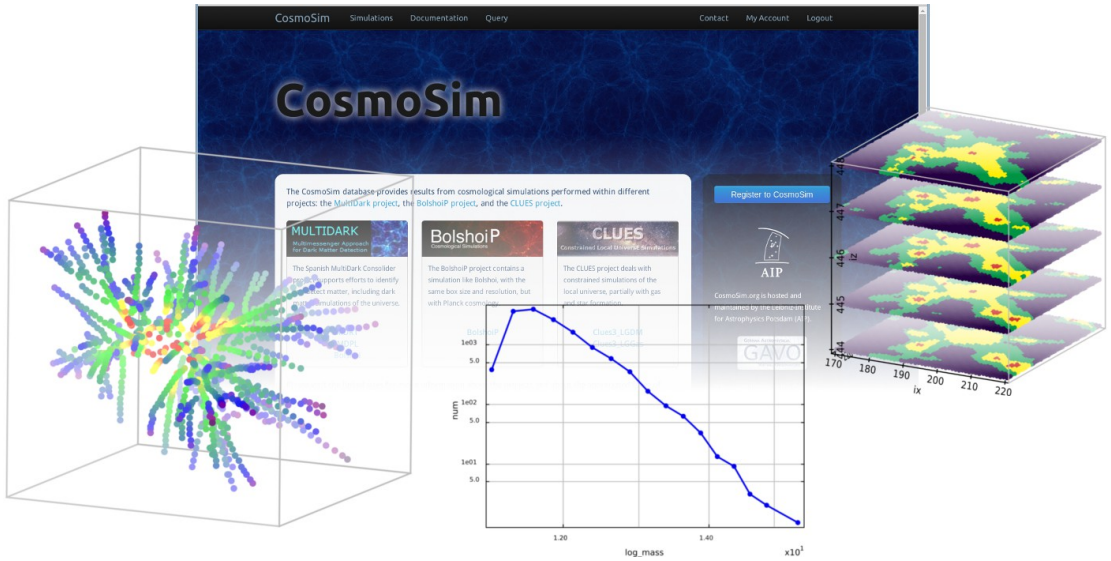
CLUES data in the CosmoSim database



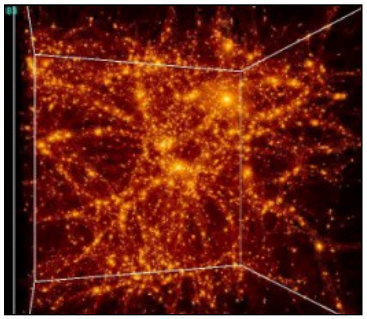
Kristin Riebe
E-Science group @AIP

Outline

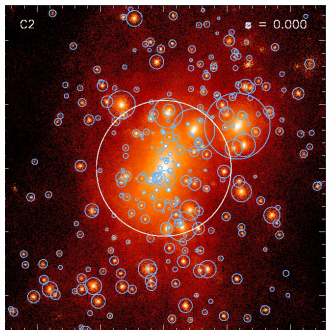
- General: Simulations and databases
- CosmoSim: database server, web interface
- Data products
- CLUES data
- Short demo
- Discussion

Cosmological Simulations

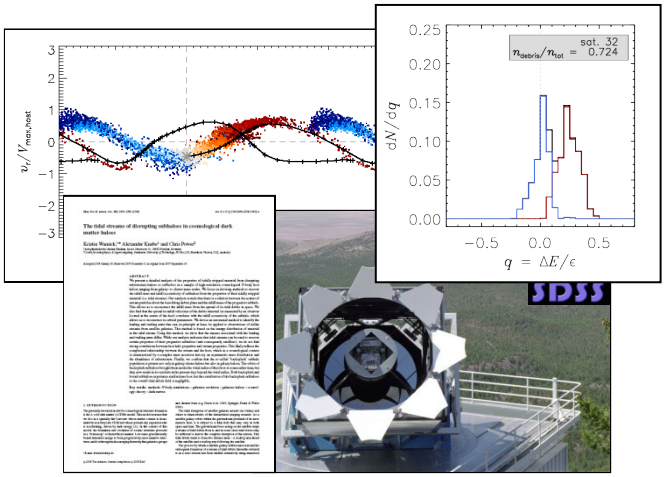
- Produce terabytes of data
- Post-processing:
  - Halo catalogues, merger trees, mock galaxy catalogues, …
  - Variety of data formats
- How to share data within collaboration? How to publish?



Cosmological Simulation



Post-Processing (e.g. halo finding)



Scientific Output

Databases

- Structured Query Language: SQL
- Uniform data formats
- Retrieve only subsets, results, **not** complete catalogues
- Examples: sort/filter halos, calculate mass functions, extract particles for halos, merger trees, substructures, ...

```
SELECT * FROM MDR1.FOF
WHERE snapnum=85
ORDER BY mass DESC LIMIT 10
```

10 most massive FOF groups at z=0
< 1 s

```
SELECT * FROM MDR1.FOF
WHERE snapnum=85
ORDER BY spin DESC LIMIT 50
```

50 FOF groups with biggest spin parameter
~ 26 s

=> Just share the query, don't need to share the subset!

Simulation Databases

- Millennium Run Database: very successful, hundreds of papers, still being used
- MultiDark Database: collaboration with Spanisch MultiDark project, ~ 20 papers, also from people outside of collaboration

Database server

- Previous setup: 1 Microsoft SQL server
  - expensive **license**, harder to share
  - **slow** retrieval times on **full table scans** (cannot have index for everything)
  - creating **index** on particle data (~ 10^{10} particles) takes ~ 1 week

- Solution: MyISAM+Spider with MariaDB
  - use MyISAM engine of MySQL/MariaDB
  - Spider engine (Kentoku Shiba) for distributed queries
    => **data distributed** over 10 nodes, queries much faster!
  - **open source**
  - own developments in E-Science group:
    PaQu, QueryQueue, libhilbert, mysql_sprng
    => see http://github.com/adrpar

CosmoSim

- new web interface:
  - Daiquiri web application, http://escience.aip.de/daiquiri
  - developed by J. Klar and A. Partl
  - modular, highly customizable
  - using PHP, Zend-framework
  - modern interface
  - authentication, query interface
  - wordpress integration
  - open source
  - also used for MUSIC, Jubilee and Curie databases in Madrid, project webpages, workshops (e.g. CLUES registration page!)

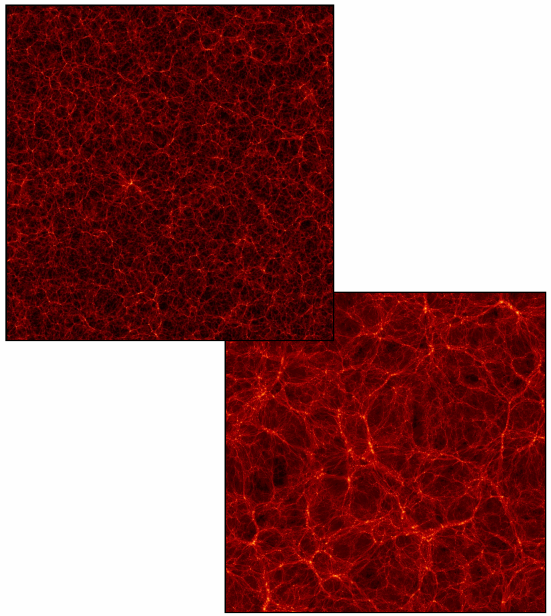
Data at CosmoSim

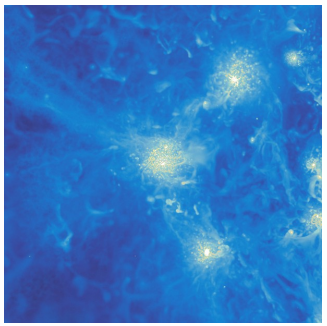
- 25 TB data, ~ 230 billion rows
- 6 simulations:
  - **MDR1**: WMAP5, 1000 Mpc/h, 2048^3 p.
  - **MDPL**: Planck1, 1000 Mpc/h, 3840^3 p.

  - **Bolshoi**: WMAP5, 250 Mpc/h, 2048^3 p.
  - **BolshoiP**: Planck1, 250 Mpc/h, 2048^3 p.

  - **2 CLUES** simulations:
    B64_WM3_186592, WMAP3:
    - Clues3_LGDM: 2 Mpc in 64 Mpc/h box, 4096^3 p.
    - Clues3_LGGas: same, but with gas+sfr

  - in preparation: SMDPL: Planck1, 400 Mpc/h, 3840^3 p.





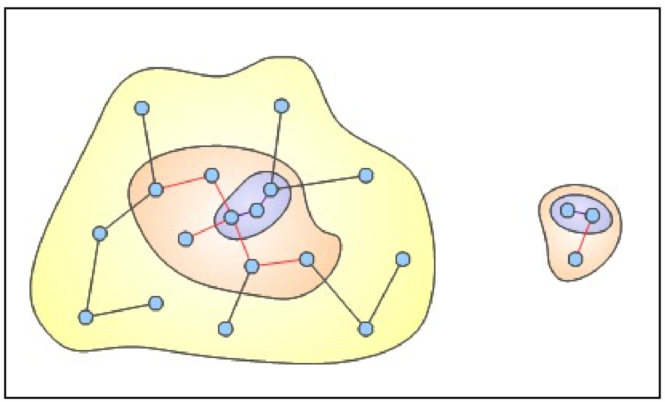
Data products

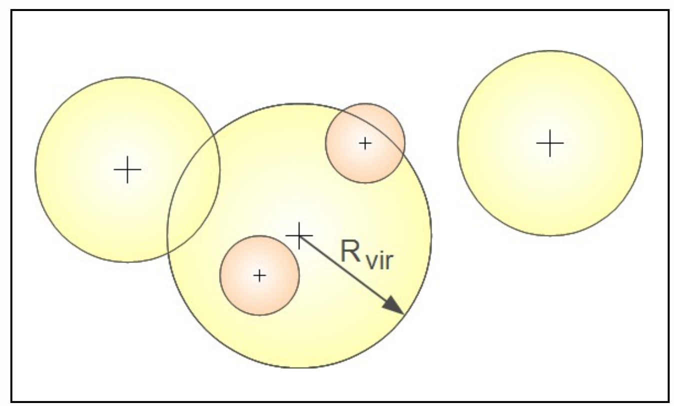
- Halo catalogues
  - AHF, BDM, FOF
  - multiple density thresholds, linking lengths

bdmId	snapnum	NInCat	hostFlag	x	y	z
8511186098	85	11186098	-1	548.8973	143.9528	895.
8512166221	85	12166221	-1	384.92	468.0325	872.
8512459068	85	12459068	-1	737.7123	482.5123	972.
8505410295	85	5410295	-1	947.049	971.8178	267.
8506742613	85	6742613	-1	276.4744	488.3719	548.
8506941522	85	6941522	[illegible]	[illegible]	[illegible]	6.
8513458743	85	13458743	-1	665.9299	986.9252	815.

1 halo/group per row

unique identifier for each halo/group





Data products

- Halo catalogues
  - AHF, BDM, FOF
  - multiple density thresholds, linking lengths
- AHF/BDM halo profiles
  - inner structure of halos

bdmId	snapnum	NInCat	hostFlag	x	y	z
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bdmId	snapnum	NinCat	R_Rvir	Rbin	np	mass
8506742613	85	6742613	1.0629464	2828.978	10582	1.880105
8506742613	85	6742613	1.1953862	3174.1658	12201	1.985926
8506742613	85	6742613	1.3382614	3561.4724	11217	2.083212
8506742613	85	6742613	1.4941747	3996.0378	7967	2.152309
8506742613	85	6742613	1.6838918	4483.628	6245	2.206469
8506742613	85	6742613	1.8875381	5030.7134	7078	2.267854
8506742613	85	6742613	0.9454057	2521.329	10907	1.788326

distance from center

AIP

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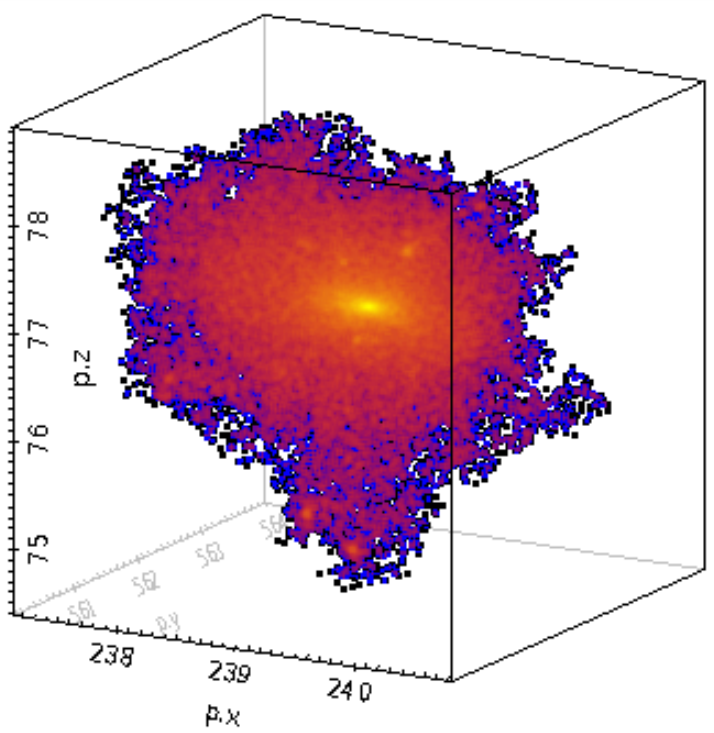
8506742613	85	6742613	1.3382614	3561.4724	11217	2.08321
8506742613	85	6742613	1.4941747	3996.0378	7967	2.15230
8506742613	85	6742613	1.6838918	4483.628	6245	2.20646
8506742613	85	6742613	1.8875381	5030.7134	7078	2.26785
8506742613	85	6742613	0.9454057	2521.329	10907	1.78832

link to BDM halo

distance from center

Data products

- Halo catalogues
  - AHF, BDM, FOF
  - multiple density thresholds, linking lengths
- AHF/BDM halo profiles
  - inner structure of halos
- Particle snapshots
  - access to all particles
- FOF particles
  - link between halos and particles



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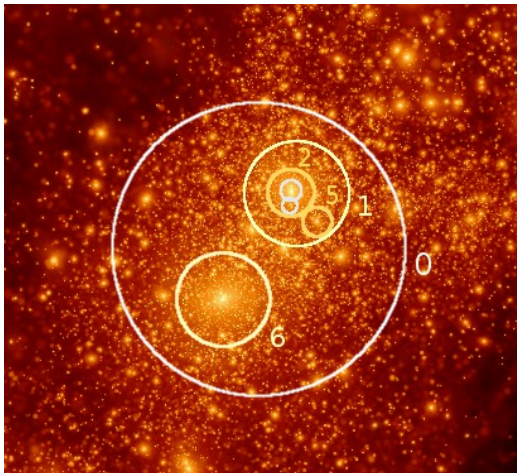
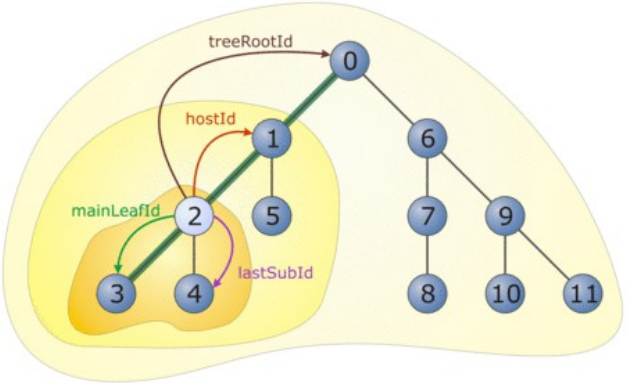
- FOF substructures, superclusters
  - hierarchy of structures





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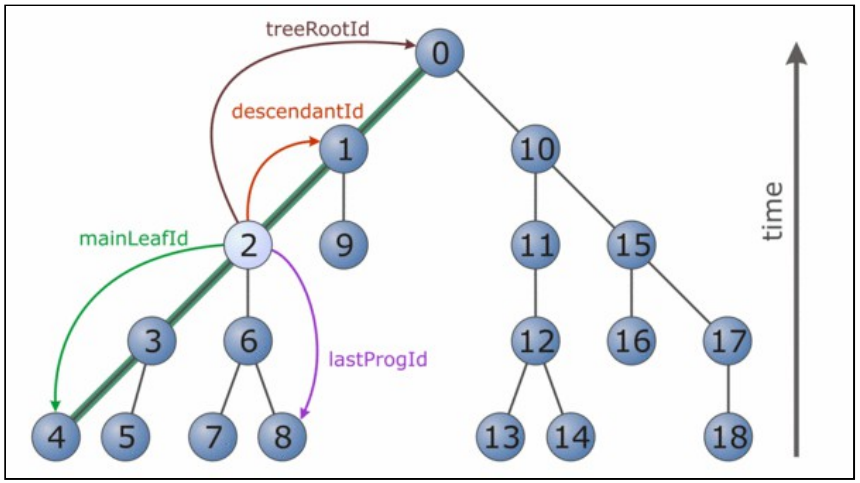
- FOF merger trees
  - evolution of FOF groups



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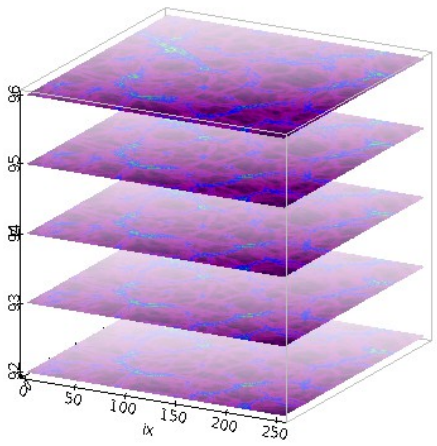
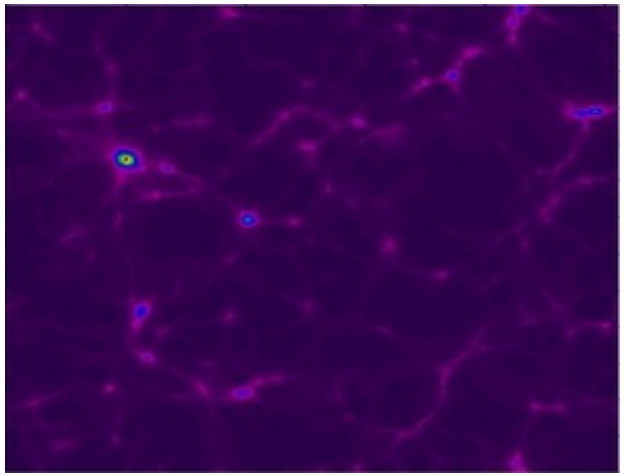
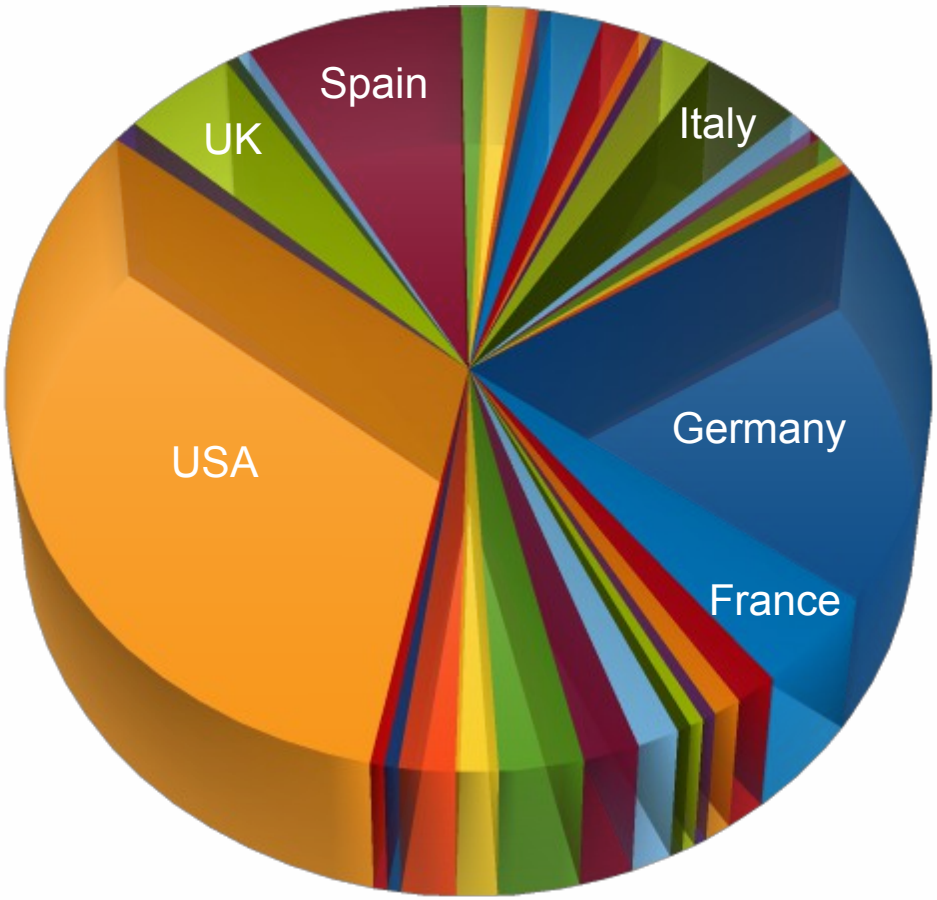
- FOF substructures, superclusters
  - hierarchy of structures
- FOF merger trees
  - evolution of FOF groups
- density, cosmic web
  - large scale structure





Database usage: users per country

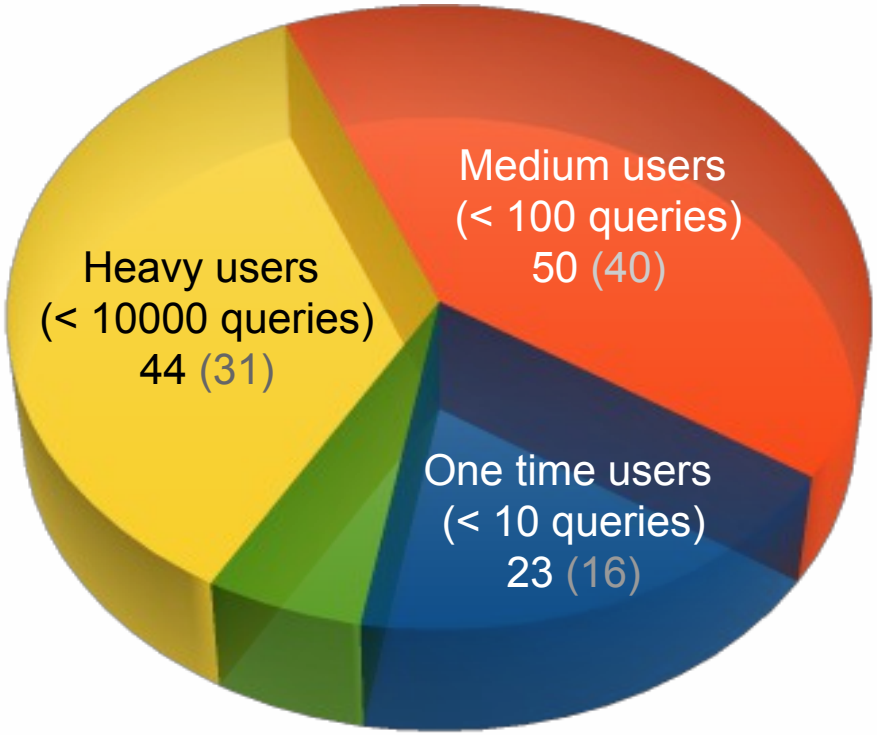


Users from 35 different countries

USA	69
Germany	40
Spain	17
France	9
UK	9
Italy	8

Argentina	Australia	Canada
Chile	China	Colombia
Czech Republic	Denmark	Ecuador
Egypt	Finland	France
Germany	Guatemala	Hong Kong
India	Iran	Israel
Italy	Japan	Korea
Malta	Mexico	Netherlands
Norway	Poland	Russia
Slovenia	Spain	Sweden
Taiwan	UK	Ukraine
USA	Venezuela	

Queries per user (03/2014)

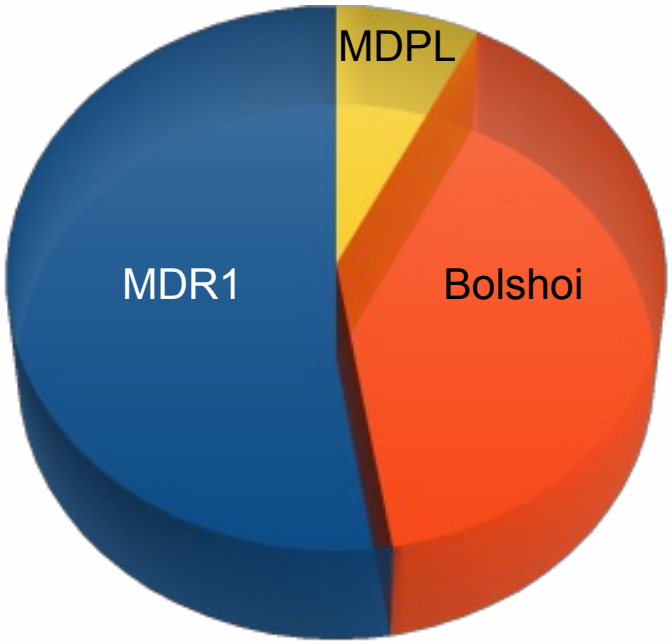


(Numbers in gray: from 04/2013)

Batch users	> 10000 qry.	7
Heavy users	< 10000 qry.	44
Medium users	< 100 qry.	50
One time users	< 10 qry.	23

Total number of users: 124
(+ 67 registered users with no queries)

Most wanted simulations 08/2014

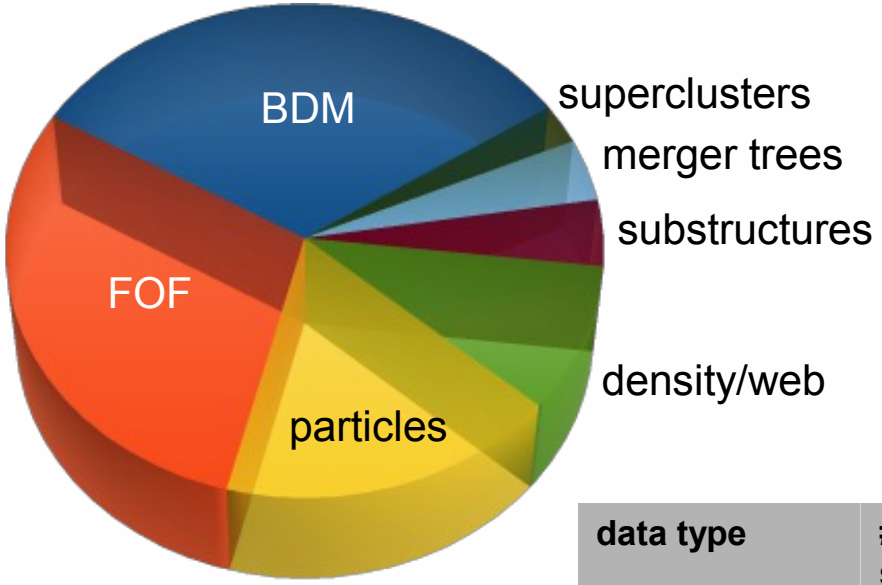


number of users per simulation

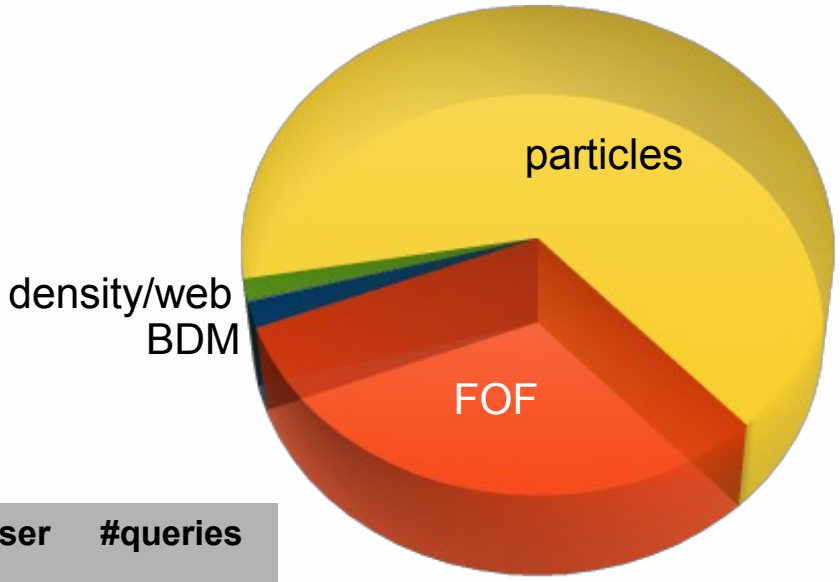
simulation	#users	#queries
MDR1	121	47658702
Bolshoi	92	16733420
MDPL	17	5175

Most wanted tables 08/2014

number of **users** per data type

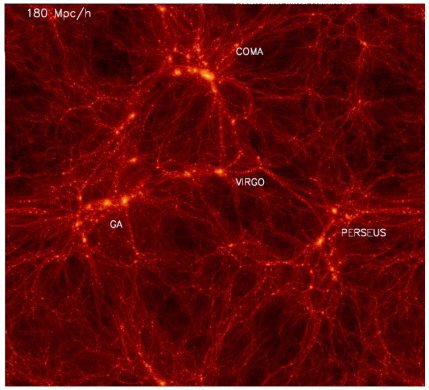


number of **queries** per data type



data type	#users	#queries
BDM	112	45324
FOF	102	825134
particles	61	1751862
density/web	33	38524
substructures	15	151
mergertree	14	1317
superclusters	9	184

CLUES data?



- first simulations now included in CosmoSim database
- AHF analysis rerun by Alexander Knebe, for consistent catalogues
- included in DB:
  - Clues3_LGDM, Clues3_LGGas
  - AHF, AHFGas, AHFStars: catalogues with halo properties
  - AHFProf: profiles of halos
  - AHFLum, AHFMag: luminosities, magnitudes for gas+sfr simulation
  - AHFMatch: links halos of gas and dm simulation

Demo: querying data from CosmoSim

Database access

- Web interface: http://www.cosmosim.org
- SAMP for sending results to VO clients
- UWS interface
  - Create, execute jobs, get results via command line
  - => allows scripting, thousands of queries at once
  - UWS-client in python (https://github.com/adrpar/uws-client)

Discussion

- More data from CLUES simulations?
  - other halo catalogues? FOF?
  - AHF/FOF merger trees?
  - better format for substructures?
  - particle snapshots => how many? AHFParticles?
  - density fields?
- Which simulations next? (WM5?)
- What about merger trees for MD-simulations?
  - Rockstar-catalogues finished? For which simulations?
  - SAMs? see new Millennium-interface, TAO!
  - => create galaxy formation catalogues online!
- Feedback from users:
  - What else would people want to be able to do?
  -
  -
  -