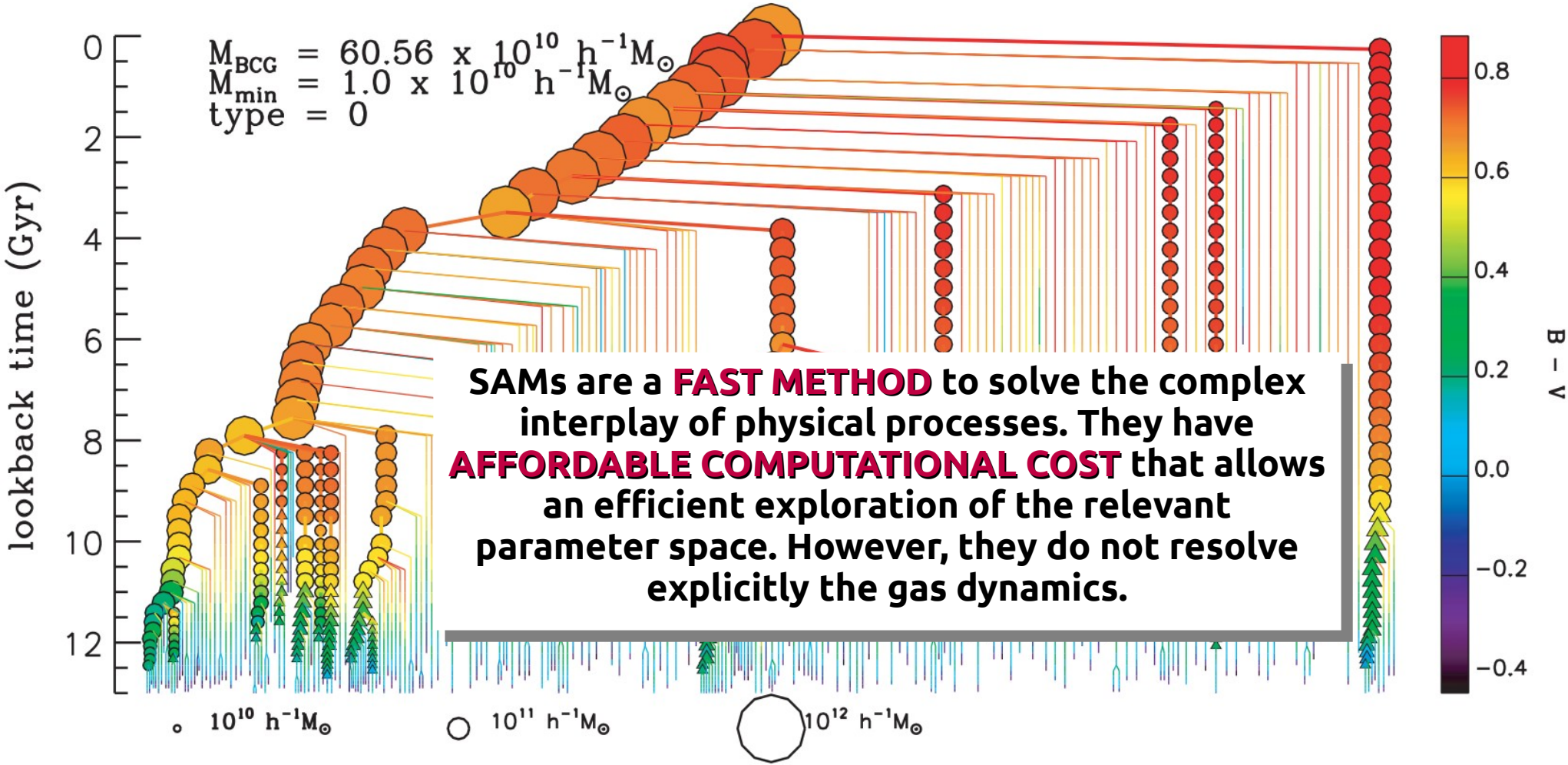
The Galaxy Evolution and Assembly (GAEA) model: a tool for multi-wavelength, multi-epoch galaxy surveys

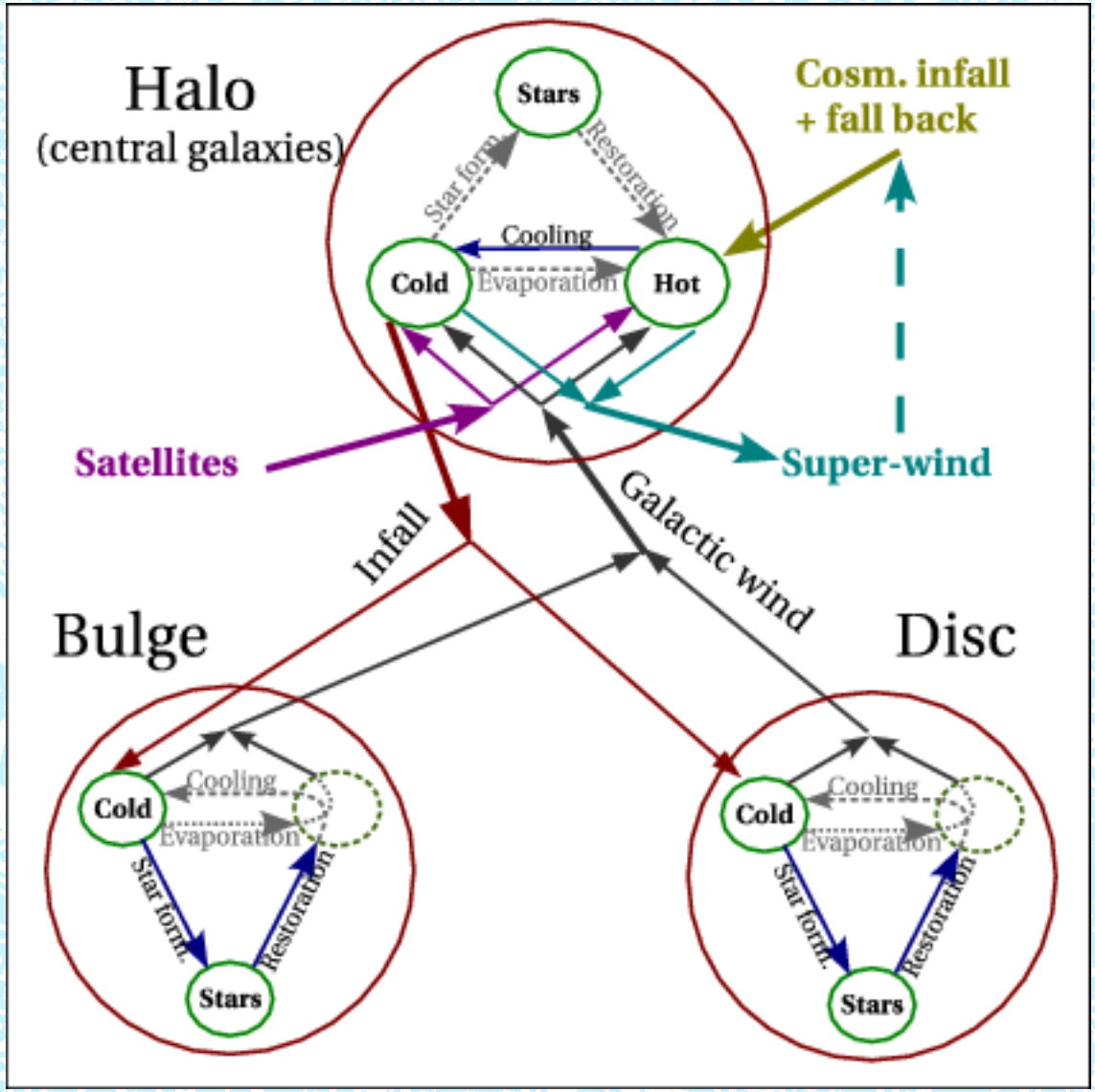
Fabio Fontanot

24/05/21

Semi-Analyic models



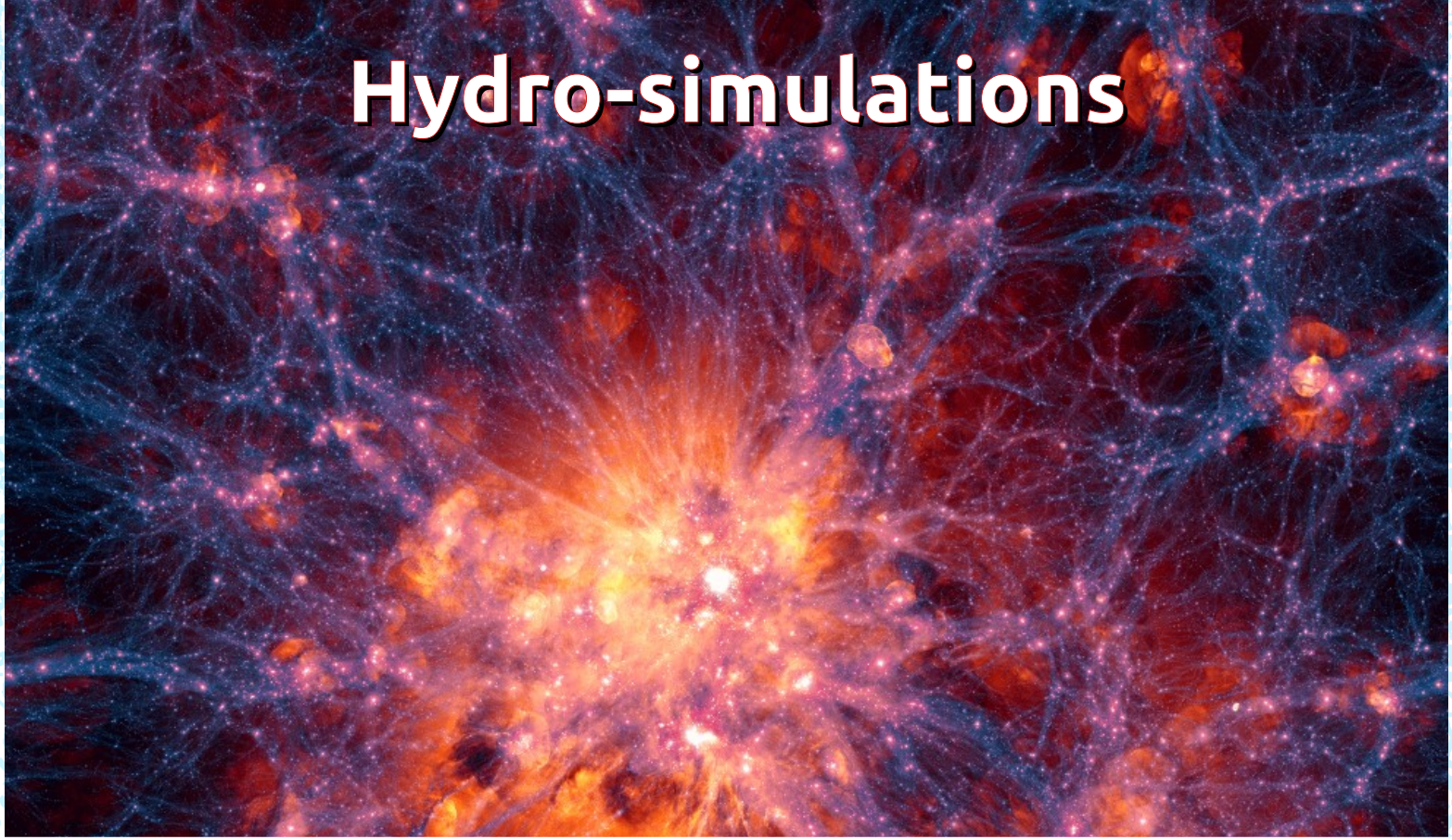
SAMs are a FAST METHOD to solve the complex interplay of physical processes. They have AFFORDABLE COMPUTATIONAL COST that allows an efficient exploration of the relevant parameter space. However, they do not resolve explicitly the gas dynamics.



SAMs

- Solving a system of differential equations
- Each process is described by an approximated prescription, either theoretically or observationally derived
- Given the relatively limited computational costs, they provide an efficient approach to explore the influence of different specific physical assumptions.

Hydro-simulations



Hydro-simulations include an explicit treatment of the gas dynamics, however, they are quite costly in terms of computational time and they still require sub-grid physical model. (Credits: ILLUSTRIS project)

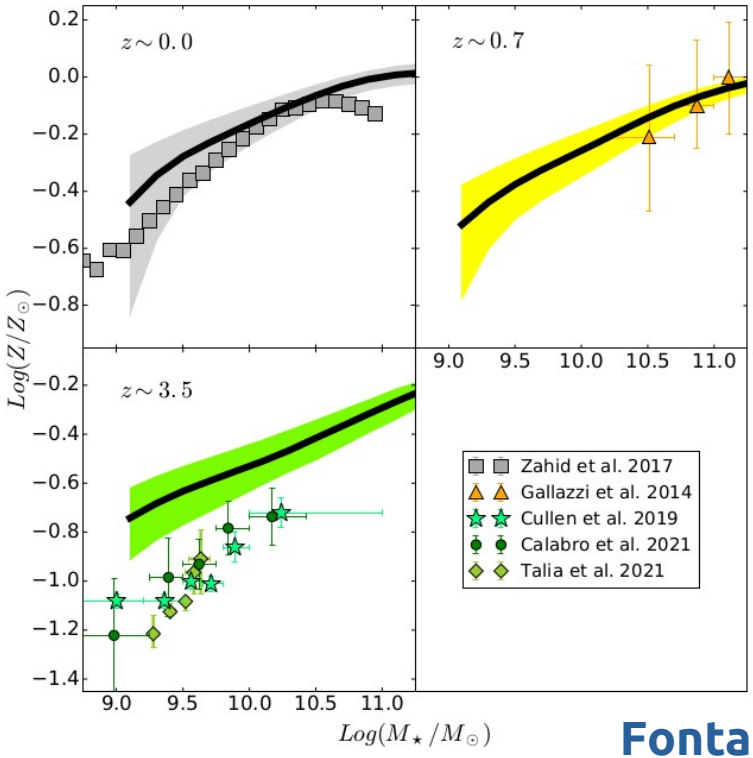
Schede INAF: ***INCC***

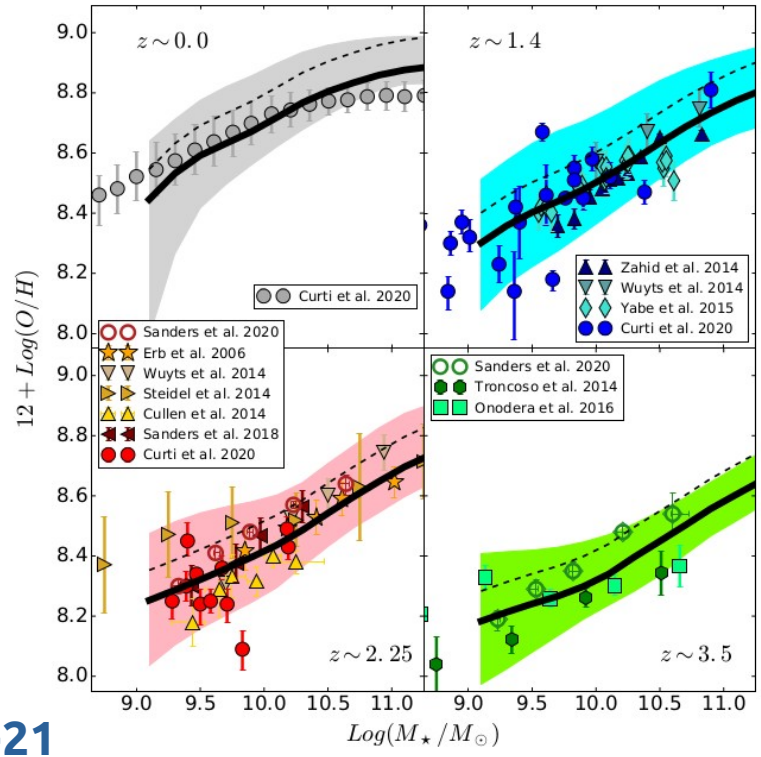
Science with GAEA

- Evolution of the De Lucia & Blaizot 2007 SAM

1) Detailed Chemical Enrichment De Lucia+14

Metal enrichment of galaxies and ISM





Fontanot+21

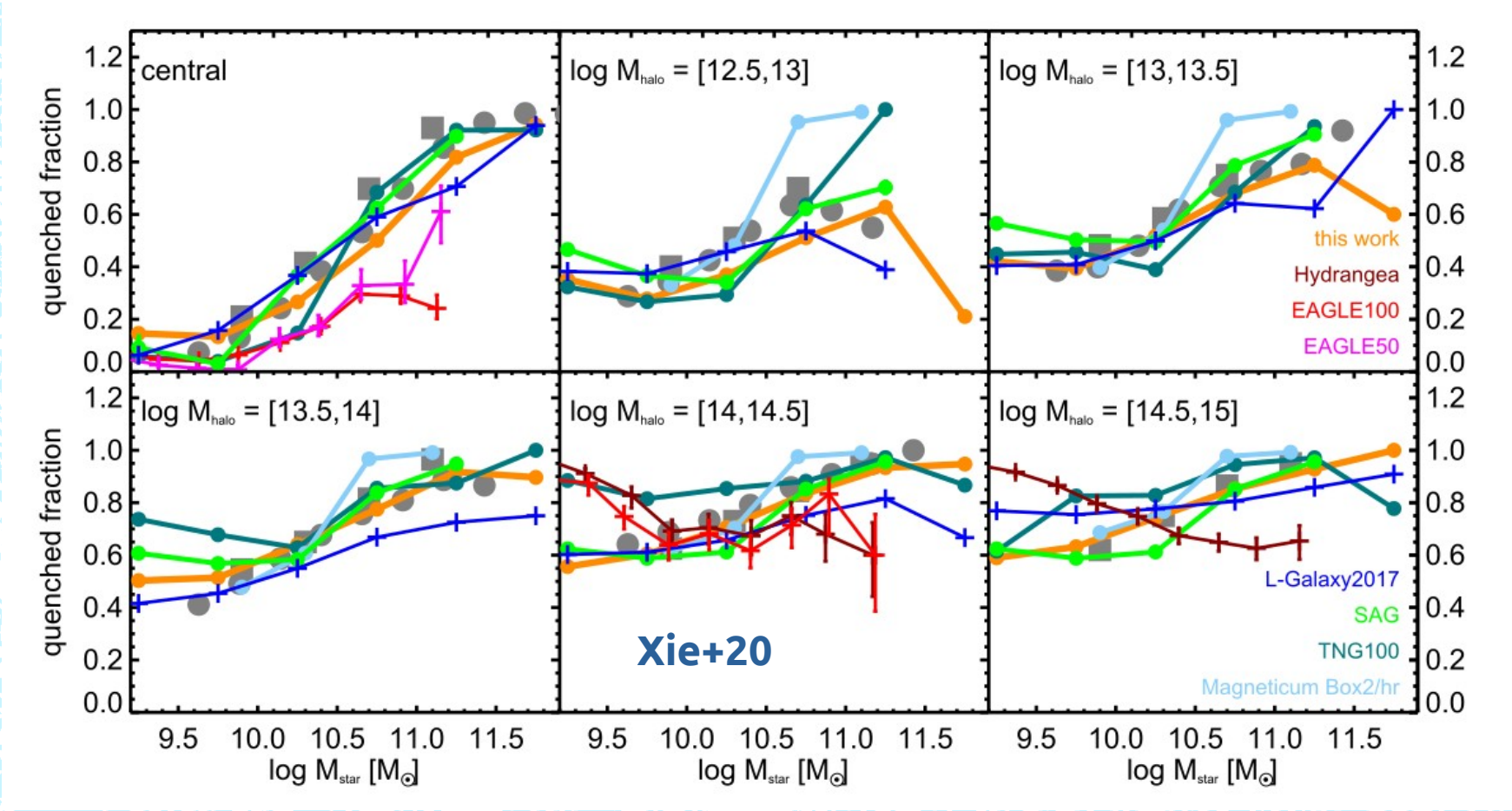
Schede INAF: ***MetEvol*** – ***VANDELS*** – ***4MOST-StePS***

Science with GAEA

- Evolution of the De Lucia & Blaizot 2007 SAM

1) Detailed Chemical Enrichment De Lucia+14
   - Metal enrichment & content of galaxies and ISM
2) Updated treatment of ejective stellar feedback Hirschmann+16 and environmental processes Xie+20

Quenched Fraction



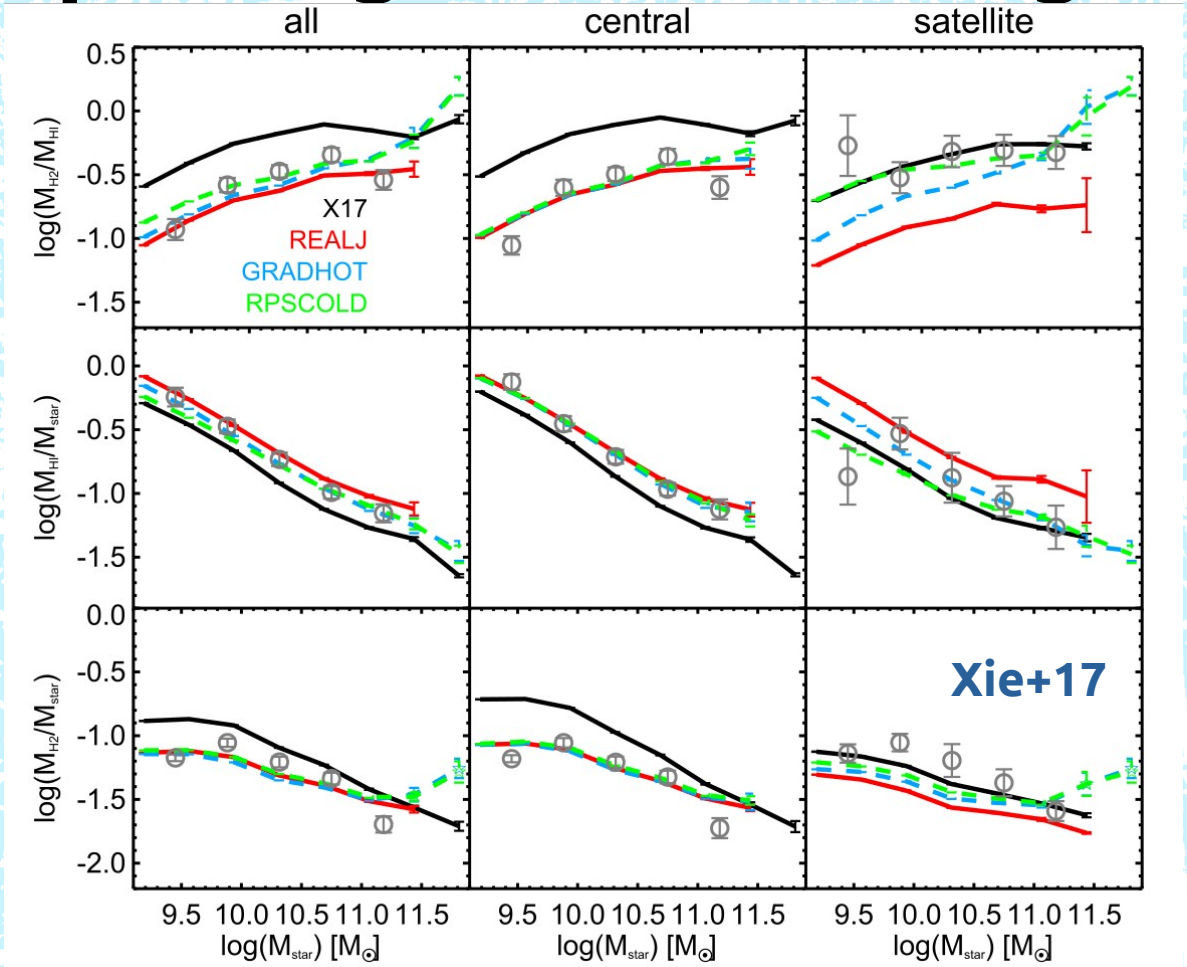
Schede INAF: ***ZOOMING*** – ***VANDELS*** – ***Infall***

Science with GAEA

- Evolution of the De Lucia & Blaizot 2007 SAM

1) Detailed Chemical Enrichment De Lucia+14
   - Metal enrichment & content of galaxies and ISM
2) Updated treatment of ejective stellar feedback Hirschmann+16 and environmental processes Xie+20
   - Galaxy quenching & mass assembly
3) HI/H2 partition for star forming cold gas Xie+17

Multi-phase gas content of galaxies



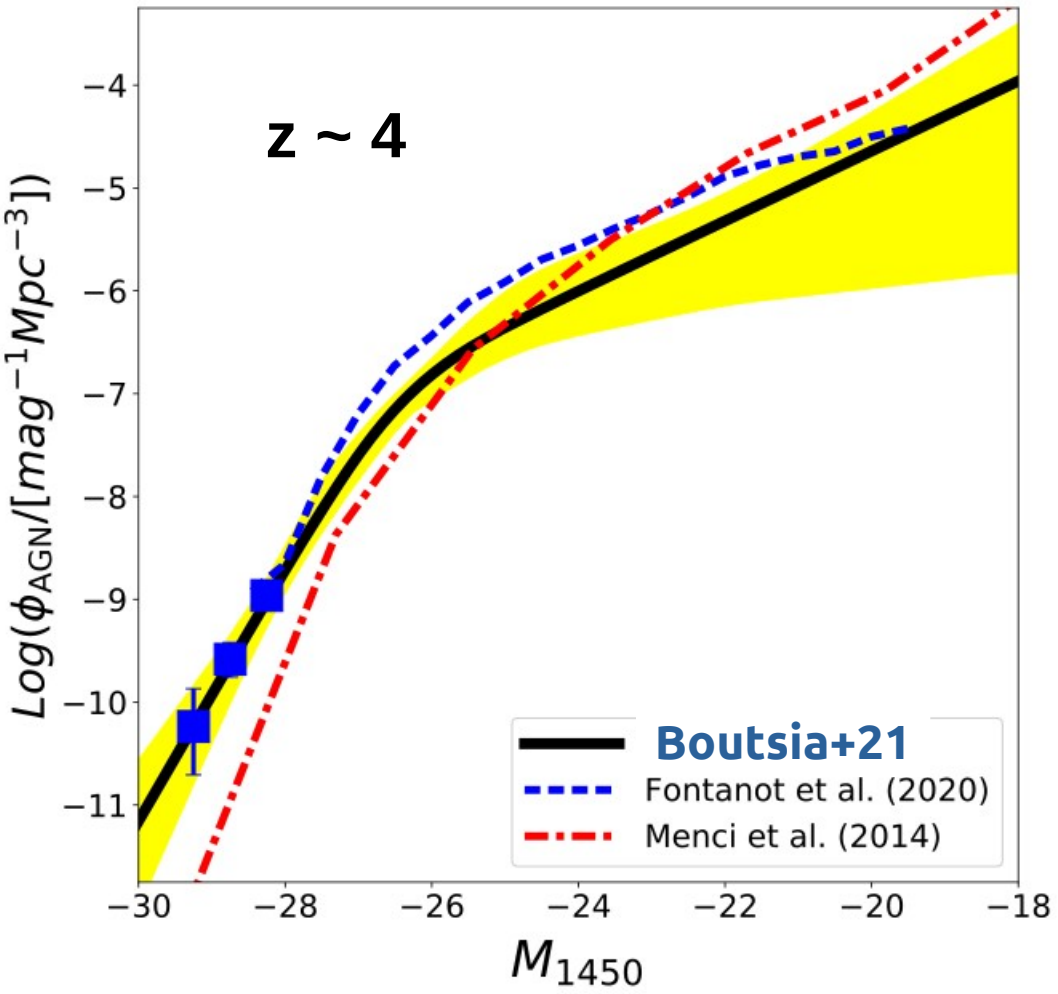
Schede INAF: ***SKA_Galev – BaryonCycling***

Science with GAEA

- Evolution of the De Lucia & Blaizot 2007 SAM

1) Detailed Chemical Enrichment De Lucia+14
   - Metal enrichment & content of galaxies and ISM
2) Updated treatment of ejective stellar feedback Hirschmann+16 and environmental processes Xie+20
   - Galaxy quenching & mass assembly
3) HI/H2 partition for star forming cold gas Xie+17
   - Multiphase gas content of galaxies
4) AGN feedback Fontanot+20

AGN vs host galaxy properties



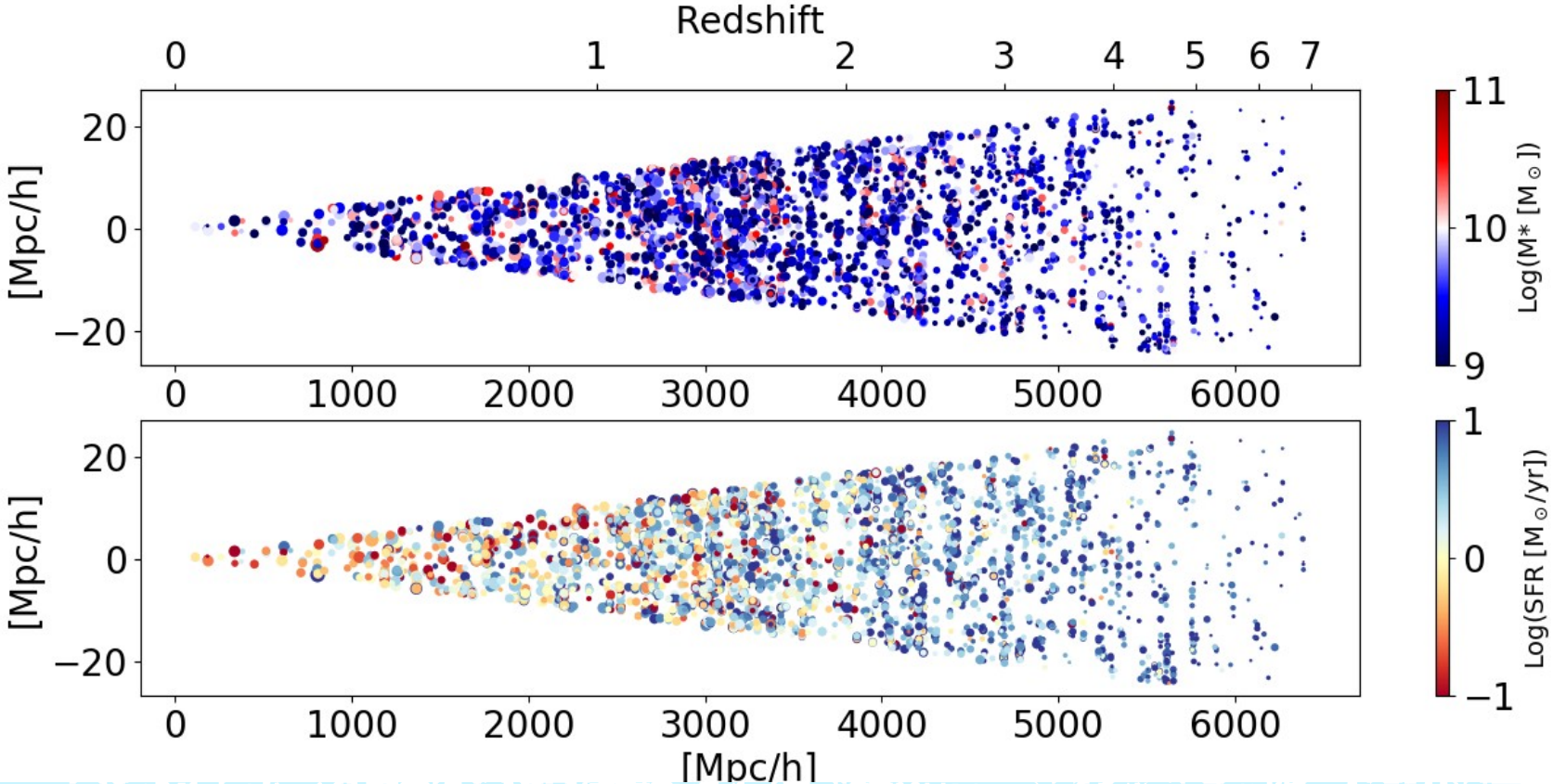
- AGN-driven vs stellar-driven outflows
- High-z QSOs/AGNs
- Reionization

Schede INAF:
NewIGM – BLACKOUT – eROSITA

Science with GAEA

- Evolution of the De Lucia & Blaizot 2007 SAM
- Detailed Chemical Enrichment De Lucia+14
  - Metal enrichment & content of galaxies and ISM
- Updated treatment of ejective stellar feedback Hirschmann+16 and environmental processes Xie+20
  - Galaxy quenching & mass assembly
- HI/H2 partition for star forming cold gas Xie+17
  - Multiphase gas content of galaxies
- AGN feedback Fontanot+20
- Variable IMF Fontanot+17,18 Schede INAF: *ETG12* – *IMF-UP*

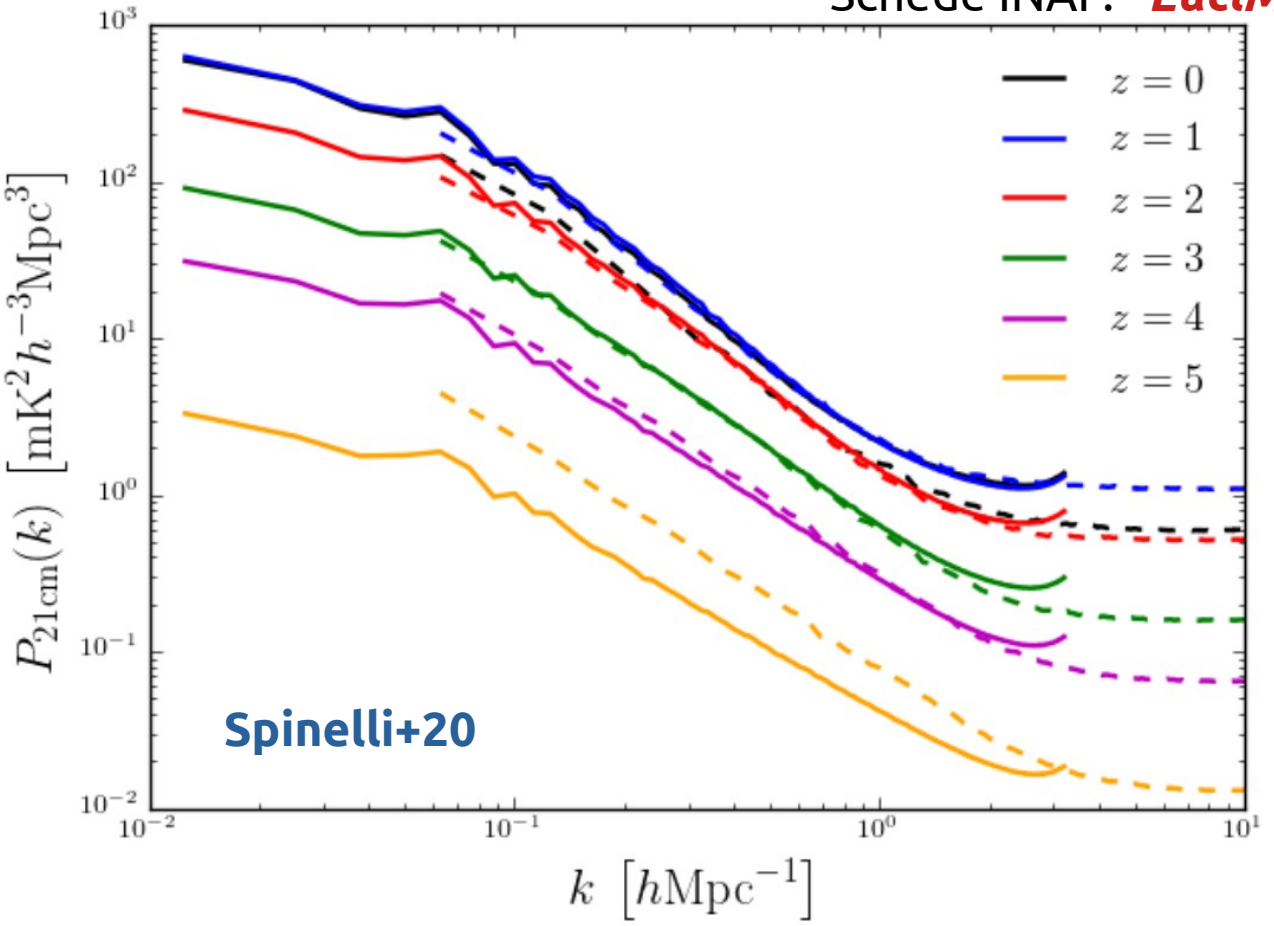
Design of future surveys (mocks)



Schede INAF: ***EuclM2*** – ***MOONS-VLT-0*** – ***SKA_Galev***

Forecast

Schede INAF: ***EuclM2*** – ***SKA_Galev*** – ***21cm_cosmology***



15. Team Summary

15. Personale INAF coinvolto

Numero di partecipanti INAF al progetto: 15

Struttura	Nfte	N0	TI 21	TI 22	TI 23	TD 21	TD 22	TD 23	Nex	Extra
O.A. TRIESTE	6	4	0.90	1.00	1.00	0.70	0.30	0.30	0	0.00
O.A. CAPODIMONTE	1	1	0.10	0.10	0.10	0	0	0	0	0.00
OAS BOLOGNA	0	1	0.00	0.00	0.00	0	0	0	1	0.20
O.A. PADOVA	0	1	0.00	0.00	0.00	0	0	0	0	0.00
O.A. ARCETRI	0	1	0.00	0.00	0.00	0	0	0	0	0.00
Totali	7	8	**1.00**	**1.10**	**1.10**	**0.70**	**0.30**	**0.30**	1	**0.20**

16. Personale Associato INAF coinvolto

Numero di partecipanti Associati INAF: 2

#	Struttura	TI 2021	TI 2022	TI 2023	TD 2021	TD 2022	TD 2023	Extra
1	Universita' degli Studi di Trieste	0.00	0.00	0.00	0	0	0	0.10
2	DARK Cosmology Centre, Copenhagen (DK)	0	0	0	0.30	0.30	0.30	0.00
	Totali	**0.00**	**0.00**	**0.00**	**0.30**	**0.30**	**0.30**	**0.10**

Core Team: 3 Staff INAF + 1 Staff in China
1 PostDoc + 1 PhD (both ending in summer)

Funding

- Direct (~750 K€ up to 2020)
  - ~2/3 ERC grant *StGDeLucia* → 1 TD 4 yrs + 2 postdocs + 1 PhD
  - MERAC Fundation Prize → 1 postdoc
  - 1 INAF PhD fellowship
  - 1 INAF OATs PhD fellowship
- Indirect
  - PRIN SKA-CTA + overheads ERC Viel -> 1 postdoc
  - Other sources → 1 PhD fellowship

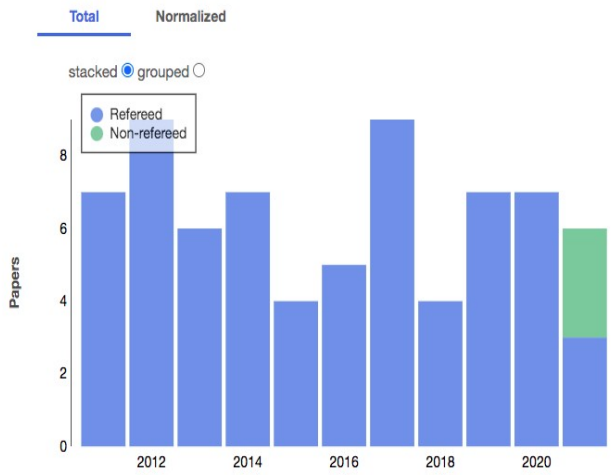
- Future?
  - PRIN-MIUR 2020?

Scientific Outcome

- More than 70 refereed papers (from 2011) that present preliminary work, specific developments of the GAEA code and/or make important use of predictions from GAEA (more than 3000 citations so far)
- 3 PhD Thesis 2014 / 2017 / 2021

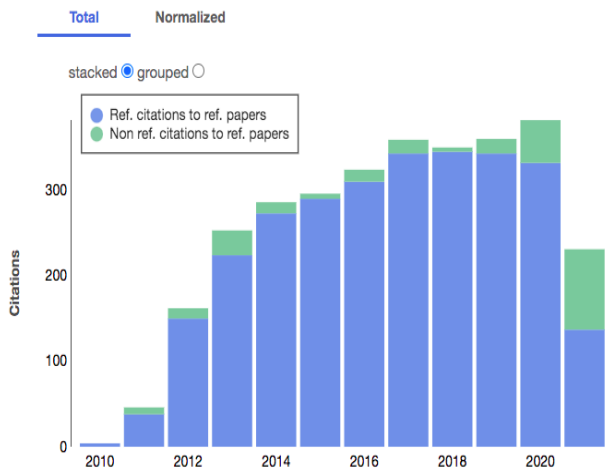
Papers

	Totals	Refereed
Number of papers	71	68
Normalized paper count	14.0	13.8



Citations

	Totals	Refereed
Number of citing papers	2156	2156
Total citations	3053	3053
Number of self-citations	274	274
Average citations	43	44.9
Median citations	20	21
Normalized citations	468.9	468.9
Refereed citations	2789	2789
Average refereed citations	39.3	41.0
Median refereed citations	18	19
Normalized refereed citations	430.0	430.0



Criticalities

- **Manpower**
  - **[Core team size] VS [Project involvement] VS [model developments]**
  - **Model developments are planned to expand the range of applicability of the model. These would put us at the forefront for the exploitation of data from projects in which INAF is investing important resources.**

Criticalities

- **Manpower**
  - **[Core team size] VS [Project involvement] VS [model developments]**
  - **Model developments are planned to expand the range of applicability of the model. These would put us at the forefront for the exploitation of data from projects in which INAF is investing important resources.**

Schede INAF: ***EUCLID*** – ***SKA*** – ***4MOST-StePS*** – ***GAUSP*** – ***GAZELLE***

Criticalities

- **Manpower**
  - **[Core team size] VS [Project involvement] VS [model developments]**
  - **Model developments are planned to expand the range of applicability of the model. These would put us at the forefront for the exploitation of data from projects in which INAF is investing important resources.**
- **Computational Infrastructure**
  - **Access to: Production (@CHIPPS) & long term storage (@IA2)**
  - **Still critical: Development resources & medium term storage**

Criticalities

- **Manpower**
  - [Core team size] **VS** [Project involvement] **VS** [model developments]
  - Model developments are planned to expand the range of applicability of the model. These would put us at the forefront for the exploitation of data from projects in which INAF is investing important resources.
- **Computational Infrastructure**
  - Access to: Production (@CHIPPS) & long term storage (@IA2)
  - Still critical: Development resources & medium term storage
- **Dissemination**
  - Make theoretical predictions available to the community at large
  - GAEA Webpage https://adlibitum.oats.inaf.it/delucia/GAEA/
  - Hirschmann+16 available at https://apps.sciserver.org (via personal agreement)
  - Relational database using Virtual Observatory tools