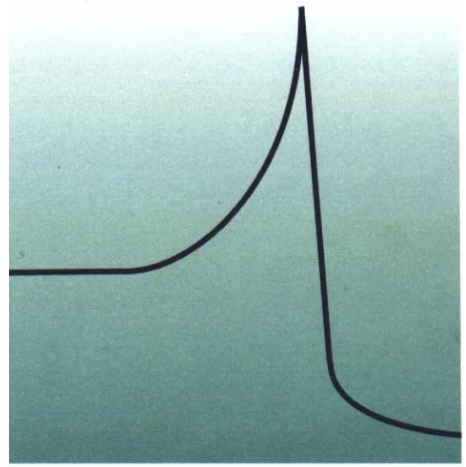
HICAT- The German Hospital-Based Light Ion Cancer Therapy Project

HICAT = Heavy Ion Cancer Therapy Facility

- **Treatment technique**
  - **Why Ions ?**
  - **How does it work ?**
- **HICAT Layout**
  - **System Requirements and Layout**
  - **Subsystems, Components**
- **Organisation**
  - **Responsibilities and Financing**
  - **Schedule, Status of the Project**



Universitätsklinik Heidelberg

dkfz Deutsches Krebsforschungszentrum Heidelberg

GSI Gesellschaft für Schwerionenforschung Darmstadt

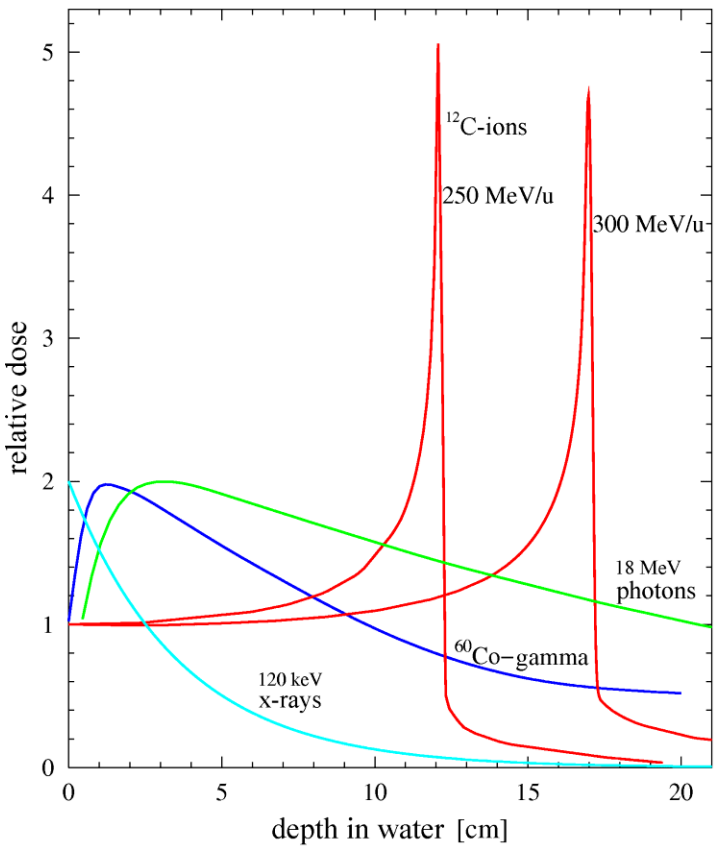
Treatment technique: Principles

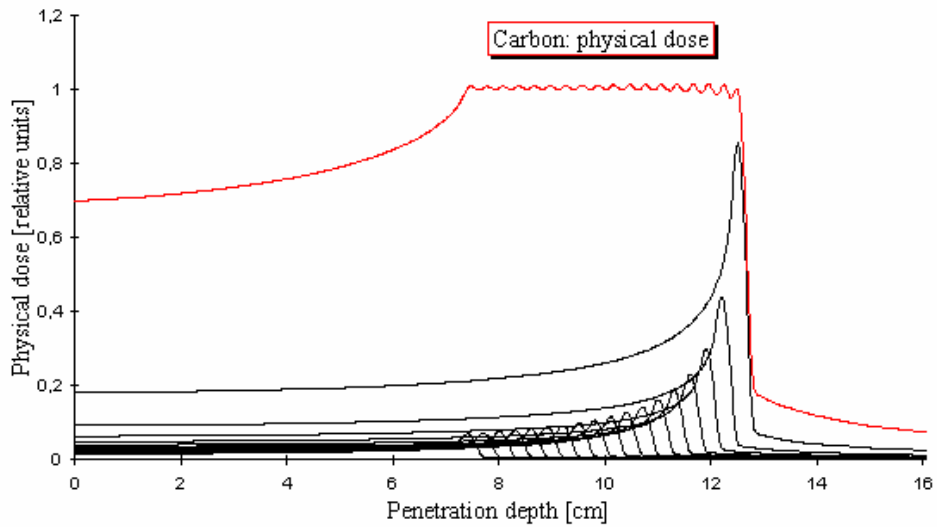
- **Radiotherapy principle**
  - **Destruction of a localised cancer via irradiation with ionising radiation**
  - **Maintaining of dose in the surrounding tissue in tolerable limits**

- **Requirements to radiation source**
  - **Adequate dose depth profile of radiation**
  - **Geometrical flexibility of radiation direction and beam size**

Treatment technique: Dose Depth Profiles

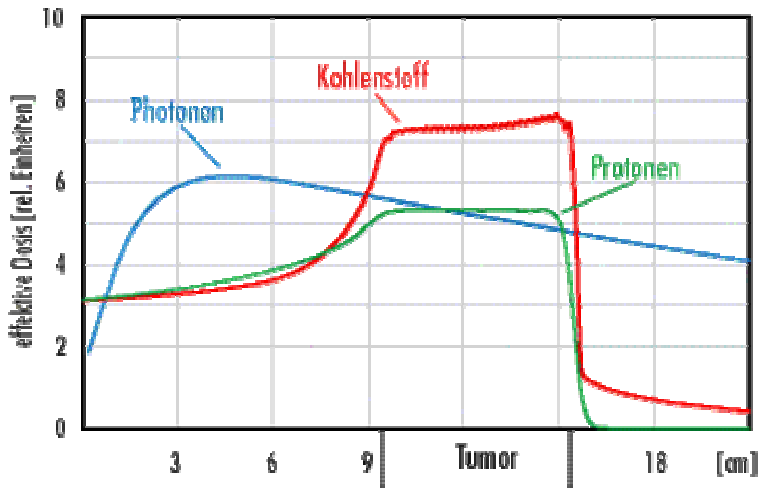
Dose Depth profile for several kinds of radiation

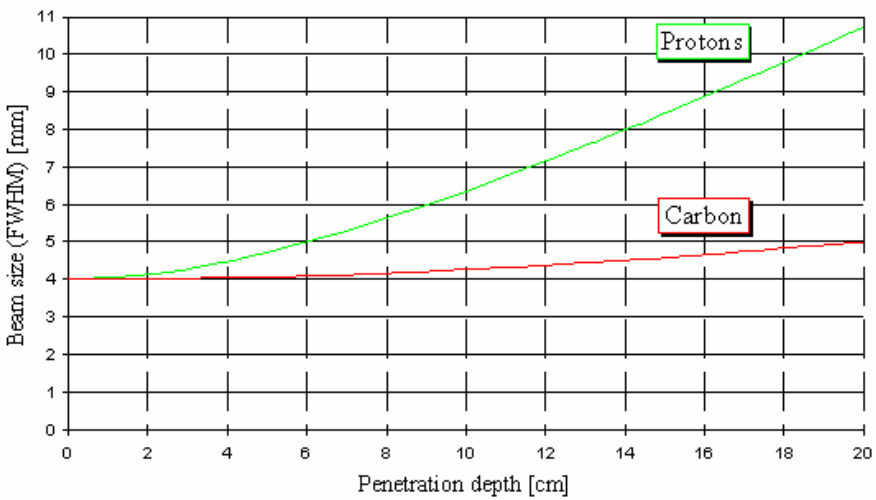




- **Irradiation with different energies => 'slicing' of the tumor in isoenergetic planes**
- **Intensity variation per plane to get flat dose distribution**

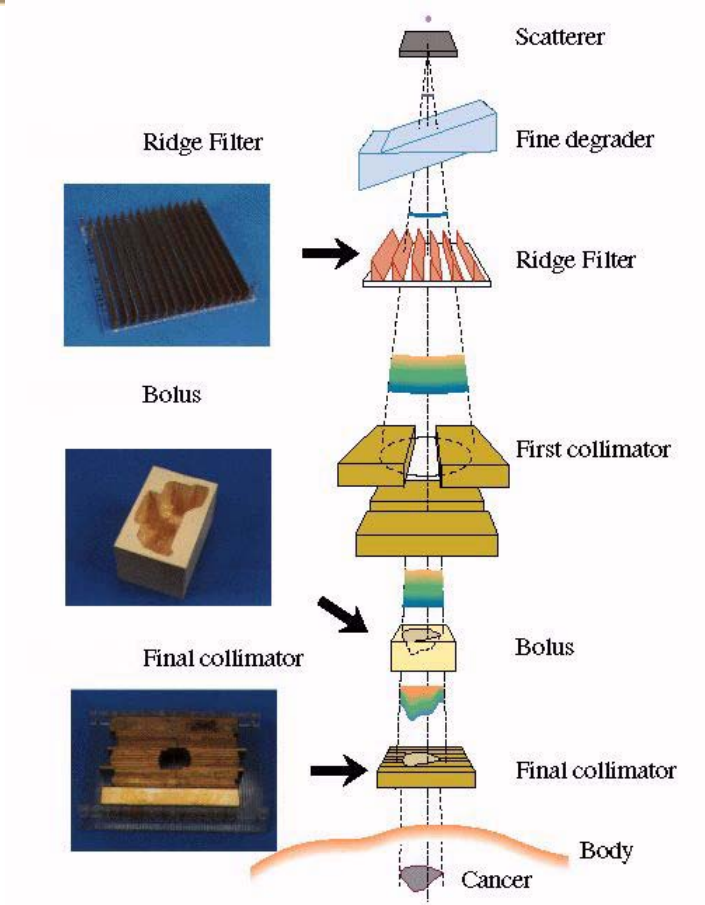
Treatment Technique: p, Ions

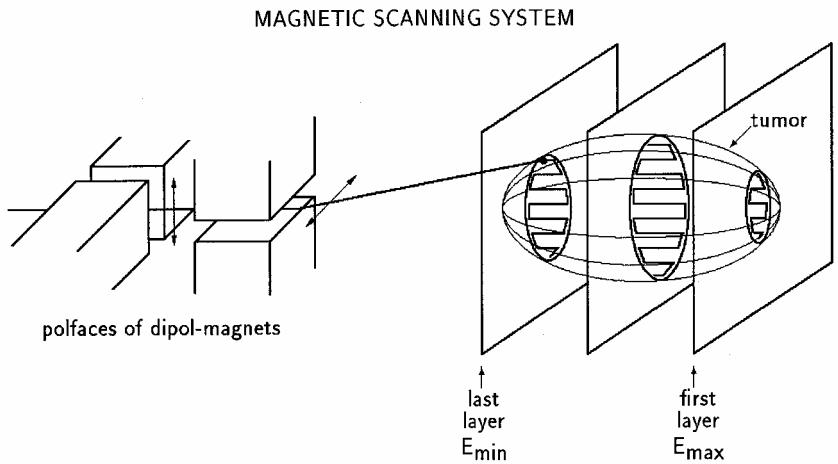




- **Treatment with C-Ions**
  - **Better ratio of dose inside/outside tumor volume (larger RBE-factor)**
  - **Only small enhancement of beam diameter vs. penetration depth -> better control for deep seated tumors**
  - **Online dose-control possible (Positron Emission Tomograph)**
- **Treatment with protons**
  - **Large medical data base for proton treatments available**

Treatment Technique: Rasterscan

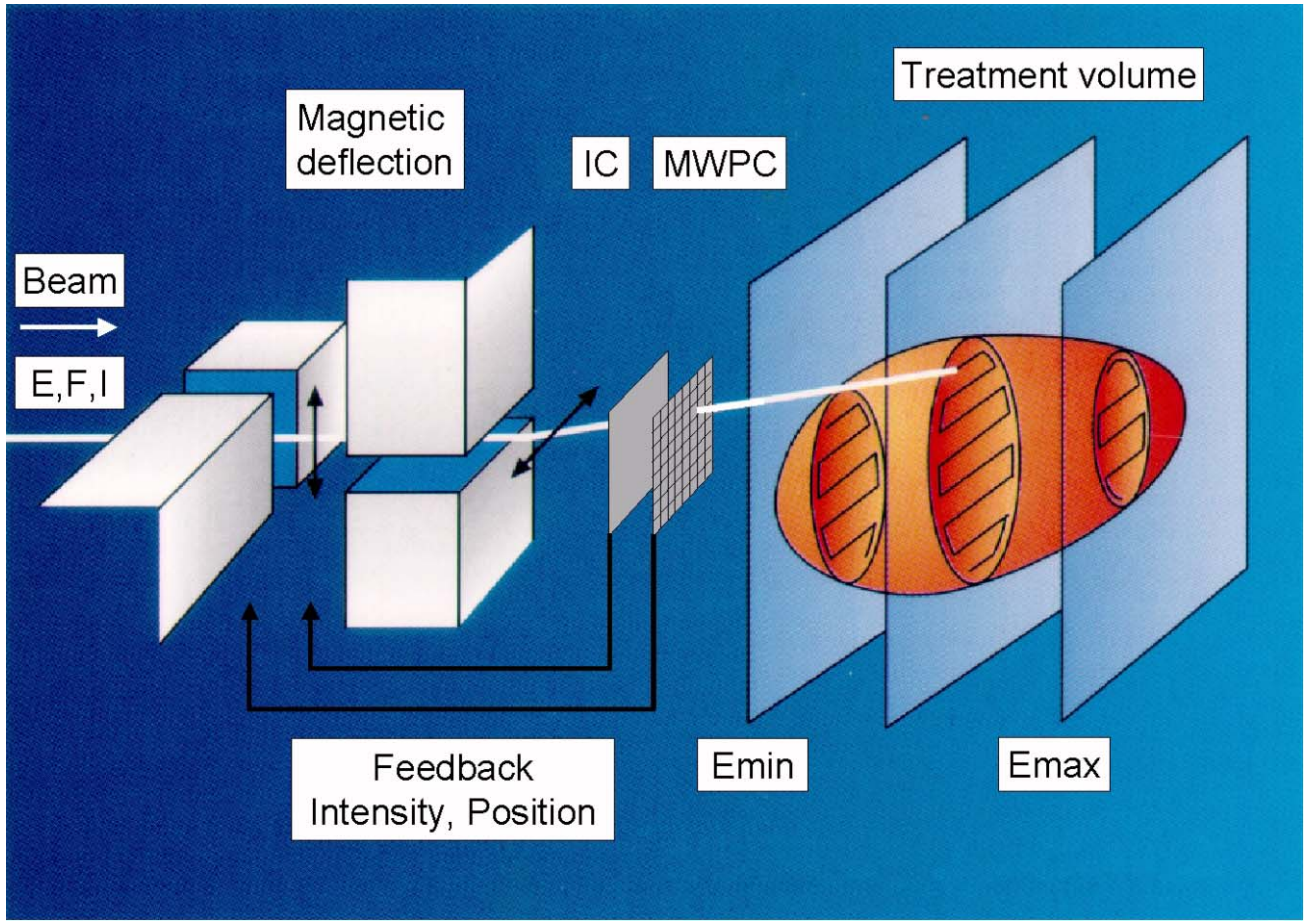




- **Conventional (passive) treatment method**

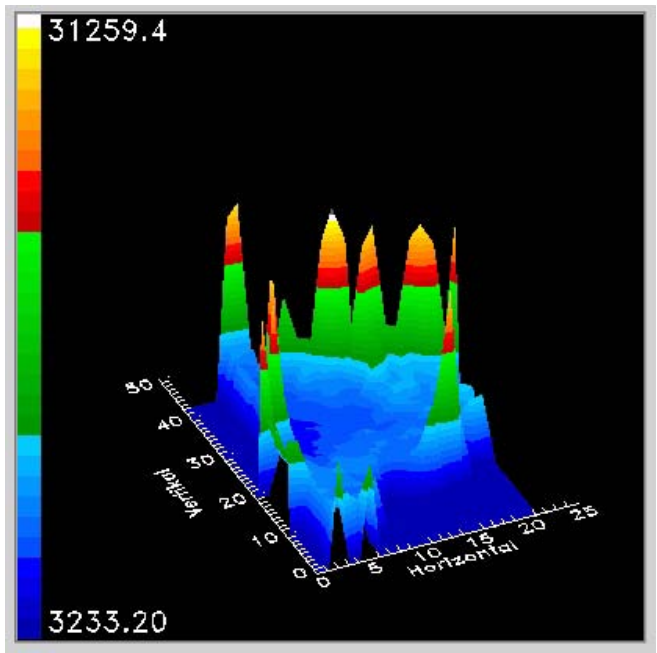
- **Rasterscan treatment (GSI)**
  - **Active energy, intensity and beam size variation**
  - **Horizontal and vertical scanning of each isoenergetic slice with fast scanner magnets**

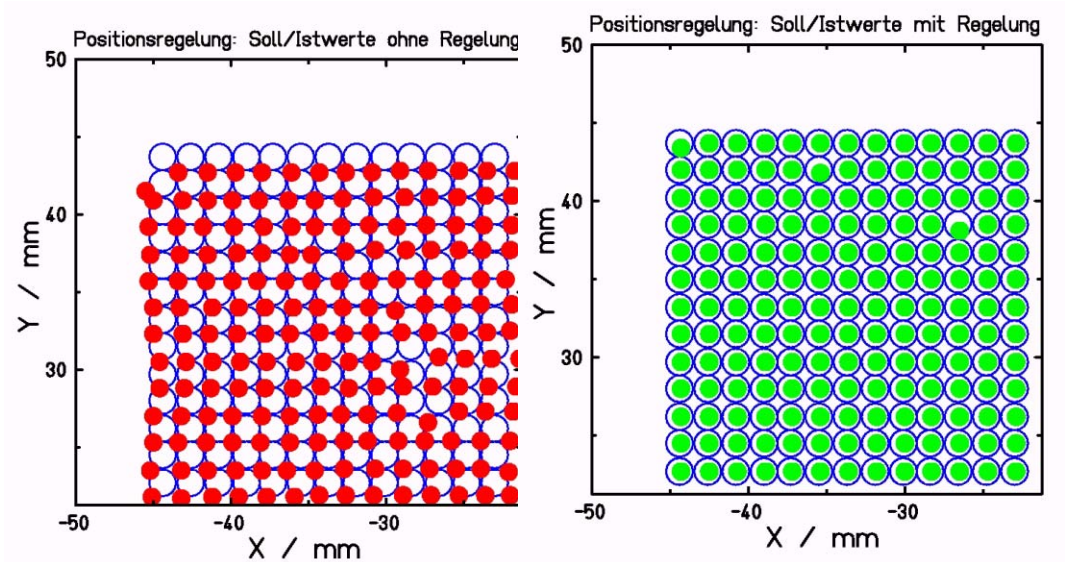
Treatment Technique: Rasterscan



- **Intensity-controlled Rasterscan-method**

Treatment Technique: Rasterscan





without feedback **with feedback**

- **Intensity-distribution (isoenergy-slice)**

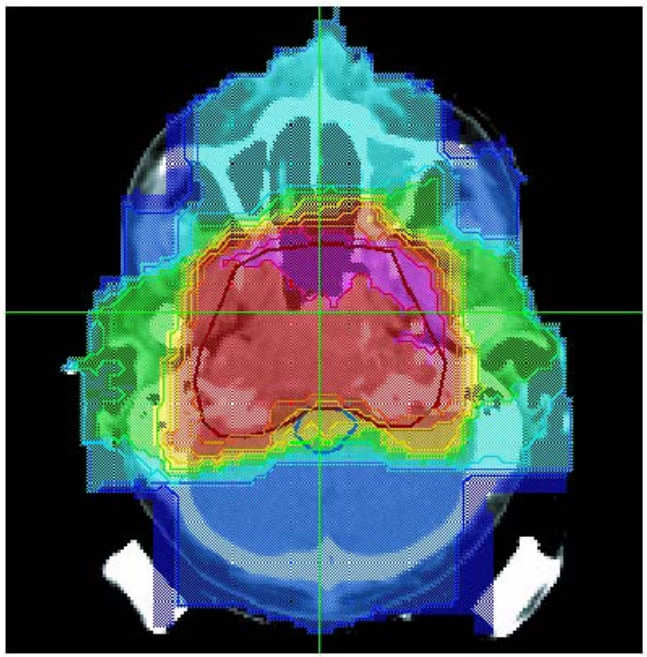
Preirradiation has to be considered _> highly inhomogenious distribution

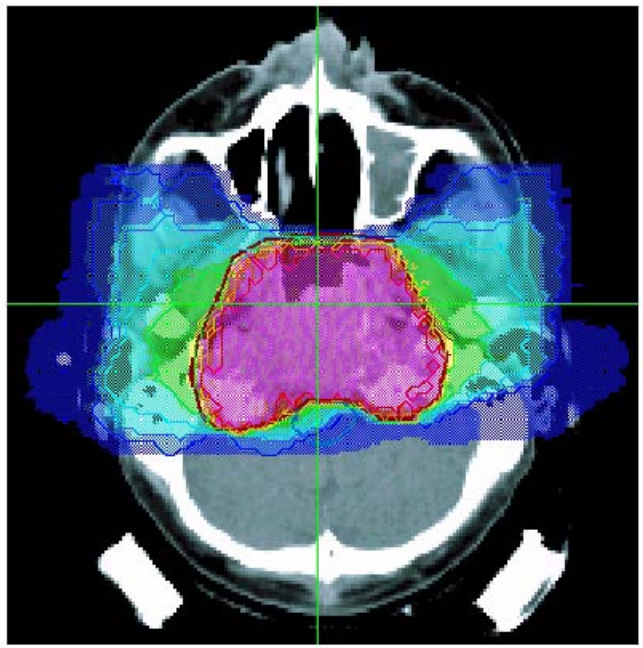
- **Beam-Position feed-back**

Feed-back Scanner /MWPC

Treatment Technique: Rasterscan

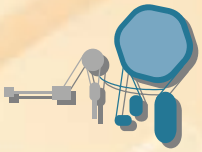
Dose-Distribution (comparison)



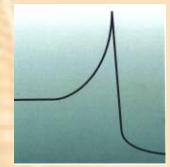


- **Photon-Treatment**
  (4 fields)

- **Carbon-Treatment**
  (2 fields)



HICAT Layout: Requirements



- **Low LET (proton, helium) and high LET (carbon and oxygen) treatment**
- **Ion penetration depth of 20 – 300 mm**

  => Ion energy range of 50 – 430 MeV/u
- **Rasterscan method**

  => FWHM of beam: 4 – 10 mm in both planes

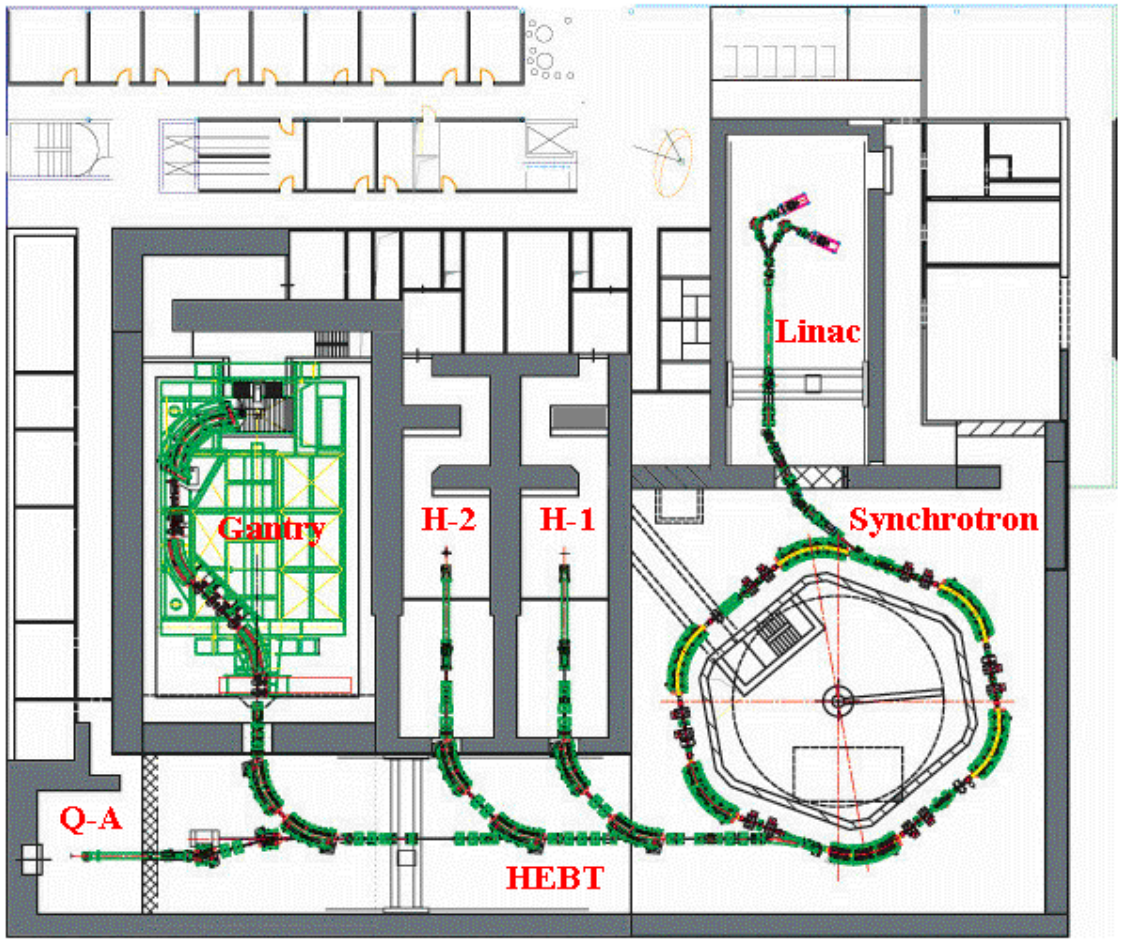
  => Beam intensity: $1 \cdot 10^6$ – $4 \cdot 10^{10}$ ions/spill

  => Extraction time: 1 – 10 s
- **Treatment of 1000 patients per year in hospital environment with about 15 fractions each**

  => total of 15000 irradiations per year

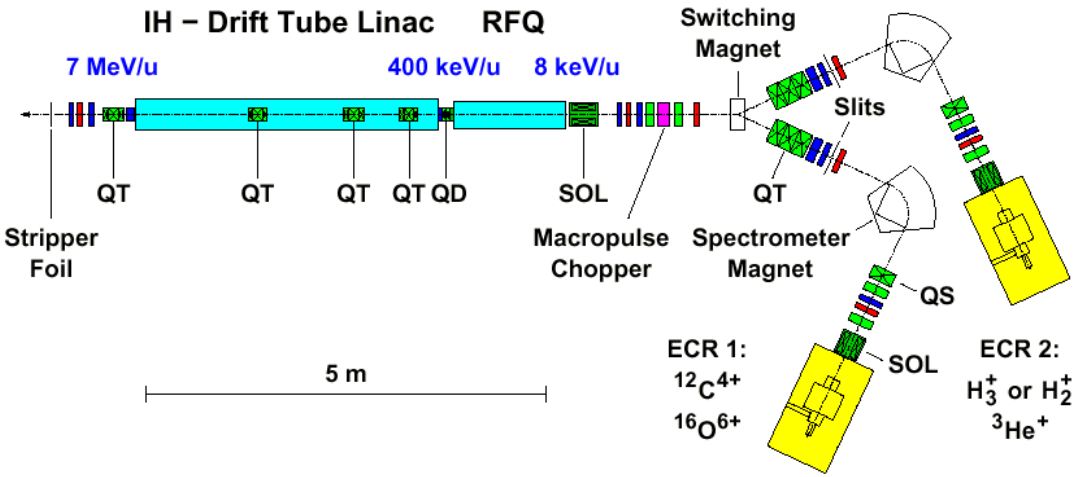
  => three treatment areas
- **One isocentric gantry**

HICAT Layout: System Plan



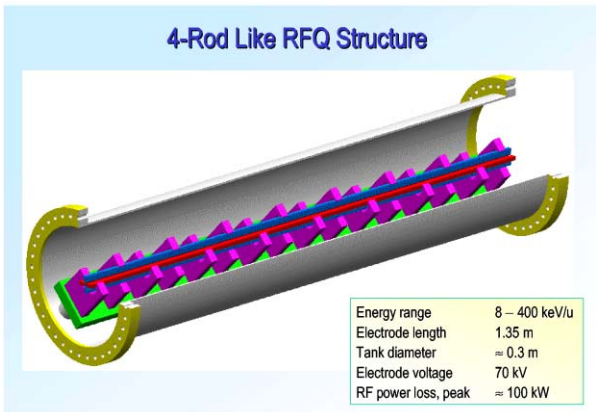
- **Accelerator sections**
  - **Two ECR sources**
  - **Injector linac**
  - **Synchrotron**
  - **Extraction via RF knock out**
  - **Two horizontal areas**
  - **One Gantry**
  - **One quality assurance place**
  - **Compact design (area restrictions)**

HICAT Layout: Injector System

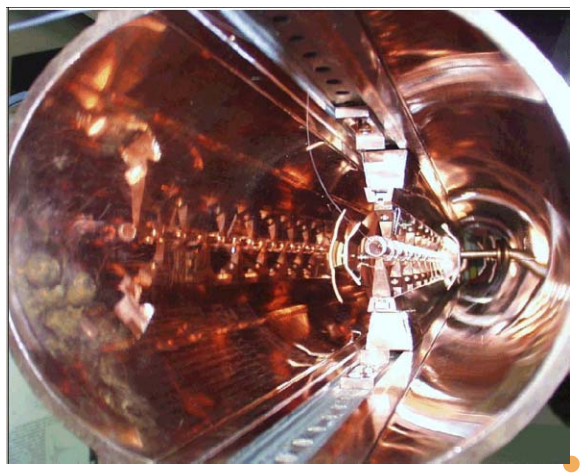


- **Features**
  - **Based on GSI experience**
  - **compact**
  - **reliable**
  - **Low operation costs**
  - **Fast switching of ions**

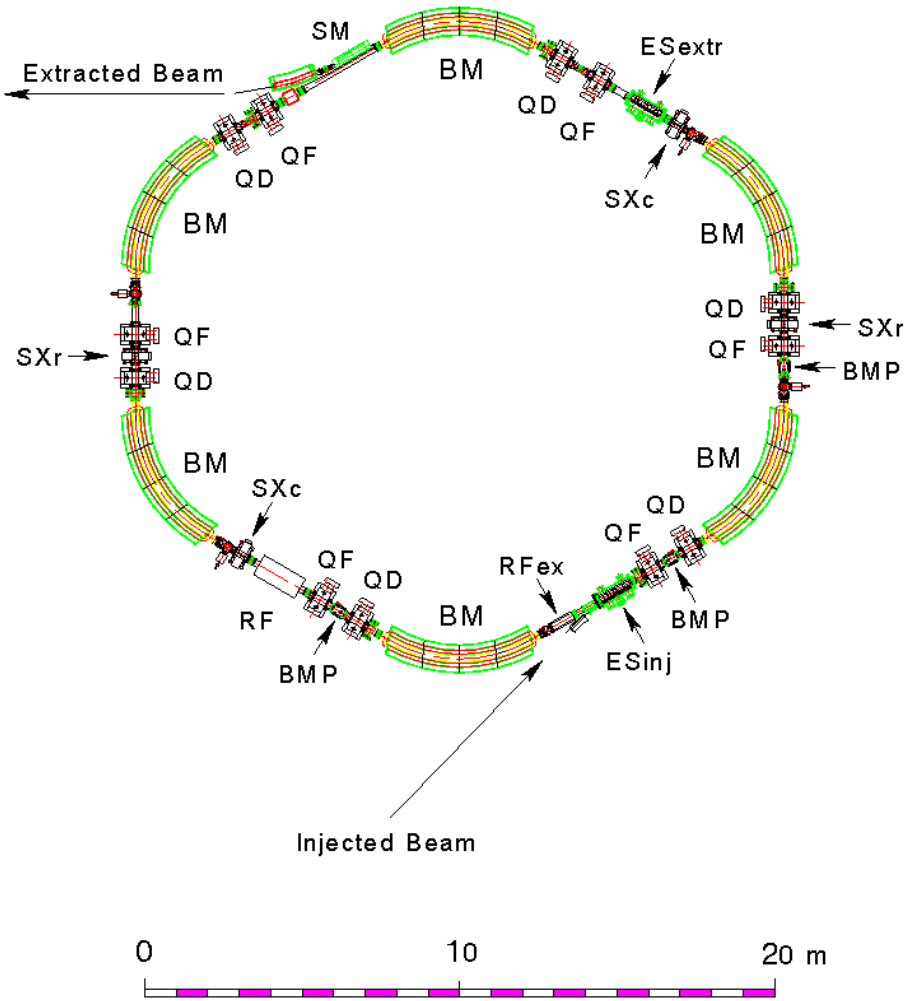
Ion source



IH - model

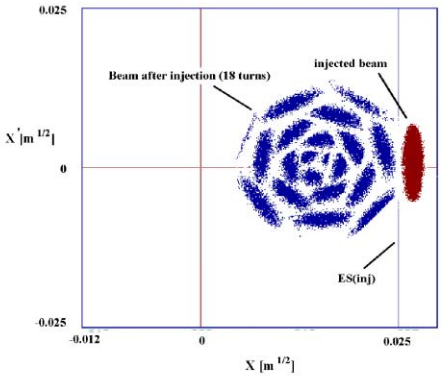


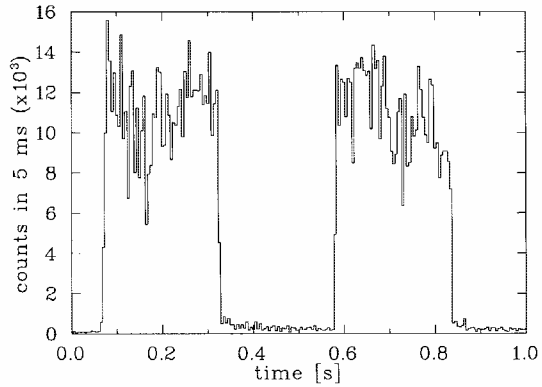
HICAT Layout: Synchrotron



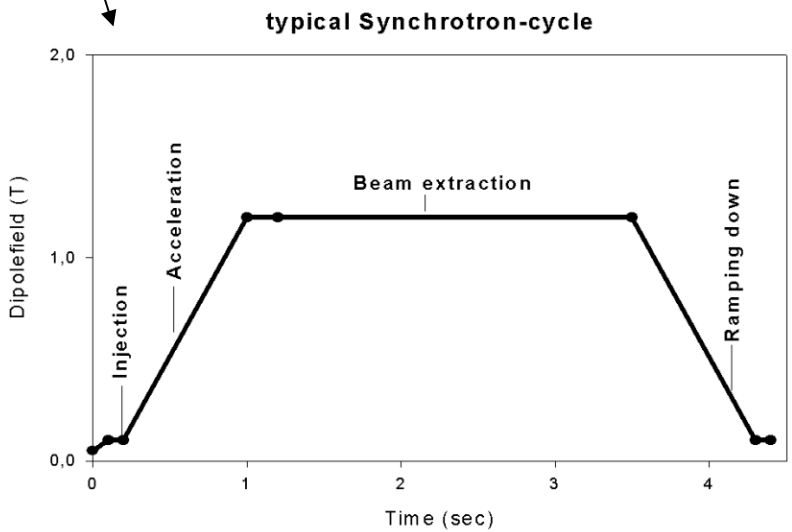
- **Features**
  - **Compact (diameter 65 m)**
  - **Conventional, approved technique**
  - **Multiturn injection**
  - **Multiple beam extraction ('transverse KO'-method)**
  - **Range of factor 16 for magnetic rigidity (factor 6 for extraction)**

HICAT Layout: Synchrotron Injection and Extraction





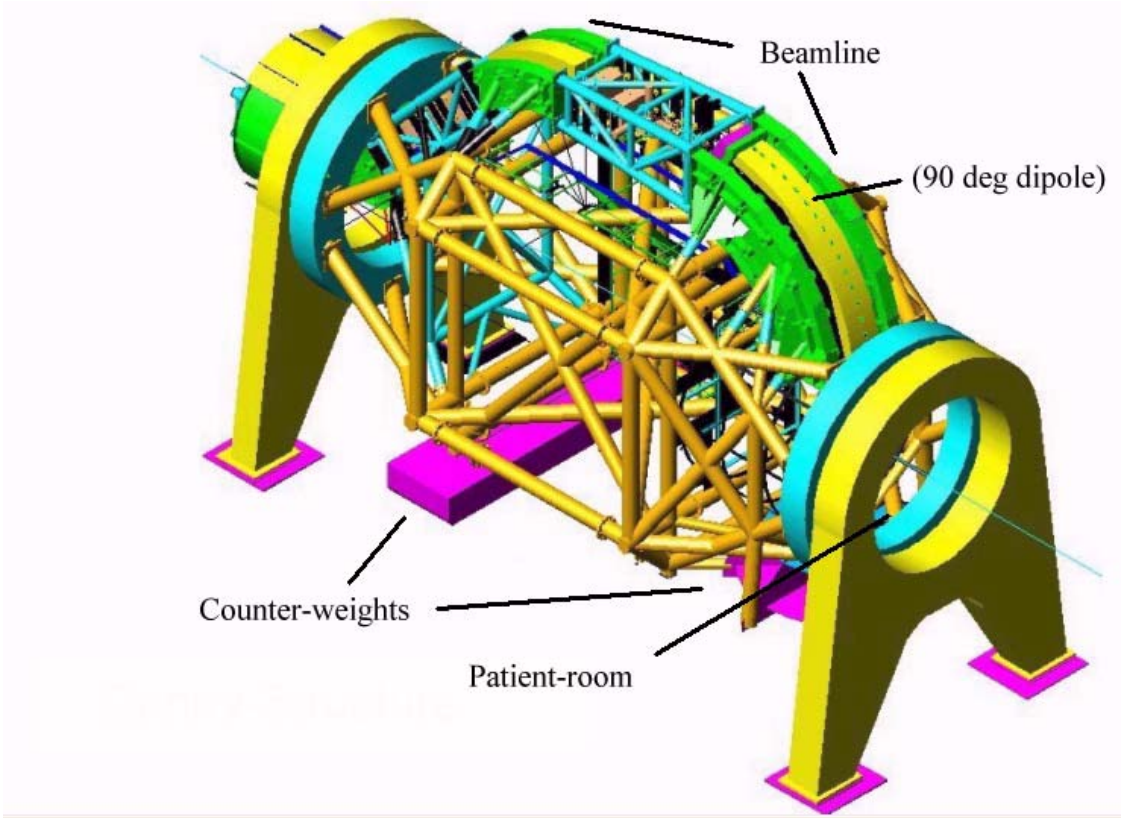
Multiturn injection for reduced ion source intensities



Multiple (gated) beam extraction

(-> reduction of treatment time)

HICAT Layout: Gantry



Features

- First heavy ion gantry
- Close to 600 to. weight
- 13 m diameter
- Maximum deformation of 0.5 mm
- Integration of rasterscan

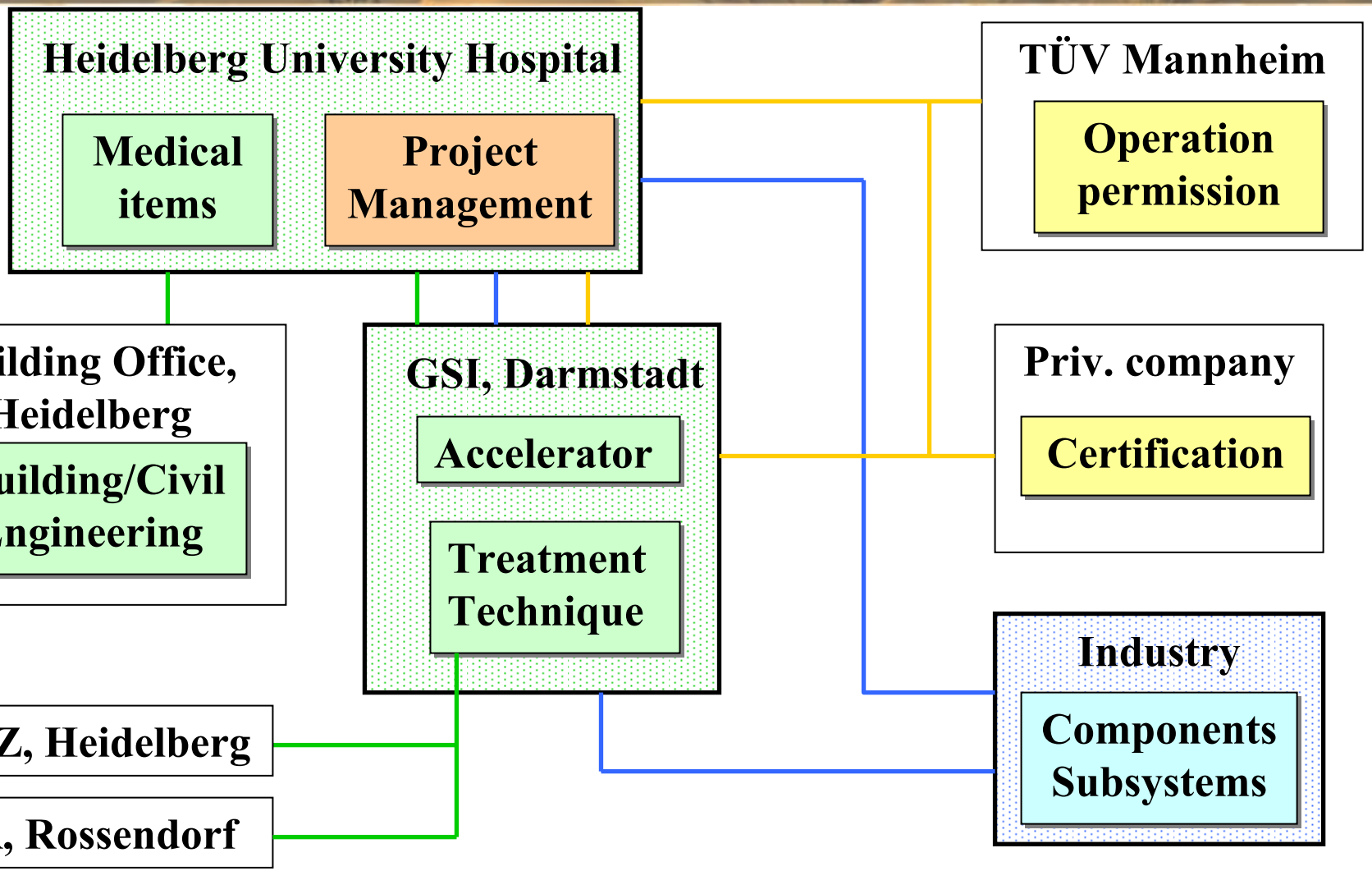
Organisation: Financing and staff

- **Total Investment** **72 M€**

- **Sharing of Investment costs**
  - **Public Financing** **50%**
  - **Heidelberg University Hospital** **50%**

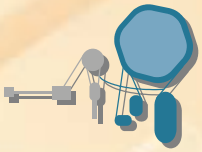
- **Personal for operation phase** **84 Positions**
  - **Includes medical personal**
  - **Patient treatment: 6 days per week, 2 shifts per day**
  - **Nights and Sundays used for planning verification, development and maintenance work**

Organisation: Responsibilities

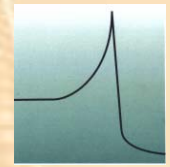


Organisation: Schedule

■ 1997	First patient treatment at GSI
■ 1998	HICAT Conceptual design report
■ 2000	Technical design report
■ May 2001	Approval by Scientific Council of Germany
■ April 2003	Final Approval by Supervisory board of Heidelberg University Hospital
■ Autumn 2003	Start of construction
■ Year 2005	Assembly of accelerator systems
■ Year 2006	Commissioning
■ End of 2006	First patient treatment in Heidelberg
■ End of 2007	Hand-over to clinics operation

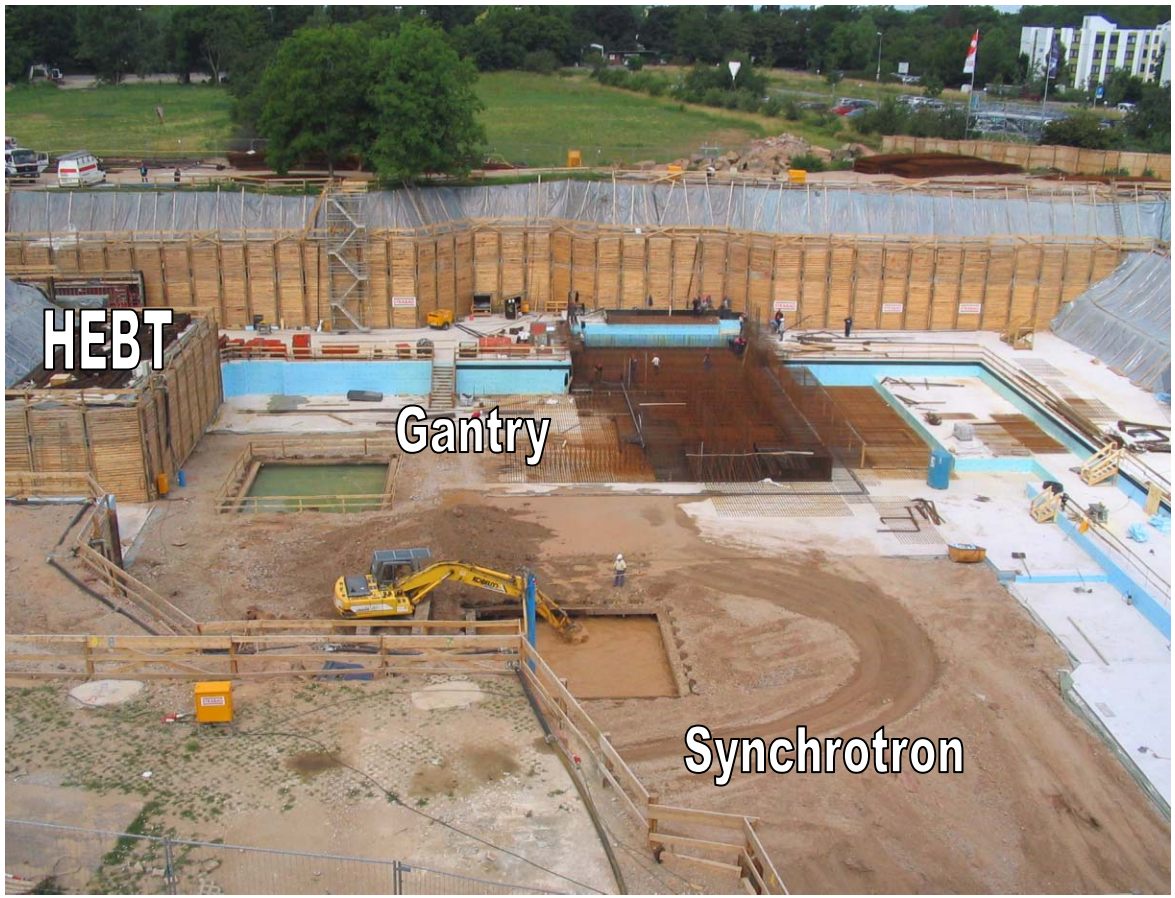


Organisation: Technique



- Subproject Accelerator
- No general contractor found -> subsystems ordered
- Orders for subsystems : June 2003
- Subproject Treatment Technique
- Tender started in June 2004
- Role of GSI (by contracts):
- technical planning (accelerator, treatment-technique)
- Technical consultant during tender
- Technical supervisor of firms
- Performs the assembly of (most) components
- Performs commissioning

Building activities



Building area (Status June 2004)

Organisation: Members of the GSI HICAT-project-group

- R. Bär
- W. Barth
- W. Bourgeois
- G. Breitenberger
- A. Dolinskii
- C. Dorn
- H. Eickhoff
- B. Franczak
- R. Fuchs
- C. Gooß
- T. Haberer
- P. Heeg
- G. Hutter
- R. Iannucci
- R. Kaminski
- K. Kaspar
- H. Klingbeil
- B. Langenbeck
- G. Moritz
- C. Mühle
- J. Naumann
- A. Peters
- K. Poppensieker
- H. Ramakers
- H. Reich
- B. Schlitt
- P. Spädtke
- P. Spiller
- K. Tinschert
- W. Vinzenz
- U. Weinrich
- C. Will

Additional contributions

- DKFZ
- IAP/ University Frankfurt
- Forschungszentrum Rossendorf
- Radiological Clinic (Heidelberg)