CHILES

COSMOS HI LARGE EXTRAGALACTIC SURVEY

Attila Popping on behalf of the CHILES team

OzSKA: radio astronomy
in the next decade.
Melbourne: April 8-10 2015

International
Centre for
Radio
Astronomy
Research

CAASTRO
ARC CENTRE OF EXCELLENCE
FOR ALL-SKY ASTROPHYSICS

THE UNIVERSITY OF
WESTERN AUSTRALIA

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ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

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+ CHILES CON POL

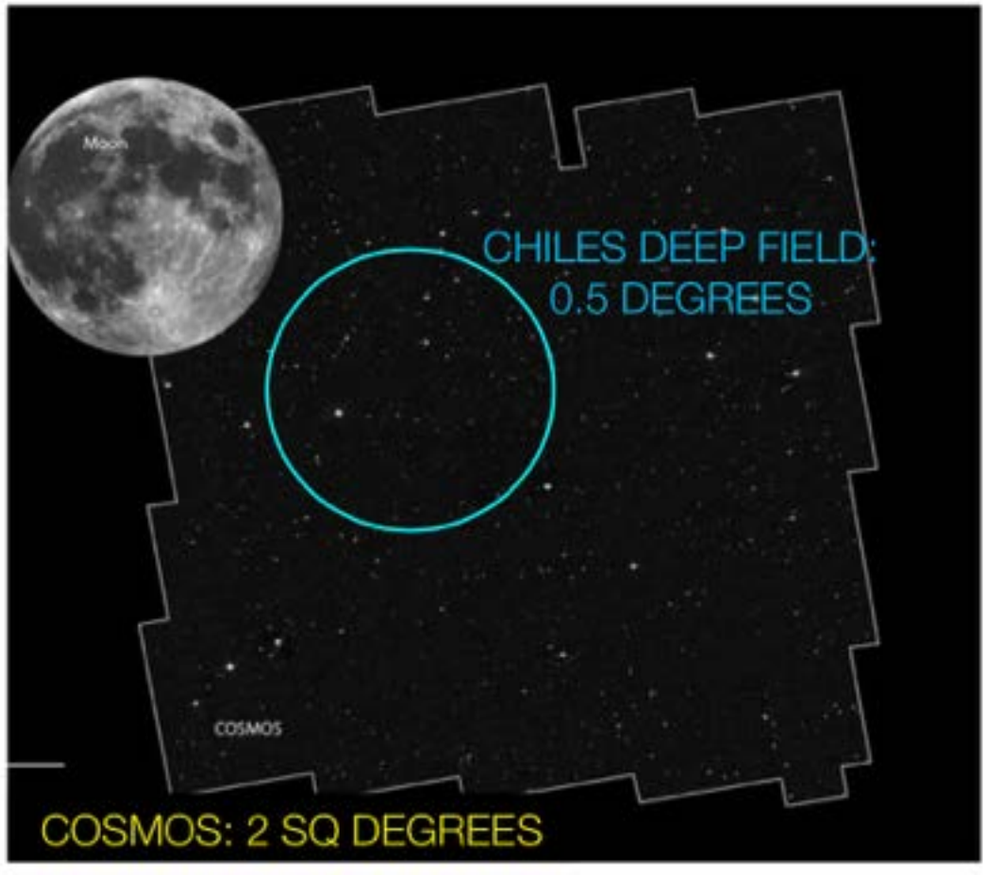
(Survey led by Chris Hales)

+ CHILES VERDES

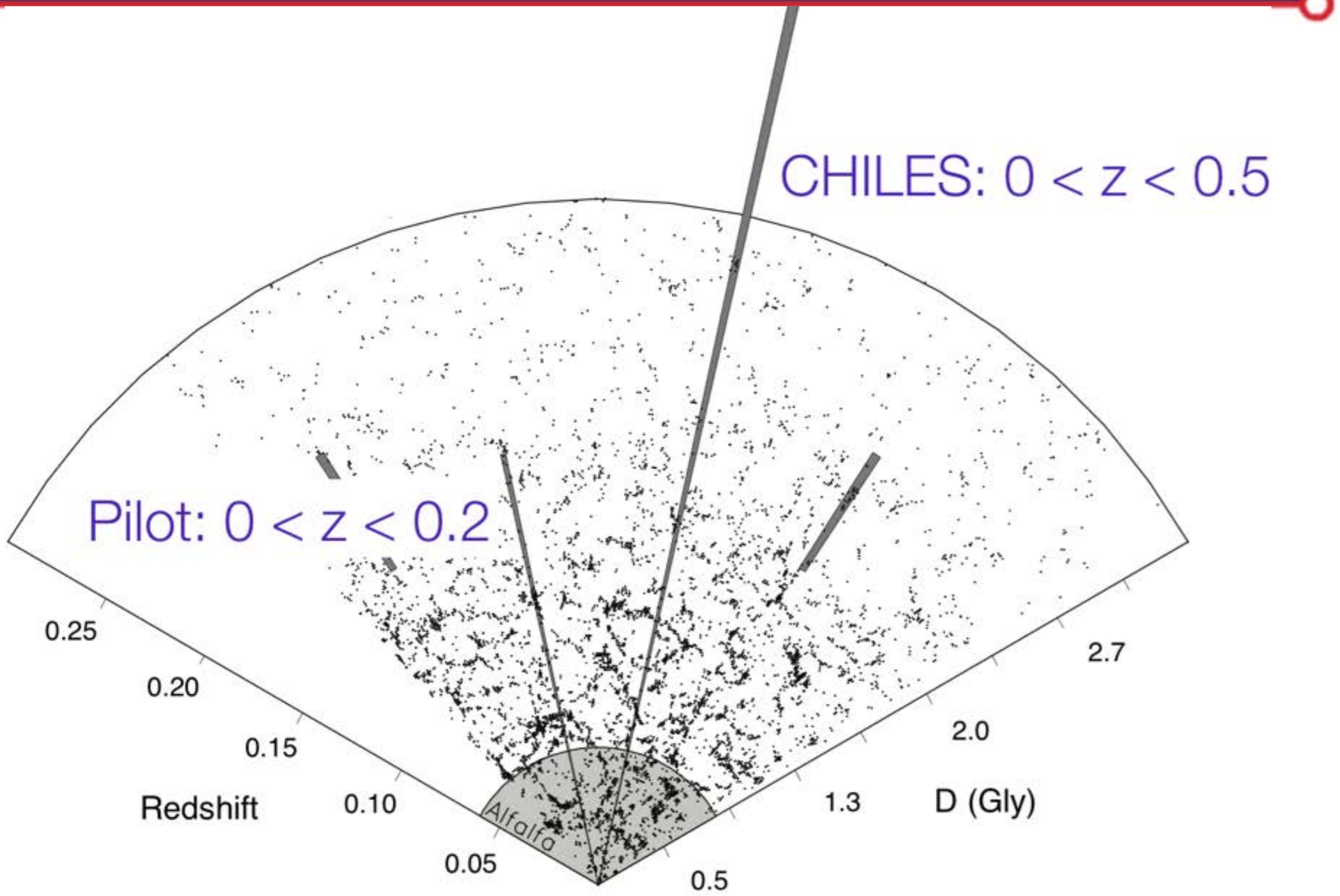
(Survey led by Laura Chomiuk)

CHILES specs

- 1000 hours, single pointing in COSMOS field
- VLA in B-configuration (5” resolution)
- freq coverage: ~950 to 1450 MHz (z=0 to z=0.5)
- 30,720 channels (3.5 km/s at z=0)



CHILES


CHILES: 0 < z < 0.5
Pilot: 0 < z < 0.2
0.25
0.20
0.15
0.10
0.05
Redshift
Alfalfa
0.5
1.3
2.0
2.7
D (Gly)

Science Drivers

1. HI images in different environments across cosmic time
   - Study galaxy properties, scaling relations and SF
   - HI images will provide constraints to simulations to study gas accretion and removal processes

2. How does the HI mass function (HIMF) evolve with redshift and environment?
   - Probe the evolution of the high-mass end of the HIMF

3. How does the cosmic HI gas density evolve with time?
   - Constrain Ω_{HI} in the interval $0 < z < 0.5$

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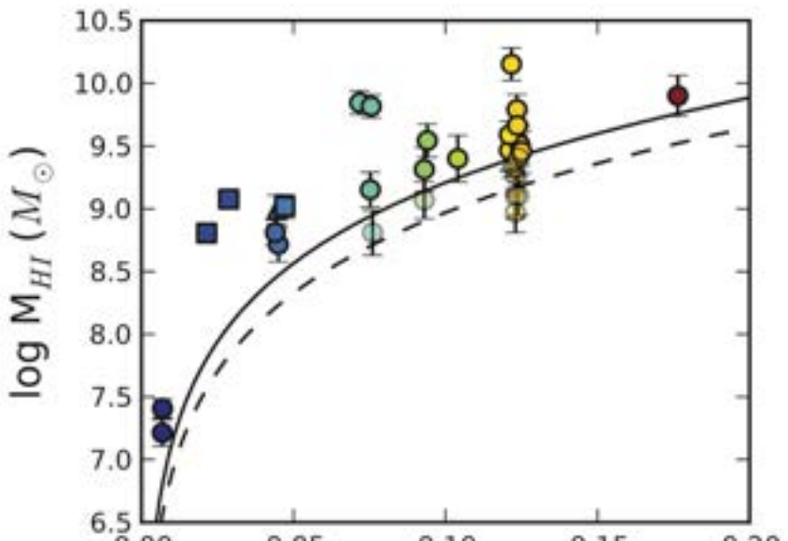
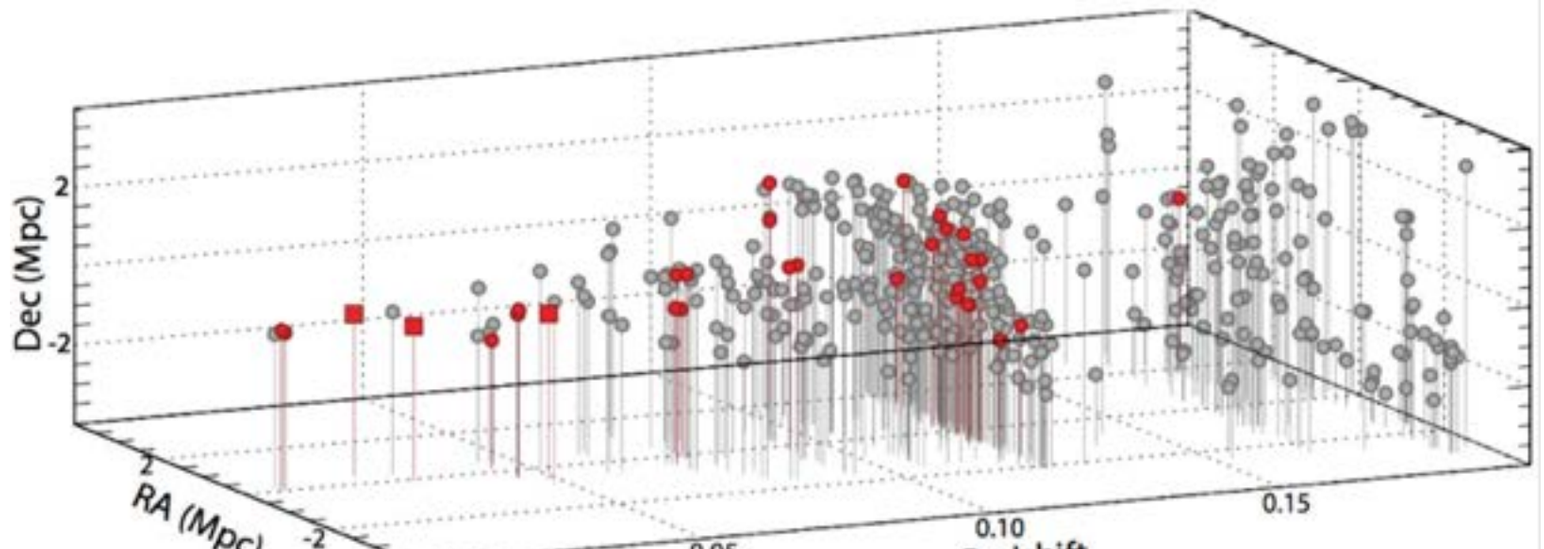
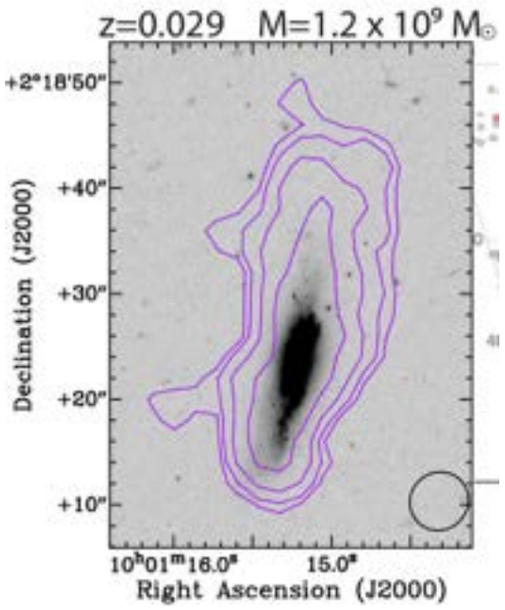
Pilot Survey

33 detections in different environments across cosmic time

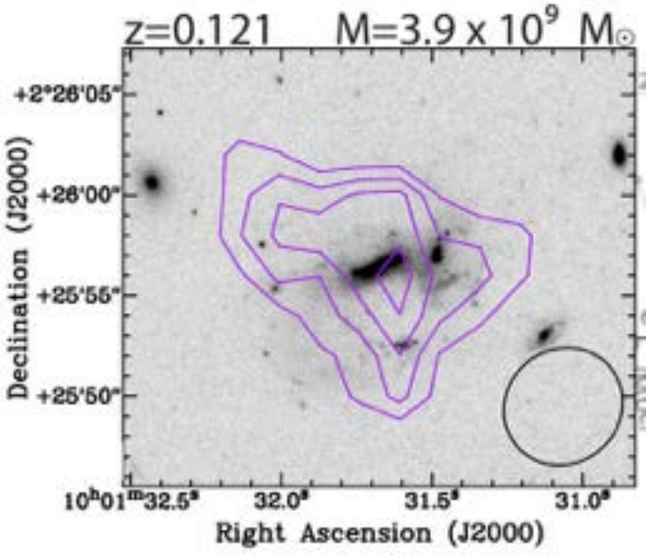




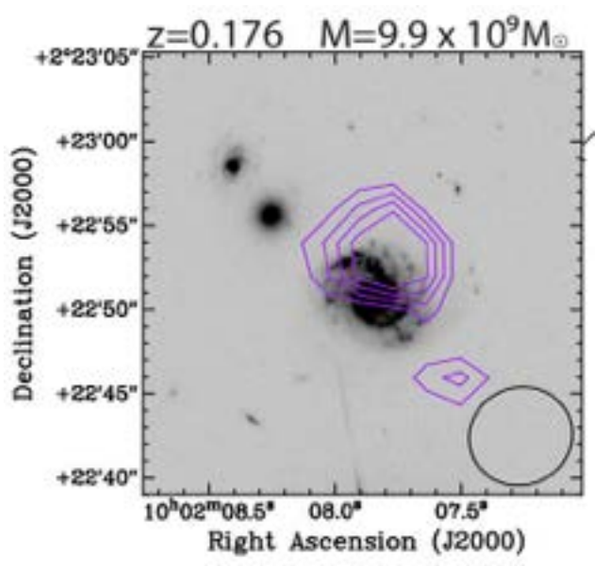
void



merger



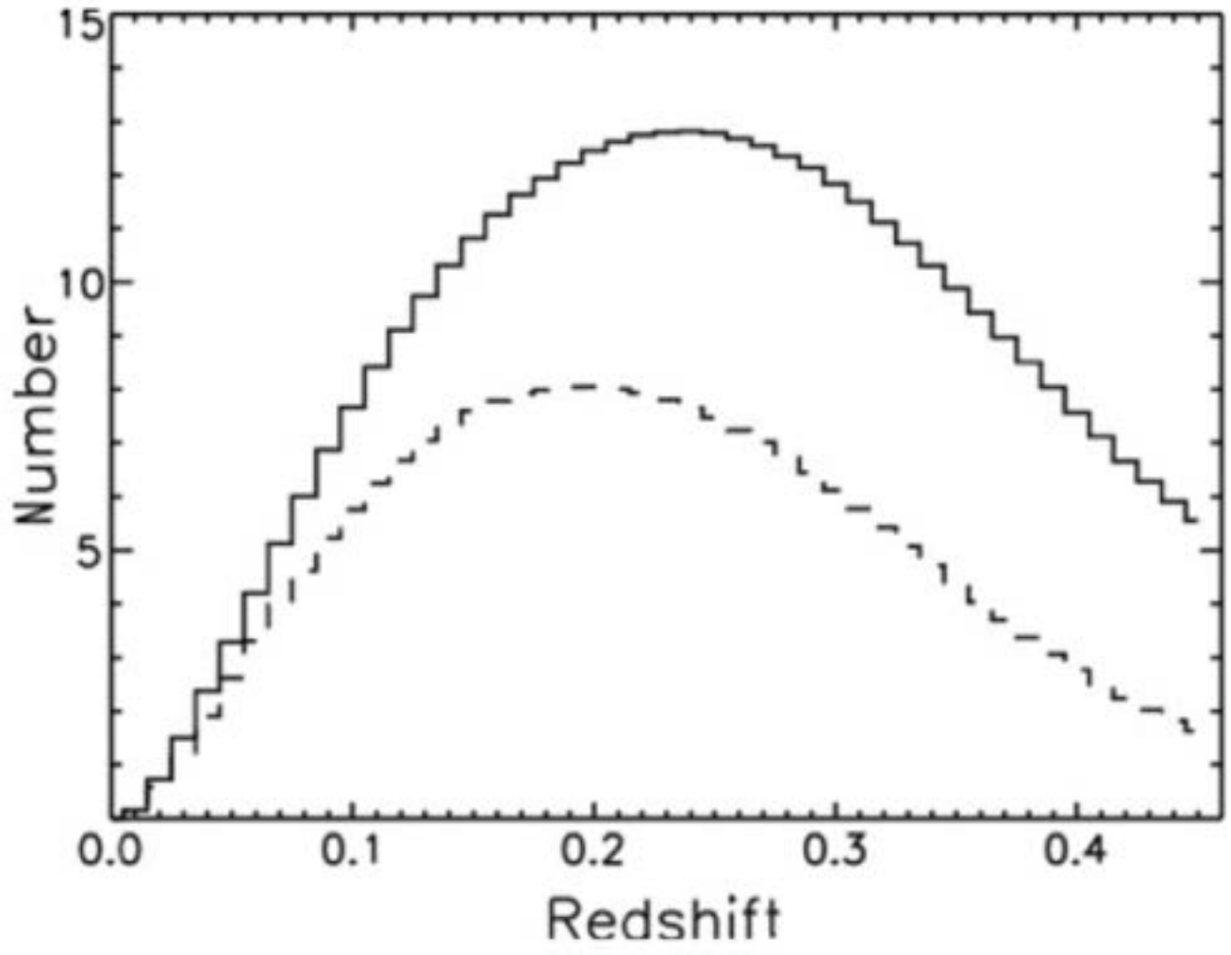
high z

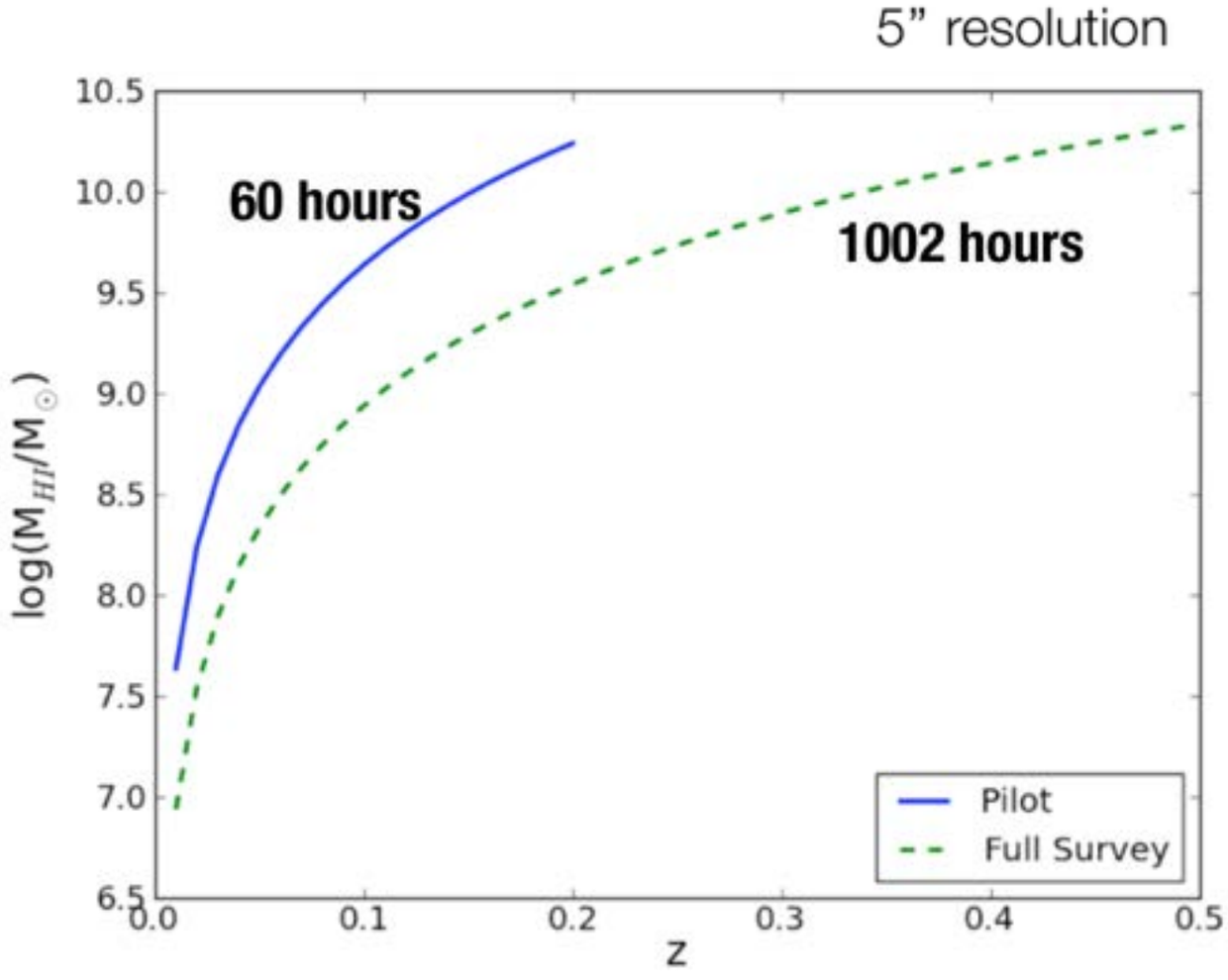


Fernández+ 13

Survey Design

1002 hours of observations will results in 300 detections





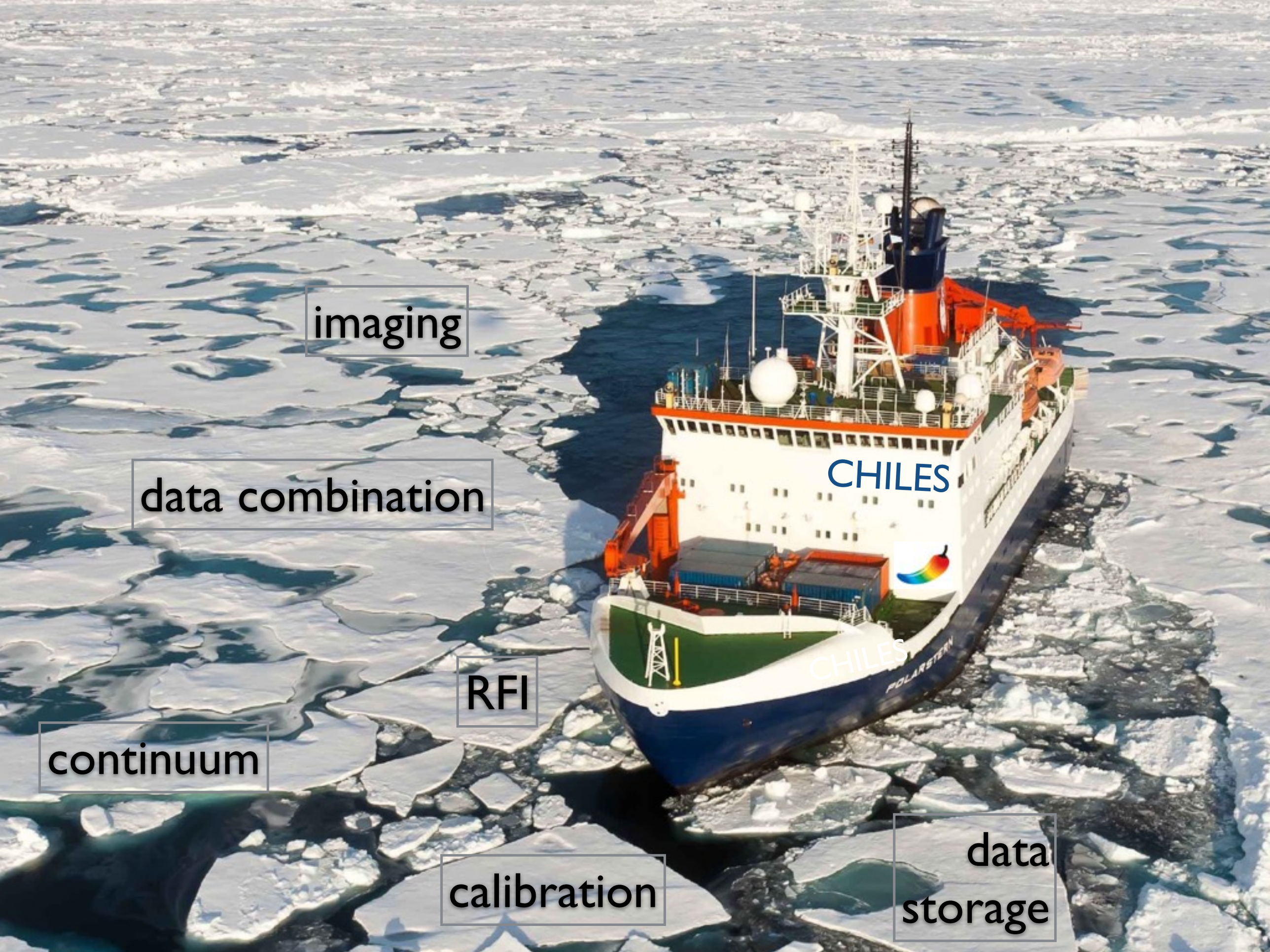
Goal: detect 3 x 10^{10} $M_\odot$ at highest z

Upgraded VLA (JVLA)

	OLD	PILOT	NEW
Bandwidth (MHz)	6.25	240	480
Channels	31	16384	30720
Velocity resolution (km/s)	40	3.5	3.5
Instantaneous z coverage	0<z<0.004	0<z<0.193	0<z<0.5

178 hours done in Fall 2013

270 hours allocated for Spring 2015

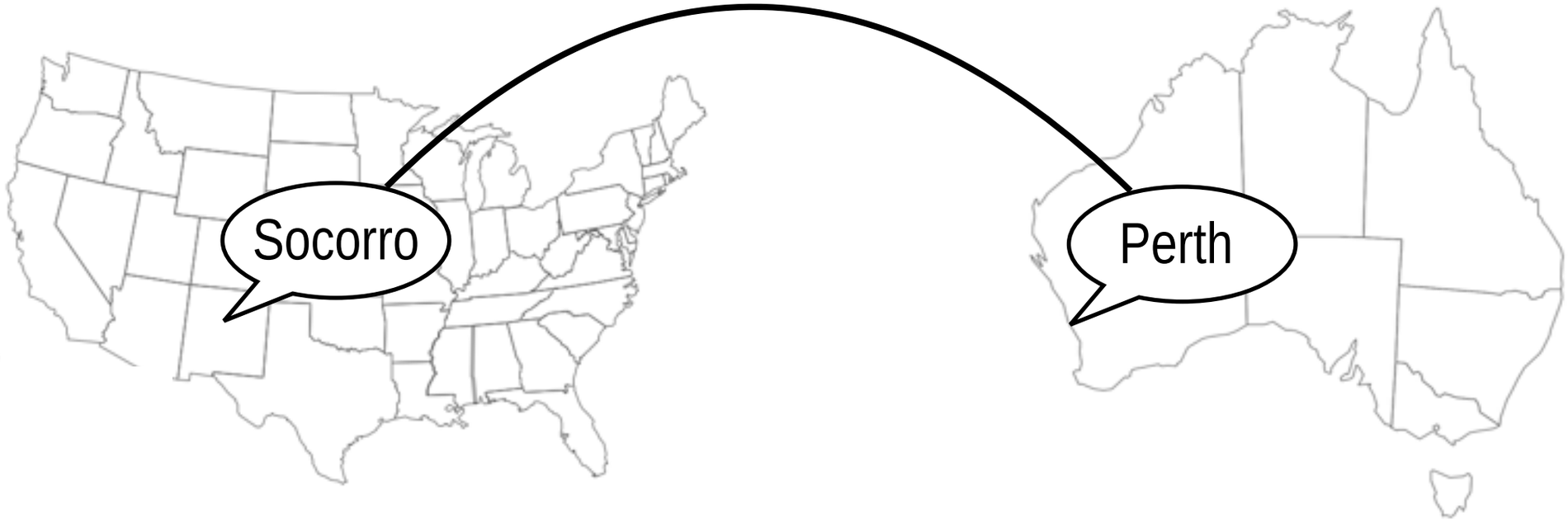

imaging
data combination
RFI
continuum
calibration
data storage
CHILES
CHILES
POLARSTERN

CHILES Workflow

Observing
Calibration
Flagging
Quality Control

CHILES Workflow

Raw data
Cal-tables
Flag-tables
Reduced Data



Observing
Calibration
Flagging
Quality Control

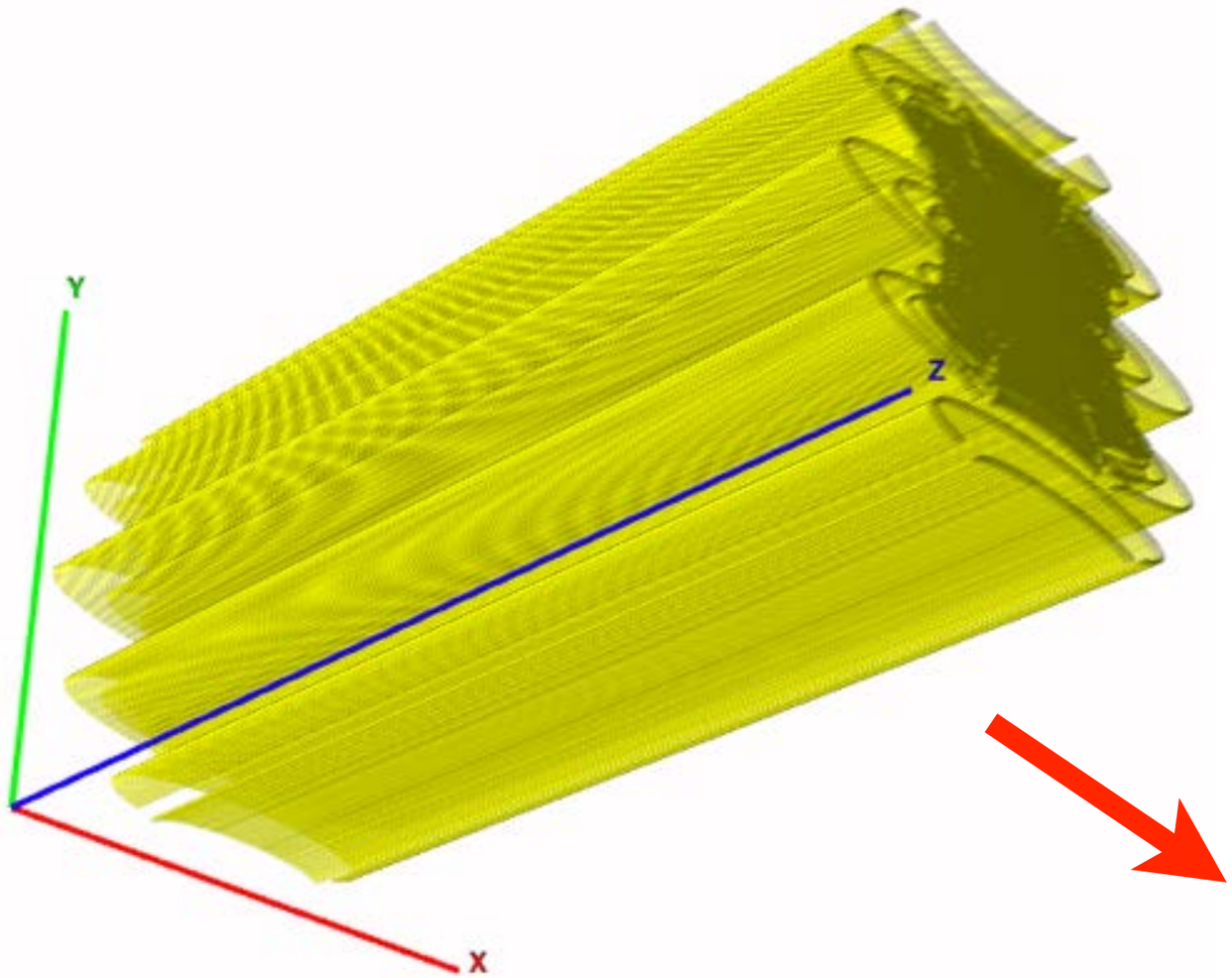
Backup
Combination
Imaging

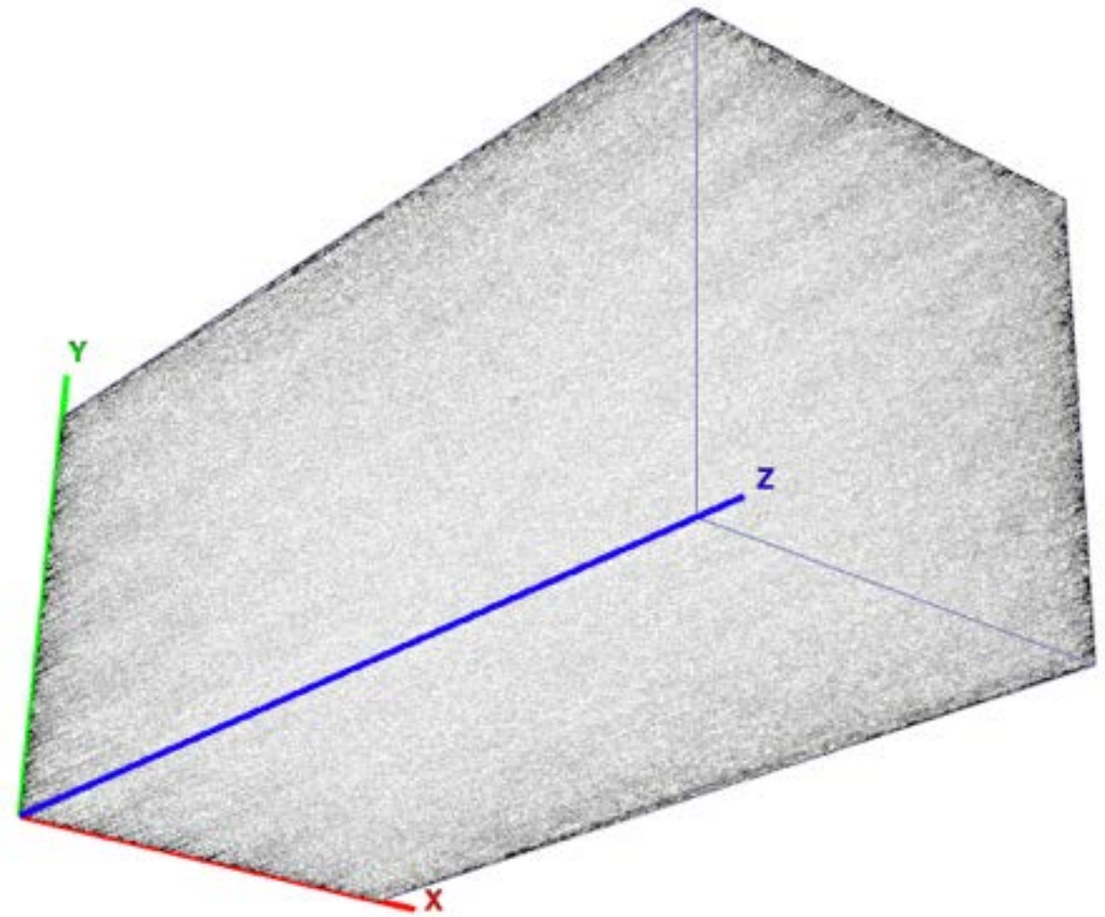
Data reduction

- 178/1000 hours done
- data reduced using CASA pipeline
- 1.5 Tb per 6 hours, pipeline runs for 60 hours
- manual quality control
- additional flagging

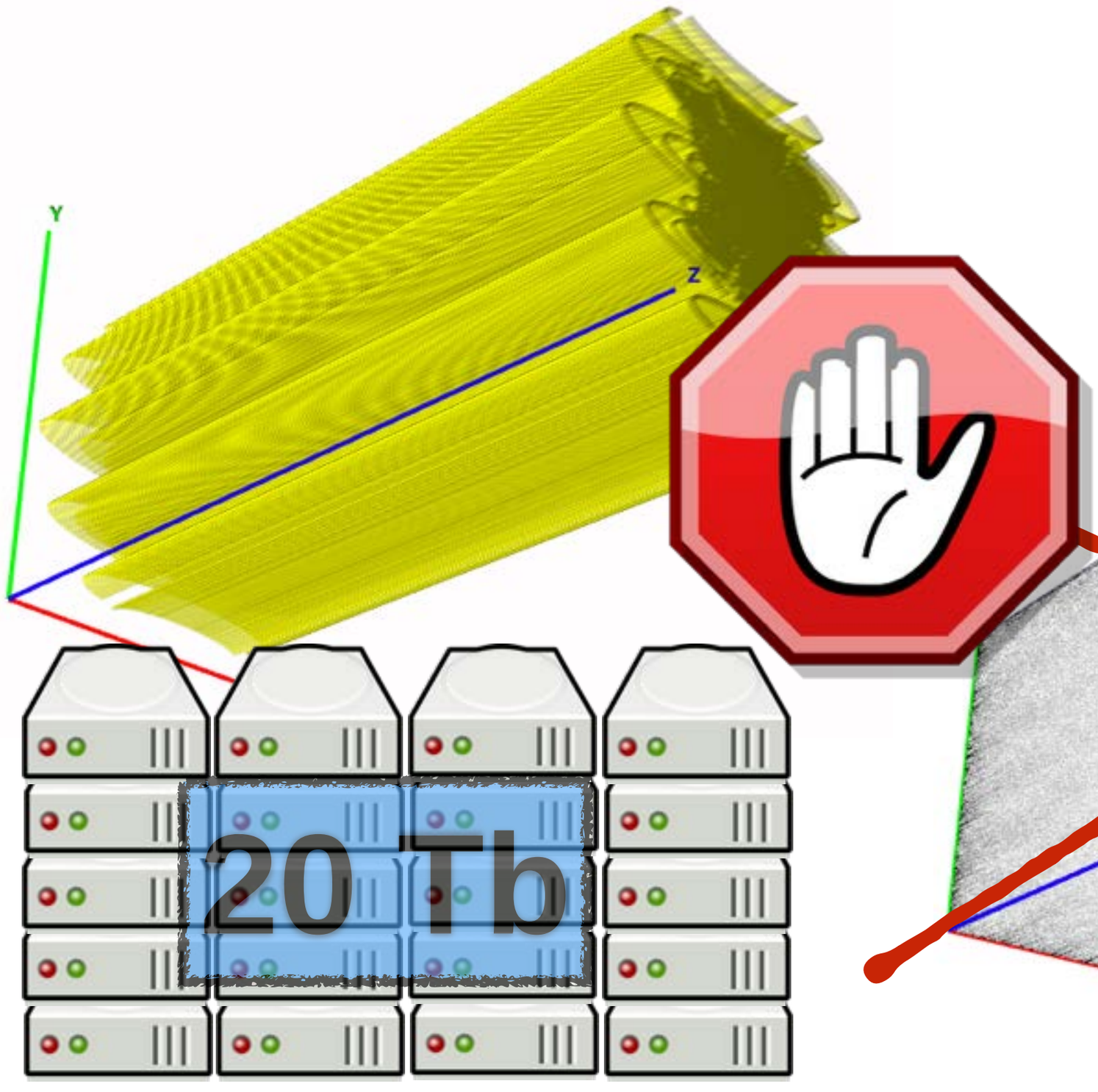
very time consuming …

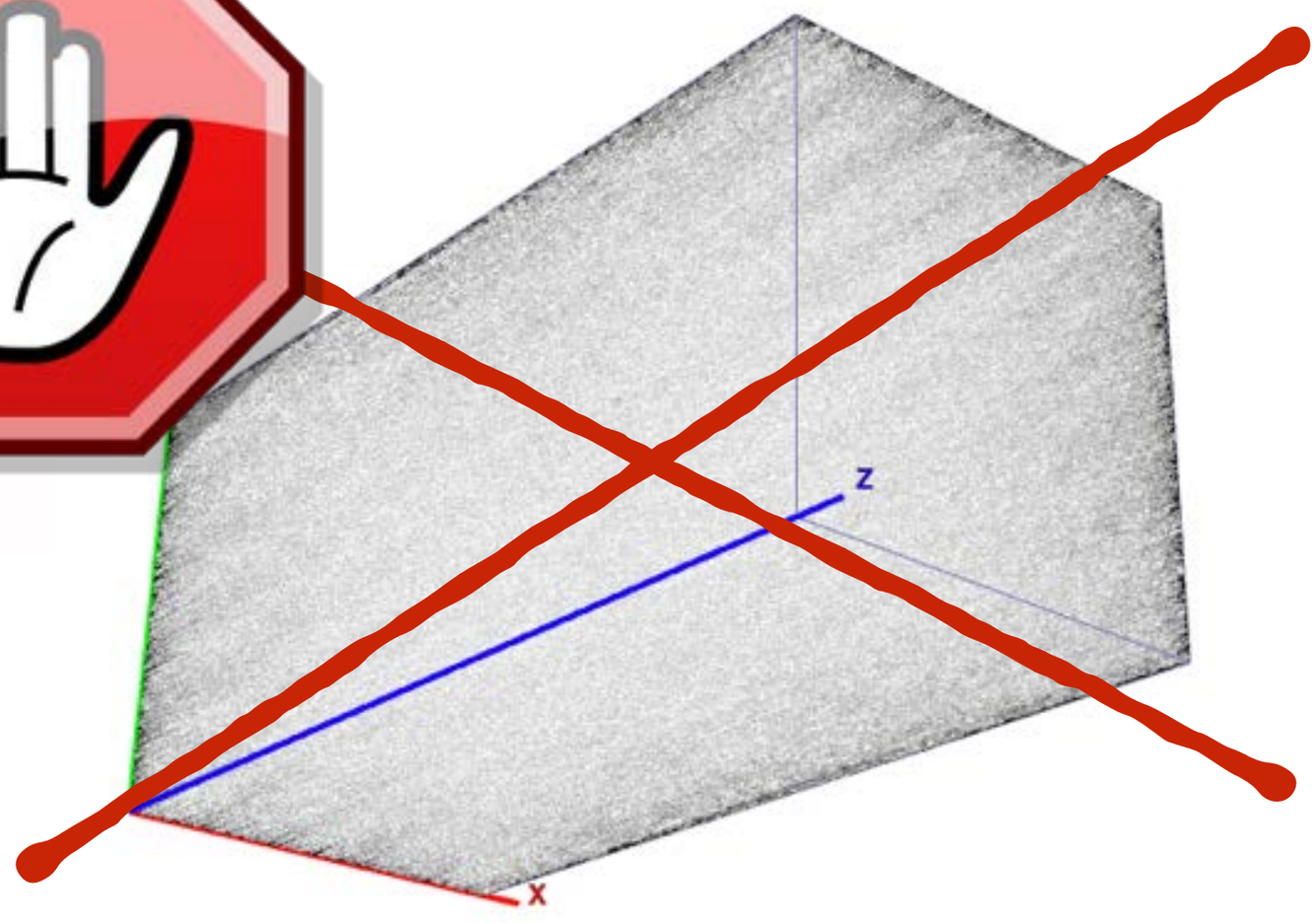
Imaging



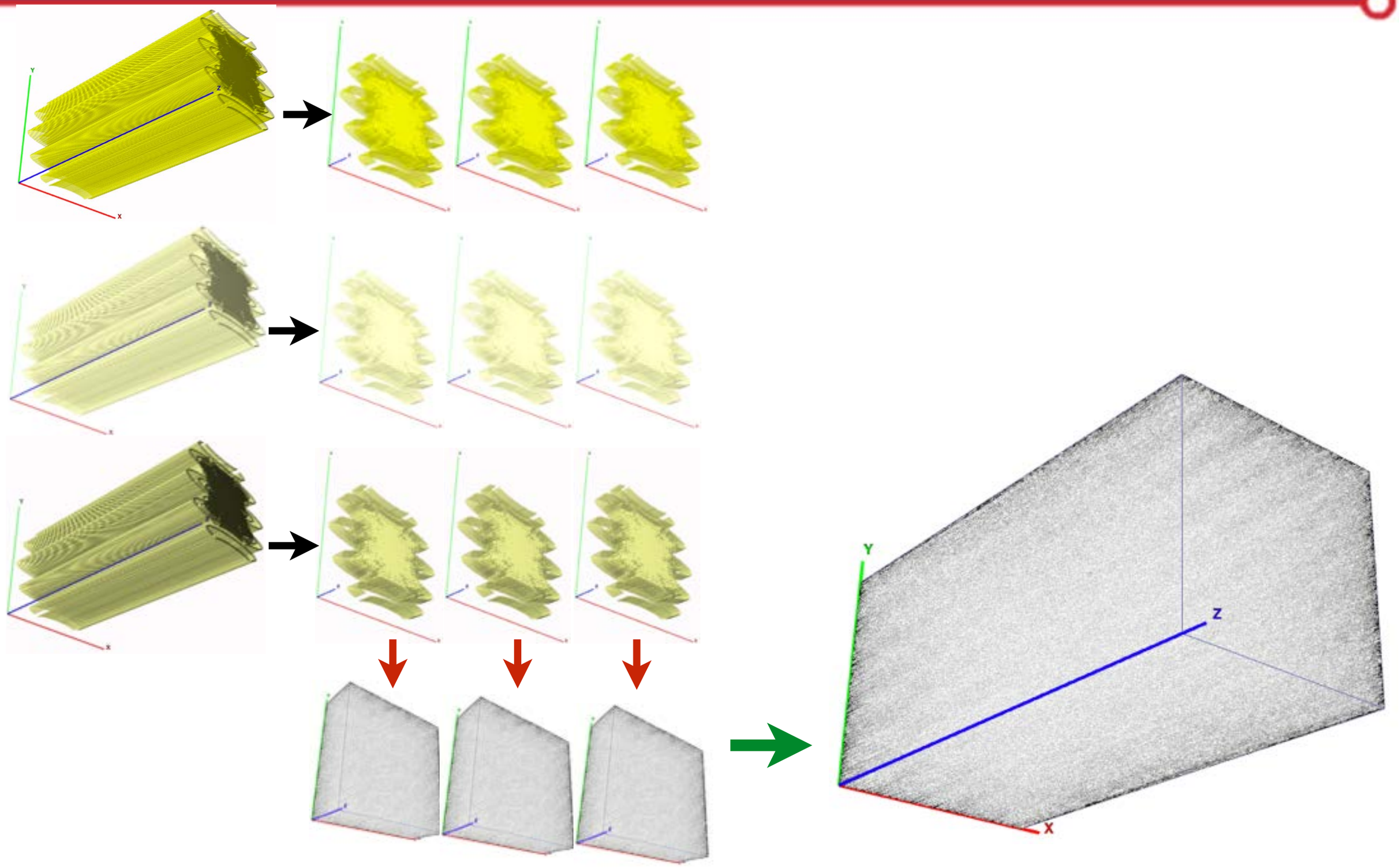


Imaging

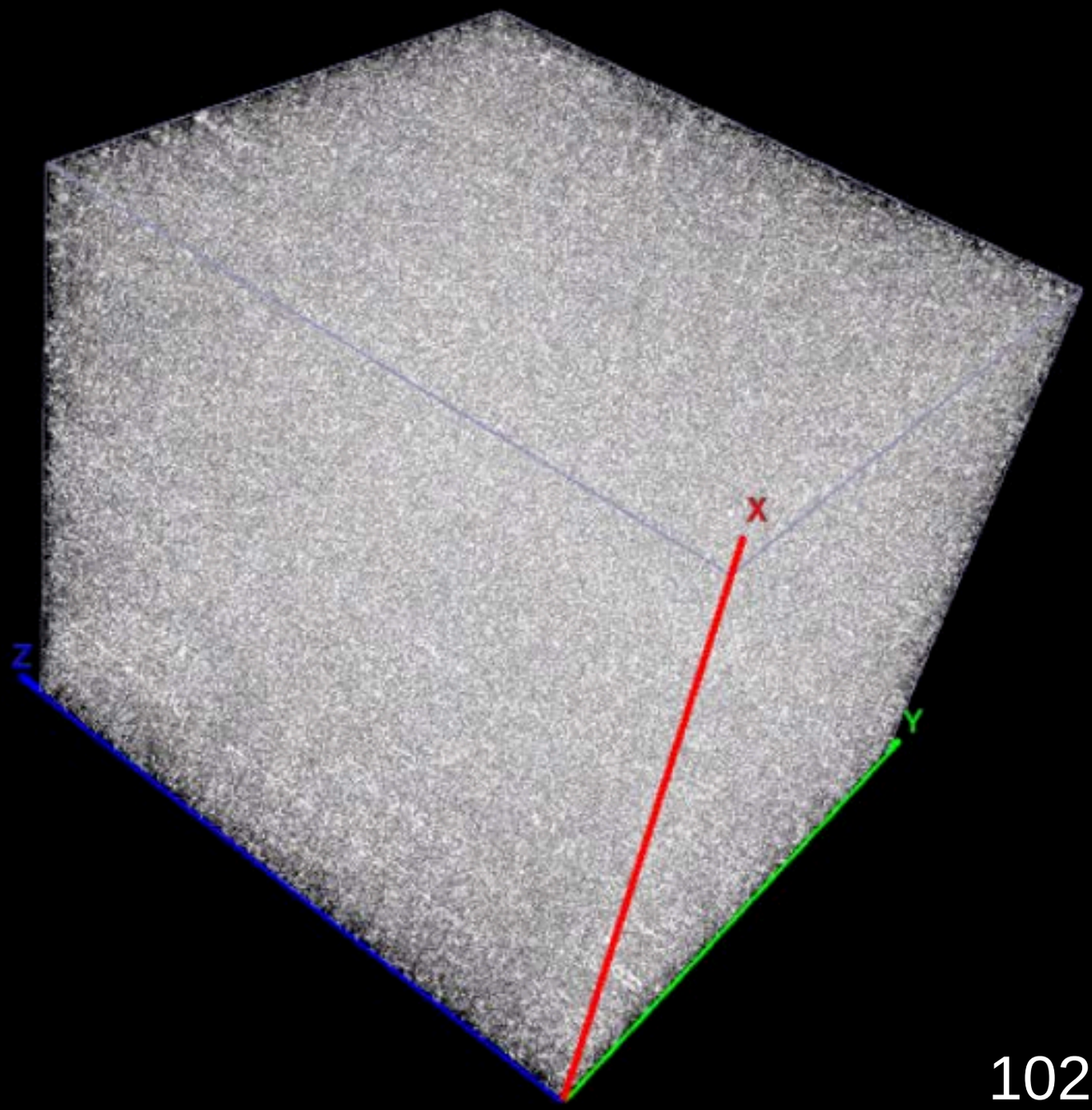




Imaging



We have now combined 42 observing runs (~20 Tb) and imaged 2048*2048*31.000 pixels (~500 Gb), covering the redshift range z=0~0.5



1020 - 1040 MHz

Computing efforts

Single Machine
Big desktop: 48 Gb RAM

Good for testing
Would take ~year to finish

Conventional Cluster (pleiades)
5 nodes each node has 2x Intel Xeon X5650 2.66GHz CPUs (6 cores / 12 HTs) with 64-192 GB of RAM

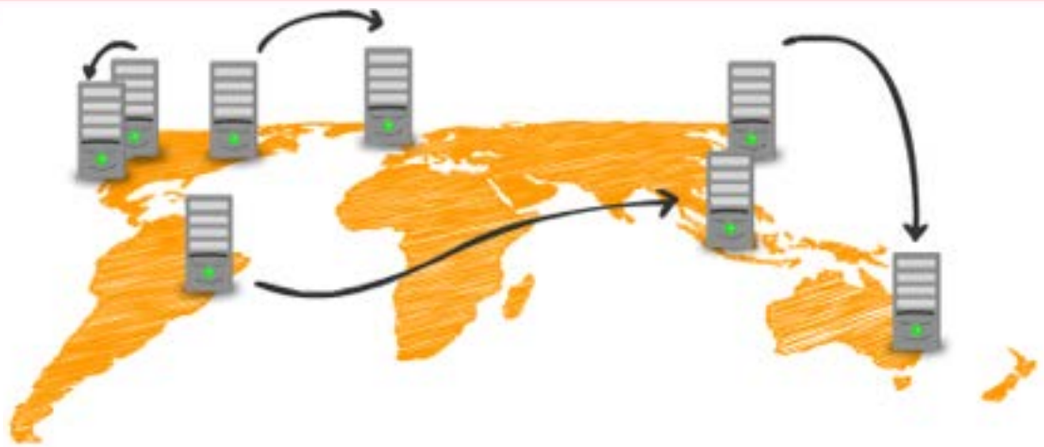
Enough computing power, however disk access limitations

Super computer (MAGNUS)
Cray XC40 - 24 cores per node

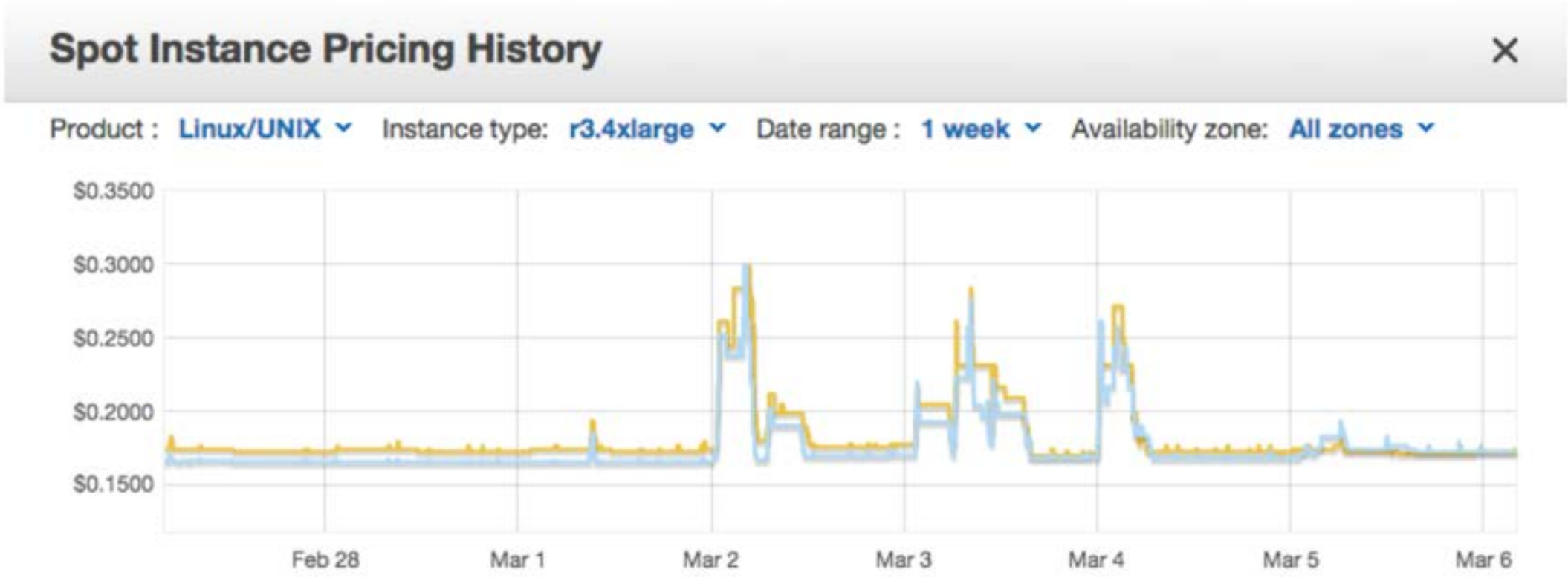
Alternative (AWS)

amazon web services™

	On demand	Spot Price
r3.4xlarge	$1.68	$0.20
r3.2xlarge	$0.840	$0.09
m3.xlarge	$0.392	$0.04
m3.medium	$0.098	$0.01



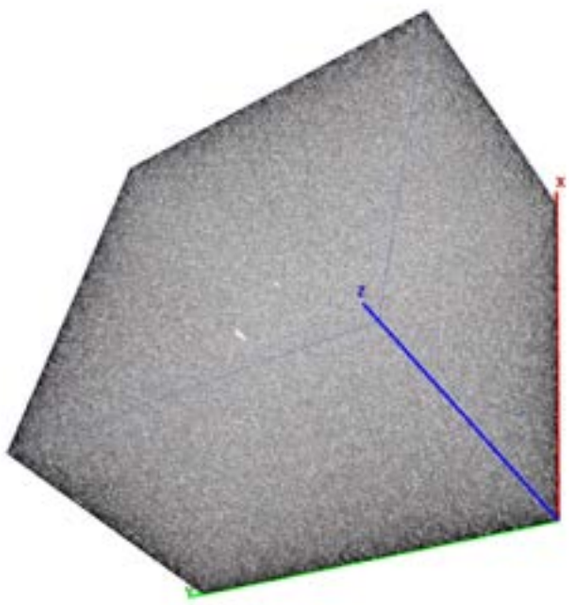
Works!
costs so far : ~$2000

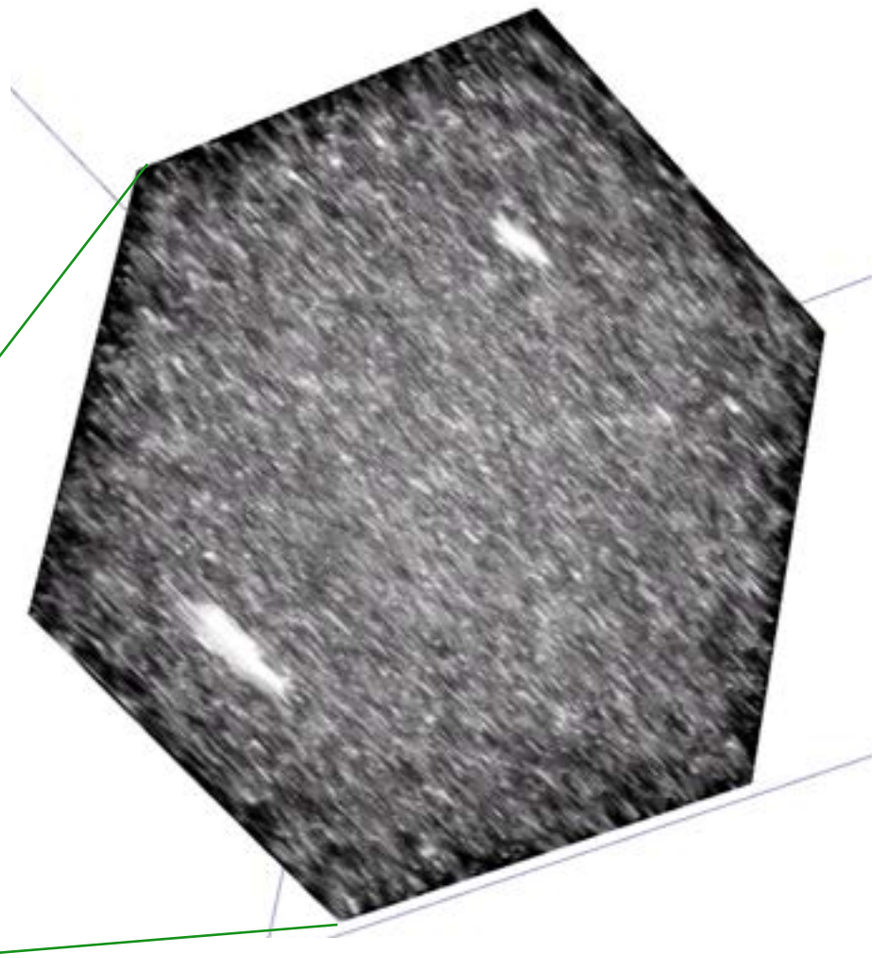


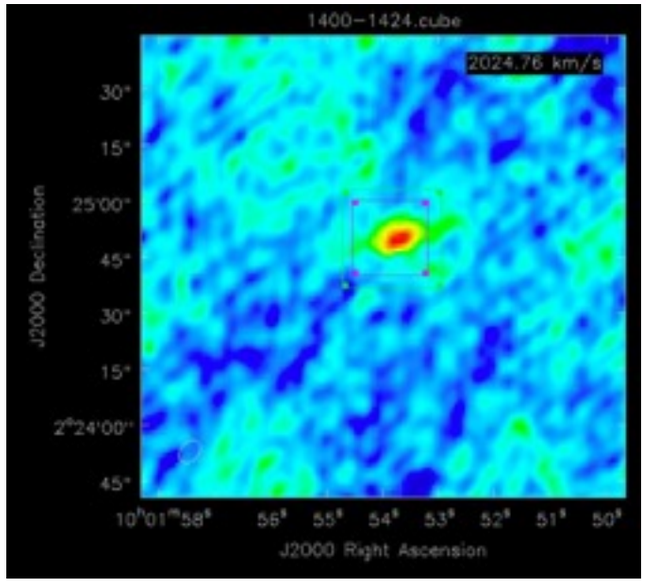
Pros and Cons of the cloud

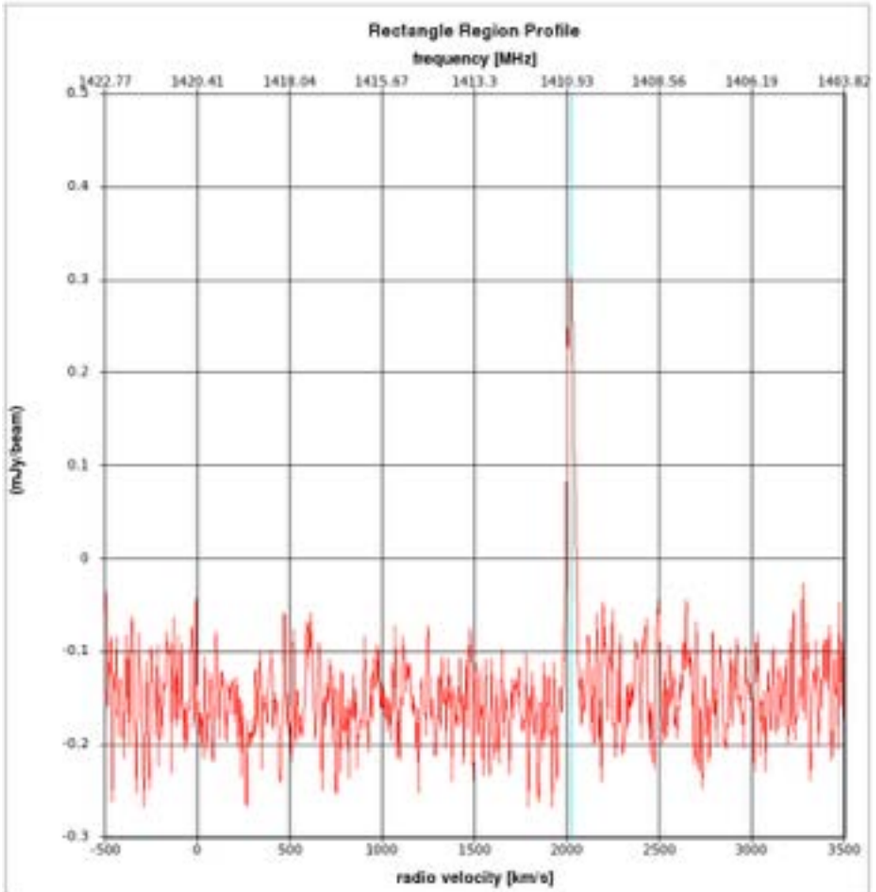
- not everyone has access to a supercomputer
- you have to pay to use cloud computing
- cloud computing gives you instant access
- a supercomputer is more powerful
- you can fit your needs (costs) to requirements
- depending on a third party
- no maintenance costs or efforts
- …
- …
- …

Detections

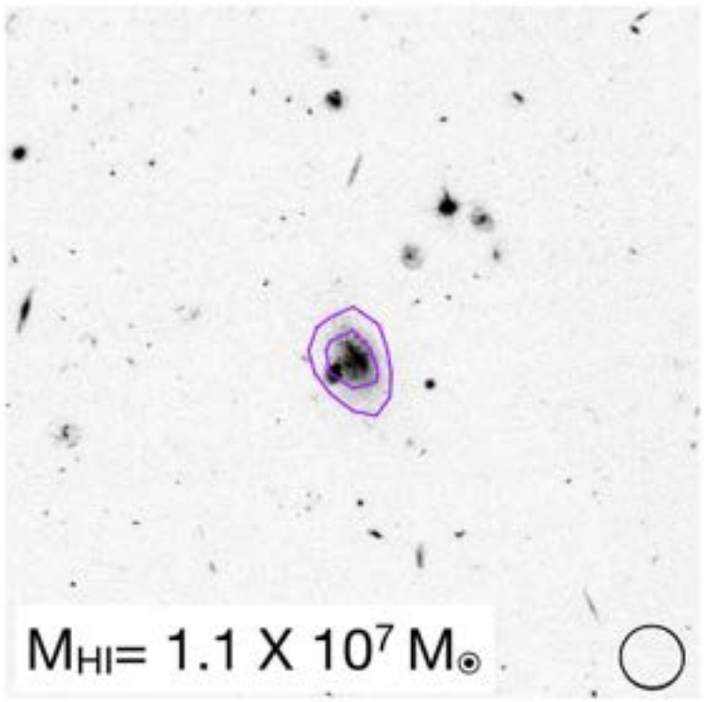


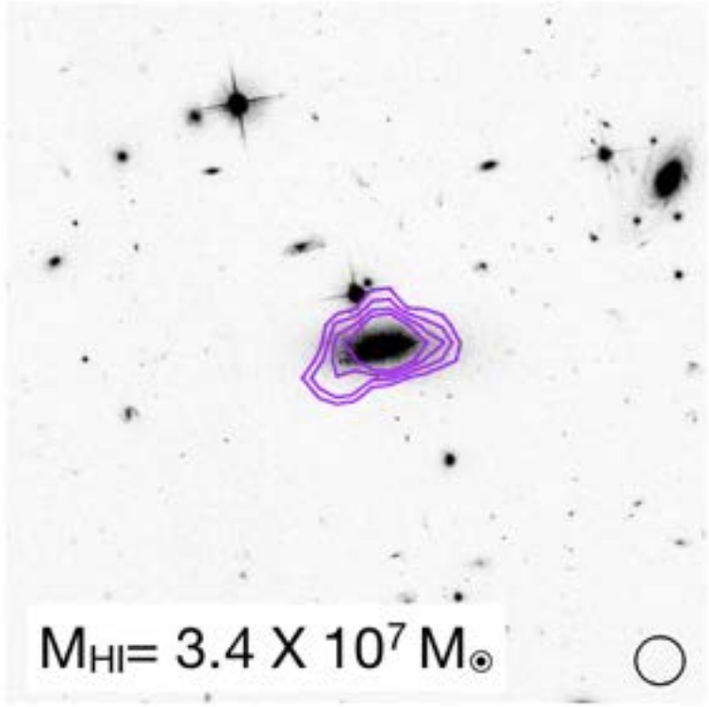



1400-1424.cube
2024.76 km/s
J2000 Declination
J2000 Right Ascension

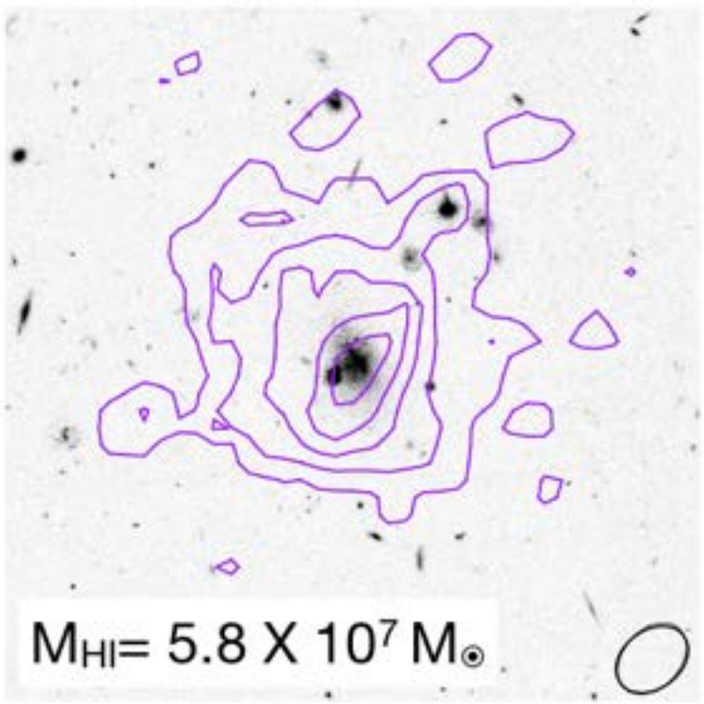

Rectangle Region Profile
frequency [MHz]
(mJy/beam)
radio velocity [km/s]

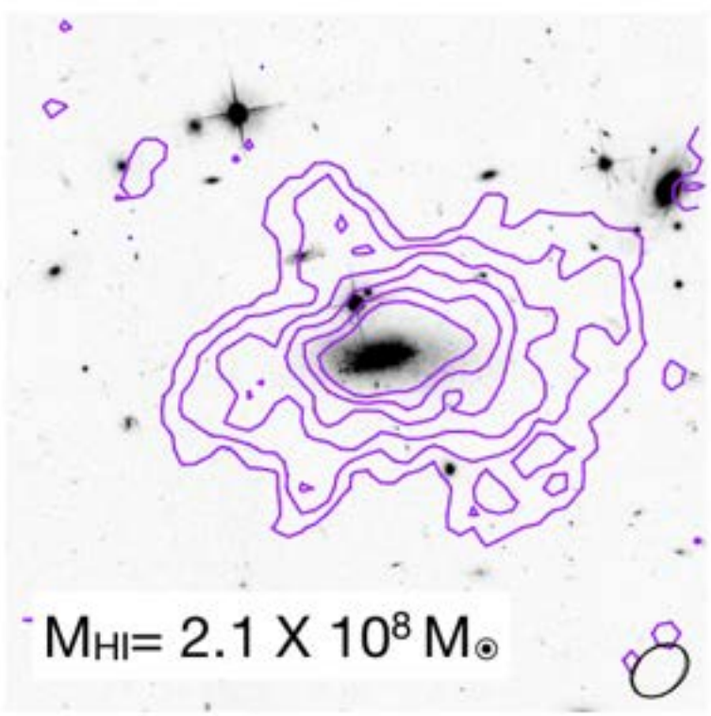
Detections





60 hours

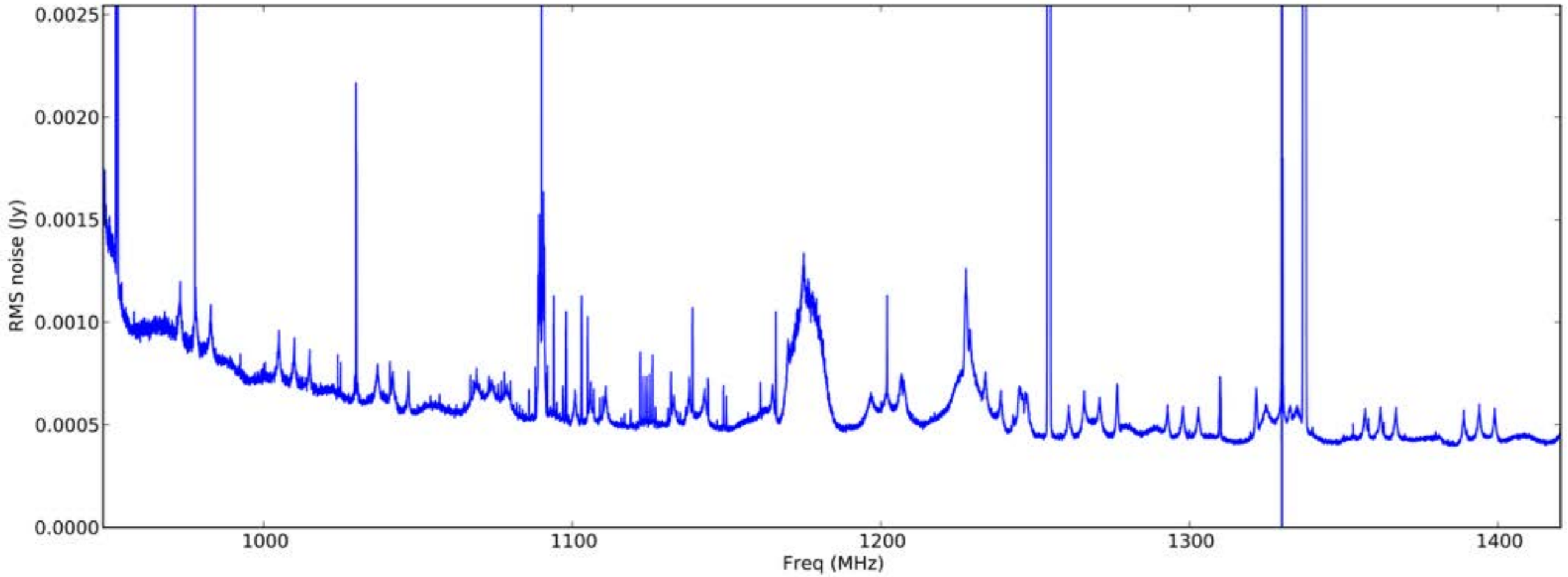




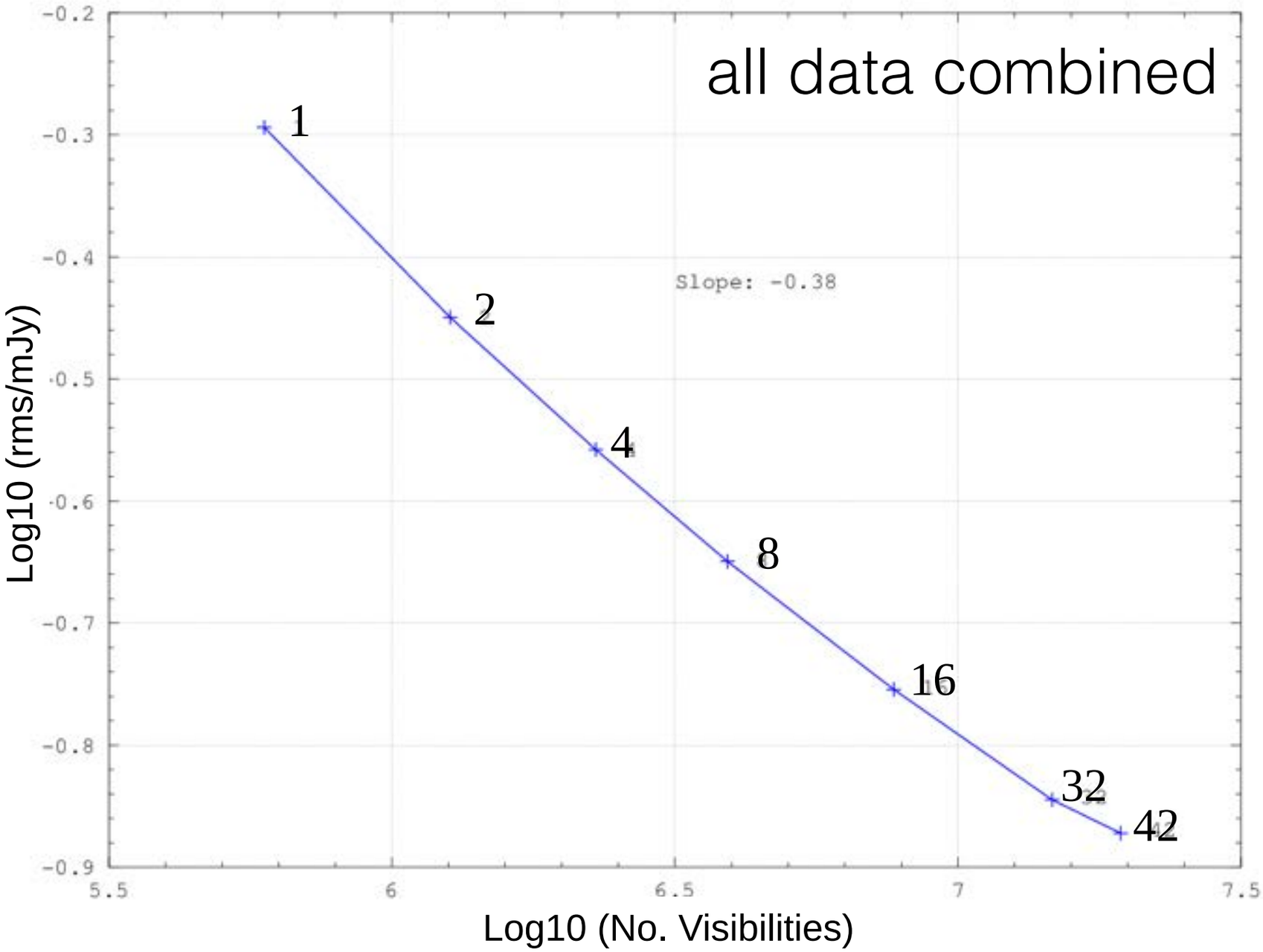
170 hours

RFI

3 sessions combined

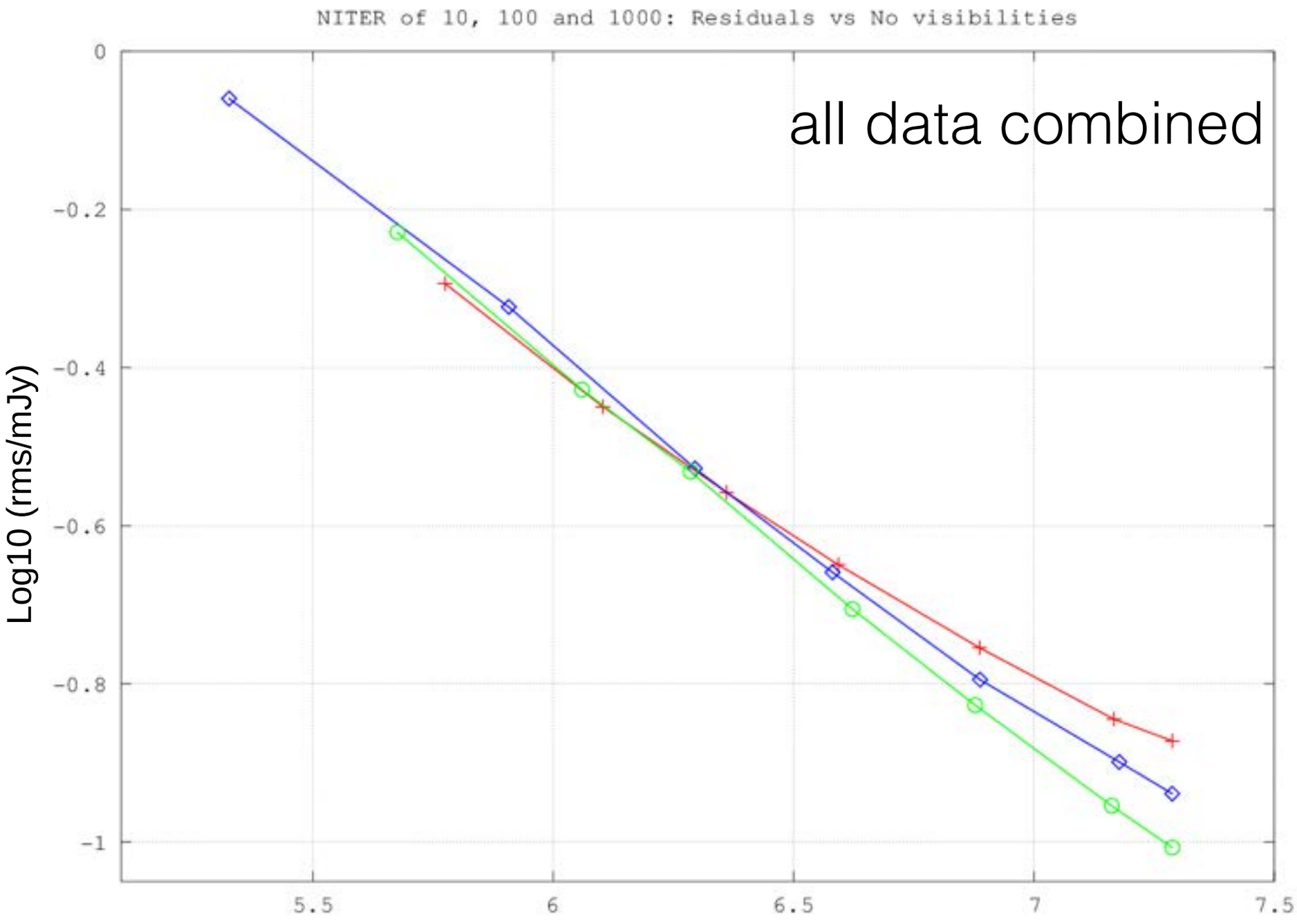


Noise



10 “clean” iterations, slope ~ -0.38

Noise

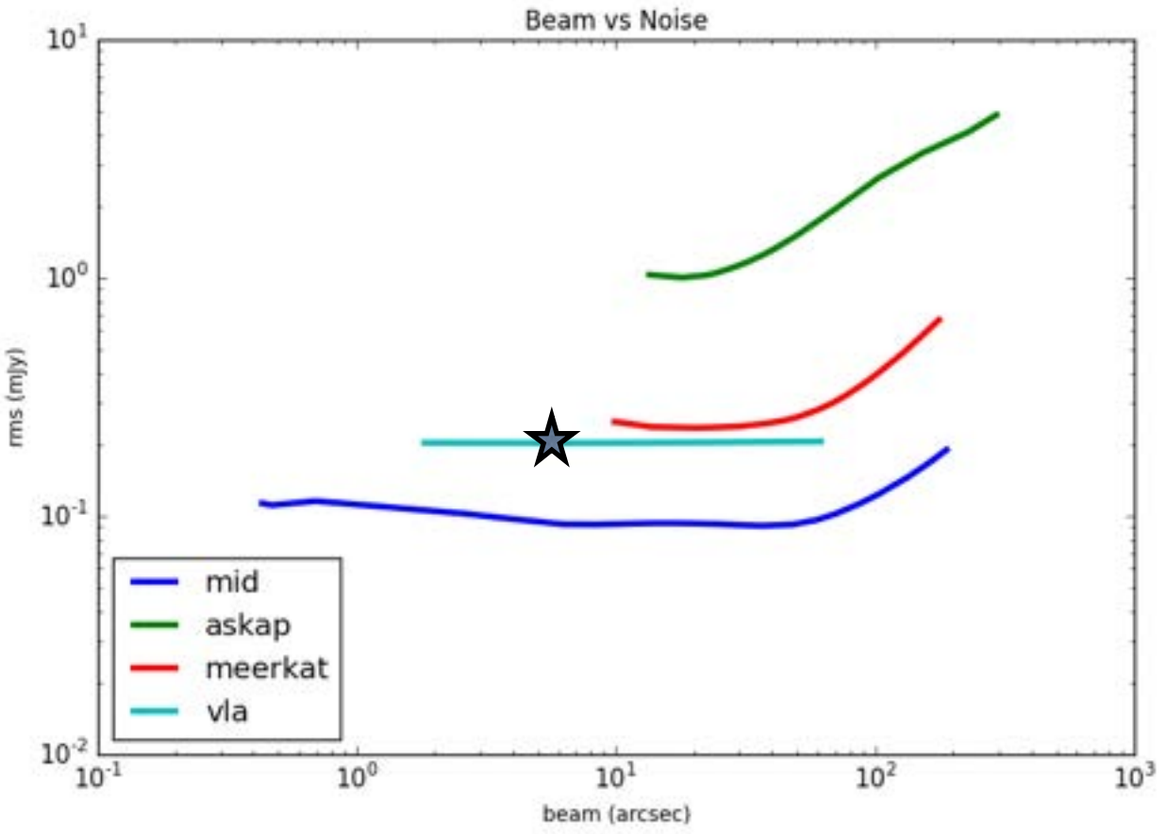


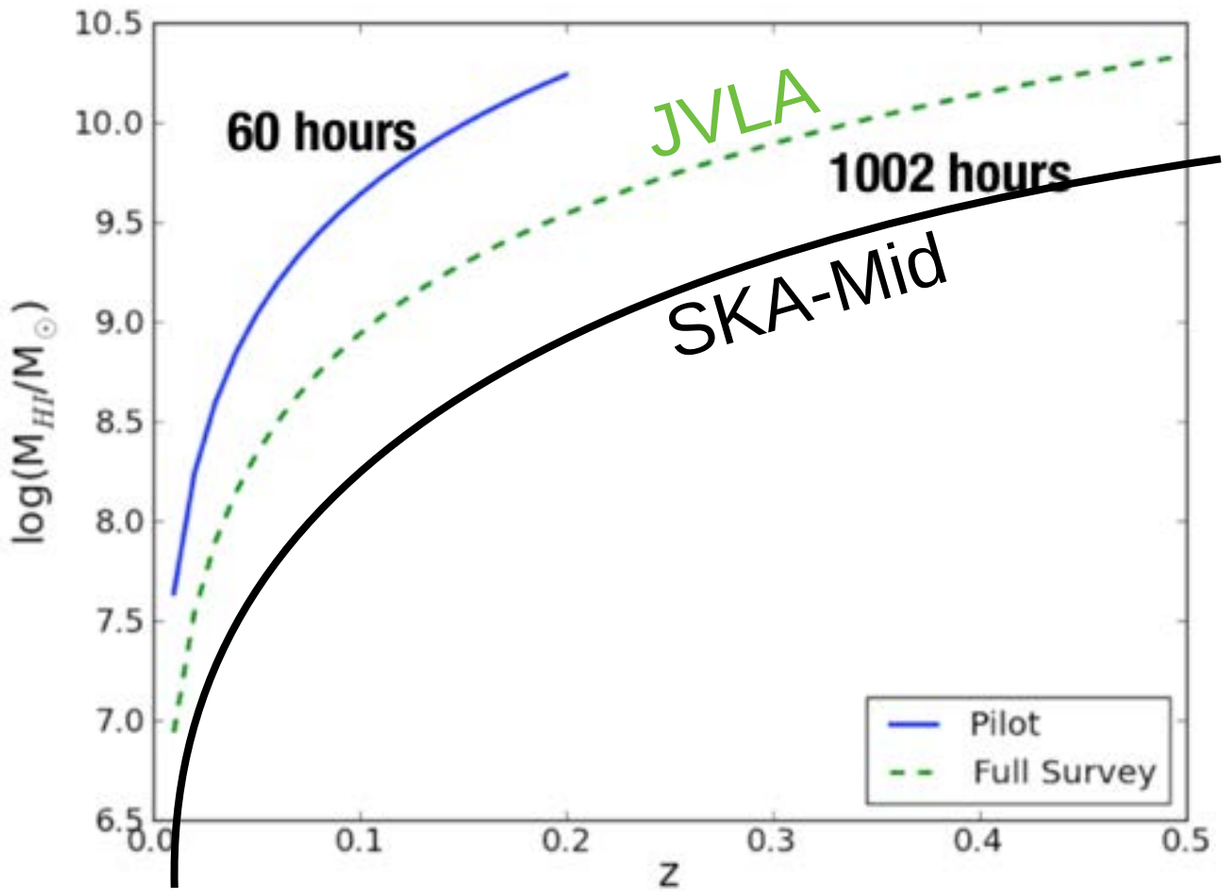
1000 “clean” iterations, slope ~ -0.484

deep survey on SKA

HI	Resolved HI kinematics and morphology of ~10^10 M_sol mass galaxies out to z~0.8	1/5
HI	High spatial resolution studies of the ISM in the nearby Universe.	2/5
HI	Multi-resolution mapping studies of the ISM in our Galaxy	3/5

SKA-Mid ~2 times more sensitive than JVLA (uniform weighting)
i.e. CHILES in ~250 hours
however: better resolution, larger volume, better PSF





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Lessons and thoughts …

- We have reduced ~178 hours of data
- We have successfully developed an implemented imaging algorithms
- First results look very promising (detections, noise)

- Difficult to do a survey with new (problematic) software
- How to do quality control of individual observations ?
- How to do quality control after many observations ?
- How to find and correct problems after many observations
- You need a good data plan
- You need computing experts (rather than just astronomers)

- How to analyse the data (i.e. how do you interact with a 500Gb cube?)