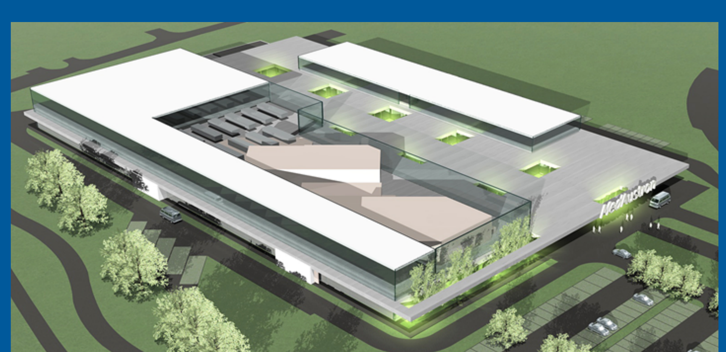
Commissioning the MedAustron Accelerator with ProShell

R. Moser[1], A. Brett[1], U. Dorda[1], M. Eichinger[1], J. Gutleber[2], M. Hager[1], M. Janulis[1], J. Junuzovic[1], M. Junuzovic[1], M. Marchhart[1], H. Pavetits[1], C. Torcato De Matos[1]
[1]EBG MedAustron, Wr. Neustadt, Austria
[2]CERN, Geneva, Switzerland,

ABSTRACT

MedAustron is a synchrotron-based centre for light ion therapy under construction in Austria. The accelerator and its control system entered the on-site commissioning phase in January 2013. This contribution presents the current status of the accelerator operation and commissioning procedure framework called ProShell. It is used to model measurement procedures for commissioning and operation with Petri-Nets. Beam diagnostics device adapters are implemented in C#. To illustrate its use for beam commissioning, procedures currently in use are presented including their integration with existing devices such as ion source, power converters, slits, wire scanners and profile grid monitors. The beam spectrum procedure measures distribution of particle species generated by the ion source. The phase space distribution procedure performs an emittance measurement in beam transfer lines. The trajectory steering procedure measures the beam position in each part of the machine and aids in correcting the beam positions by integrating MAD-X optics calculations. Additional procedures and (beam diagnostic) devices are defined, implemented and integrated with ProShell on demand as commissioning progresses.



From the "green-field" to start of commissioning in two years from 03/2011 to 03/2013.

CONTACTS

Name: Roland Moser
Organization: EBG MedAustron
Email: roland.moser@medaustron.at
Phone: +43 664 80878838
Website: http://www.medaustron.at

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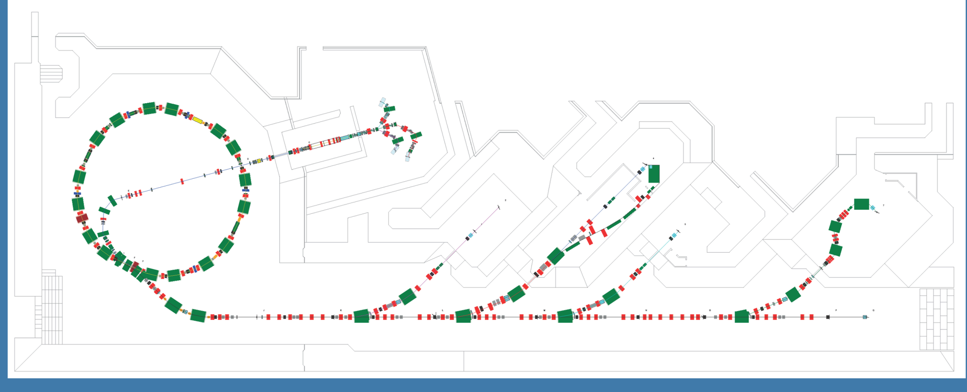

Figure 1. The accelerator, featuring four ion sources, IH-based Linac, synchrotron, three horizontal, one vertical beam line and one proton gantry. Energy ranges from 60 to 800 MeV/u, up to 250 MeV/u proton equivalent for ion therapy [2].

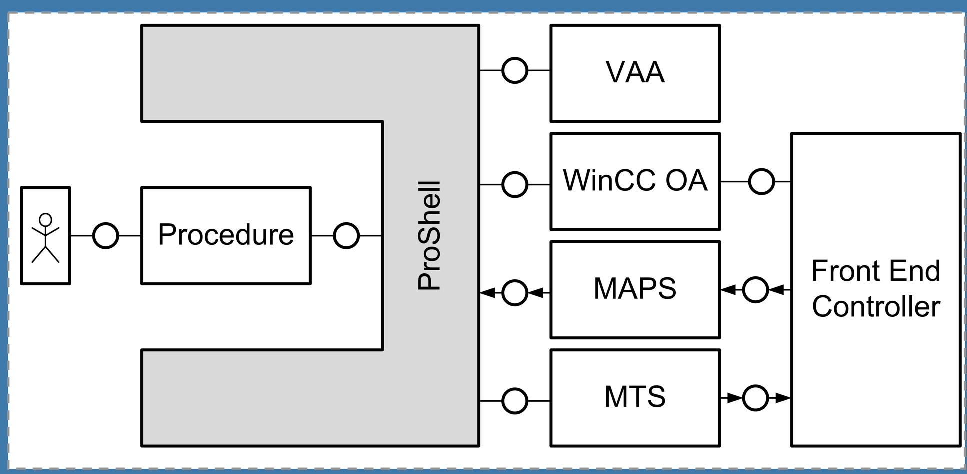

Figure 2. ProShell Architecture

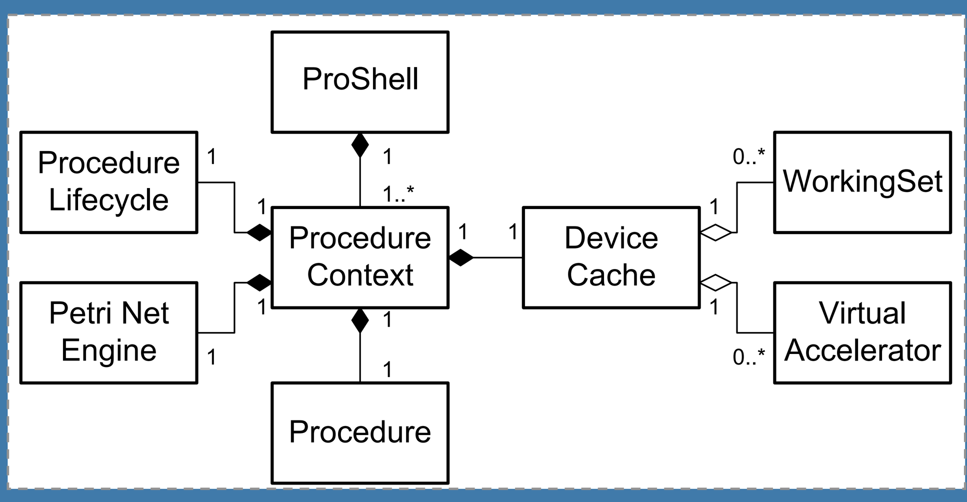

Figure 3. ProcedureContext managing the procedure and related objects

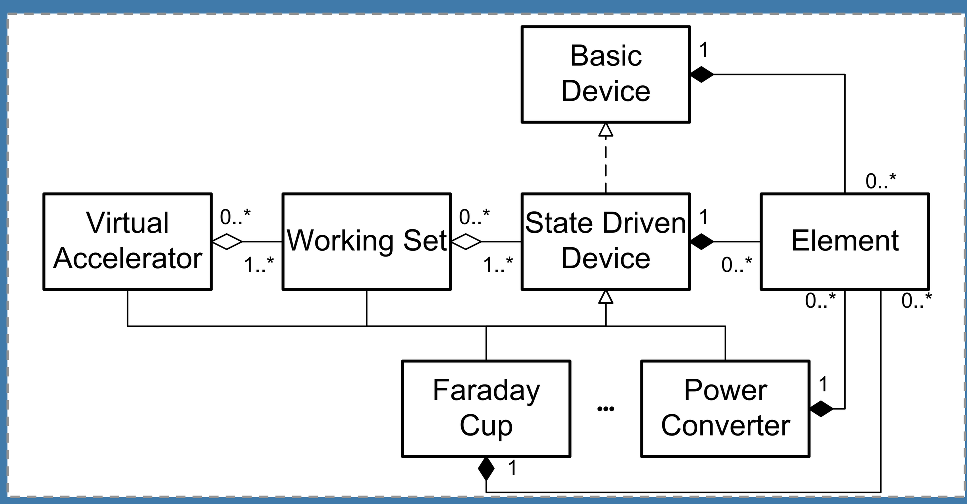

Figure 4. Class Hierarchy for resources adapters

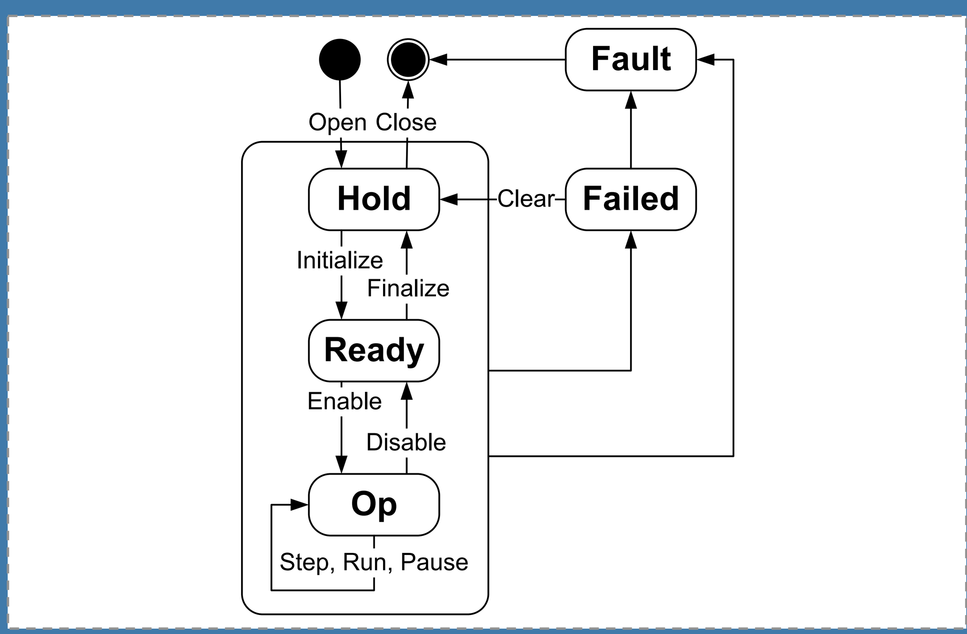

Figure 5. Procedure Context Lifecycle

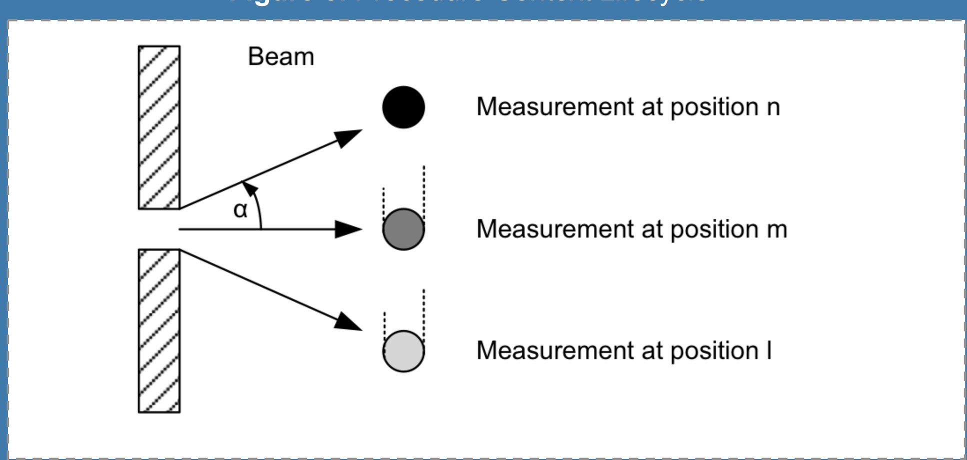

Figure 6. Measuring a beam profile for a single slit position.

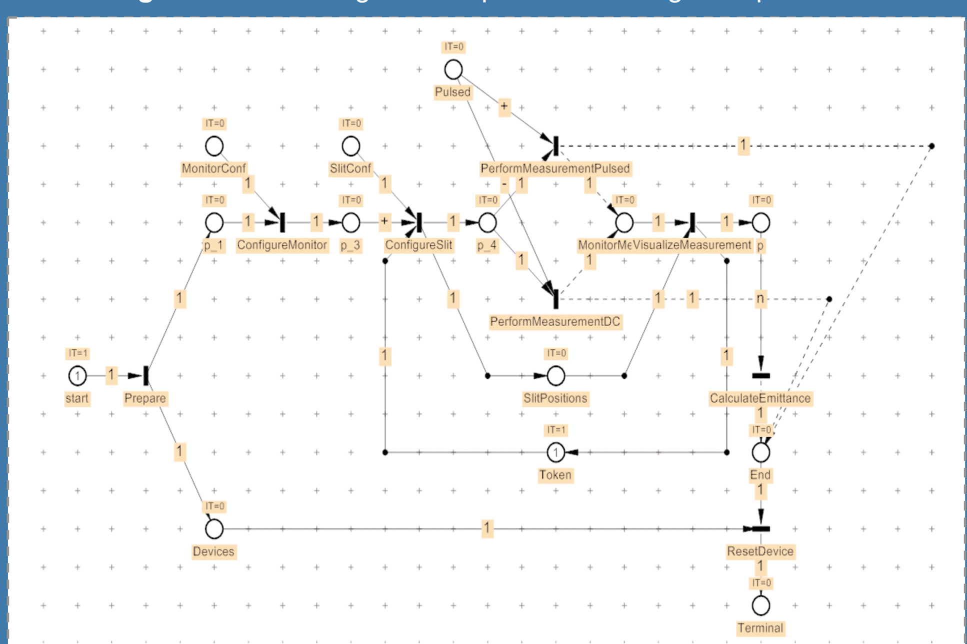

Figure 7. Phase space distribution (emittance) procedure workflow.

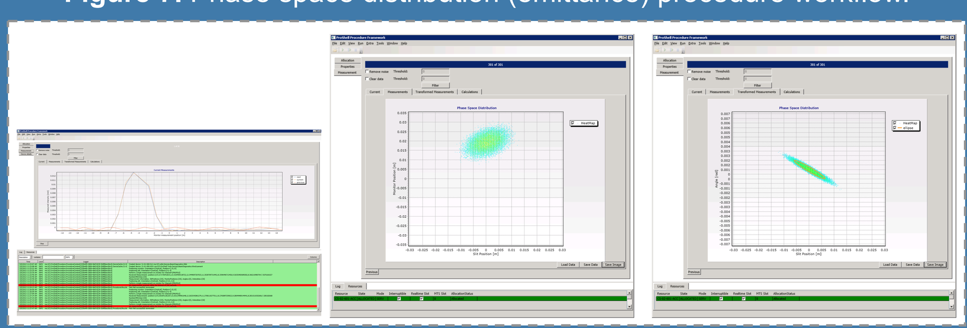

Figure 8. Screenshot of the phase space distribution procedure.

INTRODUCTION

MedAustron is an ion therapy and research centre presently under construction in Wiener Neustadt, Austria. The facility features a synchrotron-based accelerator with up to 5 ion sources for protons, carbon ions and possibly other light ions. It will provide ion beams with energies up to 800MeV to 5 beam lines, one of which is a rotating proton gantry.

The Procedure Shell Execution Framework (ProShell) is a C# application to **automate** high level **control and analysis tasks** for commissioning and during operation. Each task called a procedure implements a standardized procedure interface and is deployed as .NET assembly (shared objects).

ARCHITECTURE

ProShell is a framework to dynamically load and execute procedures implemented as C# classes. It provides access to system, software and physical devices for monitoring and control purposes. These services are accessible from ProShell through service-specific Driver objects that are used internally and are not directly accessible from the procedures:

- **Virtual Accelerator Allocator** (VAA) allocates resources for exclusive usage on behalf of user applications.
- **WinCC OA** is a SCADA system that acts as the main communication backbone between user interfaces and frontend controllers (FEC).
- **MAPS** is a publisher subscriber to forward measurements from FECs to user interfaces.
- **Main Timing System** (MTS) generates events for beam generation that are delivered to the frontend controllers with a precision of 100ns.

PHASE SPACE DISTRIBUTION

The phase space distribution measurement procedure **measures** the horizontal or vertical **beam distribution** in the low and medium energy beam transfer lines. The basic principle of this procedure is to **position** two horizontal or vertical **slit plates to form a gap** through which only the selected part of the beam can pass. Further downstream, a wirescanner **performs** a **beam profile measurement** (Figure 6).
These **beam profiles measurements** are repeated for gap-positions all across the beam pipe aperture, **combined** and transformed to a single heatmap with **intensity plotted over slit position and beam angle** (Figure 8).

TRAJECTORY STEERING

The trajectory steering procedure **computes correction values** for **steering magnet** power converter set-points in transfer lines using steering magnets and beam diagnostics devices (wire scanners and profile grid monitors) based on their optical position (s-position) within the beam line (Figure 10).
The operator can (a) directly **adapt** the current or (b) the **steering angle** which is automatically **transformed to** an integrated magnetic field Bl and subsequently to a **current using** a magnet specific **B(I) transformation curve**.
Executing the procedure **applies currents** for all **steering power converters** and **performs** destructive **measurements** with wire scanners and profile grid monitors in the order of their optical position.

KEY FEATURES

- **Resource Allocation** on behalf of a procedure.
- **Uniform access** to system, software and **physical devices** independent of communication protocols for monitoring and control purposes.
- **Measurement** reception and **visualization** of device measurements
- Management of generic procedure lifecycle and **custom procedure workflow**.
- **Parallel execution** of multiple procedures
- **Automatic procedure execution** without user intervention
- **Manual procedure execution** to step through the procedure specific workflow.
- Provide **access to control system services** hiding implementation specific interfaces and communication protocols.

SUMMARY

- **Integrated** and tested **main systems** (WinCC OA, MTS, VAA and MAPS) **concluded** in the production system.
- **Implemented resource adapters** for power converter controllers and several beam diagnostics (wire scanners, slits and profile grid monitors).
- **Implemented** and tested **Phase space distribution procedure**, used for **beam commissioning** in the production system **since April 2013**.
- **Implemented** and tested **trajectory steering procedure** with wire scanner, **final tests** with profile grid monitors planned **for October 2013**.

Future work consists primarily of two activities: First, **integrating more devices** and implementing resource adapters. Secondly, gathering requirements, elaborating designs and implementing **additional procedures** required for commissioning and operation.

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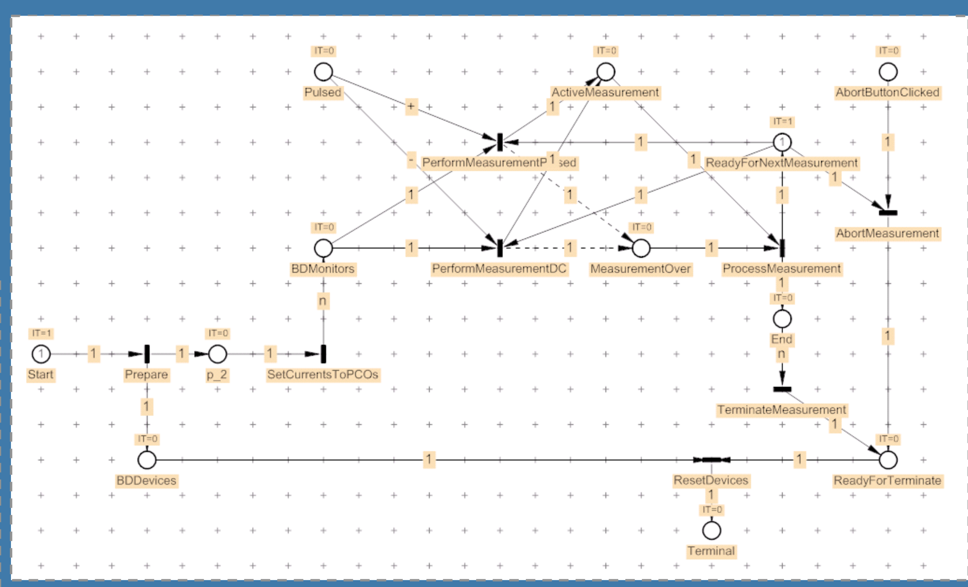

Figure 9. Trajectory steering procedure workflow.

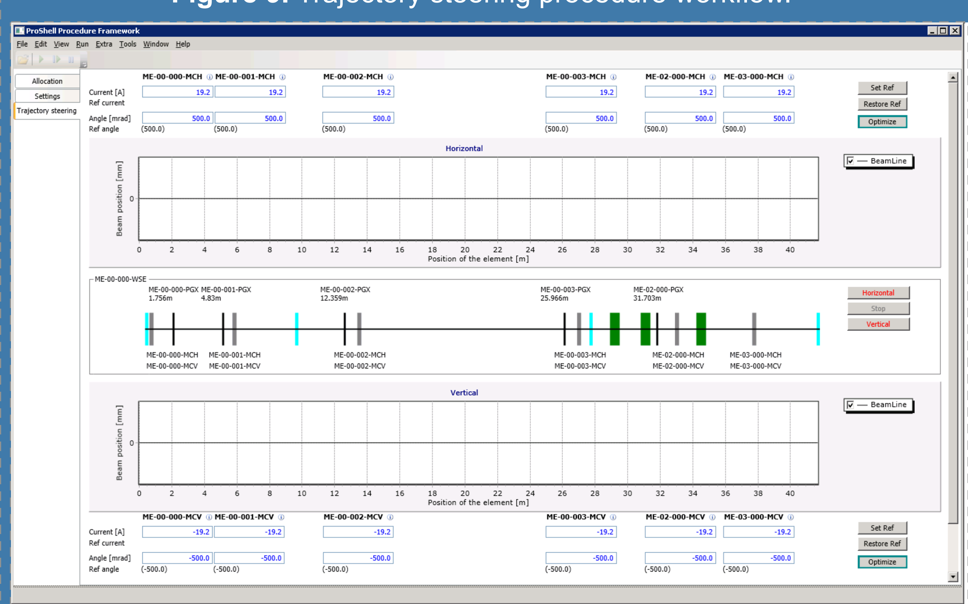

Figure 10. Screenshot of the trajectory steering procedure.