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The new Cyclotron Laboratory in Bern

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Outline

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- The SWAN Project in Bern
- The new cyclotron laboratory for radioisotope production and research
- Development of a beam monitor detector based on doped silica and optical fibres
- Conclusion and outlook

The SWAN Project in Bern

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- Initiated in 2007 by the Inselspital and the University of Bern

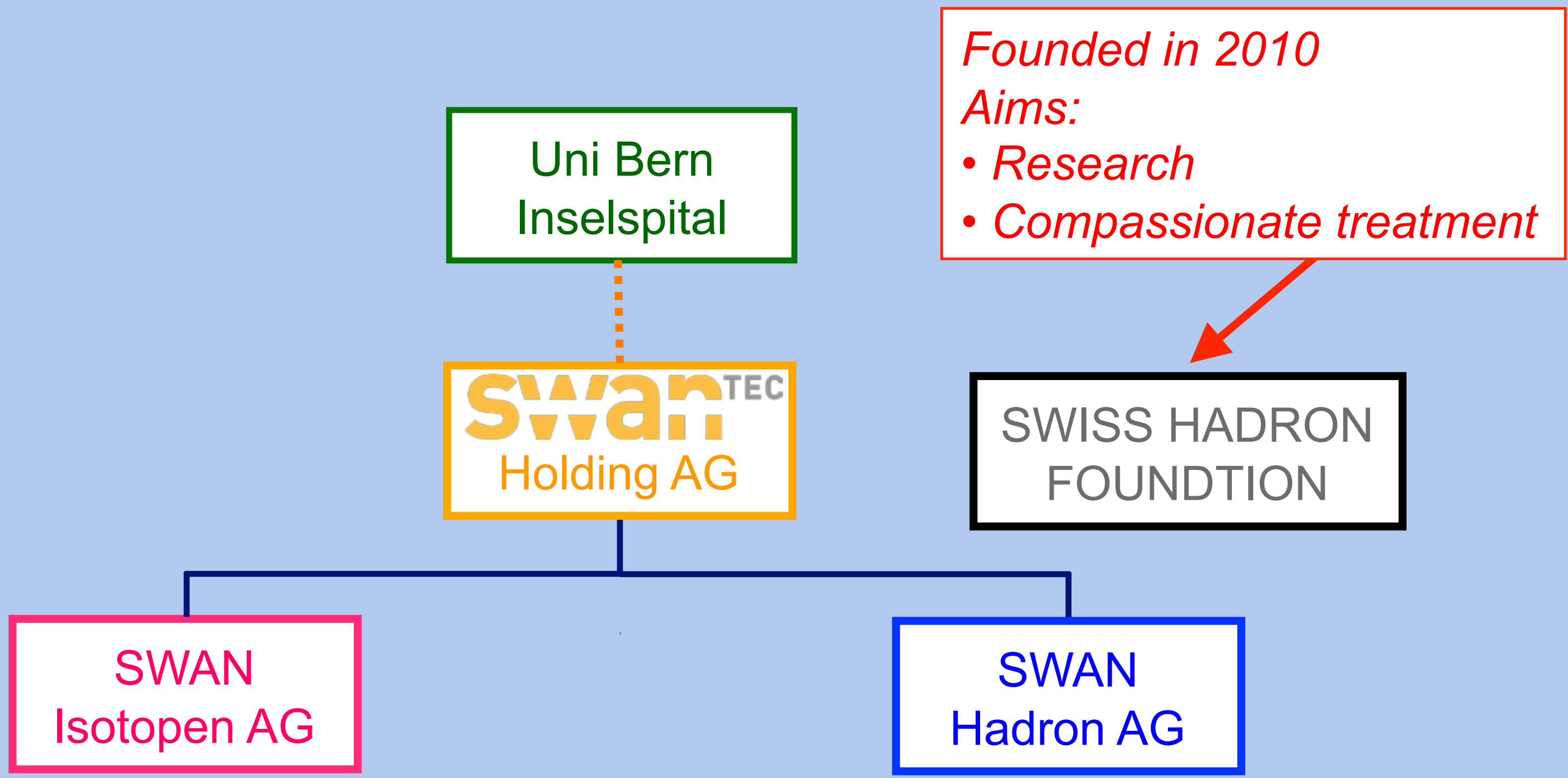
- SWAN stands for SWiss hAdroNs

- Aims:
  1. Production of radiopharmaceuticals, for PET diagnostics in particular
  2. Proton therapy
  3. Multi-disciplinary research

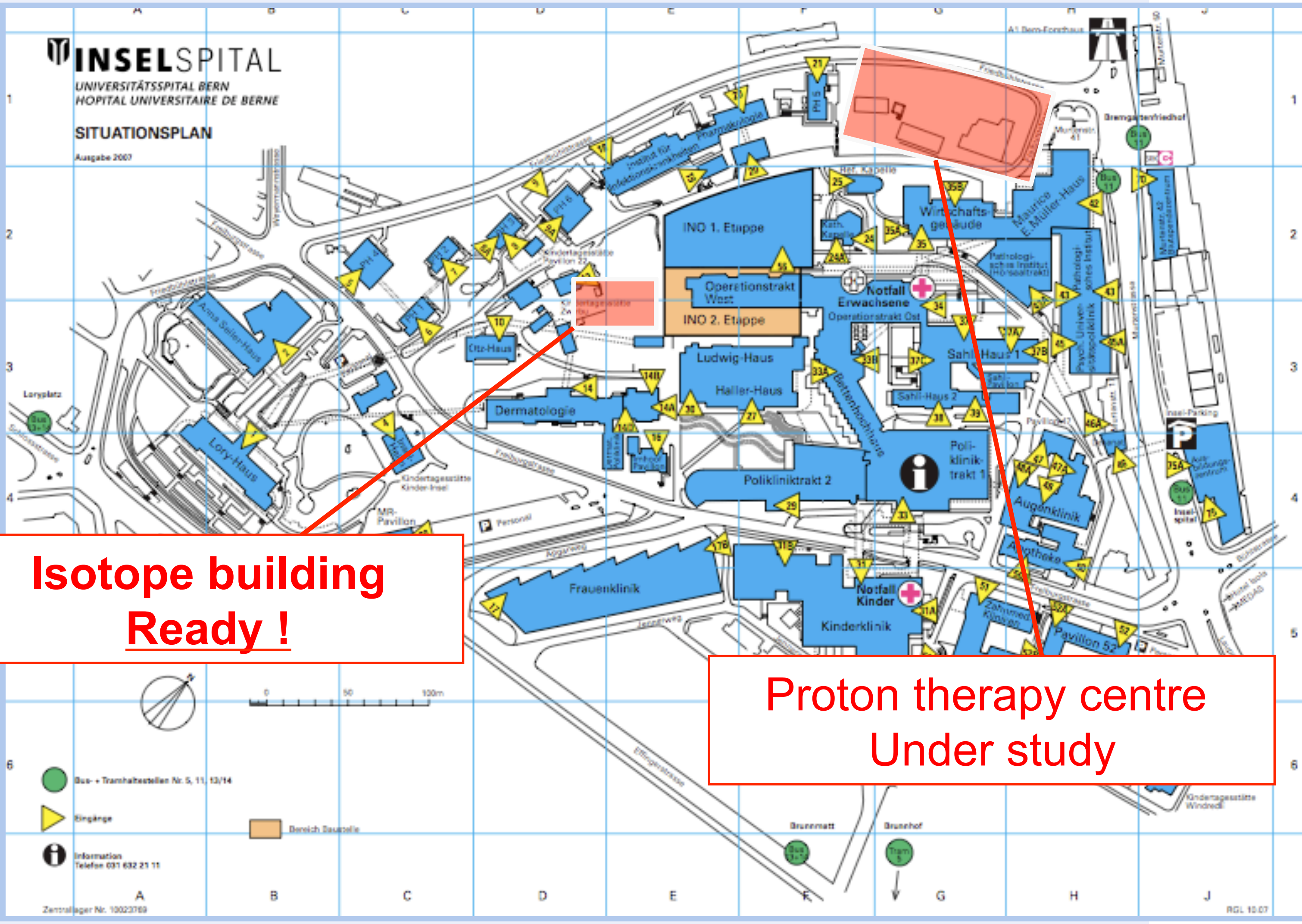
- Phases:
  1. Cyclotron laboratory for radioisotope production and research
  2. Proton therapy centre

The structure of SWAN

> SWAN is based on the synergy between public institutions and private investors



Present status of the project



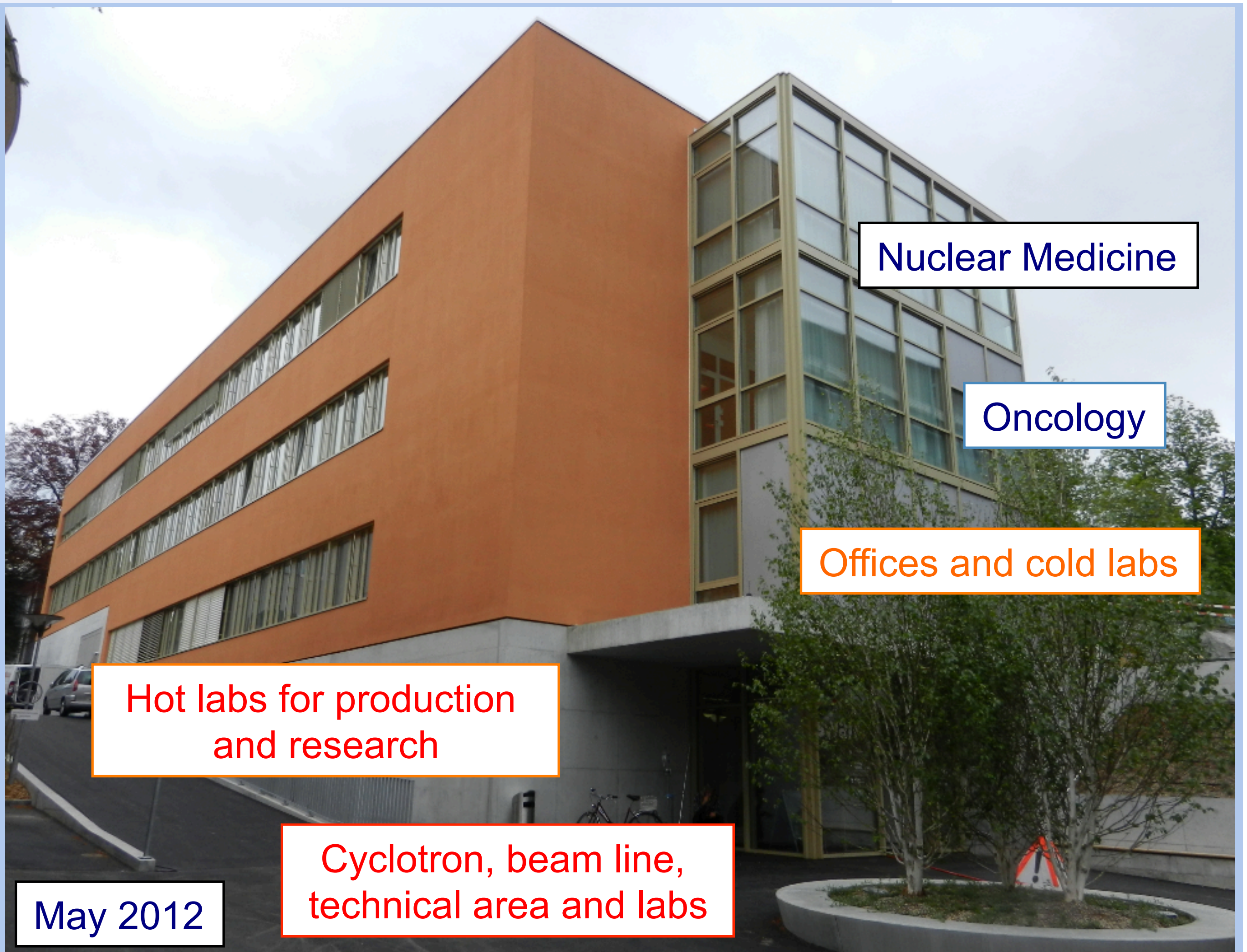
Isotope building
Ready !

Proton therapy centre
Under study

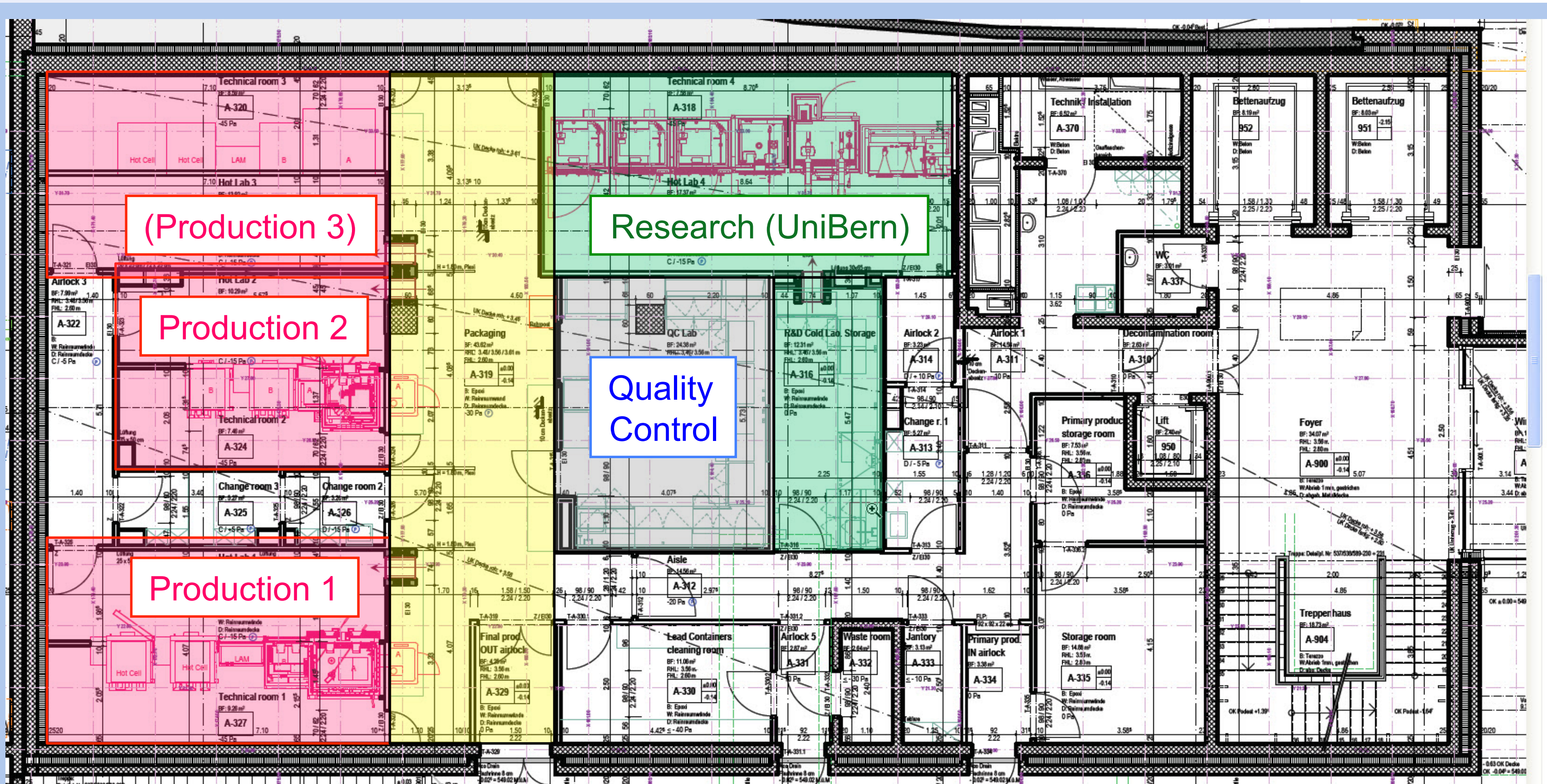
A multi-function building

The cyclotron bunker
June 2010

The cyclotron rigging
June 2011



The hot labs



- 3 GMP production labs (FDG, ^{18}F compounds, future developments)
- One multi-function research lab (Prof. A. Türler – UniBern and PSI)
- Hotcells by TEMA Sinergie (Italy)

GMP production radiopharmacy labs

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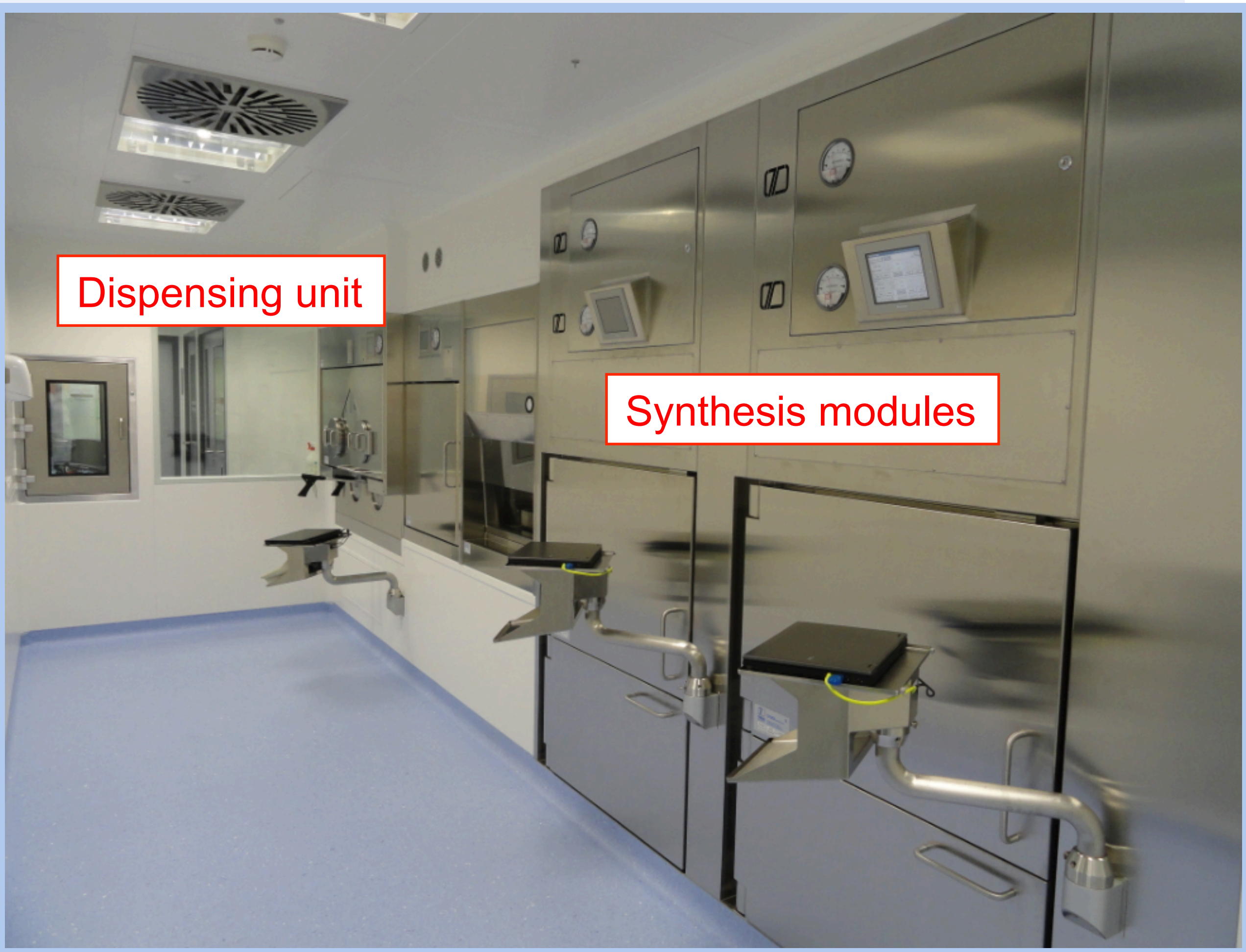
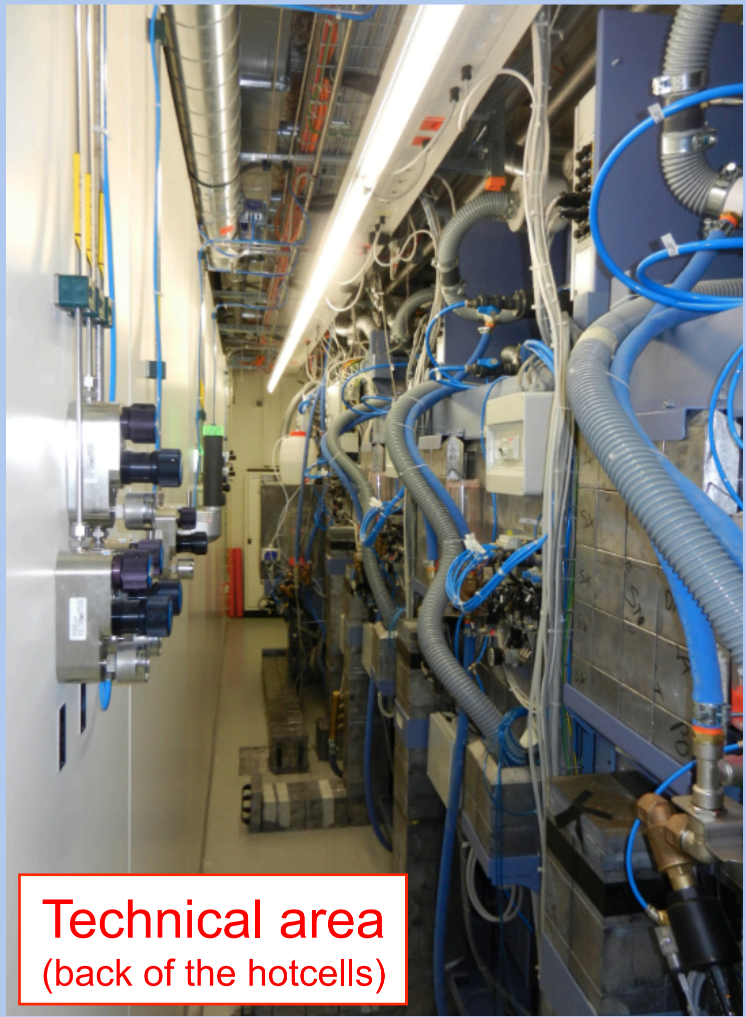
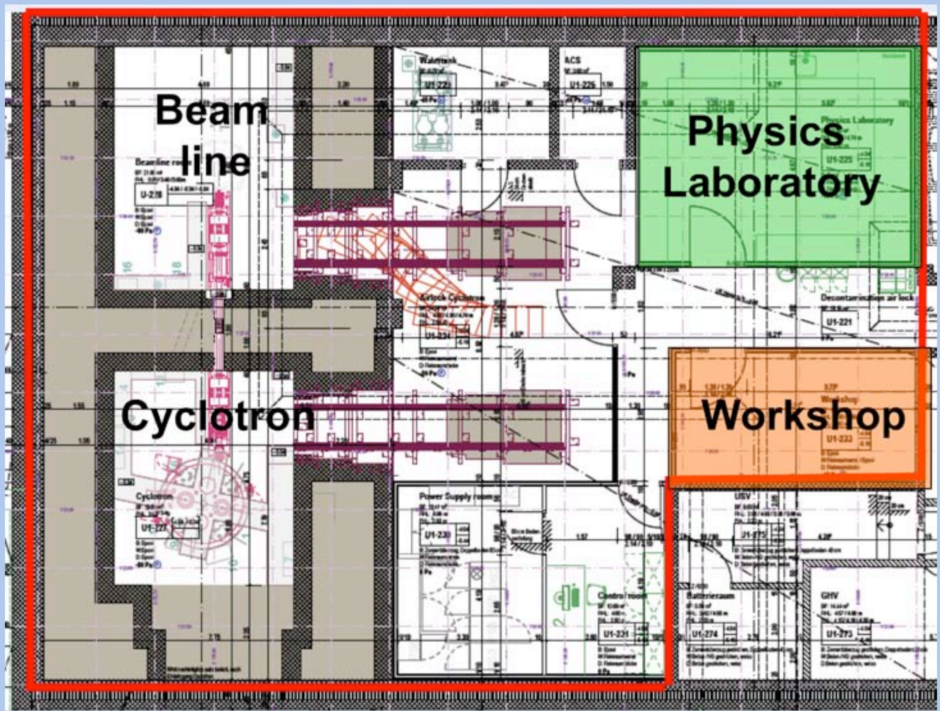


> Fully automated 18-FDG GMP production

The radiochemistry and radiopharmacy research lab



The cyclotron



- IBA 18 MeV "twin" high current cyclotron (two H^- ion sources)
- 7 out ports (4 ^{18}F liquid targets, 1 ^{15}O gas target, 2 spare)
- External beam line in a separate bunker + research laboratories
- First beams February 7th, 2012

Commissioning and Site Acceptance Tests

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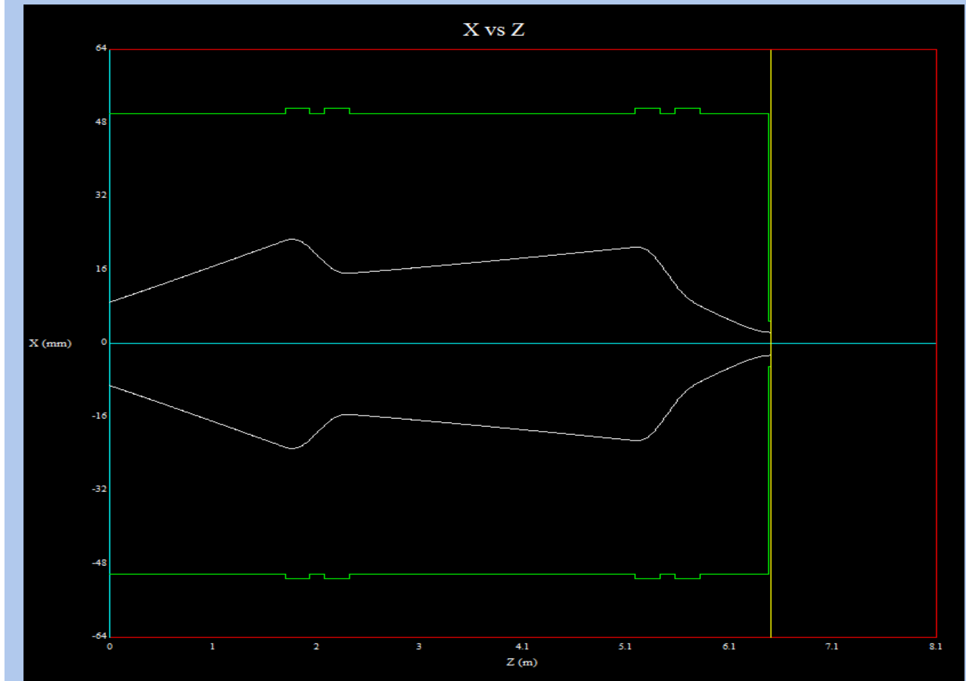
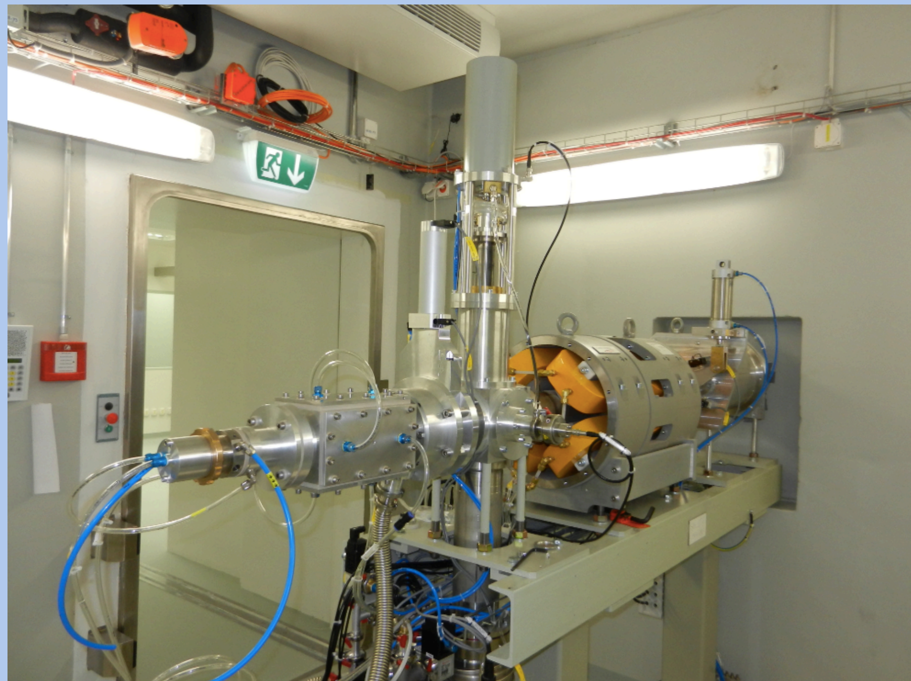
- Optimization of the cyclotron
  - Ion source
  - Central region (B field)
  - Radio frequency
  - Control system (software)
- High current tests on beam dump
  - 150 μA on target for 4 hours with both ion sources (single beam)
  - 75 μA + 75 μA on target (dual beam)
  - 100 μA + 50 μA on target (asymmetric dual beam)
- ^{18}F and FDG production (4 targets)
  - 9.6 Ci of ^{18}F in single beam (2 hours of irradiation at 80 μA)
  - 13.5 Ci (500 GBq) of ^{18}F in ≈80 minutes (75 μA +75 μA – dual beam)

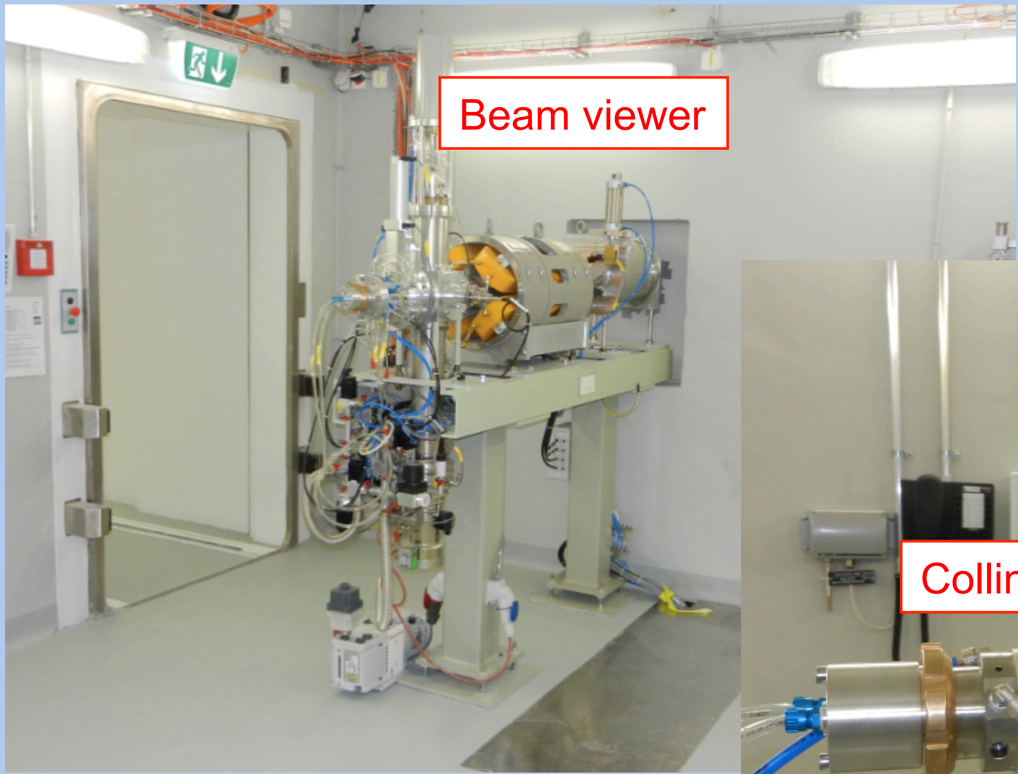
The external beam line

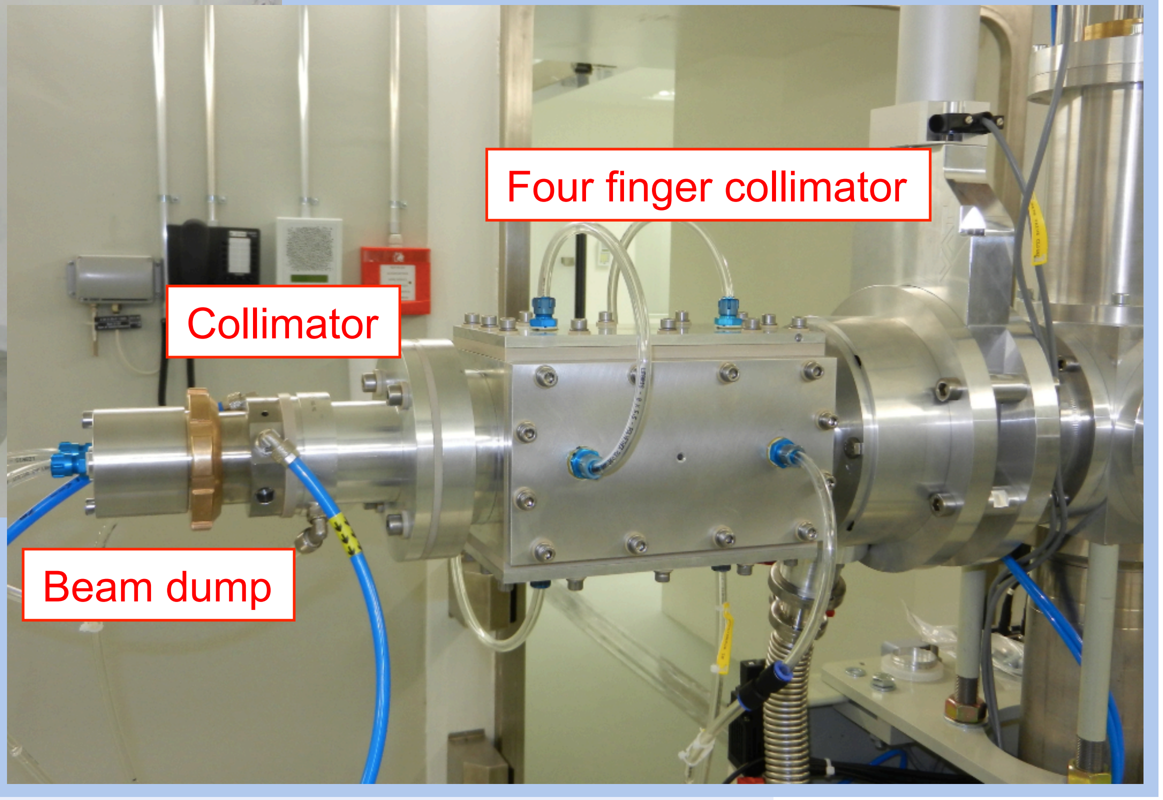




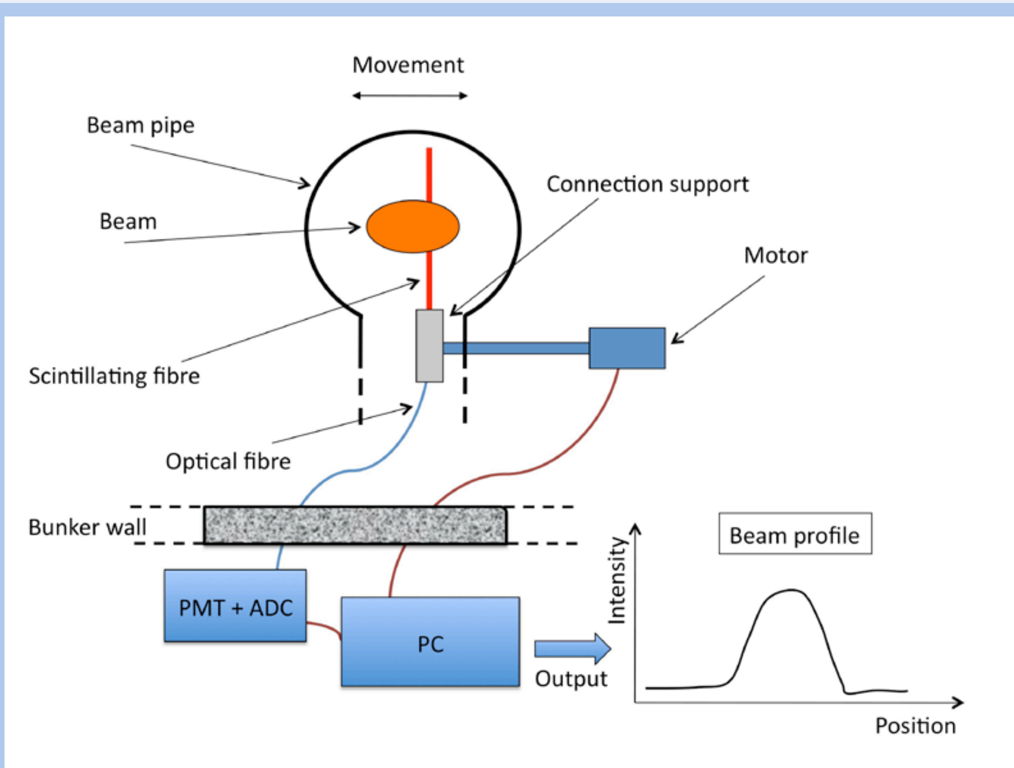
- 6 m long beam line with 2 quadrupole doublets and a neutron shutter
- Research and training activities: novel detectors, radiation biophysics, radioprotection, radiochemistry, radiopharmacy, material sciences, …
- Commissioning and tests under way

Beam monitoring



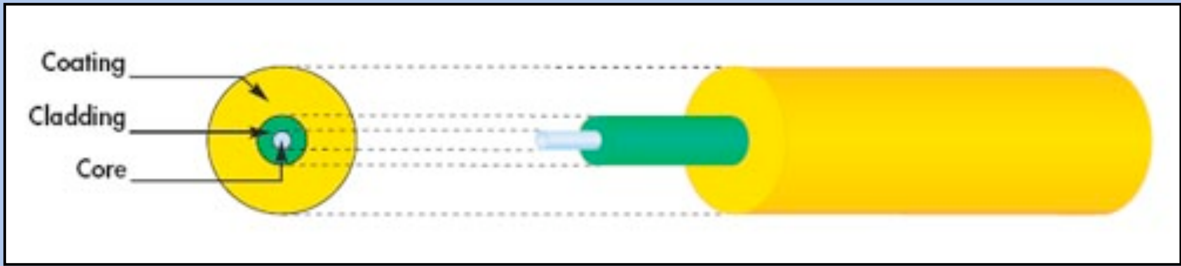


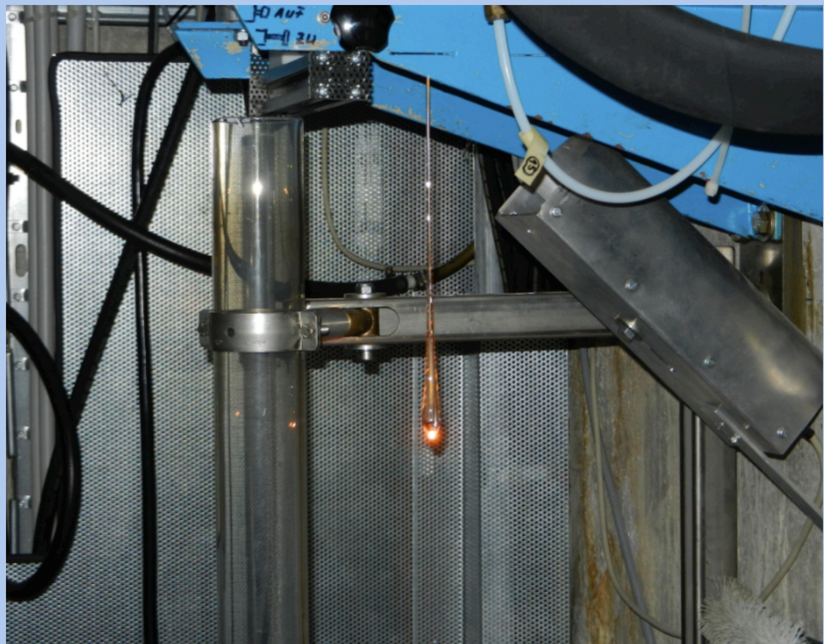
A beam monitor detector based on doped silica and optical fibres



- Goal: general purpose device for low currents (nA) and high currents (μA), continuous and pulsed beams
- Principle: a sensing fibre is moved through the beam
- For details: S. Braccini et al., 2012 JINST 7 T02001 and arXiv:1110.1583

Construction of the doped silica sensing fibres at the IAP of Uni Bern

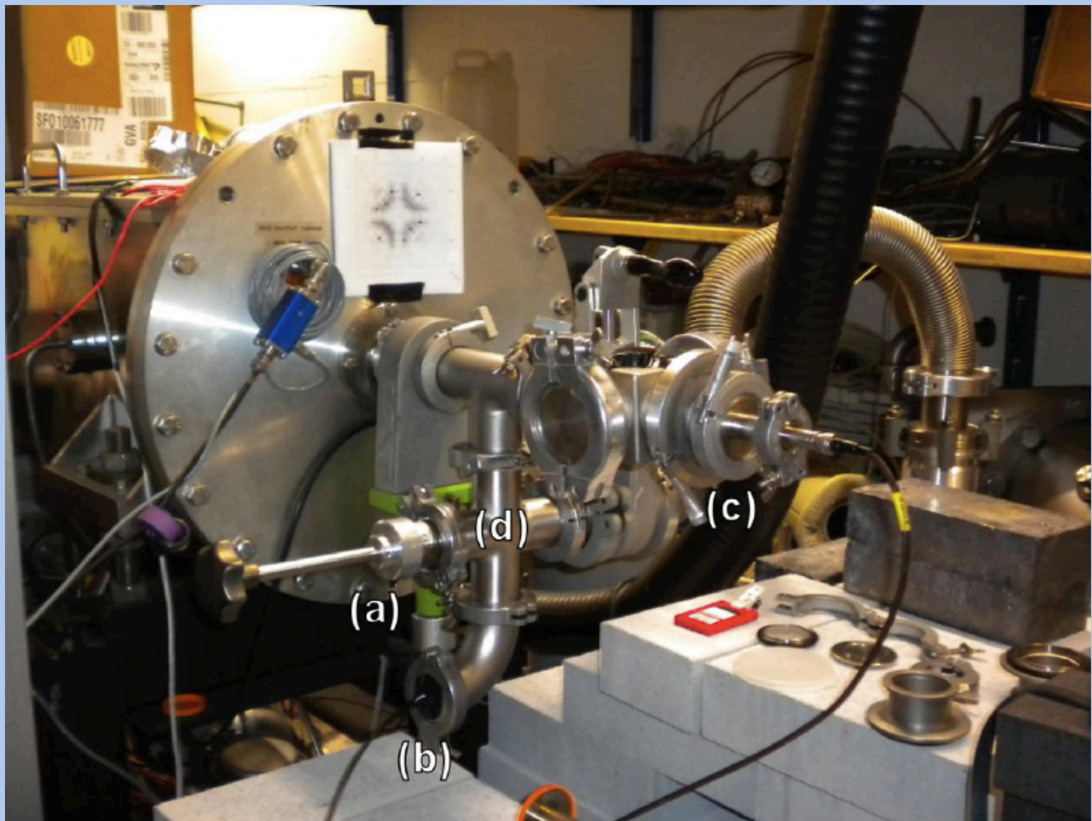




M. Neff et al., Optical Materials 31 (2008) 247–251

- Sensing fibre: good light yield + heat and radiation resistant
- Developed for laser applications
- Relatively simple method using a pre-form filled with granulated oxides
- Possible dopants: Ag, Pb, Sb, Ta, ...
- Sb^{3+} (0.5%, 500 μm diameter) doped fibres selected

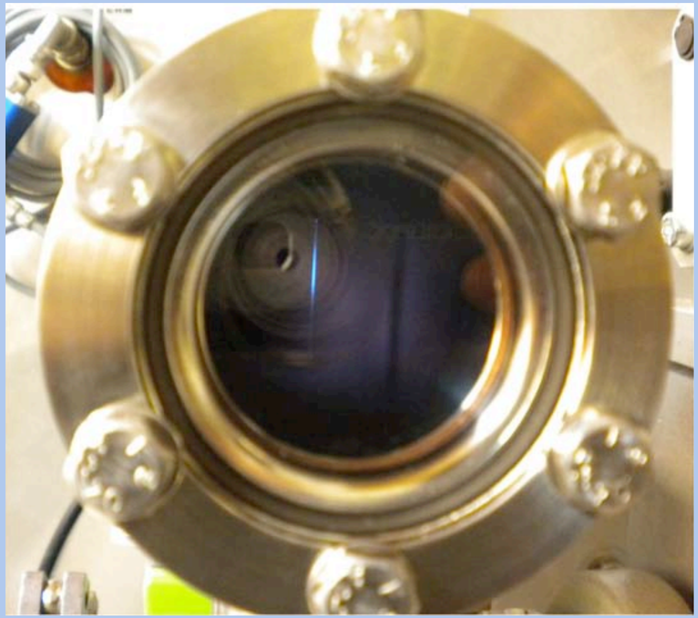
The first prototype detector

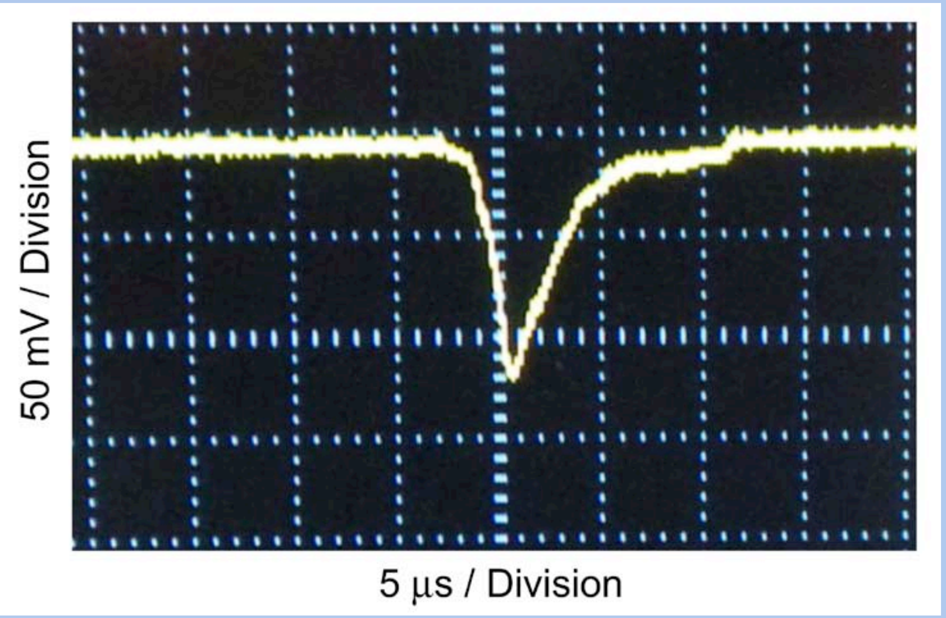


Beam tests with the 2 MeV RFQ linac at LHEP

- Use of KF40 commercial vacuum components
- Movement: vacuum tight linear feed through (a)
- Sensing fibre: fragile, attenuation db/m
- Coupling to a commercial optical fibre (db/Km) in (d)
- Feed through to extract the optical signal in air (b)
- Faraday cup (c)

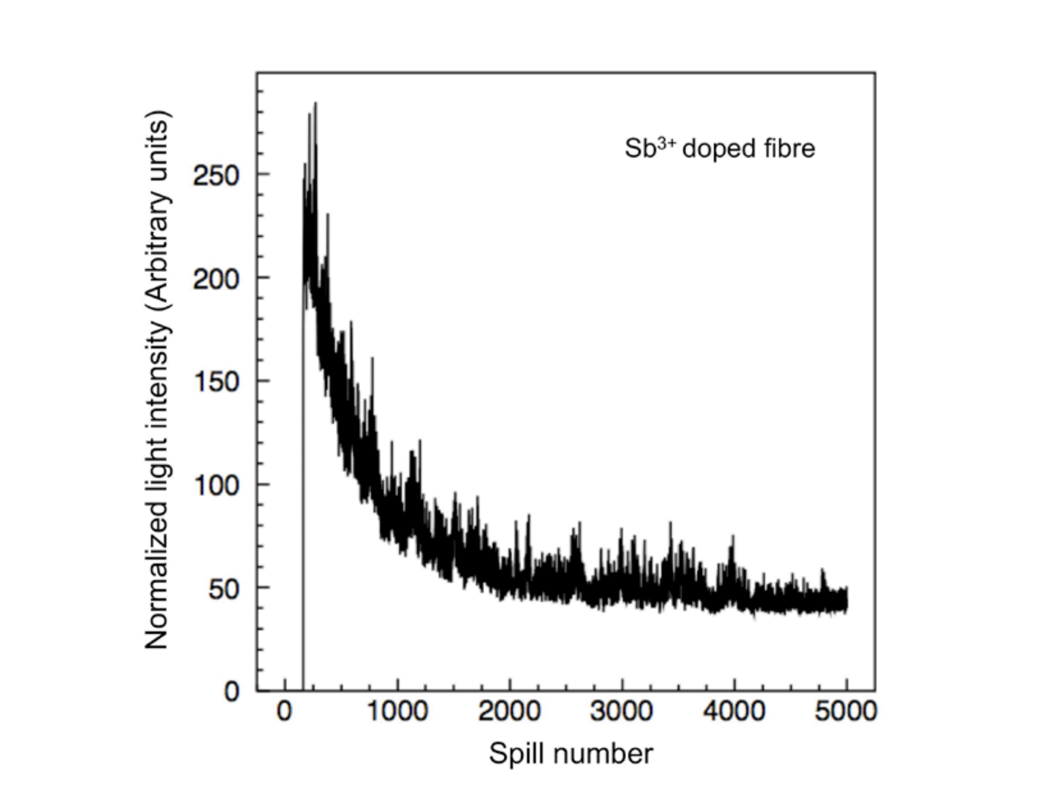
Beam tests at 2 MeV





- Beam: H^- at 2 MeV, pulsed at repetition rate 50 Hz, average current 0.8 µA, cross section at the detector ≈1 cm^2 (circular)
- Read out: photomultiplier + peek sensitive ADC
- Read out with photodiodes under development

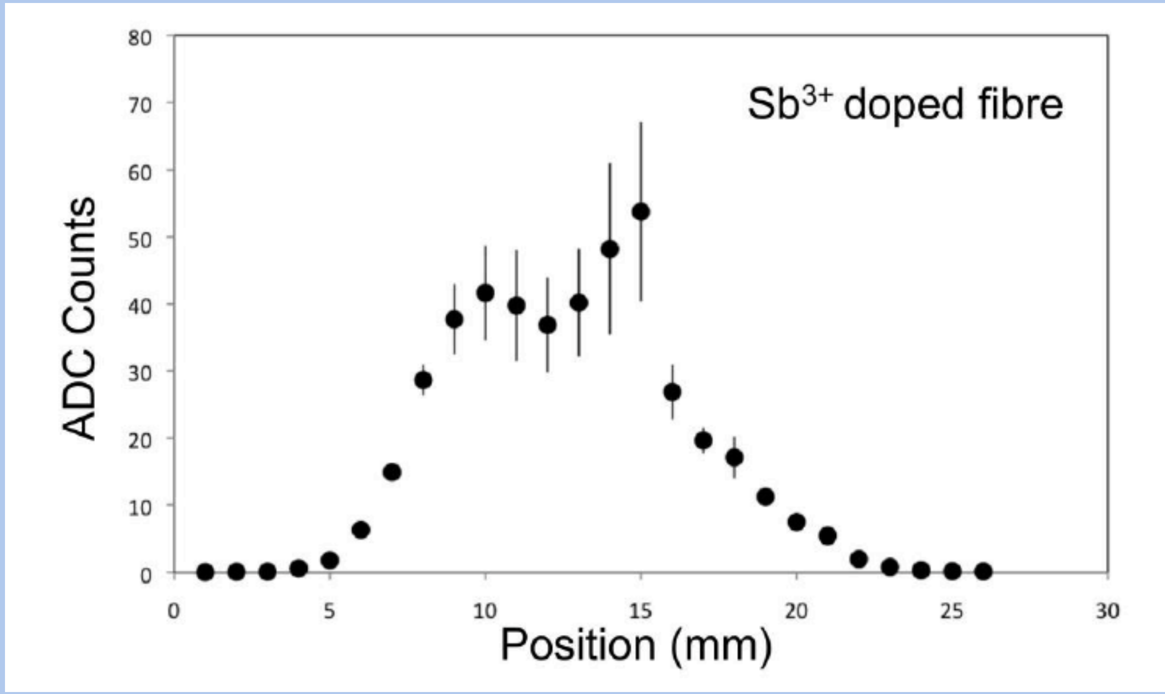
Scintillating properties of the Sb doped fibres



The light yield diminishes by rising the temperature
Equilibrium temperature estimated to be 580 K
No permanent damage observed so far

- Sb doped fibres studied for the first time
- Light yield estimated with a ^{90}Sr source (MeV beta): 0.4% of the deposited energy
- Range of 2 MeV protons in glass: 45 µm
- Light emission peaked at 490 nm (blue)
- About 10^{10} protons hit the fibre per pulse, giving 37500 photoelectrons
- Large signal!

Beam profile measurement



- The beam profile is well reproducible
- The asymmetry is a known feature of the accelerator
- The structure of the beam can be investigated with a precision better than 1 mm

Conclusions

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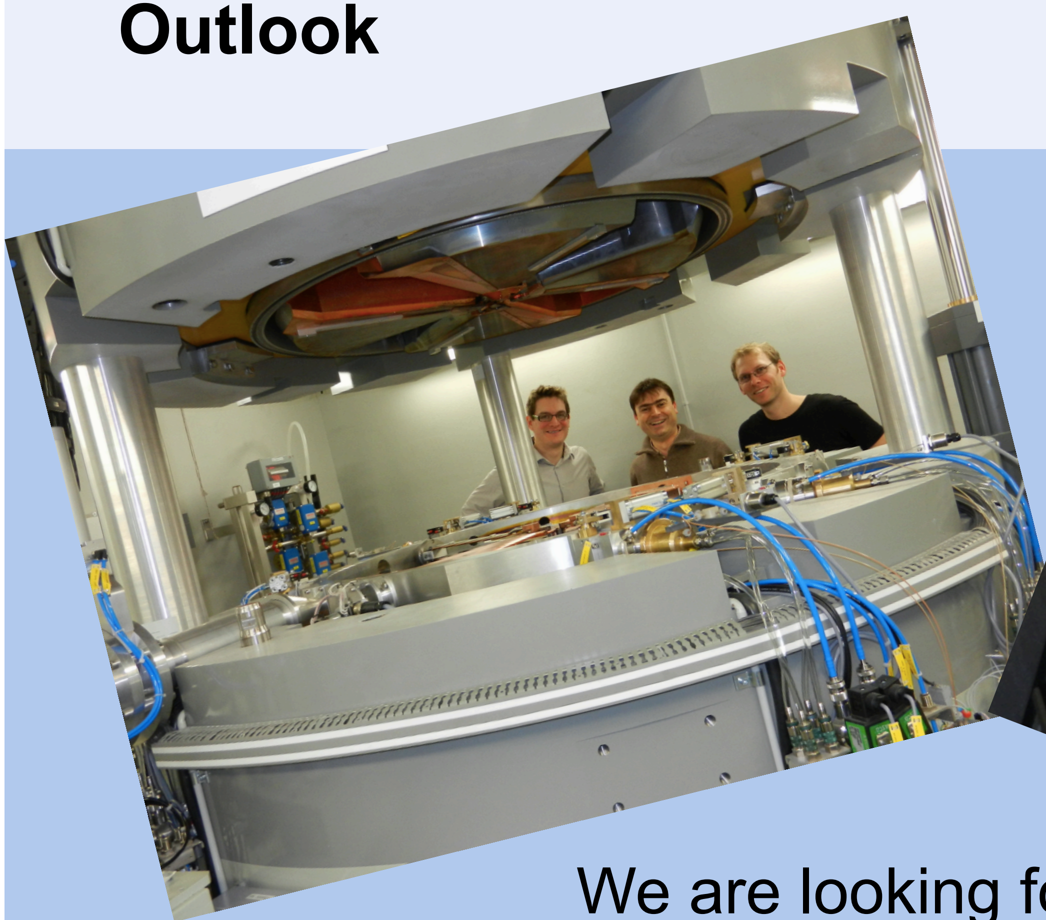
> The new cyclotron laboratory for radioisotope production and research in Bern has been constructed and the cyclotron has been successfully tested

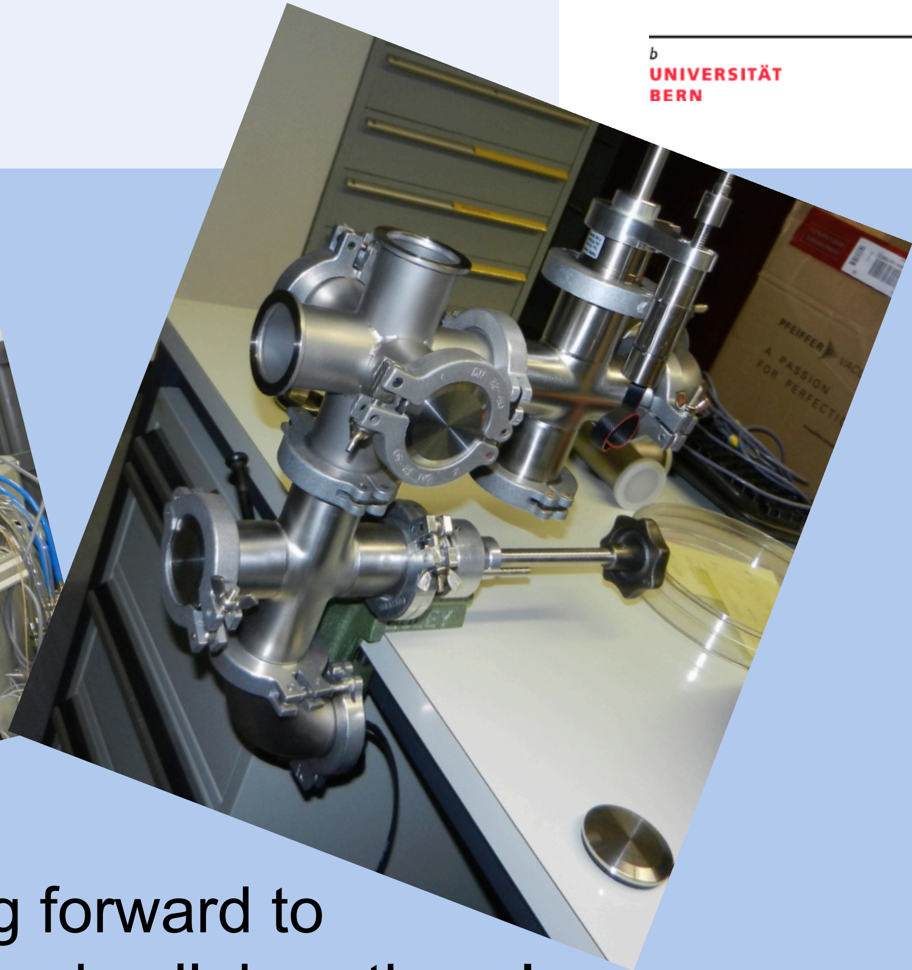
> An innovative general purpose beam monitor detector based on doped silica and optical fibres has been conceived, constructed and tested

> A motorized 2-dimensional beam profiler for the research beam line is under development

> Ta doped fibres are under study together with photodiode read out

Outlook





We are looking forward to
interesting research and collaborations !

On behalf of:
S.B., A. Ereditato, P. Scampoli (UniBern),
J. Knüsel, C. Topfel and K. von Bremen (SWAN)