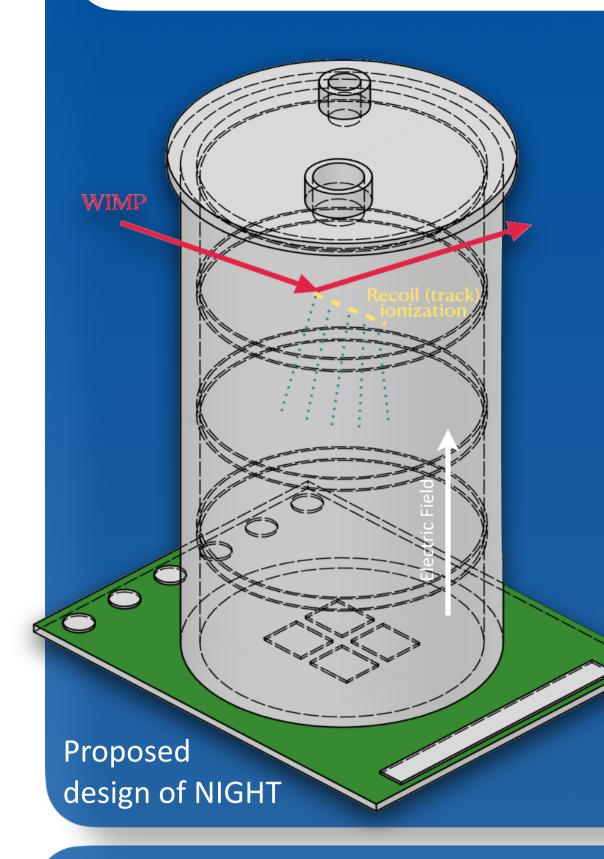
15th International Workshop on the Identification of Dark Matter 2024

Negative Ion GridPix based

FTD Bonn UNIVERSITÄT BONN

High resolution TPC (NIGHT) detector

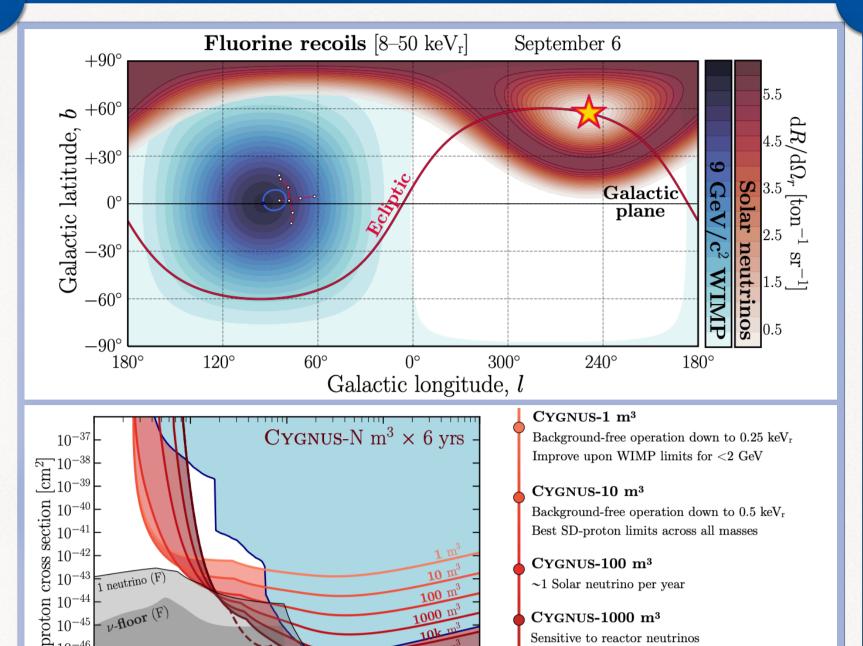
Saime Gürbüz (gurbuz@uni-bonn.de), Can Cihan Çetinkaya, Klaus Desch, Jan Glowacz, Jochen Kaminski, Michael Vogt (University of Bonn)



Directional dark matter searches

- Dark matter halo in the direction of the Cygnus constellation
- Weakly Interacting Massive Particles (WIMPs)
- Higher cross-section of WIMPs from this direction \rightarrow DM wind

WIMF Deneb GALACTIC **PLANE** WIMP Cygnus Constellation

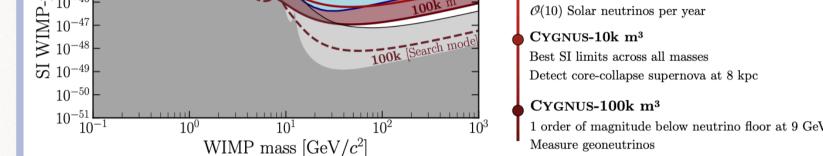


High performance and cost-effectiveness per area of readout

Time Projection Chamber (TPC) with a pixelated readout called GridPix:

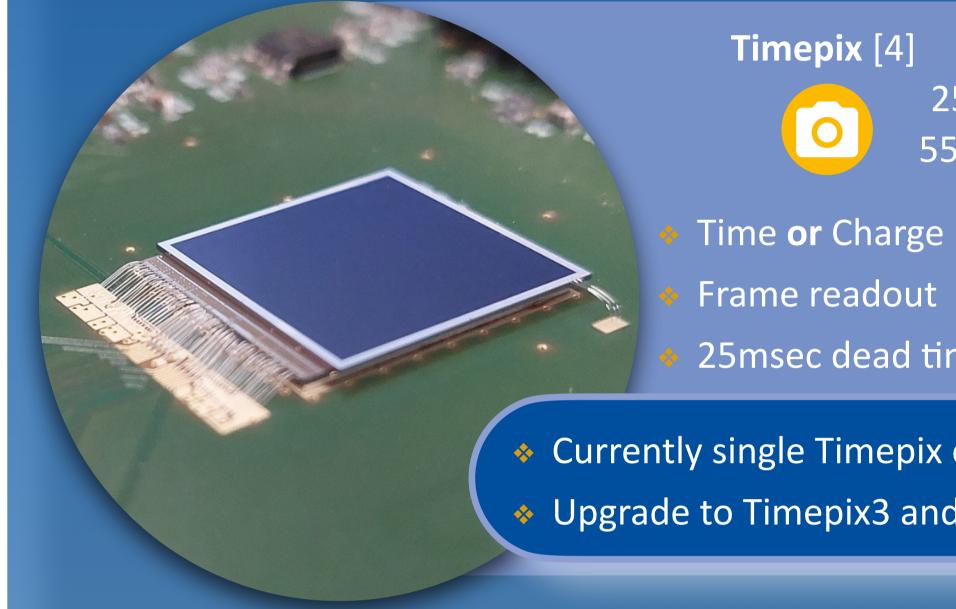
High resolution and precision in directional dark matter (DM) searches

- Negative ion drift gas SF₆ (He to operate the detector close to atmospheric pressure) Low diffusion
- A proof-of-concept detector soon to be tested



Cygnus: Feasibility of a nuclear recoil observatory with directional sensitivity to dark matter and neutrinos [1]

Readout System



256 x 256 ASICs 55 µm pixel pitch Time and Charge

- Frame readout
- Data driven readout

Timepix3 [5]

- 25msec dead time
- Dead time free
- Currently single Timepix chip
- Upgrade to Timepix3 and multi chip tests in the future

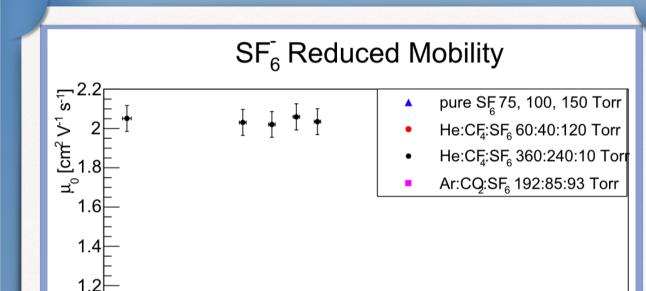




Gas system and selection of gas mixture

Negative Ion Drift (NID) gas SF₆ Low diffusion Close to atmospheric pressure by mixing with He He:SF₆ at different ratios and pressures

A gas mixing unit controlled and monitored by a PC



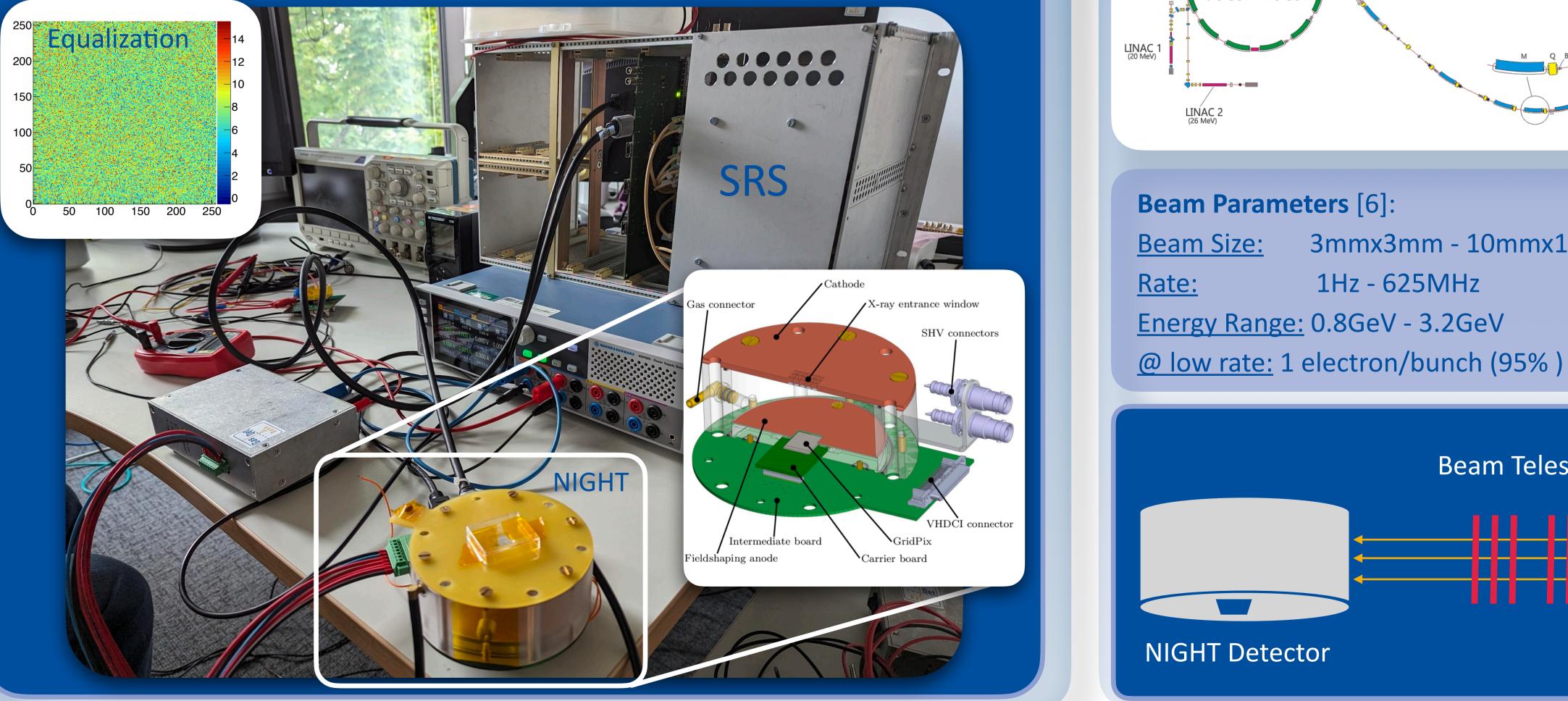
0.6 kV/cm

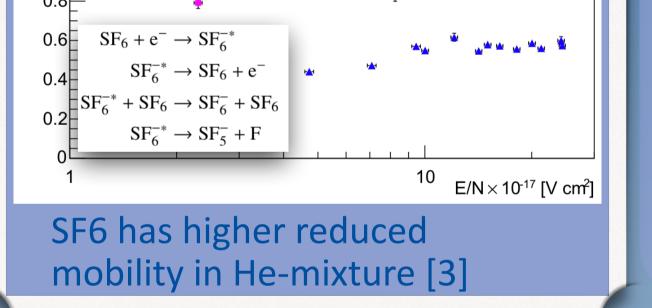
Grid 60 kV/cm

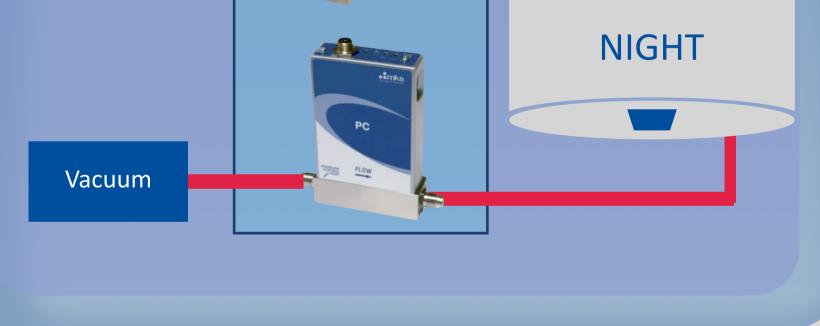
GridPix = Timepix + InGrid Grids perfectly aligned with pixels by microprocessing [2]

The proof of concept detector: NIGHT

- GridPix readout to detect single primary electrons
 - High spatial and time resolution
 - Active area of 1.4 cm x 1.4 cm
- Drift length of 3 cm
- Scalable Readout System (SRS) -> an FPGA board developed by the RD51 Collaboration at CERN
- Easy to scale readout system for larger detector



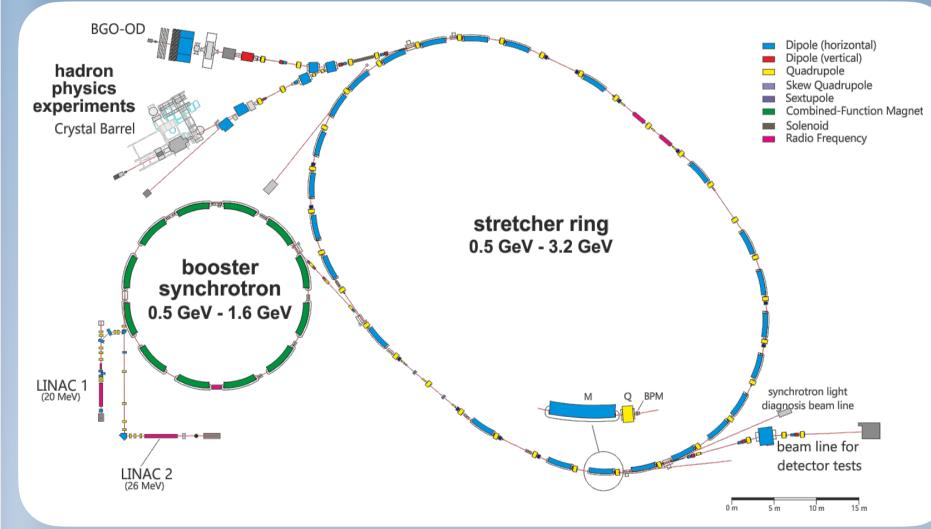




Testing the detector at ELSA beam line

SF6

He



Beam Parameters [6]: 3mmx3mm - 10mmx10mm

Beam Telescope

Single

Electrons

1Hz - 625MHz

Detector test beam line of the ELSA electron accelerator

as mixing uni

- Single electrons at a rate less than 100 Hz
 - The resonant
 - extraction method
- The beam telescope
 - Trigger
 - The track of the electron

Variables to be changed: Drift distance **Electron energy** TPC Voltage SF6 Percentage

> **Parameters to measure:** Drift velocity **Diffusion constant** Amplification



[1] S. E. Vahsen et al., "CYGNUS: Feasibility of a Nuclear Recoil Observatory with Directional Sensitivity to Dark Matter and Neutrinos", arXiv:2008.12587 [2] W. J. C. Koppert et al., "GridPix Detectors: Production and Beam Test Results", NIM in Physics Research Section A: 732, 245 (2013) [3] E. Baracchini et al., "Negative Ion Time Projection Chamber operation with SF6at nearly atmospheric pressure," J. Inst. 13(04), P04022–P04022 (2018). [4] X. Llopart et al., "Timepix, a 65k programmable pixel readout chip for arrival time, energy and/or photon counting measurements," Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 581(1–2), 485–494 (2007). [5] T. Poikela et al., "Timepix3: a 65K channel hybrid pixel readout chip with simultaneous ToA/ToT and sparse readout," J. Inst. 9(05), C05013–C05013 (2014). [6] Y. Dieter, "Setup and Characterization of the Test Beam Area for Pixel Detector Tests at ELSA", M.S. Thesis, 2017, Universität Bonn

