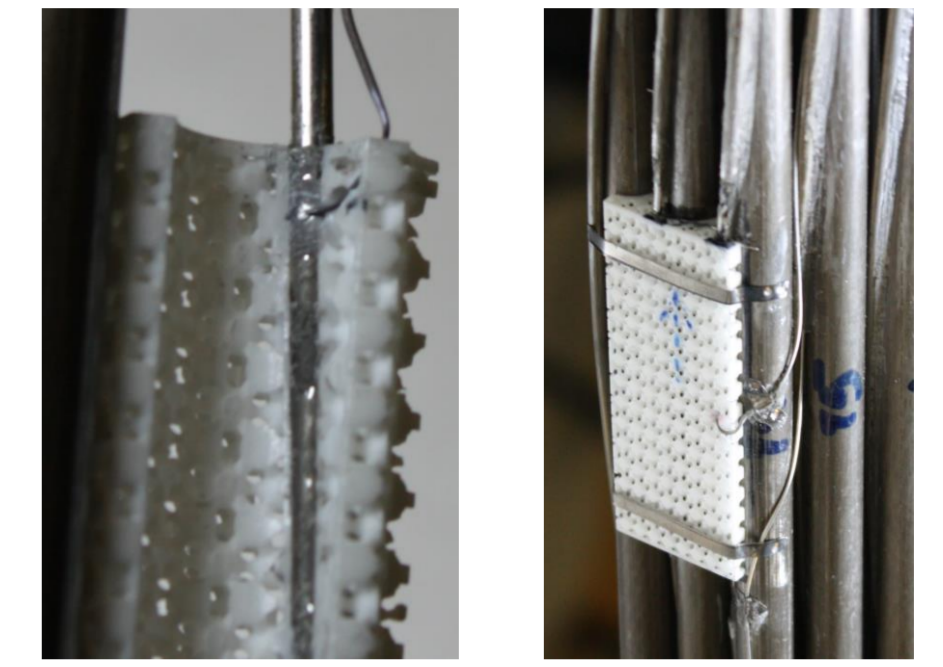
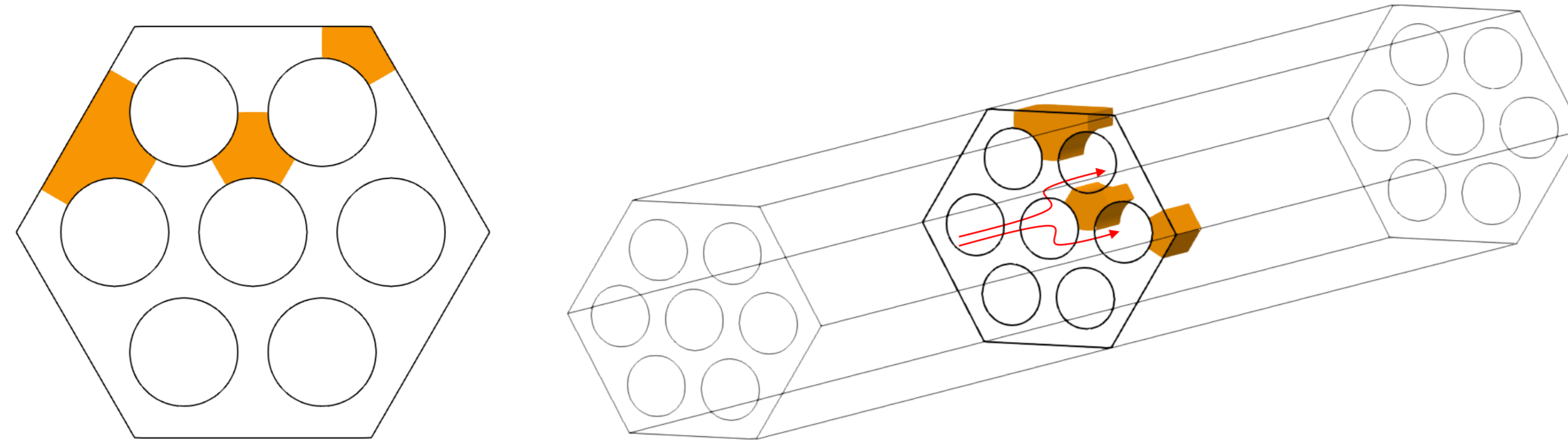


Subdomain Proper Orthogonal Decomposition of Blocked Fuel Bundles

Author: Shenhui Ruan, Andreas G. Class

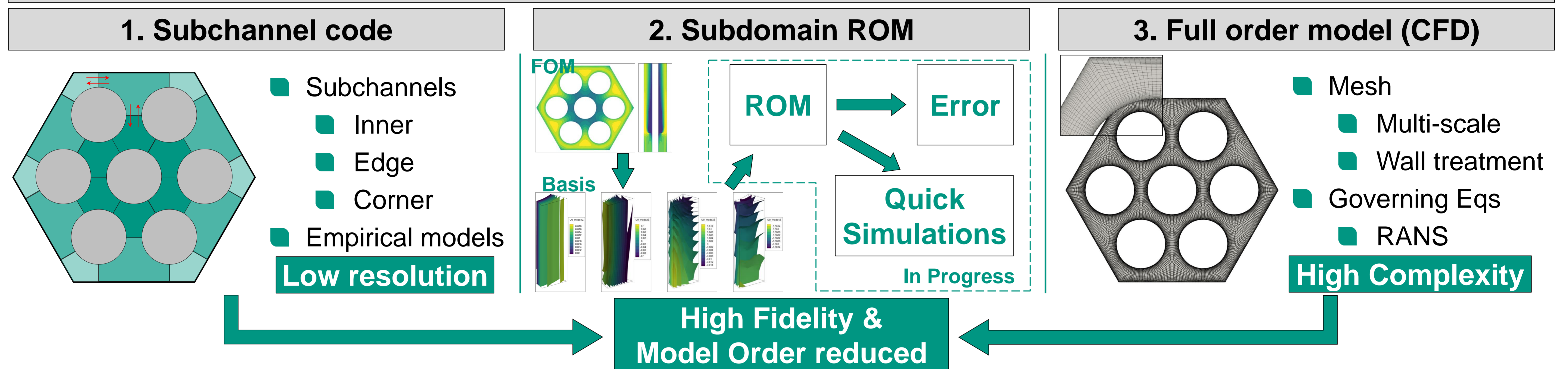
Background

- Flow blockage
 - Porous or solid
 - Extra flow resistance
 - Recirculate flow
 - Local heat transfer deterioration



Porous Blockage

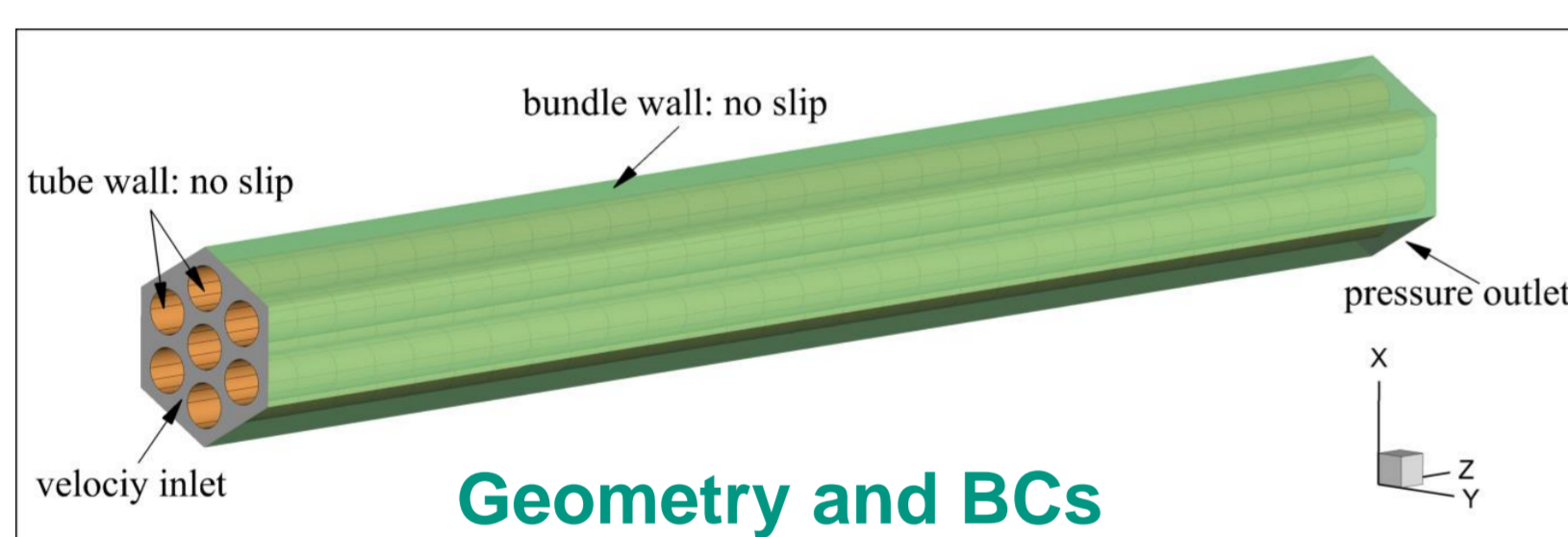
Different Simulation Methods



Subdomain Proper Orthogonal Decomposition

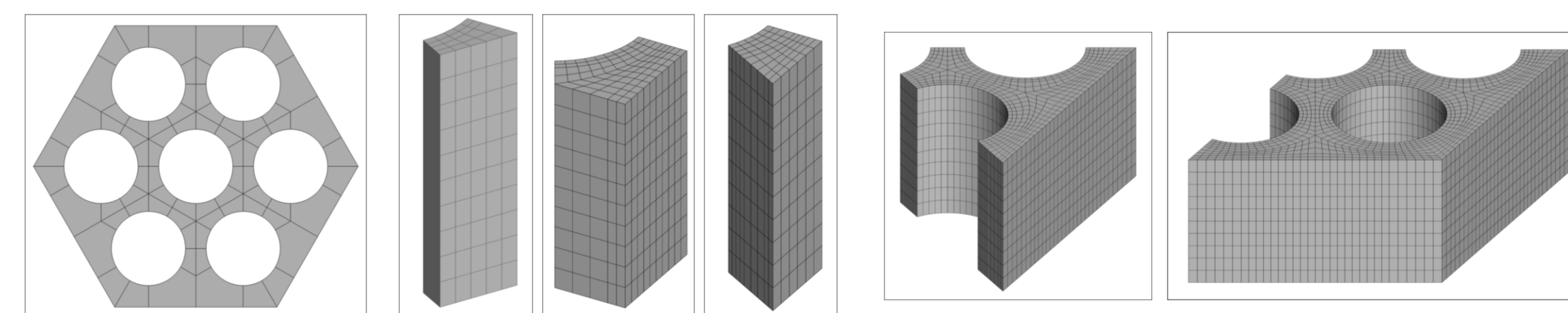
1. FOM Simulation setup and subdomains

- Physical model
 - U_{in} , P_{out} , No-slip wall
 - RANS, OpenFOAM
 - k- ϵ , Standard wall function

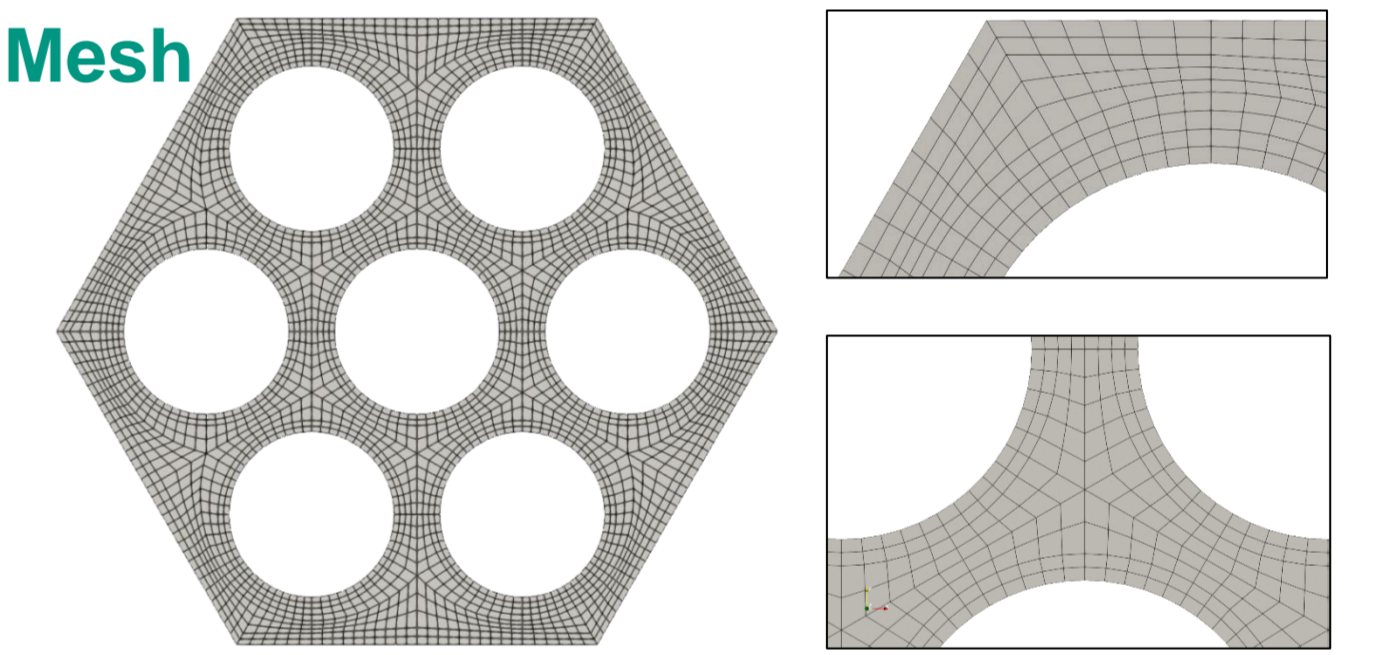


Geometry and BCs

- Domain Decomposition



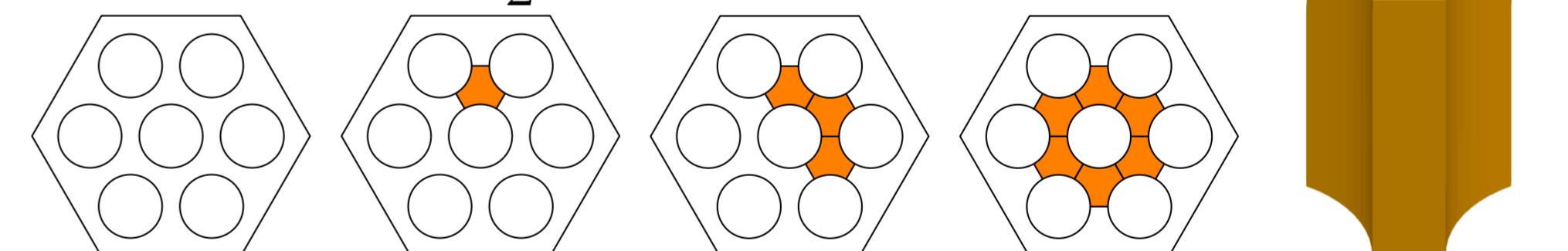
Mesh



- Porous blockages

- Darcy-Forchheimer, Homogeneous
- Source term in momentum equations

$$S_m = -(\mu d + \frac{\rho |u|}{2} f) u$$



2. Methodology

- Snapshots
 - Steady state solutions
 - Subdomain snapshots

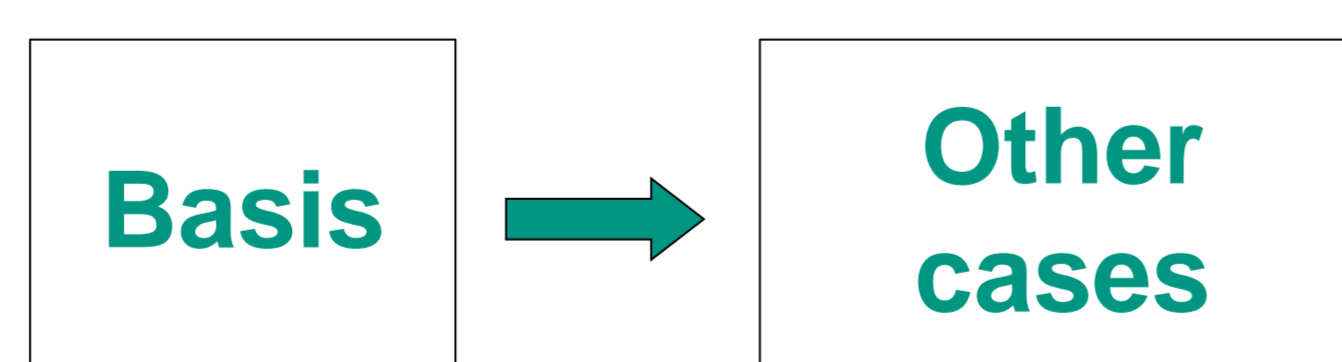
$$S = \begin{bmatrix} s_{11} & s_{12} & \dots & s_{1n} \\ s_{21} & s_{22} & \dots & s_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ s_{m1} & s_{m1} & \dots & s_{mn} \end{bmatrix}$$

- POD
 - Employing SVD
 - Truncated error

$$S = L \Sigma R^T = \Phi A$$

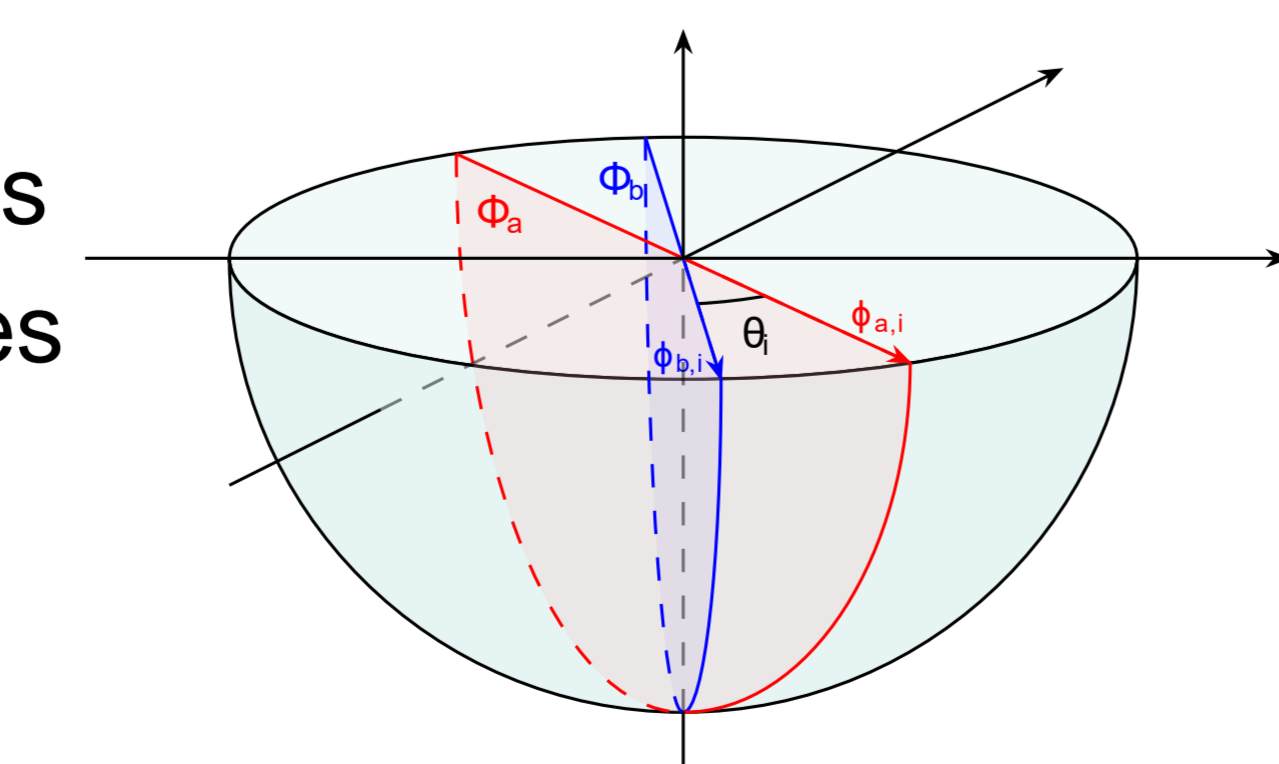
$$\epsilon = \frac{\|S - \Phi \Phi^T S\|_F}{\|S\|_F}$$

- Extrapolation of reduced basis
 - Different subdomains
 - Different mode numbers
 - Representative case
 - Approximation error



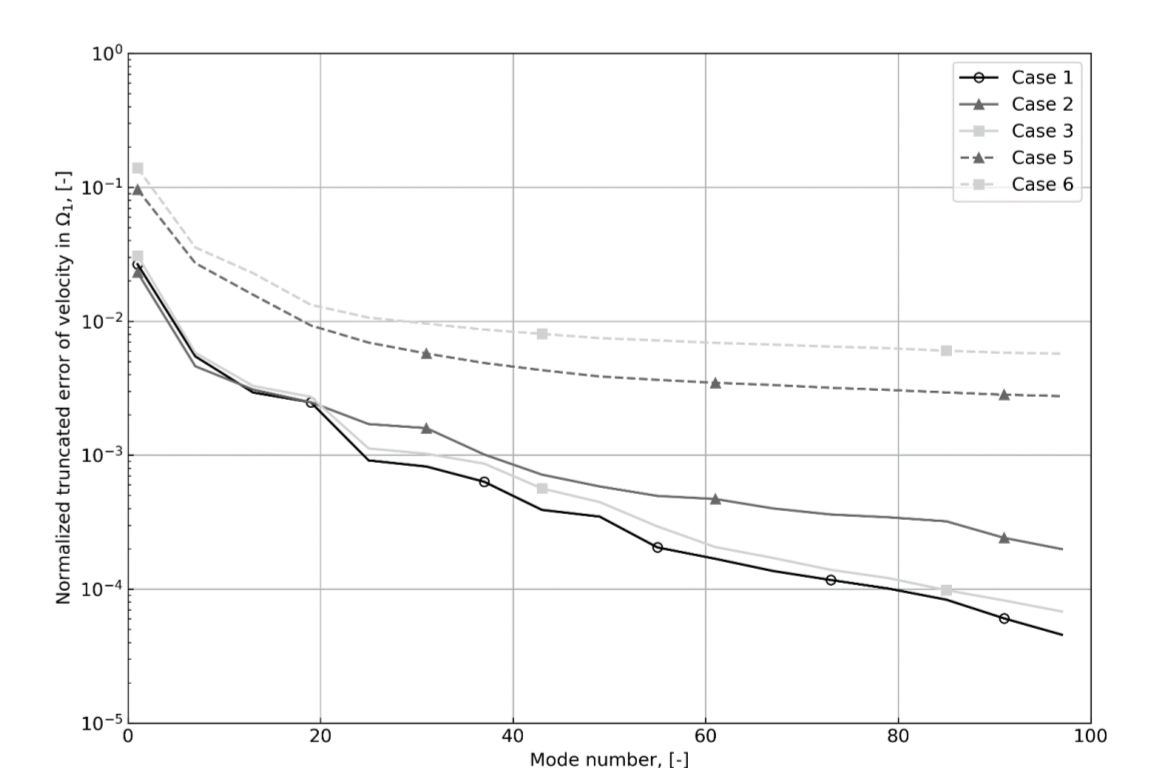
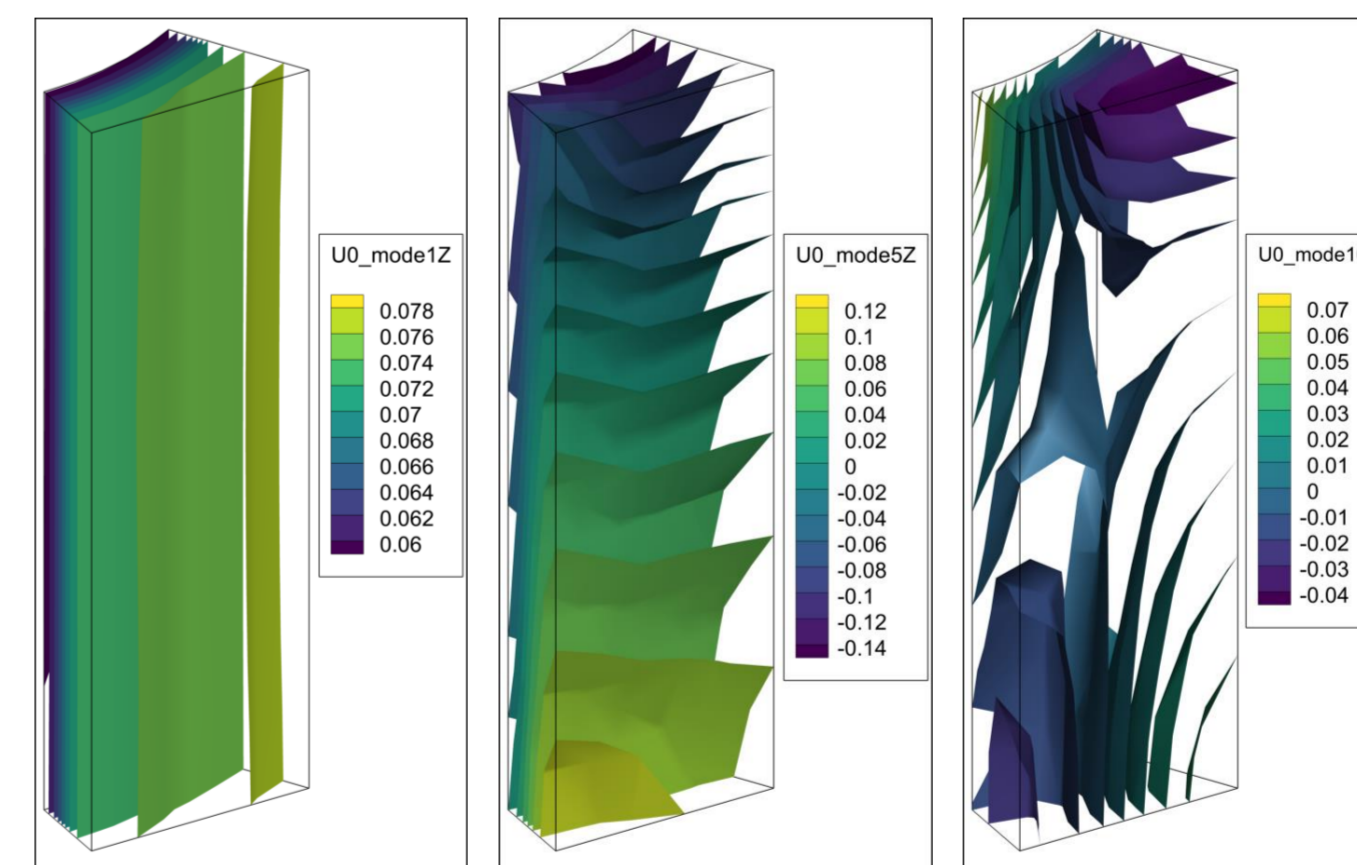
$$\epsilon_R = \frac{\|S - \Phi_R \Phi_R^T S\|_F}{\|S\|_F}$$

- Distance of reduced subspaces
 - Dissimilarities of subspaces
 - Principal angle
 - Grassmann distance

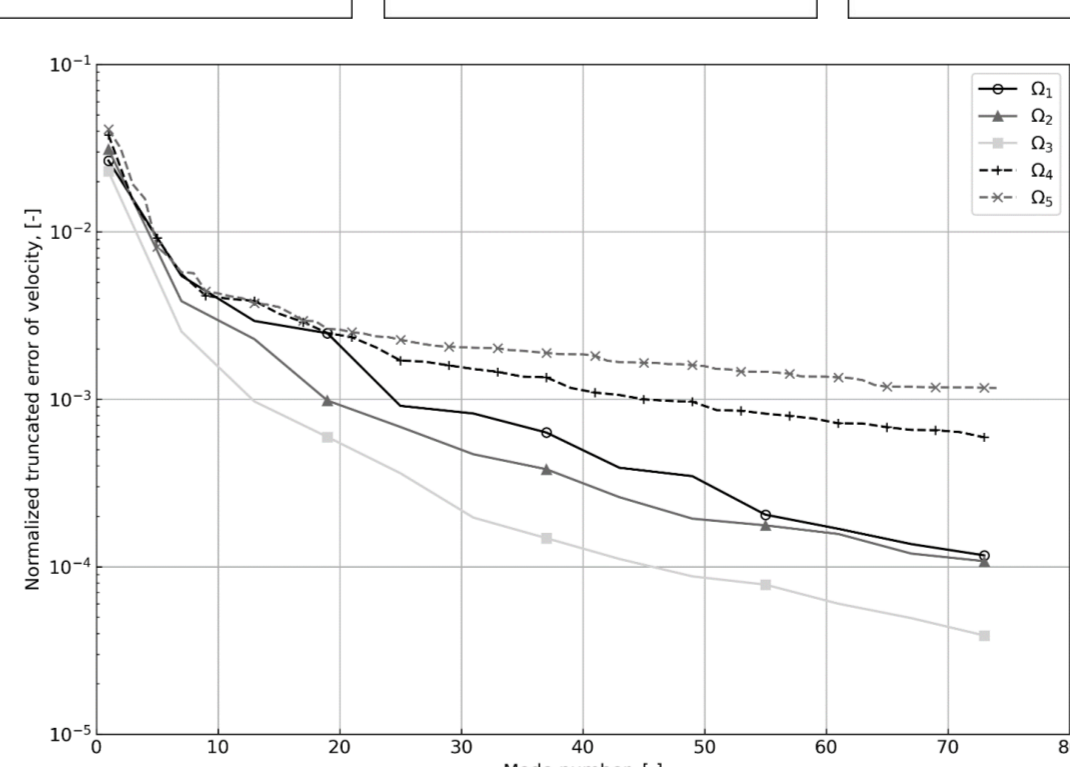


3. Results (work in progress)

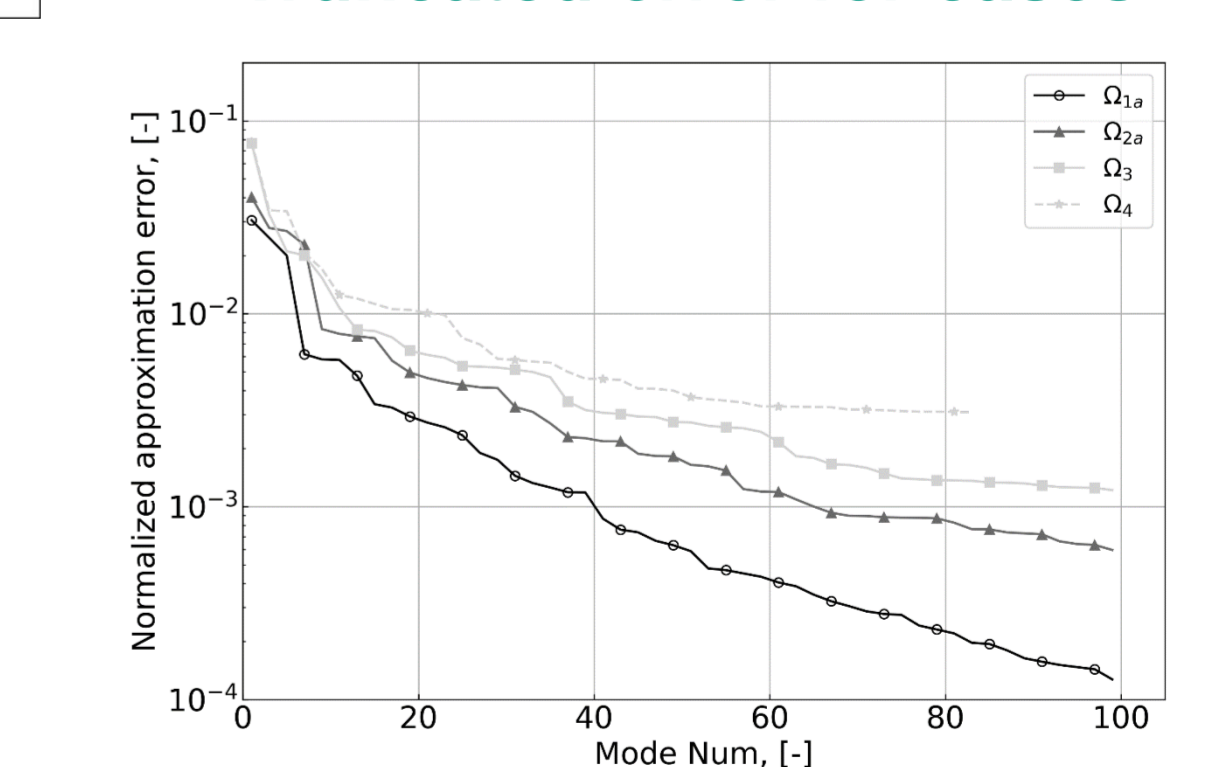
Basis



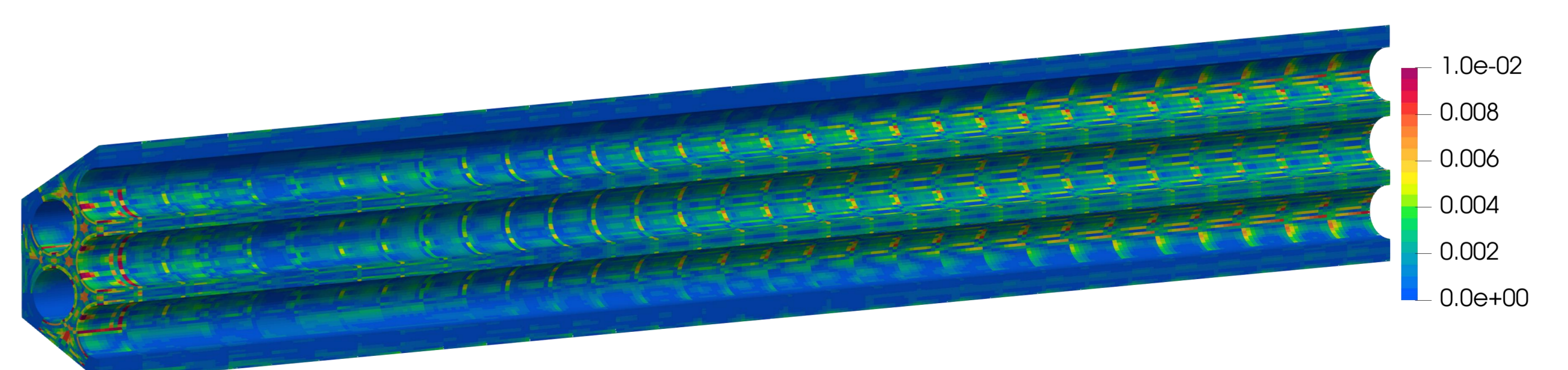
Truncated error for cases



Truncated error for subdomains



Approximation error for subdomains



Approximate velocity of an unblocked case with the reduced basis of a blocked case