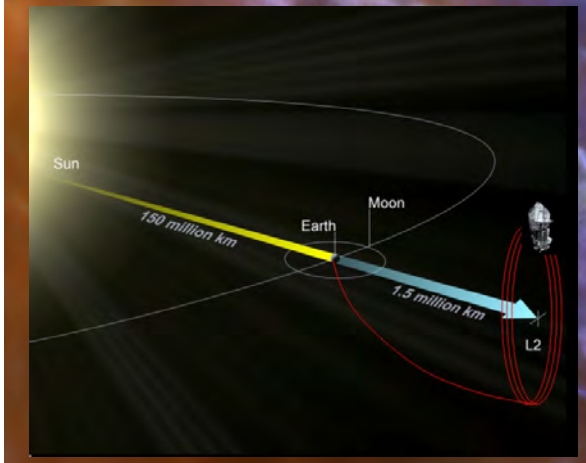
Welcome & Introduction



Herschel Calibration Workshop: Only the Best Data for the Legacy Archive

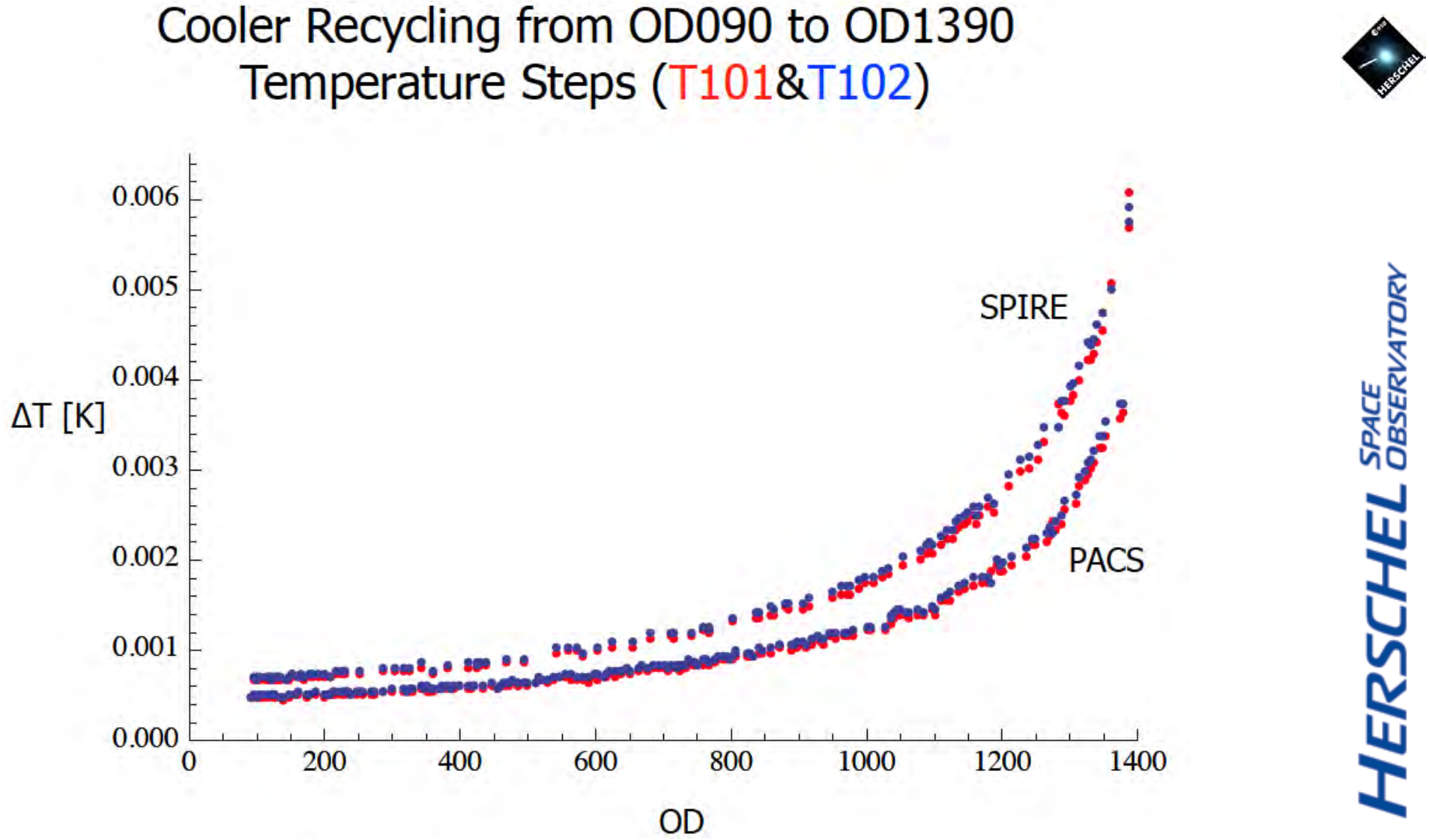
ESAC, 25-27/03/2013

Göran Pilbratt, Herschel Project Scientist, ESA
– on behalf of many many others


Launch on 14 May 2009 …
… 1000 days inflight on 8 February 2012
… 3 years in-flight on 14 May 2012

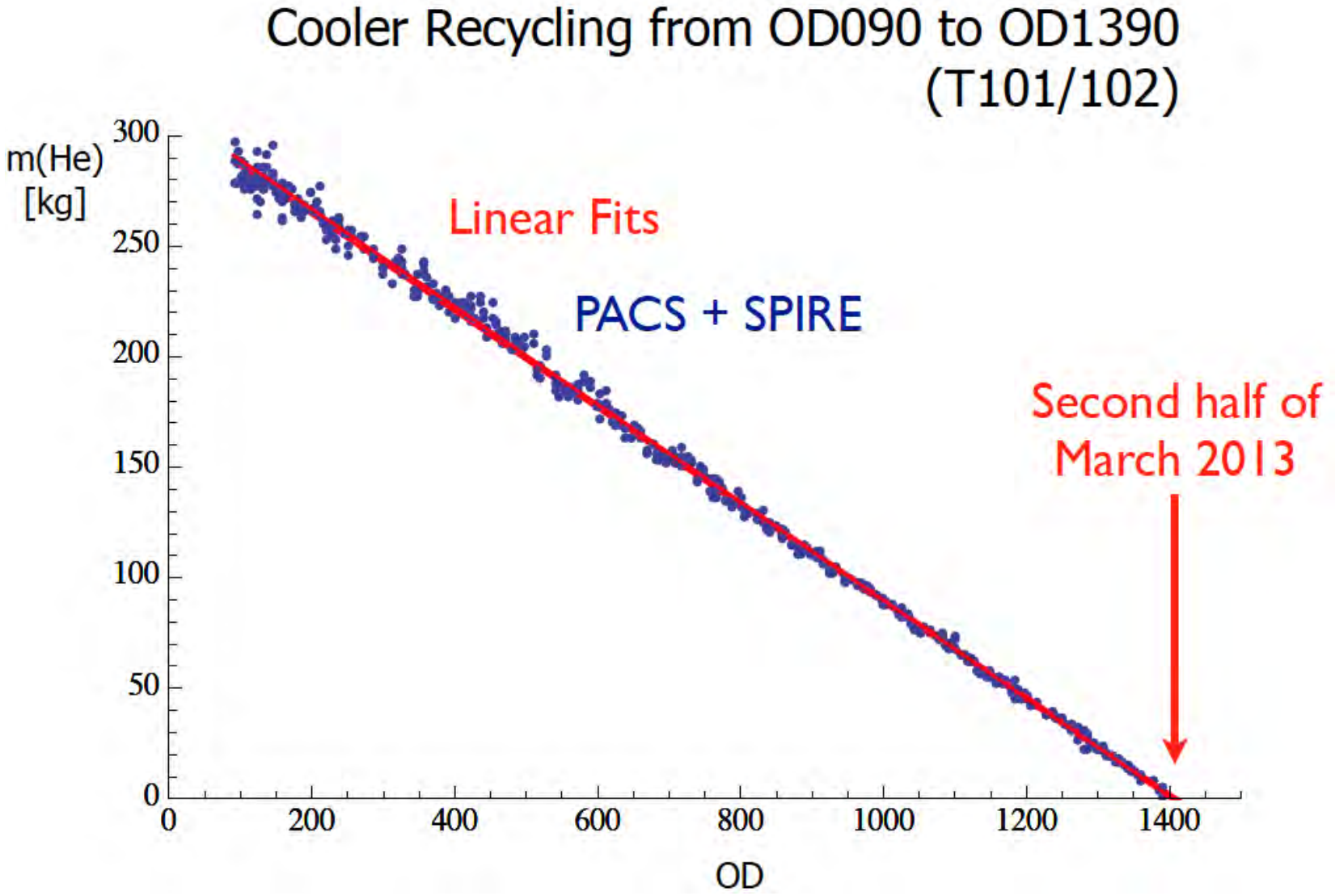

Launch on 14 May 2009 …
… 1000 days inflight on 8 February 2012
… 3 years in-flight on 14 May 2012
… right now OD#1411 is underway!
… DTCP#1411: All nominal operations were executed successfully

Cryocooler analysis OD#90-1390



HERSCHEL SPACE OBSERVATORY

Cryocooler analysis OD#90-1390 (T101/T102)



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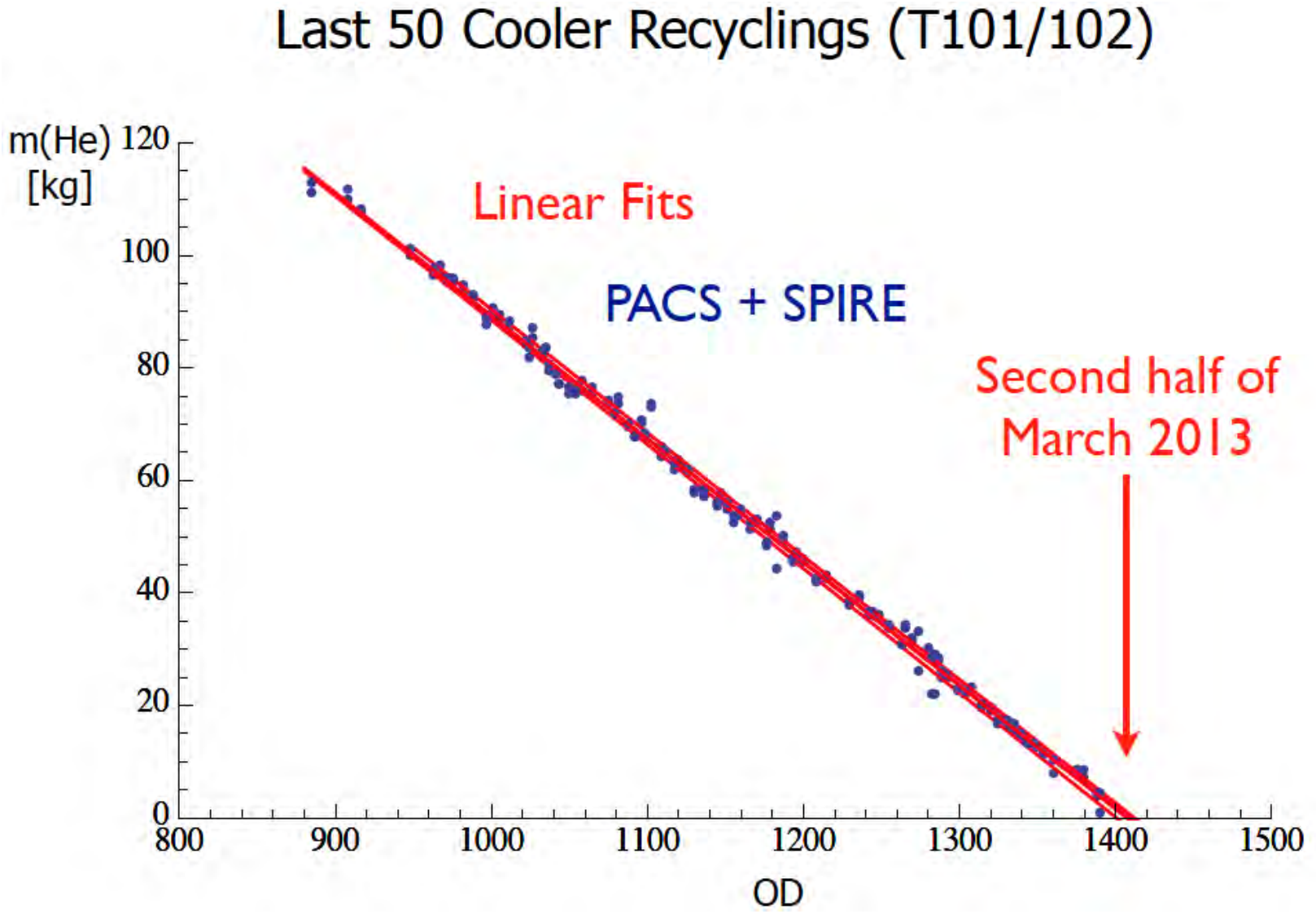
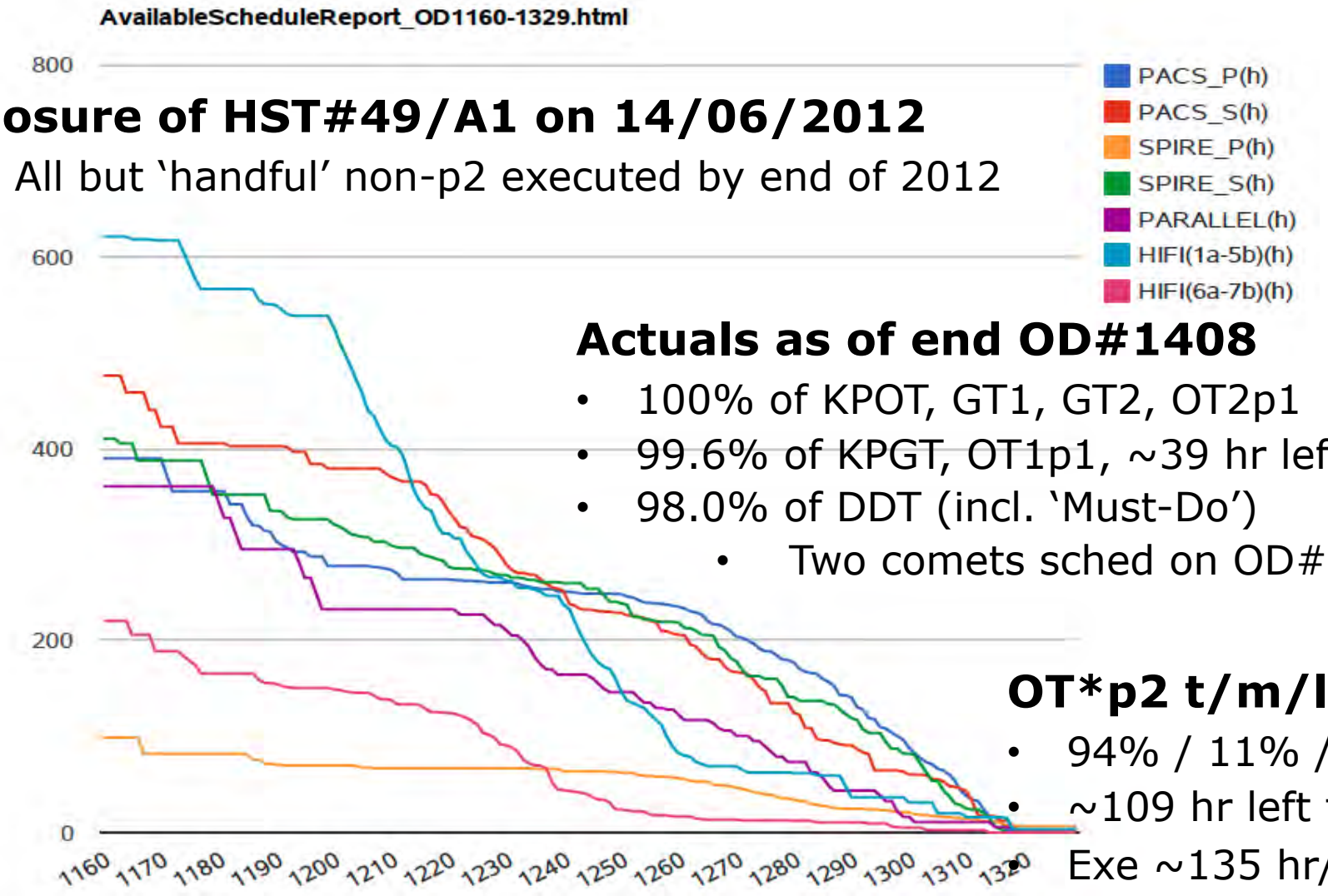


Observing – execution status



Closure of HST#49/A1 on 14/06/2012

- All but 'handful' non-p2 executed by end of 2012

Actuals as of end OD#1408

- 100% of KPOT, GT1, GT2, OT2p1
- 99.6% of KPGT, OT1p1, ~39 hr left
- 98.0% of DDT (incl. 'Must-Do')
  - Two comets sched on OD#1418

OT*p2 t/m/l tier

- 94% / 11% / 1%
- ~109 hr left top tier
- Exe ~135 hr/week

HERSCHEL SPACE OBSERVATORY

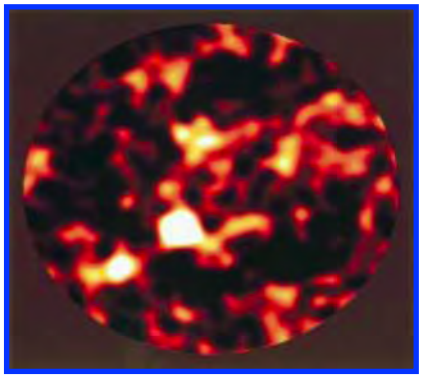
Progress in submm observations

1998

SCUBA HDF:

5 sources after 20 exceptional nights

To scale!



~3 arcmin

4×4^0

2009

Herschel-ATLAS SDP field:

~7,000 sources in 16 hours

3% of total => 235,000 !!

Lookback times for 288 COSMOS Herschel/SPIRE galaxies

Keck I & II spectra of FIR selected galaxies

- **1594 observed**
- **767 redshifts obtained**
  - **731 have z up to 2**
  - **peak z~0.85**
  - **highest z~5**

Illustration: COSMOS field

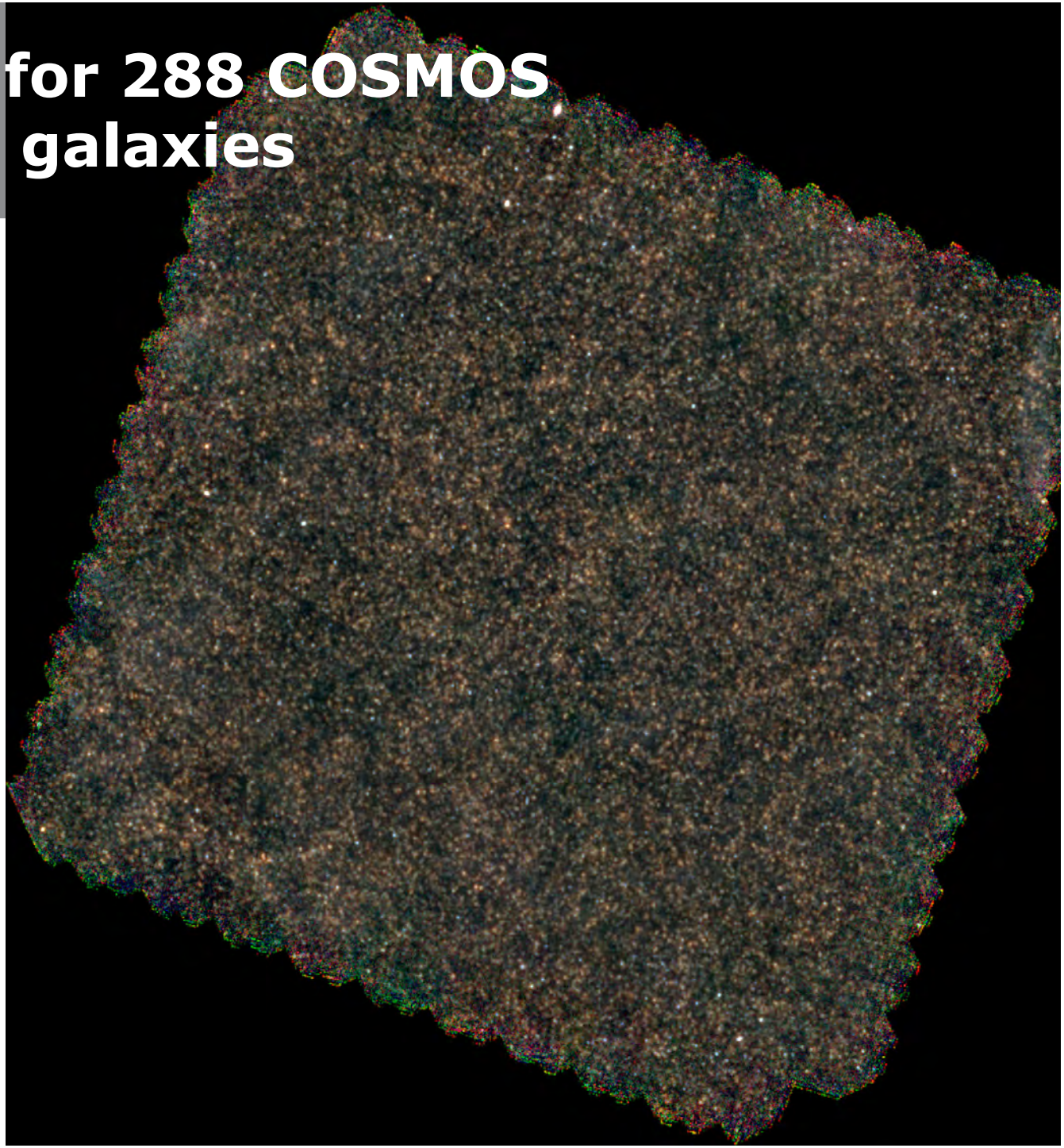
- **288 redshifts**

Five examples

- **Visible & far-infrared images**

These FIR galaxies contribute ~50% of SF out to z~2

(Casey et al. 2012 x2
ApJ 739, 139&140, 2012)



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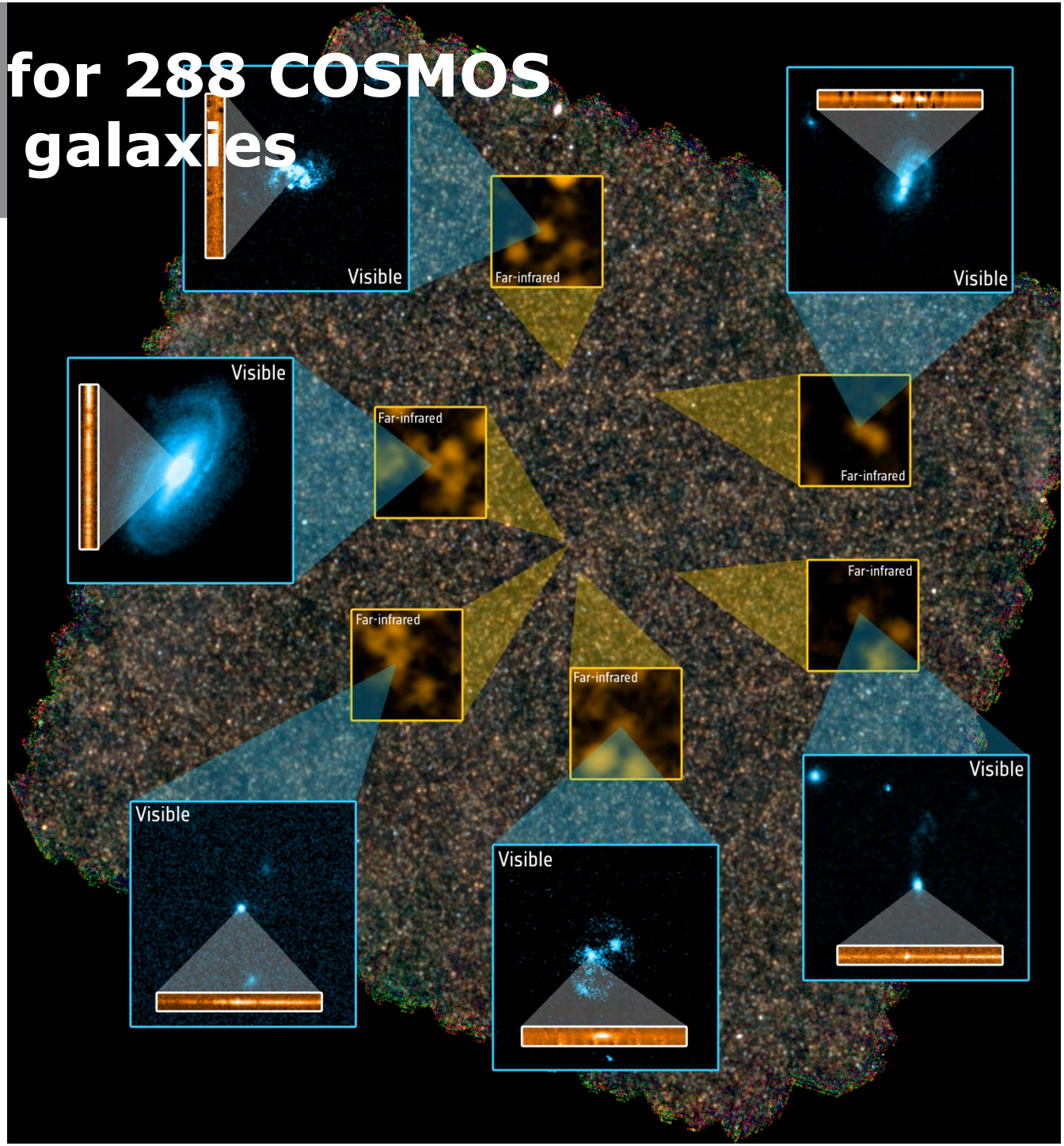

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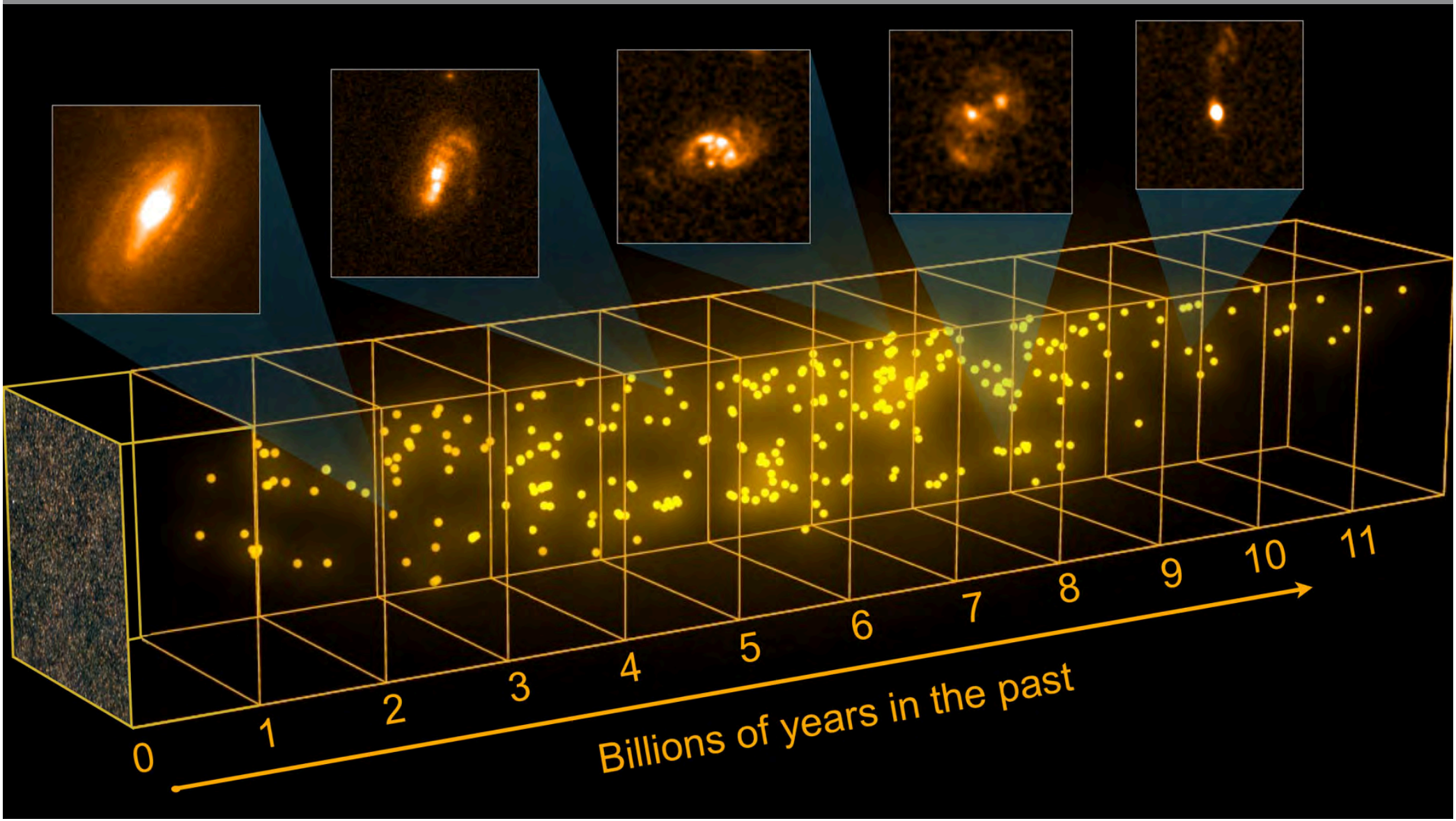
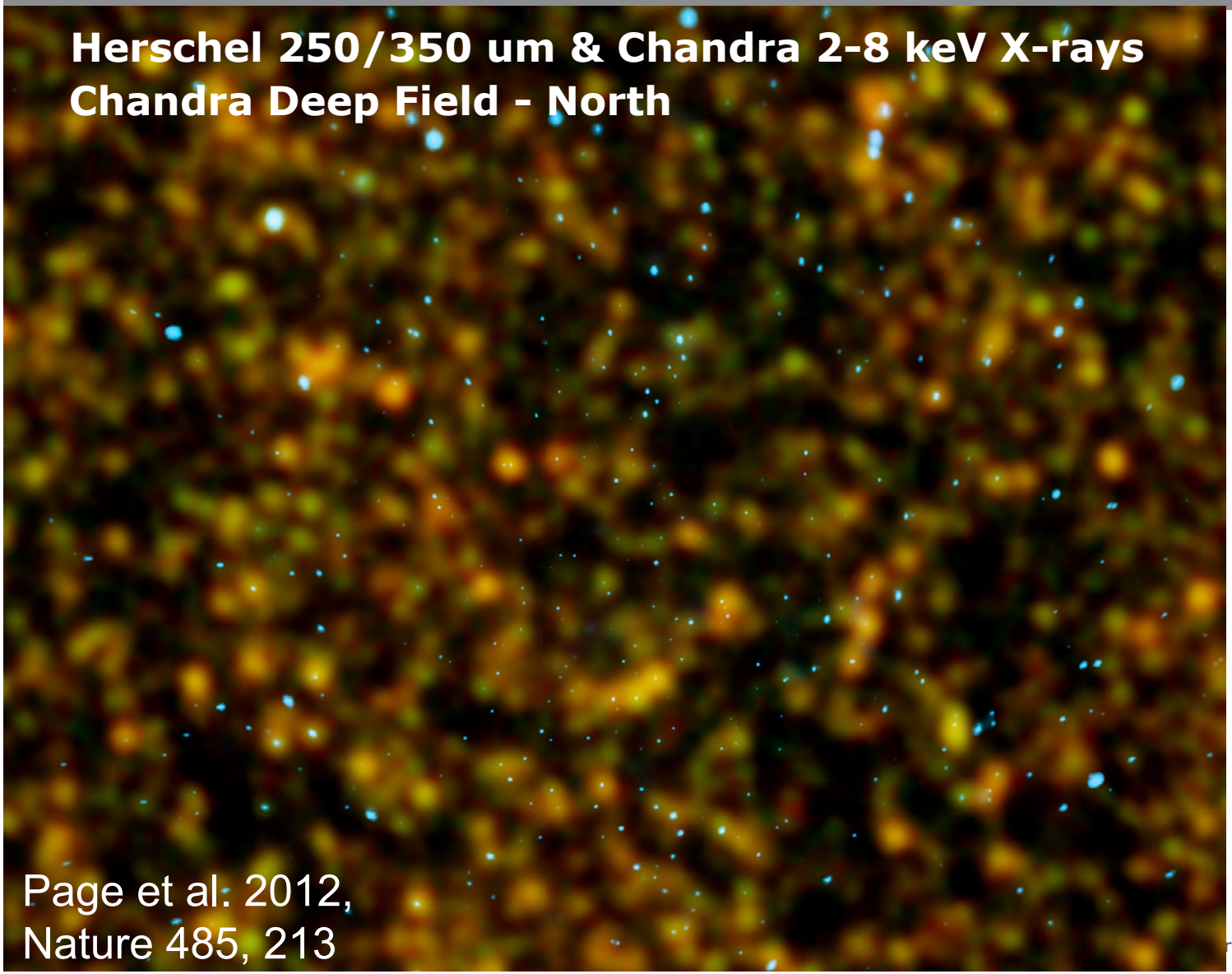


HerMES – strongest AGN quench SF?



Herschel:

Background 250/350 um green/red => dust emission => star formation

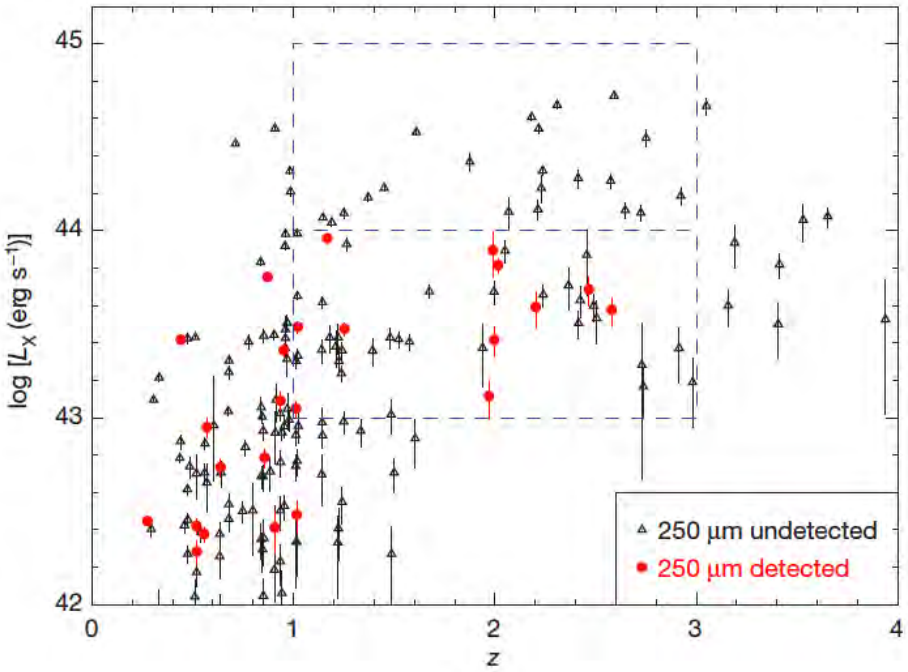
Chandra:

Blue is X-ray 2-8 keV => AGN activity

HERSCHEL SPACE OBSERVATORY

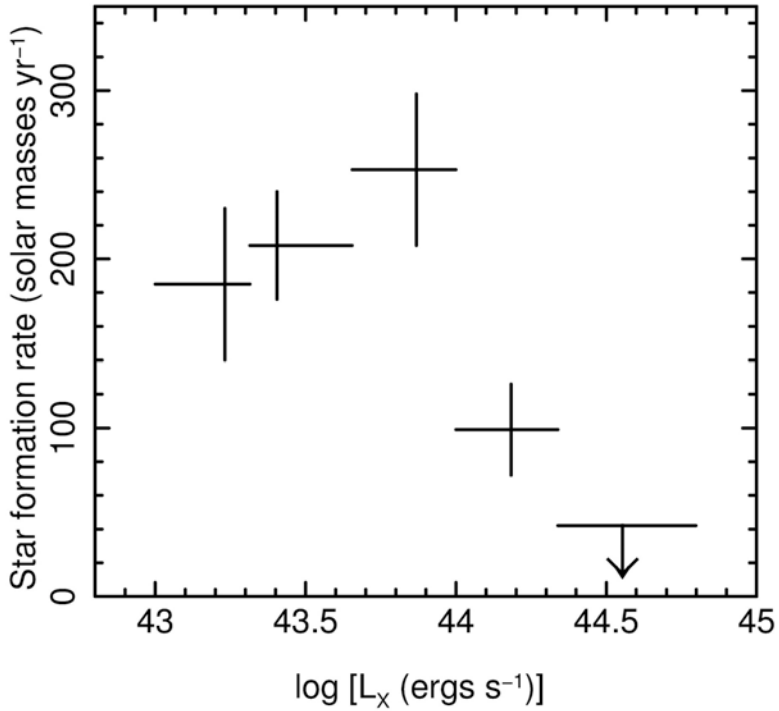
HerMES – strongest AGN quench SF!

X-ray selected (radio-quiet) z~1-3 AGN in CDF-N



Blue dashed rectangle:

Detected and undetected 250 um sources, z=1-3



250 um / star formation vs: L_x / AGN activity

Page et al. 2012; Nature 485, 213

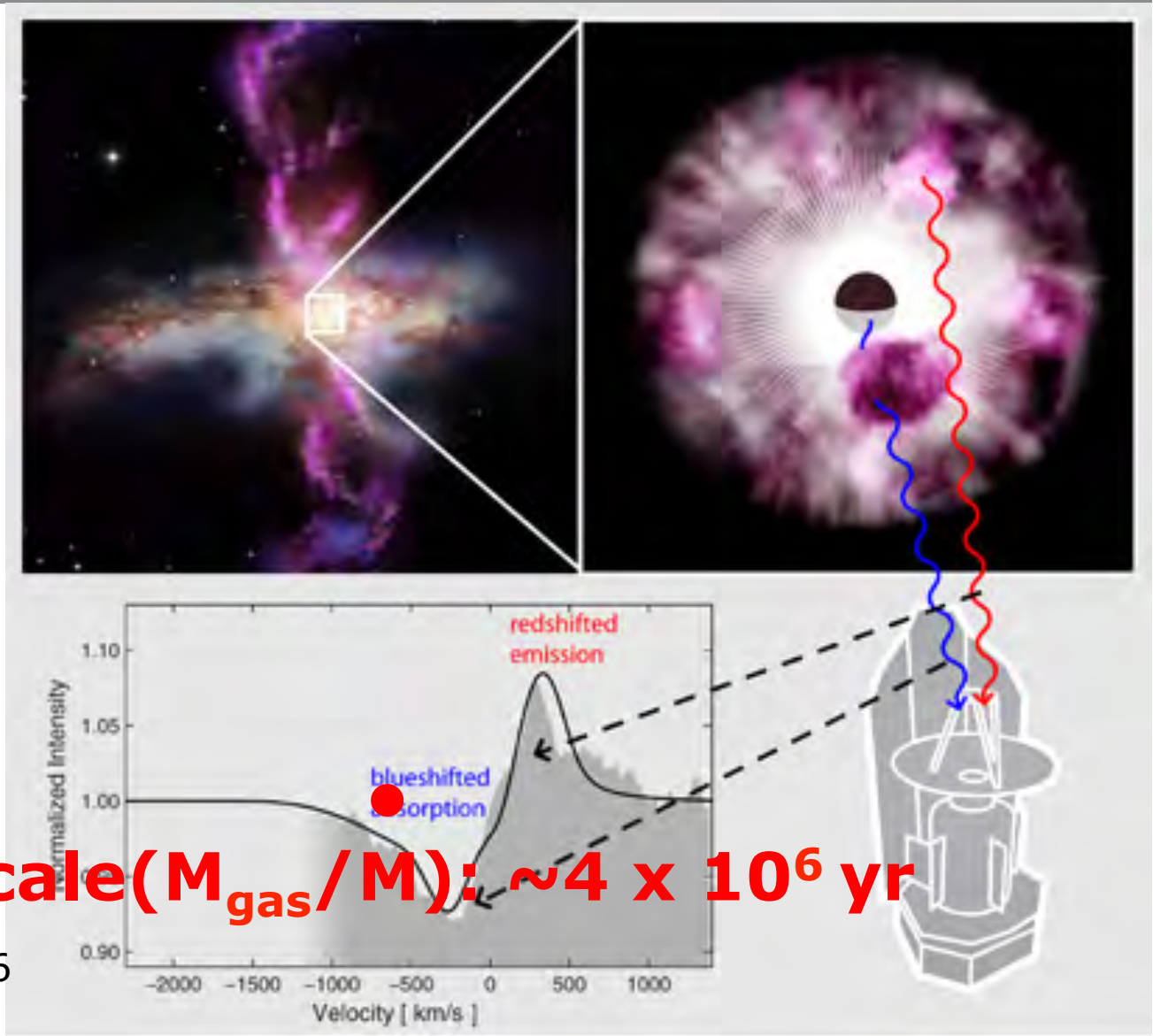
HERSCHEL SPACE OBSERVATORY

Herschel: SHINING – ULIRG/AGN outflows

Mrk 231:

$L_{IR} = 3.2 \times 10^{12}\ L_{\odot}$
(70% AGN)

P-Cygni profile with blue-shifted absorption and red-shifted emission



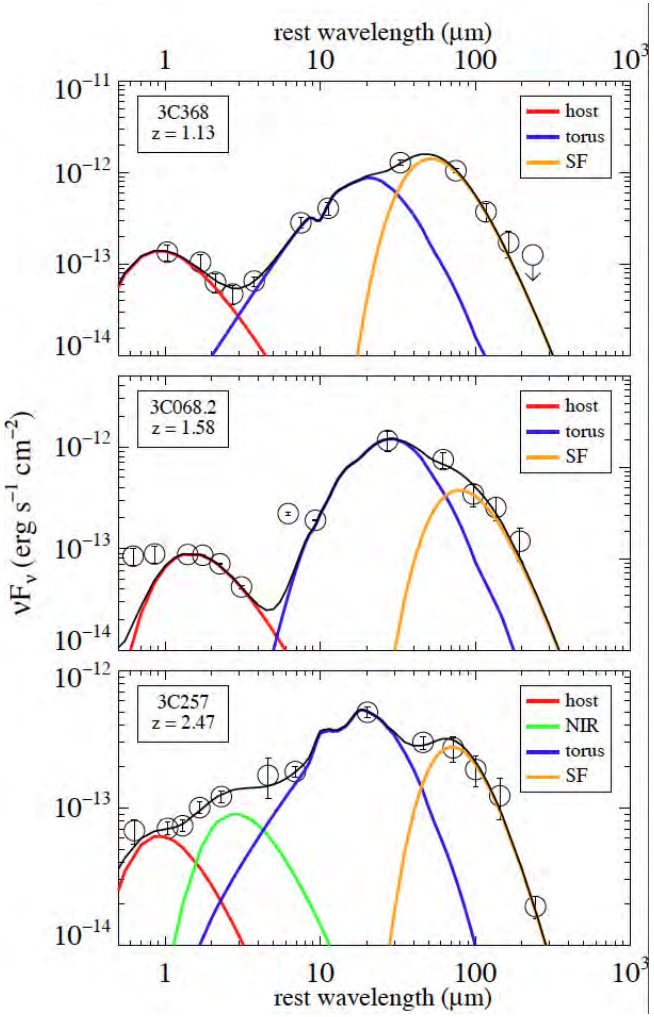
Δv ~ 1,170 km/s

Depletion time scale($M_{gas}/\dot{M}$): ~4 x 10^6 yr

Sturm et al. 2011; ApJL 733, L16

X-ray selected vs radio-selected

Powerful radio galaxies observed with Herschel



- Sample of 70 radio-loud high-z quasars & radio-gals from 3C & 4C catalogues
- Initial results 3C368, 3C68.2, 3C257
- Herschel at 70, 160, 250, 350, 500 um
- Typical fluxes 10-50 mJy

Object	Redshift	T_{cool} (K)	L_{AGN} (erg s^{-1})	L_{SF} (erg s^{-1})	L_{SF} (10^{12} $L_\odot$)	SFR ($M_\odot$ yr^{-1})
3C 368	1.132	53 ± 1	$(7.3 \pm 3.5) \times 10^{45}$	$(1.4 \pm 0.04) \times 10^{46}$	3.5 ± 0.1	610
3C 68.2	1.575	36 ± 3	$(3.3 \pm 1.0) \times 10^{46}$	$(8.6 \pm 0.8) \times 10^{45}$	2.2 ± 0.2	390
3C 257	2.474	37 ± 3	$(4.1 \pm 2.0) \times 10^{46}$	$(1.7 \pm 0.1) \times 10^{46}$	4.4 ± 0.3	770

- L_{AGN}: torus modelling; L_{SF}: 8-1000 um

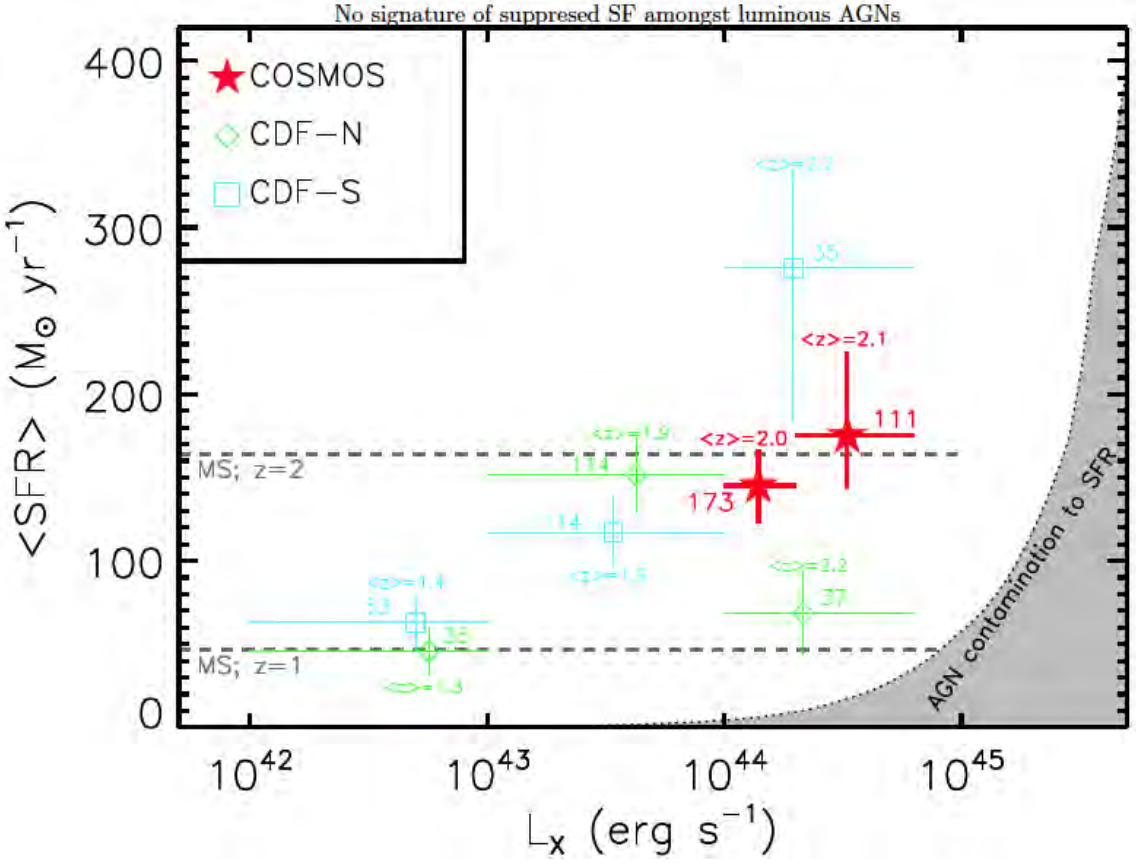
No observed SF quenching!

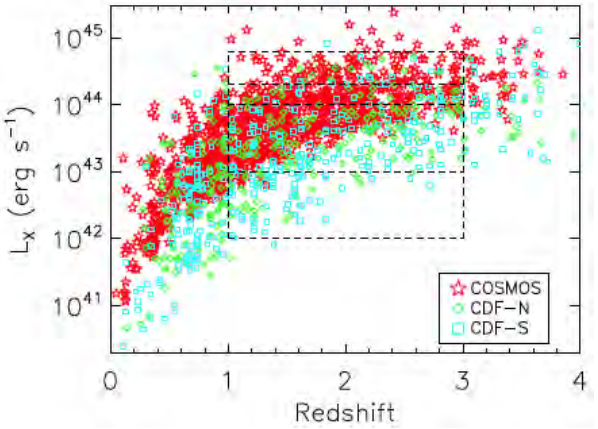
Barthel et al. 2012; ApJL 757, L26

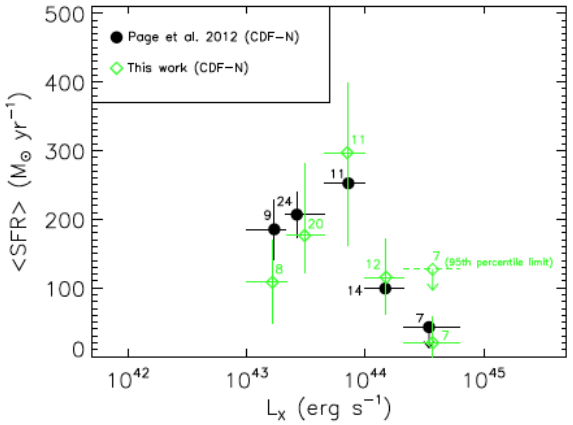
HERSCHEL SPACE OBSERVATORY

COSMOS & CDF-S added to CDF-N

Extend sample by order of magnitude







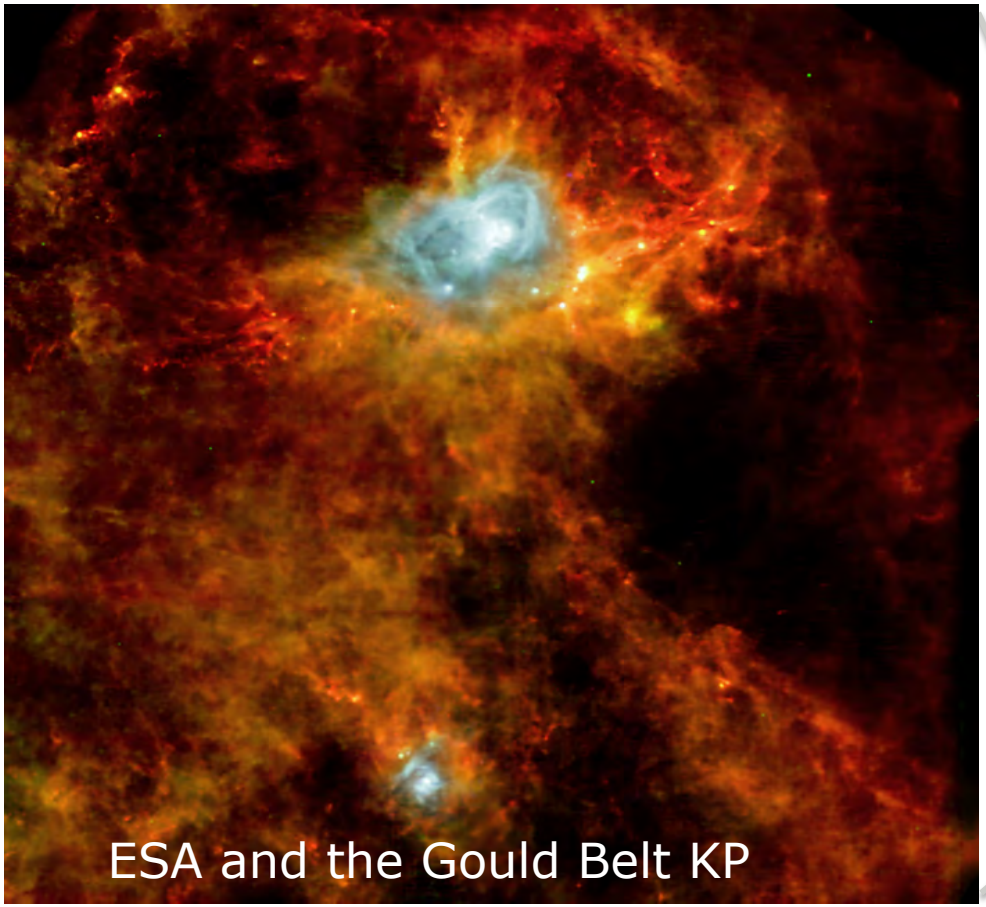
Harrison et al. 2012
ApJL 760, L15

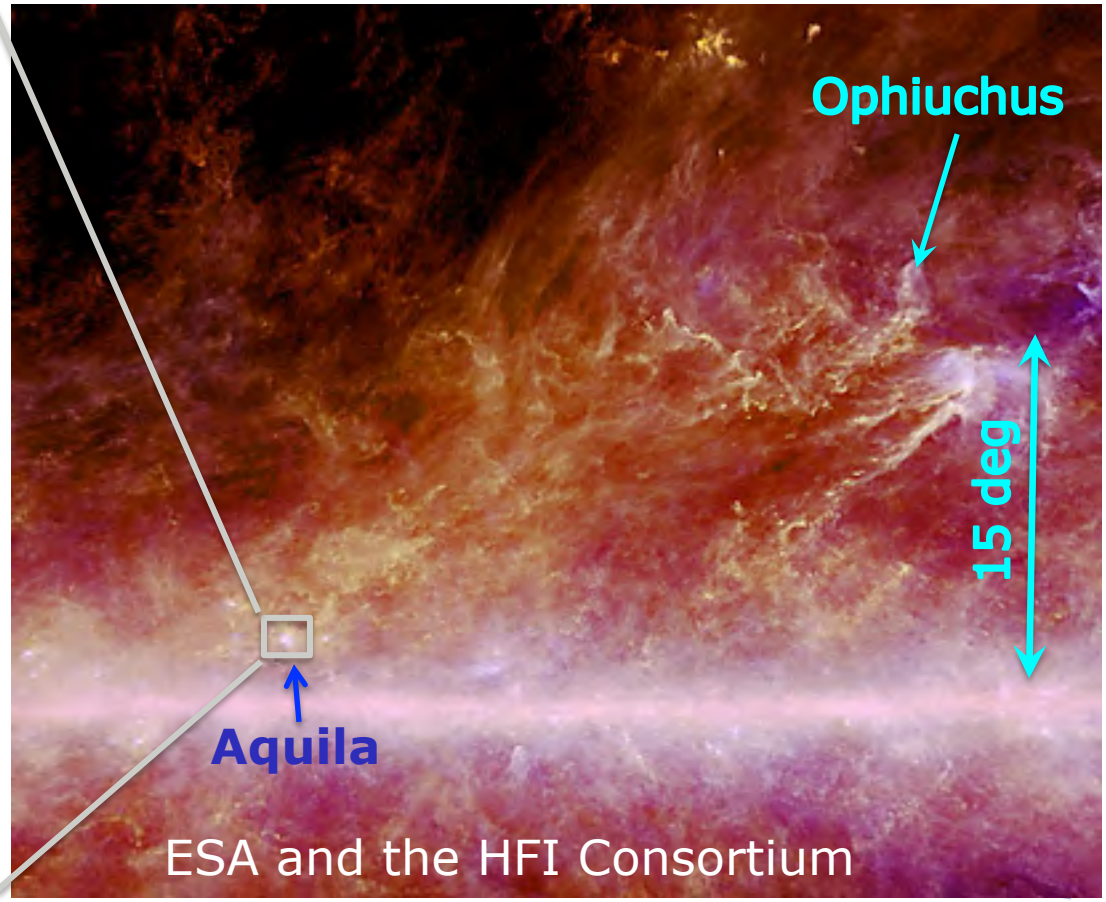
No observed SF quenching in COSMOS & CDF-S! But in CDF-N!

Structure permeate the ISM on all scales

Herschel
SPIRE 500 μm +PACS 160/70 μm

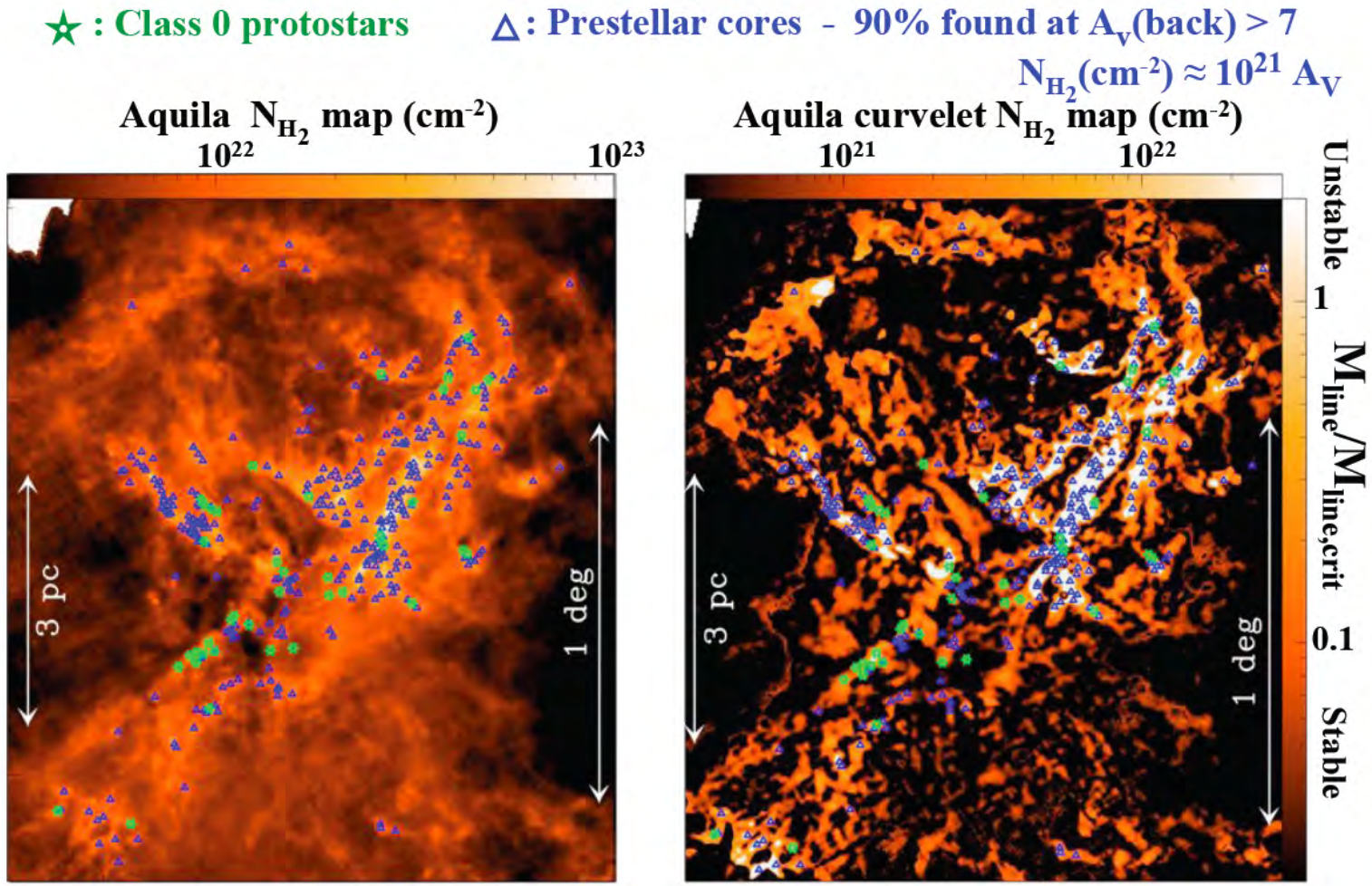
Planck
HFI 540/350 μm + IRAS 100 μm





Herschel: Aquila – stars form in filaments

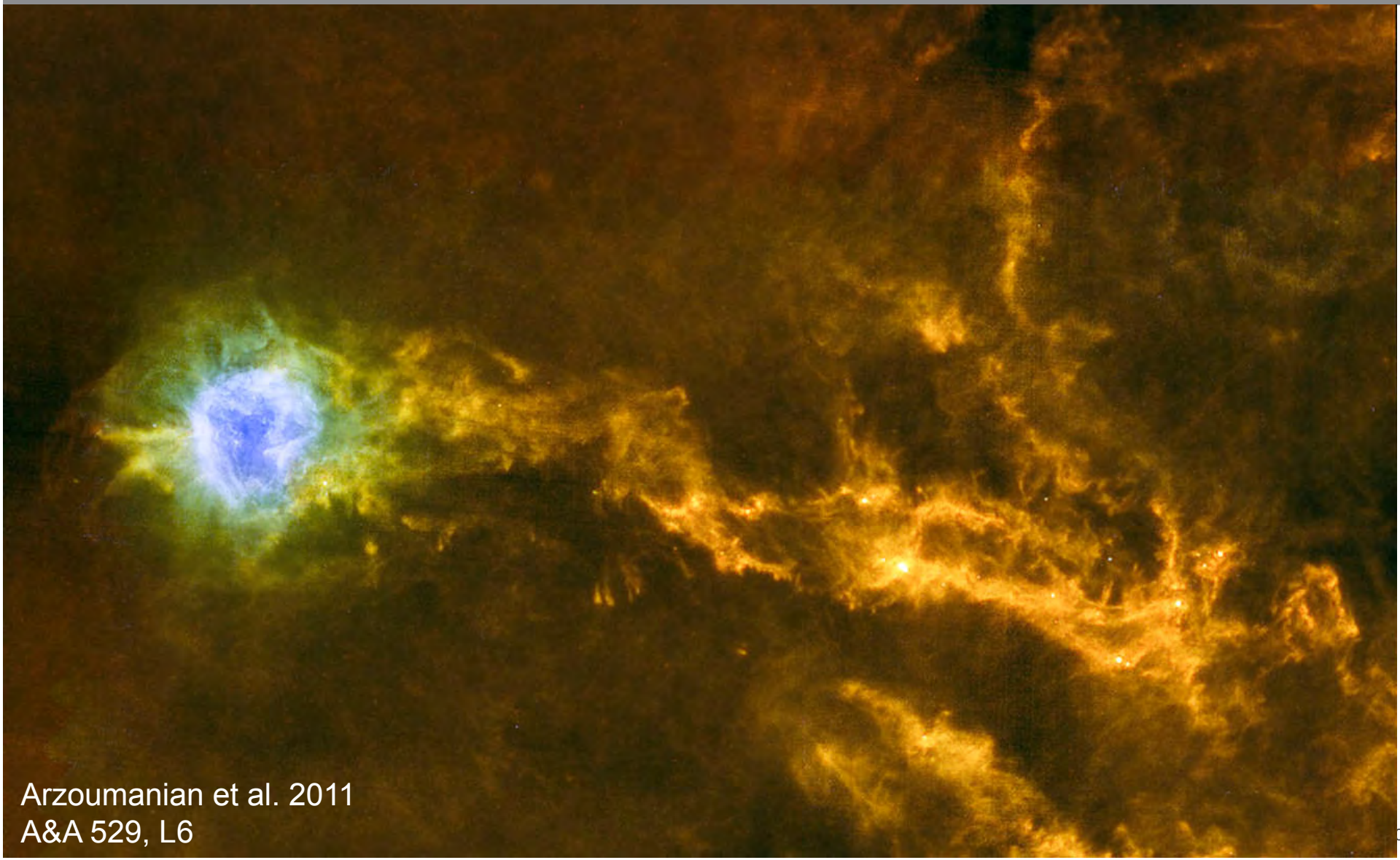
Protostars and prestellar cores are preferentially found in MC filaments with densities above a critical value



André et al. 2010

HERSCHEL SPACE OBSERVATORY

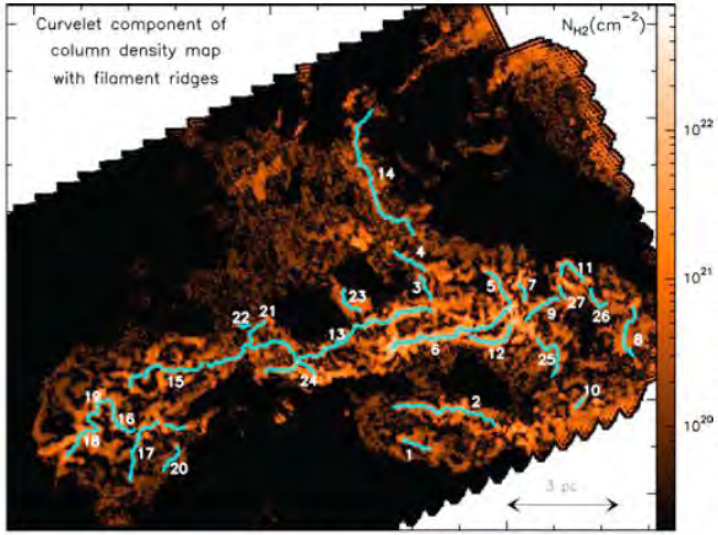
Herschel: IC 5146 filaments



Arzoumanian et al. 2011
A&A 529, L6

Herschel: IC 5146 filaments

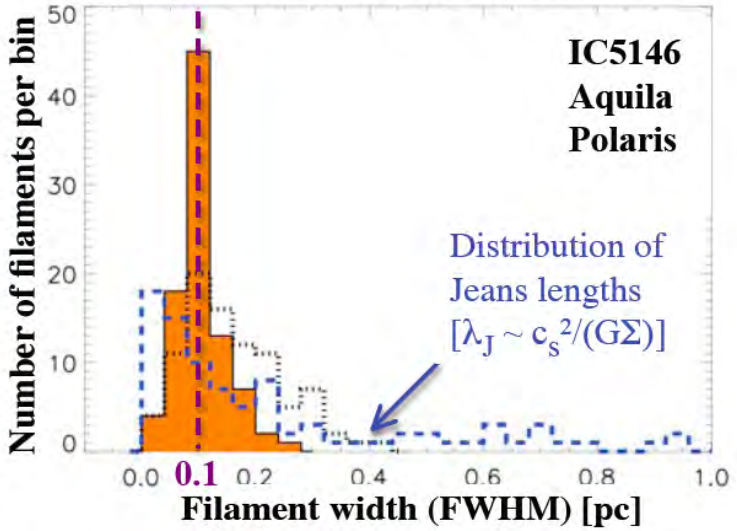
Network of filaments in IC5146



Arzoumanian et al. 2011

Using the DisPerSE algorithm (Sousbie 2011) to trace the ridge of each filament

Distribution of widths for 90 filaments



➢ **Consistent with the view that filaments form as a result of the dissipation of interstellar turbulence (cf. Padoan et al. 2001)**

Arzoumanian et al. 2011
A&A 529, L6

HERSCHEL SPACE OBSERVATORY

Hi-Gal

Herschel infrared Galactic Plane Survey

Hi-GAL Team & ESA

Herschel 70-160-350 μm composite

Molinari et al. 2010

Toward a Predictive Global Model of Galactic Star Formation

Open Time KP for a simultaneous *70-160-250-350-500 μm* continuum mapping of the entire Galactic Plane ($|b| \leq 1°$ following the warp) for a total area of 720 square degrees and 900 hours observing time to deliver a Galaxy-wide Census, Luminosity, Mass and SED of dust structures at all scales from massive YSOs to full Spiral Arms

Galactic SF occurs along filaments

Part of the OB1 region in Volpecula

l=59 deg

The movie shows l=345 -> 325 deg, eventually all the 360 deg.

Molinari & HI-GAL team

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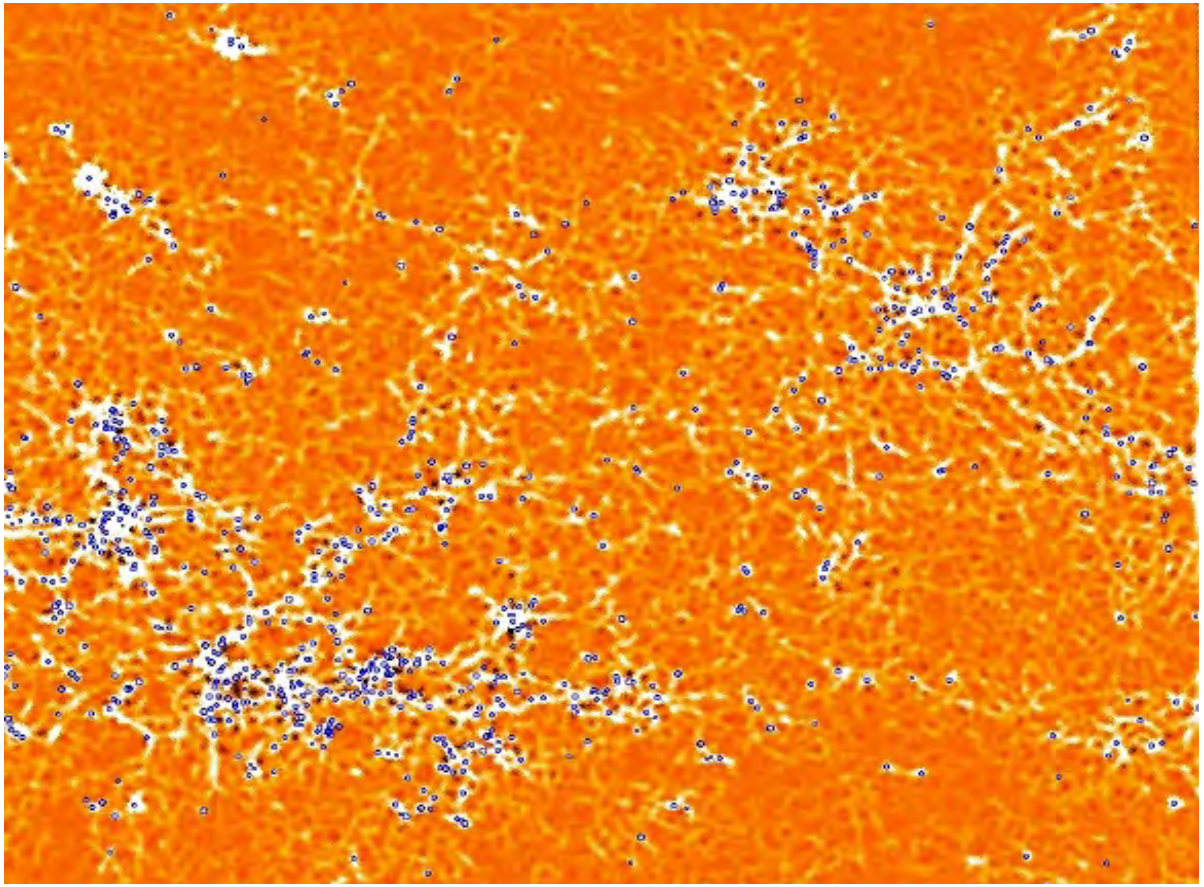
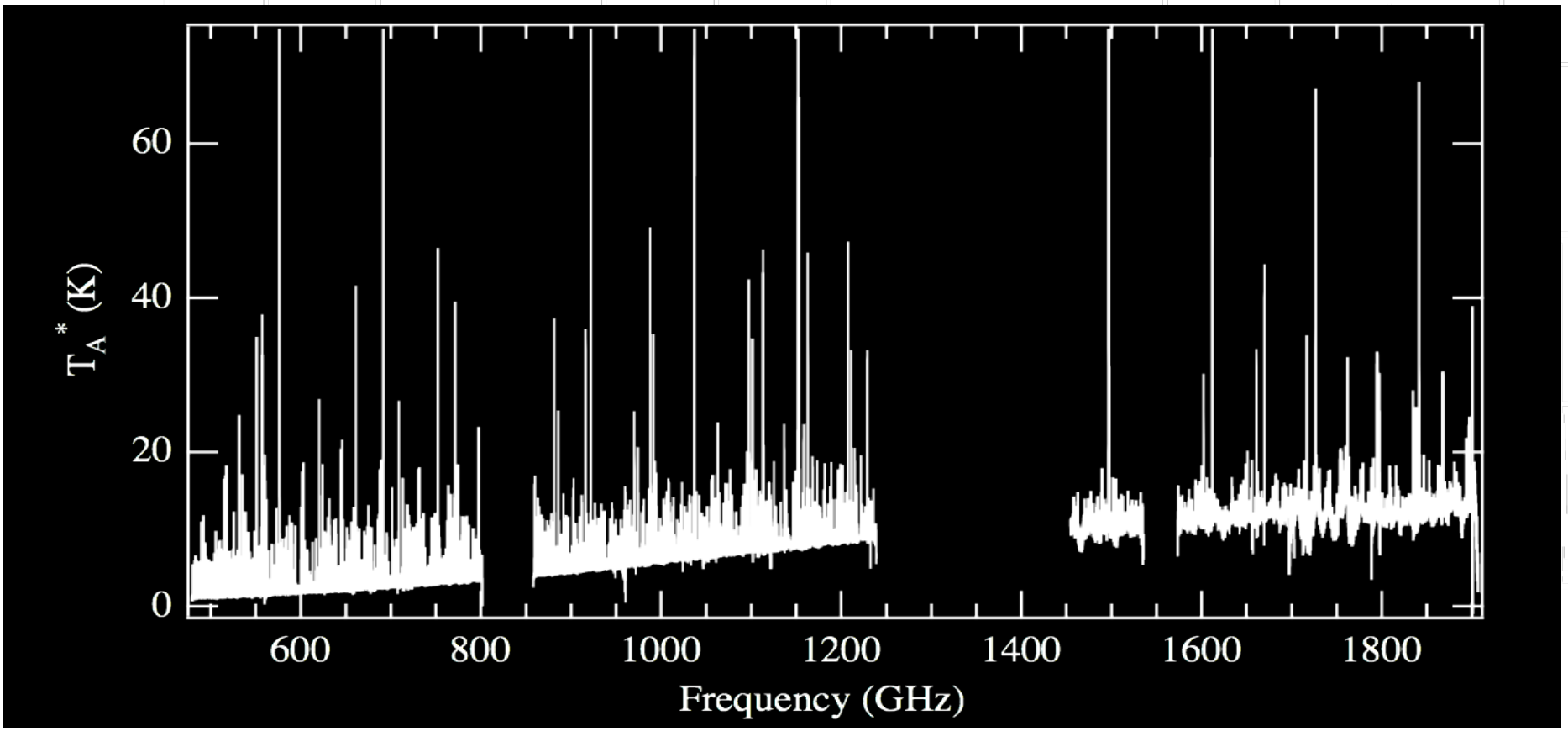


Molinari & HI-GAL team

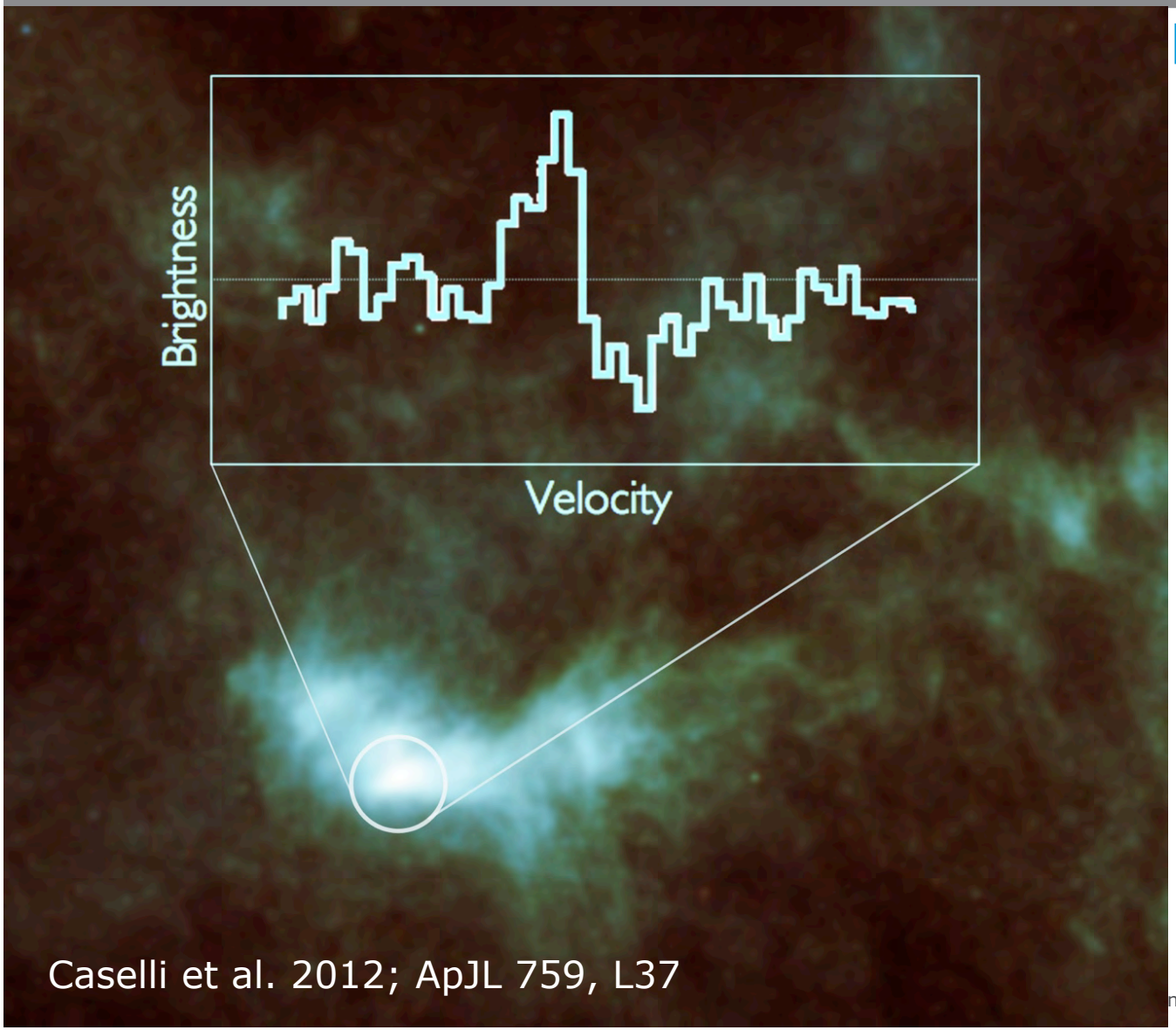
Orion: Chemistry & star formation

Complete Herschel/HIFI spectral scan of Orion KL



- 20,000 lines identified – 'only' about 5,000 from methanol…
- Astrophysics & chemistry in the making…

Water in pre-stellar core in L1544



Caselli et al. 2012; ApJL 759, L37

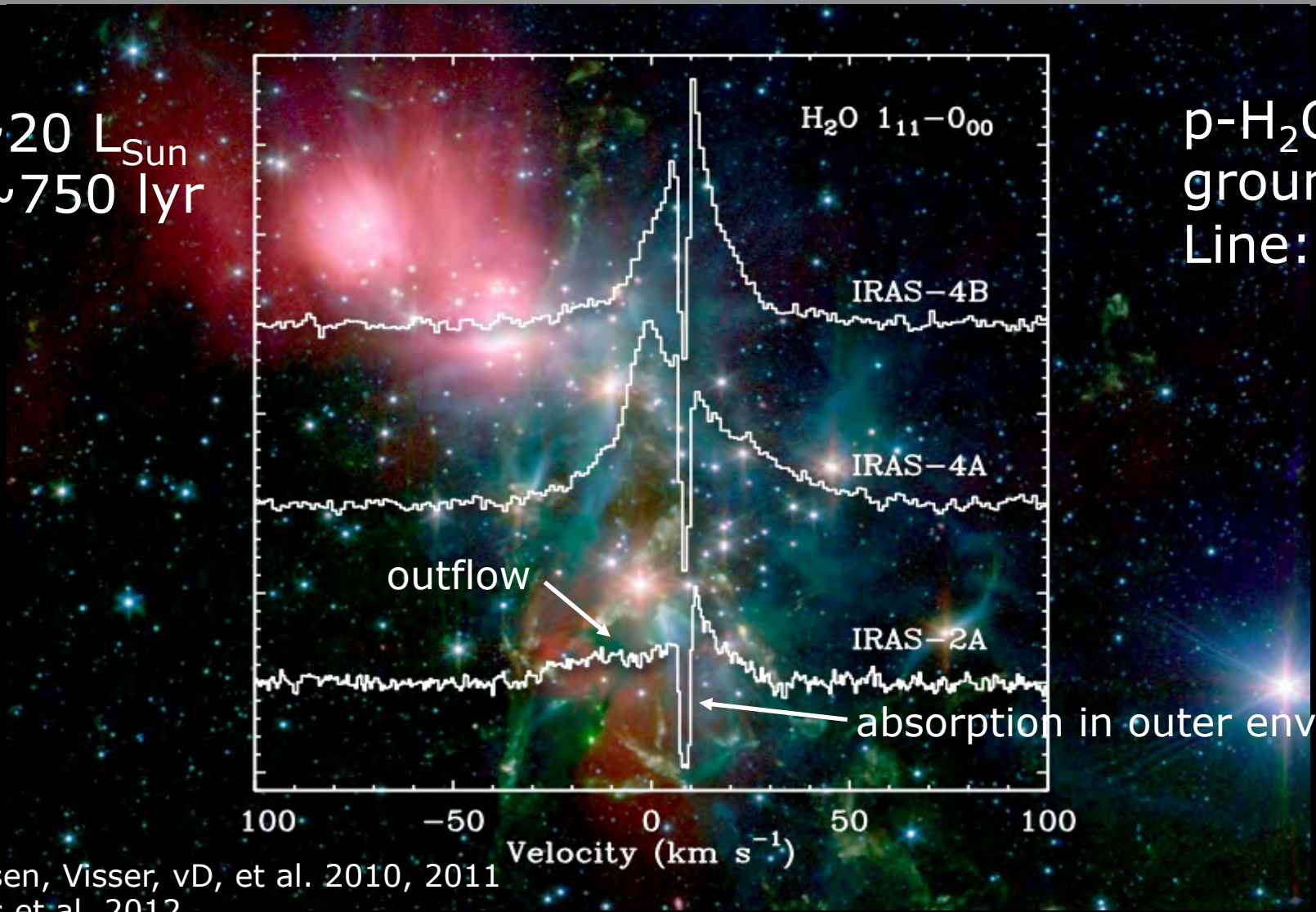
First detection of water vapour in pre-stellar core

- 13.6 hr of HIFI at 557 GHz (H_2O 1_{10}-1_{01})
- ~2000 'earth oceans' as water vapour
- ~3 million 'eo' as water ice on dust
- Vapour liberated by UV radiation, created by ionising particles colliding with H_2
- Line profile indicates infall at 1000 AU

HERSCHEL SPACE OBSERVATORY

Water emission from protostars

L~20 L_{Sun}
D~750 lyr



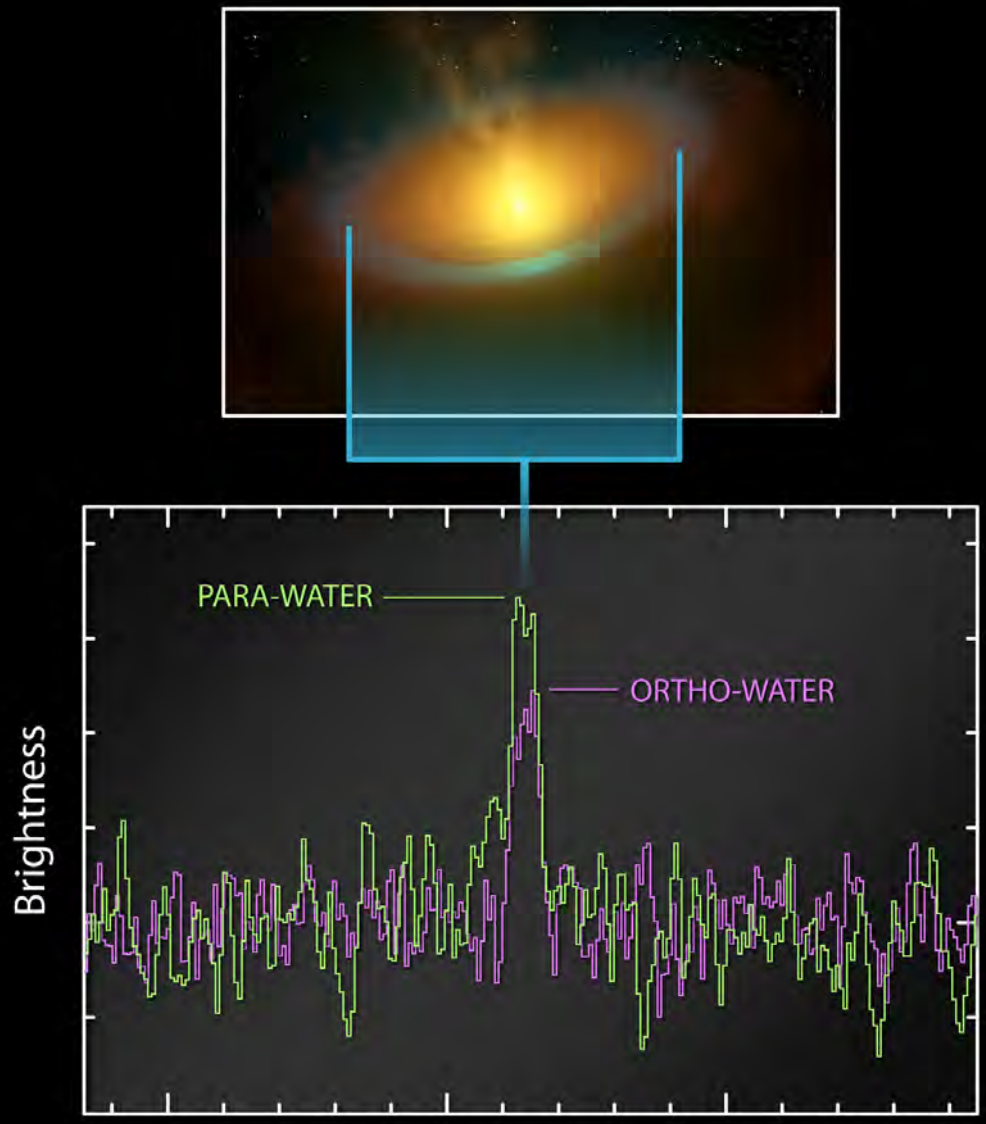
p-H_2O
ground-state
Line: 1 THz

Kristensen, Visser, vD, et al. 2010, 2011
Coutens et al. 2012

Water in disk of TW Hya

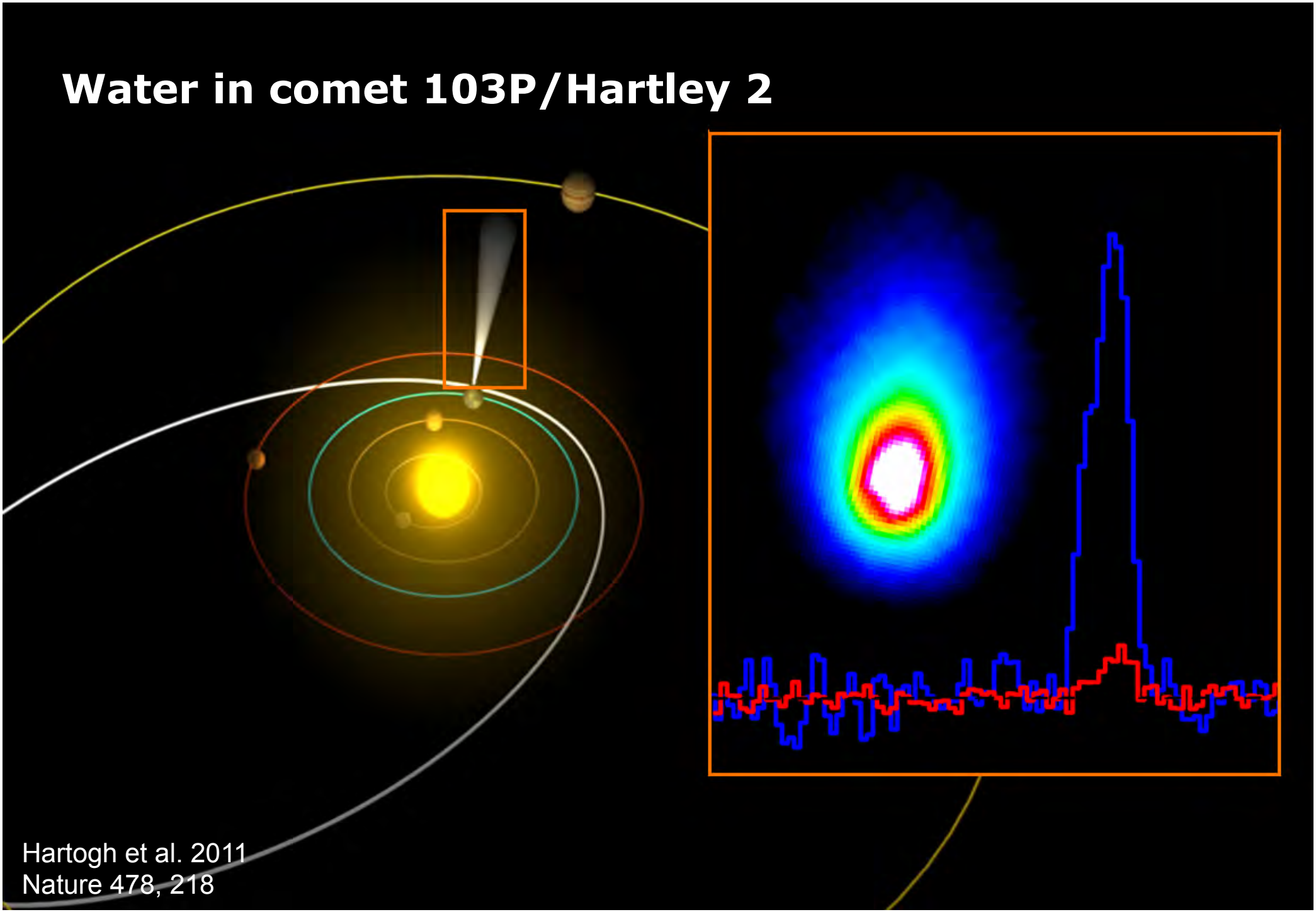
- TWHya: ~55 pc, ~ 12 Myr, ~0.6M_{sun}
- Water vapour ~0.05 'earth oceans'
- Water ice ~x1000 'earth oceans'
- On source int time 181 min at 557 GHz
- On source int time 326 min at 1113 GHz

Hogerheijde et al. 2011
Science 334, 338



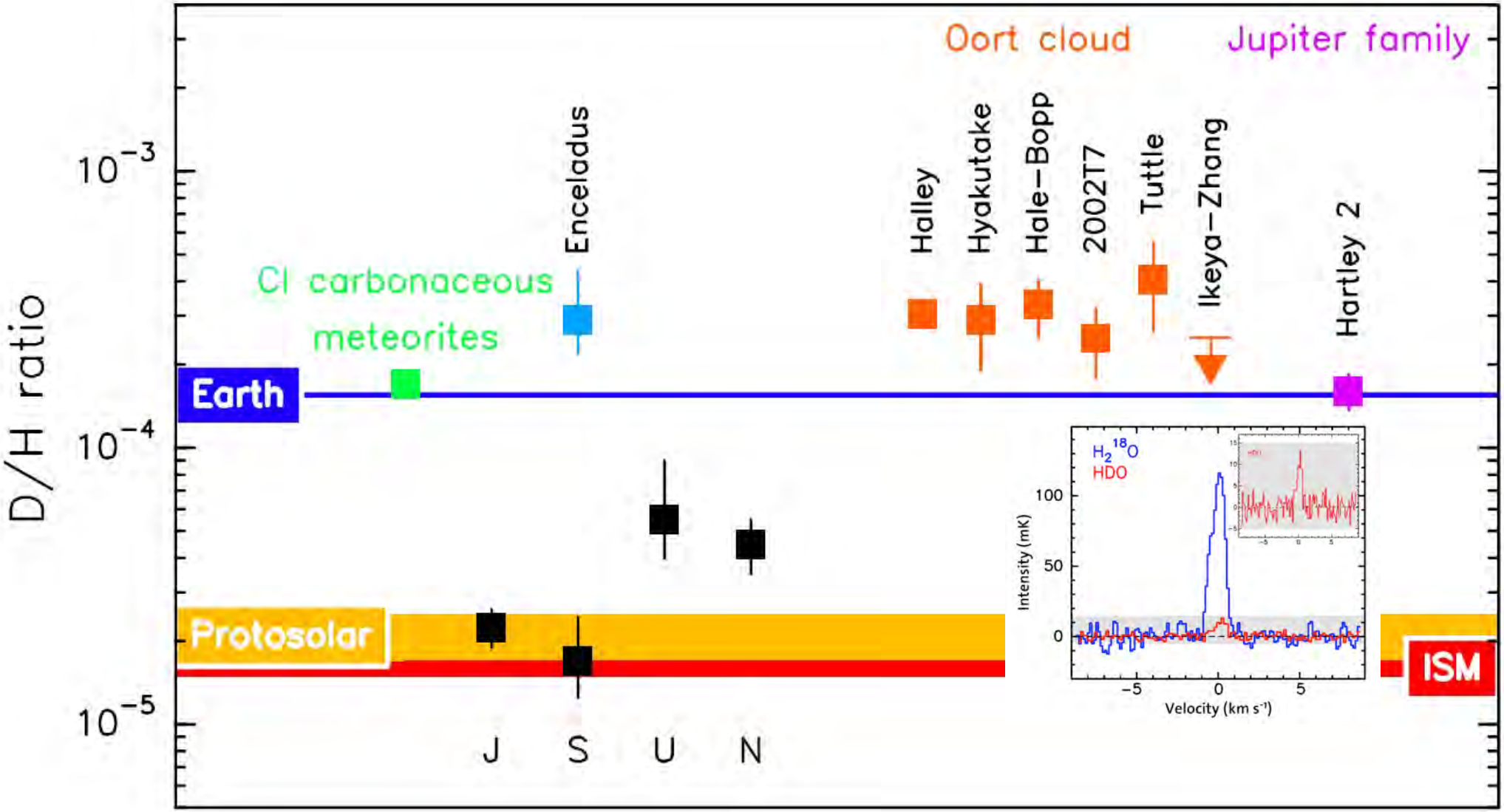
HIFI Spectroscopic Signatures of Water Vapor in TW Hydrae Disk
ESA/NASA/JPL-Caltech/M. Hogerheijde (Leiden Observatory)

Water in comet 103P/Hartley 2



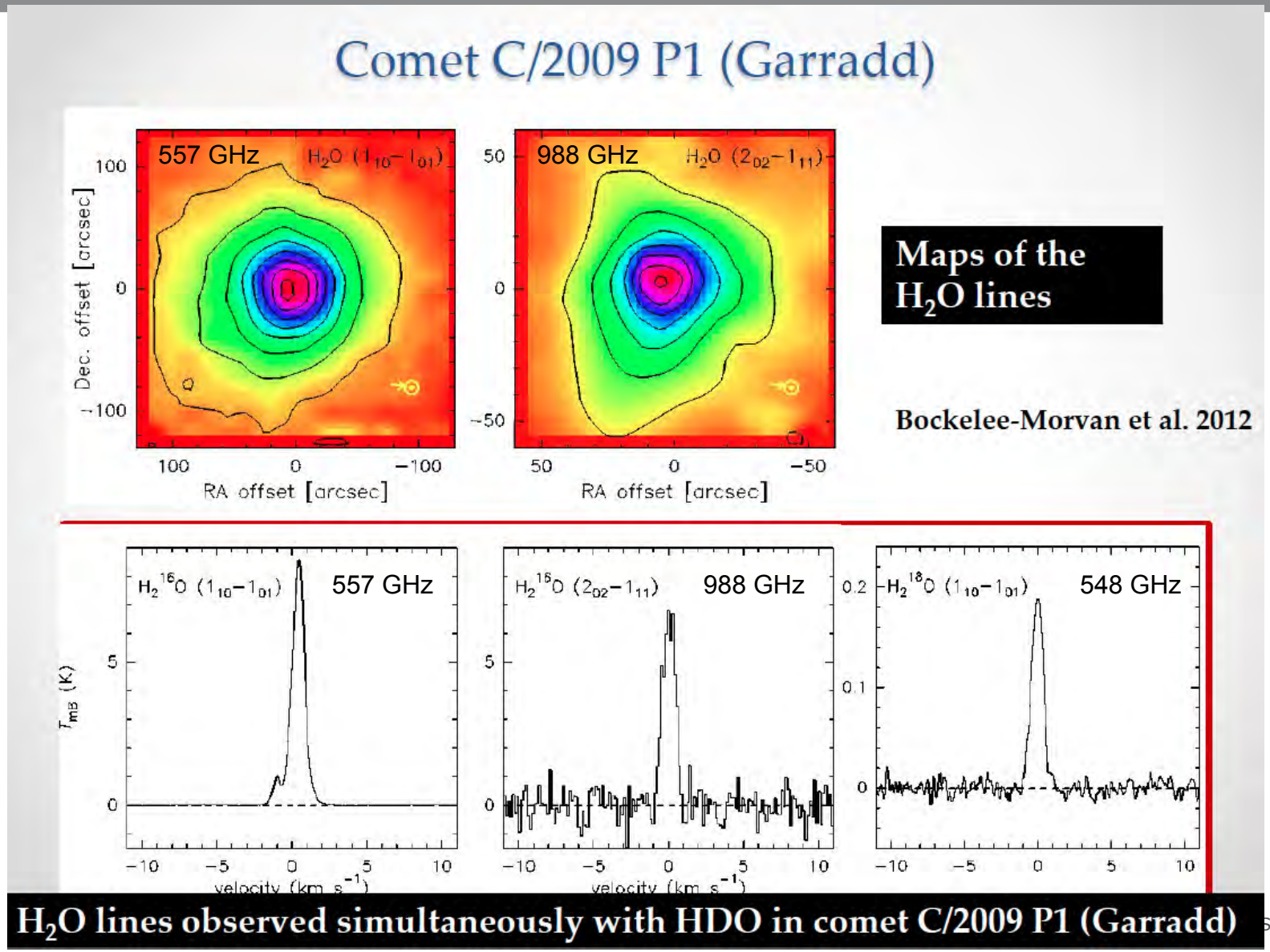
Hartogh et al. 2011
Nature 478, 218

Water in comet C/103 P Hartley 2



Hartogh et al. 2011, Nature 478, 218

...and in comet C/2009 P1 Garradd



HERSCHEL SPACE OBSERVATORY

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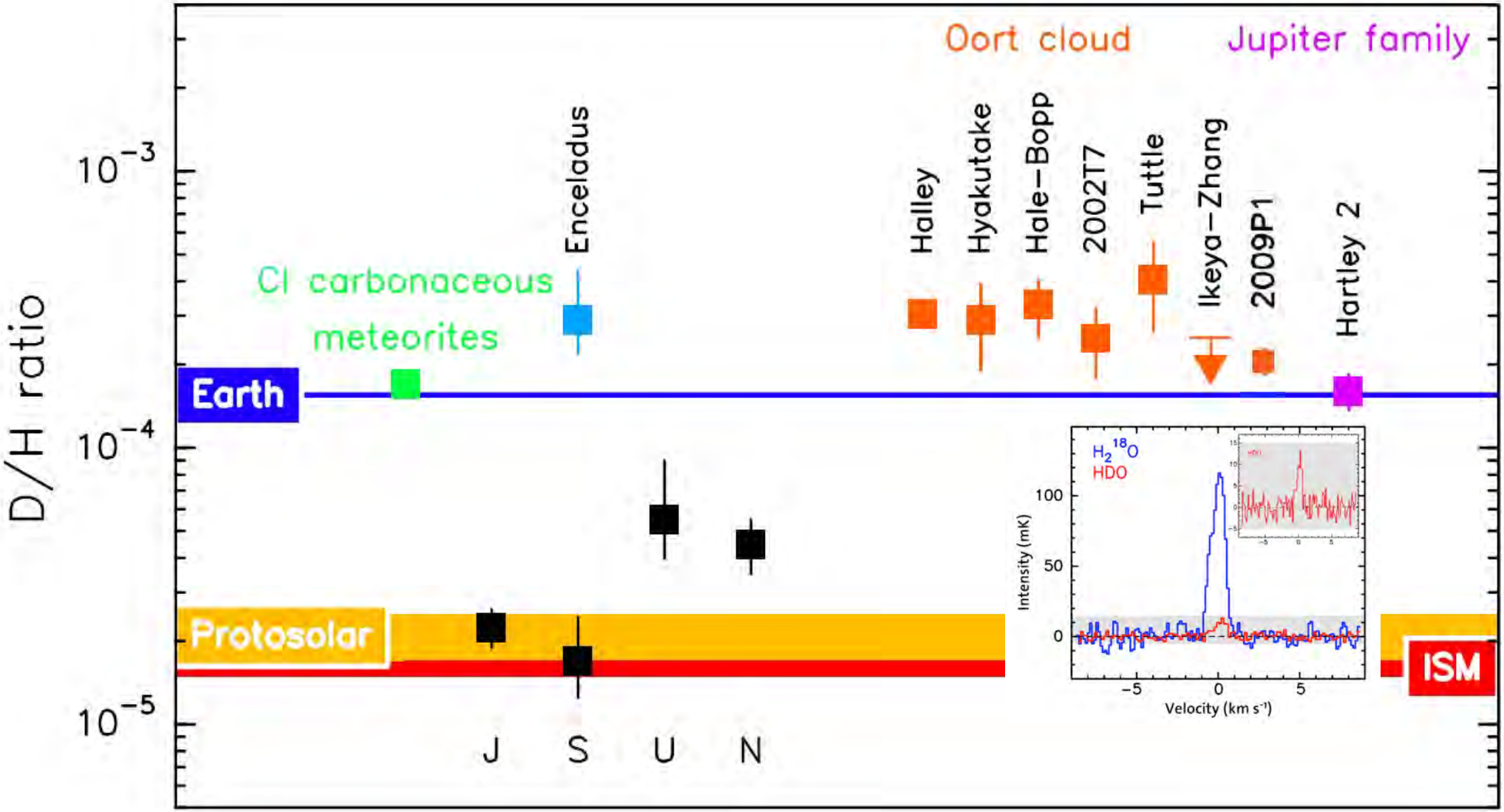
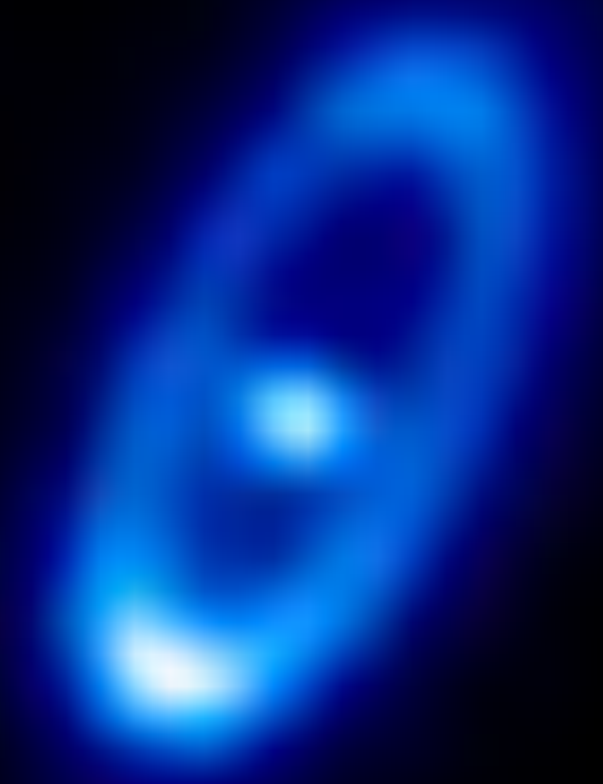


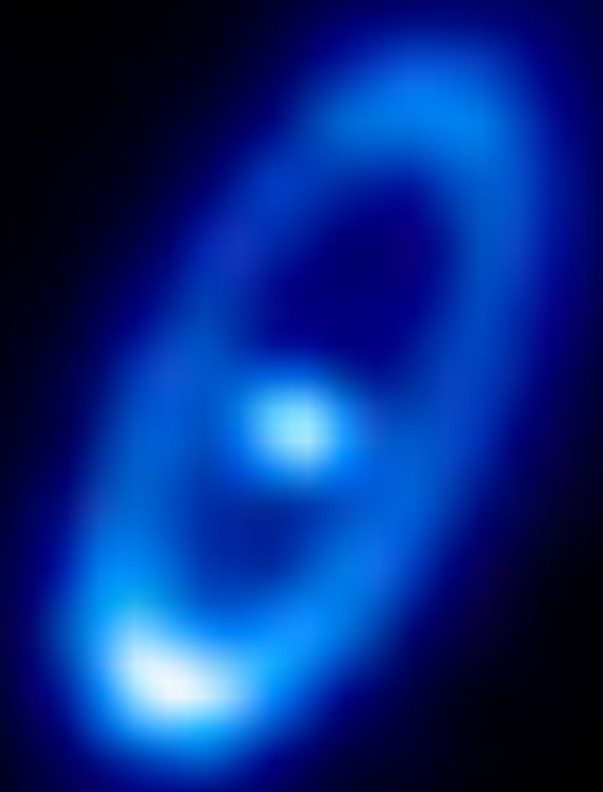
Bockelée et al. 2012, A&A 544, L15

Fomalhaut



Acke et al. 2012
A&A 540, A125

Fomalhaut



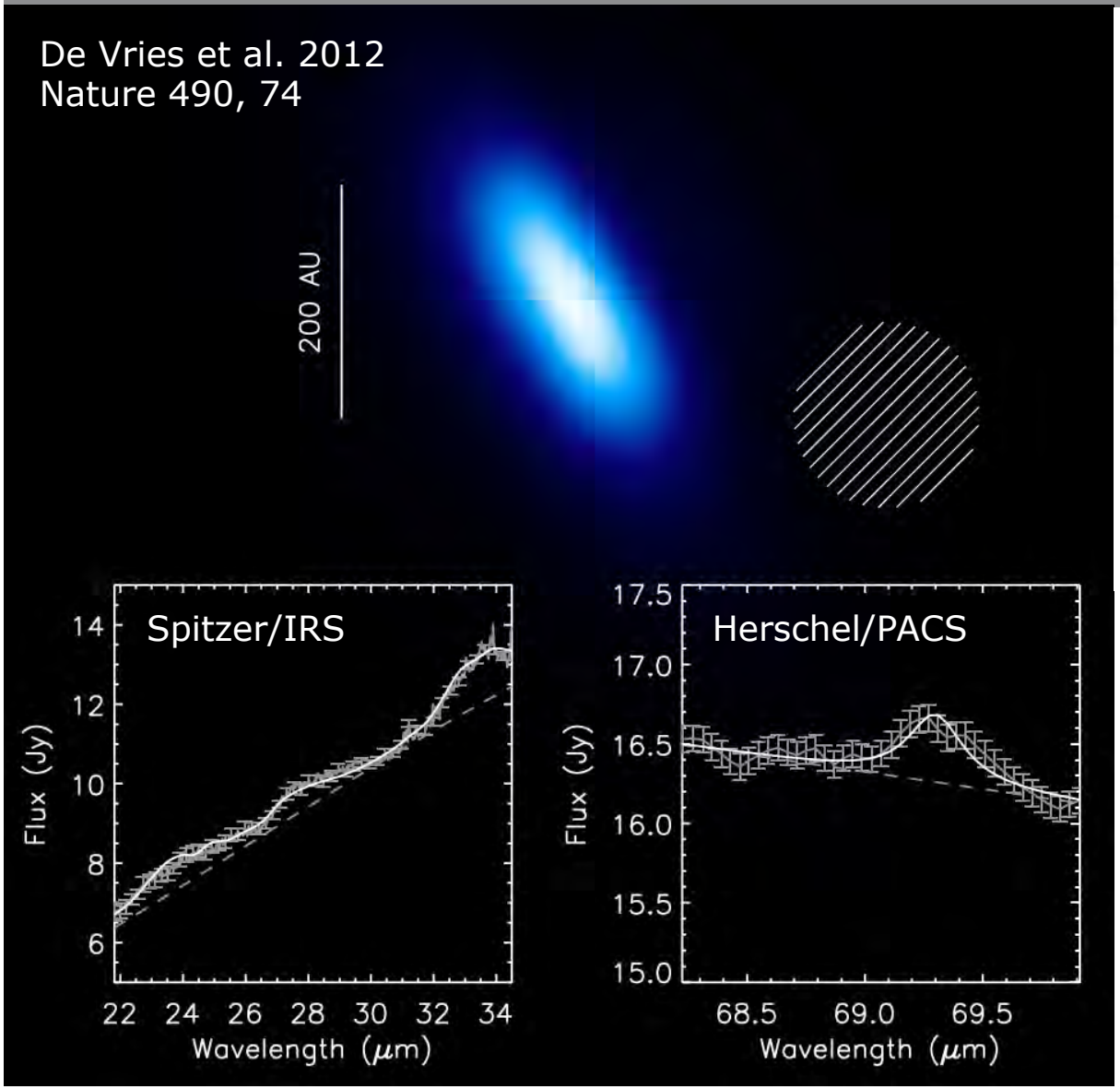
Acke et al. 2012
A&A 540, A125

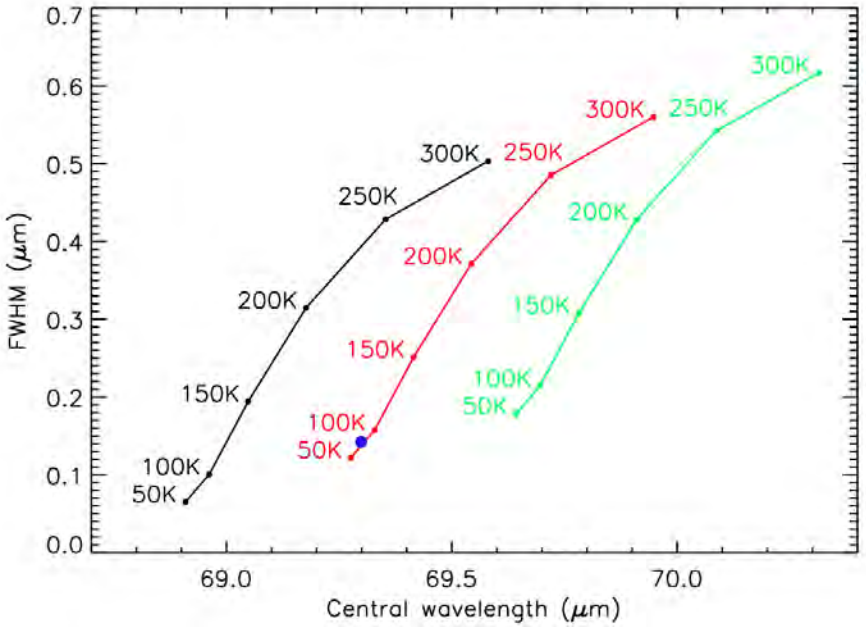
Modelling:

- Optical large >50 um grains, thermal small (blow-out) grains => fluffy aggregates
- Replenishment time ~1700 yrs
- Mass loss (=production) rate ~2000 (1 km) comets per day
- Reservoir of ~10^{13} comets, total ~100 M_{Earth}
- Currently a remarkably violent system!

Pristine material around β Pictoris

De Vries et al. 2012
Nature 490, 74

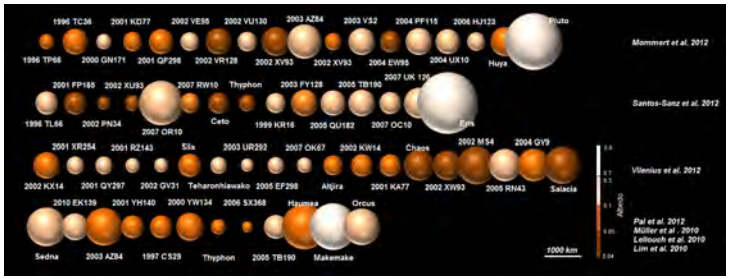




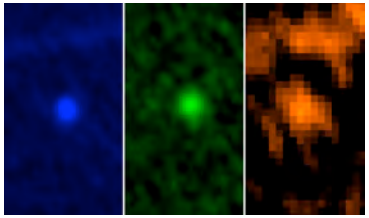
- Spitzer/IRS 22-34 um
- Herschel/PACS 69 um band => Mg-rich crystalline olivine
- Mg-rich => pristine
- Fe-rich => 'processed'

… and more!

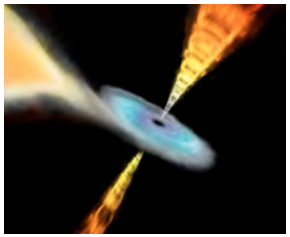
Herschel has observed ~10% of all the 1300 known TNOs =>

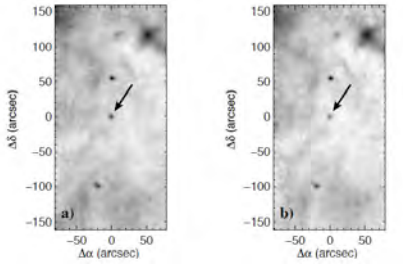


Apophis =>

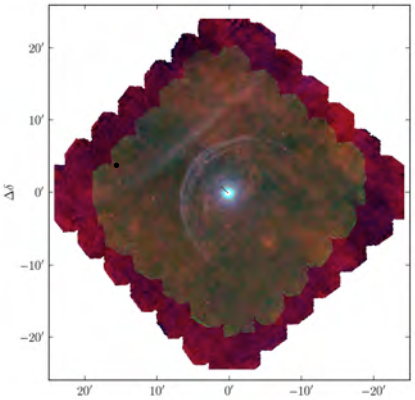


GX339-4 BH jet ⇓

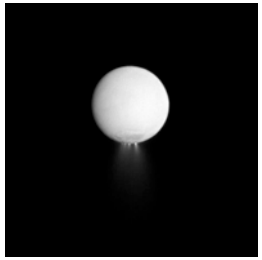


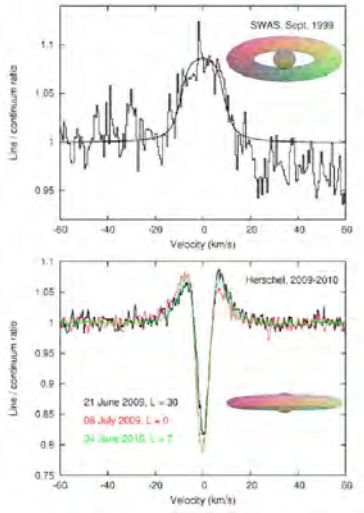


Saturn H_2O torus ⇓ ⇓

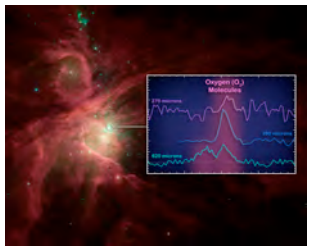


Betelgeuse





Oxygen O_2 ⇓



HERSCHEL SPACE OBSERVATORY

Herschel's Legacy

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Not sure we can say today

- We'll have to look back 5, 10, 20 years from now

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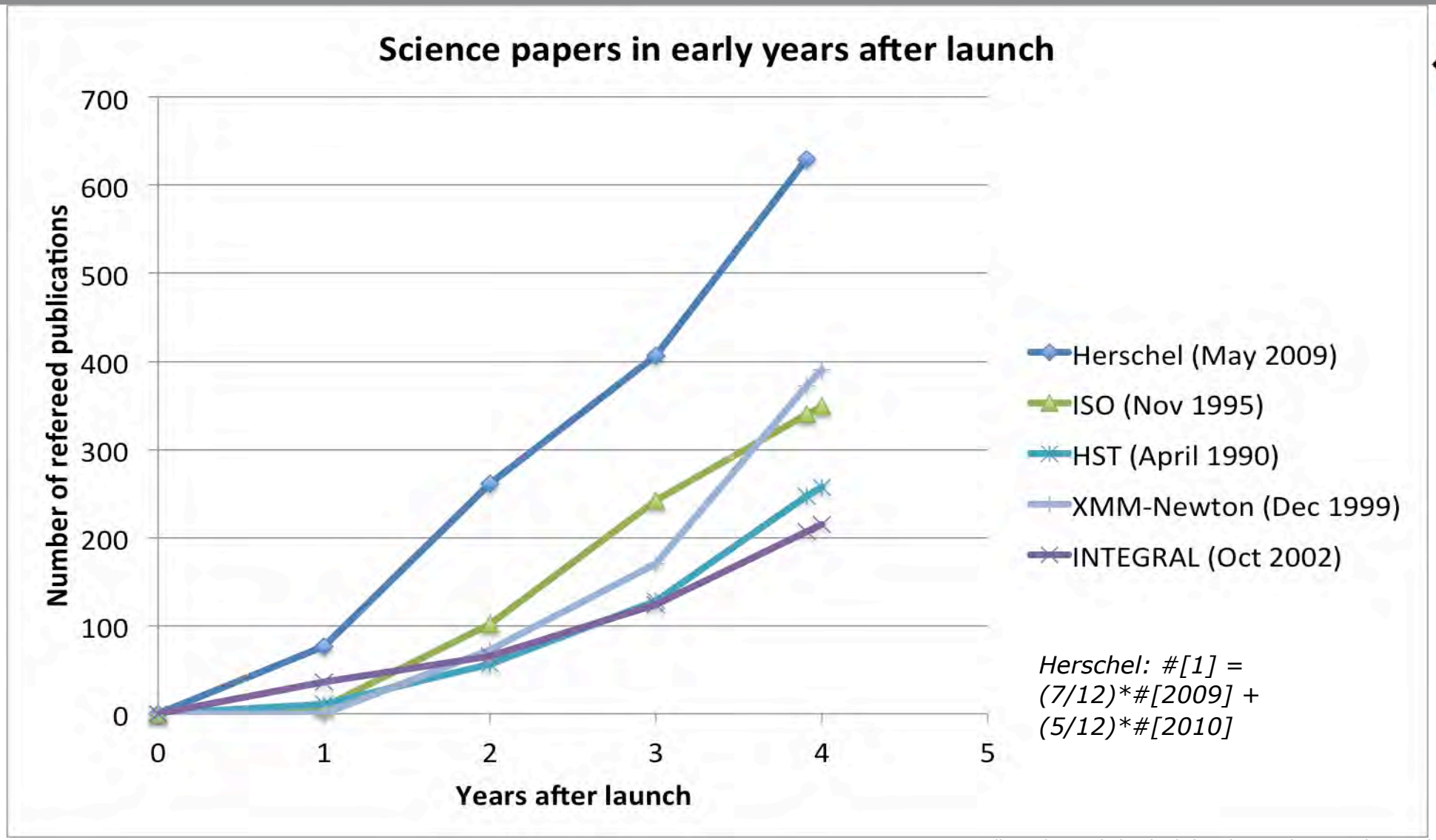
Scientific results – to date & future

- Last update of publications list 632 papers

HERSCHEL SPACE OBSERVATORY

Herschel pub stats – good start...



HERSCHEL SPACE OBSERVATORY

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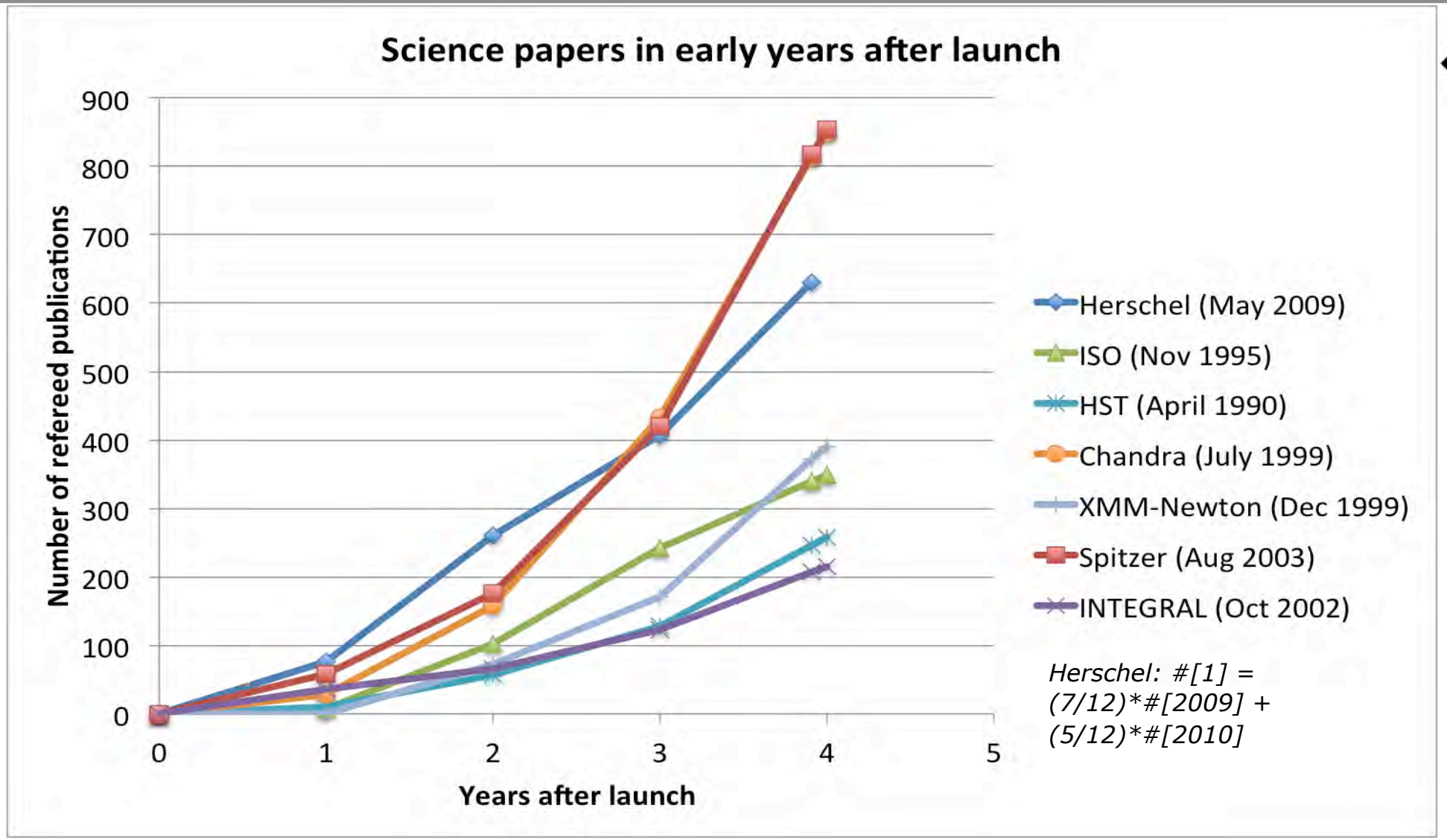

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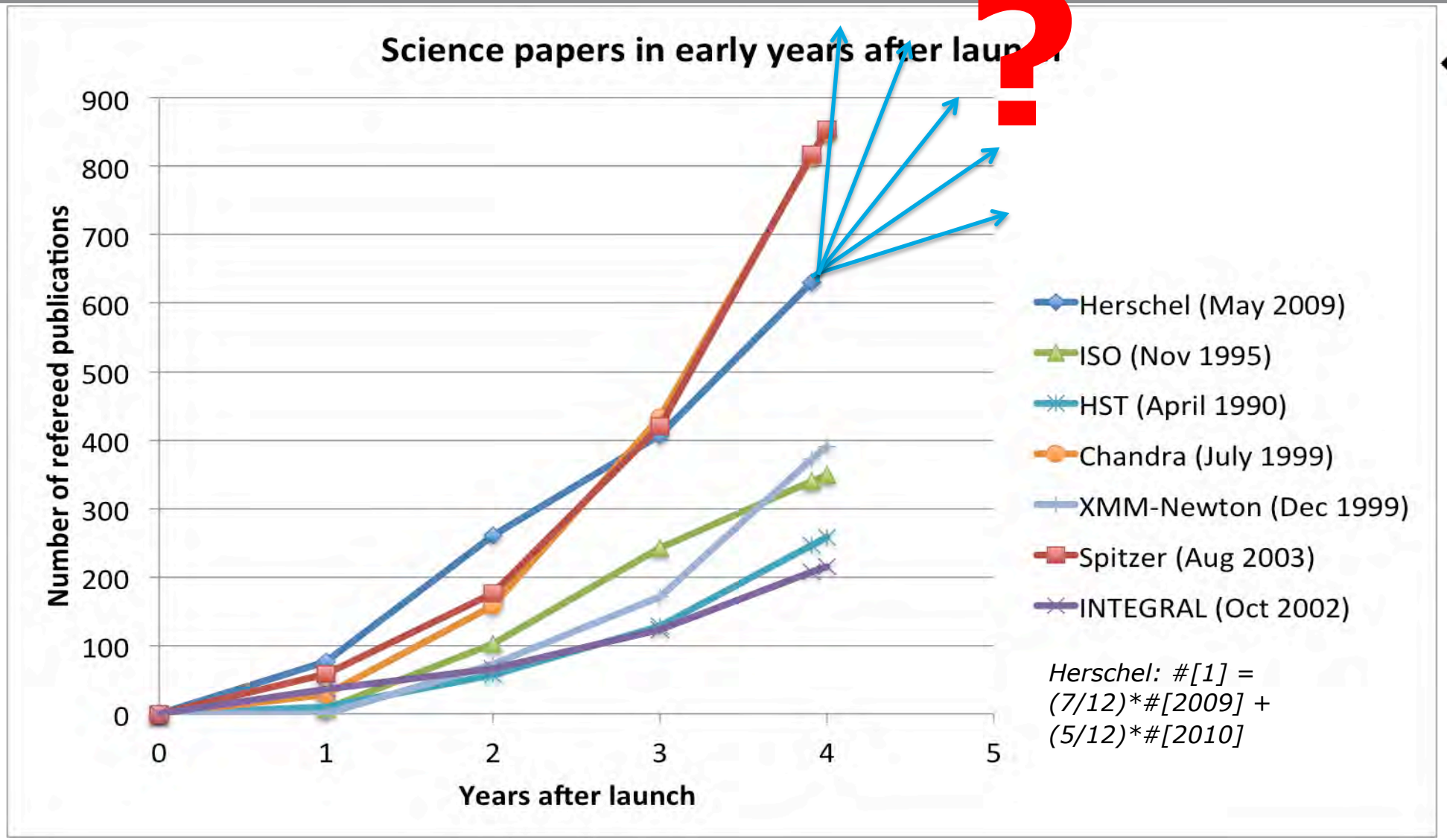

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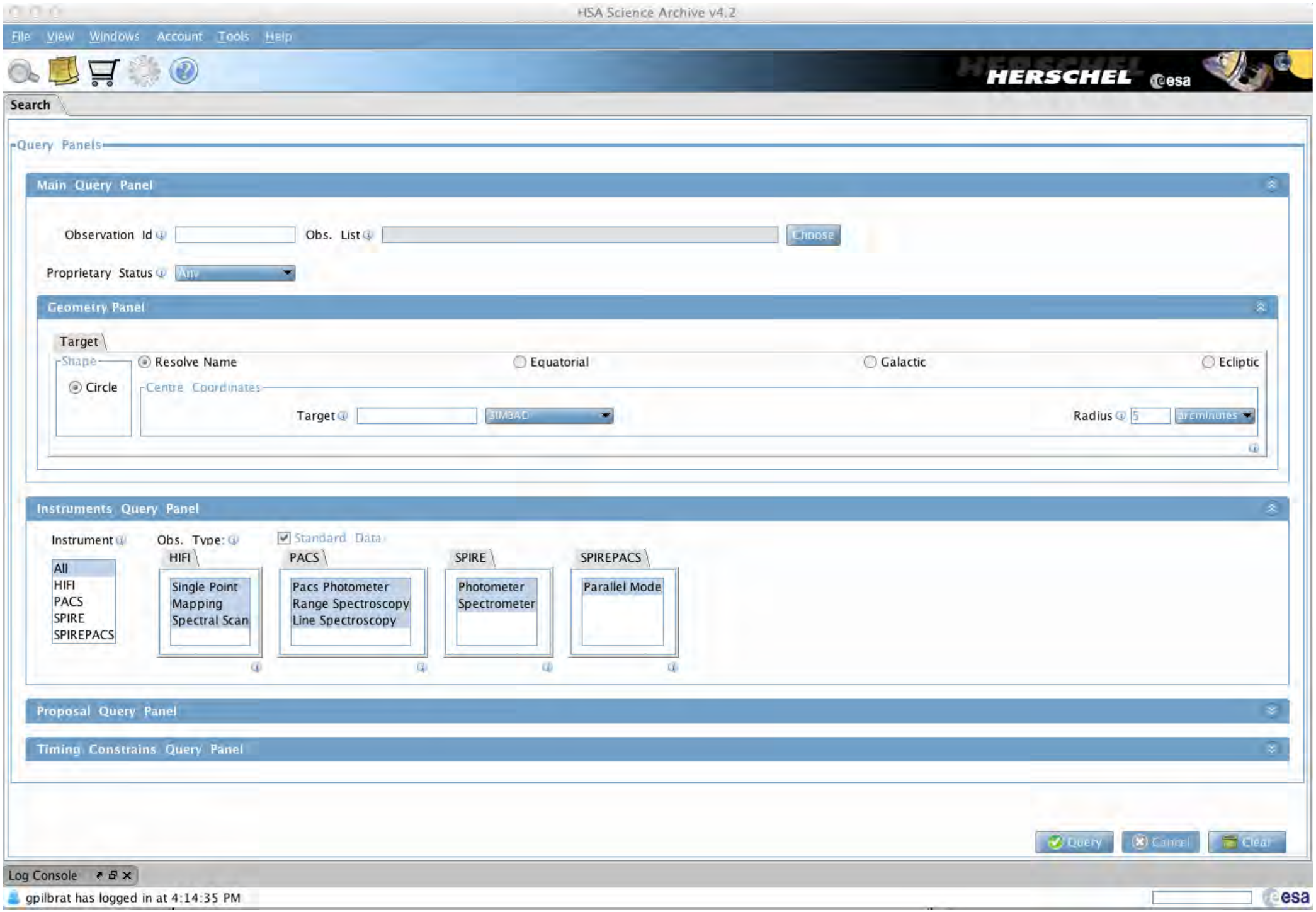
- The data, data products, calibration, software & methods, documentation, value-adding features, …

HERSCHEL SPACE OBSERVATORY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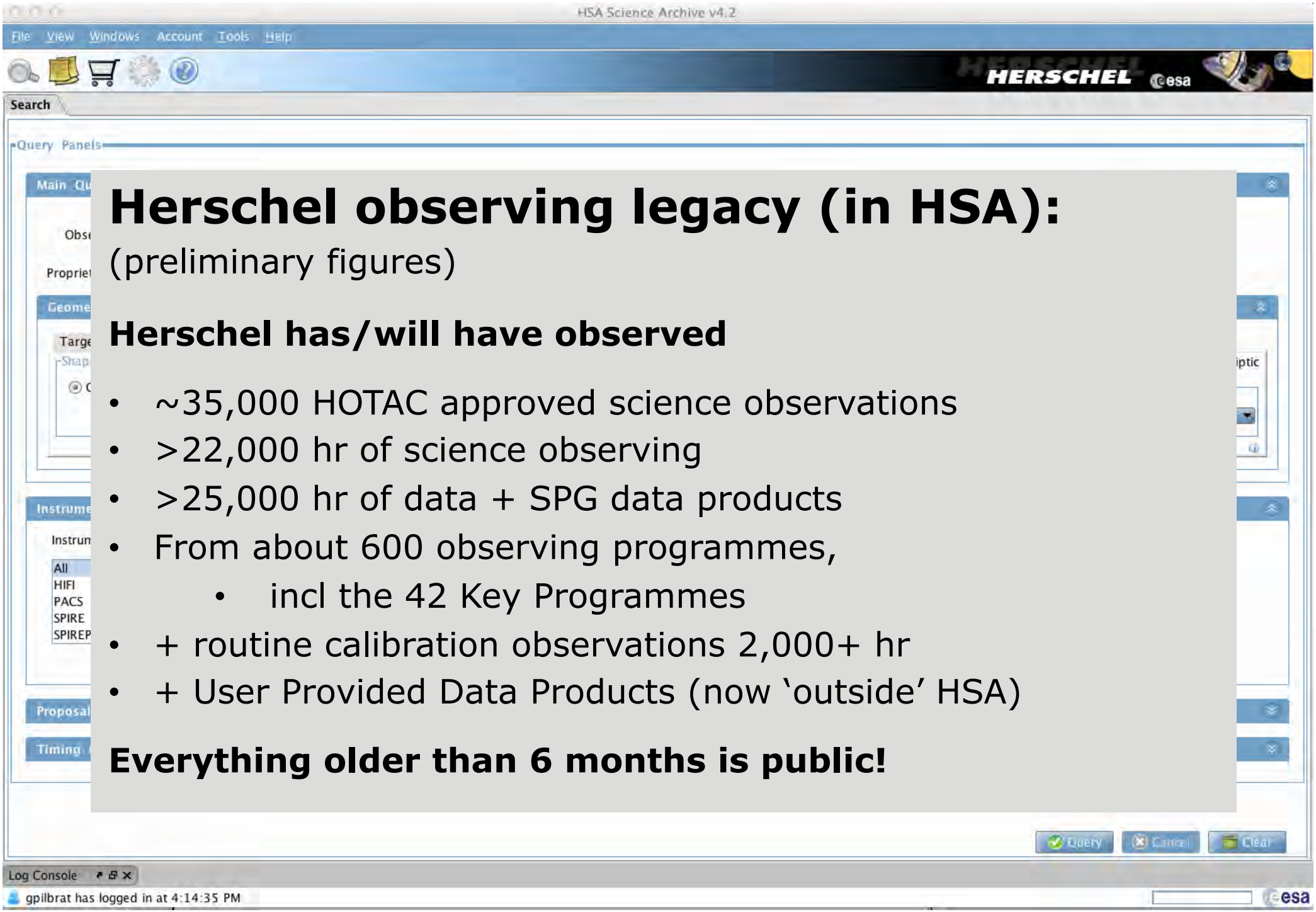
HSA Science Archive v4.2
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Timing
Herschel observing legacy (in HSA):
(preliminary figures)
Herschel has/will have observed
• ~35,000 HOTAC approved science observations
• >22,000 hr of science observing
• >25,000 hr of data + SPG data products
• From about 600 observing programmes,
• incl the 42 Key Programmes
• + routine calibration observations 2,000+ hr
• + User Provided Data Products (now 'outside' HSA)
Everything older than 6 months is public!
Query
Cancel
Clear
Log Console
gpilbrat has logged in at 4:14:35 PM
esa

User Provided Data Products – to date

Proposal ID	Proposal Name	Release Note	User Provided Data Products Repository	Related Publications	Latest update
OT1_pharve01_3	The Auriga-California Molecular Cloud: A Massive Nearby Cloud With Powerful Diagnostics For Early Stages of Star Formation.	Harvey et al. 2013	Data Repository	Harvey et al. 2013	[11-Mar-2013]
KPGT_dlutz_1	PACS Evolutionary Probe (PEP)	PEP Release Note (PACS data) PEP Release Note (SPIRE data)	PEP public data releases	Lutz et al. 2011 PEP related publications	[01-Mar-2013]
KPGT_vbujarra_1	HIFISTARS: The physical and chemical properties of circumstellar environments around evolved stars	HIFISTARS Release Note	HIFISTARS Data Repository	Bujarrabal et al. 2012	[16-Nov-2012]
KPGT_cwilso01_1	Physical Processes in the Interstellar Medium of Very Nearby Galaxies	VNGS Release note	VNGS Data release	Bendo et al. 2012	[27-Sep-2012]
KPOT_delbaz_1	The Great Observatories Origins Deep Survey : far-infrared imaging with Herschel (GOODS)	GOODS-Herschel release documentation	GOODS-North Data GOODS-South Data	GOODS-Herschel related publications	[12-Sep-2012]
KPOT_rkennicu_1	Key Insights on Nearby Galaxies: a Far Infrared Survey with Herschel (KINGFISH)	KINGFISH Data Products Delivery - DR2 User's Guide	KINGFISH Data Products (DR2) repository	Kennicutt et al. 2011	[18-Jul-2012]
KPGT_soliver_1	HerMES	HerMES Release note	HerMES Data Release	HerMES related publications	[13-Apr-2012]
KPOT_ckrame01_1	Herschel M33 extended survey (HerM33es)	HerM33es : Herschel M33 extended survey - SPIRE Data Products Delivery User's Guide HerM33es: Herschel M33 extended survey - PACS Data Products Delivery User's Guide	HermesPublicData	Kramer et al. 2010 Boquien et al. 2011	[2-Mar-2012]
KPOT_mjuvela_1	Galactic Cold Cores: A Herschel survey of the source populations revealed by Planck	ColdCores Release Note	ColdCores Data Repository	Juvela et al. 2010, 2011	[8-Sep-2011]
KPOT_jdavie01_1	The Herschel Virgo Cluster Survey (HeViCS)	Data Reduction for HEVICS Public Data Release of 2 Scan DatA	The first HeViCS public data release	The HeViCS papers	[2-Sep-2011]
KPOT_seales01_2	H-ATLAS	First data release of the Herschel ATLAS	H-ATLAS SDP images and files H-ATLAS SDP catalogue	PACS maps (Ibar et al. 2010) SPIRE maps (Pascale et al. 2010) 5-band source catalogue (Rigby et al. 2010)	[24-Oct-2010]

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KPGT_cwilso01_1	Phy				[27-Sep-2012]
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KPOT_rkennicu_1	Key			011	[18-Jul-2012]
KPGT_soliver_1	Her				[13-Apr-2012]
KPOT_ckrame01_1	Her			0 1	[2-Mar-2012]
KPOT_mjuvela_1	Ga			2011	[8-Sep-2011]
KPOT_jdavie01_1	The	Release of 2 Scan Data	data release		[2-Sep-2011]
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KP 'wrap-up' telecons:

- Held with all but one of the 42 KP consortia
- Expecting User Provided Data Products to be delivered in significant quantities in the coming 6+ months.
- 'Integration' of UPDPs into the HSA
- Advertising through other channels

Legacy in the Making

HERSCHEL SPACE OBSERVATORY

Beyond EoHe: Post-Operations Phase

End of observing is not end of the Herschel mission

- **"End-of-helium", "end-of-observing", "end of in-flight ops", …**

Post-Operation Phase – 3-5 years

- Community support for ongoing data exploitation
- Create, advertise, and deliver the Herschel Legacy
- Derive lessons learned and items for future use
- Enable personnel to perform their own science exploitation
- **In summary: Produce and provide added value**

Beyond POP – the Legacy Science Phase

- **The Herschel legacy archive will be maintained indefinitely**
- No 'Herschel-specific' activities are funded

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Now is the time!!

HERSCHEL SPACE OBSERVATORY

This meeting

Calibration was considered important upfront

- HCalSG effort initiated many years before launch by HST …
  - Initially led by Ana Heras (Leiden 2004, Madrid 2008)
- … and has been high priority ever since
  - Taken over by Tony Marston, and intensified during inflight ops

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- Herschel overall has good calibration at this point
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This meeting

- Just how good is the calibration? On what basis can we state that?
  - How do we best transmit this to our users?
- Where is there a need for improvement? Where/how can we improve?
  - What does it entail? Is there a bottleneck? Where? Why?
- Comparison with (and use of) other missions – SOFIA, Planck, …
- Establish Herschel calibration as a legacy in its own right!?

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Scientific results – to date & future

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- The data, data products, **calibration**, software & methods, documentation, value-adding features, …

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- … but time will tell!

Invitation: Herschel workshop 2013

Herschel ESLAB workshop May 2010

HERSCHEL SPACE OBSERVATORY

The Universe Explored by Herschel

An international conference dedicated to presenting, discussing, and taking stock of the scientific breakthroughs from the Herschel Space Observatory to date, and with a view towards the future

ESTEC Conference Centre, Noordwijk, 15-18 October 2013

First Announcement (8 November 2012)

Second Announcement & Call for Papers (25 January 2013)

Herschel ESLAB workshop May 2010

HERSCHEL SPACE OBSERVATORY


Hennemann et al. 2012
A&A 543, L3


THANK YOU !
&
GOOD LUCK !!
Hennemann et al. 2012
A&A 543, L3