Life-cycle and Reliability of accelerators

JUAS 2019

part 1: life-cycle

part 2: reliability

Samuel Meyroneinc
Centre de Protonthérapie – Orsay
Institut Curie

7th March 2019

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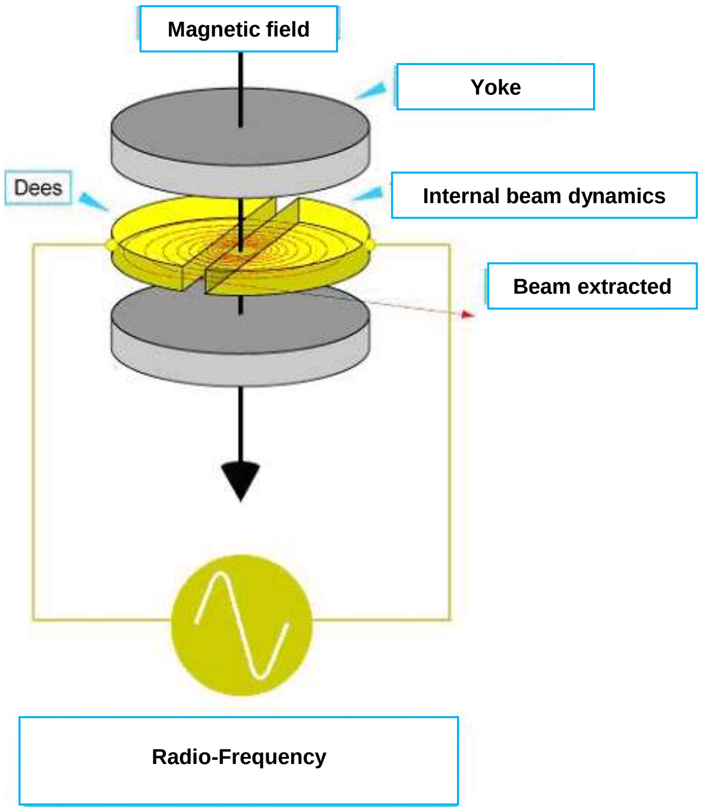
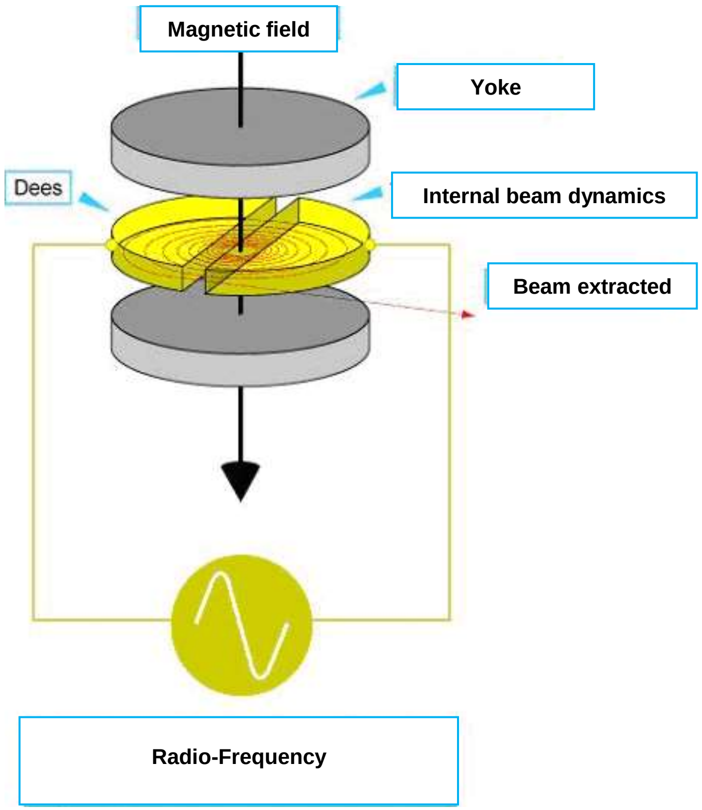
Accelerators as …

… systems



Accelerators as …

… systems



…stories

Life-cycle and reliability & of accelerators

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Summary of this morning

Introduction

Life cycle

specific exercise for Master 2 –Paris Saclay

summary

coffee break

Reliability

summary

quizz

Specific for Master 2 GI Paris-Saclay

Some parts of life-cycle already seen during our module « Organizations nad projects » (you can be neutral for some interactions)

2 particle Accelerators Hera and SSC:

Purpose of the machine (why)

Main characteristics (what)

Life cycle – steps and duration

Specificities of the life-cycle :

what was experienced and learned ?

Files available

- 2 ppt files (life-cycle and reliability) without some data

In a digital form

7 annex (specific documents)

Tomorrow on Indico
    - the full ppt files

The Institut Curie Group is a dedicated cancer center working on treatment, and basic, translational, clinical research

➢Hospital Group (2153 pers.)

▪Paris Hospital
Proton therapy center in Orsay (ICPO)
▪René-Huguenin Hospital in Saint-Cloud

➢Research Center (1077 pers.)

▪15 units in Paris and Orsay
which are associated with the CNRS,
Inserm, and universities.

▪ Translational Research Department

to the transfer of scientific innovations to the bedside to improve patient care and/or to research designed to improve understanding of cancer by performing preclinical studies,

All are in the Paris country

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About the lecturer and his institution

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Hospital + Research Center– Paris - 2000 persons

« State of art » plateau technique of radiotherapy including protontherapy

Protontherapy Centre at Orsay – 50 persons –

The lecturer: Samuel Meyroneinc

Engineer, CERN (2 years), Industry (5 years), Protontherapy (20 years)

Manager of the Engineering and Technical service:
operations, maintenances, developments, R&D
for clinics and for research

Academic groups: accelerator, particle therapy, reliability, organization

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Accelerator Reliability Worshop

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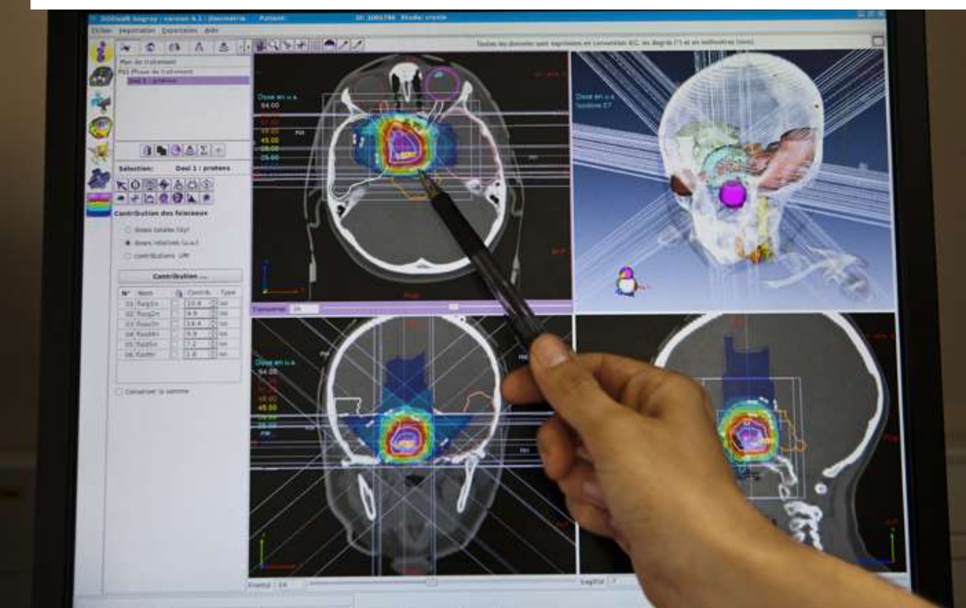
Centre de Protonthérapie d'Orsay

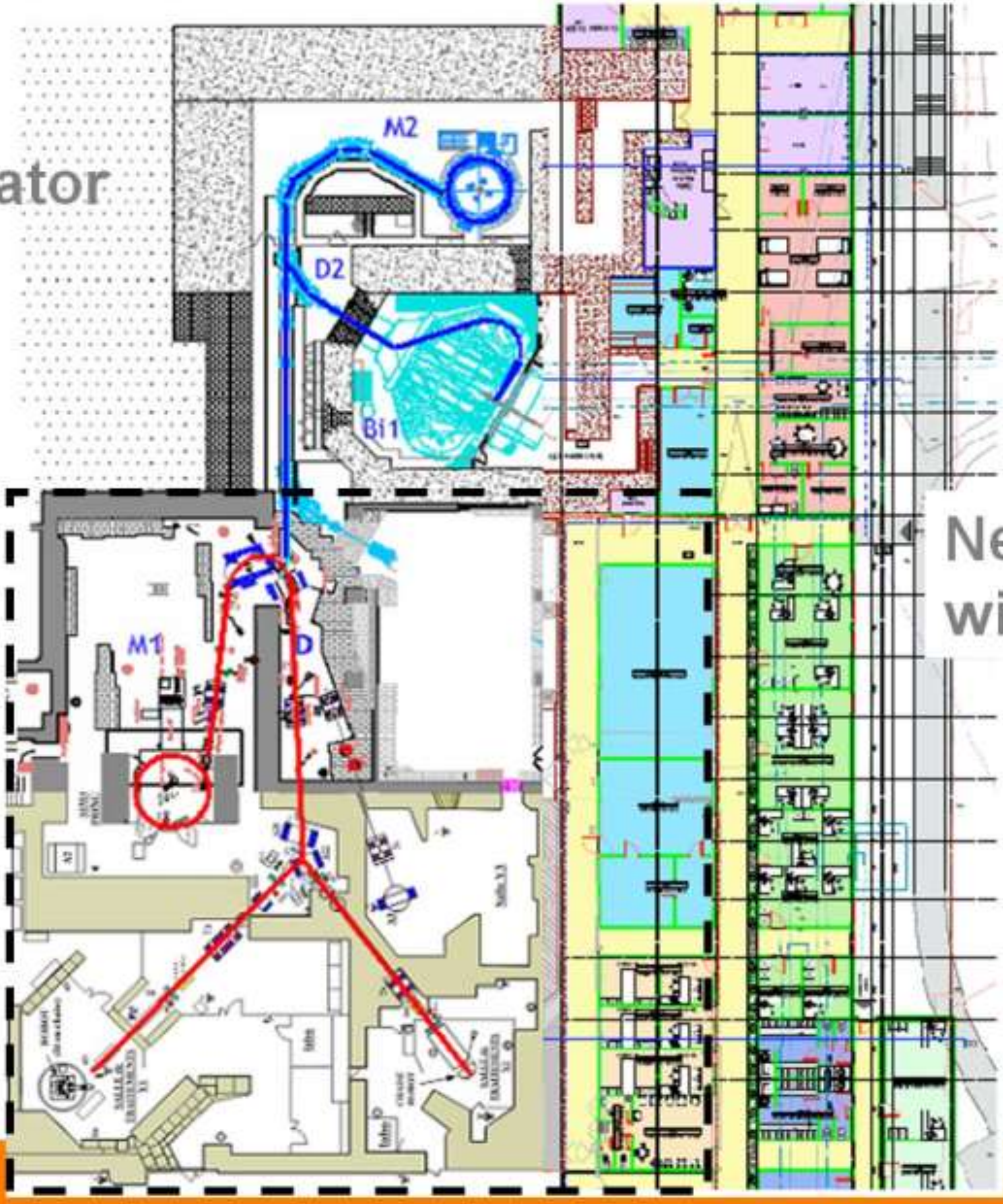
1991-2010: 5000 patient treatments
From 2010: treatments with an upgraded facility
2019: 45 patients treated per day



Gantry room

The project 2006-2010 : extension and renovation of the facility

New accelerator
+ gantry
+ beamlines



New medical wing

Existing Facility

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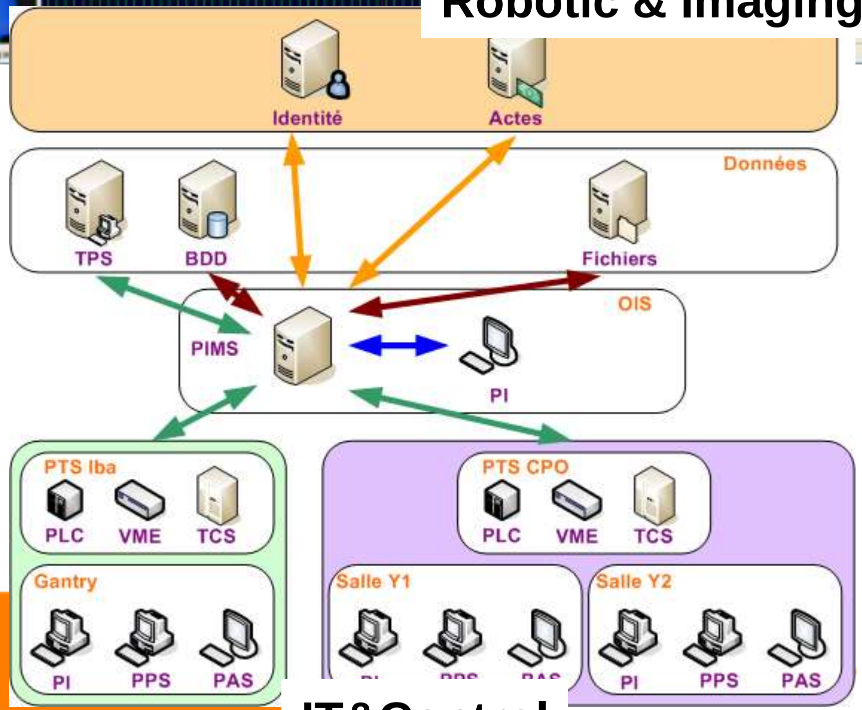
Cyclotron&Beamlines

Robotic & Imaging



R&D physics &Technology

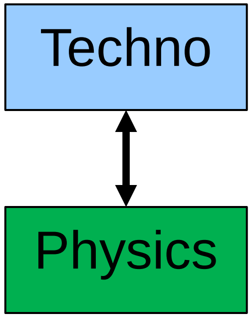
IT&Control

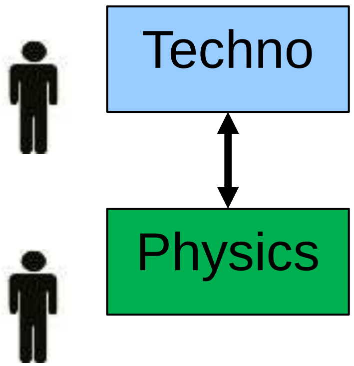
YOU ?

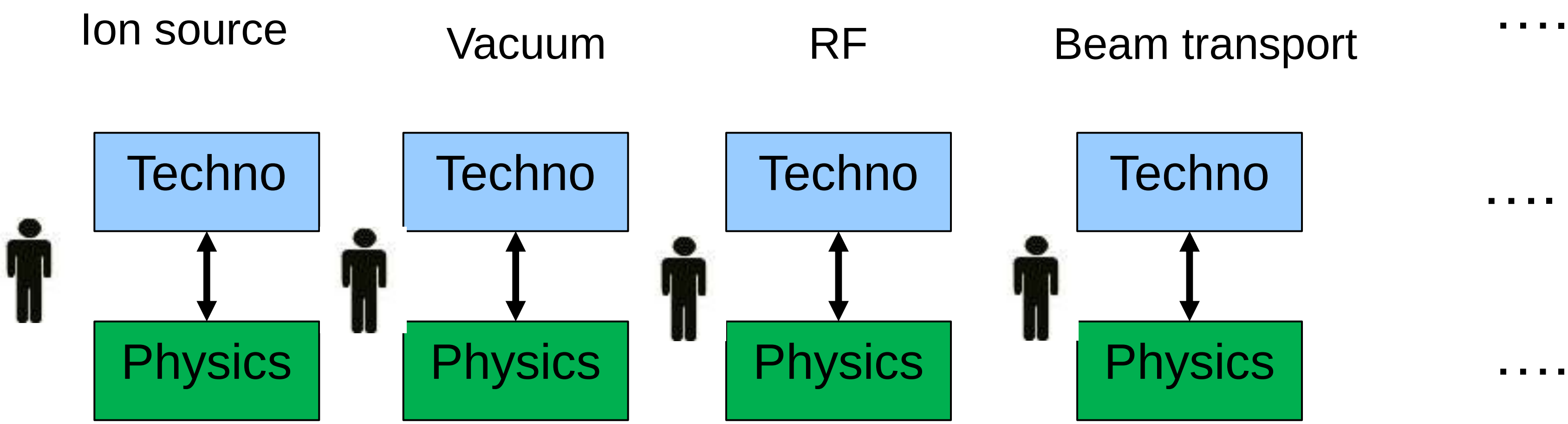
Your 2 questions

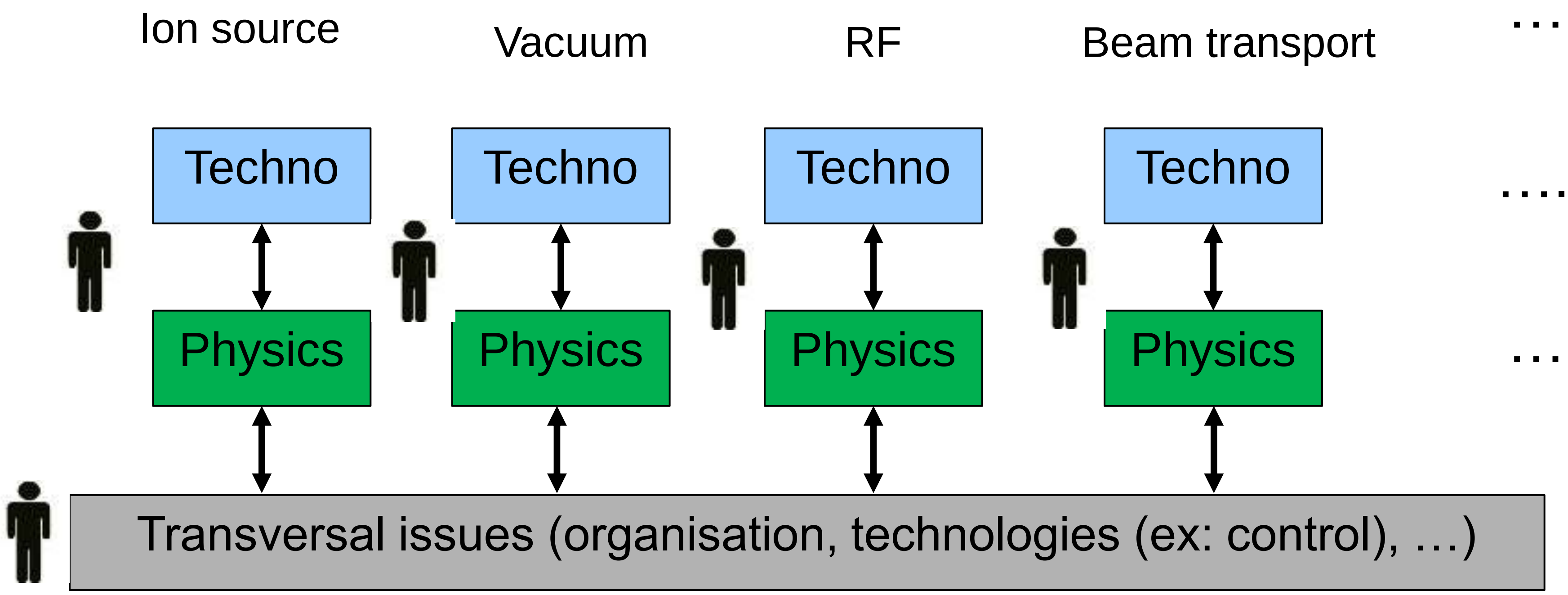
- In which accelerator project,
  I will be involved ? and interested ?

- Will I be efficient for this project ? for this job?


Techno
Physics


Techno
Physics


Ion source
Vacuum
RF
Beam transport
....
Techno
Physics
Techno
Physics
Techno
Physics
Techno
Physics
....
....


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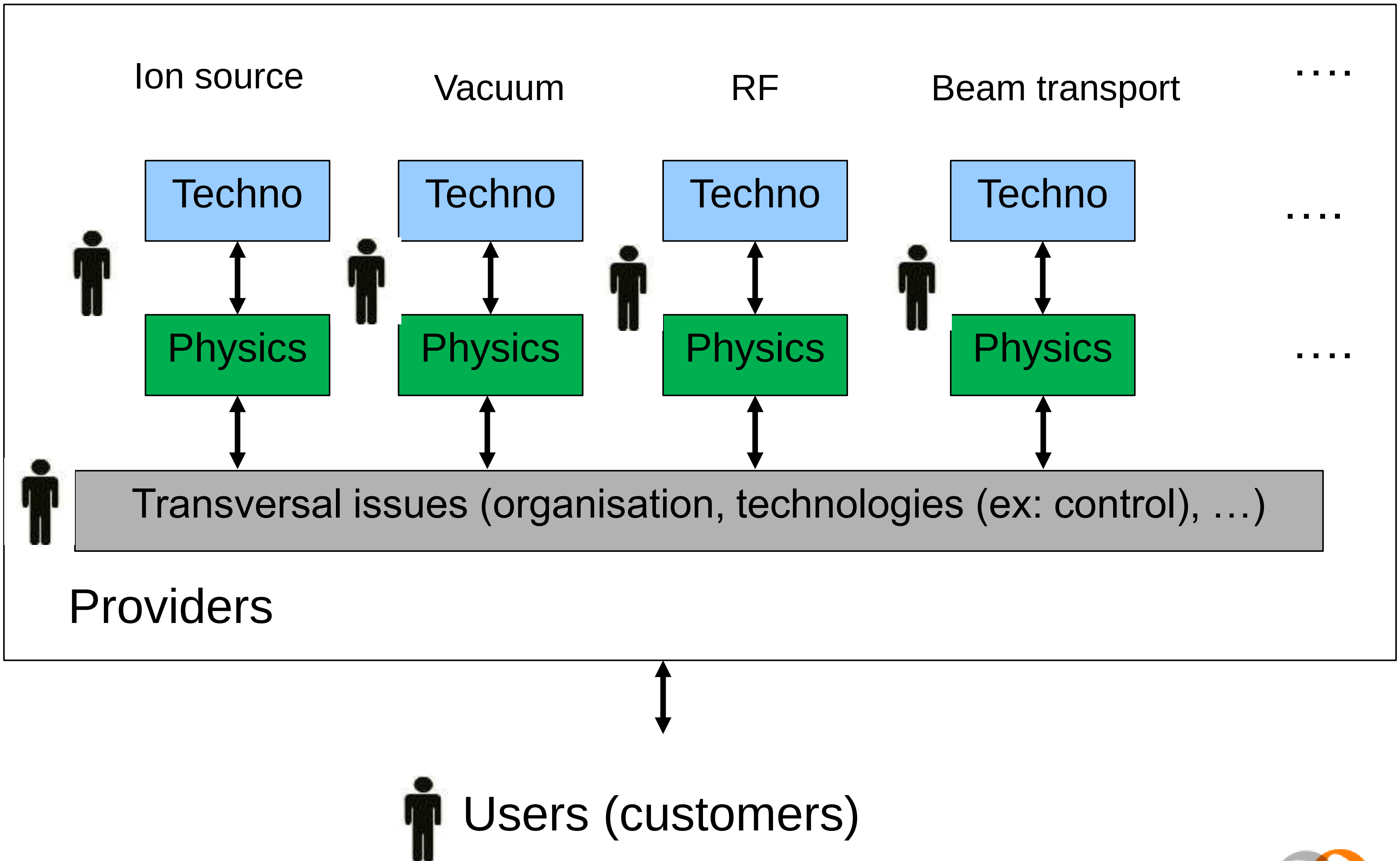
Physics
Physics
Physics
Physics
....
Transversal issues (organisation, technologies (ex: control), …)


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

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

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

Desire- Need → Preliminary design → Detailed design → Construction- Installation → Tests Com. → Operations Maintenances → Stop

The typical duration of the steps

Desire-Need	Preliminary design	Detailed design	Construction-Installation	Tests Com.	Operations Maintenance	Stop
1-10+	1-5+	1-3	1-5	1	10-40	

Desire → Make/Buy → Use

A story: the rodhotron

annex 1

read the principles
estimate dates and maturity level

About the planning

Australian Synchrotron Construction Timeline

2001

Australian Synchrotron Project funding announced by the Victorian Government

2002

Formation of scientific and machine advisory committees
Site launch and preparation

2003

Machine design announced
Building and associated facilities contract awarded
Construction started
Injection system contract awarded

2004

All particle accelerator systems contracts awarded
Beamline design process starts
Formation of industry advisory committee

2005

Building complete
Machine assembly starts

2006

Installation and commissioning of machine and beamlines begins
Selection of operator

2007

Commissioning of first beamlines complete
31 July: Australian Synchrotron formal opening

Predictives vs Retrospectives

- Retrospective (the « reality »)
  - history, knowledge, informations
  - lessons, …
- Predictive (the « planned »)
  - plan, share vision, anticipate, …
  - Adaptative …

Desire-need

Step « desire-need »

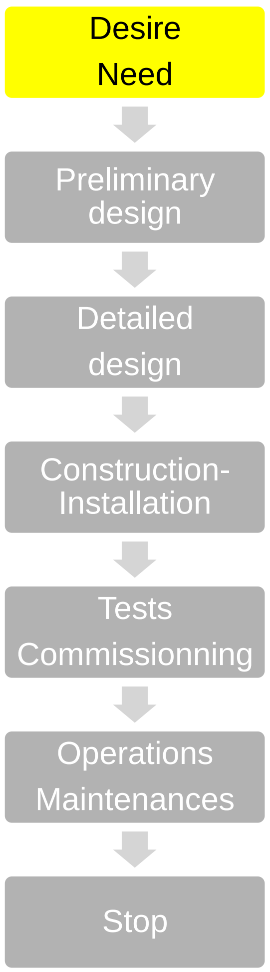
Formulate the desires

Idea-concept-feasibility-willingness

Formulate the needs

Request, requirement, specifies

Description of the need



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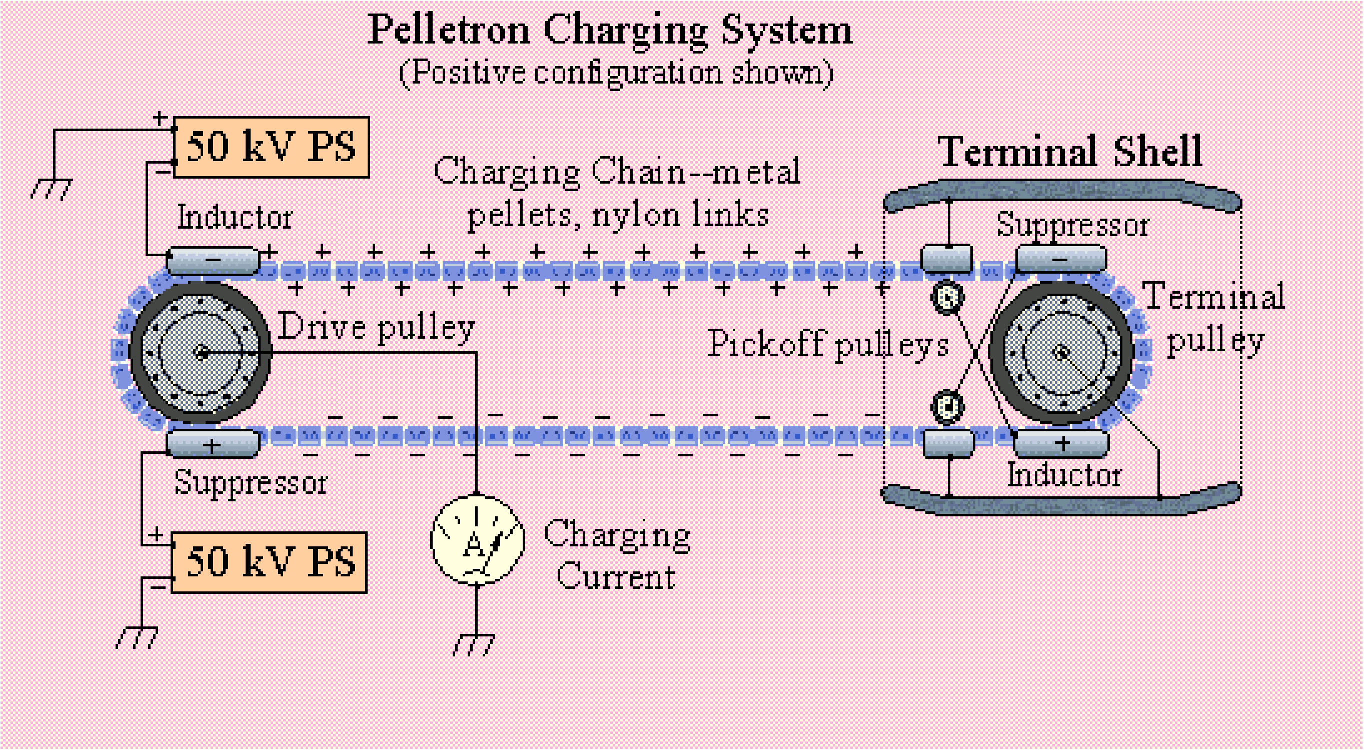
Desire-Need

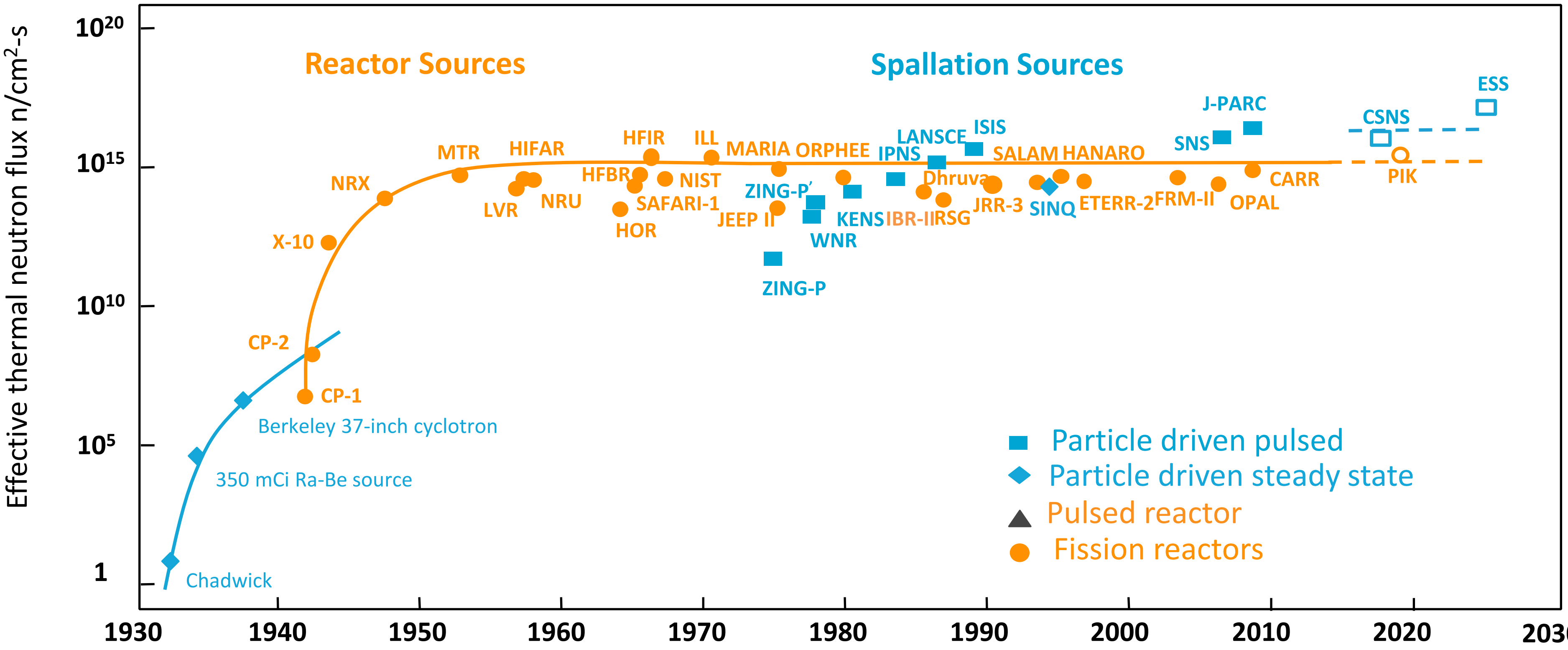
Need of an accelerator 5 MeV - 500 mA (stable +/- 2%)



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)

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Preliminary Design

Detailed Design

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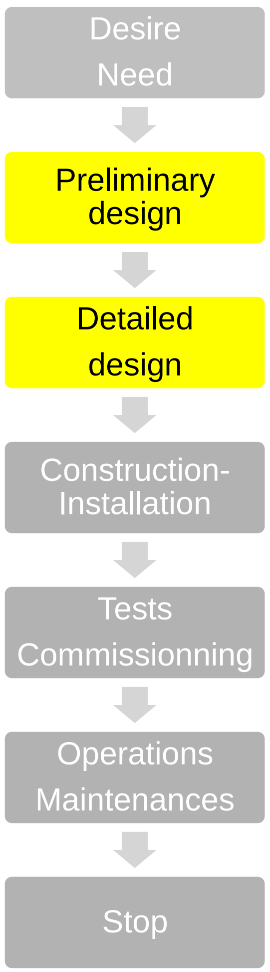
Difference between
Preliminary design/ Detailed design



Preliminary design

Obtaining the dimensioning data

Detailed design

All the data required for the construction

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Preliminary design

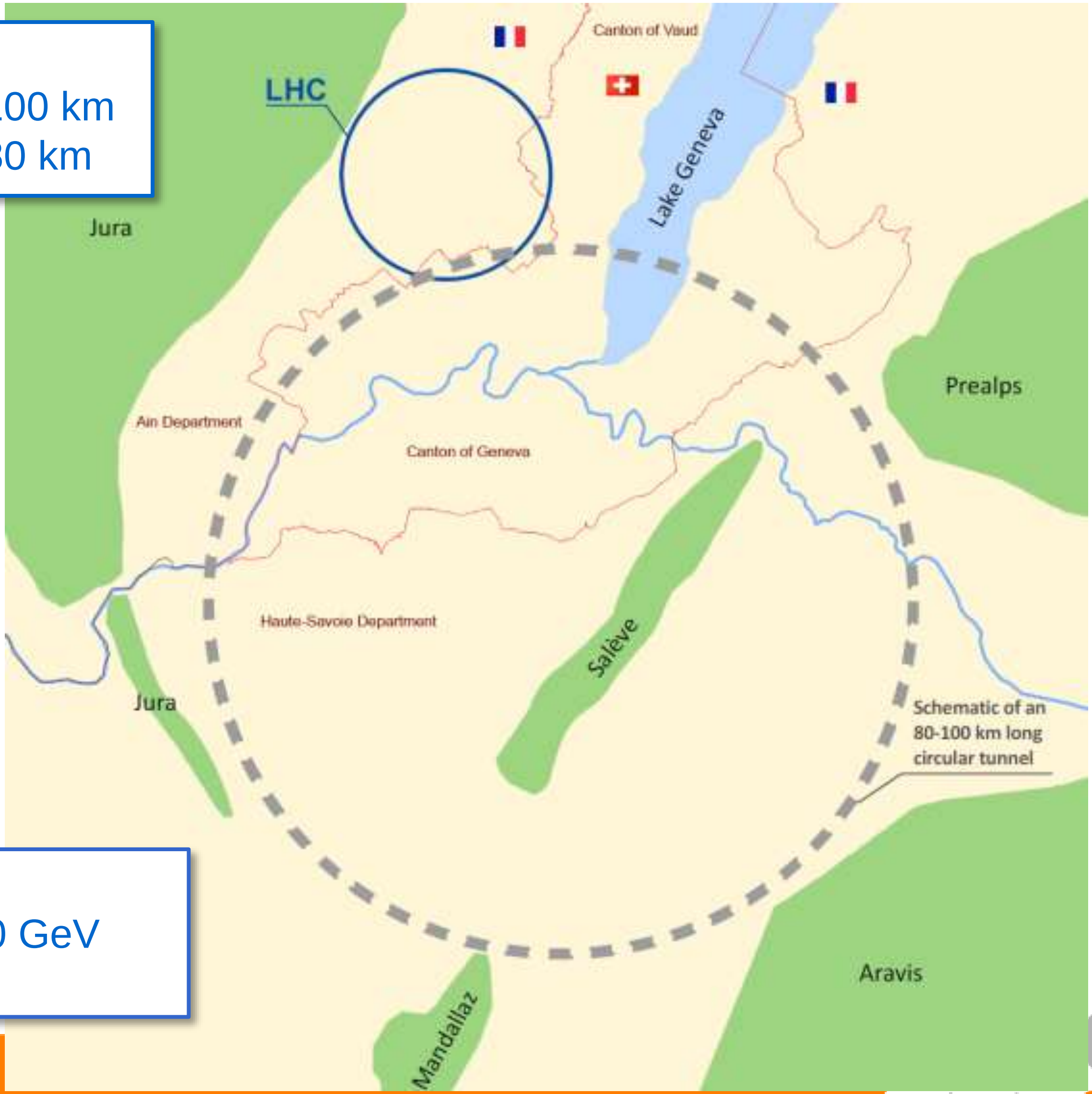
What we want

What we can

What we know

Etude FCC
Tunnel quasi-circulaire de périmètre 80 à 100 km

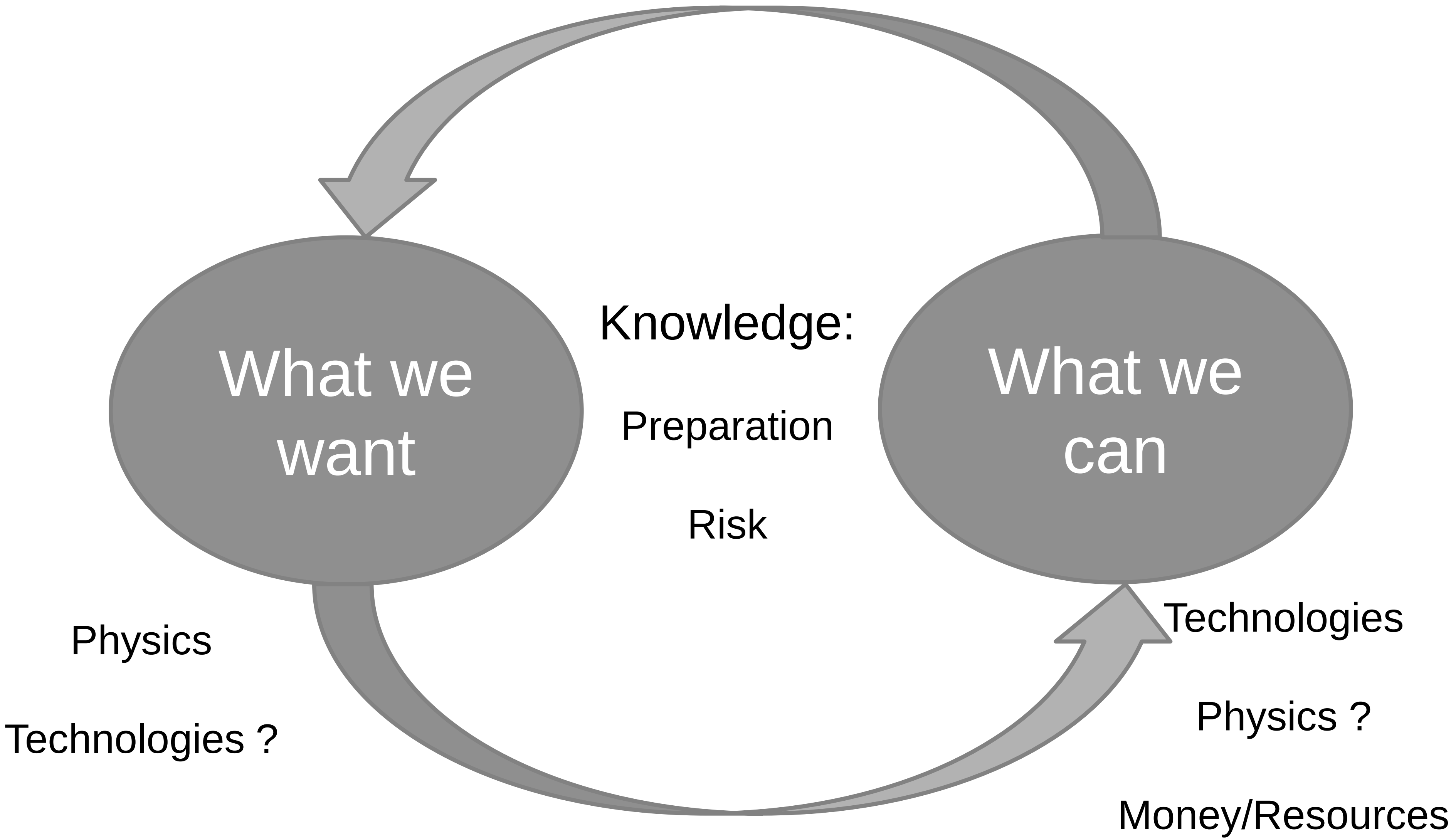
Hadrons
16 T ⇒ 100 TeV pour 100 km
20 T ⇒ 100 TeV pour 80 km



e+ e-
Energie de collision 90 à 350 GeV
Très haute luminosité

Paramètres FCC-hh comparés à LHC

parameter	LHC	HL-LHC	FCC-hh
c.m. energy [TeV]	14		100
dipole magnet field [T]	8.33		16 (20)
circumference [km]	36.7		100 (83)
luminosity [10^{34} $cm^{-2}s^{-1}$]	1	5	5 [→20?]
bunch spacing [ns]	25		25 {5}
events / bunch crossing	**27**	**135**	**170 {34}**
bunch population [10^{11}]	1.15	2.2	1 {0.2}
norm. transverse emitt. [μm]	3.75	2.5	2.2 {0.44}
IP beta-function [m]	0.55	0.15	1.1
IP beam size [μm]	16.7	7.1	6.8 {3}
synchrotron rad. [W/m/aperture]	0.17	0.33	28 (44)
critical energy [keV]	0.044		4.3 (5.5)
total syn.rad. power [MW]	**0.0072**	**0.0146**	**4.8 (5.8)**
longitudinal damping time [h]	**12.9**		**0.54 (0.32)**



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Preliminary Design
<u>Detailed Design</u>

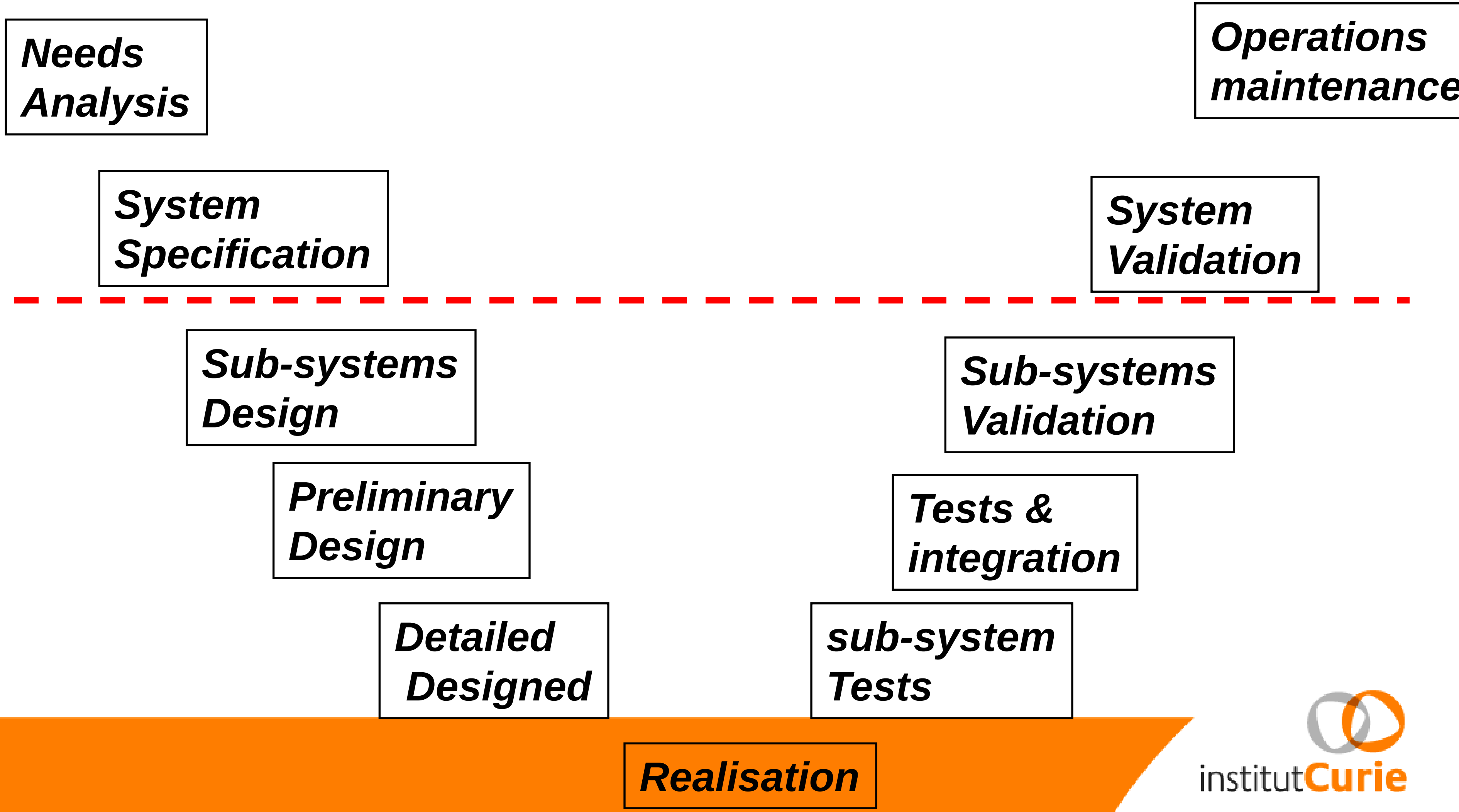
What we know-what we can (internal, external)

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

External: we can ask to do

(partnership, collaborations, sub-contract, …)

Development – the V cycle



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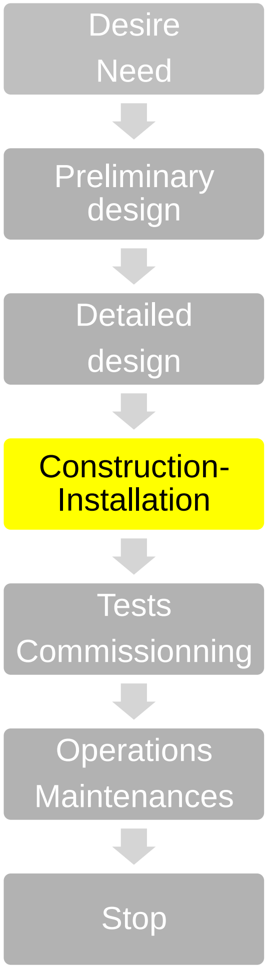
Construction-installation

Construction-Installation

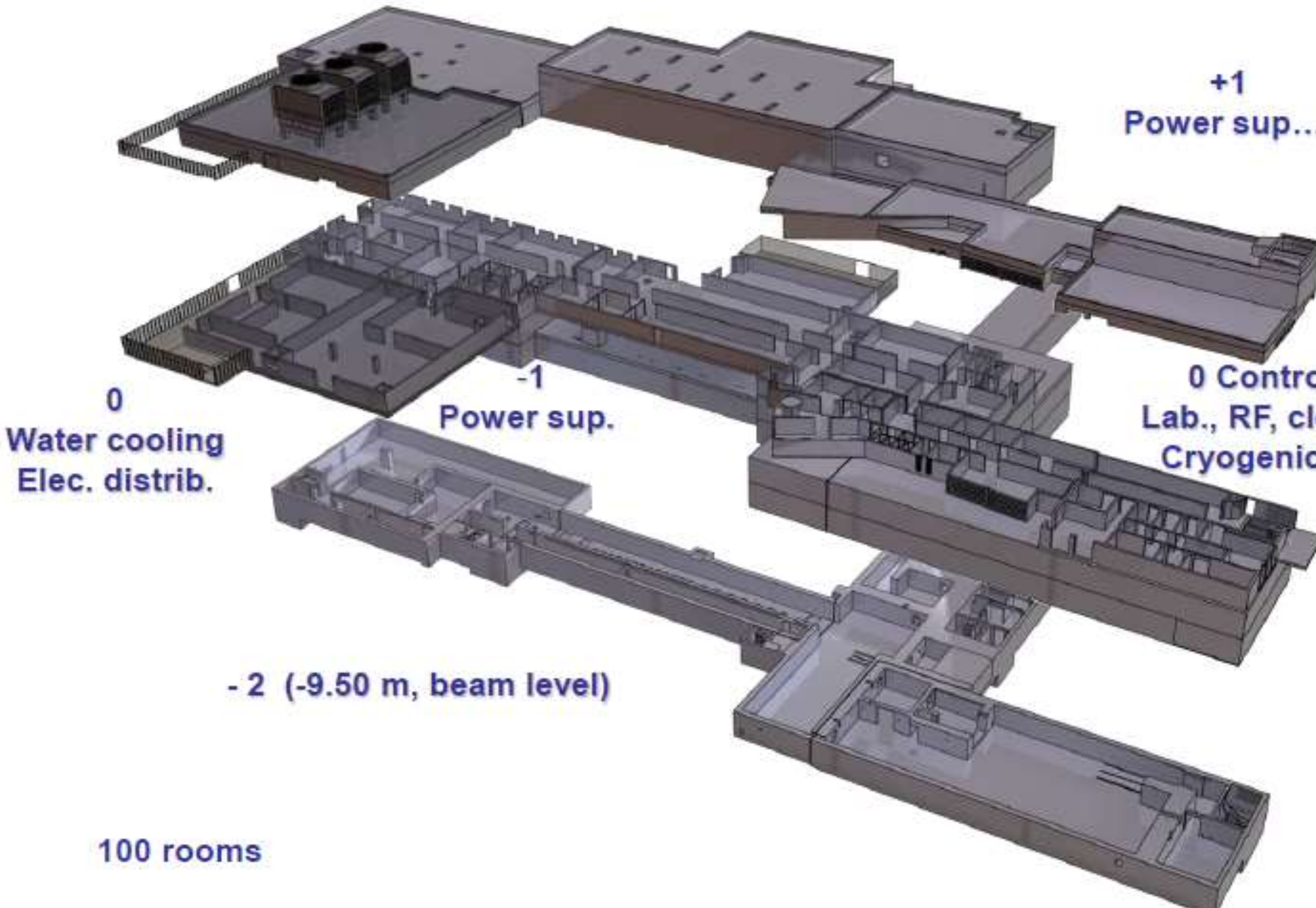


The Building

The Equipment

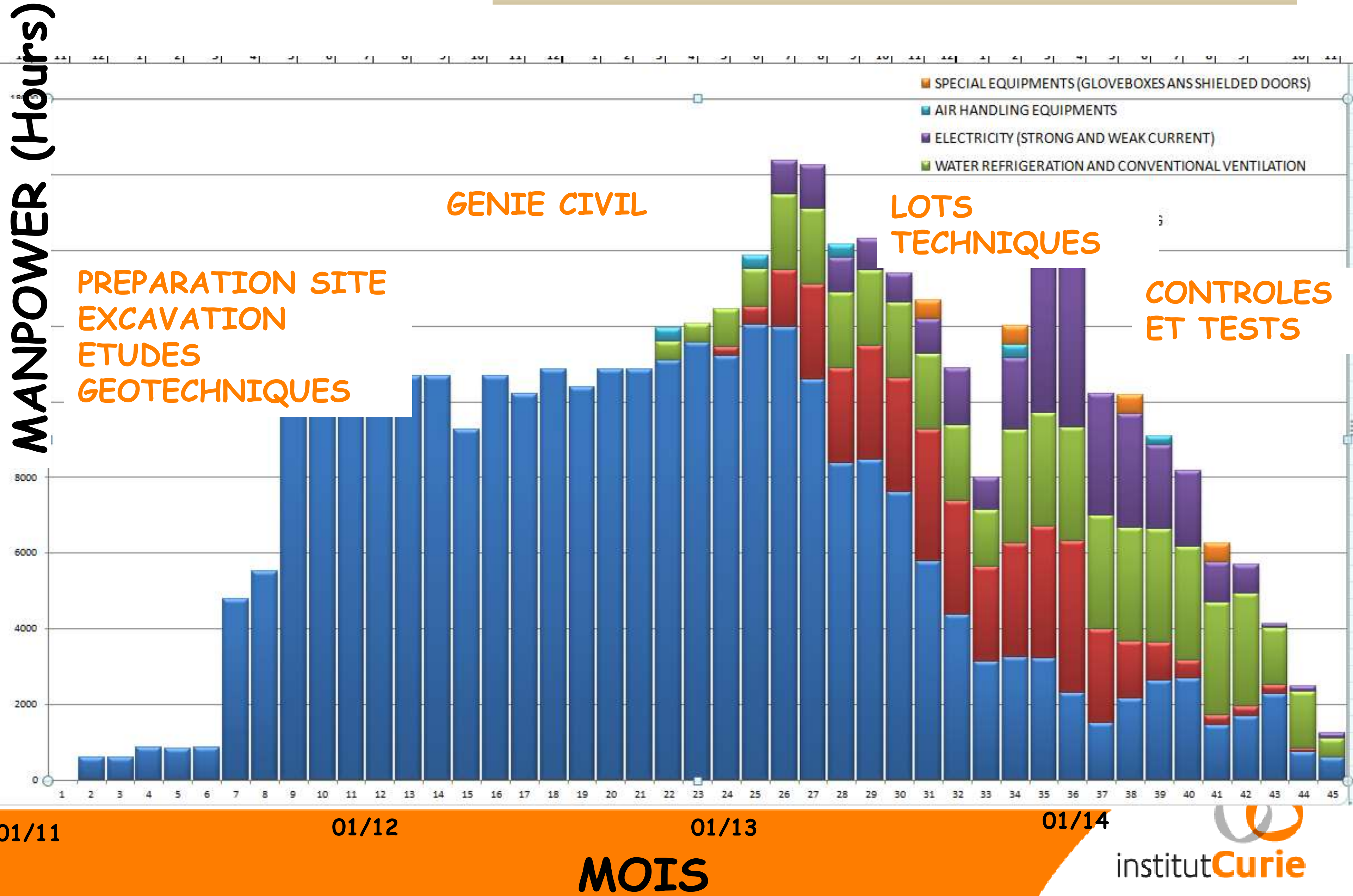
(the overall: the « facility »)

Building SPIRAL2 : 4 floors, 100 rooms !



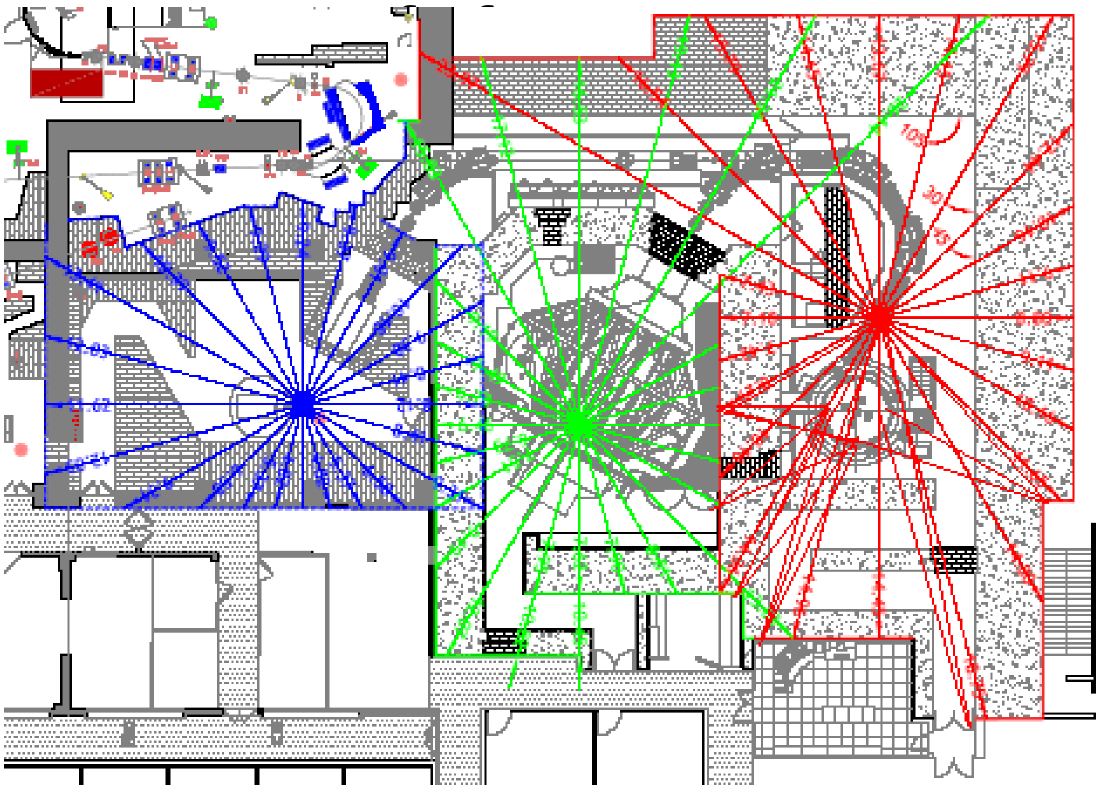
Building SPIRAL2 ...

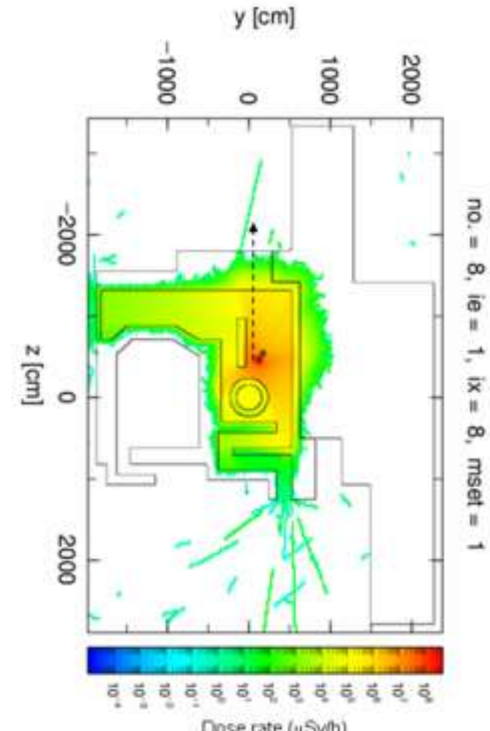
About building issues for SPIRAL2



Radiation – protection

- calculation of shieldings
- source points (to provide)





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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, …
- Cost ?
- Cost = 30%to 50% of the total cost

- 1 Good point : designers&builders often with more experience than Large Instruments stakeolders (ex: The building world as the reference for the naming of steps)
- 1 Bad point : many features are no more ajustable after first design

Construction-Installation

Desire
Need

Preliminary design

Detailed design

Construction-Installation

Operations
Maintenances

Tests
Commissionning

Stop

The Equipment

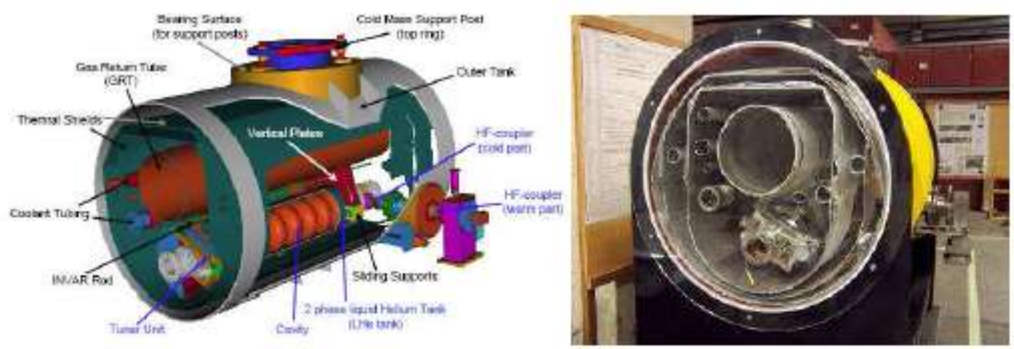


Figure 6-1: Cut-away diagram of an XFEL vacuum vessel.

Example of the cryo-modules X-Fel

irfu cea saclay — European XFEL	**Technical Specification for XFEL Cryomodule Assembly**	REFERENCE : CEA-XFEL-TS-00001-01
		Page : 100/100

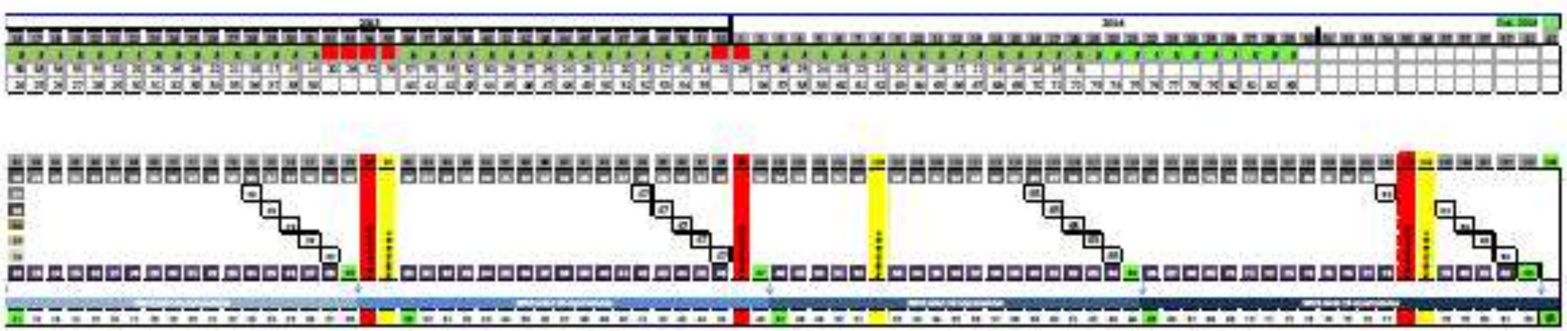
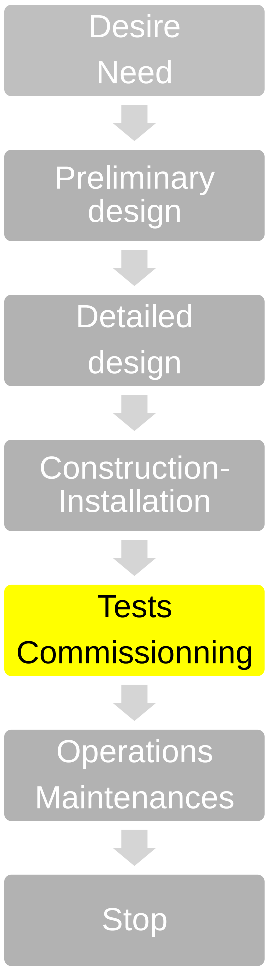


Figure 12-1 : schedule of the assembly according with the availability of cavity.

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”.



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Commissionning paper
Annex 2: titles + summary

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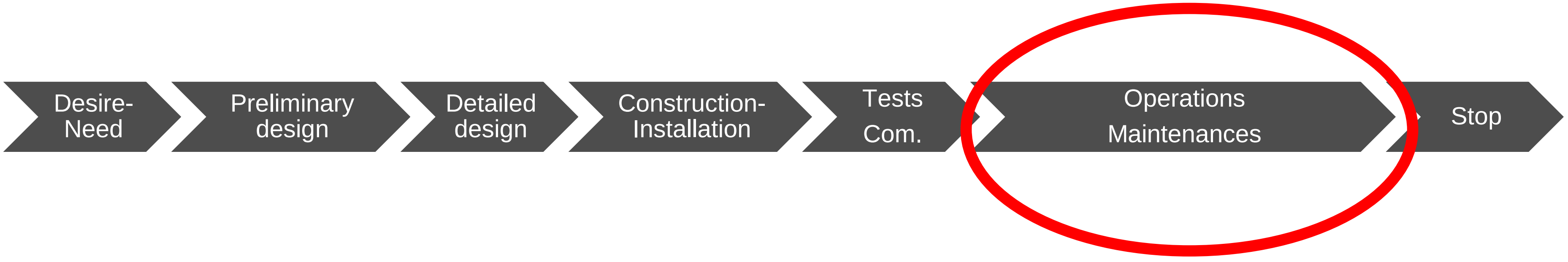
Then you are in « operations »



The 4 dimensions

MGI

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4 main dimensions during life-cyle

- Politics
- Money-Fundings
- Customers/Providers
- Regulatories

Dimension 1: politics

Politics (and associated communication)

Politics and Science

When

- early stages of a project
- inaugurations
- significant steps
- governance

Why ?

- driving the policy of science
-Image and communication
- **funding** or not

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Dimension 2: fundings-money

European Spallation Source

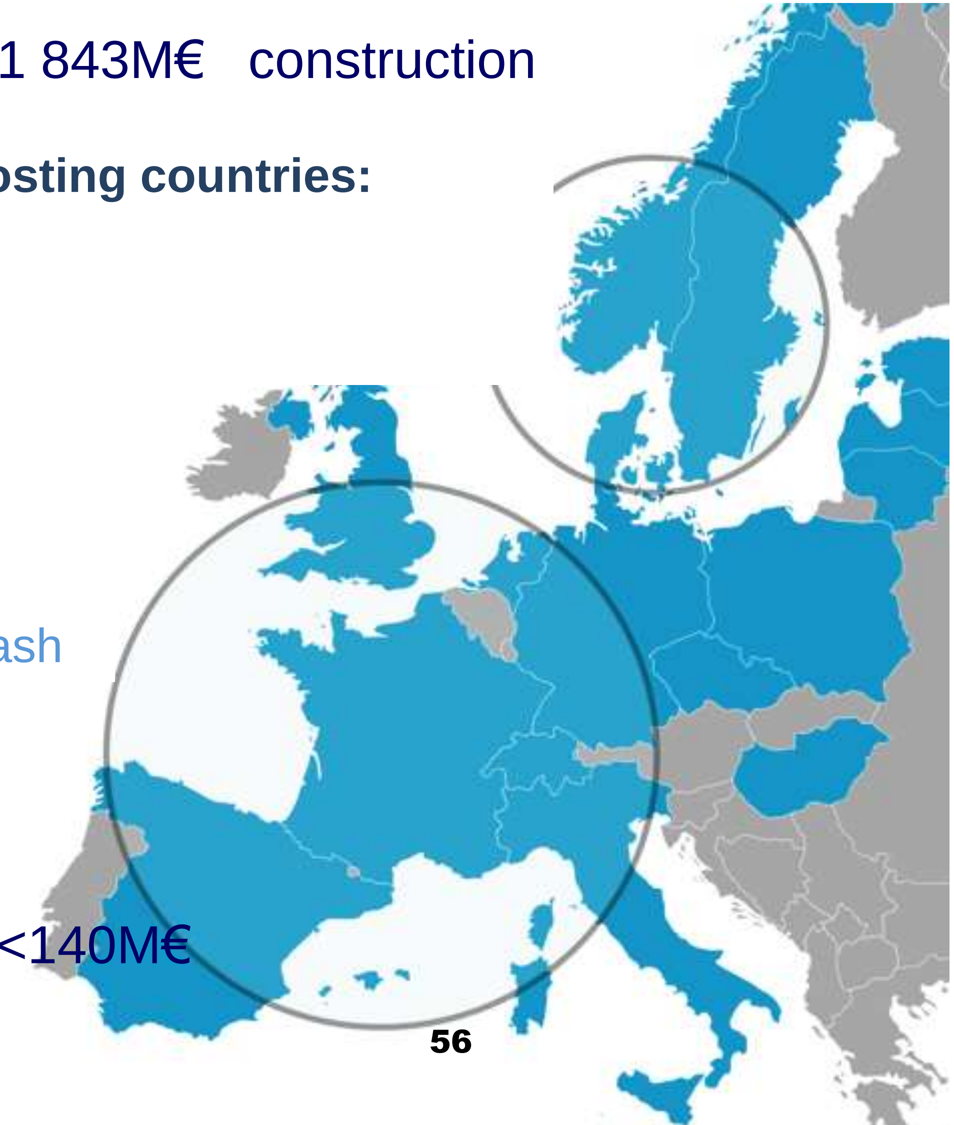
International collaborations 1 843M€   construction

Suède et Danemark – hosting countries:

47.5%   Construction
15%   Operations
100%   Cash

Partners countries:

52.5%   Construction
85%   Operations
70%/30%   in kind / in cash



Estimated running budget <140M€
Life-time ~40 years

H2020 Structure

Of interest for accelerators

Fundings and budgets

1. For studies
2. for construction (investment, F.T.E.)
3. for operations
   - salaries
   - fees (consumables, running costs…)
   - upgrades

1. in cash
2. in kind (contribution)

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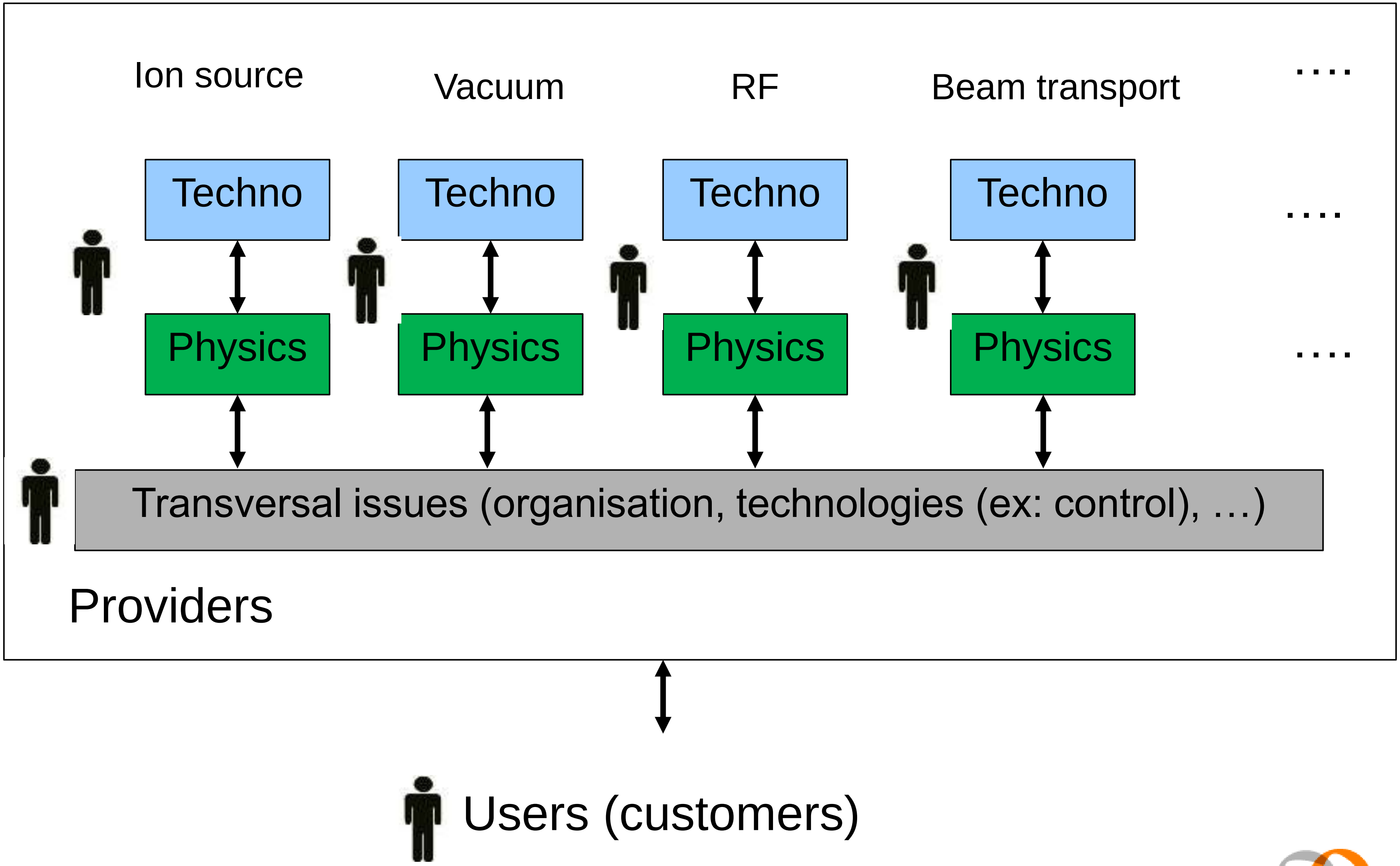
Dimension 3: customer/provider

Who is the customer of an accelerator ?


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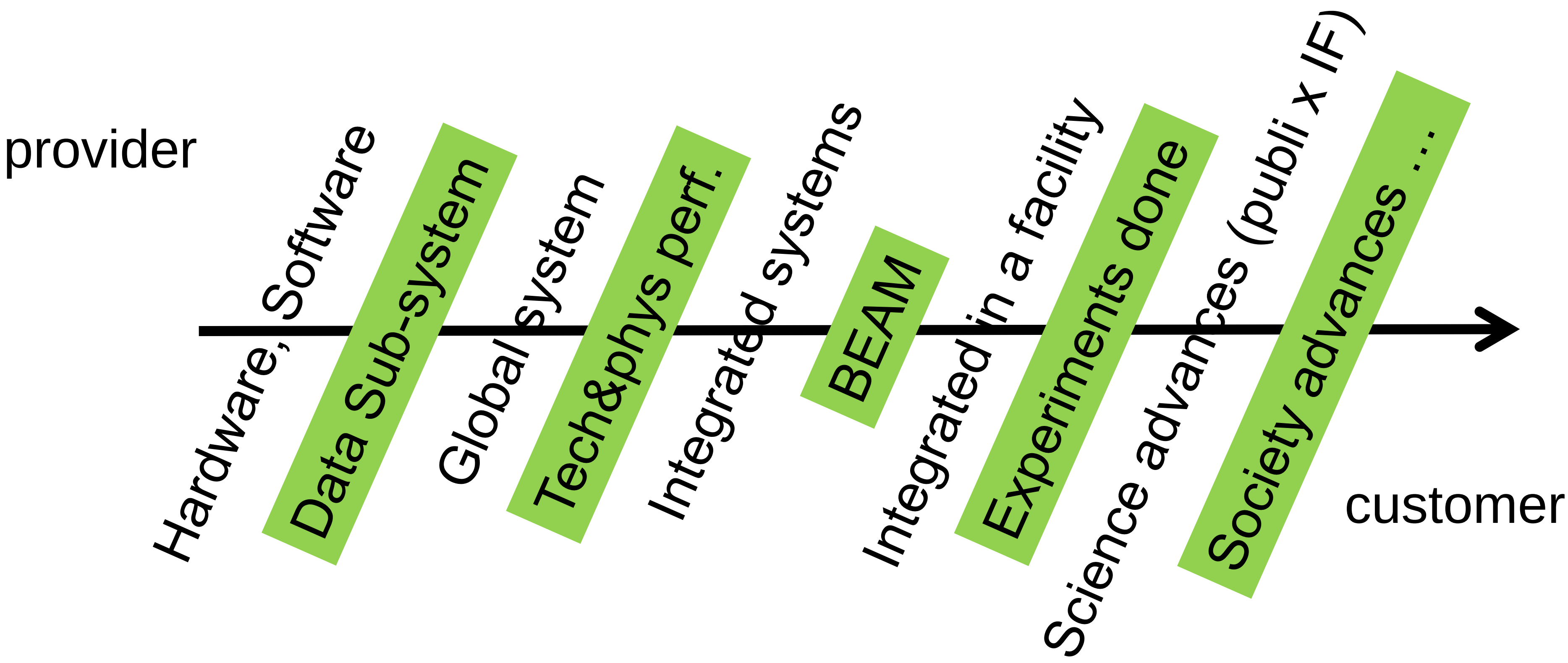
Physics
Physics
Physics
Physics
....
Transversal issues (organisation, technologies (ex: control), ...)
Providers
Users (customers)


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

Level of delivery	The supplier is delivering	The customer is expecting (so testing, accepting)	Example in particle accelerator
Parts	Part of hardware, part of software	technological data	Power supply
System	A global system	Individual technological &physics performances	RF Cavity
Systems Integrated	Many systems integrated	Global performances	BEAM
Facility	Conditions to perform the whole « job »	Resultst: experiments or production achieved	Users of Synchrotron
Societal	Service or science advances	New society	Higgs boson completing the standard model

Dimension 4: regulatories

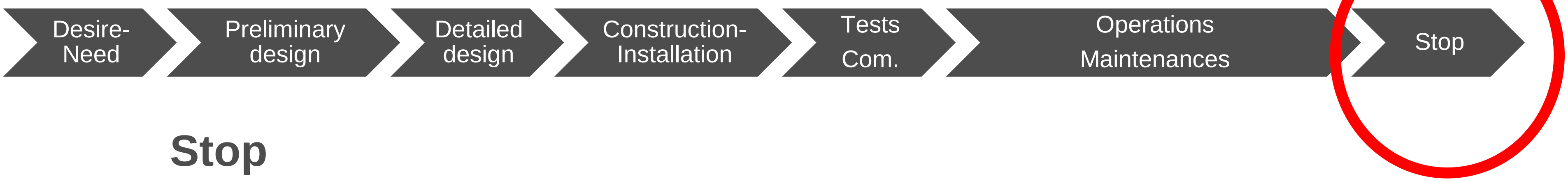
Regulatories (why ?)

Why
- Risks on personal (workers)
  - radiation protection, fire, mechanical …
- Risks on environment

2 kinds of approach:
- Authorization
- Control

Internal/ external
- internal: safety officer, radiation officer , procedures, rules
- external: national authorities, control office, norms

End of the life-cycle



Stop

Consignate

Lock-out all the networks and clearences

Dismantle

“Decommissioning”
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.

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A little history on management of facilities

years	Facilities considered	Classical management of the end of the facility
Before the 19th century	buildings, « classical » factories, etc …	abandon, reconversion, demolition.The garbage are put in … the trash
from 1970	Begining of the complex factories, including nuclear facilities	Dismantlement considered at the end of the use. The garbage are stocked.
1970-2000	Begining of the end of some nuclear facilities	Authorities introduce the question of the dismantlement at the begining of the facility
From 2000	all	Sustainable approach

Why dismantling is difficult ?

It’s complex (technics&physics & regulations)

It’s expensive (without benefits)

The target is to leave … nothing

Life-cycle

- generalities
- specificities of accelerators

Life cycle

Desire-Need → Preliminary design → Detailed design → Construction-Installation → Tests Com. → Operations Maintenances → Stop

Life-cycle

- Incompressible data : the time
- Glossary of steps, different naming, meaning, and approaches
- Which model, who decides, indicators, … (scalable, achievable, understable)

some of the definitions

Main term	Other terms and notions	goal
Desire-need	Feasibility -exploration	Express of interest
Preliminary design		Data to dimension
Detailed Design		All the data ready to build
Construction/ installation	Realisation-Production Building /Equipement Academic/Industrial	From design to real
Test/ commissionning	Acceptance/Qualification	Before starting the operations
Operations	Maintenance/upgrade	Use
Stop	Decommissionning Dismantle	Clean & clear (re-use)

Desire-Need → Preliminary design → Detailed design → Construction-Installation → Tests Com. → Operations Maintenances → Stop

Politics

Money-Fundings

Customers/Providers

Regulatories

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Specificities of accelerators

Many parameters linked to the **beam** (IS, magnetic field,vaccuum, RF, …)

Large: money (threshold), politics, time, building…

Long Duration (knowledge management, quality , obsolescence, …)

Science: uncertainties-risk, complexity,…

International (language, culture, politics, interface, regulatories, …)

Radiation: risk, safety, long-term, regulatories, …

Dimensions of analysis :

Technologies/Physics

Academics / industrials

Projects/Operations

Specific for Master 2 GI Paris-Saclay

Some parts already seen during our module « Organizations nad projects » (you can be neutral for some interactions)

2 particle Accelerators Hera and SSC:

- Purpose of the machine (why)
- Main characteristics (what)
- Life cycle – steps and duration
- Specificities of the life-cycle :
  - what was experienced and learned ?

The end (of part 1)