

Phantom Model of Intracranial Dynamics

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Background

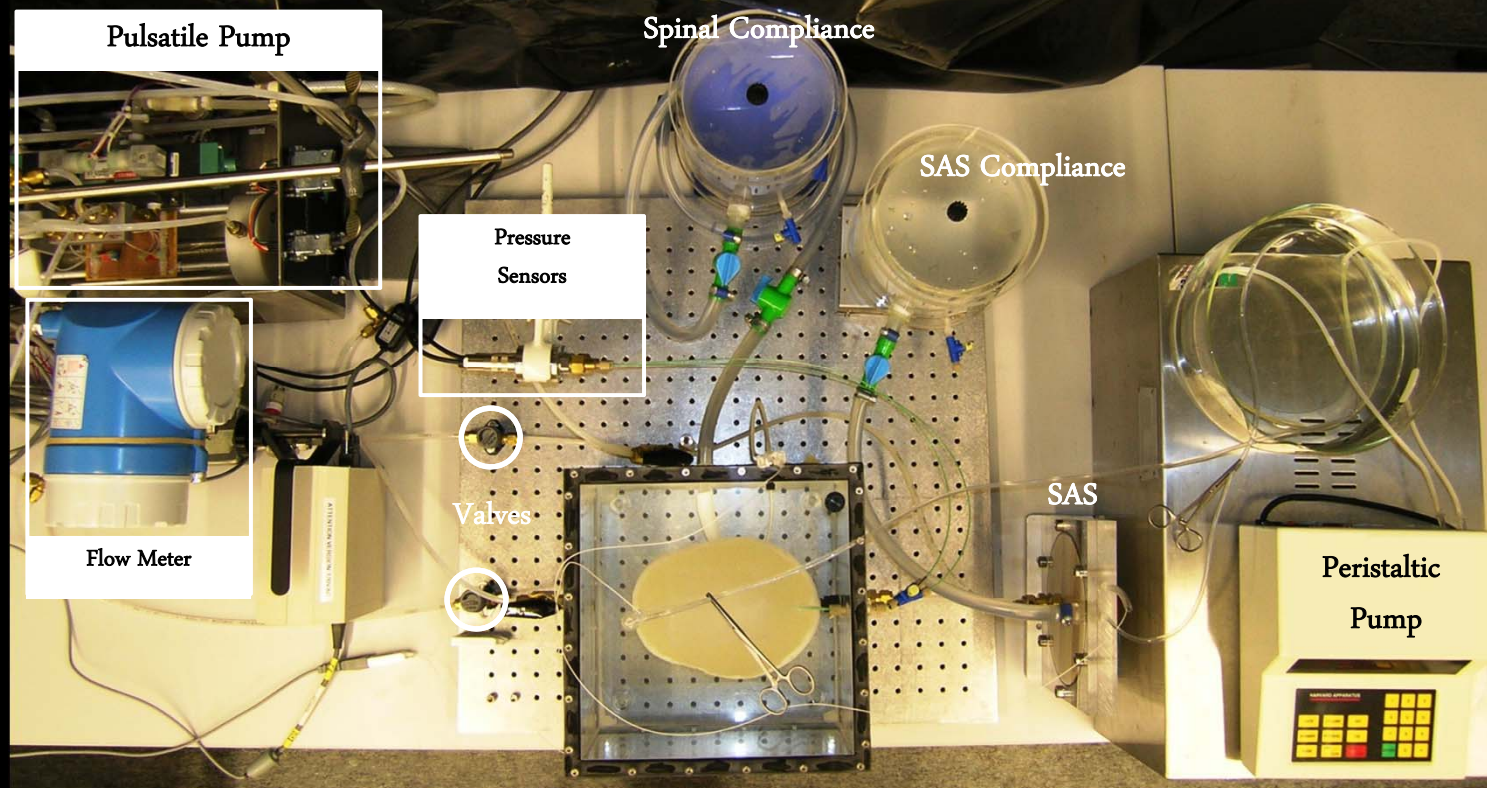
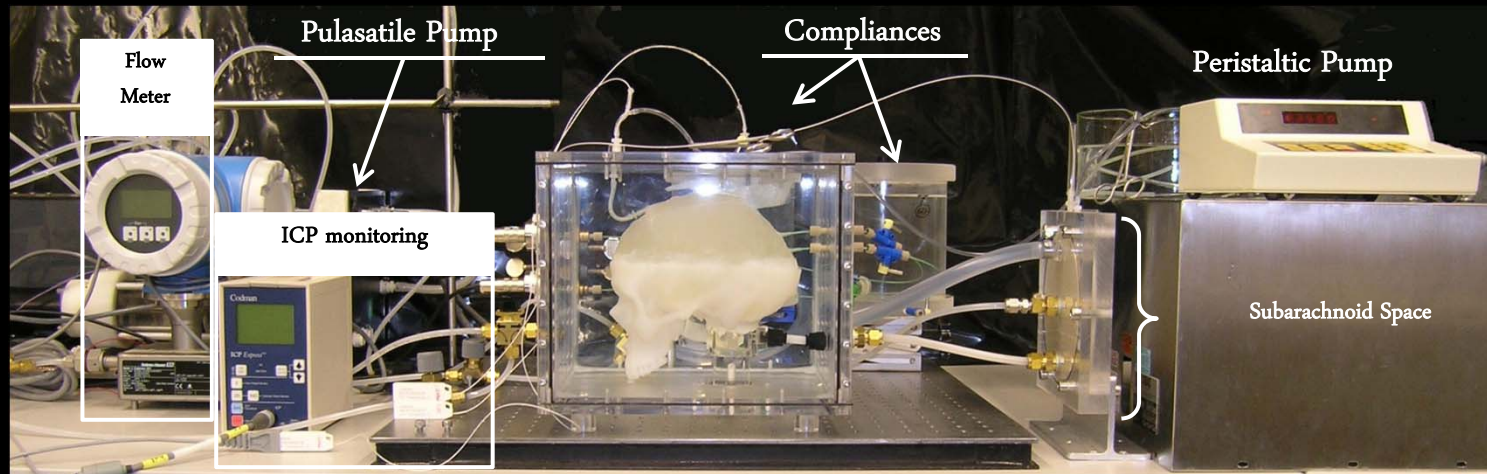
- Computational and analytical models can give otherwise not available insight into intracranial dynamics
- Such models allow for variation analysis of individual factors that influence intracranial pressure (ICP) and cerebrospinal fluid (CSF) flow
- However, they are not ideal for evaluate medical devices that influence ICP and CSF dynamics
- Animal and human studies are expensive, and raise ethical concerns

Objectives

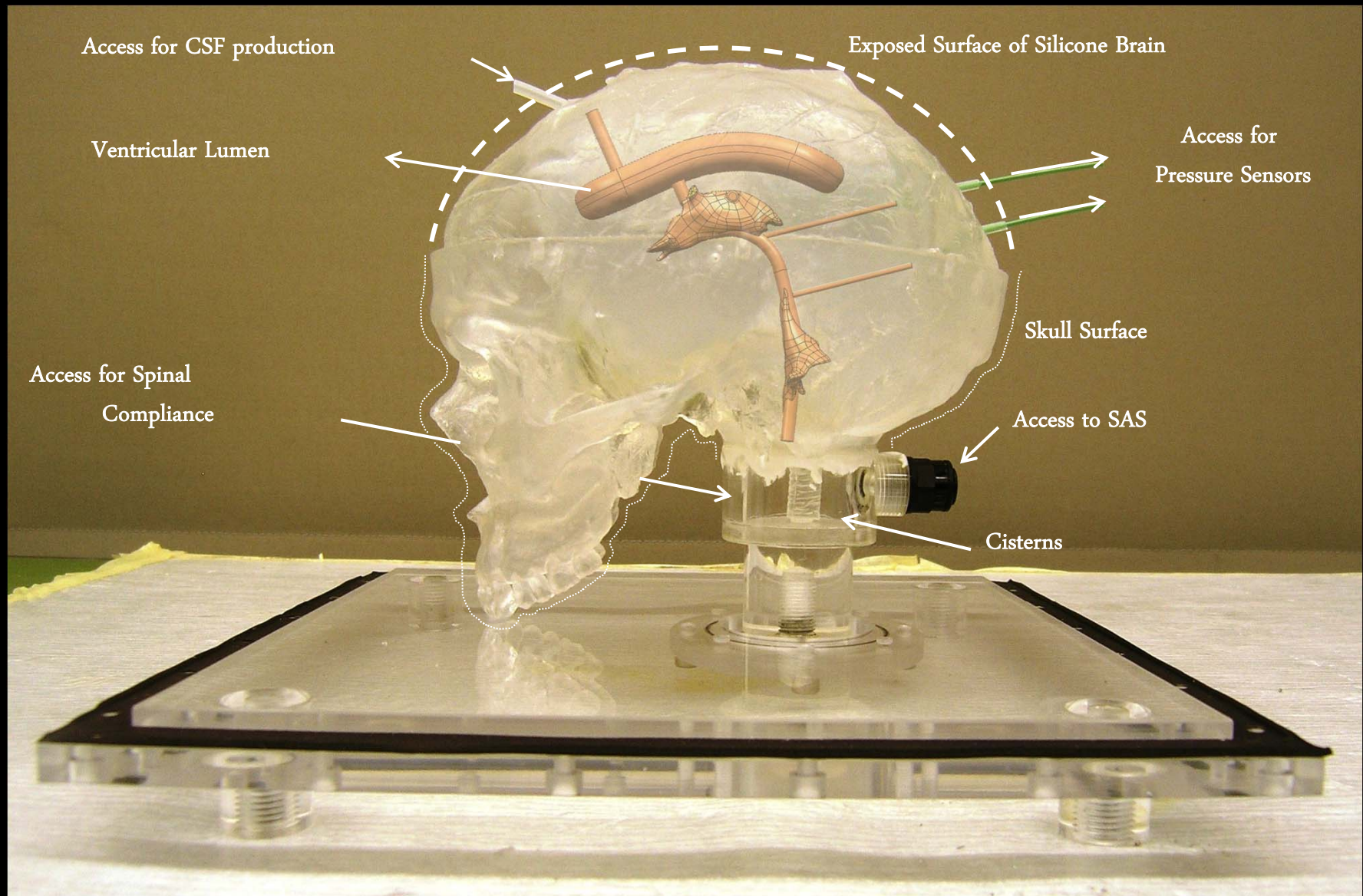
- To develop a modular phantom platform for evaluating, improving and developing medical devices that influence intracranial dynamics
- To validate an initial configuration of this phantom for the reproduction of normal physiologic conditions

Bottan et al. (2012), *IEEE T Biomed Eng*, E-Pub ahead of print

Phantom Model Setup

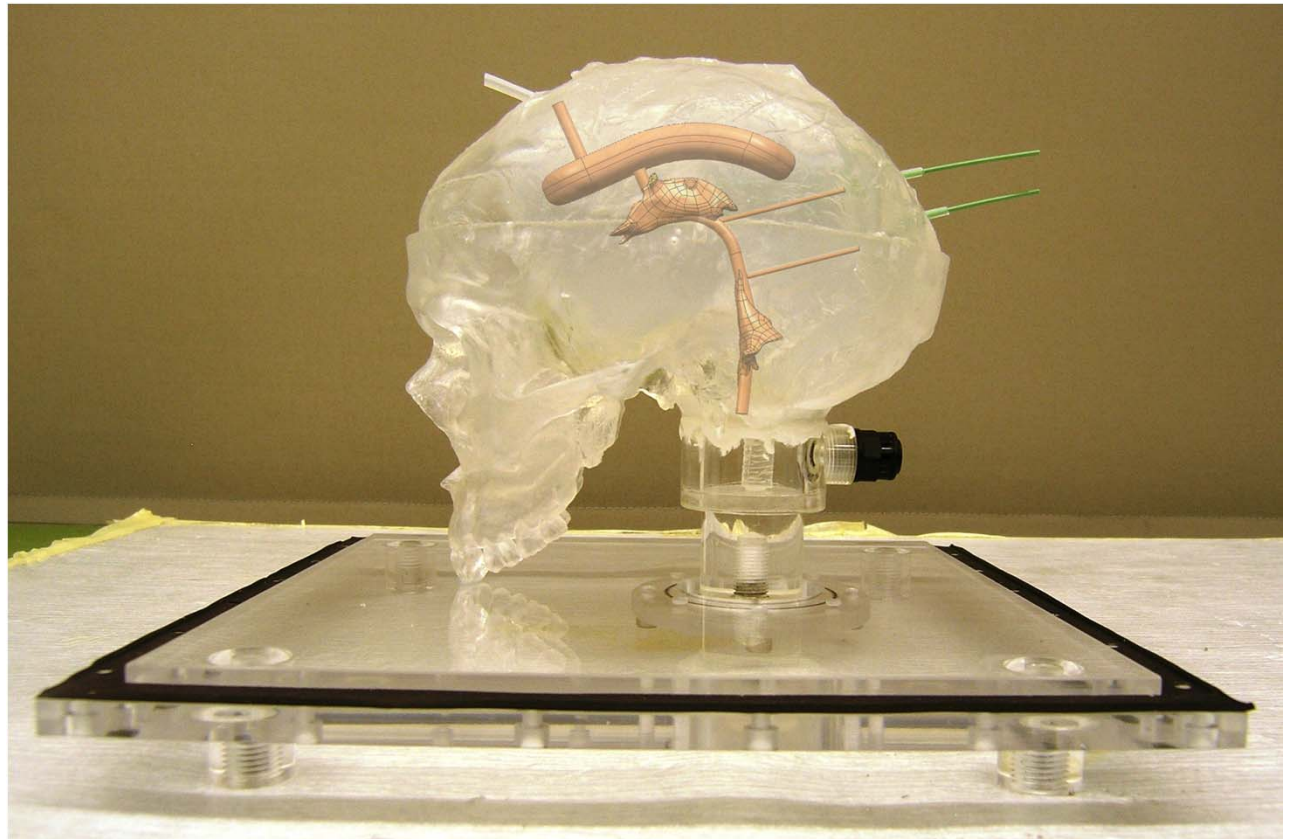


Cranial Space



Cranial Space

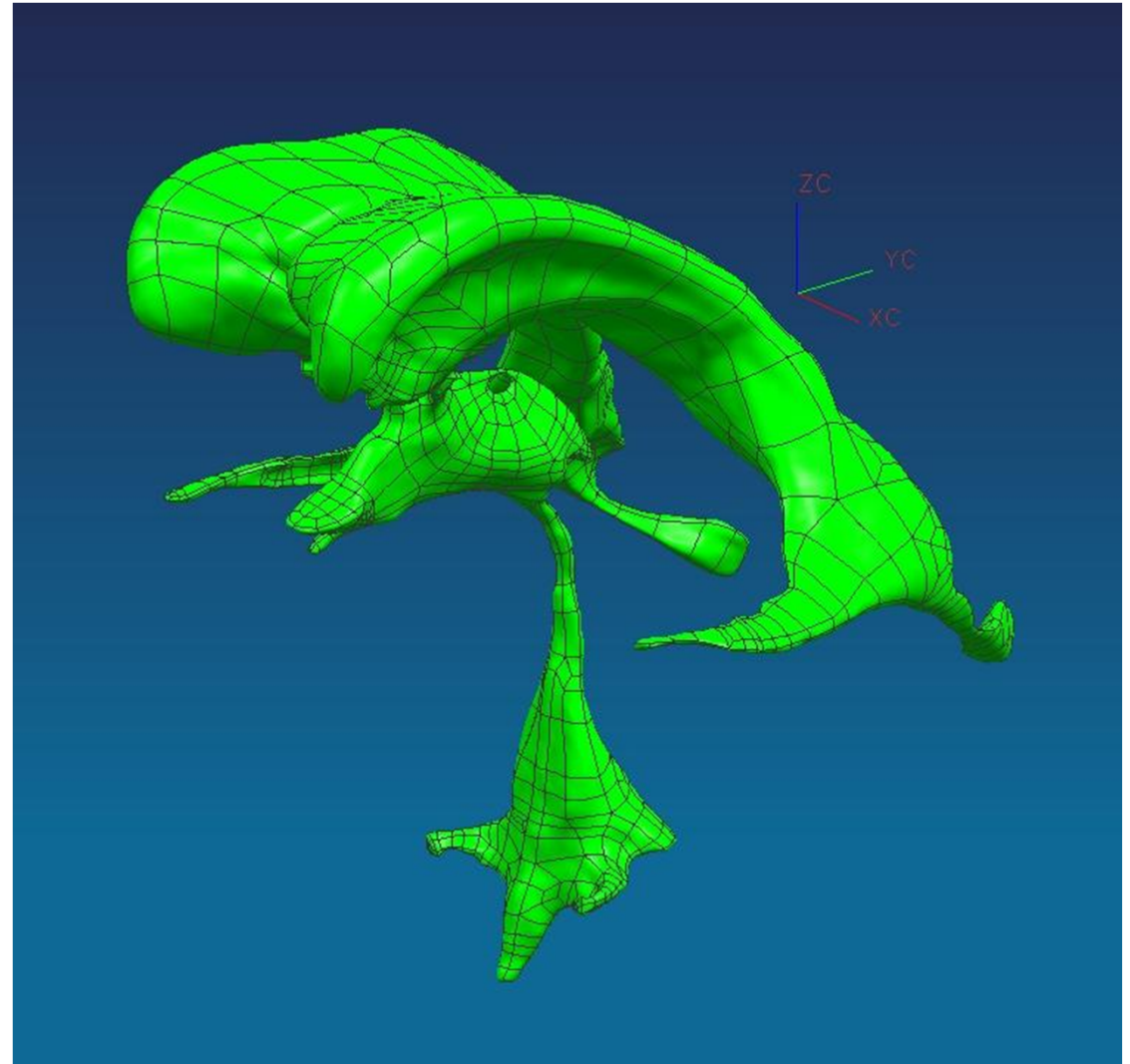
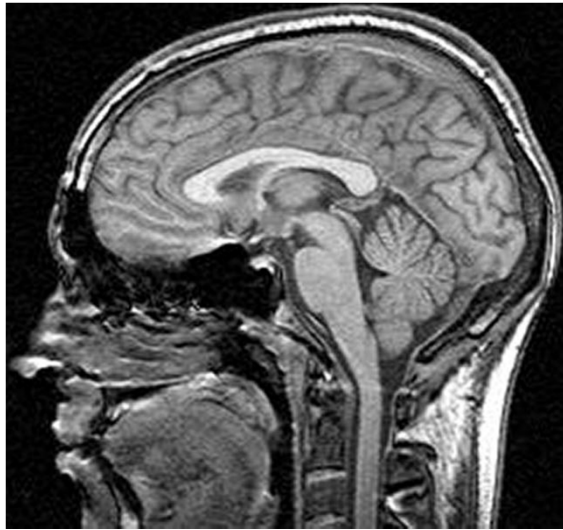
- Skull: Generic plastic model
- Brain: Sylgard 527 Silicone *, **



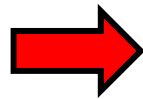
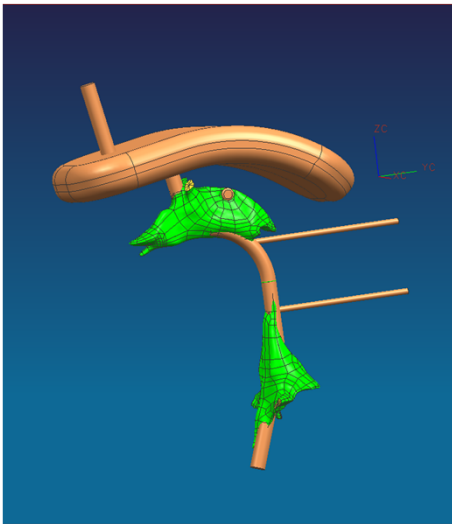
* Ma et al. (2010),
Comput Method Biomech 13:783ff

** Brands et al. (1999),
43th Stapp Car Crash Conf

Ventricular System

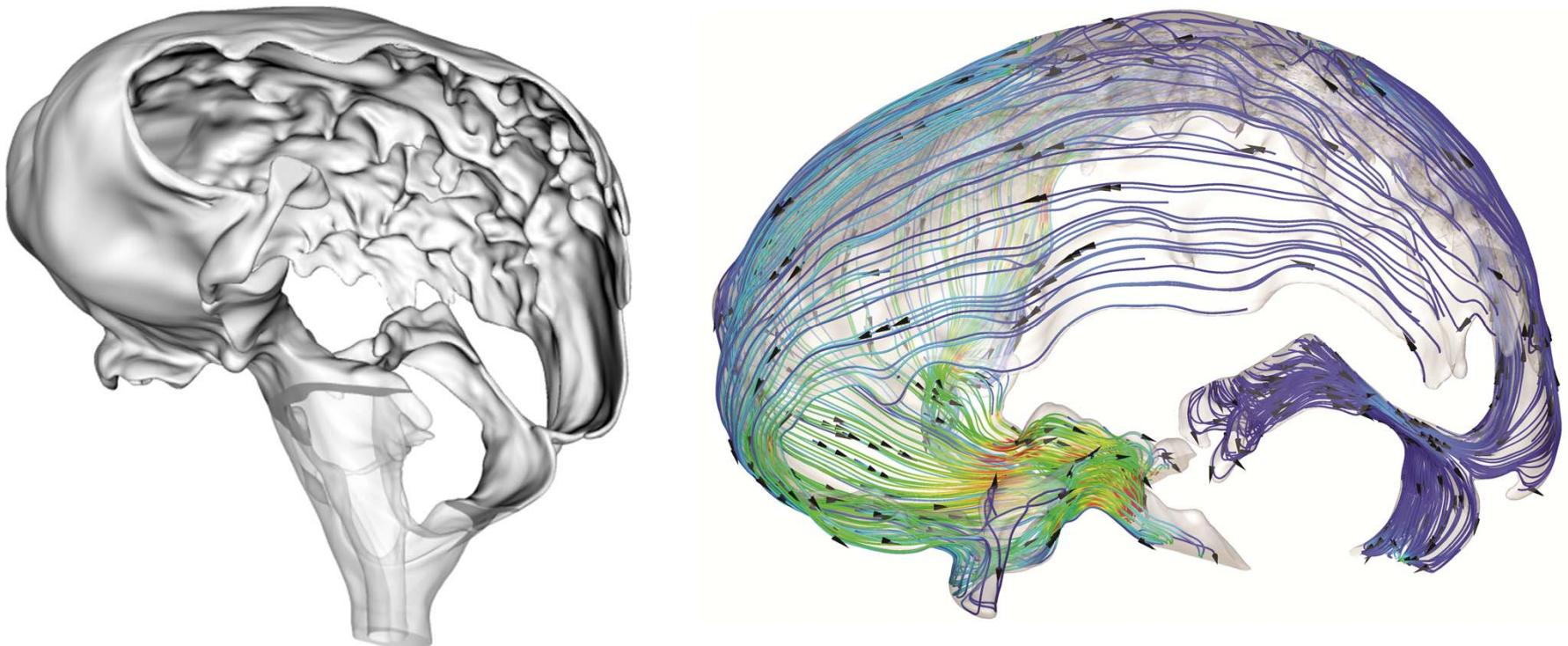


Ventricular System



Subarachnoid Space / Cisterns

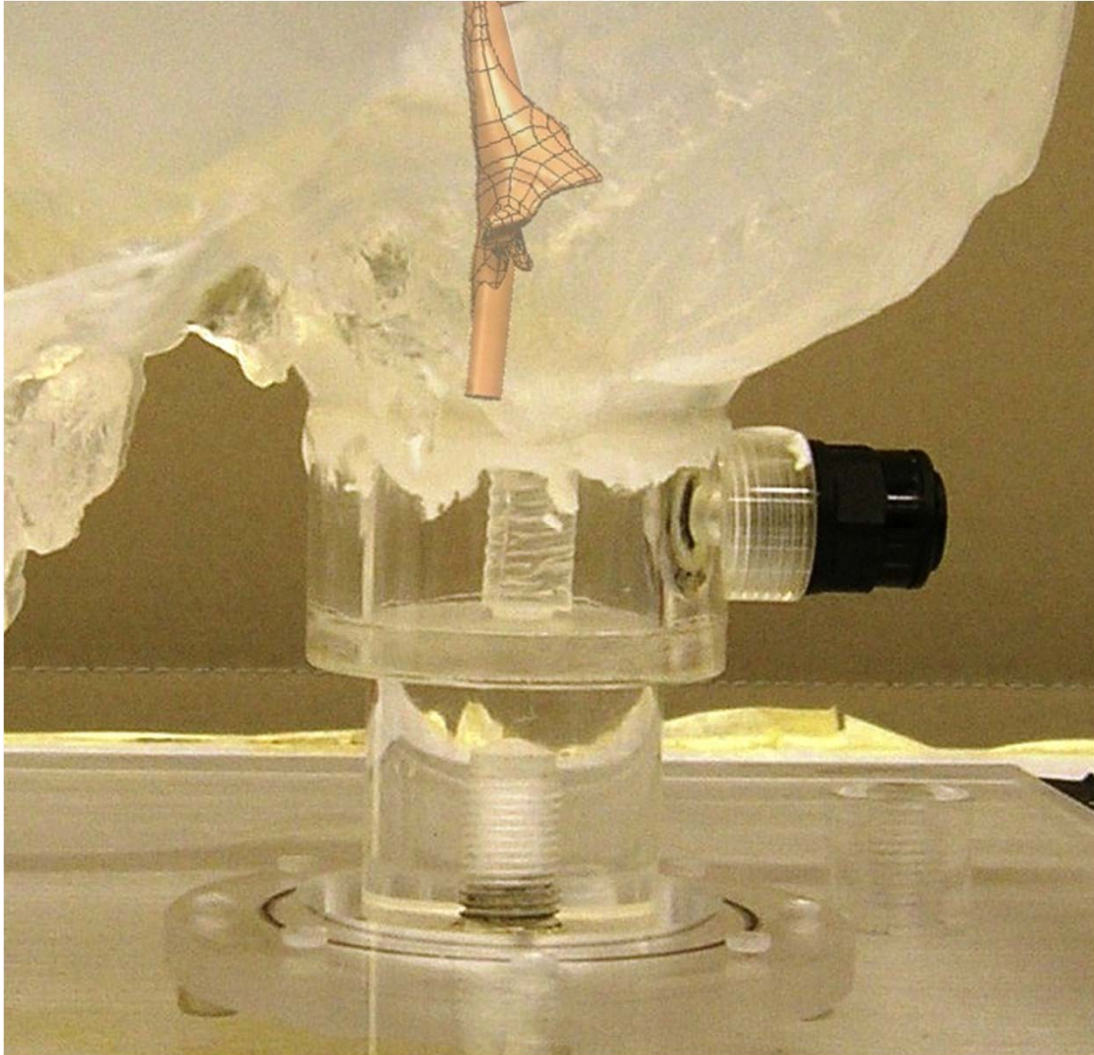
- Volume estimated based on MRI data
- Hydraulic resistance estimated based on flow simulations



Gupta et al. (2010), *J Royal Soc Interface* 7:1195ff

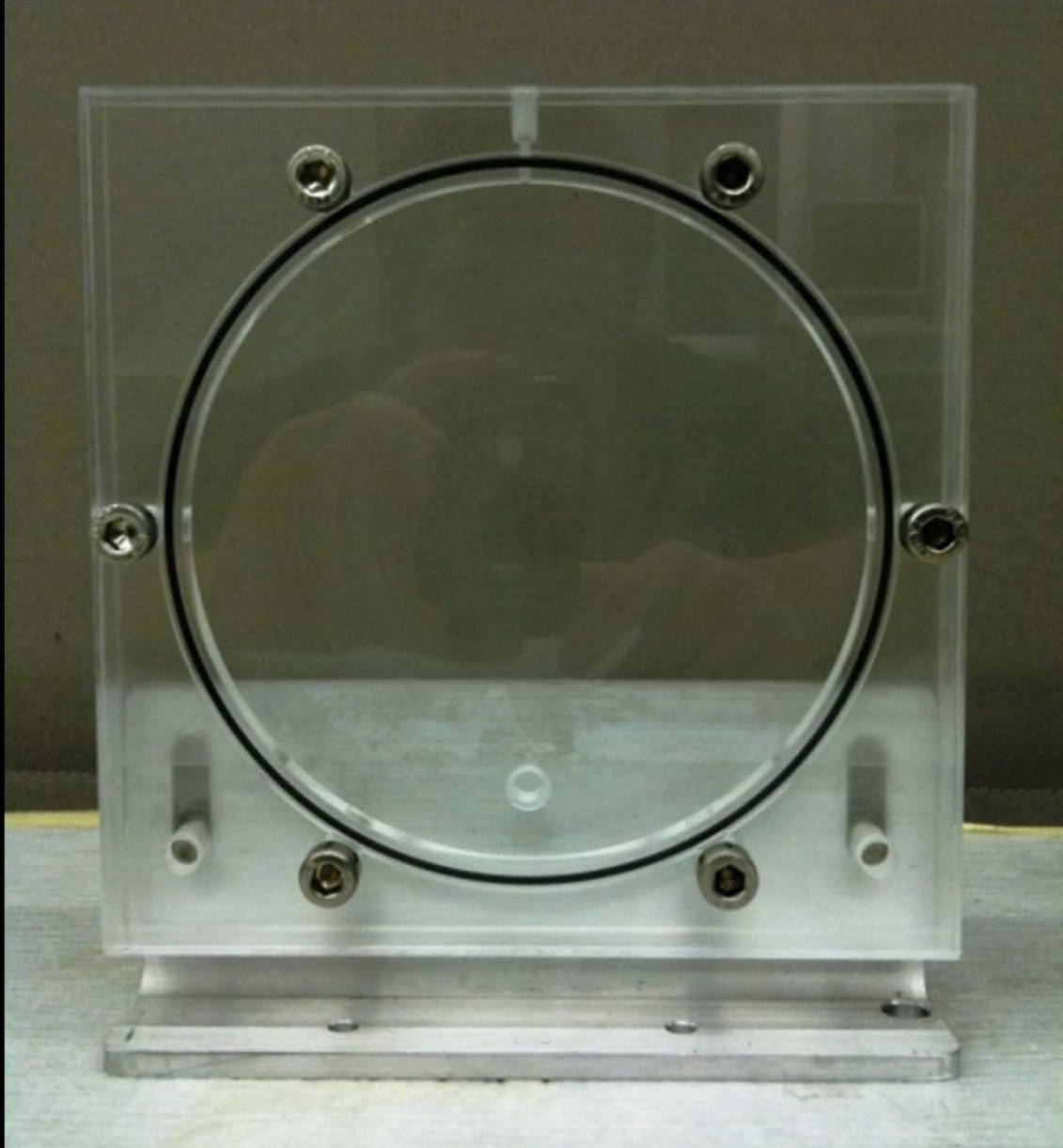
Gupta et al. (2009), *ASME J Biomech Eng* 131:021010

Cisterns

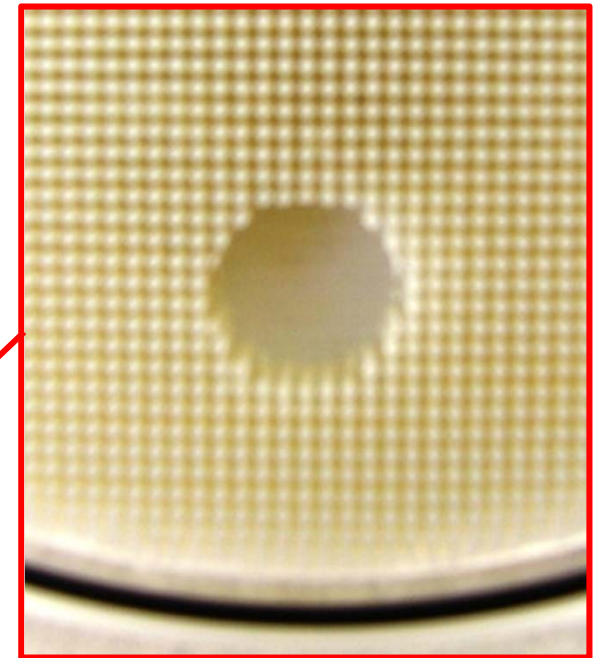
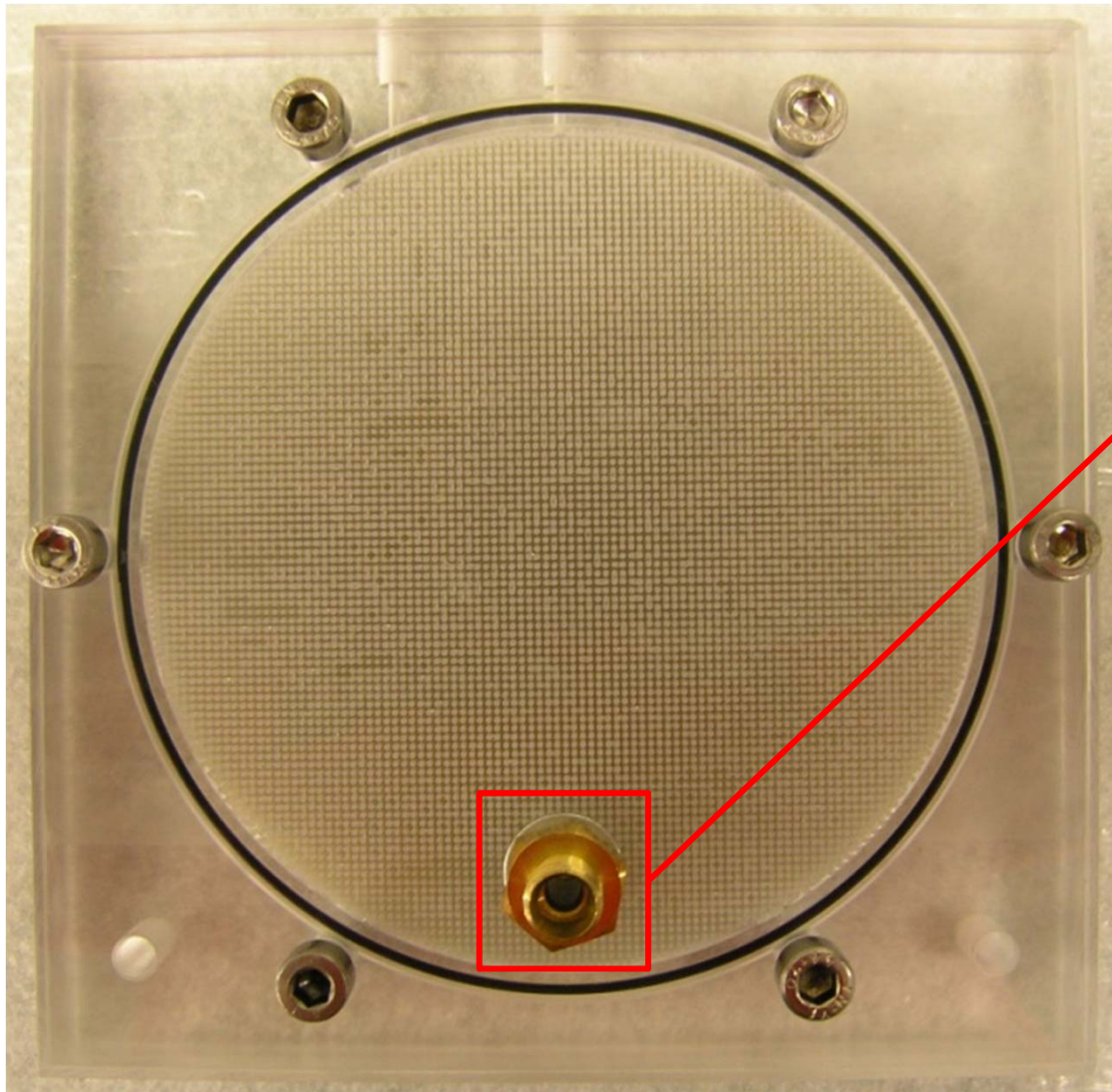


$V = 24 \text{ ml}$

Subarachnoid Space



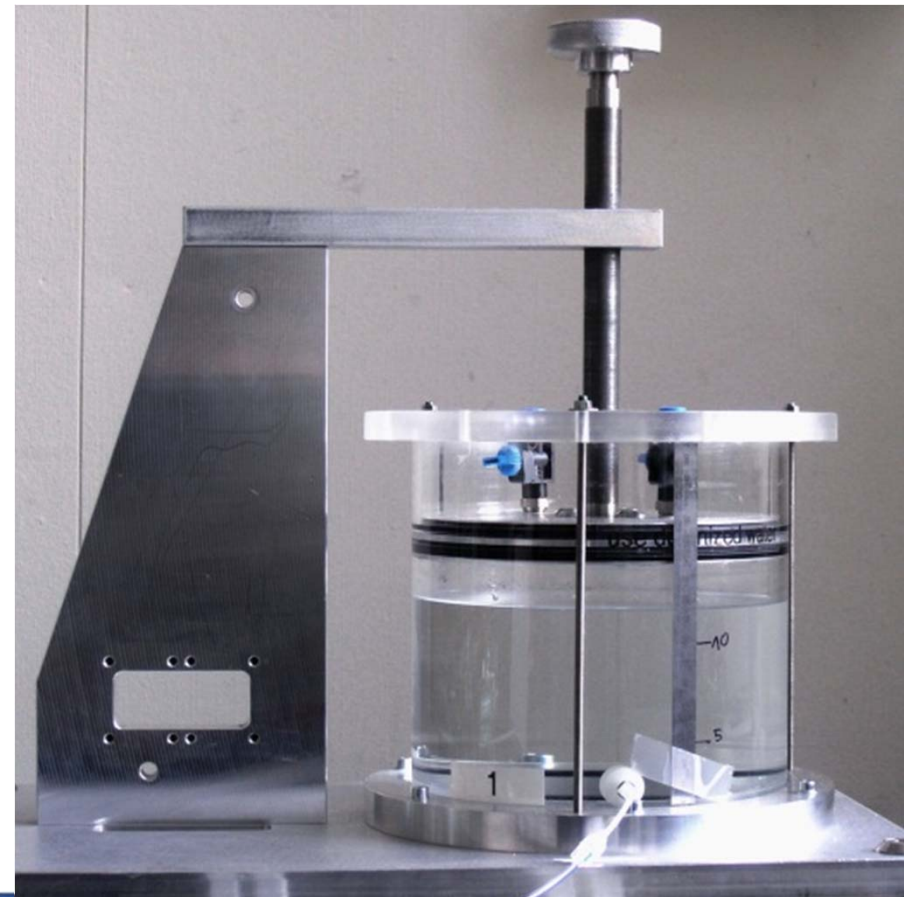
Subarachnoid Space



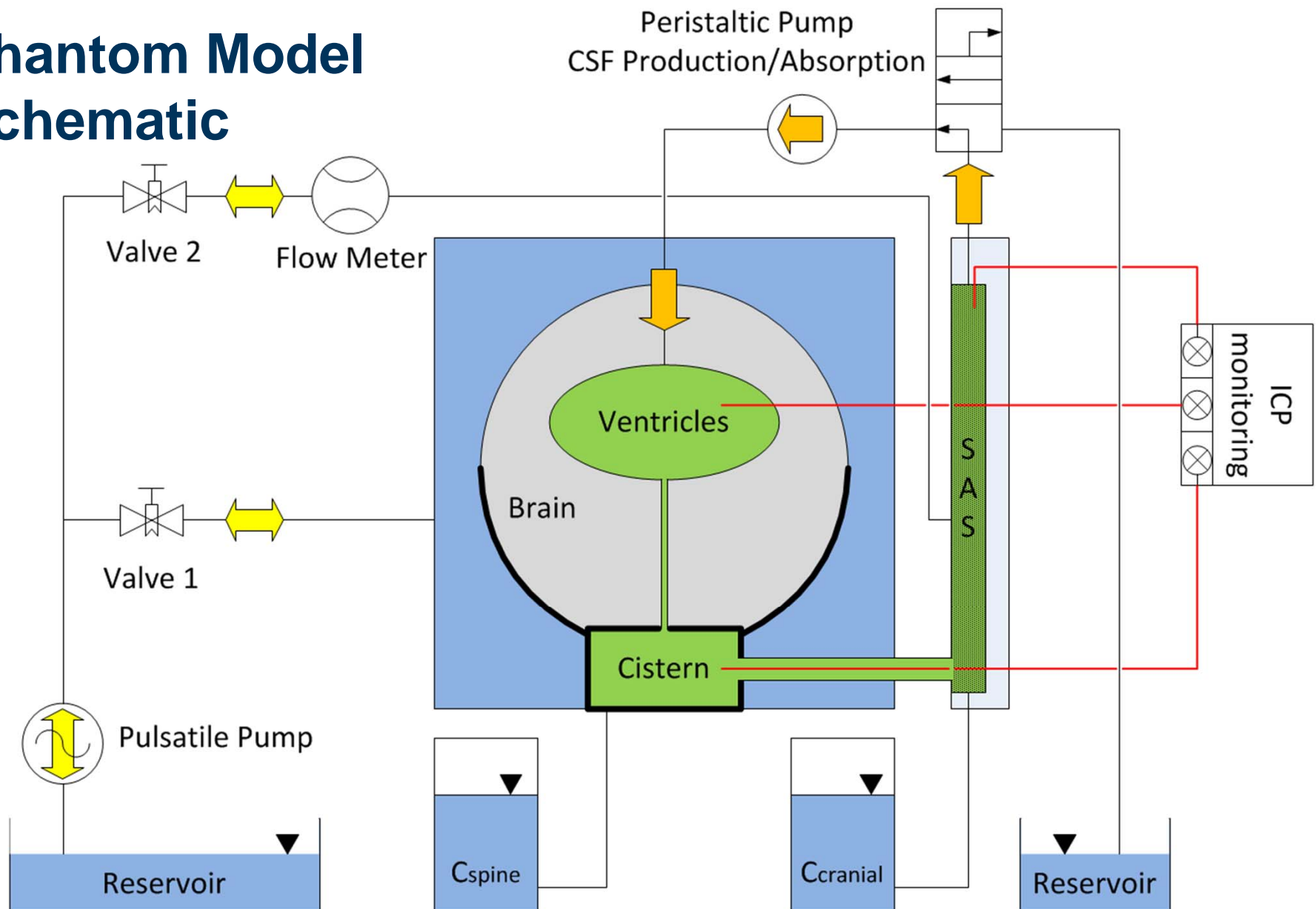
$r = 0.5 \text{ mm}$
 $L = 1.5 \text{ mm}$
 $k = 1.7 \cdot 10^{-8} \text{ m}^2$
 $V = 124 \text{ ml}$

Compliance Model via Pneumatic Chamber

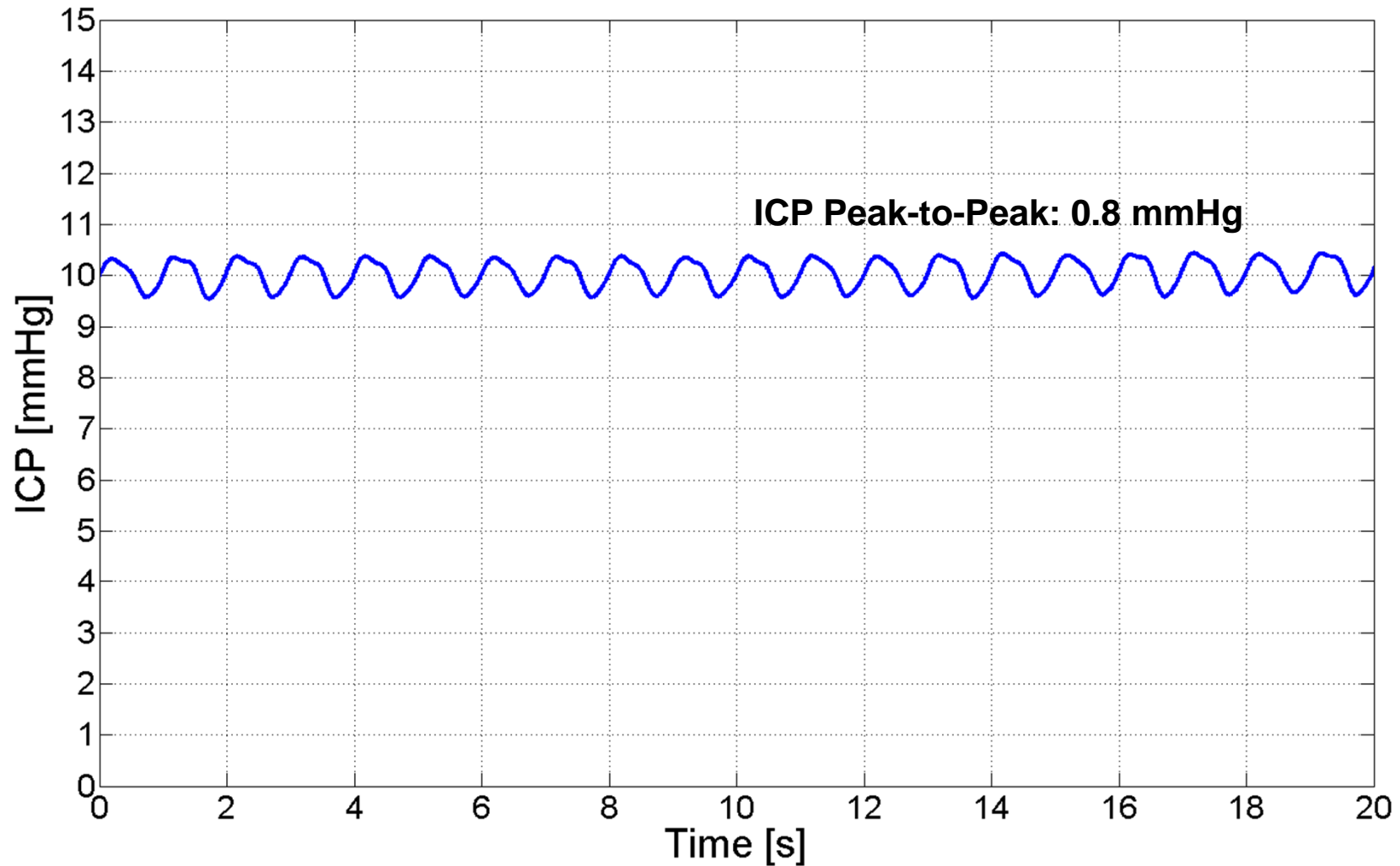
- Total compliance 1mm/mmHg
- Compliance distribution: 35% cranial, 65% spinal



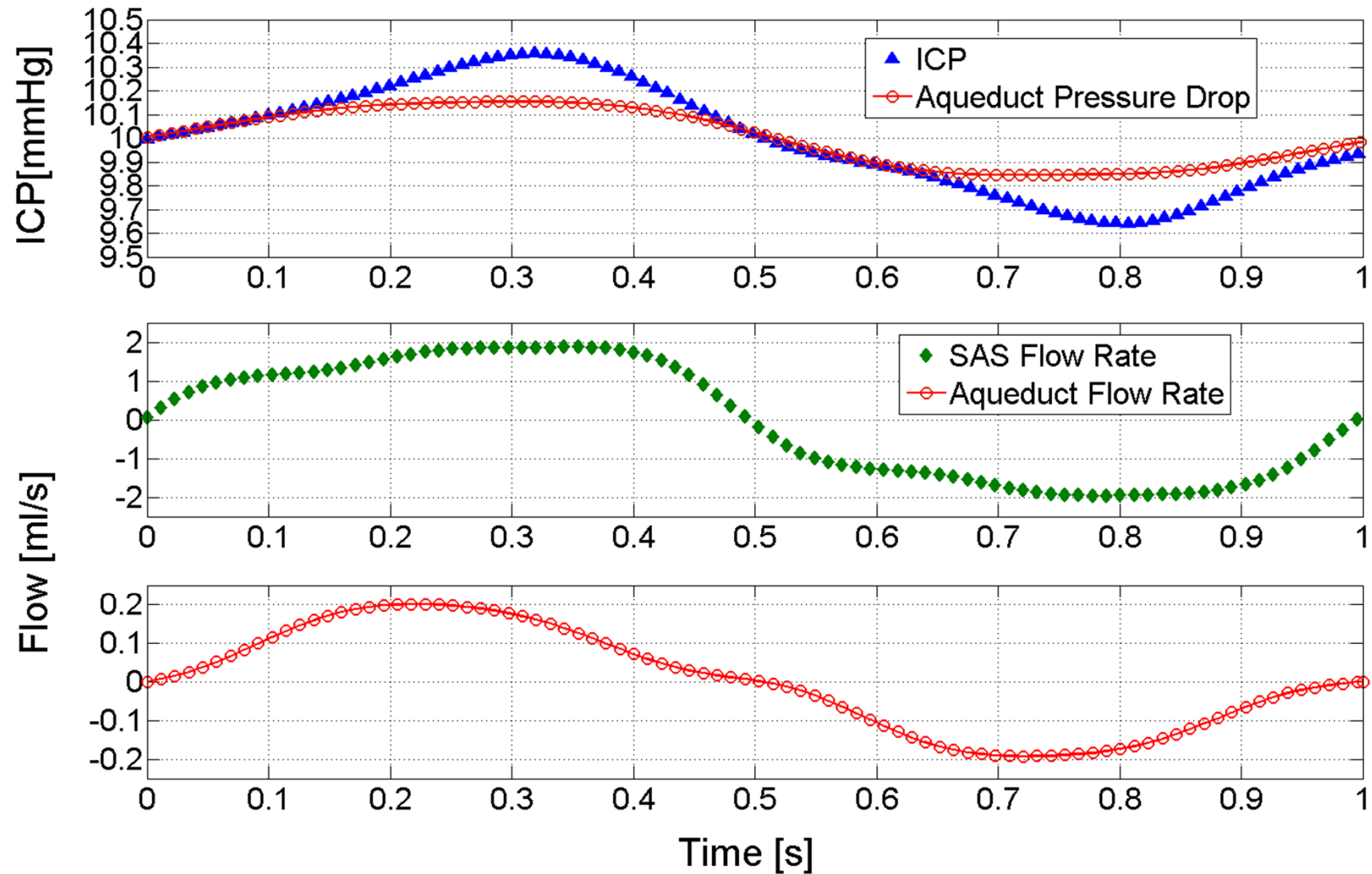
Phantom Model Schematic



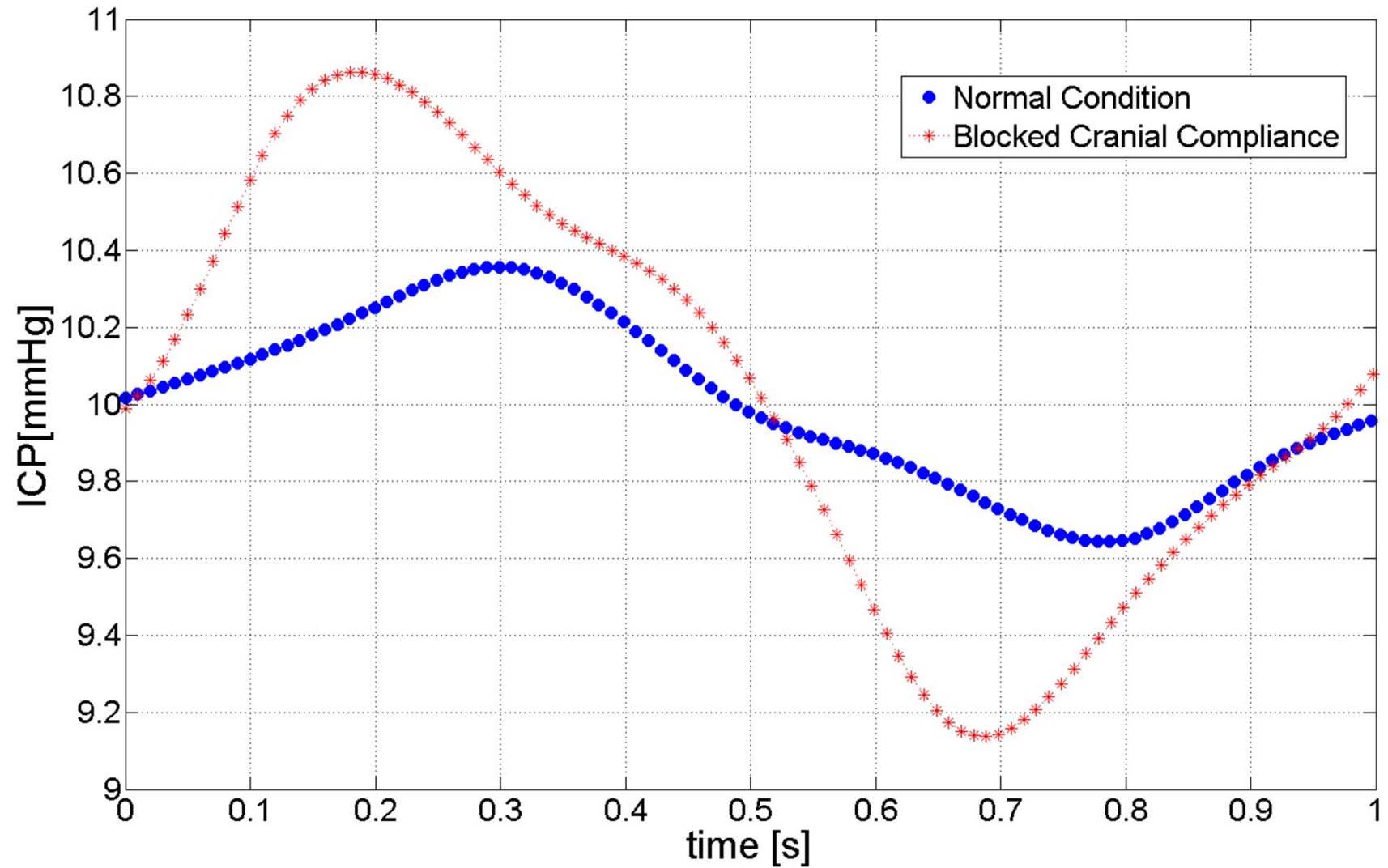
Approximation of Intracranial Dynamics



Approximation of Intracranial Dynamics



Removal of Cranial Compliance



Conclusion

- Novel phantom that approximates normal physiologic intracranial dynamics
- Modular concept allows for expansion, addition of detail or simplifications as needed

Bottan et al. (2012), *IEEE T Biomed Eng*, E-Pub ahead of print



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