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SGRT surveillance during adaptive radiation therapy for prostate cancer

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Disclosure

- Fernanda Macedo received compensation for travel expenses from Vision RT.

Introduction: ART

Account for inter-fractional motion!

Adaptive workflow!

- In-house prostate adaptive workflow combined with SBRT duration of up to 34 minutes (+ beam-on time).

Introduction: Why SGRT?

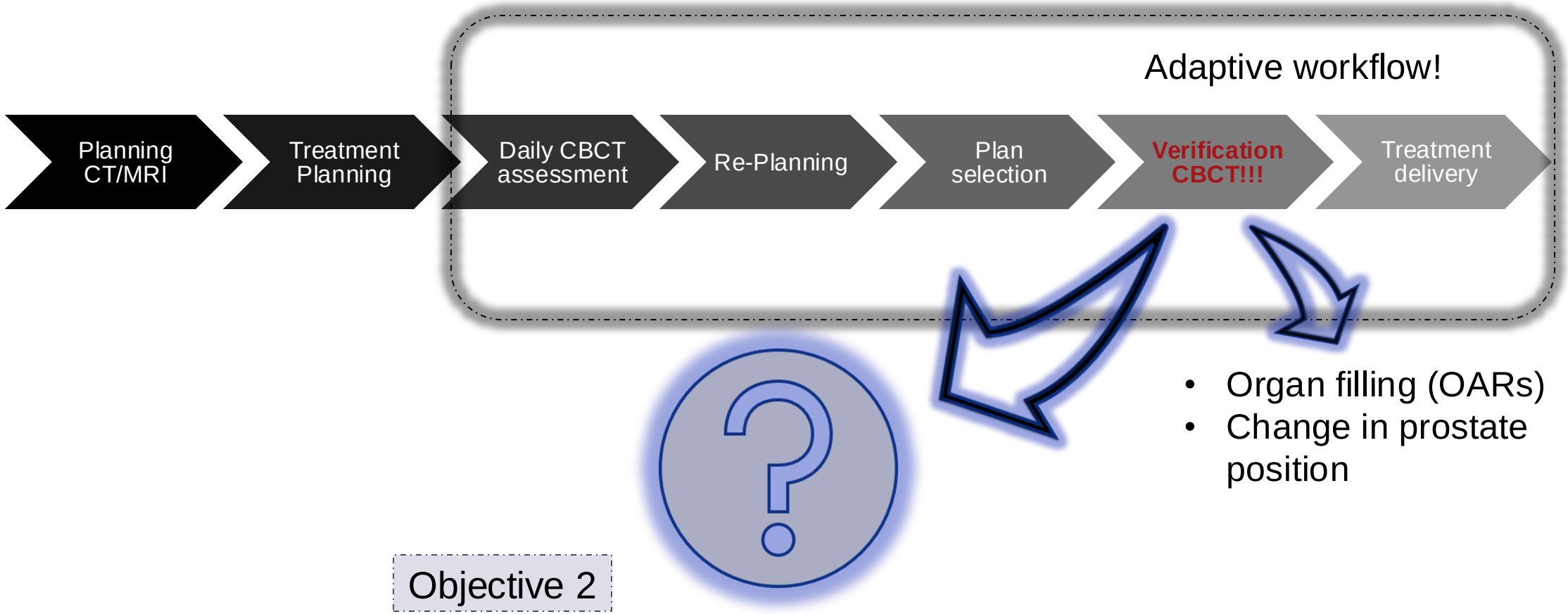
- Reported adaptive workflow duration of 20 minutes (+ beam-on time) [1], [2].
- Reported conventional pelvic RT treatment duration of 15 minutes [3].

Objective 1

Use of SGRT for continuous, dose-free monitoring over longer treatment durations!!

[1] D. N. Stanley *et al.*, "A roadmap for implementation of kV-CBCT online adaptive radiation therapy and initial first year experiences," *J Appl Clin Med Phys*, vol. 24, no. 7, Jul. 2023, doi: 10.1002/acm2.13961.
[2] M. Byrne *et al.*, "Varian ethos online adaptive radiotherapy for prostate cancer: Early results of contouring accuracy, treatment plan quality, and treatment time," *J Appl Clin Med Phys*, vol. 23, no. 1, Jan. 2022, doi: 10.1002/acm2.13479.
[3] Apicella, G., Loi, G., Torrente, S., Crespi, S., Beldì, D., Brambilla, M., & Krengli, M. (2016). Three-dimensional surface imaging for detection of intra-fraction setup variations during radiotherapy of pelvic tumors. *Radiologia Medica*, *121*(10), 805–810. https://doi.org/10.1007/s11547-016-0659-9

Introduction: SGRT vs CBCT



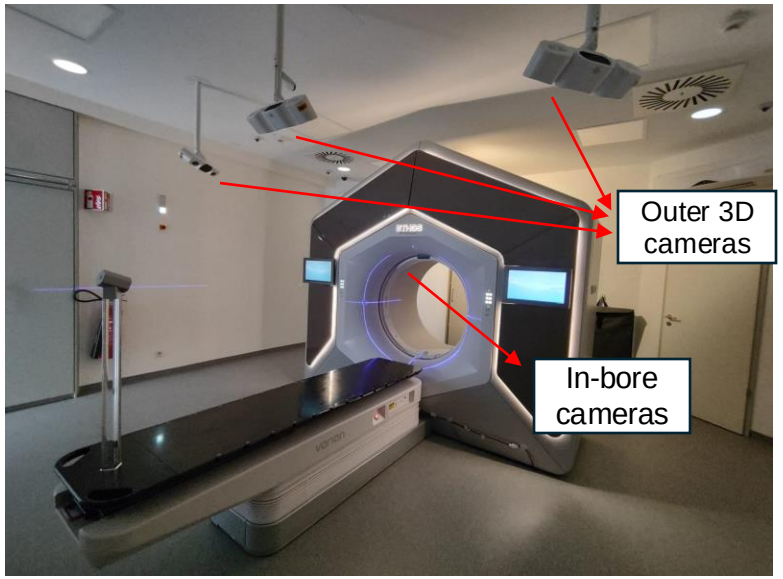
Objective 2

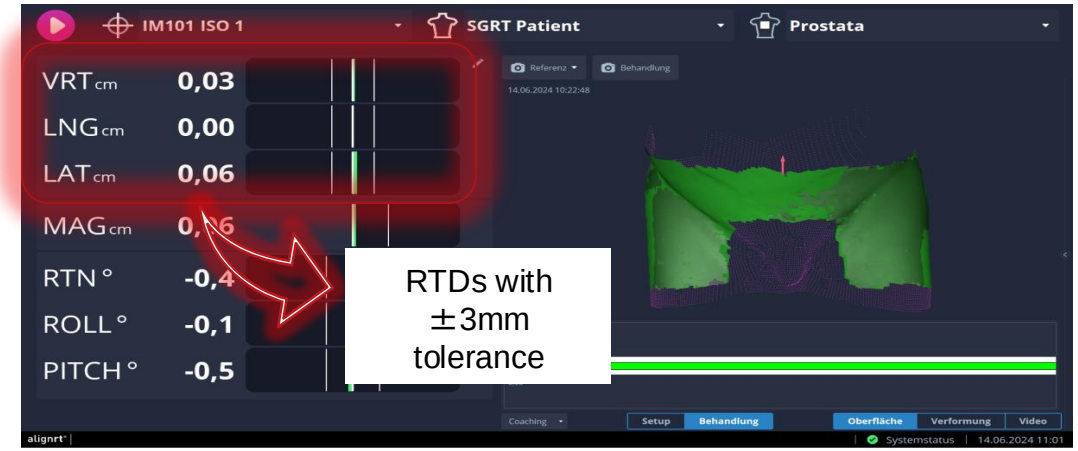
To quantify the relation between surface position detected by SGRT and internal target position as measured by CBCT.

Materials and Methods: Study design

- Retrospective study on 30 ART combined with SBRT prostate cancer patients
  - PACE trial regulations
  - 7.25 Gy/fx in 5 fractions
- 138 treatment fractions

Number of patients	30
Intermediate-risk patients	29
High-risk patients	1
Diagnosis	Malignant neoplasm of prostate
Age	70.4 (55 - 83)
Considered OAR	Bladder
	Rectum
	Urethra
	Penile bulb
	Femoral heads
	Bowel
	Testes





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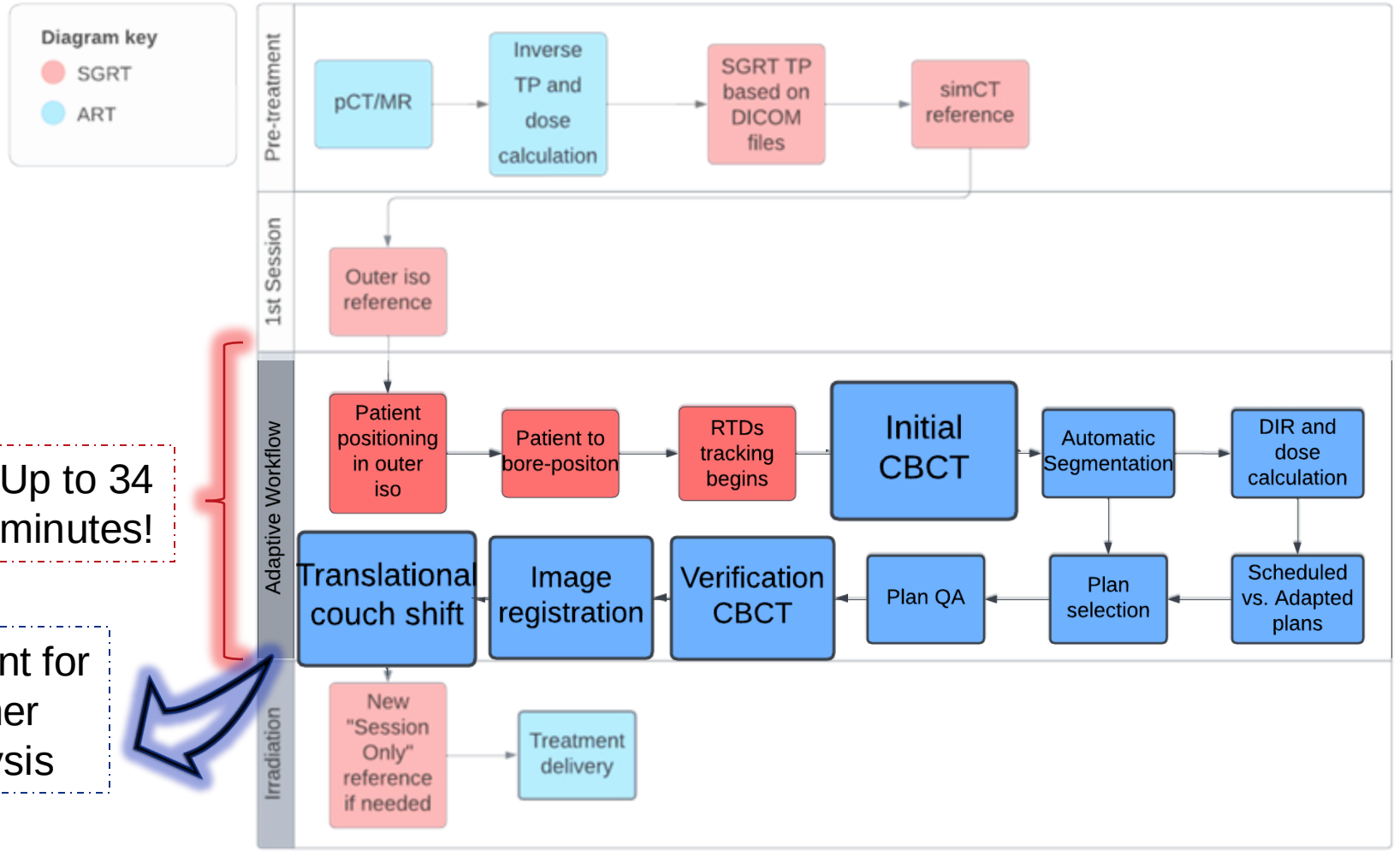
Materials and Methods: ART/SGRT workflow



Up to 34 minutes!

Relevant for further analysis

Mean duration of 44 minutes!

Materials and Methods: Intra-fractional motion analysis

Objective 1

Acquisition and matching

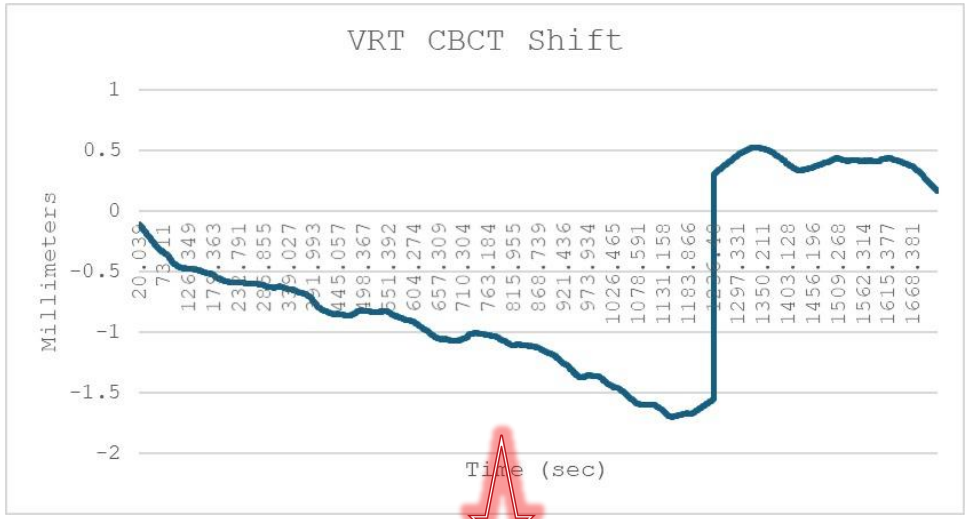
	Date Time (ms)	Elapsed Time(sec)	ROI name	D.MAG(mm)	D.VRT(mm)	D.LNG(mm)	D.LAT(mm)	D.YAW(deg)	D.ROLL(deg)	D.PITCH(deg	Is In Tolerance
19121	14-06-24 10:21:56.261 AM	1912.156	Prostata	2.753087961	-1.780299425	0.877051532	1.908090115	0.366430998	-0.132146358	-0.486903399	1
19122	14-06-24 10:21:56.261 AM	1912.266	Prostata	2.790371081	-1.810575485	0.884208739	1.930326939	0.350930065	-0.094036013	-0.438987046	1
19123	14-06-24 10:21:56.261 AM	1912.414	Prostata	2.822669356	-1.849353194	0.851018012	1.9552809	0.359395176	-0.093108676	-0.420645893	1
19124	14-06-24 10:21:56.261 AM	1912.559	Prostata	2.820413186	-1.88079071	0.742299438	1.966303229	0.376640677	-0.097422585	-0.426120907	1
19125	14-06-24 10:21:56.261 AM	1912.691	Prostata	2.863108649	-1.961844683	0.638602972	1.985130429	0.389848322	-0.100597009	-0.397368163	1
19126	14-06-24 10:21:56.261 AM	1912.776	Prostata	2.893435958	-1.981114745	0.668681562	2.000005245	0.384676754	-0.090091854	-0.374576479	1
19127	14-06-24 10:21:56.261 AM	1912.929	Prostata	2.890783372	-1.999419332	0.598899782	2.000067472	0.421898097	-0.123925507	-0.363238633	1
19128	14-06-24 10:21:56.261 AM	1913.011	Prostata	2.909989438	-2.047328234	0.528254211	1.999358177	0.38981548	-0.08685331	-0.320818245	1
19129	14-06-24 10:21:56.261 AM	1913.138	Prostata	2.93510554	-2.061190128	0.470756471	2.035860538	0.412685066	-0.099035293	-0.331226915	1
19130	14-06-24 10:21:56.261 AM	1913.286	Prostata	2.979635382	-2.095473289	0.438903689	2.072337389	0.426819503	-0.089773223	-0.322498739	1
19131	14-06-24 10:21:56.261 AM	1913.391	Prostata	3.01782445	-2.150826931	0.427808464	2.07320714	0.414775252	-0.088205434	-0.296842366	1
19132	14-06-24 10:21:56.261 AM	1913.539	Prostata	3.003279857	-2.193196535	0.368925869	2.018284559	0.429967016	-0.1205801	-0.313446581	1
19133	14-06-24 10:21:56.261 AM	1913.667	Prostata	3.031257519	-2.196234941	0.316794276	2.06511879	0.422372192	-0.094354413	-0.30646351	1
19134	14-06-24 10:21:56.261 AM	1913.766	Prostata	3.064477521	-2.250311613	0.275628537	2.061831474	0.448391855	-0.118875474	-0.306919098	1
19135	14-06-24 10:21:56.261 AM	1913.864	Prostata	3.053666915	-2.165536404	0.398892105	2.115707636	0.429516166	-0.077149294	-0.265588433	1
19136	14-06-24 10:21:56.261 AM	1914.031	Prostata	3.019776897	-2.195087433	0.368110299	2.04086709	0.43580392	-0.104391389	-0.267870963	1
19137	14-06-24 10:21:56.261 AM	1914.132	Prostata	3.046709868	-2.197986126	0.31021443	2.086879253	0.451691926	-0.109176897	-0.293538719	1
19138	14-06-24 10:21:56.261 AM	1914.233	Prostata	3.05614067	-2.217638254	0.317547768	2.078759193	0.451890141	-0.108490631	-0.296224654	1
19139	14-06-24 10:21:56.261 AM	1914.365	Prostata	3.0620515	-2.214678049	0.39643231	2.077065706	0.429527521	-0.10646043	-0.302049845	1
19140	14-06-24 10:21:56.261 AM	1914.497	Prostata	3.02052739	-2.181098461	0.392129034	2.052469254	0.449057162	-0.116460852	-0.336639822	1
19141	14-06-24 10:21:56.261 AM	1914.612	Prostata	3.039528036	-2.163659334	0.480536401	2.079998493	0.429550678	-0.109334022	-0.340180635	1
19142	14-06-24 10:21:56.261 AM	1914.741	Prostata	3.042861284	-2.158833504	0.515730441	2.081457376	0.416002154	-0.071849577	-0.329340845	1
19143	14-06-24 10:21:56.261 AM	1914.886	Prostata	2.958490223	-2.09756875	0.524785995	2.019274473	0.4132092	-0.090395562	-0.357041597	1
19144	14-06-24 10:21:56.261 AM	1914.989	Prostata	2.766320431	-1.765994072	0.629585624	2.034063816	0.377233952	-0.062351994	-0.346223801	1
19145	14-06-24 10:21:56.261 AM	1915.096	Prostata	2.334782985	-0.86960727	0.624304771	2.074906826	0.429377884	-0.105283983	-0.342242658	1
19146	14-06-24 10:21:56.261 AM	1915.274	Prostata	2.294637038	-0.613473415	0.740855694	2.083300829	0.411416143	-0.104167193	-0.359782428	1
19147	14-06-24 10:21:56.261 AM	1915.432	Prostata	2.199706999	-0.449558973	0.681576192	2.042562485	0.407513231	-0.098587416	-0.336286724	1
19148	14-06-24 10:21:56.261 AM	1915.519	Prostata	2.191524935	-0.372500896	0.62991637	2.065727472	0.414349943	-0.099264964	-0.334408134	1
19149	14-06-24 10:21:56.261 AM	1915.636	Prostata	2.210064651	-0.40052703	0.560309052	2.100004196	0.421160221	-0.102949873	-0.336797267	1
19150	14-06-24 10:21:56.261 AM	1915.8	Prostata	2.185567908	-0.421327651	0.358630776	2.114373207	0.431994528	-0.100781754	-0.328636736	1
19151	14-06-24 10:21:56.261 AM	1915.915	Prostata	2.17372105	-0.460089207	0.013587745	2.124428511	0.428212464	-0.089861862	-0.270936787	1
19152	14-06-24 10:21:56.261 AM	1916.09	Prostata	2.110588045	-0.445186347	-0.089427792	2.061163187	0.41669628	-0.098082572	-0.28834486	1
19153	14-06-24 10:21:56.261 AM	1916.209	Prostata	2.210614389	-0.488318831	-0.341917545	2.128720999	0.440418988	-0.098110169	-0.28387326	1
19154	14-06-24 10:21:56.261 AM	1916.287	Prostata	2.273084617	-0.542249322	-0.452059209	2.160676241	0.450411201	-0.088097386	-0.265464485	1
19155	14-06-24 10:21:56.261 AM	1916.443	Prostata	2.22554173	-0.548324049	-0.445620537	2.110402584	0.447536349	-0.090183683	-0.274104983	1
19156	14-06-24 10:21:56.261 AM	1916.552	Prostata	2.060087881	-0.595477343	-0.443211108	1.921700478	0.460299611	-0.079599284	-0.262919277	1
19157	14-06-24 10:21:56.261 AM	1916.639	Prostata	1.510957044	-0.647472501	-0.673272014	1.187634349	0.612868309	-0.110377789	-0.266329646	1

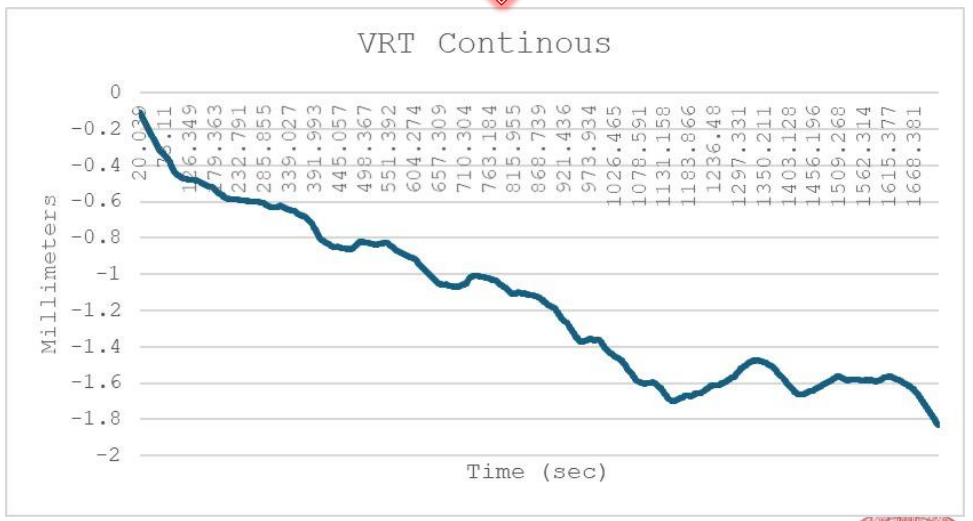
Materials and Methods: Intra-fractional motion analysis

Objective 1

Acquisition and matching

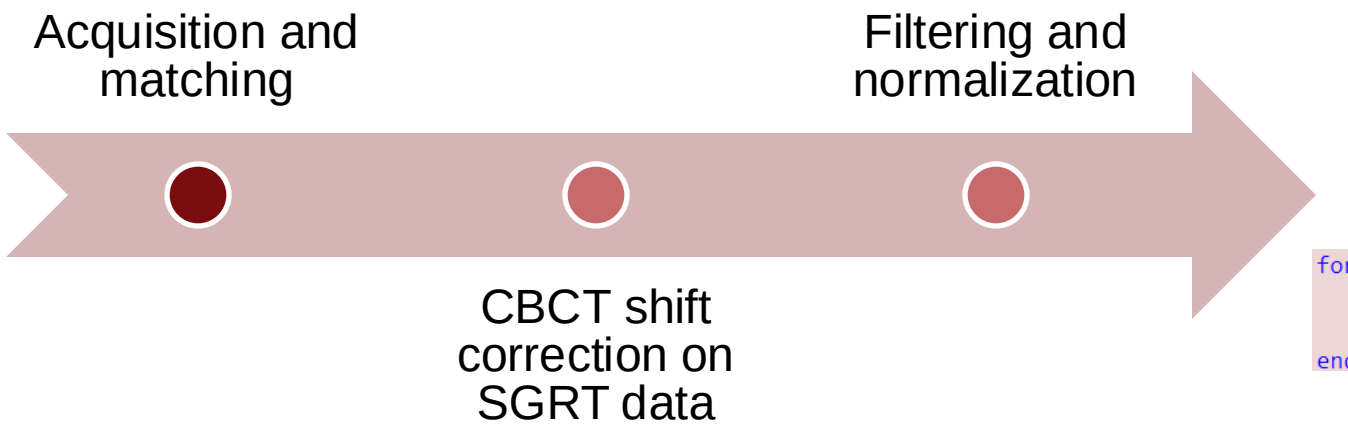
CBCT shift correction on SGRT data





Materials and Methods: Intra-fractional motion analysis

Objective 1

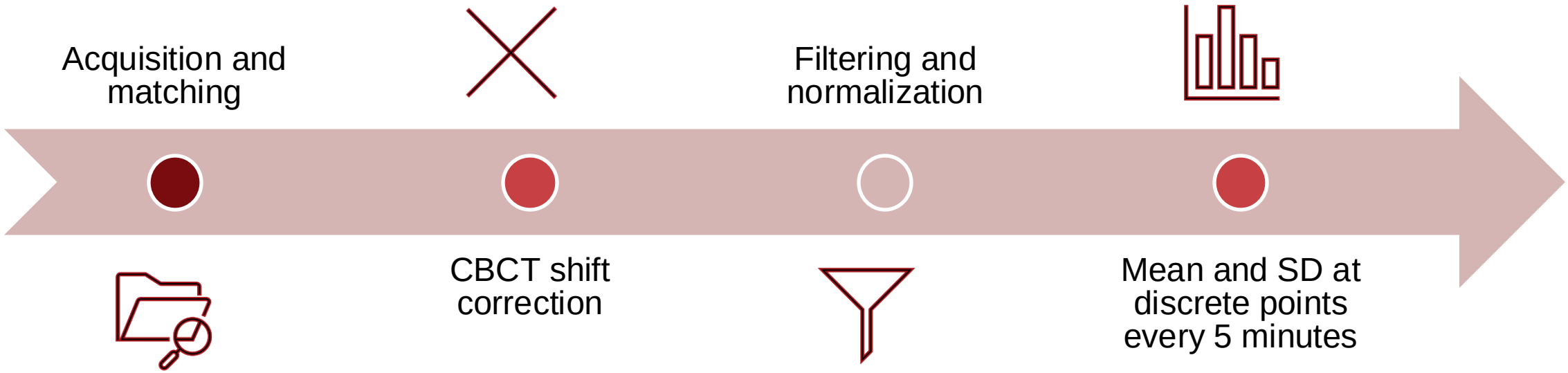



```
% Define parameters for SGolay filtering
windowSize = 951;  % Choose an appropriate window size
polynomialDegree = 1;  % Choose an appropriate polynomial degree
```

```
for col = columnsToPlot
    % Apply SGolay filtering to each column except the first one (time variable)
    smoothedData(:, col) = sgolayfilt(data(:, col), polynomialDegree, windowSize);
end
```

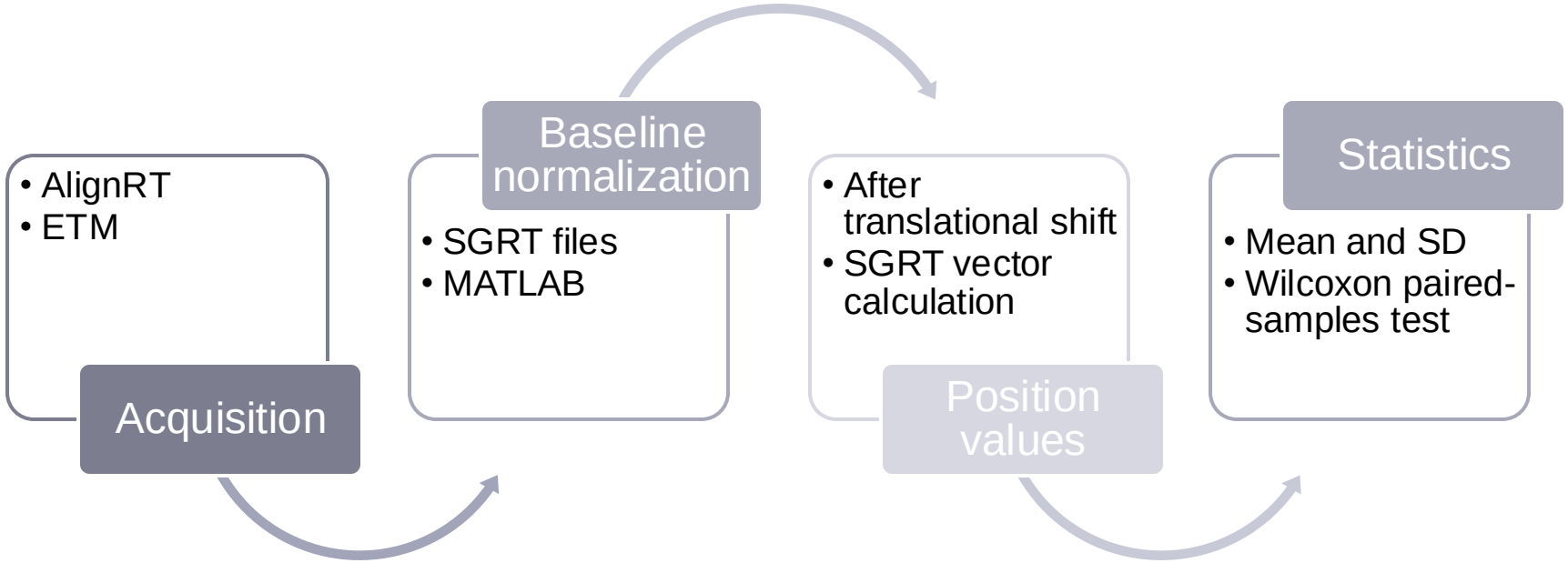
Materials and Methods: Intra-fractional motion analysis

Objective 1



Materials and Methods: Surface-tumor position correlation

Objective 2

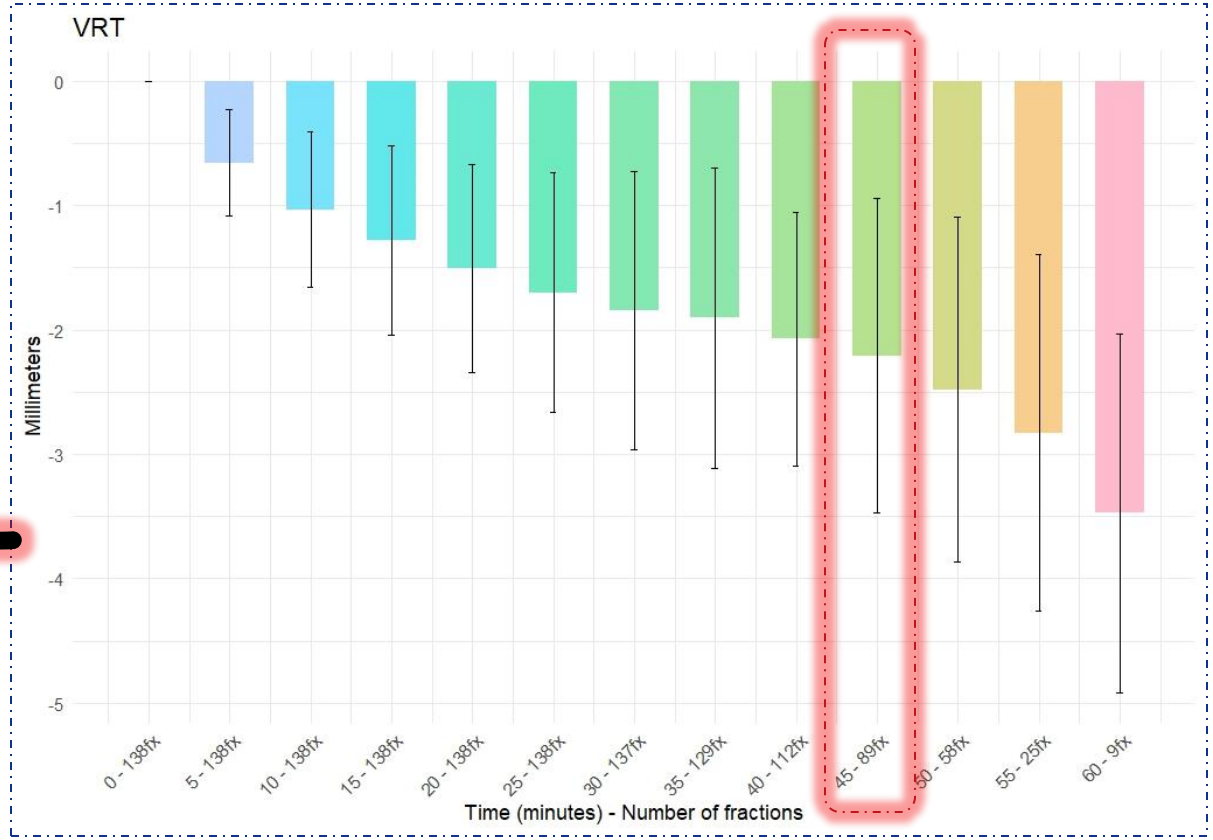


- Measure surface position after translational shift
- Compare the applied couch shift to detected surface motion

Results and Discussion: Intra-fractional motion analysis

Objective 1

Behavior due to physical stress and relaxation

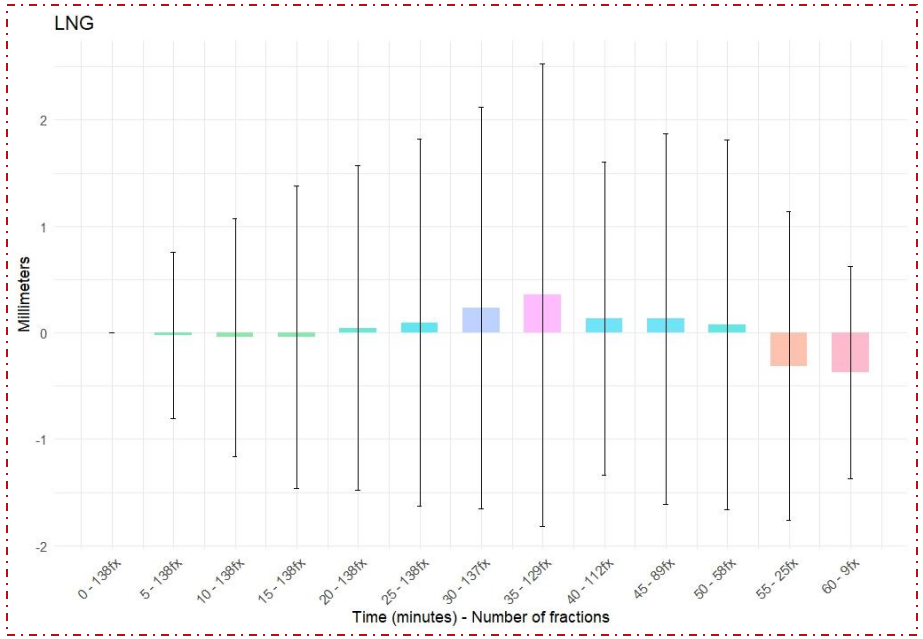


- Supporting patient relaxation without medication is complex.
- How long does the relaxation process last?

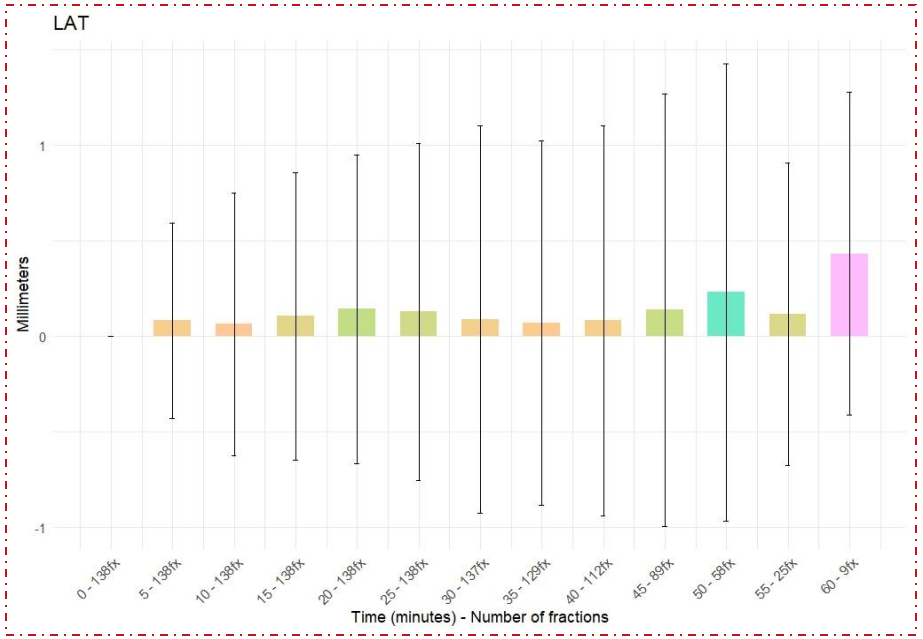
Mean (mm)	SD (mm)	Time stamp
-2.21	±1.27	45 minutes

Results and Discussion: Intra-fractional motion analysis

Objective 1



Mean (mm)	SD (mm)	Time stamp
0.36	±2.17	35 minutes



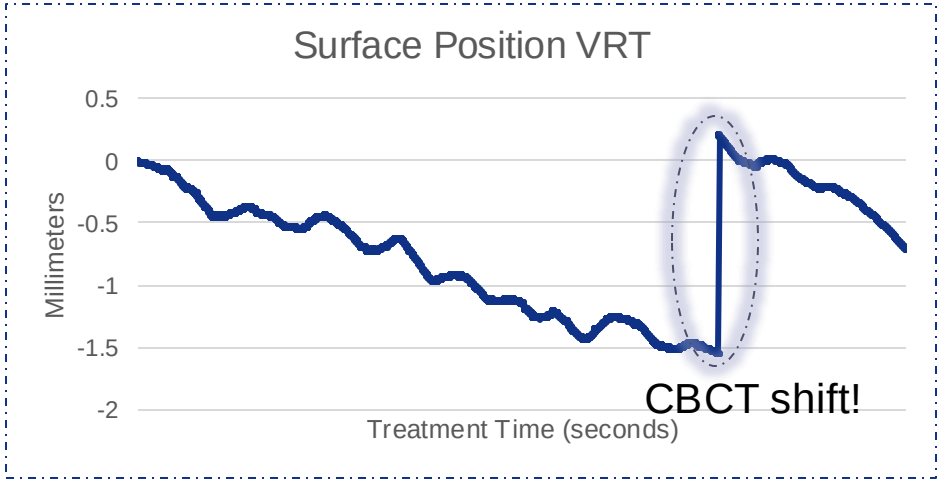
Mean (mm)	SD (mm)	Time stamp
0.14	±1.13	45 minutes

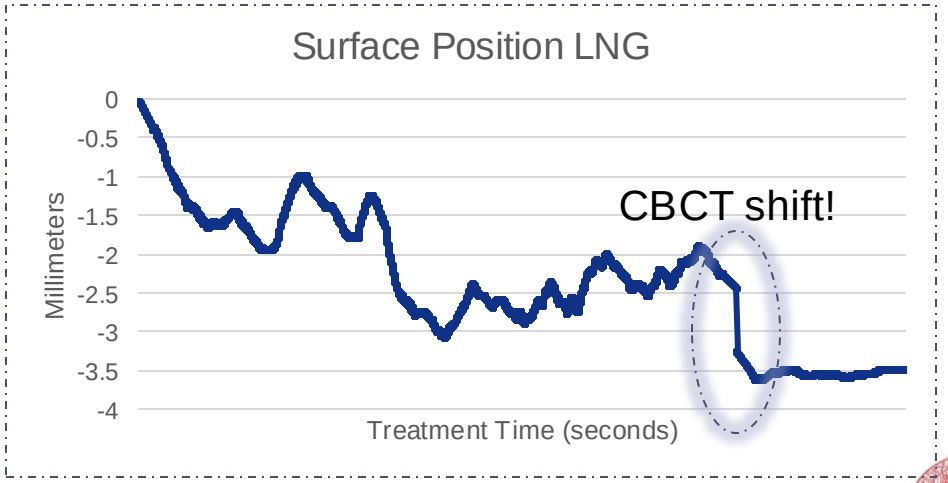
Results and Discussion: Surface-Tumor position correlation and statistics

Objective 2

	VRT	LNG	LAT
Mean (±SD) (mm)	-0.66±1.42	-0.24±1.62	0.05±0.86
Range (mm)	**8.3**	**10.02**	6.08
Wilcoxon Test result	p-value: 3.626e-4	p-value: 1.122e-6	p-value: 0.7586

- Surface position not accountable for internal prostate variability!





Conclusions

Findings

- Objective 1: VRT surface drop over the ENTIRE ART treatment duration.

- Objective 2: SGRT not accountable for internal prostate position due to WIDE RANGES in:
  - VRT
  - LNG

Implications for practice

- Recommendation:
  - Verification CBCT should remain a mandatory step to ensure correct patient positioning during conventional RT and ART.

Thank you

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