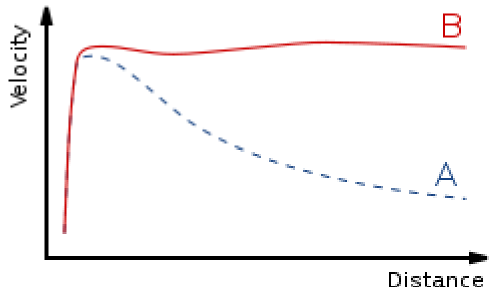
# Direct Search for Dark Matter with EURECA

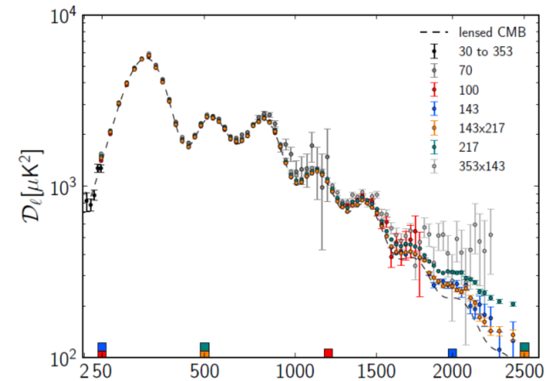
European Underground Rare Event Calorimeter Array

SIMSON Think Tank

# Why search for dark matter?

- Hints at all scales: Rotational curves of galaxies, bullet cluster, CMB power spectrum,…



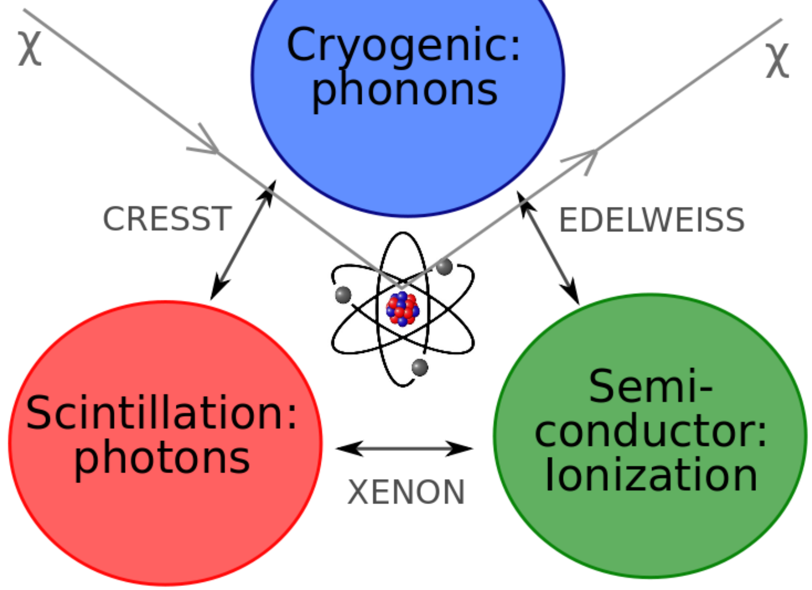




- Planck 2013: Universe = 26.8 % dark matter
- Possible composition: MACHOs, WIMPs, axions, sterile neutrinos,…

  LSP
- Detection:
  - Direct: scattering of WIMPs off atomic nuclei
  - Indirect: annihilation products of WIMPs

# Direct dark matter searches

- Dark matter particle scatters elastically off an atomic nucleus
- Measure recoil energy O(10-100 keV)
- Expected signal rate ($\sigma=10^{-45}$ cm$^2$) $\leq$ 1 event/kg/year

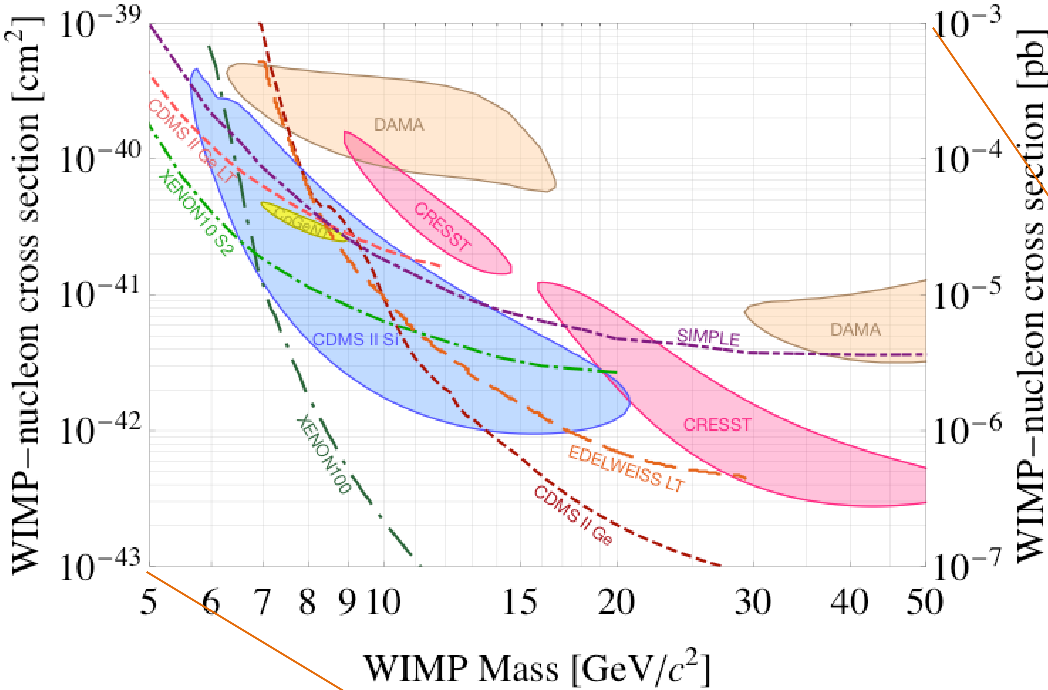



⟶ Minimize background and maximize signal:

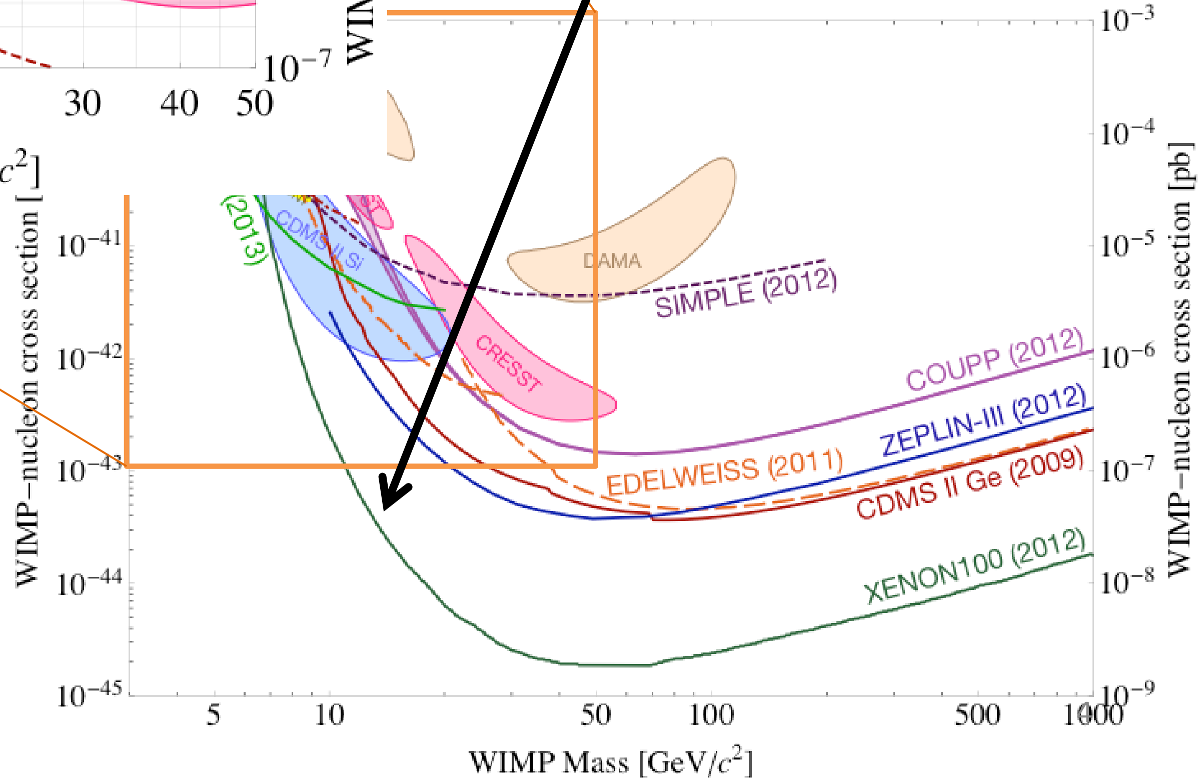
- Deep underground site
- Ultra low radio-active materials
- Combination of detection techniques
- Target nuclei with high atomic mass: $\sigma_0 \sim A^2 \sigma_{\chi-p}$
- More target material!

**Spin-independent interaction (SI)**

# Current status of direct searches (SI)



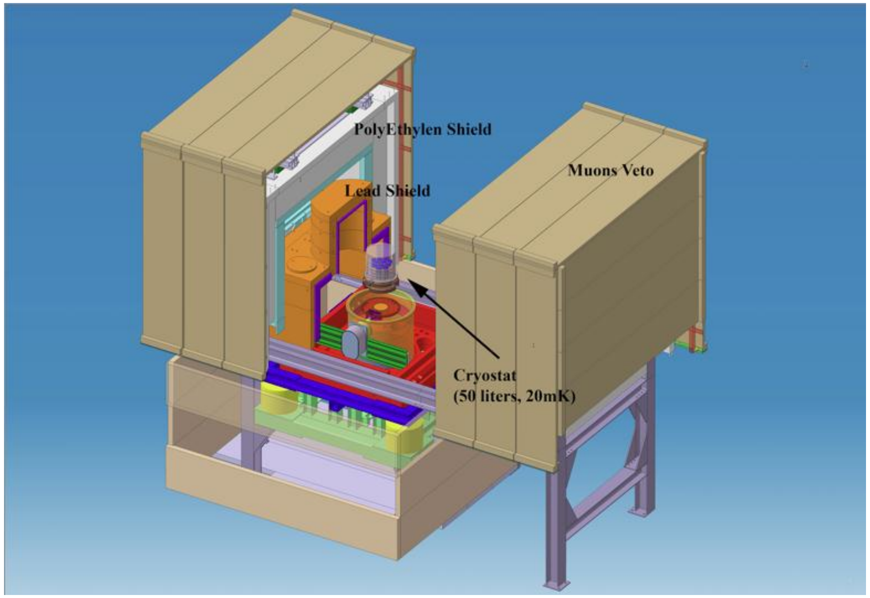

- Lines: 90% confidence level U.L.
- Shaded area: 2σ contour
- Reduced sensitivity at low WIMP mass

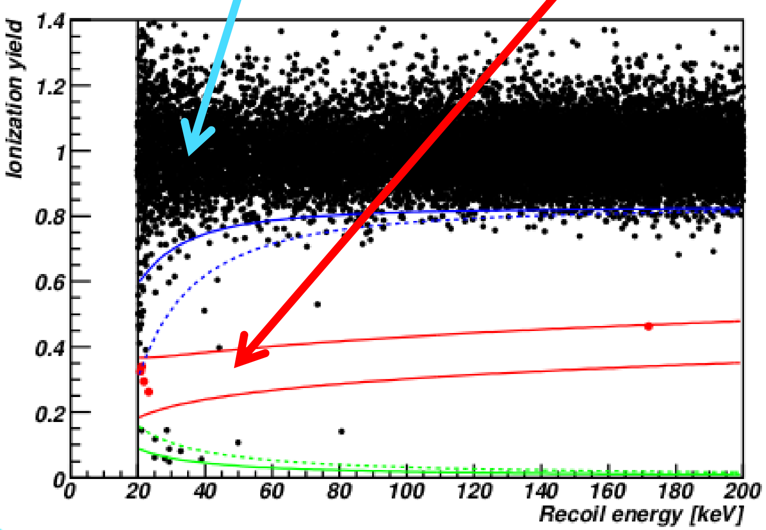



Tension between various results

# EDELWEISS-II

- At Laboratoire Souterrain de Modane
- Uses ultrapure Ge bolometers operated at 18 mK
- Combines **phonon** and **ionization** detection techniques:
  - Phonon detection provides total energy
  - Ionization detection allows discriminates between **nuclear** and **electron** recoils

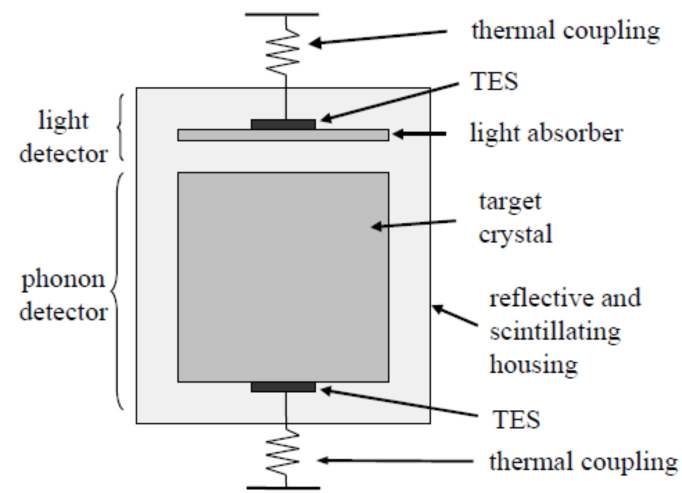



- Issue: Electron recoil near surface induces less charge
Solution: Special electrode layout that creates a clearly separated fiducial volume with background rejection power ~1 in $10^5$

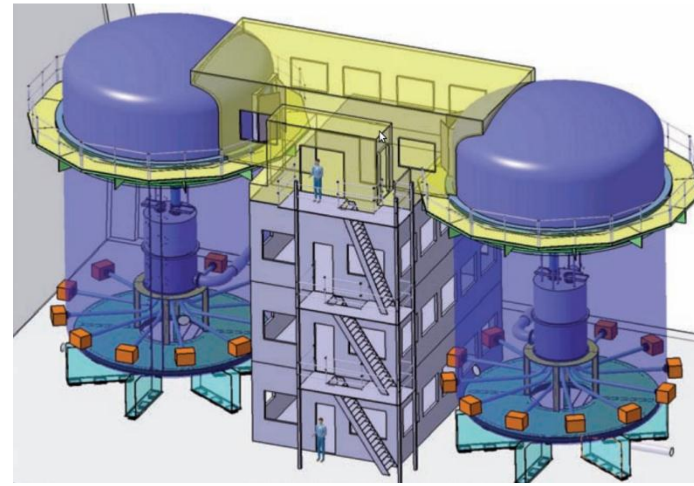
# CRESST-II

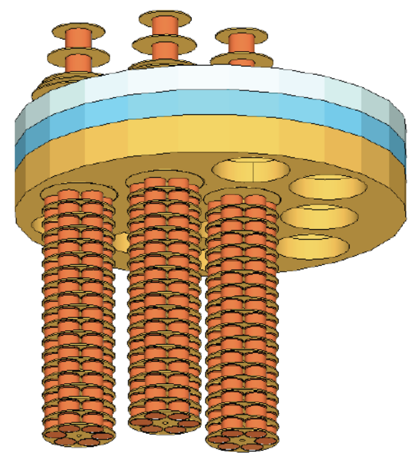
- Cryogenic Rare Event Search using Superconducting Thermometers
- Located at Gran Sasso, 1400m below ground
- Modular configuration of sensitive area. Each module consists of 300 g **$CaWO_4$ scintillator** + tungsten transition edge sensor (TES).
- System is cooled to 10 mK where tungsten sensor becomes superconducting.
- **Phonon emission** is registered as temperature change using extremely senstive SQUID ($\Delta T/T = 10^{-6}$)
- Enhance signal/background ratio:
  - Copper and lead shielding for photons
  - Polyethylene blocks for neutrons
  - Muon veto scintillator

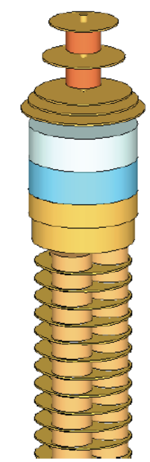



# Experimental setup for EURECA

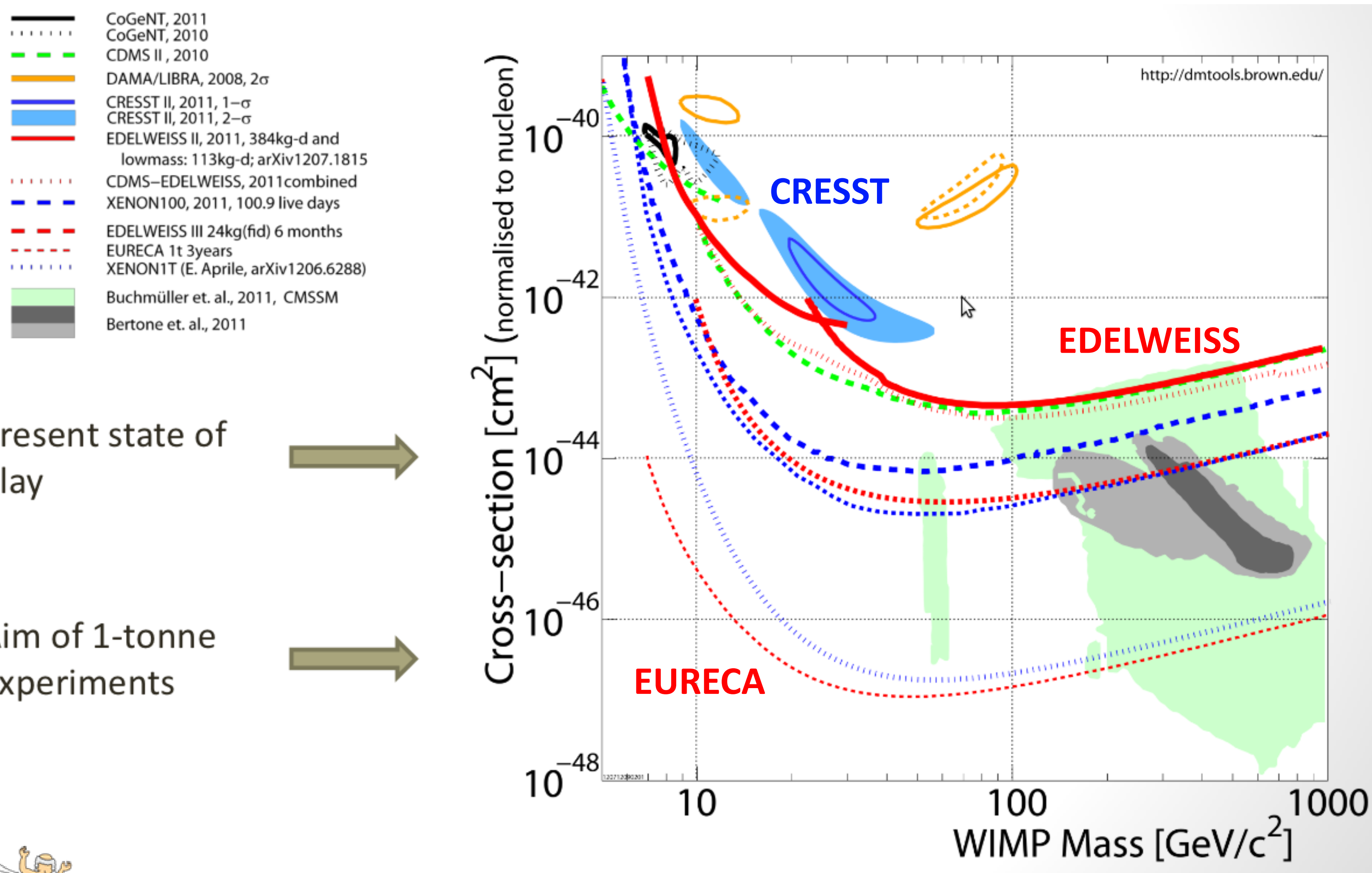
- Large target mass, up to 1000 kg
- Cryogenic calorimeter (~10 mK)
- Combination of EDELWEISS and CRESST detection technology:
  - **Phonon detection** for total deposited energy measurement
  - Measurement of **ionization** and **scintillation** light for background discrimination
- **NEW**: multiple target materials (Ge, $CaWO_4$, …)
  - Test $A^2$-scaling of WIMP-nucleus interaction
  - Allows to constrain unknown WIMP mass
  - Help determine residual neutron background
- **NEW**: tower setup
  - Use coincidence veto to gain sensitivity
  - Test uniform rates within target







# Expected sensitivity of EURECA



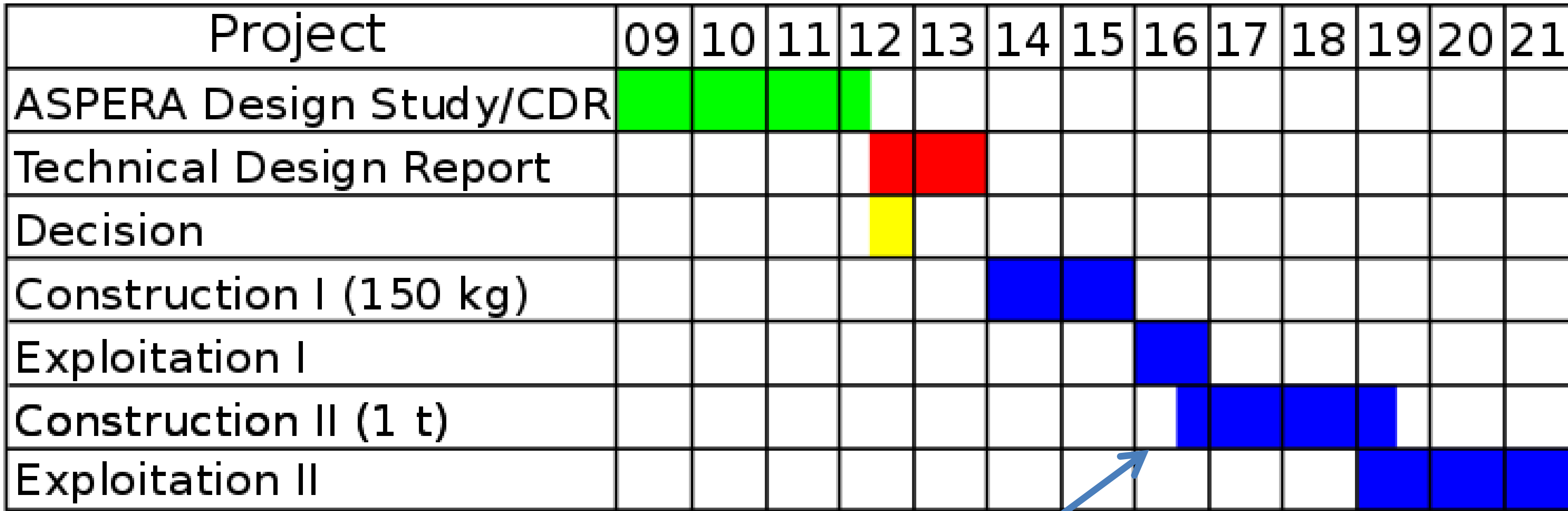

Present state of play

Aim of 1-tonne experiments

# Challenges

- Need to scale up technology (read-out, DAQ, cooling, shielding,…) in cost-effective way without deteriorating performance
- Shielding needs to allow for expected background of 1 event/tonne/year
  - Need to improve radiopurity of used materials
  - 3m water tank with PMTs
  - Put most radioactive parts of detectors and electronics behind local shield
- Lower recoil energy threshold to gain sensitivity to low WIMP masses
- R&D is ongoing

# Timeline + contribution




Phase II

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- R&D for target material is crucial for background rate and lowering threshold Examples: $ZnWO_4$, $CaMoO_4$,$Al_20_3$
- Implementation of a scalable DAQ framework

# Conclusions & outlook

- EURECA is a next-generation direct dark matter experiment with a huge potential
- We request funding for R&D for Phase II upgrade:
  - Scalable DAQ framework
  - Additional target material