GammaMRI: towards high-resolution single photon imaging using highly-polarized gamma-emitting nuclei

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Introduction. Our project aims to develop a new medical imaging modality able to overcome the limitations of existing imaging techniques and to combines their advantages. Gamma-MRI introduces the spatial resolution of MRI, the sensitivity of nuclear medicine (PET and SPECT) and possible clinical benefits of xenon isotopes [1,2]. At the same time, it eliminates drawbacks of the above-mentioned techniques. Our team is at present working on a proof-of-concept experiment [1].

Methods. Gamma-MRI is based on the detection of asymmetric γ-ray emission of long-lived polarized nuclear states in the presence of magnetic fields [2]. The nuclei used in our study are long-lived nuclear isomers of Xe isotopes: ^{129m}Xe ($T_{1/2}$ = 9 d),^{131m}Xe ($T_{1/2}$ = 12 d) and ^{133m}Xe ($T_{1/2}$ = 2 d) produced at the ILL high flux reactor in Grenoble or at ISOLDE facility at CERN [3]. The isomers of Xe are then hyperpolarized via collisions with laser-polarized rubidium vapor (Spin Exchange Optical Pumping) [4]. Once polarized and placed inside a magnetic field, they emit γ-rays whose direction of emission depends on the degree of spin polarization. This can be used to record the spins' response to rf pulses in gradient magnetic field, which is up to 10^5 more sensitive than usual signal pick-up in rf coils. They are acquired with CeGAAG crystals coupled to Si photodetectors and readout electronics compatible with strong magnetic fields, which are able to support very high count-rates.

Results and discussion. The experimental setups needed for the proof-of-concept experiment have been tested and verified. The polarization of Rb was achieved at the saturation level of about 50%. In addition, the production of ^{133m}Xe was tested at CERN and satisfying yields of ^{133m}Xe release were obtained.

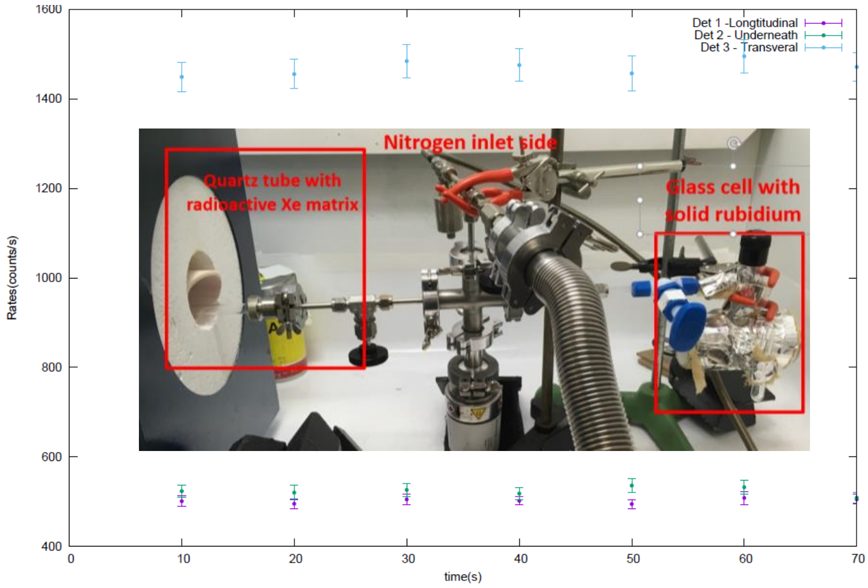

Figure 1. The setup used for the preparation of the mixture of gases: Xe, N_2 and Rb. The plot represents the count rate of γ-rays characteristic for ^{133m}Xe in presence of the laser and the magnetic field. The measurement was acquired with three detectors placed in longitudinal and transversal planes, with reference to the applied magnetic field.

Conclusion. The production of radioactive Xe isotopes: ^{129m}Xe and ^{131m}Xe at ILL is scheduled for June 2019. The aim of the experiment is to optimize the degree of polarization for both isomers after changing different experimental parameters, such as partial pressure of Xe and N_2. RF pulses will be further used to record NMR signals and later also MRI signals in a preclinical device. This contribution will present the principle and status of the gammaMRI project and the latest results.

References:

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