HORIZON 2020

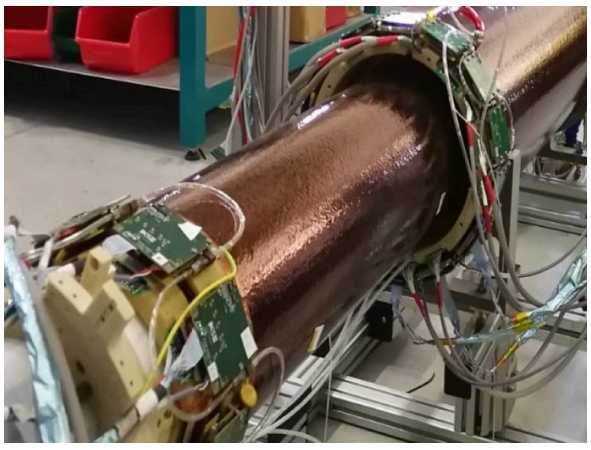
An innovative Cylindrical Gas Electron Multiplier Inner Tracker for the BESIII Spectrometer

Results in Brief

Pioneering particle detection system spawns high-tech readout techniques and cloud computing technologies

Cutting-edge applications in physics, medical imaging, and more rely on particle detection and the associated data extraction and analyses processes. EU-funded researchers have pushed the frontiers while making developments more readily accessible to smaller organisations.

FUNDAMENTAL RESEARCH



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Particle accelerators and detectors have helped us understand the fundamental nature of the Universe. The Beijing Electron-Positron Collider (BEPCII) hosting the Beijing spectrometer (BESIII) and its Inner Tracker (IT) detector is among the on-going experiments in particle physics.

After more than a decade of service, the BESIII IT needs an upgrade. Undertaken with the support of the Marie Skłodowska-Curie programme, the EU-funded BESIIICGEM project set out to develop a solution.

A potential roadblock spawns greater innovation

BESIIICGEM focused on developing a Cylindrical Gas Electron Multiplier Inner Tracker (CGEM-IT) detector for BESIII. At the frontiers of particle detection, there was only one CGEM-IT working at the time operating in a 0.5 Tesla magnetic field.

As project coordinator Prof Marco Maggiora explains, “Realisation of the pioneering prototype led to a disconcerting discovery. GEM technology was not useful for large magnetic fields (over 0.5 T). It was a very hard hit, a potential show-stopper. Basically, the CGEM-IT would have been useless.”

Rather than stopping the show, the discovery led to a complete redesign of the project plan and schedule, introducing a two-year delay while facilitating significant innovations that have serendipitously found tremendous value in unforeseen ways.

Versatile particle detection and data exploitation technologies

Large magnetic fields disrupt the spatial symmetry of the ‘avalanche’ of particles in GEM detectors, decreasing their resolution. BESIIICGEM developed a CGEM-IT consisting of three layers of cylindrically shaped triple GEMs acting like individual Time Projection Chamber (TPC detectors), and innovative custom front-end electronics (FEE) to readout their signals.

Reading out a GEM as a TPC, exploiting accurate time information from the FEE, enables a very precise reconstruction of particle trajectory even in large magnetic fields. The key to the solution was hence the readout. The team developed the Turin Integrated Gem Electronics for Readout (TIGER), a tailor-made application-specific integrated circuit (ASIC) that is the core of the FEE and one of the most significant developments of the project.

BESIIICGEM is exploring TIGER’s use for the readout of other types of detectors and sensors for satellite and medical applications and beyond. The medical applications have blossomed at an astounding rate.

As planned, partners deployed advanced computing techniques to deal with the sizeable amount of data.

Sharing the wealth

The techniques behind the TPC readout of GEM detectors have been widely disseminated and adopted in other experimental scenarios. The TIGER is a high added-value development, and BESIIICGEM is making the TIGER available to other collaborations at a relatively small fee that covers the costs incurred with use.

To make the high-tech computing techniques accessible to smaller organisations lacking manpower and cloud computing expertise, scientists developed simple

'automatic' tools to deploy and manage (micro-)cloud infrastructures. Distributed on USB devices, the tools have already been adopted by several academic collaborations and could soon enhance the competitiveness of small- and medium-sized enterprises (SMEs).

The consortium, with the addition of new partners, has successfully applied for another grant to keep the momentum going. Expect to see the outcomes of BESIIICGEM far beyond the particle physics field, in wide-ranging applications from medical imaging to homeland security.

Keywords

BESIIICGEM | Cylindrical Gas Electron Multiplier (CGEM-IT) | detection | particle detection | magnetic field | computing | Beijing spectrometer (BESIII) | cloud | readout | TIGER | ASIC | physics | medical imaging

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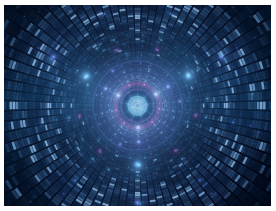

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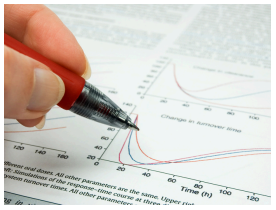

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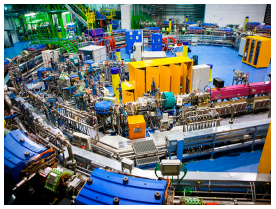

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Project Information

BESIIICGEM

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