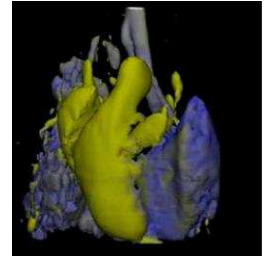


# The MARS-CT Project

September 2009

**Phil Butler** (PI University of Canterbury)  
**Anthony Butler** (PI Christchurch Medical School)



## Summary

The MARS-CT team has had great success over the past 6 months with support from the New Zealand government and research partners. Since 2008 we have been funded by a \$4.5m contract with the Foundation for Research, Science and Technology under their Research for Industry portfolio. This support underpins the research and development to bring a MARS-CT system to market.

The research team now includes research partners at University of Canterbury (UC), Christchurch School of Medicine of the University of Otago (UOC), and HIT Lab NZ (part of UC), University of Auckland (UA), European Organisation for Nuclear Research (CERN), Canterbury District Health Board (CDHB) and the Christchurch Polytechnic Institute of Technology (CPIT). Within the team there is a multidisciplinary approach with radiologists and radiographers, biologists, physicists, electrical engineers, computer scientists and mathematicians. There are currently 16 academic and 4 design staff together with 18 students. The number of students undertaking MSc and PhD theses is continuing to grow.

There has been ongoing support from the Medipix3 collaboration, as well as from commercial partners MARS Bioimaging Ltd, Right Hemisphere Ltd, and Nextspace Ltd. Local industrial sub-contractors include: ILR Ltd, Quarticom Ltd, Fabtek Ltd, Shamrock Industries Ltd, Venonese Design Ltd and Draw 2-3D Ltd.

The MARS-CT2 scanner is situated in the newly formed Centre for Bioengineering at UOC. This extended lab space with new computers is being well used by staff and students. The MARS-CT2 is collecting data sets for staff and students. Updated web pages with a full list of people involved in the project, publications and ongoing projects can be found at <http://wiki.canterbury.ac.nz/display/MARSCT/Home>.

The MARS-CT3 is nearly complete and for marketing purposes will be called the MARS-microCT. The gantry and control electronics have been tested over the last 2 months. The prototype version of the MARS-camera and interface software are working with Medipix2 and communicating with Medipix3 detectors. A production system of the MARS-camera is under test. We intend to supply complete MARS-microCT systems to research partners in the coming weeks and months.

## Publications and Presentations

The results of the MARS-CT1 and -2 scanners have 7 articles in preparation or published in respected journals as well as 20 conference presentations. Joint publications with international partners include Erlangen University, Prague-CTU, CERN and JINR (Russia). A full list can be found on the new web under publications.



Many staff and students have given presentations internationally and locally. Anthony Butler has presented to Oxford, Stanford, Berkeley, Memorial-Sloan-Kettering, Harvard, Massachusetts General Hospital, as well as locally at UC and UOC. Mike Hurrell, Robert Doesburg, Nigel Anderson and Phil Butler have given presentations to the CERN Medipix3 collaboration and Nigel to the European Congress of Radiology. Hamish Silverwood and Rafidah Zainon have presented posters at international conferences. More international student presentations are scheduled for the near future. There has also been huge success from students giving project presentations to the Physics and Astronomy Department of UC.

## MARS-camera



Earlier readout systems did not meet all our design needs so we undertook of a major project to develop a multi chip, fast frame rate system. The hardware and software is near completion to form the MARS-readout. When combined with Medipix chip assemblies it forms the MARS-camera system. A significant amount of work by ILR Ltd, Dave van Leeuwen, Syen Nik, Robert Doesburg and others has created a robust gigabit ethernet readout compatible with both Medipix2 and Medipix3. It allows a camera unit to contain up to 6 chips, and multiple cameras to be incorporated into a MARS micro-CT. A prototype of this camera has been shipped to Mayo Clinic as the first stage of an ongoing research collaboration.

UC is making the MARS-readout available to Medipix collaboration members at cost.

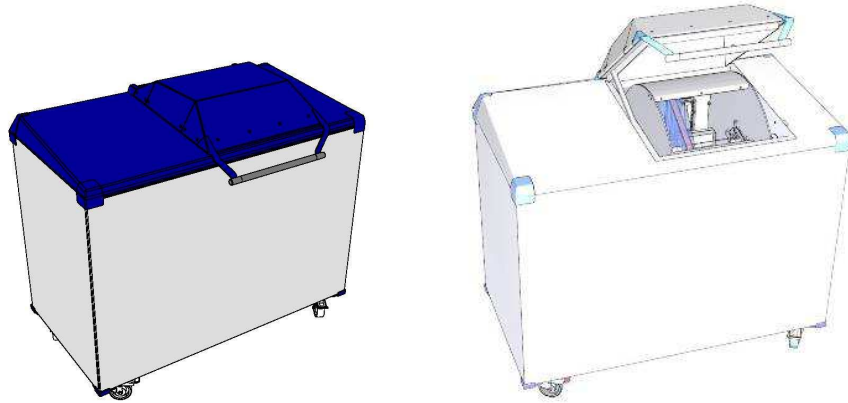
*Left: A production version of the MARS camera's motherboard*

## MARS-microCT

The production of the first MARS-microCT is almost complete. The design has been completed by UC with its commercial partners. The gantry and frame for the first MARS-microCT were completed several weeks ago. Since then they have undergone robust testing initially by technicians, then subsequently undergraduate students. Other student hardware projects include chip alignment and radiation dose simulations.

For the cabinet, the design features have been finalised and the final stage of assembly is currently occurring. Final steps for completion include colour and branding. Important functional features have all been incorporated such as easy loading and unloading of samples, gas and wet lines, adjustable magnification and fully scriptable scans. The MARS-microCT has a modular design for reliability, for servicing, and for upgrading, including the possibility of adding more camera units.





*Design of the MARS micro-CT Left: Colour Scheme. Right: With the lid open showing the gantry*

## Software development

The development of the hardware allows the software for the low level interface for motor control, chip set up and calibration and image acquisition to be finished. The software controlling the gantry and motors has been extensively tested.

There is continuing progress with the software to further analyse the datasets from the MARS-CT2 scanner including image reconstruction and artefact removal, image processing, and visualization techniques. A range of novel visualization and imaging tools has already been developed and are actually used internally by the MARS team and by our direct partners.

## Current Research

Local research collaborations with cardio-endocrine researchers, radiologists and oncologists are producing exciting results.

There is a large array of current research projects connecting research from many disciplines:

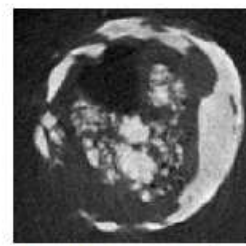
- Atheroma plaques in heart disease – Cardio-endocrine Research Lab (UOC), Biological Sciences Department (UC) and Physics & Astronomy (UC)
- CT reconstruction methods – Electrical and Computer Engineering (UC), Mathematics & Statistics (UC) and P&A (UC)
- Breast cancer imaging – Radiology (UOC), Physics & Astronomy (UC), and CPIT. Visualization methods of spectroscopic data – Radiology (UOC) and HIT Lab NZ (UC)
- Spectral analysis methods – Physics & Astronomy(UC) and Mathematics & Statistics (UC)



**Femoral plaque  
set in resin**



**2D projection  
image**



**Reconstructed 3D  
slice at 14.45 keV**

The development of new fusion algorithms to visually combine energy bin datasets is an active research area by the group. Complimentary, we are investigating the design of new user interface for multi-energy bin visualization tool. This research is being done in collaboration with end-users as radiologists, oncologists, etc.

Nextspace Ltd, an Auckland ICT company, is working with us to use Right Hemisphere's DeepServer technology to enable better data management. This will lead to better work flow and enable us to use "on server" image processing and reconstruction technology.

Internationally, we continue to work closely with Medipix3 collaborators in areas such as sensor development and testing, readout development, and material recognition. Stuart Lansley (P&A UC) has been funded by the Royal Society of New Zealand to visit Freiburg University and CERN to develop and test advanced sensors. Several papers have been prepared in collaboration with Erlangen University and Prague-CTU. UC has established a formal research relationship with the Mayo Clinic for testing of the MARS microCT. UOC is developing a formal relationship with Mayo to broaden our cardiology research, with a joint NIH grant planned for October. Syen Nik (UC PhD student), Phil and Anthony will visit Mayo Clinic within the next 3 months. We are also developing research relationships with Stanford University with Anthony and Nigel Anderson having recently visited them to exchange ideas. Syen Nik will have a longer visit in October to progress his work on optimum energy weighting for spectral CT. These interactions are upskilling our team and providing key international contacts.

## The Future

The first MARS-microCT is almost completed and will initially be tested at the Medical School for radiation safety. It will then be transferred to P&A at UC for further technical development.

The second MARS-microCT will be situated at the Centre for Bioengineering Lab UOC for continuing biomedical research. This will replace the MARS-CT2 currently in use. It will have a single camera unit with single silicon Medipix2 chip. This will be upgraded in stages, to multiple camera units each with 6 CdTe or GaAs Medipix3 chips.

The third will be shipped to the Cardiology microCT lab at Mayo Clinic in Rochester, Minnesota as part of our research collaboration. For this Mayo Clinic scanner, key electronic parts were shipped in mid August and their staff have demonstrated them to be working. Upgrades to the camera unit including multiple Medipix3 chips will be made when available.

The clinical research plan offers exploration into exciting new areas such as nano-particle labelling and brain imaging. Work continues on atheroma, fatty liver, breast, and contrast agents and has just begun on insects!

The MARS team is constantly growing with new research collaborators and staff joining for novel projects. There will also be new students with 6 UC and UOC summer scholarship students undertaking 10 week projects between December and February. We have 3 new confirmed PhD students beginning in the new year, including the first student in the UOC Bioengineering Centre.

