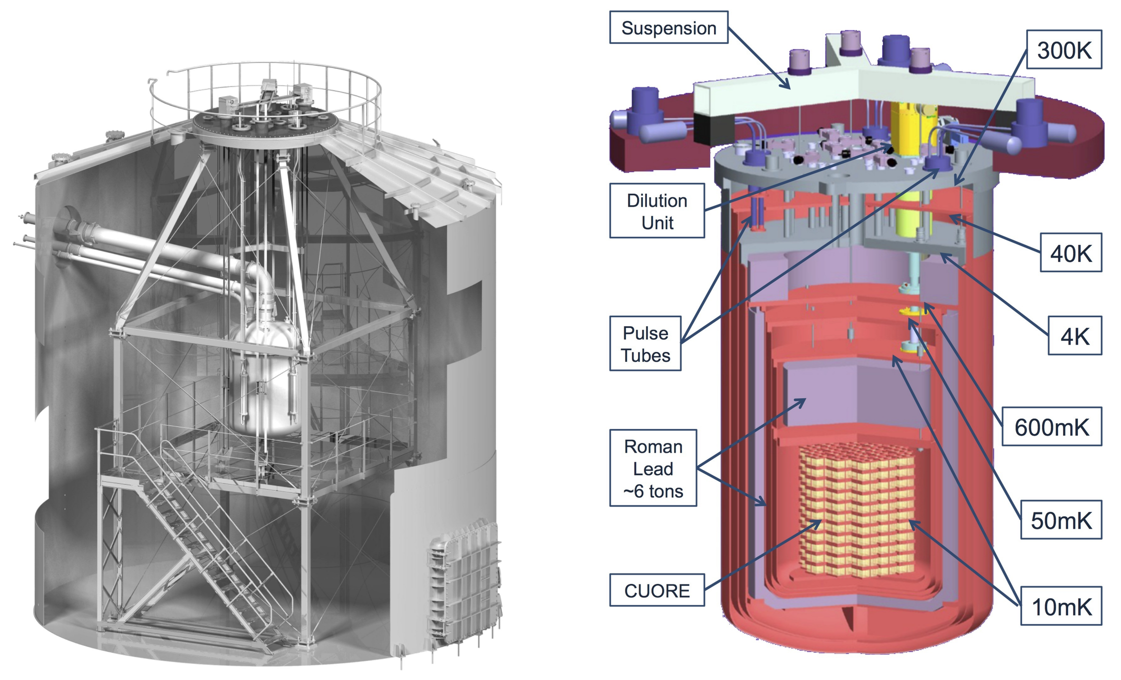
Searching for Supernova Neutrinos with Dark Matter Detectors

Introduction

When the next galactic supernova explosion will occur, conventional water or hydrocarbon detectors will provide a huge statistics on $\bar{\nu}_e$ events. However, the lack of knowledge about the initial energy distribution and the oscillation mechanism limit us to extract useful information from charged-current events alone [1].

Detectors



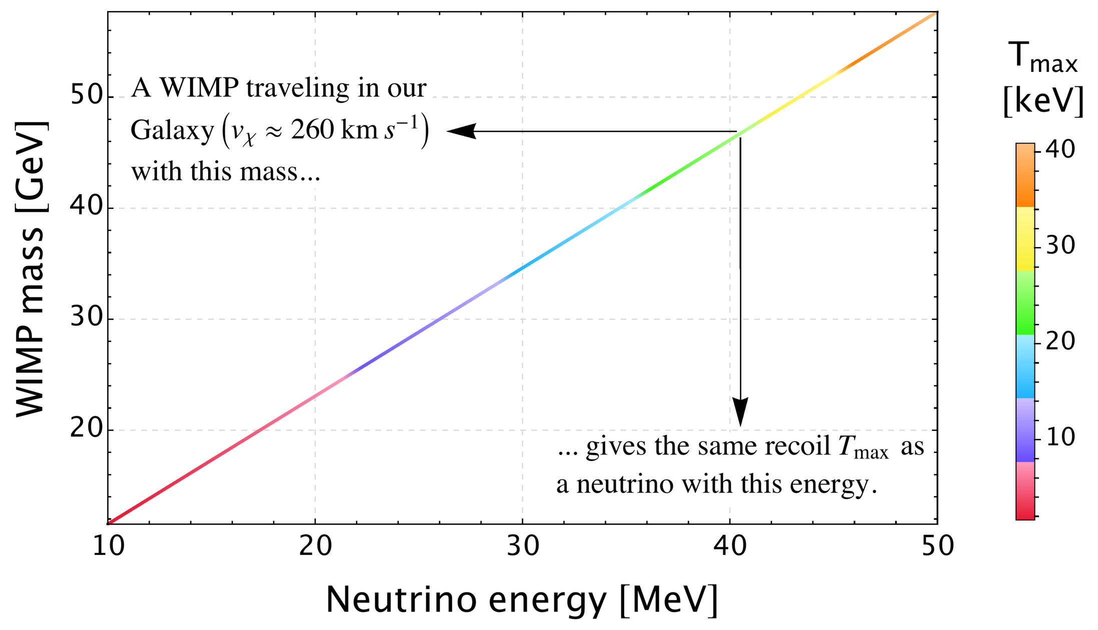
XENON1T [2]   CUORE [3]

WIMP dark matter and $0\nu\beta\beta$ detectors are in principle able to detect neutrino-nucleus coherent neutral-current scattering [4, 5]:

- large active mass;
- low threshold;
- good energy resolution;
- low background;
- same kinematics for ν and dark matter.

↓

Recoils on Xenon

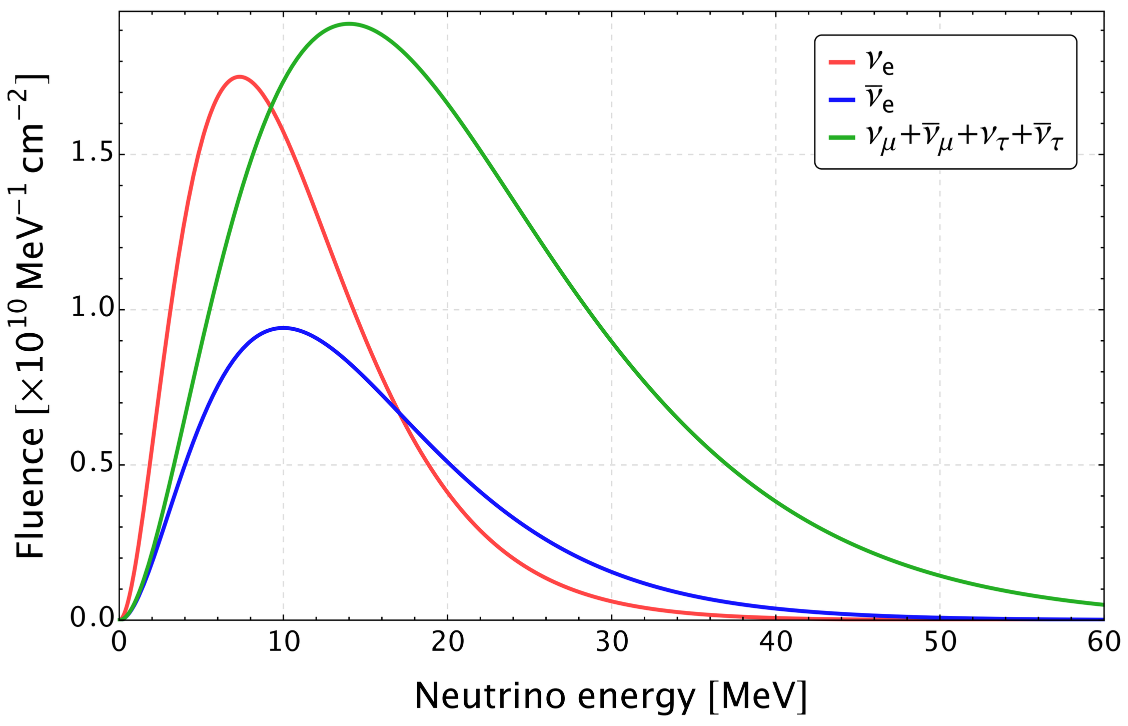


Neutrino emission

Supernova parameters	
Distance	10 kpc
Emitted energy	$3 \cdot 10^{53}$ erg
ν_e mean energy	11 MeV
$\bar{\nu}_e$ mean energy	15 MeV
ν_x mean energy	21 MeV

Standard (useful) hypotheses, e.g. [6]:

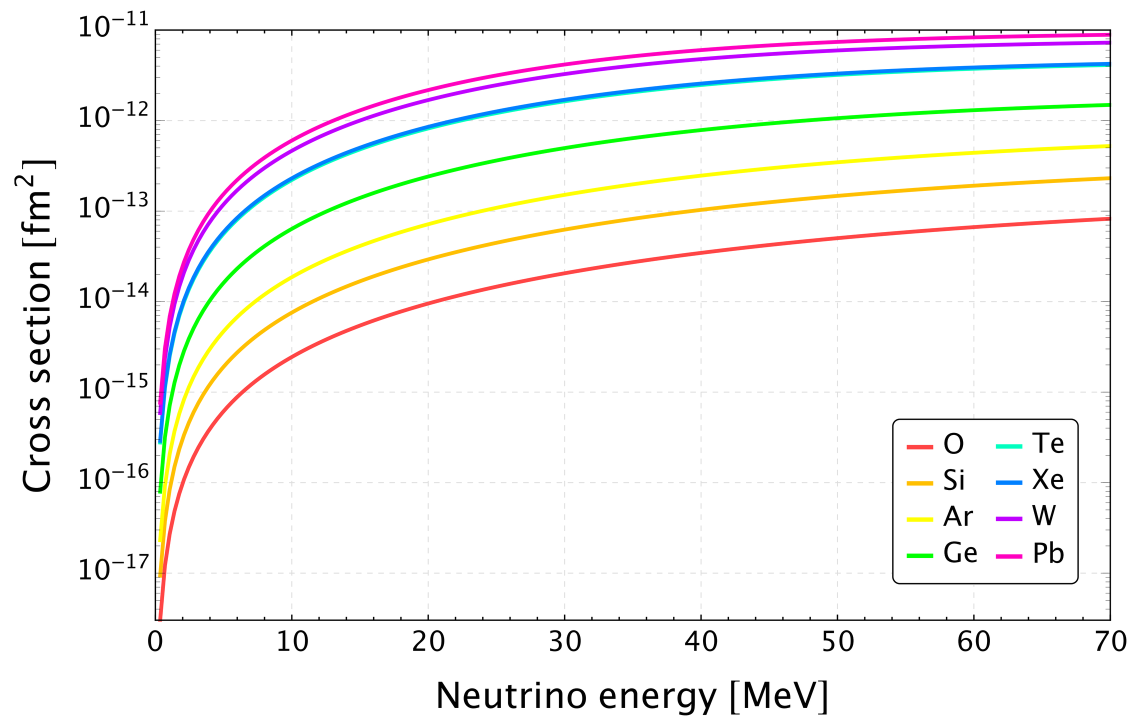
- energy equipartition among species;
- fluence (time integrated flux) $\approx$ thermal Maxwell-Boltzmann distribution.



Cross section

Features of neutrino-nucleus interaction:

- due to neutral-current;
- almost proportional to (# neutrons)^2;
- coherent superposition of interaction probabilities for all nucleons;
- form factor suppression for nonzero transferred four-momentum – Helm model [7, 8].



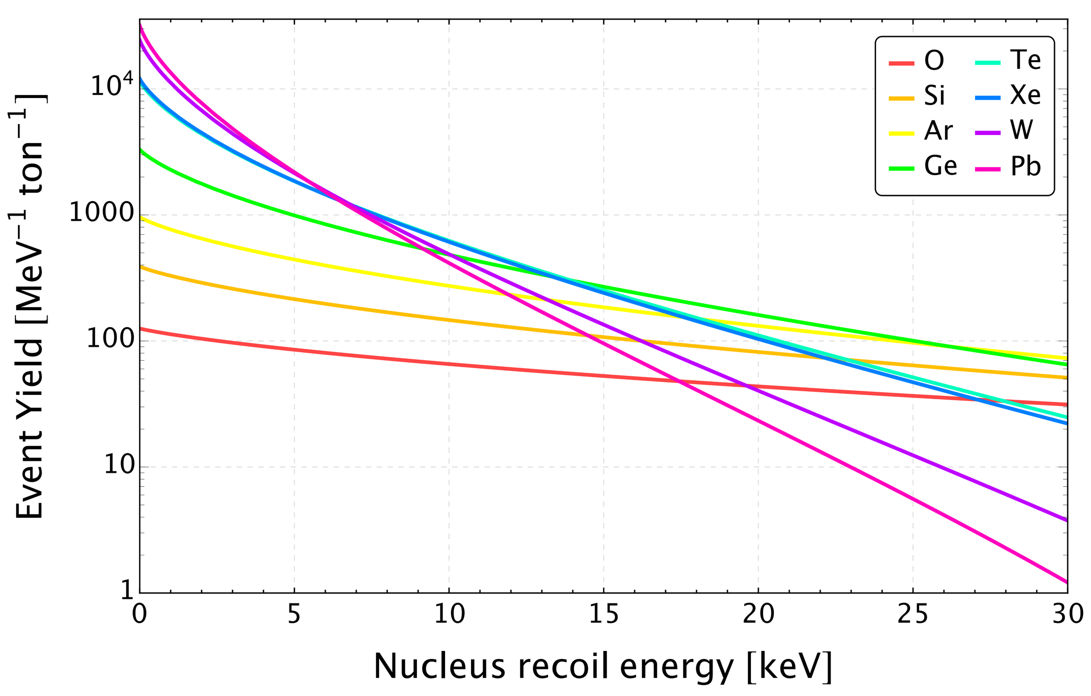
HEAVIER TARGET ⇒ MORE INTERACTION

but

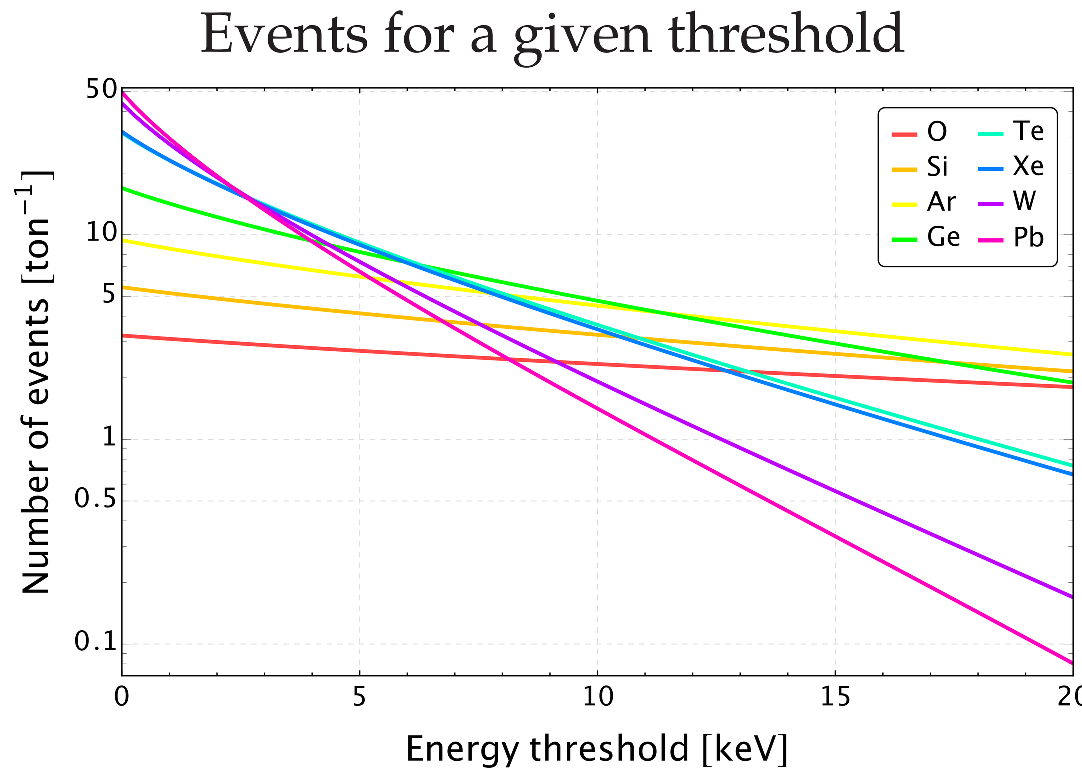
HEAVIER TARGET ⇒ FAINTER RECOIL

Number of expected events

Event yield for ton of mass



Events for a given threshold



Event yield (left) and number of expected events as a function of detector threshold (right) for ton of active mass and for different target materials.

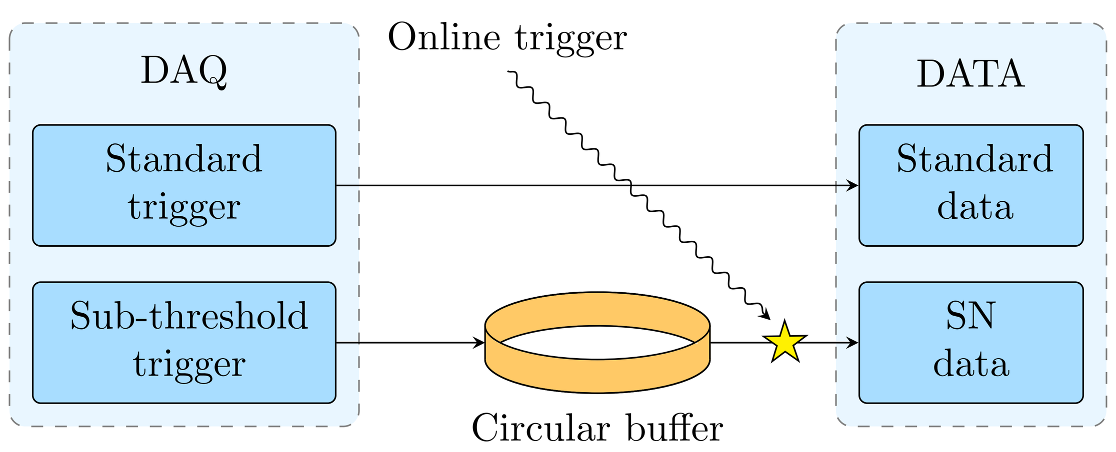
LOWER THRESHOLD ⇒ MORE EVENTS

but

LOWER THRESHOLD ⇒ HIGHER BK RATE

Trigger

Lowering the threshold for continuous data taking experiments increases, as a rule, the background rate to an unsustainable level (see however V. Gentile, poster 110317).



Solution: sub-threshold data kept in a temporary storage circular buffer and saved only in case of an external trigger.

LVD in Gran Sasso National Laboratories is well-suited for the goal [9]:

- life time $> 99\%$;
- fast – well-defined time window between supernova event and trigger;
- it coexists with XENON1T, CUORE...

Conclusions

The detection of neutral-current events from the next galactic supernova is an important goal still to be achieved. The dark matter and $0\nu\beta\beta$ detectors have a crucial physics potential in this sense. A fast trigger, provided by a standard supernova detector such as LVD, can help to lower the threshold and improve the sensitivity to this rare signal.

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