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IONTRIS
with an integrated careflow

Gaseous detectors for the Siemens IONTRIS medical application

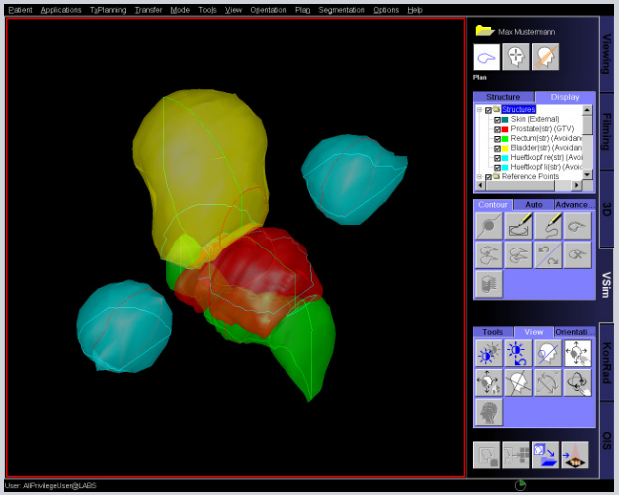
Martin Bräuer

Siemens AG
Healthcare Sector
Particle Therapy

Gaseous detectors for IONTRIS

- Raster-scanning
- Material in beam path
- Detector systems
- Detector types
- Industrial aspects
- Performance aspects

Why are we doing this ?



Example of a prostate

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Raster-Scanning

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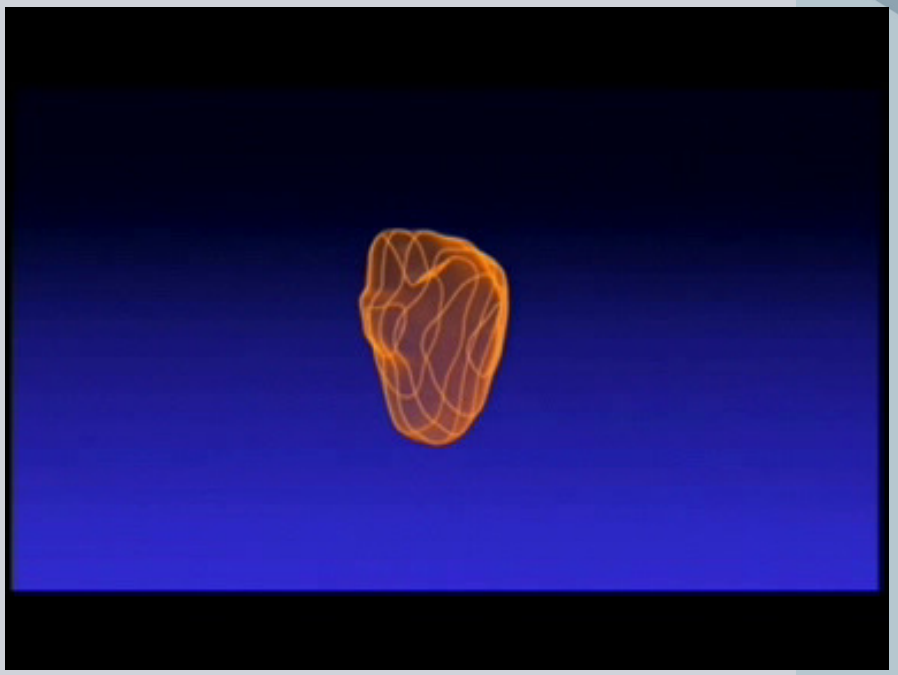

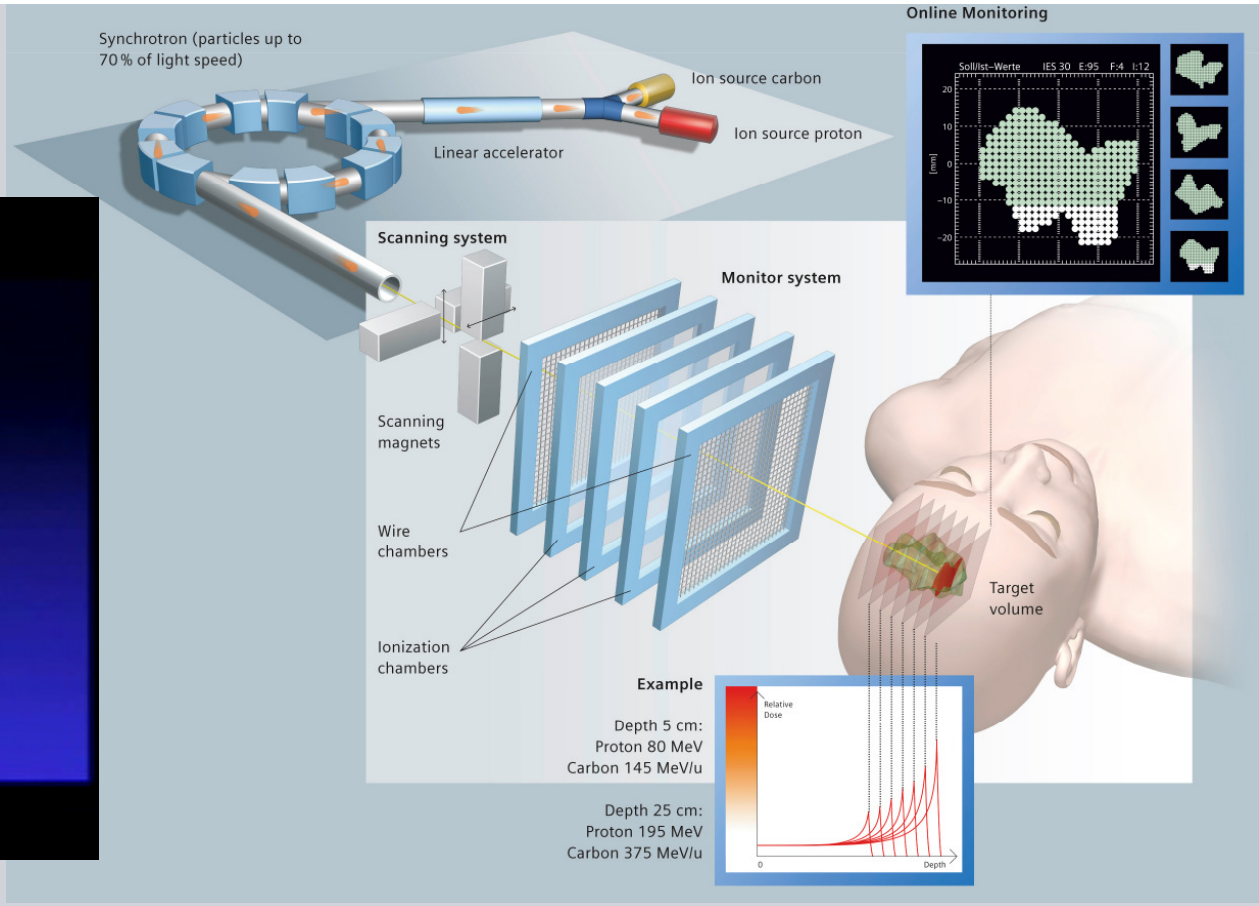

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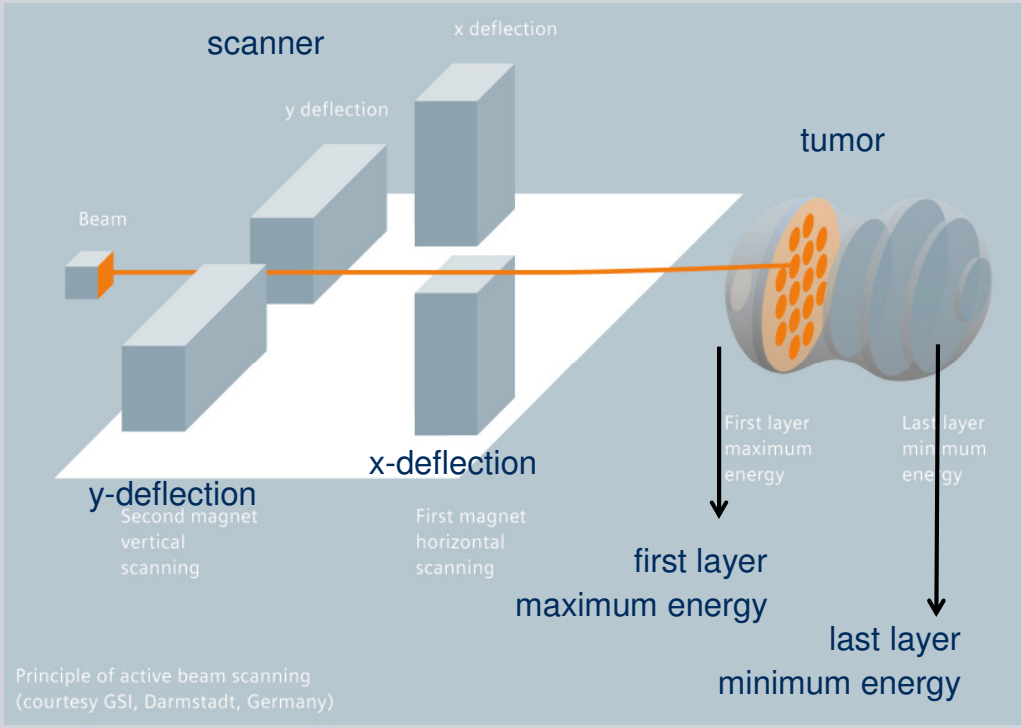
Raster-Scanning

- Fast tumor scanning with feedback loop provided by online position & dose measurements
- Prototype at GSI in clinical use for 10 years
- System being designed with respect to serviceability, cost, use of established industrial components
- Parallel beam scanning in all treatment rooms (incl. Gantry)



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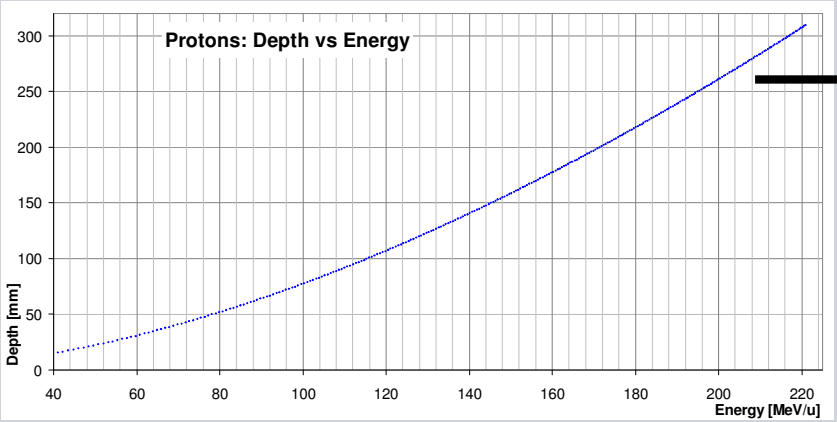
Beam application, clinical needs



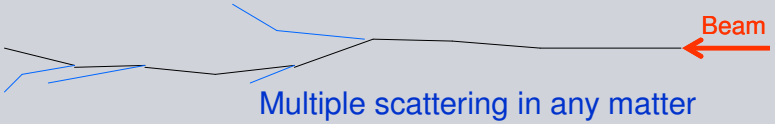
Accelerator energies and corresponding depth in tissue

The system shall operate for proton beams

- Energy range: 48 - 250 MeV
- Intensity: $4*10^7$ - $4*10^{10}$ particles / spill
- Minimal flux: $4*10^7$ protons / second

The system shall operate for carbon beams

- Energy range: 85 - 430 MeV/u
- Intensity: 10^6 - 10^9 particles / spill
- Minimal flux: $1*10^6$ carbon ions / second



Beam width of 2 - 10 mm FWHM in vacuum for p and C beams

Ultimate design goal: No material in beam-path!

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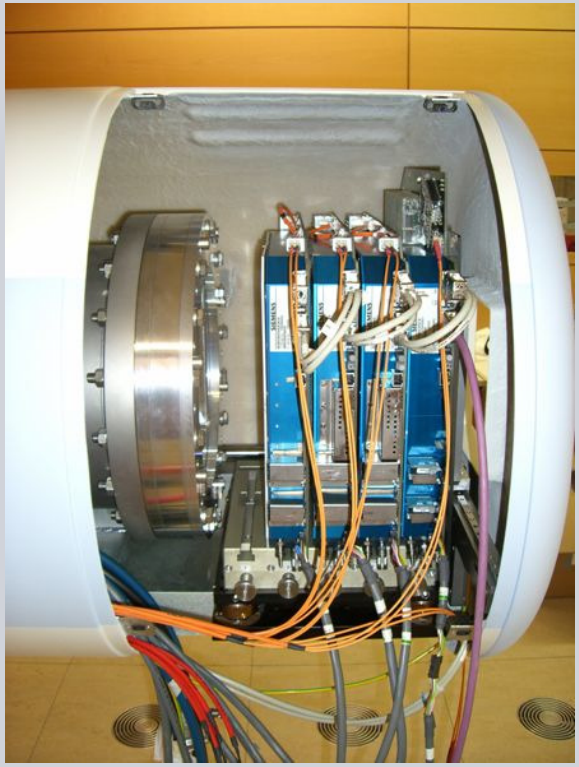
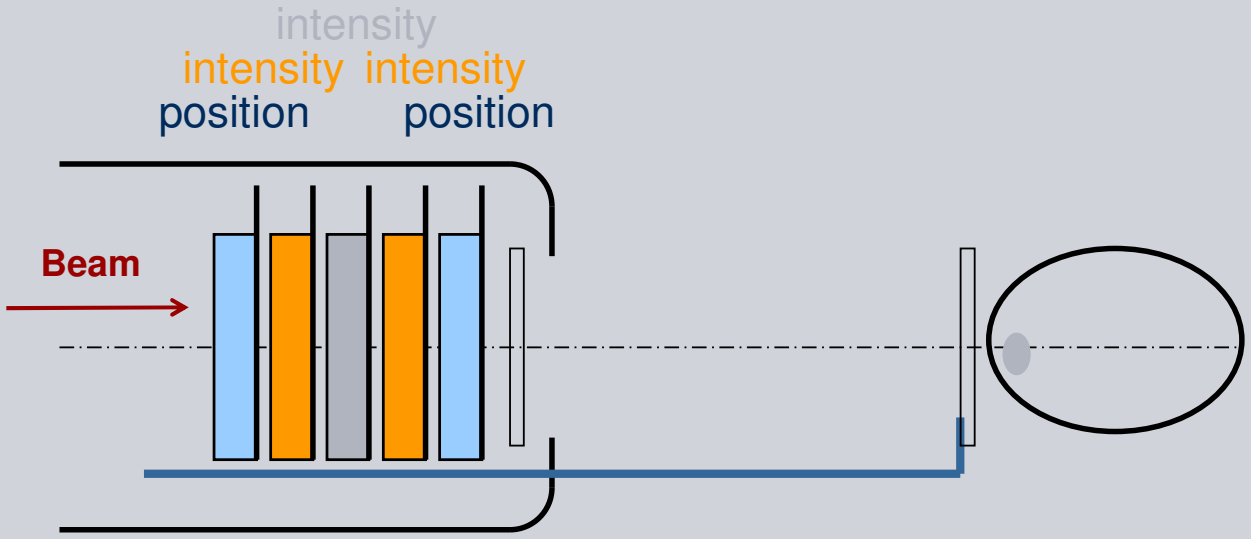
Beam application, reduced material budget in beam path



Detectors: feedback for scanner



Optional Modulators

Ripple-filter
Widen Iso-Energy-slices

Range-shifter
Decrease depth @ E_{min}

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Benefit from reduced material budget in beam path
Beam-sizes for Protons and Carbon as a function of energy

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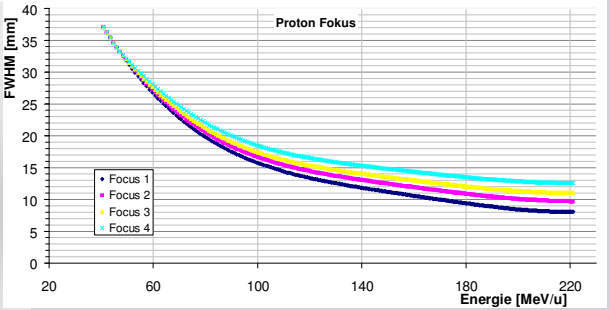
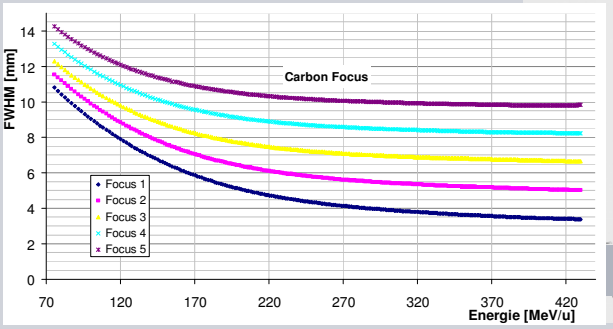
Energy





Protons

Focus

Carbon

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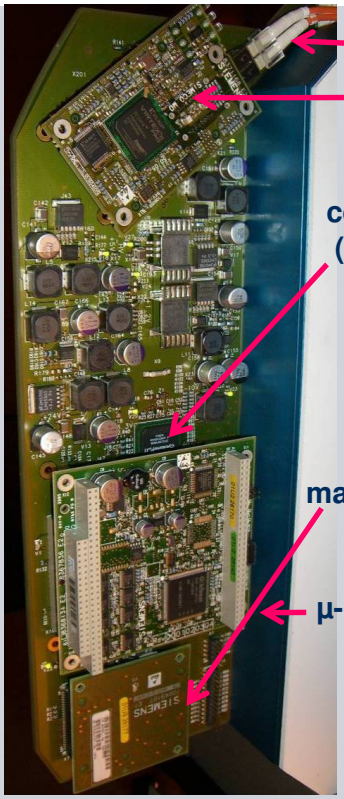
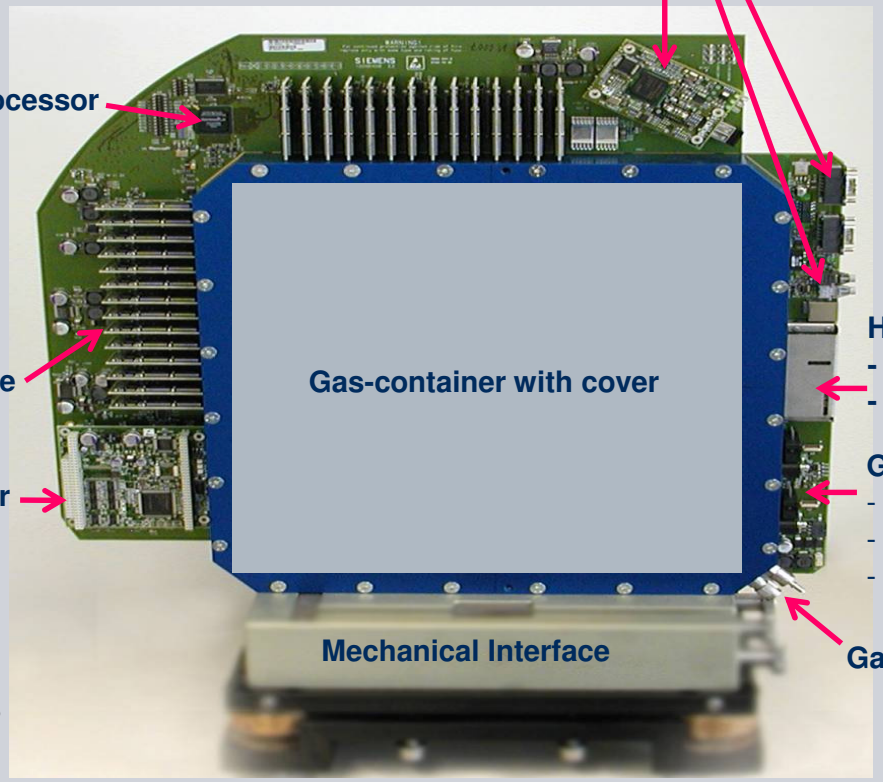
Detector Systems

- 2 Types:
  Intensity and Position
- Integrated systems
- System as identical as possible
- Adapted to in-house controls





The Siemens integrated detectors – medical series products

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Position Measurement
MWPC Detector

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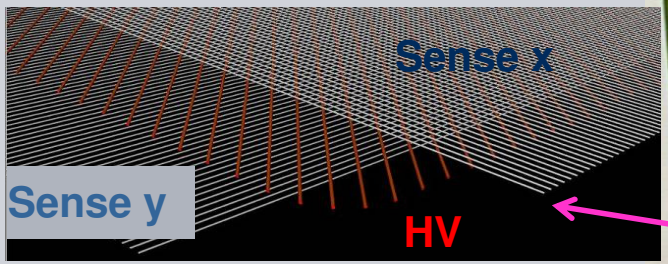
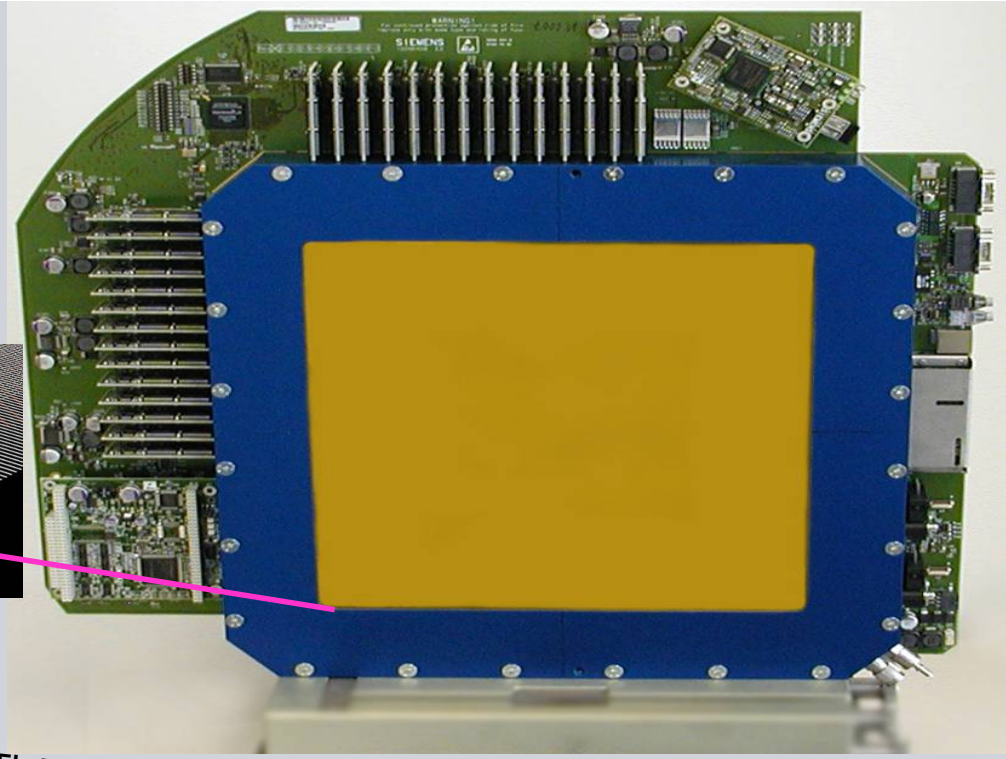
- MWPC principle
- Ar/CO_2
- According to GSI-Design of chamber

112 channels / view
Aperture > 200mm x 200mm
Resolution ≤ 0,2mm

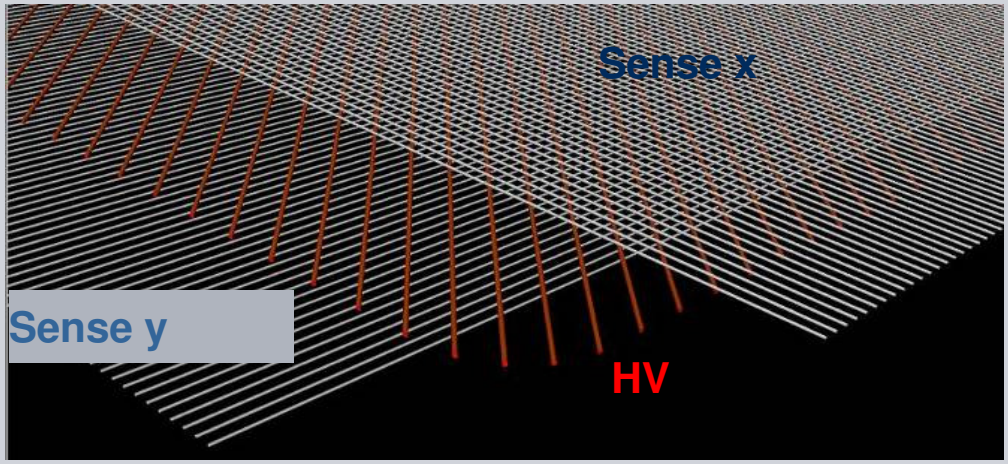


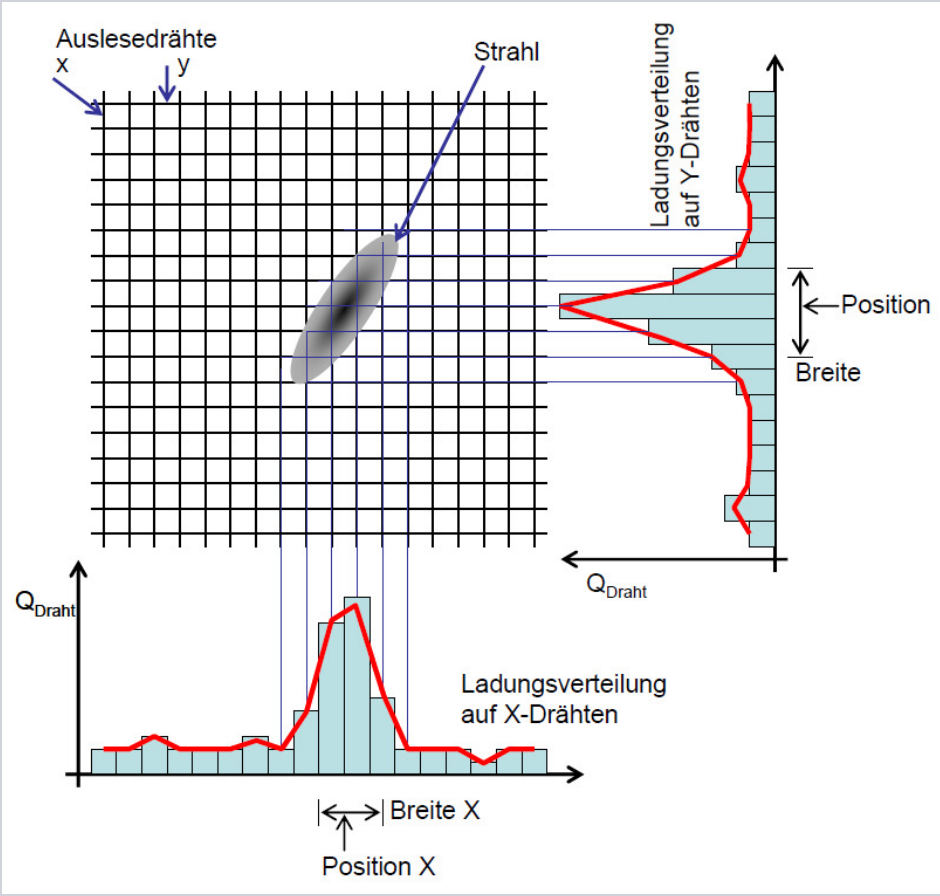


Reconstruction
- Cuts
- Weighted average
- Variance scaled to FWHM
  => assuming a “Gaussian” beam profile !

Experience: ATLAS-ALMY technology transferred to car manufacturing, algorithm issue was not solved

MWPC reconstruction and issues I





Strips: Projecting !

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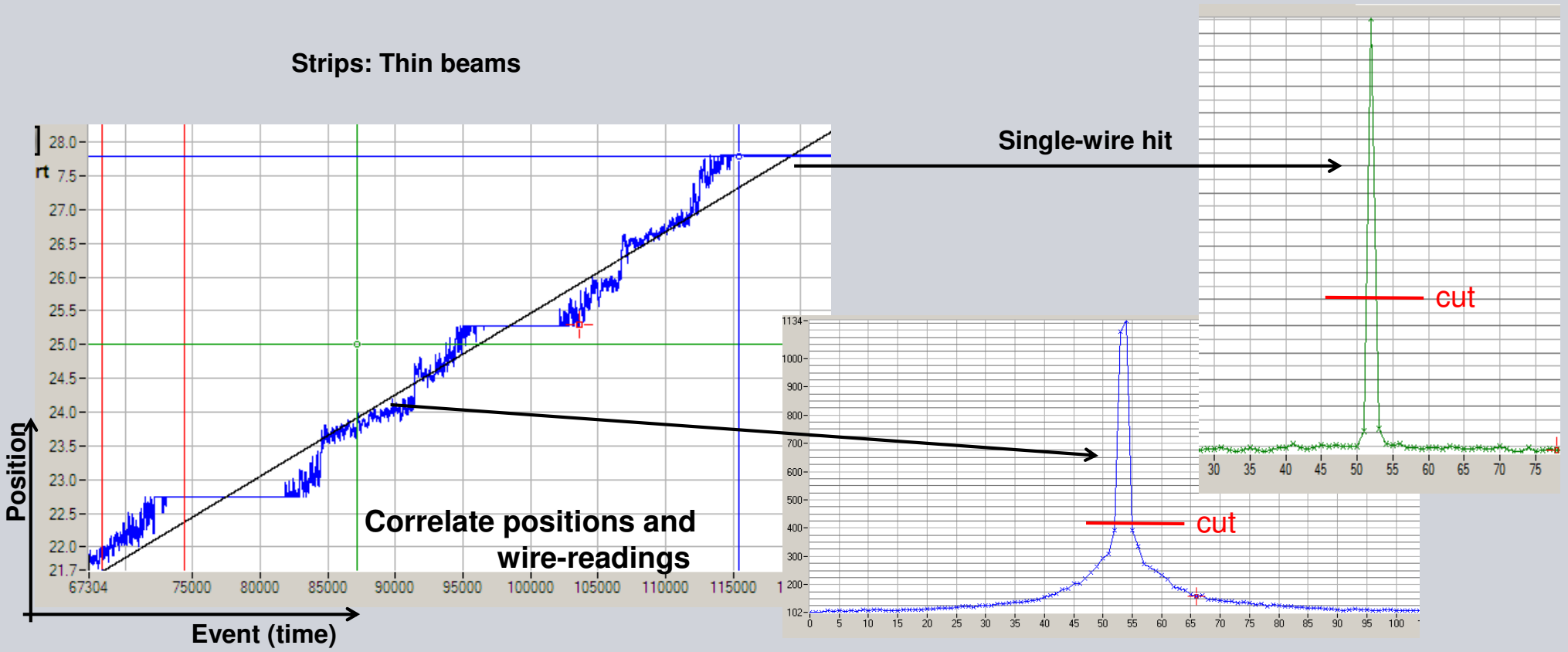
MWPC reconstruction and issues II



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Intensity (Current) Measurement
PPIC Detector

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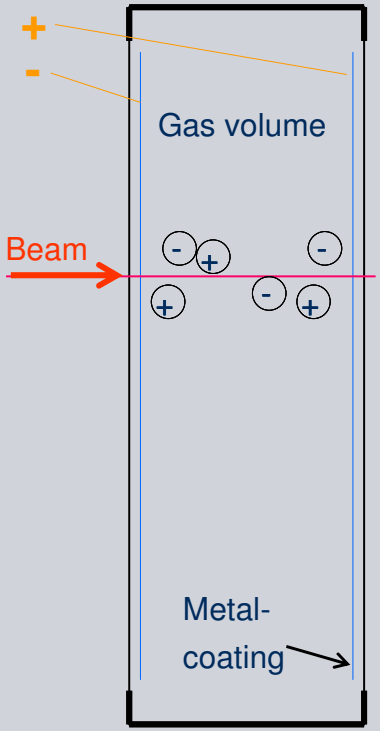

Ionization-Chamber

Measure the ionization current over the therapeutic field

Safety

Measure any beam independent on its position!

Two electric conversion methods:

IC: Analog-digital-converter (4 ranges, precise, direct)

IM: Current-frequency-converter & counter (1 range, integrating, less precise)

ADC-module

- Specific development
- Outperforming GSI design in many points
- Compact
- 0,1pA .. 20µA, 4 Ranges

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Intensity Measurement Issues

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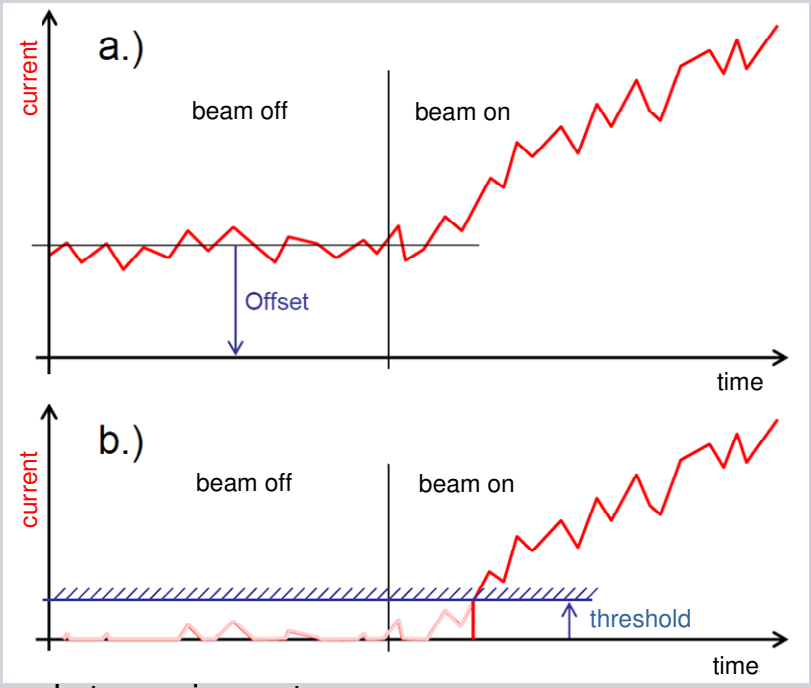
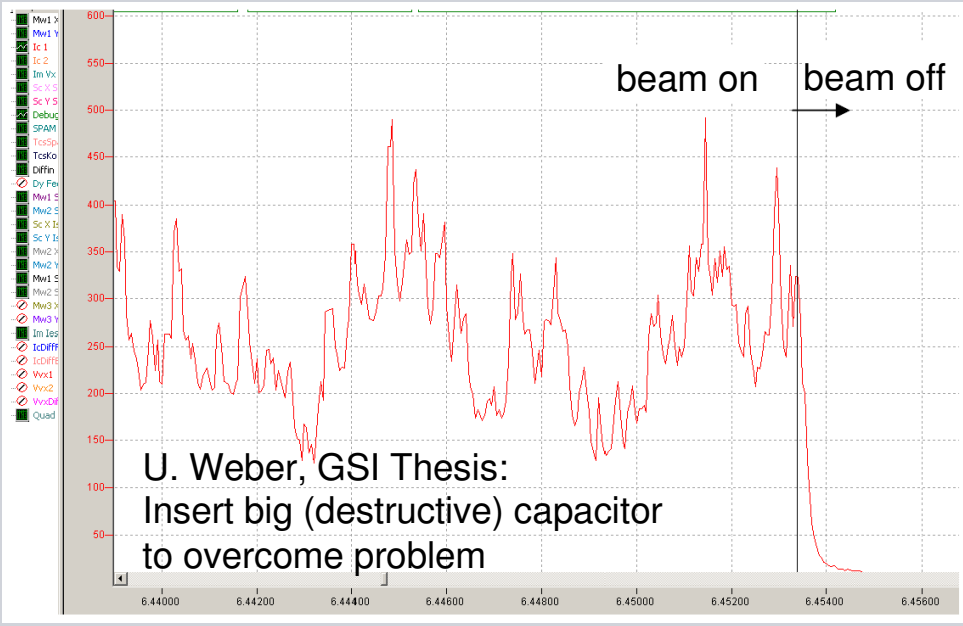
Threshold



- Late requirement
- Communication: Only positive currents
- Control system: Only integrating upwards

Signal Decay



- Overcome by changes in HV / detector RC-net
- Remaining: ~0,5ms “afterglow”

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Manufactoring / Quality Control

- Chambers are built in-house
- “in-house”: Plant in Rudolstadt
- Many people involved
- Large coordination effort
- Separated R&D / manufacturing units

- Manufacturing needs processes
- Processes must be tailored from experience – but must be written before first series sample is built

- Example of process considerations: ESD rules must be kept over whole lifetime of a detector system.

- Quality = “Processes kept” ! ?
- Scientific understanding: “Measurements on samples”
- Having two X-Ray setups
- Still doing lots of measurements at the facilities

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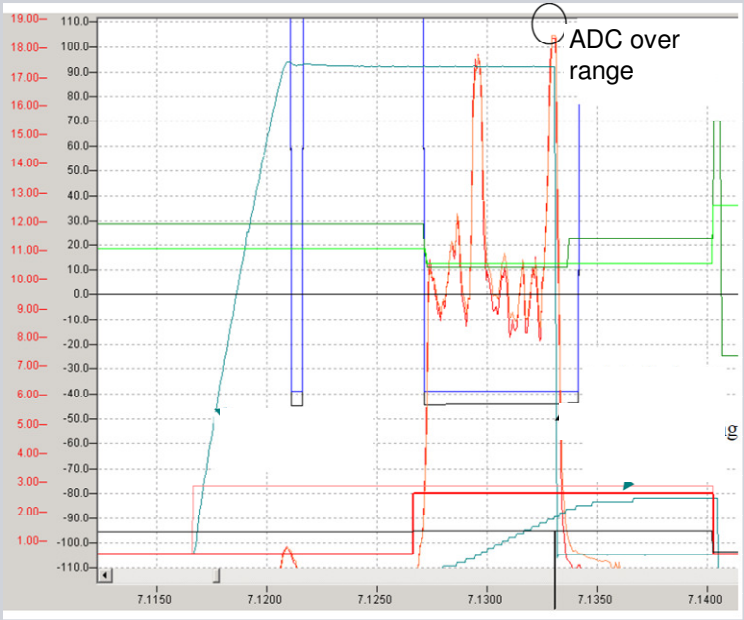
Interlocks

What is an “Interlock” ?

- Somebody entered the accelerator
- Power-supply door open
- Unexpected beam in treatment room
- PPIC ADC is in overrange
- Patient touching chamber HV

  - Clinical application needs re-consideration of traditions !
  - Detector system:
  - Signaling ADC over range => Beam off
  - HV error => Beam off, HV off, user intervention
  - HV on ground => Beam off, HV “Quick-Stop” = safe for humans,
  - hardware intervention

- => “Interlock groups”



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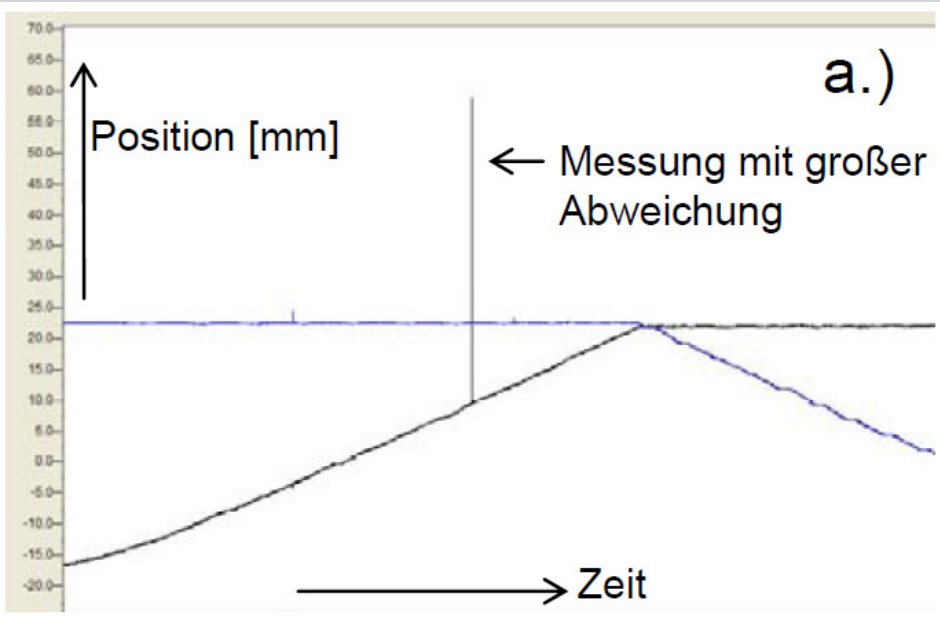
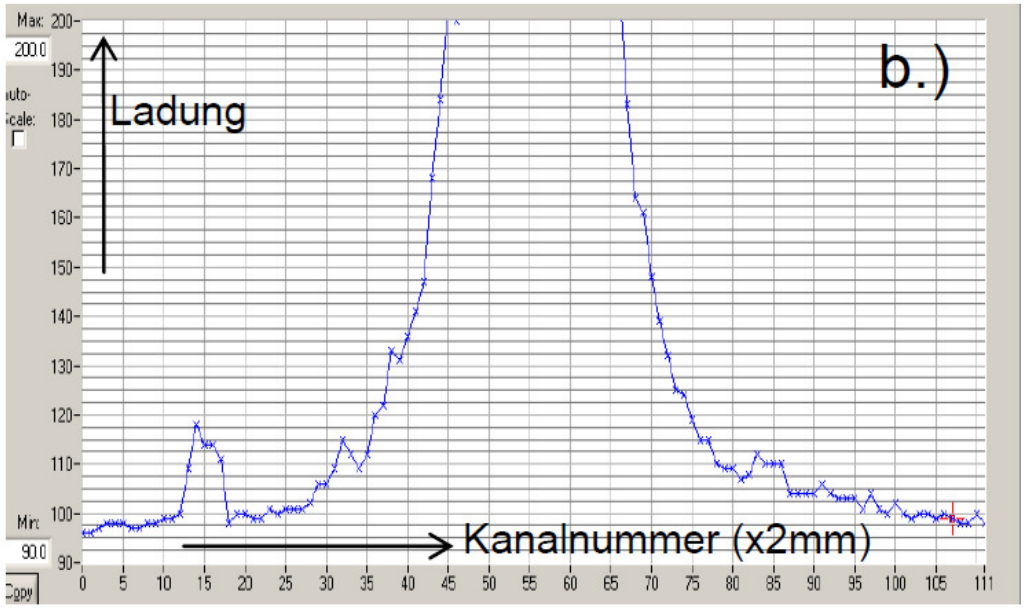
MWPC: Delta electrons





δ –electrons:
Single events with large offsets in reconstructed beam position

No interlock on “single events”: Safety ?!

Performance
Optimal intensity monitoring

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- Fast (<<10µs delay)
- Fast decay (<<500ms)
- Reliable
- No sparks
- High bandwidth
- Low noise, wide band ADC
- No solid-state system (material !)
- Low noise
- Homogenous
- Large size (> 250mm x 250mm)
- Stable in time

Performance
Optimal position monitoring

SIEMENS

- Fast (position every 100µs)
- High resolution
- No single event offsets
- 2D ?
- Improved algorithm
- Reliable
- No sparks
- High bandwidth
- No solid-state system (material !)
- Low noise
- Homogenous
- Large size (> 250mm x 250mm)
- Stable in time

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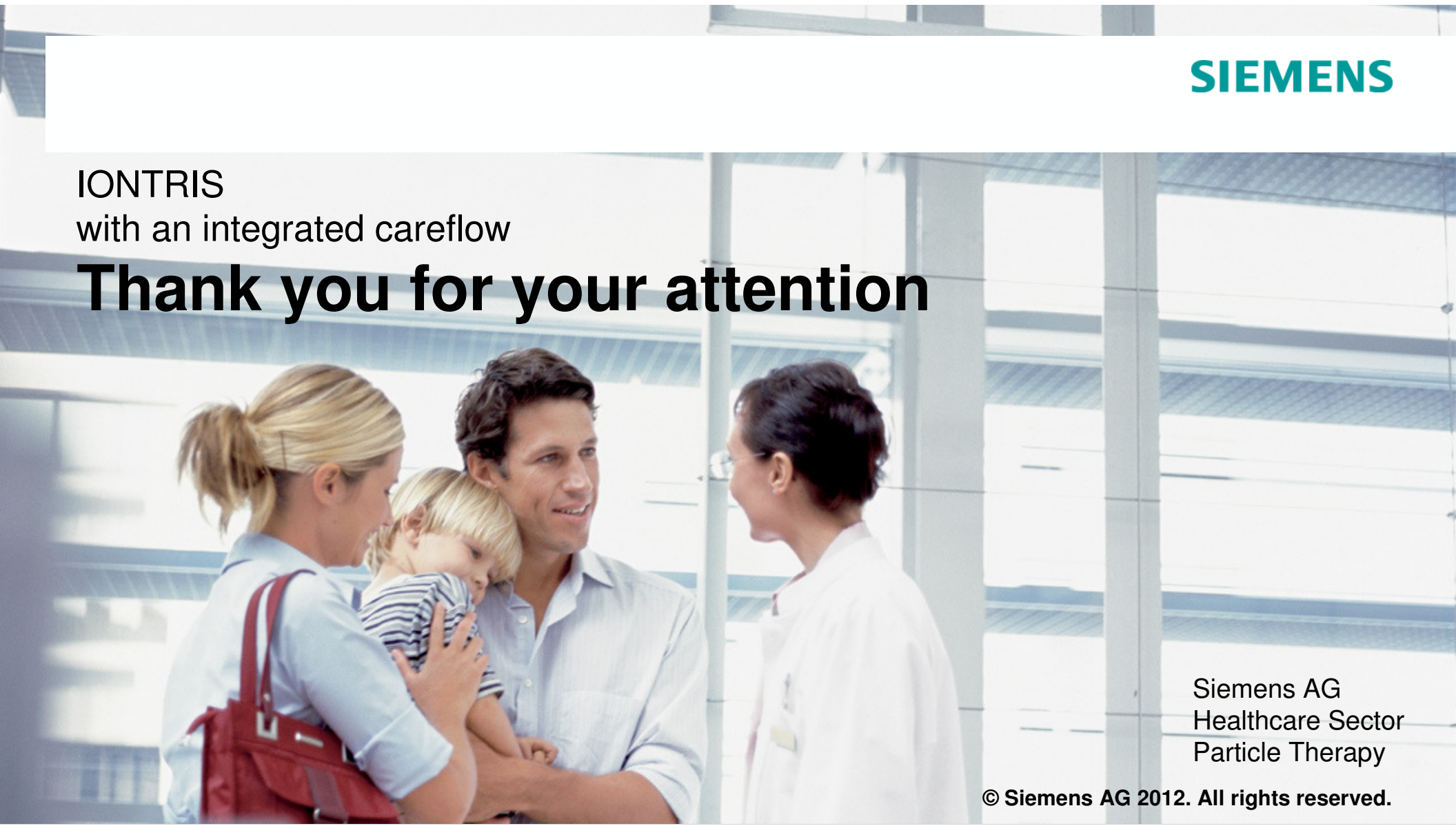
Thank you for your attention



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