MICROMEGAS DETECTORS FOR AXION SEARCHES

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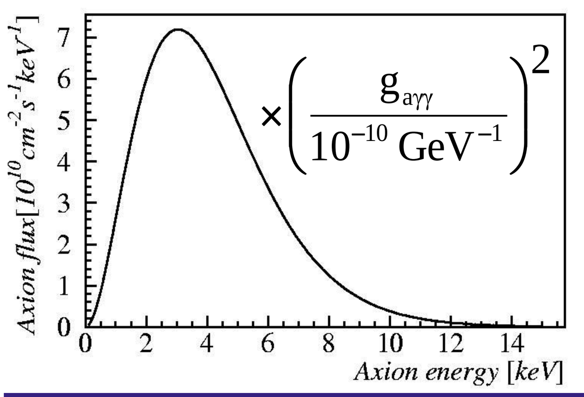
On behalf of CAST/IAXO-MM group

IMPF16
XLIV International Meeting on Fundamental Physics

CERN AXION SOLAR TELESCOPE (CAST) & INTERNATIONAL AXION OBSERVATORY (IAXO)

Axions



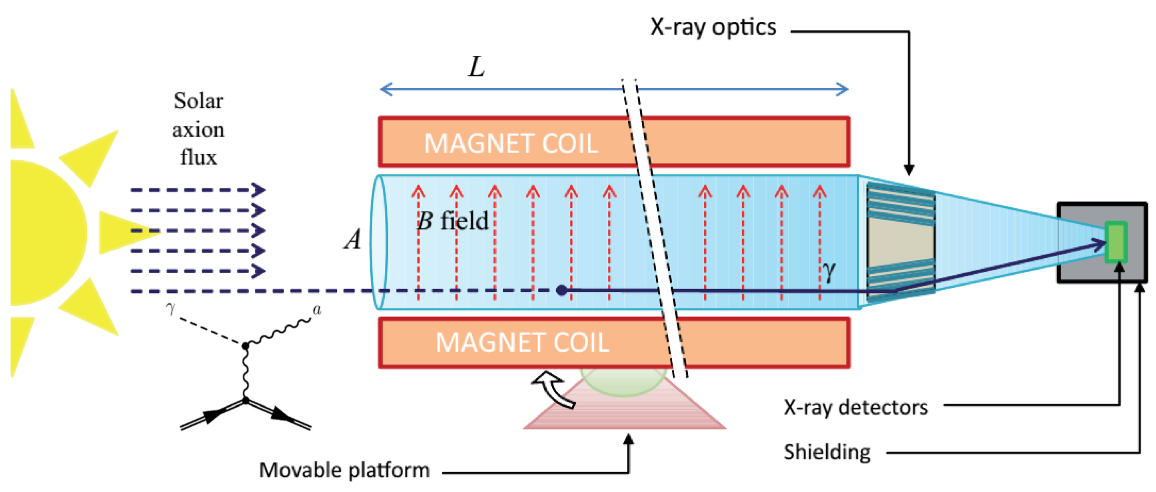
Serpico & Raffelt, JCAP04 (2007) 010

- Peccei-Quinn solution of the strong CP problem (neutron dipole moment).
- Dark Matter candidate (cold & hot).

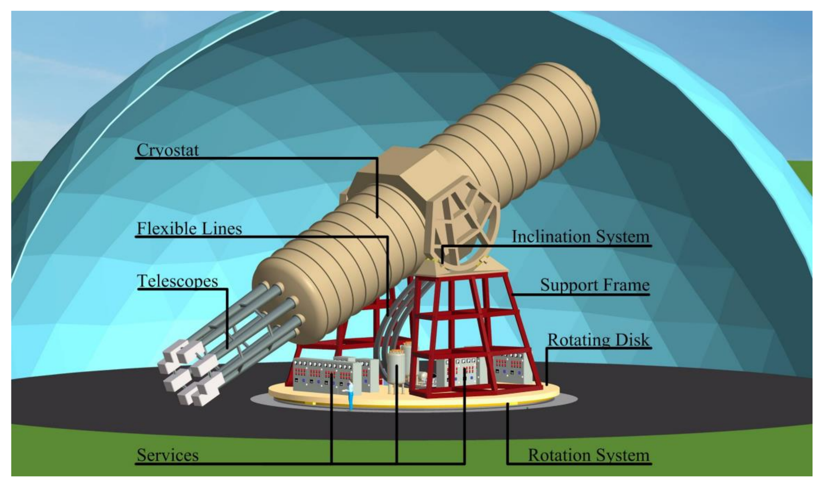
Production
Primakoff effect. Thermal photons interacting with solar nuclei (strong electromagnetic fields) produce axions.

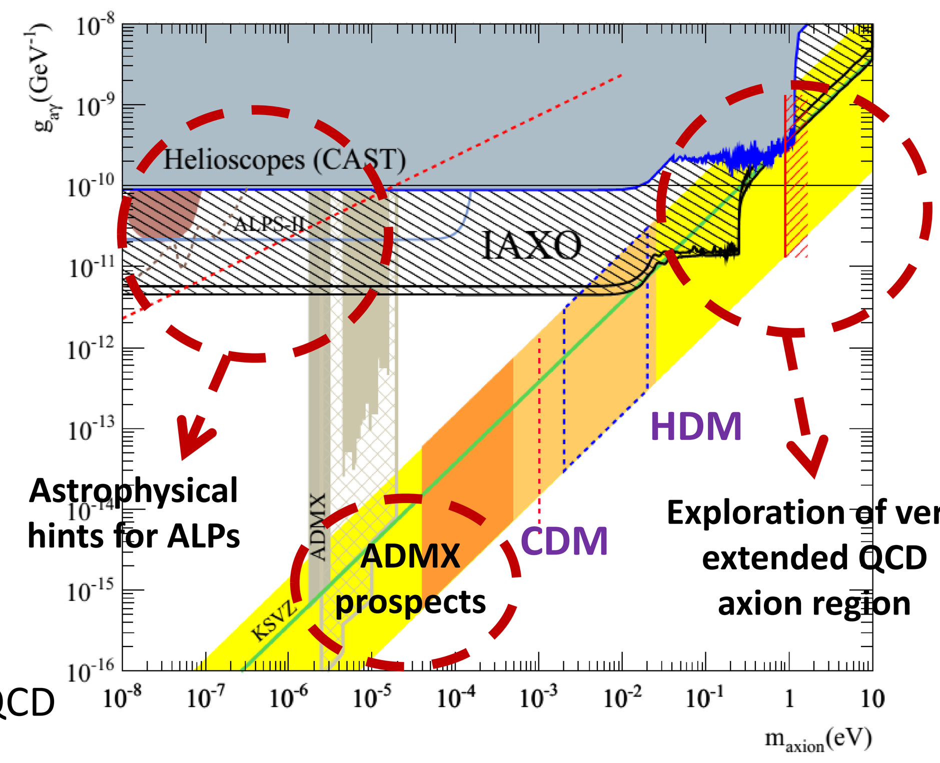
Detection
Inverse Primakoff (Sikivie 1983)
Axions in a magnet convert to photons.

Expected x-ray excess when the magnet points to the Sun.



IAXO



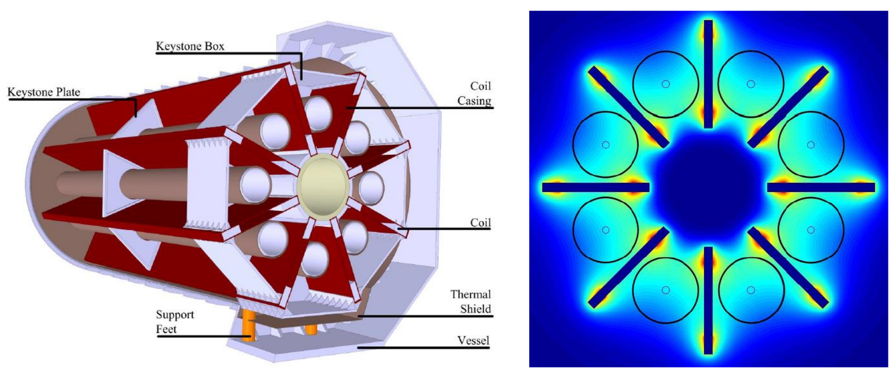


New features

- Better sensitivity (1-2 orders of magnitude).
- IAXO & ADMX can explore a big part of the QCD axion model region in the next decade.
- Potential for new physics (White Dwarfs, ALPs…)

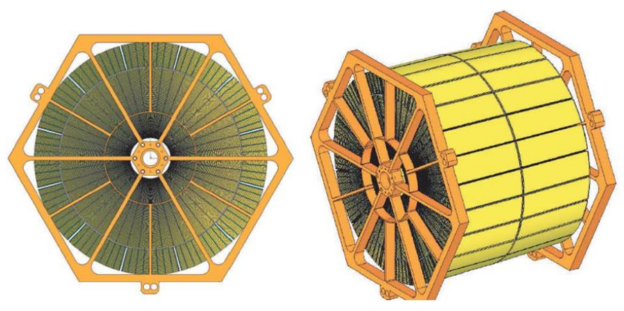
See CDR (JINST 9 T05002) & LoI (SPSC-2013-022)

Conceptual design



A dedicated magnet. Large toroidal 8-coil magnet specifically built for axion physics.

Many technical aspects defined:
length = 20 m; **bore diameter** = 0.6 m

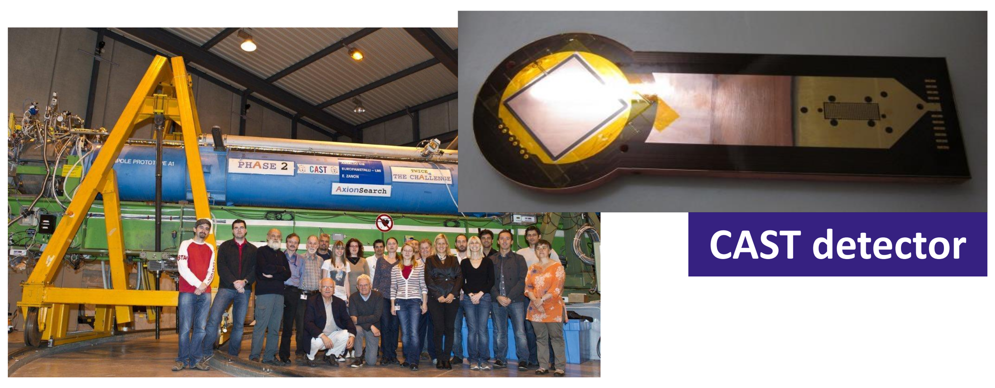


X-Ray optics. Thin glass substrates are coated to enhance reflectivity in the energy regions for axions.

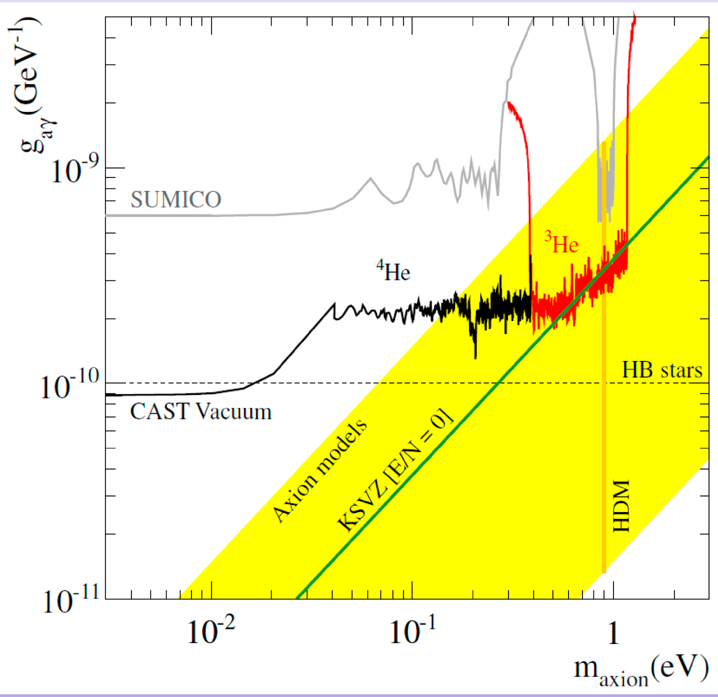
First conceptual design:
diameter = 600 mm; **focal length** = 5 m.

… and **lower background levels in the detectors**!

CAST

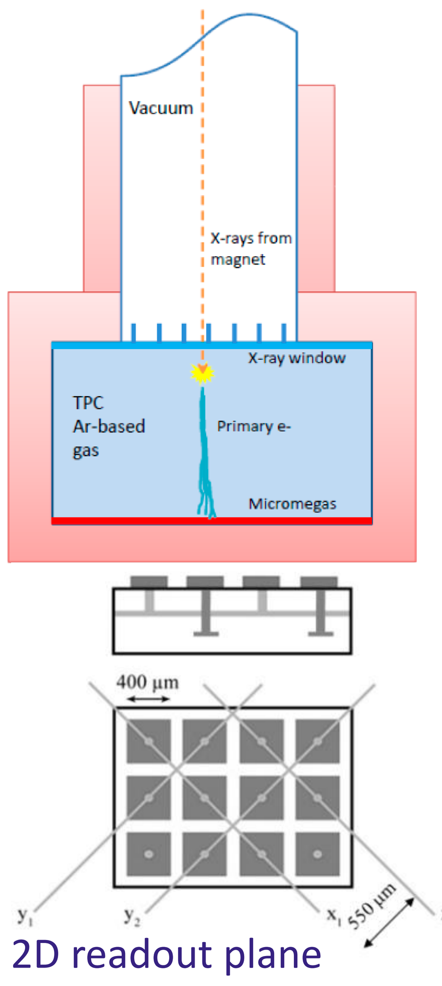


- Decommissioned LHC test magnet (L=10m, B=9 T).
- Moving platform ±8°V ±40°H.
- X-ray detectors in CAST: Micromegas & CCD.
- No axion detected yet!
  → Best exclusion limits set by CAST & ADMX



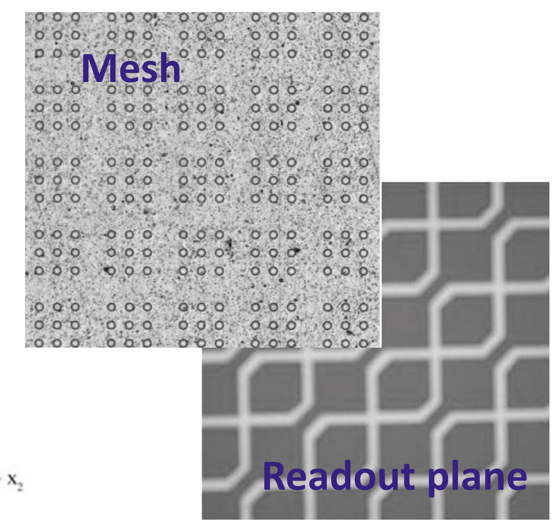
MICROMEGAS X-RAY DETECTORS FOR AXIONS

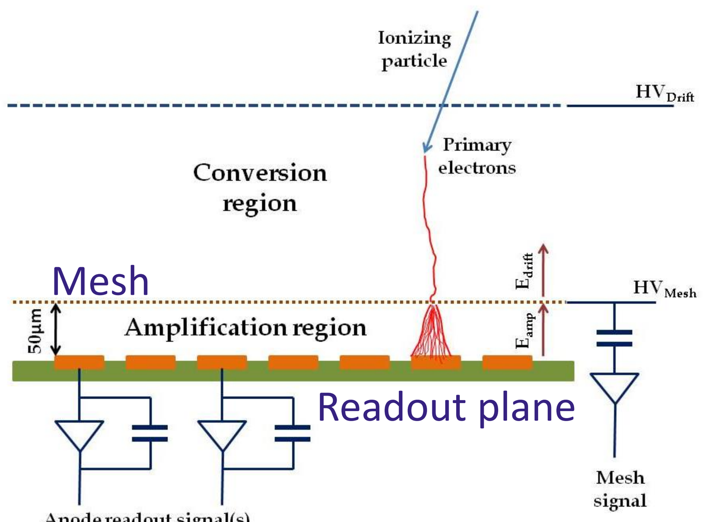
Micromegas TPC based detector



It is an amplification structure used as readout in a Time Projection Chamber.

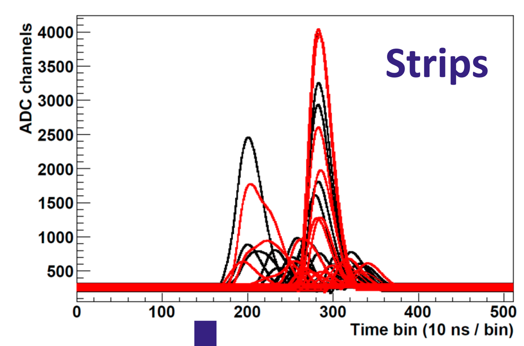
- **Drift region:** x-rays create electrons, which drift to the readout.
- **Amplification region**: electrons pass through mesh holes due to a high field difference and are amplified. Electron and ion movement induce signals in both mesh and strips.

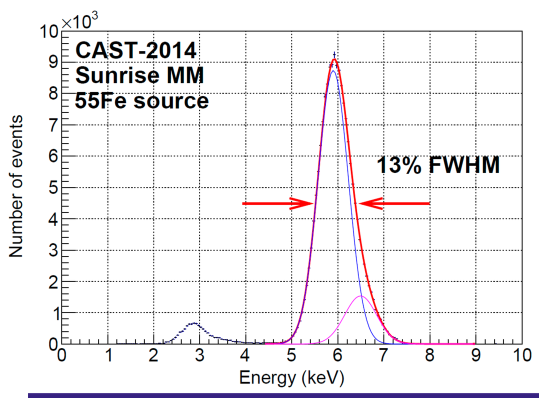




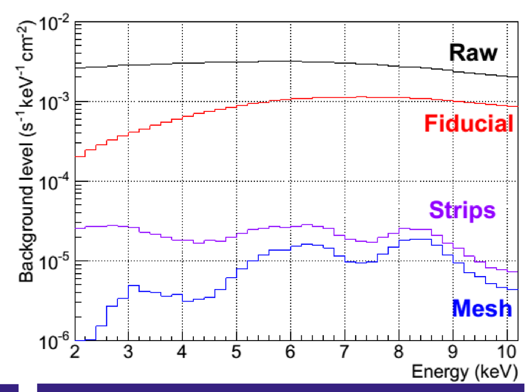
Why are they used in axion detection?

- Excellent energy resolution (**13% FWHM at 5.9 keV**).
- Topologycal information of the events.
- High power to discriminate x-rays signals from other type of events.
- Intrinsic radiopure.
- Consolidated manufacture (**microbulk technique**) & stable in time

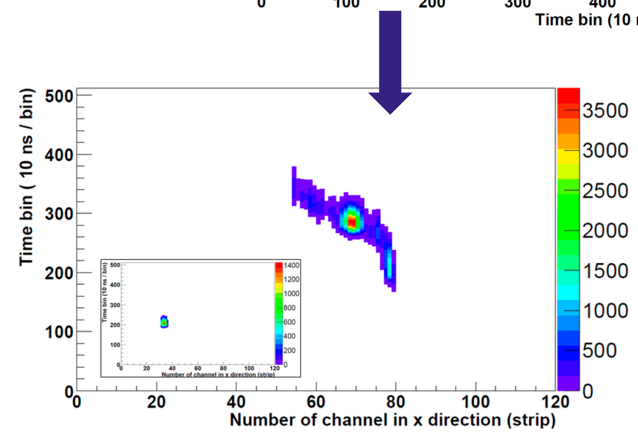




Energy spectrum of 55Fe in Ar+5%iC4H10



Background at CAST-SR



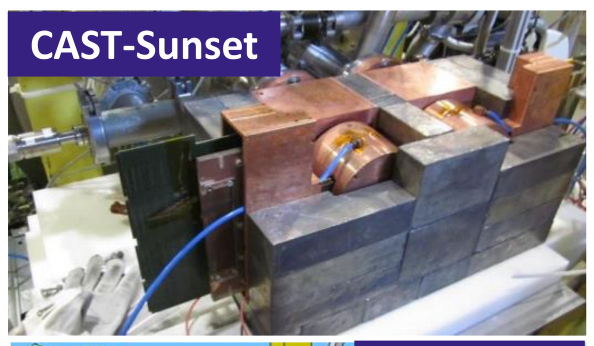
Background vs X-Ray event

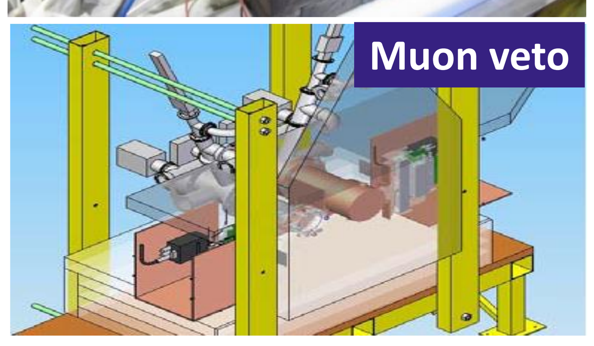
See S. Aune et al, JINST 9 (2014) P01001 for more details!

LOW BACKGROUND TECHNIQUES

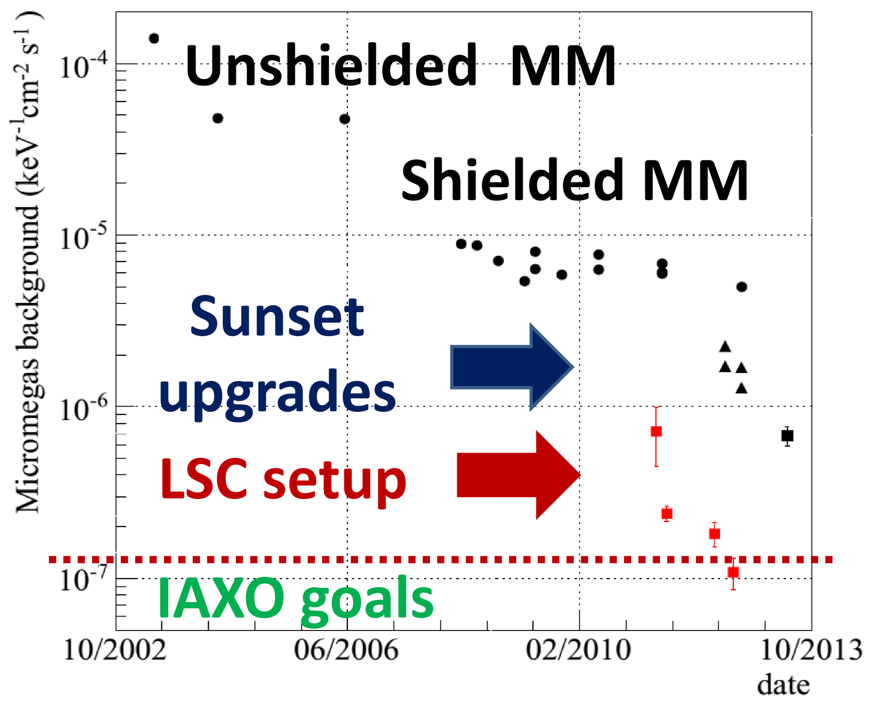
Shielding concepts at CAST-MM detectors

Contribution	Background [2-7] keV (counts s^{-1} keV^{-1} cm^{-2})	Technique
Gamma flux	~ 7 x 10^{-5}	Passive lead shielding
Muons	2 x 10^{-6} → 6 x 10^{-7}	Active veto (75% coverage)
Al cathode	(5.2 ± 1.2) x 10^{-7}	Cu cathode
Radon	~ 8 x 10^{-7}	N_2 flux
CAST-LSC lower limit	1.1 x 10^{-7}	Neutrons? Gas purity?





Improvements proposed for IAXO



- **Veto coverage optimization**
  → higher rejection of muons
- **New thinner cathode windows**
  → sensitivity improvement
- **New gas mixtures (Xe)**
  → no Ar-39, no radioactive isotope
- **AGET front-end electronics**
  → lower energy threshold

REFERENCES

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- **IAXO conceptual Design Report**: E. Armengaud et al., JINST 9 (2014) T05002.
- **Physics case**: I.G. Irastorza et al., JCAP 1106 (2011) 013.
- **Detector & optics pathfinder**: F. Aznar et al., JCAP 12 (2015) 008.
- **Micromegas microbulk technology**: S. Andriamonje et al., JINST 5 (2010) P02001.
- **Radiopurity of Micromegas readouts**: S. Cebrian et al., Astropart. Phys. 34 (2011) 354.
- **Micromegas for axion detection**: S. Aune et al., JINST 9 (2014) P01001.
- **CAST plots and results**: J.G. Garza, 2016 JINST TH 001

Learn more!!

ACKNOWLEDGEMENTS

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