# Neptune-WP2
# Imaging and Quantification

**The Rome Group:** V. Bocci, S. Capuani, D. Carlotti, A. Ciardiello, A. Cruciani, R. Faccini, L. Ficcadenti, E. Furfaro, S. Giagu, F. Iacoangeli, G. Macioce, C. Mancini Terracciano, A. Messina, L. Milazzo, D. Rotili, C. Voena, F. Vulcano

S. Bortolussi
I. Postuma
& **Pavia group**

S. Pacifico
& **Caserta group**

NEPTUNE
Nuclear process driven Enhancement of Proton Therapy UNravEled

# Goals of WP2 (imaging)

- Evaluate bio-distributions of fluorinated tracers using $^{19}$F-MRI

- $^{19}$F-MRI performances limited by low SNR ratio

test-stand: 0.35 T scanner

- Possible **hardware improvements** to $^{19}$F-MRI
  - low noise RF coil
  - software defined radio technology for signal digitization
  - new pre-amp & cooling

9T spectrometer

- Possible **sofware improvements** to $^{19}$F-MRI
  - use of deep learning to denoise and analyse images
- Choice of fluorinated molecules
  - tests on animals to have samples with correct concentrations

# Status@ Last Meeting (Jun2021)

- New antenna

  - 2 loops and 3 loops antenna almost ready to be tested on low field scanner

- Sofware Defined Radio system

  - ready to be tested

- Choice of fluorinated moleculed

  & in vitro internalization

  => F-BPA

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Multimodal evaluation of $^{19}$F-BPA internalization in pancreatic cancer cells for boron capture and proton therapy potential applications

Andrea Ciardiello [a, d], Saverio Altieri [b, c], Francesca Ballarini [b, c], Valerio Bocci [d], Silva Bortolussi [b, c], Laura Cansolino [c, e], Daniele Carlotti [d, f], Mario Ciocca [c, g], Riccardo Faccini [a, d], Angelica Facoetti [c, g], Cinzia Ferrari [c, e], Luca Ficcadenti [d], Emiliano Furfaro [a], Stefano Giagu [a, d], Francesco Iacoangeli [d], Giampiero Macioce [f], Carlo Mancini-Terracciano [a, d], Andrea Messina [a, d] ... Silvia Capuani [d, k, l]

- Ex-vivo tests

  - first mice tests perfomed. Seen less F-BPA than expected

- AI based denoiser

  - denoiser developed and tested on proton data (public data databases, SNR lowered "by-hand")

# Current Status & Plans for 2022

- New antenna & SDR
  - test of 1 loop antenna underway

- Internalization measurement with improved protocol for better quantification

- Ex-vivo tests with improved protocol for better quantification
  => new protocol allows measurement of the same sample with liquid cromatography at Caserta

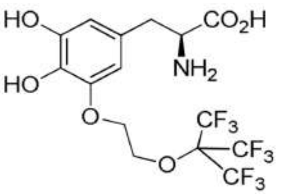
- AI based denoiser validation
  - test on $^{19}F$ images
  - **new post doc hired, dedicated to this task**
  - collaboration with IRCCS **Santa Lucia** (3T Siemens Scanner)

# Measurements with improved protocol

- Reduce resonance line broadening
  => apply better shimming and field locking to the spectromenter to reduce field disomogeneities
  => improve sample preparation i.e."extract" to reduce impact of polar macro-molecules (proteins)
- Use an internal standard (reference molecule mixed with sample)
- PFTB-DOPA:
  => see if enhances F-BPA uptake in PANC-1

perfluoro-tert-butoxy 3,4-dihydroxy-L-phenylalanine

PFTP-DOPA




- Currently protocol is being used on c6 cellular line


Internal reference

Internalized PFTB-DOPA (2h)

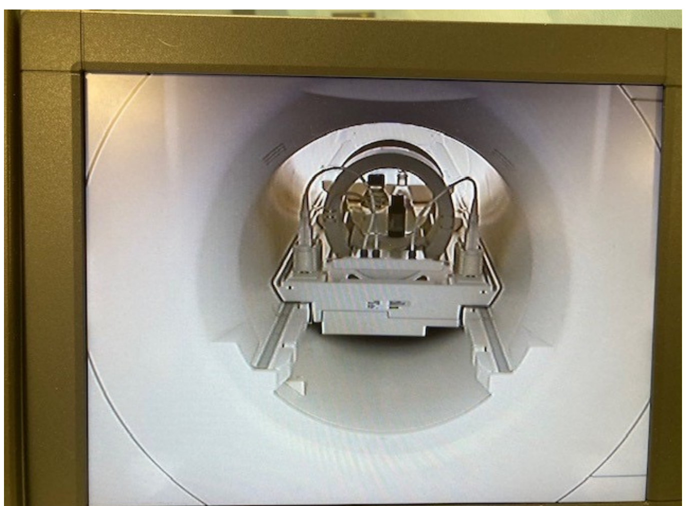
# $^{19}$F-MRI images for AI based denoiser

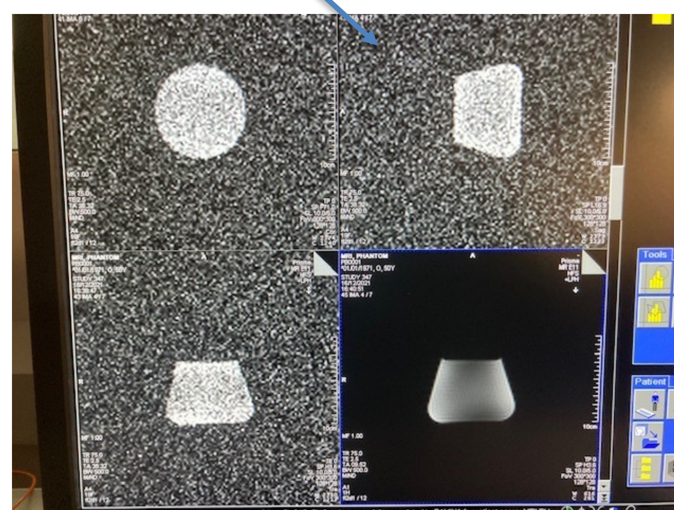
- The sample of images that will be used to validate and tune the algorithm will be taken on the new Siemens scanner (equipped with a $^{19}$F probe) at IRCCS Santa Lucia

- Fluorinated phantoms with different geometries and FBPA concentration will be measured

- First $^{19}$F images were taken with TFA adapting (with no optimization) $^{1}$H sequences

- 1 year post-doc just hired and dedicated to this task





# Summary and Perspectives

- Test of new antenna underway
- In-vitro internalization measurements with improved protocol for quantification underway
- Ex-vivo measurements with new protocol: to do. We want to coordinate with Pavia and Caserta
- $^{19}F$ probe on scanner at IRCCS Santa Lucia ready to take images (AI based denoiser)

# Backup

# Perspective for imaging of $^{19}$F in-vivo

- Original goal: improve SNR of $^{19}$F-MRI images to get concentration map of fluorinated tracers

- Grey level intensity in MRI images depends, depending on the sequences, also on relaxation times, not only on nuclei densities
$$S = S_0(1 - e^{-\frac{TR}{T1}})e^{-\frac{TE}{T2}}$$

- Residual learning CNN in k-space is effective to remove Rician noise

- Other unwanted effects are problematic in low SNR MRI, like movement artifact or field inhomogenities

- Removing the fast noise of acquisition should be considered as the first step of a MRI enhancement pipeline

- Can we use instead a modified version of the DnCNN (fast noise + inhomogeneities correction)?
=>Maybe, need a very large number of images