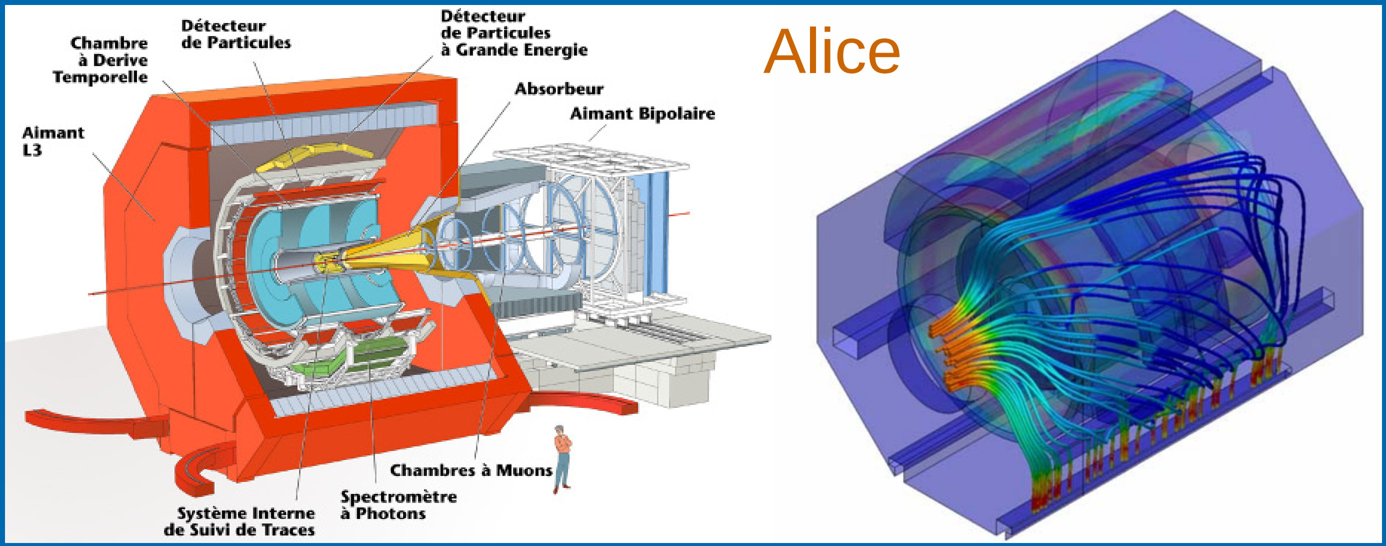
# TS/CV/DC CFD Team




# A Brief Introduction to CFD


**Sara C. Eicher**

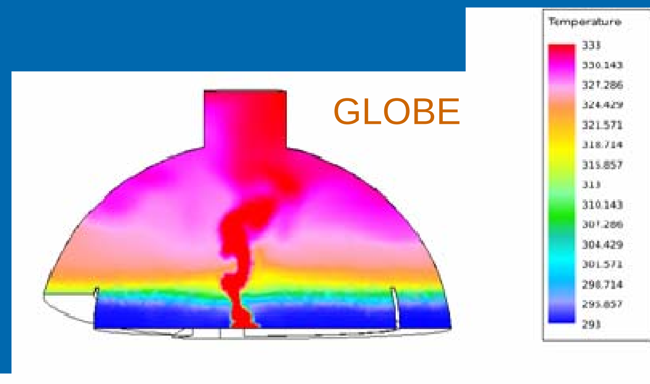
**CERN, CH**

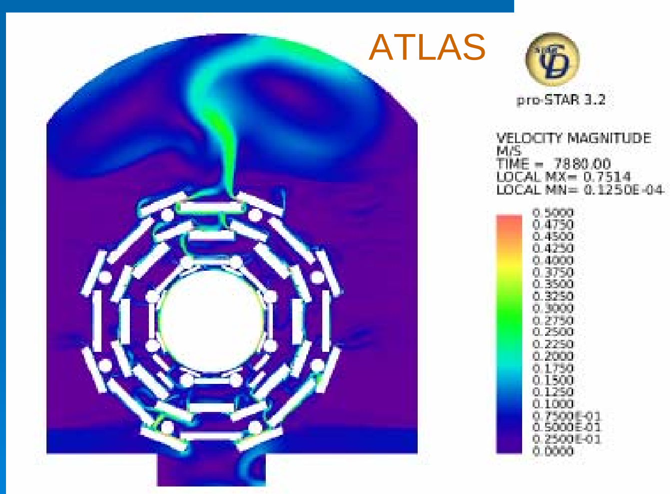
# Outline of Presentation

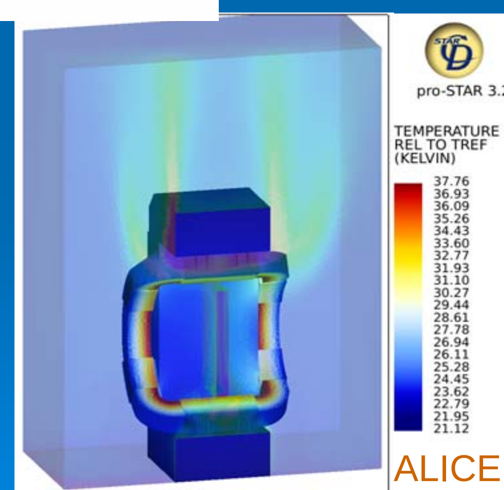
- What is CFD?
- CFD Structure
- Planning Strategy
- Errors and Uncertainties
- CFD Solving Steps

# What is CFD?

- **Solution of fluid dynamics problems by means of a computer based simulation**

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# What is CFD?

- Set of partial differential equations describing conservation laws for transport of mass, momentum, energy

| | |
|---|---|
| Mass | $\frac{\partial \rho}{\partial t} + div(\rho \mathbf{u}) = 0$ |
| *x*-momentum | $\frac{\partial (\rho u)}{\partial t} + div(\rho u \mathbf{u}) = -\frac{\partial p}{\partial x} + div(\mu \, grad \, u) + S_{Mx}$ |
| *y*-momentum | $\frac{\partial (\rho v)}{\partial t} + div(\rho v \mathbf{u}) = -\frac{\partial p}{\partial y} + div(\mu \, grad \, v) + S_{My}$ |
| *z*-momentum | $\frac{\partial (\rho w)}{\partial t} + div(\rho w \mathbf{u}) = -\frac{\partial p}{\partial z} + div(\mu \, grad \, w) + S_{Mz}$ |
| Internal energy | $\frac{\partial (\rho i)}{\partial t} + div(\rho i \mathbf{u}) = -p \, div \, \mathbf{u} + div(k \, grad \, T) + \Phi + S_i$ |
| Equations of State | $p = p(\rho, T)$ $\quad i = i(\rho, T)$ |

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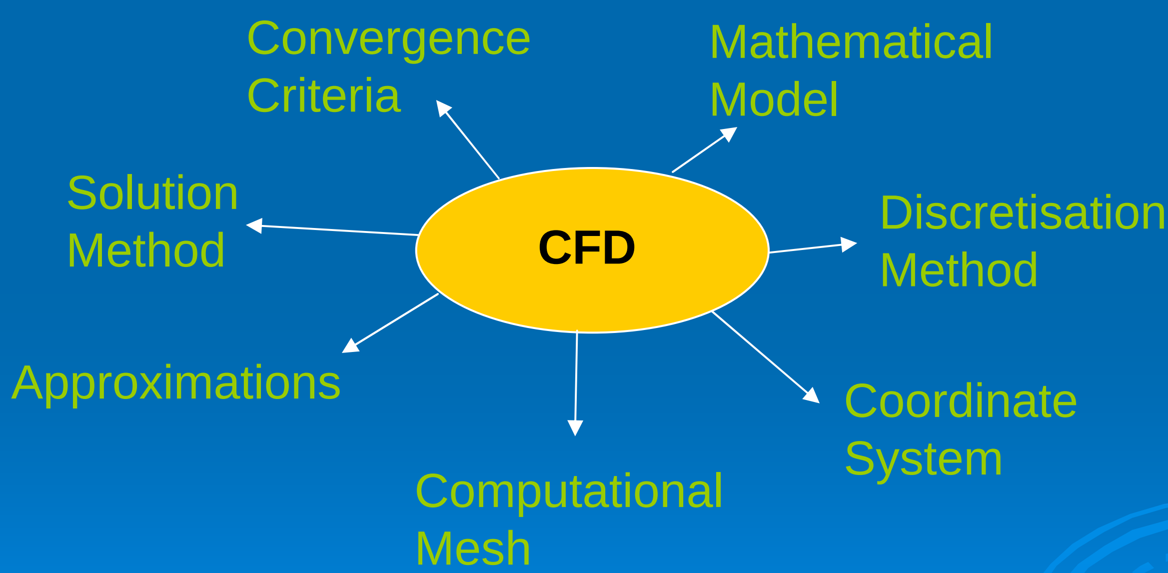
# What is CFD?

- Solution of fluid dynamics problems by means of a computer based simulation
- Set of partial differential equations describing conservation laws for transport of mass, momentum, energy
- **Components of a Numerical Simulation:**

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# CFD Structure

- CFD code consists mainly of three modules:

  - Pre-processor – problem formulation and mesh construction
  - Solver – solution of the discretised governing equations
  - Post-processor – analysis and display of results

- But firstly plan your analysis

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# Planning Strategy

1. State clearly the objective of the study: what are the required results and degree of accuracy (engineering quantities, performance, overall behaviour, etc)

2. What conditions are known? (freestream conditions, overall geometry configuration, etc)

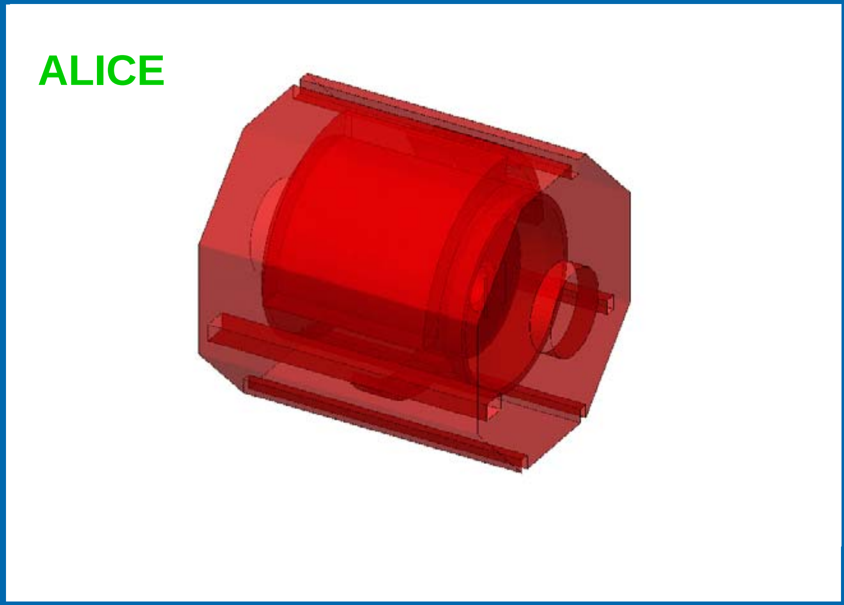
3. Choose suitable computational model: decide domain representation and boundary conditions to apply; can we use 2D or 3D, what grid topology is most suited, etc)

4. Get values for appropriate physical parameters (density, viscosity, etc)

5. Choose suitable physical models: is the flow inviscid, laminar or turbulent, steady or unsteady, incompressible or compressible; is heat transfer, combustion, particle transport important?

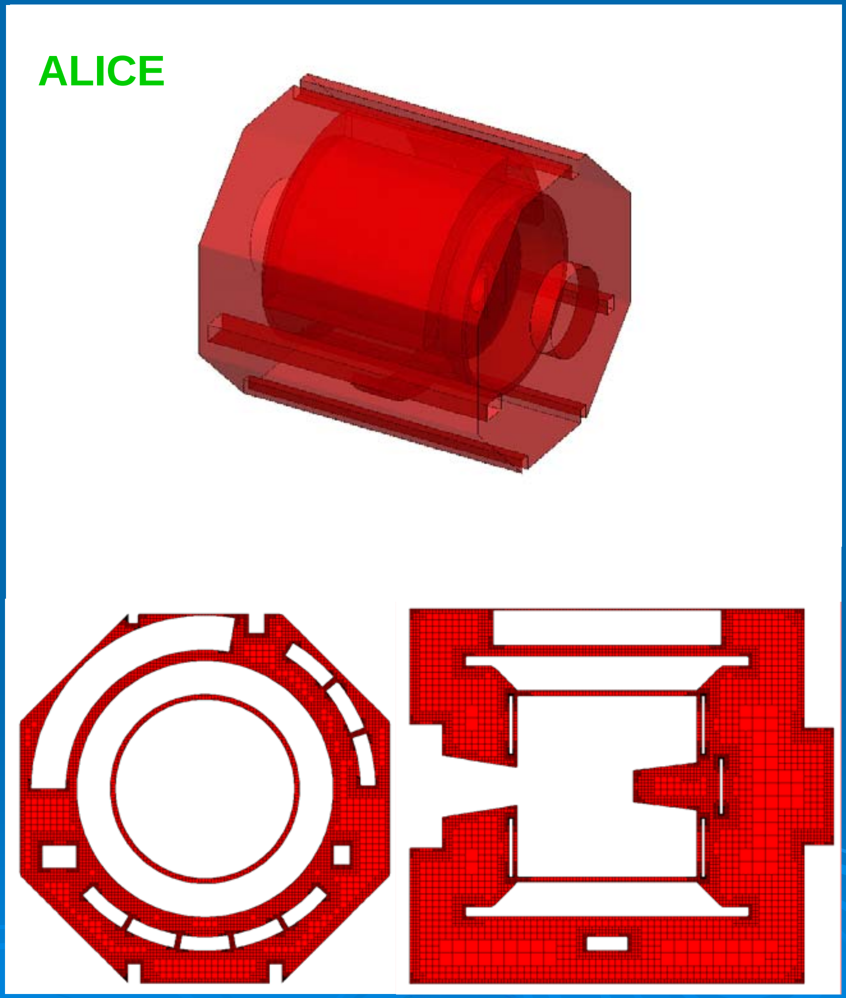
# Pre-Processor

- **Geometry Modelling**
- Mesh Generation
- Physical Models
- Boundary Conditions
- Setup of Solution Method



# Pre-Processor

- Geometry Modelling
- **Mesh Generation**
- Physical Models
- Boundary Conditions
- Setup of Solution Method

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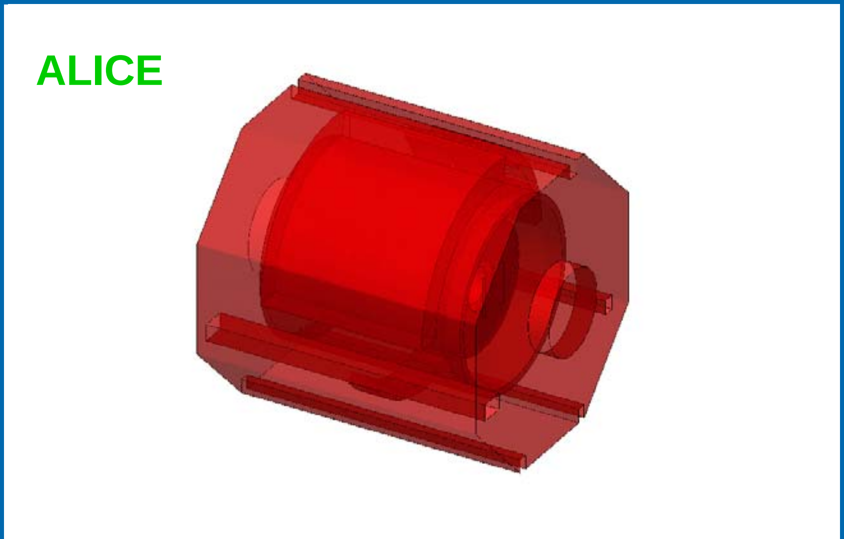
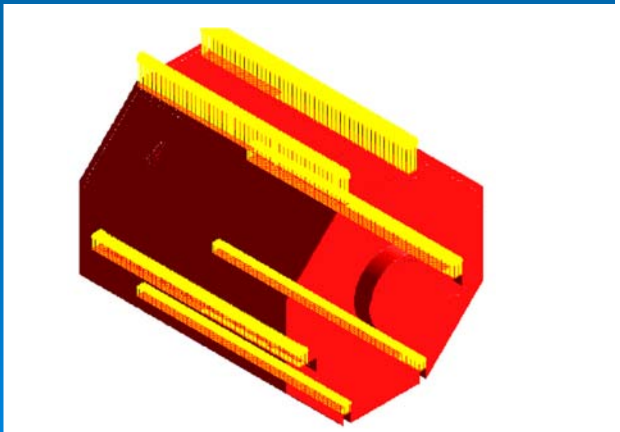
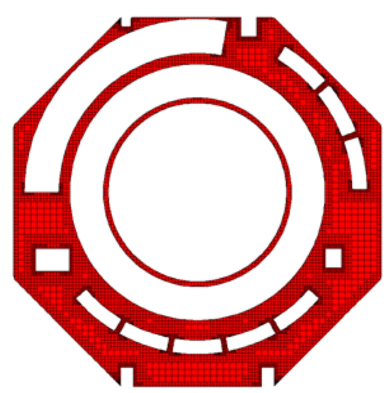
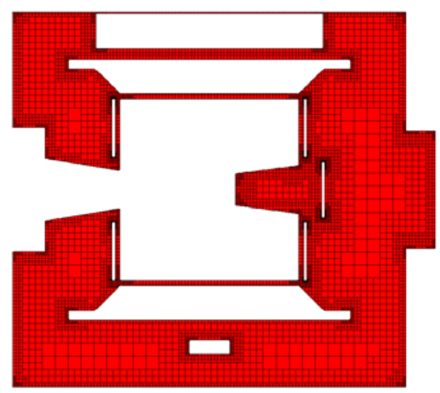
# Pre-Processor

- Geometry Modelling
- Mesh Generation
- **Physical Models**
- **Boundary Conditions**
- **Setup of Solution Method**







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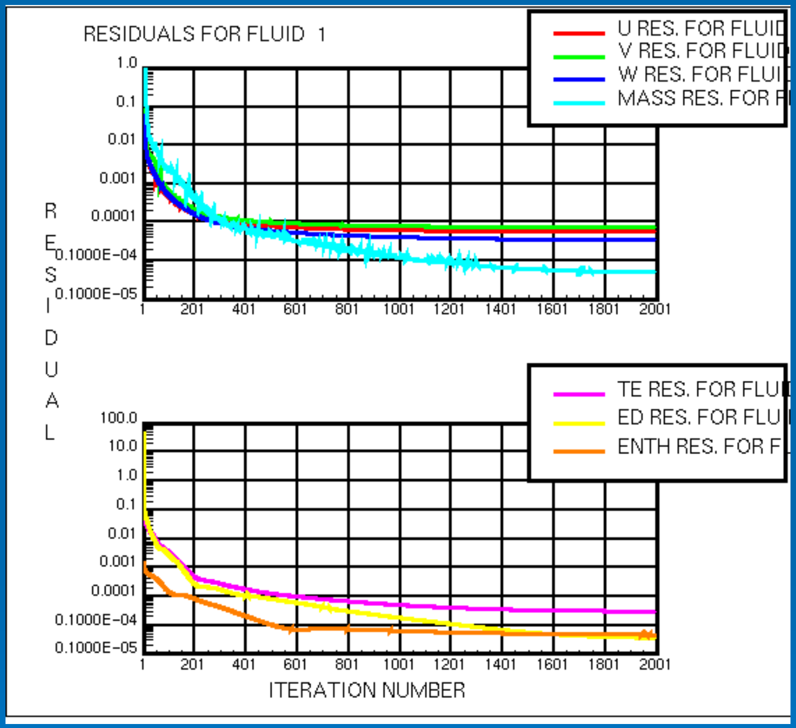
# Solver

- Input Files
- Calculation
- Running Times
- Monitoring Calculation Progress

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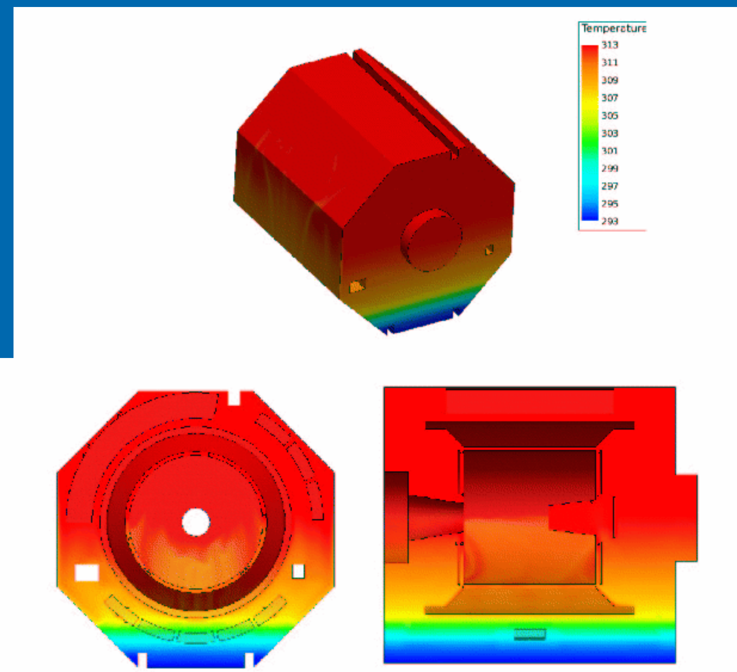
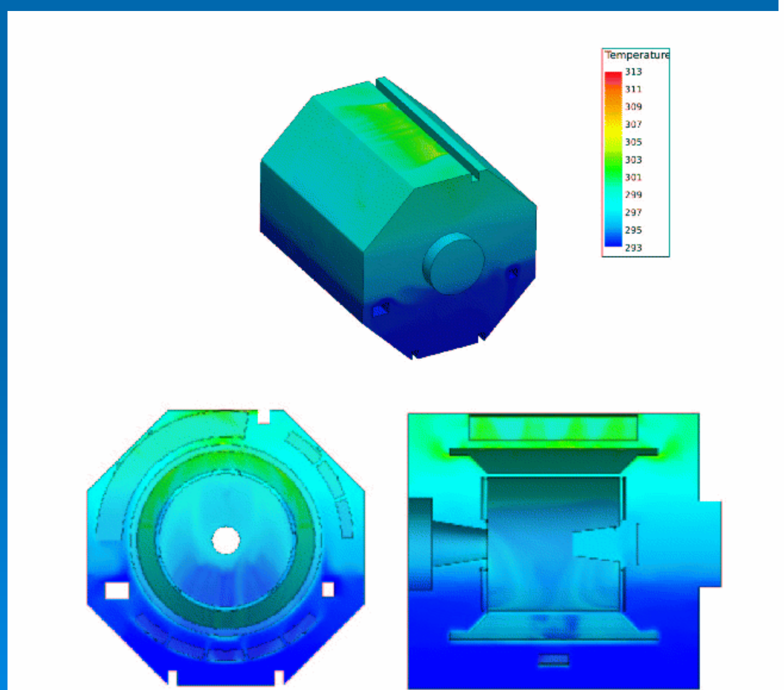
# Post-Processor

- Results Manipulation and Display
- Further Analysis
- Report Findings

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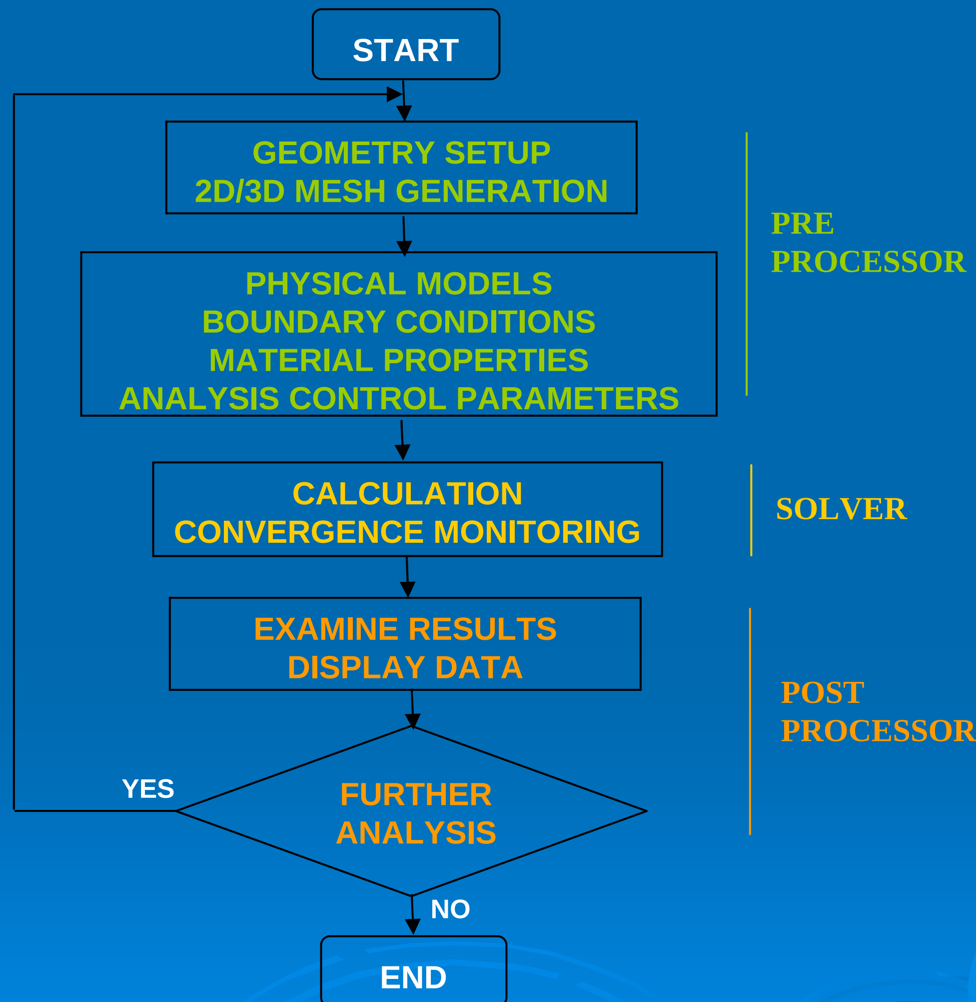
# Errors and Uncertainties

- Modelling Errors
- Discretisation or Numerical Errors
- Iteration or Convergence Errors
- Round-off Errors
- Problem Uncertainties
- User Errors
- Code Errors

# CFD Solving Steps

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