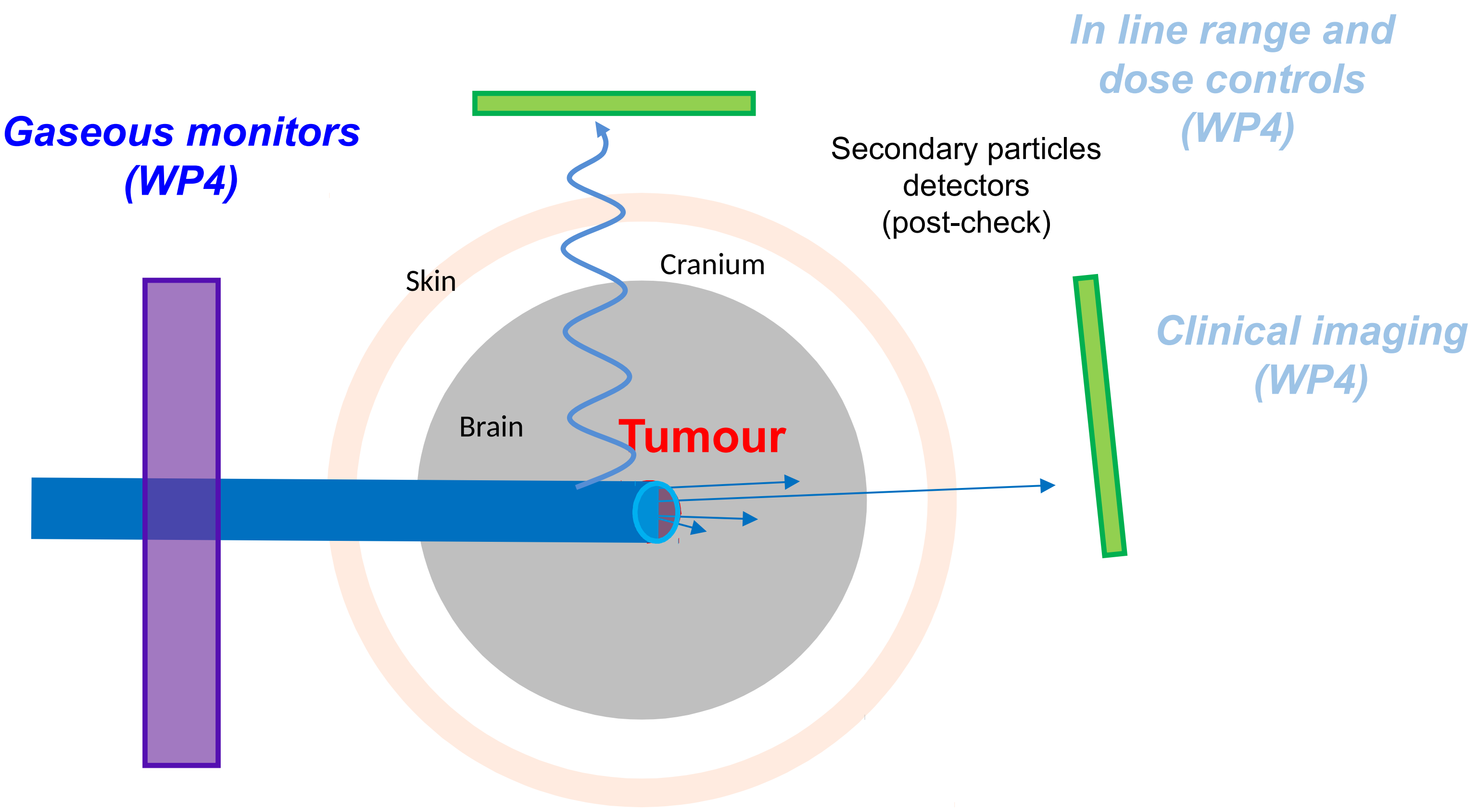
ARCHADE WP2

“Fundamental Physical and Chemical Data for Hadrontherapy”

Which field ?



Need for fundamental data to

- Better predict the dose map
- Have a better control on the irradiation
- Develop innovative imaging
- Better predict the biological radio-induced effects (killing efficiency and toxicity ⇒ WP3)

- ***Secondary fragments production***
  - ***Charged fragments***
  - ***Beta+ emitters***
- ***Fragmentation of DNA***
  - ***Gas phase***
  - ***Condensed phase***
- ***Role of hydration***
- ***Secondary electrons energy distributions emitted by nano-particles***
- ***Production of radio-elements for theranostic molecules***

Who ?

Laboratory	Members	Scientific domain
LPC Caen (AMI team)	6 senior scientists 2 PhD students 1 post-doctoral researcher Technical Services support	Secondary charged fragment production Beta+ emitter production
CIMAP (AMA & MADIR teams)	8 senior scientists 4 PhD students Workshop staff	Radio-induced molecular fragmentation in gas and condensed phase
GANIL	4 senior scientists 2 engineers	Production of radio-elements for theranostic molecules

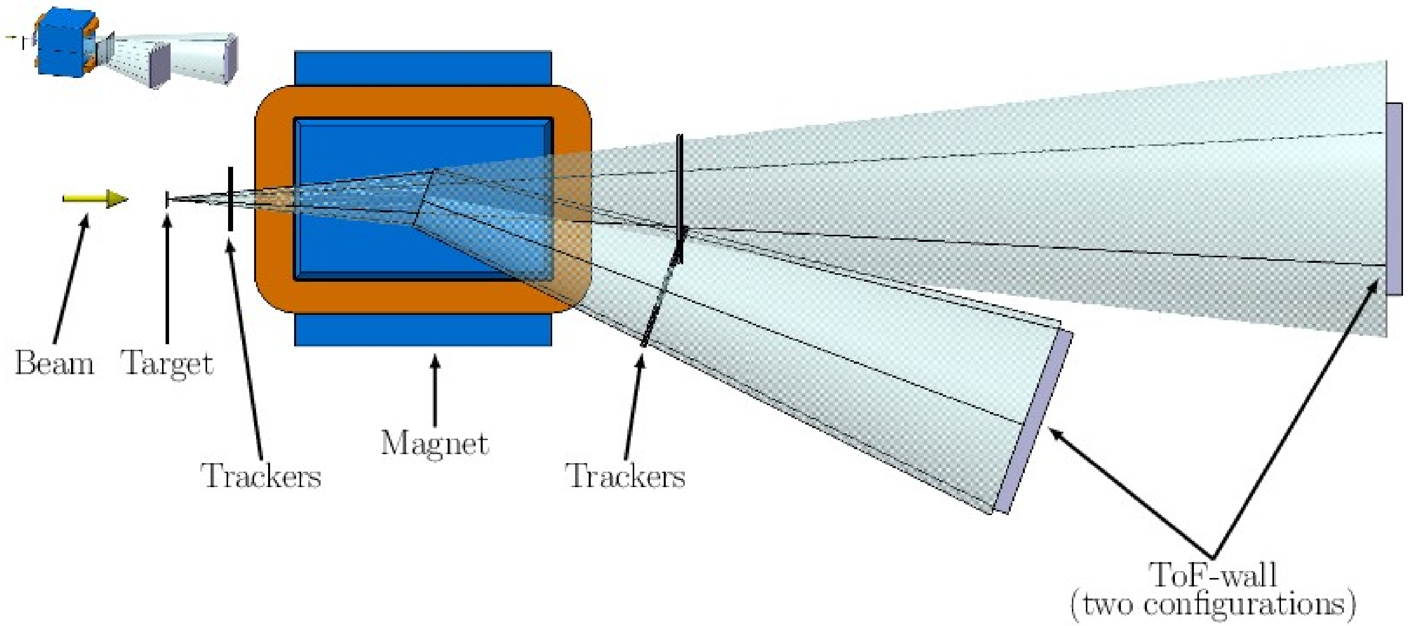
How ?

Subject	Equipments
Secondary charged fragment production	FRACAS + reaction chamber
Beta+ emitters production	PEPIT + reaction chamber
Molecular fragmentation mechanisms	PIBALE mass spectrometer
Role of hydration	CIMHAIR set-up
Production of radio-elements for theranostic molecules	Irradiation pad (installed in NFS)

FRACAS

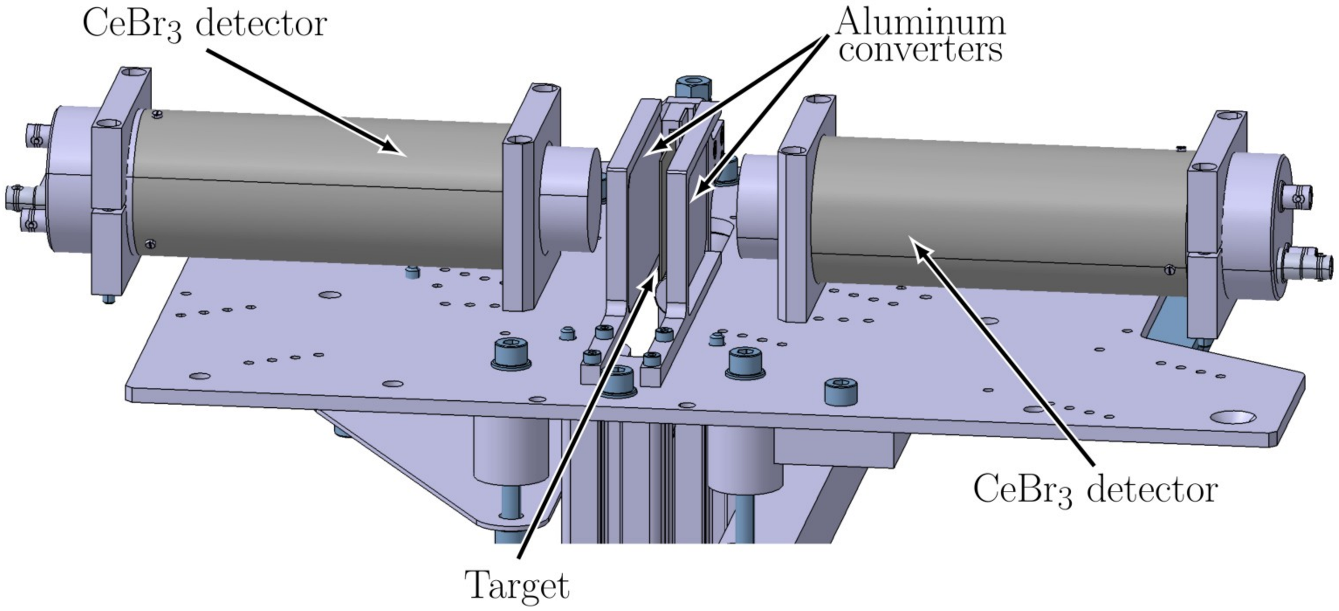
- Fragmentation of Carbon and Cross Sections

  - Large acceptance mass spectrometer
  - Measurements of the double differential fragmentation cross sections on thin target (C, H, O, N, Ca)
  - From He to O or Ne beams
  - Beam energies ranging from 100 to 400 MeV/n
  - Partly founded by REC-Hadron (vaccum chamber) and Fr-Hadron (part of the Time-of-Flight wall)

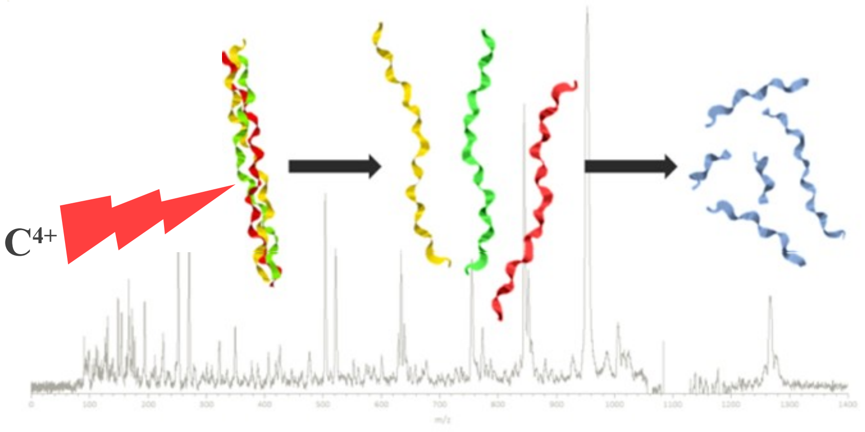


PEPIT

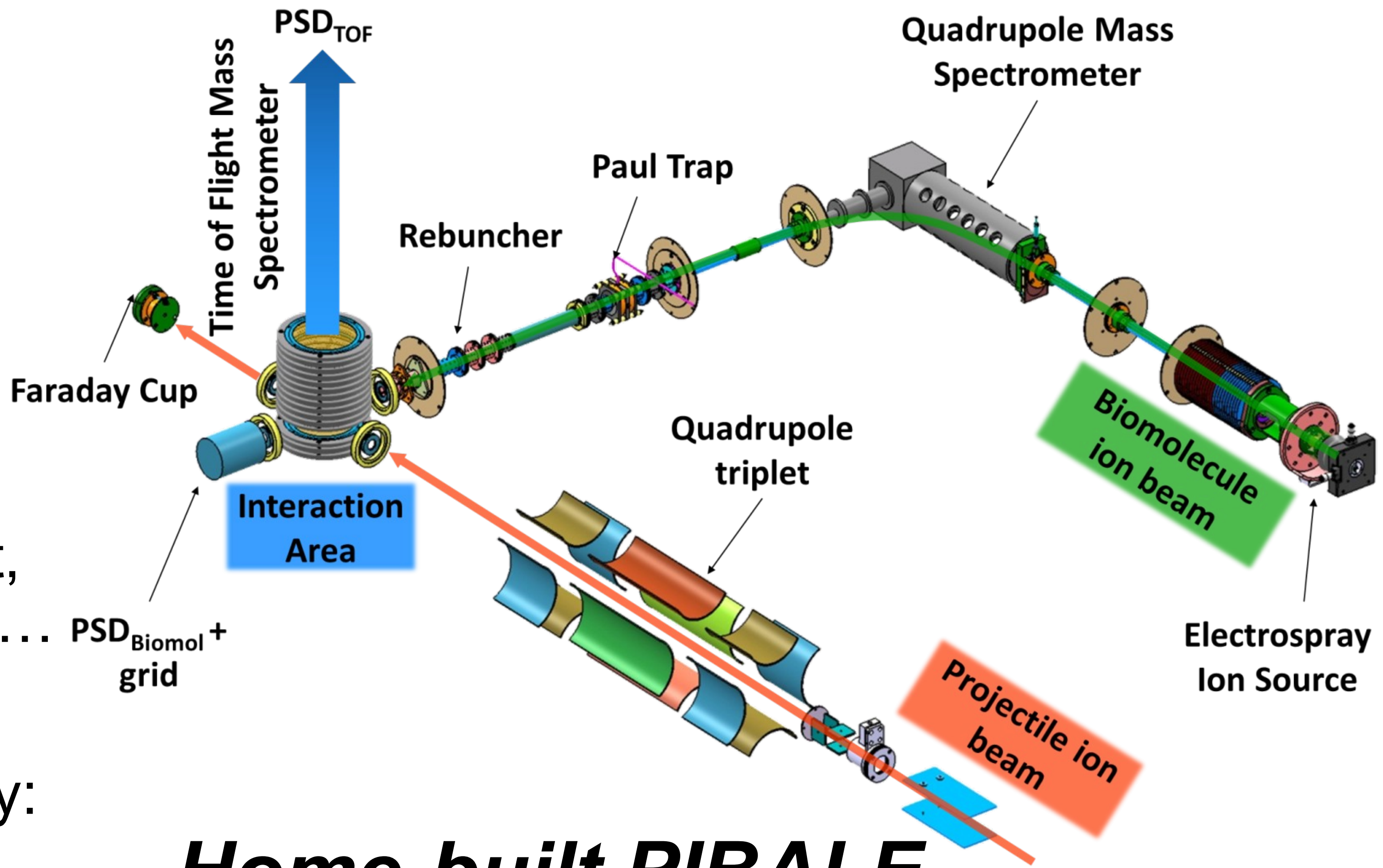
- Positron Emitters Production in Ion Therapy
  - Cross sections measurements of the positron emitters produced in targets of medical interest
  - He, C and O beams
  - From 25 to 400 MeV/n beam energies



Radio-induced physical and chemical processes in biomolecules: gas phase



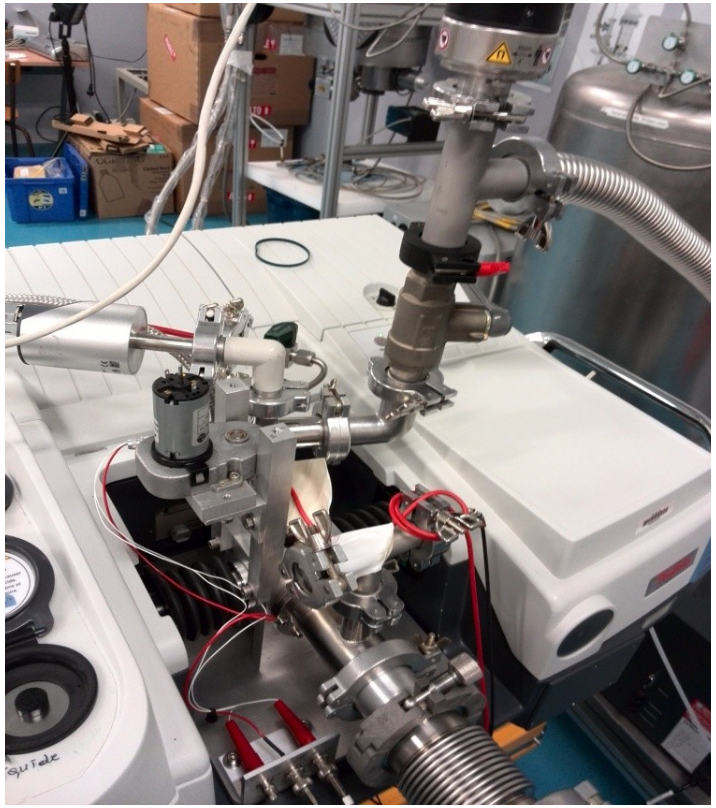
- Ionization, charge transfer, fragmentation, proton detachment, denaturation of proteins and DNA…
- X photons: synchrotron
- Carbon ions at Bragg-peak energy: GANIL
- Different ions over a large energy range: ARCHADE



Home-built PIBALE mass spectrometer

Radio-induced physical and chemical processes in biomolecules: condensed phase

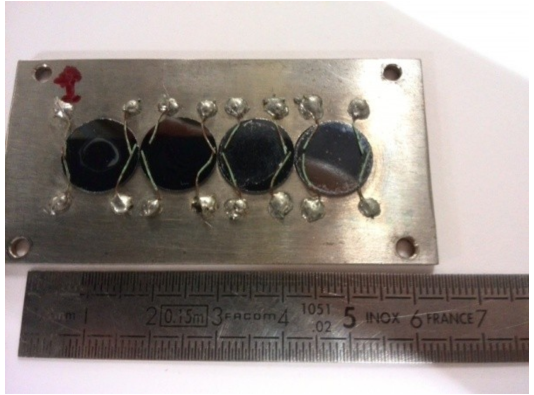
- Radiation-induced defects created at the molecular level ⇒ Vibrational spectroscopy
- Influence of molecular defects : macromolecular + supramacromolecular levels ⇒ Structural modifications
- Concurrent gas emission ⇒ Toxicity?



CIMHAIR Set-up

Influence of the
- ✓LET : Ion beam characteristics
- ✓Environment : O_2, H_2O,
- ✓Dose : high enough for proper quantification

Si-supported thin collagen films



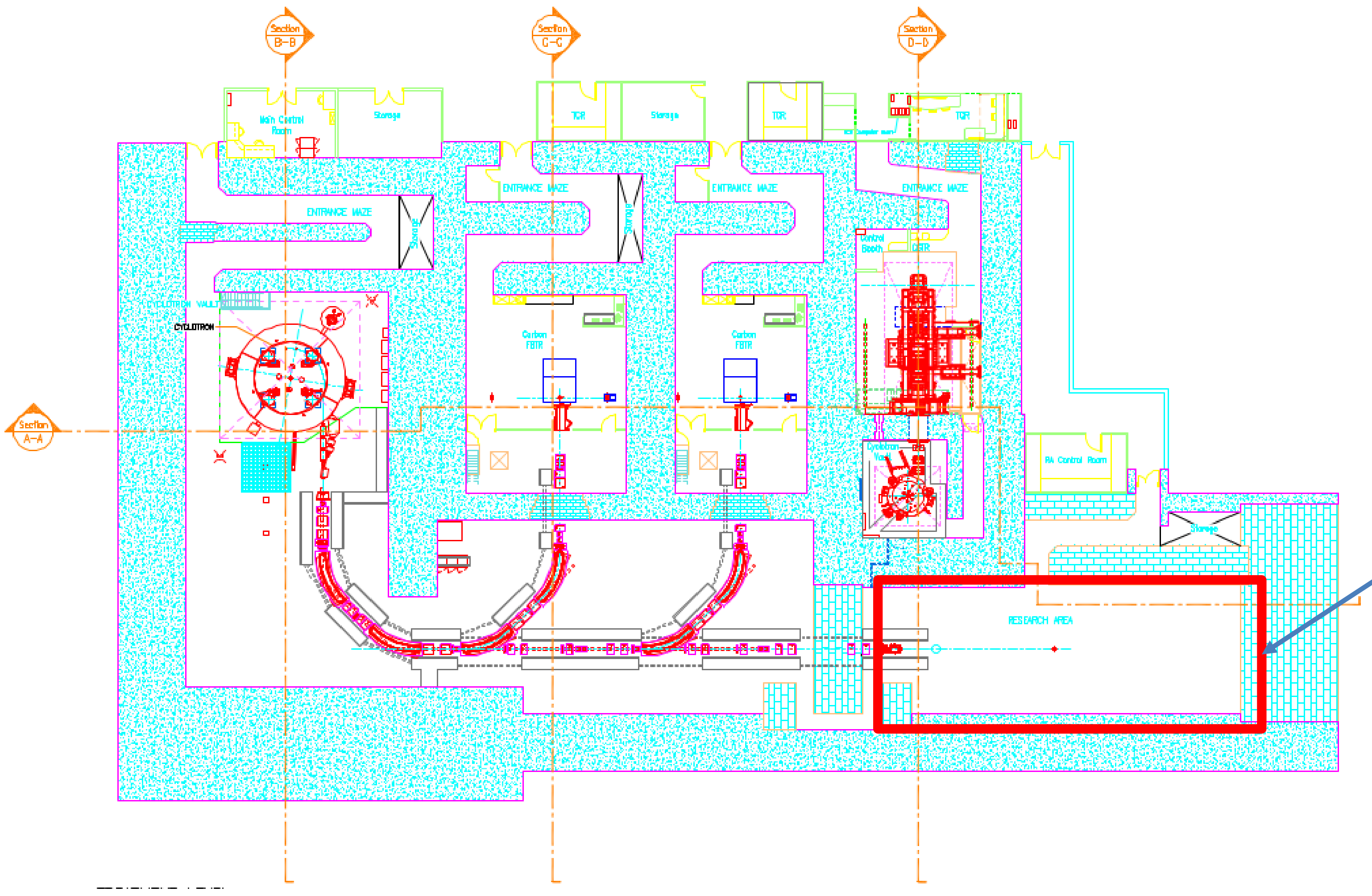
Production of innovative radio-elements

- Goals:
  - R&D to optimize the production of innovative radioelements (cross sections, production channels,…)
  - Development of high power target systems
  - Detection and quantification (evaluation of new radioelements physical characteristics)

Ongoing actions:

  - Design of a dedicated irradiation station for the synthesis of innovative radioelements. Partly installed in NFS.
  - Limited beam time on research facilities.

Where ?



B10 experimental room of the CYCLHAD center

When ?

Now

2025
(C400 beams)

- Test of the FRACAS ToF wall tiles
- Design and building of other FRACAS parts
- Design and building of PEPIT
- Design and building of set-up for radio-element production

Experiments with different ion beams (starting with 12C) and beam energies for

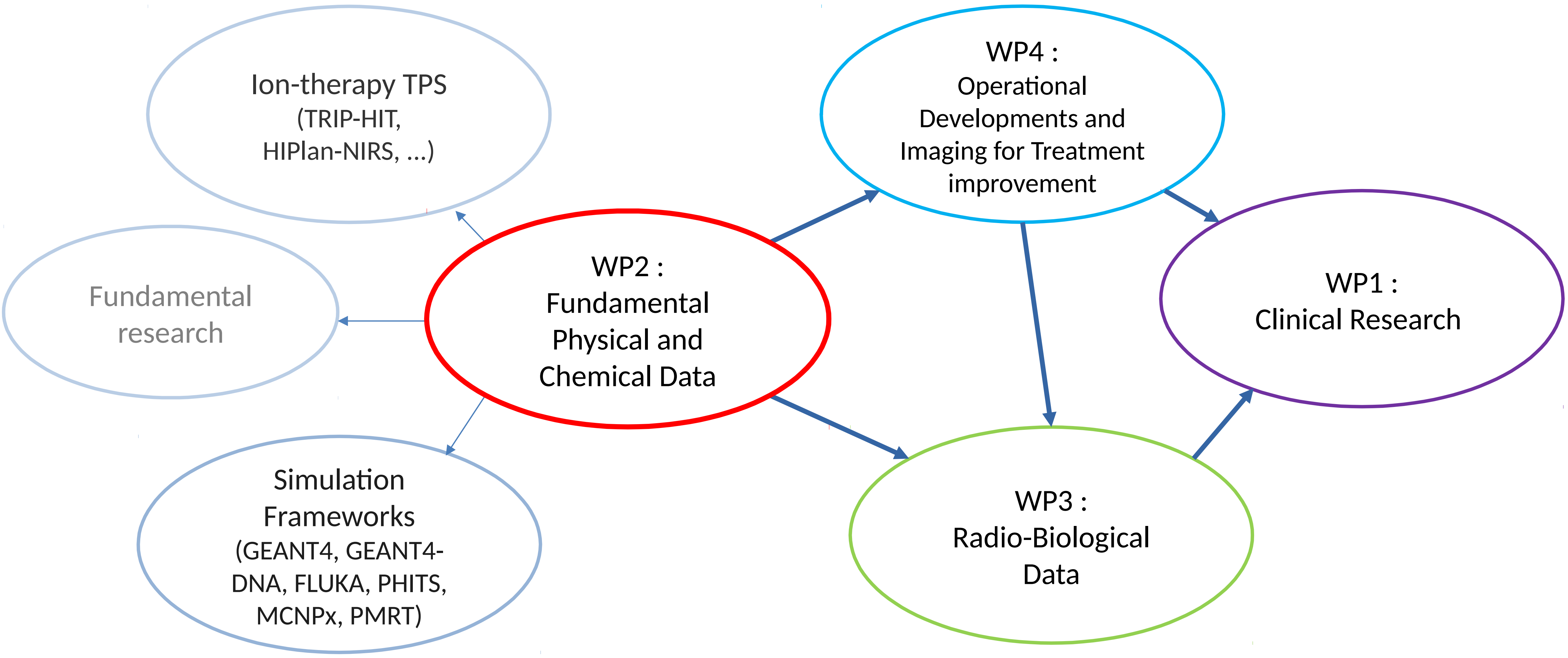
- Charged fragment production with FRACAS
- Beta+ emitters with PEPIT
- Radio-element production

- Protein, antibiotics and DNA fragmentation experiments (GANIL, synchrotrons BESSY2, PETRA3)
- Design and building of new set-up for molecular fragmentation studies
- Study of radio-induced damages on thin films of biomolecules (collagen, ...)

Molecular fragmentation and DNA denaturation experiments for

- Different ion beams
- Different beam energies

Impact of these data for hadrontherapy



More to do…

- Prompt gamma production cross sections on thin targets of medical interest
- Neutron production cross sections on thin targets of medical interest
- Activation of potentially toxic long-lived isotopes

- Radio-induced damages on cell membrane
- Radio-induced structural damages on other tissues (bones, cartilage, …)
- Radio-induced synthesis of potentially toxic chemical species
- Systematic study of the variation of ion ranges with the chemical composition of tissues (measurement of the mean ionization potential for materials with known chemical compositions)
- Measurement of secondary electrons kinetic energy distributions for different tissues and/or materials with known chemical composition
- …