Operating the GridPix detector in dark matter search experiments

Rolf Schön
G. Hemink & M. Alfonsi
N. van Bakel & P. Decowski & H. van der Graaf

NIKHEF
Nikhef, Amsterdam
Detector R&D

May 25, 2012
Dark matter

- Atoms: 4.6%
- Dark Matter: 23%
- Dark Energy: 72%

Hypothetical candidate: weakly interacting massive particle (WIMP)
WIMP detection with noble gases

dual-phase noble gas TPC

\[
\frac{S_2}{S_1} \quad \text{nuclear recoil} \quad \neq \quad \frac{S_2}{S_1} \quad \text{electronic recoil}
\]
Alternative: direct charge readout

- candidate technology within DARWIN R&D (Dark matter WIMP search with noble liquids) arXiv:1012.4767
- less S1 signal vs. high electron efficiency (better S2 resolution)
The GridPix detector

- Micromegas-like mesh, 1 µm Al
- insulating spacer, 50 µm photoresist
- spark protection layer, 8 µm silicon-rich SiN
- Timepix readout chip
GridPix features

- 65k pixels on 14 mm × 14 mm
- single electron detection efficiency > 98%
- $x - y$ resolution < 20 $\mu$m
- Timepix chip $\Rightarrow$ $\mu$TPC
- threshold 1100 electrons (at room temperature)
GridPix in dual-phase noble gas

Main challenges

- cryogenic
  - thermomechanical stress
  - high gas density

\[
\begin{array}{ccc}
T_{\ell \text{Xe}} & T_{\ell \text{Ar}} & T_{\ell \text{N}_2} \\
165 \text{ K} & 87 \text{ K} & 77 \text{ K} \\
-108 ^\circ \text{C} & -186 ^\circ \text{C} & -196 ^\circ \text{C}
\end{array}
\]

- pure noble gas
  - no quencher
  - materials must not outgas
The ArDM test cryostat

Measure in pure Ar (1 ppm impurity level)

1. at room temperature
2. cooldown to $T_{\ell\text{Ar}}$ (gas phase)
3. add liquid (dual-phase)
• recorded events of $^{55}$Fe photons (5.9 keV) in quencher-free Ar at room temperature (triggered by PMT)
Ar gas at 87 K

- low gain/no signal in pure Ar at $T_{\ell \text{Ar}}$
- amplification works at $T_{\ell \text{Ar}}$
- PMT spectrum of $^{241}\text{Am}$ $\alpha$ source (59.6 keV):

\[ S_1 / 100 \]

$\alpha$ interaction; $V_{\text{grid}} = 150 \text{ V}; V_{\text{D}} = 1.2 \text{ mm/\mu s}$
Ar gas at 87 K

α interaction; $V_{\text{grid}} = 150 \text{ V}; v_0 = 1.2 \text{ mm/µs}$

α interaction; $V_{\text{grid}} = 495 \text{ V}; v_0 = 1.2 \text{ mm/µs}$

α interaction; $V_{\text{grid}} = 310 \text{ V}; v_0 = 1.2 \text{ mm/µs}$

α interaction; $V_{\text{grid}} = 600 \text{ V}; v_0 = 1.2 \text{ mm/µs}$
No measurements in dual-phase Ar

- boiling liquid the cause?
Robustness of GridPix at $T_{\ell Xe} = 165$ K

Rolf Schön (Nikhef)
Simulating stress

⇒ reduce stress by changing structure of grid support
Timepix noise at low temperatures

![Graph showing the relationship between THL DAC value and temperature for Chip 0, Chip 1, and Chip 2.](Preliminary)
Conclusion

• We learned a lot
  • *stably operating* GridPix in quencher-free argon at room temperature
  • GridPix amplification stage works down to 87 K
  ⇒ no show-stopper: concept works, but has to be improved

• We will learn about
  • noise of Timepix at low temperatures
  • improvements on material robustness
  • gain in pure xenon (at room temperature and at 165 K)
Acknowledgements

- Bas vd Heijden, Vincent v Beveren, Joop Rövekamp, Berend Munneke, Peter Thobe, Herman v Boer Rookhuizen, Richard Rosing
- Fred Hartjes, Josef Uher
- Filippo Resnati, Devis Lussi (A. Rubbia’s ArDM group)
- and . . .
Thank you for getting up so early!