Overview

Where we've come from and where we're headed…….

- Where is the Dark Matter?
- DarkLight
- CEBAF Injector experiment

Building Blocks of Matter 2018

1968: SLAC u up quark	1974: Brookhaven & SLAC c charm quark	1995: Fermilab t top quark	1979: DESY g gluon
1968: SLAC d down quark	1947: Manchester University s strange quark	1977: Fermilab b bottom quark	1923: Washington University* γ photon
1956: Savannah River Plant ν_e electron neutrino	1962: Brookhaven ν_μ muon neutrino	2000: Fermilab ν_τ tau neutrino	1983: CERN W *W* boson
1897: Cavendish Laboratory e electron	1937 : Caltech and Harvard μ muon	1976: SLAC τ tau	1983: CERN Z *Z* boson

2012: CERN
H

+

1915: Berlin
Einstein gravity

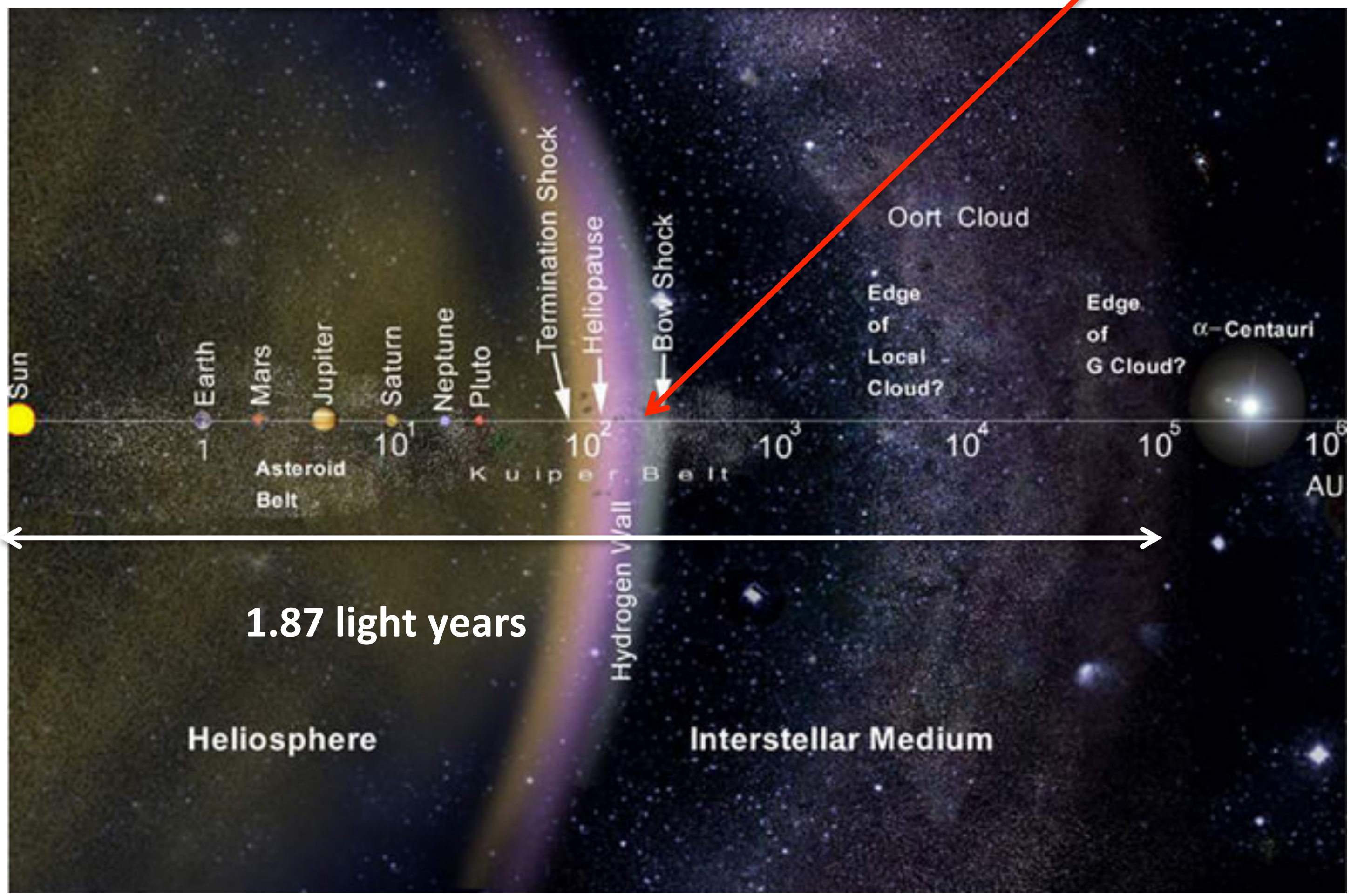
2015: LIGO
Detection of gravitational waves

Milner's Empirical Rule: Scales of 10^5

- Reduction
  - Human scale 1m
  - 10^{-5} m sheet of household aluminum foil
  - 10^{-10} m size of an atom
  - 10^{-15} m size of a proton
- Expansion
  - Earth radius 4,000 miles (64×10^5 m)
  - Earth-Sun distance 1 AU (93 million miles)
  - Size of Solar System: 10^5 AU ≈ 1 light year
  - Size of Milky Way Galaxy: 10^5 light year
  - Size of Universe: 10^{10} light year (10^{26} m)

Solar System

Location of Voyager 1
Launched 1977



Fritz Zwicky

1898-1974

At Caltech, since 1925.

Fritz Zwicky was the first ~~astronomer~~ physicist to propose the existence of dark matter, supernovas, neutron stars, galactic cosmic rays, gravitational lensing by galaxies, and galaxy clusters. However, his peers generally ignored his predictions and observations. He has been called "*the most unrecognized genius of twentieth century astronomy*" by many, and remains virtually unknown to the public to this day.

The Redshift of Extragalactic Nebulae

F. Zwicky, Helvetica Physica Acta, **6**, 110 (1933)

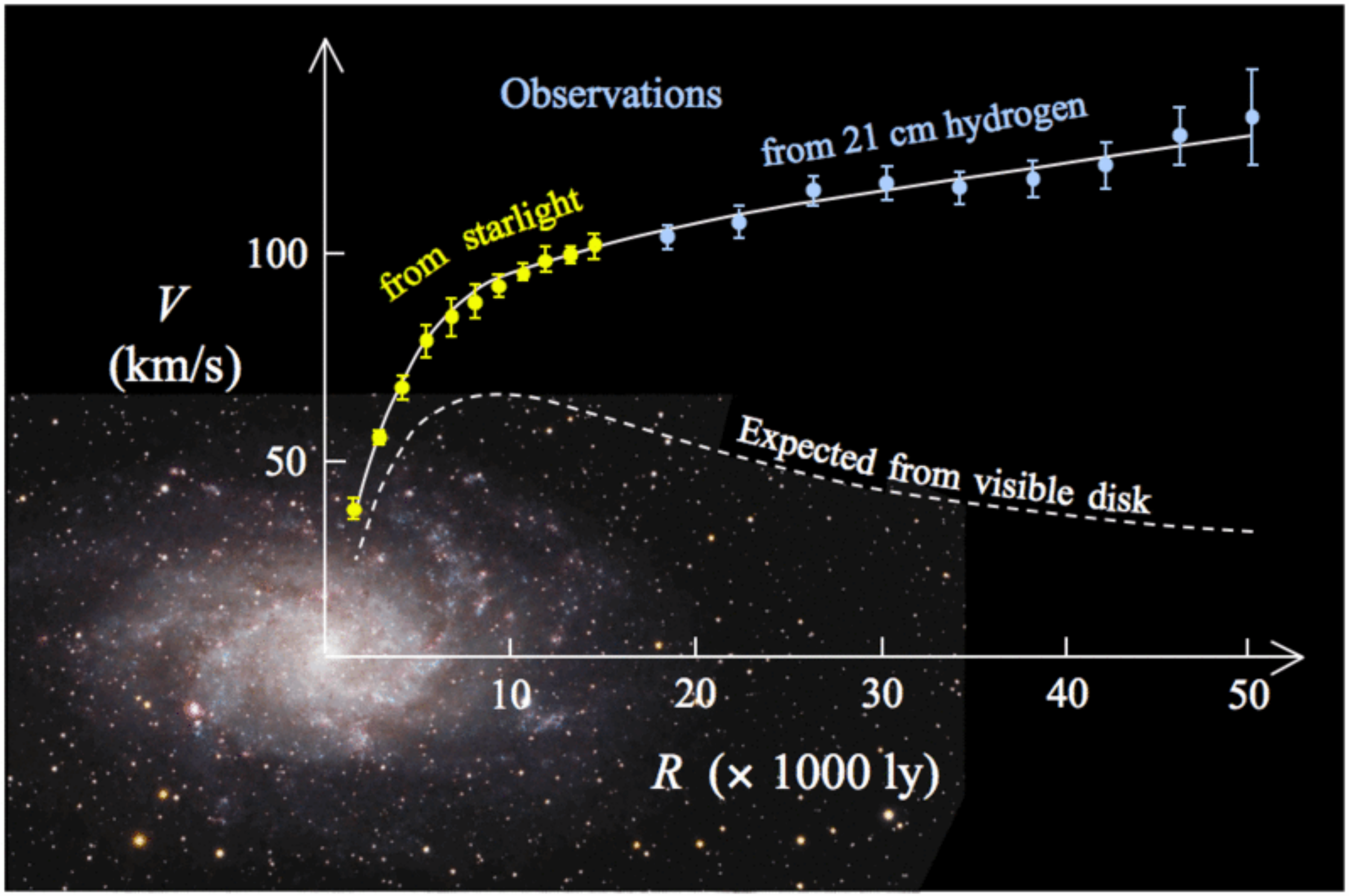
…..dunkle Materie…..

http://discovermagazine.com/2009/jan/30-the-father-of-dark-matter-still-gets-no-respect

Rotation Curve of Disc Galaxy M33

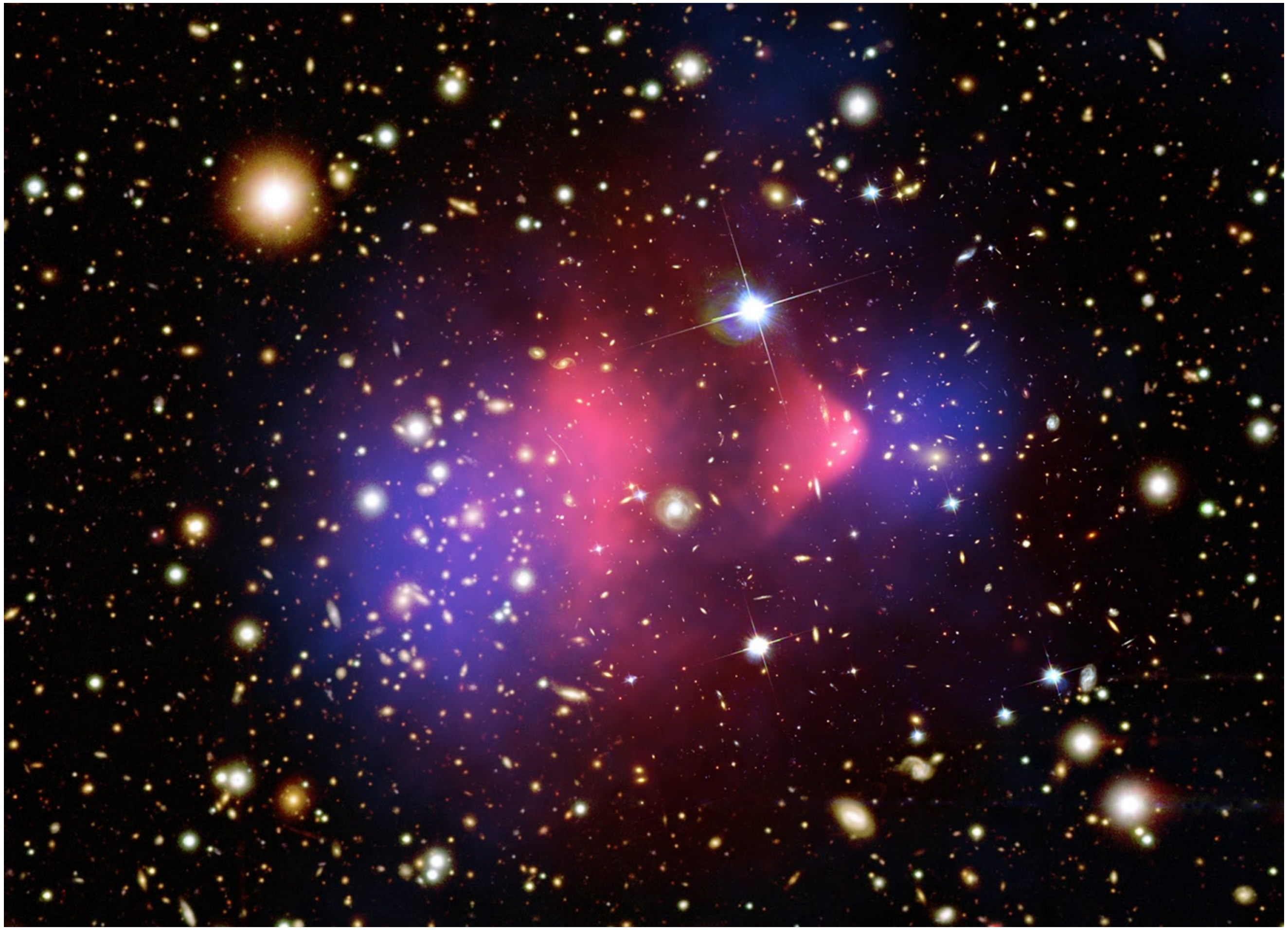
Size of M33 galaxy: 60,000 light years

1930s: Oort, Zwicky
1960s: Rubin



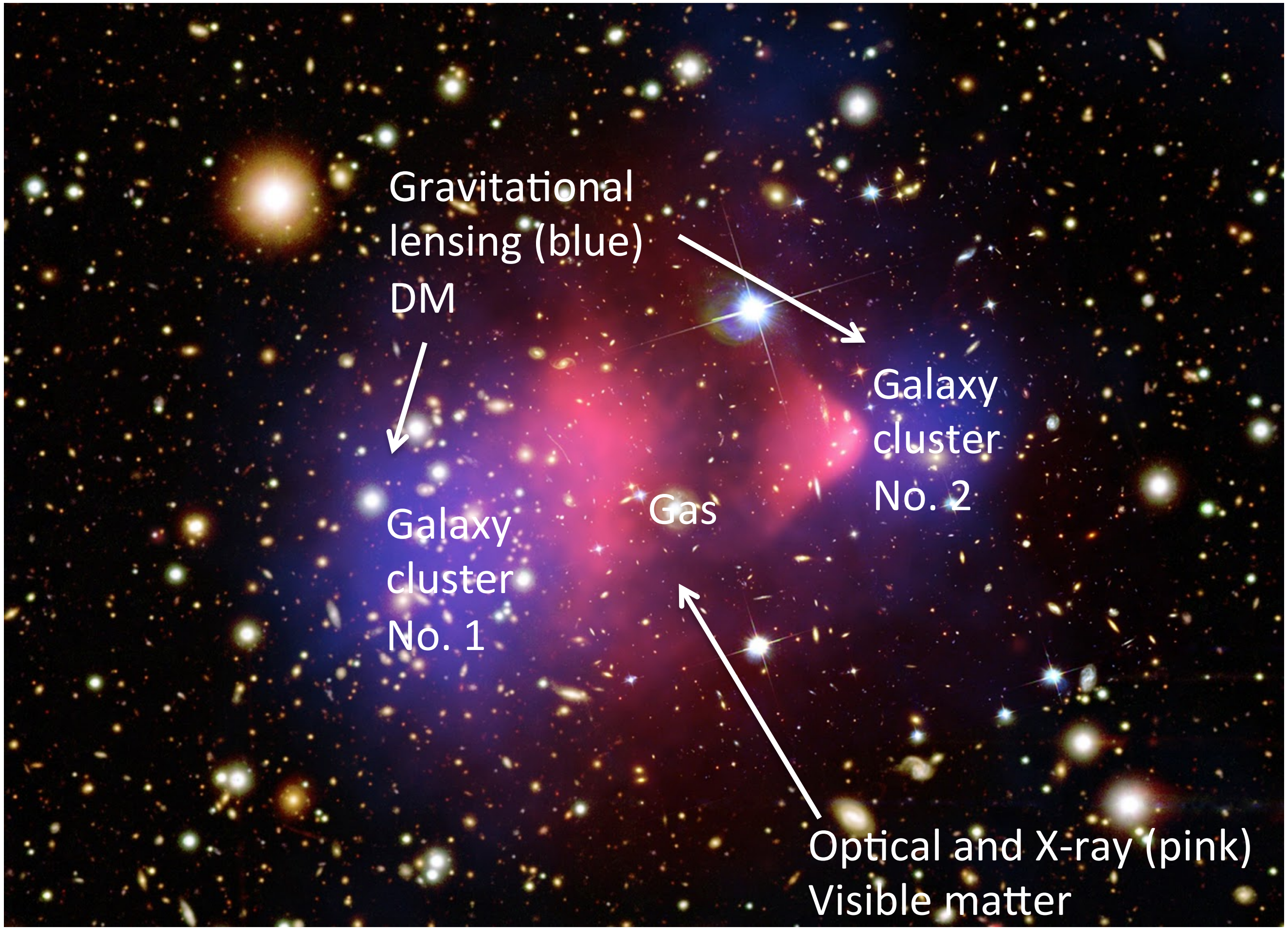
Bullet Cluster: Two Colliding Clusters of Galaxies

Hubble/Chandra/Magellan 2004



Bullet Cluster: Two Colliding Clusters of Galaxies

Hubble/Chandra/Magellan 2004



Evidence for Dark Matter

"Dark matter" refers to a substance of largely unknown composition that shapes the universe on galactic distance scales (>1 kpc). The evidence for dark matter all comes from its interactions with leptons and baryons via gravity.

1 parsec = 3.26 light years
= 3.086×10^{13} km
Size of Milky Way = 100,000 light years
= 30 kpc

- Velocities of galaxies in clusters
- Galactic rotation curves
- Baryon acoustic oscillations
- High redshift supernovas
- Cosmic microwave background temperature fluctuations
- Galactic evolution simulations
- Gravitational lensing

The collective evidence is substantial and consistent across seven orders of magnitude in distance (1 kpc to 10 Gpc).

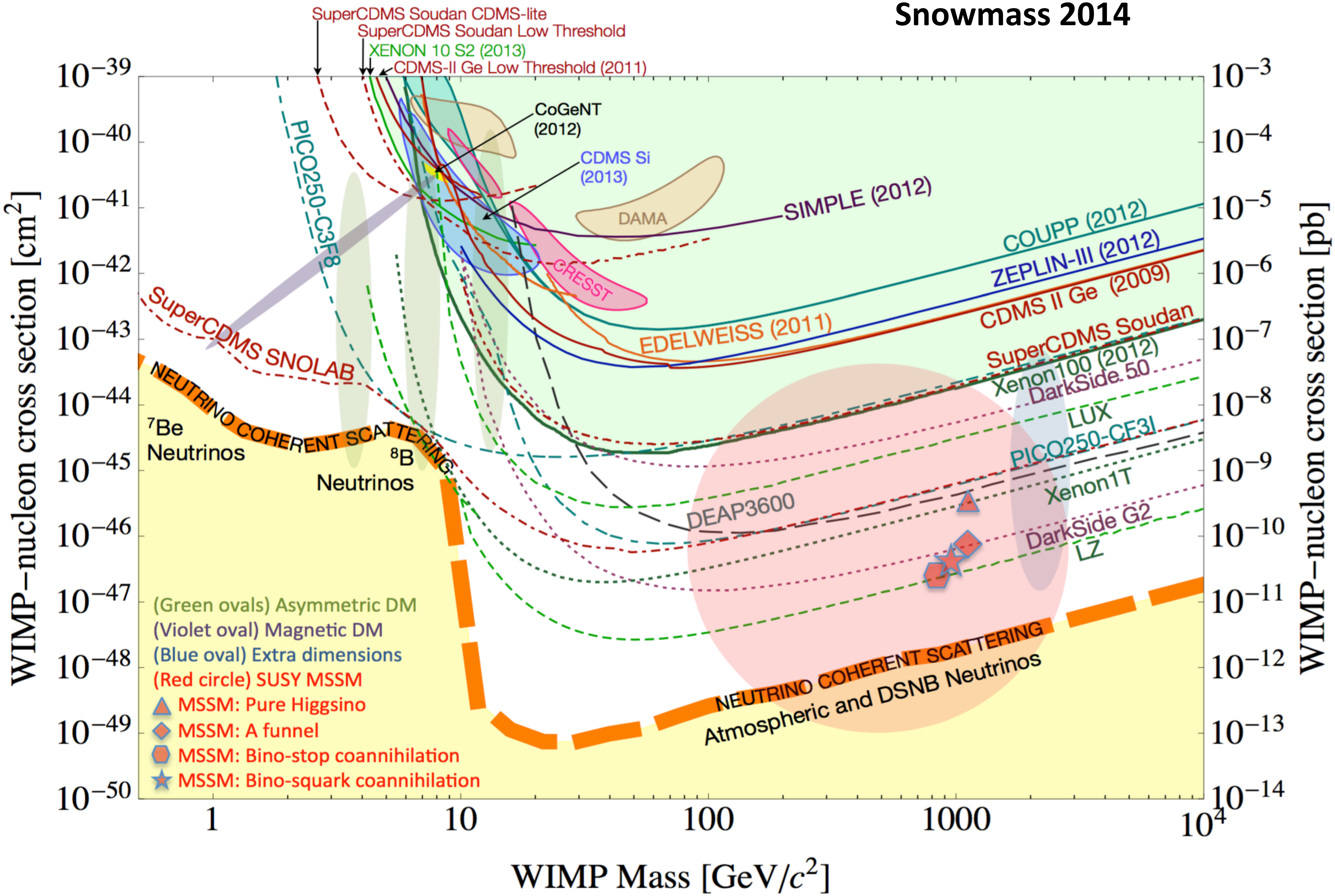
What we believe

Eighty years of astronomy tells us:

- Dark matter interacts gravitationally.
- Dark matter's non-gravitational interaction strength is of order weak or less.
- There must be some interaction between dark matter and baryons (beside gravity) in order for dark matter to be in equilibrium with other matter in the early universe.
- The local dark matter density is of order 0.3 GeV/cm^3.
- $\beta \approx 0.001$, approximate virial velocity in the galaxy.
- Dark matter does not form tightly bound systems larger than 10^4 solar masses.
- Dark matter accounts for about 25% of the matter in the universe

Aside from this, many theoretical ideas based on general principles and symmetries motivate **W**eakly **I**nteracting **M**assive **P**articles (WIMPs).

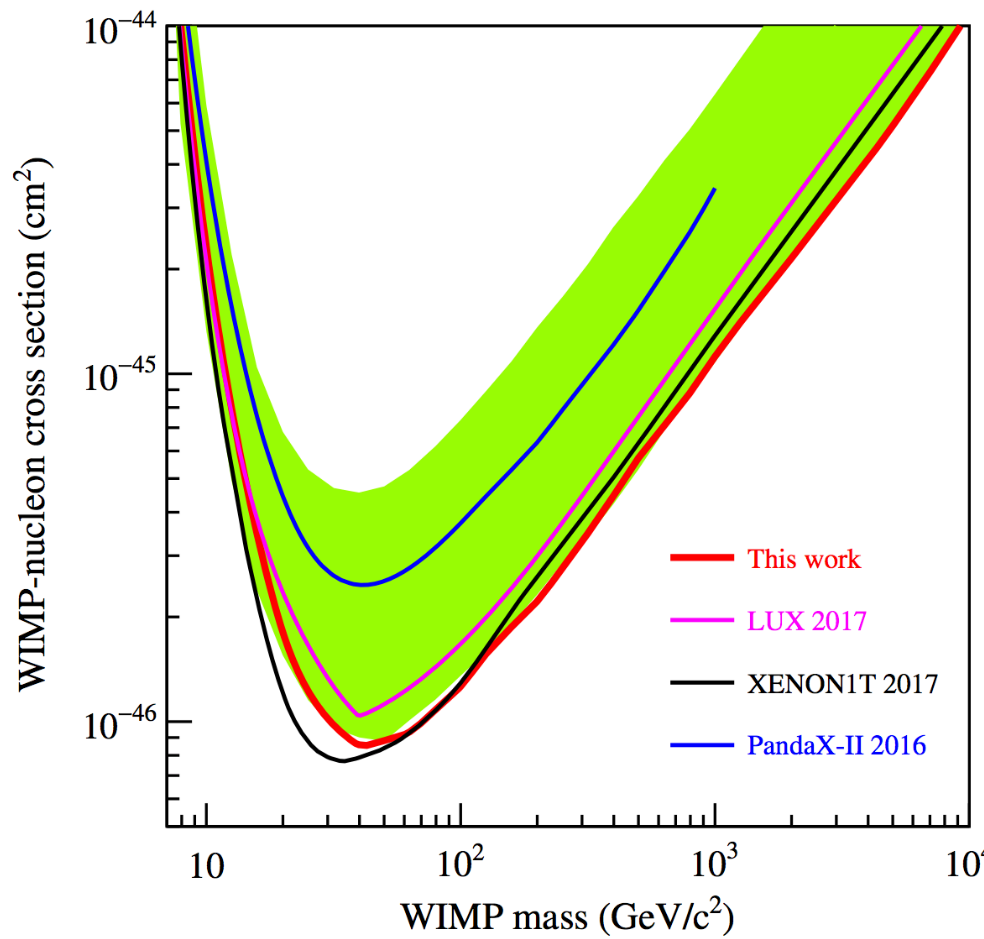
Snowmass 2014



Dark Matter Results from 54-Ton-Day Exposure of PandaX-II Experiment

Xiangyi Cui *et al.* (PandaX-II Collaboration)
Phys. Rev. Lett. **119**, 181302 – Published 30 October 2017

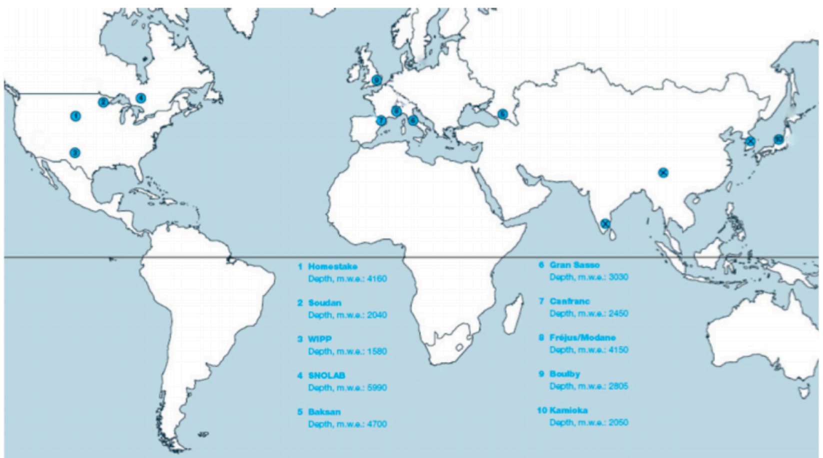
Jinping Underground Laboratory, China

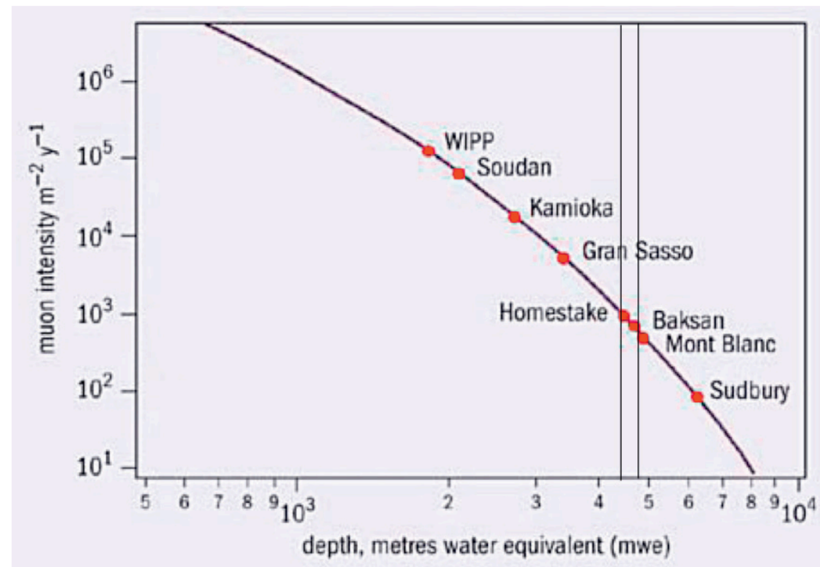


ANDES: an Underground Laboratory in South America

Claudio Dib

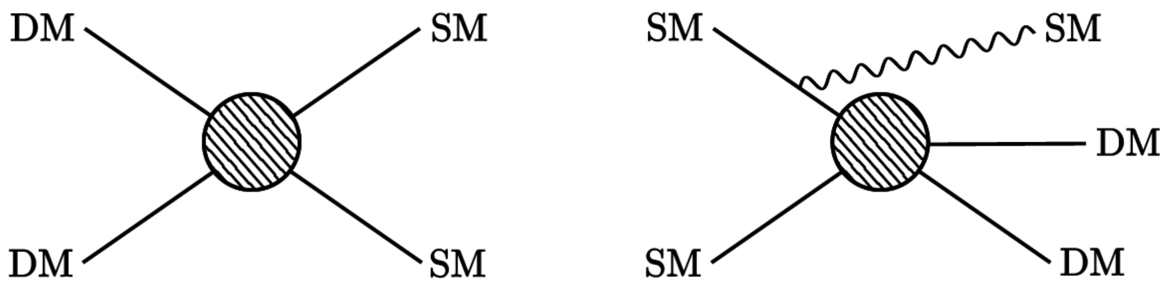
Agua **N**egra **D**eep **E**xperiment **S**ite in tunnel at Chile-Argentina border
1750 meters under the rock
First underground laboratory in Southern Hemisphere
International Laboratory managed by Latin American Consortium





Neutrino physics
Dark matter searches
Geophysics/Geology/Seismology
Biology
Nuclear Astrophysics

Searching for Dark Matter at LHC



Early Universe thermal freeze-out

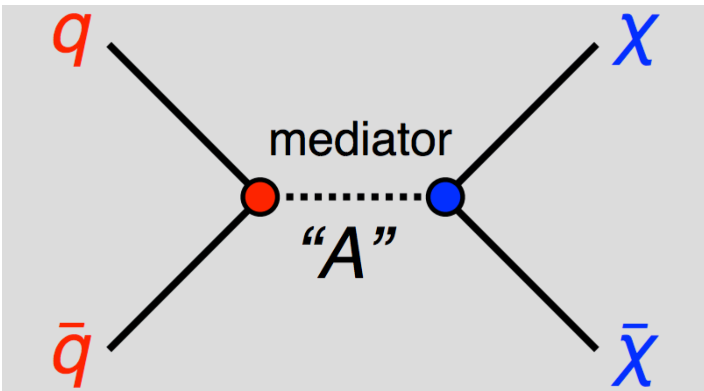
- DM particles in thermal equilibrium with SM states at high temperatures.
- Relic abundance is then set by the temperature at which the DM annihilation rate drops below the expansion rate of the Universe

$\Rightarrow$ the DM interactions become insufficient to maintain thermal equilibrium

$\Rightarrow$ the DM particles freeze out.

- New stable particles at the electroweak scale are central to models that attempt to address the gauge hierarchy problem, such as supersymmetry.
- If the DM mass is comparable to the electroweak scale (i.e. ≈ 100 GeV) and the coupling strength is comparable to that of the weak interactions, the required DM annihilation cross section can be obtained rather naturally.

Experimental Results

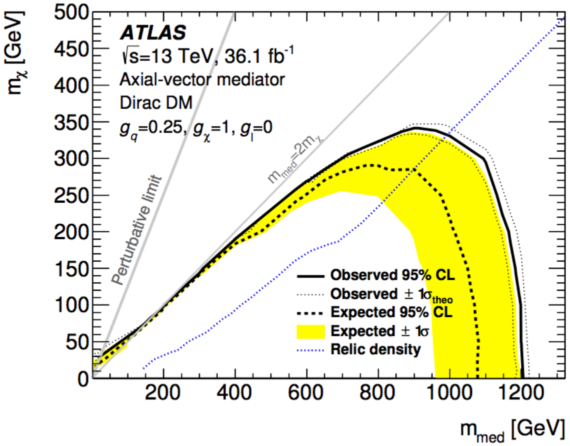


$$\sigma^{\rm sd}_{{\rm DM}\text{-}p} \sim \left(g_q \cdot g_{\rm DM} \cdot \frac{m_{{\rm DM}\text{-}p}}{(m_{\rm med})^2} \right)^2$$

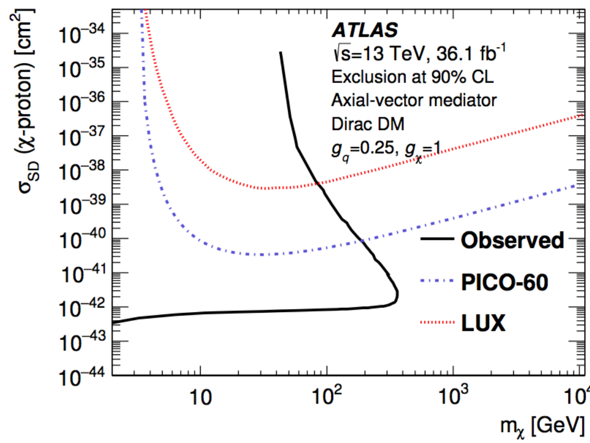
Mono object searches $$pp \to \chi\overline{\chi} + X$$

- Mono-photon, Mono-jet, Mono-Higgs

ATLAS Mono-Object Searches

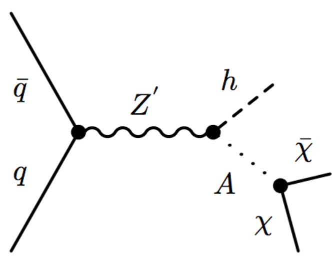


(c) Mono-photon exclusion [6]

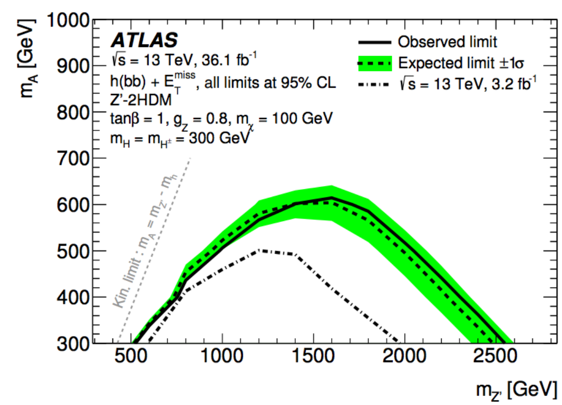


(d) Mono-photon exclusion [6]

T.M. Hong
1709.02304



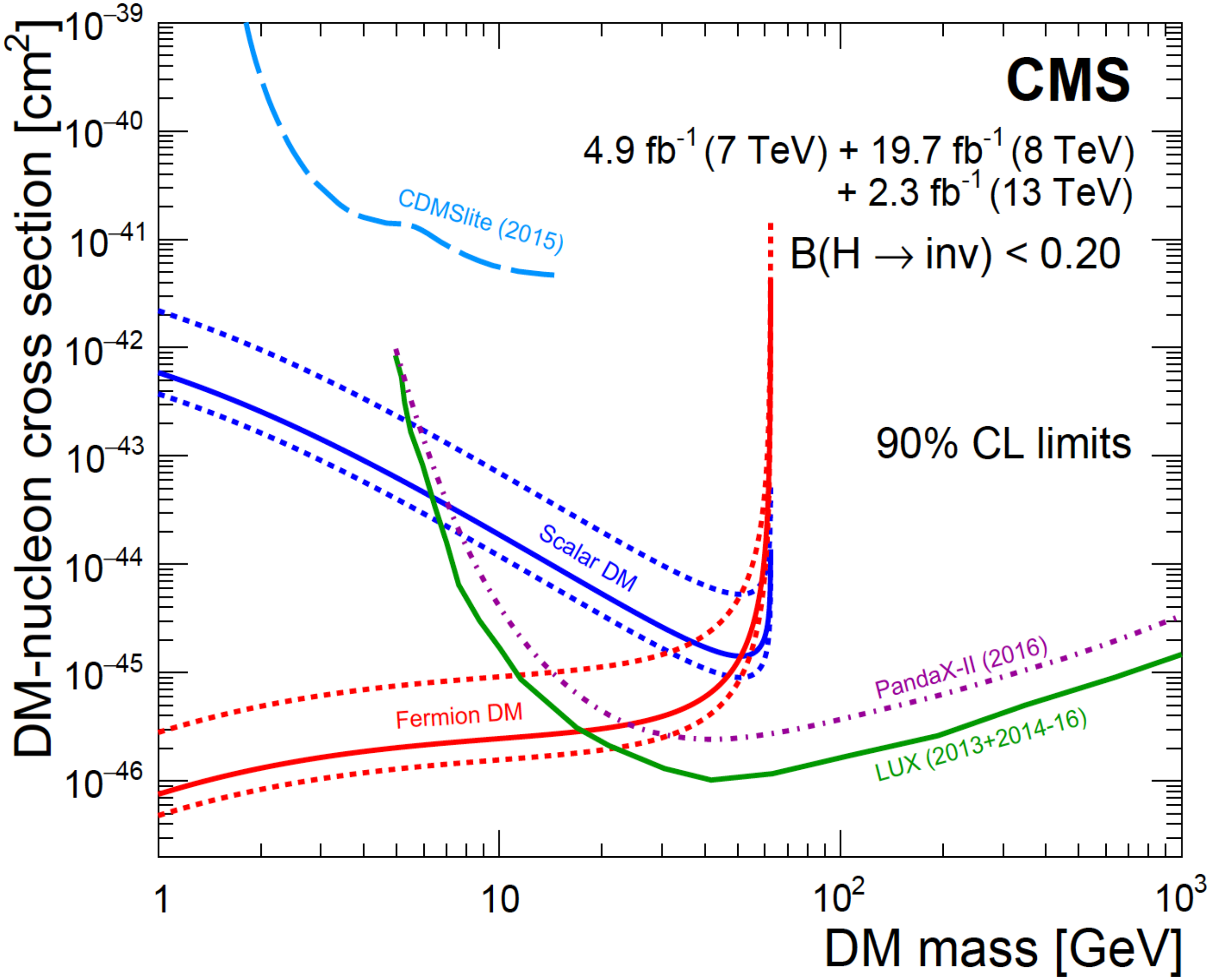
(e) Mono-Higgs diagram



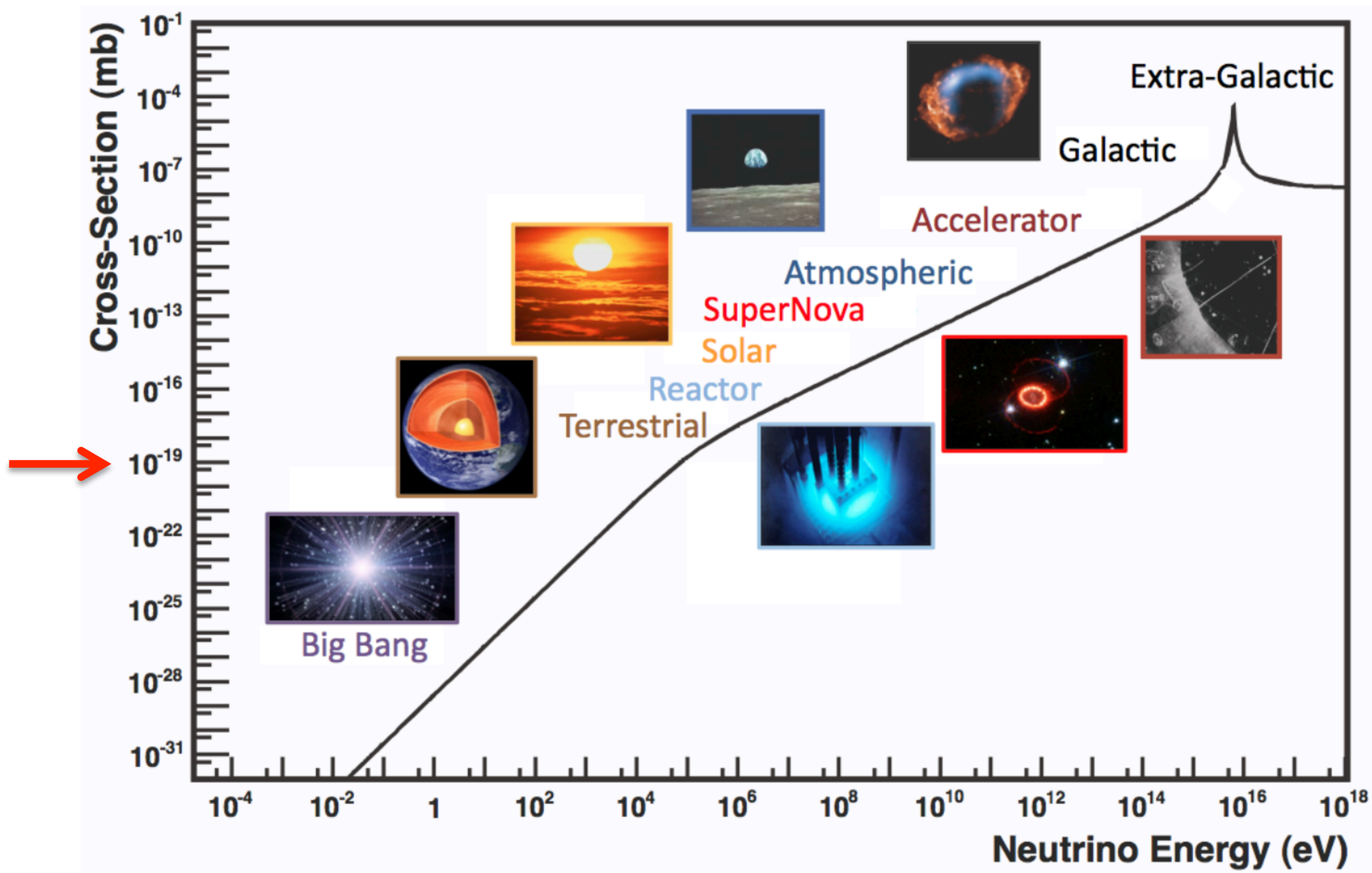
(f) Mono-Higgs exclusion [7]

Figure 3: Mono-object analyses: mono-jet (top row), mono-photon (middle row), mono-Higgs (bottom row).

Decay of the Higgs Boson to Invisible Final States



How Small is 10^{-46} cm^2?



Similar interaction strength to 10 keV neutrino

Search for New Physics in e^+e^- Final States in Elastic Electron-Proton Scattering at 100 MeV

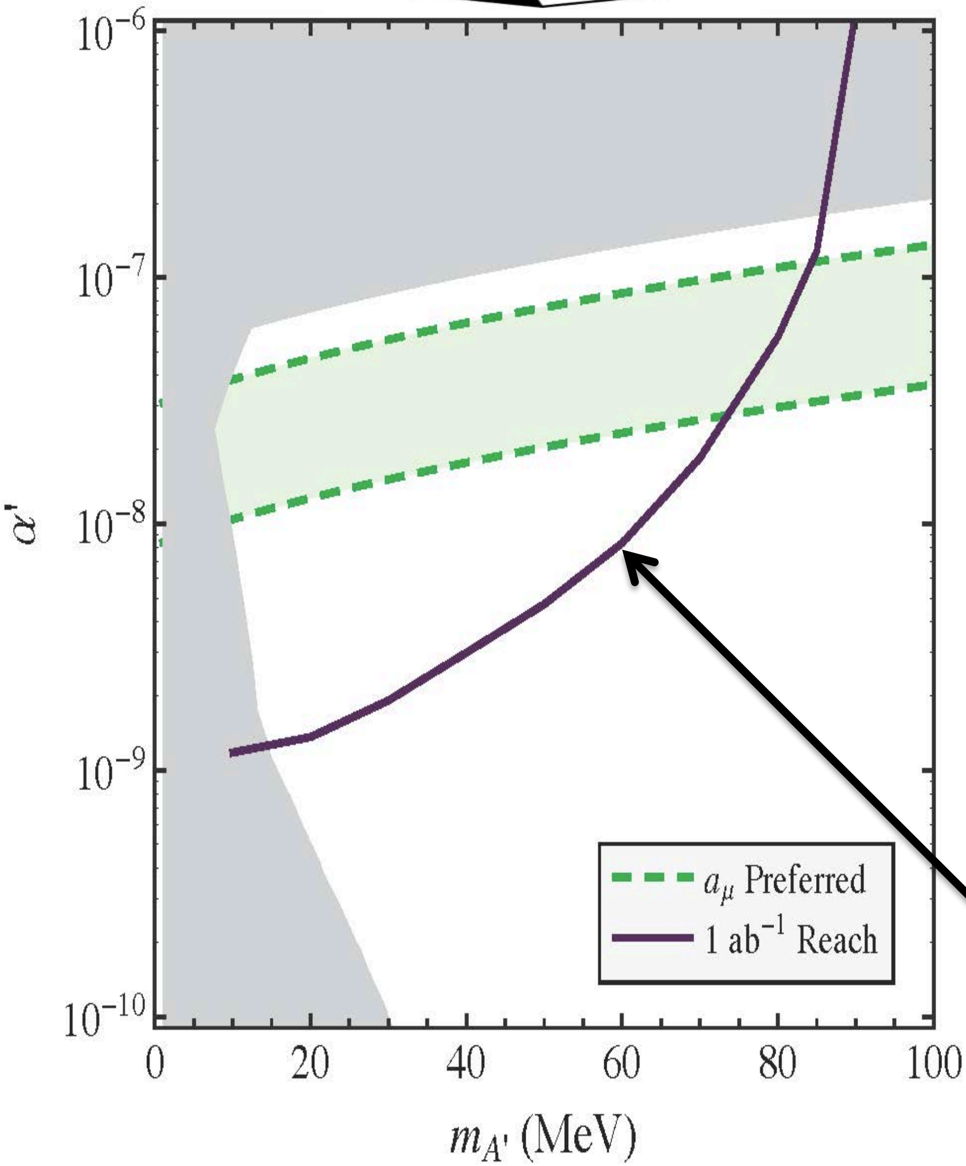
- Dark matter is heavy and the coupling to the SM **α'** is via a light gauge boson A'.
- The coupling is small.
- New theories of dark matter predict a force carrier of mass $\mathbf{m_{A'}}$ ≈10 to 1000 MeV that, in simplest consideration, couples like a photon via kinetic mixing.
- DarkLight is an experiment conceived at MIT to look for evidence of the A' via the process

  e+p -> e' + p + A' with A' -> $e^+ + e^-$ or -> $f + \bar{f}$ (invisible)
- DarkLight was initially proposed to use the JLab energy recovery linac. Successful test July 2012: PRL **111**, 164801 (2013).
- Full scientific approval with "A" rating in May 2013
- Phase I funded by NSF MRI in July 2014 ($ 1 million)

Astrophysical hints?

- The universe appears to be filled with cold, dark matter, which could be a relic particle that interacts through known forces or possibly via new forces beyond the Standard Model.
- There are several hints from astrophysical measurements of dark matter annihilation products, *e.g.*
  - WMAP haze: excess microwave emission around the galactic center
  - Cosmic positron energy distribution: may be sensitive to dark matter annihilation in the e^+ energy range of 10 to 1000 GeV (Turner and Wilczek 1990)
- Experiments are producing new data.

DARKLIGHT



M. Freytsis, G. Ovanesyan, and J. Thaler
JHEP 1001, 111 (2010)

- Huge worldwide effort to search for evidence of A': CERN, BNL, GSI, JLab,…
- No evidence to date.
- Mass-coupling parameter space excluded at 2σ.
- However, claim from ^{8}Be nuclear decay measurements of possible 17 MeV "particle".
- DarkLight planning to search in this mass region.
- DarkLight also planning an invisible search

5σ limit

NA-48: π^0 decay

$\varepsilon^2 = \alpha'/\alpha$

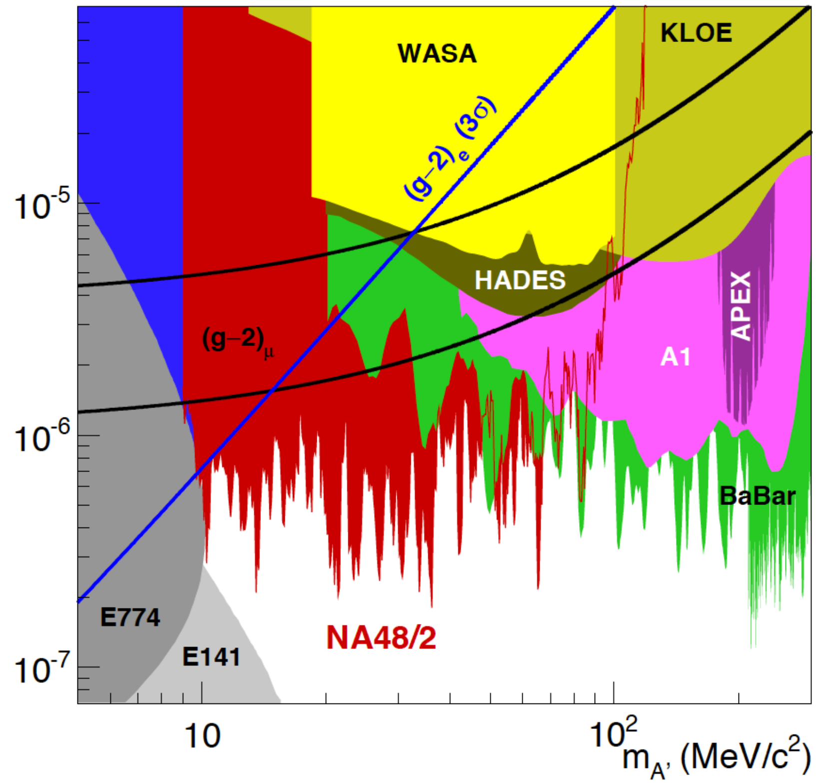
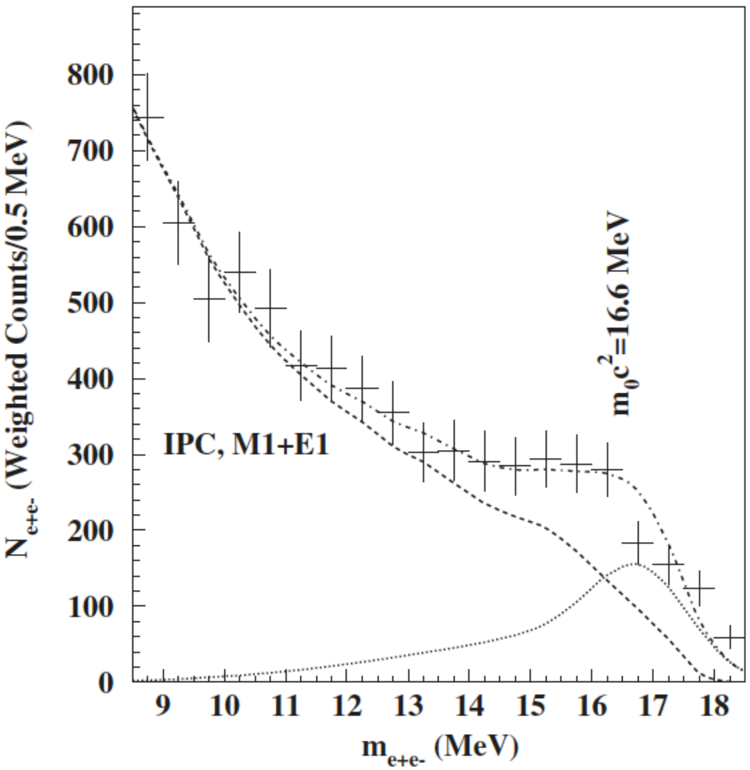


Figure 4: Obtained upper limits at 90% CL on the mixing parameter ε^2 versus the DP mass $m_{A'}$, compared to other published exclusion limits from meson decay, beam dump and e^+e^- collider experiments [15–21]. Also shown is the band where the consistency of theoretical and experimental values of muon $(g-2)$ improves to $\pm 2\sigma$ or less, as well as the region excluded by the electron $(g-2)$ measurement [2, 22].

DARKLIGHT Searches for a Fifth Force

- A’ exclusion limits are largely determined by π^0 decay.
- A’ produced via π^0 decay requires a coupling to quarks.
- It is not difficult to construct models where the quark-A’ couplings are suppressed and lepton-A’ couplings are enhanced.
- For example, a vector gauge boson *X* has been postulated which would mediate a fifth force with a characteristic range of 12 fm **Feng et al. PRL 117, 071803 (2016).**
- In this particular case, the A’ gauge field is *protophobic*, i.e. proton coupling is suppressed relative to neutron coupling.
- DarkLight is well suited to look for evidence of this X vector gauge boson.
- DarkLight can also search for evidence of the invisible decay A’ -> dark sector.
- Complementary to other planned measurements, e.g. LHCb.

Claim for anomaly at e^+e^- mass of 17 MeV



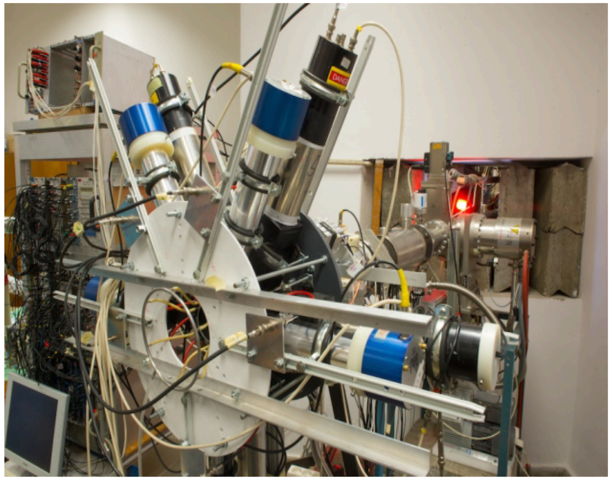
NATURE | NEWS

Has a Hungarian physics lab found a fifth force of nature?

Radioactive decay anomaly could imply a new fundamental force, theorists say.

Edwin Cartlidge

25 May 2016



MTA-Atomki

Physicists at the Institute for Nuclear Research in Debrecen, Hungary, say this apparatus — an electron-positron spectrometer — has found evidence for a new particle.

A.J. Krasznahorkay et al., Phys. Rev. Lett. 116, 042501 (2016)

Researchers should not have to wait long to find out whether a 17-MeV particle really does exist. The DarkLight experiment at the Jefferson Laboratory is designed to search for dark photons with masses of 10–100 MeV, by firing electrons at a hydrogen gas target. Now, says collaboration spokesperson Richard Milner of MIT, it will target the 17-MeV region as a priority, and within about a year, could either find the proposed particle or set stringent limits on its coupling with normal matter.

Beryllium-8

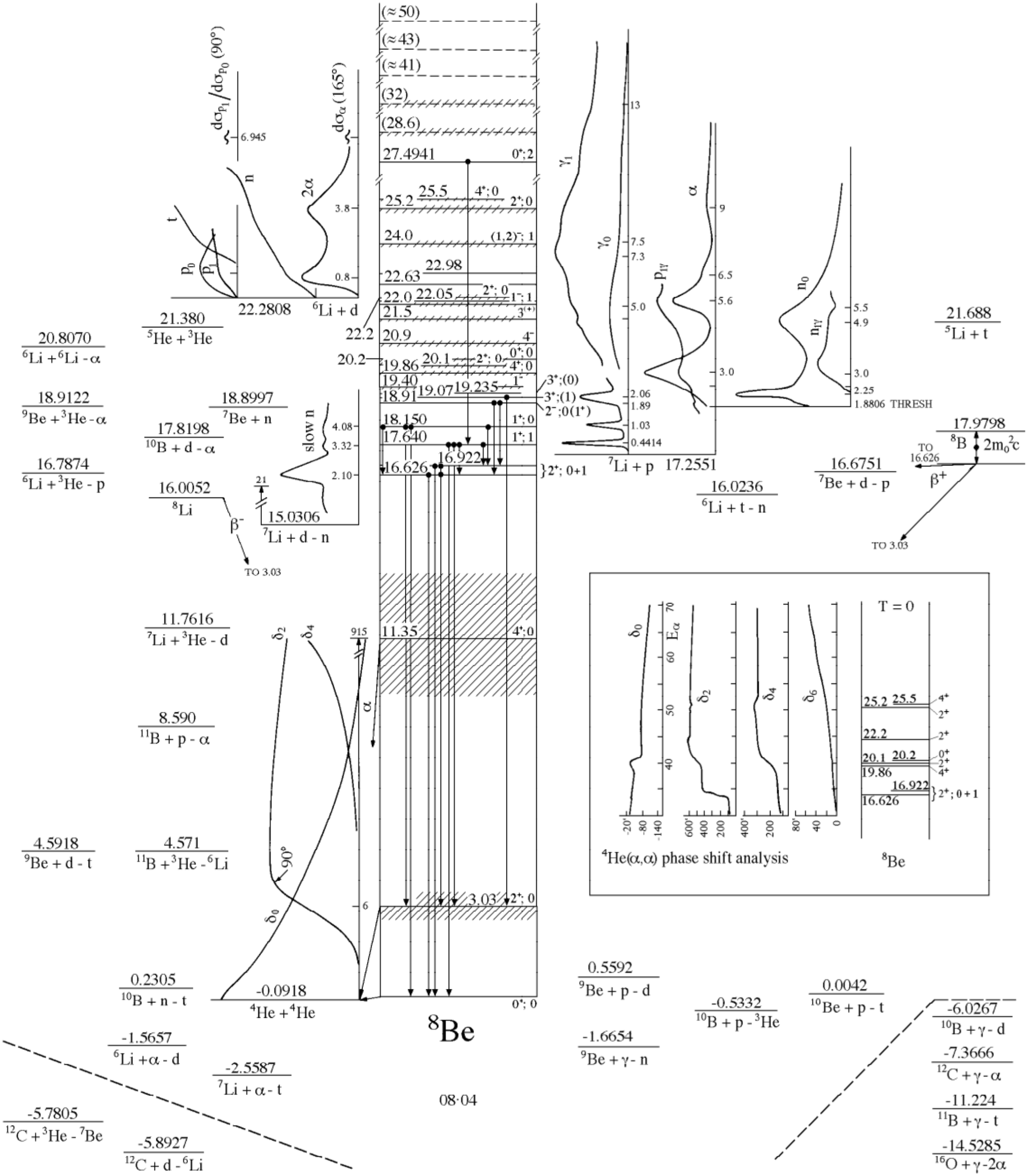


Figure 3: Energy levels of ^{8}Be. For notation see Fig. 2.

- ^{4}He + ^{4}He -> ^{8}Be
  lifetime ~ 7 x 10^{-17} s
- ^{8}Be + ^{4}He -> ^{12}C
  triple alpha process
  (Hoyle)
- Hungarian expt. populates 17.6 and 18.15 MeV 1^+ states via ^{7}Li(p,γ)^{8}Be
- Internal pair creation via M1 isoscalar and isovector transitions
- Anomaly observed only in isoscalar (18.15 MeV) transition

PHYSICAL REVIEW D VOLUME 37, NUMBER 5 1 MARCH 1988

New limits on light scalar and pseudoscalar particles produced in nuclear decay

M. J. Savage and B. W. Filippone
W. K. Kellogg Radiation Laboratory, California Institute of Technology, Pasadena, California 91125

L. W. Mitchell
Norman Bridge Laboratory of Physics, California Institute of Technology, Pasadena, California 91125
(Received 28 August 1987)

We present the results of a search for scalar and pseudoscalar particles produced in nuclear deexcitation. Measurements of the angular correlation of e^+e^- pairs emitted from excited states of ^{14}N, ^{16}O, and ^{8}Be provided sensitivity to particles with lifetimes $10^{-19} < \tau < 10^{-11}$ s within the mass range $2m_e < M_X < 5$ MeV. We find no evidence for such particles and set upper limits on the branching ratio to electromagnetic decay.

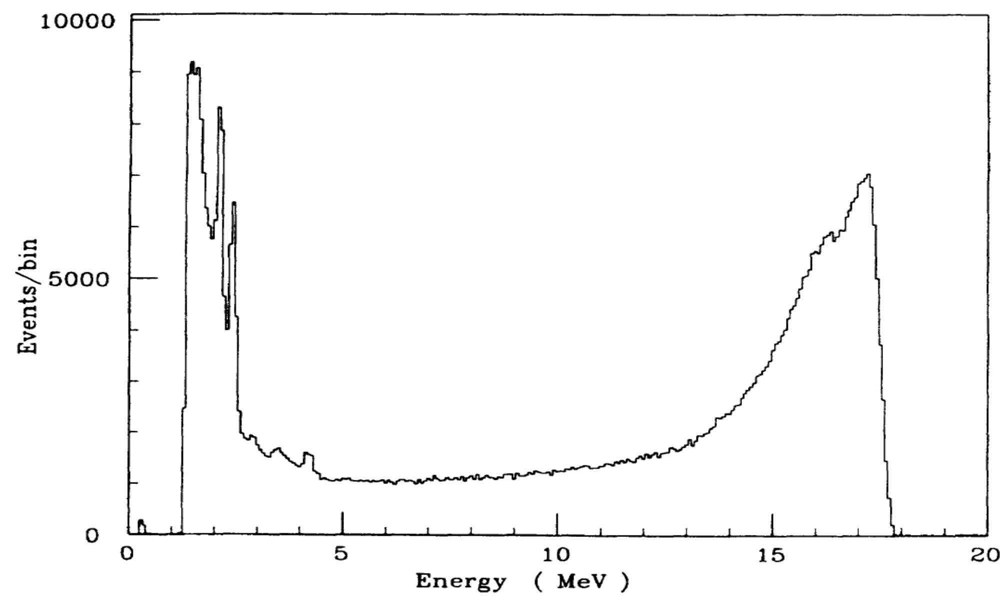


FIG. 8. γ-ray spectrum recorded during proton bombardment of the ^7Li target at $E_p = 440$ keV.

Beyond Standard Model

The Delirium over Beryllium

By Flip Tanedo · August 25, 2016 · Post a comment

Implications

So where we stand is this:

- There is an unexpected result in a nuclear experiment that may be interpreted as a sign for new physics.
- The next steps in this story are independent experimental cross-checks; the threshold for a 'discovery' is if another experiment can verify these results.
- Meanwhile, a theoretical framework for understanding the results in terms of a new particle has been built and is ready-and-waiting. Some of the results of this analysis are important for faithful interpretation of the experimental results.

Particle Physics Models for the 17 MeV Anomaly

Jonathan Feng *et al.*, Phys. Rev. D 95, 035017 (2016)

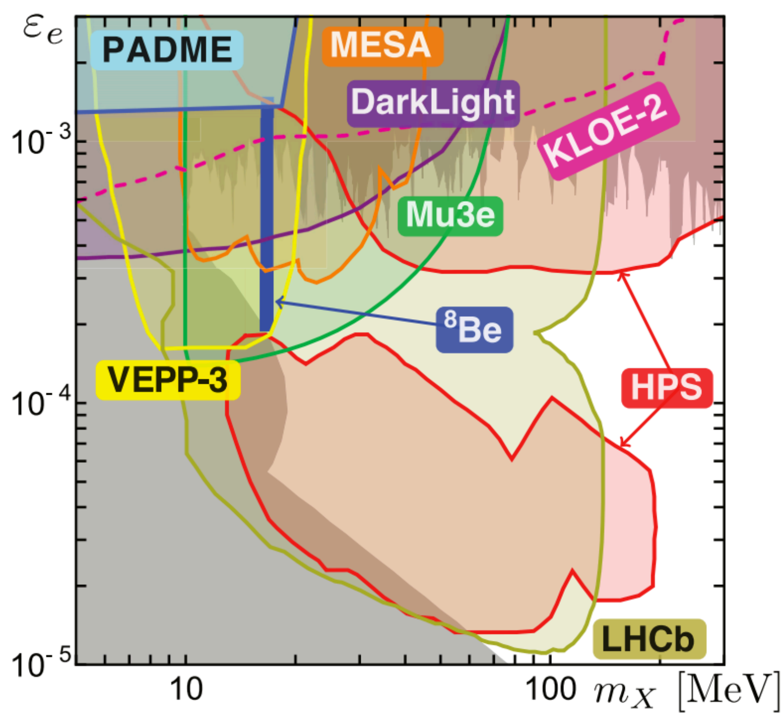


FIG. 6. The ^{8}Be signal region, along with current constraints (gray) and projected sensitivities of future experiments in the (m_X, ε_e) plane. Updated from Ref. [7].

DARKLIGHT Collaboration

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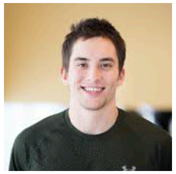
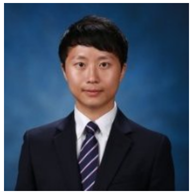
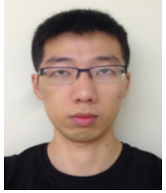
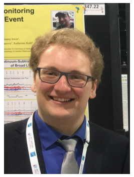





Undergraduate

Daniel Palumbo



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Douglas Hasell

Senior Research Scientist

Stephen Steadman

Research Scientists

Jan Bernauer

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Bates Research & Engineering Center

Ernie Ihloff

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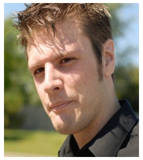

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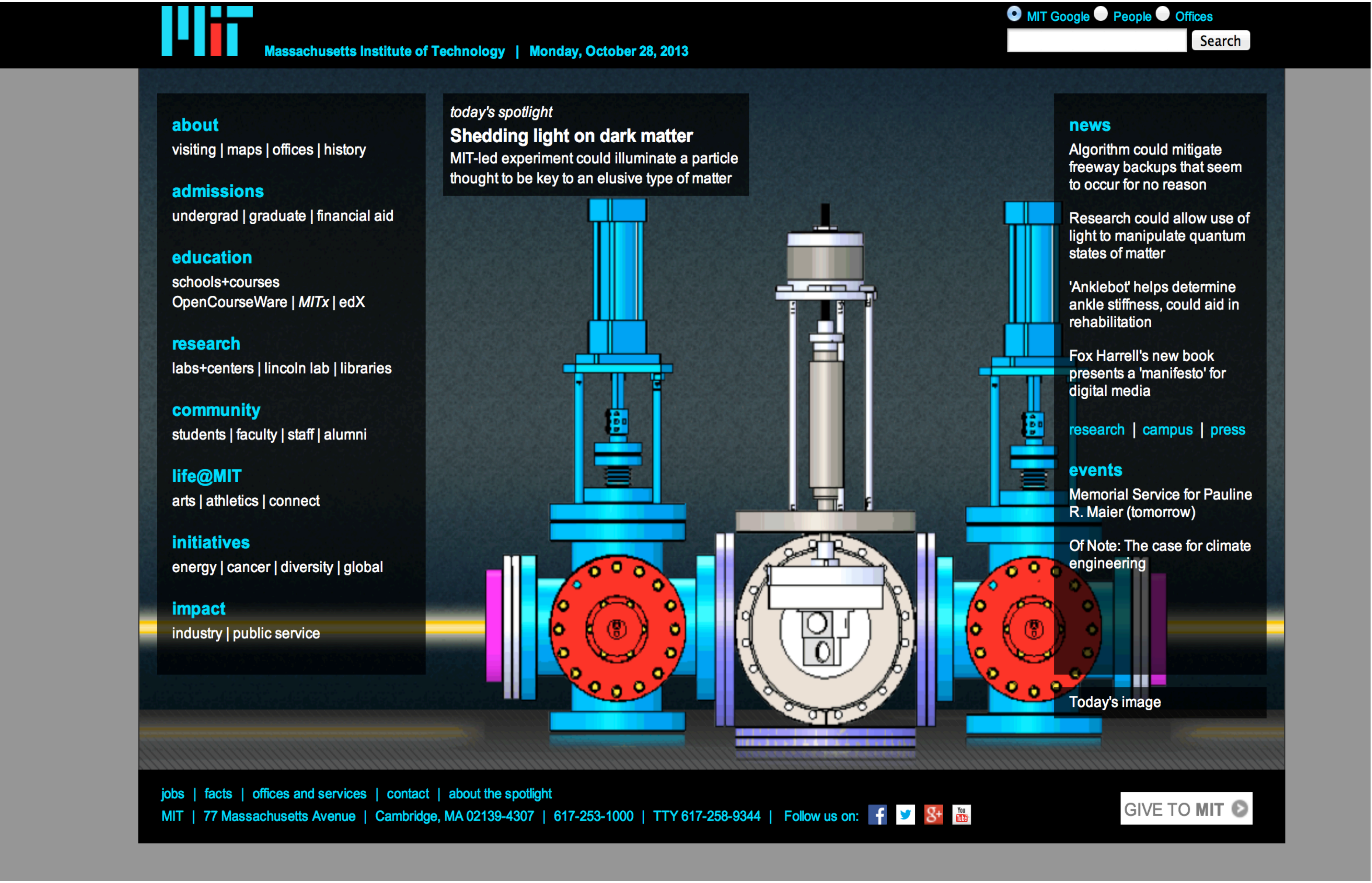
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The Washington Post

Health & Science

What scientists plan to do with the most powerful electron beam in the world

Scott Windham, left, and Jason Delk work at the Thomas Jefferson National Accelerator Facility, where scientists plan to use the world's most powerful electron beam to find signs of a particle that interacts with both dark and light matter. (Judith Lowery/Newport News Daily Press via AP)

By Tamara Dietrich June 25

NEWPORT NEWS, Va. — Look around — what do you see?

A paltry 5 percent of what the universe is made of, that's what.

Dark matter – investigating the universe's hidden secrets

One of the biggest mysteries of the Universe is that, through observations, we know we can only account for a sixth of the mass out there. The rest is put down to a mysterious substance called 'dark matter', and we need physics beyond the Standard Model of particle physics to explain it. **Professor Richard Milner** and **Professor Peter Fisher** from the Massachusetts Institute of Technology (MIT) are helping us get closer to understanding the mystery with a new experiment, soon to begin its first set of data collection.

The Standard Model of particle physics describes the most basic building blocks of matter, from electrons to quarks, and the forces that govern the way they interact. It is arguably one of the best scientific theories to date, describing with great accuracy how atoms stick together, how radioactivity works in the sun and how the Universe was formed. But it is incomplete. There are a few observations we cannot explain using the Standard Model, and one of these is called dark matter.

When astronomers peer into the Universe, they can measure the amount of mass in galaxies by studying how the galaxies move. But when the total mass from everything we can actually see is added up, there is a huge amount missing. Particles described by the Standard Model, the ones we can see, only make up a sixth of the mass of the Universe – so where is the rest of the mass coming from?

This mysterious substance has been given the name 'dark matter', because it does not interact with light the way normal matter does, so we cannot see it. It could be one kind of particle, or it could be thousands of different particles, but at the moment we do not know.

DARKLIGHT

Physicists like Professors Richard Milner and Peter Fisher from the Massachusetts Institute of Technology (MIT) are seeking to find out what dark matter is. The two now lead an MIT-conceived experiment called Detecting A Resonance Kinematically with eLectrons Incident on a Gaseous Hydrogen Target – or DarkLight for short. The experiment will use the latest technology to look beyond the Standard Model, to try and delve into the world of dark matter. The MIT DarkLight group led by Milner and Fisher includes four PhD researchers, five graduate students, several undergraduate students, and technical support from the Bates Research and Engineering Center. MIT theoretical physicist Professor Jesse Thaler and his group have provided key calculations that have guided the design of the DarkLight experiment.

In 2013, a paper was published in the journal Physical Review Letters, revealing the potential of electron beams for use in particle physics experiments. One year later, in 2014, a group of physicists from MIT, alongside others from Hampton University, Arizona State University and Temple University, were awarded a grant to build the first phase of the DarkLight experiment, at the Thomas Jefferson National Laboratory in Virginia.

Physics: Understanding the elusive dark matter

Richard G. Milner from the Department of Physics and Laboratory for Nuclear Science at Massachusetts Institute of Technology provides an absorbing insight into the search for an understanding of the elusive dark matter, one of the great scientific quests of our age

The search for an understanding of the elusive dark matter is one of the great scientific quests of our age. In the 1930s, astronomers first made determinations of the gravitational mass of galaxies that were significantly larger than expected from the observed luminosities and wrote of dunkle Materie[1]. Almost 90 years later, there is collective evidence that is substantial and consistent across seven orders of magnitude in distance scale[2], that an unknown substance (dark matter) shapes the large-scale structure of the universe.

We believe that dark matter interacts gravitationally and that its non-gravitational coupling is of order the weak interaction[3], or less. We expect that there must be some new interaction via a mediator between dark matter and atomic nuclei for dark matter to be in equilibrium with other matter in the early universe. We know the approximate density and velocity of dark matter in our galaxy. Dark matter does not form tightly bound systems larger than about 1,000 solar masses, but it appears to account for about 25% of the mass of the universe, that is about five times larger than the matter we can see.

The known, uncharged particles, for example, the neutron or neutrino, cannot account for dark matter. The focus over several decades has been to look for a weakly interacting massive particle (WIMP) via a rare scattering from an atom in a large detector, typically located deep underground to minimise the rate of background events. The recoil atom's energy is detected. Thus far, no conclusive evidence for WIMPs has been found. The present experiments set the WIMP-atom interaction limit lower than the rate of a low-energy[4] neutrino interacting with atoms[5]. Searches for WIMPS will continue for at least another decade. However, there is a fundamental flaw to this approach due to the inability to distinguish between a neutrino-atom interaction and a WIMP-atom interaction. The WIMP mass region explored by the underground experiments typically ranges from about three proton masses to about 10,000 of the same.

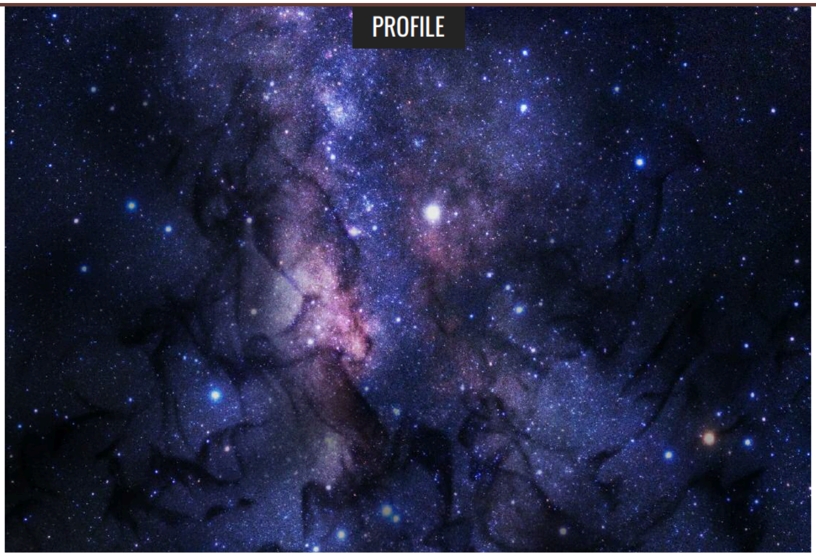
A complementary experimental thrust in the quest to understand dark matter, is to search for evidence of the mediator of a new interaction between our visible world, successfully described in terms of four forces (gravity, electricity and magnetism, nuclear force and weak force) and the world of dark matter. This new interaction would constitute the fifth force.

The simplest mediator widely considered is a dark photon that couples to the known particles via their electric charges. The searches involve experiments using particle beams delivered by accelerators to produce the mediator. The mediator decays either into (a) known, detectable particles that are sought (visible decays) or (b) into the dark sector, which are undetectable, but whose presence is deduced by observation of a large missing energy and momentum in the final-state (invisible decays). The results of the searches are usually summarised in terms of their ability to constrain the mediator-to-known-matter coupling strength and the mediator mass. At the Large Hadron Collider at CERN, Geneva, Switzerland, searching for evidence of dark matter is a major activity at the three principal experiments[6].

Recently, there has been a focus on searching for a mediator with a mass lower than the proton mass. Astrophysical observations and observed anomalies in measurements involving the muon and nuclear transitions hint at this possibility. Existing experiments, primarily using the decay of the neutral pion, have searched inconclusively for evidence of a dark photon. However, a more general fifth force, where the couplings are no longer simply the charges, remains a viable possibility.

Our MIT group is focused on searching for evidence of a fifth-force, with a mediator of mass less than about 10% of the proton's mass. In collaboration with colleagues, we have proposed the DarkLight experiment[7] at Jefferson Laboratory[8], Newport News, Virginia,

PROFILE



USA to produce the mediator in electron-nucleus scattering and searching for visible decays into a positron and electron. DarkLight requires an intense, bright and halo-free electron beam possible only with a new accelerator technology, called an Energy-Recovery Linac (ERL).

A phase-1 DarkLight experiment has been funded and a search, focused in a specific mediator mass region suggested by a reported anomaly, is in preparation. Jefferson Laboratory pioneered the development of ERLs using superconducting accelerator technology and next-generation ERLs are at present under construction at Cornell University, USA[9] and at Mainz University, Germany[10]. Searches for evidence of dark matter via low-energy signals in electron scattering are being planned at both machines.

In summary, the search for evidence and understanding of dark matter is an intensive, worldwide research endeavour by physicists using state-of-the-art accelerator and detector technology on, above[11] and beneath the Earth. Calculations by theoretical physicists are essential for the design of experiments with maximum sensitivity to uncovering new physics. This research drives technology development in high-intensity accelerators, detectors and high-rate data acquisition.

There are major new initiatives underway worldwide and this area will continue to be a forefront activity for the foreseeable future, attracting some of the best and brightest young minds. This curiosity-driven, fundamental research into understanding our universe is made possible by the generosity of the taxpayer via government support of fundamental research[12].

1 F. Zwicky, Helvetica Physica Acta, 6, 110 (1933)

2 From 1 kpc to 10 Gpc: 1 pc = 3.26 light years = 3.1×10^{16} m.

3 The weak interaction initiates the fusion process in the sun and drives beta-decay.

4 10 keV.

5 Present best cross-section limit is about 10^{-46} cm^2 at a WIMP mass of about 50 proton masses.

6 ATLAS, CMS and LHC: home.cern.

7 DarkLight experiment: arxiv.org/abs/1412.4717.

8 Jefferson Laboratory: www.jlab.org.

9 CBETA project: www.classe.cornell.edu/Research/CBETA/WebHome.html

10 MESA project: www.prisma.uni-mainz.de/mesa.php.

11 Alpha Magnetic Spectrometer experiment: ams.nasa.gov.

12 The author gratefully acknowledges the support of both the Office of Nuclear Physics of the Department of Energy and the National Science Foundation of the United States.

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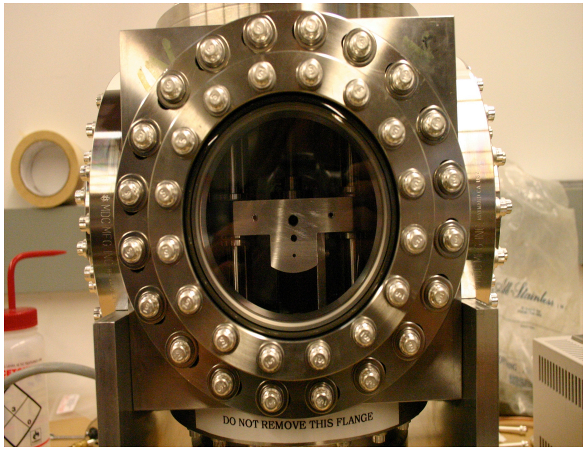
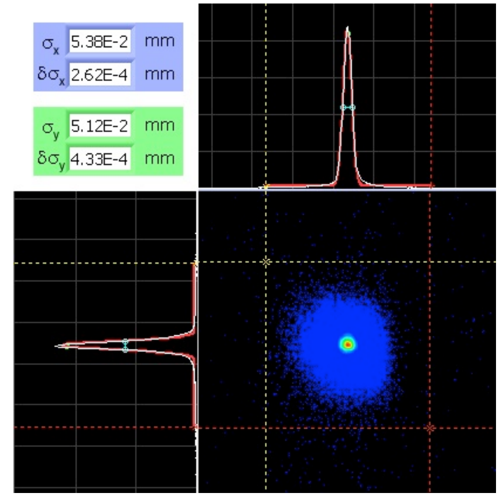
Successful DARKLIGHT beam test

July 2012



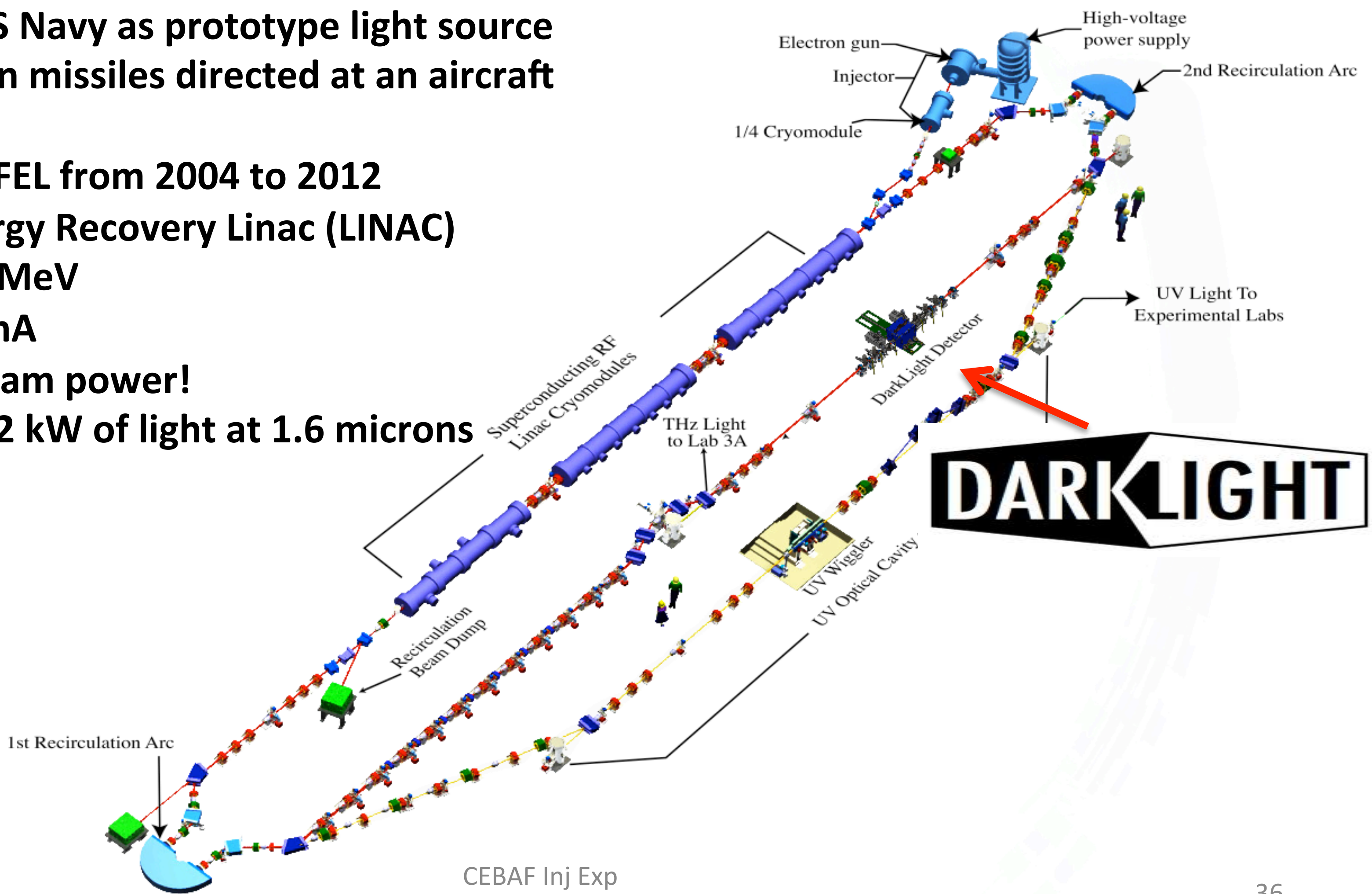
Target system designed and constructed at MIT-Bates R&E Center



- A test beam of 4.3 mA, 100 MeV (430 kWatt of e-beam power) was successfully transmitted through a 2 mm hole, 127 mm long, with a maximum loss of about 3 ppm for seven hours.
- Halo can be minimized and radiation in vault is manageable.
- The ERL has the stability required for DarkLight.
- Three papers written on test: *Phys. Rev. Lett*. **111**, 164801 (2013)
  Nucl. Instr. Meth. **A729**, 233 (2013)
  Nucl. Instr. Meth. **A729**, 69 (2013)

Low Energy Recirculator Facility (LERF) Layout

- Funded by US Navy as prototype light source to shoot down missiles directed at an aircraft carrier
- Operated as FEL from 2004 to 2012
- Employs Energy Recovery Linac (LINAC)
  - 80 to 140 MeV
  - up to 10 mA
  - MWatt beam power!
- Achieved 14.2 kW of light at 1.6 microns



NSF MRI Award 2014

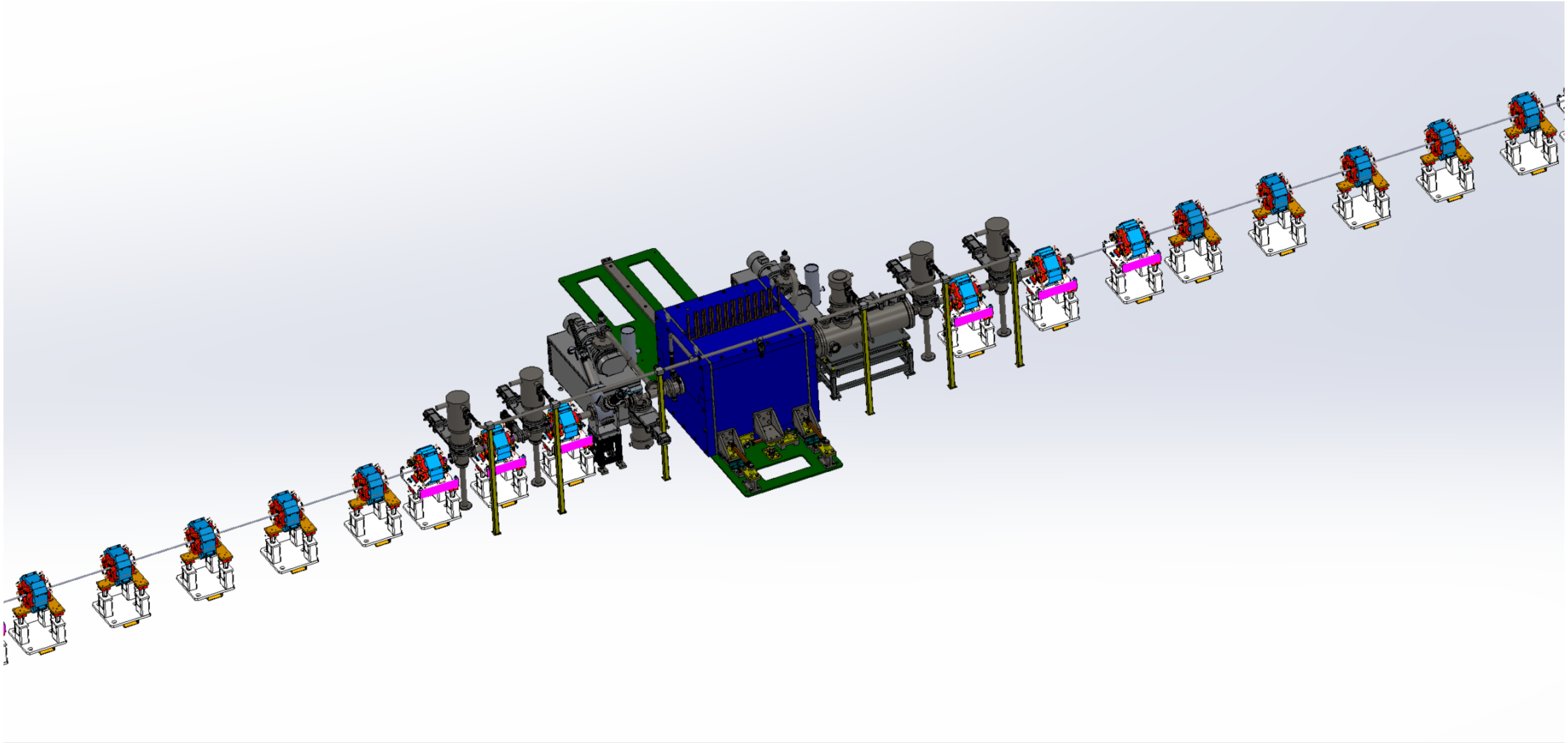
- Successful test followed by full scientific approval with "A" rating in May 2013
- MRI proposal based on existing solenoidal magnet provided by Stony Brook U
- MIT responsible for target, vacuum, Møller dump, shipping, installation
- Hampton U responsible for GEM trackers
- ASU and Temple responsible for silicon detectors
- Cost sharing from ASU, MIT, and Temple
- Strong letter of support from R. McKeown at Jefferson Lab

Scientific Goals of Phase-I DarkLight NSF MRI Phase-1

- Use 100 MeV electron beam from LERF
- Realize full luminosity: 10 mA on 10^{19} cm^{-2} of hydrogen
- Realize solenoidal magnet for complete experiment
- Realize prototype detectors and readout systems for complete experiment which enable three science goals

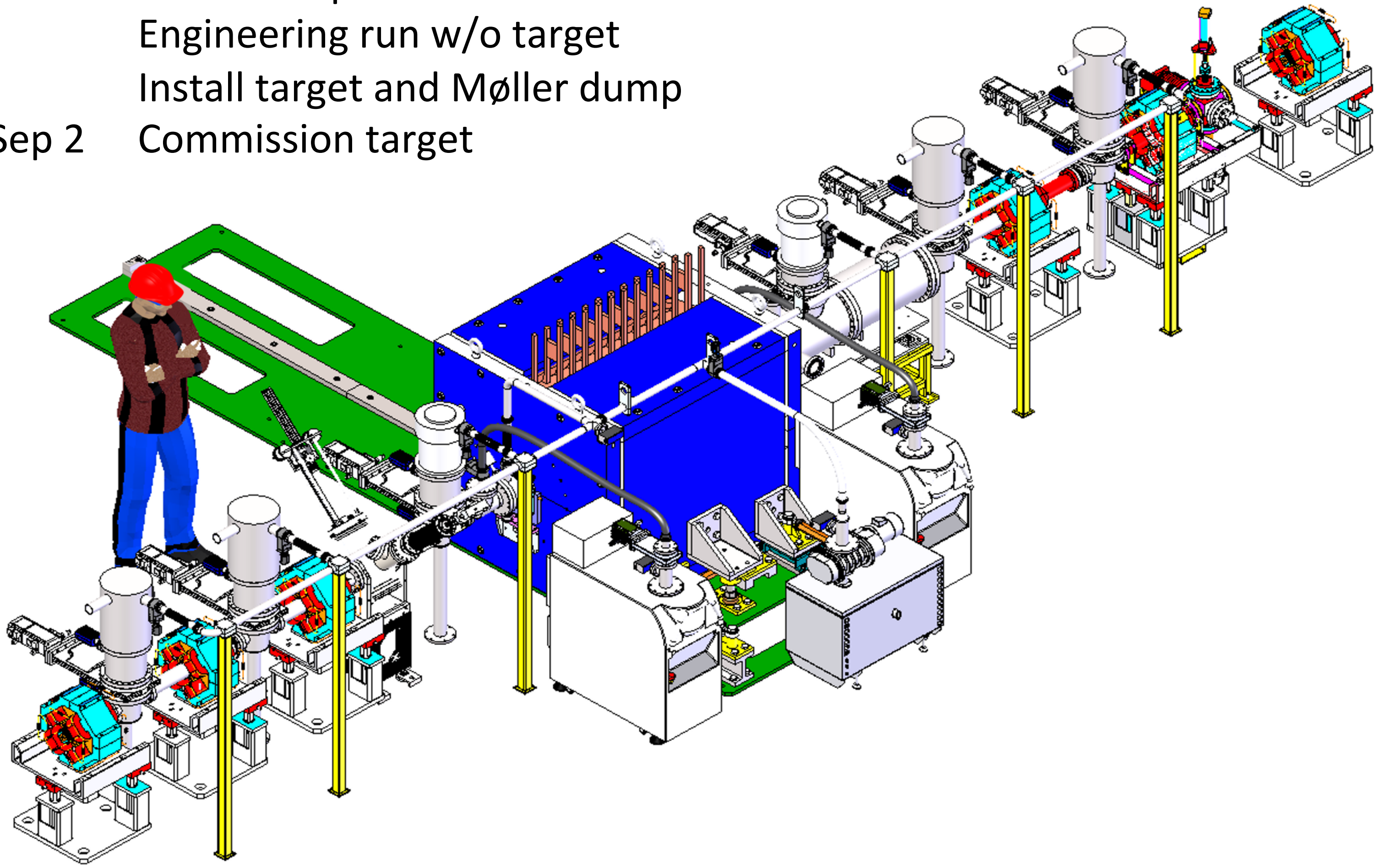
- **Science Goal 1a**: Accelerator Studies with the ERL
  - limits of energy recovery
- **Science Goal 1b**: Measurement of Radiative Møller Scattering
  - Rates depend on electron mass
- **Science Goal 1c**: Search for the A'

DarkLight Insertion

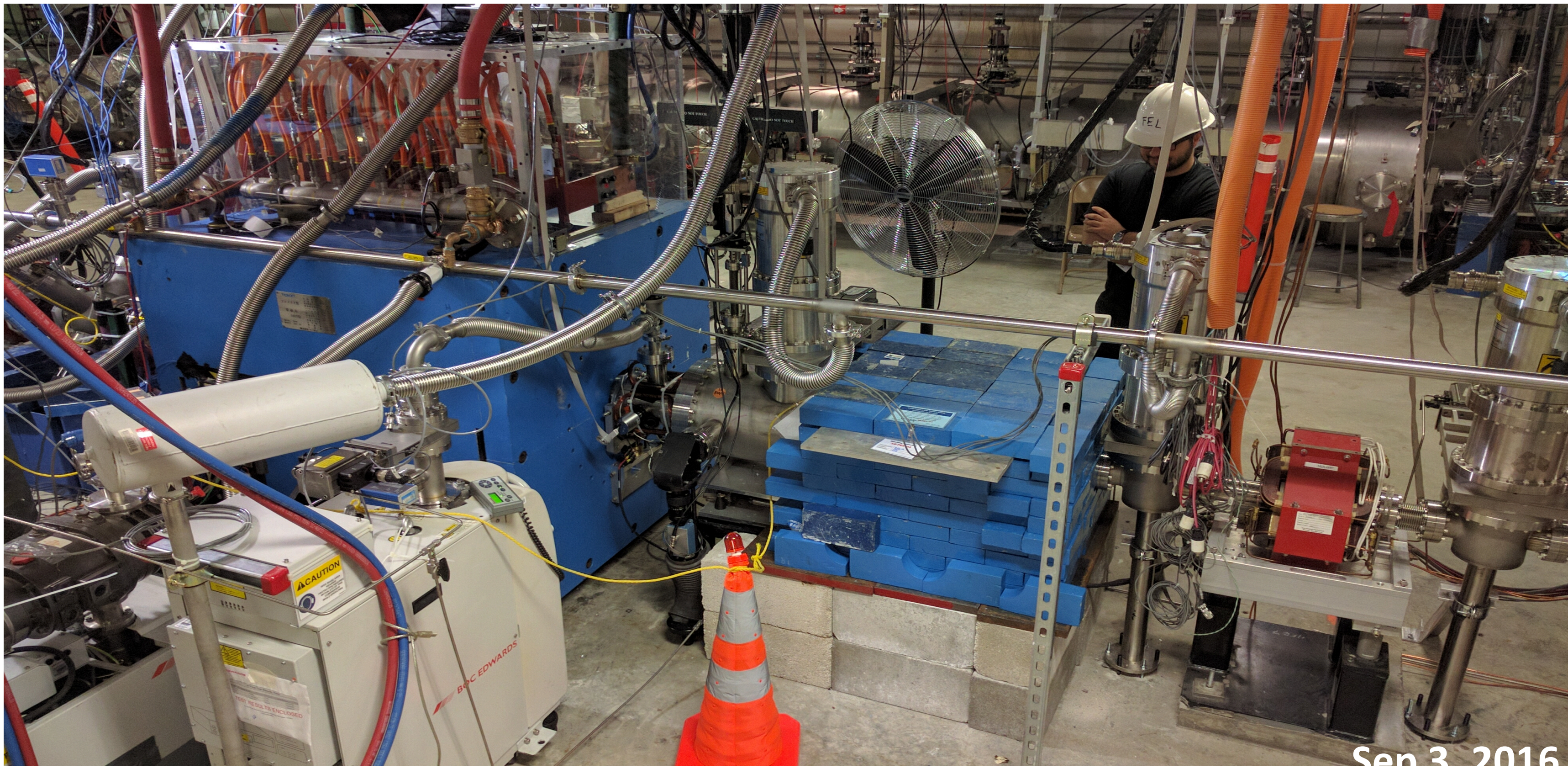


July – August 2016

- July 1-29 Phase-1 experiment installed
- Aug 1-5 Engineering run w/o target
- Aug 8-18 Install target and Møller dump
- Aug 26- Sep 2 Commission target



DARKLIGHT Experiment



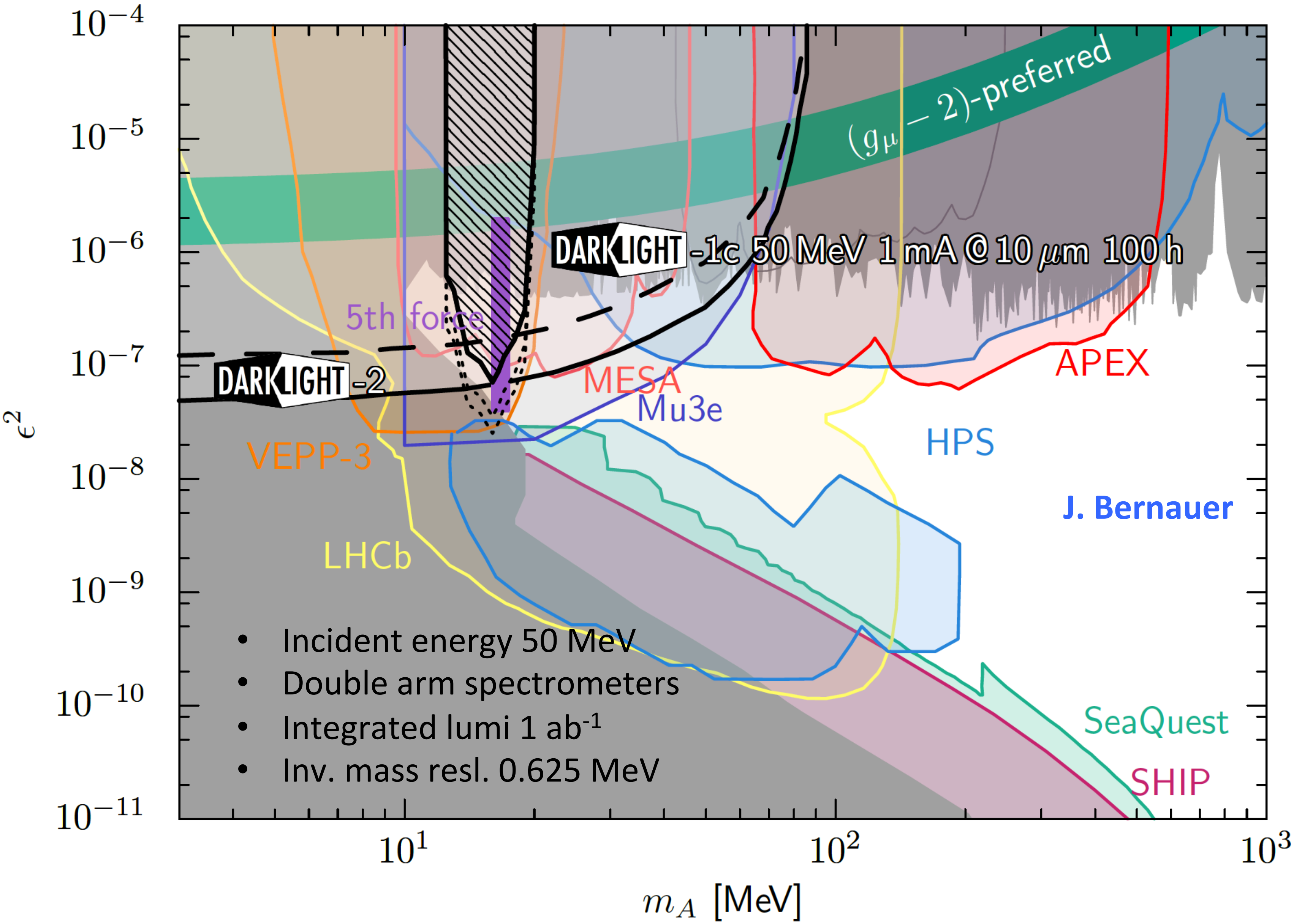
- Installed and commissioned August 2016
- 100 MeV beam on windowless hydrogen target: 2 x 10^{18} cm^{-2}
- No show stoppers encountered
- No prospects of further running for foreseeable future

Present Plan

- Carrying out a measurement of radiative Møller scattering at 2.5 MeV at MIT High Voltage Research Laboratory: thesis for C. Epstein
- Preparing a proposal to Jlab PAC46 to search in e^+e^- final-states around 17 MeV at the CEBAF Injector
  - Theses for: J. Nazeer (Hampton U), R. Johnston, S. Lee and P. Moran (MIT)
- In collaboration with Cornell (G. Hoffstaetter, J. Alexander, R. Patterson, and J. Thom-Levy) and U. Münster (A. Khoukaz and S. Grieser) starting to work out a concept for the full DarkLight experiment at the CBETA ERL under construction at Cornell: CBETA on schedule to deliver 1 mA by April 2020
- In collaboration with U. Mainz: MESA coming online 2021

Search for peak in e^+e^- invariant mass spectrum around 17 MeV

- Consider double arm spectrometers
- Carbon foil target
- Seek to constrain ε_e below about 6×10^{-4}
- Proposing experiment at CEBAF Injector
- Will request 1000 hours in July 2018 Program Advisory Committee meeting



$(g_\mu - 2)$-preferred
DARKLIGHT -1c 50 MeV 1 mA @ 10 μm 100 h
DARKLIGHT -2
5th force
MESA
Mu3e
APEX
HPS
VEPP-3
LHCb
J. Bernauer
SeaQuest
SHIP
• Incident energy 50 MeV
• Double arm spectrometers
• Integrated lumi 1 ab^{-1}
• Inv. mass resl. 0.625 MeV
ϵ^2
m_A [MeV]
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^1
10^2
10^3

DARKLIGHT Summary

- The search for dark matter is one of the great scientific quests of our age.
- Underground searches for WIMPS are approaching the ultimate limit with no observation thus far.
- The LHC has a major program at the energy frontier to look for a fifth force.
- Search for a fifth force at low energies has sound motivation and will be vigorously pursued.
- DarkLight is an unique experiment to search for a fifth force using electron-proton scattering at 100 MeV.
- The CEBAF Injector offers a unique opportunity to search in the vicinity of 17 MeV invariant mass.
- The experiment pushes the frontiers both scientifically and technically.
- It leverages the NSF MRI award and requires only modest resources.
- We have good funding prospects and an enthusiastic group of young people willing to work hard make it happen.