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ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

High Perfomance Cosmology: the PINOCCHIO code

Marius D. Lepinzan, UniTS + ICSC/Spoke1, P. Monaco, L. Tornatore

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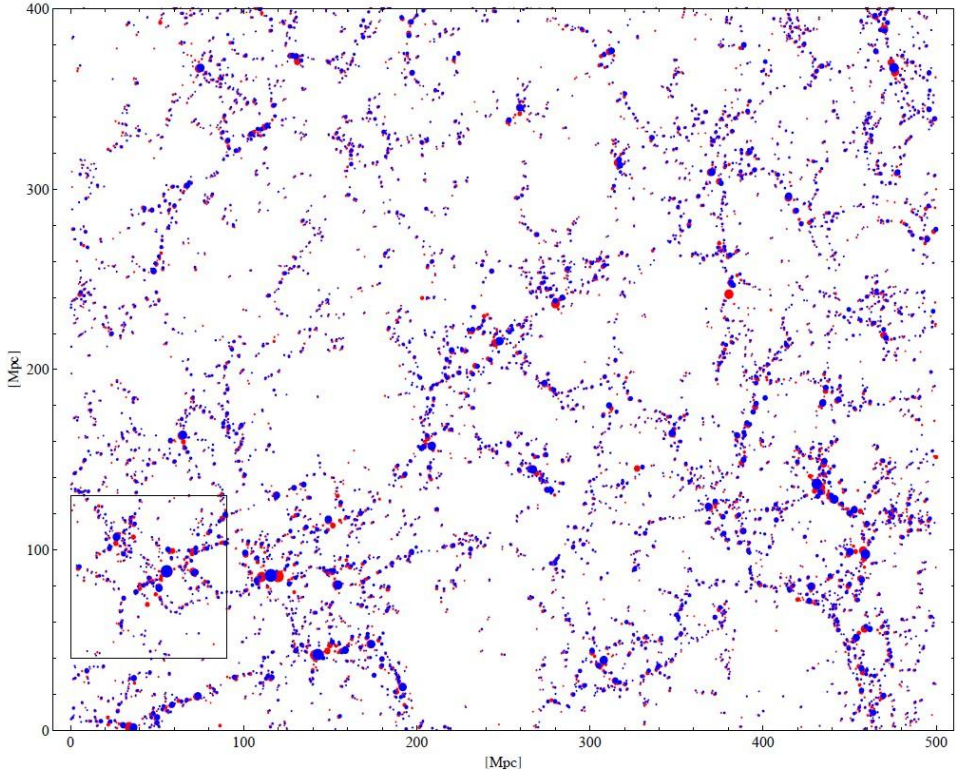
Scientific Rationale

PINOCCHIO is a code, based on Lagrangian Perturbation Theory (LPT), for simulating Dark Matter halos in cosmological volumes (*Monaco et al. 2002, 2013; Munari et al. 2017)*

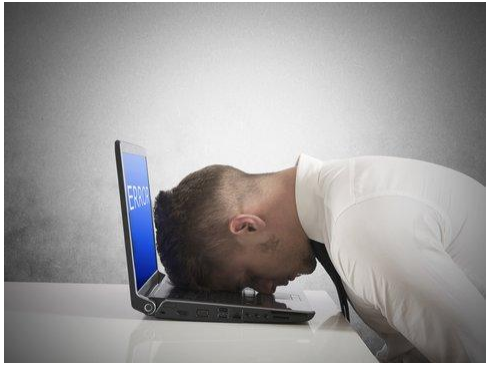
Comparison with full N-body simulations:

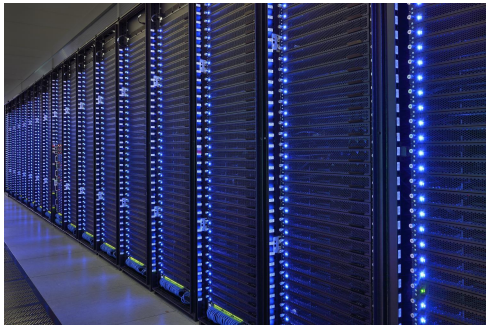
- **~1000** faster
- **5 – 10%** accuracy in reproducing 2-point statistics, mass function and bias



Technical Objectives, Methodologies and Solutions

- **Optimize the code and allow it to run on architectures with GPUs:**
  - **Improve code performance**: *suitable threadization?*
  - **Identify off-loadable regions**: *what can be ported to GPUs?*
  - **Accurate code profiling**: *main bottlenecks ? Adopting new algorithm?*
- **Adopted solutions:**
  - **Improve** the **MPI** framework: **OpenMP**
  - **Porting** collapse times to **GPU**: **OpenACC**
  - **Investigate** new fragmentation algorithm: **Deblending**
  - **Testing, testing, testing !!**

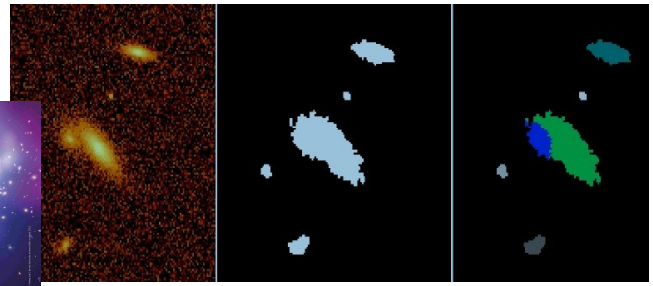


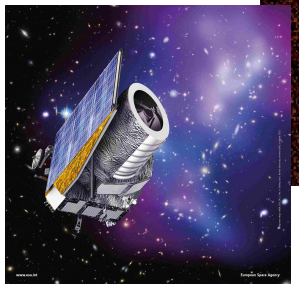


Timescale, Milestones and KPIs

- **A code to fully exploit LEONARDO computational capabilities :**
  - **MPI + OpenMP/OpenACC** code
  - **KPI**: *code delivery https://github.com/pigimonaco/Pinocchio.git, ~ 1.5 years*
  - **KPI**: *one technical paper, ~ 2 years*

- **Bottleneck optimization :**
  - New **fragmentation** algorithm as a **deblending** procedure
  - **KPI**: *one scientific paper , ~ 1 year*



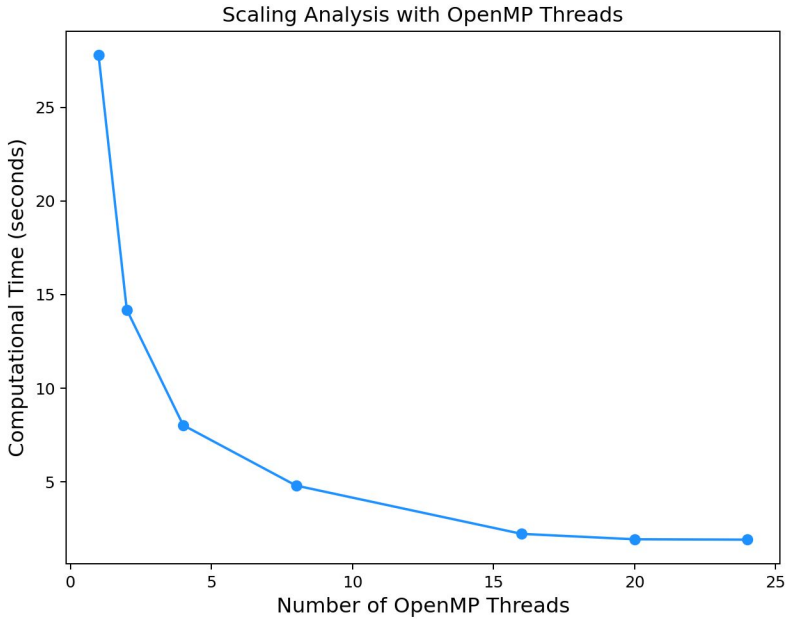


- **Key Science Project: see talk by P. Monaco**

Accomplished Work, Results

- **We have extended the existing parallel computing paradigm by integrating OpenMP into the collapse times calculation**

  - Nearly ideal scaling up to ~20 threads per single MPI Task
  - Expected nearly ideal scaling up to 36 threads
  - Large Euclid Box (box ~ 4 Gpc, 4096^3 particles) computational time: ~ 8% out of ~ 40 minutes
  - Computational time improvement: ~ 9x speed-up
  - Thousands of mocks: ~ 50 hours less



Next Steps and Expected Results (by next checkpoint: April 2024)

- **Accurate code profiling:**
  - **OpenMP scaling optimization**
  - Identification of other **bottlenecks**
- **Collapse times calculation with OpenACC:**
  - Already **implemented**
  - Testing campaign on **LEONARDO** started
- **Testing the new fragmentation procedure :**
  - Algorithm **identified**
  - Adaptation to **fragmentation** and **deblending** ongoing