Observatoire astronomique de Strasbourg

UNIVERSITÉ DE STRASBOURG

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Local reionization-s evolution with merger tree of HII regions

Jonathan CHARDIN

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OUTLINE

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- Simulation
- Reionization history
- Local Reionisation-S
- Conclusions & prospects

Introduction

Why do we use merger tree of HII regions ?

Tool to **quantify** the **simulation properties**.

↳ Constraining the impact of the ionising source models (Chardin et al. A&A 2012).

Studying **reionisation on galaxy scales** (Ocvirk, Aubert, Chardin et al. 2012, Submitted).

Investigatig **local reionisations** instead study on the global ionisation field (Chardin et al. In prep).

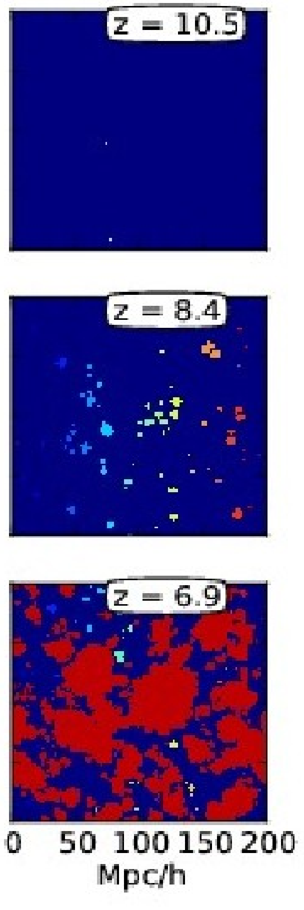
Merger tree of HII regions

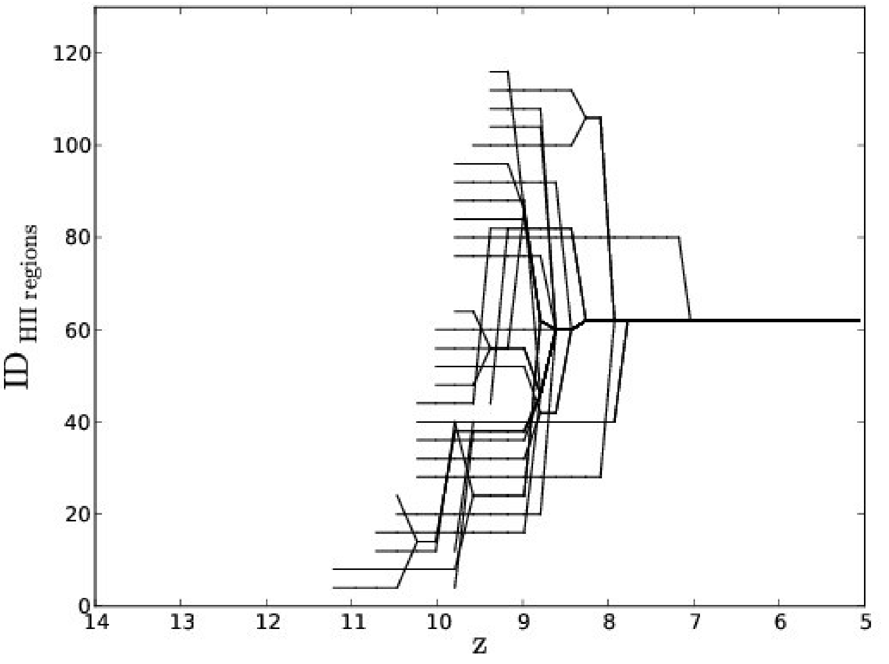
1. *Friends-of-friends* algorithm (FOF)

- Ionised cell : x≥0.5

2. Merger tree

- Follow regions from snapshot to snapshot



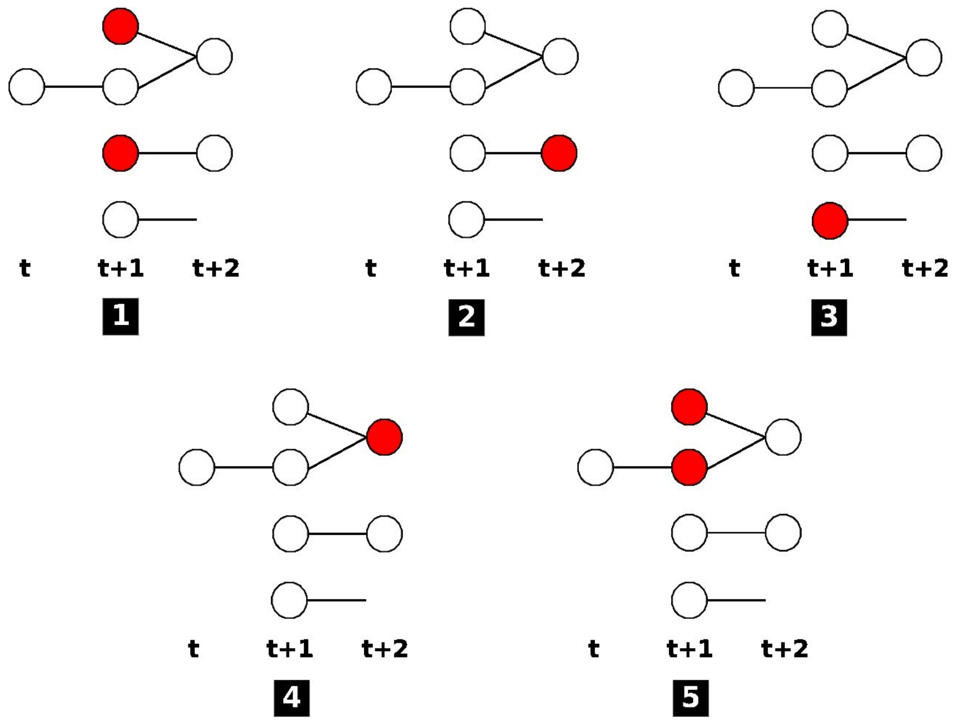


Merger tree of HII regions (2)

<u>Properties investigated with the merger tree :</u>

Number of :

- New regions
- Expanding regions
- Recombining regions
- Regions resulting from mergers
- Parents for regions resulting from mergers

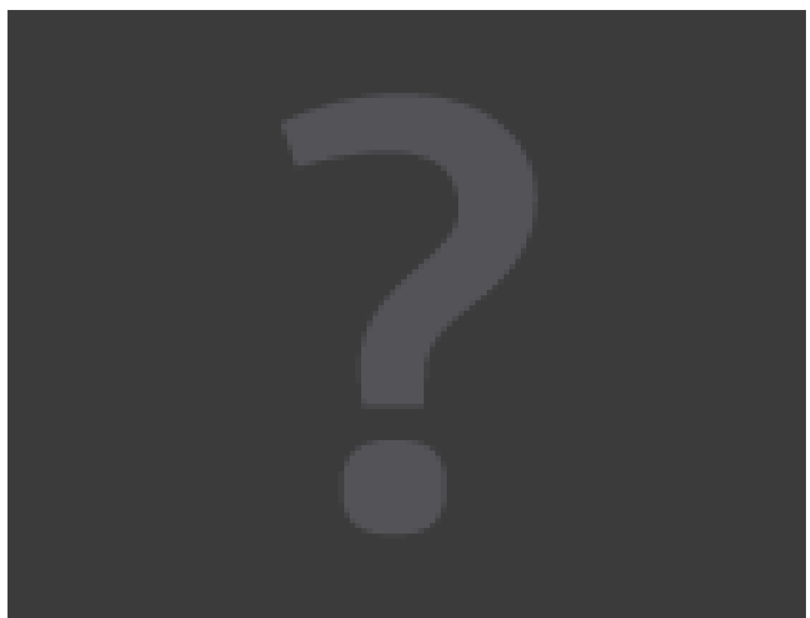


Simulation

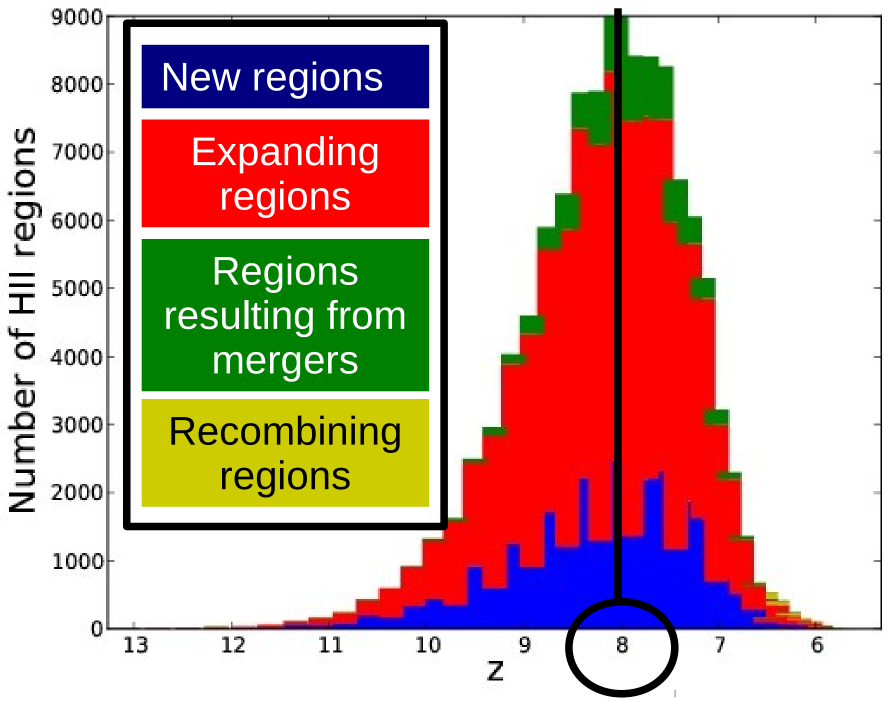
Hydrodynamic with the Ramses code (Teyssier 2002) to follow the build-up and evolution of DM halos (1024^3 + 3 levels of refinement in box of 200 Mpc/h)

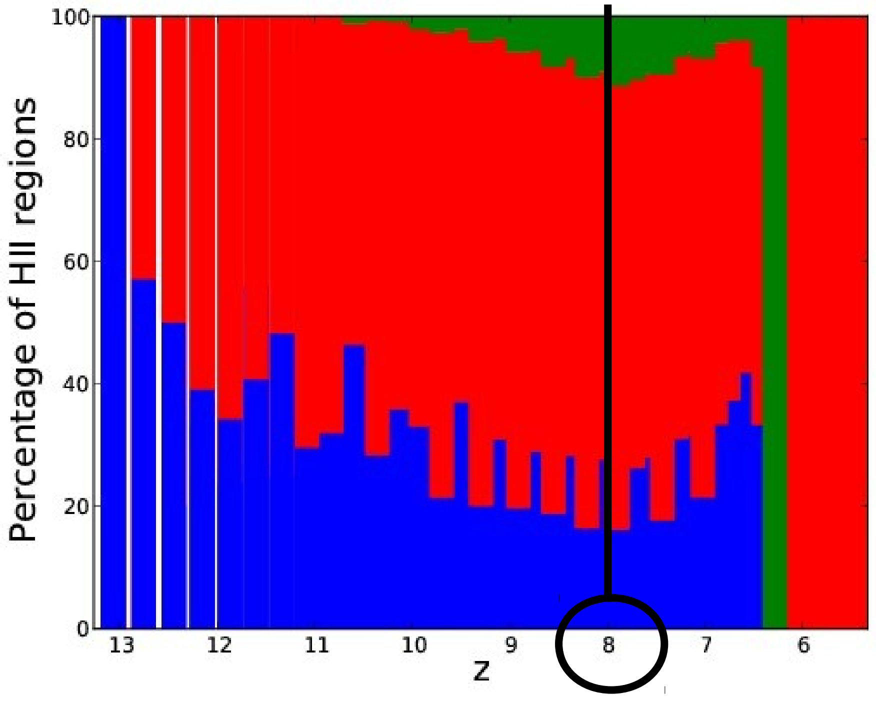
Ionizing sources : DM halos with an emissivity proportional to halo masses

Radiative transfer post-processed (1024^3) with the ATON code (Aubert & Teyssier 2008)



Number of HII regions





Peak at z~8 :

- Before the peak : Birth and expansion of HII regions

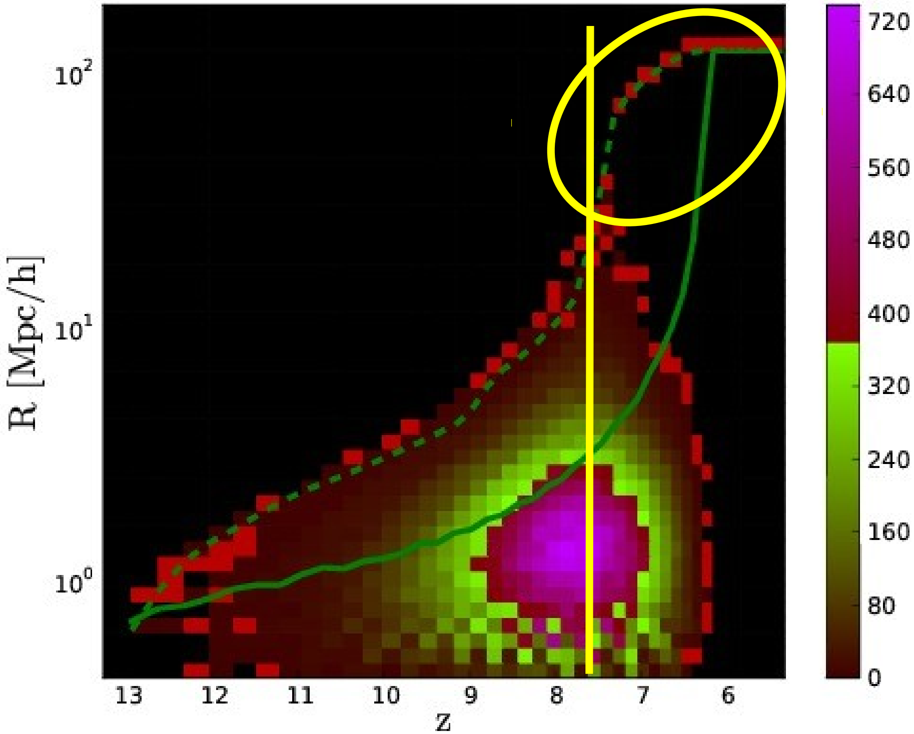
  ➡ Pre-Overlap period

- After the peak : merger of HII regions

  ➡ Overlap period

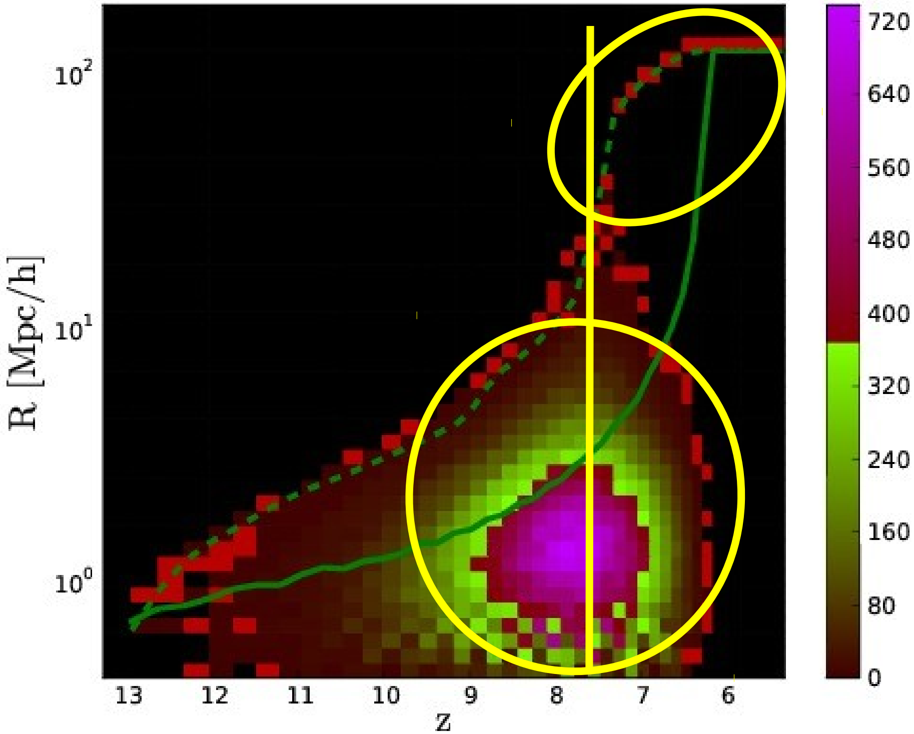
No recombining regions ➡ maintained emissivity

Size of HII regions



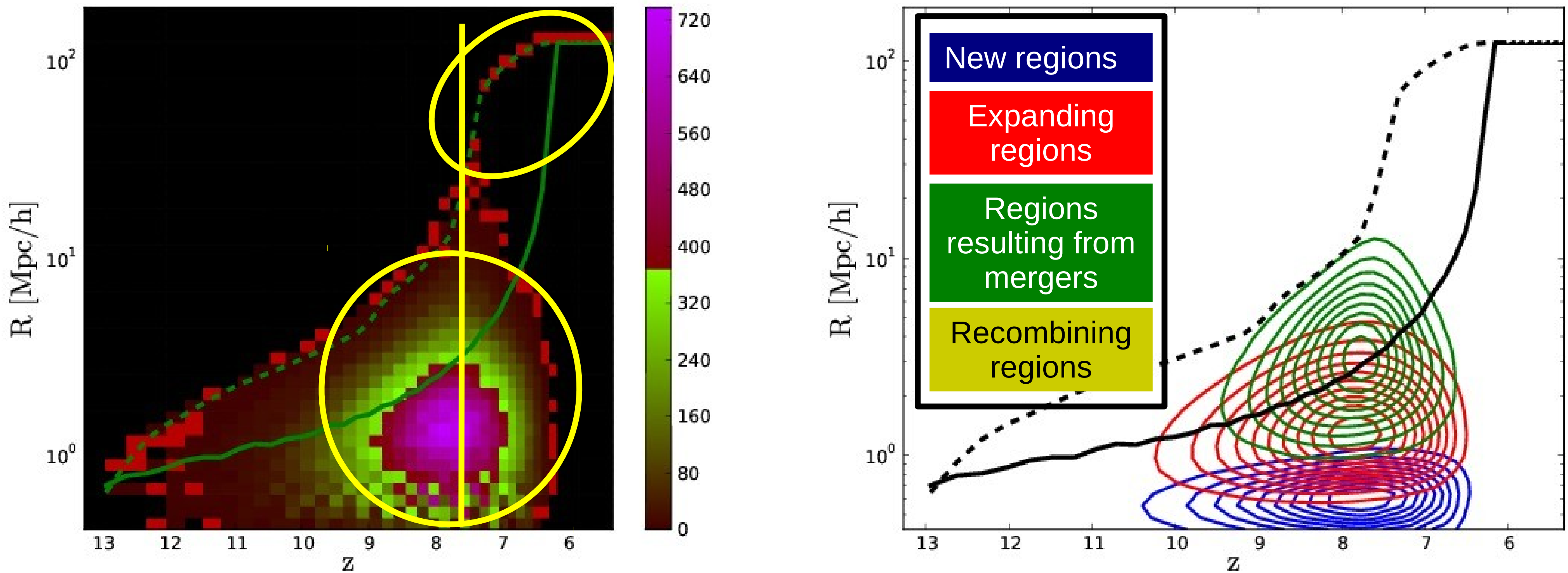
- Emergence of a main region in size in late reionization
- Late global ionized background ➡ local reionization histories can be tracked for a longtime

Size of HII regions



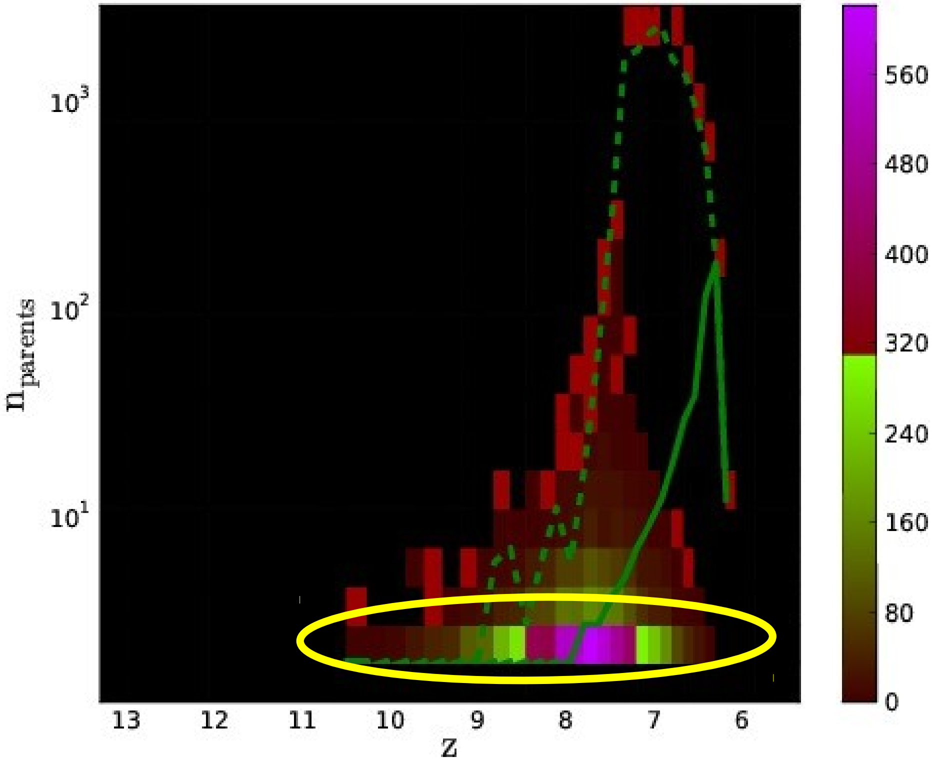
- Emergence of a main region in size in late reionization
- Late global ionized background ➡ local reionization histories can be tracked for a longtime
- Large range of radius = underlying range of halo masses

Size of HII regions



- Emergence of a main region in size in late reionization
- Late global ionized background ➡ local reionization histories can be tracked for a longtime
- Large range of radius = underlying range of halo masses
- Each type of regions occupy a dedicated range of radius in the distribution
- We can follow the typical size of HII regions before their mergers at each instant

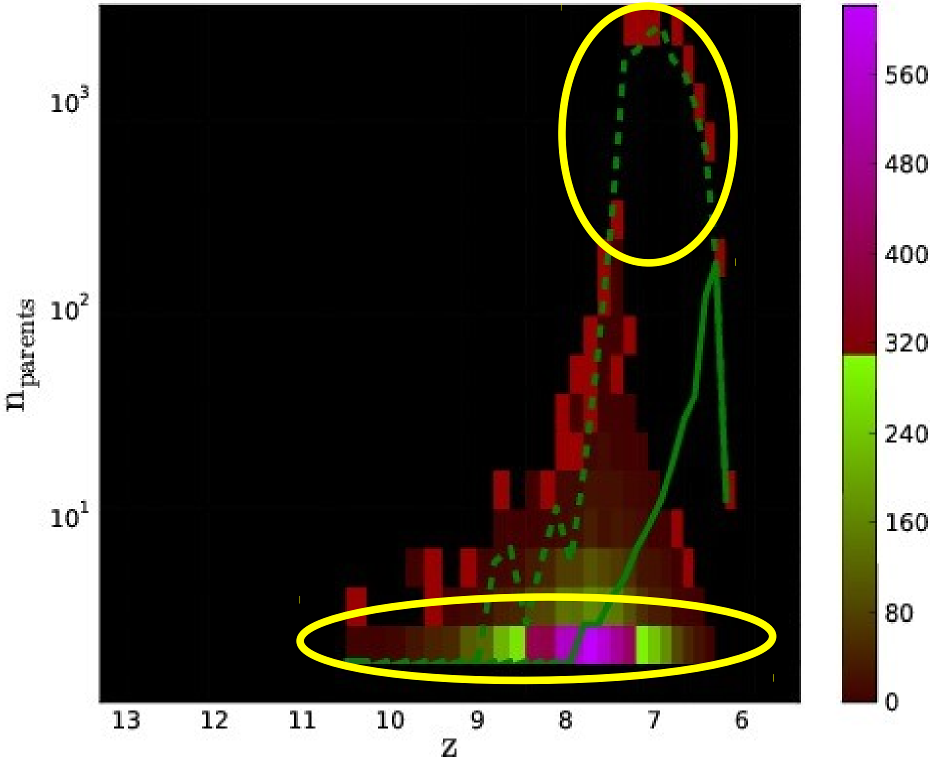
Merger of HII regions



<u>Calculation of the evolution of the distribution of the number of parents for regions resulting from mergers</u>

- Mergers occur mostly in a binary-tertiary manner

Merger of HII regions

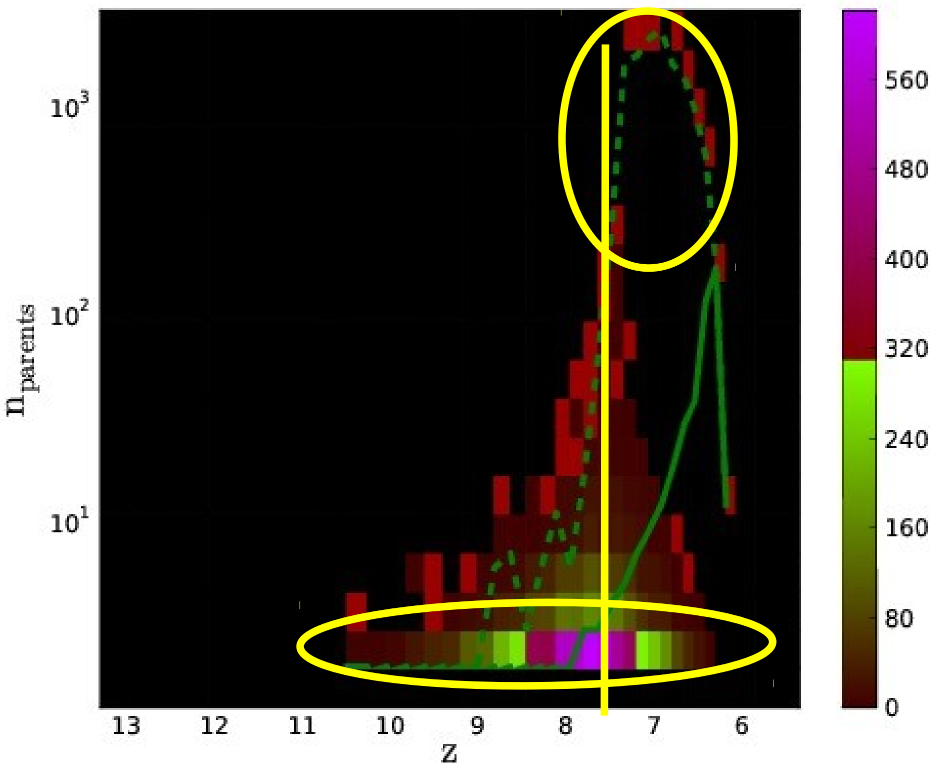


Calculation of the evolution of the distribution of the number of parents for regions resulting from mergers

- Mergers occur mostly in a binary-tertiary manner

- Single region with a greater number of parents

Merger of HII regions



Calculation of the evolution of the distribution of the number of parents for regions resulting from mergers

- Mergers occur mostly in a binary-tertiary manner

- Single region with a greater number of parents
- Main region concentrates the merger → Global ionized background
- Late in the simulation → Lot of local histories can be tracked

Summary (1)

- We developed a merger tree of HII regions to quantify the reionisation history through cosmological simulation of reionisation
- We applied the technique on one simulation with DM halos considered as ionizing sources
- We found that this technique allow us to constrain the reionization history by means of the number of HII regions, their size and the intensity of their percolation process
- We found that the local HII regions evolution can be tracked late in this simulation before the existence of a global ionized background
- The merger tree technique can be used to investigate more deeply the properties of these local reionization histories

Local reionization-S

What is the typical aspect of an HII region before it sees the Global UV background ?

Catalog of HII region properties extracted with the merger tree:

- The Volume of the region at each instant
- The number of merger with the region at each instant
- The total volume of the regions that merge with the region followed at each instant
- The Number of halos and the associated mass in the region at each instant

Global ionized background = first major merger

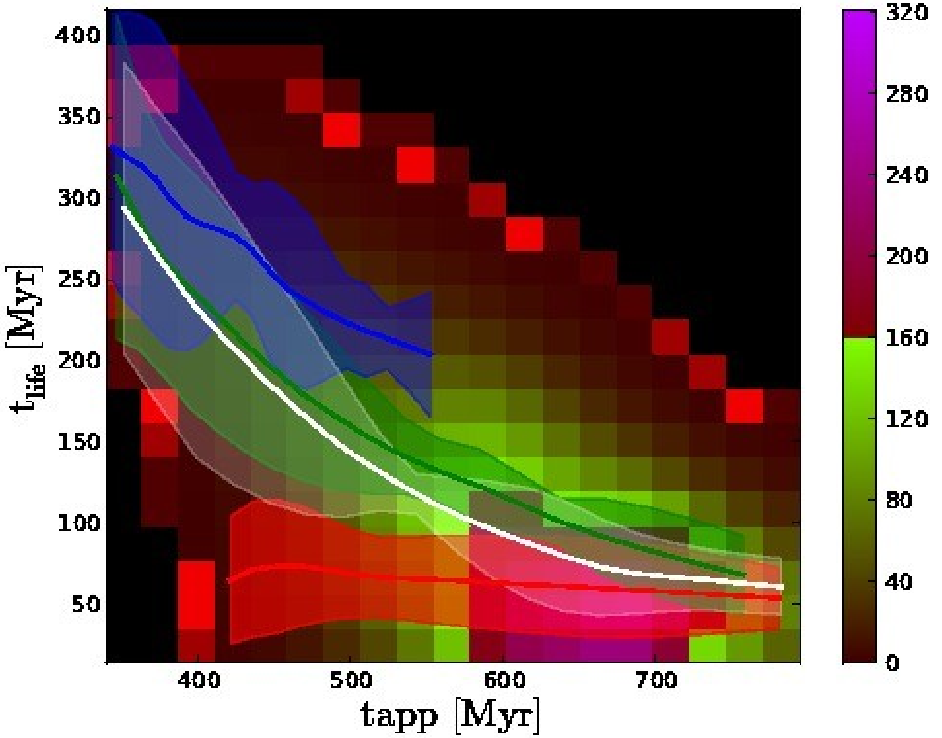
First major merger ➡ Volume of the merged regions ≥ the current volume of the region

⬇

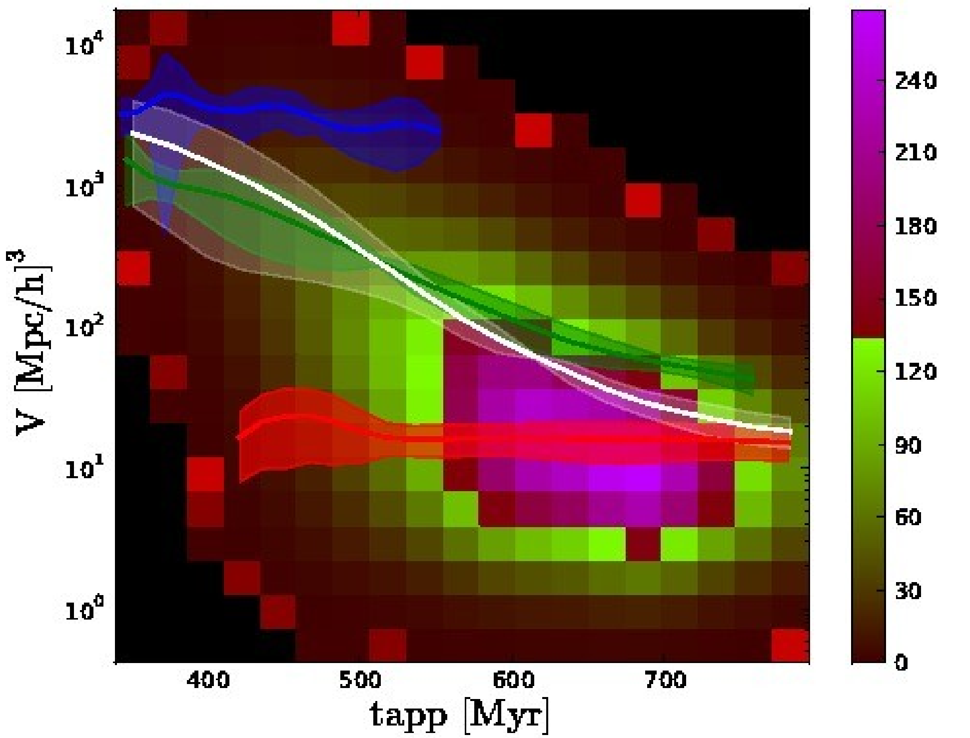
Typical local reionizations properties before the regions see the global ionized background

Local reionization-S

Lifetime before the first major merger vs cosmic time



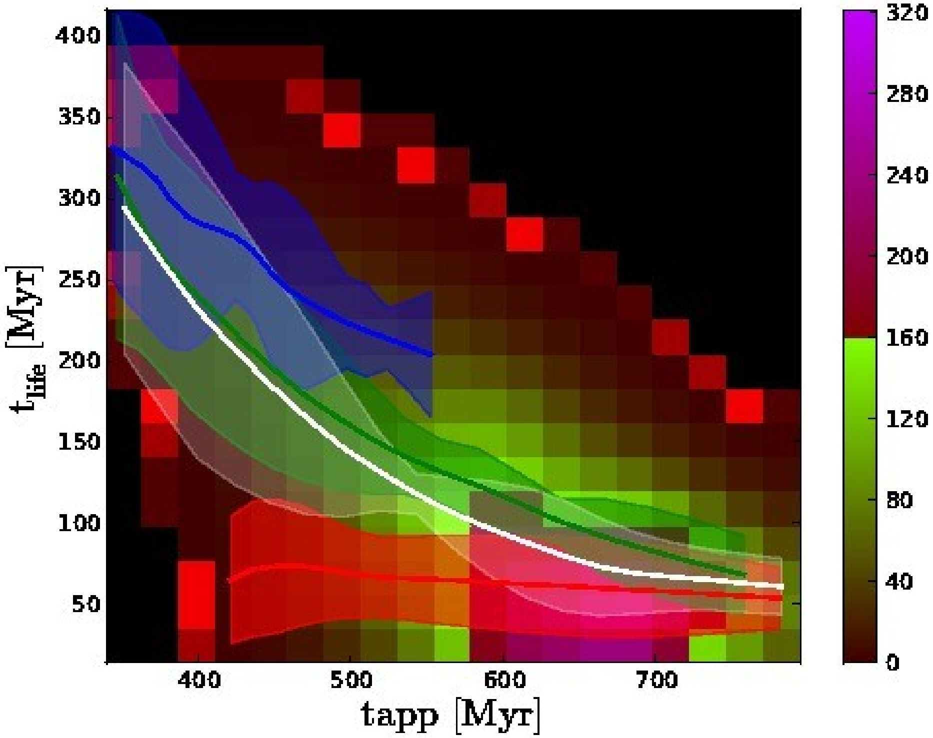
Volume before the first major merger vs cosmic time



- Mean curve in white at 1 sigma level
- HII regions have a decreasing lifetime and volume as reionization progresses
- More and more large HII regions close to new ionizing sites populate the box as reionization progresses

Local reionization-S

Lifetime before the first major merger vs cosmic time



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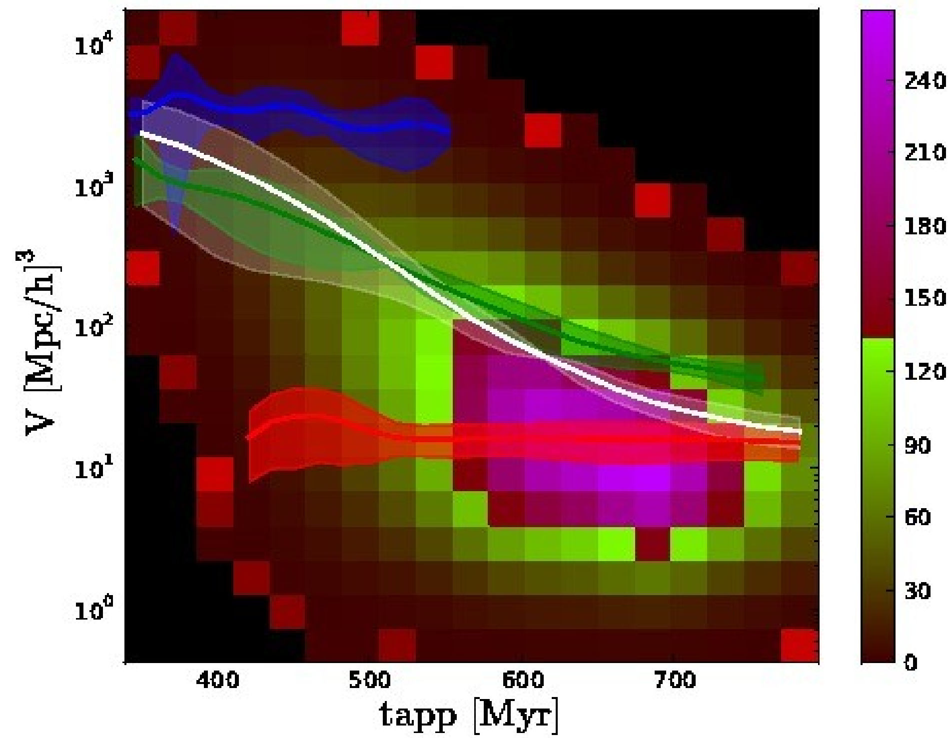


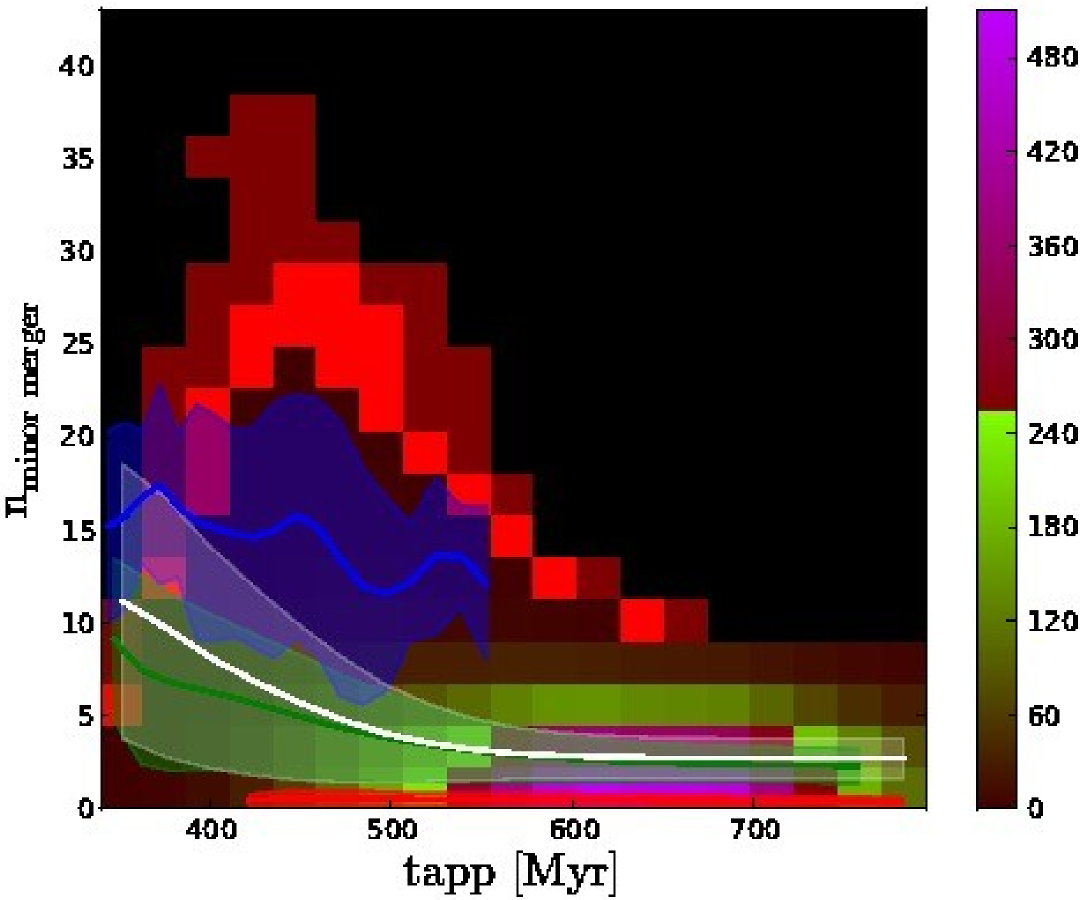
Bins of halo mass in the regions before the first major merger :

M = [1e9-1e10] , [1e10-1e11] , [1e11- 5e11] (Msun)

- The regions have increasing lifetime and volume as the mass of the DM halo progenitor increases
- Early appearance of most massive progenitor : related HII regions can expand longer with larger volume and lower mass progenitor appear close to the largest

Local reionization-S

Number of minor merger before the first major merger vs cosmic time



Bins of halo mass in the regions before the first major merger :
M=[1e9-1e10],[1e10-1e11],[1e11- 5e11](Msun)

<u>Bimodal tendency</u>

- Pre-overlap : decreasing number of minor merger before the global ionized background

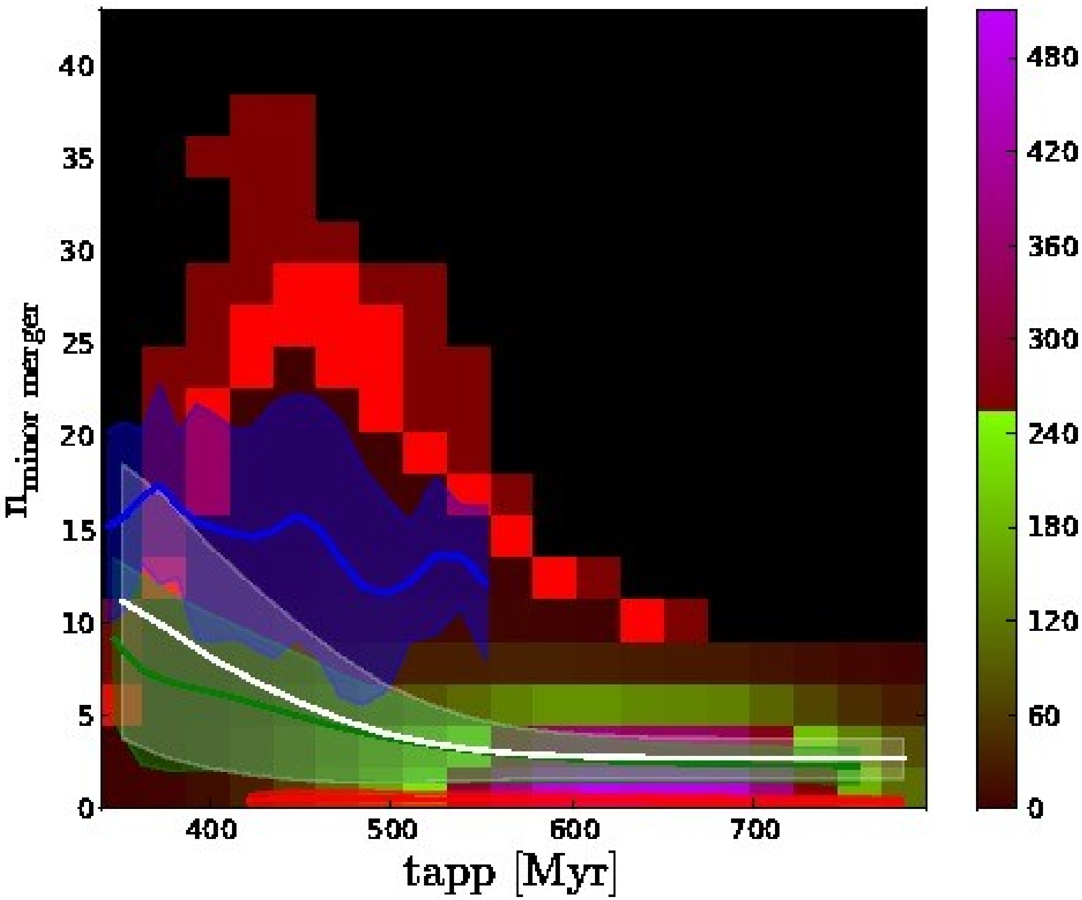
Early region merge with small one before seeing large connected patches

- Overlap : constant number of minor merger

New regions merge directly in large connected patches

Local reionization-S

Number of minor merger before the first major merger vs cosmic time



Bins of halo mass in the regions before the first major merger :
M=[1e9-1e10],[1e10-1e11],[1e11- 5e11](Msun)

- Greater number of minor merger as the mass of the DM halo progenitor increases
- Early massive progenitor install the ionized background and only have major merger with distant merged bubbles
- Lower mass progenitor appear later and merge rapidly with early large bubbles

Summary (2)

- We extracted a catalog of the HII regions properties from a simulation of cosmic reionization with a merger tree of HII regions.
- We investigated the behavior of the regions before they see the global ionized background in regards to their inner halo masses
    - The HII regions have decreasing lifetime and volume as reionization progresses and as large connected bubbles genereted by the most massive progenitor install the global UV background
    - Early massive progenitor create large early regions that can have few minor merger during the pre-overlap while lower progenitor create smaller region that appear later and merge directly with the global ionized background
- The tendency are well constrained and can be used to model the HII regions field evolution semi-analytically in future experiment.
- We are currently applying this analysis on others simulation with other ionizing sources prescriptions.

Thank you for your attention