DIAPHANE: Building a Library for Radiation & Neutrino Transport

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DIAPHANE overview

Library of modules for Radiation & Neutrino transport (c/c++)

Multiple algorithms

Usable by “any” astrophysics code

Many applications:

-Galaxy, star, & planet formation, supernovae, black hole formation

1st modules

-Radiation: Flux Limited Diffusion, STARRAD (ray casting)

-Neutrinos: Advanced Spectral Leakage

Funded by Platform for Advanced Supercomputing (PASC) CSCS

Planned release in 2017

motivation

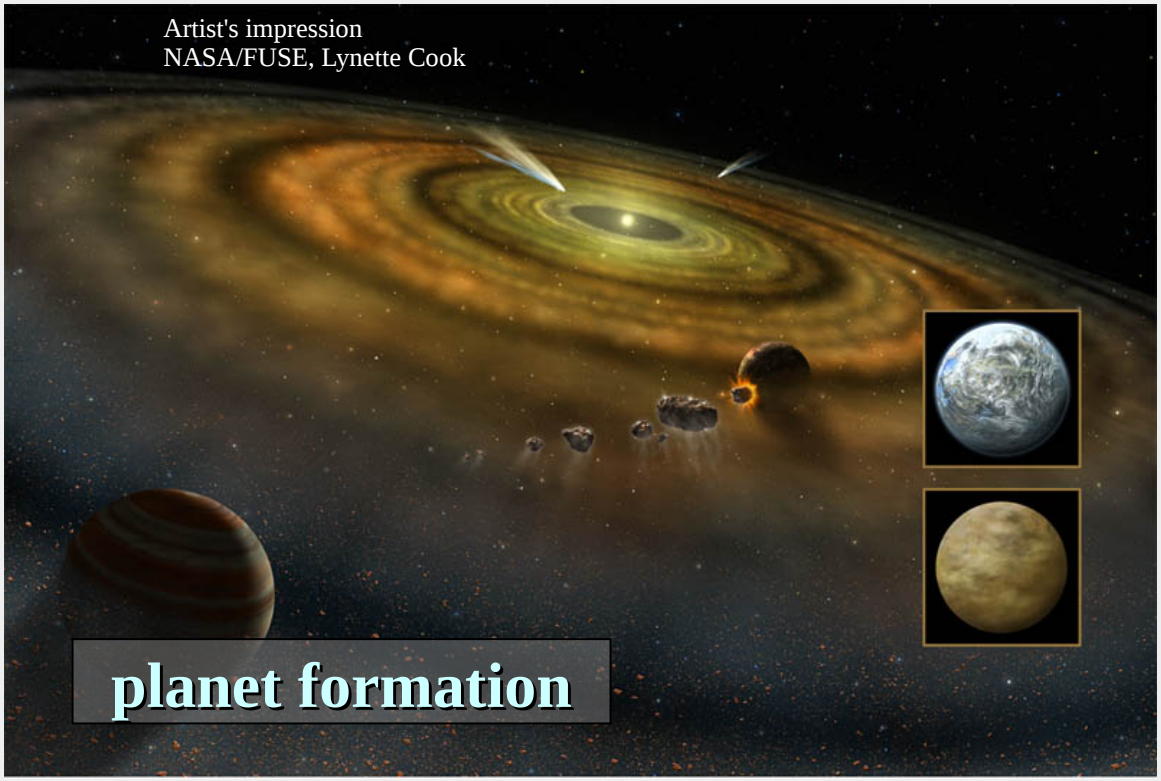
Rad./Neutrino transport important but difficult

- $c_{light} >> c_{sound}$
- Complex physics (lines, scattering, etc)

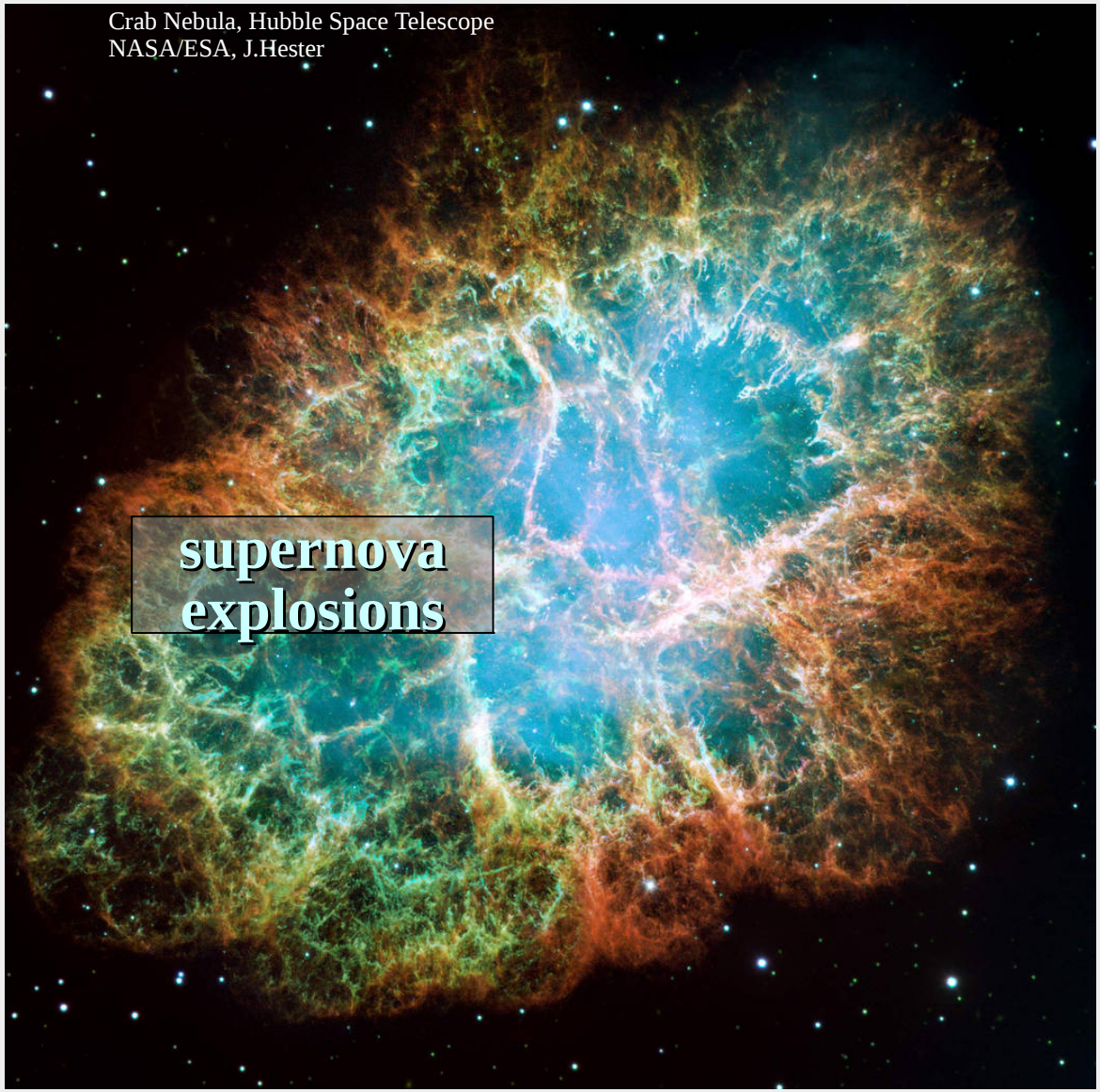
Large range in scales & opacities:

- **Require multiple algorithms in a single sim.**

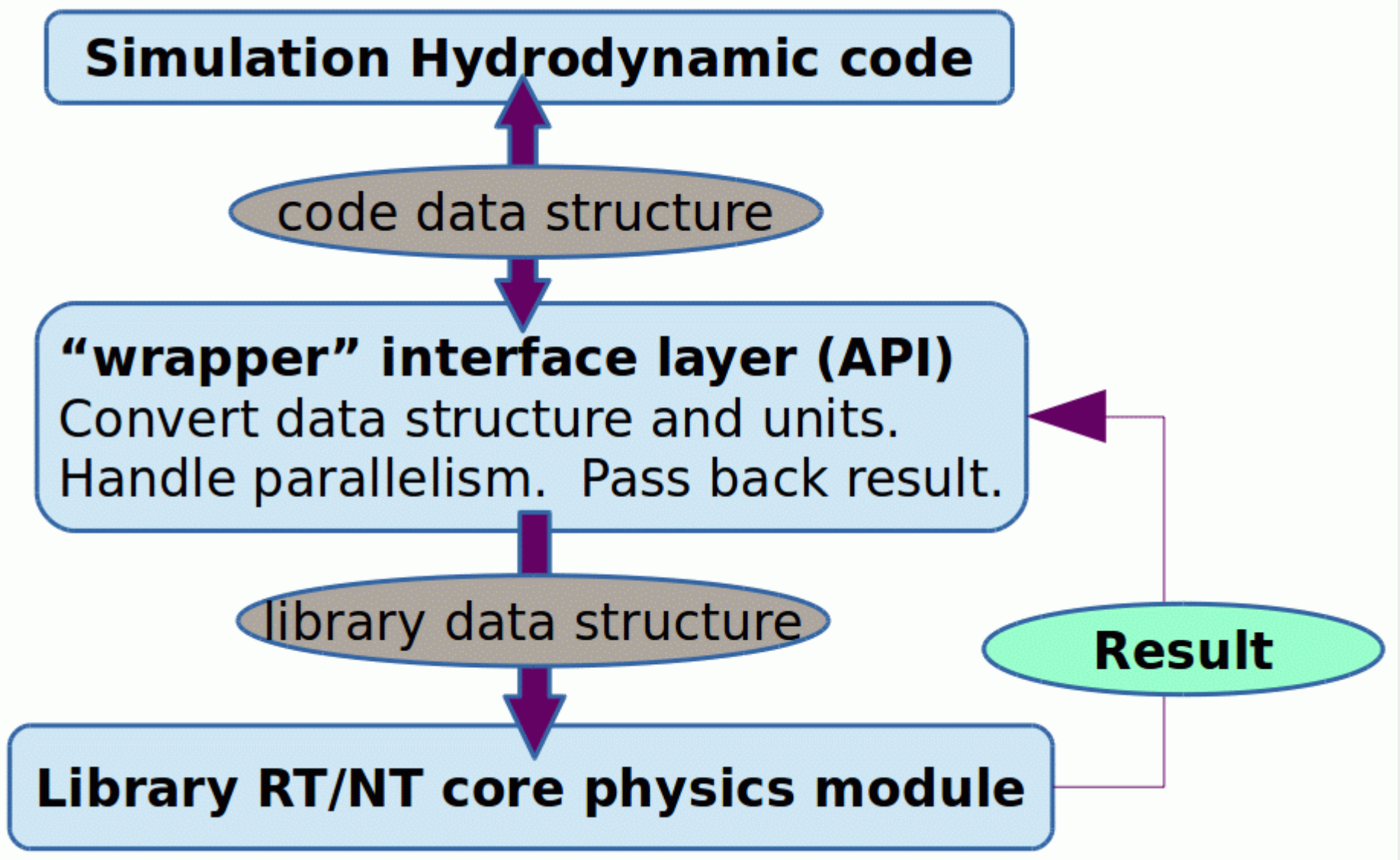
star formation



Artist's impression
NASA/JPL, Caltech

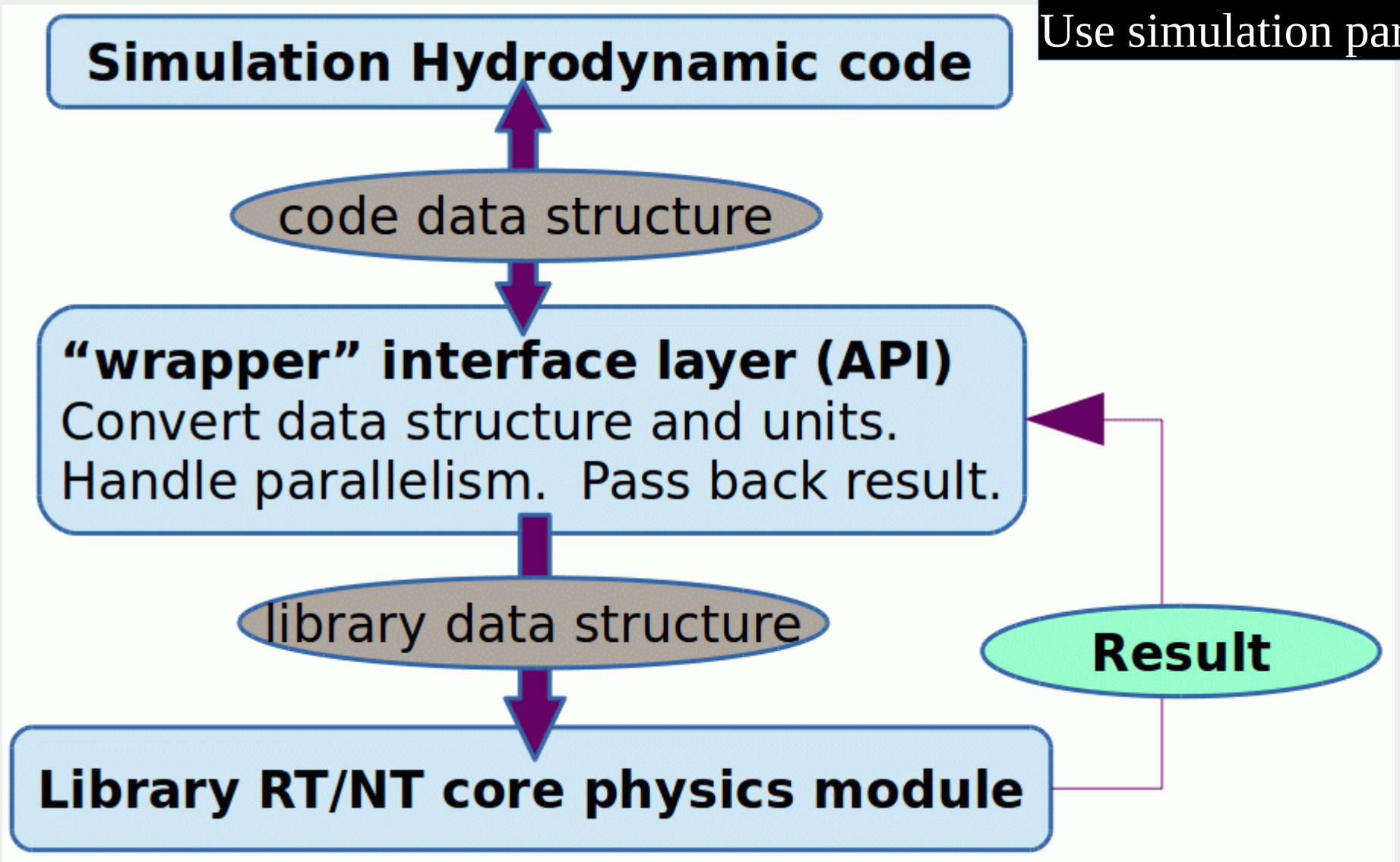

Crab Nebula, Hubble Space Telescope
NASA/ESA, J.Hester
supernova
explosions

Interaction between sim code & Lib.

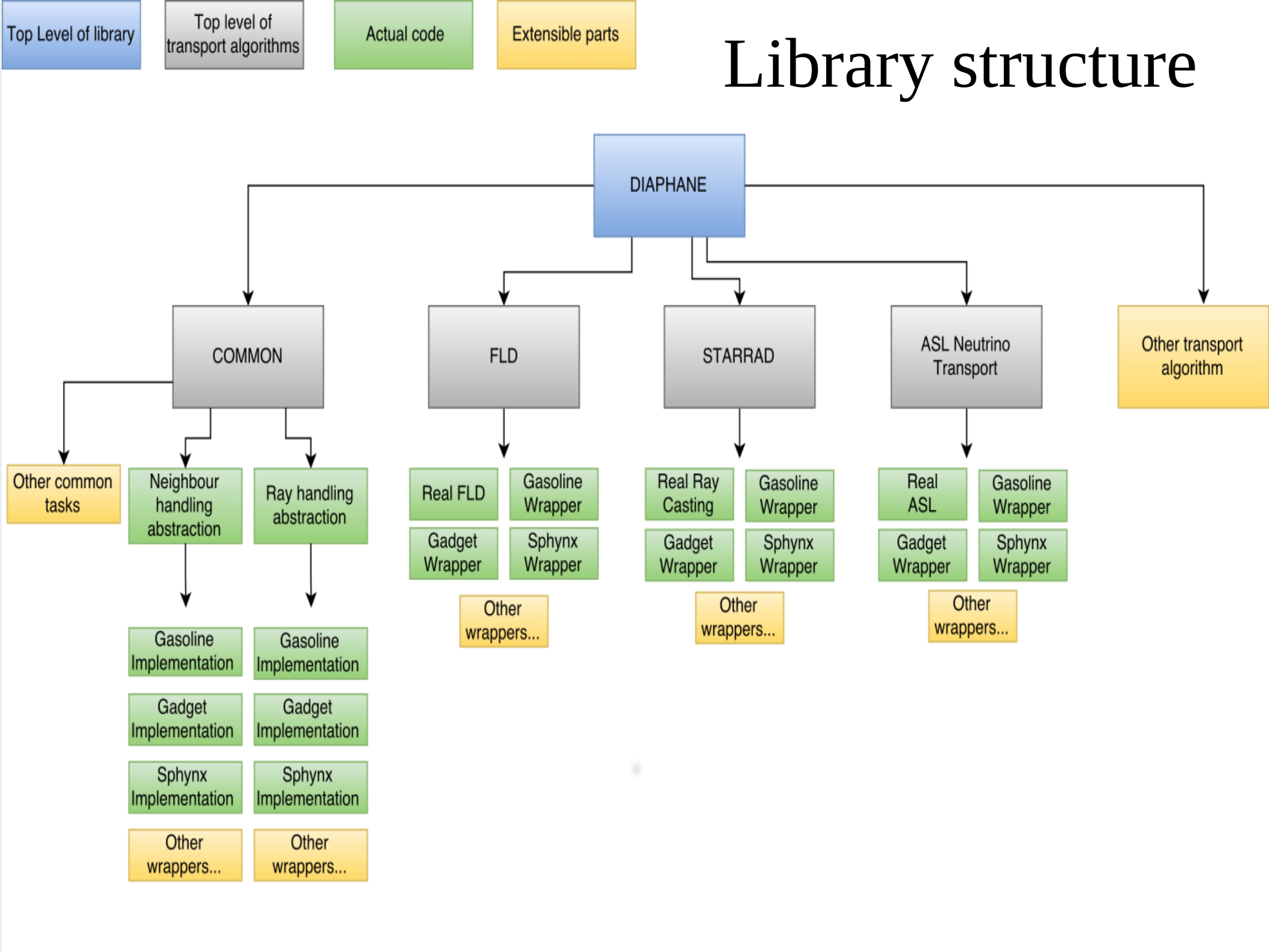


Interaction between sim code & Lib.

Version 0:
1 particle at a time
Use simulation parallelism



Library structure



Library engineering goals

Modular – physics self-contained

Extensible

Maintainable

Portable – e.g. iso_c_binding to call c from fortran

Robust

Testing & Validation

Flux Limited Diffusion Test

– only need local neighbors

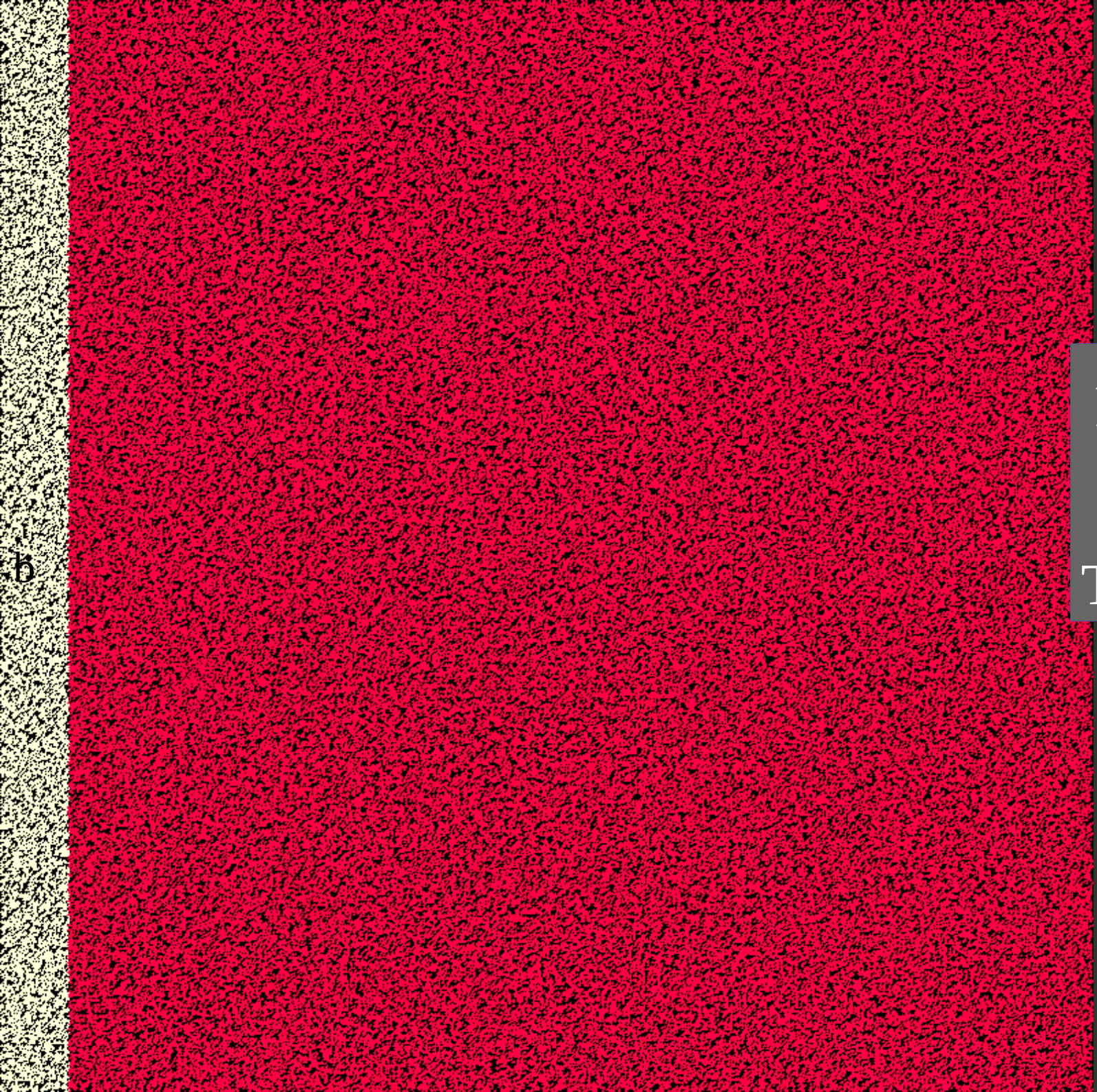
– energy flows down the local gradient

– best for optically thick gas

$$\dot{U}_a = \sum_b \frac{4m_b}{\rho_a \rho_b} \frac{k_a k_b}{k_a + k_b} (T_a - T_b) \frac{\mathbf{r_{ab}} \cdot \nabla \mathbf{W}}{|\mathbf{r_{ab}}|^2}$$

$$k_a = \frac{16\sigma}{\rho_a \kappa_a} \lambda_a T_a^3.$$

Diffusion with a “flux limiter”



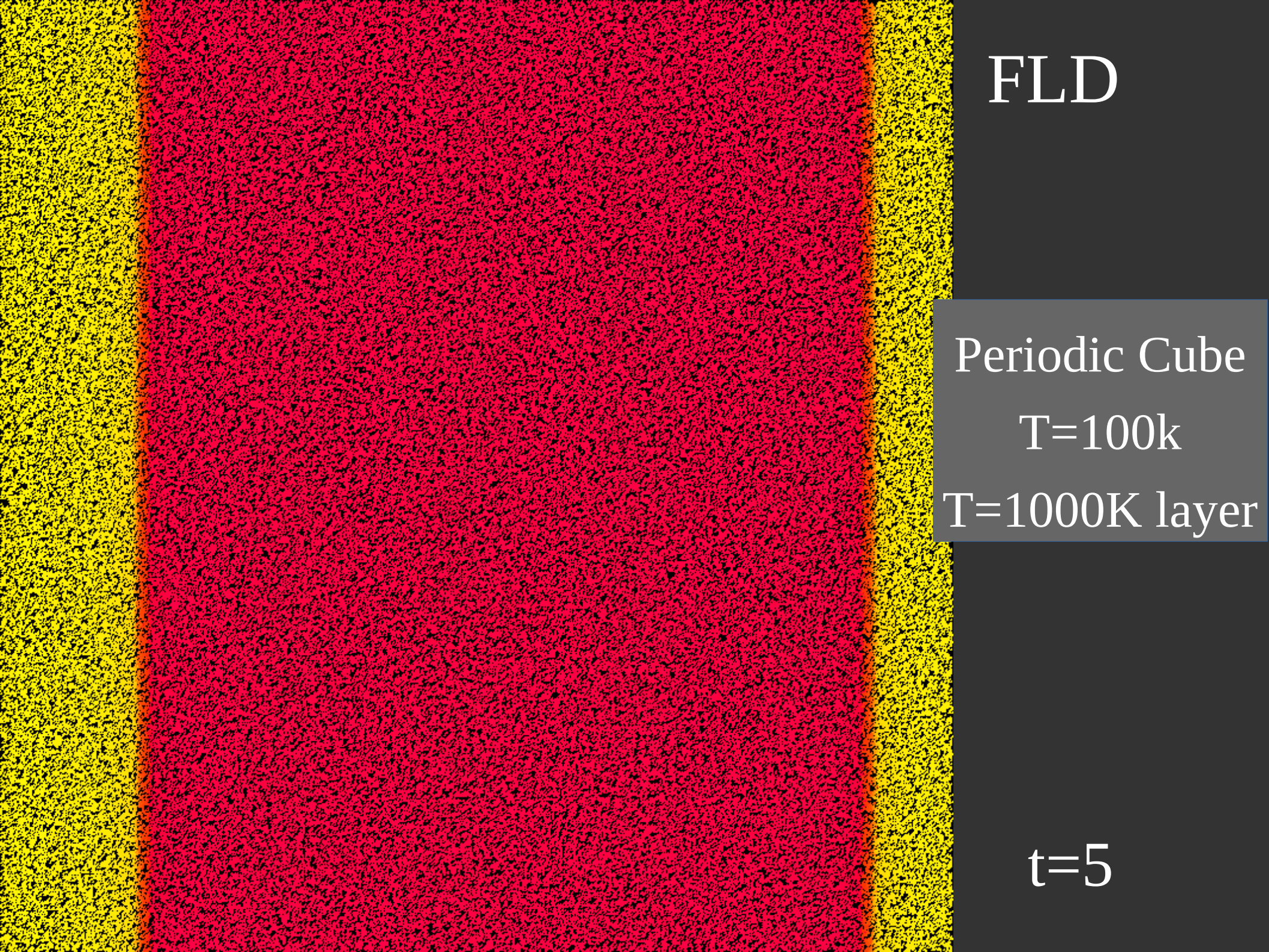
FLD

Periodic Cube

T=100k

T=1000K layer

t=0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Periodic Cube
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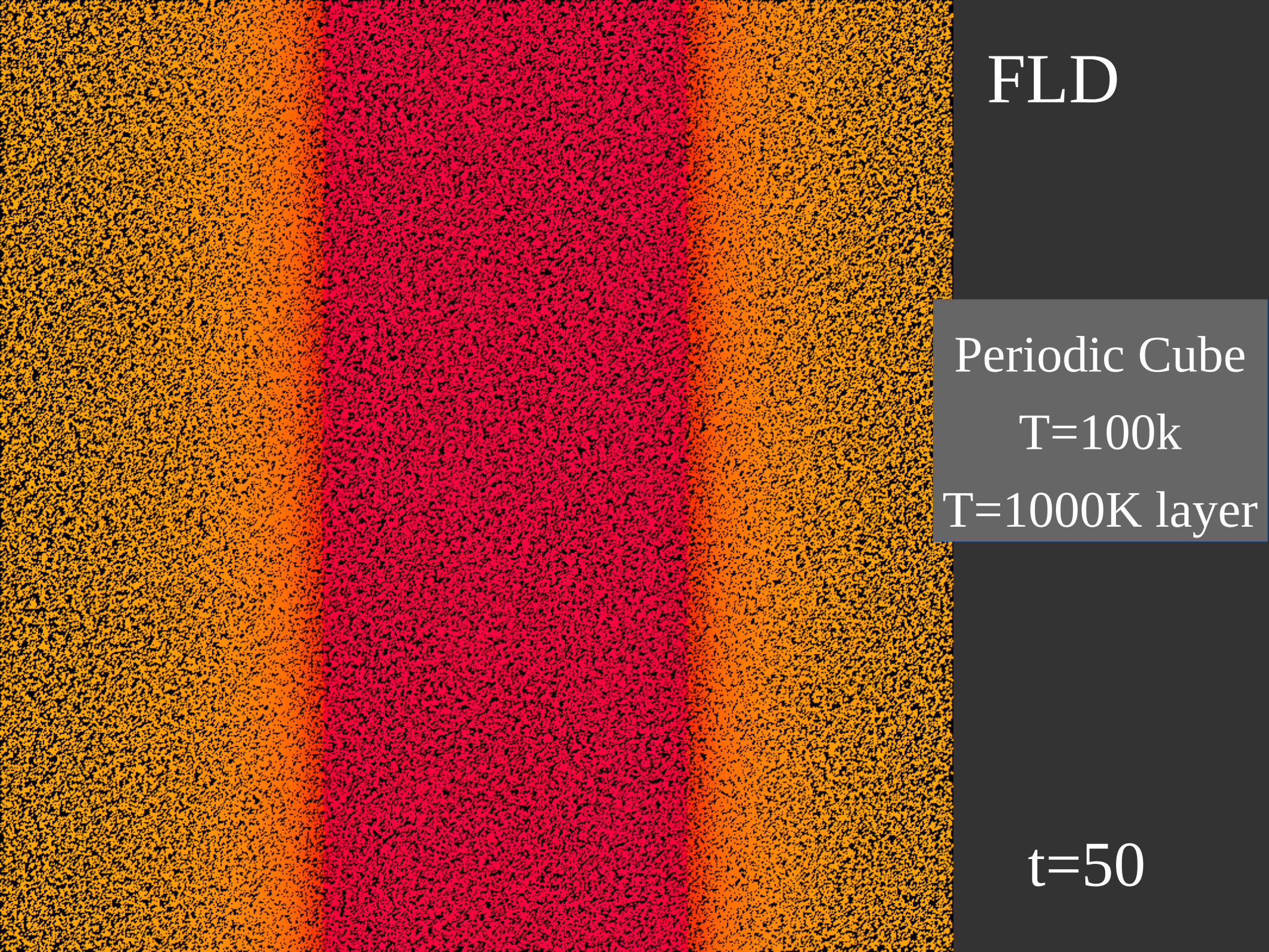
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Periodic Cube
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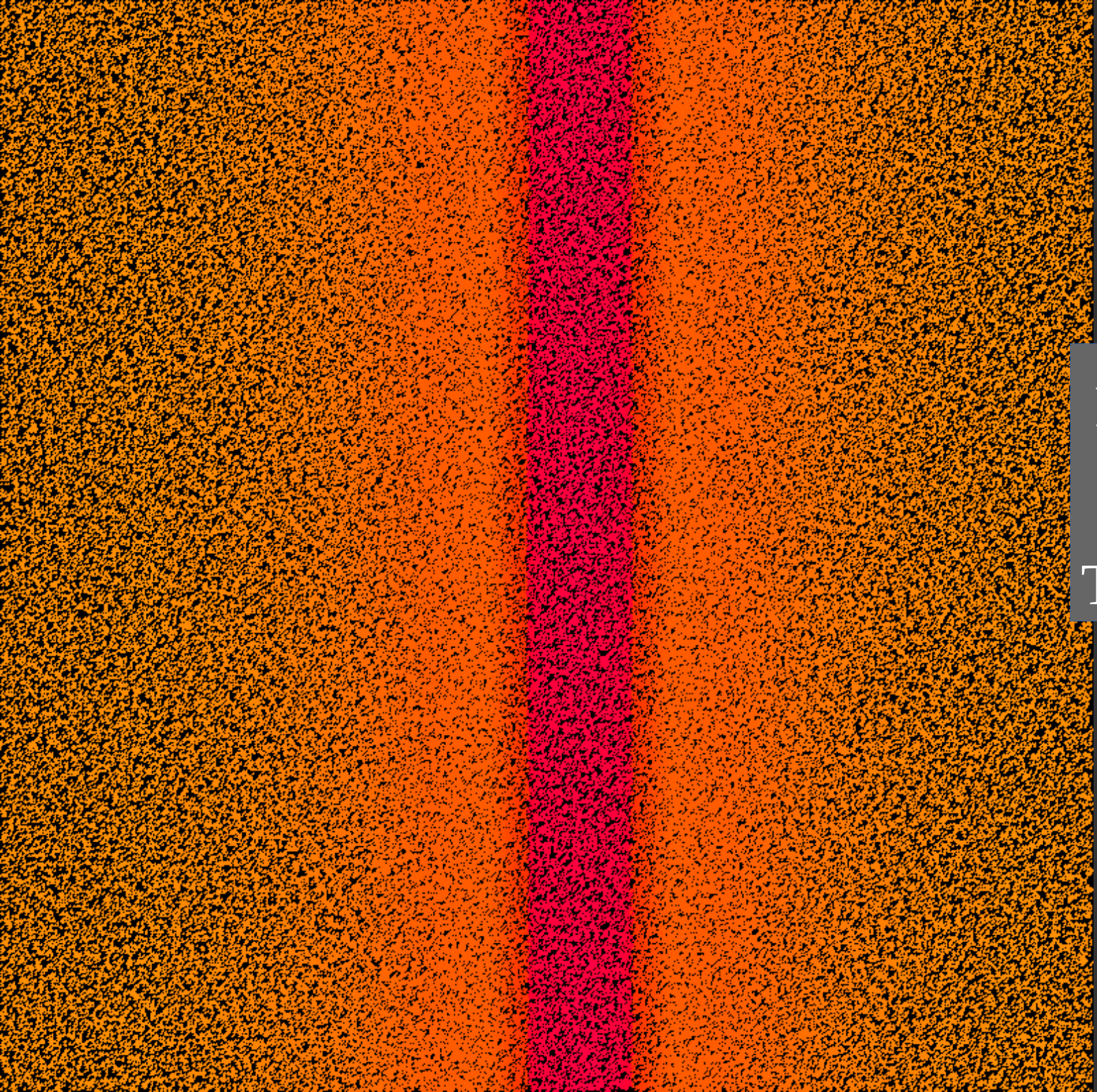
T=1000K layer
t=50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Periodic Cube
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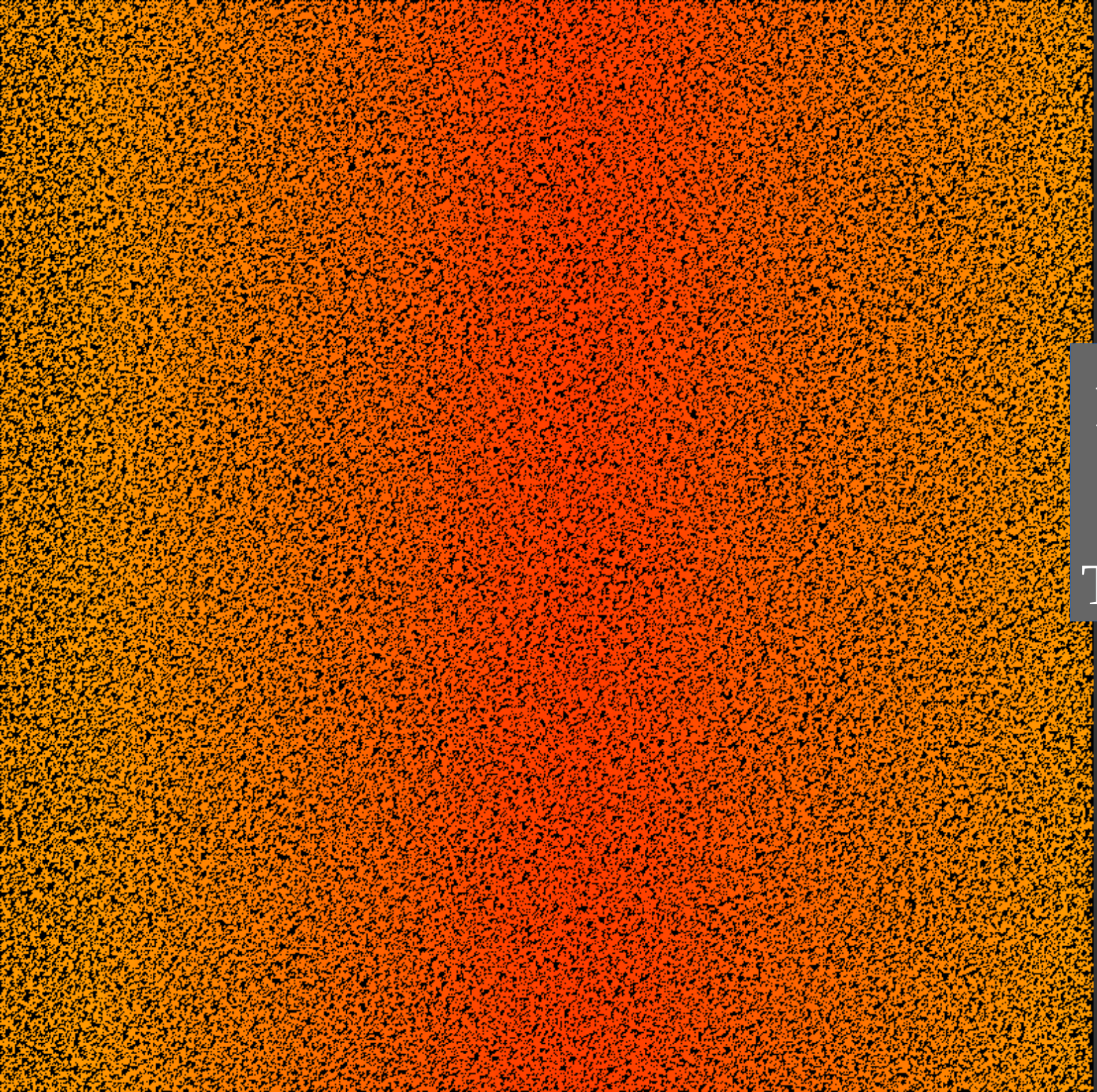
T=1000K layer
t=100



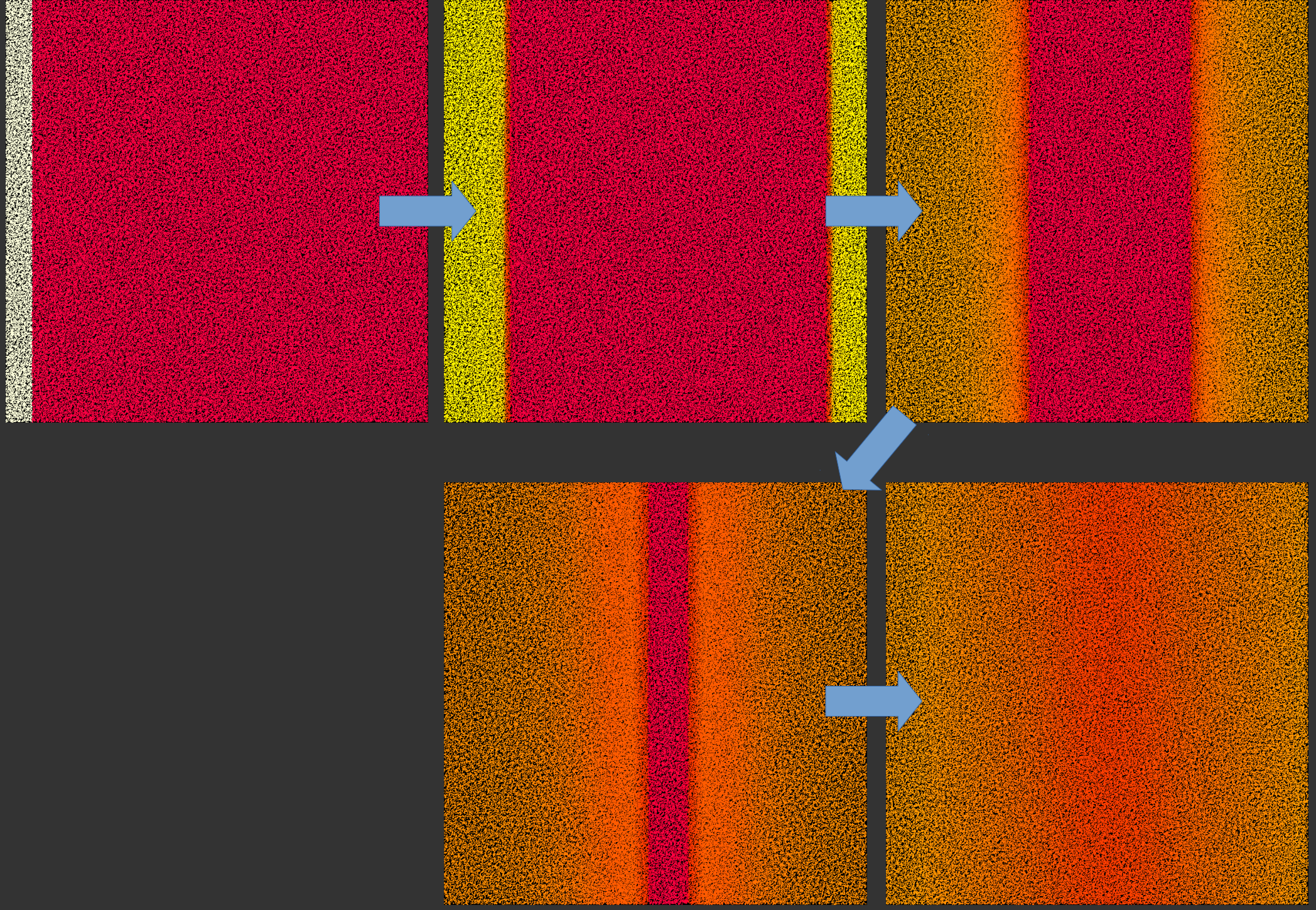
FLD

Periodic Cube

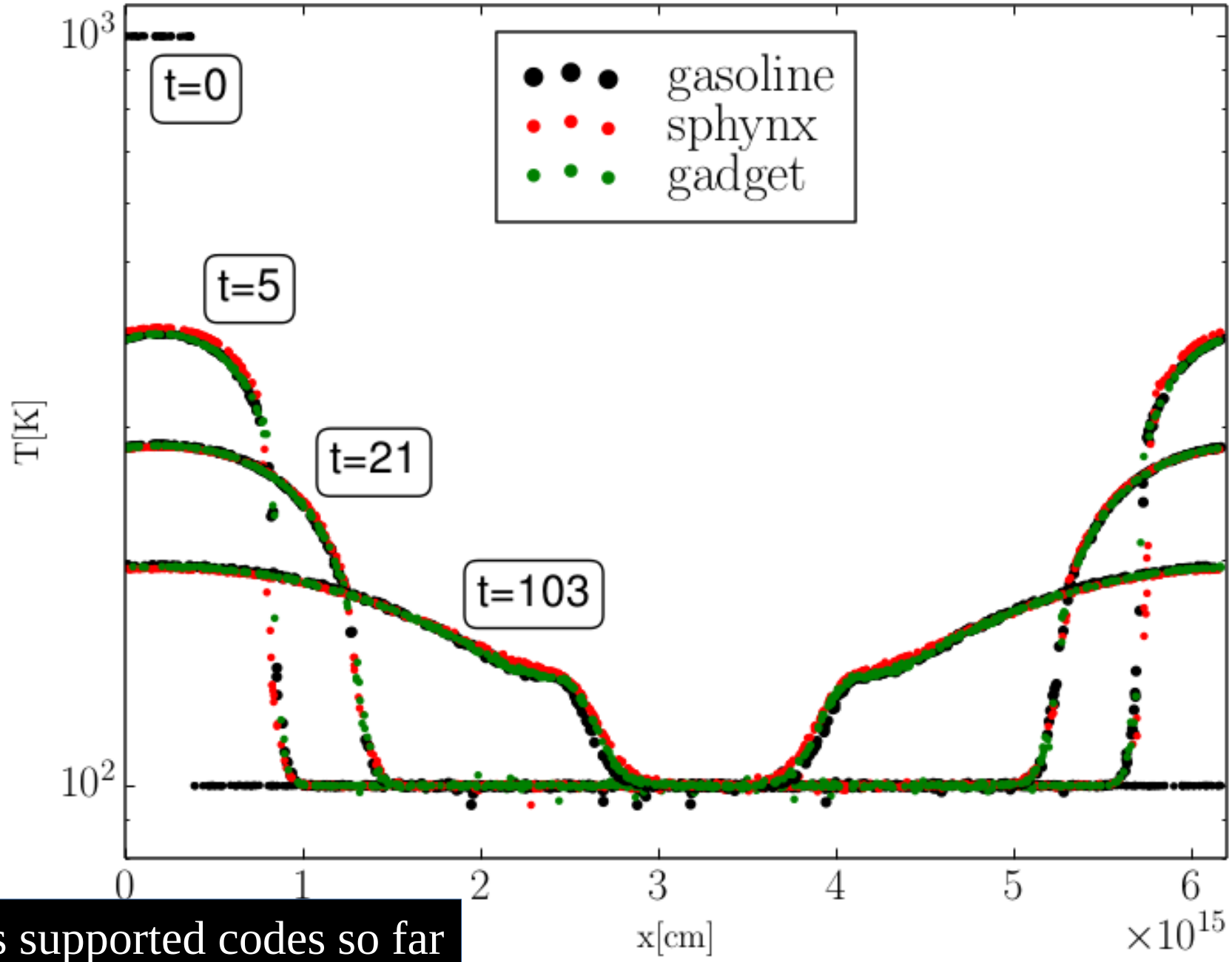
T=100k

T=1000K layer

t=300

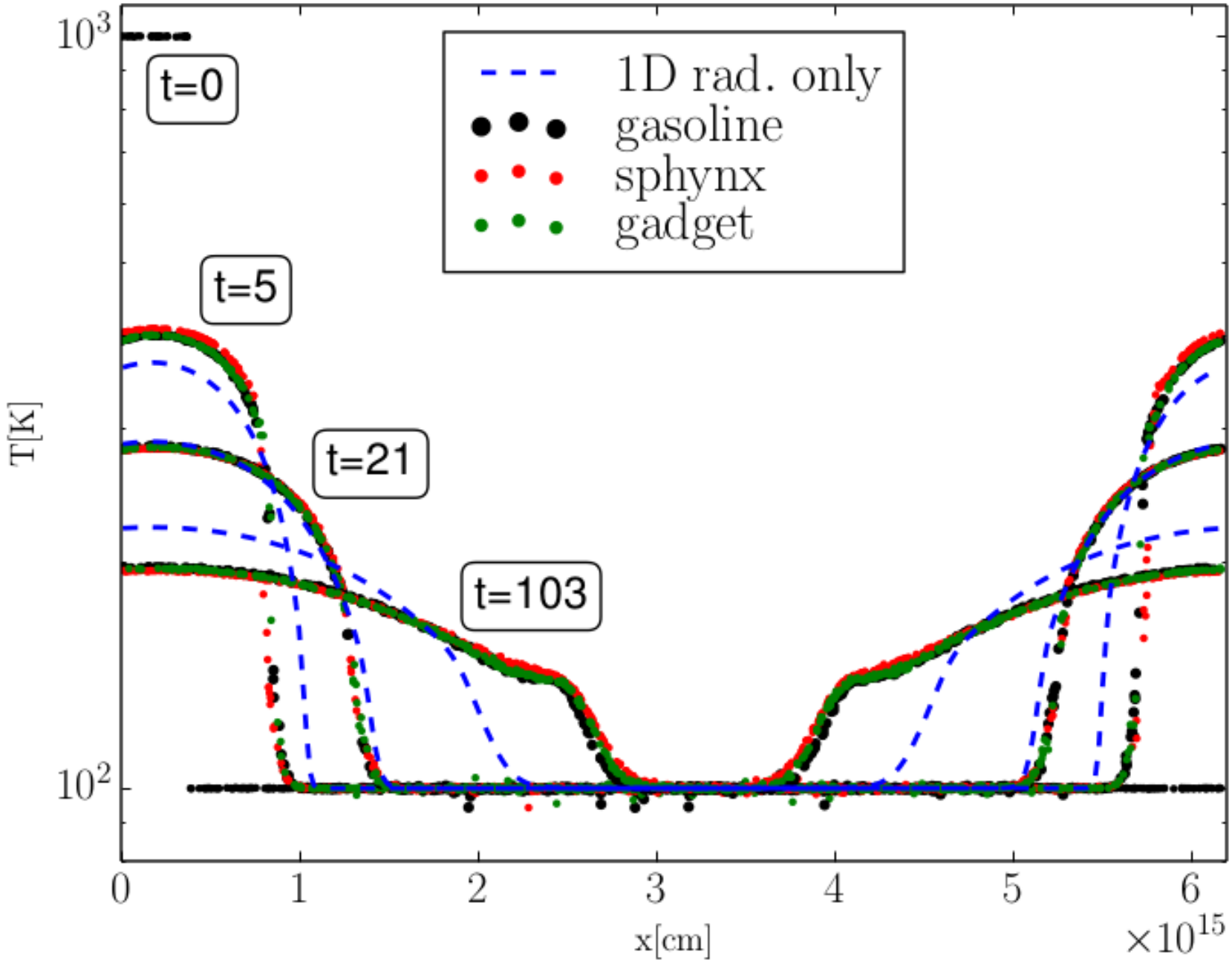


Code comparison

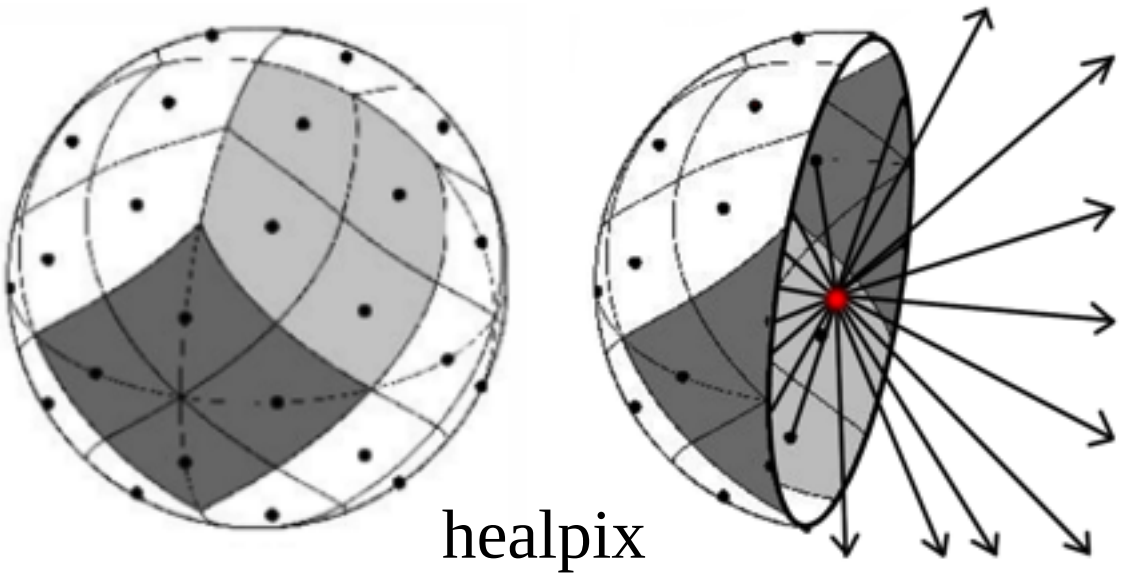


3 codes supported codes so far

Code comparison

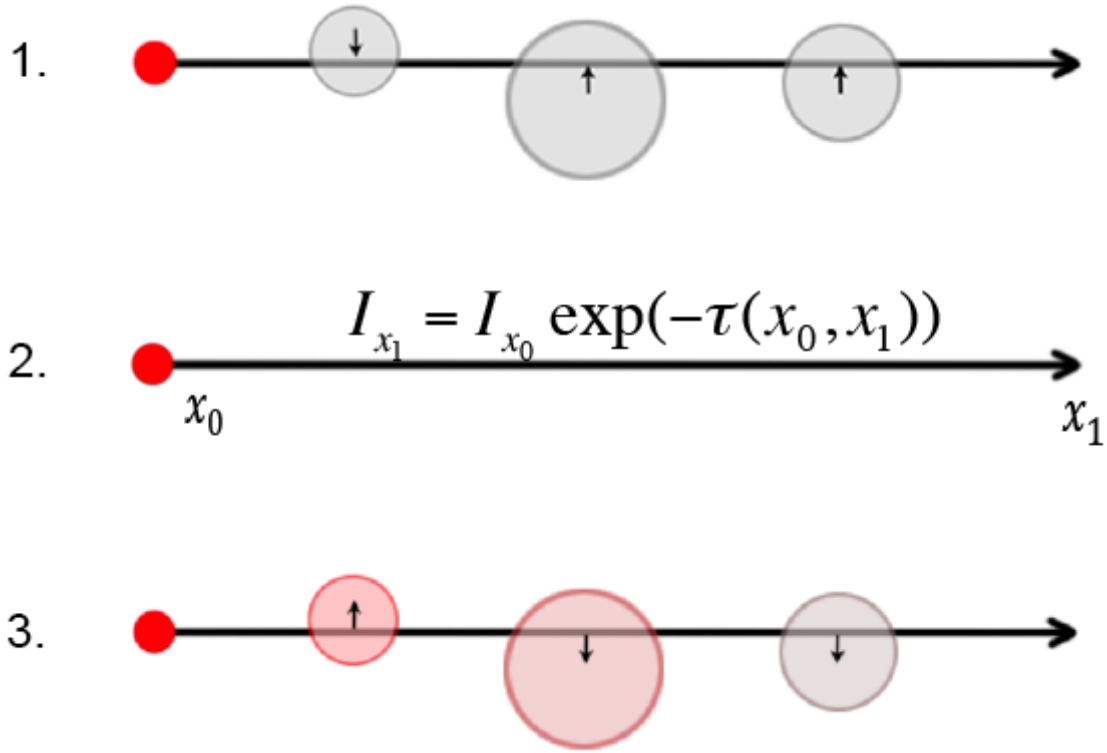


STARRAD – ray casting w/point sources



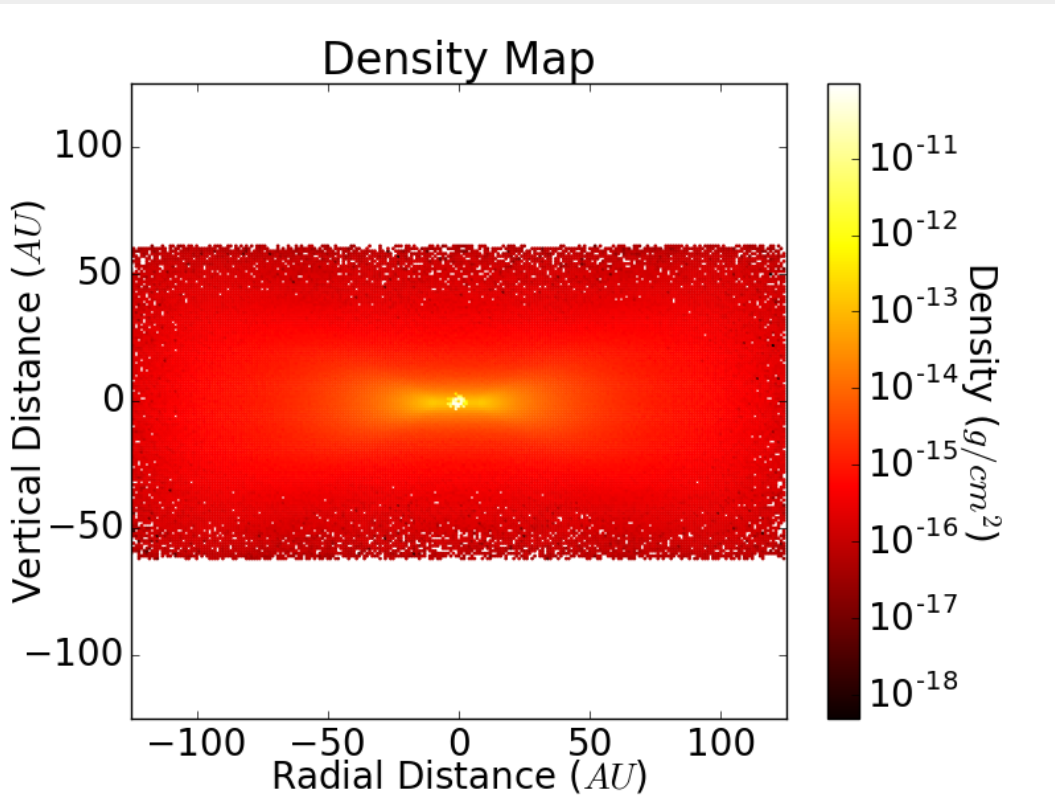
healpix

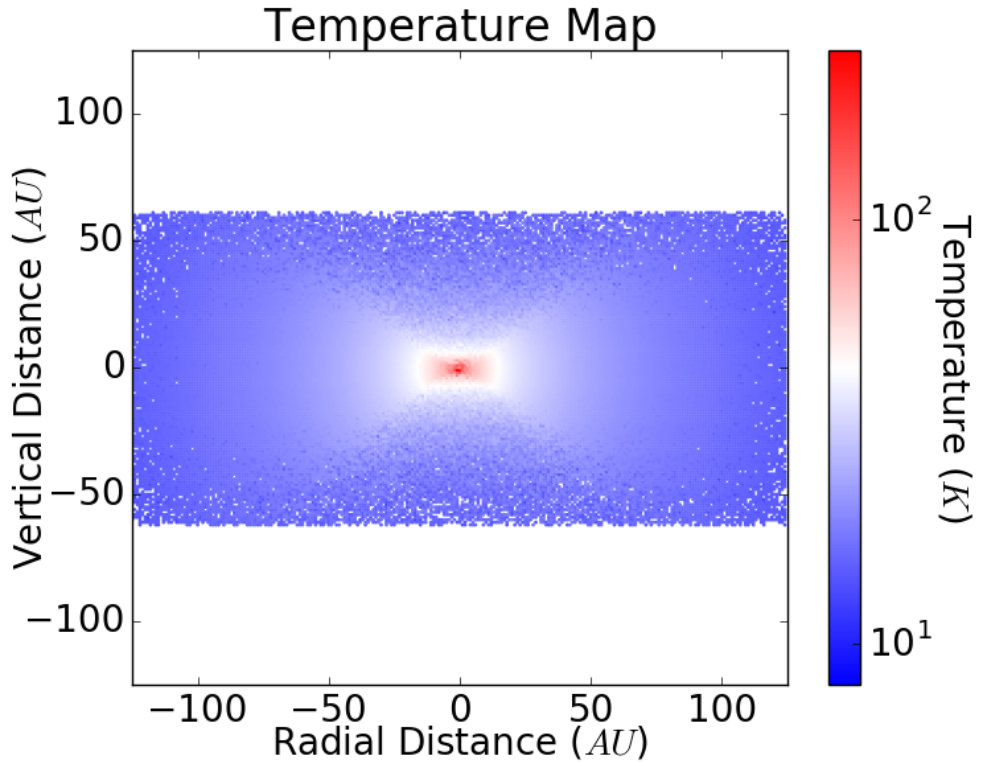
Tim Dykes

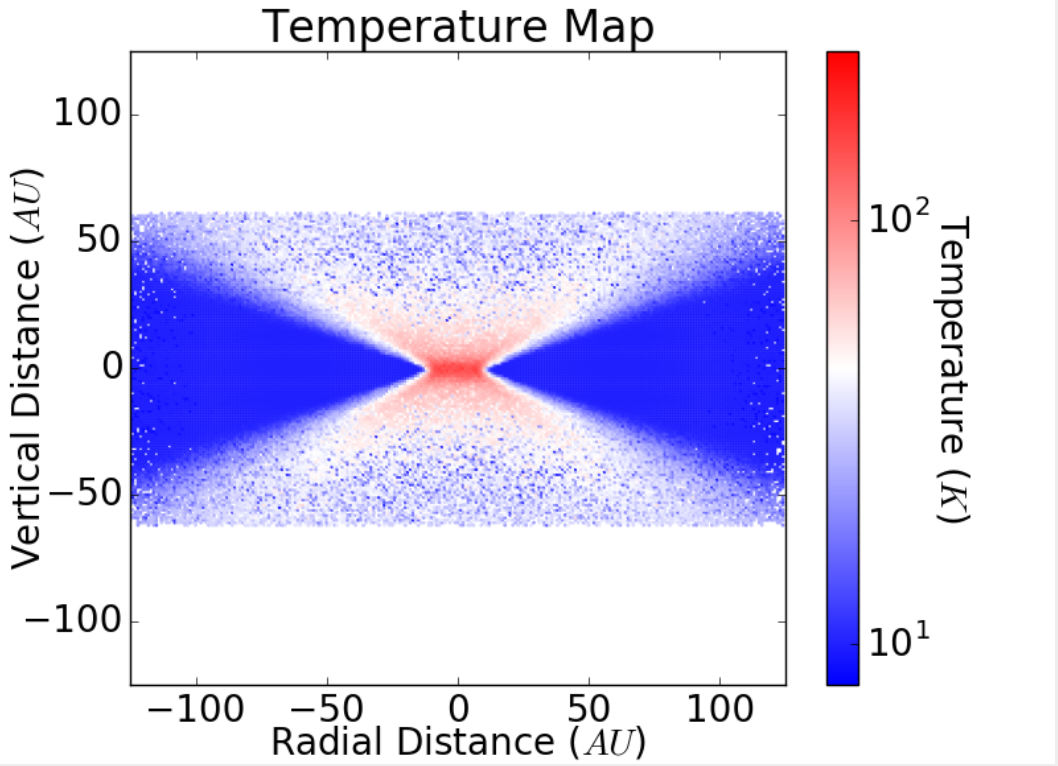


Communication:
use PKDGRAV method

starrad: test simulation

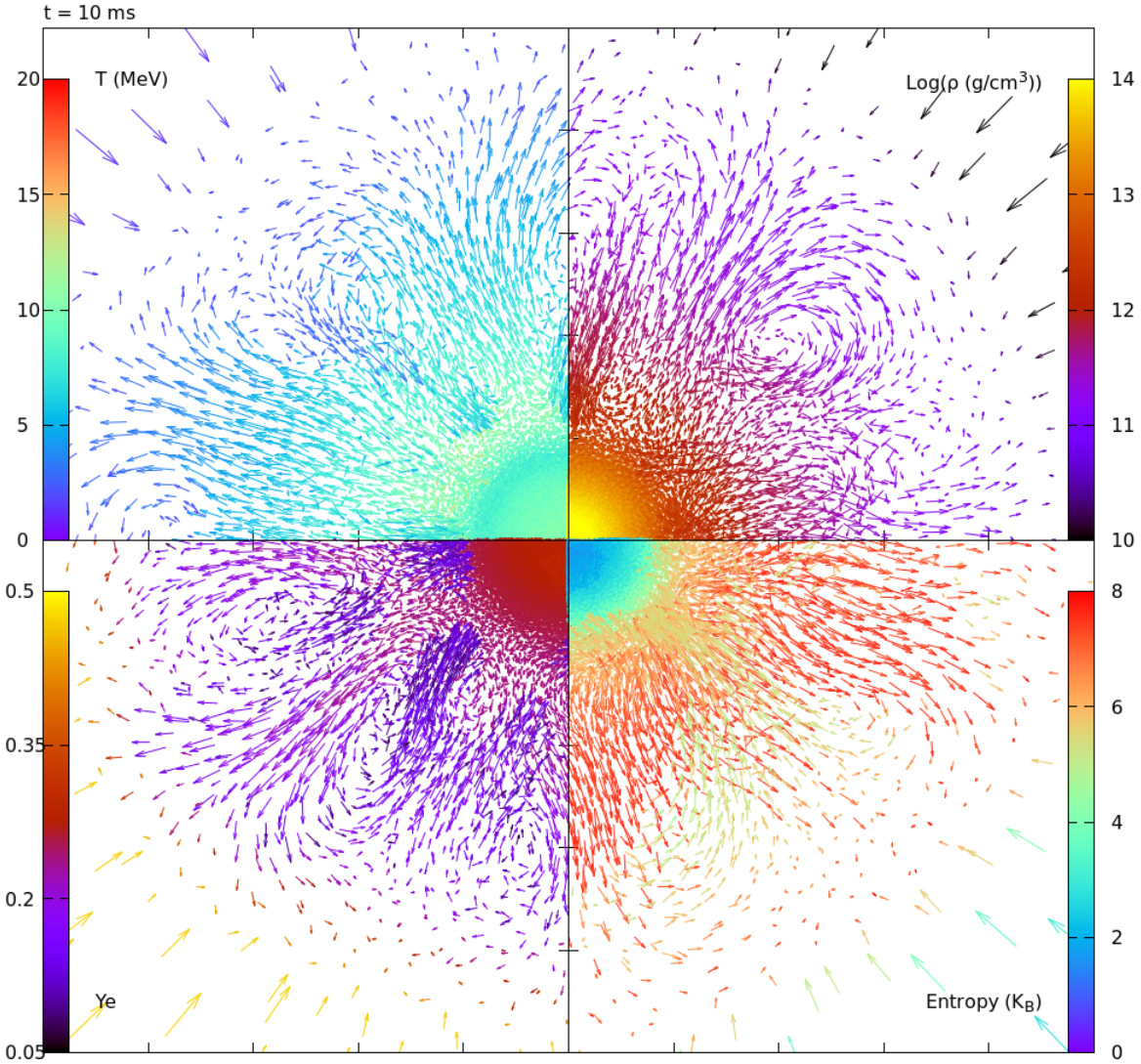






Advanced Spectral Leakage (ASL) neutrinos

Perego, Cabezon & Kappeli 2016



Future: DIAPHANE radiation & neutrino transport library

More modules: e.g. TRAPHIC

Adaptive coupling of modules

More codes, including AMR

Optimize toward Exascale

RT/NT on accelerators (GPU, MIC, ?)

Community contributions?

2017: https://bitbucket.org/diaphane/diaphane-library