Implementing ALARA in the nuclear sector

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Some figures on radiation protection at the EDF nuclear power plants in operation

- 58 reactors – 19 NPPs
- Around 50,000 workers (EDF and contractor).
- More than 300 certified contractor companies.
- 6 to 7 million hours of work/year in the RCA.
- 3 million entries/year in the RCA.
- 80% of the activities are carried out during outage over short durations (from a few weeks to a few months)
  - 400 to 500 activities for refuelling-only outage,
  - 1000 to 1200 activities for maintenance outage,
  - 1500 to 2000 activities for ten-yearly outage (excluding steam generator replacement)

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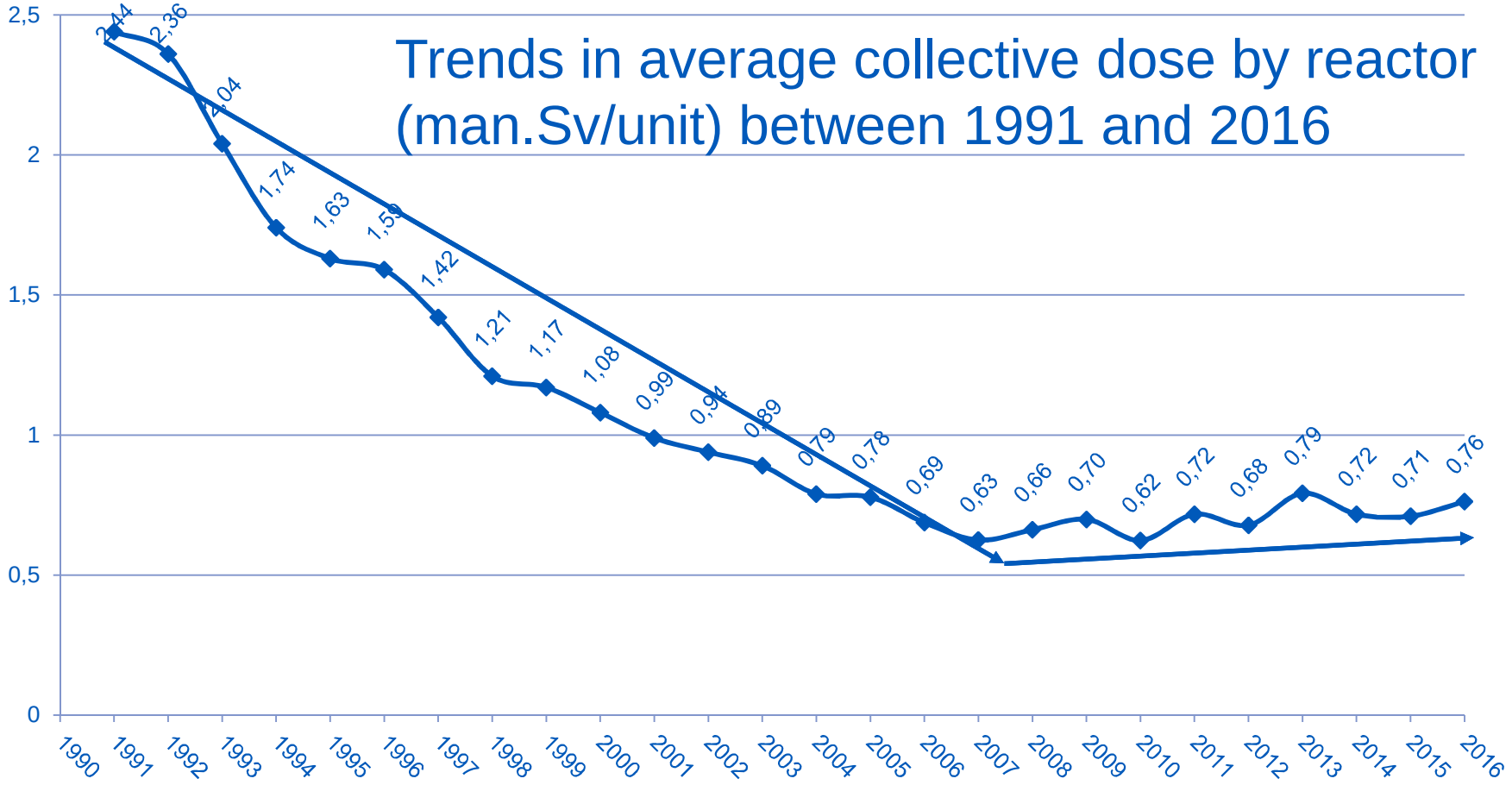
Theme 1

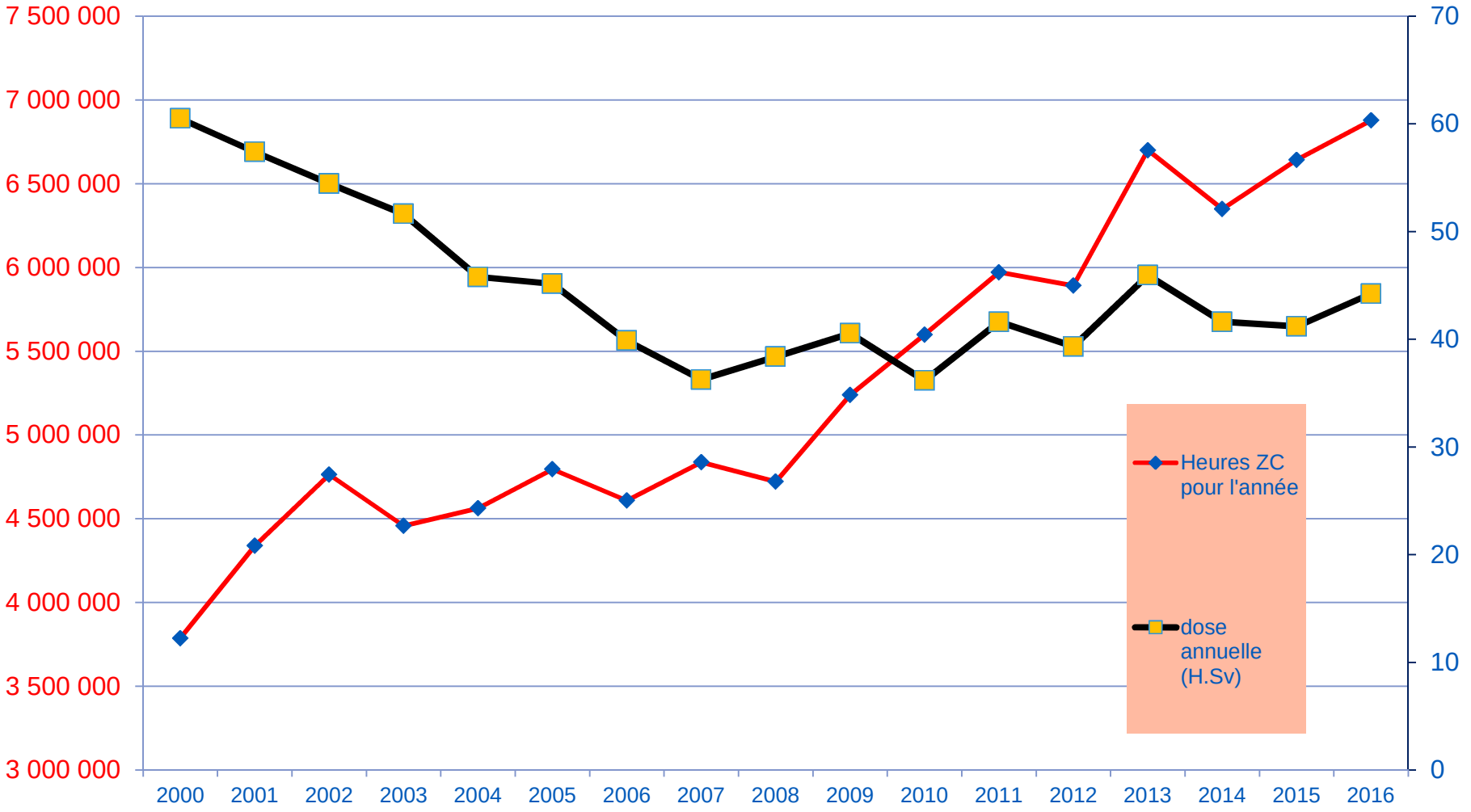
Impact of the work environment and volume of activity on collective dose

Collective dose is assessed for the volume of activities

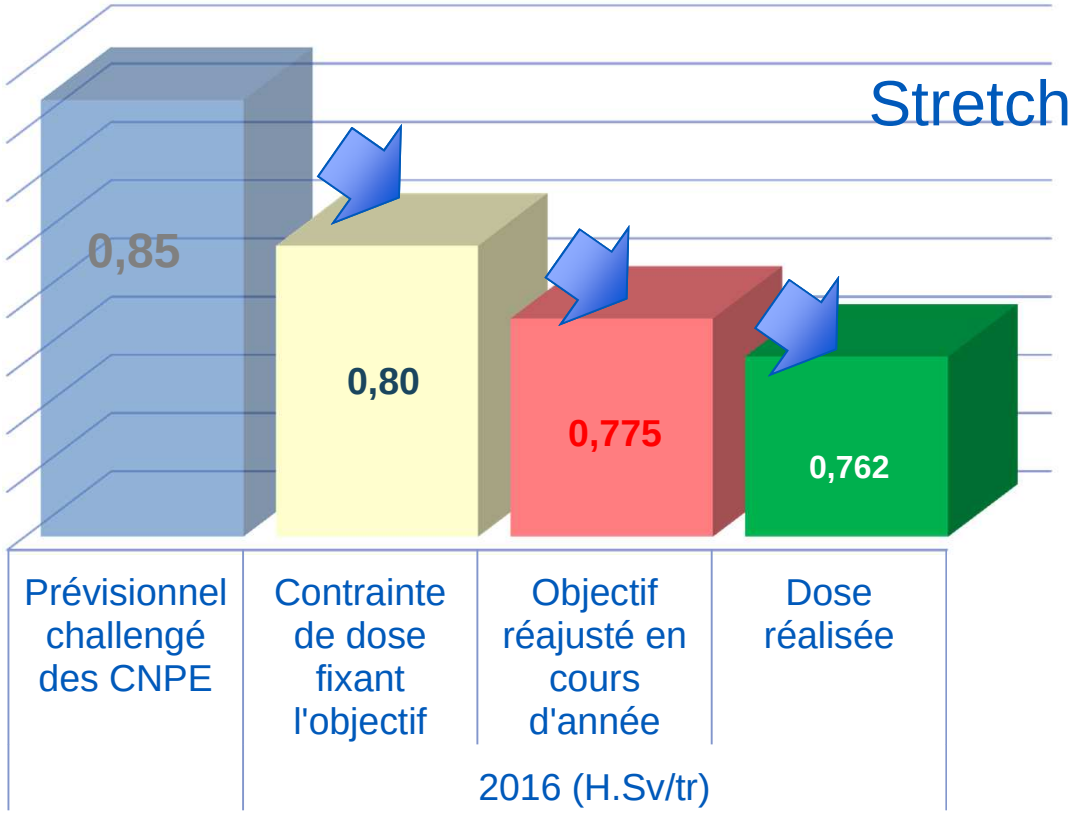


Collective dose is it a good indicator to assess the RP performance?

Collective dose is assessed for the volume of activities



Dose constraint tool: advantage of optimising collective dose within the context of the high volume of activities



The goal fixed by the DC allowed to make progress in RP within the context of a high volume activity

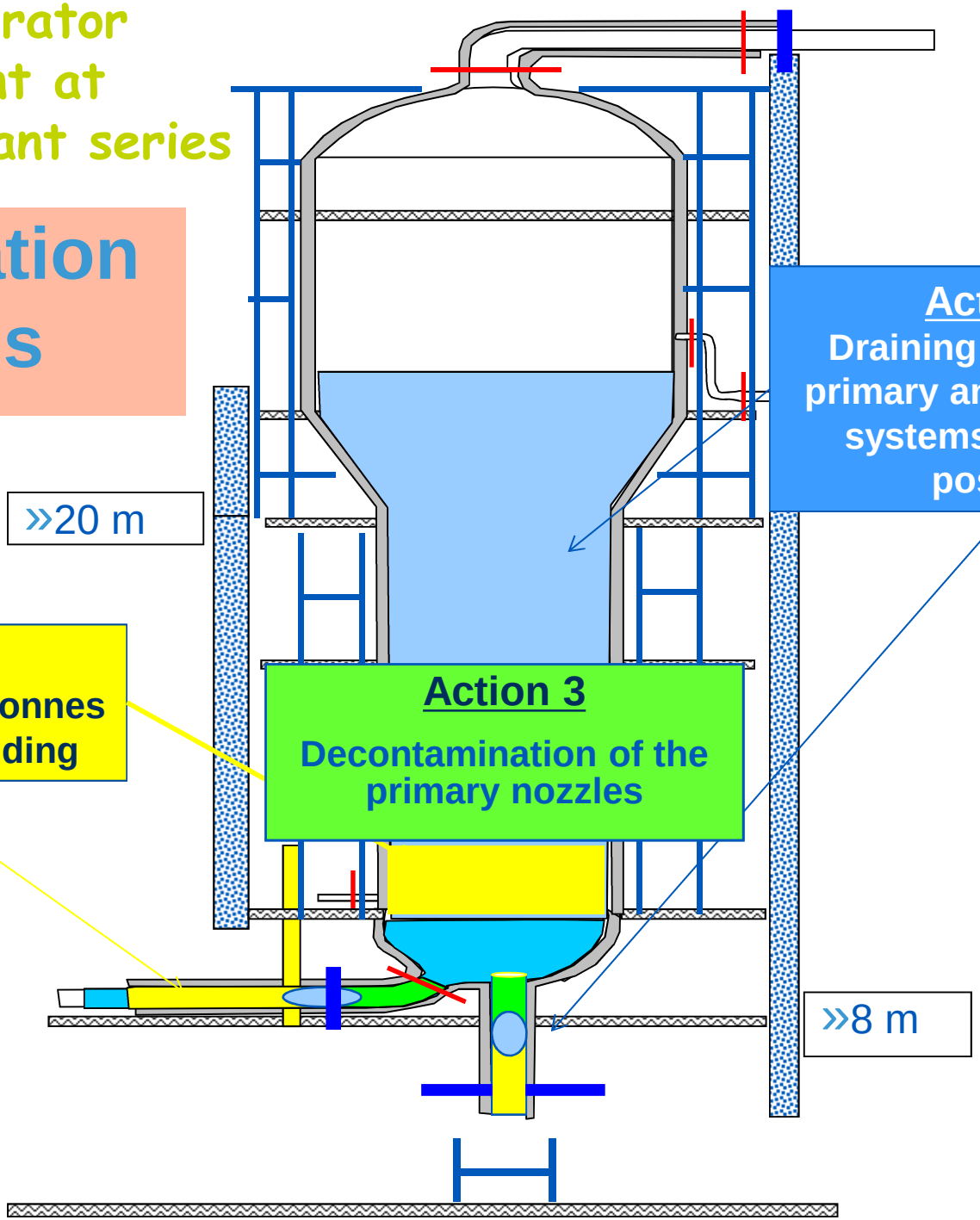
Theme 2

Sustained optimisation procedure, for example steam generator replacement

Measurement of collective dose performance must integrate the work environment and the task, in which the operation is carried out and is assessed over time.

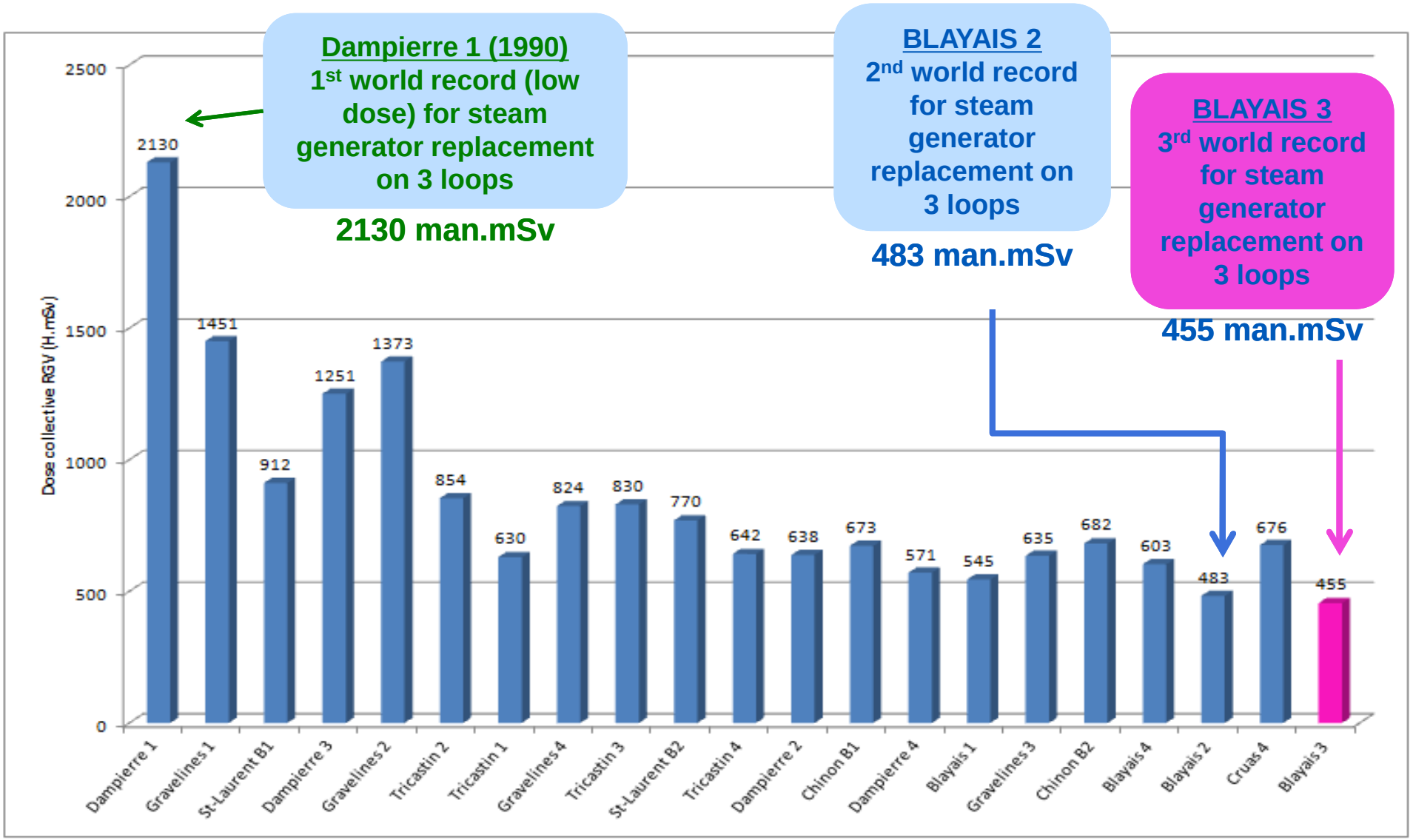
Steam generator replacement at the 900 MW plant series

Optimisation actions



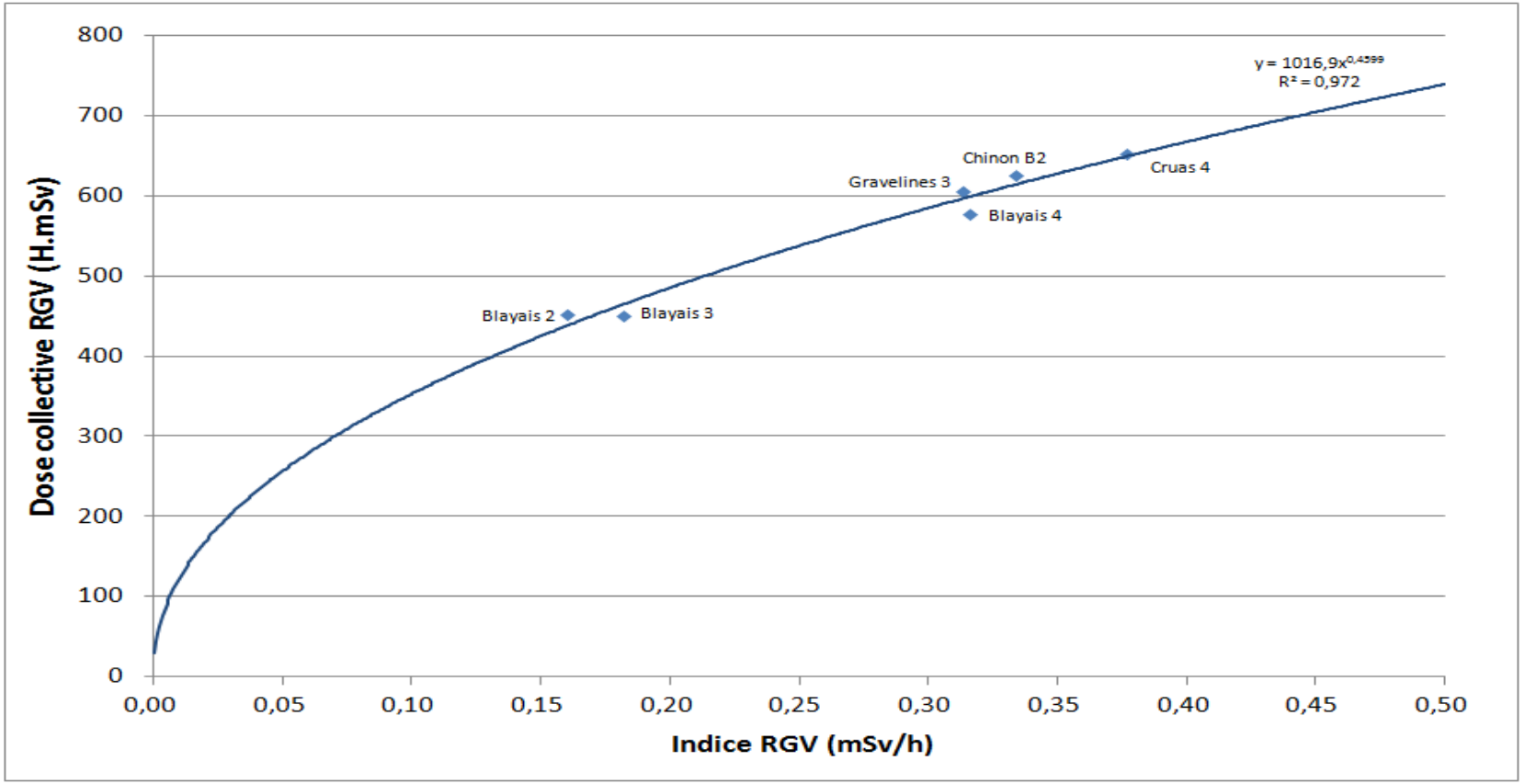
Steam generator replacement at the 900 MW plant series: collective dose for the CPY plant series

Sustained optimisation



Steam generator replacement at the 900 MW plant series

Optimised work environment:
Improve radiological condition of the primary systems



Eliminate hot spots in the worksite environment and circuit cleaning

Theme 3

Ethical approach:

Reduction of collective dose goes hand-in-hand with reduction of individual doses

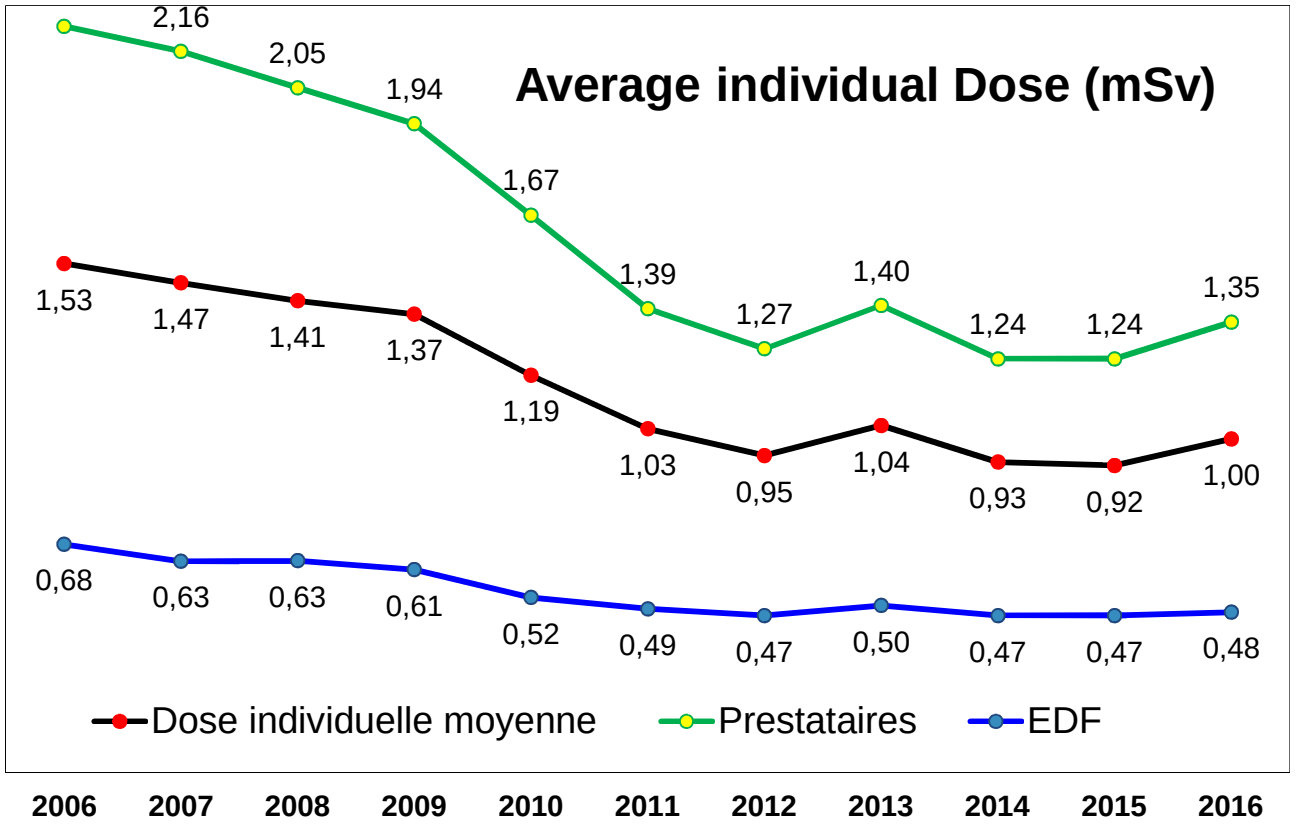
Ethical approach in Radiation Protection Optimisation

EDF workers on an equal footing with contractor workers

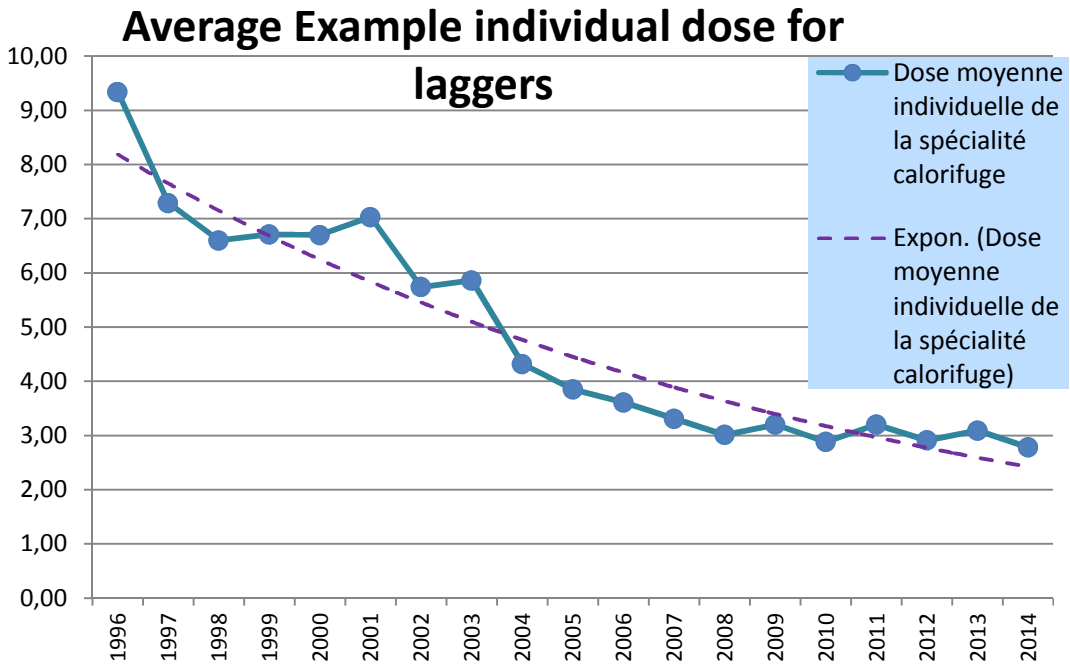
Common radiation protection practices

Non-discrimination and equity

- Deliberate intent to decrease individual doses (doses halved in 10 years both for EDF and contractor personnel)



Optimisation of dose is based on control of individual dose of the most exposed specialisations



Comparison between 2013 and 2016 for the most exposed groups

	2013	2016	difference as %
OVERALL FLEET DOSE	0,79	0,76	-4%
Laggers	3,09	2,87	-7%
Welders	2,05	1,85	-10%
Inspection	1,9	1,65	-13%
Mechanics	1,56	1,41	-10%
Logistics	1,44	1,34	-7%
Electricians and I & C technicians	0,86	0,84	-2%

Dose requirements for the most exposed groups decreased over the past 7 years with the maximum number of workers with monthly dose greater than 14 mSv per year

Year	Max number of workers > 14 mSv/year
2009	70
2010	46
2011	24
2012	20
2013	8
2014	5
2015	2
2016	1

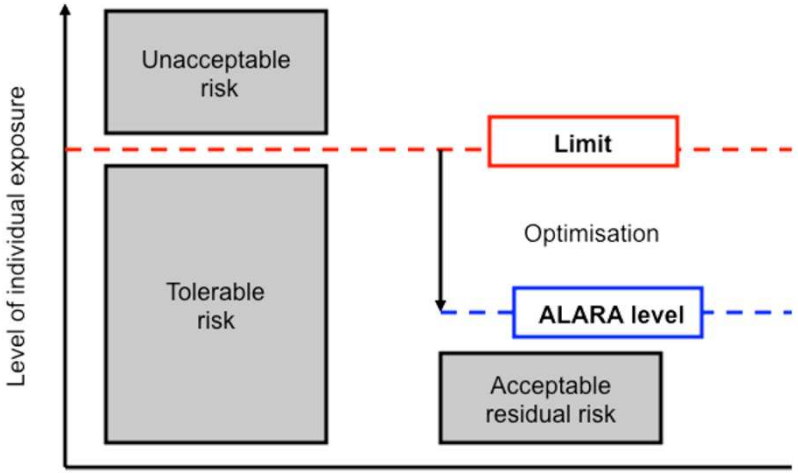
- Joint initiative and dialogue with the contractors
- Compiling and distribution of good practice guidelines (NDT, hot spots, integrated steam generator services, integrated reactor vessel services, etc)

Decision in 2016 to stretch the target (individual dose requirement) from 14 to 13 mSv

Theme 5

Prioritisation: use of man.Sievert

Use of economic argument : need for a reference value



- **Unacceptable:** corresponding to levels of exposure that would not be accepted on any reasonable basis in the normal operation of any practice; individuals could be exposed to these levels only in exceptional circumstances;
- **Tolerable:** corresponding to levels of exposure that are not welcome but can reasonably be tolerated;
- **Acceptable:** corresponding to levels of exposure that can be accepted without further improvement

- The 1970s, search for reasonable ground and conduct of **cost-benefit analyses**.
- The 1980s, **cost of man.Sievert, to translate exposure in terms of money and identify the level of protection deemed optimal.**
- As from the end of the 1990s, the search for an acceptable level resulted in the **development of initiatives involving the stakeholders**
- To keep exposures as low as reasonably achievable, economic and **societal** factors being taken into account (ICRP, Pub 103, 2007)

- These approaches require development of radiation protection culture so as to be able to initiate dialogue with the different parties concerned to assess the advantages and disadvantages of the different protection options envisaged.

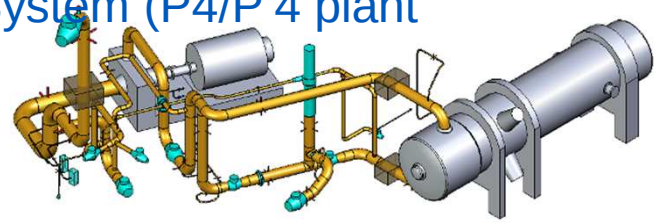
Raisonable approach : Man.mSv avoided needs to be evaluated for prioritisation and streamlining of the optimisation actions

Several foreign authorities (such as Switzerland and Belgium) and a great number of nuclear operators have set up a financial reference related to collective dose avoided.
The values adopted are variable (from a few hundred to a few thousand €/man.mSv)

Nevertheless this constitutes **an indispensable tool for supporting decision-making,** which has to be shared and recognised at fleet and international level.

Example of prioritisation for clean-up

T-piece on the Residual Heat Removal System (P4/P'4 plant series)



- Benefits:

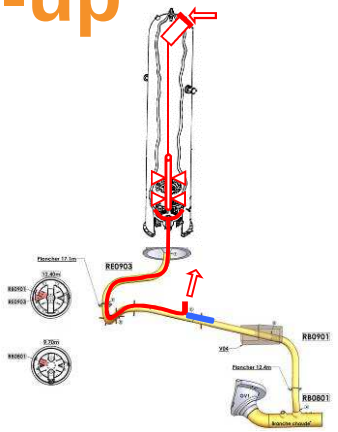
Net dosimetric savings (5 years): ~ 84 man.mSv

Cost of the operation: k€200

Development needs: zero

Cost-benefit ratio: k€2.38/man.mSv

Pressuriser



- Benefits:
  - Net dosimetric savings ~ 92 man.mSv

Cost of the operation: k€200

Development needs: average

Cost-benefit ratio: k€2.17/man.mSv

Reactor coolant pump volute

- Benefits:
  - Net dosimetric savings < 10 man.mSv

Cost of the operation: k€250

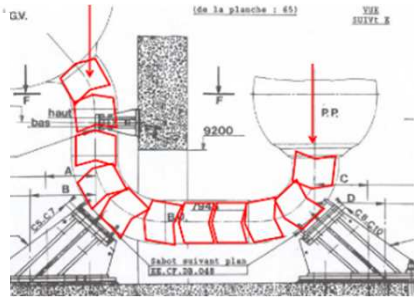
Development needs: above average

Cost-benefit ratio: > k€20/man.mSv

Cross-over leg

- Benefits:

Net dosimetric savings < 10 man.mSv



Cost of the operation: ~ k€300

Development needs: major

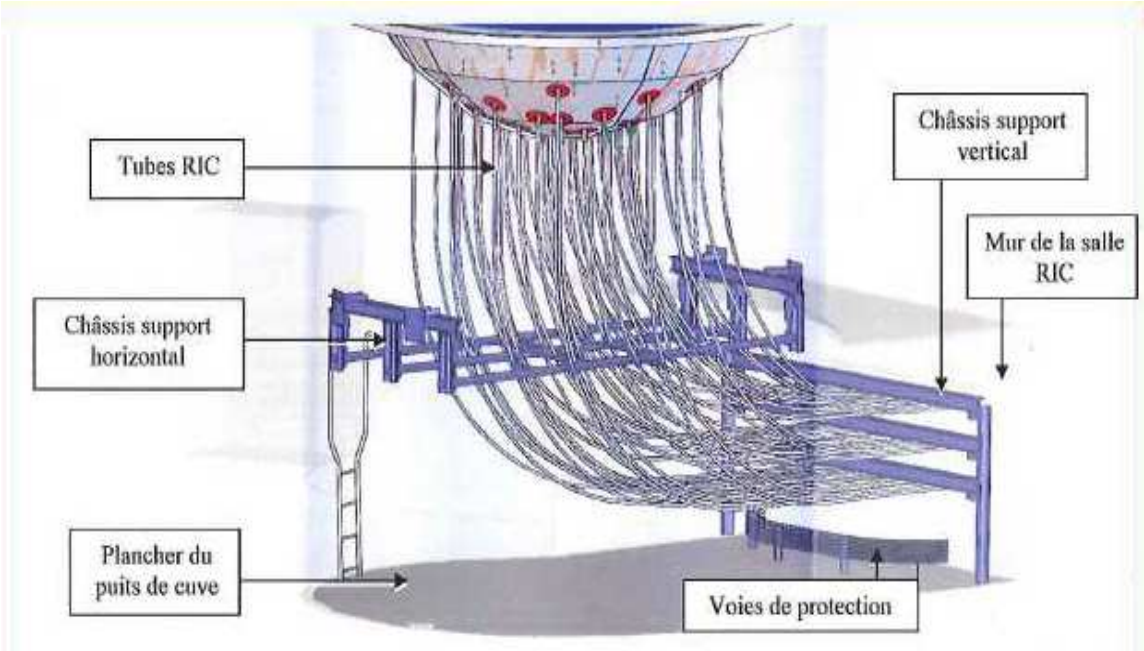
Cost-benefit ratio: > k€30/man.mSv

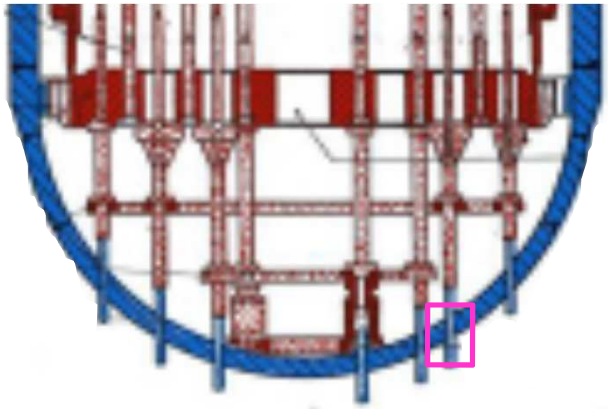
=> Importance to definer a clear criteria for decision making

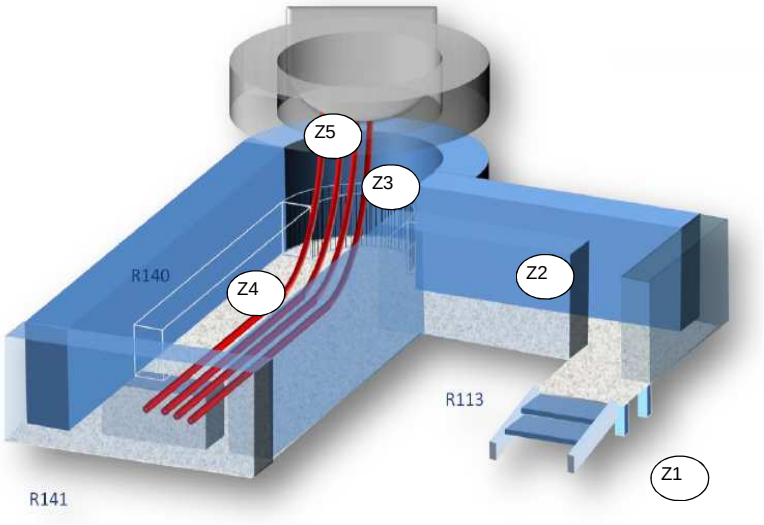
Theme 6

Optimisation within an integrated approach, for example reactor vessel bottom penetration worksite in 2016

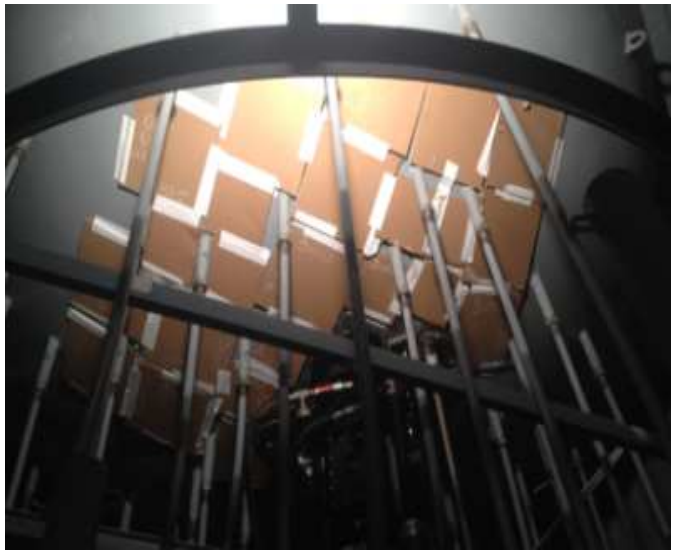
Collective dose is assessed for all the activities (for example, reactor vessel bottom penetration for Gra1)



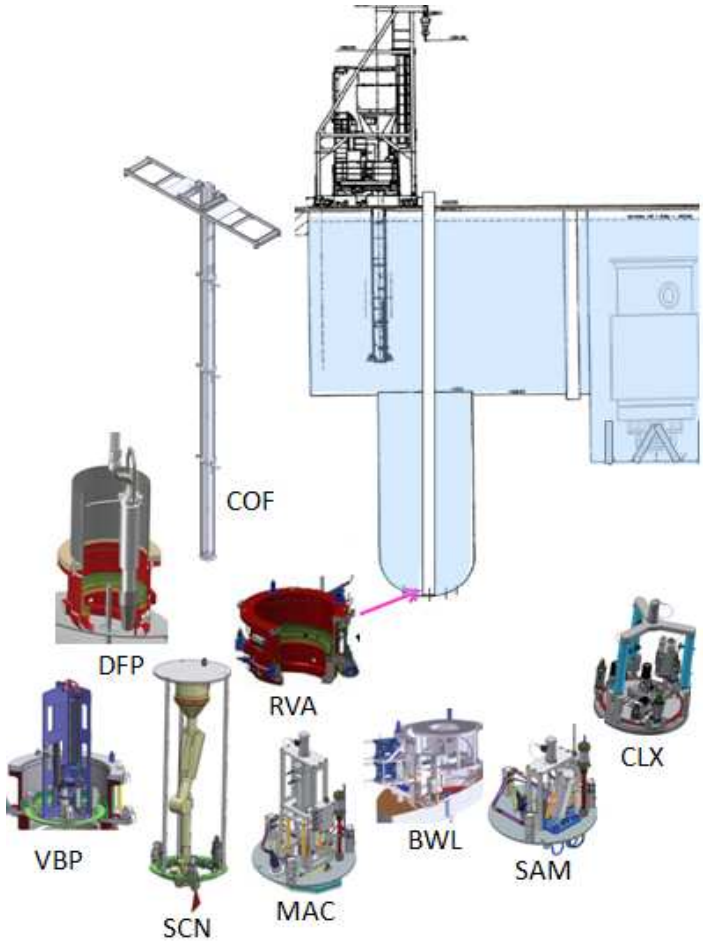




Optimisation actions need to be prioritised
(for example, reactor vessel bottom penetration 4 for Gra1)



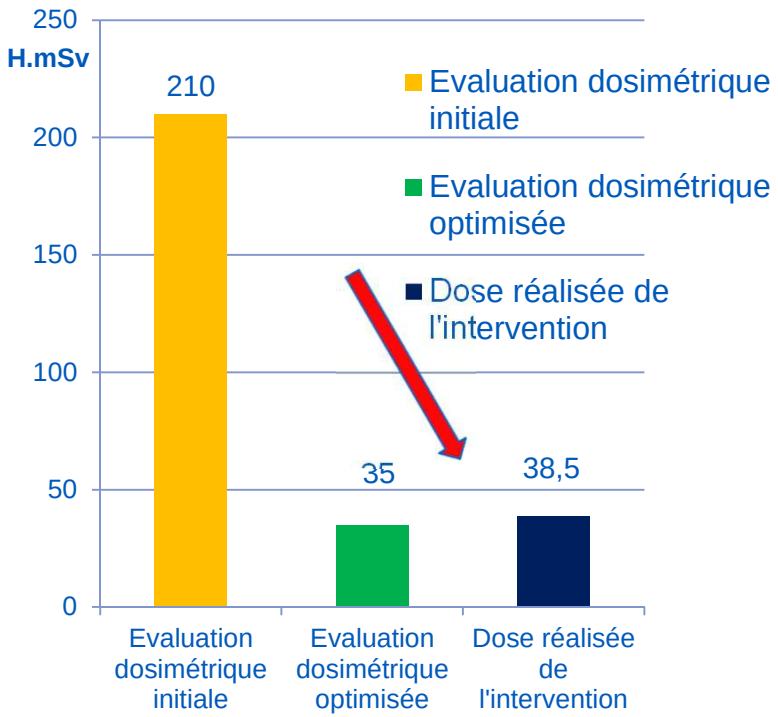
Biological shielding investigated but rejected: dose for installation and removal greater than the dose savings for maintenance work



Tools developed

Optimisation actions need to be prioritised
(for example, reactor vessel bottom penetration 4 for Gra1)

Optimisation



Operation >> M€10

Prioritise and improve optimisation

1. Obtain an overview of the operation so as not to transfer dose
2. Eliminate means of optimisation (biological shielding not viable)
3. Accept imperfect optimisation to protect vulnerable specialisations
4. Be aware that optimisation resources are limited
5. Make good use of the resources
6. Refrain from continued optimisation

Conclusion

The ALARA approach is an ongoing process

Important to keep aware of changing environnment

Criteria may change over time:

1. **technical developments**
2. **results of research**
3. **social acceptance**

However, at the outset an ALARA approach must be based on clear criteria such as cost benefit .

Thank you for your attention.