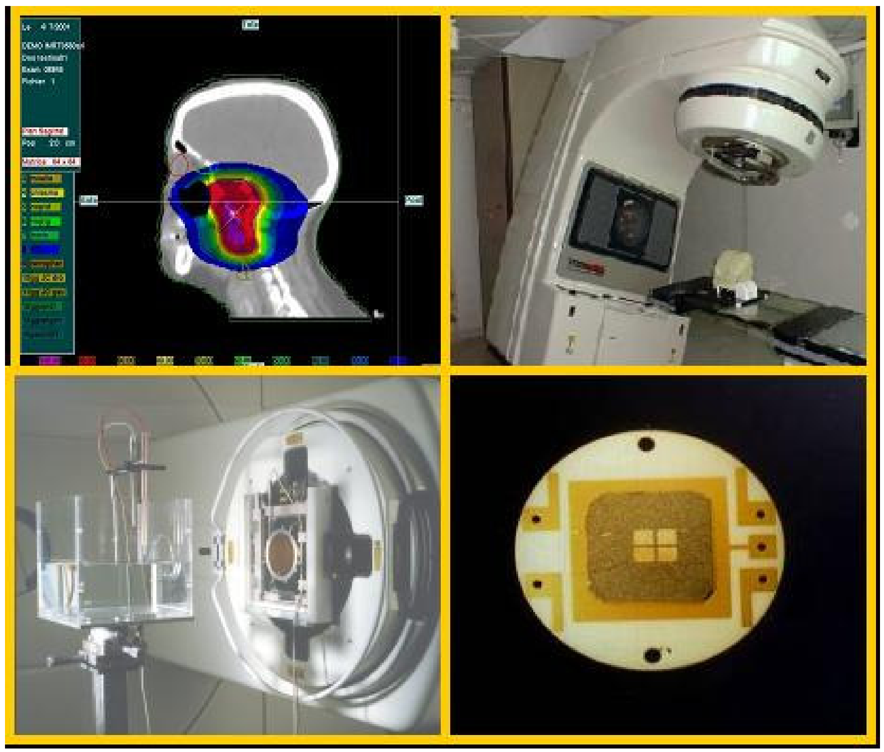
MAESTRO

Methods and Advanced Equipment for Simulation and Treatment in Radiation Oncology



Presentation

MAESTRO

- Priority in the 6th FP/ thematics : Priority 1 on Combating cancer
- Integrated Project
- Duration : 60 months (5 years), Starting Date May 1, 2004
- Budget :
  - Total Elligible Cost around 10 M€
  - Grant Commission = 7 M€

•Partners : 24 contractors

•Objectives of the project :

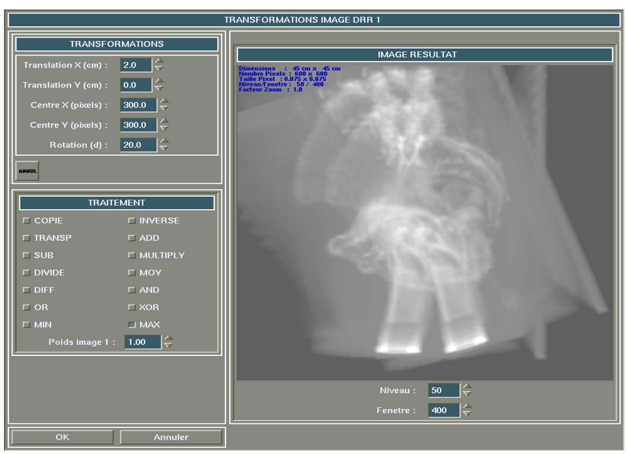
Develop and validate in clinical conditions the next generation of radiation oncology equipment for innovative treatment in clinics

Objectives of MAESTRO

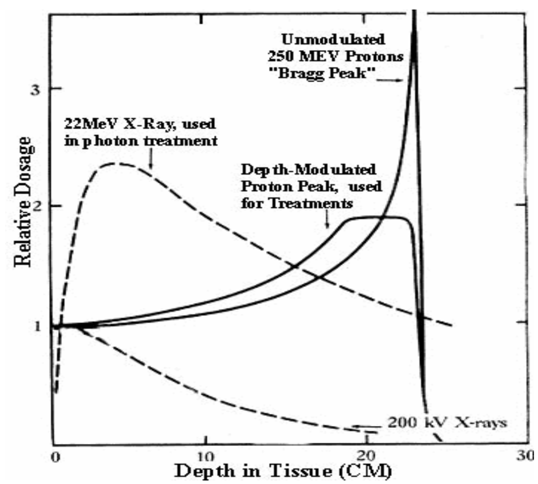
Develop and validate next generation of equipment for innovative Conformal Radiotherapy :

- **Intensity Modulation Radio Therapy (IMRT)**
- **Protontherapy (IMPT)**

Photon beam



Proton beam



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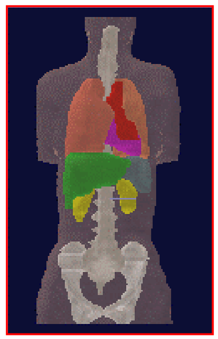
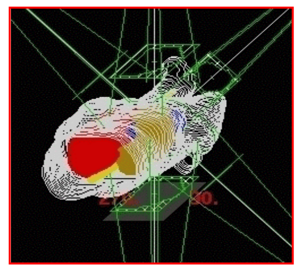
New challenges : IMRT, PT

Intensity modulation of tomorrow’s beams in oncology will be calculated using powerful software codes and MRI/PET information to obtain heterogeneous dose to be delivered

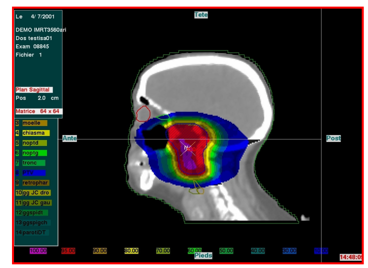
Tumour



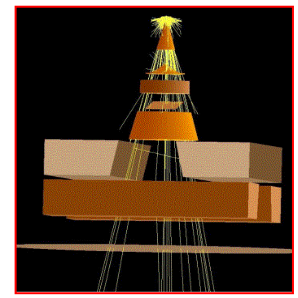
Critical Organs



Define ballistics



Dose Calculation

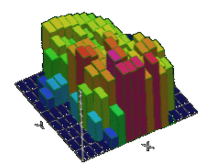


Verify Treat and control

PET

MRI

Code



Sensors

Requirements in IMRTand PT

- **Efficiency of treatment: simulation techniques**
  - Patient representation from imaging check-up
- **Realistic dose calculation models**
  - Dose rate calculation in a reasonable time (Calculation time and precision is a major issue → Need for Faster Monte Carlo codes)
- **Optimise the radiation field for the specified dose**
  - Inverse planning to obtain intensity modulation of the beam
- **Automation of patient positioning**
  - Practical treatment delivery and target tracking devices
- **Dose delivery control unit**
  - Dosimetric sensors (High Energy imaging, specific sensors for controlled motion of modulators, Artificial Diamond dosimeters)

  → Need for tissue equivalent and radiation hardness proven materials
- **Risk Assessment studies**
  - Organs at risks , patient safety

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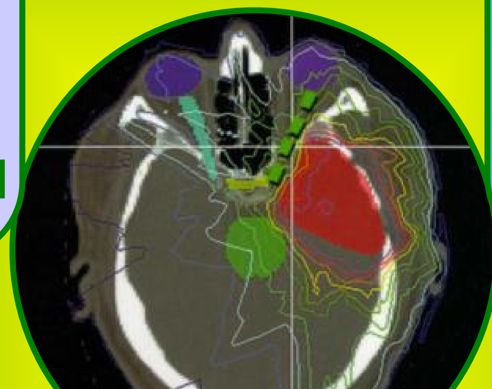
Consortium

Research

CEA, INFN, NPL
IFJ, IN2P3, ISS
Delft, Coventry
UBC, UEA, UCLM

Industrials

IBA
Dosisoft, Eldim
NRG
SCX
Elekta,
Nucletron



Clinics

IGR	**DFC**
CFB,	**IC,**
REM,	**CCO,**
UHC	**Utrech**
W,	**t**
UDE,	**Seville**
COOK	**ORCC**

9 Countries in Europe

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Outline implementation plan

WP4.0 Clinical requirements IGR, DFC, UHCW

WP1

Adaptive Radiation Delivery, tracking and control

Coventry, UEA, IBA

WP2

Radiation Therapy software development

DOSisoft, INRIA, UBC

WP3

Sensors for dose evaluation

CEA, DFC, INFN, DELFT, IFJ, ISS, SCX, IN2P3, ELDIM

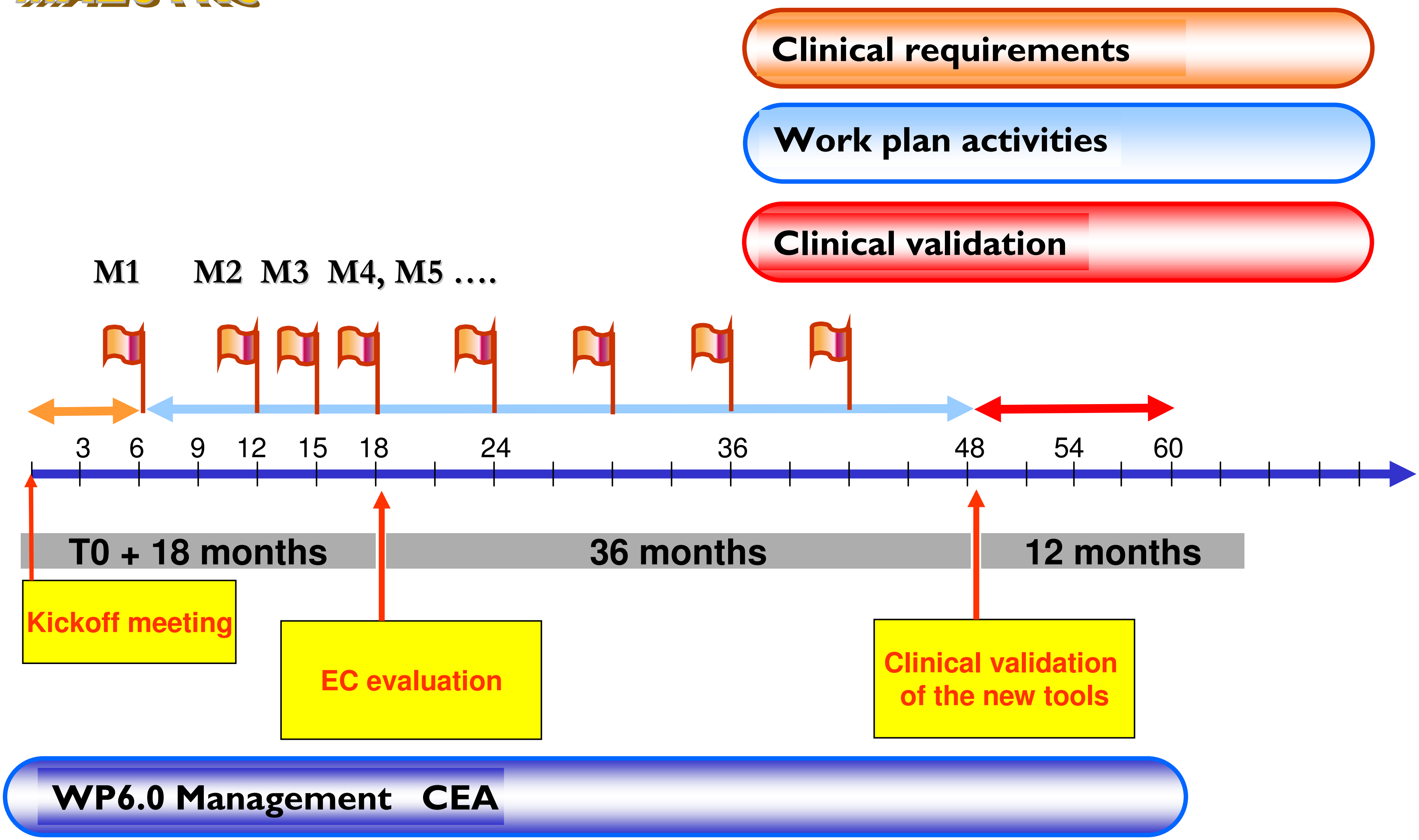
WP4.1 and WP4.2 Protocols, QA and Clinical validation IGR

WP4.3 Risk assessment studies DELFT-U

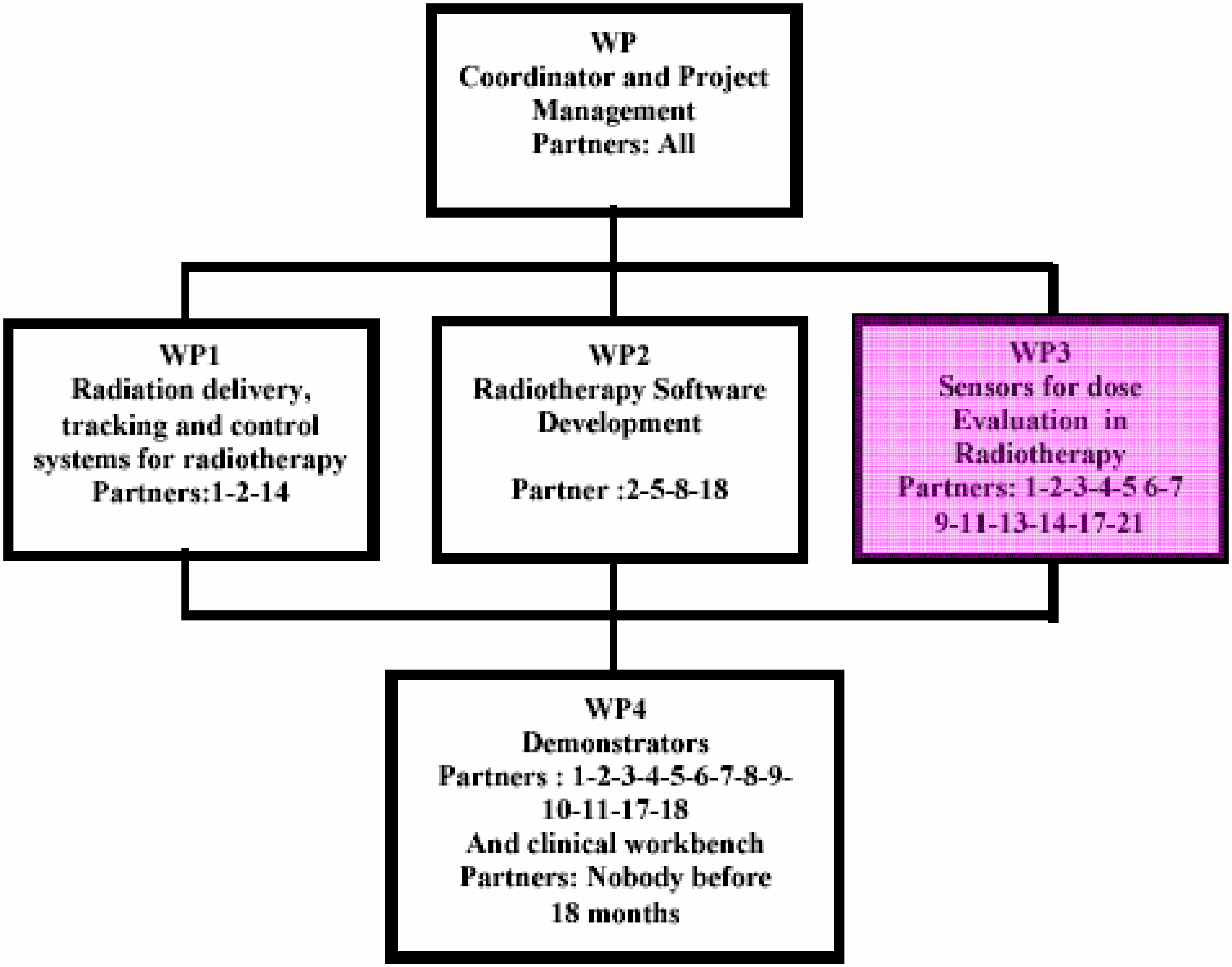
WP5.0 Training and demonstration workshops NPL, COOK

WP6.0 Management CEA

Major Milestones



Structure


WP
Coordinator and Project
Management
Partners: All
WP1
Radiation delivery,
tracking and control
systems for radiotherapy
Partners:1-2-14
WP2
Radiotherapy Software
Development
Partner :2-5-8-18
WP3
Sensors for dose
Evaluation in
Radiotherapy
Partners: 1-2-3-4-5 6-7
9-11-13-14-17-21
WP4
Demonstrators
Partners : 1-2-3-4-5-6-7-8-9-
10-11-17-18
And clinical workbench
Partners: Nobody before
18 months

Sensors for Dose evaluation in radiotherapy

- Diamond detectors for miniature dosimeters
- Optically stimulated luminescent dosimeter
- 2D large area ionisation planar detectors
- Gas ionisation chambers
- Pixel Ionisation Chambers for Protontherapy & IMRT
- Large area TL dosimeter
- 3D gel dosimetry and optical readout systems
- 3D dosimetry with plastic scintillators

Sensors for Dose evaluation in radiotherapy

→ - **Diamond detectors for miniature dosimeters**
- **Optically stimulated luminescent dosimeter**
- **2D large area ionisation planar detectors**
- **Gas ionisation chambers**
- **Pixel Ionisation Chambers for Protontherapy & IMRT**

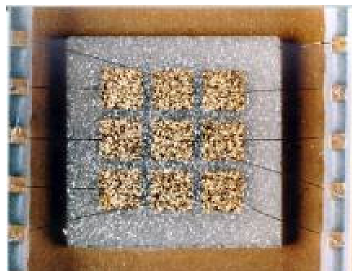
→ - **Large area TL dosimeter**
- **3D gel dosimetry and optical readout systems**
- **3D dosimetry with plastic scintillators**

on the diamond aspects:
- DFC- Florence (IT) (Pr. M. Buciolini)
- INFN (IT) (Dr Cuttone)
- IFJ- Krakov (PO) (Dr P. Olko)
- Istituto Sup di Sanita (IT) (Dr S. Onori)
- IGR, Paris (F) (Dr Lefkopoulos)

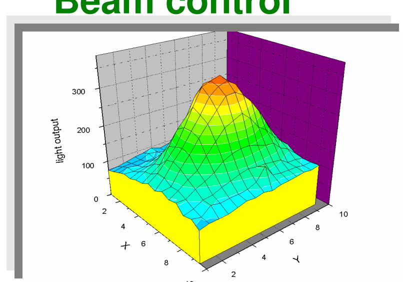
Why diamond ?

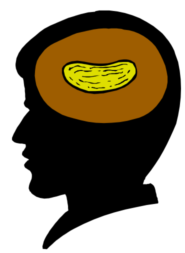
- Tissue equivalent
- Radiation hardness
- Chemically inert
- Compatible with in-vivo measurements
- Small sizes

(e.g. IMRT : Intensity Modulation
➔ high dose gradients)



Beam control





- **Beam control BEFORE treatment**
- **Real time monitoring of the dose**

Two approaches

NB : there exists commercially available devices, equipping several irradiation facilities, based on highly selected IIa type russian diamonds :
typ. 25 k$ each, delays > 12 months

☞ Diamond detection devices used as ionisation chambers
Radiation interacting in the biased device creates carrier drift etc

Requirements : - stability with time, prolonged irradiation etc
- linerarity with respect to the dose
- no effect of history

☞ Diamond layers used as large area thermoluminescent dosimeters

Requirements : - linearity with respect to the dose
- persistence of the trapped population (no fading)

Two approaches

Convincing achievements needs to be obtained within the first 18 months

☞ Diamond detection devices used as ionisation chambers

Radiation interacting in the biased device creates carrier drift etc

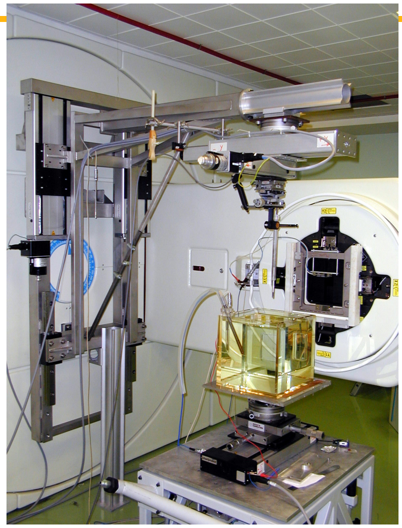
Via : - control of the effect of defect levels
- stabilising the electrical behaviour of defects
- monoX artificial diamonds for miniature dosimeters

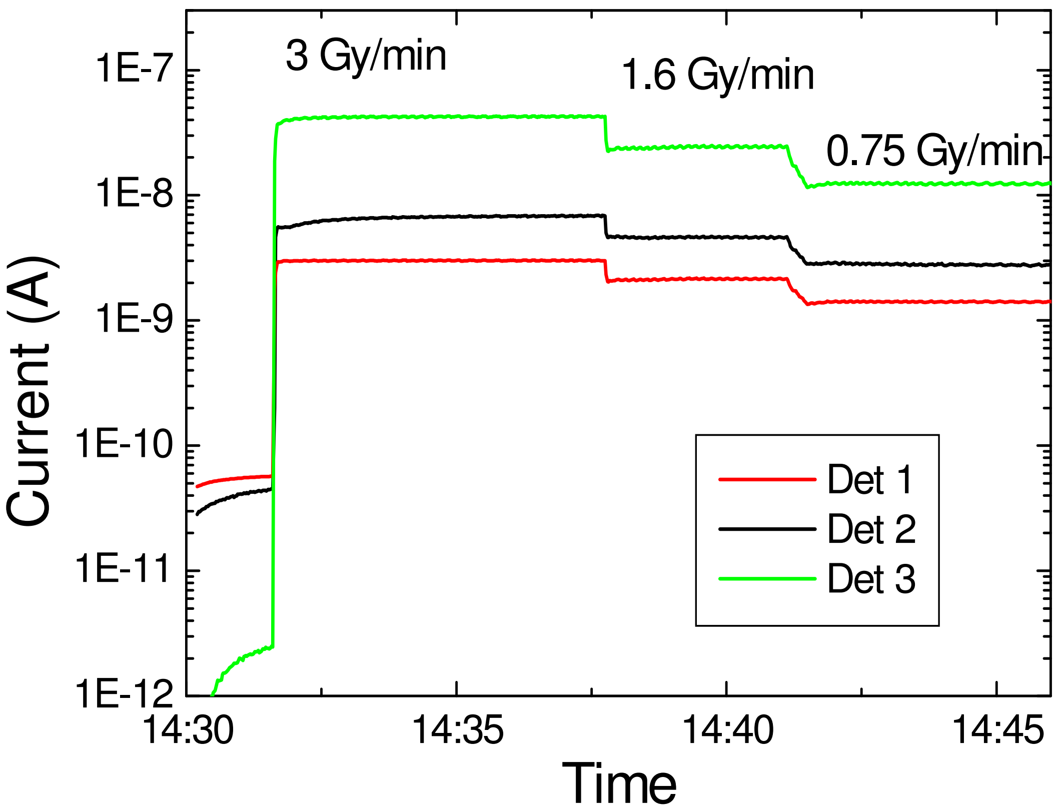
☞ Diamond layers used as large area thermoluminescent dosimeters

Via : - poly CVD for large area
- added impurities for controlled TL properties.

Study of the responses under photon beams

Experiments performed using a Saturne 43
Medical accelerator for photons and electrons
Tunable energy from 6 to 20 MeV - typ. dose = 3Gy/min





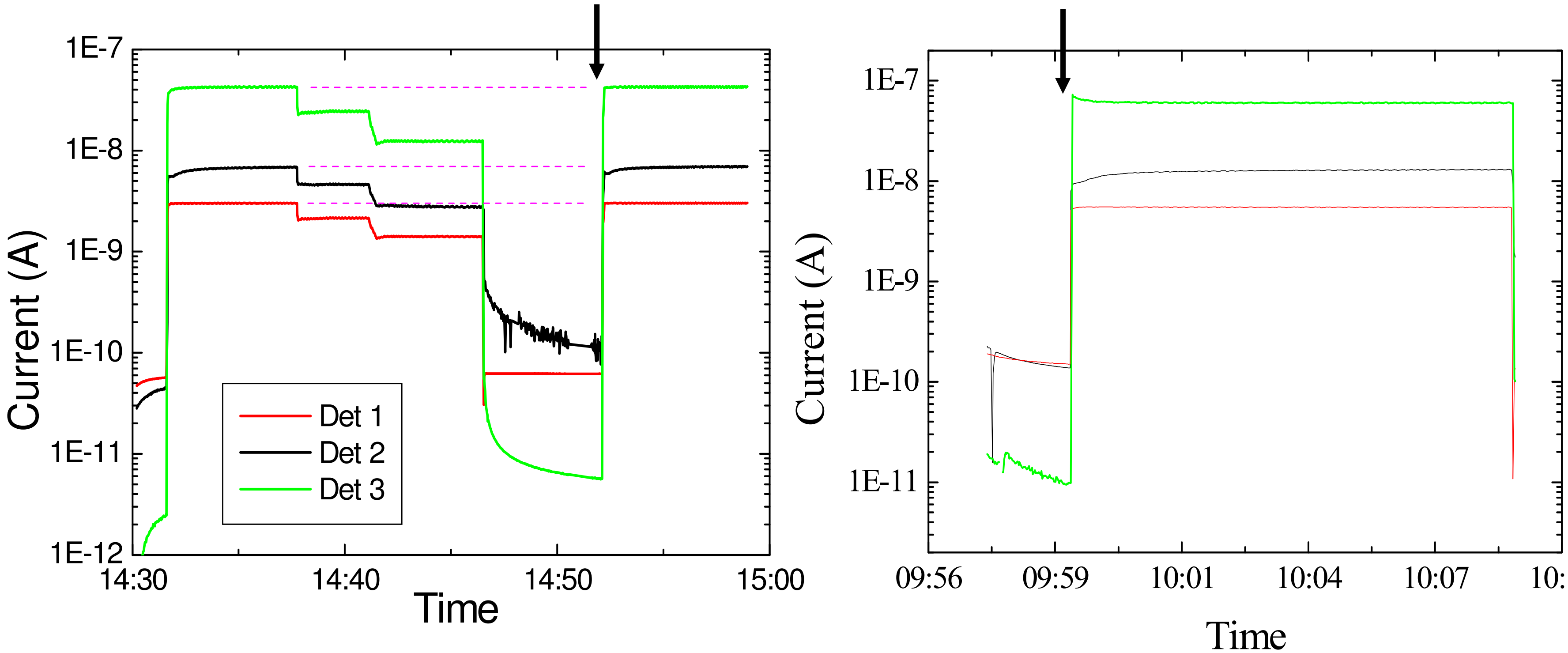
photons : 6 MeV,
Bias = 50V,

	nC/cG	nC.cGy^{-1}.mm^{-3}
Det 2	**2.4**	**0.67**
Det 1	**1**	**1.4**
Det 3	**12**	**0.6**

1- Ionisation chambers

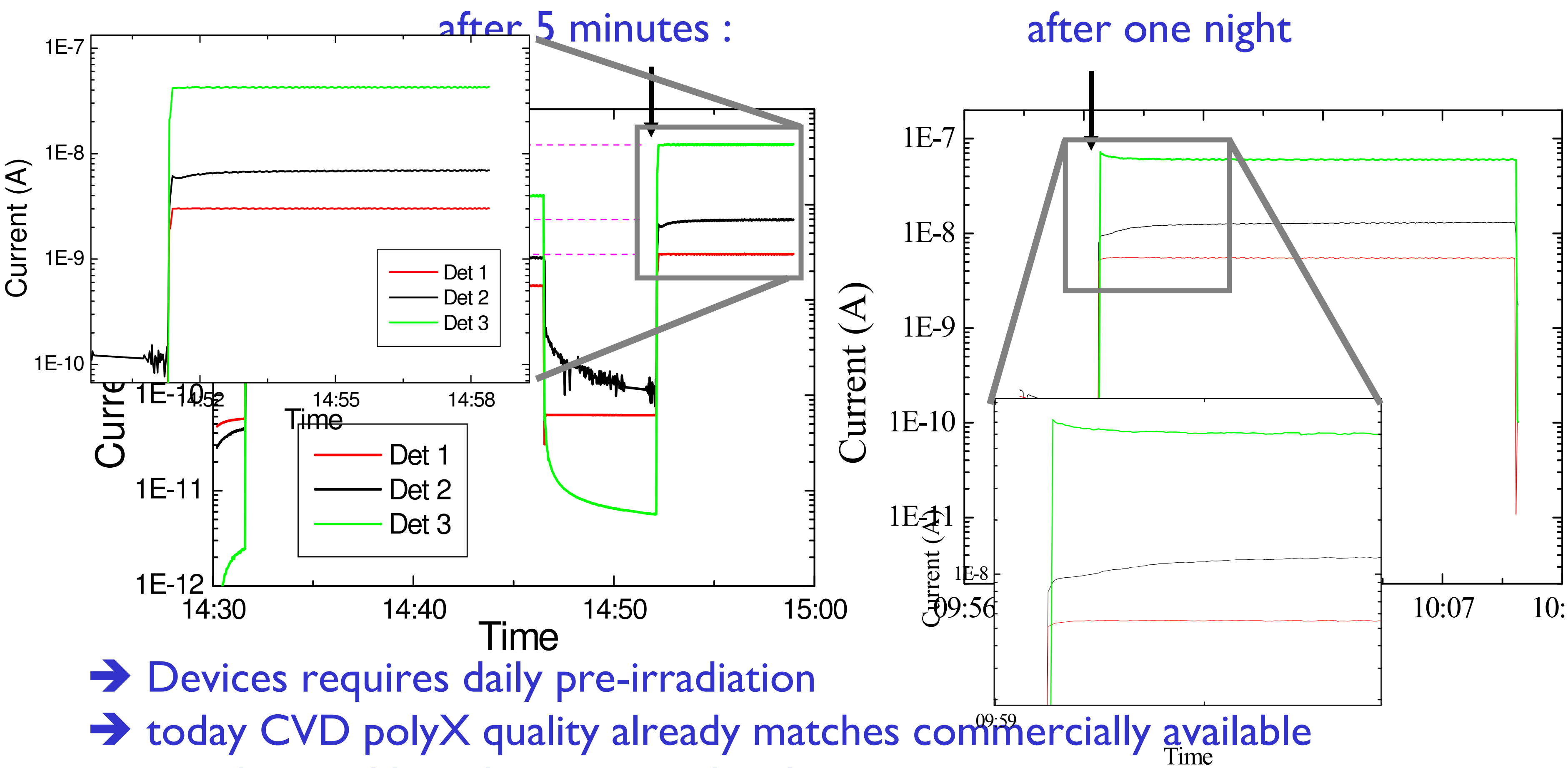
Problems at signal rises :

after 5 minutes : after one night



1- Ionisation chambers

Problems at signal rises :

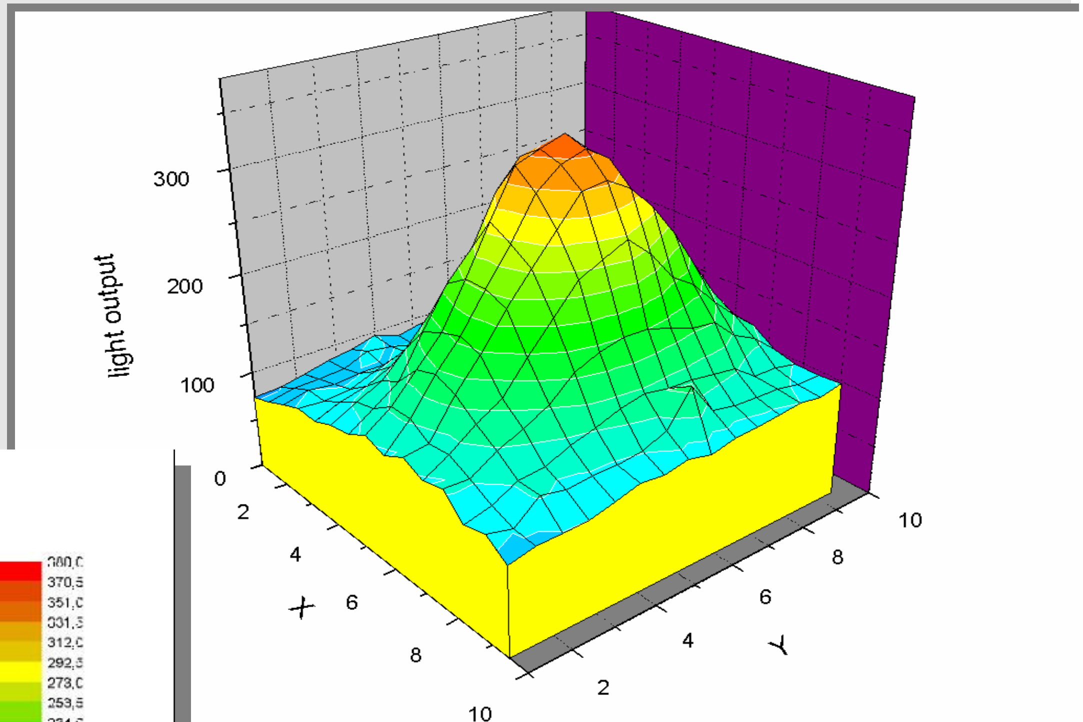


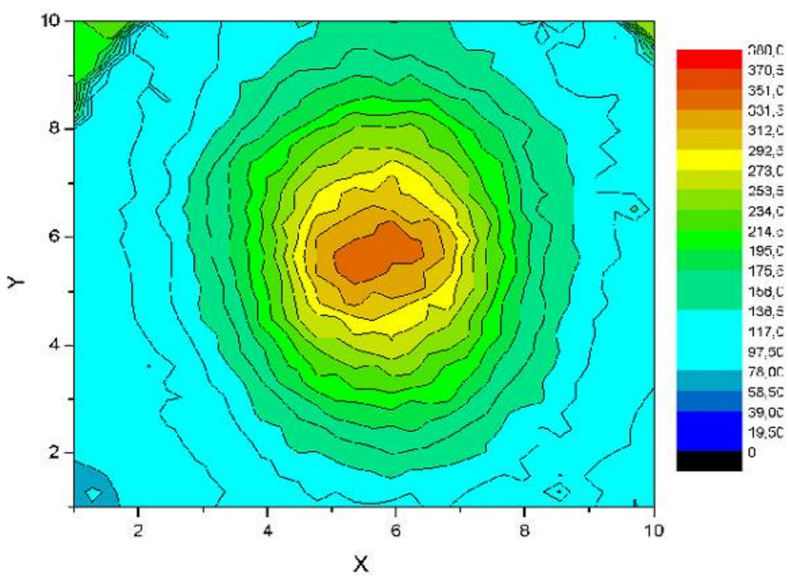
➔ Devices requires daily pre-irradiation

➔ today CVD polyX quality already matches commercially available natural diamond based ionisation chambers

2- CVD diamond TL detectors

exposure to a ^{226}Ra needle
5 hours
CVD diamond wafer,
ϕ = 5cm (CEA, Saclay)





The diamond wafer enables the measurement of the dose distribution profile

Collaborators

CEA/Saclay
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C.E. Nebel, J.A. Garrido

*Acknowledgements : EU funding from HPRN-CT-1999-00139