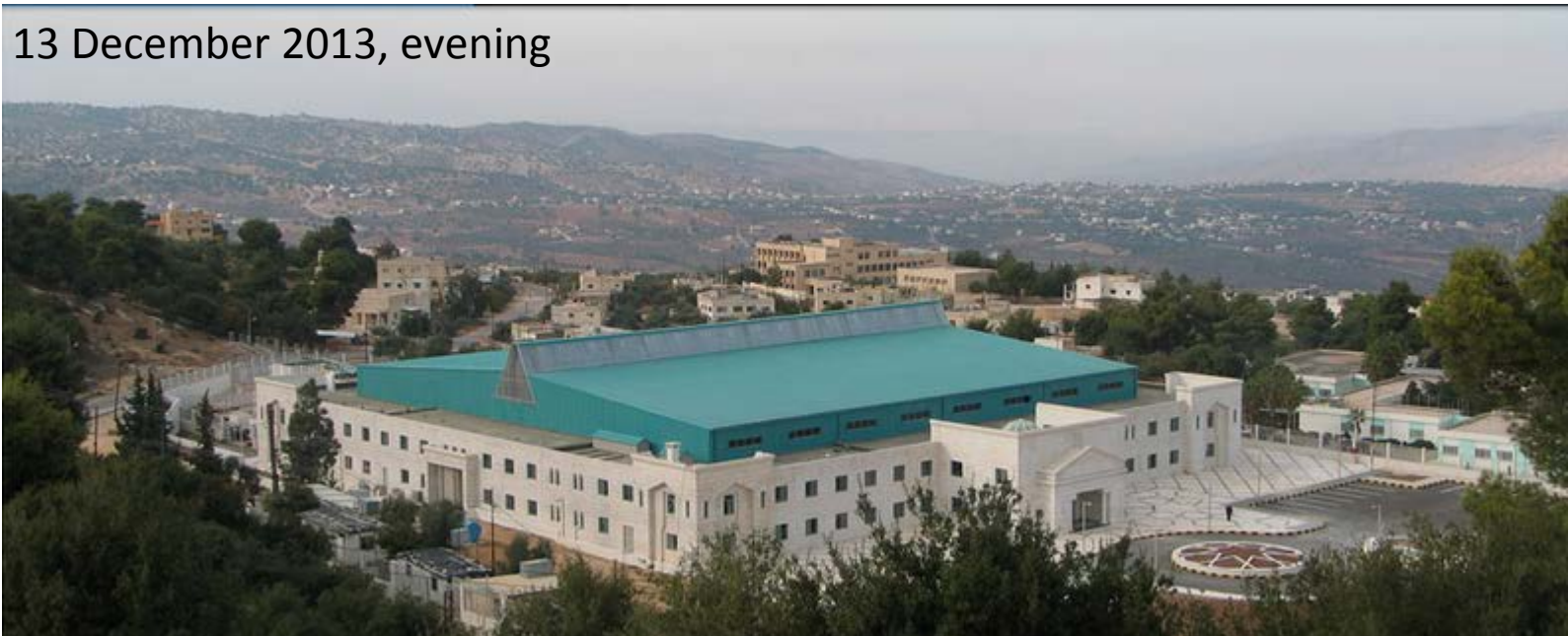




## Radiation measurements during Commissioning of SESAME's 800MeV Booster Synchrotron

13 December 2013, evening



Adli Hamad

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*Synchrotron-light for Experimental Science and Application in the Middle East  
(SESAME), ALLAN, Jordan*

## Outline

- ❖ Introduction
- ❖ Shielding objectives
- ❖ General Radiation Safety Policy.
- ❖ Commission strategy.
- ❖ Radiation Measurements.
- ❖ Conclusion.
- ❖ Future work.

# Introduction

SESAME accelerator facility comprises:

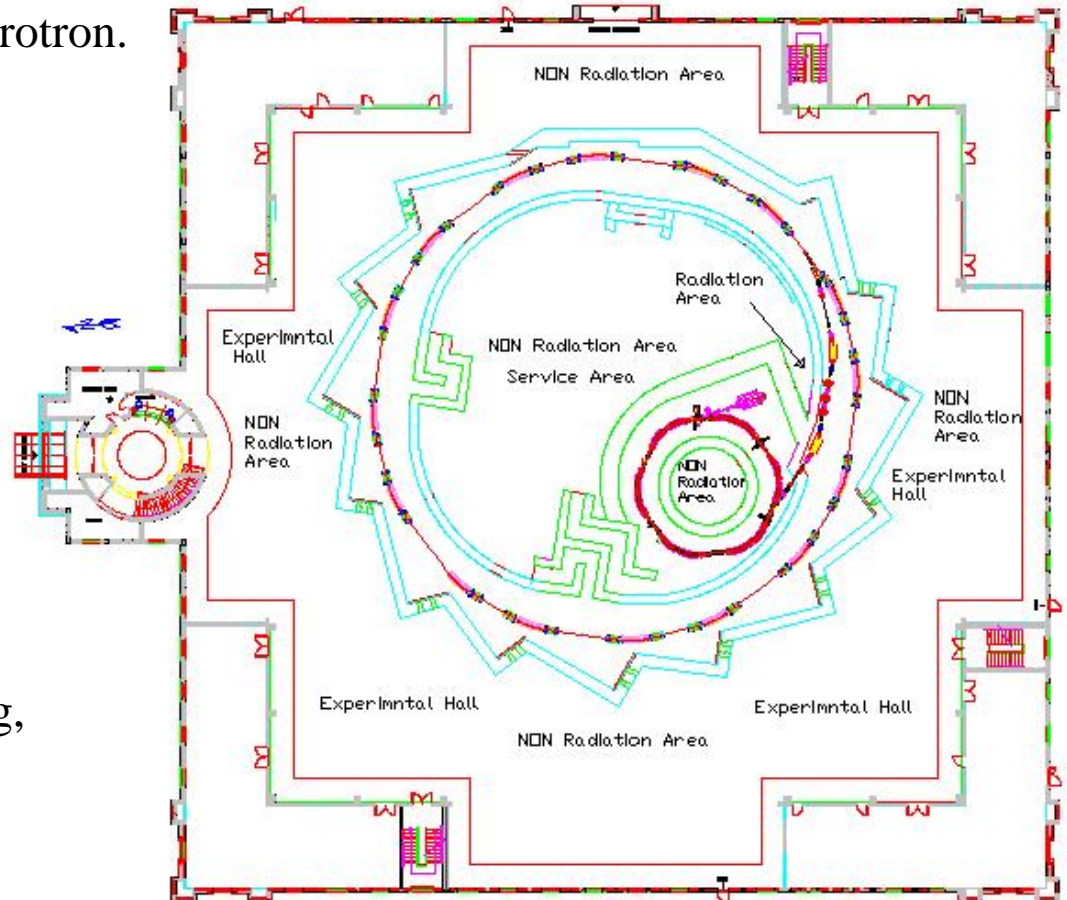
- A 22.5MeV circular medical microtron.

TL1

- A 800 MeV booster synchrotron.

TL2

- A 2.5 GeV, 400mA, storage ring, (decay mode)



## Commissioning history

- A 22.5 MeV circular microtron.

**On Monday 28 November 2011 at 1.13 a.m., the Microtron beam was successfully extracted from its final orbit (orbit 42) with the full energy of 22.5 MeV.**

- A 800 MeV booster synchrotron.

**After having successfully stored electrons from the 20 MeV Microtron in the Booster in July 2014, on 3 September 2014, the SESAME team succeeded in accelerating the electrons in the Booster to their final energy of 800 MeV/4mA.**



## Shielding objectives

At SESAME the ALARA principle is applied by guaranteeing the radiation limits for non-exposed workers (1 mSv/y, corresponding to 0.5mSv/h, for 2000 working hours per year or 2 $\mu$ Sv during 4 hours shift periods), except in controlled areas where access will not be possible during operation.

Both Microtron and booster had been operated over many hours, 3 to 4 days/week, however, in the normal operation we are going to operate both accelerators for not more than one hour daily and hence all presented measurements are belong to:

- 1- Commissioning phase only.
- 2- Worst scenarios of injections and operations.
- 3- Basic radiation measurements.

First: Local radiation permits

Microtron operation permit  
from old JNRC



**Commissioning Permit**

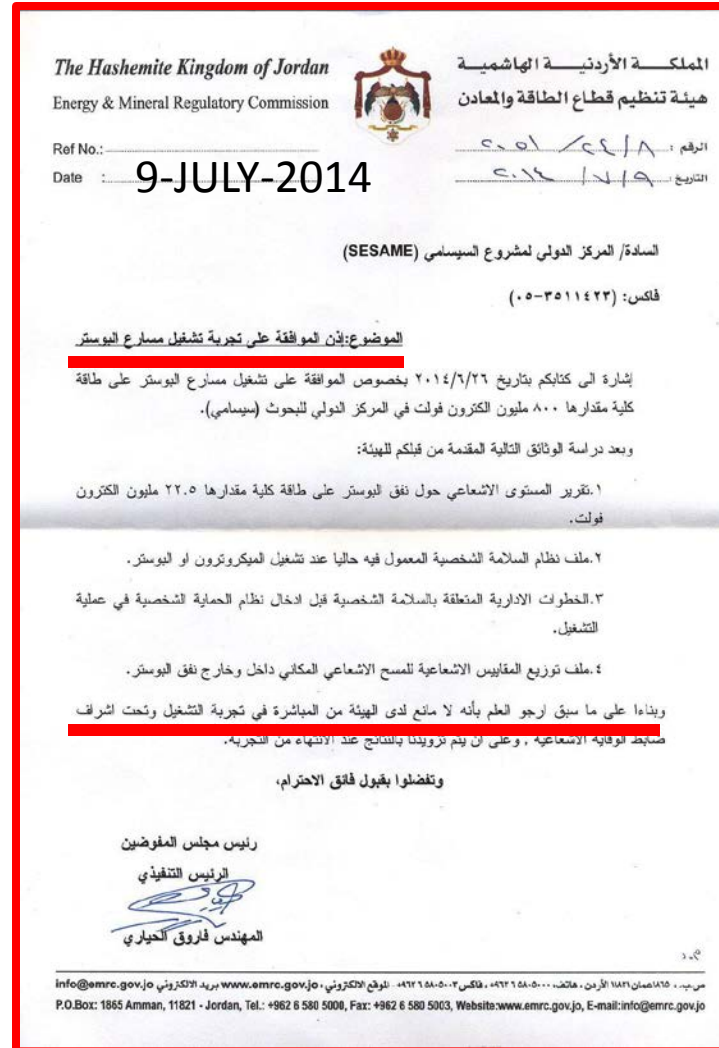
After having examined the application of Commissioning Permit for the first stage (Microtron Accelerator) of the Synchrotron-Light For Experimental Science and Applications in The Middle East at Allan site, and verified that it has satisfied all specific requirements for the Commissioning Permit in accordance with the provisions of the Law of Radiation protection, Safety and nuclear security No. 43 for the year 2007, as amended and the relevant regulations issued in line therewith, it has been decided to issue the Commissioning Permit for the first stage (Microtron Accelerator) of the Synchrotron-Light For Experimental Science and Applications in The Middle East, for the purpose of use the Microtron Accelerator, provided that the conditions and requirements mentioned in the application, and the conditions set out in the back of this Permit shall be complied with.

Issued in Amman, Date: 29 /9/ 2013

Official Seal: 

Director General  
Chairman, Board of Director  
*Majd Hawwari*  
Dr. Majd Hawwari

## Booster Operation Permit From New EMRC (up to 800MeV)



The Hashemite Kingdom of Jordan  
Energy & Mineral Regulatory Commission

المملكة الأردنية الهاشمية  
هيئة تنظيم قطاع الطاقة والمعادن

Ref No.: ٤٠٥١ / ٤٤١ / ٨  
Date: 9-JULY-2014 التاريخ: ٤٠٥١ / ٤٤١ / ٨

السادة/ المركز الدولي لمشروع السيسامي (SESAME)  
فاكس: (٠٥-٣٥١١٤٢٣)

**الموضوع: إذن الموافقة على تجربة تشغيل مسارع البوستر**

إشارة الى كتابكم بتاريخ ٢٠١٤/٦/٢٦ بخصوص الموافقة على تشغيل مسارع البوستر على طاقة كلية مقدارها ٨٠٠ مليون الكترون فولت في المركز الدولي للبحوث (سيسامي).

وبعد دراسة الوثائق التالية المقدمة من قبلكم للهيئة:

١. تقرير المستوى الإشعاعي حول نفق البوستر على طاقة كلية مقدارها ٢٢.٥ مليون الكترون فولت.
٢. ملف نظام السلامة الشخصية المعمول فيه حالياً عند تشغيل الميكروترون او البوستر.
٣. الخطوات الادارية المتعلقة بالسلامة الشخصية قبل ادخال نظام الحماية الشخصية في عملية التشغيل.
٤. ملف توزيع المقاييس الإشعاعية للمسمح الإشعاعي المكاني داخل وخارج نفق البوستر.

وبناء على ما سبق أرجو العلم بأنه لا مانع لدى الهيئة من المباشرة في تجربة التشغيل وتحت اشراف صاحب الوثيقة الإشعاعية . وعلى ان يتم تزويدنا بالنتائج عند الانتهاء من التجربة.

وتفضلوا بقبول فائق الاحترام.

رئيس مجلس المفوضين  
الرئيس التنفيذي  
*المهندس فاروق الحيارى*

د.ع

م.ب. 1885 Amman, 11821 - Jordan, Tel.: +962 6 580 5000, Fax: +962 6 580 5003, Website: www.emrc.gov.jo, E-mail: info@emrc.gov.jo  
www.emrc.gov.jo, بريد الالكتروني: info@emrc.gov.jo, هاتف: ٥٠٠٠ ٥٨٠ ٠٠٢، فاكس: ٥٠٠٠ ٥٨٠ ٠٠٣، موقع الالكتروني: www.emrc.gov.jo

## Technical team

### Second



### Staff / radiation awareness

All staff member which involved in the commissioning period (directly or no) are enforced to wear three kinds of personnel dosimeters:

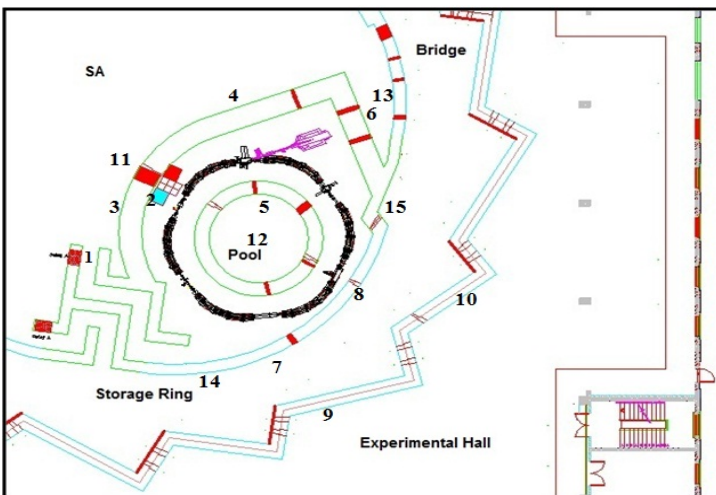
- JNRC/ whole body/ photon and electrons.
- SESAME/ DIS-1 from RADOS/ Hp (10) and Hp (0.07)/ photon and electrons.
- LANDAUER/ INLIGHT+NEUT-T 3M /photon and neutrons.

### Third

Full Coordination with an external contractors in advance and follow up the booster roof

LANDAUER/ INLIGHT+NEUT-T 3M /  
photon and neutrons.

Passive



Area monitoring 01	Booster door/ Inside
Area monitoring 02	Booster tunnel/ Injection Septum/ 0 angle
Area monitoring 03	Main SA/ Injection Septum/0 angle.
Area monitoring 04	Main SA/ Injection Septum/90 deg.
Area monitoring 05	Booster SA/ Injection Septum/ 90 deg.
Area monitoring 06	Main SA/ Microtron 0 angle/1 m height.
Area monitoring 07	SR tunnel/ cell 3/ 0 angle.
Area monitoring 08	SR tunnel/ cell 4/ 0 angle.
Area monitoring 09	Experimental Hall / cell 3/ 0 angle.
Area monitoring 10	Experimental Hall / cell 4/ 0 angle.
Area monitoring 11	Main Service Area/ Opposite to main ground opening
Area monitoring 12	Pool center
Area monitoring 13	Microtron racks back wall
Area monitoring 14	5.5 m from main SR maze first mouth
Area monitoring 15	TL2 opening/SR side
Area monitoring 16	Inside CR towards to Corridor
Area monitoring 17	Corridor/ First Floor/ West/opposite to CR
Area monitoring 18	Corridor/ First Floor/
Area monitoring 19	Corridor/ First Floor/
Area monitoring 20	Corridor/ First Floor/
Area monitoring 21	SESAME site/ North/
Area monitoring 22	SESAME site/ North East corner
Area monitoring 23	SESAME site/ South East corner



5 movable combined stations (trolleys) ready to be connected to PSS.



2 Portable  
FHT 762 Wendi-2 Wide-Energy Neutron  
Detector,  
Energy Range 25meV to 5GeV



FHT 192 Gamma Ionization Chambers,  
Energy Range 30 keV to 7 MeV( $\pm 30\%$ ),  
Dose Range 10  $\mu$ R/h to 100 R/h



2 FH 40 G portable digital gamma survey meter,  
Energy Range 30KeV to 4.4MeV

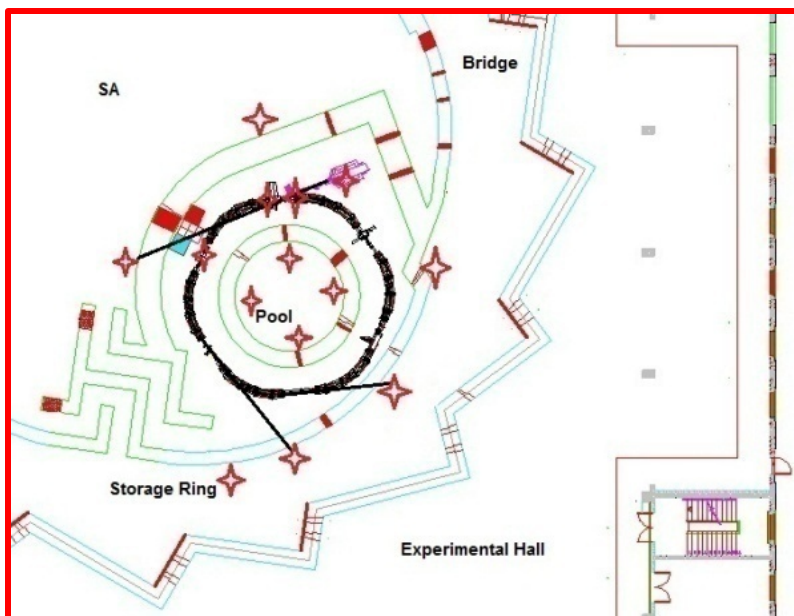
These 5 stations have been distributed around booster tunnel over 17 locations along operation days.

# Daily Radiation Map

Fifth

Radiation levels around the Booster tunnel/ real measurements using:

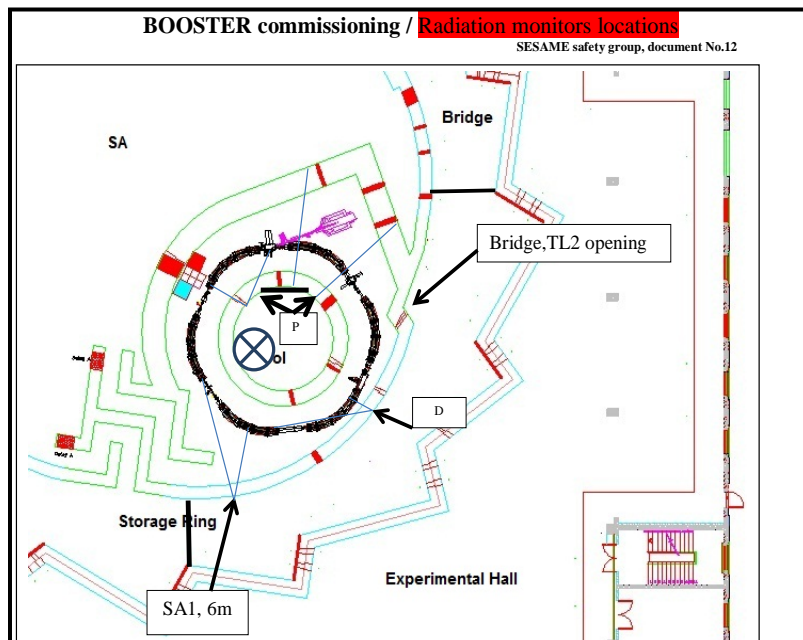
- 1- Combined radiation monitor (G&N)trolley.
- 2- Portable monitors.



17 places to be observed (4 in SR tunnel, 4 in the pool, 4 booster roof, 2 in SA and 3 for roof).

Daily Radiation Map contains:

- 1- locations of combined monitors each time during the day and
- 2- Radiation measurements.



Date: **13-11-2014**  
 Start time: 10:45AM  
 Microtron Frequency: **1Hz**

Day: **Thu.**  
 Finish time: 3:45PM  
 Electron Energy: **800MeV**

### Readings

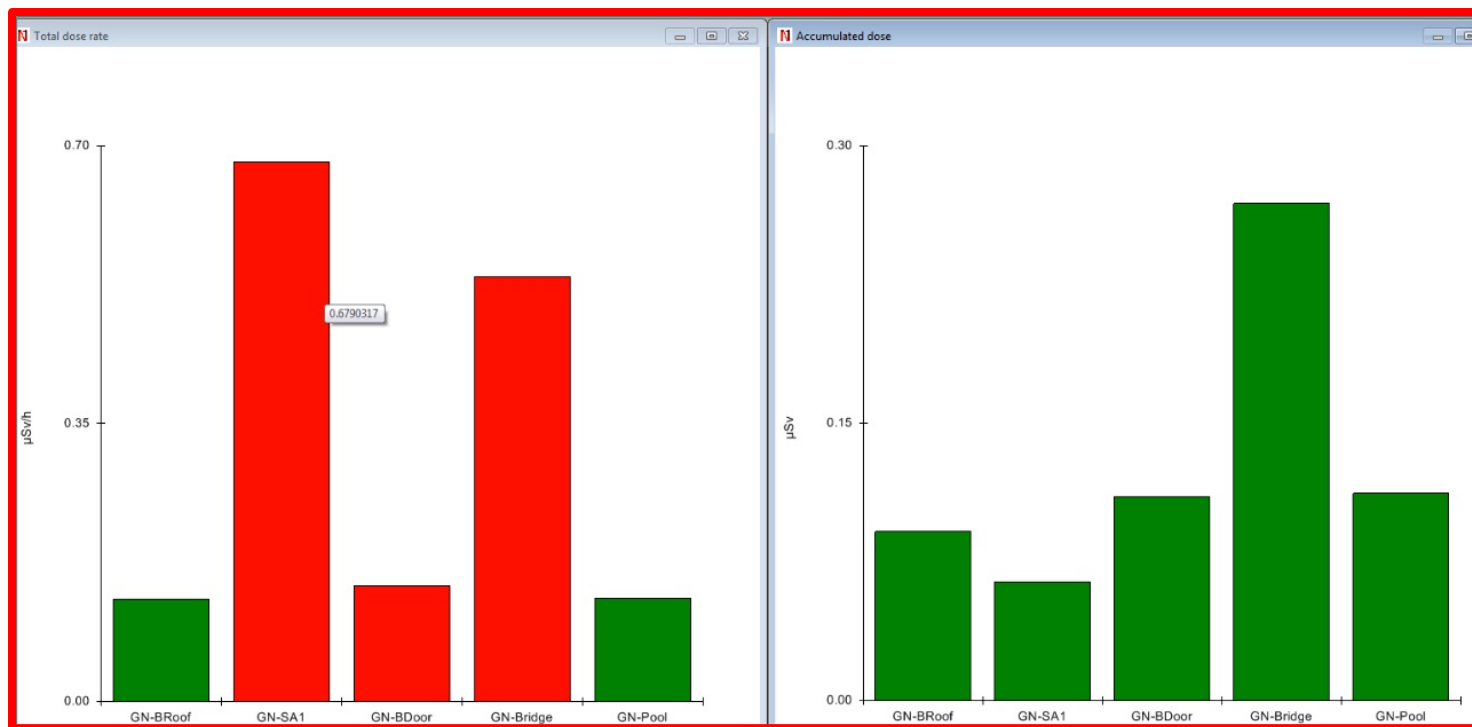
RM Location	max. TDR ( $\mu\text{Sv/h}$ )	SD ( $\mu\text{Sv}$ )	Notes
SR (SA1, D)	6.8	5.2	D: Neutron dose rates $\leq 0.95\mu\text{Sv/h}$ losses @ full energy
Pool	1.6	1.8	Neutron dose rates $\leq 0.6\mu\text{Sv/h}$ losses @ full energy
SR (TL2 opening)	100	96	Neutron dose rates $\leq 0.17\mu\text{Sv/h}$ losses @ full energy

Notes:  $I_b \leq 3.5 \text{ mA}$ , high Neutron dose rates  $\leq 0.6\mu\text{Sv/h}$  in pool. Roof dose rates  $\leq 1.5\mu\text{Sv/h}$  normal work (1 $\mu\text{Sv/h}$  Gamma + 05 $\mu\text{Sv/h}$  Neutrons). pool measured in different locations by gamma portable monitor. Shift dose only during 96 minutes.

RSO: Adli  
 Shift leader: Maher  
 SIGNATURE:

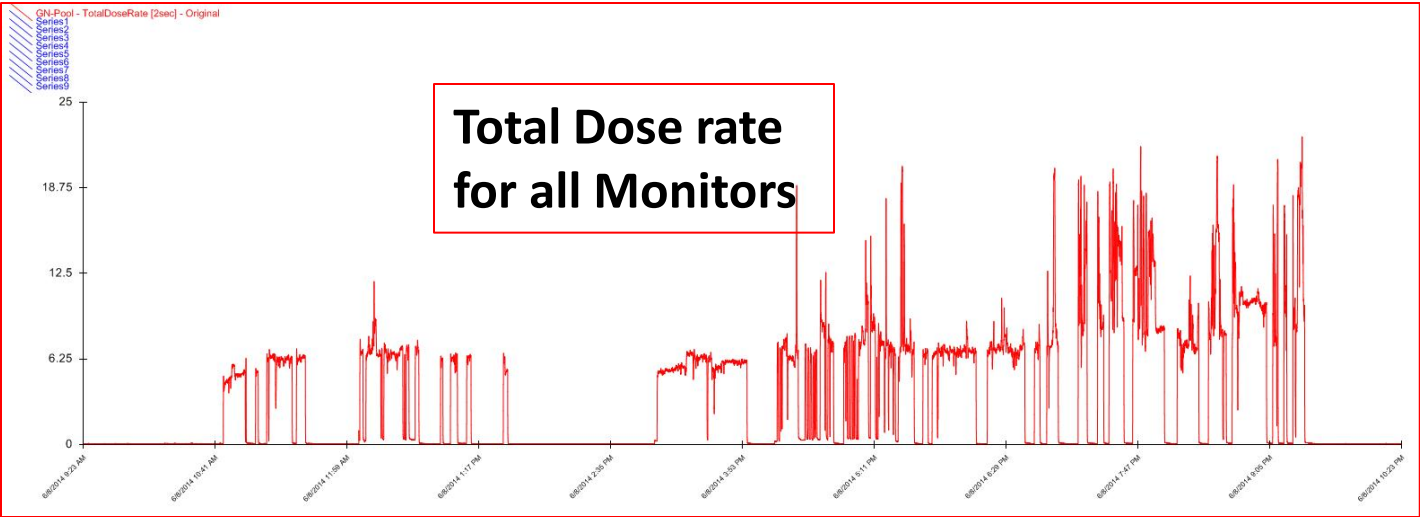
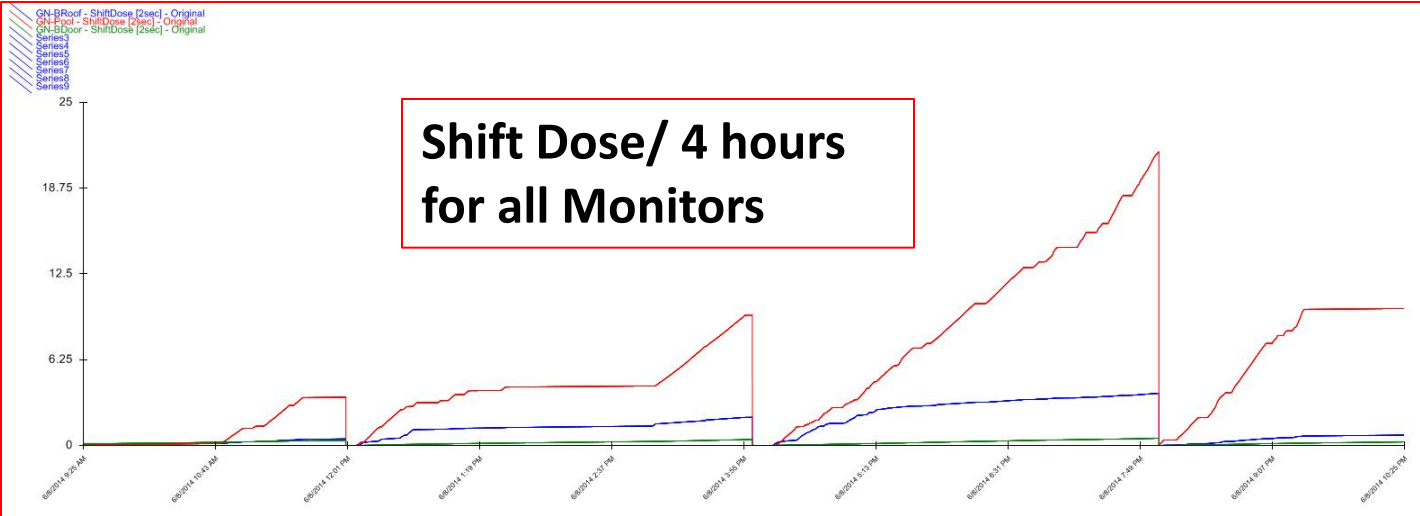
## What we can observe at once form radiation monitors

### Instantaneous “Total Dose Rates and Total Accumulated Doses”



**Predefined limitations 1mSv for 2000hrs (0.5 $\mu\text{Sv/h}$ , 2 $\mu\text{Sv/shift}$  (4h))**

# What we can see after one full day working



## FROM THE BEGINNING

### Night Shifts

Booster tunnel, using PSS “SIL3

- ❖ Searched “Cleared of personnel”
- ❖ CLOSED and LOCKED

For commissioning purposes  
Radiation monitors were NOT  
connected to PSS

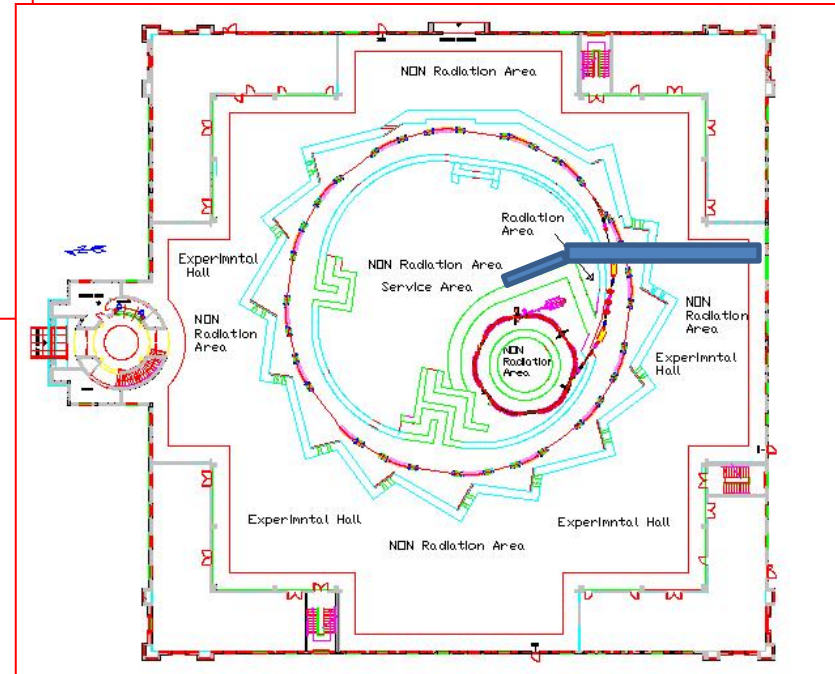
Storage ring tunnel “No PSS”

- ❖ searched, CLOSED and LOCKED manually
- ❖ Booster tunnel roof is prohibited area.
- ❖ Pool is prohibited.
- ❖ Service area is prohibited.
- ❖ Bridge is prohibited.

later

Day Shifts

Service area and Bridge are accessible



## Commission strategy

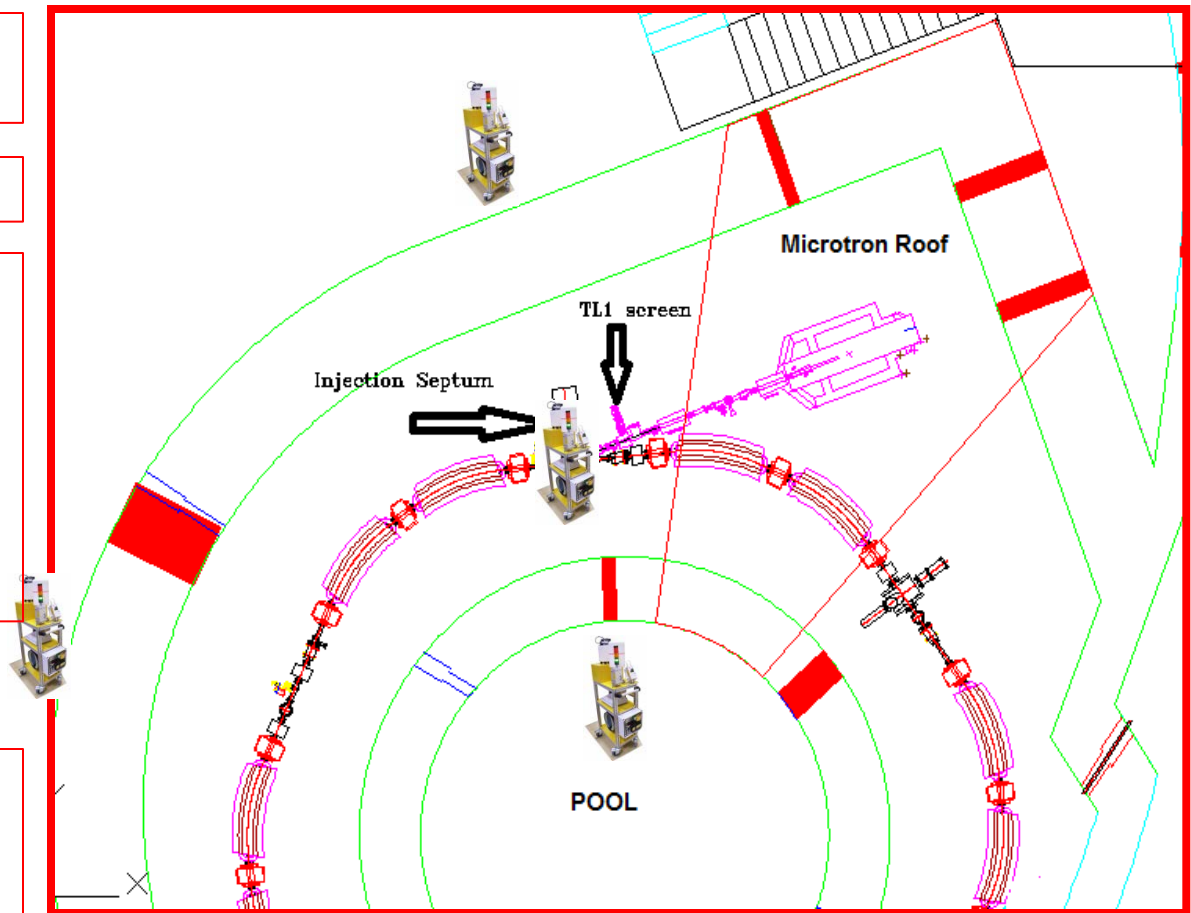
Microtron was operated at 10, 5 and 1 Hz

Booster works only at 1 Hz

Injection septum permits only for one of an electron beam bunch entering the booster ring and kick 9 bunches outside

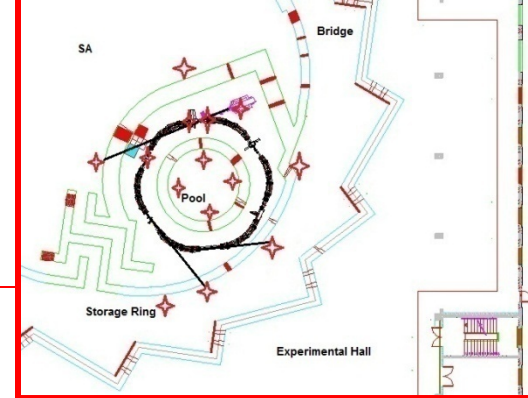
So

We expect to have high dose rates around the injection point especially in the direction of POOL and ROOF.

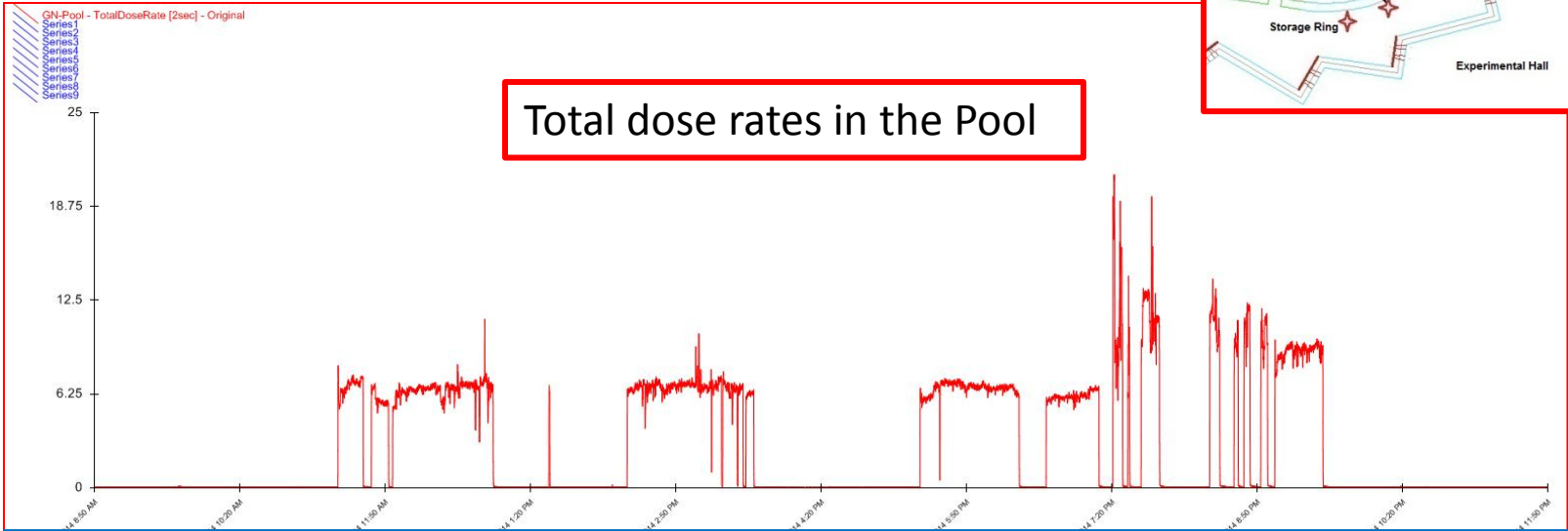


# Radiation measurements

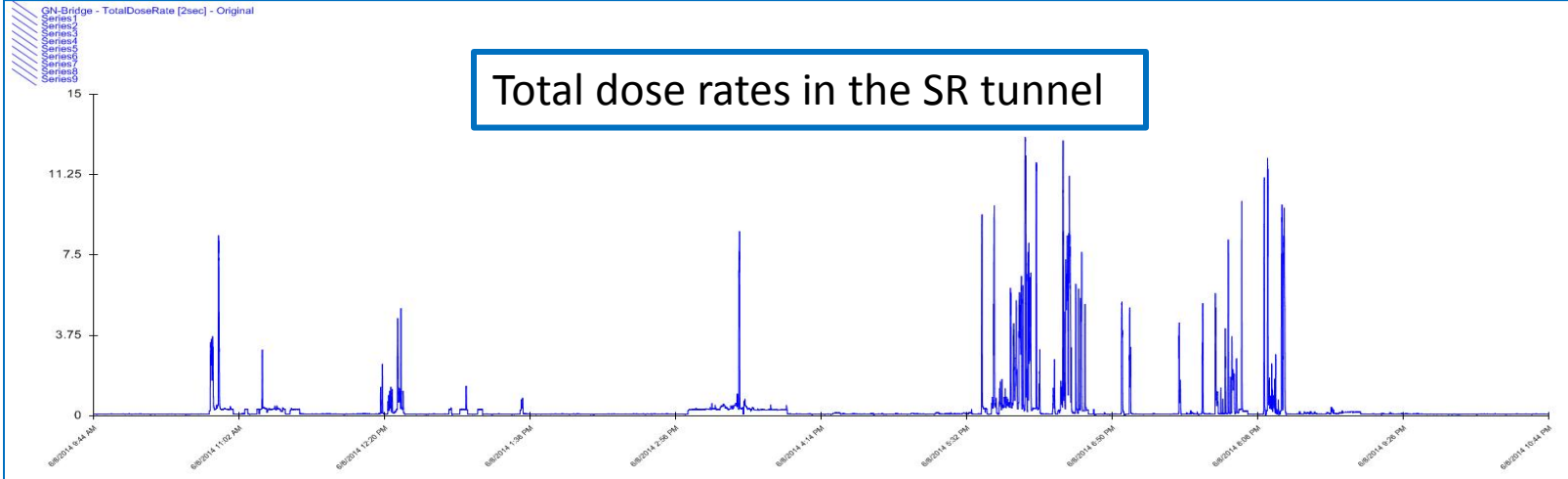
Booster commissioning @ 10 Hz, 20MeV,  
different injection scenarios.

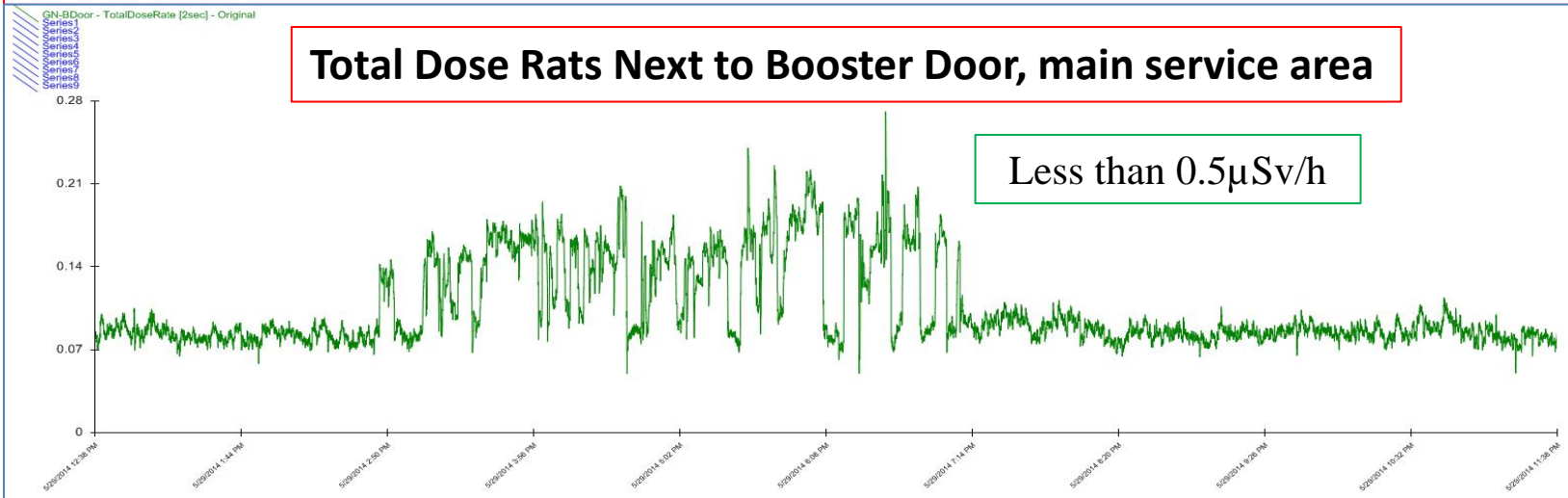
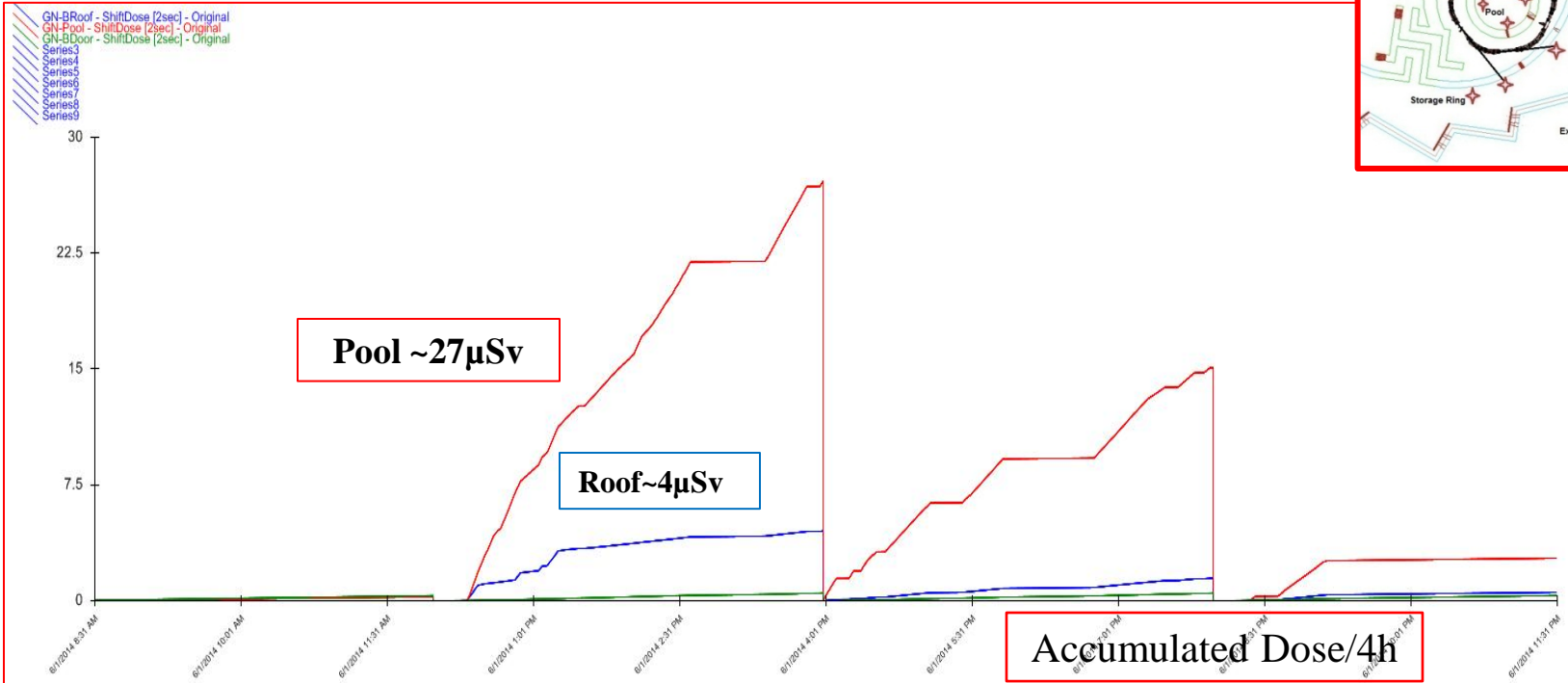


## Total dose rates in the Pool



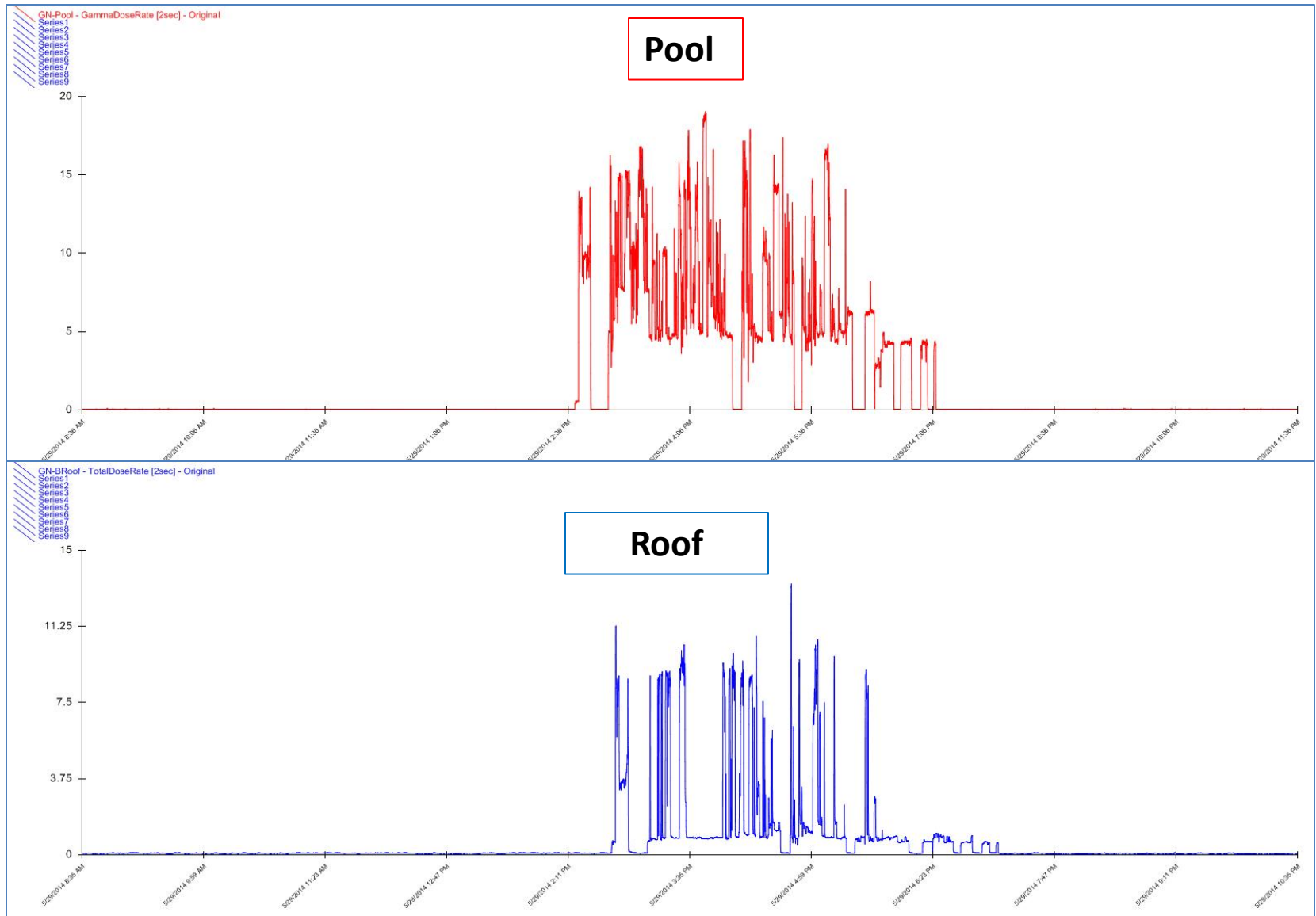
## Total dose rates in the SR tunnel



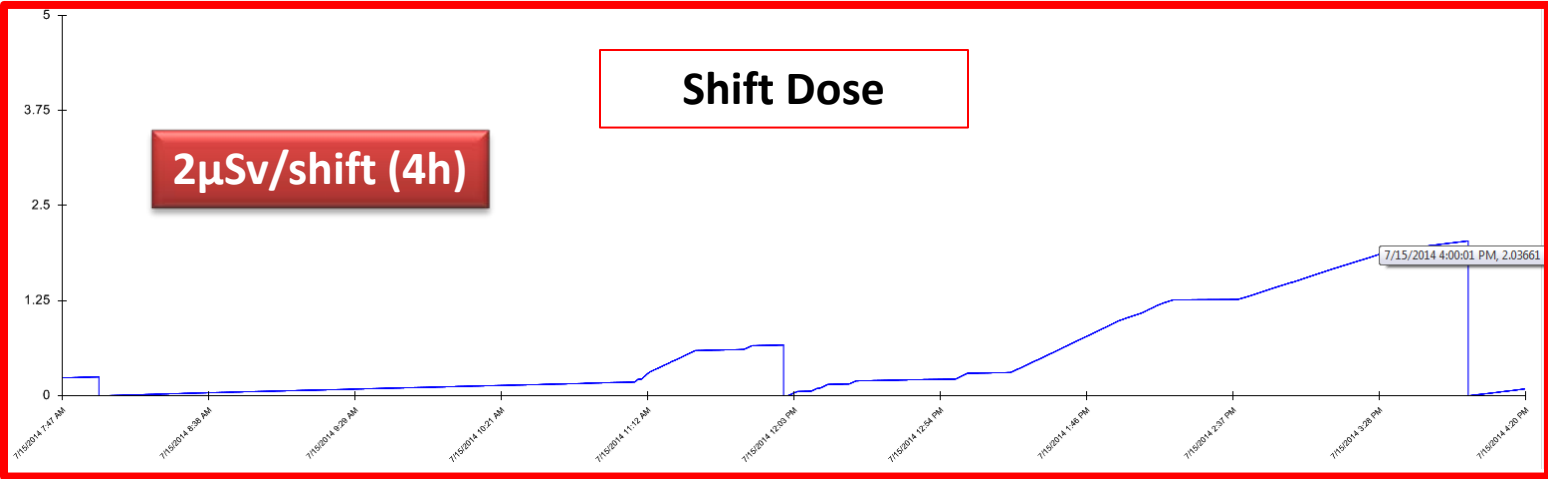
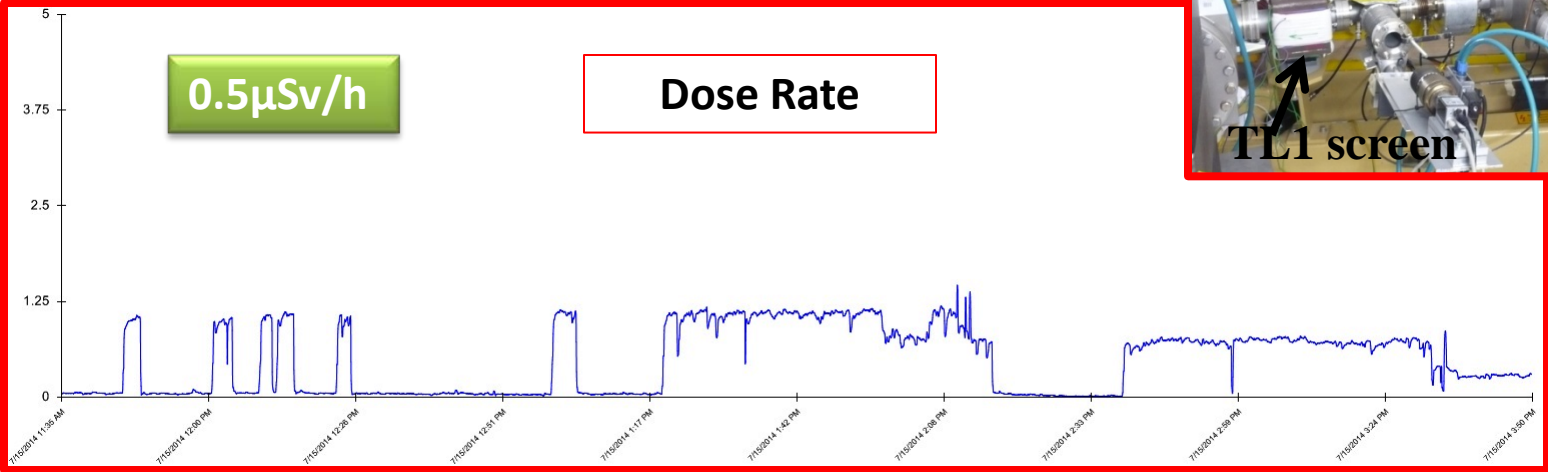
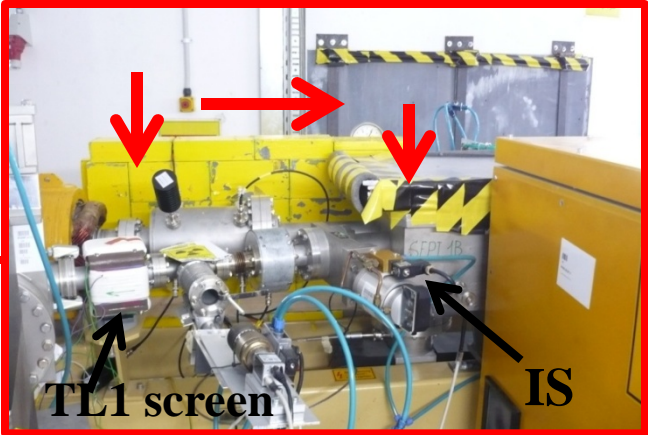




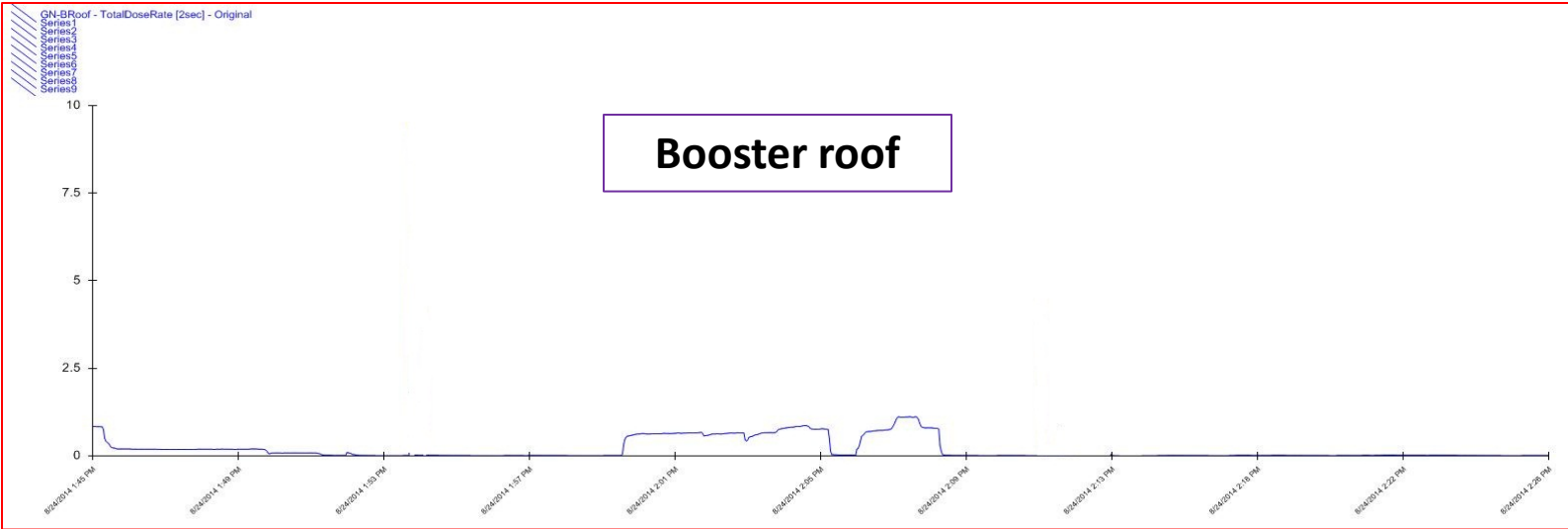
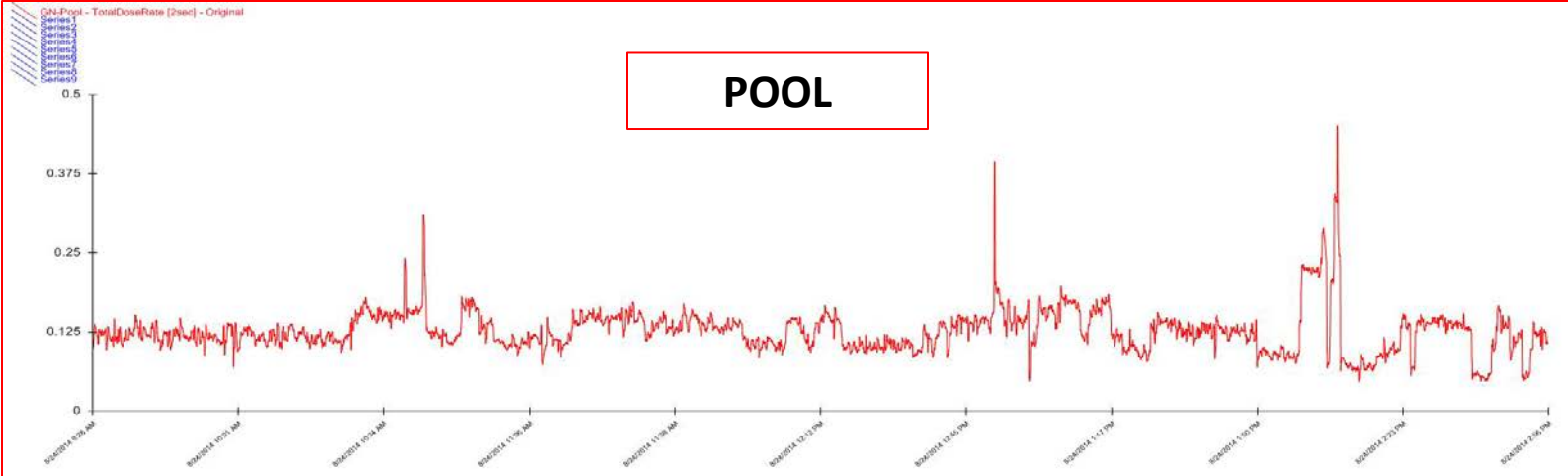
# Booster Commissioning @ 5 Hz



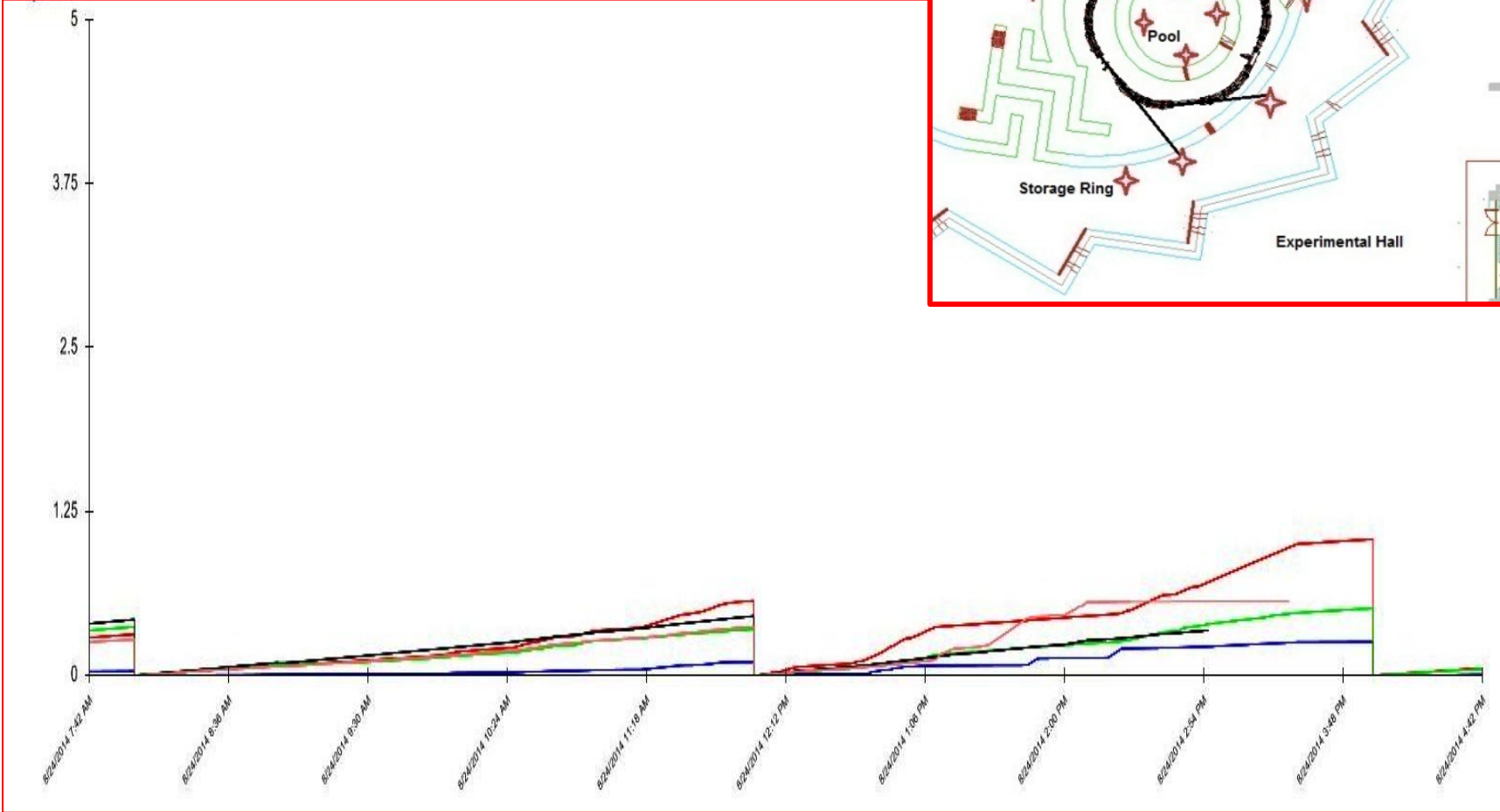
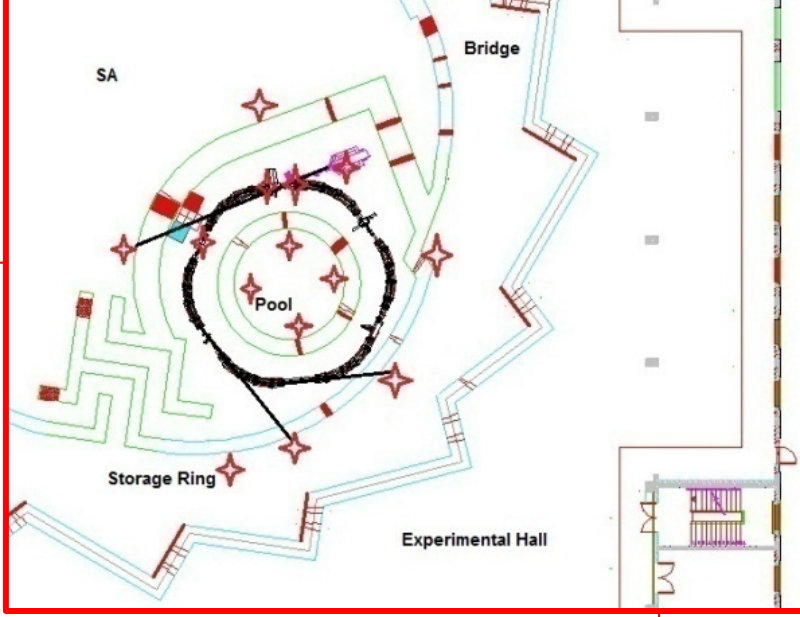
**Pool /5Hz  
lead added laterally  
In the direction of Pool and Roof**



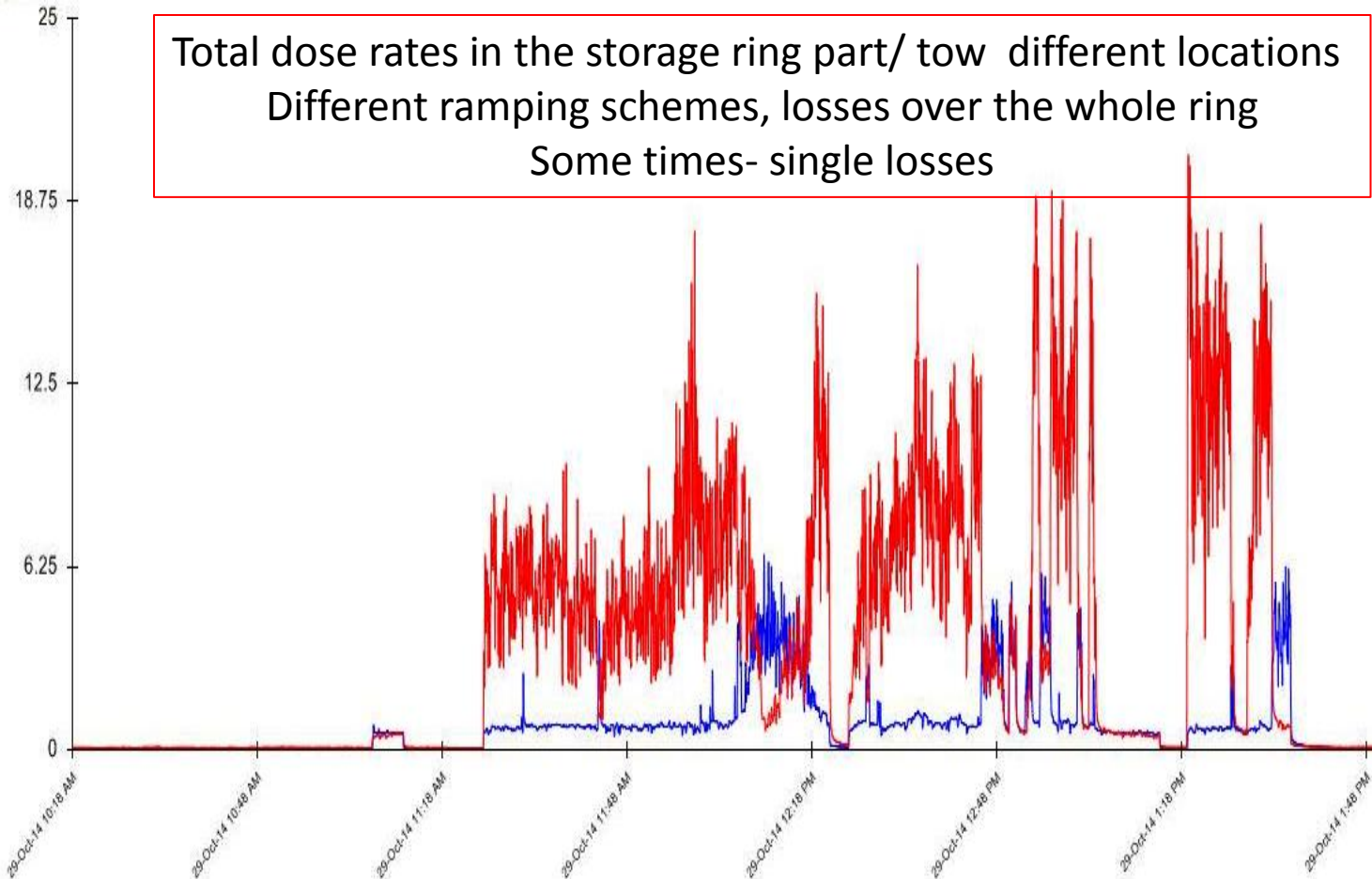
# Stored Beam @ 20MeV & 1Hz, with lead only opposite to Injection Septum

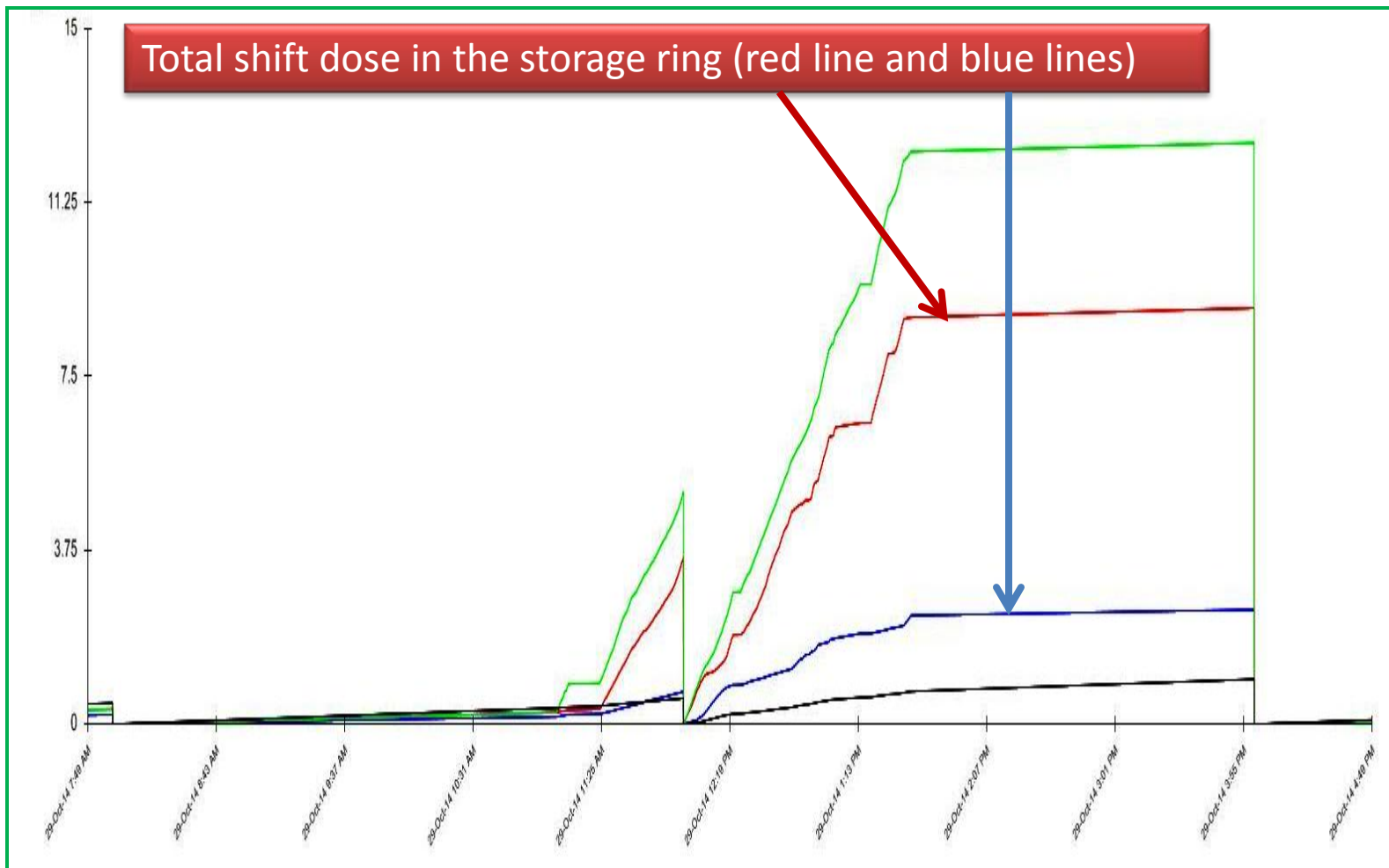


# Storage ring tunnel , Shift Dose

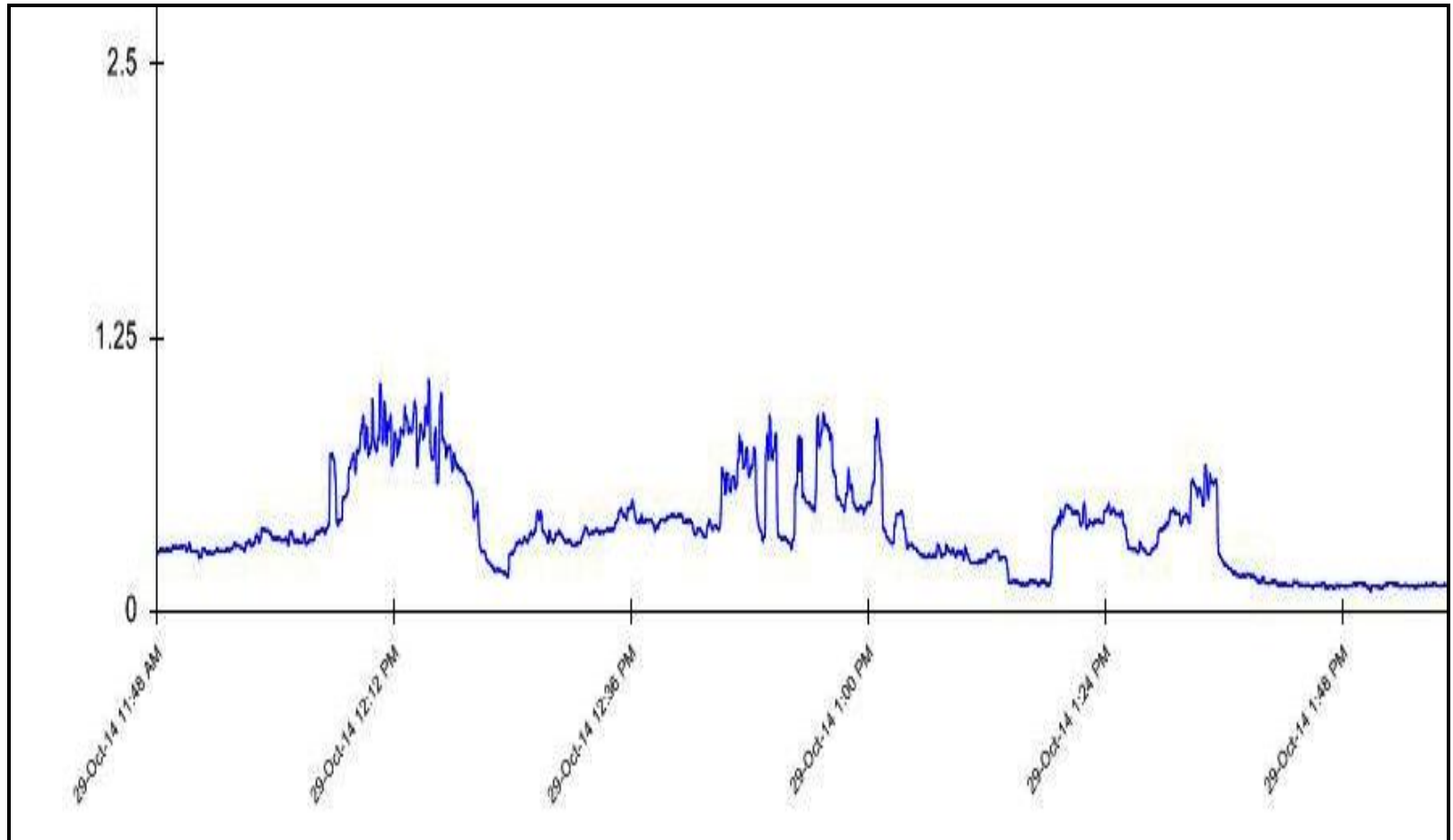


Total dose rates in the storage ring part/ tow different locations  
Different ramping schemes, losses over the whole ring  
Some times- single losses

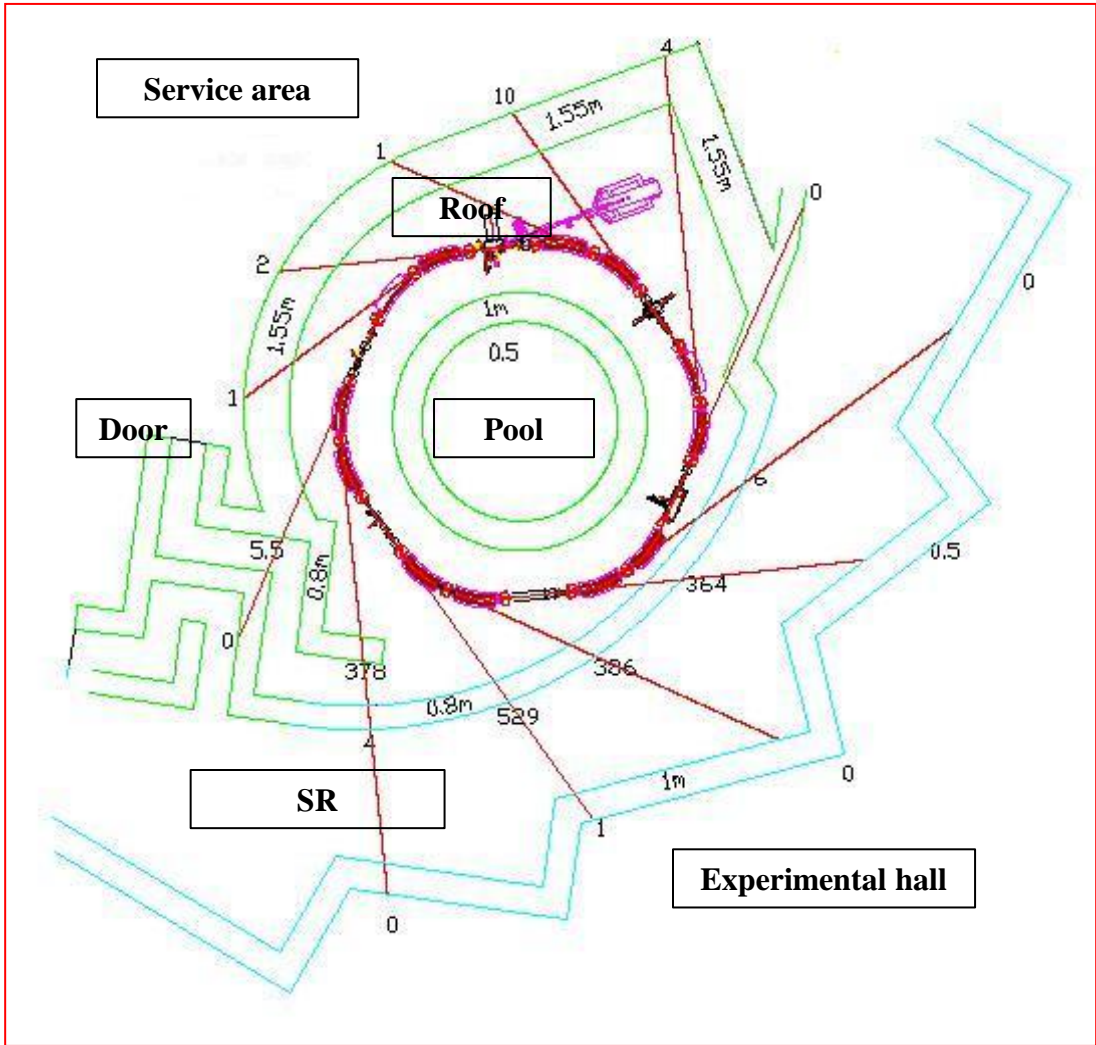




Total dose rates in the pool At 800MeV electron,  
different losses patterns



Location	Maximum Measured DR Continuous losses	Calculated DR Single losses
Roof	$\leq 1.2\mu\text{Sv/h}$	$0.5\mu\text{Sv/h}$
Pool	$\leq 1.2\mu\text{Sv/h}$	$0.5\mu\text{Sv/h}$
SR	$\leq 20\mu\text{Sv/h}$	$\leq 529\mu\text{Sv/h}$
EH	$\leq 0.1\mu\text{Sv/h}$ (portable)	$\leq 1\mu\text{Sv/h}$
SA	$\leq 0.25\mu\text{Sv/h}$	$\leq 10\mu\text{Sv/h}$
Door	$\leq 0.1\mu\text{Sv/h}$ (BG)	$0.05\mu\text{Sv/h}$



**“LANDAUER TLD”**

**Accumulated Doses over 3 months of irregular operations - all locations, outside the booster tunnel - measured values are below TLD threshold sensitivity:**

- 0.05 mSv for X-rays, gamma and beta
- 0.1 mSv for neutrons



**CONCLUSION**

**DURING Injector COMMISSIONING**

<b>Booster Operation</b>	<b>Normal losses</b>	<b>Continuous Losses/diagnostic screen inserted</b>	<b>Notes</b>
<b>Area</b>			
<b>Bridge</b>	<b>Safe</b>	<b>Safe</b>	
<b>Main SA</b>	<b>Safe</b>	<b>Safe</b>	
<b>Experimental Hall</b>	<b>Safe</b>	<b>Safe</b>	
<b>Pool</b>	<b>Safe</b>	<b>Safe</b>	With Personal dosimeters
<b>Booster roof / over IS</b>	<b>Safe</b>	<b>Safe</b>	With Personal dosimeters
<b>Storage Ring Tunnel</b>	<b>NOT</b>	<b>NOT</b>	NO accessible, to be controlled later/PSS
<b>Storage Ring Roof</b>	<b>Safe</b>	<b>Safe</b>	

Future work

Soon

FLUKA simulation  
is needed

TL2 installation  
and  
operation

By the end of 2016

Storage ring installation and commissioning

XAFS/XRF “day one beamline” shielding design  
installation and commissioning

14 December 2013, morning



Summer 2014





NOW WE HAVE NEW ROOF

**THANK YOU**