CERN Accelerator School
Accelerators for Medical Applications 2015

Case Study
the KingRing facility

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Outline

- ➔ Location and Motivation.
- ➔ Patient Workflow Estimation.
- ➔ Main parameters.
- ➔ Layout of the **KingRing** facility
  - Ion sources.
  - Linac Injector.
  - Synchrotronility.
  - Extraction and delivery
- ➔ Summary

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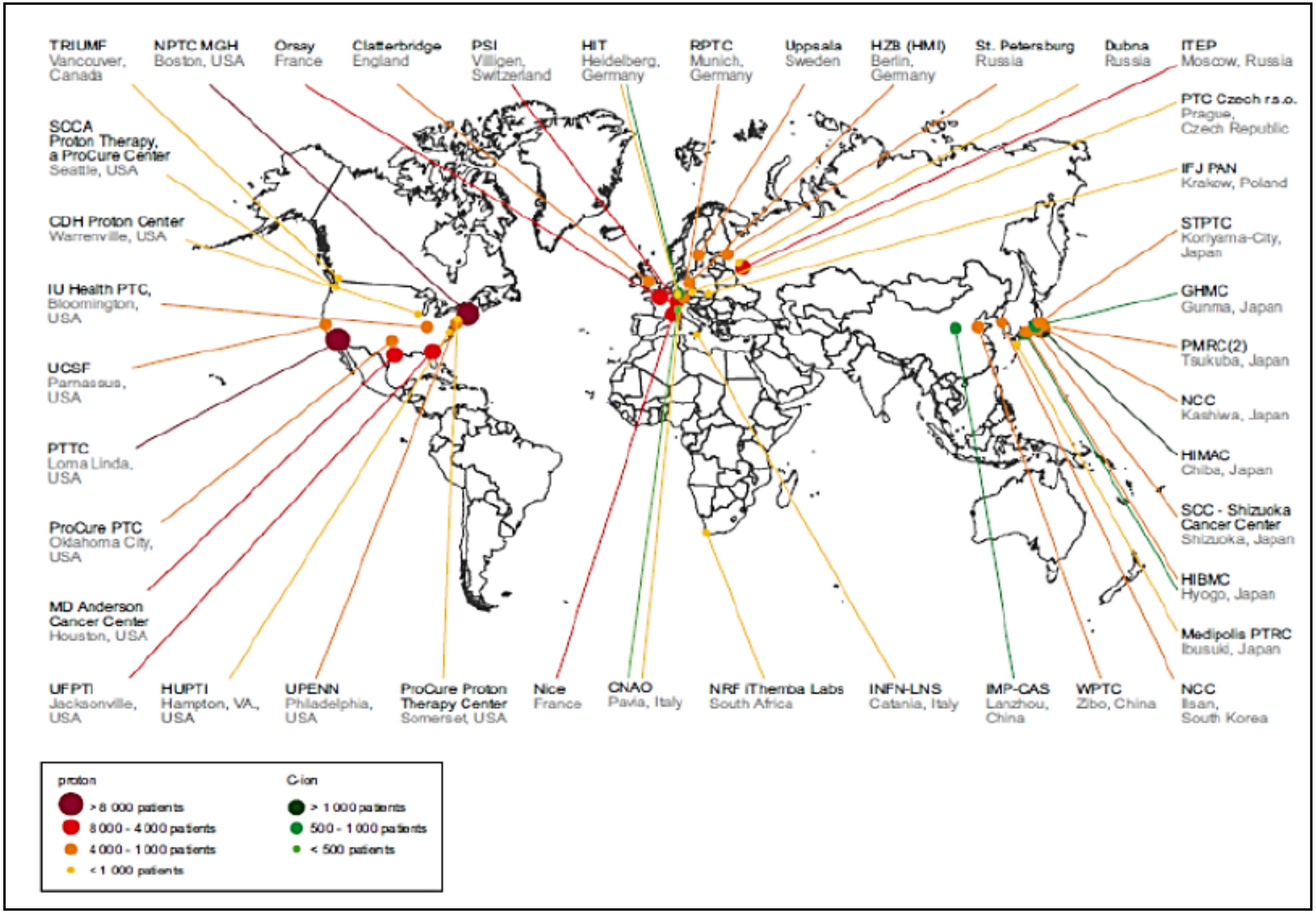
Location and Motivation

KingRing



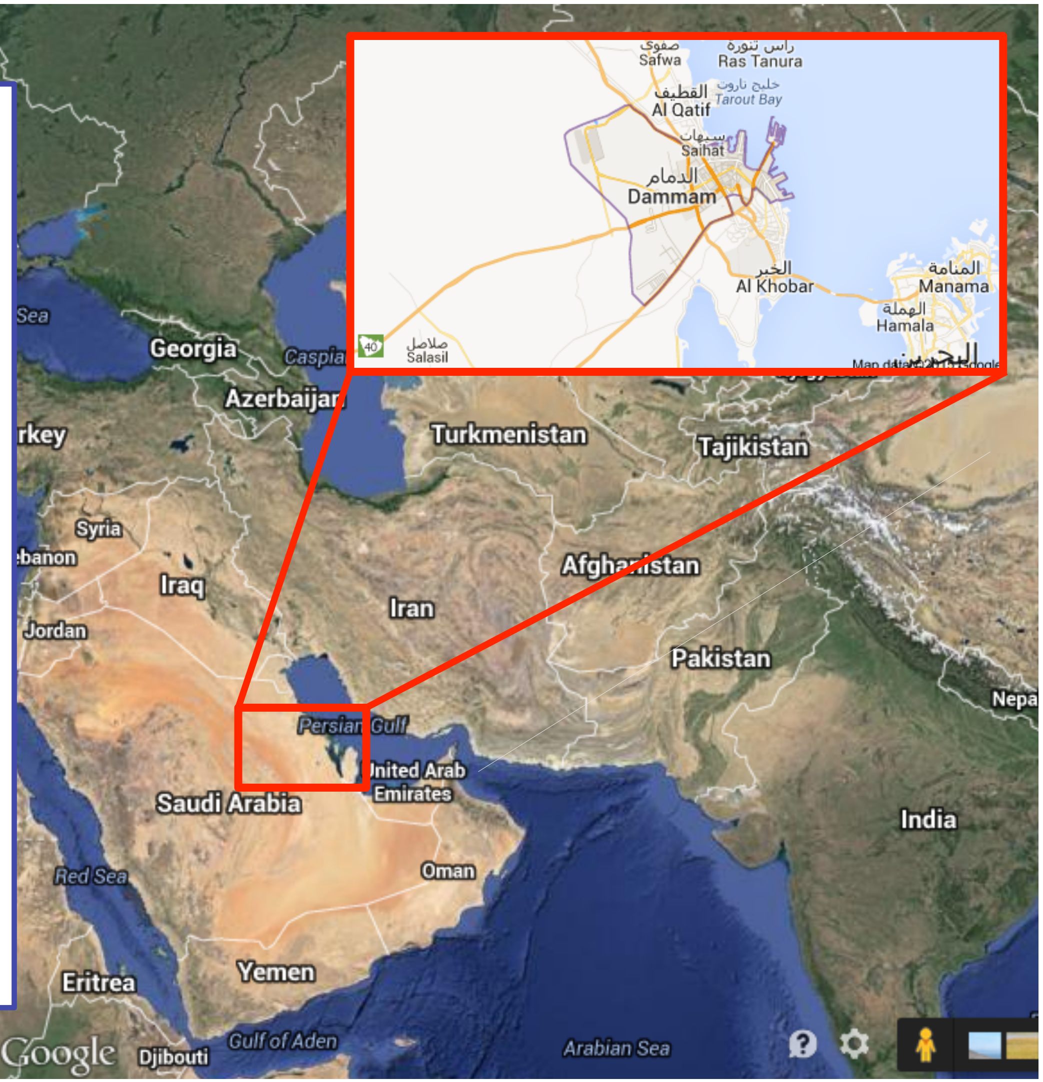
The CERN Accelerator School

Location and Motivation

- **Saudi Arabia (Dammam)**
  - Founding: Saudi Arabia government + a special contribution from local universities.
  - Goal: Developing expertise in accelerators for medical applications and physics research.

- Population: **30 M**
  - **1 %** cancer to be treated **per y**;
    20 % treated with radiotherapy;
    15 % radio-resistance.

- Long prospective: treating **9 k patients/y.**



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Patient Workflow Estimation

KingRing

46 wk/y irradiation ⟶ 828 patients /y

➔ Assuming:

- 8 to 20 h = 12 working hours for patients;
- 5 days/wk treatment + 1 day/wk maintenance + 1 day/wk + daily QA and nights for study and development;
- 3 wk/y + 2wk/y holidays for Ramadam and Pilgrim season (used also for maintenance + 1 wk/y maintenance;
- 30 min/irradiation fraction;
- 20 fractions/patient;
- 3 rooms (2 Gantries) + 1 for experiment.

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Main parameters

- Proton beam:
  - In the range of 1E10 p/spill to patient and 10 times to experimental room.
  - 250 MeV
- Carbon beam:
  - In the range of 5E8 C/spill to patient
  - 400 MeV/u

  - Pencil beam with scanning magnets (20x20 cm^2)
  - About 1 mm characteristic size at patient
- 2 Gantries (one for proton and one for carbon ions)
- No superconductive magnets (limited access to LHe).

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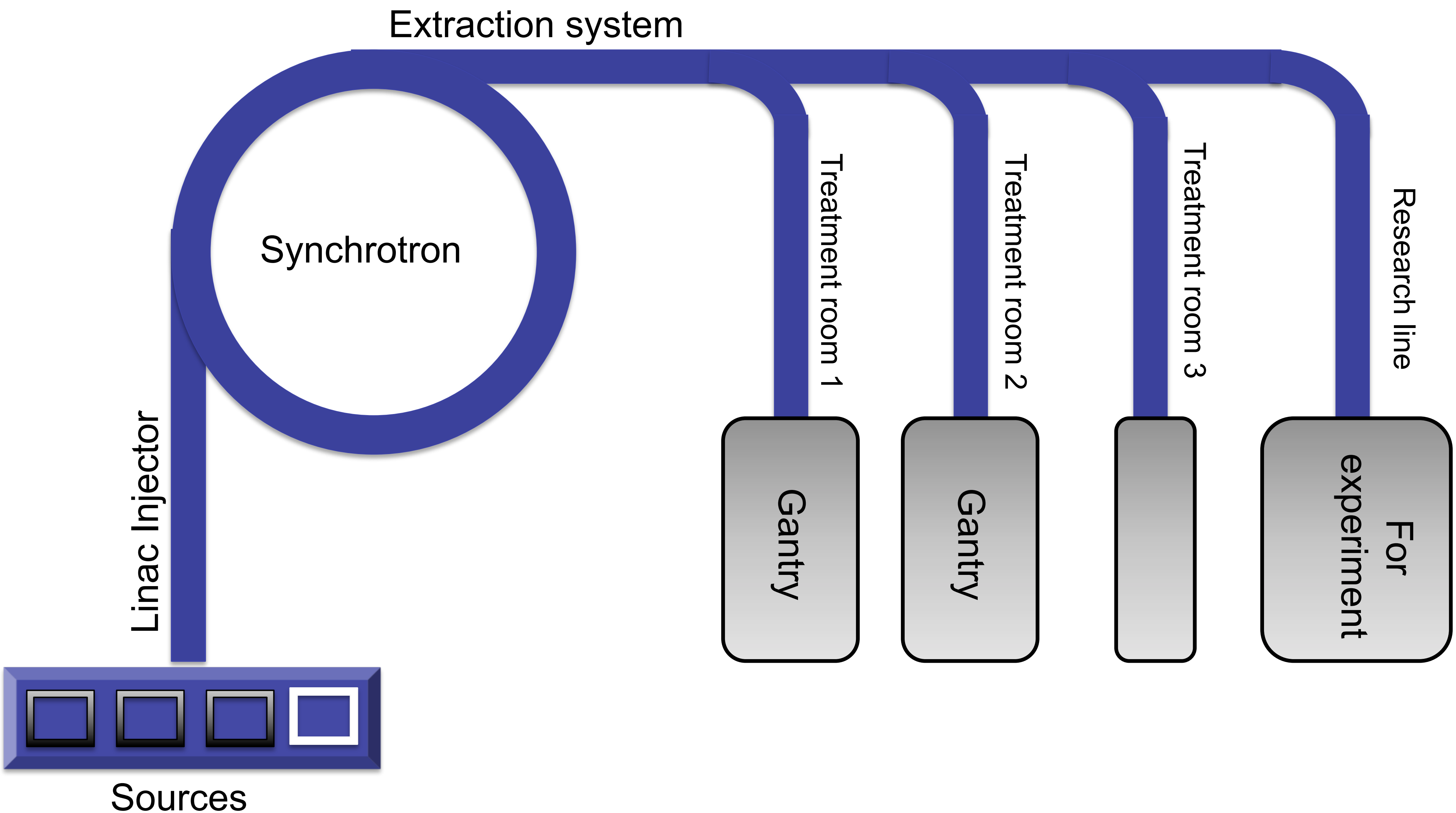
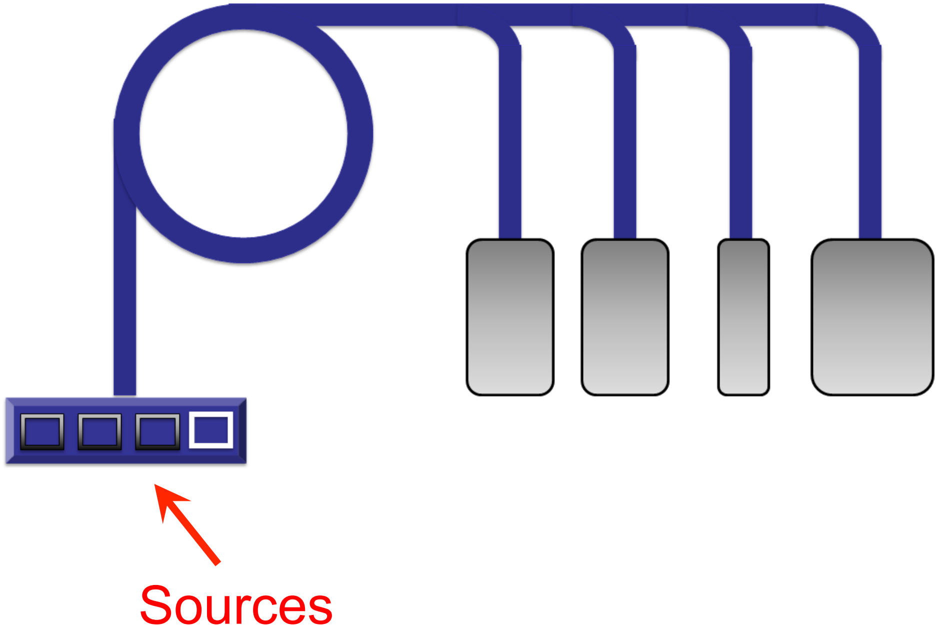
Layout of the KingRing facility



Ion sources

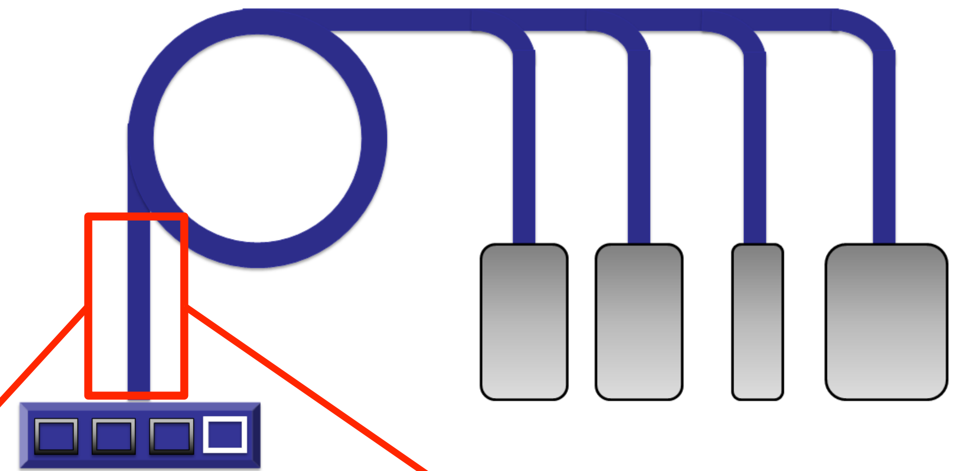
KingRing

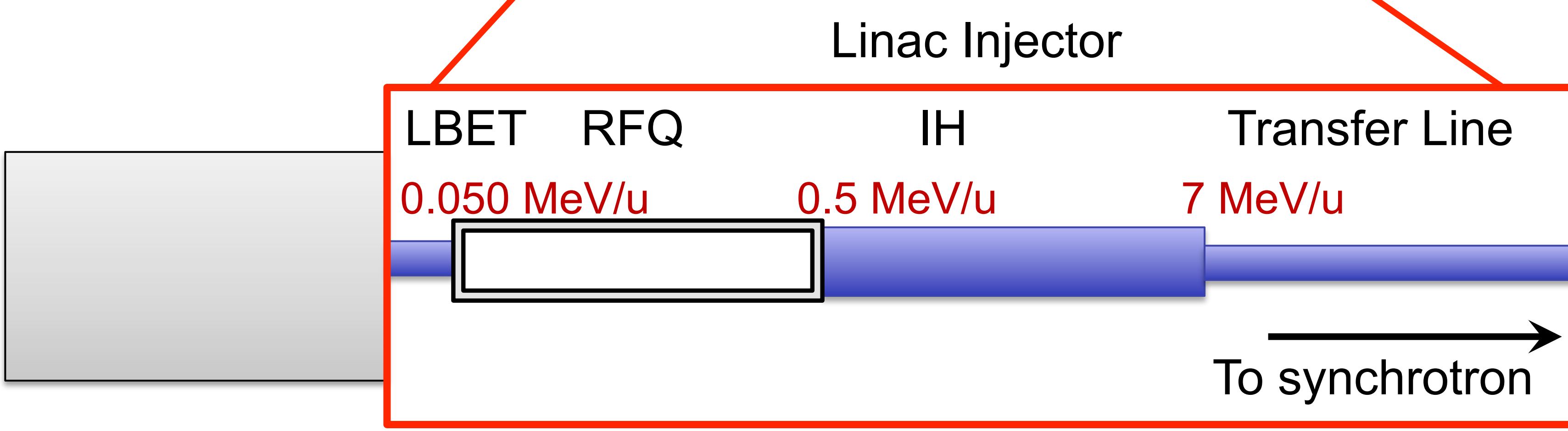
- Ion source 1:
  - Supernanogun (ECR) 14,5 GHz
  - mostly for proton
  - in reserve for carbon ions
- Ion source 2 (similar than no. 1)
  - Supernanogun 14,5 GHz
  - mostly carbon ions
  - in reserve for proton
- Ion source 3
  - Experimental ECR-ionsource for research purposes.
- Ion source 4
  - One free space to install and test new ion sources.



Linac Injector

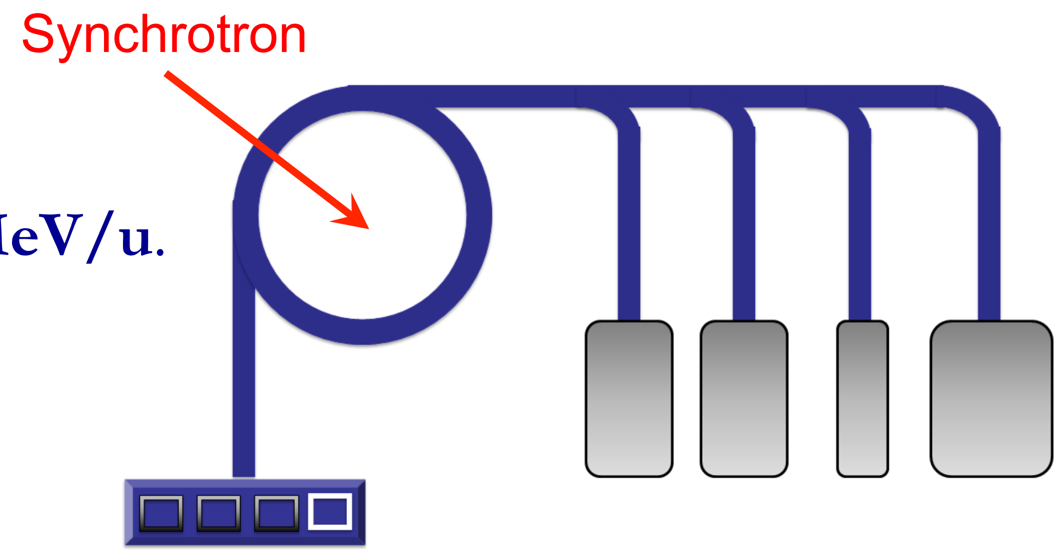
- Energy up to **7 MeV/u**
- **f = 352 MHz** (commercial tetrode at this freq as power supply, 1.05 M€)
- **RFQ** (up to 500 keV, bunched)
- **DTL** (up to 7 MeV, injector to synchrotron)





Synchrotron

KingRing



➔ Injection:

with septum magnet at energy of **7 MeV/u**.

➔ Magnetic Rigidity:

- **250 MeV protons: 2.5 T m**
- **400 MeV/u C^{6+} ions: 6.6 T m**
- **250 MeV/u He^{2+} ions: 5 T m**

➔ Dimensions:

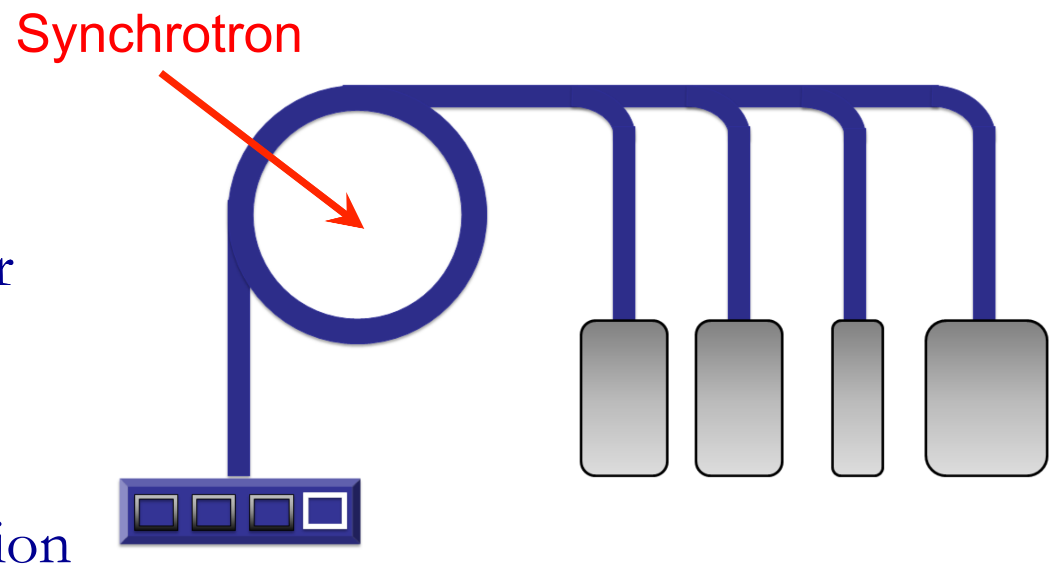
given by carbon ions requirements, since they are more rigid;

- Max bending radius at 2 T: 3.3 m
- Dipole magnets consist of 50 % of the synchrotron, therefore

  R = 6.6 m → 41 m of circumference

Synchrotron

KingRing



Components

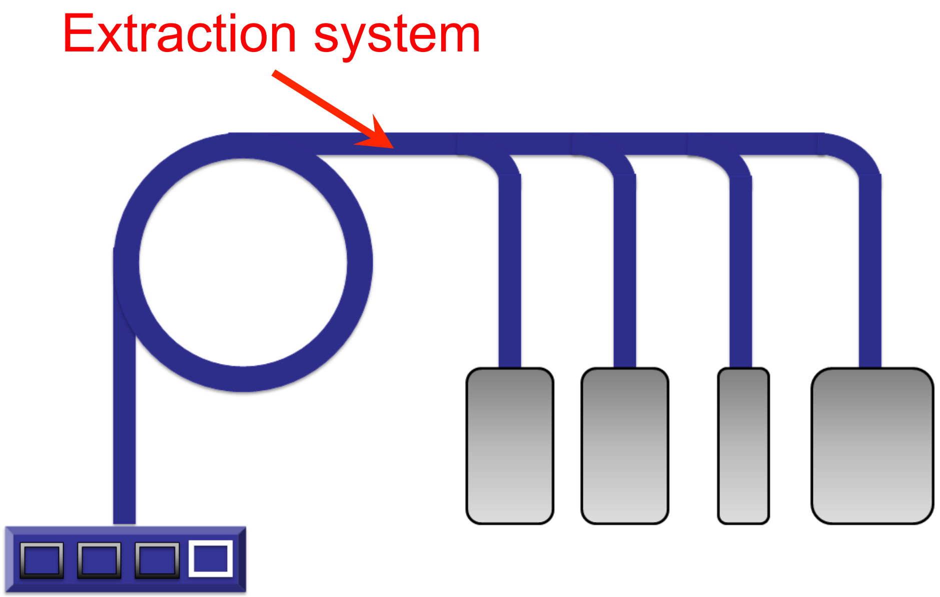
- 2 T dipoles: bending magnets
- Quadrupoles: in FODO lattices for beam focusing
- Magnet correctors (sextupoles, octupoles)
- Septum magnets: injection/extraction
- RF tank: 1 acceleration point per turn
- Beam diagnostics

Acceleration parameters

Particle	Energy [MeV/u]	Magnetic field [T]	RF frequency [kHz]
p+	7	0.12	860
	250	0.75	4390
C6+	7	0.24	860
	400	2	5120
He2+	7	0.24	860
	250	1.5	4390

Extraction and delivery

KingRing



- Extraction:
  - To start with: slow extraction (1 to 10s) with 3rd resonance excitation.
  - RF – KO with energy modulations and intensity adaptation will be developed with the aim of delivering the whole dose with one extraction. We should gain in stability and in time.

- Delivery with on-line monitoring:
  - Besides standard delivery dose monitoring
  - X-rays
  - PET (PET + CT during preparation)

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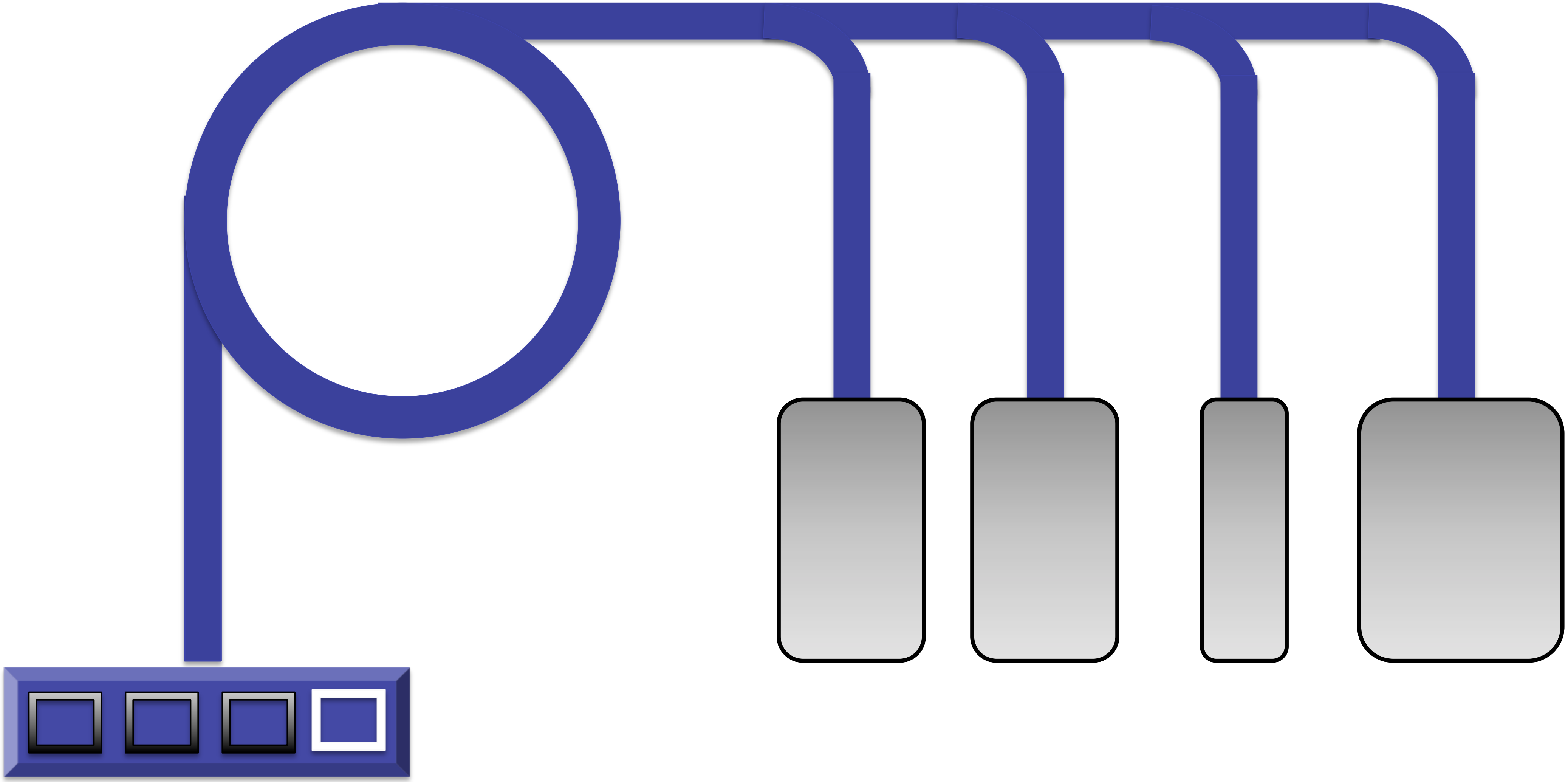
Summary and Future Plans

- ➔ KingRing will be located in Saudi Arabia.
- ➔ It will serve the whole country and Middle East regions.
- ➔ Costs covered by SA government (estimated in the order of 500 M€).
- ➔ Construction time 3 to 4 y.
- ➔ Commissioning 2 y (training necessary) + 1 y for clinical trials.
- ➔ Full reimbursement by state based health assistance.

Thank you - the KingRing team

Layout of the KingRing facility



Location

KingRing

- **Saudi Arabia (Dammam)** with government money plus a special contribution from South Arabia for developing expertise in accelerators for medical applications and physics research.

- We have to account for 30M people. With the assumptions of 1% cancer to be treated per y, of which 20% treated with radiotherapy, and 15% radio- … **9k patients/y**