Kingdom of Farland

Princess Peach Particle Therapy Center

Maren Eberhardt
Jose Sanchez Arias
Poompis "Dr T." Pattaranutaporn
Joachim Wallner
Ghislain Roy

CAS - Group 3

Vösendorf – Austria

04 June 2015

Kingdom of Farland

- Developing country, pop. 67 million over 510,000 km^2 in SE Asia
- GDP per capita = $11,000 (PPP) , $6500 (nominal)
- Already experienced with latest photon radiotherapy equipment (TrueBeam, Cyberknife, TomoTherapy, 4DCT/PETCT/MRI simulation)

Disease sites	No. w RT	% for PT	No. for PT
Brain	650	40	260
Head/Neck	2000	40-75	1150
Lung/Thorax	1600	72	1152
Breast	2575	10	258
GI tract	1500	18-50	510
Gyne	2000	8	160
Others	2500	15	375
Pediatric	380	60	228

˜4000 p. could benefit from particle therapy

At first, target of 1000 p/y (25%)

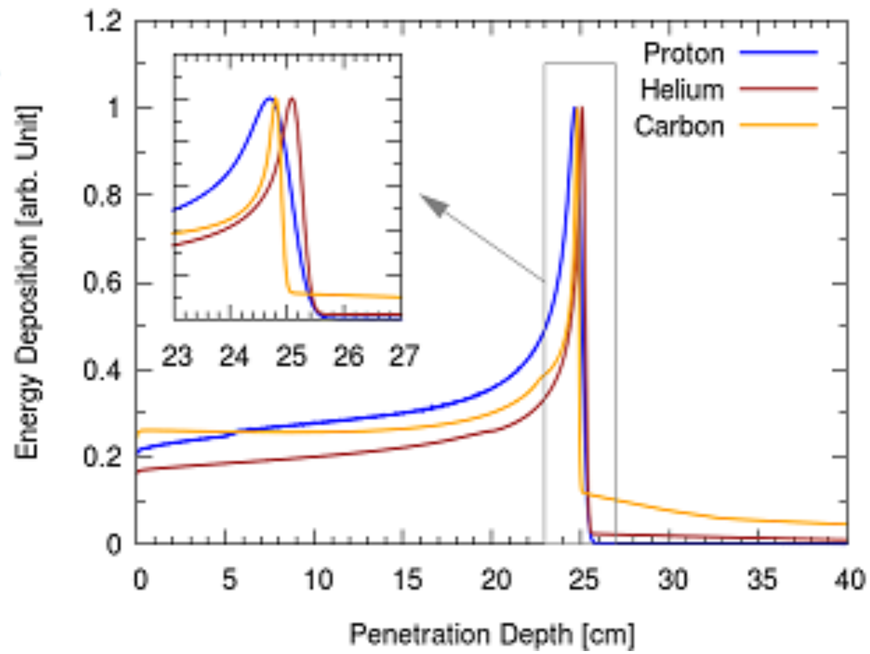
Clinical needs

- Public, government funded. Expansion of existing RT center in U. Hosp.
- Cost-effective solution focused mainly on healthcare service
- Operation time 16 h/d , 240 d/y amounts to 30,000 fractions/year

Type of Particle(s)	Proton, Helium
Main treatment sites	Lung, Upper abdomen Brain, Eye and Spine
Range	4 – 32 cm in water
Beam delivery	**Pencil beam scanning** Beam spot size : 3 mm at Maximum energy Ability to equip with respiratory gating Field size : 20 x 20 cm Fixed beam with various angles (but planned for future gantry installation)
Dose rate	Minimum 2 Gy/min/l, up to 5 Gy/min/l

Why use He^{2+} ions?

- Reduced beam broadening compared to p^+ (sharper beam penumbra)
- Small fragmentation tail (compared to Carbon)
- Simple RBE calculations (low LET like p)



Comparing H+ to He^{2+}

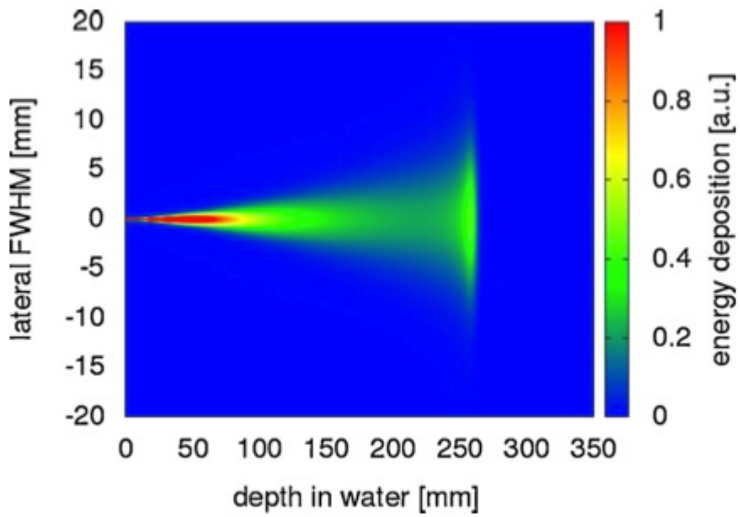


Figure 6. Top view on lateral dimension and energy deposition as function of range for a 200 MeV proton beam.

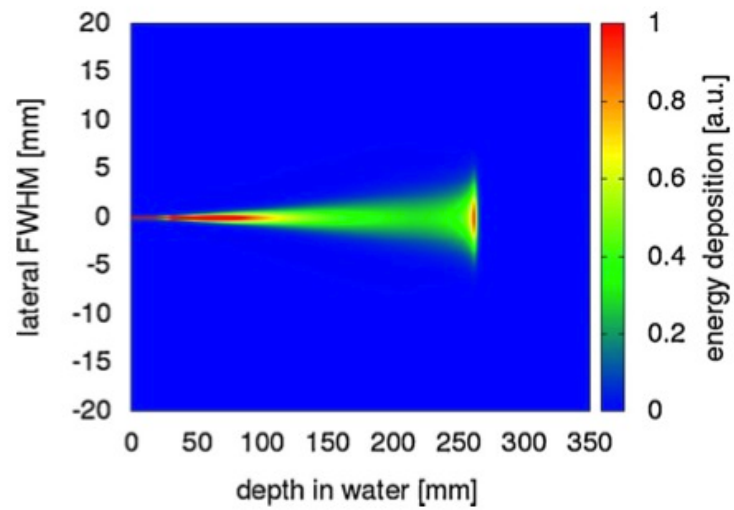


Figure 7. Top view on lateral dimension and energy deposition as function of range for a 200 MeV/A helium ion beam.

« **Comparison of basic features of proton and helium ion pencil beams in water using GATE** »

J. Ströbele et al. / Z. Med. Phys. 22 (2012) 170–178

Technical choices

- Proven technology with expertise available in the region.
- Commercially available with competition
- Limited ancillary equipment
- Simple operation
- Aiming first at patient treatment
- Low maintenance and high MTBF

-> Cyclotron

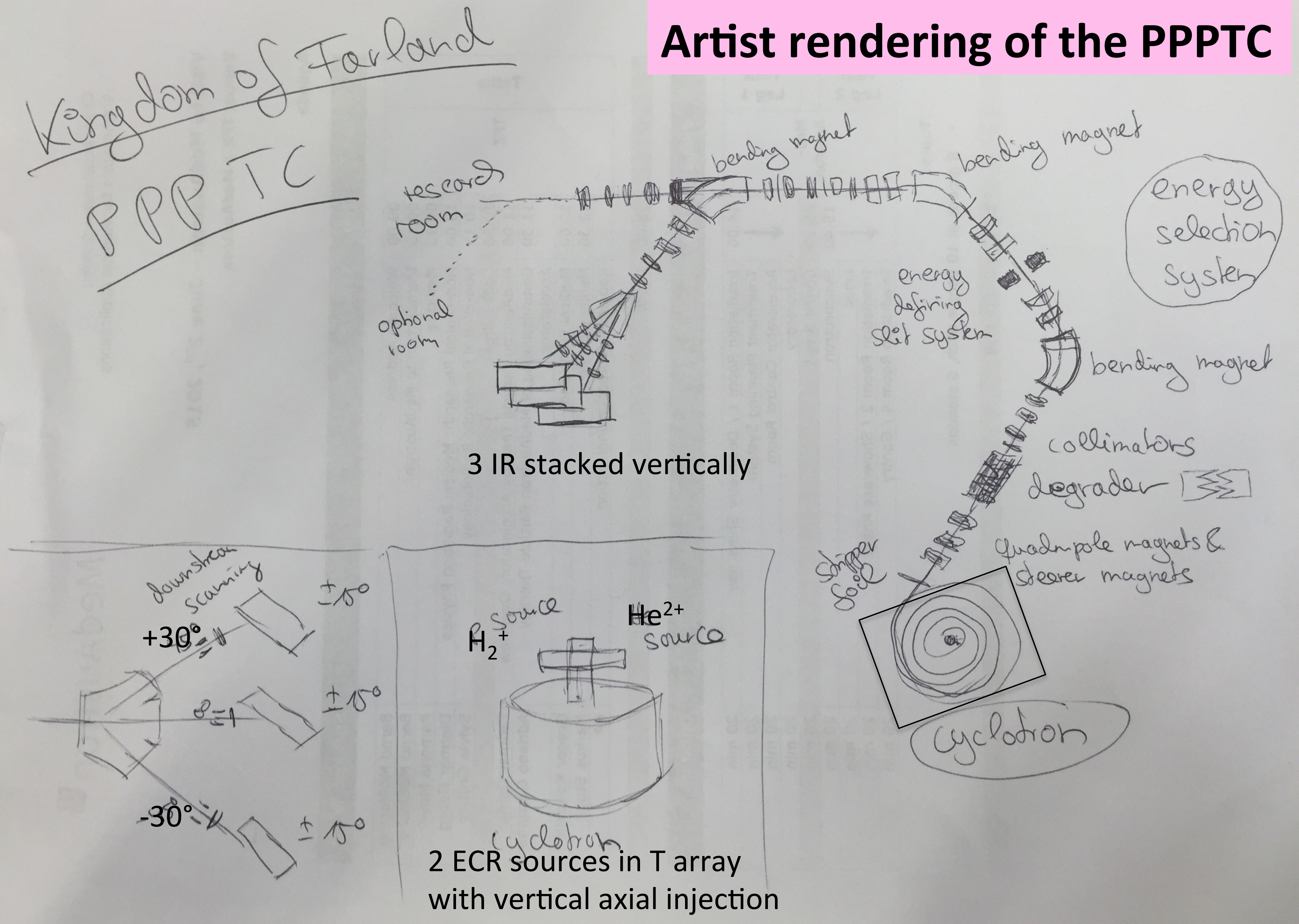
Technical choices

- 3 treatment rooms.
- Auxiliary shared clinical rooms:
  - patient preparation and immobilisation, one per IR
  - 1 dedicated and shared for imagery (X-Ray and PET/CT, MRI available in UH)
  - Interconnected with shuttle path
- Auxiliary technical rooms
  - TPS
  - Control rooms, one per IR

Possible layout

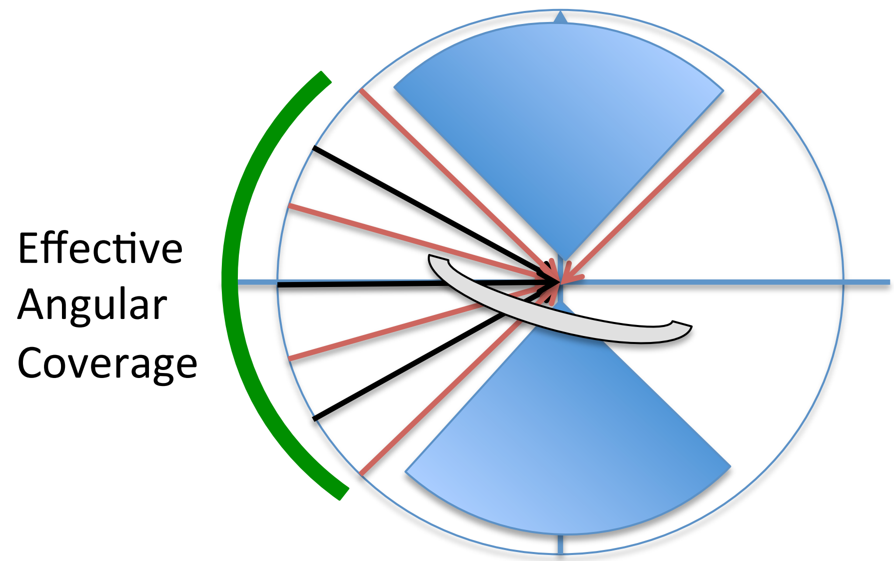
- Cyclotron sized for p and He;
  requires local shielding and separate room
- Two sources with T connection on top of cyclotron, above shielding, and axial vertical injection
- Simple commercially available ECR sources for robustness and ease of operation;
- H_2^+ and He^{2+} are similar from beam dynamics point of view. H_2^+ is stripped to 2 protons in a foil at the exit of cyclotron.
- Beam lines as short as possible

Artist rendering of the PPPTC

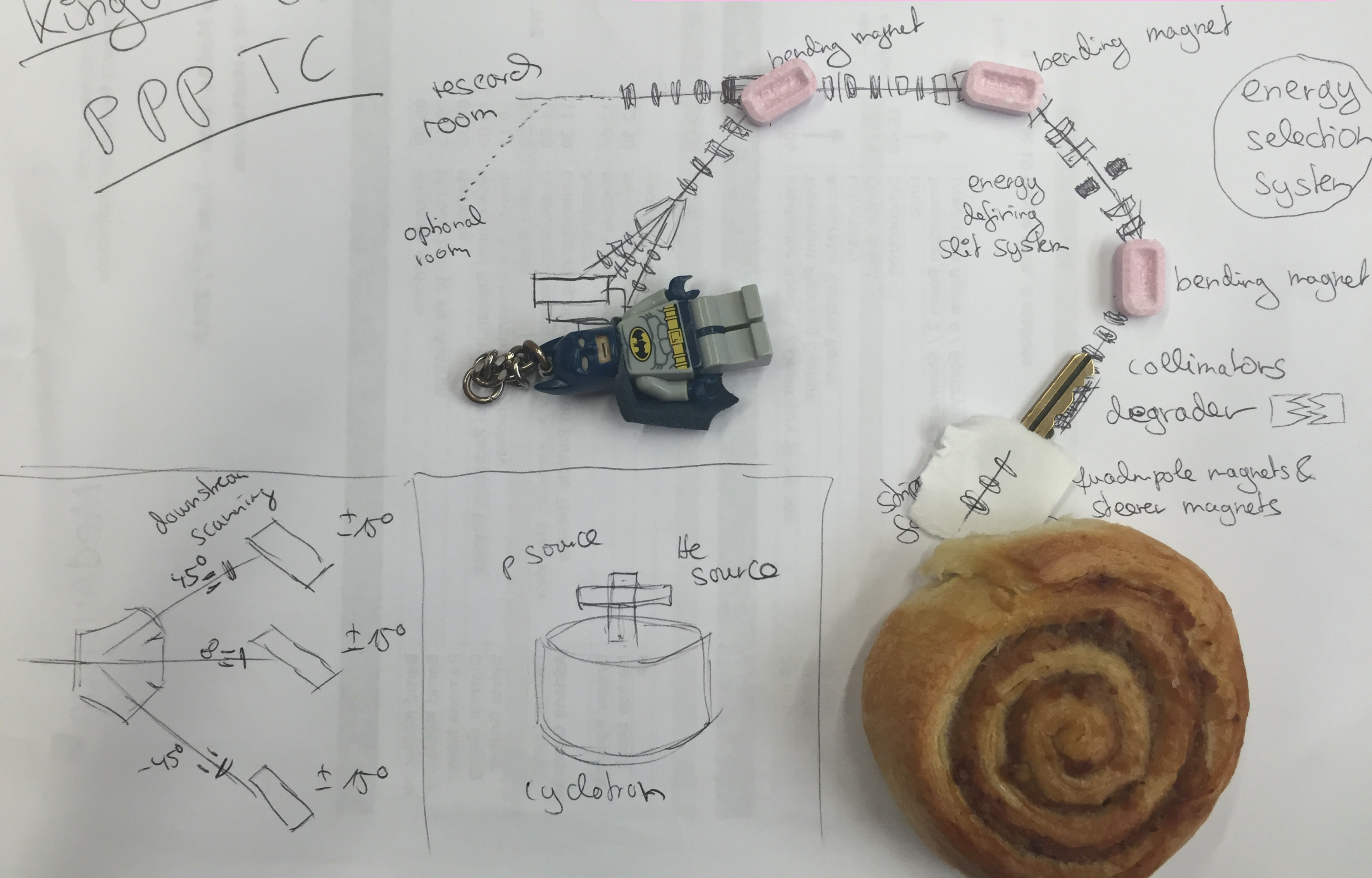


Angular Coverage

- Three stacked rooms provide effective combined angular coverage
- Patient can be treated in different rooms
- Comfort of couch at +-15° is limited.



3D model rendering of the PPPTC (Cyclotron and patient not to scale)



Beam Instrumentation

Cyclotron

- Radial Beam Probe: destructive Profile and Intensity monitor for intensity measurement and profile evaluation with camera

Beam Transport line

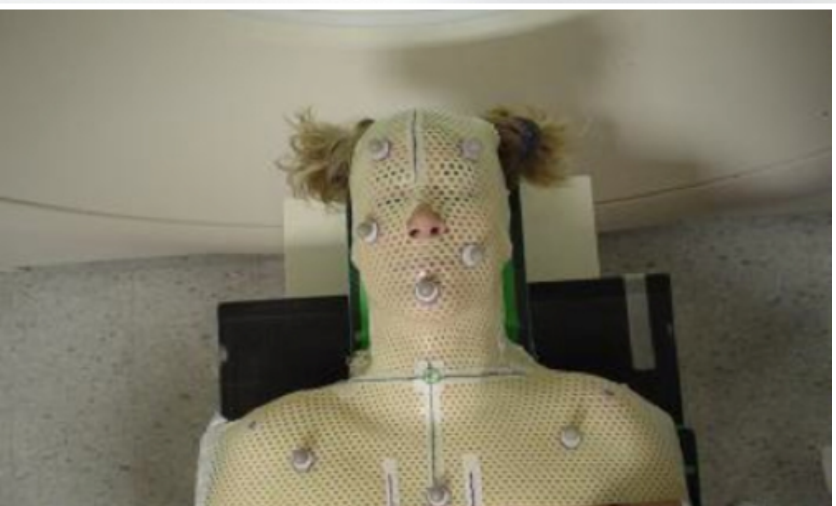
- Faraday Cups: Destructive Intensity measurement at several key points
- Scintillating cameras: destructive Profile monitor
- Current Transformers: Non destructive Intensity measurement
- Collimators for beam shaping in phase space
- Degraders: Graphite wedges. Allows energy range of 70 – 230 MeV
- Slit plates: for energy selection
- Scanning magnets at the downstream end (nozzle)

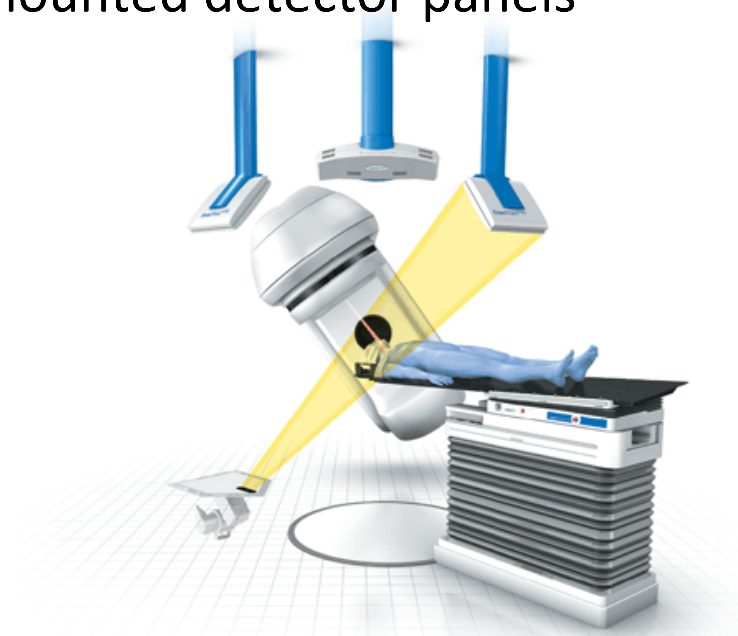
Patient positioning and verification

Patient positioning with floor mounted robotic arm, can be tilted +/- 15°

Positioning verification with

- Optical system (IR markers attached to patient or mask, ceiling mounted camera
- X-Ray system (in-floor sources, ceiling mounted detector panels





Patient workflow

1.) Immobilisation of the patient in preparation room
(one per treatment room)

2.) Transport of the patient into the treatment room with a shuttle

3.) Patient positioning and positioning verification

4.) Irradiation

5.) Optional: Dose verification after treatment in separate room equipped with PET-CT (one for all)

BEC Exashuttle

Limitations

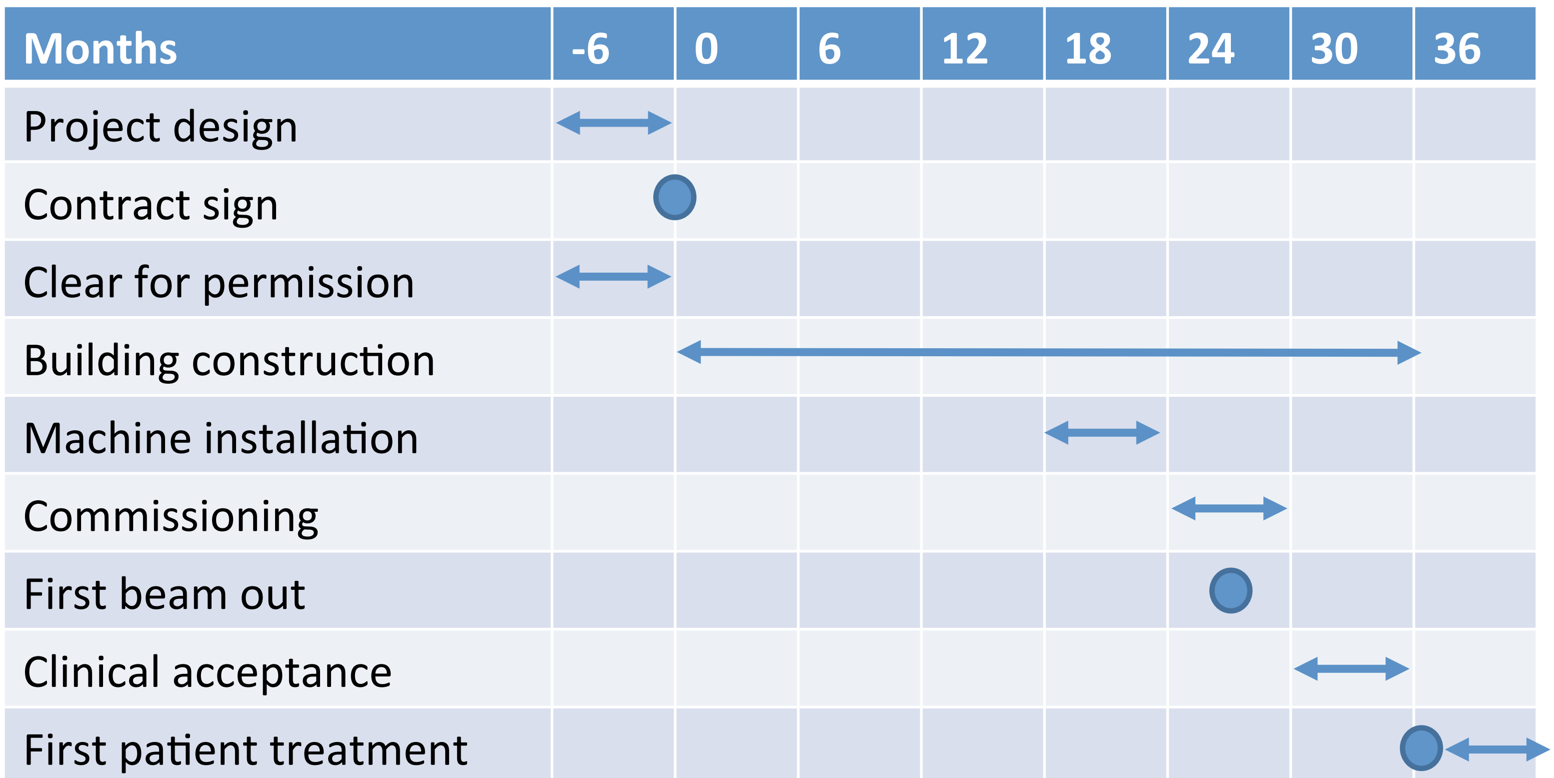
- Fixed beamlines and reduced angular coverage
- Limited penetration depth,
  hence no transmission imaging
- In-room imaging limited to position verification
- Very limited research
  beyond clinical studies with He beams.

Cost and Reimbursement

- Land and facility capital investment generously offered by the King to the kingdom
- Limited operating costs by adjoining the center to the RT center of the University Hospital
- Need to cover only operating costs

Group	Definition	Reimbursement
I	Absolute indication. Survival benefit from clinical evidences.	**Fully covered**
II	Relative indication. Possible survival or QOL/ Toxicities benefit from dosimetric study.	50% covered or Fully covered with clinical trial
III	No indication. Neither survival nor QOL/ Toxicities benefit from clinical evidences.	Not permitted for PT in PPPTC
IV	Foreigner, Private practice or Prioritized on waiting list	Not covered + 20% additional price

Project Timeline



Ready to “hit those bad tumours very hard with ion particles” at the Princess Peach Particle Therapy Center