Review of expected results for mA variation curves in routine CT AEC testing

University Hospital Southampton
NHS Foundation Trust

CT Users Group Annual Meeting

16th October 2025

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- Background & Method
- GE & Siemens Results
- Lungman Results
- Canon Results
- A question to the audience…
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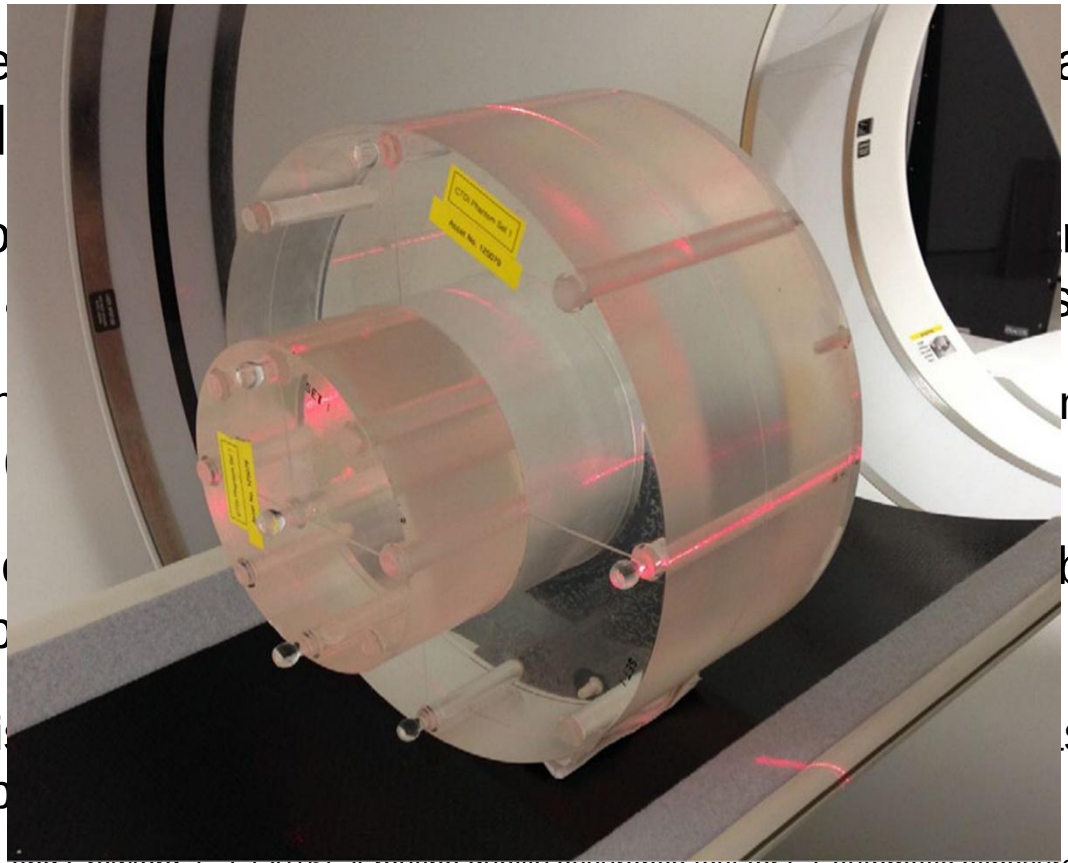
Background

- CT AEC testing is performed using the nested CTDI phantom method at UHS [1]
- AEC reproducibility is confirmed by graphing the mA variation along the z-axis and visually assessing the deviation from baseline
  - Performed only to confirm the AEC is functioning, so has no suspension criteria (performance assessed by dose audits)
- It was noticed that results from GE scanners tended to be infrequently reproducible
  - Was this operator error? Was the method unsuitable? Was the scanner incapable of reproducible results?

[1] Iball, G.R., Moore, A.C. and Crawford, E.J. (2016), A routine quality assurance test for CT automatic exposure control systems. Journal of Applied Clinical Medical Physics, 17: 291-306. https://doi.org/10.1120/jacmp.v17i4.6165

Background

- CT AEC te antom method at UHS [1]
- AEC repro riation along the z-axis seline
  - Perform no suspension criteria
- It was noti be infrequently reproducib
  - Was thi s the scanner incapab



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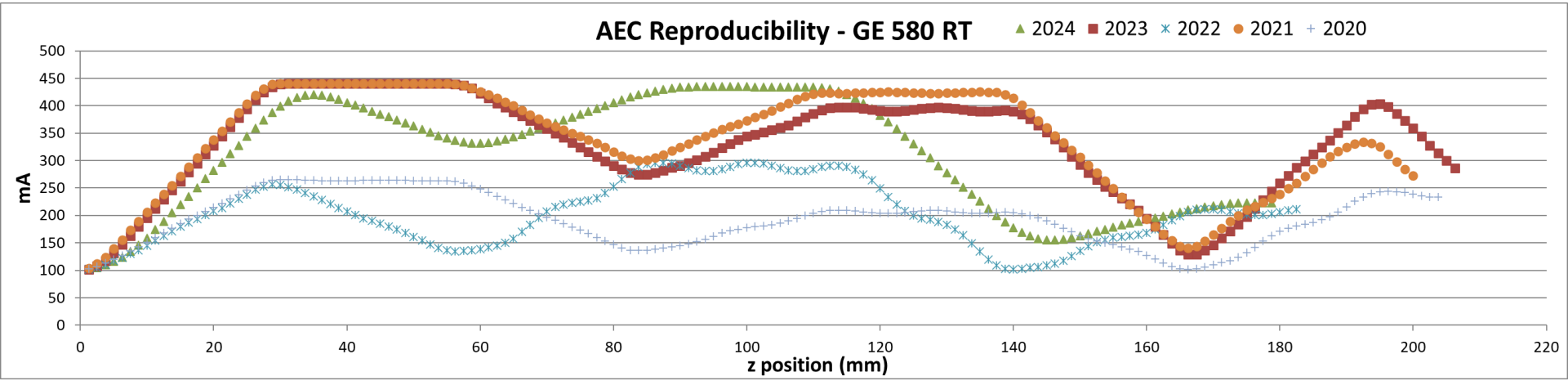
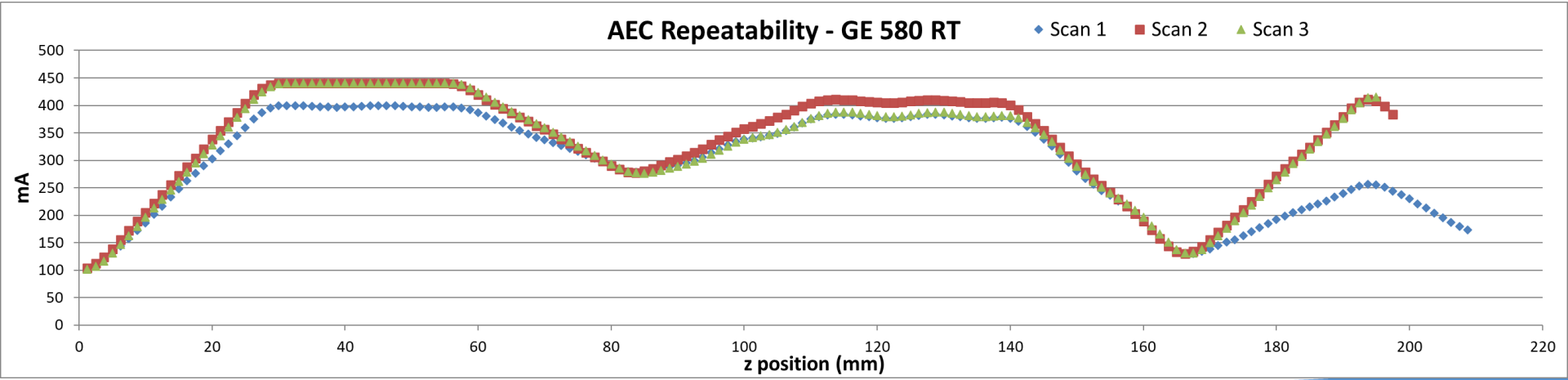
Method

- Repeatability ≈ Reproducibility
  - Perform the standard AEC test 3 times back to back and compare results
  - Repeat on a Siemens scanner to compare with GE
- Would an anatomical phantom produce more consistent results?
  - Perform the standard AEC test but using a Kyoto Kagaku Lungman phantom instead of the CTDI phantom
  - Chest plates were used

https://www.kyotokagaku.com/en/products_data/ph-1_01/

Results – GE

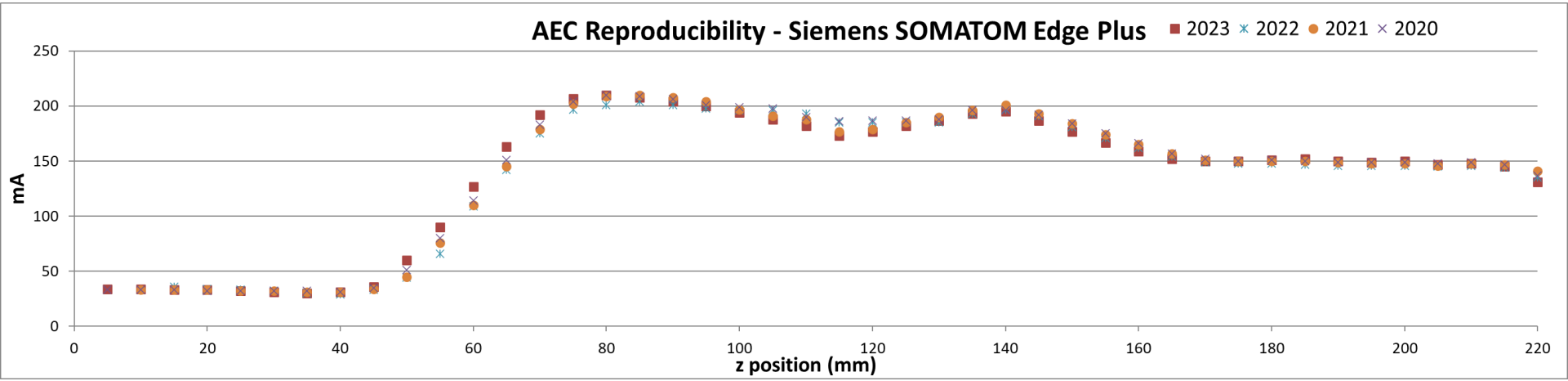

AEC Reproducibility - GE 580 RT
2024
2023
2022
2021
2020
mA
z position (mm)

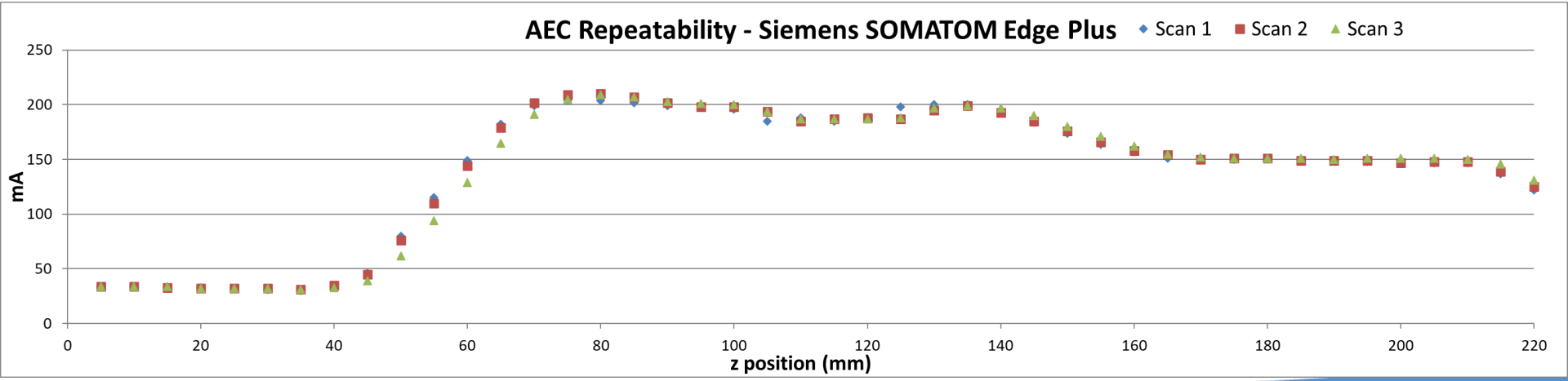

AEC Repeatability - GE 580 RT
Scan 1
Scan 2
Scan 3
mA
z position (mm)

Protocols - GE

	AEC Baseline Protocol Set 1 Fill out Baselines tab with all planned protocol information and will auto-populate below.
Protocol name	7.1 Pelvis Prosoma
Pitch	1.375
AEC setting	NI = 26.45
kV	120
mA range	100 - 440
Rotation time (s)	1
Collimation	1.25 x 16i
Slice width (mm)	1.25
FOV	large (50)
Filter (H/B)	body
Scan direction	Head first
Table height	261
Reconstruction type (i.e recon kernel, iterative, % etc)	std, full, 50% ASIR

Results – Siemens





Protocols - Siemens

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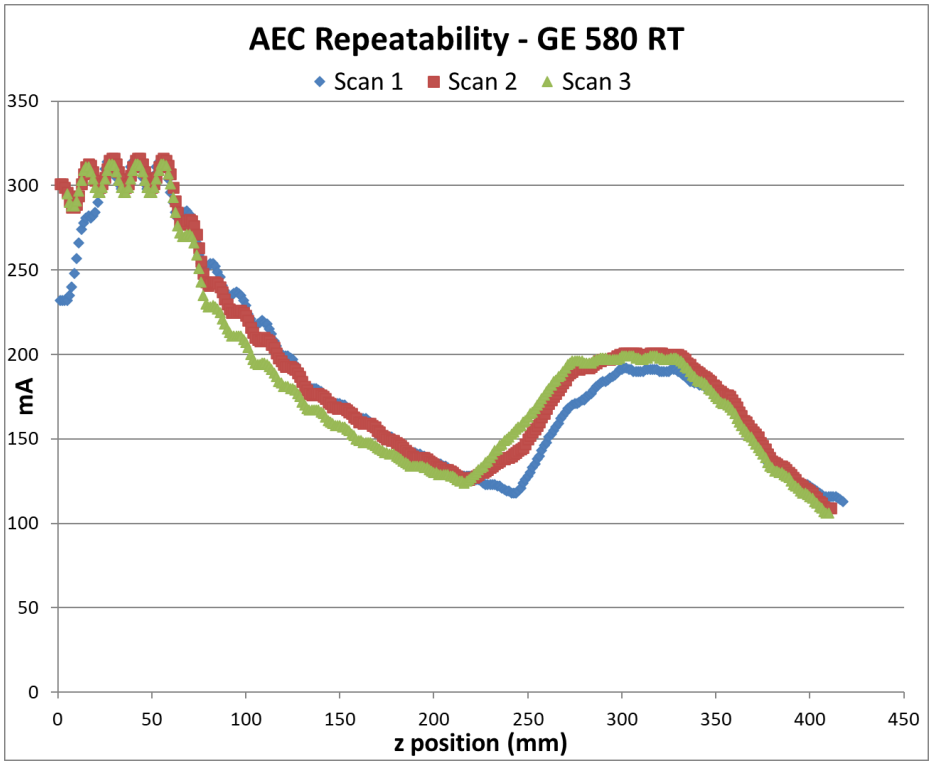
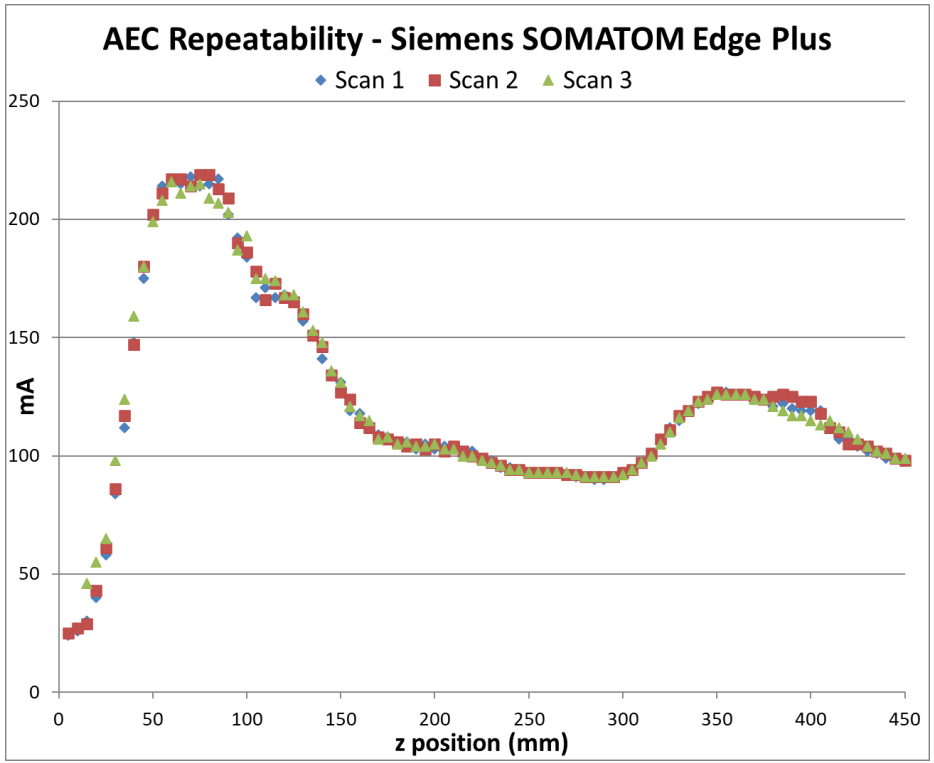
	AEC Baseline Protocol Set 1 Fill out Baselines tab with all planned protocol information and will auto-populate below.
Protocol name	AbdomenRoutine
Pitch	0.6
AEC setting	CAREDose4D on, CAREkV off, Ref mAs=147, dose opt for 7
kV	120
mA range	17-555
Rotation time (s)	0.5
Collimation	128x0.6
Slice width (mm)	5
FOV	400mm
Filter (H/B)	Standard
Scan direction	Craniocaudal
Table height	159
Reconstruction type (i.e recon kernel, iterative, % etc)	Br38

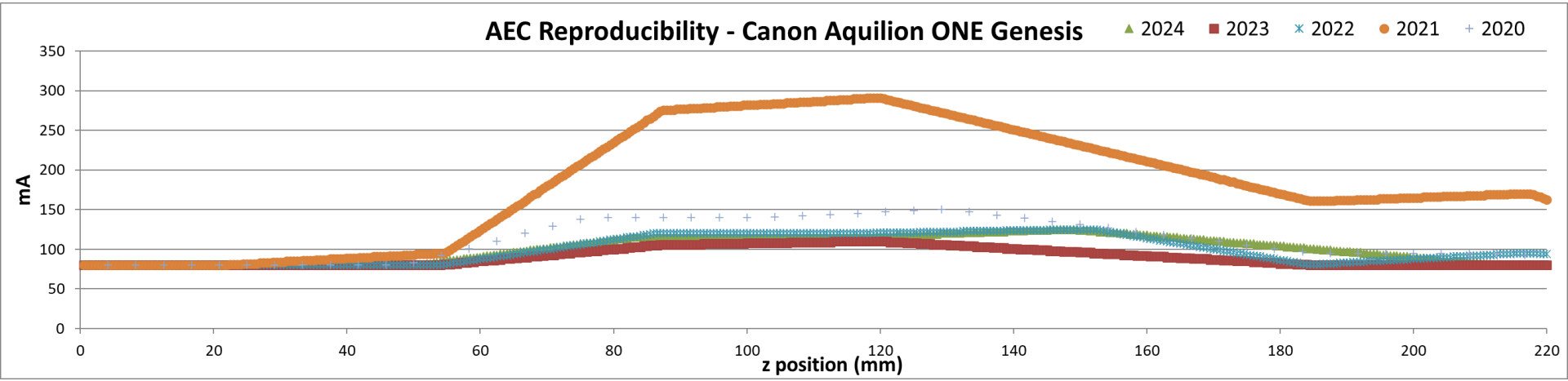
Results – Lungman

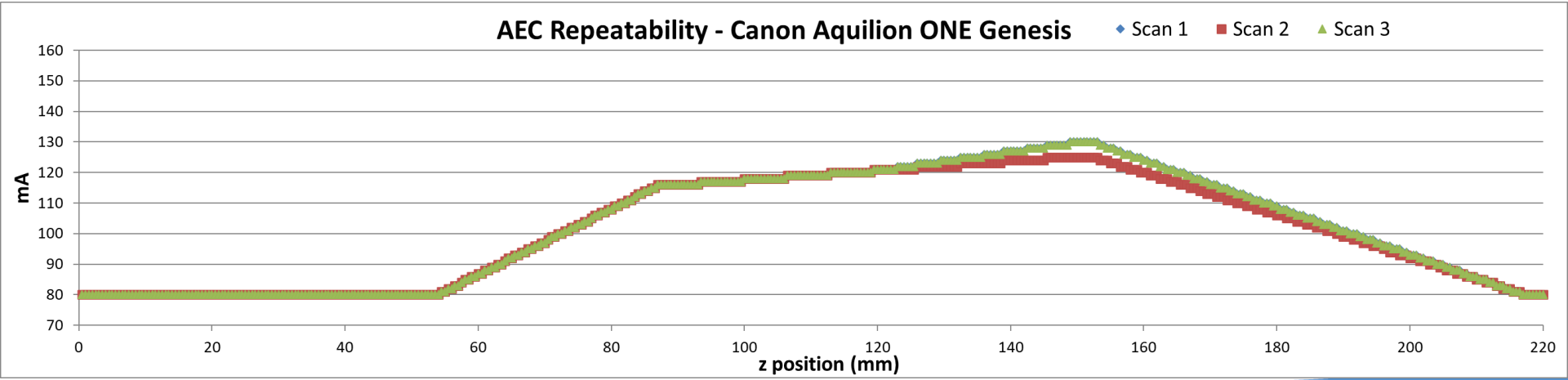




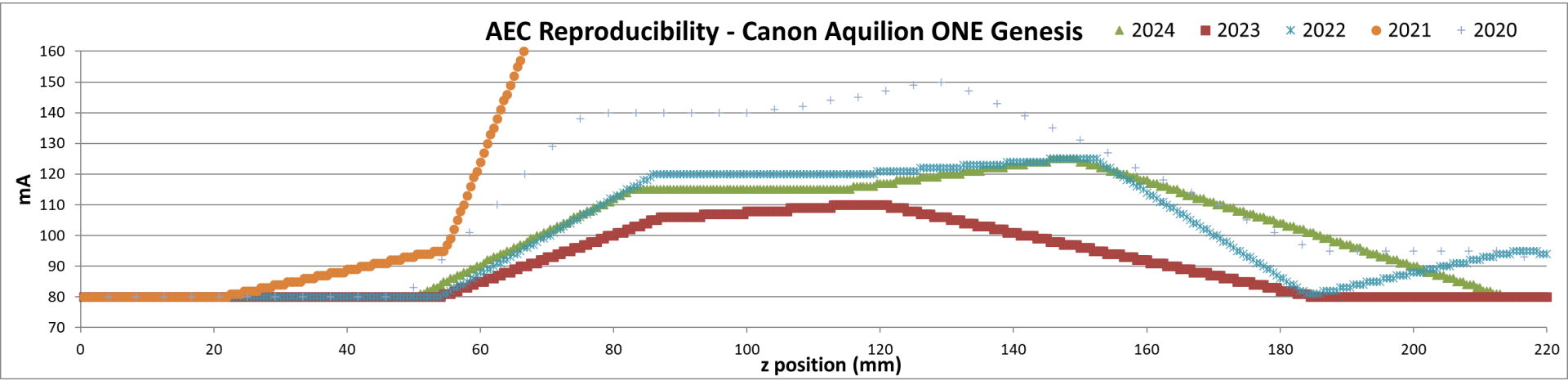
- No improvement in repeatability over the CTDI
- Offered no benefit to visual assessment either

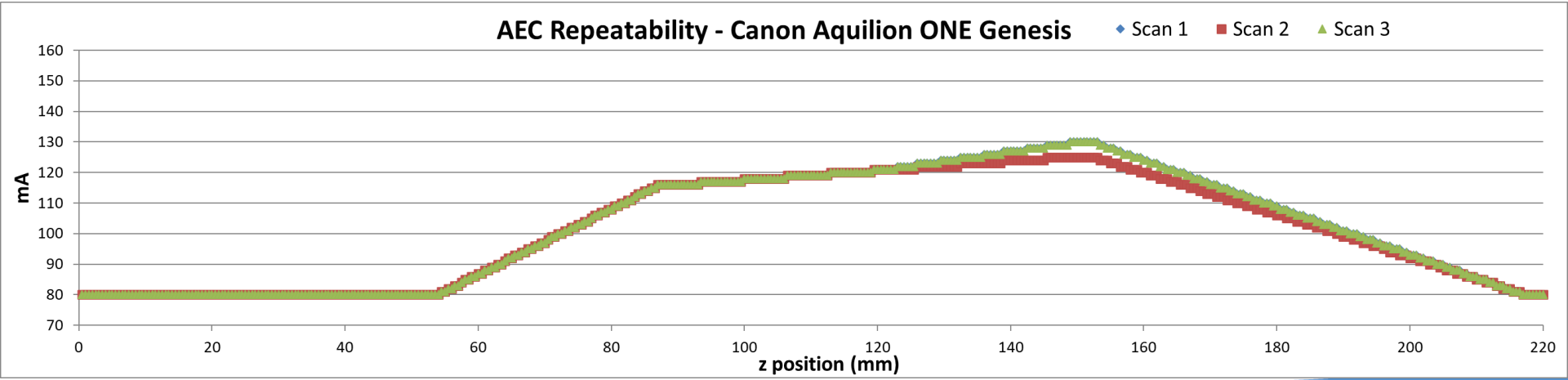
Results – Canon





Results – Canon





Protocols - Canon

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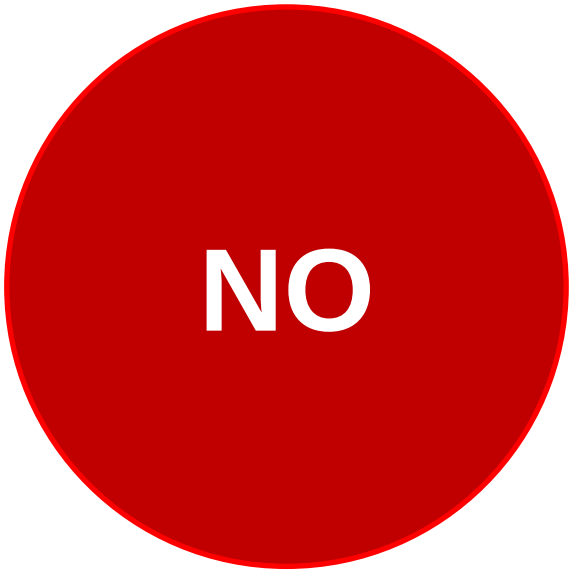
	AEC Baseline Protocol Set 1 Fill out Baselines tab with all planned protocol information and will auto-populate below.
Protocol name	User Abdo Non-contrast
Pitch	0.813
AEC setting	SureEXP 3D, sd=10
kV	120
mA range	80-500
Rotation time (s)	1
Collimation	0.5 x 80
Slice width (mm)	0.5
FOV	320 (M)
Filter (H/B)	M
Scan direction	Craniocaudal
Table height	122
Reconstruction type (i.e recon kernel, iterative, % etc)	XY on, OE off

Time for a vote

- Would you say that the Siemens results were the most reproducible?



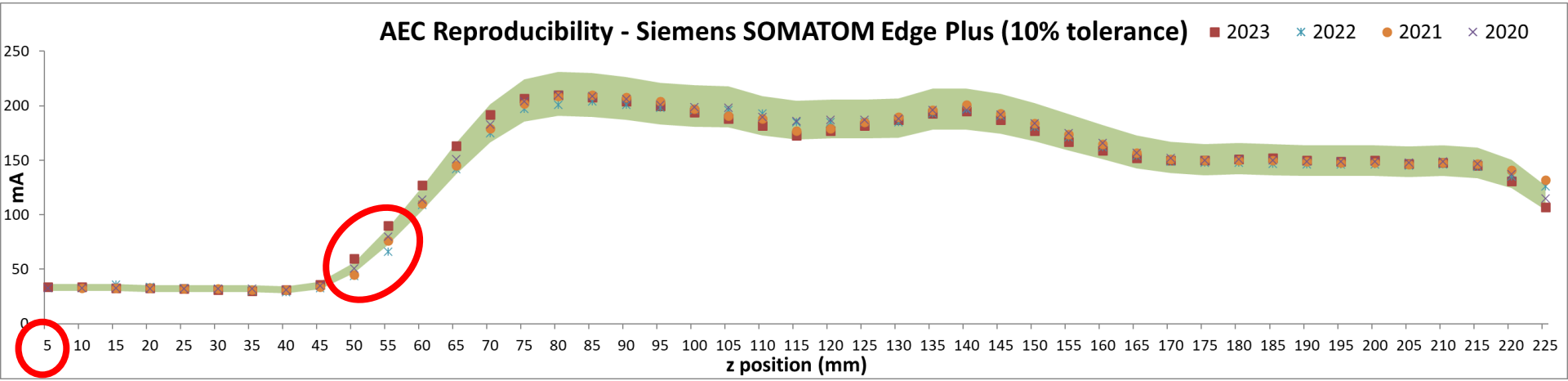
Results – Quantitative

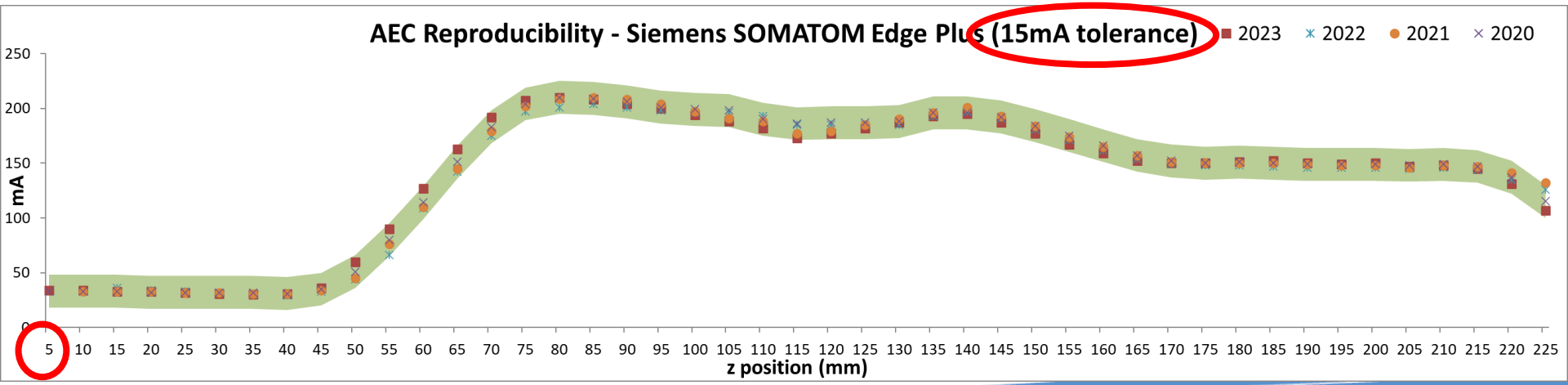
- Maximum variation between 2 individual points from:
  - Anywhere on the graphs
  - Only from points across a plateau

Max Variation	Reproducibility whole curve	Reproducibility plateau	Repeatability whole curve	Repeatability plateau
GE (2021, 2023)	24%	9%	62%	11%
Siemens	42%	8%	29%	5%
Canon (excl. 2021)	23%	12%	5%	5%

- The aim was to derive a tolerance to replace visual check
  - An average variation across whole curve would lead to max variations being out of tolerance

Results – Quantitative





Results – Quantitative

- Percentage tolerance based on the overall reproducibility deviation is too large
  - Based on the deviation across plateaus is too small
- What is a suitable value for a fixed tolerance to encompass entire graph?
- Excel isn't suitable for graphing a tolerance
  - Starts graph at incorrect z position
  - Doesn't work for non integer slice divisions

Results – Quantitative

- What about an R^2 tolerance between the curve and baseline?
  - Less of a visual aid, more of a confirmation

GE

RSQ	2020	2021	2022	2023	2024
2020	1.00				
2021	0.78	1.00			
2022	0.00	0.04	1.00		
2023	0.86	0.98	0.02	1.00	
2024	0.21	0.42	0.64	0.37	1.00

RSQ	1	2	3
1	1.00		
2	0.88	1.00	
3	0.86	0.99	1.00

Siemens

RSQ	2020	2021	2022	2023
2020	1.00			
2021	0.97	1.00		
2022	0.90	0.97	1.00	
2023	0.99	0.99	0.93	1.00

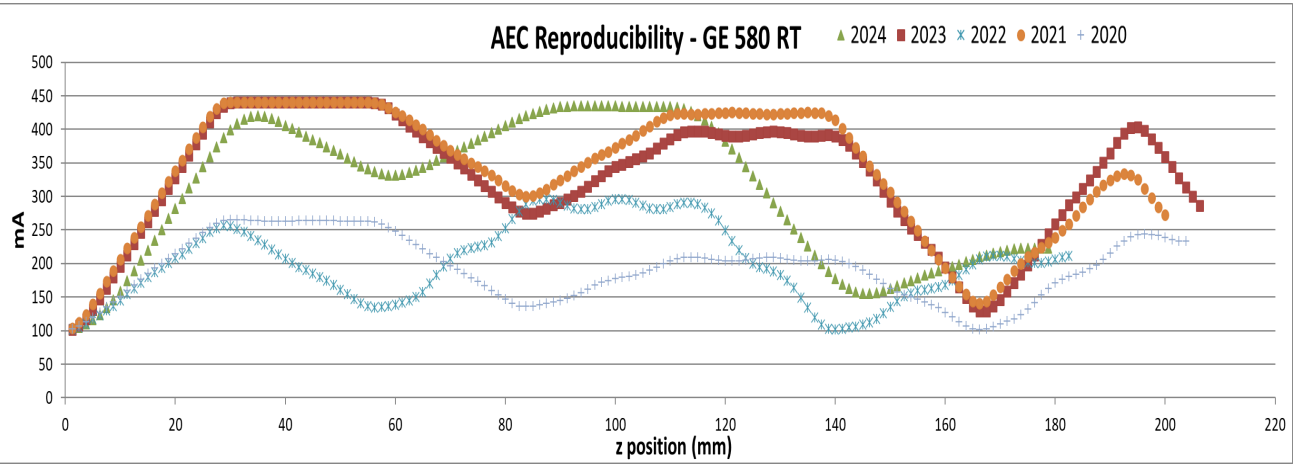
RSQ	1	2	3
1	1.00		
2	1.00	1.00	
3	0.99	0.99	1.00

Canon

RSQ	2021	2022	2023	2024
2021	1.00			
2022	0.89	1.00		
2023	0.84	0.85	1.00	
2024	0.81	0.84	0.72	1.00

RSQ	1	2	3
1	1.00		
2	1.00	1.00	
3	1.00	1.00	1.00

Results – Quantitative



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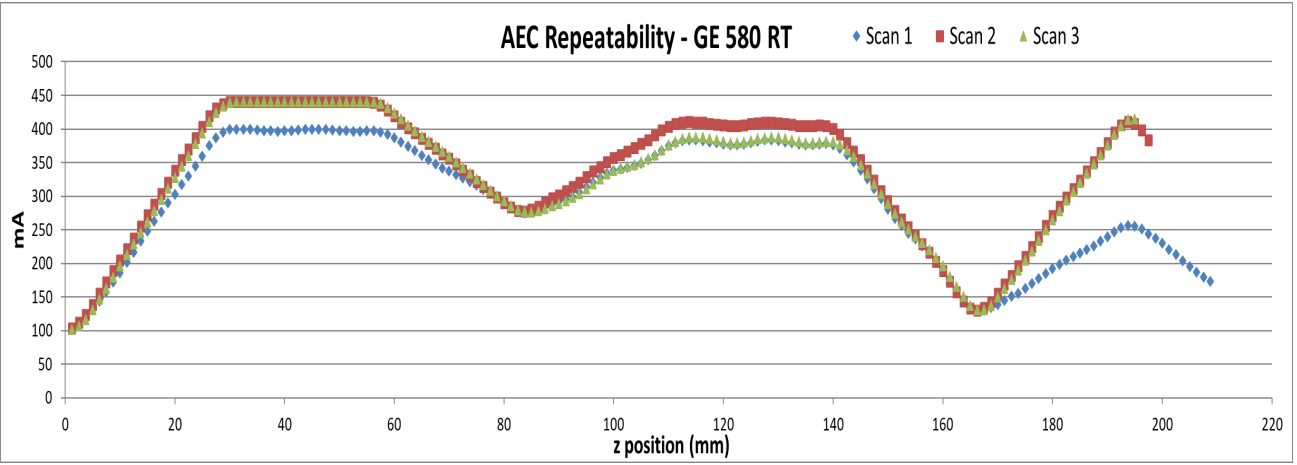

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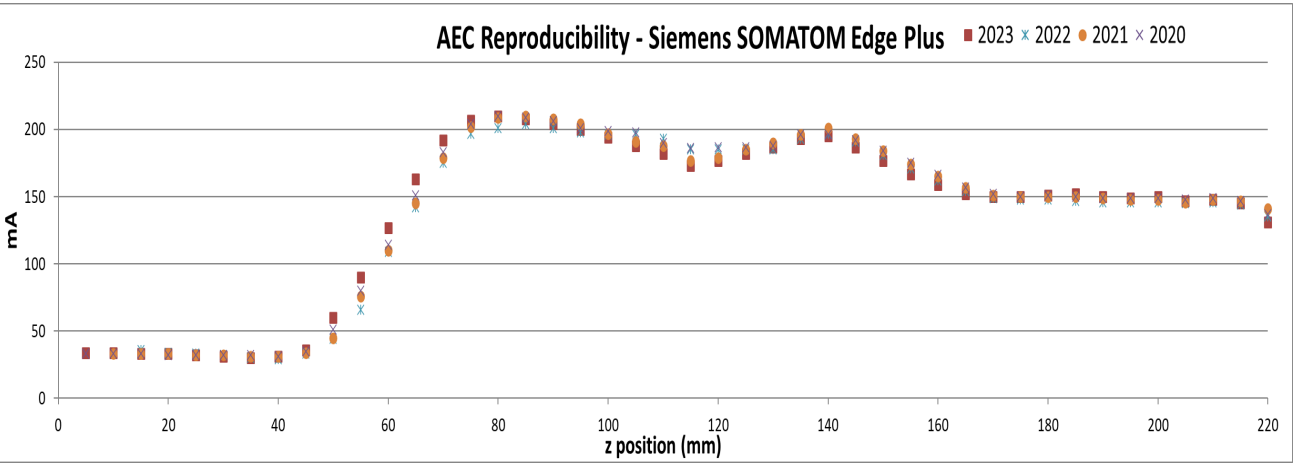
Results – Quantitative



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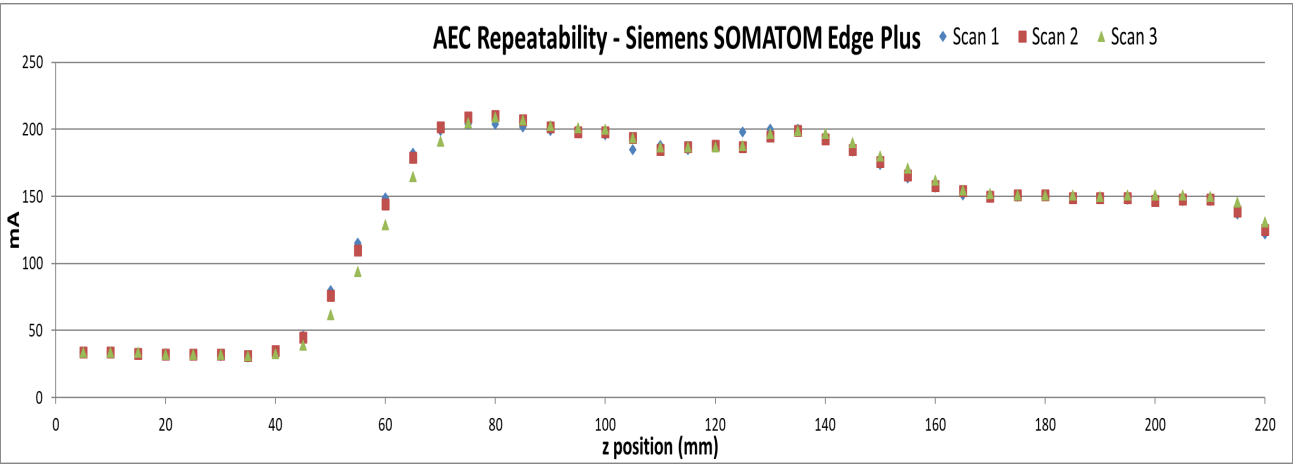

RSQ	1	2	3
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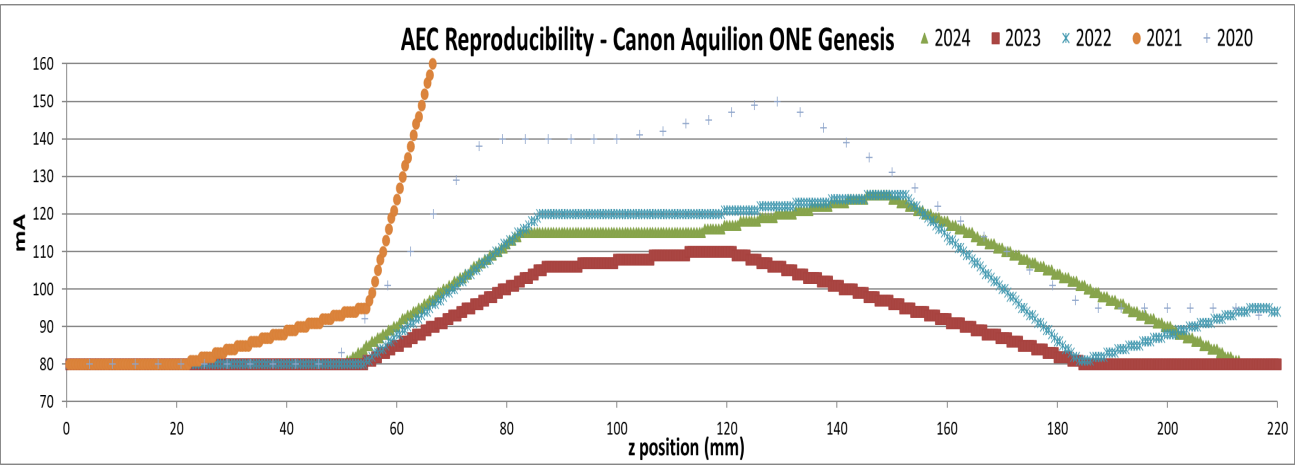
2	1.00	1.00	
3	0.99	0.99	1.00

Results – Quantitative



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2021	1.00			
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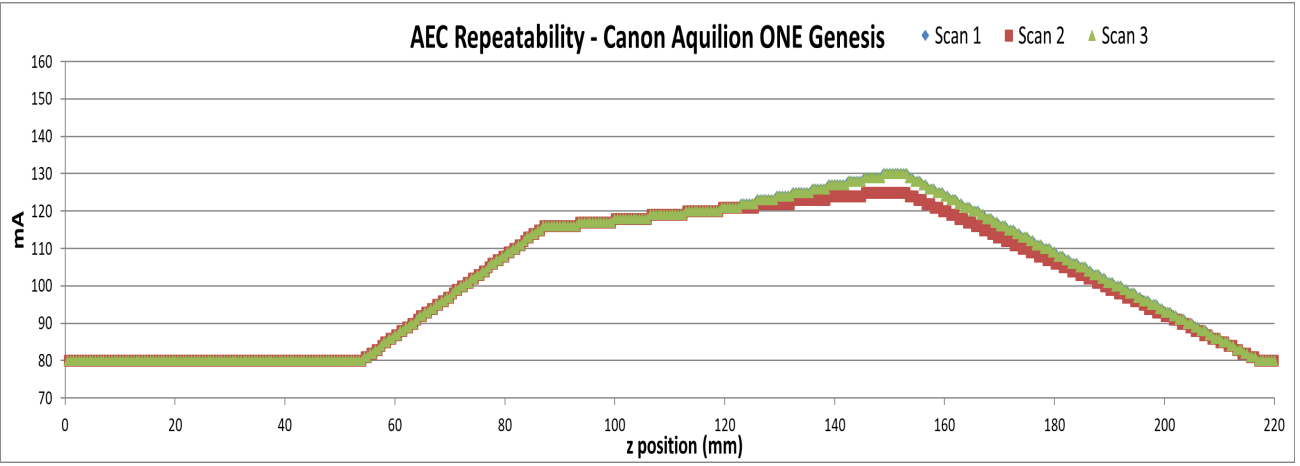
*2020 omitted as less data points



RSQ	1	2	3
1	1.00		
2	1.00	1.00	
3	1.00	1.00	1.00

Results – Quantitative

- R^2 comparison does not aid the visual check
- Nor can it produce a reliable tolerance from repeatability results to provide a confirmation of visual judgement
  - Reproducibility results could potentially be used for a system with reliable reproducibility, but unhelpful at acceptance / without historical data

Conclusions

- Visual assessment is sufficient and simpler than quantitative
- Lungman offers no benefit over the CTDI phantom
- Key criteria can be identified for GE and Siemens:
  - GE: Overall shape should be consistent, mA variations are acceptable across some but not all sections
  - Siemens: Overall shape and mA should be consistent
- Canon requires more work to determine similar guidance criteria
- *We aren't certain on our method however, is anyone doing the same or anything differently?*

Limitations

- Only one scanner of each manufacturer used
- Only one protocol (our baseline protocol) used
- Only mA considered, not noise or CT number
- Did not vary protocol setup to try and identify reasons for historical deviations
  - Suspect larger variations in GE results is from user mistakes
- Have not confirmed whether new / future results match the identified criteria

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Thank you for listening

Questions?

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