Diamond detectors

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The present

- Development of X-UV detectors
- Development of dosimeters
- Application to space
- Application to synchrotron radiation
- Application to radiotherapy

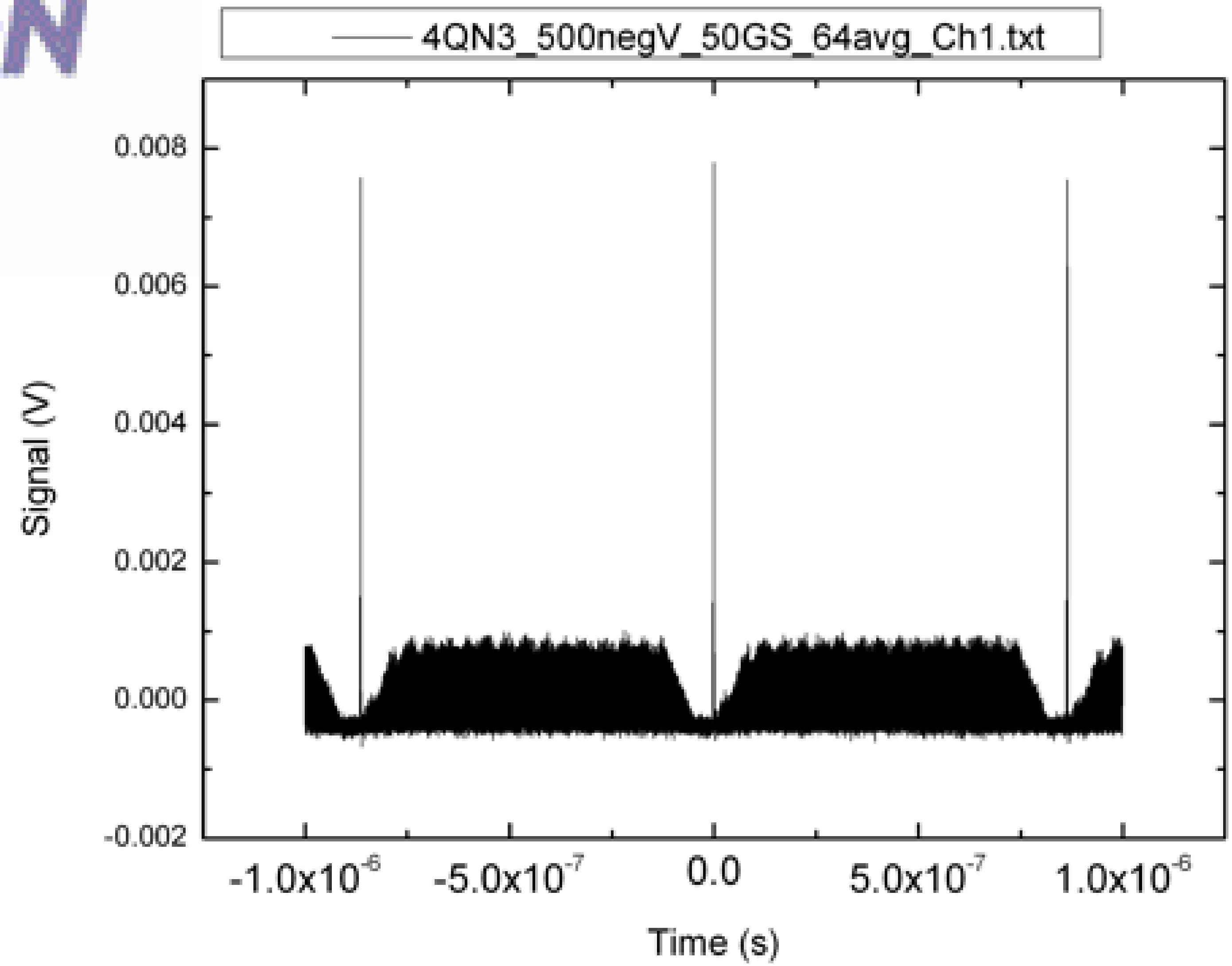
Diamond X-UV detectors

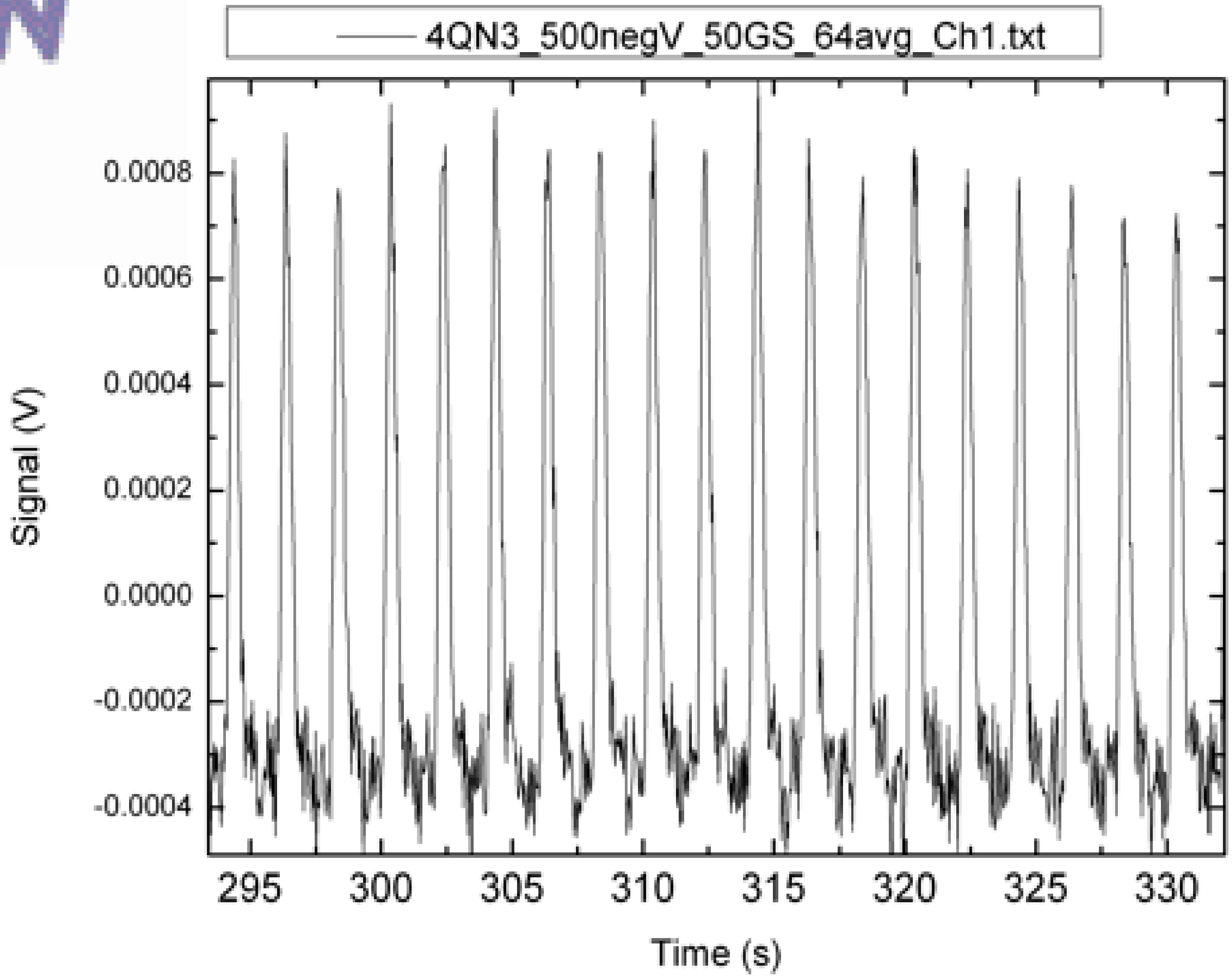
Applications to Synchrotron Radiation and space experiments

Targets

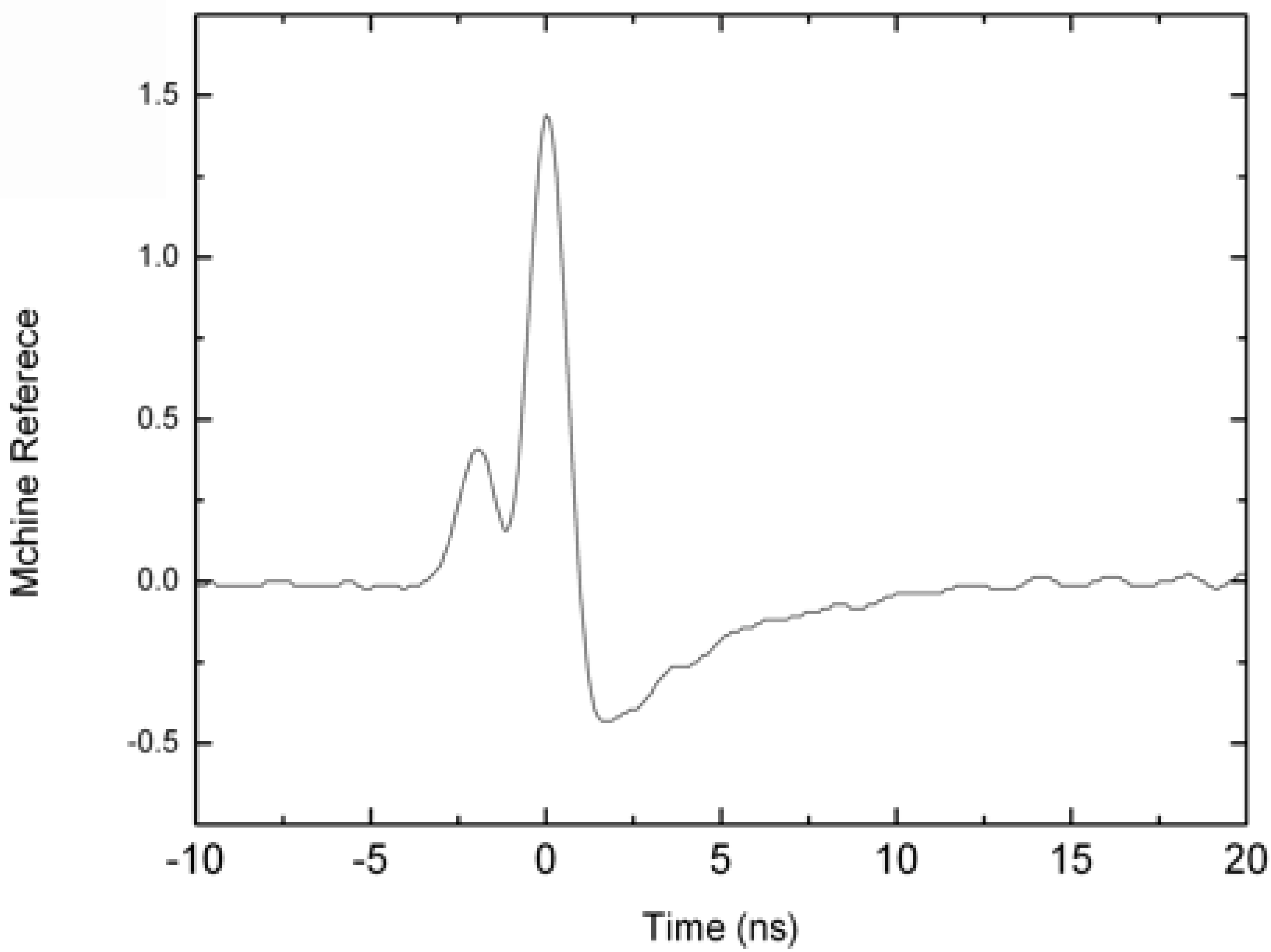
Development of

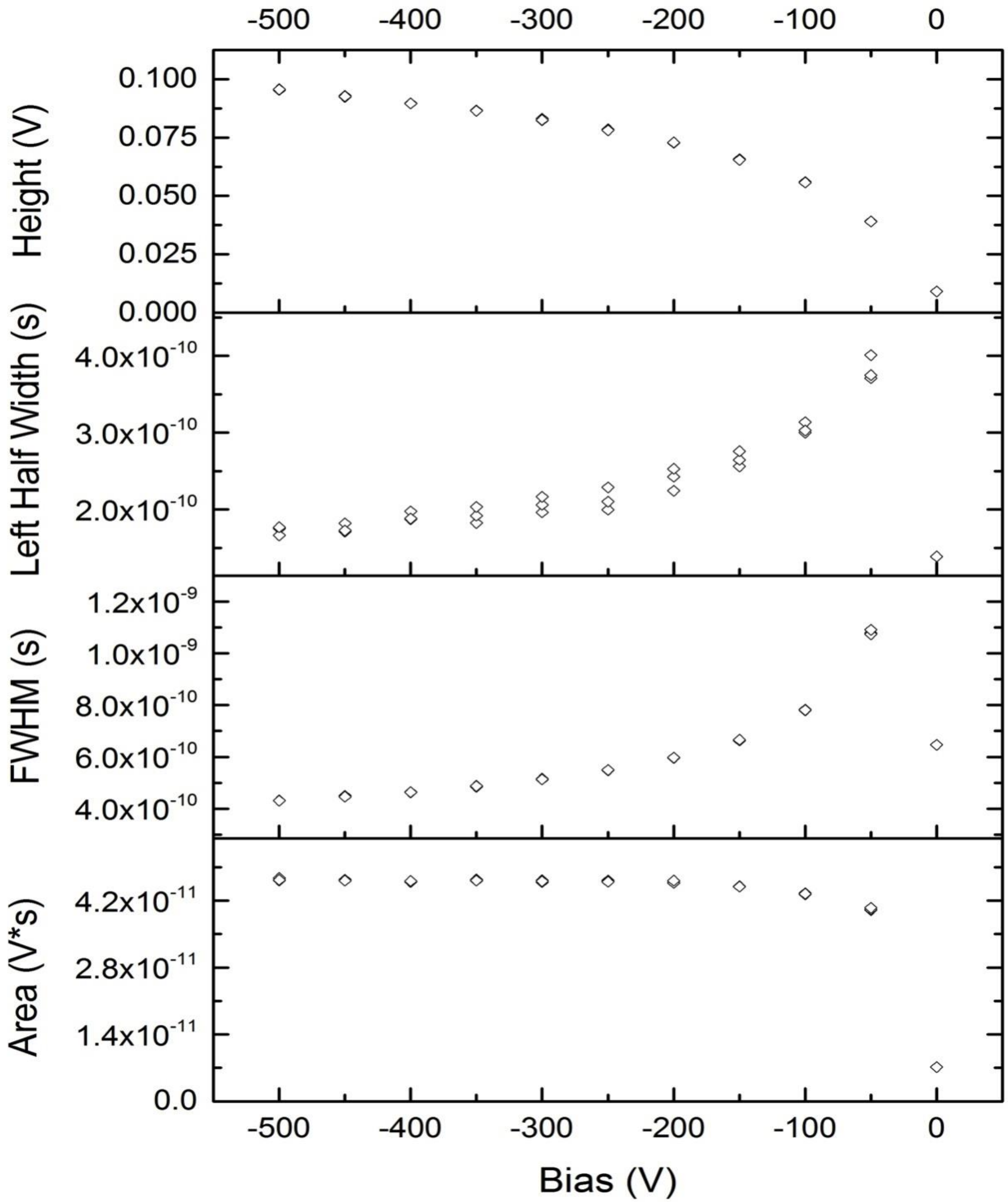
- ultrafast X-UV diamond detectors for FEL and SR applications
- Array detectors for space applications
- Ionization chambers for X-ray absorption


4QN3_500negV_50GS_64avg_Ch1.txt
0.008
0.006
0.004
0.002
0.000
-0.002
Signal (V)
$-1.0x10^{-6}$
$-5.0x10^{-7}$
0.0
$5.0x10^{-7}$
$1.0x10^{-6}$
Time (s)



4QN3_500negV_50GS_64avg_Ch1.txt
Signal (V)
0.0008
0.0006
0.0004
0.0002
0.0000
-0.0002
-0.0004
295
300
305
310
315
320
325
330
Time (s)


1.5
1.0
0.5
0.0
-0.5
Mchine Referece
-10
-5
0
5
10
15
20
Time (ns)

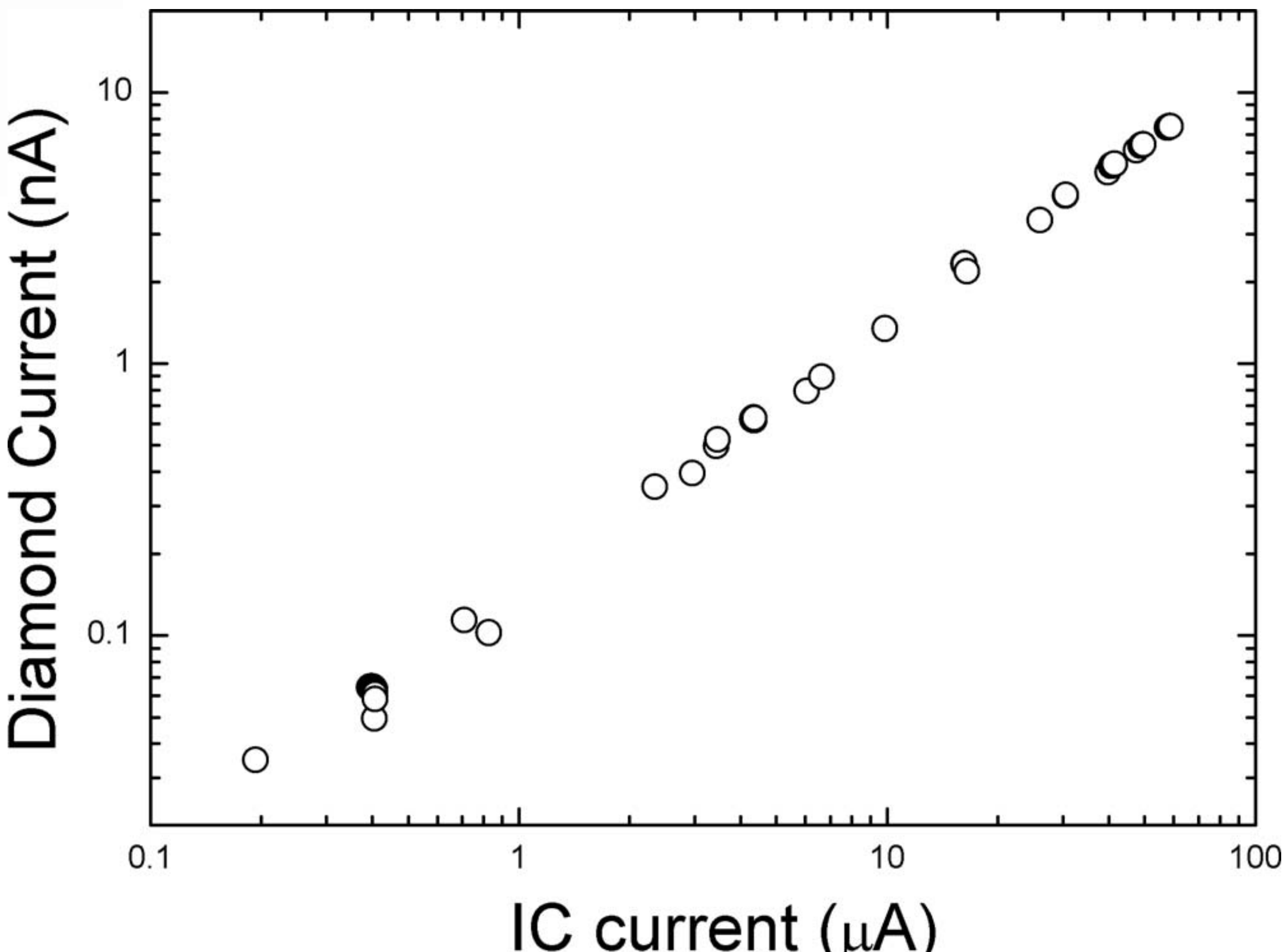


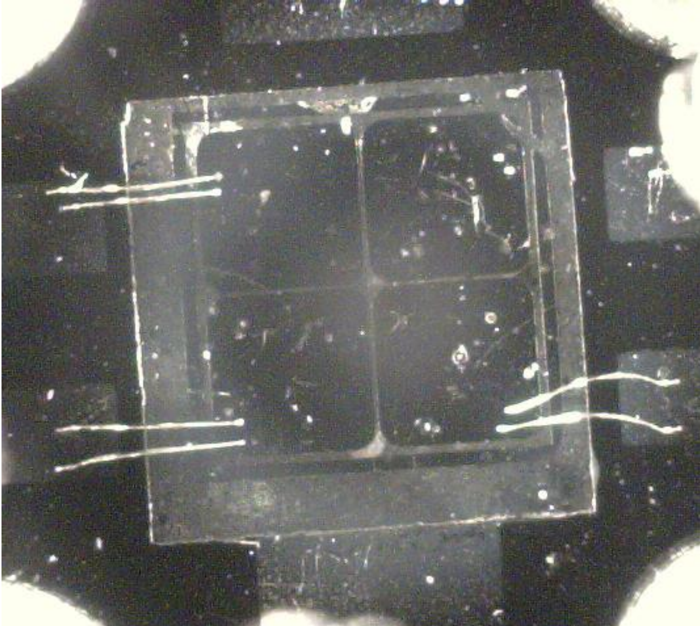
-500
-400
-300
-200
-100
0
Height (V)
0.100
0.075
0.050
0.025
0.000
Left Half Width (s)
4.0x10^-10
3.0x10^-10
2.0x10^-10
FWHM (s)
1.2x10^-9
1.0x10^-9
8.0x10^-10
6.0x10^-10
4.0x10^-10
Area (V*s)
4.2x10^-11
2.8x10^-11
1.4x10^-11
0.0
Bias (V)

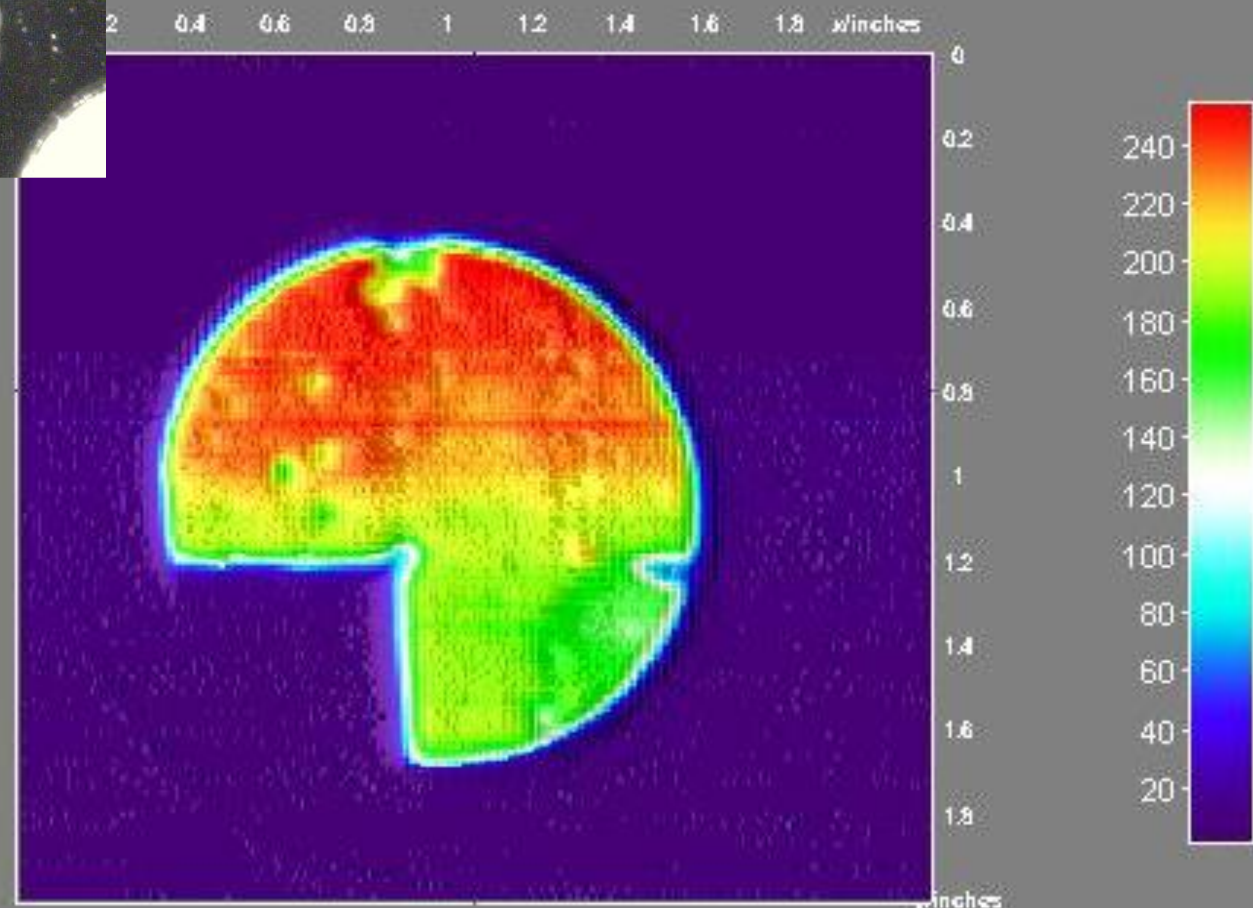
SCD/Cr-Au UNIFI

@ GILDA/ESRF

Fe **K**-edge $\mathbf{E}_0$ =7112 eV

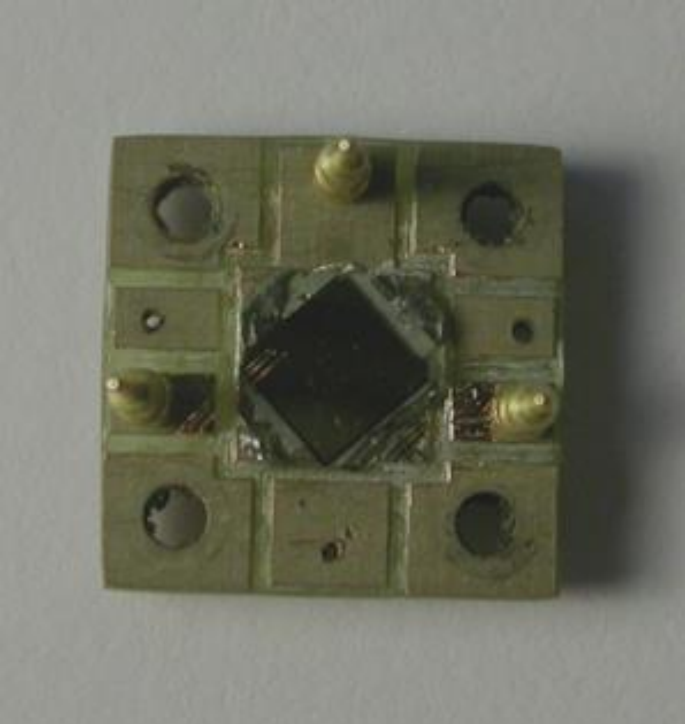


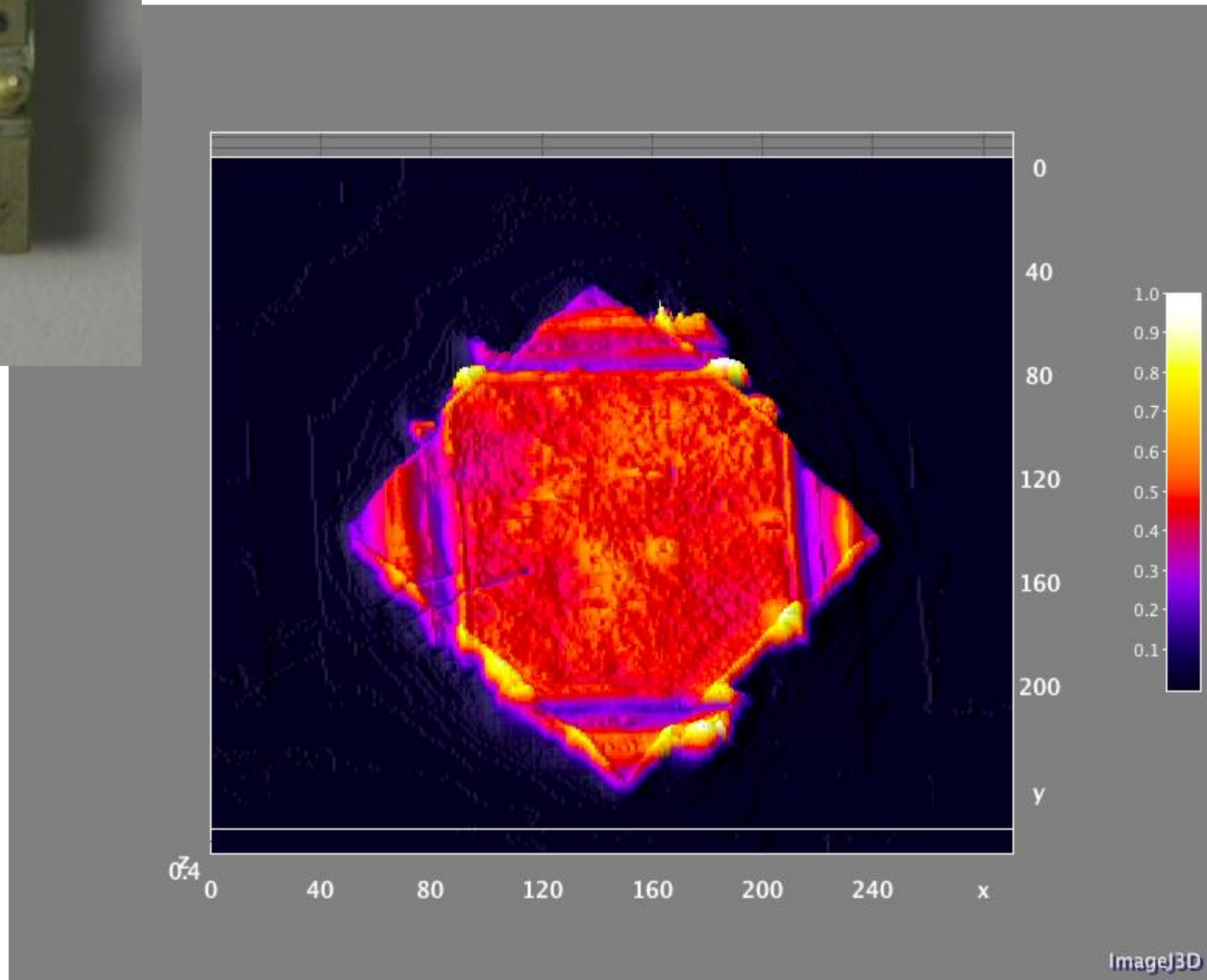




70 eV
300 V
150 μm spot size

SCD/Cr-Au CNRS/UniFi





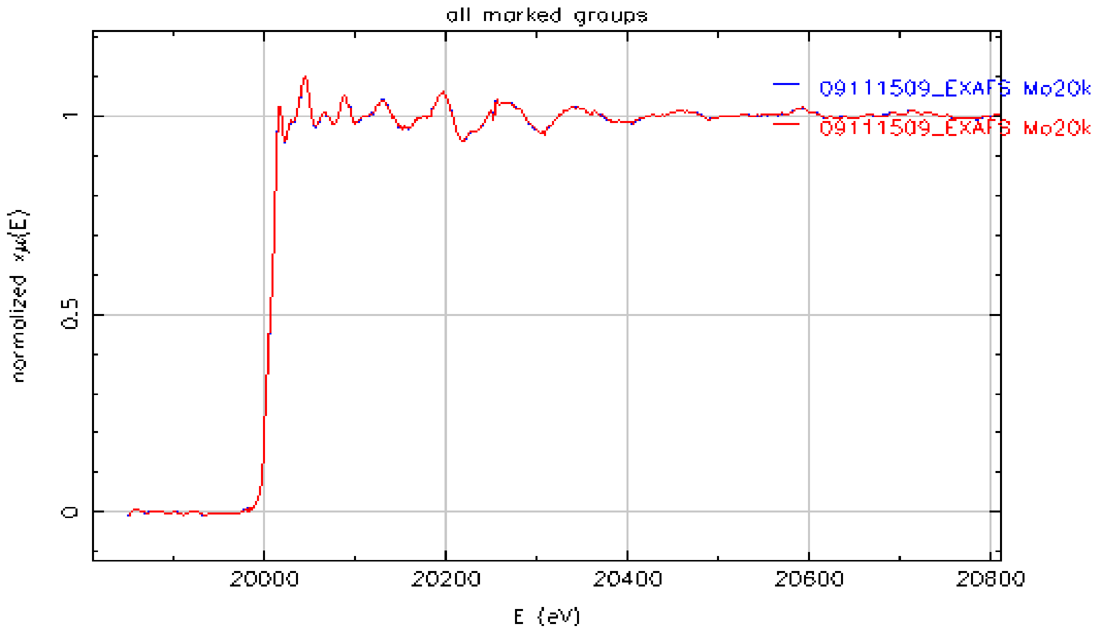
10 keV
60 V
50 μm spot size

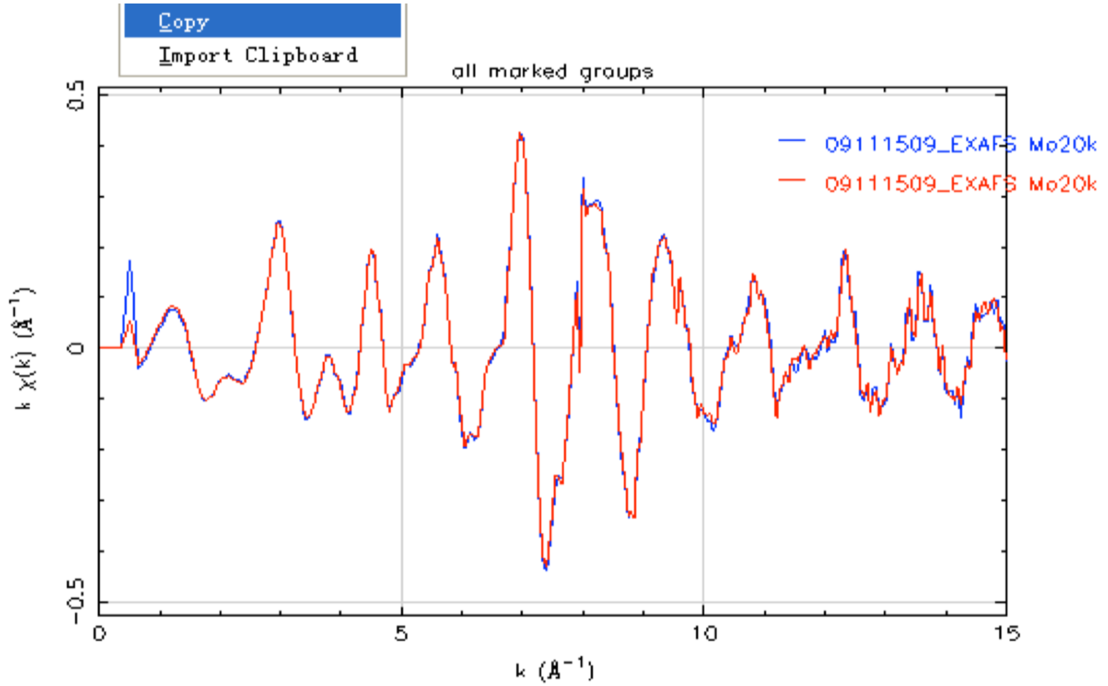
Spettri EXAFS

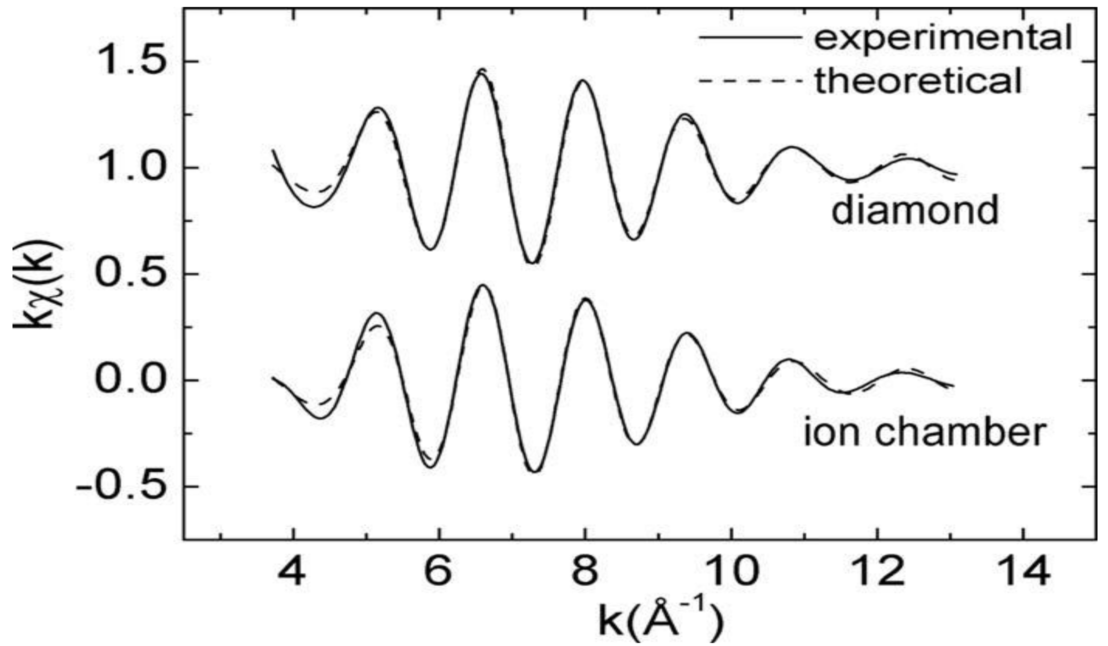
SCD/Cr-Au UNIFI

@ SSRF R.P. China

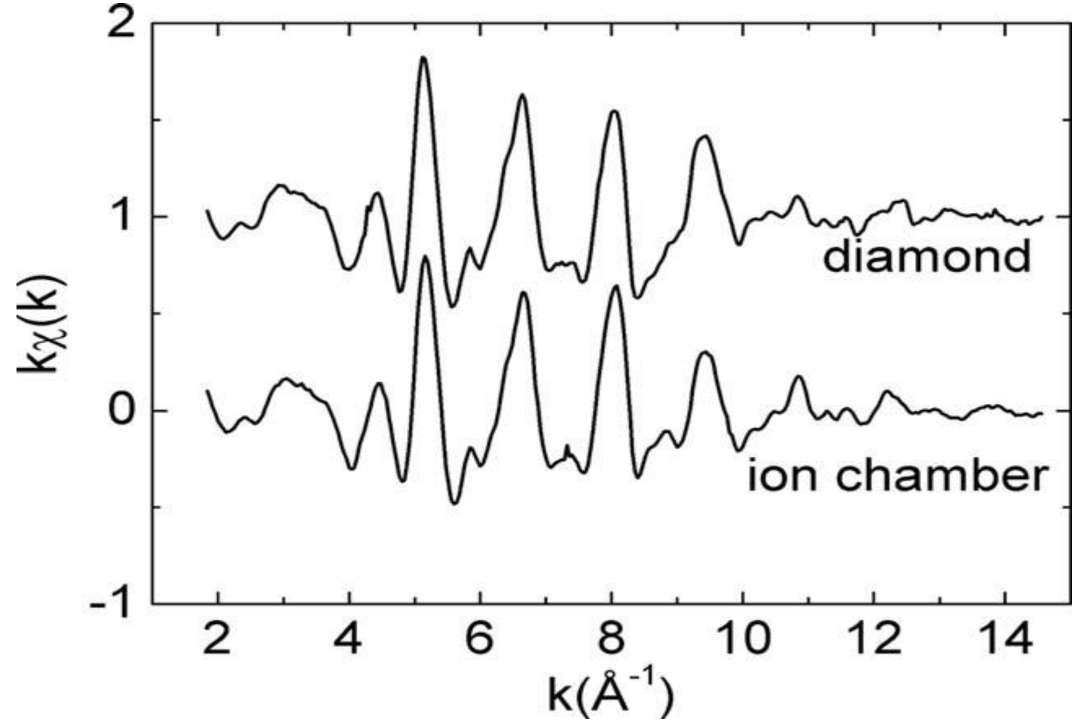
Mo **K**-edge $\mathbf{E}_0$ = 20 keV







Spettri EXAFS



SCD/Cr-Au UNIFI

@ GILDA/ESRF

Fe **K**-edge $\mathbf{E}_0$ =7112 eV

Diamond dosimeters

Applications to radiobiology and space environments

Introduction

Aim

Human exploration and studies on the origin of life requires understanding the global effects of radiation environments on biological materials.

Introduction
Radiation effects

The high energy high-Z particle and neutron irradiation in space are the most dangerous for space missions.

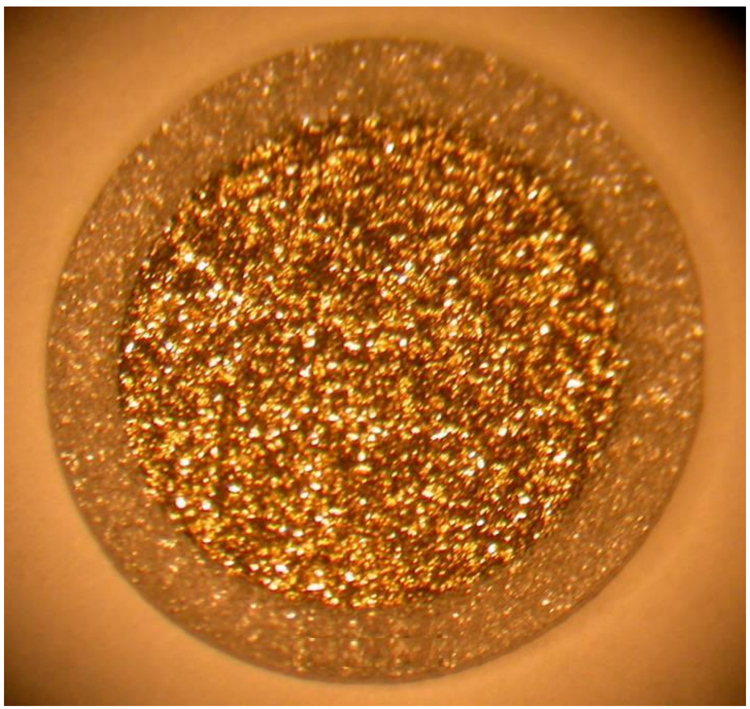
The interaction among complex organic materials, mineral surfaces and particle irradiation has to be studied in order to investigate on the evolution of prebiotic material in space.

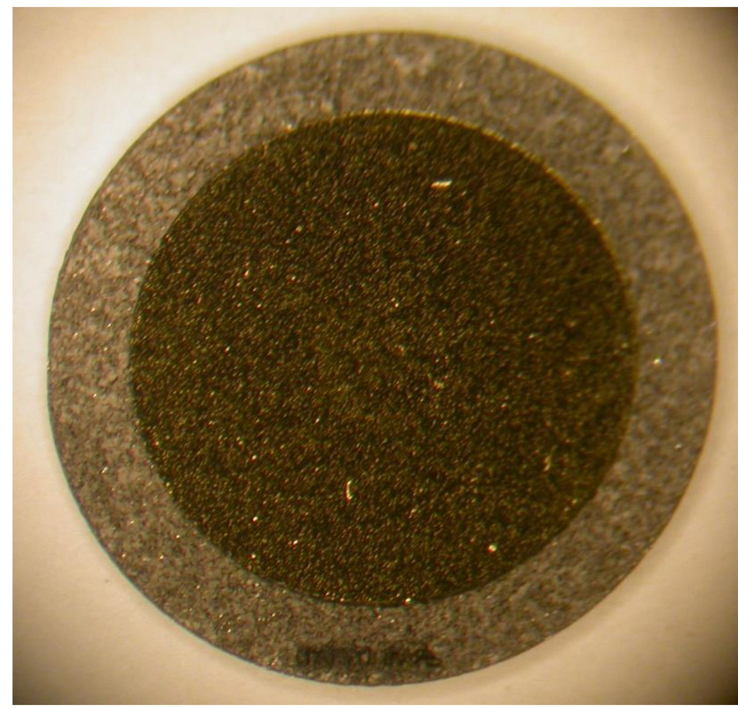
Diamond dosimeters

- Ordinary off-the-shelf dosimeters cannot be used
- Know-how from hospital applications
- Tissue equivalent
- Robust and durable (inert and rad hard)
- Compact and lightweight
- No or low power consumption
- Dose can be measured in space
- Both active and passive dosimeters available
- Very effective with protons, electrons and ions
- High sensitivity to hard X rays & low-energy γ rays

Diamond dosimeters

Single pixel



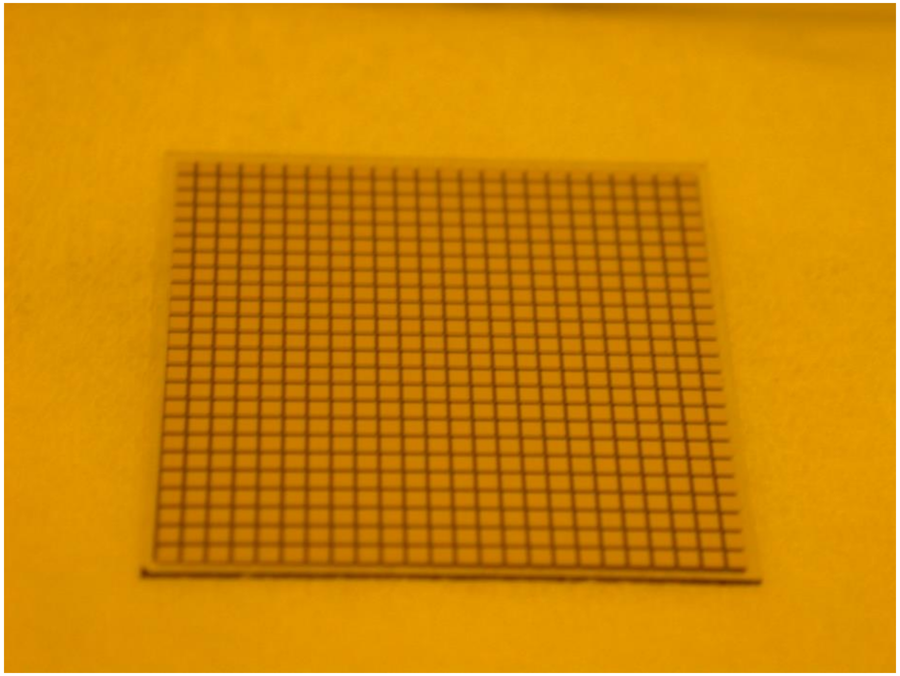


INFN

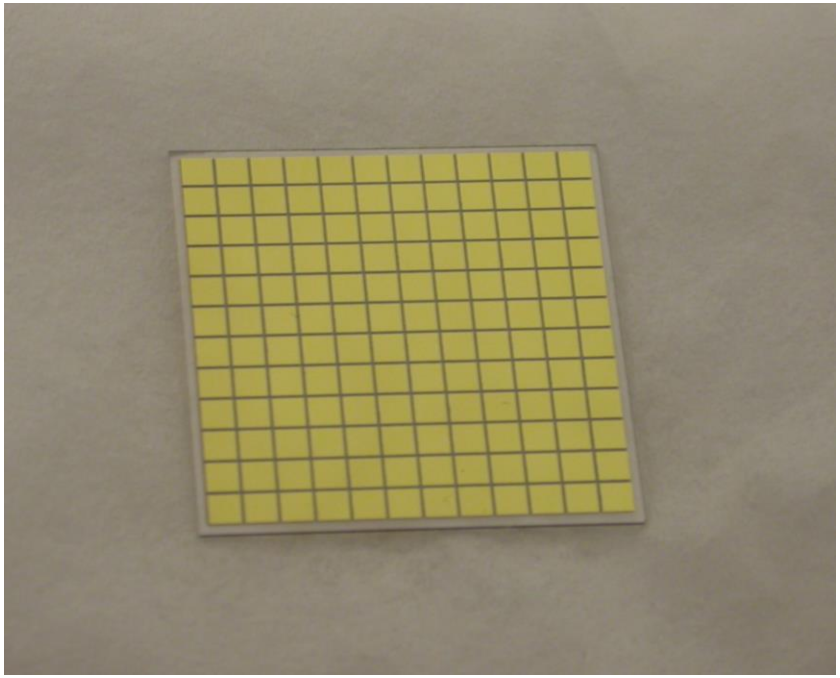
Diamond dosimeters

Arrays

25 mm side 24 x 24 1 mm pixels

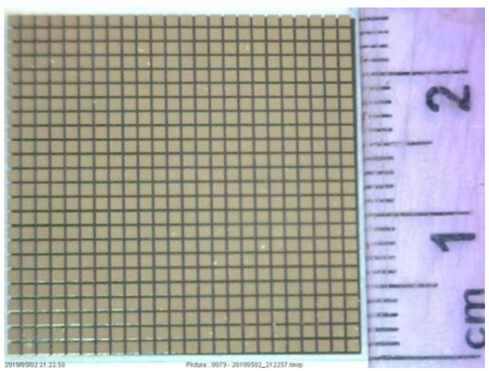


25 mm side 12 x 12 2 mm pixels



First large area 2D synthetic Diamond dosimeter prototypes

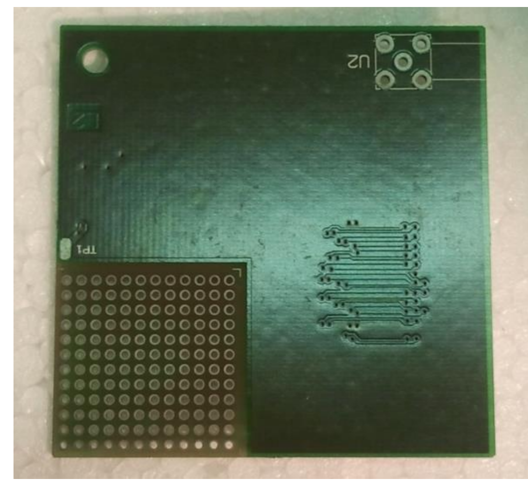
Premium Detector Grade (Diamond Detectors Ltd) polycrystalline diamond, area 2.5cmx2.5cm, thickness = 300μm. 2D matrix of pixels produced in Florence, XUV lab with Cr/Au evaporation.



24x24 matrix
pixel area 0.8x0.8mm^2

M. Bruzzi et al. JINST 2012

Modular device made of a mosaic of four 2D pCVD diamond dosimeters in view to cover an area up to 5x5cm^2.



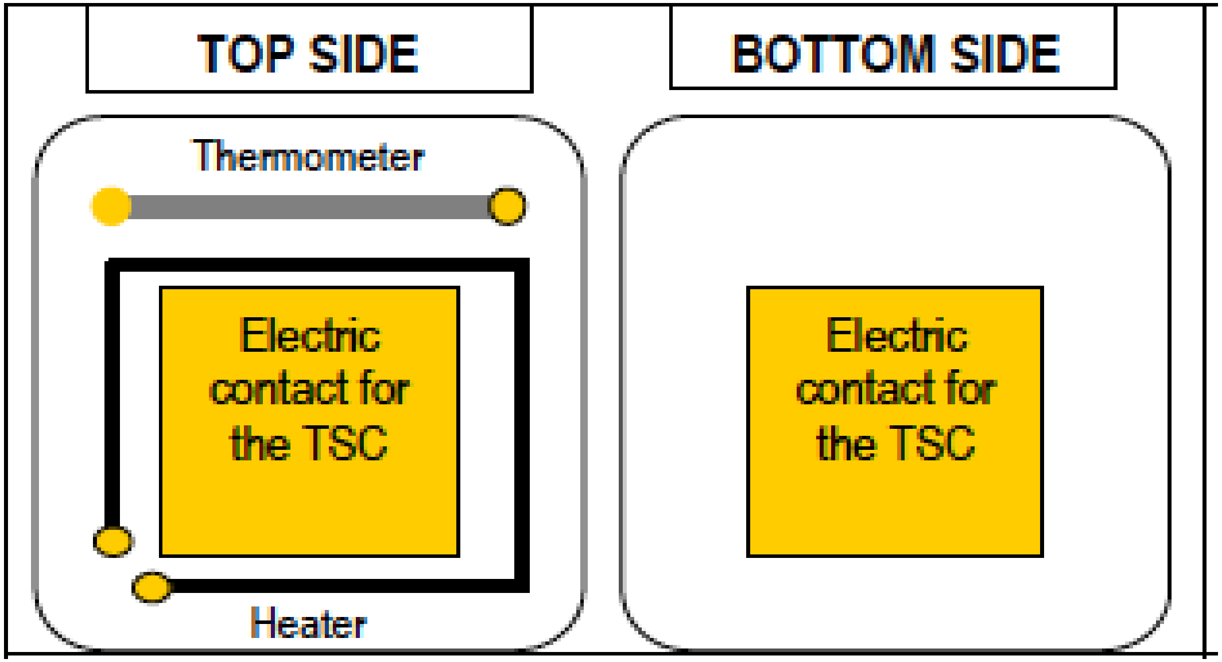
DIAPIX custom-made
PCB to connect matrix

M. Zani et al. NIM A730(2013)129–134

Diamond dosimeters

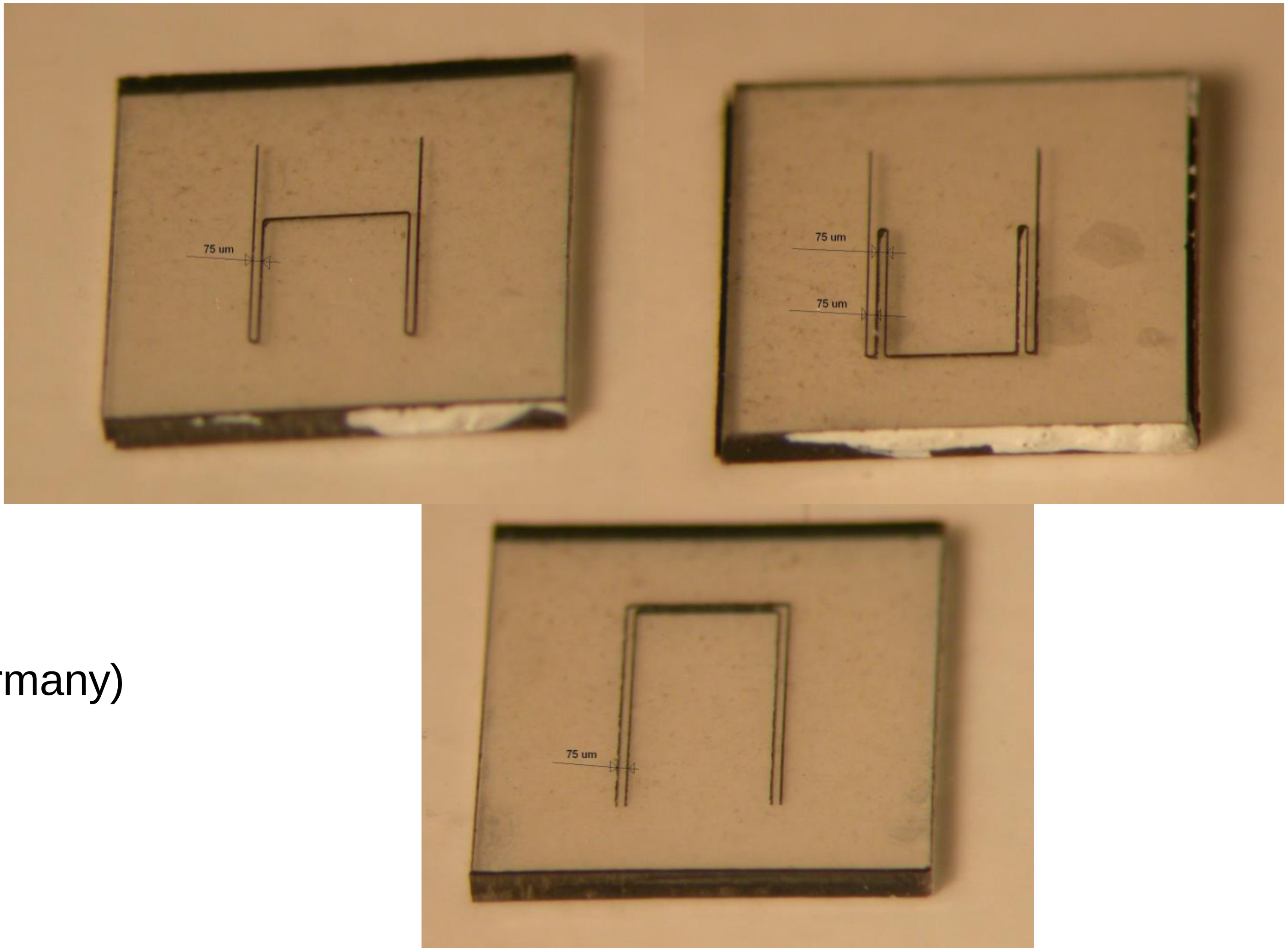
On chip heater & thermometer

Proposal RADIA EU FP7 & MONSTRE EU H2020
R. Amendola Talk



Diamond dosimeters

On chip heater & thermometer



IAF, Friburg (Germany)

DIASPACE

- First attempt to assess diamond dosimeters in a LEO space mission
- Early 2007: proposal to the Italian Space Agency
- Development and use of dosimeters based on synthetic diamond
- Viable solution to the key issue of human crew safety in space missions and in future Moon and Mars bases
- The interplanetary cosmic radiation is dangerous for both human beings, (charged particles may damage cells, tissues and organs) and biological samples that should be present in the spatial probes and/or bases.
- Opportunity: the GENESIS-LIFE mission on board the FOTON M3 satellite

INFN

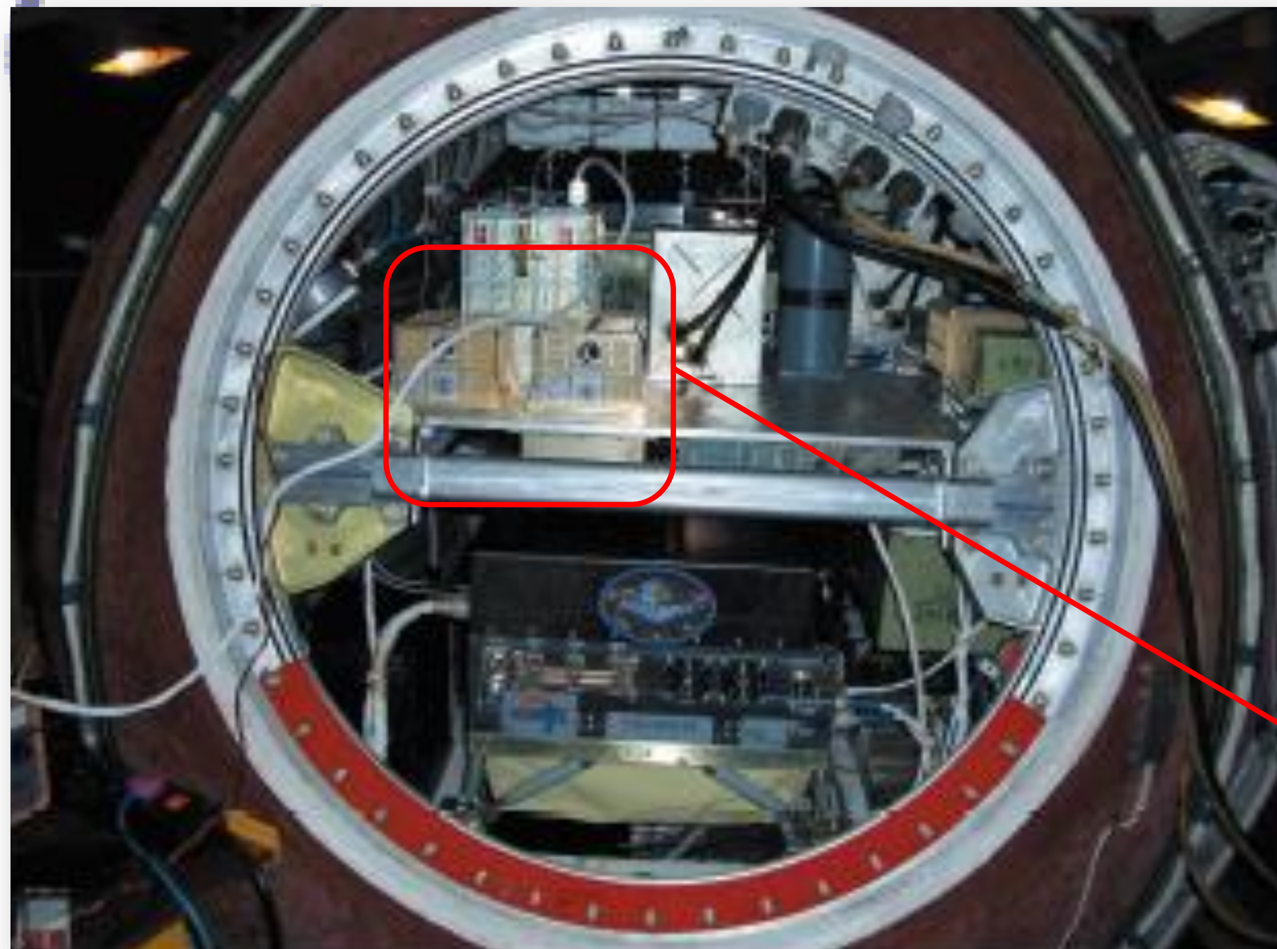
LIFE ITALIAN MISSION
FOTON M3
SCORE - PITS - THYRUD - FIS
DIASPACE - PARIDE - TARSE - MYO

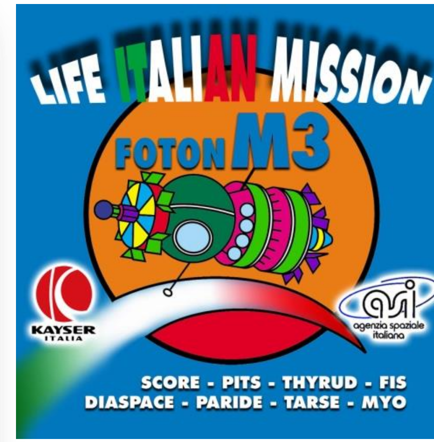
GENESIS-LIFE on FOTON-M3

FOTON M3
PHYSICS AND BIOLOGY IN SPACE

- The 8 Italian experiments were located inside two BIOKON, a standard space qualified aluminum box
- The thickness of the box envelope is 2 mm
- Technological assessment of several dosimeters in space

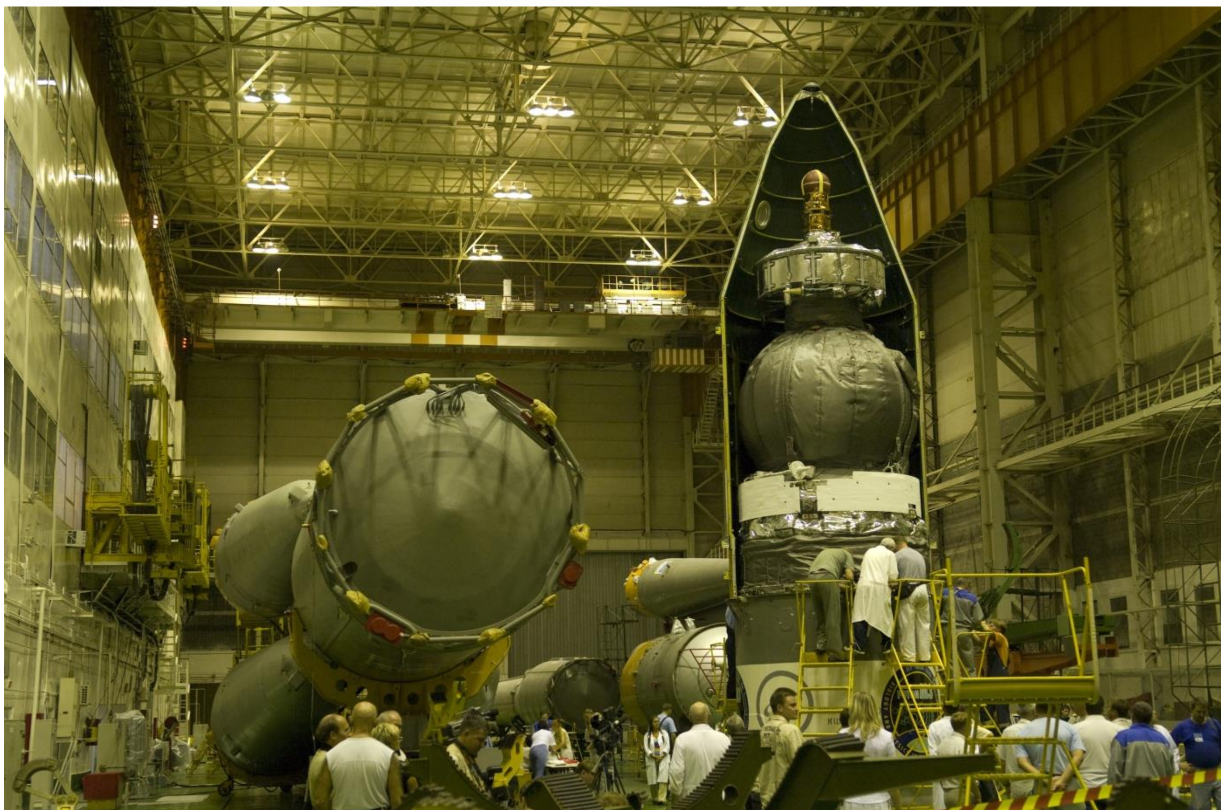
LIFE Integration

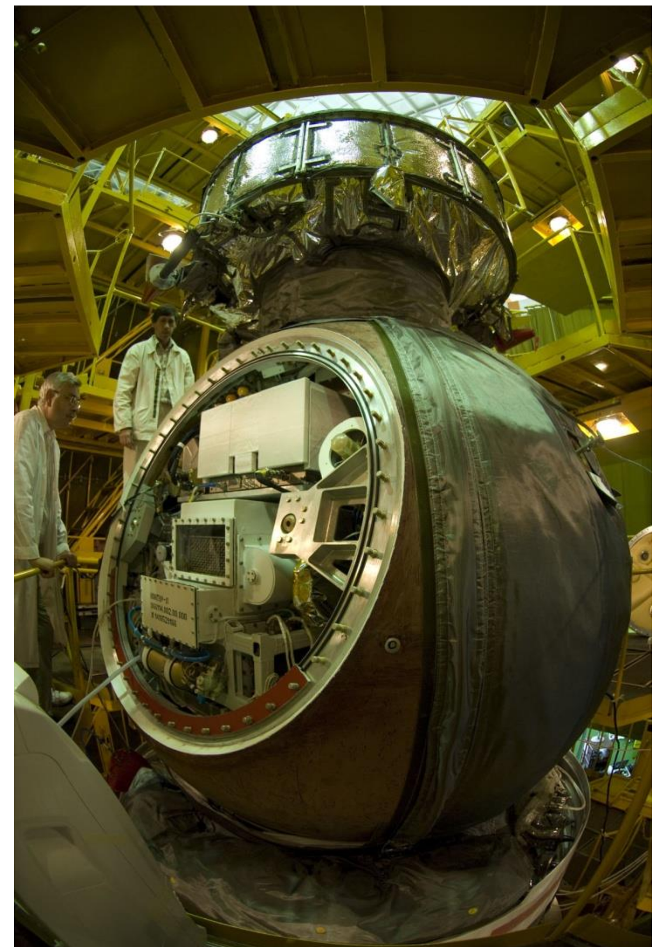




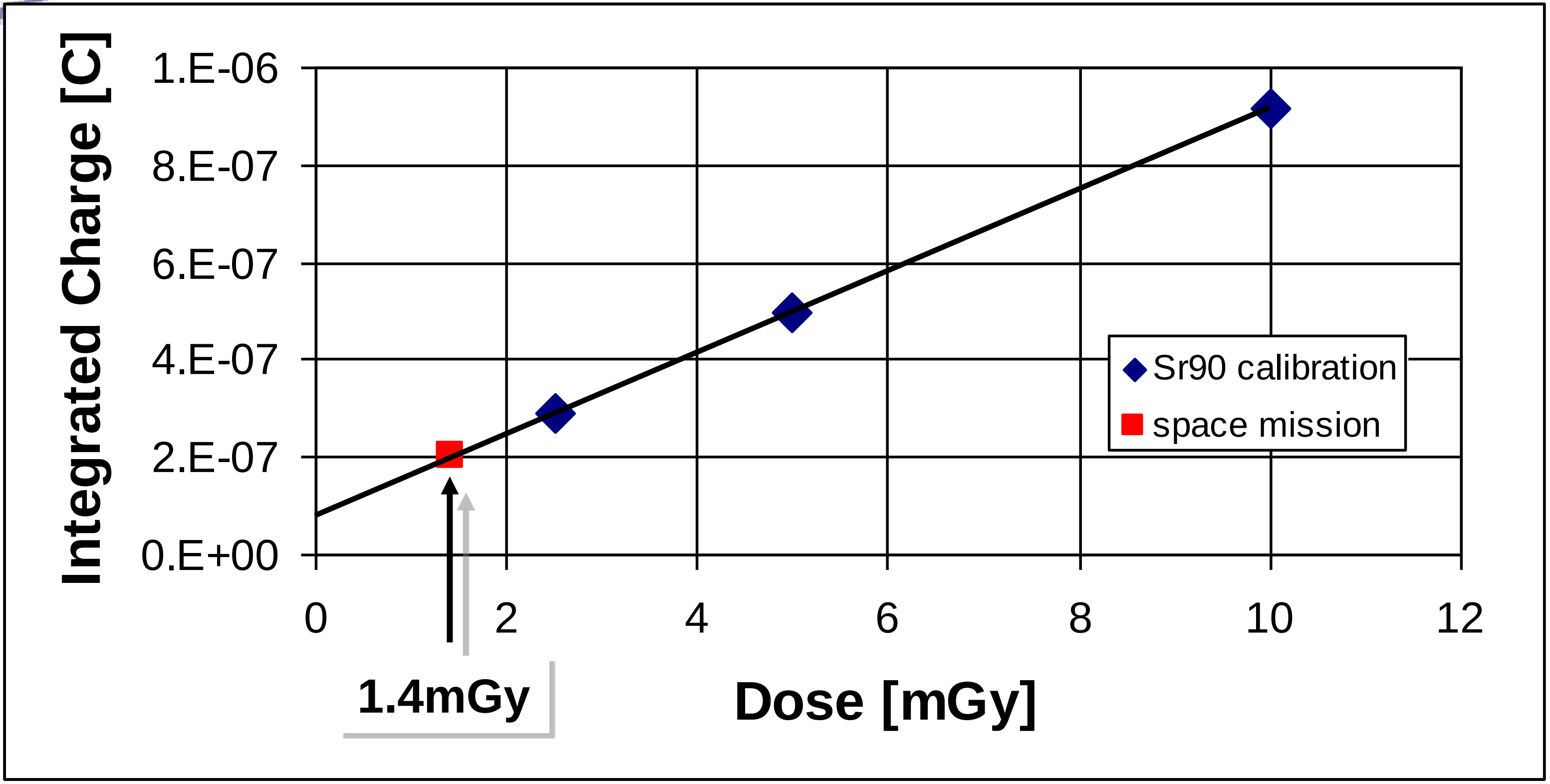
BIOKON

Foton integration

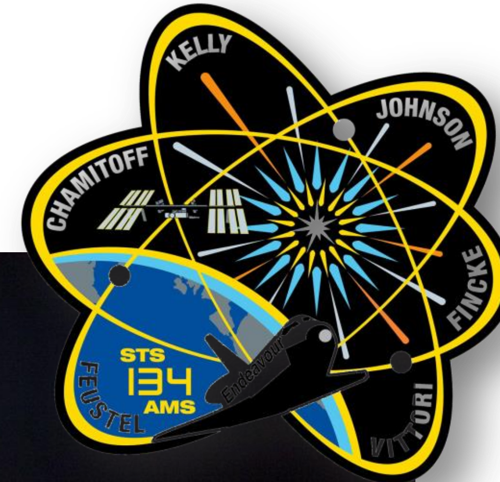




Measured dose



STS 134


KELLY
JOHNSON
FINCKE
VITTORI
FEUSTEL
CHAMITOFF
STS
134
AMS
Endeavour

BIOKIS

Multiexperimental facility

7 experiments in the area of cellular biology, effects of radiation and radioprotection, ageing, germination and plant growth.

- BioS-SPORE
- PHOTO-EVOLUTION
- HiDOSE: Heavy Ions DOSimetry Experiment
- TARDIKISS: Tardigrades in Space
- 3DISS: DNA on Diamond Dosimeters onboard ISS
- nDOSE: neutrons DOSimetry Experiment
- Arabidops-ISS

3DISS
Targets

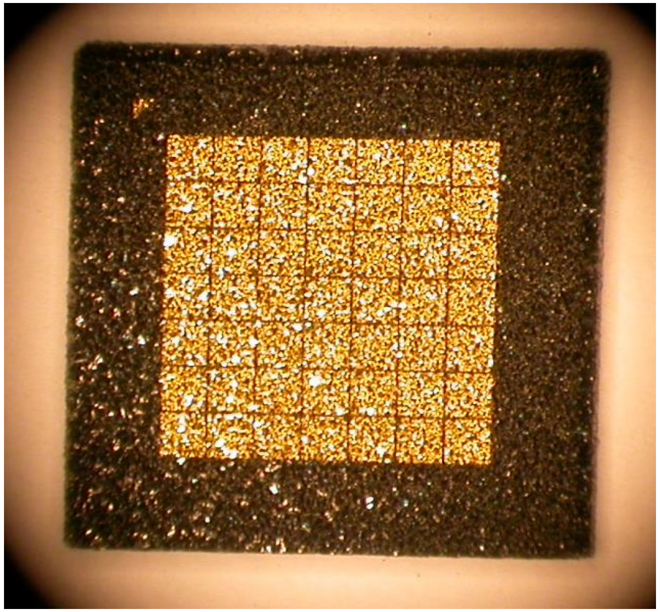
To measure the radiation dose by using an innovative device based on a tissue equivalent substrate.

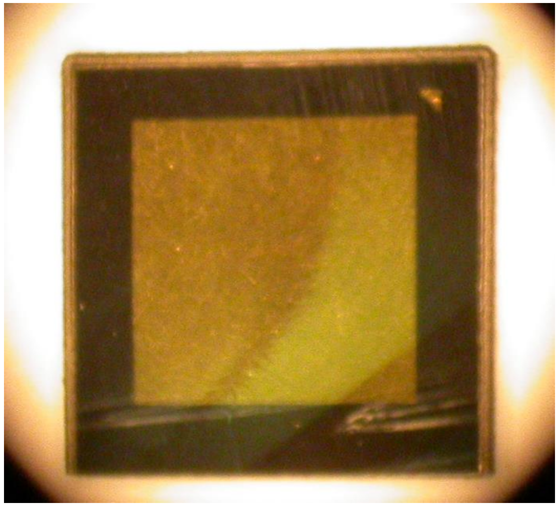
To measure the total radiation damage induced by the radiation environment on genetic material.

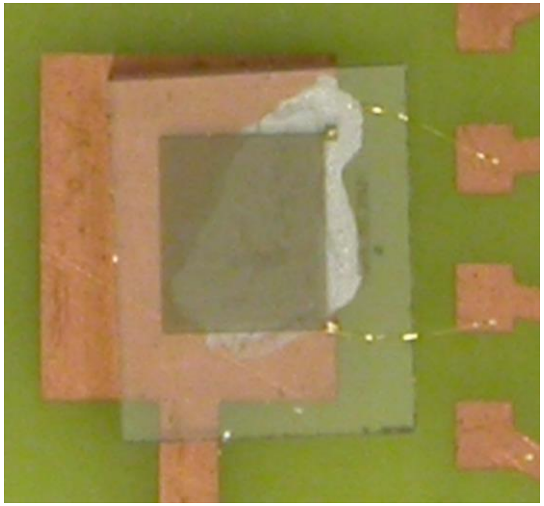
To correlate the 3DISS results with the radiation environment measured by other experiments.

To correlate dosimetric measurement with type and amount of the total radiation damage.

3DISS
Diamond dosimeters

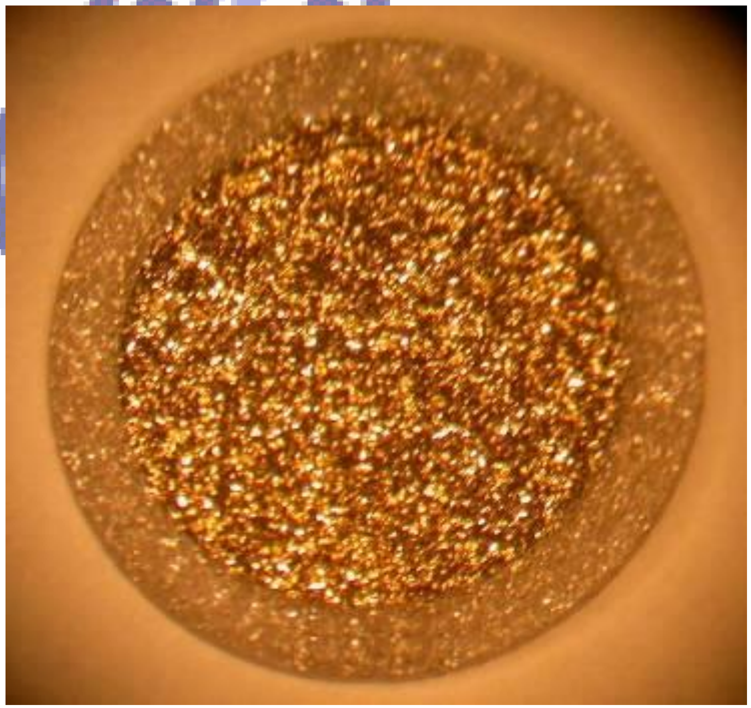






- Tissue equivalent
- Biocompatible
- Radiation hard
- Chemically Inert
- Single high temperature intra-gap defect level

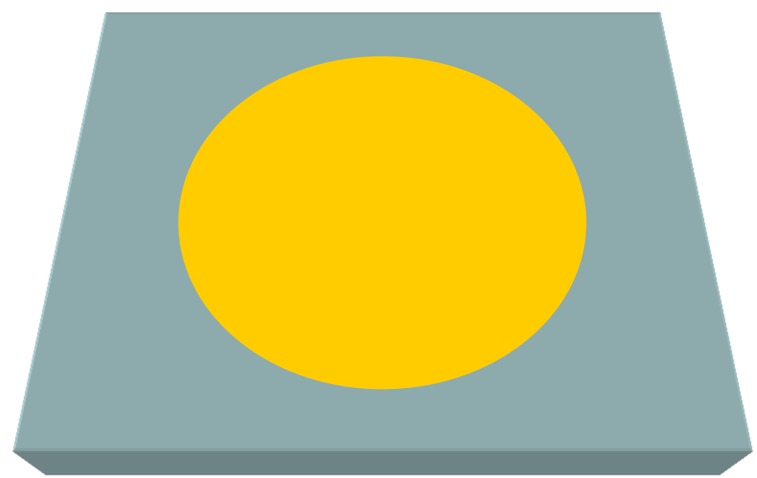
3DISS
Experiment



3 diamond dosimeters

17 NA samples

4 dosimeters + NA



Collaborations

- UniRoma La Sapienza
- ENEA - Casaccia
- Uni Roma TV
- UniRomaTre
- UniFI
- Elettra
- Sitael
- CAEN
- Kaiser Italia
- CNRS (F)
- Diamond Materials GmbH (D)
- Atomki (H)

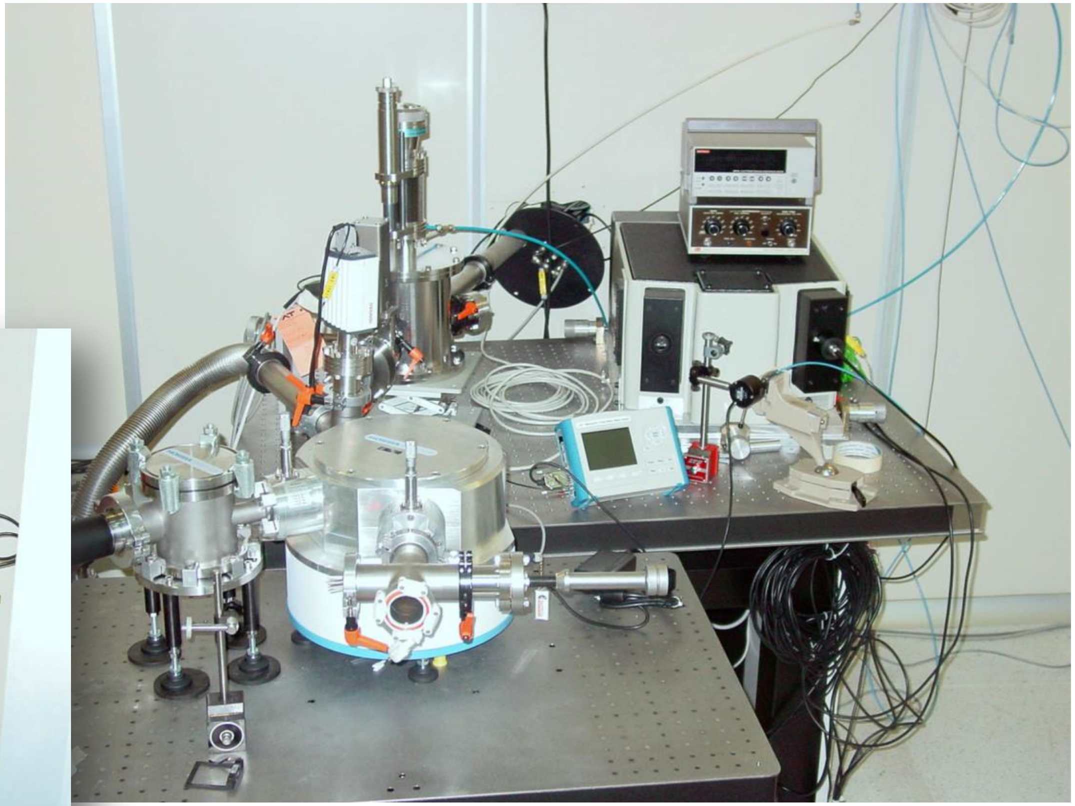
RADIA
EU FP7 project

MONSTRE
EU H2020 project

Collaborations @ LNF

- SCF Lab
- LAMPS
- XLab
- Mu2e
- 3L-2D

The lab @ DAFNE-L



The fab @ DAFNE-L

Merging instrumentation from UniFI
Human resources needed
An applied physics service recommanded

The future

- Innovation @ LNF
- Detector fab @ DAFNE-L
- Ultra-fast diamond detectors
- Pixellated and large area detectors
- Diamond micro-devices
- Space application of X-UV detectors & dosimeters
- Dosimeters for implantation
- Development of small particle “identifier”
- Integrated devices with policapillaries (XLab)
- Development of readout electronics & devices
- Non-diamond IR & UV detector a viable future