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# 3T MRI 4D flow sequence acquisition time reduction on a vascular phantom

**E. Fontaine** (1,2), N. Passat (1), S. Salmon (2), A. Mendes-Carreira (3), C. Portefaix (1,3)

(1) CRESTIC, Université de Reims Champagne-Ardenne, Reims, France (2) LMR - UMR 9008 (CNRS), Université de Reims Champagne-Ardenne, Reims, France  
(3) CHU Reims, Service de Neuroradiologie Maison Blanche, F-51100 Reims, France



# Clinical context



Saccular Aneurysm



Ruptured Aneurysm

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## Cerebral Aneurysms

- **Local dilation of a cerebral artery**
- Formation of a **blood-filled aneurysmal sac under pressure**
- **Risk of rupture**, leading to **intracranial hemorrhage**
- Possible **ischemic complications** (vasospasm, stroke)

## Key Statistics

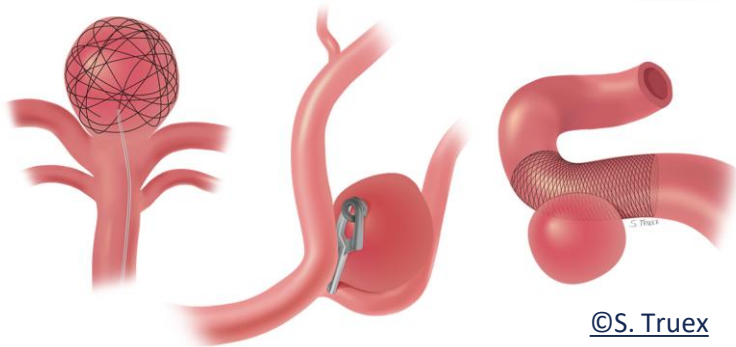
- **Prevalence:** 5% of the population affected
- **Mortality:** 60% within 3 months post-rupture

## Risk Factors

- **Exogenous:** Hypertension, age, ethnicity, smoking
- **Endogenous:** Size and location of the aneurysm

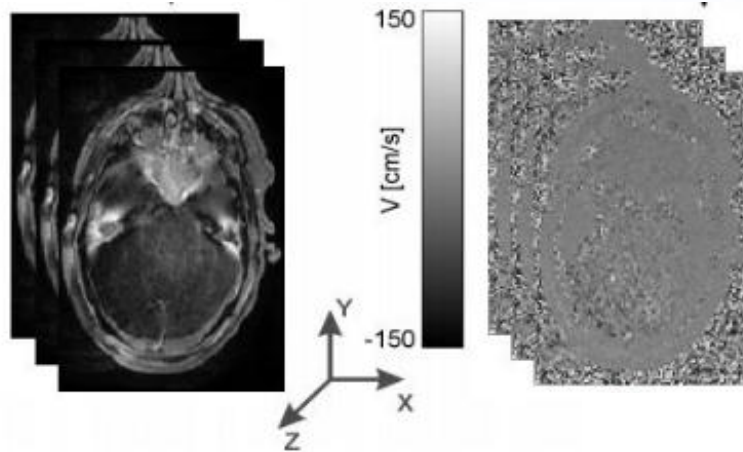
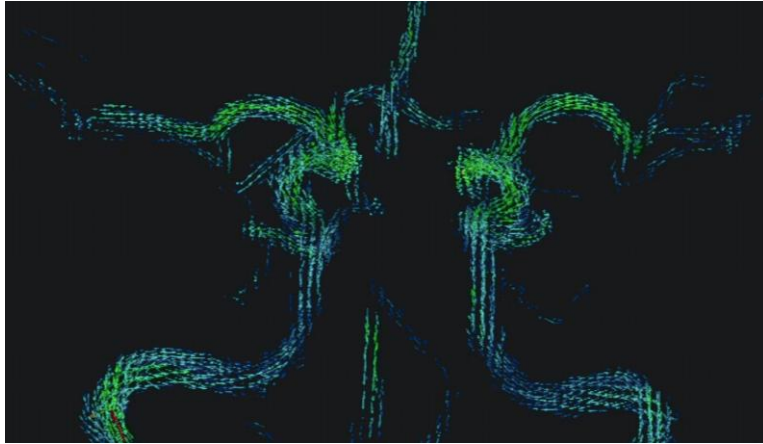
## Treatment Options

- **Surgical:** Neurosurgery
- **Minimally Invasive:** Endovascular intervention





# MRI for aneurysm detection



## Detection of aneurysms

- Conventional reference: **arteriography** (invasive, X-ray based, requires anesthesia and operating room)
- **MRI as a non-invasive alternative** using magnetic fields (non-irradiating)

## MRI 4D flow sequence

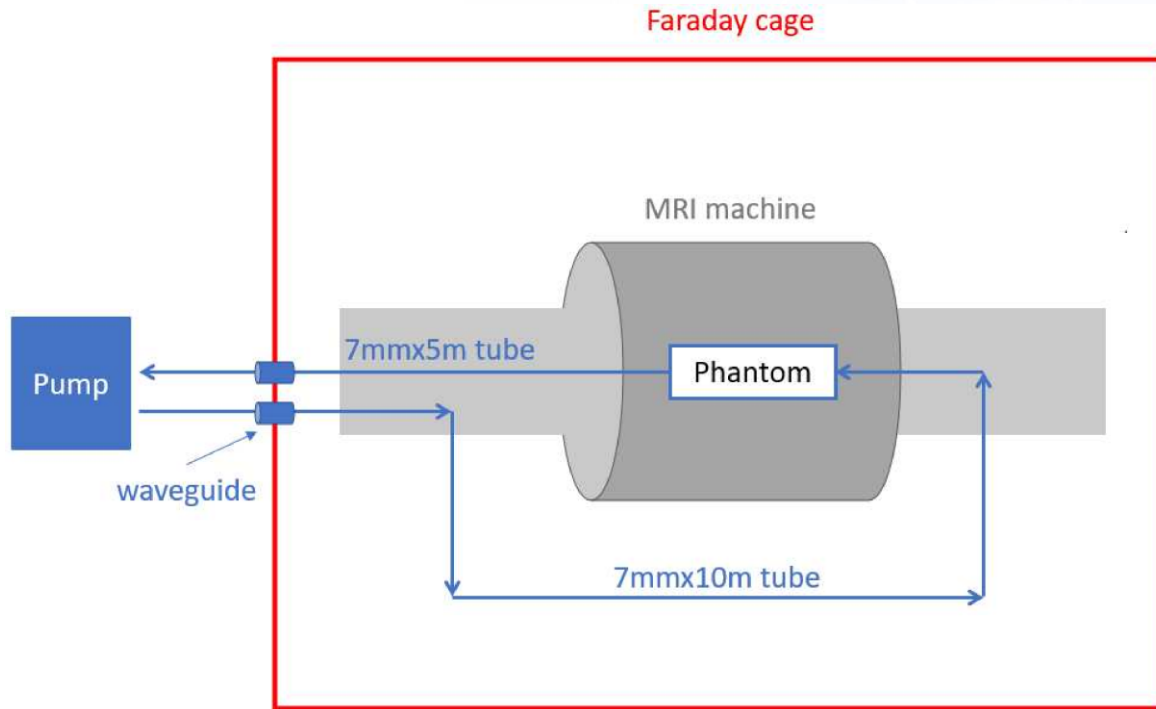
- **4D = 3D spatial + temporal dimension**
- Combines **morphological imaging** (anatomy) and **functional imaging** (blood flow) with three velocity components measured in each spatial direction ( $x, y, z$ )
- **Velocity encoding**: The phase shift of proton spins is proportional to blood flow velocity  $\Delta\phi = \gamma v G t^2$

## Applications

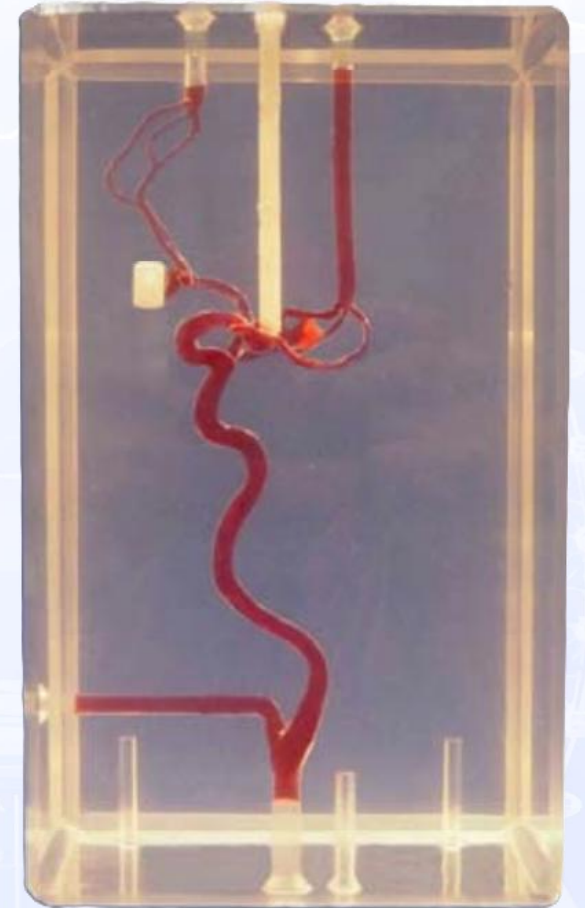
- Assessing the **risk of rupture in cerebral aneurysms**
- Detection of **hemodynamic anomalies** (turbulence, stagnation zones)
- Analyzing **vascular malformations** (stenoses, fistulas)



# MRI experiments materials



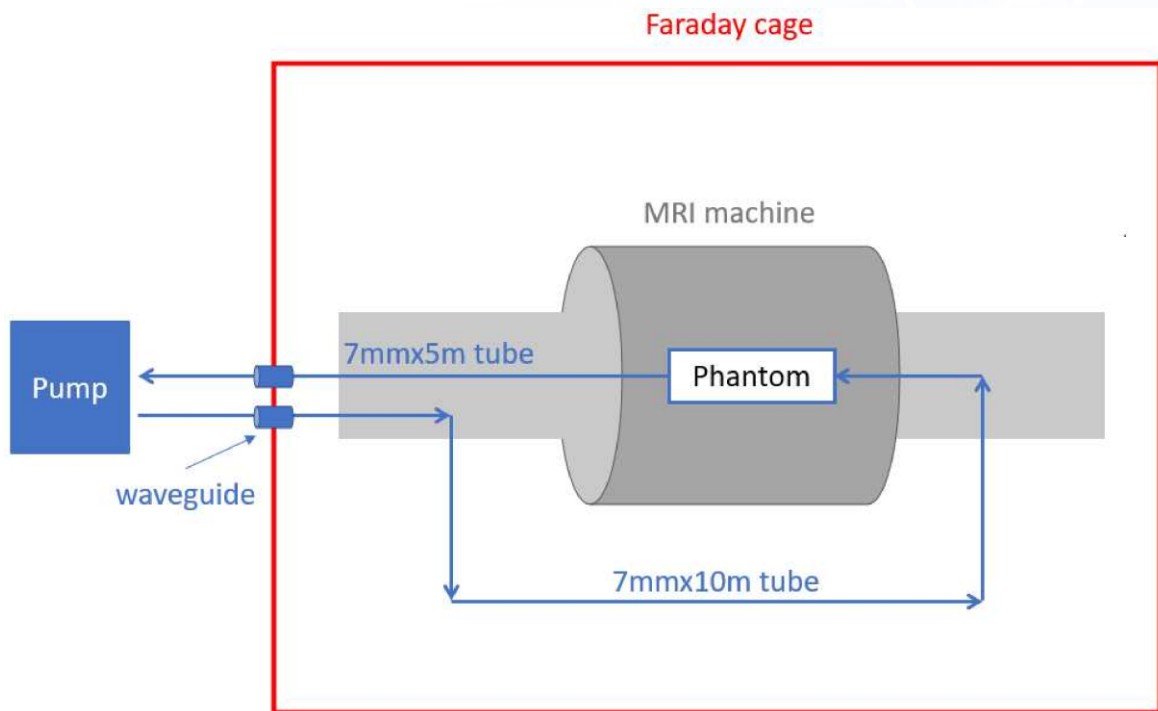
- **Realistic vascular geometry**
- **Vascular phantom:** A silicone model based on real patient geometry, featuring **three aneurysms**.
- **Consistent geometry** enables reliable and repeatable testing in MRI.



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# MRI experiments materials



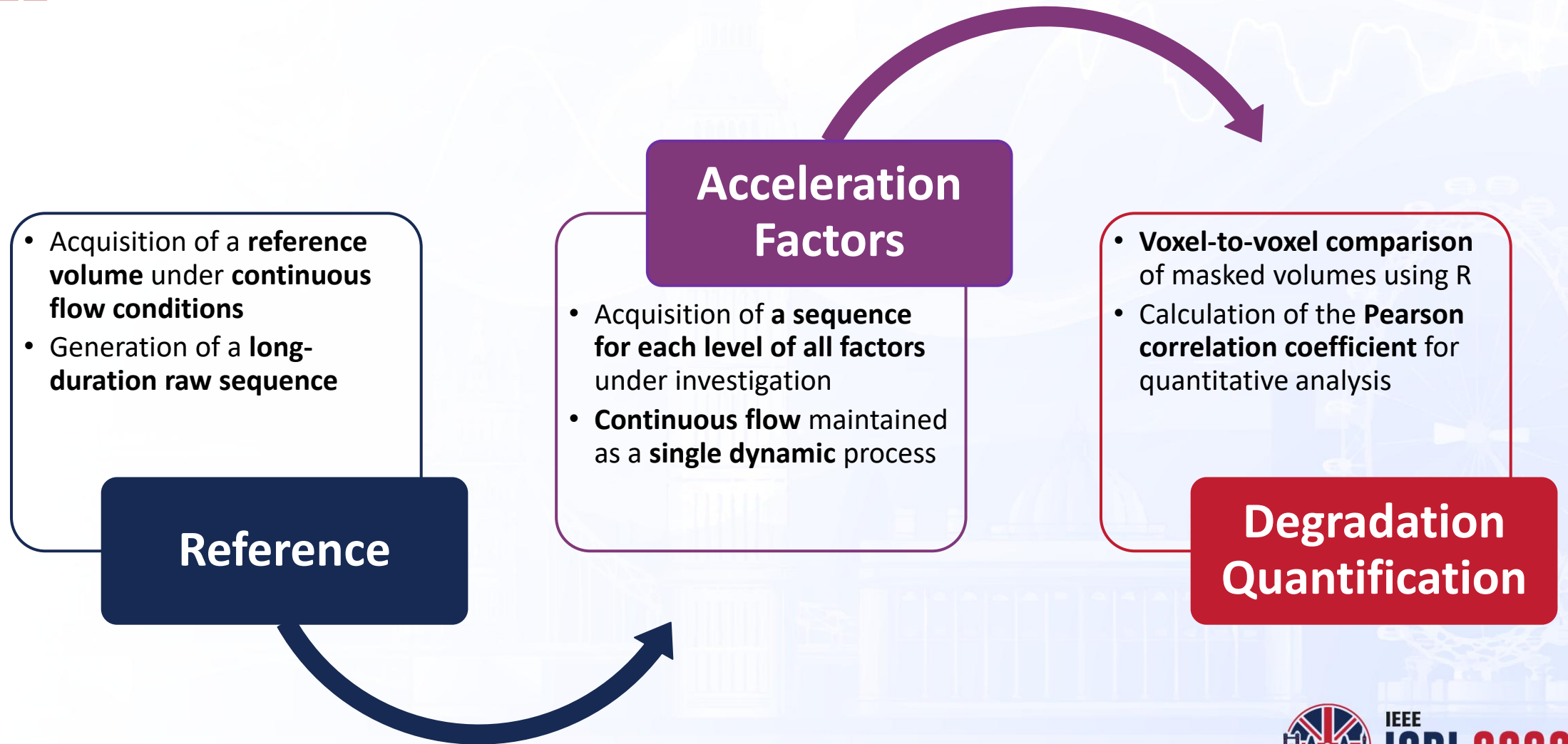
- The pump is **not MRI-compatible**
- Relocated **outside the MRI room**
- Connected to the phantom via **7-mm-diameter tubes and waveguides (total length: 15 meters)**
- Provides a **continuous flow of 1,500 mL per minute**



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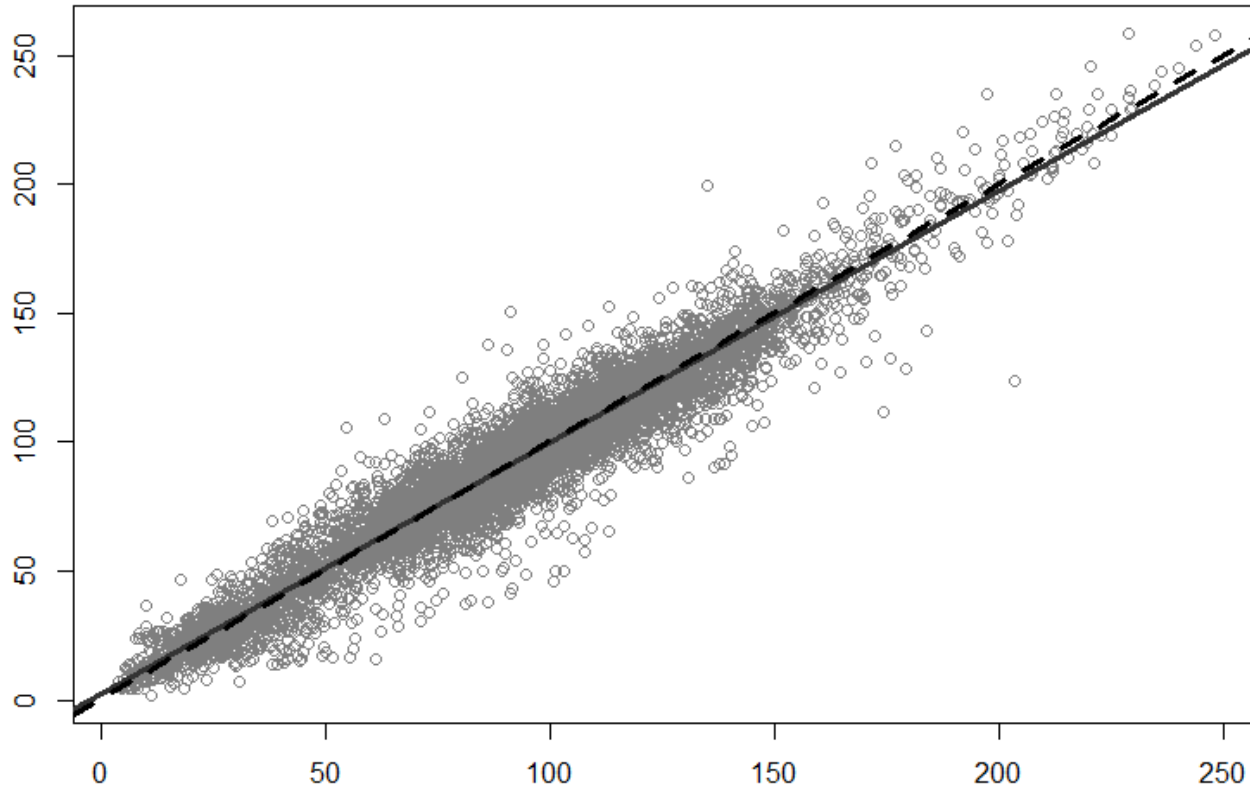


# MRI 4D flow sequence time optimization





# Comparison of two identical sequences



	Median	Mean	Std
Reference	60.75	61.95	15.29
2 <sup>nd</sup> flow	60.41	61.75	15.13
Difference	-0.19	-0.20	2.90

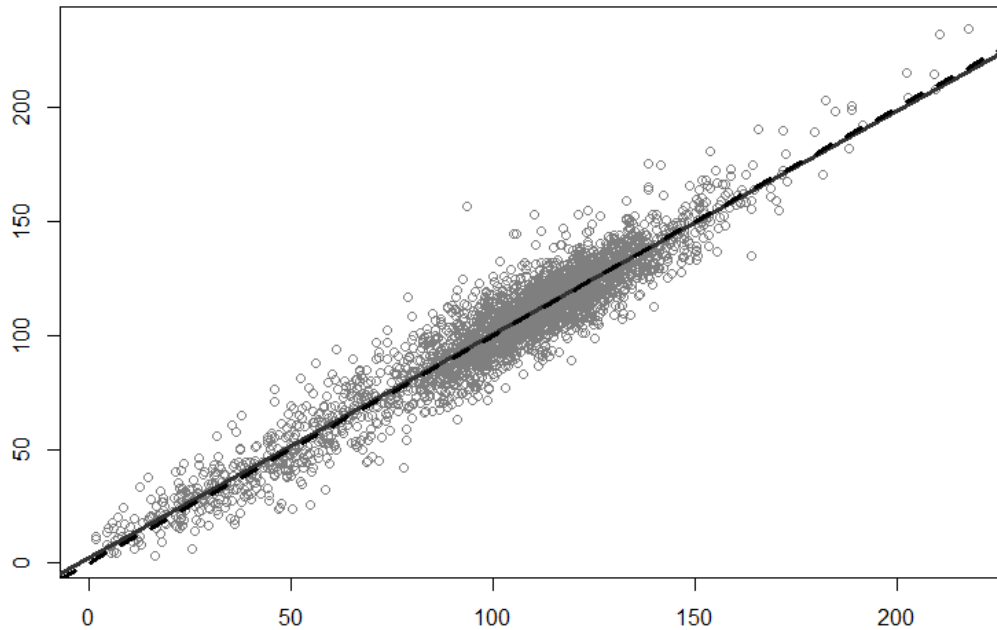
Squared Pearson correlation factor of **0.96**



# Separated GRAPPA acceleration factor

Separated GRAPPA reconstructs missing k-space lines using convolution kernels estimated from fully sampled central k-space for each coil (*pre-scan calibration*)

Choice of acceleration factor: separated GRAPPA 3



3/9/2026

	Squared Pearson correlation factor	Acquisition time on a single dynamic Tacc	Tacc Reduction
Reference	1	7'13	1
2	0.97	3'40	1.97
3	<b>0.91</b>	<b>2'29</b>	<b>2.91</b>
4	0.66	1'52	3.87
5	0.28	1'32	4.71
6	0.17	1'19	5.48
7	0.17	1'09	6.28
8	0.18	1'00	7.22



# 4D flow sequence optimization review

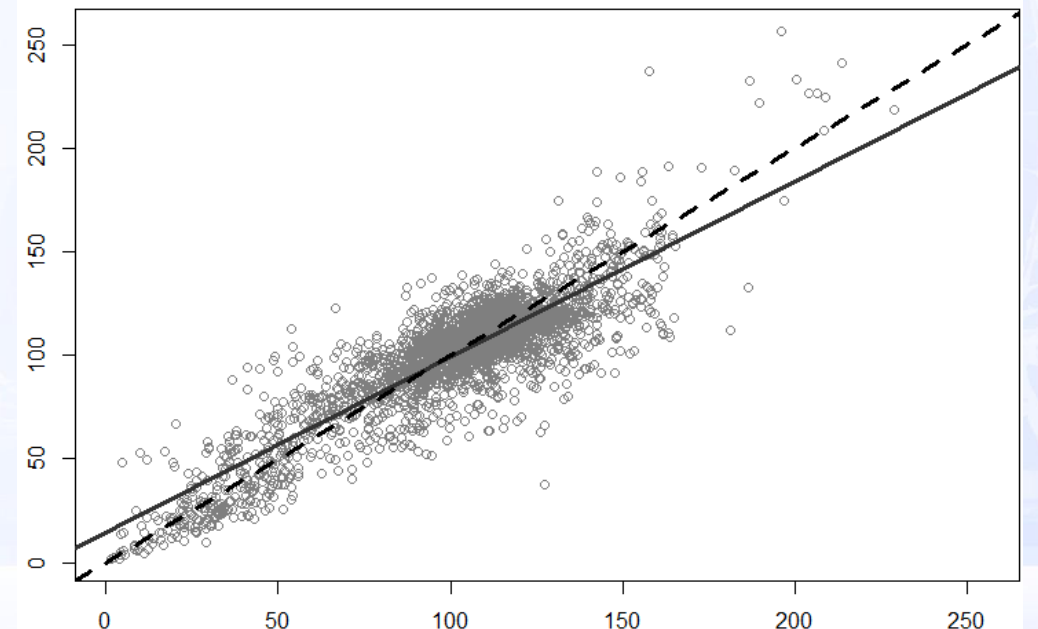
Phase resolution 40% (2.45× reduction,  $R^2 = 0.94$ ) → underestimation of high speeds → degradation of anatomical masking → addition of a filter

Slice resolution 50% (2.07× reduction,  $R^2 = 0.95$ ) and both phase and slice partial Fourier 75% (1.77× reduction,  $R^2 = 0.97$ )

Other indicators were computed and compared but did not add further insight

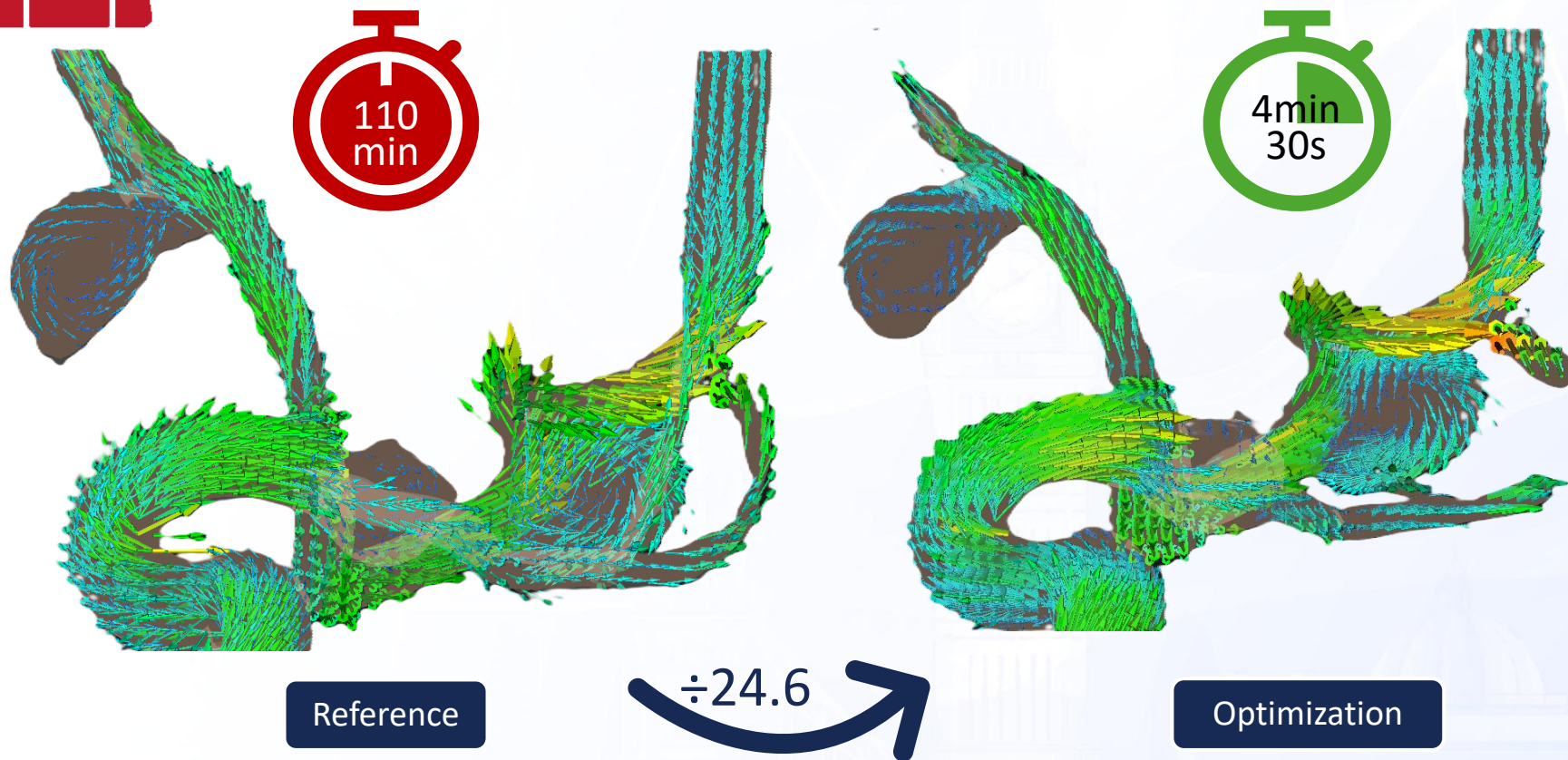
Acquisition time dependent on the patient's heartbeat (optimized to 5:34 for 60 bpm)

	Squared Pearson correlation factor	Tacc 1dyn	Tacc reduction 1dyn	Tacc 75bpm	Tacc reduction 75bpm
Reference	1	7'13	1	1'49'15	1
Optim	<b>0.77</b>	<b>0'21</b>	<b>20.62</b>	<b>4'27</b>	<b>24.55</b>





# Conclusion & perspectives



1. Tests are now conducted using **Philips and GE MRI machines**

2. Methodology demonstrates stability on a vascular phantom with aneurysms

3. Further validation required on patient data

Loss of some small vessels → Improved segmentation needed

Velocity field is smoother in the optimized version due to interpolation from acceleration factors

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# Thank you for your attention!

## Any questions?



Esther Fontaine

PhD student in applied  
mathematics for medical imaging



Esther FONTAINE

<https://estherfontaine.github.io/>

[esther.fontaine@univ-reims.fr](mailto:esther.fontaine@univ-reims.fr)



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