

# An online beam monitor detector for medical applications of ion beams

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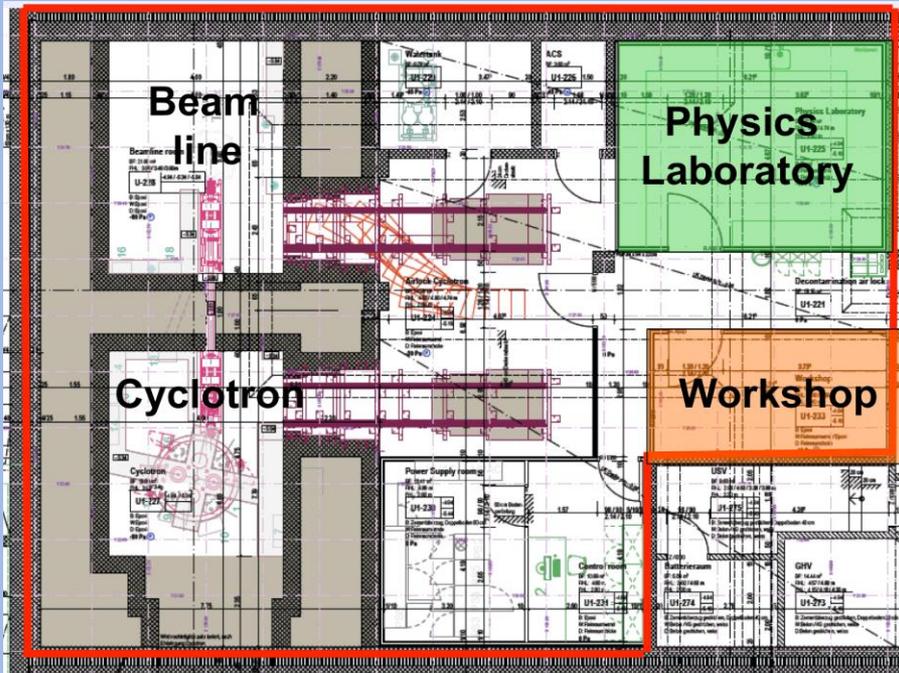
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# Background and aims

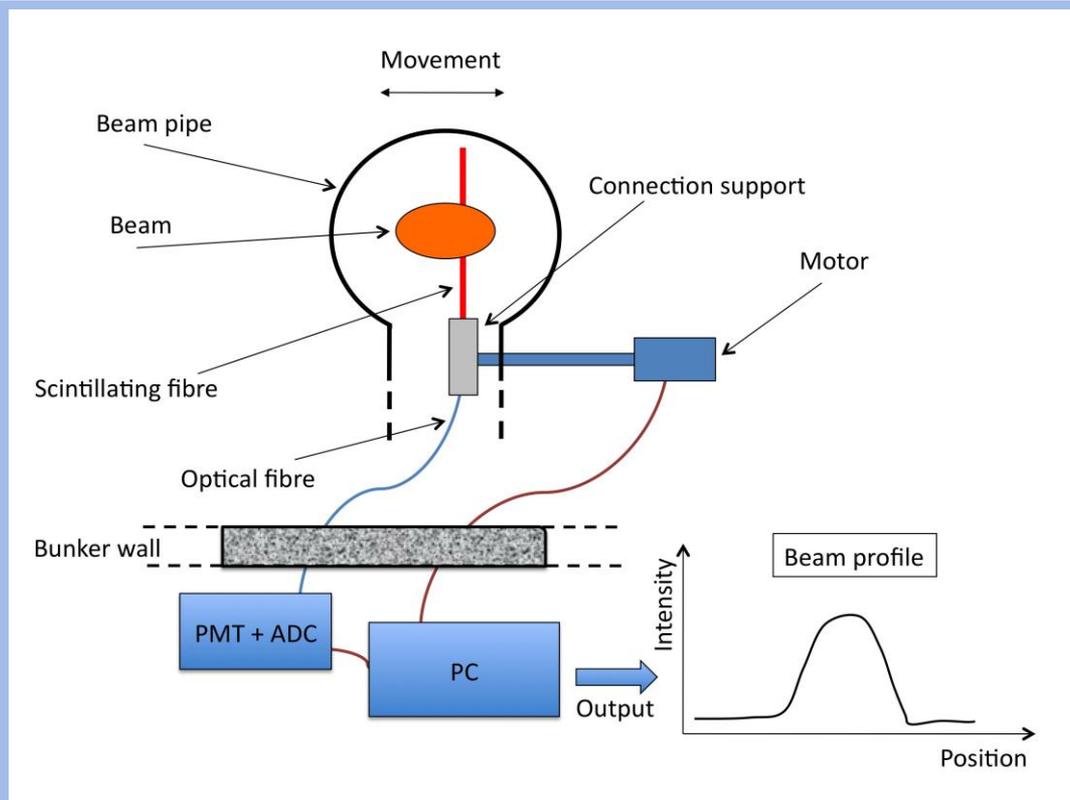
- > Beam monitoring is essential in medical applications
  - > Hadrontherapy (ex. protons: 200 MeV, < 1 nA)
  - > Radioisotope production (ex. protons: 20 MeV, 10-100  $\mu$ A)
- > Beam monitoring detectors:
  - > Destructive
  - > Non-destructive
- > Non-destructive beam monitoring techniques are investigated in Bern
  - > Continuous monitoring during irradiation
  - > Large beam intensity range: from < 1 nA to > 10  $\mu$ A
  - > Compact detectors

# The Bern medical PET cyclotron and its Beam Transport Line (BTL)



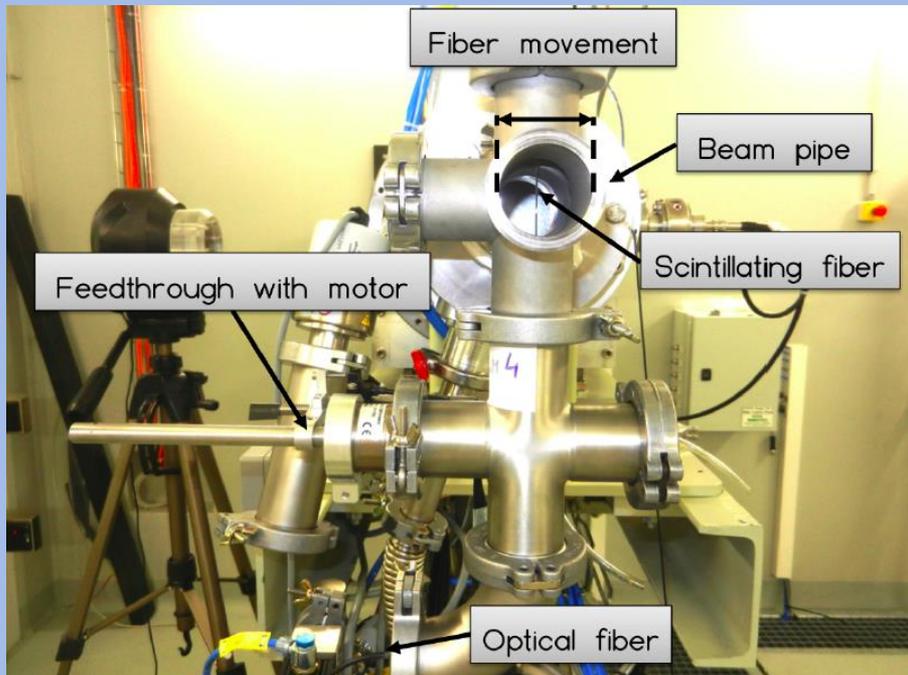
- > IBA 18 MeV high current cyclotron (up to 150  $\mu$ A)
- > Daily production of  $^{18}\text{F}$  for FDG
- > **External beam line in a separate bunker: production + research**
- > Specific method to produce currents down to 1 pA

# Universal Beam Monitor (UniBEaM)



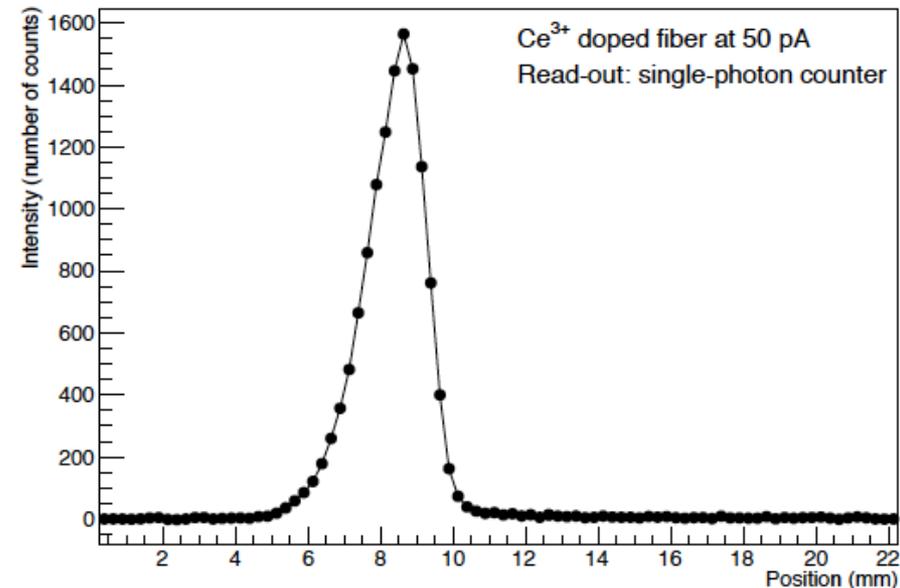
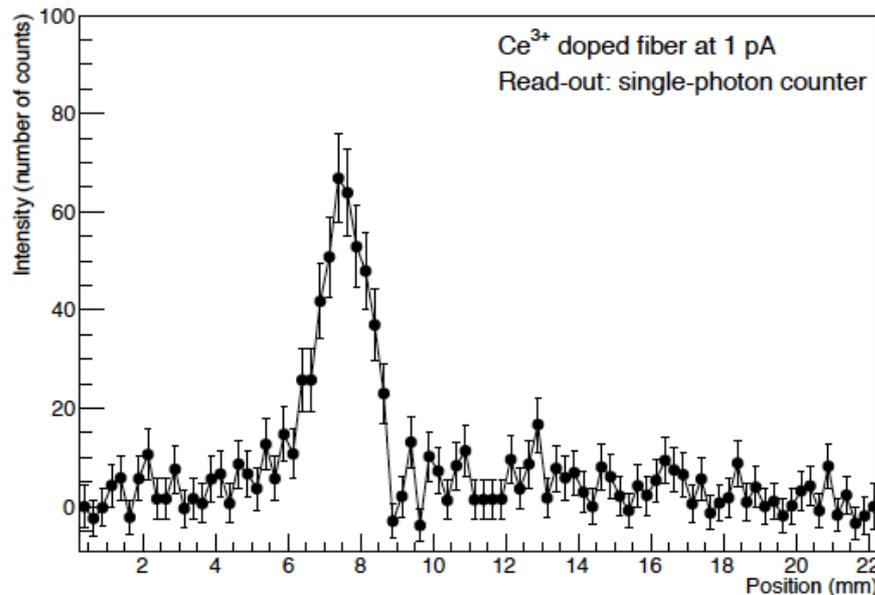
- > Beam profiler based on doped optical fibres passed through the beam
- > Light signal transported by an optical fibre
- > Minimal interference with the beam and occupancy along the beam path

# Universal Beam Monitor (UniBEaM)



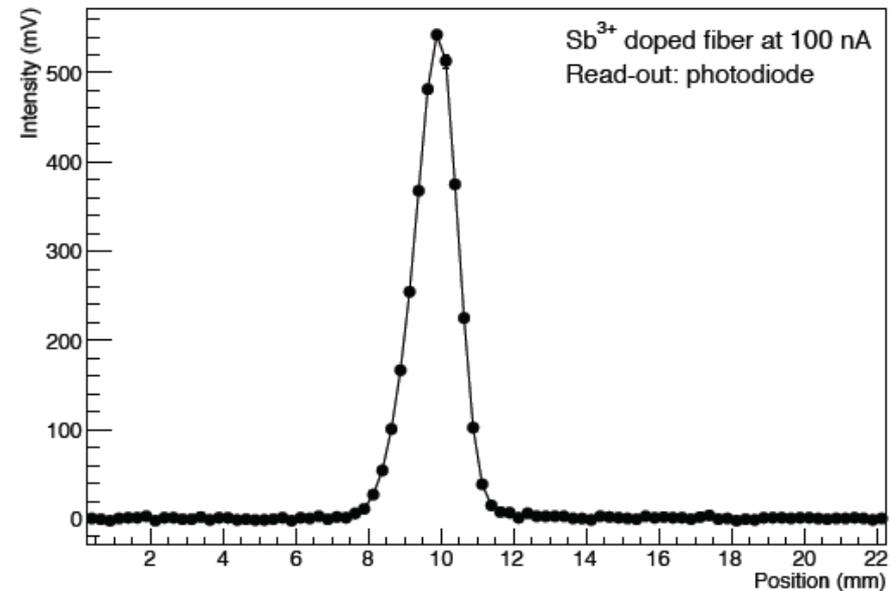
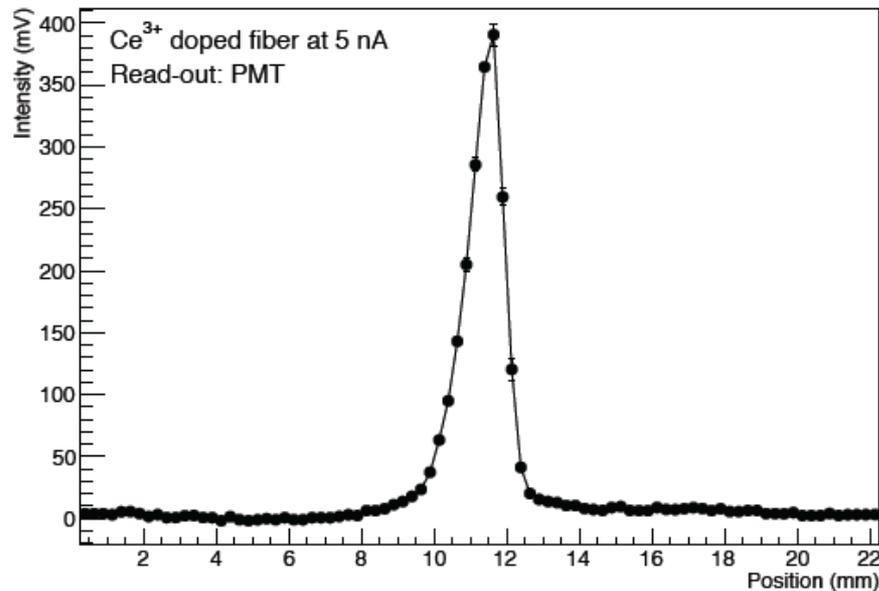
Beam tests with a continuous  
18 MeV proton beam

# Currents in the pA range



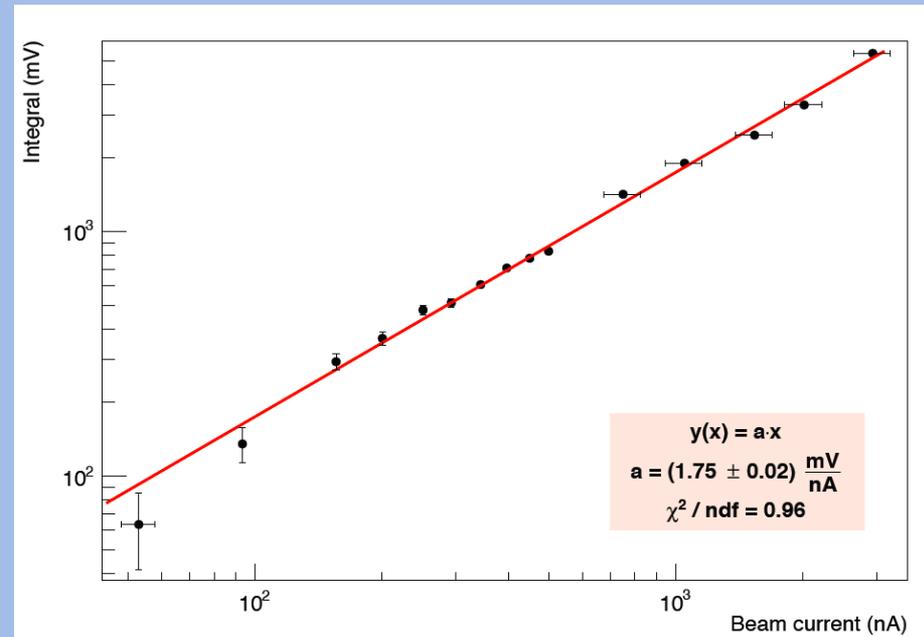
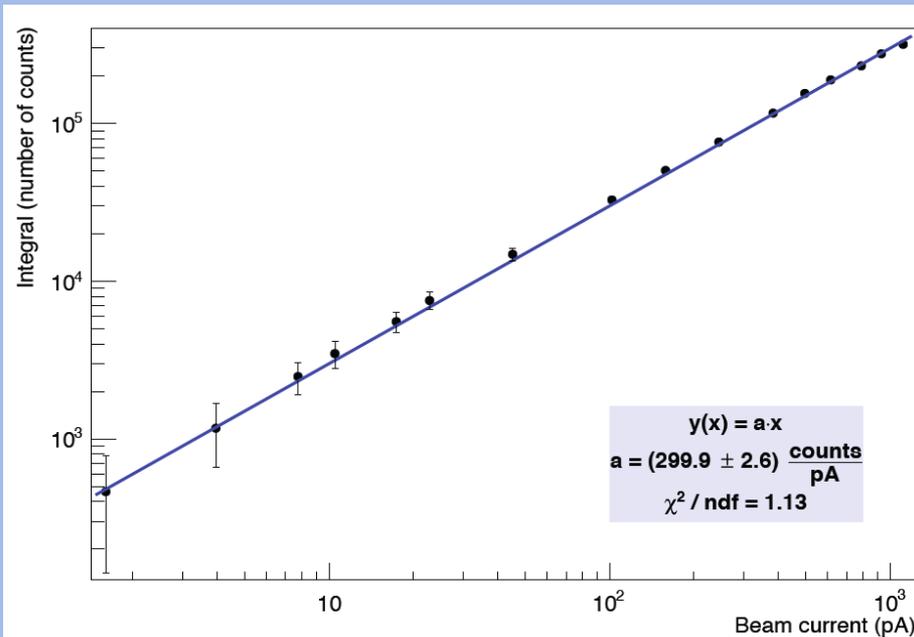
- > Ce doped sensing fibres
- > Fast low noise solid state photomultiplier (20 MHz with 20 Hz dark current)
- > Single photon counting
- > Resolution 250  $\mu\text{m}$  (one step of the motor)

# Currents in the nA range



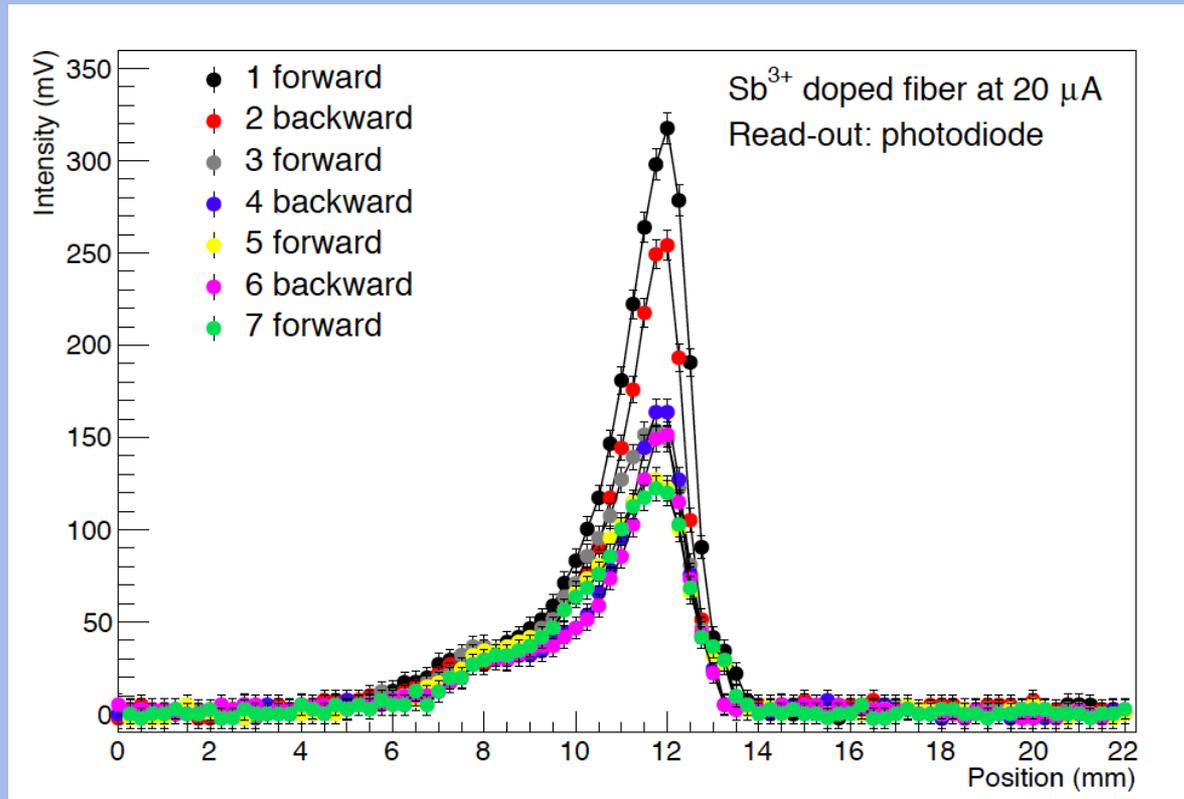
- > Ce and Sb doped sensing fibres
- > Photo-detector: PMT or photodiode
- > The motor is moved continuously and the output voltage measured
- > Resolution 250  $\mu\text{m}$

# Linearity up to $\sim 5 \mu\text{A}$



- > Beam current can be measured by integrating the profile
- > Accuracy  $\sim 1\%$

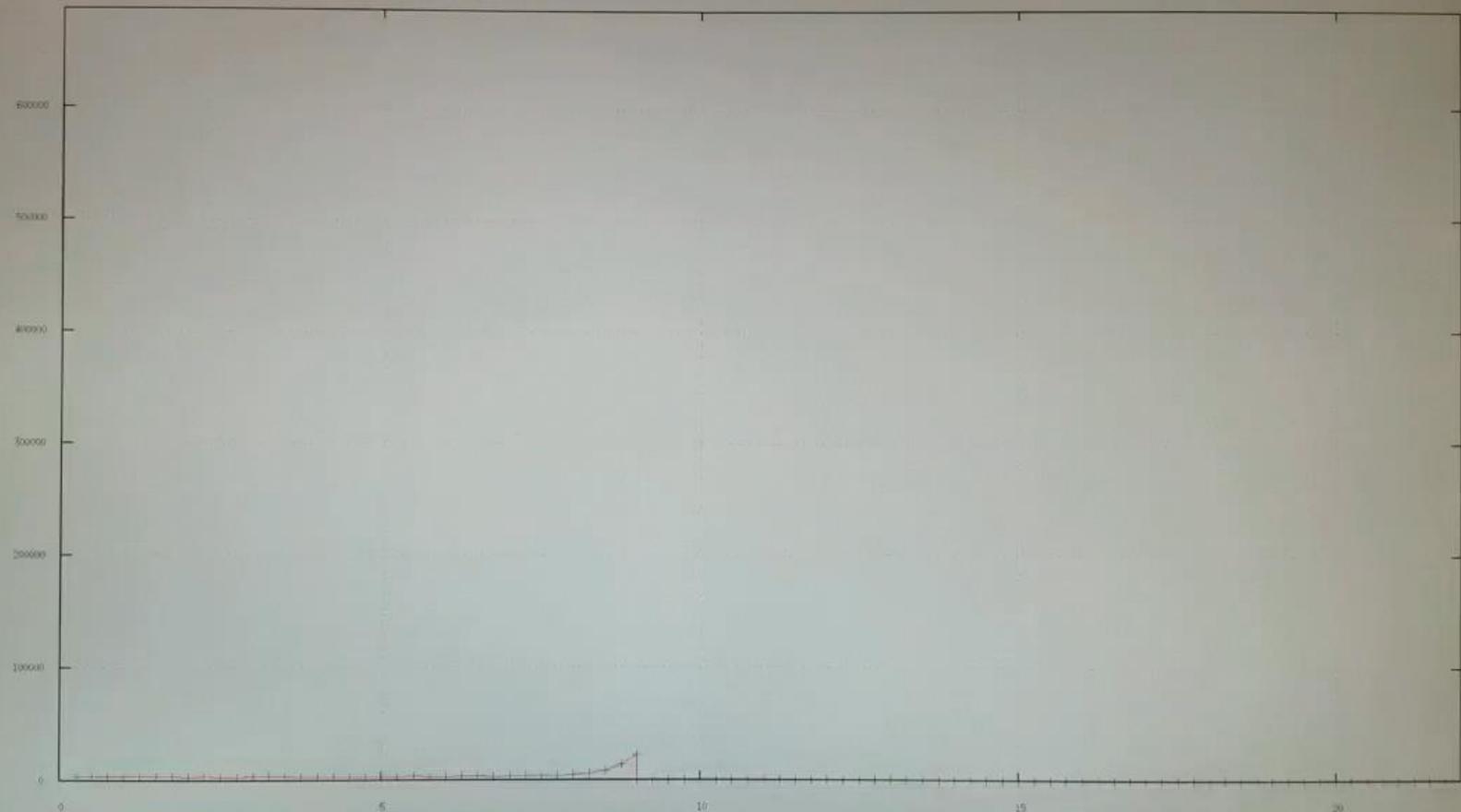
# Currents above $\sim 5 \mu\text{A}$



- > Thermal effects affect light yield and transmission
- > The profile is distorted
- > Radiation hardness under study

# On-line beam monitoring with UniBEaM

Counts

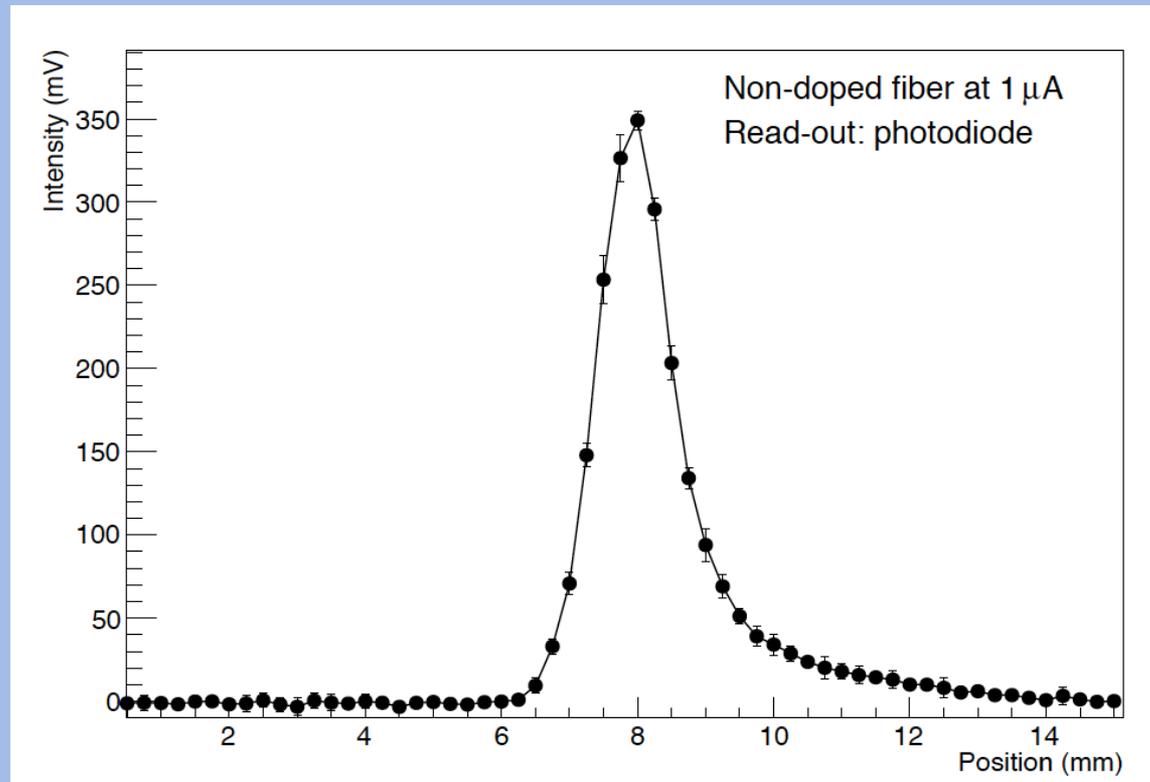


Position [mm]

# Conclusions and outlook

- > The UniBEaM detector was successfully designed, built and tested
  - Beam profiles in the range: 1 pA – 20  $\mu$ A
  - Beam current measurement up to  $\sim 5\mu$ A
  - On-line
  
- > Already in use for some applications as
  - Measurement of the transverse beam emittance
  - Beam control during cross section measurements
  
- > Industrialization on-going in collaboration with D-Pace (Canada)
  
- > Publication submitted to JINST

# A simple solution: non-doped fibre



> Above  $\sim 1 \mu\text{A}$  non-doped optical fibres give enough signal