Radiopure electronics for the Micromegas detector for IAXO

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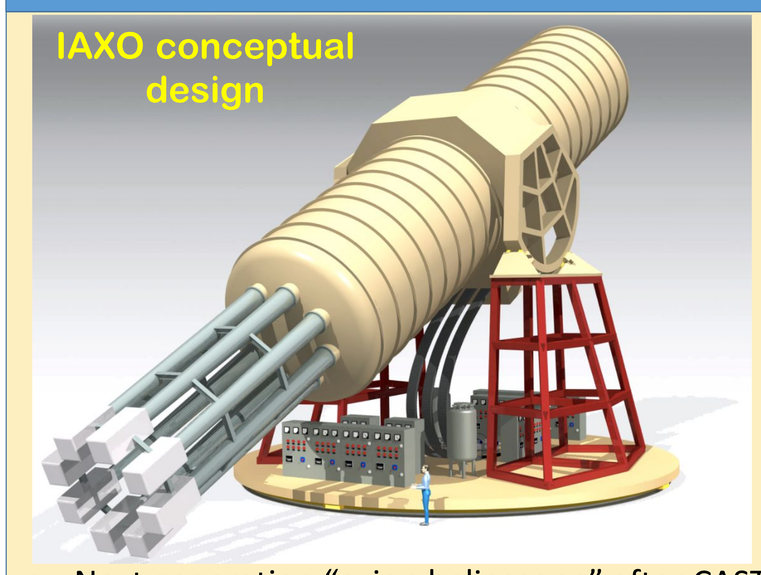
IAXO Experiment



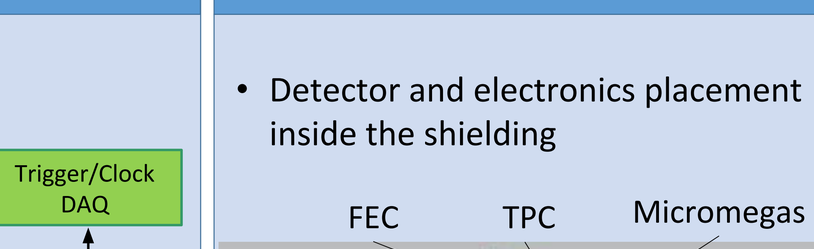
- Next generation "axion helioscope" after CAST
  - Purpose-built large-scale magnet
  - 8 conversion bores of 60 cm Ø, ~20 m long
  - Sun-tracking time is ~50% day
- Detection systems: x-ray telescope + detector
  - Low-background techniques for detectors

Micromegas Detector and AGET

- Time Projector Chamber (TPC) with MICRO-MEsh GAseous Structure (Micromegas) detector [1]:
  - Argon filled chamber with gas-tight window made of 4 µm aluminized mylar foil. as cathode
  - The Micromegas readout anode is a 2-D strip pattern of 120 strips per axis at a pitch of 500 µm covering a surface of 6x6 cm^2.
- Readout electronics
  - Based on the AGET chip [2]:
    - Provides autotrigger for each channel
  - Modular and flexible general purpose readout system for small to medium size gaseous detectors designed at IRFU, CEA Saclay.
- **Main objective** of the new readout electronics detector: reduce noise as much as possible to maximize sensitivity for IAXO.
  - Reduce detector to electronics distance
  - Use radiopure components

Background Levels

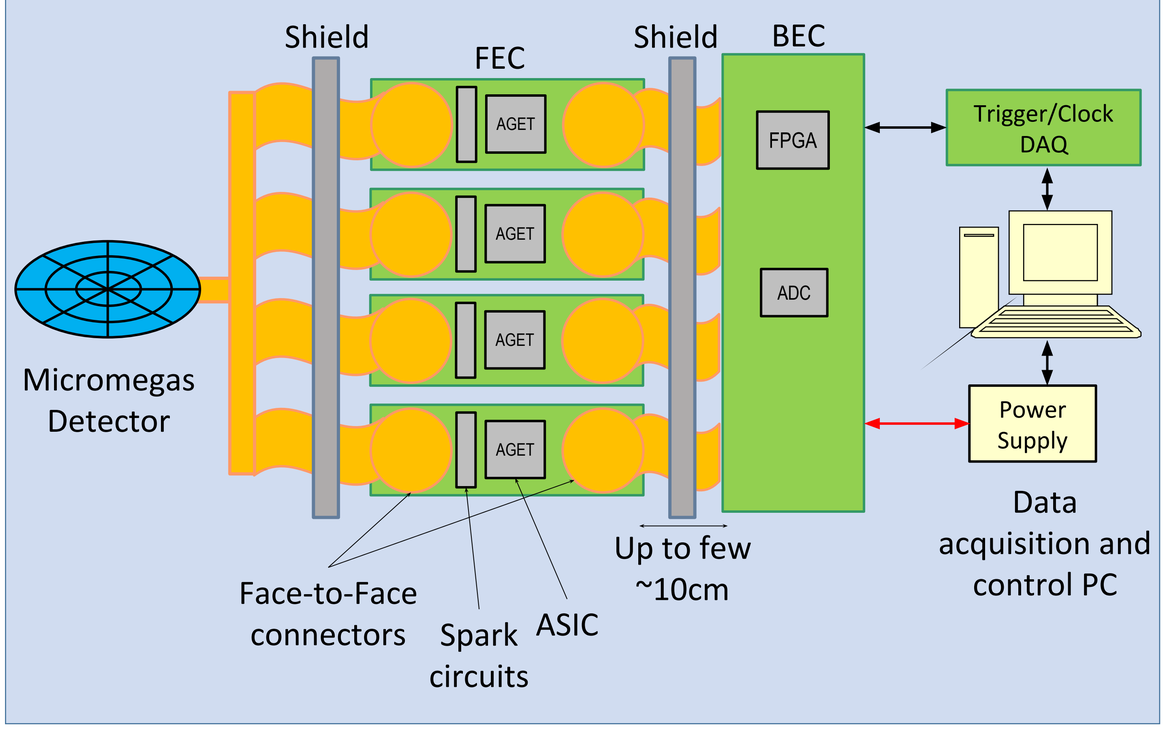
- Background levels have been reduced using highly radiopure materials, shielding and muon vetos [3].



Electronics design

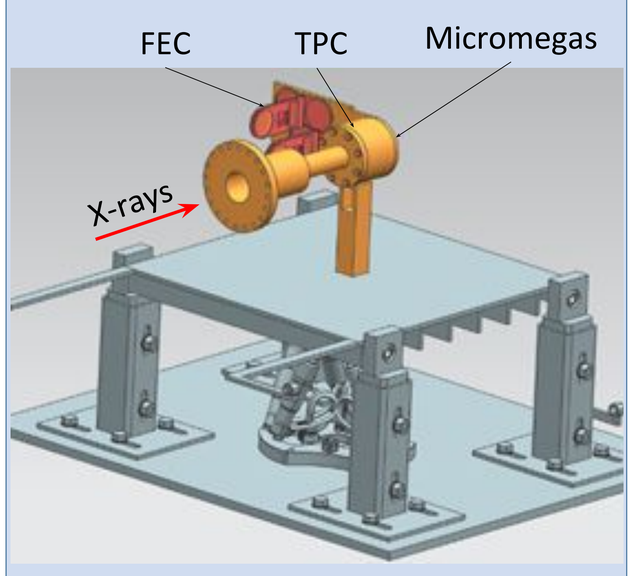
- New partition of the electronics
  - Based on the FEC-Feminos cards (Saclay)
  - Move sensitive, AGET, in Front End Card (FEC) as close as possible to the detector to optimize S/N
  - Back End Card (BEC), with FPGA+ADC, separated tens of cm by extra shielding
- Redesign of the cards
  - Different partition
  - Component selection and validation
- Radiopurity and components
  - Kapton PCB
  - Face to Face connector
  - Selection of radiopure packaging for the AGET ASIC
  - Spark protection circuits (R, C, diodes)
  - Coupling capacitors

Proposed new partition: FEC and BEC



Parts Placement

- Detector and electronics placement inside the shielding

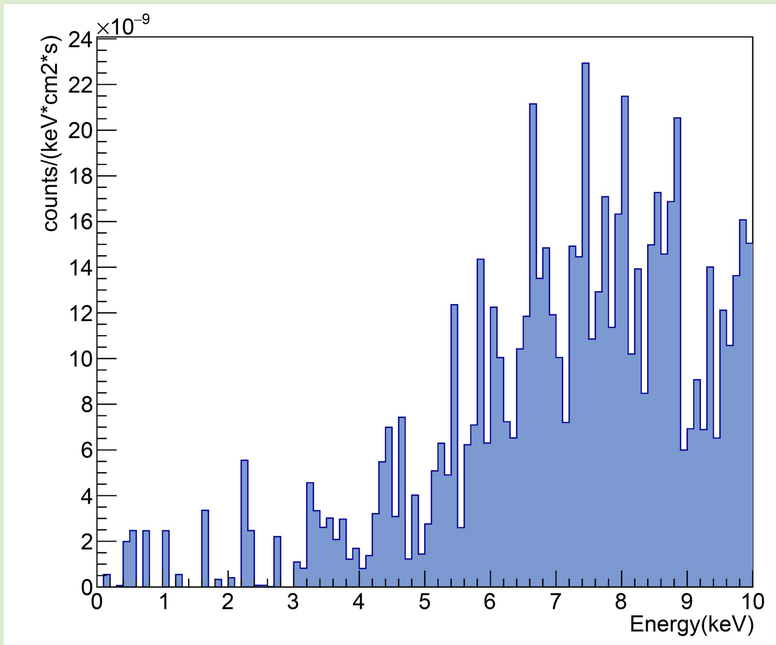


Simulation Studies

- Simulations to study the effects of the electronics on the detector
  - Replicate the design (boards and components)
  - Emission events generated via Monte Carlo
  - Estimate the energy deposited by impurities
  - REST framework
- Previous studies of background models and data analysis on the CAST experiment by the group of the University of Zaragoza.
- Search for FEC optimal placement: check several positions of the board and distances from the detector
- The elements included in the FEC simulation and their activity
  - Measured activities of components and materials obtained from a screening program of the TREX project [4]
  - If not already measured, worst cases of known similar components are used.

Electronics simulated activity

- Deposited energy in gas due to radiation emitted from the electronics.



Electronic components activities

Component	Quantity (per board)	Dimensions	^{40}K	^{60}Co	^{137}Cs	^{226}Ra	^{228}Ra	^{228}Th	^{232}Th	^{235}U	^{238}U
Capacitors	106	mBq/unit	5.29	<0.036	<0.043	5.29		8.75	8.52		10.4
Resistances	128	µBq/unit	83.6	<0.2	104	4.1		4.4	4.4		85
AGET Chip	1	mBq/unit	0.83			0.48	0.16	0.47			8.77
Diodes	64	µBq/unit							2.9	2.6	1.4

Conclusions

- Relevant components with impurities
  - AGET ASIC
  - Spark protection: diodes, resistors and capacitors
- Total integral effect of electronics at ¼ distance from the Micromegas inside the shielding has been simulated to be $2 \cdot 10^{-8}$counts/keV·cm^2·s

References

1. S. Aune et al., Low background x-ray detection with Micromegas for axion research, JINST 9 P01001 [arXiv:1310.3391] (2014)
2. S. Anvar et al., AGET, the GET front-end ASIC, for the readout of the Time Projection Chambers used in nuclear physic experiments. [DOI:10.1109/NSSMIC.2011.6154095] (2011)
3. IAXO Collaboration, BabyIAXO: the first stage of the International Axion Observatory (IAXO), Experiment Proposal to the DESY PRC (April 23, 2019)
4. S. Cebrián et al., Radiopurity assessment of the energy readout for the NEXT double beta decay experiment. JINST 12 T08003 [arXiv:1706.06012] (2017)

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