Licensing and safety aspects of the Pb/Bi loop target prototype development

EURISOL R&D projects

Kick-off meeting Pb/Bi loop target

Thursday 10th of May 2012

A. MARCHIX & V. BLIDEANU/CEA

collaboration with AP.Bernardes & J.Vollaire/CERN

Outline

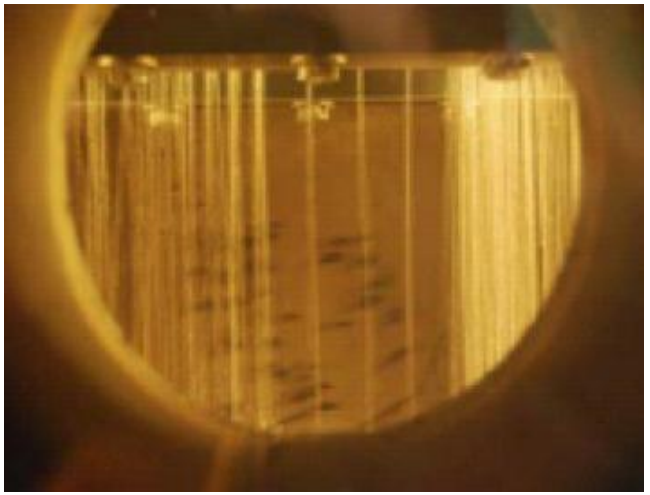
- Context
- IRFU/LENAC &CERN collaboration
- Methodology
- Conclusion

CONTEXT

The development of a new molten Pb/Bi ISOLDE target loop is a part of the EURISOL project which aims to develop the “next-generation” European ISOL radioactive ion beam (RIB) facility.

Several options have been identified for the 100KW liquid-metal target for the EURISOL project

→ A Molten Pb/Bi target may be an option



*Photograph of the 100 KW liquid-metal loop setup at **IPUL***

CONTEXT

Safety studies for the development of a new Molten PB/Bi target should be used to :

→ Develop a Safe target and appropriate installation
Safety expertise should be developed during OFF-Line development of the target in order to better assess the ON-LINE failure consequences

→ Facilitate the future licensing process
Compile data which may be used for a licensing process in future

CONTEXT

What do we know?

→ Liquid-metal target failure → containment must be guaranteed in order to avoid dispersion of radiological contaminants → failure scenario must be studied

→ Special care has to be taken concerning gas production/release and dispersion of contamination (Polonium and Astatine)

New in FLUKA: model is now able to predict interaction of secondary α which can produced dangerous radioisotopes (α,Bi) →At and (α,Pb) →Po
Acknowledgment to Alfredo Ferrari

What do we need ?

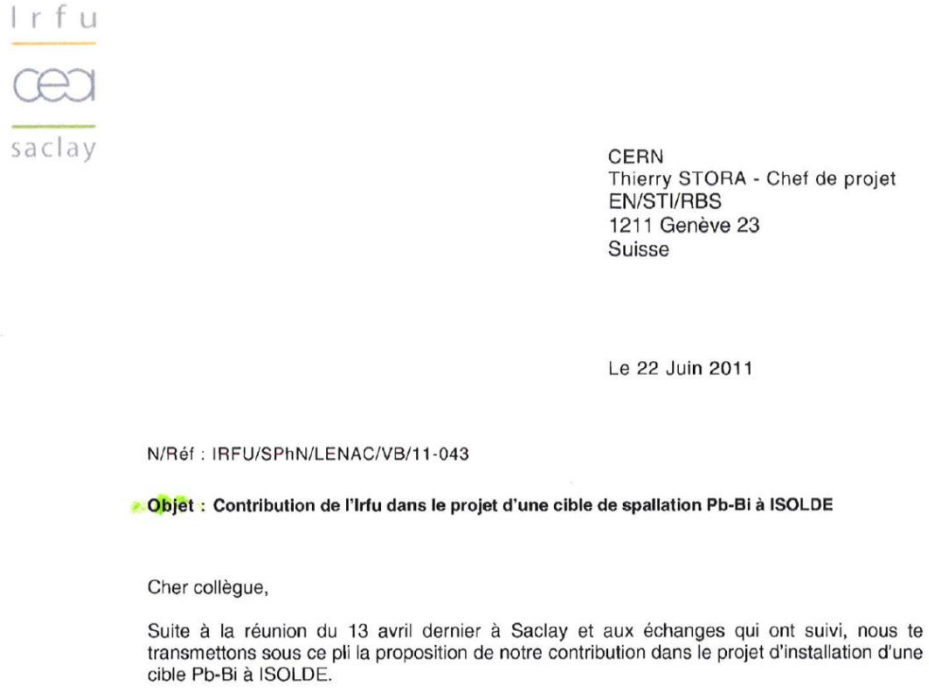
- Safety studies and risk analysis specific to an ISOLDE liquid-Metal loop target

COLLABORATION

How to achieve it ?

A collaboration has been signed between CEA/IRFU/LENAC and CERN in order to perform various safety studies such as:

- Failure analysis of the molten Pb/Bi target
- Risk assessments during development/production/operation/post-mortem
- Fire study
- Licensing documentation
- Dismantling study of the molten Pb/Bi target (cost estimation)
- Waste study



Irfu
cea
saclay

CERN
Thierry STORA - Chef de projet
EN/STI/RBS
1211 Genève 23
Suisse

Le 22 Juin 2011

N/Réf : IRFU/SPhN/LENAC/VB/11-043

Objet : Contribution de l'Irfu dans le projet d'une cible de spallation Pb-Bi à ISOLDE

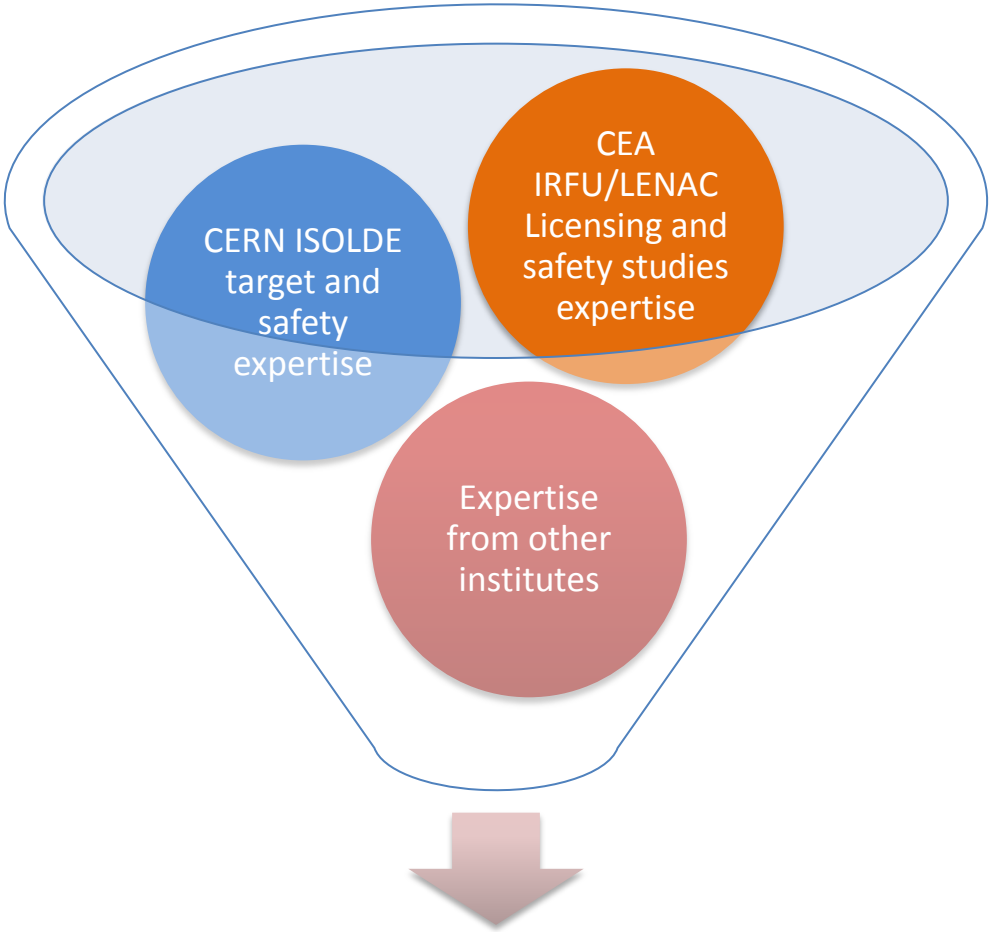
Cher collègue,

Suite à la réunion du 13 avril dernier à Saclay et aux échanges qui ont suivi, nous te transmettons sous ce pli la proposition de notre contribution dans le projet d'installation d'une cible Pb-Bi à ISOLDE.

In collaboration of J.Vollaire DGS/RP

Feed-back from PSI (MEGAPIE) and IPUL (liquid metal-loop) experience will be very welcome !

COLLABORATION



Appropriate inputs for : safety integration, future licensing or safety file at CERN

Nuclear safety principles

- **General nuclear safety objective:**

  To protect individuals, society and the environment by establishing and maintaining in nuclear power plants an effective defence against radiological hazard.

- **Technical nuclear safety objectives**

  ➢*To prevent with high confidence accidents in nuclear plants;*

  ➢*To ensure that, for all accidents taken into account in the design of the plant, even those of very low probability, radiological consequences, if any, would be minor;*

  ➢*And to ensure that the likelihood of severe accidents with serious radiological consequences is extremely small.*

IAEA INSAG - 3

In France

Nuclear safety and Transparency Act of June 2006

- **Objectives**
  - ➢ *Juridical framework on "civil" nuclear activities*
  - ➢ *Clarify and reinforce controls system and sanctions*

- **Main contribution**

↳ **ASN founding : nuclear safety independent authority**

CEA is the historical actor in nuclear safety (up to 1973)

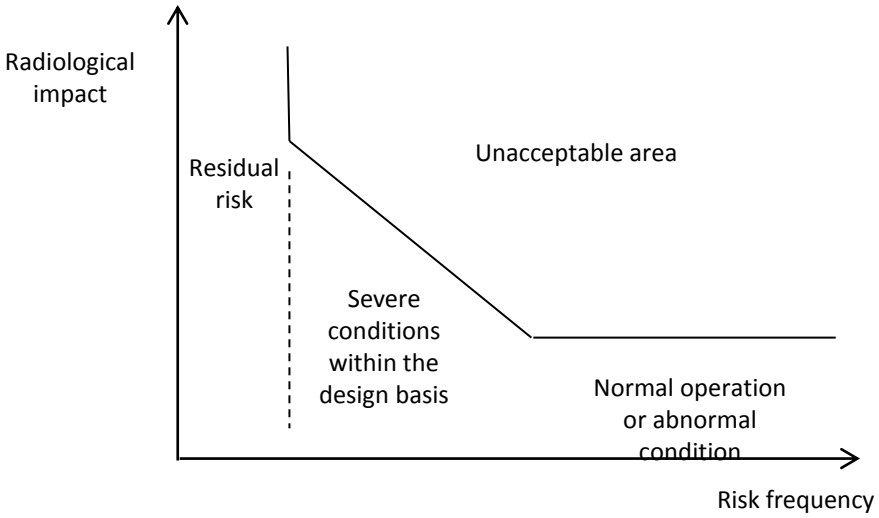
- ➢ Many different nuclear facilities (experimental reactor, accelerator...): huge nuclear safety culture
- ➢ Research and development on nuclear safety
- ➢ Permanent expert group

↳ **Nuclear safety frame of reference, methodology document, expert department assistance**

Nuclear safety framework

To secure nuclear safety function:

- *control the confinement of radioactivity*
- *control the limitation of exposure*
- *control the reactivity*
- *control the gas produced by radiolysis*
- *control the cooling*



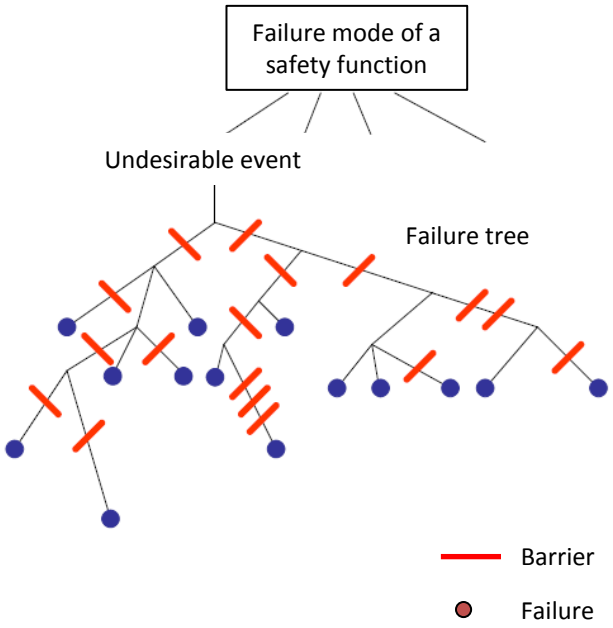
Risk frequency is based on the feedback experiment

Risks
Radiation Exposure
Confinement of radiological materials
Human factor
Fire hazard
Cryogenic, pressure and vacuum hazard
Anoxia
Chemical hazard
Electrical and magnetic field
Mechanical hazard
Dismantling
External hazard
...

Concept of the defence in depth is applied to analyse each risk and perform a safety process

Concept of defence in depth

- **Principle**
  - ➢ *to compensate for potential human and component failures*
  - ➢ *to maintain the effectiveness of the barriers by averting damage to the plant and to the barriers themselves*
  - ➢ *to protect the public and the environment from harm in the event that these barriers are not fully effective.*



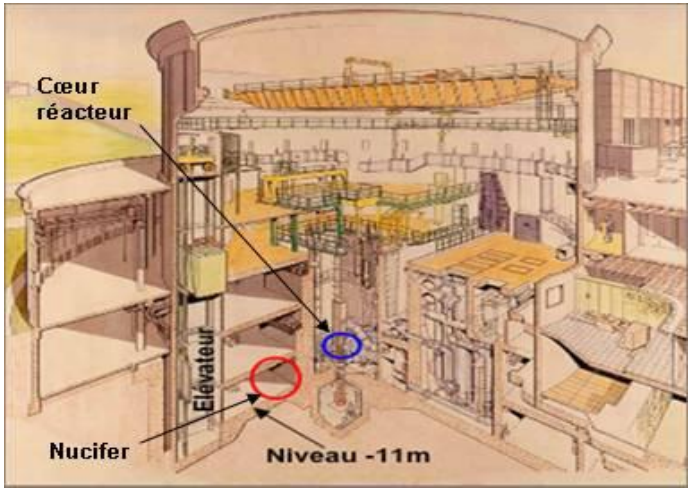
Levels	Objective	Essential means
Level 1	Prevention of abnormal operation and failures	Conservative design and high quality in construction and operation
Level 2	Control of abnormal operation and detection of failures	Control, limiting and protection systems and other surveillance features
Level 3	Control of accidents within the design basis	Engineered safety features and accident procedures
Level 4	Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents	Complementary measures and accident management
Level 5	Mitigation of radiological consequences of significant releases of radioactive materials	Off-site emergency response

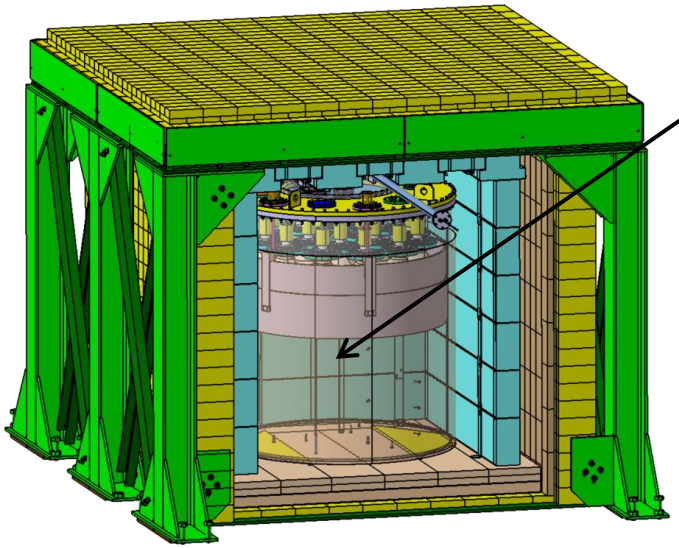
Last safety report accepted by ASN

NUCIFER project (antineutrinos detector) implanted in OSIRIS experimental reactor

Detector located at 7m from reactor core

IAEA is interested in in the feasibility of using detection of antineutrinos for safeguards purposes: monitoring reactor operation to detect possible unreported plutonium production





Target: 0.85 m^3 Gd-Liquid scintillator (0.5%)

→ Important risk of fire and explosion

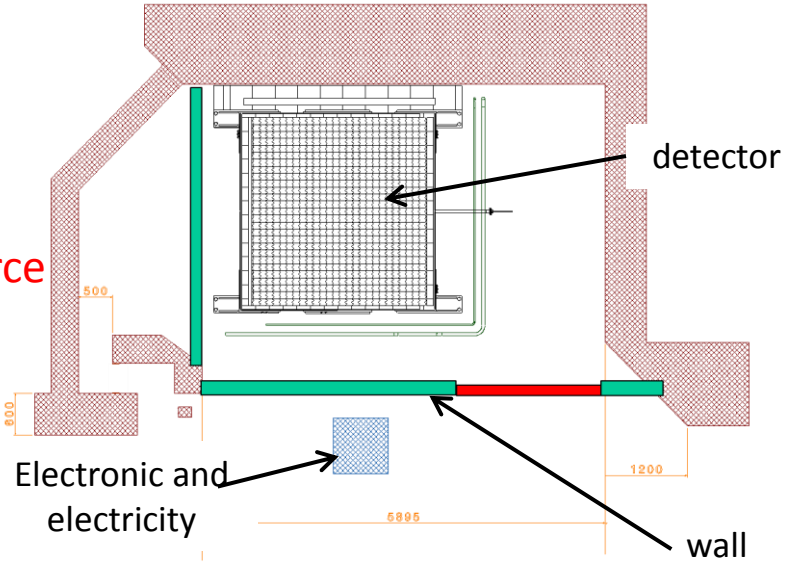
LENAC contribution:

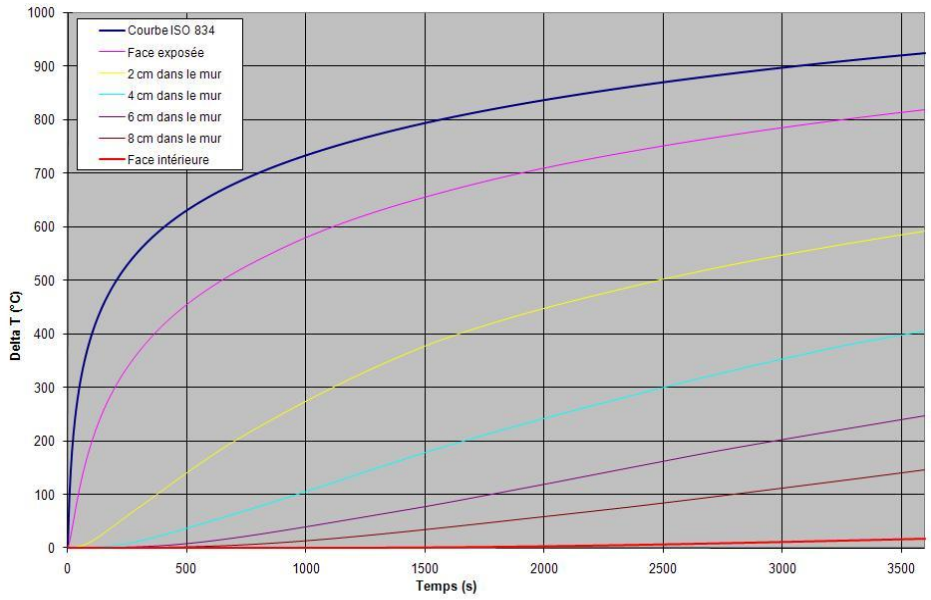
- the complete risk analysis
- the radiological impact evaluation
- the safety report
- the fire hazard study using CEA's software (CEA fire expert validation)

Example of fire hazard assessment for Nucifer project

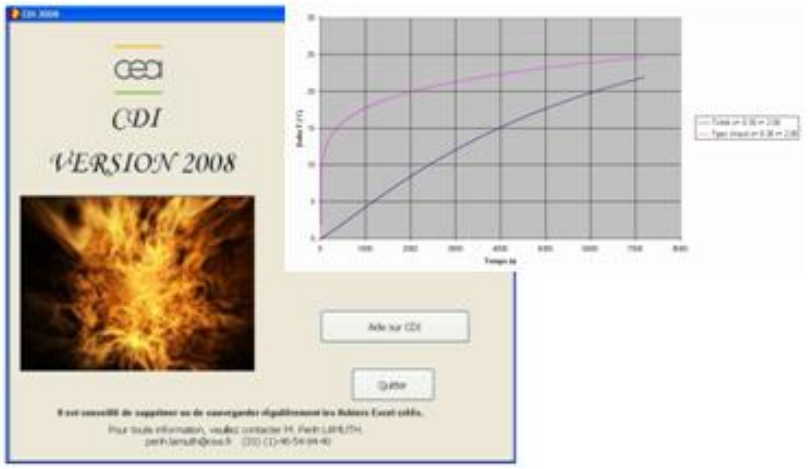
Detector is isolated from ignition source by a wall to prevent fire risk

Evaluation of the wall thickness according to the conservative fire source





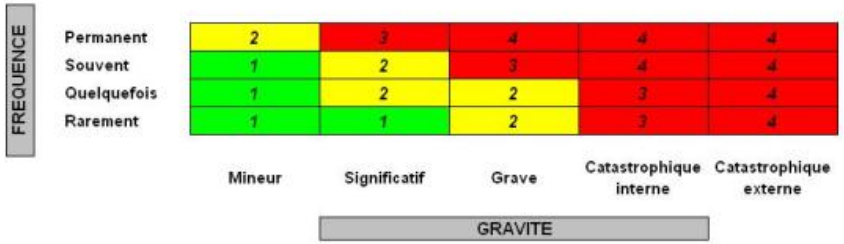
Simulation of the increasing temperature with time versus different wall thicknesses



Methodology on classical risk assessment

Each risk from MOSAR list is quantified with respect to frequency and gravity

A0- Sources de danger d'origine mécanique, physique, chutes et autres	**G0-** Sources de dangers liés au comportement humain
B0- Sources de danger d'origine chimique (produits utilisés, produits de réaction, contacts avec matériaux)	**H0-** Sources de dangers liés à l'environnement actif (hors du périmètre du système, qui risque d'interférer, d'impacter l'unité de travail)
C0- Sources de danger d'origine électrique	**I0-** Sources de danger d'origine économique et sociale
D0- Sources de danger de développement d'incendie	**Z0-** Divers, autres
E0- Sources de dangers liés aux rayonnements	



Acceptable risk
Risk as low as possible
Unacceptable risk area

MES : CEA software to assist security manager in facility operation

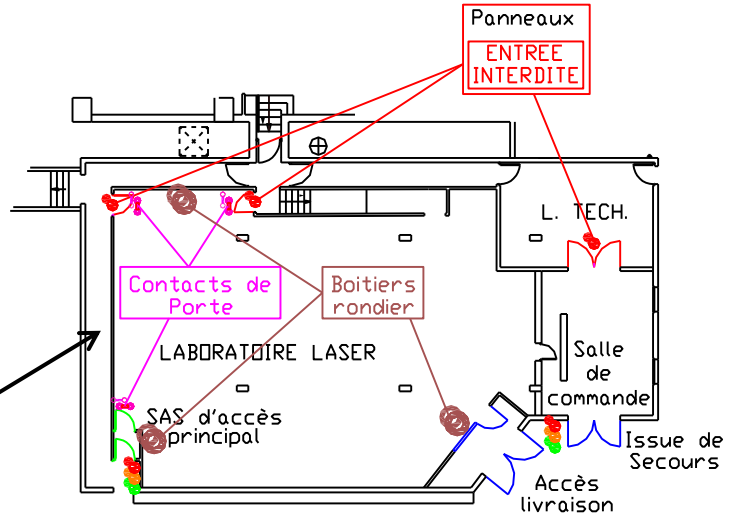
- project described step by step
- risk identified from MOSAR list
- quantification of each risk
- barriers added according to quantification of the risk

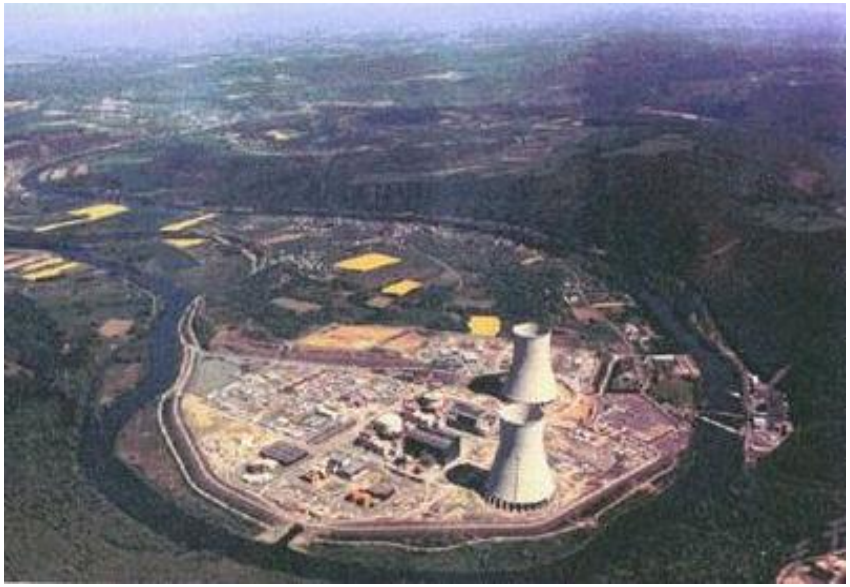
Example on classical risk assessment

LOA : laser facility with radioprotection risk

- *regulatory framework of the facility*
- *risk analysis*

Study of the access control of the laser room





Double Chooz : neutrino detectors installation on the EDF reactor site of Chooz (2*1450 MW). 2*200 m^3 liquid scintillator.

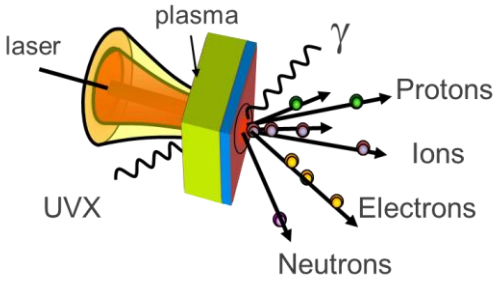
- *Environment protection report*
- *Source transfer and exploitation report*
- *Water environment protection report*

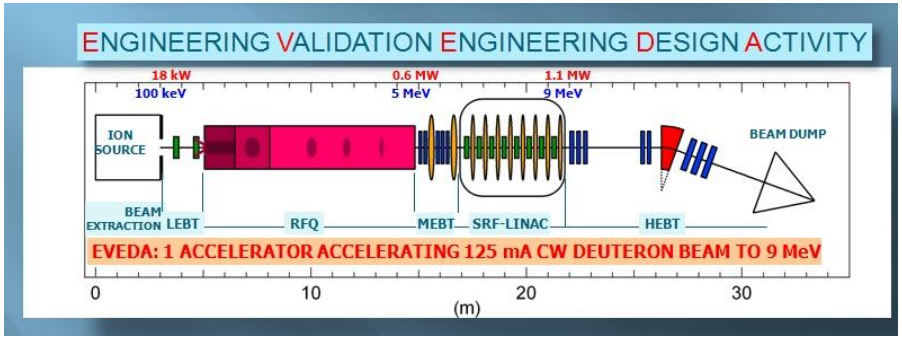
Reports submitted to ASN

Present studies related to safety

CILEX APOLLON: 10 PW laser beam interaction with matter in order to study plasma properties

- *Classical risks*
- *Radioprotection*
- *Clearance historical waste*
- *Nuclear safety*



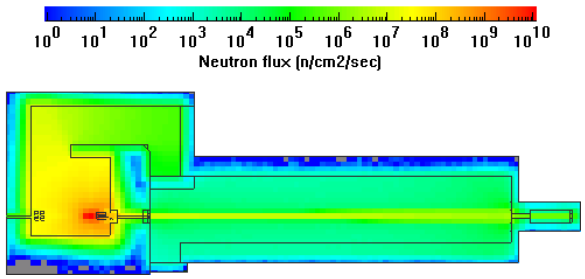


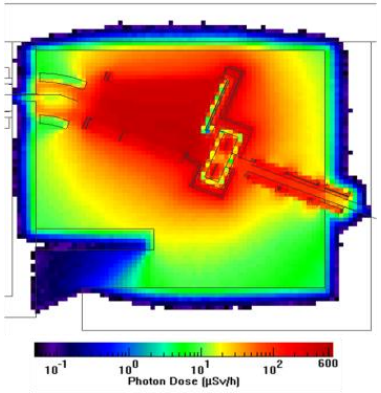
IFMIF (accelerator): neutron production facility for studies on irradiation effect on material which will be used in future fusion reactor

- *Radioprotection calculations (building design, ALARA optimisation for maintenance)*
- *Involvement in the licensing process in collaboration with Japanese team (host)*

SPIRAL2 phase1 (accelerator): heavy ion (S3) and neutron (NFS) beam for fundamental research

- *Radioprotection calculations (building design, ALARA optimisation for maintenance, technical process choice)*





Conclusion

- A collaboration has been signed between CEA/IRFU/LENAC and CERN EN/STI/RBS to bring complementary safety expertise on board on both aspects safety analyses and licensing, in collaboration with DGS/RP

- Feed-back from PSI and IPUL will be very welcome to learn from their past experienced