

# GAMMA IRRADIATION FACILITY FOR LOW DOSE/DOSE RATE IN VITRO BIOLOGICAL STUDIES

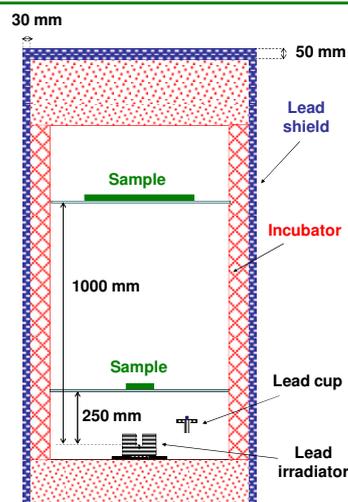
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We present a gamma irradiation facility for the exposure of cultured mammalian cells to dose rates ranging from few  $\mu\text{Gy/h}$  to some tens of  $\text{mGy/h}$ . The study of the effects of these low dose rates have important implications both in radiation protection and in therapy (late response of healthy tissues). The irradiator has been designed at the Istituto Superiore di Sanità (ISS) and, as of September 2012, is under construction.

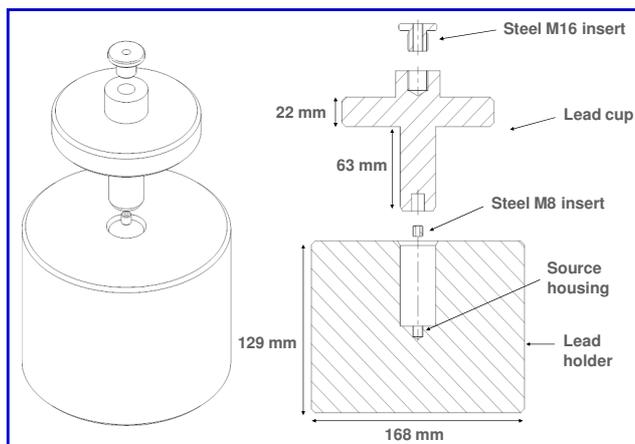
The realization of the facility has been made possible by a special EU funding, through a dedicated task, "LIBIS", of the EURATOM Network of Excellence "DoReMi" (7th FP). After the pilot studies that will test the performance of the irradiator, the facility, through proper agreement, will be available for planned experiments of other members of the network.

## Sketch of the irradiation facility



A lead irradiator (housing the  $^{137}\text{Cs}$  source) is contained inside a shielded large capacity cell culture incubator. The smallest and the greatest distances between the source and the cellular sample are 250 mm and 1000 mm, respectively

## Sketch of the lead irradiator



Three lead irradiators will be constructed, each one housing one of the three  $^{137}\text{Cs}$  sources chosen to cover a wide dose rate range:

**37 MBq** → 3  $\mu\text{Gy/h}$  at 1000 mm distance  
50  $\mu\text{Gy/h}$  at 250 mm distance

**740 MBq** → 60  $\mu\text{Gy/h}$  at 1000 mm distance  
960  $\mu\text{Gy/h}$  at 250 mm distance

**18.5 GBq** → 1.5  $\text{mGy/h}$  at 1000 mm distance  
24  $\text{mGy/h}$  at 250 mm distance

Each irradiator consists of a lead holder, housing the source, and of a lead cup electronically removable from outside the incubator

Depending on the dose rate required by the experiment, one of the irradiators will be placed inside the incubator and the cup will be remotely removed after the placement of the cellular sample. This will allow a safe operation during sample positioning

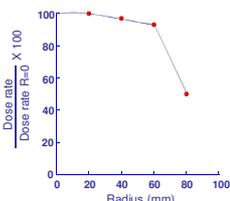
## Geant4 simulations

In the design stage, Geant4 simulations have been performed to realize a system with the following characteristics:

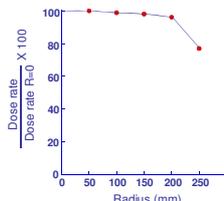
- 1) a dose rate **uniformity** on the sample such that the variations in the irradiated area are less than  $\pm 6\%$  of the average dose rate value in such area
- 2) a percentage of **662 keV** (energy of the photon released in the  $^{137}\text{Cs}$  decay) **photons** impinging on the sample **greater than 80 %**
- 3) a **shielding design** such that the **radiation risks** are kept below the **acceptance level** (0.3  $\mu\text{Gy/h}$ )

### Beam profile

Source to sample distance = 250 mm



Source to sample distance = 1000 mm



Moreover, Geant4 simulations will be performed, along with measurements, to evaluate the dose and the dose rate delivered to the cells for all different configurations (distances source-sample etc.)

## Large capacity incubator that will house the lead irradiator



The cell culture incubator will be shielded with:

- 1) two lateral lead shields 30 mm thick, 2030 mm high, 970 mm or 840 mm wide, respectively (the concrete walls will shield the other two sides)
- 2) one top lead shield 50 mm thick, and with sides of length 970 mm and 840 mm

An Interlock System will allow a safe operation during sample positioning: it will permit the opening of the incubator shielded door only if the lead cup of the irradiator is completely inserted.

An external monitor will give on line information on all the incubator parameters

## Possible uses of the gamma irradiation facility at the ISS

Besides studies on the effects induced by chronic exposures of in vitro biological systems at very low doses and dose rates (ranging from 3  $\mu\text{Gy/h}$  up to 24  $\text{mGy/h}$ ), other relevant issues that will be possible to investigate using the ISS gamma irradiation facility are the following:

- 1) comparison of the effectiveness of low dose rate chronic exposures vs acute exposures, using the  $^{137}\text{Cs}$  gamma cell of the ISS (about 0.8 Gy/min)
- 2) comparison of low dose rate exposures as a function of radiation quality, made possible by the presence of the alpha particle irradiator developed at the ISS (Esposito *et al.*, *Rad Res* 2009), giving different dose-rate depending on the source ( $^{241}\text{Am}$  or  $^{244}\text{Cm}$ ) and on the configuration (presently, with  $^{244}\text{Cm}$ , down to about 30  $\text{mGy/h}$ )
- 3) sequential irradiation studies irradiating the same sample with the two radiation types (gamma-alpha; alpha-gamma) or with gamma rays at different dose rate