ÖAW ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN

HEPHY INSTITUT FÜR HOCHENERGIEPHYSIK

FFG Forschung wirkt.

# *Spooky* dark matter and how to find it with *scary* machines

A Dark Matter Day - Halloween cross over,
and it's also about Machine Learning.

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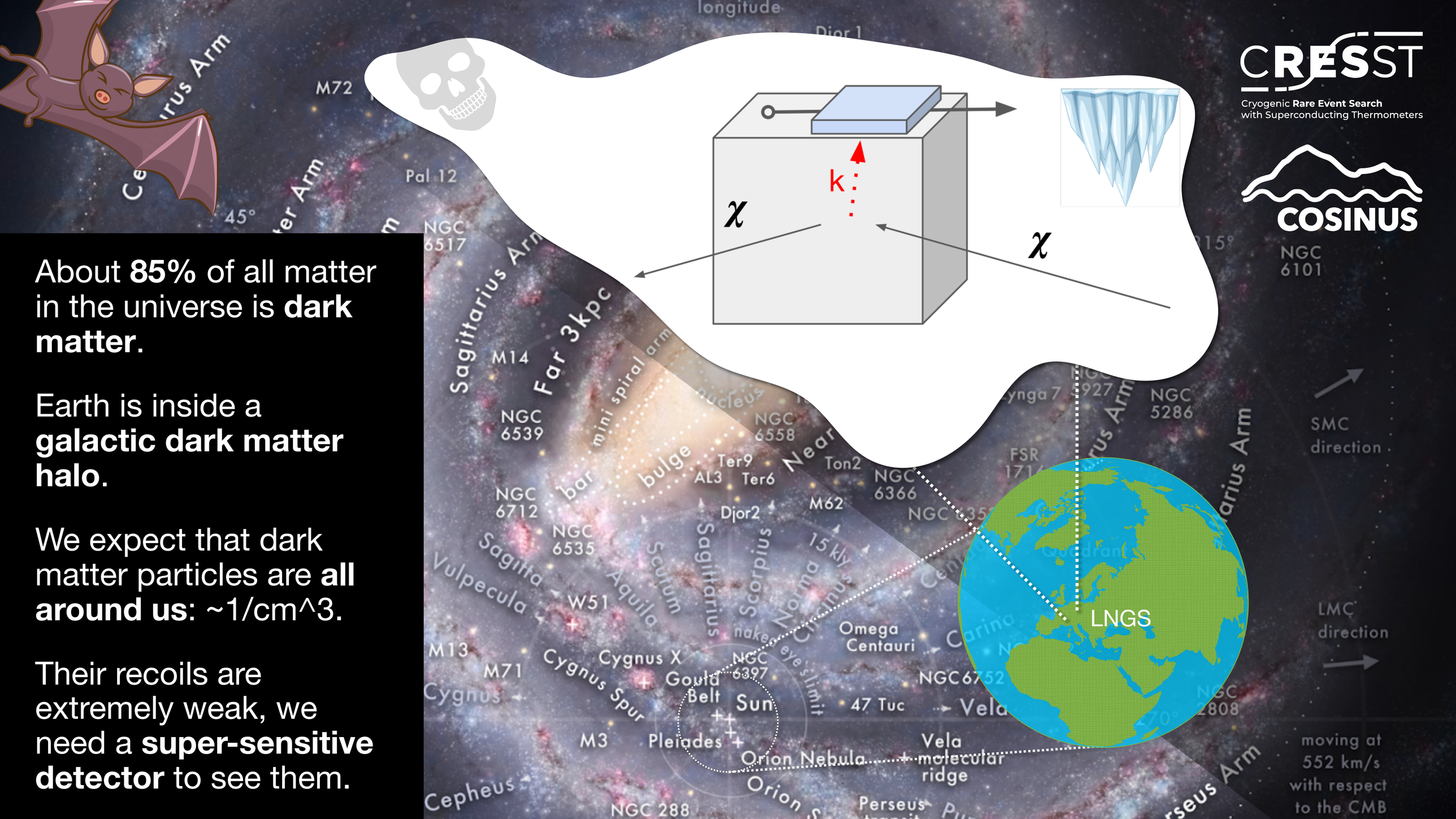
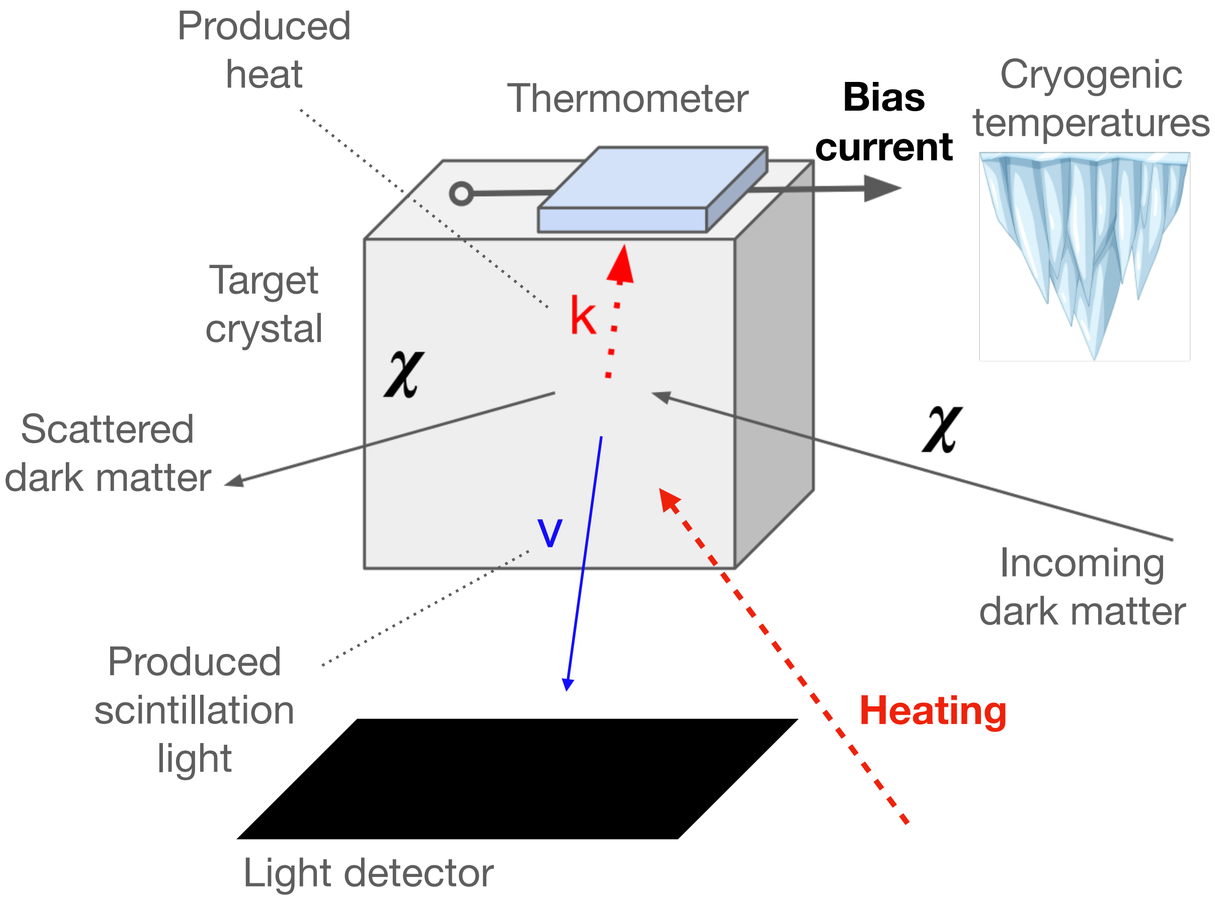
Austrian Academy of
31 October 2022


CRESST
Cryogenic Rare Event Search with Superconducting Thermometers
COSINUS
About 85% of all matter in the universe is dark matter.
Earth is inside a galactic dark matter halo.
We expect that dark matter particles are all around us: ~1/cm^3.
Their recoils are extremely weak, we need a super-sensitive detector to see them.
k
χ
χ
LNGS
SMC direction
LMC direction
moving at 552 km/s with respect to the CMB
Sagittarius Arm
Far 3kpc
mini spiral arm
nucleus
bar
bulge
Near 3kpc
Scutum
Sagittarius
Scorpius
Norma
Crux
Aquila
Vulpecula
Cygnus
Cygnus Spur
Gould Belt
Sun
Orion Nebula
Vela molecular ridge
Perseus
Cepheus
Omega Centauri
47 Tuc
Vela
Pleiades
M3
M13
M71
M14
M62
M72
Pal 12
NGC 6517
NGC 6539
NGC 6712
NGC 6535
NGC 6558
NGC 6366
NGC 6397
NGC 5286
NGC 6101
NGC 288
Ter9
Ter6
AL3
Ton2
Djor2
W51
Cygnus X
15 kly
naked eye limit
longitude
45°

# A dark matter detector

## and how to use it

- Monocristalline target coupled to superconducting thermometer.
- Cooled to millikelvin temperatures.
- Dark matter recoil produces measureable heat and scintillation light.
- Operation requires careful optimisation of constant **heating** and **bias current**.
- Optimisation is **time consuming** and requires **manual interventions**.




2 x 2 control parameters

"Randy", our poltergeist, can optimise the detector in a few hours!

# Many dark matter detectors

## ~~and how to use them~~

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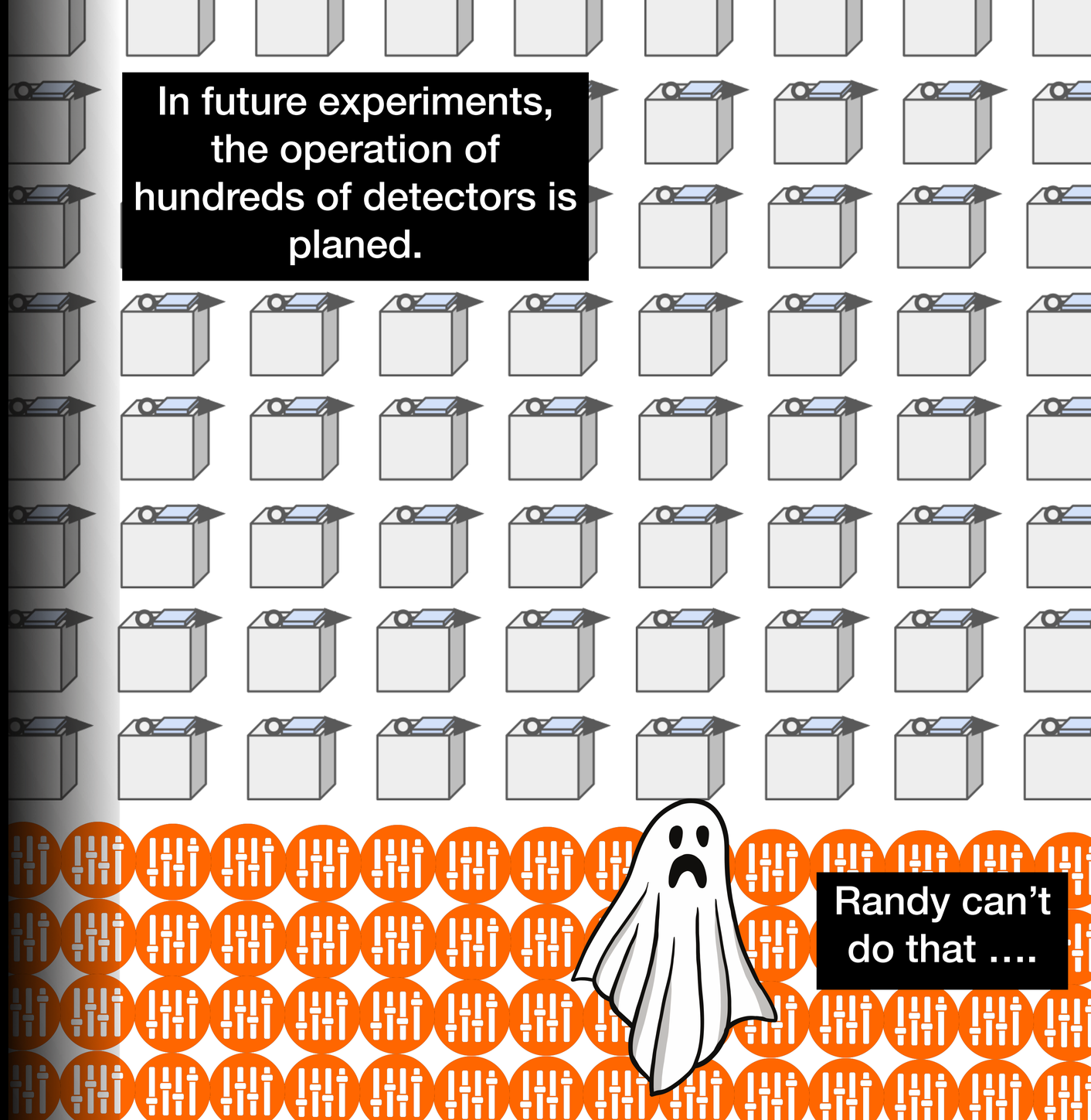

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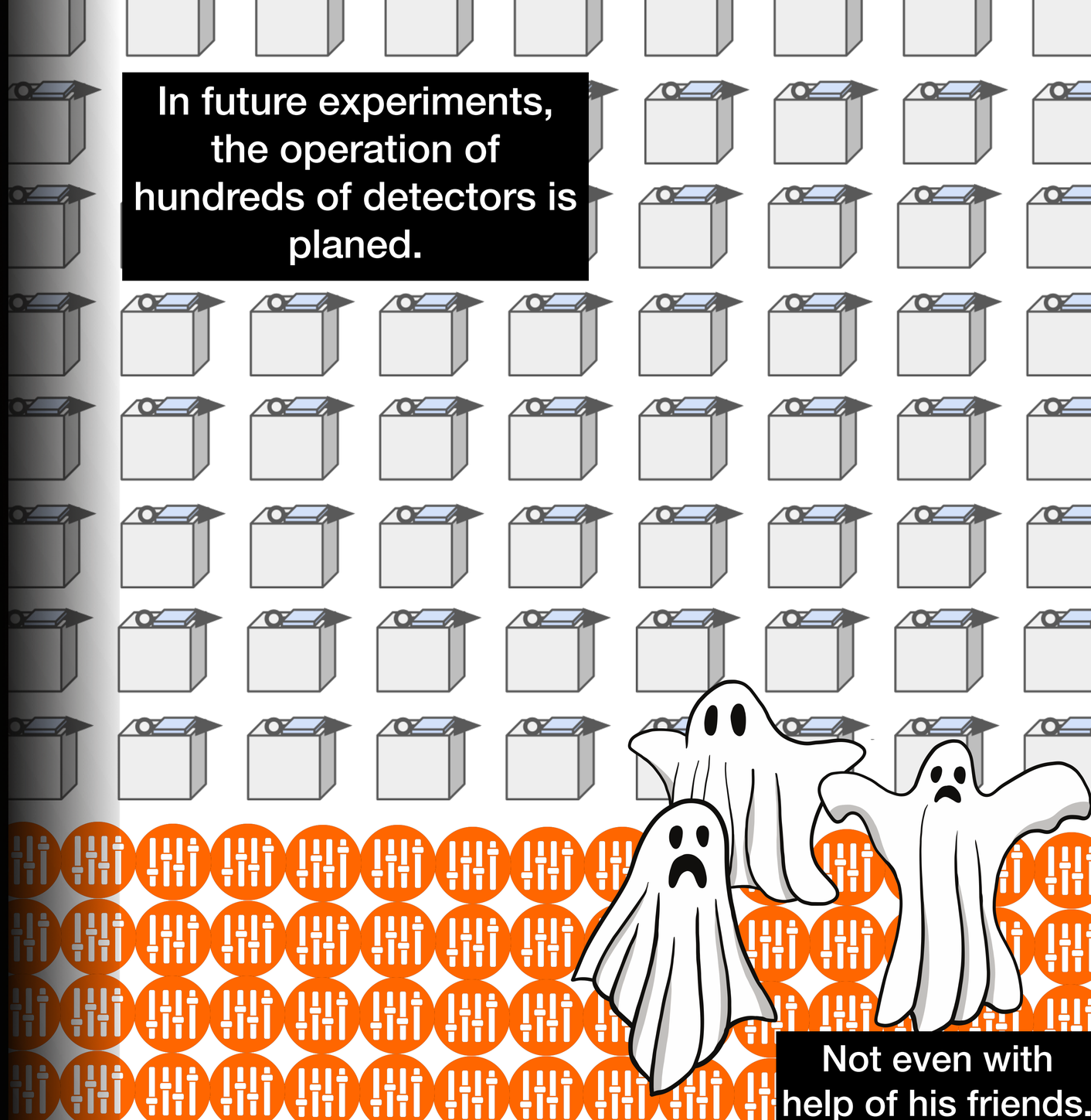
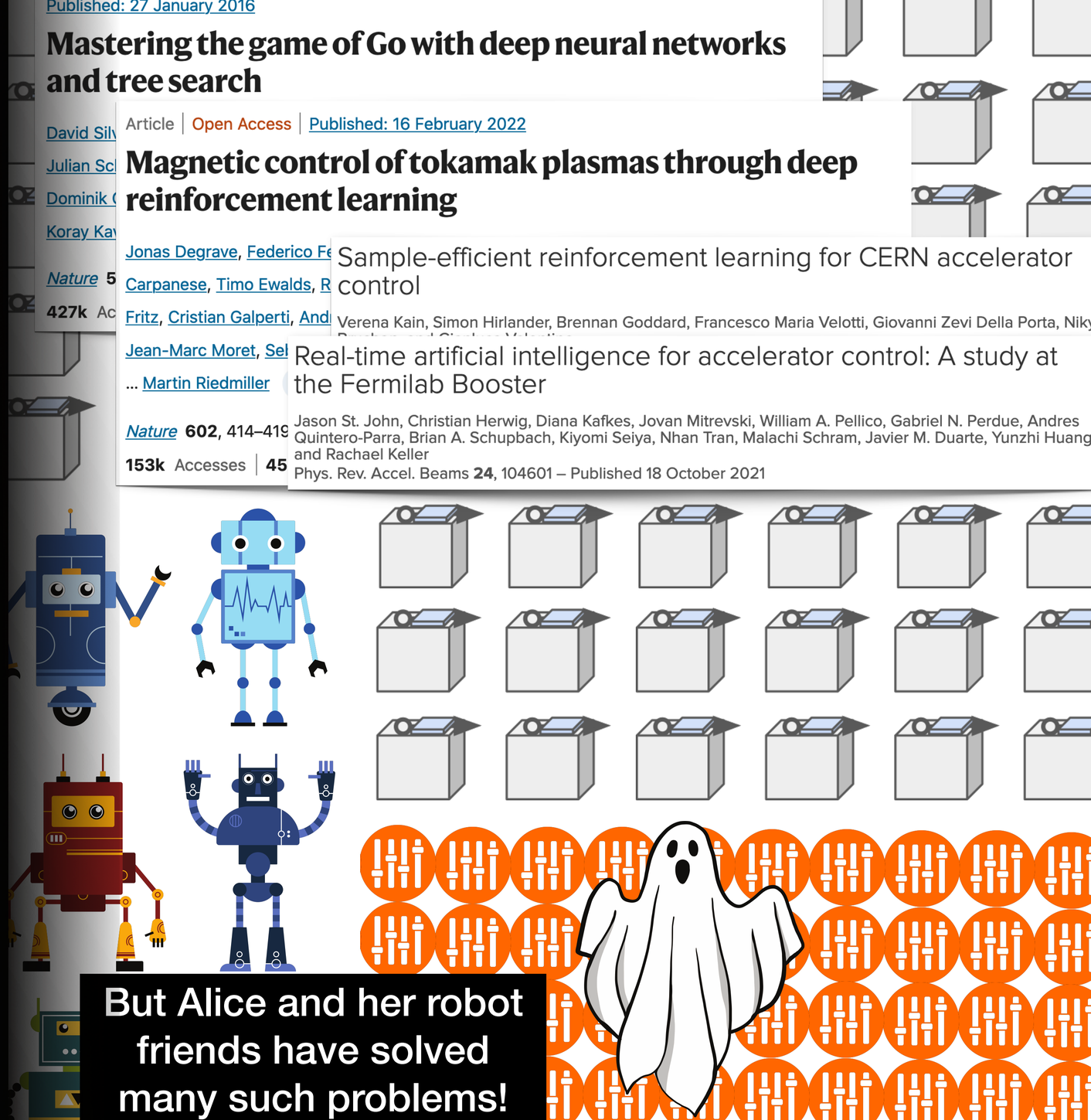


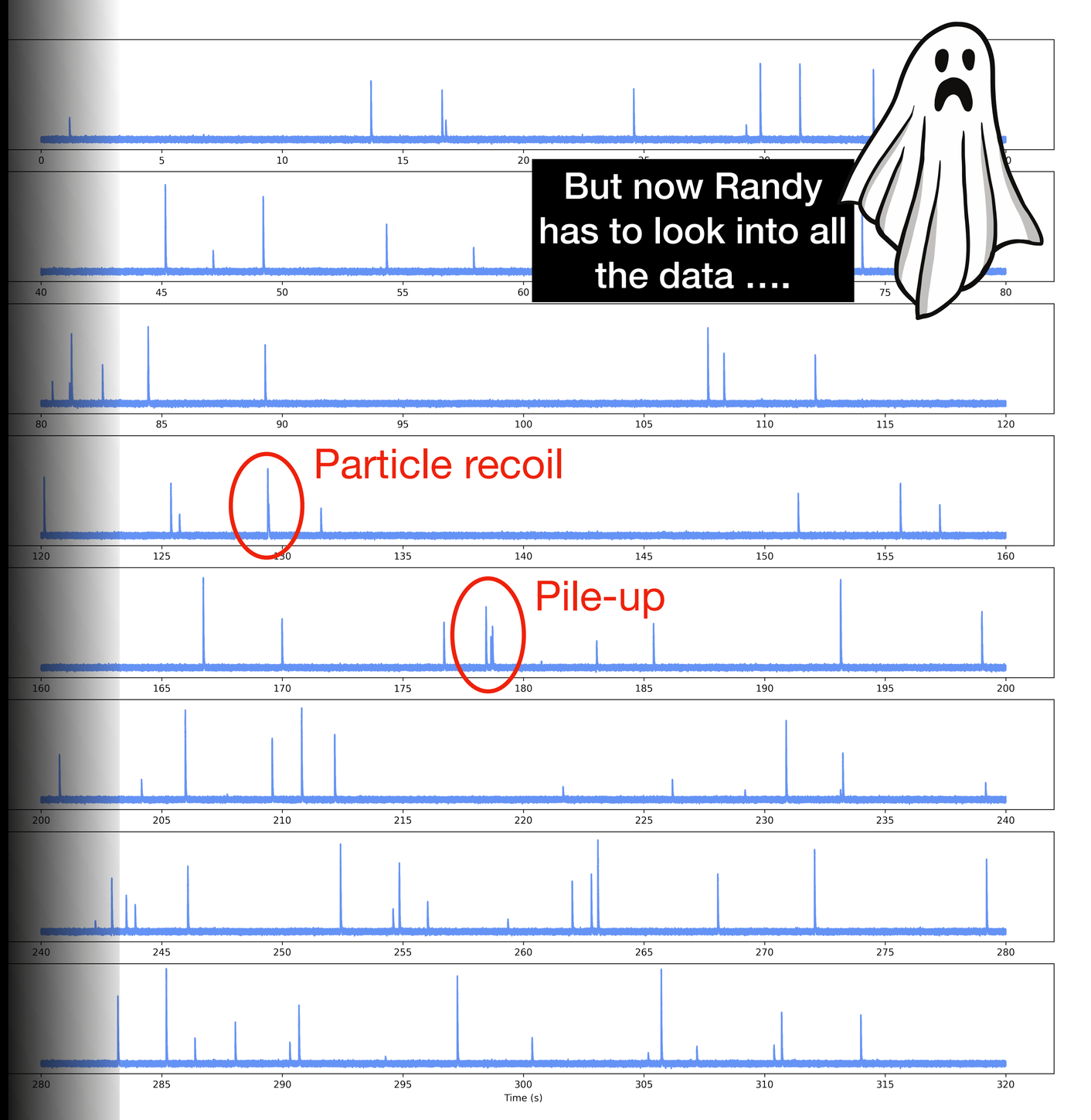
# Many dark matter detectors and how to use them

- We can optimise the detectors instead with **machine learning**.
- Currently **prototyping** is ongoing, good results in simulation.
- Later this year: first runs on **live experiment**.
- *Talk at ACAT Workshop ’22: “Control of cryogenic dark matter detectors through deep reinforcement learning” (F. Wagner).*



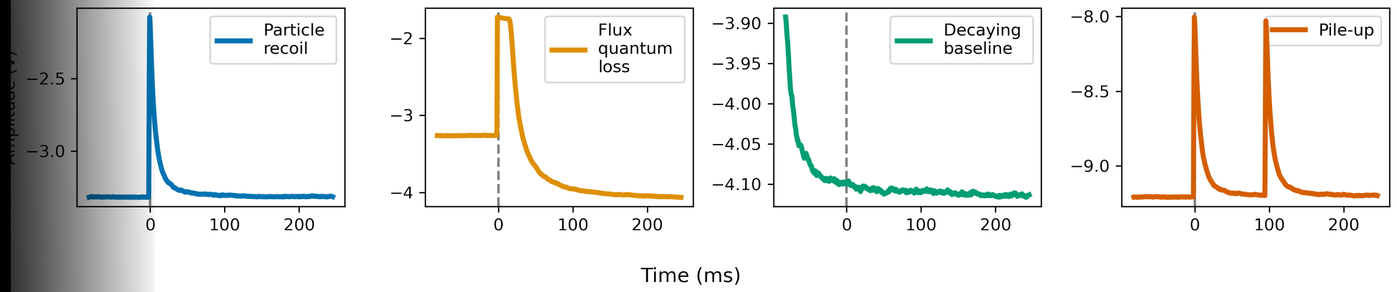
# Many dark matter detectors and how to analyse them

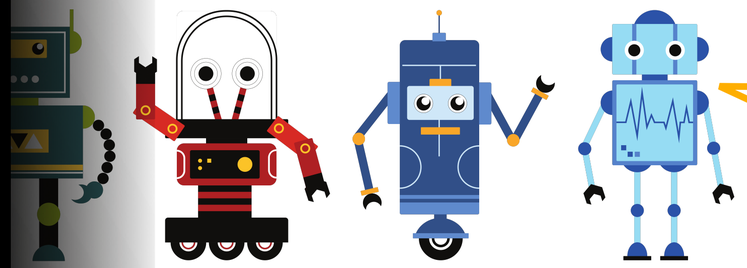
- We need to analyse the data and count the number of potential **dark matter** and **background events**.
- Harmful backgrounds are **astroparticles and radioactivity**, but also **artefacts** of the measurement setup.
- Data cleaning needs to be **automated** for analysis of future large-scale experiments.



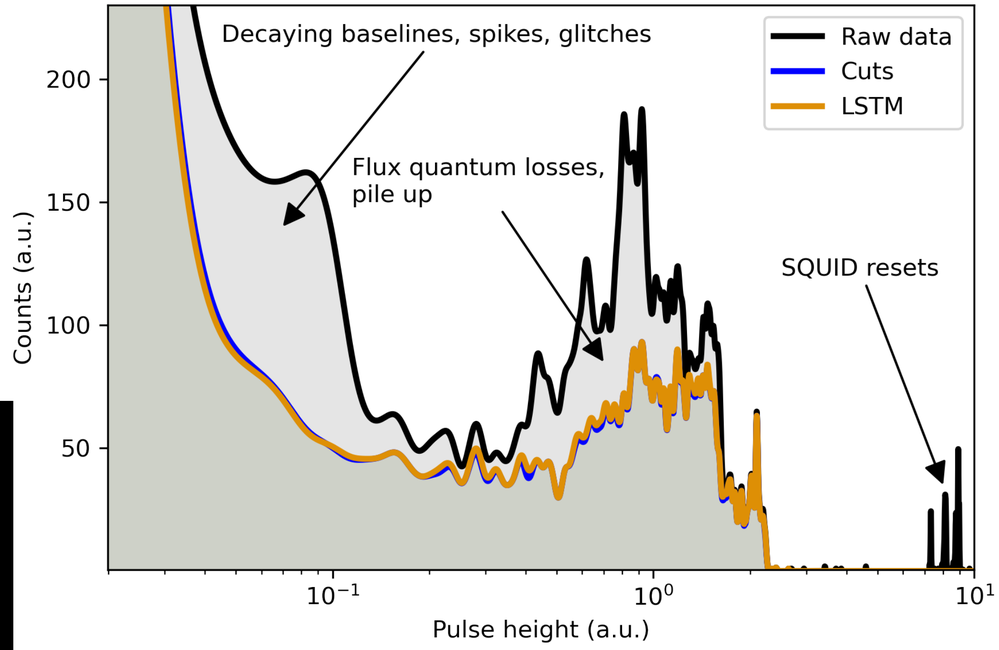
# Many dark matter detectors and how to analyse them

- We trained a **neural network classifier** for the data cleaning task.
- The neural network discriminates on an event-by-event basis **particle recoils** from **artefacts**.
- **Fully automated** and **universally applicable**: no additional information about the individual detector required!
- *Preprint on ArXiv: “Towards an automated data cleaning with deep learning in CRESST” (CRESST Collaboration).*



Hmm, I’d say that’s a YES and three NO’s!



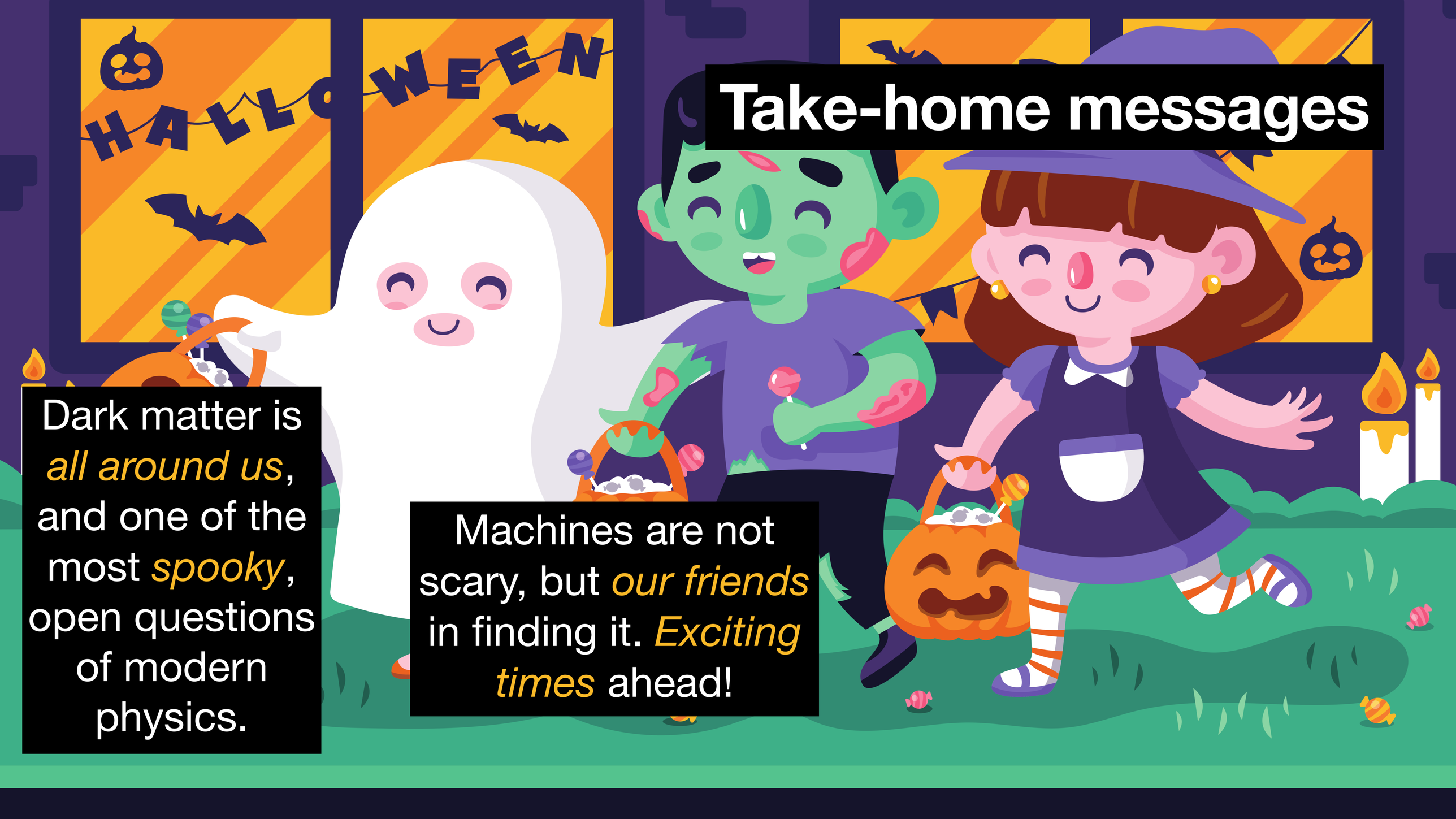

**Luckily, Acile is also an expert in data analysis and can help!**


HALLOWEEN
Take-home messages

# Take-home messages


Dark matter is *all around us*, and one of the most *spooky*, open questions of modern physics.

# Take-home messages




Dark matter is *all around us*, and one of the most *spooky*, open questions of modern physics.

Machines are not scary, but *our friends* in finding it. *Exciting times* ahead!

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**Happy *Dark Matter Day*!**
**Happy *Halloween*!**