Design of electronic data processing system for radiotherapy study: lessons learned from VoxTox

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www.comprt.org/research/voxtox

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VoxTox = link toxicity & dose on voxel level

- ~1000 patients (prostate, head/neck, brain)
- Curative IG-IMRT on two TomoTherapy units
- 5 year follow-up: acute & late toxicity
- Collaboration between Addenbrooke's hospital, Cavendish Laboratory and Department of Engineering
- Funded by Cancer Research UK

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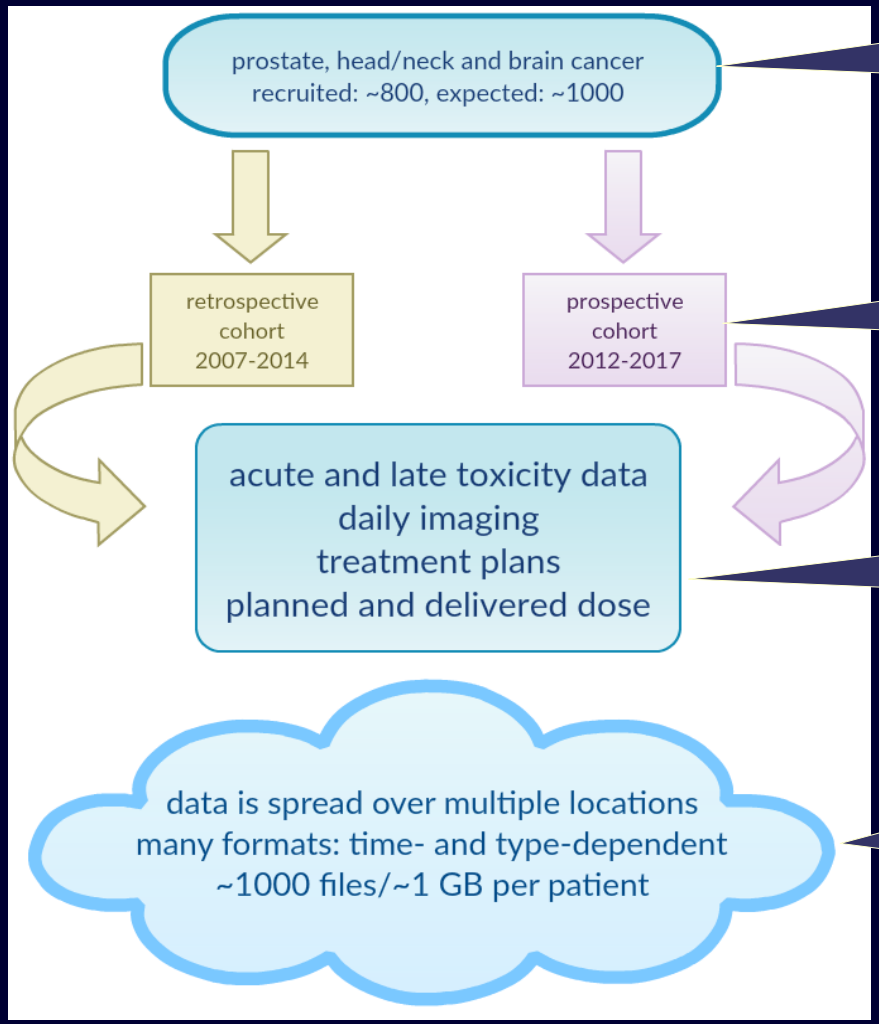
VoxTox study: challenges in the clinic



How to keep track of our patients in a busy oncology department?

10 years of data = a variety of storage formats

Calculation of delivered doses demands a lot of processing power

Retrieval and processing must not occupy clinical computers

VoxTox workflow streamlining

Integrate VoxTox into oncology workflow	⟷	Use MOSAIQ® to record toxicity and recruitment information.
Handle many data formats	⟷	Create flexible mapping software to translate data to desired formats.
Minimise use of hospital computing resources	⟷	Retrieve and anonymise at the hospital, process at research facility

Big data?

1000 patients → 1 gigabyte/patient → 1 terabyte. Not big.

1000 files/patient → 1,000,000 files. Bigger?

operation	time/patient
retrieval & transfer	120 minutes
dose accumulation	4440 minutes
contouring on daily scans	555 minutes
Total (per patient)	82.25 hours
Total (1000 patients)	10 years without rest/sleep

Very big processing.

VoxTox core team are 1 radiographer, 1 oncologist and 2 physicists.

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dose	s
contour	s
Tota	s
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Years of work to retrieve DICOM data.
Solution: write own automated software.

Very big processing.

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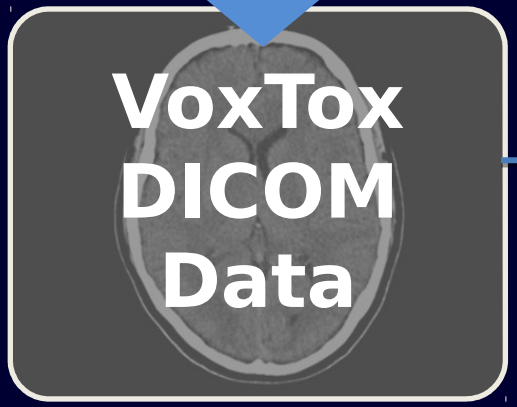
TomoTherapy®: image-guided IMRT

position patient → scan → adjust position → treat

- Mega-voltage CT for image guidance (MVCT);
- DICOM data export:
  - user hand-picks single files;
  - blocks clinical station;
  - cannot export daily positional corrections;
  - Cannot always handle data > 3 years old.

- Proprietary formats;
- Frequent changes;
- Incomprehensible;
- Bulky.

- XML:human-readable;
- Can add new types;
- Can be changed fast;
- Re-usable.



3 tier architecture:

1. Data model;
2. Application logic;
3. User interface.

✓Fully DICOM compliant.
✓Private tags hold additional data.
✓ Tokenize for research.

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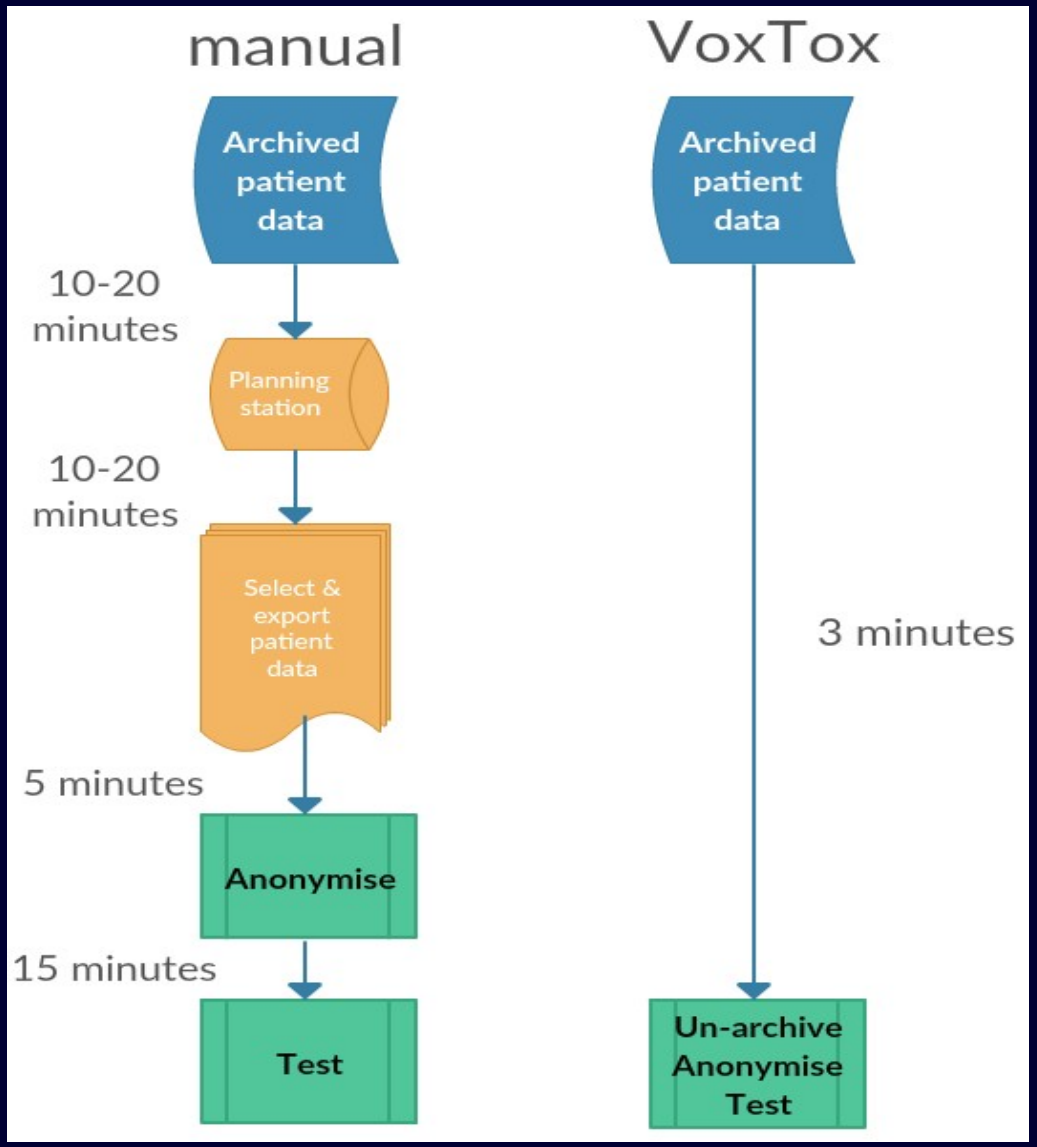
DICOM data retrieval

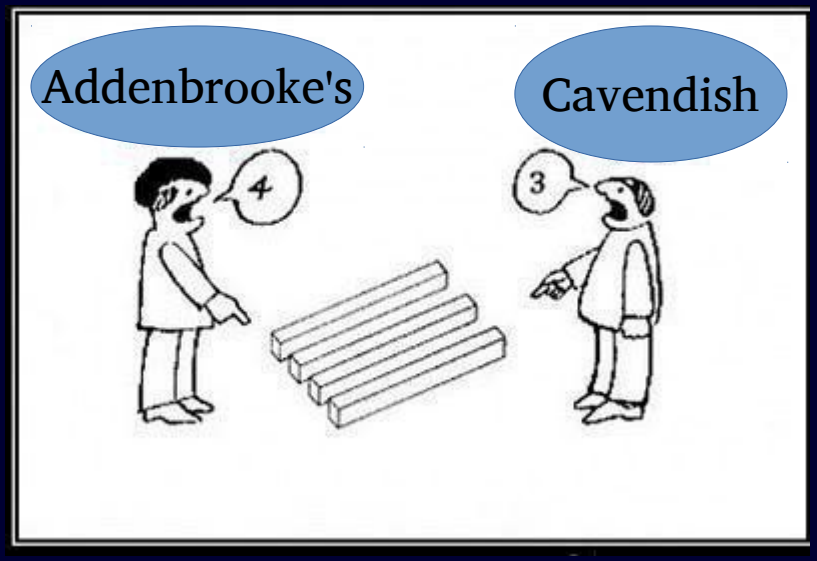


- Batched processing:

  ~700 patients in several days;
- Runs on a standard office computer (2.6 GHz CPU, 8GB RAM) as background task;
- Our DICOM data is tested on
  - Varian
  - Pinnacle
  - RayStation
  - OnQ
  - ProSoma

Data testing is important

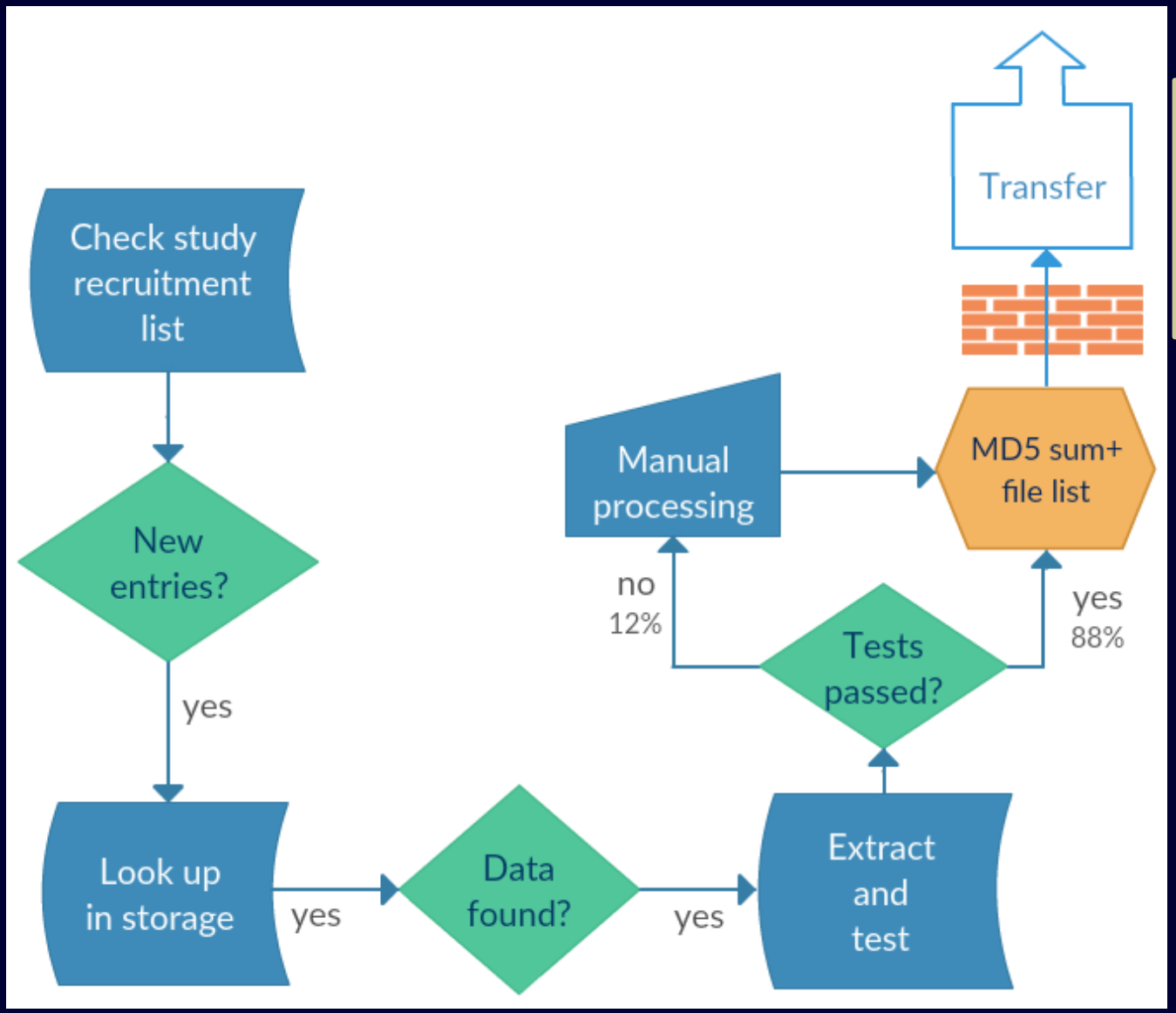
Result of the first exchange of 151 patient data sets between our sites:



Data losses during retrieval & transfer

- Network interruptions, power outages, IT department initiated computer reboots.

Retrieval and testing at Addenbrooke's hospital



Retrieval

- All retrospective cohort data is retrieved.
- Prospective patients are added in monthly batches. => almost no missing data.

Testing

- Daily scans = fractions?
- Plan CT, plan, plan dose, plan contours present?
- Does each scan contain all slices?

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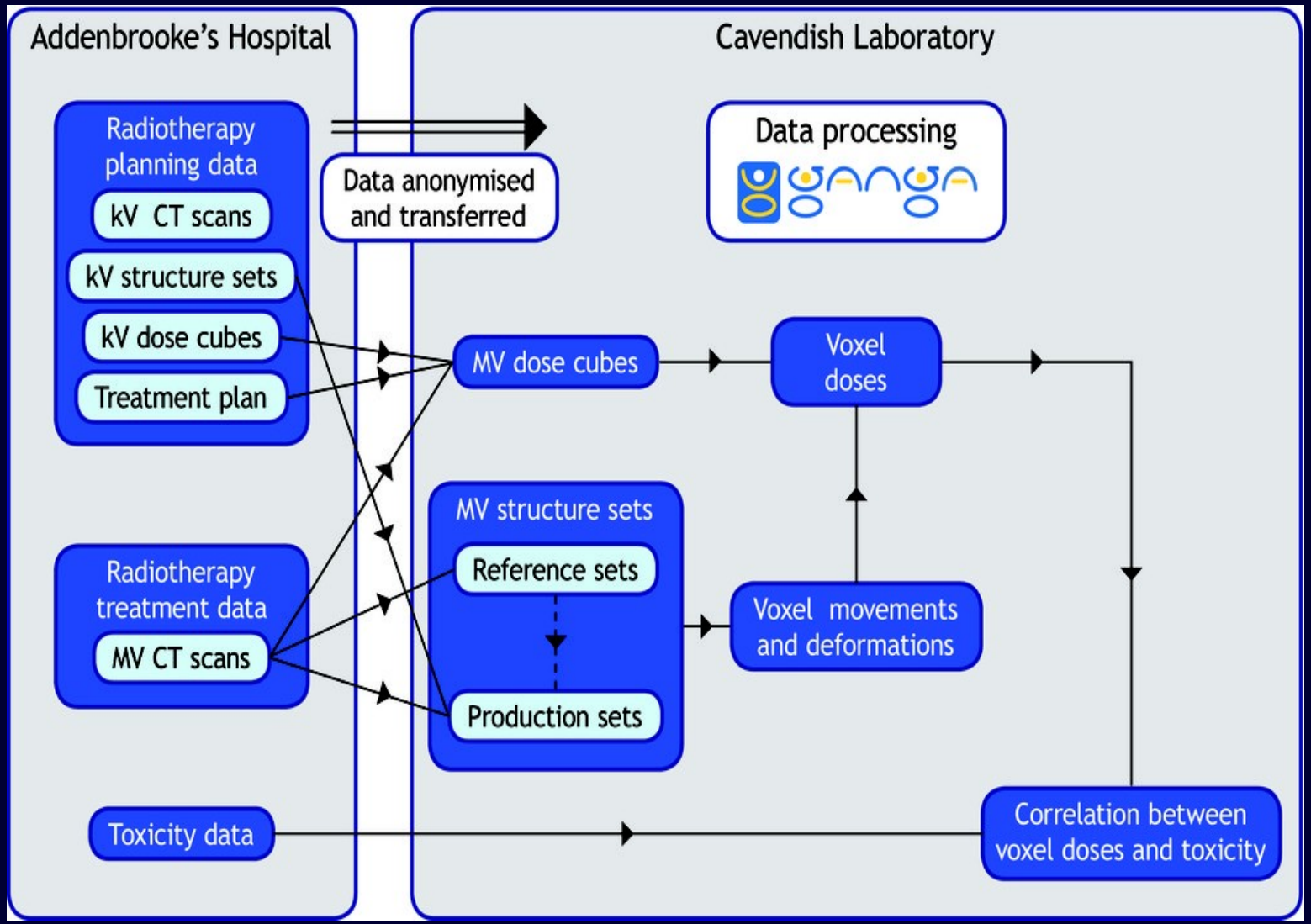
Solution for dose accumulation: parallel processing.
Solution for contouring: develop automated software.

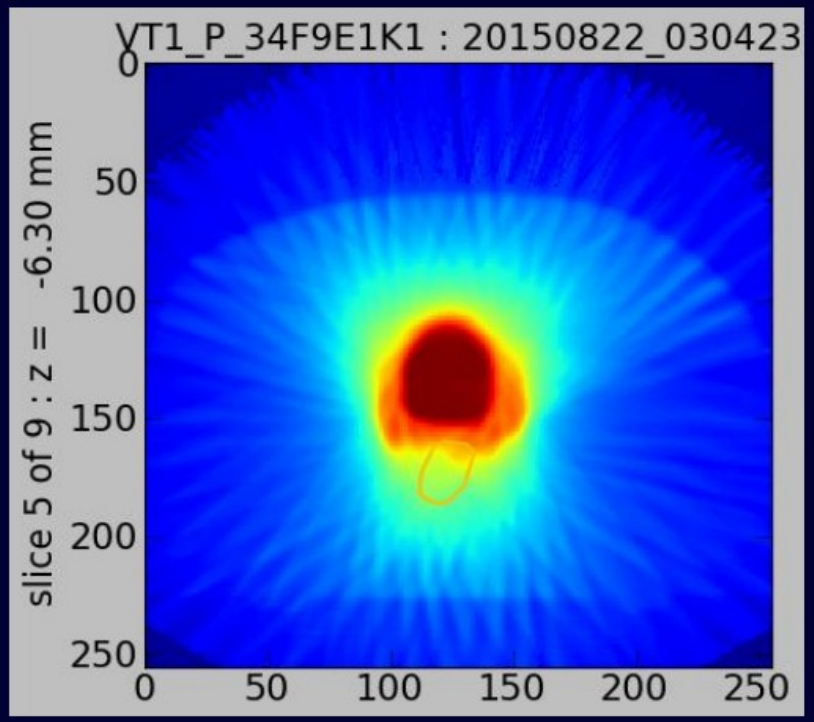
VoxTox core team are 1 radiographer, 1 oncologist and 2 physicists.

VoxTox sites

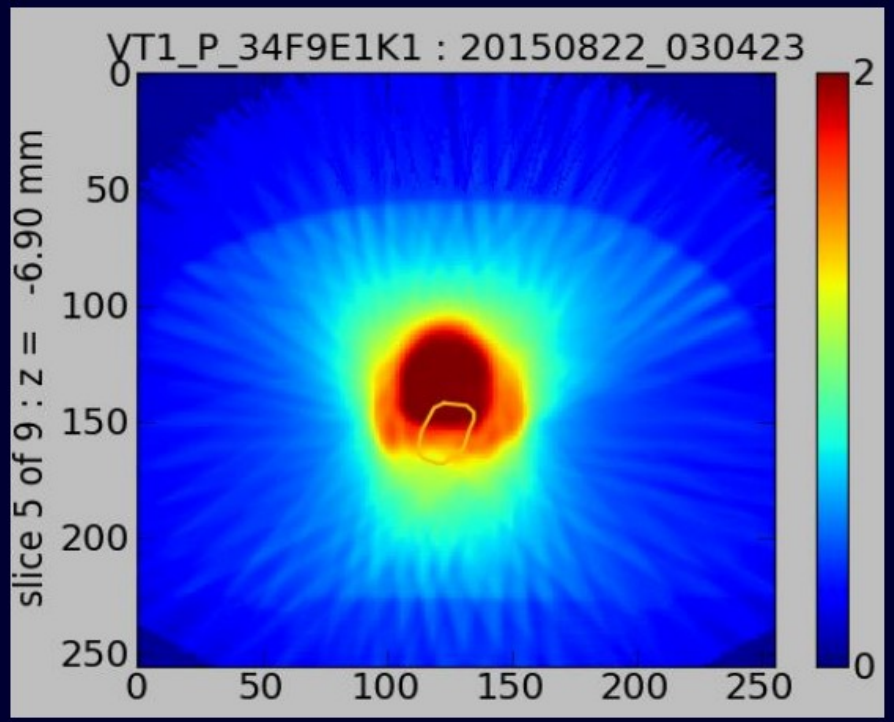


GANGA for testing

Assumption-free (black box) testing on very large number of cases aids identification of very rare errors.



Incorrectly applied ant-post shift pushes the rectum away from the high dose region.



Corrected anterior posterior shift.

Lessons learned

- Utilise full potential of existing resources;
- Lose the graphical user interfaces for the sake of batch processing;
- Separate data from processing – say “NO” to hard-coding;
- Use job management system where possible;
- Test the data independently using different methods and no assumptions = black box testing.

“Never doubt that a small group of thoughtful, committed people can change the world.“ *Author unknown.*