The Accelerator Operations Team of the Marburg Ion-Beam Therapy Centre

Claude Krantz

Workshop on Accelerator Operations 2016
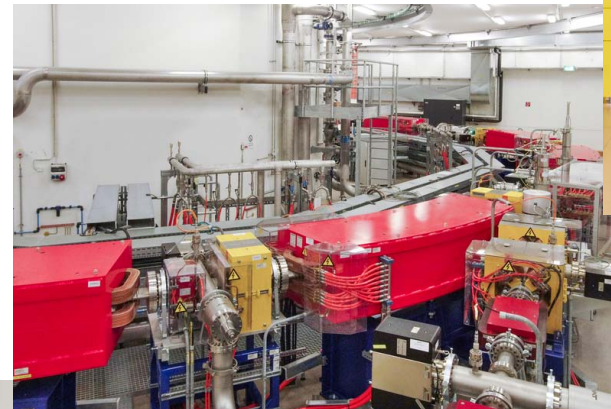
Shanghai, 20th September 2016

MIT

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Outline

MIT – A short Overview

Ion Beam Therapy in Marburg (DE)

The Accelerator

The Accelerator Operations Team

Duties

Training

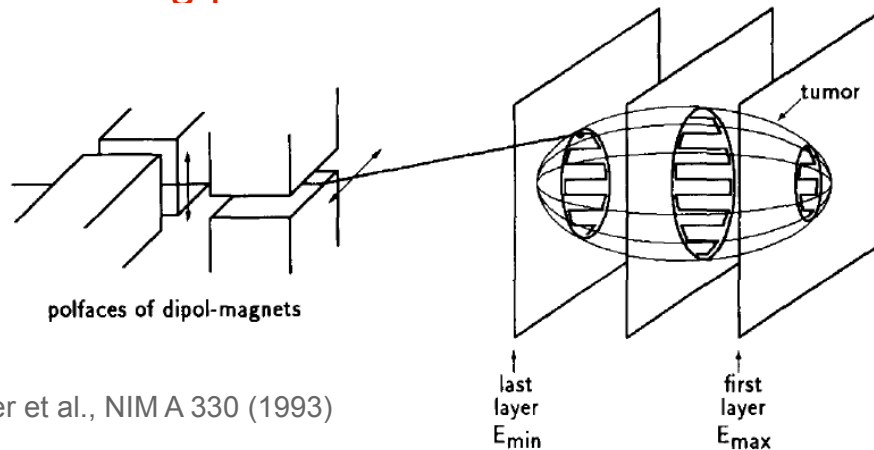Achievements so far

MIT – A short Overview

Radiation therapy with ions

p (up to 48 – 221 MeV)
$^{12}C^{6+}$ (up to 88 – 430 MeV/u)
→ 2 – 30 cm range in human tissue.

Peaking spec. energy deposition
at end-of-range (Bragg stopping).
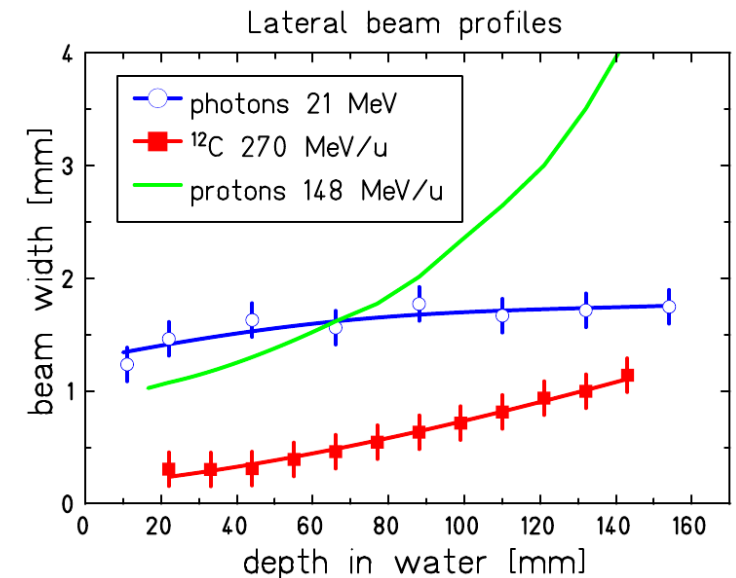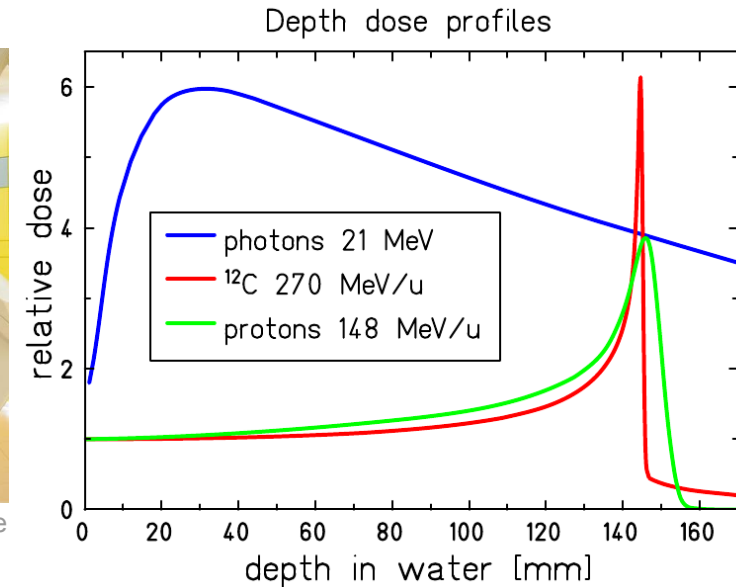
Lower lateral scattering for $^{12}C^{6+}$.

Lateral dose distribution:
Fast scanning pencil beam.

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Depth dose profiles

- photons 21 MeV
- ^{12}C 270 MeV/u
- protons 148 MeV/u

depth in water [mm]

Lateral beam profiles

- photons 21 MeV
- ^{12}C 270 MeV/u
- protons 148 MeV/u

depth in water [mm]

Krämer & Durante, Eur. Phys. J. D 60 (2010)

polfaces of dipol-magnets

tumor

last layer E_{min}

first layer E_{max}

Haberer et al., NIM A 330 (1993)

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MIT – A short Overview

Radiation therapy with ions

Physical advantages

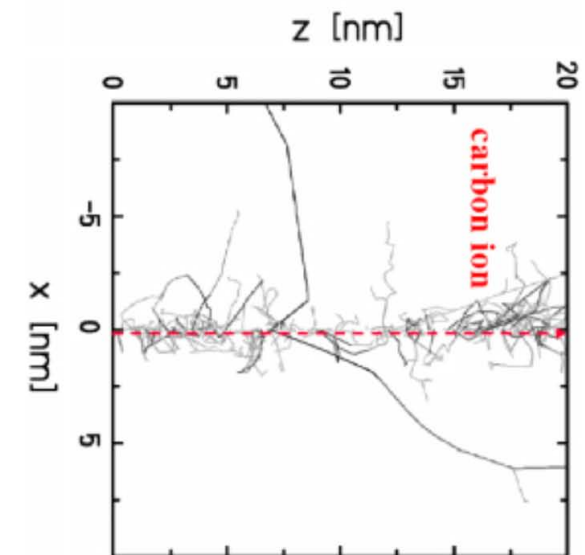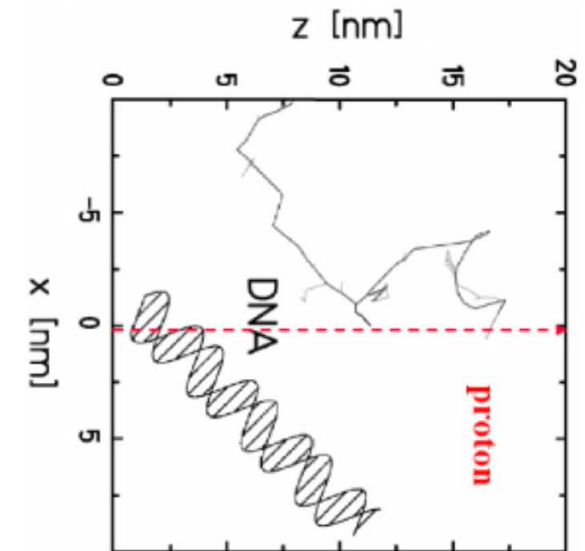Better control over dose distribution.

Protection of high-risk-organs.

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Biological advantages

Higher ionisation density dE/dz for $^{12}C^{6+}$
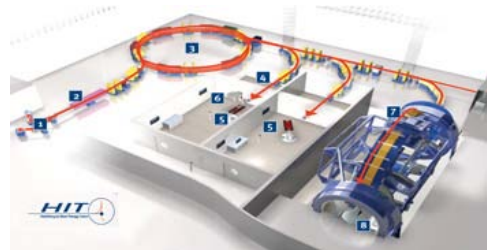
$\rightarrow$ effective on "radiation-hard" tumours.

Presently, only four p/$^{12}C^{6+}$ therapy facilities
are in operation in Europe
(1 still in commissioning)!

Amaldi & Kraft, Rep. Prog. Phys. 68 (2005)

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MIT – A short Overview

History of Ion-Beam Therapy in Marburg

klinikum.uni-heidelberg.de

HIT

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1991–1997 : Precursor studies at **GSI** [Kraft, NIM A 454 (2000)]

1997–2008 : Clinical studies at GSI [Schulz-Erntner, Int. J. Radiation Oncology Biol. Phys. 58 (2004)]

2004 : Beginning of construction of **HIT in Heidelberg**

2009 : Start of operations at **HIT**

...

Aug. 2007 : Ground-breaking for the Ion-Beam Therapy Centre
at the University Hospital of **Marburg**

Jan. 2009 : **Beam commissioning** by manufacturer (Siemens)

June 2011 : Start as Siemens **test facility**

Feb. 2012 : EU-certification as **medical product**

Sept. 2013 : **Shut-down** (due to business plan issues)

...

Sept. 2014 : Foundation of **MIT GmbH**

Univ. Hospital Heidelberg (75.1%) and Rhön-Klinikum (24.9%)

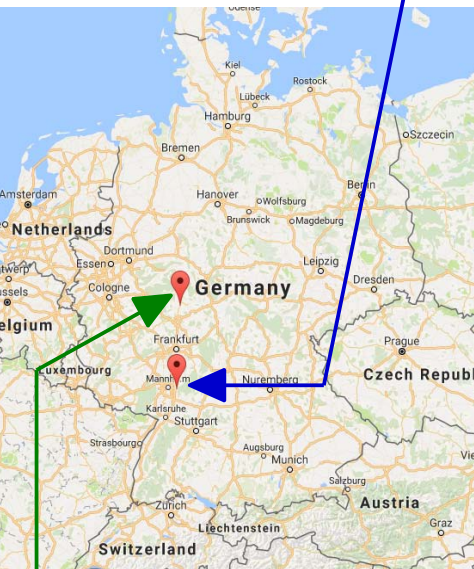Feb. 2015 : Begin of **recommissioning** of accelerator

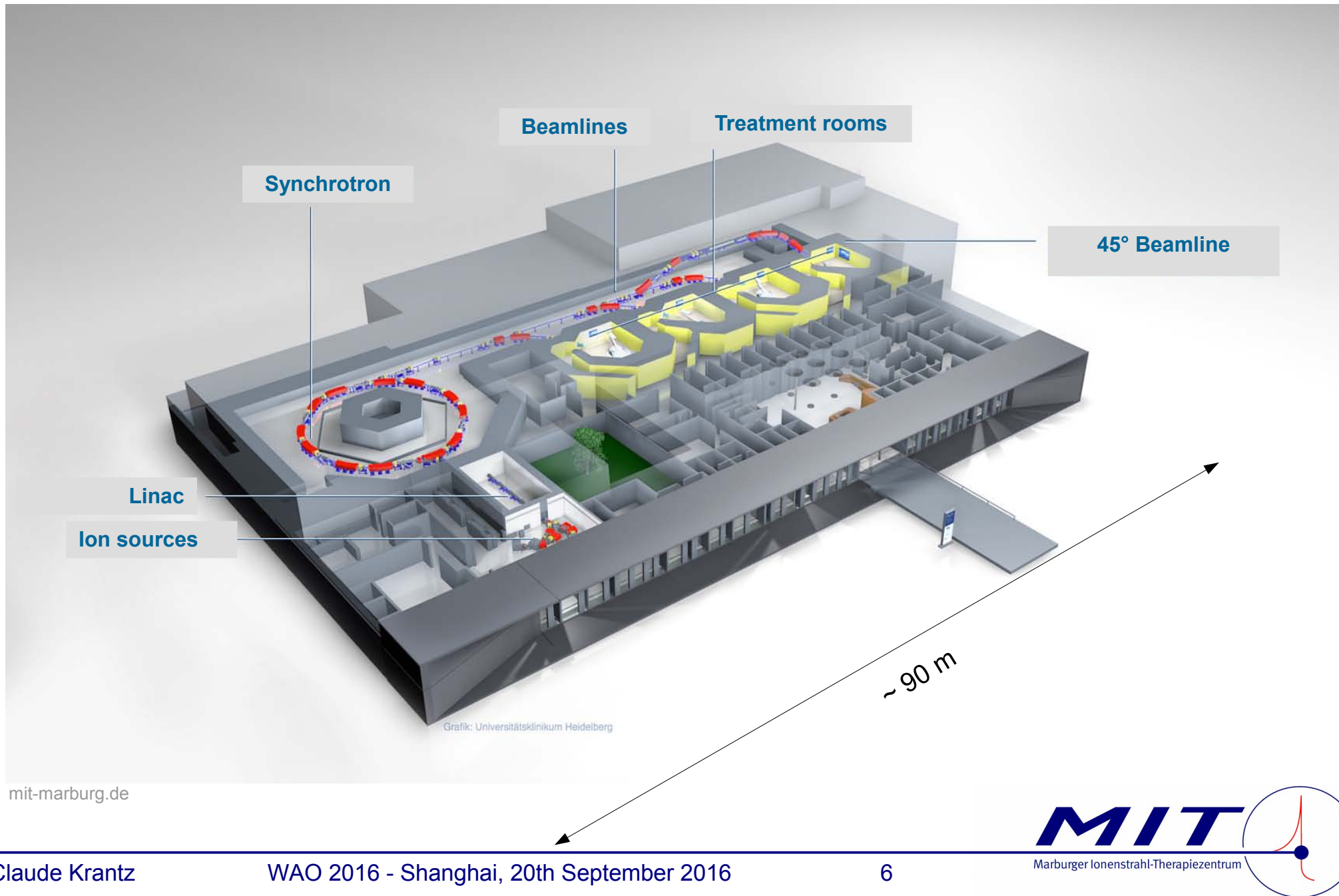Oct. 2015 : First medical **treatment**

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MIT – A short Overview

Beamlines

Treatment rooms

Synchrotron

45° Beamline

Linac

Ion sources

~ 90 m

Grafik: Universitätsklinikum Heidelberg

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Support contracts:
1st level (irradiation system)
2nd level (accelerator)

SIEMENS Healthineers

Beamlines

Treatment rooms

Administration shared with HIT

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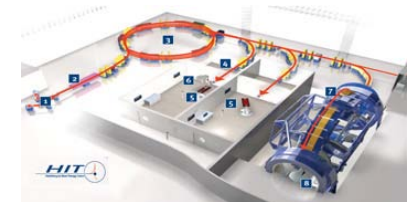
Total: 34

Irradiation

12
Medical physicists, medical engineers, nurse

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Medical staff
(11 increasing)

University Hospitals
Heidelberg and Marburg

Accelerator

18
Physicists, engineers, technicians

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The Accelerator

~ 20 m
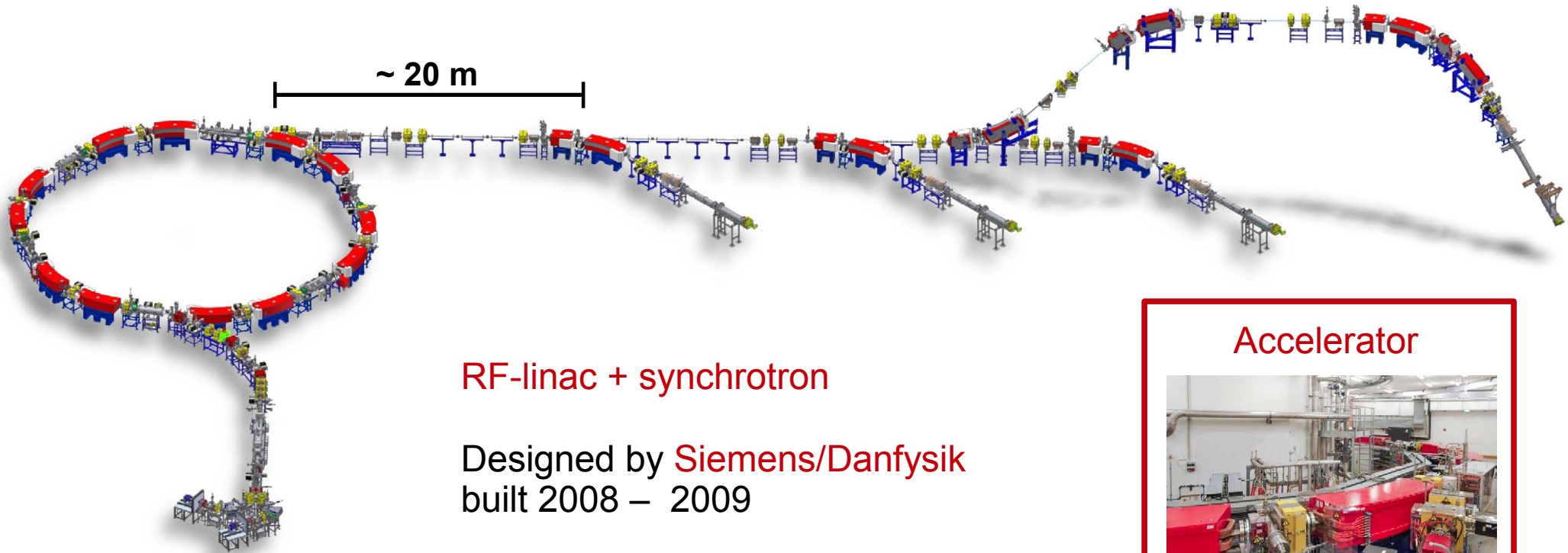
RF-linac + synchrotron

Designed by Siemens/Danfysik
built 2008 – 2009

Similar to HIT accelerator and
PIMMS-types (CNAO, MedAustron).

Prototype of SPHIC machine

Rohdjeß et al., Proc. of PAC 2009
Lazarev et al., Proc. of IPAC 2011

Accelerator

18 ❗
Physicists,
engineers,
technicians

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The Accelerator

~ 20 m

4 medical beam outlets

3 horizontal, 1 fixed 45°

Protons: **48 – 221 MeV**
$^{12}C^{6+}$: **88 – 430 MeV/u**

→ 290 energies each

Protons: **$4 \cdot 10^8 - 2 \cdot 10^{10}$**
$^{12}C^{6+}$: **$10^7 - 5 \cdot 10^8$**

→ 13 base intensities,
"Dynamic Intensity Control"

5 beam widths
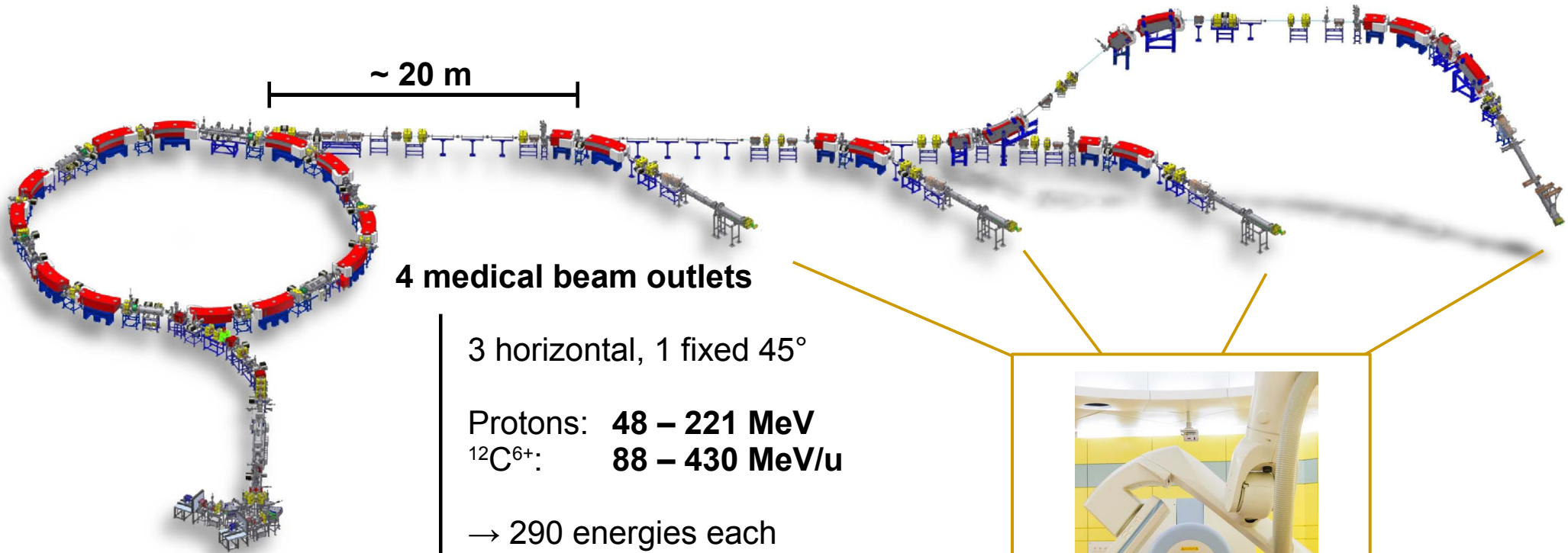
Rohdjeß et al., Proc. of PAC 2009
Lazarev et al., Proc. of IPAC 2011

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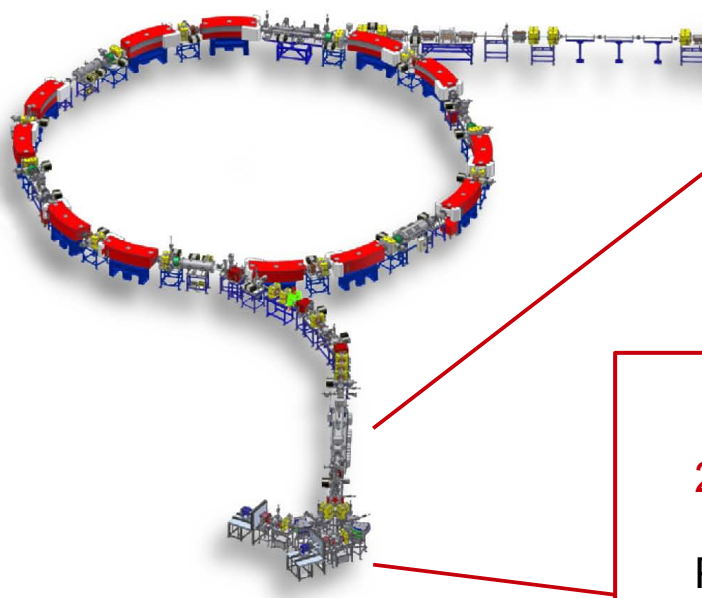
The Accelerator

Linear accelerator

RFQ (400 keV/u)
+
IH structure (7 MeV/u)

then stripping to
p and C^{6+}
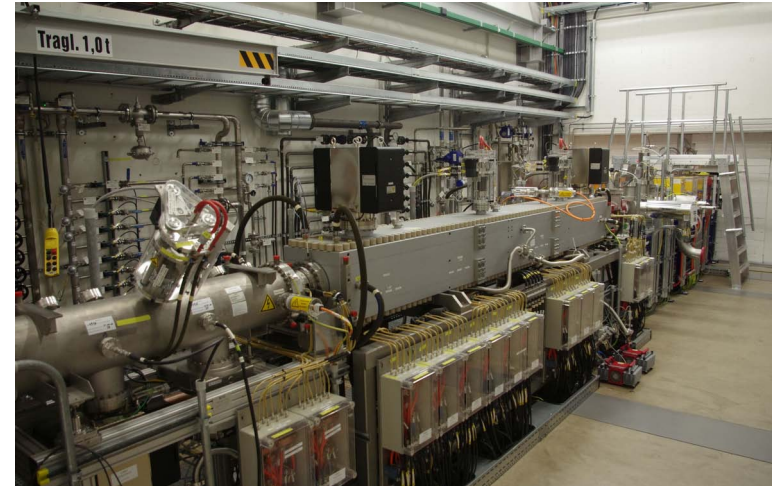
2 ECR ion sources

Pantechnik Supernanogan

H_3^+ : 800 µA
C^{4+} : 180 µA

Rohdjeß et al., Proc. of PAC 2009
Lazarev et al., Proc. of IPAC 2011

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The Accelerator
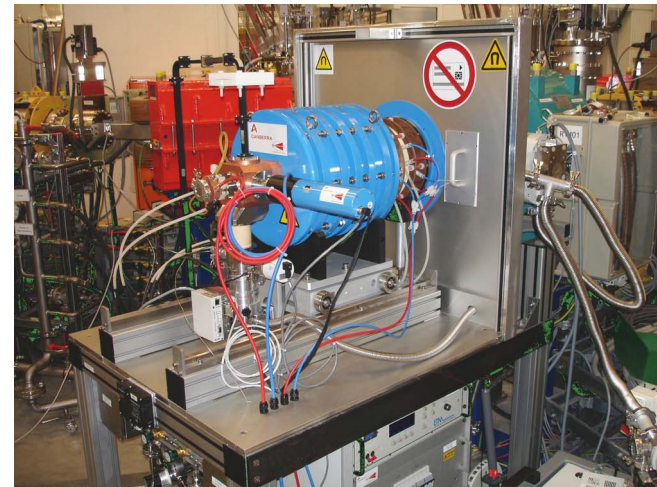
High-energy beam transport
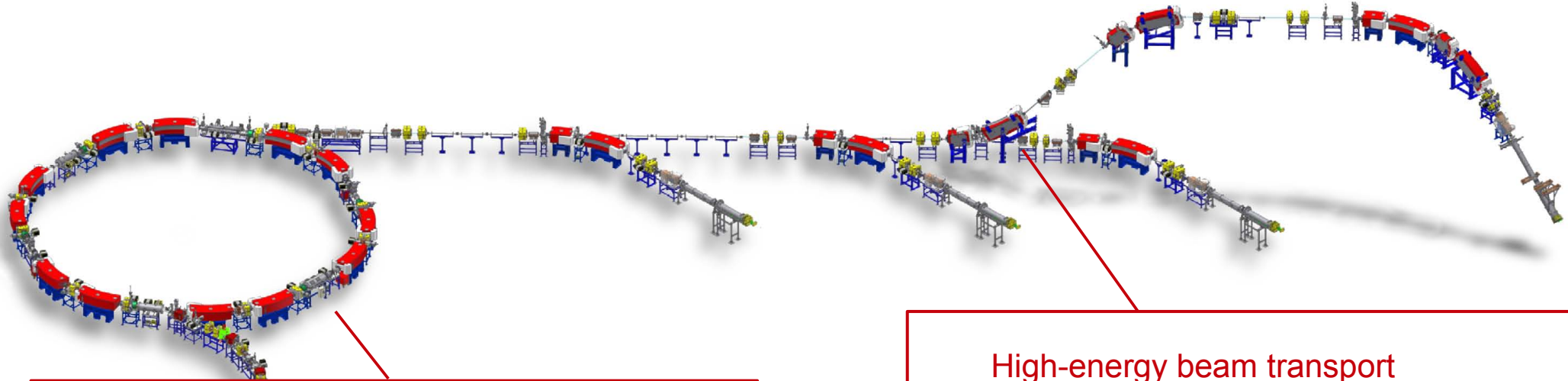
Synchrotron   **(65 m circ.)**

0.5 Tm – 6.6 Tm   Extraction 1 – 8 s
Ramping time ~1 s   (KO-excitation)

Møller et al., Proc. of PAC 2007

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The Accelerator Operations Team
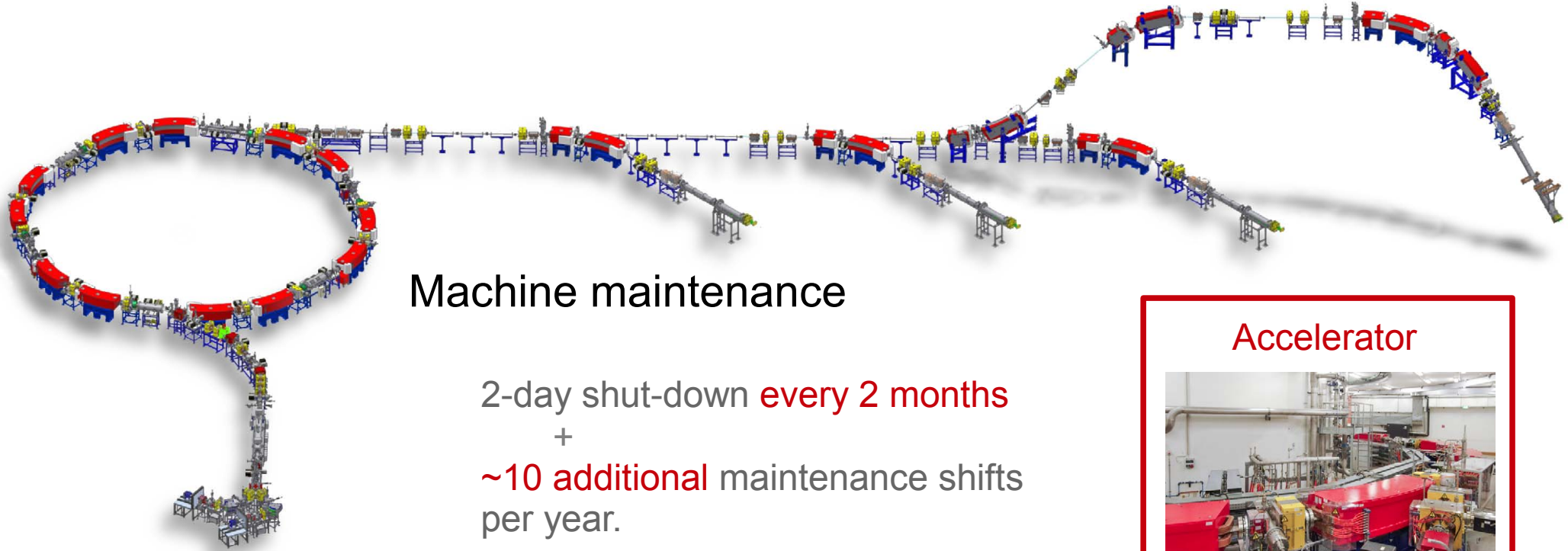
Machine maintenance

2-day shut-down **every 2 months**
+
~10 additional maintenance shifts per year.

Operating

Machine manned **24/7** by **2 operators**
+
3 experts on call

Accelerator

18 ❗
Physicists, engineers, technicians

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The Accelerator Operations Team: Duties
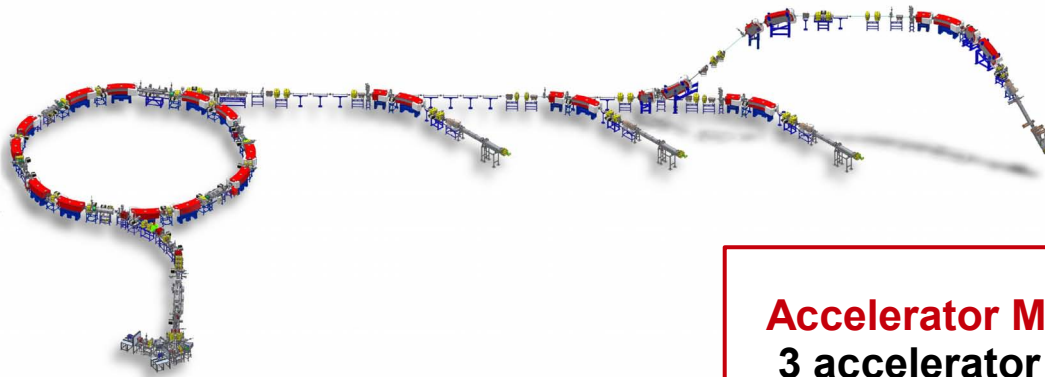
Accelerator Management
3 accelerator physicists
(1 head + 2 deputies)

IS/VAC/BD

*Ion sources (IS),
vacuum systems (VAC),
beam diagnostics (BD),
cooling system*

**2 engineers,
3 technicians**
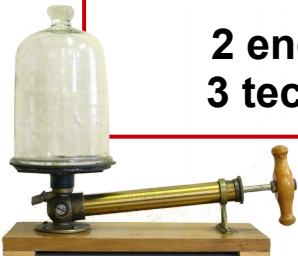
**Magnet power supplies
+ RF amplifiers**

**2 engineers,
3 technicians**

**Accelerator Control
System**

**1 physicist,
2 engineers,
2 technicians**

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The Accelerator Operations Team: Duties

Control room manned by 2 operators around the clock

→ need 6 operators per day (2 x 3 shifts of 8 hrs)

+
3 experts on call

1 for each of the 3 sub-system categories

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The Accelerator Operations Team: Duties

Shift distribution: Fixed ~1-2 months ahead by head of accelerator operations.

Operators may express preferences ...

Max. 5 night shifts in a row

usually 1 weekend per month with on-call duty

15 free Sundays per year

The Accelerator Operations Team: Duties

4:00 – 6:00 AM

Daily monitoring and evaluation of beam properties as part of QA

→ **Each operator** needs understanding of basic machine and beam properties. (in addition to his expert skills!)

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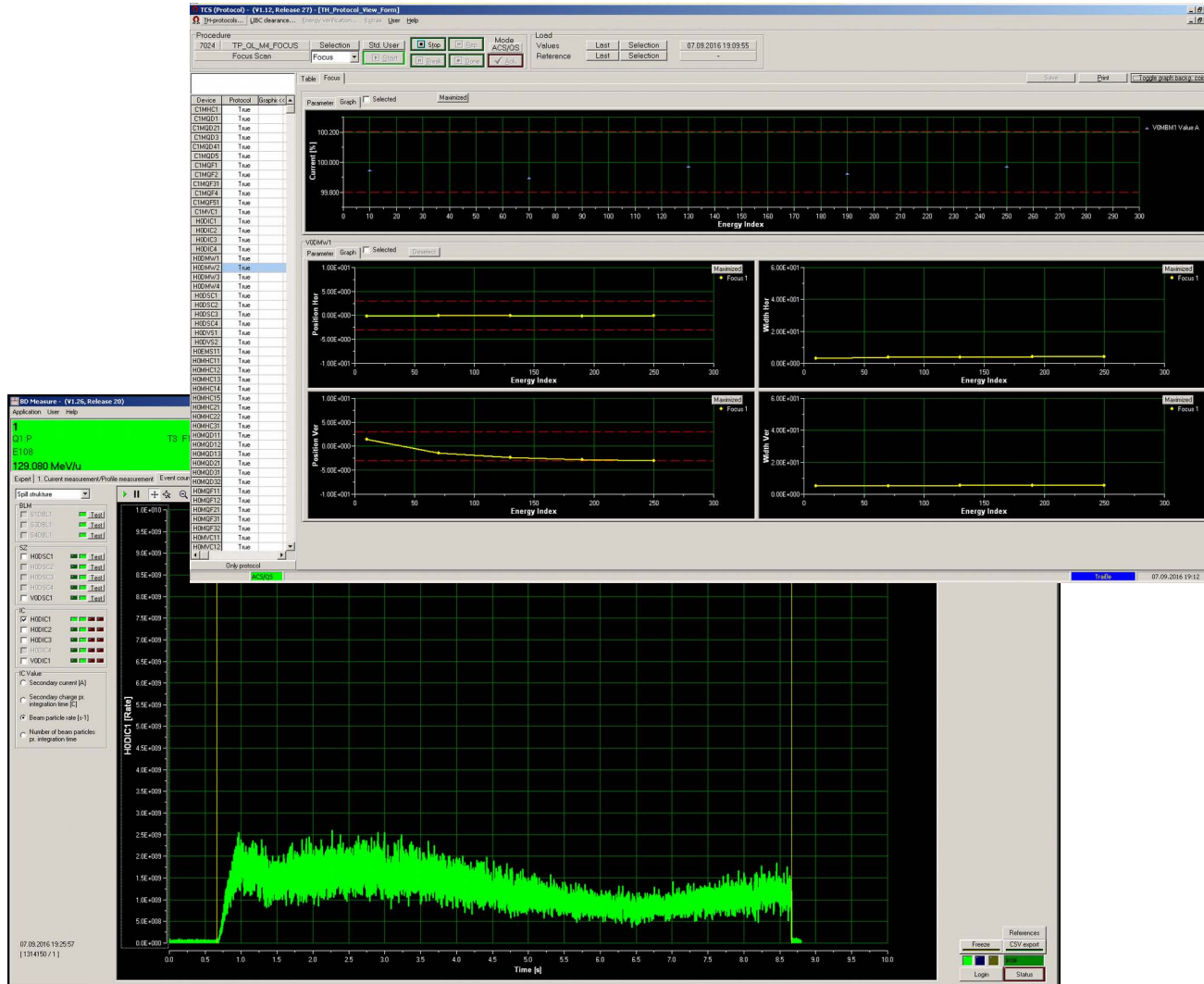
The Accelerator Operations Team

Hiring process

Sept. 2014

Foundation of MIT GmbH

From Feb. 2015

Machine recommissioning
→ In the beginning, mostly **HIT acc. experts**.

Sept. 2015

Hiring of MIT accelerator staff almost complete

Oct. 2015

First medical treatment

Employees MIT-Acc-Team
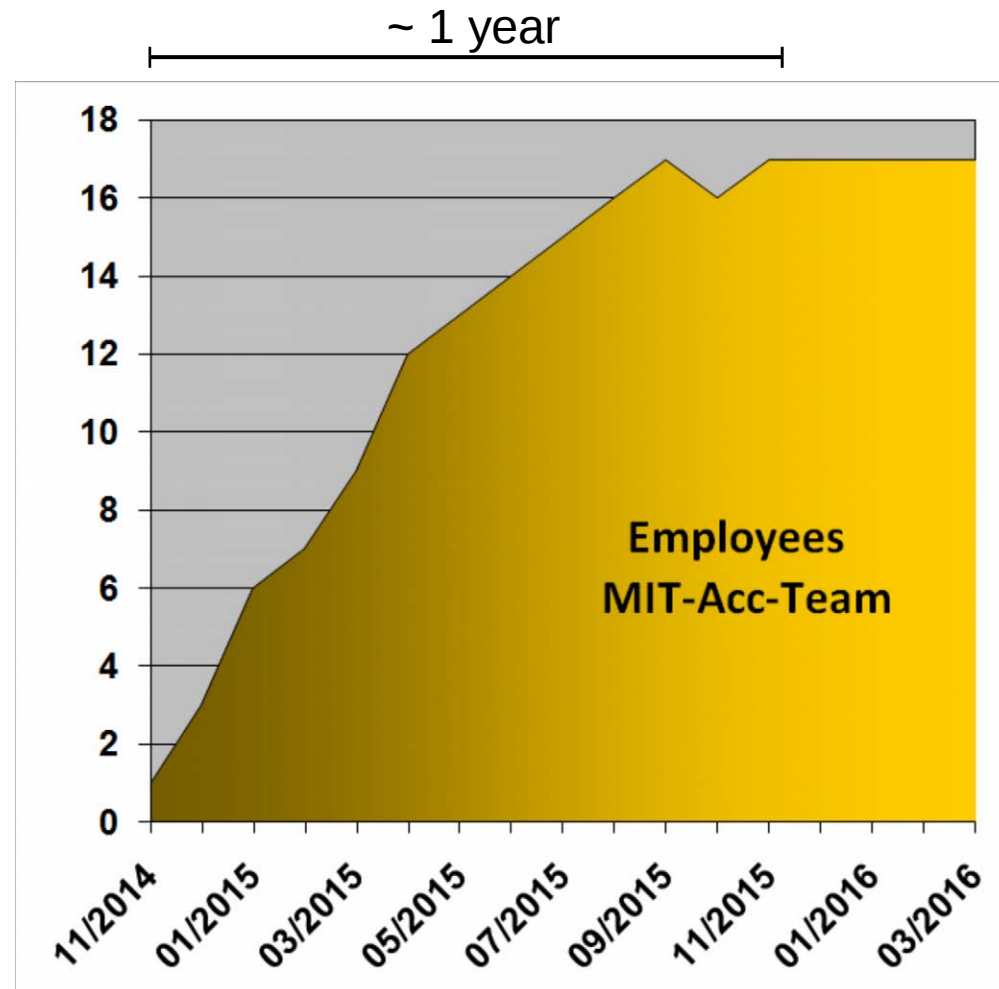
The Accelerator Operations Team: Training

Engineers, technicians

Good expert skills, partly previous working experience in their special field.

But: Mostly no experience in particle accelerators.

Physicists

All with previous work experience at research accelerators
(GSI/FAIR, S-DALINAC, MPI for Nuclear Physics)

But: No experience in therapy application of ion beams.

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The Accelerator Operations Team: Training

Lecture series

General operating,
Accelerator physics,
Beam diagnostics,
Power supplies, RF amplifiers, vacuum systems,
Control system (manufacturer) …
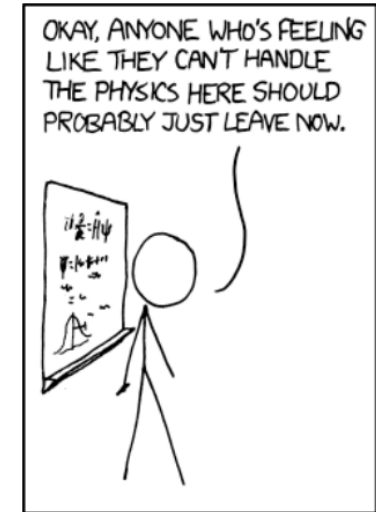
Hands-on experience (during beam commissioning)

20 shifts manned jointly by 1 HIT accelerator
physicist and 1–2 MIT operators.

Hand-over from Siemens HC acc. experts

Knowledge transfer: Acc. + Infrastructure
Had a working machine configuration.

OKAY, ANYONE WHO'S FEELING LIKE THEY CAN'T HANDLE THE PHYSICS HERE SHOULD PROBABLY JUST LEAVE NOW.

xkcd.com

The Accelerator Operations Team: Achievements

Nov. 2014
Start of recruiting …

Feb. – March 2015
Recommissioning of linac and synchrotron.

April – July 2015
Optimisation of extraction and horizontal HEBT.

August 2015
Commissioning of 45° HEBT.

September 2015
Clearance for medical application (2 horizontal beam outlets).

October 2015 (27th)
First medical treatment, Start of routine operations

January 2016
Clinical commissioning of 45° HEBT and 3rd horizontal outlet.
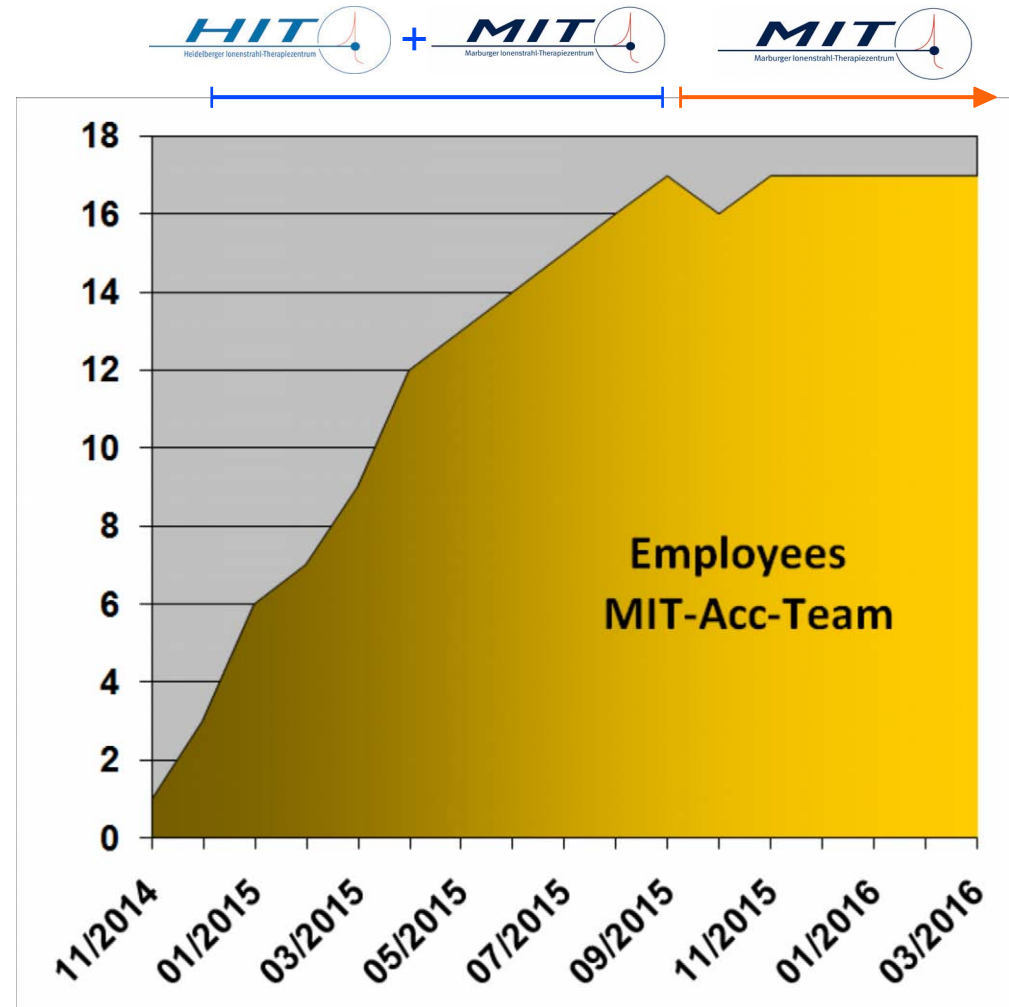
Employees MIT-Acc-Team

The Accelerator Operations Team: Achievements

Examples

Quality of beam delivered to Treatment Room 1 (horizontal)

→ Much better than medical requirement!

Scheeler at al., Proc. of IPAC 2016

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The Accelerator Operations Team: Achievements

Examples

Quality of beam delivered to Treatment Room 1 (horizontal)

→ Much better than medical requirement!

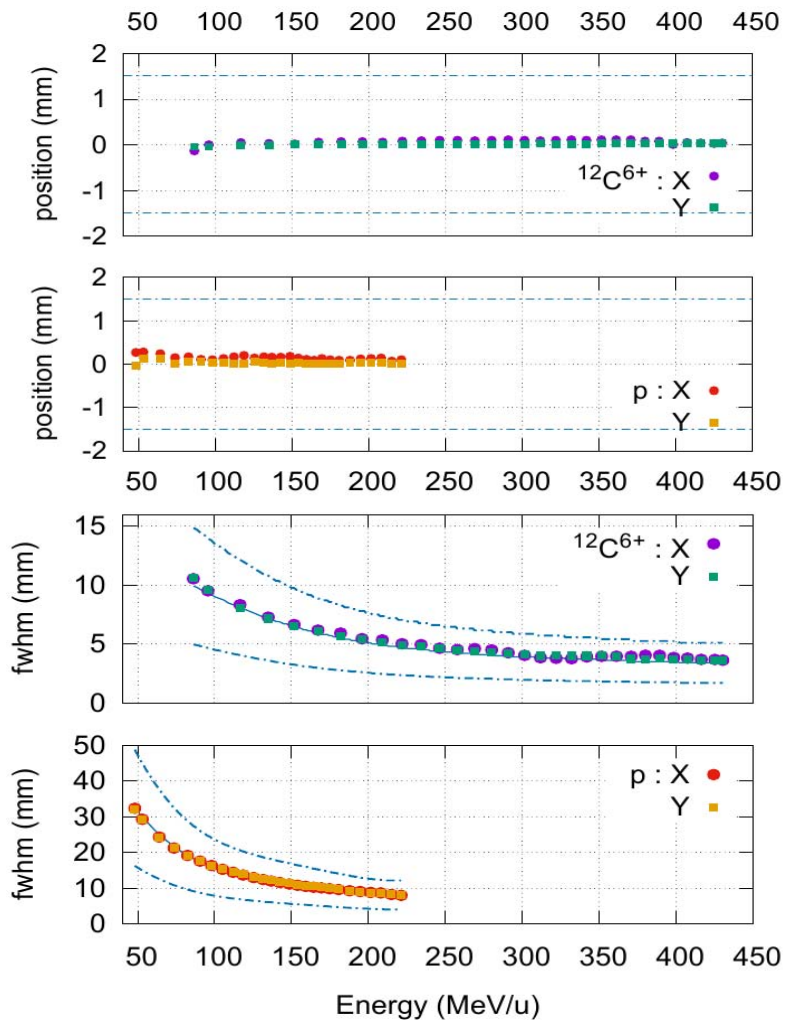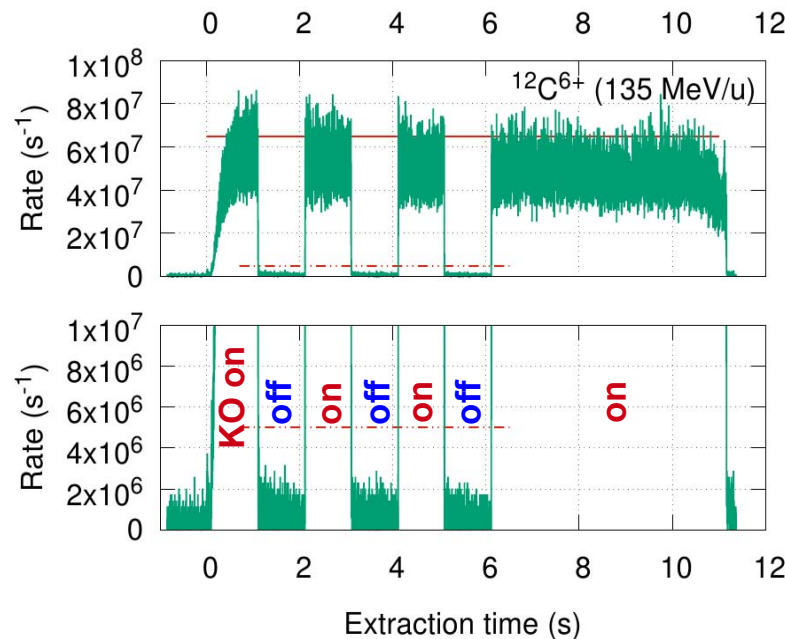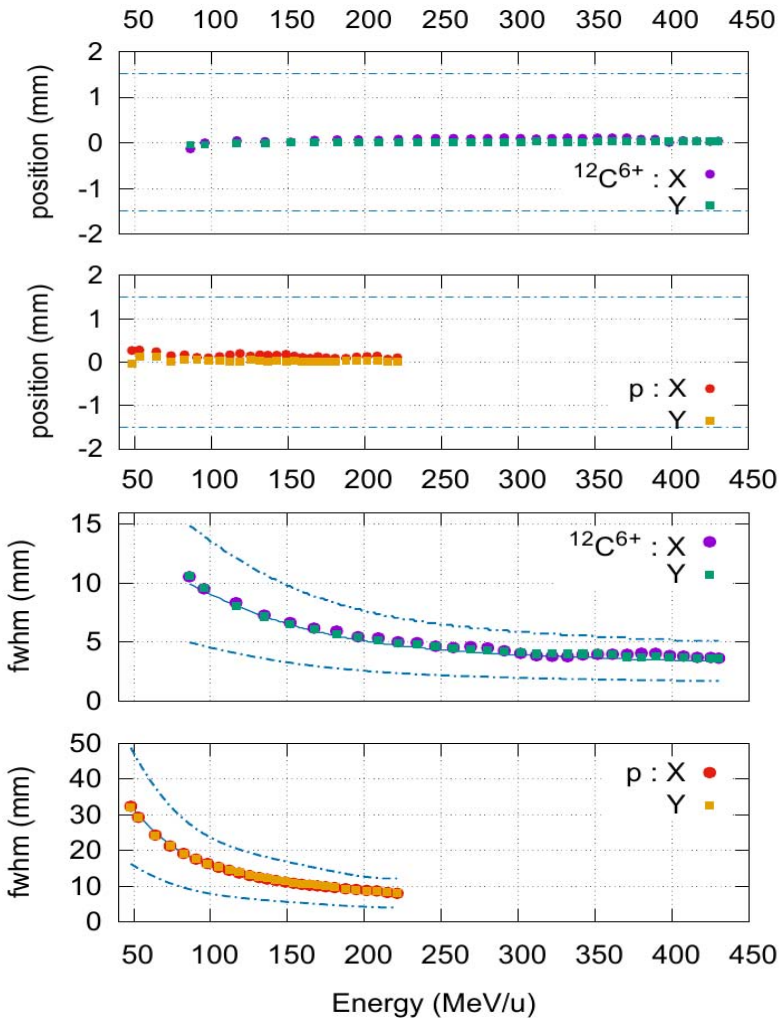Response to Dynamic Intensity Control (KO-exciter amplitude)

Scheeler at al., Proc. of IPAC 2016

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The Accelerator Operations Team: Outlook

Development projects (accelerator-related)

Improvement of Accelerator Control System

Upgrade of ion source extraction system (developed at HIT)

[T. Winkelmann et al. Proc. of ECRIS 2014]

Initial planning stage: 5th cave for non-clinical applications + experiments.

Organisational

Employ students as assisting operators (inspired by HIT)

→ Support operations team, especially during week-ends.

→ Establishes contact to local universities and academia.

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Thank You!

MIT — Marburger Ionenstrahl-Therapiezentrum

U. Scheeler
C. K.
S. Sievers
M. Strohmeier
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M. Galonska   T. Winkelmann
K. Höppner   A. Peters
J. Mosthaf   Th. Haberer

UniversitätsKlinikum Heidelberg

RHÖN-KLINIKUM AKTIENGESELLSCHAFT