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CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE

Overview of the MYRRHA Project

Multipurpose hYbrid Research Reactor for High-tech Applications

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DITANET Meeting

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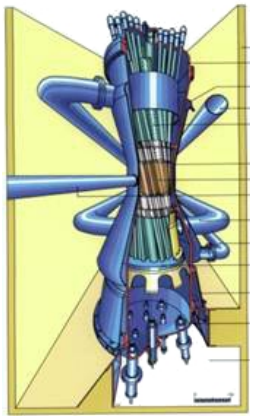
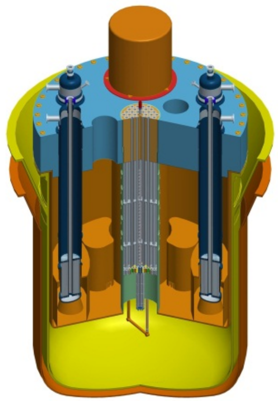
What is MYRRHA ?



1962

BR2

- Material Testing Reactor (fission)
- Fuel testing for LWR & GEN II/GEN III
- Irradiation Services:
  - Medical RI
  - Silicium Doping
  - Others



2023

MYRRHA

- Fast Neutron Material Testing Reactor (fission + fusion)
- ADS-Demo + P&T Testing (Partitioning & Transmutation)
- Irradiation Services:
  - Medical RI
  - Silicium Doping
  - Others
- Fuel testing for LFR GEN IV
- LFR European Technology Pilot Plant (ETPP)

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Why fast? Why ADS?

- fission only has a future if solution for:
  1. sustainability → optimal use of fuel's energy content
  2. waste → transmutation
- both need fast neutrons
- critical fast reactors are optimal for energy generation (GenIV)
- ADS is optimal for transmutation

MYRRHA part of ESNII
(European Sustainable Nuclear Industry Initiative)

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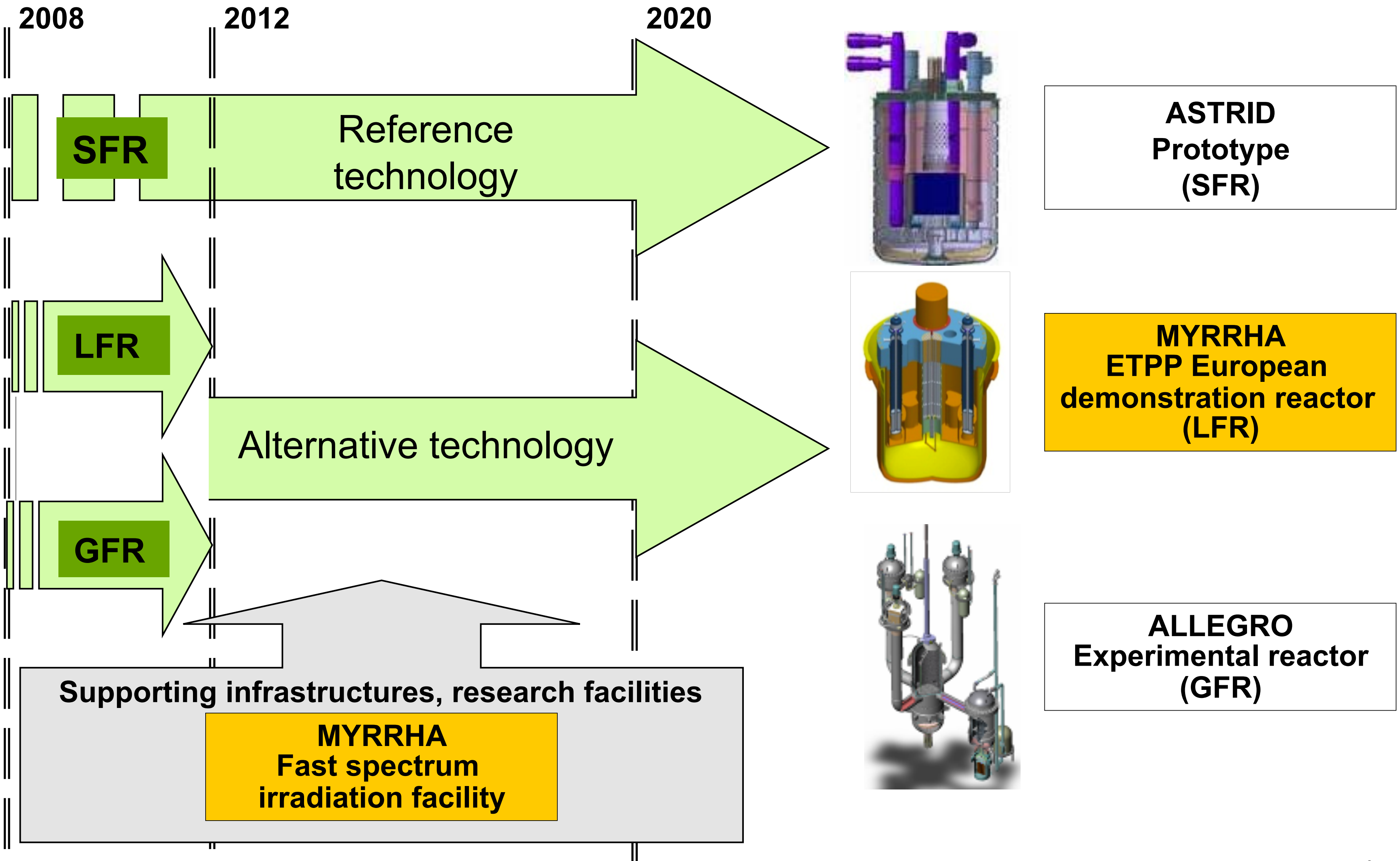

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MYRRHA in keywords

- fast neutron spectrum
- Pb-Bi cooled
- core: critical + subcritical, ~ 70 MW_{th}
- ADS demo, Pb-Bi as spallation target
- multipurpose research and irradiation facility
- European Strategy Forum on Research Infrastructures (ESFRI)

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MYRRHA is not …

- a GenIV reactor
- a transmuter

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MYRRHA ADS beam requirements

fundamental parameters	
particle	p
beam energy	600 MeV
beam current	4 mA
mode	CW
delivery	vertically from above, through a window

operational parameters	
period length	3 months
beam trip spectrum	< 3 s : unlimited > 3 s : limited to 10 per operational period

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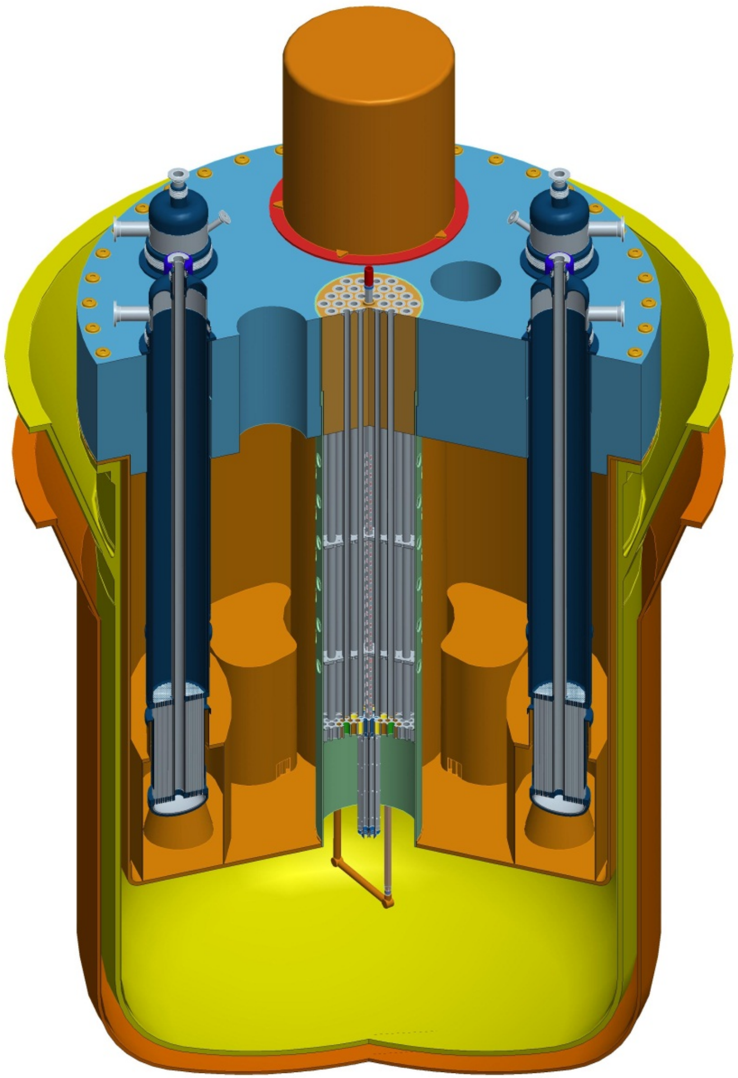
The MYRRHA reactor

research reactor → **flexibility**

- requirements
  - Fast neutron flux (E > 0.75 MeV) 10^{15} n/cm^2.s
  - available irradiation volumes: dl rather than cl
  - BR2 equivalent performances for Si and radioisotopes

- specificities : Pb-Bi
  - almost anything will float (fuel rods!)
  - very difficult visualisation
  - inert atmosphere → remote handling

Reactor layout



Inner vessel

Cover

Core barrel

Core support plate

Core plug

Above core structure

Heat exchangers

Pumps

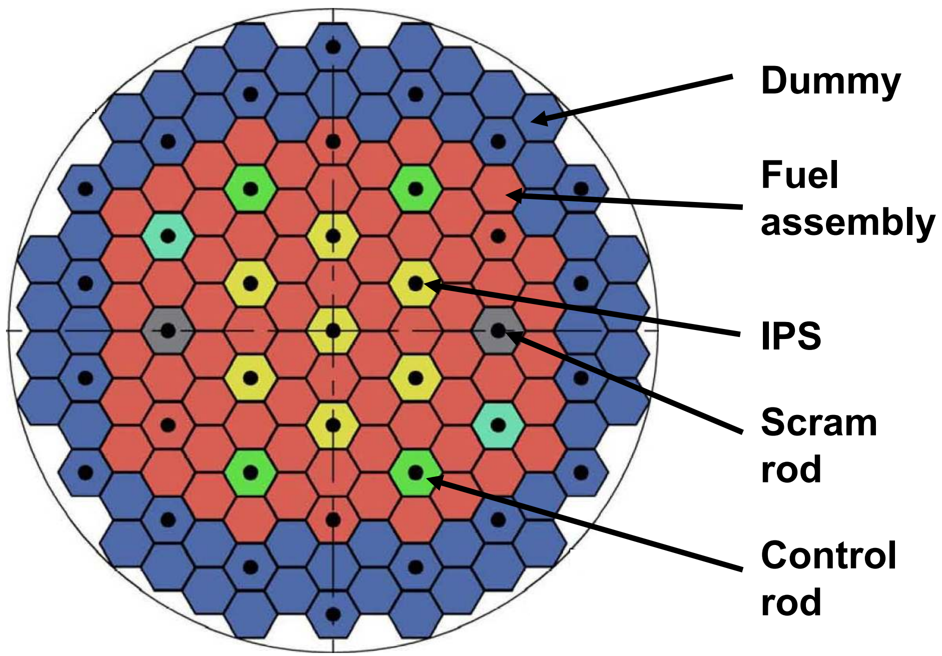
Diaphragm

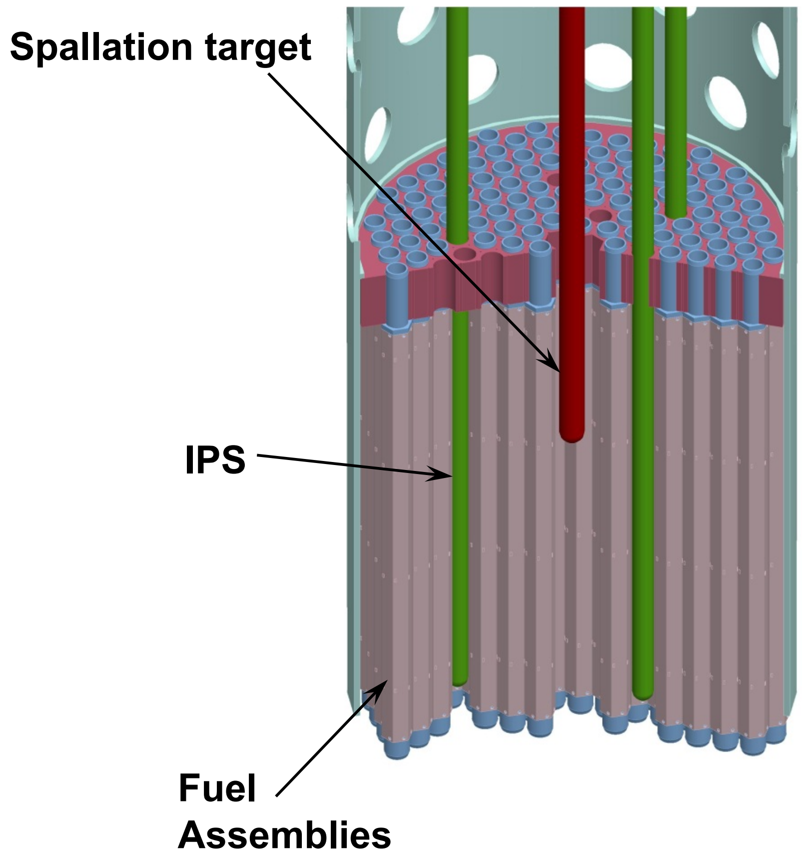
Fuel manipulators

Guard vessel

Core layout

- 151 positions
- MOX fuel typical for fast reactors
- 37 multifunctional plugs
  (IPS: In-Pile test Section)





The accelerator (MLA)

fundamental parameters (ADS)	
particle	p
beam energy	600 MeV
beam current	4 mA
mode	CW
beam MTBF	> 250 h

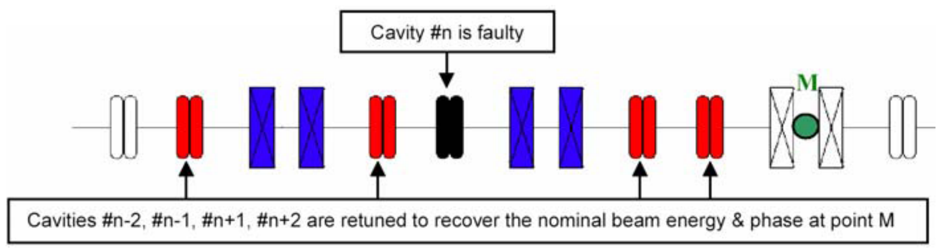
failure = beam trip > 3 s

implementation : "conventional"	
superconducting linac	
frequency	176 / 352 / 704 MHz
moderate performances, margins	

Beam availability

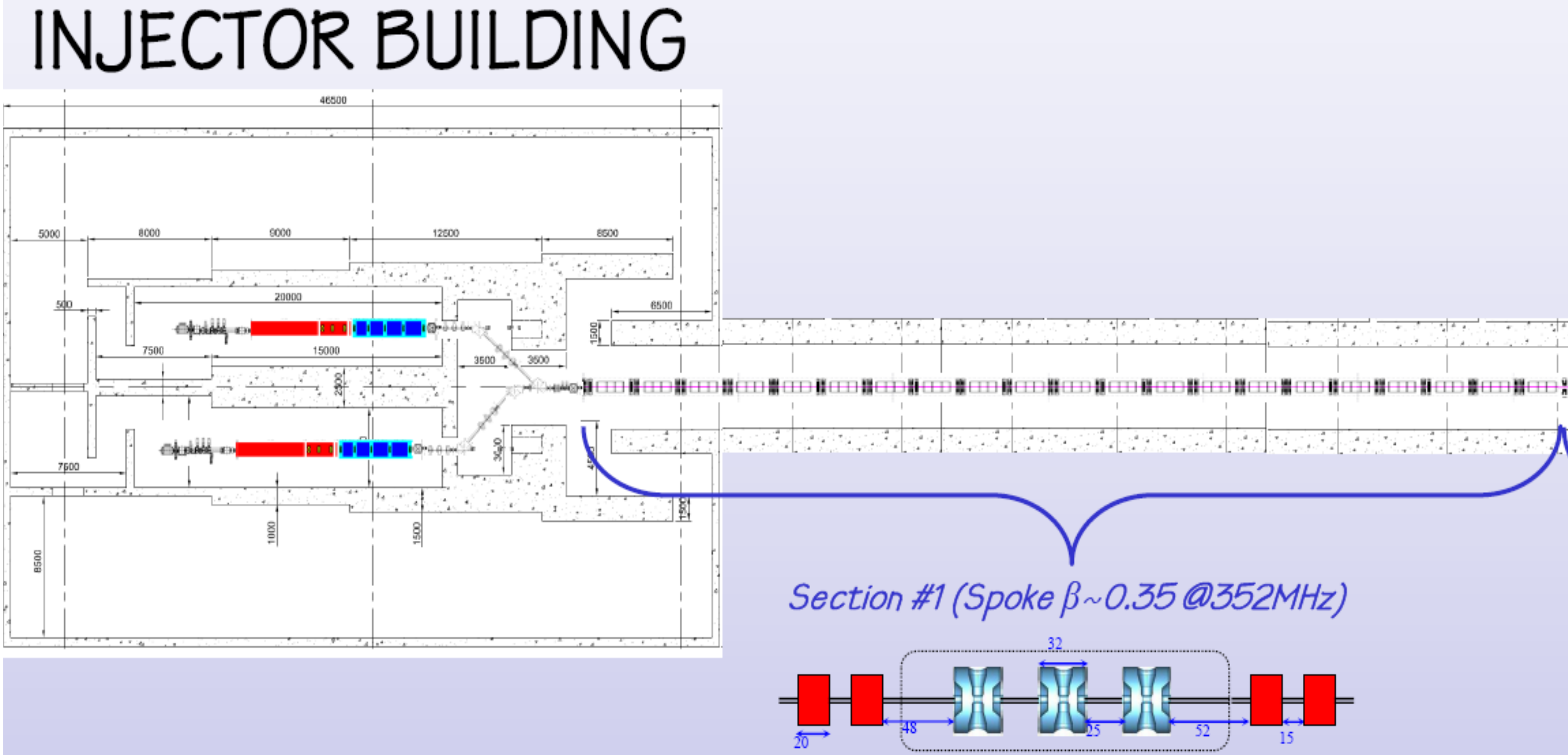
fault tolerance

- 3 keys to fault tolerance:
  1. redundancy
  2. switching time
  3. repairability



- the modularity of a SC linac is compatible with a serial redundancy scheme
- low energy : no modularity → parallel redundancy

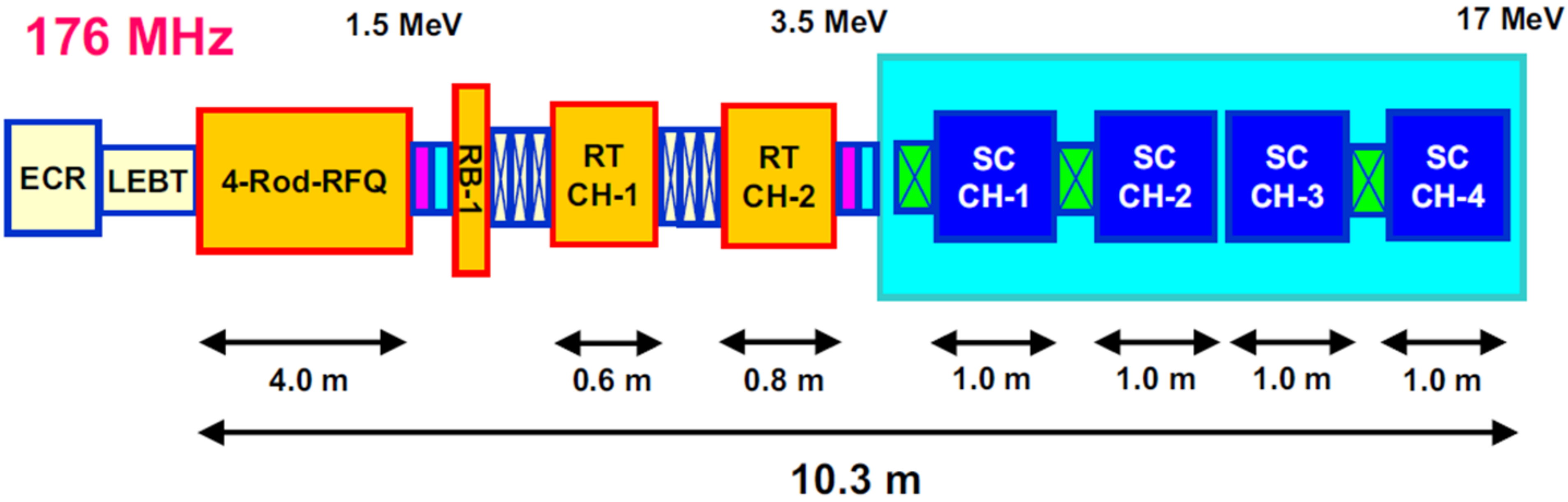
MYRRHA accelerator overview



courtesy J.L. Biarrotte, CNRS/IPN Orsay

MLA Injector

Unconventional choices for a compact and reliable injector



Fault tolerance

- The actors of the fault tolerance scheme:
  1. detection
  2. high level control
  3. low level control, esp. LLRF
- detection = diagnostics
  - component level
  - beam diagnostics
- in general: need for
  - fast diagnostics
  - reliable diagnostics
  - predictive diagnostics

Beam diagnostics

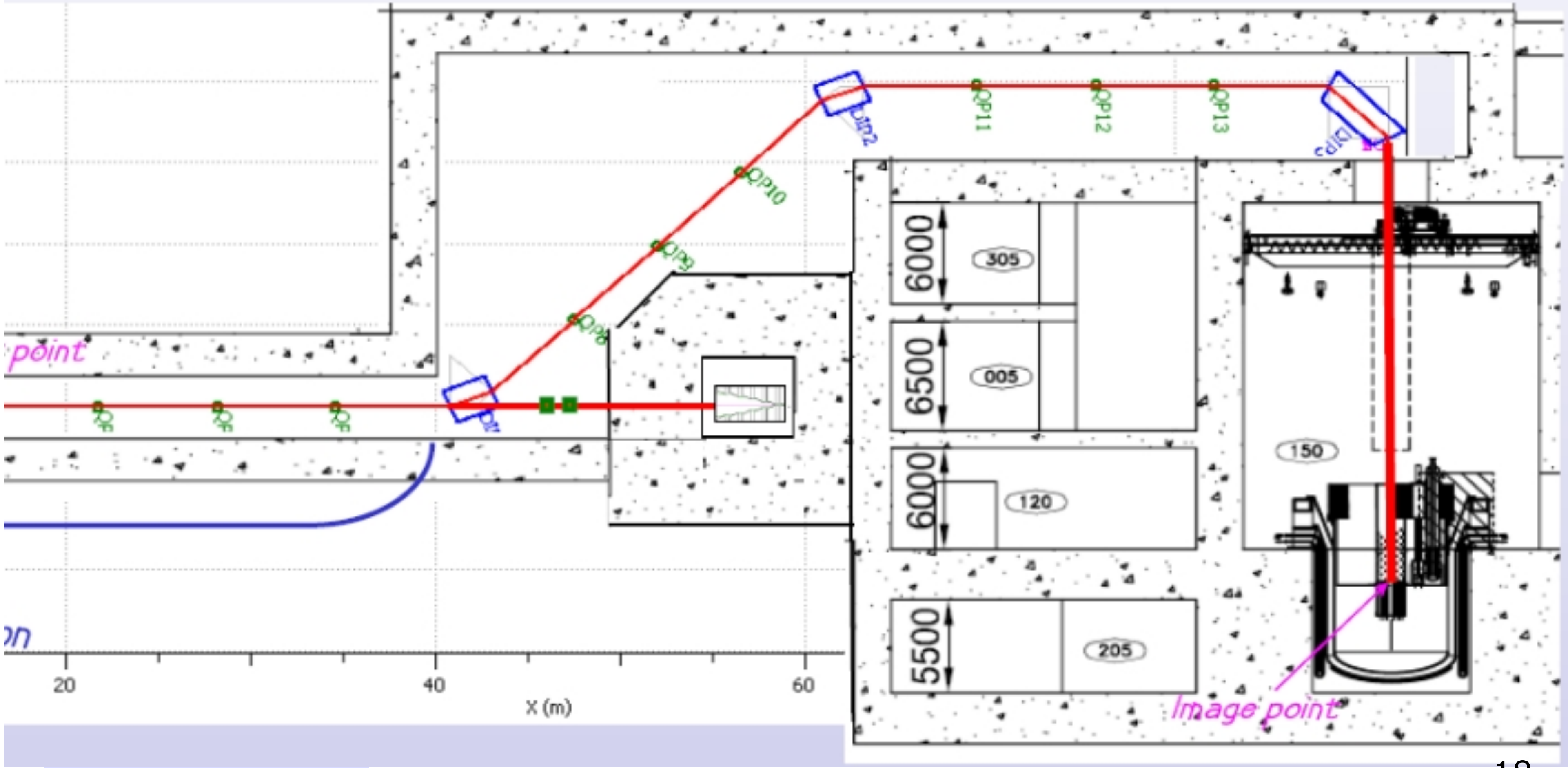
- personal view and analysis – questions!
- basic requirements in HPPA context:
  - successful beam generation and transport
  - keep losses < 1 W/m
  - machine protection with ms response time
- monitors, more or less standard:
  - current
  - position
  - profile in 3 dimensions
  - halo
  - beam loss
- high power, continuous monitoring → non-interceptive

Beam diagnostics

- ADS issues
  - no fundamental difference, but possibly specific problems
  - 3 months uninterrupted operation
    - → reliability of the devices
    - → false and spurious interlocks forbidden
    - → wrong feedback signals forbidden
    - → the provided information has to be highly reliable
      - calibration
      - redundancy of information, in space + in time
      - self-check

HEBT

REACTOR BUILDING



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Beam diagnostics

- high beam stability required due to very long drift length in HEBT
  - → accuracy
  - → strict active control of beam parameters at entry of 90° magnet
- target diagnostics: VIMOS glowing sieve cfr. PSI
- general need for predictive diagnostics ("warnings, no errors")
  - → at component level
  - → also at level of beam diagnostics

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Conclusion

- (beam) diagnostics are vital for HPPA, hence for ADS
- need for reliable, fast and accurate beam diagnostics ☺
- the actual level of performance that may be reached by the diagnostic system will be a key element in the full reliability analysis of the accelerator
- it should be possible to launch a full study in the near future