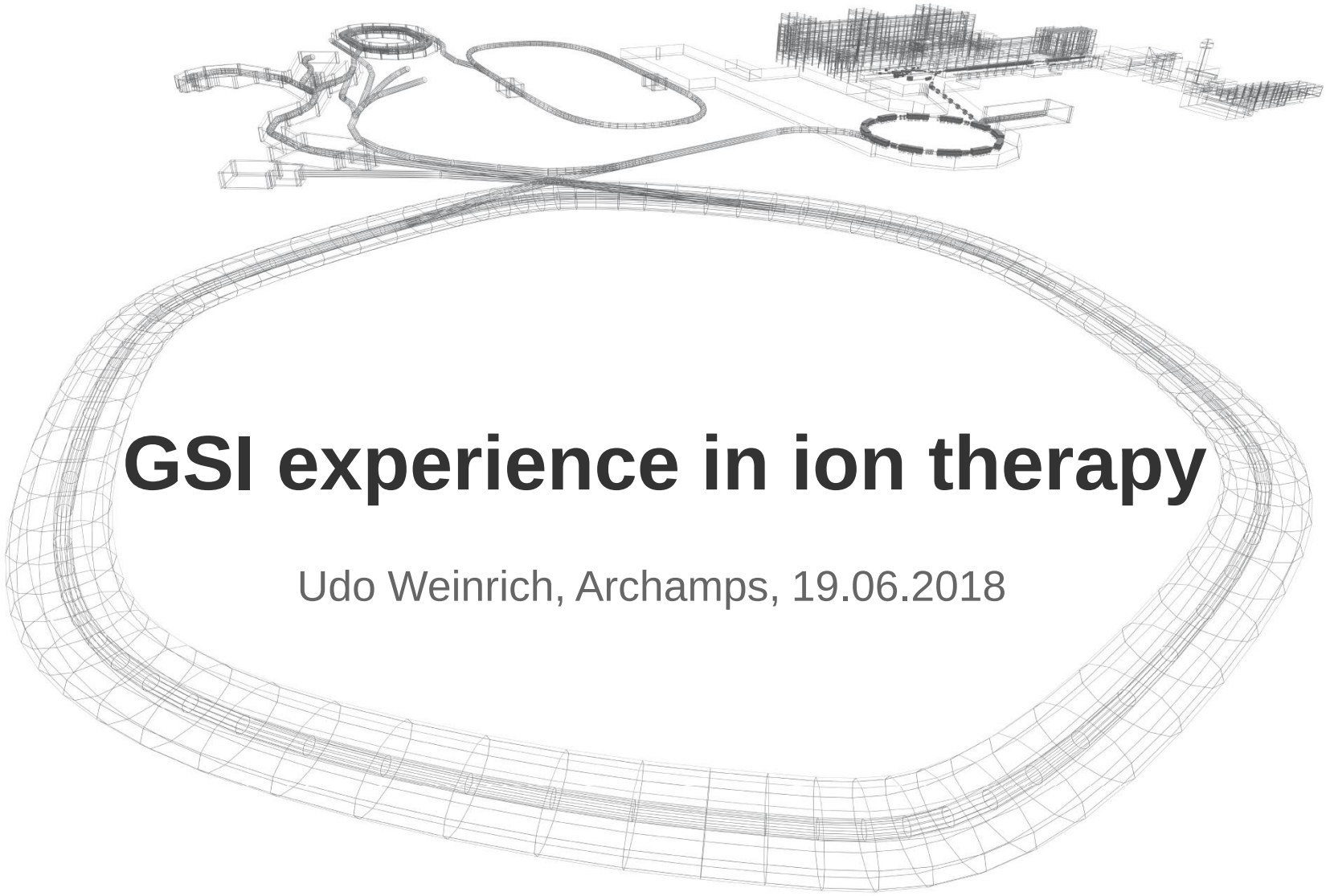


GSI experience in ion therapy

Udo Weinrich, Archamps, 19.06.2018

GSI experience with light ion therapy is very good

We developed a new and effective cancer treatment.

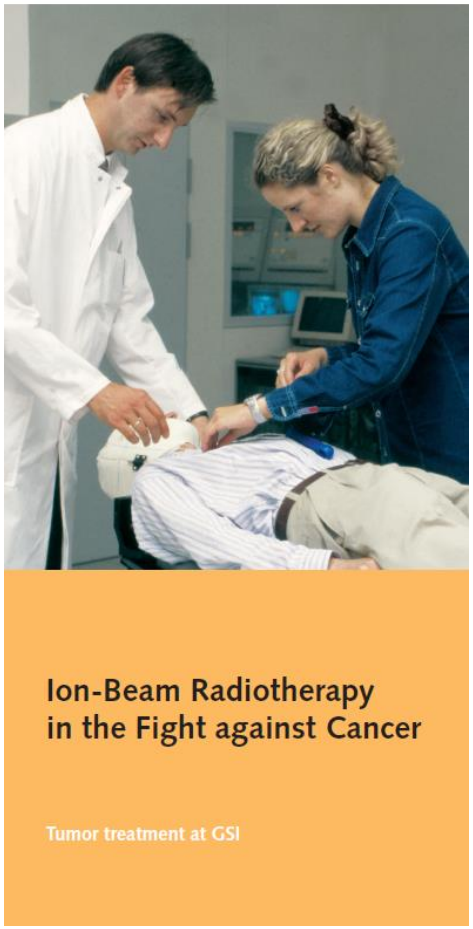
We healed patients on the GSI site using the GSI accelerators.

We built a working clinical therapy accelerator.

We transferred our knowledge to several therapy centers.

We continue to improve different treatment aspects.

Light ion therapy is a well known pillar of the GSI legacy.



Idea to explore potential of existing accelerators

Norbert Angert at GSI-FAIR Colloquium 15.05.2018 :

It was no secret that Hans Specht saw the future of relativistic heavy ion physics at CERN

But:

He saw potential for the application of energetic heavy ions at GSI on the following two fields:

- Heavy Ion Fusion
- Cancer Therapy

Heavy ion fusion, as indicated before, is a business with large linacs and rings, and low charge state ions.

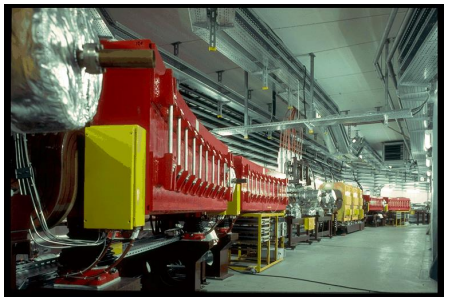
Cancer therapy calls in several respects for specific requirements to be fulfilled at an existing accelerator facility for fundamental research .

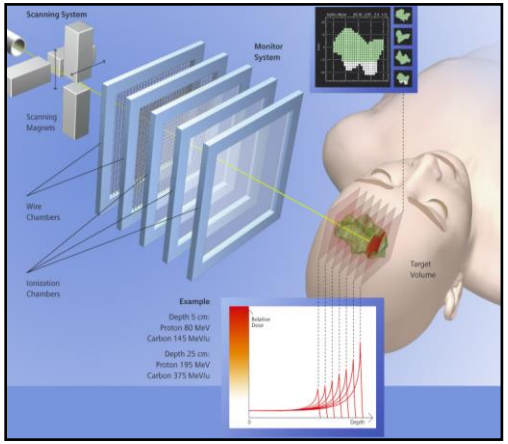
Multidisciplinary study to master main issues

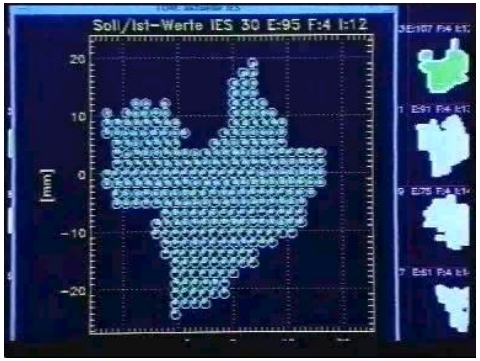
1991: Test of GSI developed raster scan method

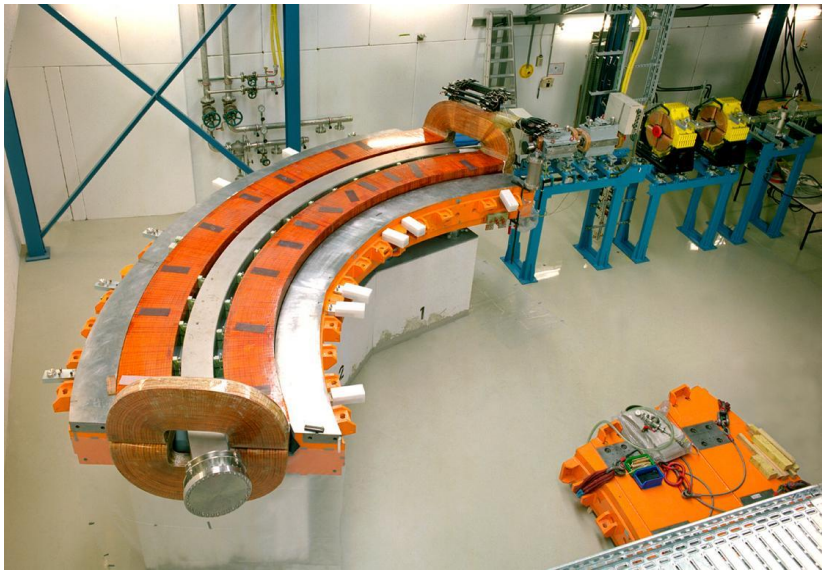
1993: Pilot project started with partners GSI, University Hospital Heidelberg, DKFZ, HZDR

- Energy and intensity variation from SIS18 synchrotron
- Raster scanning beam delivery system
- Biologically oriented treatment planning software
- PET in-situ verfication
- Design study of a gantry







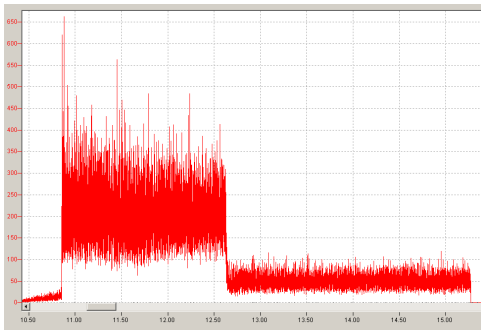


Implementation on existing facility

Norbert Angert at GSI-FAIR Colloquium 15.05.2018 :

Benefits from the upgrade of the accelerators for save therapy operation

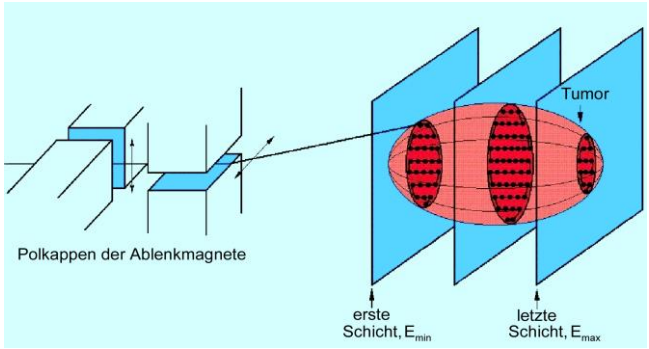
- Reproducibility was a must, not only from shot to shot, but also from each irradiation session to the following
- Precission was a must
- That meant the way from the ECR ion source to cave M, the patient, had to be under full control
- Complete understanding of all changes on this way e. g. movements of shieldings, neighbouring magnet fields, was a must. All data had to be documented because of the special rules for patient treatment
- Improvement of the spill structure for slow synchrotron extraction (macro- and micro-structure) by special measures
- All these measures lead to a great improvement of performance for all
- **Story**:At the day of the first patient treatment GSI was a forbidden area for persons not involved. The IT-boss stopped the GSI internet connection

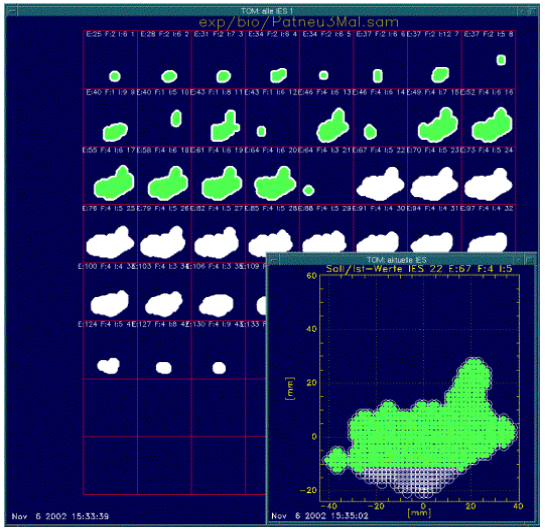


Patient treatment on GSI site (1997 – 2008)

First carbon beam treatment in Europe

More than 450 patients in total





GSI beam parameter:

- 255 energy steps (88-423 MeV/u)
- 15 intensity steps (10^6-10^8 ions/pulss)
- 7 Fokii (ca. 4-10 mm FWHM)

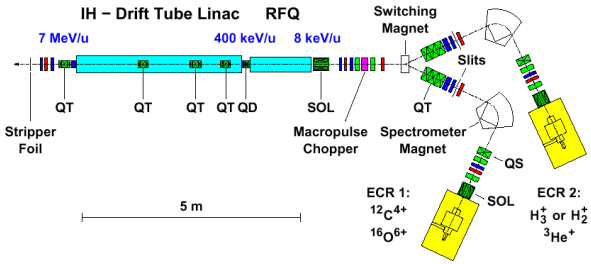
Design, construction and commissioning of HIT

Partners:	University Hospital Heidelberg, GSI, DKFZ
09/1998	Proposal for a dedicated ion beam facility for cancer therapy
09/2000	Presentation of feasibility study
11/2001	Positive votum of Wissenschaftsrat of Germany
05/2004	Foundation stone ceremony
06/2005	Roofing ceremony
09/2006	Building finished
06/2008	Accelerator commissioned
11/2009	first patient treated

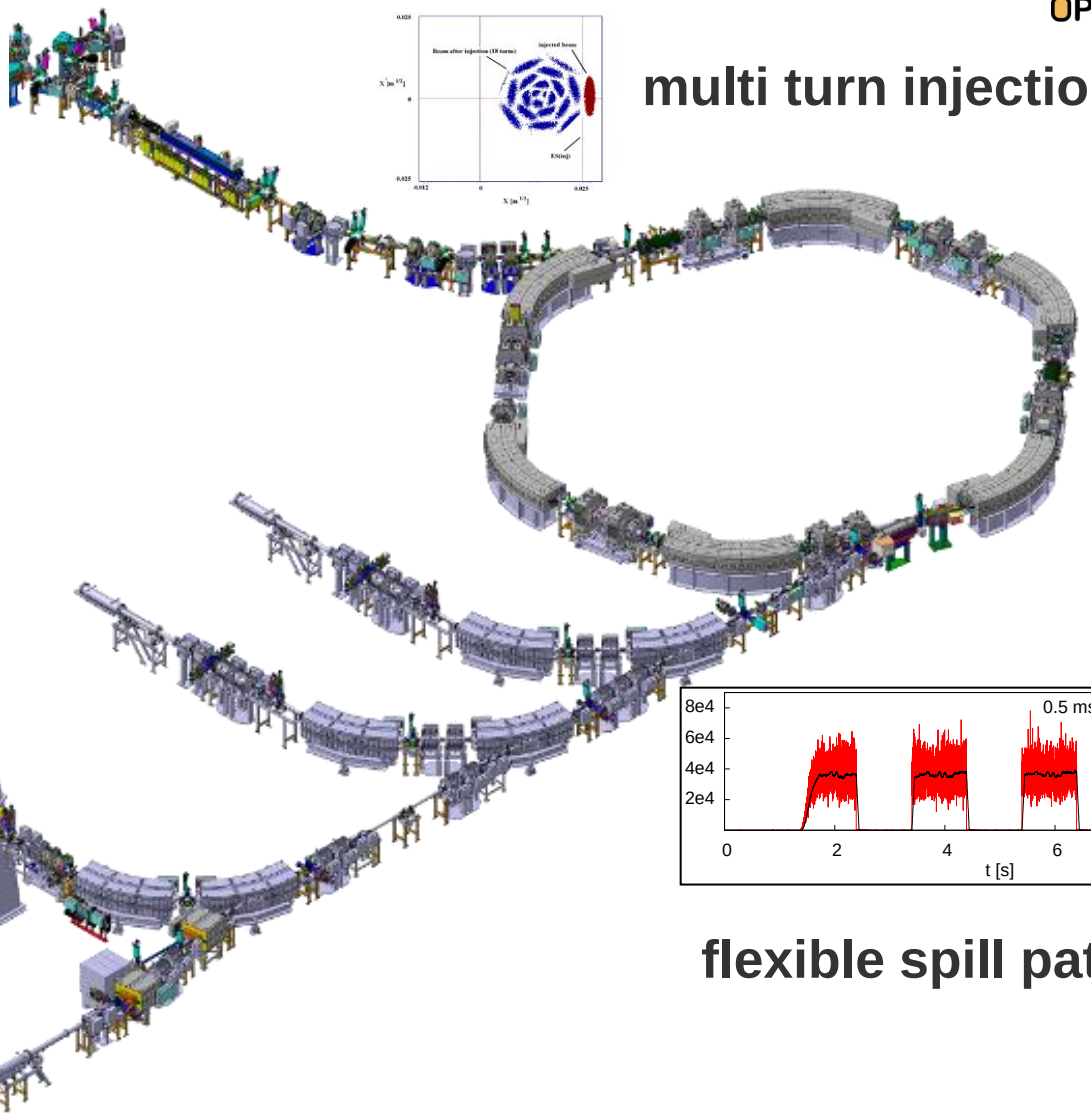
Role of GSI:

- accelerator issues: conception and design, project lead, supply of beam instrumentation, integration and installation of accelerator components, commissioning
- patient environment : conception and design, project lead

Fully dedicated heavy ion therapy accelerator design



ECR, RFQ, IH set up

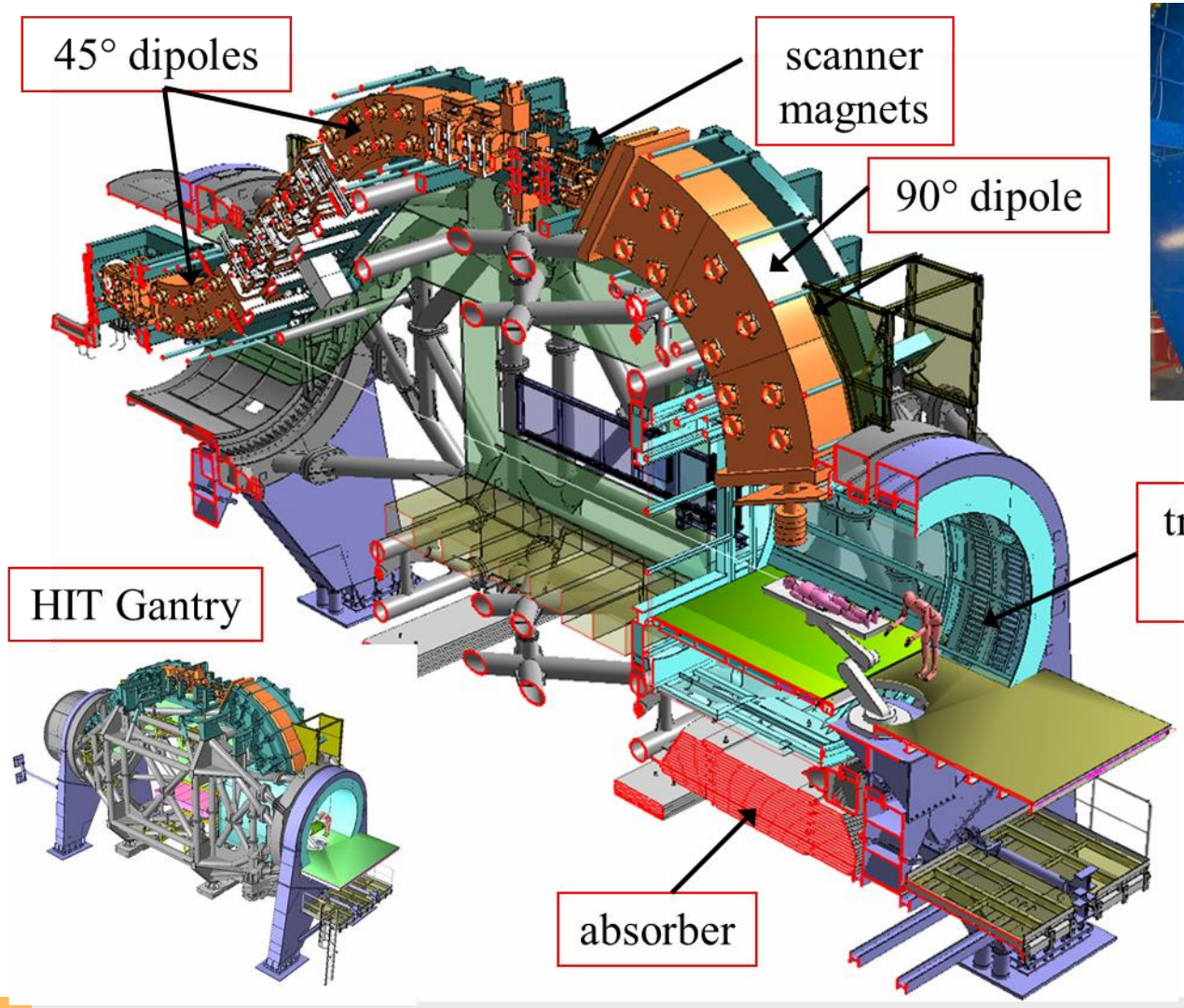


multi turn injection

heavy ion gantry

flexible spill pattern

First Heavy Ion Gantry of the world



treatment room

GSI knowledge was transferred

To the HIT GmbH

- direct personnel transfer
- training of HIT personnel
- technical documentation and handbooks

To Siemens Medical Solutions

- direct personnell transfer
- technical documentation
- participation to commissioning of Marburg center

To CNAO

- in the LINAC environment

and very likely many issues outside my field of competence

Three therapy accelerators in Heidelberg, Marburg and Shanghai are the direct outcome of GSI design work.

Active Fields of Research

Reference GSI Bio physics department:
https://www.gsi.de/work/forschung/biophysik.htm
see also: presentation of C. Graeff on Wednesday

Radiobiological Modelling

development and application of mathematical models describing and predicting biologic effects

Treatment Planning and Validation

interaction of charged particle beams, in particular carbon ions, with matter on multiple scales

Medical Physics

Clinical implementation of motion mitigation techniques

Treatment planning incorporation organ motion (4DTP)

Radiosurgery

New applications on ion therapy in noncancer diseases

Reasons for Success

Best quality of patient treatment at GSI and HIT was always the highest priority.

The direct implementation of patient treatment at the GSI accelerator complex resulted in a tremendous excitation of the multidisciplinary staff on the whole campus.

This positive momentum was used immediately to get the HICAT project (later HIT facility) funded and started.

All institutions of GSI (management, administration, boards, technical departments, etc.) backed up the HICAT project team to overcome the numerous technical, organisational and financial challenges until the successfully commissioned facility in Heidelberg.