REUSABLE PATIENT SAFETY SYSTEM FRAMEWORK FOR THE PROTON THERAPY CENTRE AT PSI

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Introduction

Proton Therapy at the Paul Scherrer Institut

Patient treatment areas:

- Gantry 1 (1996)
- Optis 2 (2010)
- Gantry 2 (2013)
- New Gantry 3

Developed in house
Commercial from Varian Medical Systems
Requirements of the new design

- Implement same safety functionality as in other areas. Most safety elements are centralised
- Interface Gantry 3 proprietary control system to the existing PSI infrastructure as part of PaSS
- Specifications not fully defined yet
- Expected lifespan 20 years
- Restricted time and manpower
- Use cases:

  - Therapy
  - Help
  - Overview
  - EPICS
  - PaSS
  - TCP
  - GUI Server
  - History
  - Log file

  Operating physicist

  Radiologist technician

  Developer, Experimental user

  TCP

  EPICS

  GUI Server

  History

  Log file
**Patient Safety System concept**

**ALOK**
- Close local beam blocker
- Activate deflector magnet

**ATOT**
- Close main blockers,
- Stop proton acceleration at cyclotron
- ALOK actions

**ETOT**
- Switch off the cyclotron’s acceleration system
- Switch off the ion source
- ALOK + ATOT actions
Patient Safety System overview

- PSI Therapy Control System
- Operator Console
- Patient Gating System
- Beam Monitors
- Beam Tuning Verification System
- Beam Blockers
- Vendor’s Gantry Therapy Control System
- Main Patient Safety Switch and Controller
- Cyclotron
- Beam Blockers
- Signal Converter Box
- Patient Safety System
- Graphical User Interface

ICALEPCS15, Pablo Fernandez Carmona, TUC3004
System architecture: Hardware

IOC: IFC1210
- COTS with PowerPC Dual core and user FPGA
- VME bus
- 2 FMC Mezzanines
- Boot from server, remote configuration, Linux OS

Signal Converter Box
- Specific design (Subcontracted)
- Configurable Multiplexer
  - 6 SFP for gigabit optical communication
  - 10 plugin ports

Plugins: Optical, TTL, 3 wire logic, redundant 24v…

Reusable Hardware

ICALEPCS15, Pablo Fernandez Carmona, TUC3004
Tosca Network on Chip (IOxOS)
Shared resources:
  Memory, DMA, Configurable clocks…
User specific block
  Optical links protocol
Generic framework
  Gantry specific logic
All resources can be mapped to io memory
**EPICS driver** maps FPGA resources to records
  - Interlock status
  - Control variables
  - Configurable measurements

**Java GUI** to access all records

User visualization
  - Operation and debug
    - Visualize and log interlock events

Tools for QA
  - Statistics
  - Trends, defects, deterioration ...

Built-in measurements
Configuration file generator

- EPICS configuration template
- C memory definition
- Xml GUI configuration
- Framework package
- Memory block
- Optical communication decoder
There is no official procedure to get a license to do proton therapy in Switzerland

What worked in the past for us:

**Preparation**
- Risk analysis
- Design specification
- PaSS Implementation
- Test specification

**Developed by different people**

**Unit test in the lab**
- Firmware simulation with Modelsim
- Extensive test with LabVIEW generated stimuli

**Integration test in the therapy area, full QA**
- Test all functions
- Test all final elements
- Generate errors and monitor PaSS response
Results: improvements

Functional PaSS with EPICS GUI in time for gantry integration

Extra functionality built in:
  Improve work tools for physicist for error debugging:
    Deterministic time tracking of interlock events
    GUI describes detailed status, source, destination and properties of all signals
  Reduce time needed for Quality Assurance
    Built-in measurement of response time of safety elements
    Many statistics available

Development time
  Comparison with the development in 2009 of the Optis PaSS (Similar system, some assumptions made)

<table>
<thead>
<tr>
<th>G3 IOC + SCB FW</th>
<th>Optis PaSS FW</th>
<th>~40% less</th>
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</thead>
<tbody>
<tr>
<td>165 man days</td>
<td>310 man days</td>
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A reusable, modular Patient Safety System was built to integrate a new commercial gantry in the existing infrastructure of the Center for Proton Therapy at PSI.

- Reusing technology: sophisticated solution, highly customised, with restricted manpower and time.
- Separation into generic and gantry specific: Fast deployment in other facilities, with only small adaptations being needed.

- GUI extensive information and deterministic log of interlock events can reduce the physicist’s response time when called by radiographer technicians

- Including built-in debug, visibility and measurement elements make possible automating some QA tasks and to predict failures by ageing and deterioration of several components.
Thank you for your attention