CAPACITIES
FP7 Support Action - European Exascale Software Initiative
DG Information Society and the unit e-Infrastructures

Addressing the Challenge of Exascale

European Exascale Software Initiative EESI

Towards Exascale roadmap implementation

EESI2 – Recommendations

Identification of turbulent flow features into massively parallel Exascale simulations

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Identification of turbulent flow features into massively parallel Exascale simulations

Motivations: ease users to extract pertinent turbulent flow features from large amount of data

- Data mining in large-scale turbulent simulations applied in many fields:

➔ climate, meteorology, combustion, aerodynamics, astrophysics, fusion, …

- Example 1: ignition of an annular combustion chamber (Philip et al 2014)
- Example 2: spray / precessing vortex core interaction (Guedot et al 2015)

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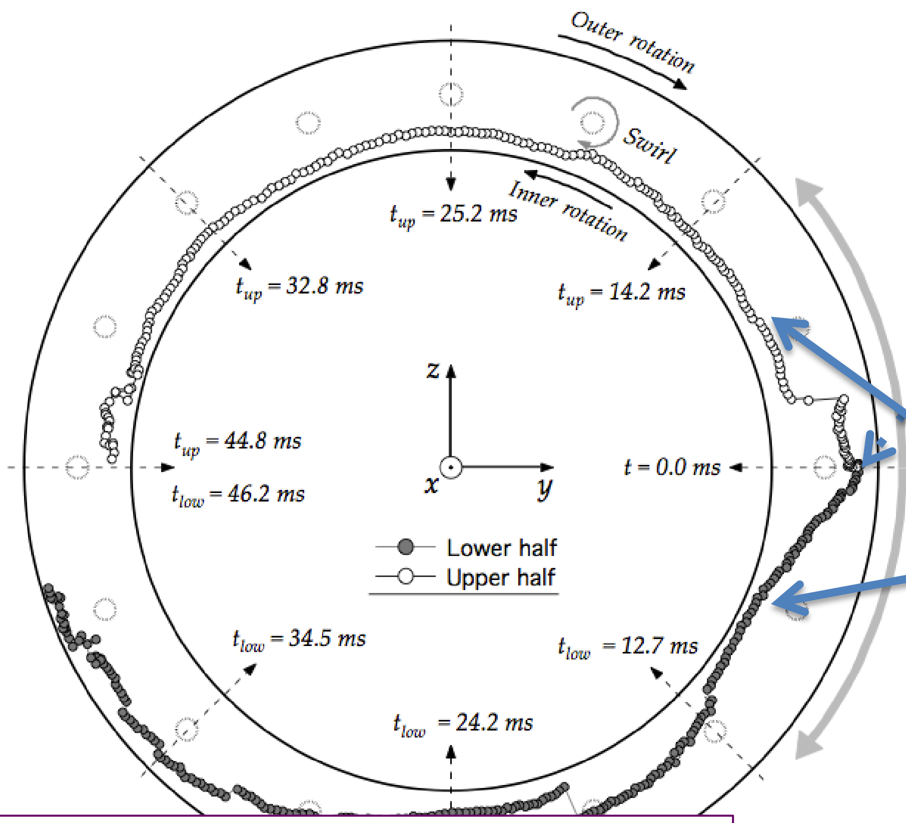

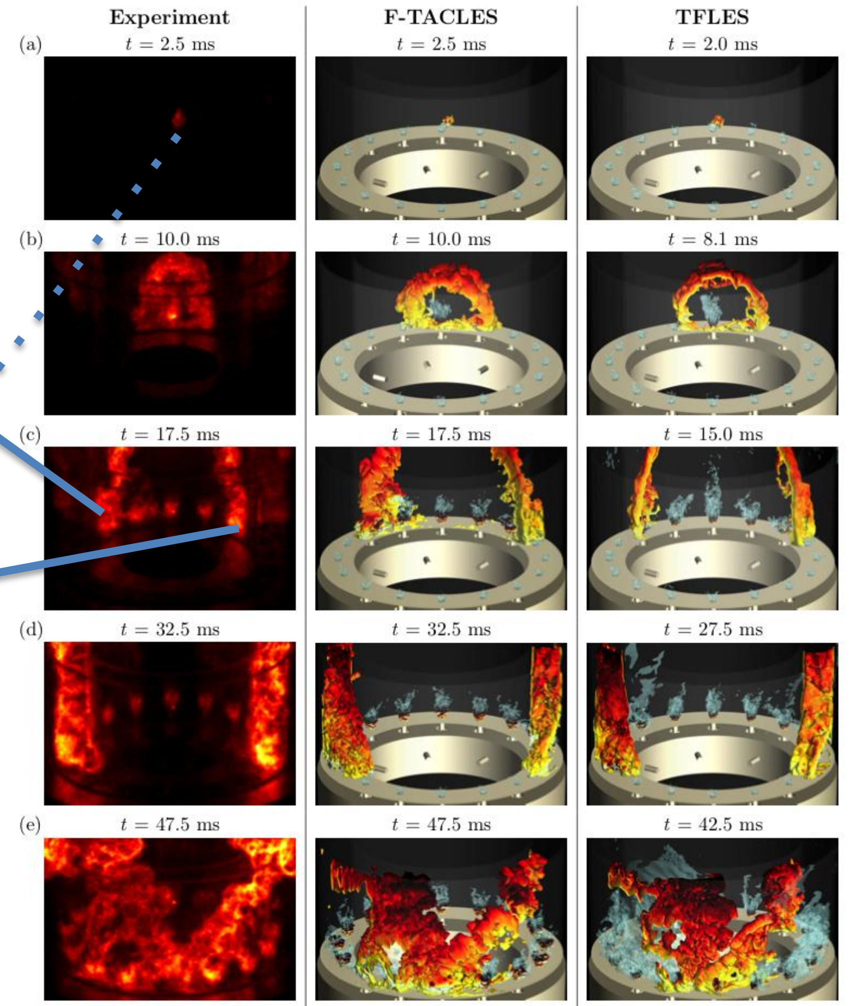

Track the flame front propagation

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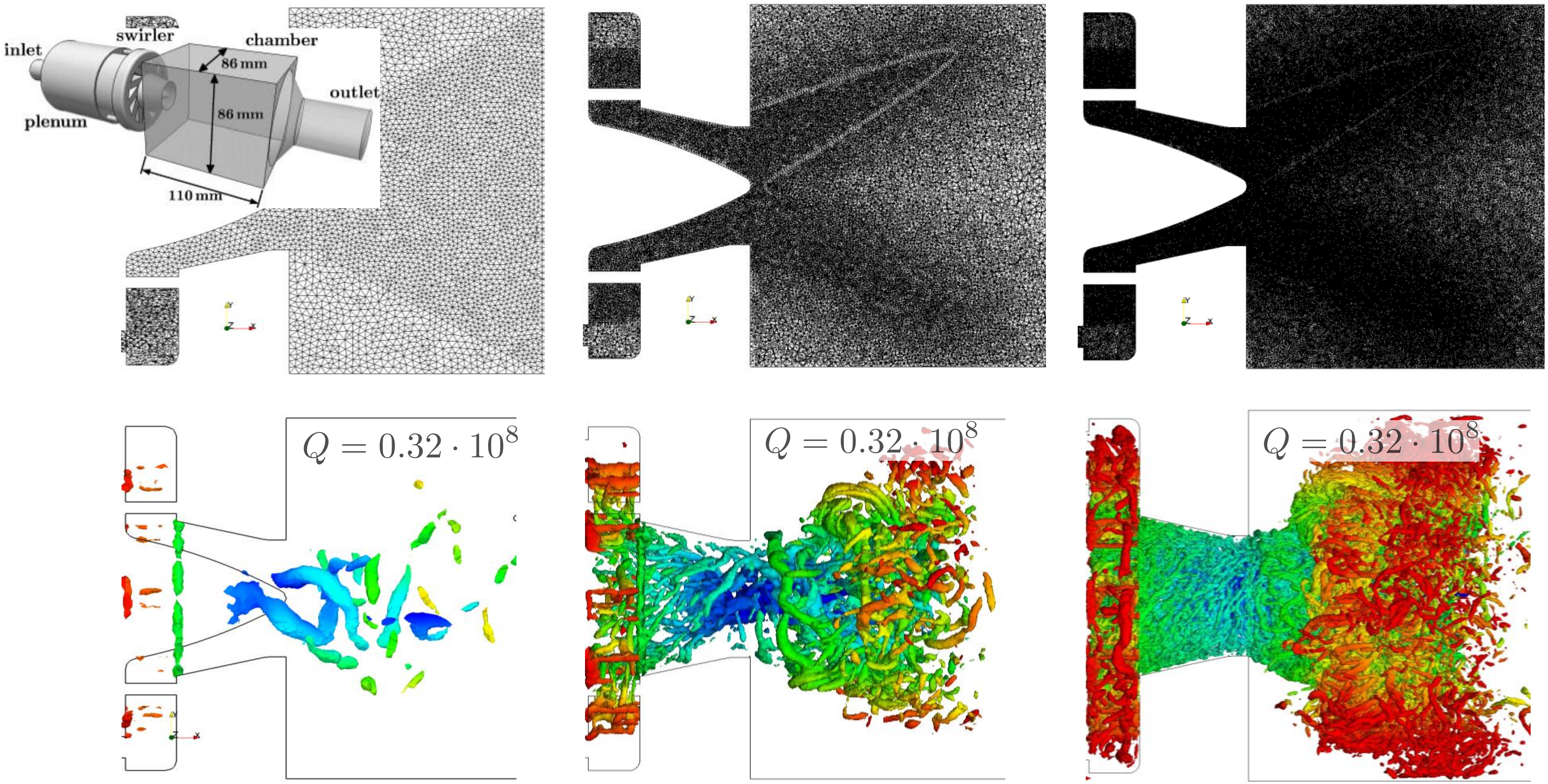

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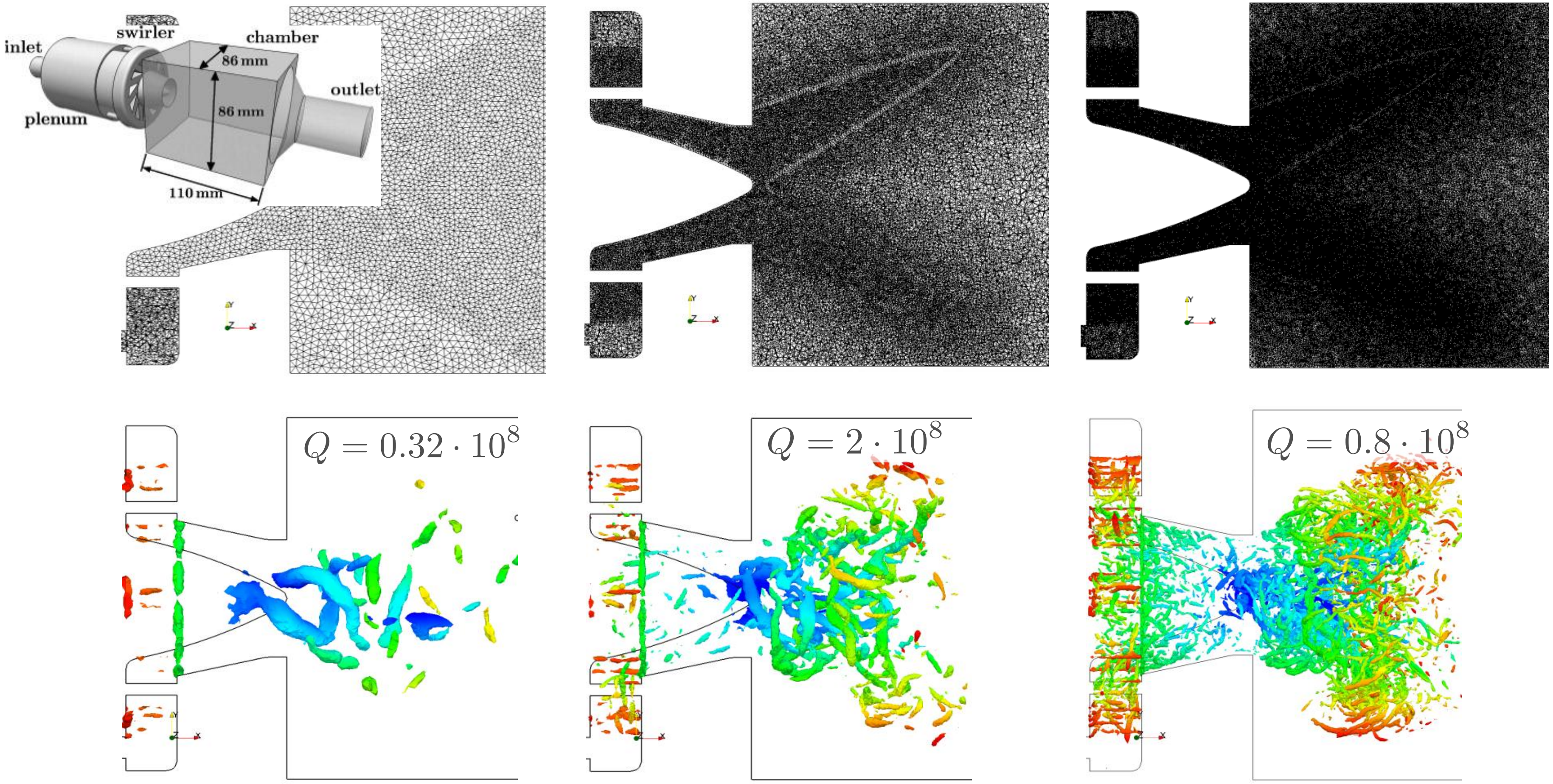

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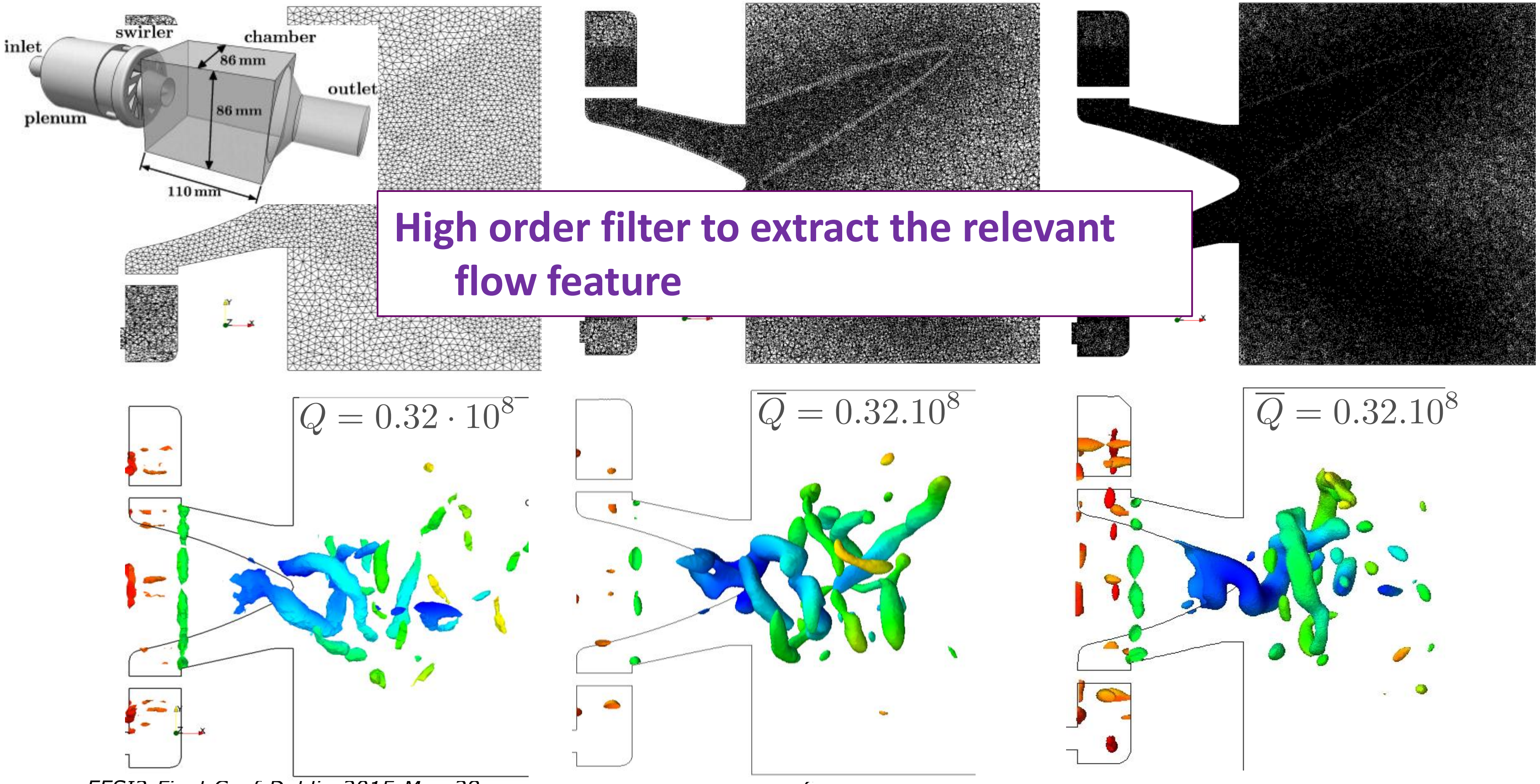

High order filter to extract the relevant flow feature

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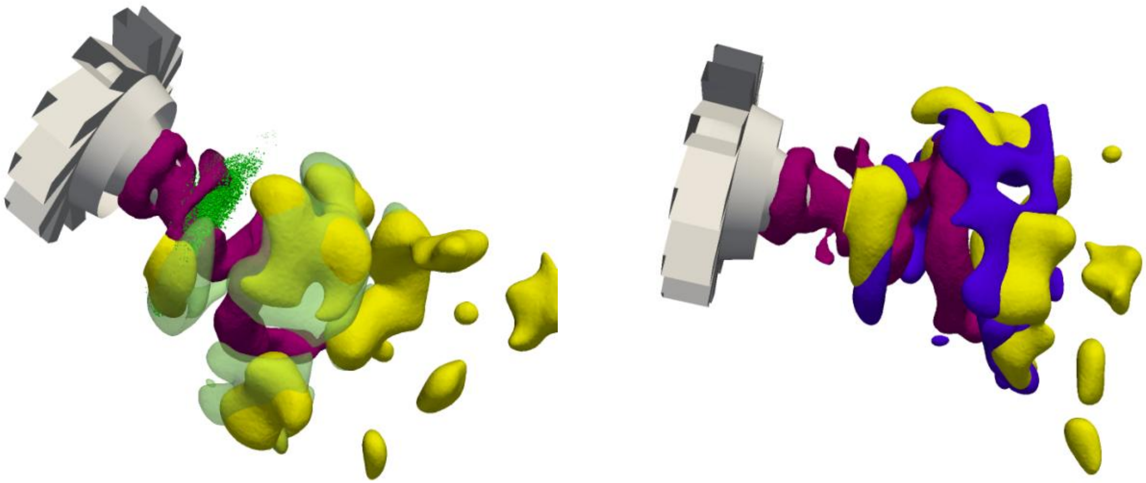
- Example: spray / precessing vortex core interaction (Guedot et al 2015)
  - PVC modifies spray shape in the injection area
  - Evaporation initiated at preferential azimuthal position
  - Kerosene evaporated in helical patterns due to convection and PVC precession
  - Flame shape is helical

    → Periodic fluctuations in heat release

PVC
Spray
Evaporation rate
Fuel mass fraction
Heat Release



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Motivations

- More and more unsteady flow simulation (LES and DNS)
- Large amount of data generated:
  - Billion cells simulations
  - Time dependant data
- Traditional ways to analyse data:
  - First and second moment of averages (mean and RMS),
  - Animations,
  - Modal decompositions: FFT, POD, DMD …
- For coming applications:
  - Large amount of data → existing tools will be limited (memory, CPU)
  - Reduce data when possible
  - Extract more pertinent information for science and design
  - Store only a reduced amount of informations

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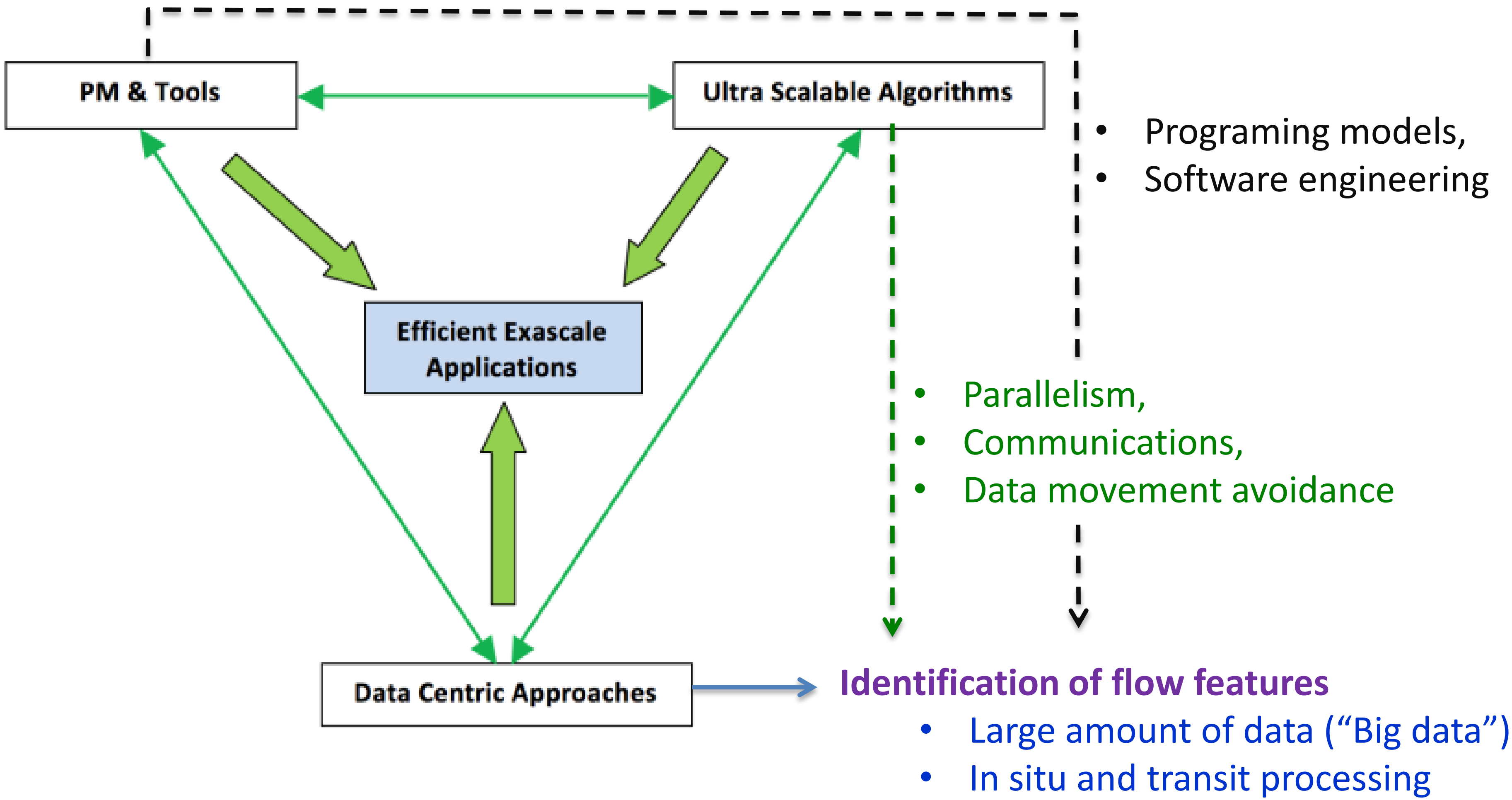

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Proposal : Fund R&D programs in order to explore

- On the fly and post-moterm treatments
- Parallel applications
- Smart tools
- Versatile to be applied to realistic geometries
- Maximize data reuse (performance)
- Minimize data movement (energy saving)
- Methods to be investigated:
  - Massively parallel high order low-pass and band-pass filters
  - Conservative high-order interpolation kernels to reduce data on coarser grids
  - Massively parallel singular value decomposition algorithms
  - Highly efficient linear solvers for symmetric matrices to treat matrices produces by implicit filters
  - Data mining: reduction, ordering, partitioning …
  - Trajectory based flow feature tracking