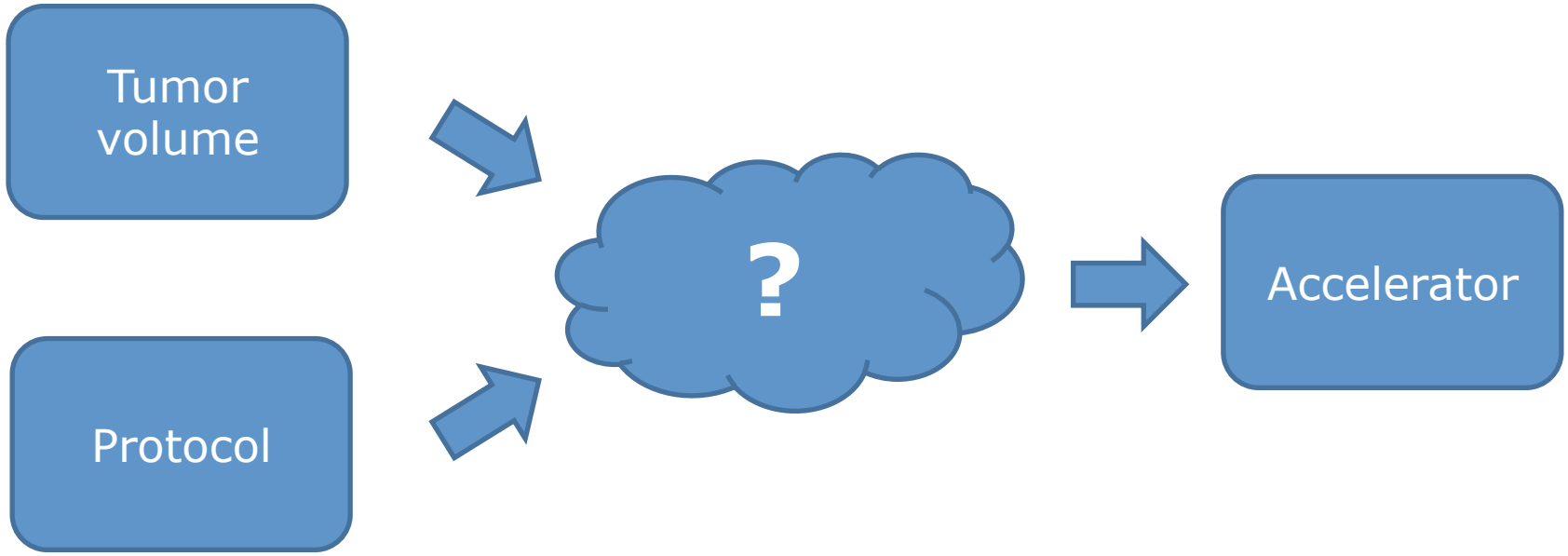
MedAustron

Medical Front-End

CERN accelerator school:
Accelerators for medical applications

June 2nd 2015
G. Kowarik

Context:
Accelerators for **Medical applications**



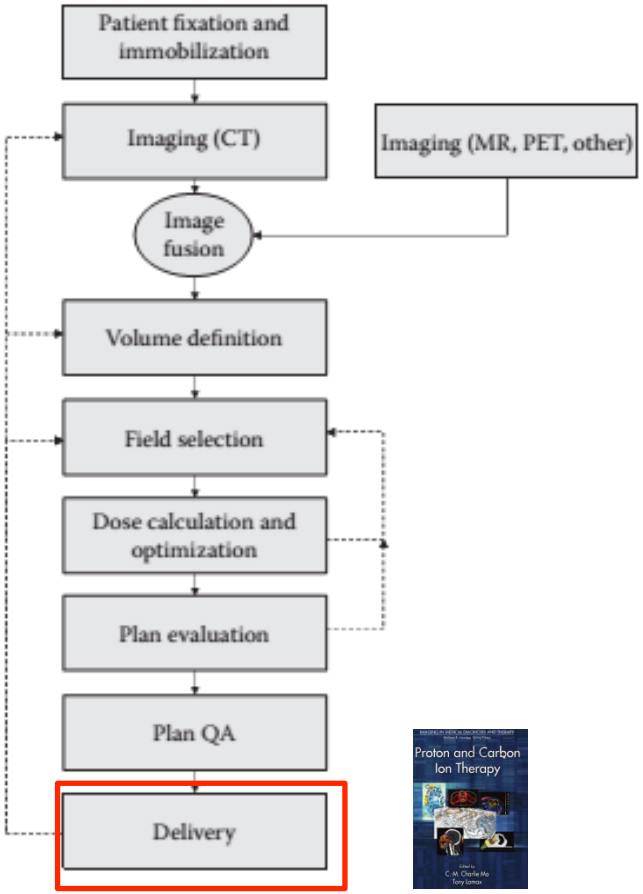
Accelerator

- Synchrotron
  - p: 60MeV-250MeV
  - C: 120Mev/n-400MeV/n
  - Slow extraction: 1-10s spill-length
  - 10^{10} p/spill, 10^{9} C/spill
  - Fixed beamlines H+V, proton Gantry
  - NCR: p 800 MeV, 0.1s-10s

Accelerator → Therapy Accelerator

- Synchrotron
  - p: 60MeV-250MeV
  - C: 120Mev/n-400MeV/n
  - Slow extraction: 1-10s spill-length
  - 10^{10} p/spill, 10^{9} C/spill
  - Fixed beamlines H+V, proton Gantry
  - NCR: p 800 MeV, 0.1s-10s
- What is missing?
  - Interface to the „clinical world" (Oncology Information System)
  - Dose delivery and monitoring
  - Active pencil beam scanning
  - „Safety net" (Risk control measures)

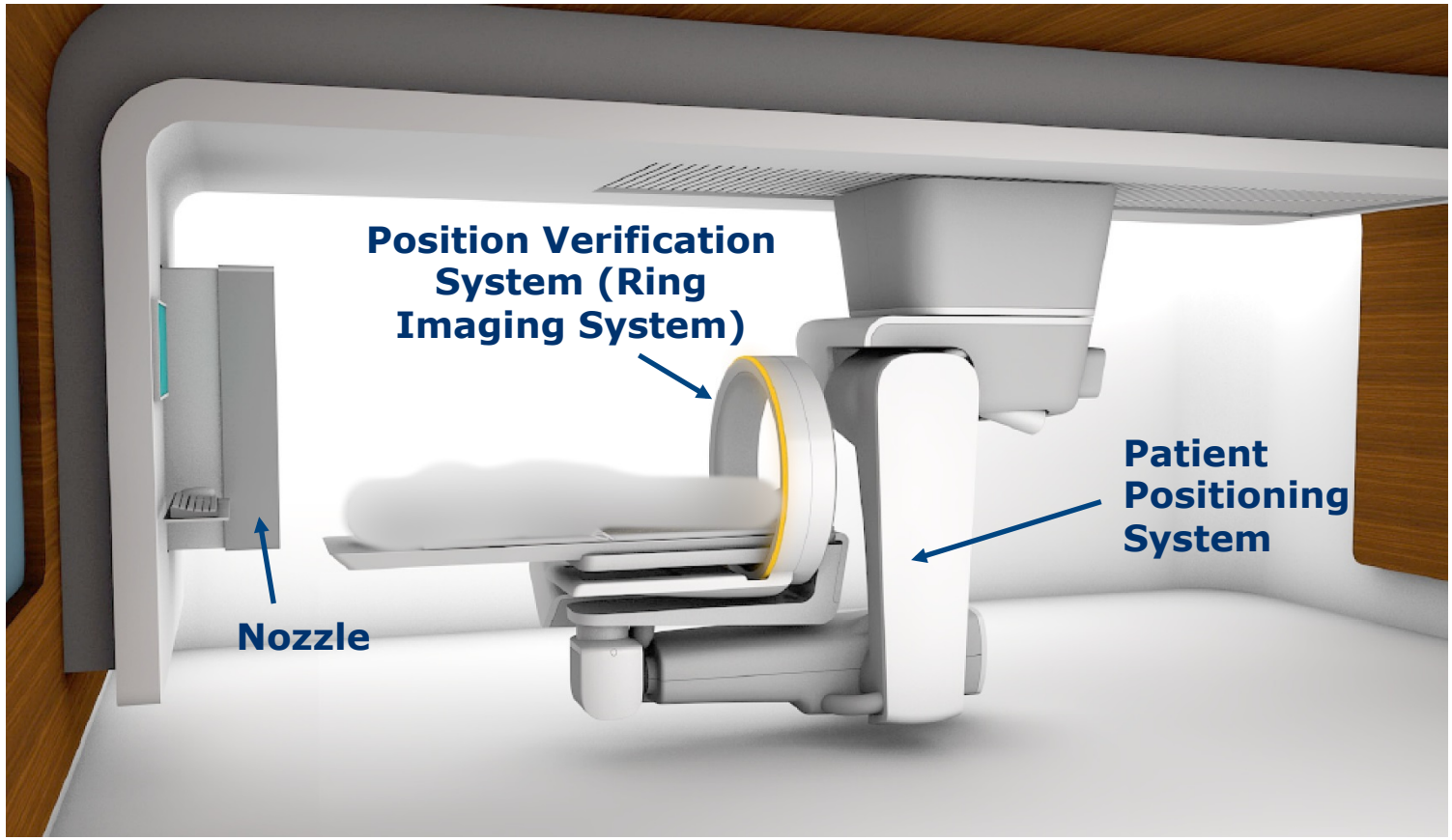
Medical application: from planning to delivery



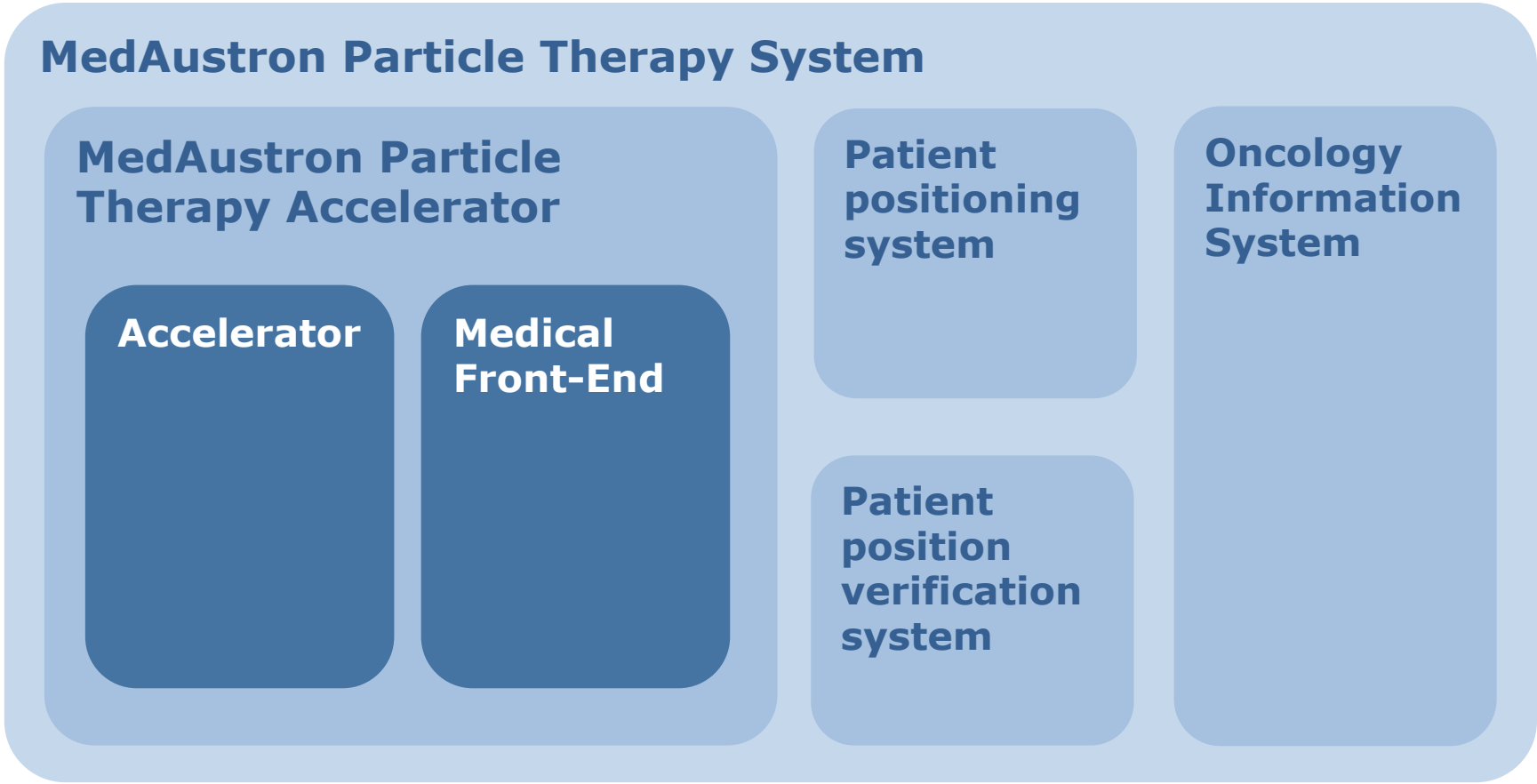
Delivery is only one part of the medical workflow!

Machine specific plans for delivery of multiple fields/portals in multiple fractions → input for the delivery

Irradiation room

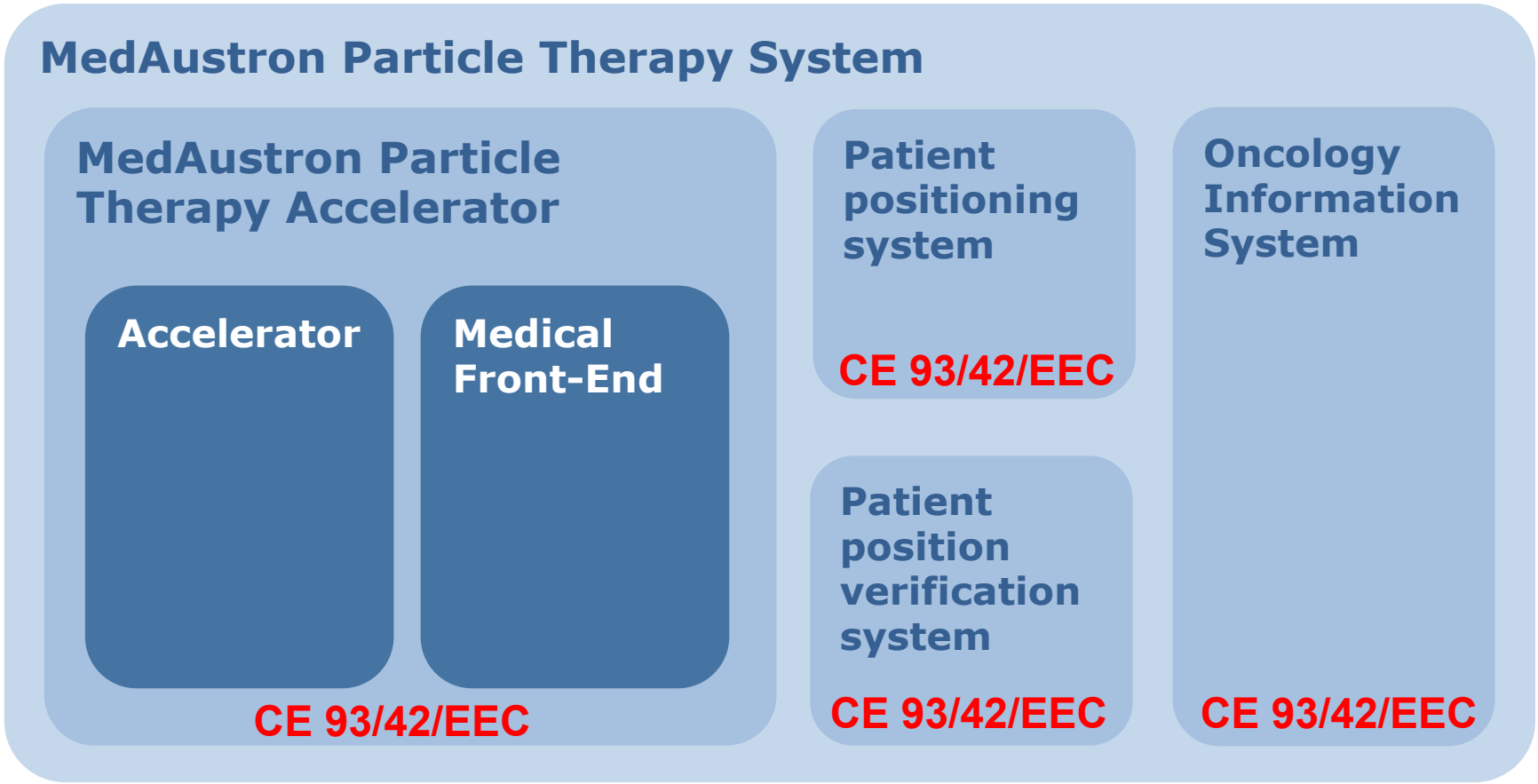


MedAustron Particle Therapy System



MedAustron Particle Therapy System

Declaration of Compatibility (Art. 12, 93/42/EEC)



MedAustron Particle Therapy Accelerator

MedAustron Particle Therapy Accelerator (MAPTA)

Industrial device

Accelerator
hard- and software

Medical Front-End

Medical devices
and components

CE according to Medical Device Directive

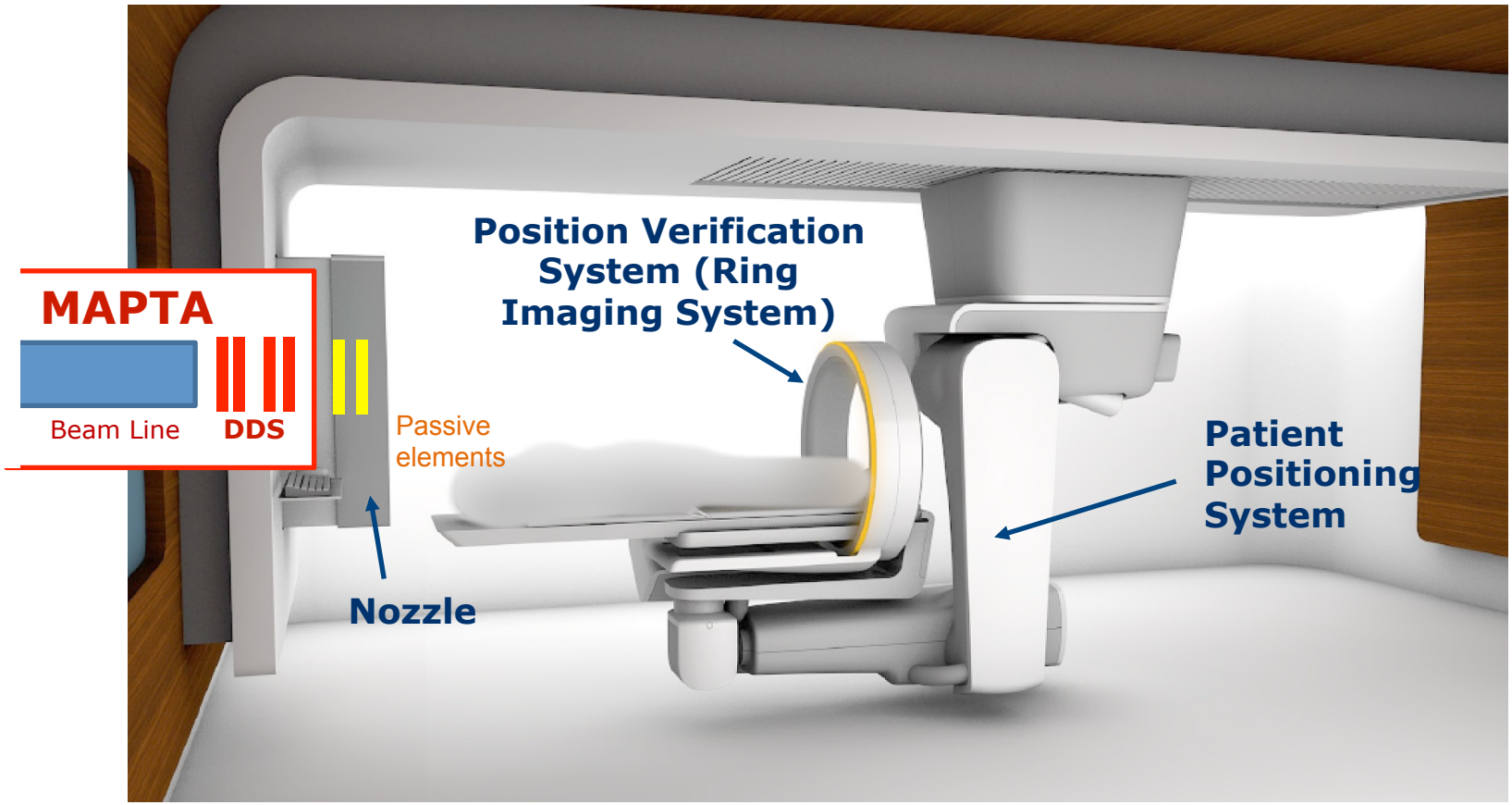
MAPTA's function is to deliver an ion beam

- according to a particular request (treatment plan),
- of defined quality,
- at a defined moment,
- at a defined location,

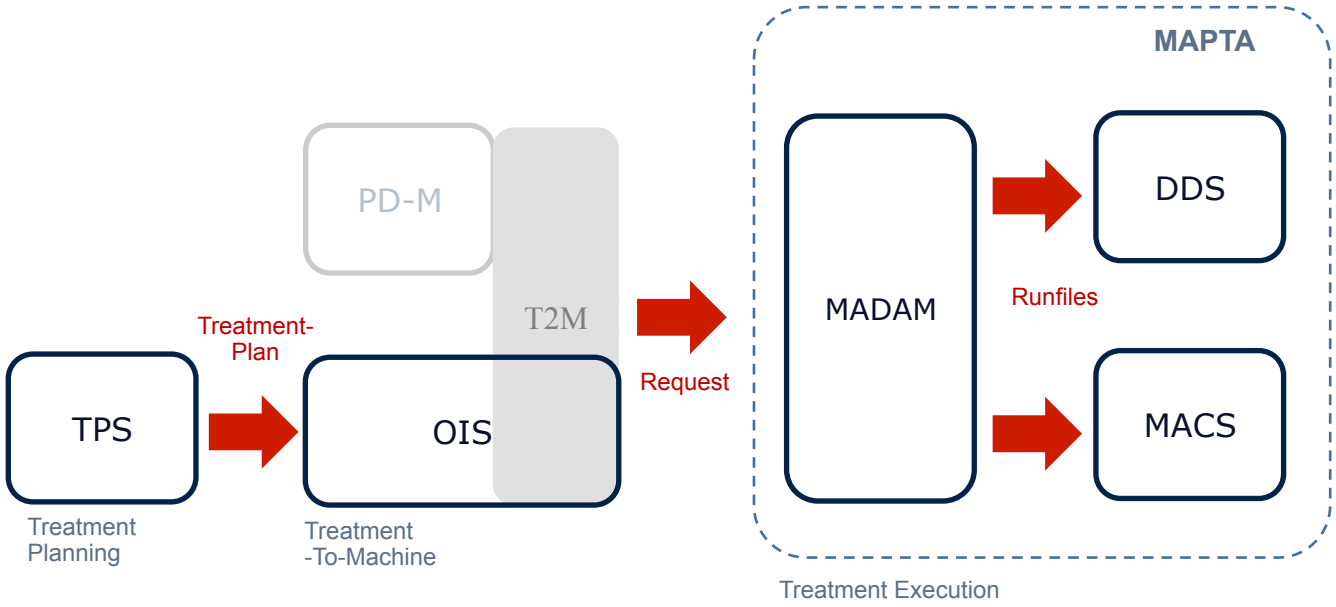
(aiming a certain dose distribution)

Medical Front-end

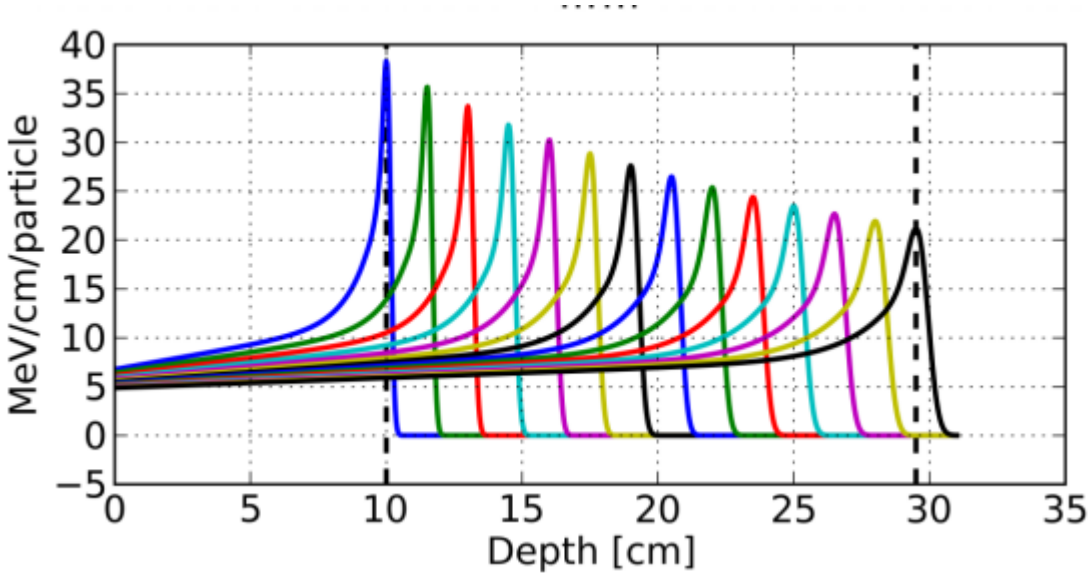
- Act as an interface from/to the Oncology Information System
- Utilise the accelerator to deliver dose according to a treatment plan:
  - Control treatment process (portal, fraction)
  - Control the accelerator for clinical operation
  - Active Pencil Beam Scanning for dose delivery
- Ensure safe operation of the accelerator
  - Monitor delivered dose; verify particular beam quality parameters
  - Interrupt or Terminate Irradiation if necessary
  - Functional safety aspects (correct irradiation room, etc.)
  - Mitigation of potential risks to the patient from the accelerator (industrial device)
  - Compliance to IEC 60601-2-64 (basic safety standard)

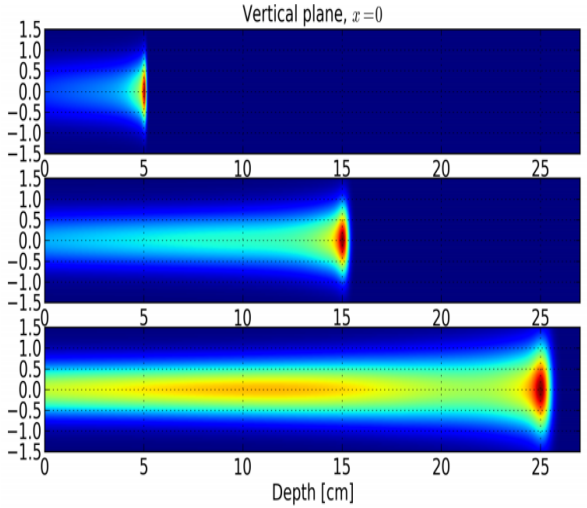

MAPTA
Beam Line
DDS
Position Verification System (Ring Imaging System)
Passive elements
Nozzle
Patient Positioning System

Treatment Plan Dataflow

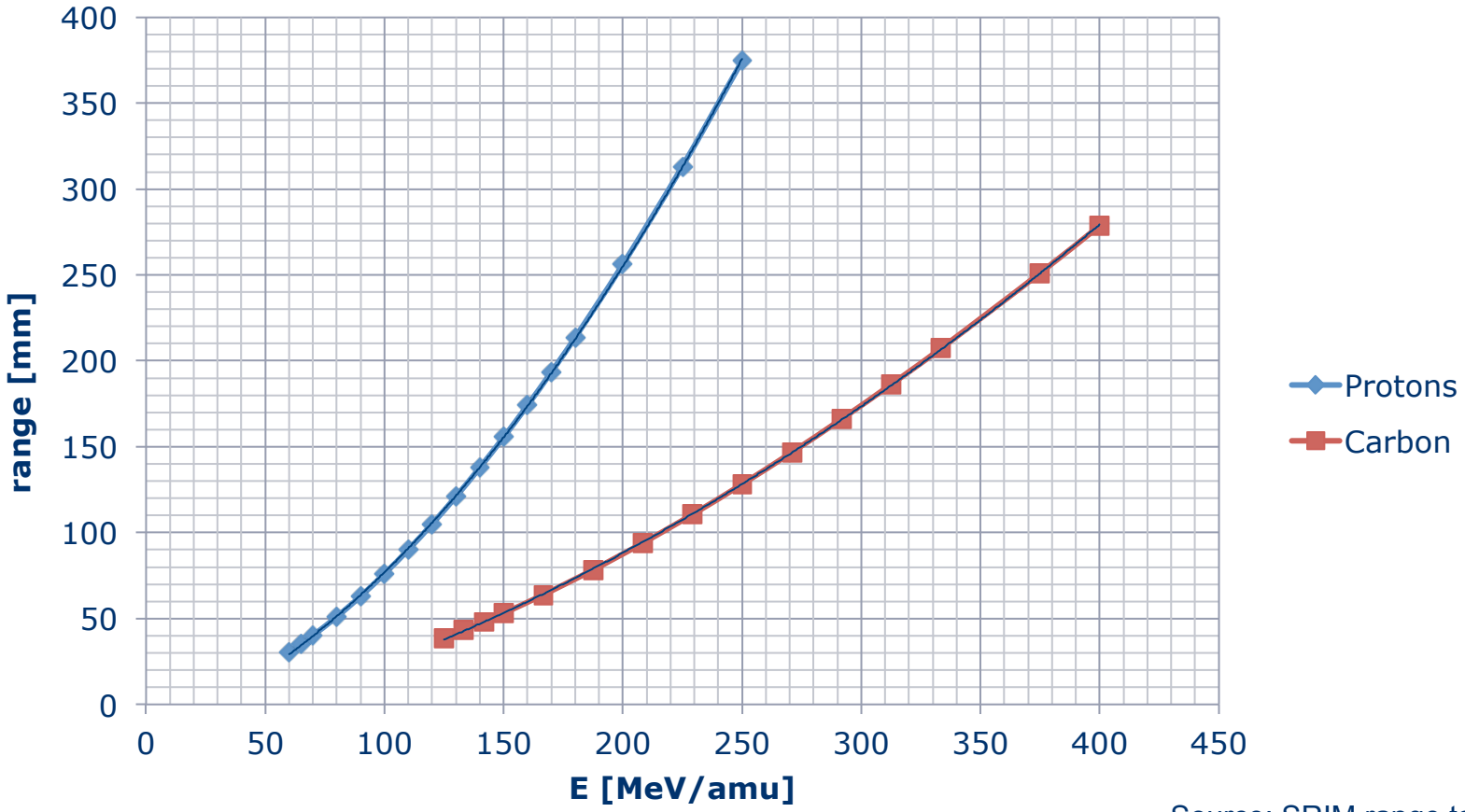


Dose Delivery – Bragg peak





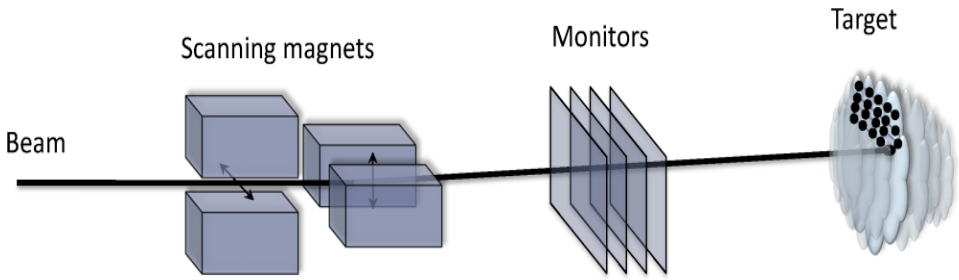
Energy – Range (in water)

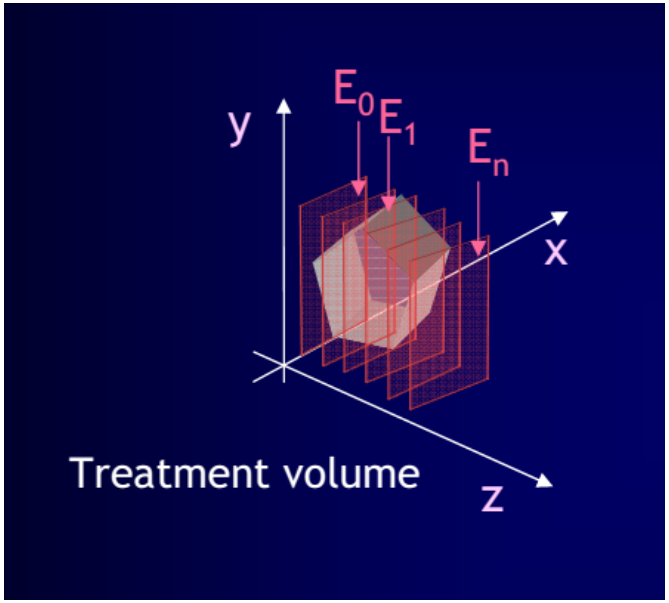


Source: SRIM range table

Dose Delivery System

„Pencil beam scanning“





„Iso-Energy Slices“

Dose Delivery System by CNAO

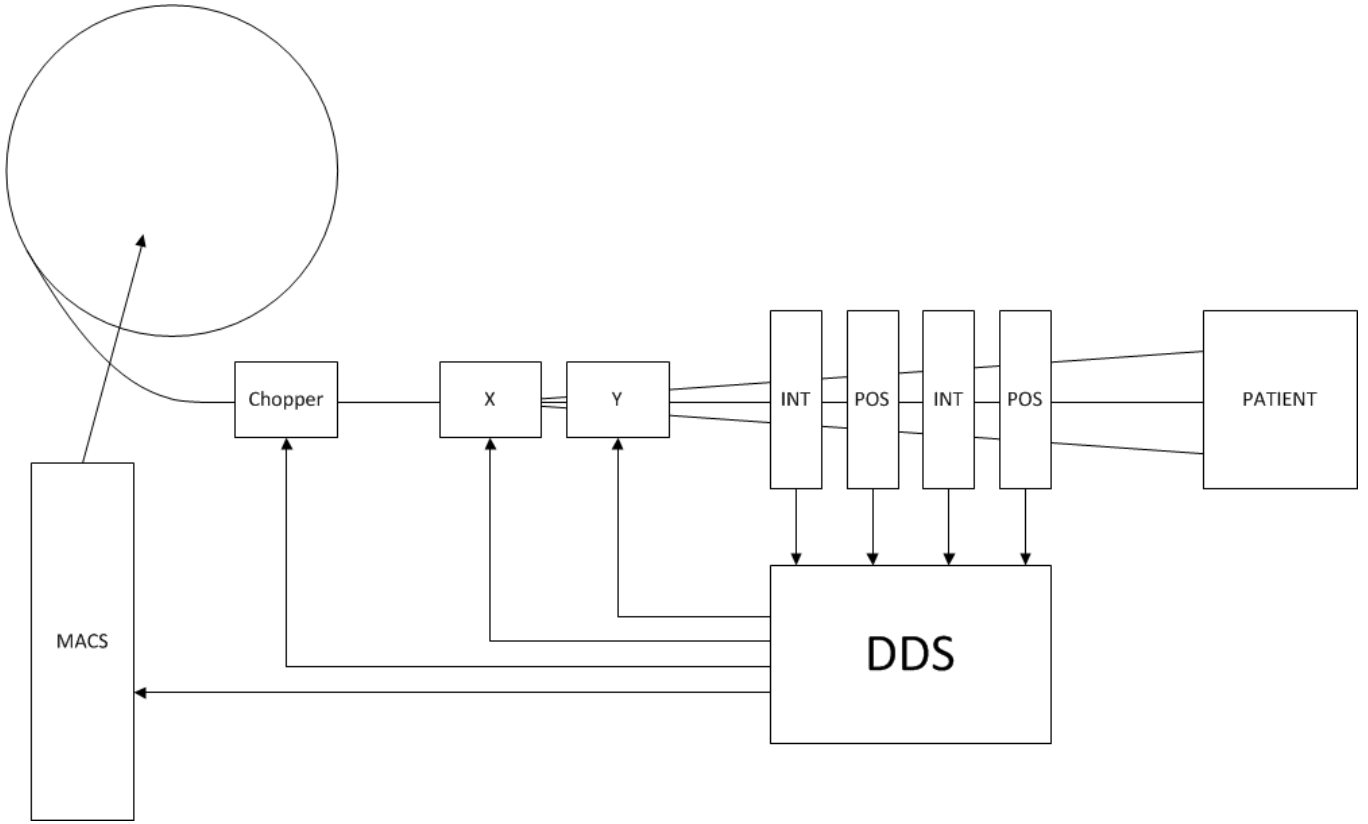
MAPTA Beam Delivery

- Field size: 20 cm x 20 cm (Gantry: 12 cm x 20 cm)
- Quasi-parallel scanning (d>6m)
- Scanning speed: ca. 200 m/s for p250; 70m/s for C400; Setpoint rate 40kHz
- Energy layers from high to low energies
- Requesting and verifying each individual energy
- Position verification and active loop control for enhanced precision

Beam parameters monitored during dose delivery

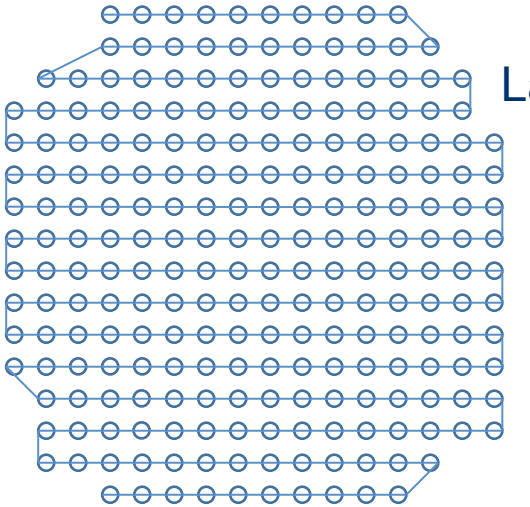
- Spot position
  - Transversal (x, y)
  - Longitudinal (z) – Energy [cycle code checked]
- Beam size (width in x and y)
- Beam intensity (particle flux)
- Delivered number of particles

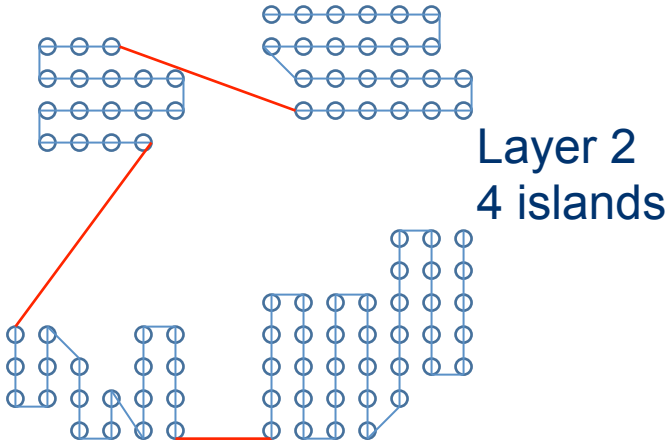
Dose Delivery System



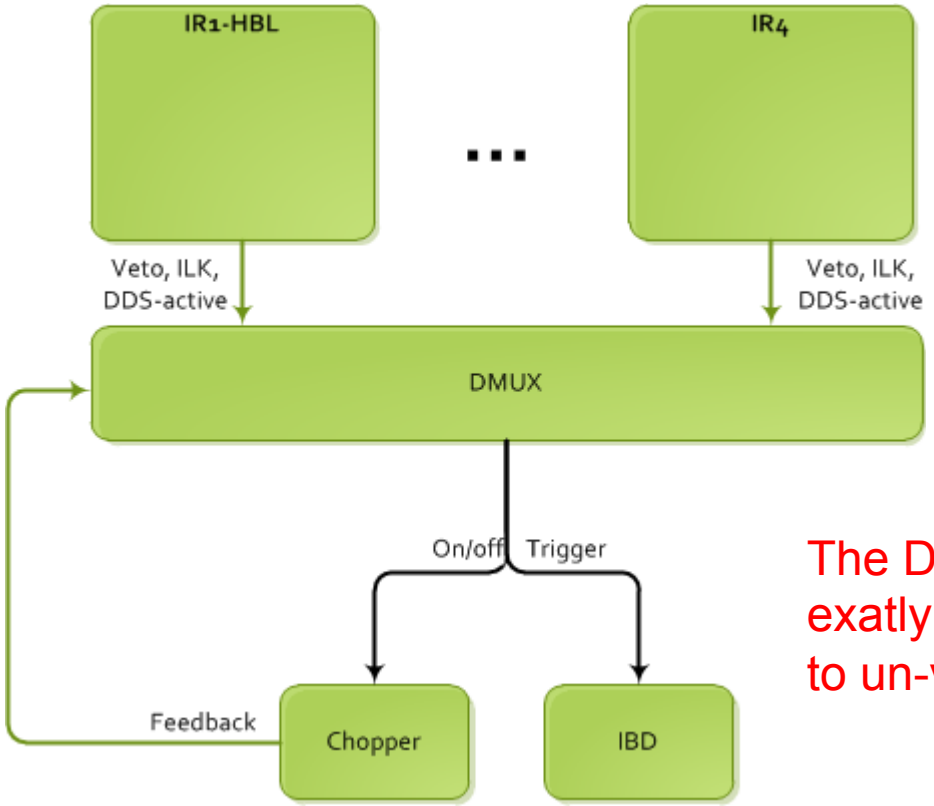
Chopper - Beam interruption

- **End of Iso-Energy slice**
- **Safety action**
  In case of failure: interrupt beam quickly: chopper performance 300 µs
- **Island jumping**
  Reduce transient dose
  Fast scanning magnets = low sweeping dose
- **(Gating)**



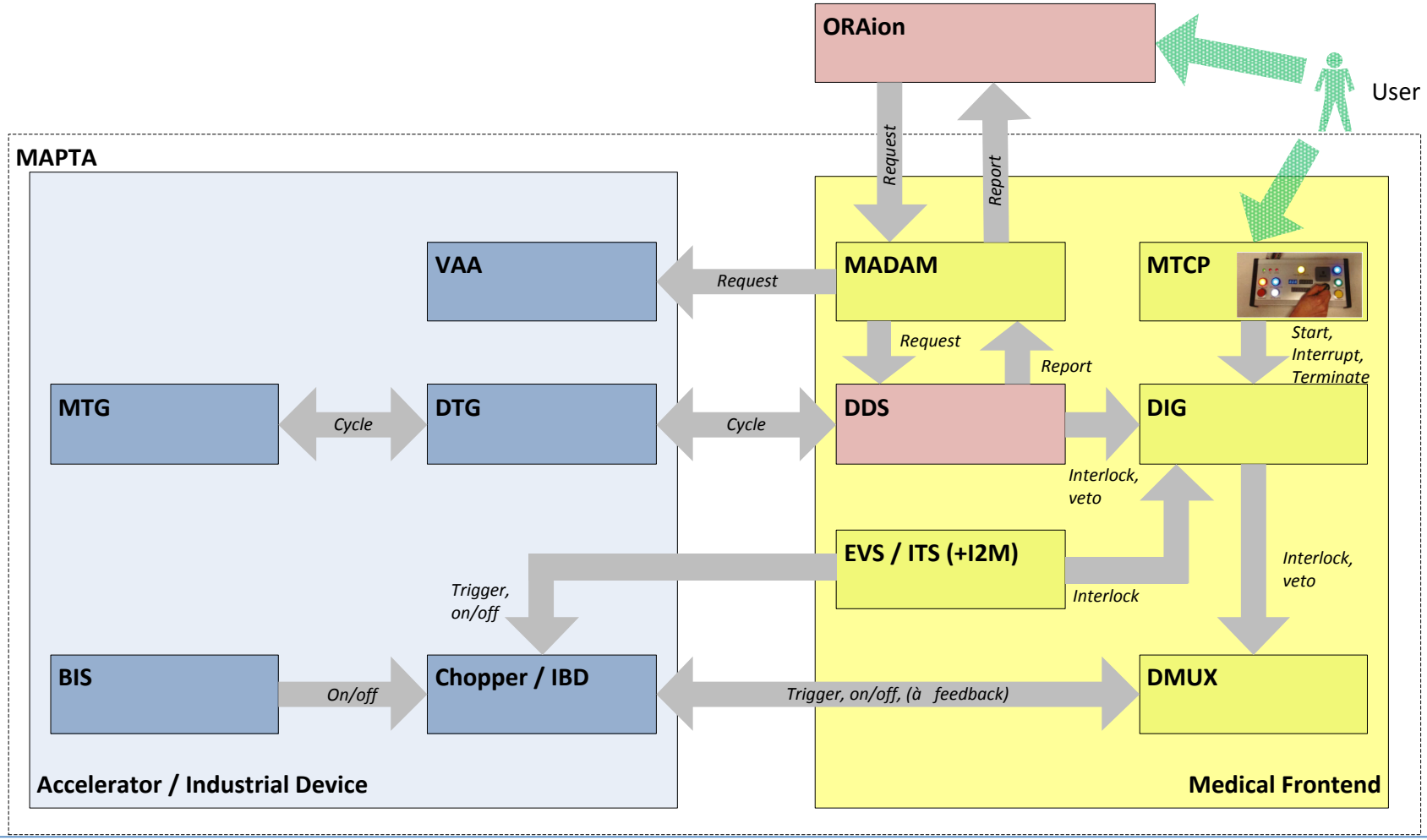


Fast interlock chain



The DMUX allows exatly one BL (or none) to un-veto the chopper

MAPTA Architecture Overview



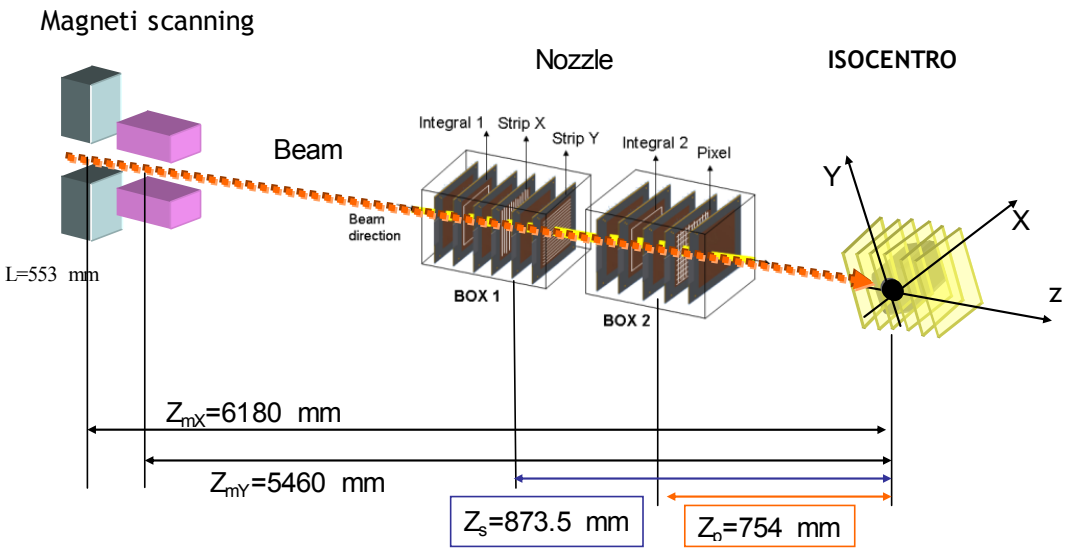
DDS – Calibration (per ion species)

Position:

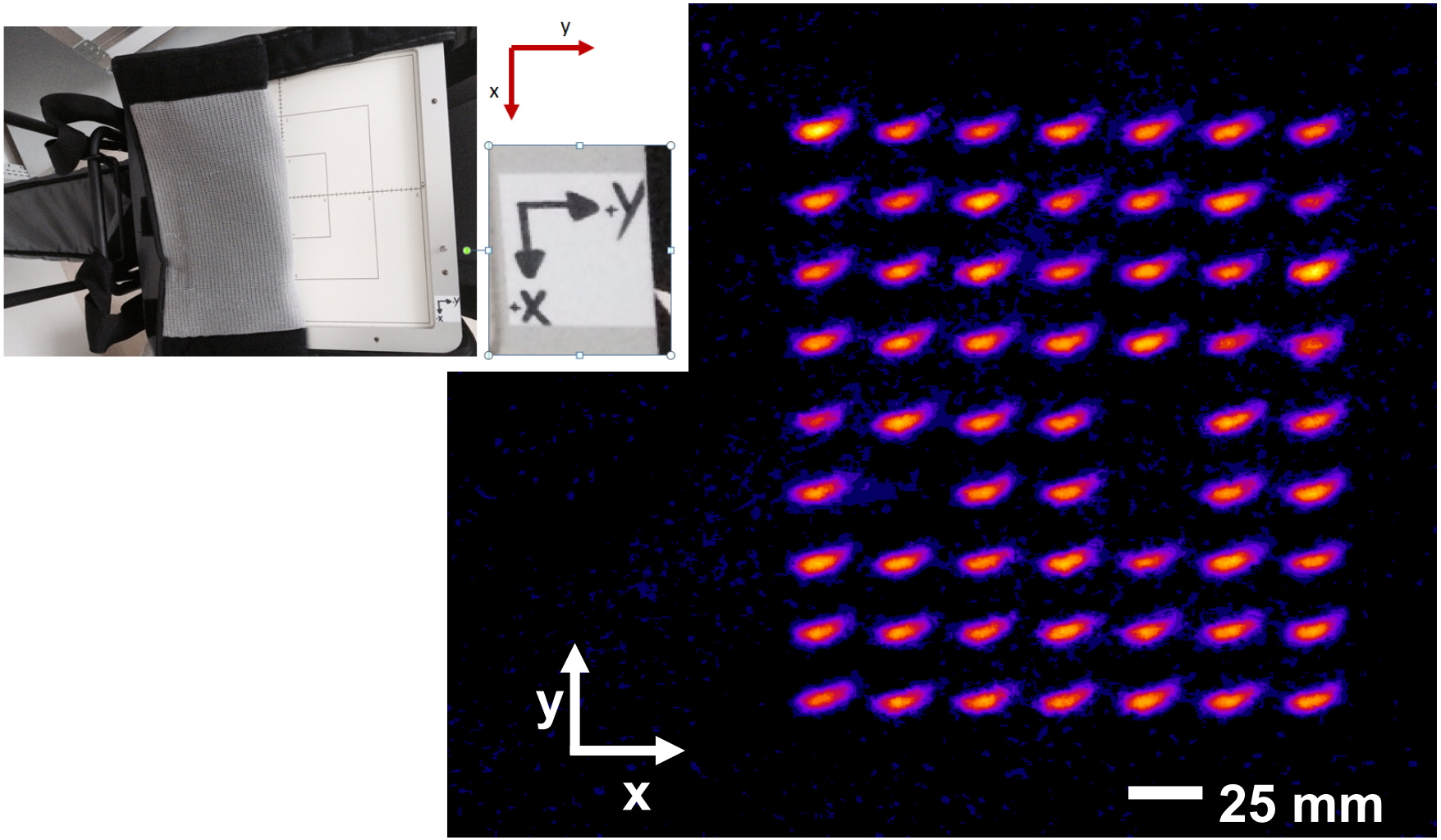
- Coordinates at the Iso-centre (Equipment Reference Point)
- Coordinates at monitors
- Current set-points for the magnets (incl. Energy dependent I/x; I/y)

Dose:

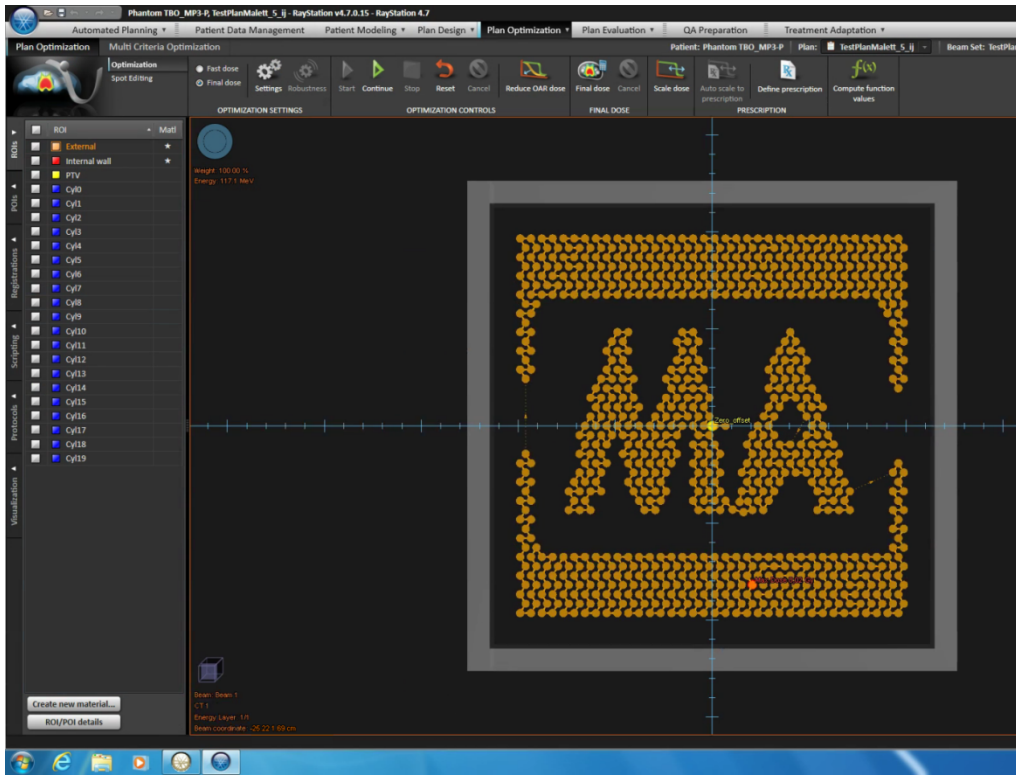
- Energy dependent monitor units

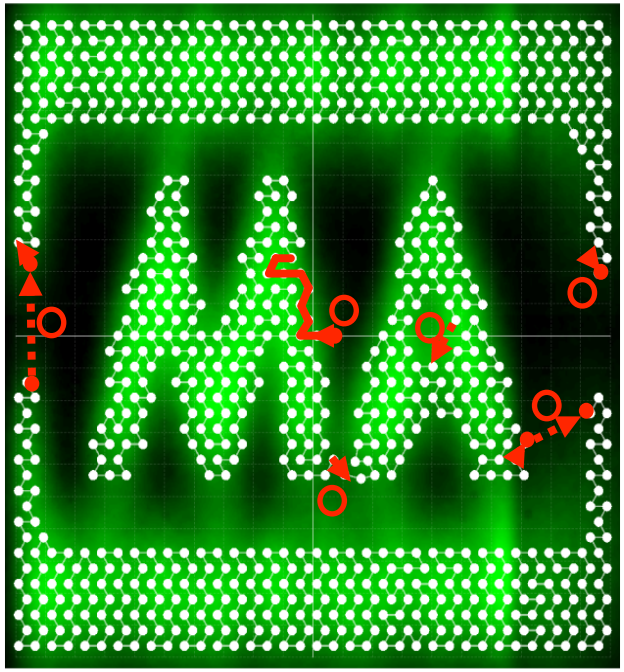


Example at CNAO for illustration only (values different for MedAustron)


y
x
y
x
y
x
25 mm

Very first try with a „real“ plan





(Potential) future developments for MAPTA

- Commissioning of all fixed BLs, Carbons, Gantry
- Increasing patient throughput: optimization of technical workflows (e.g. dynamic spill-length, dynamic intensity control)
- New indications:
  - Slice re-painting / Volumetric repainting
  - Respiratory gating / motion tracking
- Prompt dose distribution monitoring
- ...

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Thank you!