Grid LOFAR Reduction Tools

Moving Radio Astronomy to a Grid location.. and beyond!

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Alexandar Mechev

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Contents

LOFAR Introduction

LOFAR Low-Band Array Antenna

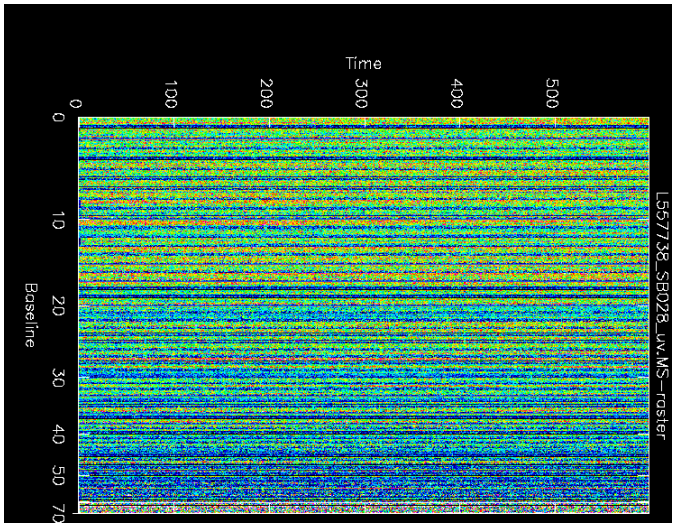
- 20-80MHz, 120-250MHz
- 7000 Antennae
- 24 core, 14 remote, 12 international stations
- 50m -> 1500 km baselines (van Haarlem et al. 2013)

LOFAR Introduction 2

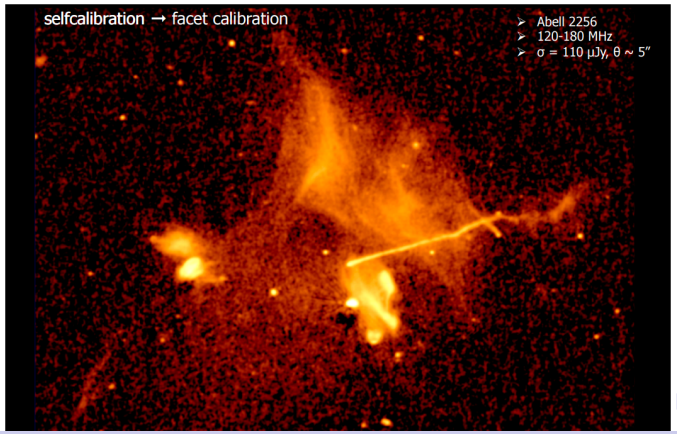
Raw data is 16 TB for 8h observation. Processing steps:

1. Flag RFI
2. *Average*
3. Demix Strong Sources
4. **Calibrate**
5. Image loop

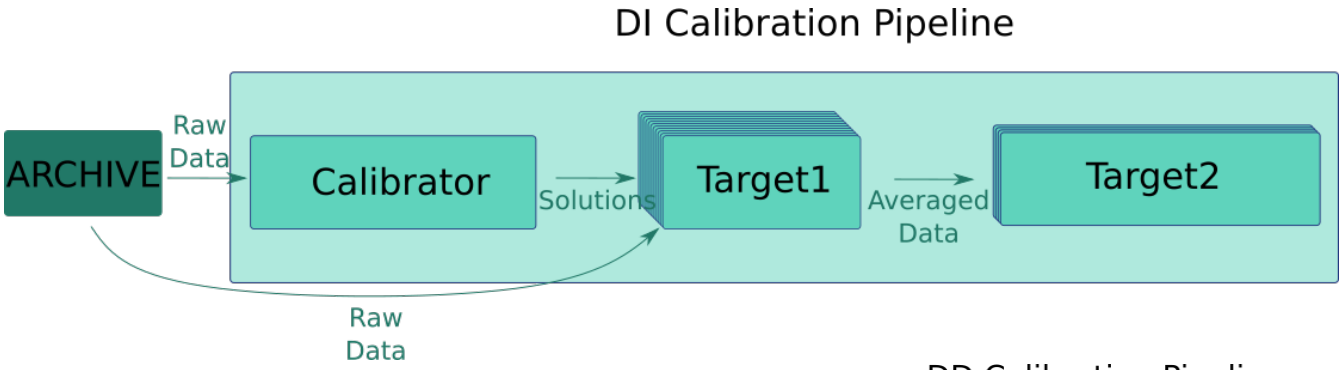
Goal: Go from initial data:



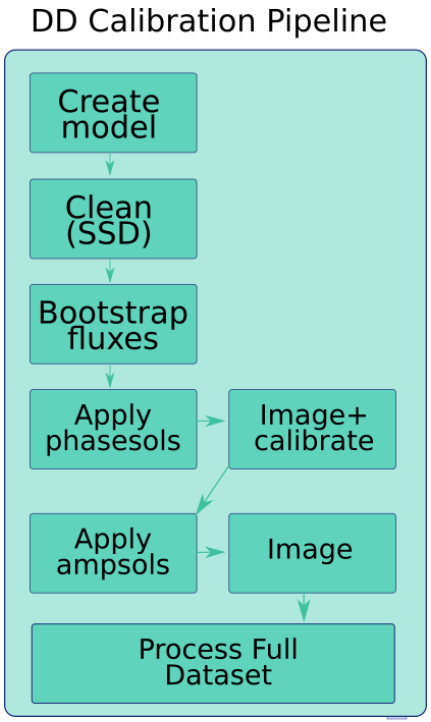
to Final image:



LOFAR Data Reduction

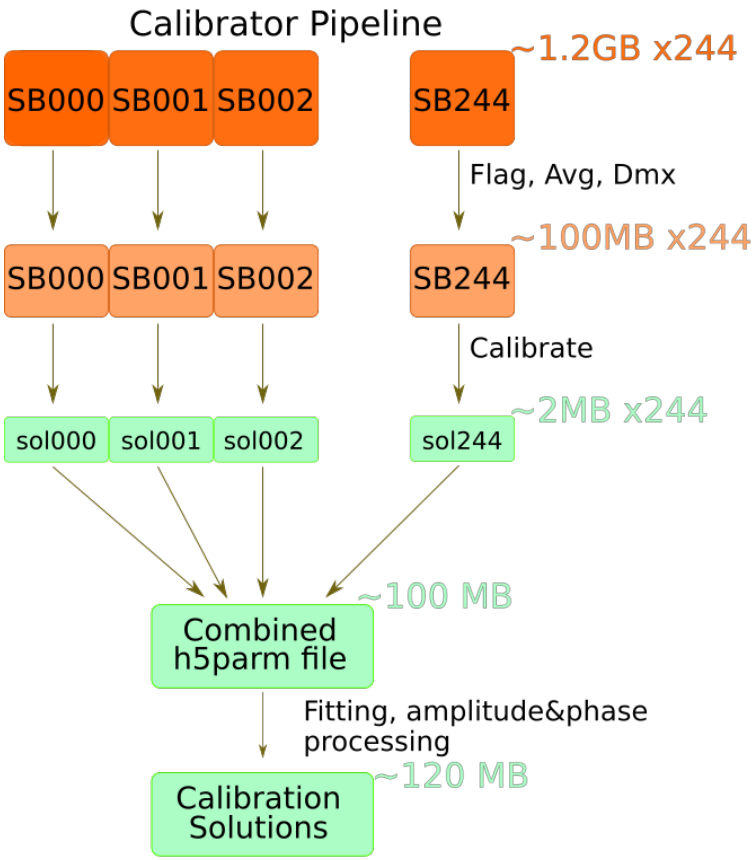


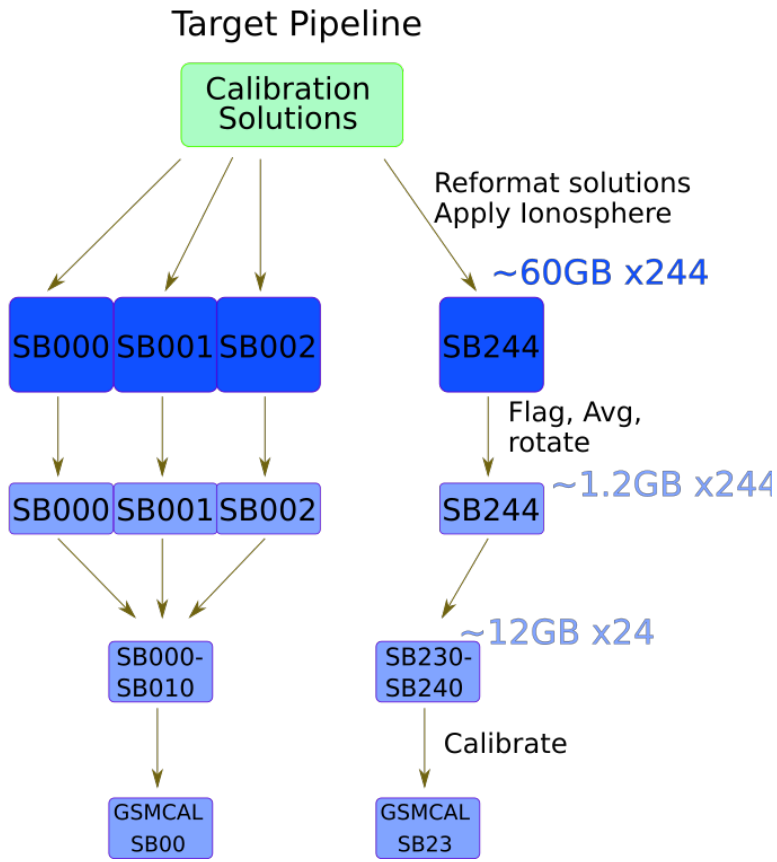
- Direction Independent/Dependent Effects
- Split data by frequency (DI) and by direction (DD)
- Majority of computation spent (LM) Minimization , FFT/iFFT and Gridding



LOFAR Data Reduction 2

Parallelization of pipeline steps.



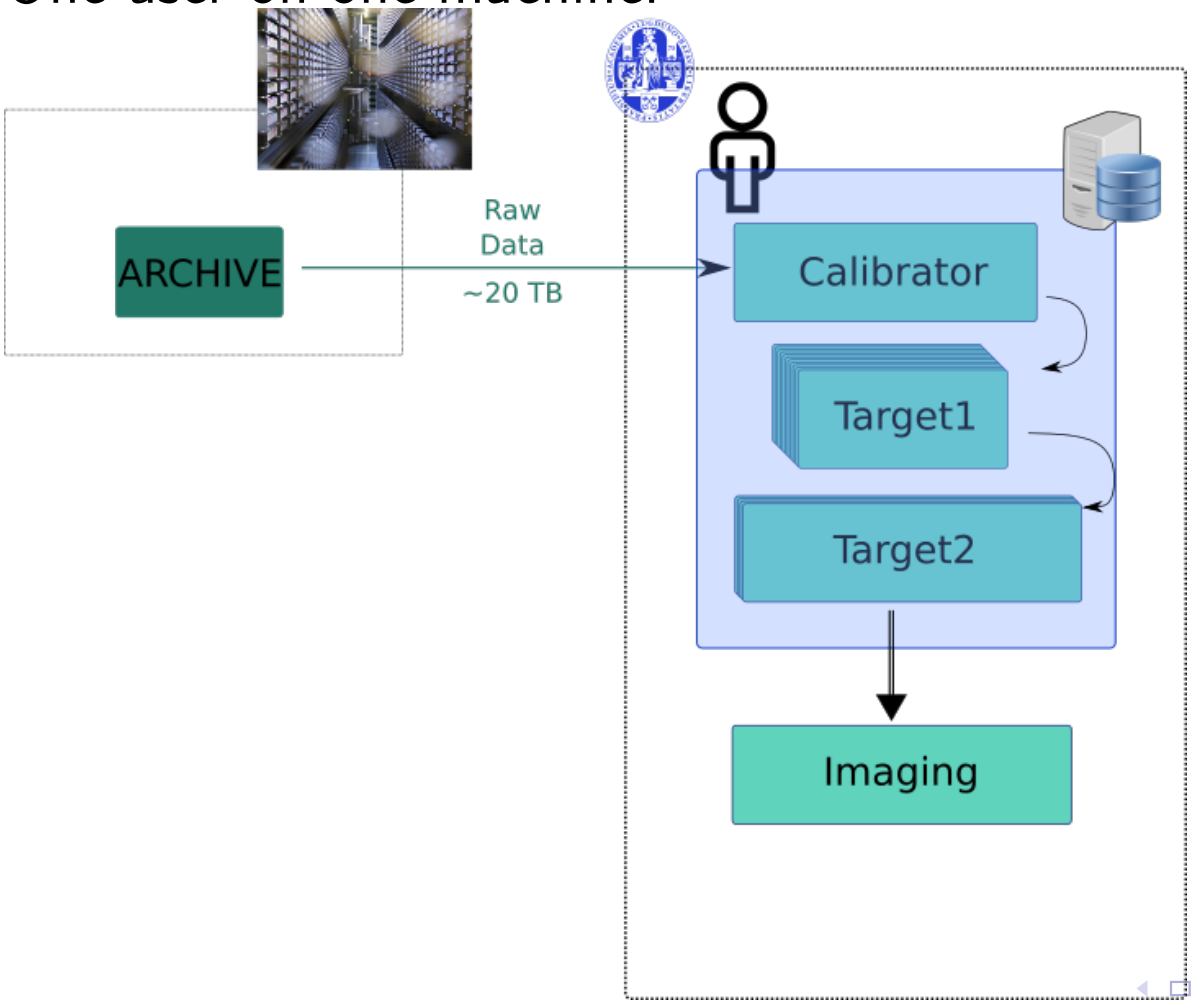


Data Rates and Processing Requirements

- Raw (antenna) data Rate: 80Gbps
- Correlated+Averaged Data: 50TB/6h
- Data produced in 2016: 5 PB
- LOFAR Survey:
  - 3100 observations of 16 TB each
  - Manual reduction takes $>$ 2wk/dataset
  - 5 Year deadline

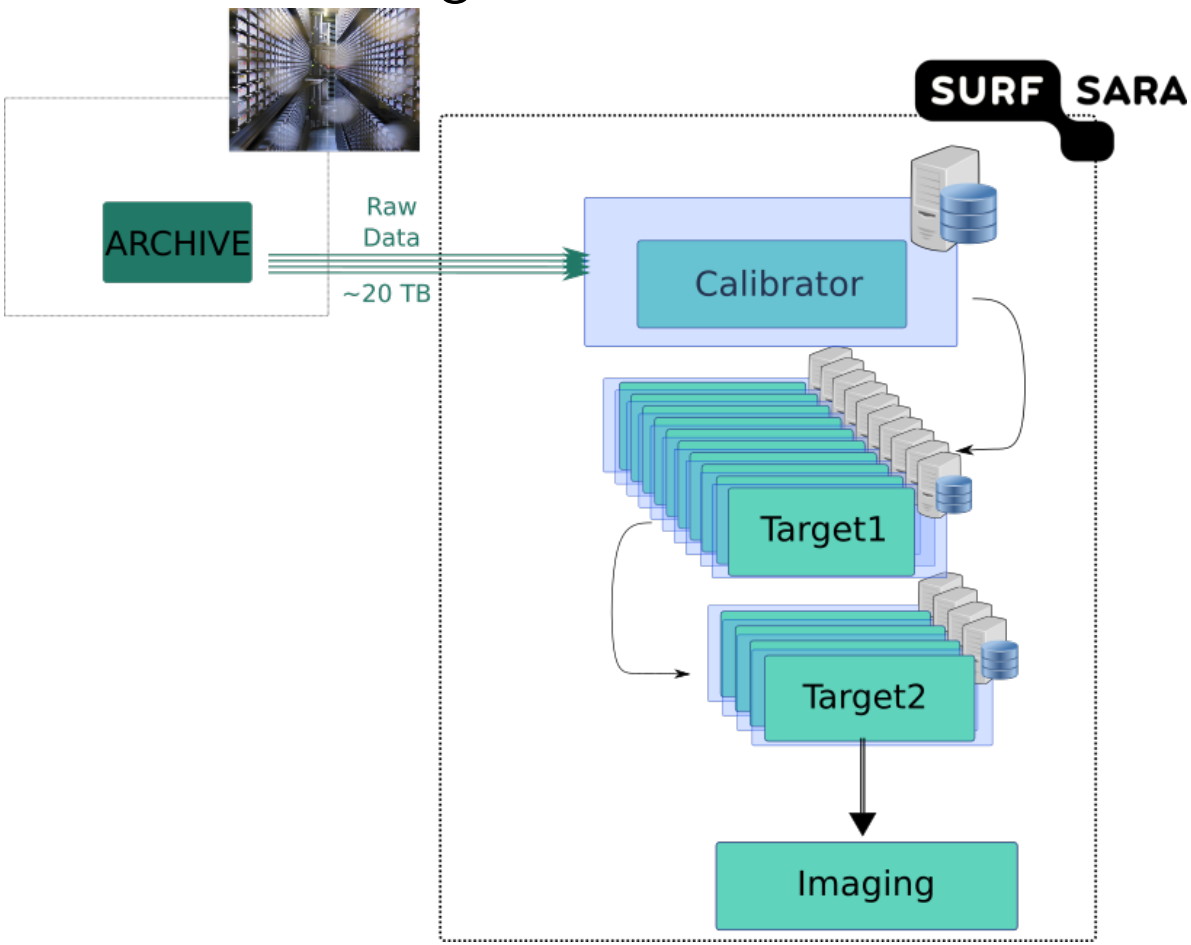
Reducing at institutes

One user on one machine:



Reducing at a GRID site

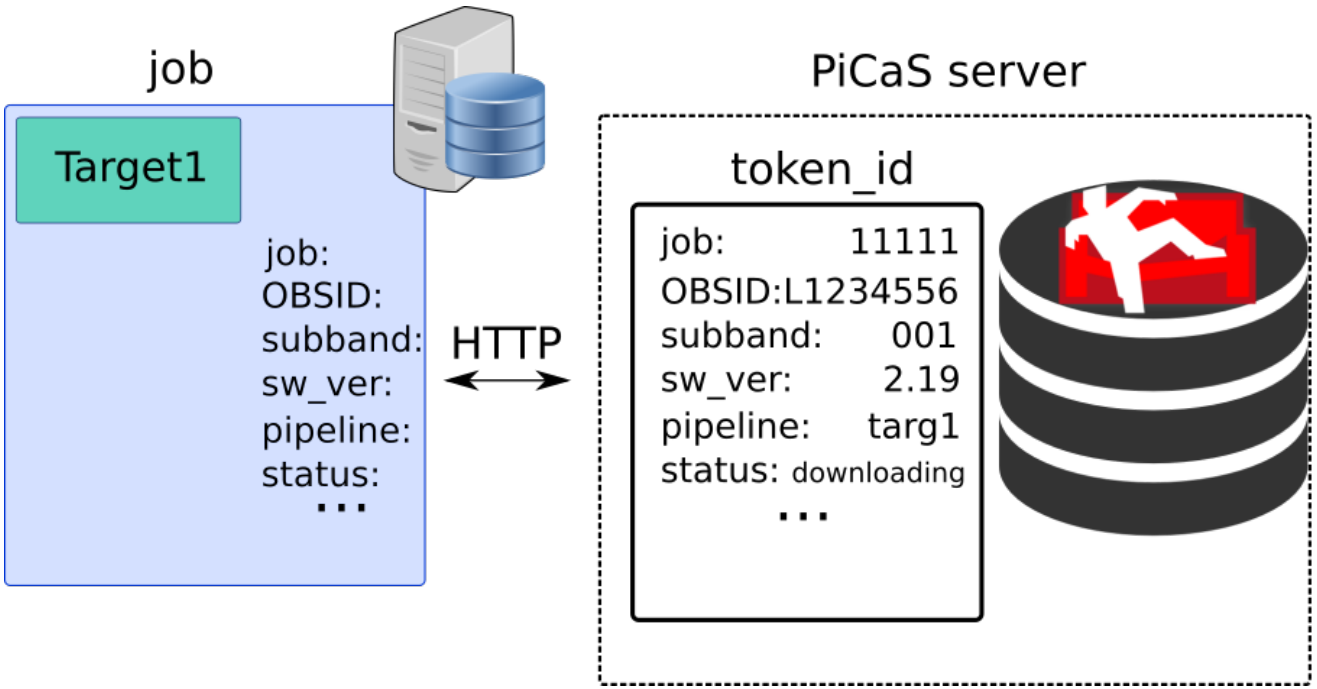
Automated management of data flow



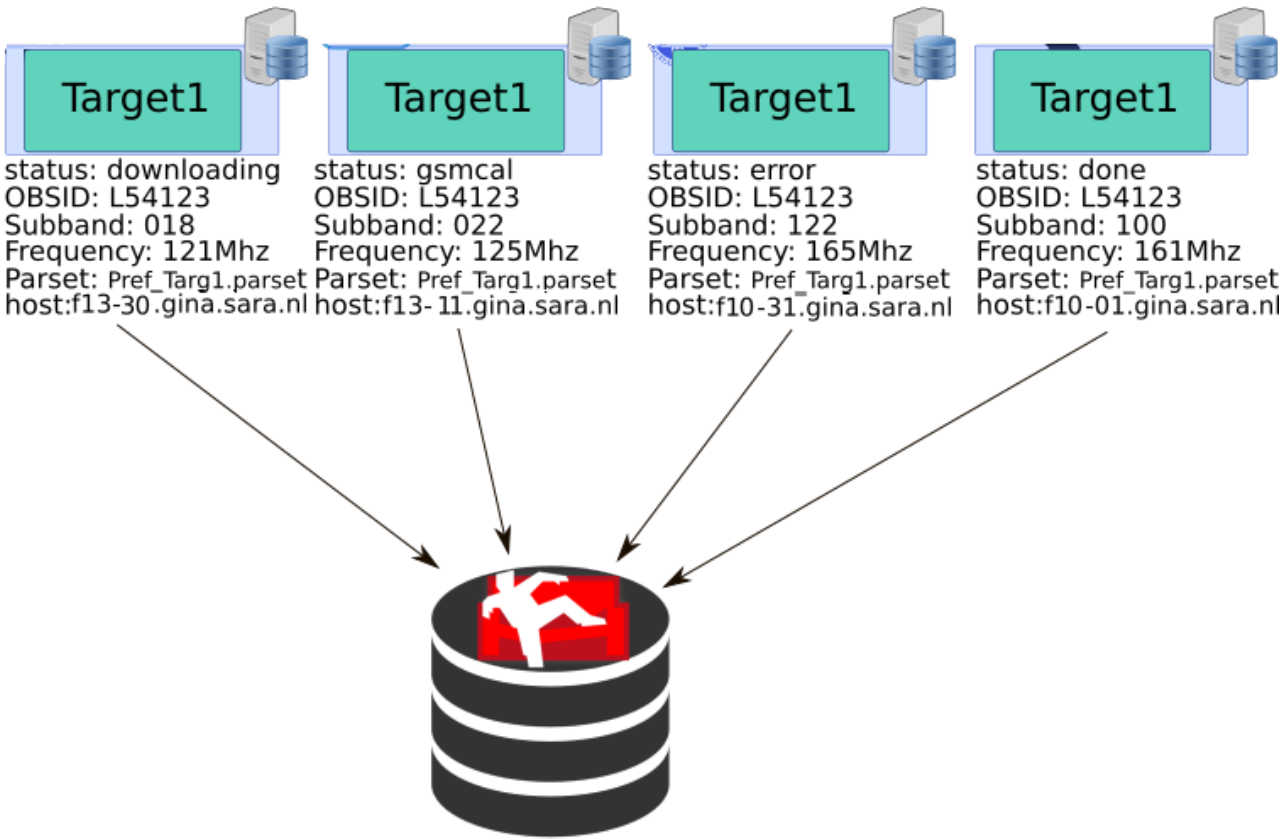
Challenges encountered

- No shared FS -> automate data retrieval/storage
- No login on worker machines -> automate logging
- Need to submit scripts as a pilot job.
  - i.e. submit a sandbox, sending files and commands to

PiCaS Tokens as 'job descriptors'



Storing status and metadata remotely



Views as 'linked jobs'

Can create views using any token field.

Ex: doc.status='error' && doc.output=11 (all error tokens with exit status 11)

Ex: doc.pipeline='targ1' && doc.status='error' (all error targ1 jobs)

Ex: Tracking concurrent reductions!

These are especially useful to list waiting jobs!

Connecting scripts with metadata

short scripts that send and pull metadata

Writing Data to CouchDB

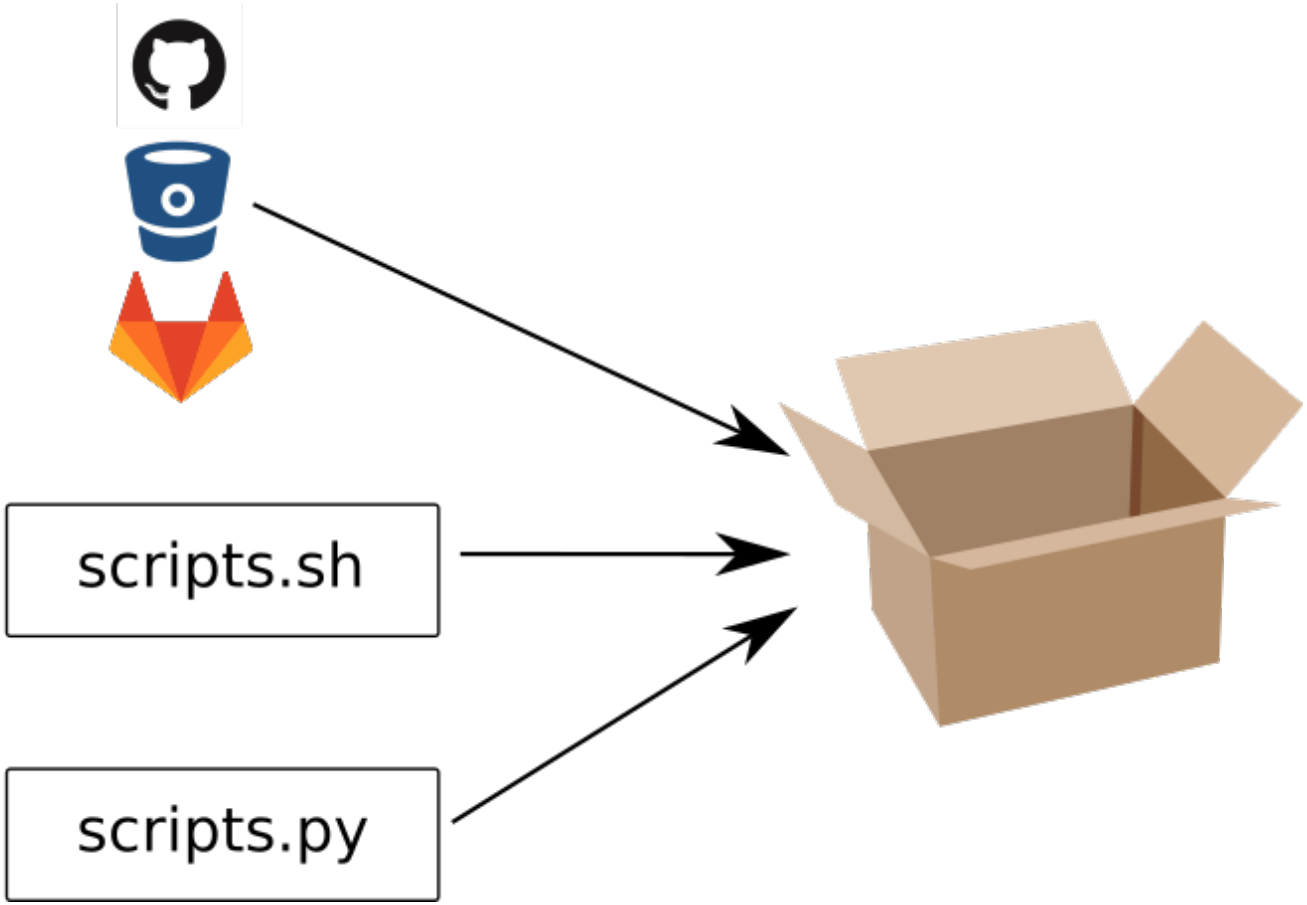
- PiCaS username
- PiCaS Password
- PiCaS database
- token_id
- field_name (key)
- value

Reading Data from CouchDB

- PiCaS username
- PiCaS Password
- PiCaS database
- token_id
- field_name (key)

Sandbox creation

Use a small yaml file to automate:



Sandbox upload and execution

- Sandboxes connected with observation (token 'type')
- upload location stored in token
  1. job starts on node
  2. job pulls helper scripts from git repo
  3. job locks a token (one token per job)
  4. job reads sandbox location and downloads sbx
  5. job untars sandbox and executes master.sh

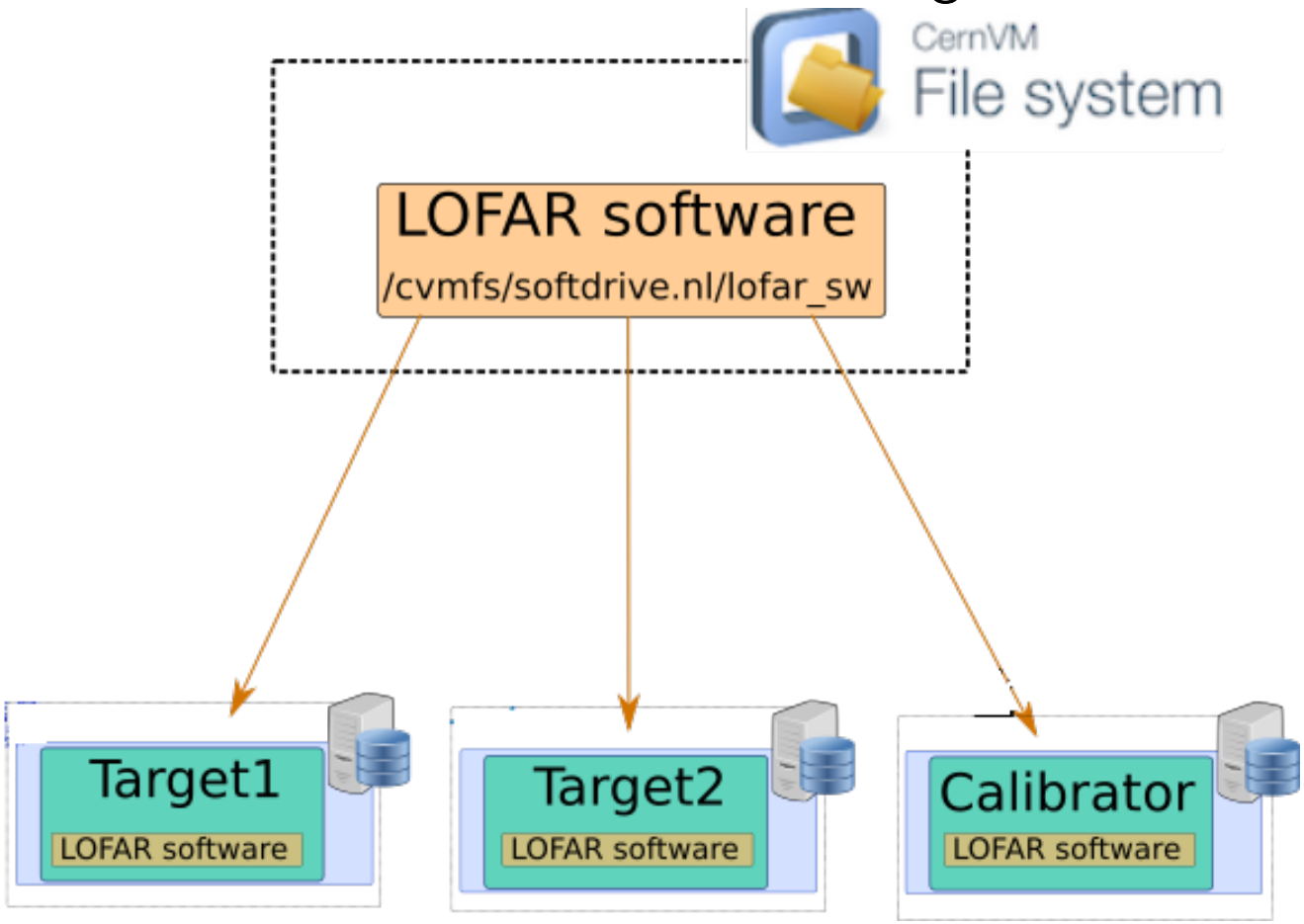
Sandbox execution on a node

master.sh procedure for LOFAR

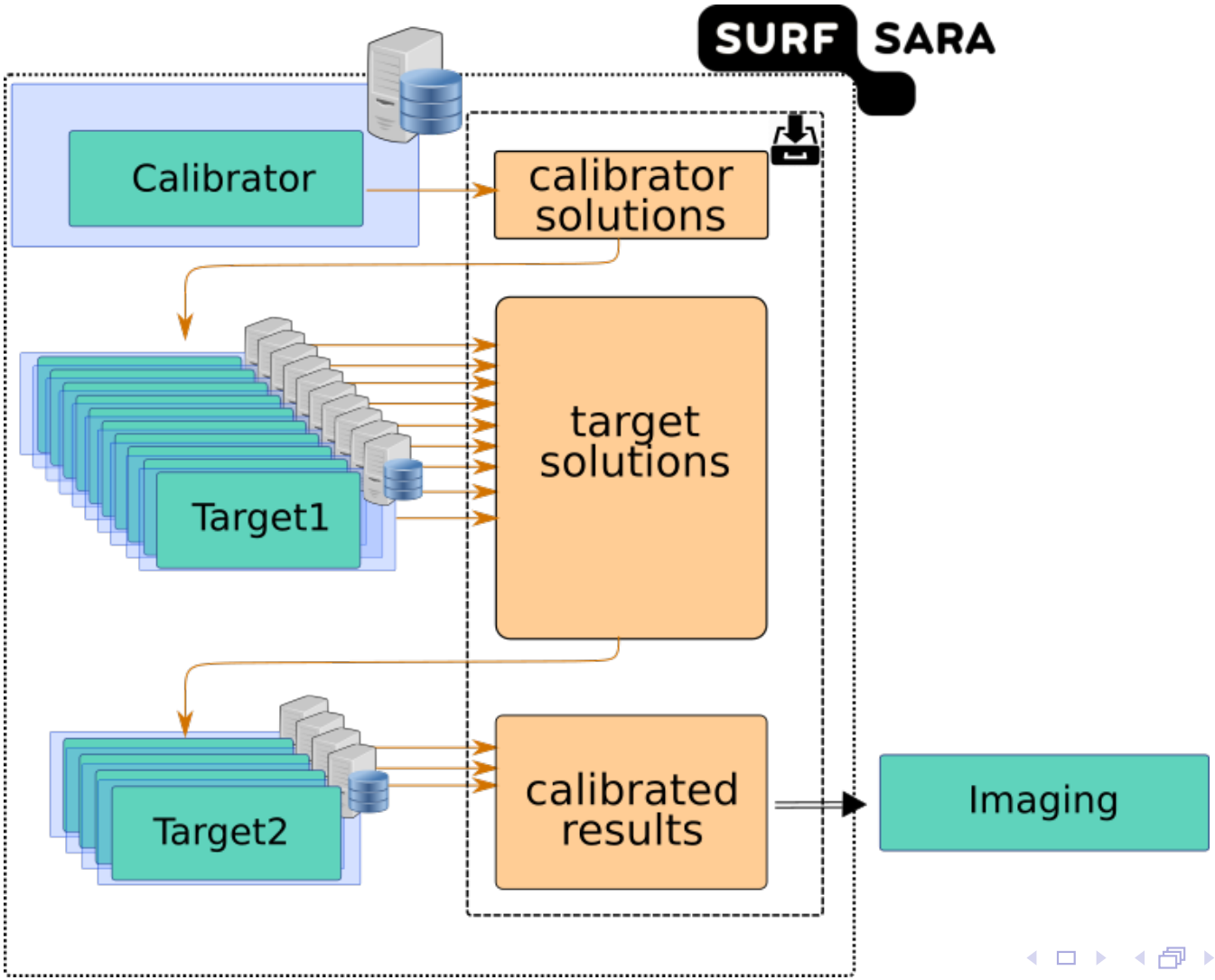
- Load functions into environment
- Read metadata and attachments from token
- Download data
- PROCESS DATA
- upload logs and plots to token

CernVM-FS software install

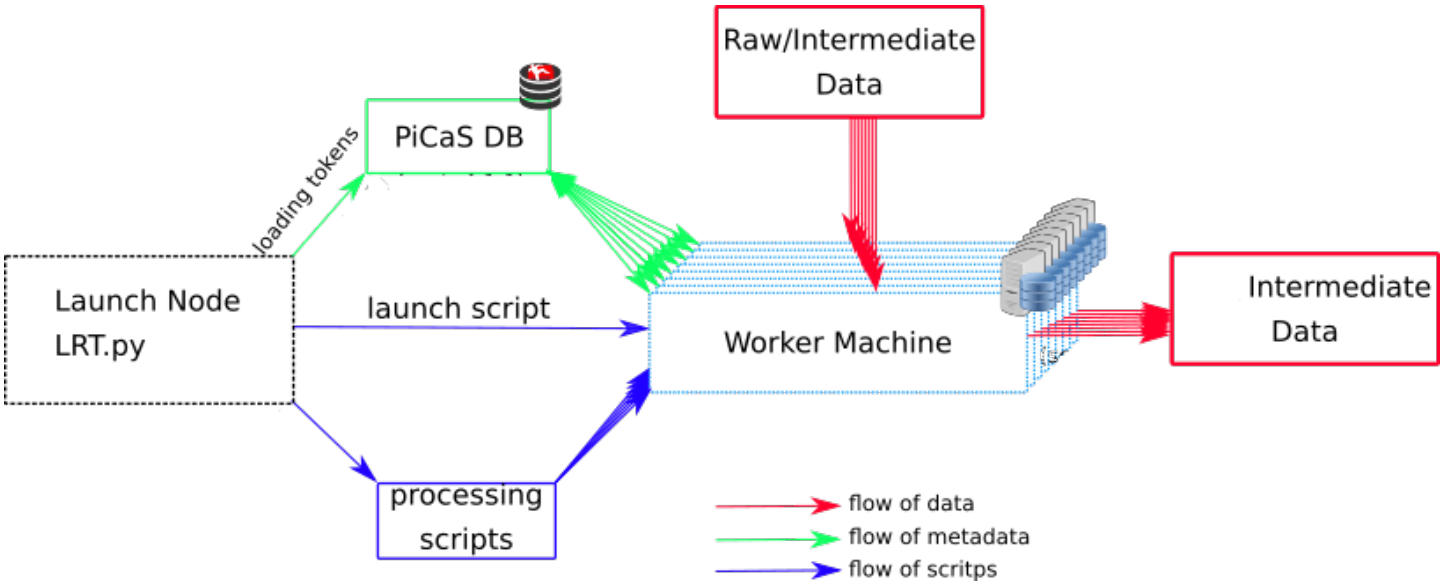
Global install of software mounted on grid nodes or cloud location



Using GRID Storage as an intermediate



Framework


Raw/Intermediate Data
PiCaS DB
loading tokens
Launch Node
LRT.py
launch script
Worker Machine
Intermediate Data
processing scripts
flow of data
flow of metadata
flow of scritps

Splitting Pipeline into Jobs

- Define each step:
  - Token structure
  - Sandbox:
    - scripts git
    - steps (set up env, download, process)
    - Token variables input
  - step_name
  - Parset, list of URLs
- Stage files
- Launch jobs

Submitting Jobs

Glite-WMS

Before

```
Executable = "/bin/sh";
Arguments = "startpilot.sh PICASDB USR PASSW ";
InputSandbox =
"sandbox/picas.tar","sandbox/couchdb.tar","sandbox/scripts.tar",
"sandbox/startpilot.sh","sandbox/pilot.py",
"sandbox/master_avg_dmx_v2.sh","sandbox/parsets.tar";
```

After

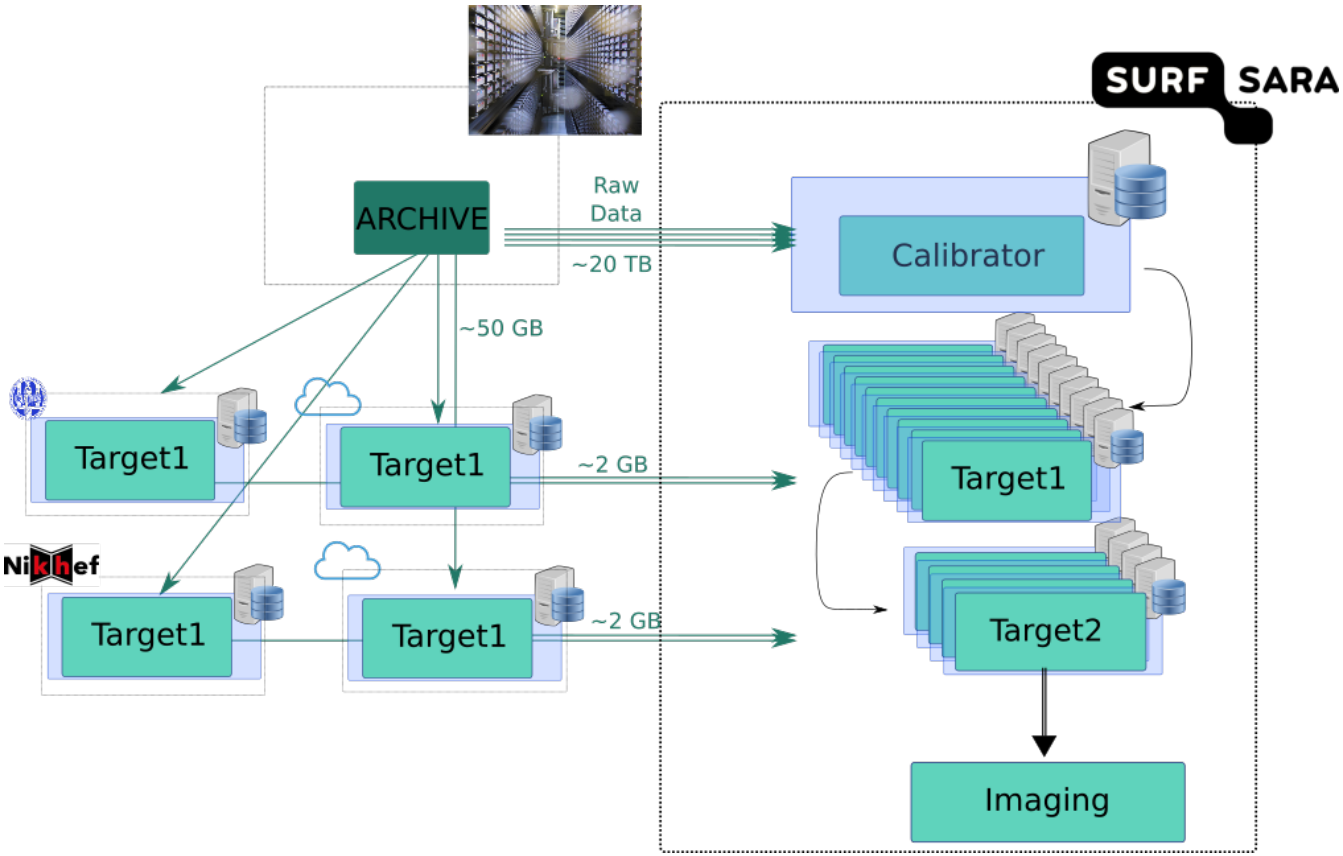
```
Executable = "/bin/sh";
Arguments = "run_remote_sandbox.sh PICASDB USR PASSW ";
InputSandbox = "run_remote_sandbox.sh";
```

Now it's easy to submit jobs! Just send a 20 line shell script
AND, can be submitted through other queues

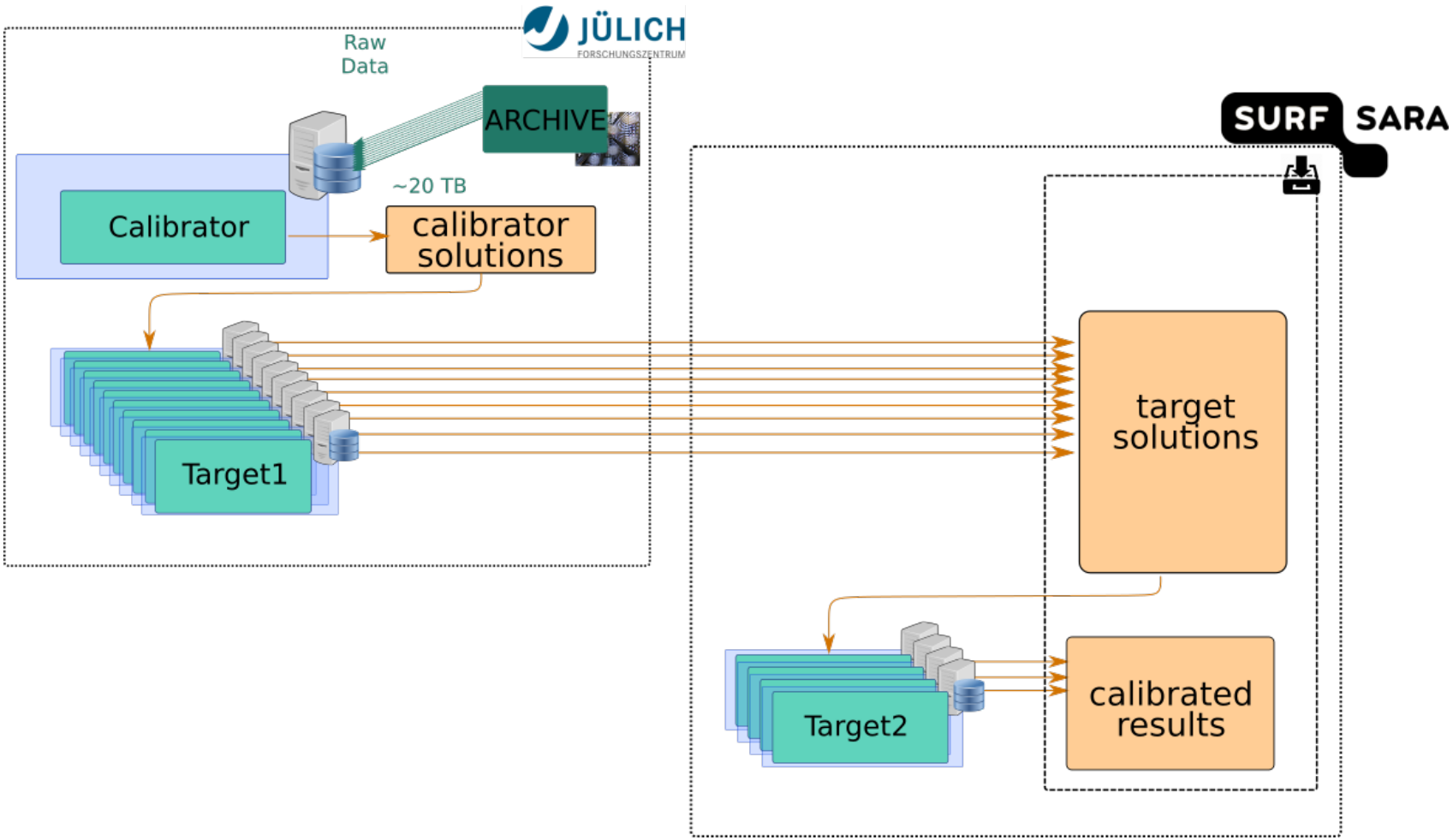
Results

15x speed-up out of the box
100+ Processed datasets in 4 Months
Can handle Multiple software packages (different pipelines)
Platform independence evolved naturally

Reducing on GRID + cloud (+institutes)

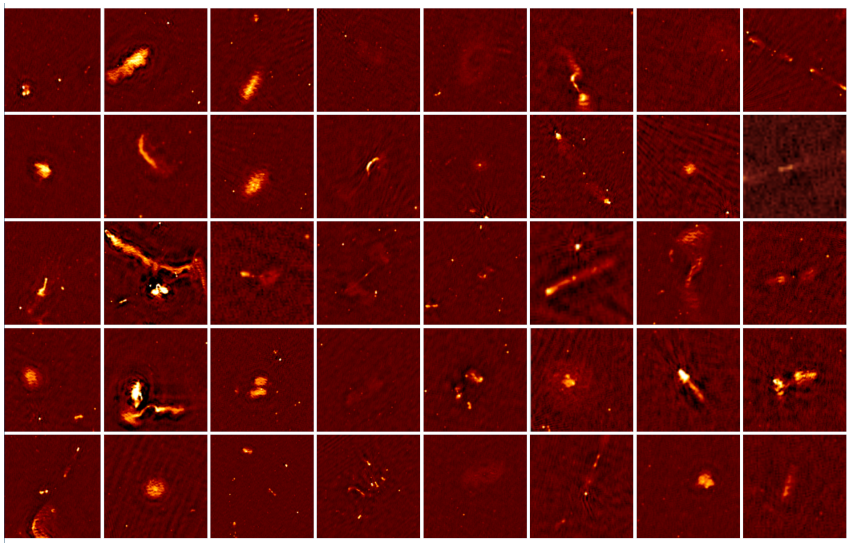


Processing Close to the Data



Overview

- Automating high-throughput processing
- Reduced unprecedented number of datasets
- Framework to send reductions at the archive sites
- Automate both pipelines
- Made images!



Acknowledgements and Source Code

Acknowledgements

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Sources

- Picas client: https://github.com/sara-nl/picasclient
- LOFAR Reduction Tools: https://github.com/apmechev/GRID_LRT
- Grid PiCaS tools: https://github.com/apmechev/GRID_picastools

Thanks for the attention!