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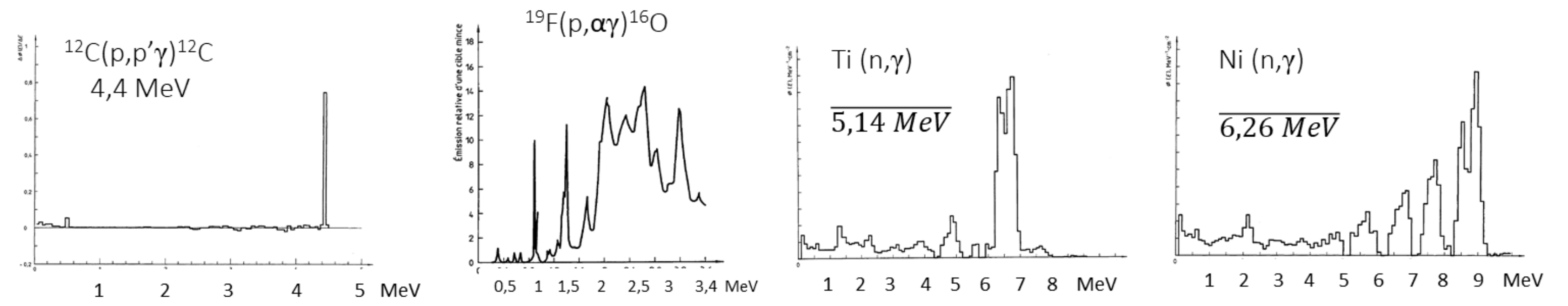
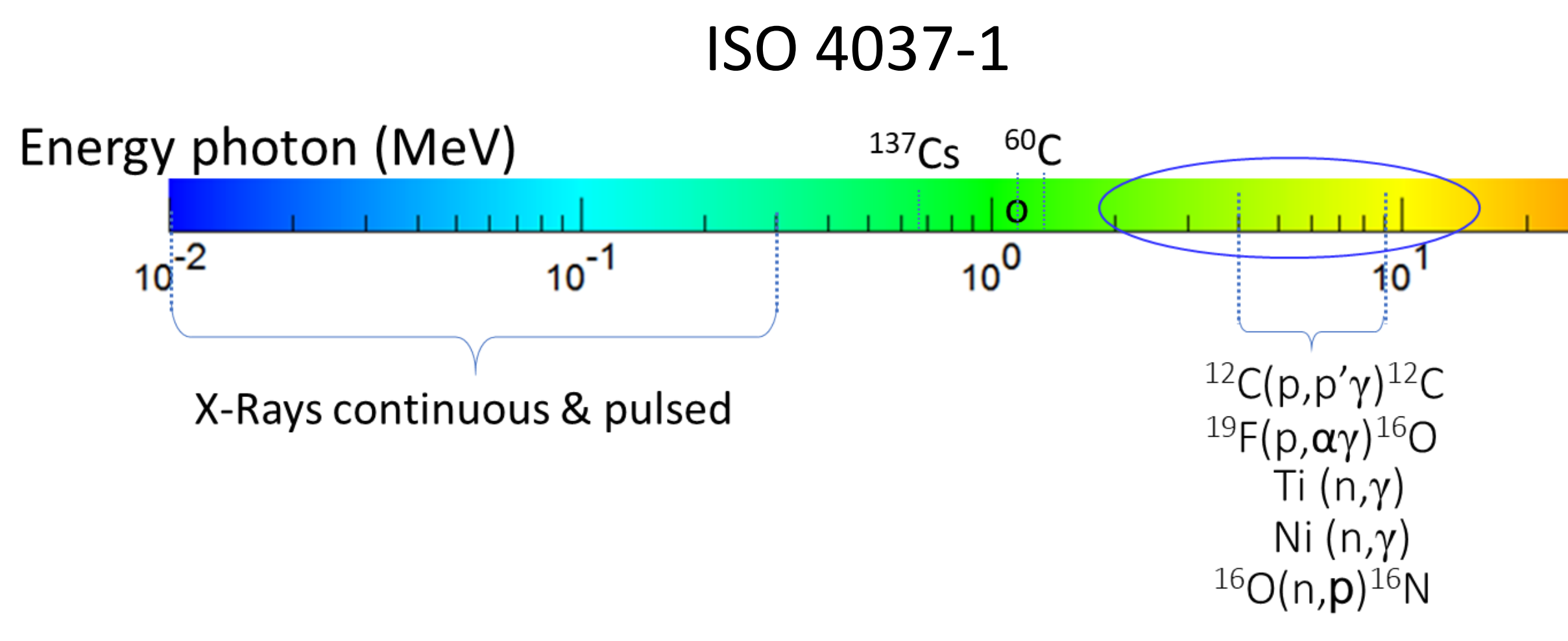
## High energy photon reference radiation beam for radiation protection based on medical LINAC facility

Faisceau de référence en photons de haute énergie pour la radioprotection produit à partir d'un LINAC médical

### Context:

The type tests of photon radiation protection dosimeters described in IEC standards require radiation fields from a few keV to 10 MeV. For the high energy range above 1.33 MeV up to 10 MeV, ISO4037 standard proposes facilities based on particle accelerators or nuclear reactors. To avoid using such high cost facilities, the CEA LIST LNE LNHB, has proposed to mutualize the use of a medical LINAC already dedicated to national references for radiotherapy.

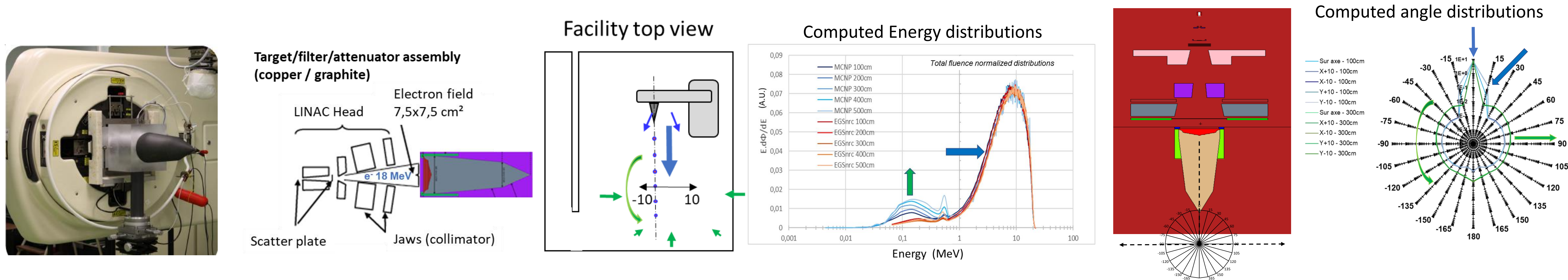
### State of the art:



<b>PTB :</b> $^{19}\text{F}(p,\alpha\gamma)^{16}\text{O}$ , $^{12}\text{C}(p,p'\gamma)^{12}\text{C}$ Traçability $K_a$ : $^{60}\text{Co}$ Coef. Conv. $H^*(10)$ et $H_p(10)$ CMC $K_{\text{air}}$ $u = 3.0\%$ CMC $H^*(10)$ : $u = 3.25\%$ Spectrometry (HPGe)	<b>JAEA :</b> $^{19}\text{F}(p,\alpha\gamma)^{16}\text{O}$ Traçability $K_{\text{air}}$ : $^{60}\text{Co}$ Coef. Conv. $H^*(10)$ et $H_p(10)$ Spectrometry (NaI(Tl)) Comparison with PTB 2016 - no CMC	<b>CEA (canal ISIS) :</b> Ti (n,γ), Ni (n,γ) Traçability $K_{\text{air}}$ : $^{60}\text{Co}$ (1990) Coef. Conv. $H^*(10)$ et $H_p(10)$ Spectrometry (BGO) (Rad. Prot. Dosim.30, 4, 237-243)	<b>VNIIM :</b> (Bêtatron 5-50 MeV Linac 4-20 MeV) Primary $K_{\text{air}}$ (Flat Ion. Chamber) CMC $K_{\text{air}}$ : $u = 1.25\%$ CMC $H^*(10)$ : $u = 1.5\%$
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### Design of the target/filter/attenuator assembly:

The assembly is put on the LINAC head in the 18 MeV electron beam (Varian-Truebeam) to get a photon radiation protection beam with an average energy above 6 MeV.



$\bar{h}_K^*$ (Sv/Gy)	1 m	6.47 MeV	3 m	6.52 MeV	5 m	6.19 MeV
		1.086 <sup>(1)</sup>		1.084 <sup>(1)</sup>		1.084 <sup>(1)</sup>
		4.2 %		8.2 %		15 %

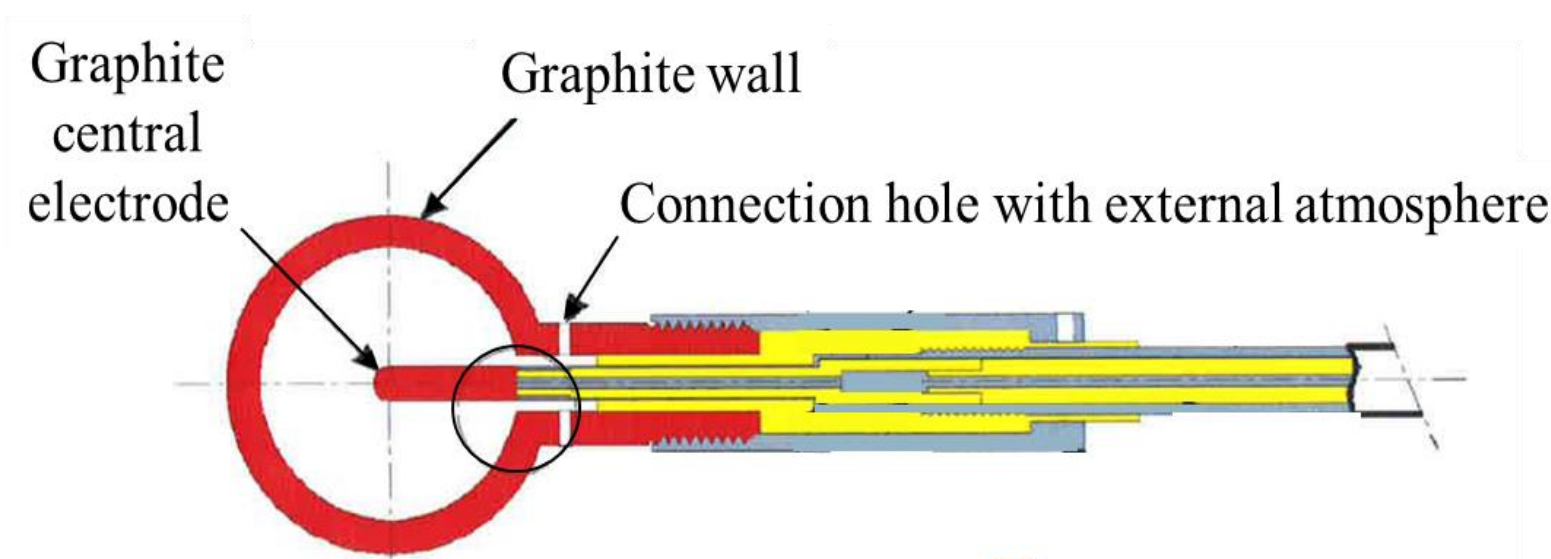
(1) based on ICRU57 conversion coefficients, for energies above 10 MeV the conversion coefficients were calculated.

### Air kerma primary measurements:

$$\dot{K}_a = \frac{I_{cor/monit}}{V \rho_{air}} (W/e)_{air} \prod_i k_i$$

$\dot{K}_a$  : Air kerma rate normalized to monitor Gy / M.U.

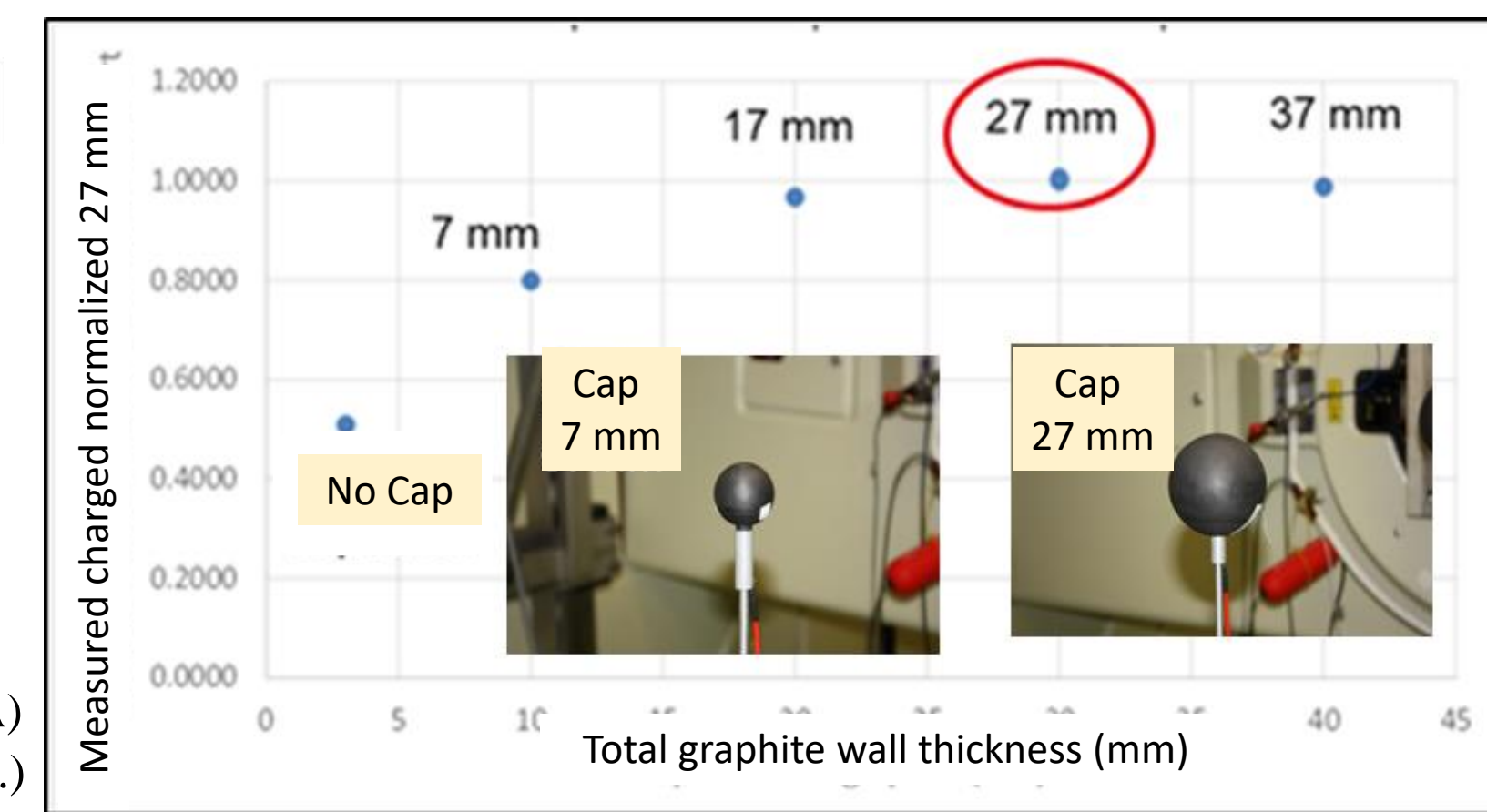
Primary vented cavity ionization chamber CEA-LNE-LNHB Design



$$I_{cor/monit} = \frac{(I_{raw,CI} - I_{BG,CI}) \prod_j k_j}{(I_{raw,monitor} - I_{BG,monitor})} \text{ A / M.U.}$$

$I_{raw,XX}$  : Average value of the current at the measurement point under irradiation. (C A)  
 $I_{BG,XX}$  : Average value of the current at the measurement point with the beam off. (M.U.)  
 $\prod_j k_j$  : Correction factors (humidity, X-Rays diffusion stick, capacitor temperature ...).

Electronic equilibrium - wall thickness



### Conclusions and perspectives:

- The calibration point is fixed at 3 m from the copper target to get a good comprised solution between scattered and direct beam components. The profile of the beam is not as flat as foreseen, a maximum 2.4% variation in terms of air kerma is found for a beam diameter of 18 cm.
- The standard uncertainty on the calibration coef. of the LINAC monitor is 2,3% (including 0.5% due to the primary chamber measurement). The standard uncertainty on the calibration coef. of a customer dosimeter is 2.4% (for ionization chambers).
- Ionization chambers and passive dosimeters can be calibrated in this radiation beam, but other dosimeters based on proportional counter or G.M. cannot be calibrated. The next step of the study is to improve the flatness of the beam profile.