Avant propos

- On continue l'expérimentation: le format est différent d'hier…
- Cosmologie numérique
  - Exemple de science case cosmologique observationnel: présentations de Mark, Chiara
- Communauté cosmo numérique française regroupée en 1 projet: HORIZON $\Rightarrow$ 1 seul science case
- P. Valiron: cas d'utilisation de GRID
- P. Marty: GRID5000

Cosmologie numérique et Observatoire Virtuel

H. Wozniak[1], J. Blaizot[2], J. Devriendt[1], F. Legrand[3],
et consortium HORIZON[4]

[1] CRAL
[2] MPA Garching
[3] IAP
[4] CEA/SAp, CRAL, IAP, LERMA, LUTH

Plan

- Simulations cosmologiques / formation des galaxies
- « Science cases » consortium VIRGO (Millenium)
  (J. Blaizot/G. Lemson MPA Garching)
- Science cases projet HORIZON
  (H. Wozniak, J. Blaizot, J. Devriendt, et al.)
- Spécificité de certains produits (snapshots, bases de données) et problèmes potentiels

Simulations cosmologiques

- Produire des réalisations de fractions d'Univers pour tester :
  - la physique de la matière et de l'énergie sombres
  - les scenarios de formation de galaxies
- Valider les hypothèses/régler les paramètres libres par comparaison avec les sondages photo/spectro profonds ou grands champs
- Trois étapes:
  1. Production des simulations
  2. *Formation des galaxies par des modèles semi-analytiques*
  3. Fabrication de catalogues & images virtuels

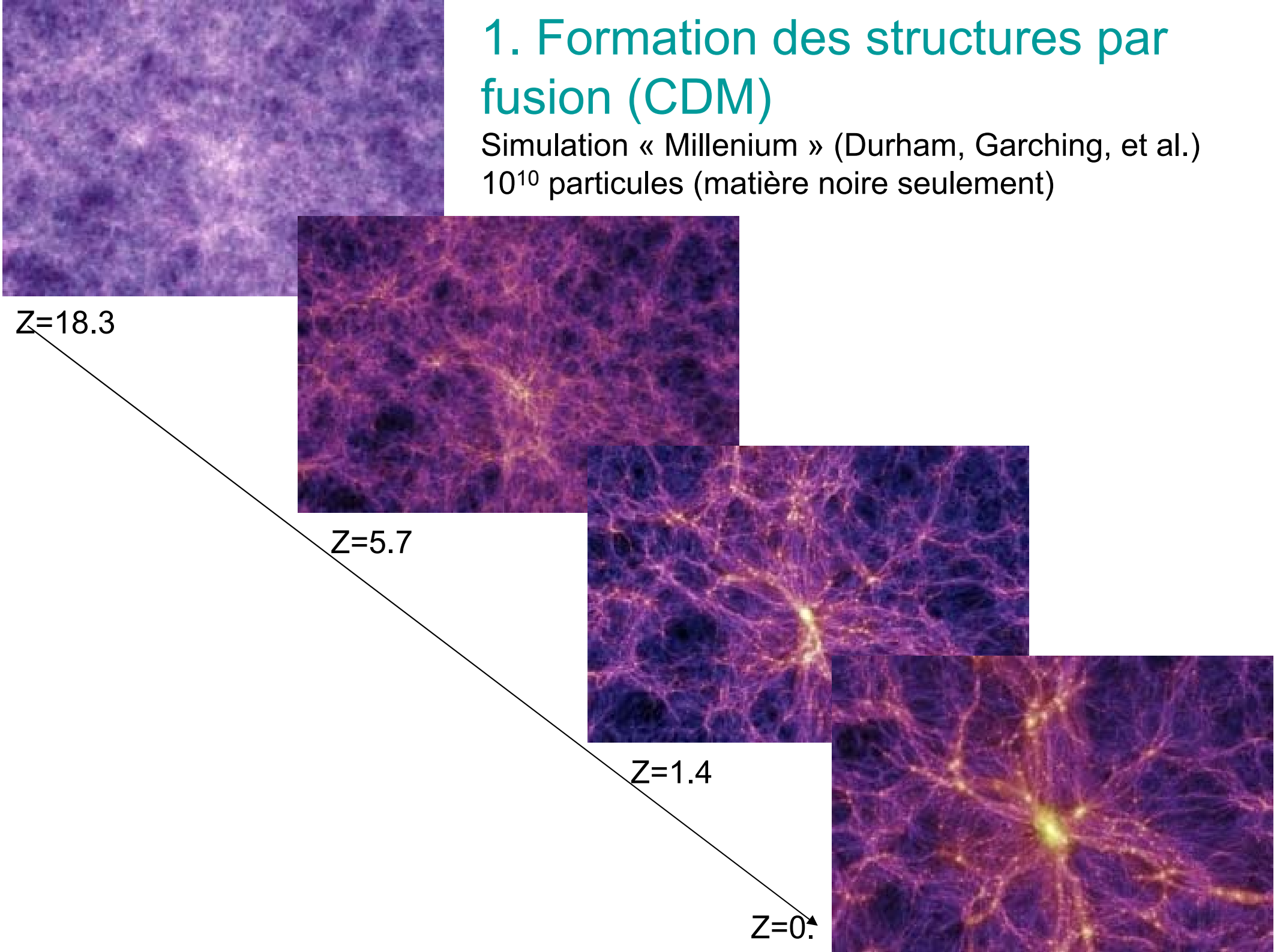
Cas simulation MILLENIUM

Consortium VIRGO

(Durham, Garching, etc.)

1. Formation des structures par fusion (CDM)

Simulation « Millenium » (Durham, Garching, et al.)
10^{10} particules (matière noire seulement)



2. Formation des galaxies dans les halos

- post-traitement par modèles semi-analytiques (SAM)
  - GALFORM (Lacey et al.)
  - Modèle de Munich (Kauffman et al.)
  - GalICS (Guiderdoni et al.)
  - …
- Ingrédients:
  - Rapport masse gaz/masse caché
  - Histoire et taux de formation stellaire (liés à l'arbre de fusion)
  - Contribution d'AGN, etc.
- Calibration sur les catalogues tirés des observations

3. production des catalogues et/ou images virtuelles

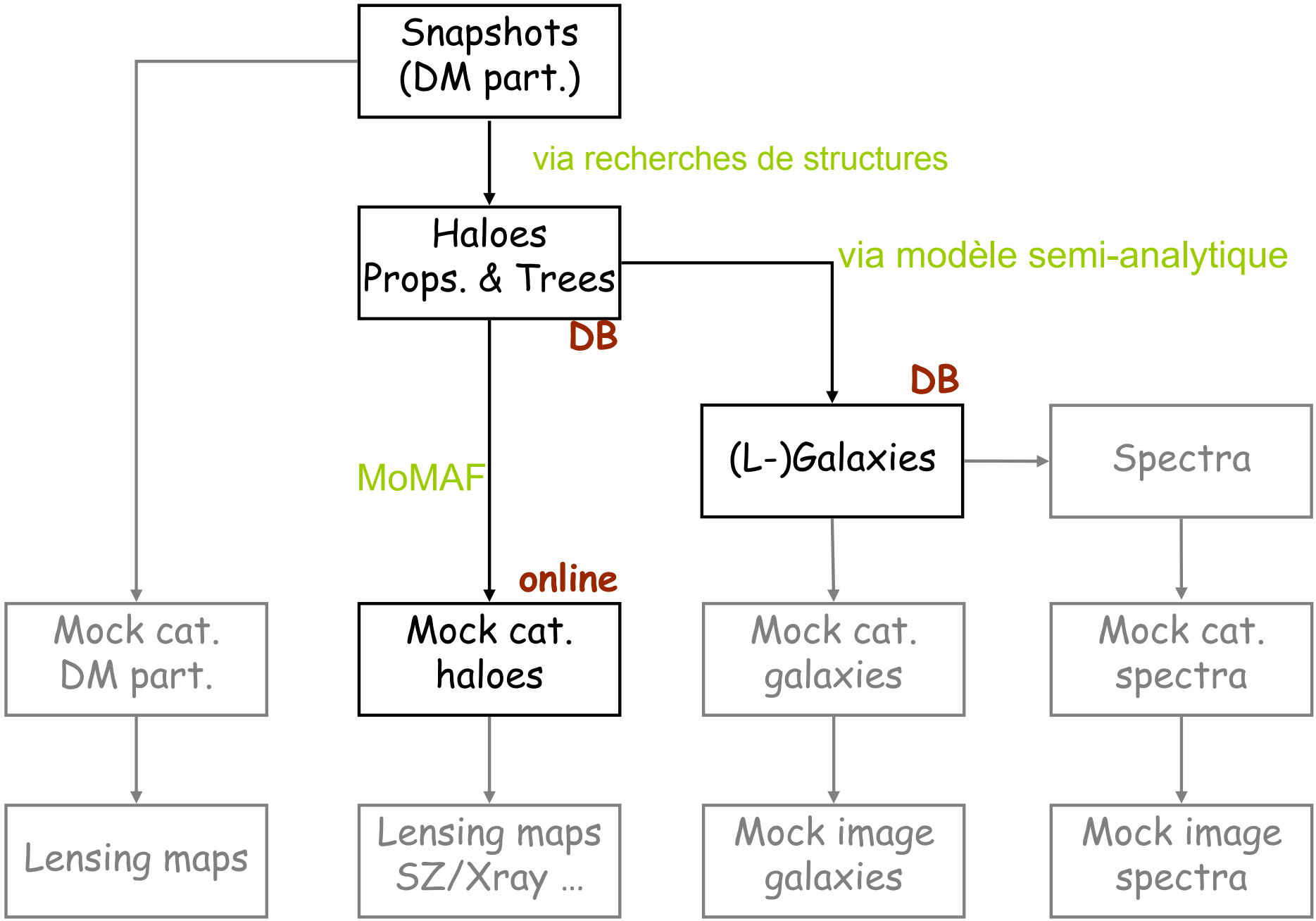
- Produits:
  - Catalogues de sources dans des cônes (études fonction de luminosité, etc.)
  - Images ‘virtuelles’

Questions scientifiques Millenium

- Return the galaxies residing in halos of mass between 10^{13} and 10^{14} solar masses.
- Return the galaxy content at z=3 of the progenitors of a halo identified at z=0
- Return all the galaxies within a sphere of radius 3Mpc around a particular halo
- Return the complete halo merger tree for a halo identified at z=0
- Find positions and velocities for all galaxies at redshift zero with B-luminosity, colour and bulge-to-disk ratio within given intervals.
- Find properties of all galaxies in haloes of mass 10^{14} at redshift 1 which have had a major merger (mass-ratio < 4:1) since redshift 1.5.
- Find all the z=3 progenitors of z=0 red ellipticals (i.e. B-V>0.8 B/T > 0.5)
- Find the descendents at z=1 of all LBG's (i.e. galaxies with SFR>10 Msun/yr) at z=3
- Make a list of all haloes at z=3 which contain a galaxy of mass >10**9 Msun which is a progenitor of BCG's in z=0 cluster of mass >$10^{14.5}$
- Find all z=3 galaxies which have NO z=0 descendent.
- Return the complete galaxy merging history for a given z=0 galaxy.
- Find all the z=2 galaxies which were within 1Mpc of a LBG (i.e. SFR>10Msun/yr) at some previous redshift.

- **Aide à l'analyse du 2dFGRS et SDSS par la production de catalogues virtuels**

Produits simulation Millenium… (mini-Millenium)



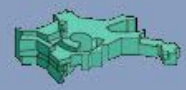
MPA Simulations Query Form - Netscape

File Edit View Go Bookmarks Tools Window Help

New Tab | MPA Simulations Query Form

GERMAN ASTROPHYSICAL GAVO VIRTUAL OBSERVATORY

Exploring the milli-Millennium simulation with a relational database




```
select *
  from MMHalo
 where snapnum=50
   and np between 100 and 1000
   and x between 10 and 20
   and y between 10 and 20
   and z between 10 and 20
```

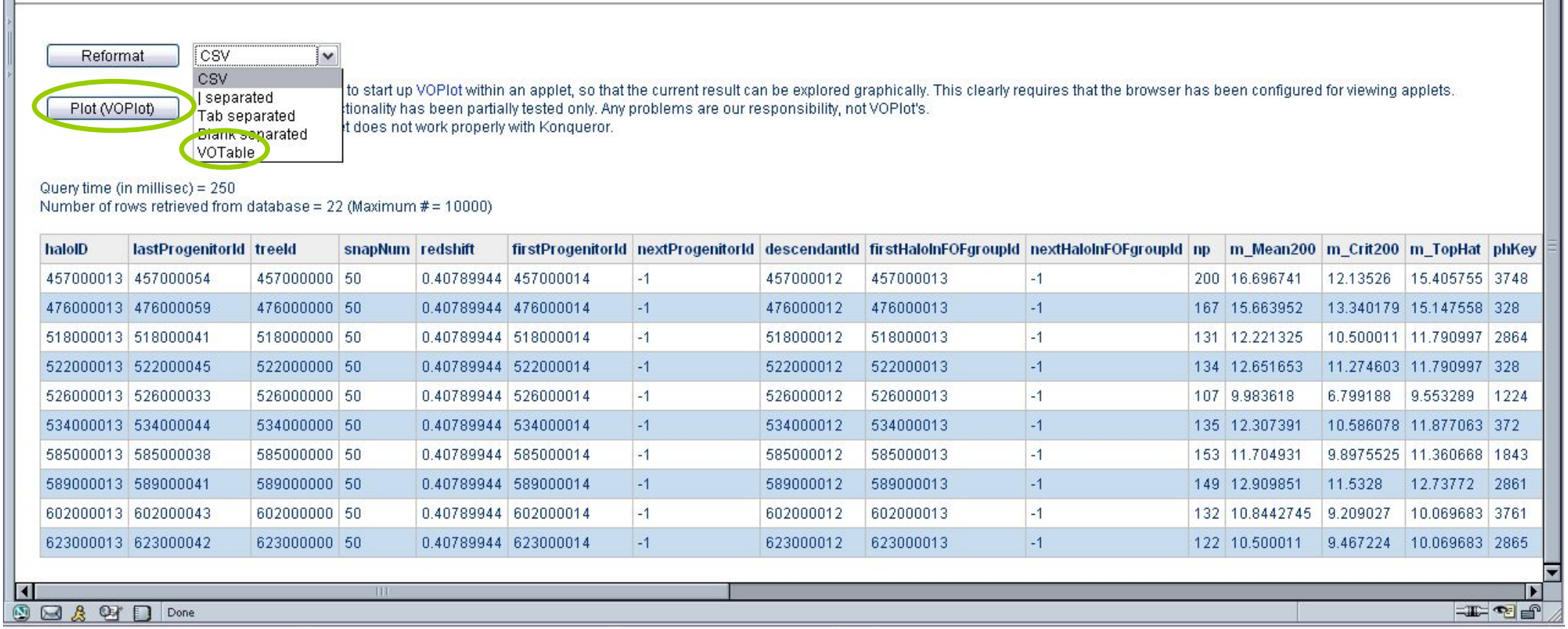
Execute Query

Clear all

Help

Maximum number of rows to return to the query form: 10

H 1	G 1	Find halos/galaxies at a given redshift (SNAPNUM) within a certain part of the simulation volume (X,Y,Z).
H 2	G 2	Find the whole progenitor tree, in depth-first order, of a halo/galaxy identified by its id (haloId/galaxyId)
H 3	G 3	Find the progenitors at a given redshift (SNAPNUM) of all halos/galaxues of mass(np)/brightness(mag_0) greater than 4000/brighter than -20 at a later redshift (SNAPNUM). The progenitors are limited in mass/magnitude as well.
H 4	G 4	Find all the halos/galaxies of mass >= 1000/mag_b < -20 that have just had a major merger, defined by having at least two progenitors of mass >= 0.2*descendant mass.
H 5	G 5	Find the mass/luminosity function of halos/galaxies at z=0 using logarithmic intervals.
	G 6	Find the Tully-Fisher relation, Mag_0/1/2/3/4 vs V_vir for galaxies with bulge/total mass ratio < 0.1.
HG 1	HG 2	Find the conditional luminosity functions for galaxies in two ranges of halo masses and find average galaxy properties for halo mass bins.
HF 1		Find all halos residing in background overdensities between 2 and 3, at Gaussian smoothing radius 5 h-1 Mpc.
HF 3		Find formation time dependence of background overdensities for halos in particular mass bin.
HF 2	GF 2	Find halo mass/galaxy luminosity functions in overdensities at two different values.



Query time (in millisec) = 250
Number of rows retrieved from database = 22 (Maximum # = 10000)

haloID	lastProgenitorId	treeId	snapNum	redshift	firstProgenitorId	nextProgenitorId	descendantId	firstHaloInFOFgroupId	nextHaloInFOFgroupId	np	m_Mean200	m_Crit200	m_TopHat	phKey
457000013	457000054	457000000	50	0.40789944	457000014	-1	457000012	457000013	-1	200	16.696741	12.13526	15.405755	3748
476000013	476000059	476000000	50	0.40789944	476000014	-1	476000012	476000013	-1	167	15.663952	13.340179	15.147558	328
518000013	518000041	518000000	50	0.40789944	518000014	-1	518000012	518000013	-1	131	12.221325	10.500011	11.790997	2864
522000013	522000045	522000000	50	0.40789944	522000014	-1	522000012	522000013	-1	134	12.651653	11.274603	11.790997	328
526000013	526000033	526000000	50	0.40789944	526000014	-1	526000012	526000013	-1	107	9.983618	6.799188	9.553289	1224
534000013	534000044	534000000	50	0.40789944	534000014	-1	534000012	534000013	-1	135	12.307391	10.586078	11.877063	372
585000013	585000038	585000000	50	0.40789944	585000014	-1	585000012	585000013	-1	153	11.704931	9.8975525	11.360668	1843
589000013	589000041	589000000	50	0.40789944	589000014	-1	589000012	589000013	-1	149	12.909851	11.5328	12.73772	2861
602000013	602000043	602000000	50	0.40789944	602000014	-1	602000012	602000013	-1	132	10.8442745	9.209027	10.069683	3761
623000013	623000042	623000000	50	0.40789944	623000014	-1	623000012	623000013	-1	122	10.500011	9.467224	10.069683	2865

MPA Simulations Query Form - VOPlot - Netscape

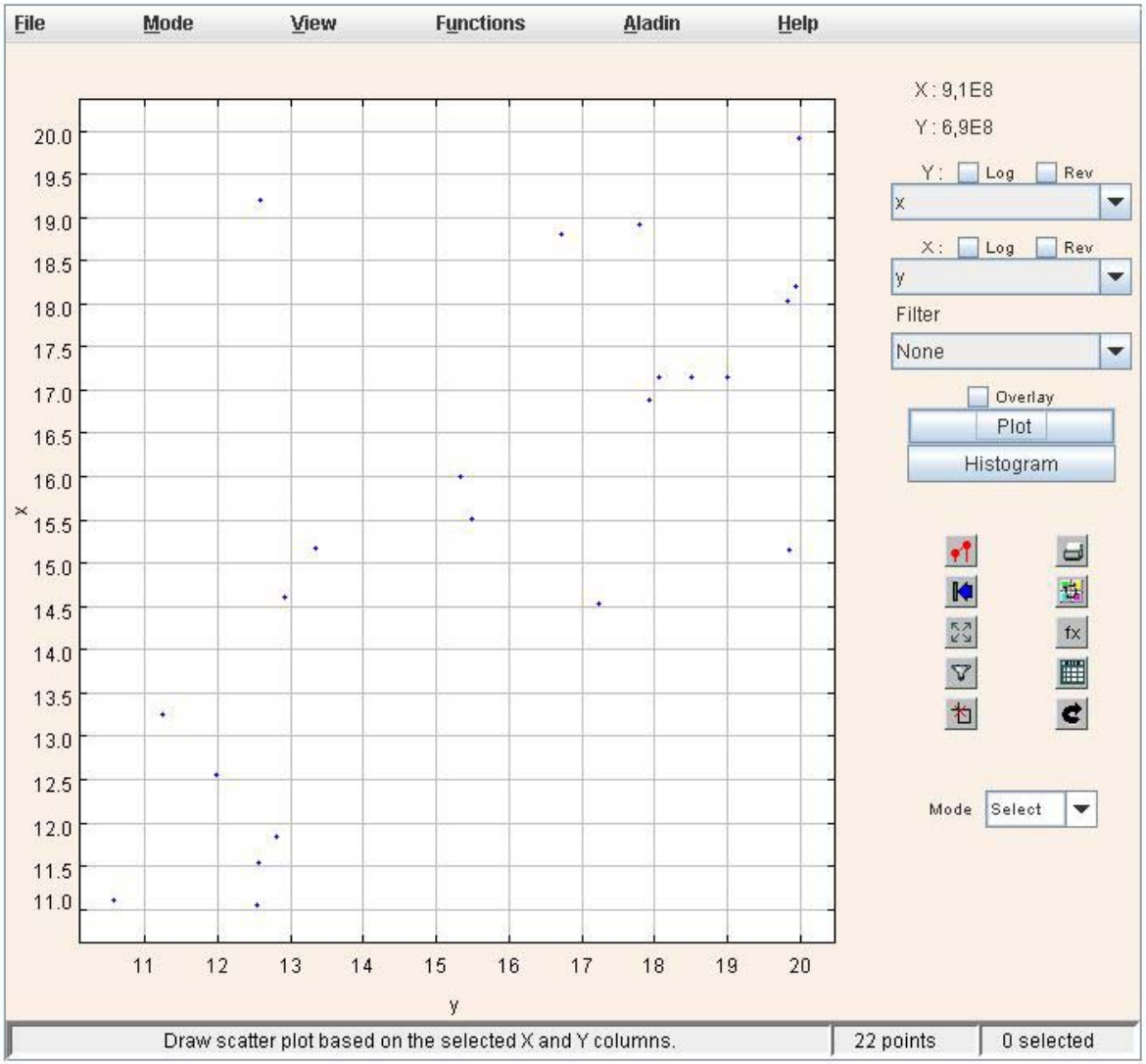
File Edit View Go Bookmarks Tools Window Help

New Tab | MPA Simulations Query Form - VOPlot

GERMAN ASTROPHYSICAL VIRTUAL OBSERVATORY

Virgo simulations in a relational database - VOPlot

For help on the use of VOPlot follow this link



MPA Simulations Query Form - Netscape

File Edit View Go Bookmarks Tools Window Help

New Tab | MPA Simulations Query Form

GERMAN ASTROPHYSICAL VIRTUAL OBSERVATORY

Exploring the milli-Millennium simulation with a relational database


```
select *
  from MMGalaxy
 where snapnum=63
   and mag_b between -26 and -18
   and x between 10 and 20
   and y between 10 and 20
   and z between 10 and 20
```

Execute Query

Clear all

Help

Maximum number of rows to return to the query form: 10

H 1	G 1	Find halos/galaxies at a given redshift (SNAPNUM) within a certain part of the simulation volume (X,Y,Z).
H 2	G 2	Find the whole progenitor tree, in depth-first order, of a halo/galaxy identified by its id (haloId/galaxyId)
H 3	G 3	Find the progenitors at a given redshift (SNAPNUM) of all halos/galaxues of mass(np)/brightness(mag_0) greater than 4000/brighter than -20 at a later redshift (SNAPNUM). The progenitors are limited in mass/magnitude as well.
H 4	G 4	Find all the halos/galaxies of mass >= 1000/mag_b < -20 that have just had a major merger, defined by having at least two progenitors of mass >= 0.2*descendant mass.
H 5	G 5	Find the mass/luminosity function of halos/galaxies at z=0 using logarithmic intervals.
	G 6	Find the Tully-Fisher relation, Mag_0/1/2/3/4 vs V_vir for galaxies with bulge/total mass ratio < 0.1.
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MPA Simulations Query Form - VOPlot - Netscape

File Edit View Go Bookmarks Tools Window Help

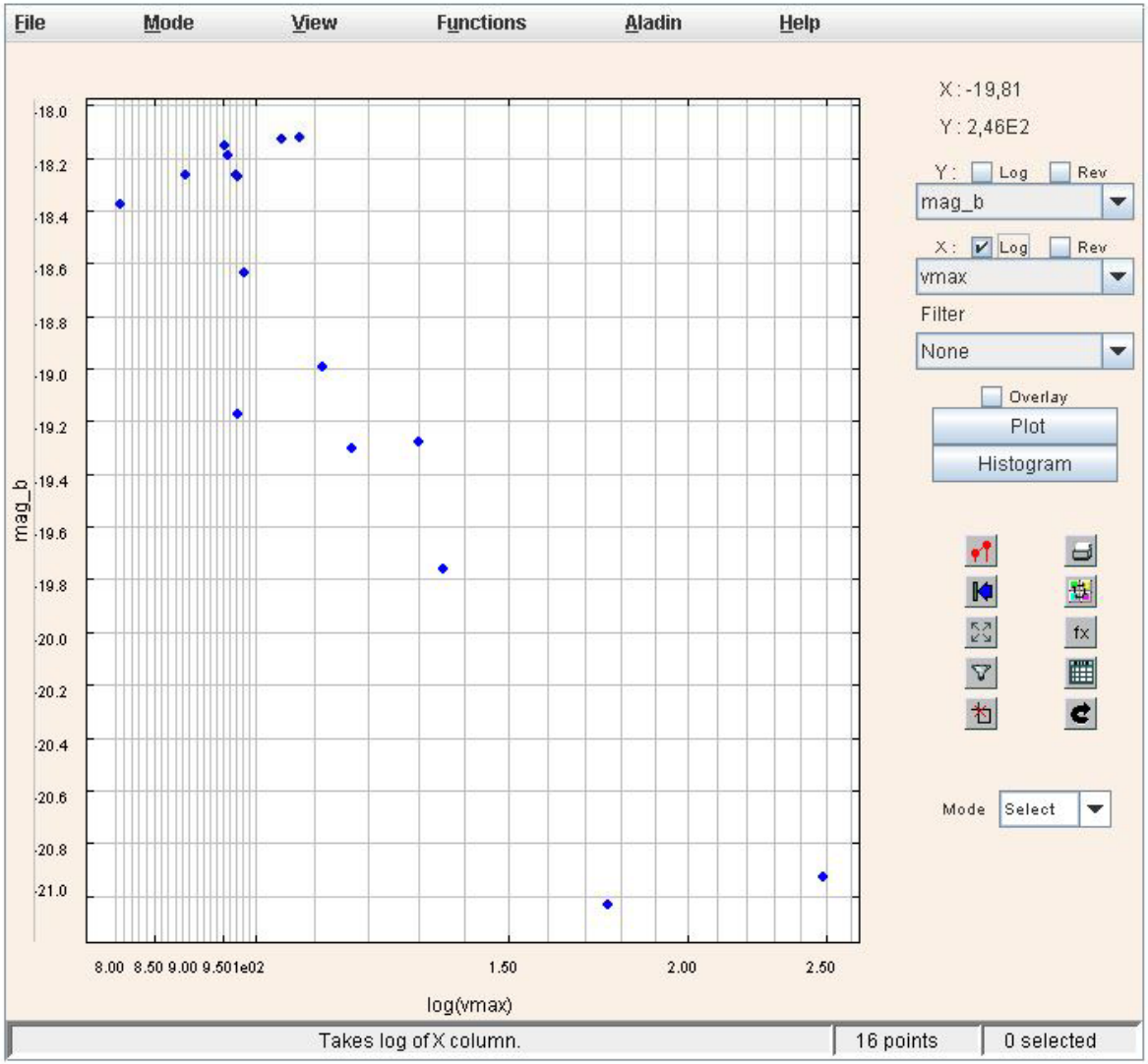
New Tab | MPA Simulations Query Form - VOPlot

GERMAN ASTROPHYSICAL VIRTUAL OBSERVATORY GAVO

Virgo simulations in a relational database - VOPlot

For help on the use of VOPlot follow this link

File Mode View Functions Aladin Help



X : -19,81

Y : 2,46E2

Y : Log Rev

mag_b

X : Log Rev

vmax

Filter

None

Overlay

Plot

Histogram

fx

Mode Select

Takes log of X column. | 16 points | 0 selected

MPA Simulations Query Form - Netscape

File Edit View Go Bookmarks Tools Window Help

New Tab | MPA Simulations Query Form | The Tully Fisher Relation

GERMAN ASTROPHYSICAL VIRTUAL OBSERVATORY

Exploring the milli-Millennium simulation with a relational database


```
select vVir, mag_b, mag_v, mag_i, mag_r, mag_k
  from MMGalaxy
 where (bulgeMass < 0.1*stellarMass or bulgeMass is null)
   and snapnum = 41
```

Execute Query

Clear all

Help

Reformat CSV

Plot (VOPlot)

This button wil attempt to start up VOPlot within an applet, so that the current result can be explored graphically. This clearly requires that the browser has been configured for viewing applets.
DISCLAIMER This functionality has been partially tested only. Any problems are our responsibility, not VOPlot's.
It seems that the applet does not work properly with Konqueror.

Query time (in millisec) = 73
Number of rows retrieved from database = 10000 (Maximum # = 10000)

vVir	mag_b	mag_v	mag_i	mag_r	mag_k
79.19628	-16.632986	-17.412676	-17.952068	-18.457636	-20.040405
77.190445	-16.120844	-16.890308	-17.425594	-17.926497	-19.483166
76.21149	-16.140694	-16.905455	-17.438732	-17.937056	-19.479727
76.92076	-15.326297	-16.057386	-16.57485	-17.054783	-18.512884
74.97255	-15.202728	-15.91887	-16.429098	-16.901783	-18.337637
72.72156	-16.323088	-17.084461	-17.615631	-18.111	-19.642773
58.915527	-14.502888	-15.154226	-15.625463	-16.060984	-17.45234
66.87775	-14.380597	-15.061023	-15.551133	-16.002077	-17.348223
71.53432	-17.330296	-18.07204	-18.592924	-19.078762	-20.593771
78.52986	-16.08363	-16.844992	-17.37658	-17.8741	-19.428852

Done

MPA Simulations Query Form - VOPlot - Netscape

File Edit View Go Bookmarks Tools Window Help

New Tab | MPA Simulations Query Form - VOPlot

GERMAN ASTROPHYSICAL VIRTUAL OBSERVATORY GAVO

Virgo simulations in a relational database - VOPlot

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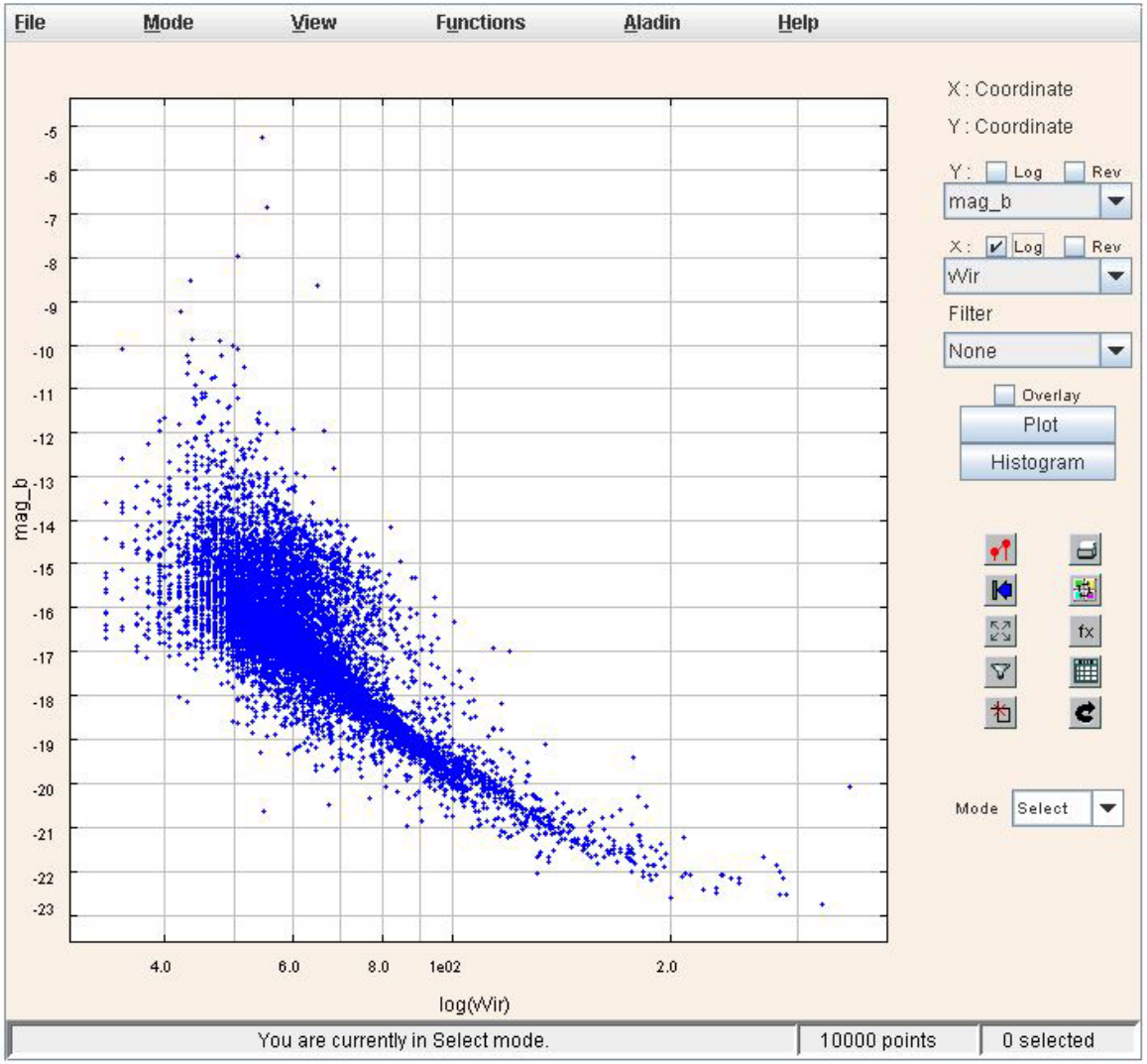
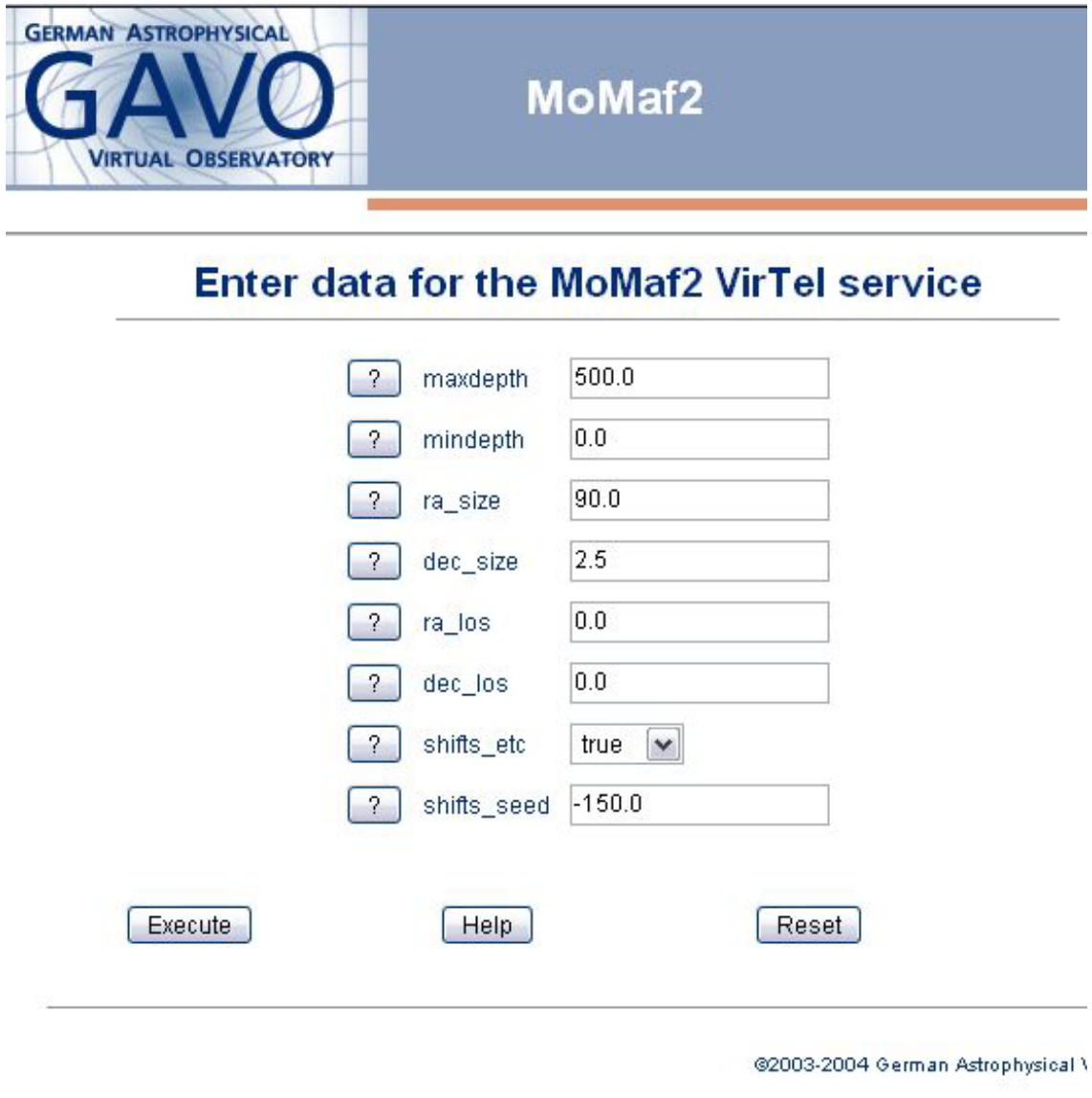


MoMaf2 (J. Blaizot MPA)
(Mock Map Facility)



MoMaf2 - Netscape

File Edit View Go Bookmarks Tools Window Help

http://gavows2.xray.mpe.mpg.de:8080/mpasims/MoMaf2?action=MoMaf2&omega_0=0.3&lambda_0=0.7&little_h=0.7&lboxp=62.5&nsteps=63.0&nsubsnaps=8.0&basedir=%2Fwork2%

Home Netscape Internet Lookup New&Cool ADS FREE Gestion ... SFR - Gérer M... Programme TV... http://cralconf...

Netscape Enter Search Terms Search

New Tab MoMaf2

GERMAN ASTROPHYSICAL GAVO VIRTUAL OBSERVATORY

MoMaf2

MoMaf2 VirTel - Results

Result files

- Halo catalogue (to be saved as "result_halo.dat")
- Metadata file (to be saved as "result_halo.setup")
- IDL reading routine (this routine provides an example of how to read the two files above)
- Log file, input file

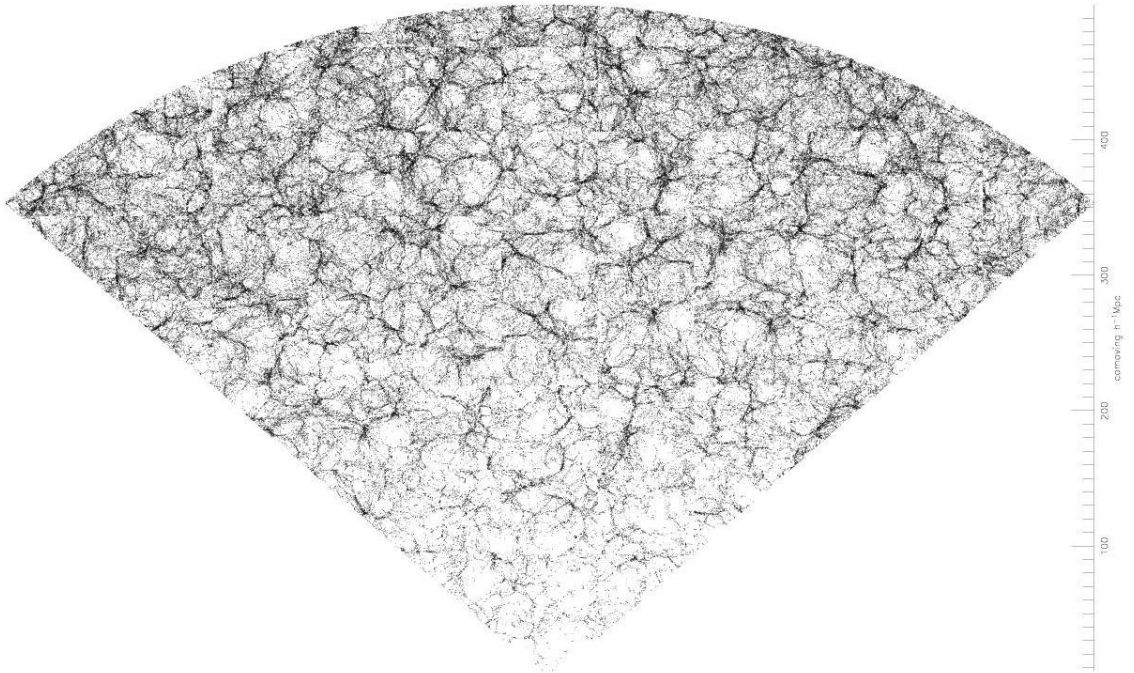
Credits

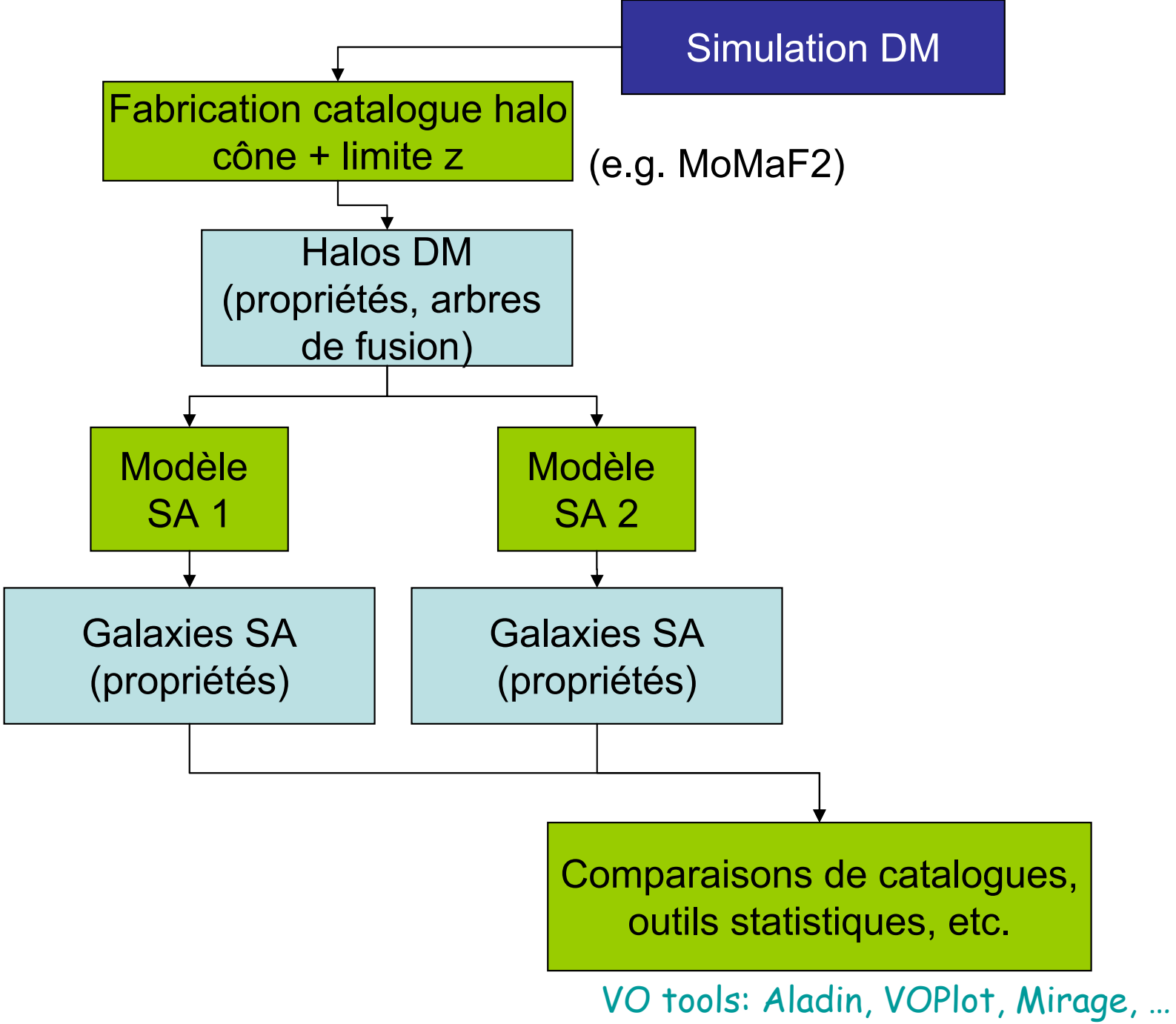
If using theses catalogues for publishable work, please give the following acknowledgements

Blaizot et al., 2005, MNRAS 360, 159-175. (link to ADS)

Springel et al., 2005, Nature 435, 629-636. (link to ADS)

X-Y projection:




Simulation DM
Fabrication catalogue halo cône + limite z
(e.g. MoMaF2)
Halos DM (propriétés, arbres de fusion)
Modèle SA 1
Modèle SA 2
Galaxies SA (propriétés)
Galaxies SA (propriétés)
Comparaisons de catalogues, outils statistiques, etc.
VO tools: Aladin, VOPlot, Mirage, …

Cas simulations HORIZON

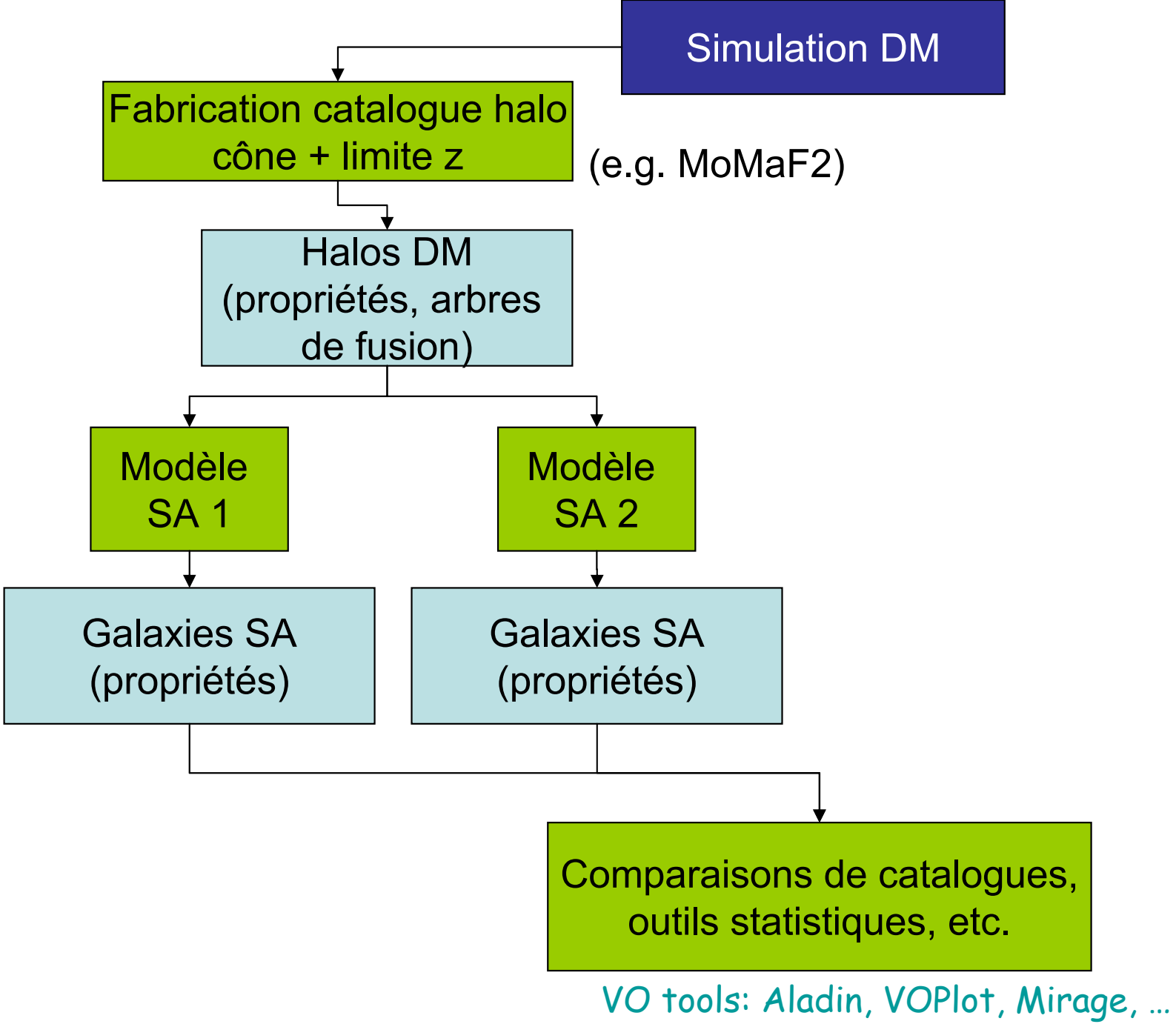
Consortium HORIZON
(CEA/SAp, CRAL, IAP, LERMA, LUTH)

Quoi de plus avec le projet HORIZON ?

- Simulations cosmologiques avec
  - moins de particules que Millenium (8 10^9 au total)
  - du gaz et des étoiles (créées en cours de simulation avec des recettes de formation stellaire)
- D'autres types de simulations
  - Simus chemodynamiques de galaxies isolées (Wozniak,…)
  - Galaxies en interaction (Combes,…)
  - Amas de galaxies (Sauvageot,…)
  - Etc.

Problématique HORIZON

- … le même que le consortium VIRGO!
- Produire des catalogues comparables aux sondages existants
- Produire des images et des cubes spectro 3D (x,y,λ) grand champ pour la préparation et l'analyse des sondages profonds
  (PLANCK, Herschel, ALMA, SKA, VLT/MUSE, JWST/NIRSpec, etc.)


Simulation DM
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Halos DM (propriétés, arbres de fusion)
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Galaxies SA (propriétés)
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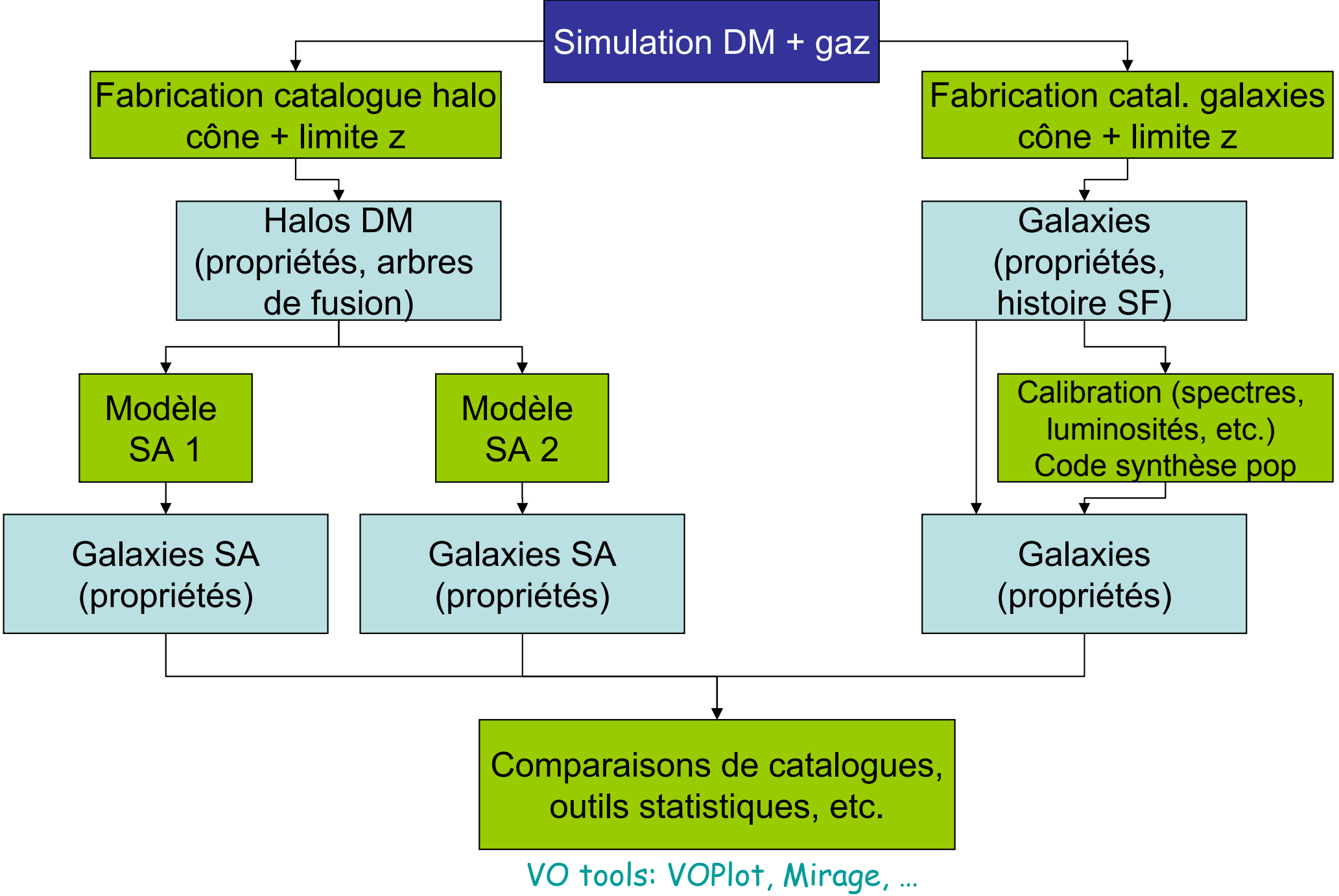
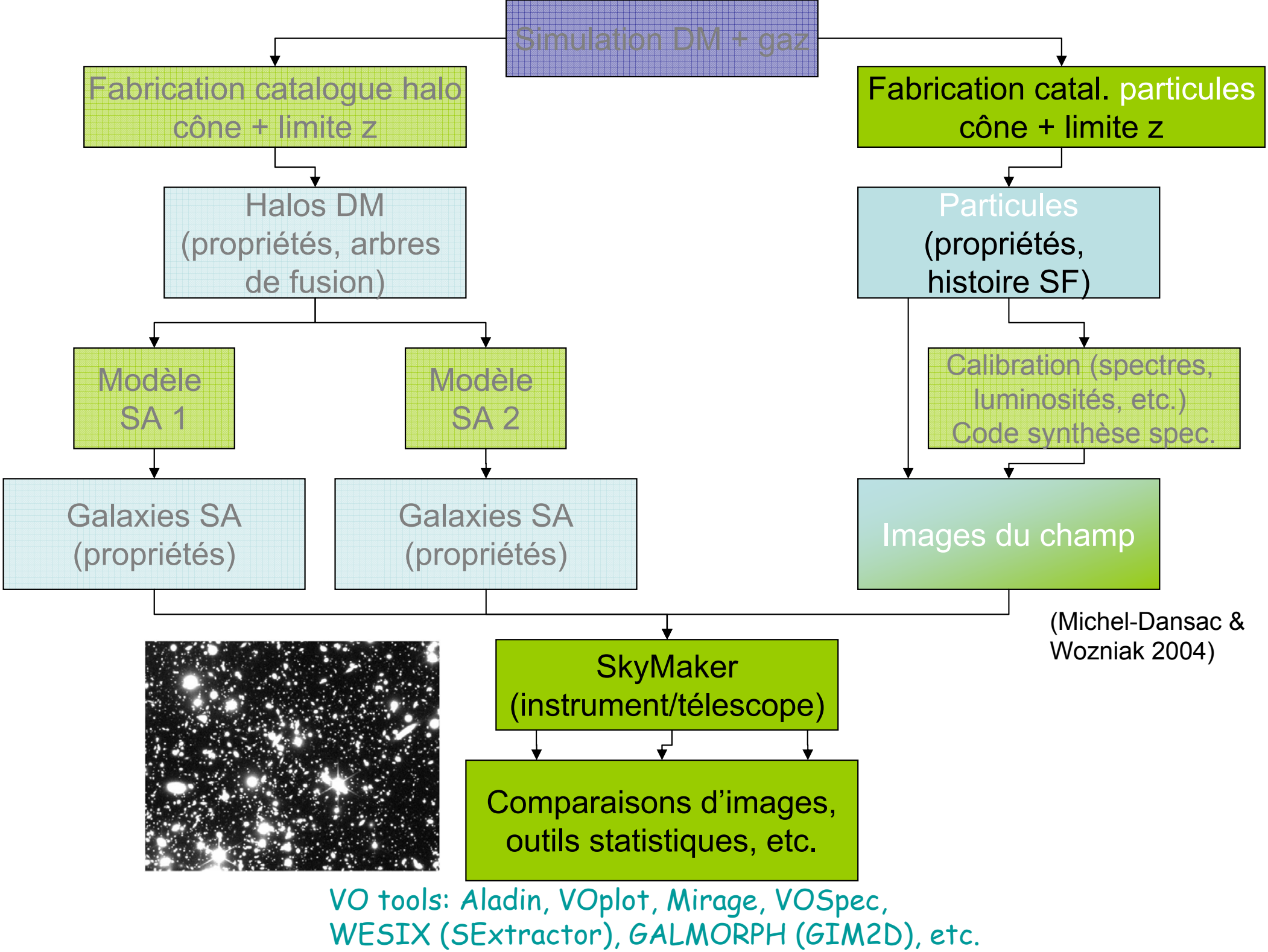

Simulation DM + gaz
Fabrication catalogue halo cône + limite z
Fabrication catal. galaxies cône + limite z
Halos DM (propriétés, arbres de fusion)
Galaxies (propriétés, histoire SF)
Modèle SA 1
Modèle SA 2
Calibration (spectres, luminosités, etc.) Code synthèse pop
Galaxies SA (propriétés)
Galaxies SA (propriétés)
Galaxies (propriétés)
Comparaisons de catalogues, outils statistiques, etc.
VO tools: VOPlot, Mirage, ...



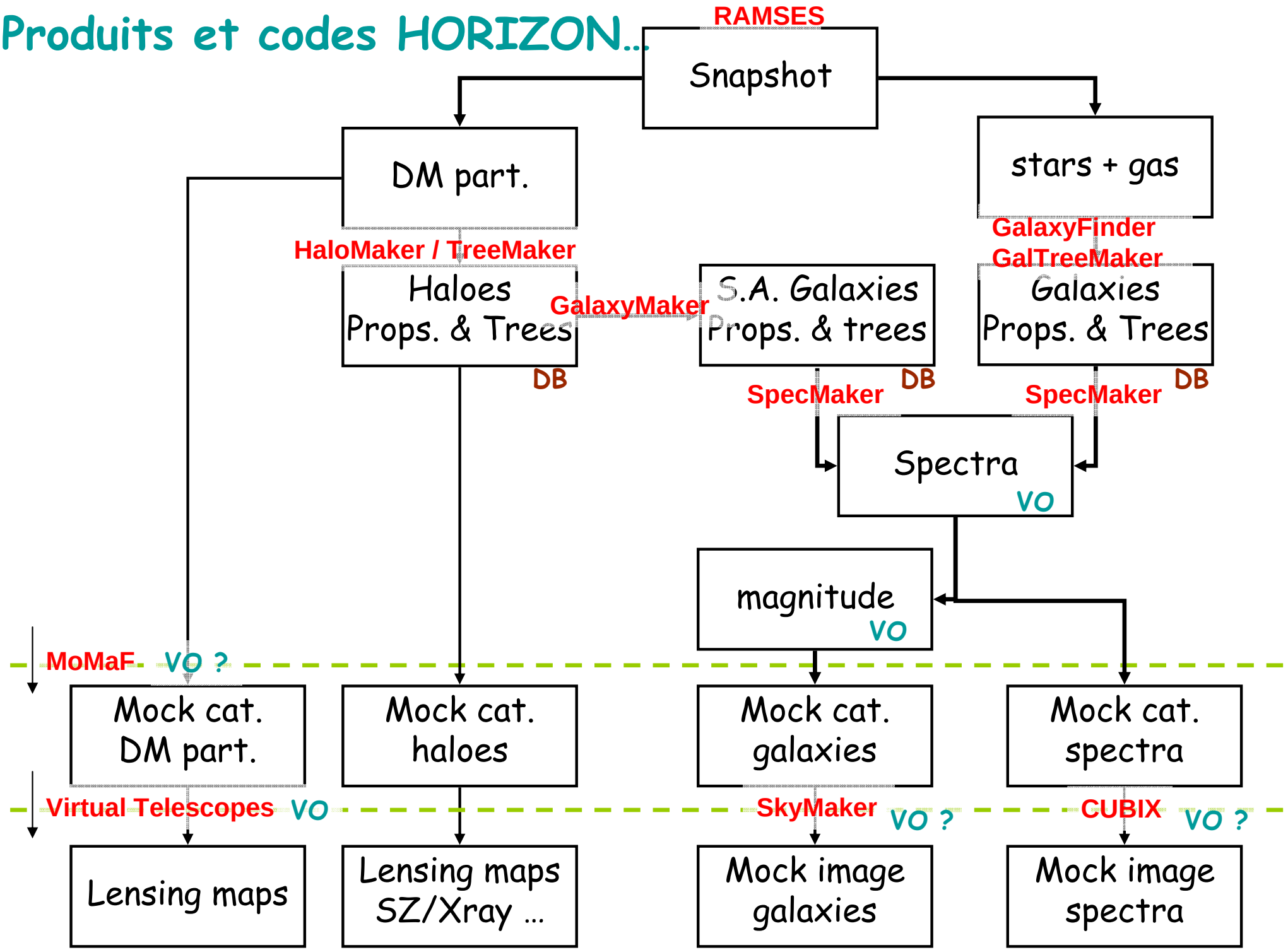
(Michel-Dansac & Wozniak 2004)

Quelques remarques en guise de conclusion

Problèmes potentiels (1)

- Quels produits doivent être mis en ligne?
  - Problématique semblable au traitement des ‘vraies’ données (données brutes, niveaux 0, 1 etc.)
  - Compromis snapshots/bases de données
    - A quel nombre de particules une architecture BD cesse d’être efficace pour le stockage des particules ?

Produits et codes HORIZON..



Problèmes potentiels (1)

- Quels produits doivent être mis en ligne?
  - Problématique semblable au traitement des ‘vraies’ données (données brutes, niveaux 0, 1 etc.)
  - Compromis snapshots/bases de données
    - A quel nombre de particules une architecture BD cesse d’être efficace pour le stockage des particules ?
- Optimisations particulières des BD
  - Indexation Peano-Hilbert optimale pour les recherches spatiales mais pas pour les propriétés physiques (e.g. luminosité)
- Faire tourner certains algorithmes sur ses propres simulations
  - e.g. MoMAF2 installé au MPA sur des simulations HORIZON au CRAL
- Faire tourner son propre algorithme sur les simulations ou les BD distantes
  - e.g. son propre modèle semi-analytique sur la Millenium

Problèmes potentiels (2)

- Les simulations doit-elle exister ?
  - Obligatoire pour les simulations de type Millenium ou Horizon
  - Peuvent être faites ‘on line’ pour les ‘petites’ simulations
- Catalogues artificiels organisés en BD
  - Obligatoire pour les simulations Millenium/Horizon
  - Transformer les codes d’analyse en services VO pour les ‘petites’ simulations ?

Services VO nécessaires pour la production de catalogues et images virtuels

- Définition des filtres photométriques
- Bibliothèques de spectres de calibration
- Utiliser les outils VO pour comparer les images et les catalogues (e.g. analyse statistique, X-identifications, etc.)
- Insérer l'ensemble dans la notion de Telescope Virtuel (cf. Lemson/MPA)