Fusion Activities at CIEMAT ICT Division

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on behalf of the development team

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Information Society and Media

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Intro (1)- CIEMAT ICT Division

- **CIEMAT**
  - Spanish Public Organism for Research and Technological Development since 1951
  - Computation activities from the 50s of the previous Century
    - Many scientific fields: Fusion, HEP, Environmental Sciences…
    - Many platforms: Vectorial, Cray, Altix, cc-NUMA, X86...
    - Open to any researcher (not only to the CIEMAT staff)
    - Some examples
      - *Uniac Solid State UCT – 1959*
      - *Univac machines (1110/81 by terminal) – 70s*
      - *Cray Computers (T3E parallel arch) – 90s*
      - *SGI Origin/Altix machines (Linux) – XXI Century*
      - *Several x86 clusters -> In 2009, new Infiniband cluster with 1052 cores*

Intro (2) - Grid activities at ICT

- **Grid Research activities at ICT Division since 2005**
  - Several Grid projects: EELA, EELA-2, EUFORIA, EPIKH, EGEE, RIB, Spanish e-Science Network...

- **Maintaining Grid Site (TIC-CIEMAT / EELA-CIEMAT):**
  - Offers >200 cores, >10TB
  - ALICE experiment, Biomed, EELA, National Grid Initiative, Ibergrid...
  - VO Fusion : >38.000 jobs successfully executed since January 2009.

- **Porting applications: Biomedicine, Radiotherapy.**

- **Specially focused on codes for Fusion devices**

- **FAFNER2**

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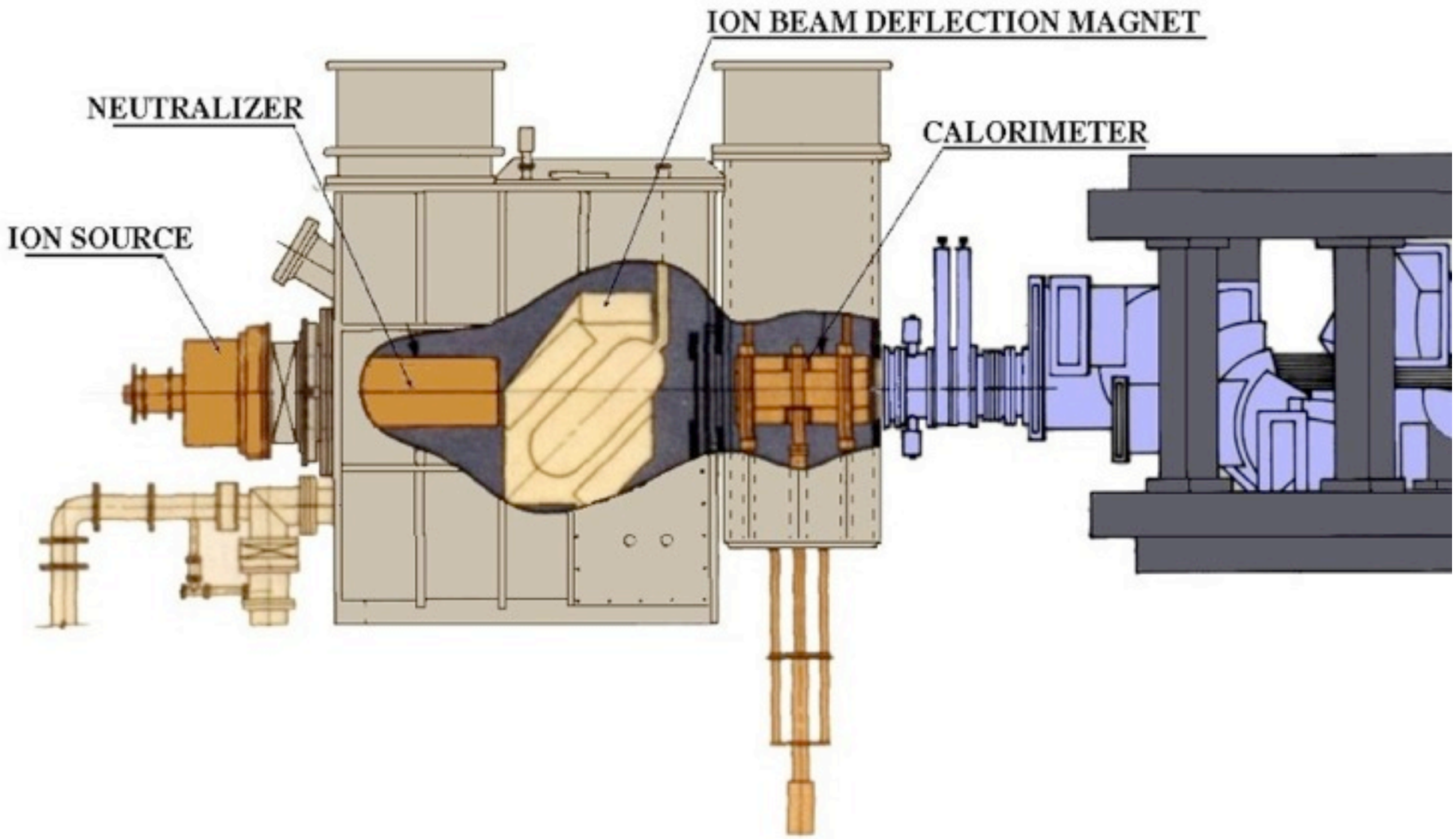
FAFNER2- NBI heating

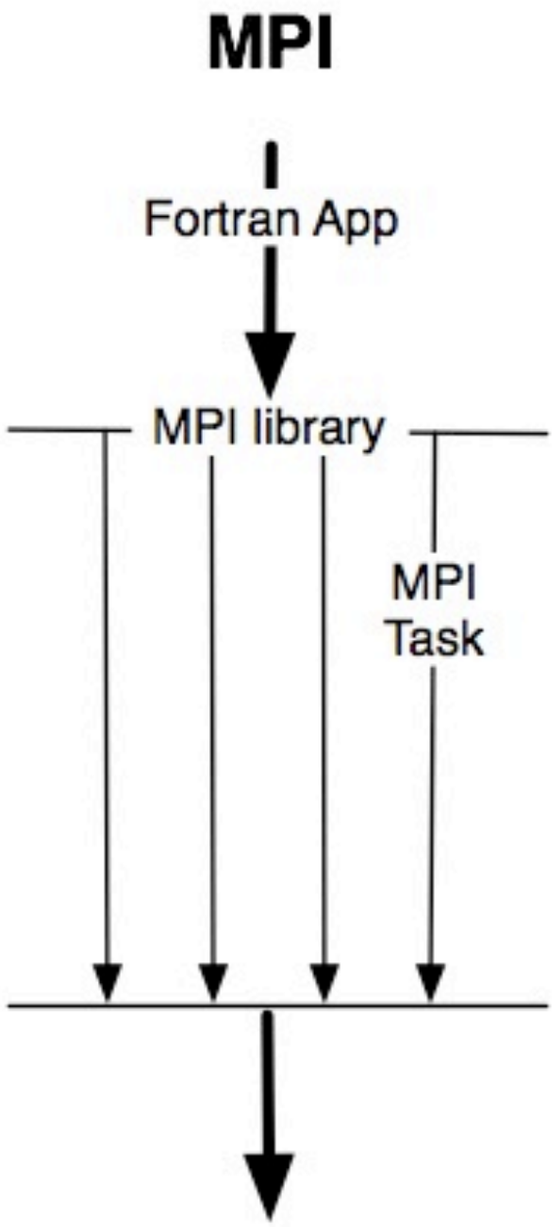
- simulates plasma heating by Neutral Beam Injection
- Employed at TJ-II and ITER

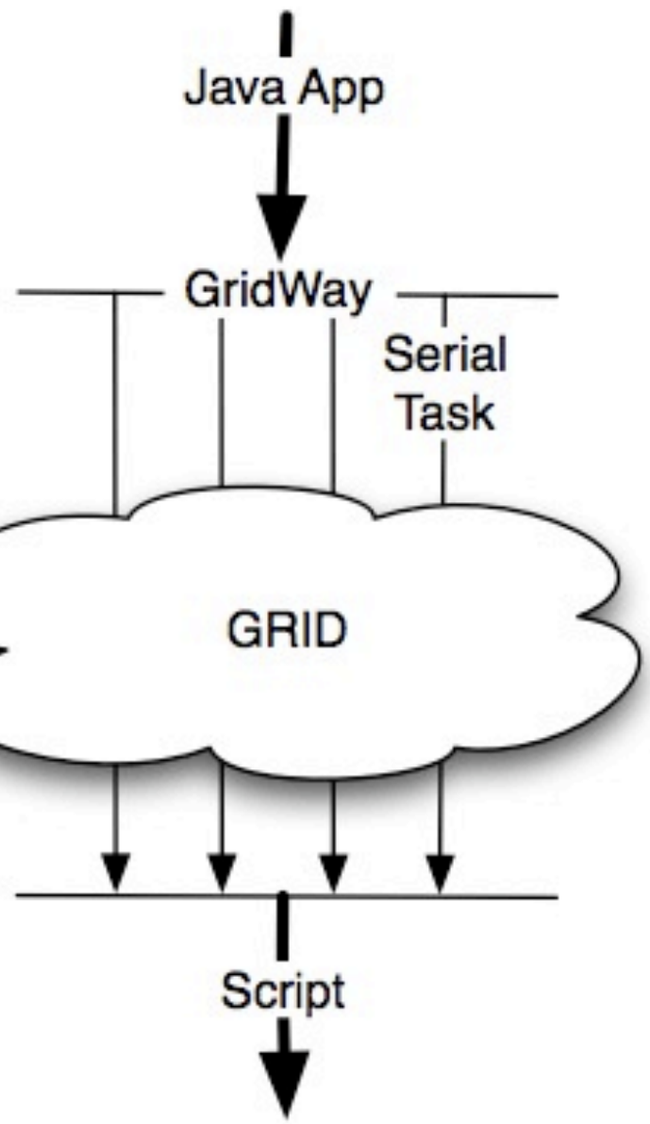


FAFNER2- The code

- **Monte Carlo code**
- **Original version**
  - Modified to include TJ-II geometry
  - updated
    - Irix O.S. over MIPS
    - Parallel library: SHMEM
- **MPI version**
  - Linux over X86
  - Parallel library: MPI
  - Grid Enabled

FAFNER2- Solution(1)





FAFNER2- Solution (2)

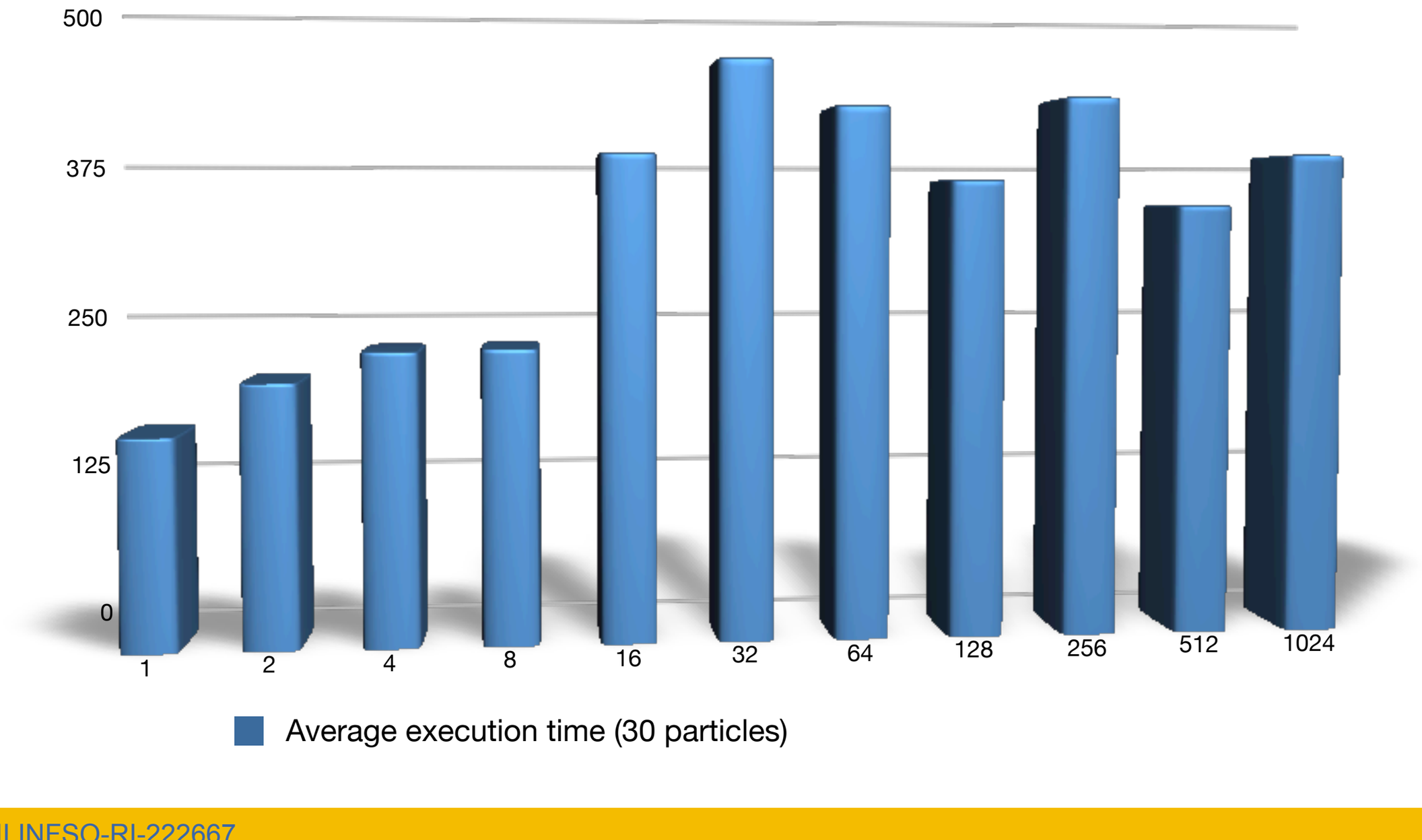
- **Benefits**
  - portability
    - when we started working, MPI not in every site
  - scalability
  - fault tolerance
  - simpler is better
- **Drawbacks**
  - increased network traffic
- **We are maintaining both versions, MPI and DRMAA**

FAFNER2- Results (1)

- **Local overhead**
  - Java DRMAA
    - ~0
  - Post process script: lineal in time
    - output files must be uncompressed and read
    - ~2 seconds/task
- **Grid overhead**
  - Prolog: lineal in network traffic
    - input data (~34 MB) must be transfered for each task
  - Epilog: lineal in network traffic
    - output data (~10 KB) must be transfered for each task
  - Wrapper?

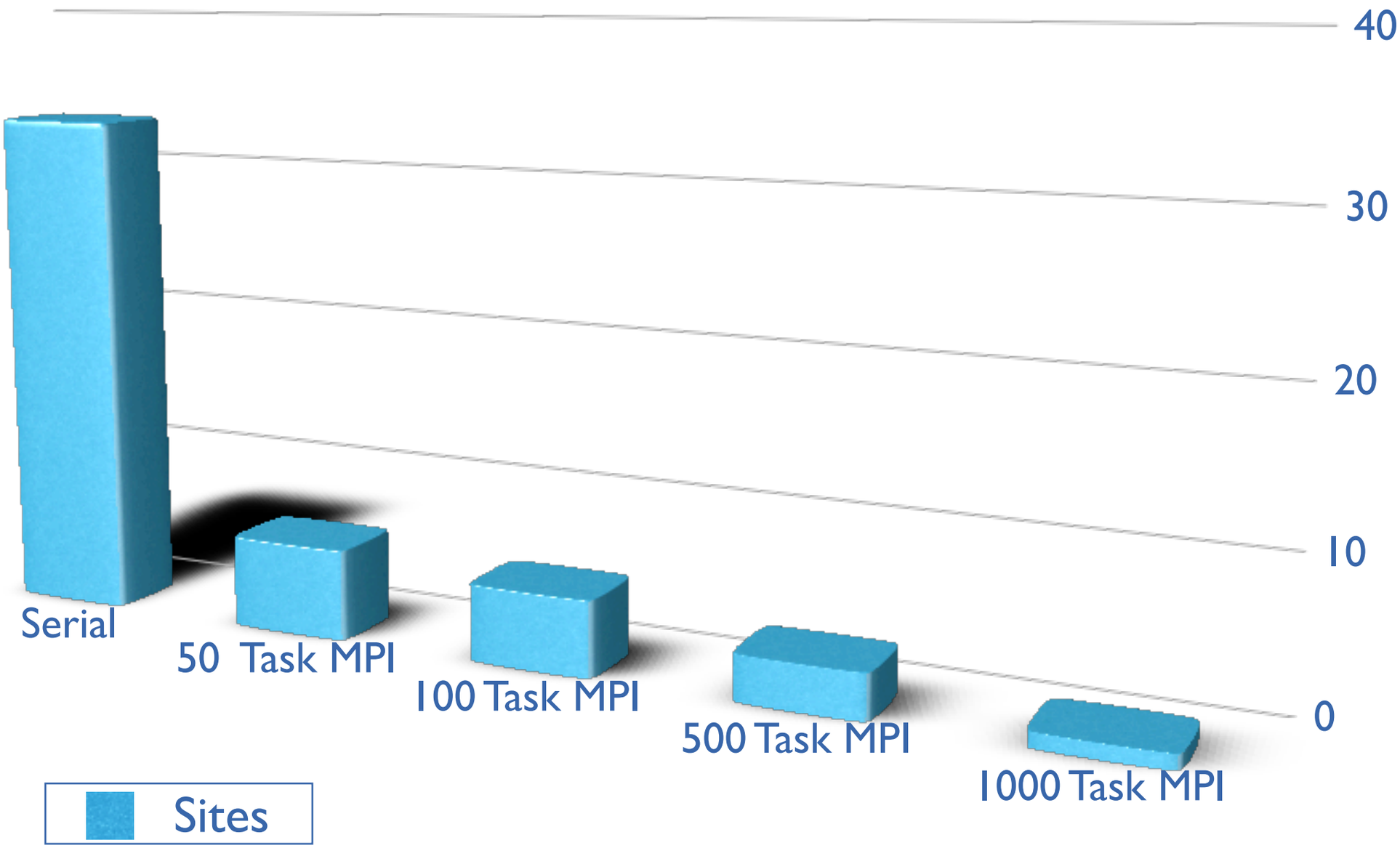
FAFNER2: Results (2)

- **scalability**
  - ~constant execution time: scales correctly

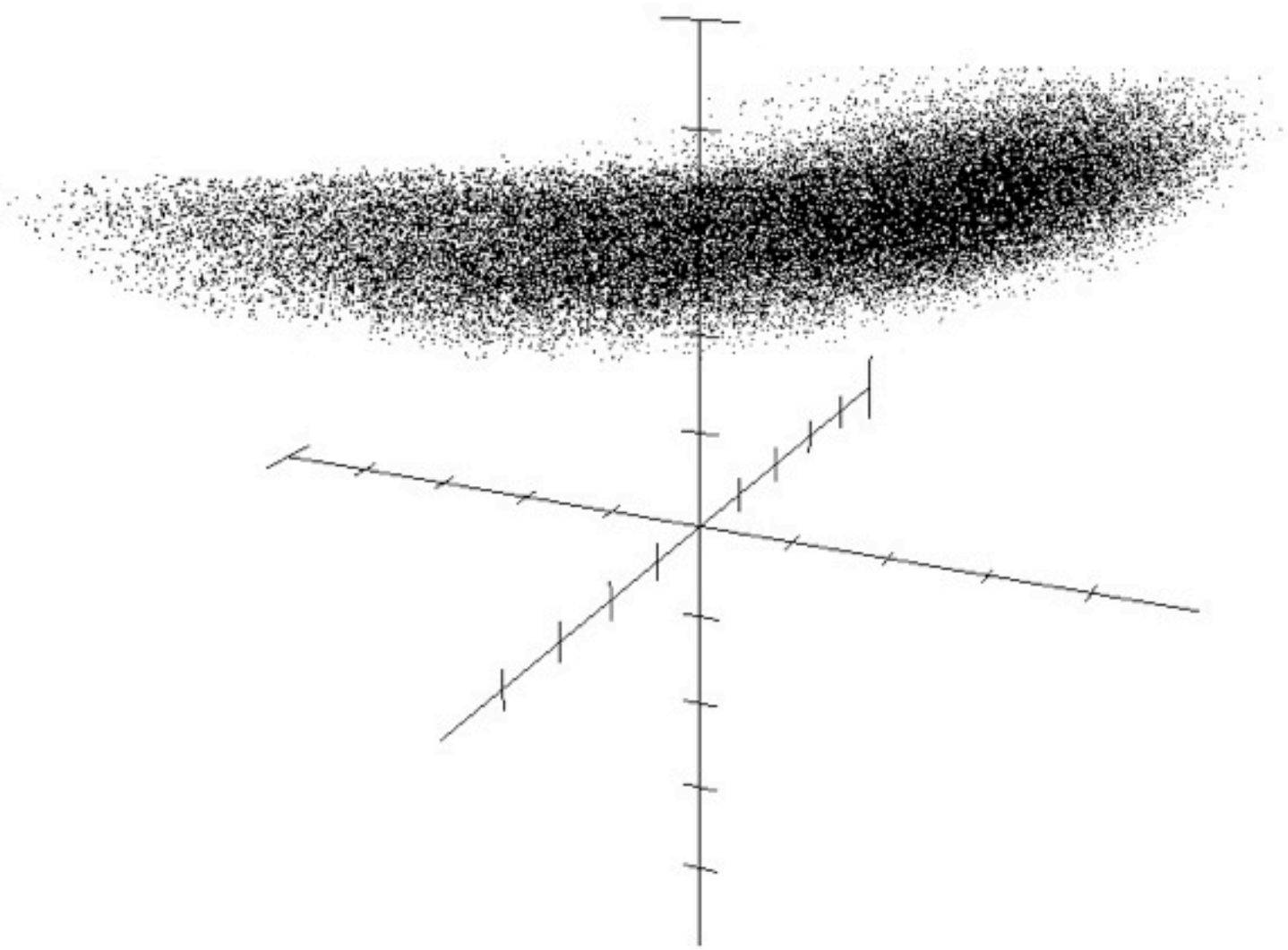


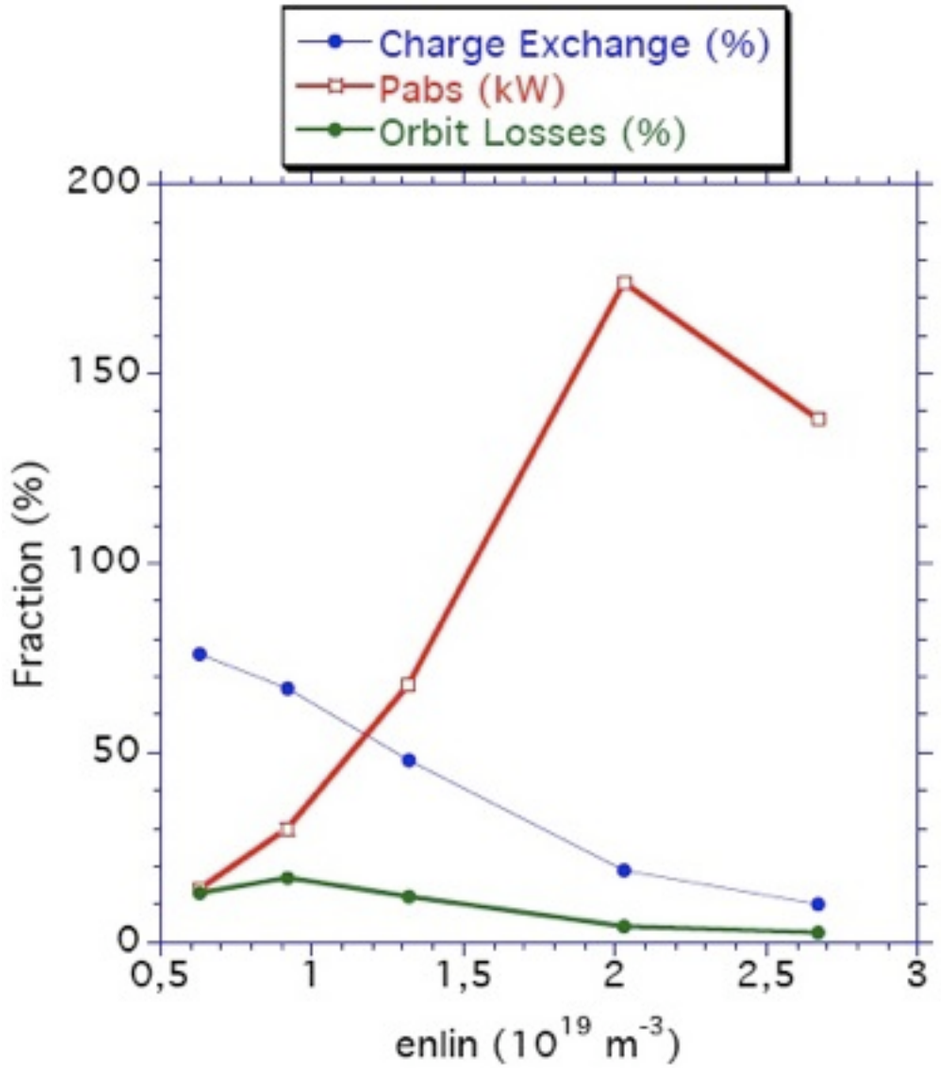
FAFNER2- Results (3)

- **Resource Availability at fusion VO where running a job with a certain degree of parallelism is possible**



FAFNER2- Physical results





- **DKEsG**

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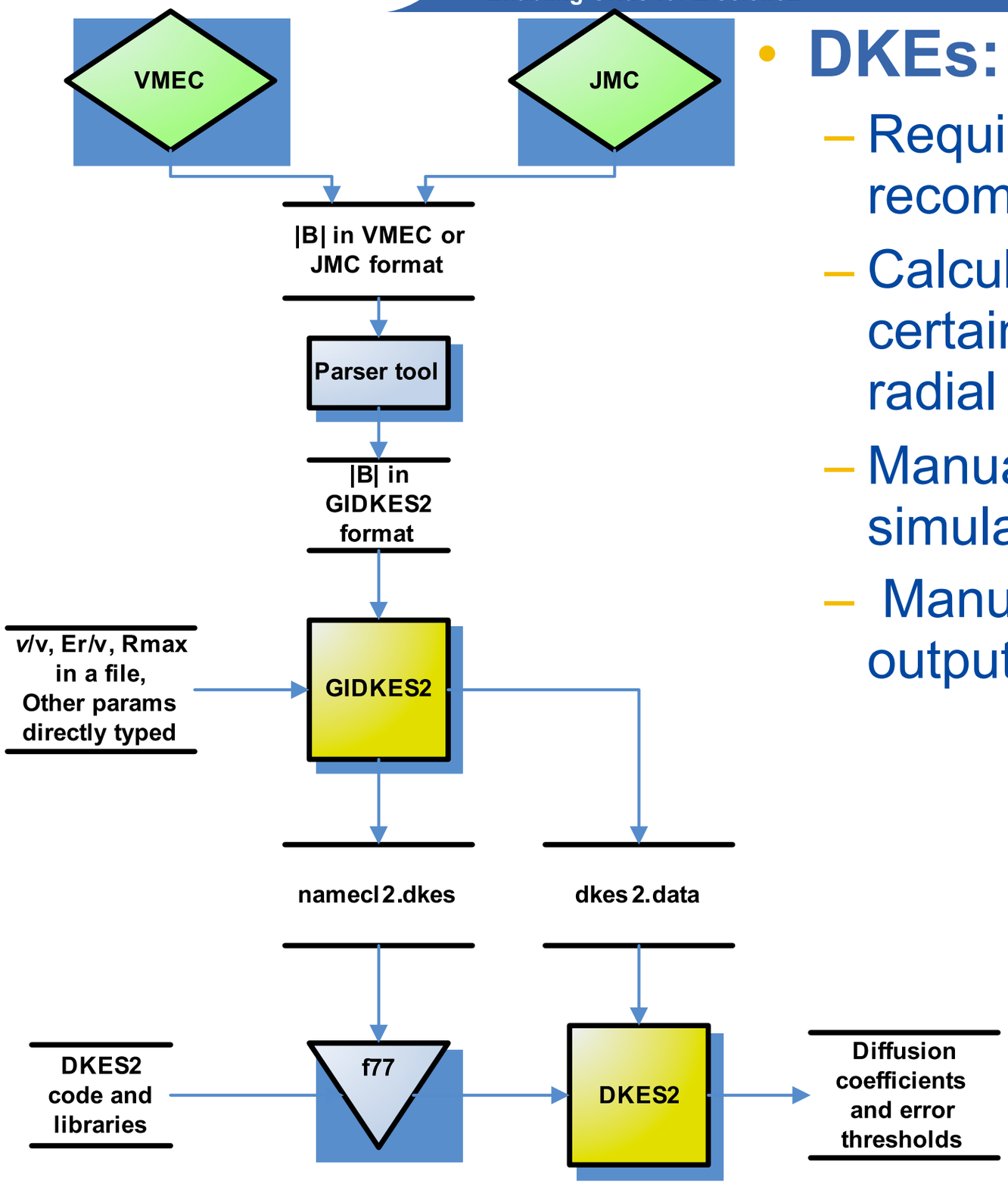
DKEsG- The code

- **DKEs: Drift Kinetic Equation solver**
  - neoclasical transport
  - Kinetic transport: guiding centre orbits in tokamaks and stellarators
  - simulates transport to estimate the energy flux to the plasma wall

- **Variational DKEs version**
  - Obtain upper and lower bounds for the neoclassical diffusion coefficients of a prescribed toroidal plasma equilibrium.
  - Parametric and sequential nature
    - Can be divided in sub-tasks: suitable to grid executions

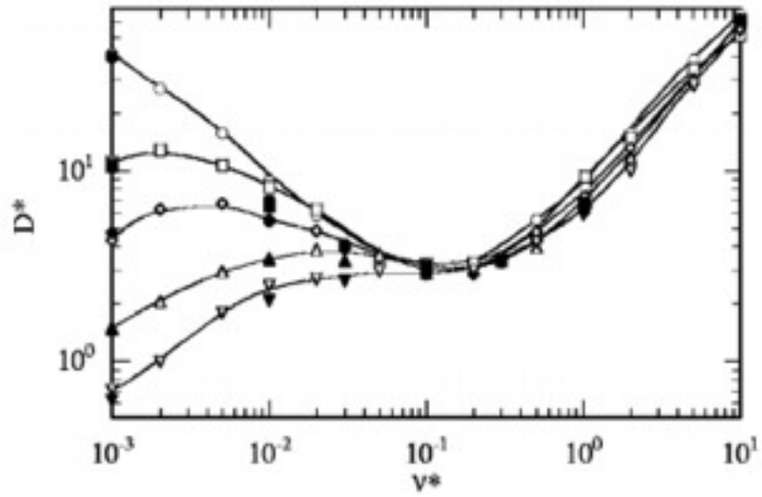
- **Objective: Filling a broad database with the complete [configuration - transport matrix – state]**
  - Bring results to Fusion Community
  - Avoid performing the same simulation twice and easy re-analysis

DKEsG - Problems



- **DKEs:**
  - Requires continuously configuring and recompiling
  - Calculates diffusion coefficients for only a certain number of collisionality/energy and radial electric field values.
  - Manual preparation and execution of simulations.
  - Manual compilation of a high number of output data files.

$$D_{ij}(K,\upsilon,\phi)$$



DKEsG - Solution (1)

- **DKEsG: a true distributed compatible application**
  - High level implemented on DRMAA Standard
  - Low level calculations based on Var. DKES
    - All code in a nutshell
    - No software must be installed in resources.
    - Only a binary per architecture and algorithm module
  - Easy to include new modules (transport coefficients)
  - Enable integration in complex workflows at application level and databases
  - Independent GUI

DKEsG- Solution (2)

- **DKEsG**
  - Calculate neoclassical transport coefficients

$$L_{ij}(n,T,\phi) = L_{ij}(\upsilon,\phi) = \frac{2n}{\pi}\int_0^\infty dK\sqrt{K}e^{-K}g_i(K)g_j(K)D_{ij}(K,\upsilon,\phi)$$

  - Reusing Var. DKES code
  - Reduce time execution & increase precision
  - Easy interaction with other Fusion applications

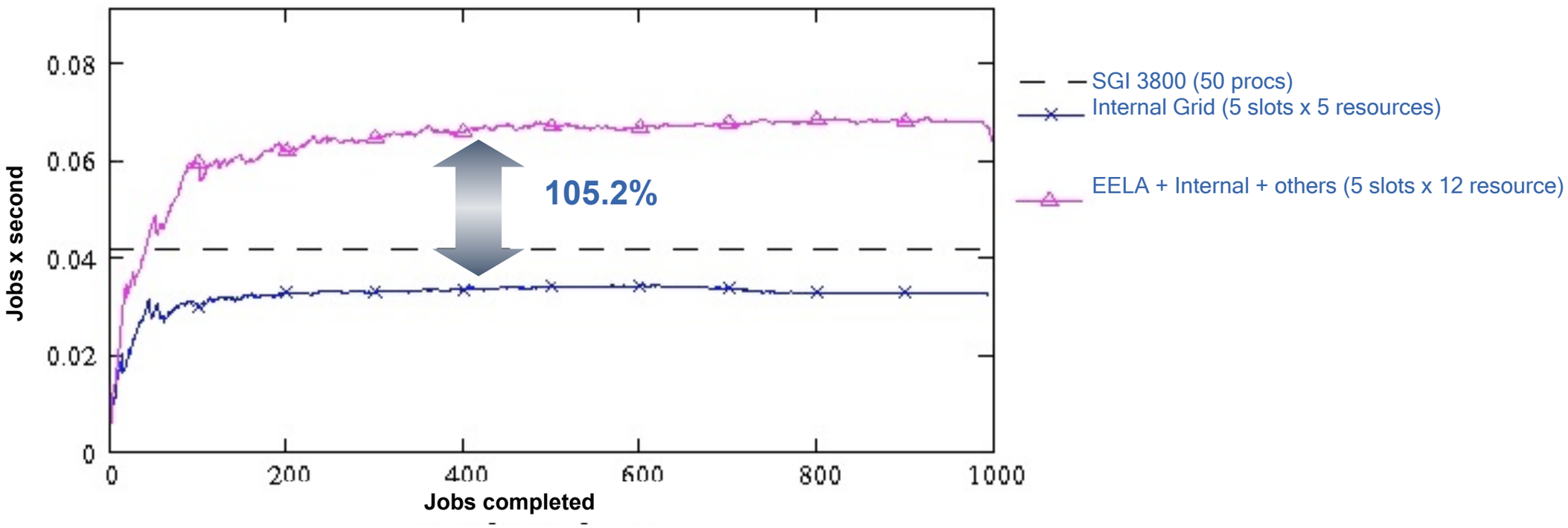
DKEsG- Results

Calculate diffusion coefficients : ~ 450 seconds

- **Xeon 3.2 GHz (2006)**
- **343 Fourier modes**
- **100 Legendre polynomials**
- **Energy and electrical field fixed**

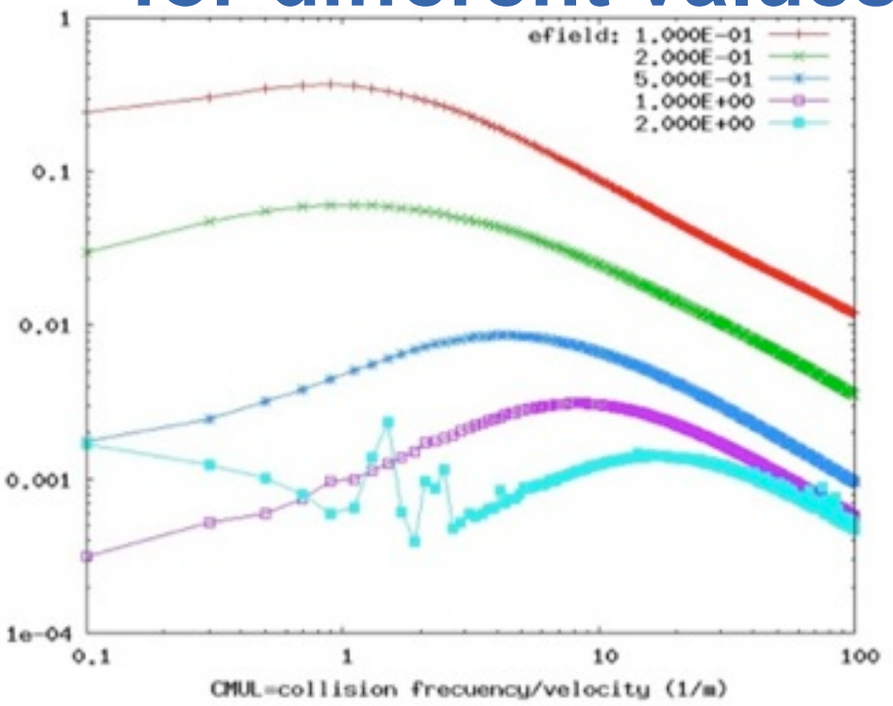
→ **1000 executions = 5,20 days**
In a single Xeon processor

1000 executions = 4 hours 22 minutes
Using 55 slots distributed among EELA and local resources



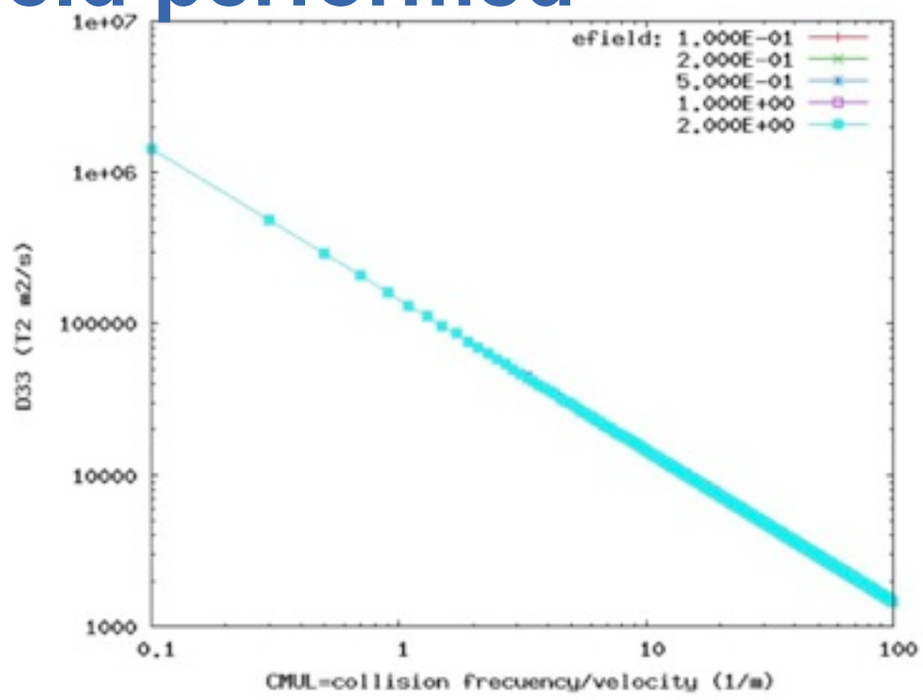
DKEsG- Physical results

- **monoenergetic coefficients as a function of collisionality for different values of the electric field performed**

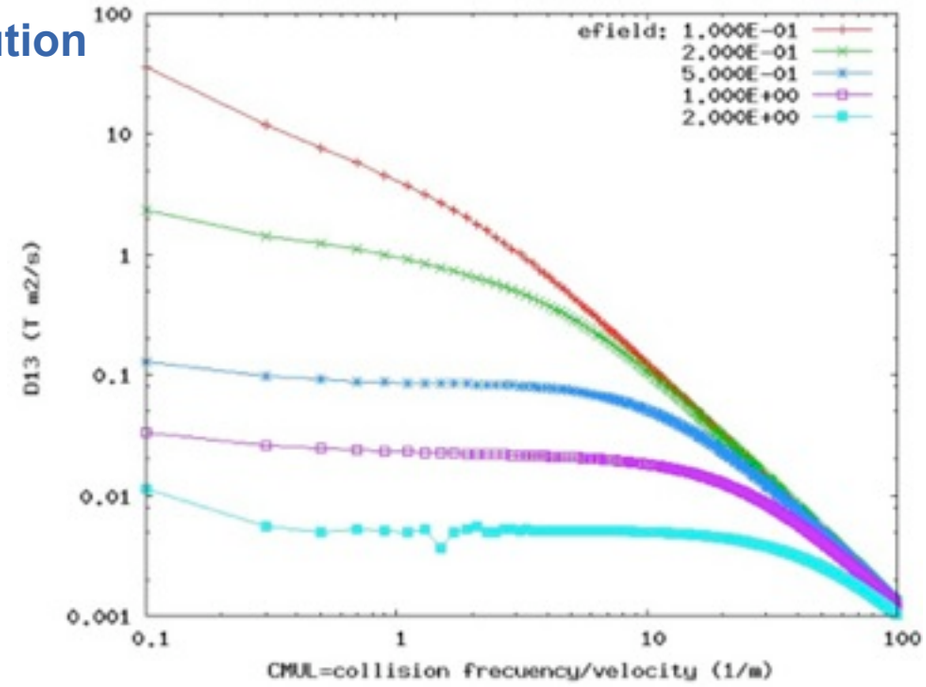


density and temperature distribution

bootstrap current



resistivity enhancement



- **gGEM**

gGEM- The code

- **GEM: Gyrofluid Electromagnetic Model**
  - studies turbulences of the core
- **Usually run in High Performance Computers**
  - highly coupled application
  - CPU intensive

gGEM- Solution

- **No need for external libraries**

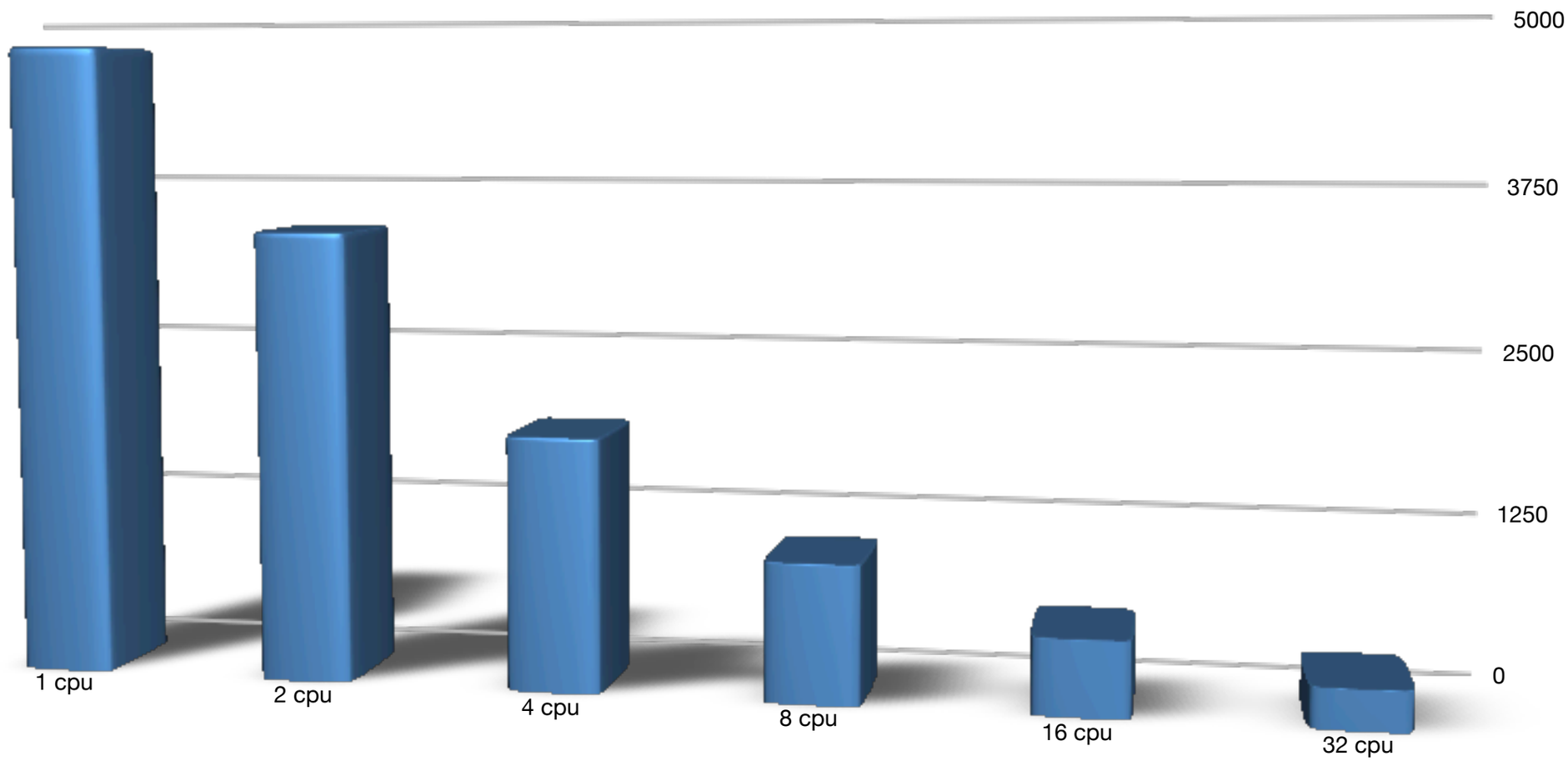
- **Local C++ application**
  - simplifies Grid submission of any number of instances
  - **ggem** *number* [*mpi*|*serial hdw tdw*] ...

- **DRMAA**
  - standard API to communicate the application with a scheduler/ metascheduler

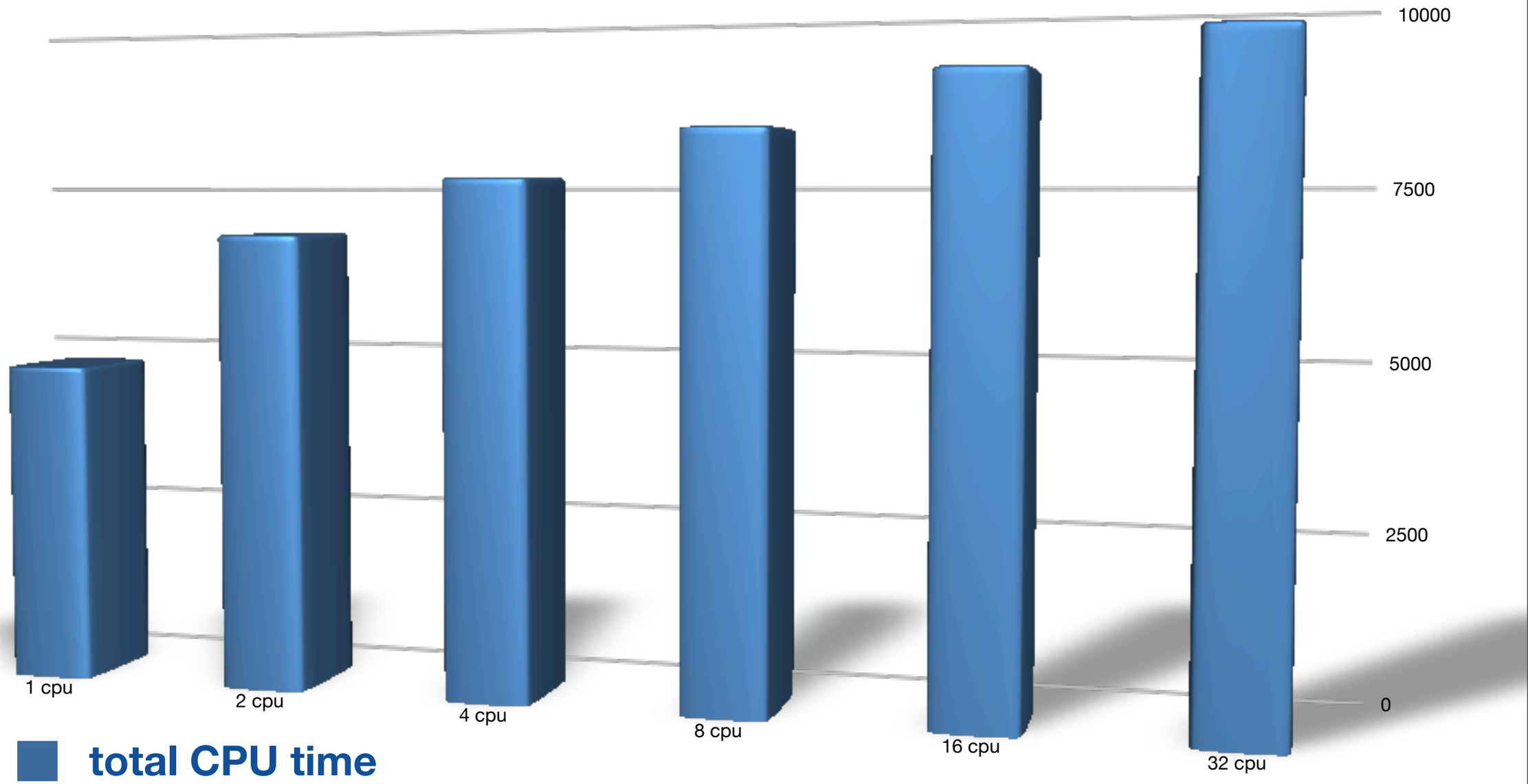
- **GridWay metascheduler**
  - job submission
  - scheduling capabilities
  - fault detection & recovery

gGEM- Results(1)

- **suitable to be executed in standard clusters**

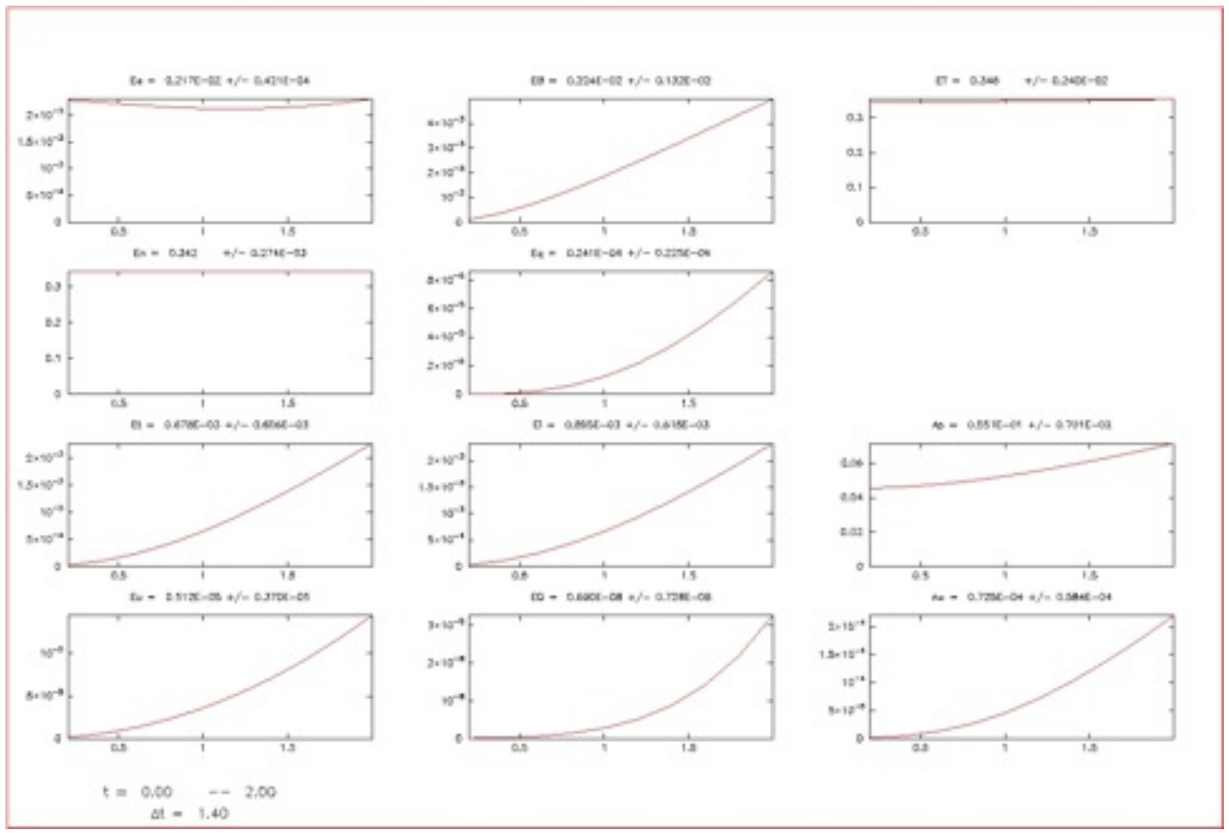


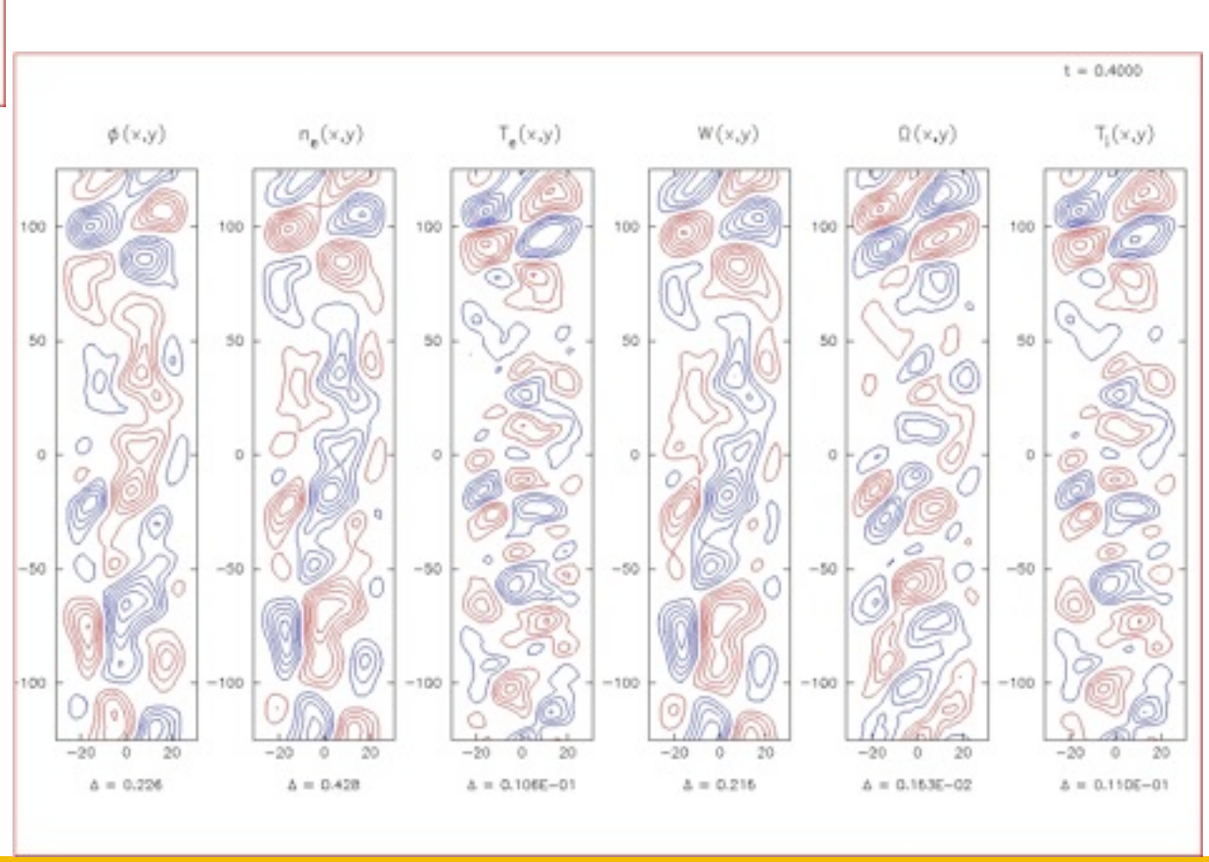
gGEM- Results(2)



- **overhead lineally scales with number of processors**
  - upper bound to the degree of parallelization, depending on the needs of the final user

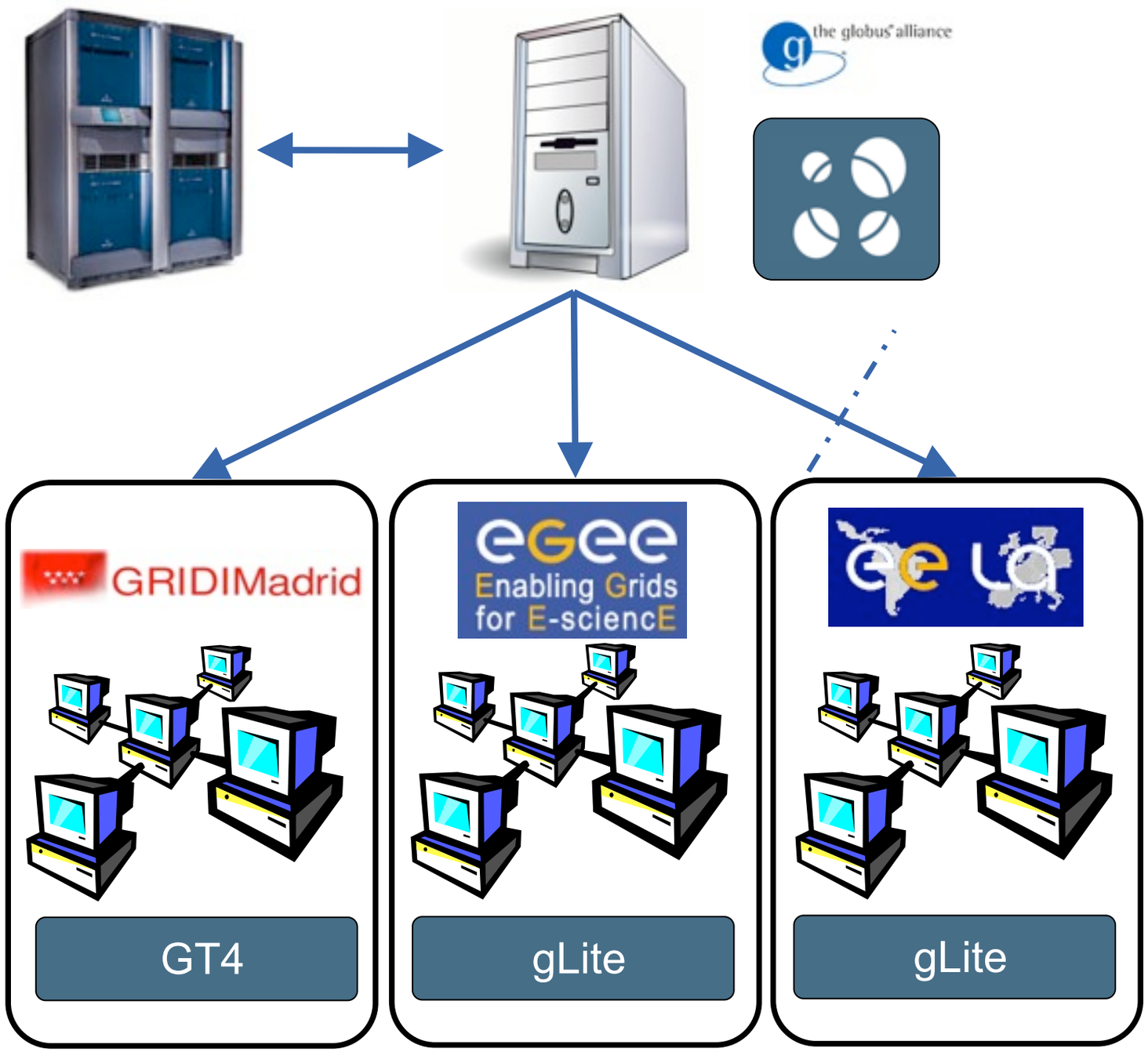
gGEM- Physical results





- **Vashra-T**

VASHRA-T



- Vashra-T allows massive Grid computations of TRUBA when it is required by ASTRA.
- TRUBA calculates Electron Bernstein Wave (EBW) heating in TJ-II
- MaRaTra is the gridified version of TRUBA
- ASTRA calculates Transport in TJ-II
- Local Machine -> Run ASTRA
  - SGI ALTIX 3700
  - 192 Itanium 64 bits
- Grid machine -> Run MaRaTra
  - Globus Toolkit 4 and GridWay 4.2
  - Access to 30 sites

Questions?

THANK YOU

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