# WP6.3 Beam Dump Meeting Madrid

**EURORIB Meeting**

**Giens – FRANCE – June 9-13th 2008**

## NUCLEAR SAFETY AND RADIATION PROTECTION IN SPIRAL 2 FACILITY

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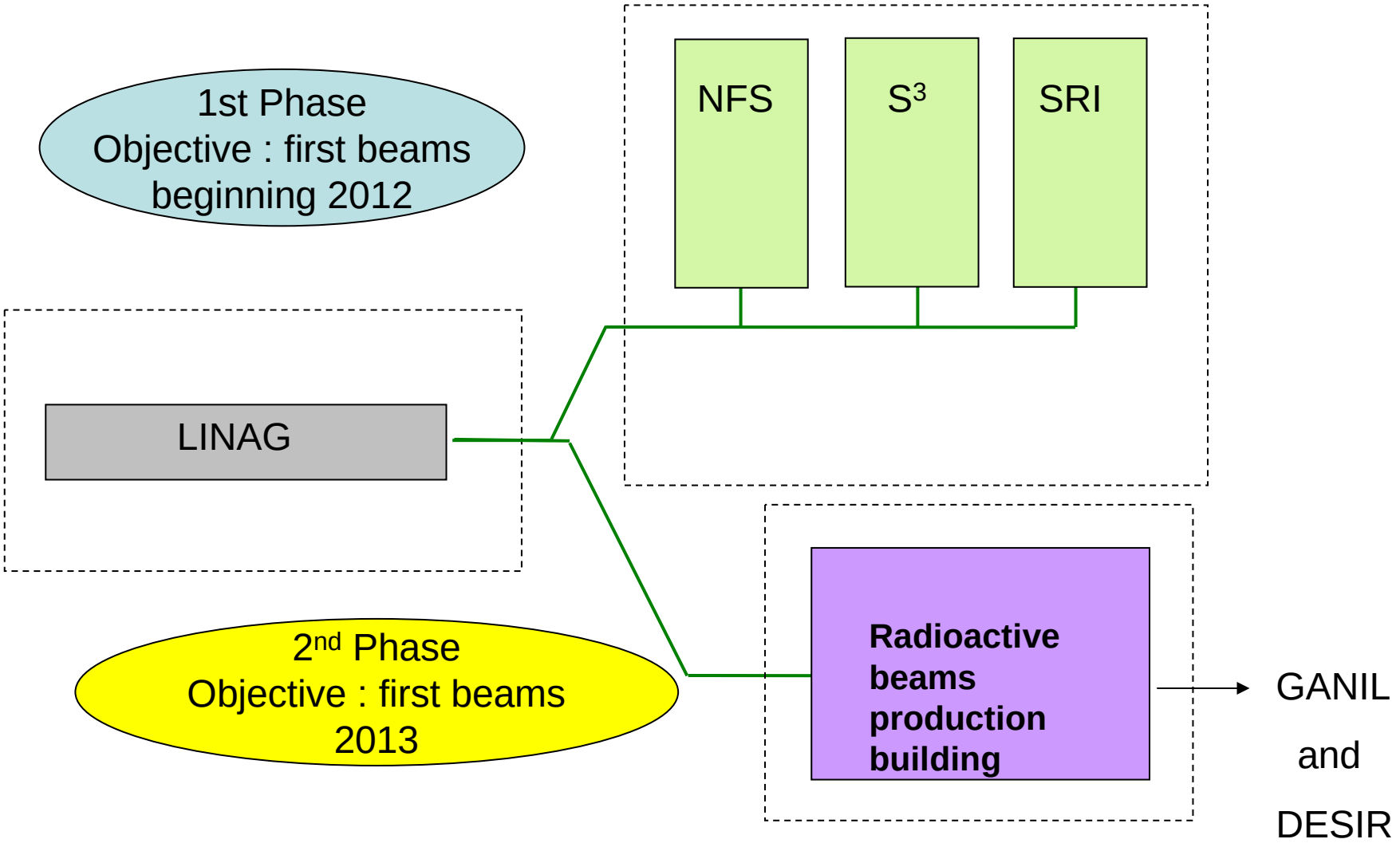
**(SSR SPIRAL 2 Project)**

## PRESENTATION

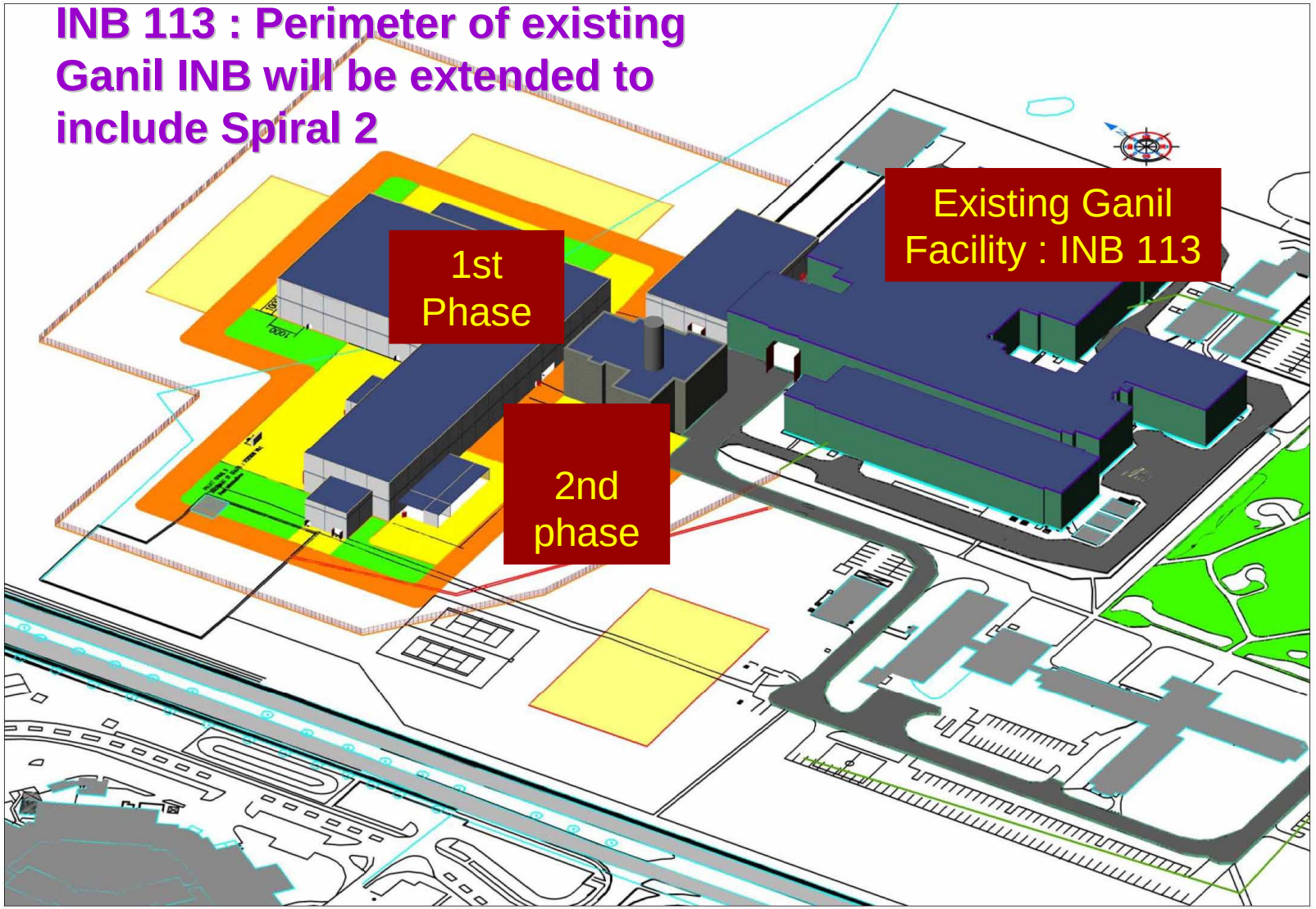
- Introduction
- Administrative licensing procedure and time schedule
- Safety and radioprotection objectives
- Different risks and safety/radioprotection requirements
- Activation and dose rate calculations
- On-going experimental program
- Next steps  (year 2008)

# PROJECT PHASES

AEL : LINAG experimental areas



# Administrative status : licensed nuclear facility (INB)



# ADMINISTRATIVE PROCEDURE

## NUCLEAR LICENSED FACILITY (INB in french)

**A global safety report (DAM report) leading to**
**a single ministerial decree with steps**

- **a single licensing procedure will be leaded (only 1 public inquiry)**
- **the decree will mention that phase 2 will be submitted to the authorization of nuclear safety authority**

⇨ **DAM report includes :**

- **Preliminary Safety Report : two level of details according to phase 1 or 2**
- **Operating domain of the whole facility and associated dimensioning**
- **Impact on environment : release of radioactive effluents (normal operation and accidental situations)**

**....**

**Time schedule for the licensing procedure is presented on the following slide**

# LICENSING TIME SCHEDULE

| | 2006 | | | | 2007 | | | | 2008 | | | | 2009 | | | | 2010 | | | | 2011 | | | | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| **LICENSING TIME SCHEDULE** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Discussions with Nuclear Safety Authority (ASN) | 16 May 2007 | | | | | | | | 11 July and 23 october 2007 | | | | | | | | | | | | | | | | | | | | | | | |
| Validation of licensing procedure & schedule | | | | | | | | | 25 January 2008 | | | | | | | | | | | | | | | | | | | | | | | |
| DAM Report (art. 8, INB decree) delivered to ASN | | | | | | | | | | | | | November 2008 | | | | | | | | | | | | | | | | | | | |
| Public inquiry | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IRSN Instruction | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Permit for construction granted (phase 1) | | | | | | | | | | | | | | | | | October 2009 | | | | | | | | | | | | | | | |
| Decree | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Prelim. safety report Phase 2 (+ Ganil reeval.) | | | | | | | | | | | | | | | | | December 2009 | | | | | | | | | | | | | | | |
| Instruction IRSN Phase 2 + Ganil reevaluation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Permanent Group (Phase 2+Ganil reevaluation) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Permit for construction granted (phase 2) | | | | | | | | | | | | | | | | | | | | | End 2010 | | | | | | | | | | | |
| RS + RGE +... Phase 1 (article 20, INB decree) | | | | | | | | | | | | | | | | | | | | | | | | | Beginning 2011 | | | | | | | |
| Operation setting Phase 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Beginning 2012 | | | |
| RS + RGE + ...Phase 2 (article 20, INB decree) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Operation setting Phase 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# ADMINISTRATIVE PROCEDURE

## MAIN DATES TO DELIVER SAFETY REPORTS

### END 2008 (Demand 1 : DAM)

**- Files to be delivered listed in art. 8 of decree 2007-1557 2/11/2007 are defined in articles 9, 10, 11**

**- Main files are :**

- Impact study (no release authorization today, so initial site status = existing Ganil facility impact)
- Preliminary safety report : with two levels of details according to phase 1 or 2, **operating domain of the whole facility and associated dimensioning**
- …

**►2009 : IRSN instruction and Public Enquiry**

**(IRSN = technical support of French nuclear safety authority)**

# ADMINISTRATIVE PROCEDURE

- **MAIN DATES TO DELIVER SAFETY REPORTS**

**END 2009 (demand 2)**

**Safety report phase 2**
**(level of a preliminary safety report )**

**Existing Ganil safety reevaluation will be sent**
**at the same date**

► **2010 : IRSN instruction and meeting of the French nuclear safety authority Expert Group**
**for Spiral 2 phase 2 + existing GANIL safety reevaluation**

# SAFETY and RADIOPROTECTION OBJECTIVES

| | Workers | People/Environment |
|---|---|---|
| Normal operation | ALARA<br>< 2mSv/year<br>(0 internal exposure) | ALARA<br>< 10 µSv/year |
| Incidental situation | < 10 mSv/year | < 10 µSv/incident |
| Major incident | < 20 mSv/incident | < 100 µSv/incident |
| Major accident | Variable according to situation and potential impact | < 1 mSv/accident |

# RISKS and SAFETY REQUIREMENTS

## EXTERNAL EXPOSURE TO IONISING RADIATIONS

**ORIGIN : neutrons, gammas, material and structure activation**

**SAFETY REQUIREMENTS : radioprotection objectives reached**

**HOW TO REACH THESE REQUIREMENTS ?**

- **BIOLOGICAL SHIELDING**
- **ACCESS MANAGEMENT SYSTEM**

## EXTERNAL EXPOSURE TO IONISING RADIATIONS

### LINAG BIOLOGICAL SCHIELDING

**Calculation hypothesis**

**Deuteron beam : 40 MeV ; 5 mA ; 200 kW**
**Beam losses : about 5 %**
**Permanent worker behind shielding**

**► Shielding thickness (high energy)**

**about 1,8 m (concrete)**

**► Beam losses monitoring**

**beam stopped (in few second)**
**if beam losses > fixed level (machine protection)**

# RISKS and SAFETY REQUIREMENTS

## EXTERNAL EXPOSURE TO IONISING RADIATIONS

► **ACCESS MANAGEMENT SYSTEM**

- **Beam on : access forbidden**
- **Beam off : access restrictions depending on the radiation level**

**2 SUBSYSTEMS**

- **UGA = Access management unit (beam on)**
- **UGB = Radiation monitoring unit (beam off) : external exposure due to activation and radioactive beam “deposited”**

# RISKS and SAFETY REQUIREMENTS

## INTERNAL EXPOSURE TO IONISING RADIATIONS

**ORIGIN**

**release radioactive matter during maintenance operation or in incidental situations (fire, explosion, earthquake, handling operation….)**

**SAFETY REQUIREMENTS**

**- zero contamination during normal operation**
**- limited contamination in incidental situations**
**- limited consequences for the public**

**HOW TO REACH THESE REQUIREMENTS ?**

**at least 2 static confinement barriers**
**increased by dynamic confinement (nuclear ventilation)**
**in area with high level of risk**

# RISKS and SAFETY REQUIREMENTS

## INTERNAL EXPOSURE TO IONISING RADIATIONS

**ACCELERATOR**

**no nuclear ventilation**

**only filtration and epuration atmosphere**

**(O3, NO2, air activation….)**

**LINAG EXPERIMENTAL AREAS**

**Actinides : 2 static confinement barriers**

**+ dynamic confinement (nuclear ventilation)**

**Static confinement barriers are building walls and :**

**► Gloves boxes during experimental sample preparation and decontamination operation**

**► Reaction chamber during experiment**

# RISKS and SAFETY REQUIREMENTS

- **INTERNAL EXPOSURE TO IONISING RADIATIONS**

**RADIOACTIVE BEAM PRODUCTION BUILDING**

**2 static and dynamic confinement barriers**

**+ 3rd static barrier (process)**

**Cryotraps : cryogenic system to trap volatile gas**

**► transfer contamination limitation**

# RISKS and SAFETY REQUIREMENTS

## NON NUCLEAR RISKS (1/2)

**EXTERNAL AGRESSIONS**

- **Plane crash : probability calculation < $10^{-6}$**

**► outside dimensioning criteria**

- **Earthquake : requirements**

**► Stability : LINAG + AEL building**

**►Stability + confinement : radioactive beam production building**

**Truck explosion : probability > $10^{-6}$**

**► Must be taken into account in building conception**

# RISKS and SAFETY REQUIREMENTS

## NON NUCLEAR RISKS (2/2)

- **FIRE : requirements**

**► 2 hours fire resistance in areas where radioactivity is important**

- **VACUUM SYSTEM FAILURE**

- **INTERNAL INONDATION**

- **….**

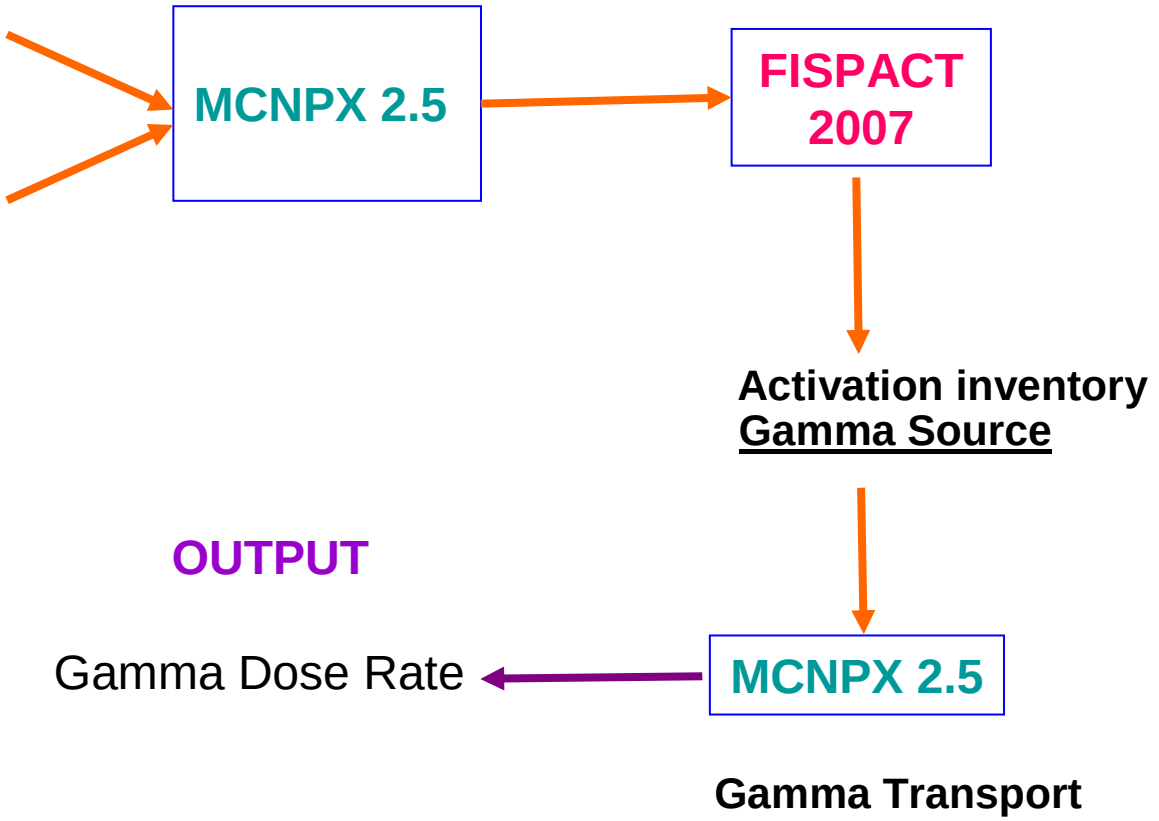
# CALCULATION METHODOLOGY

**INPUT DATA**

Deuteron losses source

d-d Neutron Source

**Deuteron and Neutron Transport**



# LINAG CALCULATIONS

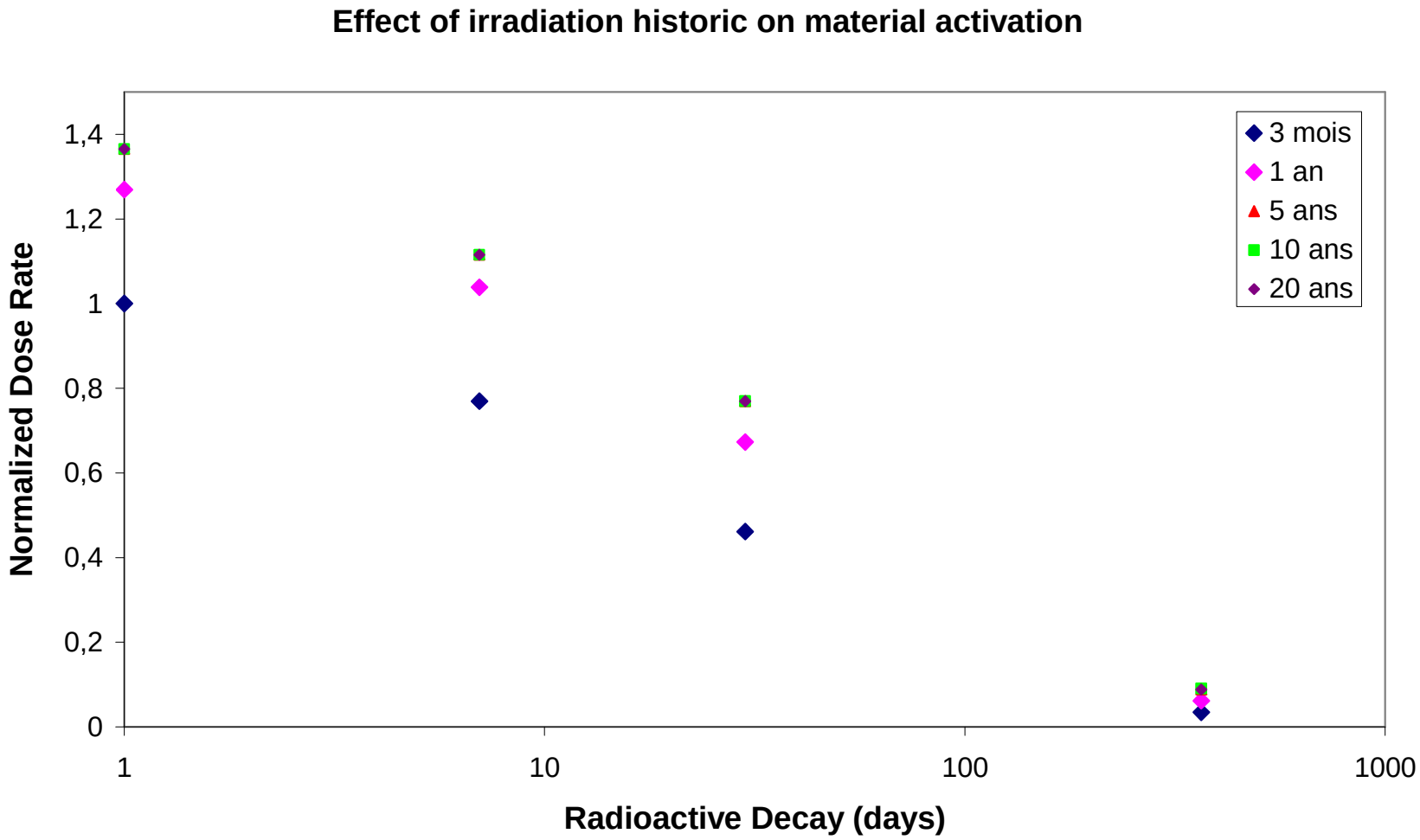
- Input data : deuteron energy 40 MeV – Beam intensity = 5 mA
  beam losses below 1 Watt/m
  LINAG equipments modelized

- Hypothesis : 3 months irradiation ; 1 month cooling

- Main results :

  - $^{56}Co$ (T= 77 d) is the main contributor for deuteron activation
  - After 1 year, deuteron activation is constant (see next slide)
  - Activation due to secondary neutrons is responsible of less than 10 % of the total dose rate

# LINAG ACTIVATION RESULTS



# RADIOACTIVE BEAM PROCESS

- **Input data : deuteron energy 40 MeV – Beam intensity = 5 mA**
  **radioactive beam production equipments modelized**
- **Hypothesis : 3 months irradiation ; 1 month cooling**
- **Calculations for different cooling times**

# ON-GOING EXPERIMENTAL PROGRAM

## OBJECTIVES

### INTERNAL AND EXTERNAL EXPOSITION EVALUATION IN NORMAL AND ACCIDENTAL SITUATION

- **Radioactive ion implantation and equipment activation**
  - ► **experiments on SPIRAL 1 at GANIL (Caen)**
- **Transfer of contamination to the pumping system**
  - ► **experiments on SPIRAL 1 (GANIL) and ILL (Grenoble)**
- **Thermal releases of radioactive ions (samples Cu, Ti, Al, W….)**
  - ► **experiments at ISOLDE (CERN) and ILL (Grenoble)**
- **Cryotraps system efficiency**
  - ► **experiment planned in 2009 on prototype (ALTO-Orsay)**

# ON-GOING EXPERIMENTAL PROGRAM

- **Neutron production with 40 MeV deuterons**

**Measurements for different convertors (march to september 2008)**

**Physics Department in Jyvaskyla (Finland)**

**- graphite**
**- heavy water**
**- light water**

# IMPORTANT NEXT STEPS THIS YEAR

- **SAFETY REPORT TO OBTAIN DECREE AUTHORIZATION**
  **(Preliminary safety report, impact study for effluent releases….)**

- **ACCELERATOR :**
  **- analysis of activation and equivalent dose rate calculations : Alara studies and strategy for maintenance intervention**

- **AEL : LINAG Experimental Areas : safety and radioprotection dispositions for actinide manipulation**

- **Radioactive beam production process : safety demonstration**

- **Accident studies : radiological consequences on people and environment**

# Implantation

# SPIRAL 2 : Phase 1

## Activation

## Dose rate

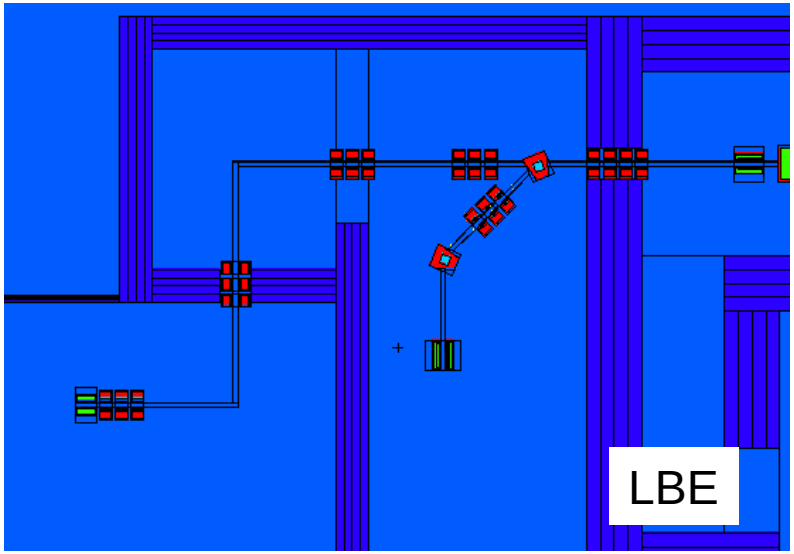
## Dose

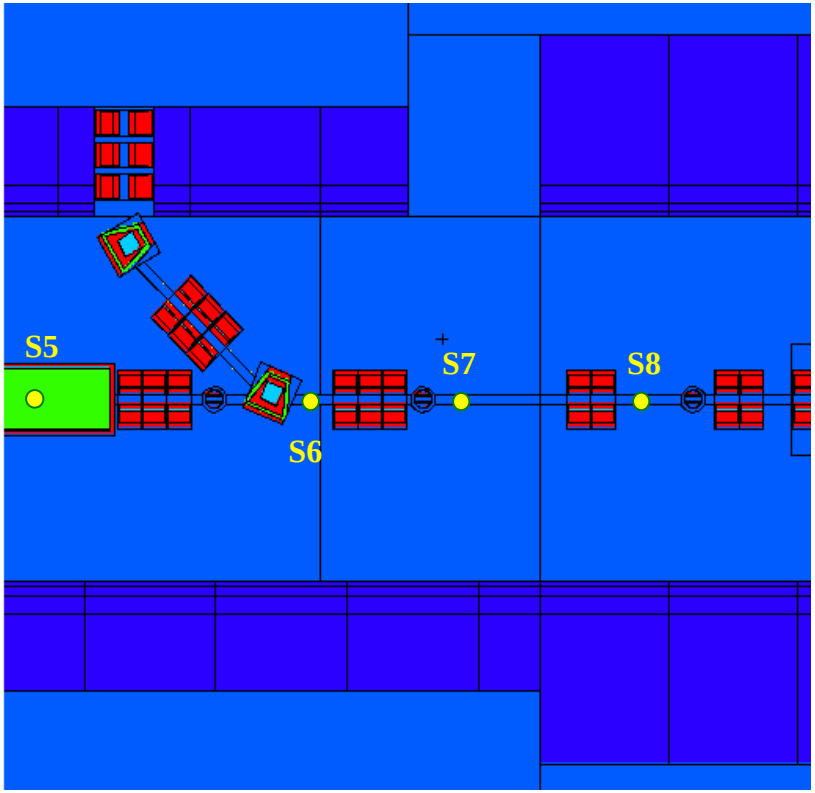
# Approach

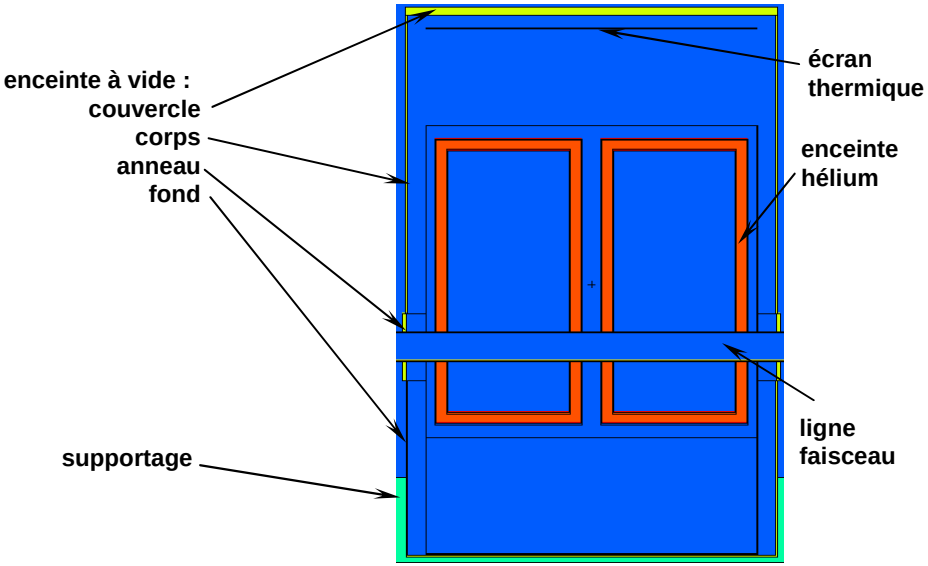
- Activation and dose
  - Equipments information (weight, material)..
  - Neutrons sources localization
  - Information of time for handling
  - Dose calculation

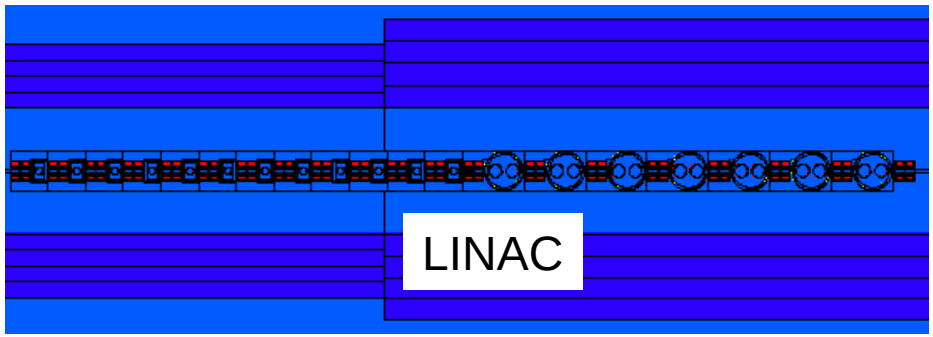
- Codes :
  - MCNPX (neutron)
  - FISPACT 2007 (Deuterons and neutrons activation)
  - MCNPX (transport)

# Model / Neutrons Sources



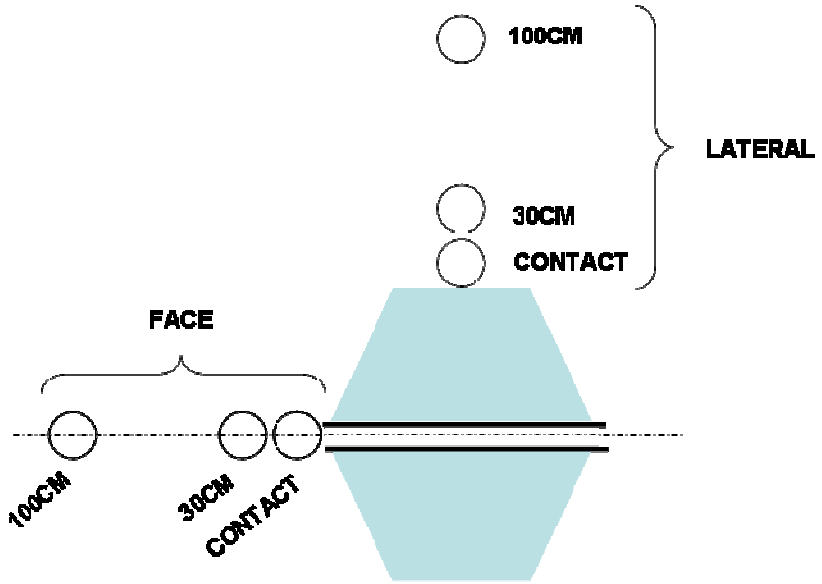



# Activation

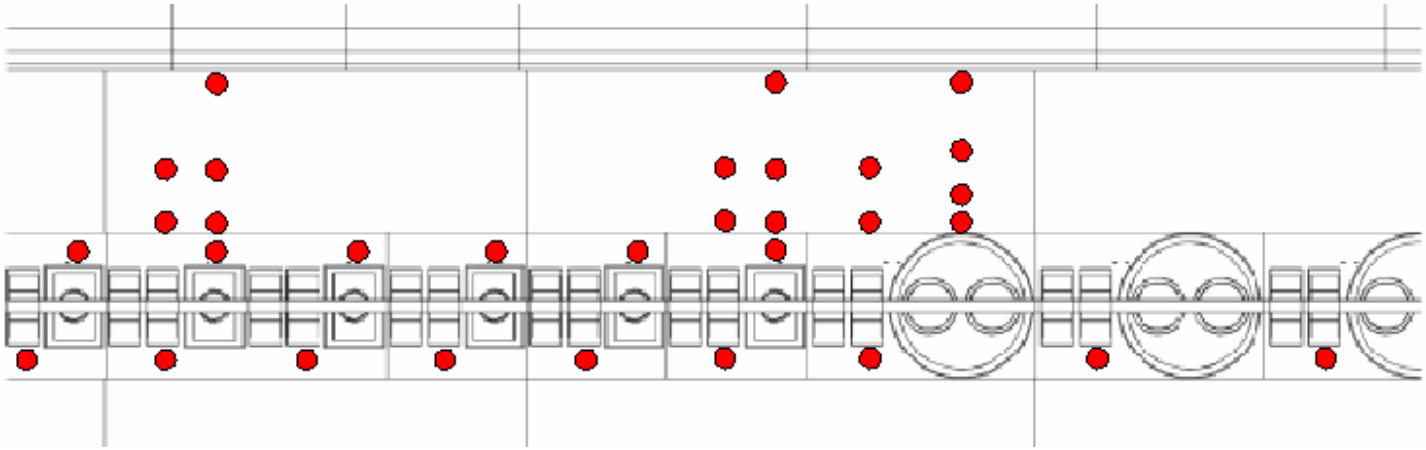
- Input :
  - 3 runs of 3 months / year – 20 years
  - Neutrons losses 0.2 W / cryomodule et 1 W / Qpoles
  - Chamber in steel 316 L
  - Dose rate at different time and different positions

# Dose rate

- Dose rate for equipments




- Dose rate map



- F:\01_0_secondes\spiral2@0_s.html

# Collective Dose

- Information for maintenance coming from GANIL or SP2 Project
- Maintenance : Operations outside LINAC tunnel

| | 0 seconde | 1 jour | 7 jours | 1 mois |
|---|---|---|---|---|
| LBE | 0.1 | 0 | 0 | 0 |
| RFQ | 0 | 0 | 0 | 0 |
| LME | 0.2 | 0 | 0 | 0 |
| CMA | 0.6 | 0.3 | 0.3 | 0.2 |
| CMB 1-4 | 0.7 | 0.4 | 0.3 | 0.3 |
| CMB 5-7 | 0.8 | 0.4 | 0.3 | 0.3 |
| LHE | **7.8** | **4.6** | **3.3** | **3.2** |
| Maintenance | 7.3 | 4.9 | 4.4 | 3.1 |
| | | | | |
| total | 17.4 | 10.8 | 8.7 | 7.1 |

Dose (H.mSv per year) for different cooling time

# Dose per operation

| | 0 seconde | 1 jour | 7 jours | 1 mois |
|---|---|---|---|---|
| **CMA** | 3,26E-03 | 1,27E-03 | 1,00E-03 | 8,01E-04 |
| **CMB 1-4** | 1,08E-02 | 5,33E-03 | 4,33E-03 | 3,20E-03 |
| **CMB 5-7** | 1,57E-02 | 7,27E-03 | 5,54E-03 | 4,21E-03 |
| **LHE** | 1,67E-02 | 1,45E-02 | 8,73E-03 | 6,57E-03 |

Dose (H.mSV) for pump maintenance

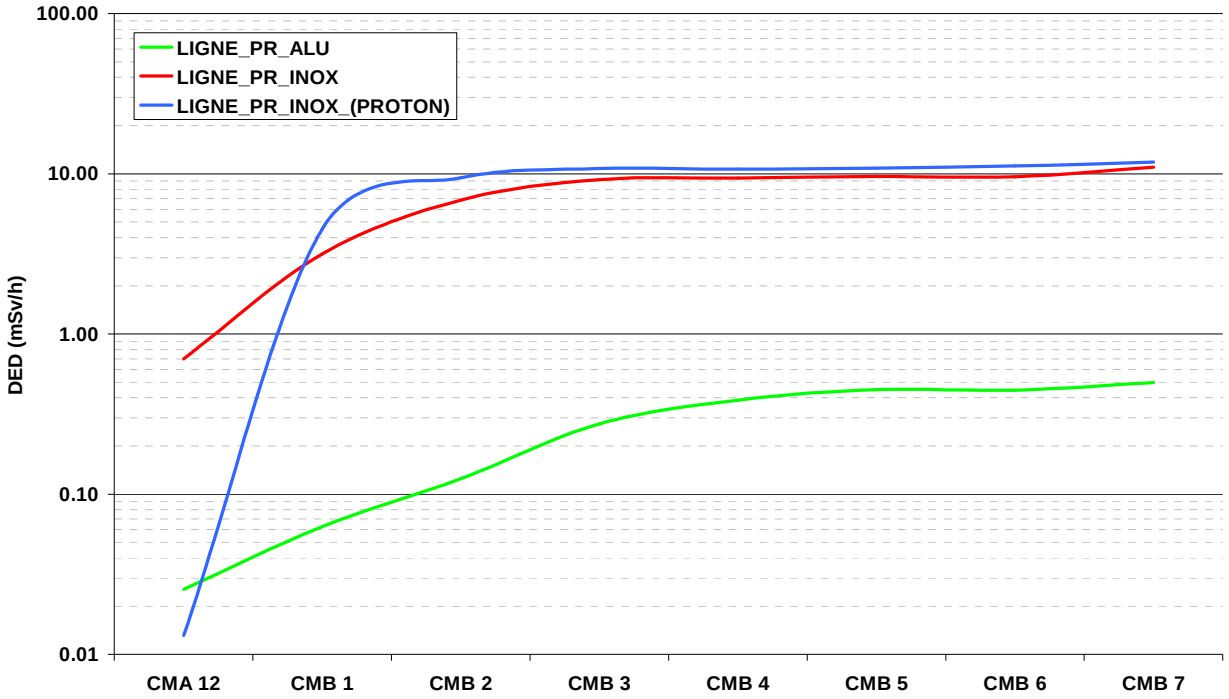
| | 0 seconde | 1 jour | 7 jours | 1 mois |
|---|---|---|---|---|
| CMA | 2,65E-02 | 1,10E-02 | 8,50E-03 | 7,00E-03 |
| CMB 1-4 | 1,06E-01 | 5,75E-02 | 4,75E-02 | 3,55E-02 |
| CMB 5-7 | 1,67E-01 | 8,05E-02 | 6,20E-02 | 4,55E-02 |
| LHE | 4,71E-01 | 2,36E-01 | 1,87E-01 | 1,40E-01 |

Dose (H.mSV) for vacuum leak

# Particular Points

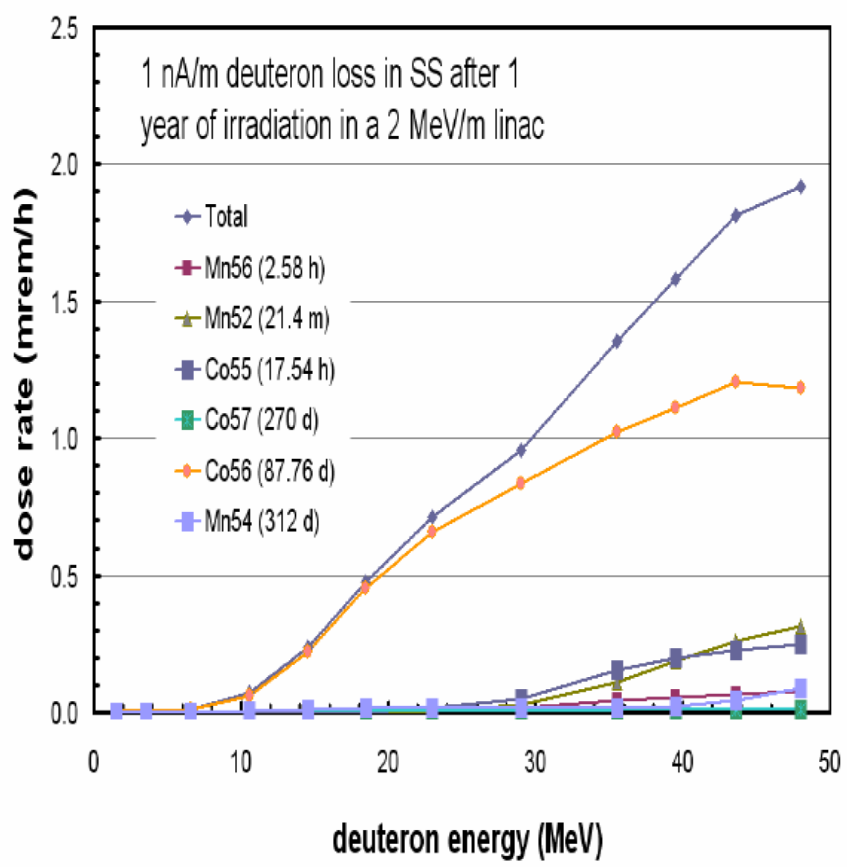
- **Activation (FISPACT 2007)**

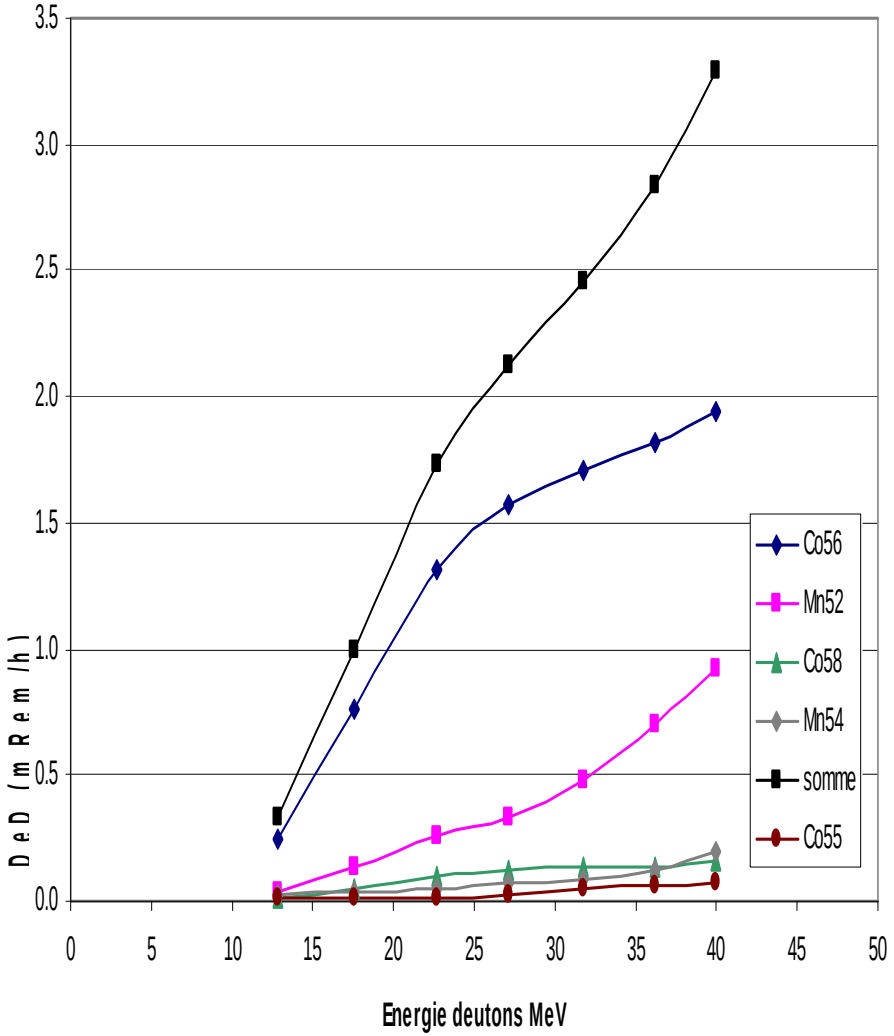
  - Comparison between proton and deuteron activation
  - Comparison between steel (316 L) and Aluminum (5083) for dose rate point of view




- **Biological protection (neutrons from deuterons source and RFQ)**

# Other slides



# THANK YOU

# VERY MUCH

# FOR YOUR ATTENTION