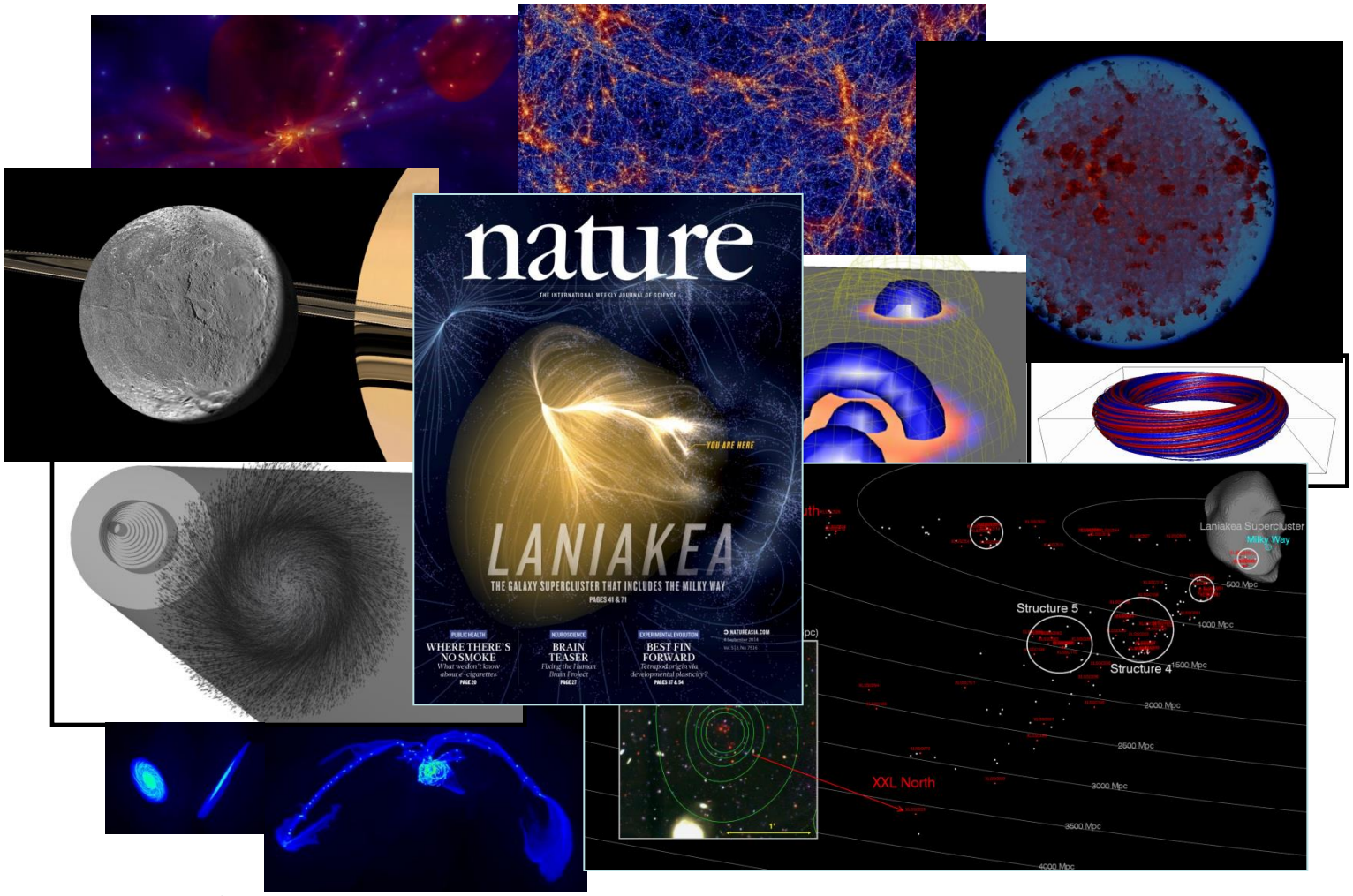
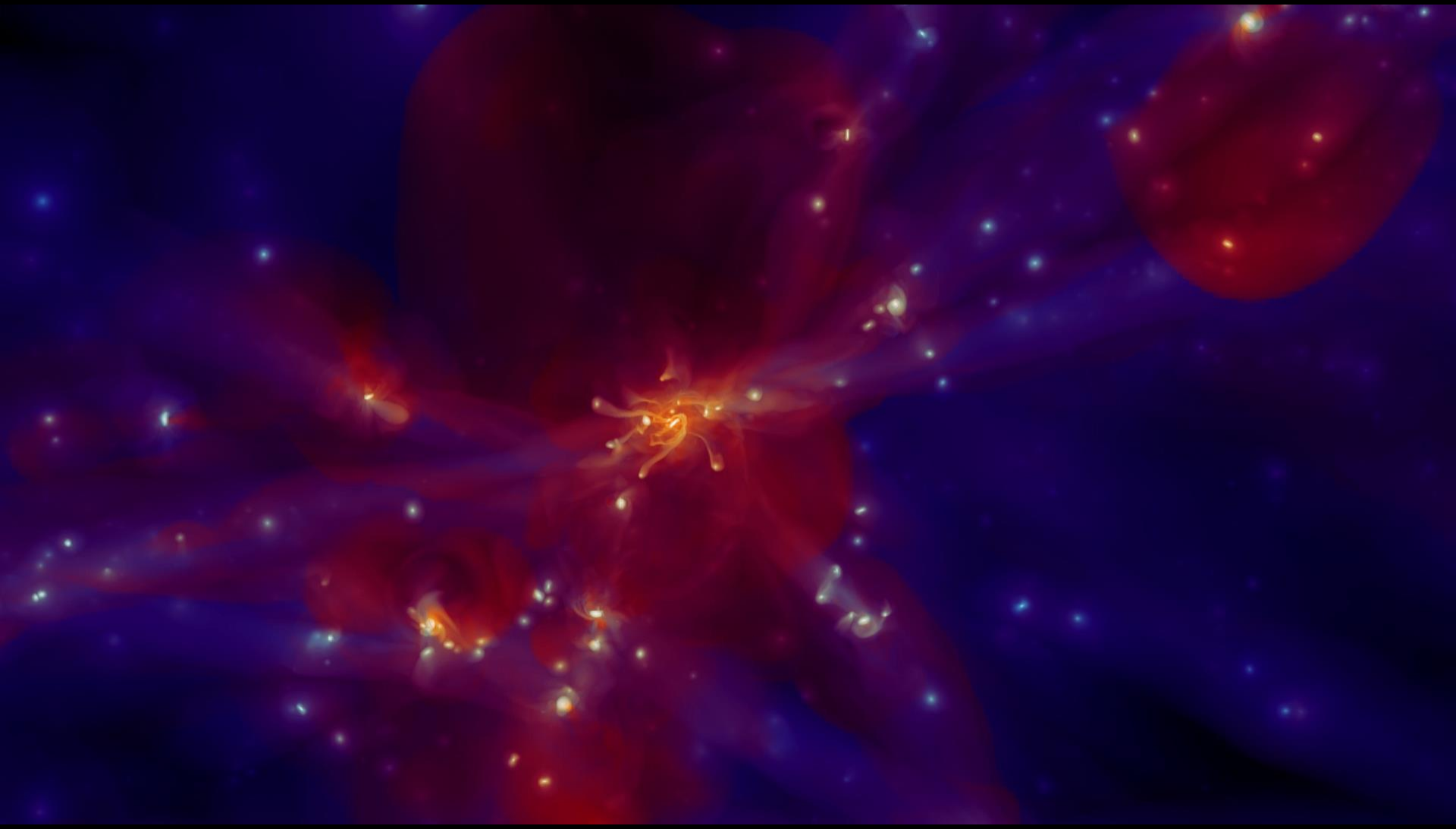
COMPLEX DATA VISUALIZATION



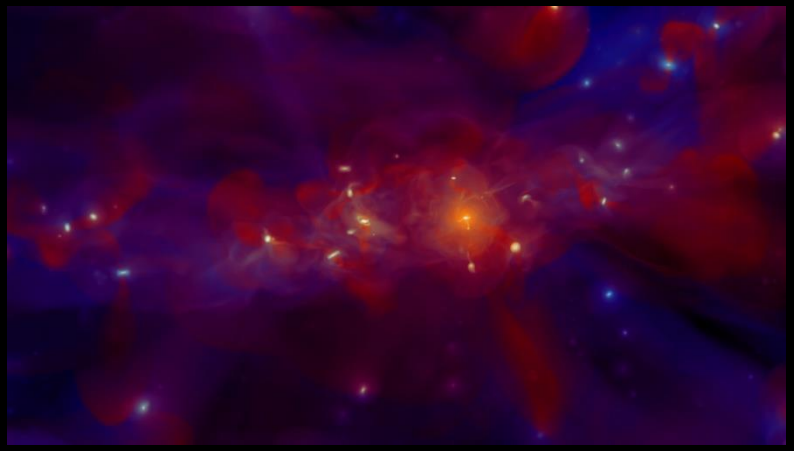
COMPLEX DATA VISUALIZATION

- **a software project established in the context of the COAST « Computational Astrophysics » IRFU Program involving SAp and SEDI**
- **main component is the *SD*vision « Saclay Data Visualization » software developed at SEDI/LILAS**
  - 90000 lines of IDL code
  - primary target: visualizing the complex, massive, three-dimensional data produced by numerical simulations in astrophysics
  - benefits to other research area:
    - observational astrophysical data
    - other domains: accelerators, fusion plasma, nuclear physics, …

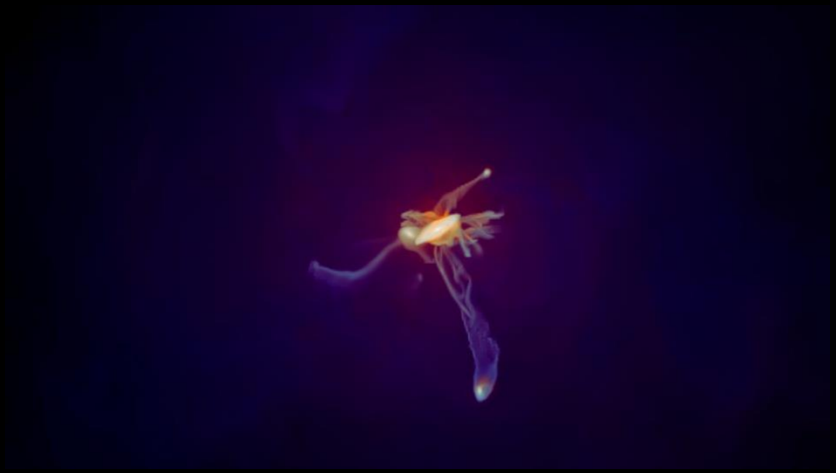
Formation of a Milky Way-like spiral galaxy in a cosmological context (RAMSES code)



The galaxy is nourished by cold gas coming from the filaments. Hot gas is injected in the environment (“supernovae feedback”).
Stereo3D movie running at Musée des Confluences in Lyon (inaugurated december 19th, 2014)

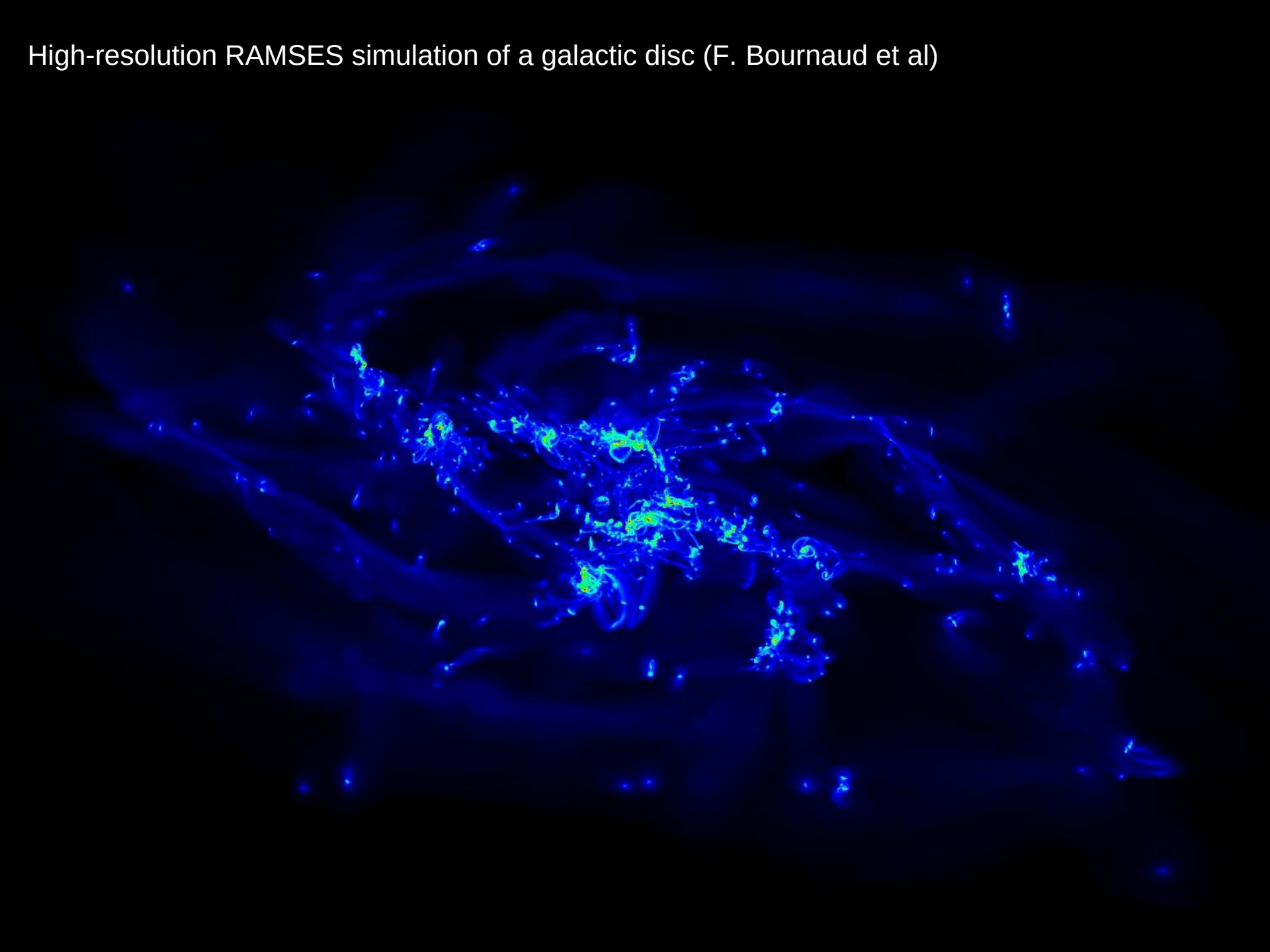


Zoom on the final state

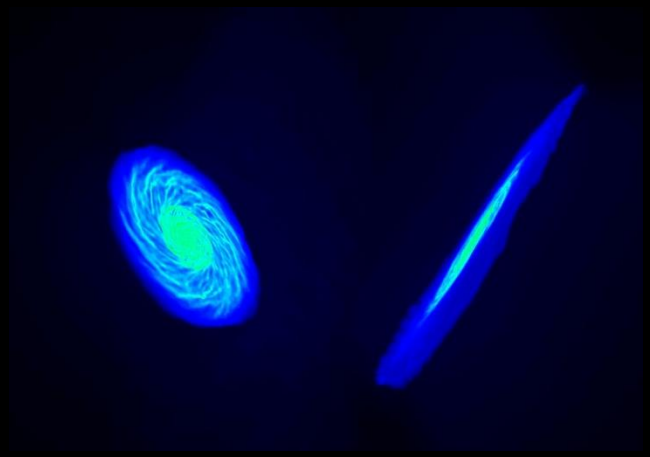


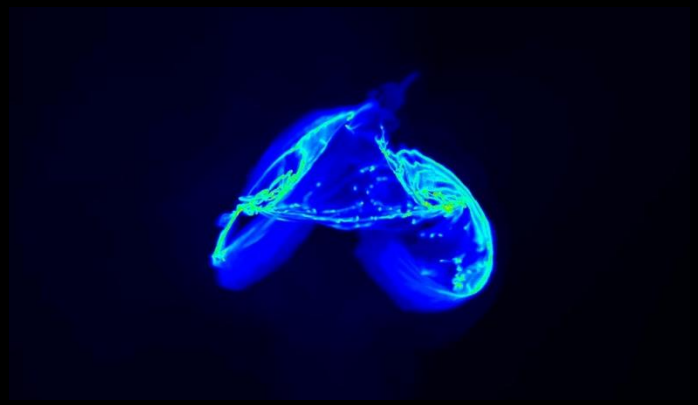
A spiral galaxy (the Milky Way) and its satellites (the Magellanic Clouds)

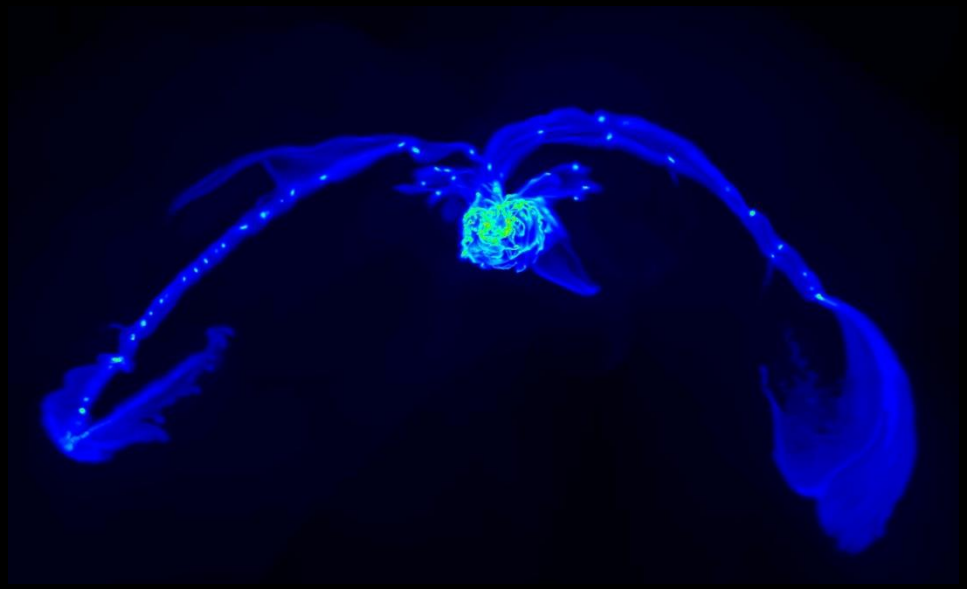
High-resolution RAMSES simulation of a galactic disc (F. Bournaud et al)



RAMSES simulation of the Antennae galaxy interaction (D. Chapon et al)

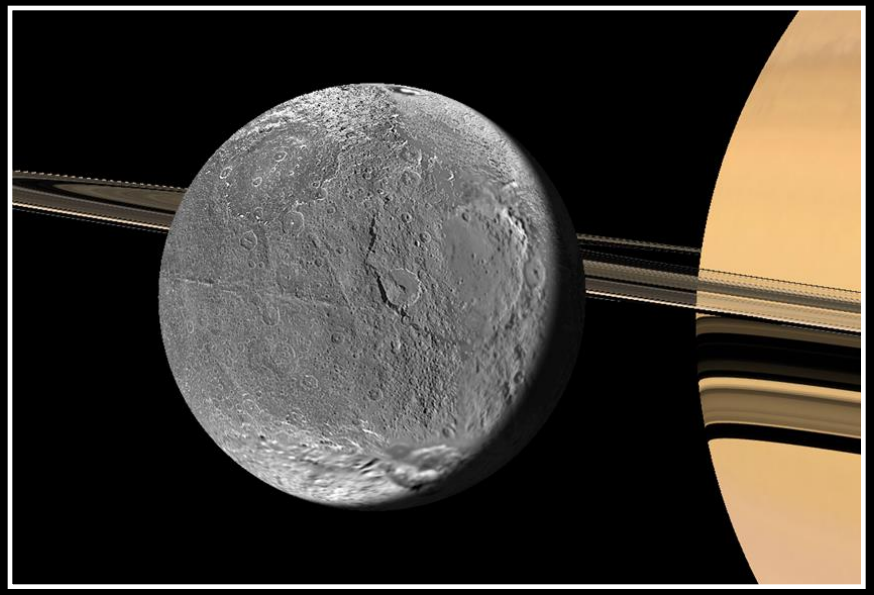




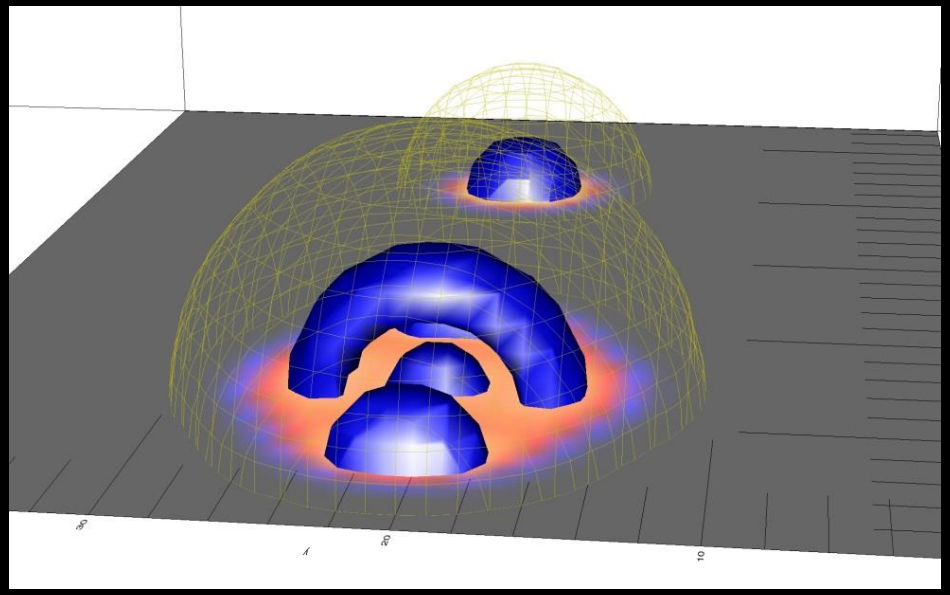


Visualization of data from IRFU and DSM-wide research

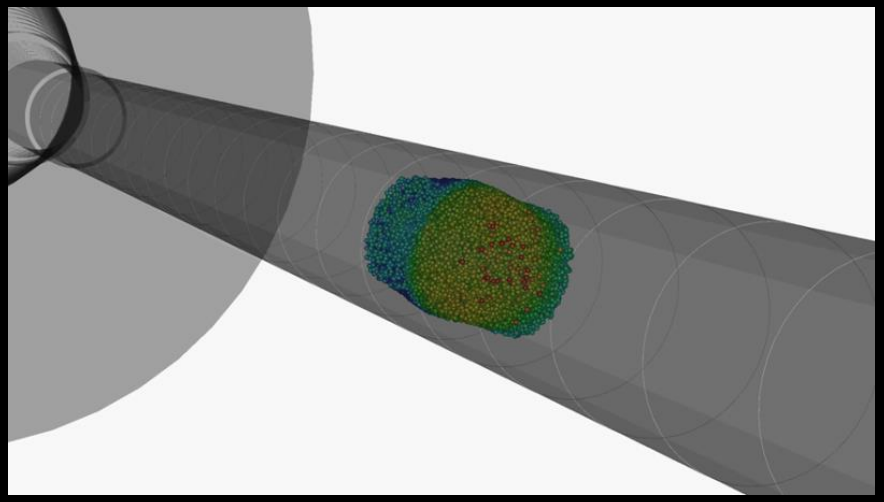
3D visual of a map of Iapetus (CASSINI, A. Brahic, IRFU/SAp)



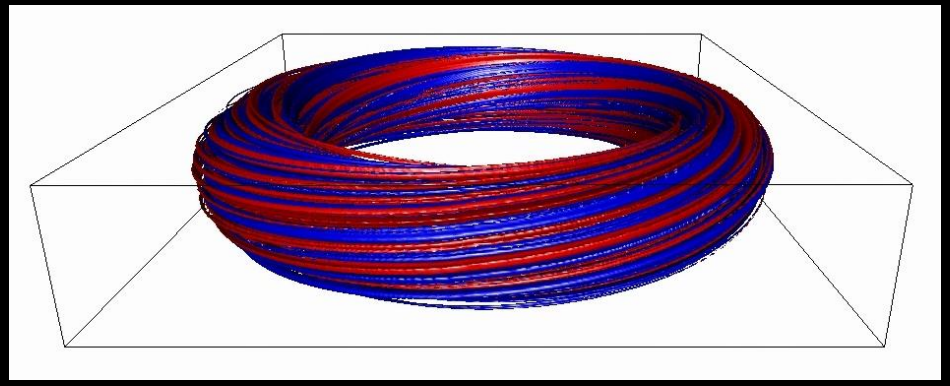
Wave function of a nuclear interaction (C. Simenel, IRFU/SPhN)



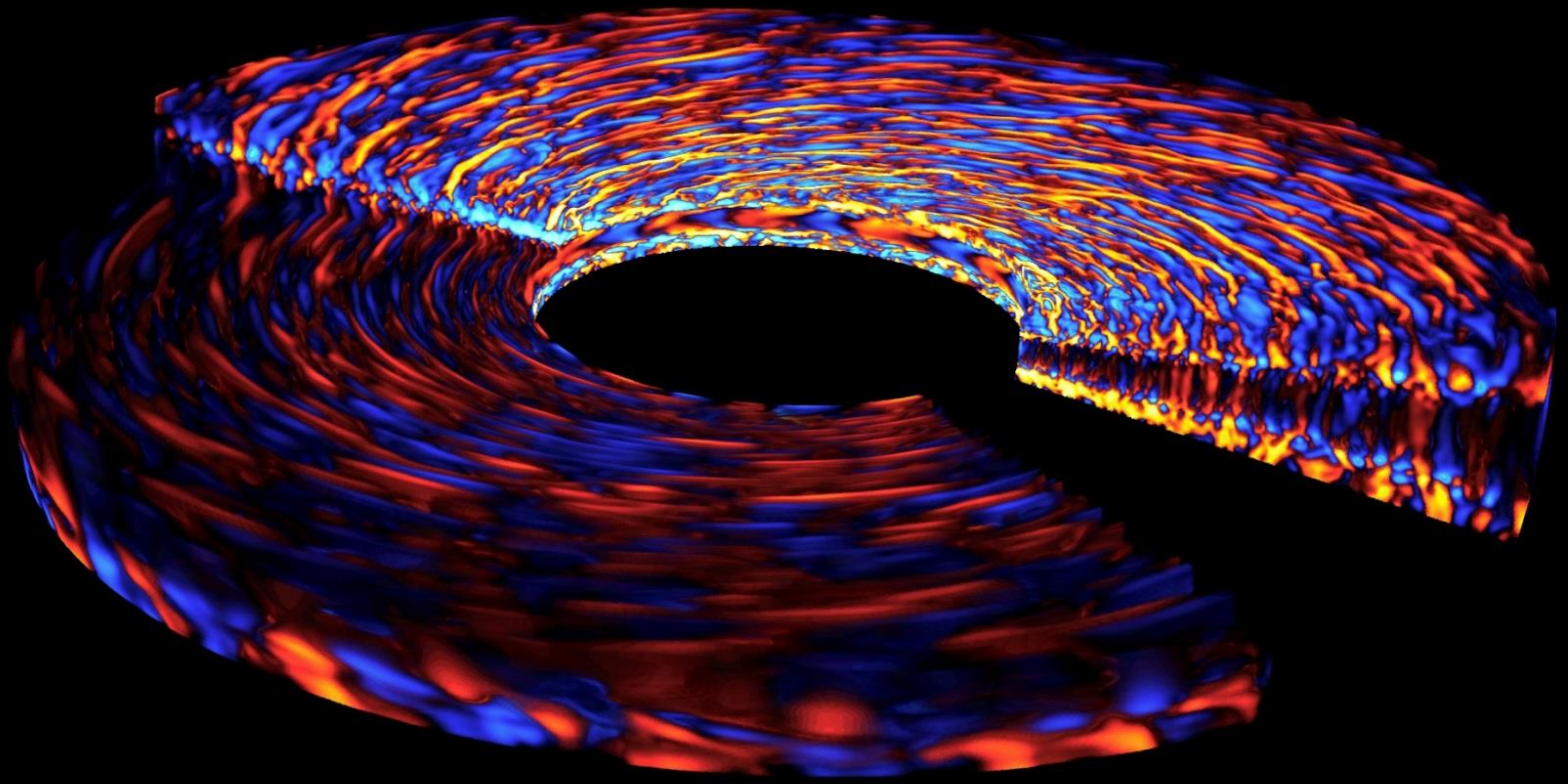
Simulation of the IFMIF-EVEDA injector (P. Nghiem, IRFU/SACM)



Simulation of the turbulent transport in the ITER plasma with the GYSELA code (V. Grandgirard, CEA/DSM/IRFC)



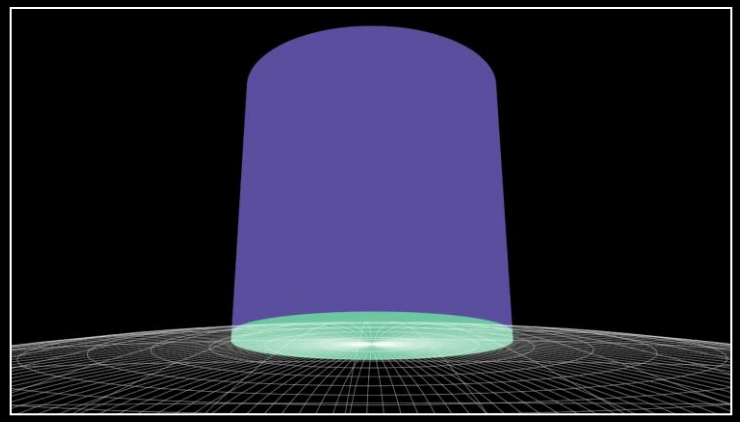
2014 Milestones: simulation of radiative MHD in a protoplanetary disc



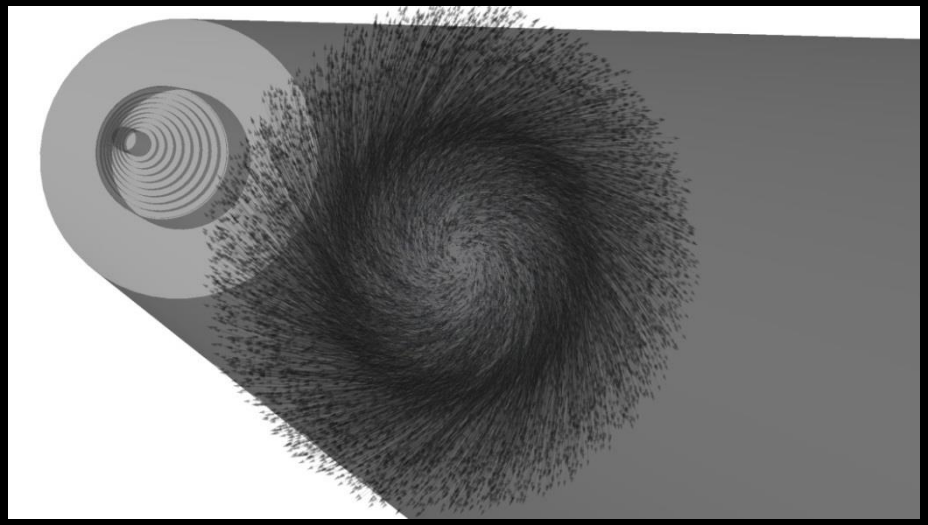
produced with the PLUTO code by Mario Flock (IRFU/SAp)
on the Curie Supercomputer at CEA/TGCC (2014)
using a 512x128x3072 grid parallelized on 1024 processors

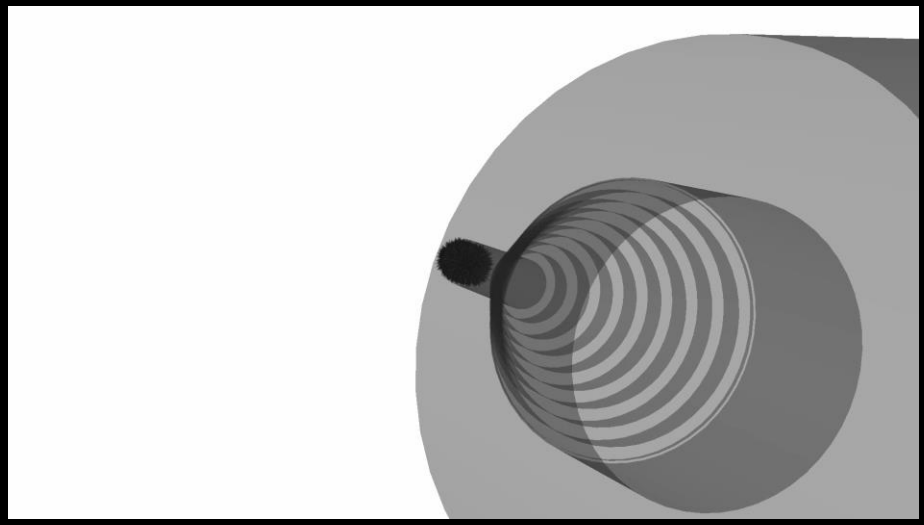
2014 milestones

- PhD Thesis defended by Marc Labadens (Ecole Doctorale de l'Ecole Polytechnique - EDX):
  - « Visualization of astrophysical simulations using the octree adaptive mesh refinment technique »
- Visualization of white dwarves MHD accretion simulations using the HADES code (SAp+CEA/DAM)

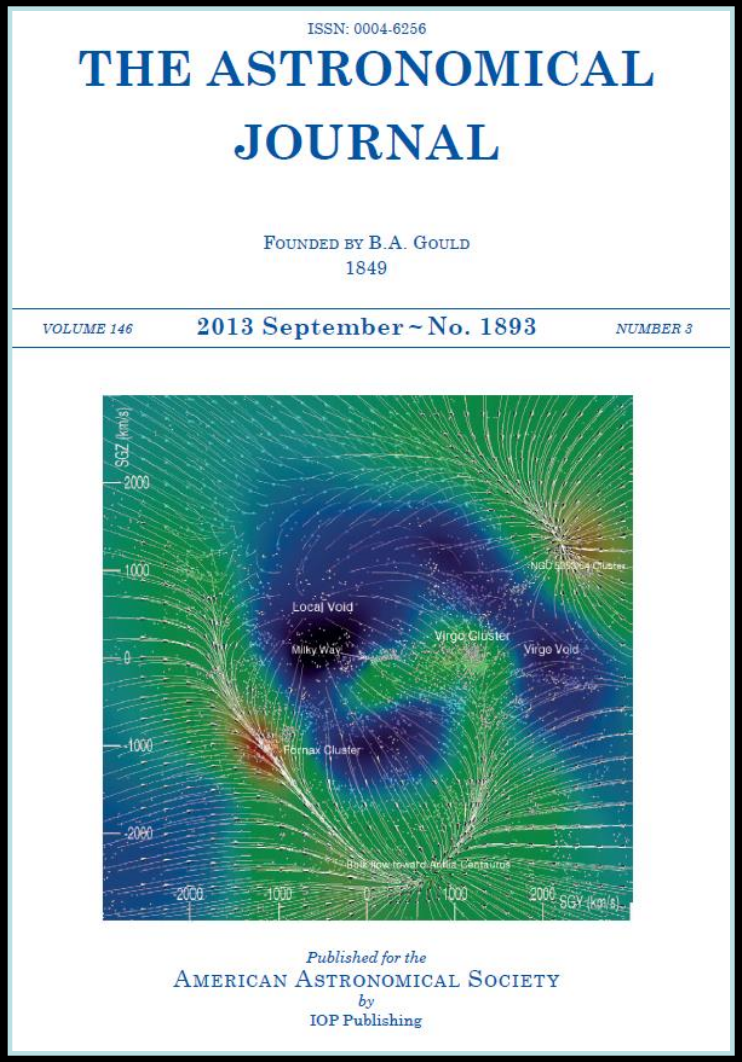


- Visualization of particle velocities in the IFMIF-EVEDA injector simulations (SACM)





Visualization of observational data: Cosmography

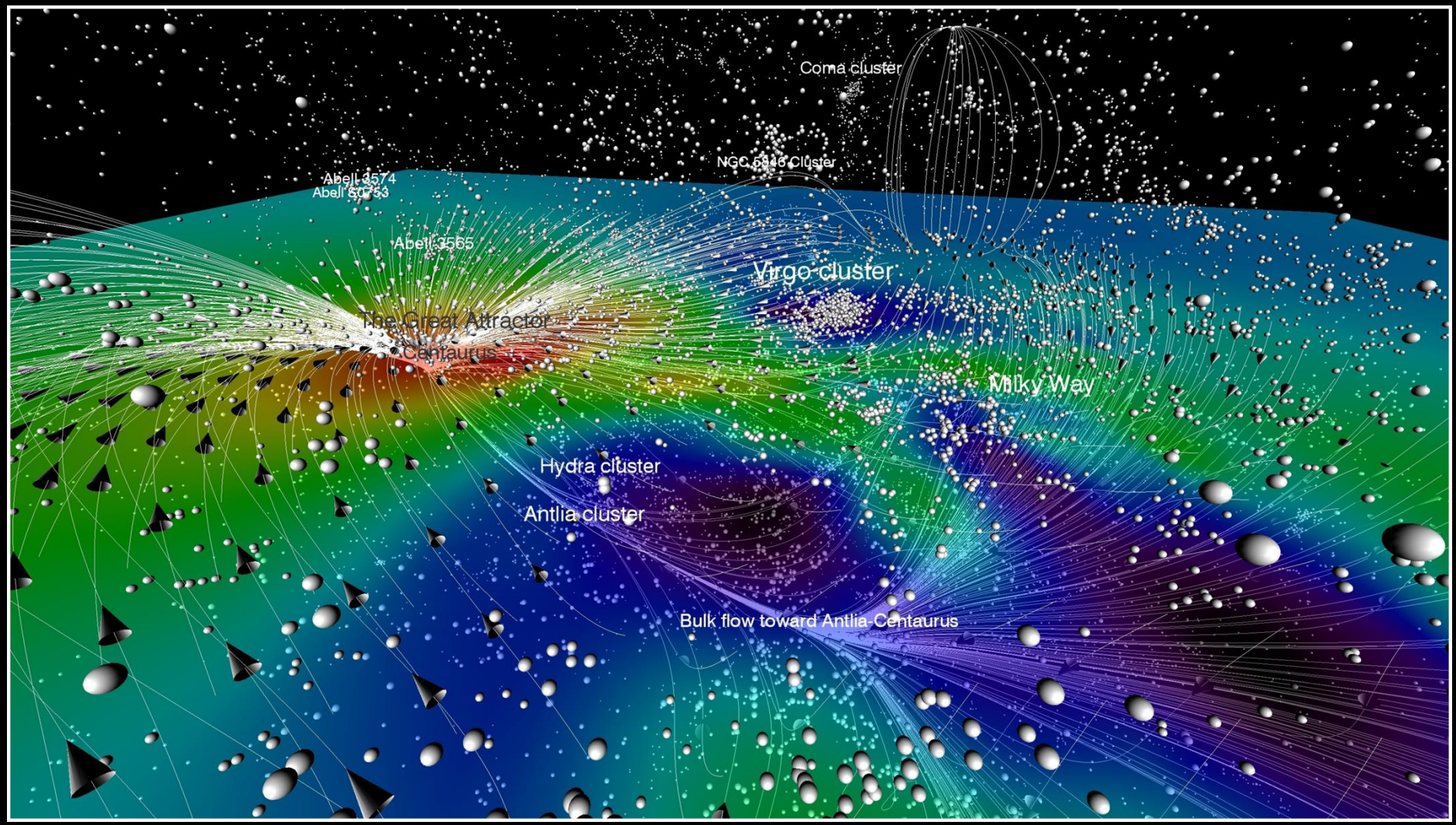


September 2013 – Cosmography of the Local Universe
Cover of *The Astronomical Journal*

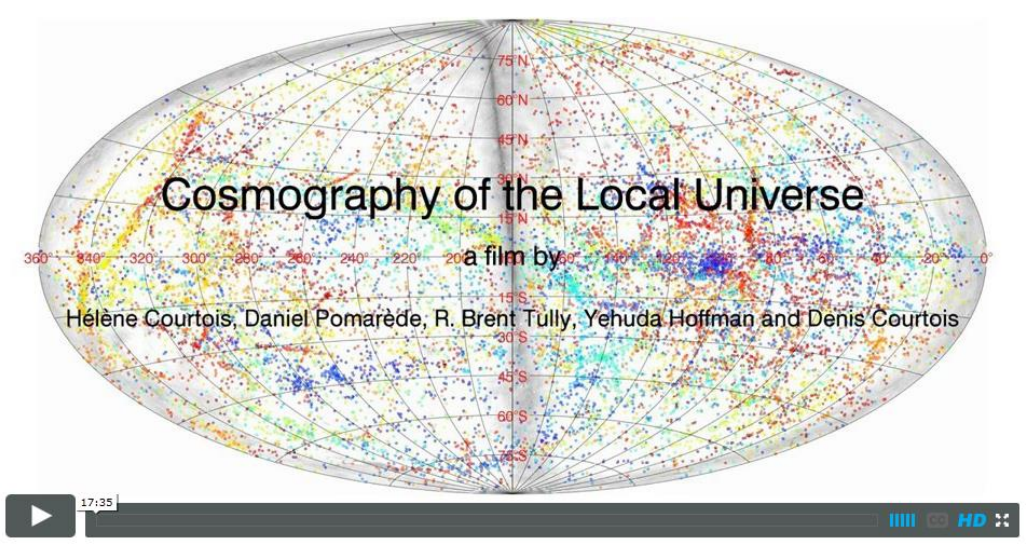
Collaboration with
- Brent Tully (U. of Hawaii)
- Hélène Courtois (U. Lyon / IPNL)
- Yehuda Hoffman (Hebrew University Jerusalem)

« *Cosmography of the Local Universe* »
- 23 maps of the stucture of the Universe in a volume of size 200 Mpc
- A 17 minutes-long video exploring and connecting these 23 maps
- Cartography of the positions of 30000 galaxies
- Cartography of cosmic flows
- Cartography of the matter density field

Visualization of Cosmic Flows



http://irfu.cea.fr/cosmography



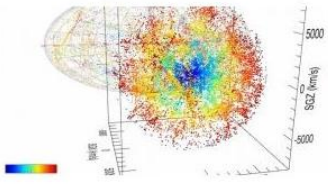
Stats : 350000 views, 50 views/day
Reference in the *Universe* article in Wikipedia
Major interest raised in media & public

MIT Technology Review

Emerging Technology From the arXiv
June 5, 2013

New Science of Cosmography Reveals 3-D Map of the Local Universe

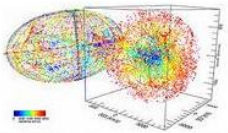
WIRED



Spectacular Cosmographic Maps Chart Galaxies and Superclusters in Local Universe

By Adam Mann
Wednesday, June 12

Los Angeles Times



This video is a trip -- through the known universe | *Jun 14, 2013*

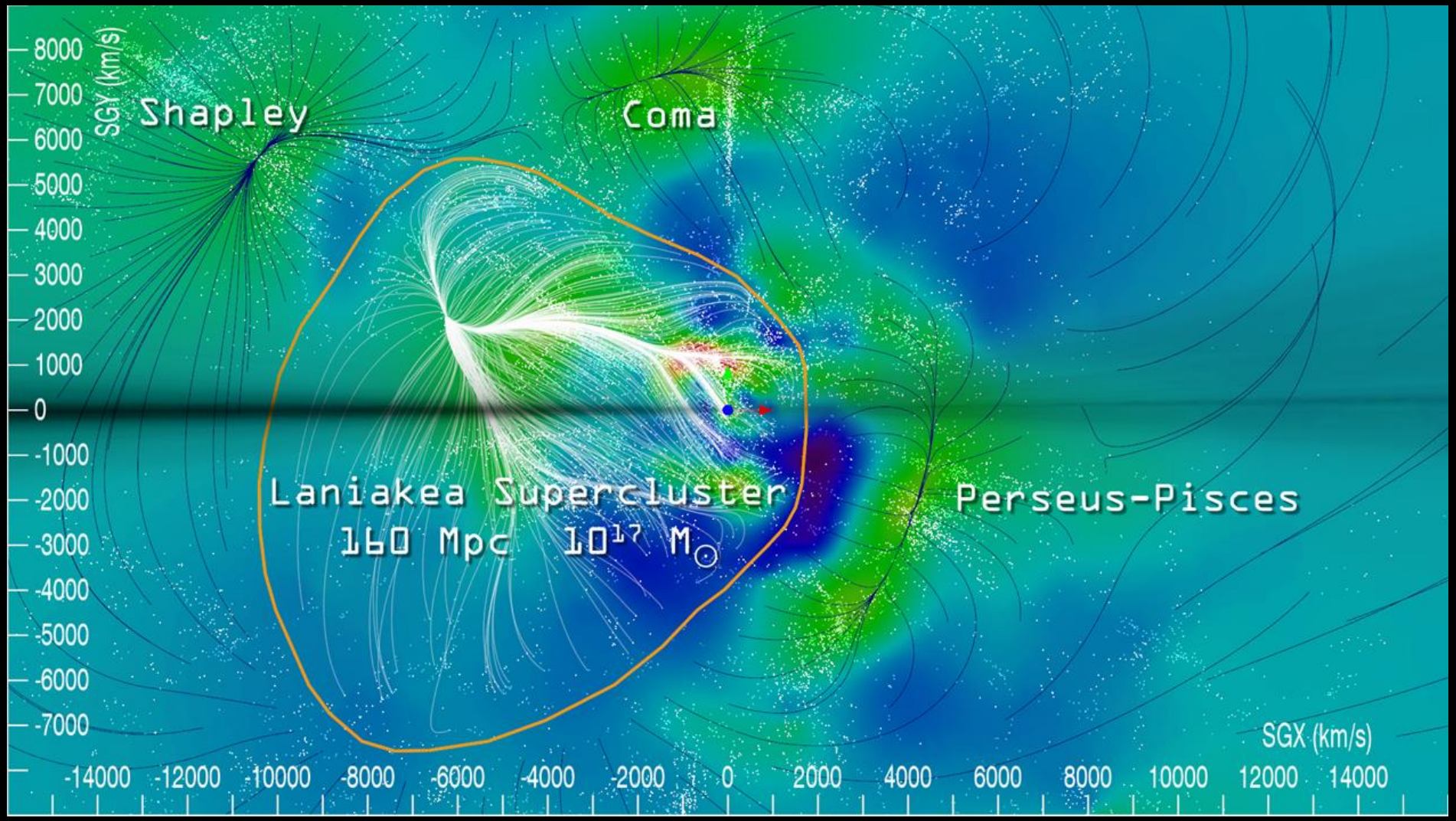
Discovery of the Laniakea supercluster of galaxies, our Home supercluster

September 2014 – Cover of *Nature*

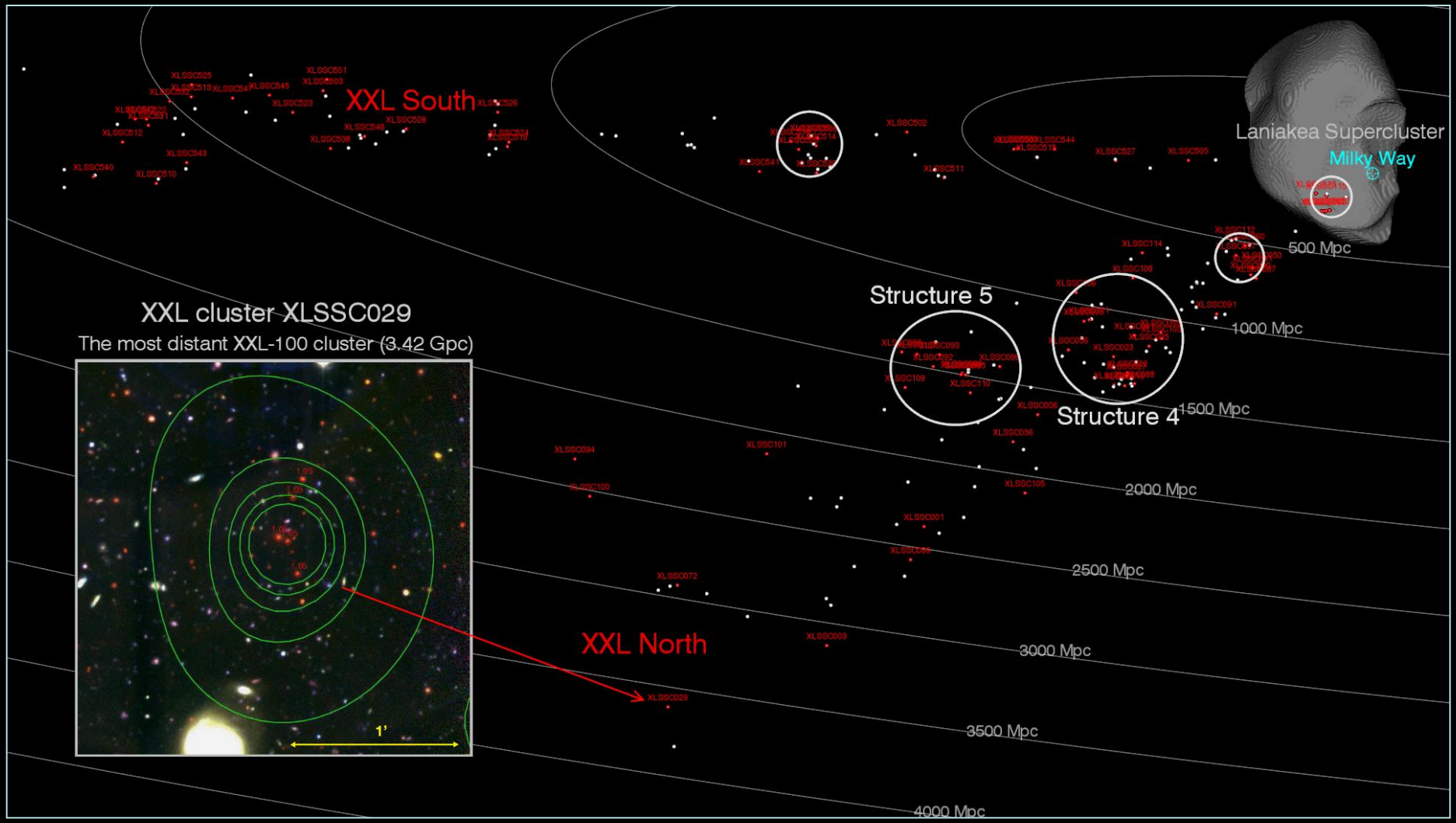
« *The Laniakea Supercluster of Galaxies* »

- 7 maps and a 7 minutes-long video exposing the cartography of our supercluster of galaxies
- Concept of gravitational basin of attraction in which are confined the cosmic flows, used to trace the 3D limits of superclusters
- Discovery of the frontiers of our supercluster, named Laniakea, *Immense celestial horizon* in Hawaiian
- Major role of visualization in this discovery
- *Nature* associated productions:
  - ✓ Cover image
  - ✓ Editorial article
  - ✓ News article
  - ✓ News & Views article
  - ✓ *Nature Video :* 4 minutes produced by Nature on the basis of our visualizations
    - 2.7 million views
    - Most popular Nature Video ever
    - (200 videos produced in 6 years)
  - ✓ Press Release

A map of the Laniakea Supercluster

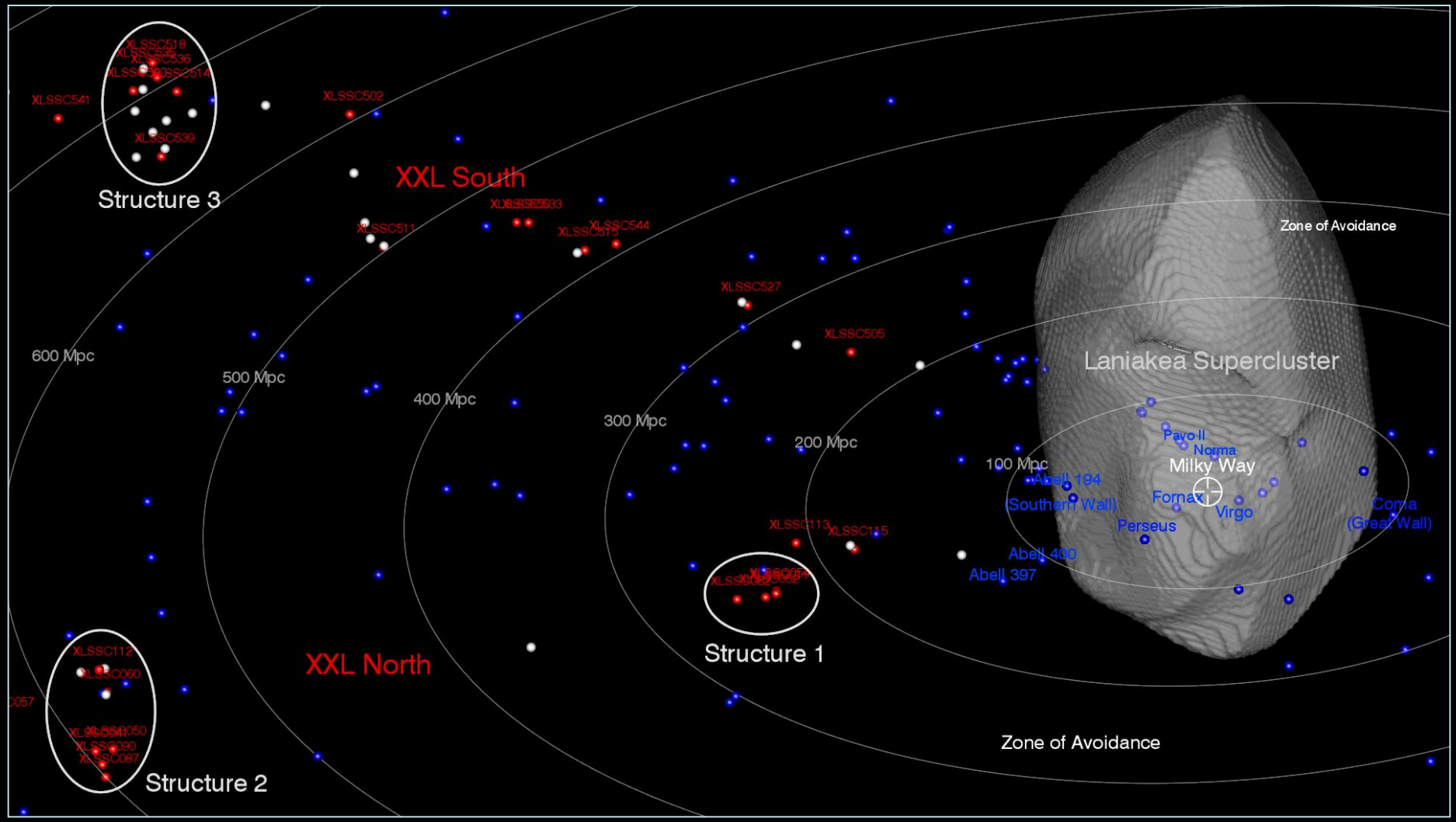


Cartography of the XXL survey of galaxy clusters (M.Pierre/SAp)



The largest XMM-Newton project, two beams of 25 deg reaching out to Z=2
Visual comparisons of XXL cosmography with Local Universe structures

Cartography of the XXL survey of galaxy cluster (M.Pierre/SAp)



The largest XMM-Newton project, two beams of 25 deg reaching out to Z=2
Visual comparisons of XXL cosmography with Local Universe structures

PERSPECTIVES

- Facing the challenges of new generations of simulations
  - fast response to demands from new simulations
  - design and development of new, specific, on-demand software modules when needed
- Cosmography
  - cartography of structures beyond Laniakea
    - ANR-2015 « COSMOGRAPHY-Zero » proposal
  - XXL Extragalactic Survey
    - 2015: publications of the first results
- Remain ready to respond to new demands in new research areas