Workshop Targets-Sources

Experiences Learned from Target design office point of vue.

Needed skills ?

TARGET Mechanical Design & Skills :

Target related designs made at SUBATECH (IN2P3 laboratory in Nantes)

- LISOR experiment 1999-2002
- MEGAPIE experiment 2000-2006
- Myhrra Design report 2006-2010
- Prospective Work on SPIRAL 2 2006-2009
- Isotopes Production Target for ARRONAX 2010 – today
  - RbCl, At211, etc
- ANR REPARE 2019-2024

Increase in personal and Skills

2000 → 2023

Accelerator driven system

LISOR
1-2 W/mm^3, 50µA / 70MeV

MEGAPIE
2-3 W/mm^3
1.74mA/600MeV/1 MW

Design report MYRRHA
3mA / 650 MeV / 2MW

System Integration in SINQ

Medical research Radioisotopes

ARRONAX
15 W/mm^3 / P 70 MeV/150µA/10kW.
15 W/mm^3 / a 70 MeV/20µA/1,4 kW.
PRODUCTION : At211, Sr82, Cu64, Sc44, Ga 68 ..

ANR REPARE.
At211

LISOR

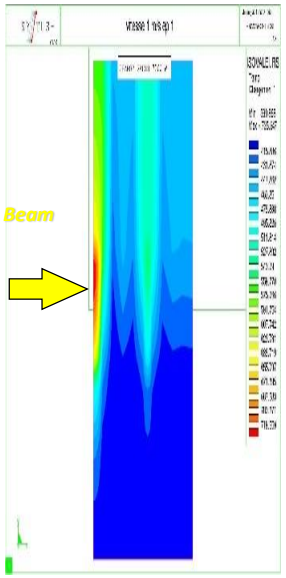
Experiment aiming to check effect of flowing LBE on stressed material sample in presence of an intense protons beam.

Experiment done at PSI.

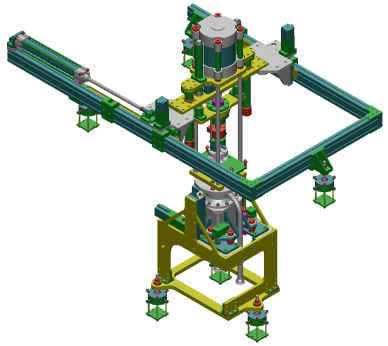
Collaboration started in 1999, without any specific skill in the field at subatech design office.

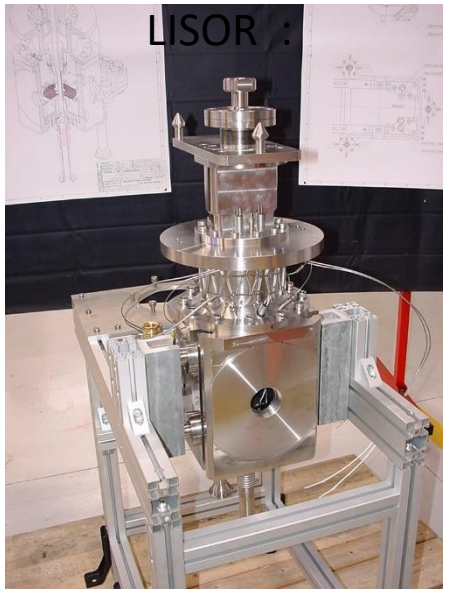
CFD was a specialist reserved field.

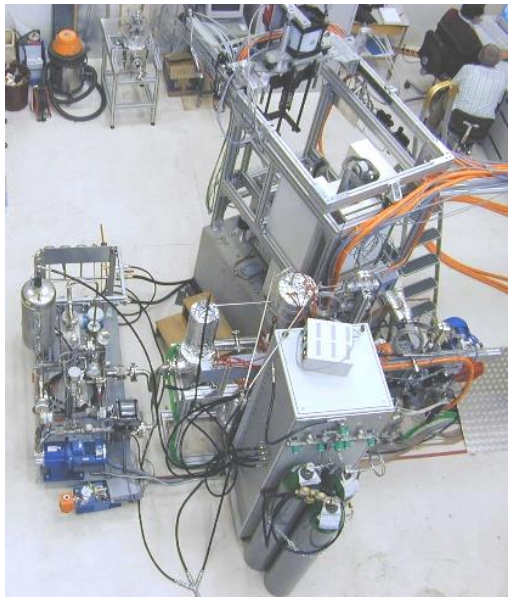
Advanced mechanics matter of specialists out of design officed.



Échauffement de la section test







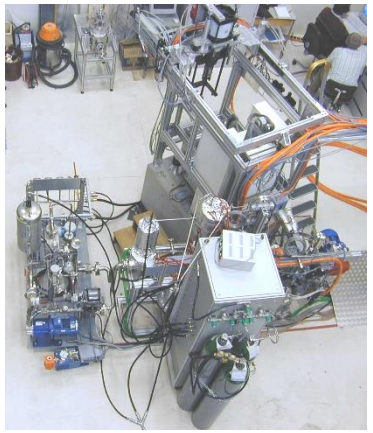
LISOR

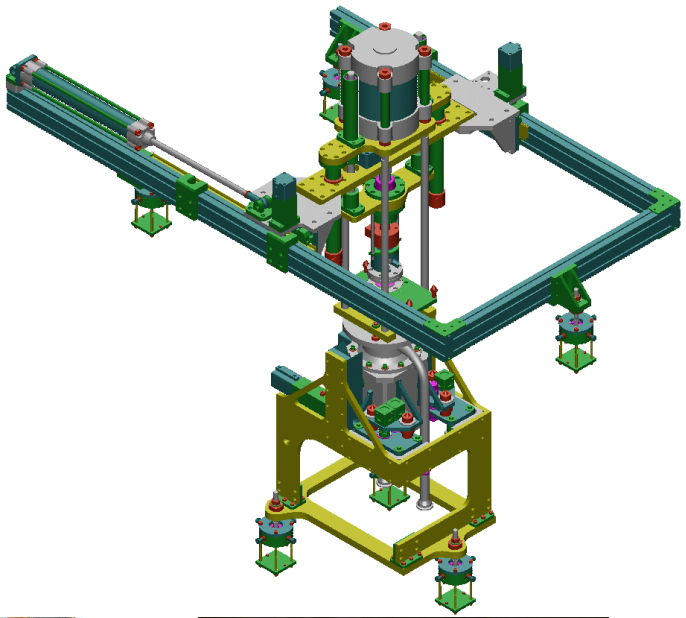
Works in very close collaboration with PSI.

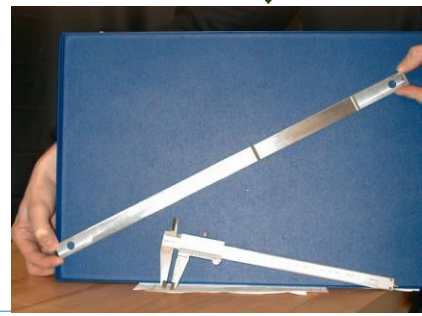
PSI had CFD specialist
Large experience in activated structures management.

Main Missing knowledge :
Electromagnetic pumps design
Liquid metal tehnology.
These knowledge was found in IPUL

LISOR allow a simple modelisation of thermal situation.
Design made according modelisation limitation







MEGAPIE :

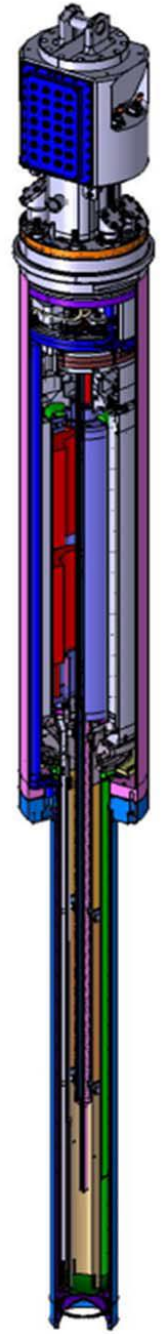
- CAO : evolution to CATIA V5 (compatibility with PSI)
- FINITE Element software : from Samcef to ANSYS

Skill gain

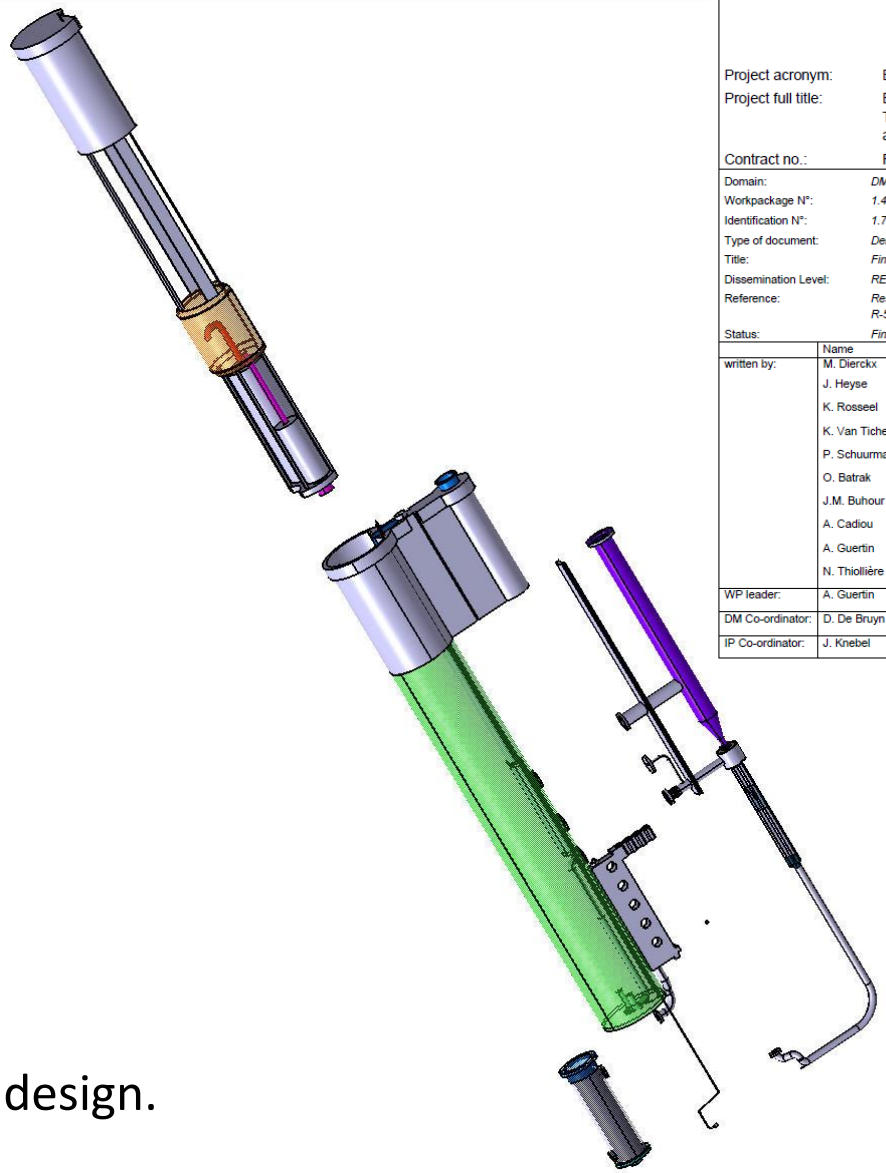
Project management
Distributed design (IN2P3 / CEA)
confidence in designing very high activity target.
Ideas about handling and tooling for managing activated structures

SKILL missing :

CFD in order to get a first order thermal map of mechanical structure.
EMP design (made by IPUL)



Myhrra



SIXTH FRAMEWORK PROGRAMME
EURATOM
Management of Radioactive Waste

Project acronym:	EUROTRANS
Project full title:	EUROpean Research Programme for the TRANSmutation of High Level Nuclear Waste in an Accelerator Driven System
Contract no.:	FI6W-CT2005-516520
Domain:	*DM1 DESIGN*
Workpackage N°:	*1.4.*
Identification N°:	*1.75*
Type of document:	*Deliverable*
Title:	*Final report on the feasibility of the XT-ADS spallation target*
Dissemination Level:	*RE*
Reference:	*Restricted Report of the Belgian Nuclear Research Centre R-5069; Mol, Belgium: SCK•CEN, 2010.*
Status:	*Final*

	Name	Partner	Date	Signature
written by:	M. Dierckx	SCK-CEN	21/09/2010	
	J. Heyse	SCK-CEN	21/09/2010	
	K. Rosseel	SCK-CEN	21/09/2010	
	K. Van Tichelen	SCK-CEN	21/09/2010	
	P. Schuurmans	SCK-CEN	21/09/2010	
	O. Batrak	CNRS	07/07/2010	
	J.M. Buhour	CNRS	07/07/2010	
	A. Cadiou	CNRS	07/07/2010	
	A. Guertin	CNRS	07/07/2010	
	N. Thiollière	CNRS	07/07/2010	
WP leader:	A. Guertin	CNRS	07/07/2010	
DM Co-ordinator:	D. De Bruyn	SCK-CEN	30/08/2010	
IP Co-ordinator:	J. Knebel	KIT		

Objective : Determine feasibility of a windowless target in the frame of ADS.

<u>Main action :</u>

SUBATECH recruit an CFD engineer.

back to school on CFD topics

<u>SKILL Gain :</u>

CFD modelisation at a correct level for mechanical design.

Arronax Targets

Metallic Rubidium as target (melted).

Encapsulated in steel case, Pressurized Water Cooled, 2 weeks lifetime under beam.

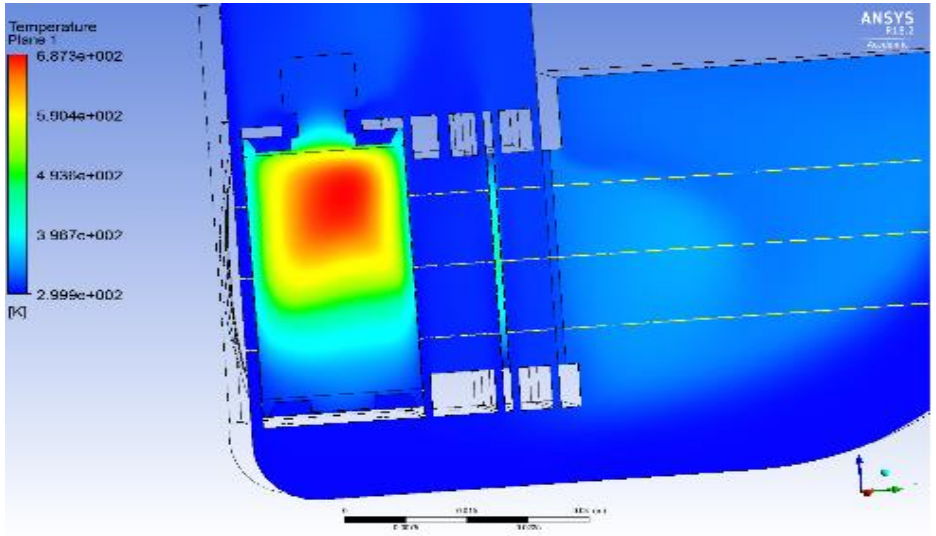
<u>Modelisation used</u>

- Heat transfer with metallic fluid.
- Intensive CFD modelisation.
- Critical heat transfer
- Non linear mechanics.
- Etc …

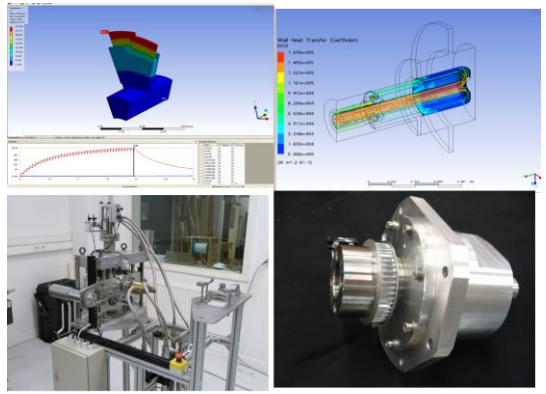
<u>Additional topics :</u>

Skills gain in designing Hot cells equipment. (tooling or chemical equipment)

Mechanical design fully home made



Example : calculated Rubidium Target température 70MeV 200µA



Dégradeur Alpha

NOTE :
All Teams of ARRONAX achieve a huge skills gain.
Radioprotection. Quality insurance, accelerator operation, chemistry group etc ..

ANR REPARE

At211 achievable Production @ SPIRAL 2

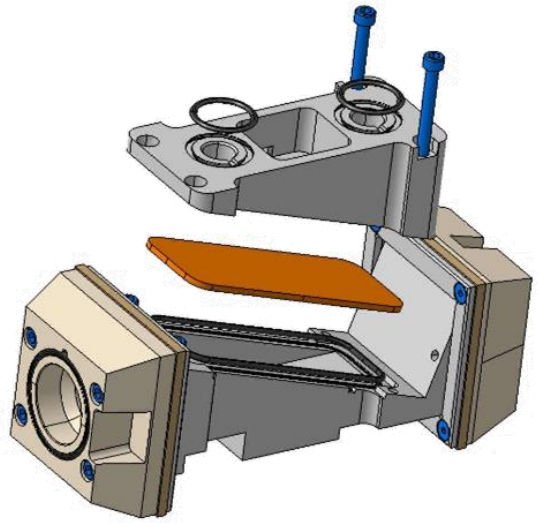
Current production assessment at **ARRONAX**

- **0.43 GBq/1h**
- Intensity limited to 20µAe by the energy degrader used to go from 68MeV to 28.6MeV

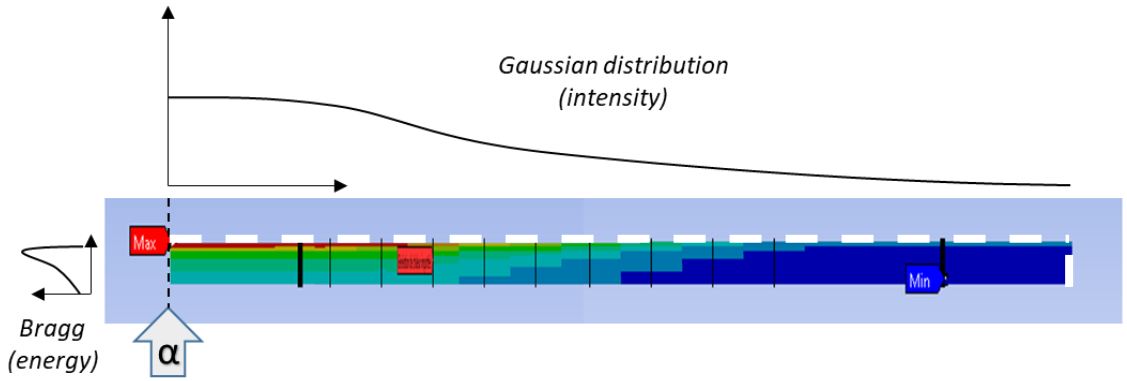
Computations

- Taking optimistic hypotheses, regardless of technical feasibility
- **Ideal solid** target production: **4.4 GBq/1h**
  - T° allowable: 271°C (bismuth fusion)
- **Ideal liquid** target production: **15.3 GBq/1h**
  - T° allowable: 600°C (engineering judgement)

⇒ Significant benefits could be achieved

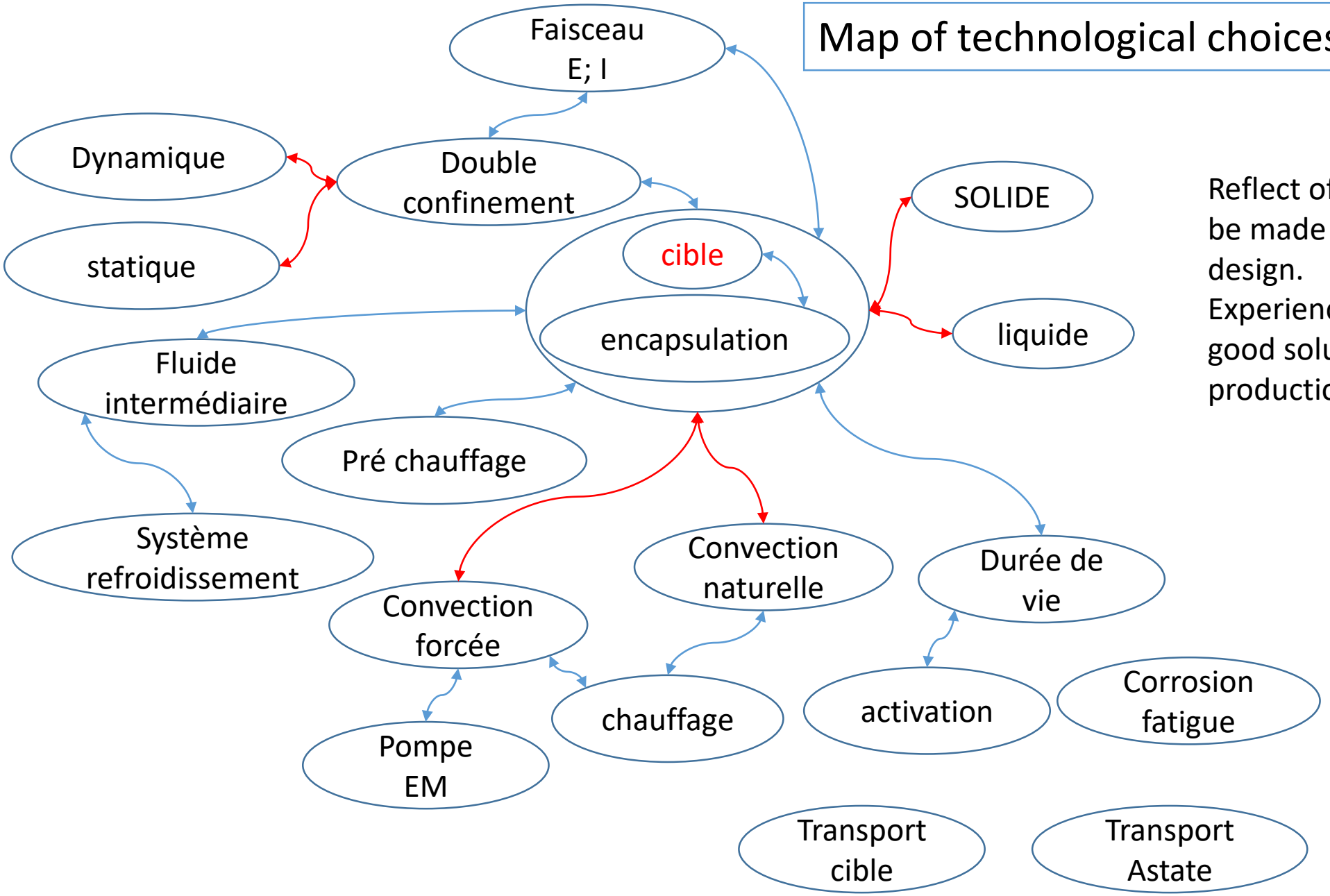


ARRONAX bismuth target

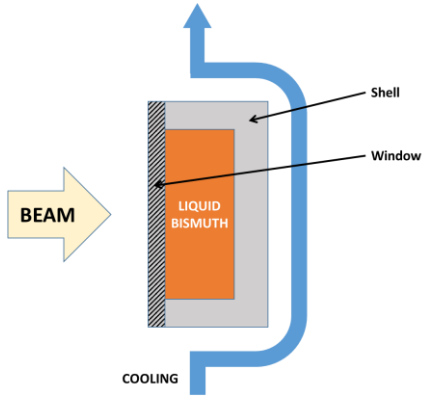


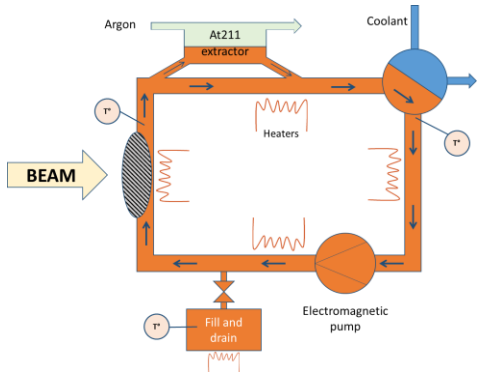
Heat generation of the ideal target model cross-section
A convection boundary condition is applied on the back plate, represented here by the dashed line.

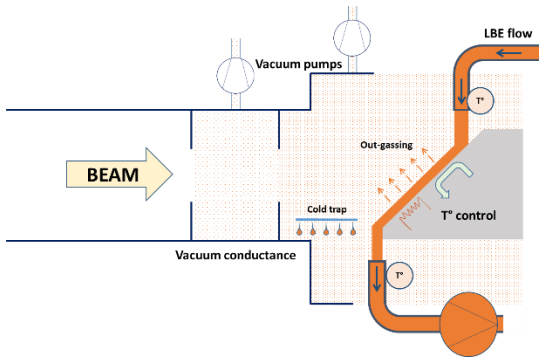
Map of technological choices for an AT211 target

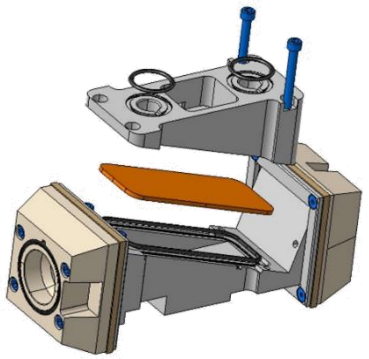


Reflect of (some) choices to be made at the preliminary design.
Experience shows that the good solution for an isotope production is not trivial.









Criteria	Bismuth Capsule	LBE loop	Windowless LBE loop	ARRONAX
Production	** **4.9 GBq - 1h**	* **0.21 GBq - 1h**	*** **11.5 GBq - 1h** ***(pending losses evaluation)***	* **~0.43 GBq – 1h TBC**
Maturity	*** In service for other targets. Curved window not demonstrated.	** Feedback from MEGAPIE.	* Lack of experience on liquid LBE in the vacuum.	***** In service.
Exploitation	*** Manual extraction, easier transport.	** In line extraction as an option. Important volume of LBE.	* In line extraction. Important volume of LBE. Beam line losses.	*** Manual extraction, easier transport.
Cost	**** Simpler system.	** Pump, pipe, exchanger…	* Pump, pipe, exchanger, beam line modifications…	**** Simpler system.
Integration	**** Simpler system.	** Pump, pipe, exchanger…	* Pump, pipe, exchanger, beam line modifications…	**** Simpler system.

Conclusion

SKILLS in design office	Mechanics linear	Advanced mecahnics	Thermal Basics	CFD basic	CFD advanced
LISOR	yes	no	Start	no	no
MEGAPIE	yes	Start	yes	no	No
MHYRRHA	yes	yes	yes	yes	No
ARRONAX / REPARE	yes	yes	yes	yes	yes

SKILLS improvement through years in our design office.

This is modest but allow us to be autonomous in some isotope production target design.
However :

- Human resource is a severe limitation in ability to take complex target in charge.
- Mechanical design require people (not only engineers)
- IN2P3 have no competences in material science under irradiation (as far as I know)

Conclusion

- Design of High power targets requires some advanced skills in mechanics and CFD.
- New generations of mechanical engineers are quite well informed on these topics.
- Thanks to software progess, Today a large part of calculations can be done in the scope of design office.
- Theses works requires a lot of time, several man.year typically.
- A big advantage exist when the designer can make himself first pertinent thermomechanical estimations. This speed up the process.
- Support of CFD specialist is highly recommended.
- At least support of material specialists or real data on irradiated material is mandatory.
  - Getting event worse with target expected lifetime increased.
  - CNRS could help on theses fields, as on mechanical and CFD knowledge.
- If designing a High power target require a lot of manpower, this is only a fraction of all work to be done to design the post irradiation work (analysis, waste management, shipping etc ..).

Thanks for your attention