# **Current detector R&D at UMD** (and looking ahead to August)

Phoebe M Hamilton





DEPARTMENT OF

#### **About me**

- Undergraduate studies in physics at Youngstown State University in Youngstown, OH
- Physics PhD right here at UMD, working on the *BABAR* experiment at SLAC
  - Studied unique "finalscan" data as well as antideuteron (antimatter version of  ${}_{1}^{2}H^{+}$ ) production
- PostDoc at UMD as group switched to LHCb
  - First followup to BaBar Colleagues' hint of Lepton Flavor Universality violation and first measurement of  $\overline{B} \rightarrow X_c \tau \overline{\nu}$  at a hadron collider.
  - Developed new ways of doing analysis, including for "1-track+neutral" B decays
- Assistant professor here since `23







New York

🕑 Virginia Beach

#### **Detector R&D at UMD**

- Additional work going on at UMD is R&D for future upgrades
- Major upgrade planned ca 2032 with stepping-stone upgrades to be installed in the 2026-2029 shutdown
  - UMD-involved project: a detector device known as the Electromagnetic Calorimeter will be totally rebuilt with new technology in highest-radiation areas





**Technical Design Report** 

19 April 2025

#### PM Hamilton

# My first calorimeter

- Basic calorimetry is sometimes a high school chemistry/physics lab exercise for conservation of energy and discussing food energy etc
  - Energy released by some process (here combustion of the hydrocarbons of a cashew) is used to heat water
  - Temperature change of the water is directly proportional to the amount of calories (energy) in the cashew
- IMPORTANT FACT: calorimetery is a <u>destructive</u> measurement.
  - $\circ~$  i.e. the cashew is, sadly, not edible after  $\circledast$



# **Electromagnetic calorimeter**

- Electromagnetic calorimeters use the same principle but for gamma-rays and high energy electrons
  - Paricle collides with a dense absorber and converts its kinetic energy into many pairs of electrons, positrons and x-rays. The process destroys the original particle
  - The secondary particles ionize a scintillation medium that converts the ionization energy to near-UV light
  - Amount of *light* is proportional to the energy of the original particle
- How do we measure that light?



# **Light detectors**

- Devices we use for light measurement are Photomultiplier Tubes (PMT)
- Can convert extraordinarily small amounts of light (down to individual light quanta for some) to large electrical pulses (milliamps!)
  - Convert light quanta into electrons via the **photoelectric effect** (a purely quantum mechanical effect – and Einstein's Nobel prize citation!) and amplify these few electrons via secondary emission cascade



# **In pictures**





# Electromagnetic calorimeter upgrade

- The key for the future calorimeter at LHCb Upgrade 2 is *timing* 
  - To be able to make use of data with many proton-proton collisions in each "snapshot", we need to resolve time-of-arrival differences of tens of *pico*seconds (pico=10<sup>-12</sup>)
  - Any devices used in this environment have to not be destroyed by the large radiation dose as well! They have to be reliable!
- Choice of PMT model is *critical* UMD is key institution in studying the candidates





#### Some photos of SpaCAL technology











#### At UMD

- UMD students plugged into research around the choice of PMT for new calorimeter technology in my lab
  - Already my undergraduate student Othello Gomes has made big impacts on the R&D
  - R&D opportunities currently best for advanced students (junior/senior), but this will expand over the next couple years
    - Students will learn skills in metrology, data flow management, data analysis, automation, circuits, PCB design and assembly...
- Future opportunities for multiple students to be involved in hands-on evaluation and testing of devices to be installed at LHCb
  - As with the UT, our students are critical to our success!



# This summer





<sup>\*</sup> DEPARTMENT OF <sup>56</sup> PHYSICS

# Looking ahead to August

- Obviously still a way off and things are in flux
- Hoping to bring you a mix of QuarkNet and LHCb-specific activities as well as information and opportunities for more chats about particle physics research at UMD
  - We're particularly interested to give a glimpse of how the sausage is made...



Jurassic calendars

#### **From this**



#### To this



#### To this

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19 April 2025

#### To this!



### What for?

- Being a bit more hands-on with LHCb data we hope you get to know:
  - a little bit of special relativity
  - $\circ~$  a little bit of coding for particle physics
  - a little bit about considerations that go into particle physics measurements (and measurement in general!)
  - a *lot* more about our weird and wonderful universe of matter and (not) antimatter!
- We're hoping you'll even be able to bring back some of the planned activities directly to your students should you chose

# That's all for now!

- There's so much going on at UMD and we are excited to share it with you!
- Particle physics:





• Particle Astrophysics:





