Life-cycle and operability of Particle Accelerators - Part 1/2

JUAS 2025

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Centre de Protonthérapie – Orsay

Institut Curie

14th March 2025

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14h15

Lifecycle

Operations

Preparation
by groups

15h15

Break

Your Presentations

Reliability

Last trends

16h15

In the perfect world

History

Team works

In the real world

Business

Documents present on Indico

Including 2 documents annex

During the lecture
3 polls with

wooclap

About the lecturer / About Institut Curie

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About the lecturer

Samuel Meyroneinc

Engineer, CERN (2 years), Industry (5 years), Protontherapy (+ 25 years)

Head of the Biomedical Technical and Engineering Service - Protontherapy

operations, maintenances, developments, R&D for clinics and for research – Institut Curie

Accelerator Reliability Worshop

Academic groups: accelerator, particle therapy, reliability, organizations

INSTITUT CURIE, THE FRENCH LEADING CANCER CENTER

Created for Marie Curie in **1909**

A non-profit foundation authorized to receive donations and bequests

3 missions

- Research
- Care
- Teaching

3 entities

- An internationally-renowned **Research Center**
- A state-of-the-art **Hospital Group**
- **A Head Office**

3,736 employees* spread over **3 sites**:

- Paris
- Saint-Cloud
- Orsay

*2021 figures

INSTITUT CURIE TODAY

Leading

- European center for breast cancer treatment
- French cancer center in terms of number of patients treated
- French cancer research center Certified **Comprehensive Cancer Center** since 2018 by the OCEI

3,736

Employees

1,225 at the Research Center

2,219 at the Hospital Group

476

PhD students, residents, nursing students

€436.6 M

in resources

(excluding provisions and dedicated funds)

242,000

active donors

740

Patents

28 start-ups

since 2002, **95%** of which are in business 5 years later.

89 contracts

For R&D collaboration with companies signed in 2021 (*X3 compared with 2015)*

Centre de Protonthérapie d'Orsay

1991-2010: 5000 patient treatments
From 2010: treatments with an upgraded facility
2025: 50 patients treated per day

Gantry room

Cyclotron&Beamlines

Robotic & Imaging

R&D physics
&Technology

Control room

YOU ?

Lifecycle of Particle Accelerators

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The typical steps of lifecycle of Accelerators
(one of the possible namings)

- Desire- Need
- Preliminary design
- Detailed design
- Construction-installation
- Tests & Commissioning
- Operations- Maintenances
- Stop

The typical duration of the stages ?

Desire-need

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Step « desire-need »

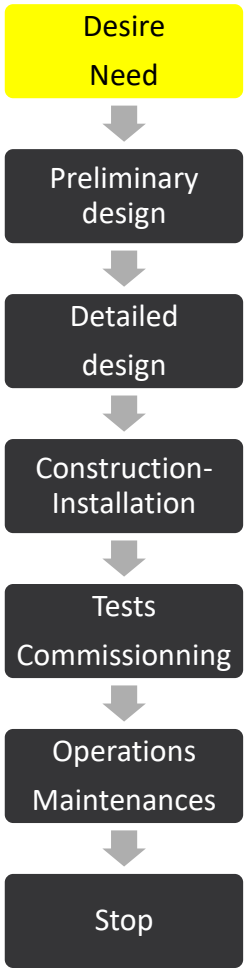
Formulate the desires

Idea-concept-feasibility-willingness

Formulate the needs

Request, requirement, specifies

Description of the need



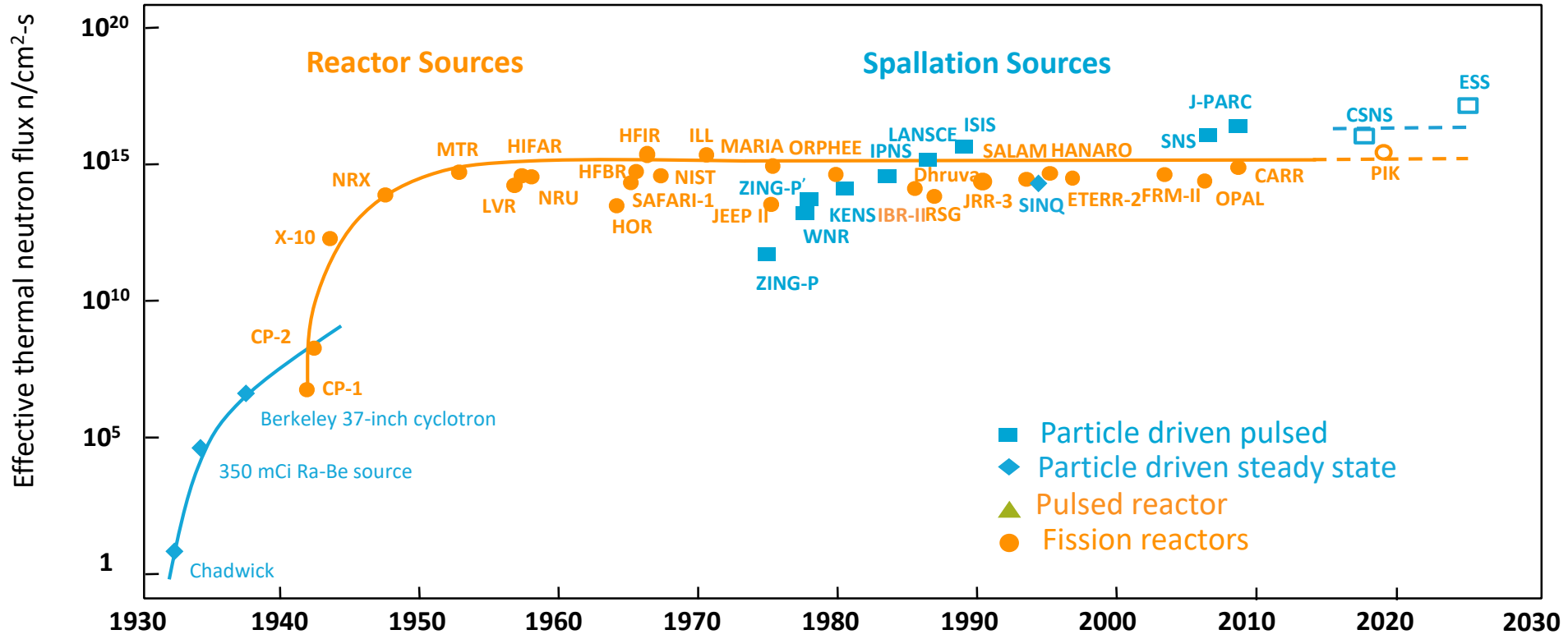
Desire-Need

Need of an accelerator of - Electrons - 5 MeV - 500 mA (stable +/- 2%)

ESS- Future Neutrons Source

EUROPEAN SPALLATION SOURCE

Increase flux of neutrons



(Updated from *Neutron Scattering*, K. Skold and D. L. Price, eds., Academic Press, 1986)

Preliminary Design

Detailed Design

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Difference between Preliminary design/ Detailed design

Preliminary design

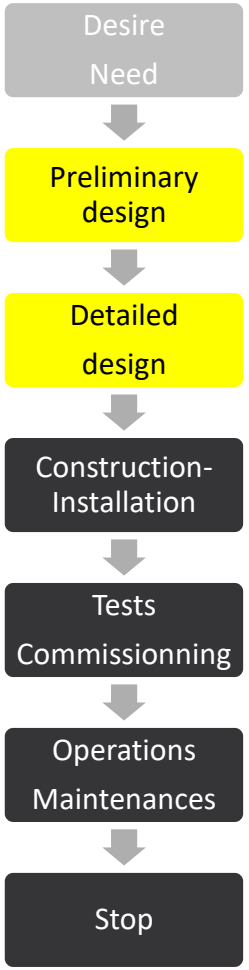
(CDR: Conceptual Design Report)

Obtaining the dimensioning data and 1st rough budget

Detailed design

(TDR: Technical Design Report)

All the data required for the construction



Preliminary design

What we want

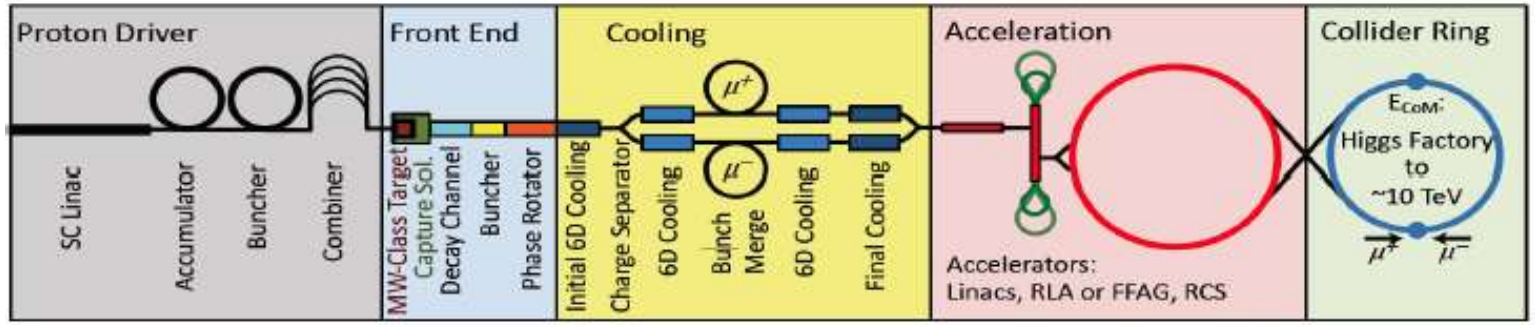
What we can

What we know

On the Muon collider (feasibility studies in process)

Collider Concept

Fully driven by muon lifetime, otherwise would be easy



Short, intense proton bunch

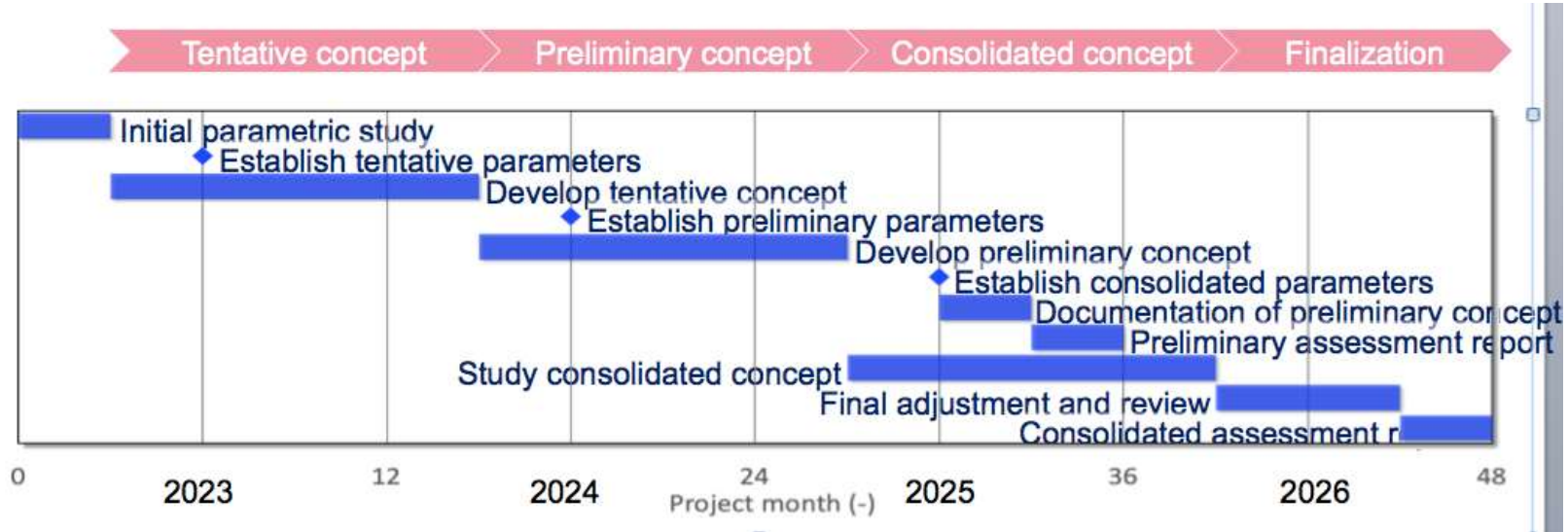
Ionisation cooling of muon in matter

Acceleration to collision energy

Collision

Protons produce pions which decay into muons
muons are captured

D. Schulte Muon Collider, IM



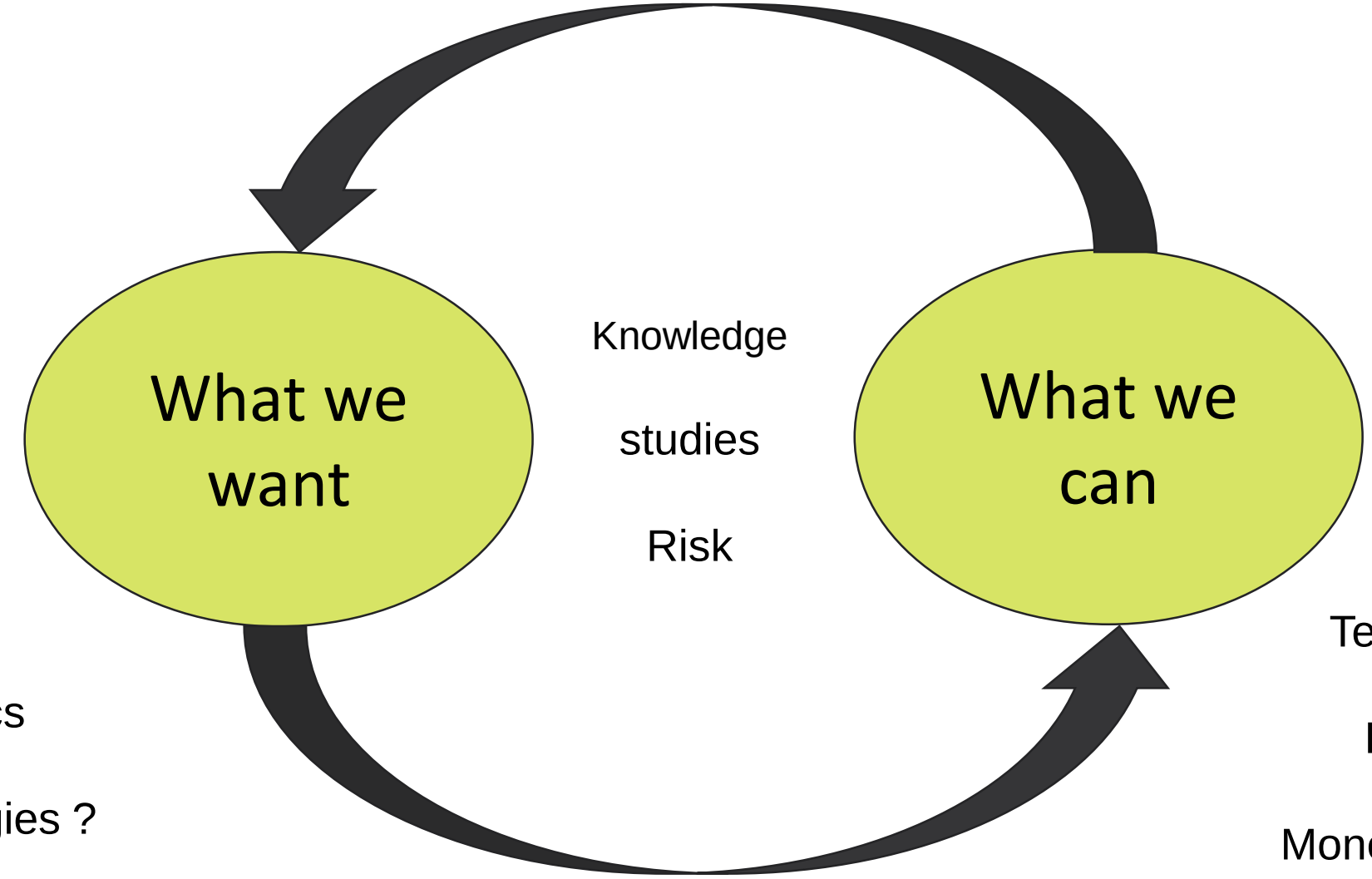
Example on some challenges to consider

Different regime compared to conventional RCS

	RCS1	FNAL	J-PARC
Circumference, $2\pi R$ [m]	5990	468	348
Energy factor, E_{ej}/E_{inj}	5	20	7.5
Repetition rate, f_{rep} [Hz]	5 (asym.)	15	25
Magnetic ramp	Linearized	Sinus	Sinus
Number of turns	17	42 k	17 k
Max. RF voltage, V_{RF} [MV]	21000	0.86	0.44
Energy gain per turn, ΔE [MeV]	14800	~0.4	~0.2

→ Significantly **more RF voltage** than any other RCS

→ **Much fewer turns**



Physics

Technologies ?

Technologies

Physics ?

Money/Resources

What we know-what we can (internal, external)

Internal: experience, skills (people, teams), methods, …

External: we can ask to do
(partnership, collaborations, contract with industrials, …)

Preliminary Design
Detailed Design

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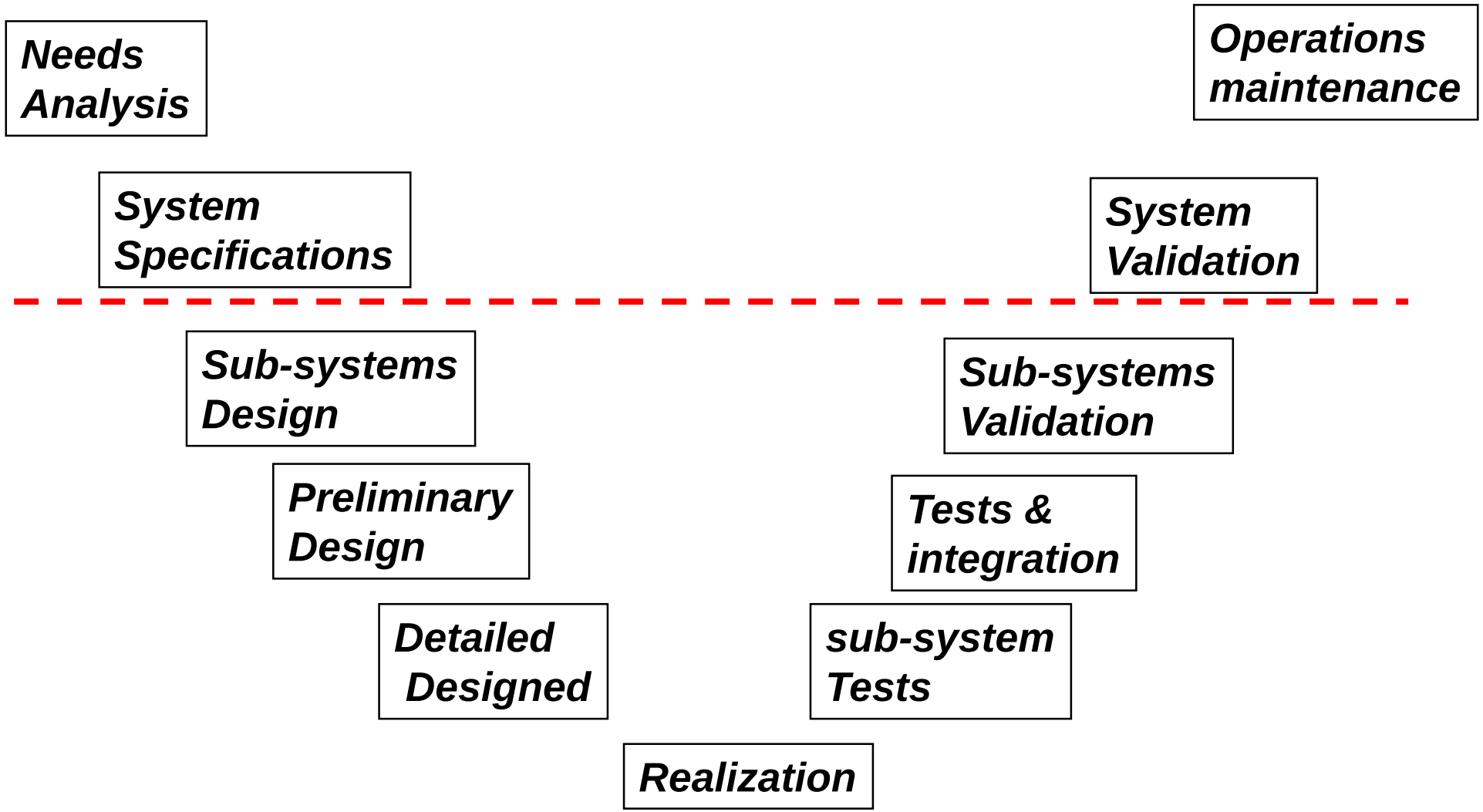
Development – the V cycle



Construction-installation

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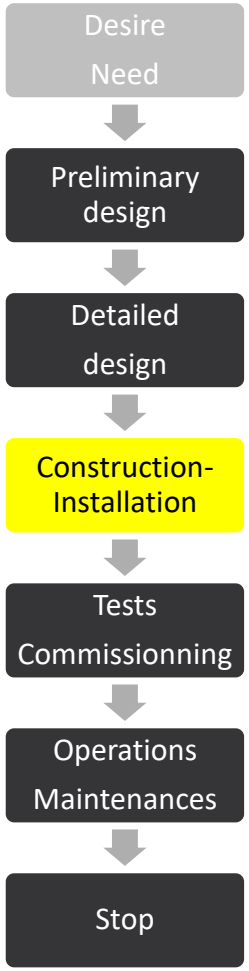
Construction-Installation

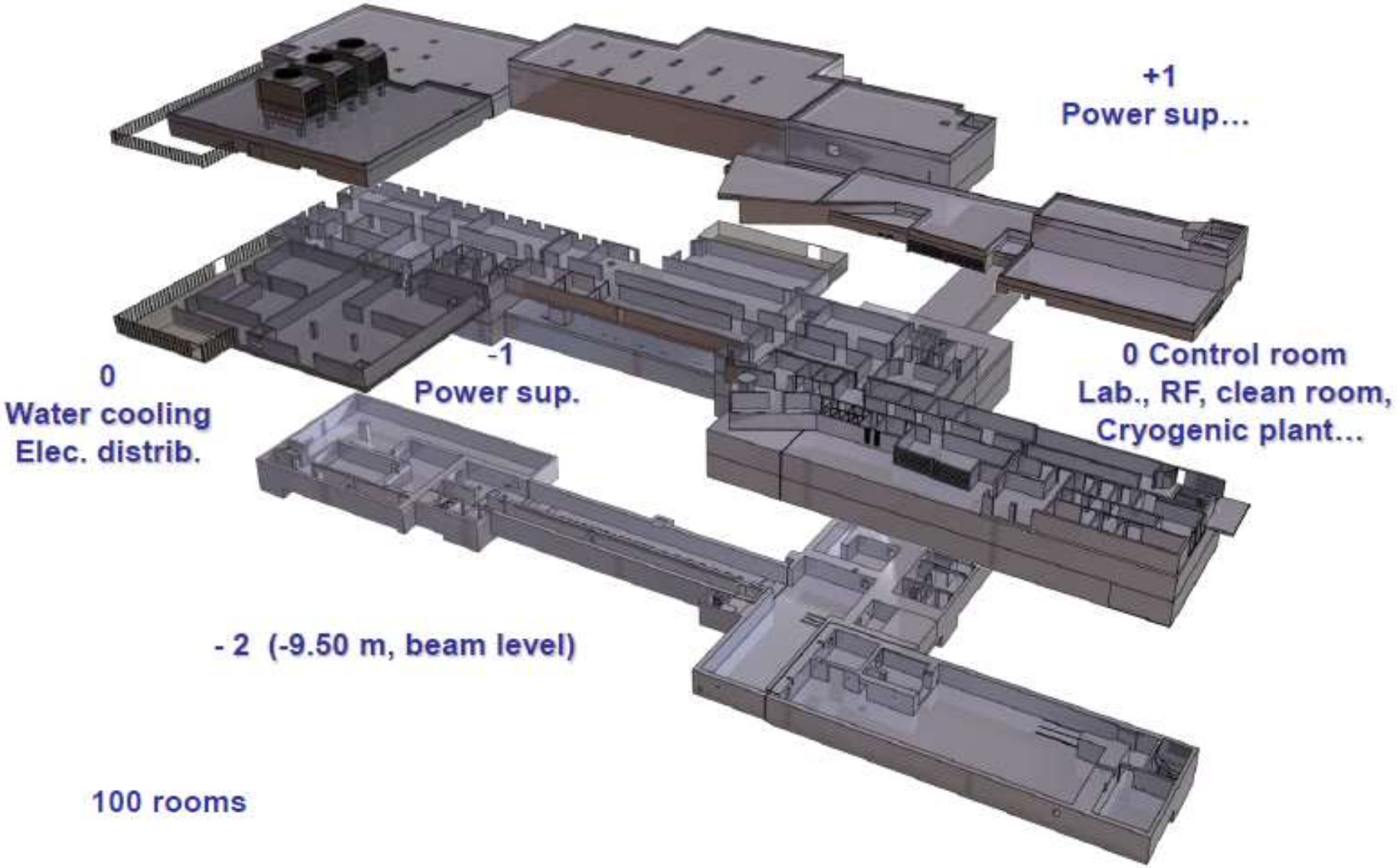
The Building

The Equipment

(the overall: the « facility »)



Building SPIRAL2 : 4 floors, 100 rooms !



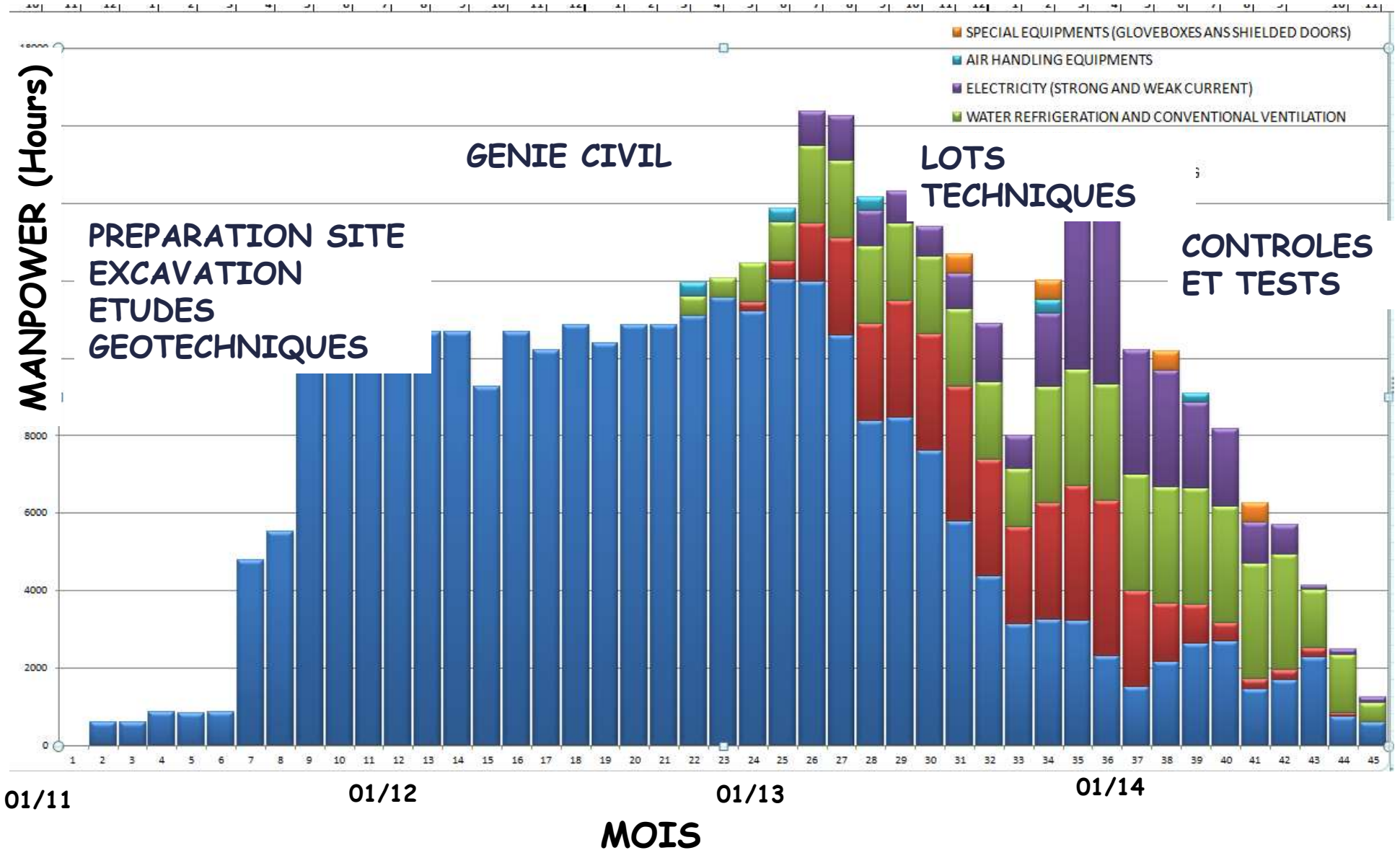
Building SPIRAL2 ...

Production building / -13.10 m

Building and infrastructures

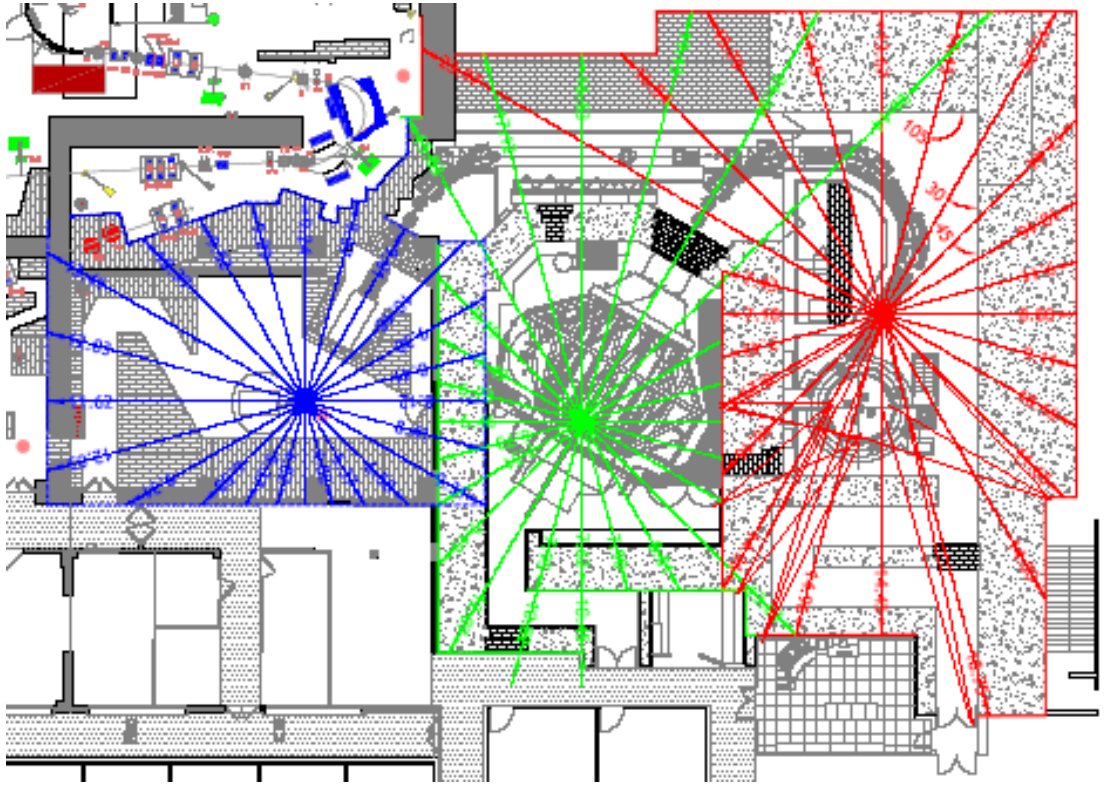
Excavation
Génie civil
Ventilation nucléaire
Ventilation conventionnelle
Système de refroidissment (eau)
Electricité
Equipements de manutention
Equipments spéciaux

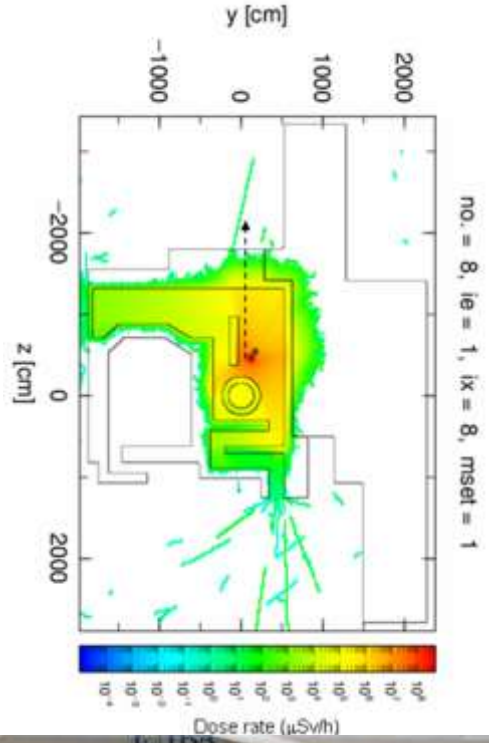
About building issues for SPIRAL2



Radiation – protection

- calculation of shieldings
- source points (to provide)
- proof of concept to dismantle





The building-the infrastructure

- The instrument is the « overall »
- Building first: 1st milestone “Building Occupancy Date”
- Building and ancillaries are specific and complex
- Interfaces, large numbers of areas
- To be designed for users, maintenance, upgrades, … (for long-term)
- Cost = 30%to 50% of the total cost

Construction-Installation

The Equipment

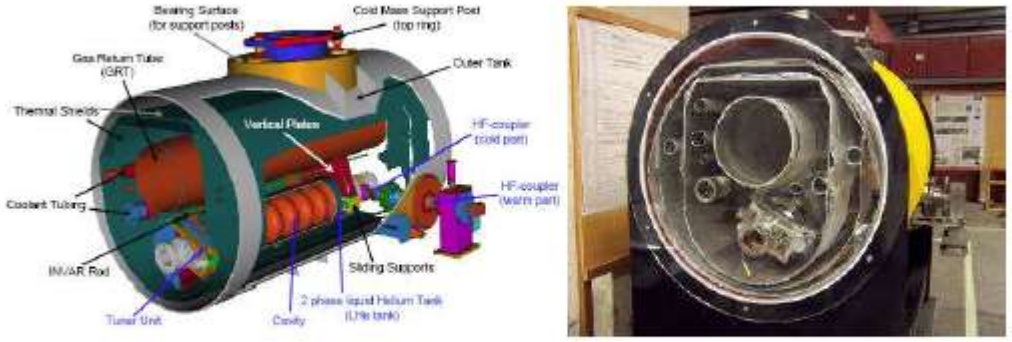


Figure 6-1: Cut-away diagram of an XFEL vacuum vessel.

Example of the cryo-modules X-Fel

- Desire Need
- Preliminary design
- Detailed design
- **Construction-Installation**
- Operations Maintenances
- Tests Commissionning
- Stop

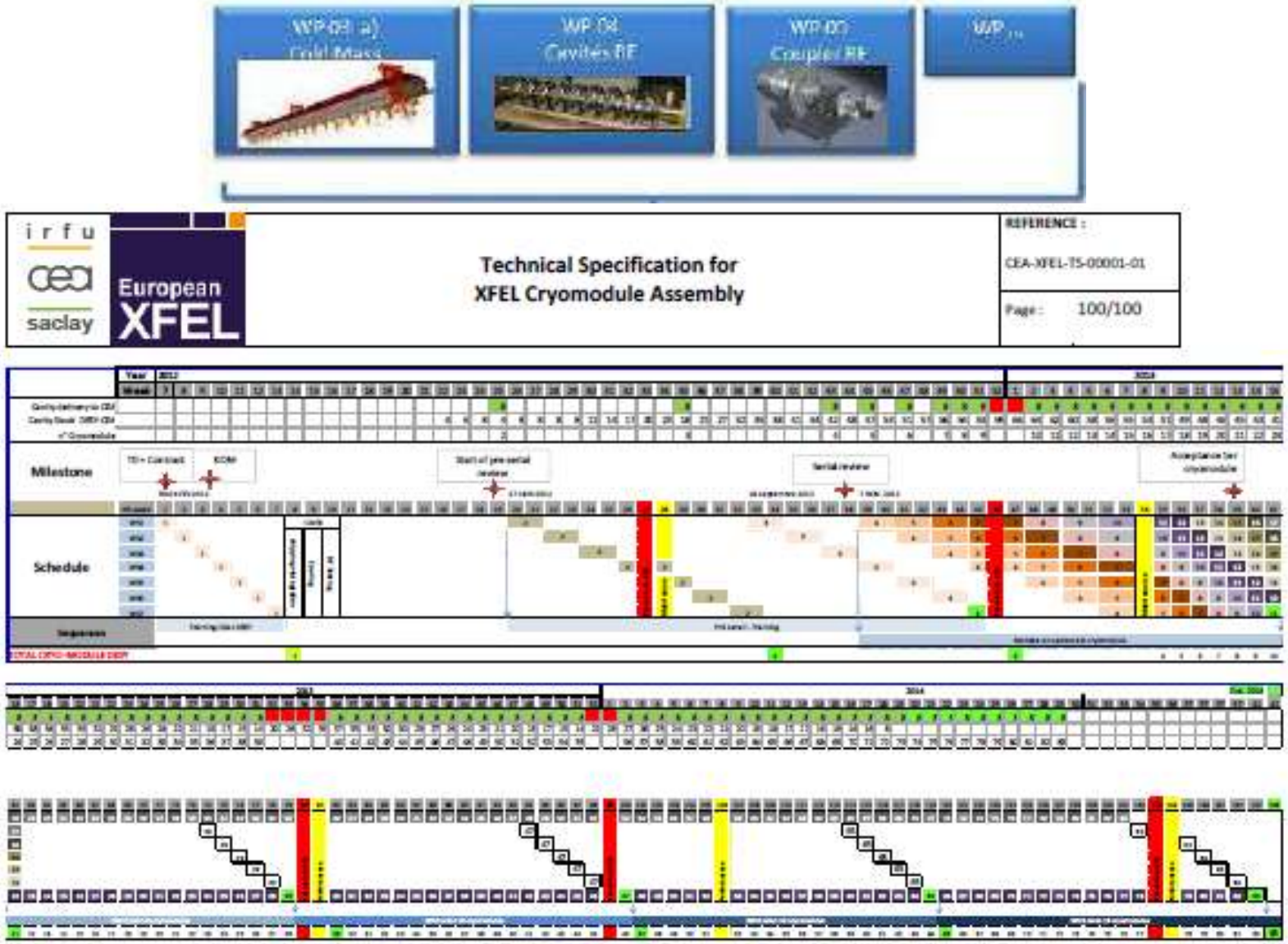
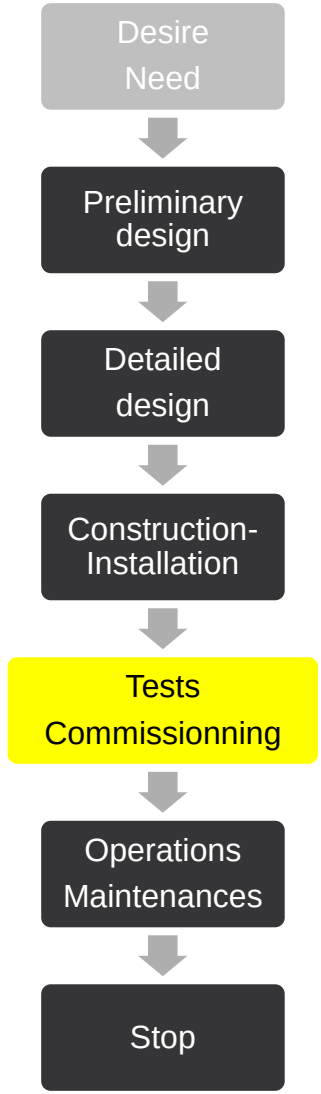


Figure 12-1 : schedule of the assembly according with the availability of cavity.

Tests and Commissionning

Tests, Tests, Tests, …

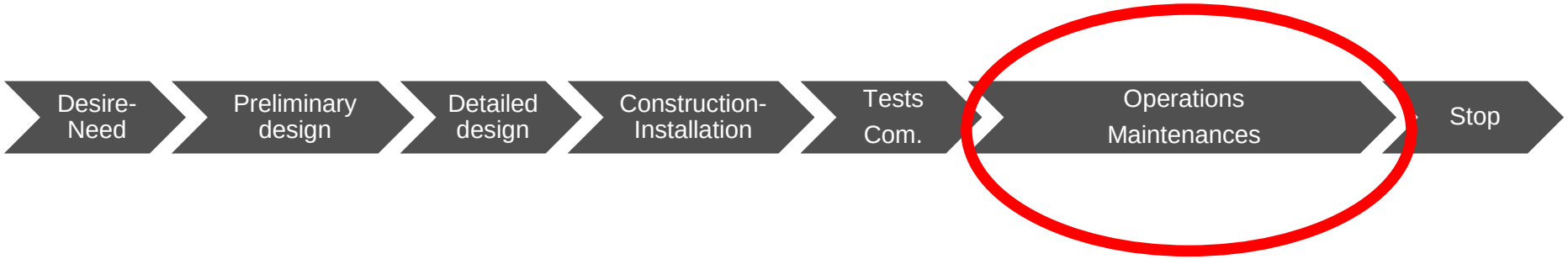
The commissionning: « The process during which components and systems, after construction, are made operational and verified to be in accordance with design assumptions and performance criteria".



Commissionning paper of JPARC
Annex 1: titles + summary

5 minutes of (fast) reading

Then you are in « operations »



Operations

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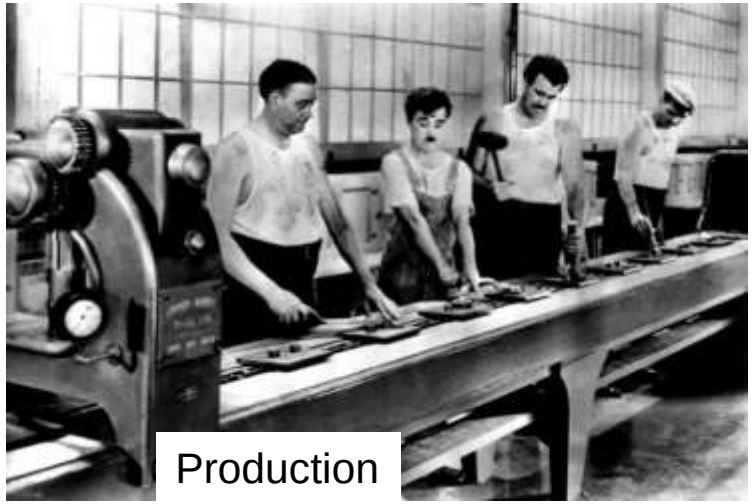
Operations ?

Operations management is an area of management concerned with **designing and controlling** the process of **production and redesigning** business operations in the production of **goods or services**

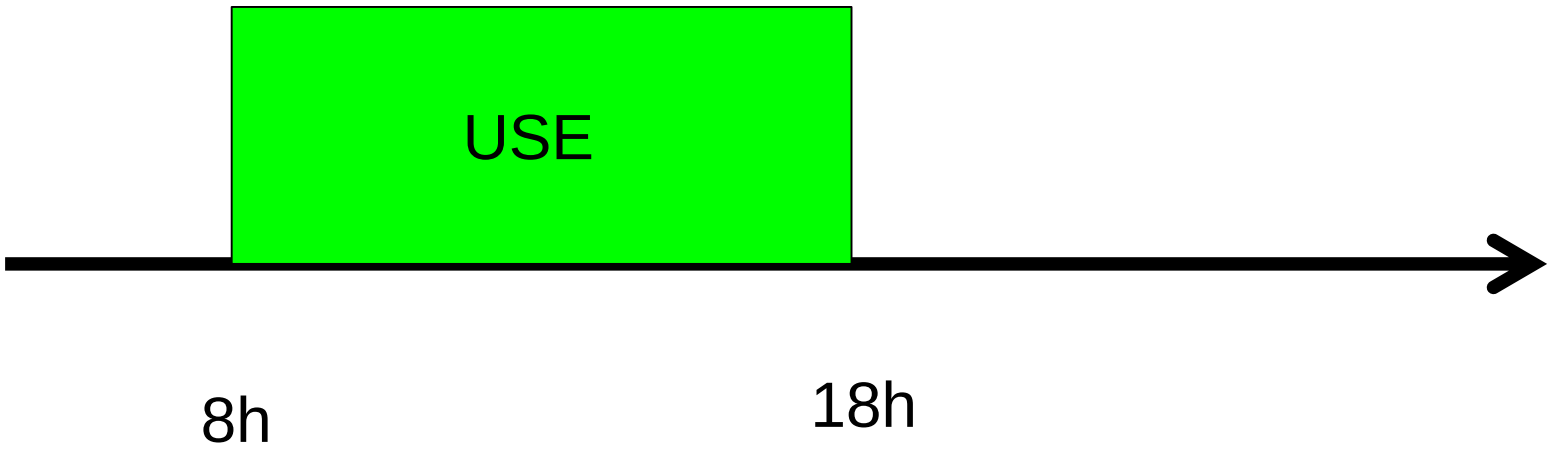


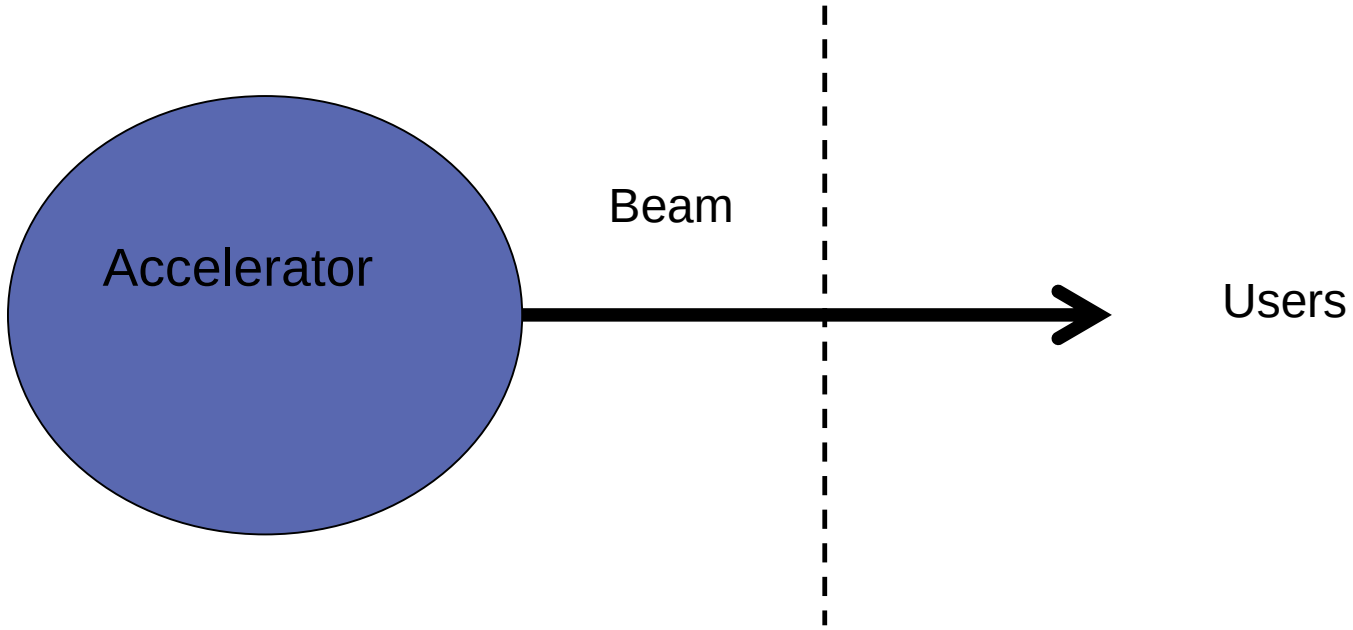
Production

Military operations

Amazon robots

Control room (ex: PSI): the main place to operate


USE
8h
18h


Accelerator
Beam
Users

Different kinds of users

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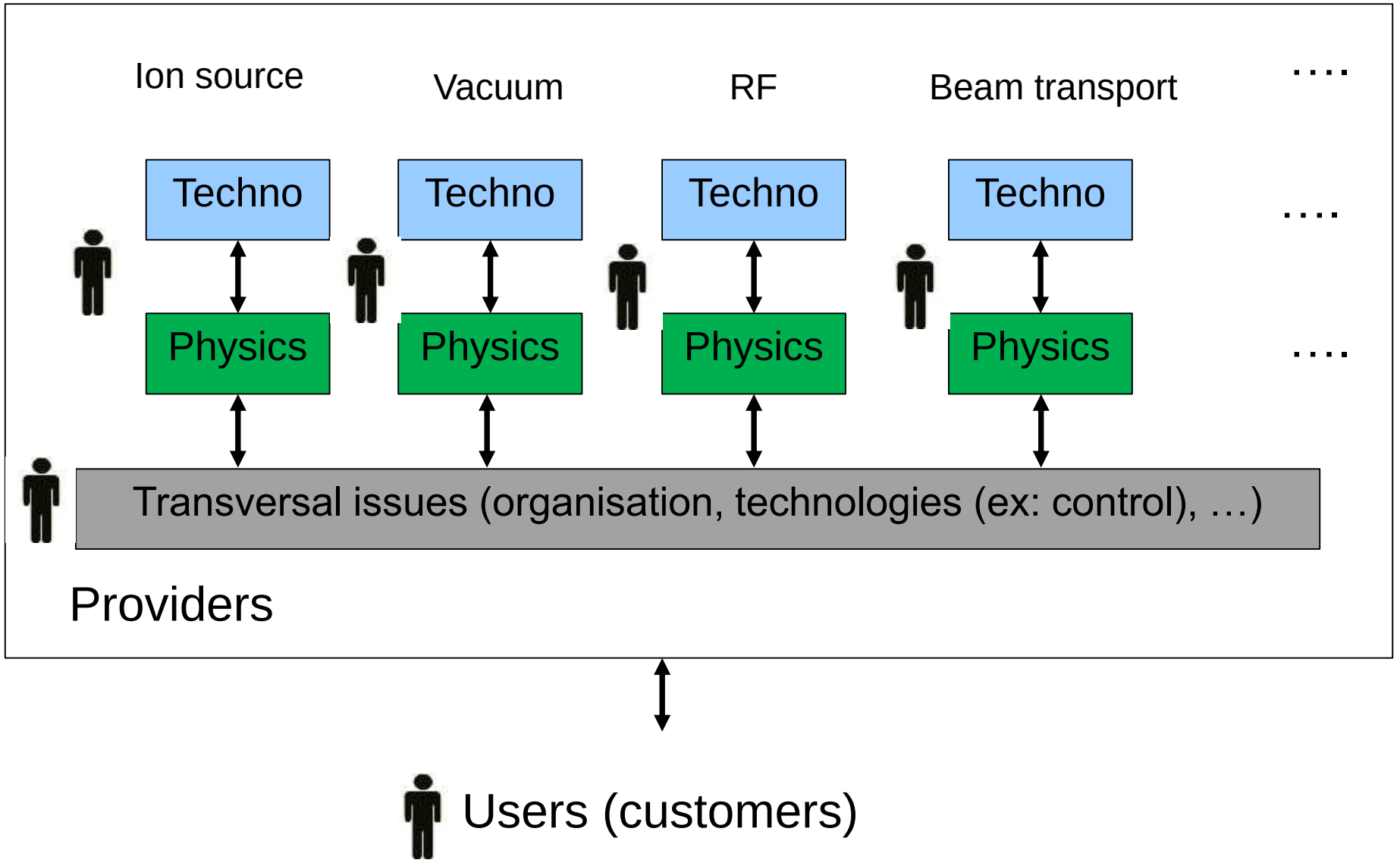
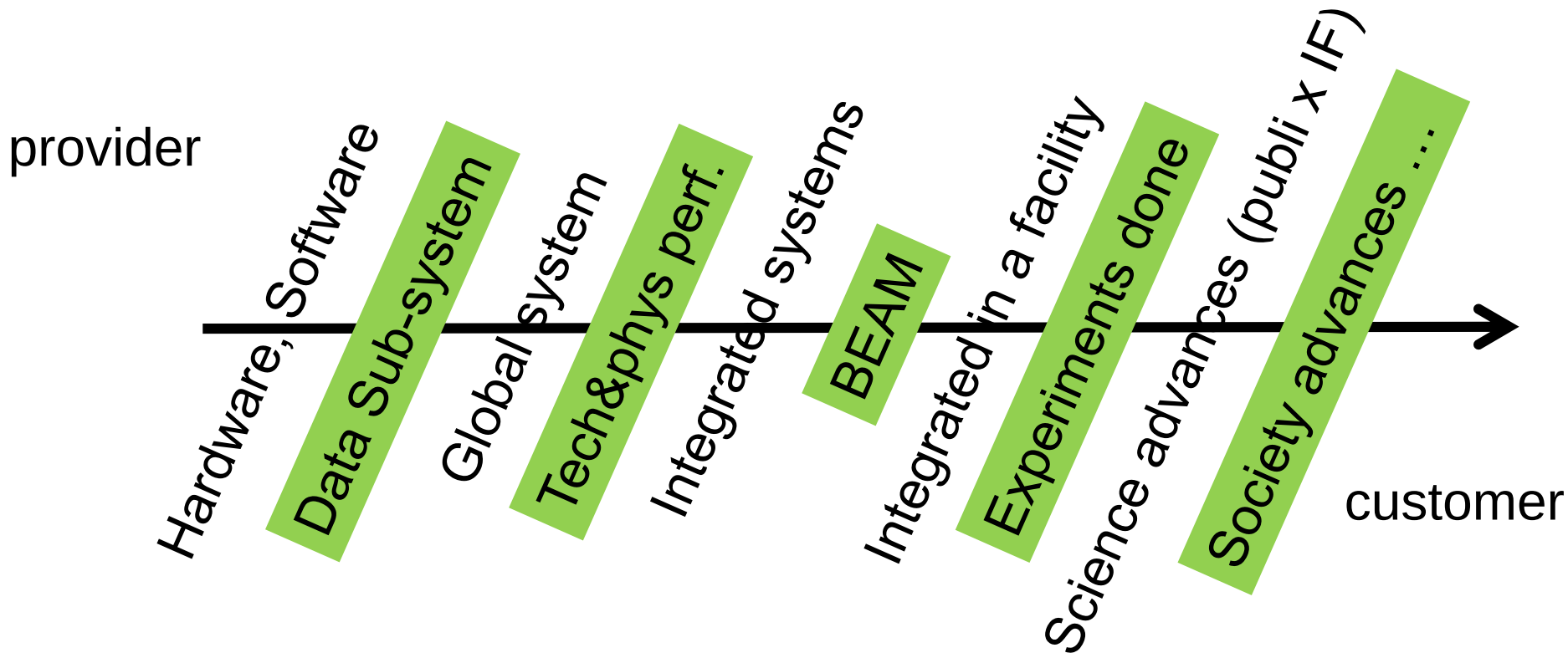
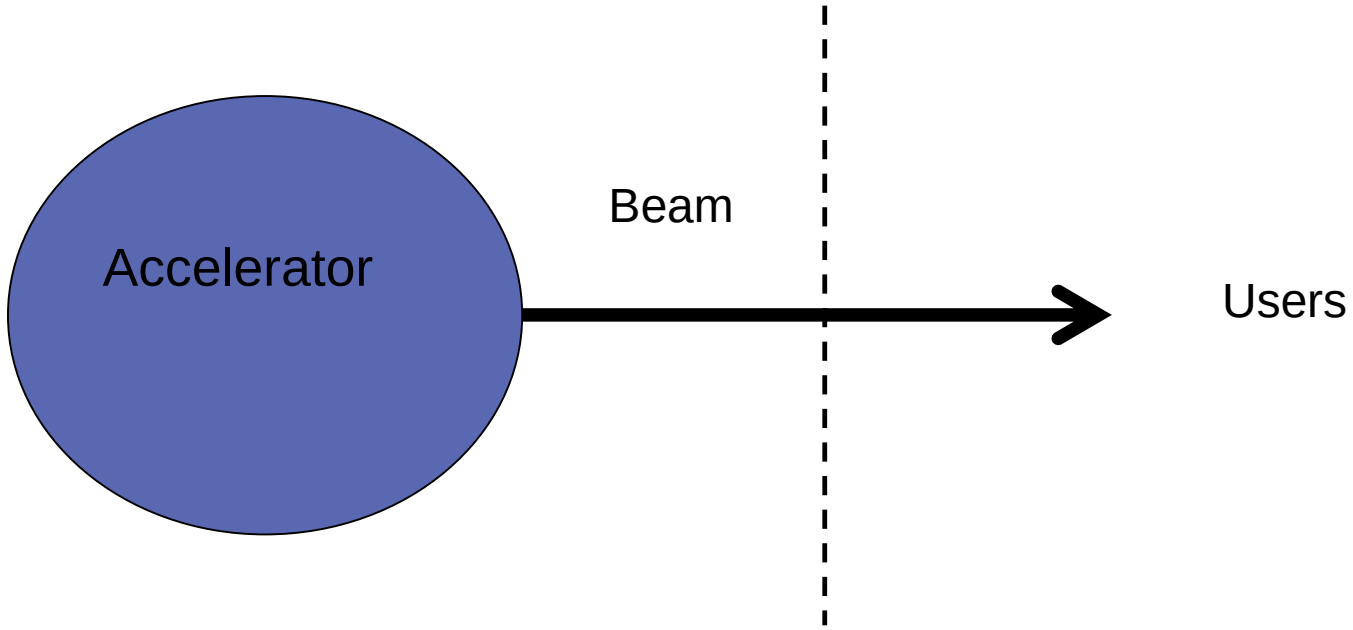

Ion source
Vacuum
RF
Beam transport
....
Techno
Techno
Techno
Techno
....
Physics
Physics
Physics
Physics
....
Transversal issues (organisation, technologies (ex: control), …)
Providers
Users (customers)

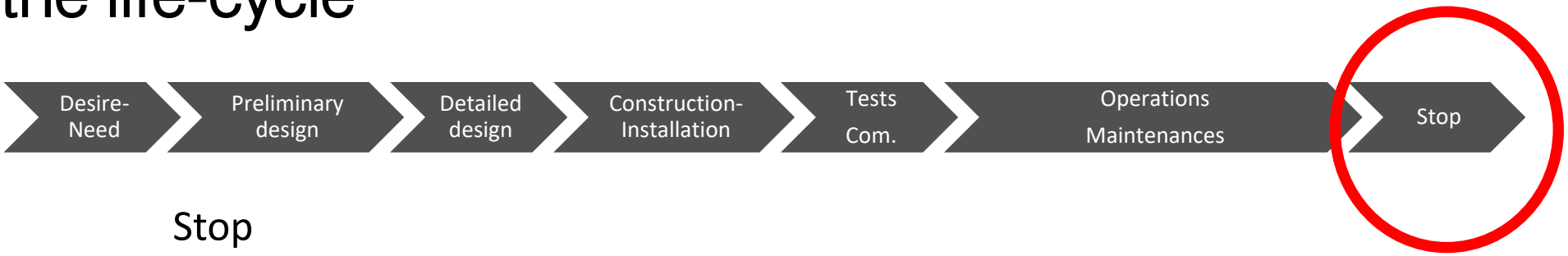

provider
Hardware, Software
Data Sub-system
Global system
Tech&phys perf.
Integrated systems
BEAM
Integrated in a facility
Experiments done
Science advances (publi x IF)
Society advances …
customer



What is the **product (service)** delivered ?

What is the expected **quality** defined ?

End of the life-cycle



Stop

Consignate

Lock-out all the networks and clearences

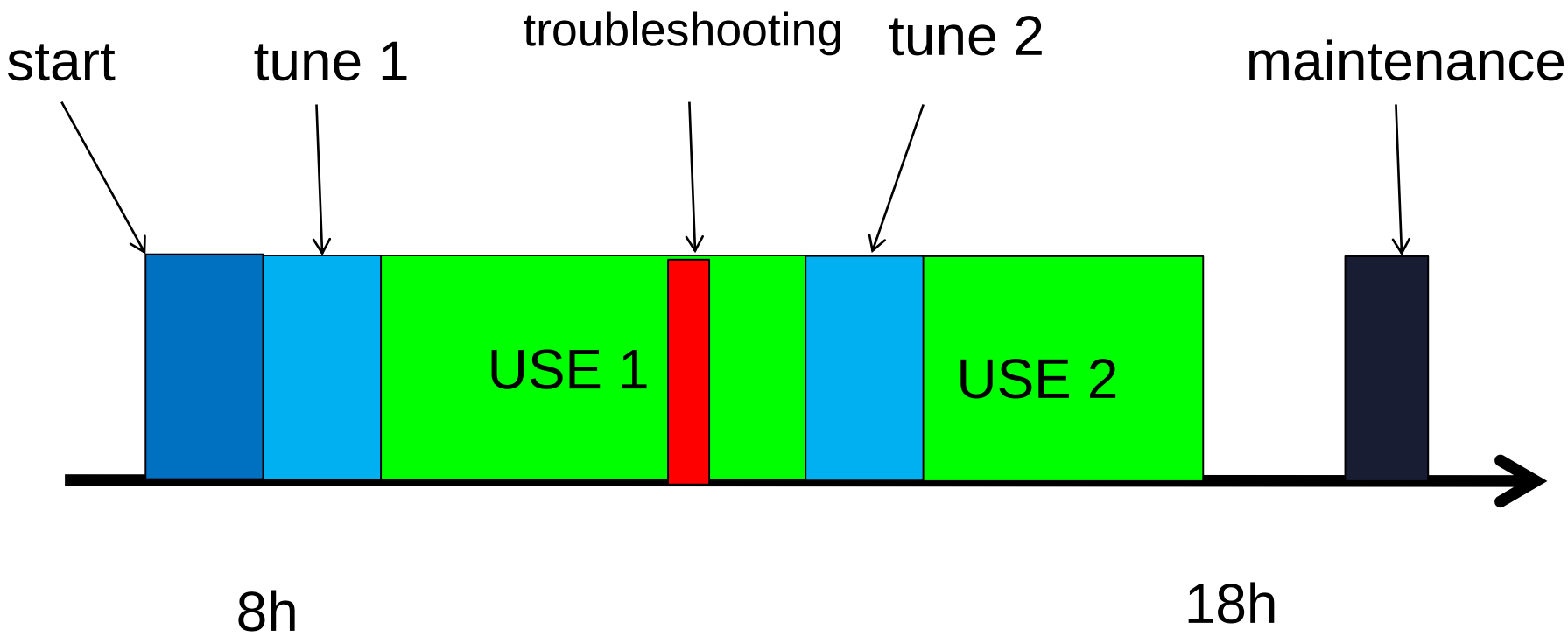
“Decommissioning” and or “Dismantling”
The process by which the facility is permanently taken out of operation at the end of the plant lifecycle with adequate regard for the health and safety of workers and the public, and protection of the environment.

Why dismantling is difficult ?

- It’s complex (technics&physics & regulations) % measurement % simulations
- It’s expensive (without benefits)
- All the knowledge of the history of the facility is required
- The target is to leave … nothing

POLL # 1

In the real world



Collective exercise (and challenge !)

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Panel organized by Benjamin TODD - CERN

1. Choose the person/facility that you find the more « interesting » (5 min. max)
   position your name on the google sheet

2. In each group you prepare a short presentation of 3 minutes max (15 min)

- About the facility and the physics done
- What are the challenges to obtain high avaibility
- What do you find interesting-relevant in the person

3. Then 3 persons from each group will present (3 minutes max/group)

And we will vote for the best presentation