EUROPEAN SPALLATION SOURCE

Machine protection plans in ESS

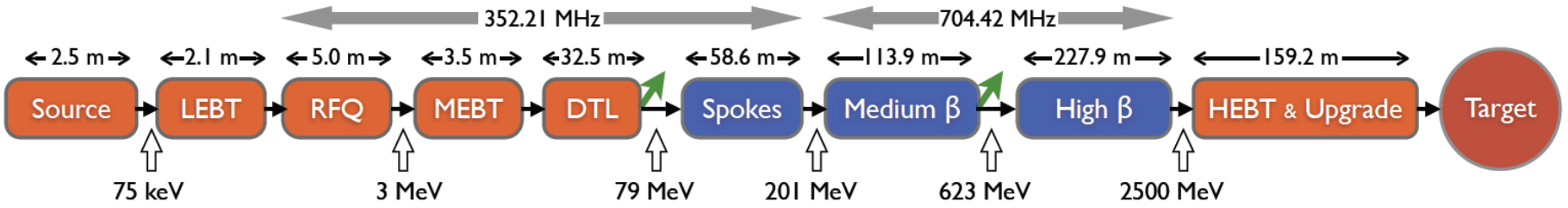
Overview

- About ESS & Cosylab
- Machine Protection System
  - Overview
  - Requirements
  - Functionalities as services
  - Reliability & safety
- Questions & open dilemmas

About Cosylab

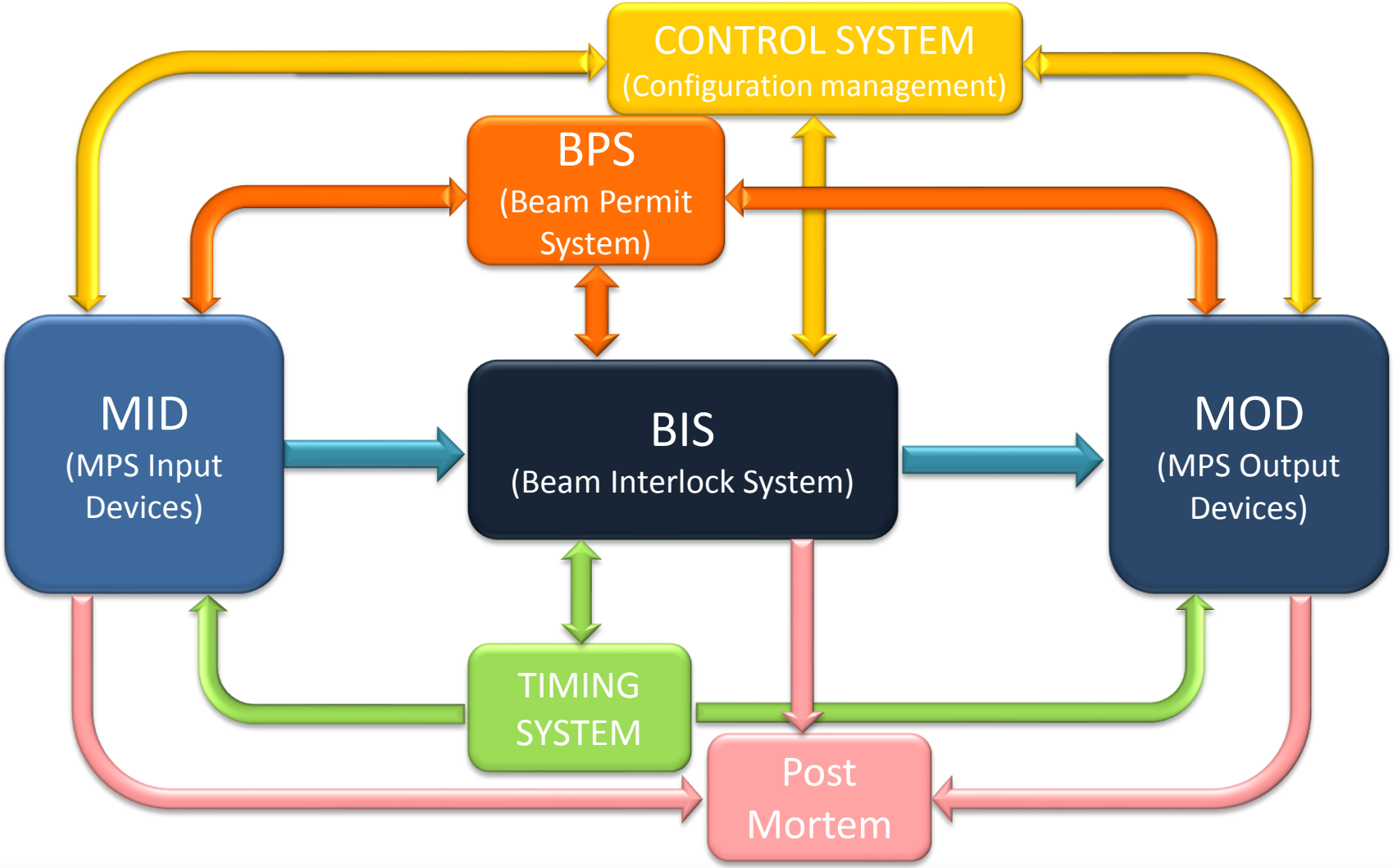
- Cosylab is a company with 65 engineers, providing solutions in the area of **Control System** for large physics experiments
  - Conceptual studies
  - Device integrations
  - Complete timing system solution
  - Core CS development: EPICS (v4), ACS...
- Our customers are from more the 50 labs from all over the world: ITER, ESS, SNS/ORNL, MedAustron, etc...
- Our collaboration with ESS Control System group (Garry Trahern) is currently covering control system box, timing system, MPS and database

European Spallation Source

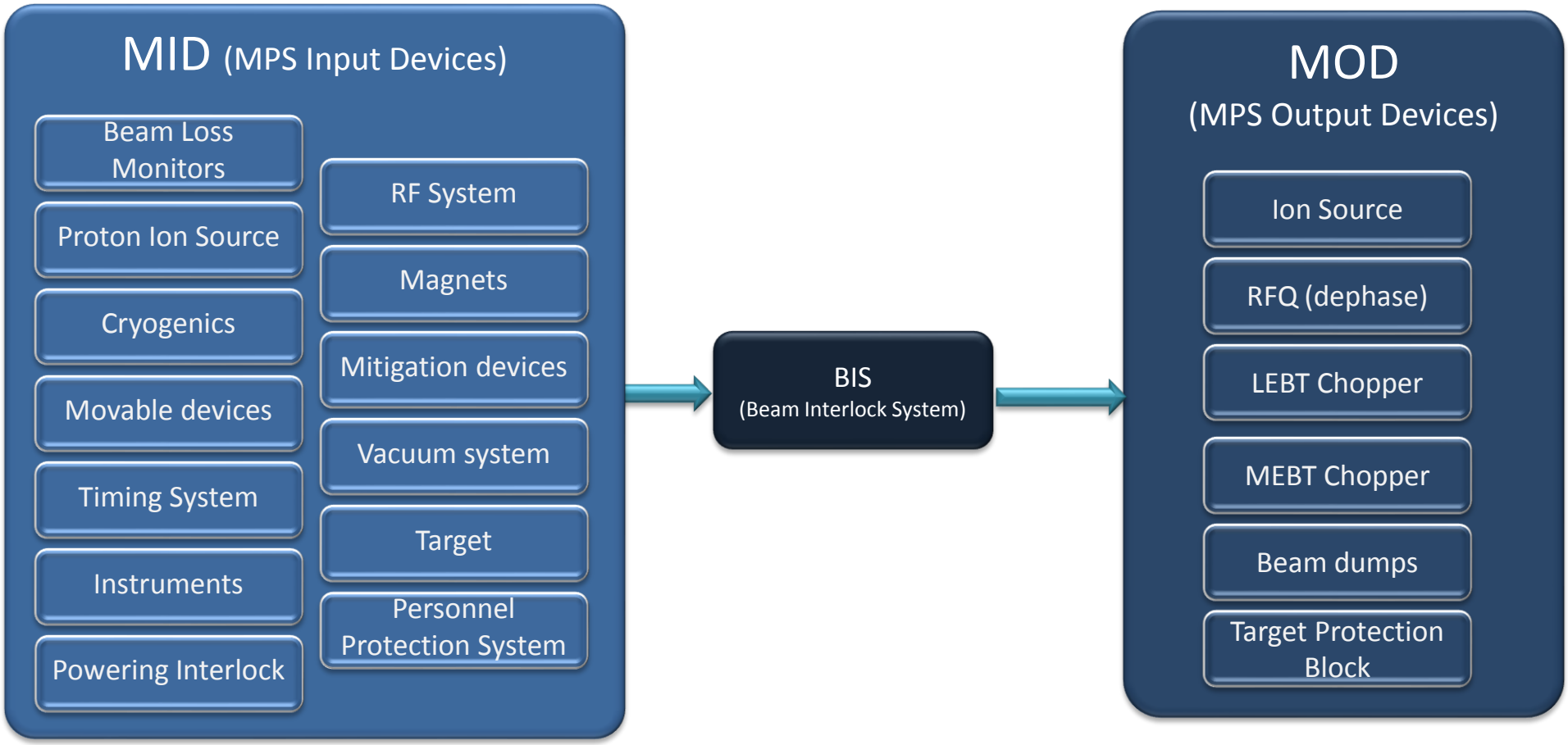


- Length: 605.2m
- Proton kinetic energy: 2.5GeV
- Beam Power: 5MW
- Pulse length: 2.86ms
- Pulse repetition rate: 14Hz

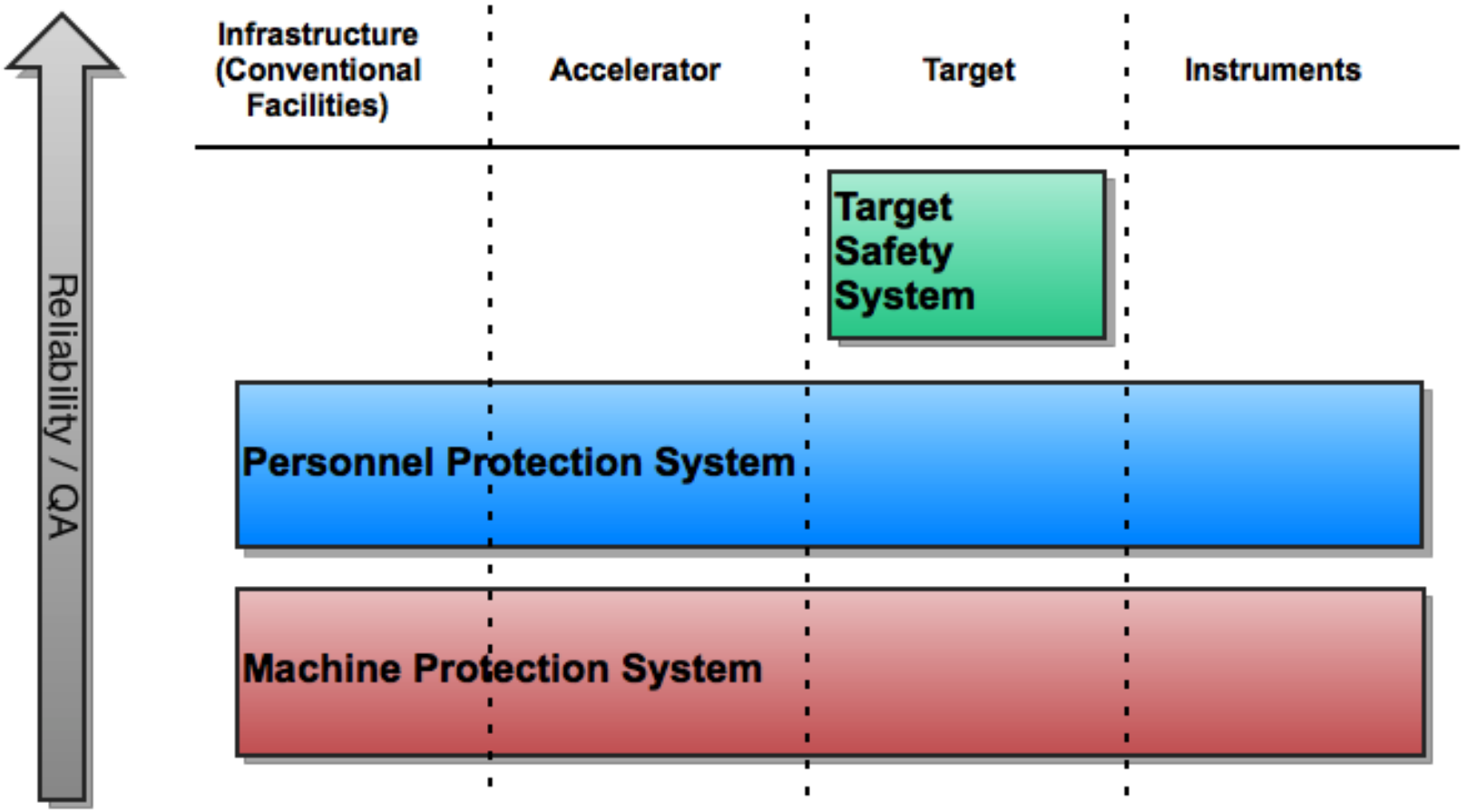
Machine Protection System



Machine Protection System



MPS, PPS and TSS relation



MPS as a service

- MPS provides service to many devices
  - Around 1000 MID devices (inputs)
  - Few MOD devices (outputs)
- Two main services:
  - Beam Permit
  - Beam Interlock
- Additional services like:
  - Support for different machine modes
  - Support for commissioning phase
  - Support for post-mortem

Beam Permit

- BPS (Beam Permit System) validates all devices including BIS devices
- If configuration is correct, BPS issues Beam Permit
- BPS revokes Beam Permit after BIS stops the beam/machine
  - Can any other system stop the machine? Which one?

Beam Interlock

- Fast Beam Abort
  - Stop the beam a.s.a.p.
    - If the machine is in the middle of the pulse, abort it
  - Required response time 5-10µs
    - MID detection time + BIS time + MOD mitigation time
    - Exact times under evaluation
    - Propagation delay must be taking into account (3µs for 600m)
- Next Pulse Inhibit
  - MPS allows current pulse to finish, but prohibits next one
  - Pulse repetition rate 14Hz -> 68ms for response
  - Who is responsible to know when the pulse finishes?
    - BIS or mitigation device

Support for machine modes and commissioning phase

- Different configurations for different machine modes
  - Machine mode might change during run-time
- Input masking
  - Ignoring non-critical inputs temporarily (as long as the machine is in safe mode)
  - Masked signals will be logged
- Step-by-step commissioning
  - MPS grows with the machine

Support for Post-Mortem

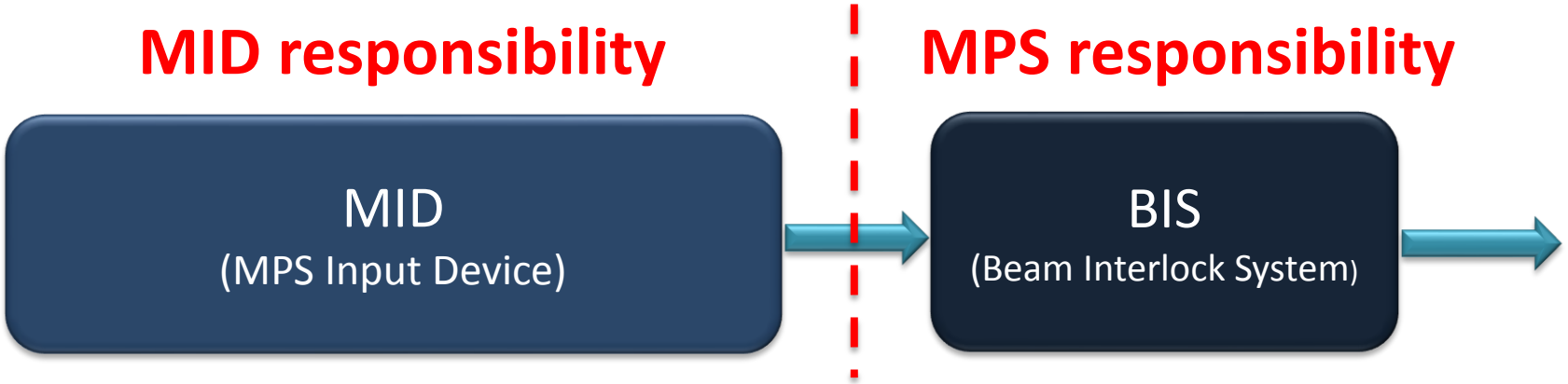
- Data from operational MID devices will be logged
  - Circular buffers may be overwritten
  - MPS tells when to stop logging (via TS)
- BIS devices log all signal changes with precise timestamp
  - All BIS devices are synchronised with TS
- Post Mortem analysis
  - Collect logs from all devices (MID, MOD, BIS)
  - Merge into a single timeline
  - Provide different views on what was happening, which device caused machine to stop, etc.

Reliability and safety

- ESS targets high reliability – 95%
- MPS reliability assured with
  - Fail-safe design
  - Redundancy
  - Self-diagnostics
- MPS safety
  - SIL3 ?
- MPS security
  - Configuration security: who can change settings?
  - (Re)Start security: Who has rights to (re)start the machine? What are restart preconditions?

Other questions and open issues

- MPS responsibility boundaries

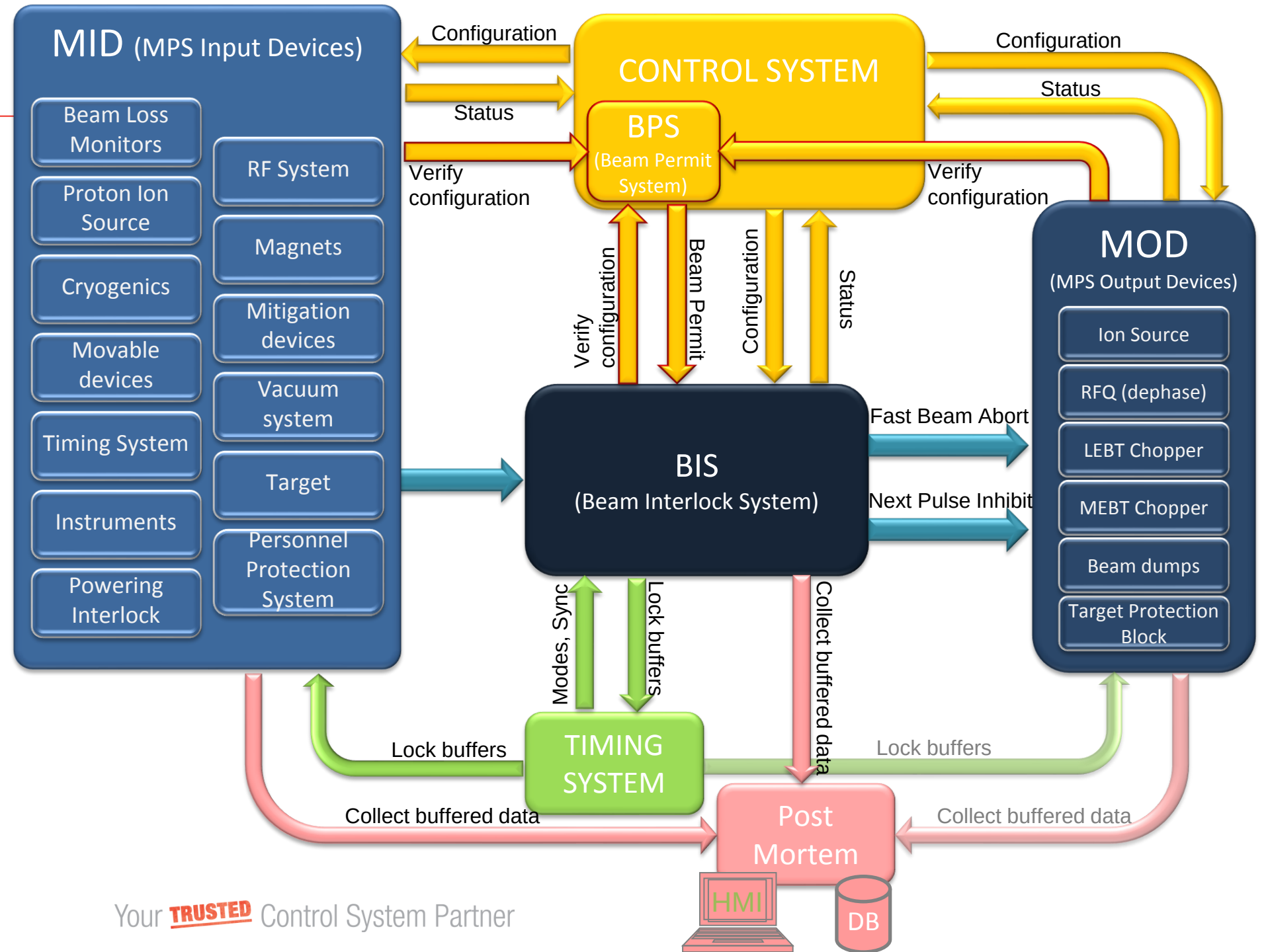


  - "Device Integration guidelines" should be prepared
- Machine modes/operation modes
- Confirmation on existence of mitigation devices
- MPS reliability assessment - failure catalogue

The End

Thank you!

Backup


MID (MPS Input Devices)
Beam Loss Monitors
Proton Ion Source
Cryogenics
Movable devices
Timing System
Instruments
Powering Interlock
RF System
Magnets
Mitigation devices
Vacuum system
Target
Personnel Protection System
Configuration
Status
Verify configuration
CONTROL SYSTEM
BPS
(Beam Permit System)
Configuration
Status
Verify configuration
MOD
(MPS Output Devices)
Ion Source
RFQ (dephase)
LEBT Chopper
MEBT Chopper
Beam dumps
Target Protection Block
Verify configuration
Beam Permit
Configuration
Status
BIS
(Beam Interlock System)
Fast Beam Abort
Next Pulse Inhibit
Modes, Sync
Lock buffers
Collect buffered data
TIMING SYSTEM
Lock buffers
Lock buffers
Collect buffered data
Collect buffered data
Post Mortem
HMI
DB
Your TRUSTED Control System Partner

Customers From Nearly All Major Labs Worldwide

COSYLAB