TetraBall

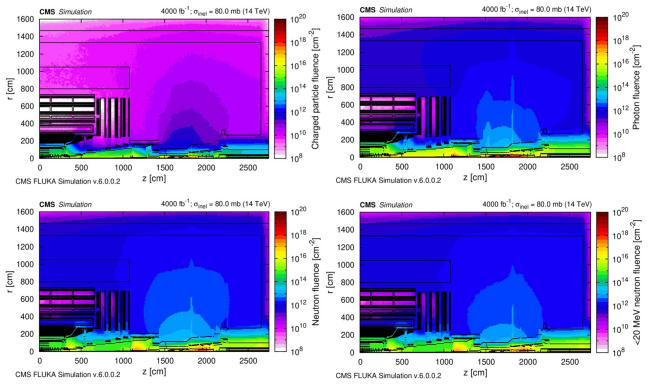
a Single-Moderator Neutron Spectrometer for HL-LHC

Marco Costa on behalf of the joint LNF/Torino TetraBall team (*), under the CMS-BRIL collaboration

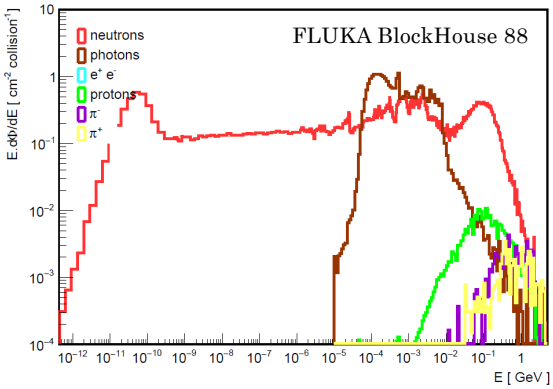
A Neutron Monitor for the CMS BRIL (Beam Radiation, Instrumentation, and Luminosity) Upgrade Project

- To benchmark FLUKA simulation with real data, to provide reliable predictions of the radiation environment in the CMS cavern.
- To inform future maintenance and upgrades (beyond RUN 4) and to allow maintenance and intervention to be carried out with adequate efficiency.

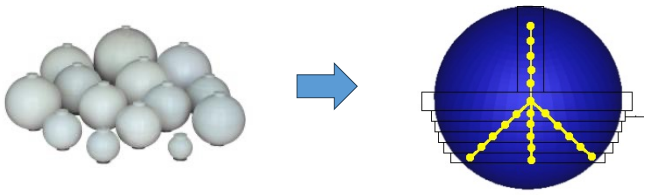
Challenge 1: Mixed field of Neutrons, Photons and Charged particles



Challenge 2: Wide Neutron Energy Range (eV to GeV)



From Bonner Spheres Spectrometer (BSS) to Single Moderator Neutron Spectrometer (SMNS)



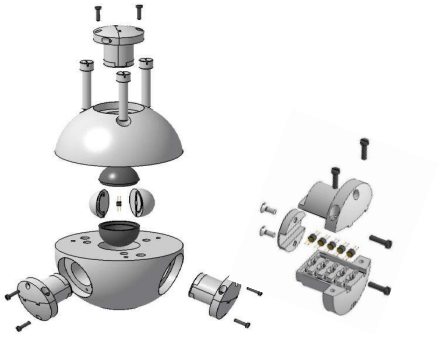
BSS: Several spheres of different radii with a single detector at the centre
=> Sequential exposures

SMNS: Single sphere with multiple sensors at various radii
=> Single exposure

SMNS features:

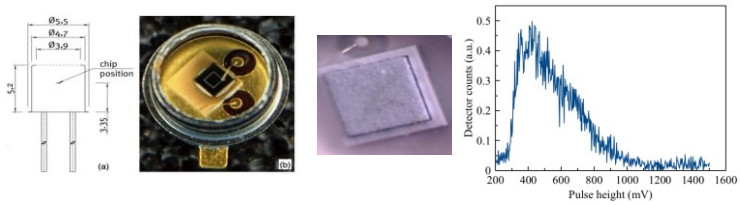
- High Density Polyethylene (HDPE) as moderator material
- Thermal to GeV range sensitivity (lead insert to exploit the cascade reaction)
- Isotropic response
- Well established unfolding techniques
- Fluence determined with <5% uncertainty
- Resolving power limited only by the shape of the response functions

TetraBall: A Novel Tetrahedral SMNS, tailored for the Phase-2 CMS BRIL Upgrade



First Tetraball expected to be ready in 2025

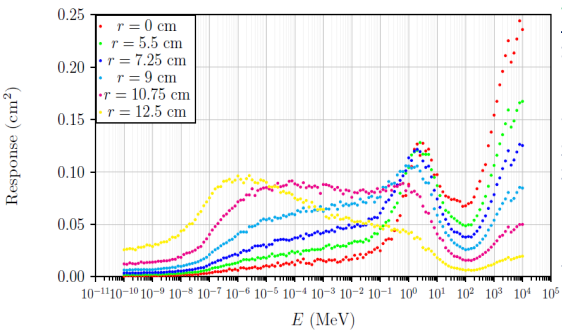
It embeds 21 Radiation Resistant Thermal Neutron Detector Units at different radii, along 4-axis



- **Silicon Carbides (SiCs),7.6 mm²**, slightly biased to reduce noise without increasing gamma response
- Tested at large accumulated fluence @ TRIGA reactor (LENA Pavia)
- **Basic unit:** 2 SiCs in a "sandwich":
  - (1) Coated with ^{6}LiF
  - (2) Uncoated

- Differential reading to extract the neutron signal only
- Custom multi-detector analog and digital boards
- Individually calibrated in thermal neutron fields

Response Curves (Tetraball Φ = 27 cm)



MCNP simulation: Average over the responses of detectors at the same radius, per unit incident fluence, as a function of neutron energy
Spherical lead insert around the innermost detector

References

NIMA 677 (2012) 4-9
NIMA 767 (2014) 159-162
Eur. Phys. J. Plus (2015) 130: 24
NIM A 1018 (2021) 16585
Eur. Phys. J. Plus (2022) 137:1358

Aknowledgements

- This work is part of a collaborative effort. We acknowledge the support of the funding agencies in the design and the construction of the CMS BRIL Upgrade Project.
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