LIPAc Control Systems

A Reliability Approach

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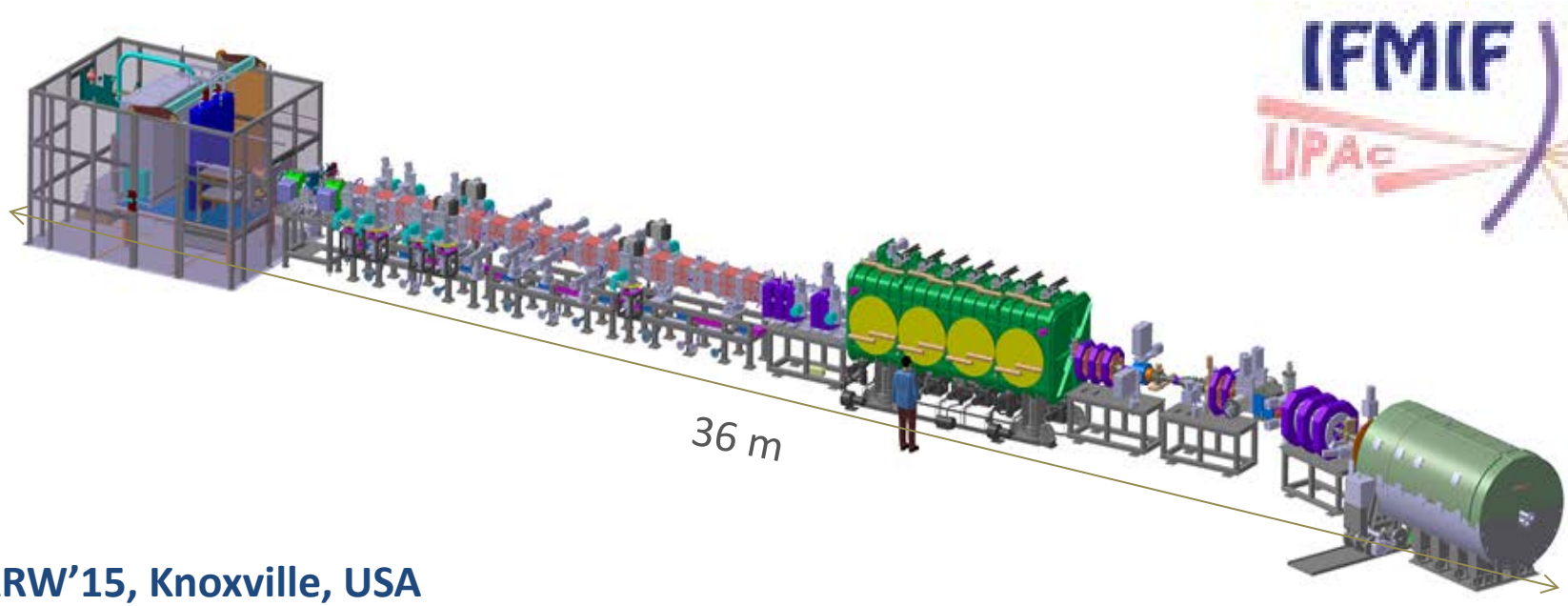


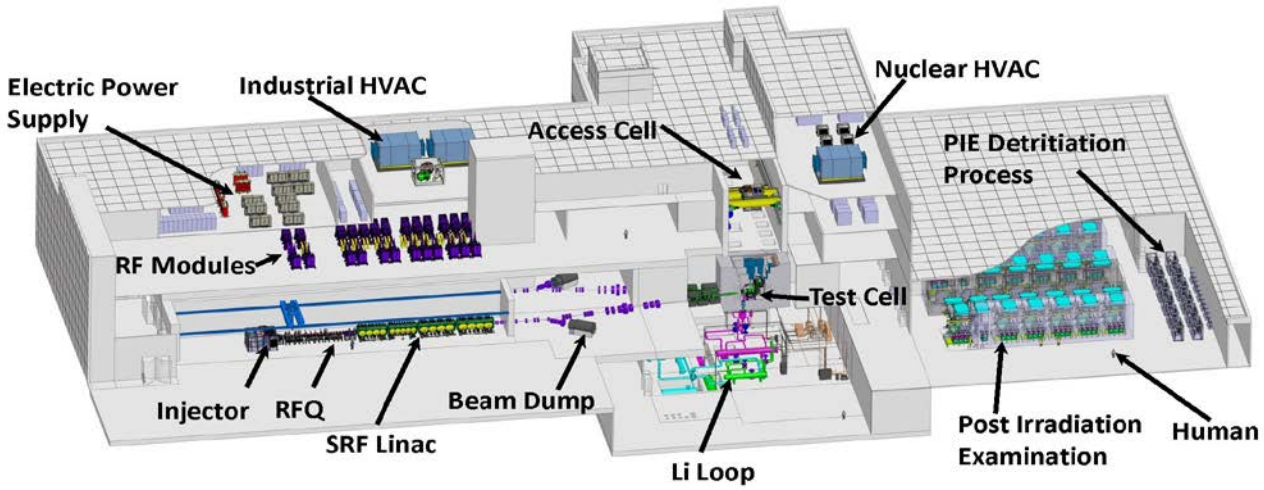
ARW'15, Knoxville, USA

Introduction to IFMIF/LIPAc

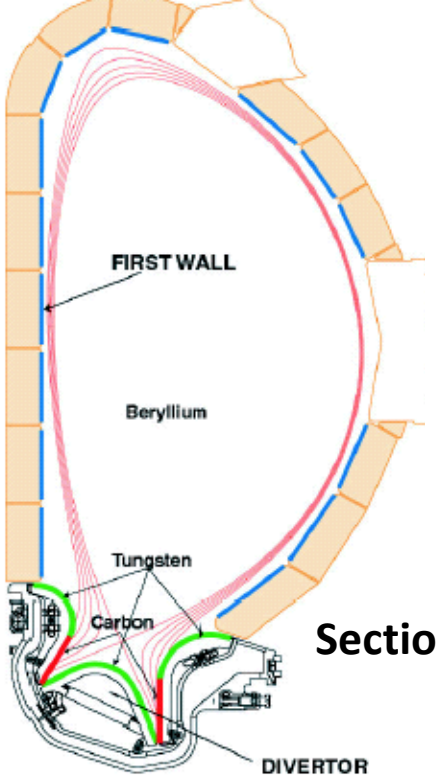
LIPAc -> Linear IFMIF Prototype Accelerator

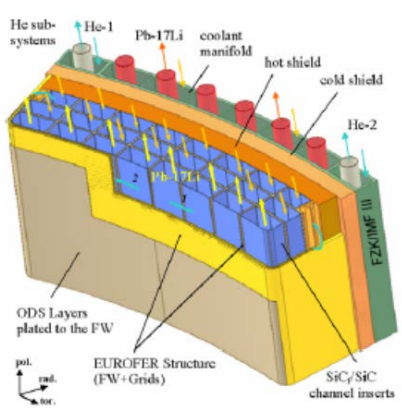
IFMIF -> International Fusion Materials Irradiation Facility

(the fusion relevant neutron source)



Neutrons in first wall





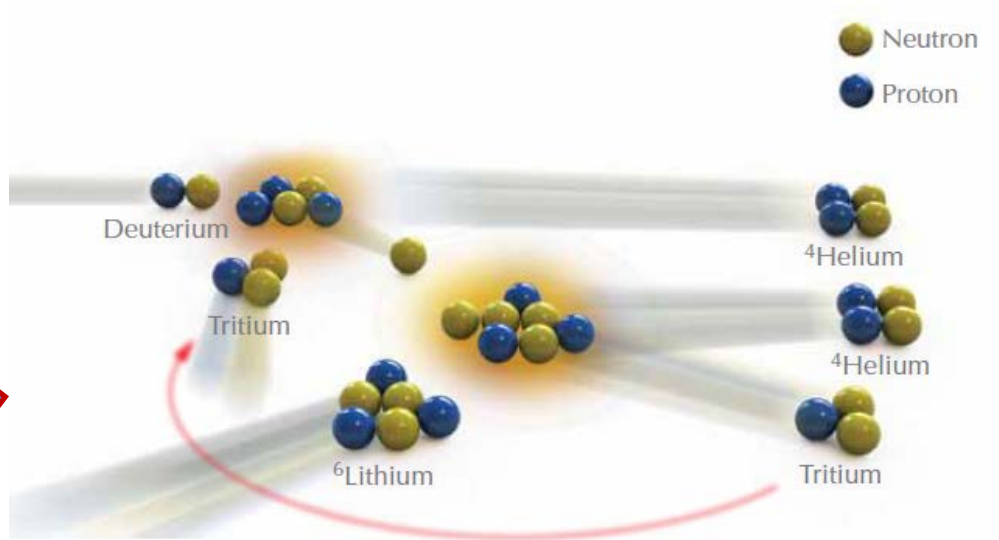
Section of Vacuum Vessel of a Tokamak

ITER first wall will present
<2 dpa at the end of its operational life

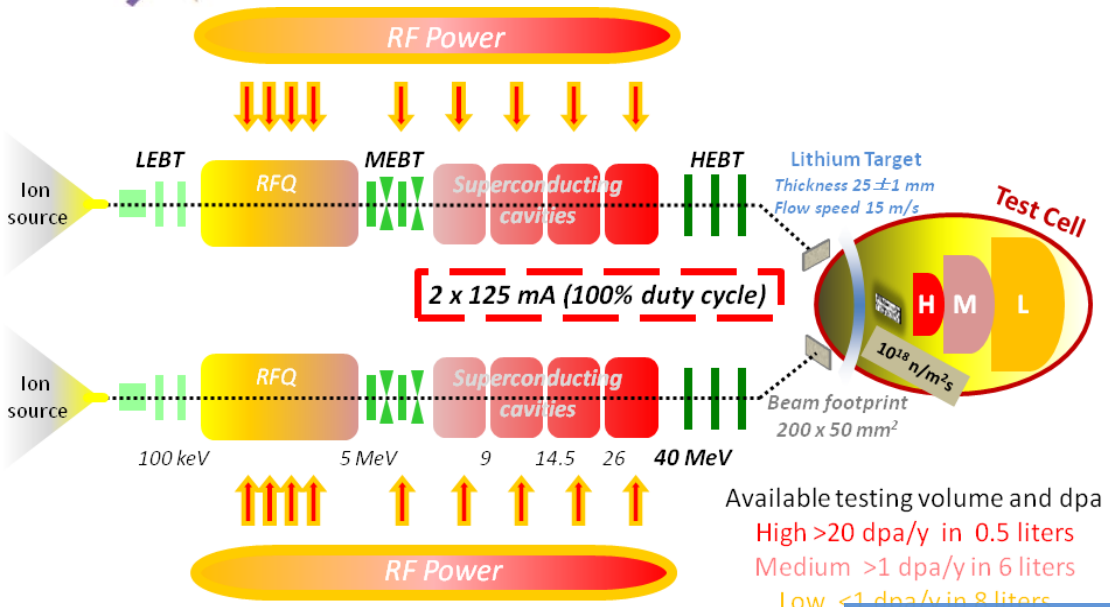
In a Fusion power plant
~150 dpa within 5 years are expected

Existing neutron sources do not provide the needed answers

The first wall
of the reactor vessel shall
absorb neutrons energy
and
breed tritium



IFMIF concept

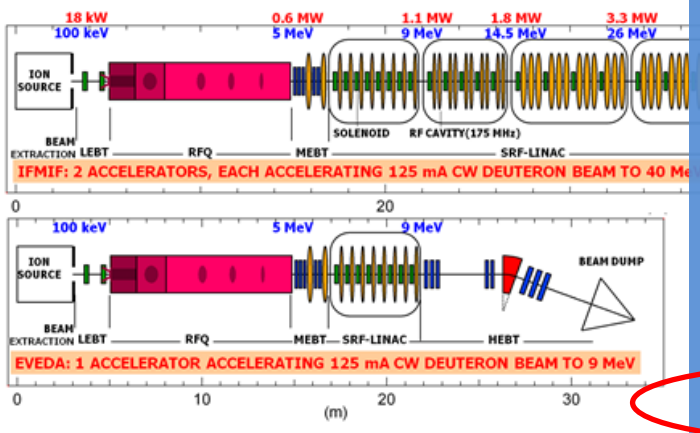


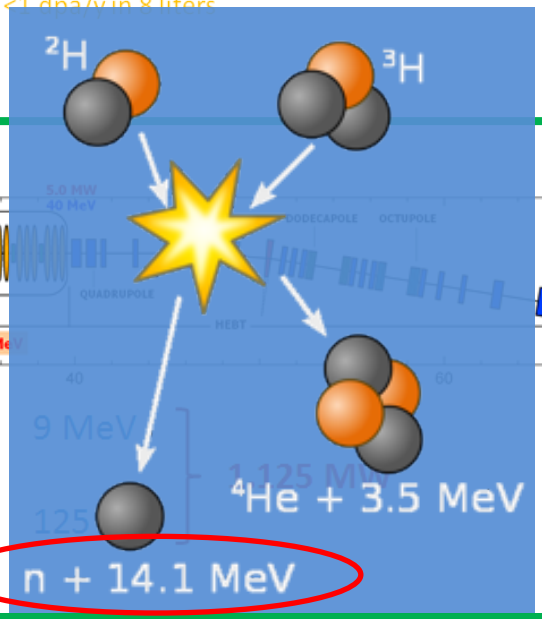
Available testing volume and dpa
High >20 dpa/y in 0.5 liters
Medium >1 dpa/y in 6 liters
Low <1 dpa/y in 8 liters

Deuterons at 40 MeV collide on a liquid Li screen flowing at 15 m/s

A flux of 10^{18} n·m^{-2}s^{-1} is stripped with a broad peak at 14 MeV

EVEDA Phase: LIPAc





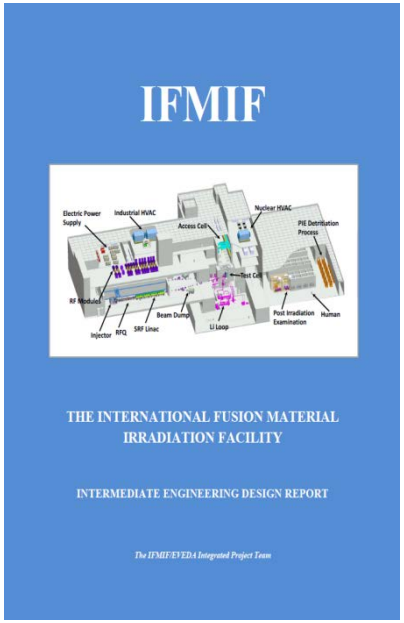
IFMIF/EVEDA

A fruitful Japanese- European International collaboration

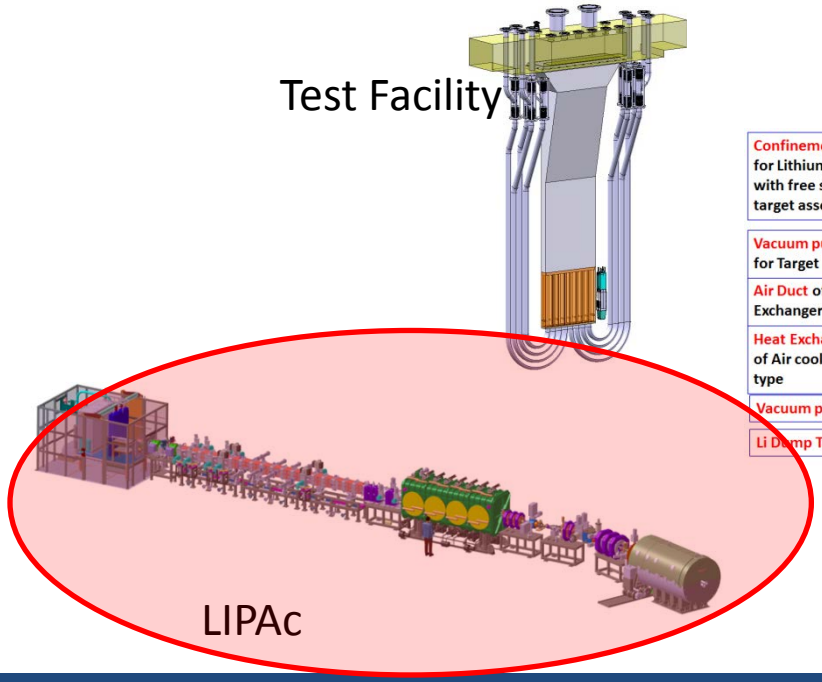
(under the Broader Approach Agreement)

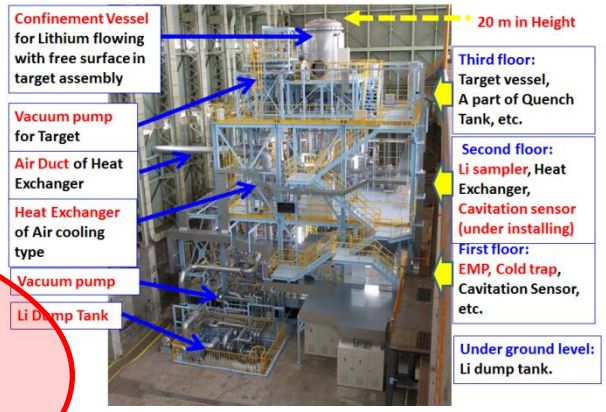
EDA phase:

EVA phase:



IFMIF I-EDR

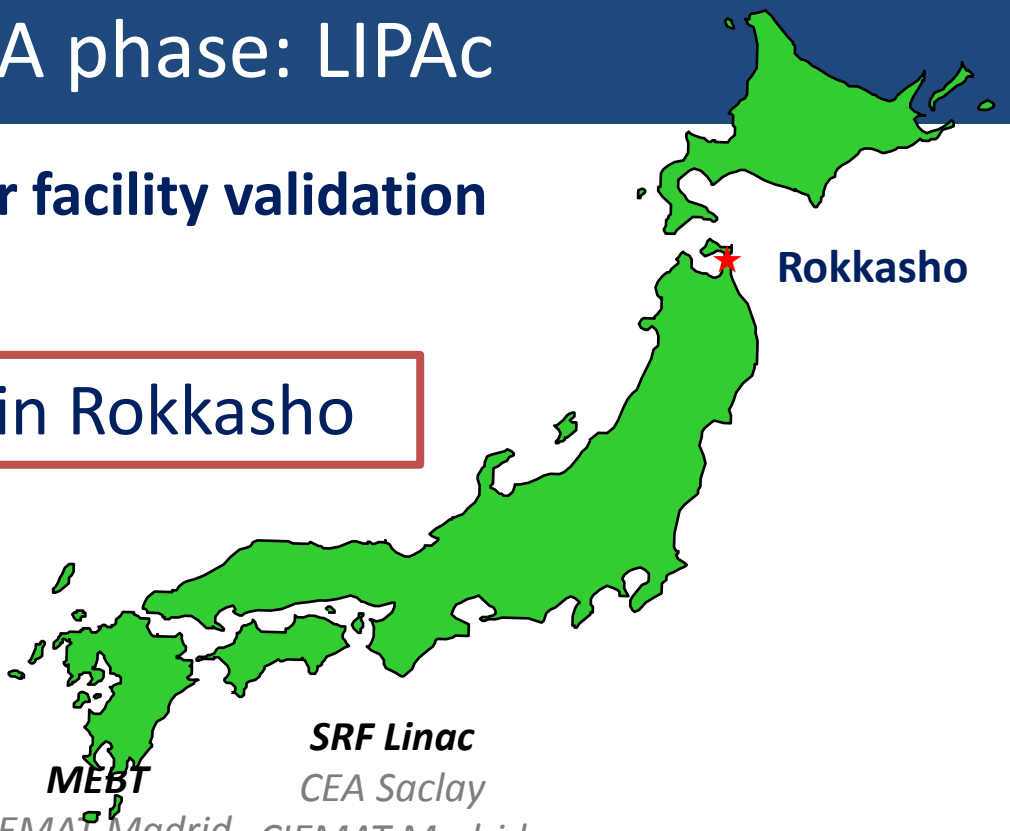




Target Facility

EVEDA phase: LIPAc

Accelerator facility validation



Installed and commissioned in Rokkasho

Injector + LEBT
CEA Saclay

RFQ
INFN
JAEA Tokai

MEBT
CIEMAT Madrid

SRF Linac
CEA Saclay
CIEMAT Madrid

HEBT
CIEMAT Madrid

BD
CIEMAT Madrid

36 m

Diagnostics
CEA Saclay
CIEMAT Madrid

RF Power
CIEMAT Madrid
CEA Saclay
SCK Mol

IFMIF/EVEDA

A fruitful Japanese- European International collaboration

(under the Broader Approach Agreement)

LIPAc contributions on control systems:

Japanese implementing agency

European implementing agency

(European coordinator)

Central systems:

- **Network infrastructure**
- **Central control system**
- **Machine Protection system**
- **Personnel Protection system**
- **Timing system**

Local control systems:

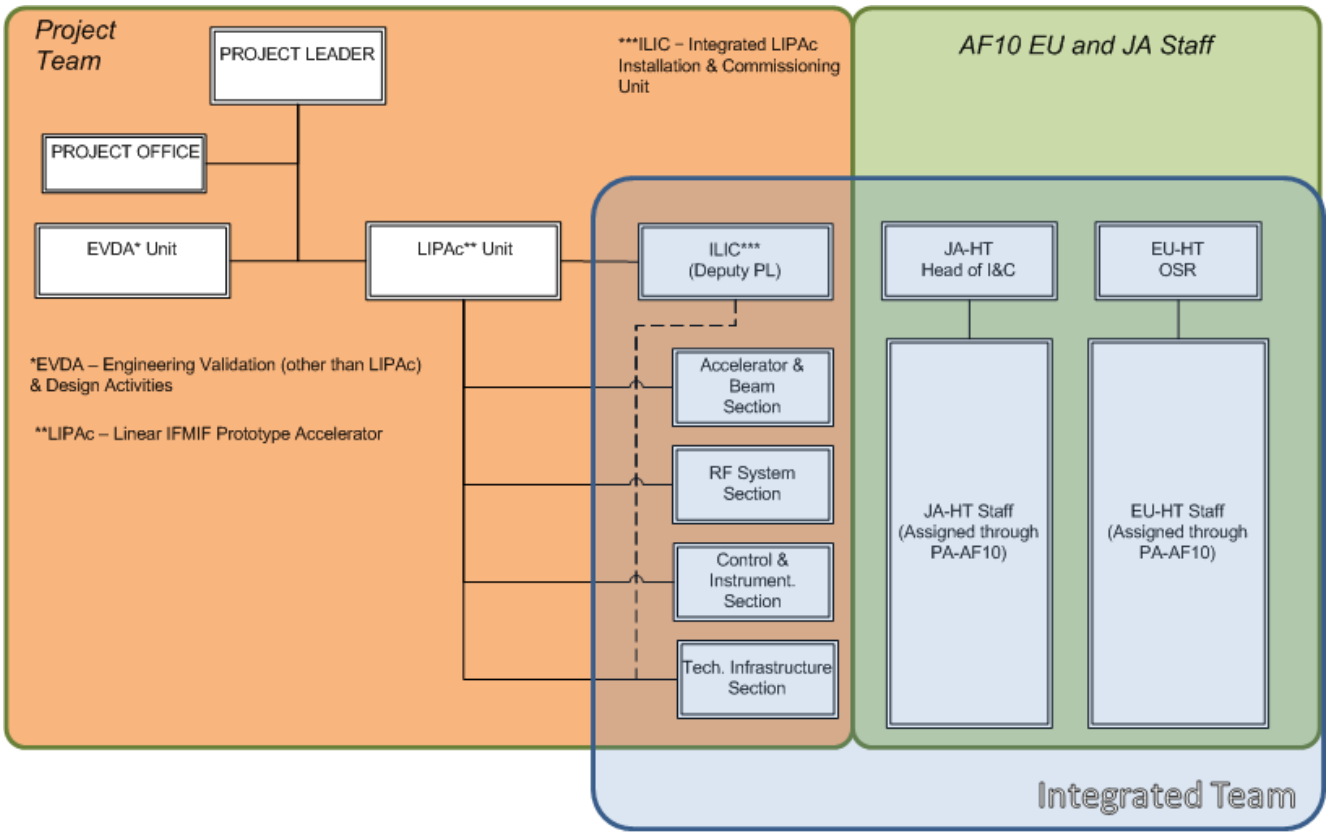
- **Injector + LEBT**
- **RFQ**
- **LLRF**
- **MEBT**
- **+ (…)**

Beam Instrumentation

On-site organization:

Japanese implementing agency

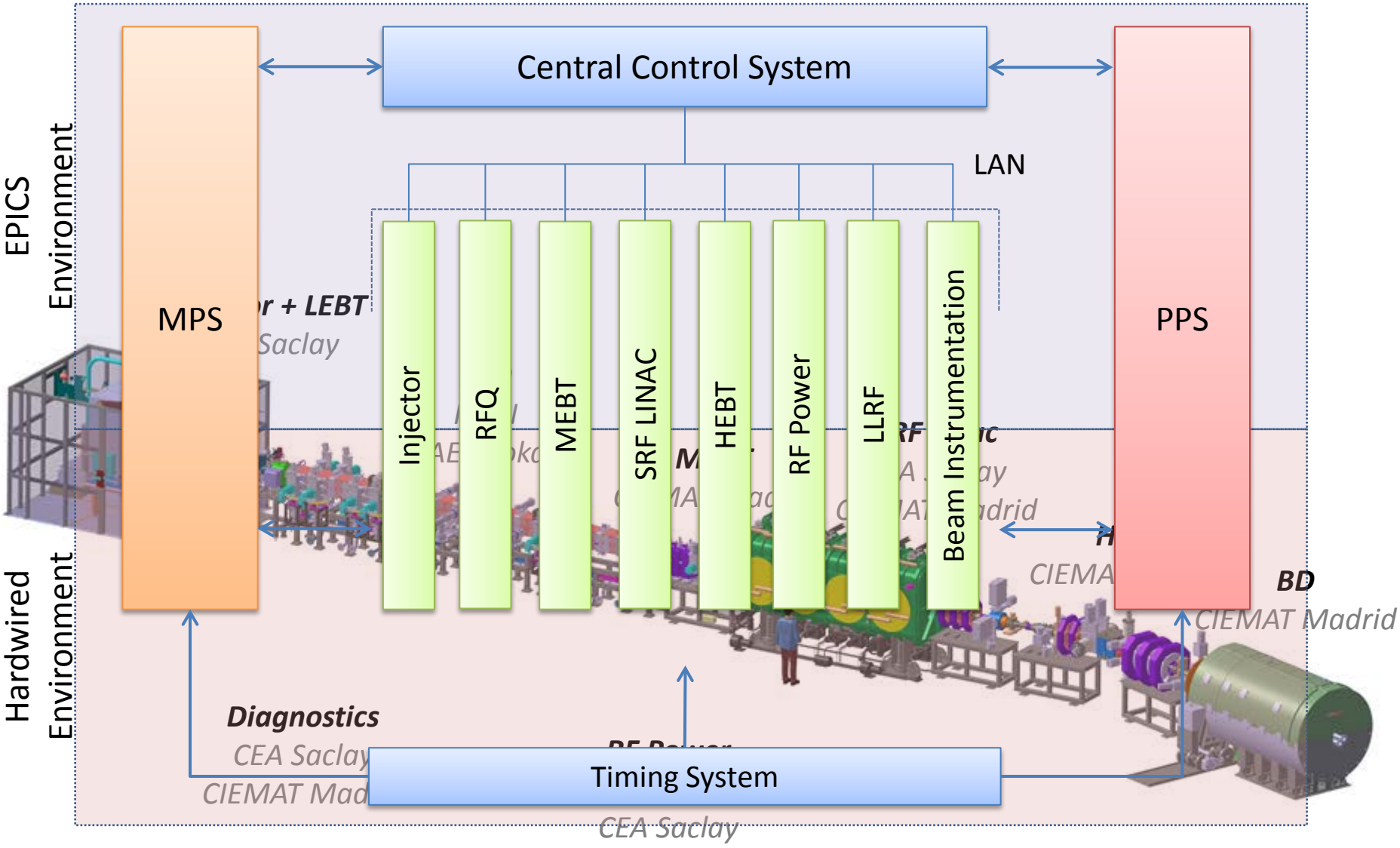
European implementing agency



Integrated Team, responsible for:

- **Design Verification**
- **Installation coordination & QA**
- **Commissioning**
- **Operation**
- **Systems maintenance**

Overview of LIPAc Control Systems



Overview of LIPAc Control Systems

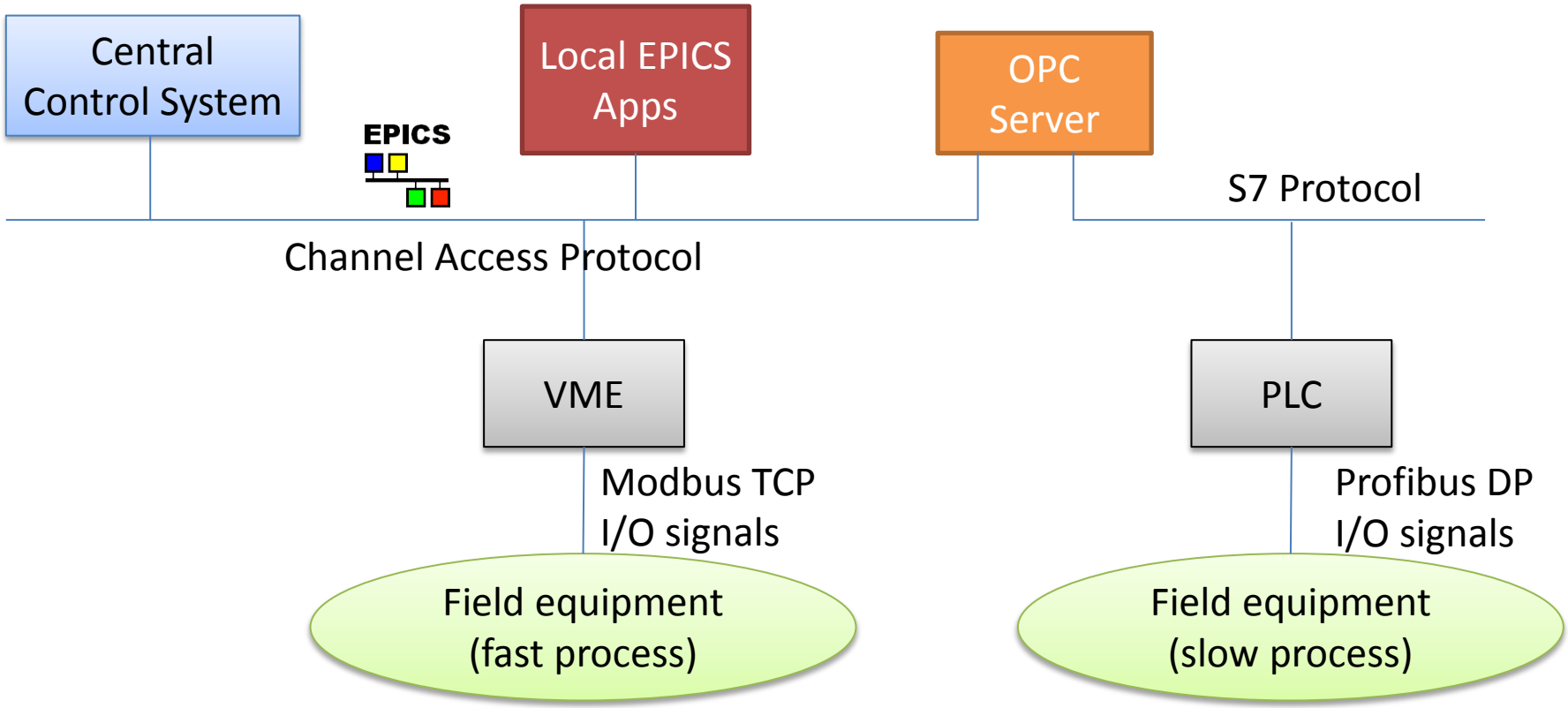
LIPAc Control System: Main characteristics

- Modular design, following the architecture of the whole LIPAc, based on procurement 'in-kind':
  - independent subsystems with common interface.
- Based on EPICS and CSS for software applications (OPI, archiving, alarms…)
  - common standardized EPICS platform
- Around 20.000 process variables managed globally
  - considered medium size facility
- MPS fastest response (beam shutdown, hardwired loop) of around 20us
  - But also has to manage slower PLC signals

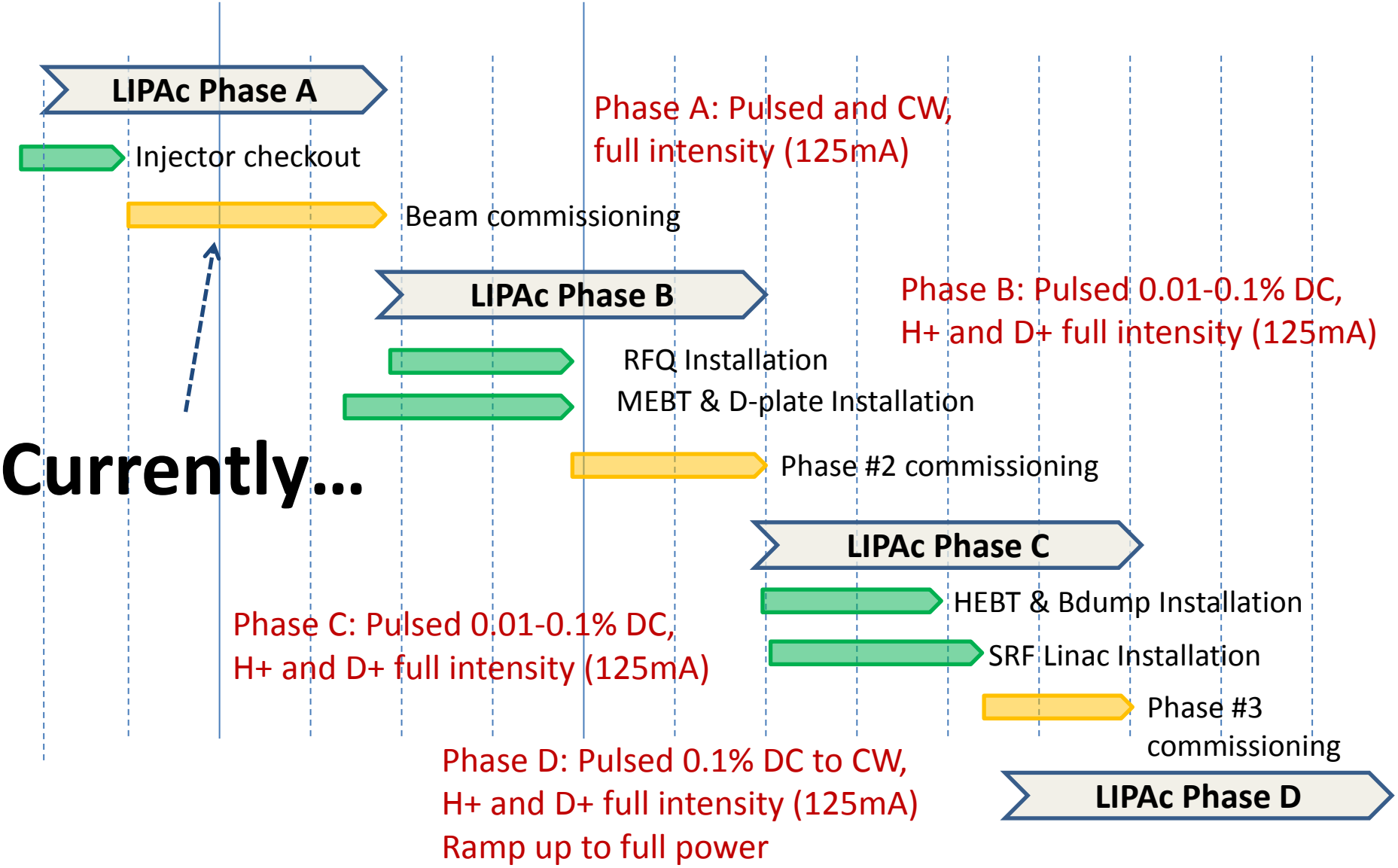
Local Control Systems

Standard LCS architecture (standalone configuration)

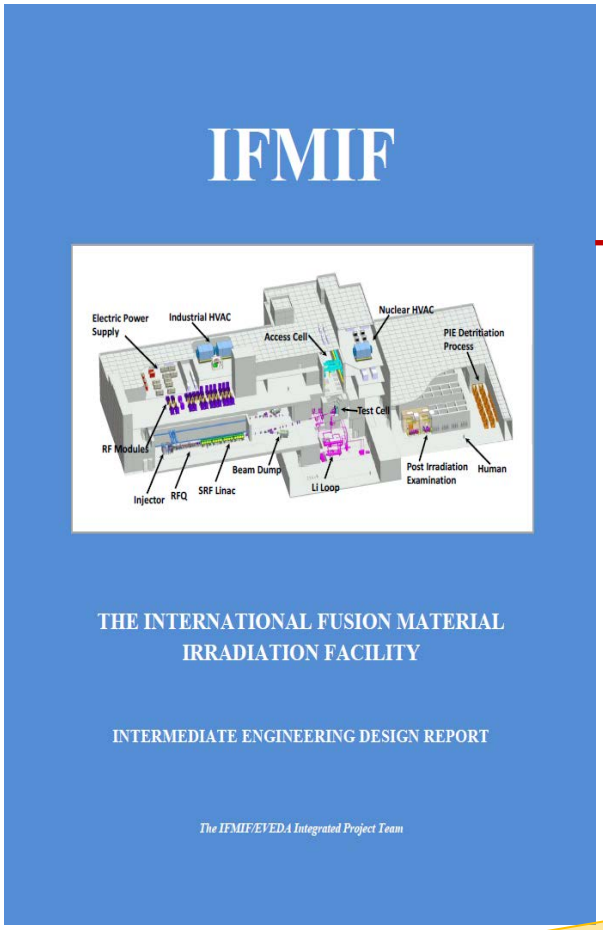
- European contribution, coordinated by CEA
- EPICS standardization though guidelines, common EPICS/CSS platform
- Delivered in local configuration to Rokkasho (to undergo acceptance tests before integration)



LIPAc Schedule

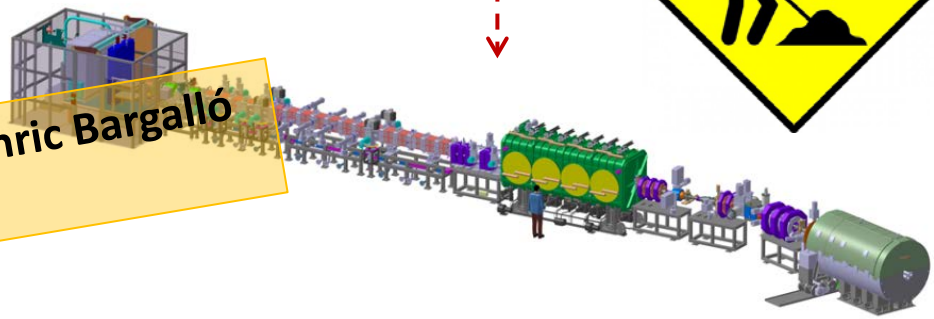


IFMIF Reliability Aspects



IFMIF inherent availability goals

IFMIF Facilities	Availability requirements
Test Facility	96%
Target Facility	94%
Accelerator Facility	87%
Conventional Facilities	98%
Central Control System & Common Instr.	98%
TOTAL (product)	75%



Many thanks to Jose Manuel Arroyo and Enric Bargalló for their superb job on RAMI for IFMIF

Reliability of Control Systems

Recommended good practices during the design:

Control System

- **Identification of critical components,**
  implement redundancy in these systems
- **Good diagnosis tools, both HW**
  for early identification of
- **Standardiz** … **sible,**
  to reduce the … **gue of potential failures**
- **Use of isolation cards for I/O**
  easier to identify when failures are localized
- **Implement exhaustive V&V methodology,**
  errors are less prone to occur when identified at the early design stages!

If we cannot focus on MTBF,
Let's improve MTTR

First runtime experiences

LIPAc Ion source operating since November:

- LCS “Successfully” commissioned mid-November
  (before ownership transfer)
- 3 month stop due to piping improvement in cooling system for safer D+ operation
- Several isolation and multiplexer cards IC damaged
- Modbus modules communication problems
- Old PLC interlocks still in place
- Sometimes software still requires reboot…

Early conclusions

When problems appear…

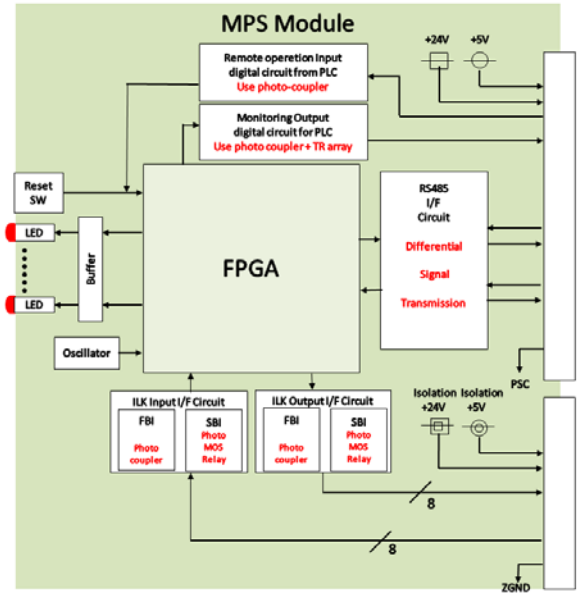
- Documentation not always fully helpful (same with drawings)
- Remote support (+7/8h) limited availability
- Several “black boxes” identified
- Intervention on the delivered control system seems unavoidable

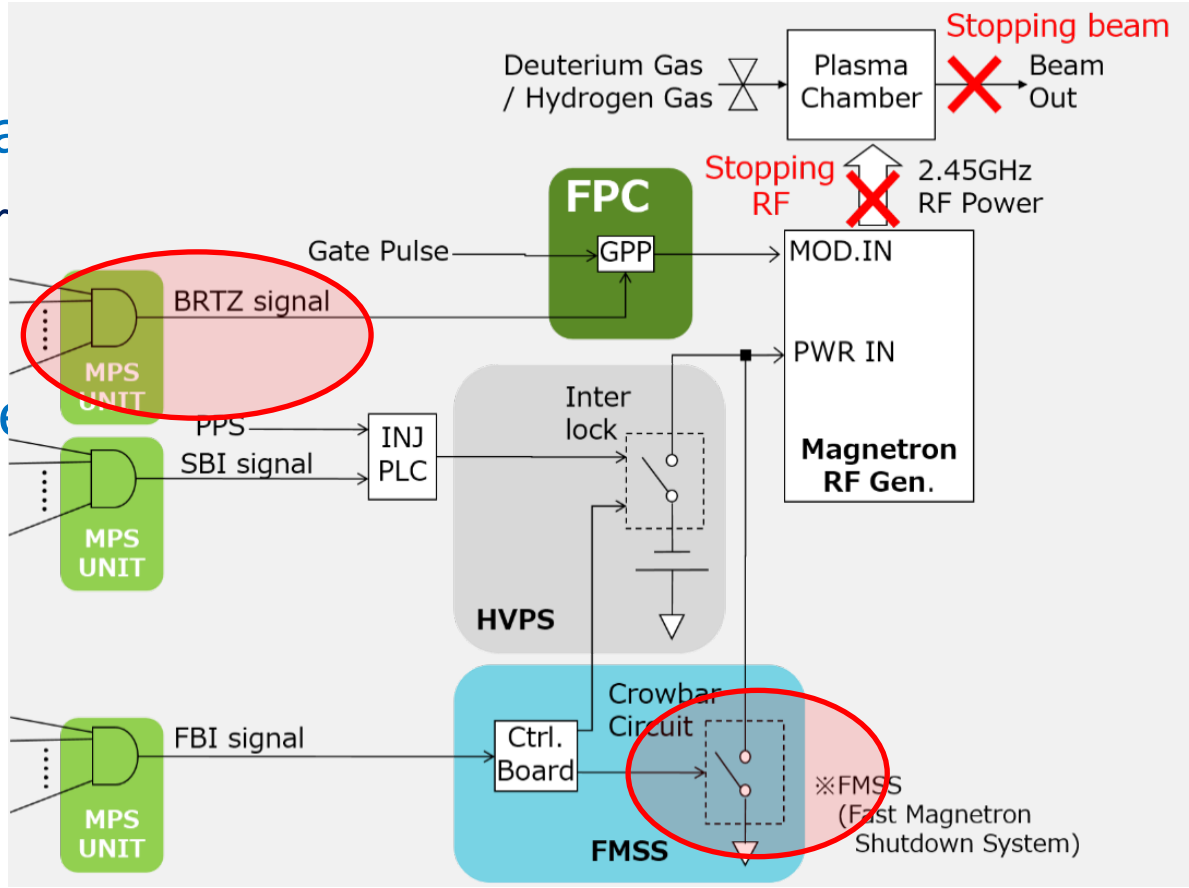
Typical situations in in-kind procurement…

The MPS particularities

- A trade-off between investment protection (avoid unsafe errors by all means) and availability (avoid spurious triggers as much as possible)

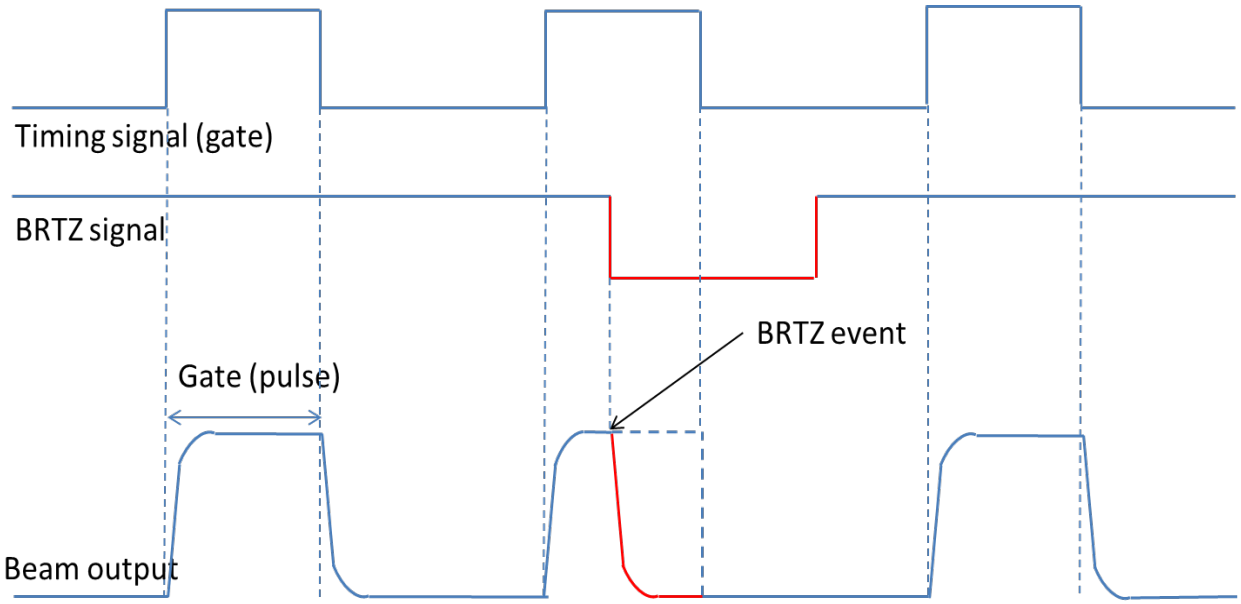
- LIPAc's case: ba
  from J-PARC exper





The BRTZ case

- Increase availability by reducing re-arming time after beam shutdown:
  - Directly Inhibiting the timing gate input
  - Valid for RF issues (arcs, reflected power) or BLoM events
  - Avoid reset and rearm by operator, when safety conditions are met
  - Interfaces mostly LLRF, cavities and BLoM



Next steps

Thank you

Images from sakura festival at Hirosaki, Aomori pref.