BULLKID-DM Readout Electronics

Timo Muscheid on behalf of the BULLKID-DM collaboration





Dark Matter Search



- Dark Matter has not been observed so far
- Many possible DM characteristics already excluded by past experiments
- Area of interest: Small cross section, low energy
- Difficult to detect!





Direct Dark Matter Search of WIMPs



- Dark matter interacts with nucleus
- Nucleus emits observable photons

Energy measurement with KIDs



- Emitted phonons are absorbed by KID
- Change in resonance frequency of the detector



BULLKID-DM detector concept



Readout requirements:

- Frequency bandwidth: 250 MHz (700 MHz 950 MHz)
- Detector bandwidth: 100 kHz

See Talk by D. Delicato on Friday



DAQ system architecture

AMD/Xilinx ZCU216







DAQ system architecture



Prototype setup @ Sapienza University, Rome



Prototype detector:

- 3" wafer
- 60 channels
- 3 layer stack









- Internal VNA module enables "all-in-one system", no reconnection required
- Fully configurable in software
- Python script built around peak_finder algorithm

Automatic detection of resonance frequencies





-400 -200 ò 200 400

400

400

VNA

Resonator circles

> Calibrate trigger

Energy calibration

Energy calibration system based on LEDs

- Transmission of a known amount of photons from room temperature to the KIDs
- Currently stand-alone system, will be integrated as an FMC+ Extension Board

See Poster by G. Del Castello

Ressource consumption

Ressources for a single readout line:

	DSP	BRAM	URAM	LUT
VNA	20	23.5	0	7000
Comb Gen.	0	0	8	1000
Channelization	78	24.5	0	22000
Trigger	6	30	0	10000
Storage	3	45.5	0	15000

- More ressources required for full-scale FDM
- VNA can be implemented as individual image
- Sufficient DSP for advanced trigger algorithm

Projection to full-scale system:

Noise characterization

Needs update!

Noise increases with reduced tone power

Conclusion

Current status:

- All steps in calibration routine implemented
- System ready for scale-up
- First measurement campaigns with the demonstrator system for characterization

Next steps:

- Long-term measurement campaign with demonstrator system
- Analysis of the acquired pulses
- Integration with the calibration system and the active veto
- Evaluate external amplifier to increase tone power

