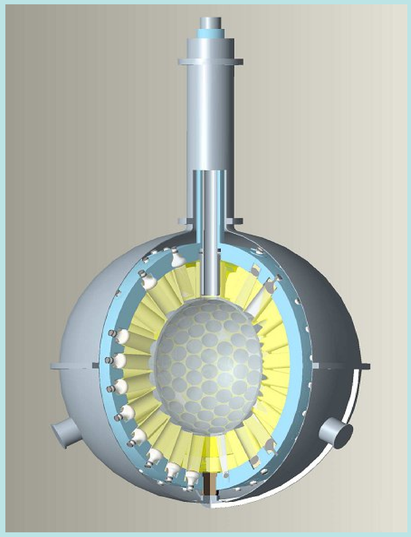
Detection Of Heavy Dark Matter Particles In DEAP-3600

Michela Lai on behalf of DEAP-3600 Collaboration

DEAP-3600 is a dark matter detector filled with Atmospheric liquid argon, designed for the WIMP search.



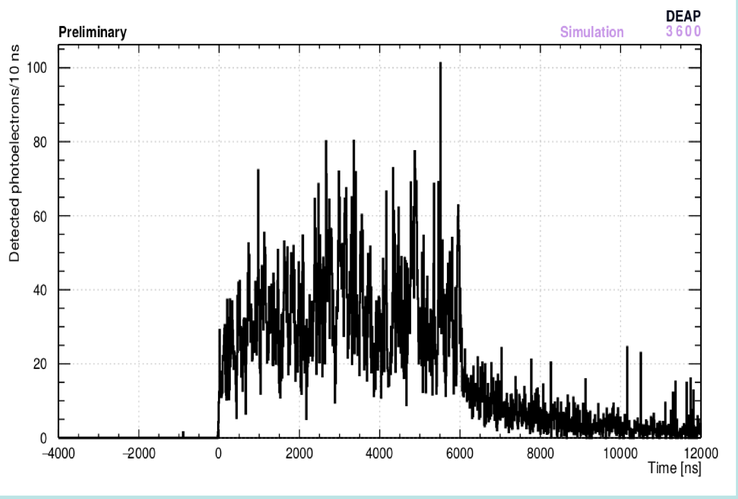
"Design and construction of the DEAP-3600 dark matter detector", DEAP Collaboration, Astroparticle Physics, 108, March 2019

- single-phase design
- **3.3 ton of target mass**, all contained in the acrylic inner vessel. **It is the largest running dark matter detector based on noble liquids.**
- connection to the surface through a long neck, which allows for the cooling of the vessel and eventual operations
- light yield of **7 photoelectrons/keV**
- Photodetection performed by 255 photomultipliers tubes (PMTs), coupled to the vessel via acrylic guides
- All contained in a stainless-steel sphere
- All submerged in a cylindrical tank filled with ultrapure water, observed by 48 PMTs
- Set at SNOLAB, under **2 km of rocks** (6 m.w.e).

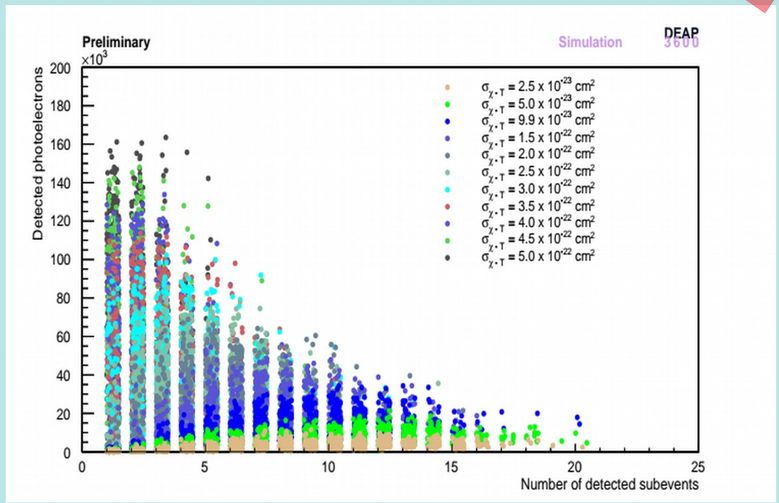
Identikit of Multi-Scattering Heavy particles:

- Mass >> 100 TeV, **up to the Planck Mass**
- Dark matter-target **cross-section > 5 x 10^{-25}cm^2**
- produced in the early universe via several mechanisms, like out-of-equilibrium production or pre-heating
- the high mass allows to **reach underground detectors, such as DEAP-3600**
- the high cross-section determines **multiple scatterings** in the detector.

The response of the detector to this signal is simulated in RAT, assuming the present geometry of the detector.

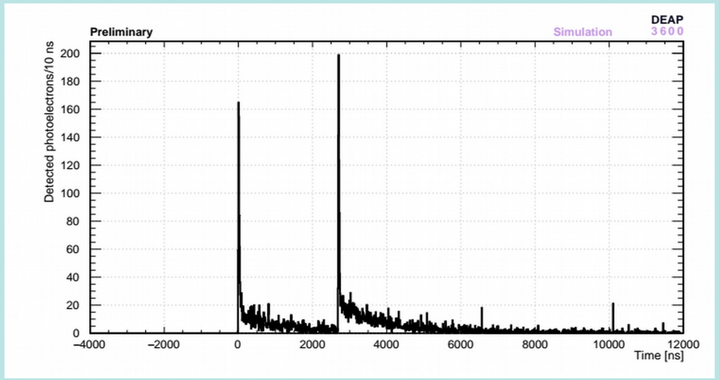


The number of subevents, so **the outstanding peaks along a waveform, identifies multiple recoils in the same acquisition window, as for** the present dark matter candidate.



At such high cross-sections, the particle performs hundreds, even thousands of scatterings. **The distribution of the subevents vs the number of detected photoelectrons** for several cross-sections **was compared to that from the expected background.**

Any **background** event performing one single scatter in the detector will be **rejected** by the present analysis by requiring more than one subevent.
Still, more background recoils can happen in the same acquisition window. These are referred to as "**pile-up**" events, the dominant background for the present analysis.



Three Regions of Interests (ROIs) are determined, according to the expected background level.

ROI	Detected photoelectrons
1	4000-20000
2	20000-70000
3	70000- 4 x 10^8

A custom selection cut in the number of subevents was hence optimized up to 10 MeV, divided in ROI #1 and ROI #2 in order to **reject our multi-scattering dark matter particles from pile-ups.**

No pile-ups are expected above 10 MeV, so **70 kqPE**. Here the dominant background are **muons** entering the inner vessel. **This is ROI #3**, where the background suppression is mainly done by the rejection of the events in coincidence with the water tank trigger.

After all the selection cuts, the expected background level in each ROI will be far below 1.
Thanks to the high exposure DEAP-3600 will be the first direct detection experiments scanning for heavy multi-scattering dark matter particles up to the Planck Mass.

The unblinding procedure will start pretty soon, so …

Stay tuned!