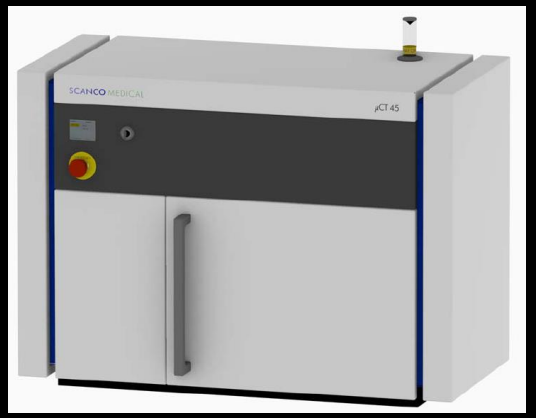
Penn Center for Musculoskeletal Disorders (P30-AR069619)

PCMD MicroCT Imaging Core Learning Lunch Series

Introducing our NEW µCT45 scanner featuring a 20-sample holder carousel

X. Sherry Liu, Ph.D
Wei-Ju Tseng, M.S
Yilu Zhou, Ph.D
Rebecca Chung, Ph.D

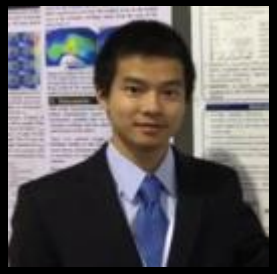


Dec 4th, 2019

Mckay Orthopaedic Research Laboratory
Department of Orthopaedic Surgery
Perelman School of Medicine
University of Pennsylvania
Philadelphia, PA

Personnel

X. Sherry Liu, Ph.D
Director



Yilu Zhou, Ph.D
Wei-Ju Tseng, MS
Manager

Rebecca Chung, Ph.D
Coordinator

Our contact email:
pcmd.microct@gmail.com

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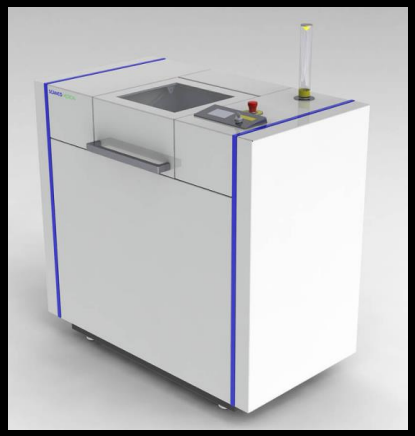
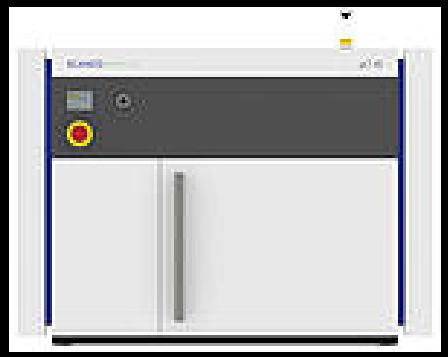
Available Scanners at PCMD µCT Imaging Core

- Specimen µCT
  - µCT 35
  - µCT 50
  - µCT 45 *new!*
- *In Vivo* µCT
  - vivaCT 40
  - vivaCT 75
  - vivaCT 80 *new!*
- Clinical µCT
  - XtremeCT II





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Which Scanner Should I Use for My Study?

- µCT 35 and µCT 45 (McKay Lab)
  - Small specimen scans (under diameter of 35-45 µm)
  - Mouse bone microstructure phenotyping must use µCT 35/45
- vivaCT 40 (McKay Lab)
  - Rodent study (rats and mice) requiring in vivo scans (IACUC approval required)
  - When µCT 35/45 is fully occupied
- vivaCT 80 (McKay Lab)
  - Rodent study (rats and mice) requiring in vivo scans (IACUC approval required)
    - In vivo study of rat vertebrae and skull must use vivaCT 80 instead of vivaCT 40
  - Large specimen scans (above diameter of 50 µm)
- vivaCT 75 and µCT 50 (VA Hospital)
  - Only accessible to investigators with VA affiliations
  - µCT 50: studies requiring high resolution characterization
  - vivaCT 75: large specimen scans (above diameter of 50 µm)
- Extreme CT II (CHOP Nutrition and Growth Lab)
  - Clinical studies (IRB approval required)
  - Large specimen scans (above diameter of 80 µm)
- For consistent results, please use the same model of scanner for all samples/animals from the same study

PCMD *ex vivo* µCT Scanners

	µCT 35	µCT 45	µCT 50
Use	Specimen	Specimen	Specimen
X-Ray Source	30 - 70 kVp	45, 55, 70, 90 kVp	30 - 90 kVp
Max Scan Size	37.9 x 120 mm (Ø x L)	50 x 120 mm (Ø x L)	50 x 120 mm (Ø x L)
Max Specimen Size	75.8 x 140 mm (Ø x L)	90 x 120 mm (Ø x L)	100 x 160 mm (Ø x L)
Best image voxel size	3.5 µm (Ø :7 mm)	3.0 µm (Ø: 9 mm)	1.5 µm (Ø: 3 mm)
Location	McKay Lab	McKay Lab	VA Hospital

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µCT 35

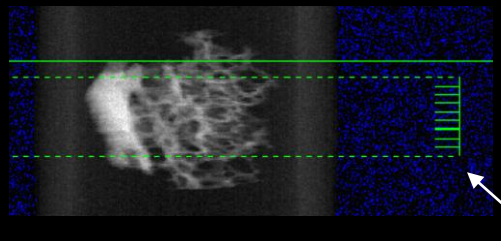
Time cost per stack: ~23 min

Tube Diameter	Max Resolution	Slice# per Stack	Max length per stack
7 mm	3.5 µm	235	0.81 mm
11.5 mm	6 µm	233	1.40 mm
20 mm	10 µm	232	2.32 mm
30 mm	15 µm	231	3.47 mm
37 mm	18.5 µm	231	4.27 mm

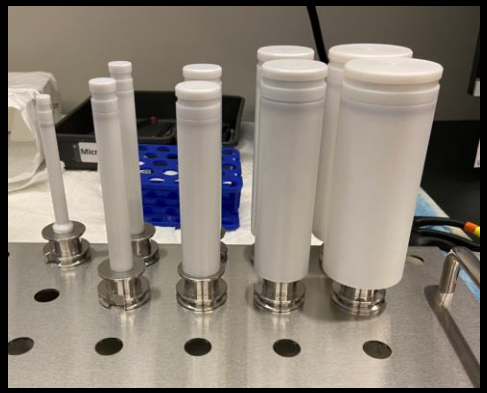
µCT 45

Time cost per stack: ~48 min

Tube Diameter	Max Resolution	Slice# per Stack	Max length per stack
9 mm	3 µm	1032	3.10 mm
14 mm	4.5 µm	1032	4.64 mm
24 mm	7.4 µm	1032	7.64 mm
34 mm	10.4 µm	1032	10.73 mm
48 mm	14.6 µm	1032	15.07 mm



Adjust stacks



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µCT 35

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µCT 45

Time cost per stack: ~48 min

Tube Diameter	Max Resolution	Slice# per Stack	Max length per stack
9 mm	3 µm	1032	3.10 mm
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24 mm	7.4 µm	1032	7.64 mm
34 mm	10.4 µm	1032	10.73 mm
48 mm	14.6 µm	1032	15.07 mm

µCT 35: 3.5 µm for 1032 slices: 115 min

µCT 45: 3 µm for 1032 slices: 48 min

µCT 35: 10 µm for 1032 slices: 115 min

µCT 45: 10.4 µm for 1032 slices: 48 min

Resolution	You can use these tubes
3 µm	9mm
4.5 µm	9mm, 14mm
7.4 µm	9mm, 14mm, 24mm
10.4 µm	9mm, 14mm, 24mm, 34mm
14.6 µm	9mm, 14mm, 24mm, 34mm, 48mm

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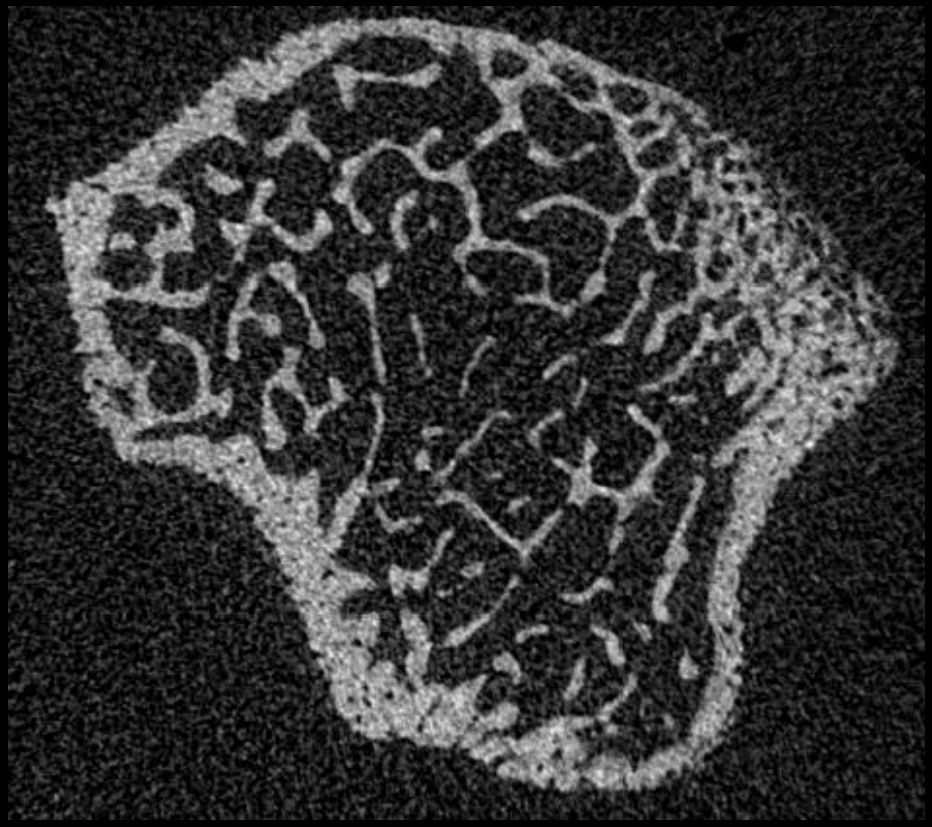
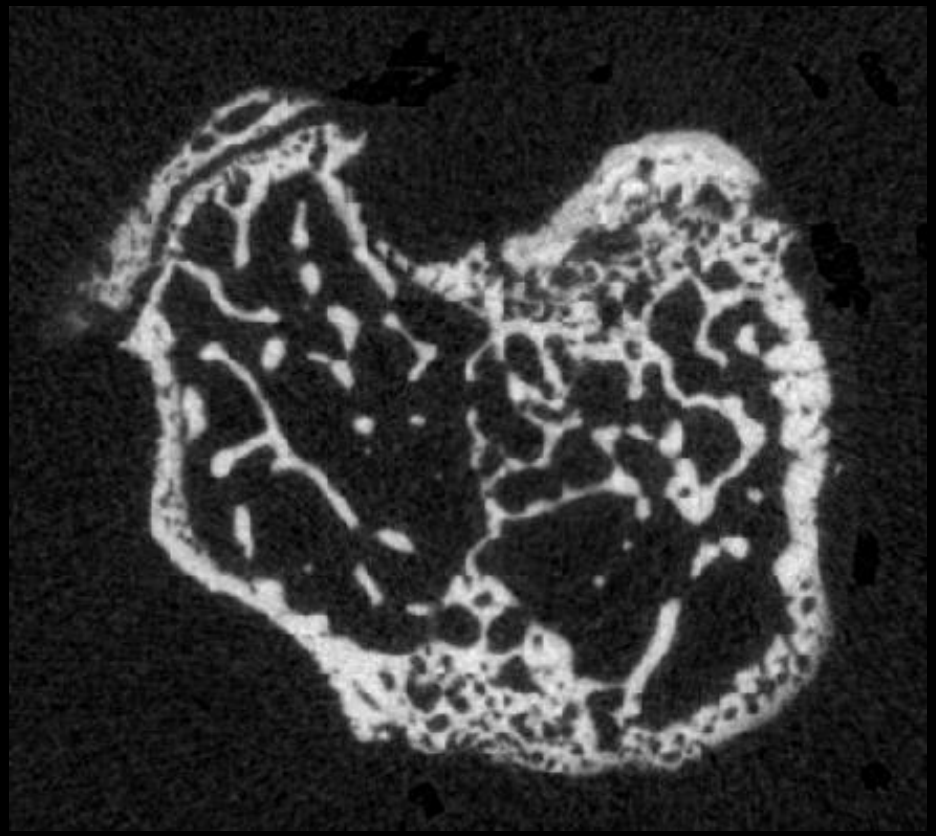
µCT 35

6.0 µm



µCT 45

7.4 µm



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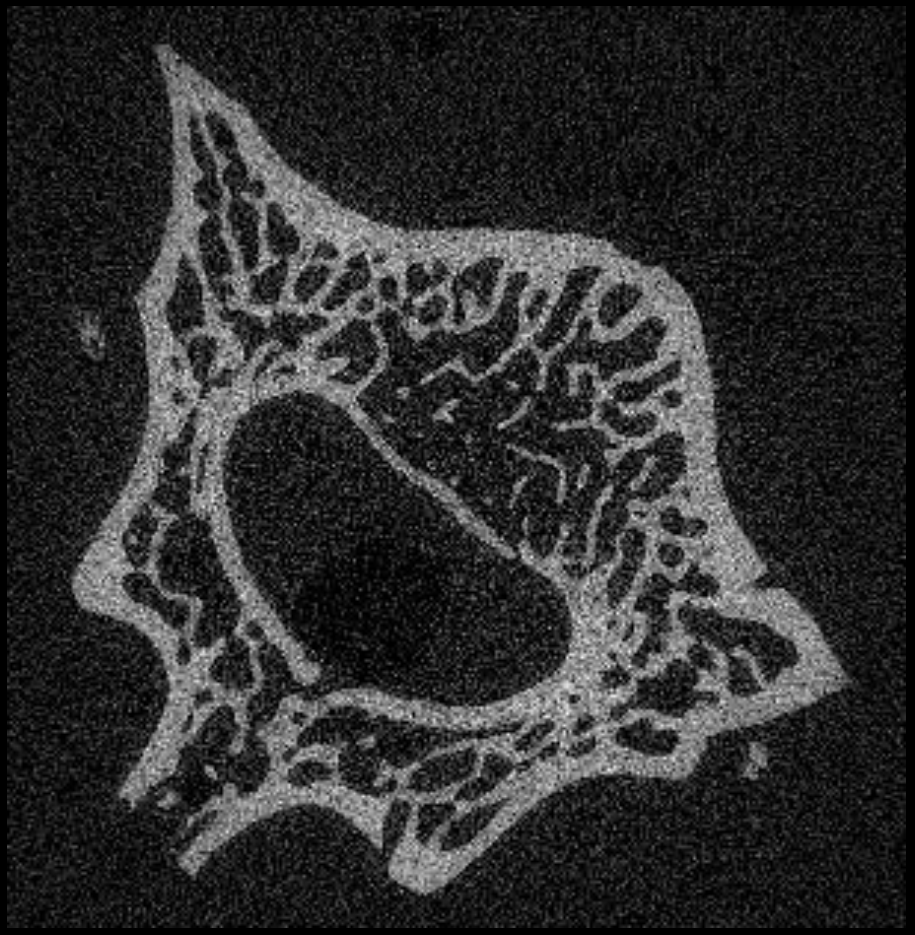
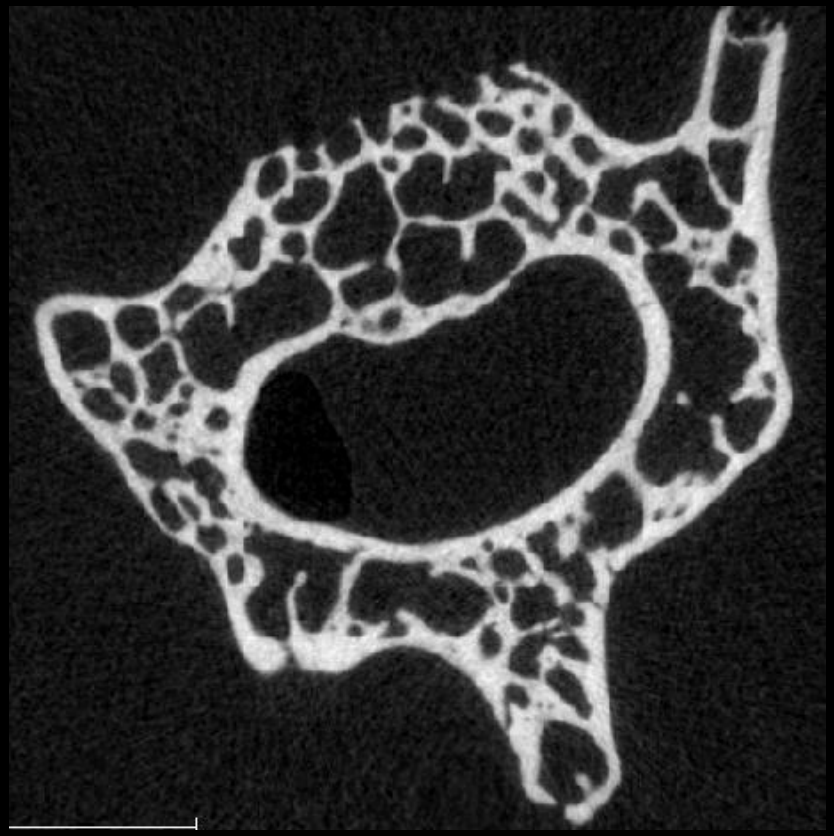
µCT 35

6.0 µm



µCT 45

7.4 µm



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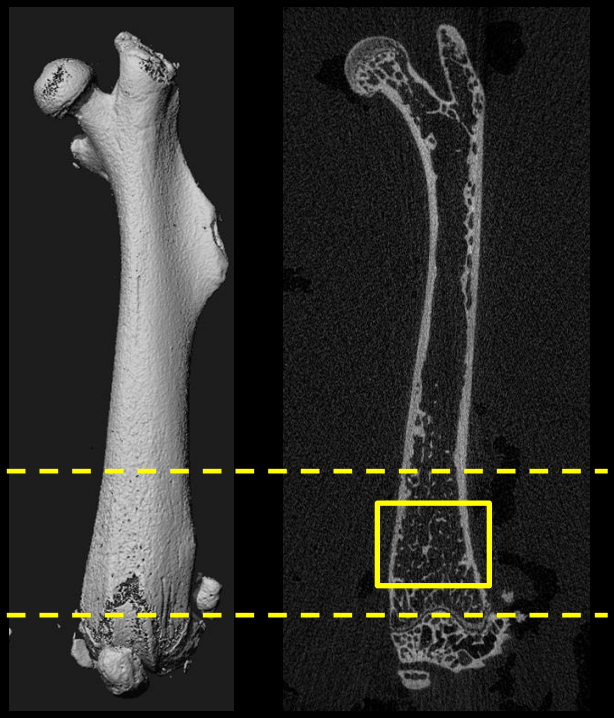
Phenotyping

- Mouse trabecular bone (long bone)
  - Distal femur, proximal tibia
  - µCT35:
    - 6 µm, 1-2 stacks, ~210-420 slices (1.4-2.8mm); Scan time: 24-48 mins
  - µCT45:
    - 7.4 µm, 1 stack, 1031 slices (7.64mm); Scan time: 48 mins
  - Analysis region
    - 100-200 slices, 0.5-1mm from the growth plate
  - Outcome measures: BV/TV, Tb.Th, Tb.N, Tb.Sp, SMI, Conn.D, BMD, TMD



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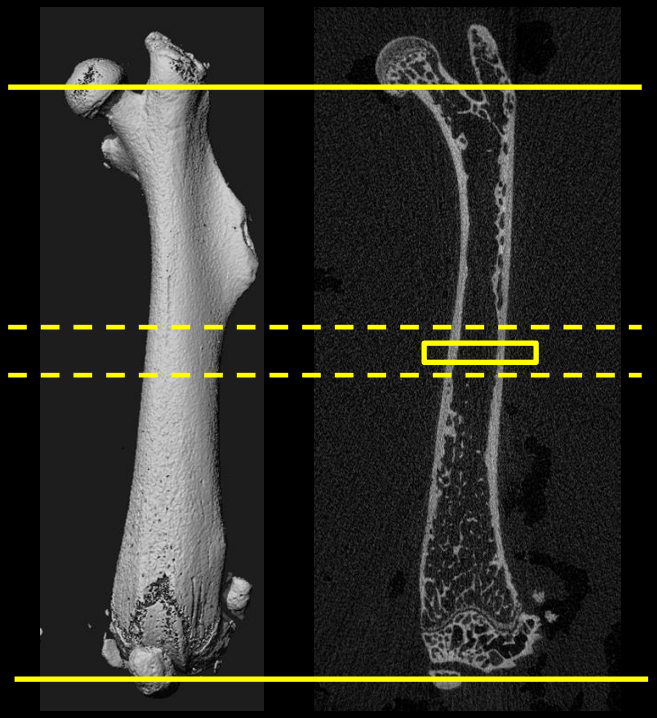
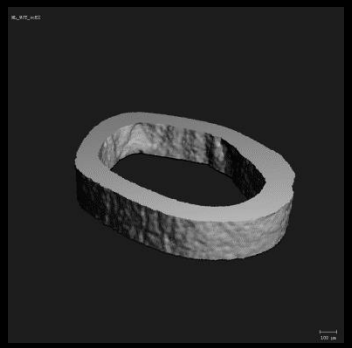
Phenotyping

- Mouse cortical bone (long bone)
  - Midshaft of tibia or femur
  - µCT35:
    - 6-10 µm, 1 stack, ~210 slices (1.4-2.3mm); Scan time: 24 mins
  - µCT45:
    - 7.4-10.4 µm, 1 stack, 1031 slices (7.6-10.7mm); Scan time: 48 mins
  - Analysis region
    - Middle 50 slices
  - Outcome measures: Ct.Area, Ct.Th, pMOI, Ct.Po, TMD





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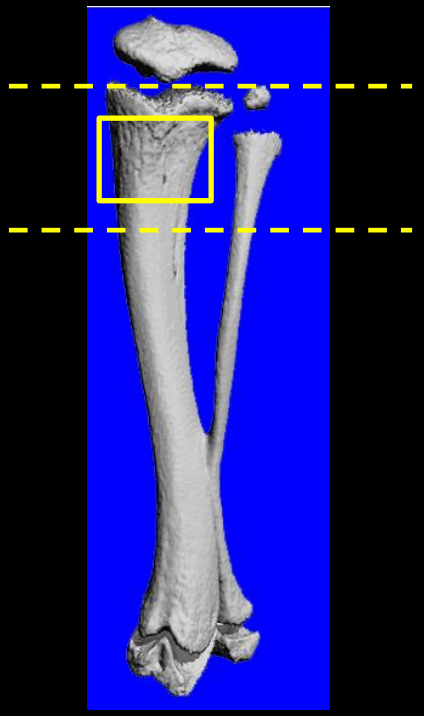
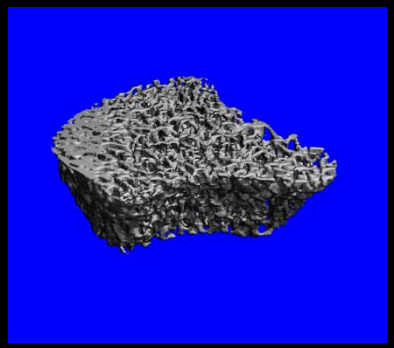
Phenotyping

- Rat trabecular bone (long bone)
  - Proximal tibia
  - µCT35:
    - 6-10 µm, 2 stacks, ~420 slices (2.8-4.6mm); Scan time: 48 mins
  - µCT45:
    - 7.4-10.4 µm, 1 stack, 1031 slices (7.6-10.7mm); Scan time: 48 mins
  - Analysis region
    - ~200 slices, 1-2mm distal to the growth plate
  - Outcome measures: BV/TV, Tb.Th, Tb.N, Tb.Sp, SMI, Conn.D, TMD





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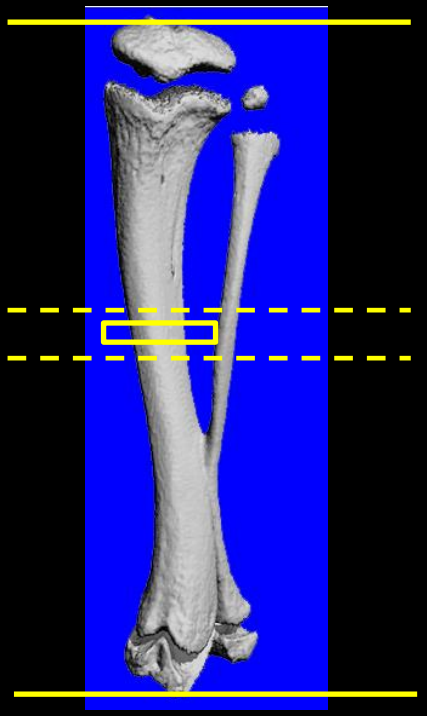
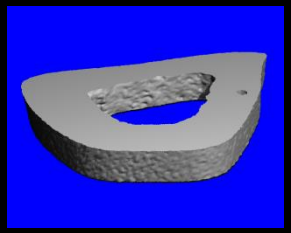
Phenotyping

- Rat cortical bone (long bone)
  - Midshaft of tibia or femur
  - µCT35:
    - 6-10 µm, 1 stack, ~210 slices (1.4-2.3mm); Scan time: 24 mins
  - µCT45:
    - 7.4-10.4 µm, 1 stack, 1031 slices (7.6-10.7mm); Scan time: 48 mins
  - Analysis region
    - Middle 50 slices
  - Outcome measures: Ct.Area, Ct.Th, pMOI, Ct.Po, TMD





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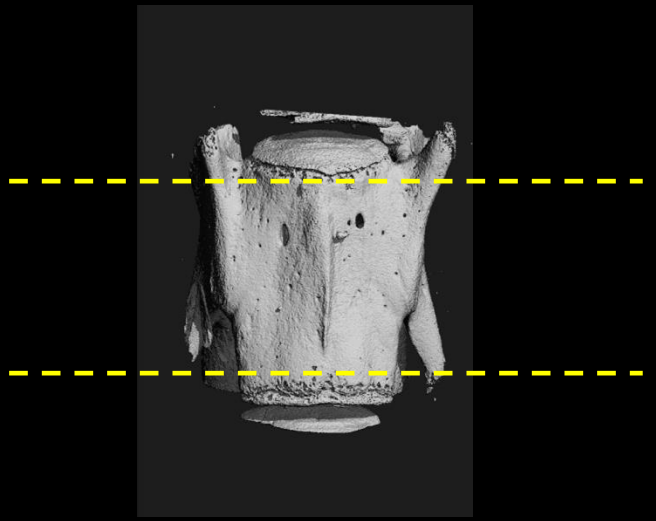
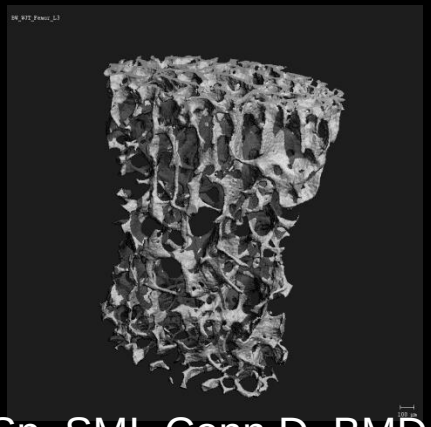
Phenotyping

- Mouse/Rat vertebral trabecular bone
  - Lumbar vertebra L1-L4
  - µCT35:
    - 6 µm (mouse) / 6-10 µm (rat)
    - 2-3 stack, 420-630 slices
    - Scan time: 48-72 mins
  - µCT45:
    - 7.4-10.4 µm, 1 stack, 1031 slices
    - Scan time: 48 mins
  - Scan Region: Between end plates
  - Analysis region
    - Between two end plates,
    - Middle 150-200 slices
  - Outcome measures: BV/TV, Tb.Th, Tb.N, Tb.Sp, SMI, Conn.D, BMD, TMD





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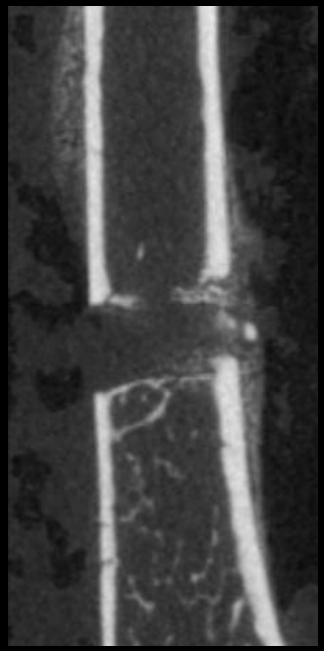
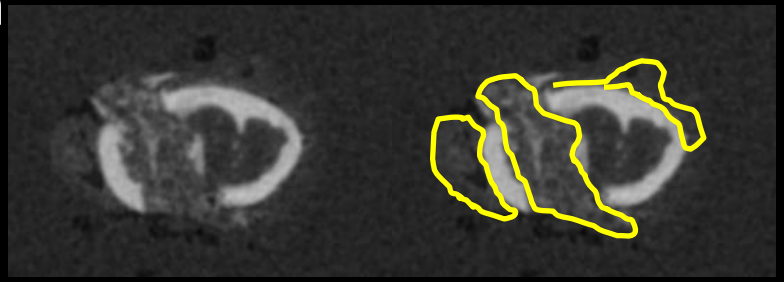
Fracture Healing

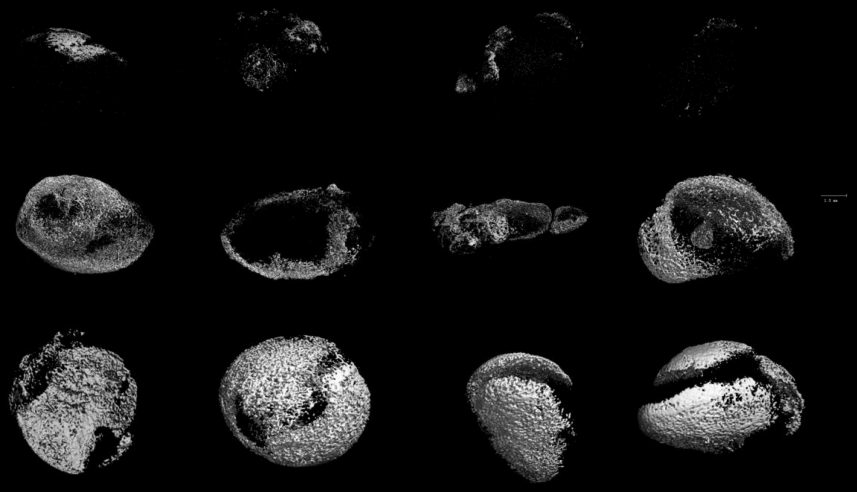
- µCT35:
  - 6-10 µm
  - Scan vertically: 1-2 hours
  - Scan horizontally: 15-30 mins
- µCT45:
  - 7.4-10.4 µm
  - Scan vertically: 48 mins
  - Scan horizontally: 48 mins
- Scan region: Whole bone
- Analysis region: whole healing region excluding cortical and trabecular bone
- Outcome measures
  - BV: Callus Volume
  - Avg callus area = Callus Volume/ Total Length





Scaffolds

- PLA, PGA, PCL, etc.
  - Scan Region: Whole scaffold
  - µCT35:
    - 6-10 µm
    - Scan time: 0.5-2 hours
  - µCT45:
    - 7.4-10.4 µm
    - Scan time: 48 mins
  - Analysis Region: Whole scaffold
  - Outcome measure:
    - Total mineralized tissue content (BV * TMD)
    - Total mineralized tissue volume (BV)



Courtesy of Dr. Masahiro and Dr. Kenta Uchibe

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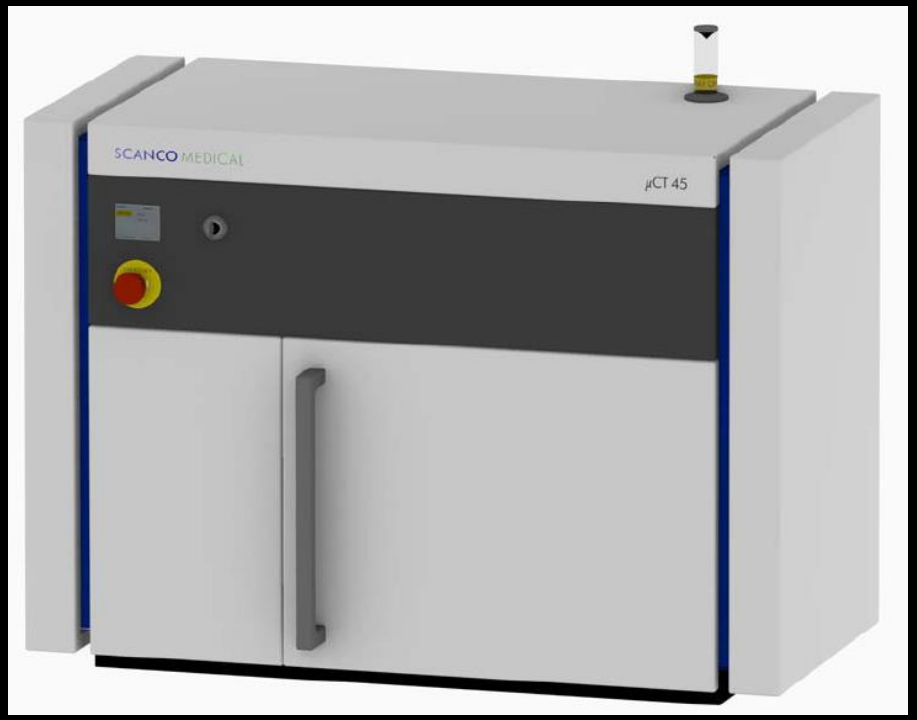
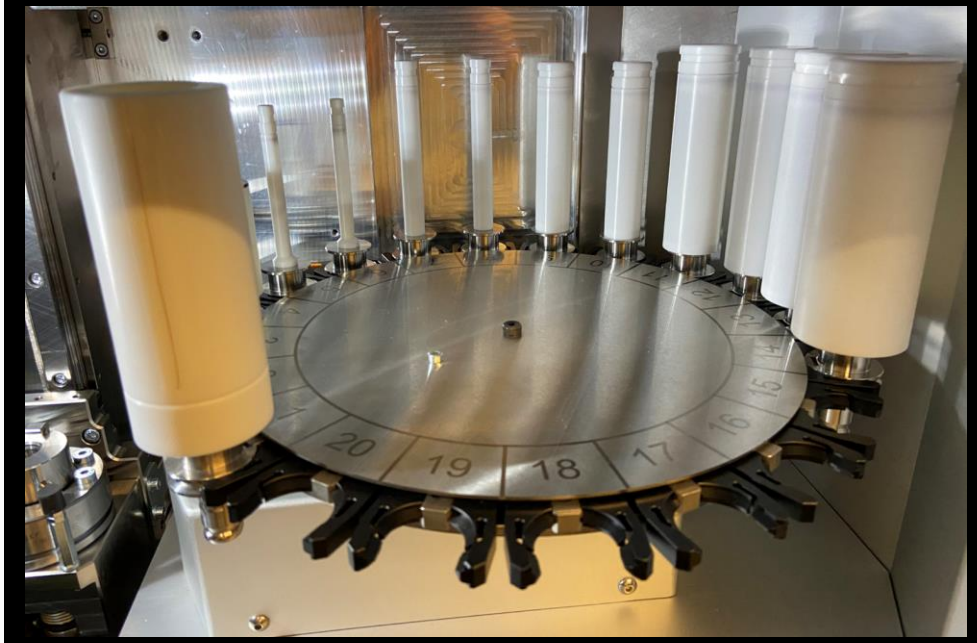
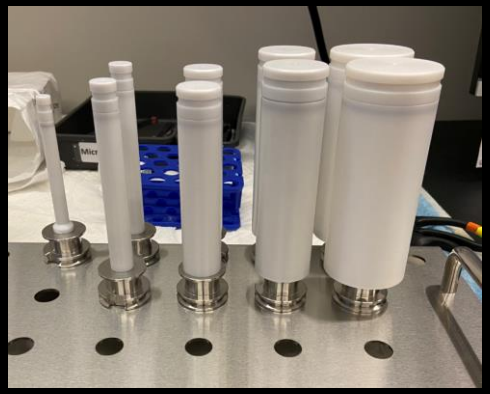
µCT 45 with a 20-sample holder carousel







Please write down the position# once you load the sample tube!

Note: Sample tubes from µCT 35 are NOT compatible with µCT 45.

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µCT 45 with a 20-sample holder carousel

Use the flashlight (we provided) to view sample placement

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µCT 45 with a 20-sample holder carousel

Demo of sample loading on uCT 45 https://www.youtube.com/watch?v=NaxH4ycriDg

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µCT 45 with a 20-sample holder carousel

SCANCO MEDICAL
µCT 45

X-Ray
55 kVp
145 µA

Carousel Position:
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Click here after closing the door

Check/Refresh | Unload | sample 5 is ready for measurement

Click here if you want to open the door

Measurement Sample:

Number:
Name: Test Scan
Date of Birth:
Meas. Remarks:

Other... | Modify... | New...

Measurement History: * = aborted

```
  1: No.:     2  CTR:   4   100 Slices * 11-NOV-2019 10:37 P
  2: No.:    29  CTR:  12  1032 Slices    2-DEC-2019 16:26
  3: No.:    30             633 Slices    2-DEC-2019 17:44
```

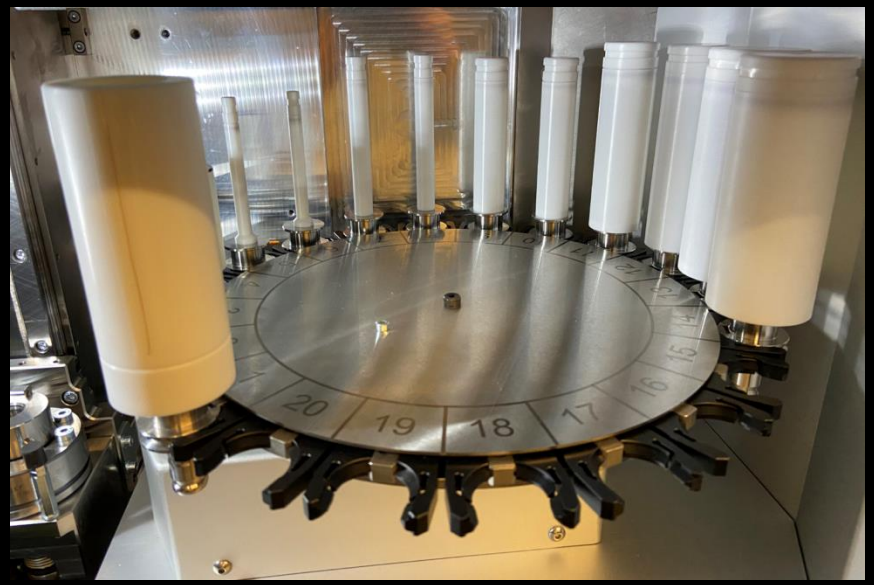
Controlfile:

```
 4:  QC1 90kVp, 0.1mm Cu, 1200mg HA (custom)
 5:  QC2 70kVp, 0.5mm Al, 1200mg HA (monthly)
10:  Test Scan
11:  PCMD-55kVP-3um-300ms-FOV10.2mm
12:  PCMD-55kVP-4.5um-300ms-FOV15.3mm
14:  PCMD-55kVP-7.4um-300ms-FOV25.2mm
15:  PCMD-55kVP-10.4um-300ms-FOV35.4mm
16:  PCMD-55kVP-14.6um-300ms-FOV49.6mm
```

Modify... | Delete... | New... | Lock...

Scout-View... | Scan... | Reset

Add Scout | Add Scan | Task List...



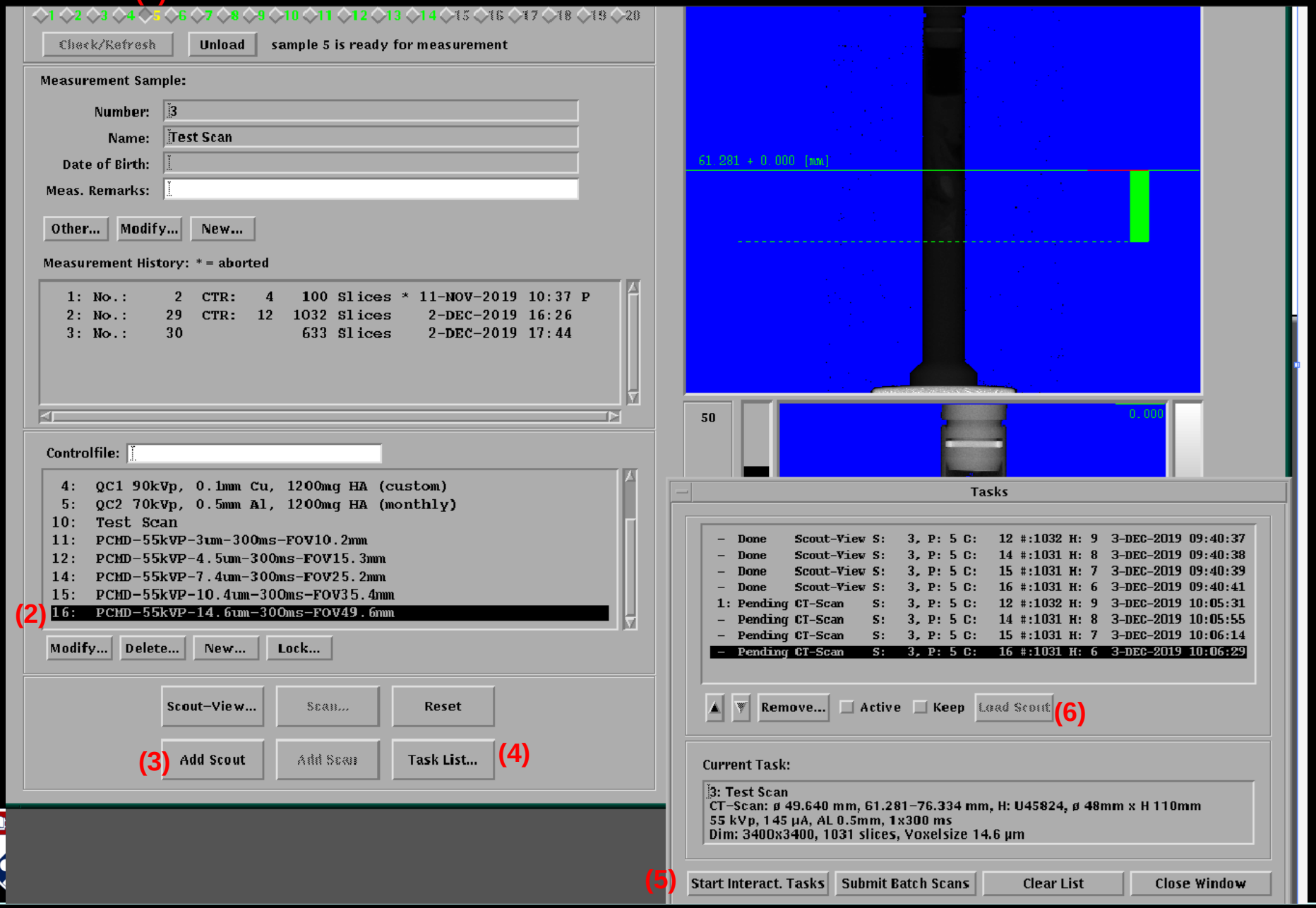
Please confirm

Insert or remove the sample holders now!
To start a measurement, please close the door and press yes.

Do you want to start a measurement?

Yes | No | Cancel

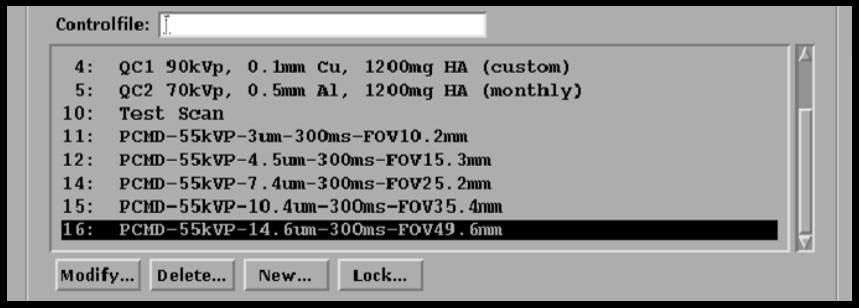
Scout-View for multiple tubes



Scout-View for multiple tubes

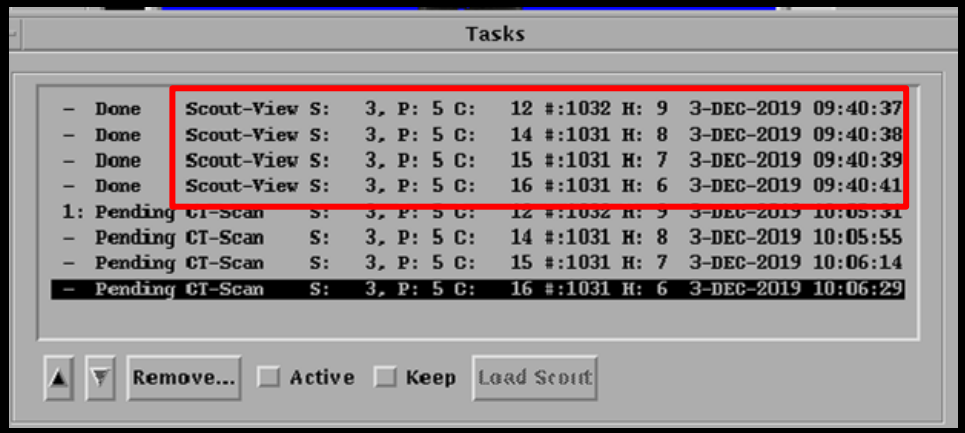
- We suggest you do scout view for all tubes first before selecting scanning regions:
  1. Select carousel position#

  2. Select Controlfile#



  3. Click "Add Scout"
     Do NOT click "Scout-View..."

  4. All scout tasks are listed in the "Task List..."



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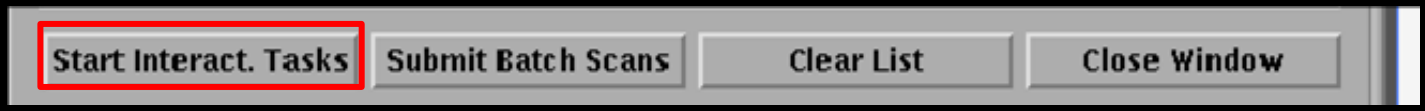
Scout-View for multiple tubes

- We suggest you do scout view for all tubes first before selecting scanning region:
  5. Repeat steps 1~3 until all tubes are in "Task List...", then click "Start Interact. Tasks"



  Take a break. Scout view may take ~5 min/tube. (If you have 10 tubes, you can come back in 1 hour)
  5. After scout view for all tubes are done, load each scout view ("Load Scout") to select scanning region.

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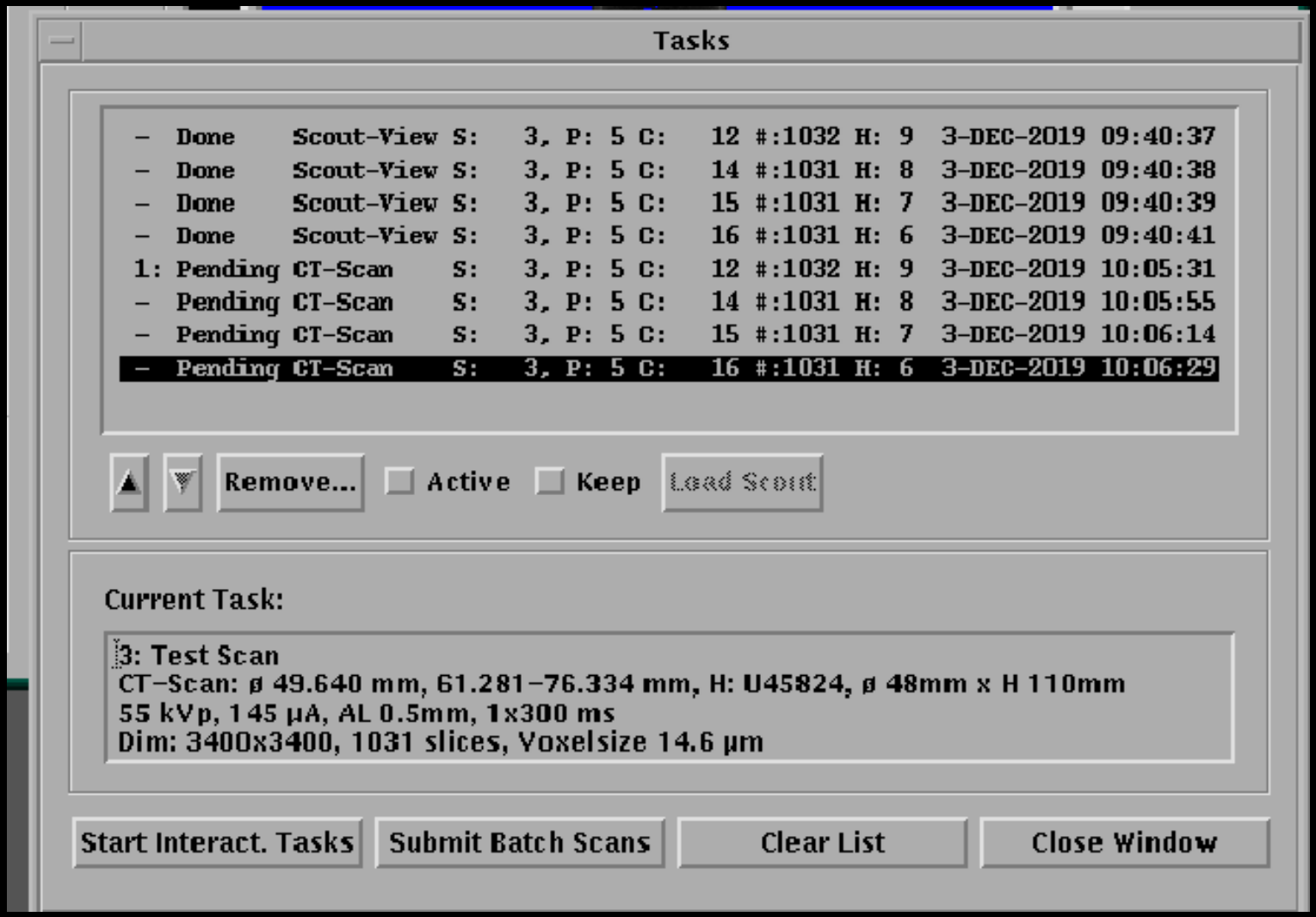
Scout-View for multiple tubes



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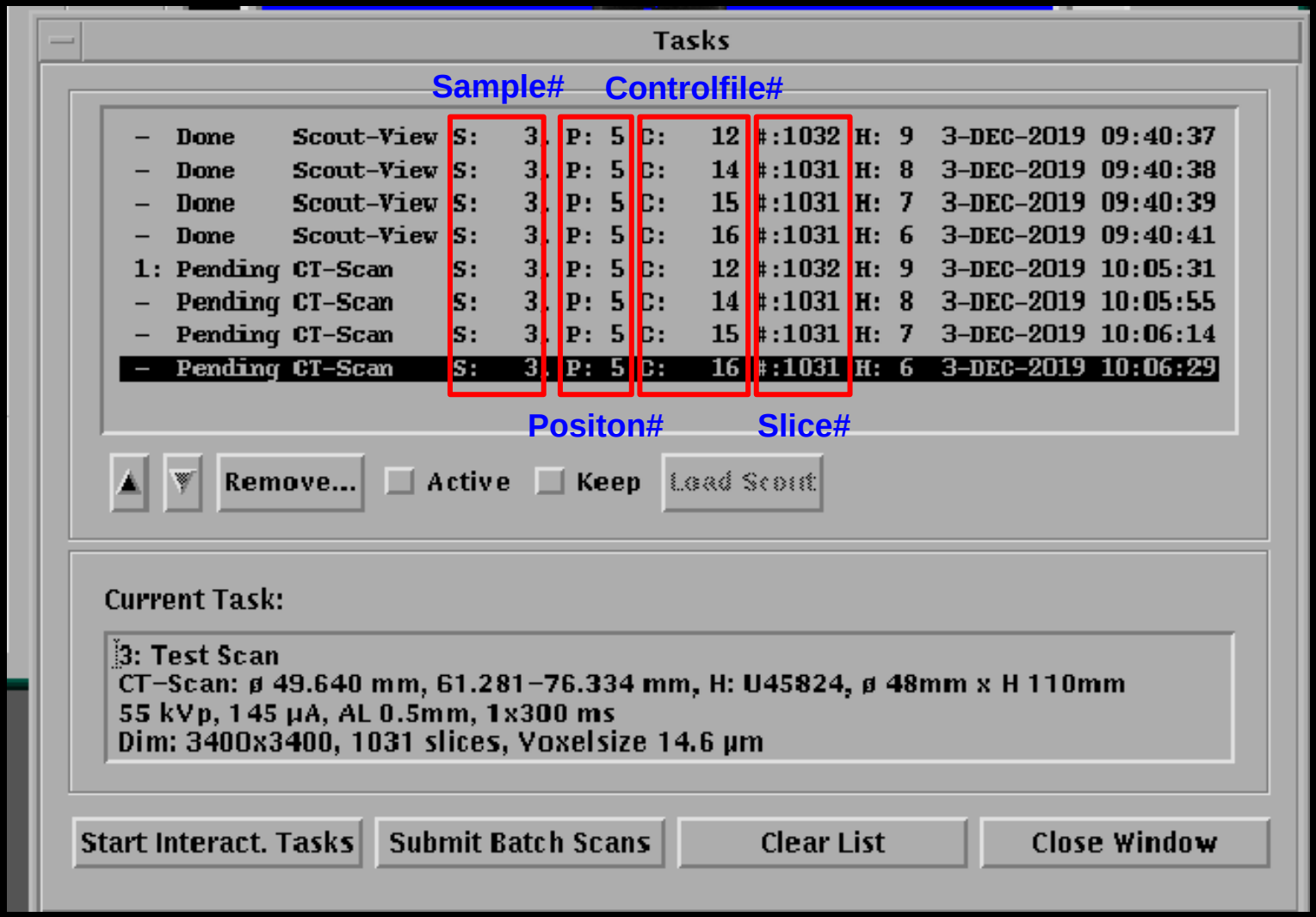
Scout-View for multiple tubes



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Room 335A: µCT35 & µCT45

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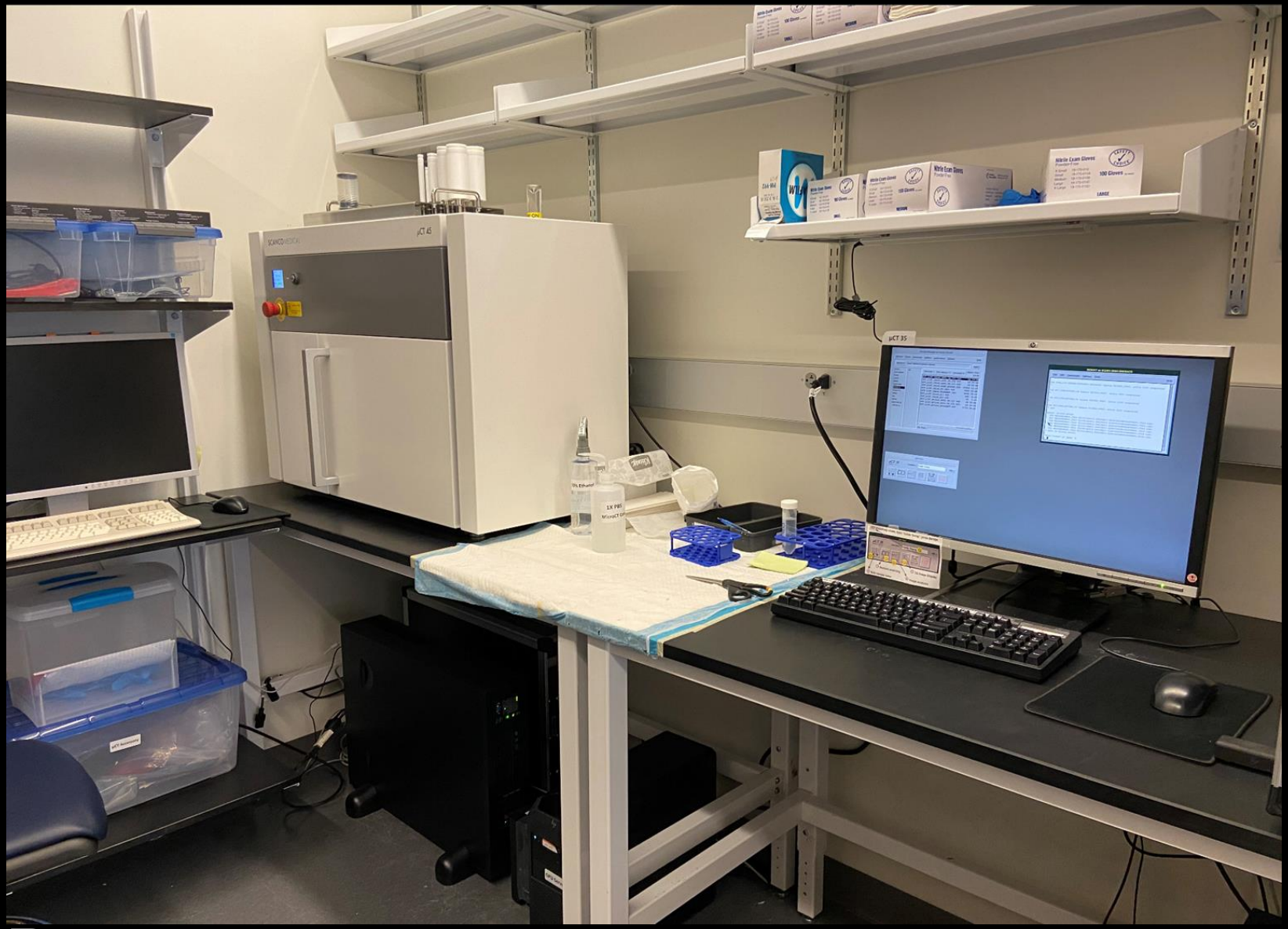
Room 335A: µCT45



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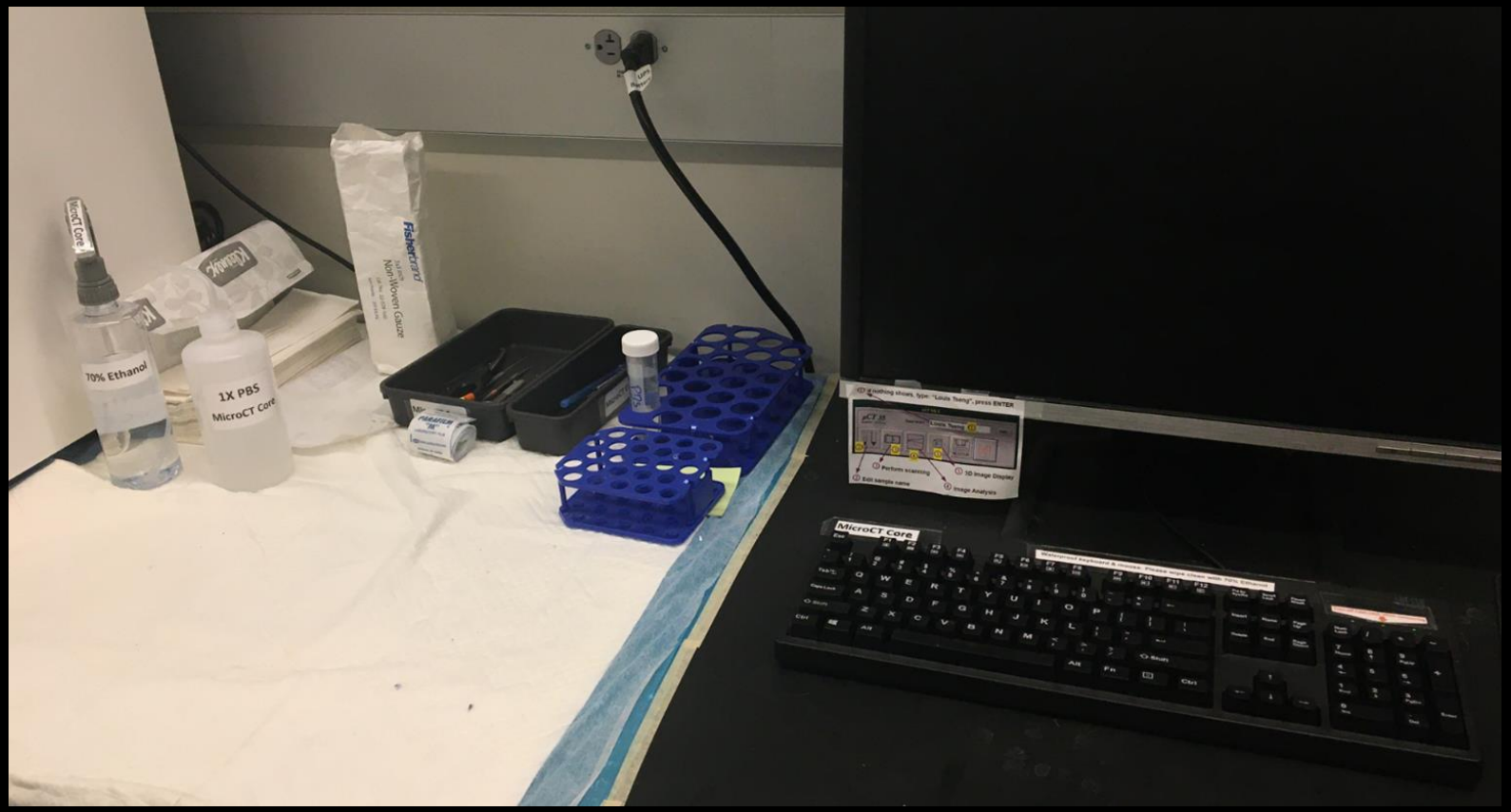
Recent Update: Basic tools are provided



- Basic tools, ethanol, PBS, and markers are provided
- Allowing users to wear gloves on waterproof keyboard
- Please wipe keyboard with 70% ethanol after use

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Room 368C: vivaCT 40

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Recent Update: Basic tools are provided

- Basic tools, ethanol, PBS, and markers are provided
- Allowing users to wear gloves on waterproof keyboard
- Please wipe keyboard with 70% ethanol after use

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Room 368B: vivaCT 80

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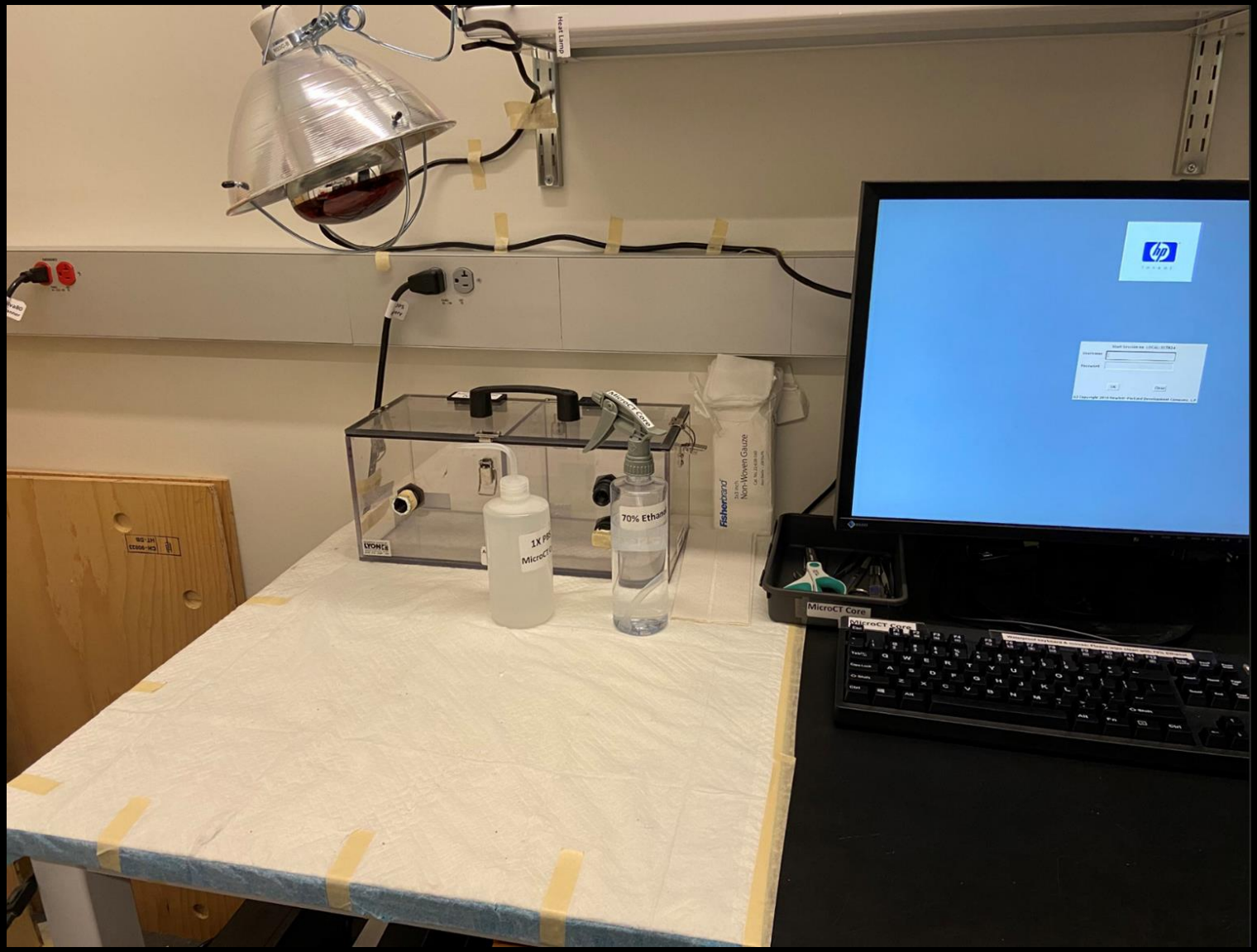
Room 368B: vivaCT 80



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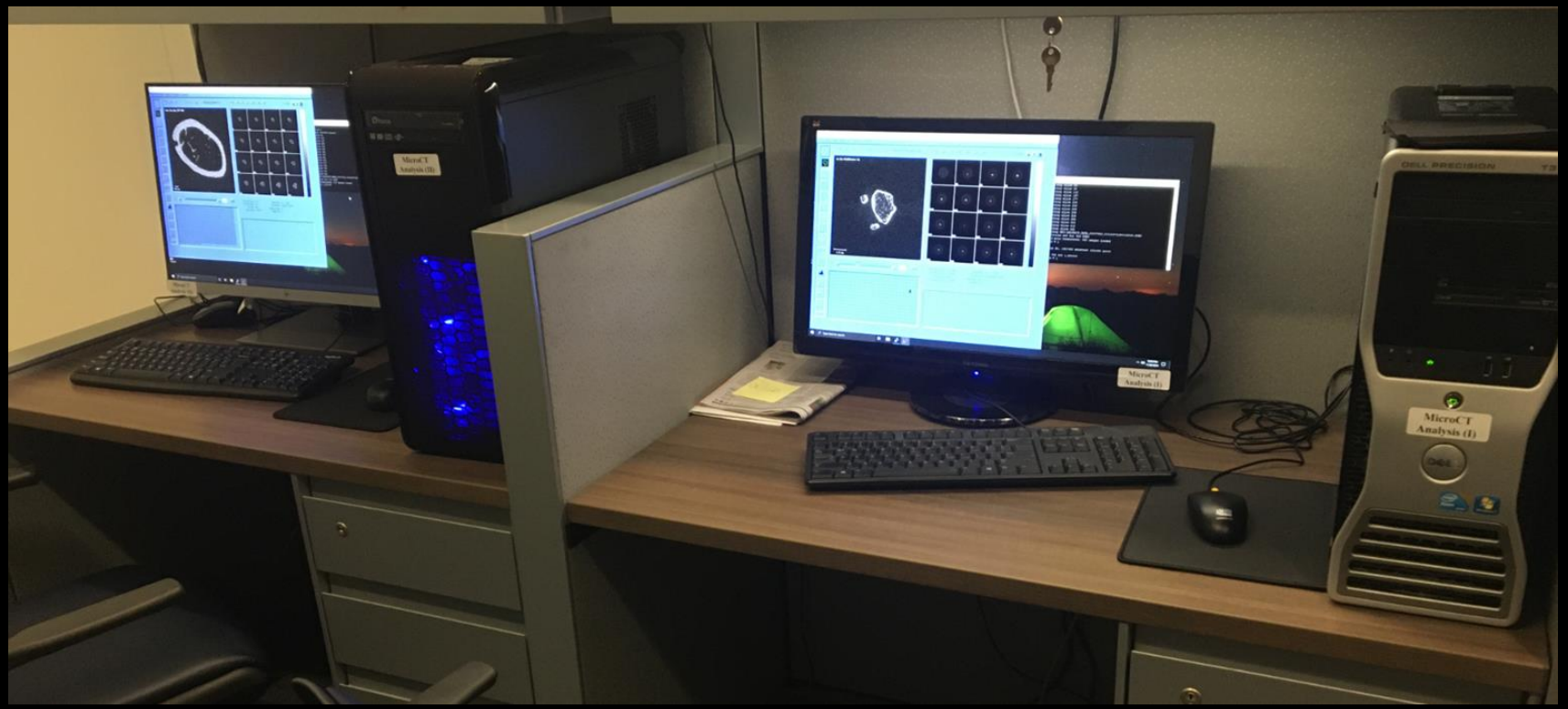
Room 315: Analysis Computer



- Before use, restart the computer to avoid previous errors
- For calendar access, send request to pcmd.microct@gmail.com

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Room 315: Analysis Computer

- Video tutorial https://www.youtube.com/watch?v=Fz0KfaLYDKw
  (You may adjust your preferred video speed in Youtube)

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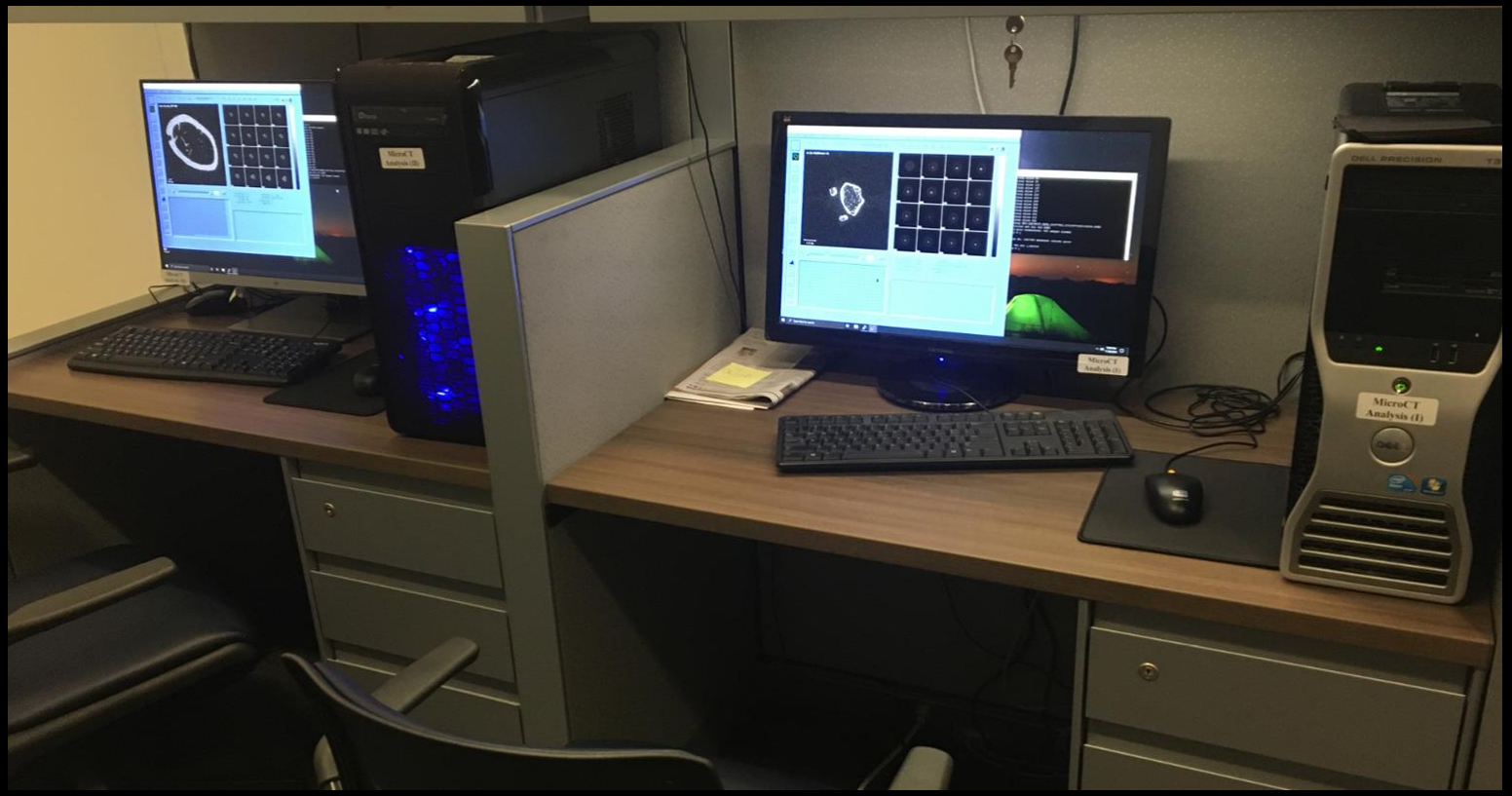
Room 315: Analysis Computer



- Policy: No hours limit, but 30-min “No Show” is NOT allowed.
  Calendars for analysis computers:
  MicroCT Analysis (I) - Room 315
  MicroCT Analysis (II) - Room 315

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Booking Policies for µCT Scanner

- Calendars for scanners:
  MicroCT35 MicroCT45 VivaCT40
  VivaCT80
- Label your Google event "PI's initial_PennKey_scan only_Phone Number", e.g.:
  XSL_yiluz_scan & analysis_1234567890
- **30 min "No Scan" is NOT allowed. Adjust your reservation if your plans change!**
- No restrictions for off-hours (< 9am or > 5pm) & weekend.
- No restrictions for *in vivo* (live animal) scanning.
- Currently, no restrictions for vivaCT 80 and µCT 45.
- Scanning user always has priority over "analysis only" user.

- µCT 35 & vivaCT 40:
  4 hours maximum per lab per weekday (9-1pm or 1-5pm)
  (Exception: On your scanning day, you can reserve if additional time is available)

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Scanning Policies

Sample naming: Starts with PI's initial + user's initial or first name or pennkey (for billing purposes)

Scanning:

- All *in vivo* µCT scans require IACUC approval
- In the case of error messages, please capture photos of the error message, and send to pcmd.microct@gmail.com
- Any scan extending **10 min** into other user's period will be stopped by manager

After CT scanner use:

- Clean up
- Do NOT turn off the CT scanner
- Do NOT "session out" the system
- Samples will be trashed if left over 2 days after scanning

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Data Storage Policies

- Google Drive auto-share: Requested files will be removed (from Google drive) 14 days after sharing

- Image files will be removed from servers to offline tapes within 3 months after scanning.
  (If you are still analyzing samples scanned 3 months ago, please let us know in advance!)

- Retrieving image files from tapes is very time consuming and depends on the availability of both tape drive and server space.

  Please request tape file retrieval at least 7 days in advance!

microCT Sample Database

MicroCT_Sample_Database

File Edit View Insert Format Data Tools Add-ons Help

100% View only

	A	B	C	D	E	F	G	H	I	J	K
1	2019-11-26 16:03 Last updated by MicroCT35		MicroCT35	sorted by scan date			File & Tape Request Form (v201912)				
2	PI| User	Sample Name	Scan starts	Scan ends	Sample#	Measure#	RSQ Size	ISQ Size	File Types	Analyzed?	Controlfile
3	FXL| Fangfang	Long_Fang_8511	2019-11-26 18:07	18:32	7527	18383					109: PCMD-bone-6um-D11.5mm-300ms
4	FXL| Fangfang	Long_Fang_8511	2019-11-26 17:19	18:07	7527	18382					109: PCMD-bone-6um-D11.5mm-300ms
5	FXL| Fangfang	Long_Fang_8533	2019-11-26 16:31	17:19	7526	18381					109: PCMD-bone-6um-D11.5mm-300ms
6	FXL| Fangfang	Long_Fang_8533	2019-11-26 16:06	16:31	7526	18380					109: PCMD-bone-6um-D11.5mm-300ms
7	FXL| Fangfang	Long_Fang_8509	2019-11-26 15:41	16:06	7525	18379	0KB				109: PCMD-bone-6um-D11.5mm-300ms
8	FXL| Fangfang	Long_Fang_8509	2019-11-26 14:52	15:40	7525	18378	1.84GB	3.15GB			109: PCMD-bone-6um-D11.5mm-300ms
9	FXL| Fangfang	Long_Fang_8534	2019-11-26 14:04	14:52	7524	18377	1.84GB	3.50GB			109: PCMD-bone-6um-D11.5mm-300ms
10	FXL| Fangfang	Long_Fang_8534	2019-11-26 13:31	13:56	7524	18376	969.72MB	1.79GB			109: PCMD-bone-6um-D11.5mm-300ms
11	SY| Yang	sy-ly-r11m20tazoc-3m	2019-11-26 8:51	9:39	7523	18375	1.81GB	3.46GB			10: Test Scans
12	SY| Yang	sy-ly-r5m20tazoc-3m	2019-11-26 8:03	8:51	7522	18374	1.81GB	3.46GB			10: Test Scans
13	SY| Yang	sy-ly-367r1moc-3m	2019-11-26 7:09	7:57	7521	18373	1.81GB	3.46GB			10: Test Scans
14	FXL| Chao	Long lab_chao_7483 N2P	2019-11-26 3:39	5:10	7520	18372	3.73GB	7.09GB			109: PCMD-bone-6um-D11.5mm-300ms
15	FXL| Chao	Long lab_chao_7482 N2p	2019-11-26 2:08	3:39	7519	18371	3.73GB	7.09GB			109: PCMD-bone-6um-D11.5mm-300ms
16	FXL| Chao	Long lab_chao_7477 N2P	2019-11-26 0:37	2:08	7518	18370	3.73GB	7.09GB			109: PCMD-bone-6um-D11.5mm-300ms
17	FXL| Chao	Long lab_chao_7467 N2P	2019-11-25 22:59	11-26 0:30	7517	18369	3.73GB	7.09GB			109: PCMD-bone-6um-D11.5mm-300ms
18	FXL| Chao	Long lab_chao_7599 N2P	2019-11-25 21:11	22:42	7516	18368	3.73GB	7.09GB			109: PCMD-bone-6um-D11.5mm-300ms
19	FXL| Chao	Long lab_chao_7476 N2P	2019-11-25 19:40	21:11	7515	18367	3.73GB	7.09GB	AIM,GOBJ,TXT	Analyzed	109: PCMD-bone-6um-D11.5mm-300ms
20	FXL| Chao	Long lab_chao_7460 N2P	2019-11-25 18:08	19:39	7514	18366	3.73GB	7.09GB			109: PCMD-bone-6um-D11.5mm-300ms
21	FXL| Chao	Long lab_chao_7451 N2P	2019-11-25 16:37	18:08	7513	18365	3.73GB	7.09GB			109: PCMD-bone-6um-D11.5mm-300ms

CT35_By_date | Viva40_By_date | Viva80_By_date | CT45_By_date | CT35_By_sample | Viva40_By_sample | Viva80_By_sample

Sort by scan date

Sort by sample#

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Automated File Request

MicroCT_Sample_Database

File Edit View Insert Format Data Tools Add-ons Help

100% View only

	A	B	C	D	E	F	G	H	I	J	K
1	2019-11-26 16:03 Last updated by MicroCT35		MicroCT35	sorted by scan date			File & Tape Request Form (v201912)				
2	PI| User	Sample Name	Scan starts	Scan ends	Sample#	Measure#	RSQ Size	ISQ Size	File Types	Analyzed?	Controlfile
3	FXL| Fangfang	Long_Fang_8511	2019-11-26 18:07	18:32	7527	18383					109: PCMD-bone-6um-D11.5mm-300ms

- Fill in this file request form, and send to pcmd.microct@gmail.com

Your Gmail: meniscus@gmail.com

MicroCT35			Vivact40			Vivact80		
Sample#	Measure#	File_Types	Sample#	Measure#	File_Types	Sample#	Measure#	File_Types
7234	17817	DICOM						
7234	17816	DICOM						
7234	17815	DICOM						
7234	17814	DICOM						
7234	17813	DICOM						
7234	17812	DICOM						
7233	17811	DICOM						
7233	17810	DICOM						
7233	17809	DICOM						
7204	17726	DICOM						
7204	17725	DICOM						
7204	17724	DICOM						

Example (1)

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Automated File Request

- Fill in this file request form, and send to pcmd.microct@gmail.com

Your Gmail:	meniscus@gmail.com, tendon@gmail.com, muscle@gmail.com, bone@gmail.com							
MicroCT35			Vivact40			Vivact80		
Sample#	Measure#	File_Types	Sample#	Measure#	File_Types	Sample#	Measure#	File_Types
						134	839	AIM, TXT
						134	840	AIM, TXT
						134	841	AIM, TXT
						134	842	AIM, TXT
						134	843	AIM, TXT
						134	844	AIM, TXT
						134	845	AIM, TXT
						134	846	AIM, TXT
						134	847	AIM, TXT
						135	850	AIM, TXT
						136	851	AIM, TXT

Example (2)

After analysis, we suggest you keep a copy of GOBJ and TXT.
Analysis results are in the TXT file with the name “3DRESULTS”.
(Open it with Excel, NOT notepad.)

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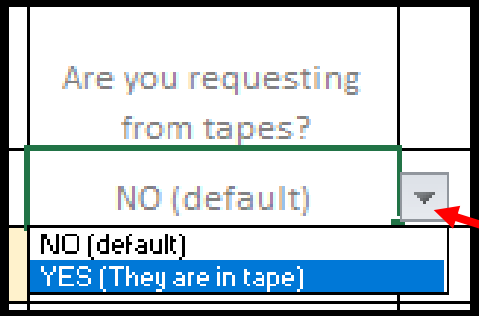
Tape Retrieval Request

- If your samples have been moved into tapes, please select "*YES (They are in tape)*" at cell P2
- Send to pcmd.microct@gmail.com
- Tape retrieval may take over 1 week! (Please send to us as early as possible)



please select "*YES (They are in tape)*" at cell P2. (See Example 3)

Are you requesting from tapes?

YES (They are in tape)

Vivact80		MicroCT45	
Sample#	Measure#	Sample#	Measure#
260	940		
261	939		
262	944		
263	943		
264	942		
265	947		
266	946		

Example (3)
For Tape Retrieval

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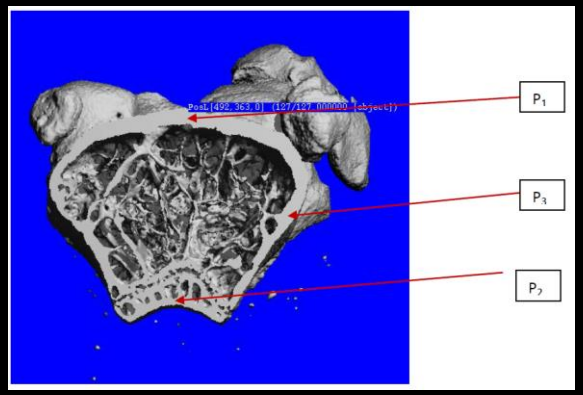
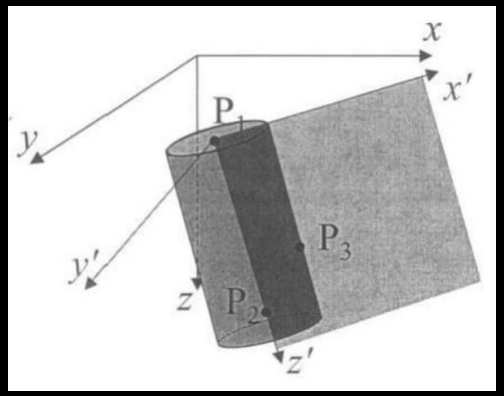
Automated System for Sample Re-alignment

- Examples:
  - Scanning angle is too far away
  - From transverse to sagittal or coronal plane





1	2. Fill in all yellow and red boxes (4 boxes: B2, A4, B4, C4) 3. Fill in this Excel sheet, 1 row for ONLY 1 measure number 4. Send this Excel sheet to pcmd.microct@gmail.com					
2	1. Enter your email here:	bone@gmail.com				
3	2. Select machine:	3. Select rotating options:	4. Select import options:			
4	MicroCT35	3 Point Rotation (AlignZ)	Import with new sample name	Use COMMA btw each number, e.g.: 100,100,100		
5	**Sample#**	**Measure#**	**New Sample#**	**P1**	**P2**	**P3**
6	1606	8335	1608	174,224,0	173,99,0	93,154,0
7						
8						
9						
10						

Current status: In development (expected 02/2020)

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Questions?

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