MINING FOR DARK MATTER INTERACTIONS

SCOTT HASELSCHWARDT

JUNE 29, 2022

OUTLINE

- About me - my education and path into science
- What is being an experimental physicist like?
- DARK MATTER
- Break for questions
- The LZ dark matter experiment

WHO AM I?

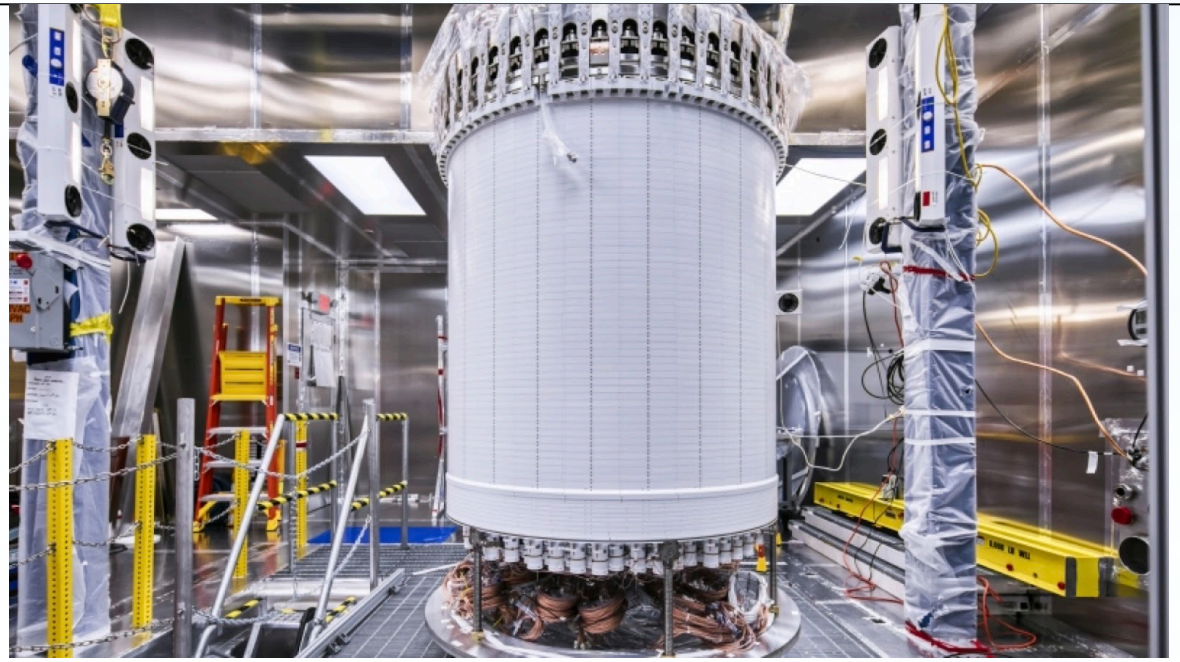
Postdoc @ LBNL

Undergrad @ Univeristy of Michigan, Ann Arbor, 2012

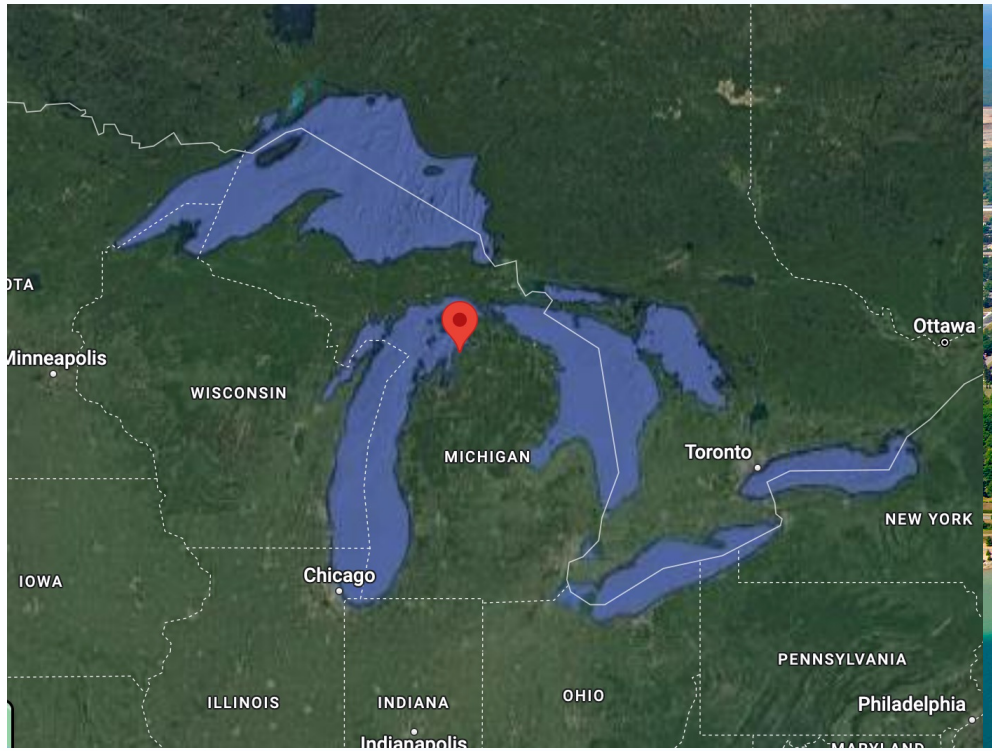
PhD @ UC Santa Barbara, 2018:

"Radioassay of Gadolinium-Loaded Liquid Scintillator and Other Studies for the LZ Outer Detector"

Direct detection of dark matter with the LZ experiment



BORN (1989) AND RAISED IN CHARLEVOIX, MI

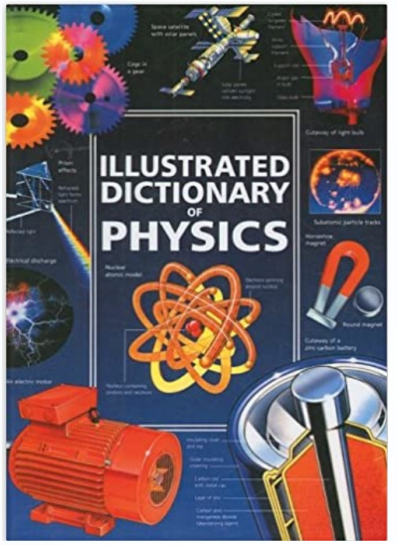


Small town, about 3,000 people

MY SCIENTIFIC INTEREST ORIGINS

Coal mine exhibit @MSI… relevant later

Trip to Museum of Science & Industry, Chicago in 6th grade:

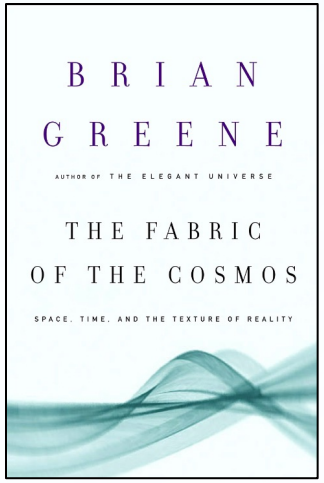


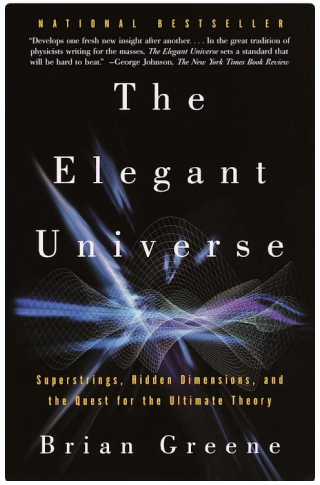
Atoms! Nuclear Fission & Fusion!

High school, math and science – no AP classes

Brian Greene's String Theory books!

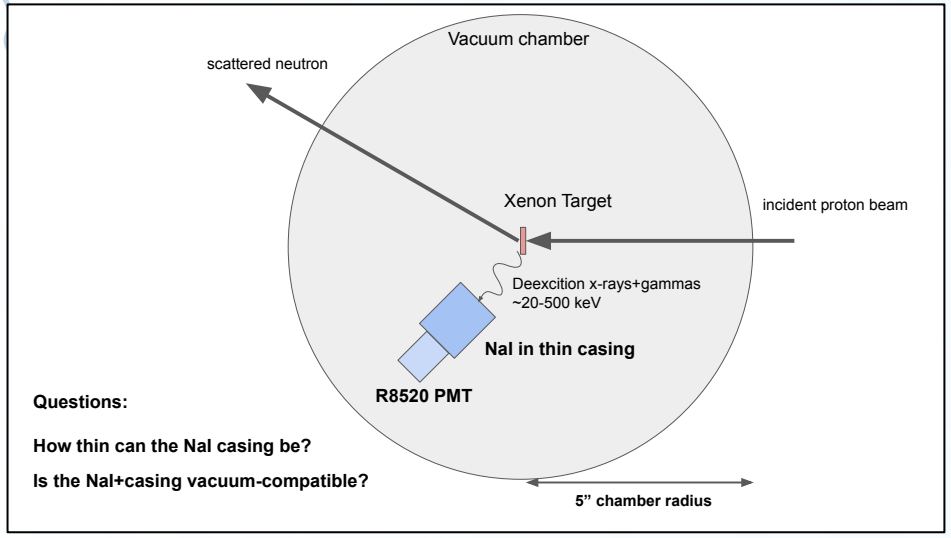
But also… building stuff at home!

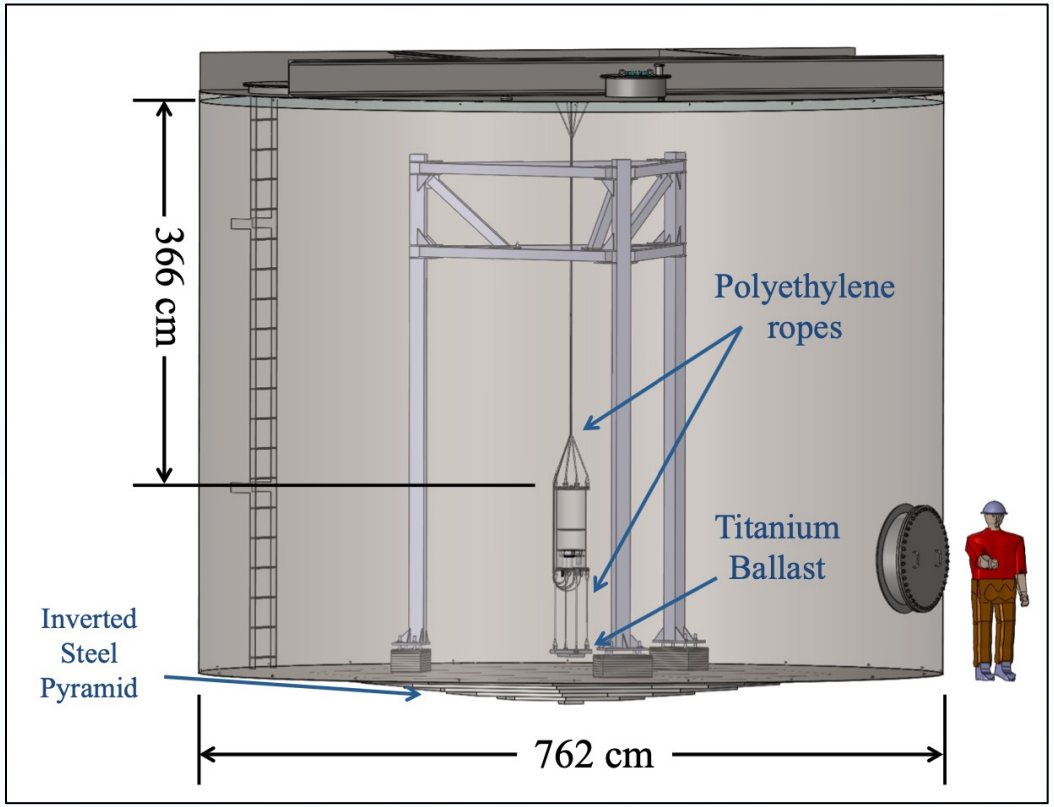


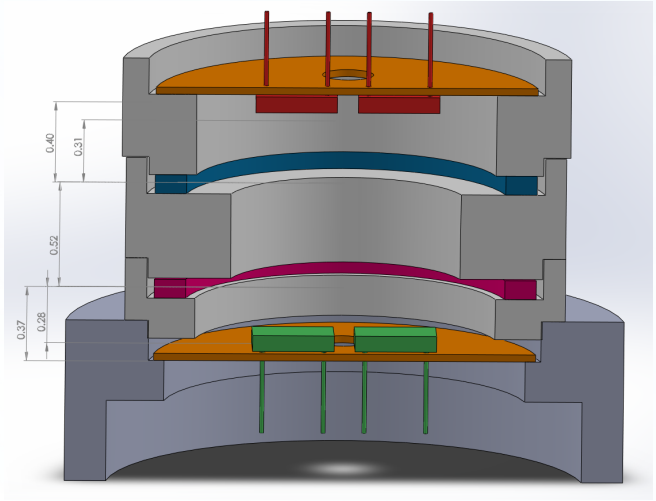


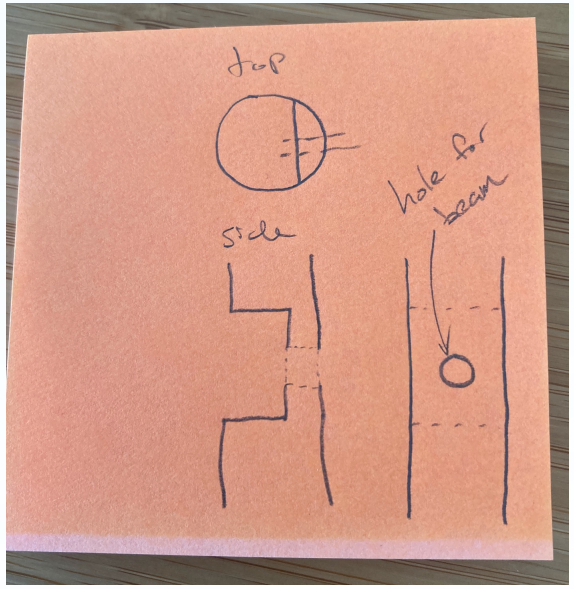
WHAT DO I DO?

- Brainstorm/plan/design experiments



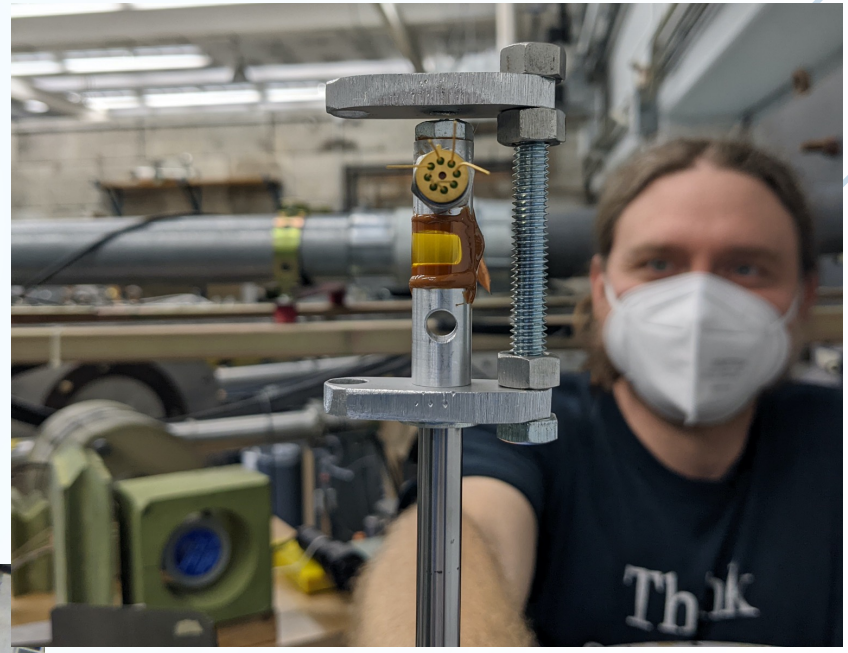


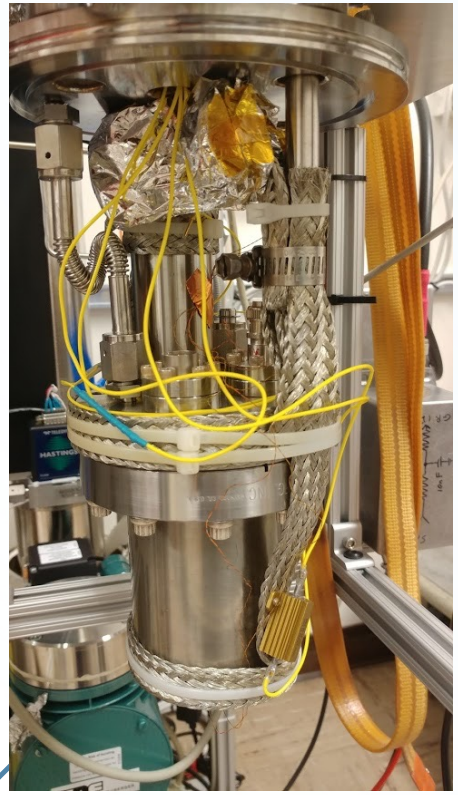




WHAT DO I DO?

- Brainstorm/plan/design experiments
- Lab work: building, testing, taking data!





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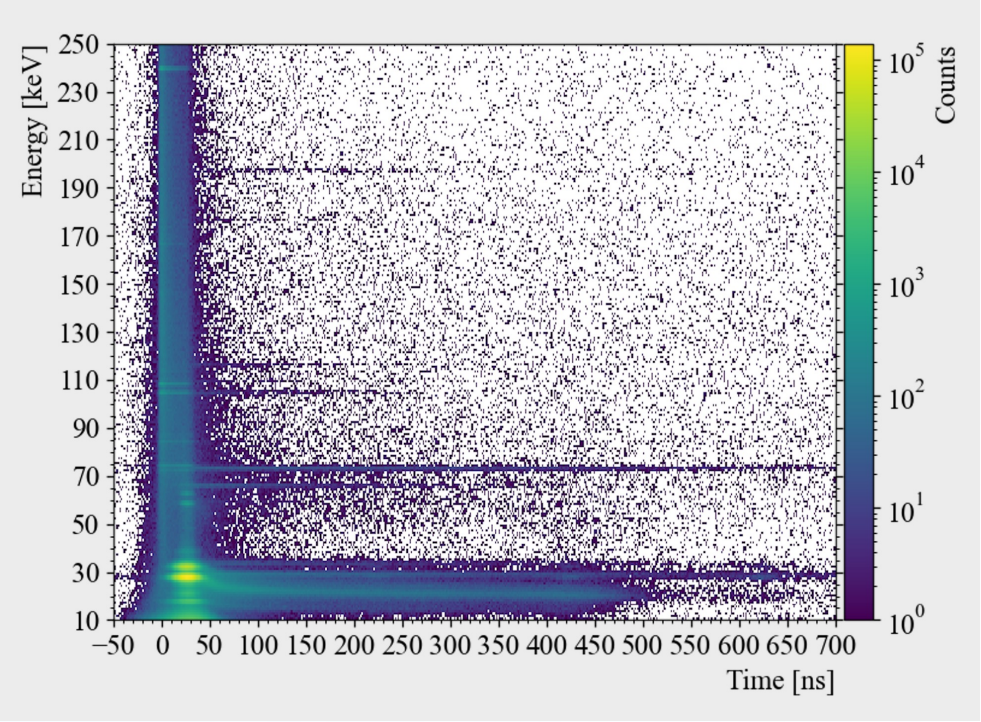

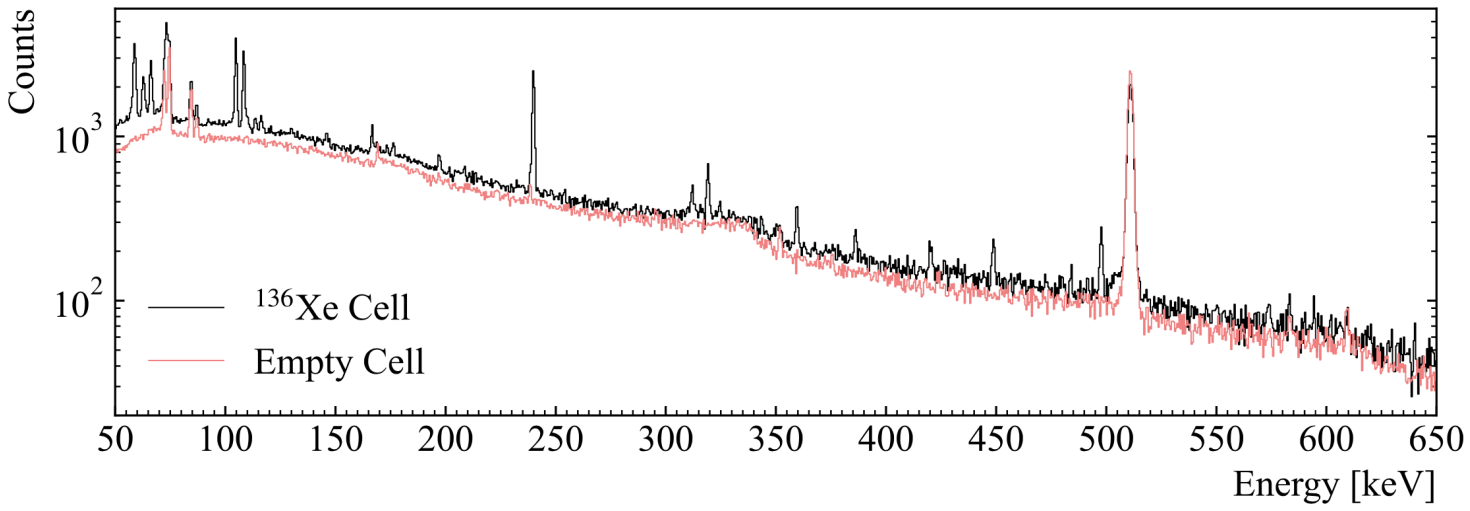

WHAT DO I DO?

- Brainstorm/plan/design experiments
- Lab work: building, testing, taking data!
- Data analysis – writing code, making plots
- Communicate with others!
  - Write papers
  - Give presentations

"The first paper I tried to publish was rejected on the grounds that I had used the word 'bublet'."

DONALD GLASER
Nobel Prize in Physics 1960

Solar neutrino detection in liquid xenon detectors via charged-current scattering to excited states

Scott Haselschwardt,[1,a] Brian Lenardo,[2,b] Pekka Pirinen,[3,c] and Jouni Suhonen[3]

[1] *Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720, USA*
[2] *Stanford University, Department of Physics, 382 Via Pueblo, Stanford, CA 94305, USA*
[3] *University of Jyvaskyla, Department of Physics, P. O. Box 35 (YFL), FI-40014, Finland*

(Dated: September 2, 2020)

BEST PARTS OF MY JOB

- Large variation in the types of work
- “no two days are really the same”
- Collaborating with lots of (very smart) people
- Seeing/measuring things **no other humans** have before

The LZ collaboration

DARK MATTER

INVISIBLE

Dark matter doesn't emit, absorb or reflect light, so it's impossible to 'see'.

IMPORTANT

Scientists think dark matter helps hold the universe together.

Advanced detectors help us to

SEARCH

for dark matter

Planets, stars, the stuff we can see makes up just

5%

of the universe.

DARK MATTER is EVERYWHERE

WEIRD

Normal 5%

The other 95% is a mystery

DARK MATTER BENDS LIGHT

That's how we know it exists.

MYSTERIOUS

It's been many decades since we first theorised the existence of dark matter but we still haven't PROVEN it!

A PARTICLE?

OR

GRAVITY

Most scientists think dark matter might be a stange type of particle. Others think it could be an undiscovered property of gravity.

DARK MATTER IS OUT THERE

1933

Swiss astronomer Fritz Zwicky theorises the existence of a mysterious substance he calls 'dark matter'.

1970's

Vera Rubin discovers evidence to support the existence of dark matter.

1990's onwards

Scientists begin running dark matter particle detectors in deep under-ground labs.

2000 onwards

Space-based detectors launched to search for indirect evidence of dark matter fragments.

Present day

THE SEARCH GOES ON

WHAT EVIDENCE DO WE HAVE FOR DARK MATTER?

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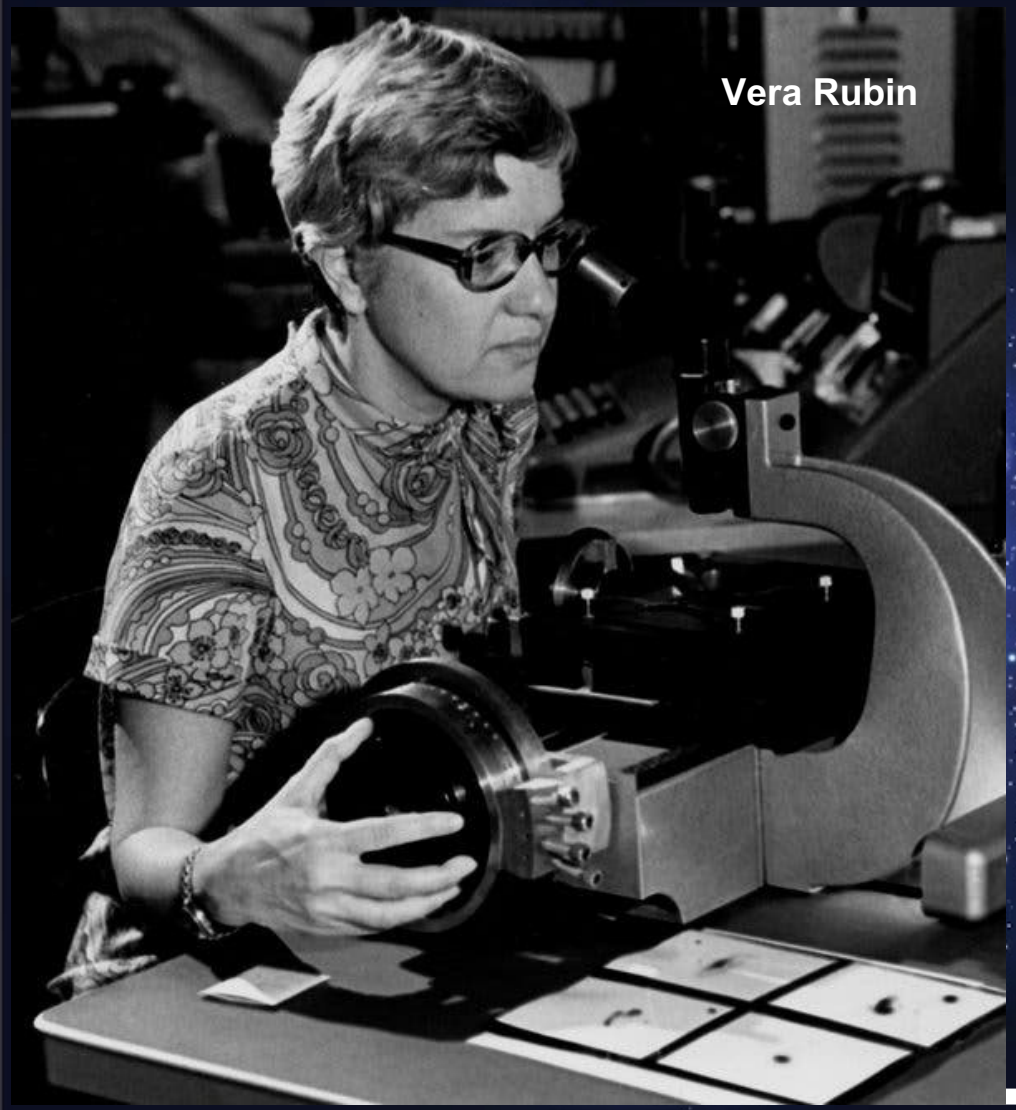
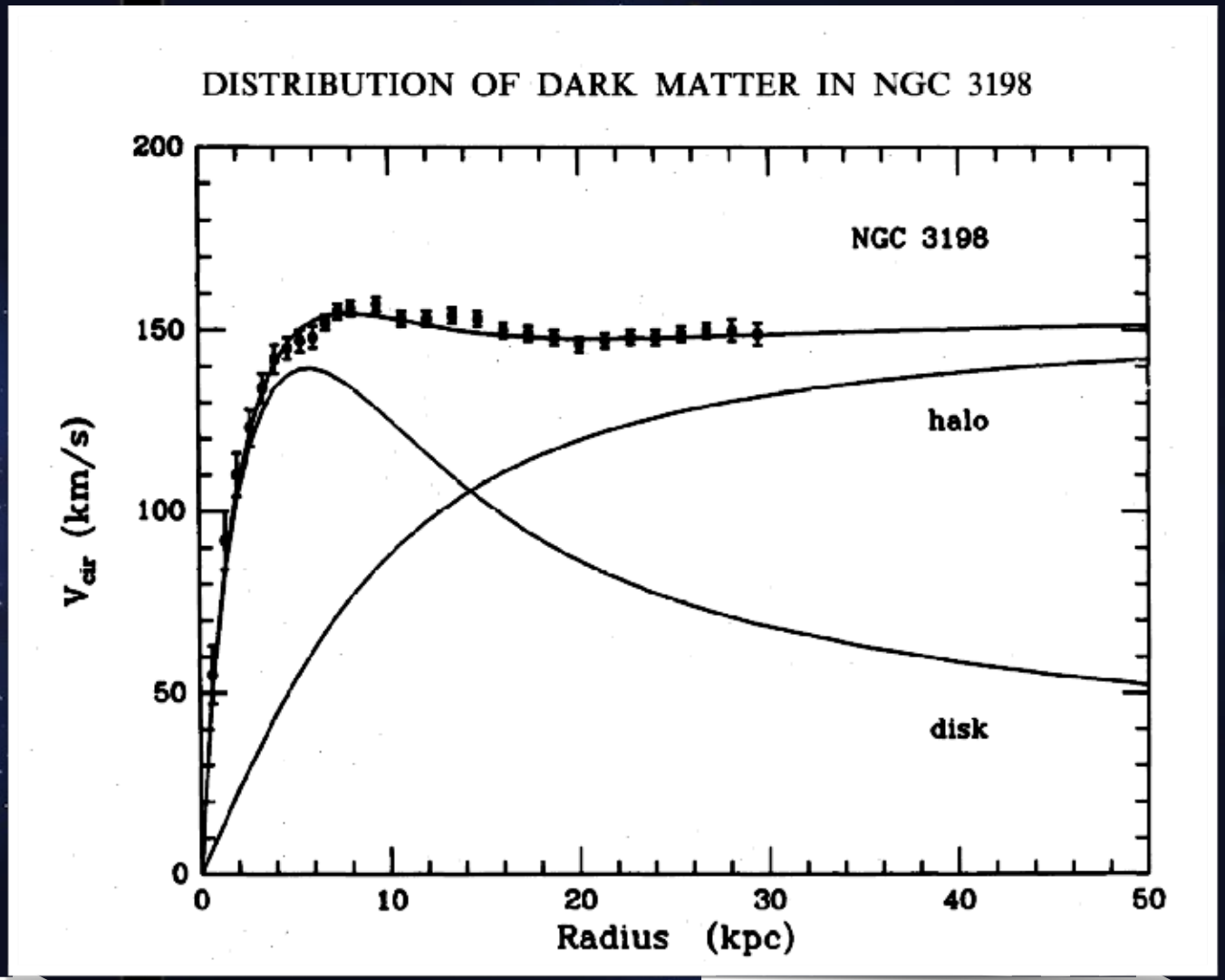
With dark matter



Distance from center

Without dark matter

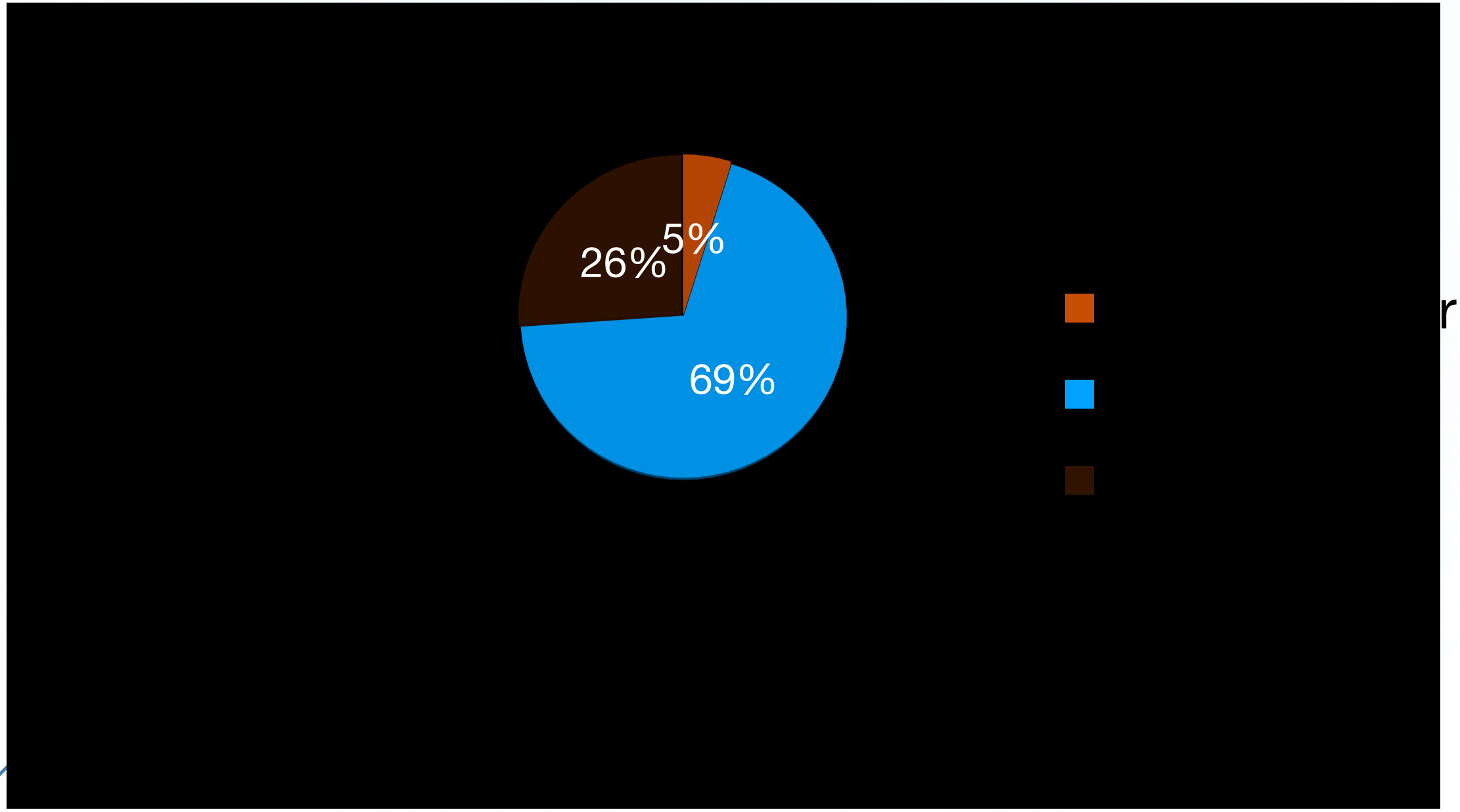


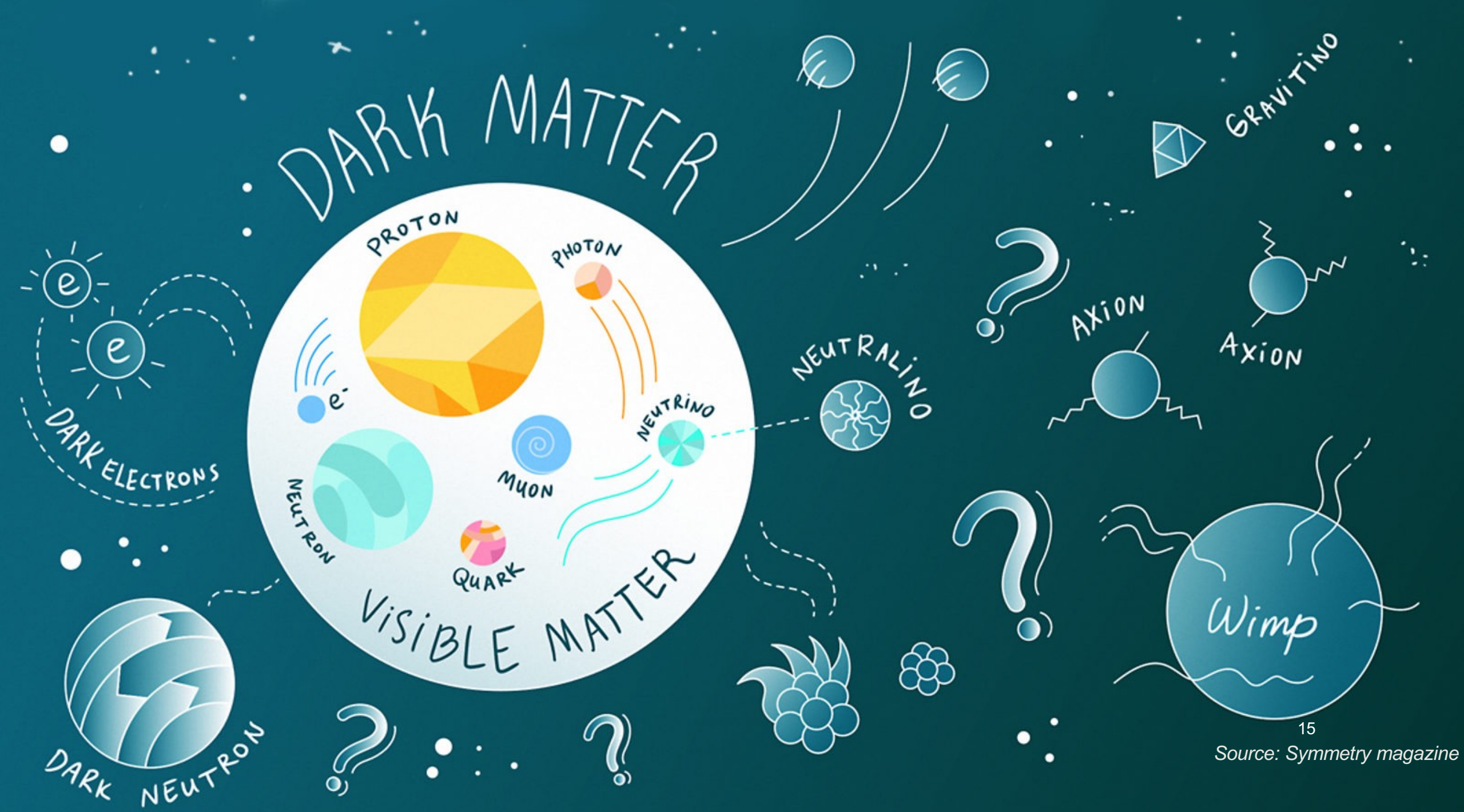
Distance from center

Numerical simulations

Credit: ESO/L. Calçada

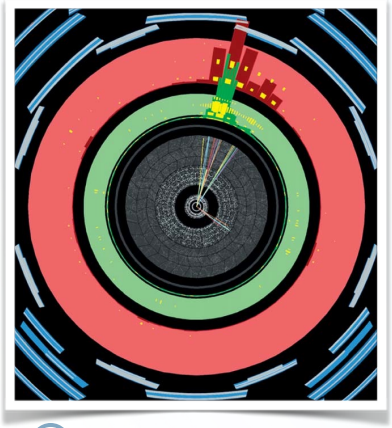
UNIVERSE SIMULATION

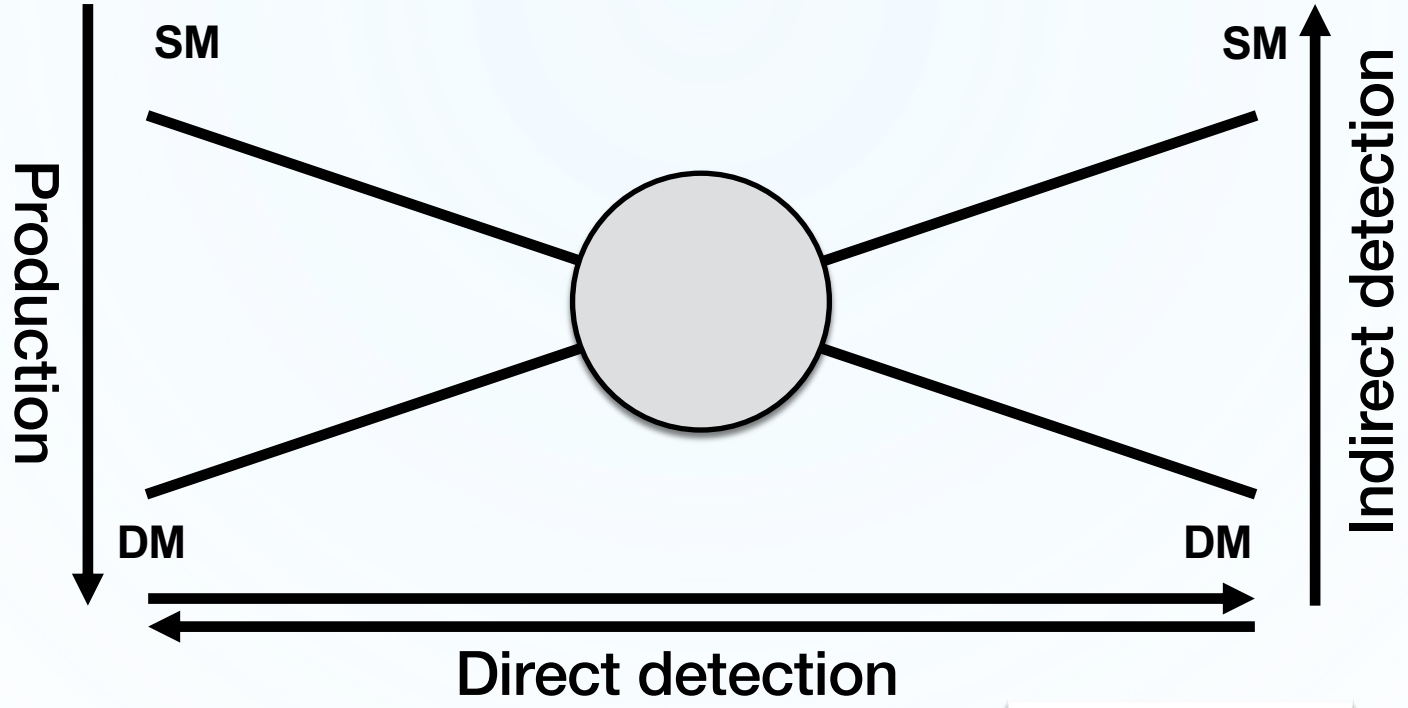


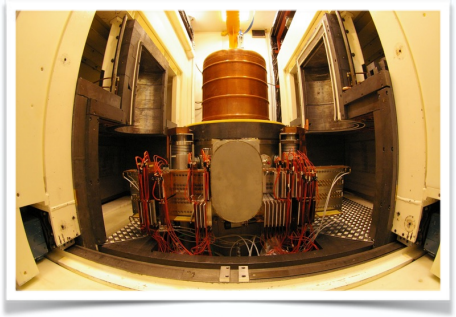


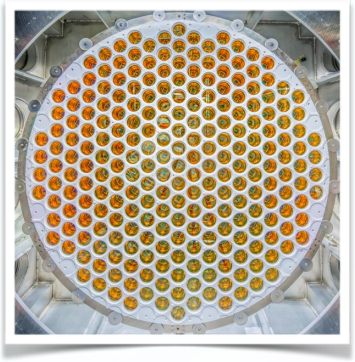
Source: Symmetry magazine

DARK MATTER DETECTION STRATEGIES





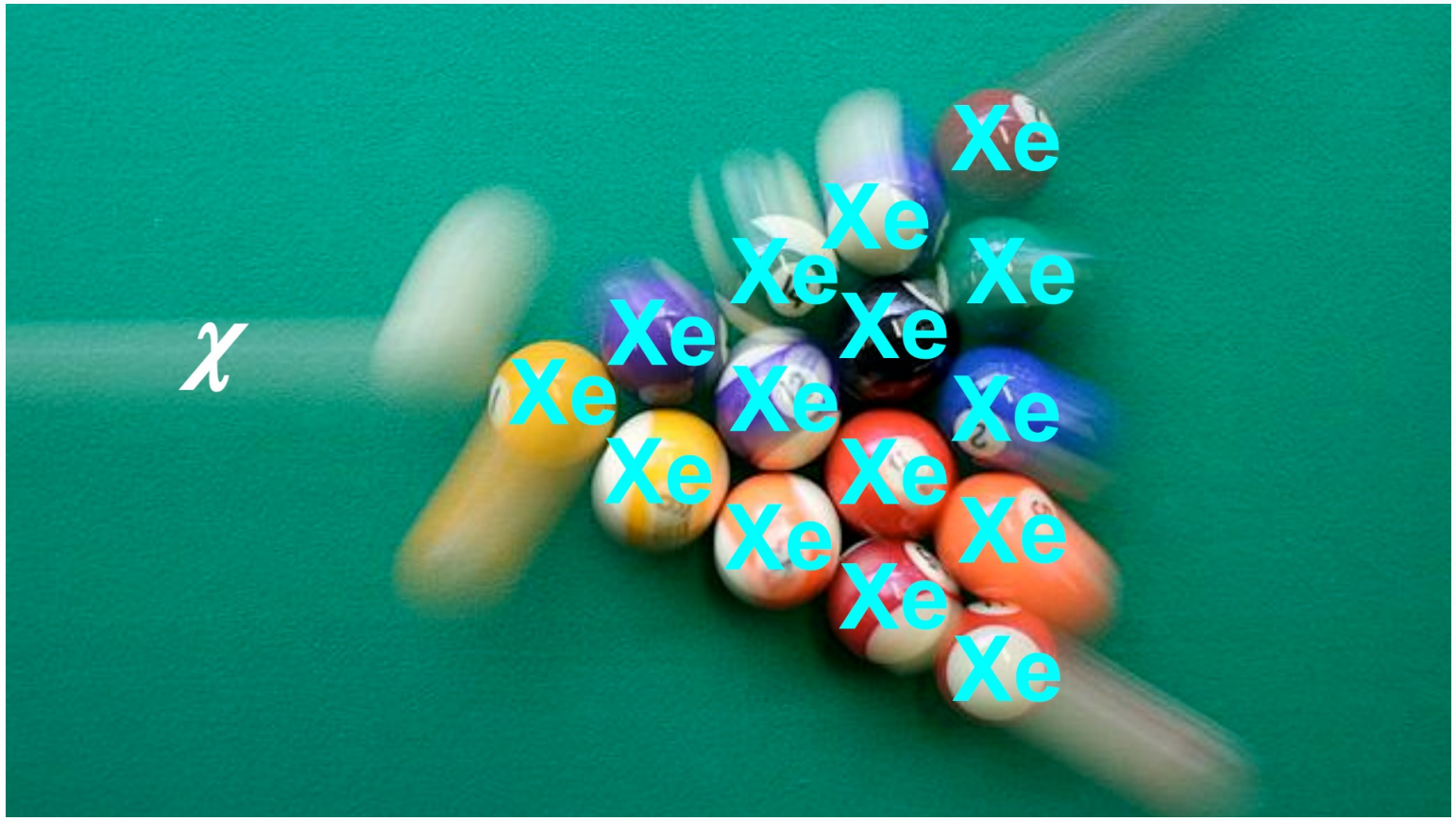




BREAK FOR QUESTIONS & COMMENTS

THE DARK MATTER WIND…

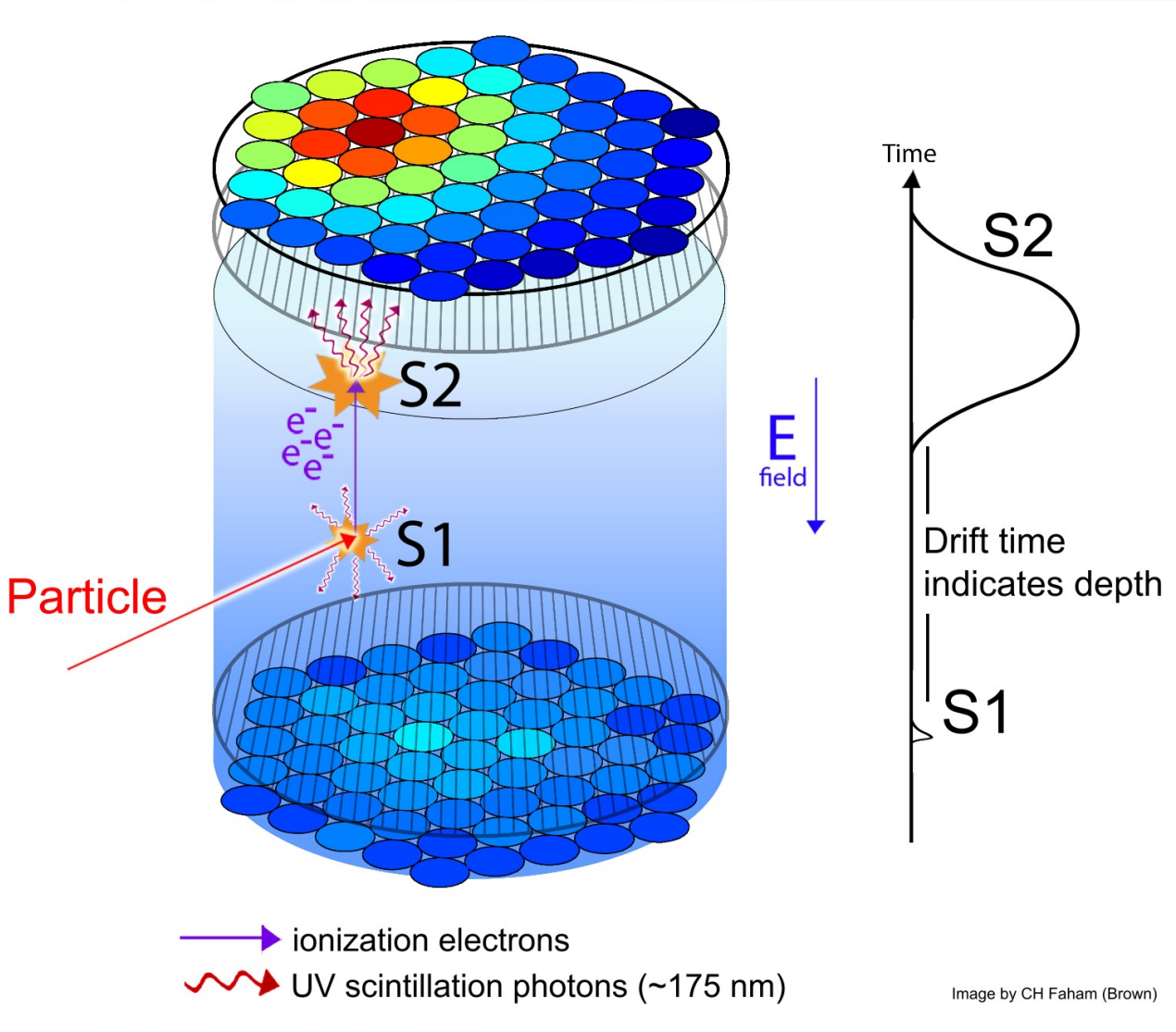
ALLOWS FOR THE POSSIBILITY OF COLLISIONS WITH A TARGET!



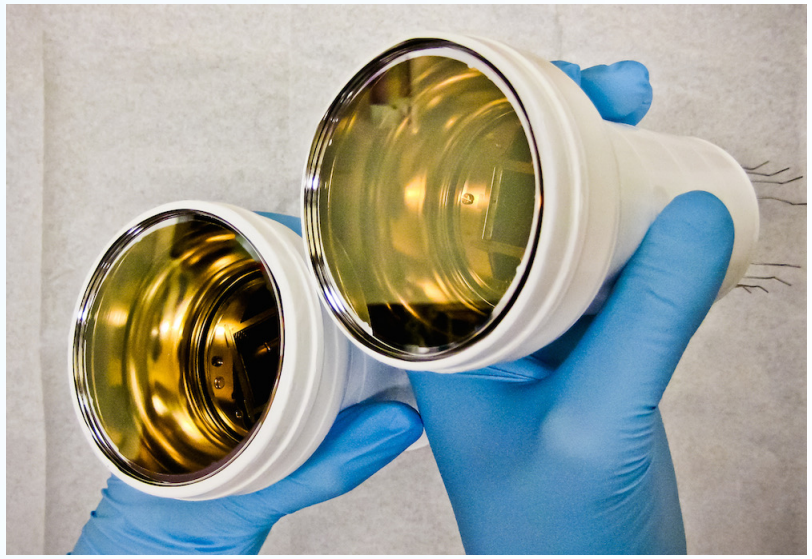
We are playing astrophysics billiards

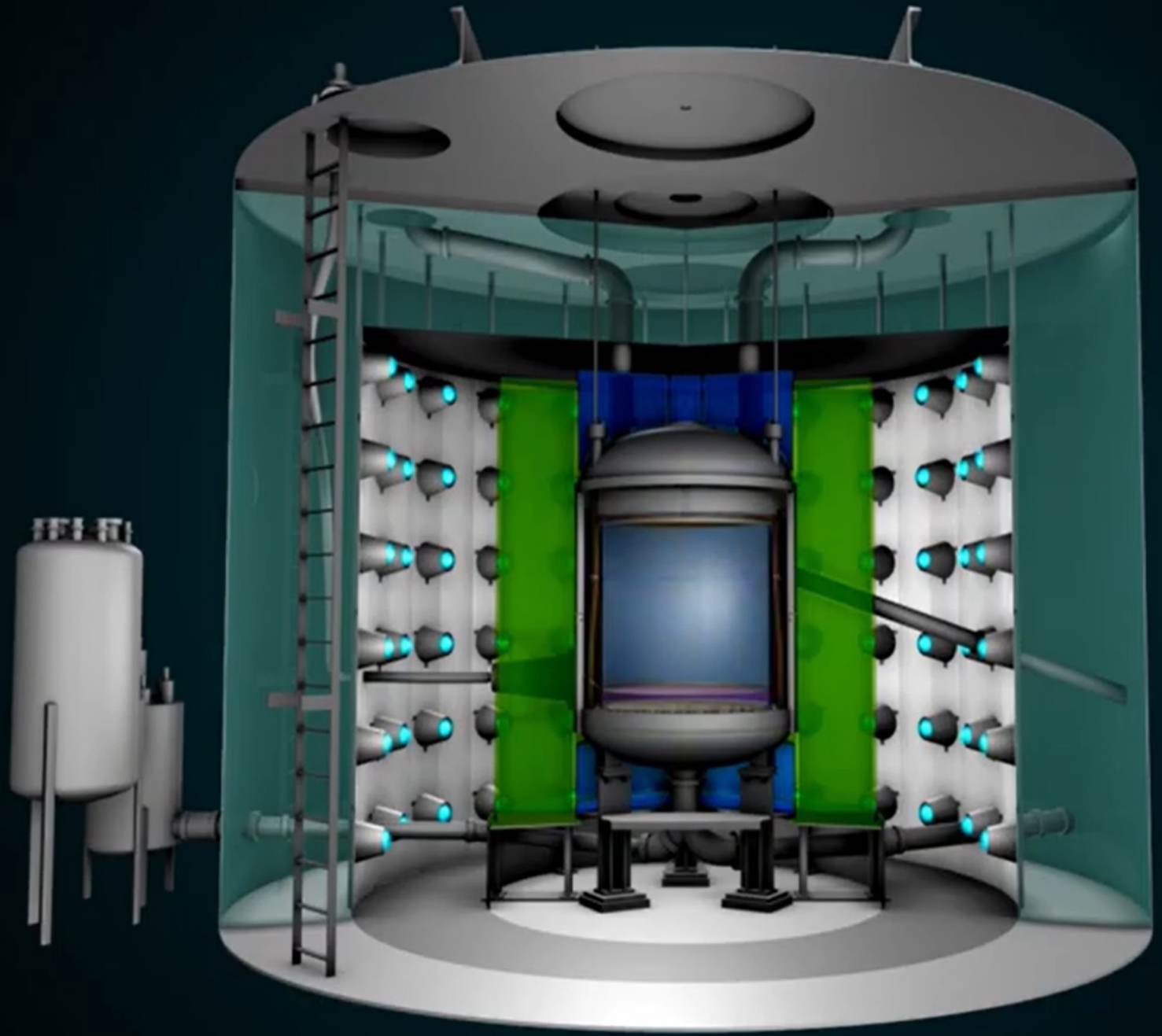
- **dark matter is the cue ball**
- **LZ uses xenon atoms as the target**

HOW DOES LZ WORK?



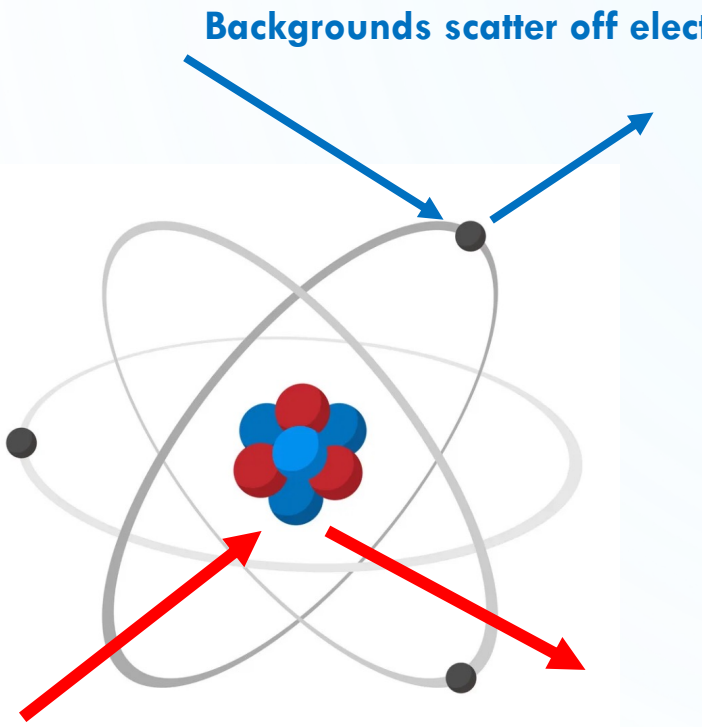
A pair of LZ photomultiplier tubes (PMTs)

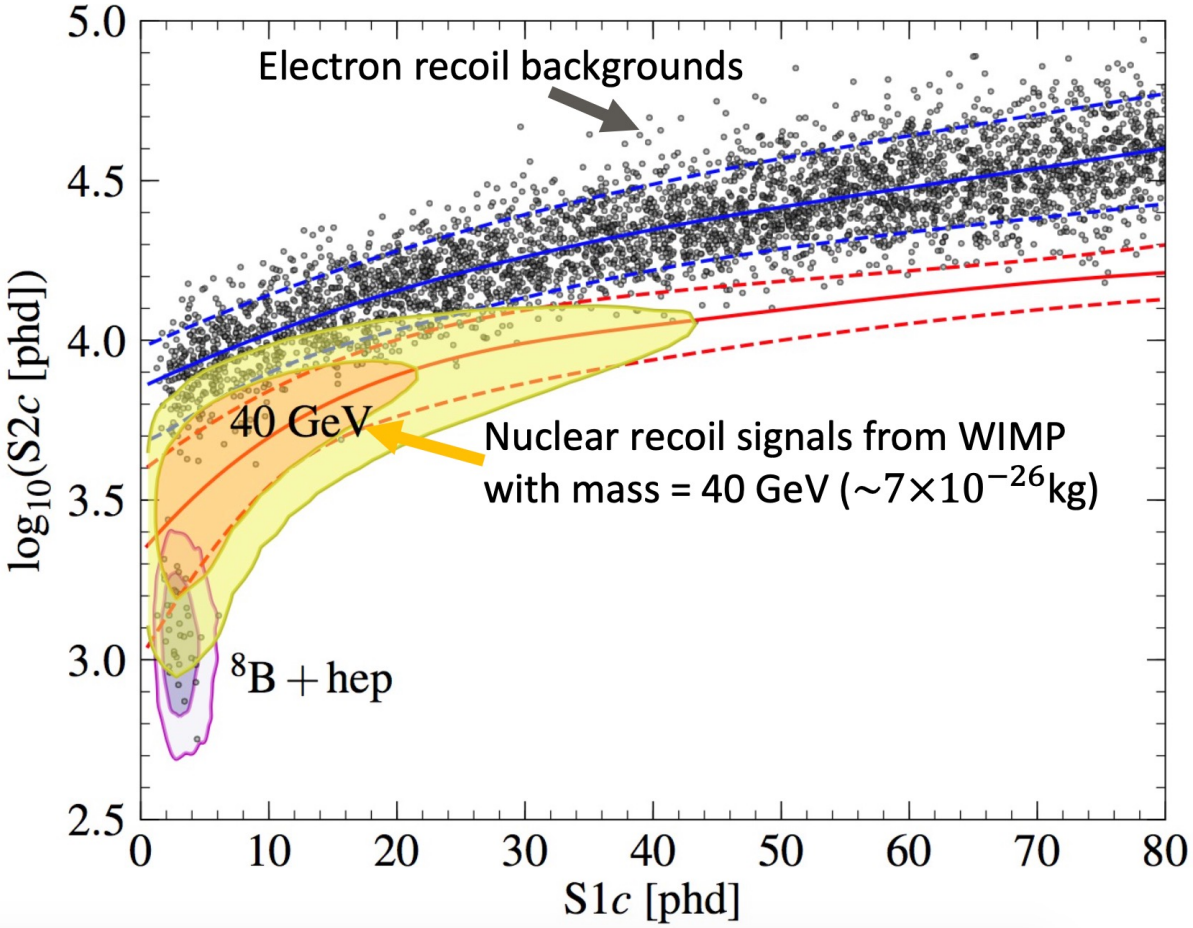




LUX-ZEPLIN
(LZ)

SO… HOW DO WE FIND DARK MATTER WITH LZ?

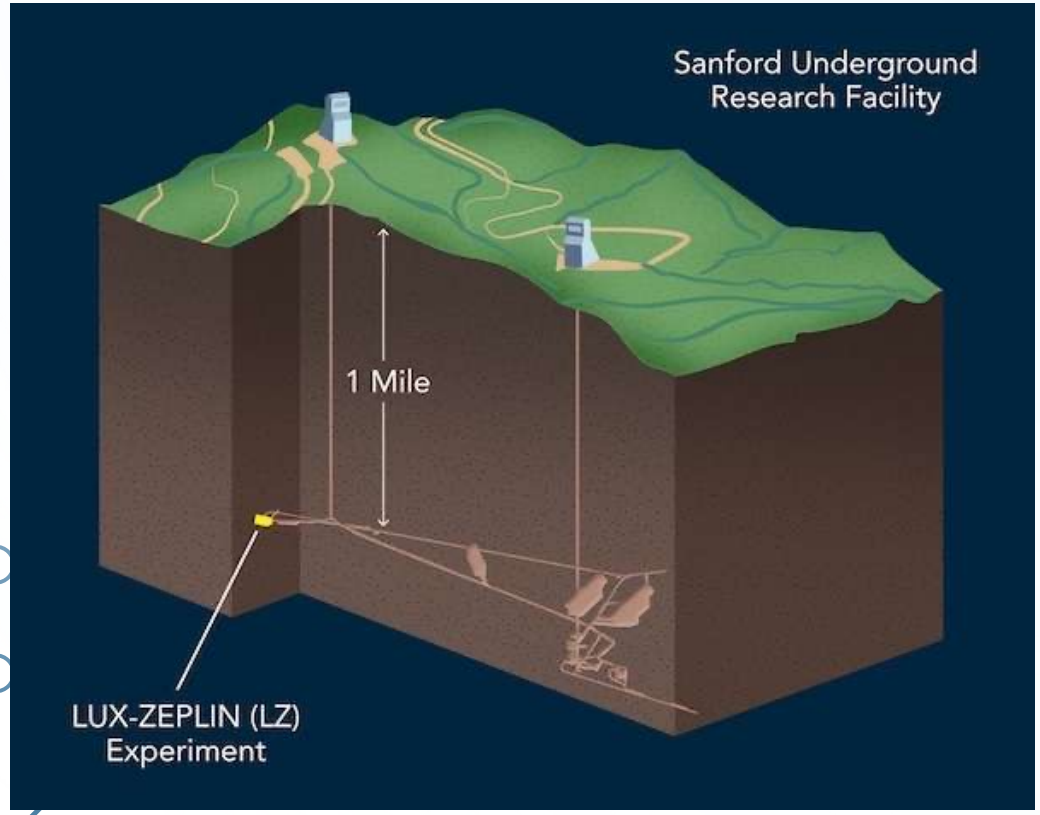


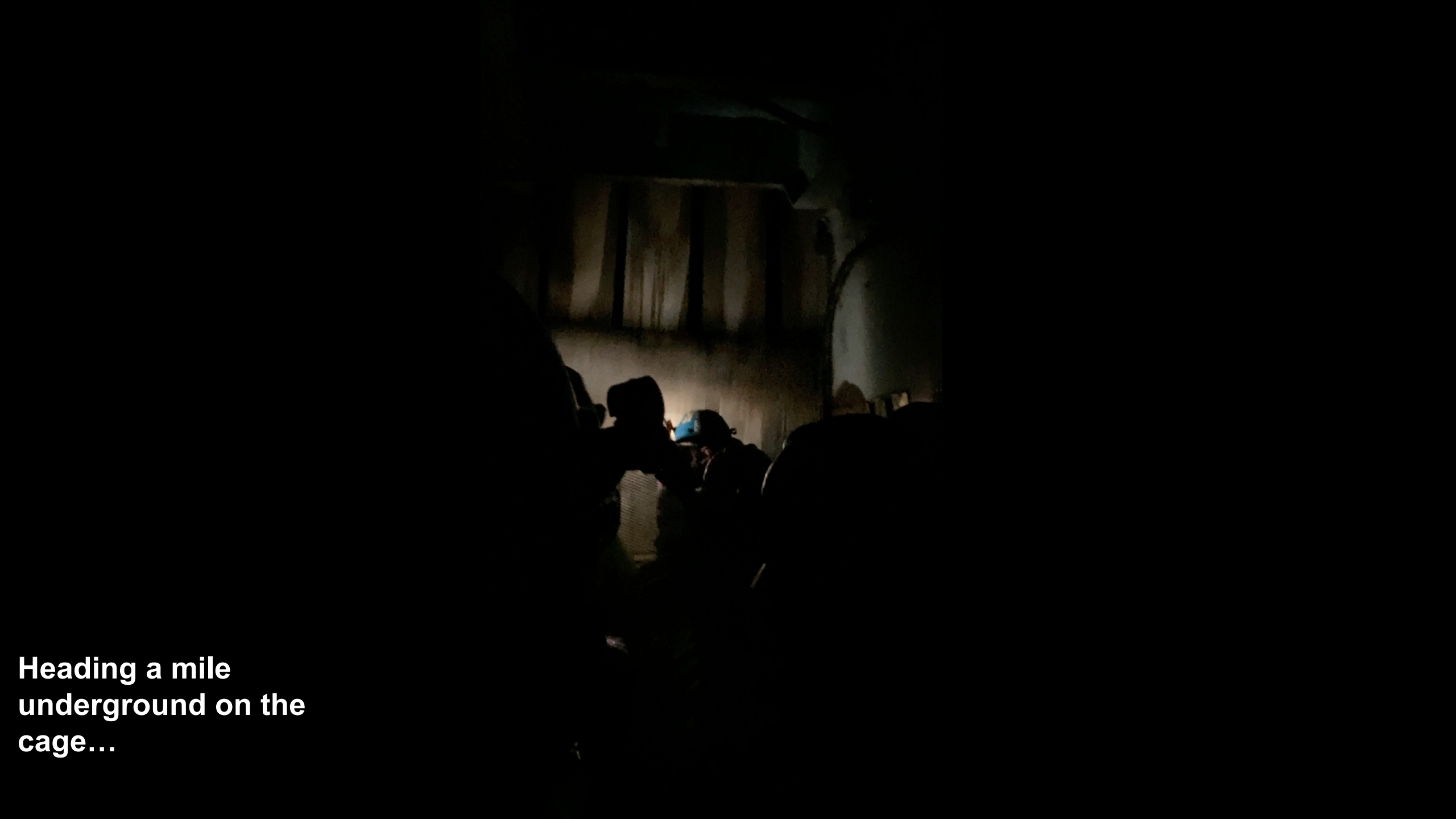


“MINING FOR DARK MATTER” @ SURF

SURF = Sanford Underground Research Facility

Formerly the **Homestake Gold Mine in Lead, South Dakota**





Heading a mile underground on the cage…

BUILDING LZ

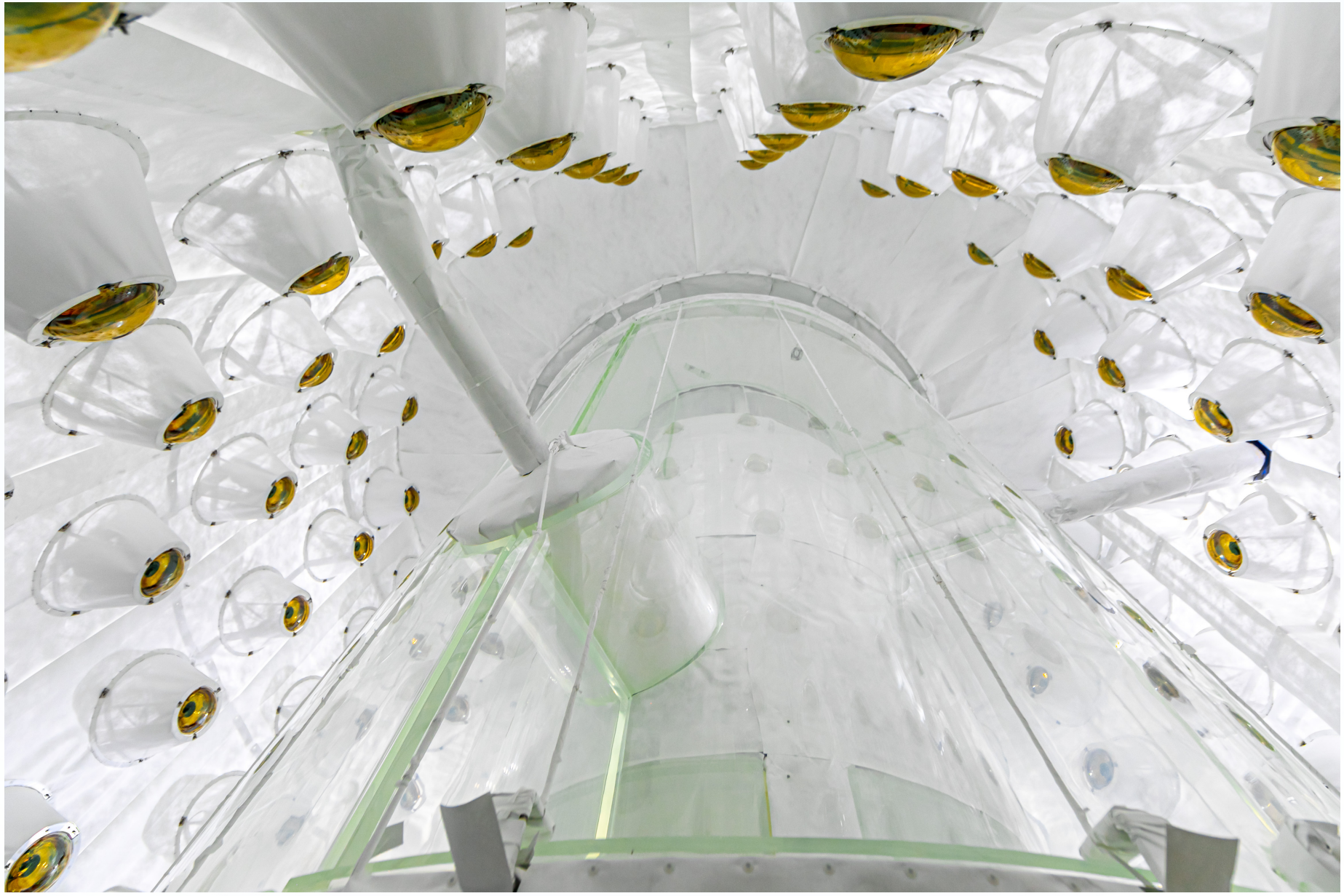
Taking a break inside the water tank

Leak checking the outer cryostat in the surface cleanroom

Attempting to pose with the finished Outer Detector

Filling with liquid scintillator from clean room underground

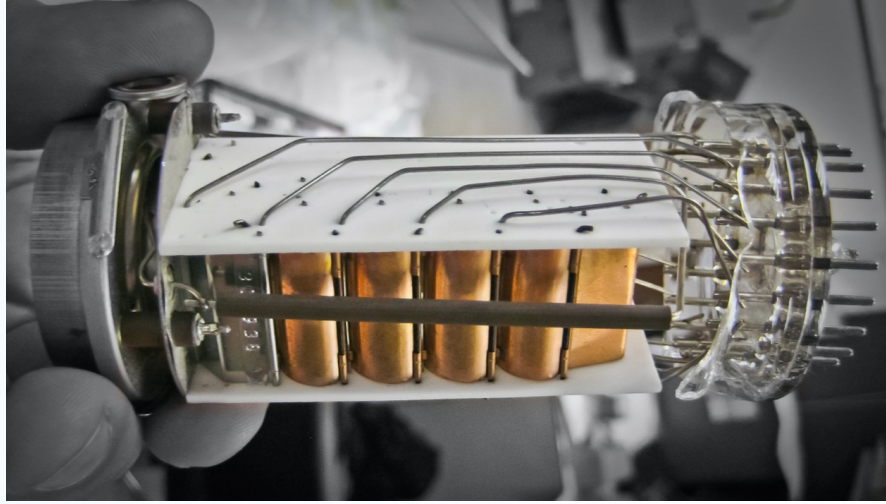
A better view…

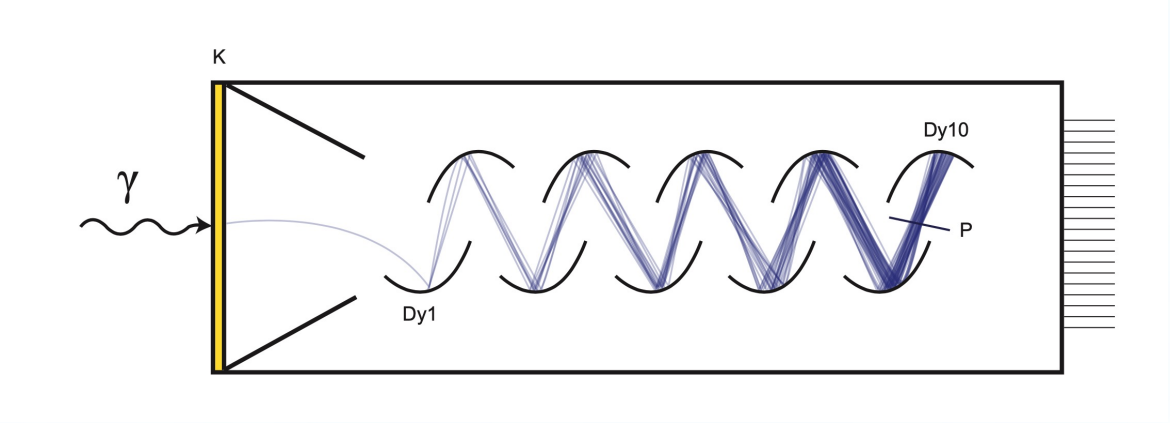


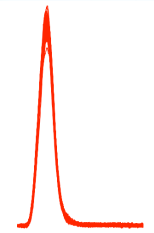
THANK YOU!

BACKUP/ADDITIONAL SLIDES

PHOTOMULTIPLIER TUBE (PMT)







Outfitting the Davis Cavern for science