pFoF

A highly scalable halo-finder for large cosmological data sets

Fabrice Roy, Vincent Bouillot, Yann Rasera

Brief history

Situation in 2008:

- Serial fof developped severial years earlier by Edouard Audit
- 9 large RAMSES n-body simulations planned (1024^3 particles)
- Discussion with Patrick Hennebelle who suggested the idea behind pFoF (parallel Friends-of-Friends halo finder)
- Development of the first version of pFoF (Roy, Bouillot, Rasera, 2014)
- New version in 2015

What is this idea behind pFoF?

- Divide the simulation box
- Perform a serial halo detection in each subdivision
- Merge the halos that extend across several subdivisions

Merge = give each halo particle the same halo ID

From this idea, 2 versions of pFoF

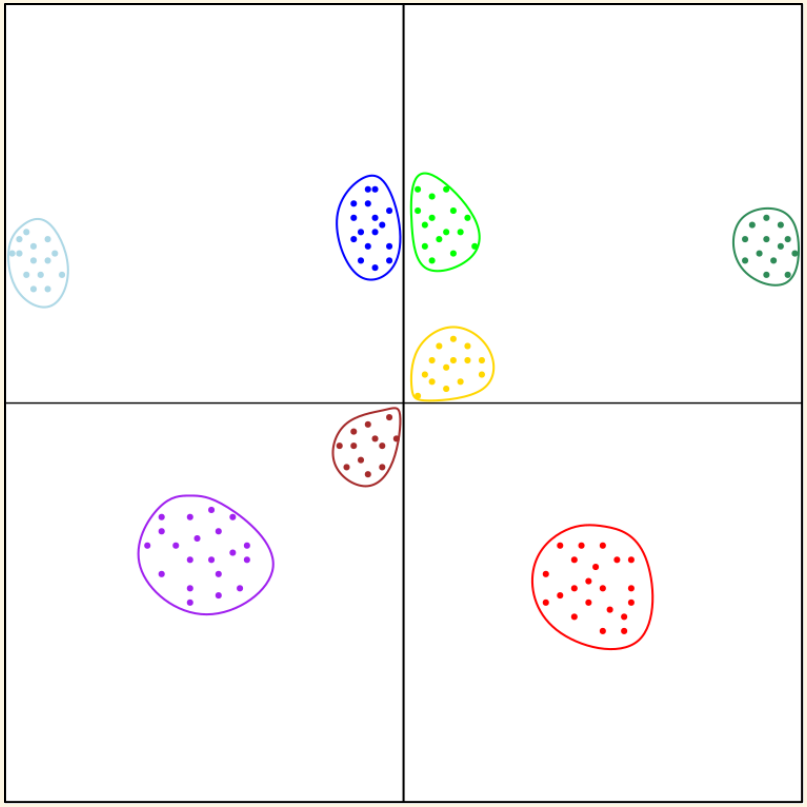
pfof_snap for RAMSES snapshots

- Analyses a RAMSES particles snapshot
- Assumes the boundary conditions are periodic
- Can write the particles distributed in cubic subdivisions ("cube files")
- Can read RAMSES binary files or previously written cube files
- Writes 2 kinds of files: halo properties and list of particles per halo

pfof_cone for RAMSES lightcones

- Analyzes a RAMSES particles lightcone
- First version by Vincent Bouillot for DEUS-FUR lightcones (>100 billions particles) in 2012
- New optimized version in 2015
- pfof_cone processes are "mapping" the cone
- No boundary conditions
- Only reads hdf5 shells produced by a tool (conepartcreator)
- Writes 2 kinds of files: halo properties and list of particles per halo

What does it look like?



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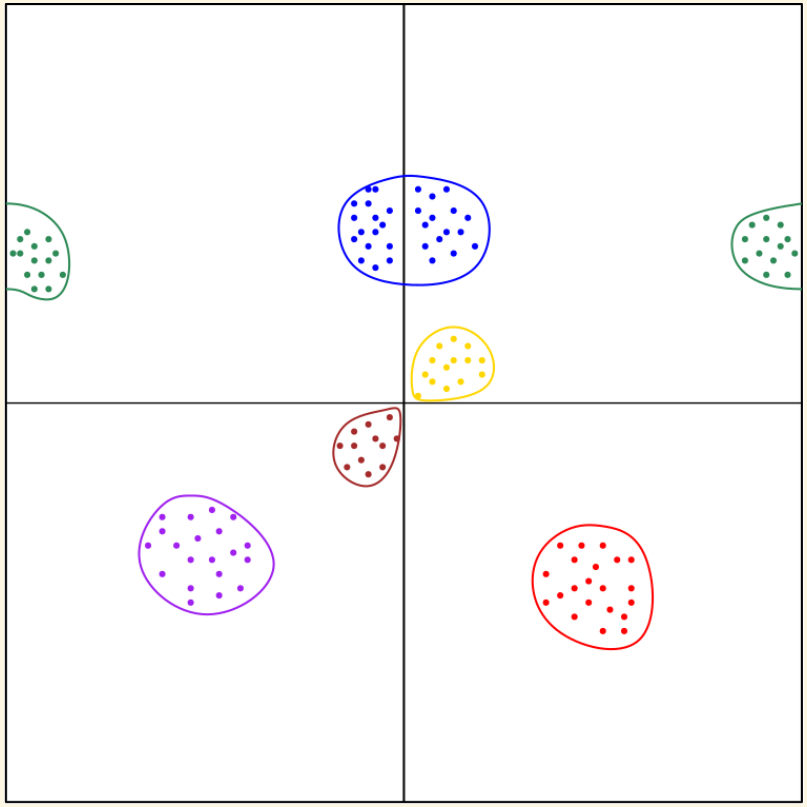
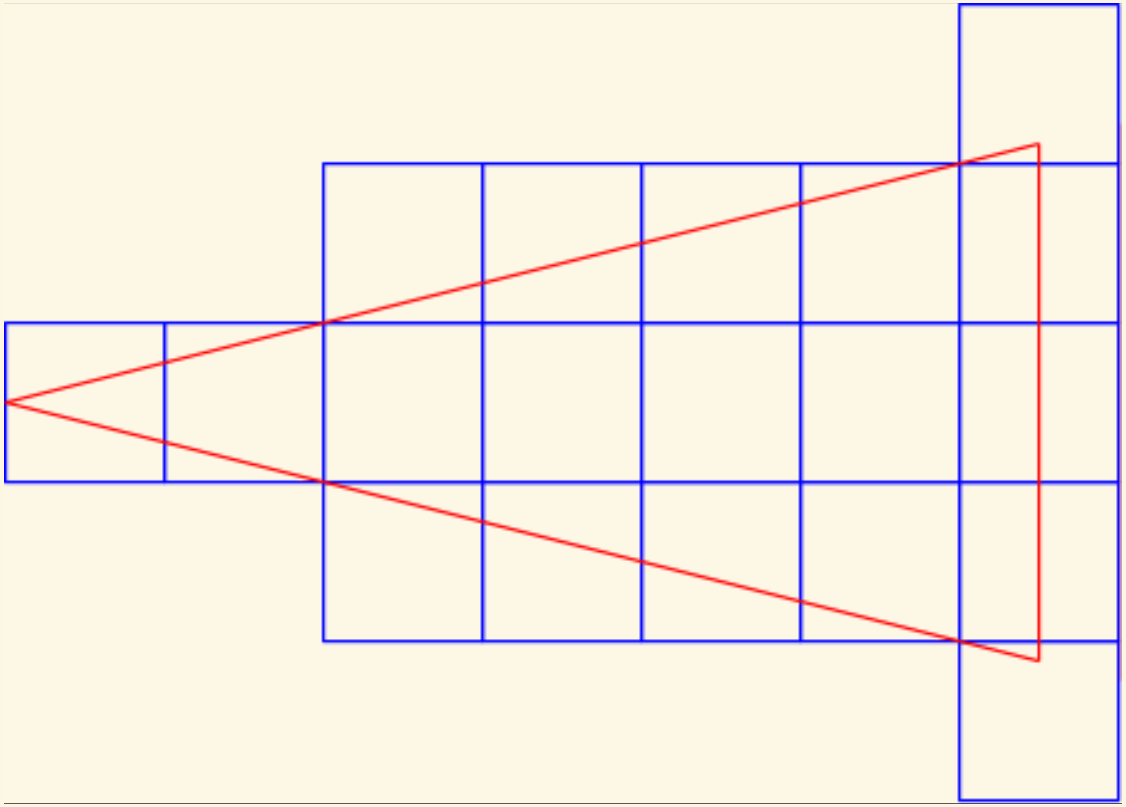


How is the lightcone mapped?



Halo properties file

HDF5 file, with some metadata (RAMSES parameters, pfof parameters, etc...)

- Only 1 file, parallel write
- Contains a list of halos with:
  - their number of particles
  - the position and velocity of their center of mass
  - the "radius" of the halo

Halo particles files

HDF5 files, with some metadata (RAMSES parameters, pfof parameters, etc...)

- Several files, 1 per process or 1 per group of processes (parallel write in this case)
- One group per halo
- In each group, the properties of each particle

Pros/Cons of these files

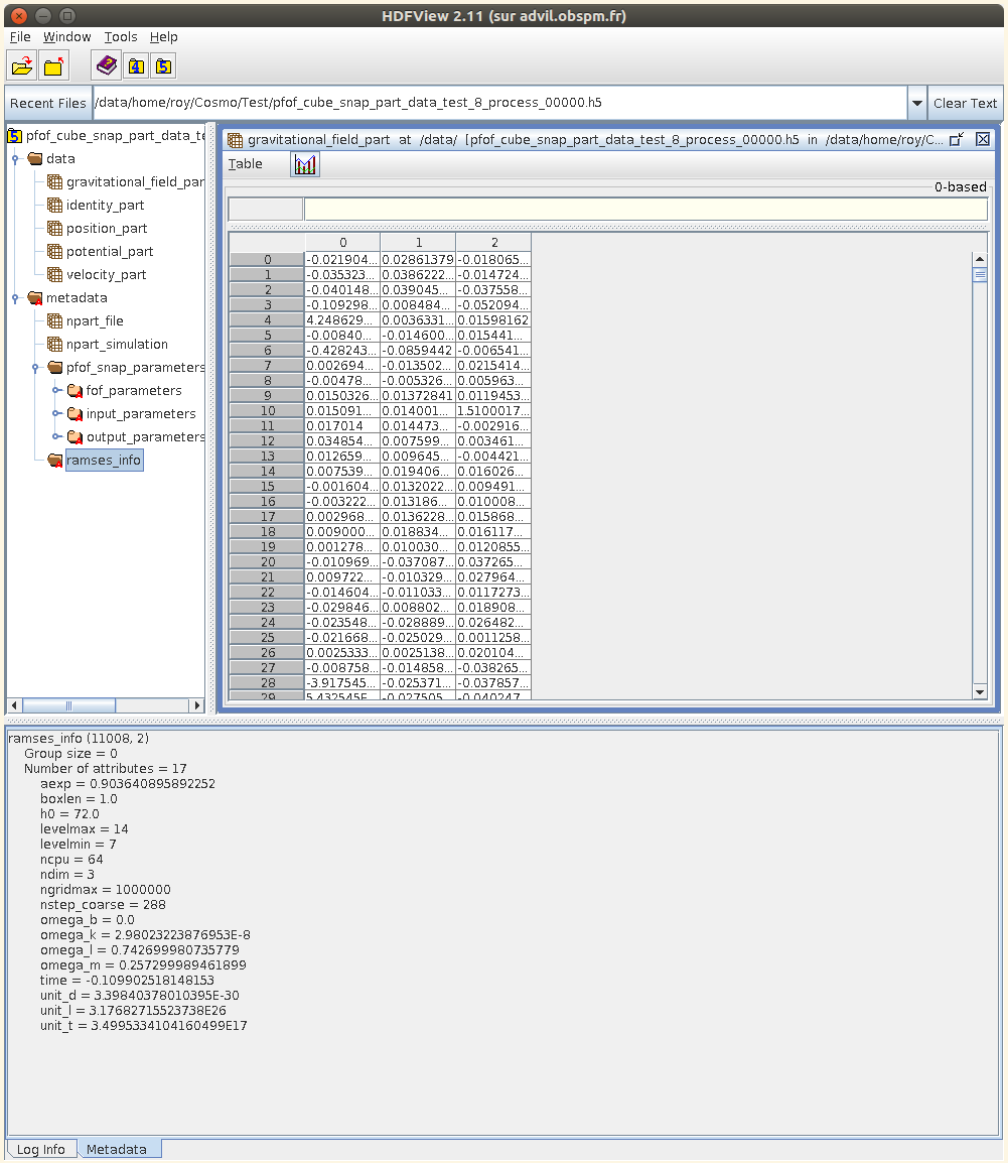
Pros:

- Output files allow easy further analysis (with pFoF, other halo finder, other codes)
- You can perform a FoF with a lower b from halo particles files
- Cubes are easier to handle than the RAMSES binary files
- Parallel writes reduce the number of files

Cons:

- Very costly: lots of communications to gather the particles
- See performance for an example

HDF5 structure of the files



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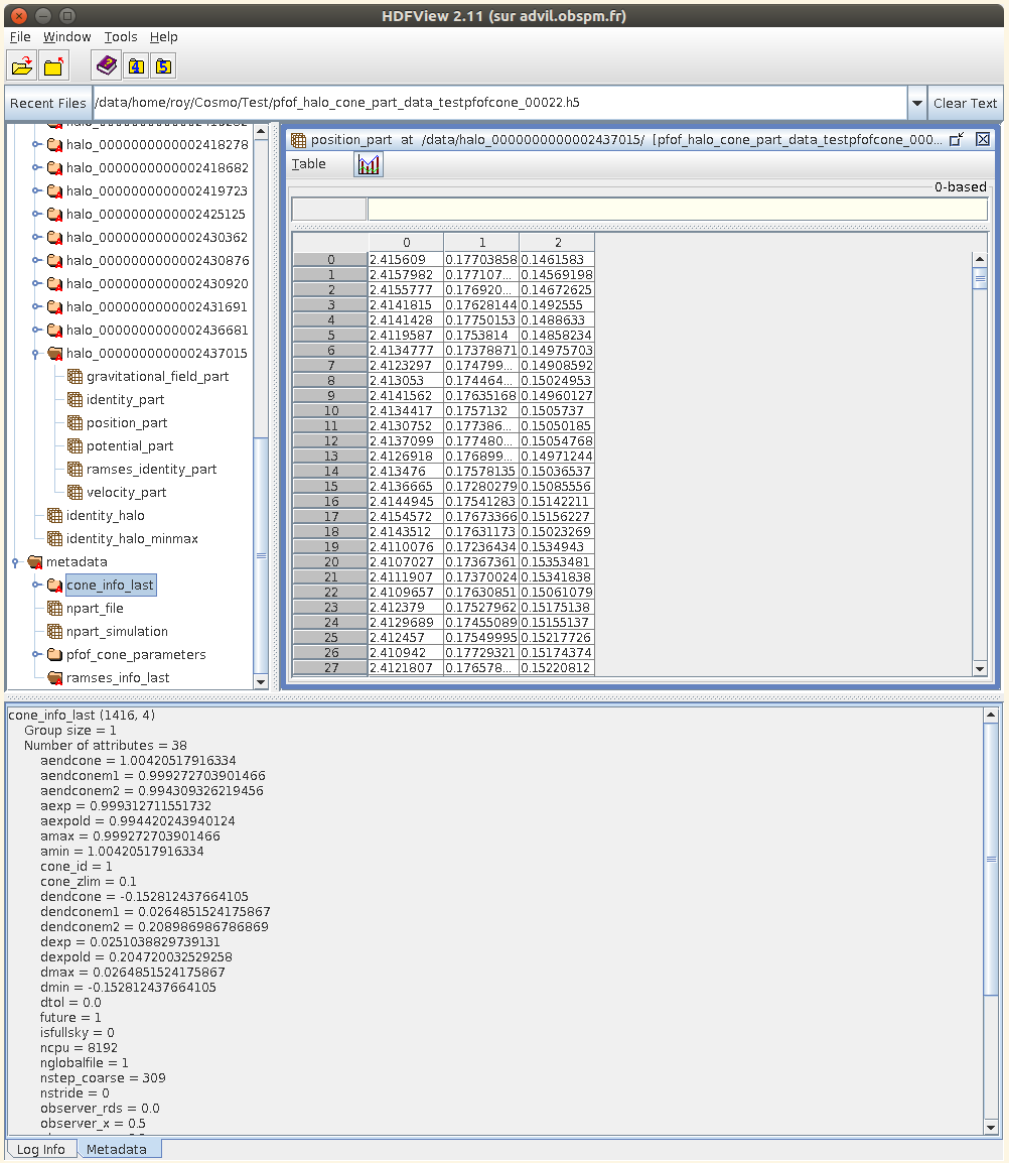

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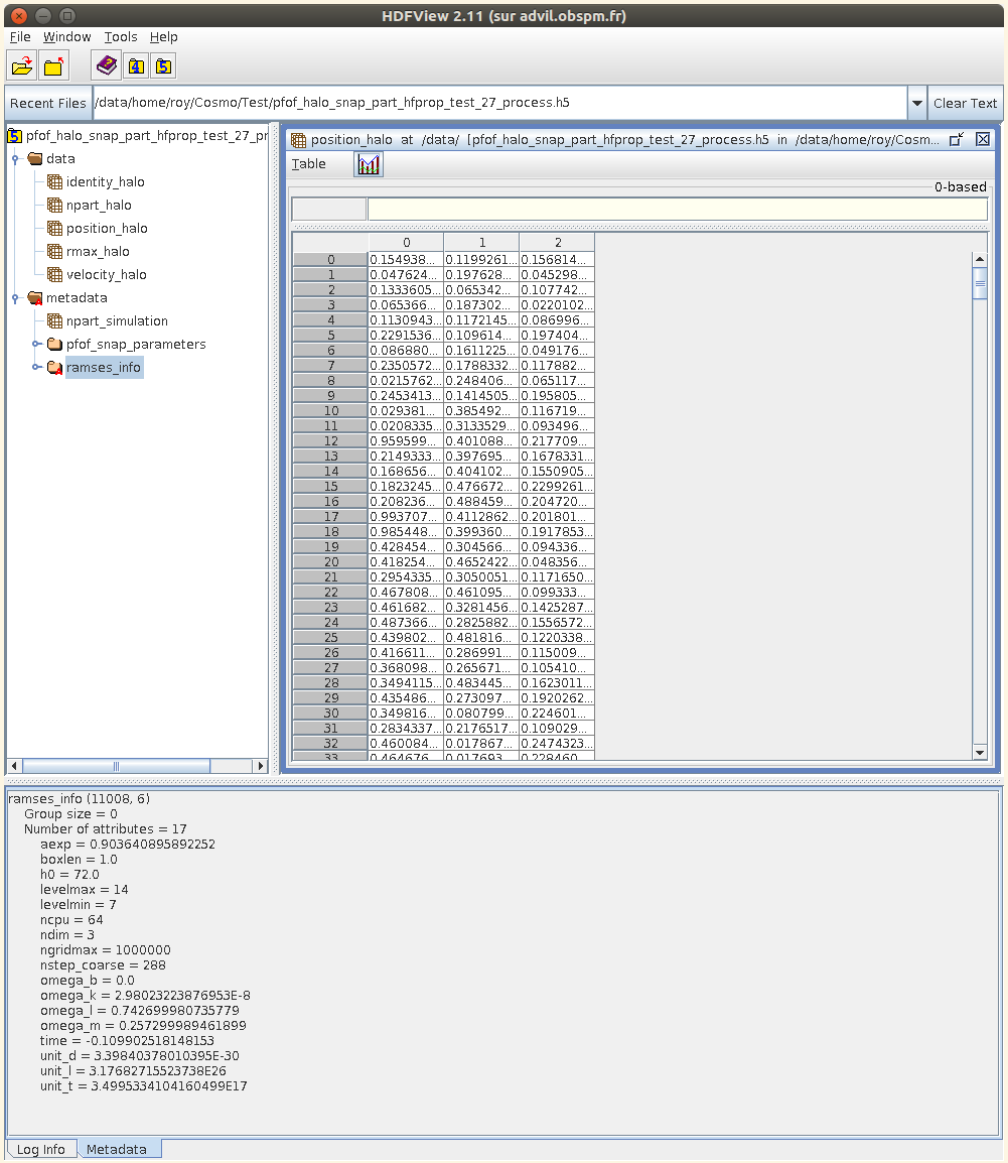

Performances (1) - Weak scaling

ΛCDM, a=0.3, b=0.2, 1024^3, 64 proc., on Curie (TGCC): 483 s.

- input: 57 s.
- local fof + merging: 43 s.
- halo properties + output: 232 s.

ΛCDM, a=0.3, b=0.2, 4096^3, 4096 proc., on Curie: 1923 s.

- input: 605 s. (bad)
- local fof + merging: 47 s. (good)
- halo properties + output: 1015 s. (bad)

Bad comm. scheme + poor I/O scaling on Curie with >512 processes (Alimi et al. 2012)

Performance (2)

Some examples of pfof_cone execution on Curie

- Narrow cone, ΛCDM, 648 Mpc/h, 2048^3, ~7.9×10^9 part., b=0.2, 1332 proc.: 190s.
- A large part of the costly I/O is done by conepartcreator: 1h30 on 16 proc.
- Fullsky, ΛCDM, 2592 Mpc/h, 2048^3, ~9.2×10^9 part., b=0.2, 1472 proc.: 206s.
- conepartcreator: 3h. on 16 proc.

Performance (3)

Largest snapshot analyzed with pFoF (previous version, 2012):

- ΛCDM, 21Gpc/h, a=1, b=0.2
- 8192^3 particles, 32k proc., on Curie
- Walltime = approx. 2h

Future developments: some ideas

- improve the input and halo properties/output phases
- develop an hybrid MPI-OpenMP version
- add subhalo detection
- add unbinding
- adapt pFoF for zoom and hydro simulations
- ...

If you want to use pFoF

- No public git or subversion yet, it will come soon!
- You can send me an email: fabrice.roy@obspm.fr
- I would be glad to help you install/use/adapt pFoF
- People have already used it at Strasbourg Observatory and KASI in Daejeon (Korea)

Thank you!

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