Experiences Using EPICS in Commercial Contexts

Cosylab

Rok Šabjan, Remote EPICS Meeting,
2020-10-20

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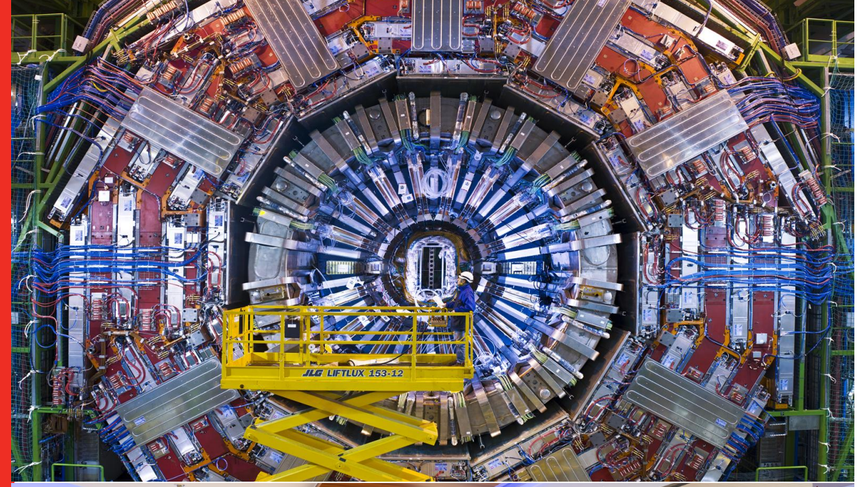
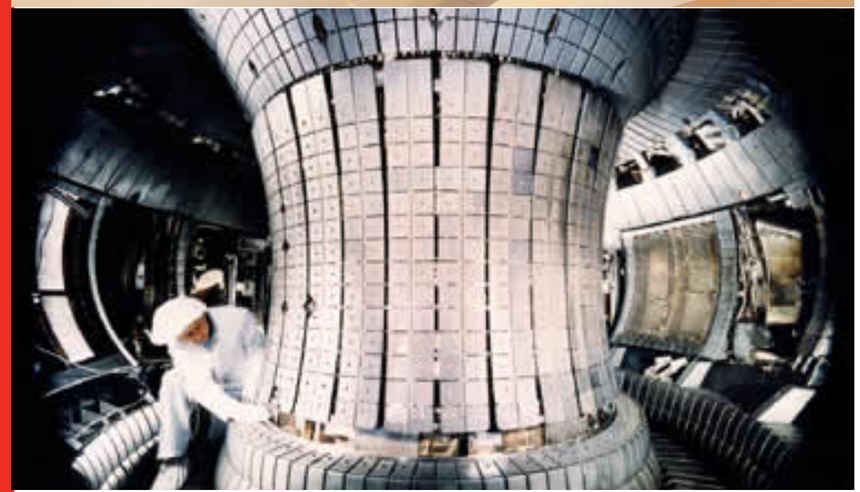
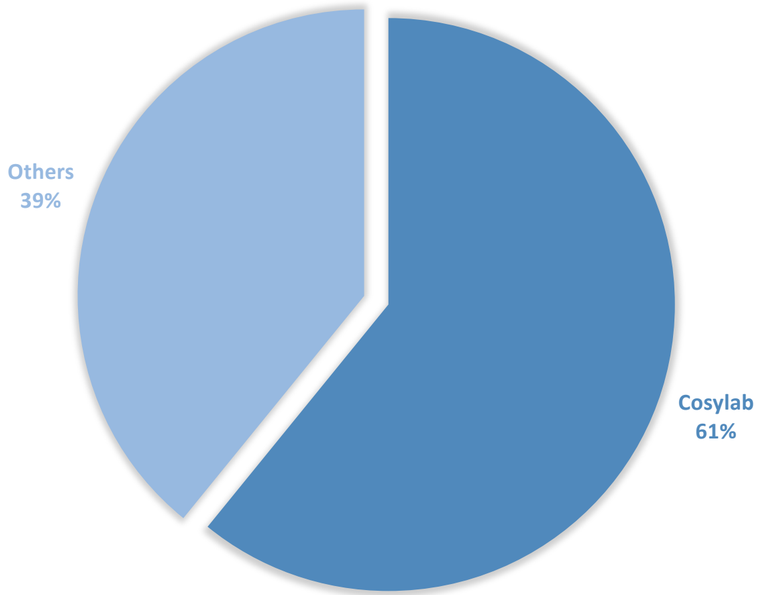




The World Leader in System Integration and Software for Science and Proton Therapy

- **6 of the 10 Largest Big Science** International Projects
- **61% market share** in Control Systems for **Particle Therapy**



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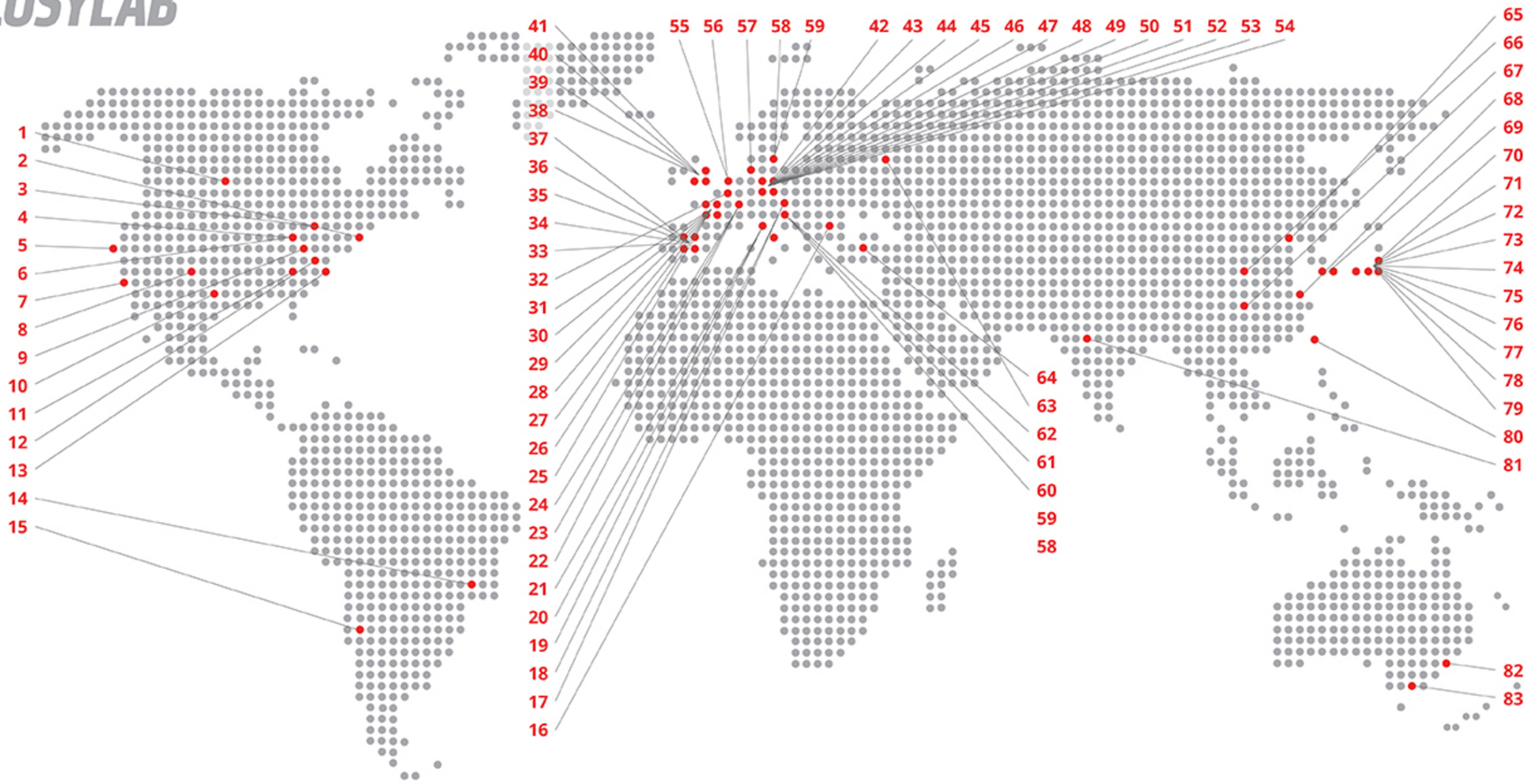


Customers From All Major Labs Worldwide

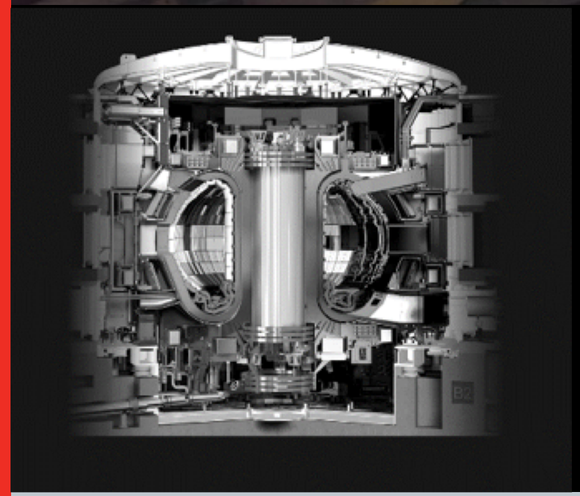
1. Canadian Light Source - CSL (CA)
2. Brookhaven National Laboratory - BNL (US)
3. Facility for Rare Isotope Beams - FRIB (US)
4. Advanced Photon Source - APS at Argonne National Laboratory (US)
5. Stanford Linear Accelerator Center - SLAC (US)
6. Ferni National Accelerator Laboratory - FNAL (US)
7. Varian medical systems (US)
8. Los Alamos National Laboratory - LANL (US)
9. Indiana University (US)
10. National Instruments - NI (US)
11. Spallation Neutron Source - SNS (US)
12. National Radio Astronomy Observatory - NRAO (US)
13. Thomas Jefferson National Accelerator Facility - JLAB (US)
14. Brazilian Synchrotron Light Laboratory (LNLS)
15. Atacama Large Milimeter Array - ALMA (RCH)
16. IFIN-HH (RO)
17. Cividec Instrumentation GmbH (AT)
18. EBG MedAustron (AT)
19. Sinchrotrone Trieste - ELETTRA (IT)
20. Kyma (IT)
21. Instituto Nazionale di Fisica Nucleare - INFN-LNL (IT)

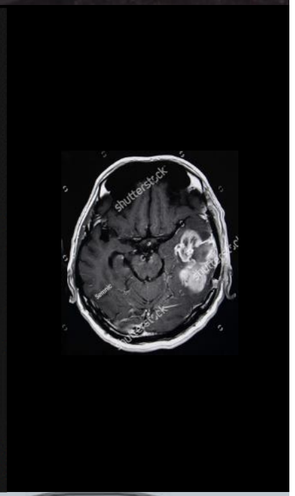
21b. Instituto Nazionale di Fisica Nucleare - INFN-LNF (IT)

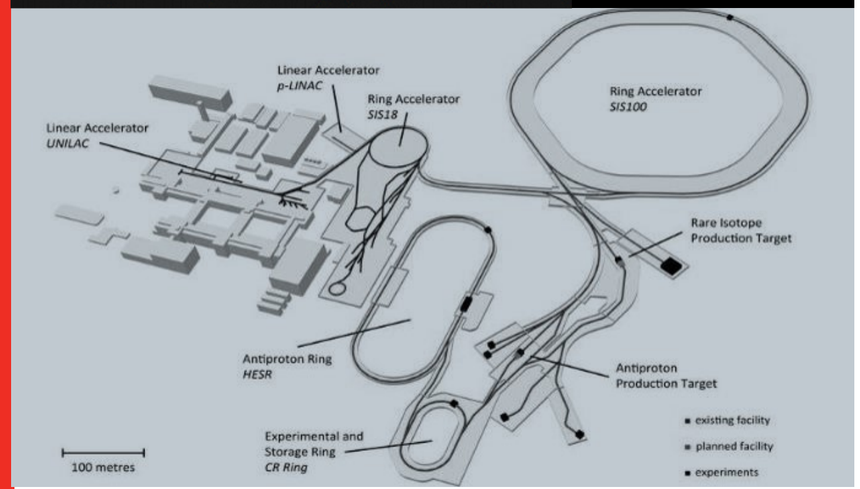
22. CERN - European Organization for Nuclear Research (CH)
23. Paul Scherer Institut - PSI (CH)
24. Linde Kryotachnik (CH)
25. Maatel Scientific Instrumentation (FR)
26. Xenocs (FR)
27. French Atomic Energy Commision (FR)
28. International Thermonuclear Experimental Reactor - ITER (FR)
29. European Synchrotron Radiation Facility - ESRF (FR)
30. bioMérieux (FR)
31. Synchrotron Soleil (FR)
32. Ion Beam Applications - IBA (B)
33. Procon Systems (ES)
34. CELLS - ALBA (ES)
35. Ciemat (ES)
36. Observatorio Astronómico Nacional - OAN (ES)
37. ESS Bilbao (ES)
38. Rutheford Appelton Laboratory (UK)
39. Daresbury Laboratory (UK)
40. Diamond (UK)
41. FMBO Oxford (UK)
42. Siemens (DE)
43. ACCEL (DE)

44. Electron accelerator - ELSA (DE)
45. Helmholtz Zentrum Berlin fur Materialien und Energie (DE)
46. European Molecular Biology Laboratory - EMBL (DE)
47. Physikalisch-Technische Bundesanstalt Berlin - PTB (DE)
48. Jenoptik AG Jena (DE)
49. Forschungzentrum Karlsruhe (DE)
50. Dortmunder Elektronen Speicherring Anlage (DE)
51. Deutsches Elektronen-Synchrotron DESY (DE)
52. European Southern Observatory ESO (DE)
53. Gesellschaft fur Schwerionenforschung (DE)
54. Feinwerk-und-Messetechnik GmbH (DE)
55. Imtech Vonk (NL)
56. Kernfysisch Versneller Institut - KVI (NL)
57. Danfysik (DK)
58. European Spallation Source (SE)
59. MAX-lab, Lund University (SE)
60. J. Stefan Institute (SI)
61. ISKRATEL (SI)
62. BioSistemika (SI)
63. National Research Centre "Kurchatov Institute" (RU)
64. Turkish Accelerator and Radiation Laboratory at Ankara (TUR)
65. Tsinghua University (CN)

66. Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou (CN)
67. Southwestern Institute of Physics - SWIP, Chengdu (CN)
68. Shanghai Institute of Applied Physics, Chinese Academy of Sciences (CN)
69. Pohang Accelerator Laboratory (KR)
70. Hiroshima University (JP)
71. Institute for Molecular Science (JP)
72. Riken (JP)
73. Repic Corporation (JP)
74. Nichizou Denshi Seigyo Kabushikigaisha (JP)
75. Japan Atomic Energy Research Institute - JAERI (JP)
76. High Energy Accelerator Research Organisation - KEK (JP)
77. The University of Tokyo (JP)
78. Hitachi Zosen (JP)
79. Japan Synchrotron Radiation Research Institute - JASRI (JP)
80. NSRRC - National Synchrotron Radiation Research Center (TW)
81. Raja Ramanna Centre of Advanced Technology - RRCAT (IN)
82. Australian national nuclear research and development organisation - ANSTO (AU)
83. Australian Synchrotron - AS (AU)







Areas Of Expertise

- We offer **services** and **products** which require **expert knowledge**
- We develop **state-of-the-art hardware** and **software**
- We **integrate** them into **mankind‘s most complex machines**

COSYLAB

Who are we?

- **9** locations **worldwide**
  - USA, China, Korea, Japan, Ukraine, Slovenia, Switzerland, Sweden, France

- **~250 people**
  - 180 + highlly skilled developers and engineers
  - 22 PhD holders from STEM fields

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History of Cosylab

- Founded in 2001 as spin-off from largest physics institute in Slovenia – Josef Stefan Institute
- Before esatblishing the company, founders worked on design, construction and commissioning of **Elettra**, **SLS** (PSI, Switzerland) and **ANKA** (FZK, Germany)
- Actively involved from start in open source control system **communities**, e.g. developing core parts of EPICS
- Expanding into control system for medical devices since 2007

COSYLAB

How Do We Do It?

People

- We only recruit the best talent

Professionalism

- **CosyAcademy** – own education and training system
  - 190 finished EPICS academies!
- **Strong company culture** and great **employee loyalty**
- Salary based on **customer satisfaction**

Processes

- ISO 9001, ISO 13485
- IEC 60601 family, ISO 14971, IEC 62304, IEC 62366

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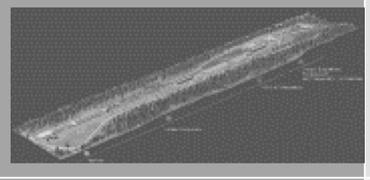
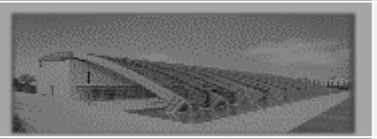
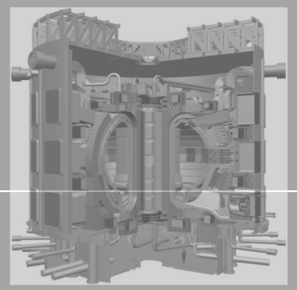
Relevant Cosylab Scientific Project References

Reference	Description	Project size
PSI SwissFEL & Swiss Light Source 	SwissFEL –Free electron laser SLS – Synchrotron radiation light source	On-site team (6 people at the peak)
ELI-NP 	Laser and gamma beam facility	3M+ EUR
SLAC LCLS/LCLS-II 	Free electron laser	On-site team (8 people at the peak
European Spallation Source (ESS) 	Neutron source based on high-power proton linac	Over 20 FTE at the peak
ITER IO 	Biggest scientific project, international collaboration, collaborating since 2008	10M+ in 12 years
USITER, F4E	US and EU contribution to ITER	Big framework contracts
PAL XFEL 	Central control system	<1M

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The one control system partner for your project

- **Turnkey control system adapted to your accelerator** – with open source components
- **Integration of subsystems and equipment** into your control system
- **Experts outsourcing**
- **Master all Software and Hardware Technologies**

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EPICS Projects (in Commercial Contexts)

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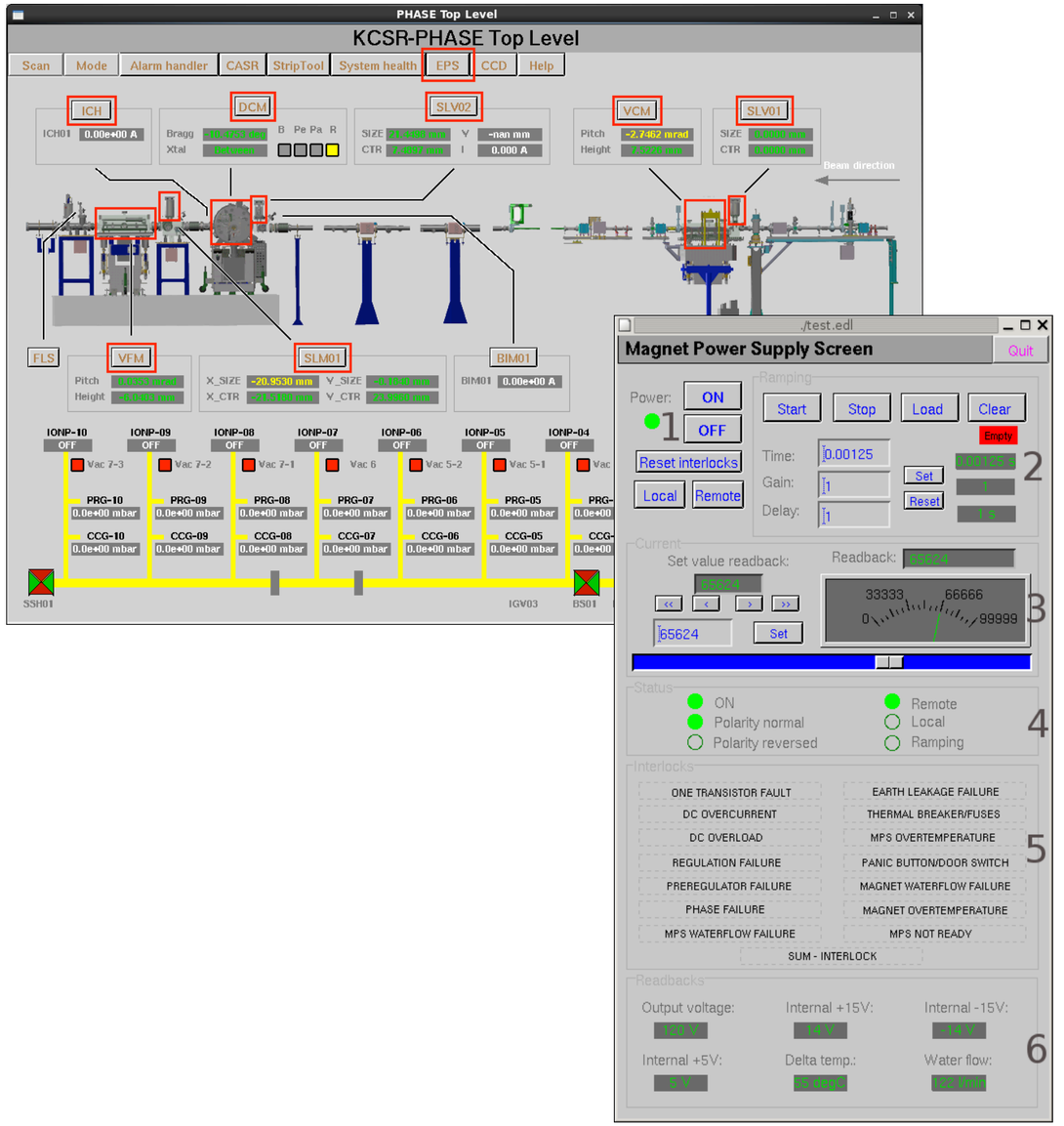
Subcontractors to subsystem providers (SCI market)

- Scientific facility outsources parts of the project to a turnkey provider together with control system
  - Injection system (ASP booster)
  - Beamline (~10 photon beamlines)
  - Insertion devices
  - Cryoplants etc.
- More popular with greenfield sites
  - Get up and running faster
  - Not have a local controls team or does not have time
- Not too many of such projects

EPICS made it easier

- Experience from first projects (ANKA) helped – we knew what is timing, power supplies ramping, beam diagnostics etc.
- Many useful building blocks available (drivers, scanning software etc.)
- Community was very helpful with advice (free and paid)



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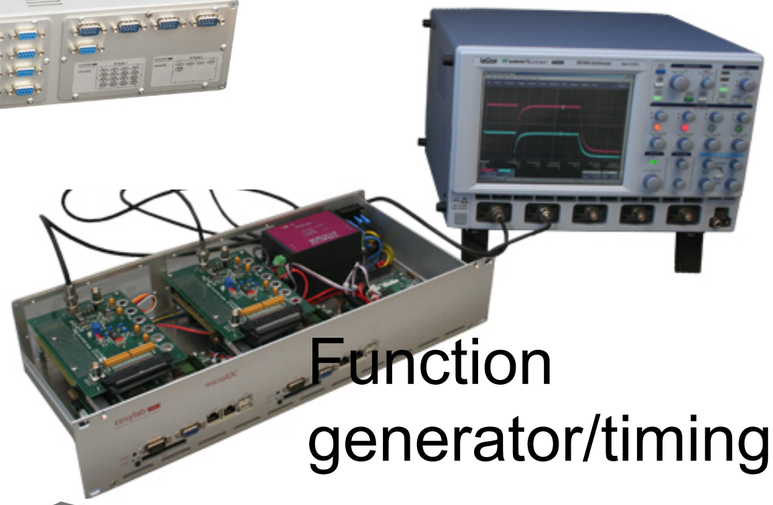
Integrate Devices into EPICS

GPIB

RS 232/422/485

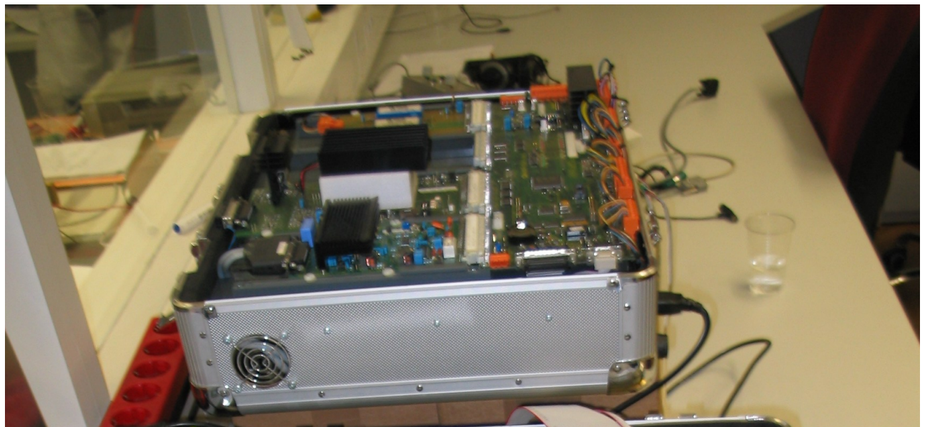
Analog/digital I/O

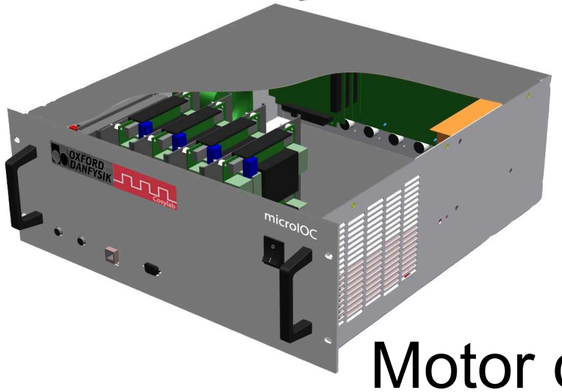
USB/Ethernet camera



Function generator/timing

Danfysik power supply





Motor controller/driver

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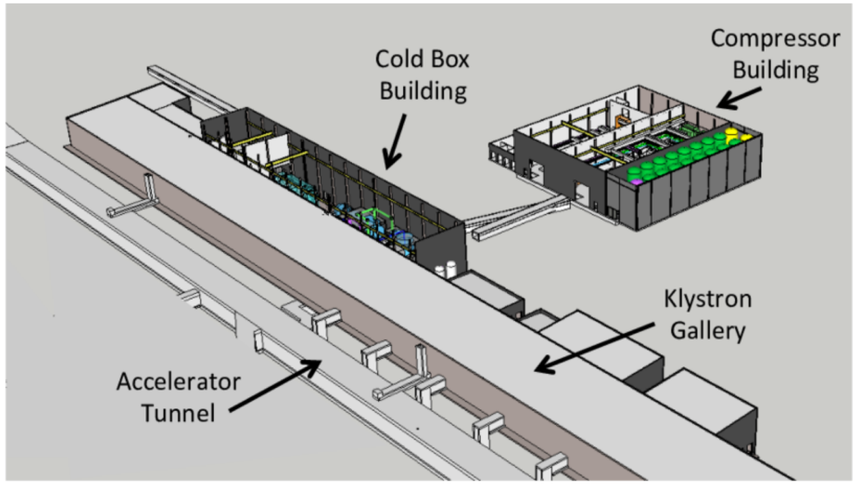
Cryoplant controls for ESS

- Working as a subcontractor to a major European cryoplant provider
  - They develop the control system using Siemens PLCs
  - Requires integration to facility control system (EPICS as being used at ESS)
    - Big part are the user interfaces
- Project challenges
  - Extracting interfaces (data blocks are not fixed during development)
  - Siemens PLC driver and decide which layer contains the master setpoints
  - Mid-project display manager change (BOY -> Display Builder) -> Flexibility!!



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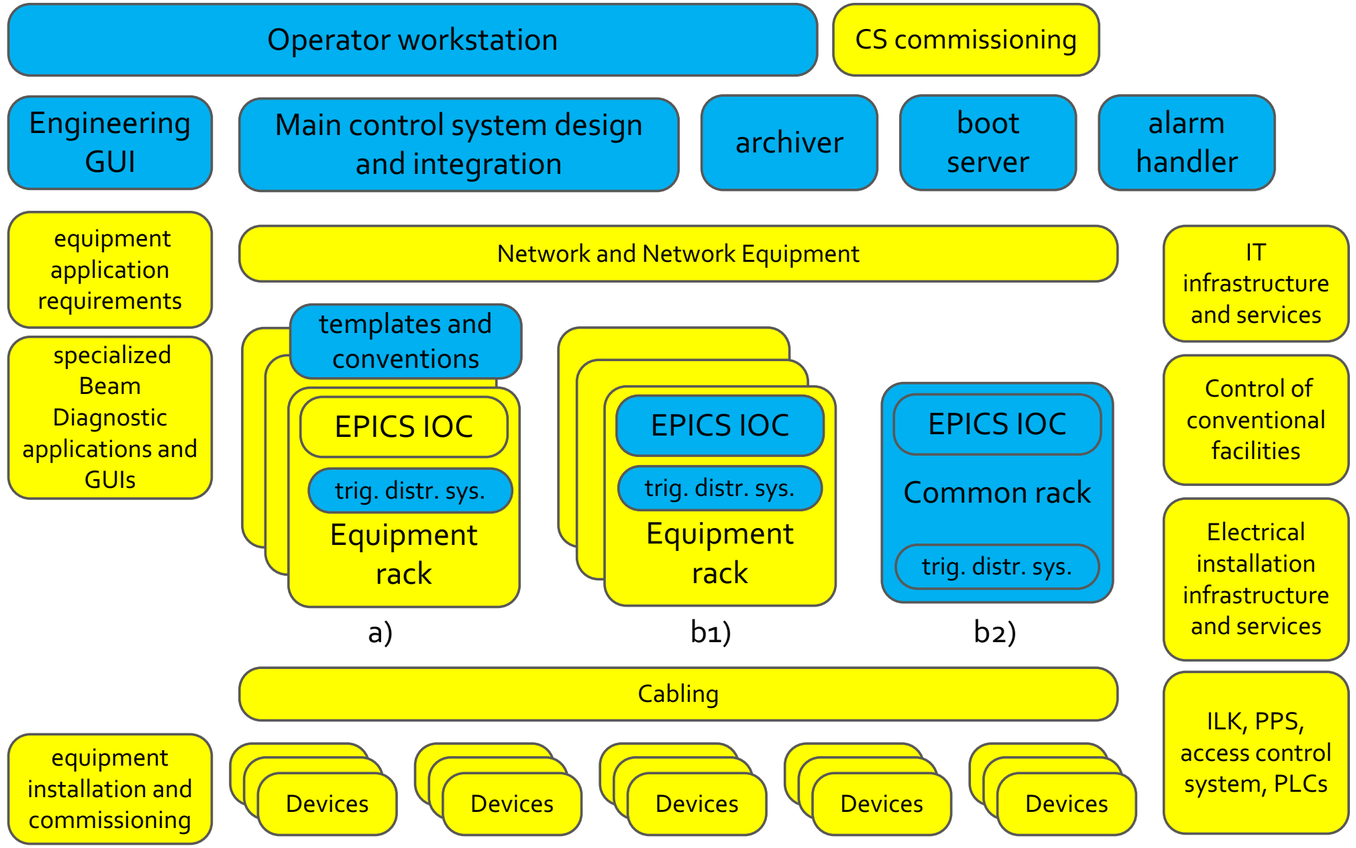
Eli-NP, Romania
– The World‘s most advanced laser and gamma beam facility

- Customer: INFN Frascati
- Provide all major aspects of the control system
- EPICS SW and HW
- Reuse of Software
- **Turnkey Control System**
  - **Lower costs and development time**

EuroGammaS Consortium

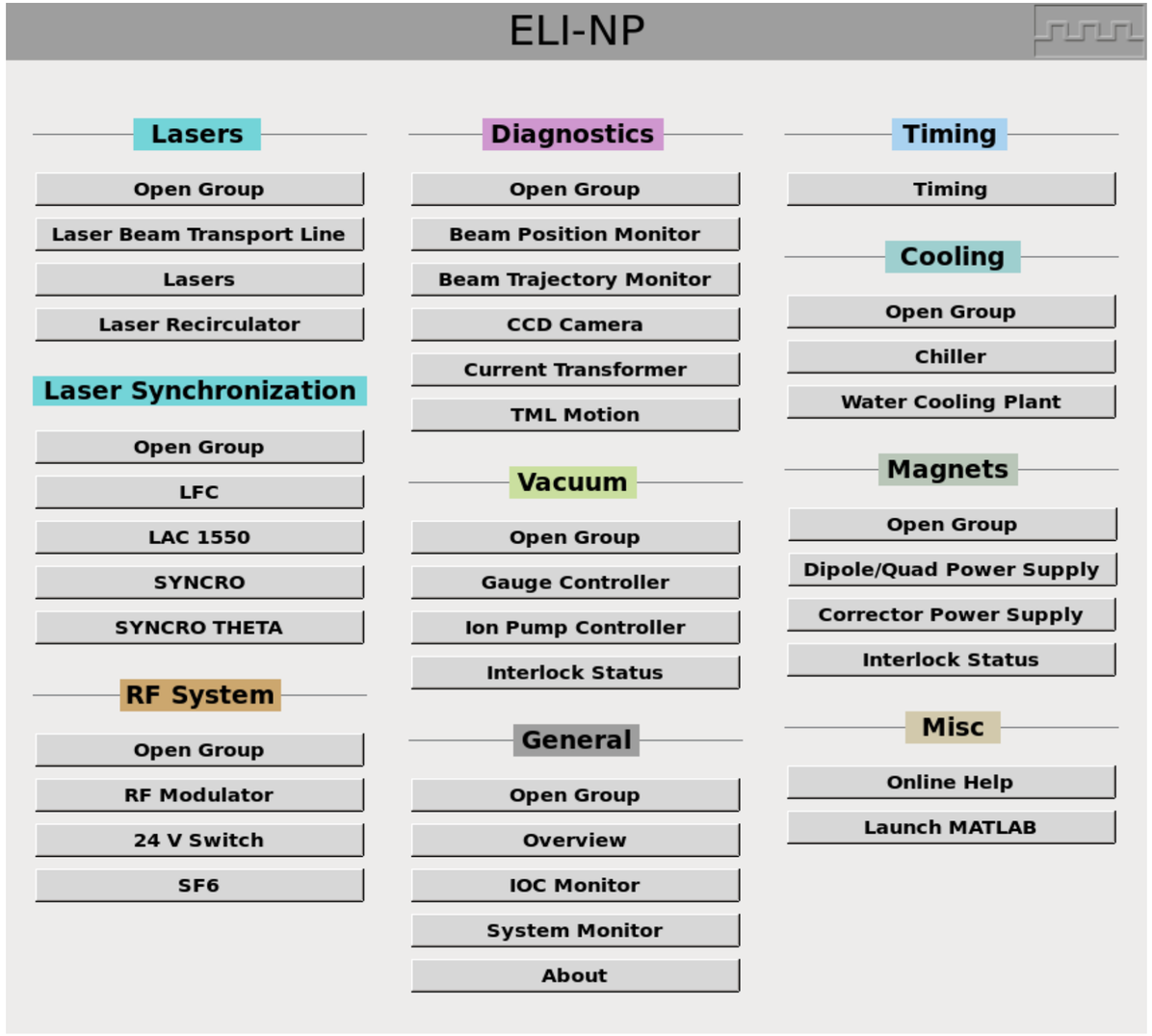
- Amplitude
- Alsyom
- CNRS
- COMEB
- **INFN – Consortium Leader**
- Sapienza
- Scandinova

- ALBA
- **Cosylab**
- Danfysik
- Instrumentation Technologies
- M+W
- Menlo Systems
- Research Instruments
- STFC“



Different integration approaches for different subsystems

ELI-NP Subsystems



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ELI-NP Integrated devices

- Fast digitizers (4 GS/s) for current transformers
- Basler GigE Vision Cameras
- I-Tech Liberas
- I-Tech LLRF
- Scandinova RF Modulators
- Simple motion controller, in/out (iPOS3604 HX-CAN)
- Beckhoff modules for simple I/O
- Siemens PLCs for Vacuum and Magnet PS
- MRF Timing
- …

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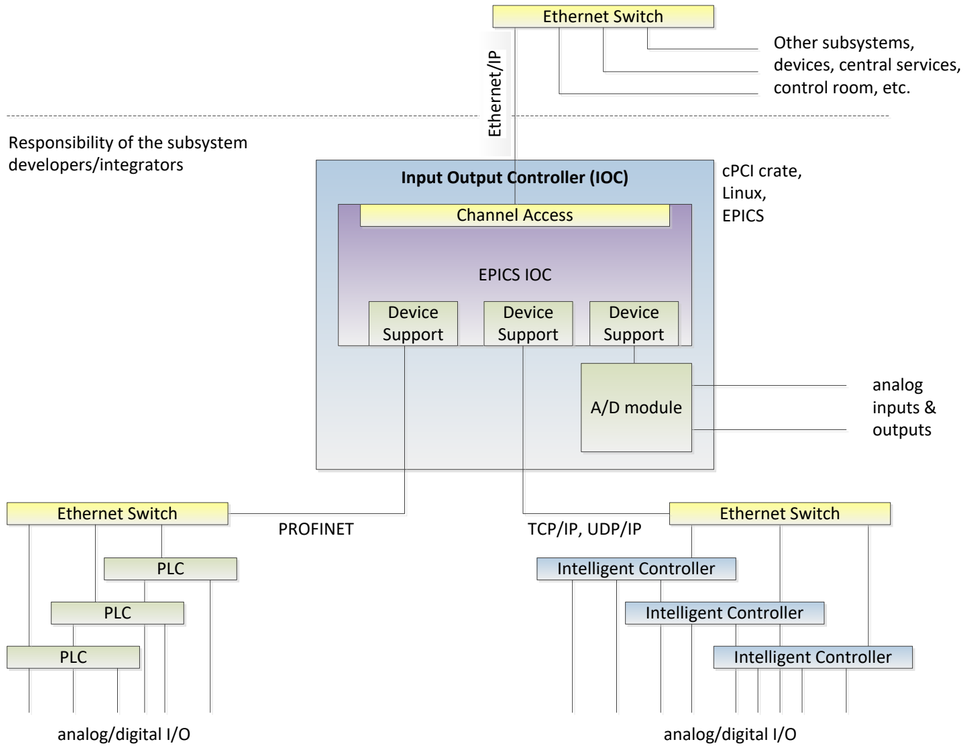
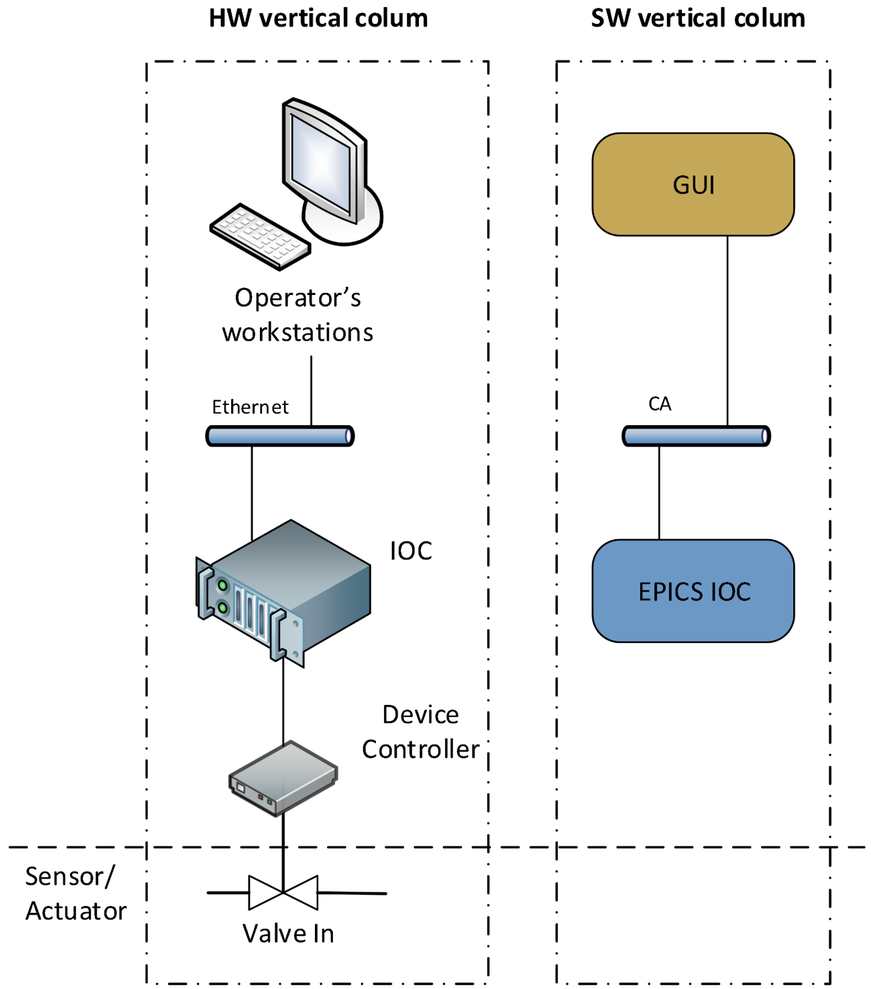
Vertical Column

- A vertical column is an abstraction which describes how the concrete device type is integrated into the control system. It starts from the device sensors and progresses up to the GUI





ELI-NP Controls Hardware

cPCI is the main form factor used:

- MRF timing
- Keystone digitizers
- Ethernet devices

Pizza boxes for soft IOCs (Siemens PLC and Beckhoff, some Modbus/IP interfacing: Chiller, Vacuum, Magnets)

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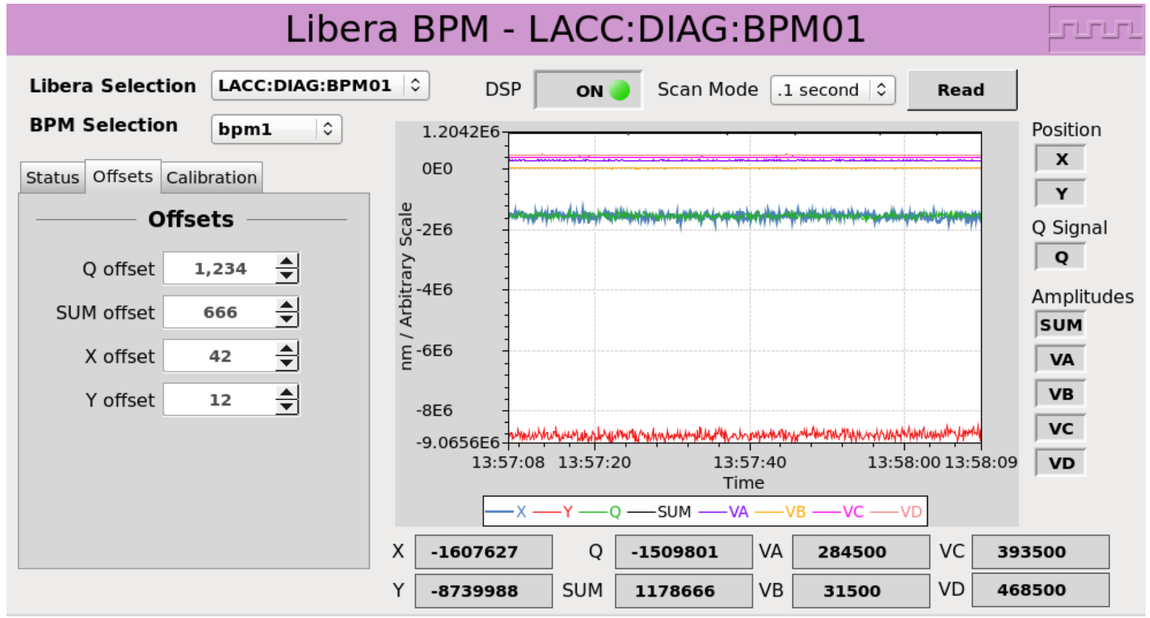
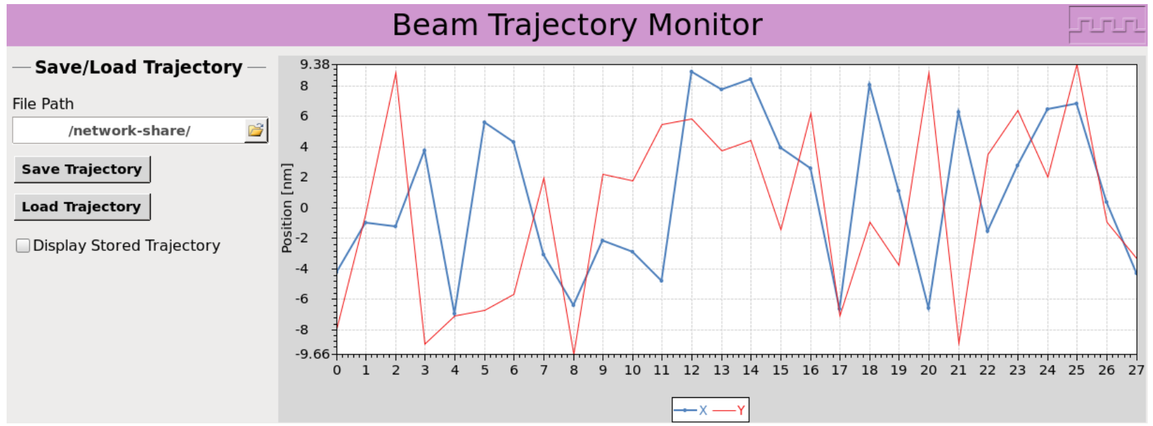
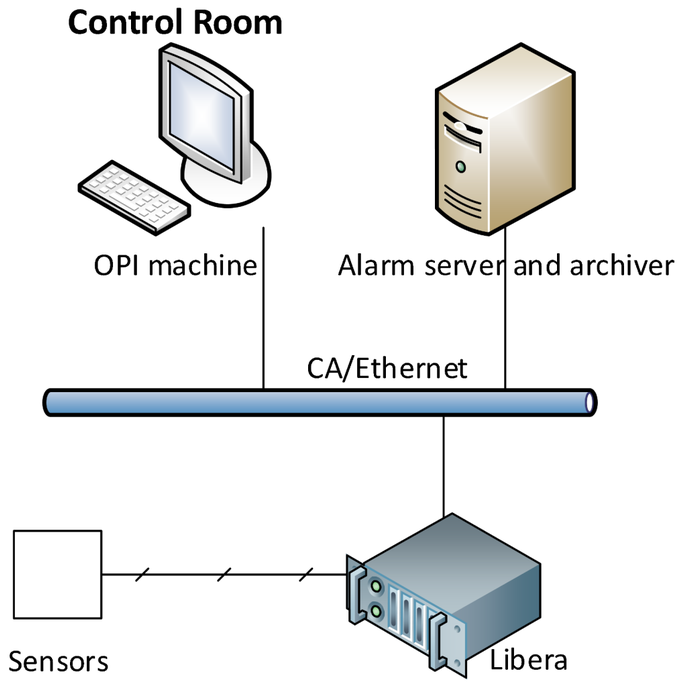
ELI-NP Diag: Libera BPMs

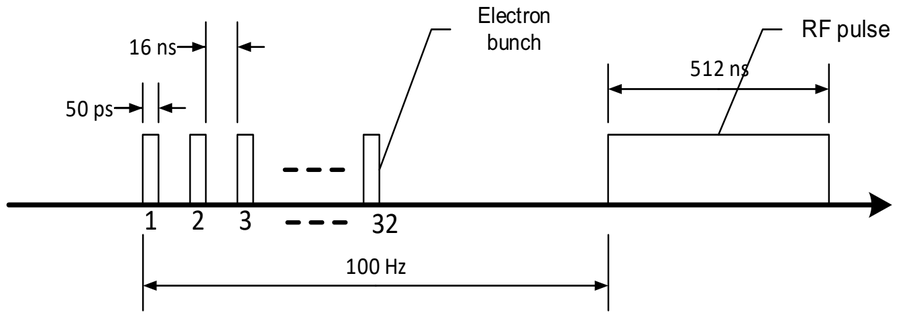




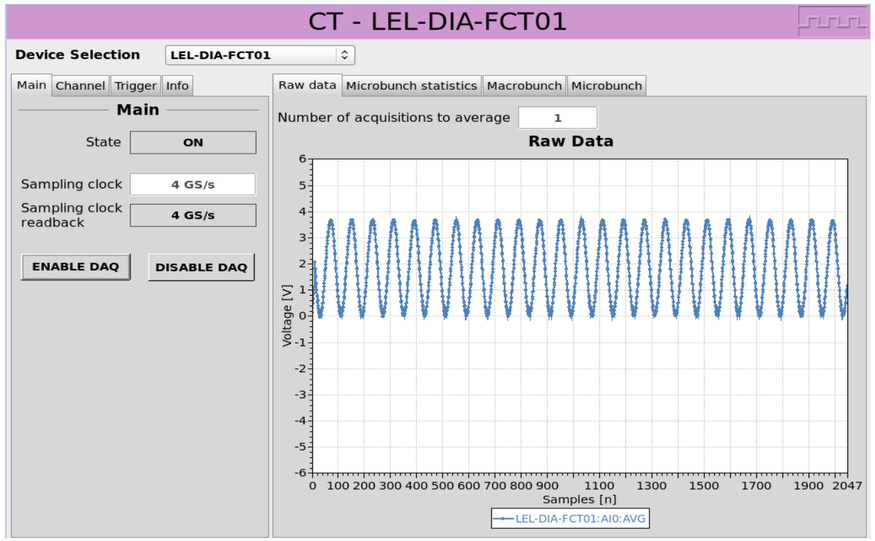


ELI-NP Diag: Current Transformers

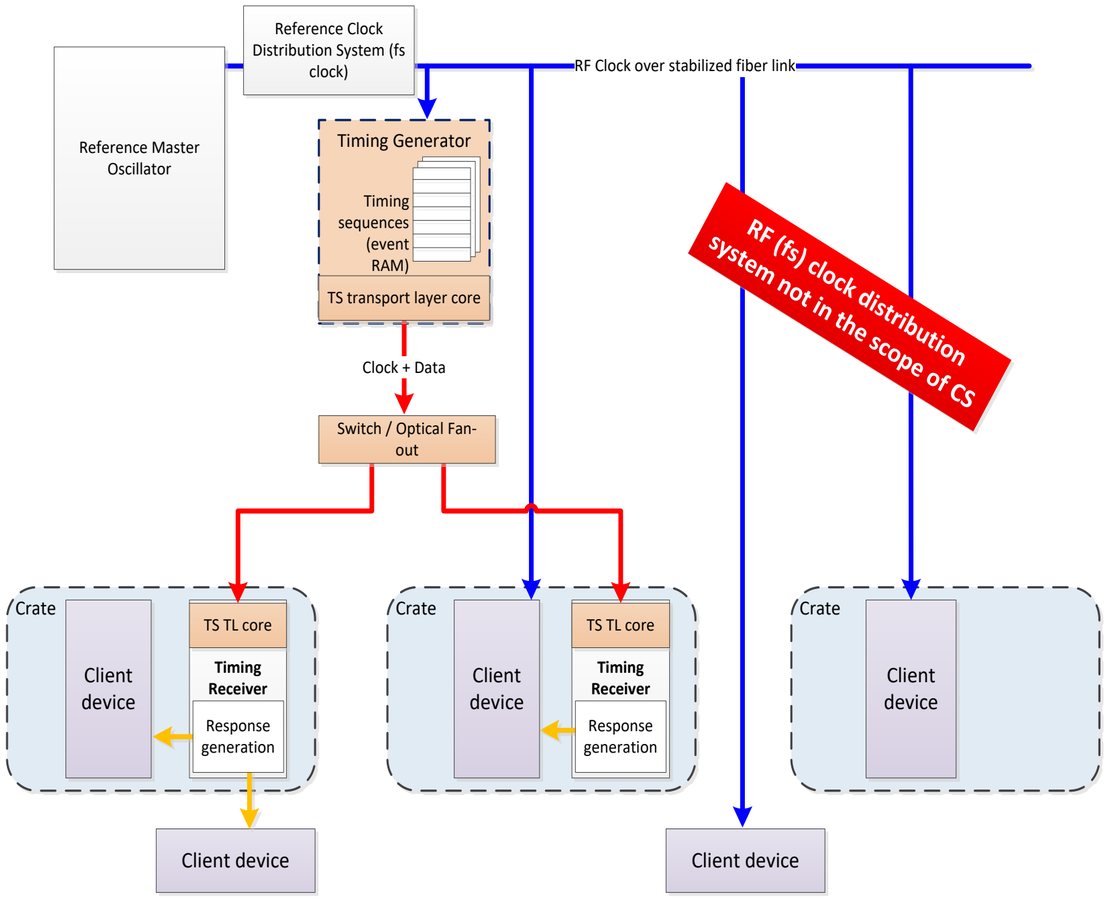
- Time situation



- Bergoz sensor elongates the pulse by factor of ~100 => 5ns
- At 10 measurements per pulse (0.5 ns => 2 GS/s)
- 2-4 GS/s solution was chosen
  - Not many cards in this range, additional complication is the platform (reduces possibilities) and desired voltage range (even further reduction)
- Nominal Device Support was used



ELI-NP Picosecond Timing Triggering System



Client Device	Count	Type	Comment
CCD Cameras	23	TTL	Assuming each camera needs one trigger [RD78]
Beam Position Monitor	7	TTL	Info obtained from A. Falone, April 24, 2015 11:11:53 AM, Subject: Re: System integration of Libera BPM; "…the Libera units (7) will be installed in two adjacent racks in GP08"
Current Transformer (FCT, ICT)	4	TTL	Assuming each Digitizer requires one trigger [RD78]
Laser subsystem (IP, LBTL)	12	TTL	system shown in [RD78] Figure 20: Interaction point components; trigger count and equipment location "GP-P-08" obtained from Kevin Cassou during skype meeting on 6 Mar 2015
RF Modulator	15	TTL	Assuming each modulator requires one trigger line, number of triggers is a sum of instances [RD78], Ch. 11.1.5. installed instances, HW is connected to ROOF level rack room
LLRF	15	LVPECL	Information on trigger count and type provided by I-Tech, 12 Mar 2015
HI efficiency camera	2	TTL	one per camera
Gamma	8	TTL	4 in ACC bay 1, 4 in ACC bay 2
Experiment	4	TTL	1 EVR board in experimental area, timing fiber optics is provided
Spare	16	TTL	one EVR with 4 TTL triggers per RACK room: 04, 06, 08 and ROOF

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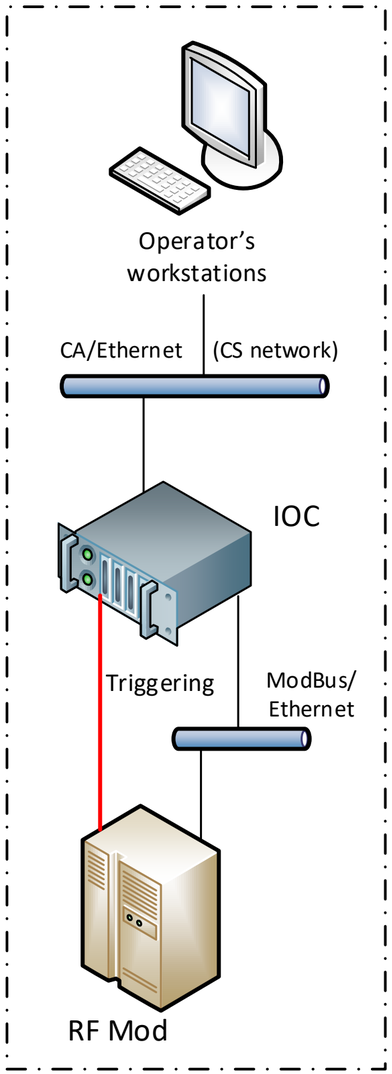
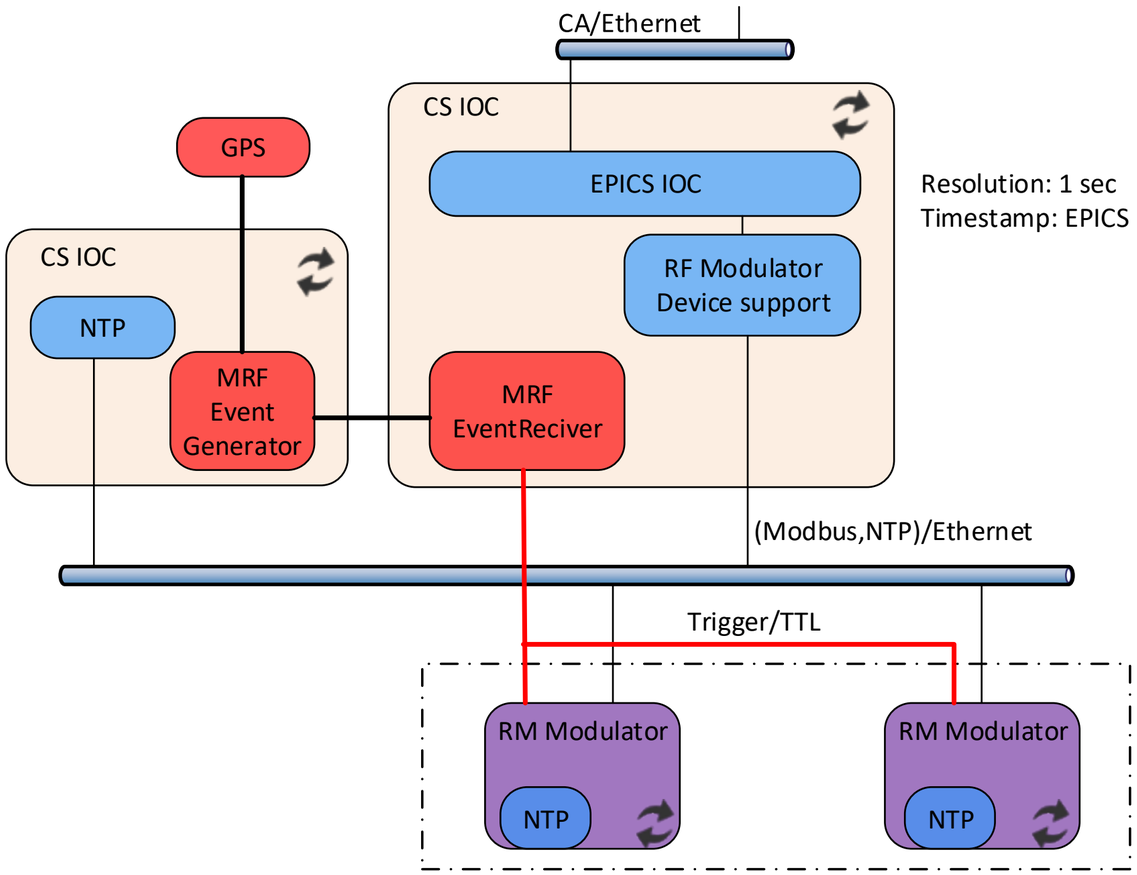
ELI-NP RF: Scandinova Modulators





LLRF was implemented via Libera-LLRF (black box system)

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Medical and Industrial Accelerators

- Example: Accelerators used for cancer treatment or radioisotope production
- Many similarities to scientific projects with some notable differences
  - Better defined projects, focus on time to market (hit the ground running!), quality (development processes!), reliability and/or price
  - Less focus on flexibility
  - Detailed specification is not trivial, but we help with that too (avoid over-complication)
  - Goal is to create a unified and coherent control system
- EPICS provides great solution
  - Robust architecture
  - We could very easily use what we learned on scientific projects and adopt solutions already done in EPICS
  - Still an open source solution at the end

Community (open-source) contribution

- EPICS V7 “base” co-operation
  - pvData (new data model)
  - pvAccess (network protocol)
- Java Channel Access
- Visual DCT
- Nominal Device Server
- DISCS Collaboration (High-Level Apps)

Conclusion

- EPICS is a great control system framework for big and high performance controls projects
  - Great SCADA system for any control system application
  - Especially excels in large complex distributed systems with high performance requirements (e.g. big physics infrastructure)
- Community is great – it is one of EPICS biggest assets which must be treasured
- Cosylab is grateful to EPICS as it contributed to growth of our company
  - It’s still our (my?) favorite control system
- For any more questions do not to hesitate to contact me
  - rok.sabjan@cosylab.com

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Thank you!

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