Optimized follow-up scheduling for PLATO

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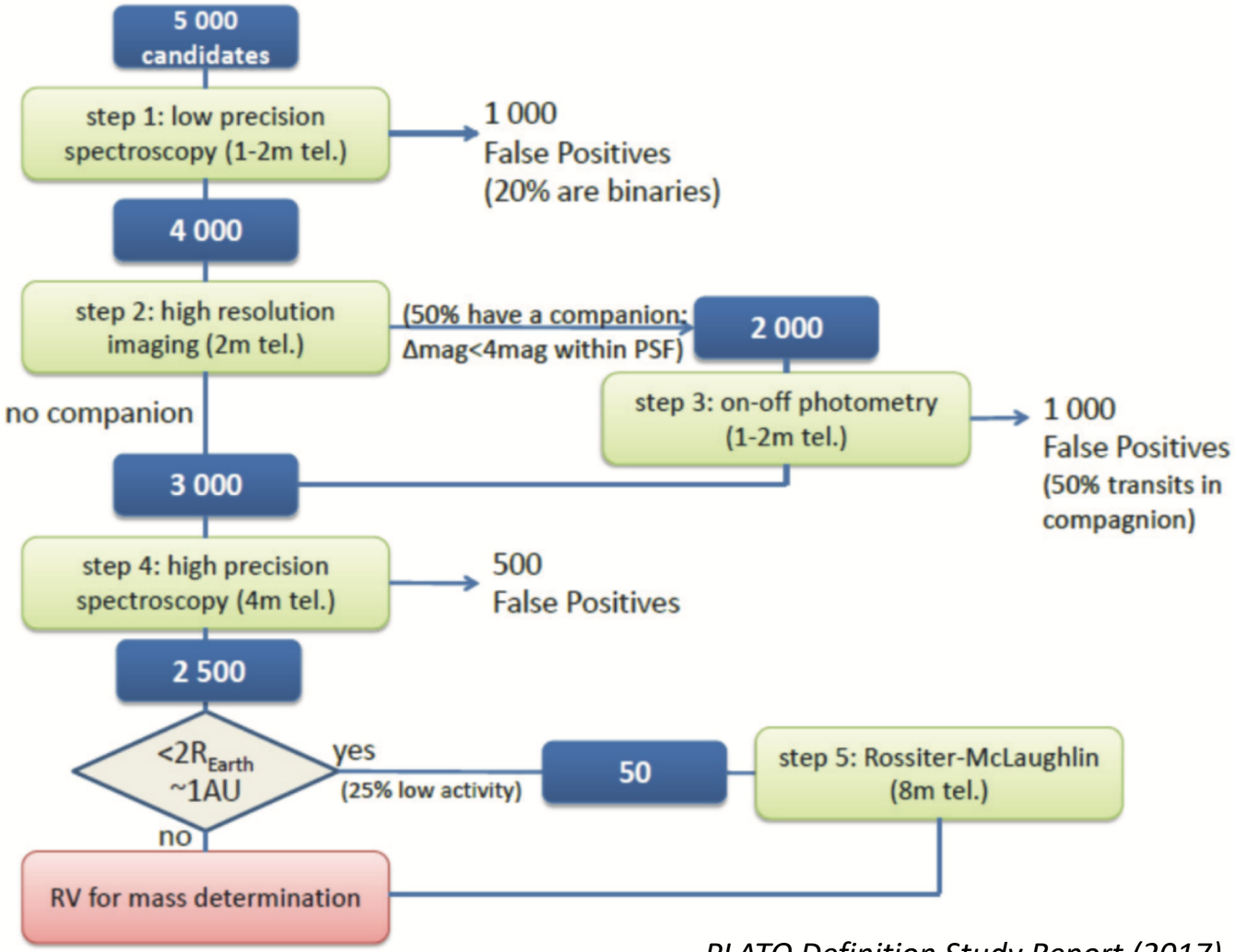
PLATO follow-up (FU): Hierarchical approach



2-m class telescopes (10+)

4-m class telescopes
(HARPS, HARPS-N, NIRPS, CARMENES, SPIRoU, +)

10-m class telescopes
(ESPRESSO, +)

PLATO Definition Study Report (2017)

PLATO follow-up (FU): Hierarchical approach

Telescope Class	Filtering/Candidate Confirmation		Radial Velocity Measurements		Total Nights
	(nights/year)	(Total nights in 7 years)	(nights/year)	(Total nights in 9 years	
1-2m low-resolution spectroscopy	~35	~245	-	-	~245
1-2m high-resolution imaging	~15	~105	-	-	~105
1-2m on-off photometry	~10	~70	-	-	~70
1-2m high-resolution spectroscopy			~3	~30	~30
4m high-resolution spectroscopy	~20	~140	~100	~900	~1040
8m high-resolution spectroscopy	~5	~35	~80	~720	~755

PLATO Definition Study Report (2017)

PLATO follow-up (FU)

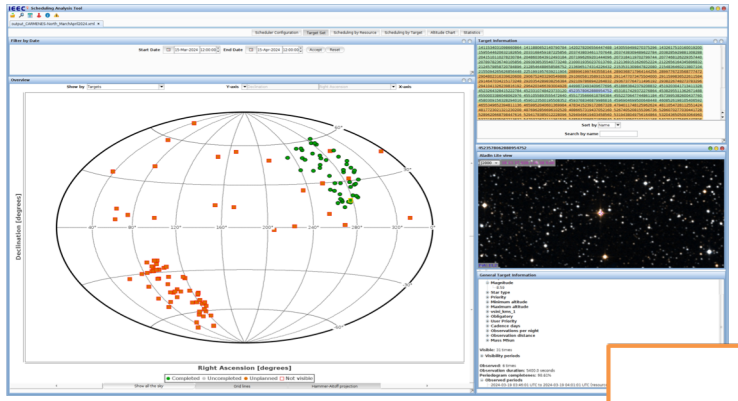
- Of order of 20+ facilities with different sky visibilities, weather conditions, availability patterns, etc.
- 22000 hours of observations with a heterogeneous collection of telescopes and instruments
- Various potential requirements:
  - Redundancy (critical events)
  - Consistency of time series (same instrument)
  - Cross-checking (overlaps)
  - …

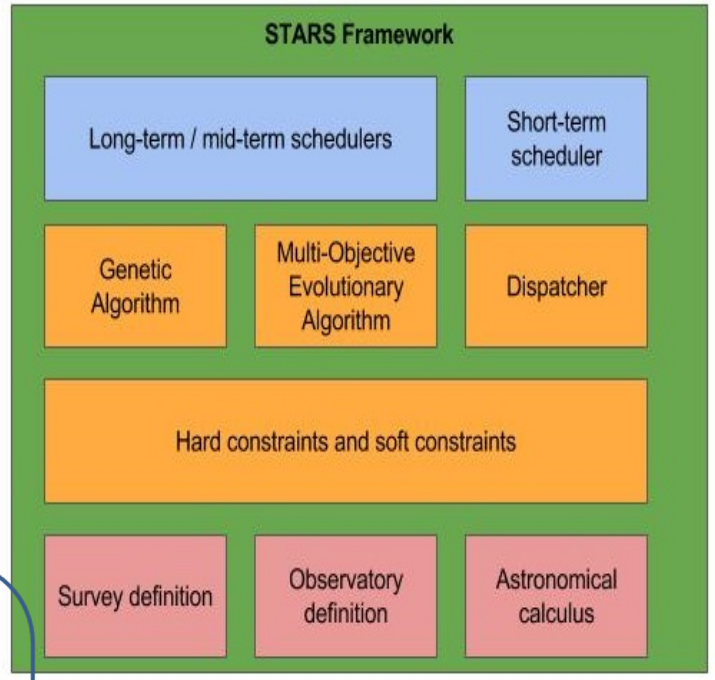
Automatic & dynamic planning is essential
Optimization is a big plus

Scheduling application framework

STARS framework:

Scheduling Technologies for Autonomous Robotic Systems





ATP
Analysis Tool for Planning
Configuration + Visualization
Java Front-end

STARS

XML files &
DB-SQL (proposals,
weather data, etc.)

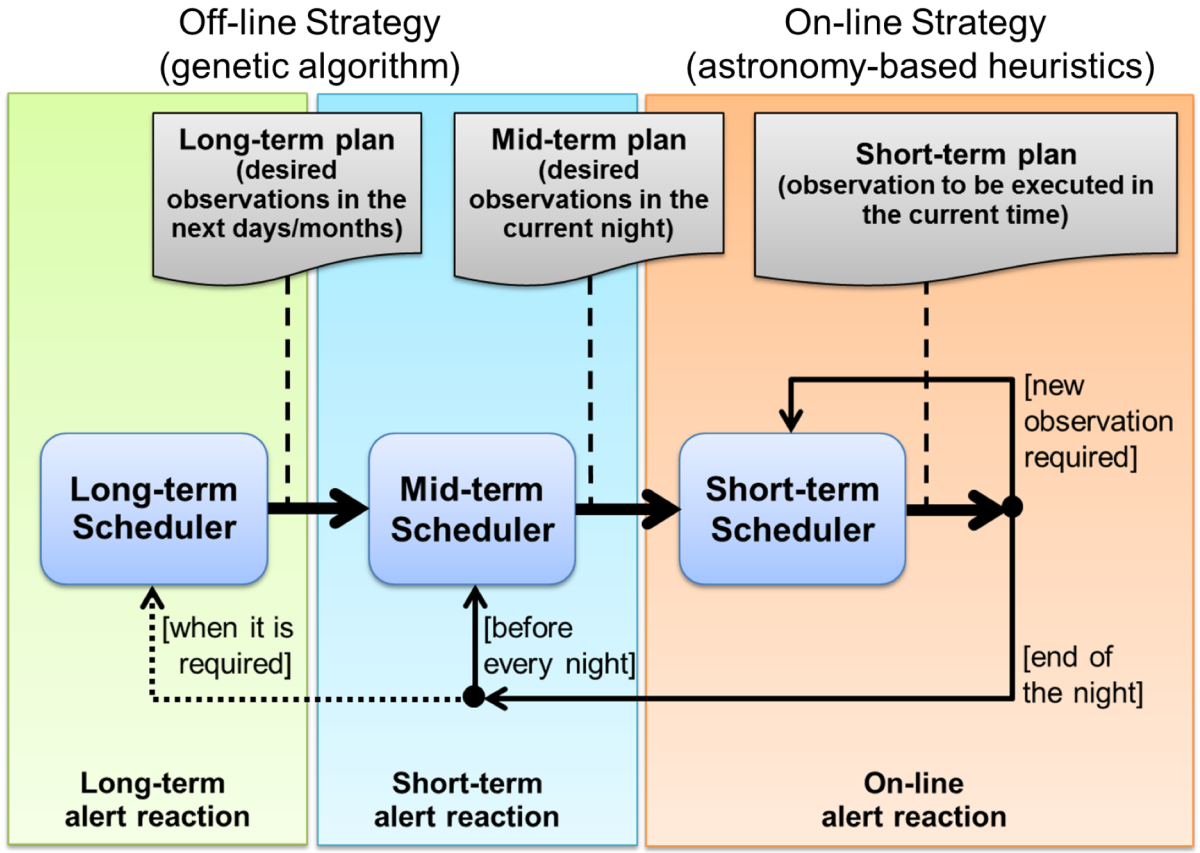
Astro-lib
AI Algorithms
Constraint models
C++

MISSION I/F
(OCS, TCS, ICS
IOSDC-MOC)

Scheduling application framework

Performance metrics

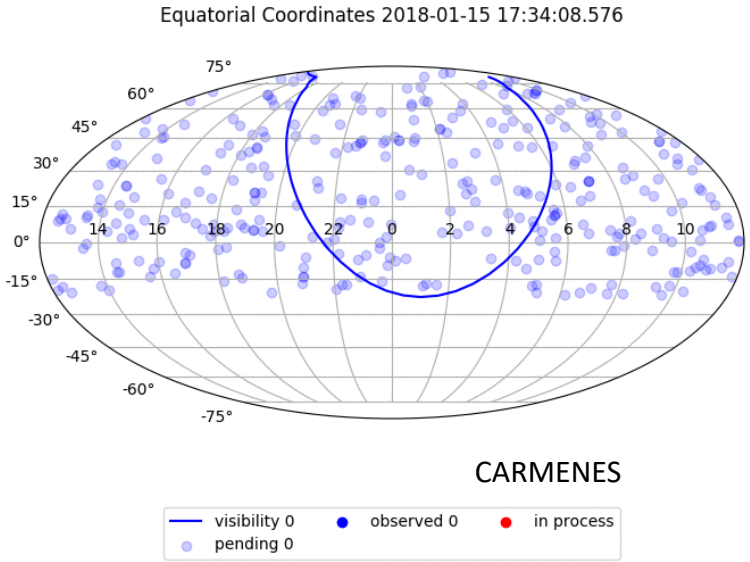
- Observing time optimization
  - The **time** in the schedule during which the **telescope** is **observing** objects should be maximized
- Optimization of scientific return
  - The observation of completed targets should be maximized in order to increase the scientific efficiency of the mission
  - Observation of the priority targets should be promoted
  - Observation deviation to ensure that all targets with the same priority will have a proper share of assigned observing time
  - Observing cadence according to the observation strategy



STARS, framework for scheduling telescopes and space missions

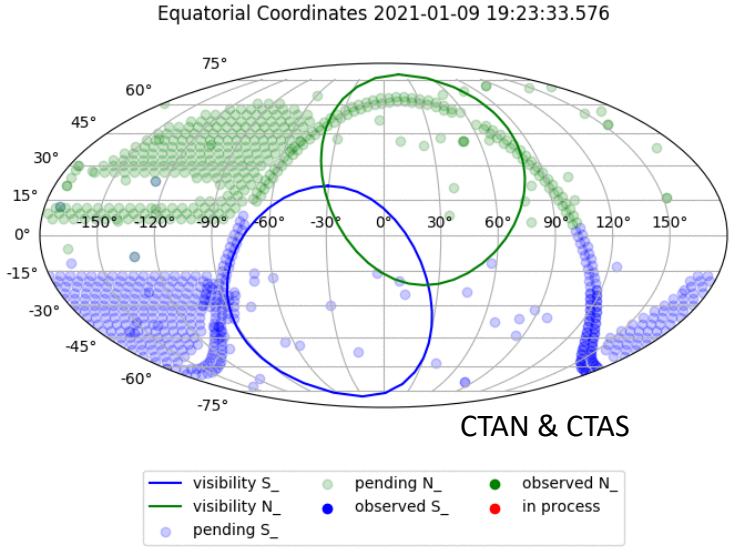
- In operation: CARMENES & TJO
- Under construction (simulation mode): ARIEL-ESA, CTA & CTA-SKA
- Research project (simulation mode):
  CTA & GASKAP **multi-observatory coordinated scheduling**
- **Heritage for PLATO: architecture, algorithms, metrics**

Real-time service in an operational control architecture



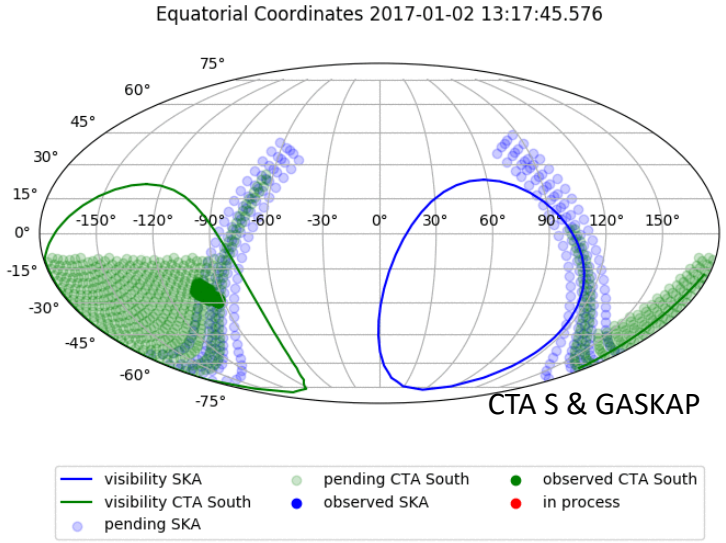
CARMENES

Optimization of time-critical events



CTAN & CTAS

Multi-observatory coordinated observations



CTA S & GASKAP

PLATO FU

IEEC team working on a preliminary definition of the PLATO follow-up:

- Overall architecture
- Interfaces and protocols
- Requirements
- Optimization metrics
- Simulations (Proof-of-Concept)

PLATO FU

Interfaces:

- From Telescopes: visibility, availability, observing constraints
- Task submission to Telescopes: short/dynamic or mid-term (night) plan
- Task status from Telescopes to scheduler archive
- Reactive or pro-active communication
- Protocols: VO visibility & observing constraints, VOEvents, heterogeneous protocols

PLATO FU

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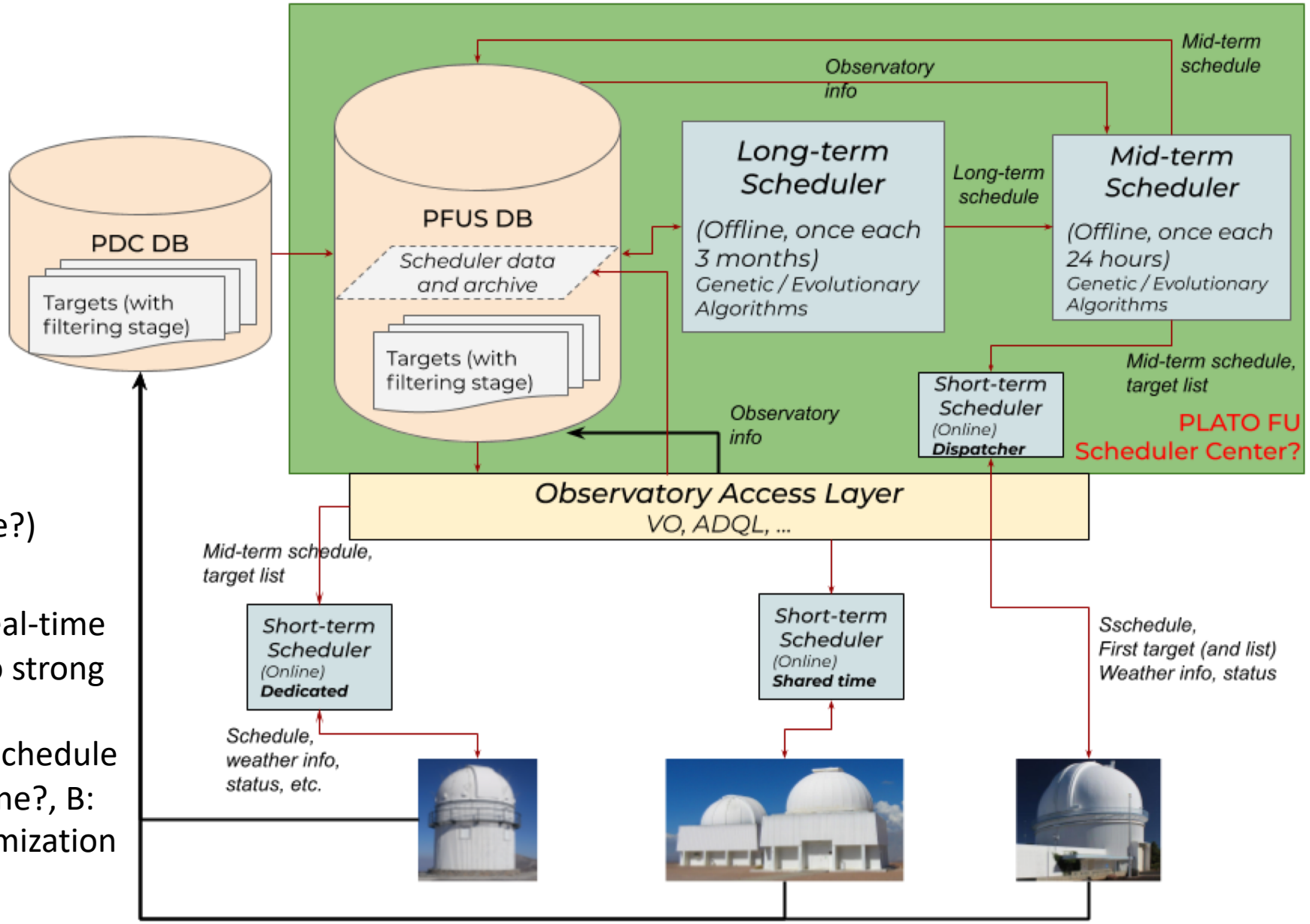
PLATO FU

Scheduler:

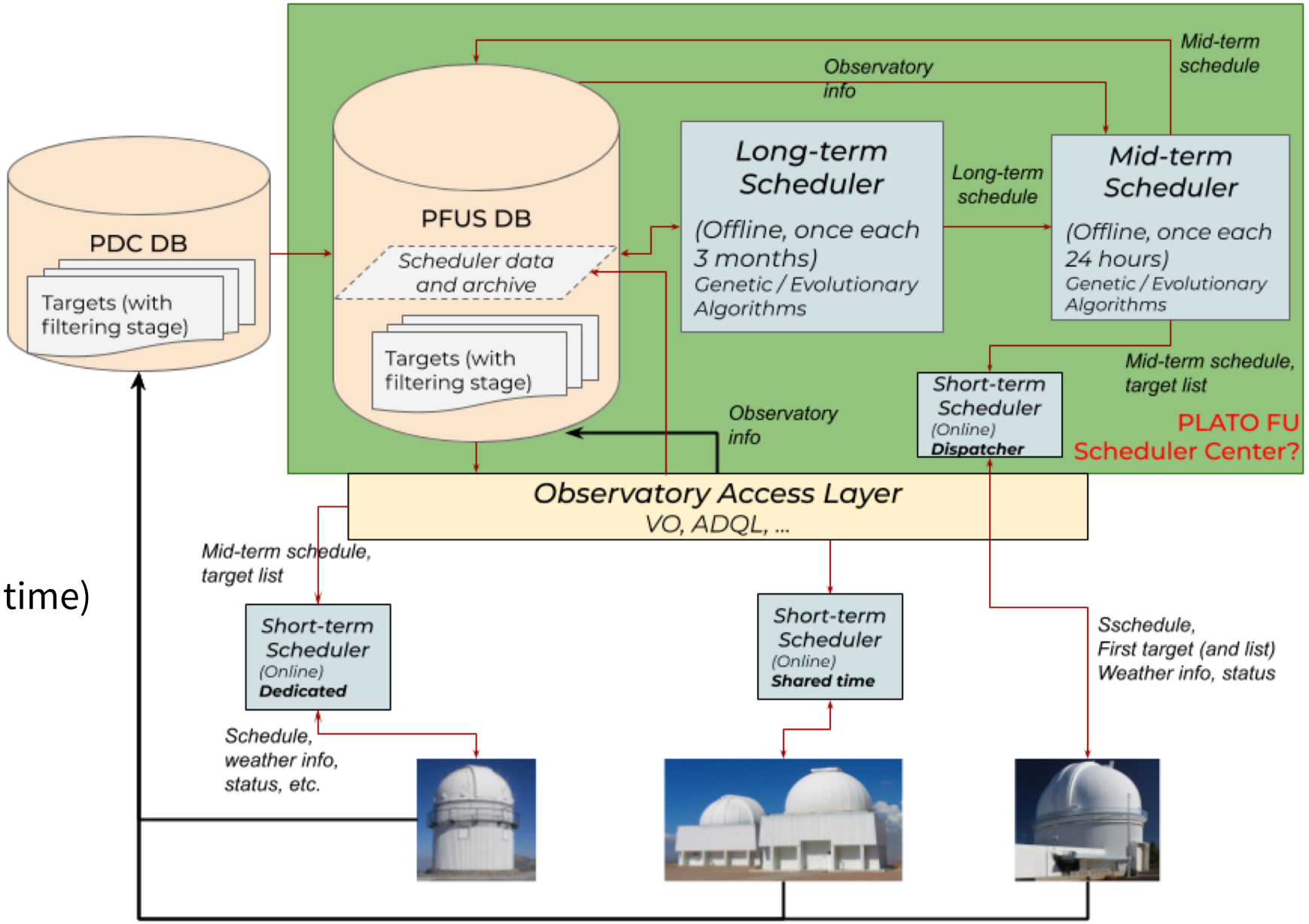
- Optimization objectives
  - Time optimization
  - Scientific return (completed targets)
  - Priority targets
  - Consistency of time series
- FU strategies
  - Redundancies (# at each stage?)
- Optimization hierarchy
  - Dispatcher mode: dynamic/real-time response – prioritized list (too strong operational dependencies?)
  - Distributed mode: mid-term schedule with priorities (A: must be done?, B: fillers?), local short-term optimization & stand-alone operation



PLATO FU

Scheduler archive (PFUS):

- Target list: observability constraints, status & history data (validation stages 1-5)
- Scheduler plans (long-, mid-, short-term)
- Telescope availability pattern (dedicated, shared time) & status

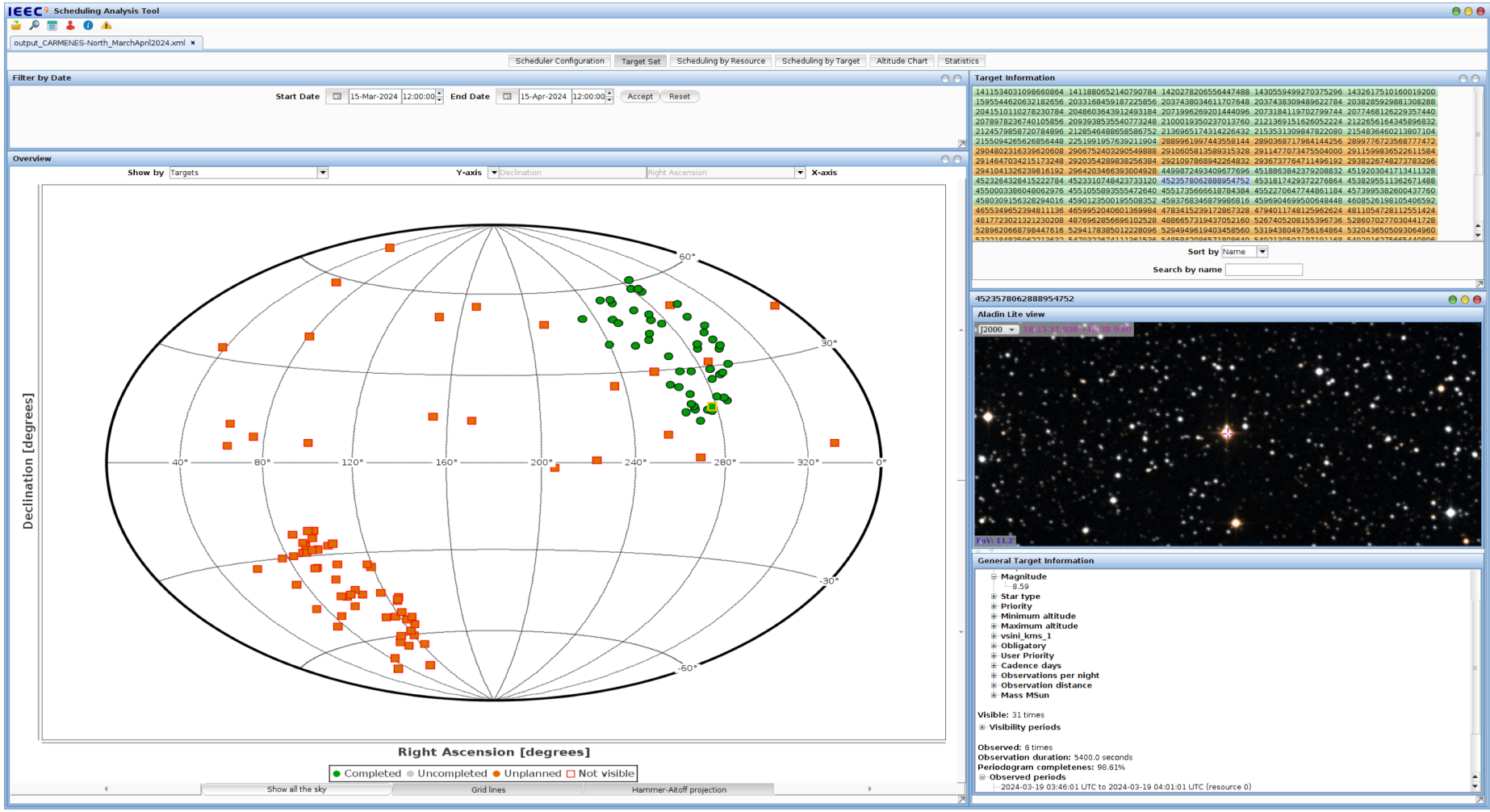


PLATO FU scheduling

Simulations using 100 Gaia DR2 sources randomly picked up from PLATO N+S fields

Scheduler executed using CARMENES configuration, simulating:

- March+April 2024
- Bad weather
- Only targets with h ≥40º
- Exposure time fixed to 15 min
- Telluric standards used in CARMENES

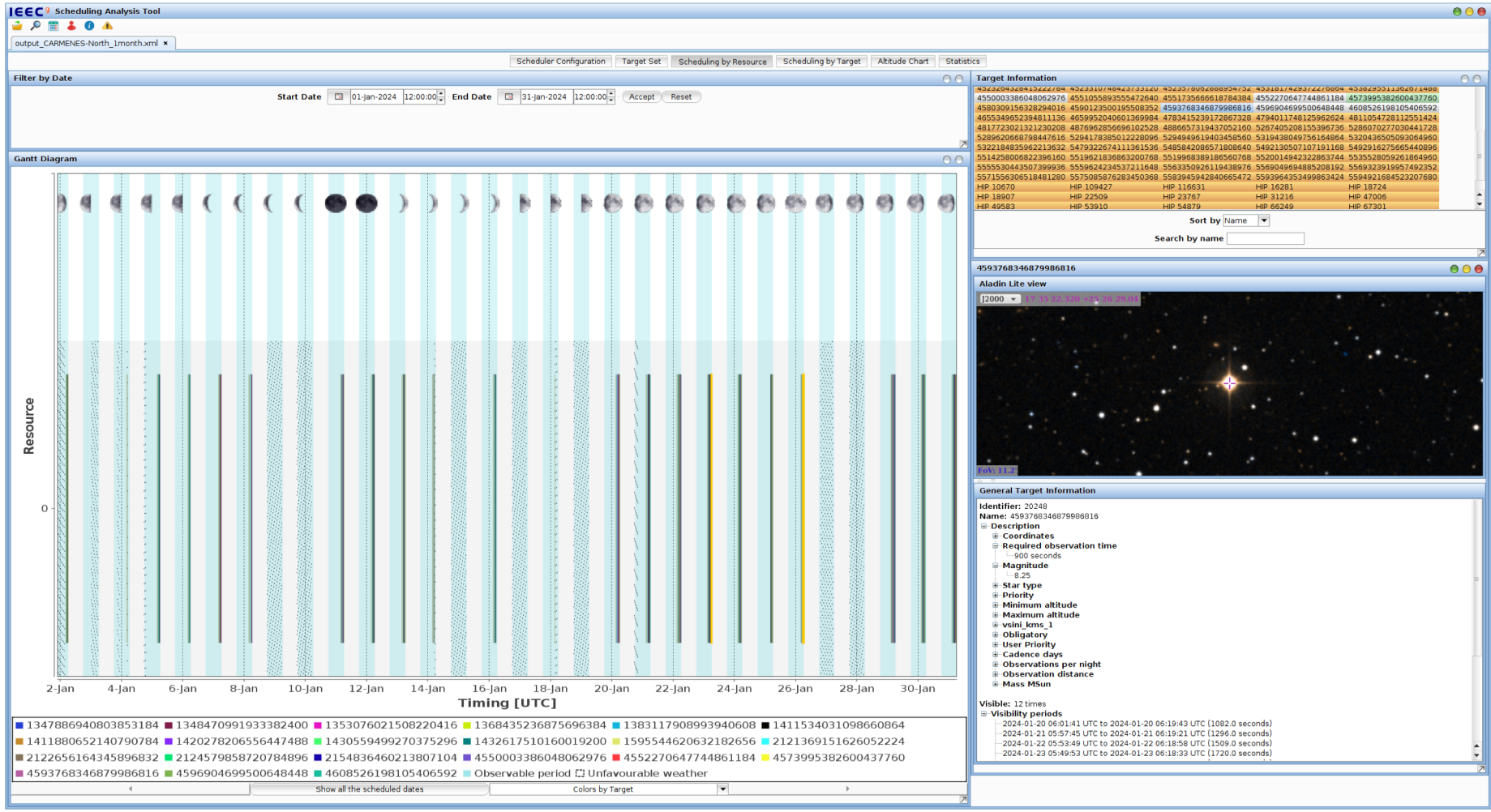


PLATO FU scheduling

Simulations using 100 Gaia DR2 sources randomly picked up from PLATO N+S fields

Scheduler executed using CARMENES configuration, simulating:

- January 2024
- Bad weather
- Only targets with h ≥40º
- Exposure time fixed to 15 min
- Telluric standards used in CARMENES



PLATO FU: Next steps

- Identification of PLATO FU requirements
  - Overall architecture
  - Protocols and standards to be used
- Identify existing tools, approaches or best practices that may be reused
  - E.g.: Las Cumbres Observatory (TOM), ESA VO protocols (ObjVisSAP, ObjLocTAP), TFOP, Gaia Alerts, LIGO/Virgo EM follow-up…
- Update STARS (and ATP visualization tool) as a PLATO Proof-of-Concept