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# XENON challenges and uniqueness thereof

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# XENON challenges and uniqueness thereof

Challenge 1: I have never figured out how to talk about cyberinfrastructure effectively

Rarely agreement on solutions

Sometimes agreement on *problems*

Challenge 2: XENON has limited manpower so ingenuity key to survival

See all my numba and PyHEP talks

Challenge 3: Community building harder for us

Therefore: interrupt and ask anything or give unsolicited feedback

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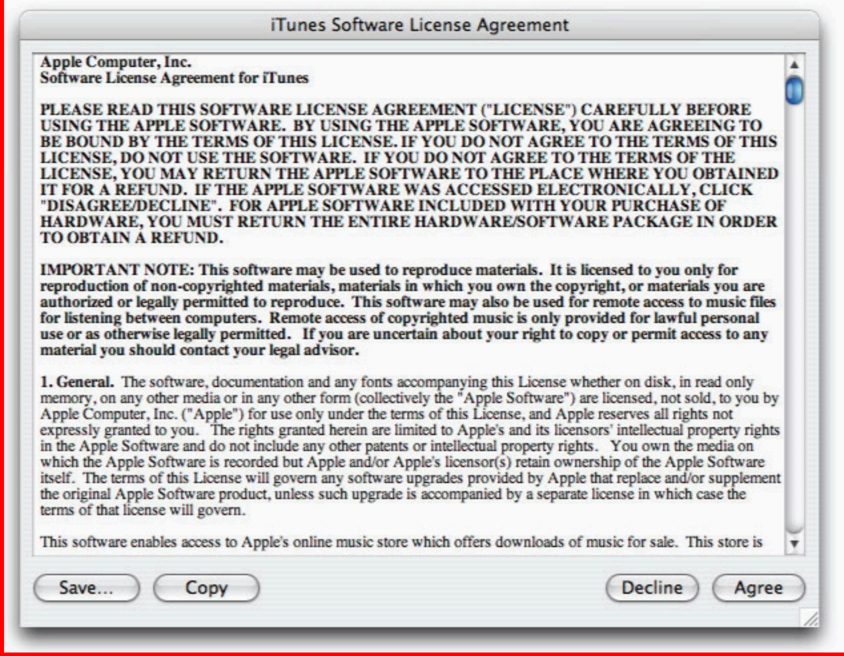
## Views are my own.

The information contained within is an incomplete survey of the field. The presentation purpose is to communicate the current state of the field to the best of my knowledge, though this is subjective. The bias of the author may unintentionally be present. For official information from the collaboration, please contact the collaborations directly. Using this talk as a reference is unwise as I have selective hearing. I am not looking for a fight with collaborations but the opposite: understanding for mutual collaboration. By going further, the audience member agrees to not make the various experiments regret talking to the speaker. Don't get angry at me but educate me.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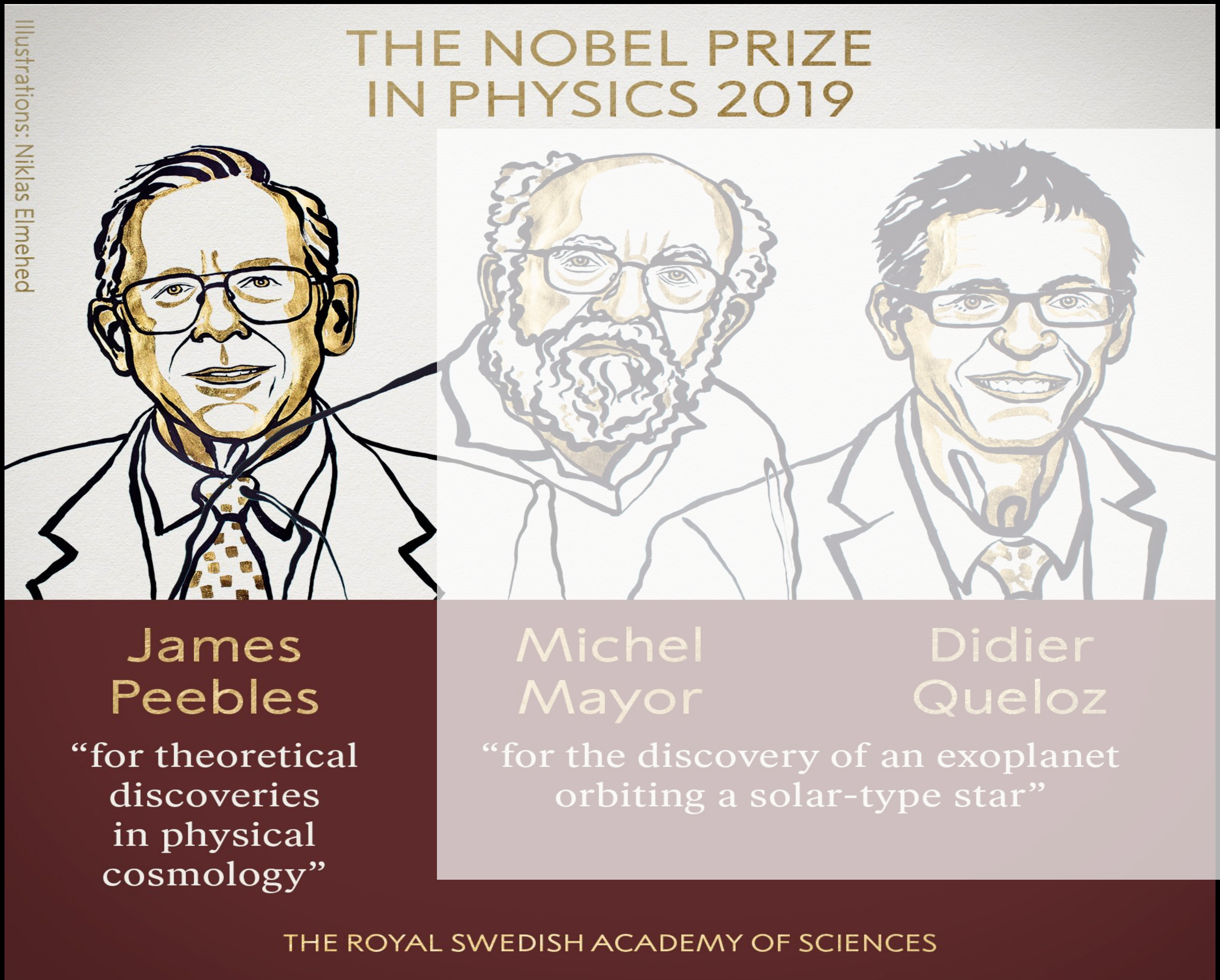
# First some news:
# Cosmology Nobel for Dark Matter Discovery



# But what is Dark Matter?

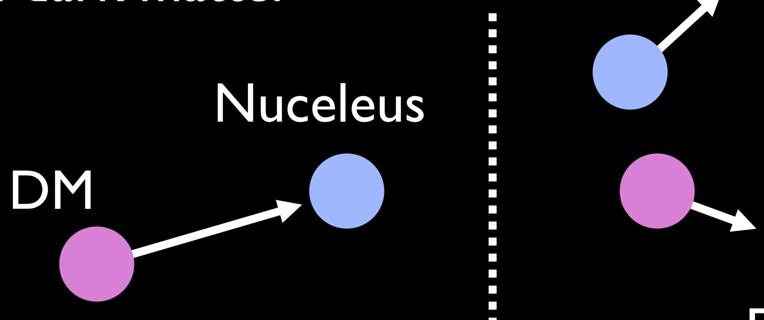
PHYSICAL REVIEW D VOLUME 31, NUMBER 12 15 JUNE 1985

## Detectability of certain dark-matter candidates

Mark W. Goodman and Edward Witten
*Joseph Henry Laboratories, Princeton University, Princeton, New Jersey 08544*
(Received 7 January 1985)

We consider the possibility that the neutral-current neutrino detector recently proposed by Drukier and Stodolsky could be used to detect some possible candidates for the dark matter in galactic halos. This may be feasible if the galactic halos are made of particles with coherent weak interactions and masses $1-10^6$ GeV; particles with spin-dependent interactions of typical weak strength and masses $1-10^2$ GeV; or strongly interacting particles of masses $1-10^{13}$ GeV.

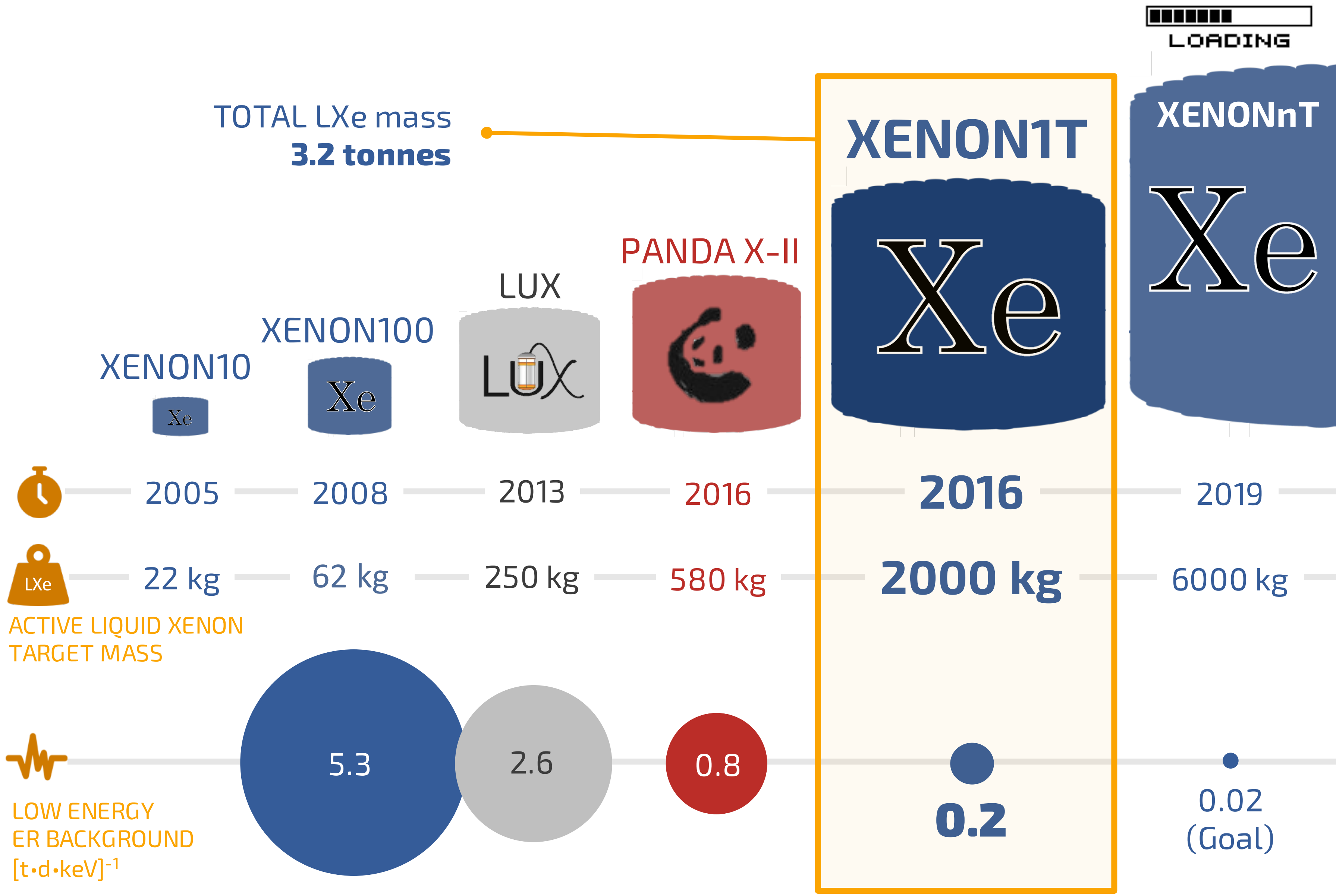
Theory:
Elastic scattering of galactic-bound dark matter



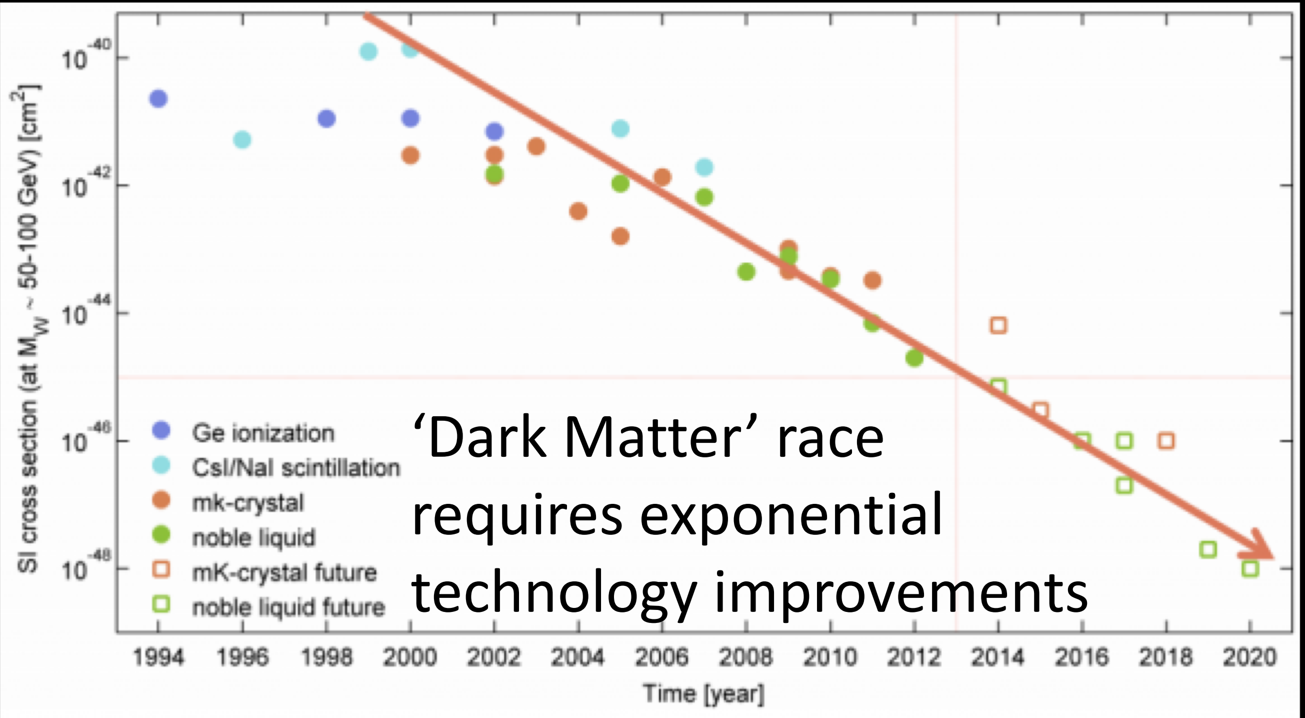

Experiment:
Detect faint fast keV* signal in tonne-scale background-free cryogenic experiment

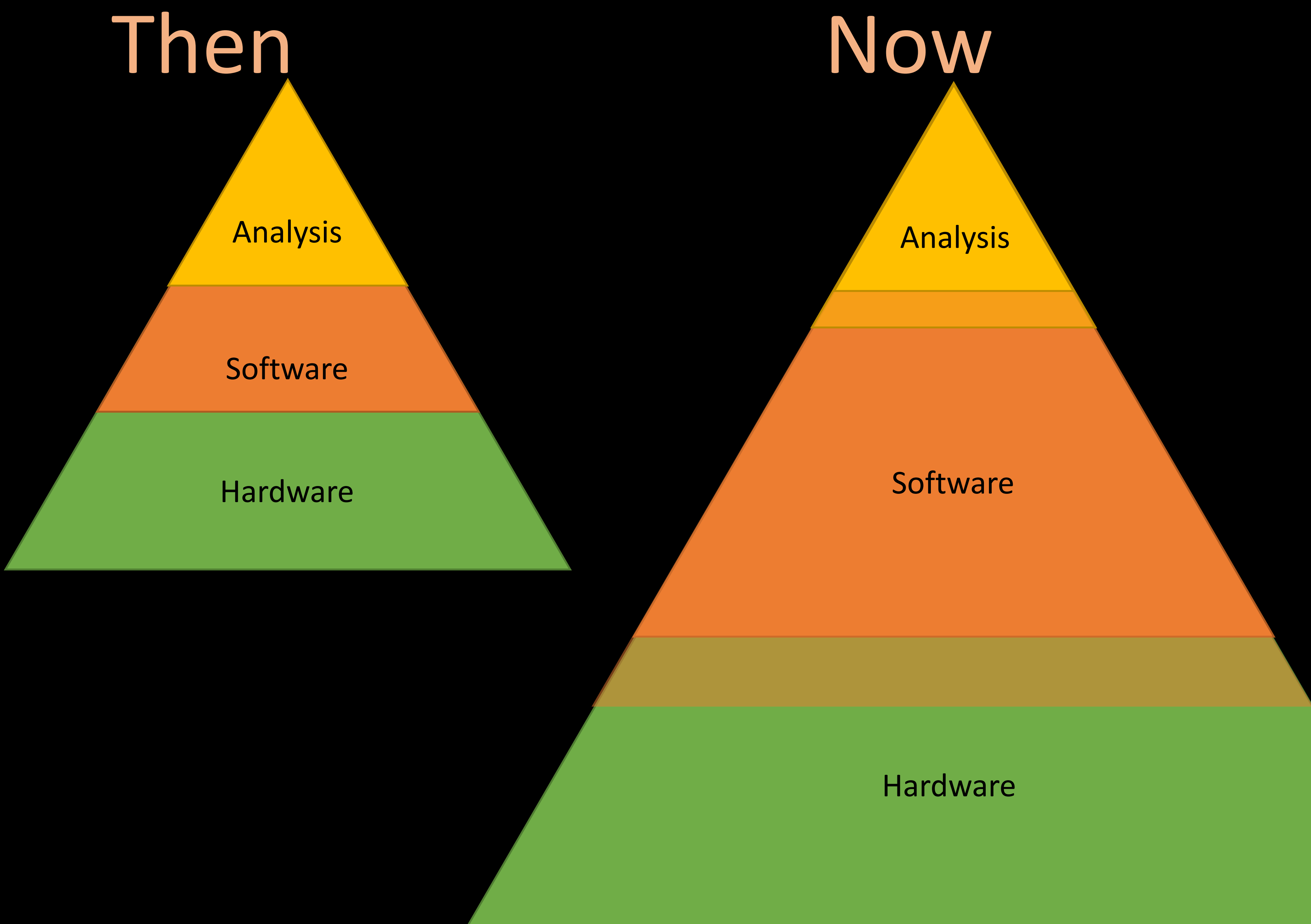
*keV not a typo!

# Xenon two-phase detectors



# Claim 1:
# Exponential increase in experimental requirements (incl. computational)




Then
Analysis
Software
Hardware
Now
Analysis
Software
Hardware

# Corollary 2: We became "data intensive" in last decade with requirements per developer also increasing

Transition from informally run unorganized collectives (e.g. XENON10/100) at LNGS to collaboration structure with more division of labor (XENON1T) spreading data around.

In XENON, DAQ, data management, software stack, and MC all have fraction of postdoc each. Lack of operations program means maintain this is difficult

Like CDMS, ~5 FTE with high turnover due to limited career prospects in physics and high work load compared to industry

# Claim 3:
# Few inter-collaboration computational R&D efforts, despite opportunity

See dance.rice.edu for work towards solutions here, ranging from training to R&D funds

# Claim 4:
# Our requirements often mismatch with other communities, hard to benefit from their prior work given limited manpower

XENON: First non-ATLAS Rucio user, large initial investment (though probably worth it?) since no core lab

LZ: NERSC is for high performance instead of high throughput computing, so engineering effort goes there

DarkSide: e.g. user management

# ~~Claim 4:~~
# ~~Our requirements often mismatch with other communities, hard to benefit from their prior work given limited manpower~~

Counterexamples:

SuperCDMS/XENON with Science Gateways potentially?

Ceph in XENON

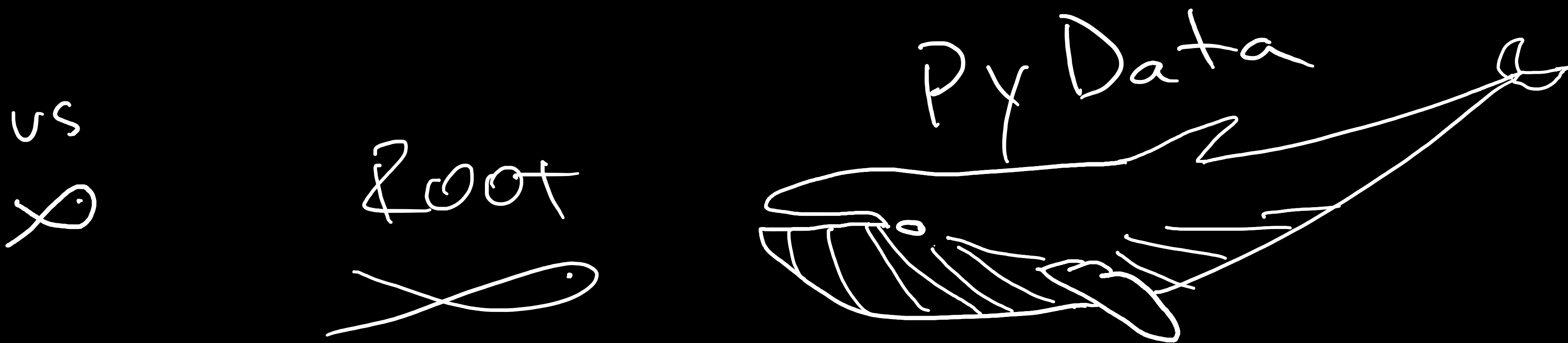
DOE Dark Matter experiments have engineers to leverage prior investments

# Corollary 5:
# LHC experiments have support timescales and legacy requirements not applicable for us

- We build experiments every few years instead of decades
- Fewer developers, fewer users
- Smaller code base

# Claim 5:
# Around LHC commissioning, technology companies surpassed HEP in Big Data

- Can we follow the “LSST” model of organically using new things to lower manpower requirements and increase science output?
- Can we forget ROOT and join another community that is better supported and transferable?

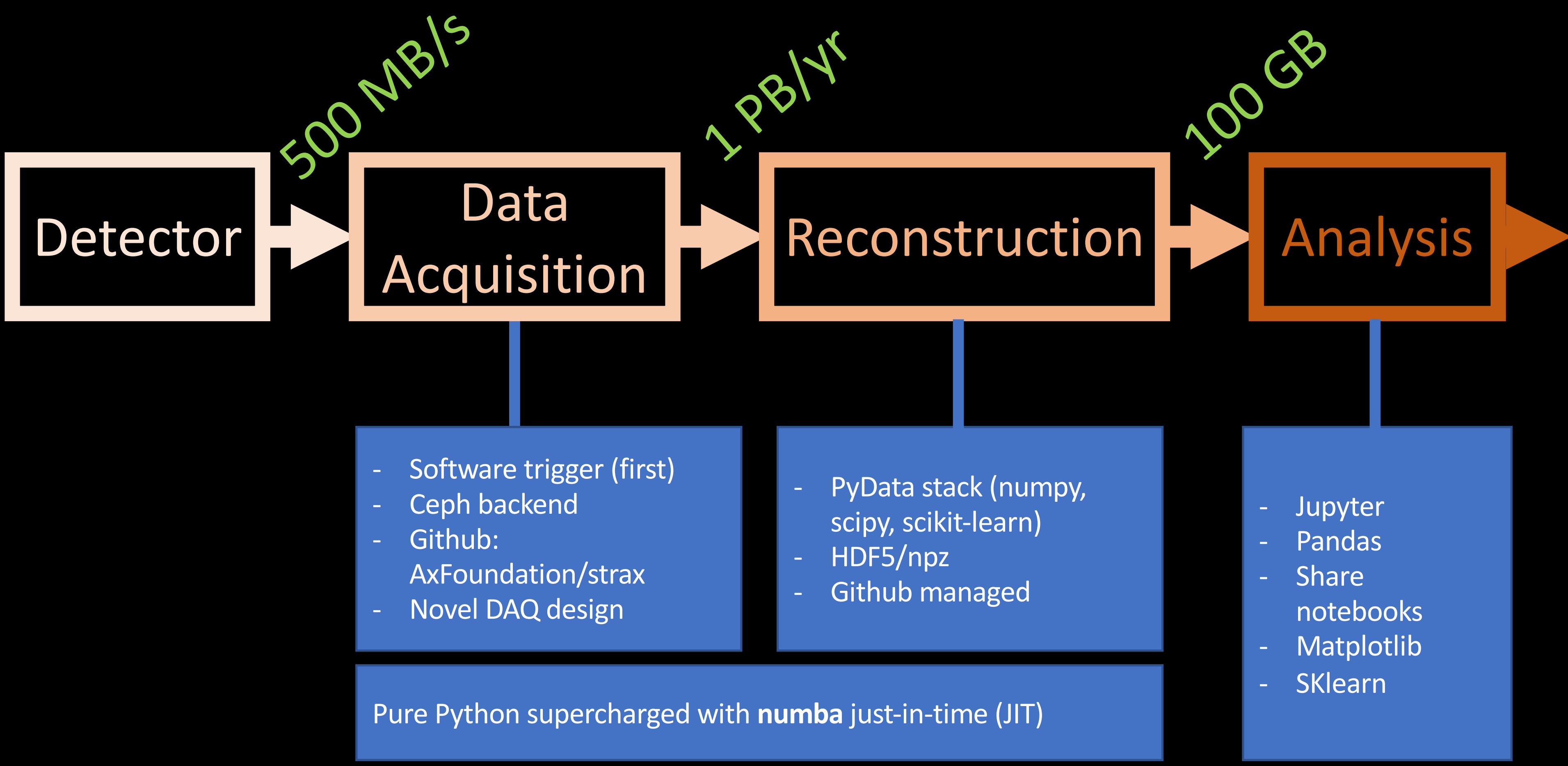


# Claim 6:
# All general frameworks stink, so better to modularize to limit scope where useful

e.g. matplotlib plotting, uproot/HDF5 I/O, nestpy NEST microphysics, g4py, NodeJS webesites

[LZ disagrees here due to LUX history]

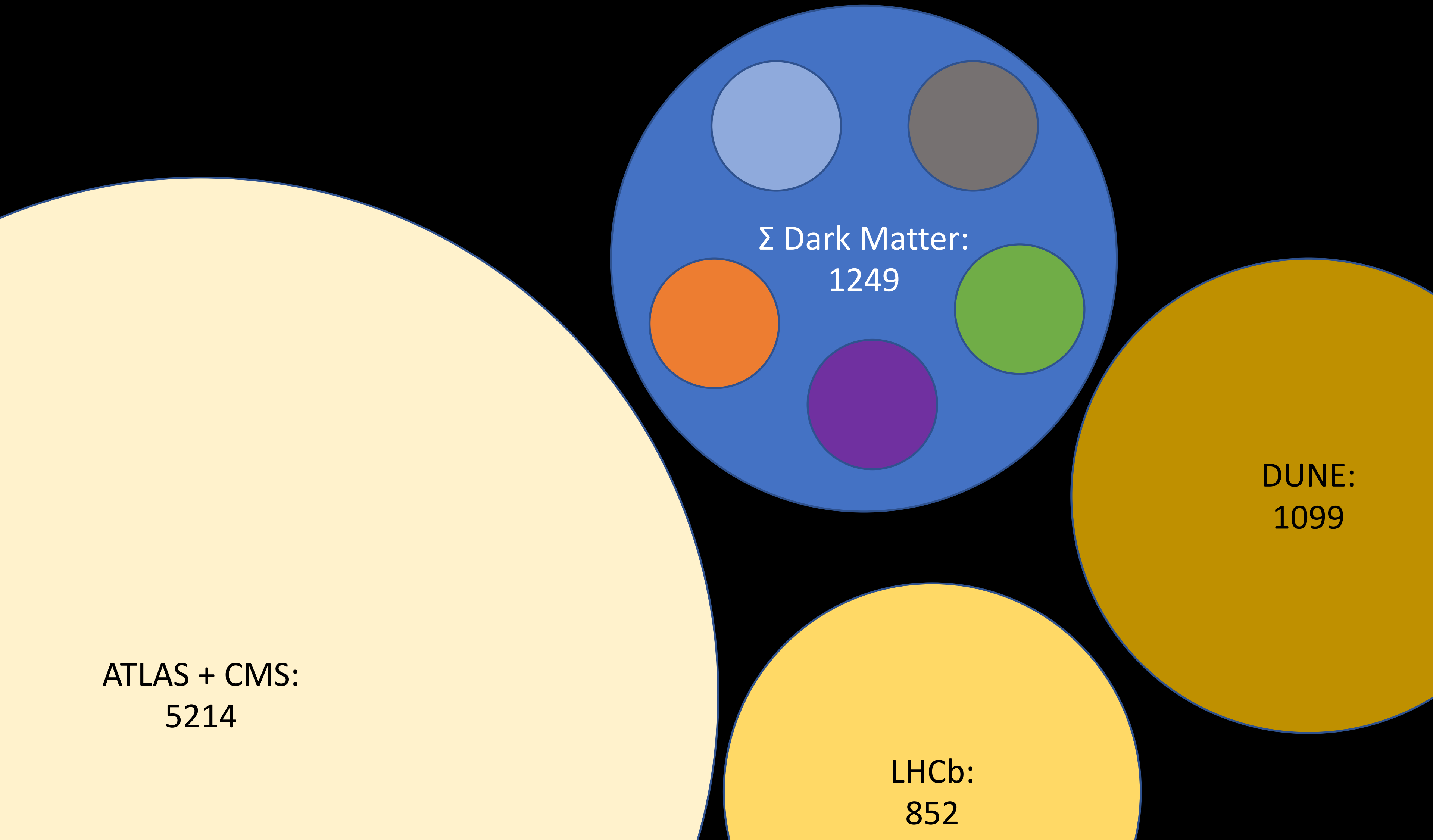
# Can prototype ideas in production




See Github organizations: XENON1T, XENONnT, AxFoundation

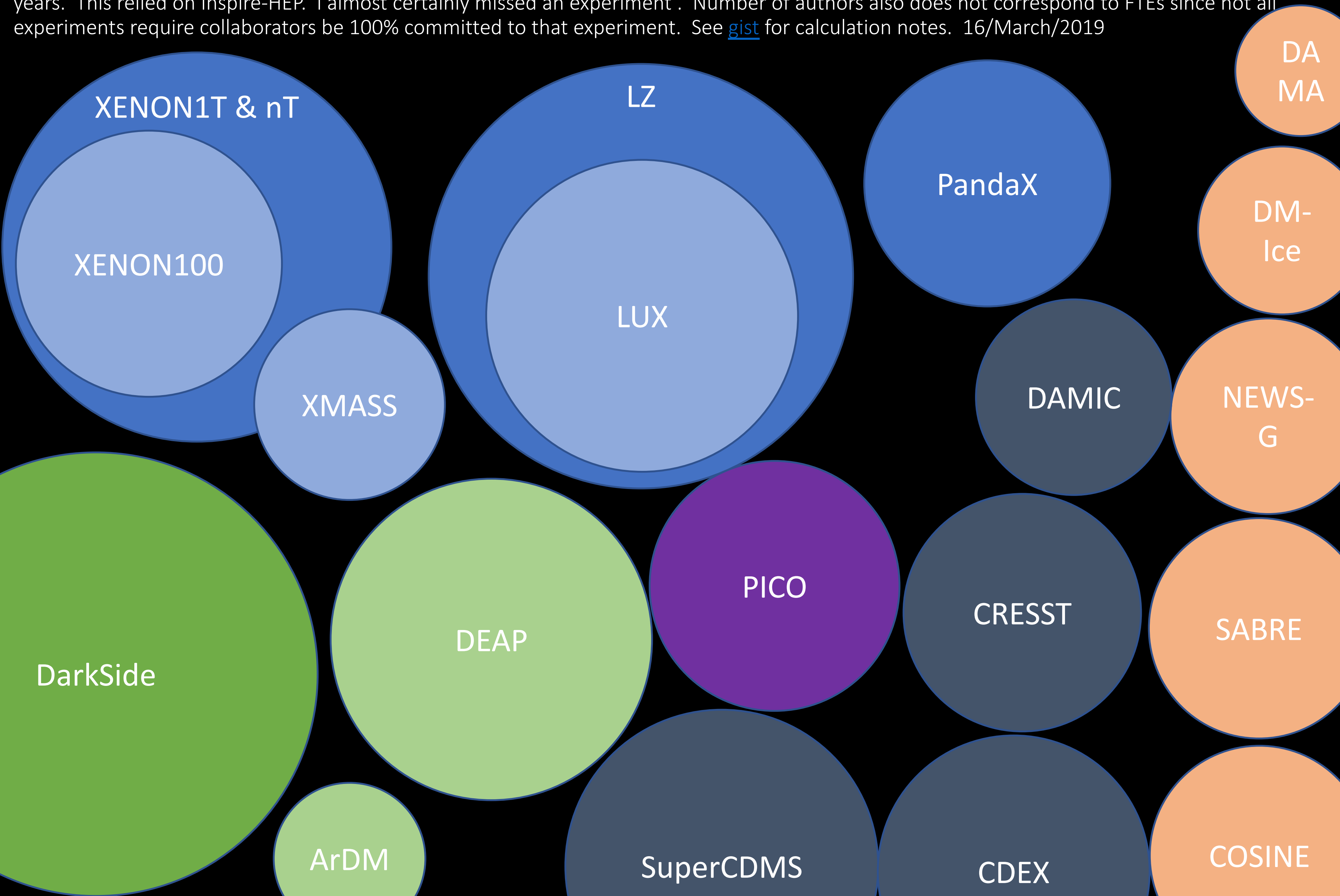
# Dark Matter Detection community big

Area corresponds to number of people based on most recent publication from any experiment that has published scientific papers in the last two years. This relied on Inspire-HEP. I almost certainly missed an experiment . Number of authors also does not correspond to FTEs since not all experiments require collaborators be 100% committed to that experiment. See gist for calculation notes. 16/March/2019



# But 1249 Dark Matter users spread out

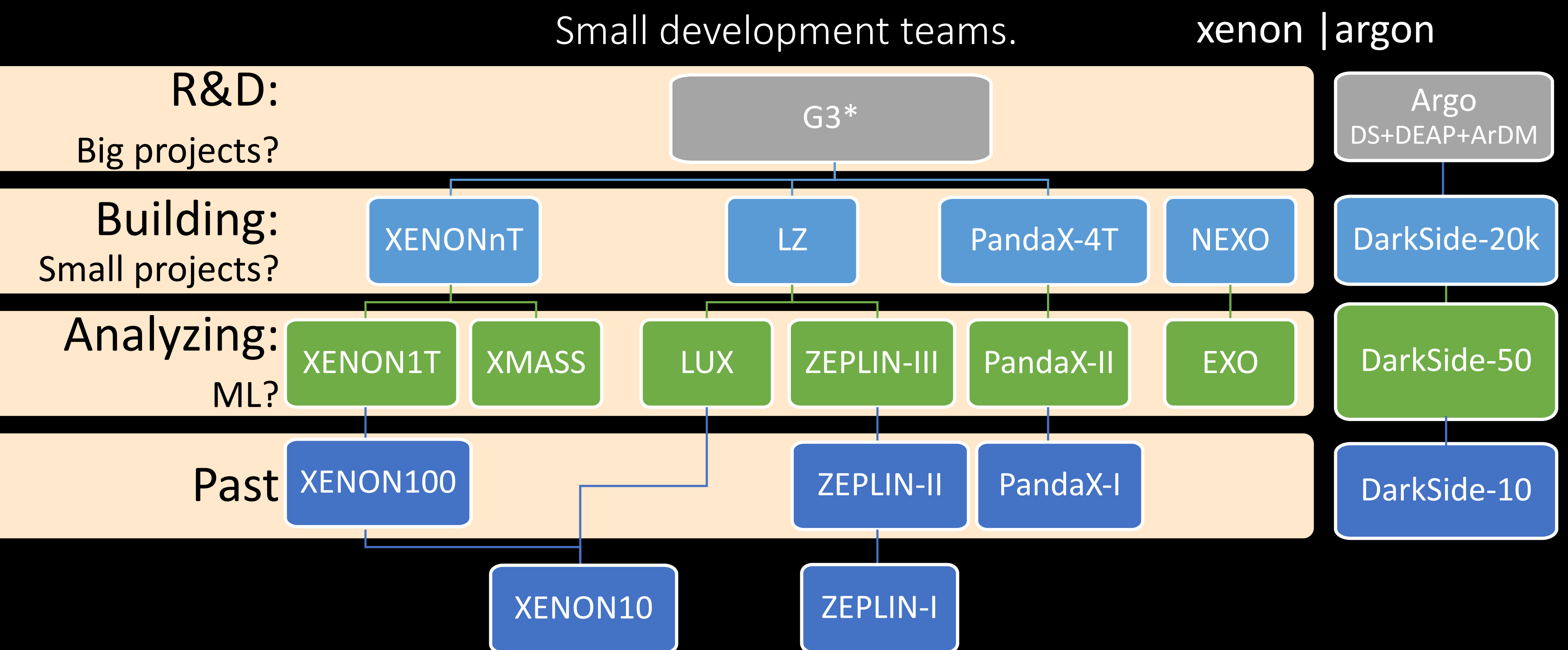
Area corresponds to number of people based on most recent publication from any experiment that has published scientific papers in the last two years. This relied on Inspire-HEP. I almost certainly missed an experiment . Number of authors also does not correspond to FTEs since not all experiments require collaborators be 100% committed to that experiment. See gist for calculation notes. 16/March/2019



# DM Experimental statuses… stati?

Dark Matter experiments are HEP-like: O(PB) raw data, analysts often work on reduced data, groups of analysts often work O(year) on publications.

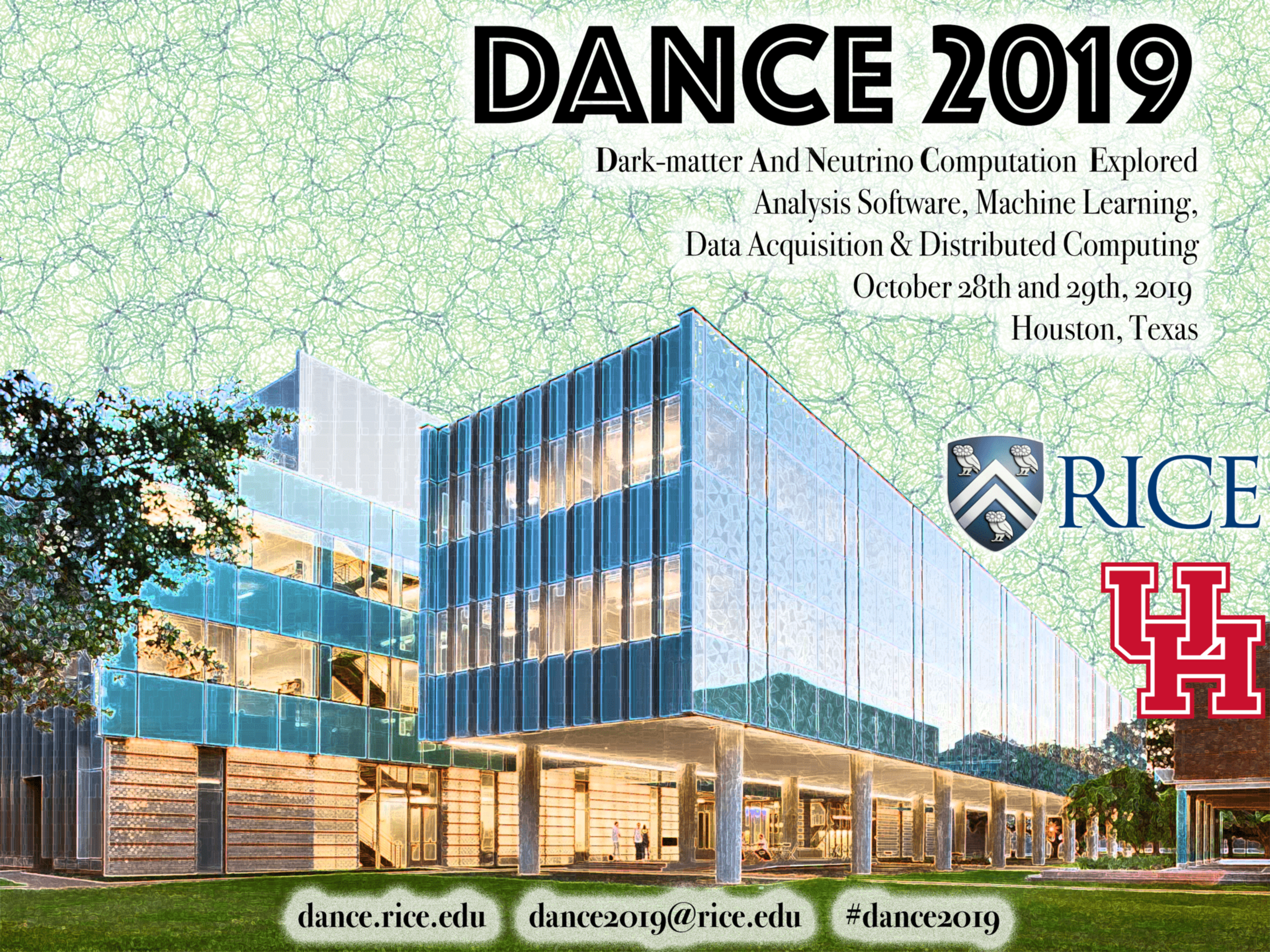
Many phases of experiment and opportunities for collaboration, prototyping, and support by wider particle-physics software community.




*There are concrete proposals for what "G3" would look like. This is on the European roadmap as "Darwin". Young faculty from the US XENON, LZ, nEXO groups are exploring R&D avenues. The Chinese have plans too in their nice new underground lab. The physics and R&D are clear, if the politics of it are still to converge.

# Collaboration is **not** zero sum game

Collaboration is **not** zero sum game


DANCE 2019
Dark-matter And Neutrino Computation Explored
Analysis Software, Machine Learning,
Data Acquisition & Distributed Computing
October 28th and 29th, 2019
Houston, Texas
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# DANCE status

- Great buy in from collaborations
  - Key computational physicists from: XENON, SuperCDMS, PandaX, LUX, LZ, DarkSide, DEAP, ARGO, EXO, nEXO, MiniClean, NEST, NOvA, JUNO
  - External participants from: Geant4, ML researchers, IRIS-HEP, Anaconda, TACC (?)
- 32 probable attendants [up to 41] – quarum
- Goals:
  - Figure out what one another does
  - Agree on needs/challenges in document for field to support
    - Can reference in experimental proposals
    - Identify small collaborations [e.g. w/ SuperCDMS JupyterHub Science Gateway]
    - Form community to address training and technology issues to prevent science bottleneck

# DIDACT Institute

- Data Intensive Discovery Accelerated by Computational Techniques
- This month is first of machine learning institute conceptualization supporting ML in physical sciences starting with xenon TPCs as test case
  - NSF Press
  - Through NSF HDR
- For us, read this as “new ML methods to improve position and energy resolution” for DM and 0nuBD science cases
  - Graph models
  - Bayesian networks
  - Inverse-problem graph regularization
    - “embed part of reconstruction/simulation into network”
- Data science done completely different in physics than other fields (model -> data)
- Expanding to oceanography, meteorology, material science. Can’t include HEP but can collaborate and synergize.