MedAustron Accelerator Control System

ICALEPCS 2011

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The Project
The Project

- Ion-therapy and research centre in Wiener Neustadt, Austria
- Proton/ion synchrotron accelerator
  - Ion-therapy for cancer treatment
  - Clinical research and applied research
- Multiple ion sources
  - p + Co for ion therapy
  - Light ions for research
- 5 beam lines
  - Experimental: 1 horizontal
  - Clinical: 1 horizontal, 1 horizontal + 1 vertical, 1 proton gantry
Location

50 km
Status of Project

- **Summer 2008**: Start of Planning
- **Spring 2009**: Start of Environment Impact Assessment (EIA)
- **October 2009**: Hand-in of EIA, EIA passed December 2010
- **March 2011**: Start of building construction
- **October 2012**: Installation of accelerator components
- **Q2 2013**: Commissioning of accelerator
Challenges for the Control System

\[ P \times S \times B \times E \times D \times L = 240'000 \]

- Particle types: 2
- Ion sources: 4
- Energy levels: 500
- Beam lines: 5
- Spill lengths: 3
- Beam dimensions: 4
Challenges

- **Pulse-to-pulse** modulation, **cyclic** operation (technical)
  - Large number of possible settings
  - Keep dead-time between cycles small (pipelined operation/reconfiguration)

- **Concurrently operating partitions** (technical)
  - Staged commissioning of machine parts
  - Interleaved clinical operation and commissioning

- **Low staff-headcount** (organisational)
  - Design of unattended operation
  - Keep engineers team low

- **Aggressive** realization **schedule** and budget (organisational)
The Blueprint
Control System Architecture

- Multi-tier architecture
- Separation of concerns
  - Interfaces between tiers
  - Identification of functional components in tiers
- Industry oriented
- Modular
- Stepwise extensible
- Responsibility of accelerator workpackages
Design Choices

- Presentation tier (1)
  - Ethernet, TCP/IP
  - WinCC OA, SRDP

- Processing tier (2)
  - Ethernet, TCP/IP
  - OPC, STM/MAPS, HTTP

- Equipment tier (3)
  - Ethernet, TCP/IP
  - OPC, MRF, 8B10B custom

- Frontend tier (4)
  - Ethernet, TCP/IP

Recommendations for RS 422 & digital IO

Virtual Machines

- VMware
  - Meas. Studio
  - QVI
  - PXIe
  - NI SV

- Inhouse C#
  - Oracle
  - VMware

- PLC, controllers, Power converters

- Rack mounted PC (PCIe)

Equipment for:
- Meas. Studio
- Qt
- PXIe
- Meas. Studio
- QVI
- PXIe
- NI SV

Presentation tier (1)

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Frontend tier (4)

- Ethernet, TCP/IP

Recommendations for RS 422 & digital IO
WinCC OA (PVSS) is the core operating system of the accelerator control system!
• Keeps overall system status image
• Single entry point into systems
• ~ 100 kDPEs on 6 VMs
Control System Architecture

- **Presentation tier (1)**
- **Processing tier (2)**
- **Equipment tier (3)**
- **Frontend tier (4)**

**Measurement Studio**

**PXIe platform and LV-RT** is the processing platform of tier-3! Light **Front-End Control Operating System (FECOS)** implemented. Light framework to adapt all devices and processes to tier-2.
Subsystems Based on PXIe/LV-RT

- Main timing system
  - Real-time Event Distribution Network (REDNet)
  - Based on MRF transport layer (cPCI MTG and PXIe EVRs)
- Power Converter Controller
  - FlexRIO optical adapters + RT link + FPGA-based FED
- Beam Diagnostics and Instrumentation
  - Front End Controller Operating System (FECOS) LV-RT framework
- MedAustron Publisher/Subscriber
  - High rate data exchange C#/LV-RT based on NI’s STM protocol
- TINE protocol on LV/LV-RT to integrate Thomson’s iLLRF
- Pantechnik ion sources on PXI crates with OPC interface
Examples

- UI panel with Qt widget
- REDNet
- Power Converter Controller
GUIs with WinCC OA + Qt

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REDNet

- Based on Micro Research Finland (MRF) hardware layer
  - PXI running, PXIe event receiver cards under development
  - Drivers and libraries for LV and LV-RT developed
- Event broadcast sequencer
  - General-purpose “cycle sequence-player” system
- Symmetricom S350 GPS integrated for 100 ns timestamps, 1μsec event granularity
  10 nsec granularity for synchronizing 2 injection devices
- 50 receivers needed (but scales to several hundreds)
- Implemented by Cosylab
- In-device response via RT bus or Universal IO modules
Cycle Operation

- Cycles last about 2 seconds
- A run has between 250 and 500 different cycles
- Frontend re-configuration takes less than 500 msec
Power Converter Controller

- All 262 power converters operated via NI-FlexRIO based distributed system
  - High density 8-16 FlexRIOs in 1 chassis (around 70 PCOs per chassis)
- Power converters are
  - RS-422 serial devices for slow controls (uniformed interface design for all power converters)
  - Voltage sources driven via in-house built regulation board (DSP)
  - Special magnets with optical trigger for setpoints via RS-422
PCC Developments

- Built FlexRIO adapter with 6 optical SFPs
- Defined and implemented real-time protocol (100 kHz)
- Build Front-End Device (FED) to interface to Power Converters
- Switched from PXI to PXIe after evaluating PXI crates+CPUs
- Implemented LV-RT drivers, applications software
Conclusions

• MedAustron control system very much COTS orientated
  • Core based on ETM/WinCC OA (formerly PVSS II)
  • Equipment tier based on NI PXIe, LV-RT
  • Direct integration of PLCs into processing tier
  • Inhouse C# framework (ProShell) for BD and supervisory procedures

• Several in-house developments
  • REDNet, FlexRIO optical adapters, FECOS
  • Framework agreement with Cosylab for development
  • Project has aggressive time-plan and is goal-oriented
    • Building construction now until June 2012
    • Start of accelerator controls commissioning early 2013
ADDITIONAL MATERIAL
Principles of Application

Bragg-Peak

• Well defined point at which beam deposits energy
• Co ions have direct physical effect on tumour cell

Pencil Beam Scanning

• Precise deposition of dose
• Reduce irradiation time
• Improve dose homogeneity
• Treat problematic tumours