MedAustron Accelerator Control System

ICALEPCS 2011

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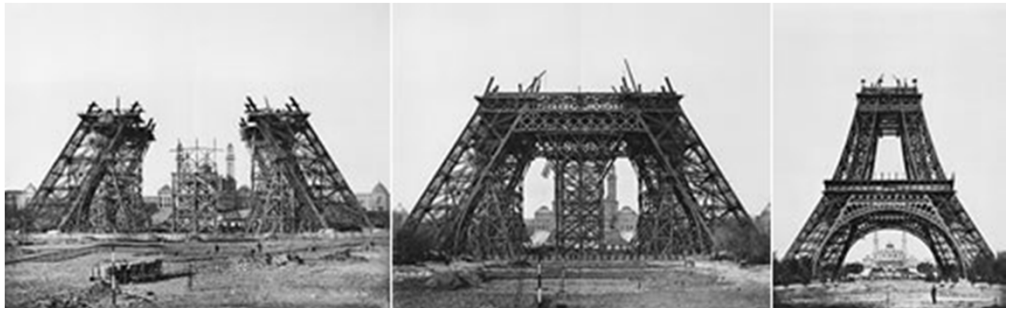
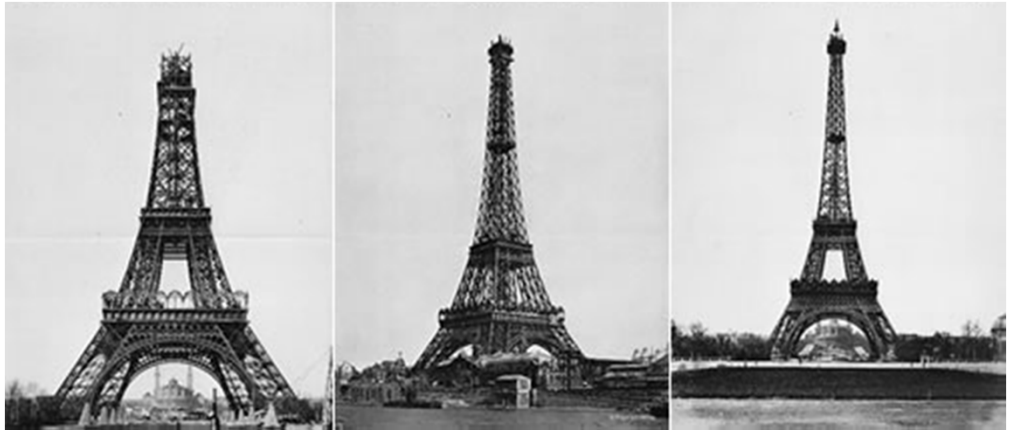
CERN PH & BE

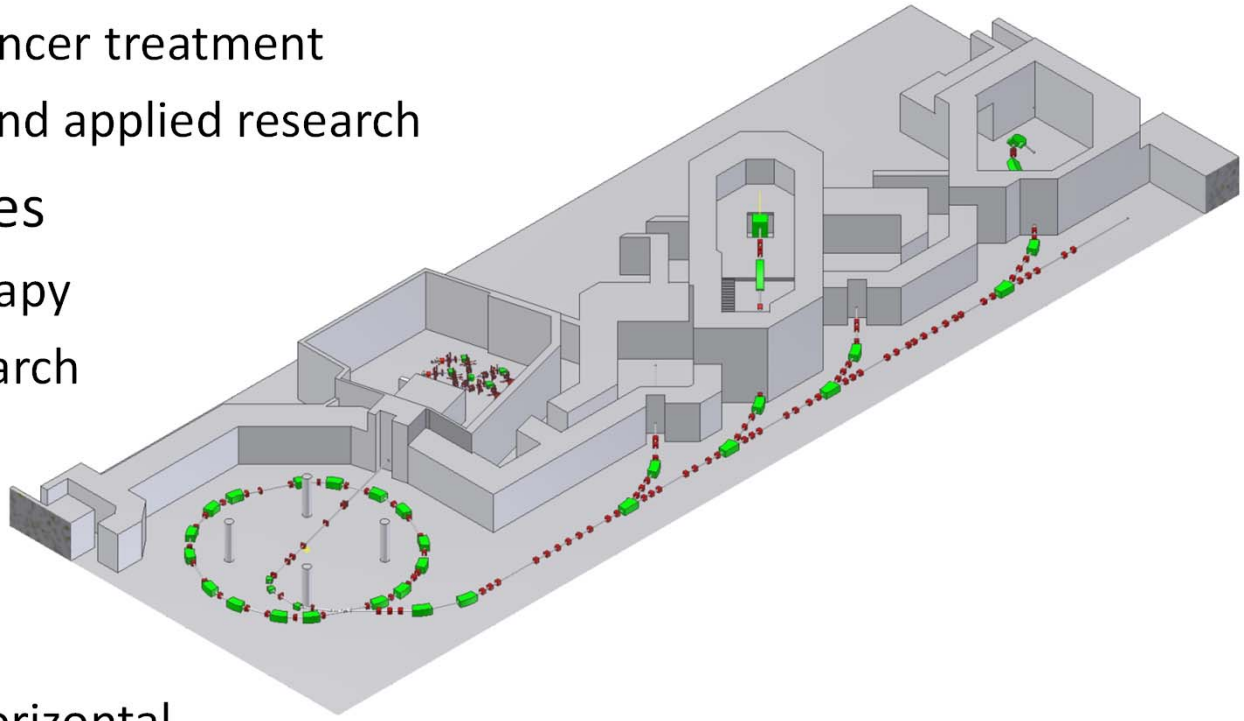


The Project



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



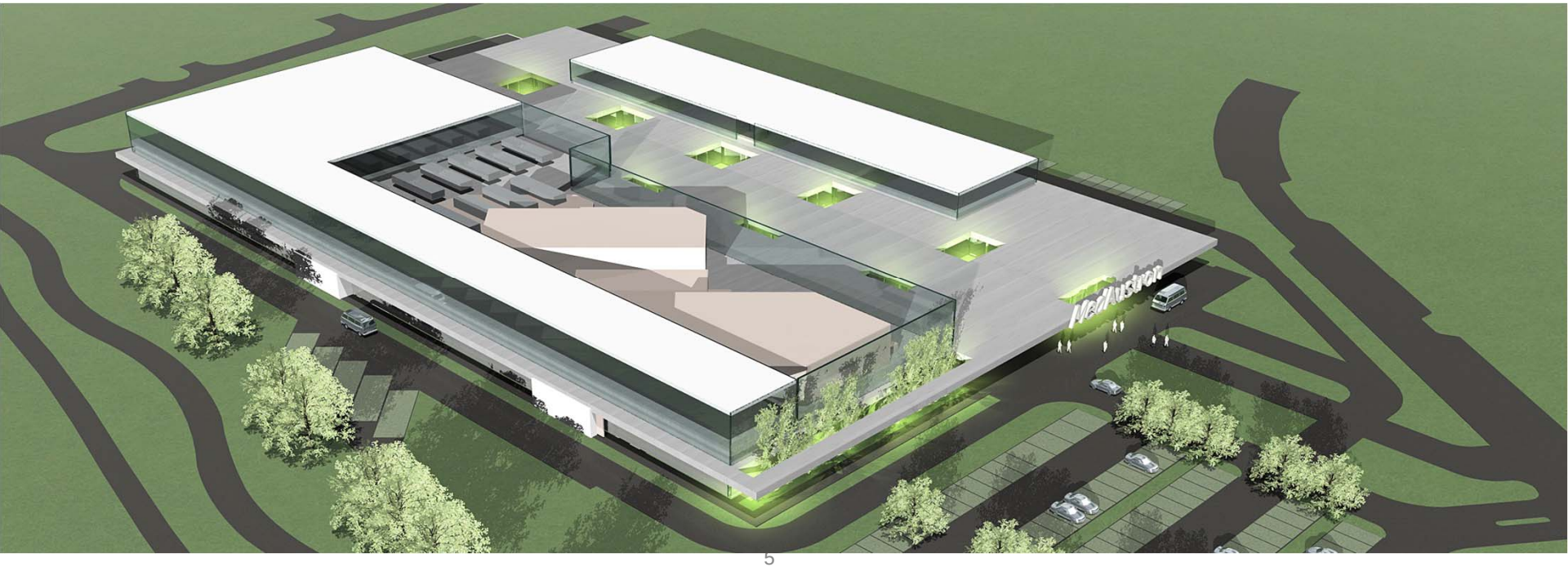
- 5 beam lines
  - Experimental: 1 horizontal
  - Clinical: 1 horizontal, 1 horizontal + 1 vertical, 1 proton gantry

Location


Austria
CZECH REPUBLIC
GERMANY
AUSTRIA
SWITZ.
LIECH.
ITALY
SLOVENIA
HUN.
SLO.
CROATIA
Gmünd
Krems
Vienna (Wien)
St. Pölten
Linz
Wels
Steyr
Baden
Mariazell
Salzburg
Bregenz
Kufstein
Feldkirch
Innsbruck
Landeck
Bischofshofen
Bruck
Leoben
Graz
Badgastein
Lienz
Klagenfurt
Villach
Ljubljana
Zagreb
50 km
0 25 50 mi
0 25 50 km
49°
48°
47°
46°
10°
12°
14°
16°
© maps.com

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

Ion sources: 4

Energy levels: 500

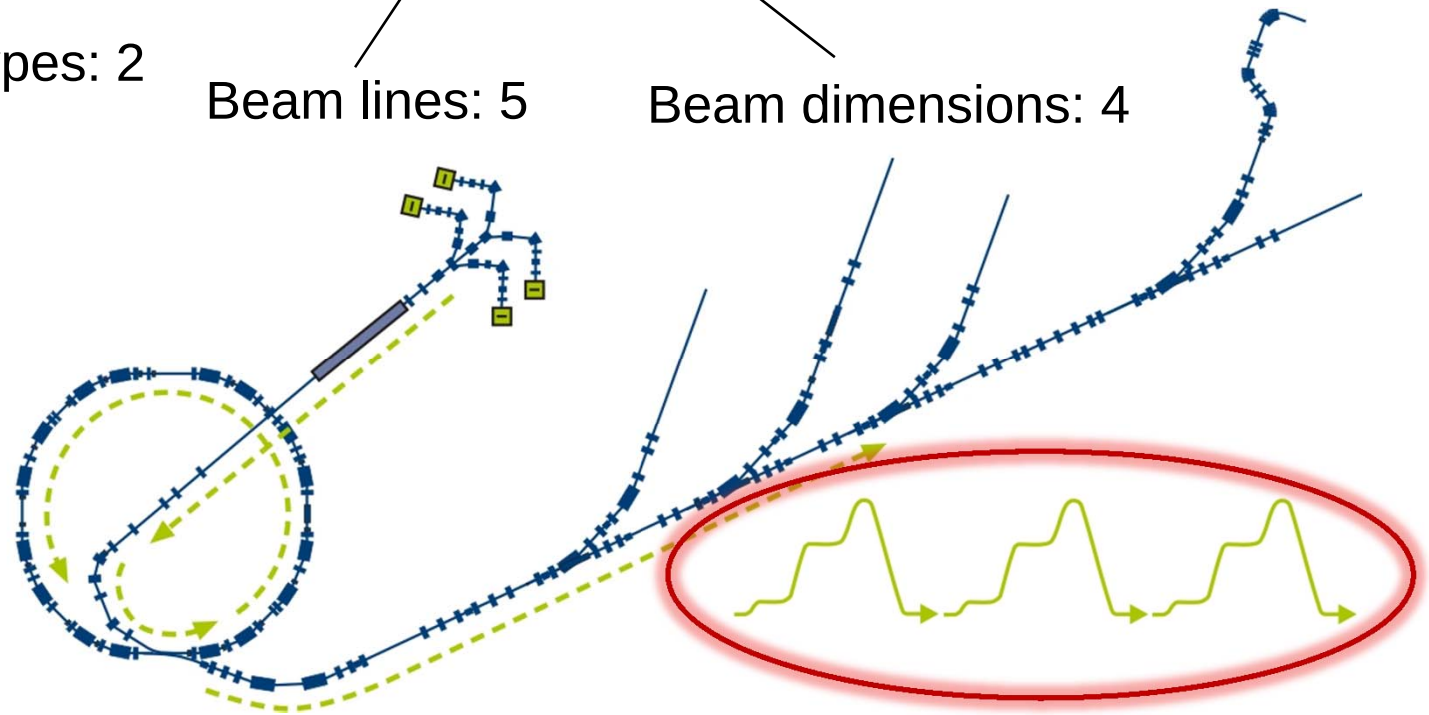
Spill lengths: 3

$$P \times S \times B \times E \times D \times L = \mathbf{240'000}$$

Particle types: 2

Beam lines: 5

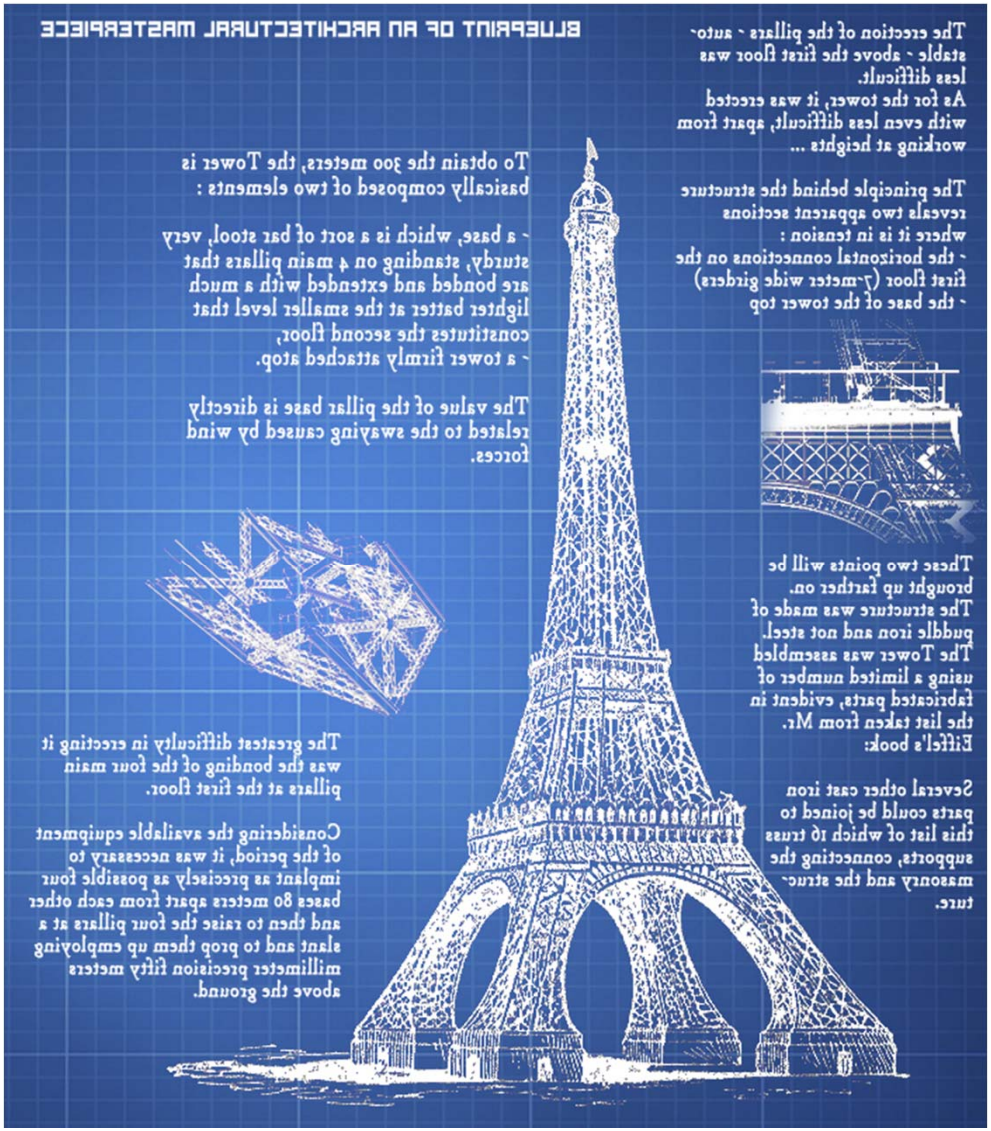
Beam dimensions: 4



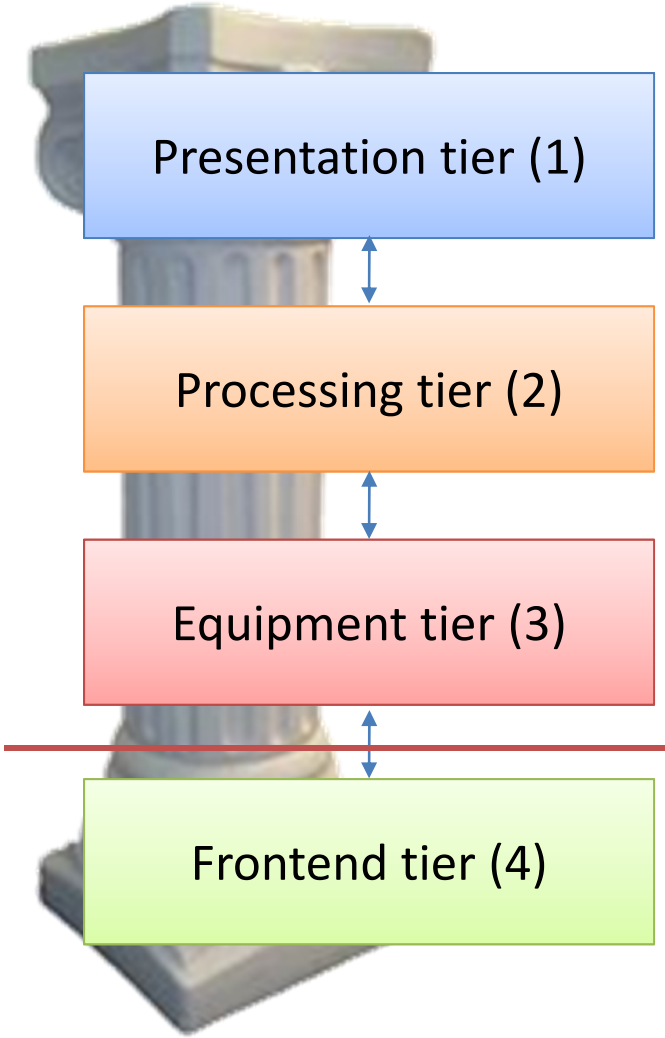
Challenges

- **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



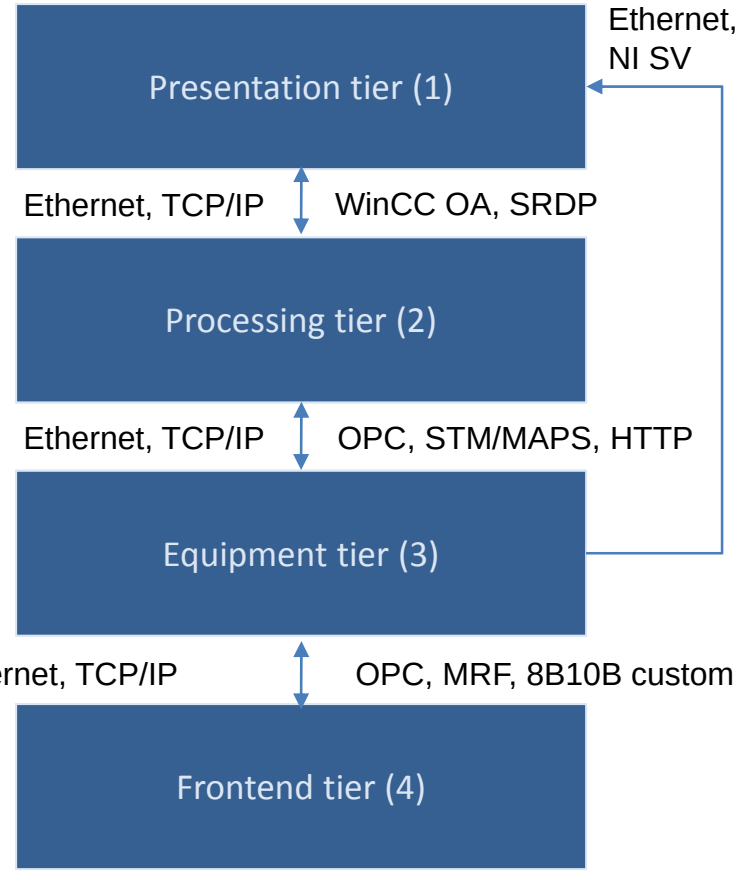
Control System Architecture



- 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



Recommendations for
RS 422 & digital IO

Meas. Studio

Qt

PVSS II

Inhouse C#

ORACLE

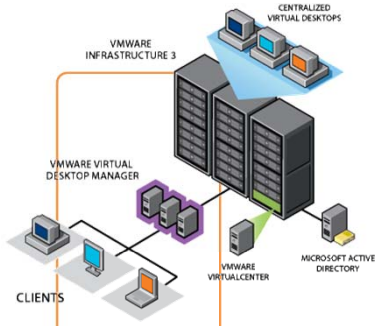
vmware

NATIONAL INSTRUMENTS

National Instruments LabVIEW

SIEMENS

Virtual Machines

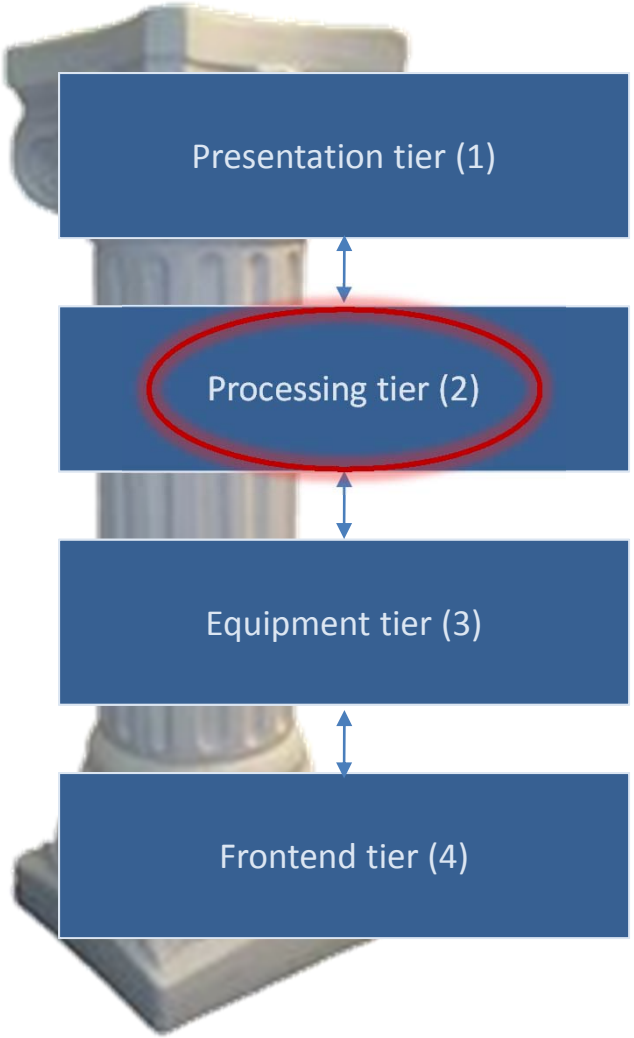


Rack mounted
PC (PCIe)

PXIe

PLC, controllers,
Power converters

Control System Architecture



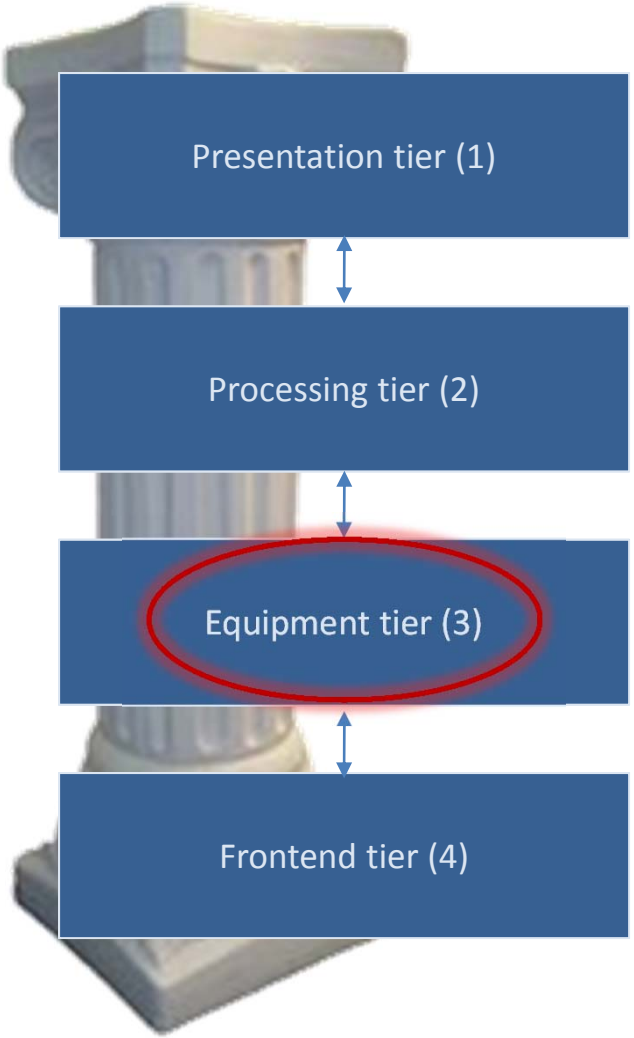
Measurement Studio

PVSS II

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



Measurement Studio

PXIe platform and LV-RT is the processing platform of tier-3!
Light **F**ront-**E**nd **C**ontrol **O**perating **S**ystem (**FECOS**) implemented.
Light framework to adapt all devices and processes to tier-2.

NATIONAL INSTRUMENTS
National Instruments LabVIEW

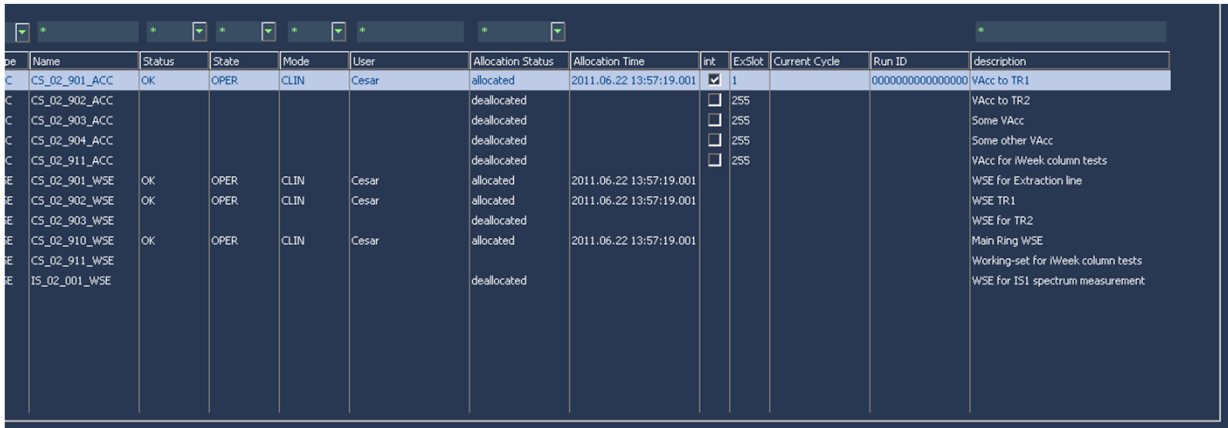
Subsystems Based on PXIe/LV-RT

- 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

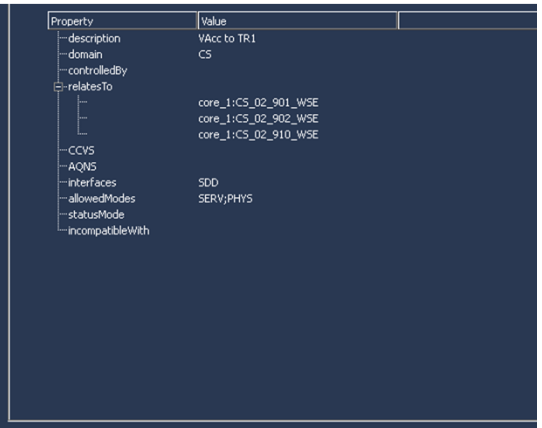
Examples

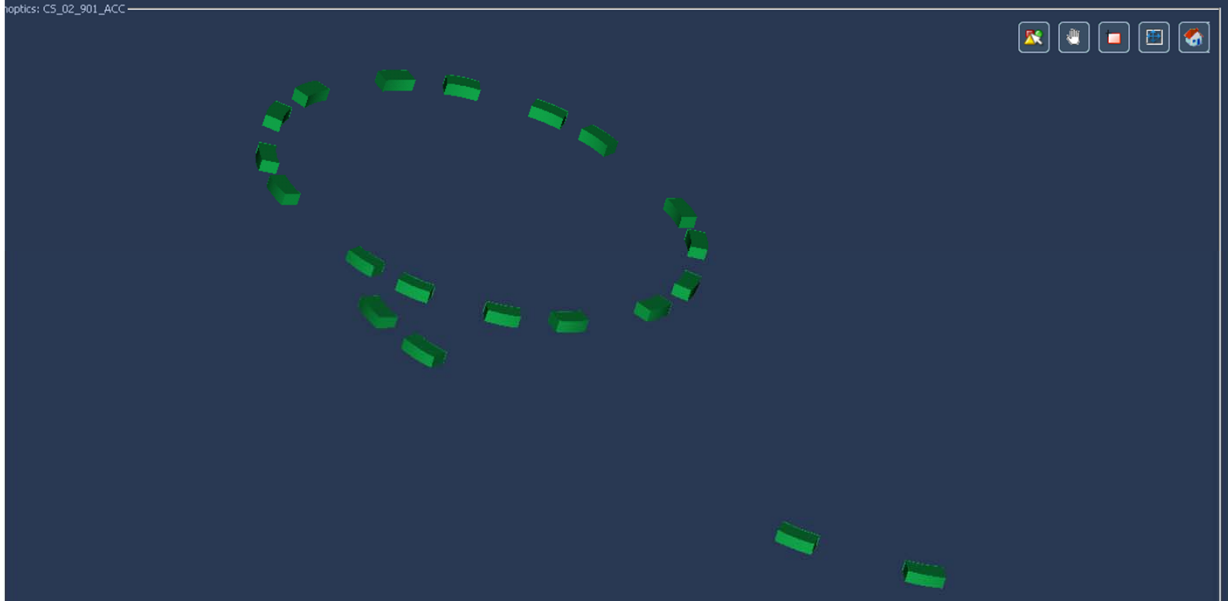
- UI panel with Qt widget
- REDNet
- Power Converter Controller

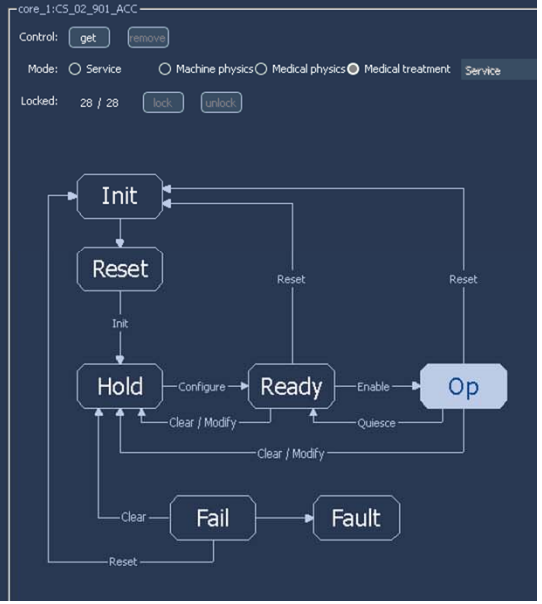
GUIs with WinCC OA + Qt



Name	Status	State	Mode	User	Allocation Status	Allocation Time	int	ExSlot	Current Cycle	Run ID	description
CS_02_901_ACC	OK	OPER	CLIN	Cesar	allocated	2011.06.22 13:57:19.001	☑	1		0000000000000000	VAcc to TR1
CS_02_902_ACC					deallocated		☐	255			VAcc to TR2
CS_02_903_ACC					deallocated		☐	255			Some VAcc
CS_02_904_ACC					deallocated		☐	255			Some other VAcc
CS_02_911_ACC					deallocated		☐	255			VAcc for iWeek column tests
CS_02_901_WSE	OK	OPER	CLIN	Cesar	allocated	2011.06.22 13:57:19.001					WSE for Extraction line
CS_02_902_WSE	OK	OPER	CLIN	Cesar	allocated	2011.06.22 13:57:19.001					WSE TR1
CS_02_903_WSE					deallocated						WSE for TR2
CS_02_910_WSE	OK	OPER	CLIN	Cesar	allocated	2011.06.22 13:57:19.001					Main Ring WSE
CS_02_911_WSE											Working-set for iWeek column tests
IS_02_001_WSE					deallocated						WSE for IS1 spectrum measurement



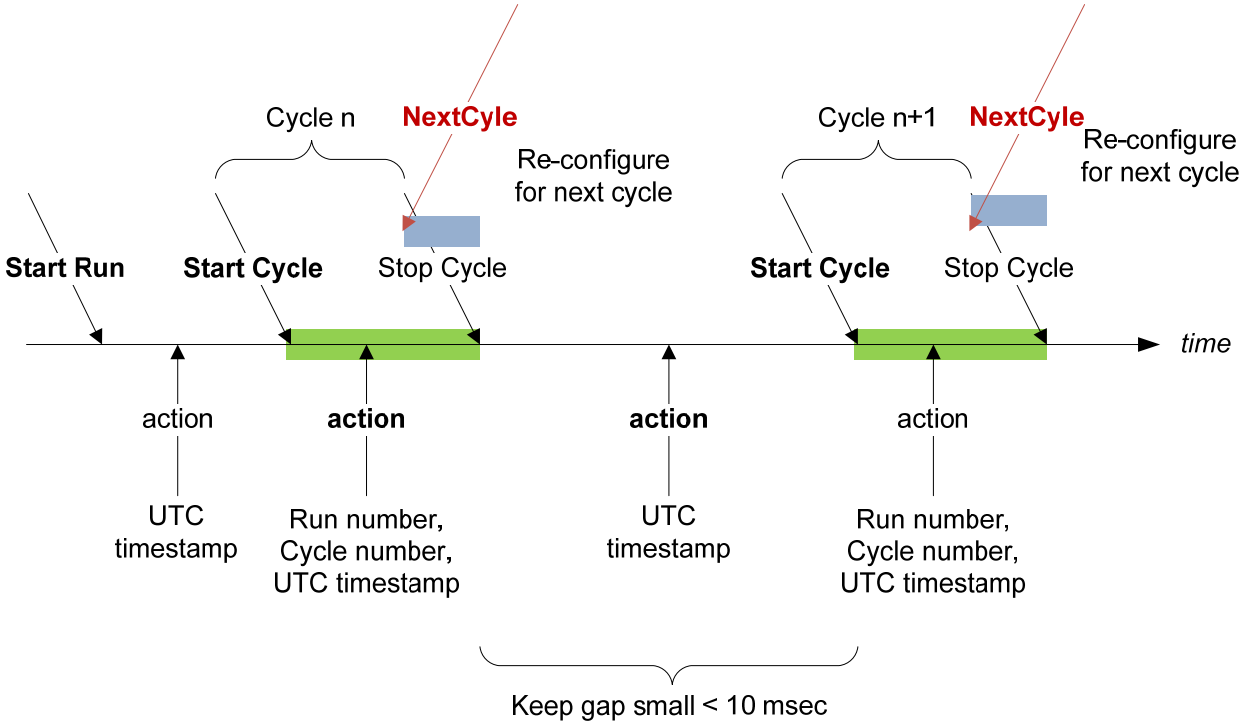




REDNet

- 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,
  1 µsec 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



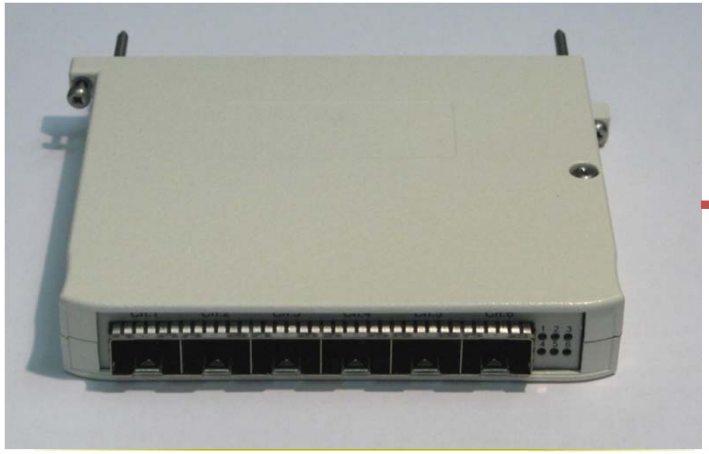
- Cycles last about 2 seconds
- A run has between 250 and 500 different cycles
- Frontend re-configuration takes less than 500 msec

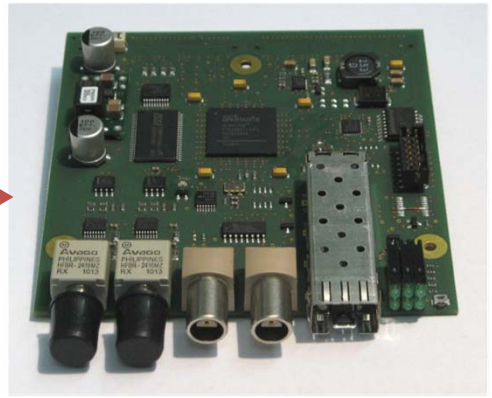
Power Converter Controller

- 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



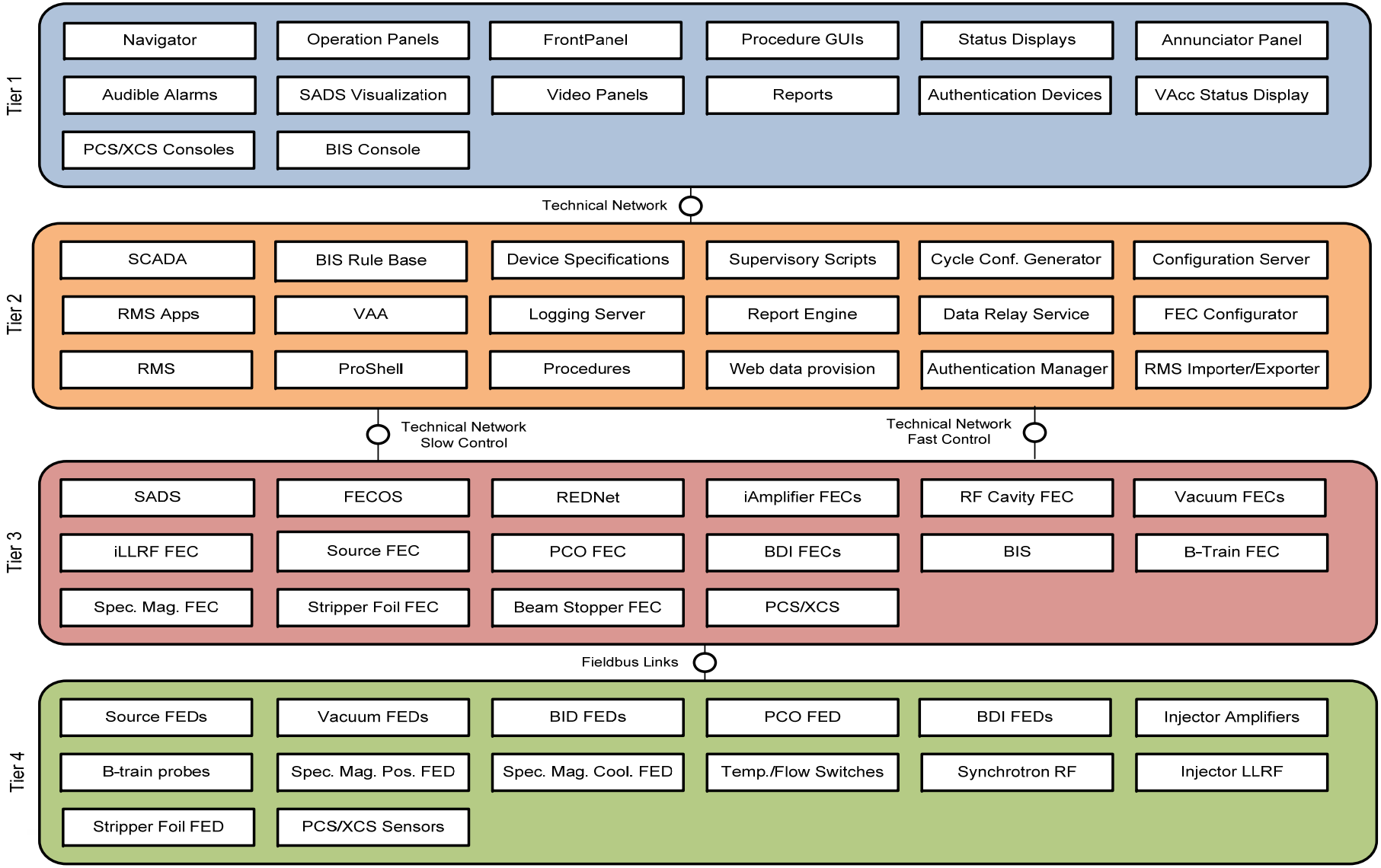


Conclusions

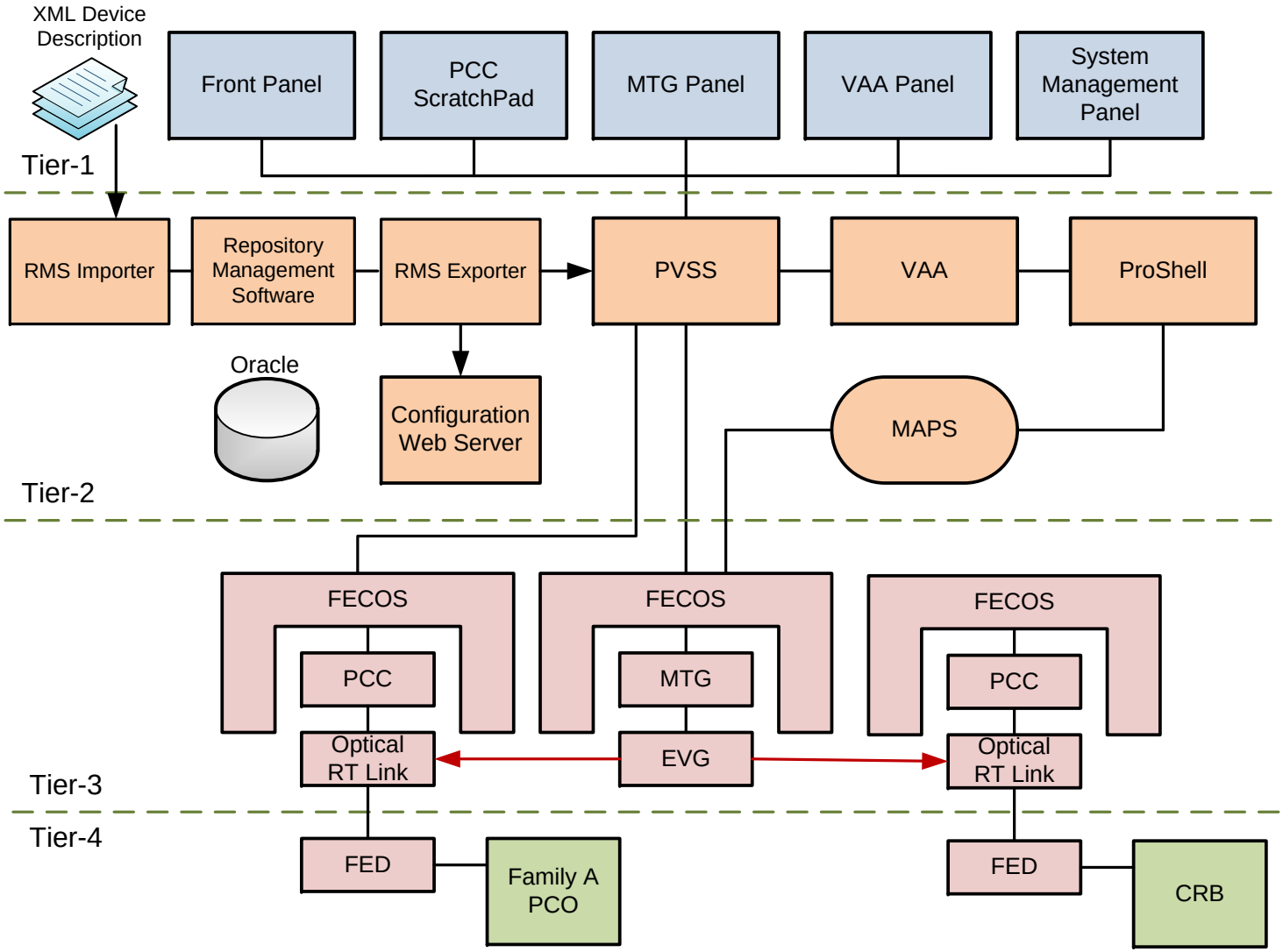
- MedAustron control system very **much COTS orientated**
  - Core based on **ETM/WinCC OA** (formerly **PVSS II**)
  - Equipment tier based on NI **PXIe**, **LV-RT**
  - Direct integration of **PLC**s into processing tier
  - Inhouse **C#** framework (ProShell) for BD and supervisory procedures
- Several 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 comissioning early 2013

ADDITIONAL MATERIAL

Architecture Overview



Column

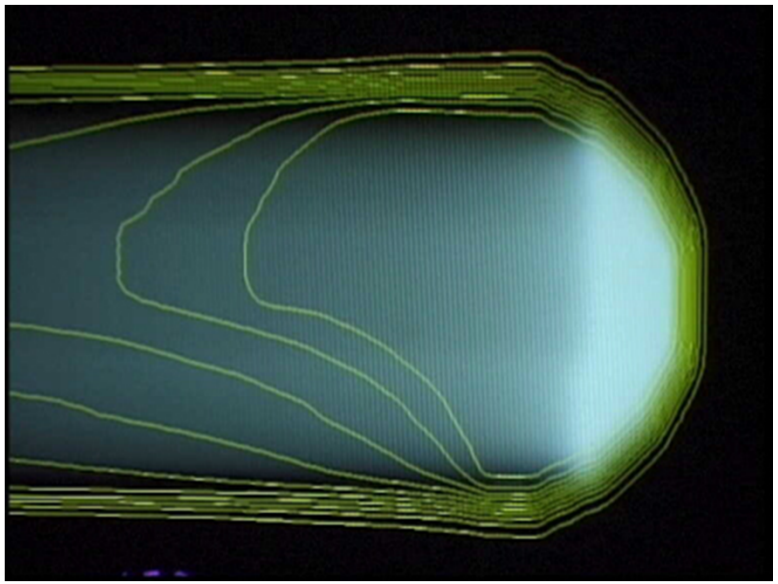

XML Device Description
Front Panel
PCC ScratchPad
MTG Panel
VAA Panel
System Management Panel
Tier-1
RMS Importer
Repository Management Software
RMS Exporter
PVSS
VAA
ProShell
Oracle
Configuration Web Server
MAPS
Tier-2
FECOS
FECOS
FECOS
PCC
MTG
PCC
Optical RT Link
EVG
Optical RT Link
Tier-3
Tier-4
FED
Family A PCO
FED
CRB

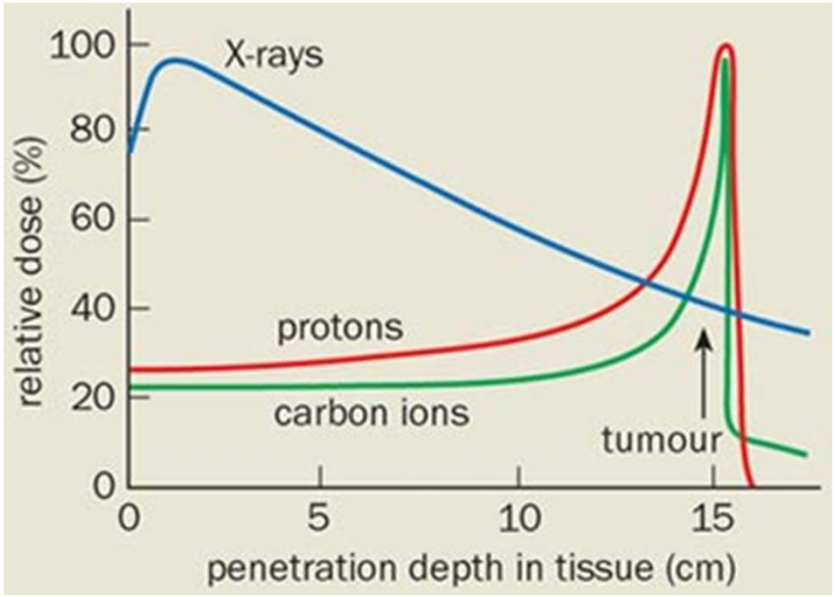
SUMMARY

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