



HSE
Occupational Health & Safety
and Environmental Protection unit





HL-LHC alignment: Preliminary RP considerations

A. Infantino, C. Adorisio

HSE-RP-AS

EDMS 2220425



Context and Aim

“Scope of the review:

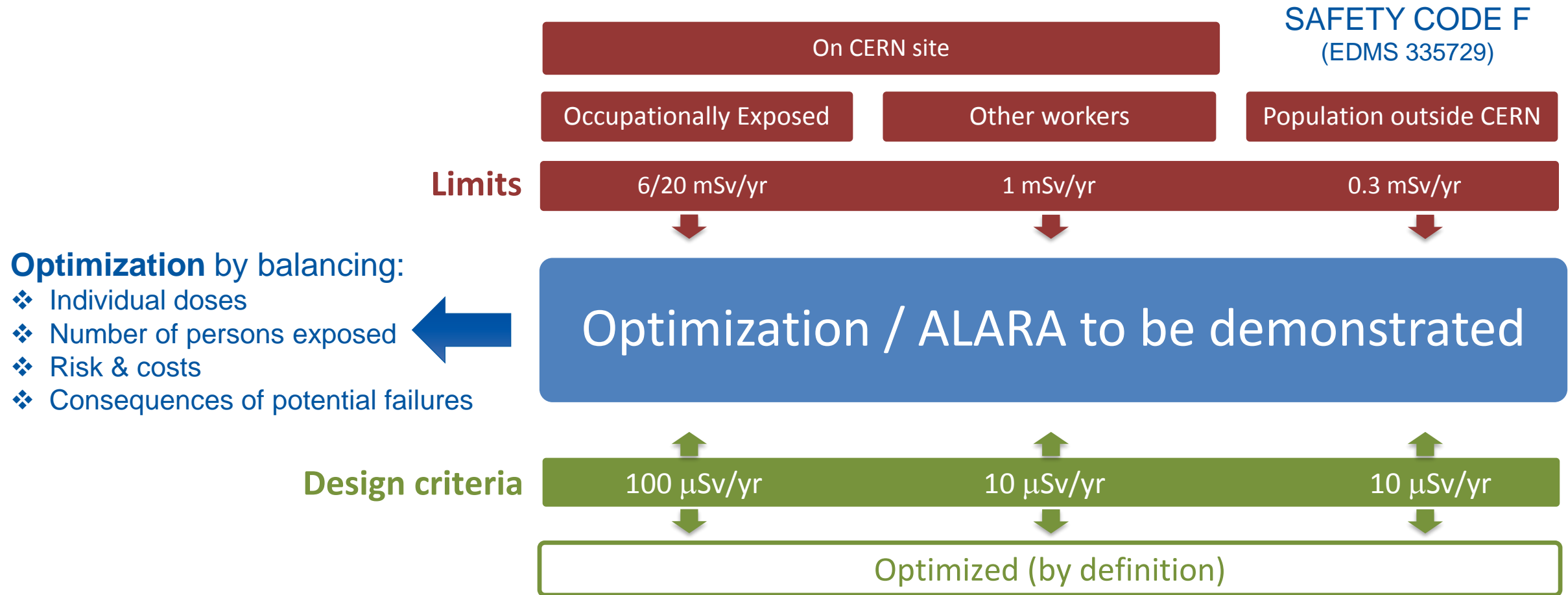
The scope of this review is:

- ...
- *To put in evidence possible integration issues and safety aspects.*”

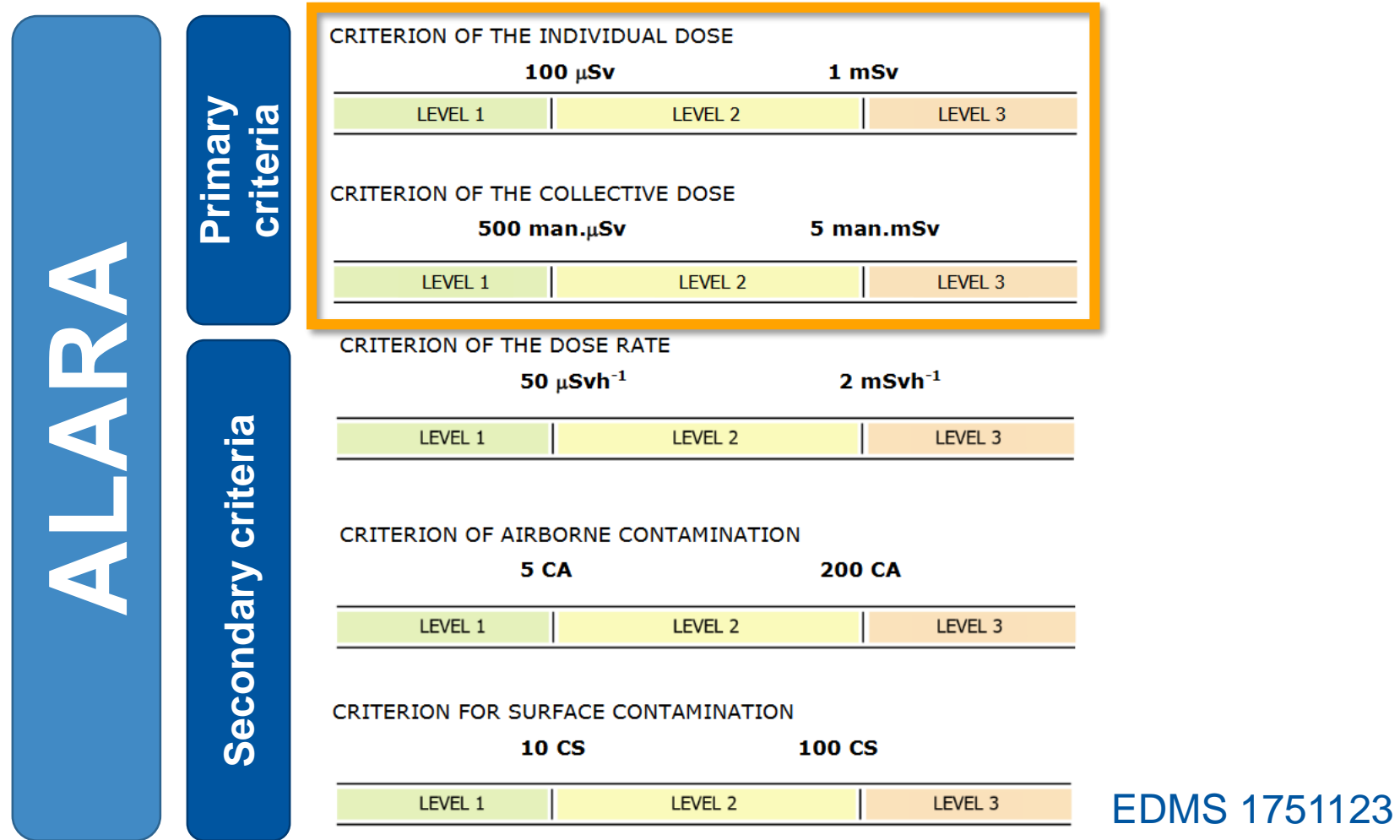
(<https://indico.cern.ch/event/831552/overview>)

- This presentation summaries the data reported in [EDMS 2168987](#)
- Based on **FLUKA** Monte Carlo simulations (HL-LHC v1.3)
- **Preliminary** RP overview → (!SPOILER!) new estimation needed considering **HL-LHC v1.5**
- As we saw yesterday ([Oliver's talk](#)) a significant number of elements in the IR must be replaced → (!SPOILER!) a **detailed planning** of the activities is required also from the RP point of view.

Recall of RP optimization at CERN



Recall of RP optimization at CERN



Recall of RP optimization at CERN

❑ Operation

- dose equivalent to personnel by stray radiation in accessible areas
- activation of water and air and their release into the environment as well as the resulting annual dose to the reference groups of the population
- dose equivalent to personnel and environment in case of abnormal operation or accidents

❑ Shutdown

- induced radioactivity in accelerator components and related residual dose equivalent rate
- individual and collective doses to personnel during interventions in radiation areas

❑ Decommissioning

- waste minimization
- radionuclide inventory for waste disposal

Recall of RP optimization at CERN

Optimization = Iterative process

1. Calculation of residual dose rate maps

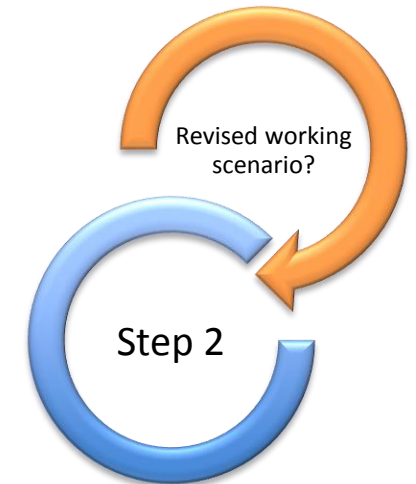
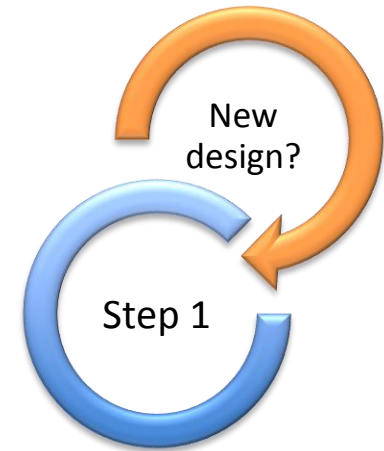
- for cooling times typical of interventions scenarios
- based on (nominal) operational parameters
- definition of geometry and materials as detailed as needed (and available)

2. Calculation of individual and collective intervention doses

- based on a realistic work scenarios, including locations, duration, number of persons involved,..
- identification of cooling times below which work will be impossible
- communication of results and constraints to equipment groups

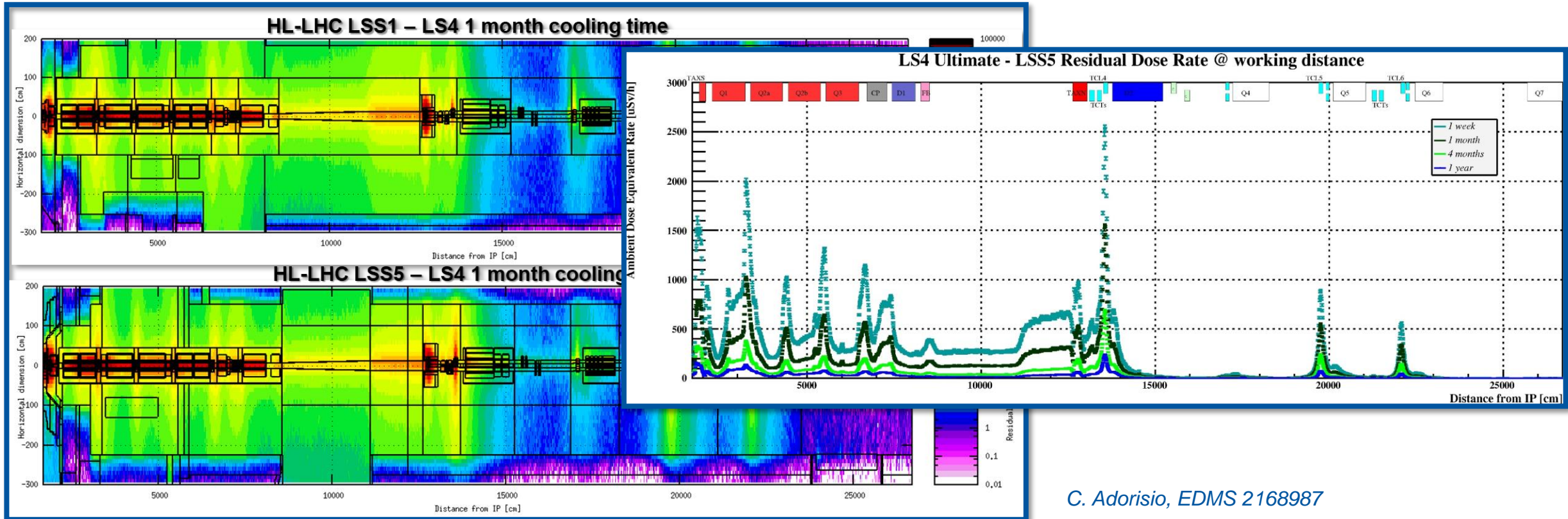
3. Revision of design and/or work scenario

- start with conservative scenarios that give highest individual or collective doses
- consider optimization measures (distance, tooling, material choices, etc.)
- identify if remote handling is possible



1. Calculation of RDR maps

- ✓ Maps available for IR1 and IR5 (LHC & HL-LHC v1.3) and for LS2/LS3/LS4 at different cooling times (1h-1yr)
- ✓ Shared models with the FLUKA/R2E team (see Giuseppe's talk)
- ✓ Maps used to estimate the individual/collective doses



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2. Calculation of individual and collective dose: an example

LHC's procedure

- ❑ First estimation done considering the current procedure (elements from D1 up to cell 6).
- ❑ vertical measurements, **2 workers, 10 minutes** next to each element, **~2 hours work**.
- ❑ measurements have to be done “**as soon**” the machine stops.
- ❑ alignment, if needed, can be done at **longer cooling time**.
- ❑ Very **high individual and collective doses** even at long cooling time.

		LSS5 (one side only)							
		residual dose rate (uSv/h)				10 minutes dose (uSv)			
	distance from IP (cm)	1 week	1 month	4 month	1 year	1 week	1 month	4 month	1 year
D1	7442	800	410	140	55	133		23	9
	8450	350	150	50	20			8	3
TAXN	12626	900	450	150				5	9
	13047	400	220	80					5
TCL4	13511	2500	1550						42
D2	13779	650							11
	15224								1
crabs	15600-15800								1
Q4 mask									1
Q4								2	1
TCL5								1	1
Q5 mask						22	11	5	3
Q5					10	21	11	4	2
					5	3	2	1	1
TCL6				140	50	85	52	23	8
Q6 mask	2200	50	40	20	10	12	7	3	2
Q6	2200	50	30	10	5	8	5	2	1
	23205	10	5	5	5	2	1	1	1
						1239	703	291	112
						2 hours (μSv)			
aisle	-	50	25	10	5	100	50	20	10

For example:
 measurement (1 week cooling time)
 +
 alignment (all elements (!), 4 months cooling time)
Collective dose: ~1.6 man.mSv

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Collective Dose (man.μSv)	1339	753	311	122
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3. Review of design and/or intervention scenario

HL-LHC's procedure

- ❑ Full Remote Alignment (FRA)
- ❑ Permanent **remote** monitoring system for the equipment up to Q5
- ❑ **Motorized jacks** for the main components (D1, TAXN, D2, crab cavities, Q4, Q5)
- ❑ Fast adjustment system made of plug-in motors to perform **remote alignment** (estimated time to plug it in and out: 2 minutes)
- ❑ Access for measurement and alignment needed only on cell 6 elements (TCL6, mask and Q6), as it is done today

		LSS5 (one side only)			
		10 minutes (uSv)		2 minutes (uSv)	
	distance from IP (cm)	1 week	1 month	4 month	
D1	7442	0.0	0.0		
	8450	0.0	0.0		
TAXN	12626	0.0			
	13047				
TCL4	13511				
D2					
crab					
					0.0
					0.0
			7.2	2.3	
		0.0	1.0	0.5	
		0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0
	22062	85.0	51.7	23.3	8.3
	22256	11.7	6.7	3.3	1.7
	22472	8.3	5.0	1.7	0.8
Q6	23265	1.7	0.8	0.8	0.8
		107	64	61	23
aisle	-	50	25	10	5

For example:
measurement (1 week cooling time)
+
alignment (all elements (!), 4 months cooling time)
Collective dose: 228 man.µSv

C. Adorisio, EDMS 2168987 Collective Dose (man.µSv) 157 89 71 28



Conclusions

- ✓ The preliminary estimation was performed considering the first LS in the HL era (**ultimate conditions**) → nominal conditions ~ 30% less (EDMS 2168987).
- ✓ Secondary elements measurement and alignment not taken into account in these examples (e.g. vacuum equipment, BPMs...) → more detailed list of actions would give a **more accurate estimation**.
- ✓ This preliminary evaluation clearly shows the benefit of an optimized (& **remoted**) procedure.
- ✓ Time is mature to perform a **new estimation** since HL-LHC v1.5 optics now available.



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ANGELO INFANTINO

CERN HSE-RP-AS

@ angelo.infantino@cern.ch

