Gaia: The Science Alert Mode

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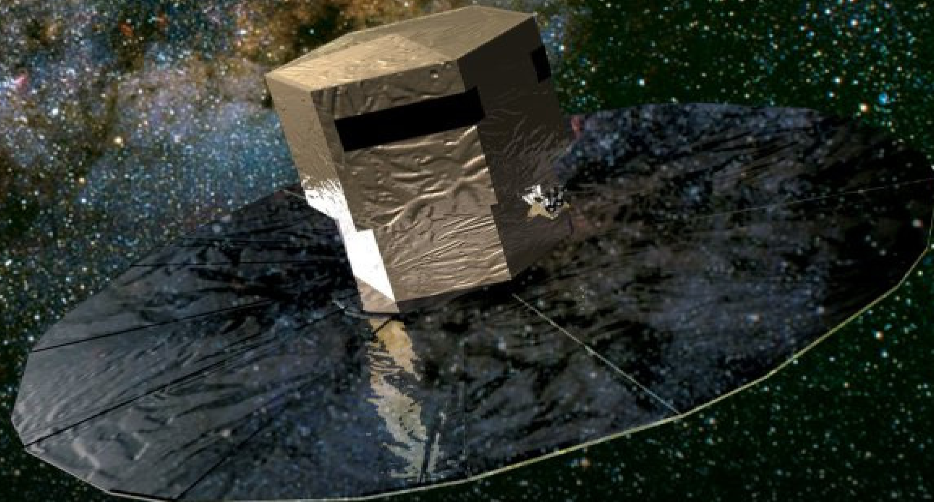
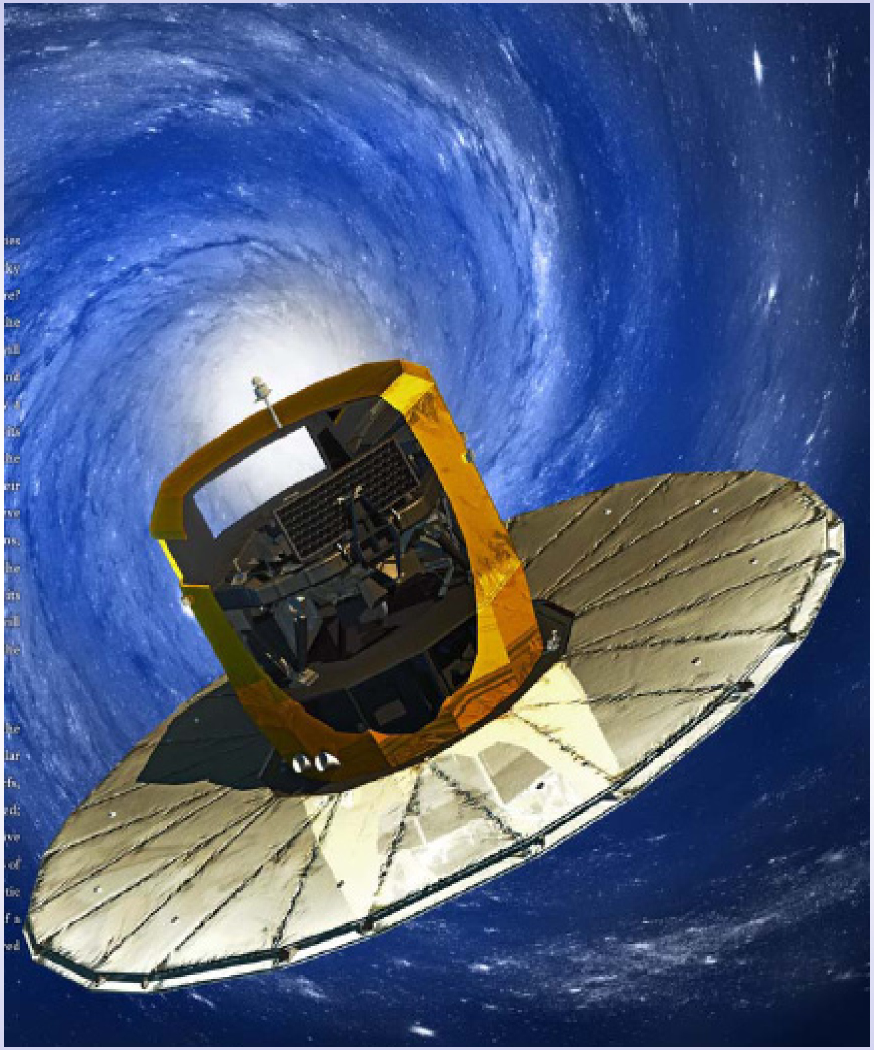
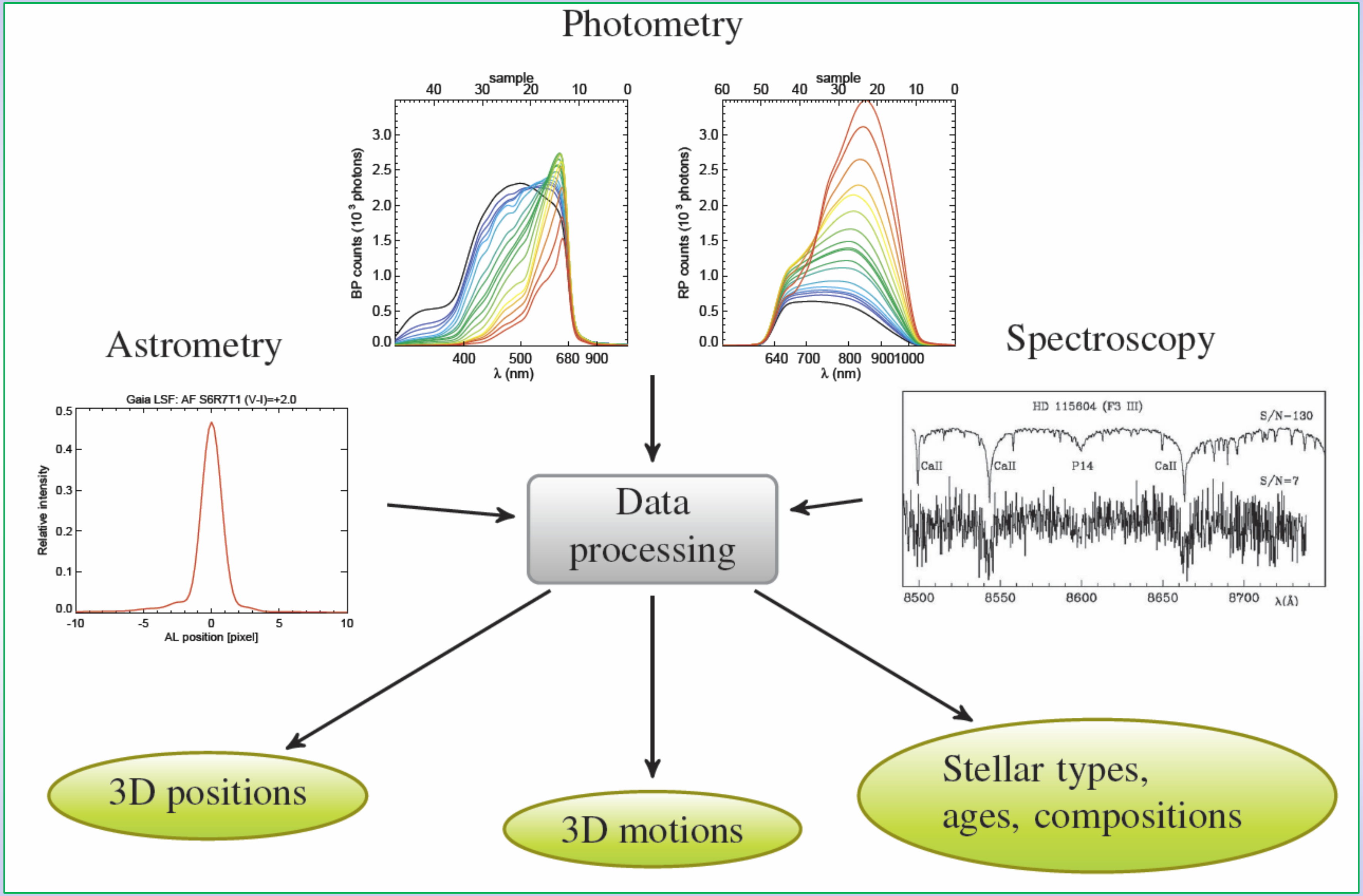


Outline

- Gaia and science alerts
- Gaia short term schedule
- Early operation schedule
- Issues for the Solar System alerts



What Gaia can deliver



cartoon: A. Brown

Gaia and the Science Alerts

- Gaia is a survey mission observing continuously
  - it detects and observes every sufficiently point-like source to V ~20
  - it is not a pointing mission and it has a rigid scanning law
- Data are transmitted to the ground station every day
  - during visibility passes of the spacecraft
- A quick and simplified processing can be done within 24 to 48h
  - nothing global in astrometry or photometry
  - using best available instrument calibration
  - attitude can be obtained with a 1D astrometry on a scan circle
- From this solution one can release alert information

Definition of a Gaia Alert

Alert

science data that would have little or no value

without quick ground-based follow up

- Typically:
  - a transient photometric/spectro event evidenced in the Gaia data,
  - a fast-moving solar system object without known orbit ➔ this WS.
- but without possible monitoring by the Spacecraft

General Terminology for Gaia

- SA or GSA : Science Alerts or Gaia Science Alert
  - to be used for general presentations related to the Gaia alert mode
  - ASA: Astrometric Science Alerts
    - i.e : Solar System objects
      - SSO can be used also as suffix when relevant (like Gaia FUN-SSO)
  - PSA: Photometric Science Alerts ➔ Talk of Lukasz Wyrzykowski
    - i.e photometric detection of transient phenomena
  - SSA: Spectro Science Alerts
    - probably in support of the PSA

Main Features of the Gaia Alerts

- Astrometry, Photometry and Spectroscopy could be the source of a Gaia Alert
- Gaia releases the alert to the science community
- Immediate follow-up needs the participation of that community
- Alerts will be intermingled with false alerts
  - This feature is common to all kind of Gaia Science Alerts
- A validation procedure will be needed to tune the thresholds
  - it should be light for the Solar System, but harder for photometry

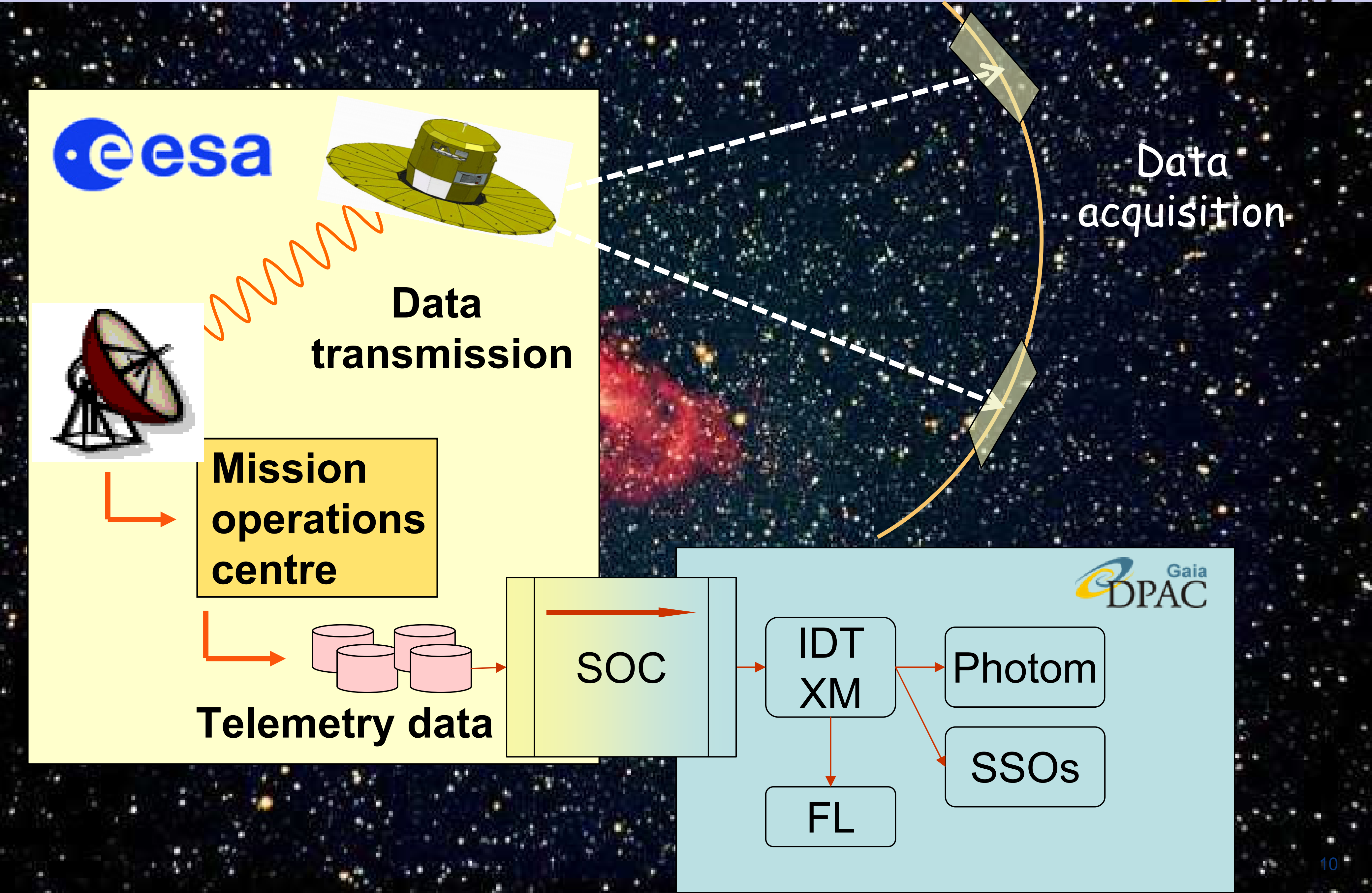
Alerts and Ground-based Observations

- Science Alerts (SA) need first a verification
  - Verification is part of the SA and managed by DPAC
- SA make sense only if there is an immediate follow-up
- follow-up execution must be done by the community
  - but DPAC should ensure that it is organised
    - for SSO, one must provide predictions for the observers
      - this cannot be fitted in the information sent to MPC
      - this is an interface between DPAC products and community service
  - ASA Follow-up provides feedback to the SSO processing
    - the return is important to help the processing
- Verifications are needed to qualify the alert systems
  - therefore the **coordination** of these observations must involve GBOG

General Data Flow

Constraints on the Science Alerts

Observations to transmission to DPAC

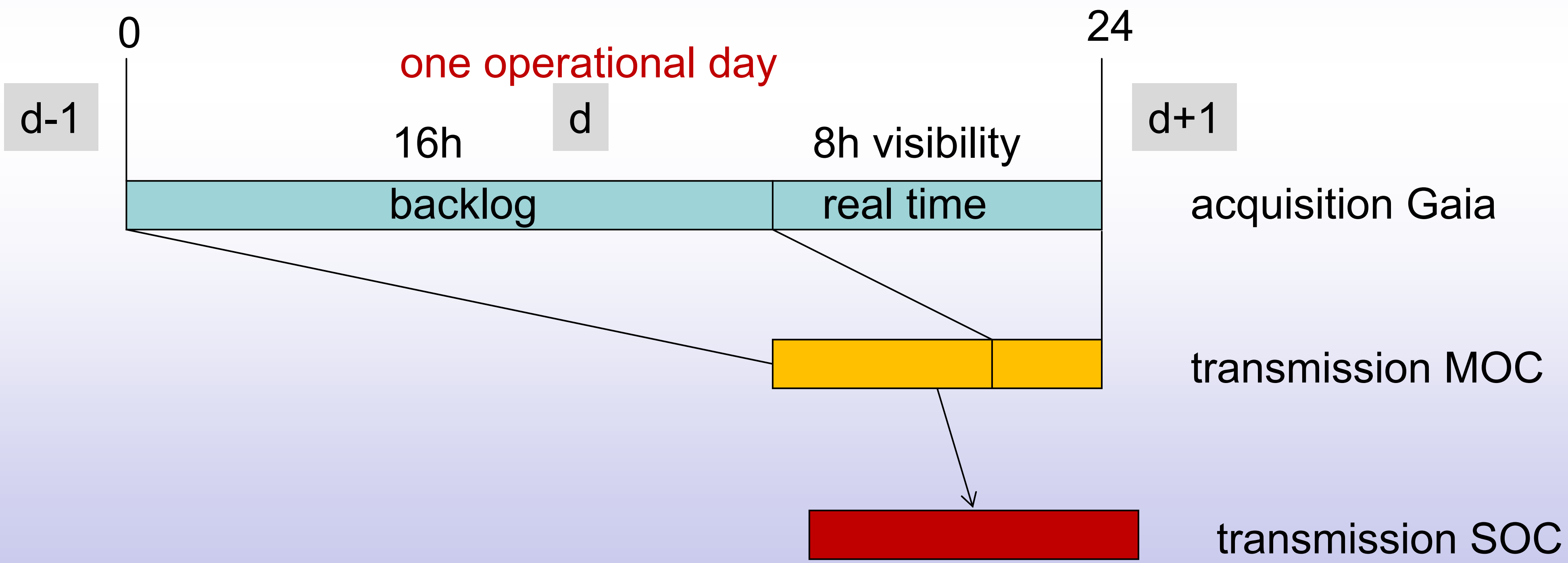


How and when data is down linked

- Gaia collects data 24 h per day
- Ground-station coverage, limited to ~8 h per night
  - standard case with a single station
- Data temporarily stored on board
  - There is a ~ 850 Gb solid-state mass memory
  - compressed star packets are stored
- The priority of star packets is based on the measured magnitude
  - fainter sources have lower priority
- Special care is given to FL requirements to always receive some faint-star data with high priority
- At worst a normal observation is on ground after 24h
  - but faint stars in dense regions may never be downlinked

Timeline for the data flow to SOC

- A day is the time between two successive satellite visibilities
- It starts at the end of pass, after 8 h of data transfer
  - 16 h blind + 8h visible
- Typical case with no on-board memory saturation



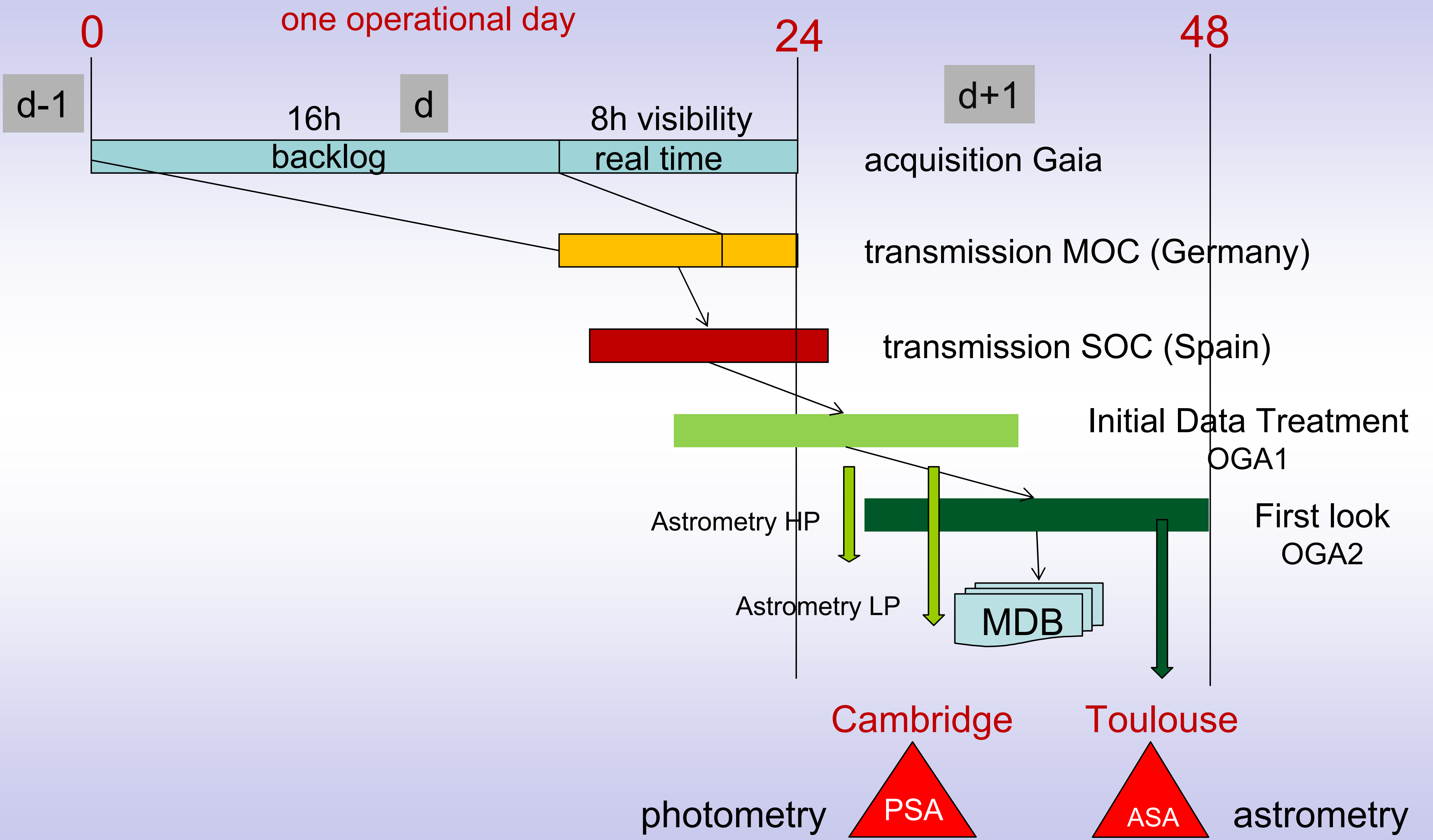
Data flow from SOC to DPC I

- 24 h of data must be processed (IDT/FL) in at most 24h
- Tasks to be accomplished during the day
  - IDT
    - creation of raw data objects from decompression of star packets
      - these are the original measurements, never updated
      - a transit ID is assigned to these observations
    - transit times and fluxes in IDT to produce intermediate objects
      - will be further improved with better calibration later
      - transit times in OBMT (on-board Gaia time)
    - Calculate improved attitude (50 mas) and 2D position on the sky
    - Cross matching intermediate objects to sources
    - Stored the results in the IDT/FL database

Data flow from SOC to DPC II

- First Look
  - one day calibration in astrometry, photometry, spectroscopy
  - one-day astrometric solution (ODAS) with 1D attitude to 100 muas
  - Detailed First look Monitor and Evaluator
  - Storage in IDT/FL database
- MDB updates
  - results of IDT/FL ingested in the MDB
- Timeline
  - IDT works on the fly as telemetry flows in the SOC system
  - F/L is more global and processes one day of observations
  - Data observed in day *d* is available to DPCs for alerts during day *d +1*
    - oldest observations may be 48h old
    - most recent observations could be less than 12 h

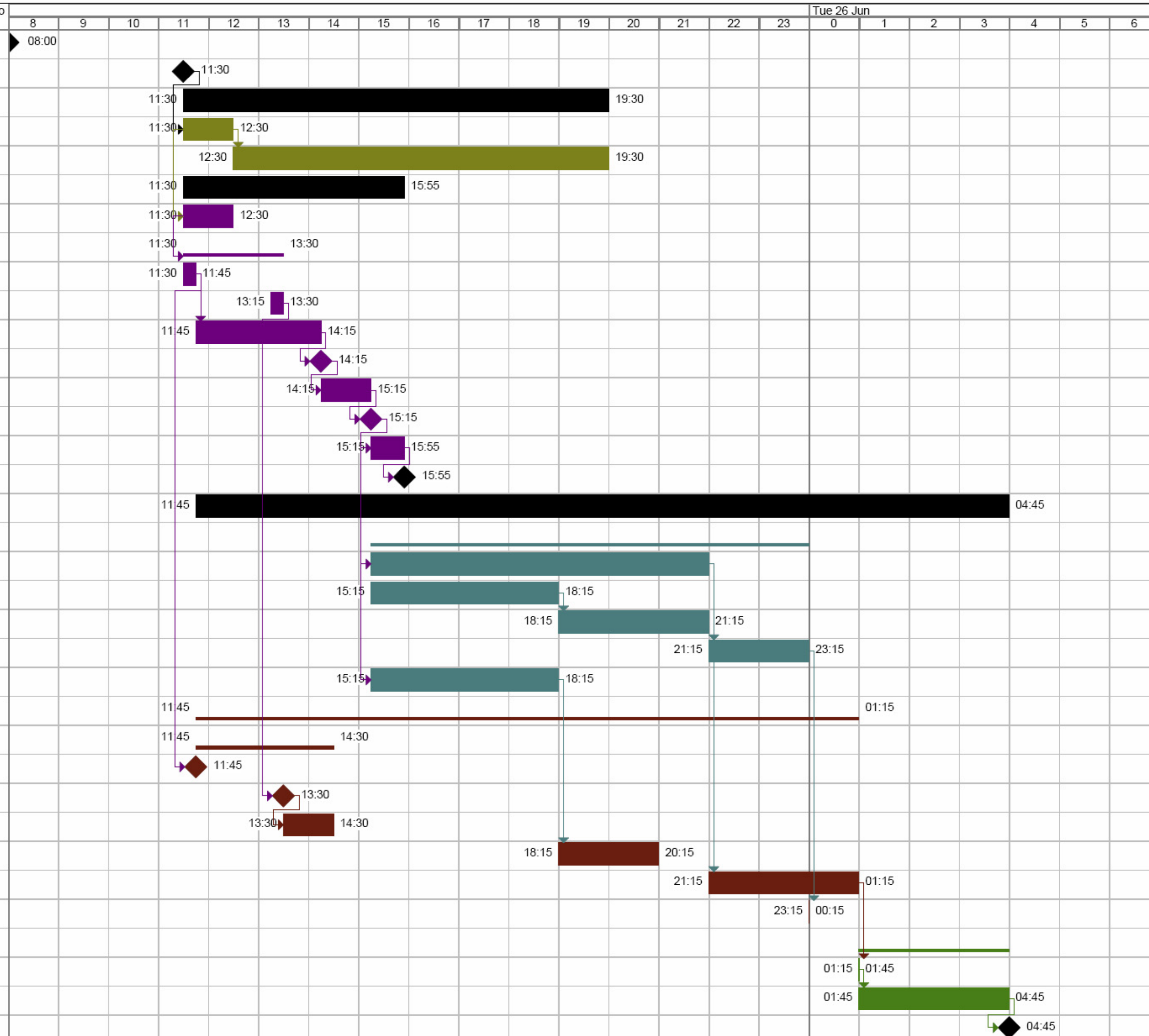
Timeline for the data flow Alerts



Gaia DPAC

Gaia DPAC OSG
OR#1 Day#1 Schedule

ID	Task Name	Duration	Predecesso
2	Start of MIT	0 mins	
3	Start of simulated contact from MOC	0 hrs	
4	**MIT CONTACT#1**	**480 mins**	
5	MIT CONTACT#1 (16 hrs data up to prority 49)	1 hr	3
6	MIT CONTACT#1 (24 hours all priorities)	7 hrs	5
14	**IDT RUN#1**	**265 mins**	
15	INITIALIZATION	60 mins	5SS
47	SUBRUNS (0->16hours day#1)	120 mins	15SS
48	First IDT SUBRUN	15 mins	
53	Last IDT SUBRUN	15 mins	
54	AP JOBS	150 mins	48
55	IDT_XM _START	0 hrs	54
56	FINAL XM	60 mins	55
57	IDT_XM_END	0 hrs	56
58	Maintenance	40 mins	57
59	**End of IDT RUN#1**	**0 hrs**	**58**
109	**FL RUN#1**	**1020 mins**	
111	ODC	480 mins	
112	ODAS	360 mins	57
113	primary adjustment	180 mins	
114	secondary source update	180 mins	113
115	LODC	120 mins	112
116	CODC	180 mins	57
117	DFLM	810 mins	
118	IDT related diagnostics	165 mins	
119	First IDT related diagnostics	0 hrs	48
120	Last IDT related diagnostics	0 hrs	53
121	IDT related DFLM diagnostics	60 mins	120
122	CODC DFLM	120 mins	116
123	ODAS DFLM	240 mins	112
124	LODC DFLM	60 mins	115
125	DFLE	210 mins	
126	Report Generation	30 mins	123
127	Human Inspection	180 mins	126
128	**End of FL RUN#1**	**0 hrs**	**127**



Early Operations Schedule I

- L = Launch in fall 2013
  - Cruise and insertion to L2 takes about one month
  - Followed by outgassing and return to thermal equilibrium
- First TM (Telemetry) data → L + 2.5 months
- Instrument Commissioning Phase → + 4 to 6 weeks
  - In-orbit spacecraft verification and early calibration
  - Evaluation of the scientific performance
  - Test of the different operation modes, adjusting AOCS, spin rate ...

Early Operations Schedule II

- Processing initialisation phase → + ~ 2 months
  - use a specific scanning mode (Ecliptic poles) with repeated observations
  - Initialise DPAC processing subsystems
  - More in-depth instrument calibration

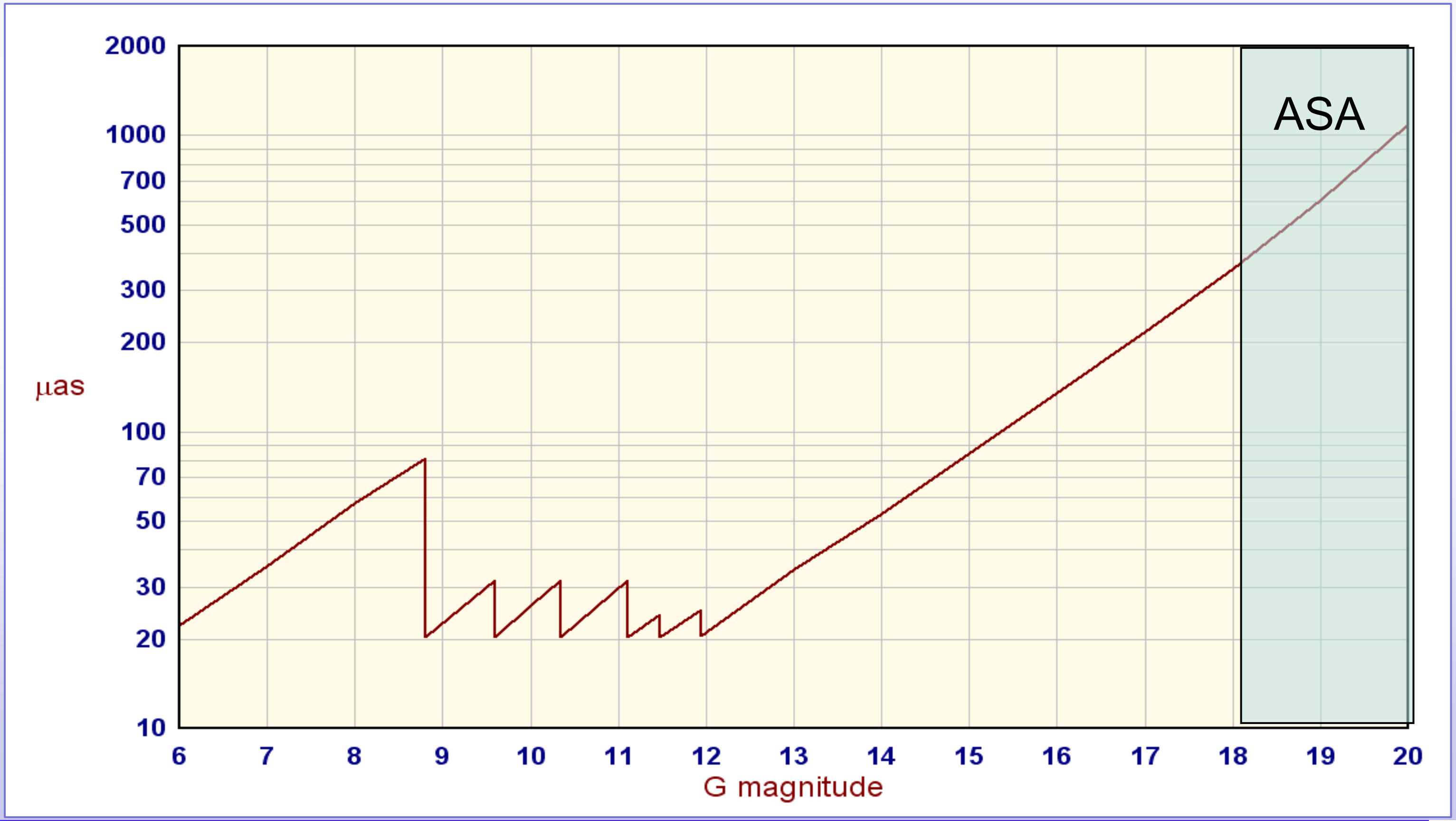
Start of Routine Operations : Launch + 6 months

- Regular data accumulation on the sky
  - Photometric & Astrometric alerts released internally
    - verification phase with ground-based observations
  - Routine alert systems in place
    - alert data made public

Some Issues for the Solar System Alerts

Astrometric accuracy: single observation

- Small field accuracy with final attitude
- Single observation accuracy ➔ orbit, solar system
  - one field transit
  - point source



Short term astrometric accuracy

- Depends on :
  - centroiding accuracy
  - geometric calibration
  - attitude reconstruction

Attitude precision and accuracy	Random	Syst.
IOGA = initial on-ground attitude from AOCS	6 arcsec	
OGA1 = on-ground attitude IDT	10 to 50 mas	~ 50 mas
OGA2= on-ground attitude FL	100 muas	~ 50 mas
~~OGA3= AGIS attitude~~	~~20 muas~~	~~< 1 muas~~

not available for alerts

Interval between observations

- Typical Sequences
  - **Successive observations :**
    - PFOV, FVOV, PFOV ….
    - FFOV, PFOV ….
  - **a short sequence of successive observations is *a bundle***
    - it corresponds to an epoch for astrometry
    - it is very important for solar system object identification
  - **Return of a short sequence after few weeks**
    - Typical gaps of 30 days, but smallest gap < 10 days
- Dependence with ecliptic latitude
- over the mission: about 85 observations and 30 epochs

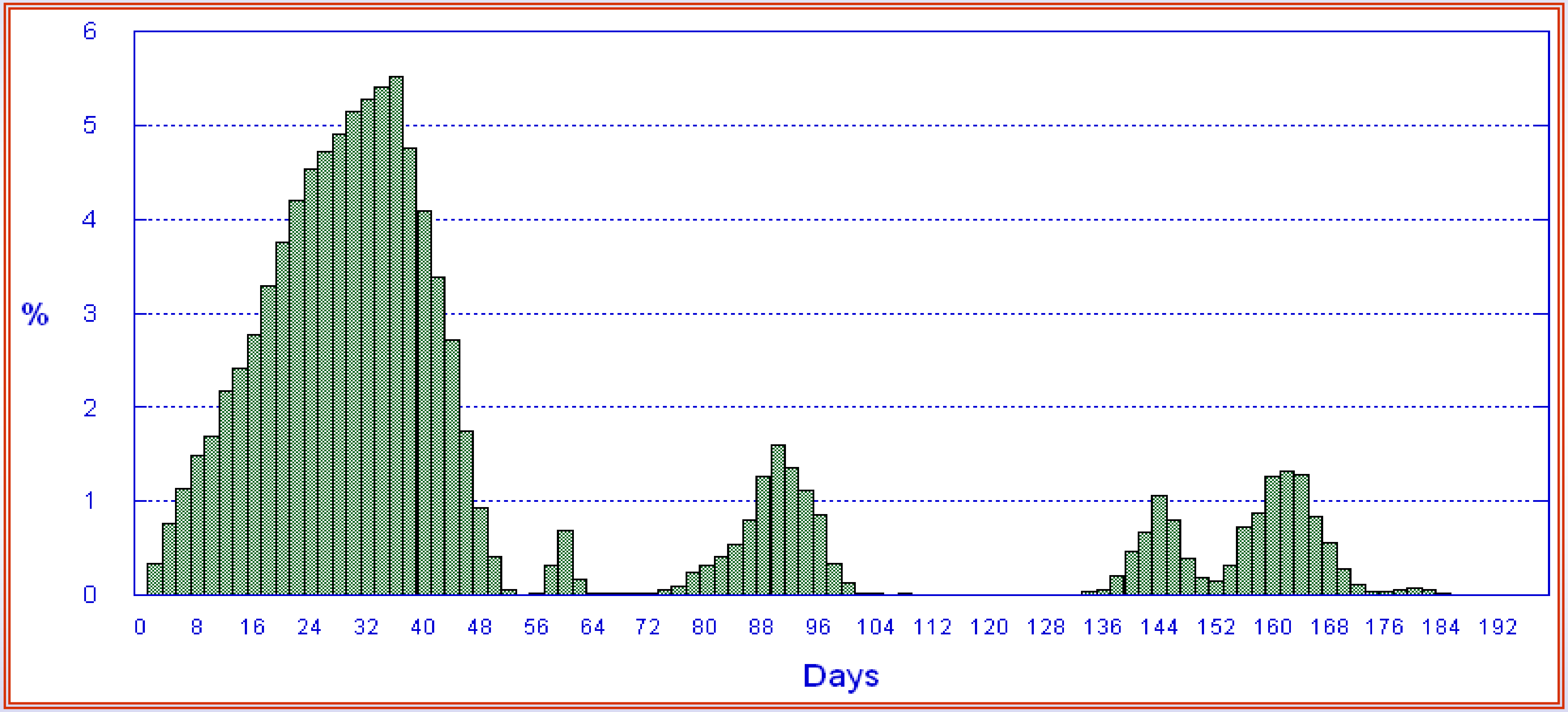
Distribution of short sequences

P… (70%)	Freq		F… (30%)	Freq
	%			%
P	24		F	56
PF	60		FP	23
PFP	6		FPF	14
PFPF	6		FPFP	2
PFPFP	1		FPFPF	2
PFPFP…	3		FPFPF…	3

- Statistics from solar system objects

Distribution of long gaps

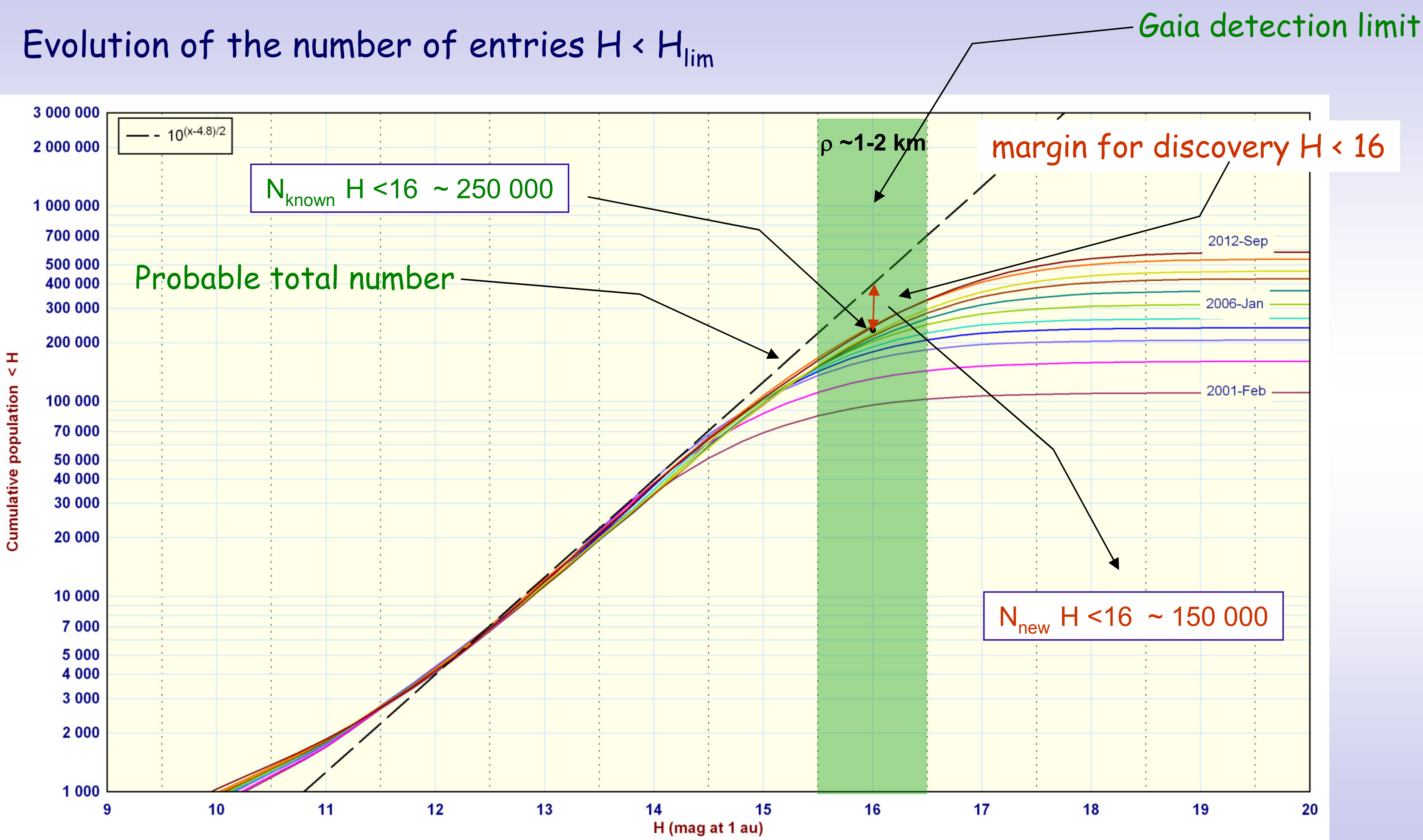
- Histogram of the gaplengths between two short sequences



- Only single epoch observations available for GSA

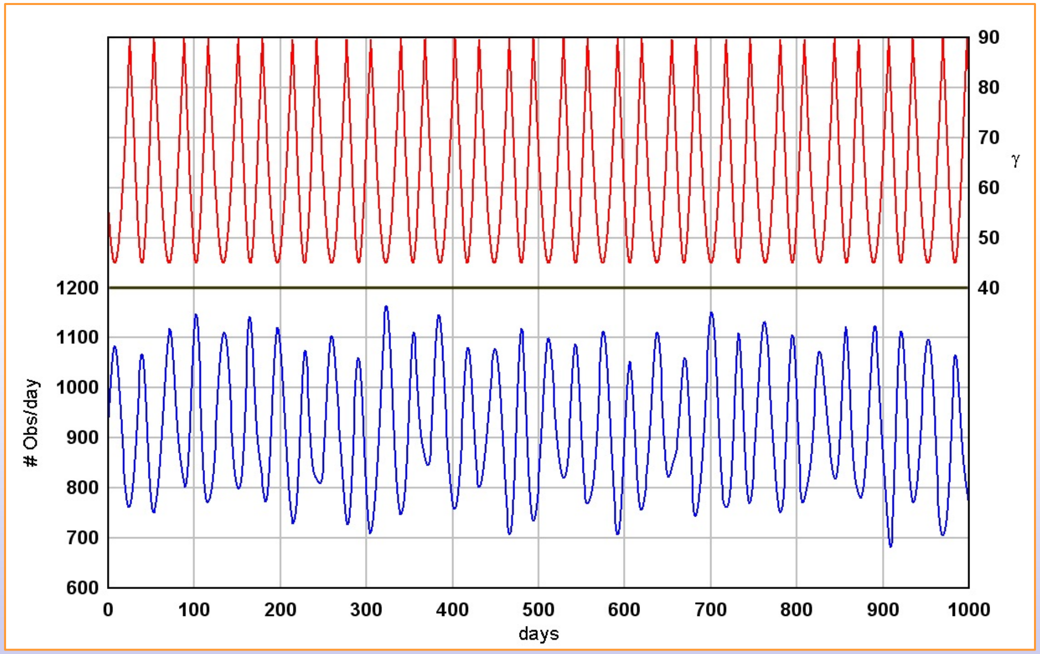
How many new asteroids for the ASA ?

- Evolution of the number of entries $H < H_{lim}$

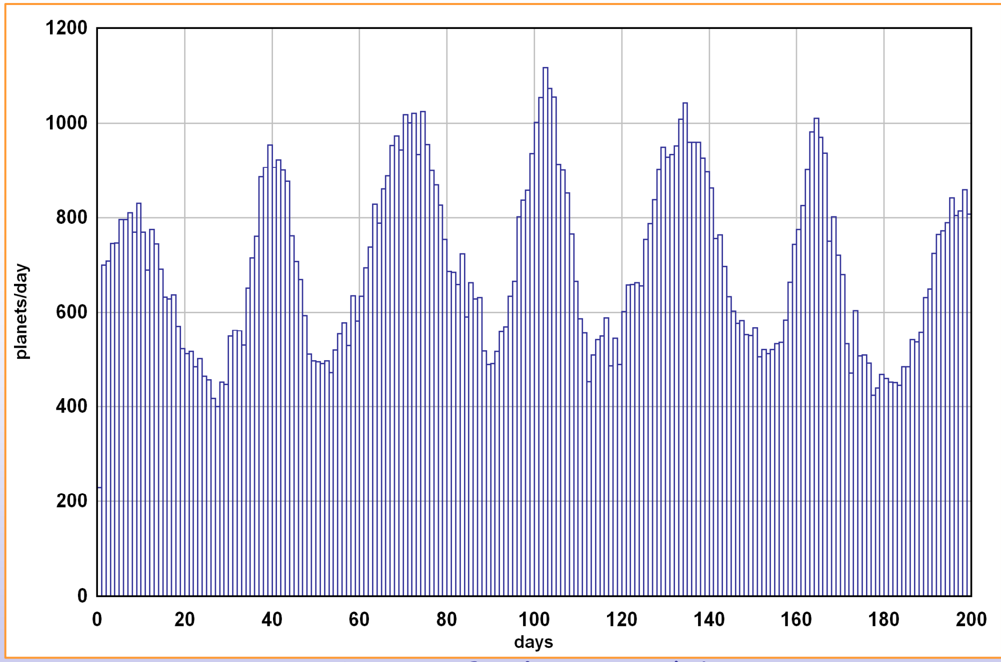


Number of new planets per day

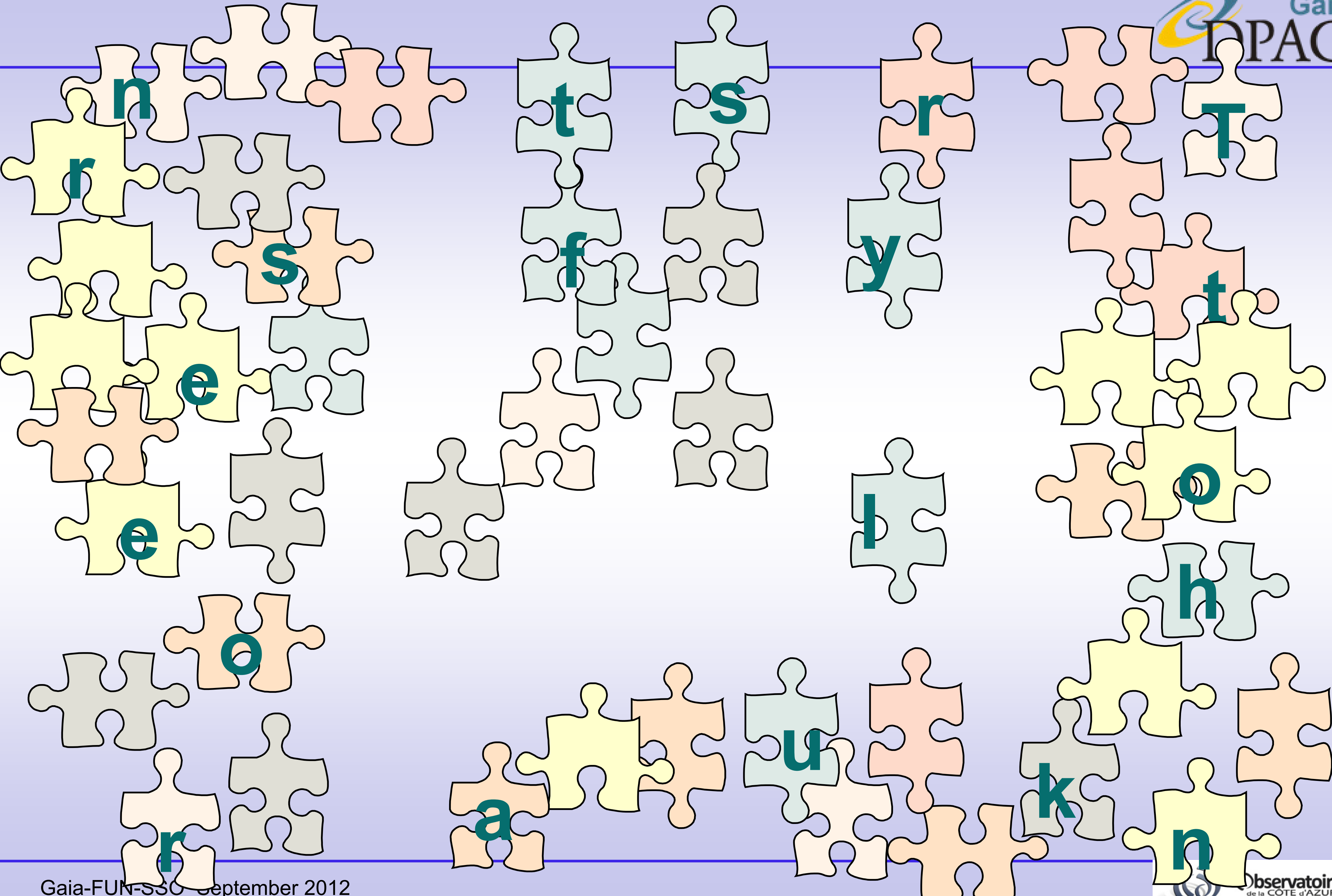
- Assume there are **30,000** potential discoveries
  - on the average this gives 900 transits per day
    - small scatter (+/- 15%) with the inclination of the scan to the ecliptic
  - But same planets observed 1, 2 or more times
    - average number of 700 planets, with large scatter +/-40%



Number of observations/day



Number of planets/day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