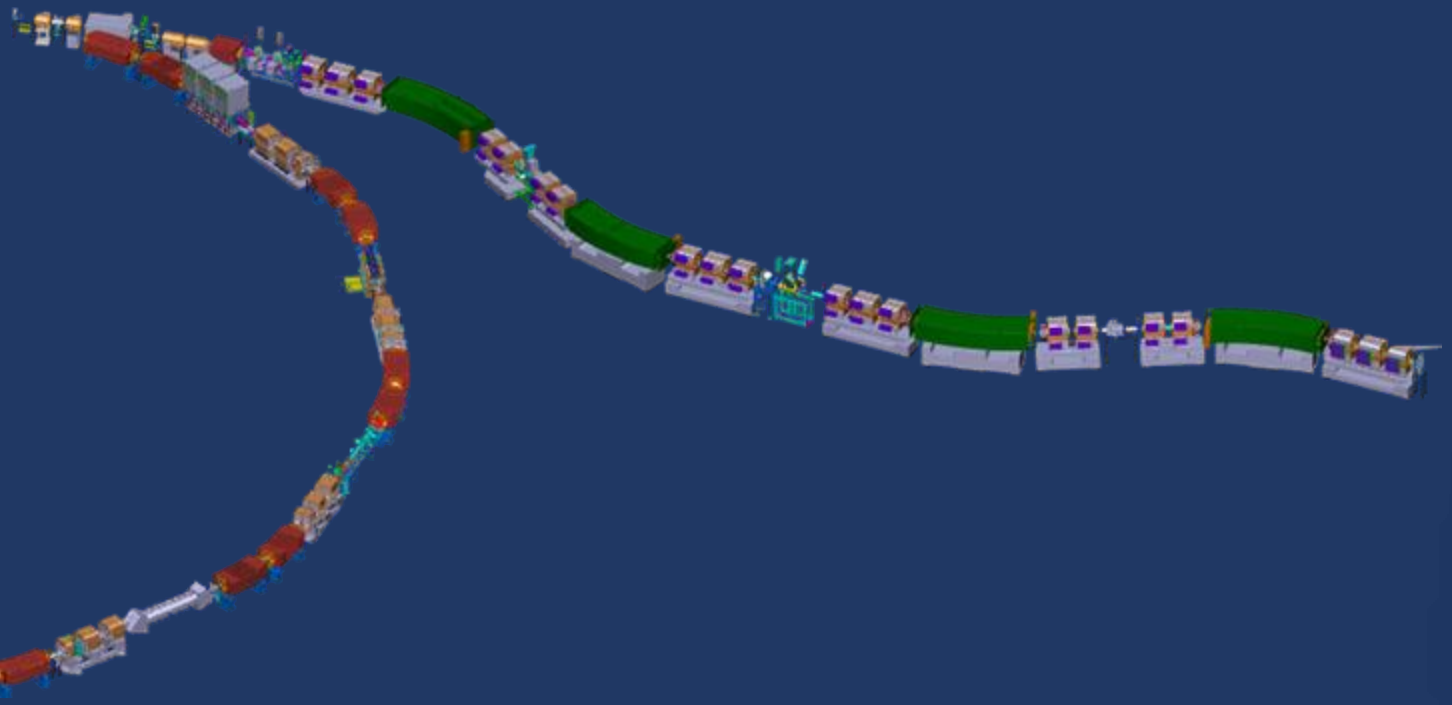
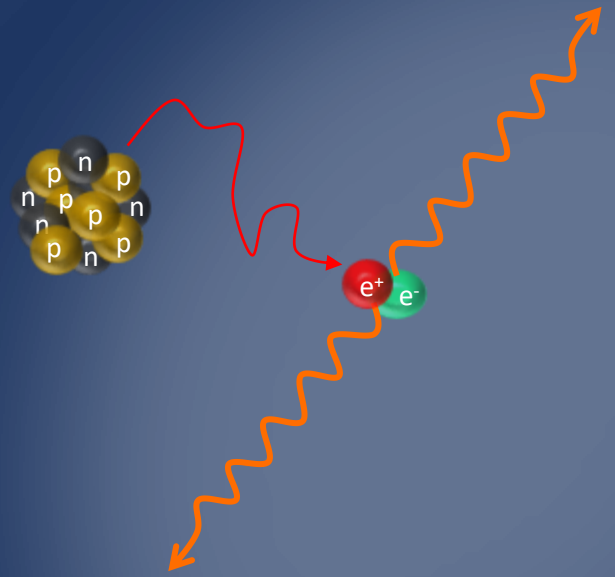




Towards the Therapeutical Applications of ^{15}O

Sivaji Purushothaman for the Super-FRS EC

Daria Boscolo, Peter Dendooven, Timo Dickel, Marco Durante, Tuomas Grahn, Emma Haettner, Daria Kostyleva, David J. Morrissey, Sivaji Purushothaman, Christoph Scheidenberger, Christoph Schuy, Olga Sokol, Walter Tinganelli, Ulrich Weber**… to be extended**

Super-FRS experiment collaboration
GSI Biophysics department
The University Medical Center Groningen
Michigan State University

Quasi-real-time range monitoring: Why 15O?

Quasi-real-time range Monitoring

Range verification

- **Achieved with the lowest possible dose as early as possible**
- **Availability of therapeutic-quality beam intensity and purity**

Beam intensity
→ Production cross section

^{16}O → Be
- ^{15}C : 43 mb
- ^{15}C : 1.2 mb

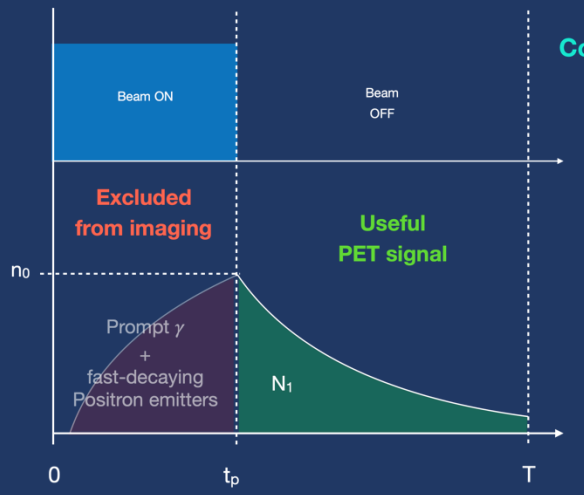
^{12}C → Be
- ^{11}C : 46.7 mb
- ^{10}C : 4.3 mb

? What is the best candidate for quasi-real-time range monitoring

Half life

^{11}C : ~ 20 min
^{15}O : ~ 2 min
^{14}O : ~ 1.2 min
^{10}C : ~ 0.3 min

Beam pulse time structure



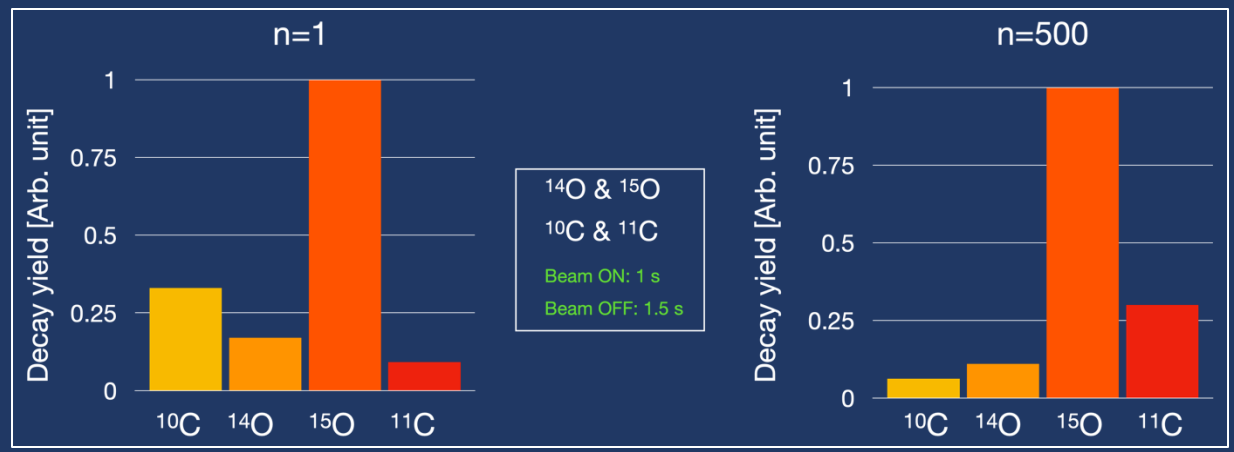
Coincidence event yield during the beam pause

After *1* implantation cycle

$$N_1 \propto n_0 \left[1 - e^{-\lambda(T-t_p)}\right]$$

After *n* implantation cycles

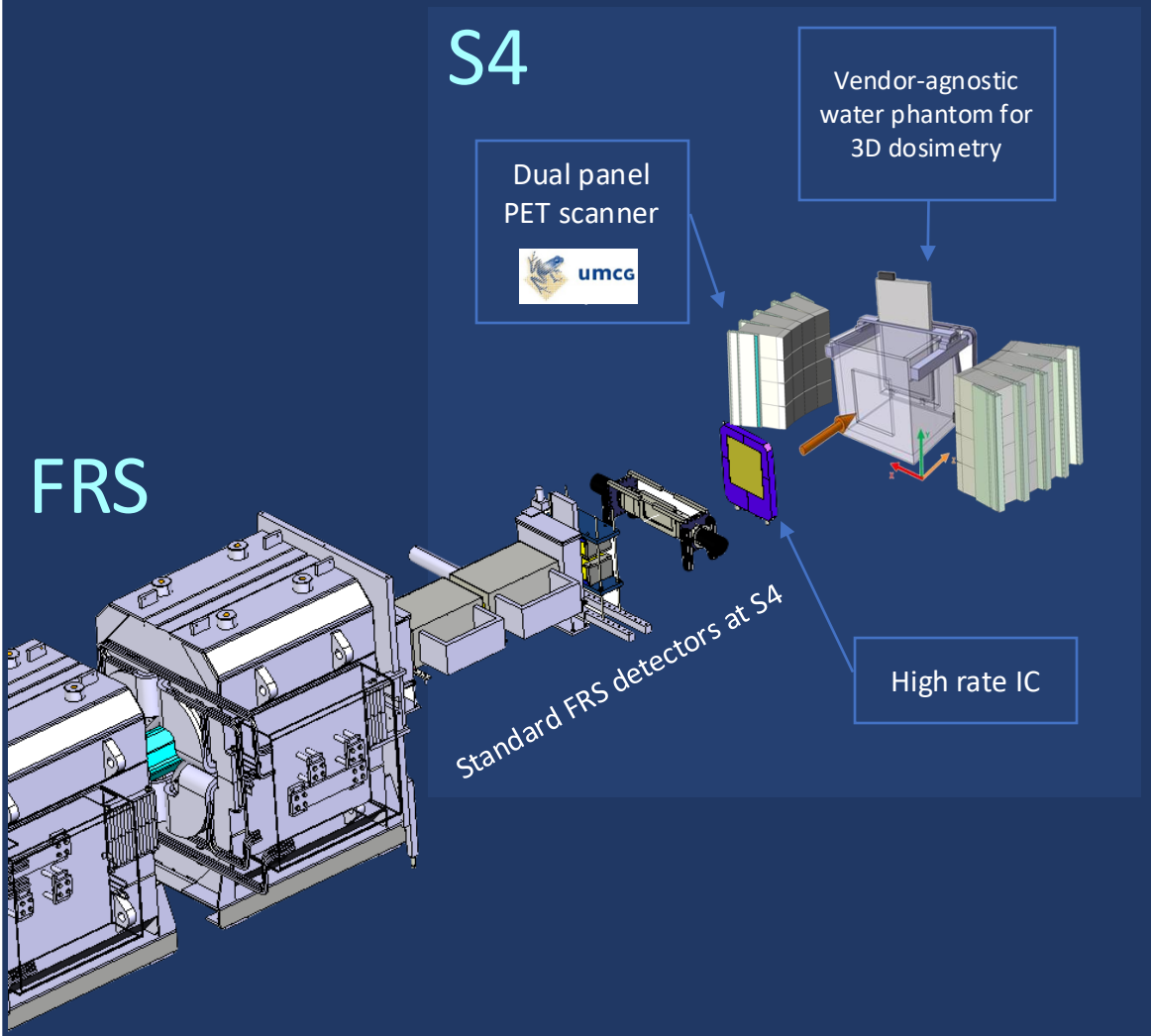
$$N_n \propto N_1 \sum_{j=0}^{(n-1)} (n-j)e^{-\lambda jT}$$



P. Lindstrom et al., (1975). LBNL Report No.:LBL-365
S. Purushothaman et al., Sci Rep 13, 18788 (2023)
D. Kostyleva et al., Phys. Med. Biol 1 (2023)

Simultaneous PET imaging and physical dosimetry

Simultaneous 3D dosimetry and PET imaging set up



Quantitative and qualitative demonstration of ^{15}O as probe beam

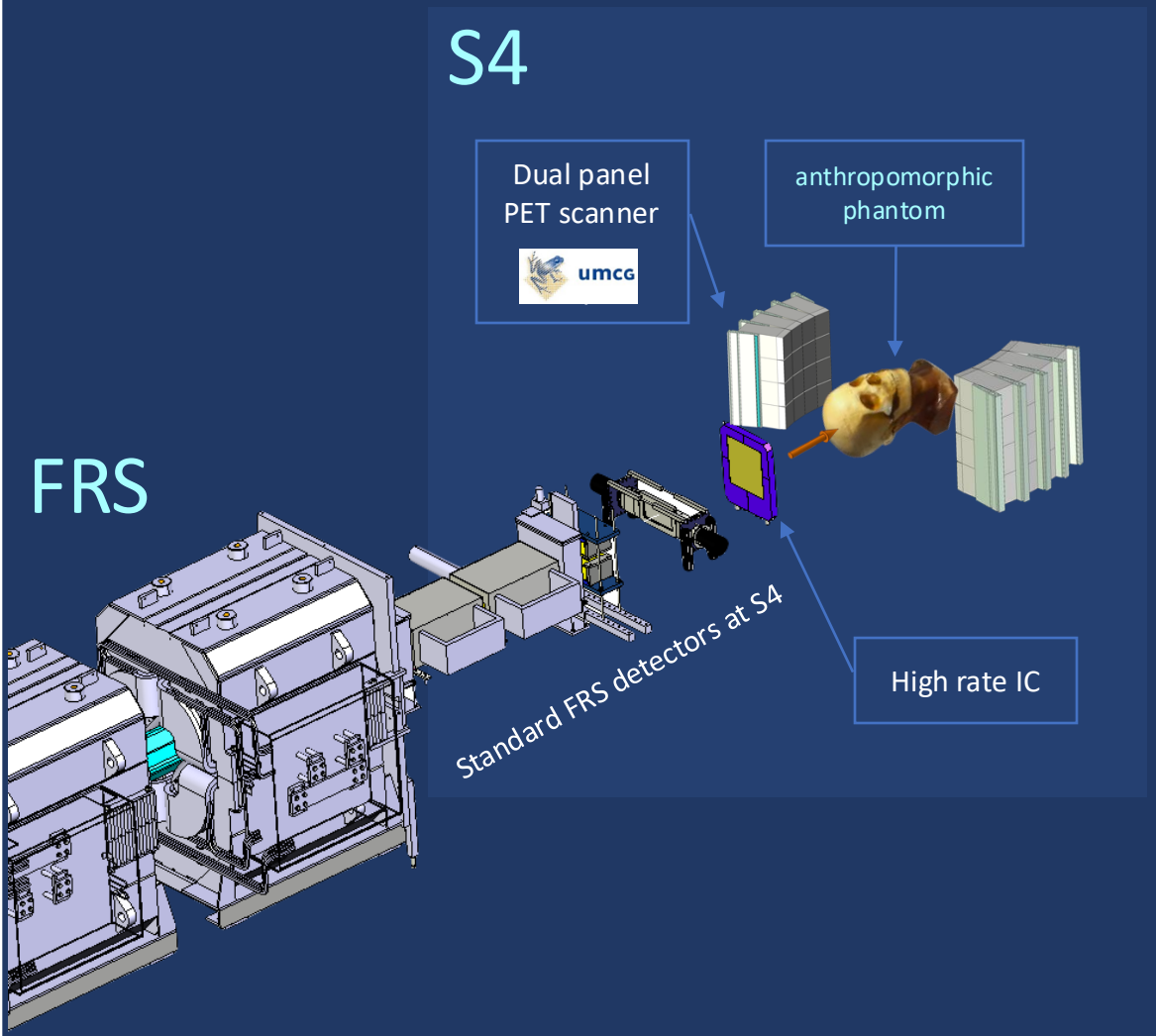
- Demonstrate the feasibility of scaling the range correction of ^{16}O therapeutical beam using the range information based on the positron activity peak of the ^{15}O probe beam ⇐ Pristine and SOBP cases
- Positron activity and dose peak position comparison

Quantitative and qualitative demonstration of 15O as therapeutical beam beam

- Achieve highest intensity ^{15}O beam ⇐ High transmission mode of FRS
- Quantify the achievable dose ⇐ Pristine and SOBP cases
- Positron activity and dose peak position comparison

Experimental setup at S4

PET imaging set up with anthropomorphic phantom and compare it with Hounsfield units from CT scan

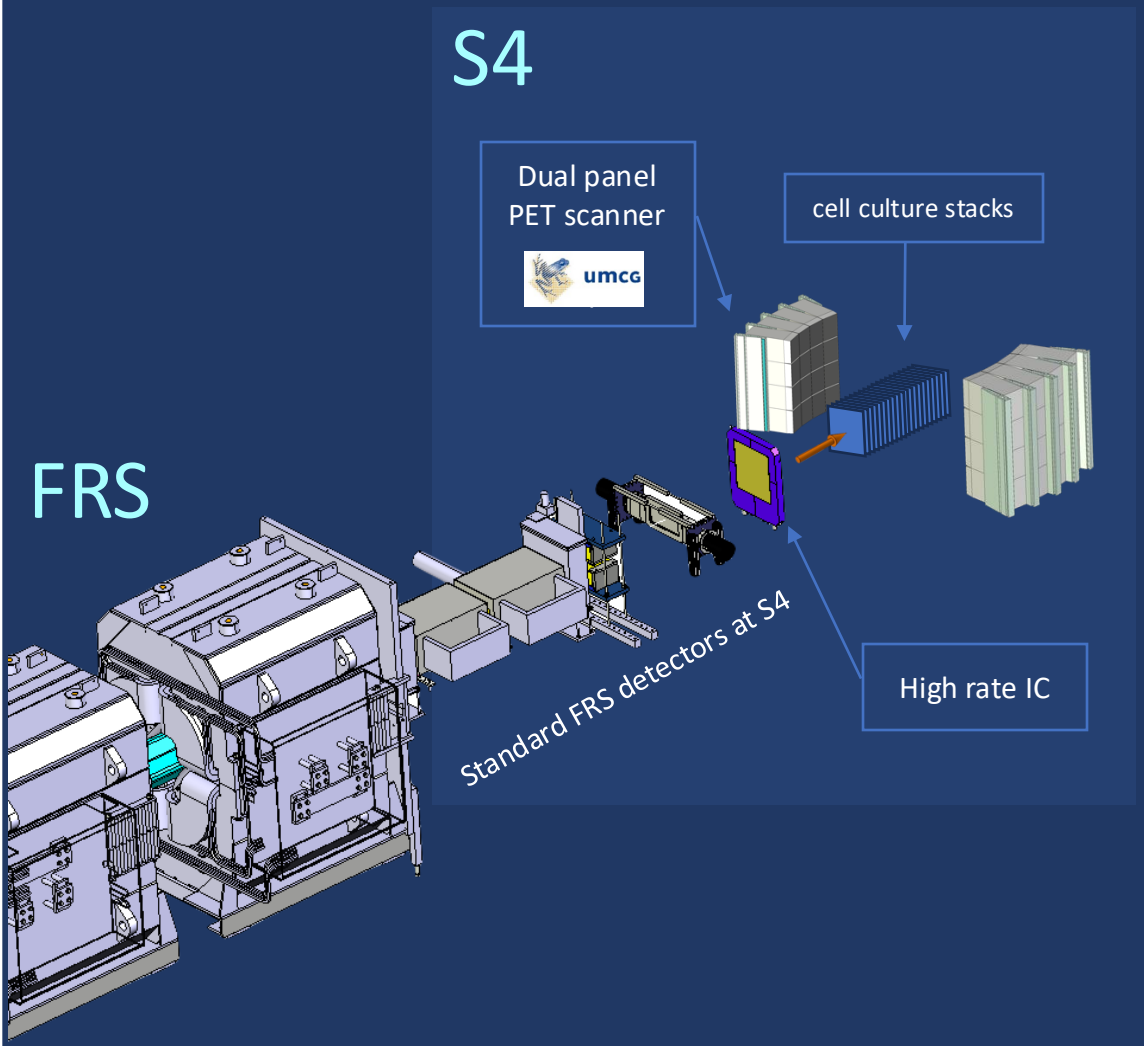


Demonstration of quasi-real-time range monitoring and correction using an anthropomorphic phantom

- Compare Montecarlo range prediction with PET imaging

Simultaneous PET imaging and biological dosimetry

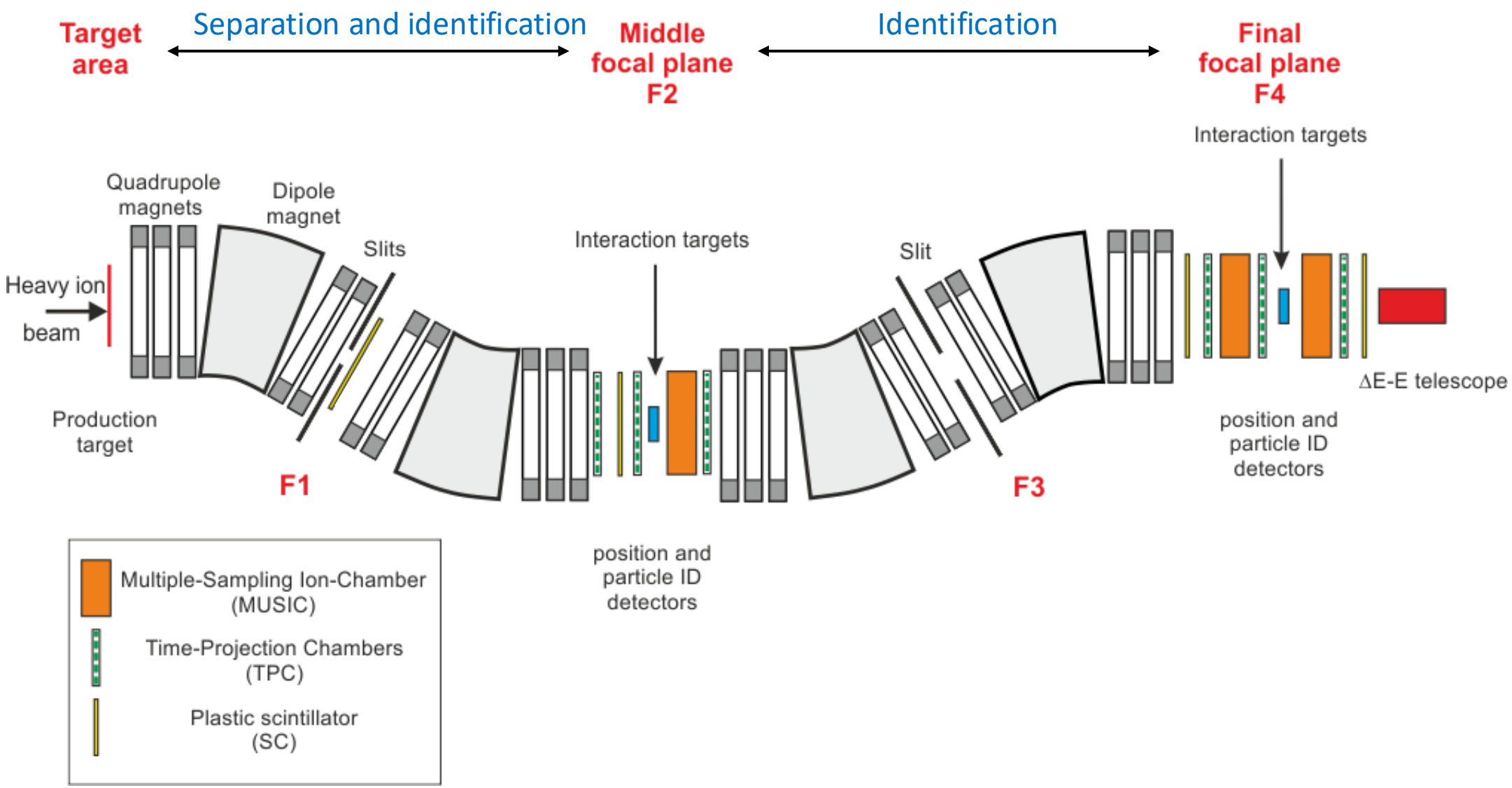
Simultaneous irradiation of cell culture stack and PET imaging set up



Study the cell survival as a function of positron activity profile

- Irradiate cell culture stacks at at therapeutical doses (2 and 5 Gy) ⇐ Pristine and SOBP cases

Experimental setup for cross-section measurements



cross-section measurements – Available data

Projectile atomic number	Projectile mass number	Projectile chemical formula	Target atomic number	Target mass number	Target chemical formula	Cross-section (mb)	Cross-section lower error (mb)	Cross-section upper error (mb)	Cross-section type
8	14	O	4	9	Be	871	14	14	cc
8	14	O	6	12	C	884	18	18	mc
8	14	O	6	12	C	885	23	23	mc
8	14	O	13	27	Al	1292	54	54	mc
8	15	O	7.42	18	H2O (Water)	1502	8	8	mc
8	15	O	29	64	Cu	2580	630	630	mc
8	15	O	4	9	Be	912	23	23	mc
8	15	O	6	12	C	922	49	49	mc
8	15	O	6	12	C	915	13	13	mc
8	15	O	13	27	Al	1310	28	28	mc

Beam Request

- Primary beams : ^{16}O
- Secondary beam : ^{15}O
- Energy: 100 MeV/u - 500 MeV/u
- Intensities: 5×10^{3} - 5×10^{10}
- Secondary targets: Water, Be, PE, Carbon (glassy and graphite)
- Required Shifts for measurement: 9