

14 April 2010 – IRRAD Working Group

# **EIROFORUM RADHARD Workshop in Lisbon 16-18 March 2010**

**Markus Brugger & Michael Moll**

**- some comments –**

***Note:** A report on the Workshop conclusions is being prepared  
(to be submitted to management of EIRO members)*

***Note:** CERN members of organizing committee (Anghinolfi, Brugger, Moll)  
have planned to give a presentation at CERN when the report is finalized*



# What is EIROforum?



## • EIROforum

- EIROforum is a partnership of Europe's seven largest intergovernmental research organizations. In EIROforum, these organizations pursue joint initiatives, combine resources, and share best practices.

## • The seven EIROforum members are:

- **CERN - European Organization for Nuclear Research**
- **EFDA - European Fusion Development Agreement**
- **EMBL - European Molecular Biology Laboratory**
- **ESA - European Space Agency**
- **ESO - European Organisation for Astronomical Research in the Southern Hemisphere**
- **ESRF - European Synchrotron Radiation Facility**
- **ILL - Institut Laue Langevin**

**RADHARD  
Workshop**

## • EIROforum Instrumentation Group (*1 out of 5 EIRO working groups*)

*The seven intergovernmental organisations involved in EIROforum have extensive expertise in large infrastructures relying on high-technology instrumentation. In the general context of integrated instrumentation systems, the Instrumentation Thematic Working Group develops its activity around two main areas:*

- *Exploring the fields of expertise of the EIROs, and identify areas where cooperation would bring clear added value.*
- *Fostering an efficient information exchange across their organisations by means of specific and dedicated tools such as schools, workshops and databases. While large audience conferences are organised mainly according to disciplines (synchrotron radiation, fusion, astronomy etc.), these dedicated events will be built up to encourage more targeted networking within the EIROs.*



# Euroforum Workshop – March 2010



## EIRO WORKSHOP

RADIATION HARDNESS MEASUREMENT,  
TESTING AND MATERIALS

16-18 MARCH 2010, LISBON, PORTUGAL



Home Team Contact

you are here: [home](#)

News

Overview

Programme

Guidelines to speakers  
and participants

Registration

Registered participants

Venue

Accommodation

How to reach Lisbon

Moving around Lisbon

Organizing Committee

Contact Information

About Lisbon...

EIROforum

Registration page  
intermittent failure

## Welcome to the Radiation Hardness Measurement, Testing and Materials Workshop Portal



Workshop on Radiation hardness, jointly organized by the EIROforum organizations



The first topical Workshop on "Radiation Hardness Measurement, Testing and Materials" – RadHard2010 - will be held from 16 to 18 March 2010, in Lisboa, at "Instituto Superior Técnico", the largest Portuguese engineering school ([www.ist.utl.pt](http://www.ist.utl.pt)). The RadHard2010, sponsored by the EIROforum Instrumentation Working Group, is organized by "Instituto de Plasmas e Fusão Nuclear" (IPFN) ([www.ipfn.ist.utl.pt](http://www.ipfn.ist.utl.pt)), the leading research unit of Association EURATOM-IST, on behalf of EFDA-JET.

The exposure to radiation and its impact on performance and operability of the experimental equipment is a common aspect which congregates the challenges faced by most of the EIROforum members. The main purpose of the workshop is bringing the various experts together from all EIRO's and allowing for exchange between them on methodologies and experiences in this specific field, and providing some seeds for future cooperation. Based on the presentations and discussions, opportunities for future collaborations will be explored.

### news

Registration page intermittent failure  
2010-03-09

Map - Location of Auditorium of Complexo Interdisciplinar  
2010-03-06

Registration webpage is open!  
2010-01-21

Rad Hard 2010 1st Announcement  
2009-06-03

[More news](#)

<http://radhard2010.ipfn.ist.utl.pt/>



# 45 Participants



Surname	Name(s)	Institution
Angelone	Maurizio	ENEA
Anghinolfi	Francis	CERN
Bagatin	Marta	DEI - University of Padova
Boccardi	Andrea	CERN
Bracco	Chiara	CERN
Bravin	Enrico	CERN
Brichard	Benoît	SCK-CEN
Brugger	Markus	CERN
Carlier	Etienne	CERN
Erd	Christian	ESA
Faccio	Federico	CERN
Farthouat	Philippe	CERN
Fernandes	Luis	INOV
Ferrere	Didier	Uni of Geneva
Glaser	Maurice	Cern
Gonçalves	Bruno Soares	IPFN
Hernando	Montse Felip	Fusion for Energy
Hessey	Nigel	Nikhef
Léon	Agustín Fernández	ESA
Lousã	Pedro	INOV
Moll	Michael	CERN
Murari	Andrea	JET
Nieminen	Petteri	ESA
Ortigão	Catarina	LIP
Perna	Lorenzo	Fusion for Energy
Piedade	Fernando	INOV
Pillon	Mario	ENEA Frascati
Plewinski	Francois	ESS Scandinavia
Poivey	Christian	ESA

Ravotti	Federico	CERN
Rodrigues	Pedro	LIP
Sanz	Raquel	Ibérica del Espacio
Semprimoschnig	Christopher	ESA
Silva	Antonio	Instituto de Plasmas e Fusão Nuclear
Spiezia	Giovanni	CERN
Syme	Brian	EFDA CCFE Association
Tavlet	Marc	CERN
Vale	Alberto	IPFN
Varela	Paulo	IPFN
Vicente	Sehila M. Gonzalez de	EFDA
Villari	Rosaria	ENEA
Vincke	Helmut	CERN
Watkins	Michael	EFDA-JET CSU
Wijnands	Thijs	CERN
Wong	John	ESA

**38% CERN – HEP (17)**

**47% EFDA – Fusion (21)**

**13% ESA – Space (6)**

**1 person from ESS**



# Participation: Facilities Working Group



## Programme Committee



The scientific programme will be prepared by a Programme Committee in which all interested EIRO organizations will be represented. At this stage, the committee is composed by the following nominated members:

### EFDA-JET:

- Bruno Gonçalves (✉ [bruno@ipfnSPAMNOT.ist.utl.pt](mailto:bruno@ipfnSPAMNOT.ist.utl.pt))
- Andrea Murari (✉ [amura@jetSPAMNOT.uk](mailto:amura@jetSPAMNOT.uk))

### CERN:

- Michael Moll (✉ [Michael.Moll@cernSPAMNOT.ch](mailto:Michael.Moll@cernSPAMNOT.ch))
- Markus Brugger (✉ [Markus.Brugger@cernSPAMNOT.ch](mailto:Markus.Brugger@cernSPAMNOT.ch))
- Francis Anghinolfi (✉ [Francis.Anghinolfi@cernSPAMNOT](mailto:Francis.Anghinolfi@cernSPAMNOT))

### ESA:

- Alan Owens (✉ [aowens@rssiSPAMNOT.esa.int](mailto:aowens@rssiSPAMNOT.esa.int))
- Christian Erd (✉ [cerd@rssiSPAMNOT.esa.int](mailto:cerd@rssiSPAMNOT.esa.int))

### ESRF:

- Cyril Ponchut (✉ [ponchut@esrfSPAMNOT.fr](mailto:ponchut@esrfSPAMNOT.fr))

### ILL:

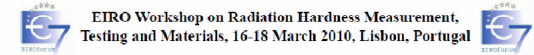
- Bruno Guerrard (✉ [guerard@illSPAMNOT.fr](mailto:guerard@illSPAMNOT.fr))

## Speakers

### CERN

1. Francis Anghinolfi (CERN)
2. Markus Brugger (CERN)
3. Federico Faccio (CERN)
4. Yacine Kadi (CERN)
5. Michael Moll (CERN)
6. Marc Tavlet (CERN)
7. Jan Troska (CERN)
8. Helmut Vincke (CERN)
9. Thijs Wijnands (CERN)
10. Nigel Hessey (CERN)

## Presentation on behalf of Working Group



### Present and Future Irradiation Facilities at CERN

Michael Moll

CERN- PH-DT - Geneva - Switzerland

- for the CERN irradiation facilities Working Group -

<http://www.cern.ch/irradiation-facilities>

#### OUTLINE

- Need for irradiation facilities at CERN
- What is an irradiation facility?
- CERN accelerator complex and CERN irradiation facilities
- A survey on future needs
- Future facilities and plans (possible facility upgrades)
- Summary & Input for discussions

**Facilities working group members**

... find a copy of the final version on our website : <http://www.cern.ch/irradiation-facilities/>



# Euroforum Workshop: Sessions



## Welcome and Introduction

- CERN, Philippe Farthouat
- Joint European Torus - JET, A. Murari
- ESA, Christian Erd
- European Spallation Source, Francois Plewinski (ESS)

## 1: Radiation Environments; Markus Brugger

- Challenges arising from the Super-LHC project -- Nigel Hessey (CERN)
- Monte Carlo Simulations of Radiation Fields in Accelerator Environments -- Markus Brugger (CERN)
- Radiation Shielding in Accelerator environments -- Helmut Vincke (CERN)
- Space radiation environment and shielding -- Petteri Nieminen (ESA)
- Radiation environment and shielding for fusion -- A.Murari (EFDA-JET)
- Determining the radiation field in a fusion machine -- B. Syme (EFDA-JET)

## 2: Standardization, Radiation Hardness

### Assurance & Qualification; Christian Poivey

- Space radiation hardness assurance -- Christian Poivey (ESA)
- Standardisation & qualification for space -- Jonh Wong (ESA)
- Status of ECI and other European qualification programs -- J.Wong (ESA)
- Radiation hardness policy in LHC experiments -- F.Anghinolfi (CERN)

## 3: Materials; Federico Ravotti

- Materials in space environment -- Christopher Semprinoschnig(ESA)
- Material damage studies at CERN -- Marc Tavlet (CERN)
- In-orbit testing of Materials and Components -- C.Semprinoschnig (ESA)

## Topics organized in 6 sessions

## 4: Components; Francis Anghinolfi

- Design techniques and tools for the radiation hardening of ASIC and FPGA -- Agustin Fernandez-Leon (ESA)
- Radiation related challenges for space applications -- Christian Poivey (ESA)
- The technology of CVD diamond detectors for fusion -- Mario Pillon (EFDA)
- LHC experiments: a large scale application of HBD for ASICs -- F.Faccio (CERN)
- Radiation damage in optoelectronic components and optical fibers -- Jan Troska (CERN)
- Evaluating SEU sensitivity in the LHC environment -- Federico Faccio (CERN)

## 5: Irradiation facilities; M. Watkins

- Irradiation Test facilities and methods for component testing -- C.Poivey (ESA)
- Present and future Irradiation Facilities at CERN -- Michael Moll (CERN)
- Test & Qualification of electronic components for accelerators-- T.Wijnands (CERN)
- Irradiation test facilities for fusion -- Sehila M. Gonzalez (EFDA)

## 6: Radiation Monitoring; P.Nieminen

- Dosimetry and radiation monitoring(for Instrumentation protection) at CERN -- Thijs Wijnands (CERN)
- Dosimetry and radiation monitoring for space applications -- P.Nieminen (ESA)
- Calculation of shutdown dose rate for fusion devices -- Sara Villari (EFDA-JET)

## 7: Roadmaps (summary by session chairs); C.Erd

## 8: Wrap-up and way forward; Bruno S. Gonçalves



# Session 5: Irradiation Facilities

## Christian Poivey - ESA



### Irradiation Test Facilities and Methods for Component Testing

Christian Poivey  
ESA  
Component Space Evaluation and Radiation Effects Section

### TID Test Standards

- Test Standards
  - ESCC 22900 issue 3
  - US MIL-STD1019.7
- Test guidelines
  - ASTM F1892

### TNID Standards and Guidelines

- Test Standards
  - No standard currently
- Test guidelines
  - “proton test guidelines – lessons learned” NASA GSFC guideline, August 2002
  - ESA guideline in progress
    - Imaging devices
    - Optocouplers, LED, Phototransistors
    - Bipolar devices
  - ECSS planned

### SEE Test Standards and Guidelines

- Test Standards
  - ESCC 25100, “Single Event Effects Test Method and Guidelines,” Issue 1, October 2002
  - MIL-STD750E Method 1080 “*Single Event Burnout and Single-Event Gate Rupture*”
    - Specific for SEB and SEGR in power MOSFETs
- Test Guidelines
  - JESD57 “Test Procedures for the Measurement of Single-Event Effects in Semiconductor Devices from Heavy Ion Irradiation”
  - ASTM F1192M-95 “*Standard Guide for the Measurement of SEP Induced by Heavy Ion Irradiation of Semiconductor Devices*”
  - JESD89-1A “*Test Method for Real-Time Soft Error Rate*”
    - Heavily used for SER testing for ground level applications

- **TID, TNID, SEE - testing**
- **Test standards defined for radiation tests**
  - **Standards for TID and SEE testing available**
  - **No standard for TNID available (under preparation)**



# Session 5: Irradiation Facilities

## Christian Poivey - ESA



### Irradiation Test Facilities and Methods for Component Testing

Christian Poivey  
ESA  
Component Space Evaluation and Radiation Effects Section

### TID Irradiation Test Facilities

- Isotron UK: providing 60Co, electron beam and protons up to 10MeV.  
<http://www.isotron.com/>
- ENEA-Casaccia (Rome , Italy) Calliope 60Co gamma ray facility (in pool)  
<http://www.casaccia.enea.it/>
- Náyade-CIEMAT (Madrid, Spain) 60Co irradiation test facility (in a pool)  
<http://www.ciemat.es>
- UCL (Louvain-la-Neuve, Belgium) 60Co facility, <http://www.uclouvain.be/en-universite.html>
- CEA (Saclay, France) 60Co facility  
[http://www.cea.fr/le\\_cea/les\\_centres\\_cea/saclay](http://www.cea.fr/le_cea/les_centres_cea/saclay)
- ONERA DESP (Toulouse, France) 60 Co facility, <http://www.onera.fr/desp-en/facilities.php>
- ESTEC (Noordwijk, The Netherlands) 60Co facility,  
<https://escies.org/ReadArticle?docId=251>

### European Test Facilities - Protons

- Paul Scherrer Institute, Switzerland  
<http://pif.web.psi.ch/>
  - Low energy PIF
    - Energy range: 6 to 70 MeV
    - Proton flux:  $<5 \cdot 10^8$  p/cm<sup>2</sup>/sec
    - Beam spot: circle, up to 9 cm diameter,
    - Beam uniformity: > 90% over 5 cm diameter
  - High energy PIF
    - Initial proton energies: 254, 212, 150, 102 and 60 MeV.
    - Energies available with PIF degrader: quasi continuously from 35 MeV up to 300 MeV
    - Gaussian-form initial beam profiles with minimum FWHM=6 cm. (Can be flattened)
    - The maximum diameter of the irradiated area:  $\phi$  9 cm.
    - Neutron background: less than  $10^{-4}$  neutrons/proton/cm<sup>2</sup>.
- CYCLONE , Universite catholique de Louvain, Louvain-la-Neuve, Belgium [www.cyc.ucl.ac.be](http://www.cyc.ucl.ac.be)
  - Proton beam line (LIF)
    - 10 to 75 MeV, either by cyclotron adjustment or using plastic degrader
    - 10% uniformity over 10 cm diameter
    - neutron fluence/proton fluence  $1-5E-4$  (depending on neutron energy)
- Many others in Netherlands, France,...

### European Test Facilities – Heavy Ions

- CYCLONE , Universite catholique de Louvain, Louvain-la-Neuve, Belgium  
[www.cyc.ucl.ac.be](http://www.cyc.ucl.ac.be)
  - 2 cocktails, 3.75 MeV/u and 9 MeV/u
- RADEF, Jyvaskyla University, Jyvaskyla, Finland,  
<https://www.iyu.fi/fysiikka/en/research/accelerator/radef/>
  - ~ 10 MeV/u ion cocktails

### European Test Facilities - Neutrons

- CYCLONE , Universite catholique de Louvain, Louvain-la-Neuve, Belgium [www.cyc.ucl.ac.be](http://www.cyc.ucl.ac.be)
  - Monoenergetic Neutron Beam Line
    - Energy range 25 to 75 MeV, via protons on lithium target
    - Collimated beam
- Many others in France, Belgium, Sweden,...

### European Test Facilities – Heavy Ions

- GANIL, Caen, France,
  - 50 MeV/u beams (one ion at a time)
- GSI, Darmstad, Germany,
  - 1GeV/u beam (one ion at a time)
- LNS, Catania, Italy,  
<http://www.maprad.com/nuovo/lns/en/index.php>
  - 25 MeV/u beam

- Long list of facilities covering needs for ESA (TID, TNID and SEE)
- To my understanding no need/interest for CERN facilities



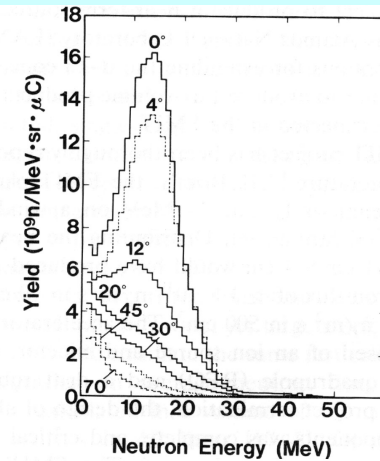
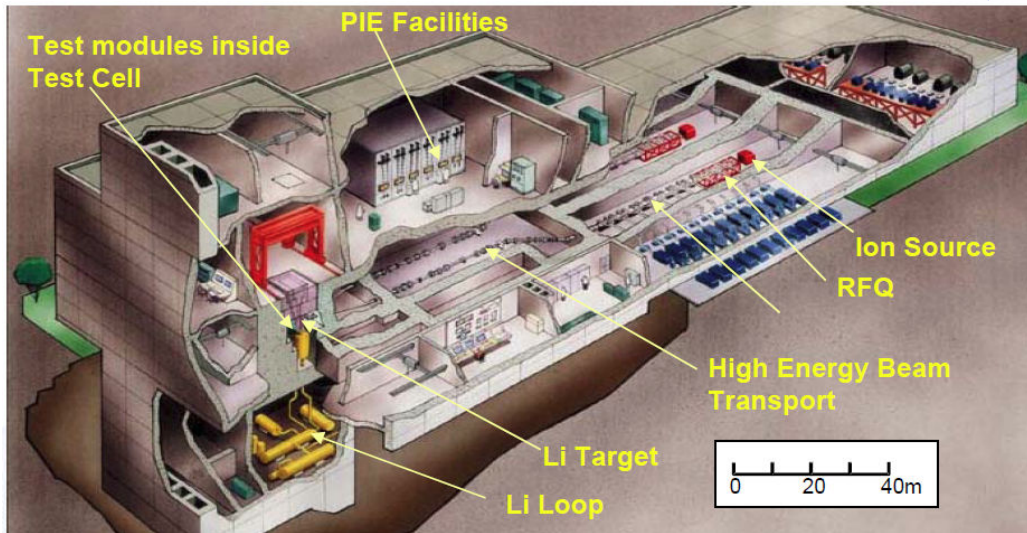
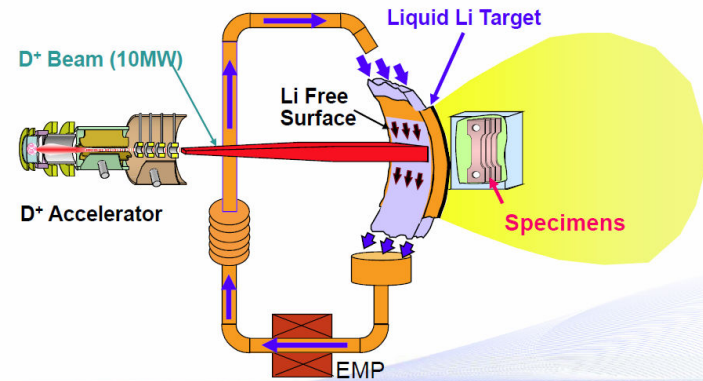
**Irradiation test facilities for fusion**

Sehila M. González de Vicente  
Materials Responsible Officer  
EFDA-Garching CSU

Eric. R. Hodgson  
CIEMAT, SPAIN

250 mA D<sup>+</sup> beam

IFMIF uses the reaction:  ${}^7\text{Li} (d, n) {}^7\text{Be}$



- **Need very high intensity neutron source for material testing of inner wall and other components** (*14 MeV n up to 3dpa for ITER, up to 20-50 dpa for follow-up reactors*)
- **Planned Facility: IFMIF in Japan ..... operational in 2020??**



# Session 5: Irradiation Facilities

## Sehila M. González de Vicente - EFDA



**Irradiation test facilities for fusion**

Sehila M. González de Vicente  
Materials Responsible Officer  
EFDA-Garching CSU

Eric. R. Hodgson  
CIEMAT, SPAIN

Materials	Experiments	Actual parameters
Austenitics, RAFM, ODS, Ni-alloys, Cu, Cr, W-alloys	SOSIA, SUMO, SPICE, SIWAS, SIRIO, SINAS, SICCROWD, ExtreMat	350-1200 K Na, water, He Up to 15 dpa_SS
Divertor materials and mock-ups; Primary Wall Modules; Irradiation-Creep/Stress Relaxation	PARIDE, ExtreMat, POSITIFE, STROBO	400-1200 K He Up to 3 dpa
Graphites, doped graphites, SiCSiC	SICCROWD, INNOGRAPH, ExtreMat, BLACKSTONE,	500-1300 K He, CO <sub>2</sub> Up to 25 dpa_g
Li-ceramics, Pb-alloys, Beryllium, PebbleBeds	EXOTIC, LIBRETTO, HICU, HIDOBE, PBA With He+H <sub>2</sub> purge, with monitoring of <sup>3</sup> H production and permeation	600-1200 K He (+H <sub>2</sub> ) Up to 20% Li burn-up and 20 dpa_SS

● **Example:**  
**Ongoing test at High Flux reactor in Petten (NL)**

- **High intensity neutron sources used (e.g. SINQ PSI or nuclear reactors in Petten and Mol where material is placed in reactor core for e.g. one year)**
- **High intensity gamma sources (e.g. 70 kGy/hr in Petten) and high intensity ion sources for some experiments. (Note: Gif++ has 50 Gy/day at 50cm)**



# Summary of Session 5: Irradiation Facilities

## Michael Watkins – EFDA JET



### Aims

- Collect specific areas with potential for collaborative approach to developments which would increase synergetic benefits
- Identify common facility requirements
- Identify synergies, as well as common grounds (challenges, problems, proposals).
  - Areas of common interest to several organisations
  - Areas viable for knowledge transfer from one institution to others
  - Areas viable for collaborations (sharing) of infrastructure (both available and investment), possibly providing cross institutional access to infrastructure at the partner institutions
  - Potential new technical developments with goals common to more than one institution

### Presentations

- Irradiation Test facilities and methods for component testing: Christian Poivey (ESA)
- Present and future Irradiation Facilities at CERN: Michael Moll (CERN)
- Testing and Qualification of electronic components for accelerators: Thijs Wijnands (CERN)
- Irradiation test facilities for fusion: Sehila M. Gonzalez de Vicente (EFDA)

### Overall conclusion

Session provided good overview and basis for exploring common requirements and challenges, potential for collaborations, developments to facilitate exploitation of synergies



# Summary of Session 5: Irradiation Facilities

## Michael Watkins – EFDA JET



### Needs of each EIRO

#### *Facility capability, availability and upgrade*

- Type of radiation field ( $\gamma$ -rays, electrons, protons, heavy ions, neutrons, mixed radiation fields)
- Sample type and size
- Identification of short-comings
- Sufficiency of beam time (low energy, OK; high energy neutrons, not ok;  $^{60}\text{Co}$  source for  $\gamma$ -rays fully utilised?)
- Plans: e.g. for higher intensity protons, high intensity mixed, 14MeV neutrons

**PROJECT: Catalogue existing and planned irradiation facilities**

**INTERESTED PARTIES: ???**

- Larger size proton beams (Uppsala; upgrade of PSI could be relatively straight forward)

**PROJECT: Upgrade of beam size at PSI**

**INTERESTED PARTIES: Faccio, Wijnands, Poivey**



# Summary of Session 5: Irradiation Facilities

## Michael Watkins – EFDA JET



### Bespoke facilities

- Some facilities constructed to address specific needs of a particular community
- Very high energy beams; structural material testing (hardening, loss of ductility)
- Facility experiment in itself; take full responsibility for much more than just technical specification
- Access by other communities feasible, but legacy issues (eg waste)
- Bespoke facilities likely to have fairly limited common-use demands

**NO PROJECT: Include in Catalogue Project and disseminate information**

### • Outcome of this session (M.Moll view):

- *CERN on-site facilities seemingly not interesting to EIRO partners*
- *Common interest in SEE testing at facilities outside of CERN*
- *What was lacking to my opinion: Participation of Y.Kadi cancelled – Target for high flux beams should be of interest to Fusion, CERN and (ESS).*



# Summary of Session 5: Irradiation Facilities

## Michael Watkins – EFDA JET



### Common-use facilities

- Pointers to potential for collaborative development and use of facilities
- Overlap in testing electronics (bespoke and off-shelf), cabling, power supplies, insulators etc.
- Same intermediaries often used for access to facilities
- Pointers towards specification of common (similar) requirements
- Beneficial to improve accessibility and support structure
- Standardise set-up to facilitate porting of samples between facilities and common-use (ESA purchase equipment/services to allow better use of facility; others eager to exploit)
- Cost and schedule

**PROJECT: Common-use upgrades**  
**INTERESTED PARTIES: ???**



# Summary of Session 5: Irradiation Facilities

## Michael Watkins – EFDA JET



### Testing approaches and challenges

- Merit in comparing results, calibrations, application of standards
- Sharing information on generically similar components
- Testing standards (eg. ESCC 12900, 25100; MIL-STD750E, 1019.7) and guidelines (ASTM F1892); documentation and degree of adherence to recommendations
- Standards require updating, e.g. in view of enhanced effects at low dose rates
- Improve efficiency of testing: validation of high dose rate simulations of low dose rates
- Degree of testing and statistics on variability
- Re-reading existing reports might bring benefits, but labour intensive
- Single Event Effects: Standards, guidelines, statistics for hard errors
- Need for low LET ions, low energy protons

**PROJECT: Document and exchange experience**

**INTERESTED PARTIES: ???**



# Next step .... ongoing



## Template: 1 Session: *SESSION XY*

- **Create documents for each session identifying:**
- Areas of **common interest** to several organizations
- Areas viable for **knowledge transfer** from one institution to others
- Areas viable for collaborations (sharing) of **infrastructure** (both available and investment), possibly providing cross institutional access to infrastructure at the partner institutions
- Areas for collaborations of **software utilities/generic parts**
- Potential **new technical developments** with goals common to more than one institution

- 1.1 **Synergies & Common Challenges and Problems**  
- Try to summarize all points that came up during the discussions.  
- Try to describe common projects & developments, sharing of infrastructure as well as knowledge transfer programs with potential for evolution into concrete projects in more detail below  
- please provide one section for each potential project/development.

1.2 **Name of Potential Technical Development A**

1.2.1 **Interested Partners**

- Identify the interested institutions and contact names

1.2.2 **Purpose of Development**

- Describe why the partners need this development
- Are there any conflicting interests?

1.2.3 **Technical Specifications**

- Give a detailed description of the required development

1.2.4 **Development Steps/Phases**

1.2.5 **Target Timescales of Intended Availability**

1.2.6 **Preliminary Schedule**

1.2.7 **Estimate: Cost and Funding Source/Contributions**

- Rough Order of Magnitude Estimate

1.2.8 **Strategic Way Forward for Implementation**

- Try to identify strategies to arrive to implementation plans

1.3 **Possible Technical Development B**

.....

1.4 **Possible other Collaborations between Organizations**

- Include list of organizations and respective contribution