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The ASTAROTH project

An innovative light detector based on Silicon PhotoMultipliers for rare event physics and its applications in dark matter direct detection experiments

Valerio Toso[1,2], for the ASTAROTH collaboration

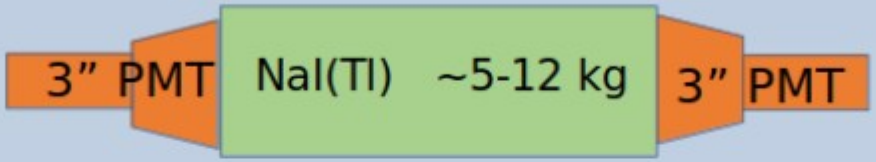
[1]Università degli Studi di Milano; [2]INFN Milano

The ASTAROTH experiment

An alternative to PMTs

All current generation NaI(Tl)-based detectors share concept and limitations:

Energy region of interest: up to 6 keV_{ee}



e.g. DAMA [2], SABRE [3], ANAIS [4], COSINE[5]

1. Emitted: 40-42 photons / kev  Detected: 7-15 ph.e. / kev. 
2. High noise from PMTs at low energy [partly "after-glow" but not well understood]
   - ↳ resulting spectrum dictated by PSD efficiency

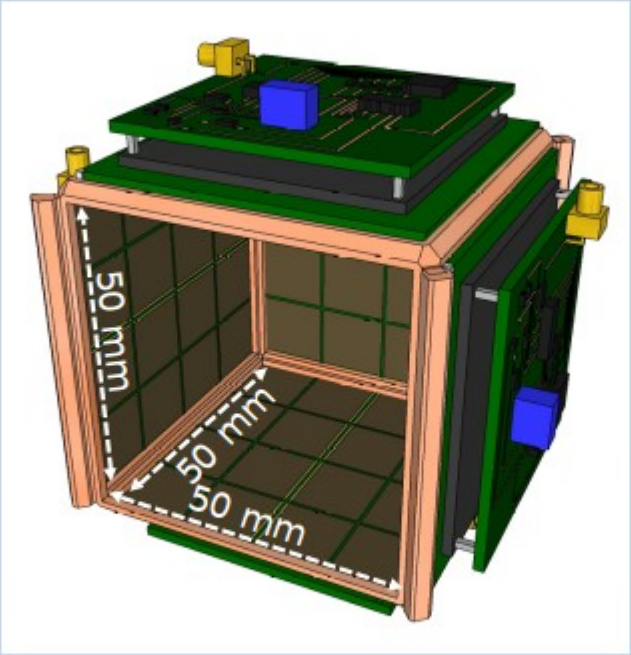
Currently, recoil energies below 1 keV_{ee} are not detectable

3. *Challenging* to achieve ultra-high purity crystals of this length (≳ 20 cm)

The ASTAROTH experiment

ASTAROTH aims to overcome these limitations in the next generation detectors:

***All-sensitive* design**:
light read-out from every face



Higher conversion efficiency
SiPM **PDE: up to 55%**
PMT QE: 30-35%
@420nm NaI(Tl)
peak emission

5×5×5 cm^3 cubic crystals
Six 25 cm^2
SiPM matrices

Aim at > 20 ph.e. / keV
(optical simulations ongoing)

Single channel
(sum) read-out

No “after-glow”

Lower dark count than PMTs
at low temperature (<150 K) [1]

Negligible sensor radioactivity
(i.e. dominated by electronics)

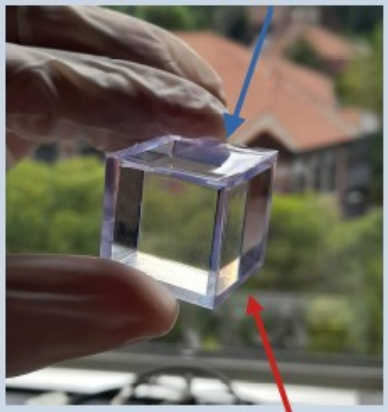
SiPM require cryogenic operation

The ASTAROTH experiment

Challenge: fully transparent moisture-tight case

1. Fused silica (soldered vs. glued solution)
2. Epoxy resin:
   - Stycast 1266
   - Epotek 301-2
   - Masterbond EP29LPSP

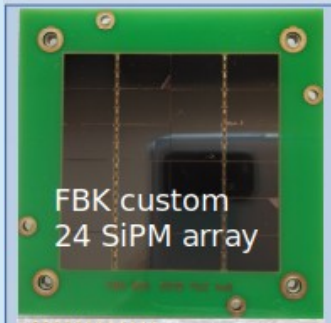
25x25x25 mm



ASTAROTH size: 5x5x5cm

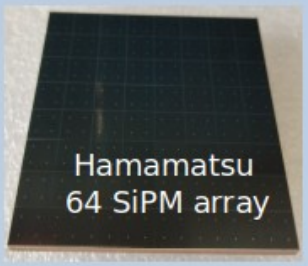
Future physics phase of 8-10cm: ultra-high-purity crystals

"complex 'cuisine' work! Ask the Presenter for details!"



Compare SiPM from two vendors:

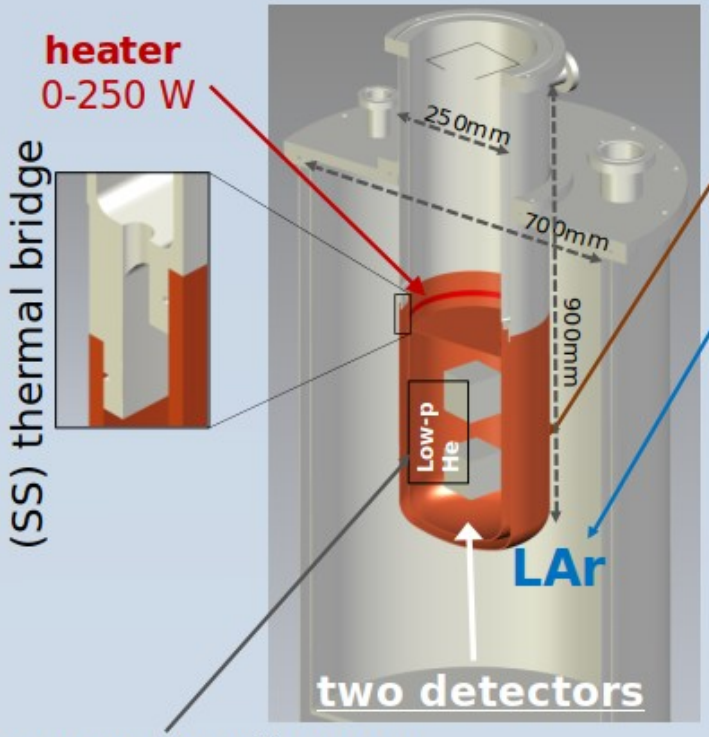
1. FBK NUV-HD-Cryo [1]
   pitch 40 µm, Low Field, wire bonded.
2. Hamamatsu S13361-6050 series
   pitch 50 µm



Compare two array layouts:

1. 8x12 mm² (24 devices)
   "2s3p" ganging on array; front-end: 4 channels + sum [6]
2. 6x6 mm² (64 devices)
   variable ganging on the front-end (in development)

The ASTAROTH experiment



Copper chamber
vacuum-insulated
dual wall

Liquid Argon bath
excellent **scintillator**

Instrument the outer
volume as **veto**!

Heating power
(tunable heater)

Dynamic
equilibrium

through the bridge

Cooling power
(LAr)

87 K < *tunable* working temperature < 150 K

choose the optimal working point for both crystals and SiPM

The ASTAROTH experiment

Thank you!