EUROPEAN SPALLATION SOURCE

The Modular Control Concept of the Neutron Scattering Experiments at the European Spallation Source ESS

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www.europeanspallationsource.se

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Outline

- The European Spallation Source
- Neutron Beam Characteristics
- Neutron Beam Line + End Station = Instrument
- Challenges and Requirements for a Control System
- Modular Instrument Control Concept
- Time Stamping and Synchronisation
- Use Cases: Motion Control + Robotics
- Acknowledgments

ESS – a collaborative project

EUROPEAN SPALLATION SOURCE

Aarhus University
CEA Saclay, Paris
CNRS Orsay, Paris
ESS Bilbao
INFN, Catania
Lund University
Uppsala University
Accelerator Science and Technology Centre, Daresbury and Oxford
CERN, Geneva
Cockcroft Institute, Daresbury
DESY, Hamburg
ESS Bilbao
Fermi National Laboratory, Chicago
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National Centre for Nuclear Research, Poland
Oslo University
Rostock University
Spallation Neutron Source, Oak Ridge
Stockholm University
Techical University of Darmstadt
Nuclear Physics Institute Of The ASCR
Czech Technical University, Prague
Aarhus University
University Of Copenhagen
University Of Southern Danmark
Technical University Of Danmark - DTU
Institut Laue-Langevin - ILL
Laboratoire Léon Brillouin - LLB
Wigner Institute, Budapest
Helmholtz-Zentrum, Geesthacht
Technical University, Munich
Forschungszentrum, Jülich
Elettra-Sincrotrone Trieste
Università Di Perugia
Consiglio Nazionale Delle Ricerche
Delft University Of Technology
Institute For Energy Technology, IFE
Linköping University
Mid Sweden University
École Polytechnique Fédérale De Lausanne - EPFL
Paul Scherrer Institute - PSI

ESS – 17 European partner countries

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National Centre for Nuclear Research, Poland
Oslo University
Rostock University
Spallation Neutron Source, Oak Ridge
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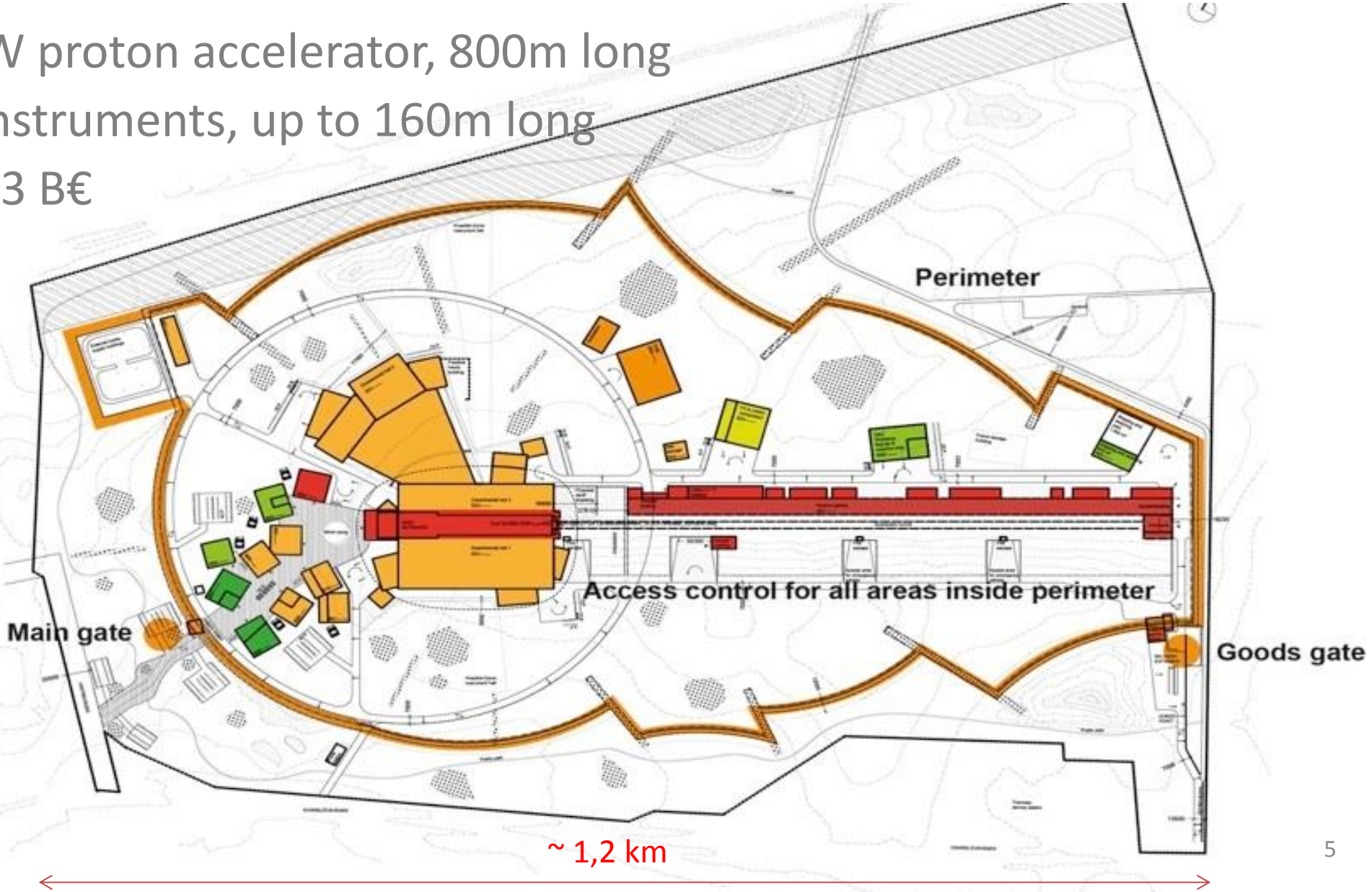
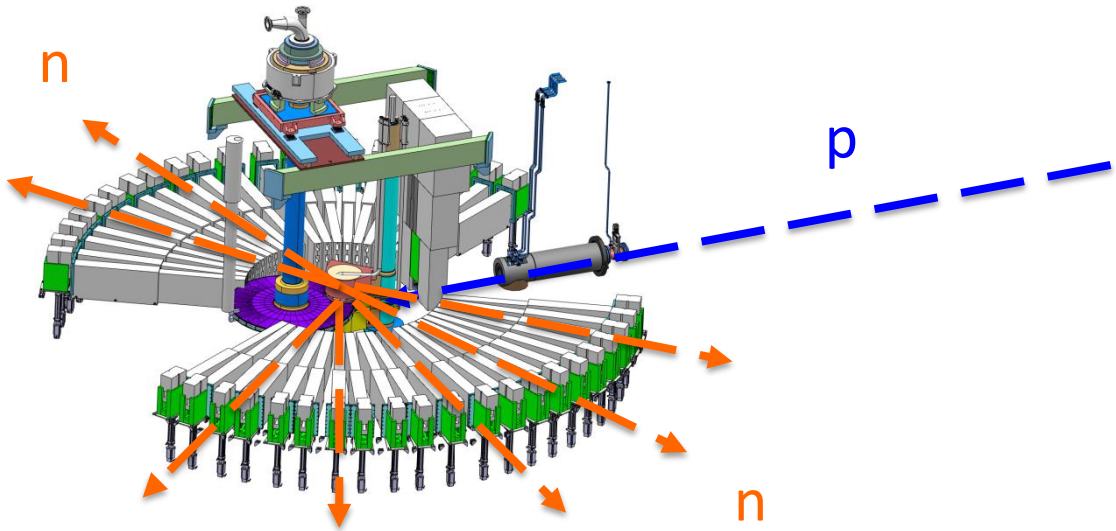
ESS – worlds most powerful source of neutrons
(for science applications)

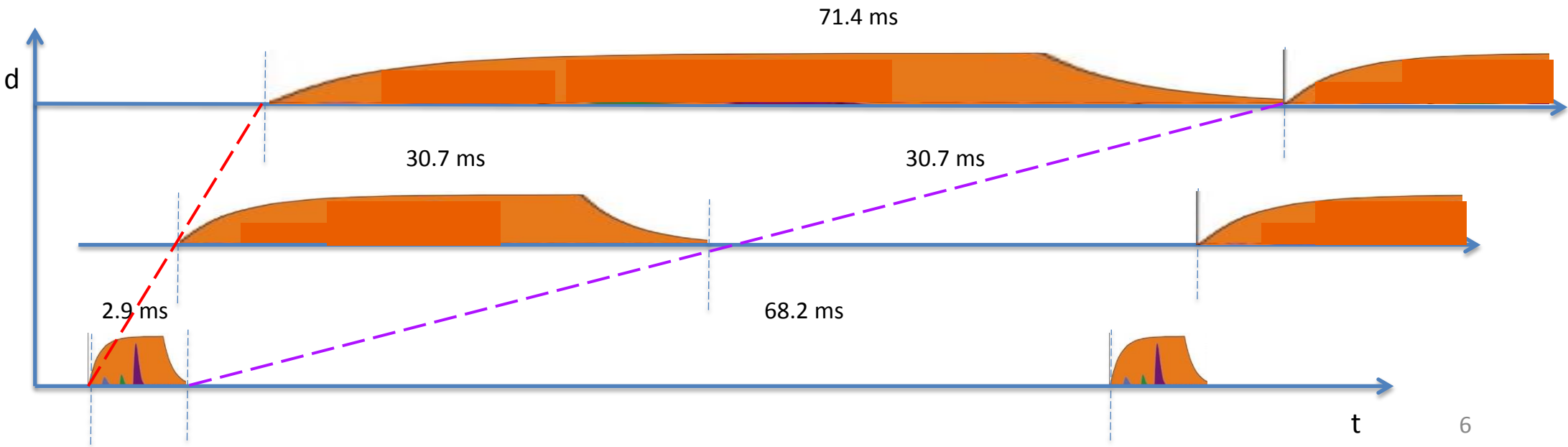
- 5MW proton accelerator, 800m long
- 16 instruments, up to 160m long
- 1.843 B€



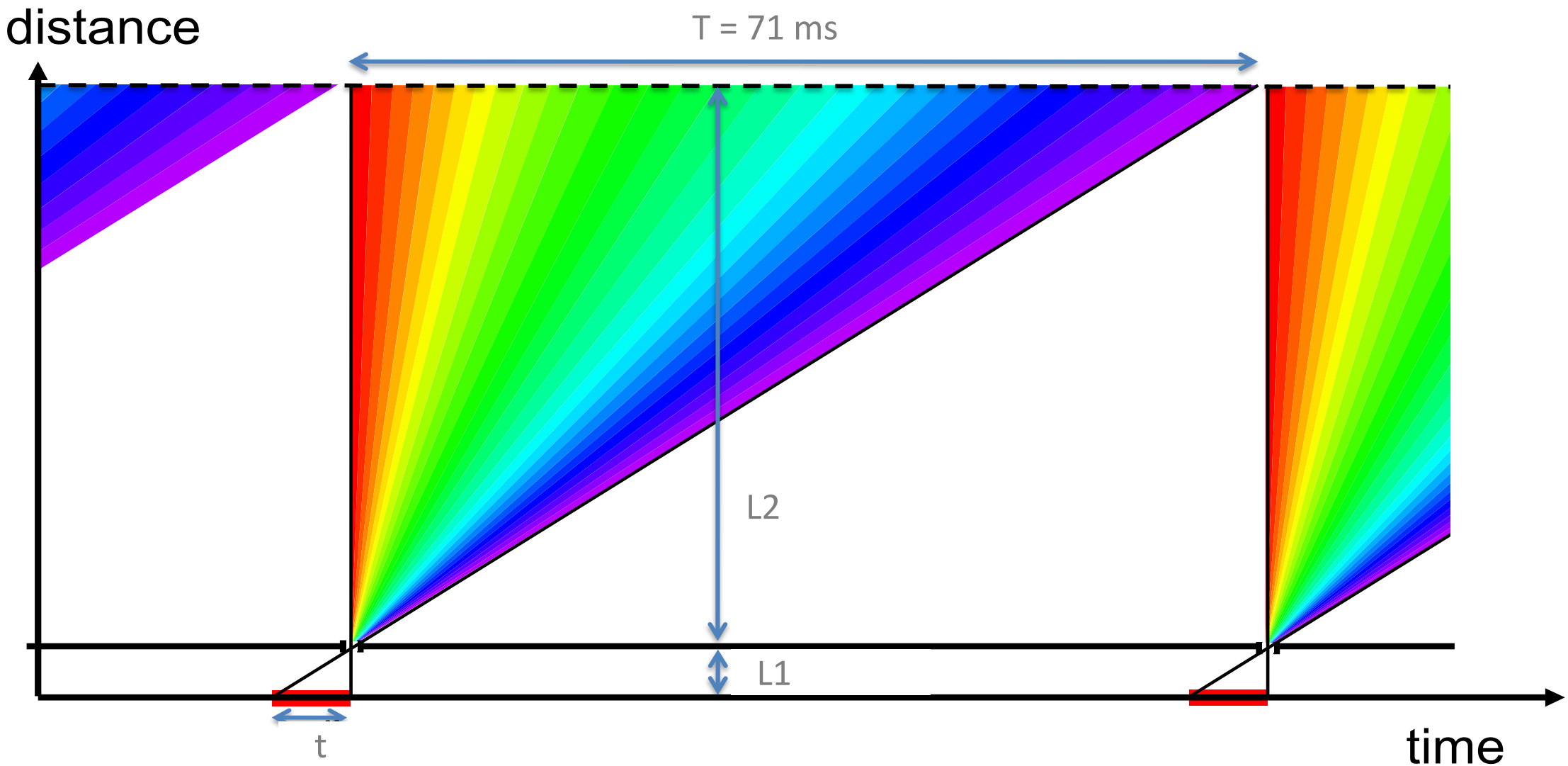
Neutron Beam Characteristics



- 14 Hz rep rate
- 71.4 ms cycle time
- 2.86 ms pulse time
- 4% duty cycle
- Energy range meV to eV, speed 2000 – 200 m/s



Time Distance Diagram and Instrument Length

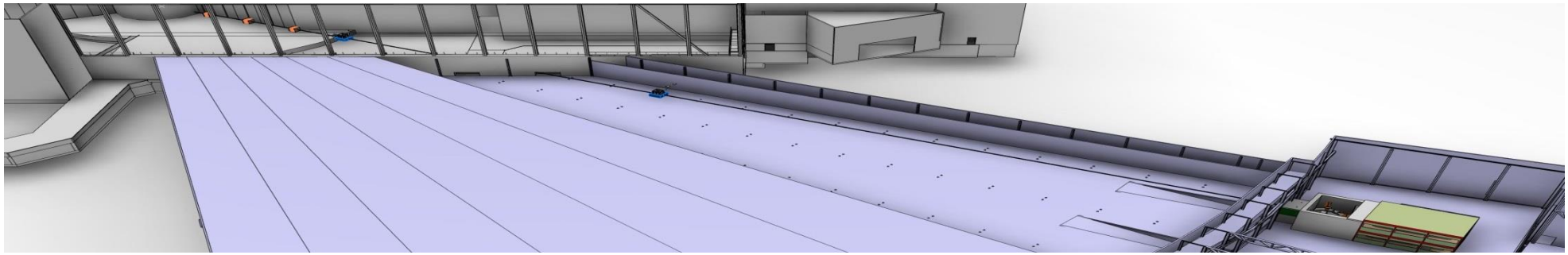


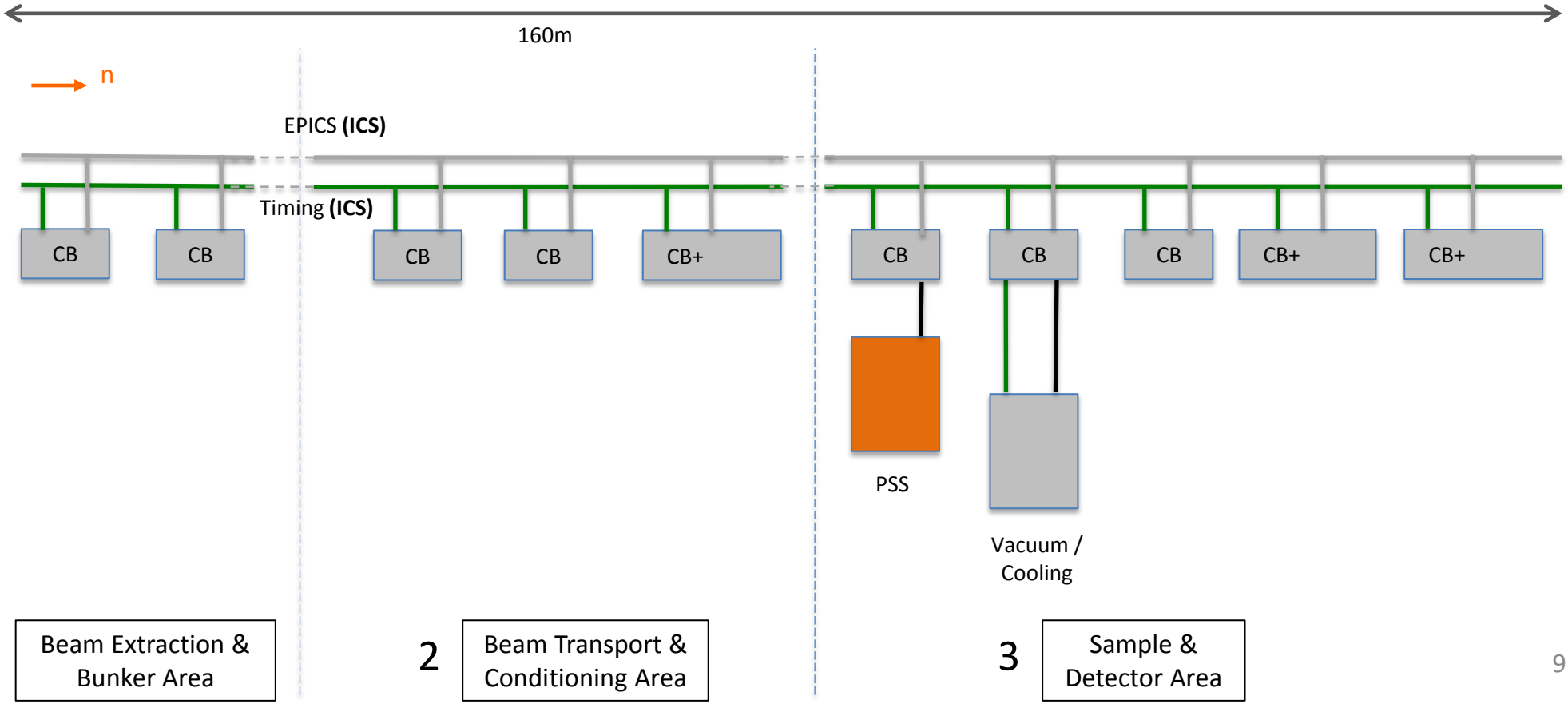
White beam instrument with mechanical chopper, instrument length up to 160m

Challenges and Requirements

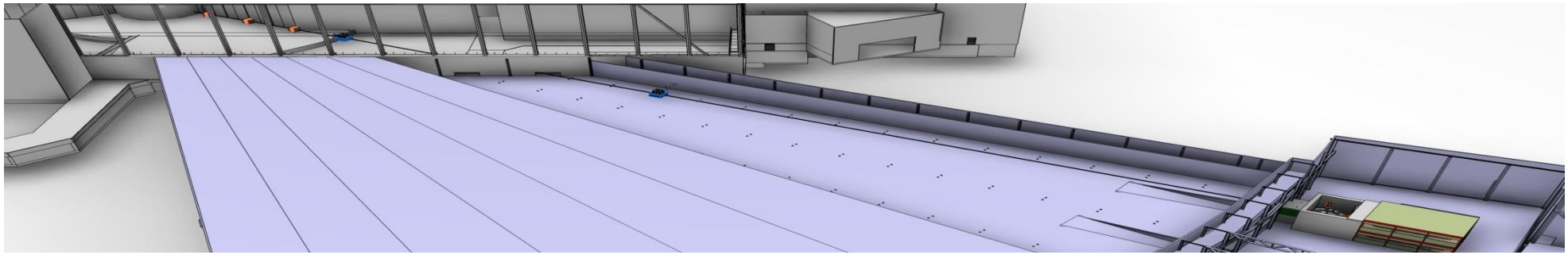
- Organisational (in-kind)
  - Standardized controls infrastructure provided by ESS
  - Need for modularity and clear interface definitions
- Technical (pulsed neutron source, large area)
  - Distribution of centralised timing signal
  - Synchronisation experiments to proton pulse
  - Time stamping of data
  - Electrically separate parts of instruments into zones (grounding concept)
- Operational (large area, high availability, limited access)
  - Advanced diagnostics tools, remote diagnostics
  - Standardised modules, easy to replace
  - Preemptive maintenance

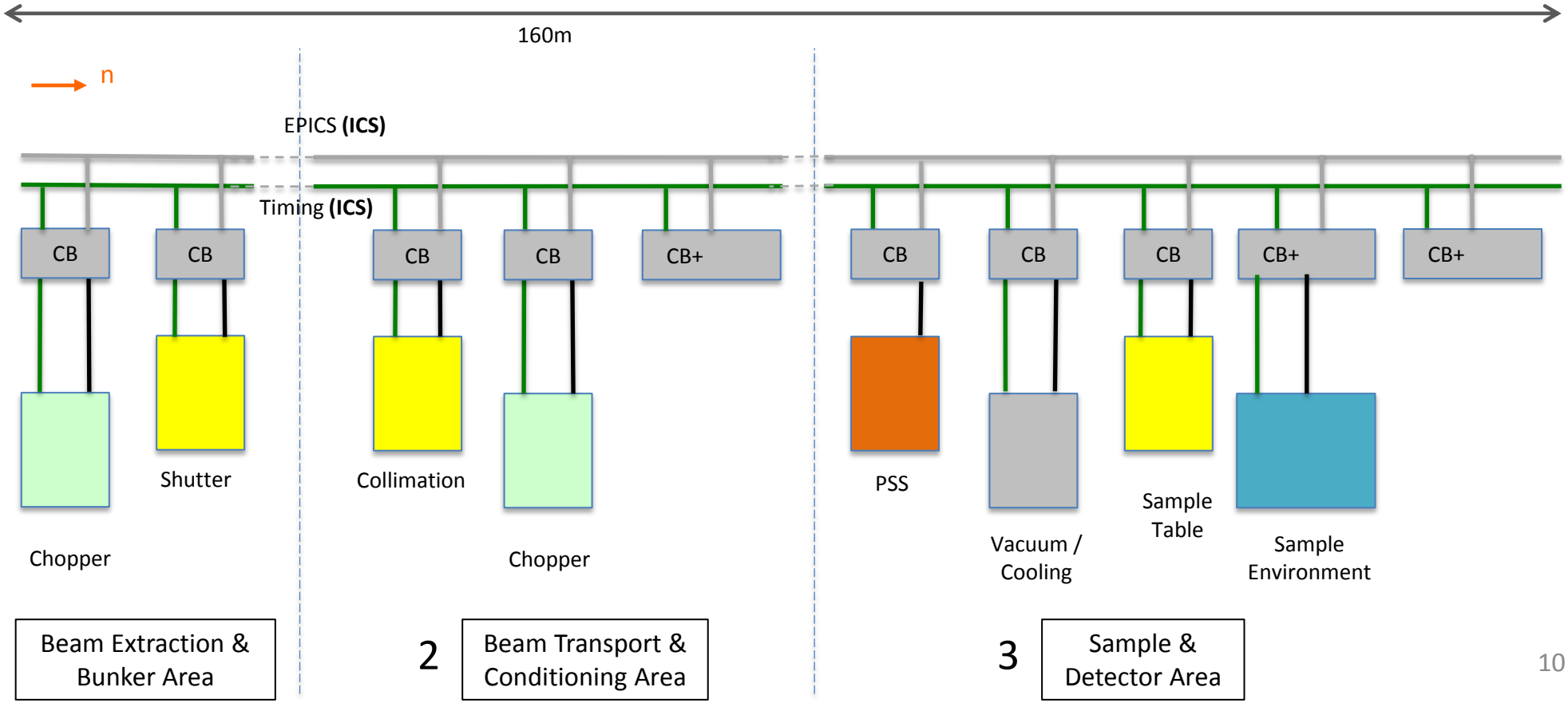
Modular Instrument Control Concept



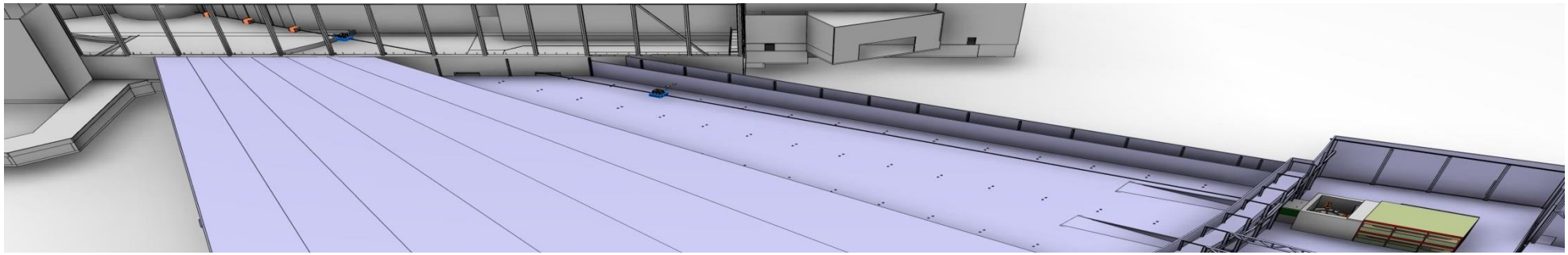


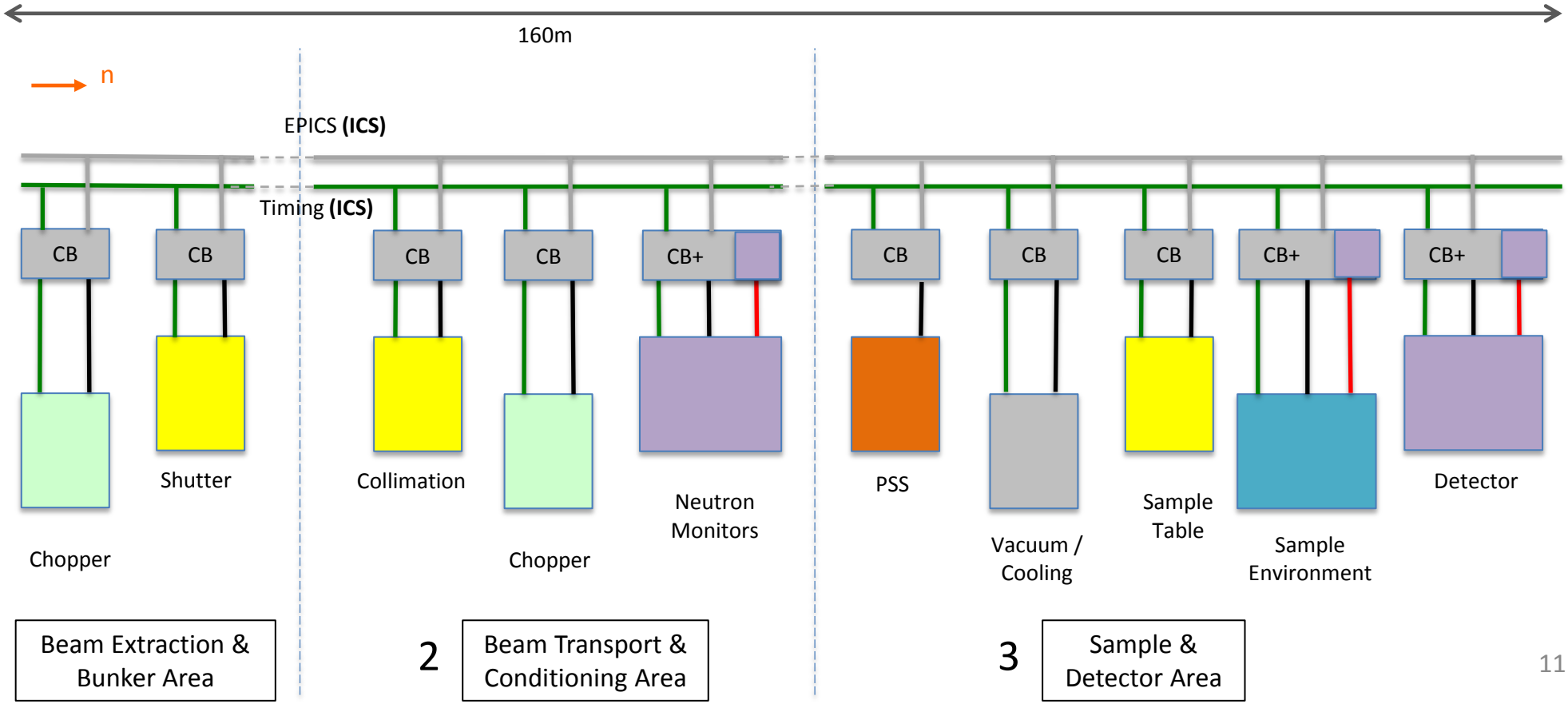
Modular Instrument Control Concept





Modular Instrument Control Concept





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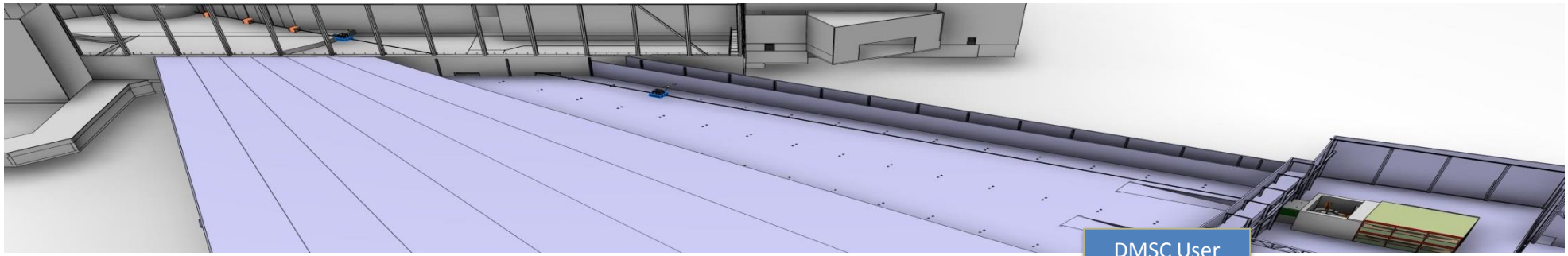
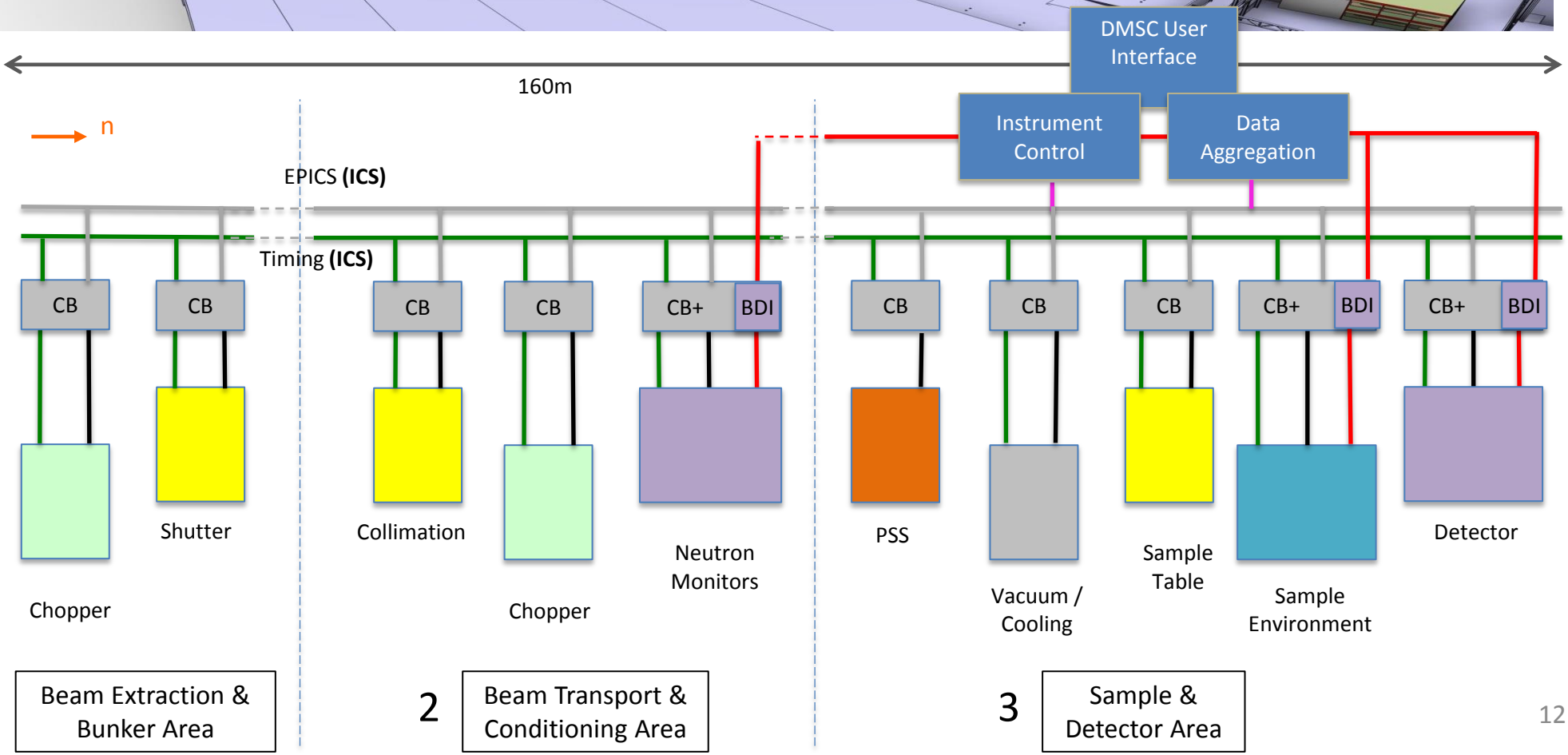
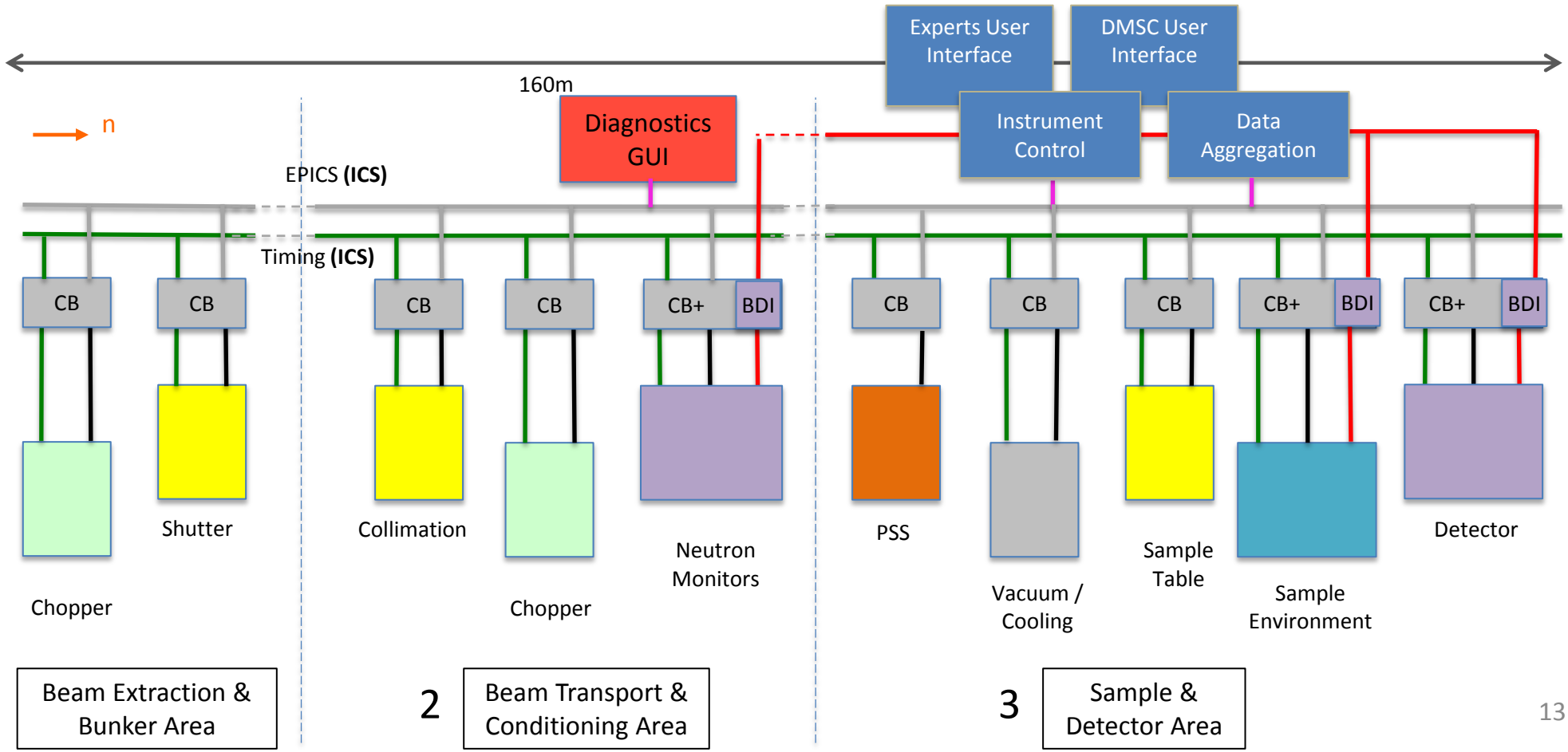




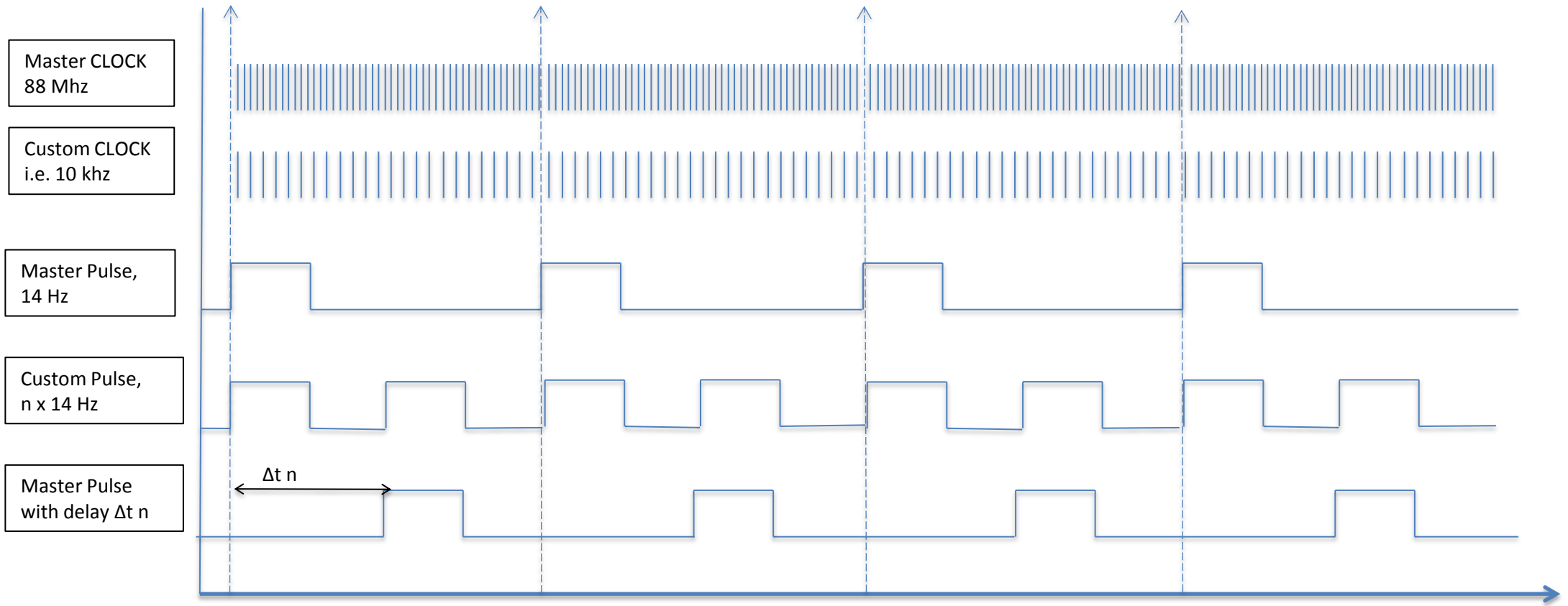
Modular Instrument Control Concept

- What can (or has to) be done locally will be done locally
- Clear functionalities and interfaces for a single box
- Linked together by an already existing facility wide network infrastructure

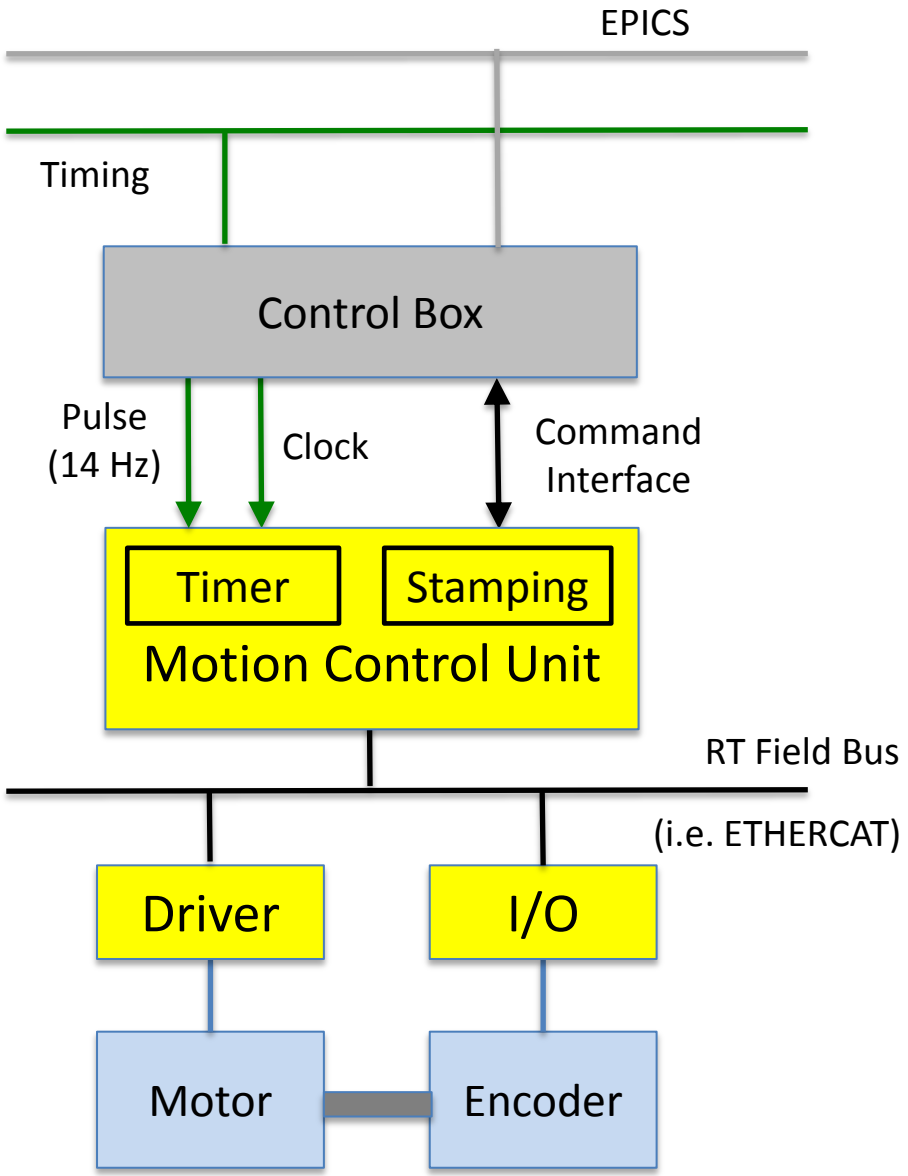


Timing system (synchronisation)

- Coupling of all timing to one single source – high precision (1ns jitter)
- Everywhere in the facility available, (time-) compensated cable lengths
- Custom clocks could be used in synchronized motion control as virtual axis



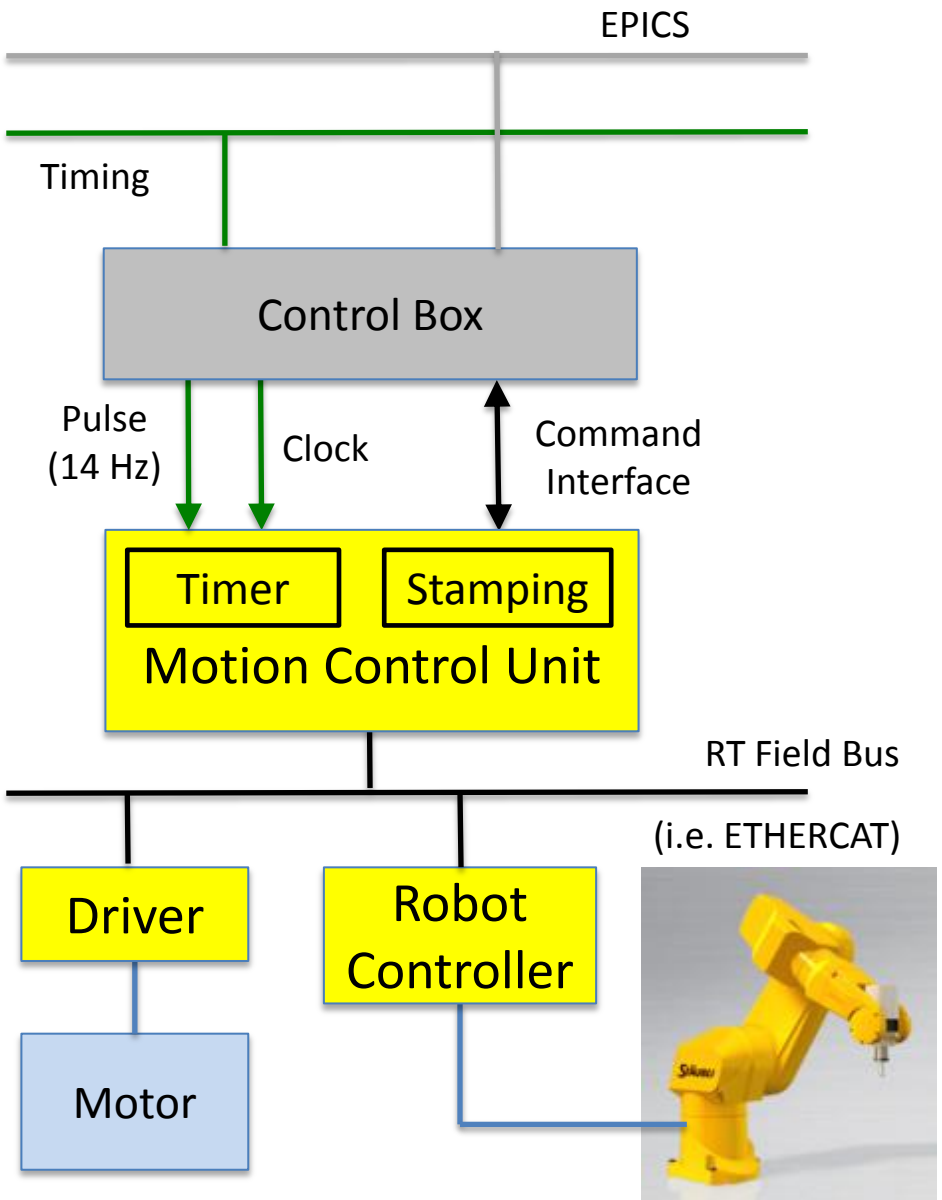
Timing synchronisation (Motion Control)



Transfer absolute timing information from Control Box to the local HW control unit

- Synchronise a timer on the control unit (pulse + absolute time information over Command interface)
- Timestamp in the control unit direct readings of the sensor with minimal latencies
- Transfer the sensor readings through the Control Box into EPICS
- Local distribution of control unit functionalities with real time field busses

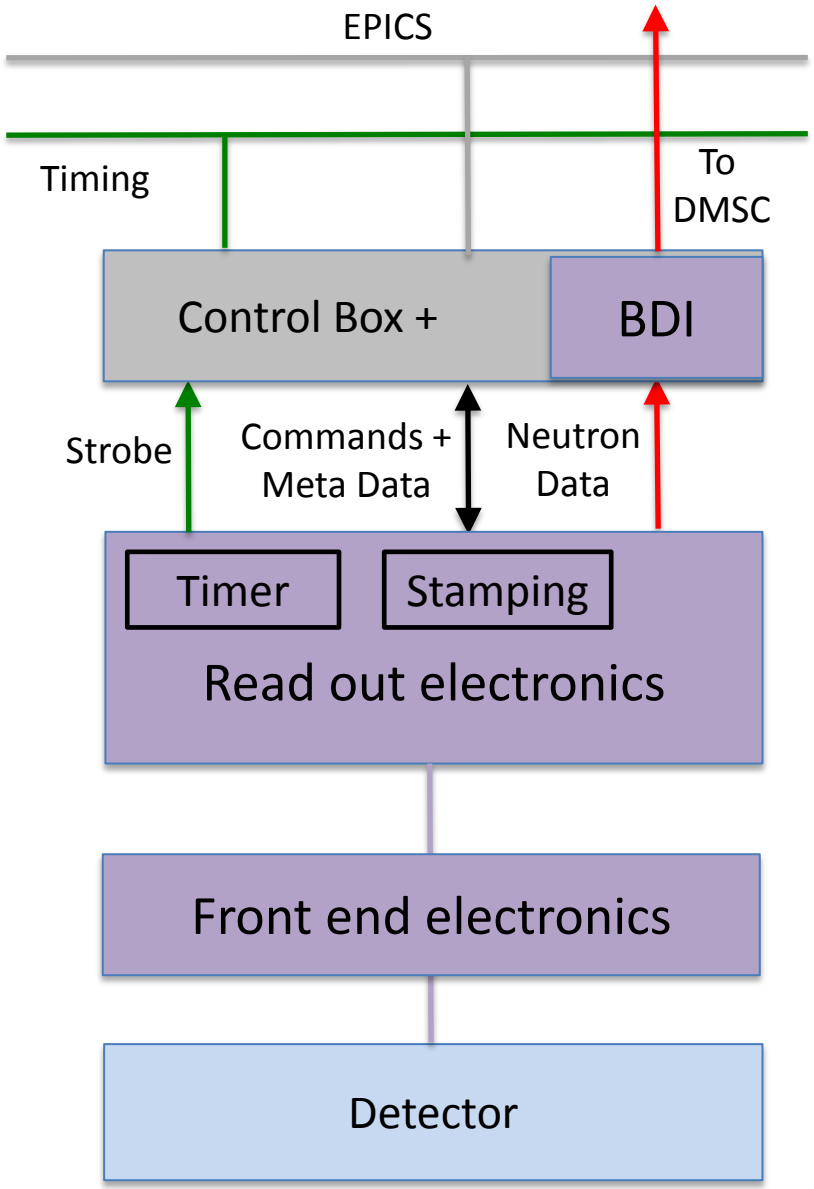
Timing synchronisation (Robotics)



Coordinated movement of robot and standard motion control

- Use motion control unit as master for both types of control
- Synchronise motion control unit with facility timing as described
- Distribute time and connect standard axes and robotics controller over RT field bus
- Ethercat interfaces to robot controller
  - mxAutomation (KUKA)
  - UNIVAL (Stäubli)

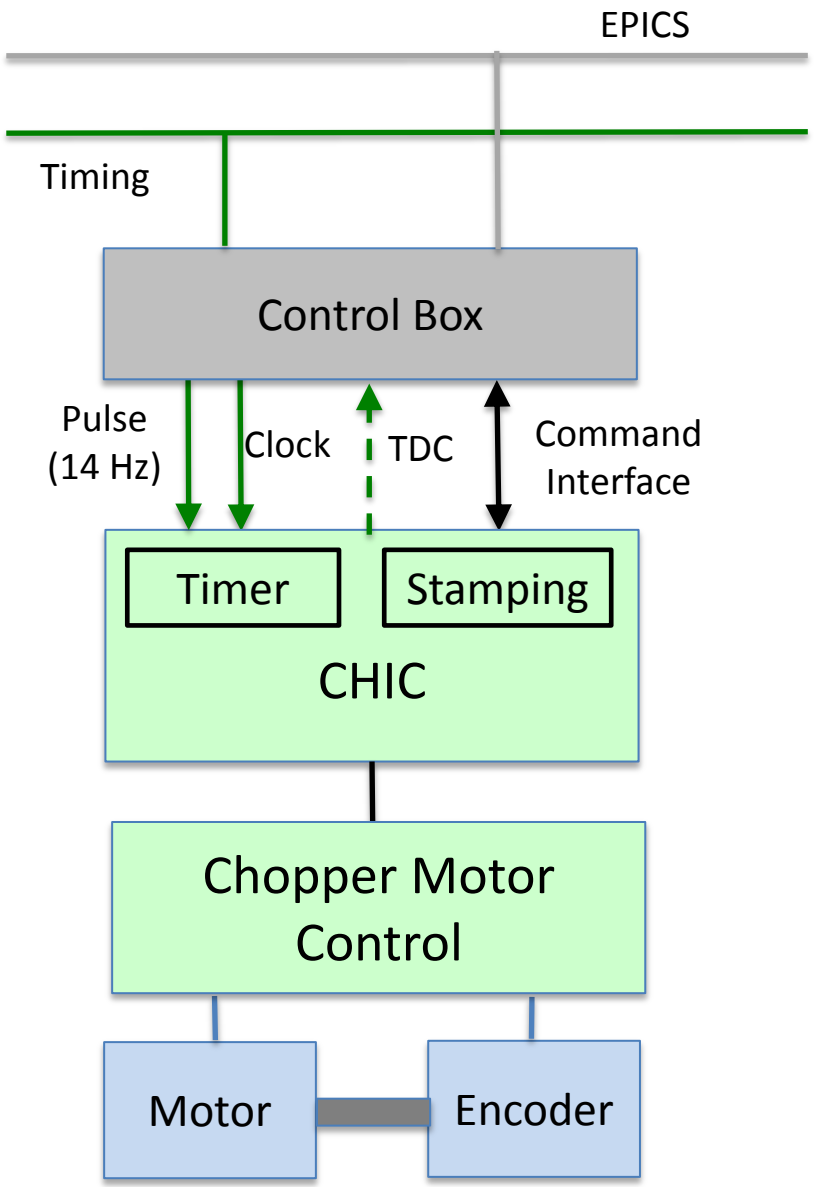
Timing synchronisation (Detector electronics)



Transfer absolute timing information from Control Box to the local HW control unit (read out electronics):

- Synchronise a timer on the electronics
- Timestamp Neutron data and meta data in the read out electronics with minimal latencies
- Transfer Neutron data (large volumes) through the Bulk Data Interface (BDI) to the DMSC data aggregator
- Transfer the meta data (small volumes) through the Control Box into EPICS
- Synchronously vs. asynchronously

Timing synchronisation (Chopper)



Transfer absolute timing information from Control Box to the local HW control unit:

- Synchronise a timer on the control unit
- Timestamp in the control unit; direct readings of the sensor with minimal latencies
- Transfer the TDC readings through the Control Box into EPICS
- Alternative: Time stamp in Control Box (needs digital input in CB)

Thanks

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Thanks

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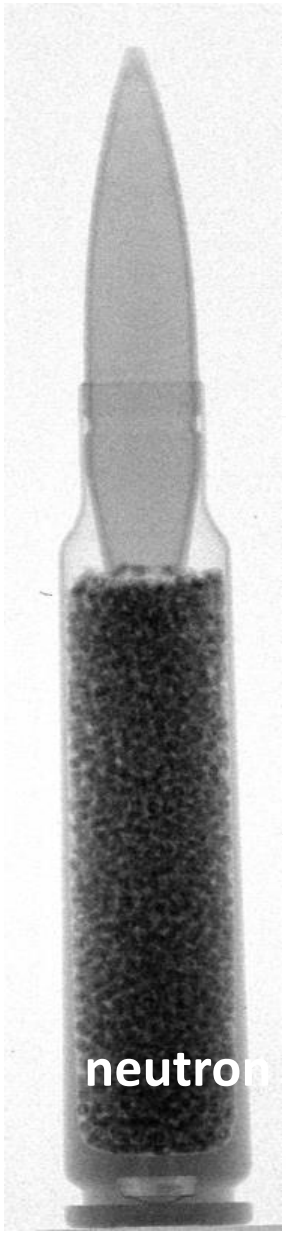
… and to you!

Neutrons see the light elements



Images from the NIAG group, PSI, Switzerland.