

DISCOS: A common control software for the SRT and the other italian radiotelescopes

Sergio Poppi
on behalf of the DISCOS team

DISCOS Team

- **Carlo Migoni (INAF)**: core developer, VLBI integration.
- **Andrea Orlati (INAF)**: team leader - project manager - core developer.
- **Marco Buttu (INAF)**: core developer, test driven development.
- **Marco Bartolini (INAF)**: core developer, continuous integration.
- **Simona Righini (INAF)**: astronomical advisor, observations, documentation.
- **Antonietta Fara (INAF)**: system administrator.
- **Sergio Poppi (INAF)**: core developer, astronomical advisor, observations.



Project History

- 2004 Development SRT Control Software - NURAGHE started
 - team: Giuseppe Maccaferri, Andrea Orlati, Francesco Palagi, Carlo Migoni, Matteo Murgia, Francesco Schillirò (GAI SOFTWARE - SRT)
- Goal:
 - Provide the Sardinia Radio Telescope of control software with enhanced performances.
 - Build a common infrastructure for the three radio telescopes.
- 2007 ESCS Enhanced Single-dish Control System (Medicina and Noto)
 - team: GAI SOFTWARE + Simona Righini, Rashmi Verma, P.Libardi
- 2015 DISCOS: unifies the three development lines.



Telescopes Configurations

	SRT	Medicina	Noto
Main mirror	64 m	32 m	32 m
Optical configuration	Gregorian	Cassegrain	Cassegrain
Mount	Altazimuthal, fully steerable 12 motors + cable wrap	Altazimuthal, fully steerable 4 motors	Altazimuthal, fully steerable 4 motors
Antenna Control Unit (main servo system)	Beckhoff PLC ethernet vendor protocol	VxWorks based PC ethernet vendor protocol	VxWorks based PC ethernet vendor protocol
Primary Focus	three degrees of freedom INAF defined protocol	three degrees of freedom INAF defines protocol	
Secondary Focus	six degrees of freedom ethernet INAF protocol	five degrees of freedom ethernet INAF protocol	five degrees of freedom RS232 vendor protocol
Active Surface	1008 aluminium panels 1116 actuators rs485/ethernet vendor protocol	not available	240 aluminium panels 244 actuators rs232 vendor protocol

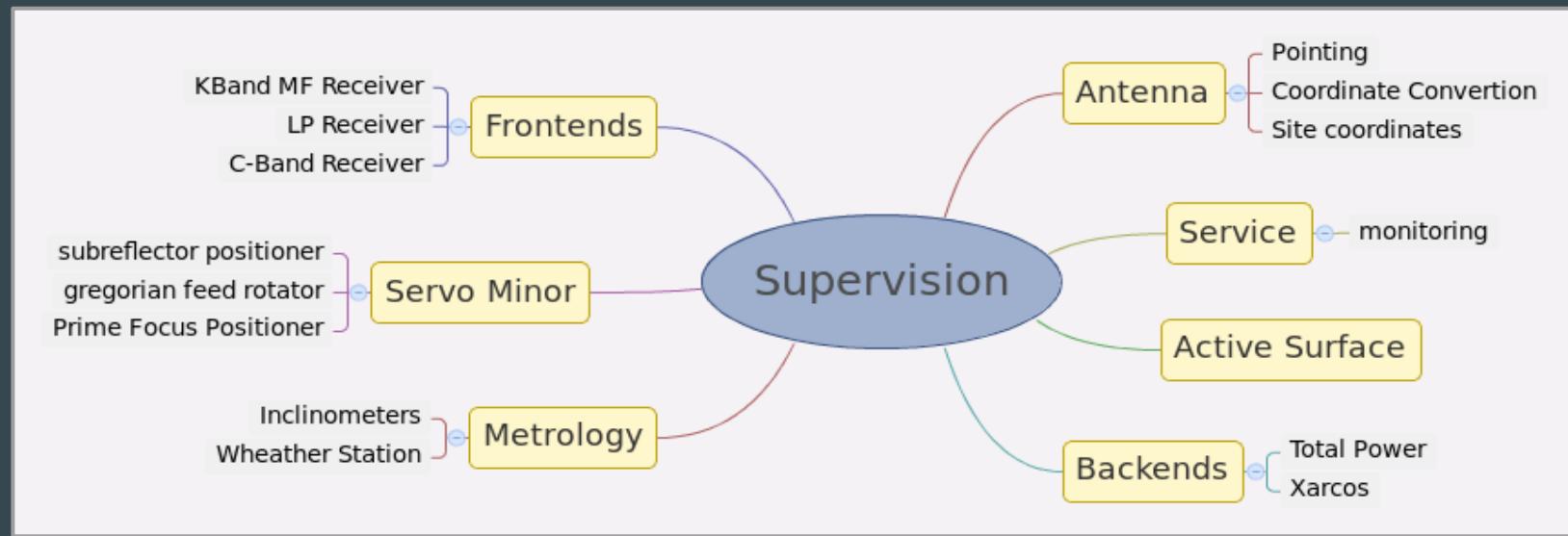
Telescopes Configurations

	SRT	Medicina	Noto
Main mirror	64 m	32 m	32 m
Receivers*	0.305-0.410 1.3-1.8 5.7-7.7 18.0-26.0, 7 feeds	1.35-1.45 1.595-1.715 2.2-2.36 4.30-5.80	0.317-0.320 1.40-1.72 2.20-2.36 4.70-5.05
GPIB and ethernet		5.90-7.10	8.18-8.58
INAF protocol	8.18-8.98 18.0-26.0, 2 feeds	18.0-26.0, 2 feeds GPIB and ethernet and RS232 various protocols	22.18-22.46 39.0-43.3 GPIB and RS232 various protocols
Backends*	<u>TotalPower (continuum)</u> 0.1-2.1, 1-1000 ms, 14 inputs <u>XARCOS (spectro-polarimetry)</u> 0.0005-0.125, 10 s, 2048 bins, 14 inputs <u>Roach(spectro-polarimetry)</u> 0.512, 10-1000 ms, 8192 bins, up to 14 inputs <u>DFB3(pulsar)</u> 1.024, 1-4000 ms, 8192 bins, 4 inputs DBBC	<u>TotalPower (continuum)</u> 0.1-2.1, 1-1000 ms, 4 inputs <u>XARCOS (spectro-polarimetry)</u> 0.0005-0.125, 10 s, 2048 bins, 14 inputs	<u>TotalPower (continuum)</u> 0.1-2.1, 1 ms, 4 inputs DBBC

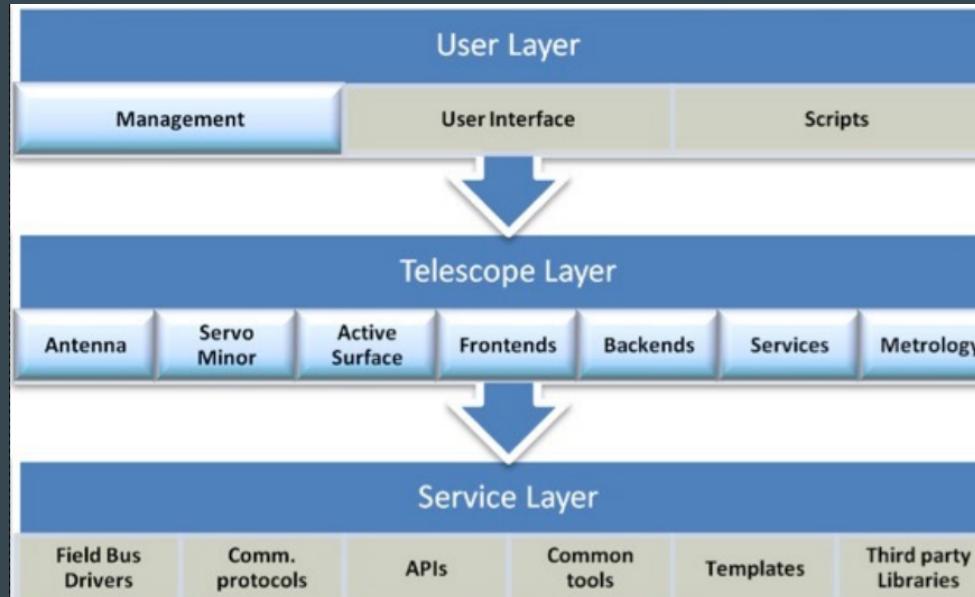
DISCOS features

- Based on **ALMA Common Software**
 - Distributed objects architecture
 - ACS component as the basic unit which performs tasks
 - Components expose interfaces to other components.
- **Common** interfaces design for the three telescopes
- Components organised in subsystems
- Each subsystem has a “boss” component, which has in charge the communications inward and outward the subsystem

DISCOS Design

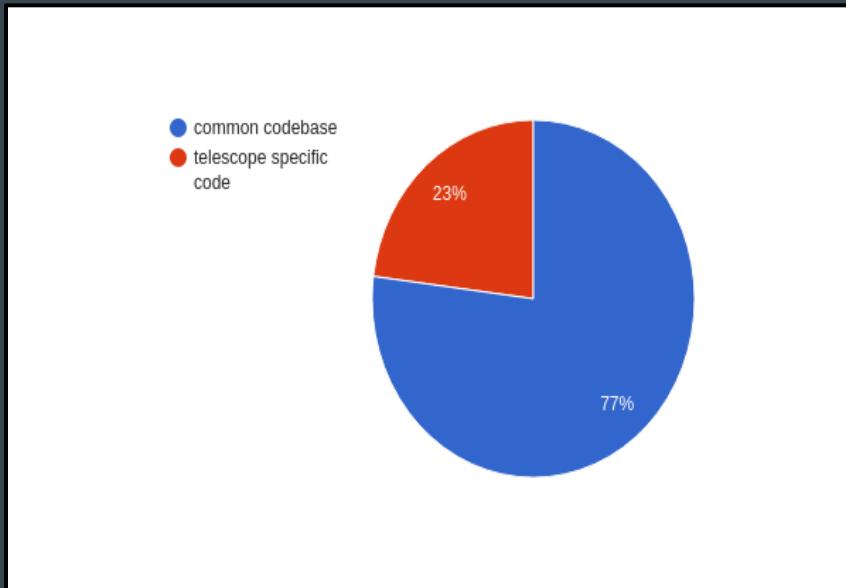


DISCOS Design



DISCOS implementation

- DISCOS - NURAGHE (SRT)
- DISCOS - ESCS (Medicina and Noto)
- A common monolithic codebase (77%):
 - management (scheduling, observing modes)
 - subsystem bosses
 - user interfaces
 - libraries
- Specific code coping differences among telescopes



How big is DISCOS?

Totals grouped by language (dominant language first):

cpp:	383778 (72.59%)
xml:	85988 (16.26%)
ansic:	30854 (5.84%)
python:	26607 (5.03%)
sh:	1328 (0.25%)
fortran:	144 (0.03%)
perl:	14 (0.00%)

Total Physical Source Lines of Code (SLOC) = 528713

generated using David A. Wheeler's 'SLOCCount'.

statistics by www.openhub.net

Maintenance pitfalls

- Big codebase
- Different production lines
- Development and testing during productions

Automatized tasks are needed!

Nightly builds

- **build server: AZDORA**
- Completely automated setup of a virtual machine with ACS installed and configured along with all necessary dependencies
- Jenkins installation for continuous integration



VM MANAGER

Vagrantfile hosted on
github.
[com/discos/azdora](https://github.com/discos/azdora)

Provisioning Scripts

bash

users.sh yum.sh ...

Static Contents Provisioning

ACS.tar.gz qt.tar.gz

CentOS BOX

OS
Customization

ACS Setup

Build Server Jenkins

Common Build & Test

SRT Build & Test

MED Build & Test

NOTO Build & Test

DISCOS
Releases

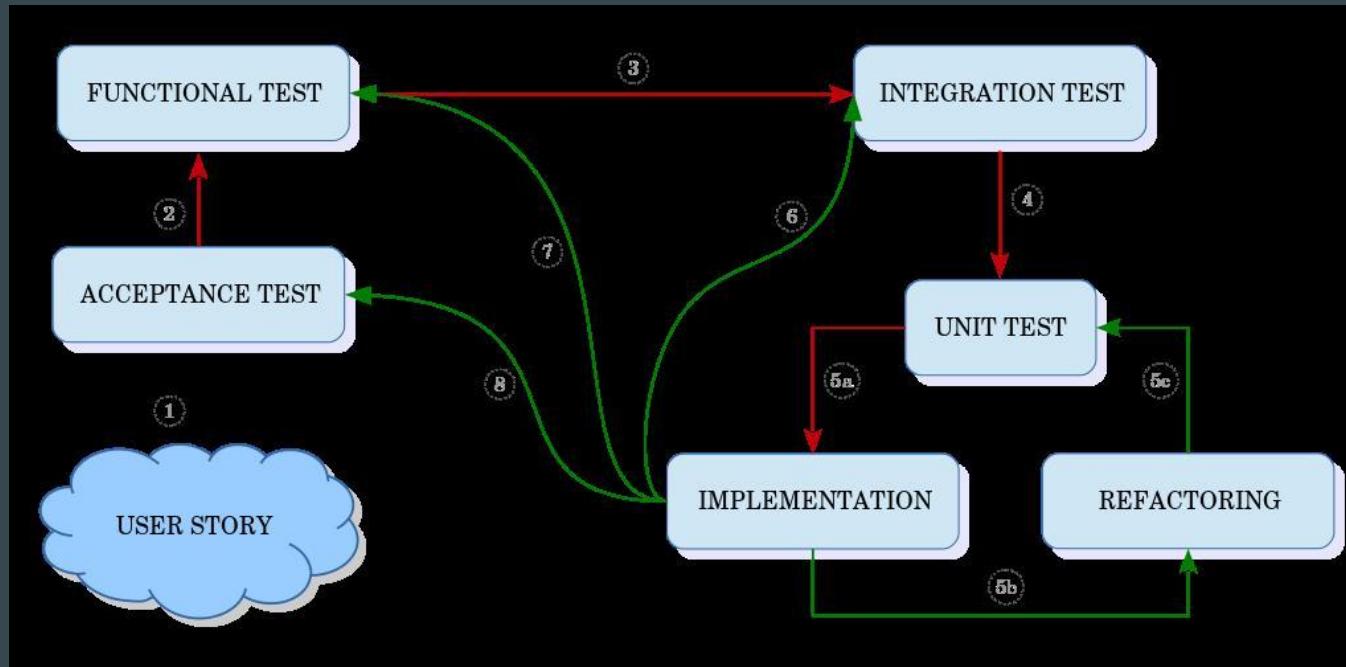
Azdora WEB
Interface

MANTIS
BugTracker

developer's
mailbox

Test driven development

- Development of new functionality will be test driven

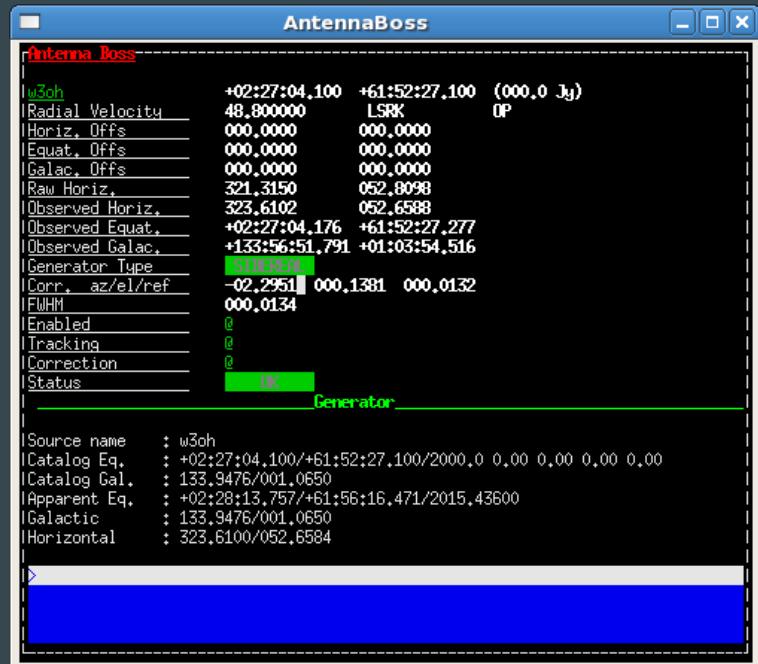


DISCOS at work



Antenna boss

- Shows the informations from “antenna boss”
 - tracking flag
 - observed positions
 - generator of the coordinates
 - Sidereal
 - On the fly
 - Status flag



Operator input

- It is the console where the users give commands to the system:
 - start and stop schedules
 - system setup



The screenshot shows a terminal window titled "OperatorInput". The window contains a list of 14 numerical values, each preceded by a line number from 00 to 13. The values represent radial velocity measurements in LSRK, OP. The list is as follows:

- <53> radialVelocity=48.8,LSRK,OP
- radialVelocity\
- <54> tsys
- tsys\
- 00) 111.397073
- 01) 109.015391
- 02) 111.538860
- 03) 104.120204
- 04) 112.725521
- 05) 989.737731
- 06) 104.833489
- 07) 106.897704
- 08) 119.851481
- 09) 109.515176
- 10) 104.830085
- 11) 112.177135
- 12) 111.535893
- 13) 177.923244
- <55> azelOffsets=0.0d,0.0d
- azelOffsets\
- <56> radialVelocity=48.8,LSRK,OP
- radialVelocity\
- <57> ■

Receivers boss and backend panels

GenericBackend

GenericBackend: BACKENDS/TotalPower

Time	:	2015-160-11:58:01.000	Integration	:	40	Busy	:	0	Time_Sync	:	0
Sections	:	14	Inputs	:	14	Busy	:	0	Suspended	:	0
S00	0050.0	0300.0	00	2.50000e-05	Pol- 00001	100	07.0	00	0109.0	Sampling	0
S01	0050.0	0300.0	00	2.50000e-05	RIGHT 00001	101	07.0	01	0106.2	CmdLine	0
S02	0050.0	0300.0	01	2.50000e-05	LEFT- 00001	102	07.0	02	0109.9	DataLine	0
S03	0050.0	0300.0	01	2.50000e-05	RIGHT 00001	103	07.0	03	0103.2		
S04	0050.0	0300.0	02	2.50000e-05	LEFT- 00001	104	07.0	04	0111.9		
S05	0050.0	0300.0	02	2.50000e-05	RIGHT 00001	105	07.0	05	0989.3		
S06	0050.0	0300.0	03	2.50000e-05	LEFT- 00001	106	07.0	06	0103.6		
S07	0050.0	0300.0	03	2.50000e-05	RIGHT 00001	107	07.0	07	0105.8		
S08	0050.0	0300.0	04	2.50000e-05	LEFT- 00001	108	07.0	08	0118.4		
S09	0050.0	0300.0	04	2.50000e-05	RIGHT 00001	109	07.0	09	0108.5		
S10	0050.0	0300.0	05	2.50000e-05	LEFT- 00001	110	07.0	10	0103.7		
S11	0050.0	0300.0	05	2.50000e-05	RIGHT 00001	111	07.0	11	0111.2		
S12	0050.0	0300.0	06	2.50000e-05	LEFT- 00001	112	07.0	12	0110.7		
S13	0050.0	0300.0	06	2.50000e-05	RIGHT 00001	113	07.0	13	0169.2		
S14						114					
S15						115					
S16						116					
S17						117					
S18						118					

Receivers

Receivers

Current Setup : KKG

Mode : SINGLEDISH

Status : OK

Feeds : 7

IFs : 2

L0 : 21964.0 (x14)

Start Freq. : 00100.0 (x14)

Bandwidth : 02000.0 (x14)

Polarization : LCP (x7) RCP (x7)

Dewar Positioner

Configuration: BSC

Dewar is ready

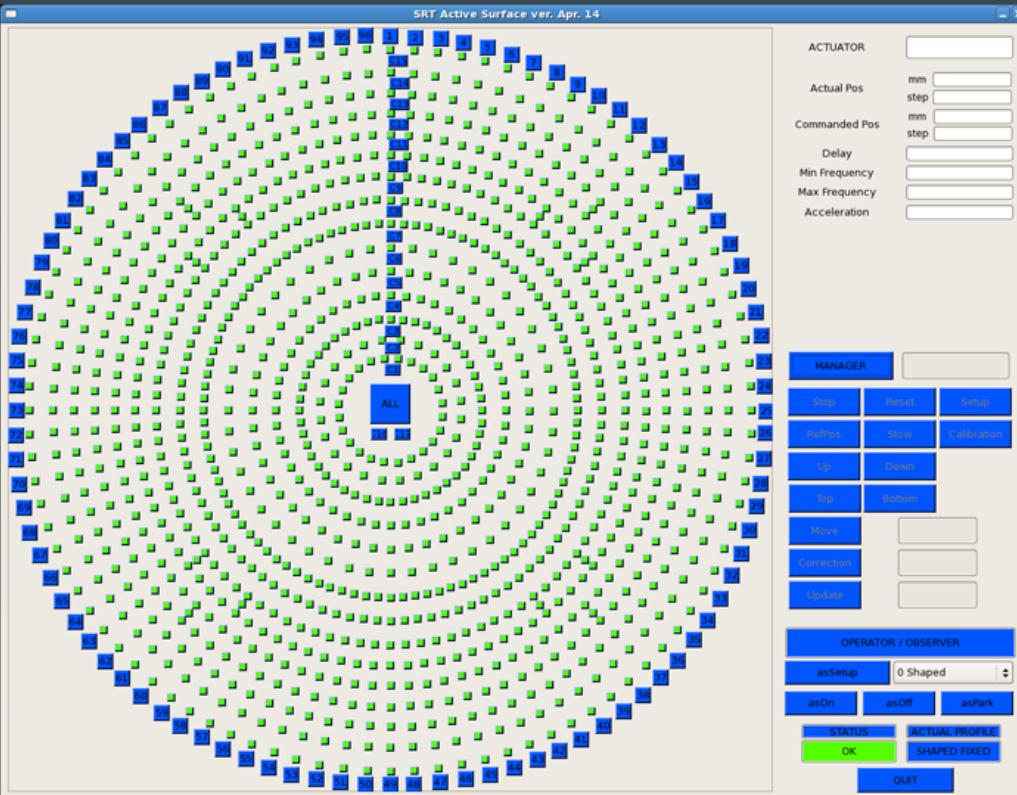
Absolute Position: 036.8

I / P / D / R: -19.2 / 056.792 / -00.875 / 000.0

Rewinding not required

>

Active Surface



Possible configurations:

- Shaped with elevation tracking
- Shaped at fixed elevation
- Parabolic with elevation tracking
- Parabolic at fixed elevation

SRT

Minor Servo system

- Fast switching of the receives
 - Primary Focus Positioner for prime focus obs.
 - Gregorian Feeds Rotator
 - M3 Positioner for
 - Subreflector positioner
- Subreflector motion for focus Tracking



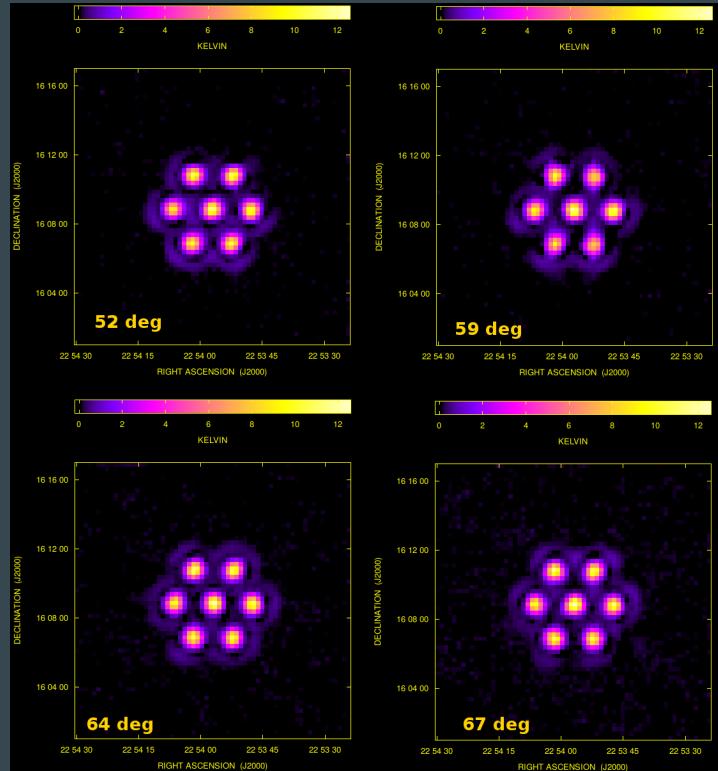
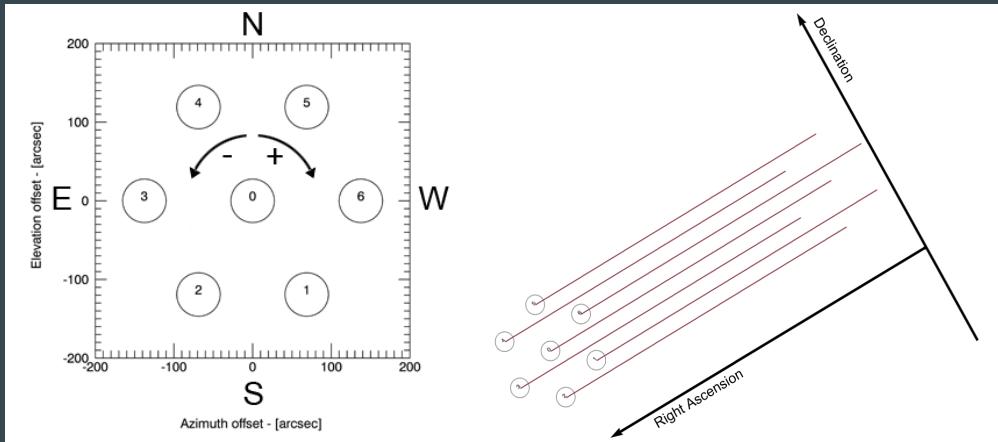
Scheduler

- Schedules are text based
- A schedule generator helps the observer to generate schedules for:
 - sidereal tracking
 - cross scans
 - OTF mapping
 - raster scan mapping
 - beam switching and nodding
- Frequency tracking for spectroscopic backends

(see: M. Bartolini, P. Libardi, S. Righini. "ScheduleCreator User Manual" internal report [IRA 466/13](#))

Derotator

- The Multifeed K-band receiver hosts an hardware derotator to follow the parallactic angle
- Derotation during sidereal and OTF



Courtesy of SRT Astronomical Validation

SRT

Data Format

FITS format

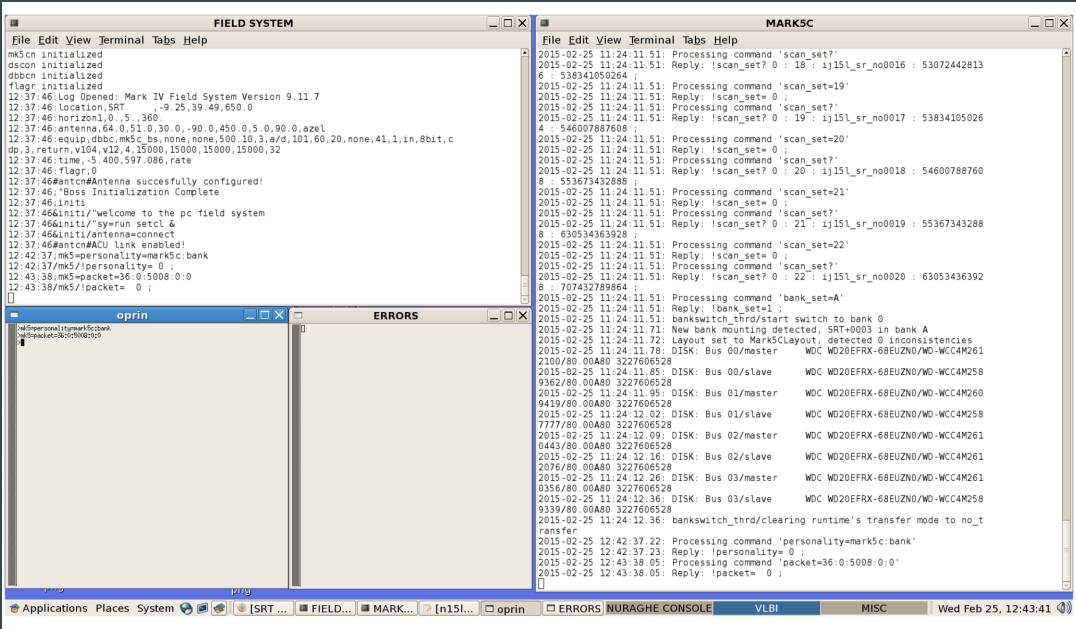
- standard data format through converters:
 - GILDAS/CLASS
 - SDFITS
- MBFITS output under development

Index	Extension	Type
0	Primary	Image
1	SECTION TABLE	Binary
2	RF INPUTS	Binary
3	FEED TABLE	Binary
4	DATA TABLE	Binary
5	ANTENNA TEMP TABLE	Binary
6	SERVO TABLE	Binary

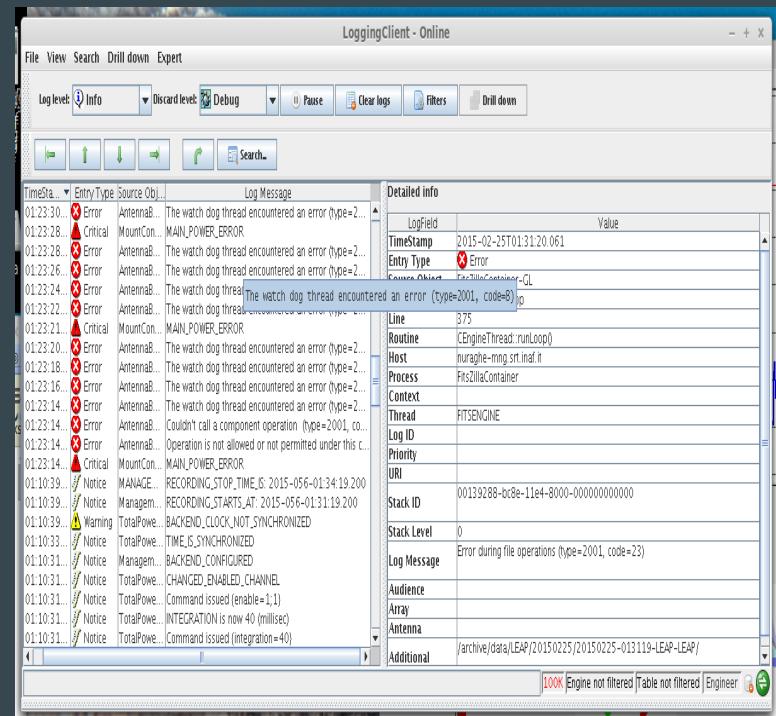
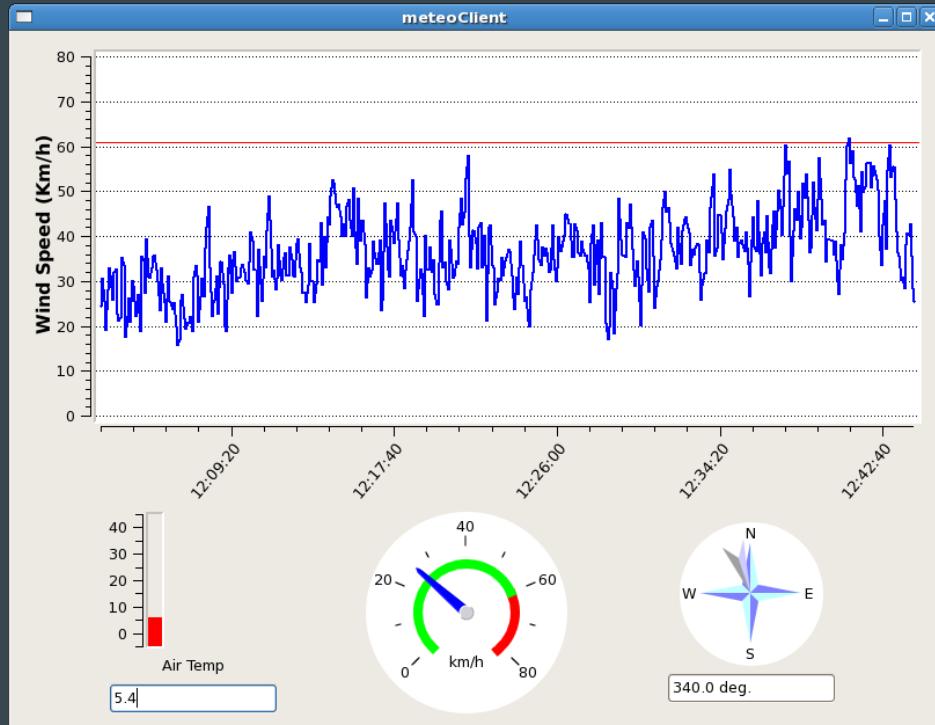
Select	<input type="checkbox"/> id	<input type="checkbox"/> xOffset	<input type="checkbox"/> yOffset	<input type="checkbox"/> relativePower
	J	D	D	D
<input type="checkbox"/> All				
Invert	Modify	Modify	Modify	Modify
1	0	0.000000000000E+00	0.000000000000E+00	1.000000000000E+00
2	1	1.027805000000E-03	0.000000000000E+00	9.700000000000E-01
3	2	5.139030000000E-04	-8.901180000000E-04	9.900000000000E-01
4	3	-5.139030000000E-04	-8.901180000000E-04	9.700000000000E-01
5	4	-1.027805000000E-03	0.000000000000E+00	9.500000000000E-01
6	5	-5.139030000000E-04	8.901180000000E-04	9.700000000000E-01
7	6	5.139030000000E-04	8.901180000000E-04	9.700000000000E-01

VLBI - Field system

- The FS sends commands to DISCOS through an external clients port



Weather monitor and system logs



Future development

- ESCS-Noto to be completed
- Graphical user interfaces (web based UI)

Summary

- DISCOS has been designed to be suitable for all the italian radio telescopes
- Different implementations cope with the differences among telescopes
- The growth of the project requires new development techniques
- From the user's point of view DISCOS is a common platform for all the telescopes: the observer will have:
 - same user interfaces
 - same tools
 - same data formats

Questions?

See:

<http://discos.readthedocs.org/>

