After NEMA-NU2

Establishing a Quality Control Programme

ANZSNM Physics SIG Workshop

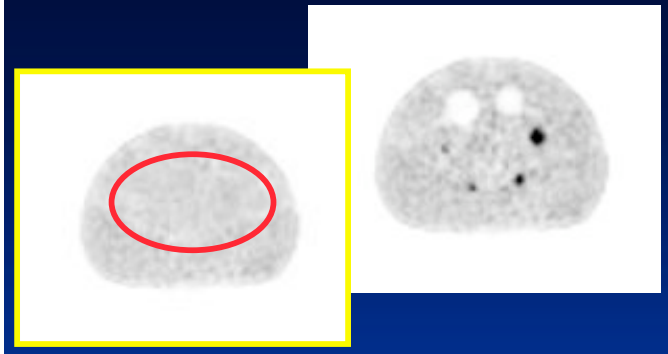
10th December, 2007

Graeme O'Keefe

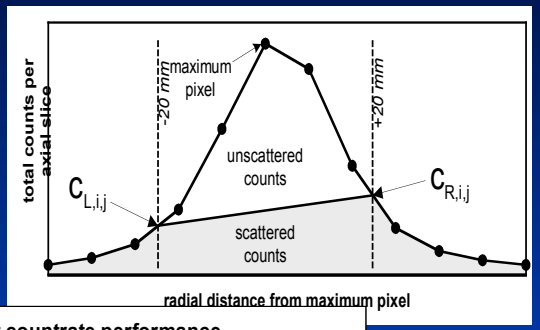
Centre for PET

Austin Health

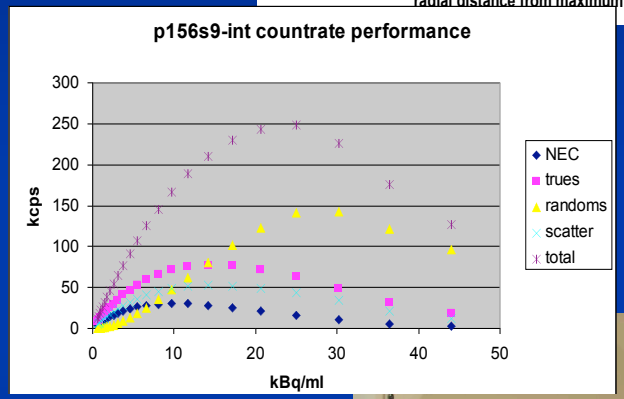
Austin Health

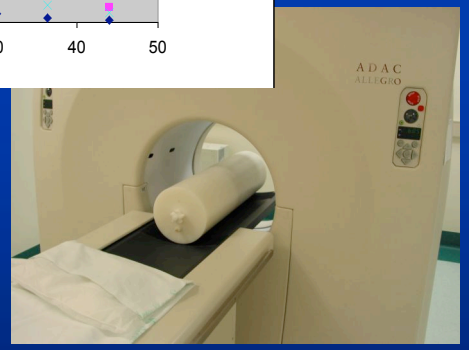


NEMA-NU2
Acceptance Testing



- Spatial Resolution
- Scatter Fraction
- Countrate Losses
- Randoms Measurement
- Sensitivity
- Corrections
- Image Quality
- Accuracy of Attenuation/Scatter corrections





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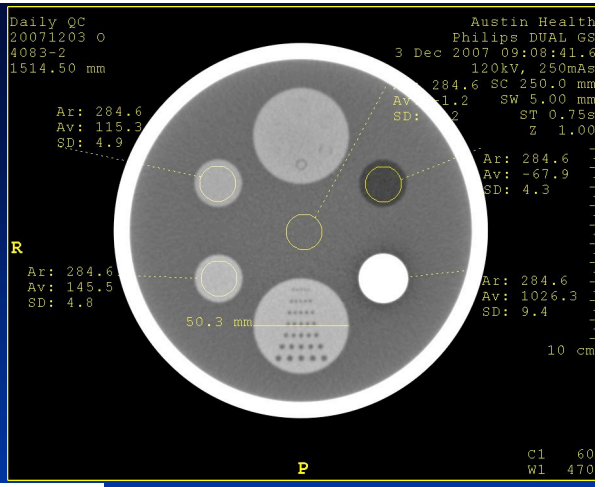
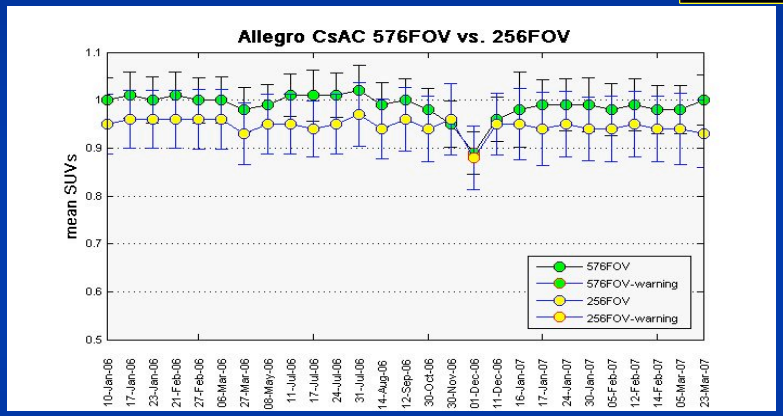
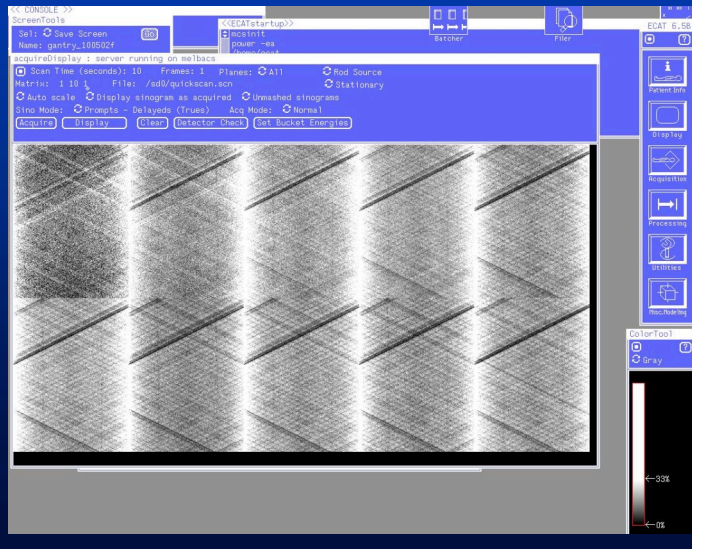
After NEMA-NU2

PET / CT QC



- What?
- Why?
- How?
- When?





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PET / CT QC / QA

What & Why

- Monitor Performance
- Confirm Integrity
- Detect Anomalies
- Trouble-shooting

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PET / CT Quality Control

- Daily : Vendor Specific
  - Clinical programme integrated
    - Technologist
- Weekly : Vendor Specific
    - Technologist / Physicist
- Monthly / Quarterly : Vendor Specific
  - Maintenance
    - Engineer + Physicist
- Annually : Vendor Specific
  - Maintenance
    - Engineer + Physicist
    - Vendor sub-set of NEMA-NU2
    - Site specific tests

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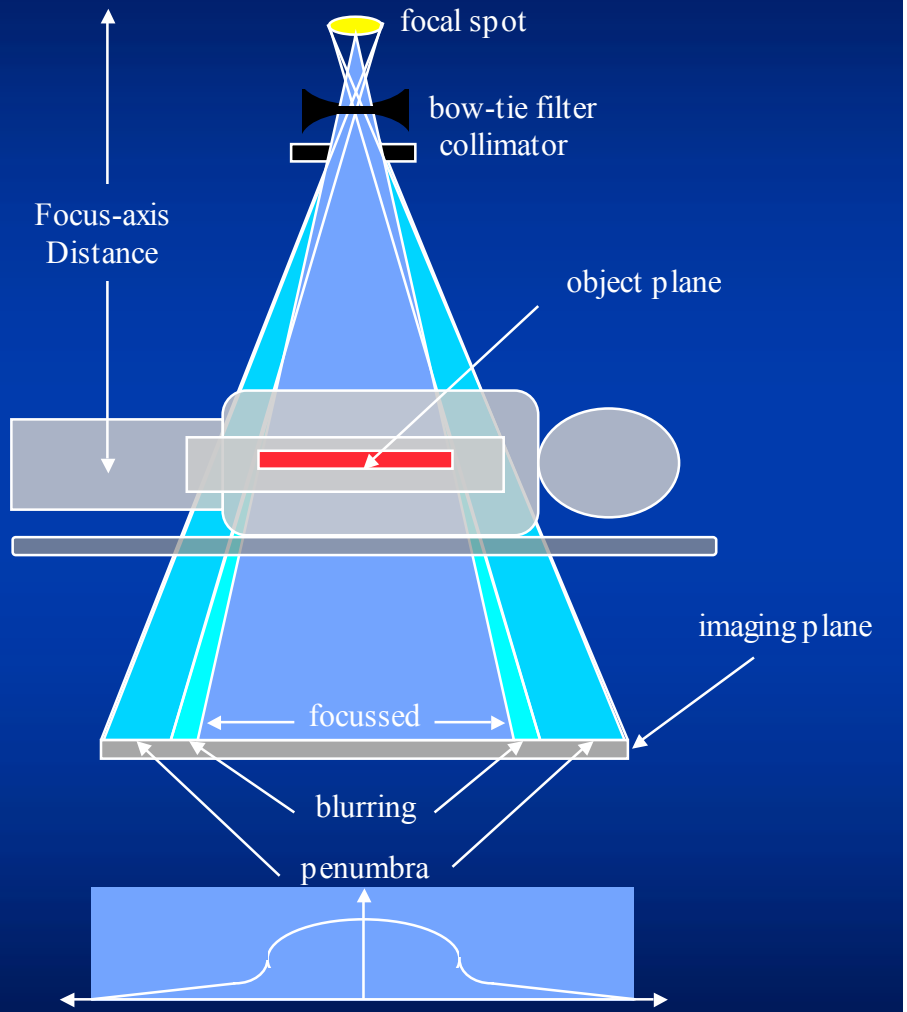
Quality Control

CT elements

- X-ray generator
- Detector
- Collimation
  - slice-thickness



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Quality Control
CT daily regimen

- Tube conditioning
  - Filament adaptation
- Air Calibration
  - Anode current / Sensor response

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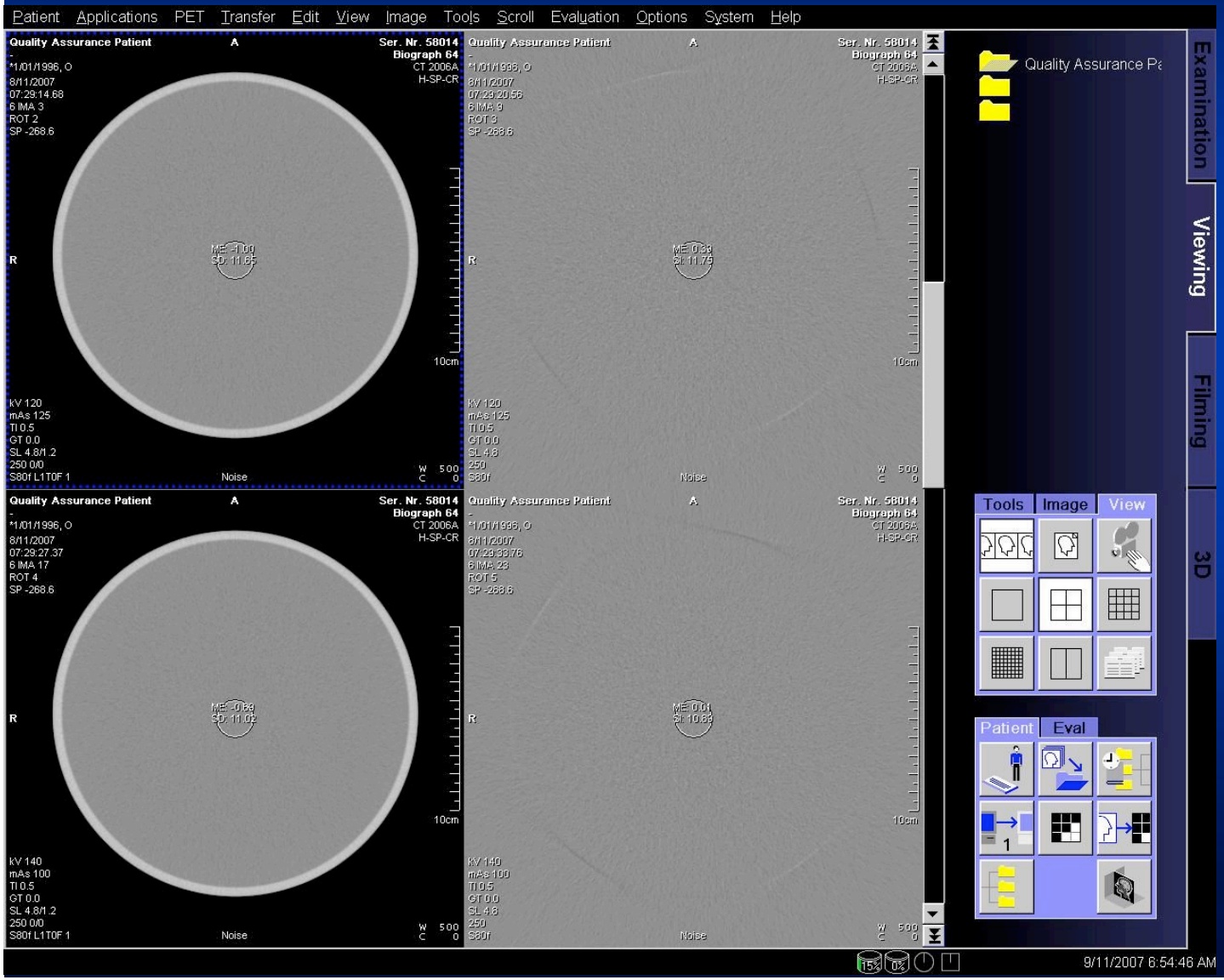
Quality Control
CT daily regimen



- Scan water layer
  - Measure water HU
    - CTAC
  - Check for artifacts
    - Ring artifacts
      - Redo conditioning
      - Redo Air Cal

Courtesy: Stefan Eberl, RPA

Quality Control
CT weekly regimen

- Hounsfield Unit Calibration
  - ROI means
  - ROI standard deviation range
    - mAs setting accuracy
- kVp, mAs exercising
  - Filament adaptation
  - Collimation
- MTF & Slice thickness
  - Physics layer
- Check error log

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Quality Noise Results

Date: 29.10.2007 07:45:13

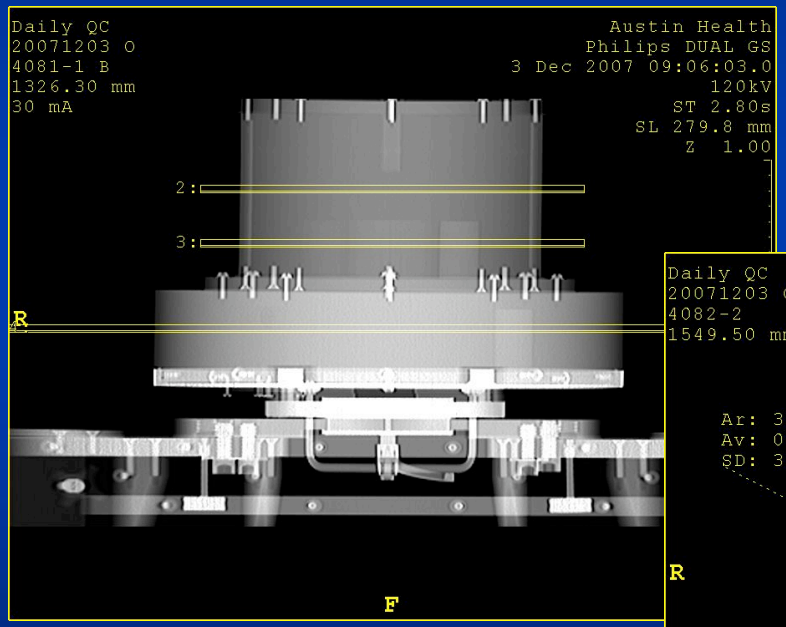
		Water [HU]	Sigma [HU]	Voltage [kV]
row 1	Reference:	-0.93	---	80.0
	Tolerance:	+/- 4.00	---	+/- 8.0
	Result:	-2.88	---	80.0
row 2	Reference:	-0.93		
	Tolerance:	+/- 4.00		
	Result:	-0.50		
row 1	Reference:	-0.18	18.45	104.2
	Tolerance:	+/- 4.00	+/- 1.85	+/- 10.0
	Result:	-1.26	18.19	104.2
row 2	Reference:	-1.25		
	Tolerance:	+/- 4.00		
	Result:	-1.22		
row 1	Reference:	0.16	17.14	124.0
	Tolerance:	+/- 4.00	+/- 1.71	+/- 10.0
	Result:	-0.76	16.93	124.0
row 2	Reference:	-0.57		
	Tolerance:	+/- 4.00		
	Result:	-1.14		

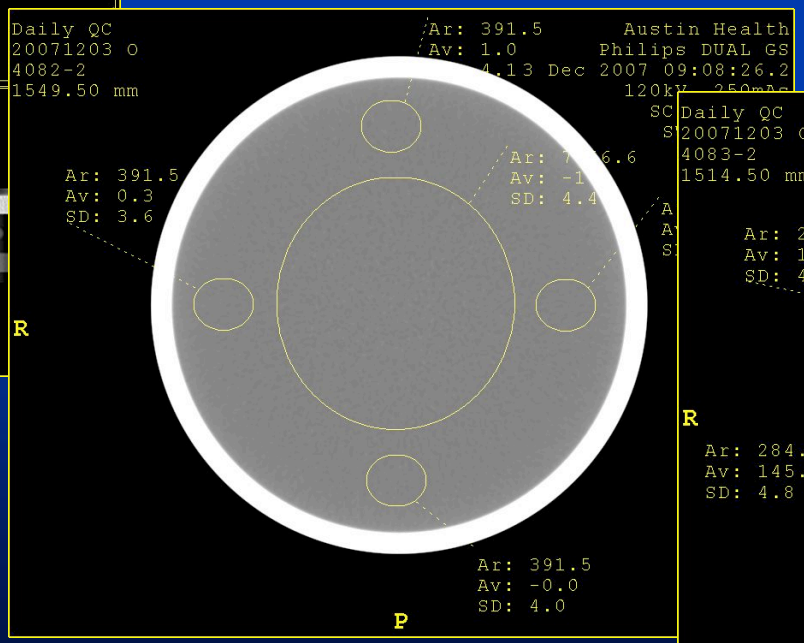
Courtesy: Stefan Eberl, RPA

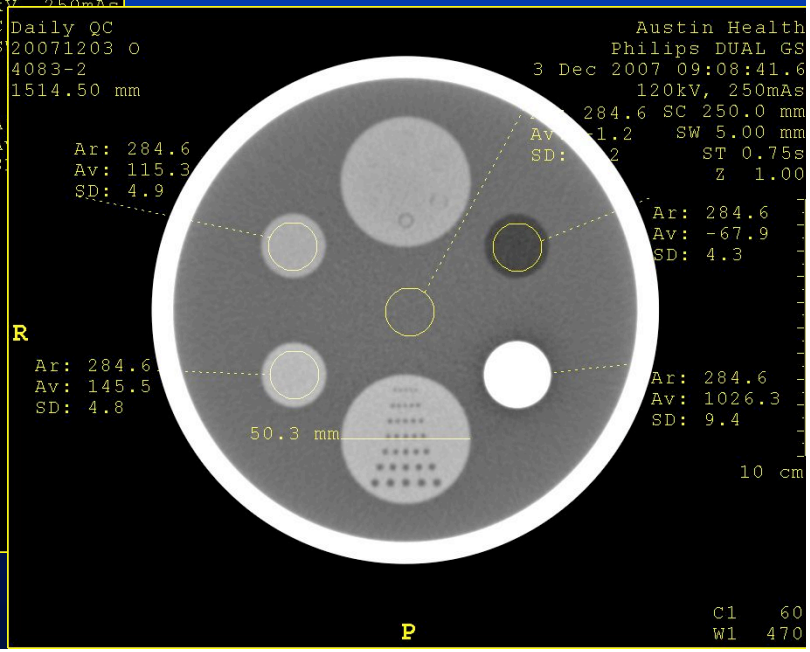
Quality Control

CT weekly regimen

- HU calibration check
  - Water
  - Air
  - Teflon







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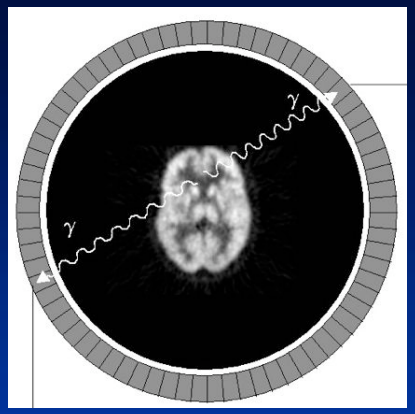
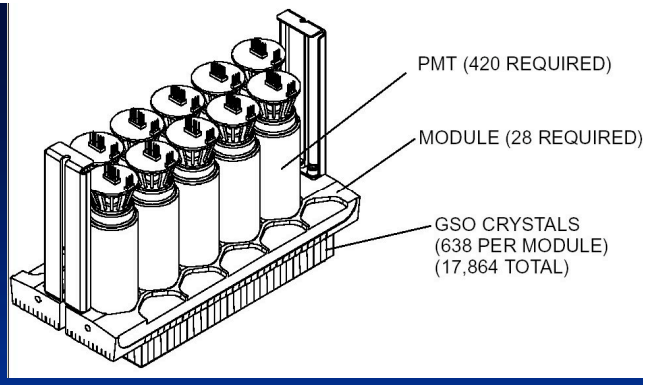
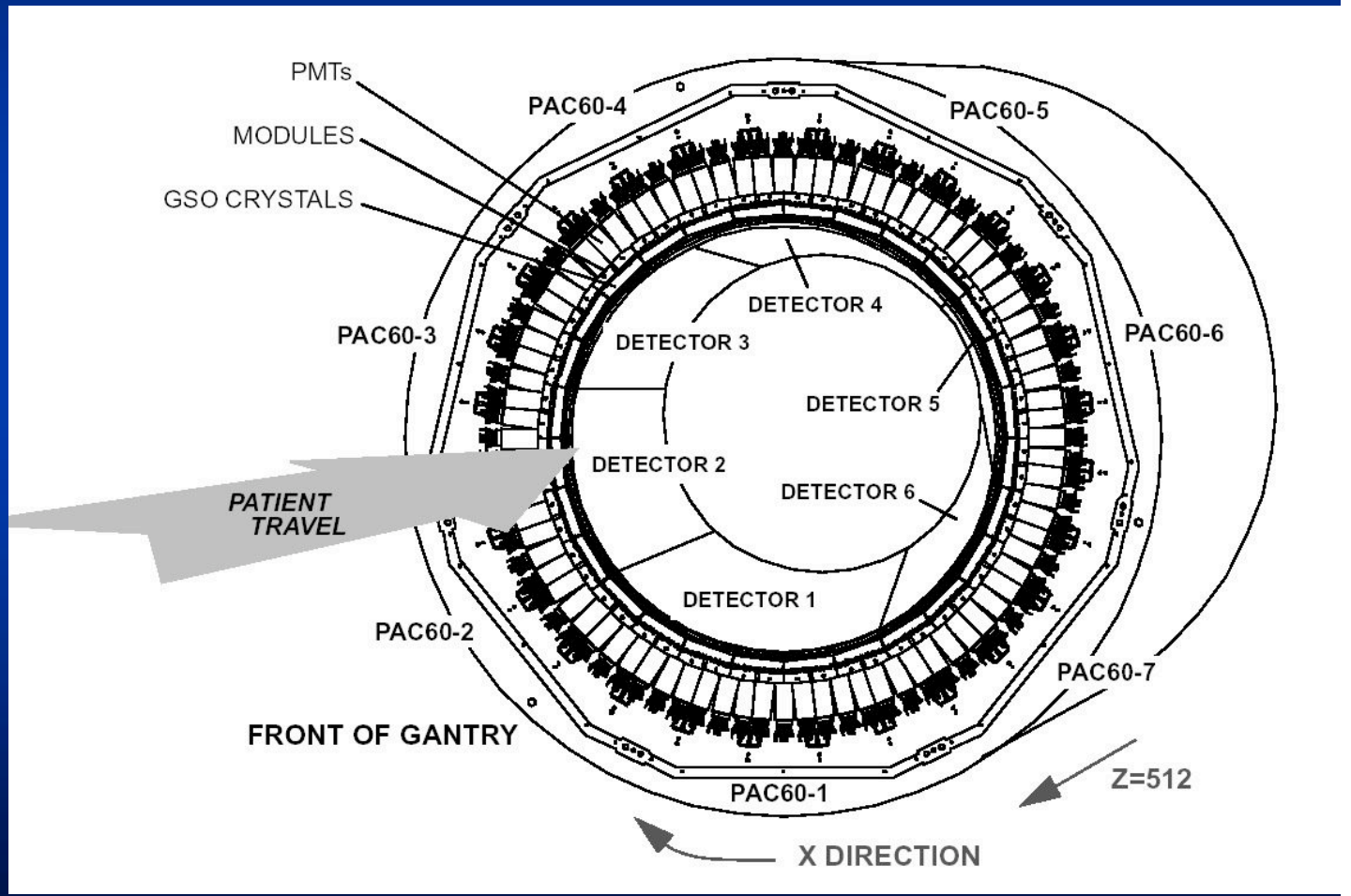
Quality Control
PET





- Multiple modules
  - buckets
- Detectors/module
  - blocks
- Crystals/detector
- Coincidence
- Energy/Position



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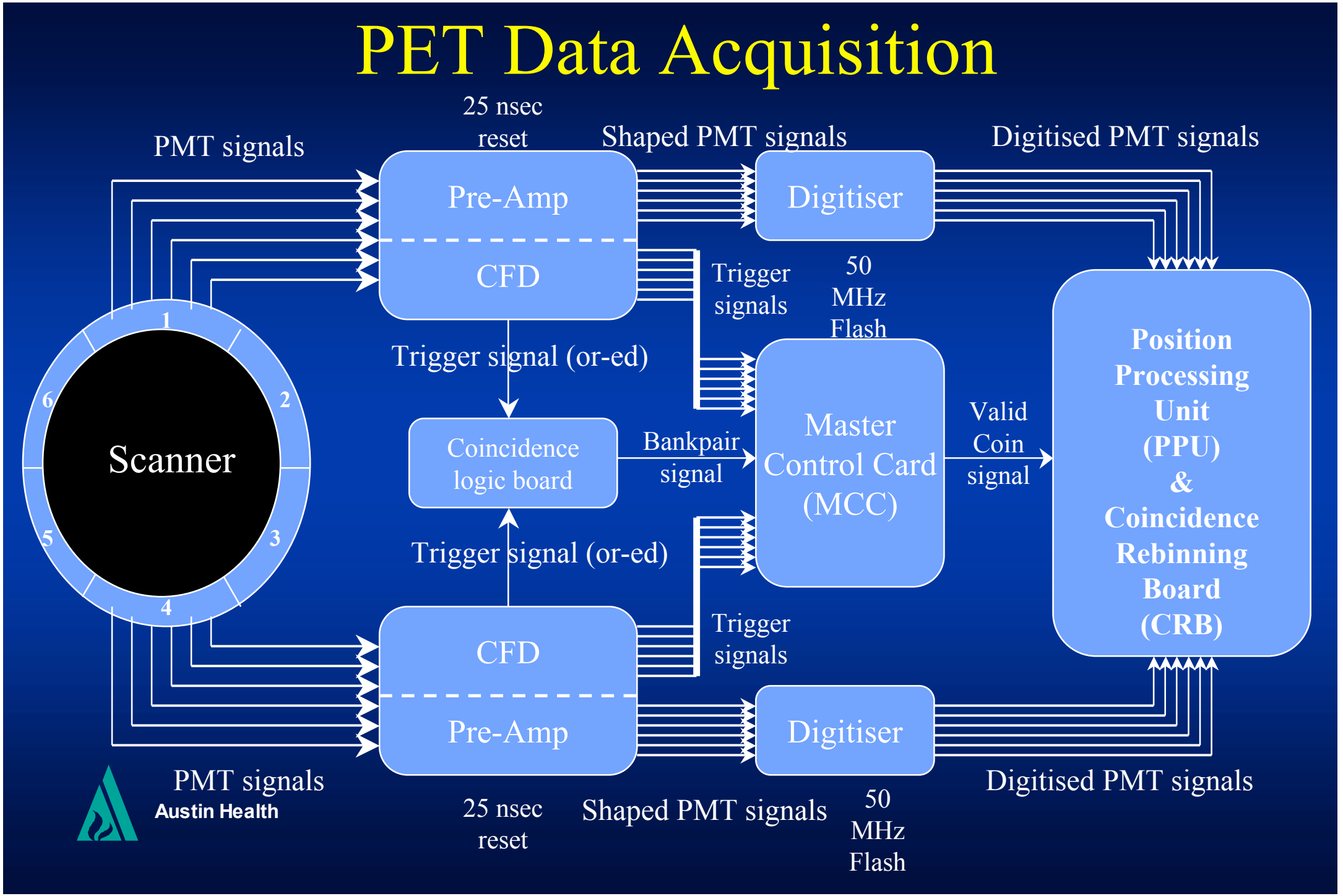
Graphic from Allegro User/Service Manual
Courtesy Philips Medical Systems

PET Data Acquisition



Quality Control
PET daily regimens

- Gains
  - PMT, SumAmps
- Event Energy
  - Photopeak measurement
- Event Positioning
  - Crystal maps
- Event Timing
  - Optimal coincidence rate
- Uniformity
  - Blank or Uniform phantom measurement
- Total measurement time ~ 10 mins

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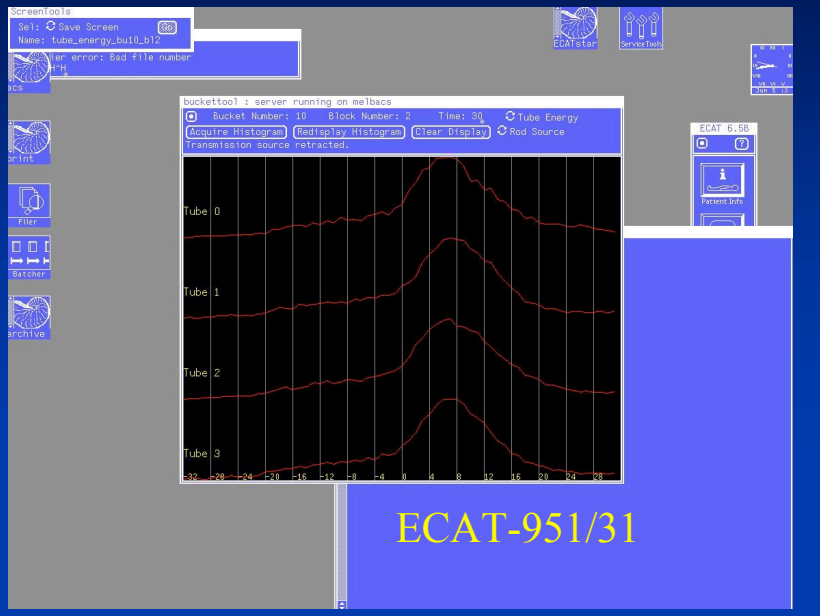
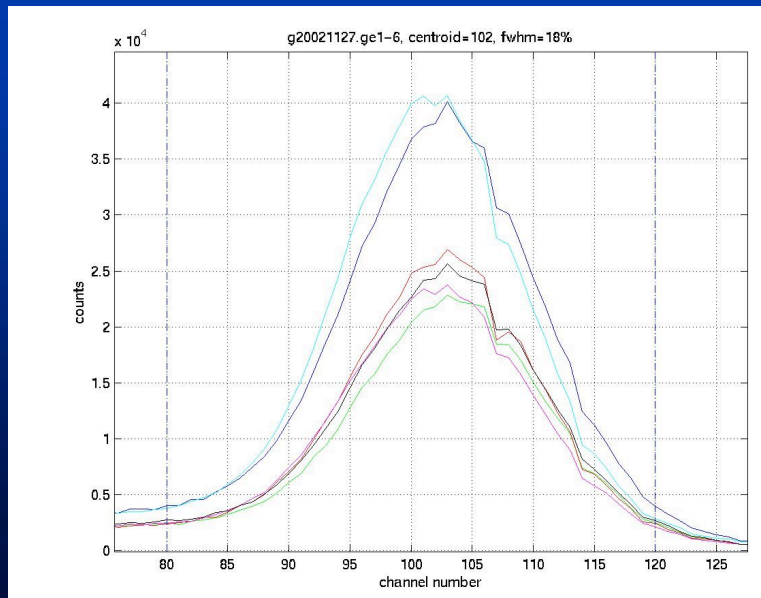
Quality Control - daily

PET - Energy

- Source measurement
  - Pass / Warning / Fail Report
  - Typically no spectra generated
  - Failure
    - Re-run QC / cycle power
    - Call Vendor
    - Localise fault
      - Philips : listmode acq.





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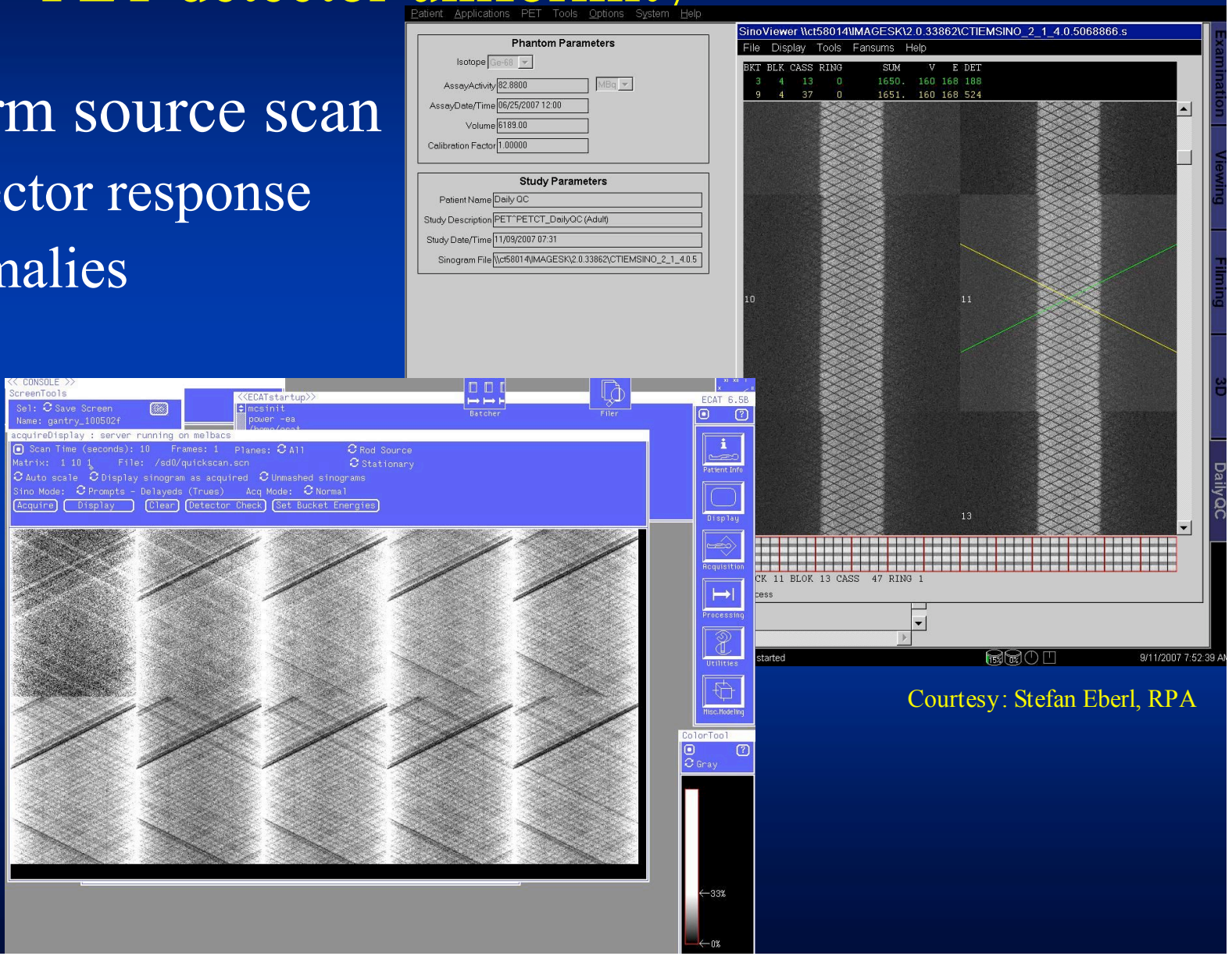
Quality Control - daily

PET detector uniformity

- Uniform source scan
  - Detector response
  - anomalies
- Blank scan



Courtesy: Stefan Eberl, RPA

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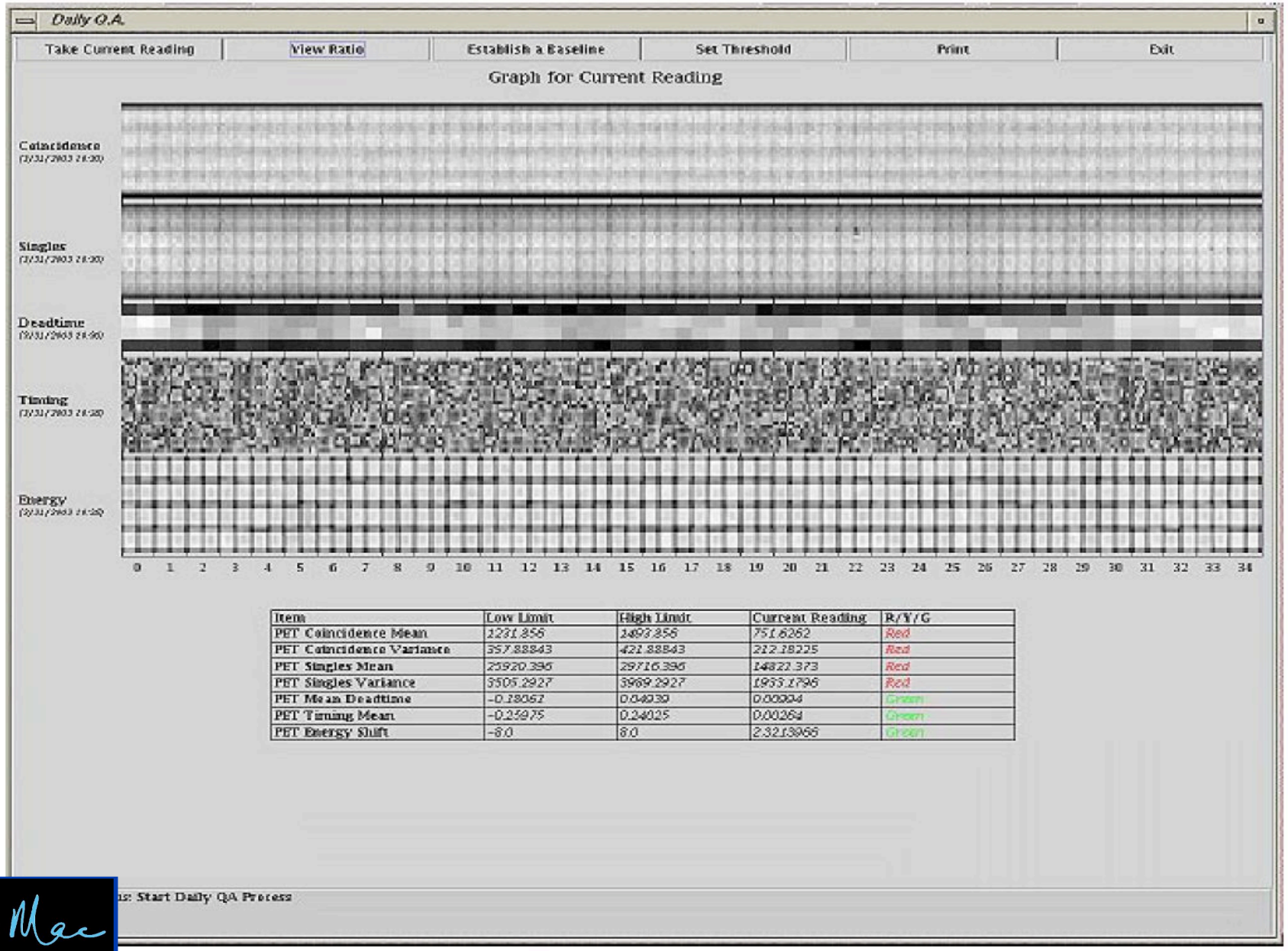
PET Daily Quality Assurance (DQA)



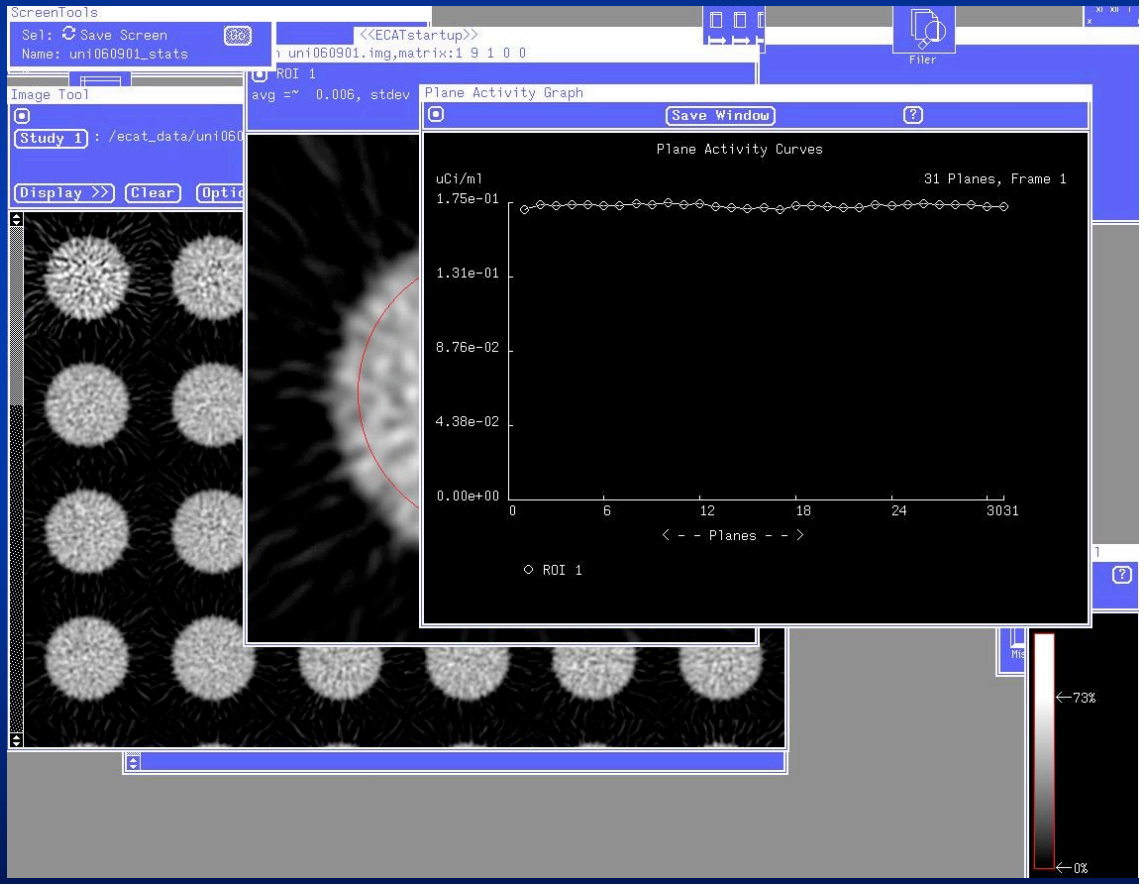
Item	Low Limit	High Limit	Current Reading	R/Y/G
PET Coincidence Mean	1231.856	1493.856	751.6262	Red
PET Coincidence Variance	357.88843	421.88843	212.18225	Red
PET Singles Mean	25920.396	29716.396	14821.373	Red
PET Singles Variance	3505.2927	3969.2927	1933.1796	Red
PET Mean Deadtime	-0.18062	0.04039	0.00004	Green
PET Timing Mean	-0.25975	0.24025	0.00264	Green
PET Energy Shift	-8.0	8.0	2.3213966	Green

Courtesy: David Binns, Peter Mac

Quality Control - weekly

PET - Normalisation & Spatial Uniformity

- Uniform cylinder source
  - ^{18}F or ^{68}Ge
    - clinical dose levels
    - 50 - 100 MBq
  - Acquire 20-min scan
  - Reconstruct
  - ROI(μ,σ)/slice
- Standard Uptake Value
  - calibration check



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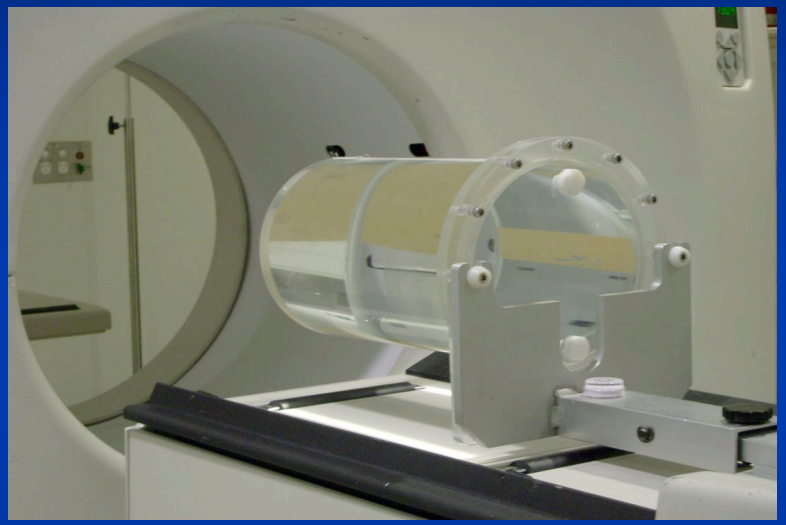
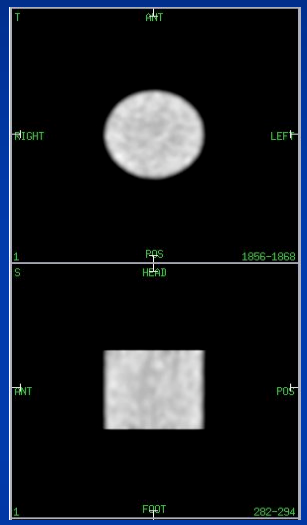
Quality Control - weekly

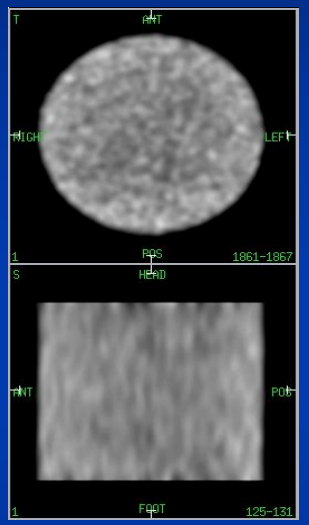
Normalisation / SUV calibration

576FOV 256FOV

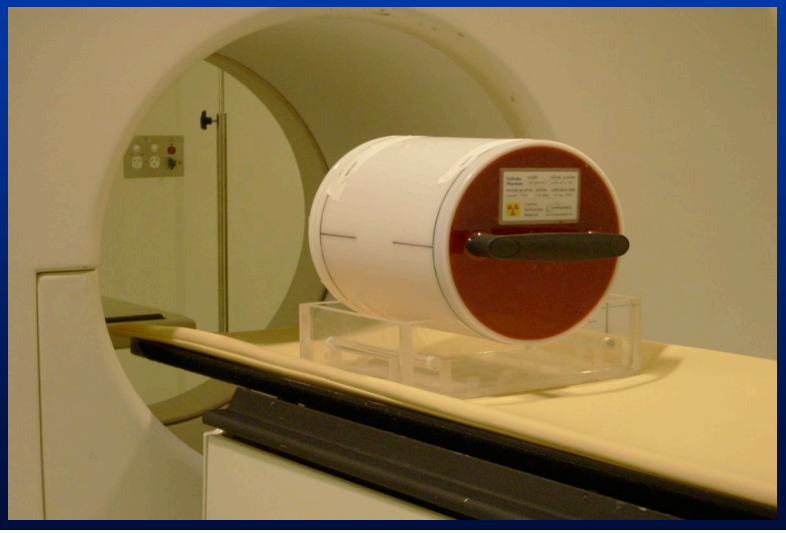
^{18}F flood phantom is mounted on the phantom holder over the end of patient bed

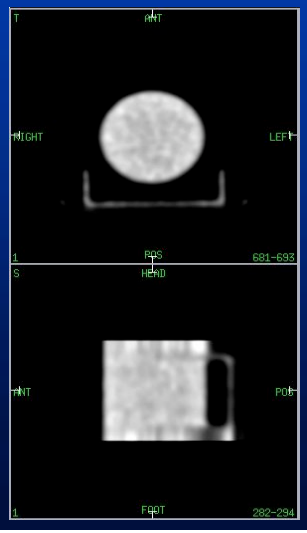


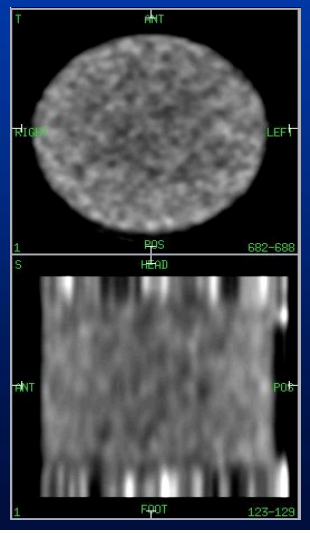




^{68}Ge solid phantom is placed on the patient pallet with a phantom support







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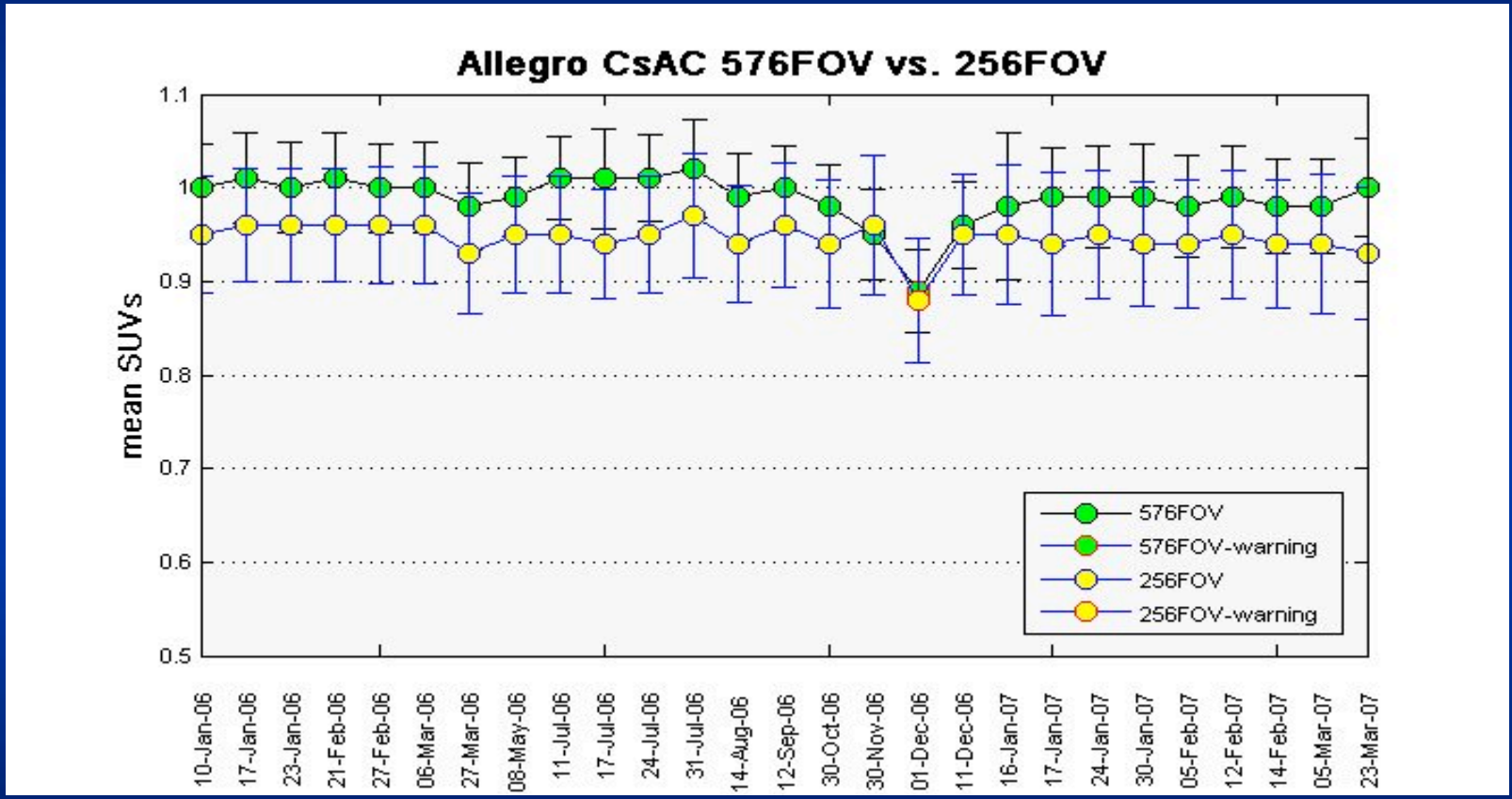
Quality Control
Longitudinal uniformity



Comparison of mean SUVs of VOIs (Allegro CsAC 576FOV vs. 256FOV)

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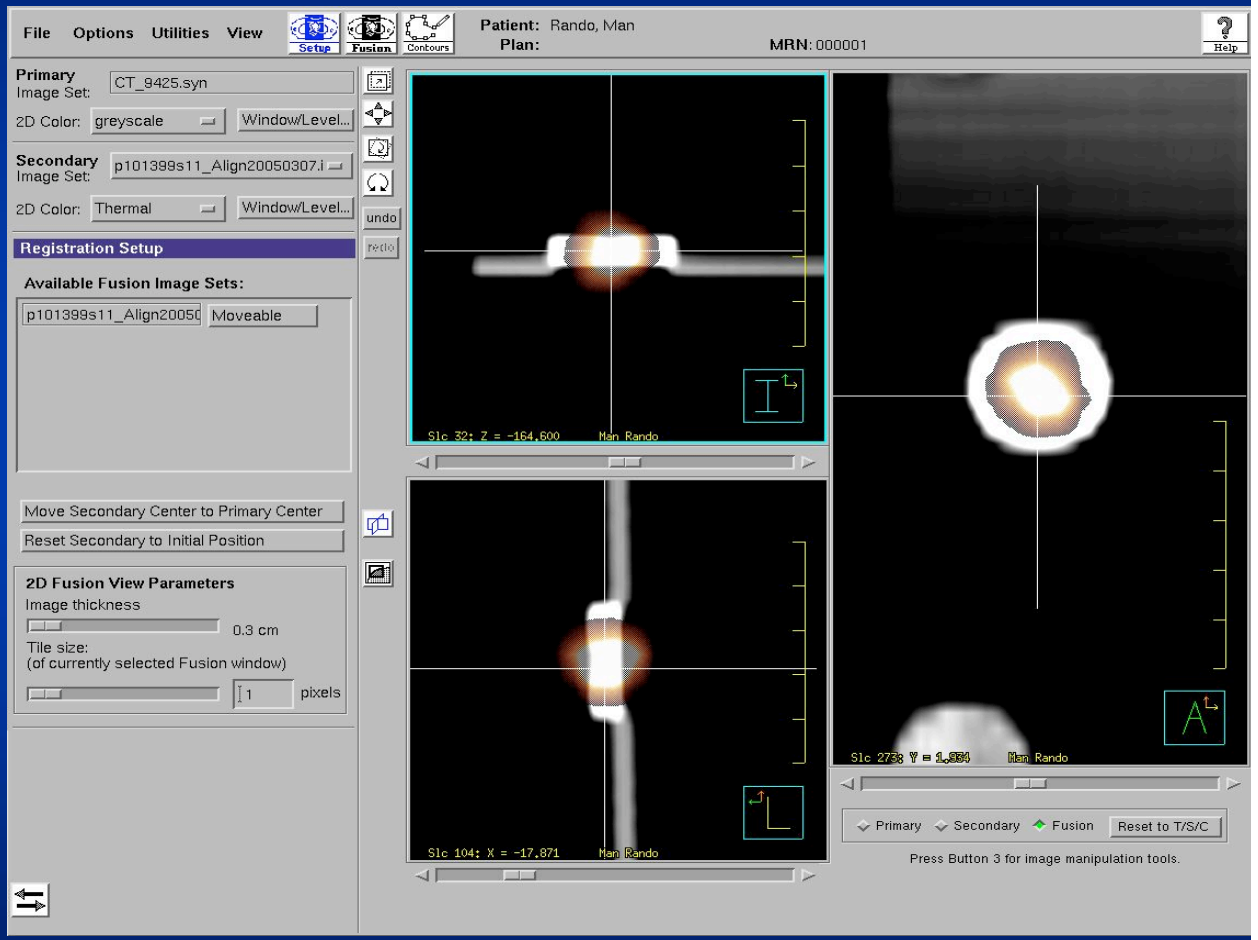
Quality Control - Quarterly

PET/CT System Alignment

- Alignment matrix
  - ✓proper CTAC
  - ✓PET/CT registration



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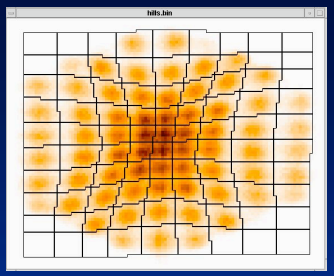
Quality Control - annual

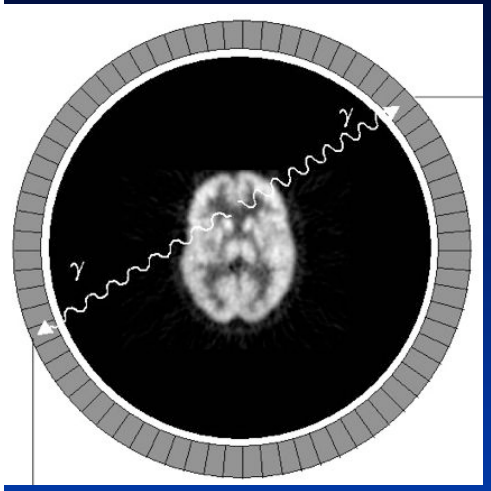
PET - Crystal Maps

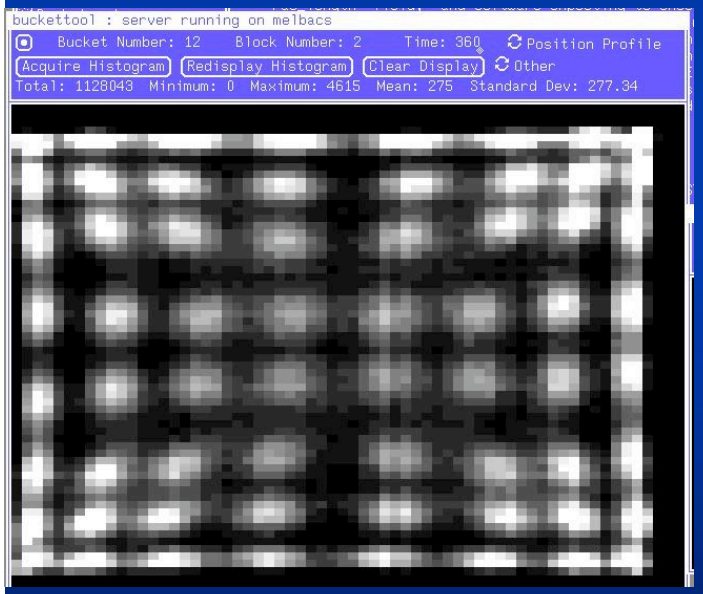


- Crystal position encoding
  - Light sharing characteristics
  - Calibrated at installation
  - Replaced modules / blocks
- Checked annually
- Performed by service engineers

Quality Control - annual

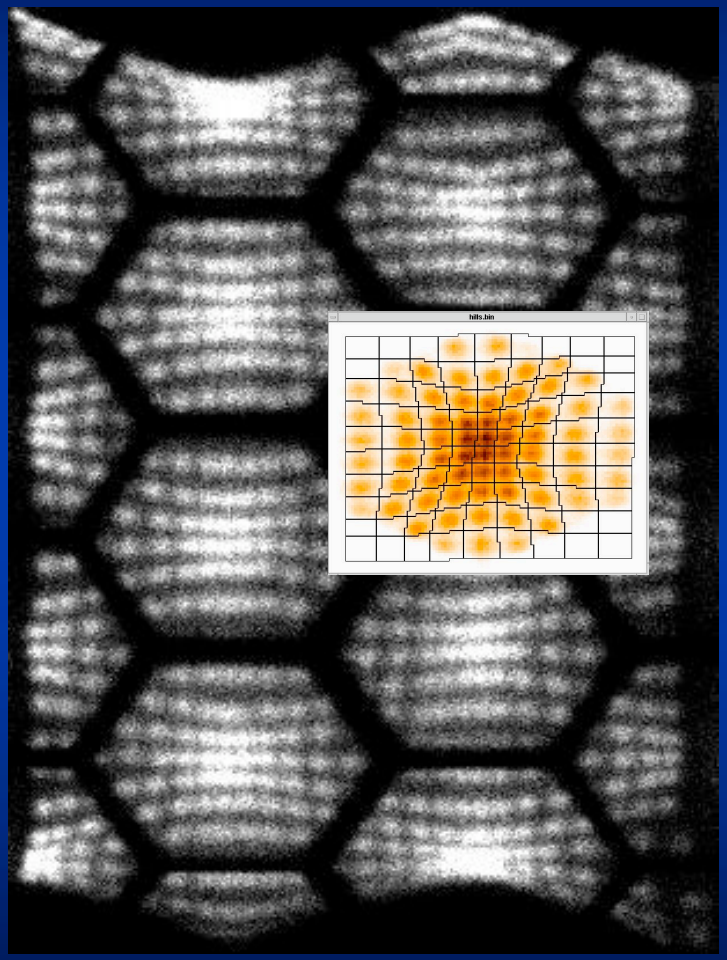
PET Crystal maps





ECAT 951/31R

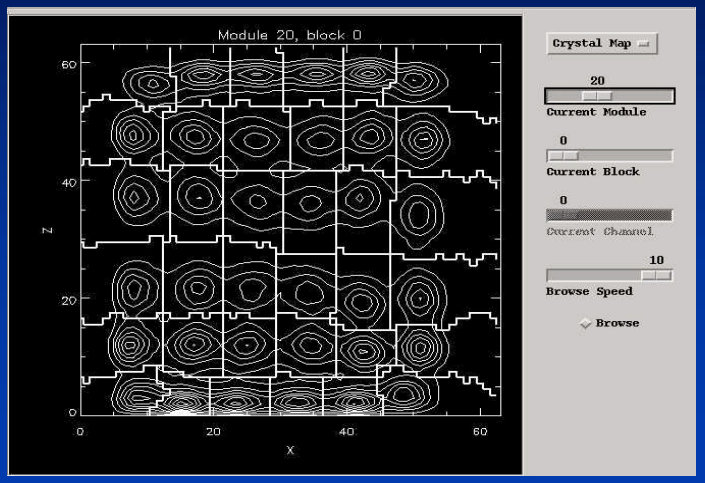
Block calibrated once



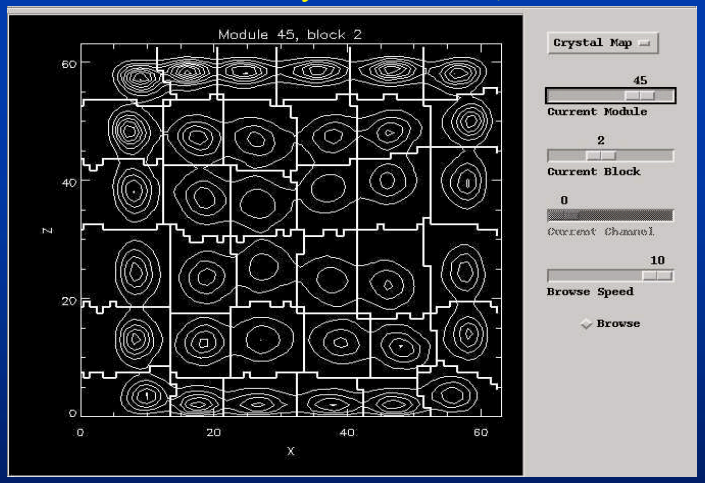
Philips Allegro

Checked annually

re-creved if failure



GE-DSTE8 Courtesy: David Binns, Peter Mac



GE-DSTE

New block calibrated

Checked annually

recalibrated

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Quality Control - annual
PET

- Vendor
  - Gains / Timings
  - Blank(^{137}Cs) / Normalisation
  - Deadtime / SUV calibration
  - Gantry alignment
  - GDR - Crystal maps
- Site - NEMA-NU2 subset
  - Resolution
  - Sensitivity
  - Scatter
  - Corrections
  - Countrate

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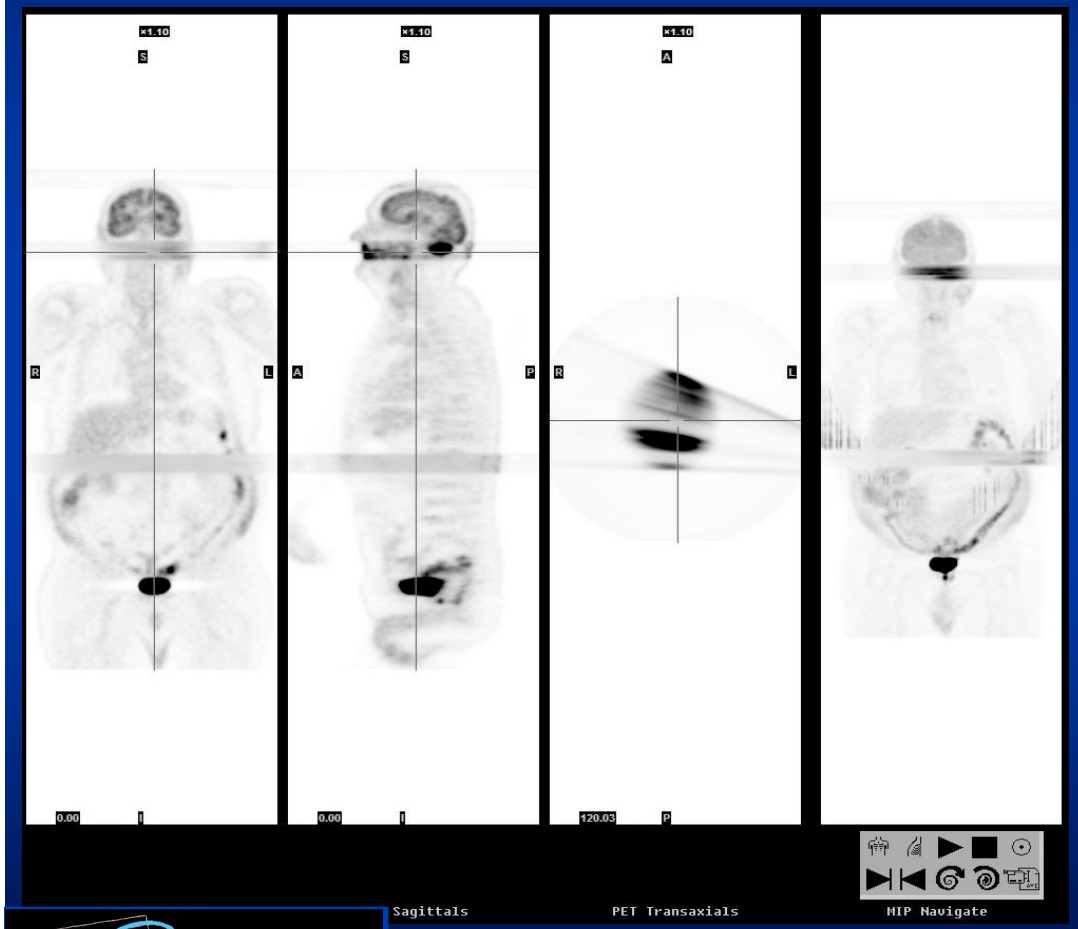
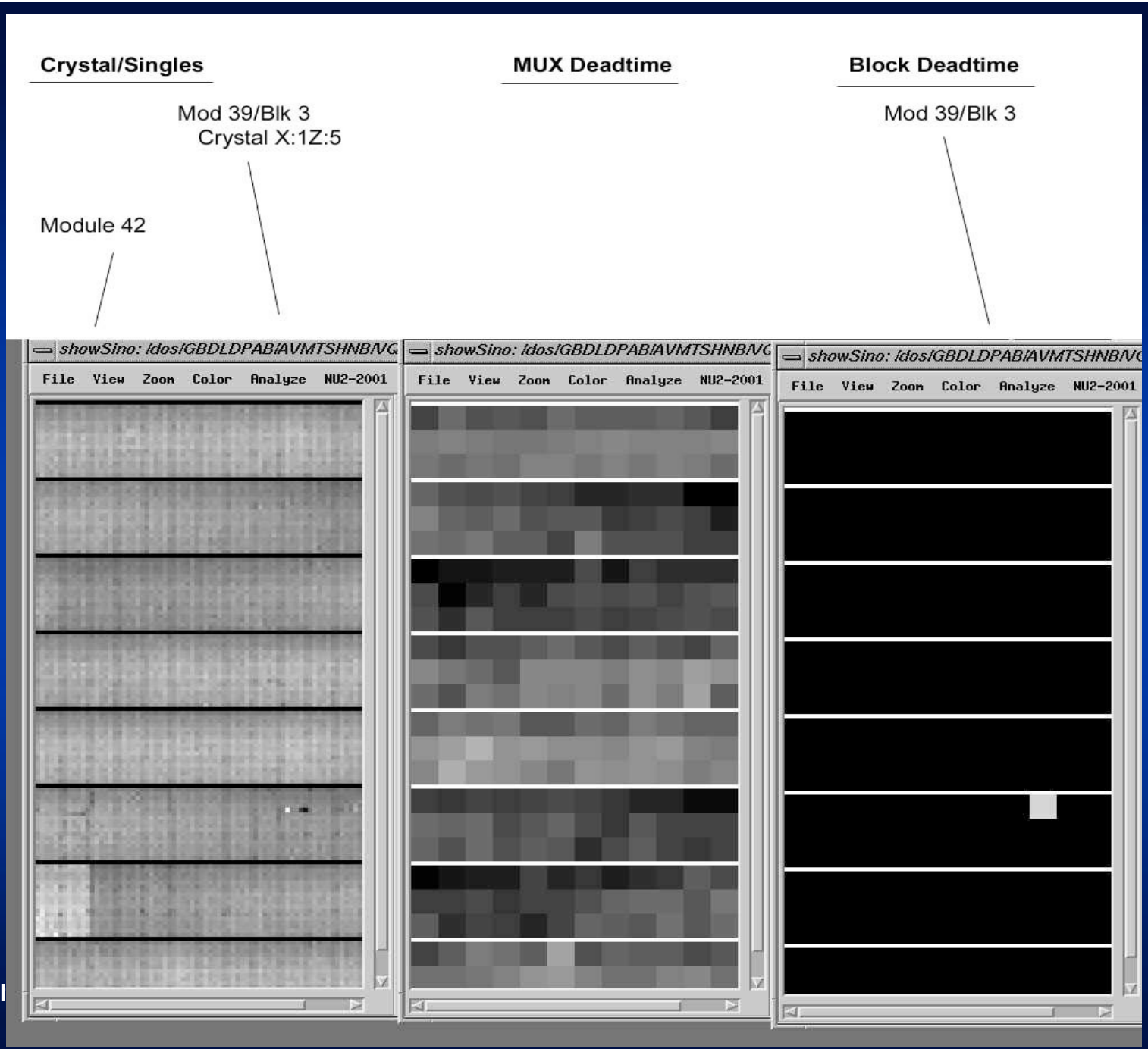
Other Tools for Fault Finding -Case Study

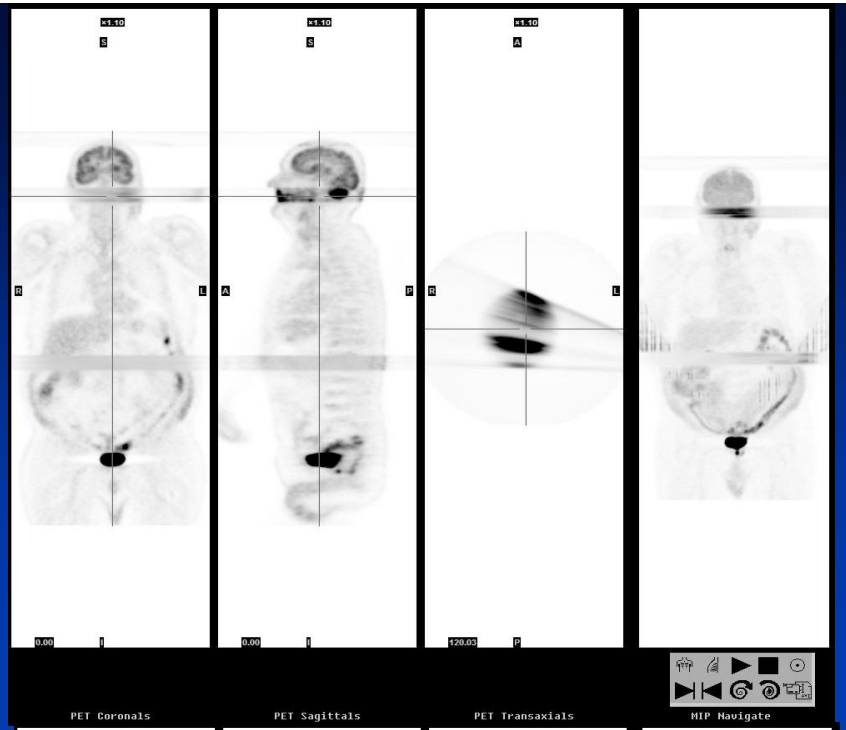


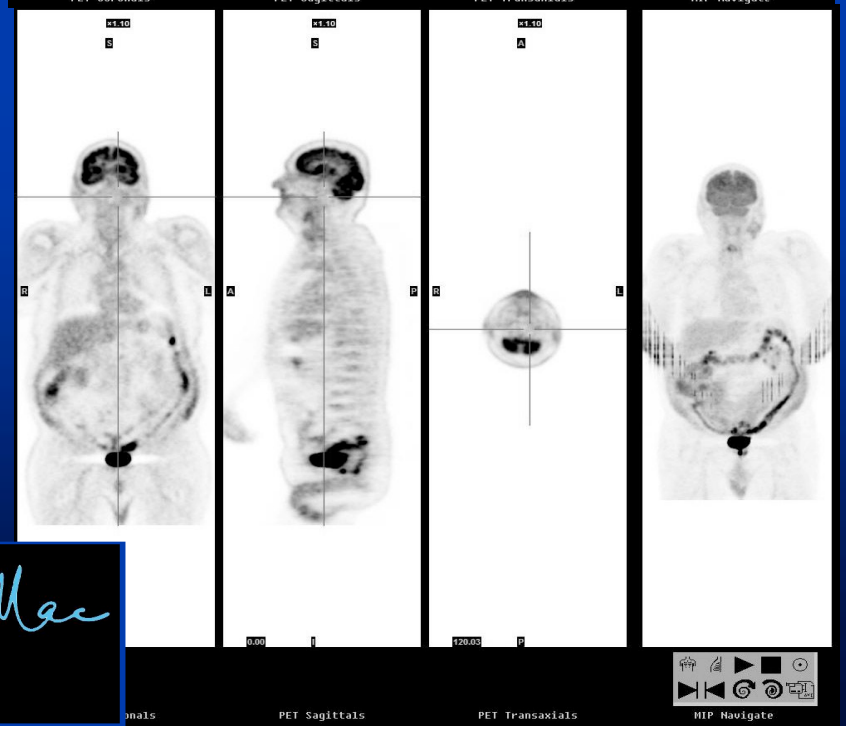
- GE DLS PET/CT. Passed Daily QA.
- Intermittent Problem. 'Block' based fault
- Raw sinogram – OK
- ? reconstruction dependency
- 'Investigator'
  - Visualization package – displays multiple performance characteristics of detectors.

Courtesy: David Binns, Peter Mac



Courtesy: David Binns, Peter Mac

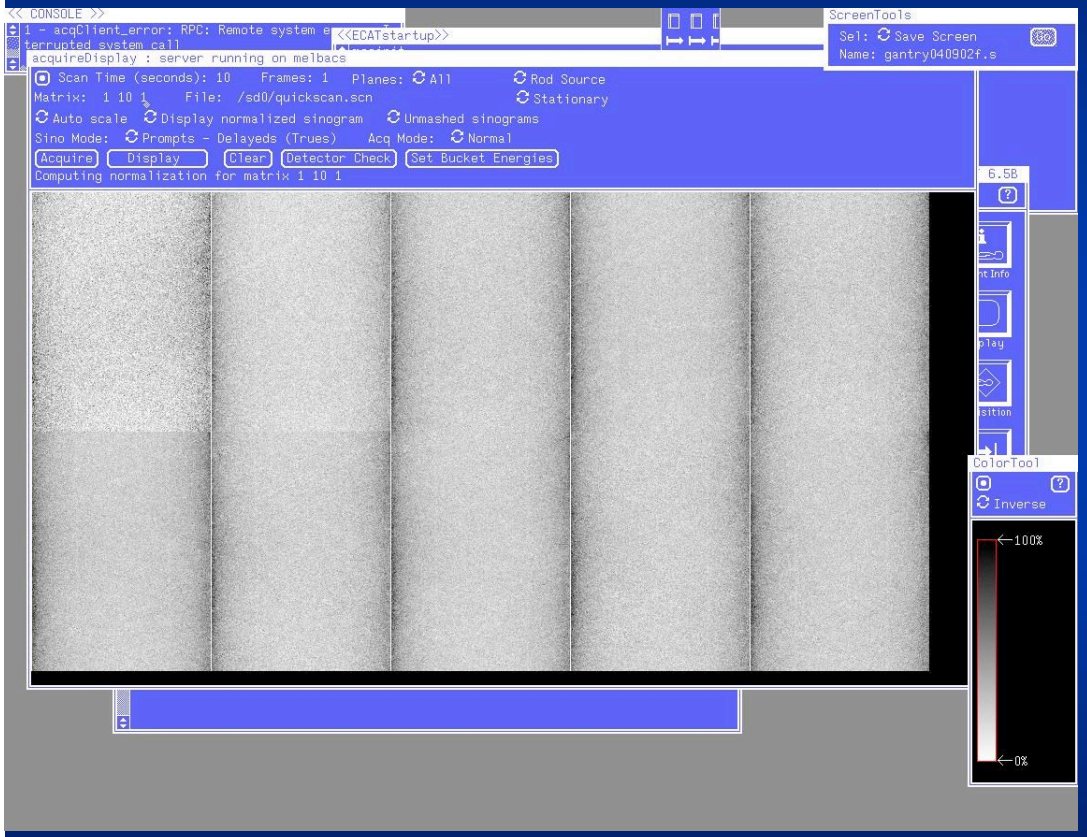




- DTC applied (reconstruction)
- No DTC applied

Courtesy: David Binns, Peter Mac

QC – failed block



Pass

Fail

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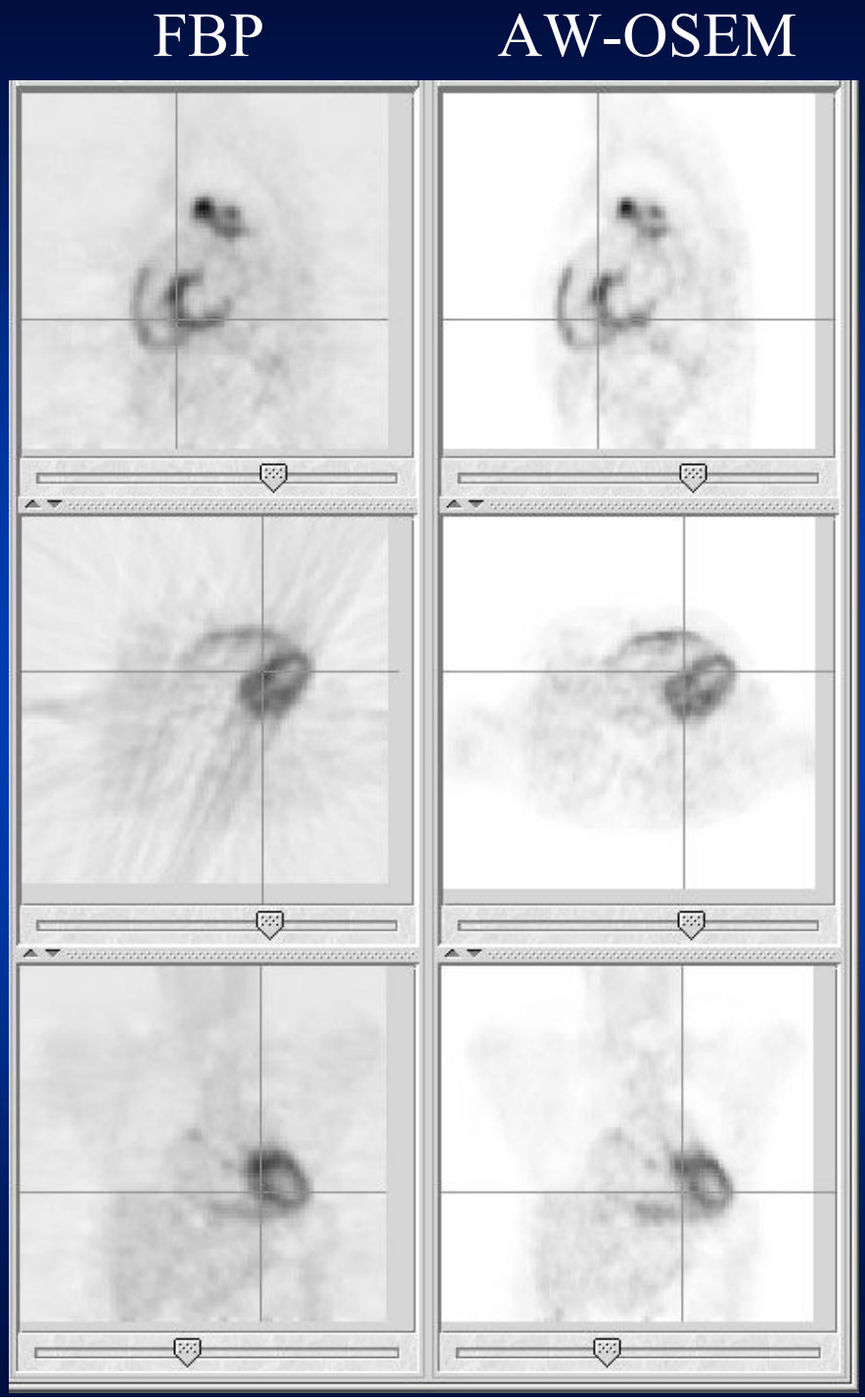
Fan beam artifact

Comparison of FBP and Attenuation Weighted OSEM



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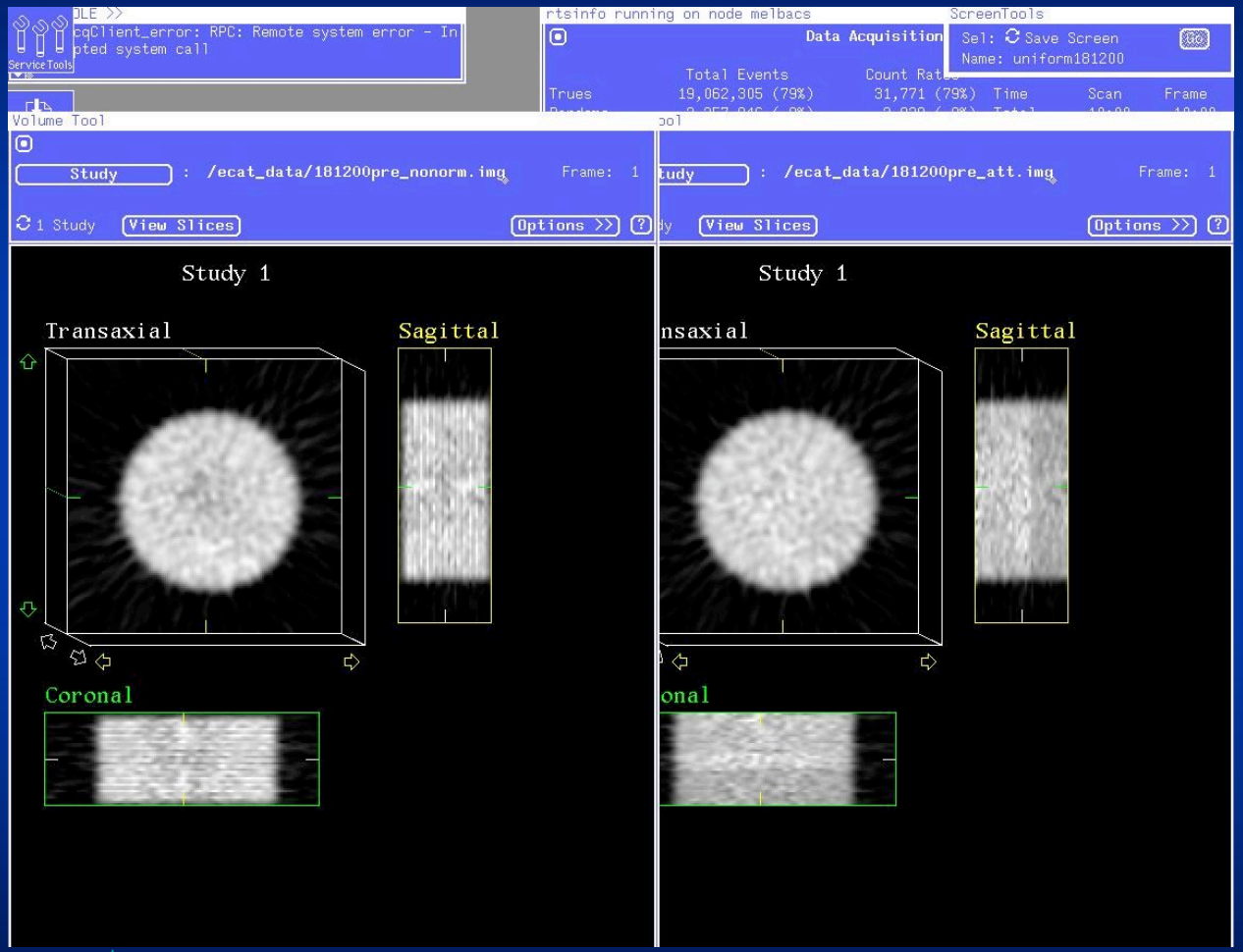
PET - Uniformity



- HV supply
  - Separate ring supplies

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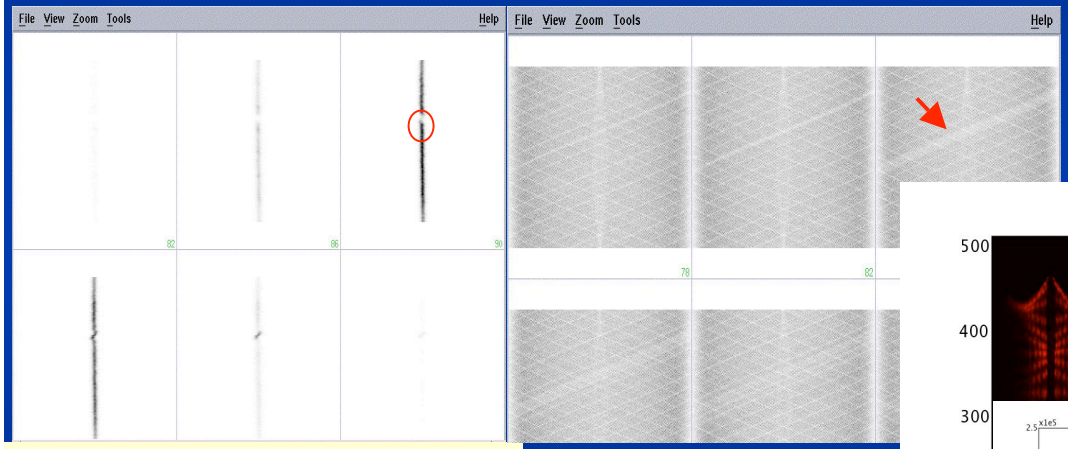
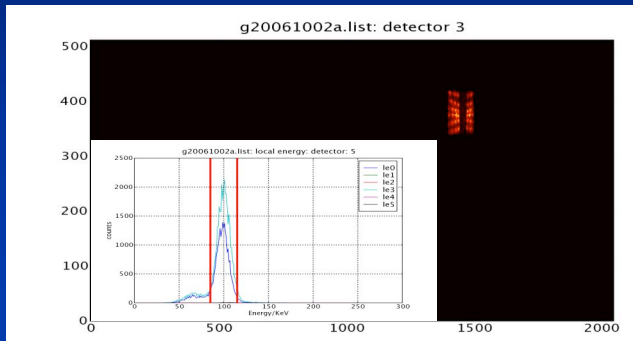
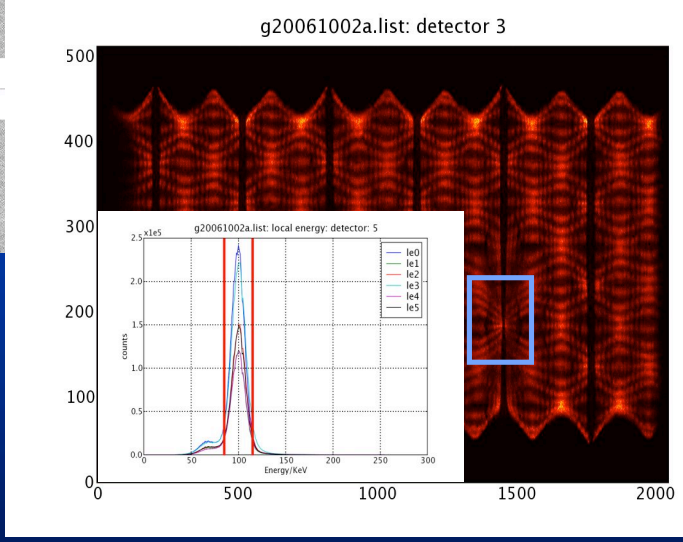
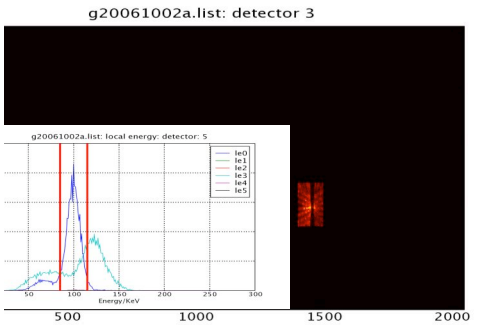
Quality Control
PET - Module Fault

- Anomaly in point source acquisition









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Listmode PHA analysis of virtual detector 3 in the anomalous region of the crystal map reveals that virtual detector 0 has normal Photopeak positioning whilst virtual detector 3 has a ‘high-gain’.

Quality Control
Conclusion

- Routine QC
  - Daily / Weekly
  - Quarterly / Annually
- System specifics
  - Vendor training
  - Site training
- Logfiles
  - maintain / monitor
- Normalisation files
  - Archive

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Acknowledgements

- Sylvia Gong - Austin Health
- Seu Som - Liverpool
- Stefan Eberl - Royal Prince Alfred
- David Binns - Peter MacCallum Cancer Institute

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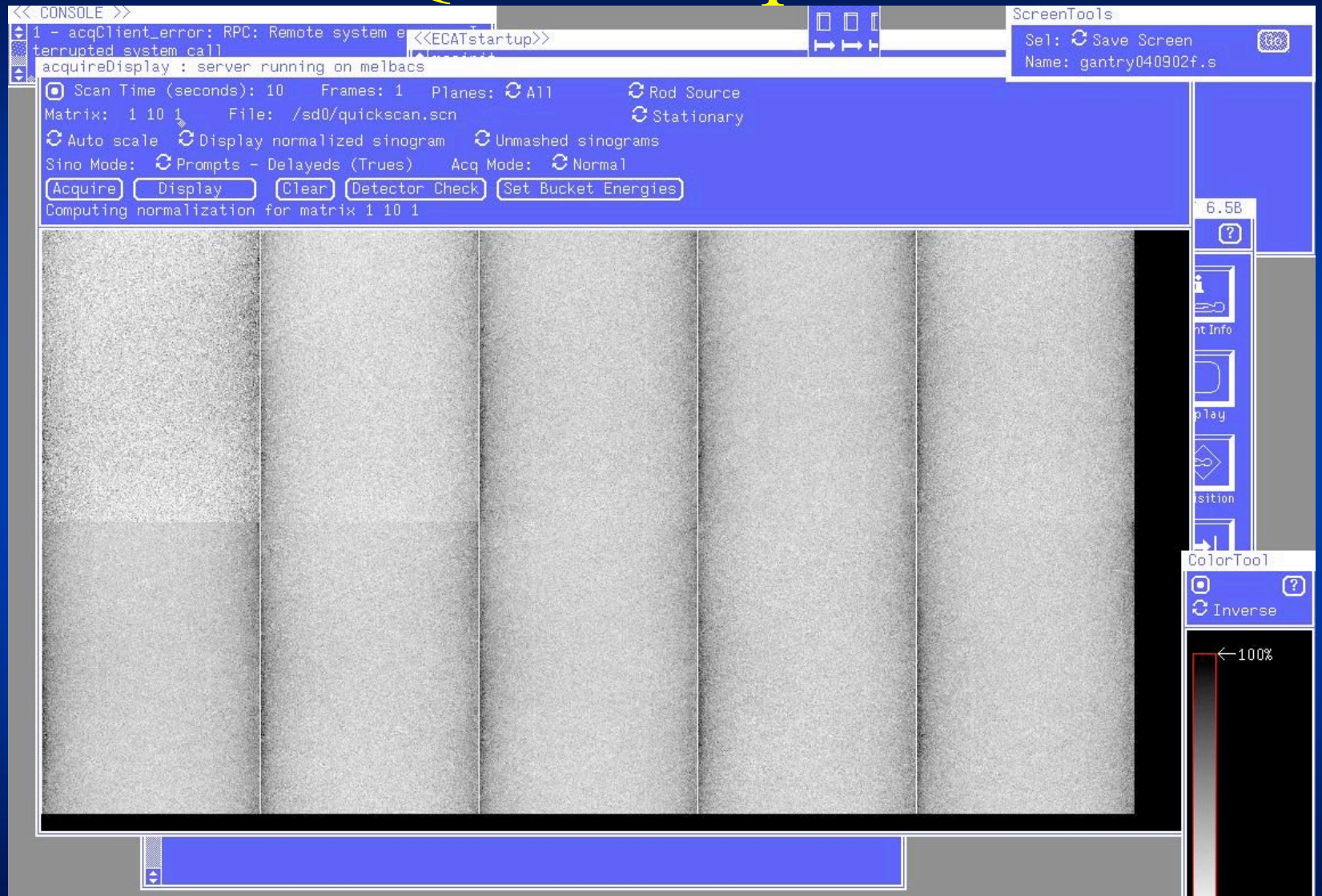
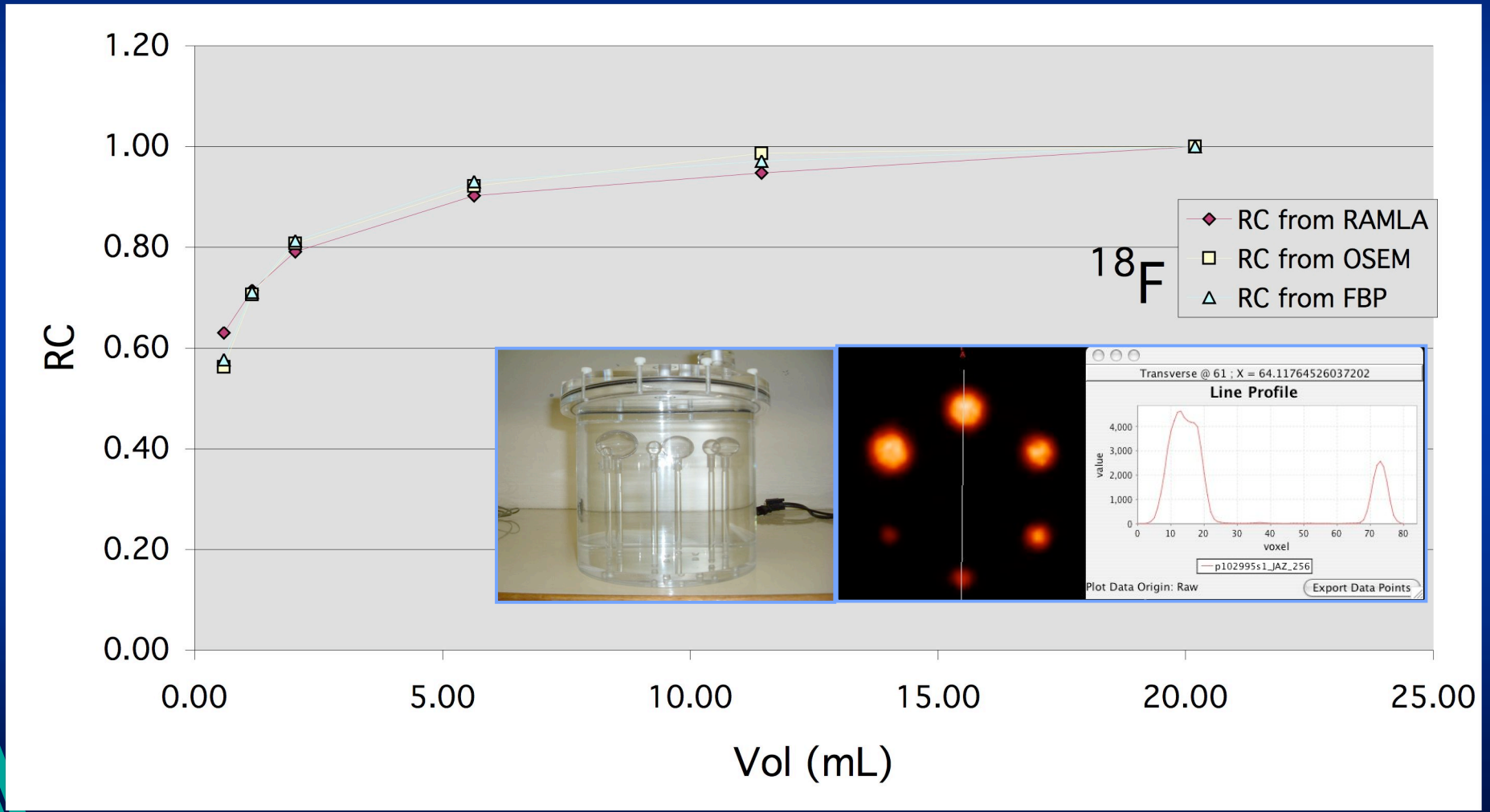
QC - accepted

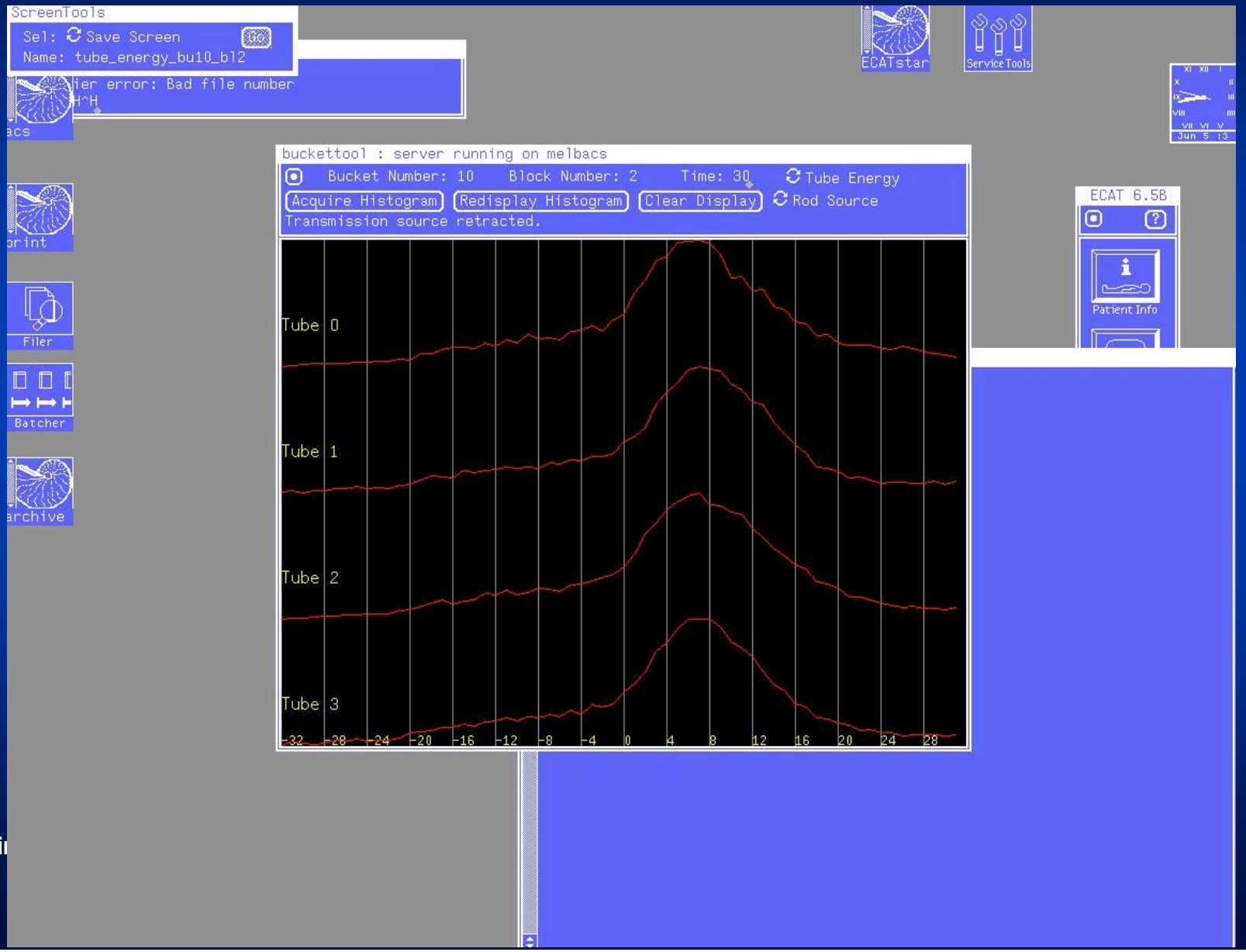

CONSOLE
1 - acqClient_error: RPC: Remote system e
terrupted system call
<<ECATstartup>>
acquireDisplay : server running on melbacs
ScreenTools
Sel: Save Screen
Name: gantry040902f.s
Scan Time (seconds): 10
Frames: 1
Planes: All
Rod Source
Matrix: 1 10 1
File: /sd0/quickscan.scn
Stationary
Auto scale
Display normalized sinogram
Unmashed sinograms
Sino Mode: Prompts - Delayeds (Trues)
Acq Mode: Normal
Acquire
Display
Clear
Detector Check
Set Bucket Energies
Computing normalization for matrix 1 10 1
6.5B
ColorTool
Inverse
100%
0%

PET/CT GTV Markup

Partial Volume



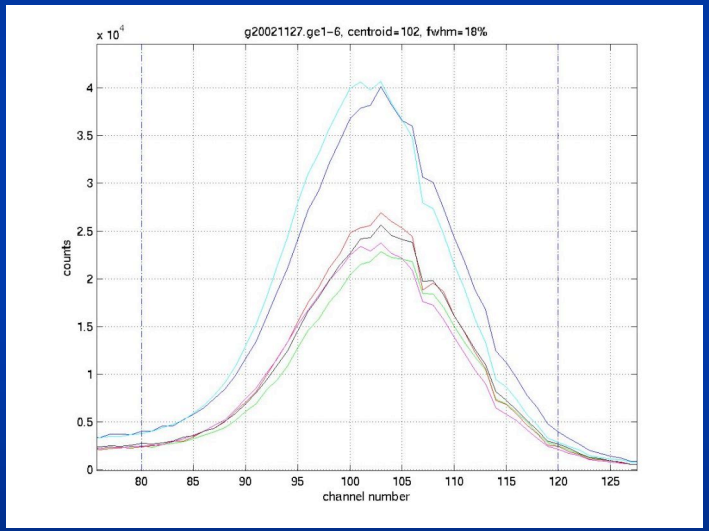
QC – energy peak/resolution



Austi

Allegro Operational

- Daily QC
  - PreAmp/SumAmp baseline measurement.
  - Photopeak centroid and FWHM ~ 5 min
  - Emission/Transmission ~ 5 min.
  - Pass/Warning/Fail status
- Routine Calibrations
  - Quarterly
    - PreAmp/SumAmp
    - CFD Thresholds
    - Timing
  - 6-monthly
    - Normalisation – SUV/Deadtime
    - Spatial Resolution
    - Countrate performance.



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