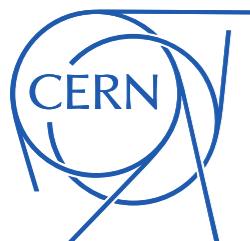


Direct Dark Matter Searches

Broader Context

Joachim Kopp (CERN & Uni Mainz)
on behalf of the ApPEC Direct Detection Committee | 2 Feb 2021



Key Points

- ☑ Direct detection is **unique** and **complements** other DM searches
- ☑ **Dark Matter Detectors** are not single-purpose experiments any more, but have evolved into **multi-purpose observatories**
- ☑ DM detectors rely on **advanced infrastructure**

Complementarity Between WIMP Searches

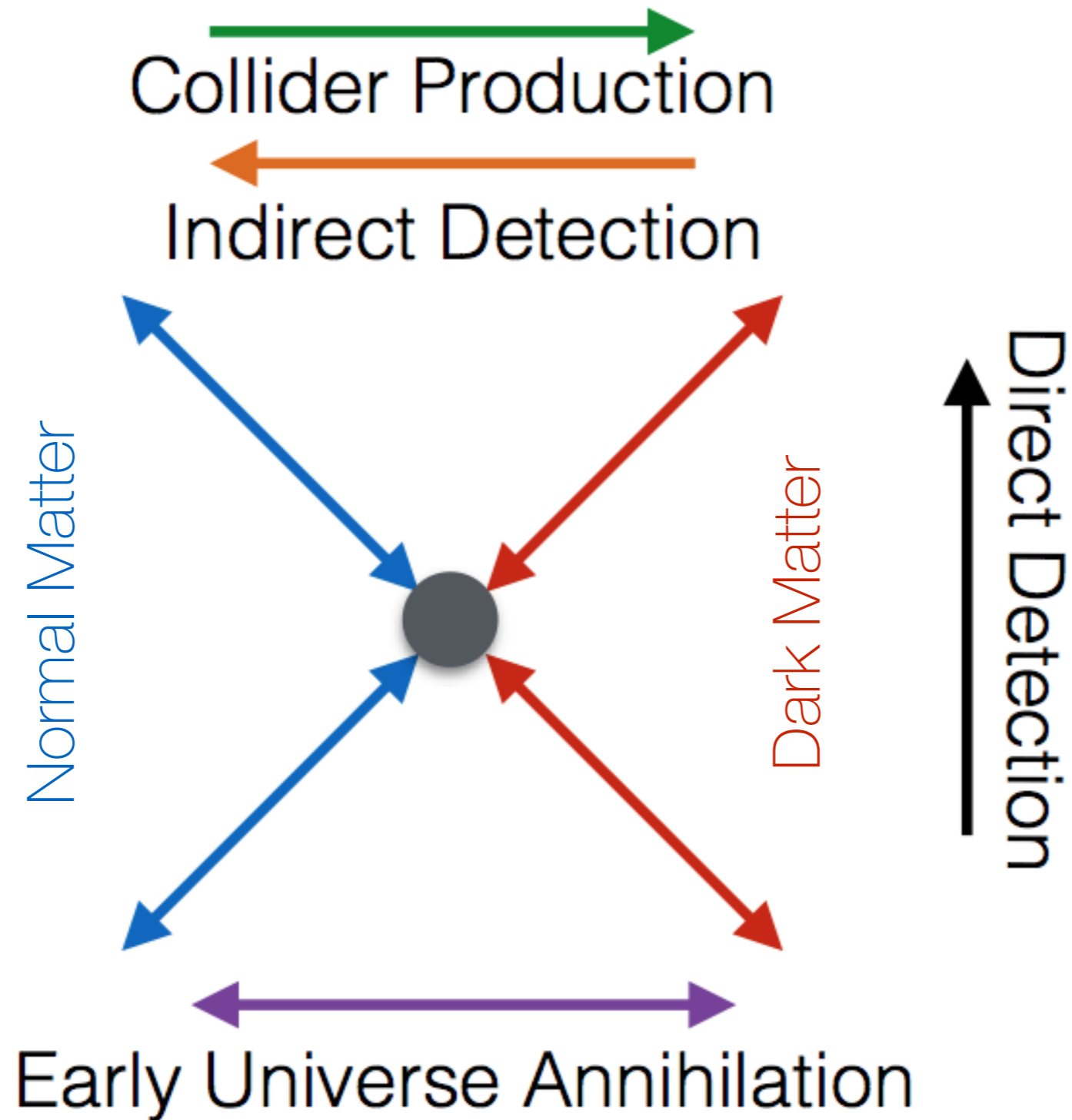


Image: Matthew Buckley

Complementarity Between WIMP Searches

Collider Production
Indirect Detection

“make it, break it, or shake it.”

Early Universe Annihilation

Image: Matthew Buckley

Complementarity Between WIMP Searches

Collider Production
Indirect Detection

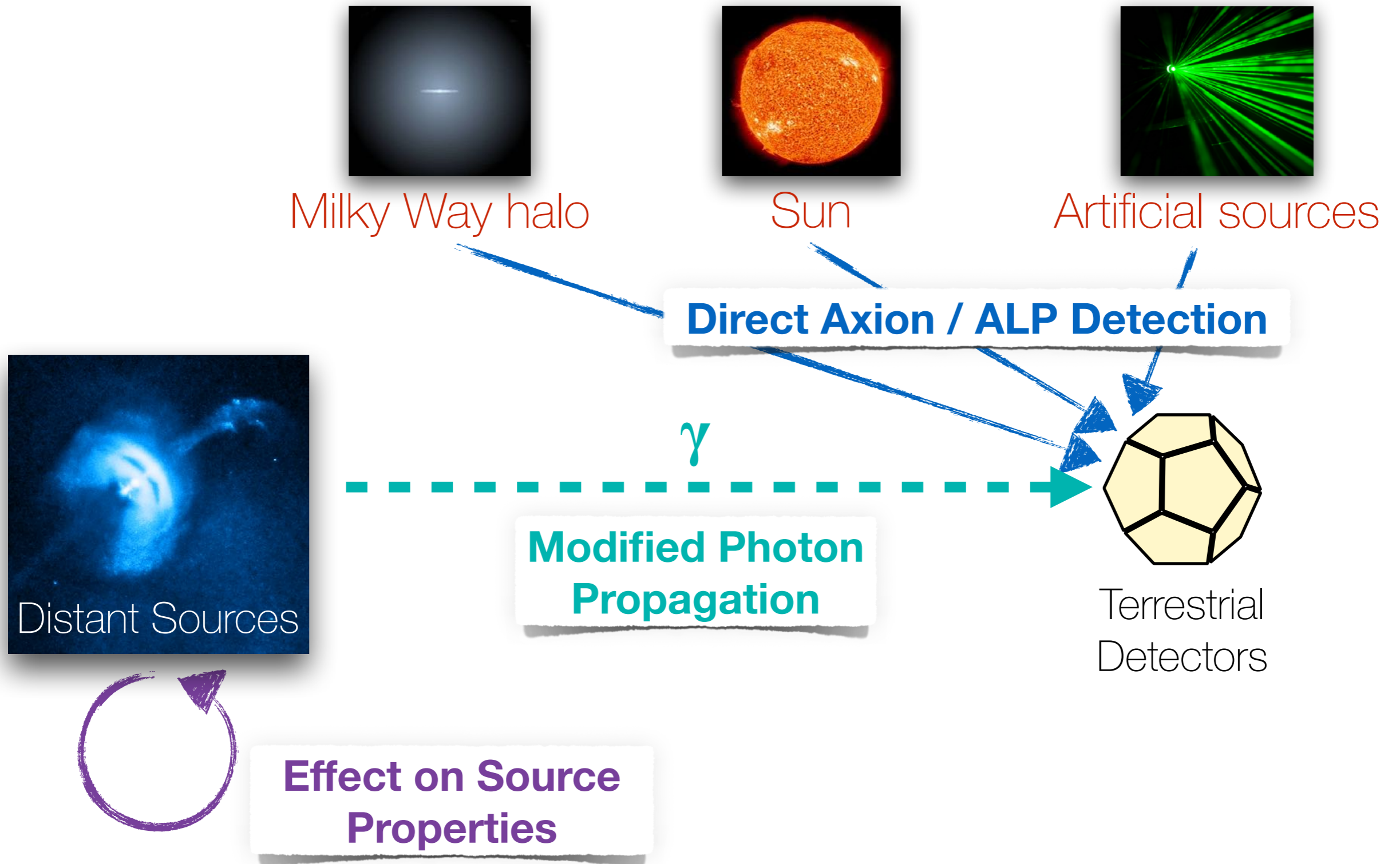
+ astrophysical probes

“make it, break it, or shake it.”

Early Universe Annihilation

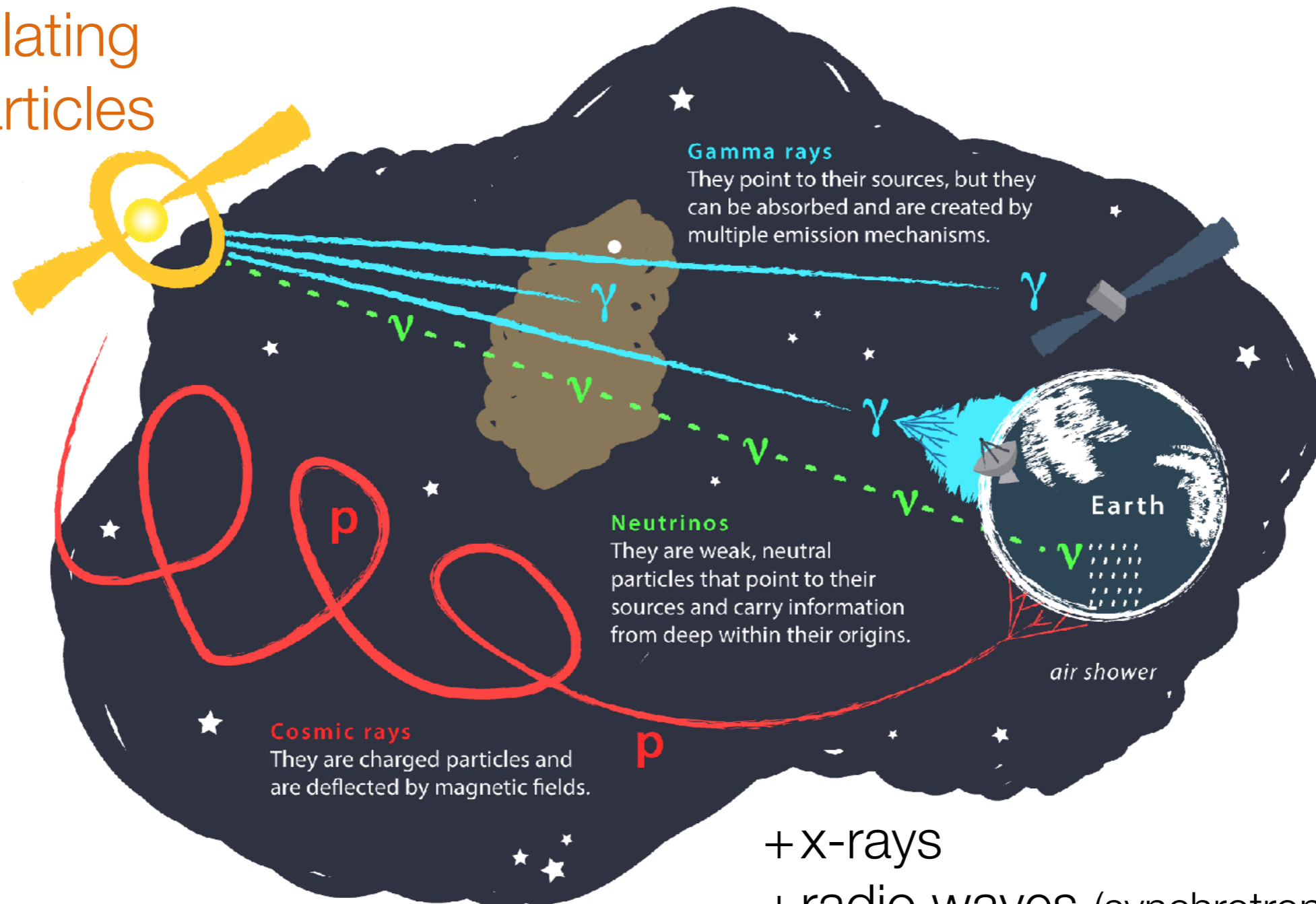
Image: Matthew Buckley

Complementarity Between Axion/ALP Searches



Indirect DM Searches

Annihilating DM particles



+ x-rays
+ radio waves (synchrotron emission)
+ ...

Image: J.A. Aguilar and J. Yang, IceCube/WIPAC

Indirect DM Searches

Annihilating
DM particles

Pro:

- information on DM **distribution** in the Universe
- connection to the **early Universe**

Contra:

- backgrounds
- systematic uncertainties
- astrophysical impostors

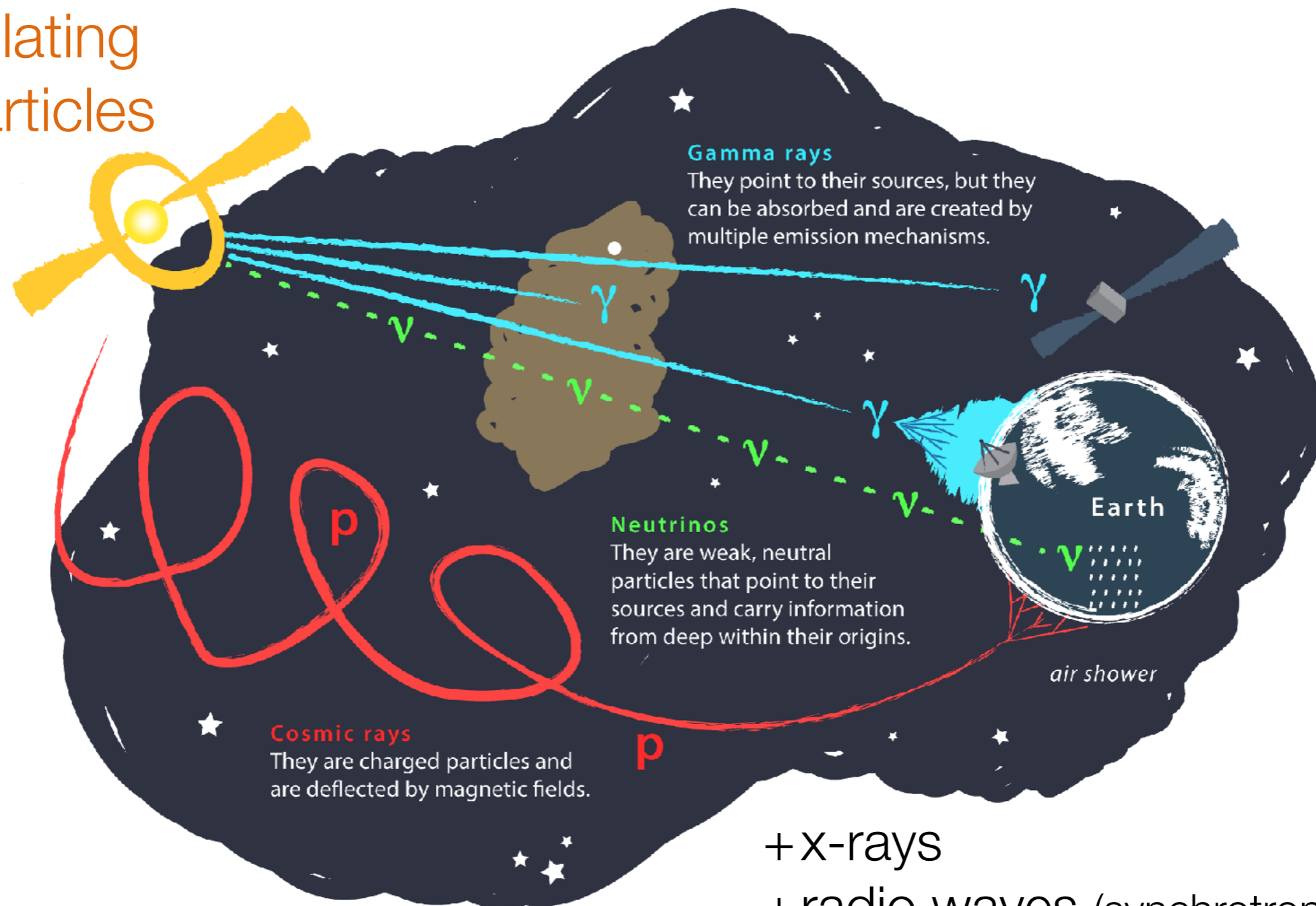
+ ...

Image: J.A. Aguilar and J. Yang, IceCube/WIPAC



Indirect DM Searches

Annihilating DM particles

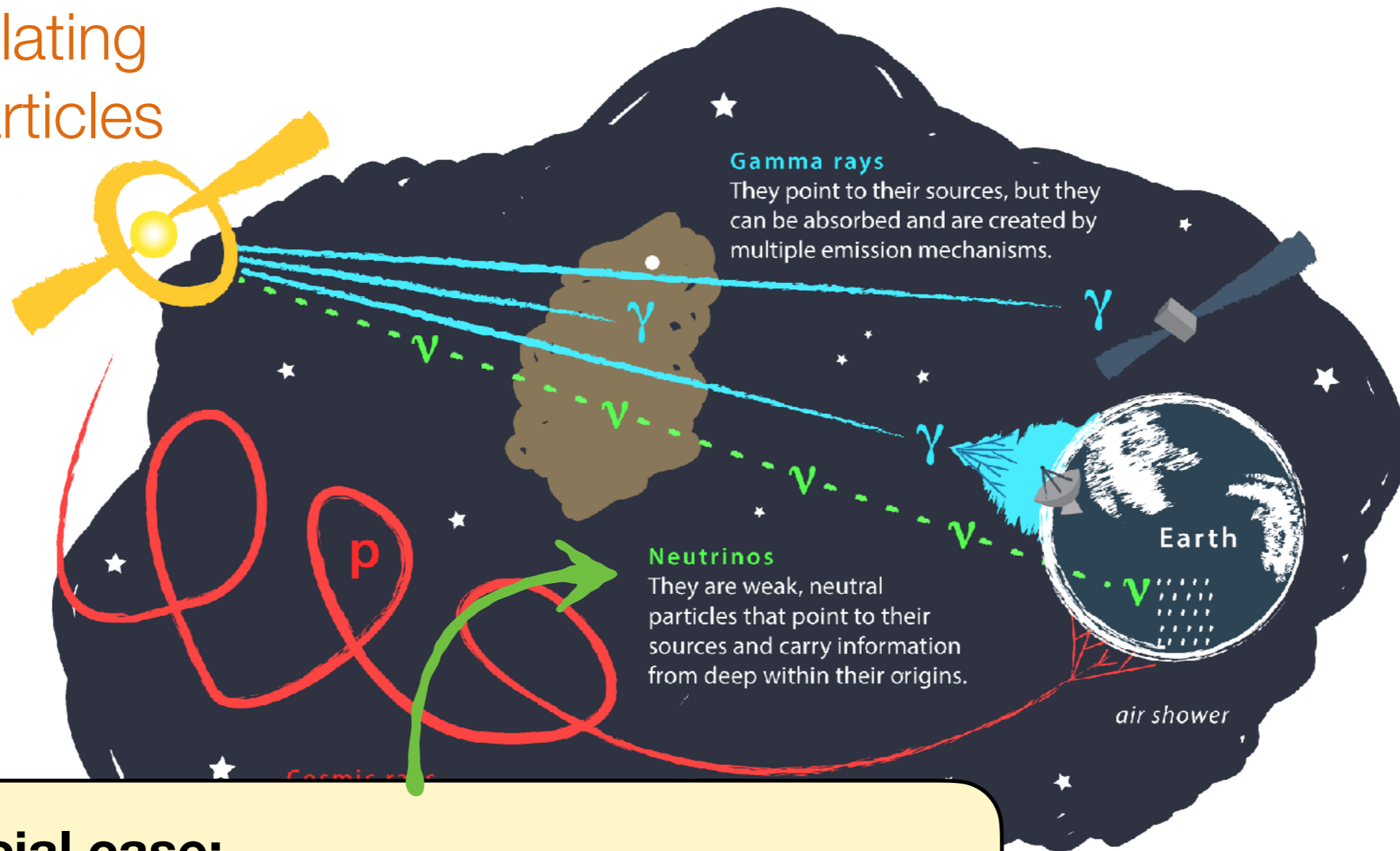


+ x-rays
+ radio waves (synchrotron emission)
+ ...

Image: J.A. Aguilar and J. Yang, IceCube/WIPAC

Indirect DM Searches

Annihilating DM particles



Special case:

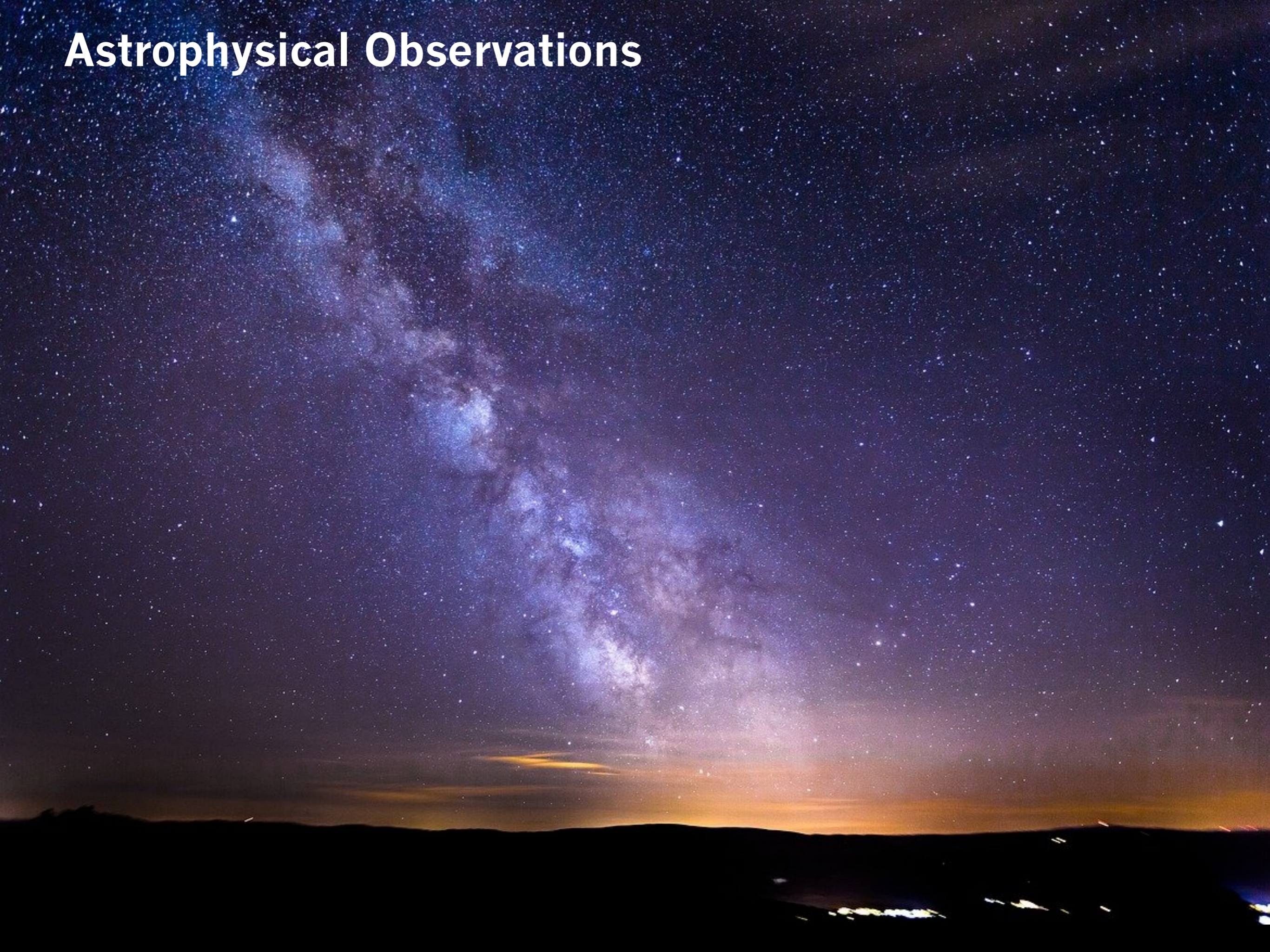
WIMP capture & annihilation in the Sun

▮▮▮▮ → probes same parameters as direct detection

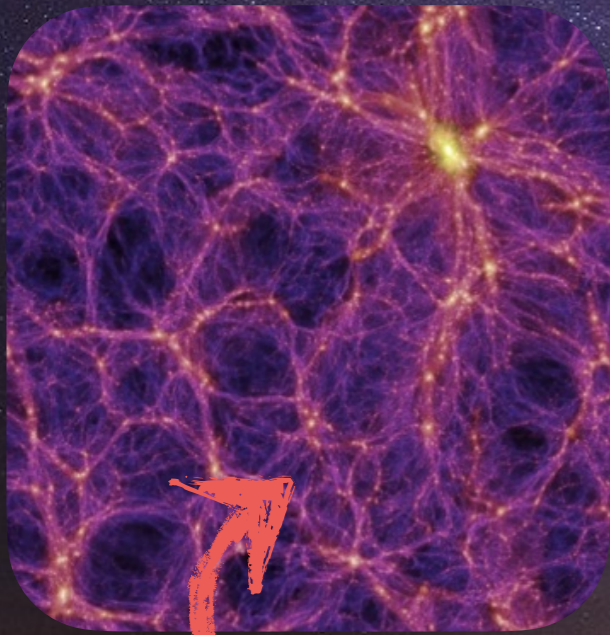
waves (synchrotron emission)

Image: J.A. Aguilar and J. Yang, IceCube/WIPAC

Astrophysical Observations



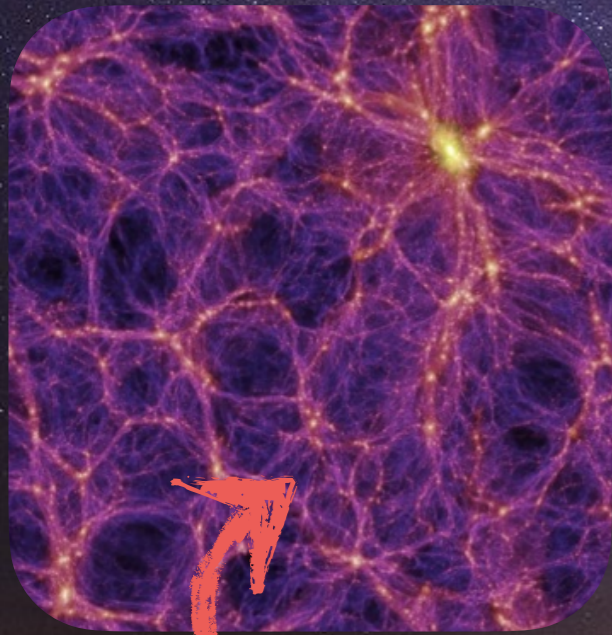
Astrophysical Observations



Large Scale Structure

density profile;
DM self-interactions

Astrophysical Observations



Large Scale Structure

density profile;
DM self-interactions



Stochastic Gravitational Waves

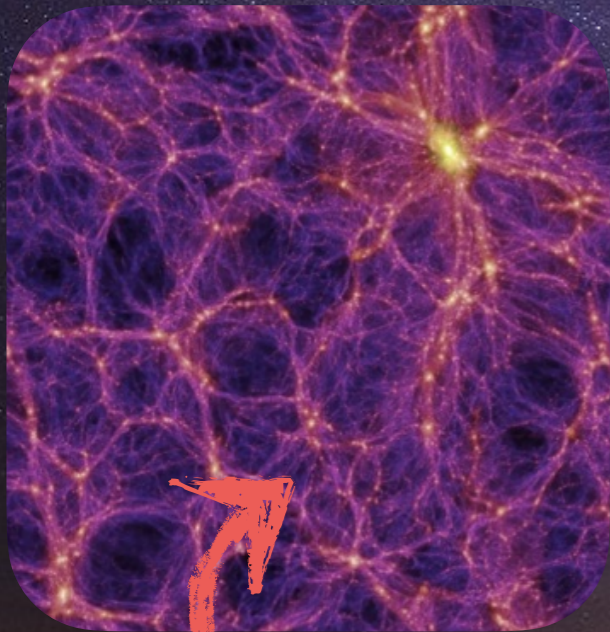
model-dependent constraints in some
WIMP, ALP, and PBH scenarios

Astrophysical Observations



Gravitational Lensing

DM substructure; compact DM objects (axion minihalos, primordial black holes)



Large Scale Structure

density profile;
DM self-interactions



Stochastic Gravitational Waves

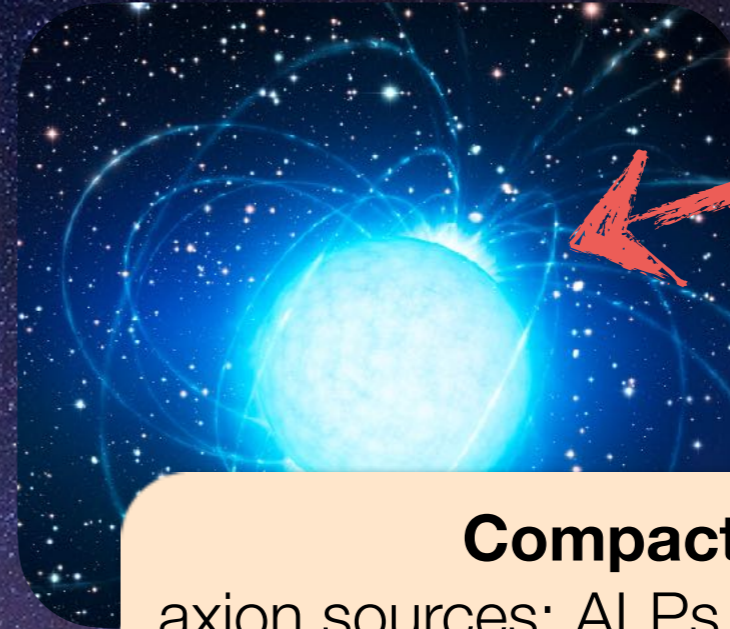
model-dependent constraints in some
WIMP, ALP, and PBH scenarios

Astrophysical Observations



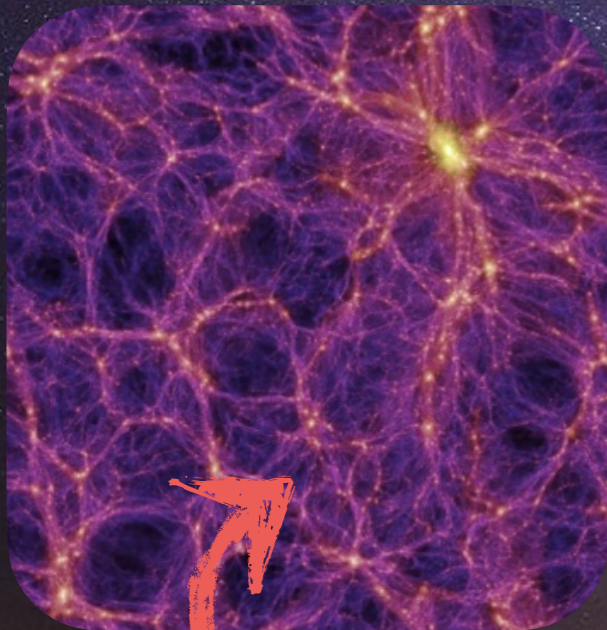
Gravitational Lensing

DM substructure; compact DM objects (axion minihalos, primordial black holes)



Compact Stars

axion sources; ALPs as explanation for observed anomalies



Large Scale Structure

density profile;
DM self-interactions

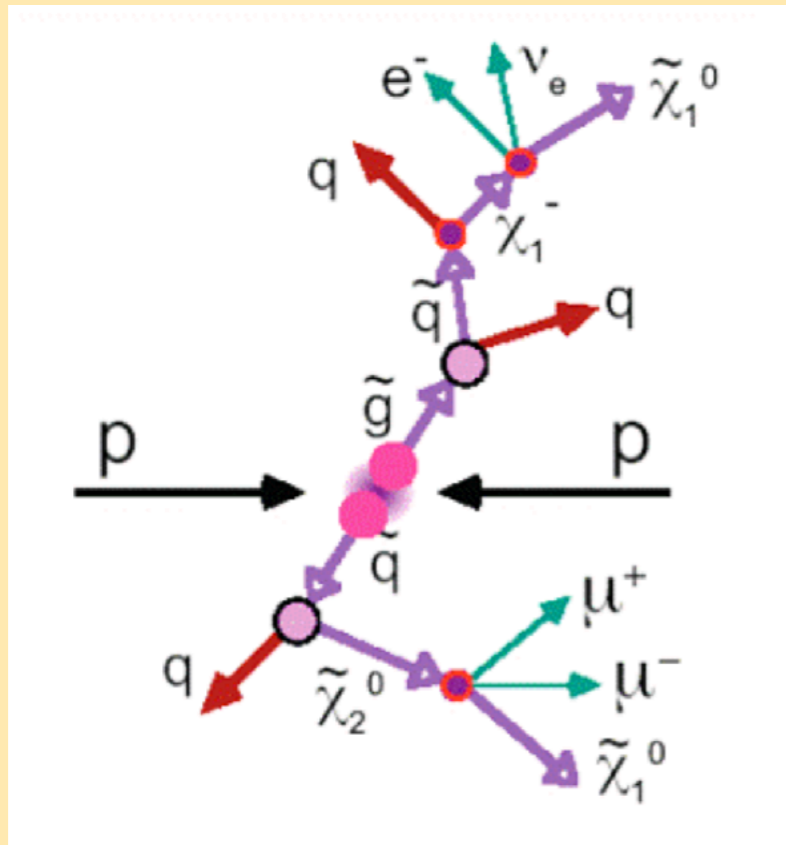


Stochastic Gravitational Waves

model-dependent constraints in some WIMP, ALP, and PBH scenarios

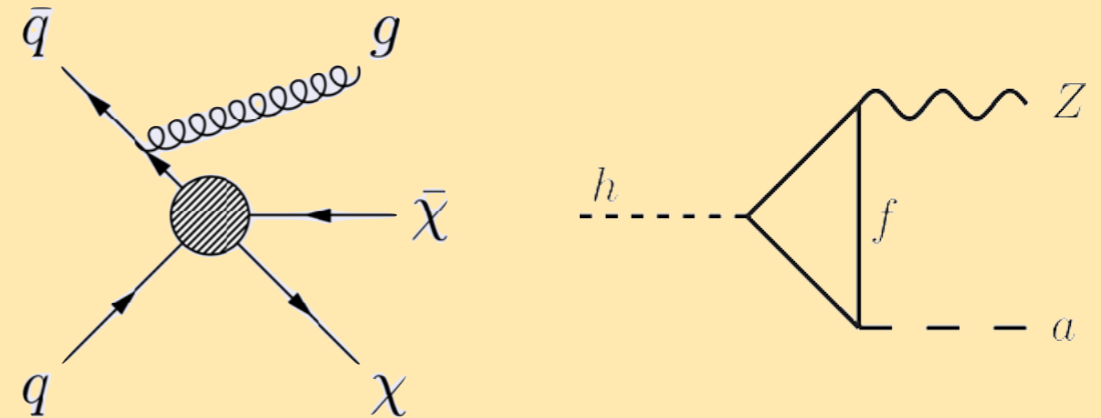
DM Searches at Colliders

Top-Down Models

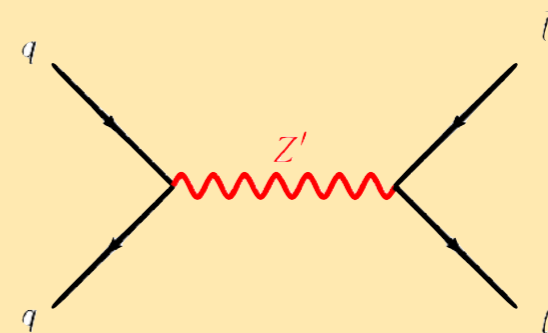


- missing p_T signatures
- highly model-dependent

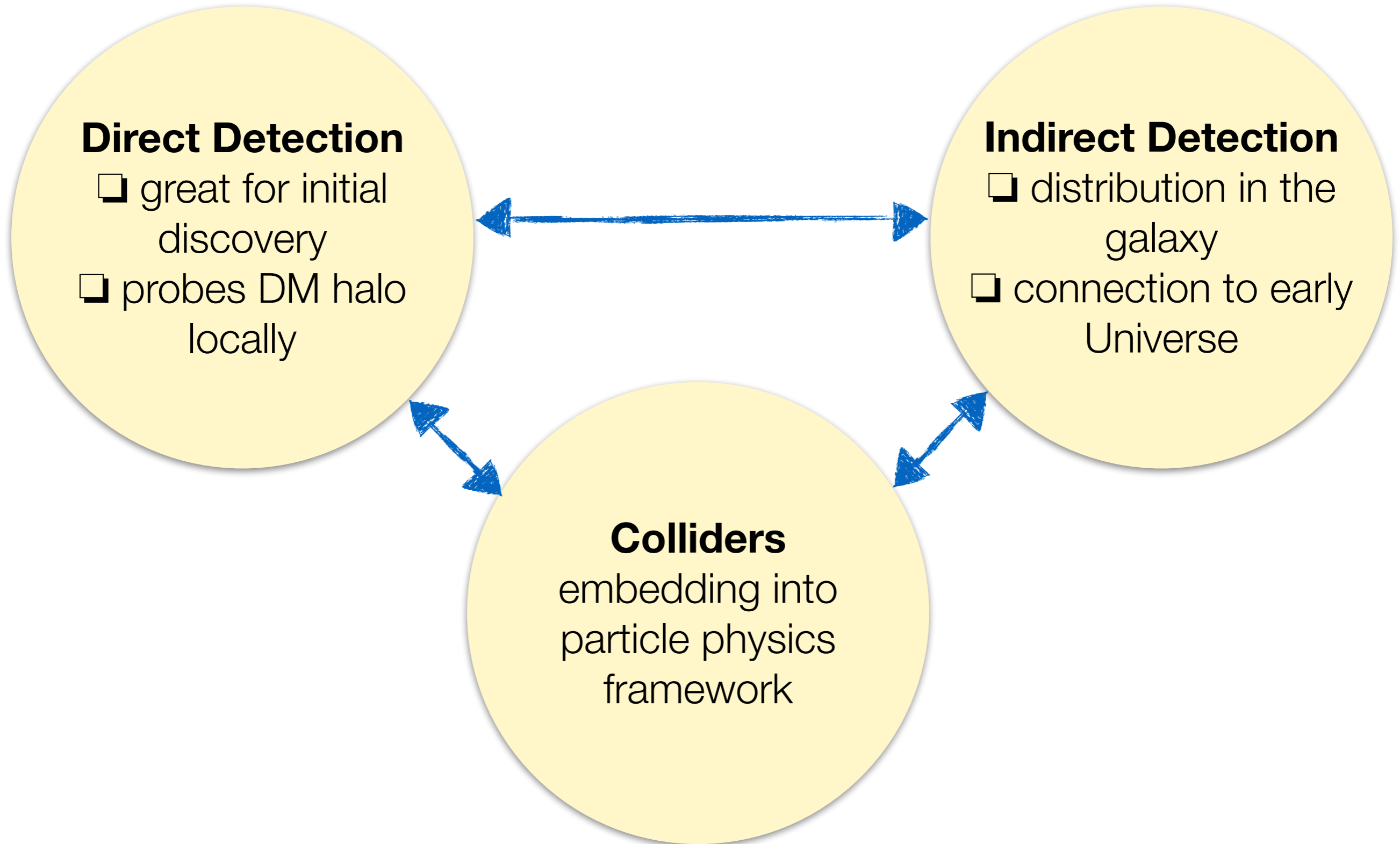
Simplified Models



- generic signatures
- less sensitive
- searching for mediators is often more promising

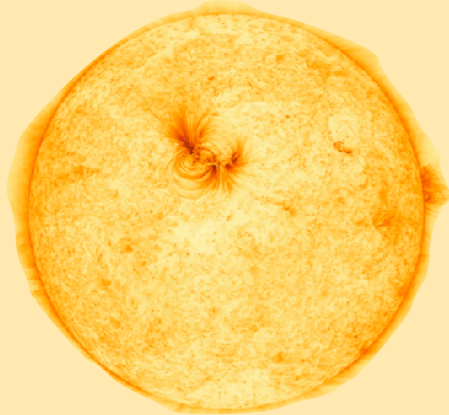


Interplay of DM Search Strategies



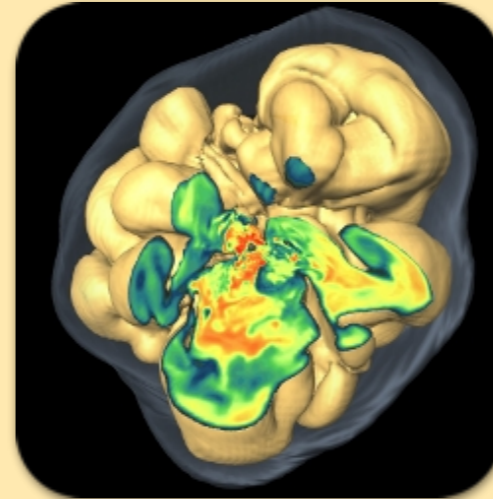
Opportunities Beyond Dark Matter Search

Solar Neutrinos



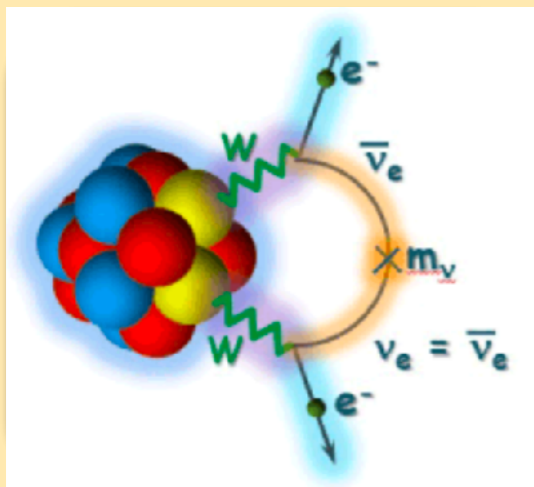
- ✓ sub-per cent measurement of pp neutrino flux
- ✓ solar metallicity problem

Supernova Neutrinos



- ✓ hundreds of CEvNS events for Galactic SN
- ✓ all-flavour sensitivity

$0\nu 2\beta$ Decay



- ✓ technological similarities
- ✓ competitive with dedicated searches

Beyond the Standard Model



- ✓ ν magnetic moments
- ✓ non-standard ν interactions
- ✓ solar dark photons
- ✓ ...

Key Points

- ☑ Direct detection is **unique** and **complements** other DM searches
- ☑ **Dark Matter Detectors** are not single-purpose experiments any more, but have evolved into **multi-purpose observatories**
- ☑ DM detectors rely on **advanced infrastructure**