Radiation tests and Facilities

Julien Mekki on behalf of the Radiation Working Group (RadWG)

Radiation to Electronics Extended project meeting
23 October 2012

Outline

- I. Summary or radiation test
  - *CERN (CNRAD and H4IRRAD)*
  - *PSI*
  - *Others …*
- II. Test reports
- III. Upcoming requirements/requests
- IV. Status of facilities
- V. Conference/forums

CNRAD Radiation test area (1/2)

Mixed radiation field similar to the one expected in LHC

Measured quantities:
- **Dose (SiO_2)**
- **Hadron>20MeV fluence**
- **1MeV neutron eq. fluence**

- **Hottest test location (Target area)**

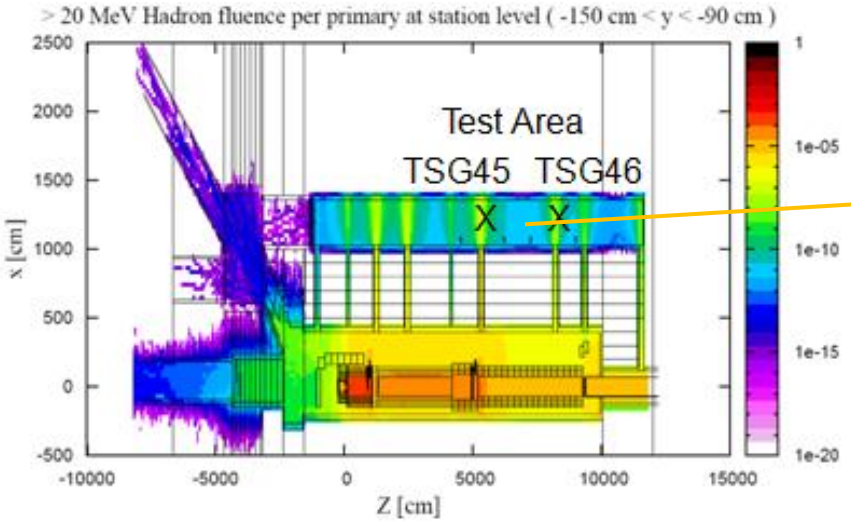
HEH fluence ≈ 3×10^{12} cm^{-2}/week
Dose ≈ 500 Gy/week

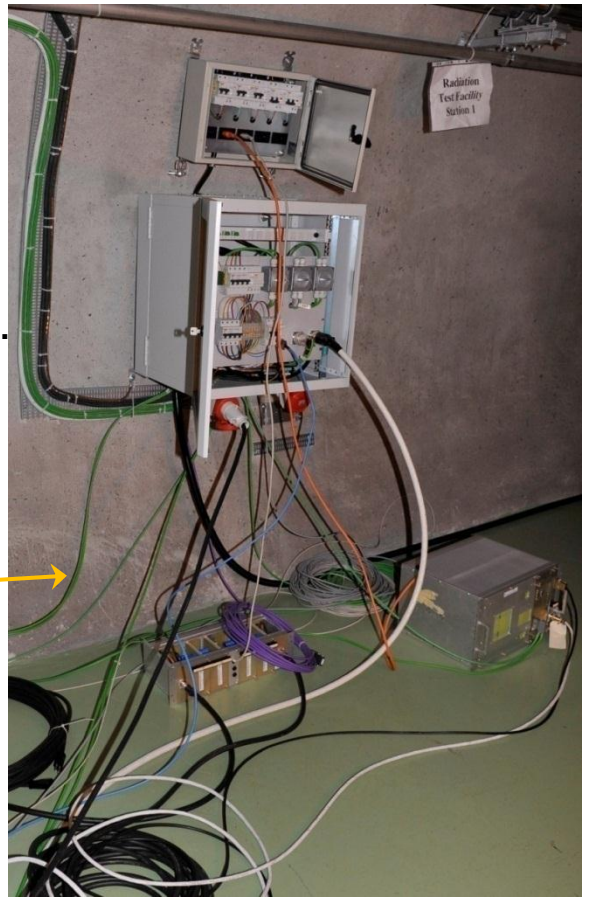
- **Low Flux locations (TSG46)**

HEH fluence ≈ 2×10^{10} cm^{-2}/week
Dose ≈ 3 Gy/week

Extensive Monitoring:
- **RadMons**
- **Compared to BLMs**
- **Gold Foils, TLDs,…**

Detailed FLUKA Simulations for:
- **TID (air), Hadron>20MeV fluence**
- **1MeV neutron-equivalent fluence**
- **Particle-Energy Spectra, Thermals,…**





CNRAD Radiation test area (2/2)

Mixed radiation field similar to the one expected in LHC

Year	Groups/projects	Total number of Slots	Total number of groups
2009	WorldFIP, BPM, BLM, Cryo, QPS, BIC/PIC, Survey, PO	**7**	**8**
2010	Fire detectors, Remote/reset timing, CV, WIC, Ethernet-Switch, Collimation, Timepix, Power converters, CPLDs	**7**	**9**
2011	BLM, DerivFIP, BPM, Power converters, LED warning system, QPS	**6**	**7**
2012	Ethernet switches, Wifi AP, Cryo, Power converters, LED warning system, QPS, BPM, Acquisition crate load sensors, IT beacons, RadMON V.6, RF MosFETs	**4**	**11**

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2010	Fire detectors, Remote/reset timing, CV, WIC, Ethernet-Swi… Collimation, Timepix, Pow… converters, CPLDs		9
2011	BLM, DerivFIP, B… converters, LE… QPS		7
2012	Ethernet switche… Power converters, … system, QPS, BPM, … crate load sensors, IT … RadMON V.6, RF MosFE…	4	11

Since 4 years

24 Slots

35 groups/projects

H4IRRAD Radiation test area (1/2)

Mixed radiation field similar to the one expected in LHC

Measured quantities:
- **Dose (SiO_2)**
- **Hadron>20MeV fluence**
- **1MeV neutron eq. fluence**

- **Hottest test location (downstream target – 2012)**

HEH fluence : 6×10^{12} cm^{-2}/week
Dose: 40 Gy/week

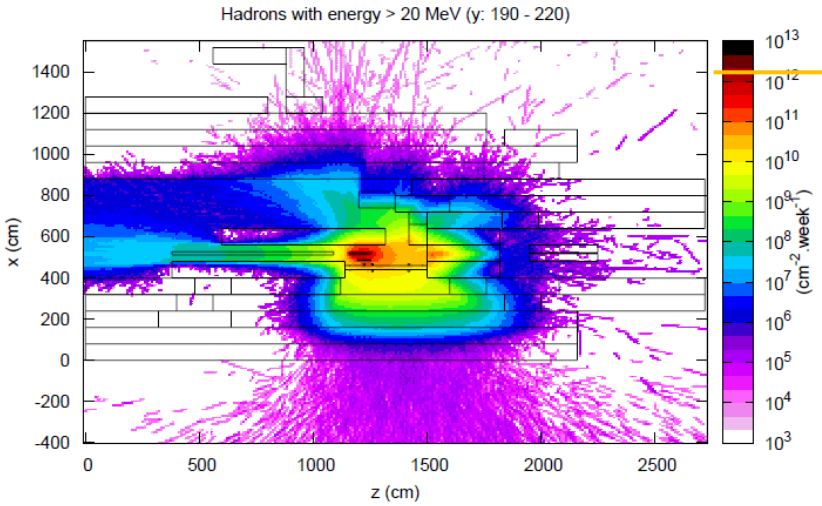
- **External Zone – 2012**

HEH fluence : 8×10^{9} cm^{-2}/week
Dose: 3 Gy/week

Internal/External zone:
- **RadMons**
- **Compared to BLMs**
- **Gold Foils, TLDs,…**

Detailed FLUKA Simulations for:
- **TID (air), Hadron>20MeV fluence**
- **1MeV neutron-equivalent fluence**
- **Particle-Energy Spectra, Thermals,…**

- **For small to bulky equipment**



H4IRRAD Radiation test area (2/2)

Mixed radiation field similar to the one expected in LHC

Year	Groups/projects	Total number of Slots	Total number of groups
2011	EN/STI component tests, PLCs, EN/EL, GTO, ESA SEU monitor, power converters, CMS experiments, Dosimeters RP	**3**	**7**
2012	TE/ABT IGBTs & GTOs, power converters, IT equipments, BPM, EN/STI components, XWCA electronics, Dosimeters RP, RadMON V.6, ESA SEU monitor, EN/EL, EN/ICE, TE/CRG test equipment, SRAM Montpellier, MediPIX test	**3**	**14**

H4IRRAD Radiation test area (2/2)

Mixed radiation field similar to the one expected in LHC

Year	Groups/projects	Total number of	Total number of groups
2011	EN/STI component tests, PLCs, EN/EL, GTO, ESA SEU monitor, power converters, CMS experiments, Dosimeters RP		7
2012	TE/ABT IGBTs & GTO converters, IT equi EN/STI compon electronics, Do RadMON V.6, E EN/EL, EN/ICE, equipment, SRAM MediPIX test		14

Since 2 years

6 Slots

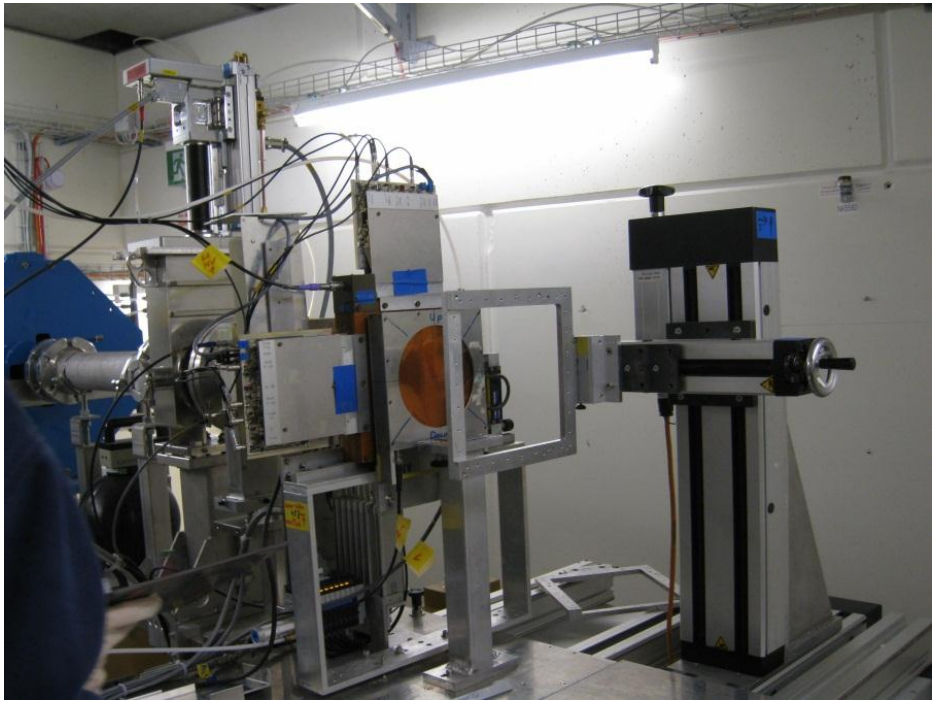
21 groups/projects

PSI – PIF facility (1/3)

Monoenergetic proton beam from 30 – 230 MeV

Measured quantities:

- **Dose (SiO_2)**
- **Proton fluence**
- **Displacement Damage**



- **Beam time available via special agreement (since 2011)**
- **Beam spot < 9 cm**
  - **→ (5 cm uniformity ≈ 90 %)**
- **Maximum Flux at 230 MeV**
  - **→ 1.5×10^8 p/cm^2/s**
- **TID and Displacement Damage (DD) tested at the same time**
- **Accelerated radiation test**
- **(ELDRS not tested)**

PSI – PIF facility (2/3)

Monoenergetic proton beam from 30 – 230 MeV

Year	Groups/projects		Total number of campaigns
2010	April	RadMON, BatMON	2
	December	DerivFIP, RadMON	
2011	February	RadMON, EN/STI Components for PowConv	7
	March	EN/STI Components for PowConv	
	April	FipDiag, NanoFIP, EN/STI Components for PowConv	
	June	EN/STI Components for PowConv, RadMON	
	September	EN/STI Components for PowConv	
	December	EN/STI Components for PowConv, Memories	
	December	NanoFIP	

PSI – PIF facility (3/3)

Monoenergetic proton beam from 30 – 230 MeV

Year	Groups/projects		Total number of campaigns
2012	February (1)	PXI power Supply	12
	February (2)	EN/STI Components for PowConv	
	March (1)	BPM electronics	
	March (2)	EN/STI Components for PowConv, RadFets	
	April	RadMON prototype, EN/STI Components for PowConv, BLM	
	May	OSL, TLD, BE/BI detector	
	June	EN/STI Components for PowConv	
	July (1)	EN/STI Components for PowConv, Profibus Module	
	July (2)	BPM components	
	September	RadMON, EN/STI Components for PowConv	
	October	EN/STI Components for DAQ conditioner	
	November	ADC-DAC for PowConv	

PSI – PIF facility (3/3)

Monoenergetic proton beam from 30 – 230 MeV

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2012	February (1)	PXI power Supply	12
	February (2)	EN/STI Components for	
	March (1)	BPM electronics	
	March (2)	EN/STI Compo	
	April	RadMON p PowCon	
	May	OSI	
	June	F	
	July (1)	E Mod	onv, Profibus
	July (2)	BPM co	
	September	RadMON, E	Components for PowConv
	October	EN/STI Components for DAQ conditioner	
	November	ADC-DAC for PowConv	

Since 3 years

21 test campaigns

Others (Neutron facilities)

NRI (Czech Republic), PTB (Germany), IFE (Norway) , ILL (France)

Year	Groups/projects	Total number of campaigns
2009 (NRI)	Memory Calibrations (RadMON)	**1**
2010 (PTB)		**1**
2010 (ILL)		**1**
2011 (Oslo)		**1**

Others

CEA – Valduc (Neutrons/Gamma)

Year	Groups/projects	Total number of groups
2011	Calibrations of Pin diodes	1
2012	RadMON V.6, Components for PowConv	2

ESTEC, Fraunhofer Institute and IRA (Gamma – Co-60)

Year	Groups/projects	Total number of campaigns
2010 (IRA)	RadFET Calibrations (RadMON) Optical fibers	1
2010 (ESTEC)		1
2012 (Fraunhofer)		1

Others

CEA – Valduc (Neutrons/Gamma)

Year	Groups/projects	Total number of groups
2011	Calibrations of Pin diodes	1
2012	RadMON V.6, Components f	2

ESTEC, Fraunhofer Institute and IR

Year		Total number of campaigns
2010 (IRA)	alibrations adMON) Optical fibers	1
2010 (ESTEC)		1
2012 (Fraunhofer)		1

Since 4 years

10 test campaigns

To summarize …

- CERN experimental test areas:
  - CNRAD and H4IRRAD:
    - **Since 4 years: 56 groups/projects**
- Outside CERN:
  - PSI:
    - **Since 2 years: 21 test campaigns. Framework contract**
  - Other (CEA, ESTEC, Fraunhofer, PTB …) :
    - **Since 4 years: 10 test campaigns**
  - **Since 4 years: Total → 31 test campaigns**

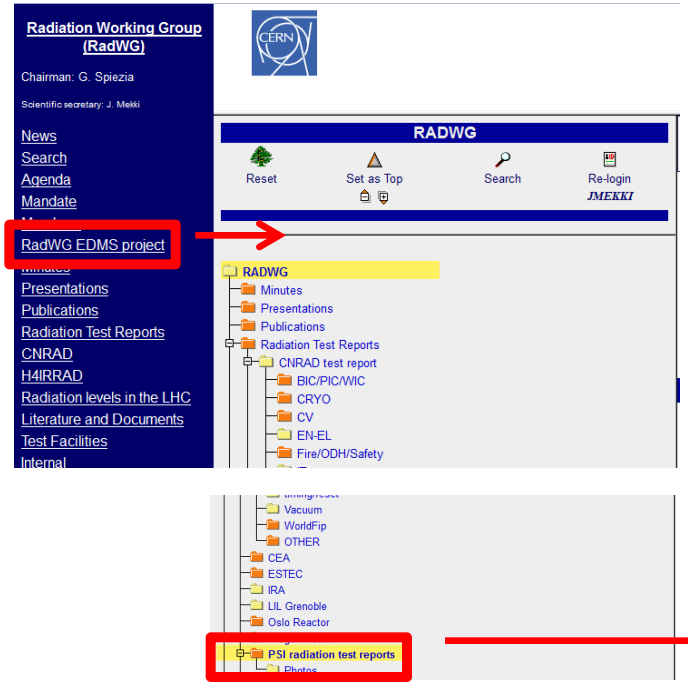
Huge amount of radiation tests

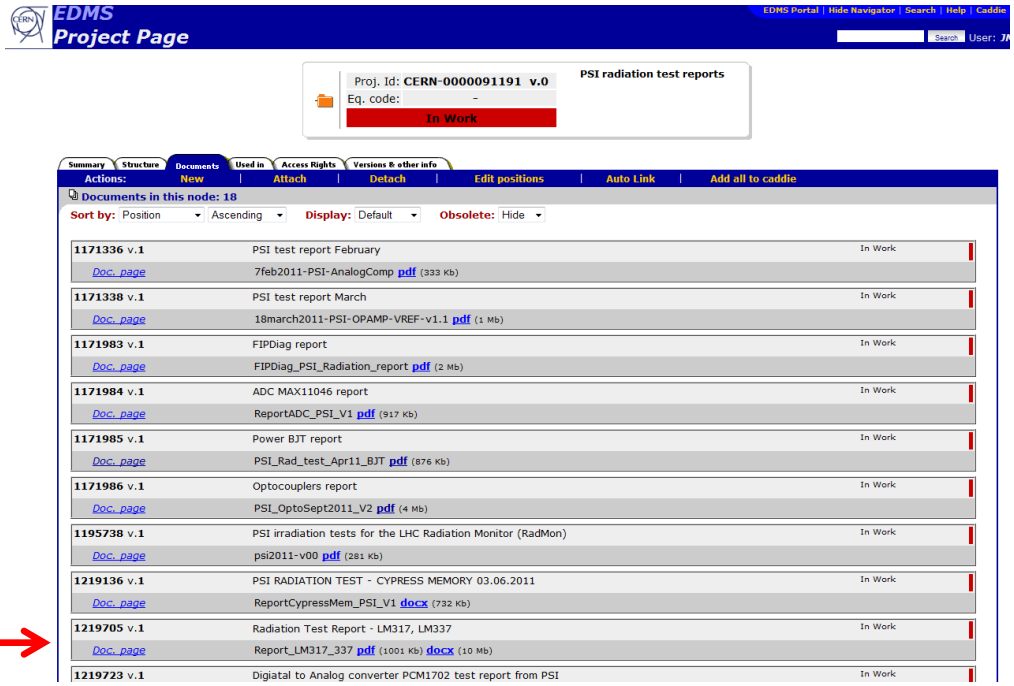
Test reports (1/3)

- Reports are requested at the end of each radiation test.
  - Necessity to keep track of the huge amount of tests
  - Often reminded during meetings (e. g. RadWG)
  - Reports are openly accessible via EDMS
    - https://edms.cern.ch/nav/P:CERN-0000083951:V0/P:CERN-0000083951:V0/TAB3
  - Also accessible via RadWG website
    - http://radwg.web.cern.ch/RadWG/

Test reports (2/3)

- Reports are requested at the end of each radiation test.
  - Necessity to keep track of the huge amount of tests
  - Often reminded during meetings (e. g. RadWG)
  - Report are openly accessible via EDMS and RadWG website





Test reports (3/3)

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  - Necessity to keep track of the huge ar
  - Often reminded during meetings (e. g.
  - Report are openly accessible via EDM

3. OUTLINE

e. g. PSI test report - MosFETs

Upcoming requirements/requests (1/3)

- **Who is requiring tests for next years ?**
  - New LHC-related developments and tunnel remained exposed (up to 20XX)
    - NanoFIP, **Power converters** (**RadTol developments** (up to 2015): FGC-Lite, 120A/600A/4-6-8 kA), **QPS**, Cryogenics, Collimation, RadMON and others …
  - Injector chain (**increase of requirements**)
    - SPS BPM, SPS/PS interlock, BI electronics of transfer lines, PS-Ventilation/Access, RF upgrade of the booster and others …
  - Others
    - LIU/SPS, CLIC, ISOLDE, LHC-Upgrade, LHC experiments….
  - Materials
    - Cables and fibers (impact on all machine), Magnets, Collimators

Upcoming requirements/requests (2/3)

- **2013 – PSI PIF facility**
  - **TE/EPC**
  - **BPM** (2 Slots)
  - **QPS** (1 or 2 slots)
  - **NanoFIP** (2 slots)
  - **Renewal of the contract is ongoing**
  - Legal office prepares a note to get up to **15 slots per year**
    - **In 2013, PSI is the only facility that we will have.**

@ G. Spiezia - RadWG

Upcoming requirements/requests (3/3)

- **Beyond LS1**
  - **Bottleneck** for testing exists already

    → **Will become severe as from 2013/2014**

  - Test campaigns can be significantly optimized if performed partly **«in-house» and in LHC-like (mixed field) environment.**

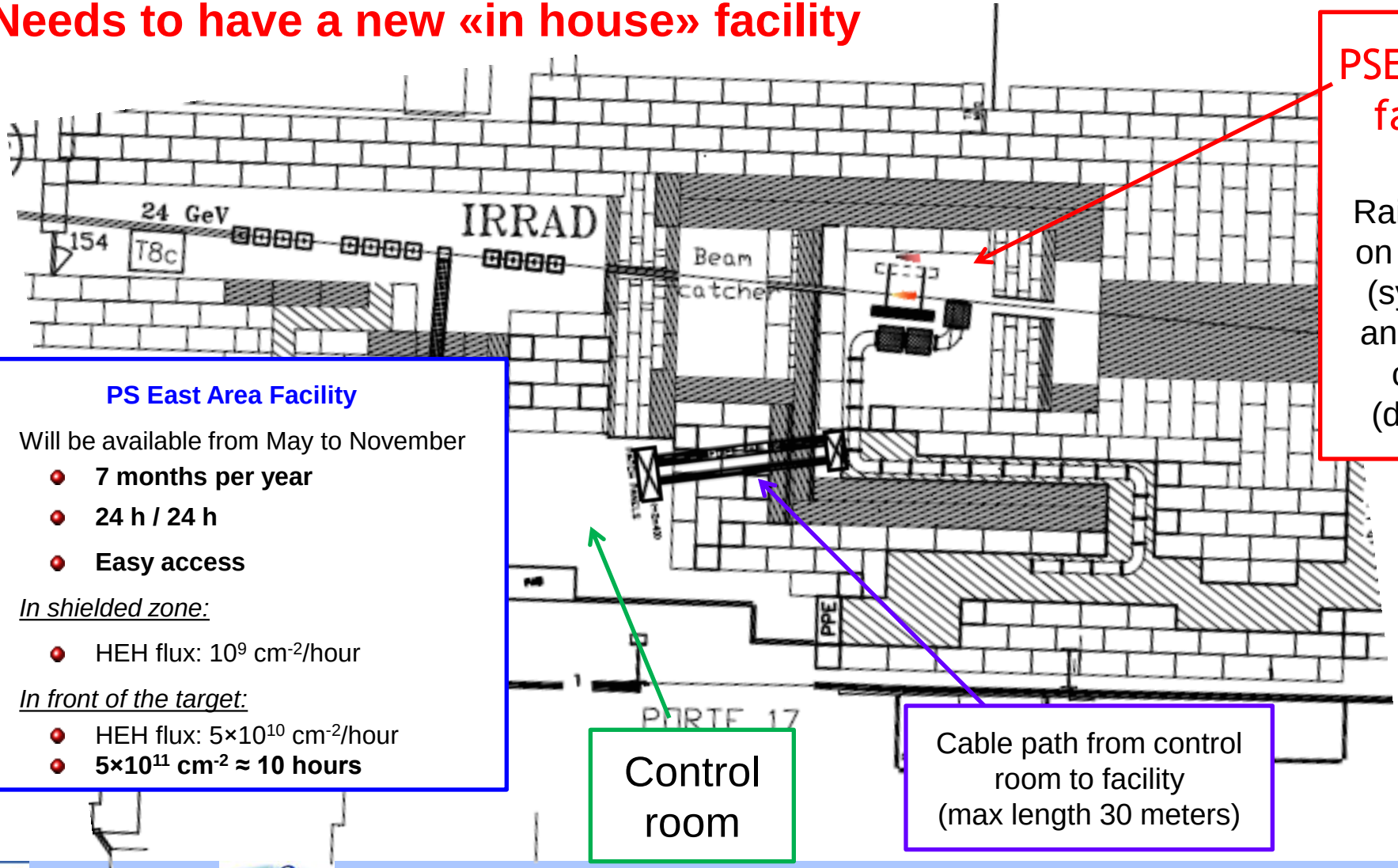
  - **During LS1, the new PS East Area Facility will be built**

Status of facilites (1/3)

- **Beyond LS1**
  - **According to:**
    - **Tests from 2009 to 2012:**
      - **56 groups/projects** (in house CERN) + **31 outside CERN test campaigns**
    - **The huge amount of radiation test in the coming years:**
      - Power converter, QPS, NanoFIP, BLM, RF, BPM, Cryogenics, Collimation, SPS/PS Interlock, PS Ventilation access, LIU/SPS, CLIC, ISOLDE, LHC Upgrade, Cables, fibers, magnets, collimators, IT equipments, RadMON sensors/new version, etc…
    - **The stop of the CNRAD activity**

Status of facilites (2/3)

- **Needs to have a new «in house» facility**



PS East Area Facility

- Will be available from May to November
  - **7 months per year**
  - **24 h / 24 h**
  - **Easy access**
- *In shielded zone:*
  - HEH flux: 10^9 cm^{-2}/hour
- *In front of the target:*
  - HEH flux: 5×10^{10} cm^{-2}/hour
  - **5×10^{11} cm^{-2} ≈ 10 hours**

PSEAIRRAD facility

Rail system on the floor (systems) and on the ceiling (devices)

Control room

Cable path from control room to facility (max length 30 meters)

Status of facilites (3/3)

- Status of the existing facilities/experimental test areas

@ M. Brugger - R2E Review - 2011

	H4IRRAD	External	PS East Area IRRAD
Availability:	Limited	Limited	**Ok**
Access & Space	Acceptable	Limited	**Ok**
Services:	Ok	Limited	**Ok**
Flexibility:	Limited	Limited	**Ok**
Intensity:	Limited	Ok	**Ok**
Physics:	Ok	Very Limited	**Ok**
Long-Term:	Limited	Limited	**Yes**
Man-Power:	High	-	**Ok**
Costs:	Ok	High	**Reasonable**

Conferences/forums

- **Radiation Working Group**
  - Internal CERN Working Group:
    - **Allow to share/distribute:**
      - **Ideas** to perform radiation tests
      - Feedbacks on **sensitive devices**
      - Radiation test **results** (PSI, CNRAD, H4IRRAD and others …)
      - **Radiation levels** inside LHC shielded areas and tunnel
      - Follow-up of **Single Event Effects** inside LHC
      - Update on the **new PS East Area Facility**
      - Summary of **international conferences/workshops**

Conferences/forums

- Through the **Radiation Working Group**
  - This year:
    - Summary of the **SEE symposium** (Viliam Senaj)
    - Summary of the **NSREC conference** (Slawosz Unanski)
    - «Upcoming» Summary of the **RADECS conference** (Salvatore Danzeca, Ruben Garcia Alia, Julien Mekki)
    - **Very useful** for the RadWG community to participate:
      - **Scientific paper:** Dosimetry, SEE mechanisms, modeling, hardening etc …
      - **Radiation data workshop:** Radiation test results sharing (a huge amount of tested devices by the radiation effects community)
        - Power devices, FPGA, sensors, bipolar transistors, optocouplers, SRAM memories etc ….

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    Garcia Alia, Julien Mekki)

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Very important for CERN people:
- To share results
- To take advantage of discussing with experts of the field
- To take contact
- To make collaboration

Conclusions

- **Huge amount** of radiation tests ***performed***
  - CERN (**56 groups/projects** – 4 years)
  - Outside CERN (**31 test campaigns** – 4 years)
- Needs of **radiation test reports** → Openly accessible (RadWG website and EDMS)
- **Huge amount** of radiation tests ***to be performed***
  - New developments
  - LHC-tunnel remained exposed
  - Injector chain systems
  - Materials
  - Other experiments at CERN

→

During and after LS1:
- **PSI facility**

Beyond LS1:
- H4IRRAD
- **New PSEAIRRAD**

(LHC-like – 7 months/year – 24h/24h – Operation 2014)

- Very useful **to participate to the RadWG and conferences** in order to share knowledges and results → Provides a lot of insights for future developments and LHC failure observations.