The Design of Neutron Imaging Instruement combined with PGAA set up at Maamora Triga Reactor

Afaf OUARDI

Centre National de l'Energie des Sciences et des techniques Nucléaires

ABSTRACT

A new neutron imaging instrument will be built to support the area of neutron radiography and tomography At Maamora Triga research Reactor (CNESTEN Research Centre, Rabat). This neutron imaging set up will be combined with Prompt gamma with the prompt gamma-ray activation. The whole system will be mounted on the tangential channel. Both techniques are complementary and their combination provides full picture about sample by obtaining the material's composition and the spatial distribution of the material in the sample set up. In this configuration the convergent part consist on the association of material with capability to reduce rapid neutrons and gamma (Borate Iron, Borate polyethylene and lead), and a primary shutter.

The installation of these parts is in process. The second part is housed in the Triga Reactor hall, and including: The drum exchanger Collimator, Flight tube and Beam delimiter. As defined in our previous works basing on Geant4 simulations, fast neutron (5cm sapphire) and gamma (5cm bismuth) filters will be inserted in the convergent part. The L/D drum exchanging is housing 4 pinhole collimator with apertures of 1cm, 2cm, and 2,5cm and will reduce the beam size to 8 cm x 8 cm, 12 cm x 12 cm and 20 cm x 20 cm at the detector position respectively. The whole instrument will operated in three different positions, one for high resolution and the other for high

INTRODUCTION

Recent developments towards an imaging set-up at the PGAA instrument are done (PGAI) at Maier -Leibnitz Zentrum (MLZ) and NIPS-NORMA at Budapest Nuclear Centre). These instruments are designed with regard to the different possible beam options. In our case the combination was chosen to explore the same beam tube (tangential beam) and both set up can be used separately as well as in combination (Fig.1). This project is supported by IAEA under MOR1010.

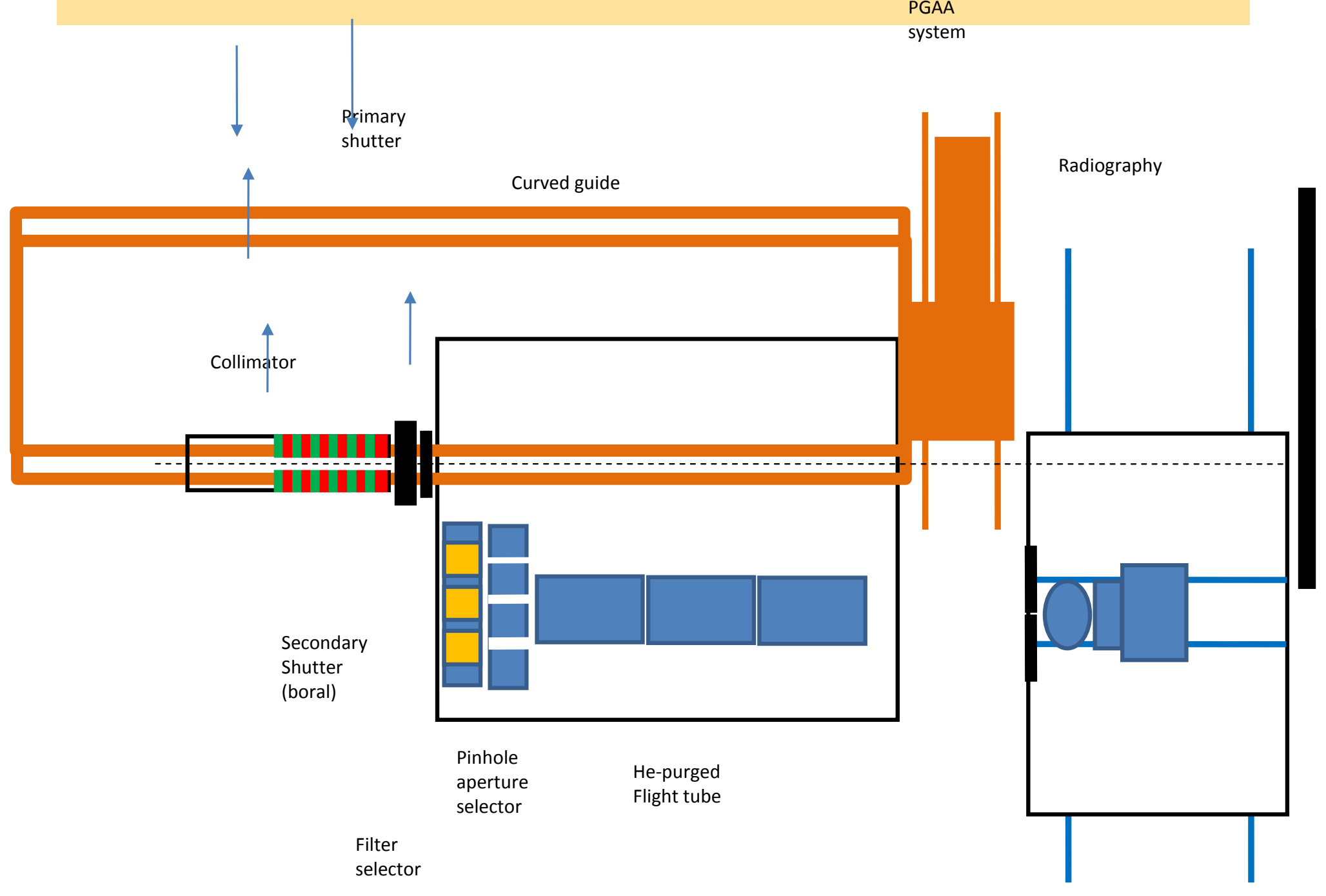


Fig 1

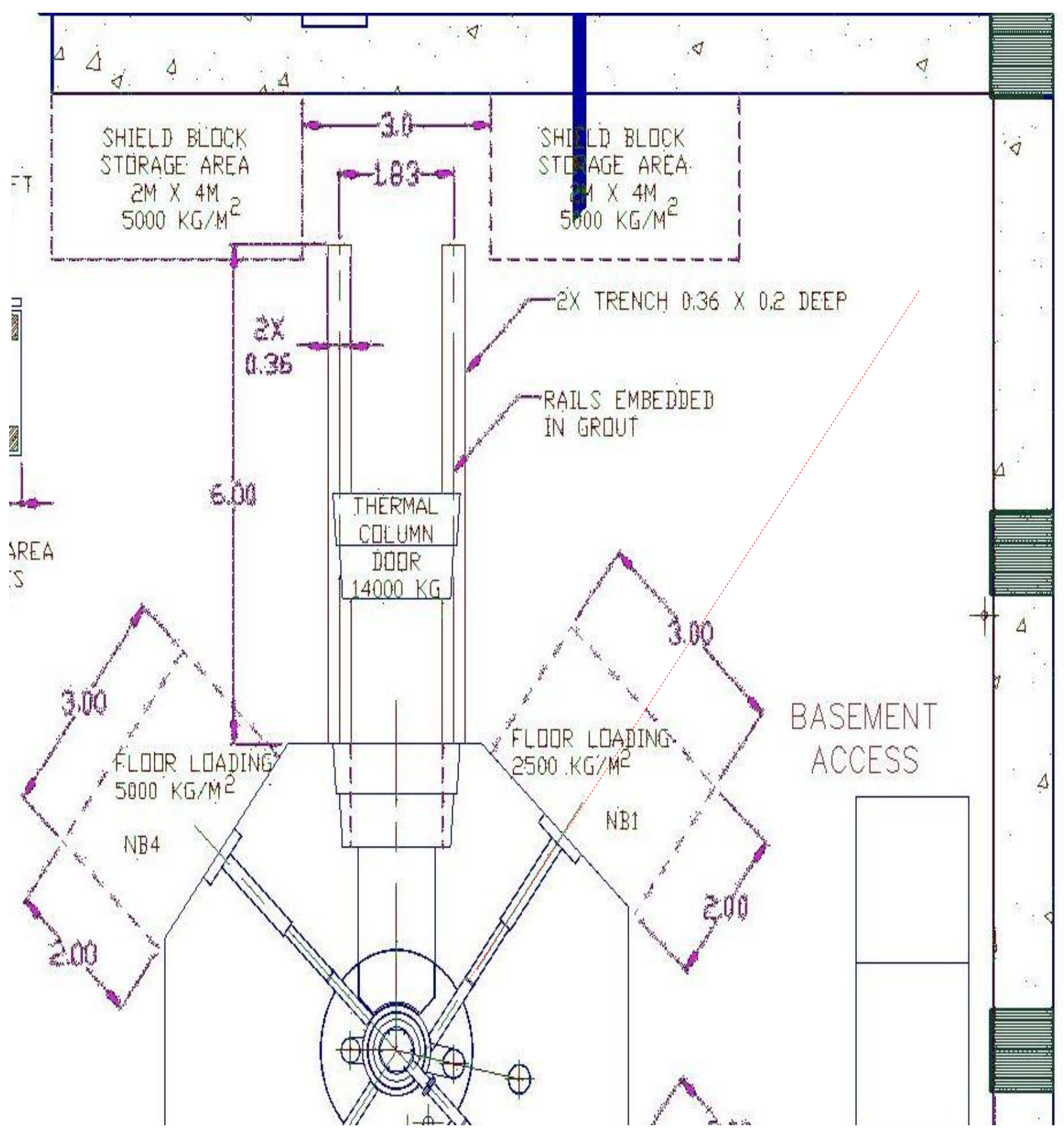


Fig.2: Position of the NI Instrument: tangentiel beam tube

Total neutron fluence rate: 8,14E+09 n.cm-2.s-1

EXPERIMENTAL SET UP

Since the NI and PGAA instrument used the same beam line they has a common component primary :

- Primary collimator housing 5cm Sapphire (1m low carbon steel + 45 PE+B4C rings with length of 45cm) inserted in the tangential channel

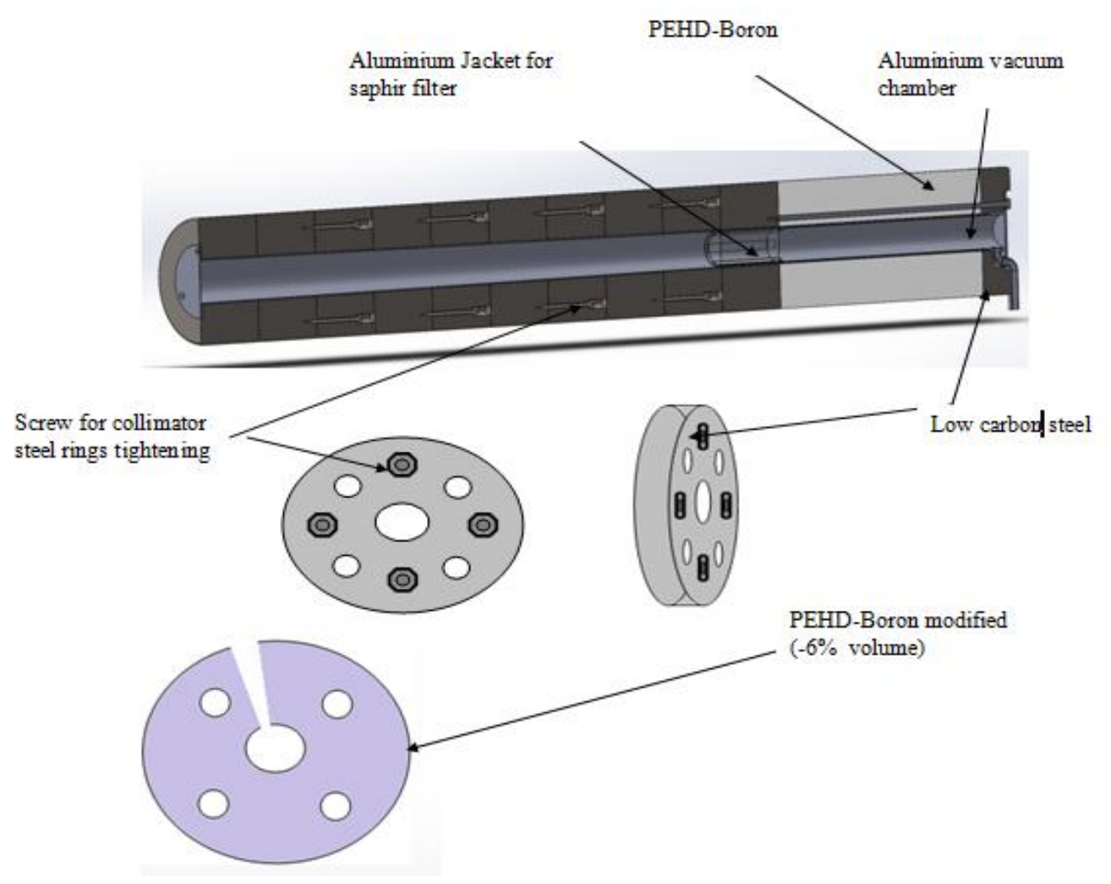


Fig 3 : Primary collimator

Primary shutter housing 5cm Bi : a sandwich of shielding material (PE, Pb, PE(5% B), Iron, Mirrobor).

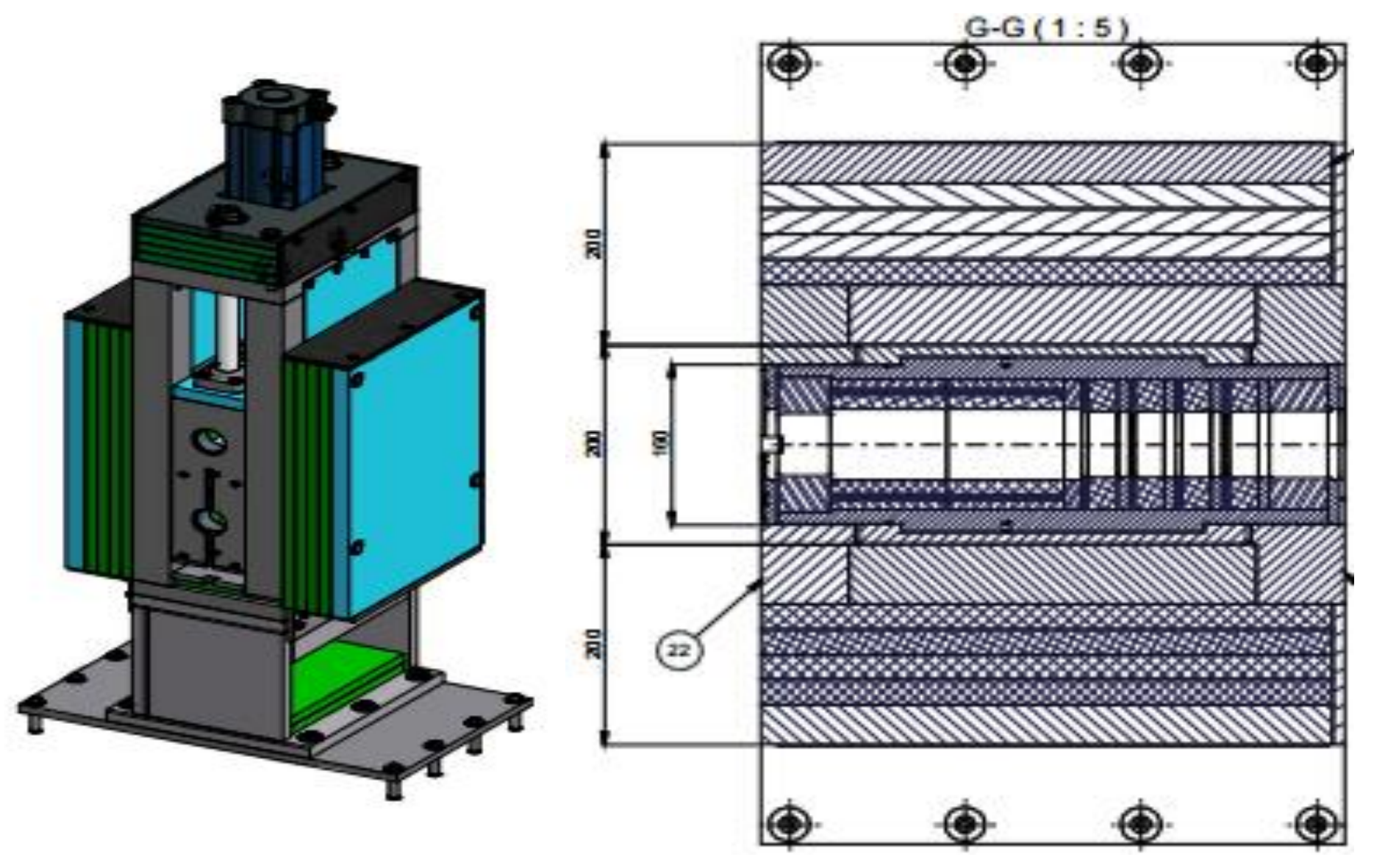


Fig 3 : Primary shutter

The configurations the Neutron Imaging on ON and OFF modes are presented schematically in Fig. 4.

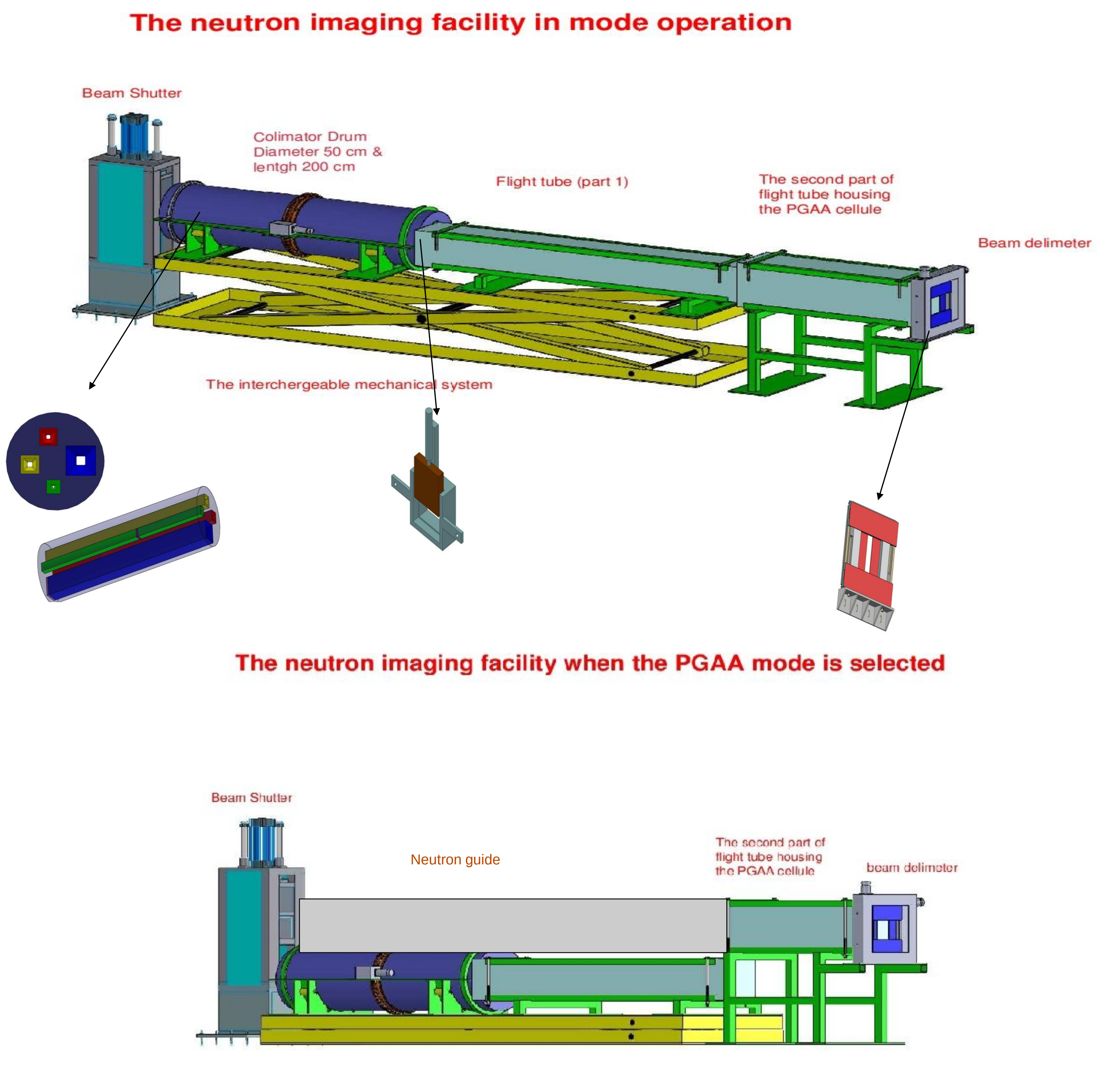


Fig 4 : neutron Imaging facility on ON and OFF modes

Beam line layout

	Setting 1	Setting 2	Setting 3
Inlet aperture [mm]	10	20	25
Filter options (e.g. Bi, Be, Si, saphire,)	Bi,Saphire	Bi,Saphire	Bi,Saphire
Aperture - detector distance [cm]	500	600	600
Resulting L/D (estimated)	500	300	240.
FOVs [mm]	80X80	120X120	240X240
Flux uniformity (e.g. flat, gaussian, other)	flat	flat	flat
Corresponding intensity [cm^{-2} s^{-1}]	0.17 x 10^6	0.55 x 10^6	0.68 x 10^6

SHIELDING ASPECT

Several commercial High-density concrete commercially available under the name Hormirad mixed with different ratio of the boral (15%, 5% and 1.19%), Hormirad are investigated to define the Optimal material. The Geant4 Simulation resulmts shows that the shilding material should have 50% of Iron.

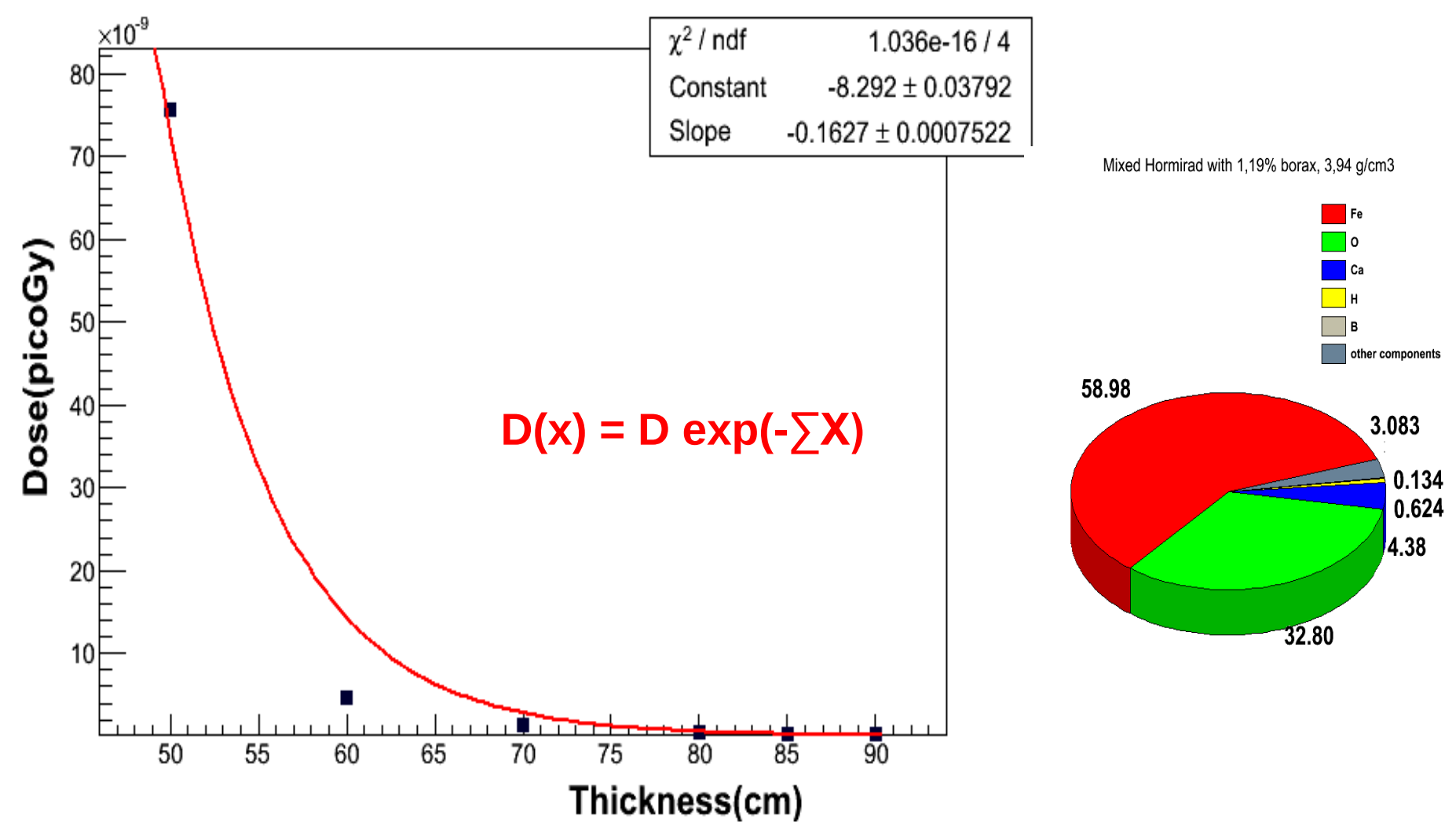
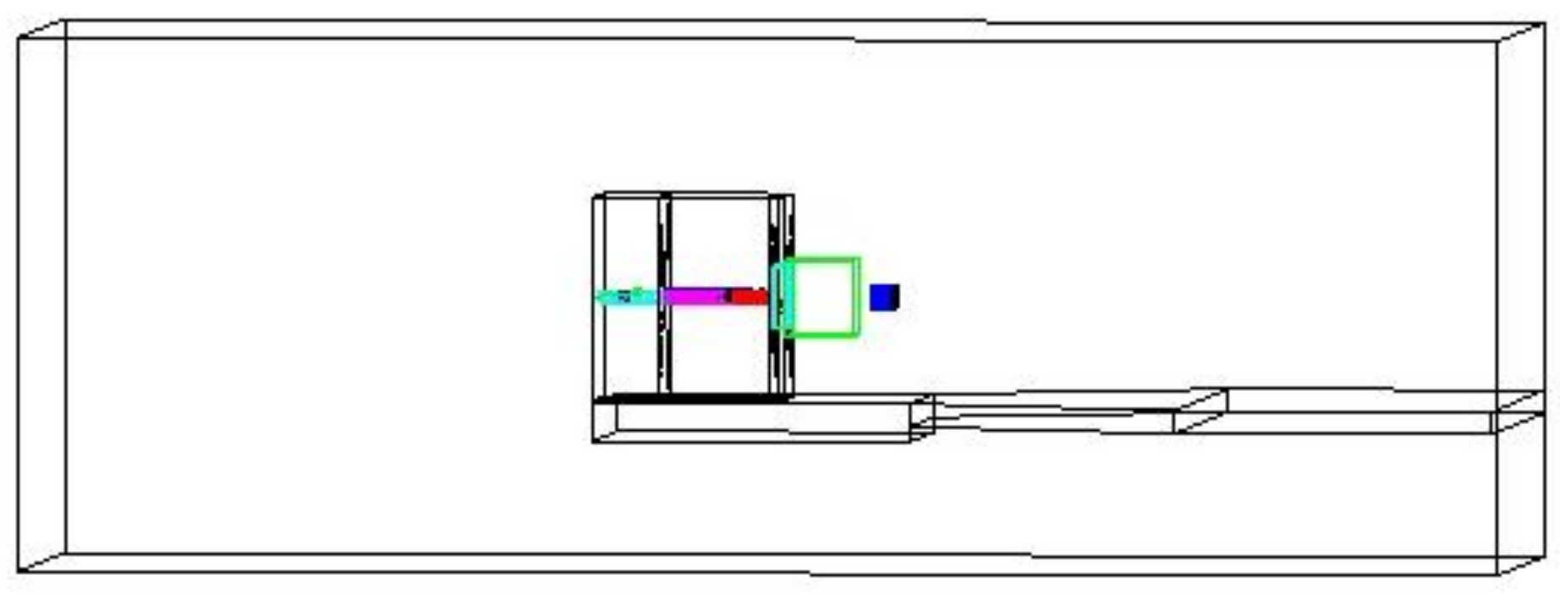


Fig 5 : neutron dose as function of shield thickness for hormirad mixed with borax(1.19%)

The ∑sim value is generally, corresponding to absorption and diffusion (cm-1) specific optimized concrete, here this coefficient is equal 0.16 which corresponding to Iron. Other laboratoriy measurements are conducted in Budapest to evaluate the ∑exp with neutron source (4MeV). The ∑exp obtained is of 0.1627

As the optimal shieding composition is corresponding to material with 50% of iron wewill use a mixture of *50% Ciment +50% borate steel as shielding material*



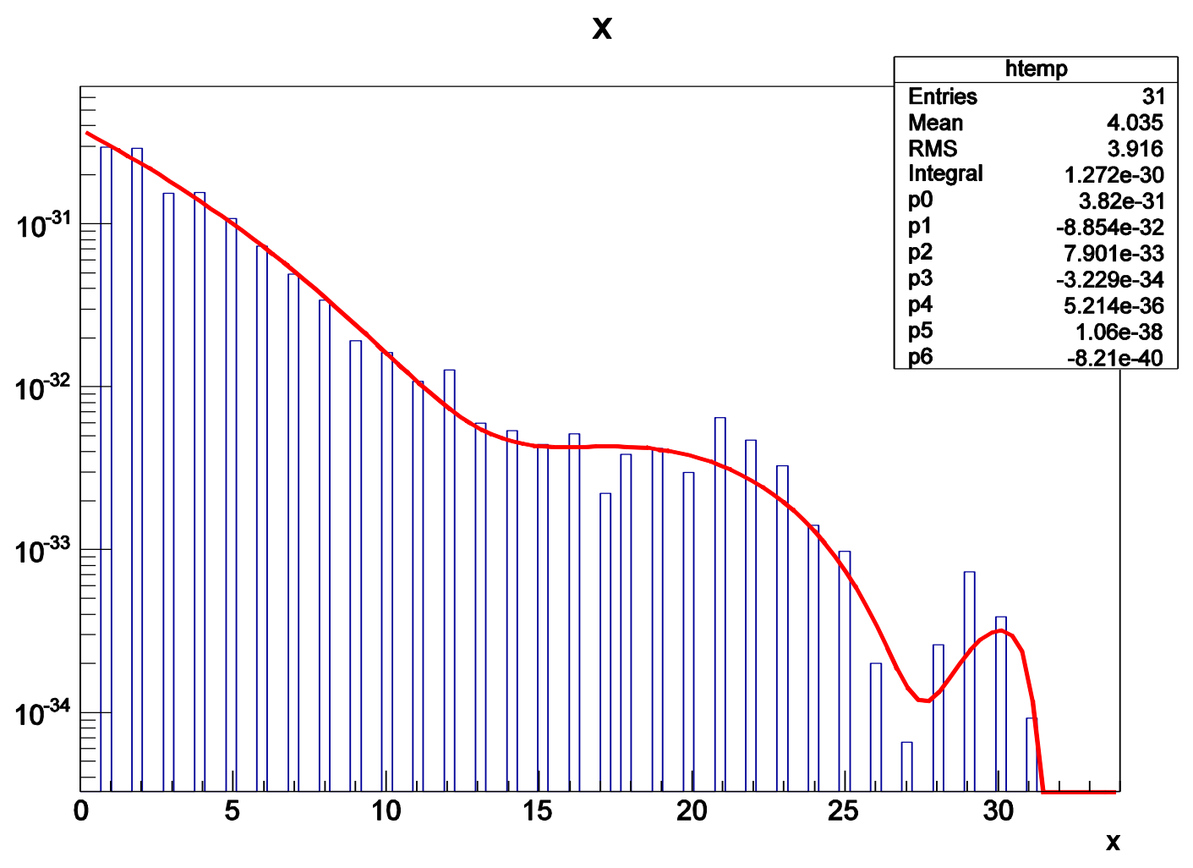


Fig 6 : The simulated dose deposition generated by thermal, epi-thermal and fast neutron & gamma

30 cm of the shielding materail containing 50% of iron in his composition can stop neutrons

CONCLUSIONS

As presented above the final version of the combined imaging set-up with the PGAA instrument is well defined. These instruments are designed with regard to the different possible beam options.

Both facilities will be build in two phases :

Phase I : consist in the installation of the primary collimator (including the filters) and the primary shutter (December 2017).

Phase II : the installation of the rest of facilities componts (L/D exchanger, fast shutter, flight tube, beam delimeter, beam stop, neuteon guide, system detector...). In this phase, we project also to bulid shielding around the facilities (December 2018).

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