MedAustron – the Austrian Ion Therapy and Research Centre

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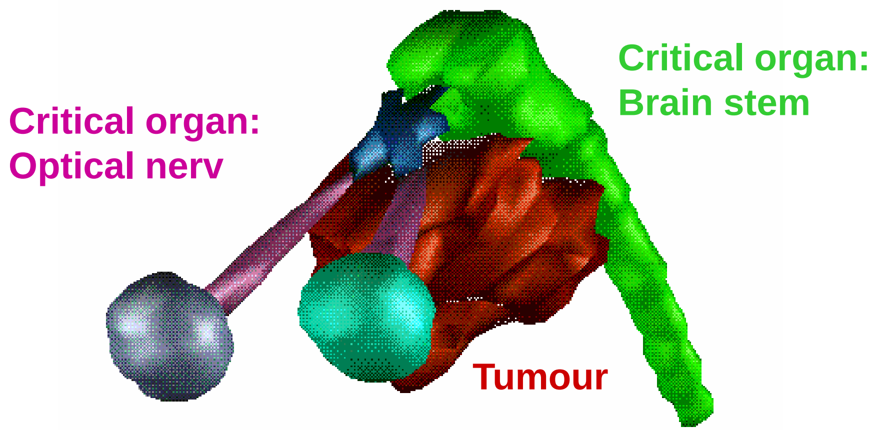
on behalf of Michael Benedikt

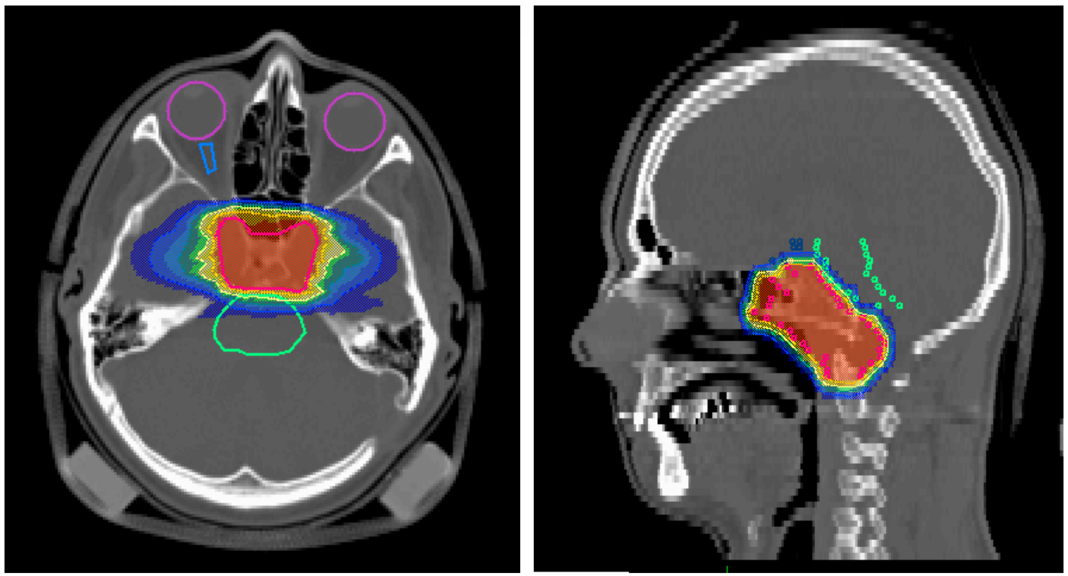
1st June 2012
CAS ion sources, Senec, Slovakia

Contents

Introduction radio-therapy

- **Target**
  - Deposition of high radiation dosis to target volume killing tumour cells.
  - Minimalize effect on healthy tissue and critical organs.
  - Dosis distribution optimized for tumour shape.
- **Particle types**
  - Conventional therapy: photons, electrons
  - Hadron therapy: protons, ions





Courtesy GSI

European study – tumour therapy (i)

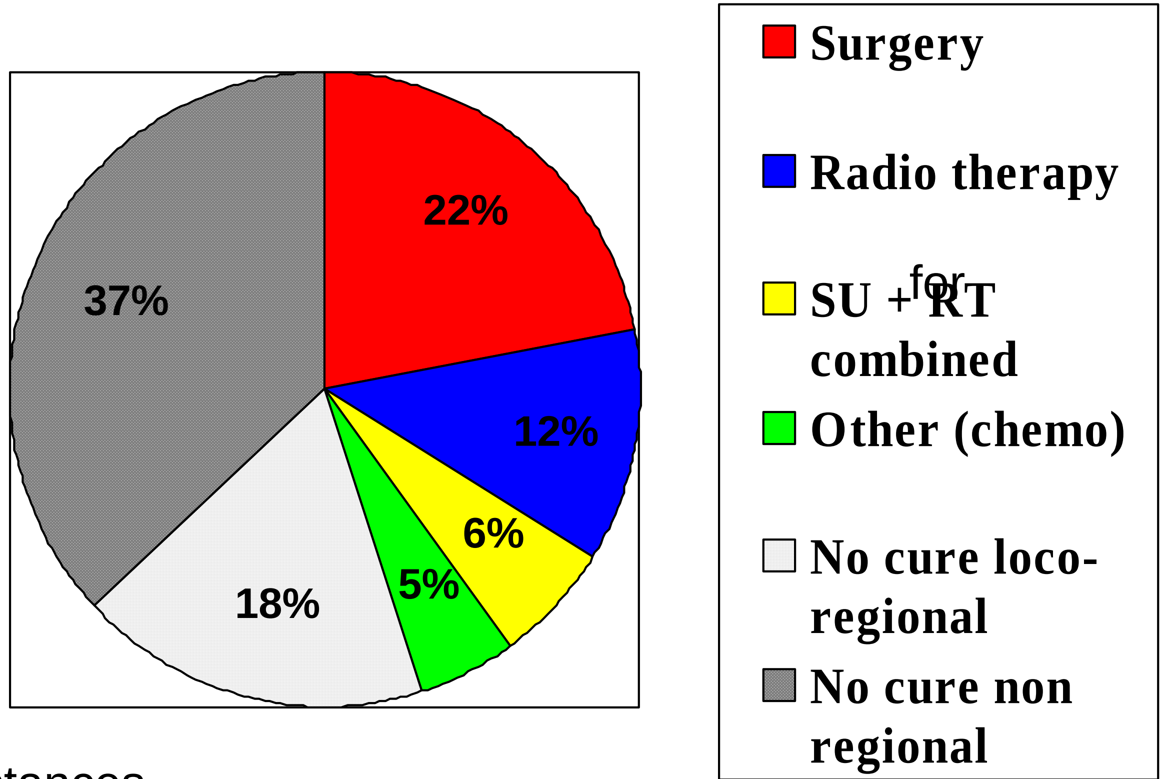
- **EU report 1996:**
- **Statistically every third EU person suffers from a tumour.**

Unsuccessful treatment			55%
Successful treatment			45 %
Surgery	22%		40% (Surgery + Radio-therapy + Surgery&RT combined)
Radio-therapy	12%	18% (Radio-therapy + Surgery&RT combined)	
Surgery&RT combined	6%		
Other (chemo)			5%

- RT used in 18/45 successful treatments i.e. 40%.
- Surgery/RT used in 40/45 successful treatments i.e. 90%
  - Surgery/RT used for regional tumours only, no metastases

European study – tumour therapy (ii)

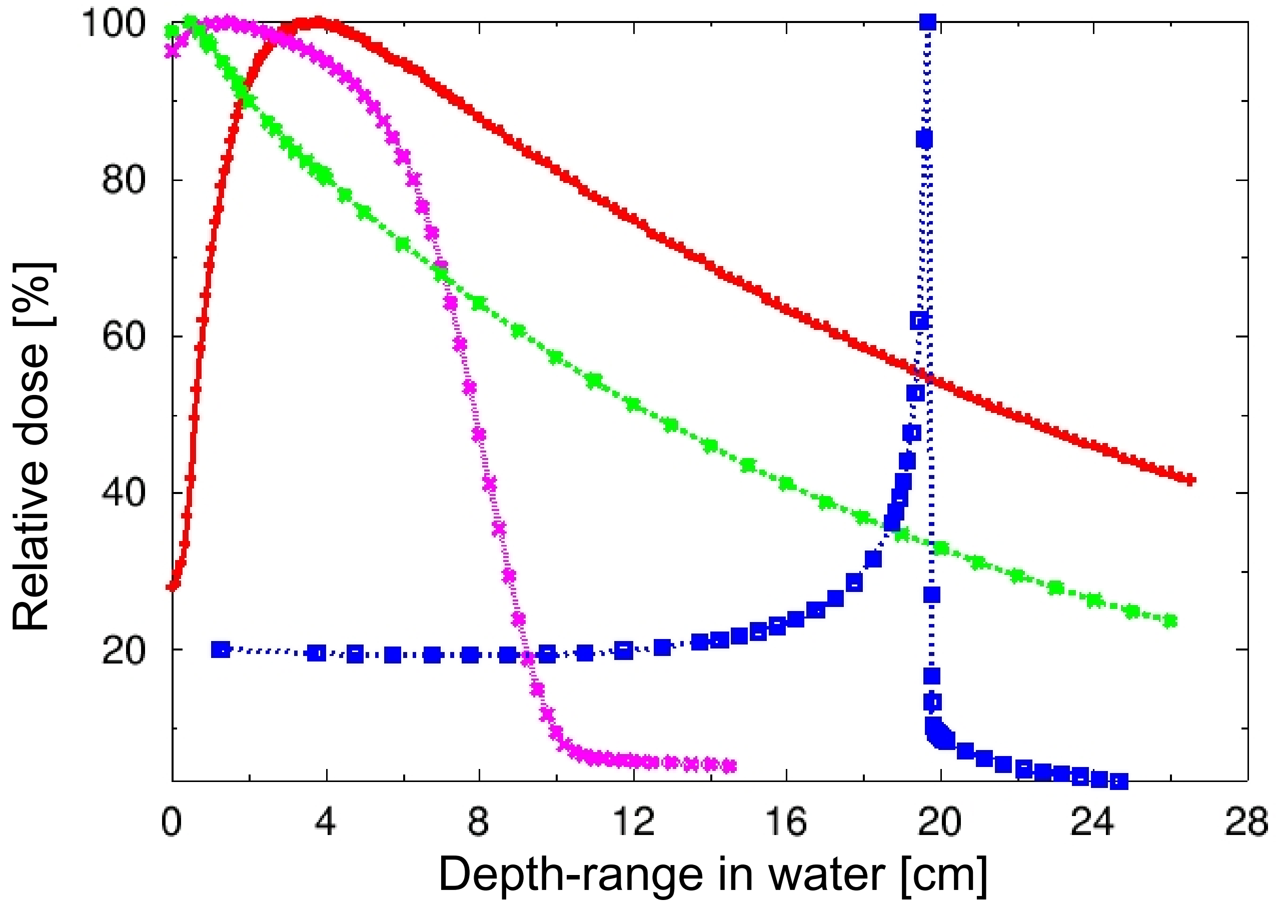
- **18% regional but not curable**
- **Improvements:**
  - Different method for application on local affection
- **60-65% total success**
  - If local cases treated



- **Main difficulties:**
  - Surgery: anatomic circumstances
  - Radiation therapy: radiation resistant, proximity of critical organs.
- **Therapy with protons and ions as a potential improvement**
  - Allows more precise and more localised dose distributions

Longitudinal energy deposition – “Bragg-peak”

Measurement in water phantom (~tissue equivalent)

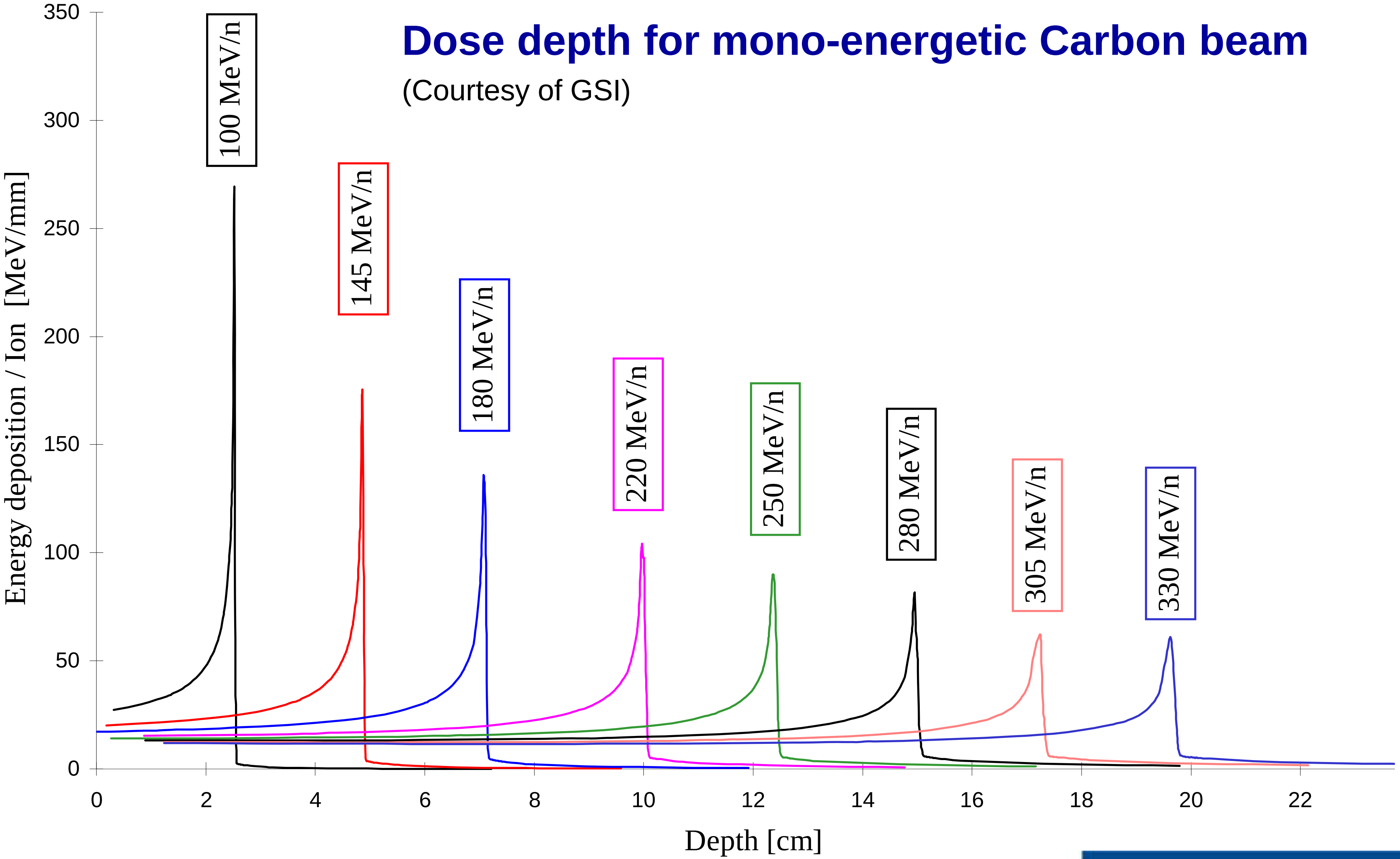


references:

Photons and electrons:
University Clinics Vienna

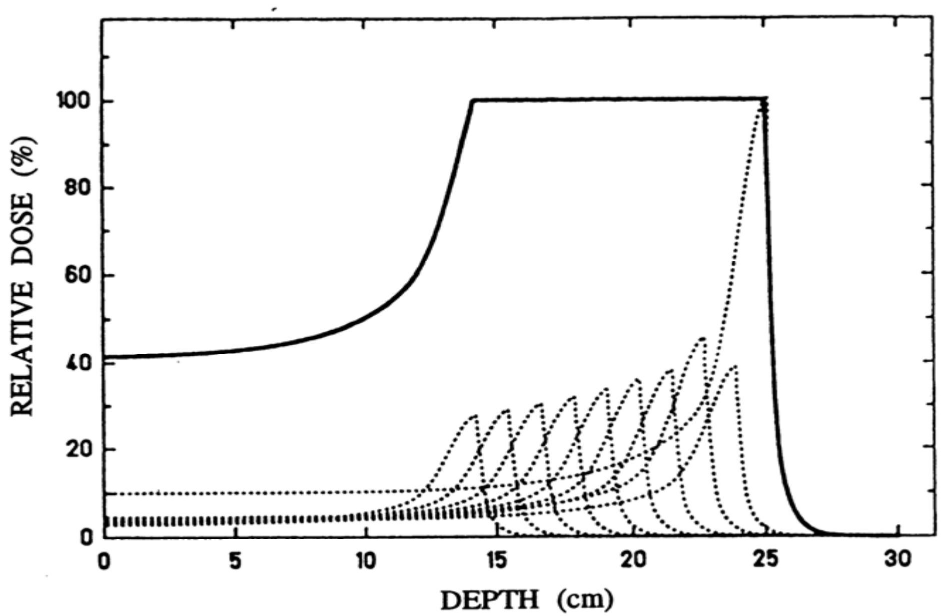
C-Ionen:
GSI Darmstadt

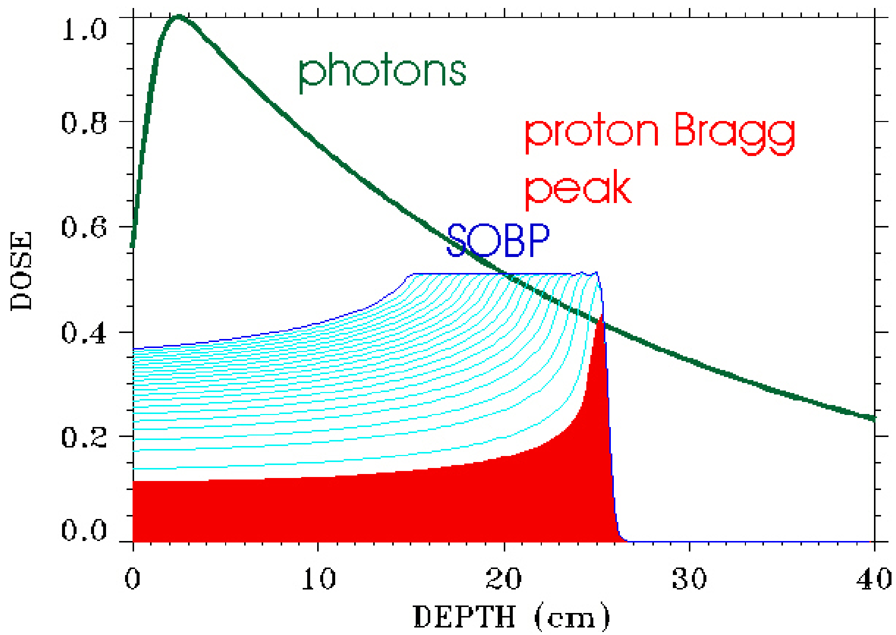
“Bragg-peak” – energy dependence



Spread-out “Bragg-peak”

- **Bragg-peak to be spread out over whole tumour depth**
  - Super-positioning of several beams with different energy
  - Active (synchrotron) or passive (cyclotron) energy variation.





- **Beam must also cover the full transverse tumour dimensions.**
  - Transverse scanning with small beam or scattering too large beam size.

Beam generation

- **Particle accelerator: synchrotron or cyclotron**

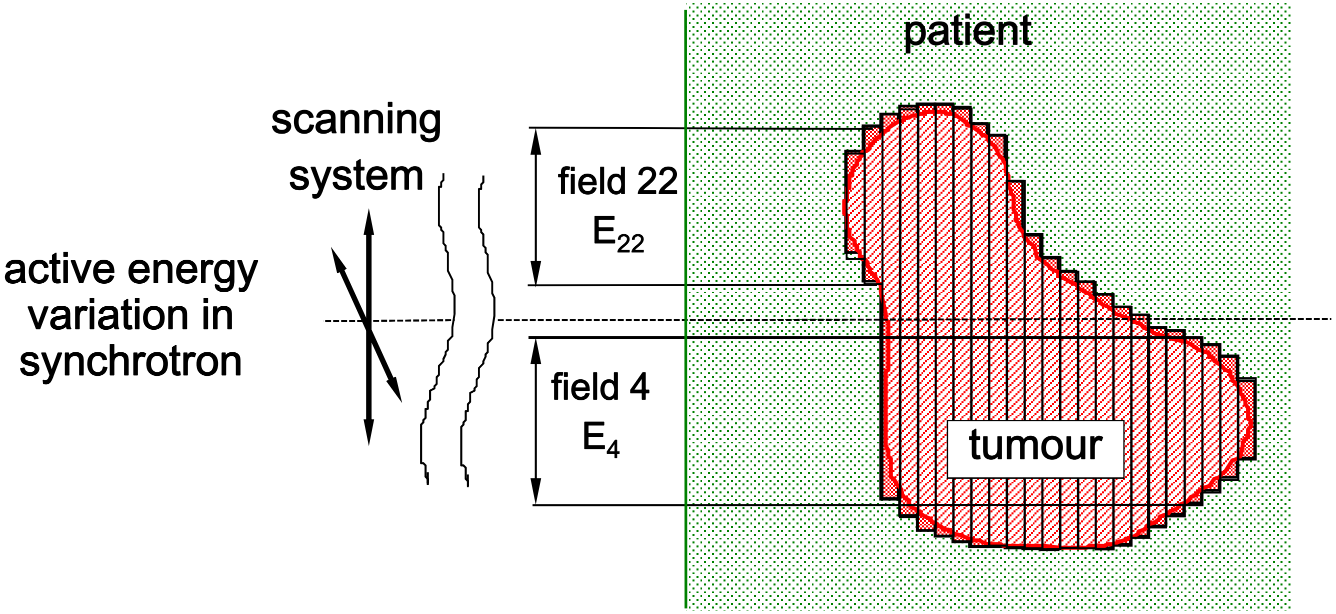
- **Adjustment of beam energy to maximum tumour depth**
- **Modulation of beam energy for SOBP**
- **Adaptation of the beam size to the tumour cross section**

- **Passive systems (material in beam path):**
  - Scattering block for transverse beam size
  - Energy absorber for SOBP
  - Applicable for cyclotron and synchrotron

- **Active systems (no material in beam path):**
  - Transverse scanning across the tumour cross section with small beam size
  - Energy variation by accelerator machine
  - Chosen method with synchrotron

Active beam generation

- "Slicing tumour in iso-energetic layers".
- Transverse scanning, slice by slice
- Intensity and beam size adjustable slice-by-slice



- Most optimized dose distribution achievable
- Strong time-location correlation (critical for moving organs).

Experience in hadron therapy

- **Proton therapy**
  - Facilities in Japan, USA and Europe
  - More than 50.000 patients treated
  - Highly promising, clinical results
- **Carbon therapy**
  - Japan, Germany, Italy: first facilities operational
  - A few hundred patients treated
  - Very promising results, ongoing studies indicate high potential for future development and application

Need for hadron therapy

Tumour cases in the EU : 2,8 Mio annually, of which

– Lethal without metastasis:
514.000 patients annually

– Candidates for hadron therapy:
51.400 patients annually

Need in the Austrian region:

– About 2000 – 3000 patients annually are patients, where hadron therapy is optimum treatment method.

– Expected treatments > **1200 Patienten.**

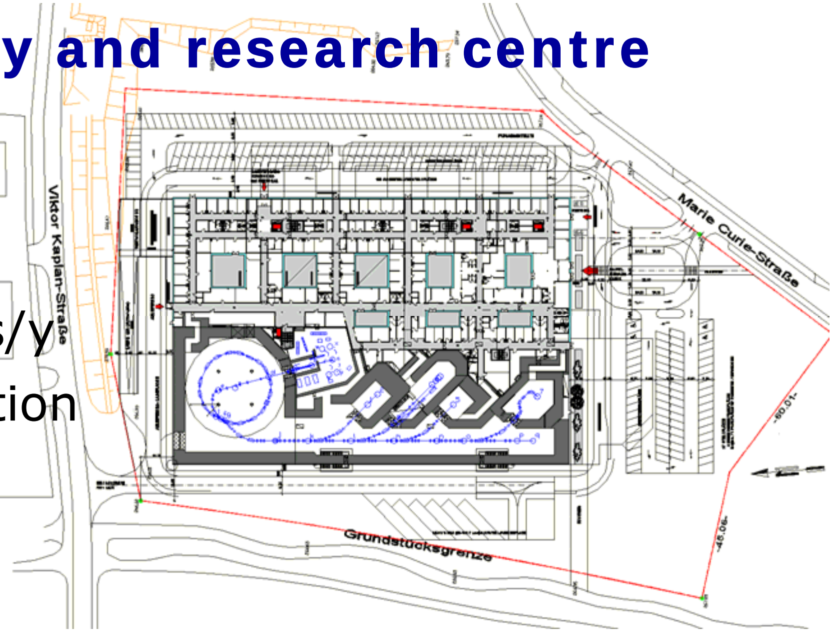
Additional aspects at MedAustron:

– Patients from neighbouring countries

– Increasing patient numbers for hadron therapy because of advancement in treatment method

Goals of the MedAustron project

- **Construction of an ion-therapy and research centre**
  - Proton and Carbon ion therapy, clinical research (incl. patient)
  - Non clinical research (NCR)
  - Beam operation 24/7, >300 days/y
  - Beam time sharing clinical operation and NCR, about equal beam time



- **Synchrotron based accelerator complex**
  - Operation phase 1: protons and C-ions
  - Design allows for operation with other light ions (He, O,..) with q/m > 1/3 for later operation phases.

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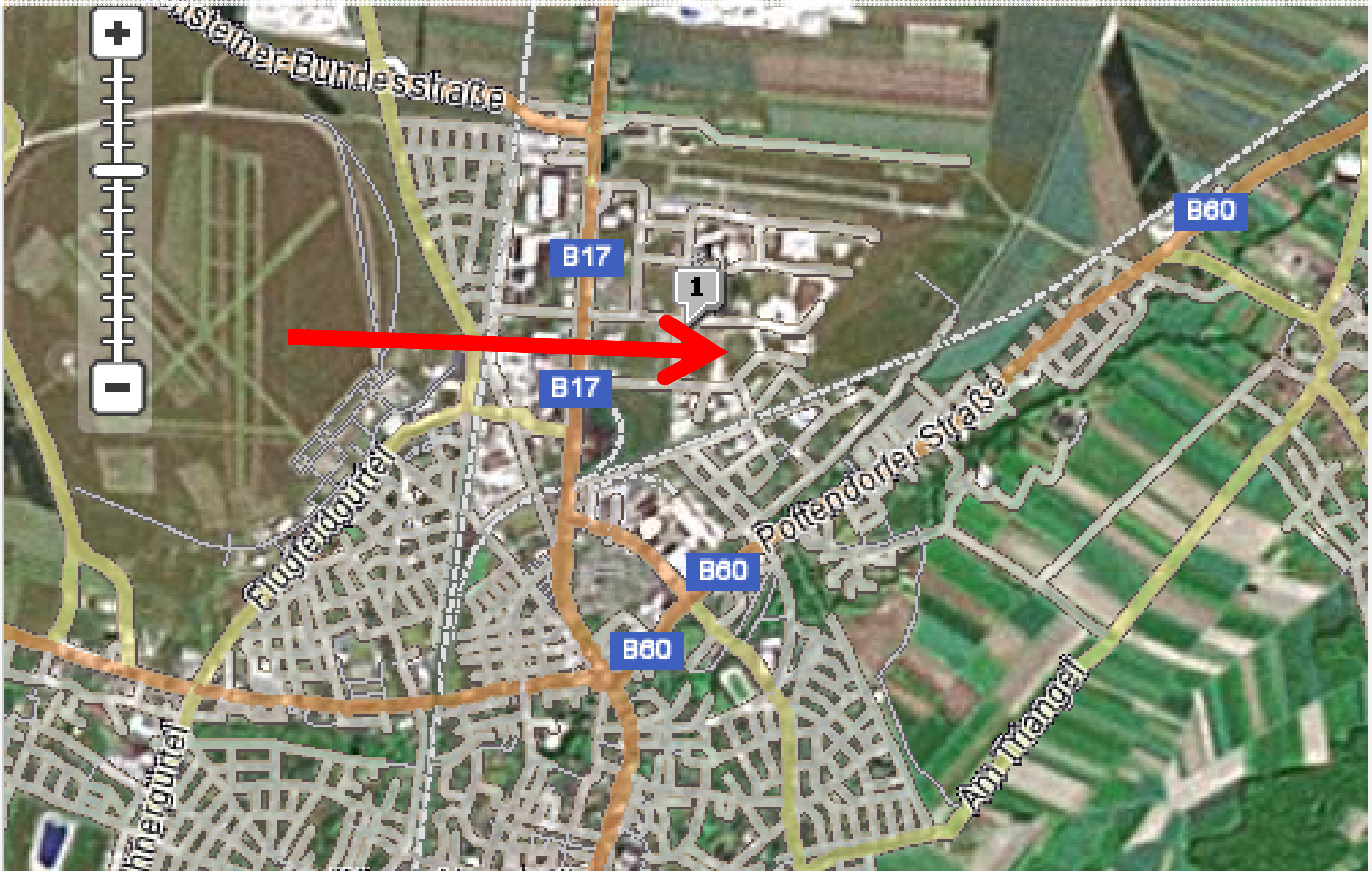
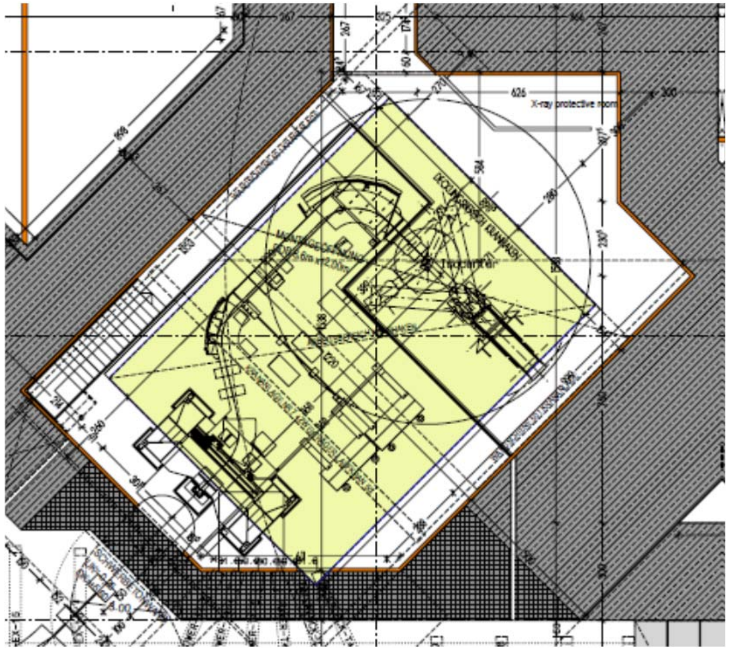
MedAustron Site

- City of Wiener Neustadt, 40 km south of Vienna
- Terrain 32.000 m²
- Vicinity of Fachhochschule and new hospital project WN



Medical requirements

- **Treatment capacity ~ 1200 patients/year**
  - Centre designed for 24.000 single fractions/year corresponds to about 100 patients/day



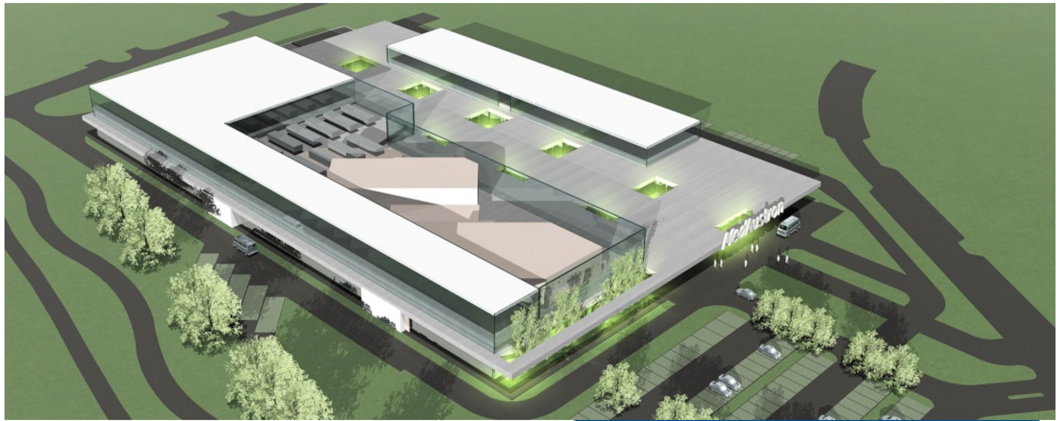
- **Medical operation phase 1**
  - Medical operation 5 working days/week
  - 2 shifts, 06:00 – 22:00 incl. QA
- **Optimization of patient flow**
  - 3 medical treatment rooms
  - 3 rooms for patient set-up per treatment room
  - Optimum usage of accelerator complex

Non clinical research

- **Medical radiation physics and radiation biology**
  - Research fields close to clinical operation (translational research)
  - MedAustron will be „state-of-the-art" infrastructure for these areas
- **Experimental physics (detector tests, nuclear physics)**
  - Increase of proton energy to (250 → 800 MeV)
- **One irradiation room exclusively for NCR in addition to the three medical treatment rooms**
- **Establishing links to university and international partners essential for success and quality of research**

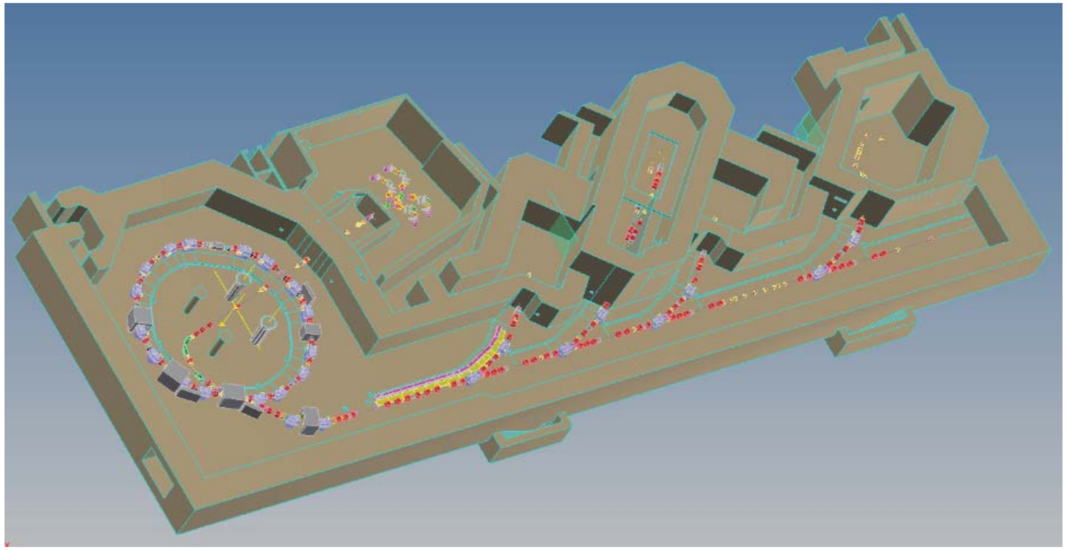
Beam parameters

- **Beam energy**
  - Protons: 60-250 MeV (medical), pulse-to-pulse modulation (ppm)
  - Protons: up to 800 MeV for experimental physics in research room
  - C-ions ($^{12}C^{6+}$): 120-400 MeV/n, ppm
- **Beam delivery – active scanning**
  - Horizontal – vertical fast scanning system with magnets
  - Energy variation with synchrotron (ppm)
- **Intensities in irradiation rooms (ppm)**
  - Dose build-up: ~ 1 minute to deliver 2 Gray in 1 liter
  - Protons: ≤ $1*10^{10}$ /puls
  - C-ions: ≤ $4*10^{8}$ /puls
  - Repetition rate < 0.5 Hz
- **Beam size at iso-centre**
  - 4 to 10 mm FWHM, (ppm)



Irradiation rooms

- **Medical irradiation rooms**
  - IR2: horizontal- and vertical beam, identical iso-centre, p, C-ions
  - IR3: horizontal beam, p, C-ions
  - IR4: Gantry (-30/+180), only protons, based on PSI gantry II collaboration with PSI



- **NCR irradiation room**
  - IR1: horizontal beam, p (up to 800 MeV), C-ions
    - Variable iso-centre, allows 5m shift to install experiments simultaneously

Financing

Republic of Austria

- € 41 Mio. for construction
- € 5.5 Mio. p.a. for operation and non-clinical reearch

Country of Lower Austria

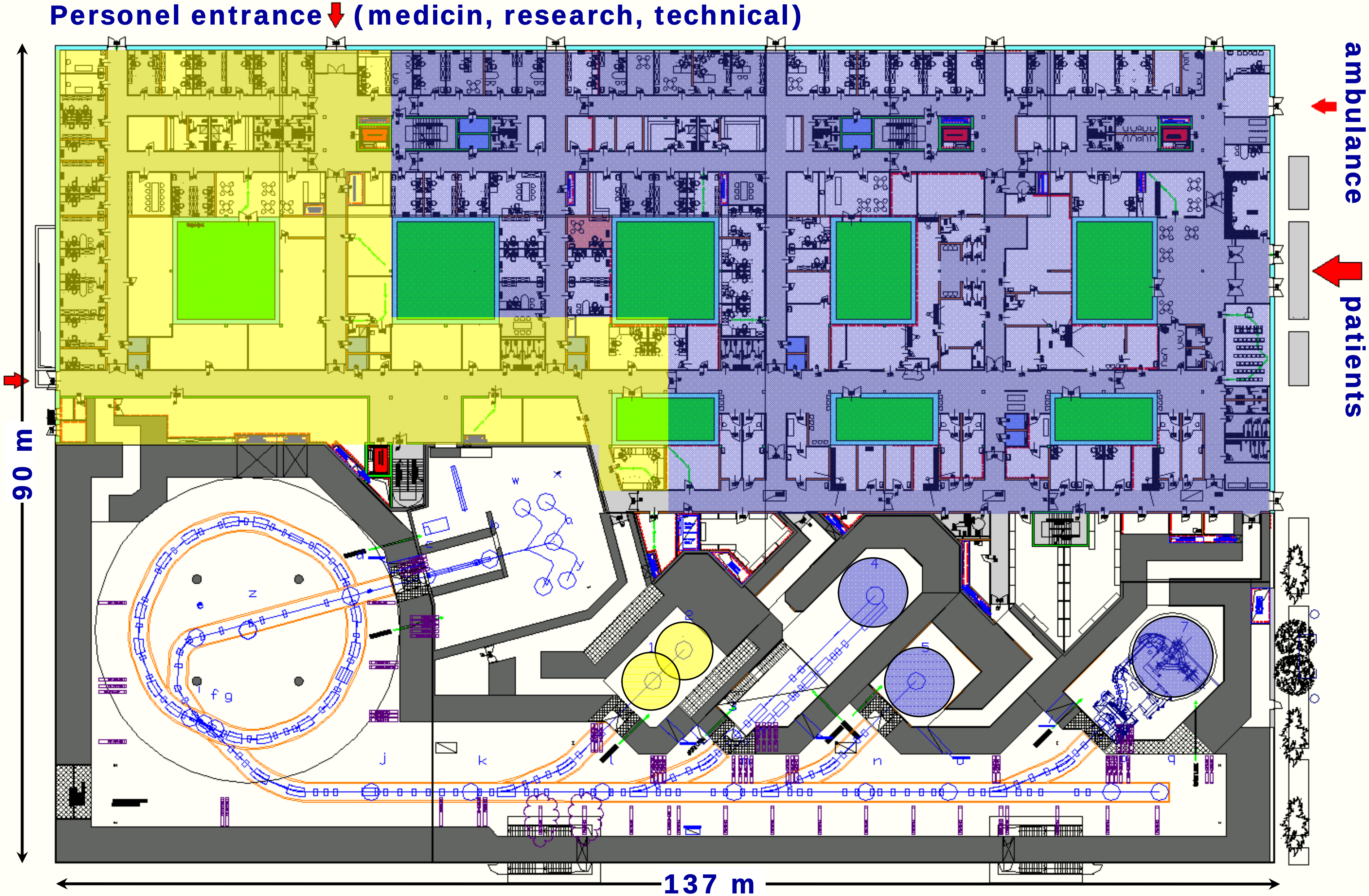
- Owner through EBG MedAustron GmbH
- Warranty for 120 Mio.€

City of Wiener Neustadt

- Provided construction site (3,2 ha)
- contributes 1.6 Mio. € for NCR equipment

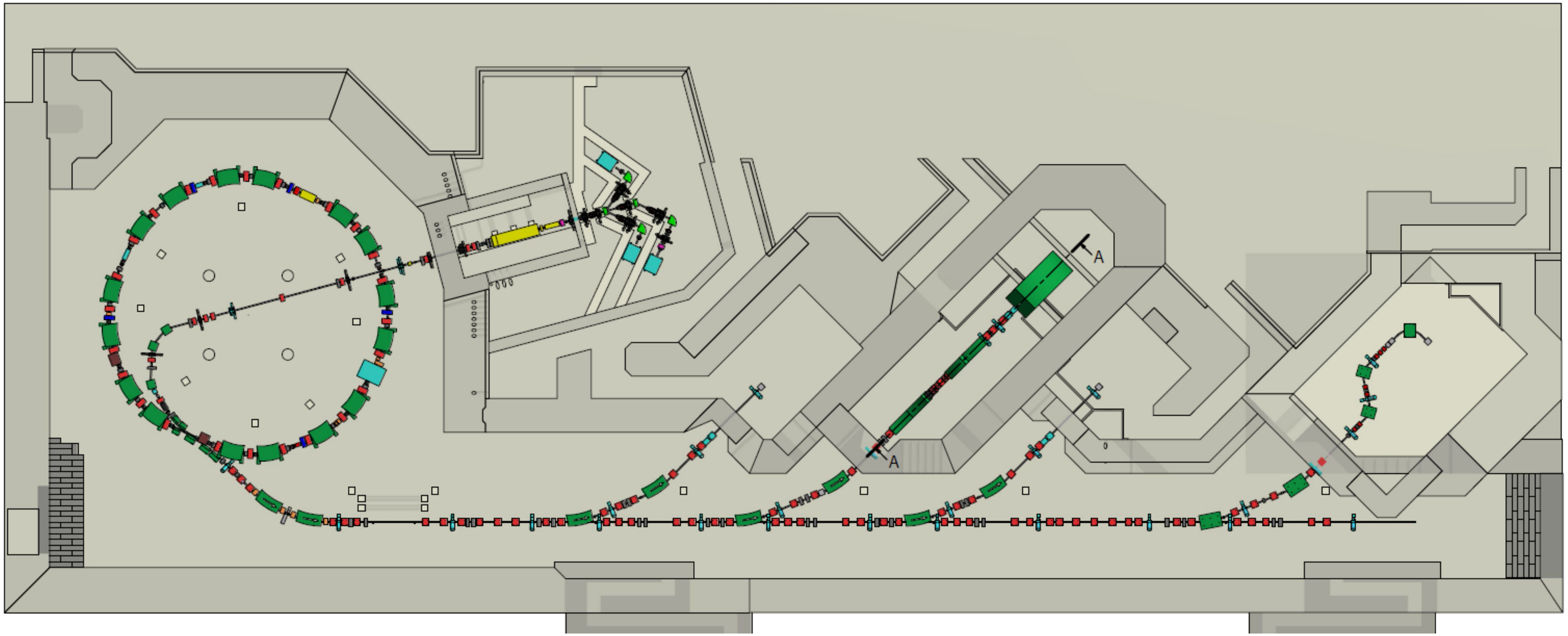
Total investment costs: 184 MEURO

Ground floor – main work areas



Accelerator layout

- 3 ion sources for phase 1 (one additional source possible)
- Pre-accelerator – RFQ & IH Linac
- Main accelerator – synchrotron (77 m circ.) CERN/PIMMS/CNAO design
- Extraction line
- Irradiation rooms: research: horizontal,
  medical: horizontal & vertical, horizontal, proton-gantry



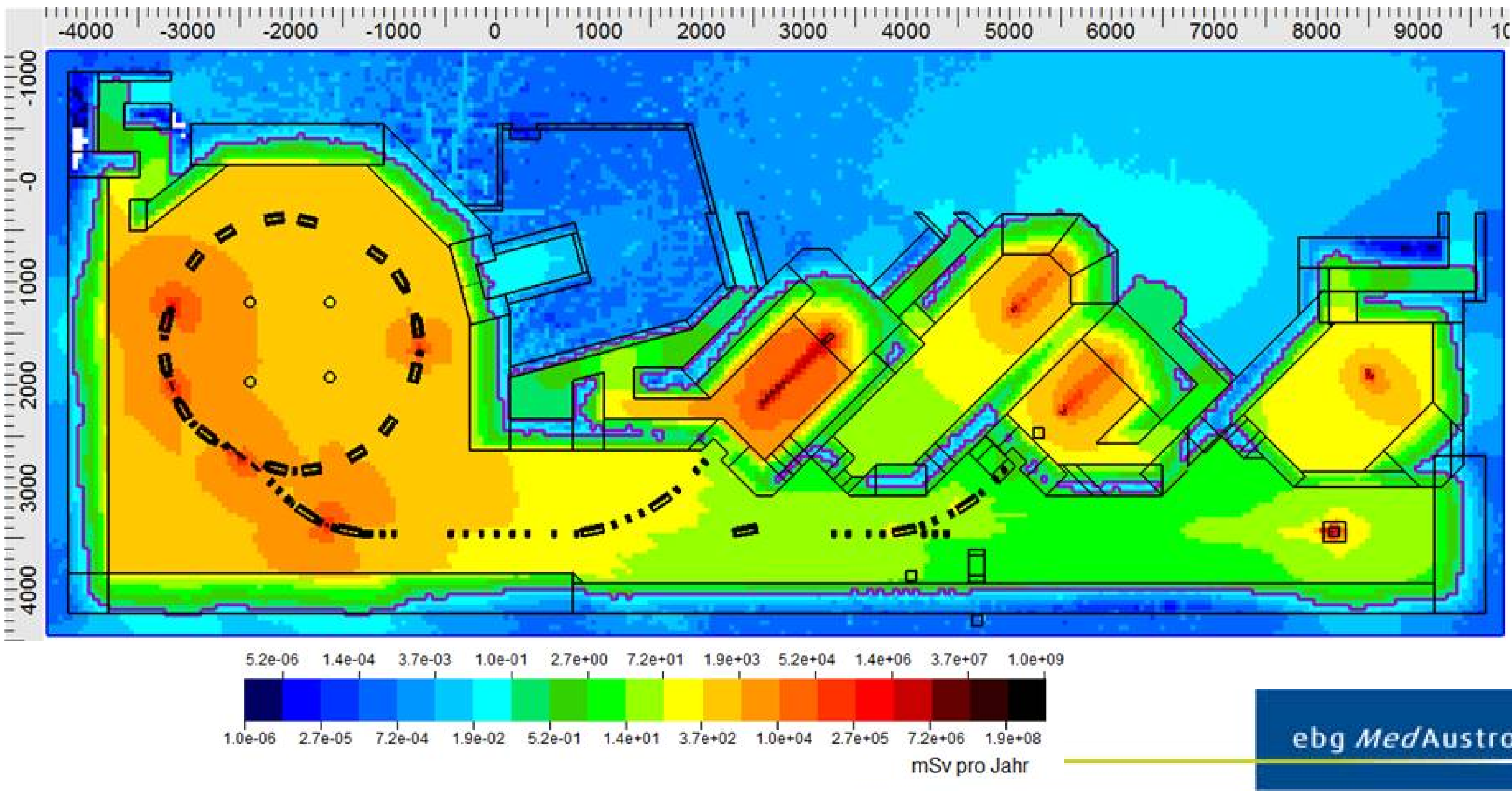
CNAO Synchrotronanlage

Strategy for accelerator design

- **Collaborations with international partners:**
  - CNAO (IT): design drawings of beam line elements, beam delivery system
  - CERN (CH): Design and construction of accelerator. CERN is the „Austrian accelerator center".
  - PSI (CH): Know-how on interface from accelerator to medicine and on and gantry
- **Work packages with core competences:**
  - Areas of medicine, medical radiation physics, accelerator technology
    - Personnel sent to international collaboration partners during designa and procurment
    - Training agreement with medical universities and hospitals

Environmental impact assessment

- **Environmental impact assessment (accelerator > 50 MeV)**
  - All relevant legal areas (RP, statics, EL, hospital, etc.) taken into consideration.
    - Documents submitted to authority (local government) November 2009
    - Permission for construction and test operation obtained in December 2010
    - Heavy procedure at early stage of the project, but guarantees conformity



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Building construction

- **Activities in 2011**
  - Ground breaking March 2011
  - Start building construction May 2012, total area 25.000 m2
  - Rain tightness end 2011
  - Start installation of technical infrastructure March 2012

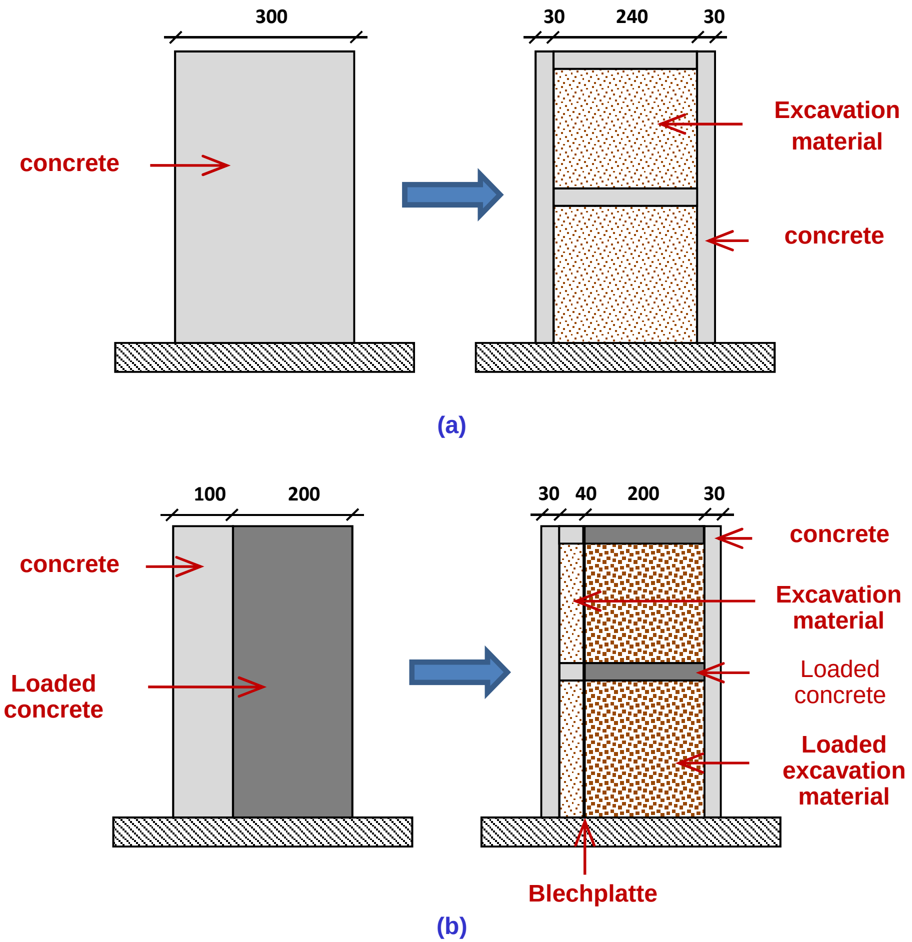
Hochbau Fortschritt

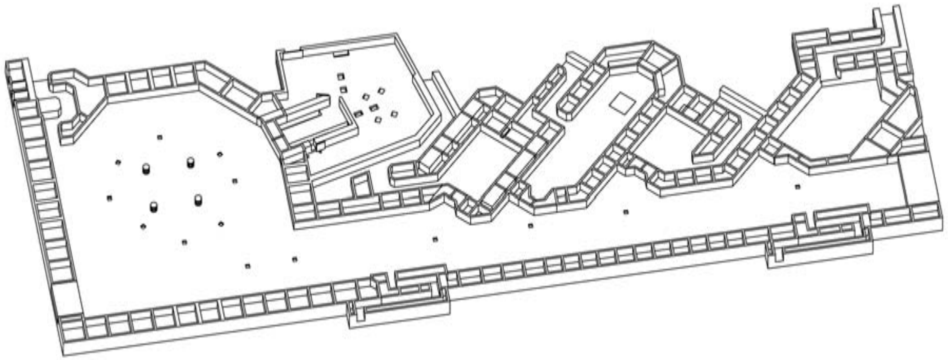
- **Ground breaking March 2011**

Status – Autumn 2011

Sandwich-construction

- **Replace full-concrete walls for RP-shielding by honey combs filled with excavation material.**
  - Saving 30.000 m3 concrete, truck transports …





May 2012

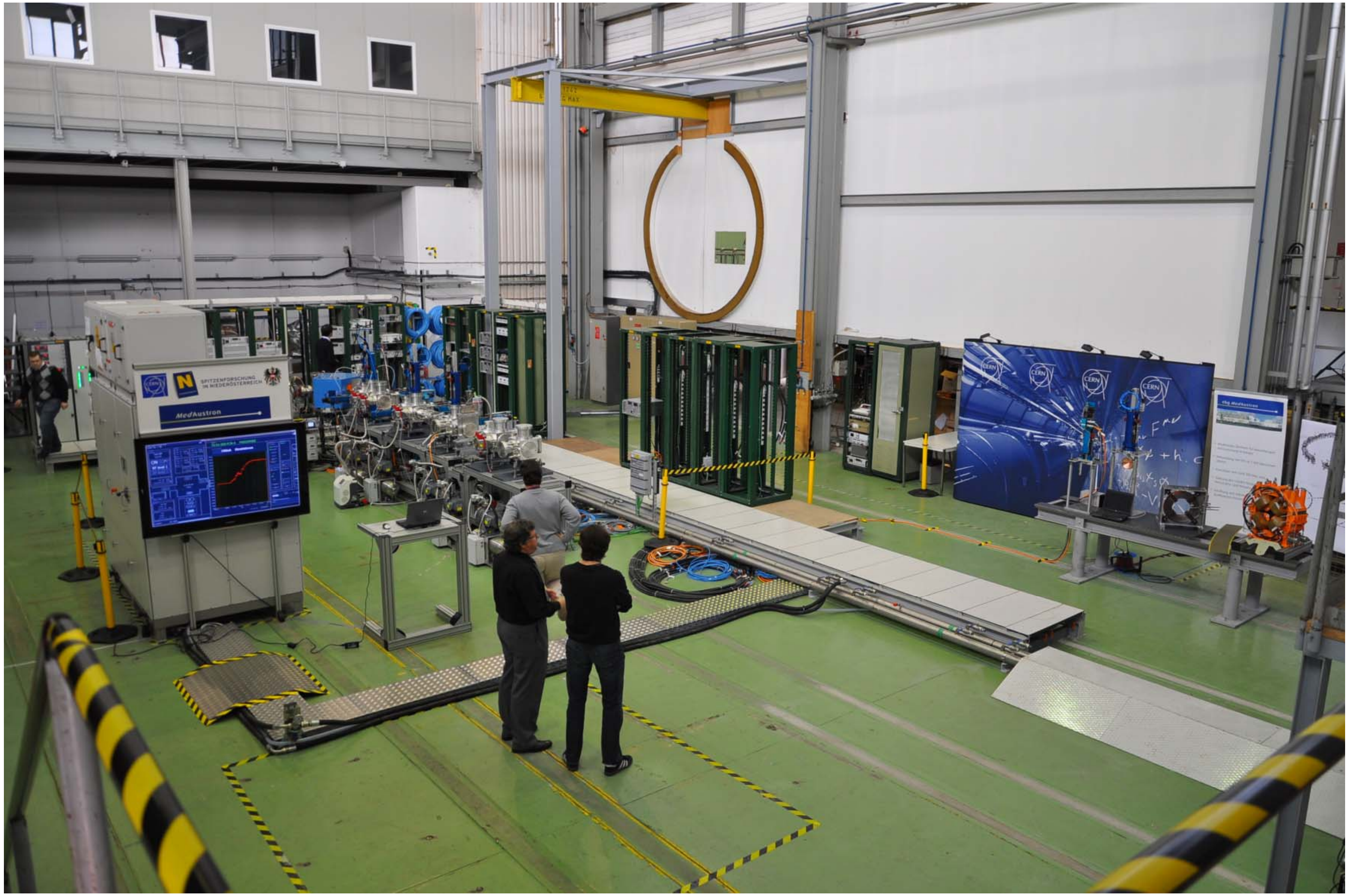
Injector test stand at CERN

- **Main motivations for test stand are:**
  - Tests and tuning of ion source and other equipment such as beam diagnostics tools, newly developed RFQ
  - Learning process for the team for installation, operation, etc.
  - Possibility to prepare for operation, independently from civil engineering and TI progress in Austria → decoupled schedules!
  - Once building is ready, a fast removal to WN and a fast commissioning and start of operation is possible.

- **Status**
  - All TI installations were finished in autumn 2011
  - Ion source delivered in November 2011
  - Beam operation since December 2011.

- ISR hall 184, 25.01.2012

March 2012



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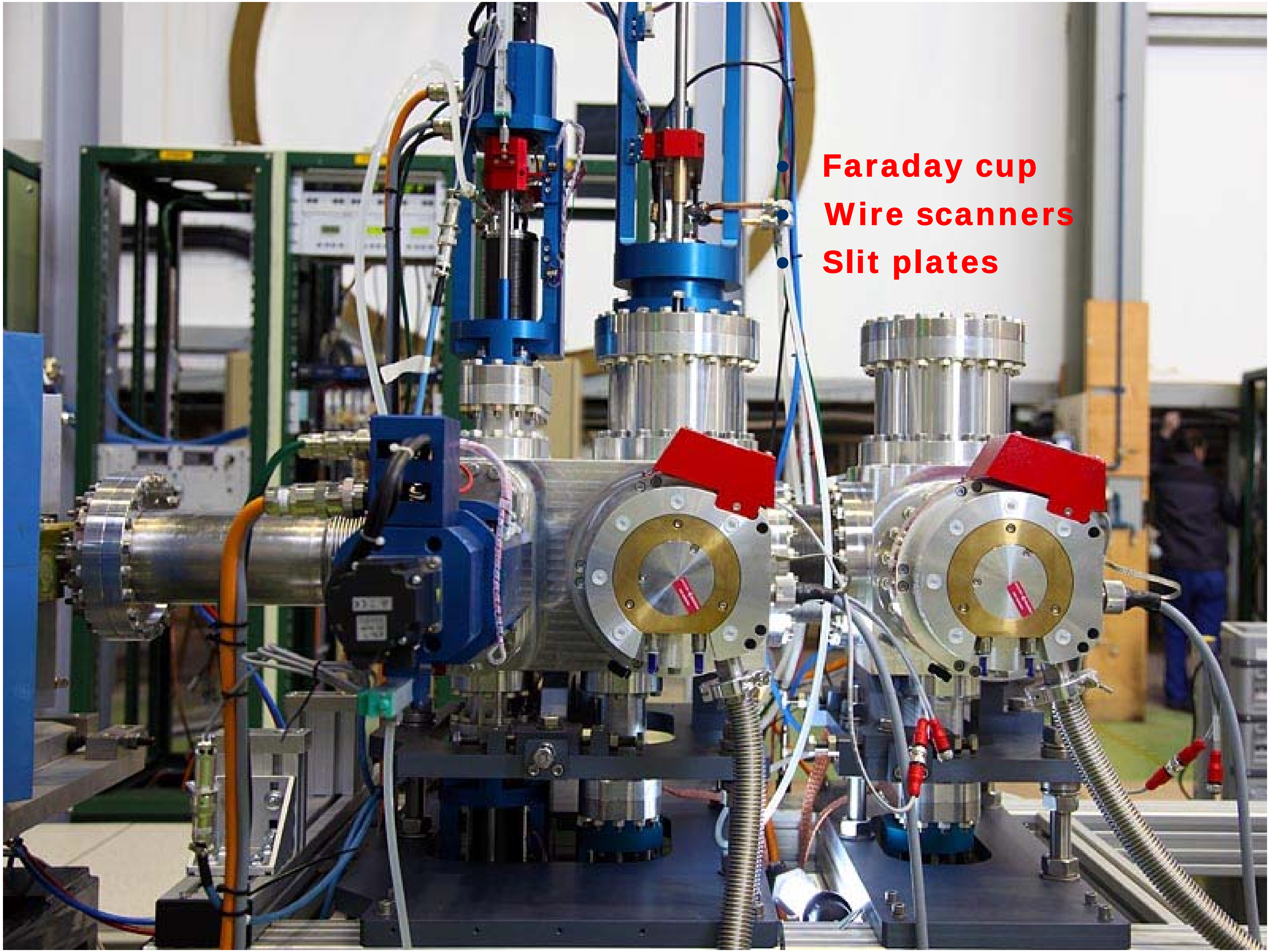
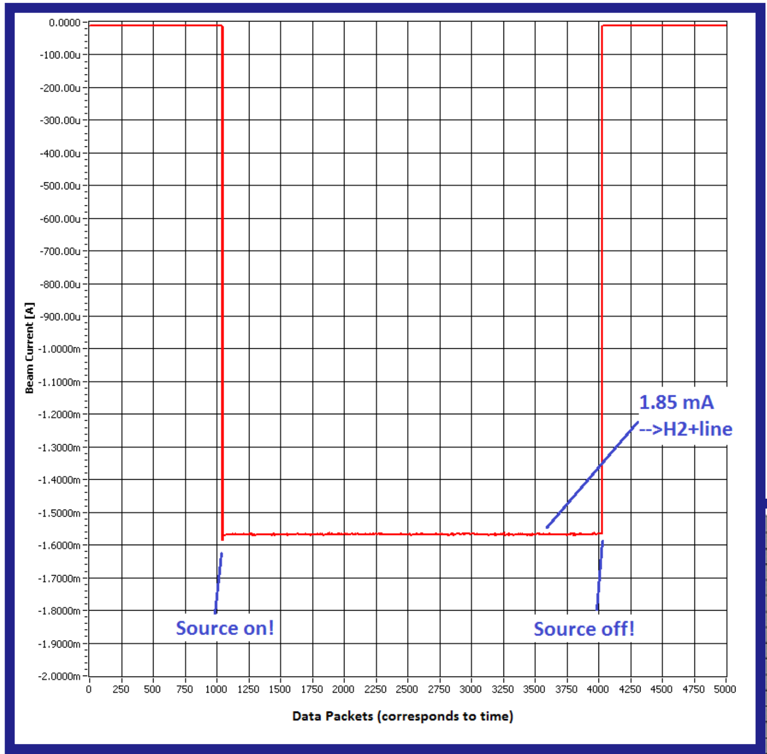
ITS beam line

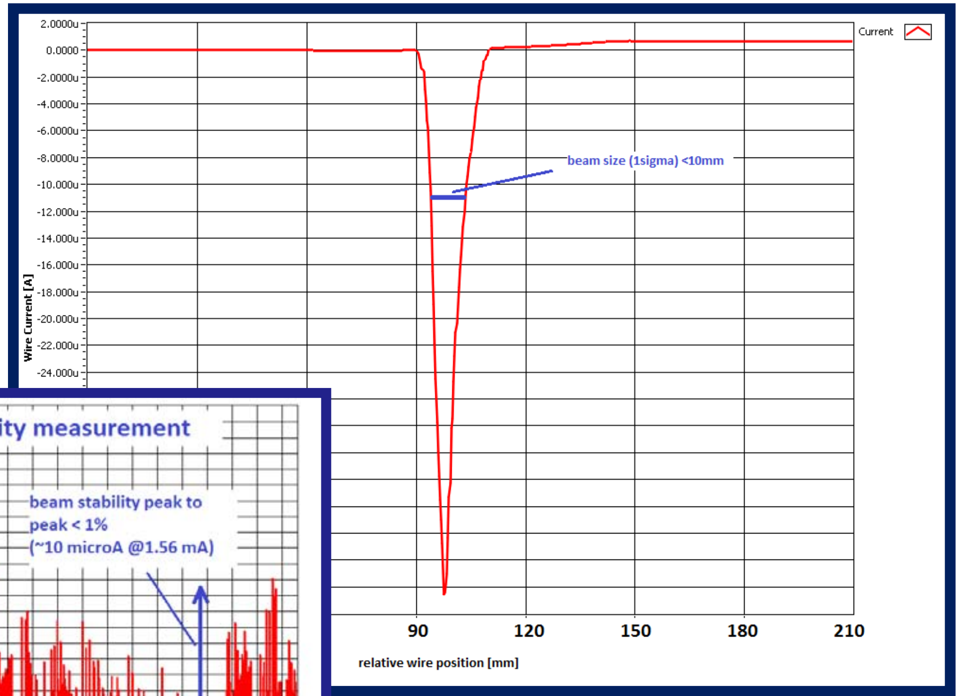
- **ISR Hall 184 presently installed**
  - ECR source (H_3^{+}, $^{12}C^{4+}$)
  - Spectrometer
  - Beam diagnostics

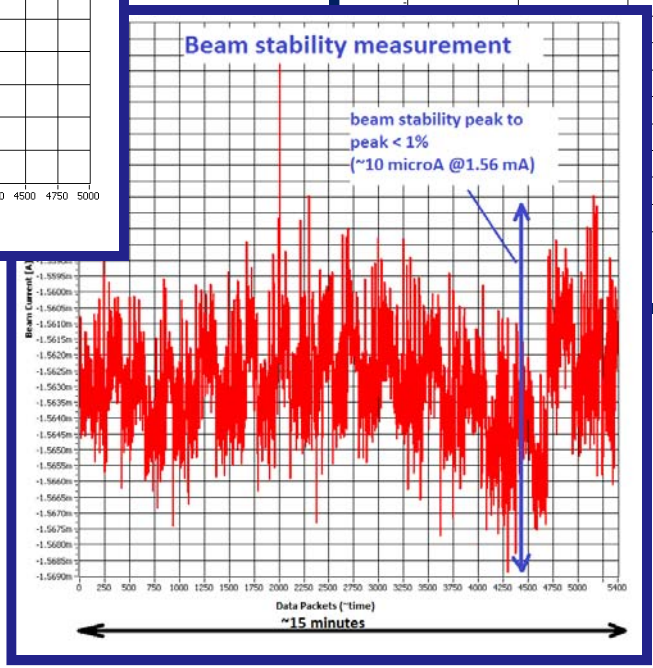
- RFQ Installation in July 2012


Faraday cup
Wire scanners
Slit plates

Beam current /profile measurements







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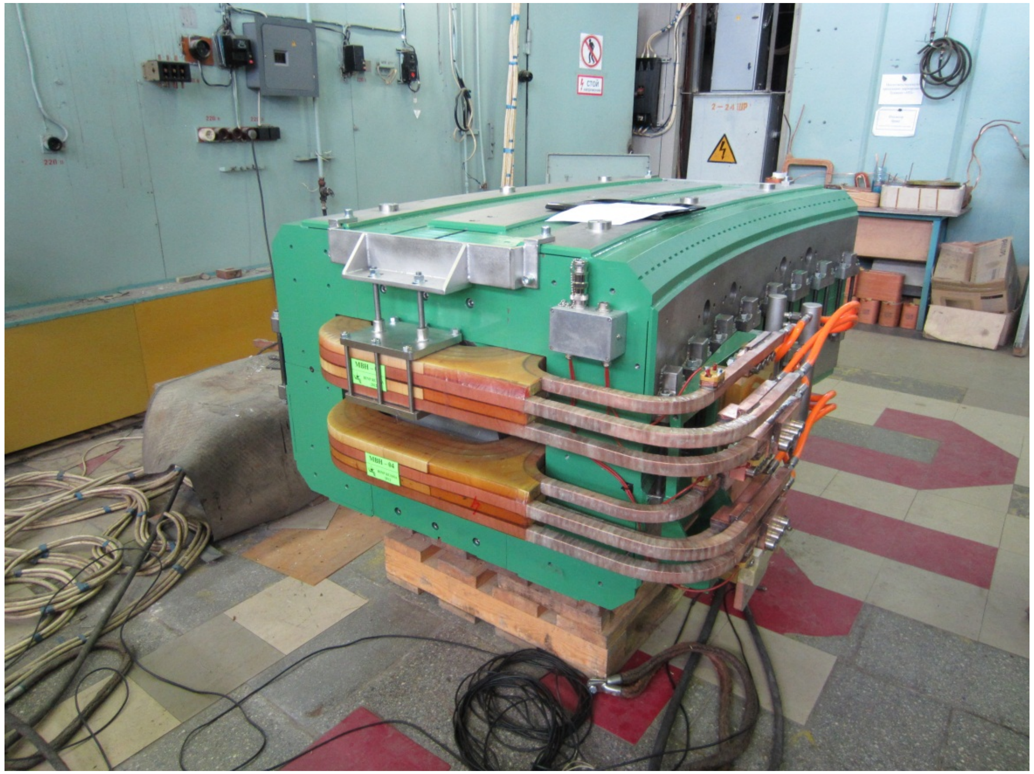
Linac elements

- RFQ and DTL linac

- Delivery July 2012

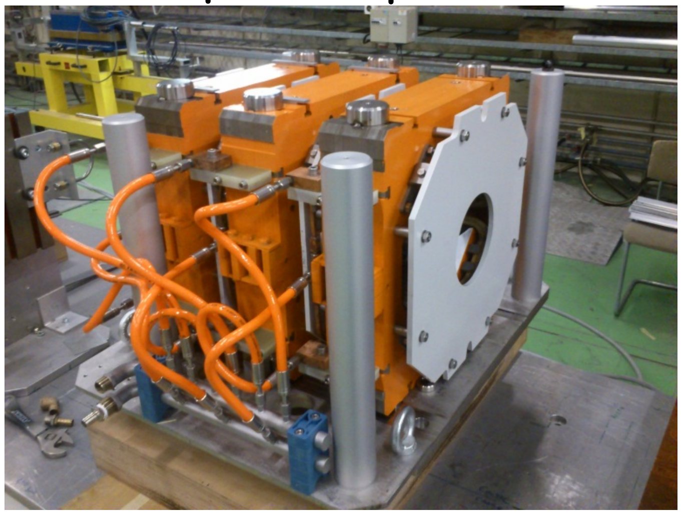
Sept. 2012

Magnet production



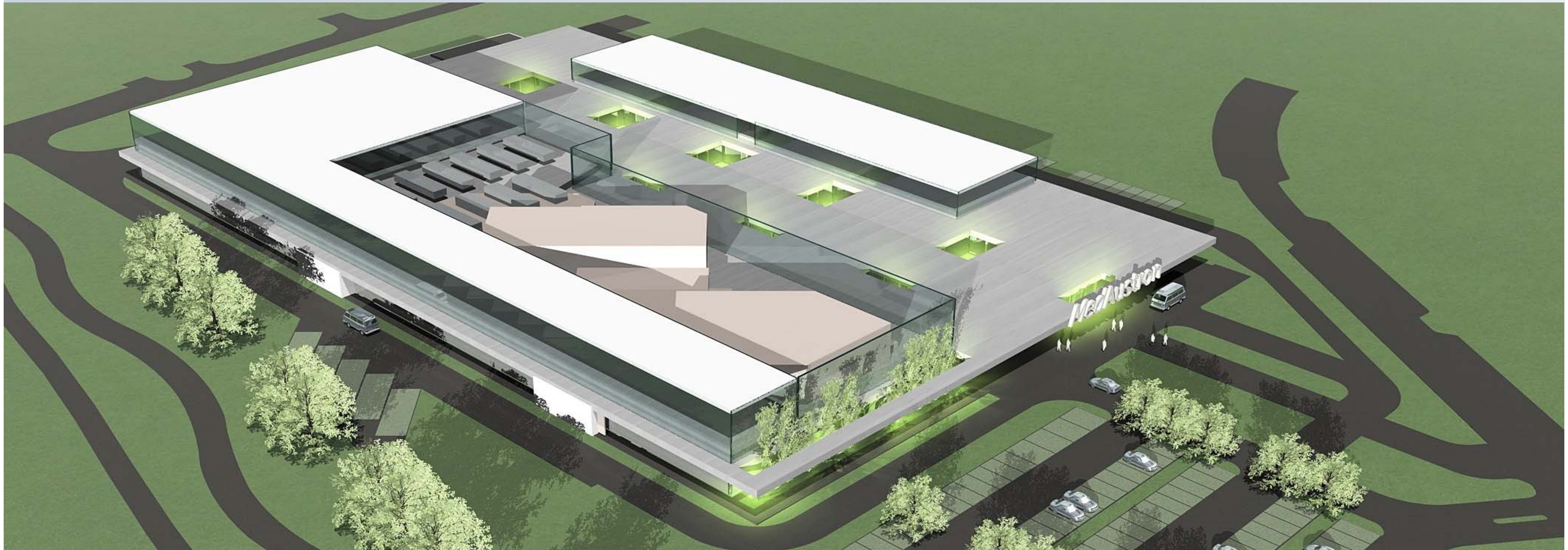
1st synchrotron dipole

LEBT quad triplet



Overall project timeline

Summer 2008	Start of planning
December 2010	EIA accepted, all permission to build
February 2011	Ground breaking, site preparation, CE start
September 2012	Start accelerator installation
March 2013	Start commissioning accelerator, sequential
Second half 2015	First patient treatment



Installation in Wiener Neustadt

- Status last week

- Supports for beam line elements installed
- Next: cable pulling

Summary

- MedAustron will be a „state of the art" ion therapy- und research centre in Austria.
- Project is based on international collaborations with experienced partners for the conception and construction.
- Collaboration with CERN is an excellent example for technology transfer and essential for project progress.
- MedAustron advances according to schedule and within budget. Construction phase started with accelerator components and civil engineering.
- Goal is start of medical operation in 2015.