**Scintillation detectors:**

Uses liquid scintillators or scintillating crystals as target medium

Dama uses room temperature sodium iodide (NaI) scintillating crystals. Looks for annual modulation to distinguish signal from background

XMASS uses single phase LXE, detects scintillation photons with PMTs. Reconstructs event location using PMT timing, and uses self shielding to discriminate backgrounds

Liquid Argon experiments such as DEAP and CLEAN can’t use self shield due to Ar39 background. Instead use pulse shape discrimination to differentiate signal from background. Scintillation in liquid noble gases is produced by the decay of singlet or triplet excimers. The triplet state emits light over a longer period of time, and the light can be suppressed by destructive interactions such as Penning ionization and electron-triplet spin exchange. Nuclear recoils produce higher excitation densities, and therefore more destructive interactions with the triplet excimers, leading to a difference in the pulse shape of NR and ER events.

**Ionization detectors:**

CoGeNT uses low input capcitance p-type contact germanium cystals.

Operates at 77K.

Can achieve threshold as low as 400 eV.

Also use pulse shape discrimination. ER background events scatter at multiple events sites, leading to a wider pulse. WIMPs interact rarely and scatter at most once, leading to a narrower pulse shape

**Phonon detectors:**

The cryogenic Underground Observatory for Rare Events (CUORE) uses TeO\_2 crystals as target medium. The heat capacity of the crystals is so small that the phonon energy released from recoil event generates a measurable increase in temperature.

Operates at 10 mK

Phonon signal is read with doped germanium thermistors.

Does not have discrimination capabilities, so relies on radio-pure construction materials

**Phonons + Ionization:**

The Cryogenic Dark Matter Search (CDMS) in the Soudan mine. Uses Ge and Si detectors cooled to ~40mK. Collects ionization electrons drifted by an electric field and collected by electrodes. Also generates phonons which are collected by superconducting transducers on the other face.

The ionization yield of a nuclear recoil is lower than an electron recoil, so the ratio of the two signals can be used for discrimination.

5 keV threshold

**Phonons + Scintillation:**

The Cryogenic Rare Event Search with Superconducting Thermometers (CRESST) - Gran Sasso Lab. Uses Calcium tungstate (CaWO$\_4$) crystals with transition edge sensors to detect phonons and scintillation.

Operated at 10 mK to enhance phonon signal and lower thermal noise.

The top of each crystal has a layer of silicon light absorber that converts scintillation photons to heat that are detected by thermometers. Bottom sensors detects phonons.

“The main part of this detector is a cryogenic calorimeter with a scintillating crystal as absorber. A particle interacting in this absorber produces heat and scintillation light. While the heat is measured directly in this calorimeter as before, the scintillation light escapes from the absorber and is detected by a nearby second calorimeter especially optimised for this purpose. Since in this scintillation crystal a nuclear recoil produces about 10-40 times less scintillation light than an electron recoil, a comparison of heat and scintillation signal can be used to distinguish between nuclear and electron recoils.”

**Scintillation + Ionization detectors (Dual Phase TPCs)**