The Gaia-Follow up network for Solar System Objects

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&
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Outline

- Gaia framework and goal
- the Gaia-FUN-SSO network
- Actions 2012, 2013…and future

Need of ground-based SSO observations

- Solar System Objects : important part of the Gaia mission
- Gaia obs. for asteroids : prec. singl meas.: 0.3-3 mas
- 300 000 asteroids (most known)
- including several NEAs, Trojans, Centaurs
- Other SSO: comets, natural satellites

- High astrometric accuracy but…

limiting factors for SSO ←

- Scanning law
- Sampling
- Limiting magnitude

↓

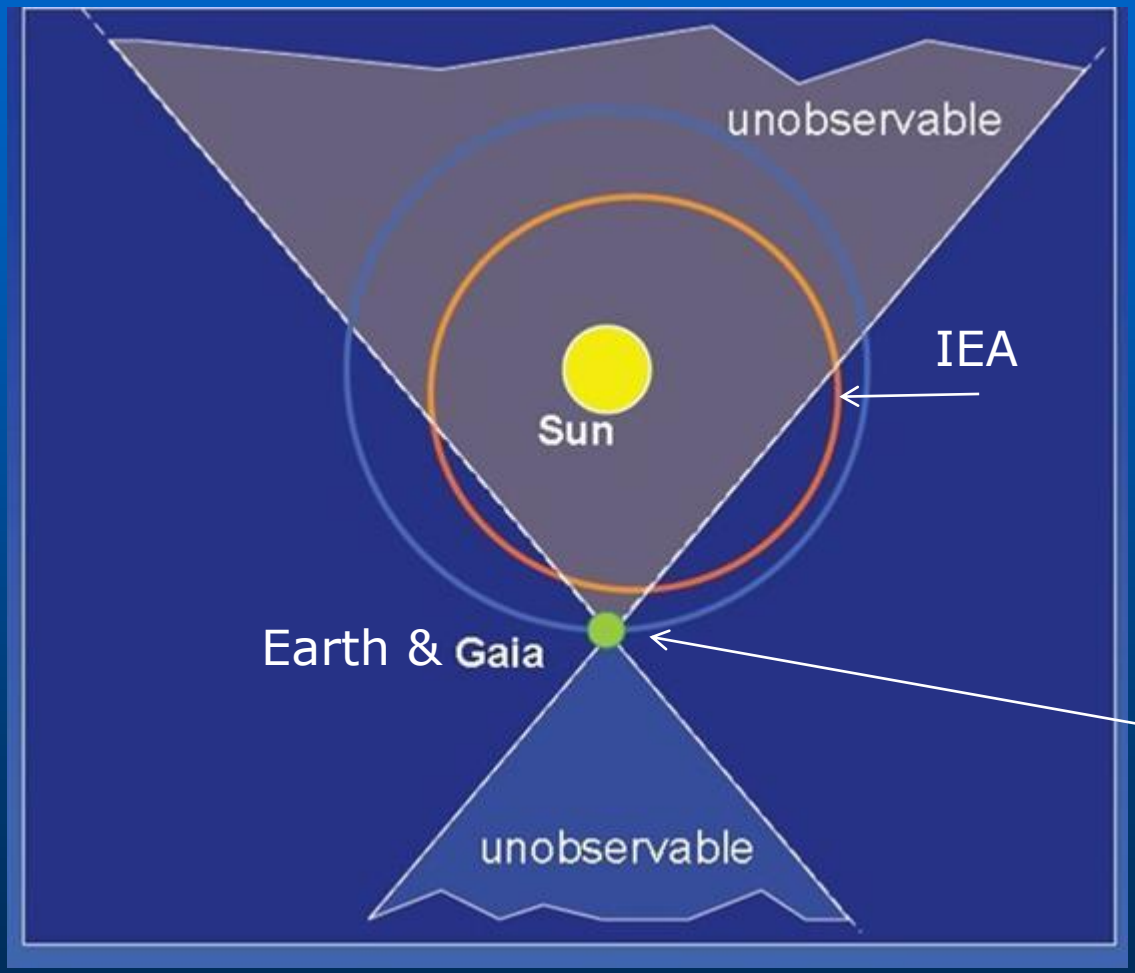
Complementary GB observations required

- to confirm some new detection
- to avoid the loss of moving objects
- to improve orbit poorly observed by Gaia

gaia

Gaia FUN SSO

Observable region in ecliptic



Gaia will observe at low Solar elongation ~ 45 deg.

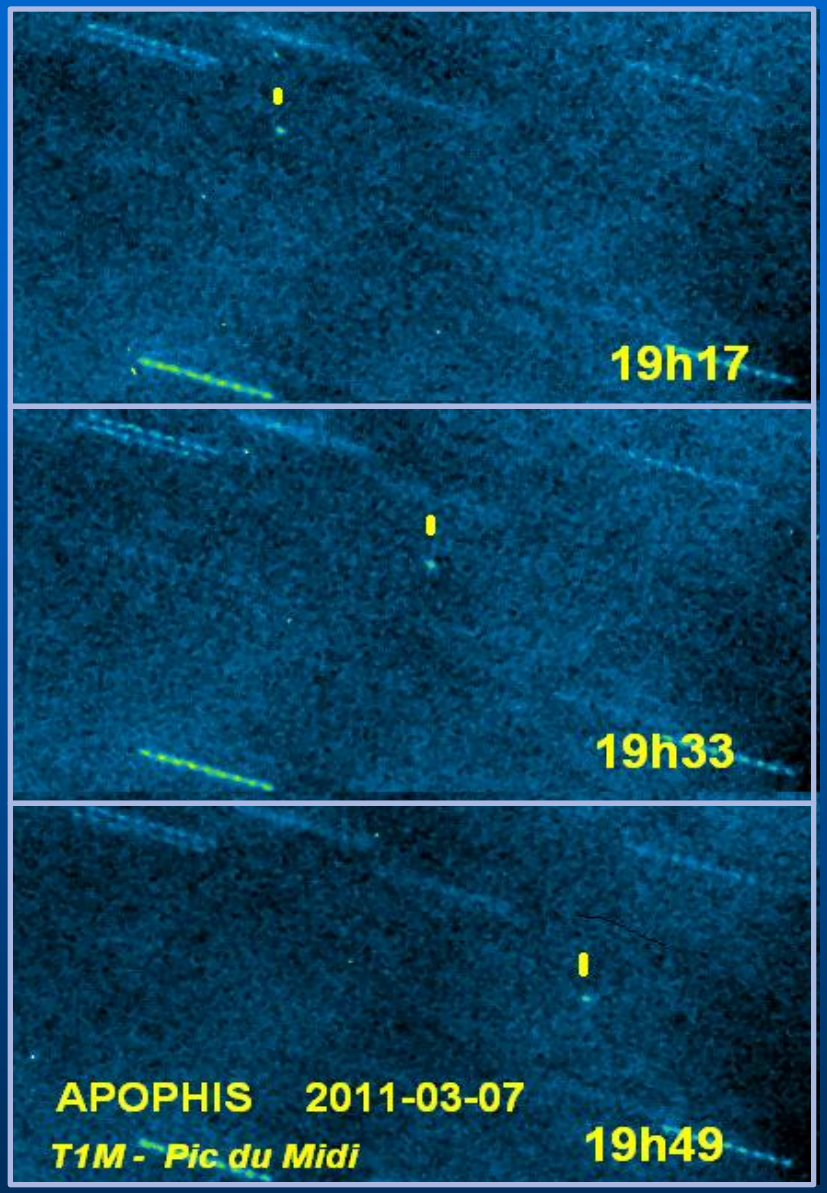
Detection of Inner Earth Asteroids possible

Earth
+ Gaia at L2
(1.5 Mkm)

Observers: F. Colas, F. Vachier, M. Birlan (IMCCE)

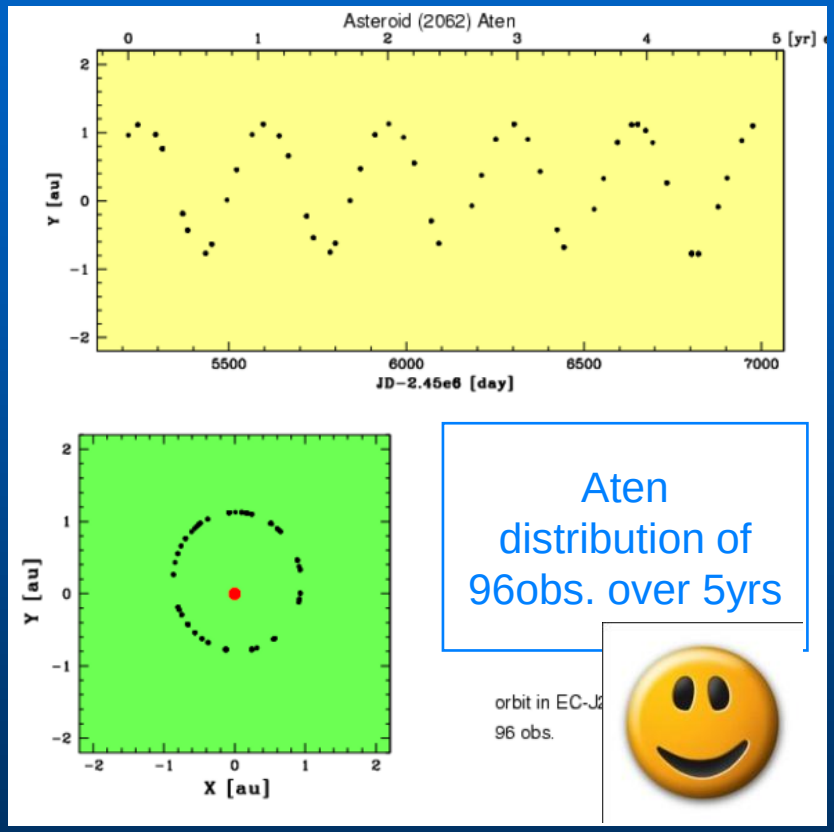
- ✓ Pic-du-Midi Obs. (French Pyrenean mont., 2877 m)
- ✓ 1m telescope
- ✓ Dates: 4.8 to 7.8 March 2011
- ✓ 69 observations

- ✓ Observed in twilight conditions (elong. 49 deg.):
  - Low above the horizon at the sunset (30-24 deg.)
  - Magnitude : ~21
  - Velocity 2.7 arcsec/min.

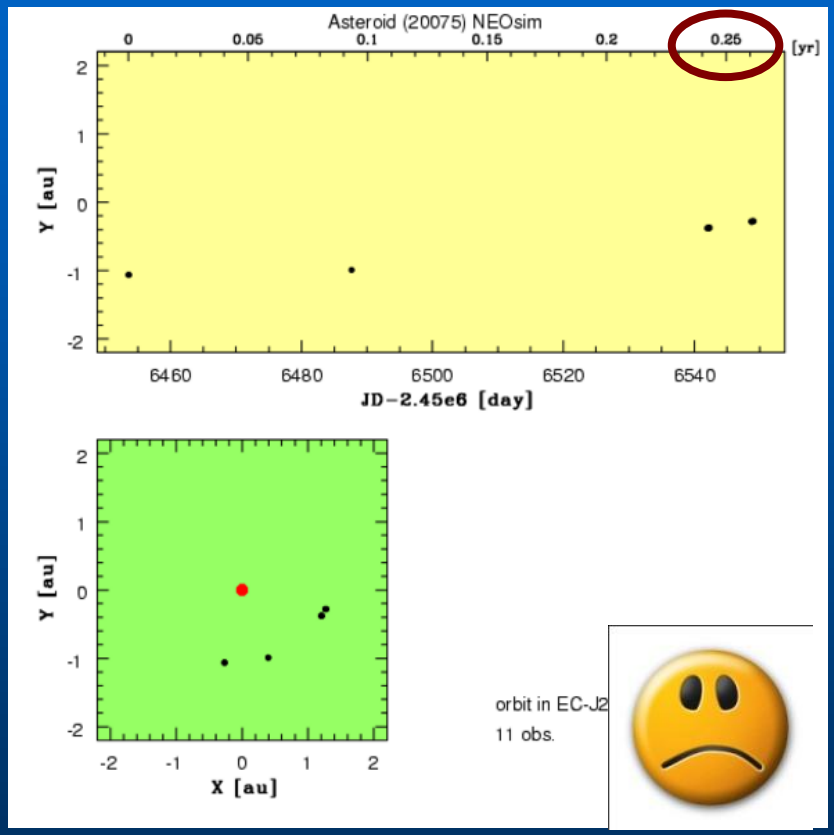


Need of ground-based observations

5 years



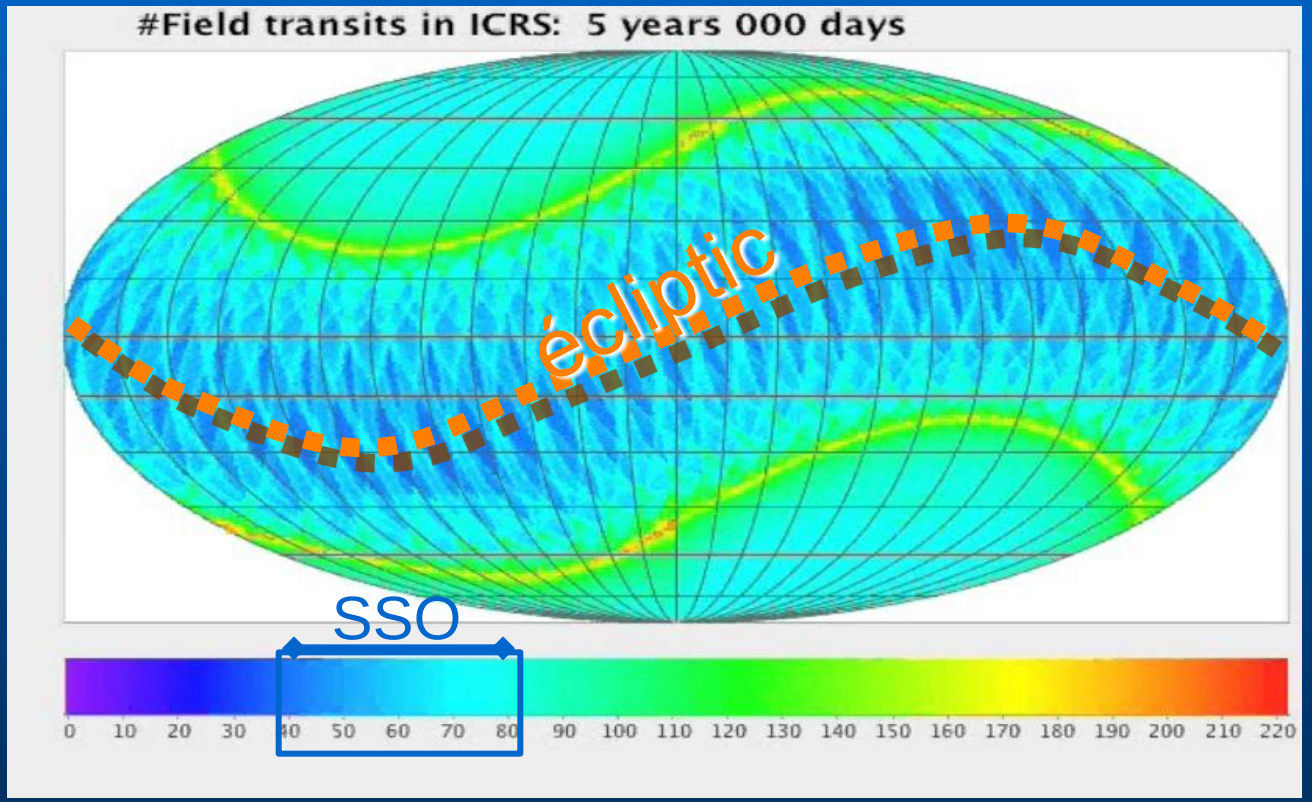
0.25 years



Gaia observations

≈300.000 asteroids

- mag. V≤20
- scanning law
- ≈ 60 obs./ SSO



Gaia observations

Detection of New objects?

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- mag. V≤20
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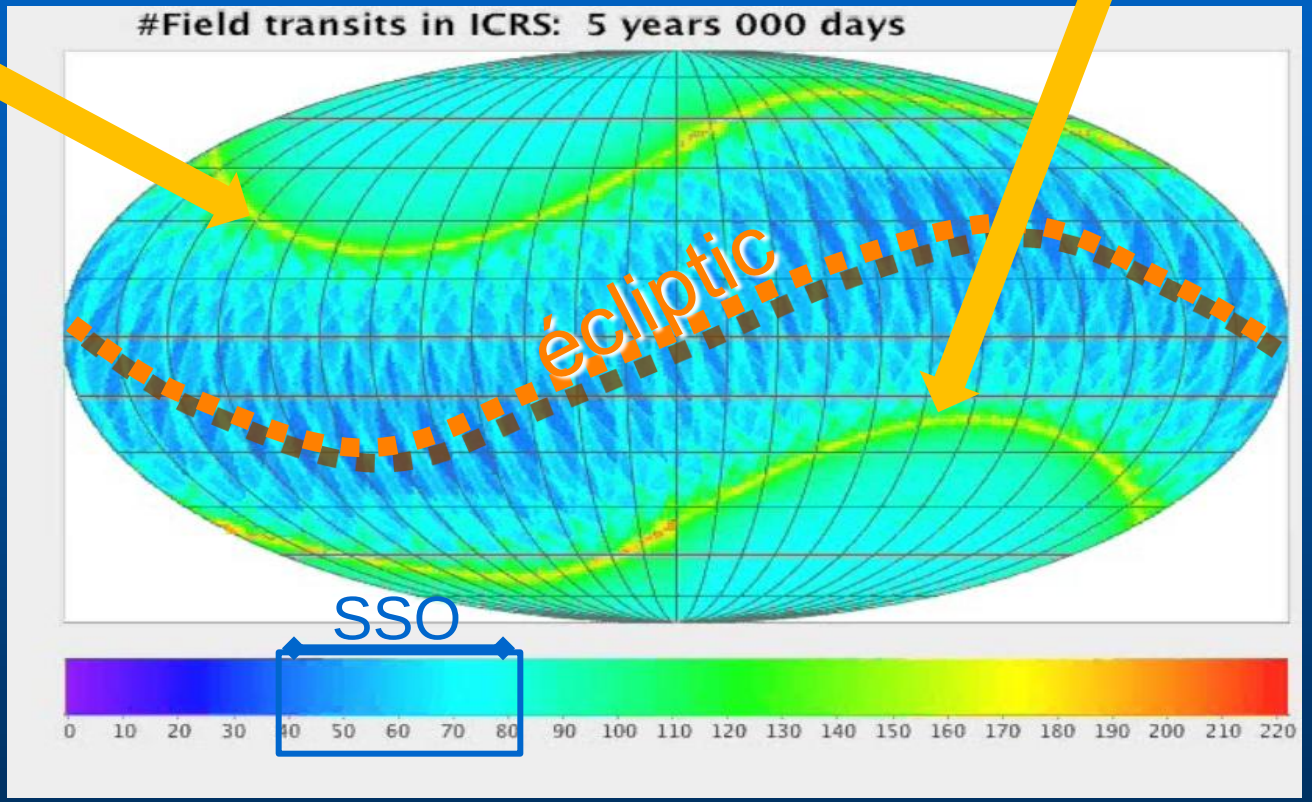


Need of ground-based observations

- Dedicated network
- Capacity to observe on alert
- CCD Astrometry & photometry
- Coordinated action

- DPAC –CU4 specific task
- Network Gaia-FUN-SSO

Need of ground-based observations

✓ GBOT network: Ground Based Optical Tracking for Gaia

➔ No alert – astrometry of the probe

✓Photometry/Spectroscopy Science alerts network

✓➔ Transient events – astrophysical objects (GRB, SN, …) sometime very fast reaction required

Possible synergy

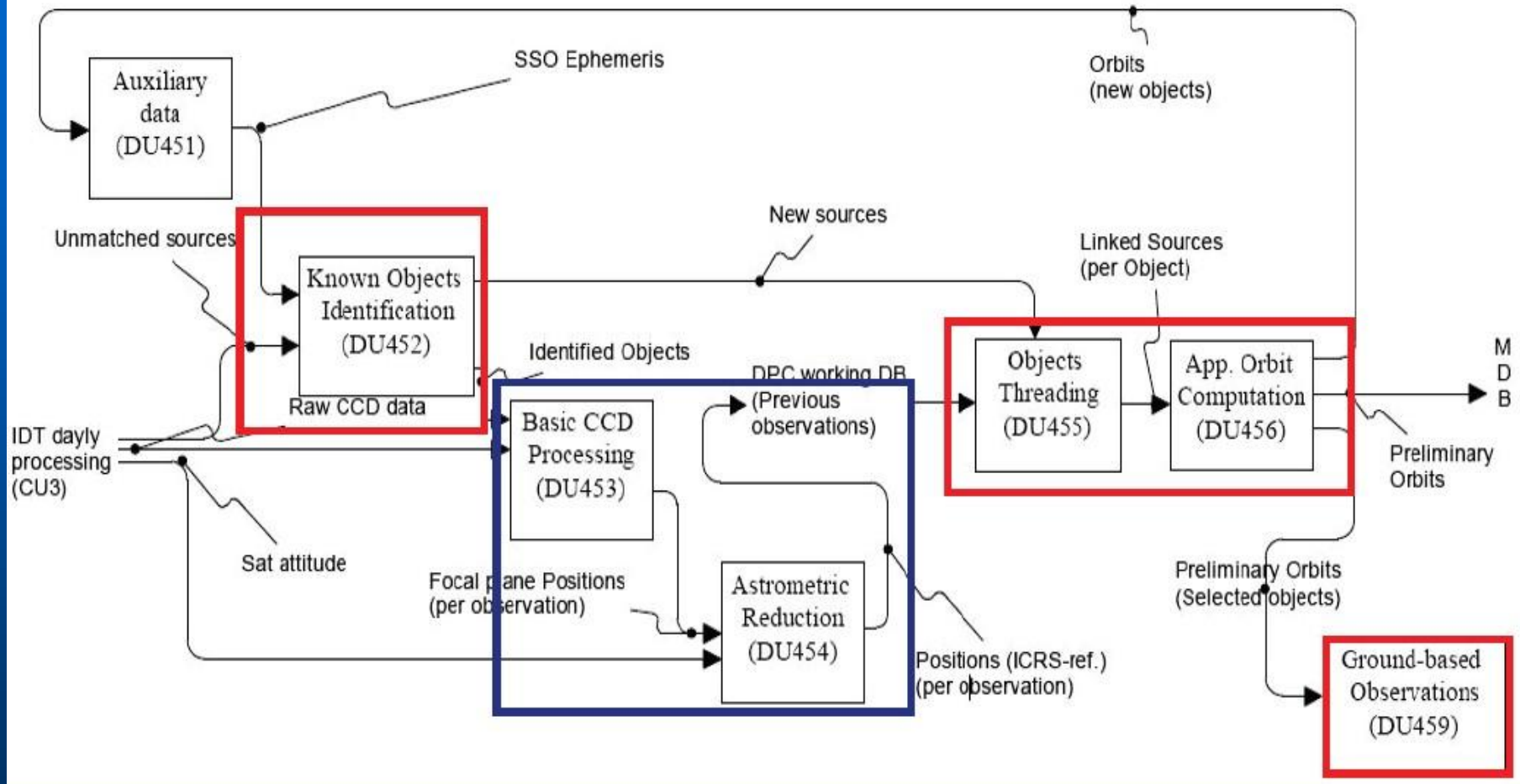
- Getting in touch with common observing sites
- Crossed links on web pages / wiki
- Joint meetings / invited talks

✓Gaia-FUN-SSO : Gaia Follow-Up Network for ground-based observation of peculiar (critical) Solar System Objects

➔ Astrometric alerts for Solar System Objects: main task

➔ Photometry follow-up : possibly

CU4 SSO: data flow (daily processing)



Central node activity: Data to diffuse

- Role of DU459:
  - receive alerts
  - change Gaia data (gbins) in data useful for GB observations
    - focusing a sky zone of interest
    - providing ephemerides (center of FOV) in topo. coord. (ASCII)
    - for GB campaign for 10 to 30 days
    - providing vizualisation of this zone with known objects and target possible positions (snapshot / URL for a link)

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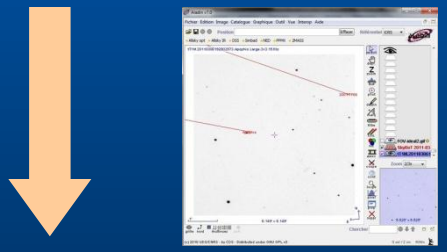
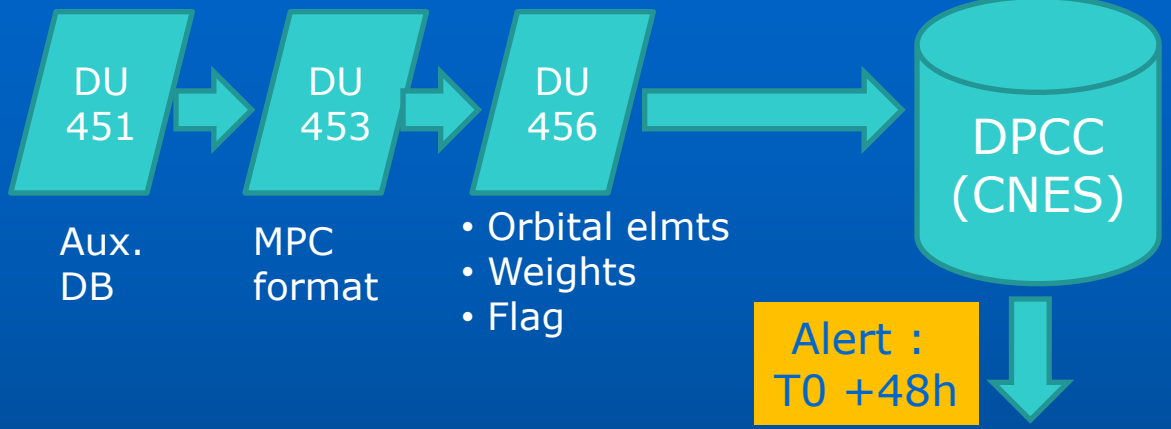


  - deliver these data to the central node for diffusion in Gaia-FUN-SSO
  - make this process automatic (+monitoring and control)
  - keep archives (on wiki presently)

- Gaia framework and goal
- the Gaia-FUN-SSO network
- Actions 2012, 2013…and future

Detection : T0

Short term processing

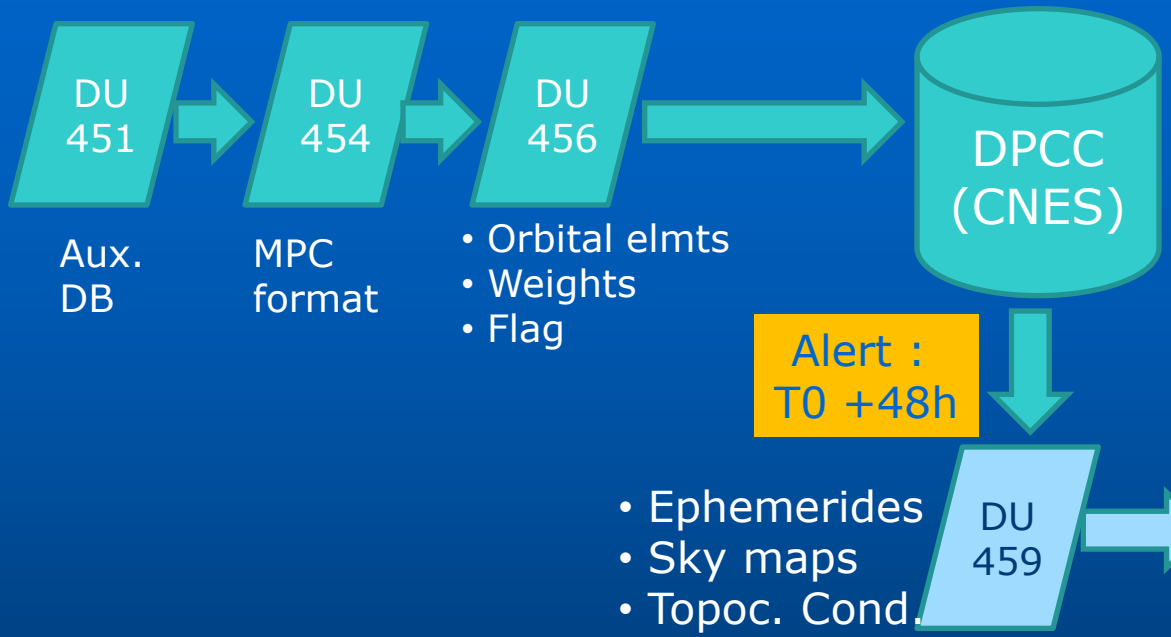


Work chain For SSO Ground based Follow-up

Detection : T0

Work chain For SSO Ground based Follow-up

Short term processing



Work chain For SSO Ground based Follow-up

Detection : T0

Short term processing

DU 451 → DU 454 → DU 456 → DPCC (CNES)

Aux. DB

MPC format

- Orbital elmts
- Weights
- Flag

Alert : T0 +48h

- Ephemerides
- Sky maps
- Topoc. Cond.

DU 459

Gaia-FUN-SSO

Central Node

- Station 1
- .../...
- Station 37

ASTORB Data base

Lowell Obs.

« Gaia » format

MPC format

MPC

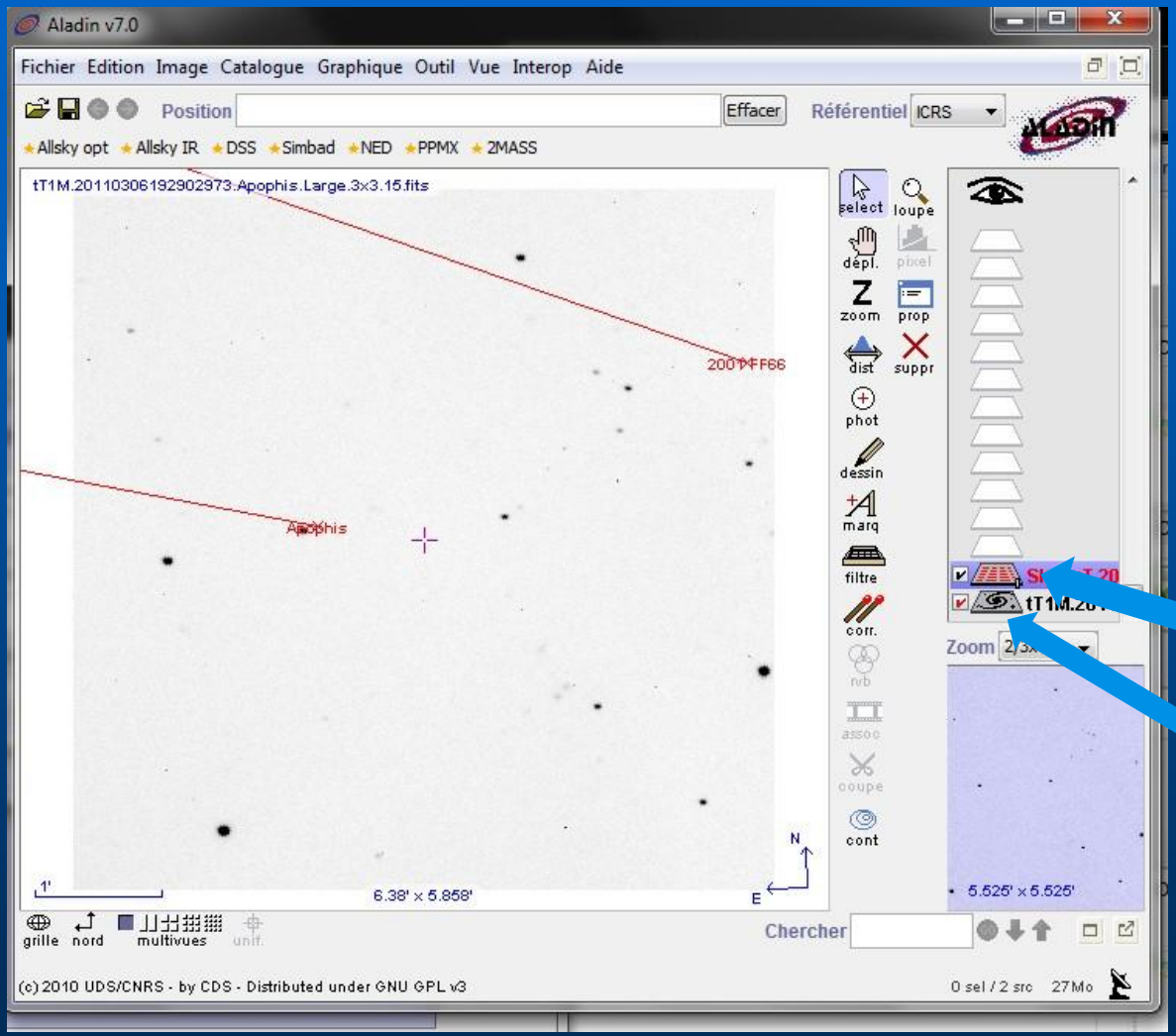
+ SSA

Central node activity: Data to diffuse

Sky maps:
diffusion of a link to Aladin Sky Atlas
http://aladin.u-strasbg.fr/

- Ephemerides
- Topoc. Cond.

Central node activity: Data to diffuse

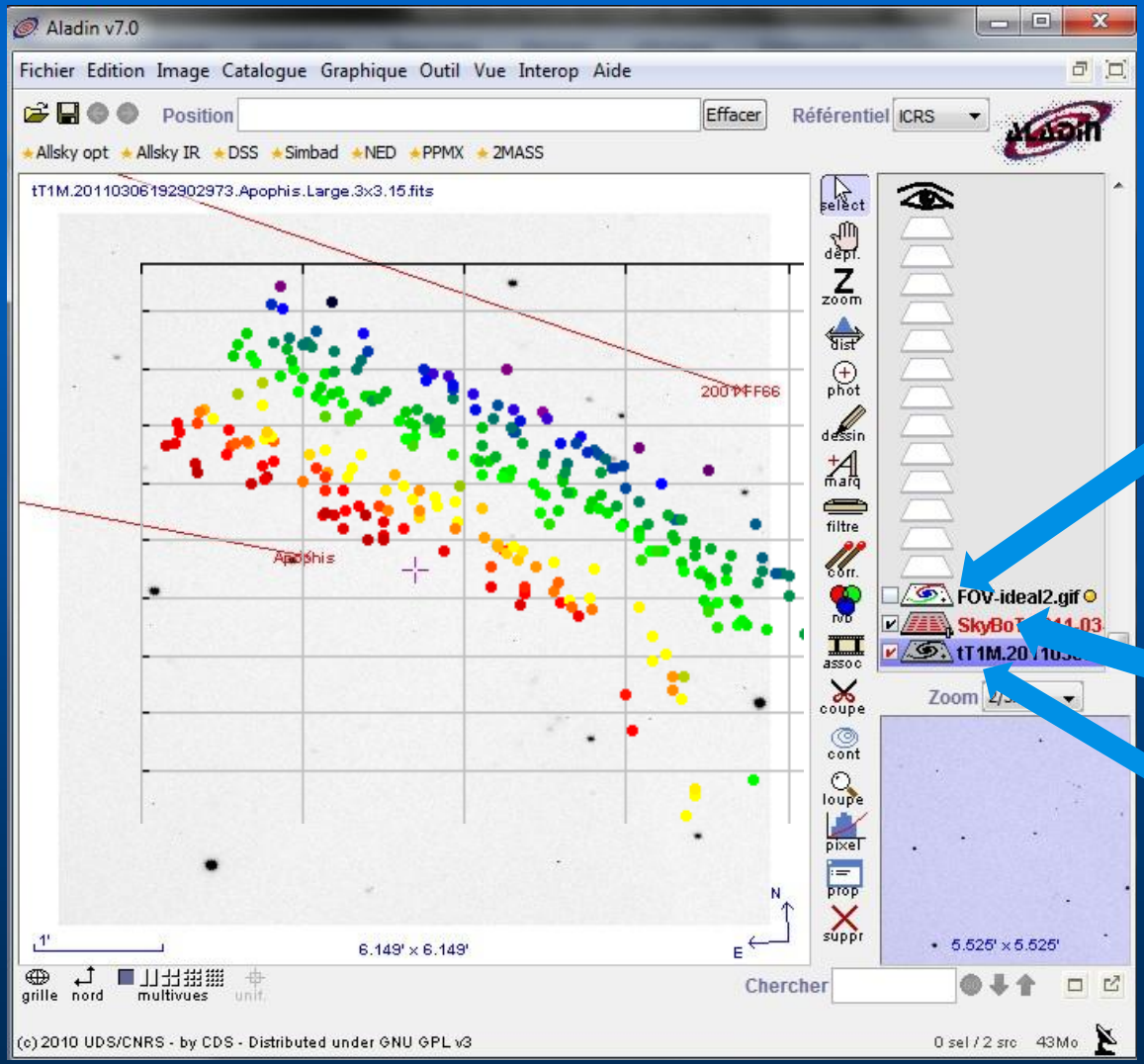


- Sky maps: diffusion of a link to Aladin Sky Atlas http://aladin.u-strasbg.fr/
- Ephemerides
- Topoc. Cond.

2) Known SSO in FOV (SkyBoT)

1) DSS field

Central node activity: Data to diffuse



3) Probable locations of target in FOV

2) Known SSO in FOV (SkyBoT)

1) DSS field

Gaia-FUN-SSO in 2012 (1/2)

First workshop Gaia-FUN-SSO Nov. 2010
+
Various direct contacts

Forms for registration

- Localization
- Instrument specification
- Observer contact
- Possibility of alert mode?
- Administrative contact
- Complementary information
- Needs
- Past and present domains of observation
- Comments

Wiki open in 2011

List of participants

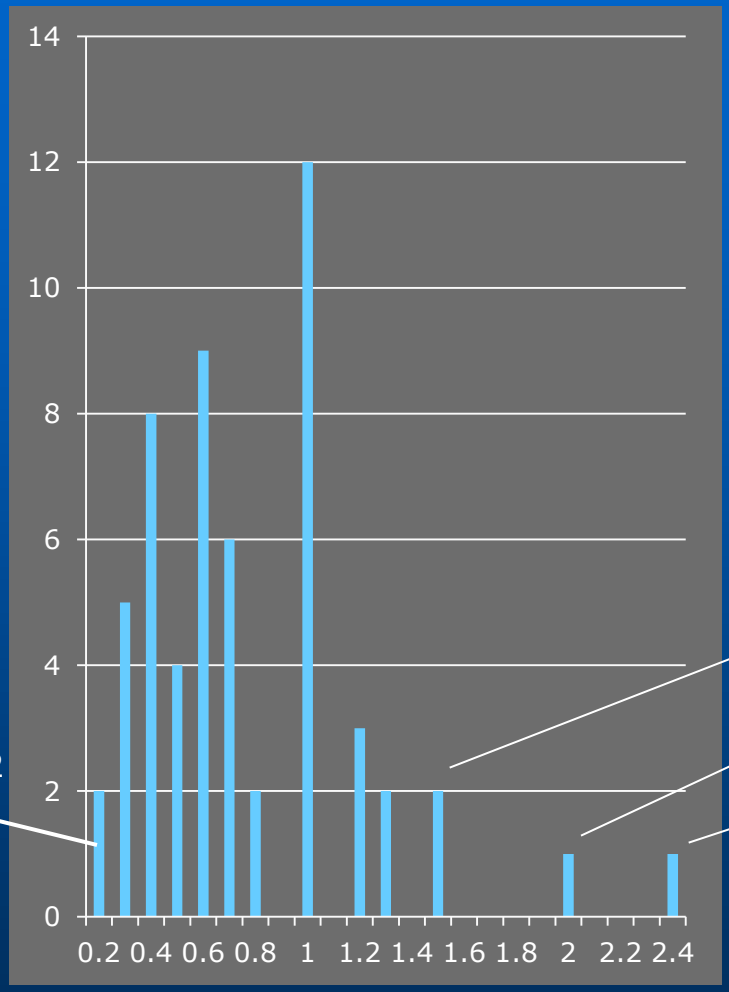
Gaia-FUN-SSO in 2012 (1/2)

Name	Location	Diameter (m)	Needs?
Zadko, Perth	Australia	T1 Robotic	Yes
Rozhen Obs.	Bulgaria	T2/T0.7 Schmidt	Yes
ESA Optical Ground St.	Canary Isl.	T1 Robotic	Yes
Tarot 2/ESO La Silla	Chile	T 0.25 Robotic	-
Santiago Cerro el Roble	Chile	T0.7 Maksutov	Yes
Yunnan obs. Lijiang,	China	T 2.4	Yes
Xuyi , Nanjing	China	T 1 Schmidt	Yes
Weihei Shandong	China	T1	-
Ondrejov	Czech rep.	T0.65/T1.54	-
Pic-du-Midi obs.	France	T 1	-
St Michel-OHP	France	T 1.2	-
Bordeaux-Obs.	France	T0.6	-
Cote d'Azur Obs.Calern	France	T1/T1	-
Tarot 1, Calern	France	T 0.25 Robotic	-
Les Makes, La Réunion	France	T0.6	-
ISON-Abastunami	Georgia	T1.25/T0.7	Yes
Konkoly	Hungaria	T1/T0.6/T0.4 Schmidt	Yes
Devashtal	India	T1.30	Yes
Armagh Obs.	Ireland	T0.4 ?	-
OVDA	Italie	T0.8	Yes
Bisei-Spaceguard	Japan	T1/T0.5	Yes

Gaia-FUN-SSO in 2012 (2/2)

Observers	Location	Diameter (m)	Needs?
Pulkovo Obs.	Russia	T0.32/L 0.33 / L 0.65	Yes
Kislovodsk (Pulkovo)	Russia	T0.5 Maksutov	Yes
ISON-Ussurijsk Obs	Russia	T0.5	Yes
ISON-Terskol	Russia	T0.8	Yes
Sobaeksan	South-Korea	T0.6	-
ISON-Sanglok	Tadjikistan	T1/T0.6	Yes
ISON-Gissar	Tadjikistan	T0.7	Yes
Tubitak, Antalya	Turkey	T1 /T0.4 Remote	-
NAO Nikolaev	Ukraine	T 0.5/T0.3	Yes
Los Molinos obs.	Uruguay	T0.46/T0.35/T0.3	-
AZT-8 Evpatoria	Ukraine	T0.7	Yes
ISON—Lesnyky-Kiev	Ukraine	T0.7/T0.48	Yes
ISON-Chugevskaia,	Ukraine	T0.7	Yes
ISON-Simeiz	Ukraine	T1/T0.6	Yes
NAO Nikolaev	Ukraine	T 0.5/T0.3	-
Los Molinos obs.	Uruguay	T0.46/T0.35/T0.3	Yes
Lick Nickel	USA	T1 Kitt Peak ?	-
Super Lotis	USA	T0.6 Robotic ?	-
ISON-NM MayHill	USA	T0.45	Yes
Vatican-VATT	USA	T1.8 ?	-
ISON-Maidanak	Uzbekistan	T1.5/T0.6	Yes
ISON-Kitab	Uzbekistan	T0.4	Yes

Gaia-FUN-SSO



Telescope diameters (m)

Tarot 1 & 2

- ESO La Silla Danish tel. –Ondrejov
- Maidanak Astr. Obs.,Tashkent (Uzbekistan)

IAU71-NAO Rozhen, Smolyan, (Bulgaria)

Yunnan Observatory
Lijiang station (China)

Gaia-FUN-SSO

39 (43?) observing Sites

55 operating instruments

Including:

✓ 3 Schmidt tel.

Rozhen / Xuyi / Konkoly

✓ 4 (-?) robotic tel.

Tarot 1 & 2 / Zadko / ESA-OGS

Super Lotis (?) / Nickel (?)

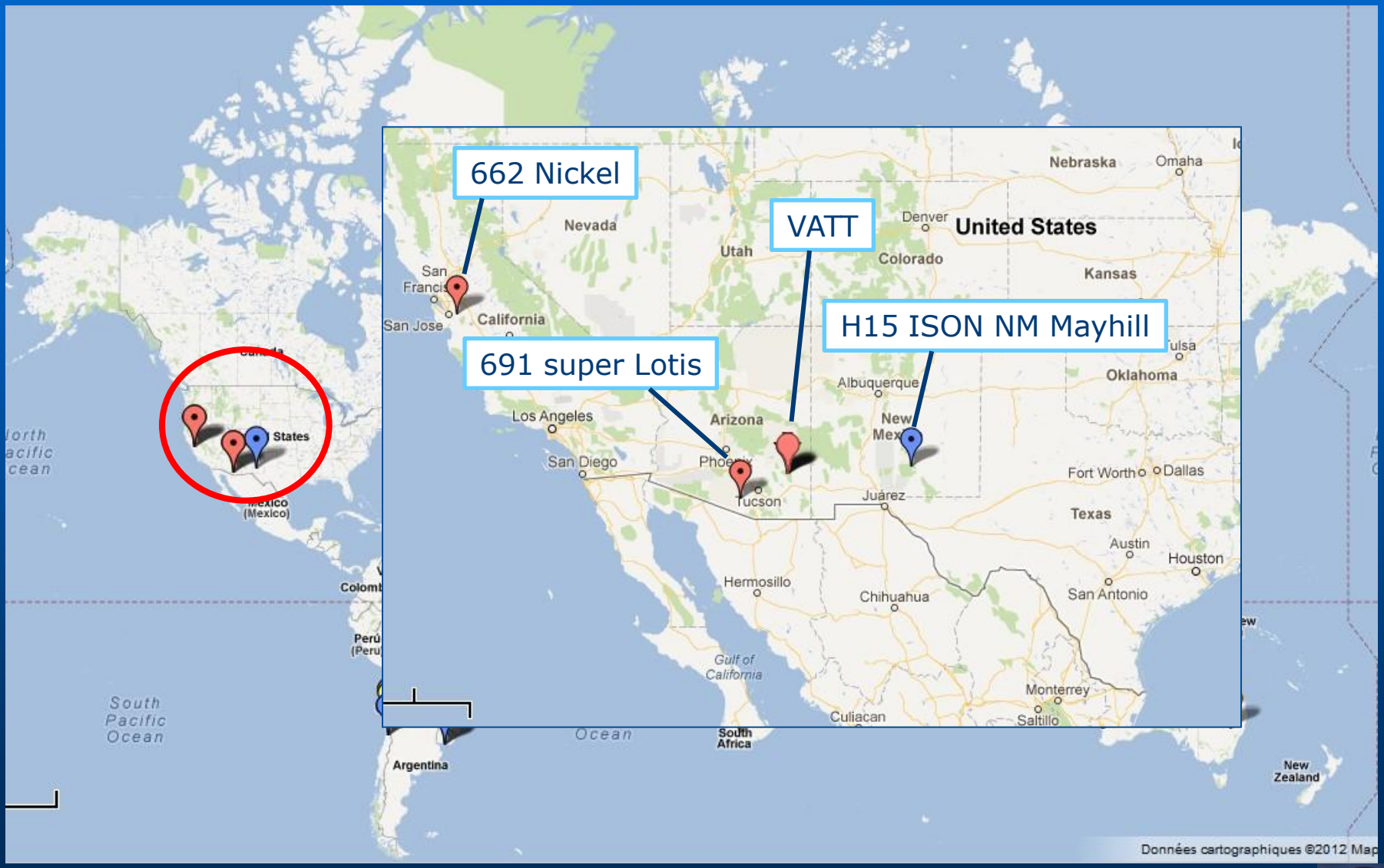
✓ 2 remote tel.

NM-Mayhill / Tubitak

Gaia-FUN-SSO


Kalaallit Nunaat (Greenland)
Suomi (Finland)
Sverige (Sweden)
Ísland (Iceland)
Norge (Norway)
Россия (Russia)
Canada
United Kingdom
Казахстан (Kazakhstan)
Монгол Улс (Mongolia)
España (Spain)
Italia (Italy)
States
North Atlantic Ocean
中国 (China)
日本 (Japan)
México (Mexico)
العراق (Iraq)
ایران (Iran)
افغانستان (Afghanistan)
پاکستان (Pakistan)
India
الجزائر (Algeria)
ليبيا (Libya)
مصر (Egypt)
السعودية (Saudi Arabia)
Mali
Niger
تشاد Tchad (Chad)
السودان (Sudan)
Nigeria
Ethiopia
Venezuela
Colombia
Kenya
DR Congo
Tanzania
Indonesia
Papua New Guinea
Perú (Peru)
Brasil (Brazil)
Bolivia
Angola
Namibia
Madagasikara (Madagascar)
Indian Ocean
South Pacific Ocean
South Atlantic Ocean
Australia
South Africa
Argentina
New Zealand
Données cartographiques ©2012 Map

Gaia-FUN-SSO


662 Nickel
VATT
H15 ISON NM Mayhill
691 super Lotis
Nebraska
Omaha
Nevada
Denver
United States
Utah
Colorado
Kansas
San Francis
San Jose
California
Oklahoma
Albuquerque
Los Angeles
Arizona
San Diego
Phoenix
Tucson
Juárez
Fort Worth
Dallas
Texas
Austin
Houston
Hermosillo
Chihuahua
San Antonio
Gulf of California
Monterrey
Culiacan
Saltillo
South Africa
Argentina
New Zealand
South Pacific Ocean
Ocean
Perú (Peru)
(Mexico)
States
Données cartographiques ©2012 Map

Gaia-FUN-SSO

Possible evolution:

- More observing sites :
  North America
  South hemisphere

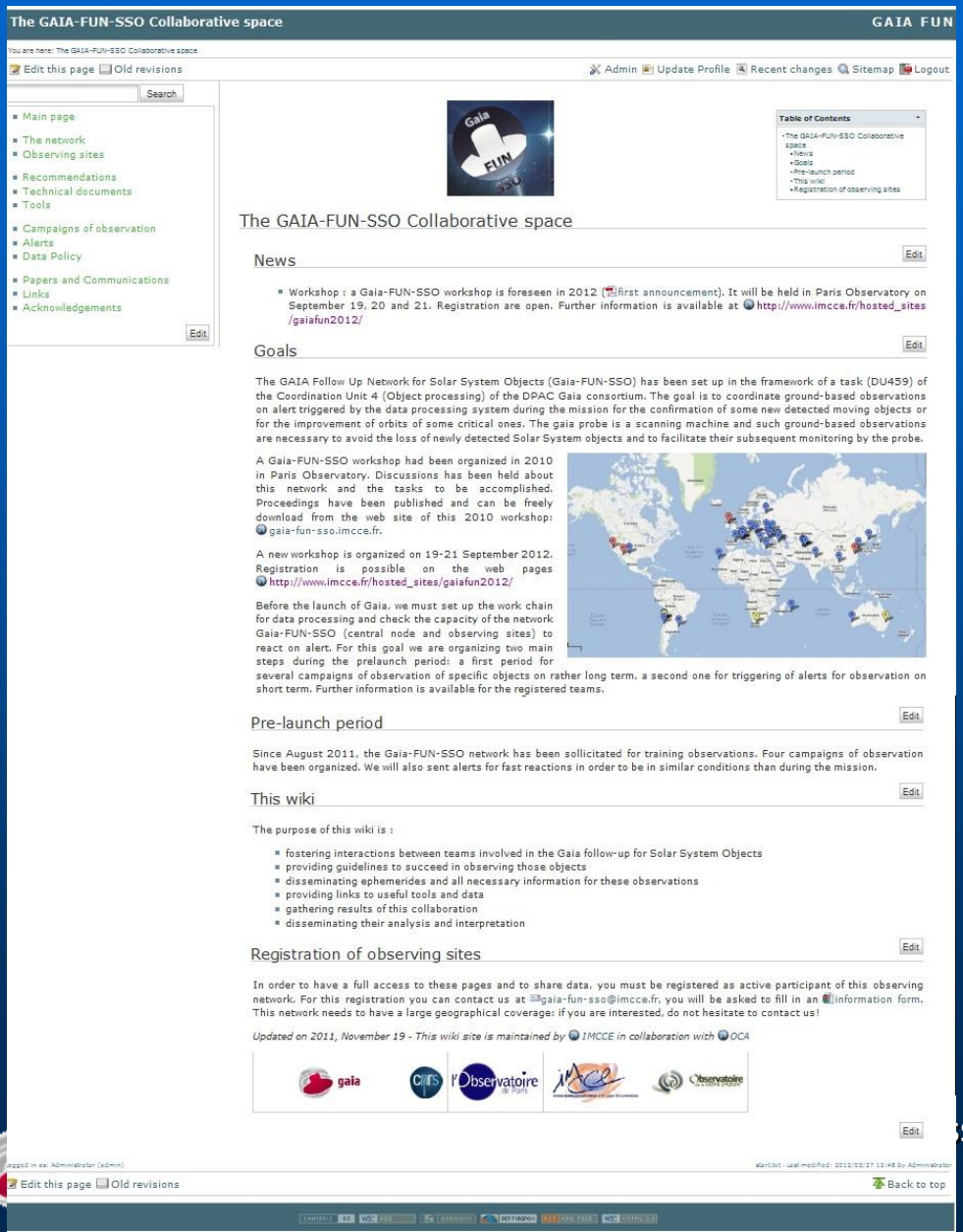
Requirements

- obs. on alert
- FOV >10 arcmin
- scale < 1 arcsec/pix

Welcome:
- large FOV
- robotics

- Gaia framework and goal
- the Gaia-FUN-SSO network
- Actions 2011-2013

WIKI access at https://www.imcce.fr/gaia-fun-sso



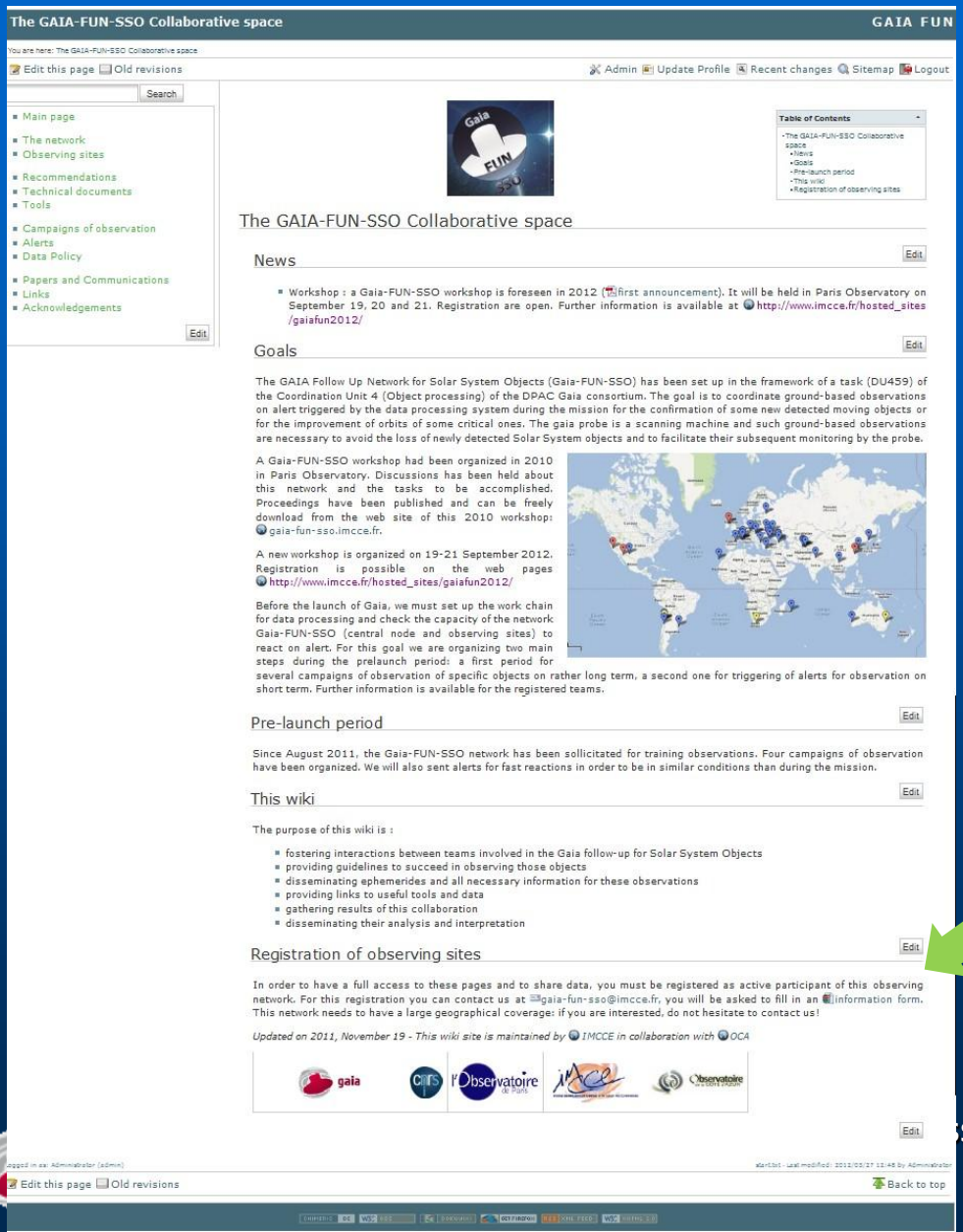
Data repository :

- Goals
- Observing method
- Tools
- Publications
- Links

Campaigns:

- Targets ephemerides
- Measurements
- Results (O-C)

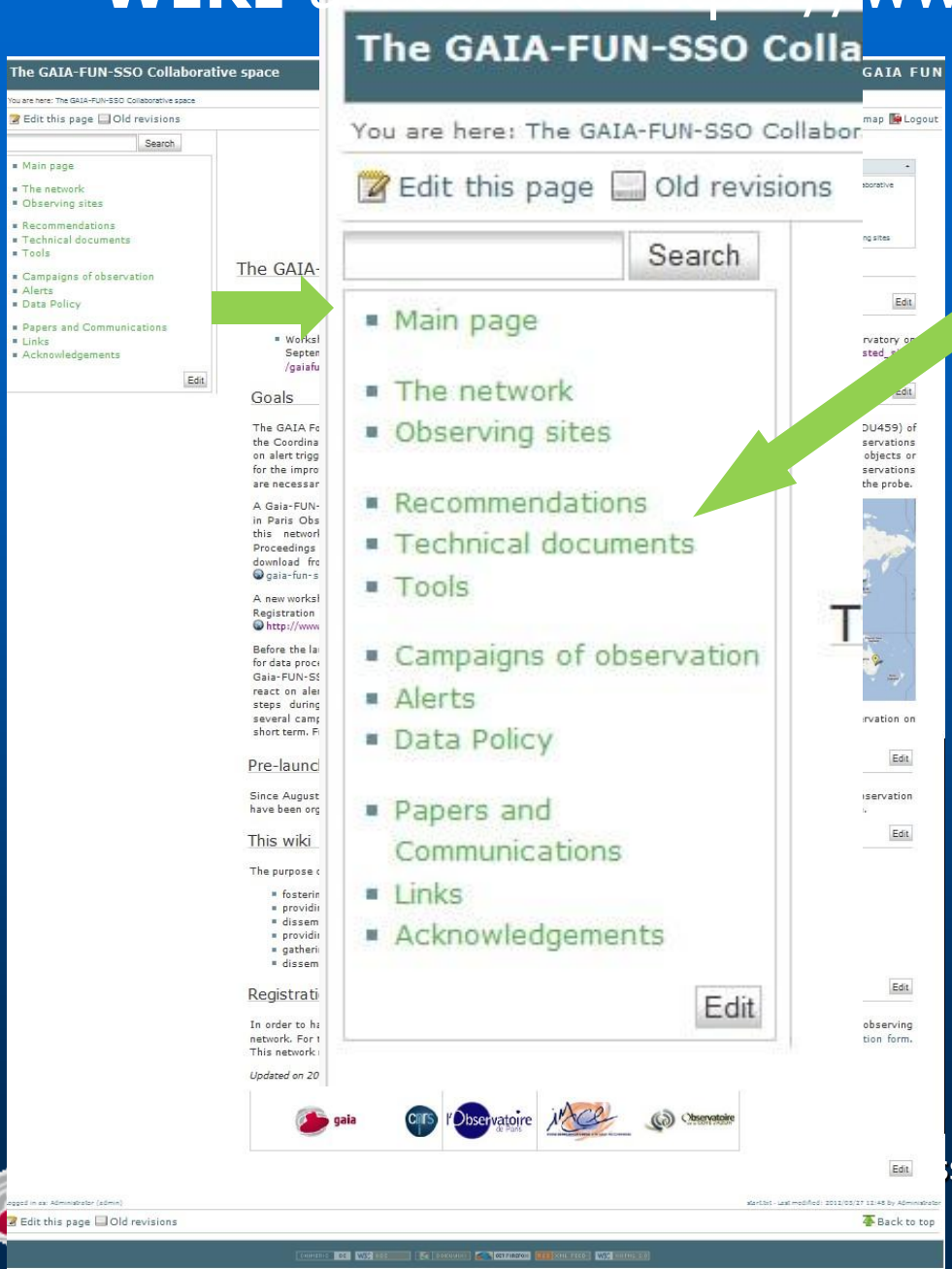
WIKI access at https://www.imcce.fr/gaia-fun-sso



- Public home page
- Invitation to join

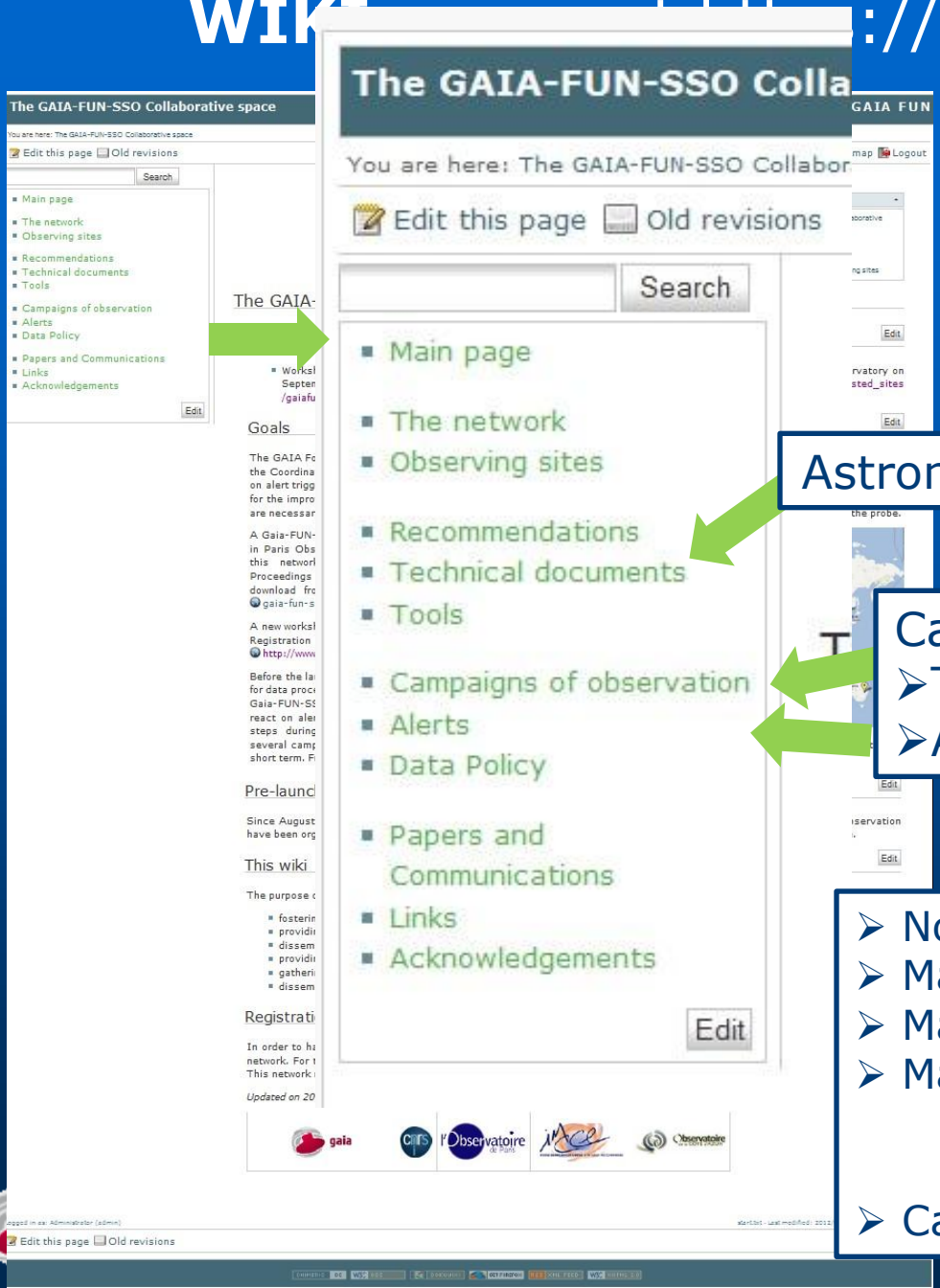
Registration form

WIKI access at https://www.imcce.fr/gaia-fun-sso



Accessible when registered

WIKI: http://gaia-fun-sso.imcce.fr



Astrometric pipeline PRAIA

Campaigns and alerts:
- Topocentric ephemerides
- Astrometric measurements

- Nov. : 2005 YU55 (many obs. success)
- March: 99 942 Apophis (poor: faint object)
- March: 1996 FG3 (poor: faint and crowdy)
- March: alert 2012 BS67
  (poorly obs. but success)

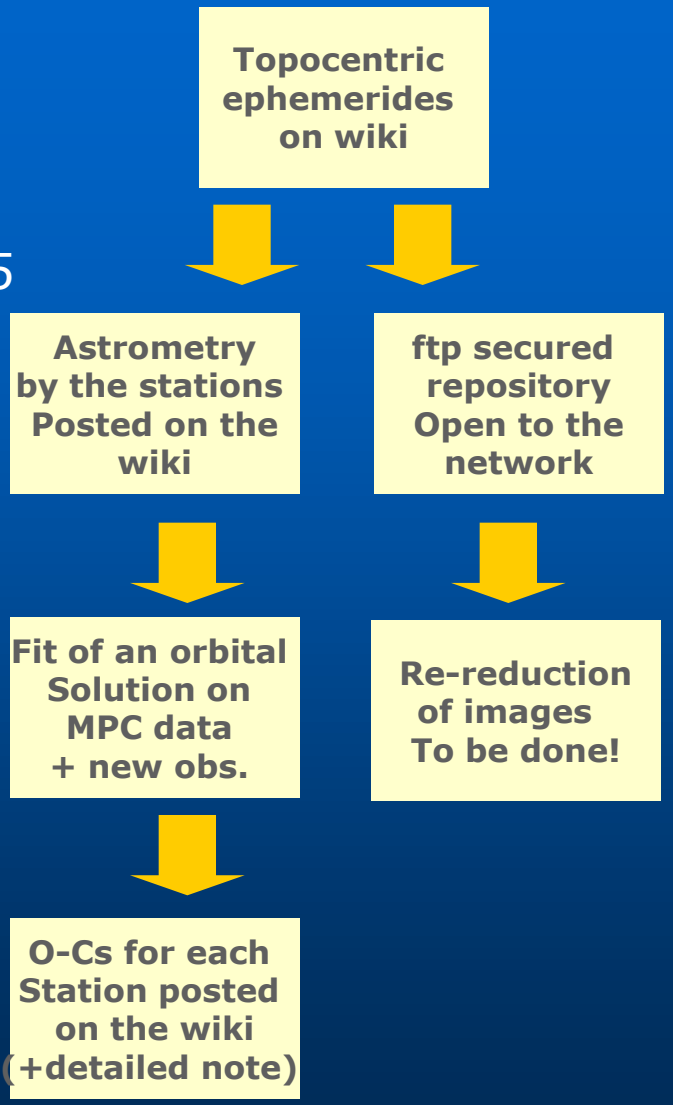
- Calculation of all O-C's

Campaign 2005 YU55

PHA on close approach 2011 Nov. 8
Obs. by the network spanning Nov.-Dec.

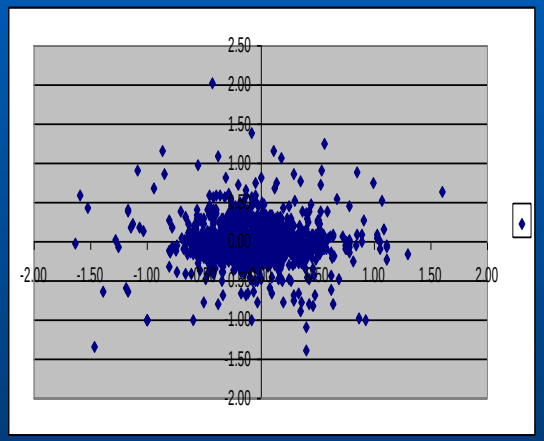
- fit on N=3586 obs. over 2187 days since 2005
- including 1556 positions Gaia-FUN-SSO
- r.m.s= 0.30 arcsec.
- New orbital elements are computed
- data sent to MPC

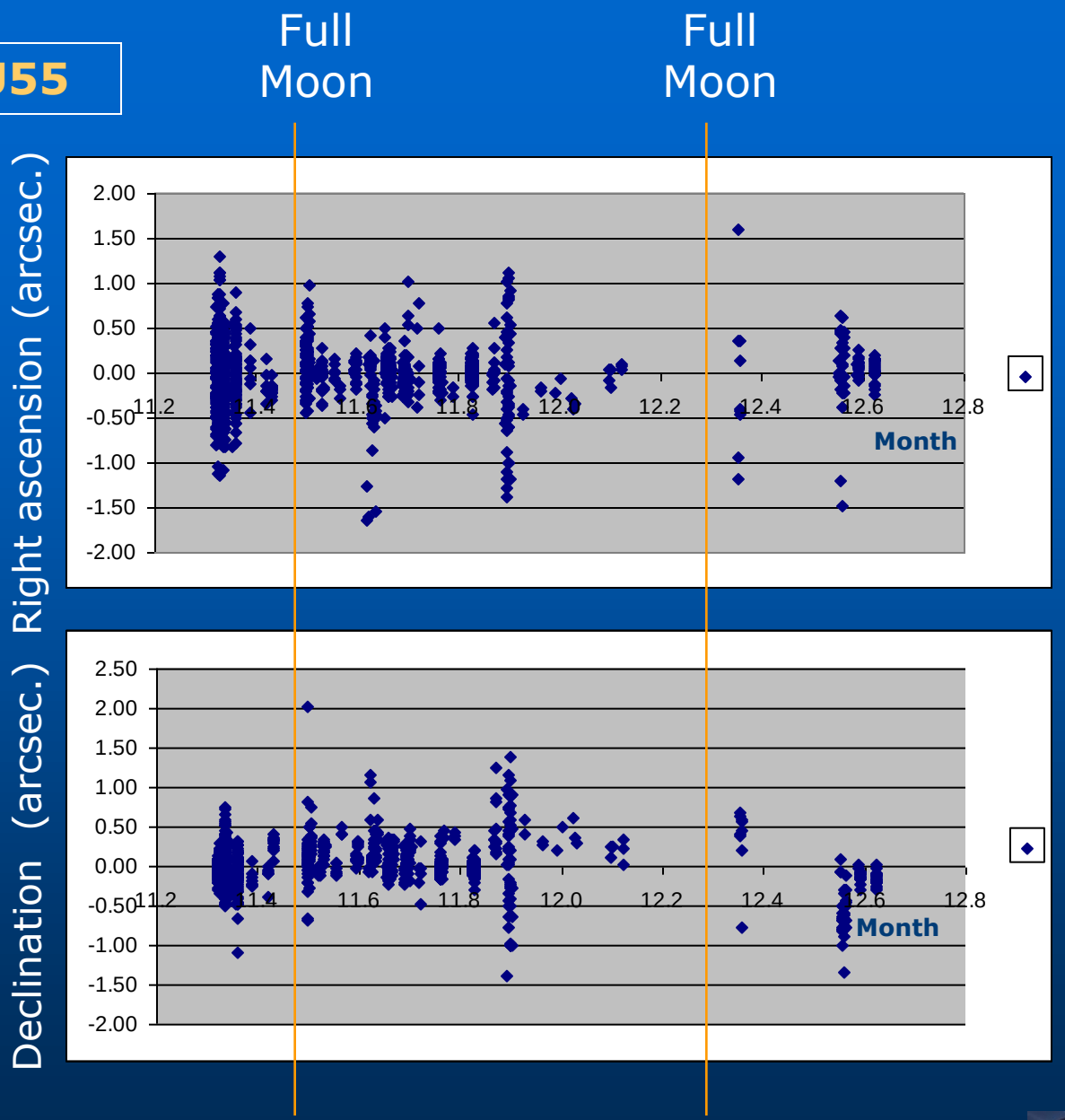
- (071) NAO Rozhen, Smolyan
- (084) Pulkovo
- (181) Les Makes, la Réunion
- (345) Sobaeksan Optical Astronomy Observatory
- (461) University of Szeged, Piszkéstető Stn. (Konkoly)
- (586) Pic du Midi
- (A84) TUBITAK National Observatory
- (B04) OAVdA, Saint-Barthelemy
- (B17) AZT-8 Evpatoria
- (C20) Kislovodsk Mtn. Astronomical Stn., Pulkovo Obs.
- (D20) Zadko Observatory, Wallingup Plain
- (D39) Shandong University Observatory, Weihai
- (G96/G84) Mt Lemmon
- (XXX) Lijiang obs. (no IAU code)




Kalaallit Nunaat (Greenland)
Canada
States
México (Mexico)
North Atlantic Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Venezuela
Colombia
Perú (Peru)
Brasil (Brazil)
Bolivia
Argentina
Ísland (Iceland)
Sverige (Sweden)
Suomi (Finland)
Norge (Norway)
Россия (Russia)
España (Spain)
Italia (Italy)
Türkiye (Turkey)
الجزائر (Algeria)
ليبيا (Libya)
مصر (Égypt)
العراق (Iraq)
ایران (Iran)
السعودية (Saudi Arabia)
Казахстан (Kazakhstan)
افغانستان (Afghanistan)
پاکستان (Pakistan)
India
Монгол Улс (Mongolia)
中国 (China)
日本 (Japan)
ประเทศไทย (Thailand)
Mali
Niger
تشاد Tchad (Chad)
السودان (Sudan)
Nigeria
Ethiopia
Kenya
DR Congo
Tanzania
Angola
Namibia
Botswana
South Africa
Madagasikara (Madagascar)
Indonesia
Papua New Guinea
Australia
New Zealand
Données cartographiques ©2012 Map

Campaign 2005 YU55





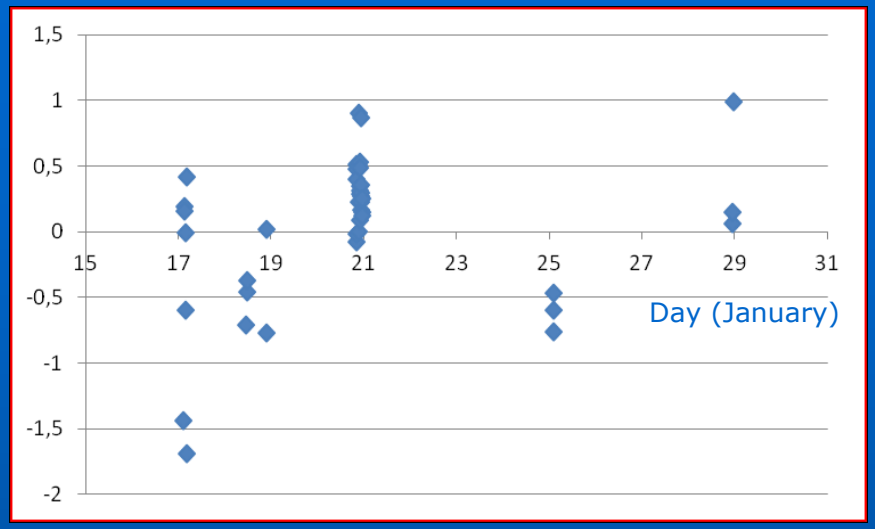
2012 January 17:
1 Alert triggered by Th. Pauwels (012 Uccle, Belgium) after detection of a new object
TP3522 => 2012 BS67

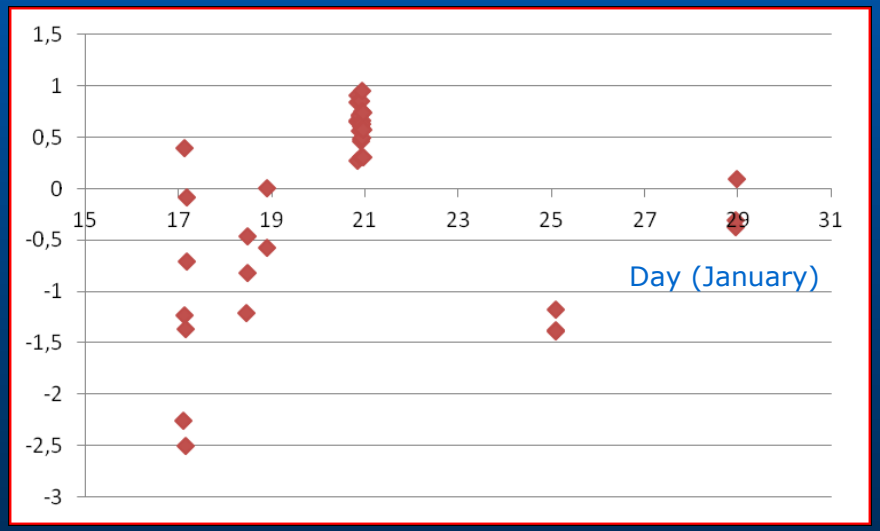
Similar to a Gaia detection:

- mag ~ 20-21
- Solar elong. ~ 133°

- first obs 1.4 day after
- 17 to 29 January 2012
- 7+35 observed positions
- meas. from 4 stations:

H15 ISON NM Mayhill
A84 Antalya
C20 Kislovodsk - Pulkovo
461 Konkoly





Registrered at MPC?

77 total observations over interval: 2011 11 02.46655 – 2012 03 13.31813

+ G96 Mont Lemon on 2/11/2011

012 Uccle on 17/1/2012
→ H15 ISON NM Mayhill
A84 Antalya
→ C20 Kislovodsk - Pulkovo
→ 461 Konkoly
→ A84 Antalya

- Fast reaction by 1 station (H15)
- Not many stations but enough to be registered by MPC
- Need to quickly send the data to MPC as son as obs. at 3 dates (2?)
- Satisfying for a training observation (detected and registered)
- …but Gaia alerts could require more stations operating on alert

Dec. 2010

→ Dec. 2011

Jan. – Jun 2012

Jul. – Dec 2012

✓Kick off Workshop

✓Extension of network

✓ Obs. campaign 1
2005 YU55

✓Obs. campaign 2
99942 Apophis , 1996 FG3

✓Alert test 1 : 2012 BS67

Obs. campaign 3,…

Alert tests

Sept: Workshop 2

✓ Wiki

✓Astrom. Tools

✓Work chain in progress

Dec. 2010

→ Dec. 2011

Jan. – Jun 2012

Jul. – Dec 2012

Jan. – oct. 2013

Launch in october

✓Kick off Workshop

✓Extension of network

✓ Obs. campaign 1
2005 YU55

✓Obs. campaign 2
99942 Apophis , 1996 FG3

✓Alert test 1 : 2012 BS67

Obs. campaign 3,…

Alert tests

Sept: Workshop 2

Link Minor Planet Center

Work chain DU459

Short time Alert tests

✓ Wiki

✓Astrom. Tools

✓Work chain

Strategy

Analysis

Data policy

Diffusion

Storage

Thank you!

Courtesy L. Elenin