DevDet, WP9: CONSTRUCTION OF IRRADIATION FACILITIES AT CERN

WP9 Editor: M.Capeans (CERN)
Total cost (direct + indirect): 3 ME, of which requested EU contribution is 1 ME

Task 1: GIFF++ (Task leader: M.Capeans)
Task 2: p,n facilities (Task leader: M.Moll)
Task 3: Material studies (Task leader: J.Greenhalgh)

Partners:

Institute	Shortname	Contact	Email	Task 9.1	Task 9.2	Task 9.3
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WP.9

The high radiation levels expected in SLHC detectors require extensive R&D to study detector performance and their optimization under such conditions, as well as to finding suitable materials, performing control sensors and innovative approaches for detector assembly procedures. The ability to ~~simulate~~ investigate neutron, proton, X-ray, and gamma radiation effects in an experimental setting allows anticipating component failure or developing new systems that can withstand these radiation exposures. In LHC detectors, background rates will be dominated by low-energy photons and neutrons in the outer region (muon systems) and by charged hadrons in the inner part (tracking) of the detectors. Numerous irradiation facilities worldwide have been used extensively to qualify and irradiate detectors in beams compatible with those conditions. At CERN, the existing Gamma Irradiation Facility and the PH Irradiation Facilities in the PS T7 and T8 (protons and neutrons) have been used at 100% of their capacity. To cope with the demanding detector R&D for SLHC, these two facilities need to be significantly upgraded in terms of radiation dose and infrastructure to minimize administrative and setting up procedures, as well as test time. It is also important to improve their user interfaces and accessibility such that more users can use them at short notice, if needed.

Comment [mm1]: I would include a comment regarding the machine at one point to demonstrate that there is a wider community that will use the facilities to be constructed/upgraded.

Comment [mm2]: ..test or investigate ….. for me and maybe also in the context of the proposal (WP2) a simulation is something computer based

Comment [mm3]: ….Gif++ justification and thoughts about facilities in SPS missing…

A major issue facing the design teams on the LHC detectors was that the required assembly materials performance data was not available or not sufficient, therefore their performance could not be accurately predicted. The SLHC detector community demands for a compilation effort to understand what has worked well in LHC, establishing the parameters and test procedures that are need to validate and fully characterize the materials and fluids for the particle detectors foreseen for SLHC.

…. pointing out advantage to have centralized radiation facilities at CERN
…. unique character of irradiation facilities at CERN (high energy)

This work package addresses therefore 3 fundamental issues needed to tackle properly the detector upgrade plans for SLHC:

- The construction of a new gamma facility GIF++ at CERN.
- The upgrade of the proton and neutron irradiation facilities in the CERN PS-T7/T8 beam lines.
- A common research, compilation and dissemination effort towards a global database of suitable materials for SLHC detectors and their services (gas, cooling).

WP.9-Task.1 – Construction of GIFF++

1. General description of the task activities

The CERN gamma irradiation facility (GIF) started to operate in 1997. It allows testing in situ detectors exposed to a high gamma flux from an intense Cs-137 source. Until 2004, detectors placed in the GIF facility could simultaneously be tested in the SPS X5 fixed target beam. Following the dismounting of the SPS West Area beams, simultaneous beam tests are no longer possible, and the facility is scheduled to be shutdown in 2008. This set-up has permitted, in an accelerated manner, the extensive characterization of LHC detectors in presence of background radiation and the optimization of their system services such as the recirculating gas systems for the LHC muon gas detectors. Over the years, the GIF facility has proved to be among the best tools for R&D programs to approve and finalize the detector technologies for LHC. The combination of background radiation and muon beam has made it unique in the world. Moreover, it has often provided a forum where different experiments could fruitfully interchange their experiences and coordinate their studies.

The present plans to develop detectors, especially for SLHC, calls for the construction of new gamma irradiation facility at CERN with an improved layout of the test zone, higher source intensity and the simultaneous presence of a high-energy particle beam. Moreover, new users communities, such as groups working on large silicon detectors, will need to test prototypes and full size detectors with background for noise, oscillation, cross-talk and robustness in a severe high background environment. Access to common infrastructure such as trigger system, readout chain, slow control monitor system, and gas systems are key factors to perform efficient tests. The upgraded facility, called GIF++, is expected to be operational towards 2010. The goal of this task is therefore the identification of the optimal set-up and its dedicated beam line and to supply the generic infrastructure for it.

2. Organization participation

Participant acronym	CERN	Weizmann Institute of Science				
Estimated person-months per participant:						

3. Objectives

(Bullet-style, 1 or 2 lines per objective, 1 objective per sub-task)

- Design the optimal gamma irradiation facility to probe efficiently LHC test detectors and SLHC detector prototypes, freezing the technical requirements for the new source and area layout and infrastructure.
- Define and set-up common infrastructure for the use of the facility.
- Build and operate the facility.

4. Description of work

(~1/2 page, describe the work in the context of the objectives. possibly broken into sub-tasks, indicate for each sub-task the purpose of it, the participants involved in it and their role. If really indispensable, you can divide into subtasks.)

Collect user requirements and perform the design studies to freeze the technical specifications for the optimal gamma irradiation facility. The user requirements will be collected via BLA BLA
The technical specifications will include: area conditioning (heavy work, mechanics, source, filters, safety and RP aspects, control room) and the optimized layout of common services (gas systems, cooling, slow control, dose monitoring, common trigger and readout).
The final objective is the contribution to the construction and operation of the facility.

List of Deliverables for the task

Deliverables of task 1	Person month estimate	Description/title	Nature[1]	Delivery month[2]
9.1.1		Design study of GIFF++ facility	R	M12
9.1.2		Construction of new GIF facility	O	M30
9.1.3		Services for GIF++ operational	O	M36
9.1.4		First Performance and operation report of the new GIF facility	R	M48

List of Milestones for the task

Milestones	Description/title	Tasks involved	Delivery month[2]	Means of verification
9.1.1	User requirements collected	9.1.1	M6	
9.1.2	Area conditioning and heavy work completed	9.1.2	M24	
9.1.3	Commissioning GIF++	9.1.3	M32	
9.1.4	First results from GIF++	9.1.4	M42	

[1] Nature: R=Report, P=Prototype, D=Demonstrator, O=Other
[2] Counted from the starting date

WP.9-Task.2 – Upgrade of ~~Future of present n, p at the PS, possibly combined with CERF++~~proton and neutron irradiation facilities

1. General description of the task activities

It is expected that the demand for irradiation experiments will rise over the coming years: In view of the upgrade towards the SLHC an~~An~~ intense irradiation program will have to take place~~ for the next few years, ~~. Initially, it will ~~at first to~~focus on the ~~investigate~~development and selection ~~the~~of the most suitable ~~best~~ radiation hard technologies for the various detector components of the LHC Experiments and, at a later stage, ~~tracker devices for the upgrade of the LHC General Purpose Detectors (GDP's), and after to~~ assess and monitor the radiation hardness of the qualified ~~devices~~ components during production. In addition it can be expected that, although most of the LHC

Comment [mm4]: To my taste the introduction was too much focussed on tracking detectors, we should keep in mind that although the main users will be coming out of the inner tracking detector community, other communies have an interest in radation tests (e.g. E-CAL!, Electronics,....)

components have been thoroughly tested for their radiation hardness, some might degrade or even fail due to radiation damage. This will call for immediate and extensive irradiation test programs to identify and analyse the failure and qualify replacement components.

The CERN PS-T7 24 GeV/c proton and the PS-T8 neutron irradiation facilities, allowing for high fluence proton and neutron irradiations, have been and still are heavily used for radiation hardness studies of detector and electronic components by a large and varied community of users focussing mainly , and especially for theon the development and validation of detectors for LHC. In the proton irradiation facility samples with an area up to 2x2 cm^2 can be exposed to fluences up to $5x10^{13}$ p/cm^2/hour. In the mixed field of the neutron irradiation facility samples of up to 30x30x30 cm^3 and 5 kg weight can be exposed to fluences up to 10^{12} n_{eq}/cm^2/hour (1 MeV neutron equivalent).
However, fFor SLHC applications, However, ddepending on the sample areas to be covered irradiated and required accumulated dose for the validation of technologies for SLHC applications, the particle intensities and the size of the beam spot may not longer be fully sufficient. For instance, the present design anticipated for the ATLAS tracker upgrade foresees 10x10 cm^2 sensors. and the The R&D program for the SLHC tracker and Vertex detectors will require to achieve irradiation fluences ranging fromup to $1x10^{15}$ cm^{-2} n_{eq} (microstrip detectors) and up to $1x10^{16}$ cm^{-2} n_{eq} (pixel detectors).

The irradiation field radiation doses received by thein the tracker devices in the SLHC areis mainly composed by charged particles emerging from the interaction (adequately represented by the 24GeV/c protons from the CERN/PS) and backscattered neutrons from the calorimeter area of the GDP'sExperiments. -The charged particles will dominate the radiation spectrum at low radii from the beam axis, while the neutrons will be the dominant component at larger radii. The contribution of the neutral and charged particles will be equal at about 20-25 cm from the beam axis. All the microstrip layers will therefore sit in a volume where the radiation damage The radiation field in most of the tracking detector volume is thereforewill be ideally reproduced by a mixed spectrum of 24GeV/c protons and spallation neutrons. A mixed particle irradiation facility to mimic the SLHC spectrum would beis therefore an important tool for the microstriptracking -detector community. Although the a much lower intensity is low compared to the maximum dose received in the tracker and a beam can be envisaged, that would require longeer exposure time is needed, such a facility would still allows a cross check of the radiation results obtained with monochromatic monochromatic particles or with the neutron source only. and will be a plus for the irradiation program towards the SLHC.

At present, other important limitations of the existing CERN/PS proton and neutron (mixed field) irradiation facilities are their restricted space, particles superimposed to the primary beam due to backscattering, the neutron facility is parasitic to a running experiment that limits flexibility, and the proton and neutron facilities are located in different beam lines therefore parallel operation is difficult. The new facility aims at combining proton and neutron irradiation facilities in one, get a proprietary beam line, to increase space for irradiation areas improving also the protection of personnel that will be less exposed to radiation, to allow the exposure of components to high particle flux in reasonable time, the possibility to move samples into beam without entrance into irradiation area, and at establishing an optimized infrastructure to minimize administrative and setting up procedures thus increasing significantly the turnaround.

Therefore tThis task includes design studies and the implementation of the necessary changes to adequate technically the existing PS/T7/T8 facility to the new demands of SLHC, as well as the optimization of its operation and infrastructure to cope with the ever-increasing user community.

2. Organization participation

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Comment [mm5]: We will have a hart time to increase the intensity of the beam significantly – some increase can be gained by activating less the area

Comment [mm6]: Note: The present neutron irradiation facility is already a spallation source!!

Participant acronym	CERN	Glasgow	Liverpool	Sheffield	Weizmann ????
Estimated person-months per participant:					

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3. Objectives

General lines; CERN takes care of fixed, basic infrastructures
UK groups of monitoring systems, set-ups….

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- Elaboration and evaluation of different scenarios to upgrade and adopt the neutron and proton irradiation facilities at CERN in view of the upcoming SLHC irradiation programs
- Design of new proton and neutron irradiation facilities according to outcome of evaluation study.
- Construction and commissioning of the upgraded proton and neutron irradiation facilities according to available funds and approval of CERN management.
- Set up of a scanning table with >10cm^2 reach with local dose monitor and self calibrating scanning software
- Design, construction and commissioning of a temperature controlled cold box for large detector and module irradiation suitable for the scanning table
-
- Set up of a scanning table with >10cm^2 reach with local dose monitor and self calibrating scanning software
- Preparation of a temperature controlled (cool) irradiation box for the scanning facility
- Preparation for cool and under bias irradiation for the single spot (1x1cm2) program??
- Development of a system for monitoring and biasing a large number of Silicon detectors during irradiation
- Use medipix to characteriseDevelopment, design and construction of the online radiation monitoring systems in the proton and neutron areas

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4. Description of work

An evaluation of the requirements of the High Energy Physics community for irradiation facilities based on the very high energy and intense proton beams available at CERN will be performed. The resulting requirement list (M 9.2.1.) will be taken as an input to develop upgrade scenarios for the presently existing facilities. This might for example also include the move of the facilities from their present location in the CERN-PS to the higher energetic CERN-SPS complex. For the most feasable options operation scenarios and cost estimates will be worked out and presented to the CERN management. Upon selection and approval of a specific facility a detailed construction plan will be worked out and finally this workpackage will serve to contribute to the construction and commissioning of the new facilities. In detail the CERN contribution will aim for the area conditioning (heavy work, mechanics, beamlines, safety and RP aspects, control room) and the optimized layout of common services (electrical and gas systems, cooling, slow control, common trigger and readout).
The UK groups Glasgow, Liverpool and Sheffield will design and deliver a cold box that can be scanned through the proton beam to achieve uniform fluences across an area of about 10x10 cm^2 surface. It will be constructed in such a way that it can be installed in the new or the presently existing proton irradiation facility. The system will be monitored in terms of stage position and

movement, temperature and humidity inside the box and fluence. Its main purpose will be the irradiation of Silicon detectors and modules. Therefore,

A facility that allows fast irradiation to SLHC levels with a single exposure to the beam (which implies an homogeneous beam spot larger than 1x1 cm^2) for the intense miniature detector program will be highly regarded by the tracking detector community. Besides the qualification and production quality monitoring program will require the irradiation to high doses of the large area devices, therefore a scanning system to homogeneously irradiate the 10x10 cm^2 surface should be set up, with accurate monitoring of the delivered dose as a function of local position.

The UK groups Glasgow, Liverpool and Sheffield will deliver a cold box that can be scanned through the proton beam to achieve uniform fluences across large samples (~90?) of full-size prototype Si detector and modules. The system will be monitored: stage position and movement, temperature inside the box and fluence. Tthe system will be capable of biasing the detectors and monitoring their current to reproduce realistic operating conditions. Monitoring the current has been shown to be a useful way of characterising the radiation damage [ref]. The system will be based on the system that was used for the ATLAS Si irradiation programme that was built by members of the UK groups [refs].

A beam monitoring system that can monitor the relative fluence remotely will be developed. This will monitor the relative fluence across the box as a function of time to ensure that the devices are uniformly irradiated. Absolute fluence calibration will then be achieved with passive dosimeters positioned inside or on the box. This can be calibrated against Al-foils to determine the absolute fluence delivered during the irradiation. Previous irradiations used glass and foils to monitor the uniformity of the fluence, however this can only be determined at the end of the irradiation. Theeo monitor will consist of a the fluence during the irradiation, a pixellated detector based on a rad-hard technology such as diamond. will be developed, again this builds on previous expertise [refs].

The final deliverable will be a cold box system with a stage and monitoring commissioned in the CERN proton irradiation facility. Operation of the cold box system will then be taken over by the CERN group with the UK groups providing maintenance and expert support.

….. role of Weizmann institute ???????

List of Deliverables for the task
(typically 1 per task per year)

Deliverables of task 1	Person month estimate	Description/title	Nature[1]	Delivery month[2]
9.2.1		Design of cold box systemDesign Report for upgraded proton and neutron facilitiesy	R	M 18246
9.2.2		Design for upgraded proton and neutron facilitiesDesign Report of the cCold box	R	M21M1824
9.2.34		Tested cold box system ready; for delivery to CERN	O	M36
9.2.45		Cold box commissioned at CERN	DO	M 48
9.2.5		Radiation Monitoring system commissioned	DO	
9.2.656		Upgraded facilityies constructed and operationalcommissioned	DO	M48M42
9.2.767		Performance and operation reports of upgraded proton and neutron , n facilityies	R	M48

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List of Milestones for the task

Milestones	Description/title	Tasks involved	Delivery month[2]	Means of verification
9.2.1	Collect requirements from LHC upgrade communities	9.2.19.1 9.29.2.2	M68	Requirements List Report
9.2.1	Collect requirements from LHC upgrade communitiesEvaluation of upgrade scenarios for proton and neutron facilities	9.2.1 9.2.19.22	M12128	Requirements ListFeasibility Report
9.2.2	Outline design of full- scanning table system	9.2.29.21 9.2.2	M14	Design Report
9.2.3	Outline design of irradiation facilities Build and test of sub-systems	9.2.29.2	M18	Design Report
9.2.4	Outline design of radiation monitoring system	9.2	M36	Design Report

[1] Nature: R=Report, P=Prototype, D=Demonstrator, O=Other
[2] Counted from the starting date

WP.9-Task.3 – Qualification of materials and common database

1. General description of the task activities

(Give a short introduction to the general context and objective aimed for in about 1/4 of a page. The text shall be understandable by an outsider. Avoid using too many acronyms.)

The construction of the particle detectors in consideration for the LHC upgrade demands an exhaustive and systematic search for new yet commercially available materials, with attractive properties in terms of density, expansion coefficient, elasticity modulus, radiation hardness, electrical and chemical properties, etc.

A major issue facing the design teams on the LHC detectors was that the required materials performance data were not available. This meant that in some cases excessively conservative designs had to be used and some iterative testing of physical assemblies was required. The lack of data for simulation meant that the performance cold not be accurately predicted. In this task we will establish the shortfall in data for on or more of the LHC upgrade experiments, establish a set of procedures for obtaining the data, stress those procedures by making some tests, and publish the results and the procedures on the web for the benefit of the whole community.

The Task will have three sub-tasks:

Sub-task 1: Compilation of existing knowledge
Find historical info of materials used in LHC
Establish a list of materials being considered for the upgrade, known properties and identification of those that need to be characterized
Search of promising Commercial off-the-shelf (COTS) products

Sub-task 2: Establish procedures for generic bBasic irradiation studies of candidate materials. Select appropriate irradiation facilities. Establish suitable test procedures and locate test facilities. This will include study of activation of module or test structures based on different materials. If the samples are activated, it becomes much harder to make post-irradiation tests.

Use of irradiation facilities for characterization of demonstration materials and beyond (i.e., finding proper assembly procedures for them, chosen for urgency of required data and to exercise the procedures we have established.)
Radiation test of glues, gases, liquids, materials and complete devices that go into the volumen of the Experiments.

Activities proposed by C.Buttar (GLASGOW)
Look at activation of module or test structures based on different materials.

Sub-task 3: Material Web DB
Publishing of basic properties of candidate materials for particle detectors (and their service systems) such as radiation tolerance, radiation length, mechanical properties, thermal properties, compatibility with fluids, aging, history of use, suppliers, etc. Publishing of procedures to allow rapid testing of other materials.

2. Organization participation

Participant acronym	CERN	RAL	Karlsruhe	Glasgow	Liverpool	
Estimated person-months per participant:	152	24		12	12	

3. Objectives

(Bullet-style, 1 or 2 lines per objective, 1 objective per sub-task)

- Publish a report with the history of materials used in LHC and defining the most important chararcteristics for SLHC
- Report on procedures for testing and results on selected materials for SLHC
- Set-up the WEB DB
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4. Description of work

(~1/2 page, describe the work in the context of the objectives. possibly broken into sub-tasks, indicate for each sub-task the purpose of it, the participants involved in it and their role. If really indispensable, you can divide into subtasks.)

The guiding principal will be that where materials that were used before remain suitable they should be used again. Possible reasons why this might not be so are

- they did not work very well before (eg adhesive did not always adhere)
- they are no longer available
- their performance matched the requirements of LHC but does not match SLHC (eg radiation tolerance)
- a significantly better material is available (cheaper, lighter, stronger, etc), whose performance in key areas has been demonstrated by trustworthy methods

Subtask 1 requires us to establish the critical performance parametesrparameters for the materials and to document what materials were used before, and what promising alternative candidate materials there are. This will be carried out by a survey of literature about the original detectors, and by eliciting knowledge from the relevant members of the teams. This will allow us to explore the materials that were used before, materials that were recjectedrejected before, and promising candidate materials. A simple database (excel or word) will be compileliied of the results of the search. From this we will be able to establish what further materials tests are required. These will fall into one of the following categories:

- The required parameter was not measured before and cannot be inferred from test results
- The required parameter was not measured at the level required for SLHC (eg radiation tolerance)
- The material is new and the required parameter has not been measured in a reliable way

Subtask 2 requires us to establish procedures to fill in the missing data items identified at the end of subtask 1 where radiation testing is involved. For this we will need access to mechanical, electrical and thermal testing equipment and to suitable irradiation facilities. It may be necessary to make tests on active samples, although this will be avoided if at all possible because of the expense.

Subtask 3 will require some database expertise, as well as a full set of results from subtasks 1 and 2 and a specification of the required functionality of the database.

Leave this is in or delete from final draft – it's here to help me plan!

	Year 1	Year 2	Year 3	Year 4
Task	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx
Review of existing data	Xxxxxx			
Identify requirements	Xxxxxx			
Identify shortcomings	Xxxxxx			
Write test procedures		xxxxxxxxx	xxx	
Carry out sample tests		xxxxxx	xxxxxxxxxxxx	
Put results on web				xxxxxxxxxxxx
Effort per Q	6 6 6 3	3 3 6 6	3 3 3 3	3 3 3 3

List of Deliverables for the task

(typically 1 per task per year)

Deliverables of task 1	Person month estimate	Description/title	Nature[1]	Delivery month[2]
9.3.1	12	Description of materials used in SLHC trackers and indication of required properties for SLHC	R	M6
9.3.2	9	Identification of missing data items	R	M12~~9~~
9.3.3	12	Draft ~~Programme of work to supply missing data~~Document giving procedures for tests	R	M~~1~~212
9.3.4	6	Final Set of test procedures	R	M27
9.3.5~~4~~	12	~~Full s~~Set of demonstrator test results	R	M36~~30~~
9.3.6~~5~~	9	Database of results on web	O	M48~~36~~
9.3.7	3	Procedure on web	O	M48

List of Milestones for the task

Milestones	Description/title	Tasks involved	Delivery month[2]	Means of verification
9.3.1	Identify key performance parameters and missing data items	1	M12	
9.3.2	Identify suitable testing and	2	M18	

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	radiation sources			
9.3.3	Irradiation set complete	2	M36	
9.3.4	Post-irradiation tests complete	2	M36	
9.3.5	Database specification produced	3	M39	
9.3.6	Database published	3	M48	
9.3.7	Post-implementation review held	1,2,3	M4836	

[1] Nature: R=Report, P=Prototype, D=Demonstrator, O=Other
[2] Counted from the starting date