Massively Parallel simulation of combustion in Gas Turbines
European Centre for Research and Advanced Training in Scientific Computation

- Electromagnetism
- Global Change and Climate Modeling
- Aviation and Environment
- Parallel Algorithms
- CFD:
  - Aerodynamics
  - Combustion
Objectives

- Perform 360° full combustion chamber simulation for current R&D challenges in Gas turbines:
  - Thermo-acoustic Instabilities
  - Quenching
  - Ignition / Re-ignition
Ignition
CERFACS's code : AVBP

- Massively parallel : MPI / Fortran (with C allocations)
- Large Eddy Simulations approach:
- Compressible
  - AIAA J. May 2004
- 3rd order space and time accuracy
- Thickened flame model
- Hybrid grids and unstructured meshes
The drive towards real engine simulations
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(1) 40M cells case - 1 step chemistry
(2) 18M cells case - 1 step chemistry
(3) 75M cells case - 1 step chemistry
(4) 37M cells case - 1 step chemistry
(5) 29M cells case - 7 step chemistry
(6) 10M cells case - No chemistry
I/O Patterns and Strategy

- Master / Slave parallel pattern:
  - I/O handled by MASTER core only (synchronisation required).
  - PHDF5 under study (limitation of parallel file systems).

- Two computing modes:
  - All process compute: Compute server mode
  - Only slaves compute / Master handles I/O only: Distinct server
I/O Patterns and Strategy

- Unsteady phenomena: A lot of snapshots allowing easy restart.

- Dynamic partitionning and a root / multiple master strategy is studied to increase I/O performance.
Performance

- Performance has been analyzed with PAPI, Tau and performance analyser (intel).

- Possible bottlenecks:
  - Specific sub-communicator for low memory version to use all reduce.
Status and Scalability

- Today: 10k cores, Tomorrow: 50k.
- Ideal Cells/proc ratio in BGP seems higher than in BGL.
- Global communications seem to exert a great toll on performance: communication scheme?
- Current scalability was achieved by developing the low memory version of the code and synchronization of the processors prior to send/receive of “big” buffers on BGL (not needed in BGP).