VBM for INSIDE in-beam PET images

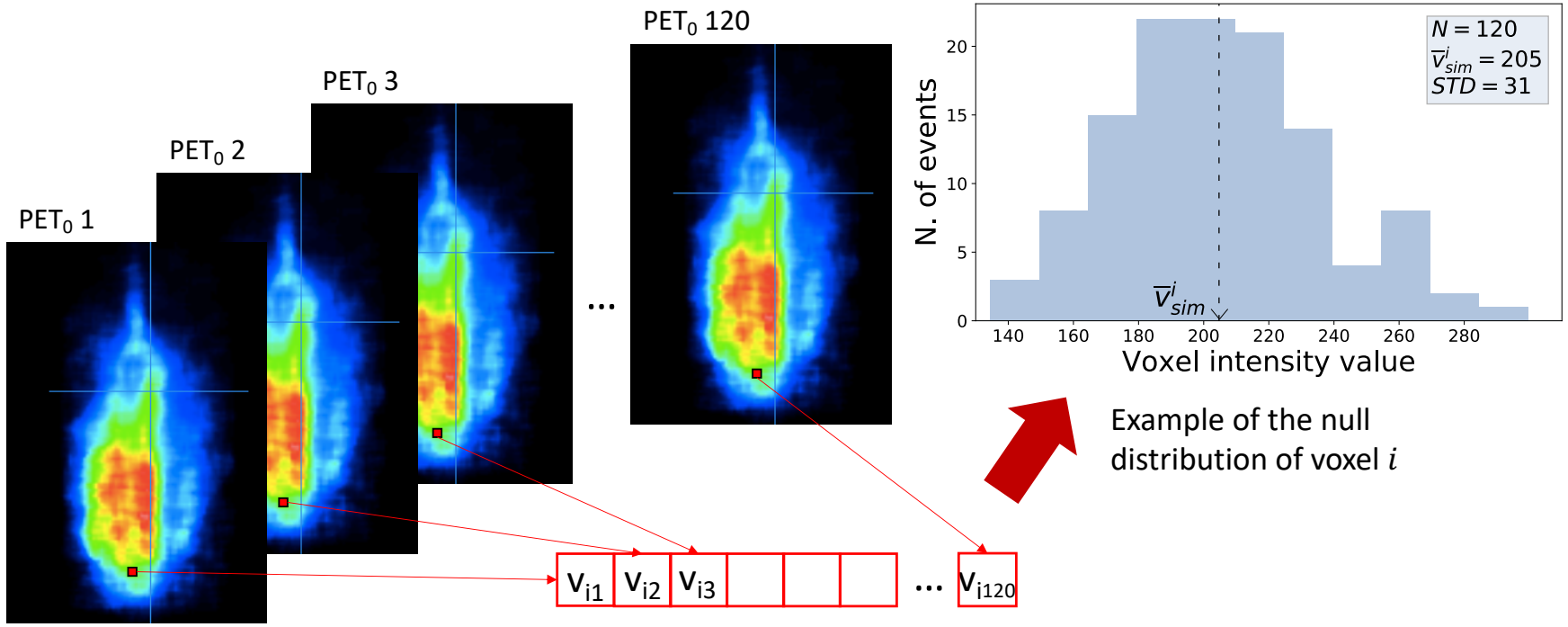
Pisa-group

Outline

- Reminder of method
- Paper: *Localization of anatomical changes in patients during protontherapy with in-beam PET monitoring: a Voxel-Based Morphometry approach exploiting Monte Carlo simulations*
  - Study started with Master thesis of Andrea Berti (currently borsista University of Pisa)
  - Detailed presentation see meeting last time
  - Paper layout:
    - Introduction
    - Methods and Materials
    - Results
    - Discussion
    - Conclusion
- Approach to follow for real data

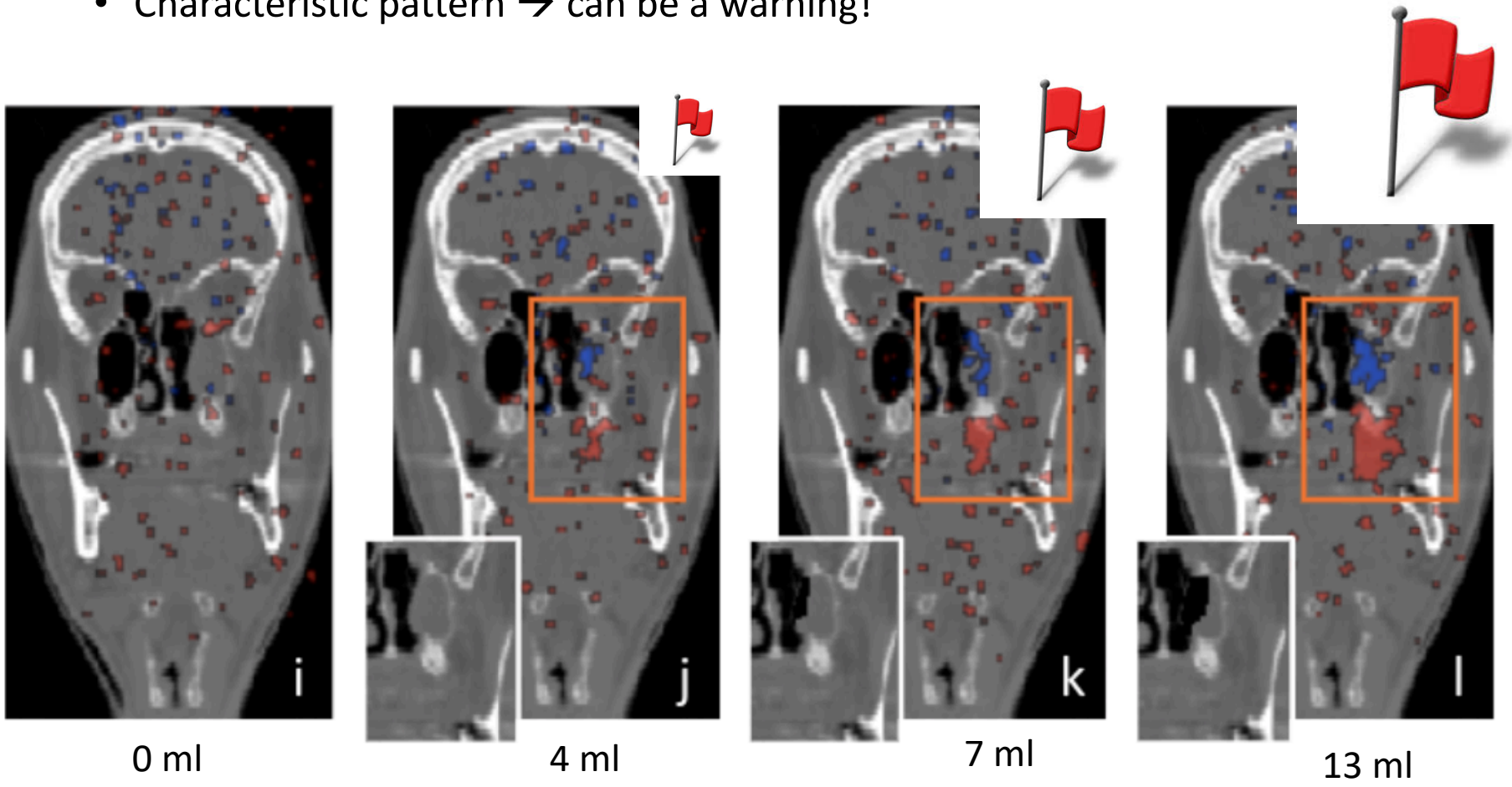
Paper: Methods and Materials

- Try to apply Voxel-based morphometry approach to PET monitoring images
  - Identify anomalous intensity values in voxels by calculating p-value
  - Reference distribution obtained with Monte Carlo simulations
- In order to confirm the validity of the idea, tested first purely on MC simulations
  - Not obvious whether can be done for in-beam PET (artefacts…)
  - Test how ‘quantitative’ the method is



Paper: results (1)

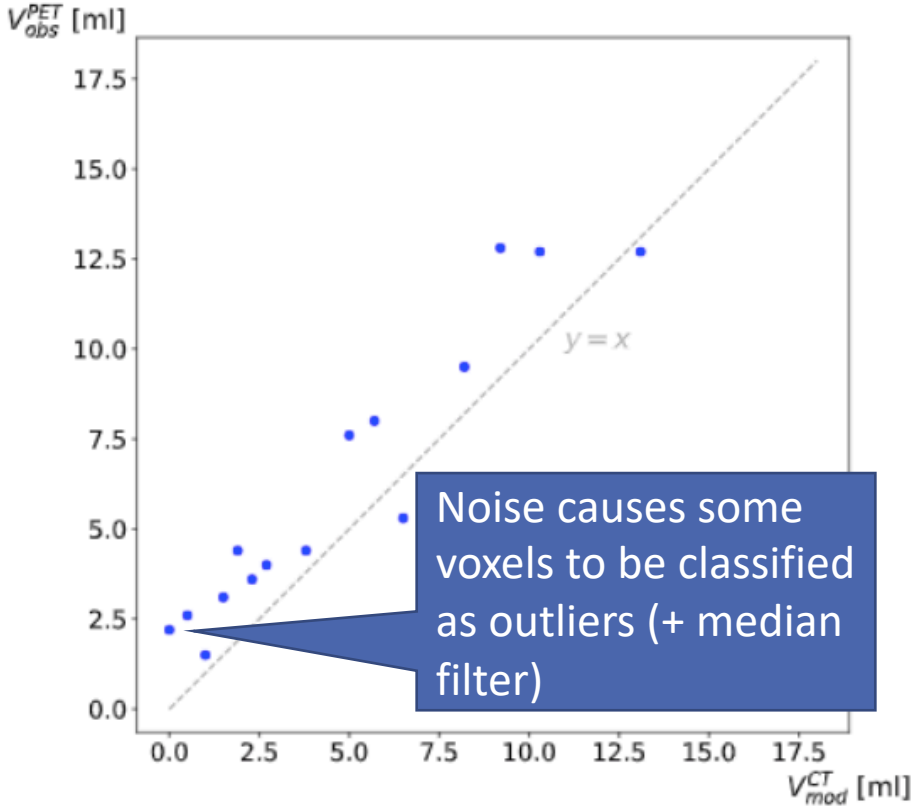
- Example of result: colored p-value map, indicating excess of activity (red) and lack of activity (blue) with respect to expectations
  - Characteristic pattern → can be a warning!



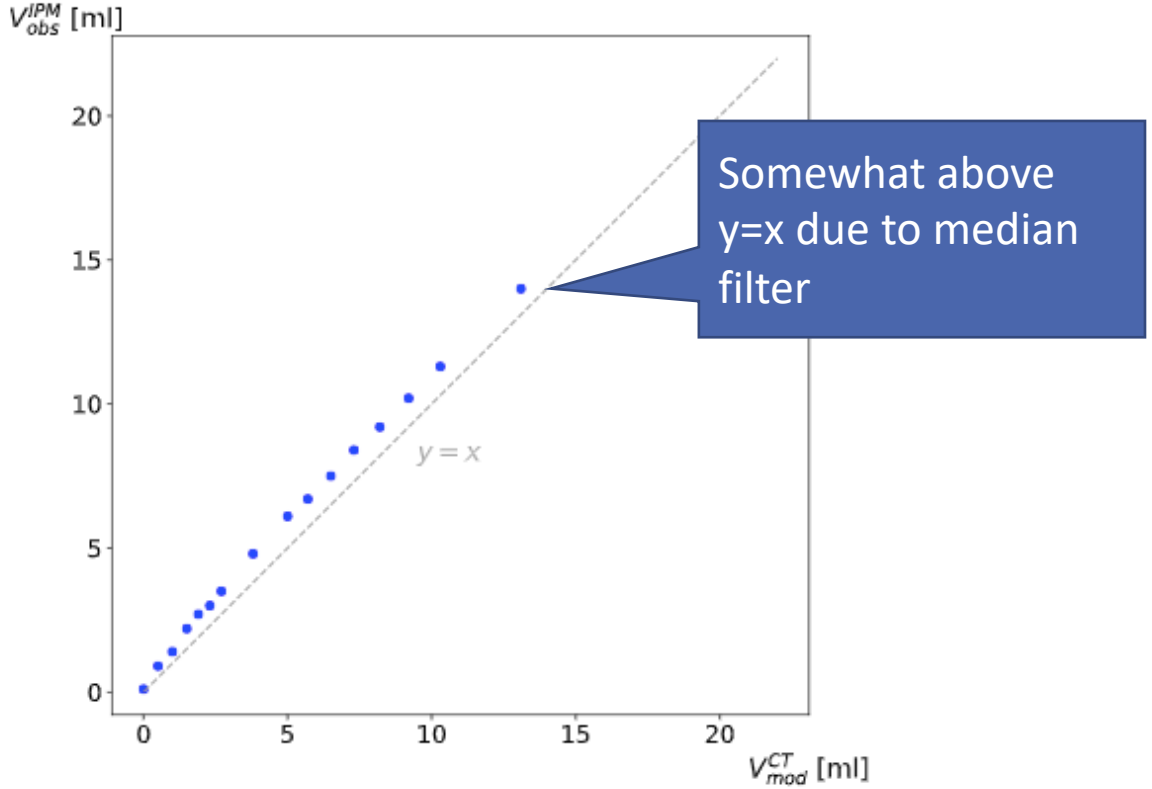
Paper: results (2)

- Method is quantitative: correlation between volume of cavity with the volume that was identified as anomalous.

Including detector and image reconstruction



Monte Carlo truth

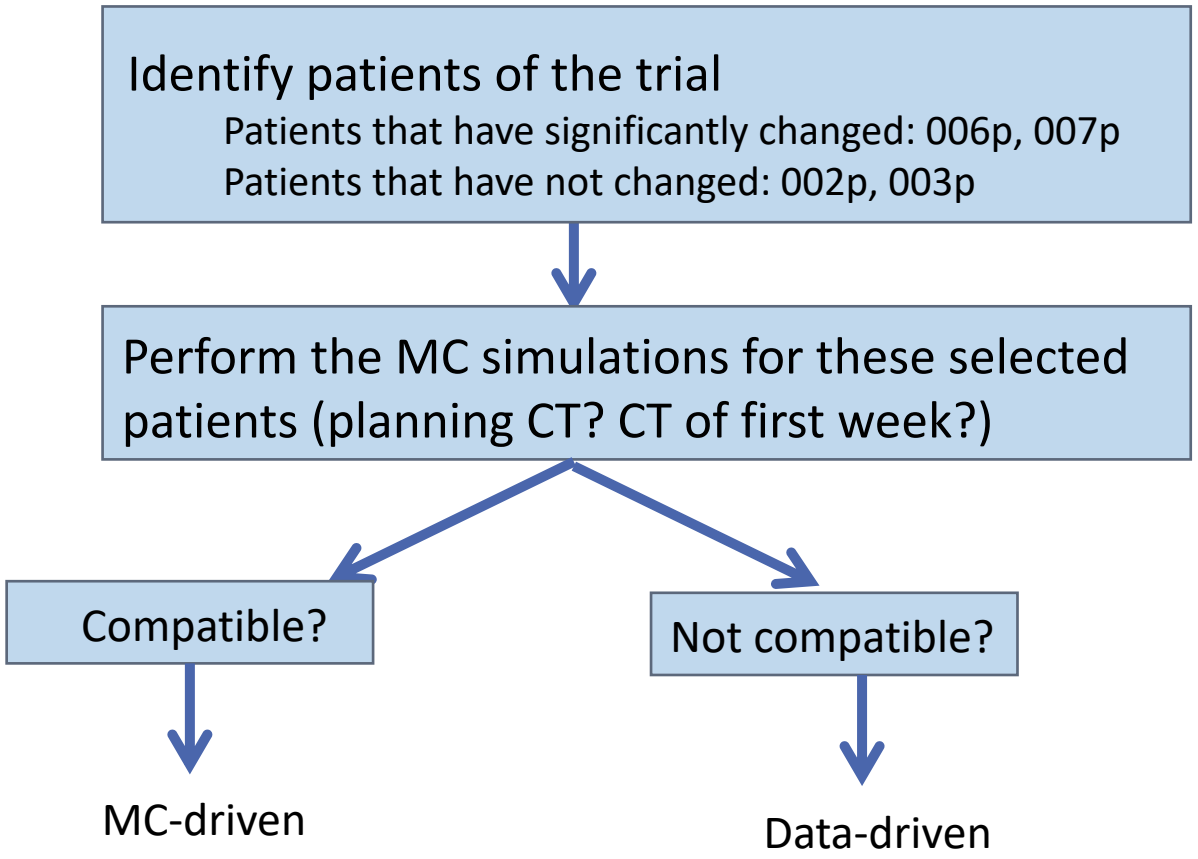


Status since last meeting

- Paper writing started in October 2020
- Andrea Berti joined as ‘borsista’ since December 2020, after he graduated last summer
- Refinements done since Master thesis:
  - Tested different median filters: from 0 to 5 mm
  - Tested different thresholds in the 3-D activity maps
  - Two-tail test versus one-tail test in statistical analysis
  - In sensitivity plot: definition of ‘region of interest’
  - Tested on first and second control CT’s
- Abstract submitted to PTCOG
- Abstract submitted to AAPM
- **Paper submitted to Medical Physics yesterday (now “Under consideration”)**

- We believe the method is interesting and worth advertising. Even if it has not been tested and it may be difficult with INSIDE data, it is an interesting example of a cross-disciplinary approach for analyzing PET monitoring data. It may be interesting also for in-room or after-beam PET, or to other imaging modalities…

Approach for analysis on real data



MC-driven approach

- Apply the method proposed in the paper to
  - Patient that does not change
  - Patient that changes
- To do:
  - Perform N=120 (?) MC simulations for a few patients
  - Compatibilty check: compare simulated distributions of voxel intensities with real patients data
  - Perform VBM–based statistical analysis of acquired data for various fractions to the simulated reference distributions
- Status:
  - Have several difficulties with step 2 of simulations of patient 006P (we changed to FLUKA2020…)
    - ✓ Installed and ran with FLUKA2020
    - ✓ Step 1: output didn't align well on CT --> now fixed
    - Step 2: output doesn't align well on CT yet. (voxel.vxl changed? geometry? Isocenter?)

Data-driven approach

- In progress… next time!