Development and test of ^{11}Carbon PET-aided hadron therapy

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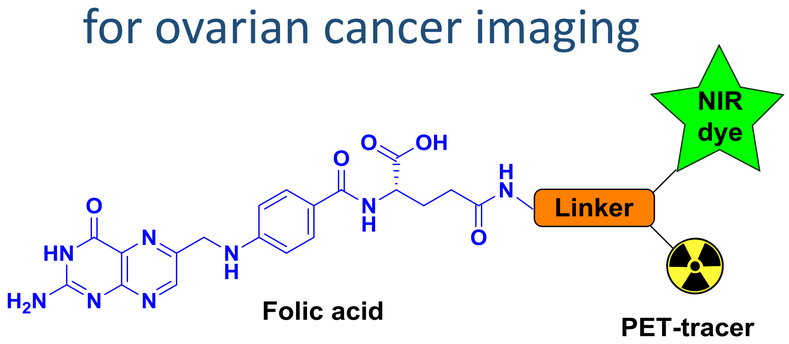
Bifunctional fluorescent and PET bioligand for ovarian cancer imaging



Design of bifunctional PET/optical imaging probe for ovarian cancer

- **Folate receptor-α** (FR-α) is overexpressed in 90-95% of patients with ovarian cancer and it is absent on healthy cells. It is a suitable target for imaging and therapeutics of tumors overexpressing FR-α.
- Folic acid, a ligand for FR-α, will be conjugated to a near-infrared dye and a PET tracer through a covalent linker, resulting in a bifunctional imaging probe.
- The presence of the PET tracer in the probe would allow for preoperative PET-imaging, while the presence of a near-infrared dye would enable intraoperative imaging of ovarian cancer.

Investigation of bimodal imaging probes for ovarian cancer in animal models

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Objective: Develop and validate preclinical imaging techniques for assessment of bio-distribution and performance of new tracers in animal models for prediction of therapeutic efficacy of new radio-labelled compounds.

Different imaging techniques could be applied for ovarian cancer visualization. Imaging diagnostics like CT, FDG-PET/CT and MRI provide an architectural drawing that help the surgeon perform optimal primary cytoreductive surgery.

A bimodal imaging probe (combining PET and optical imaging) is developing on the basis of folate receptor alpha.

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In case of questions don't hesitate to contact us!

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^{11}C charge breeding — Johanna: johanna.pitters@cern.ch
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Acknowledgement:

This research project has been supported by a Marie Skłodowska-Curie Innovative Training Network Fellowship of the European Commission's Horizon 2020 Programme under contract number 642889 MEDICIS-PROMED.

^{11}C Injector

Hadron therapy with primary beam of radioactive ^{11}C (β^+, $t_{1/2}$=20.4 min) allows for range verification via PET imaging

Challenge: Effective treatments require $4 \cdot 10^8$ ions/s delivered to the patient!

➢ Large scale production + optimized beam preparation of ^{11}C

Target material

Boron Nitride (BN)

→ ^{11}B(p,n)^{11}C, ^{14}N(p,α) ^{11}C

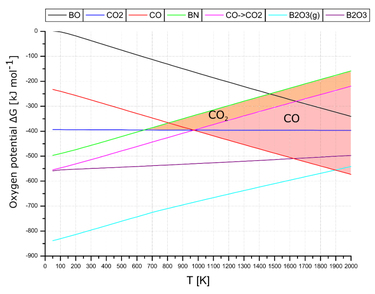
BUT: Extraction is known to be difficult

➢ Control microstructure (porosity, density)

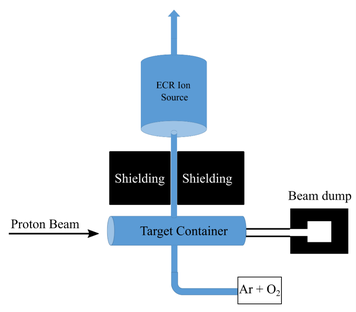
➢ Spark Plasma Sintering (SPS)

Isotope extraction

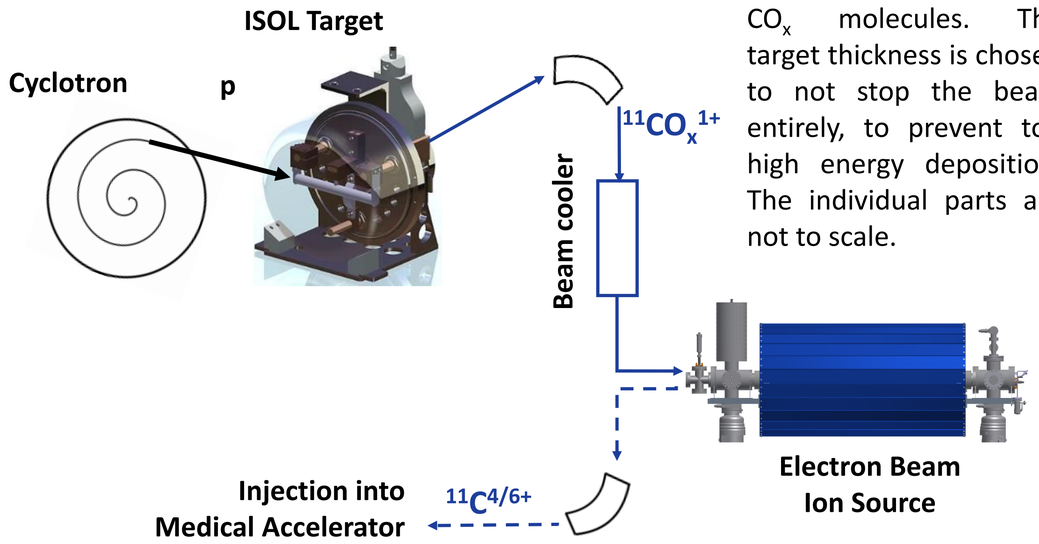
Carbon is extracted in molecular form: CO_x



Ionization



Schematic design of the target ion source unit for the production of ionized CO_x molecules. The target thickness is chosen to not stop the beam entirely, to prevent too high energy deposition. The individual parts are not to scale.



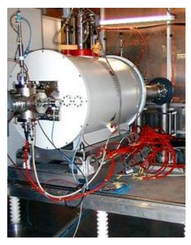
Beam Cooling

After mass separation, the 1+ ion beam coming from the primary source needs to be cooled to match the EBIS acceptance.

➢ RFQ ion beam cooler

or

➢ Penning trap



Charge Breeding

The highly compressed, intense electron beam inside the EBIS

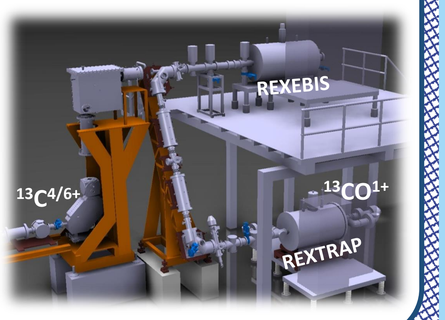
➢ breaks up molecules

➢ increases average charge state

After mass separation $^{11}C^{n+}$ is extracted with a pulsed beam structure

CO tests at REX-ISOLDE

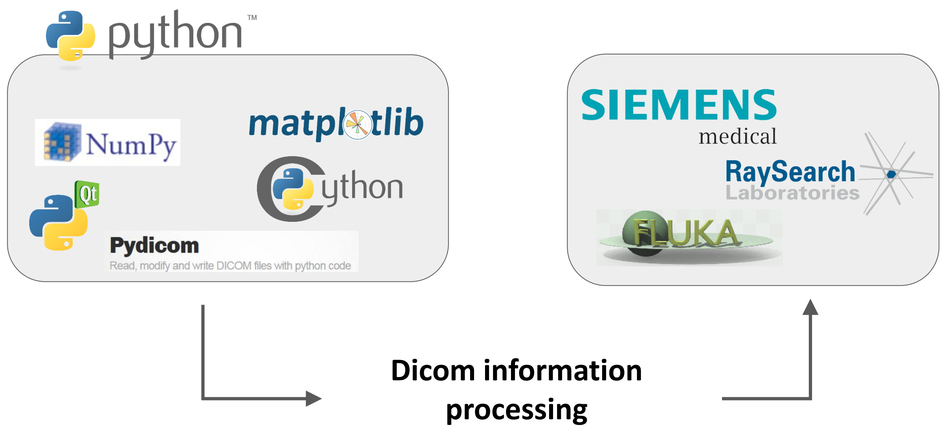
Limitations of CO charge breeding and break-up of the molecular beam are explored at REX-ISOLDE, where REXEBIS and REXTRAP are available.



Left: Photograph of REXTRAP with 3T superconducting solenoid. The main purpose of the Penning trap is to accumulate and cool the 1+ ion beam from ISOLDE before injection into REXEBIS.

Right: REX-ISOLDE with REXTRAP, REXEBIS and the A/q separator. In REXEBIS the beam is charge bred for a higher efficiency during the following reacceleration of the ion beam.

Treatment planning support systems built with Python



Python is a very useful tool for reading and processing dicom files, and it has high potentials. However, Python by its nature is limited in computation time. This disadvantage can be overcome with Cython or by compiling C or C++ code directly with C compiler for Python.

Multiple tools are developed to support treatment planning at CNAO and those programs are useful in understanding various issues in the field of particle therapy.