Accelerator tasks with respect to MPS, PSS and TSS

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European Spallation Source
Accelerator Division

TAC, 6 October 2016, Lund, Sweden

Outline

1. Introduction
2. MPS
   - Overview and interfaces with accelerator
   - Risk analysis and beam losses calculation
   - Organizational aspects and plans
3. PSS
   - Location of the interfaces
   - Interfaces status
   - Accelerator tasks
4. TSS
5. Conclusions

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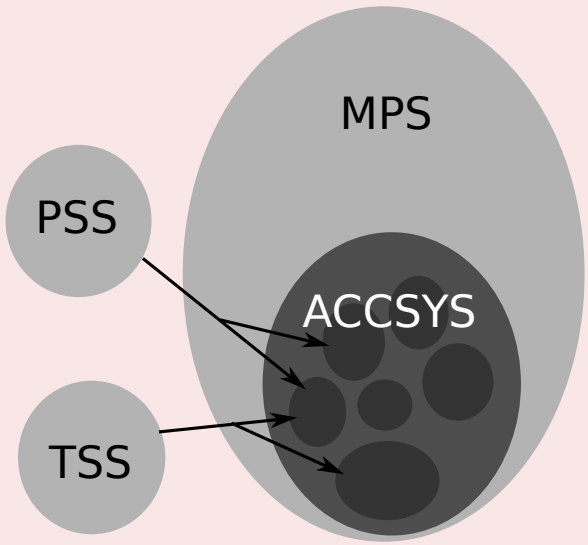
Introduction

Interactions between systems



- The accelerator has interfaces with **3 independent systems**:
  - the Machine Protection System (**MPS**)
  - the Personnel Safety System (**PSS**)
  - the Target Safety System (**TSS**)
- There is one contact person in the Accelerator Division whose role is to:
  - give expertise (when possible) on the linac systems
  - coordinate the tasks relative to the protection and safety systems
  - put in contact the stakeholders with the protection and safety system teams
- The presentation will:
  - give an overview of the design choices of the 3 systems
  - give the status of the interfaces
  - summarize the accelerator tasks relative to the 3 systems

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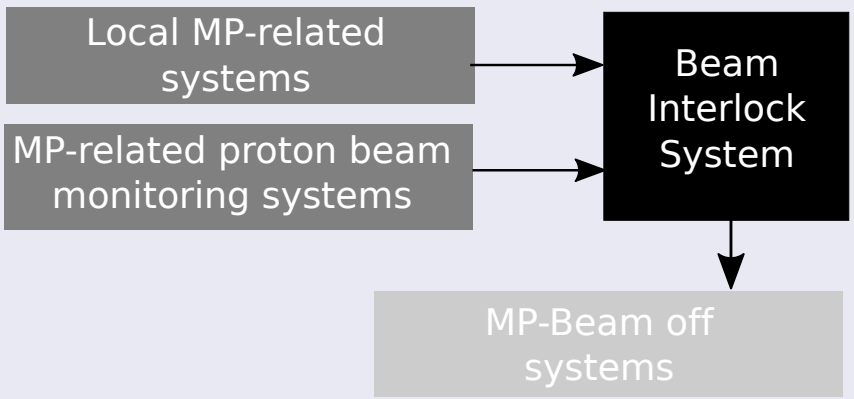
MP system-of-systems and main requirements

MPS SoS



MPS top requirements

1. Machine protection shall detect all off-nominal states that can lead to relevant damage to the machine and take appropriate actions to prevent and mitigate damage
2. Machine protection shall detect all off-nominal states that can lead to relevant unwanted beam-induced activation and take appropriate actions to prevent and mitigate damage activation

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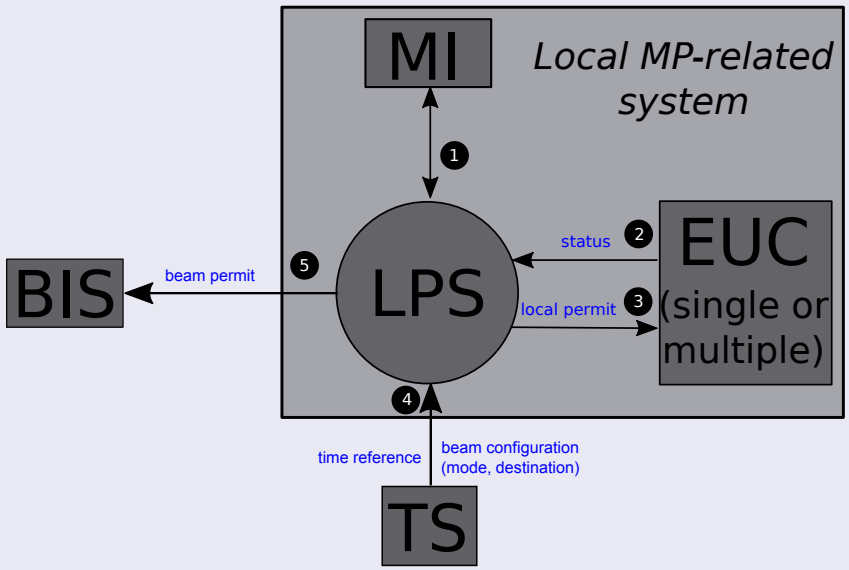
Interfaces with accelerator

MP-related systems



Acc. systems: Vacuum, water cooling, RF, instrumentation, interceptive devices, magnet PS, etc

- **Local MP-related systems:** concept exists and communicated but not formally approved by AD and ICS
- **Beam monitoring systems:** signal thresholds/pattern not yet determined
- **MP-beam-off systems:** high level requirements captured (rise time, power on dump) but more detailed design is needed

- Even if the physical interfaces are known, a global risk and availability study should be performed to determine the integrity of the beam permits and beam aborts
- Beam loss calculations should also be performed besides the hazard analysis to identify the MPS reaction times (BIS) and abort thresholds (BCMs and BLMs)

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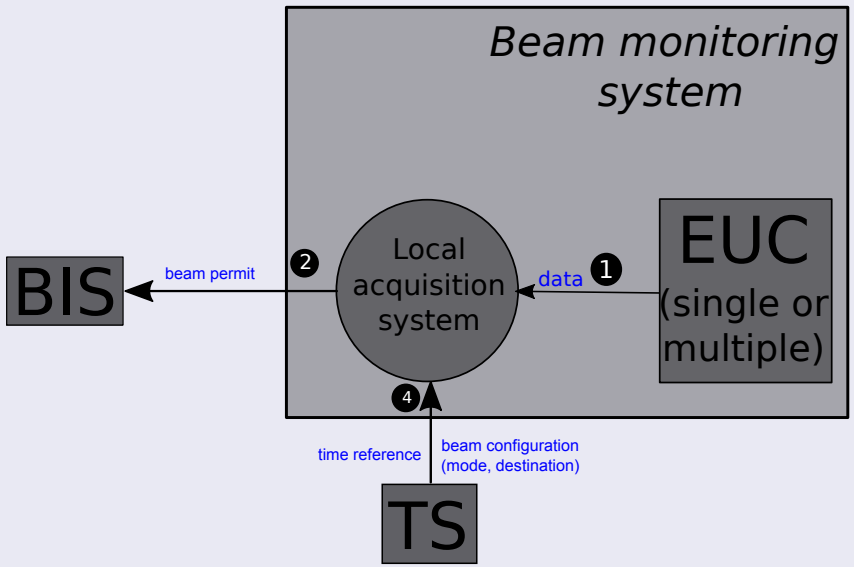
Interfaces with accelerator

MP-related systems



Acc. systems: BCM, BLM and BPM

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Interfaces with accelerator

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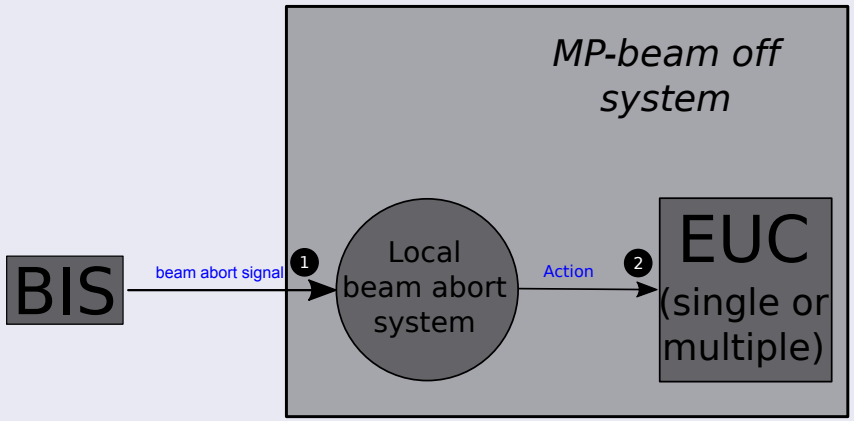

Acc. systems: Ion source magnetron, LEBT chopper and MEBT chopper

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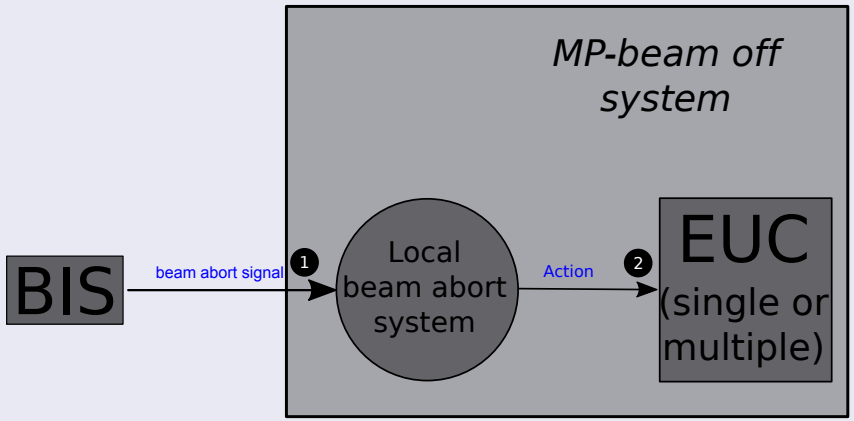

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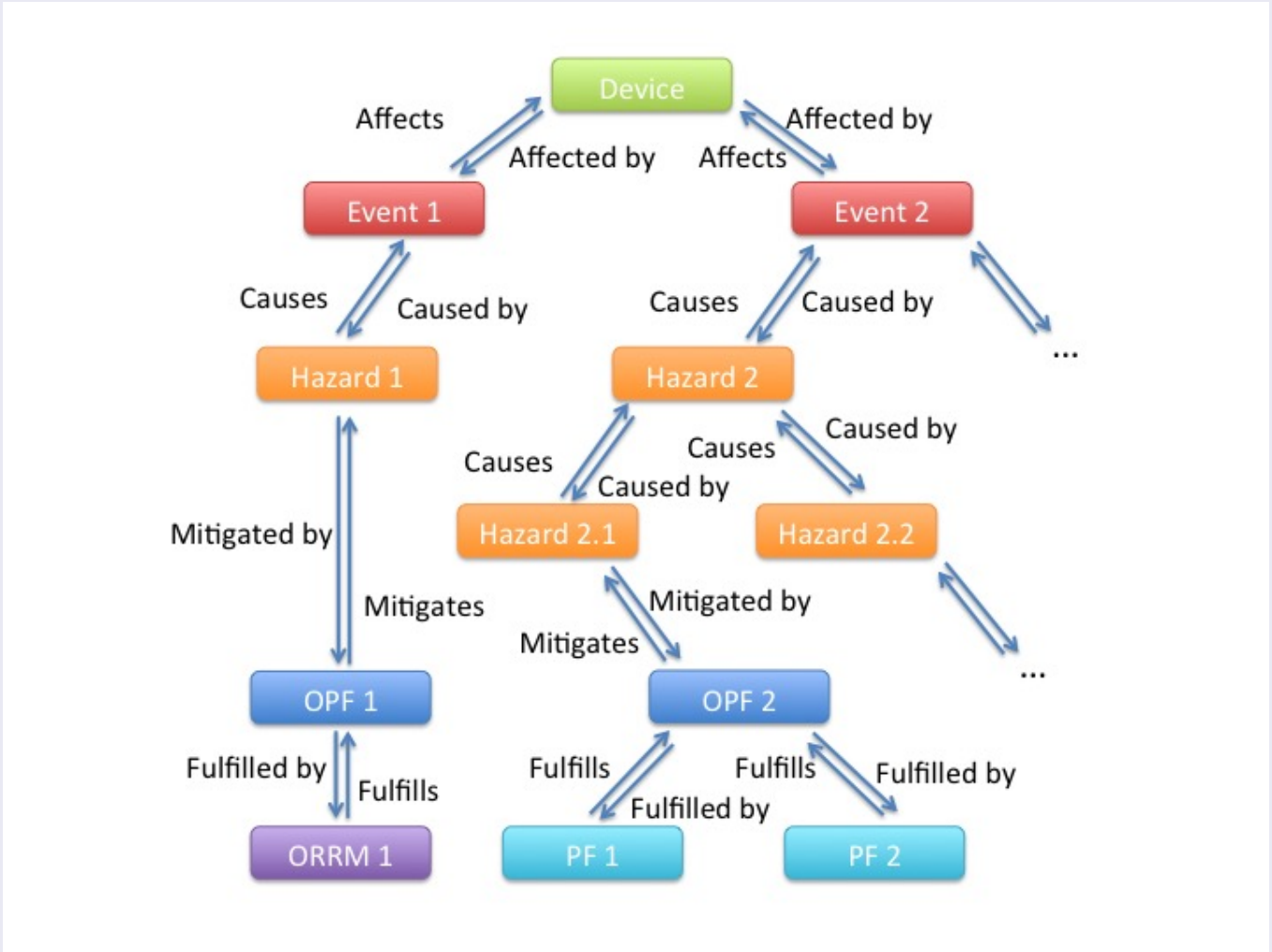
MP and RAMI risk management

Work lead by E. Bargalló

Risk tracker tool



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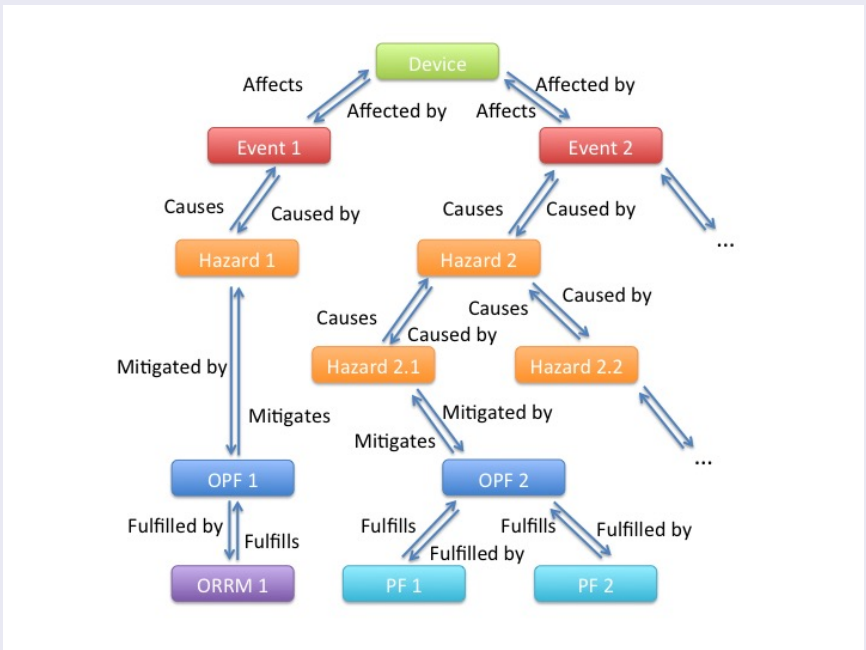

Risk management

- Series of "Beam induced hazards" workshops in 2015/2016 to identify and collect hazards in the linac
- Machine risks are going to be tracked
- Work in line with the ESS availability strategy
- **Objectives:** Definition of the protection functions, associated PIL, mitigations, beam permits requirements

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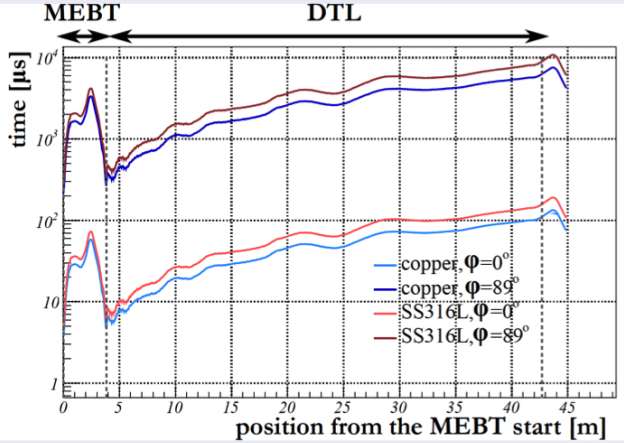
Beam loss calculations

Performed by M. Eshraqi, R. Myamoto, R. de Prisco and I. Dolenc

Review on overall MPS strategy (December 2015)

Recommendation: "The most stringent MPS requirements should be challenged, in particular the sub 10 μs response time for damage."

Melting time in MEBT and DTL (from I. Dolenc's calculations)



- Reaction time was based on the melting time due to a uniform beam hitting a block of copper or stainless steel (L. Tchelidze, Feb. 2012)
- Updated calculations from I. Dolenc (August 2016):
  - confirmation of the response time for perpendicular impacts
  - 2 orders of magnitude difference between very shallow and perpendicular incidences
- Beam impact worst case scenarios studied by the Beam Physics Section (angle, density, energy): bad combination of steering values can lead to hit perpendicularly the blade of the scrapers in the MEBT while unlikely in the DTL

Future actions

- Finalization of the study including scraper material (Tungsten or Graphite), better DT's geometry model (face angle) and realistic beam angle
- Requirement for the BIS response time
- Long term effects of micro-losses in SC cavities

Organizational aspects and plans

ACC-MPS working group

- Weekly meeting with permanent members and relevant actors when required
- A. Nordt (Group Leader, ICS/Protection and Safety Systems), E. Bargalló (Accelerator reliability expert), R. Andersson (PhD student, MP/Reliability analysis), A. Ponton (Accelerator Physicist)
- Mission is to develop the requirements relating to MPS and determine the operational strategies

Short-term plans (December)

- Preparation of the templates for the ICDs
- Completion of the ICDs for beam off systems and BCTs in the warm linac
- Completion of the risk analysis for the front-end

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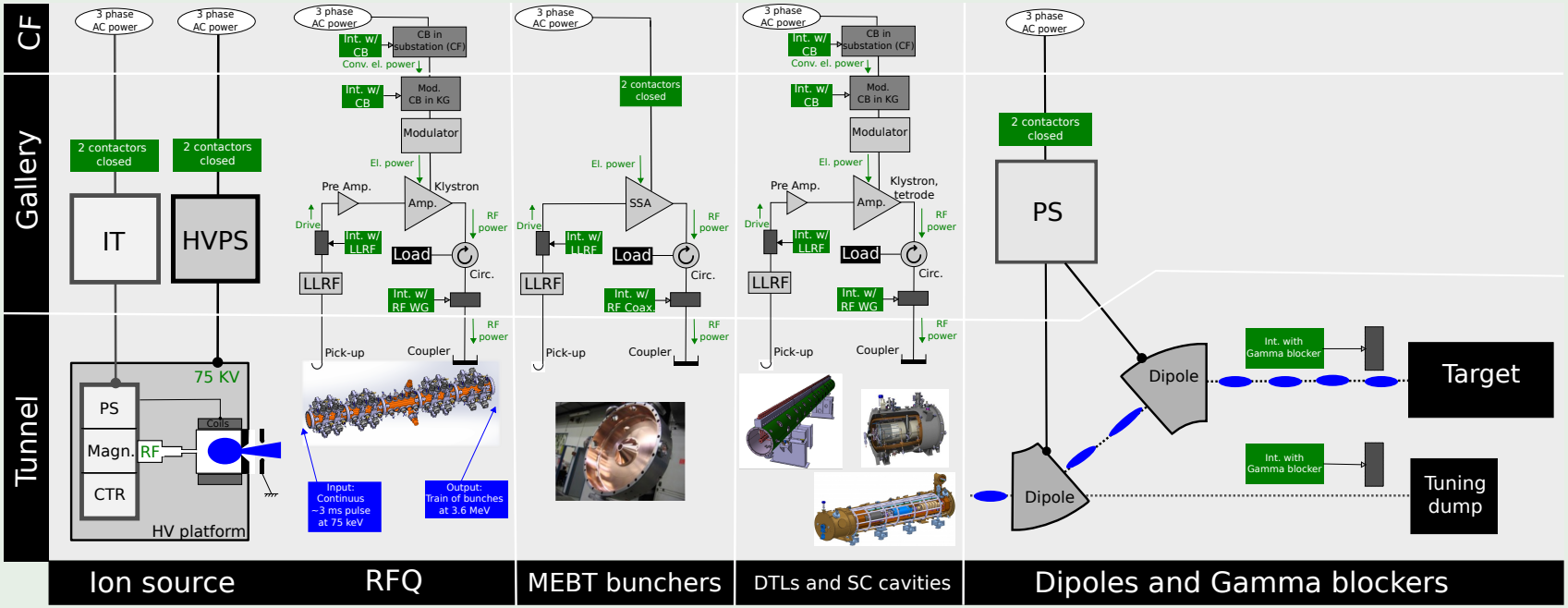
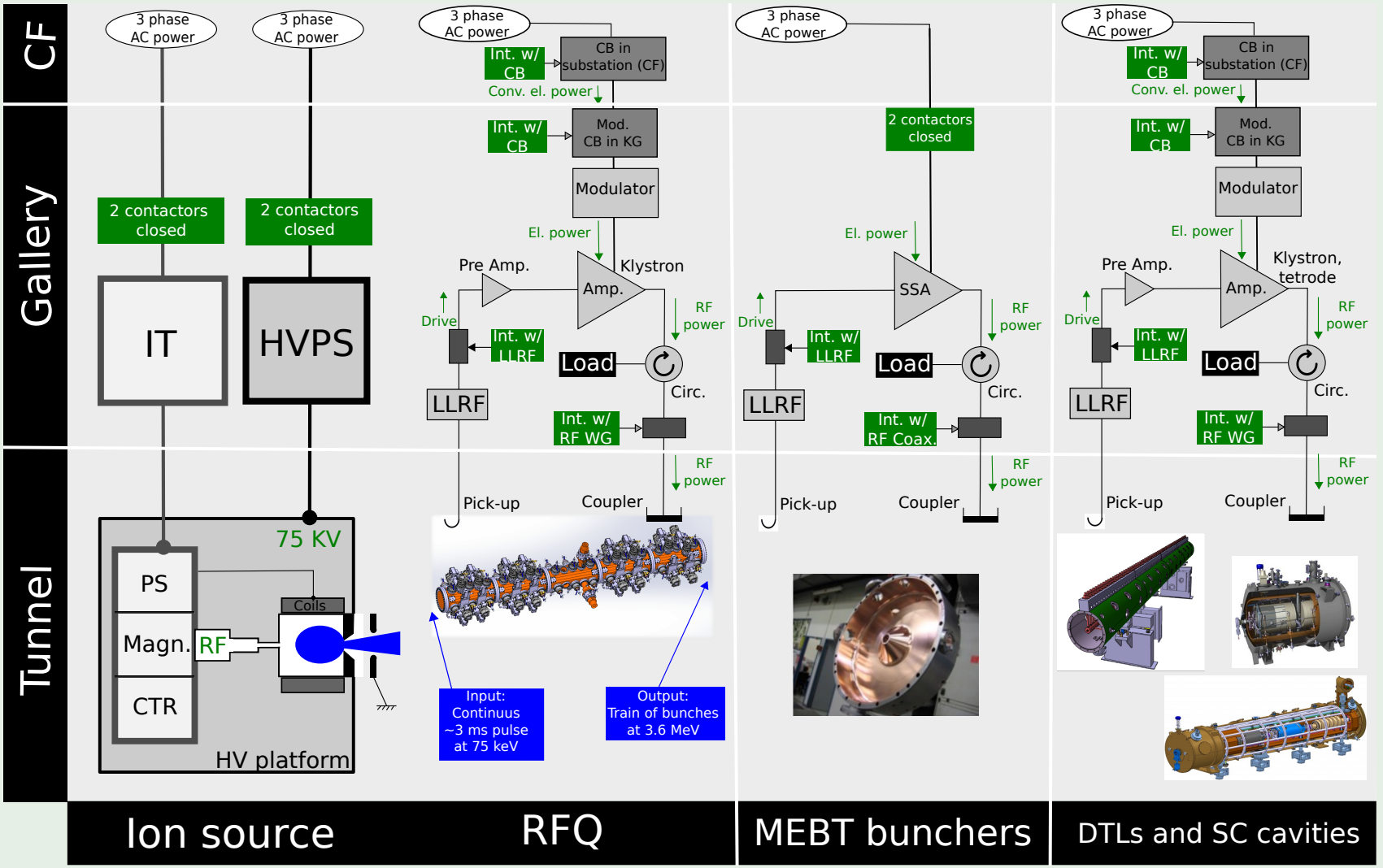
Main modes

Tunnel closed



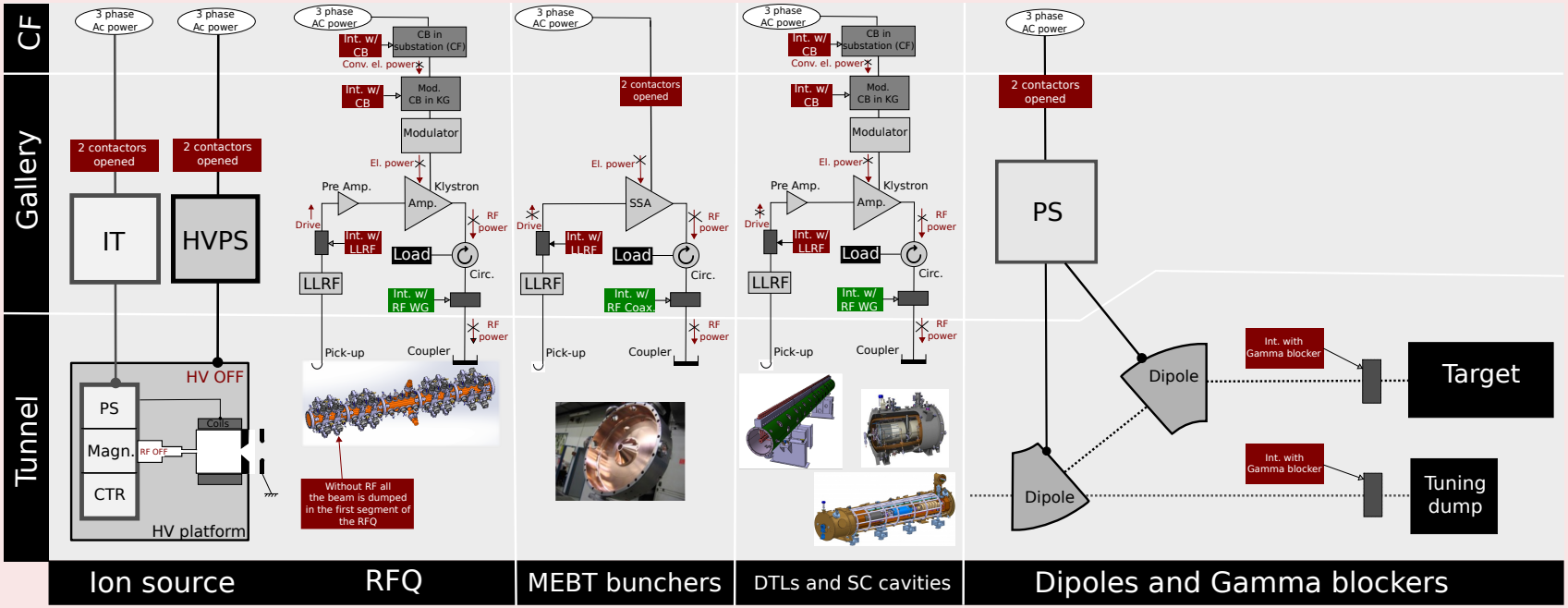
Main modes

Tunnel closed: zoom on the linac



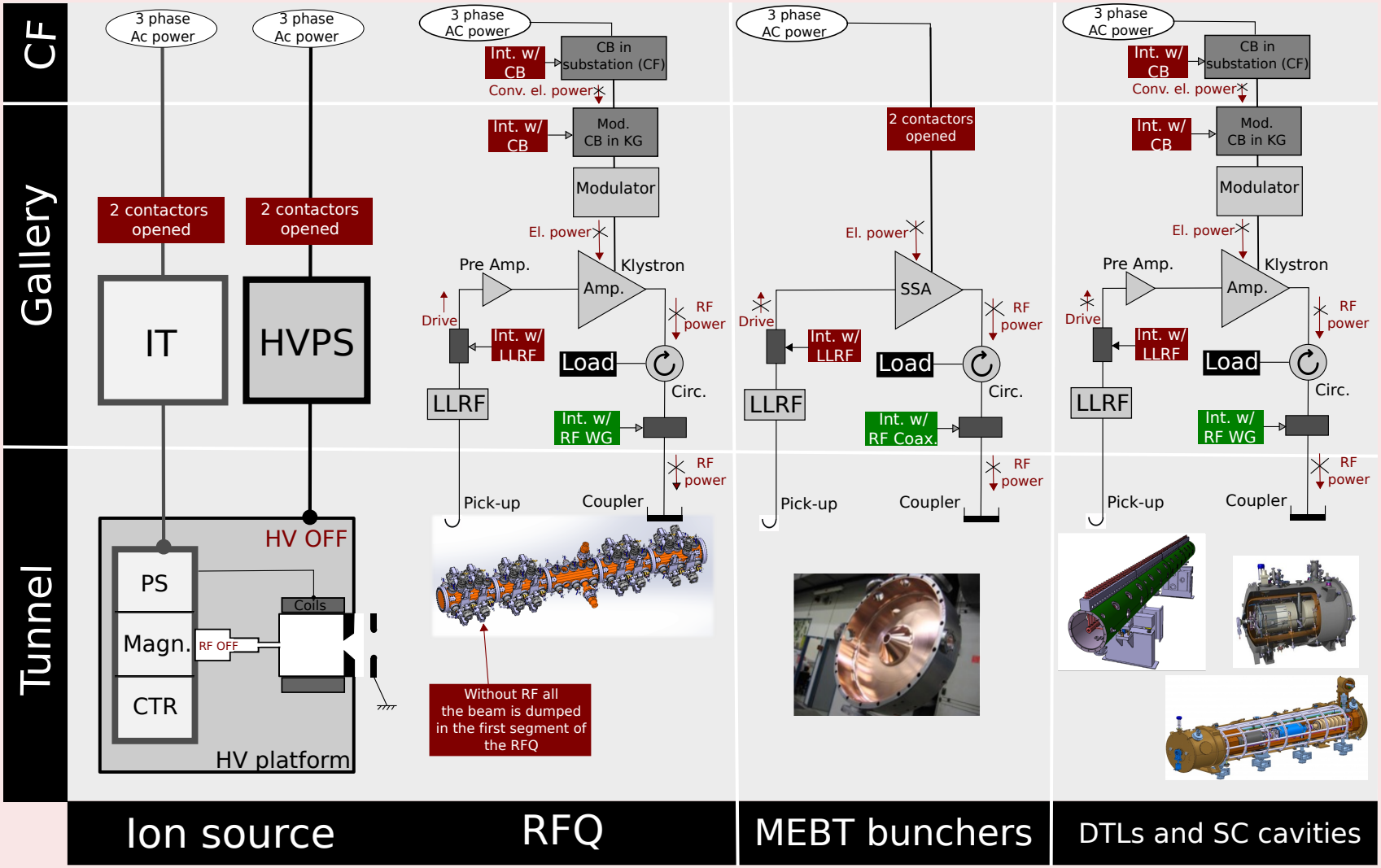
Main modes

Alarm



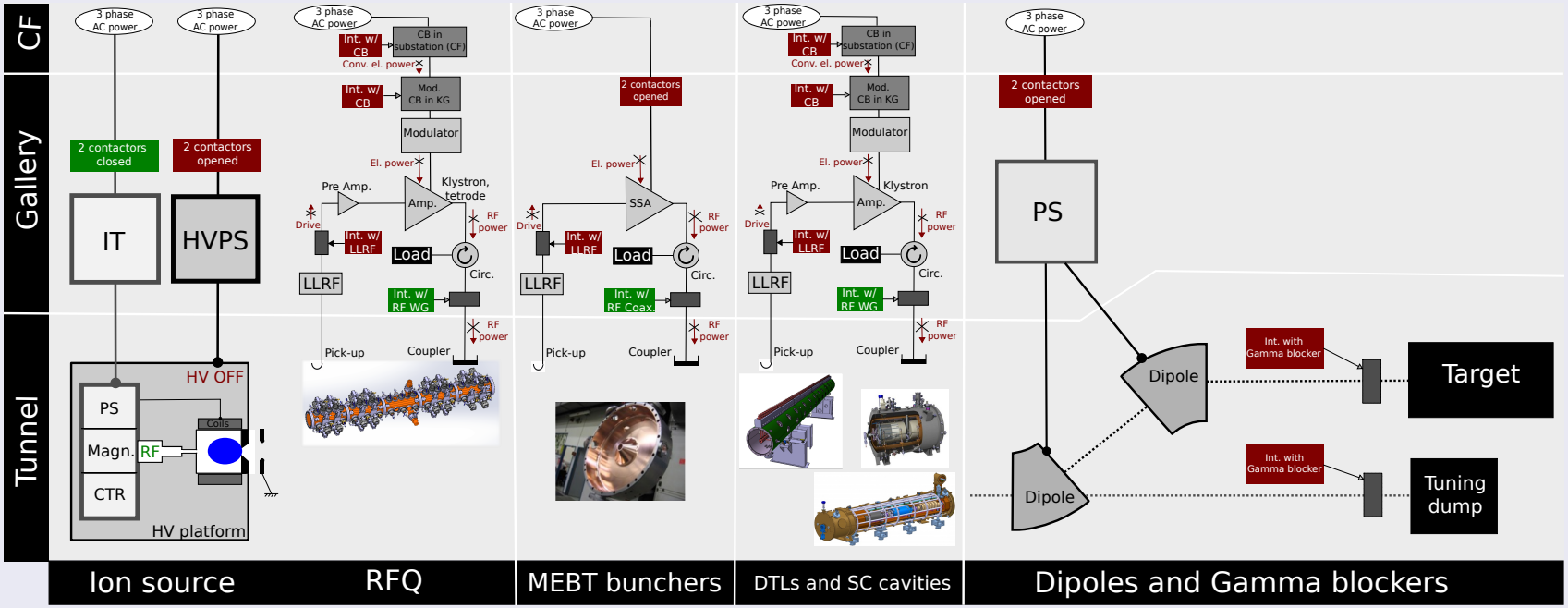
Main modes

Alarm: zoom on the linac



Main modes

Access to tunnel authorized



Main modes

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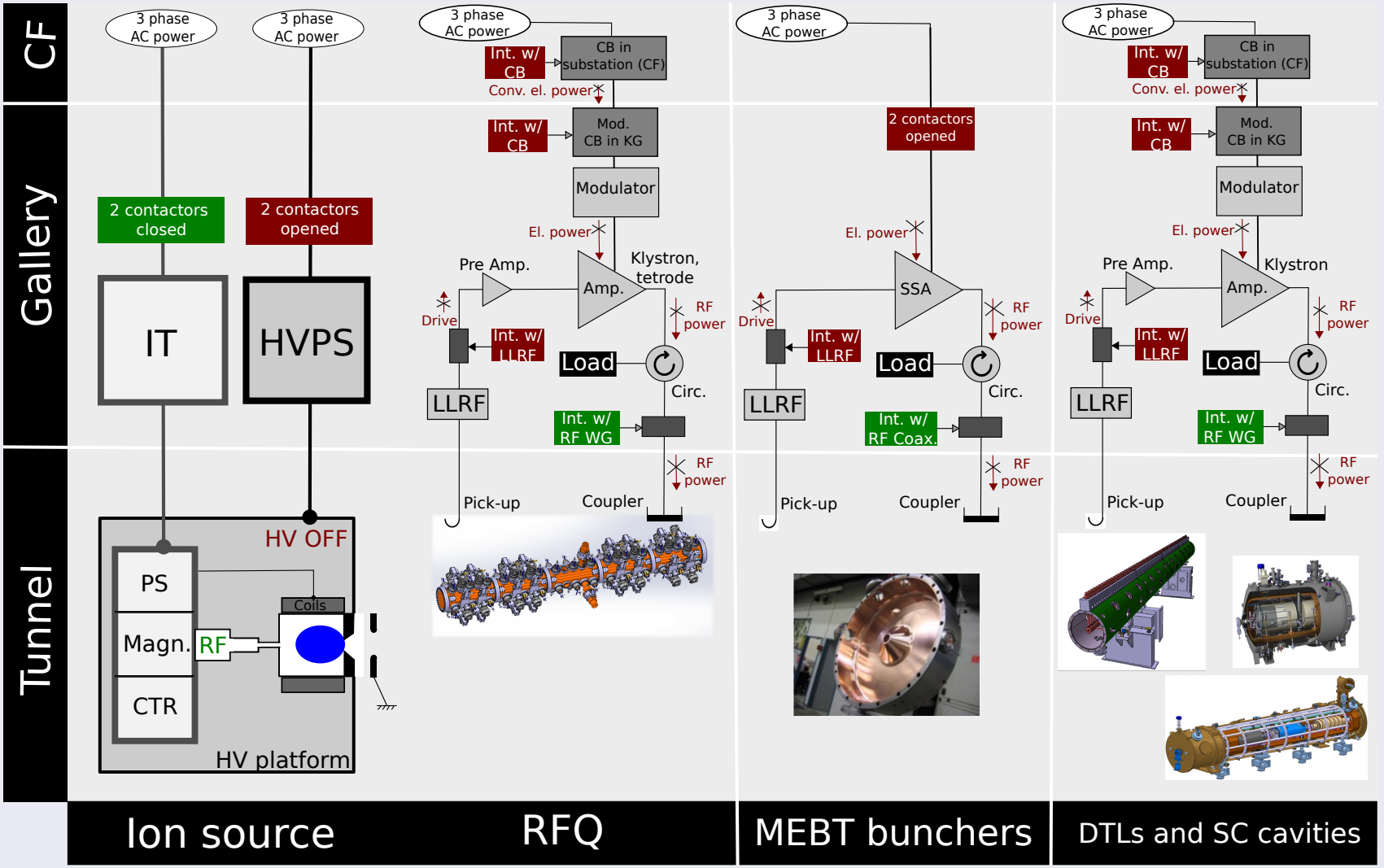
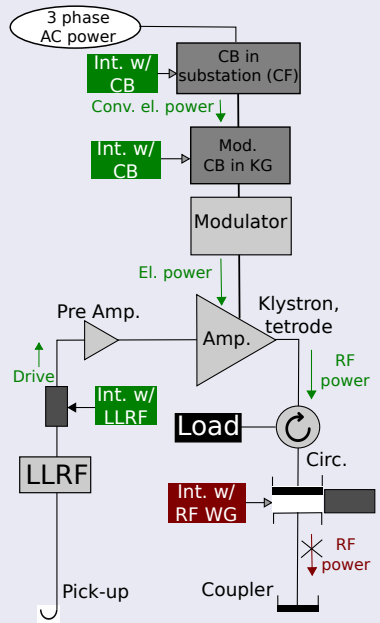
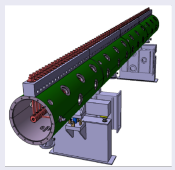
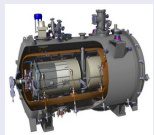


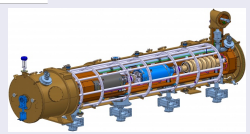
Sub-modes for RF tests and linac tuning

RF test

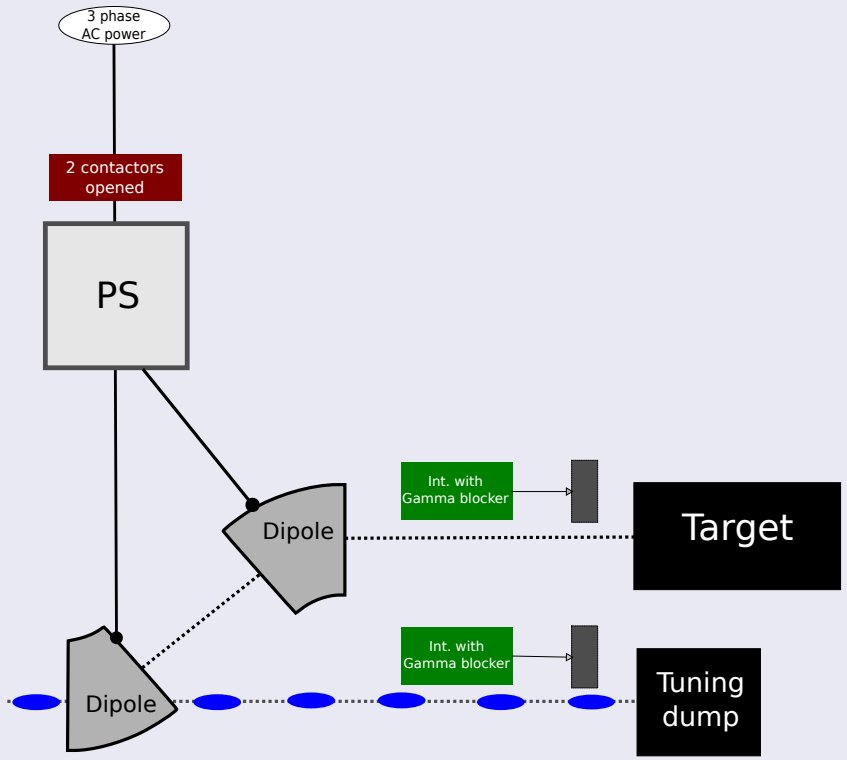








Beam to tuning dump



Interfaces status

Interfaces	Hazard/Mitigation	Status	Actions required
Ion Source	2 actuator systems to stop the beam	ICD in preparation	Baseline documents
RF for RFQ	1 actuator system to stop the beam	ICD in preparation	Baseline documents
RF for MEBT bunchers	Prevent X-rays in the tunnel	ICD in preparation	Baseline documents Design choice for coax switch
RF systems	Prevent X-rays in the tunnel	ICD in preparation	Baseline documents WG: Shutter switch, PSS flange?
Dipoles	Electrical Radiation in the target area	Discussion started Only conceptual ideas	Detailed design
Gamma blockers	Radiation	Discussion started Only conceptual ideas	Detailed design Radiation calculations

- Choices for switches of the coaxial and the WG to be made to allow RF test mode
- More details on the design of the Gamma blockers and the dipoles are necessary
- **Interfaces between PSS and the accelerator seem to be in general well identified**
- **However a global effort from AD to produce a "formal" detailed hardware baseline is mandatory**

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Accelerator tasks

PSS review in July 2016

The PSS review committee has addressed a messages to the AD: "Current Accelerator design does not contain sufficient detail for PSS to perform the required Hazards Analysis and support detailed design; in particular interfaces are not well enough known to support PSS design"

Linac detailed technical baseline for PSS

- The information exists in most cases (not always!) but at different levels of completion, in different formats and not always approved formally
- It has been sometimes difficult to get the required level of information from our in-kind partners
- The integration section with the support of the ACCSYS WPs is leading a global effort to document our linac technical baseline:
  - Among other documents: design specifications, cable list, interfaces, racks, etc.
  - Track of changes, formal chain of approval
  - Single folder in CHESS
- Weekly meeting: PSS team with stakeholders
- Main objective is to have a "minimal baseline configuration" to allow the PSS team to proceed and finalize the design of PSS 1 thus to be ready for the start of the beam commissioning in November 2017

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TSS

Beam off systems

- Ion Source:
  - A pair of contactors (same strategy as for PSS but not the sanme contactors!) on the incoming power cable to the HVPS
  - Two racks in separate rows and two cabinets with contactors have been allocated in FEB
- RF for RFQ: Two options for placement of contactors
  - 2 contactors in CF substation
  - 1 contactor in CF substation + 1 contactor in gallery

High energy bending magnets

- Need to prevent the beam from hitting the target when the latter is not ready
- Proposal to use manually locked contactors at power circuit to dipole magnets

Status

- ICDs for TSS-Accelerator containing all the relevant information exists and needs to be updated
- More analysis is necessary for the bending magnets
- Investigations on how to limit the beam power onto the target and the tuning dump are on-going

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Conclusions

- Lots of "work in progress"
- A long way to go
- Very good dynamic in place with talented teams
- Support from AD is mandatory
- Collaboration spirit beyond the divisional aspects is a key towards success

Many thanks to:

- ACC-MPS WG: R. Andersson, E. Bargalló, A. Nordt
- PSS team: S. Birch, Y. Kian Sin, M. Mansouri, D. Paulic
- TSS team: L. Coney, M. Olsson, A. Sadeghzadeh
- M. Zaera Sanz for developing the PLC-based systems
- and all AD, ICS and TGT members who are making this work possible

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