Cosylab for FAIR

Slovenian contribution to controls at FAIR NUSTAR week 2017

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² Agenda



- About Cosylab
- About Slovenian in-kind contribution for FAIR
- Contribution to controls
 - Control system services: Alarm System, Diagnostic Logging System, Archiving System, Post Mortem System, Beam Transmission Monitor System
 - Integration of devices into FESA control system (various BPMs, COFB, LLRF, RGA, Ion Source, DSO, etc.)
 - White Rabbit Timing Receiver Boards (development and production)
 - Front-End Controllers (serial, motion)
 - Vacuum Control System
 - Interlock System
- Conclusion





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World Leader in Accelerator and Proton Therapy System Integration and Software **COSYLAB**

Customers: many large Big Physics International Projects



 Curing cancer with proton accelerators
 Over 10 PT projects, such as MedAustron, HIMM (China), etc.



Customers From Nearly All Major Labs Worldwide

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1 Canadian Light Source - CLS (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) 13 6. Fermi 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) 15 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 Millimeter Array - ALMA (RCH) 16. Fisheries and Rural Development, Zagreb (CRO) 17. Cividec Instrumentation GmbH (AT) 18. EBG MedAustron (AT) 19. Sinchrotrone Trieste - ELETTRA (IT) 20. Kvma (IT) 21. Instituto Nazionale di Fisica Nucleare - INFN-LNL (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. Átos Origin (FR) 33. Ion Beam Applications - IBA (B)

3 34. Procon Systems (ES) 35. GGS - ALBA (ES) 36. Ciemat (ES) 37. Observatorio Astronómico Nacional - OAN (ES) 38. ESS Bilbao (ES) 39. Geographic/Data Support Ltd (UK) 41. STAR-APIC (UK) 42. Rutheford Appelton Laboratory (UK) 43. Daresbury and oratory (UK) 44. Diamond (UK) 45. FMBO Oxford (UK) 46. Siemens (DE) 47. ACCEL (DE) 48. Electron accelerator ELSA (DE) 49. Helmholtz Zentrum Berlin fur Materialien und Energie (DE) 50. European Molecular Biology Laboratory - EMBL (DE) 51. Physikalisch-Technische Bundesanstalt Berlin - PTB (DE) 52. Jenoptik AG Jena (DE) 53. Forschungzentrum Karlszuhe (95) 27. Jage (95) 24. Dortmunder Elektronen Speickering 24. Jage (95) 24 55. Deutsches Elektronen-Synchrotron DESY (DE) 56. European Southern Observatory ESO (DE) 57. Gesselshaft fur Schwerionenforschung (DE) 58. Feinwerk-und-Messetechnik GmbH (DE) 59. Imtech Vonk (NL) 60. Kernfysisch Versneller Instituut - KVI (NL) 61. Danfysik (DK) 62. European Spallation Source (SE) 63. MAX-lab, Lund University (SE) 64. J. Stefan Institute (SI) 65. Hidria (SI) 66. ISKRATEL (SI)

67. National Research Centre "Kurchatov Institute" (RU)

16 68, Telsima (SI) 69. AET (S) 70. Slovenian Ministry of Agriculture Food and Forestry (SI) 71. Seaway (SI) 72. Slovenian Environmental Agency - ARSO (SI) 73. The Surveying and Mapping Authority of the Republic of Slovenia-GURS (SI) 74 The National Veterinary Administration - VURS (SI) 75. Instrumentation Technologies - I-TECH (SI) 76. Electronic Institute Milan Vidmar -EIMV (SI) 77. Slovenian Ministry of the Environment and Spatial Planning (SI) 78. Smart Com (SI) 79. SOU (SI) 80 Bio Sistemika (SI) 81. Turkish Accelerator and Radiation Laboratory at Ankara (TUR) 823Tsinghua University (CN) 434 Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou (GN) 84. Southwestern Institute of Physics - SWIP, Chengdu (CN) 385. Shanghai Institute of Applied Physics, Chinese Academy of Sciences (CN) 86. Pohang Accelerator Labolatory (KR) 87. Hiroshima University (JP) 88. Institute for Molecular Science (JP) 89. Riken (JP) 90. Repic Corporation (JP) 91. Nichizou Denshi Seigyo Kabushikigaisha (JP) 92. Japan Atomic Energy Research Institute - JAERI (JP) 93. High Energy Accelerator Research Organisation - KEK (JP) 94. The University of Tokyo (JP) 95. Hitachi Zosen (JP) 96. Japan Synchrotron Radiation Research Institute - JASRI (JP) 97. NSRRC -National Synchrotron Radiation Research Center (TW) 98. Raja Ramanna Centre of Advanced Technology - RRCAT (IN) 99. Australian national nuclear research and development organisation - ANSTO (AU) 100. Australian Synchrotron - AS (AU)

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Who are we?

- 150 people worldwide
 - >100 "developer/engineer"
 - Always ~30 students in the pipeline
- Branches: Sweden, USA, Japan, China, Switzerland





7 How Do We Do It?

People

- We know how to recruit best people
- Own education and training system
 - "CosyAcademy"
- Strong company culture and great employee loyalty





Best Employer in Slovenia 2015 Award

Processes

ISO9001, ISO13485,
 ISO14971, IEC62304









About Cosylab

About Slovenian in-kind contribution for FAIR

Contribution to controls

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Conclusion

Slovenian contribution to FAIR COSYLAB

- Slovenian contribution is in-kind
- Consortium of several companies TEHNODROM
- □ Tehnodrom is internally divided into two pillars:
 - Control System, lead by Cosylab
 - Beam Diagnostics, lead by Instrumentation Technologies
- Control System part has the following partners:
 - Atech elektronika
 - Emsiso
 - Inea
 - iSYSTEM Labs
 - Xlab
 - and Cosylab as a trustee

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11 Control System contributions



- **C1:** Alarm System (PSP 2.14.10.2.7)
- **C2:** Diagnostic Logging System (PSP 2.14.10.2.8)
- **C3:** Archiving System (PSP 2.14.10.2.9)
- **C5:** FESA device classes (PSP 2.14.10.2.11, 2.14.10.2.12)
- **C6:** Timing Receiver Boards (PSP 2.14.10.3.3.1, 2.14.10.3.3.2)
- **C7:** Industrial type FEC systems (PSP 2.14.10.5.9)
- **C8:** Vacuum Control System (PSP 2.14.10.6.1, 2.14.10.6.2, 2.14.10.6.3, 2.14.10.6.4)
- **C9:** Interlock System (PSP 2.14.10.11.3)
- **C10:** Beam Transmission System (PSP 2.14.10.11.4)
- **C11:** Post Mortem System (PSP 2.14.10.11.5)

12 Control System Services



- □ Alarm System
- Diagnostic Logging System
- Archiving System
- Post Mortem System
- Beam Transmission Monitor System
- Application software, written in C++ and Java
 High performance data storage
 GUI

13 Device integration



- □ FESA Front-End Software Architecture
 - Developed by CERN
 - Extended by GSI
- □ Integration of:
 - Different devices for p-Linac Ion Source (Impedance Adapter, Magnetron, Mass Flow Controller)
 - Residual Gas Analyser (Spectrometer), including GUI
 - Various Beam Position Monitoring devices (SIS-100, HESR, CR, HEBT, pLinac)
 - Closed Orbit FeedBack system
 - p-Linac RF system
 - Stepper motor controller, including GUI
 - Interlock system, including GUI
 - Other devices: Oscilloscope, Switching matrix

□ Software (drivers, FESA classes) written in C++

GUI written in Java



❑ White Rabbit Timing System
Wikipedia: White Rabbit is the name of a collaborative project including <u>CERN</u>, <u>GSI Helmholtz Centre for Heavy Ion Research</u>, and other partners from universities and industry to develop a fully deterministic <u>Ethernet</u>-based network for general purpose data transfer and sub-nanosecond accuracy <u>time transfer</u>. Its initial use was as a timing distribution network for control and data acquisition timing of the accelerator sites at CERN as well as in GSI's <u>Facility for Antiproton and Ion Research</u> (FAIR) project.







Development and production of Timing Receiver Boards PMC form factor



Bringing WR timing to older systems (PMC carrier)





- Development and production of Timing Receiver Boards
 AMC form factor
 - MTCA.0 host
 - PCIe to host
 - IRQs
 - 5 front LEMO los



- MTCA.4 host
 - 8 bidirectional IOs on backplane
 - 4 bidirectional clocks on backplane





IOs

- LEMO connectors
- Bidirectional, LVTTL levels
- Capable of driving 50 Ohm load
- Internal 50 Ohm termination
- Generation of clocks up to 200MHz
- Schedule pulse generation (pulse trains) with 1ns resolution
- Timestamping of events on inputs
- Interrupt generation to host bus
 - PCI or PCI Express



- Development and production of microlOC serial
 - For integration of peripheral devices with serial interface
 - Support communication with RS232, RS422, RS485, GPIB, Ethernet or USB type of devices
 - Up to 24 RS232/RS422/RS485 ports
 - Slot for PCI mezzanine card (usually for PMC Timing Receiver Board)









- Development and production of microlOC MBOX
 - For controlling of up to 8 stepper motors
 - 6 output and 6 input signals available per motor
 - Galvanically isolated connection to motor driver unit
 - Slot for PCI mezzanine card (usually for PMC Timing Receiver Board)







- Development and production of microlOC PDC
 - For driving up to four 5-phase stepper motors
 - Support for analog and SSI encoders
 - Up to 300m distance between control and power unit
 - Up to 70m distance between power unit and motor





Control motors via Control system (FESA, EPICS, etc.) Standalone GUI application

\$			Slit Loc	al Control			- 🗇 🗙	
Eile Help								
	Connected to: localhost:666	Communication status 🥥	System mode: local config	guration	Initialize driver	Display units: mm		
Main Motor Drive Motor	Setup							
Motor1 & Motor2 Motor3	& Motor4 Motor5 & Motor6 Motor7 & Moto	8						
Status Hotor1 Outer HW end limit set Outer HW end limit set Outer SW end limit set There SW end limit set Moving Prask Position tolerance	Fatal following error Arquiffer fault Overheat Avas interfood Potentiometer reference error Midde switch		General status MAC commeror Consider commeror Shared memory error	General status PMAC comm error Encoder comm error Shured memory error		 Fatal following error Amplifier fault Overheat Asis Interlock Potentiometer refere Midde switch 	 Fatal following error Amplifier fault Overheat Axis interdok Potentiometer reference error Middle switch 	
Notor Position Notor 2								
-100.0 -80.0	-60.0 -40.0 -20.0	0.0 20.0 40.0	60.0 80.0 100	-100.0 -80.0 -60	.0 -40.0 -20.0	0.0 20.0 40.0	60.0 80.0 100	
Motor Drive Motor1				Motor Drive Motor2				
Position Set position	10	10.0 [mm] 10.0 0.0 20.0 40.0	Continuous	Position Set position	-100.0 -80.0 -60.0	0.0 [mm] 10.0 -40.0 -20.0 0.0 20.0	Continuous	
Actual position	1. To outside limit	.0 [mm] To Position Test Start Stop	To inside limit	Actual position Move	To inside limit	.0 [mm] To Position Test Start Stop	To outside limit	
Move relative	Move out	0.0 🔶 [mm]	Move in	Move relative	Move in	0.0 🚔 [mm]	Move out	
Reset position		0.0🚔 [mm]	Reset	Reset position	[0.0 🚔 [mm]	Reset	
PMAC position Copy actual position to setup	20.0 (mm) P R Copy to outside limit	fotentiometer 10.000 [V] keference voltage N/A [V] Copy to offset	SSI raw value N/A Copy to inside limit Hide	PMAC position Copy actual position to setup	20.0 [mm] F Copy to inside lmit	Potentiometer 10.000 [V] Reference voltage N/A [V] Copy to offset	SSI raw value N/A Copy to outside limit Hide	
19:0431 - A unknown command was received: null								



- Control motors via
 - Control system (FESA, EPICS, etc.)
 - Standalone GUI application
 - LCD on the front panel of MBOX



Control single motor or pair of motors (e.g. slits)



23 Vacuum Control System



- Vacuum and Bake-out control system for all FAIR machines
- Based on Siemens PLC and UNICOS

UNICOS (**UN**ified Industrial **C**ontrol **S**ystem) is a CERN-made framework to develop industrial control applications.

http://unicos.web.cern.ch/

- Control of different devices (pumps, valves, gauges, etc.)
- Software (Unicos, SCL, WinCC Scada)
- □ Installation of hardware (EPLAN)



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²⁶ Conclusion



- Cosylab is the World Leader in Accelerator, Big Physics and Proton Therapy System Integration and Software
- Over 150 employees worldwide
- Working with GSI / FAIR for more than 10 years
- Experts in
 - Various control systems (EPICS, Tango, LabView, FESA, etc.)
 - Motion control
 - Timing Systems (MRF, White Rabbit)
 - Machine and Personnel Protection Systems
 - Fast MPS (FPGA based, response time in micro-seconds)
 - Interlock system (PLC based)
 - Personnel Protection Systems (Safety PLC based)
 - Proton Therapy systems
 - and more

THANK YOU!

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