8BeP: A ^{8}Be Experiment at Purdue

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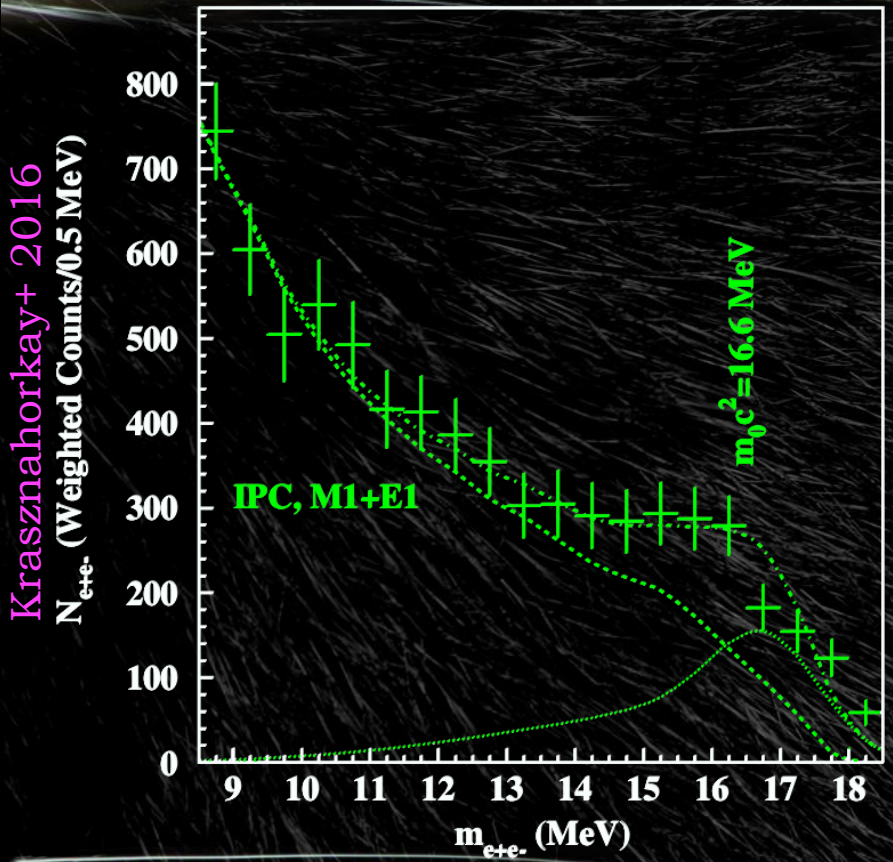
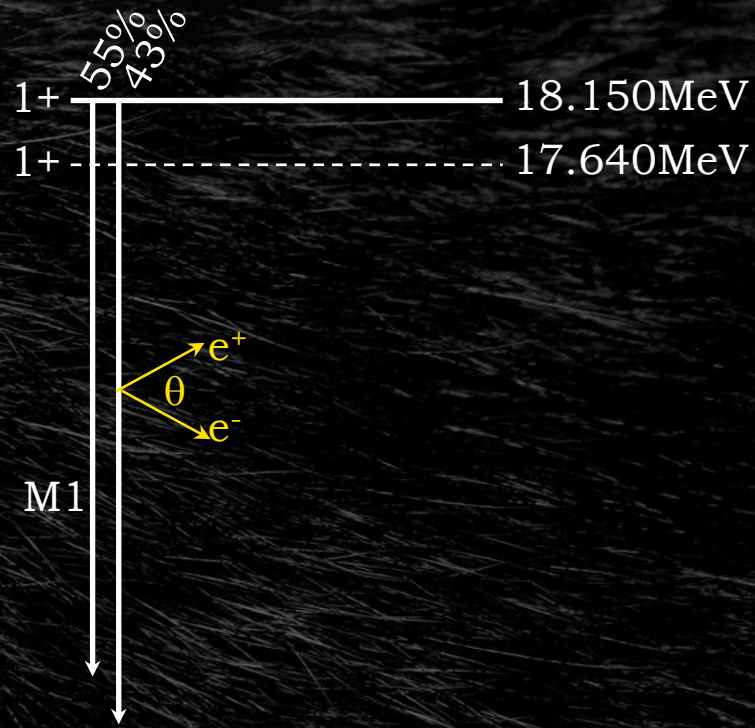
New Ideas in Dark Matter, College Park, March 2017

Hunting Bumps? Need Resolution!





www.nndc.bnl.gov/nudat2

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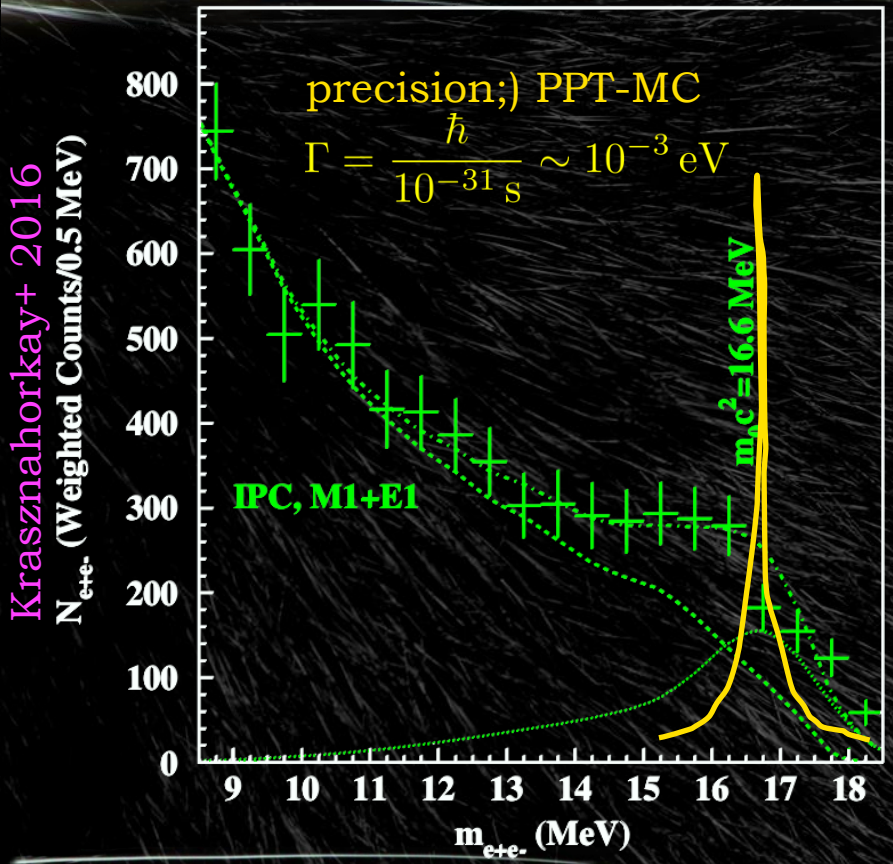

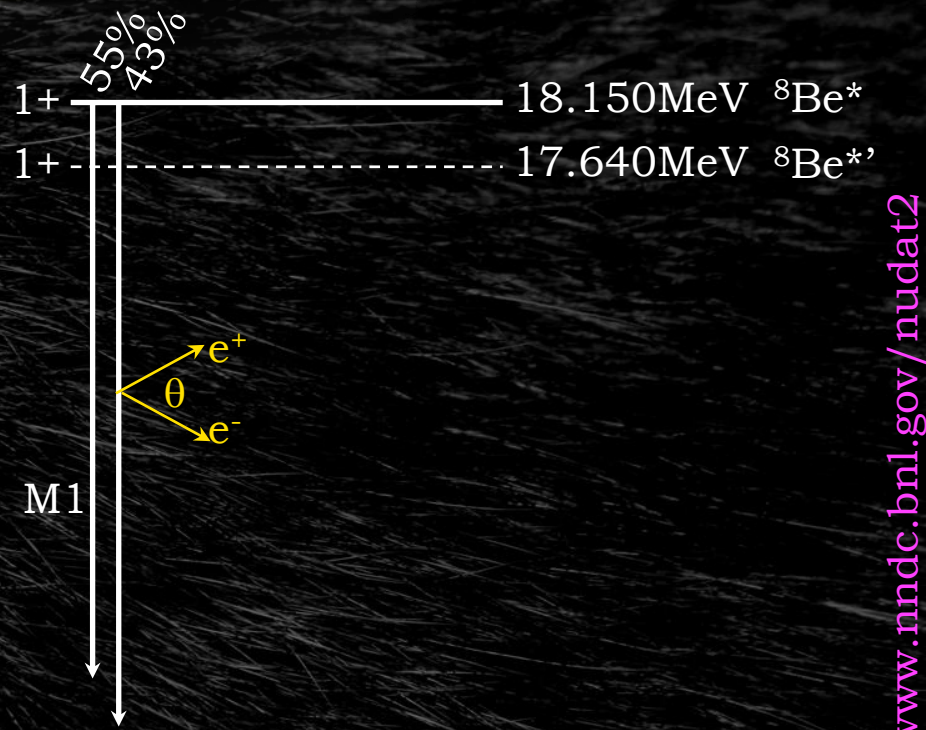

Krasznahorkay+ 2016

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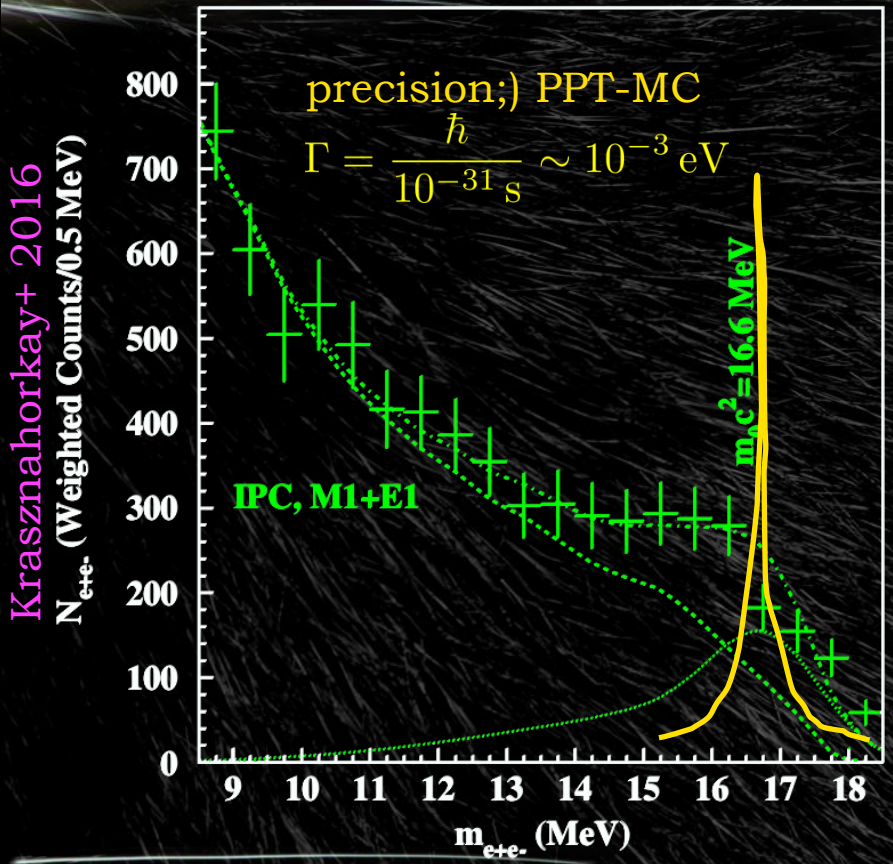

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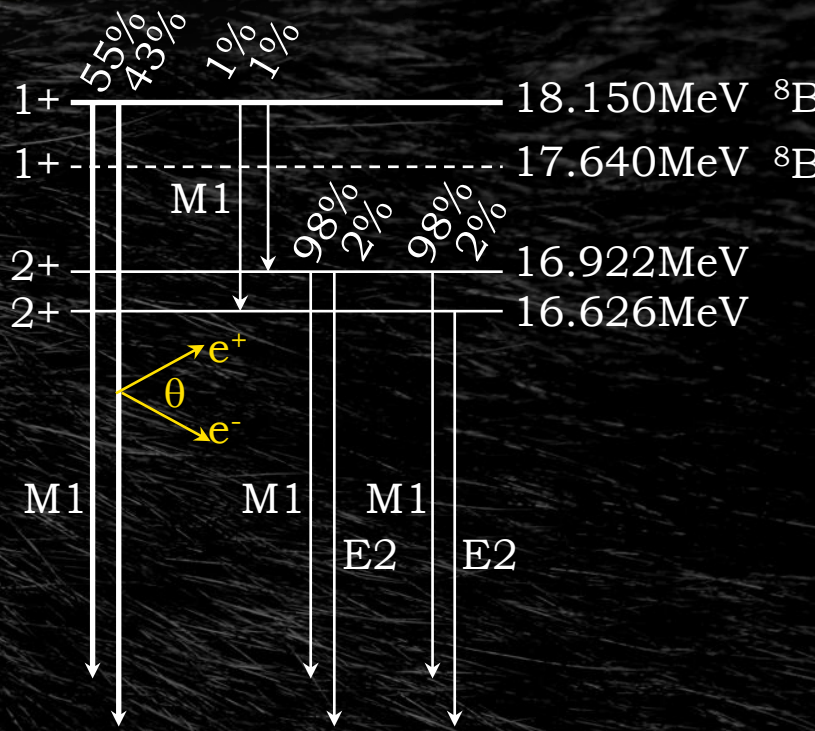

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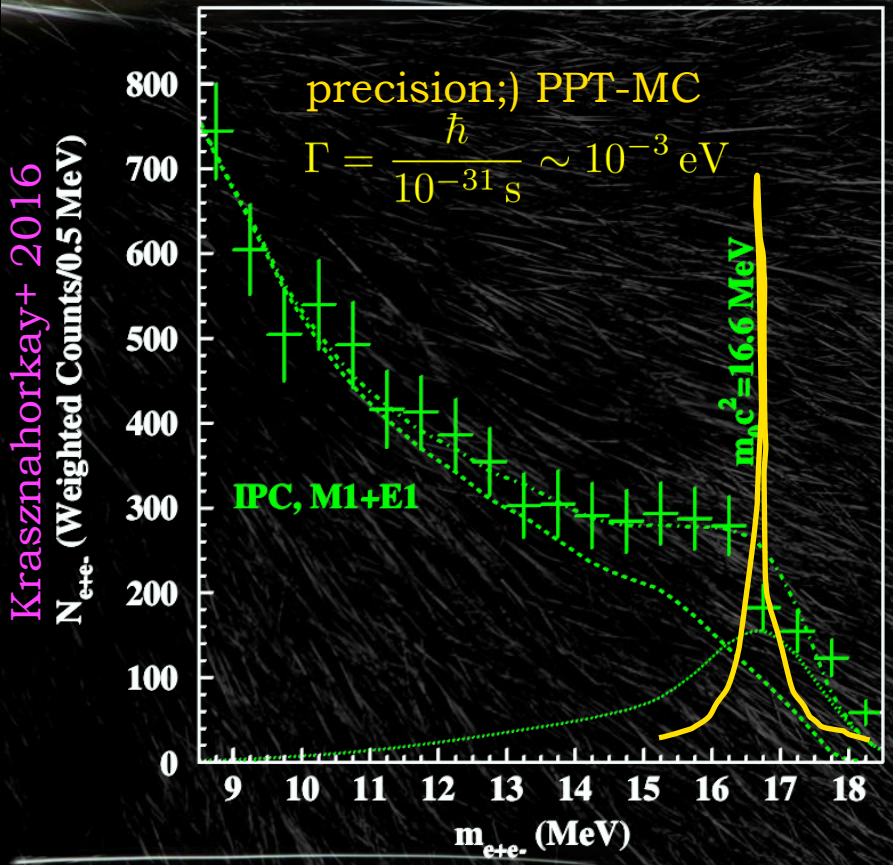

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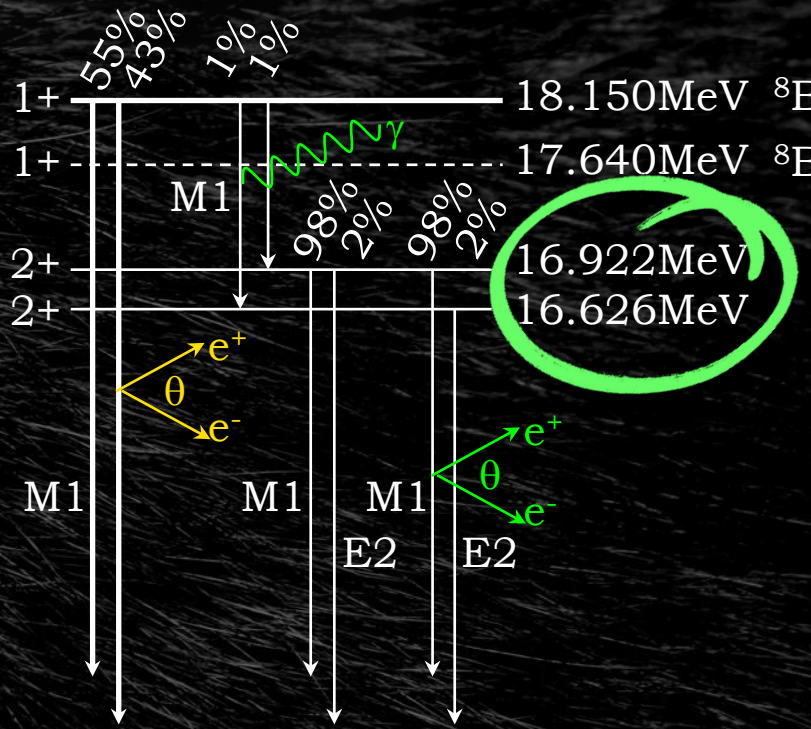

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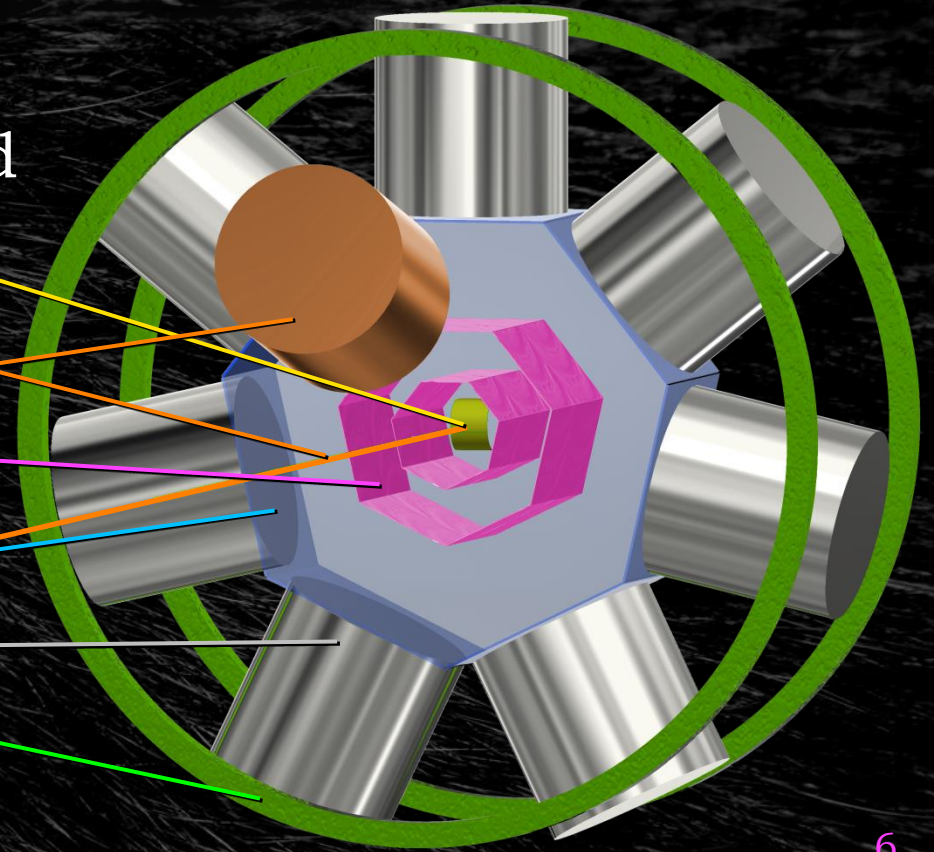
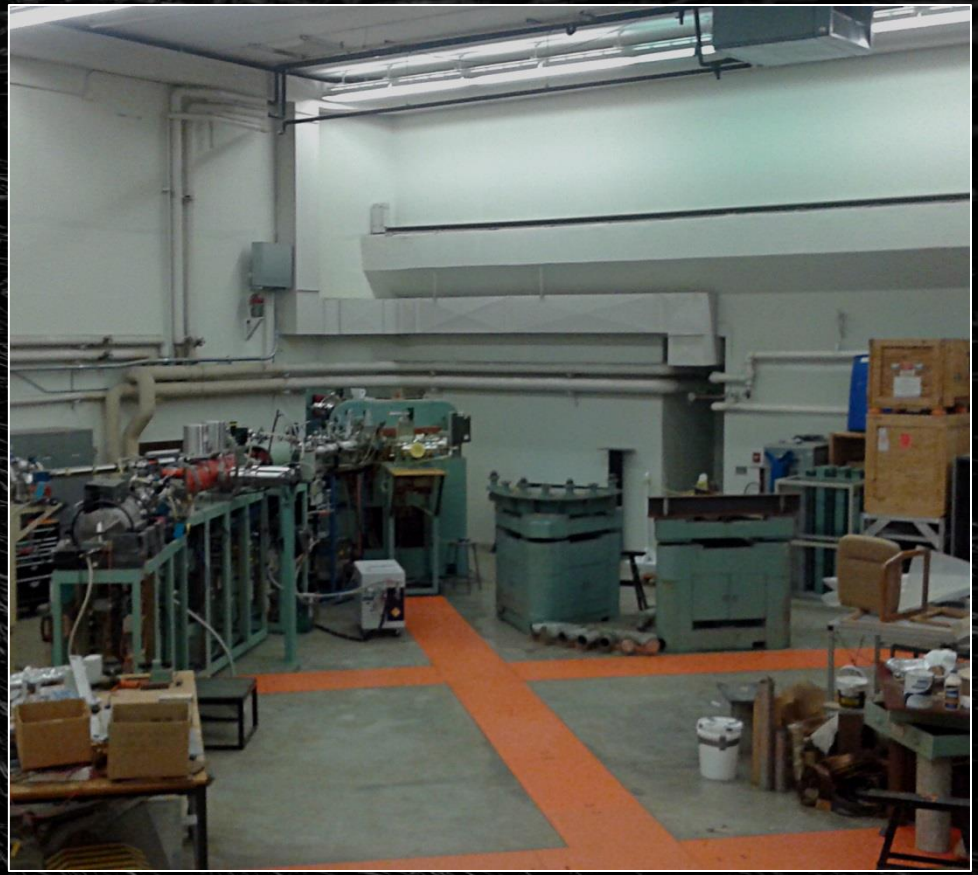
also look for 16.xMeV cascade

High Resolution Magnetic Spectrometer

Design driven by energy and angular resolution, particle ID, equipment availability and expertise



Accelerator: Available



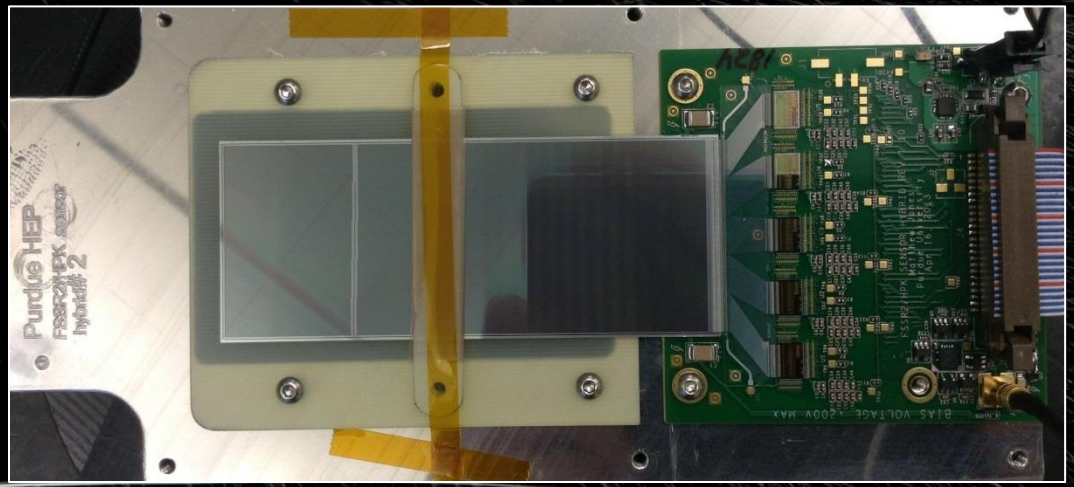
AMS Facility: proton beam available 2m above floor

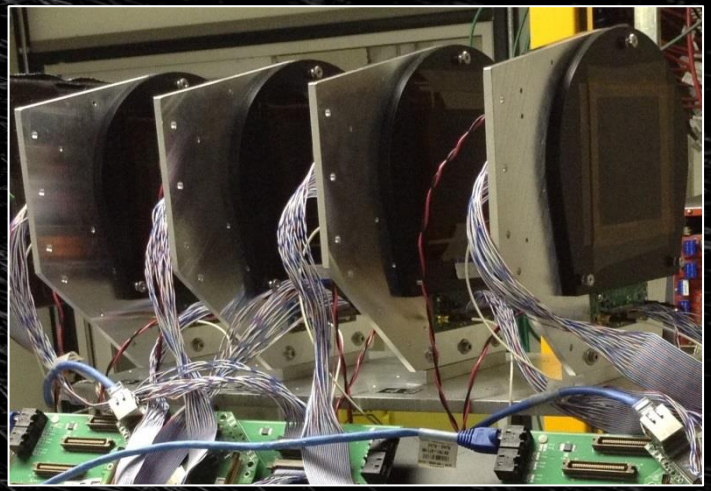
- spot size <6 mm
- current ~1 μA
- energy ~0.5MeV – 8MeV

e^+e^- Tracking: Available with PO

300μm thick Si strip detectors (>1M$ development)
639 strips, 30μm strip pitch, 60μm readout pitch
sensitive area 3.8 cm x 9.8 cm, resolution ~25 μm

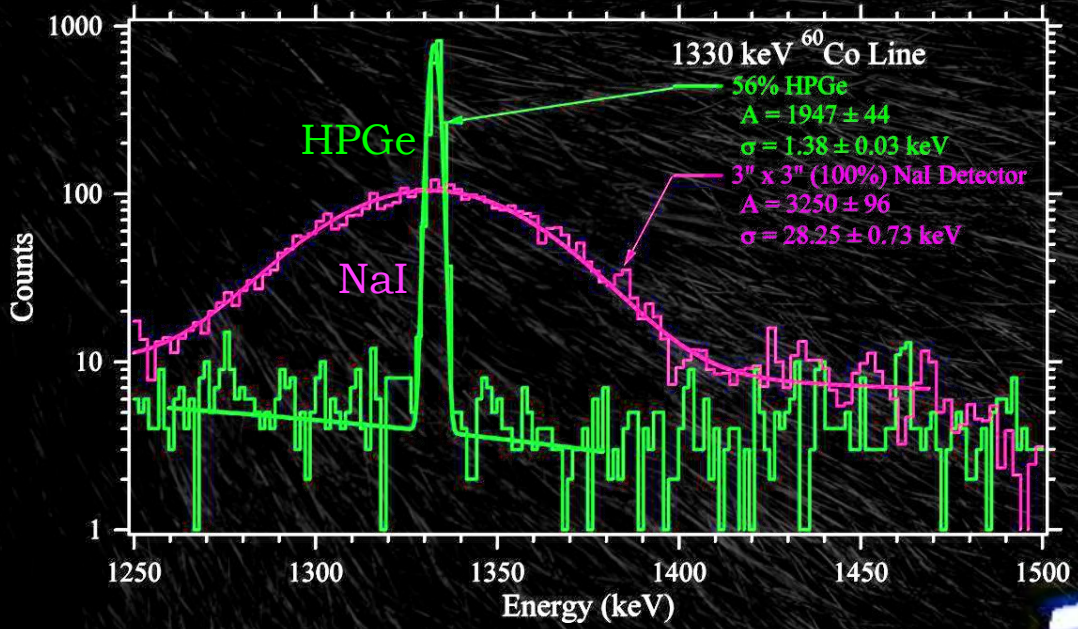
Operation in vacuum, pairs @20mm & 40mm from target

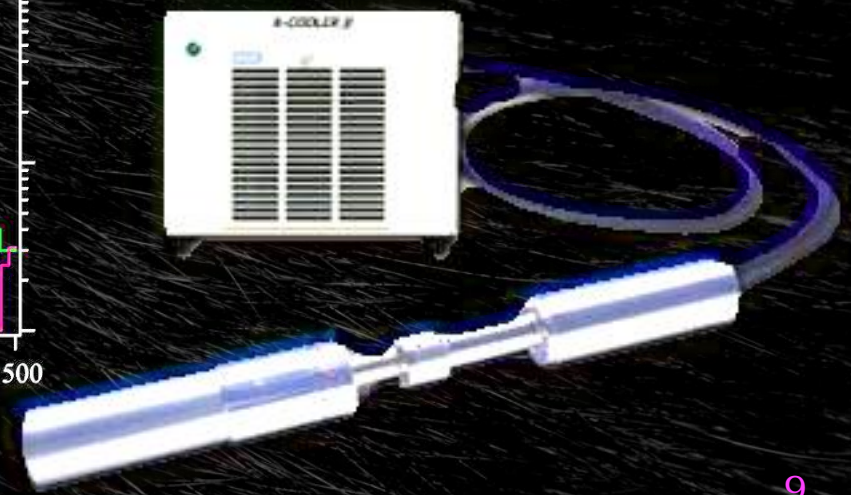




High-Res Calorimeter: Available

8 HPGe detectors (60%-100% eff.) with stable cooling, average ∅ 71 mm, energy resolution 0.1% (~1M$)





Mass Resolution

$$m^2 \approx \left(1 - y^2\right) E^2 \sin^2 \frac{\theta}{2} \qquad y \equiv \frac{E_{e^+} - E_{e^-}}{E_{e^+} + E_{e^-}},\ E = E_{e^+} + E_{e^-} + 2m_e$$

- Spectrometer in vacuum:
  reduced multiple scattering
- Magnet charge identification:
  e^+ contributes $2m_e$ more energy than e^-
- HPGe Energy Resolution:
  $\delta E/E \sim 0.1\% \Rightarrow \delta m \sim 20\,\mathrm{keV}$
- Si Strip Detectors:
  $\delta x/x \sim 25\,\mu\mathrm{m}/20\,\mathrm{mm} \Rightarrow \delta m \sim 5\,\mathrm{keV}$
- Expected Resolution $\sigma_m < 70\,\mathrm{keV}$

Feng+ 2017

DAQ and Analysis: Available

- Readout DAQ for all components available and used, including dedicated trigger and FPGA firmware.
- Dedicated computer cluster (320+ nodes) for MC and to process streamed data.
- Experienced team (accelerators, nuclear physics, this hardware, analysis).

Target and Target Chamber

Items to build:

- LiF_2 target evaporated on Al foil on spools
  p dE/dx in target = resonance width
  work with FERMILab Mu2e experts
- Stepper motor to keep target fresh
- Vacuum vessel
  including Si strip detector feedthroughs

Beam & target monitoring using another HPGe (available)

Our Approach

Phase I:

- Rapid follow-up (<2 years)
- Build on available equipment and expertise (<750k$)
- Improved design (resolution, particle ID, cascades)
- Confirm or refute Atomki anomaly

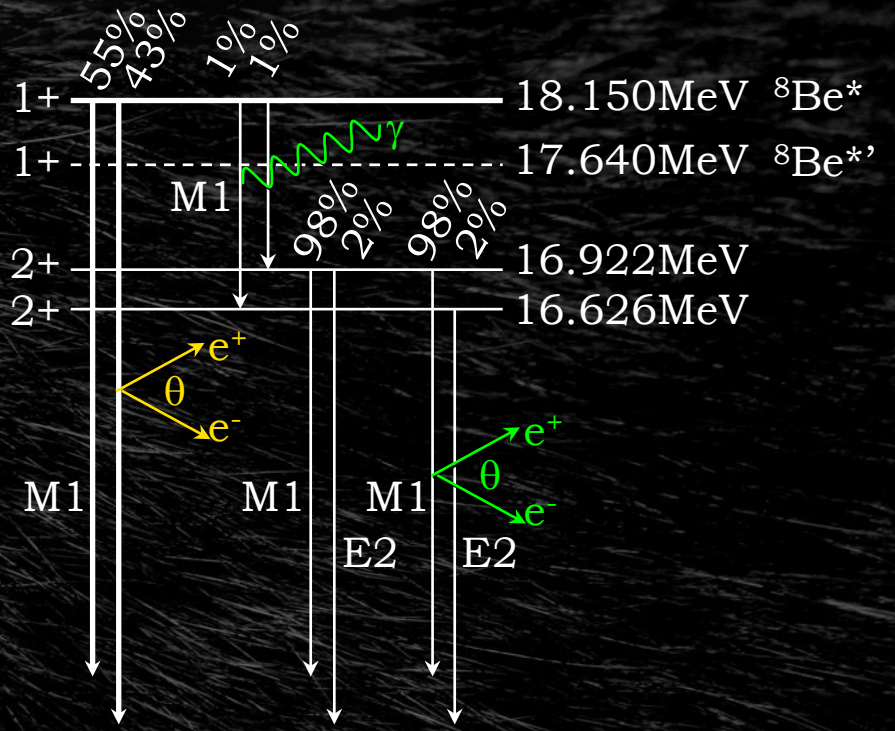
- Increase luminosity
- Polarize beam

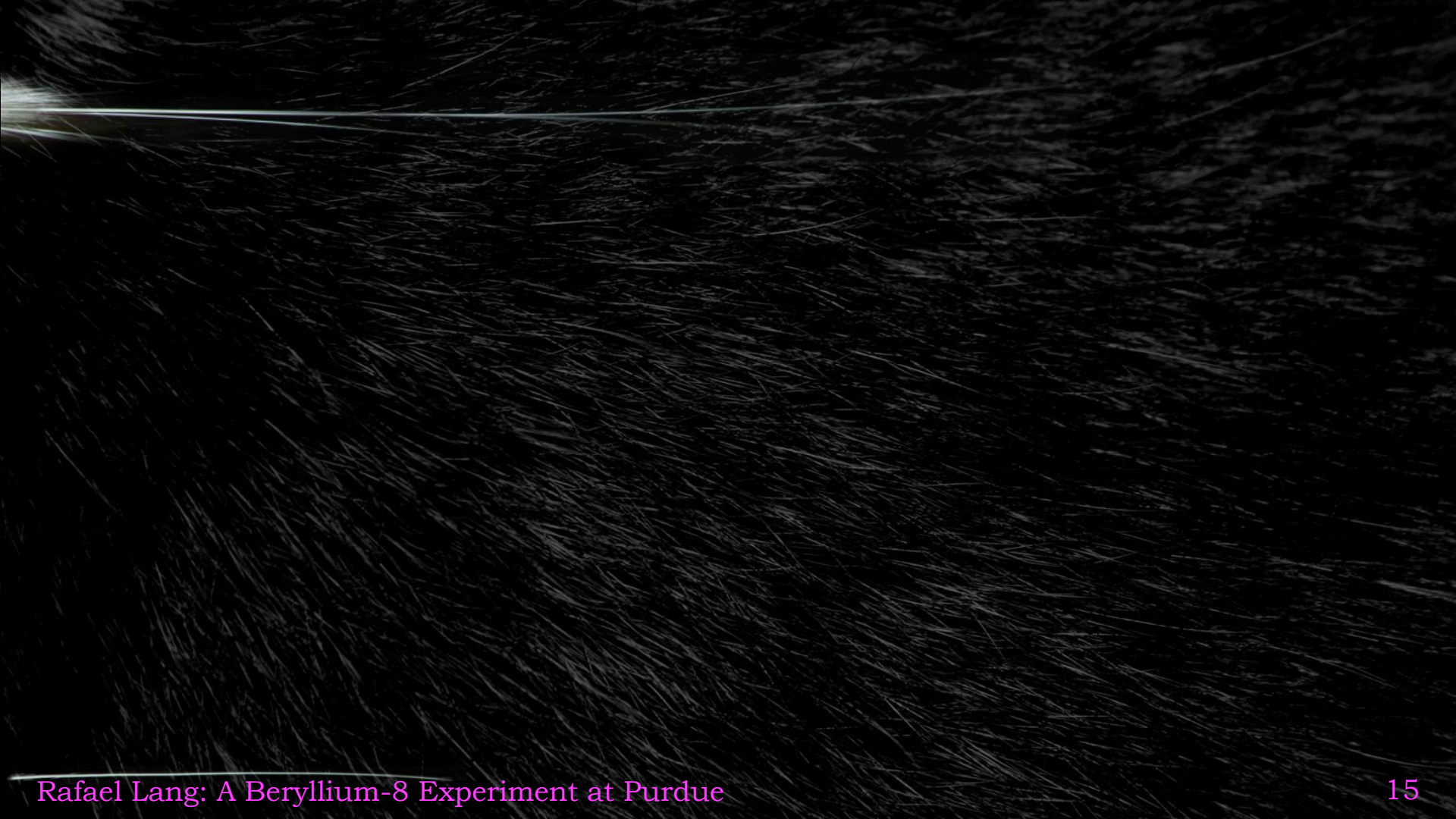
Phase II:

- Improve measurements of ^{8}Be system
- Improve limits on new interactions

Fully Explore ^{8}Be System

- Largely use existing infrastructure and expertise for rapid, phased approach.
- Investigate ^{8}Be system including 16.6&16.9MeV states, measuring cascade decay (not measured before).
- Simultaneously measure IPC from 1+ states



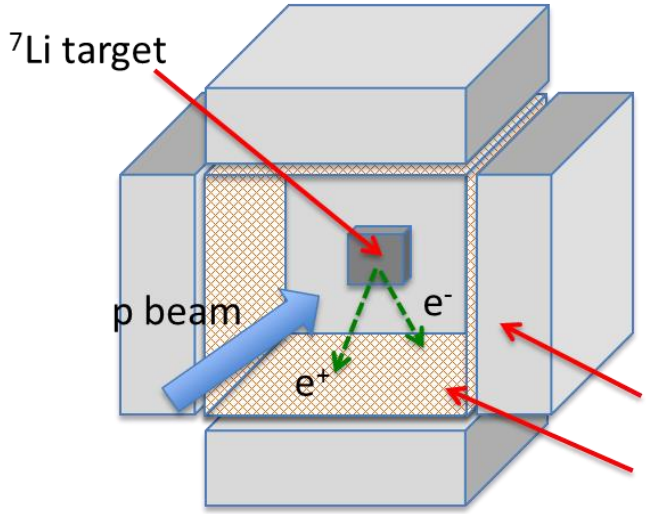


COLORADO SCHOOL OF MINES
Electroweak Interactions Group

INSTITUTE FOR STRUCTURE AND NUCLEAR ASTROPHYSICS

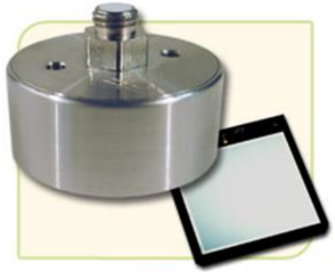
A ^{8}Be IPC Decay Measurement at the Notre Dame-NSL

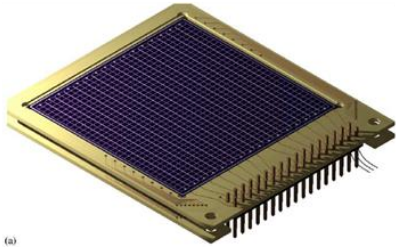
M. Brodeur (U. Notre Dame) and K.G. Leach (Colorado School of Mines)



Sketch of detector system

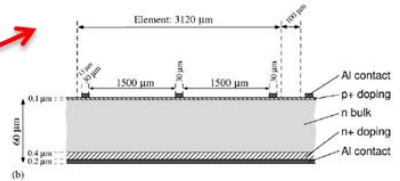
(Not shown: front and back annular Si detectors)



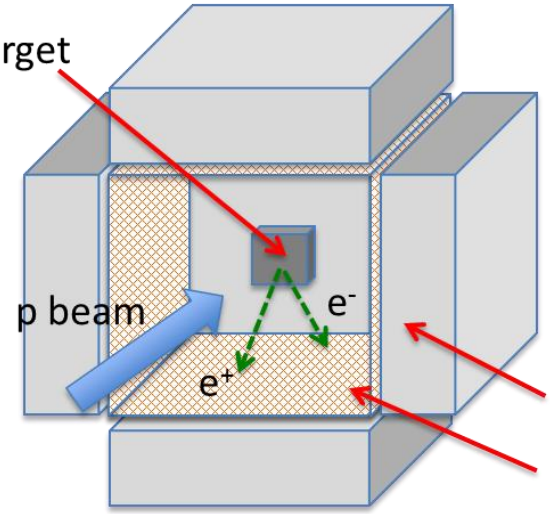


Thick Si wafer

Si strip detector



- In design stage. Location: Nuclear Science Laboratory (NSL) at Notre Dame.
- Initial goal: confirm/refute Atomki measurement using different technique.
- Use ^{7}Li(p,γ) reaction to produce 18.15 MeV state in ^{8}Be.
- Proton provided by 5 MV, 200 μA 5U accelerator gives factor of 200 increase in beam intensity relative to previous measurement.
- Experimental setup: solid ^{7}Li target surround by 4π array of Si strip detectors
- Increase production rates, better angular and E resolution vs. Atomki.
- $750k to proceed with initial confirmation measurement, includes manpower.
- Time scale: 1-2 years after receiving funds.



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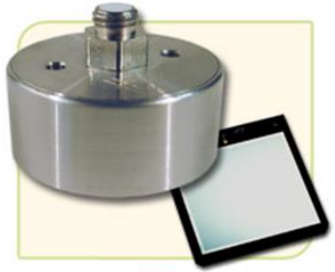

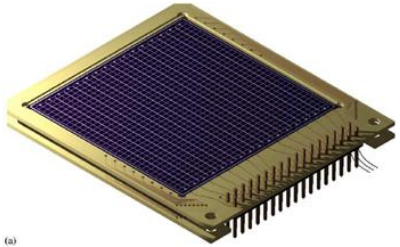

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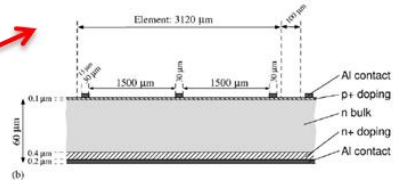

The Nuclear Science Laboratory of the University of Notre Dame