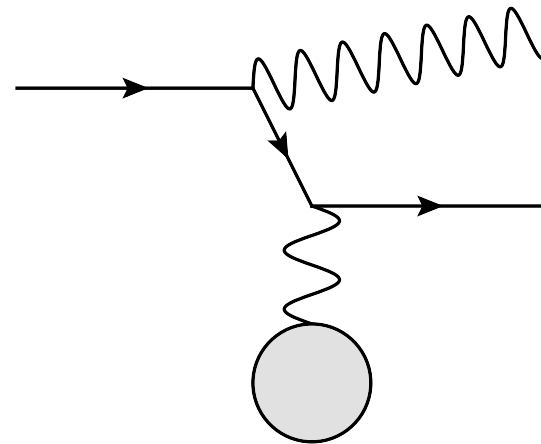
[Reece,Wang'09;Bjorken,Essig,Schuster,Toro'09;Batell,Pospelov,Ritz'09;Andreas,Lebedev,Ramos-Sanchez,AR in prep.]

- Production mechanism in eN scattering: Bremsstrahlung,

$$\sigma \sim \frac{\alpha^3 Z^2 \chi^2}{m_{\gamma'}^2}$$

⇐ electron has charge χe
under the hidden $U(1)$

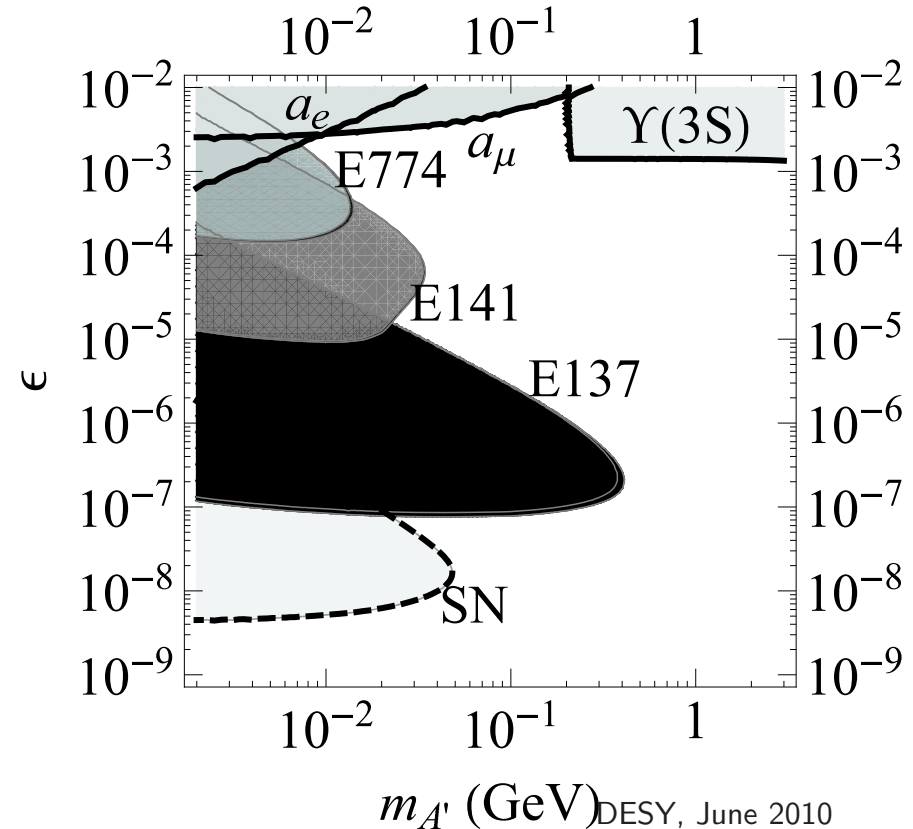
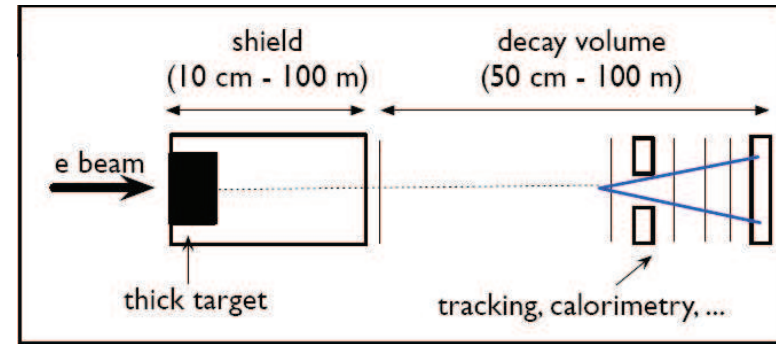
* kinetic mixing parameter χ
expected to lie in range
 $10^{-11} \lesssim \chi \lesssim 10^{-2}$



• Past beam dumps:

[Bjorken, Essig, Schuster, Toro '09]

- SLAC E137:
30 C, 20 GeV, 200 m, 200 m
- SLAC E141:
.3 mC, 9 GeV, 10 cm, 35 m
- Fermilab E774:
.8 nC, 275 GeV, 30 cm, 7 m



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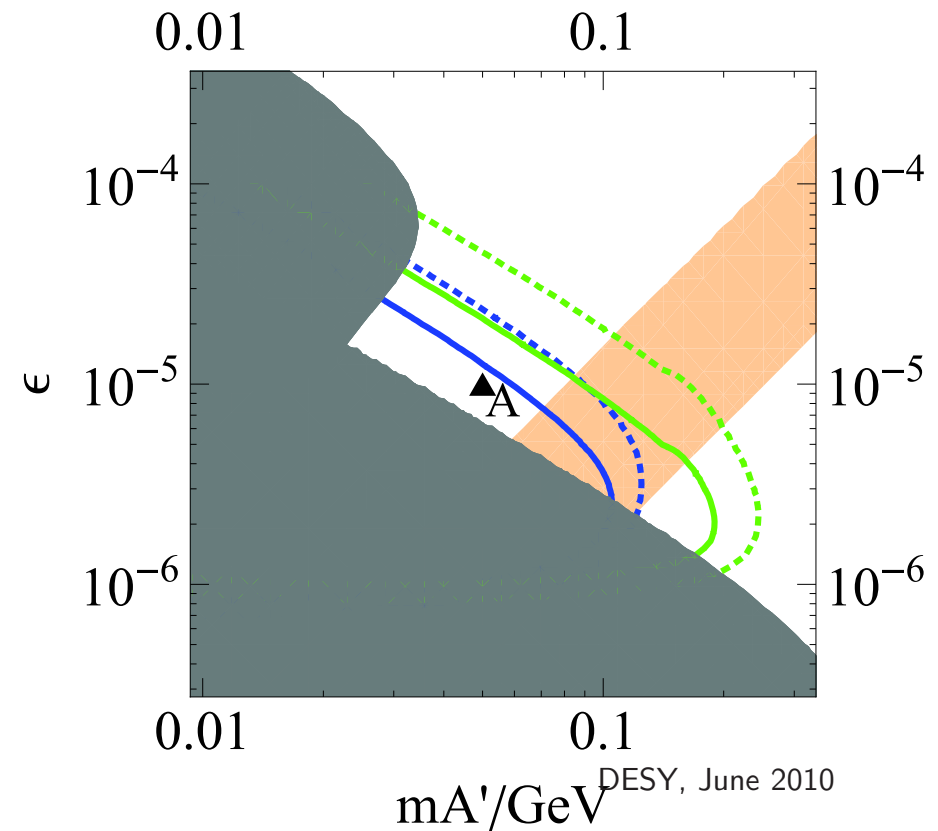
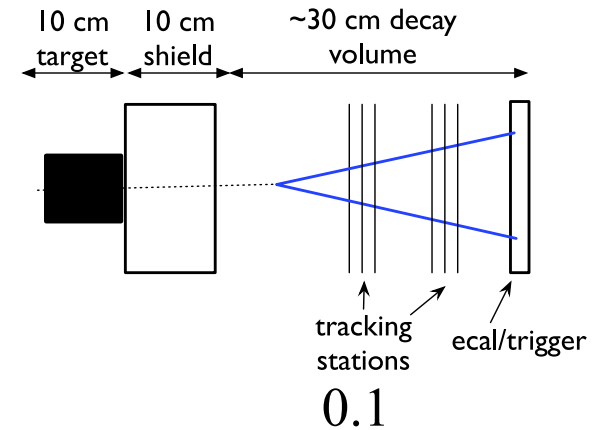
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• New beam dump suggested:

[Bjorken,Essig,Schuster,Toro '09]

- Low power W beam dump
.3 C, 200 MeV, 20 cm, 50 cm
.1 C, 6 GeV, 3.9 m, 7 m



– Searching for sub-GeV scale hidden-sector particles ... –

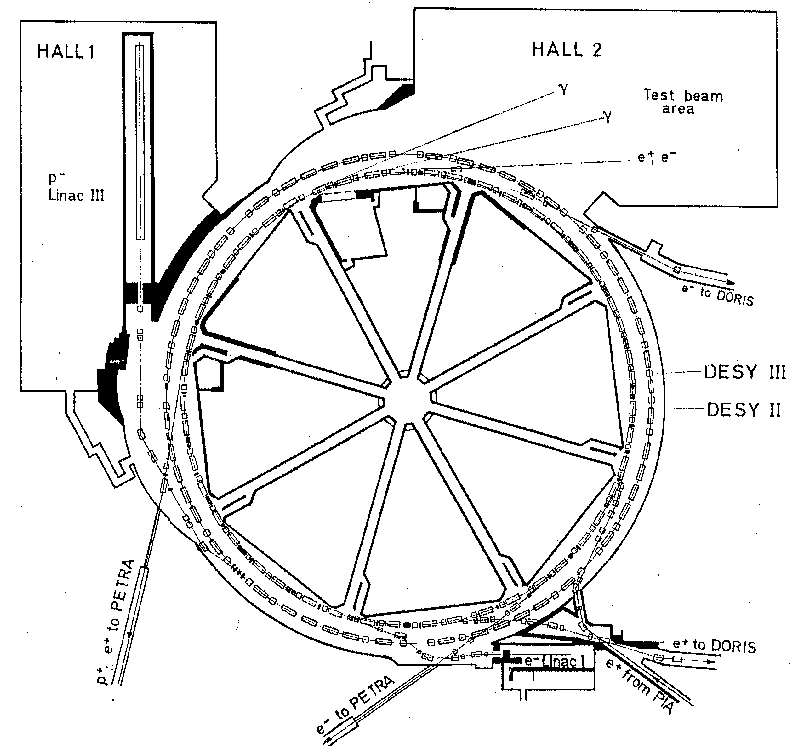
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- New experiment at **DESY**?

- **HIPS** at **DESY II**

[Andreas, Bechtle, Ehrlichmann, Garutti, Gregor, Lindner, Meyners, Redondo, AR]

* ~ 10 nA with 0.45 - 7 GeV



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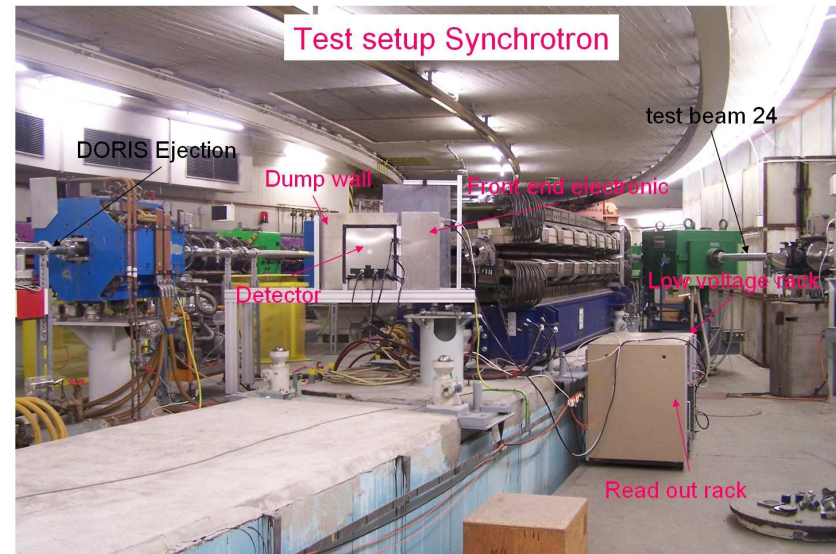
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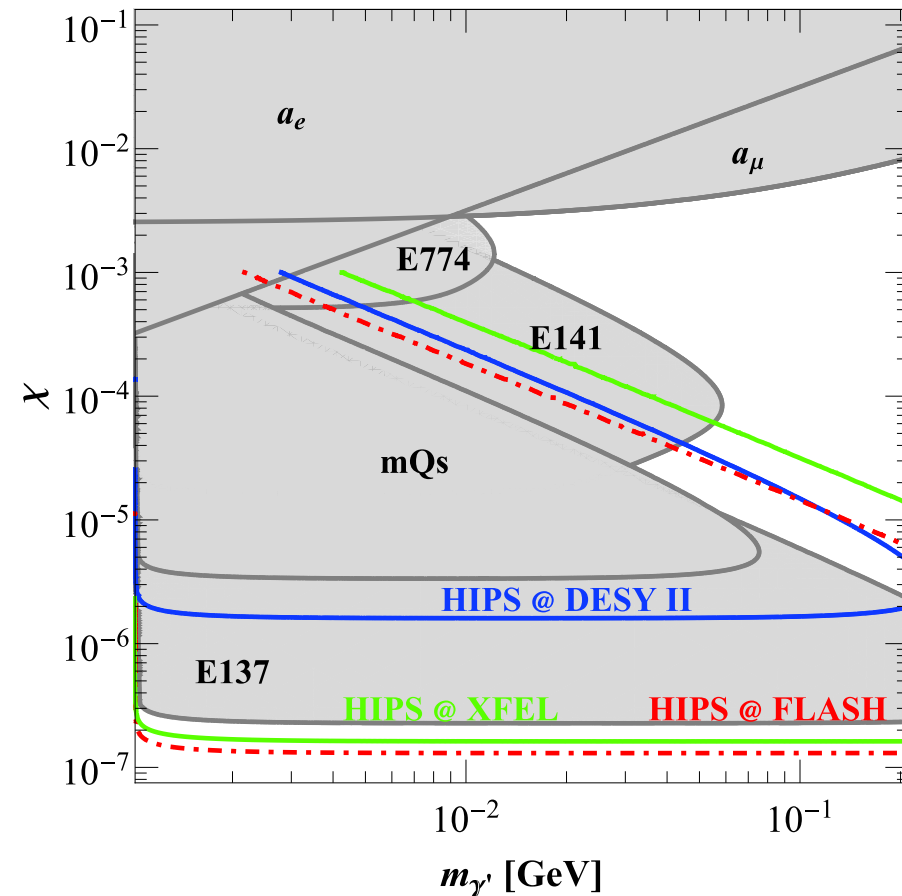


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- * ~ 10 nA with 0.45 - 7 GeV
- * detector (spare parts of H1) installed in January
- * if background handable, full proposal in Summer; experiment can be started in 2010
- * first estimates of beam dump sensitivity
- * parasitic use of **FLASH** and **XFEL** beam dump increases sensitivity

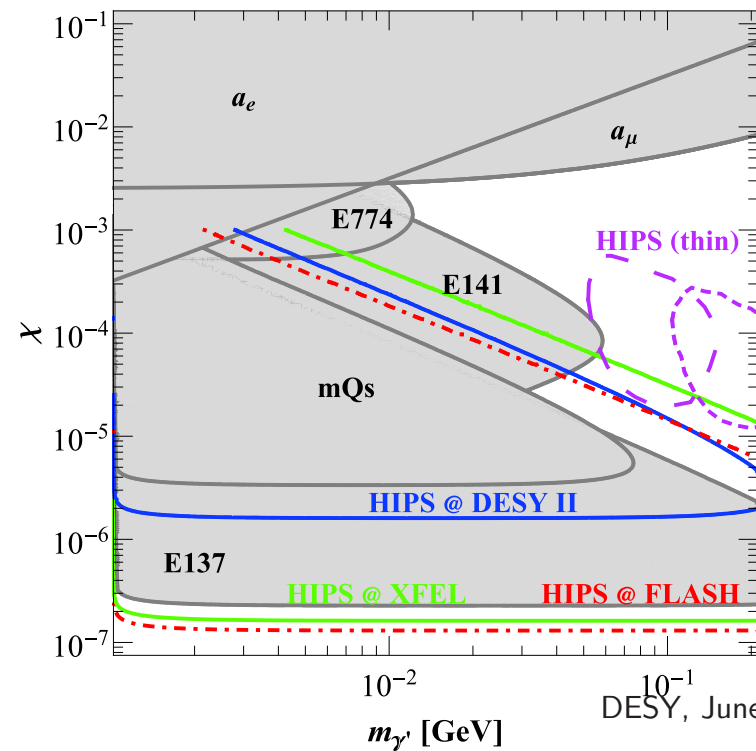
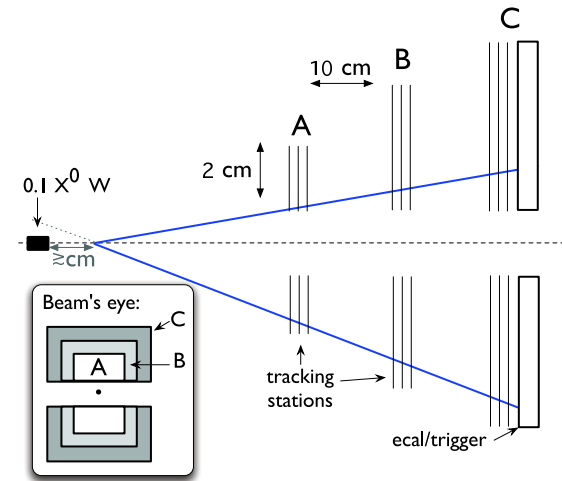


- **Thin-target suggestions:**

[Bjorken, Essig, Schuster, Toro '09]

- Thin target, double arm spectrometer

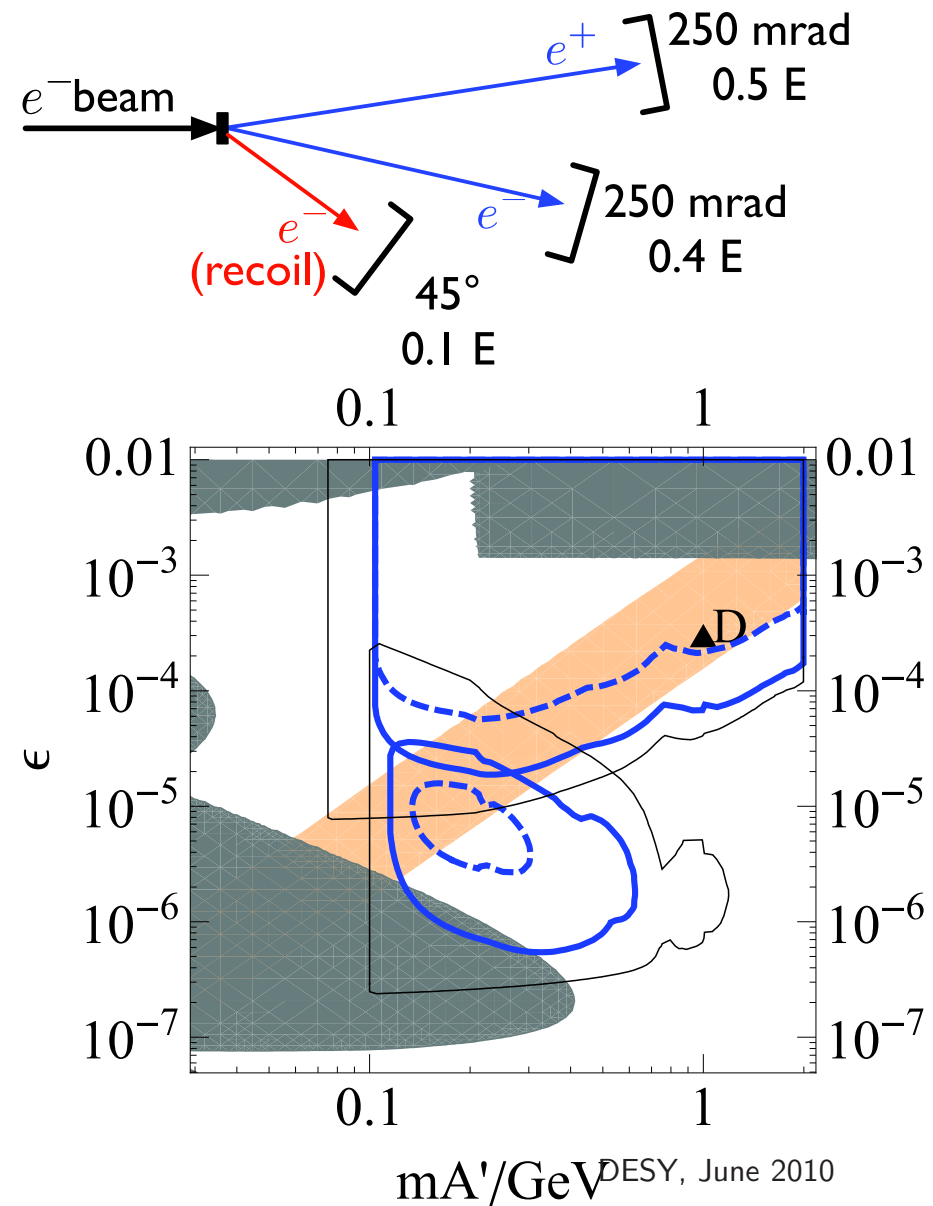
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- **Thin-target suggestions:**

[Bjorken, Essig, Schuster, Toro '09]

- Thin target, double arm spectrometer
0.1 C, 6 GeV, 20-55 mrad
 - High resolution, high rate trident spectrometer
 $\sim 100 \mu\text{A}$, 6 GeV
- $\Rightarrow$ proposed by CEBAF Hall A Collaboration at JLab

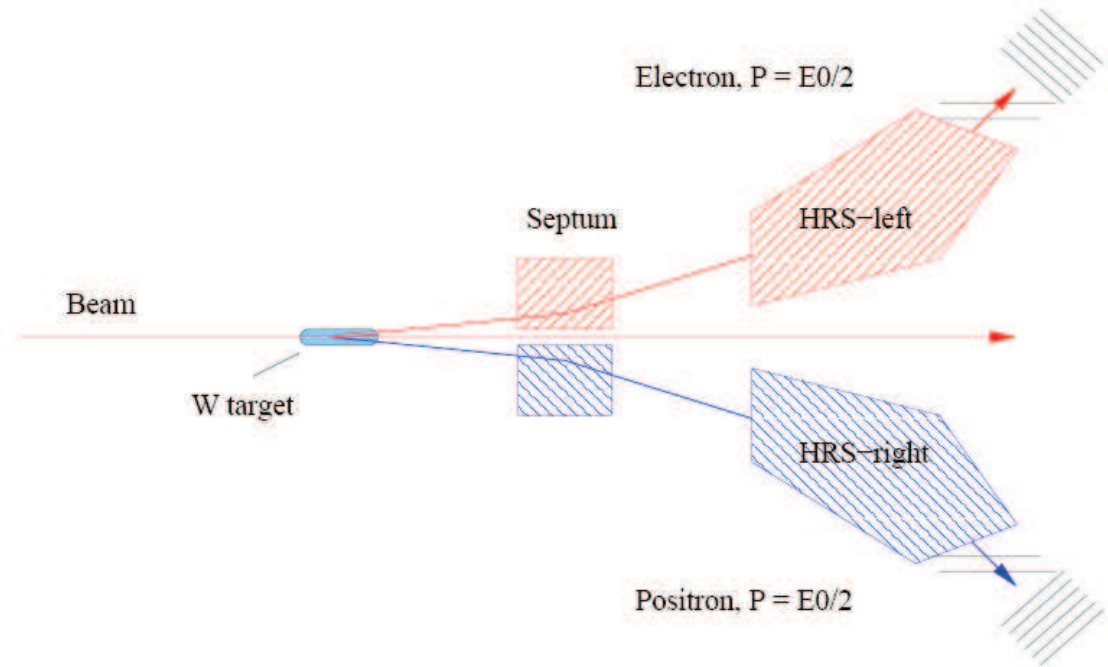


⇒ **New experiment at JLab?**

– **Fixed-target experiment in CEBAF Hall A**

[Hall A Collaboration]

- * $80 \mu\text{A}$ at $2 \div 4 \text{ GeV}$
- * proposed for period after CEBAF upgrade, but first short run in Summer 2010

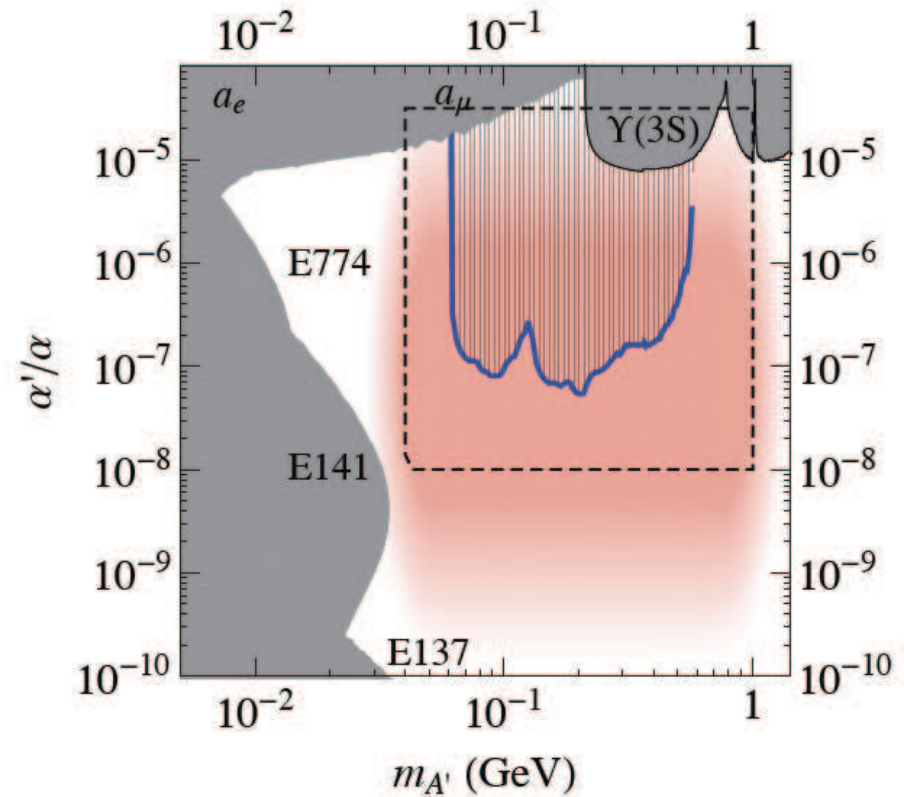


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Conclusions

- Strong physics motivation for the possible existence of GeV-scale hidden photons:
 - bottom up: anomalies associated with dark matter
 - top down: many hidden $U(1)$ s in string compactifications
 - Fixed-target experiments well suited to attack dark forces
 - Large parameter space requires multiple search strategies and experiments
 - low coupling/mass: new beam dump experiments
 - intermediate region: new forward-geometry experiments
 - high coupling/mass: standard wide-angle spectrometers (as in [JLab](#))
- ⇒ Great opportunities for parasitic particle physics experiments at the high intensity frontier at [DESY](#)! Could compete with [CEBAF](#) at [JLab](#)!
- ⇒ **Need access to the electron beams before they are dumped!!!!**
- ⇒ Multi-user facility: HIPS, QCD tests, detector tests, ...