Contribution ID: **97** Type: **Oral**

SAFIR a PET-insert for MRI

Wednesday 21 September 2022 14:00 (20 minutes)

SAFIR (Small Animal Fast Insert for MRI) is a PET (Positron Emission Tomography) insert for the Bruker BioSpec 70/30 pre-clinical MRI (Magnet Resonance Imaging) system. It is aiming at truly simultaneous PET/MRI acquisitions allowing imaging time frames of seconds instead of minutes. SAFIR is intended for operation at up to 500MBq injected activities in mice, 10x higher than in other systems. All electronics including power conversion are integrated inside the bore of the 7T MRI magnet. The system achieves a coincidence resolving time of ˜220ps FWHM at 511keV. Imaging in mice and rat was successfully performed.

Summary (500 words)

SAFIR is a PET-insert designed for a commercial pre-clinical MRI system, Bruker BioSpec 70/30 [USR]. It aims at truly simultaneous quantitative and dynamic PET-MR imaging with time frames of ˜5s (compared to typical PET acquisitions of several minutes). The short time frames result in low count rates, compromising image quality. In order to partially compensate for this, the insert is designed to operate at injected activities up to 500MBq, more than ten times higher than usual in small rodents. The large activity results in count rates of ˜40kHz per LYSO crystal, leading to pile-up and an increased number of random coincidences. In order to limit the random coincidence rate and the resulting reduction of the NECR (Noise equivalent Count Rate), we require a CRT (Coincidence Resolving Time) of better than 300ps FWHM. We have completed the first SAFIR detector, SAFIR-I [1] with 4320 readout channels and axial coverage of 54.2 mm and performed first in-vivo measurements.

The SAFIR-I (fig. 1) PET-insert is a full-featured particle detector, comprising state-of-the-art detector elements, integrated readout electronics, synchronization and power conversion. The entire detector electronics (including DC-DC converters) are integrated into the limited space inside the bore of the 7 T MRI magnet. It is facing similar challenges to those found for instance in the barrel-timing-layer of the CMS MIP timing detector.

The detector is arranged as cylindrical shell with inner and outer radius of 57.0 mm and 99.5 mm, respectively. Its carbon fiber composite structure provides RF screening reducing interference between the MRI system and the SAFIR readout electronics. SAFIR uses 8x8 Hamamatsu MPPC (SiPM) arrays with 2.0x2.0mm2 sensors, one-to-one coupled to 2.1x2.1x13.0mm3 LYSO arrays. The signals are processed and digitized by PETA6SE [2,3] ASICs. Twelve identical DAQ boards (fig. 2,3) are arranged on a dodecagon inside the cylinder shell. Each DAQ board has three PETA ASIC boards, which host 4 flip-chip bonded PETA6SE ASICs each and connect directly to the MPPC arrays. A Xilinx Kintex-7 FPGA per DAQ board provides readout and control of the PETA6SE, data and control interface to the DAQ computer via optical Gigabit transceivers and control of the bias voltage board. Power conversion is performed using DC-DC converters [4], followed by low drop-out regulators. Timing precision is achieved by deriving the 625MHz PLL reference clock of the PETA6SE from a common system clock using jitter attenuators. Precision timing calibration is achieved using data from a 22Na source placed in the center of the scanner. SAFIR-I achieved a CRT ranging from 209ps FWHM at low activity to the 327ps at ˜550MBq. First PET-MRI images where successfully acquired (fig. 4).

Presently SAFIR-II, providing a larger axial coverage of ˜145mm, is being constructed (see figure 5 for an image of the DAQ board). It uses the new PETA8 ASIC featuring zero suppression and double hit buffers to reduce data loss at highest activities, 10 Gbit/s SFP modules and an increased number of readout channels of 11520 across 384 PETA8.

Authors: Mr BEBIE, Pascal Laurent (Institute for Particle Physics and Astrophysics, ETH Zurich); Mr BECKER, Robert (Institute for Particle Physics and Astrophysics, ETH Zurich); Dr COMMICHAU, Volker (Institue for Particle Physics and Astrophysics, ETH Zurich); Mr DEBUS, Jan (Institute for Particle Physics and Astrophysics, ETH Zurich); Prof. DISSERTORI, Guenther (Institute for Particle Physics and Astrophysics, ETH Zurich); Mr DJAMBAZOV, Lubomir (Institute for Particle Physics and Astrophysics, ETH Zurich); ELEFTHERIOU, Afroditi (Institute for Pharmacology and Toxicology, University of Zurich); Prof. FISCHER, Peter (Institut fuer Technische Informatik (ZITI), University Heidelberg); Dr KHATERI, Parisa (Institute for Particle Physics and Astrophysics, ETH Zurich); Dr LUSTERMANN, Werner (Institute for Particle Physics and Astrophysics, ETH Zurich); Dr RITZER, Christian Edwin (Institute for Particle Physics and Astrophysics, ETH Zurich); Dr RITZERT, Michael (Institut fuer Technische Informatik, University Heidelberg); Mr ROESER, Ulf (Institute for Particle Physics and Astrophysics, ETH Zurich); Prof. TSOUMPAS, Charalampos (University of Groningen); Dr WARNOCK, Geoffrey (Institute of Pharmacology and Toxicology, University of Zürich); Prof. WEBER, Bruno (Institute for Pharmacology and Toxicology, University of Zurich); Dr WYSS, Matthias (Institute for Pharmacology and Toxicology, University of Zurich); Dr ZAGOZDZINSKA-BOCHENEK, Agnieszka (Institute for Particle Physics and Astrophysics, ETH Zurich)

Presenter: Dr LUSTERMANN, Werner (Institute for Particle Physics and Astrophysics, ETH Zurich)

Session Classification: Systems, Planning, Installation, Commissioning and Running Experience

Track Classification: Systems, Planning, Installation, Commissioning and Running Experience