# Life Sciences @ TRIUMF

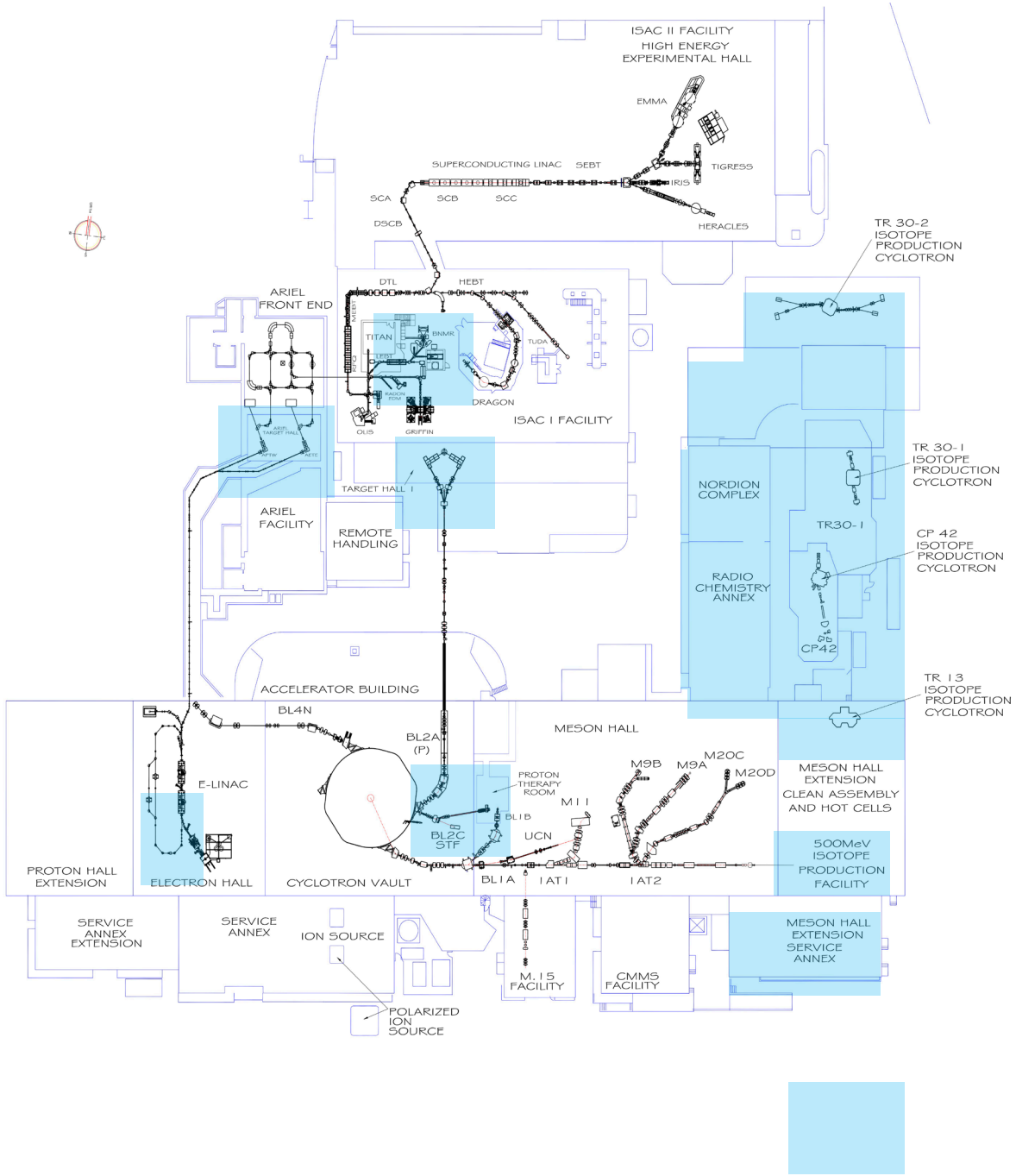
Cornelia Hoehr

Senior Research Scientist

Science Week 2023

Discovery, accelerated

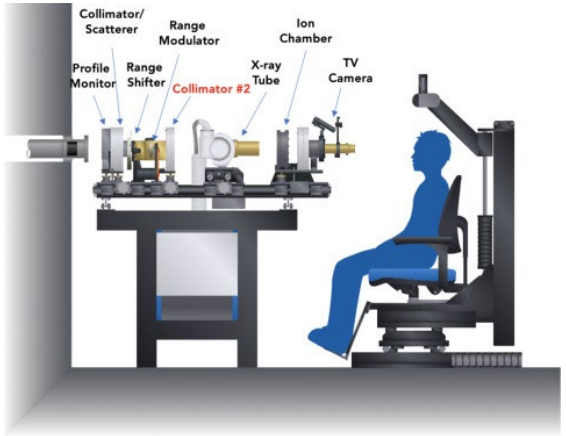
# Life Sciences @ TRIUMF



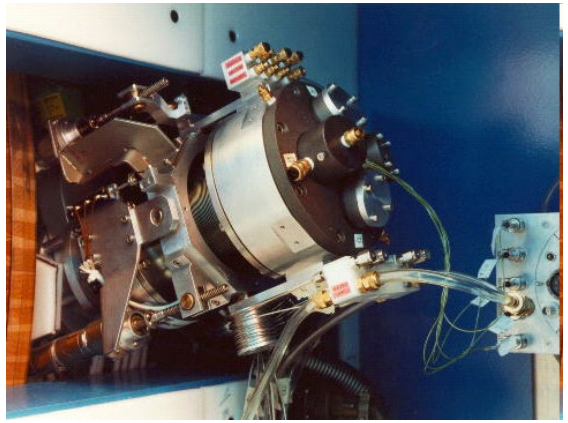

- Cyclotrons:
  - Isotope production
  - Radiochemistry
  - Proton Therapy
  - Bio-βNMR
  - Detector development
- E-linac:
  - FLASH Therapy
  - Detector development

# Life Sciences Division

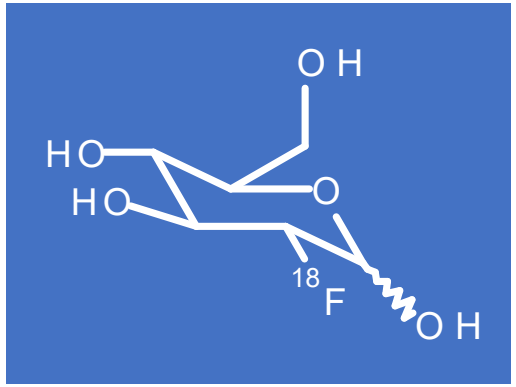
## Applied Ion Beams




## Nuclear Chemistry



## Applied Isotopes



# Life Sciences Division

## Applied Ion Beams

Cornelia Hoehr

Monika Stachura

## Nuclear Chemistry

Valery Radchenko

Paul Schaffer

## Applied Isotopes

Hua Yang

Caterina Ramogida

# Life Sciences Division

## Applied Ion Beams

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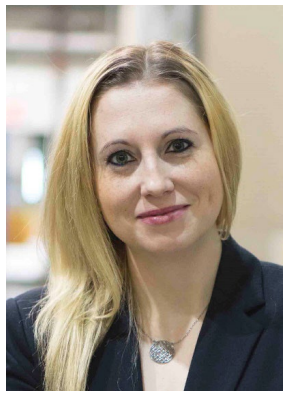

Monika Stachura

## Nuclear Chemistry

Valery Radchenko

Paul Schaffer

## Applied Isotopes

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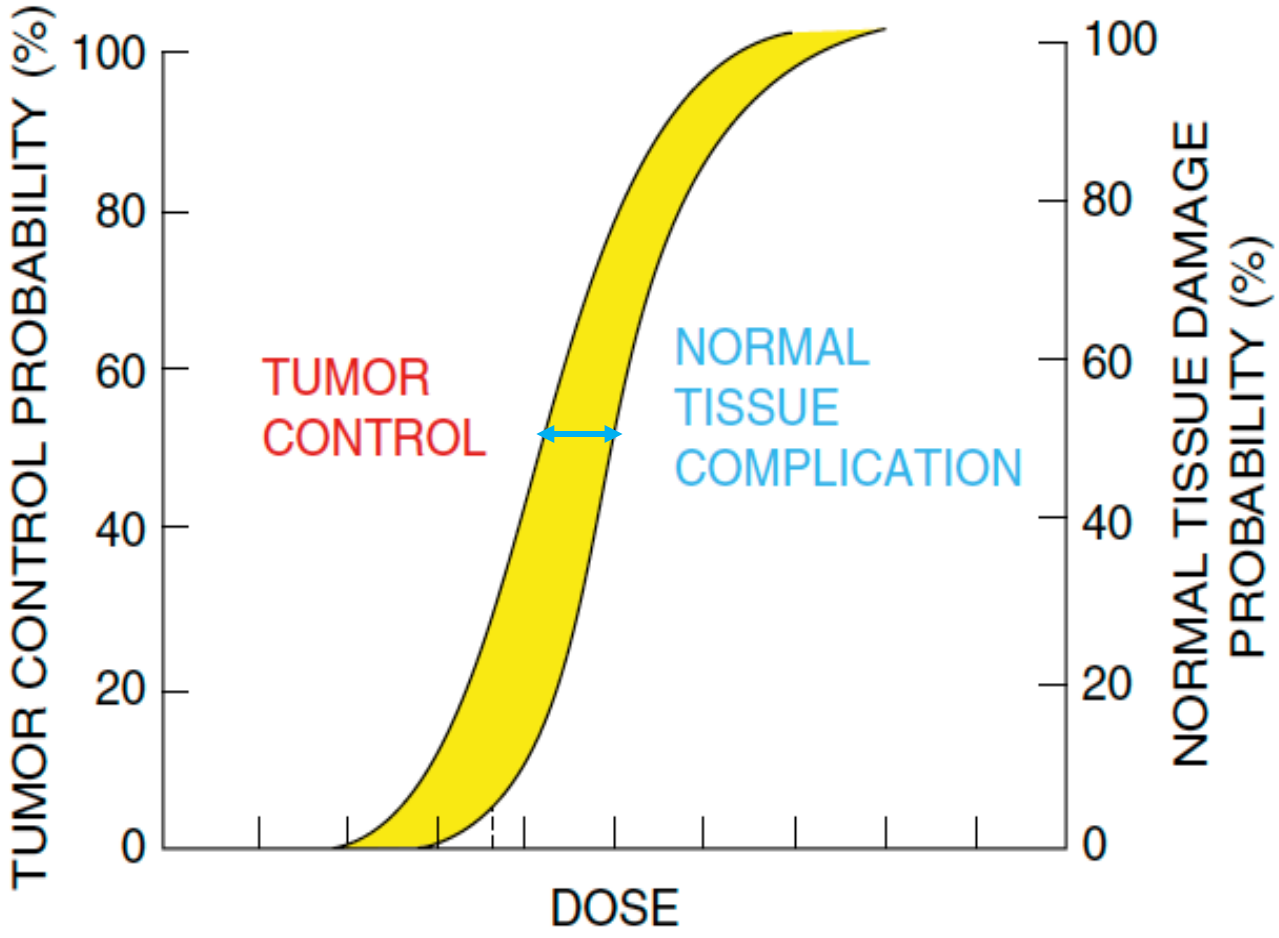
# Life Sciences – Improving Cancer Treatments

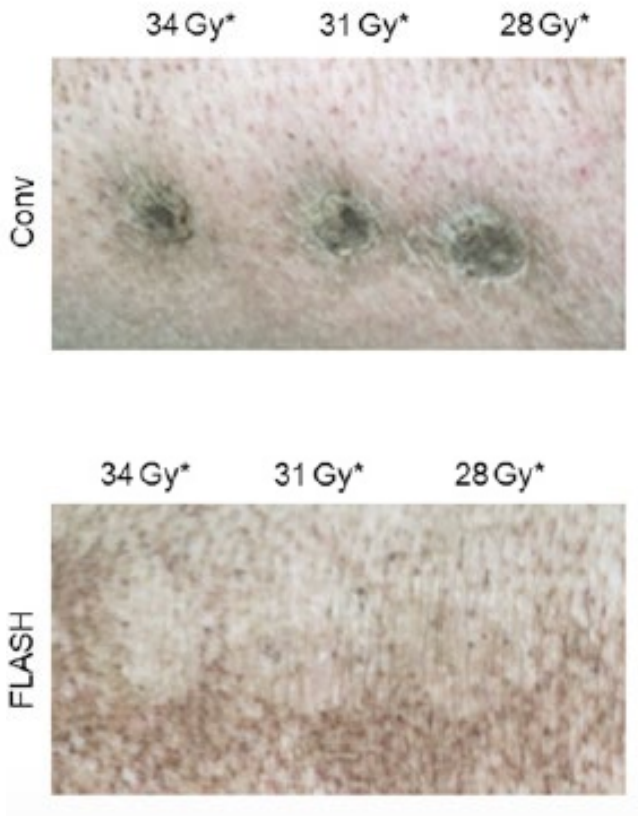
- Surgery
- Chemotherapy
- Ionizing radiation (internal or external beam)

- Holy grail of cancer research: **Increase gap (therapeutic index/ window) as much as possible**



# Radiotherapy – FLASH

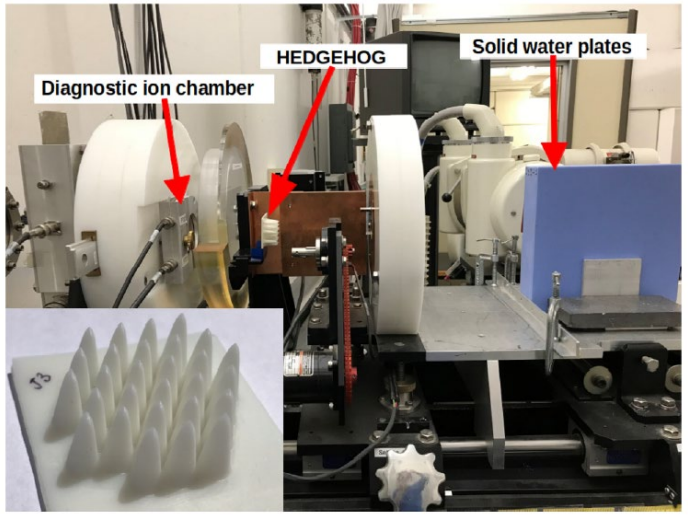
- FLASH effect: Increased sparing of healthy tissue when therapeutic dose delivered in a single fraction in less than a second (> 40 Gy/s).



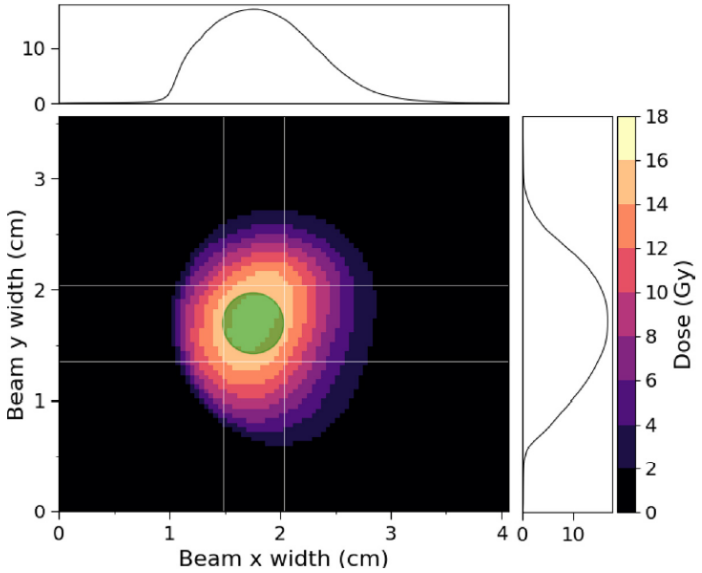

Vozenin *et al.*, 2018

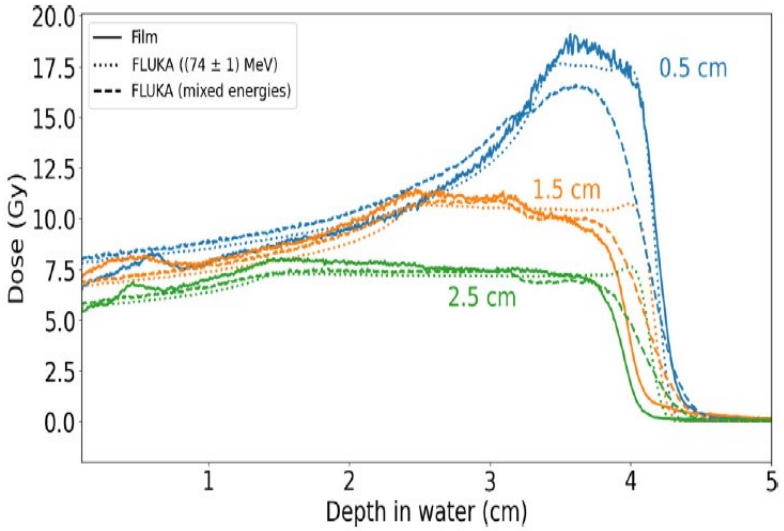
# Radiotherapy – proton FLASH

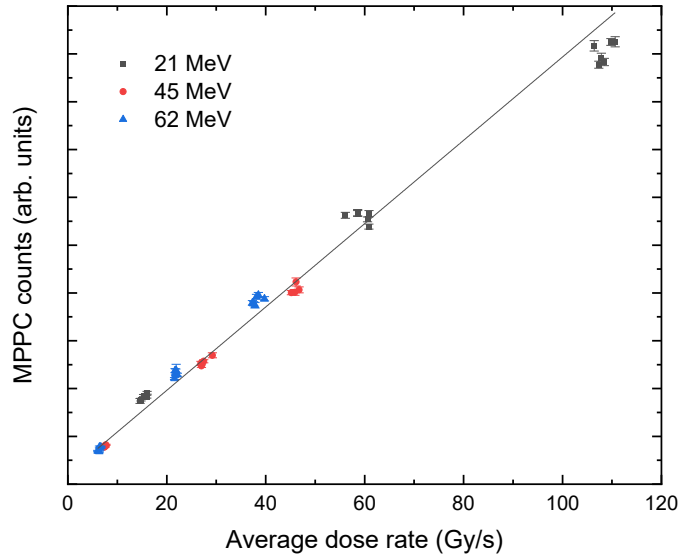
- FLASH effect: Increased sparing of healthy tissue when therapeutic dose delivered in a single fraction in less than a second (> 40 Gy/s).
- TRIUMF ideal facility for high dose rates
- FLASH established







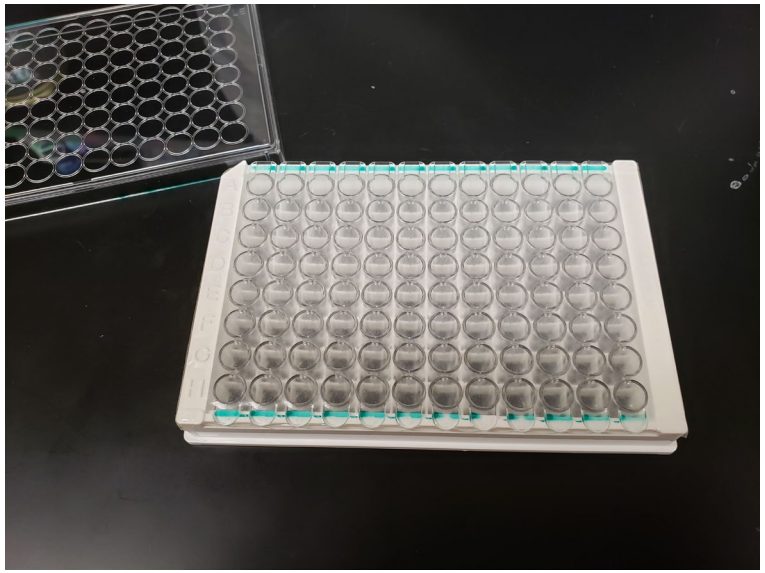



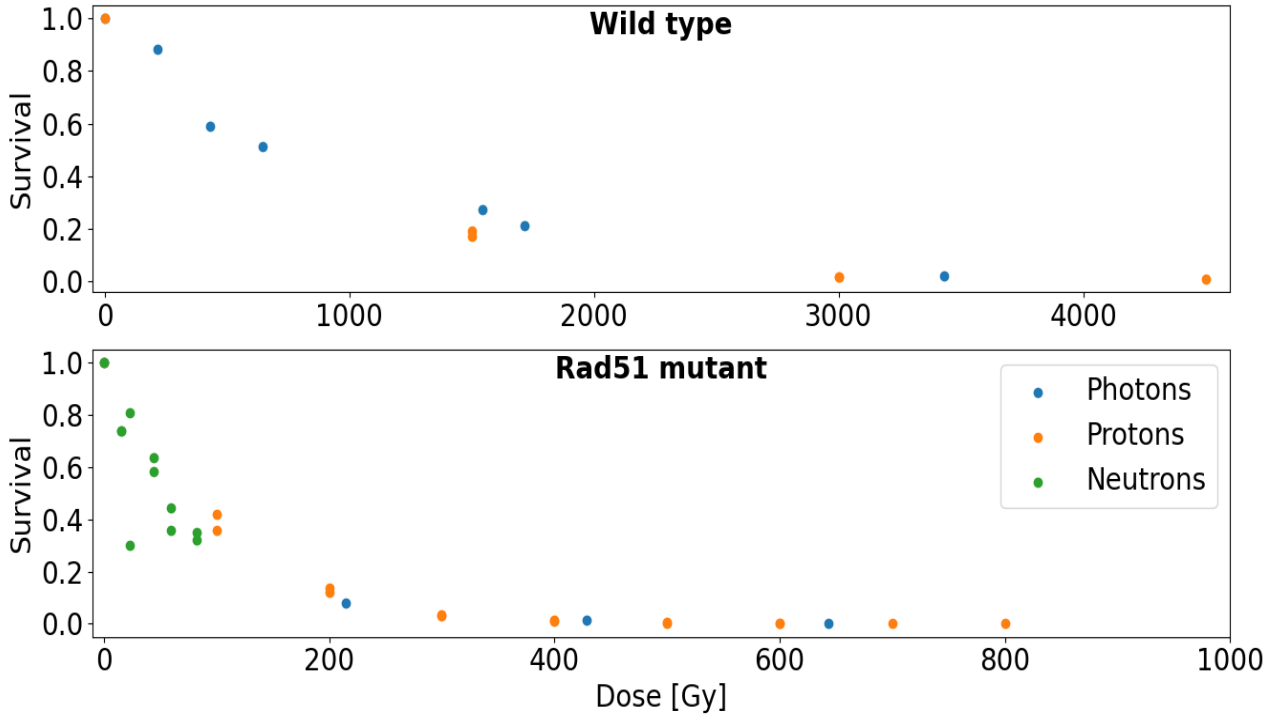
# Radiotherapy – proton FLASH

## Desiccated yeast cells (NOSM):

- Transport, storage, …:
  No specific requirements;
  Can be prepared off-site
- Conditions (e.g. desiccation):
  Can be controlled



- Measuring irradiation effect of yeast cells in irradiations environments (proton **conv** and FLASH, neutron **conv**, photons **conv** and FLASH)



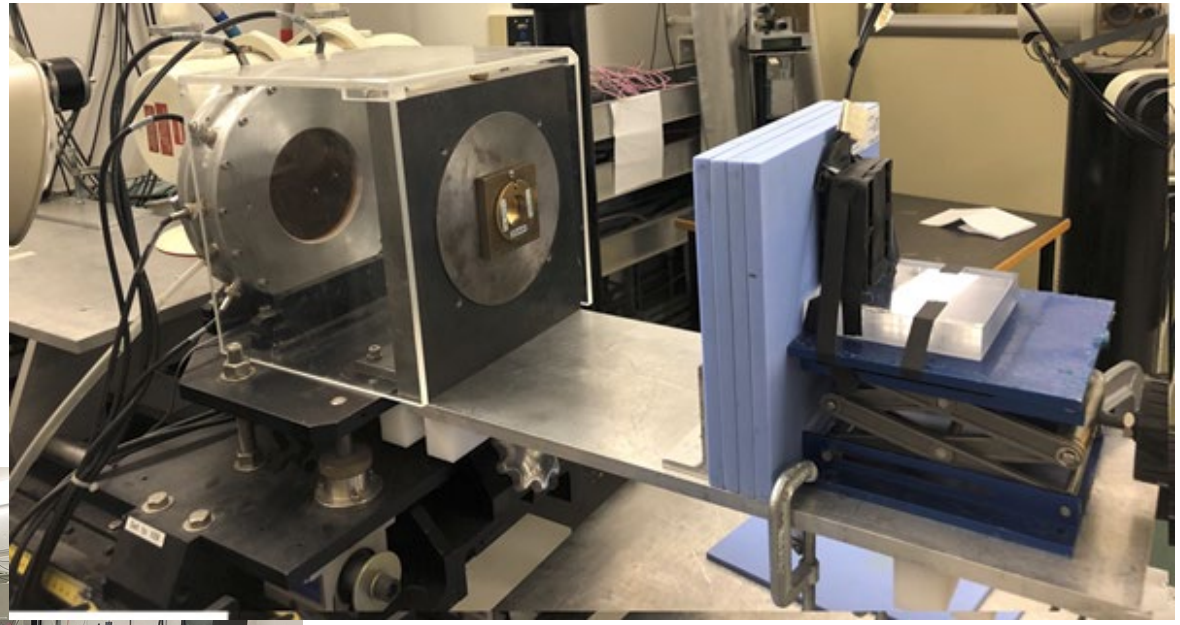
# Fiber detector for proton therapy

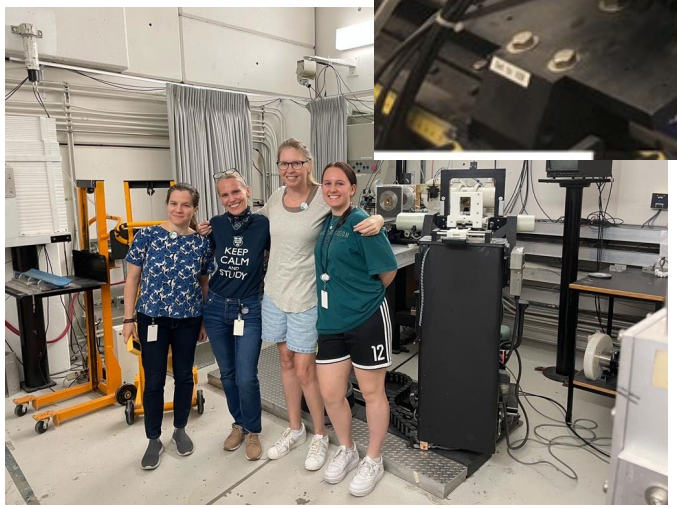
**Ideal dosimeter:**

- real-time,
- linear in dose,
- independent on dose rate,
- independent in particle energy,
- sub-mm spatial resolution,
- temperature independent,
- magnetic field independent,
- sensitive to particle type (proton vs. neutron vs. Cherenkov)
- water-equivalent,
- multi-point sensor

# Fiber detector for proton therapy

3D printed phantom with optical fibers embedded – see poster by Sophia Andru





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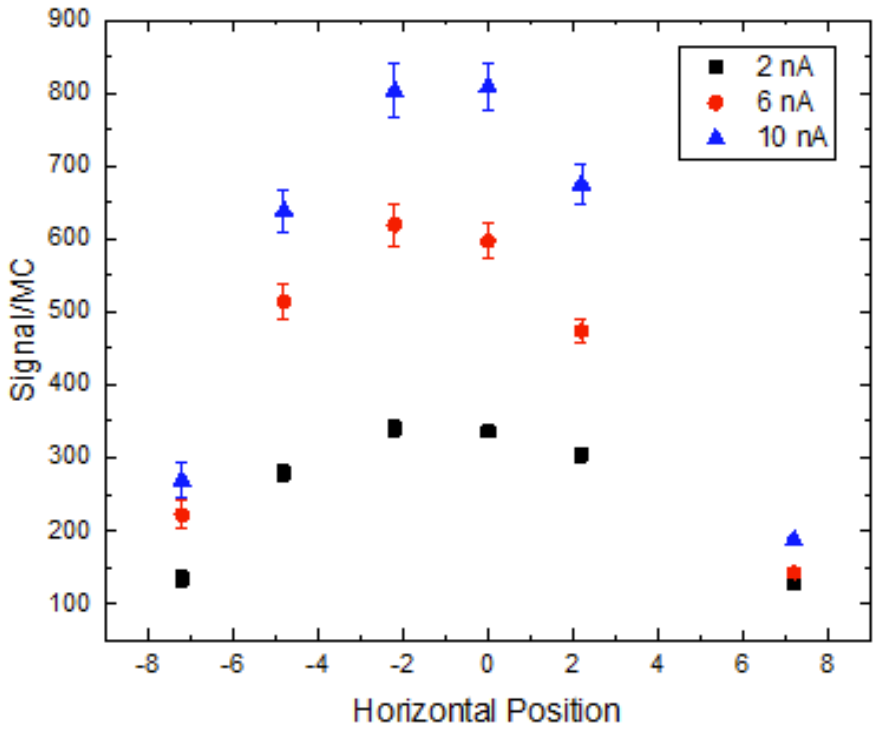
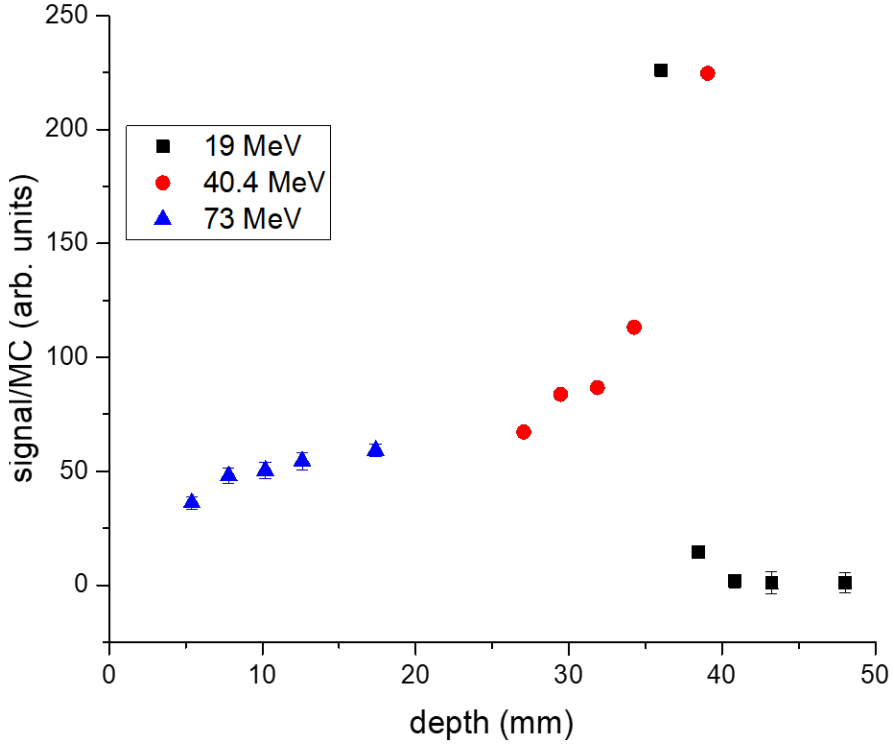
# Fiber detector for proton therapy

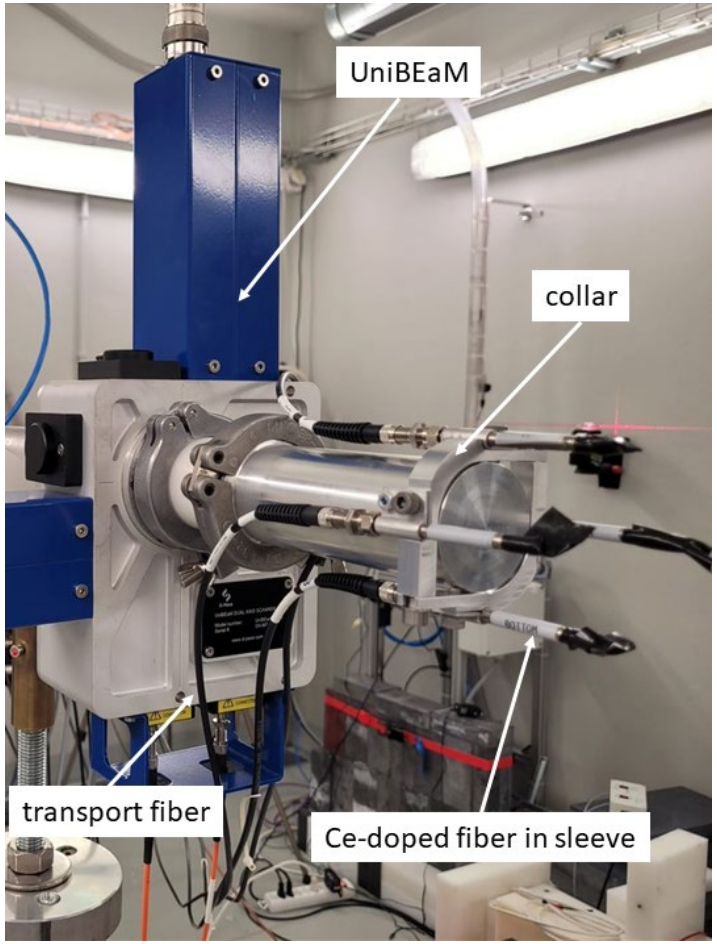
Horizontal profile




Axial profile



# Fiber detector for isotope production target

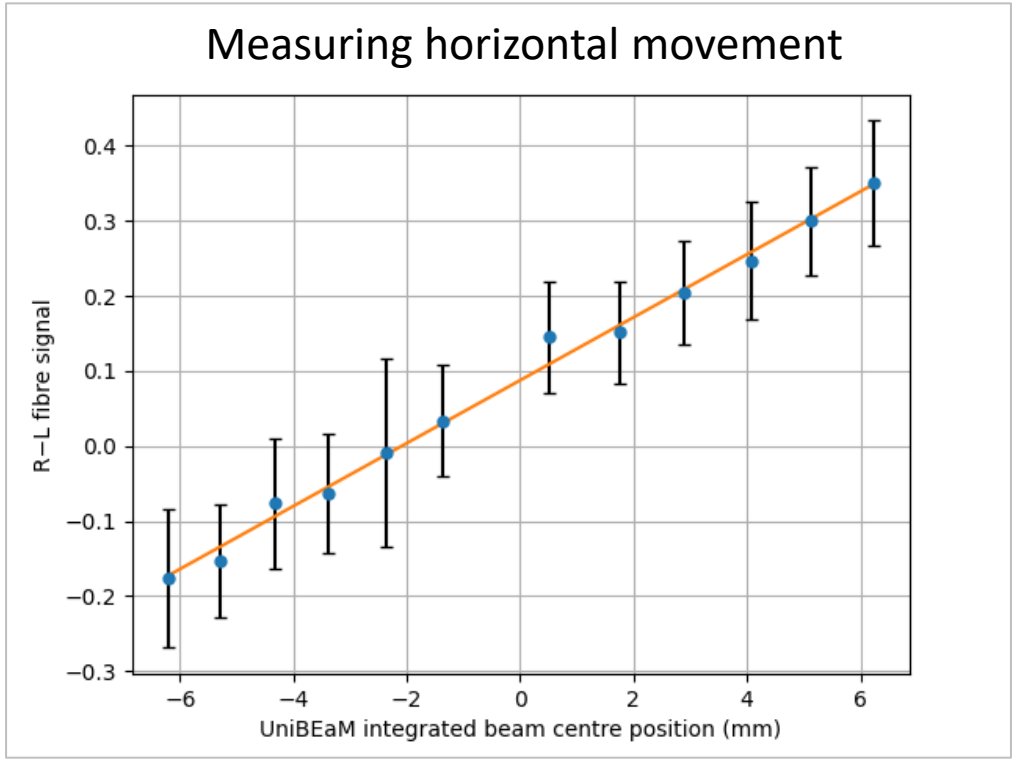



- Fibers mounted on a collar around a beam dump or target.
- Outside of the vacuum envelope
- Easy installation and operation
- Sensing gammas and neutrons during irradiation

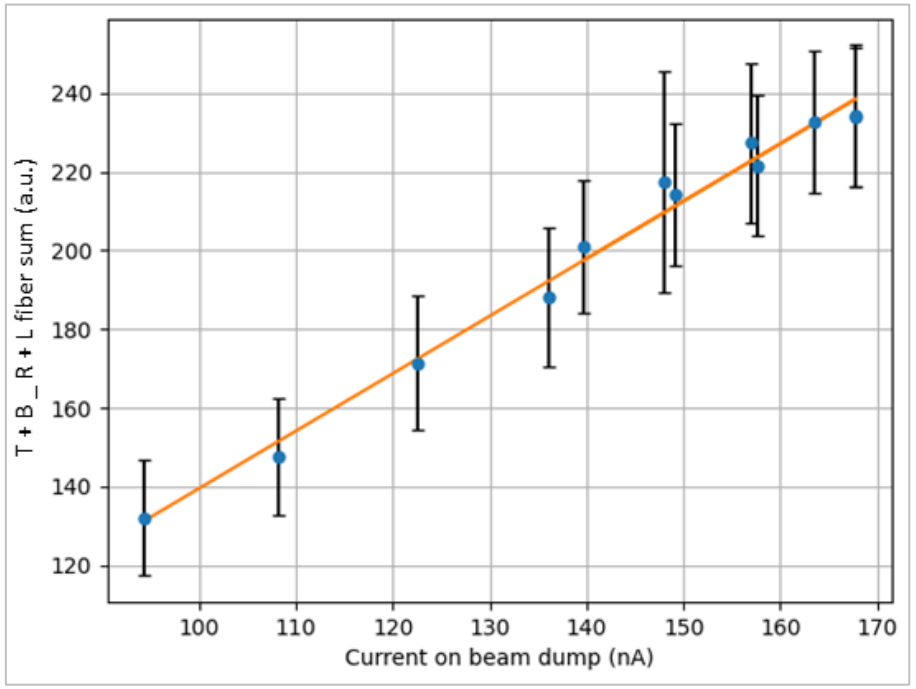
Uni Bern, Braccini

# Fiber detector for isotope production target

Measuring horizontal movement

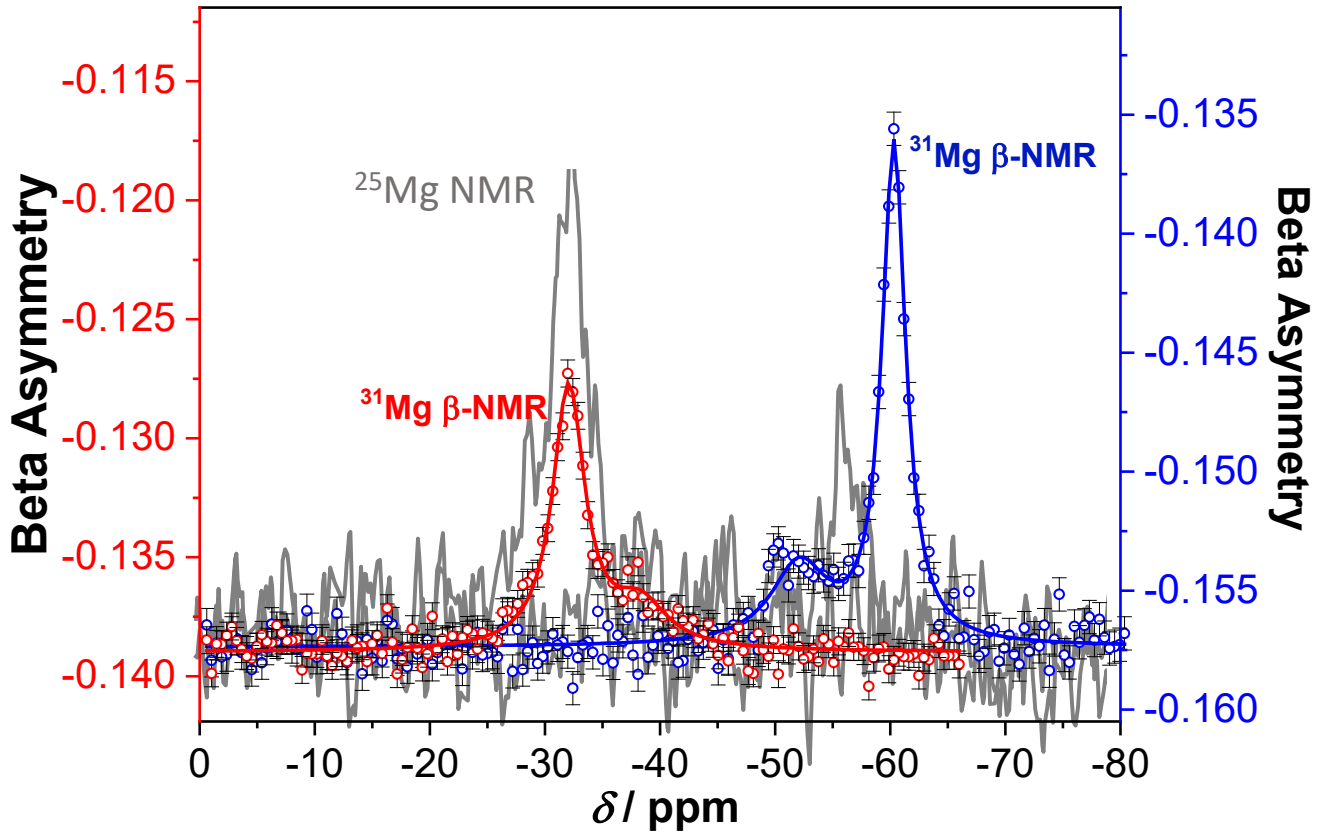



Measuring total beam current

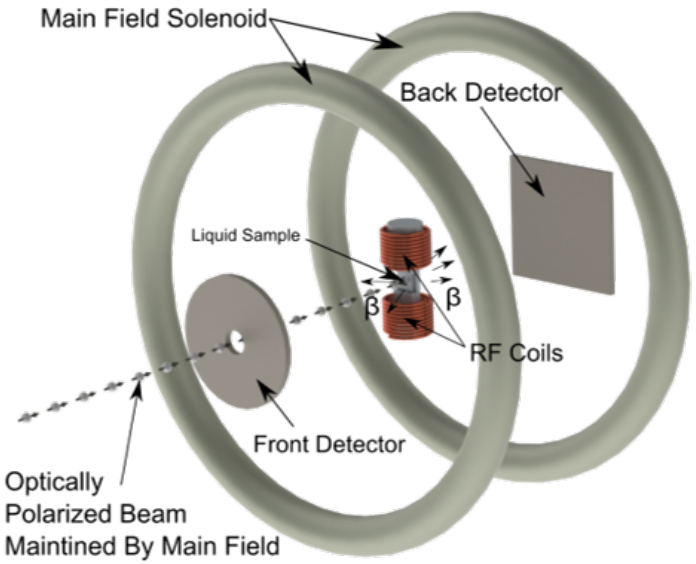



Future plans: measuring difference in beam profiles

# Using ion beams to understand correlation chemistry



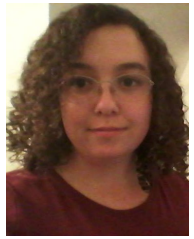

D. Szunyogh, *et.al*. Dalton Trans. 2018, **47**, 14431-14435.



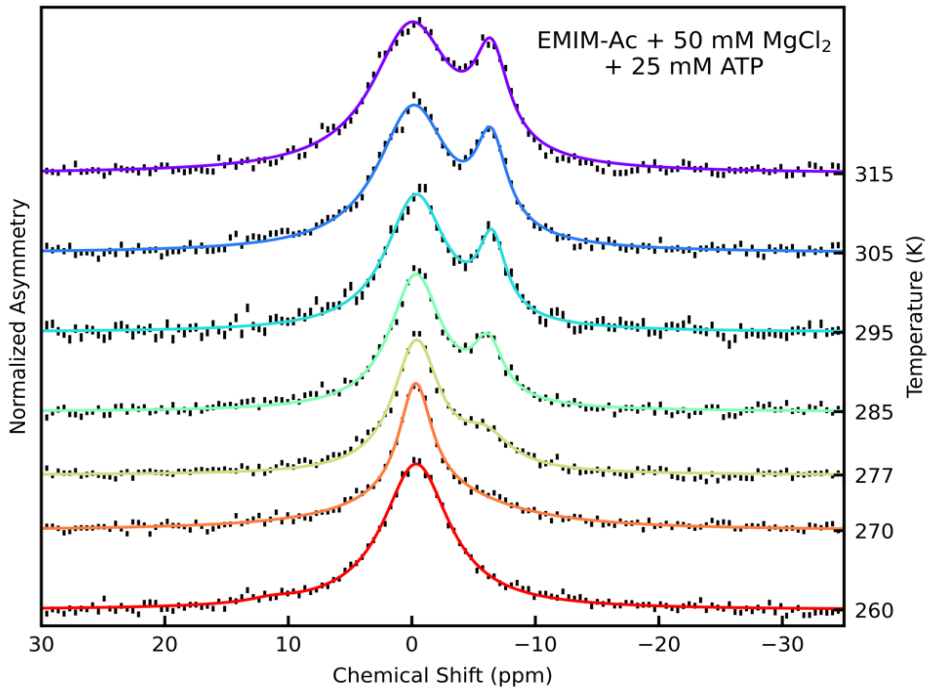

| β-NMR | Properties | NMR |
|---|---|---|
| $^{31}$Mg | Isotope | $^{25}$Mg |
| 1/2 | Spin | 5/2 |
| 3.41 | Magnetic Field (T) | 11.7 |
| 22 | Temperature (°C) | 72 |
| 2-4 | Sample volume (uL) | 550 |
| 20 min | Time of meas. | 72 hours |

# bNMR with $^{31}$Mg=ATP complexes in EMIM-Ac

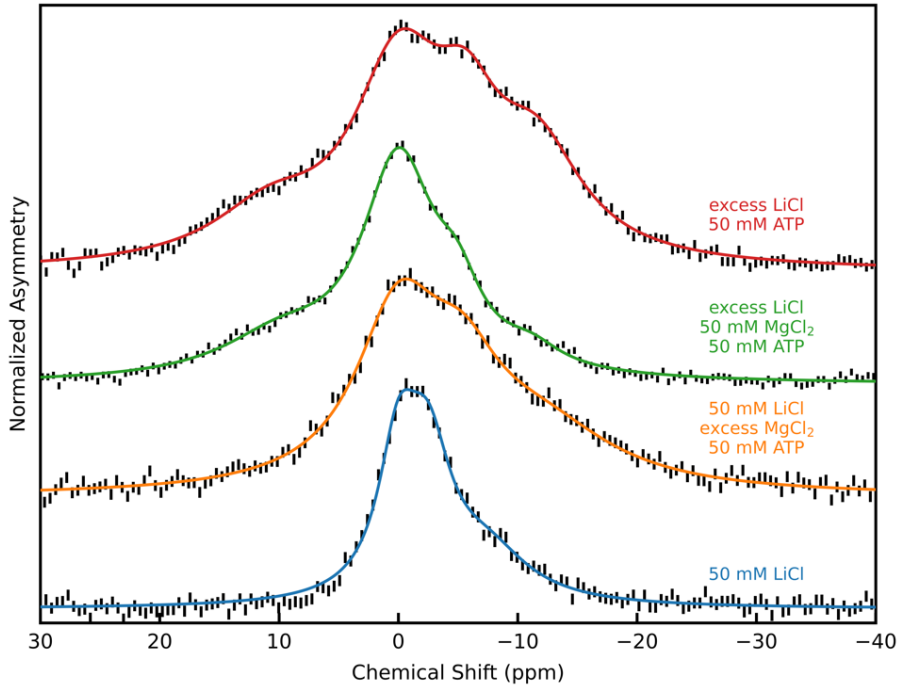
R. Haynes



V. Karner




Temperature evolution of the 31Mg resonance in EMIM-Ac measured at 3.2 T.

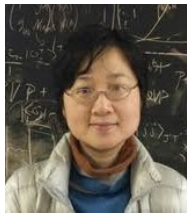



Comparison of the $^{31}$Mg resonance spectrum for EMIM-Ac with varying amounts of LiCl, $MgCl_2$, and ATP measured at 295 K and 3.2 T.

# Novel applications of bNMR: Optical Pumping of $Ac^+$ Isotopes

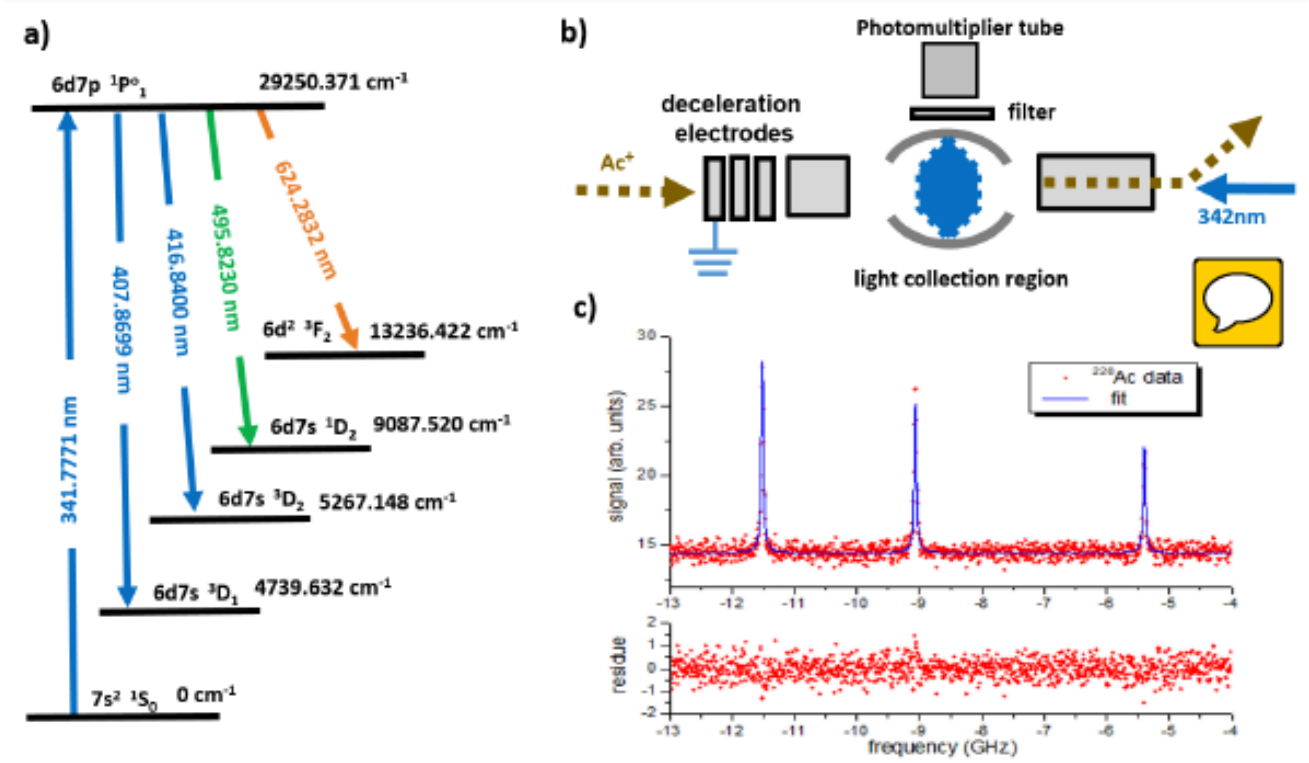
## Interdivisional endeavor:

M. Stachura
Life Sciences Div.



R. Li
Accelerator Div.

A. Teigelhoefer
Physical Science Div.




R. Li et al., Recent upgrades and developments at TRIUMF's laser nuclear-spin-polarization facility. NIM B, under revision

Thank you
Merci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