20 years of Radiation Protection experience in the Steam Generators Replacements at EDF

CPY standard plant series (900 MWe)
Steam **G**enerator **R**eplacements

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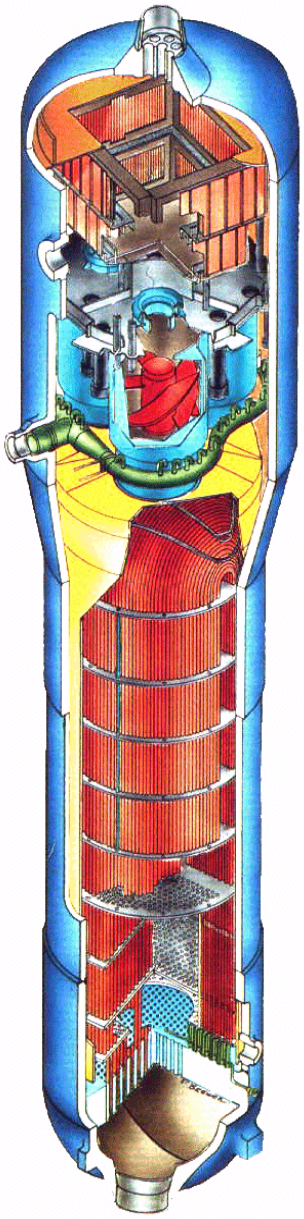
Summary

- Description of Steam Generator Replacements on CPY
- Steam Generator Replacements and Radiation Protection
- Last Steam Generator Replacements RP results on CPY (Dampierre 4 and Blayais 1)

What is a **S**team **G**enerator?

- SG = Heat Exchanger between primary water system and secondary water system,

- Characteristics:
  - Height ≈ 21 m,
  - Lower diameter ≈ 3,5 m and Upper diameter ≈ 4,5 m,
  - Empty weight ≈ 320 tons and Full of water ≈ 530 tons,
  - Approx. 3350 U-tubes and 4750 m² of heat exchange area,

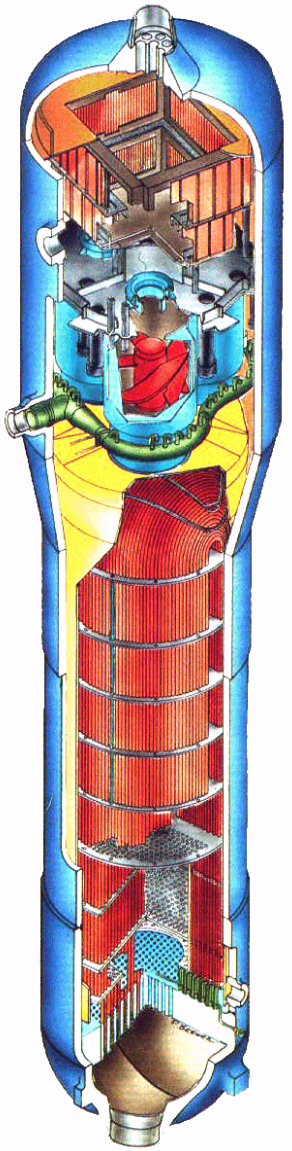


Why do we replace **S**team **G**enerators ?

- Causes:

Degradation of tube bundle: stress corrosion cracking in primary system, of the alloy used for the tubes,

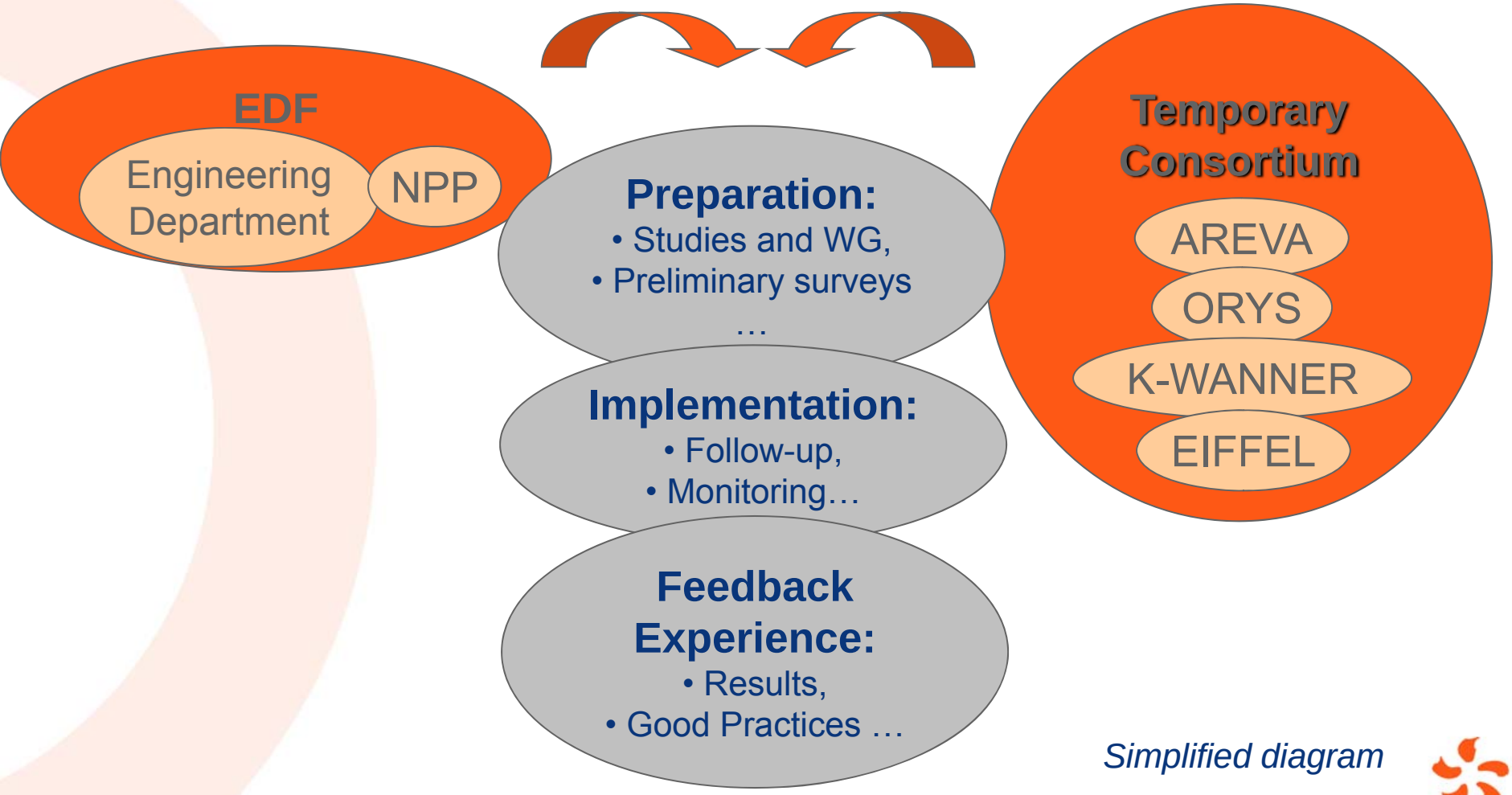
- Consequences:
  - Safety Risk (SG tube break),
  - Loss of availability. Plugging rate.
- Solutions:
  - Provisional: Tube plugging,
  - Eventually: **S**team **G**enerator **R**eplacement.



How is the operation performed?

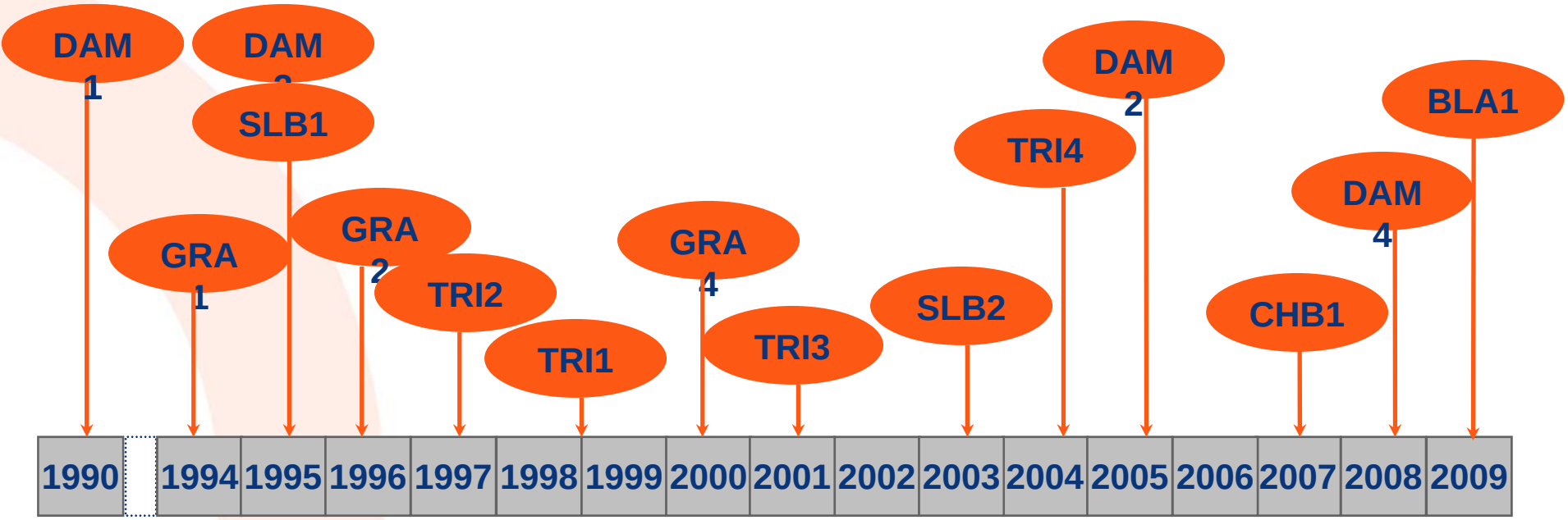
- The main technical options chosen for the 900 MWe – CPY:
  - Replacement of 3 SG with possible removal of primary elbows,
  - Evacuation / Introduction of the one piece SG,
  - Primary and secondary piping cutting,
  - Primary piping Decontamination over ≅ 1m by EMMAC process (soft chemistry) and finish by HP lancing,
  - Primary piping machining,
  - Primary piping welding by automatic orbital TIG with narrow groove,
  - Use of standard methods for the cutting and welding of the secondary piping,

Who is involved during a **S**team **G**enerator **R**eplacement?



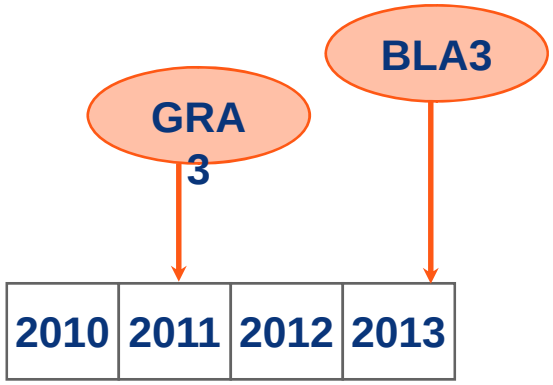
Simplified diagram

How many replacements on the CPY and since when?



15 SGR performed on CPY

CPY SGR to be done



Radiation Protection of SGR

Work Planning and ALARA WG

Main means for the optimization

Work site follow-up

Feedback Experience and Continuous Improvement Loop

Work Planning and ALARA Working Group

The surveys allow the Consortium to note, get or ask for all the information they need for the SGR studies completion, including radiation protection field

- Survey N-2 and N-1 ➔ performing mapping at work station:
  - More accurate knowledge of the doserates of a given plant unit,
  - Working basis for the teams sizing,
  - Working basis for the definition of radiation protection actions:
    - Definition of the biological shielding set-up

Work Planning and ALARA Working Group

- Optimized Provisional Dose Assessment - Initial Goal:
  - Mapping performed at the N-1 outage (State 10: PC full, without Biological Shielding),
  - Work Analysis,
  - Transposition Coefficients (TC),
  - Provisional schedule of the activities at the N outage.

$$OPDA_i = DR_{N-1} \times TC \times EW_{N-1} \times k$$

OPDA : Optimized Provisional Dose Assessment
DR : DoseRates
EW : Expose Workload

- Optimized Provisional Dose Assessment - Updated Goal:
  - Similar approach to that of initial goal calculation considering:
    - Mapping performed at the N outage (State 10),
    - New Work Analysis,
    - Provisional schedule of the activities at the N outage.

$$OPDA_u = DR_N \times TC \times EW_N \times k$$

Work Planning and ALARA Working Group

- **T**ransposition **C**oefficients

Extract of a summary table of doserates in mSv/h

Name of the area	State 10 PC full Without BS Used SG Before deconta. Second. full	State 20 PC full With BS Used SG Before deconta. Second. full	State 30 PC empty With BS Used SG Before deconta. Second. full
Lateral BU +4m	0.115	0.066	0.075
SG bunker 11m	0.198	0.118	0.126
Reactor Coolant Pump 8m	0.182	0.150	0.177

x TC

Work Planning and ALARA Working Group

- The SGR Radiation Protection planning is carried out by the **ALARA** **W**orking **G**roup (ALARA WG).

- This ALARA WG is managed by the Engineering Department and consists of representatives from:
  - Engineering Department,
  - NPP (Contact-person for the job, Contact-person for each trade impacted by the SGR),
  - Temporary Consortium (AREVA as head of Consortium for the RP issues).

Work Planning and ALARA Working Group

The main assignments of the ALARA WG are:

- Support in establishing the provisional doses,
  - Initial goal,
  - Updated goal.

  Objective: to share all the studies performed by the all people involved
  ➔Global and consistent approach
- Choice of the radiation protection actions to be implemented,
- Management of interferences between all the job scheduled during the outage,
  - SGR,
  - NPP Maintenance,
  - System Modifications Operations.
- Definition of the means and the organization to be established for the follow-up and the justification of the noticed gaps (Information sent to French Safety Authority),
- Knowledge of the Plant organization in order to fit its recommendations and its constraints (radiological cleanness, servicing, …).

Main Radiation Protection optimization means

- Total Collective Dose ≅ 1400 man.mSv after purification,

- Main optimization means:
  - Biological shielding set-up (estimated saving ≅ 200 man.mSv),
  - Decontamination of the primary piping tube ends using EMMAC process (estimated saving ≅ 320 man.mSv),
  - Drainage « at the latest » of secondary circuit (estimated saving ≅ 180 man.mSv),

- Implementation of these means leads to **a significant decrease of the total collective dose by approx. 700 man.mSv.**

Biological Shielding

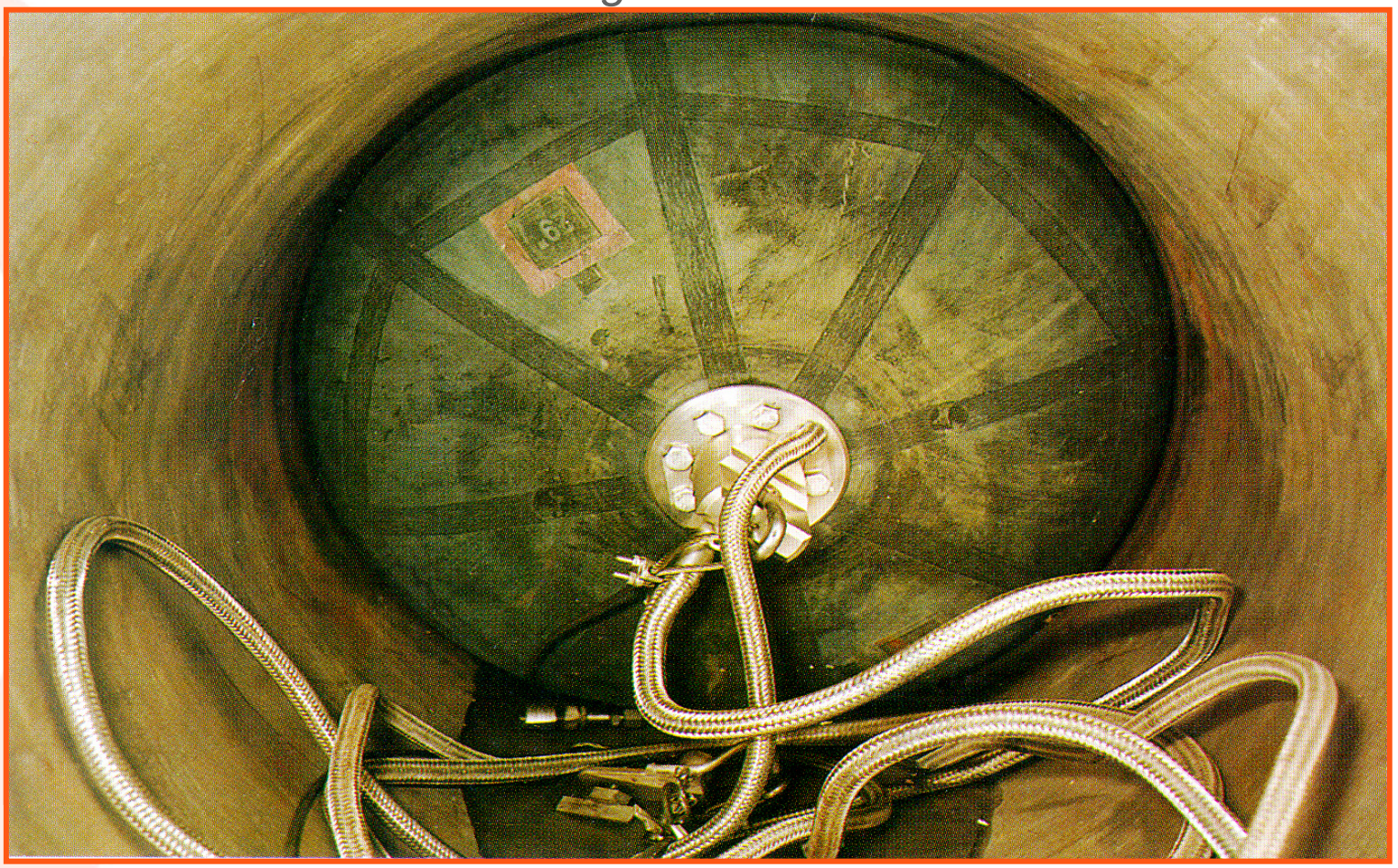
Biological Shielding strapped on the piping

Biological Shielding on screens

Decontamination

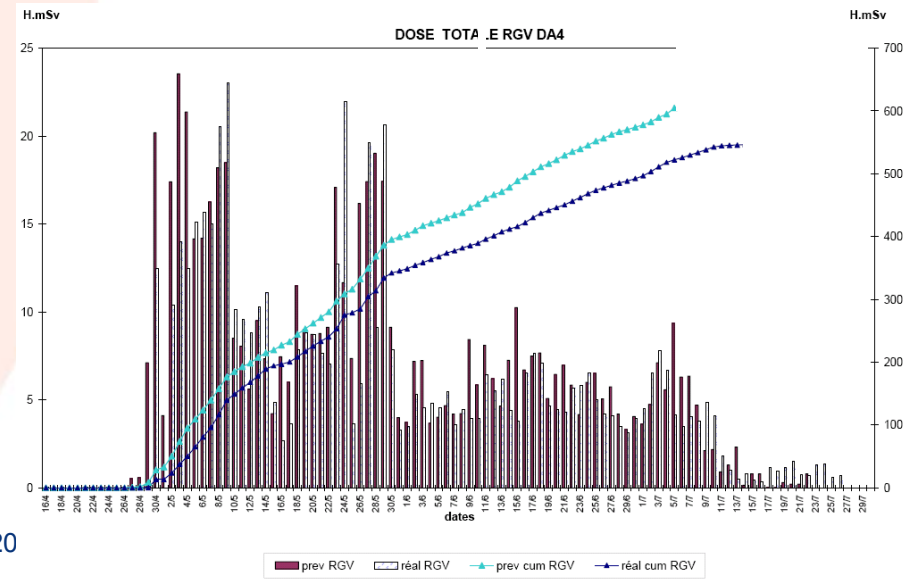
Decontamination of the primary piping tube ends

Basic diagram and Picture



Work site follow-up

- Objective: promote actions suitable to anticipate, restrict or correct any deviation compared with the radiation protection objectives,
- Daily monitoring, by each entity, of :
  - the integrated dose
  - the exposed workload achieved and radiological cleanliness criteria by job,
    - allowing the implementation of corrective actions at the earliest stage in case of drift,
- Performing reactor building mapping at different steps in order to follow the evolution of the ambient conditions.

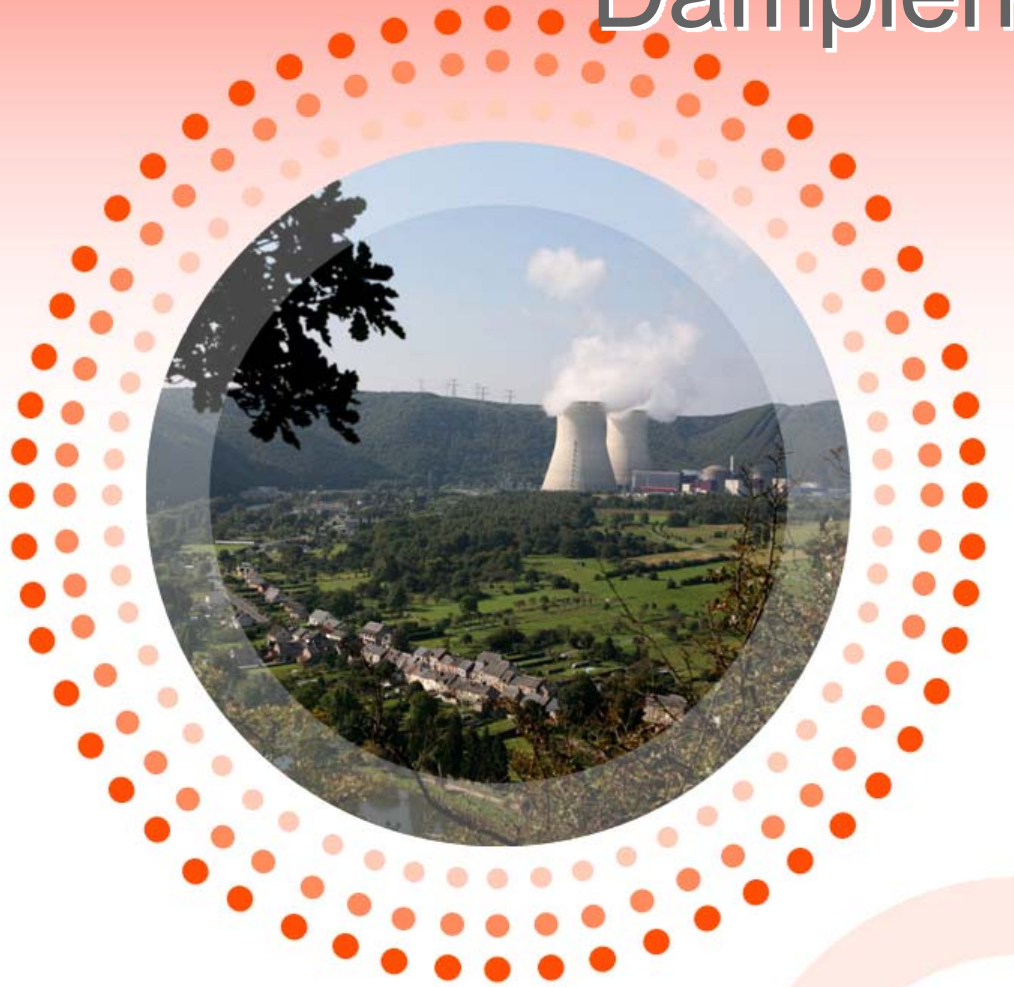


Example of collective dose SGR follow-up

Feedback Experience and Continuous Improvement Loop

- Level 1 (Consortium)
  - Synthesis of dose results of the SGR,
  - Presentation of the potential mishaps having a RP impact,
  - Justification of the potential gaps between Updated Goal et Achieved Dose,
  - Proposal of improvements of the dose model.
- Level 2 (Engineering Department) to be sent to the Safety Authority
  - Based on Level 1 Analysis,
  - Proposal of improvements for the next SGR.
- Radiation Protection Annex (Engineering Department) integrated to the working documents
  - Description of thoughts and resources used since the design of the SGR to control the dosimetry during this job
  - Increase of revision number after several SGR,

Dampierre 4 and Blayais 1 SGR

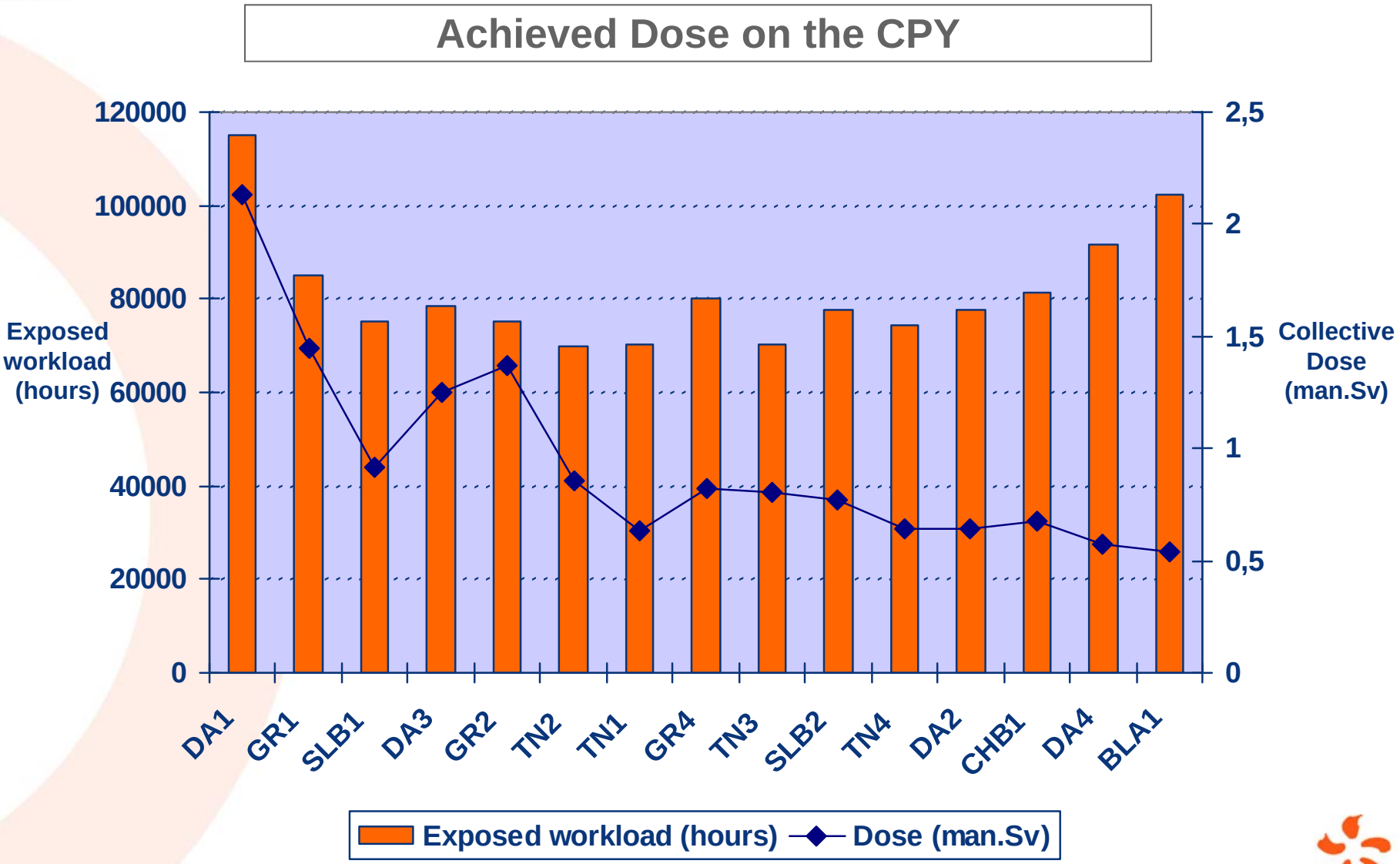


RP Results
French Reactors Results
International Results
Results Analysis

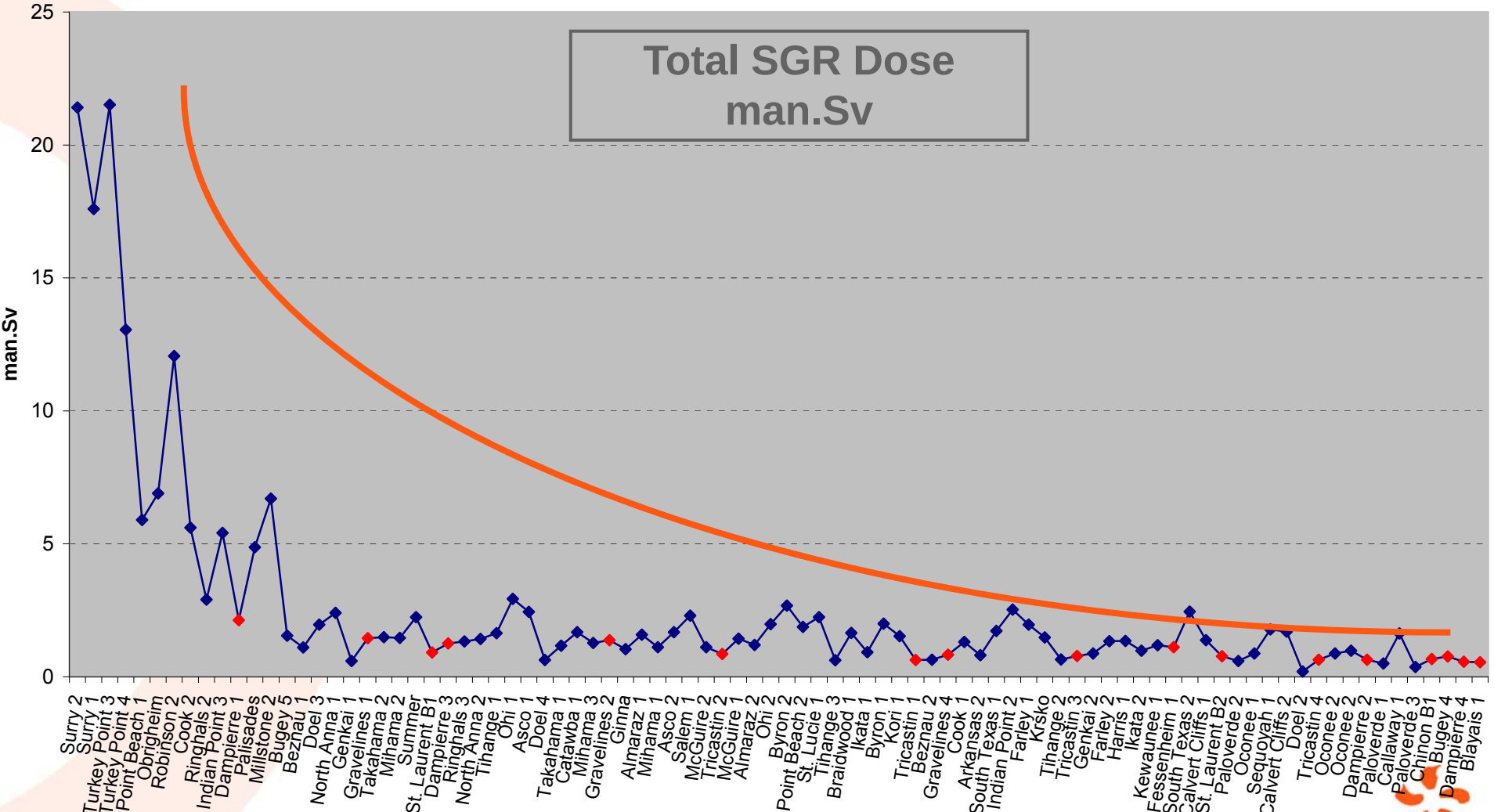
Dampierre 4 & Blayais 1 RP Results

	DAM 4	BLA 1
Updated Goal	572 man.mSv	543 man.mSv
Achieved Dose	570 man.mSv	545 man.mSv
RP Events	0	0
“C3” Contamination	0	0
“C2” Contamination	0.29 %	0.23 %

French Reactors Results



International Results, source: ISOE database



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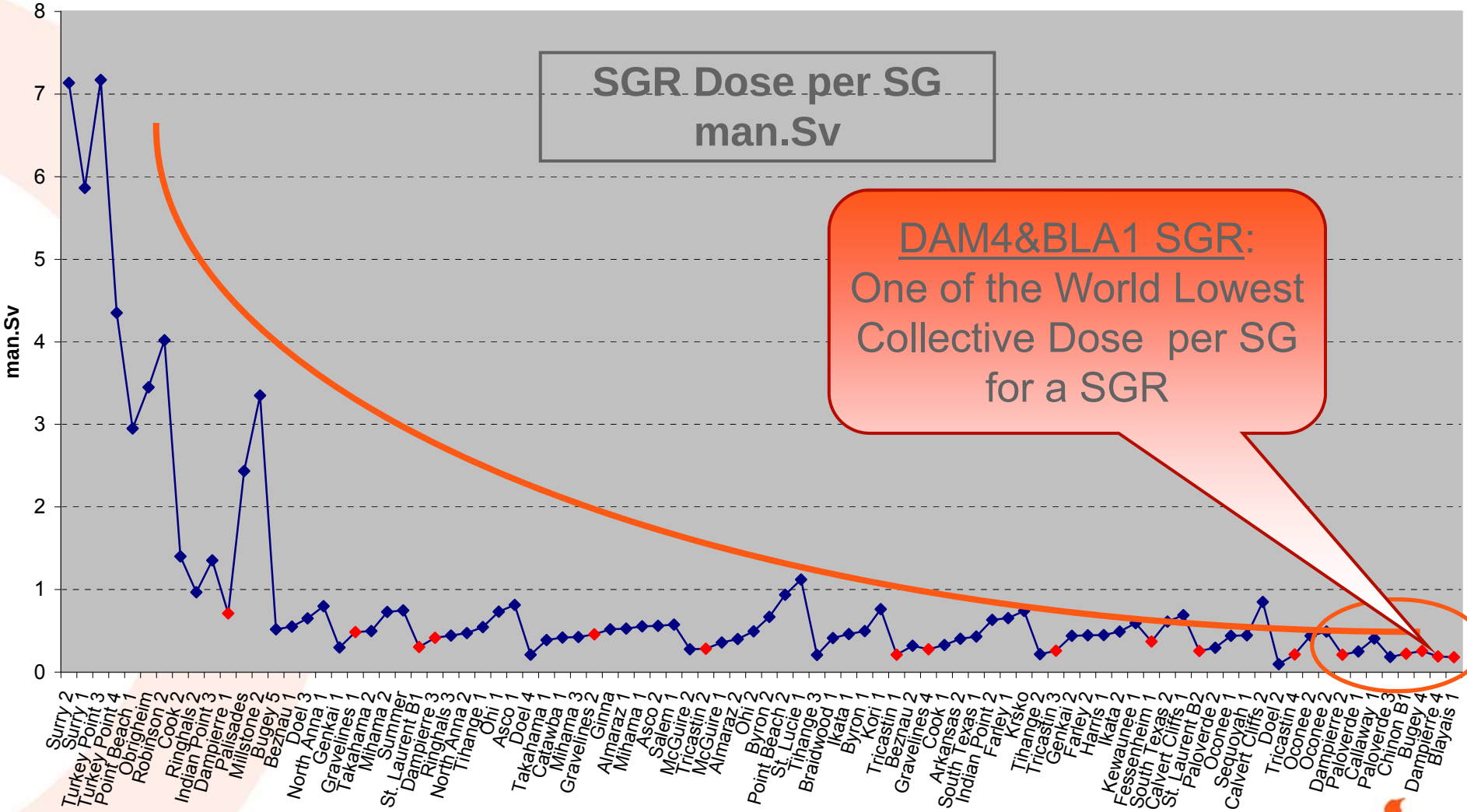

Dampierre4 and Blayais1 Results Analysis

Small gap between Updated Goal and Achieved Dose

- Significant Feedback Experience (15 SGR on the CPY),
- Mature model, notably :
  - Dose assessment,
  - Means for the optimization and their implementation.

Low Achieved Dose

- The SGR of DAM4&BLA1 benefited from positive factors:
  - Relatively low doserates,
  - Active and Voluntarist Policy from all the people involved (NPP, Consortium and Engineering Department).

Conclusion

Well Planned Work = Well Controlled Dose

➔ Dose savings more and more difficult to achieve,

Variation of 0,1 µSv/h x 100 000 h Exposed workload
➔ Variation of 10 mSv

➔ Importance of:

- Doserates monitoring and potential drift,
- Human behavior on work site,
- Organization and motivation of the 3 participants (Consortium, NPP and Engineering Department).