



# ANGRA 1 STEAM GENERATOR REPLACEMENT



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RADIOLOGICAL PROTECTION DIVISION MANAGER



**ELETRONUCLEAR**  
ELETROBRÁS TERMONUCLEAR S.A.

13/10/2009

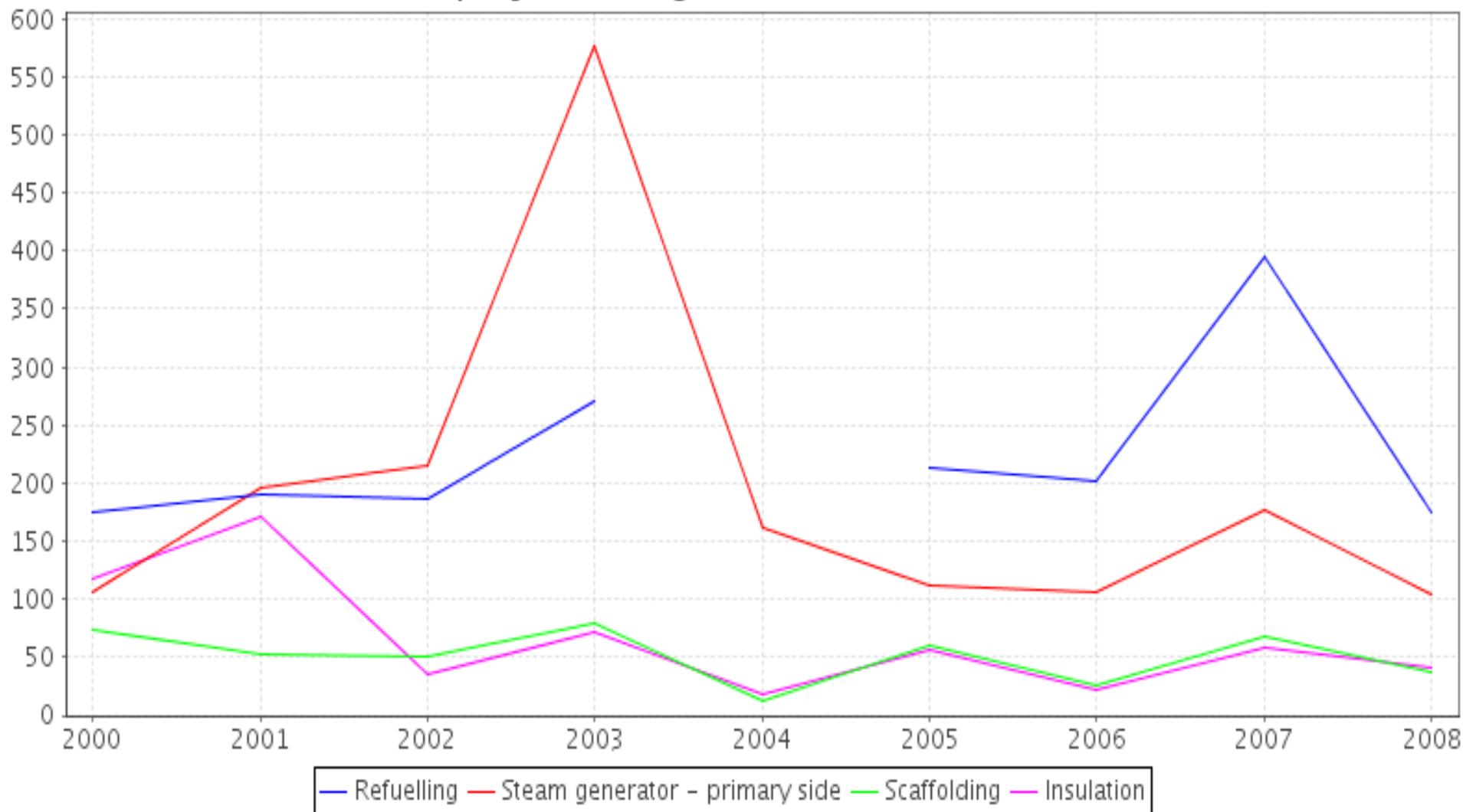
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# CHRONOLOGY

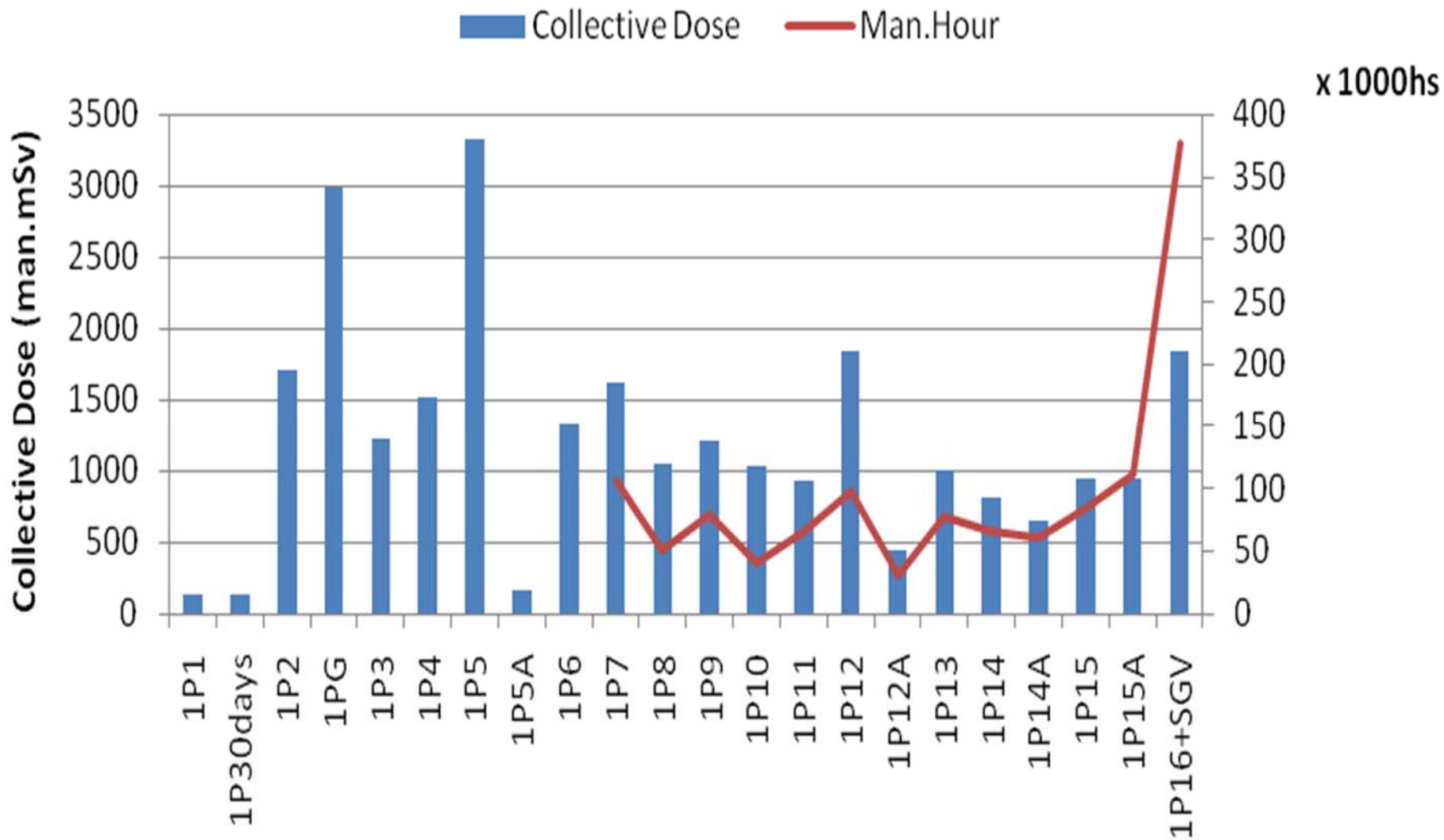
- 2003 – 1P12 – High Primary to Secondary Leak Rate – 2041 man.mSv
- 2004 – 1P12A – 100% ECT – 607 man.mSv – No Refueling
- 2005 – 1P13 – 1,157 man.mSv
- 2006 – 1P13A + 1P14 – 938 man.mSv
- 2007 – 1P14A + 1P15 – 1,827 man.mSv – FM in RCS + RCP burned + spent resin in RCS + waste evap.
- 2008 – 1P15A – N-1 Outage – 1,109 man.mSv

# CHRONOLOGY

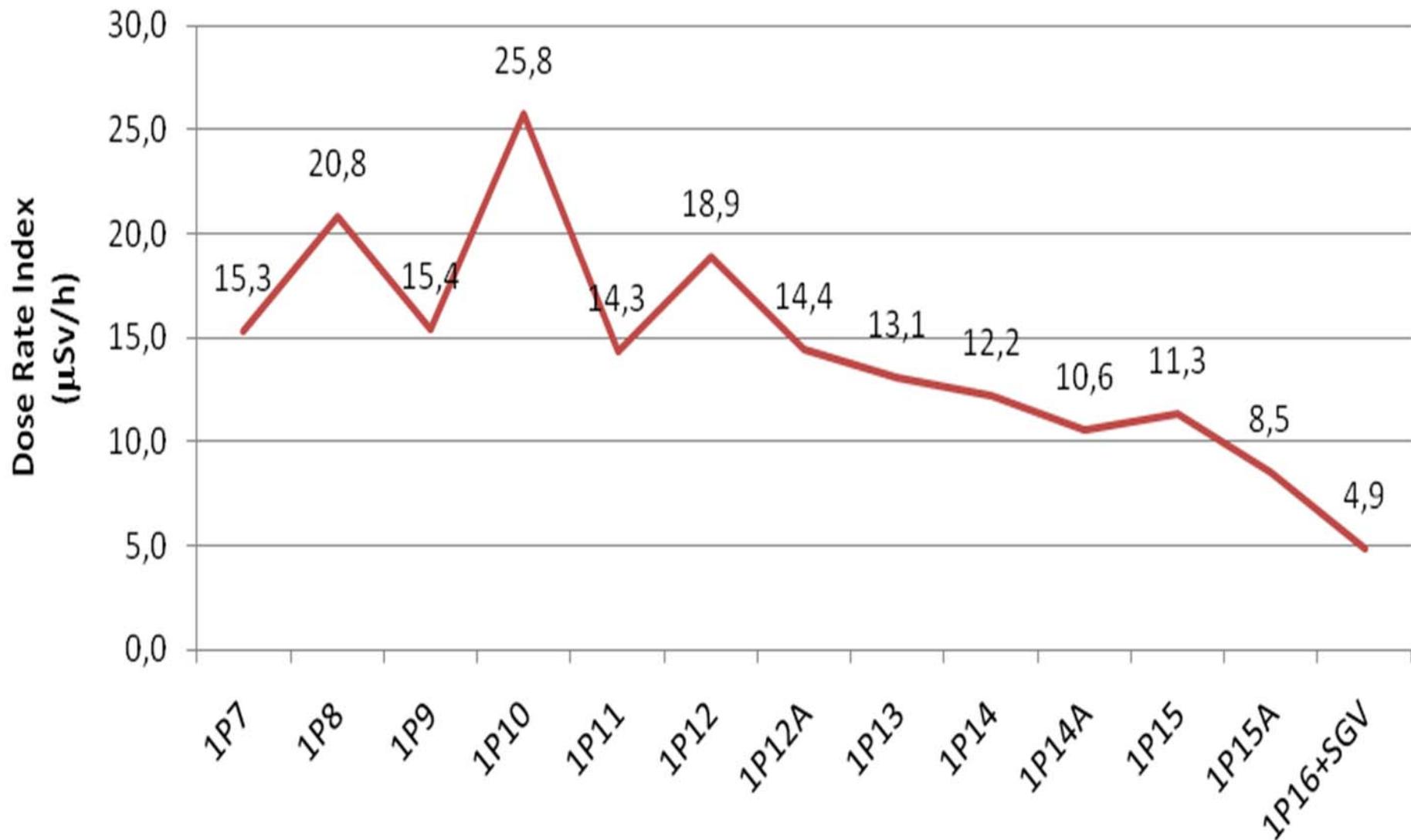
Evolution of the dose per job for Angra 1 between 2000 and 2008 (in man.mSv)



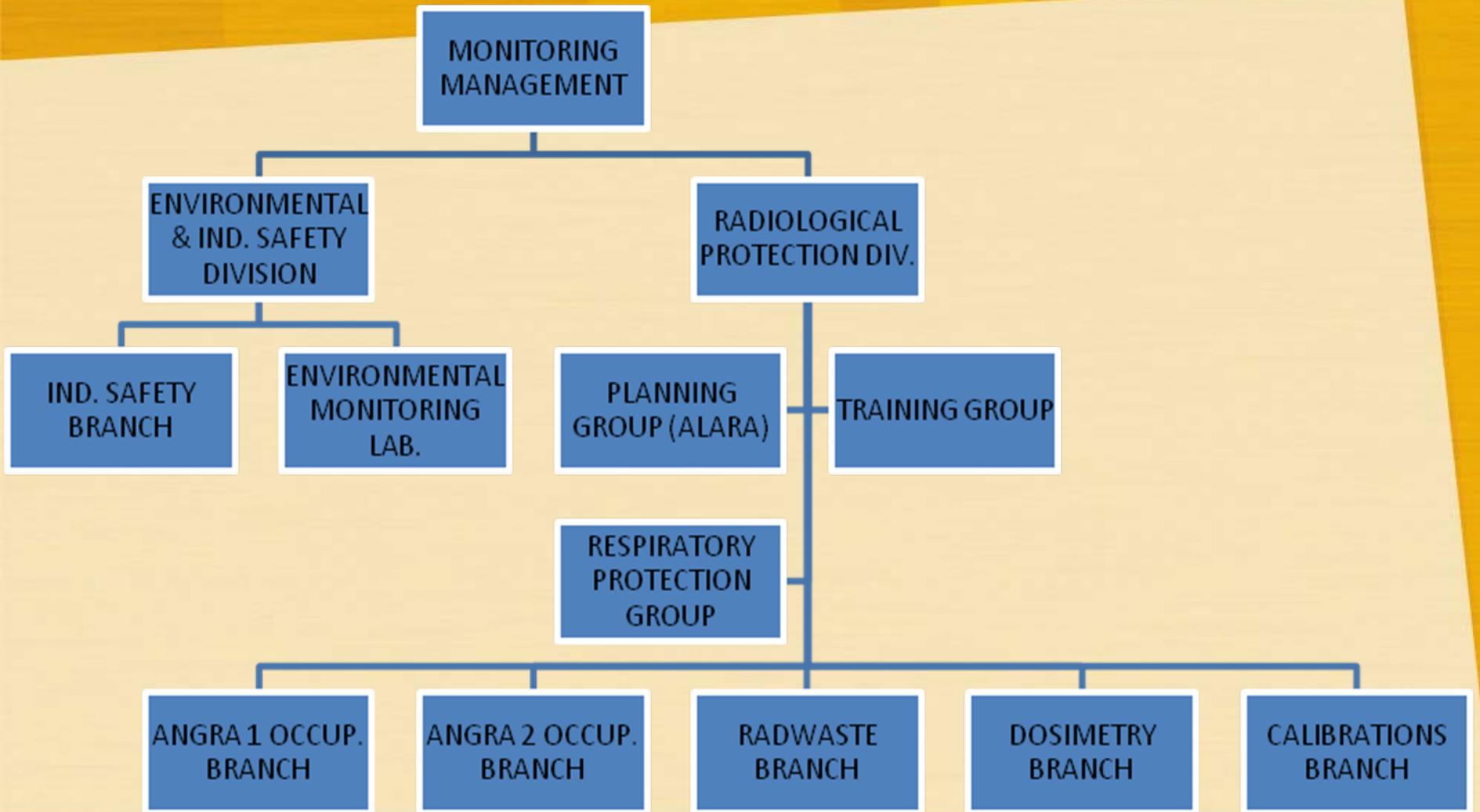
# CHRONOLOGY



# CHRONOLOGY



# RP ORGANIZATION

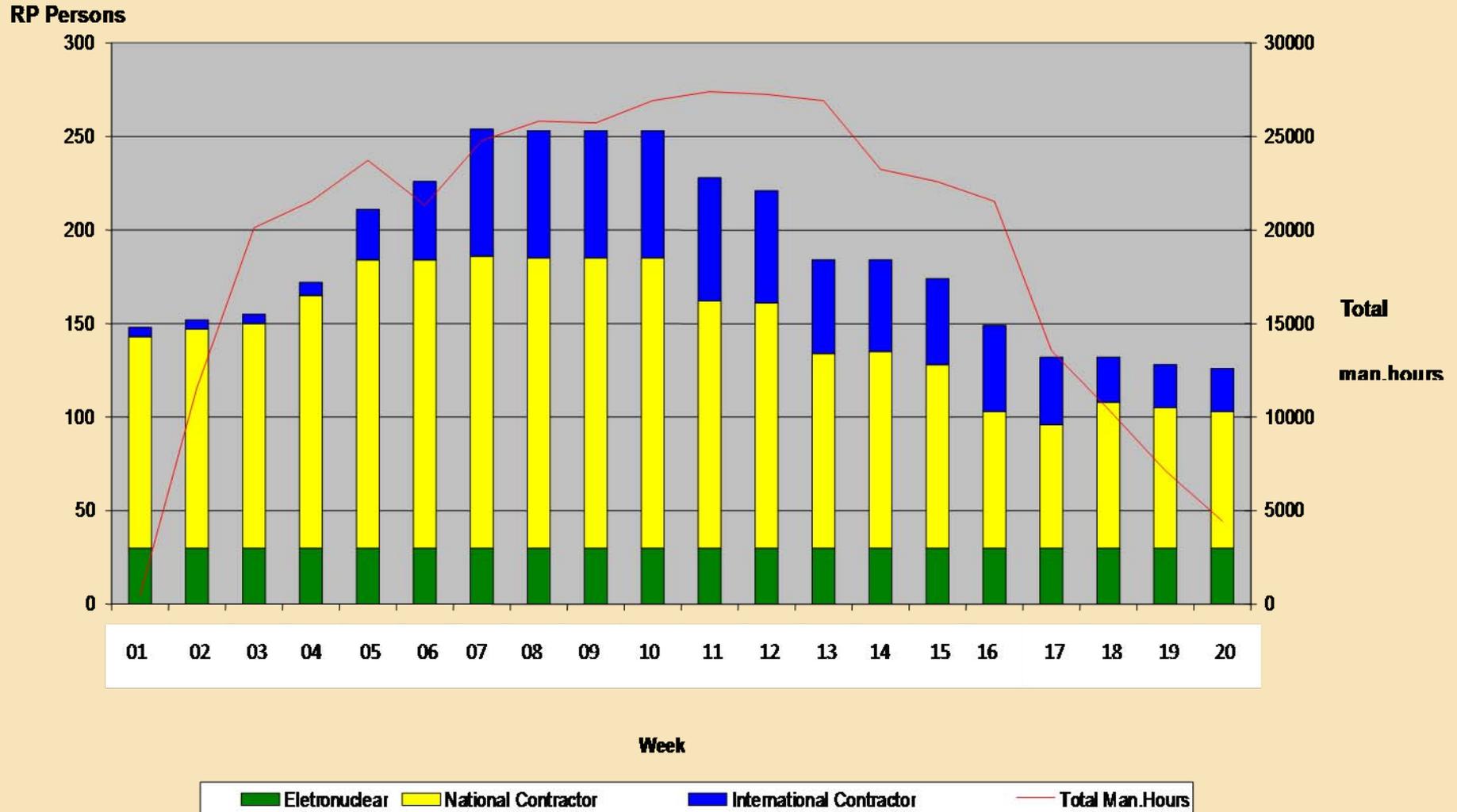


# RP ORGANIZATION

## Total effort of RP (Angra 1) during SGR

Function	ETN	Brazilian Contractor	International Contractor
Manager	1		
Coordinators	3		
Supervisor	5		8
Senior Technician	12		35
Junior Technician	4		20
Aux. Technician	5	40	
Decon Technician		25	5
Helper		90	
Total	30	155	68

# RP ORGANIZATION



# TECHNIQUES & TECHNOLOGIES

Emergency lights – red lights were used during high risk evolutions, blinking to warn the workers about the risks in the area, like in the job of radiography, “sand boxes” in the reactor cavity, primary legs cutting out and others.



# TECHNIQUES & TECHNOLOGIES

CCTV and Tele-dosimetry, with radio system and pager, made a powerful combination for the online coverage of the jobs in field.



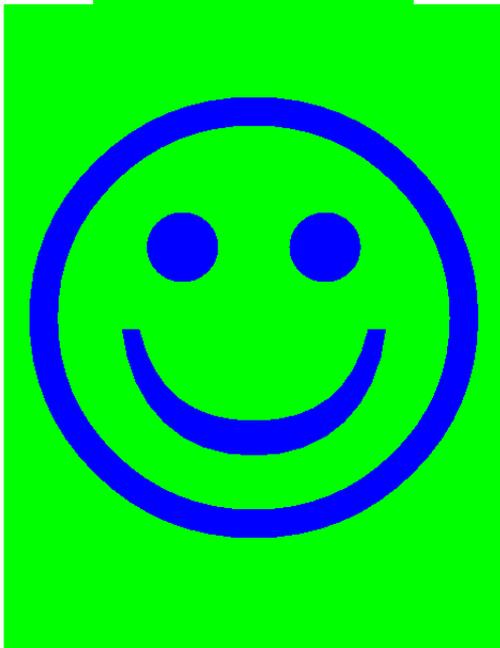
# TECHNIQUES & TECHNOLOGIES



Material's Clearance Management – a special team was composed to manage the materials clearance.

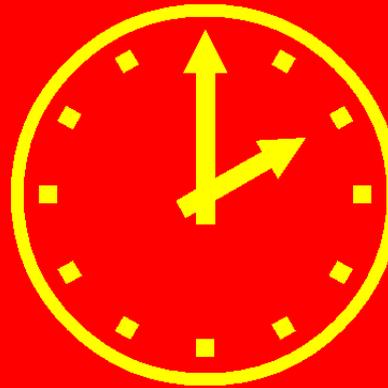
# TECHNIQUES & TECHNOLOGIES

WAITING AREA



ÁREA DE ESPERA

CONTROL YOUR TIME -  
MINIMIZE YOUR DOSE!



CONTROLE SEU TEMPO -  
MINIMIZE SUA DOSE!

NÃO PERMANEÇA NESTE  
LOCAL  
DESNECESSÁRIAMENTE!



DON'T STAY HERE IF NOT  
NECESSARY!

Colored Postings and Warning Messages – contributed to save doses as the workers remained informed about the areas status.

# TECHNIQUES & TECHNOLOGIES

SHIELDING—  
not only for  
high dose  
rates points,  
but also to  
reduce the  
low dose  
rates in the  
transit areas,  
like corridors,  
stairs and  
stay areas.



# TECHNIQUES & TECHNOLOGIES



RP Identification – RP personnel used red jackets in the field.

# TECHNIQUES & TECHNOLOGIES

## SOURCE TERM REDUCTION

Zinc addition for the RCS during operation

H<sub>2</sub>O<sub>2</sub> in the shutdown to achieve less than 0.05  $\mu$ Ci/gram of Cobalt 58

## LEAD SHIELDING

~ 40,000 kg of lead shielding were used

## WATER SHIELDING

## MOCKUP AND TRAINING

# CONTAINMENT OPENING CONTROL



# CONTAINMENT OPENING CONTROL



# CONTAINMENT OPENING CONTROL



# CONTAINMENT OPENING CONTROL



# SG TRANSPORTATION

TLD and tele-dosimeters were used to record and control the doses for the personnel during the OSG transportation for the mausoleum.



# SITE FACILITIES



# SITE FACILITIES



# SITE FACILITIES



# SG TRANSPORTATION

A complete radiological survey was done, both for doses and contamination.

No events during transportation.



# OSG STORAGE

The OSG were stored in a mausoleum, with the low level radwaste produced directly from the SGR.

The RP Team provide the radiological safety for the transportation and secured the route to avoid any unplanned exposure.



# RADWASTE

103 boxes with Thermo 12 (asbestos) / 41 boxes sent for mausoleum / 62 boxes were segregated, with the below results:

<b>Total monitored</b>	<b>5,553.90 Kg</b>
<b>Total cleared</b>	<b>5,088.40 Kg – 92%</b>
<b>Total encapsulated</b>	<b>465.50 Kg – 8%</b>
<b>Released boxes</b>	<b>52</b>
<b>Stored boxes in the mausoleum</b>	<b>10</b>

A total of 51 Metallic Boxes with thermal insulation containing asbestos are stored in the mausoleum.

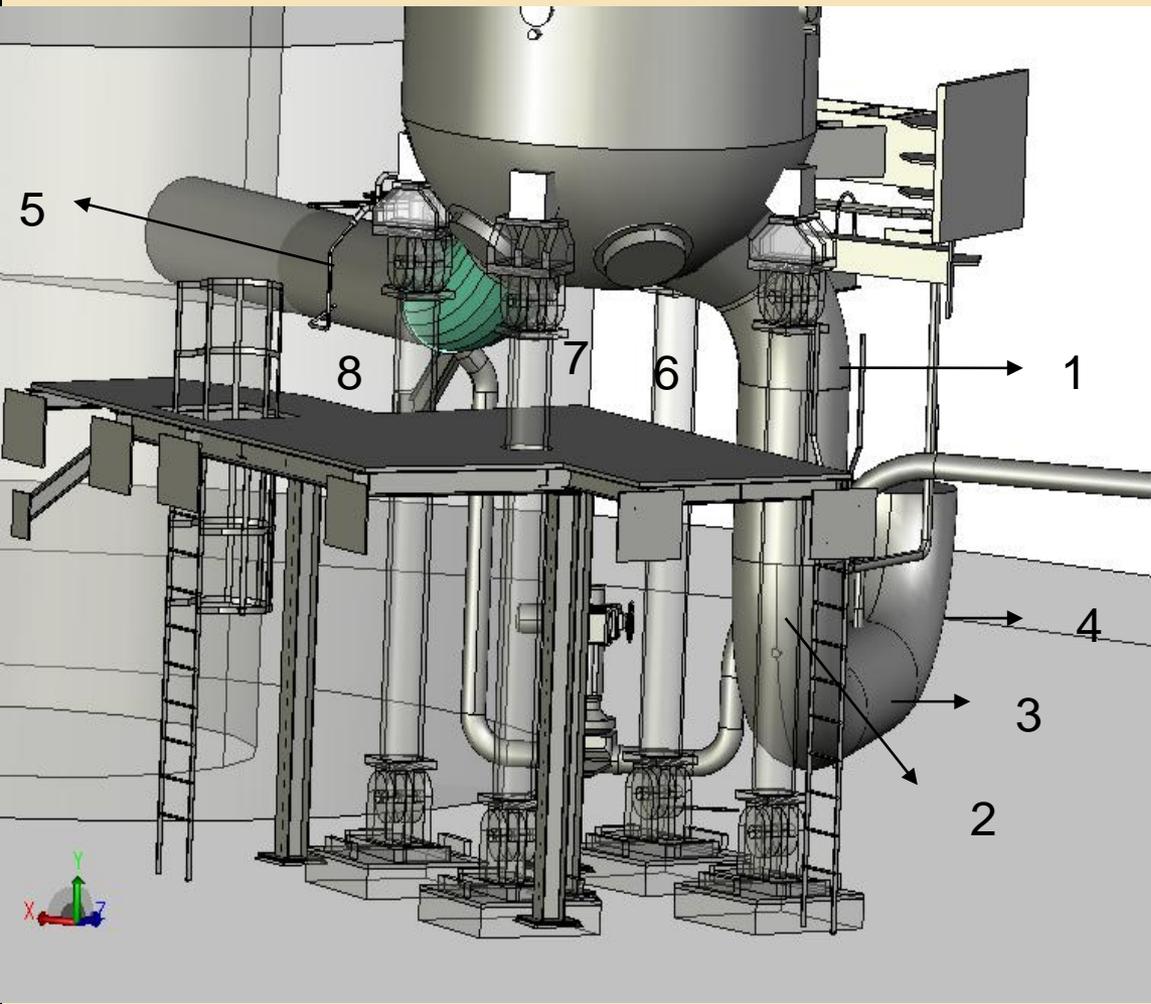
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# TECHNIQUES & TECHNOLOGIES

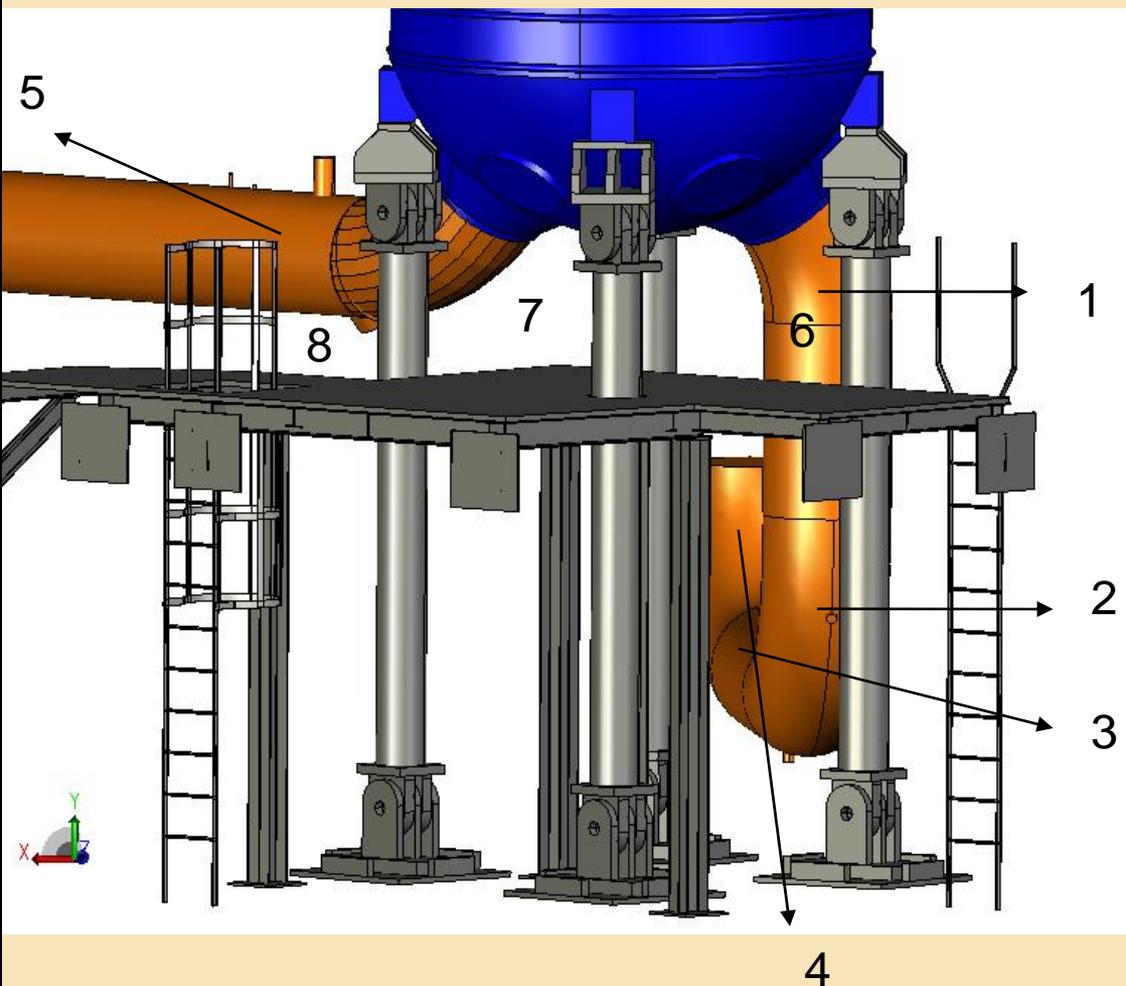
RCS loop 1 – Measurements for shielding efficiency ( $\mu\text{Sv/h}$ )



Place	W/O Shielding	With Shielding
1	325,0	154,0
2	1950,0	480,0
3	1400,0	449,0
4	330,0	170,0
5	1115,0	520,0
6	55,0	25,0
7	20,0	10,0
8	90,0	20,0

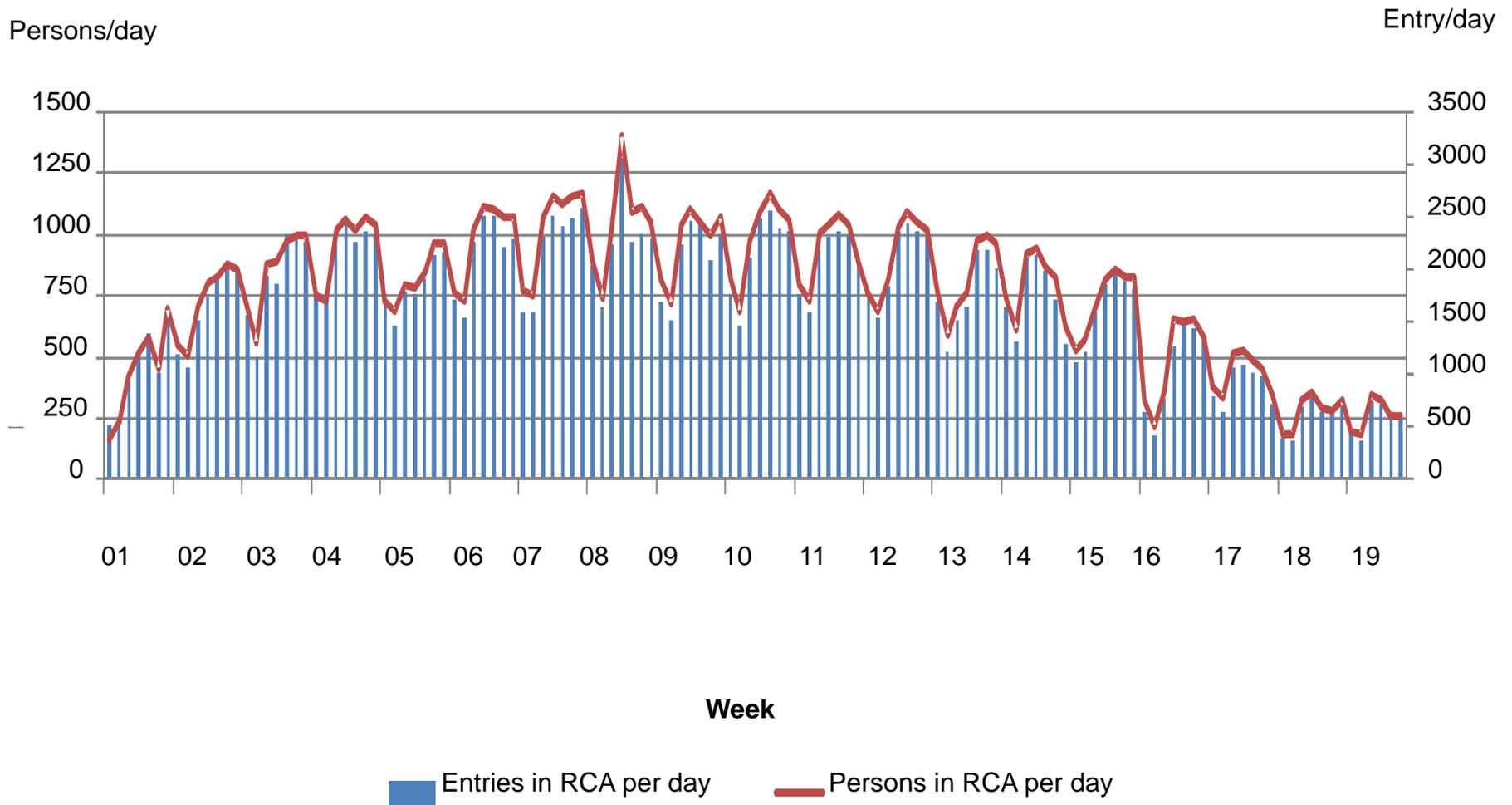
# TECHNIQUES & TECHNOLOGIES

RCS loop 2 – Measurements for shielding efficiency ( $\mu\text{Sv/h}$ )

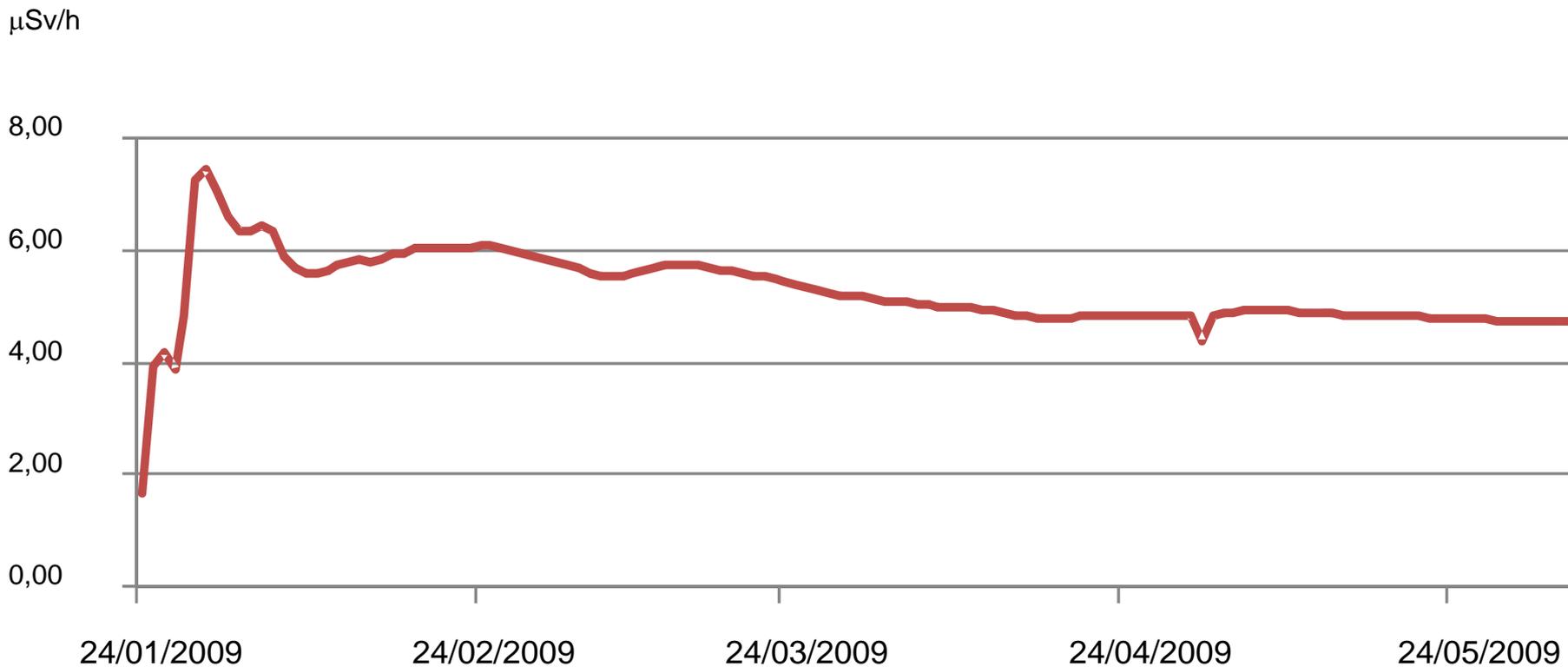


Place	W/O Shielding	With Shielding
1	420,0	210,0
2	1220,0	220,0
3	460,0	280,0
4	300,0	248,0
5	735,0	400,0
6	25,0	16,0
7	15,0	7,0
8	65,0	30,0

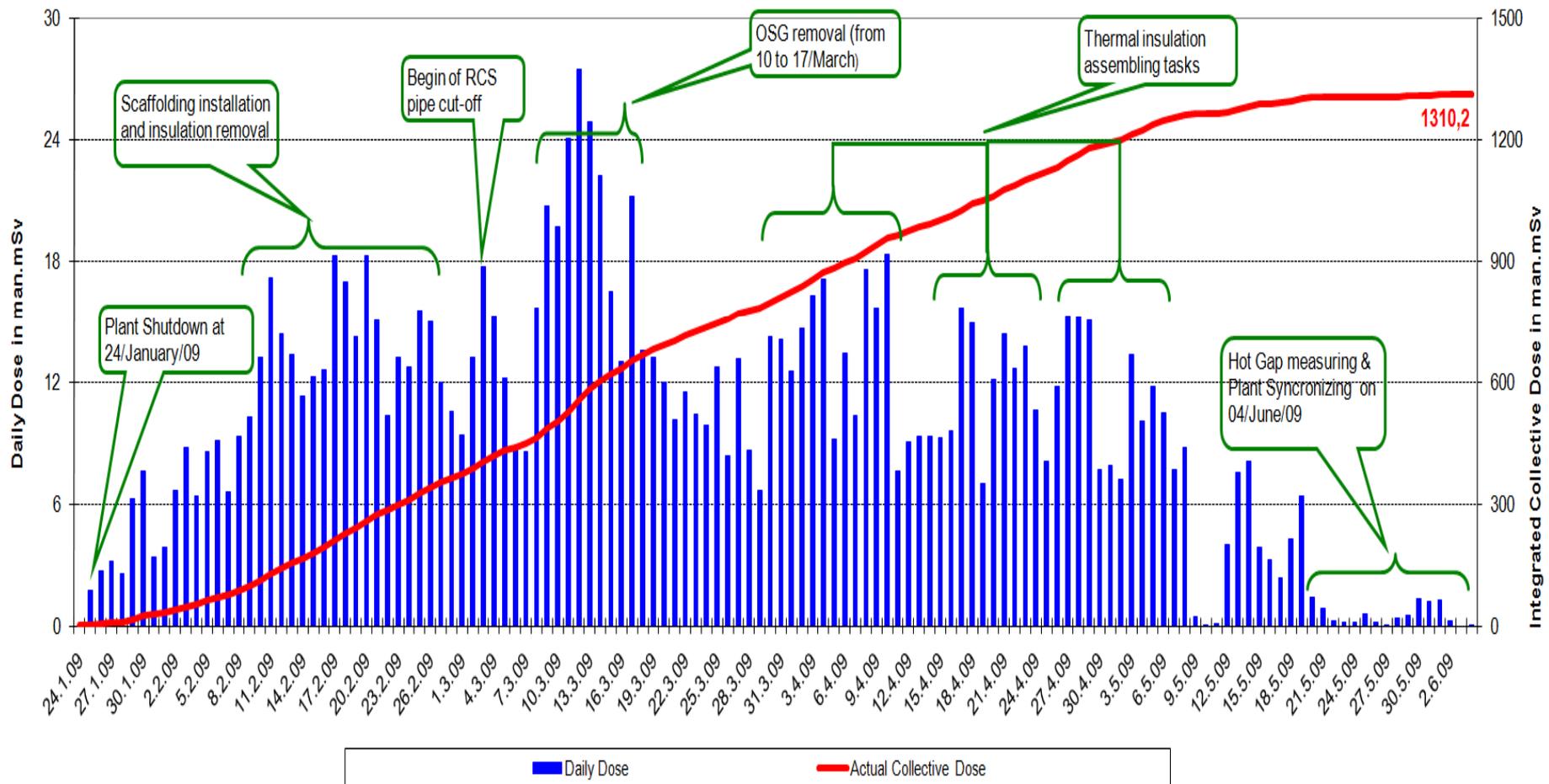
# RESULTS



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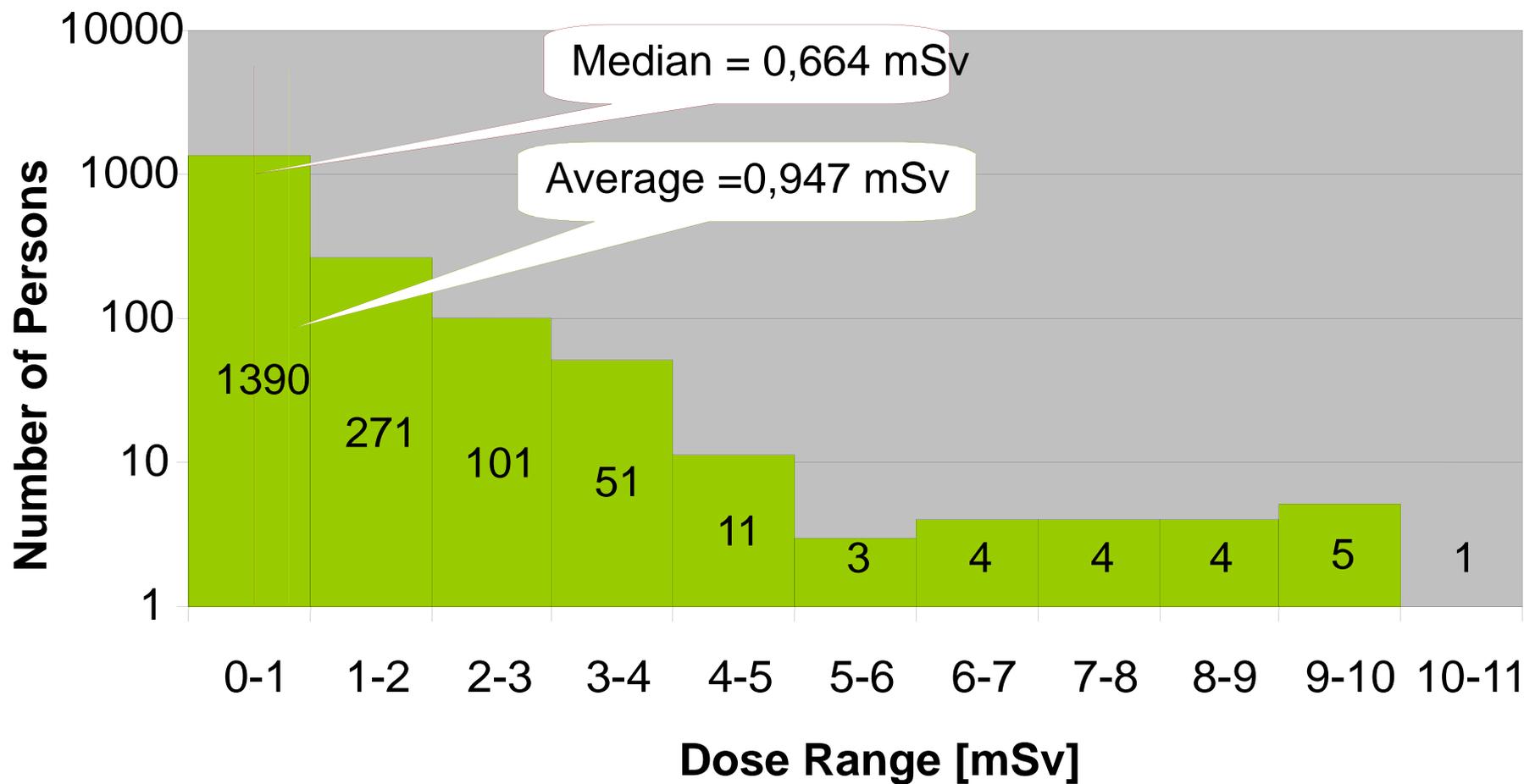


# RESULTS

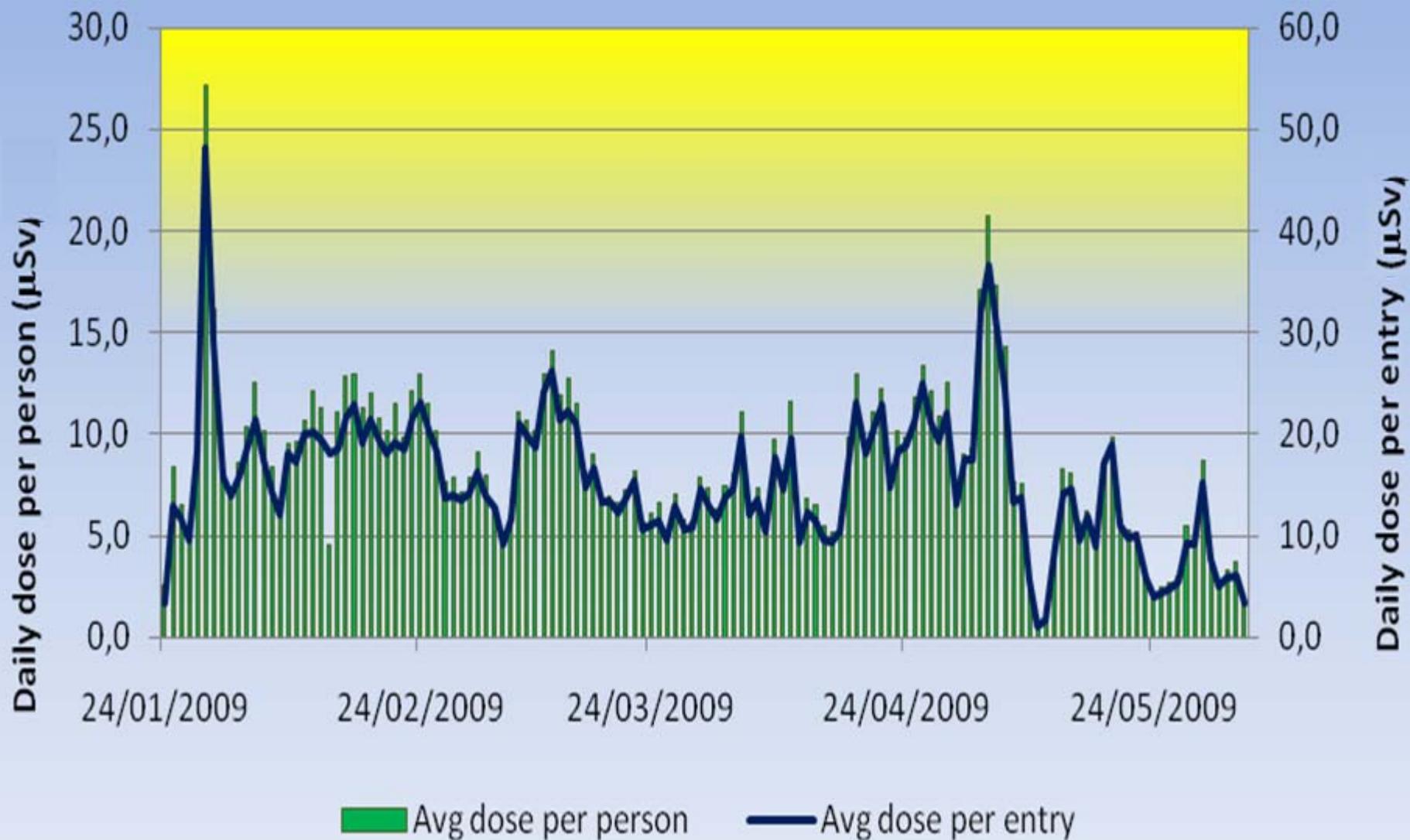


# RESULTS

## Number of Persons x Dose Range



# RESULTS



# Thank you!

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