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# A PIPELINE FROM MRI 4D FLOW SEQUENCE TO NUMERICAL SIMULATION

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## INTRODUCTION

- Purpose:** Assess **patient-specific hemodynamic factors** to facilitate the growth diagnosis of intracranial aneurysms.
- Materials:** Siemens Skyra 3T, **4D Flow sequence:** dynamic extension of Phase Contrast sequence, 3D flow encoding.
- Methods:** The sequence was initially developed for large vessels, and **has to be optimised** for intracranial arteries. The optimisation is driven by tests with a vascular phantom and a pump.

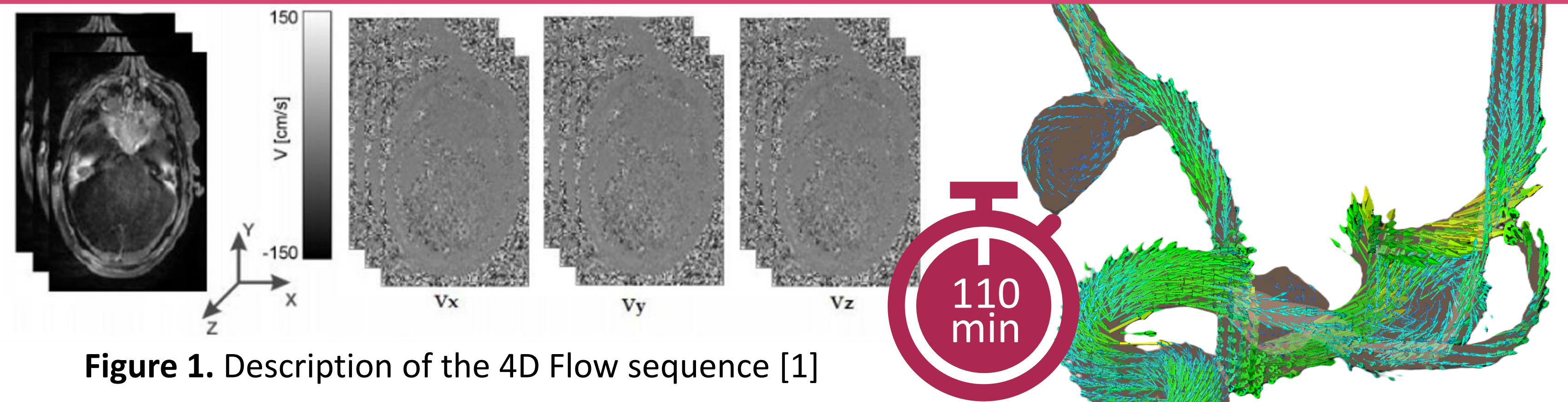


Figure 1. Description of the 4D Flow sequence [1]

## OPTIMISED PARAMETERS

### ACCELERATION FACTOR $\div 2.9$

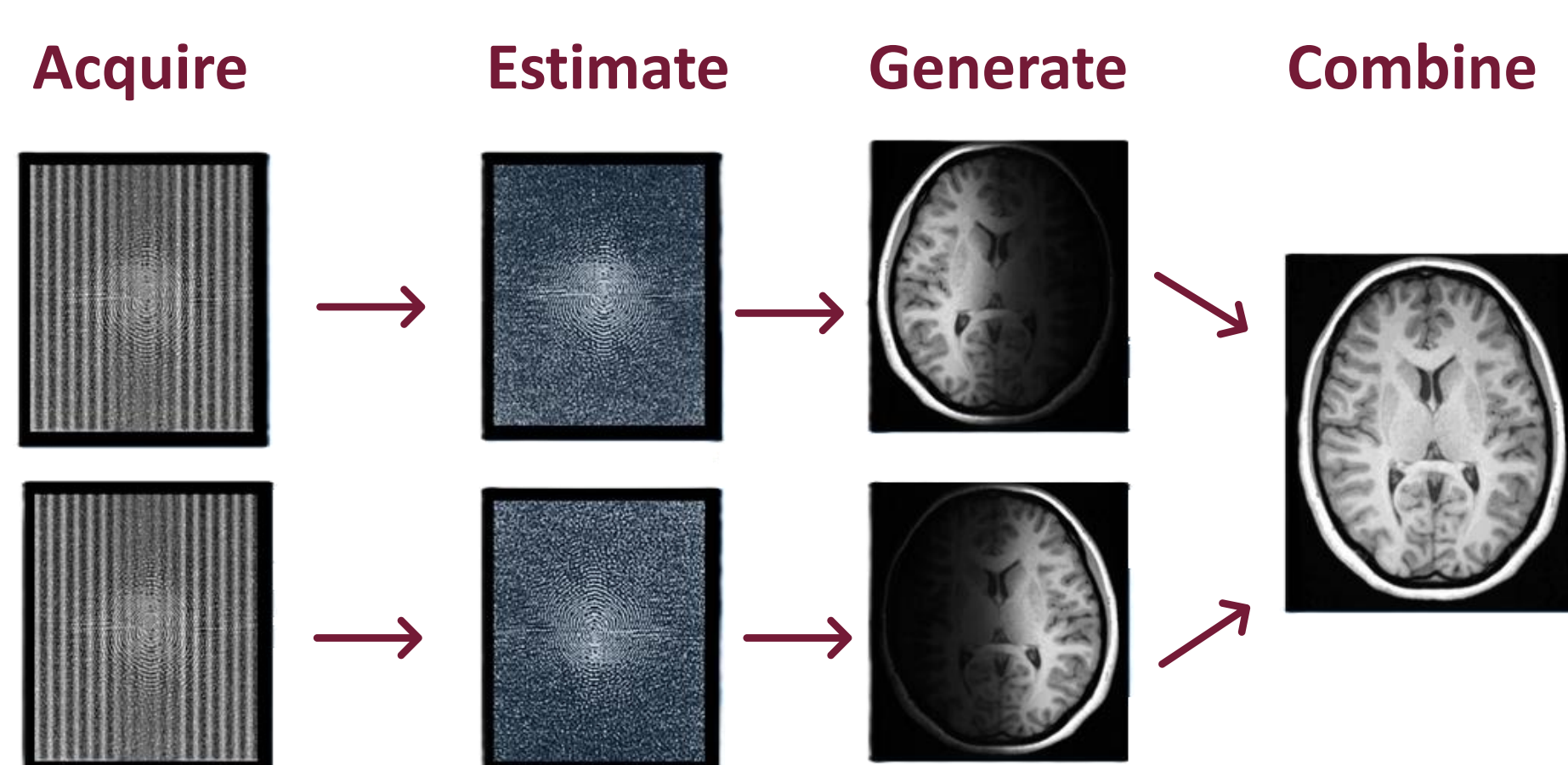


Figure 2. GRAPPA 2 Separated technique [2]

	GPA2	GPA3	GPA4	GPA5	GPA6	GPA7	GPA8
Ref	0.98	0.95	0.81	0.53	0.42	0.41	0.43

Figure 3. Correlation factors between reference and GRAPPA sequences

### PHASE RESOLUTION $\div 2.5$

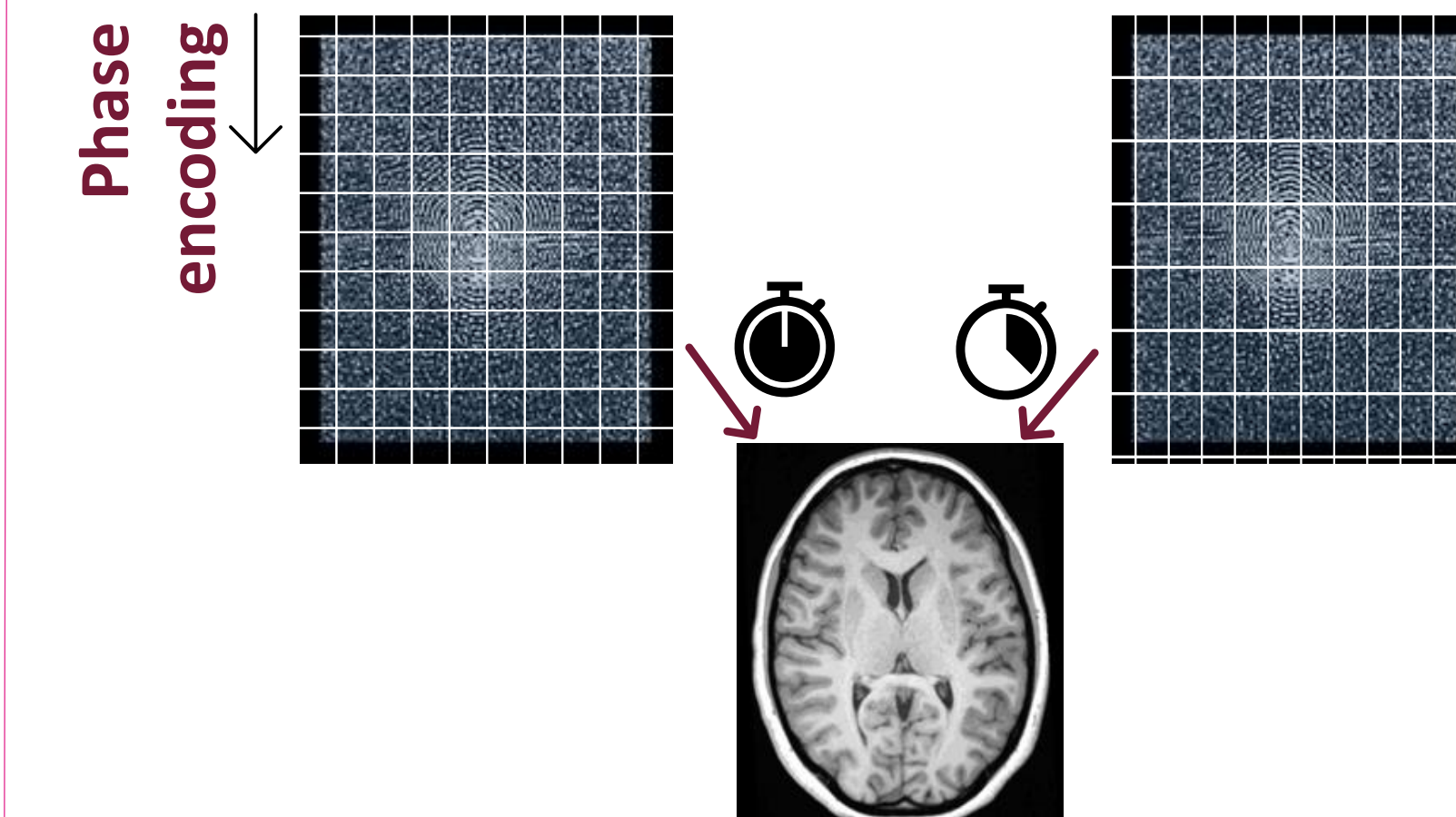
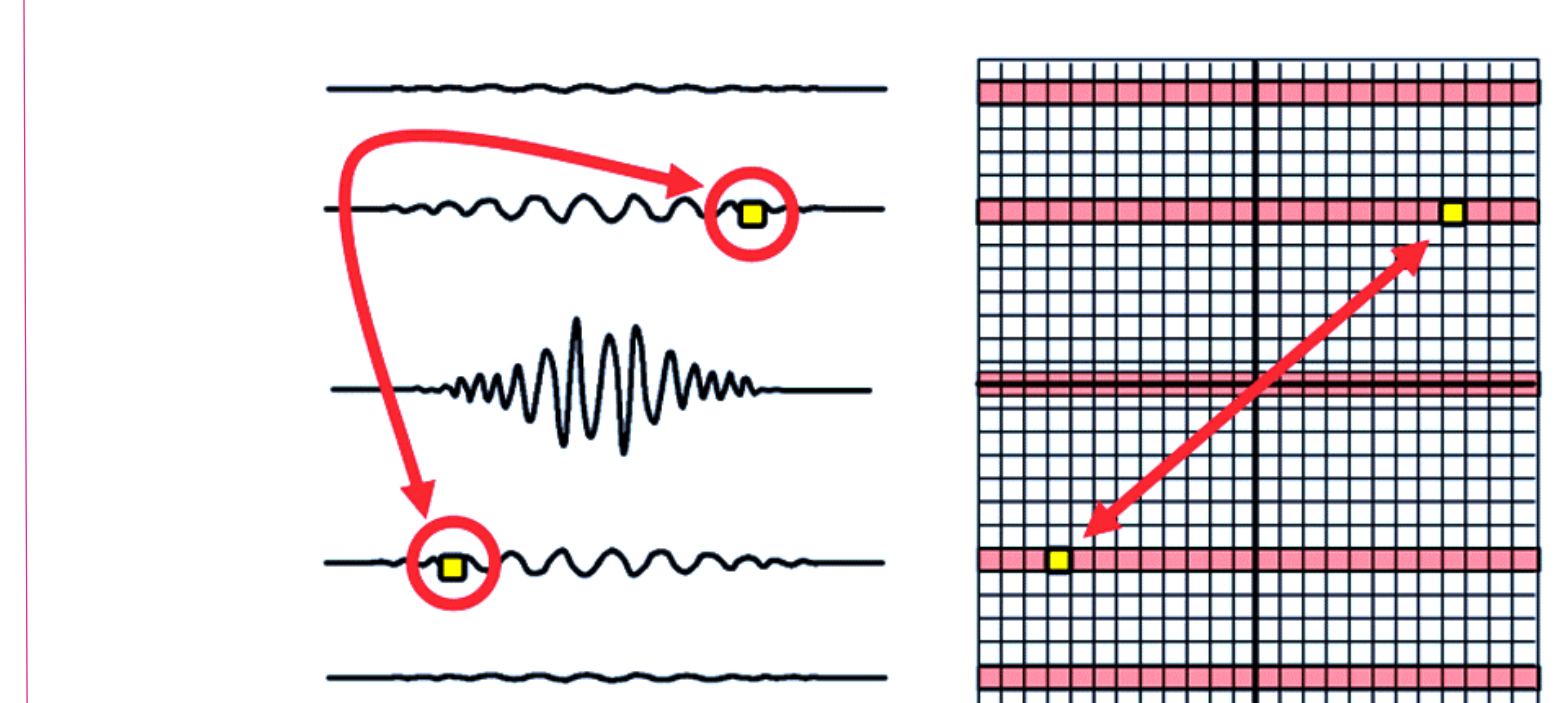


Figure 4. Phase Resolution technique [2]

	PR90%	PR80%	PR70%	PR60%	PR50%	PR40%	PR20%
Ref	0.99	0.99	0.99	0.99	0.98	0.97	0.92

Figure 5. Correlation factors between reference and Phase resolution sequences

### PARTIAL FOURIER $\div 1.8$



Mirror images across the origin of k-space have identical amplitudes but opposite phases

	Phase	Slice	Phase & Slice
Ref	PF 7/8	PF 6/8	PF 7/8
	PF 6/8	PF 7/8	PF 6/8

Figure 7. Correlation factors between reference and Partial Fourier sequences

## DISCUSSION AND CONCLUSION

- Other optimised parameters:
  - 50% Slice resolution** with a **0.98** correlation factor (reduction by 2 times)
  - Use of the **PreAcq Normalize** machine filter for **better segmentation** that does not change the correlation factors
- Sequence optimised by **24.6 times** with a **0.88** total correlation factor
- Same threshold used for each segmentation
- Use of a rigid phantom
- First tries on **patients** led to a **7min30s** sequence

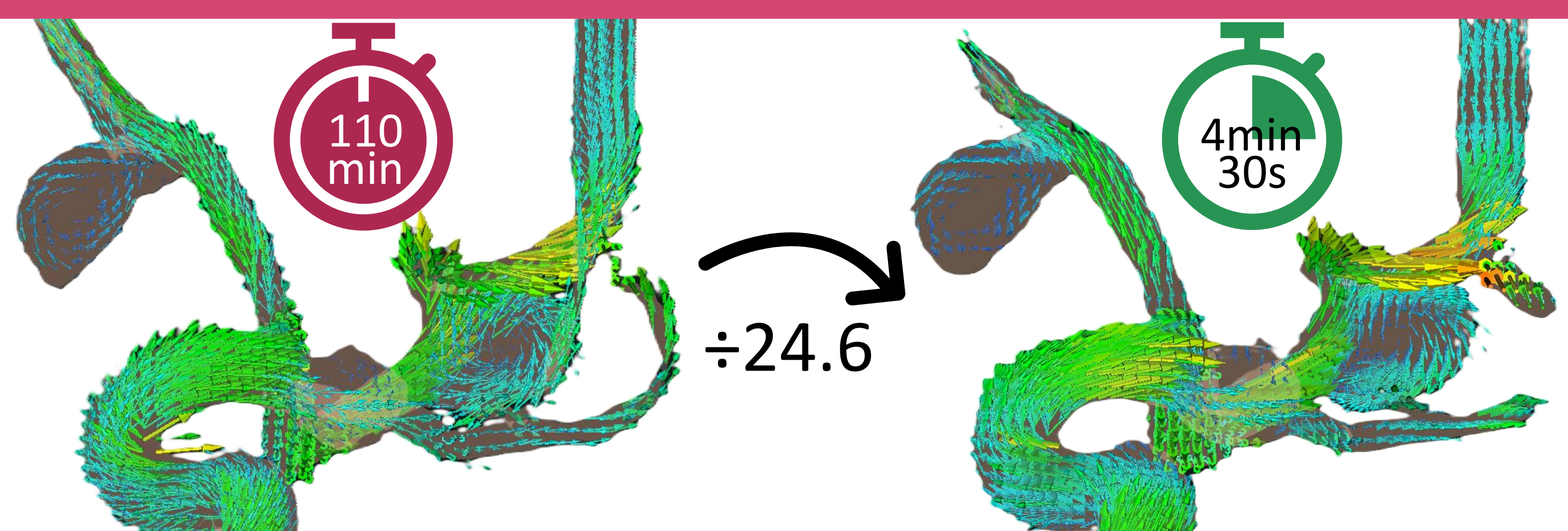


Figure 8. Visualisation of the reference and optimised sequence

## PERSPECTIVES

- Comparison between the 4D flow sequence and the Computational Fluid Dynamics (CFD)** gold standard for biomarkers of aneurysm evolution [3]
- Generation of a **realistic simulation** of blood flow

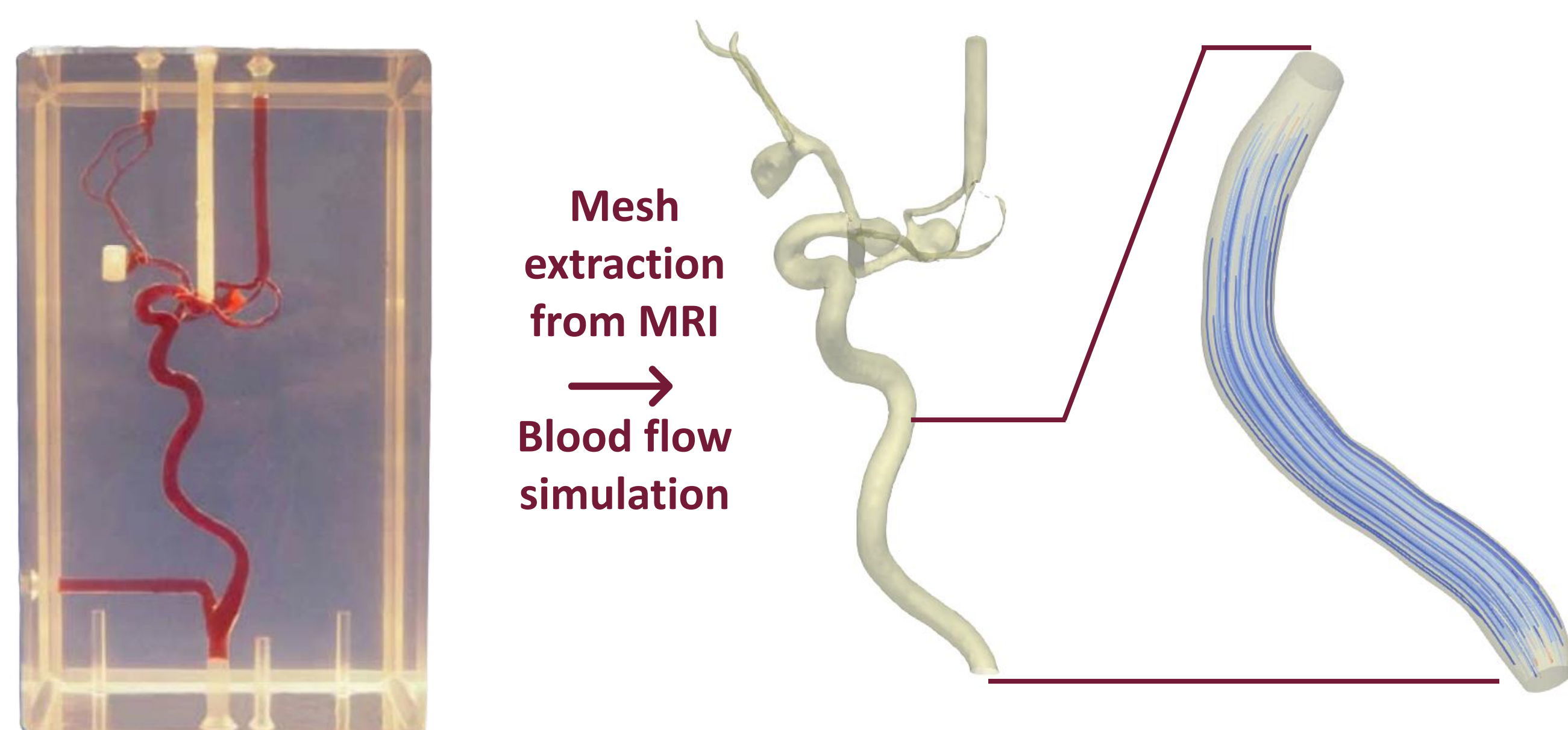


Figure 9. Description of the 4D Flow-CFD pipeline

- Use of the pipeline on healthy patients** and then on pathological patients to extract biomarkers of aneurysm evolution.

## REFERENCES

- [1] M. Tamraoui, "Visualisation 4D des images médicales". Tech. Rep. 2019.
- [2] A. D. Elster. "Questions and answers in MRI." <https://mriquestions.com/> (accessed Sept. 4, 2024).
- [3] S. Salmon, M. Thiriet, and J.-F. Gerbeau, "Medical image - based computational model of pulsatile flow in saccular aneurysms", *ESAIM Math. Model. Numer. Anal.*, vol. 37, no. 4, pp. 663-679, 2003.

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