

**the Lucky Star project:
exploring the outer solar system beyond
Neptune using stellar occultations**



Bruno Sicardy

European Research Council Advanced Grant 2015

Université Pierre et Marie Curie &
Observatoire de Paris-LESIA

kick-off meeting April 18-22 (Paris Obs.)

an artist view of Pluto's surface



mixture of professional and amateur astronomers

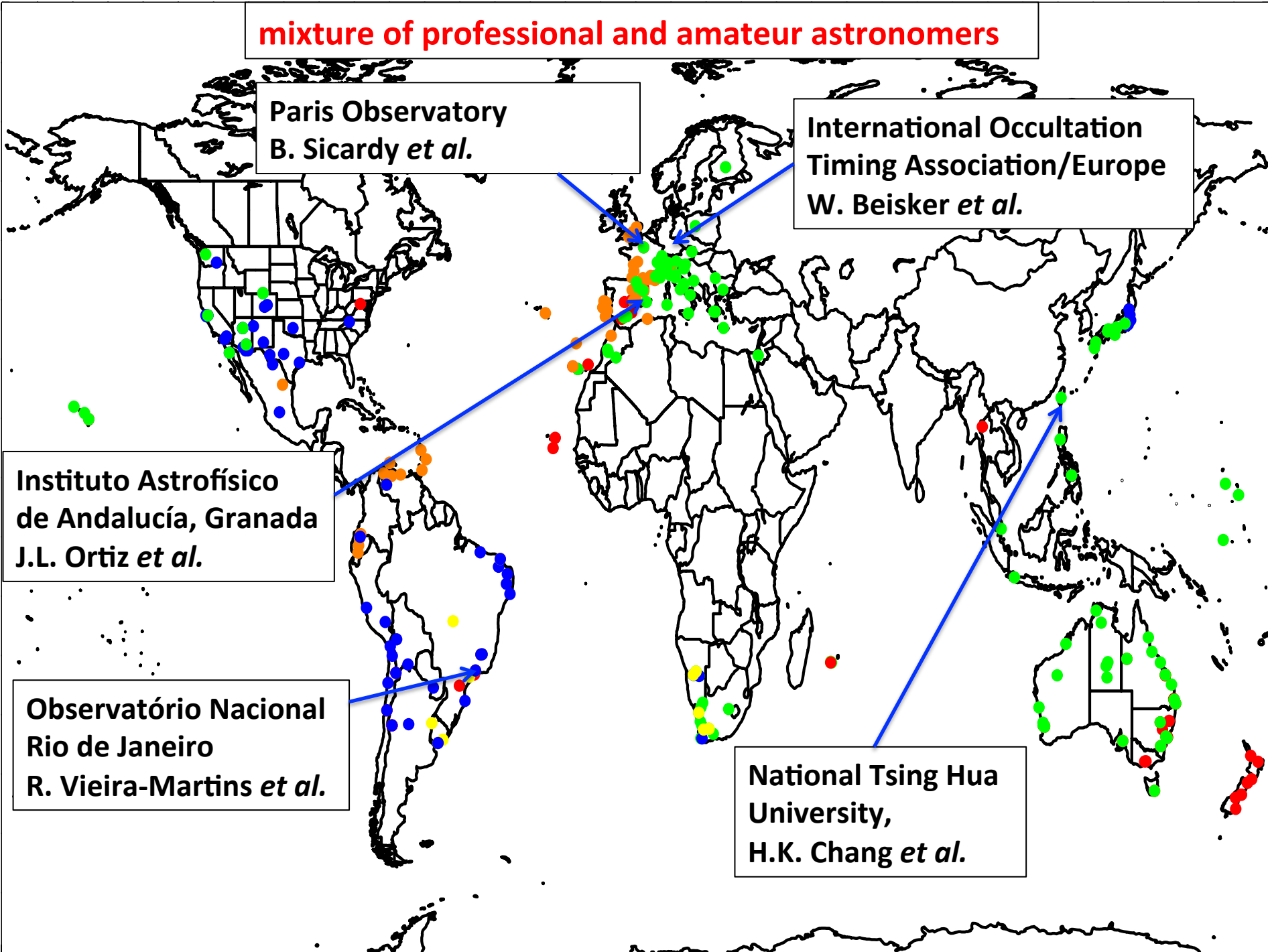
Paris Observatory
B. Sicardy *et al.*

International Occultation
Timing Association/Europe
W. Beisker *et al.*

Instituto Astrofísico
de Andalucía, Granada
J.L. Ortiz *et al.*

Observatório Nacional
Rio de Janeiro
R. Vieira-Martins *et al.*

National Tsing Hua
University,
H.K. Chang *et al.*



✓ our detections ✓ other groups



Pluton

Éris

Makemake

Haumea



2003 VS₂



2002 VE₉₅



Sedna



Chariklo



Orcus & Vanth



Quaoar



Varuna



2002 TX₃₀₀



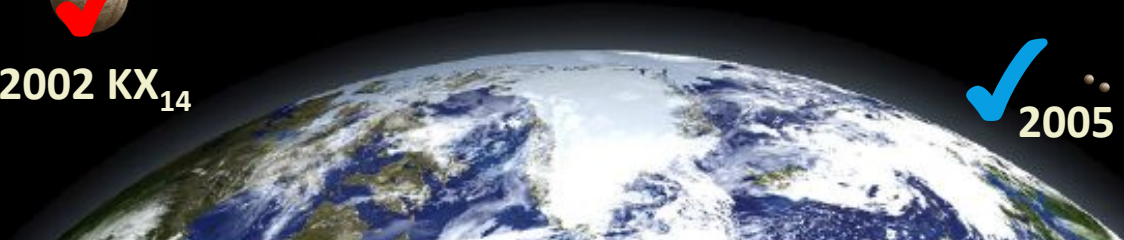
2002 KX₁₄



2005 TV₁₈₉



2003 AZ₈₄



The Lucky Star work-packages

Work-package 1: rings around small bodies

Explore Chariklo's rings (radius, width, optical depth, albedo...) and understand the origin of rings around small bodies, and rings in general.

Work-package 2: very small, sub-km TNOs and Oort Cloud objects

Detect small TNOs using serendipitous stellar occultations. Distinguishing the Kuiper Belt Objects (KBOs), i.e. TNOs within about 1000 AU, and Oort Cloud objects, much farther away, from ~1,000 to ~50,000 AU.

Work-package 3: Pluto's atmosphere

Better define Pluto's atmospheric structure, dynamics and seasonal evolution. Discover atmospheres around other large TNOs.

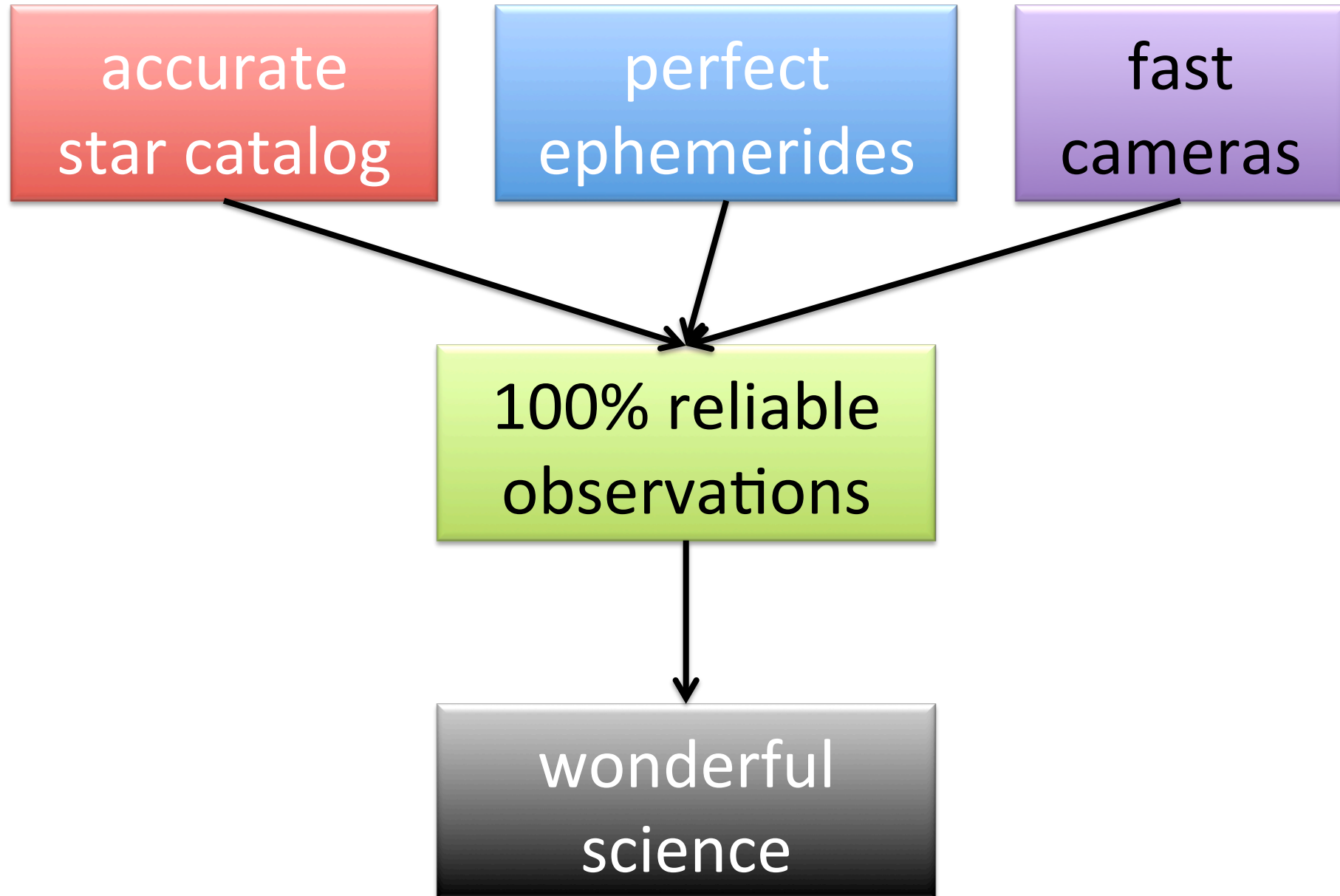
Work-package 4: other large TNOs

Obtain key physical parameters of large, representative TNOs. Unveil the variety of TNOs.

The Lucky Star budget

- about **30 travels** per year (meetings, campaigns)
- about **10** EMCCD kits, or **30** Cmos kits
- possibility **to invite personnels** at Meudon (analysis, modeling, etc...)
- possibility to buy **telescope time** (astrometry, campaigns)
- **eleven years of post-doc + one 3-year PhD**
 - * serendipitous detections of small TNOs & Oort Cloud Objects (OCOs)
 - * ephemerides, catalogs, predictions, campaigns
 - * ring dynamics and origin
 - * Pluto's (and others') atmosphere

Lucky Star: let's have a dream



Lucky Star: let's have a dream

- * **Define** scientific goals
- * **Choose** events according to scientific interest
- * **Plan** observations well in advance (big/small scopes)
- * **Publish** results

2016		
02 February 2016	Eris	Pacific W. of NZ, twilight ?
28 February 2016	2002 MS4	E. Africa twilight, Europe low
04 March 2016	2005 CC79	Australia
12 March 2016	2002 WC19	USA, Canada
22 March 2016	2004 NT33	W. Europe low, morning twilight
24 March 2016	Varuna	Off Earth, Russia ?
28 March 2016	Chariklo	N. Chile, Uruguay, Brazil
16 April 2016	2002 KX14	Africa, S. Europe ?
27 April 2016	Haumea	China, Japan, Hawaii
06 May 2016	Chariklo	N. NZ
18 May 2016	Chariklo	S. RSA
25 May 2016	2010 EK139	S. Chile
11 June 2016	Chariklo	NZ, AUS
12 June 2016	Chariklo	N. NZ, N. AUS
20 June 2016	2004 NT33	Off Earth NZ, AUS
01 July 2016	Chariklo	AUS, S. RSA
19 July 2016	Pluto	Europe, Middle East, N. Africa
20 July 2016	Chariklo	S. NZ
29 July 2016	Amycus	NZ, AUS twilight
07 August 2016	Haumea	Indian Ocean
10 August 2016	Chariklo	S. RSA
11 August 2016	Chariko	NZ, S. AUS ?
15 August 2016	Chariko	NZ, AUS
20 August 2016	Chariko	S. AUS low
24 August 2016	Chariklo	S. Chile, SOFIA ?

Lucky Star: let's have a dream

- **detect many km-size** TNOs and OCOs and reconstruct early solar-system collisional history
- reconstruct **Chariklo's shape and ring structure**, **discover new ring systems** and understand how rings form and evolve
- Reconstruct and understand **Pluto's atmospheric structure** and evolution, **discover new atmospheres**
- Measure shapes of very elongated TNOs (Varuna, Haumea), compare to Jacobi shapes, assess **hydrostatic equilibrium**
- Unveil some crazy behaviors that **no one thought of**

Lucky Star: let's have a dream



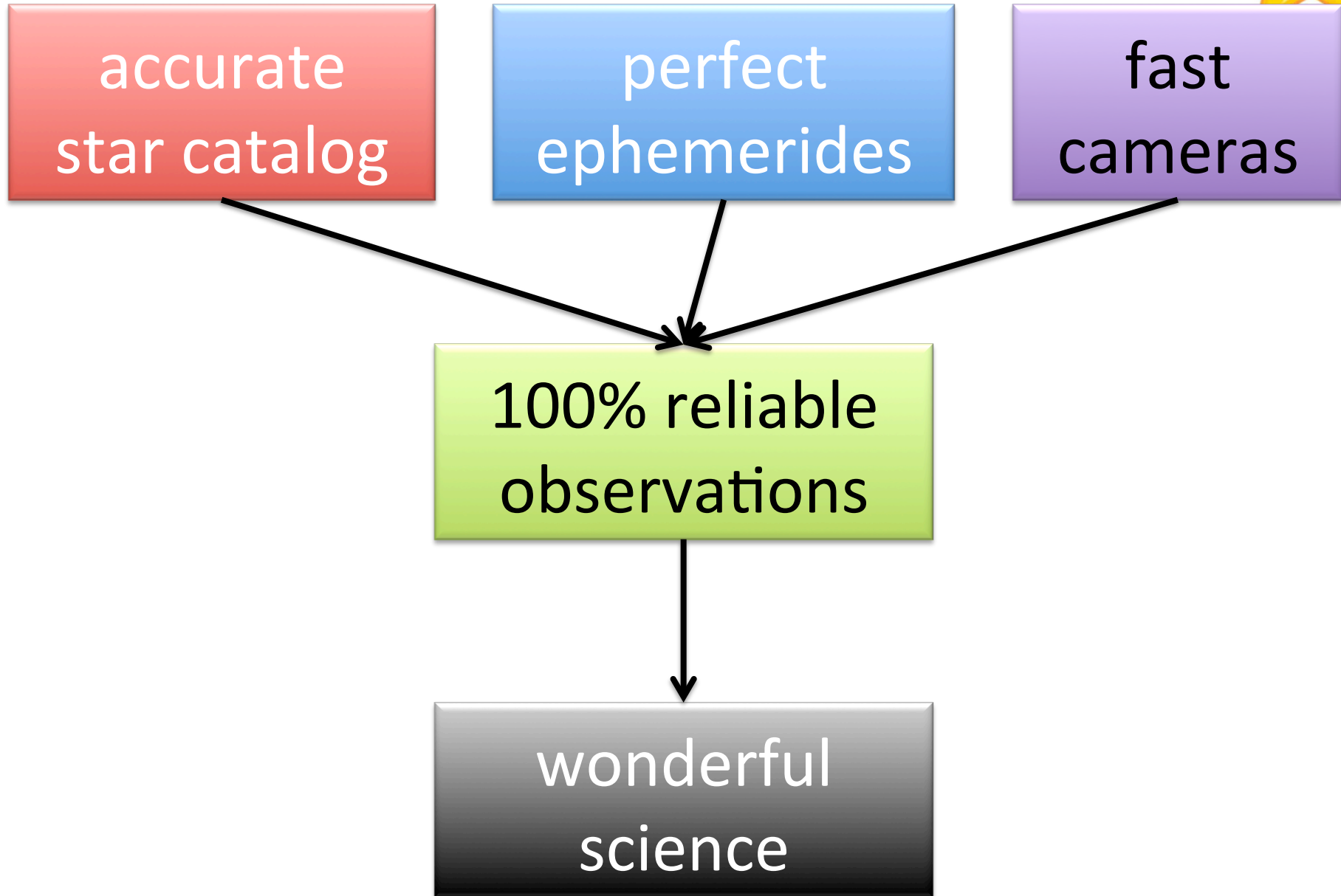
accurate
star catalog

perfect
ephemerides

fast
cameras

100% reliable
observations

wonderful
science



Lucky Star: reality



accurate
star catalog

GAIA release Sept. 2016

- is 1-mas accuracy **achievable**?
- is **implementation** into prediction programs straightforward or painful?
- are there **hidden flaws**?

Lucky Star: reality

perfect
ephemerides



after GAIA release Sept. 2016

- how to transfer **GAIA accuracy to ephemerides?**
- **how to maintain** good ephemerides for tens of objects?

Lucky Star: reality



- choices of cameras: better to have **many cheap systems** staying at various sites or a **few good detectors** transported from place to place?
- are **timing issues** solved, at last?

100% reliable
observations

- **many** biggish amateurs and smallish professional scopes worldwide: logistics, coordination, etc... become painstaking