Modernizing Accelerator Control System Towards CSNS-II

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Outline

I. Brief Introduction of CSNS and CSNS-II

II. Present Status of Accelerator Control System

III. Upgrade of Accelerator Control System

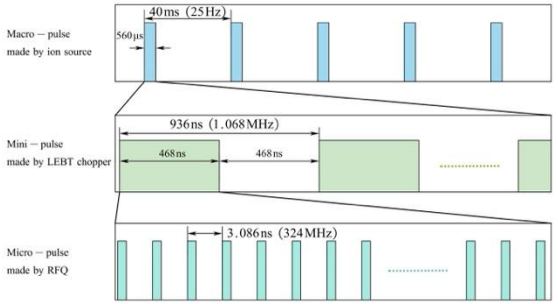
IV. Summary

CSNS Site

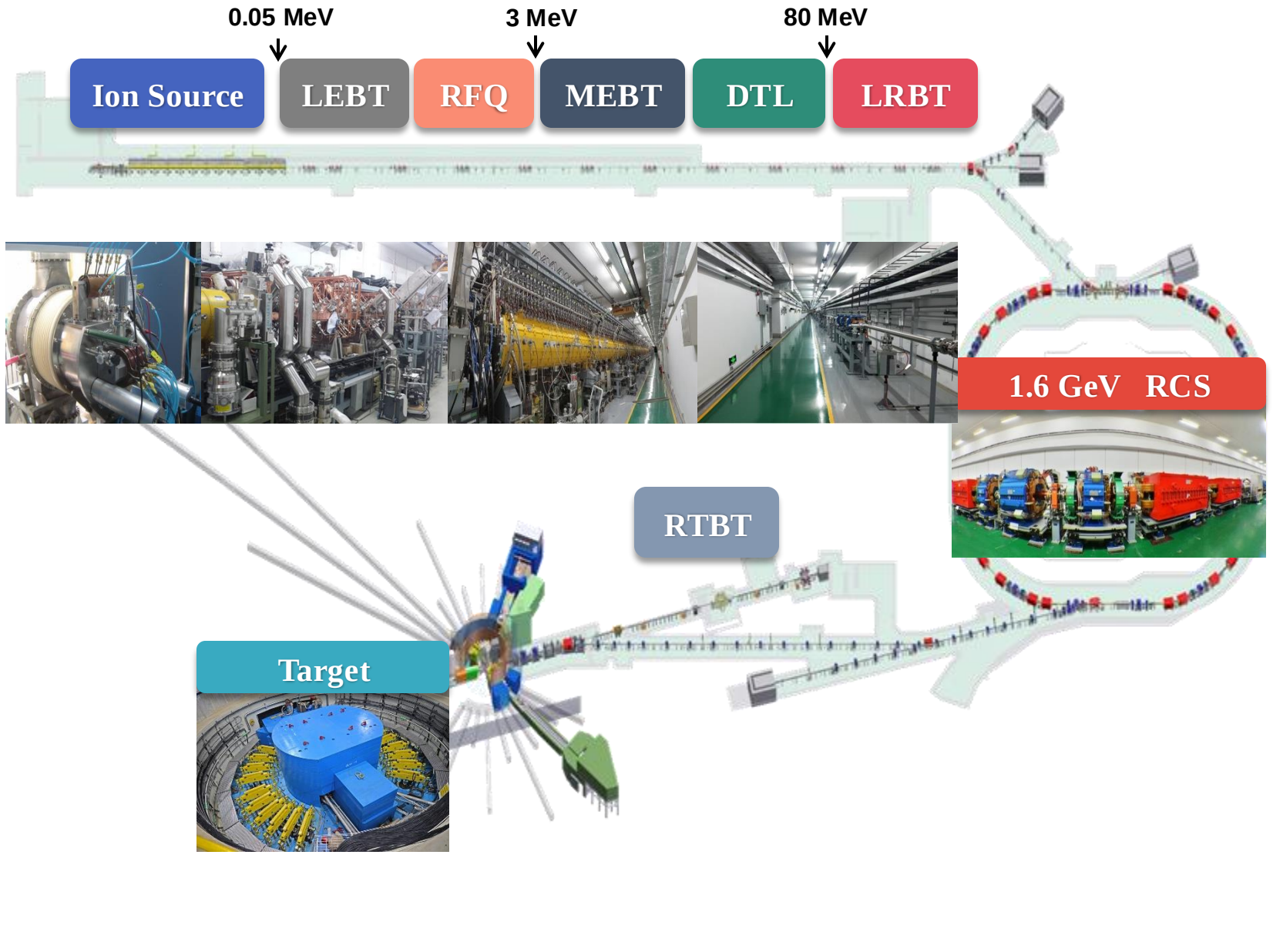

克斯坦
蒙古
吉尔吉斯斯坦
塔吉克斯坦
基斯坦
印度
缅甸
老挝
中华人民共和国
北京
朝鲜
韩国
>2000kM
CSNS★
2024)0999号, © 2024 TomTom, © 2024 NavInfo

CSNS Bird's Eye View

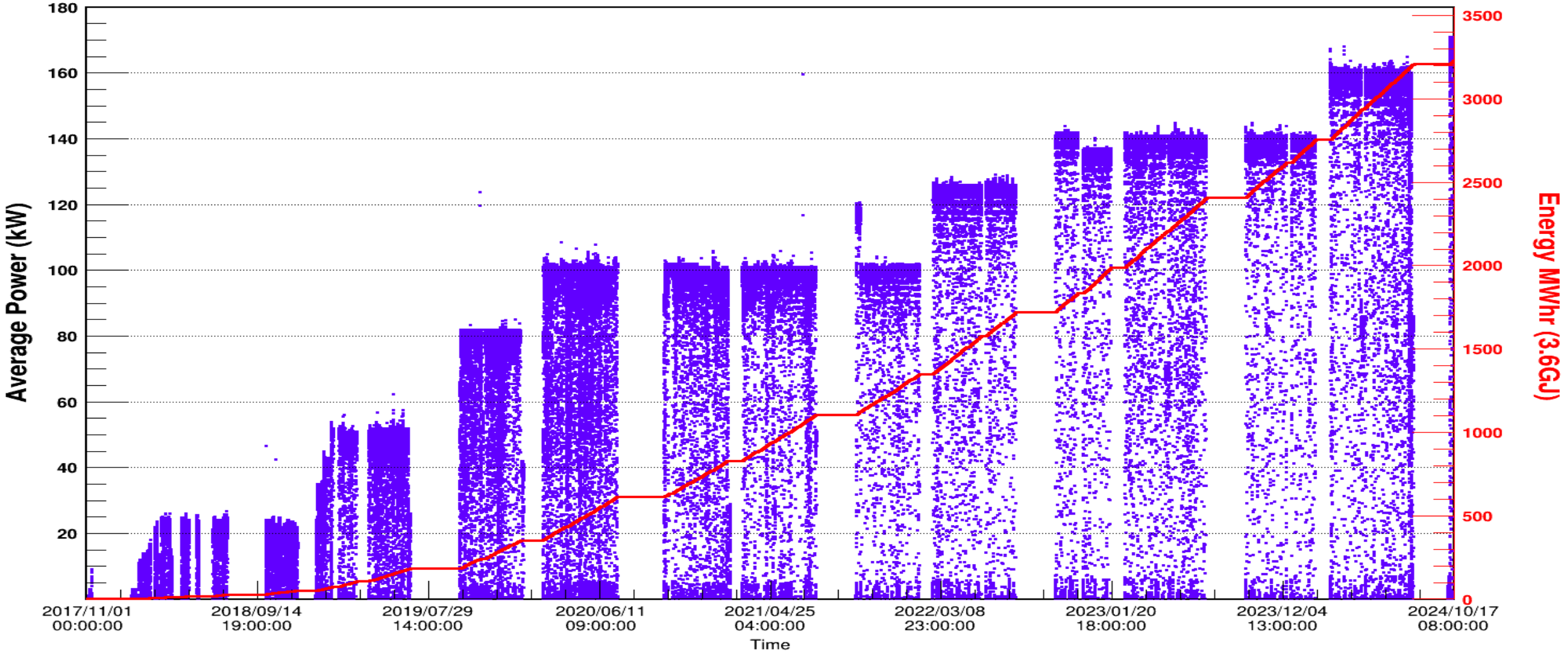
CSNS Facility



Beam Power on target [kW]	100
Proton energy [GeV]	1.6
Average beam current [uA]	62.5
Pulse repetition rate [Hz]	25
Linac energy [MeV]	80
Linac type	NC
Linac RF frequency [MHz]	324
Macropulse duty factor	1.05
RCS circumference [m]	228
RCS harmonic number	2
Target	1
Spectrometers	3



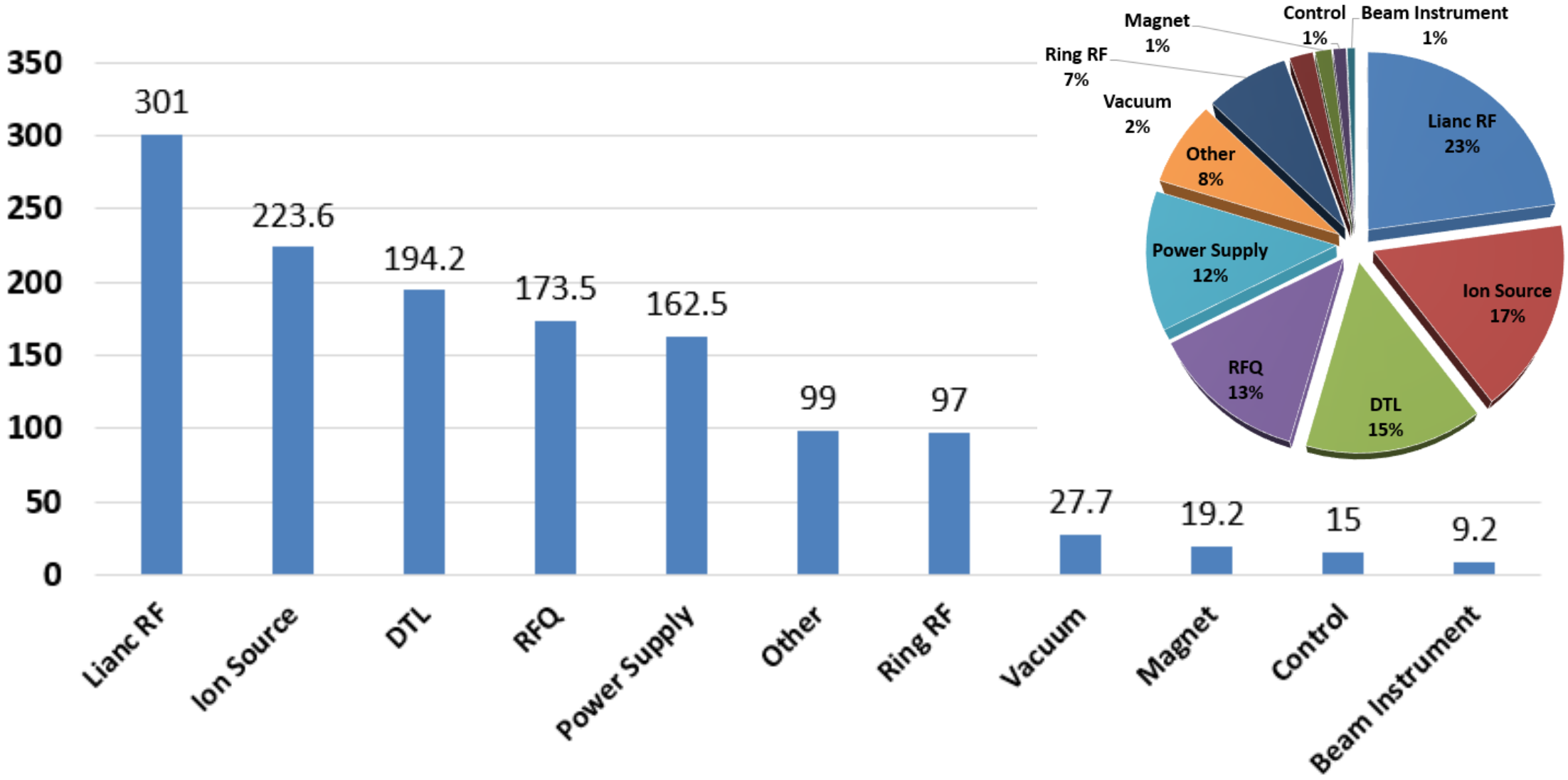
CSNS Beam Power history



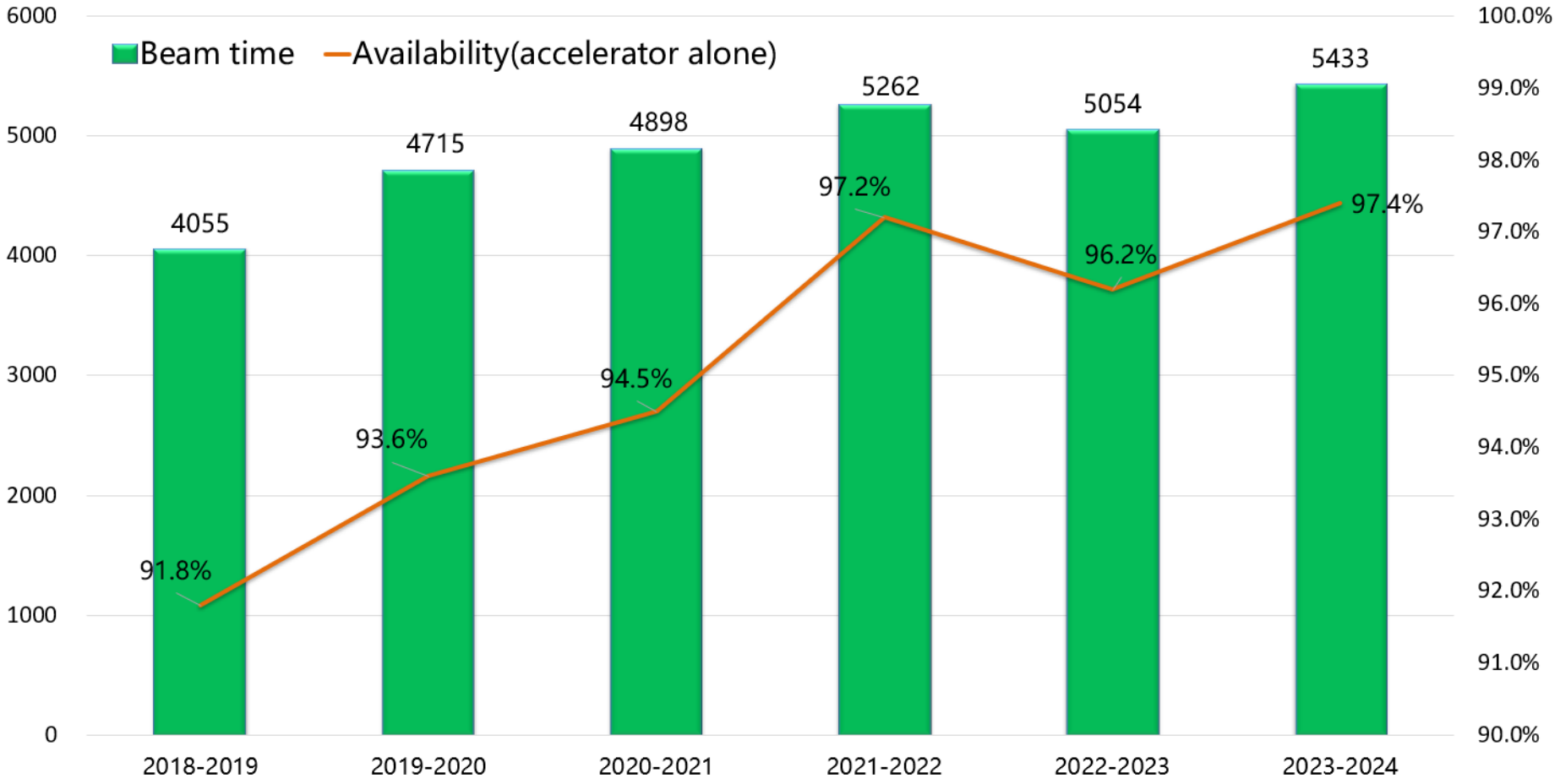
10kW Nov. 2017 | 20kW Mar. 2018 | 50kW Jan. 2019 | 80kW Sep. 2019 | 100kW Feb. 2020 | 125kW Feb. 2022 | 140kW Oct. 2022 | 160kW Mar. 2024 | 170kW Oct. 2024

Downtime Statistics

- **Downtime statistics in hours by system during user experiments over the past 6 years**

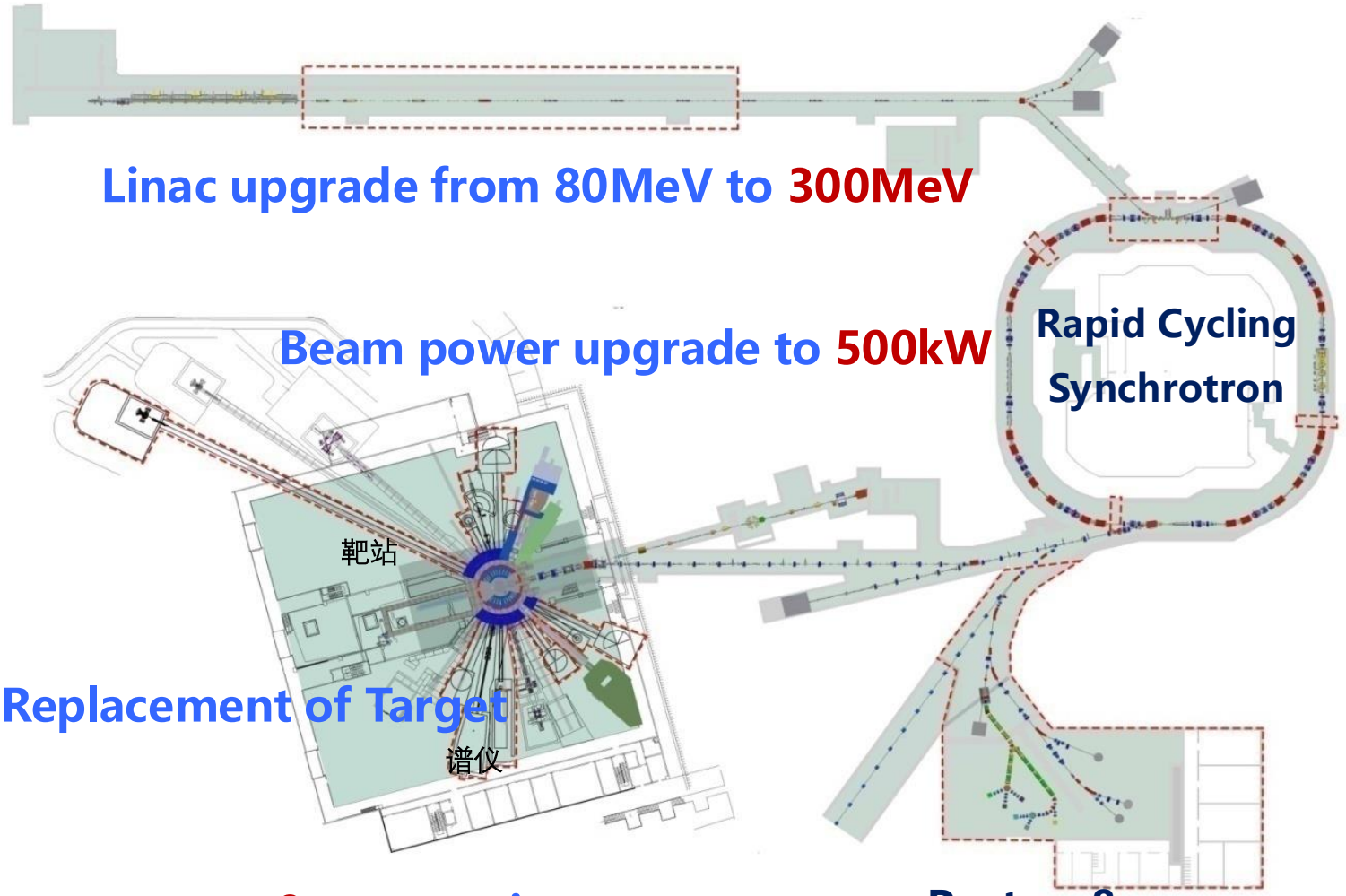


Accelerator performance



- The accelerator routinely operates with >95% availability in recent years
- From October 2023 to July 2024, the beam availability has been improved to 97.4%.

Scope of the CSNS-II



	CSNS	CSNS-II
Beam Power on target [kW]	100	500
Proton energy [GeV]	1.6	1.6
Average beam current [uA]	62.5	312
Pulse repetition rate [Hz]	25	50
Linac energy [MeV]	80	300
Linac type	RT	RT+SC
Linac RF frequency [MHz]	324	324/648
Spectrometers	3	11+8

Beam Power Upgrade （two-steps）

1. **Linac（80MeV）+ RCS upgrade 200kW (the first step)**
   - ✓ **New dual harmonic RF system**
   - ✓ **Adding AC trim quadrupoles, sextupoles and octupoles**
   - ✓ **New injection region**
2. **Linac （300MeV+）+ upgraded RCS 500kW (the second step)**
   - ✓ **SC linac to 300MeV**
   - ✓ **Upgrade the power supplies for main magnets**

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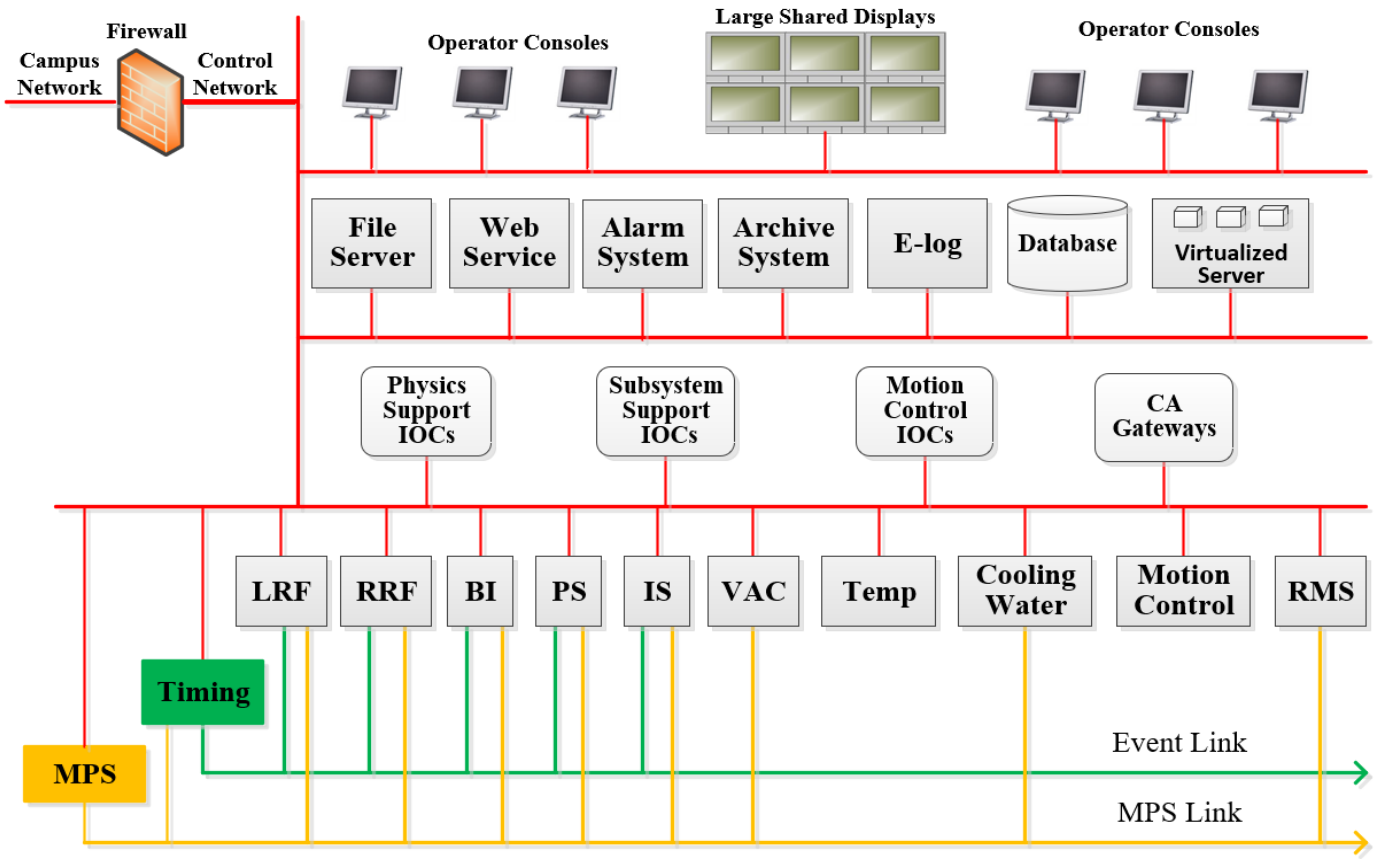
Accelerator Control System Status

- EPICS based large distributed control system
- Standard three layers architecture system

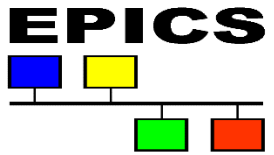


Accelerator Control System Scope

- **Global systems**
  - Timing system
  - Machine protection system
  - Control Network
  - Servers and Virtualization platform
- **High level applications**
  - Database
  - Services
  - High level applications
    - Desktop application
    - Web application
- **Low level & remote controls**
  - Vacuum/Power Supply/RF
  - IS/Front End/DTL
  - Inj. & Ext. PS
  - Strip Foil/Collimator
  - Back-n(white neutron source)
  - APEP
- **Conventional facility integration**
  - UPS/Isolated transformer
  - Cables/fibers/racks
  - Control rooms

Control System Software Fact

- **Both open source and commercial software were adopted**
  - **EPICS Base3.14.12.5 and synApp5.6**
  - **CSS 3.2.16 and Phoebus CSS**
  - **Archiver Tool**
  - **Redhat Linux 6.5**
  - **VxWorks 5.5**
  - **VMWare vSphere 7.0**



Archiver Appliance

Control System Hardware Fact

- **Off the shelf and unified hardware for front-end control and IT infrastructure**
  - **Yokogawa & Inovance PLC**
  - **Moxa embedded industrial computer**
  - **1G and 10G mixed network**
  - **VME platform**
  - **Blade server**

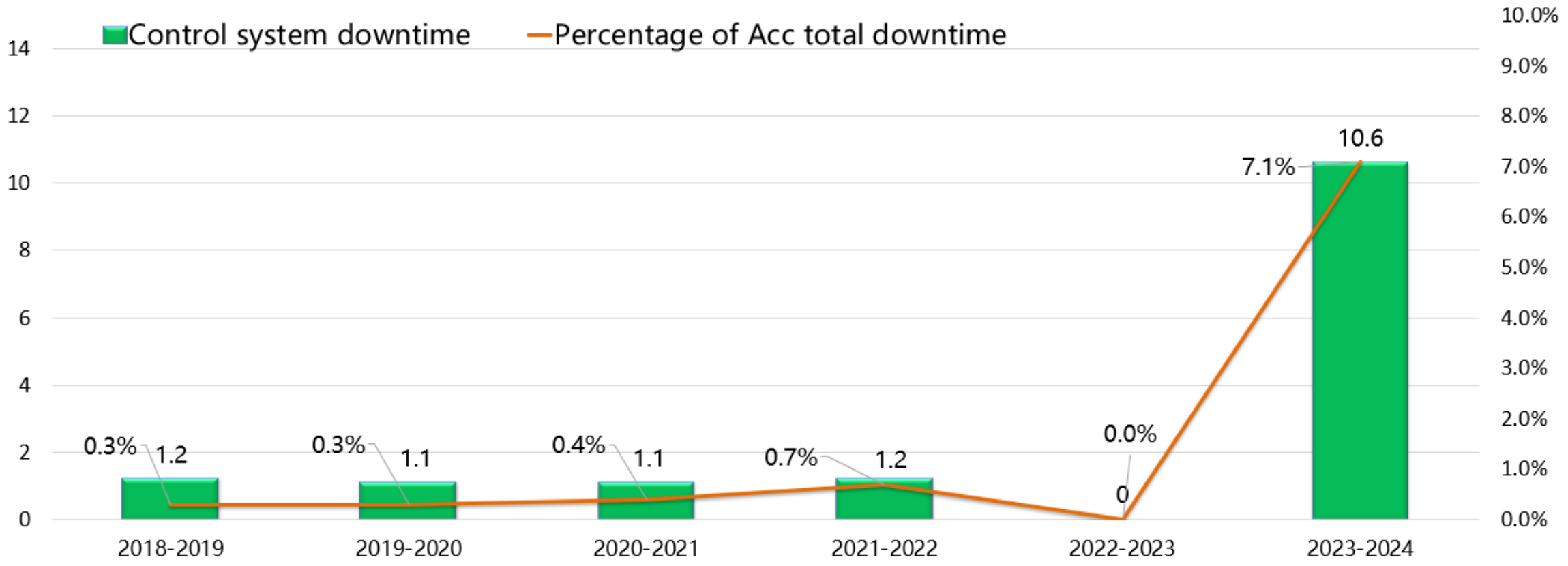
Control System Statistics

- **180 EPICS IOCs and 90K PVs**
- **The number of PVs will be more than 200K after CSNS-II**

	Number
Linux IOCs	130
Windows IOCs	30
VxWorks IOCs	22
PVs	≈90000
Archived PVs	35000
MPS Inputs	662
IPs	645

Operation of Control System

- **The availability of control system is more than 99% except last year.**
- **Some aging issues with devices have started to appear.**



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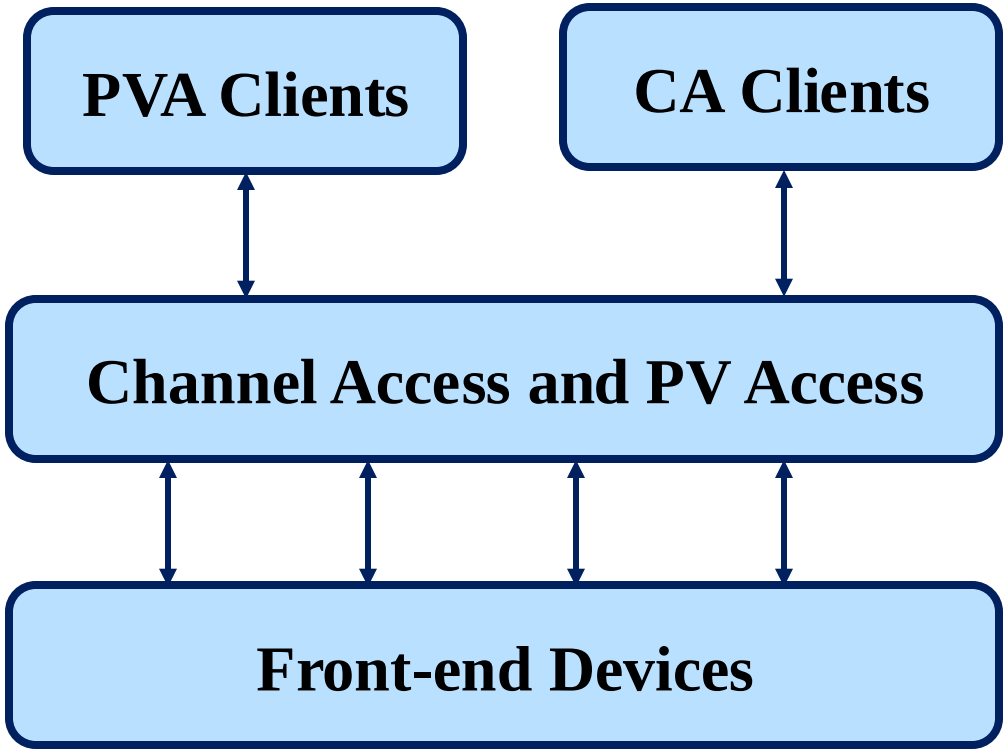
Considerations of control system upgrading

- No need for disruptive changes to the EPICS based architecture, it has proven reliable, extensible and sustainable.
- The hardware and software obsolescence issues must be addressed, and also keep a close eye on advanced technologies.
- The current control room tools are basic, improvement and replacement are needed.
- To provide big data and artificial intelligence resource should be considered.
- Challenges - No longer possible to have the control system down for an extended period so upgrades must be phased in during scheduled outages.

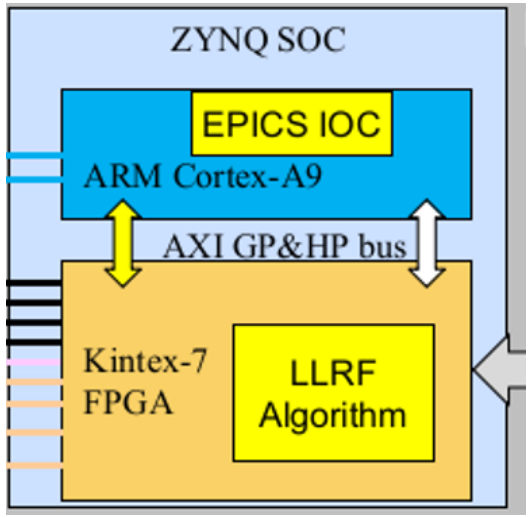
Upgrade to EPICS 7

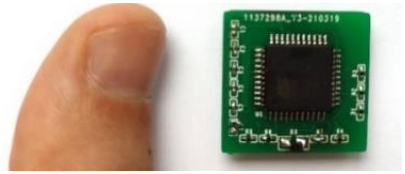
- **Upgrade to EPICS 7，supporting PV Access and structured data type for big data**
- **Existing EPICS 3 systems peacefully co-exist with EPICS 4 systems**



Convert VME to MTCA Platform

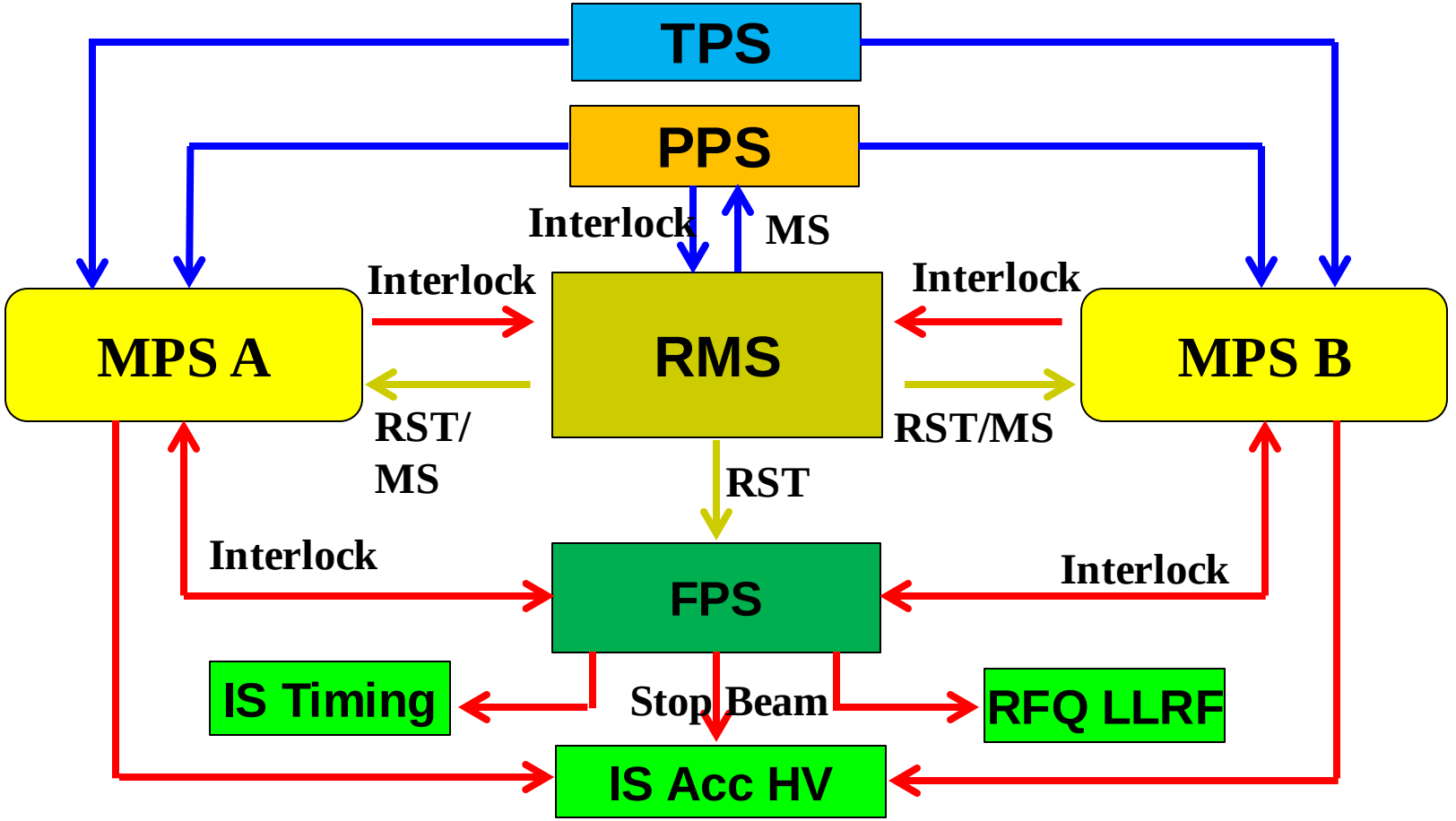
- **MTCA.4 platform was determined as the fast control platform for timing system, LLRF, beam diagnostics**
- **The domestic MTCA.4 hardware platform has been developed and tested**
  - **High performance specifications**
  - **Software and firmware with independent intellectual property rights**
  - **Lower costs and more flexible topology**





Accelerator Machine Protection System

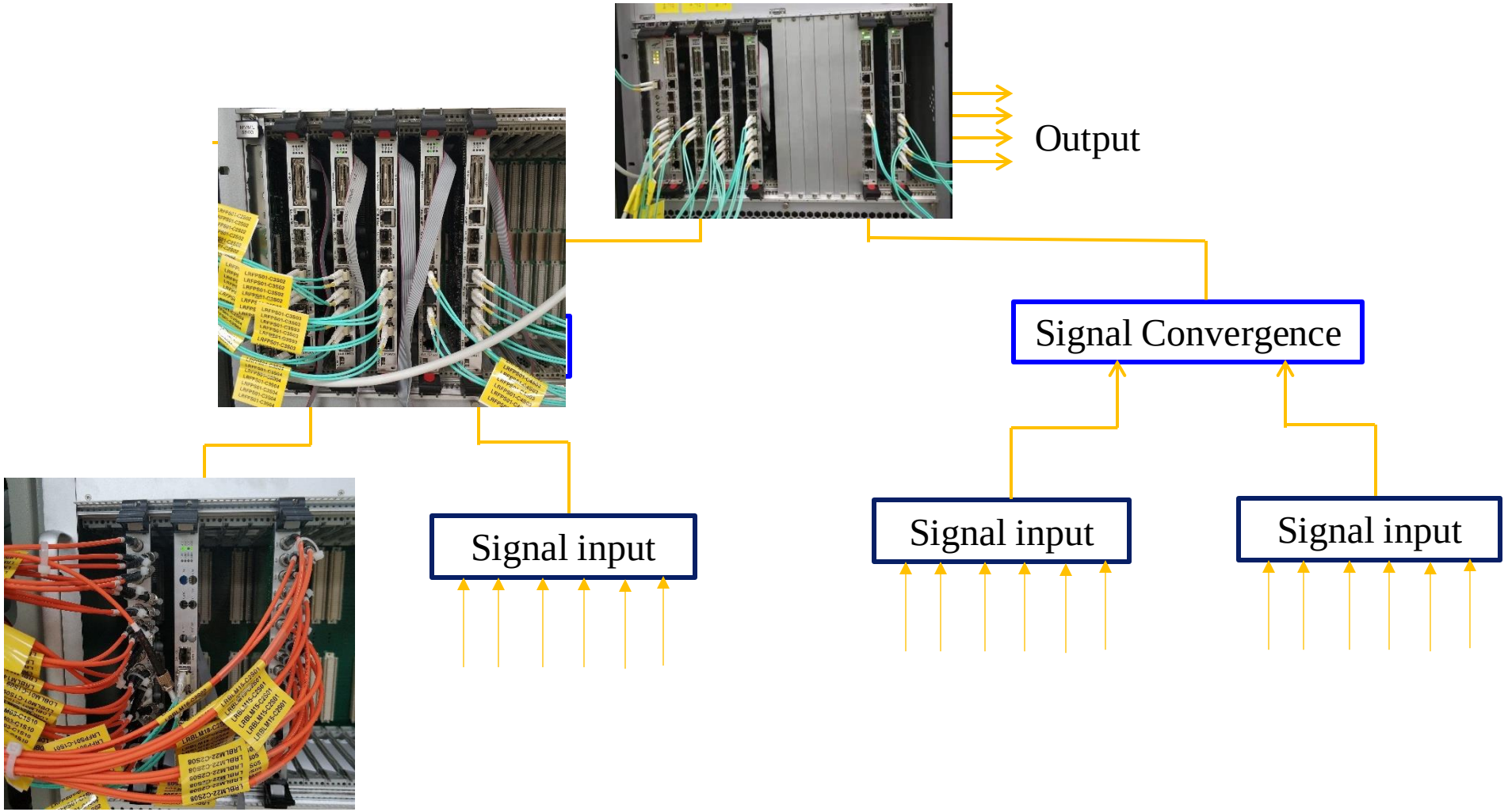
- CSNS accelerator machine protection system consists of PLC-based Normal MPS and FPGA based FPS. Normal-MPS consists of two independent systems(NMPS-A and NMPS-B)
- Both NMPS and FPS use independent cable route to interlock beam.



MS: Machine Status RMS: Run Management System

FPS Architecture and Techniques

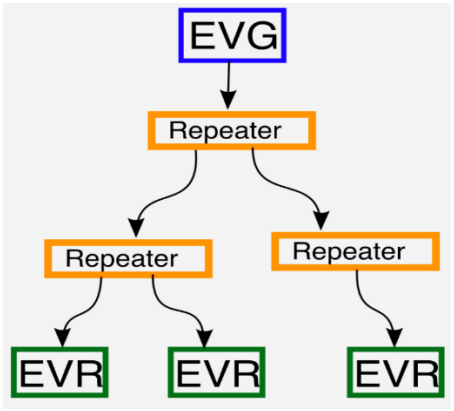
- **The tree topology was selected by FPS consists of three layers.**
- **All signals are transmitted through optical fibers.**



Global systems

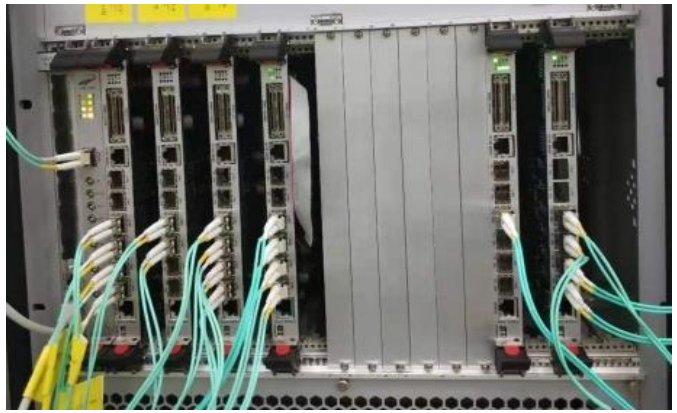
IT Infrastructure

- Increasing network bandwidth and more segmentation for additional requirements.
- Increasing computing, storage and memory resources.



Timing system

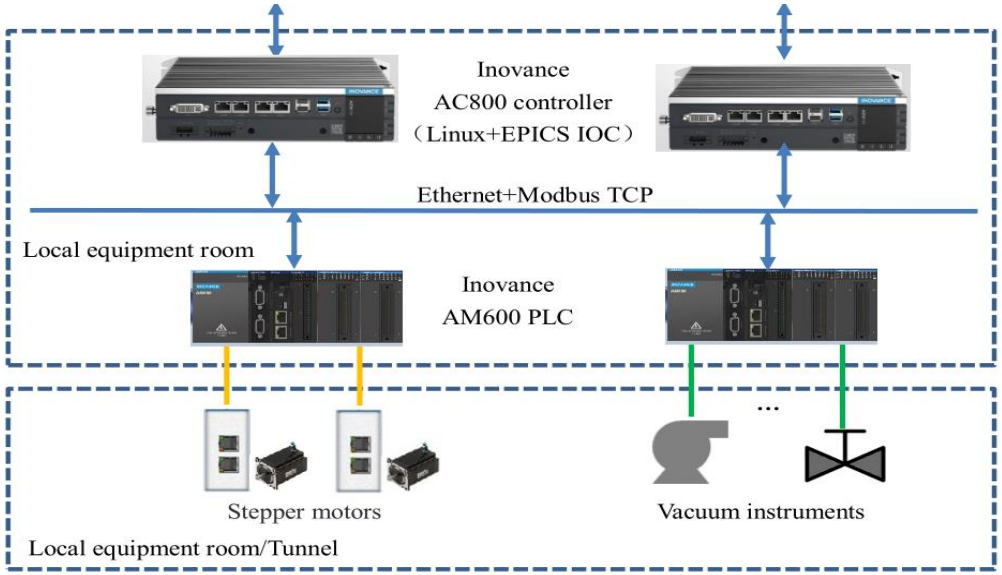
- The SoC or µTCA boards will be deployed for new requirements
- The existing VME form board will be converted to SoC or µTCA in phase

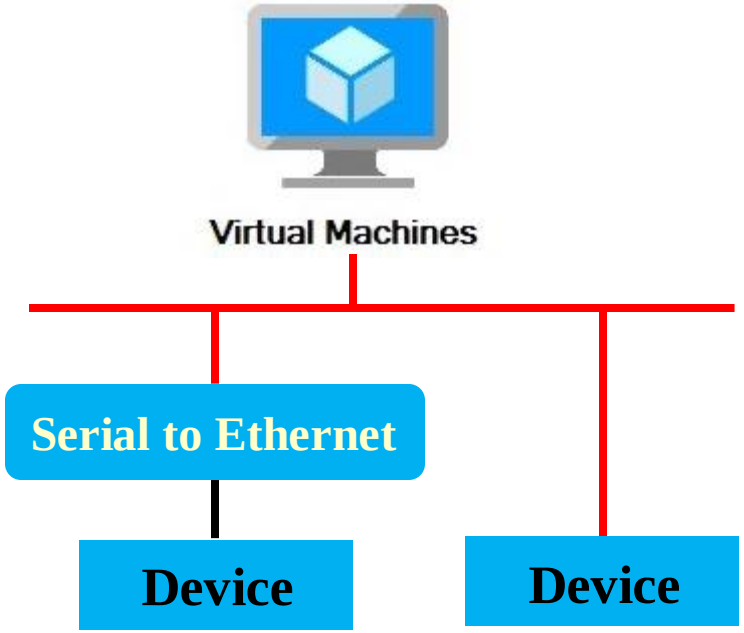


MPS

- Newly developed SoC boards will be deployed to replace the VME boards used by FPS.
- The existing PLCs used by MPS will be replaced by the domestic PLCs.

Front-end systems





PLC based slow control

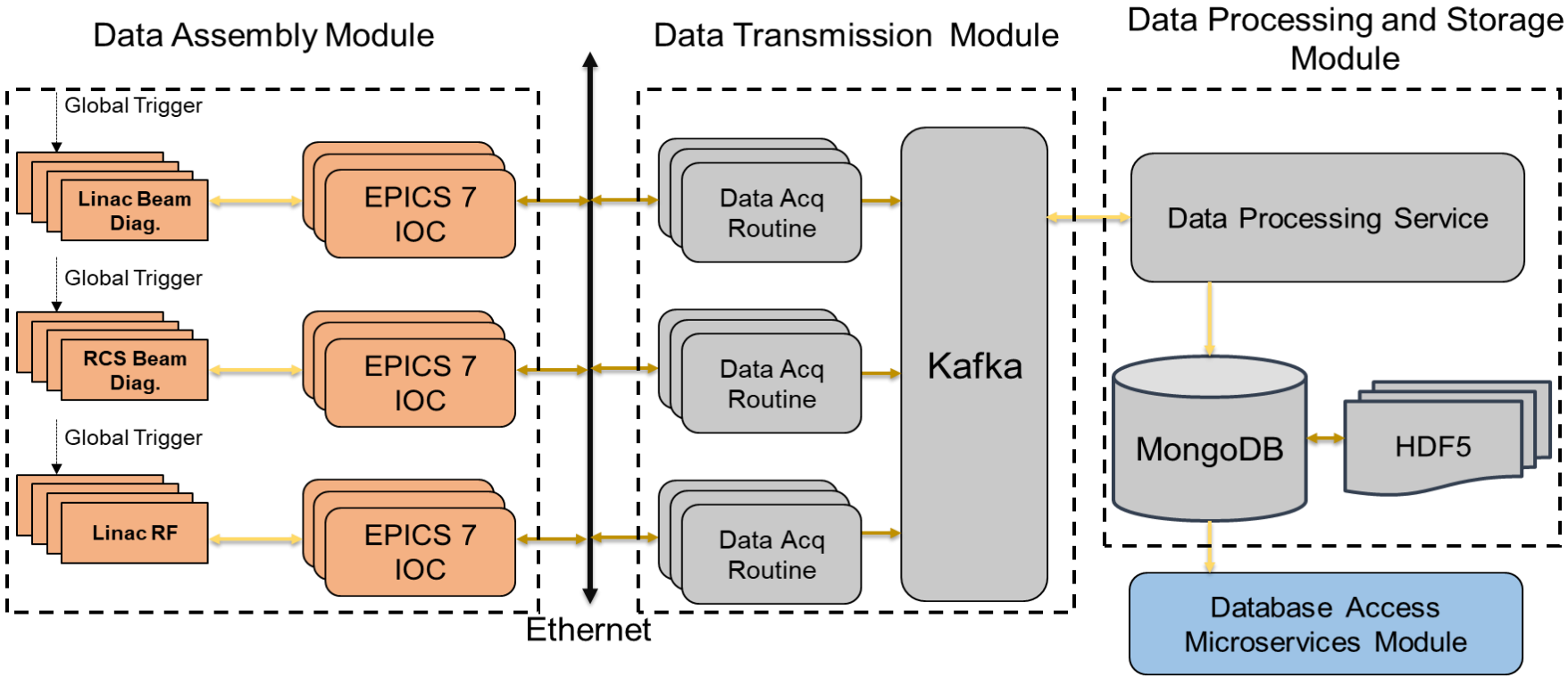
- The domestic PLCs will be adopted for the slow control
- EPICS drivers for the domestic PLC has been tested online for more than 3 years

Virtual Machines

- More virtual machines based Soft IOCs will be used to replace the industrial computer based EPICS IOCs
- Easy to manage and maintain, higher availability

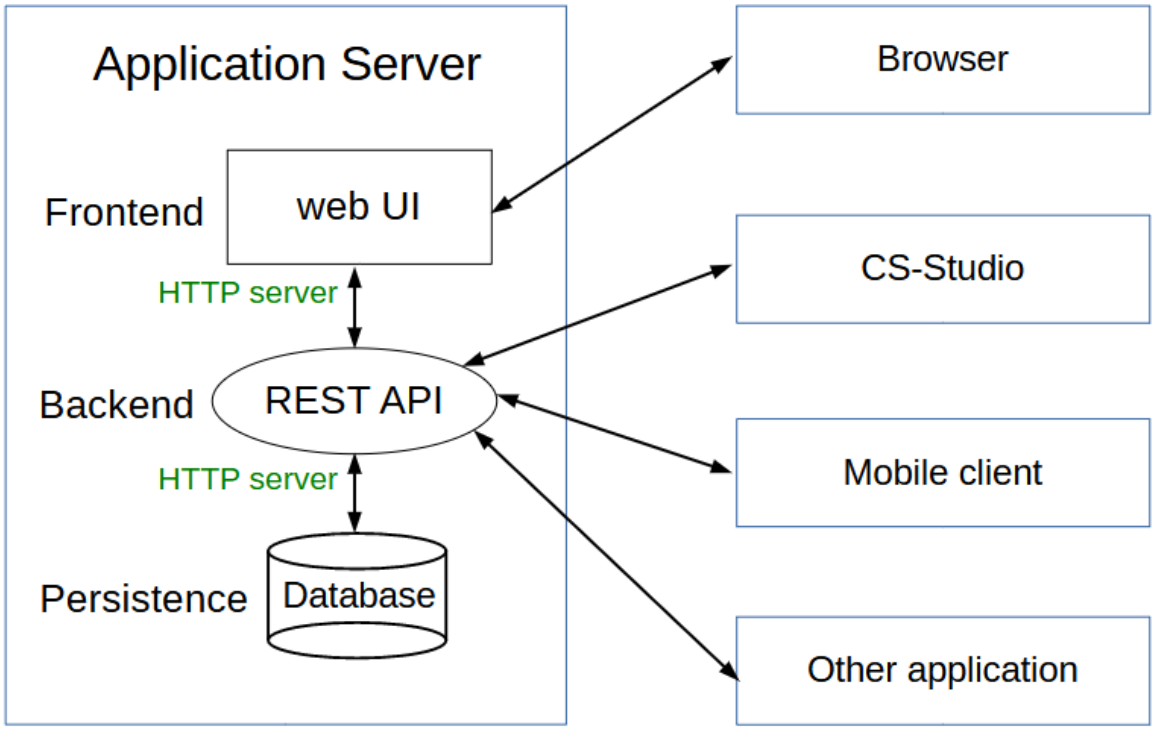
Beam Synchronous DAQ system

- BSDAQ system collects data synchronized with beam cycle from the whole accelerator and provide time correlated data
- Can be used for commissioning, troubleshooting, performance monitoring and early fault detection



High Level Applications

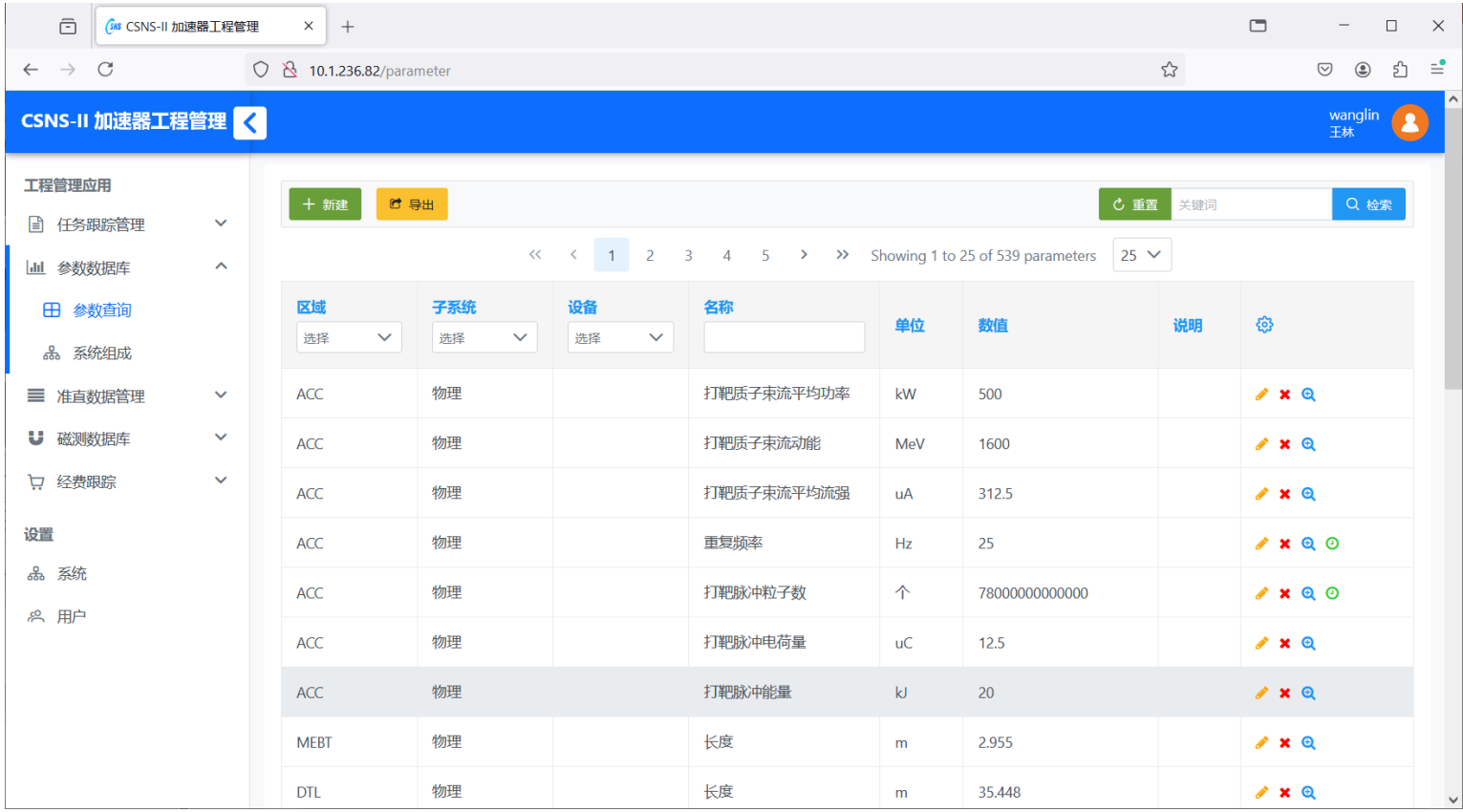
- **Started to develop from 2018**
- **Manage data and information during accelerator operation and maintenance**
- **Developed based on web and database technologies**
- **This is a continuous effort work based on the requirements**



High Level Applications

CSNS-II Project Management System

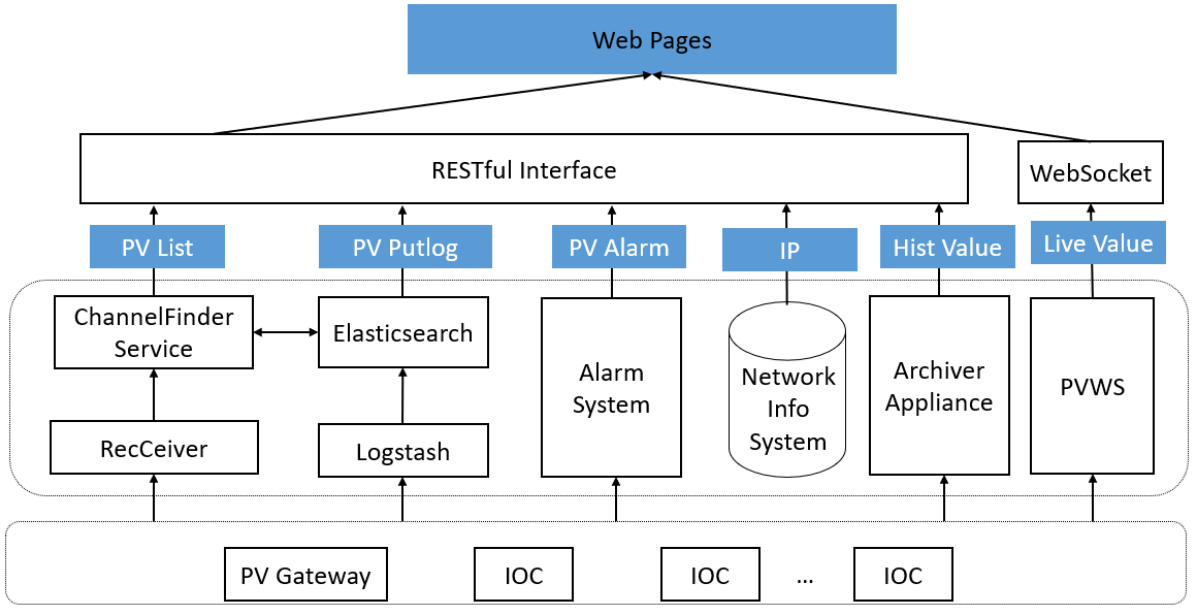
- **Manages tasks, parameters, measurement data and budget.**
- **Included modules**
  - Task tracking and management
  - Machine parameter database
  - Magnet measurement database
  - Alignment measurement database
  - Budget tracking system

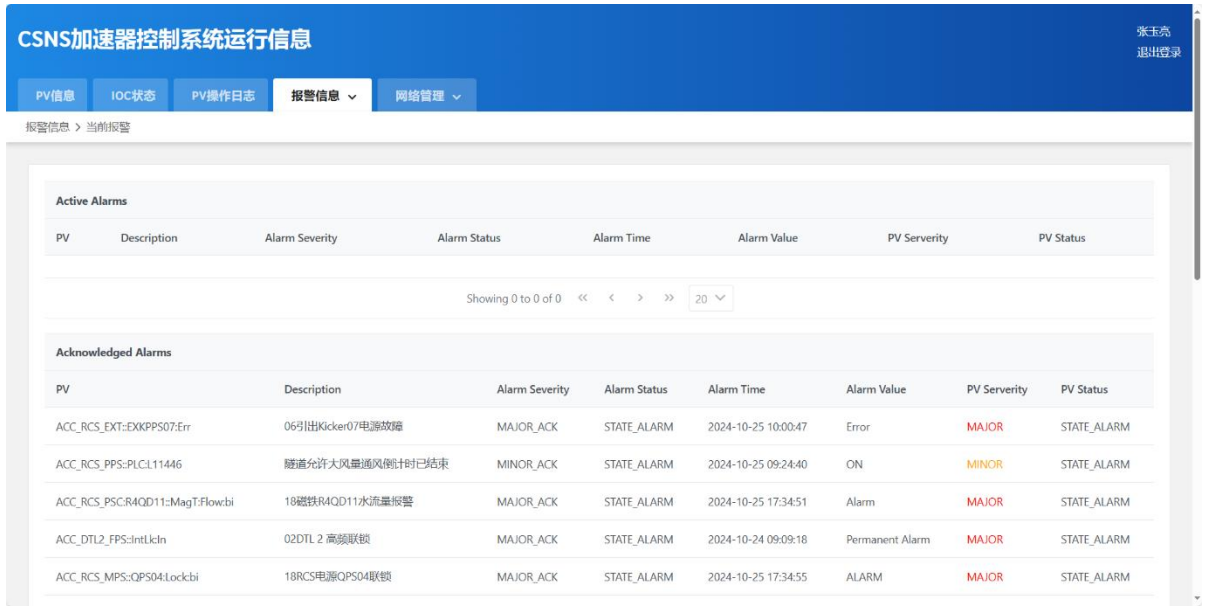


High Level Applications

EPICS PV Browser

- **A Web Based EPICS PV Information Query System**





High Level Applications

General purpose applications

- Can be used for CSNS, and can also be used for other facilities

- **Clog (Compact Electronic Logbook System) 2.0**
  - https://github.com/wanglin86769/clog2
- **EPICS Channel Access client for Node.js**
  - https://github.com/wanglin86769/node-epics-ca
- **EPICS Portable Channel Access Server for Node.js**
  - https://github.com/wanglin86769/node-epics-pcas
- **Publishes Archiver Appliance status as EPICS PVs**
  - https://github.com/wanglin86769/archiver-status

Summary

- **The CSNS accelerator control system was completed in 2018, but the hardware and software platform was determined in 2012. The control system achieved high availability during operation.**
- **The control system has been growing, evolving since original commissioning, some new technologies has been tested and put into operation. It is the time to modernize the control system towards CSNS-II requirements.**
- **Manpower is not enough, we are looking for good engineers and also collaboration.**

Thank you for your attention!