ICALEPCS 2017

EUROPEAN SPALLATION SOURCE

ESS Accelerator Safety Interlock System

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ESS/ICS/PS

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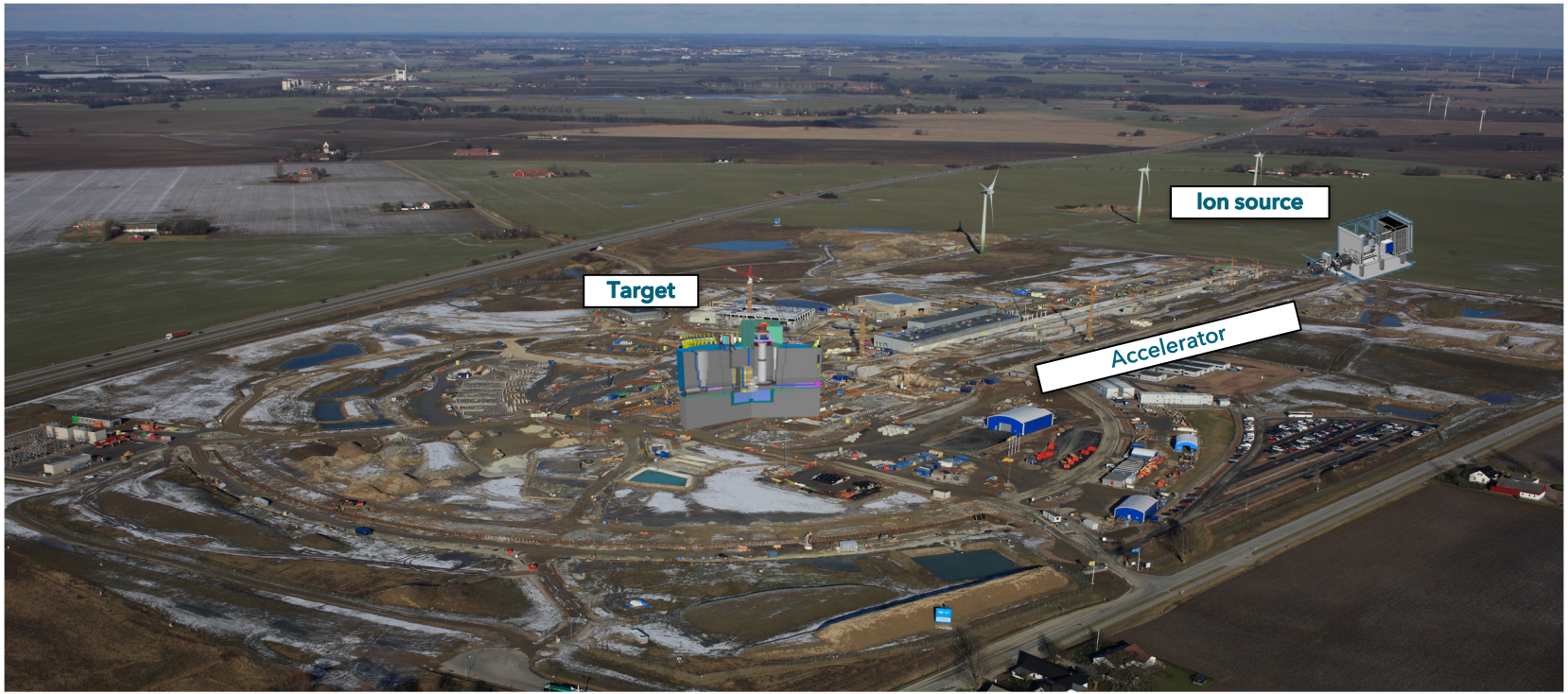
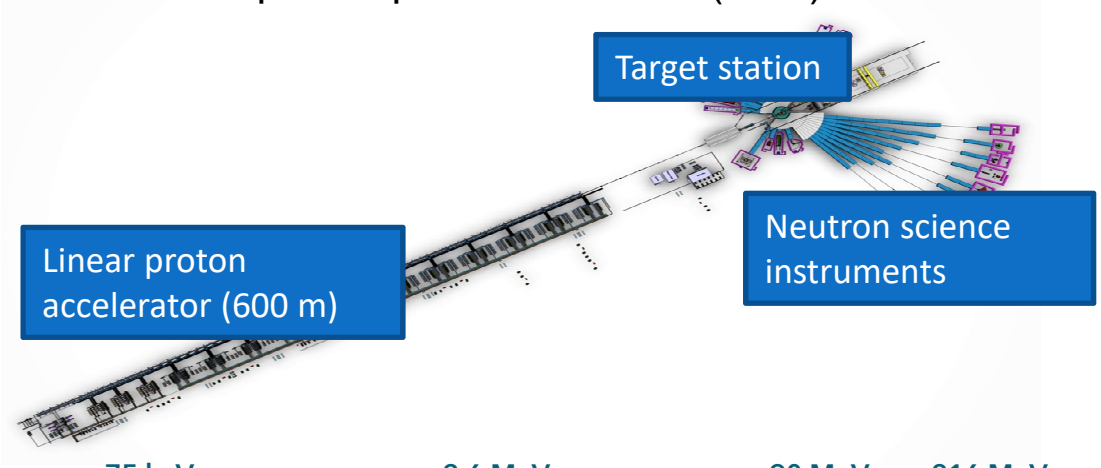
ESS Overview



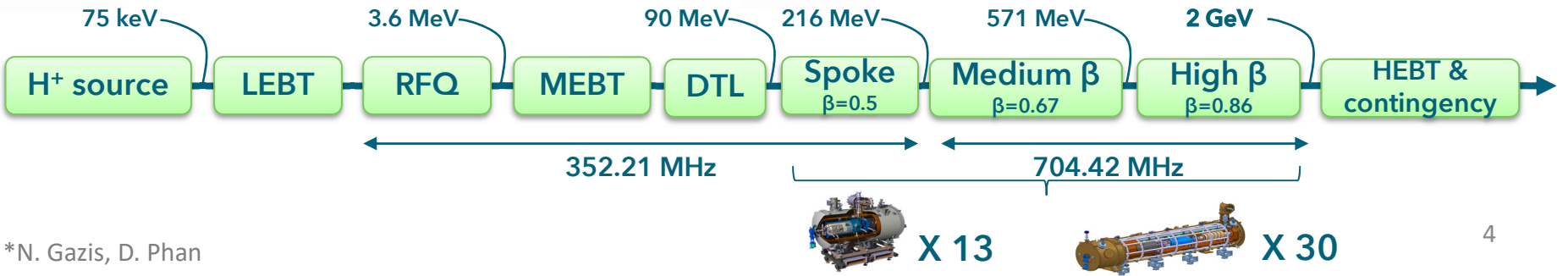
*D. Phan

ESS Linac Overview

- The European Spallation Source (ESS) will house the most powerful proton LINAC ever built.



Parameter	Value	Units
Max energy	2	*GeV*
Peak current	62.5	*mA*
Repetition rate	14	*Hz*
Pulse length	2.86	*ms*
Average power	5	*MW*
RF frequency	352/704	*MHz*
Maximum losses	1	*W/m*



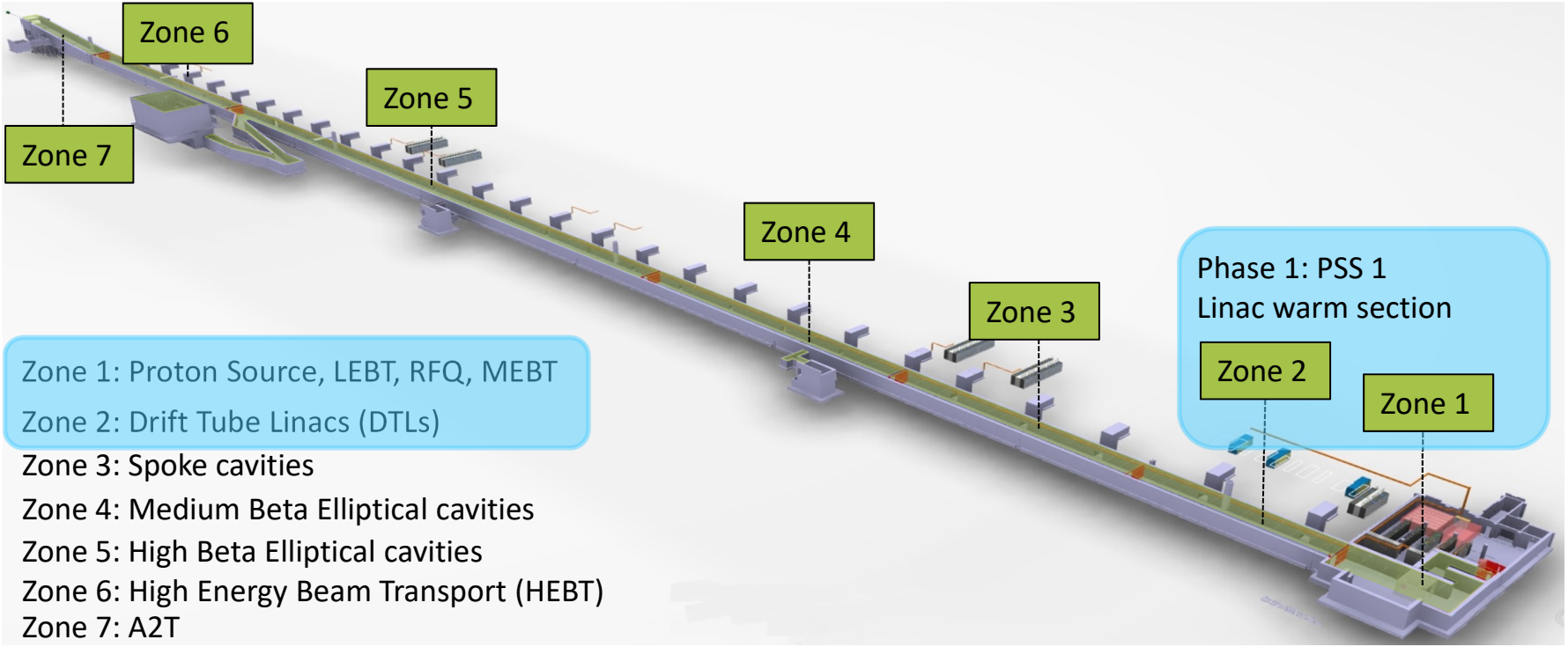
*N. Gazis, D. Phan

Governance for PSS

- **IEC 61508 : 2010**
  - Functional safety of electrical/electronic/programmable electronic safety-related systems
- **IEC 61511 : 2016**
  - Functional safety - Safety instrumented systems for the process industry sector
  - PSS Application Program
    - IEC 62443 - Security for Industrial Automation and Control Systems
    - NIST Special publication 800-82: Guide to Industrial Control Systems (ICS) Security
- **The Swedish Radiation Safety Authority (SSM)**
  - Radiation risk analysis shall be carried out before the facility is taken into operation.
  - A formalised search of each PSS controlled area shall be carried out before the facility is operated.
  - Two independent technical design solutions will be used in each system.
  - External events, single failure, common cause failure, redundancy, diversity, separation

NIST = National Institute of Standards and Technology

Accelerator PSS Overview



Zone 1: Proton Source, LEBT, RFQ, MEBT

Zone 2: Drift Tube Linacs (DTLs)

Zone 3: Spoke cavities

Zone 4: Medium Beta Elliptical cavities

Zone 5: High Beta Elliptical cavities

Zone 6: High Energy Beam Transport (HEBT)

Zone 7: A2T

*M. Mansouri

Accelerator PSS Subsystems

- **Safety Interlock System (SIS)**
  - If the area is searched and Beam requested → Allow Beam operation
  - If Access is allowed → Prevent Beam operation
  - If Emergency → Hard switch-off all hazardous equipment
    - Intrusion into PSS controlled area
    - Increased radiation levels (Radiation high) in supervised areas
    - Manual request (Emergency stop)
- **Access Control System (ACS)**
  - Controling (preventing) the entry to PSS controlled areas
    - Authorisation and authentication
    - Double-gated access stations and their subsystems
  - Signalisation lights and sounders
- **ODH Detection System**
  - If oxygen level is below treshold → No Access, activate red lights and sounders

ODH = Oxygen Deficiency Hazard

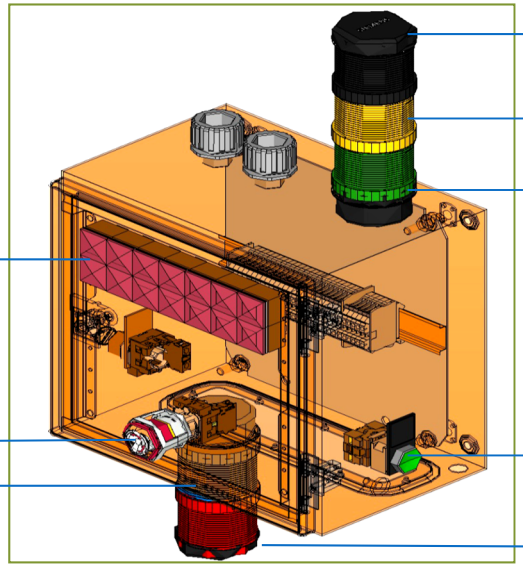
Accelerator SIS Hazards

- Ionising prompt radiation from the proton beam
- Ionising prompt X-Ray radiation from the RF systems
- Electrical hazard (high voltage)
- Magnetic field hazard
- Radio frequency (RF) field hazard

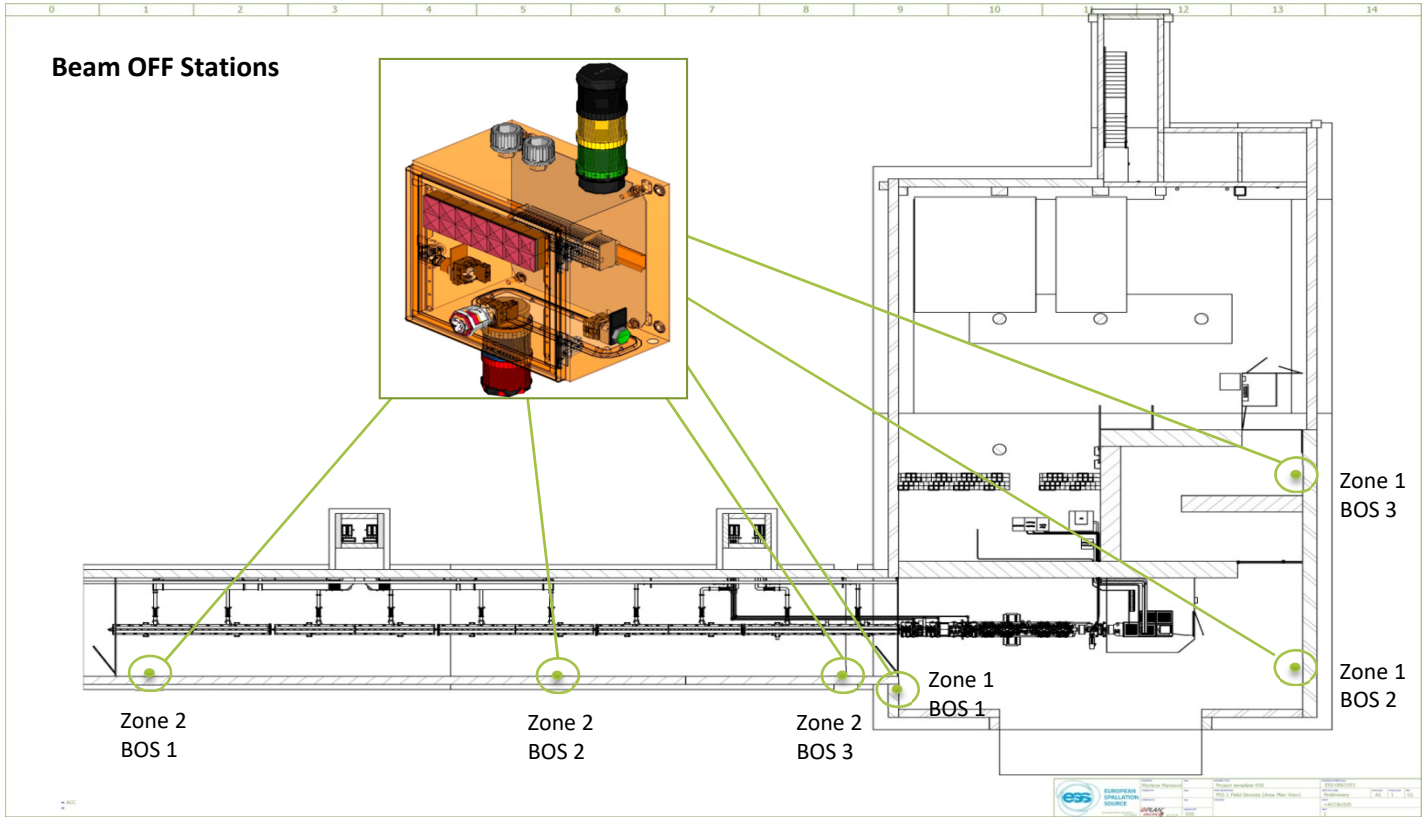
Accelerator SIS Overall Requirements

- **Switch off beam and all hazardous equipment** if anybody tries to enter the PSS controlled area during the operation of beam and/or any of the hazardous equipment.
- Provide a solution to **manually switch off beam** and hazardous equipment from inside the PSS controlled area.
- **Prevent beam operation** and operation of hazardous equipment **if access** to PSS controlled area is allowed.
- **Switch off** the proton beam upon receiving an interlock signal from the radiation monitoring system that has detected an elevated dose critical for personnel in a specific/controlled (monitored) area.
- **Prevent all hazardous equipment operation**, which is not procedurally prepared for testing, if access to PSS controlled area is allowed.

Beam OFF Station Prototype



Beam OFF Stations Placement in PSS1



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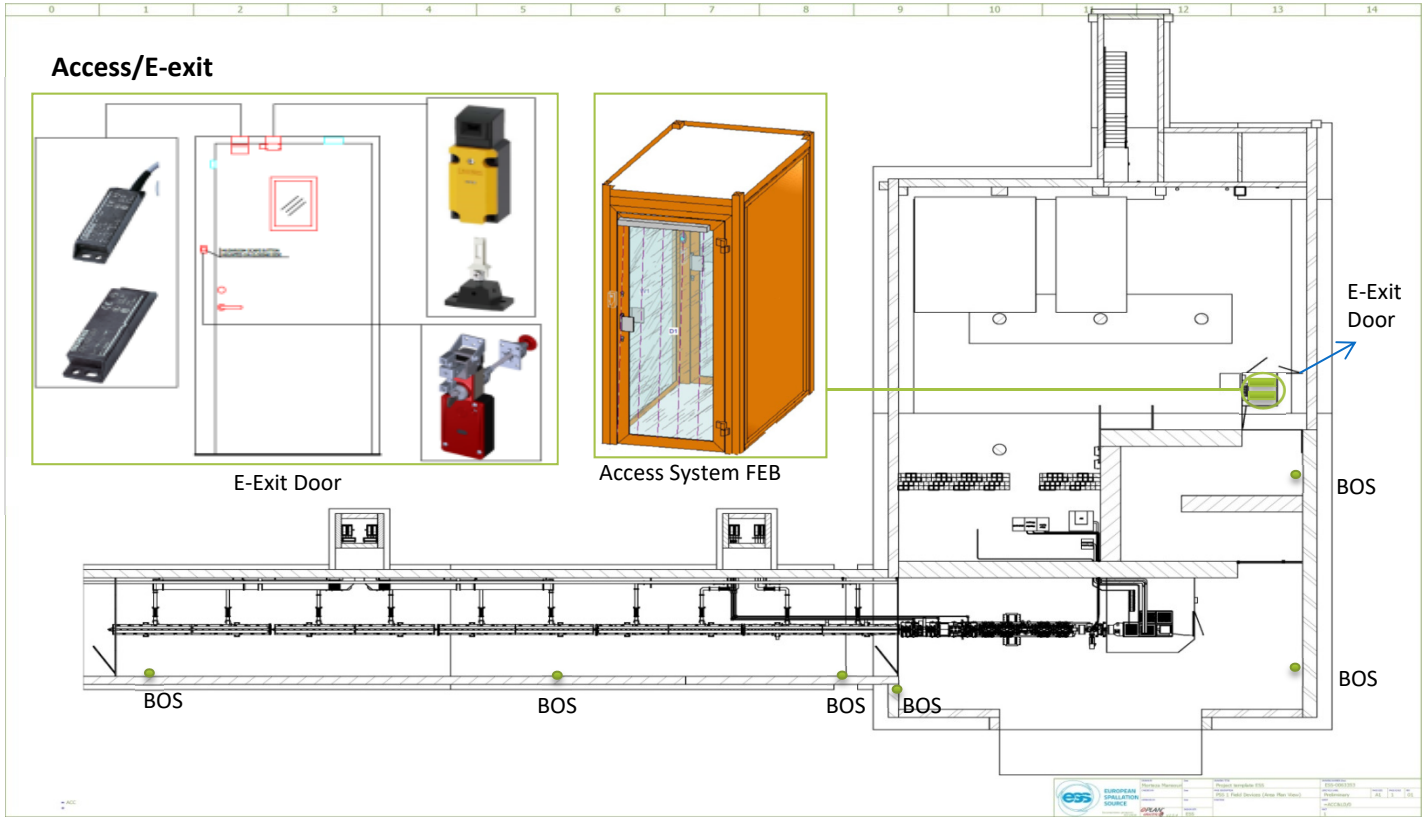
Access & E-exit Doors



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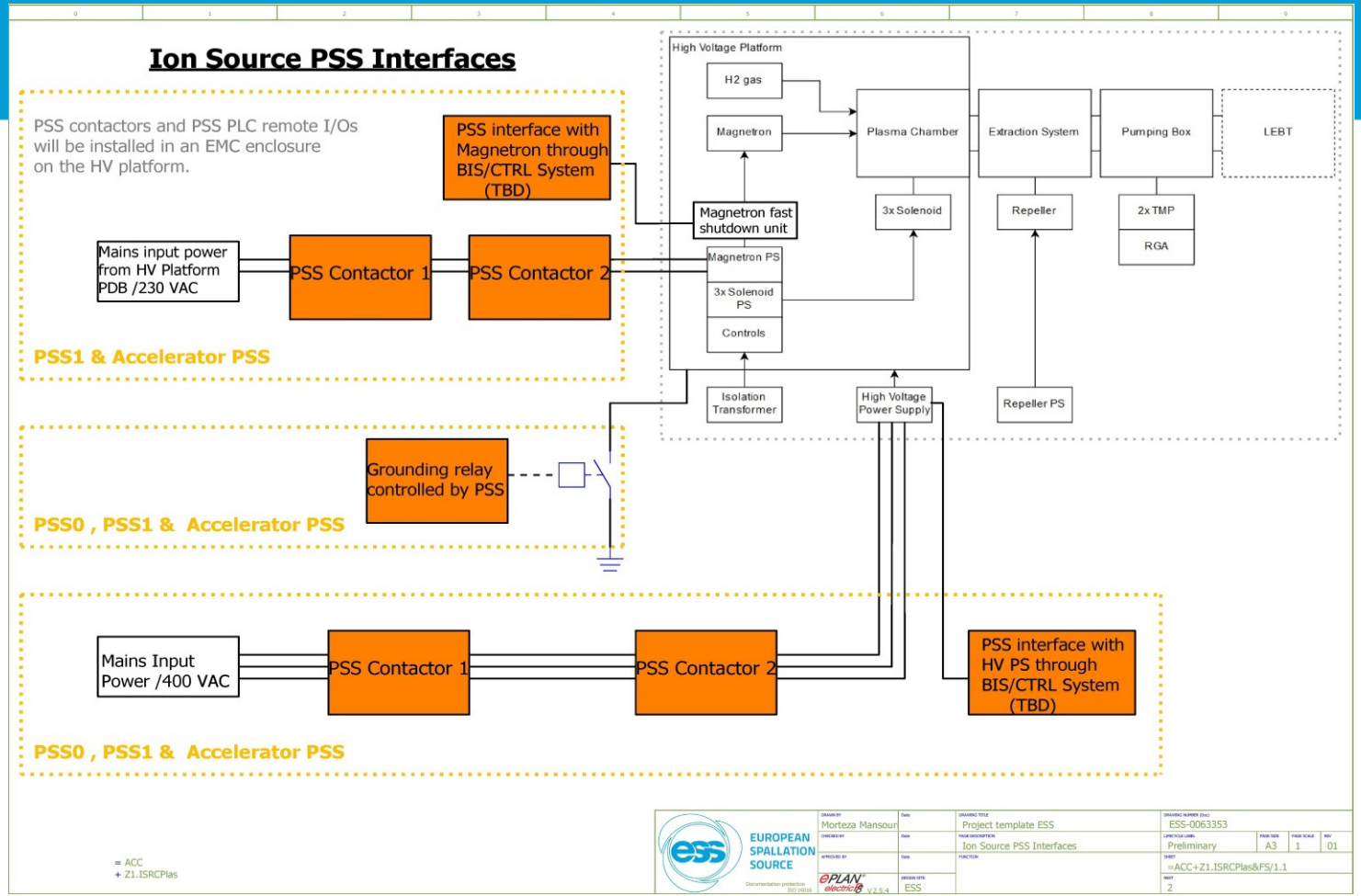
Accelerator SIS Interfaces

- Switching-off the proton beam and mitigation against high voltage:
  - The Ion source plasma generator system
  - The Ion source extraction system
  - The RFQ modulator system
- Mitigation against X-ray hazards:
  - MEBT bunchers solid state amplifiers
  - Drift Tube Linacs modulator systems
  - Spoke cavities tetrodes
  - Elliptical medium beta cavities modulator systems
  - Elliptical high beta cavities modulator systems

Interface Example: Ion Source



- Positively driven (mirror) contacts
- "Safety Contactors" according to IEC 60947-4 Annex F

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Implementation

- All safety equipment will be powered by Uninterruptible Power Systems (UPS).
- Two independent Siemens S7-1518 F-PLCs will be used for functional safety implementation, principally through safety functions in the software (TIA Portal V14 SP1).
- All sensors and actuators for Accelerator SIS will be connected locally to the Siemens ET200SP distributed I/O stations with fail-safe I/O modules.
- The Accelerator SIS application program will follow IEC61511 development lifecycle.
- The concept, design, devices and all procedures will be tested and verified in PSS test stand to ensure the SIS safety functions.
- After commissioning, all modifications in the system/software will strictly follow the rules from PSS configuration management.

Questions?

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Thank you for your attention!