Beyond Herschel:

SPICA
Space Infrared Telescope for Cosmology and Astrophysics

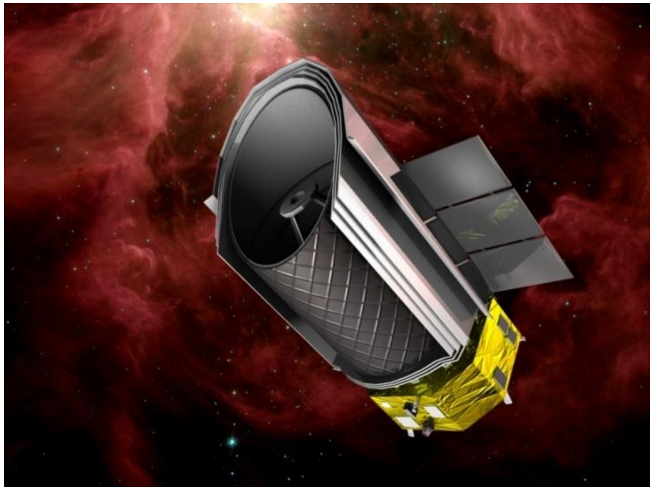
The next-generation space infrared astronomy mission

Herschel conference 2013
18 October 2013

Takao Nakagawa (ISAS/JAXA)
Peter Roelfsema (SRON)

SPICA Mission Overview

- Science objective
  - To reveal the evolution of Baryonic Matter in the Universe
- Telescope: 3.2m, 6 K
  - Superior sensitivity limited by ***astronomical background***
- Core wavelength: MIR-FIR
  - Original baseline: 5-210 μm
  - Working towards extending up to 350 μm
- Orbit: Sun-Earth L2 Halo
- Mission Life
  - 3 years (nominal), 5 years (goal)
- Launch: 2026 (new date)
- International mission
  - Japan, Europe, Korea, Taiwan, (USA)



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JAXA
Japan Aerospace Exploration Agency

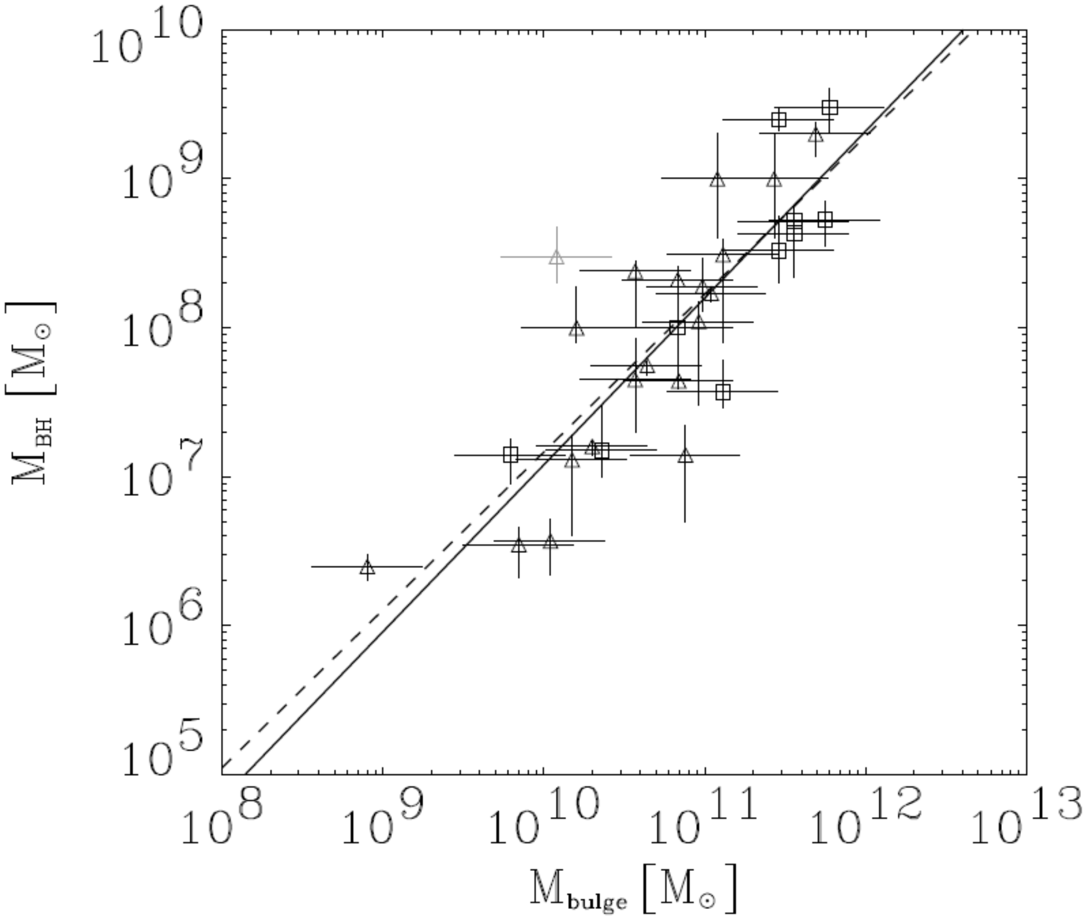
Science Goals: Herschel Heritage

SPICA Science Goals

Unveil the evolution of Baryonic Matter in the Universe

- *Planetary Systems Formation*
- *Birth and Evolution of Galaxies*
- *Life cycle of interstellar & Intergalatic matter*

What makes the M_{BH} vs M_{bulge} relation ?



Haring & Rix 2004

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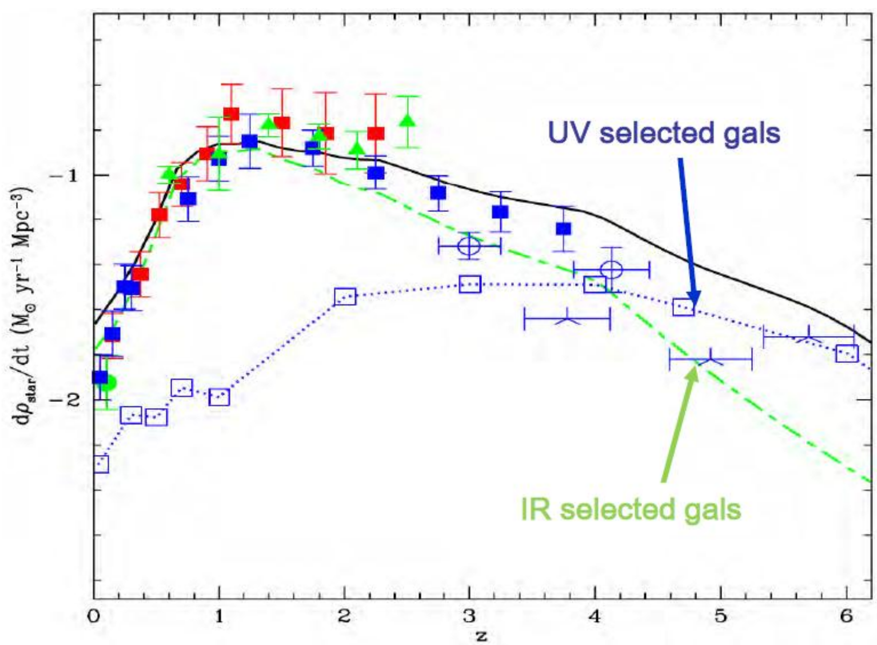
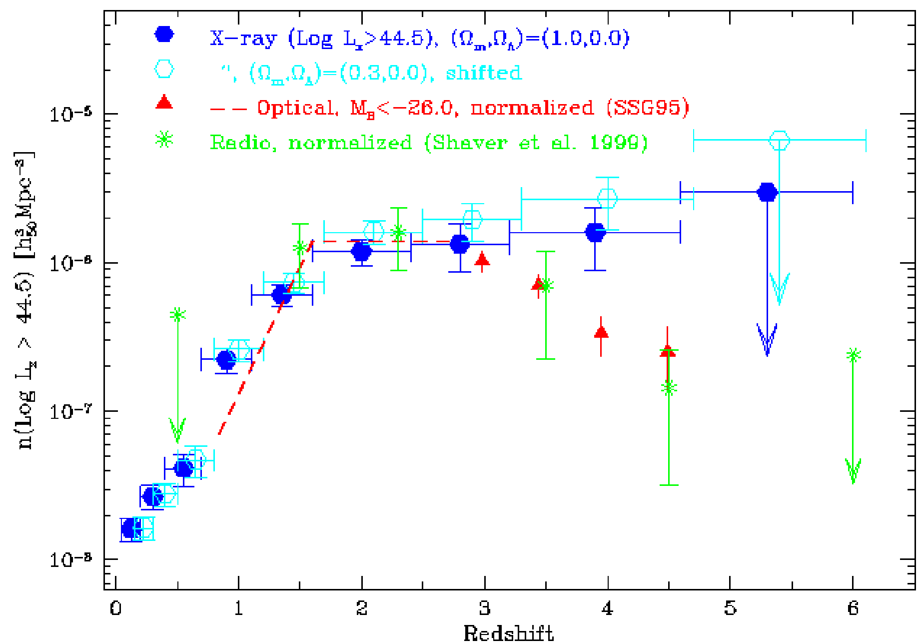
What happened at z~2 ?

- Star-formation Rate
- AGN Population





Vaccari et al. 2013; Marchetti et al. 2013

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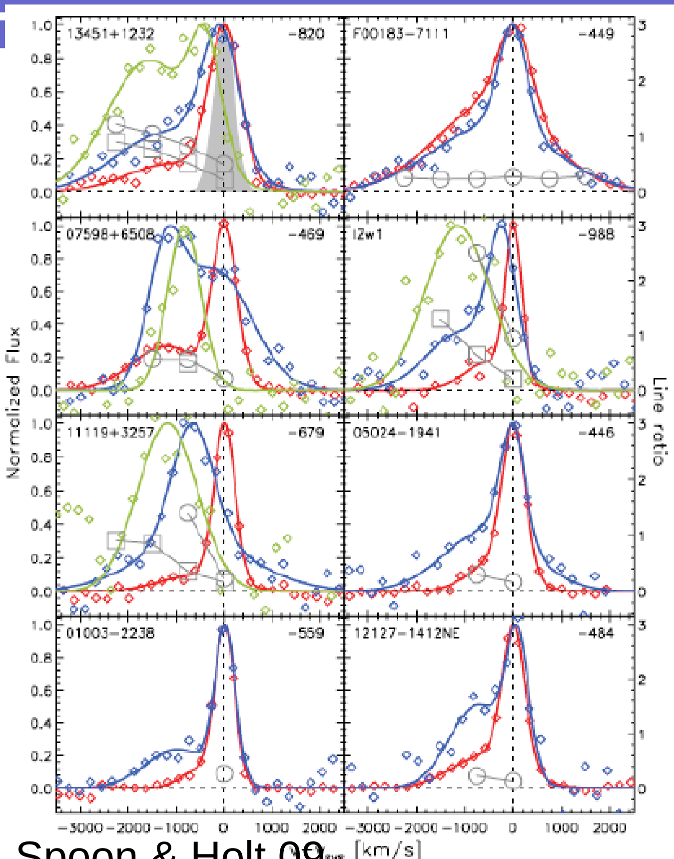
Observational Evidence for AGN Feedback ?



Spoon & Holt 09

n AGN have been invoked to
of both the BH and spheroidal

Fabian 2012

	Quality
es in quasars	Strong
	Strong
	Strong
ster galaxies	Strong
	Strong
cool cluster cores	Indirect
	Indirect
	Indirect
, quasars	Indirect
Steep $L-T$ relation in low T clusters and groups	Indirect

Evidence so far: Mostly ionized gas

-> How about molecular gas (material for SF) ?

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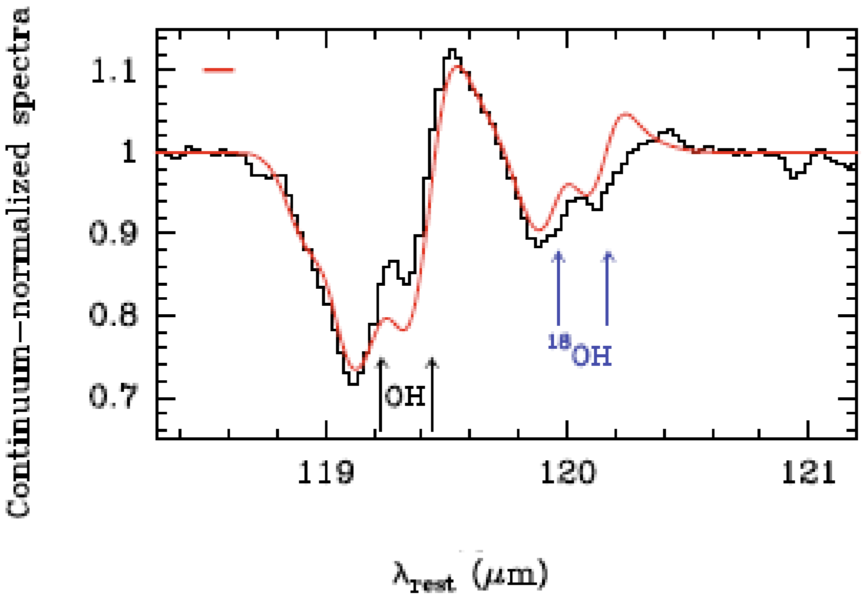
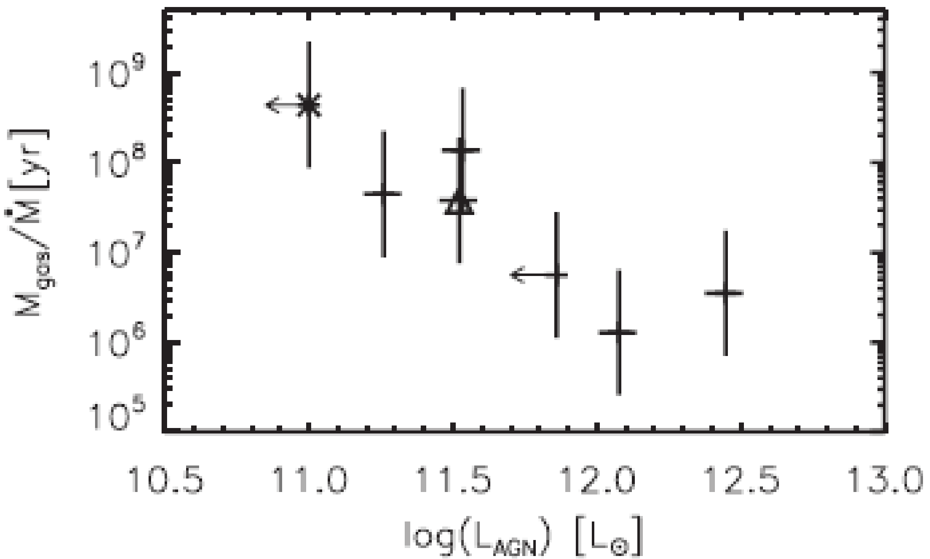
Herschel Discovery: Molecular Outflow



- Molecular Outflow
  - P-Cyg profile of OH toward Mrk 231
  - Fischer et al. 2010



- Outflow is probably AGN-powered
  - dM/dt ~ 1000 Mo/yr
  - Strum et al. 11, Spoon et al. 13, Veilleux et al. 13

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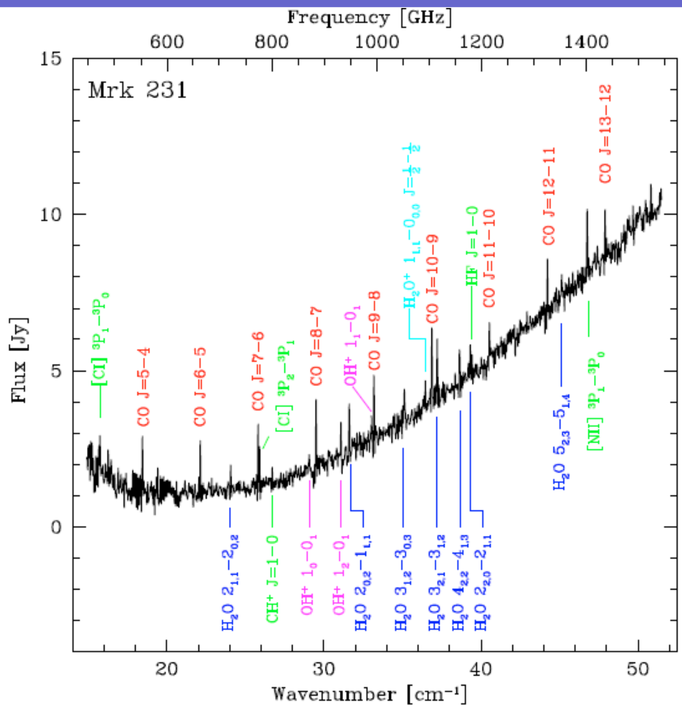
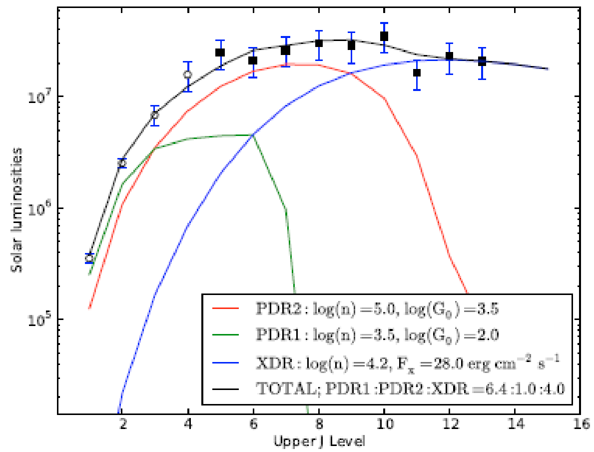
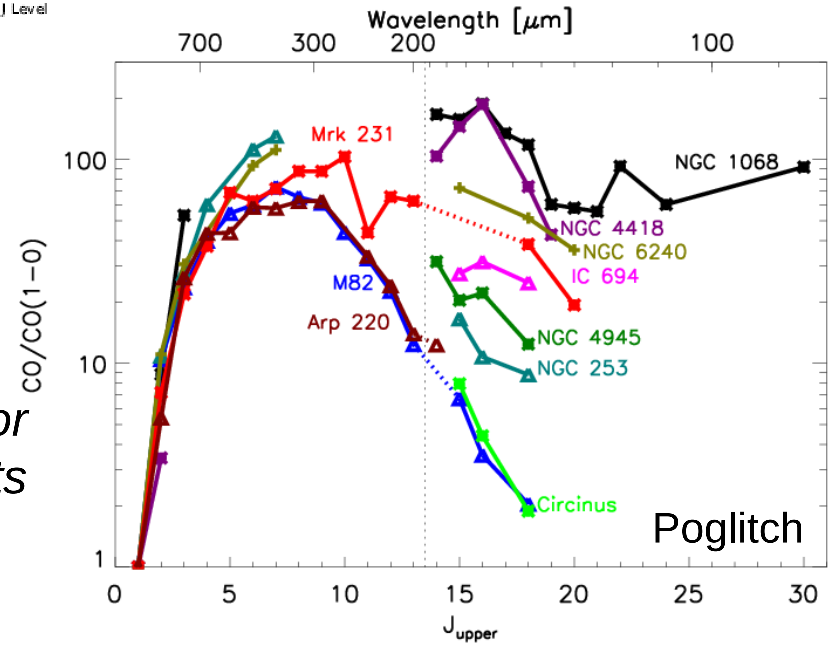
Herschel heritage:
CO Ladder: what excites them ?





Van der Werf et al. 2010, A&A, 518, L42

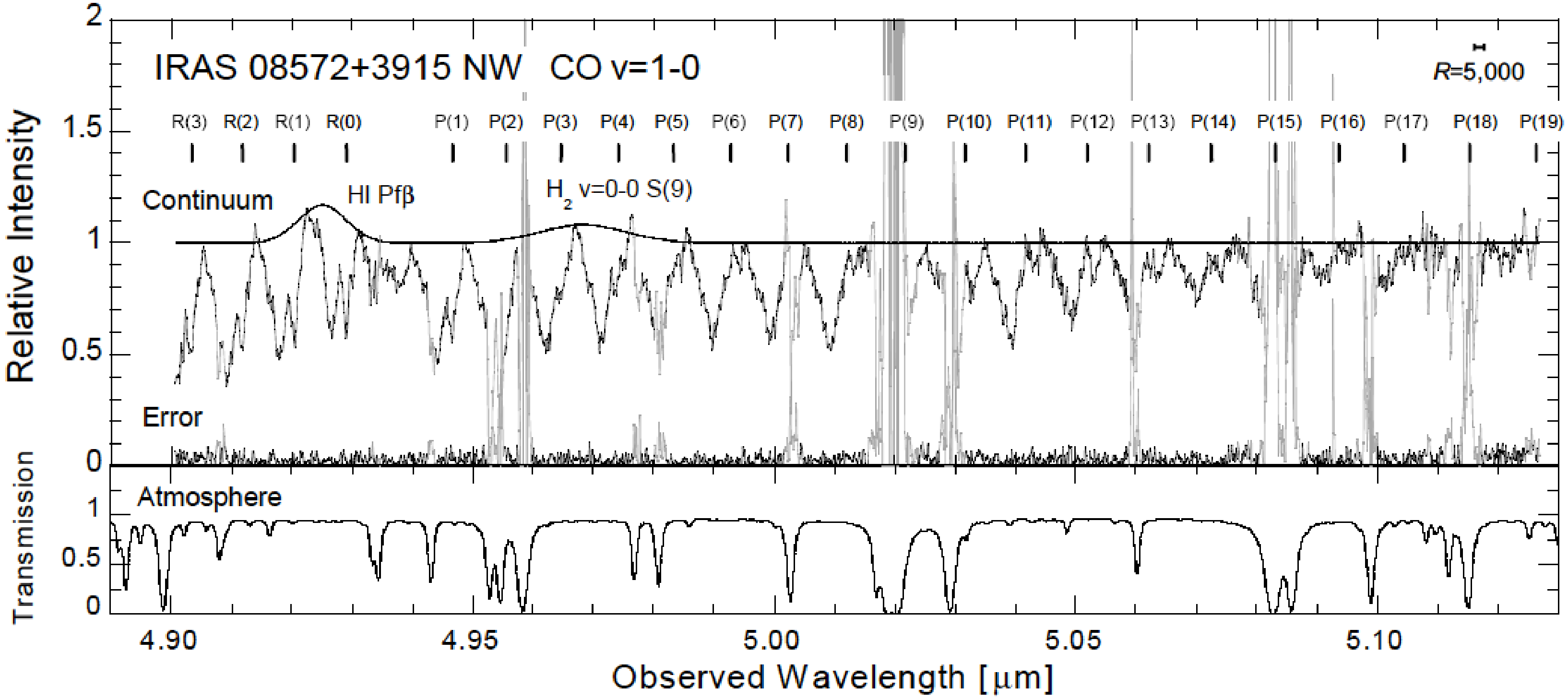
XDR is required to excite high-J CO lines
But Shock ?
Dense Starburst ?



SPICA will allow this analysis for many more objects

CO Ladder in Absorption

- v=0-1, ΔJ=±1 @ 4.6μm
- AKARI survey -> Subaru Follow-up

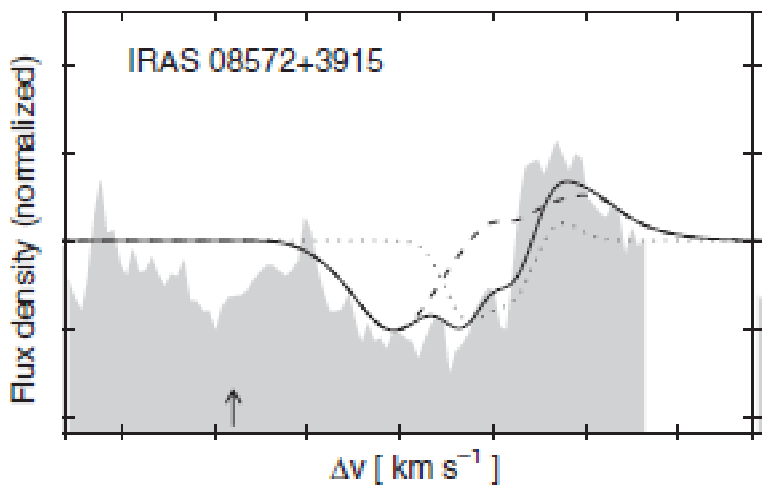


λ

Shiratata, Nakagawa et al. (2013)

Two types of molecular flow ?

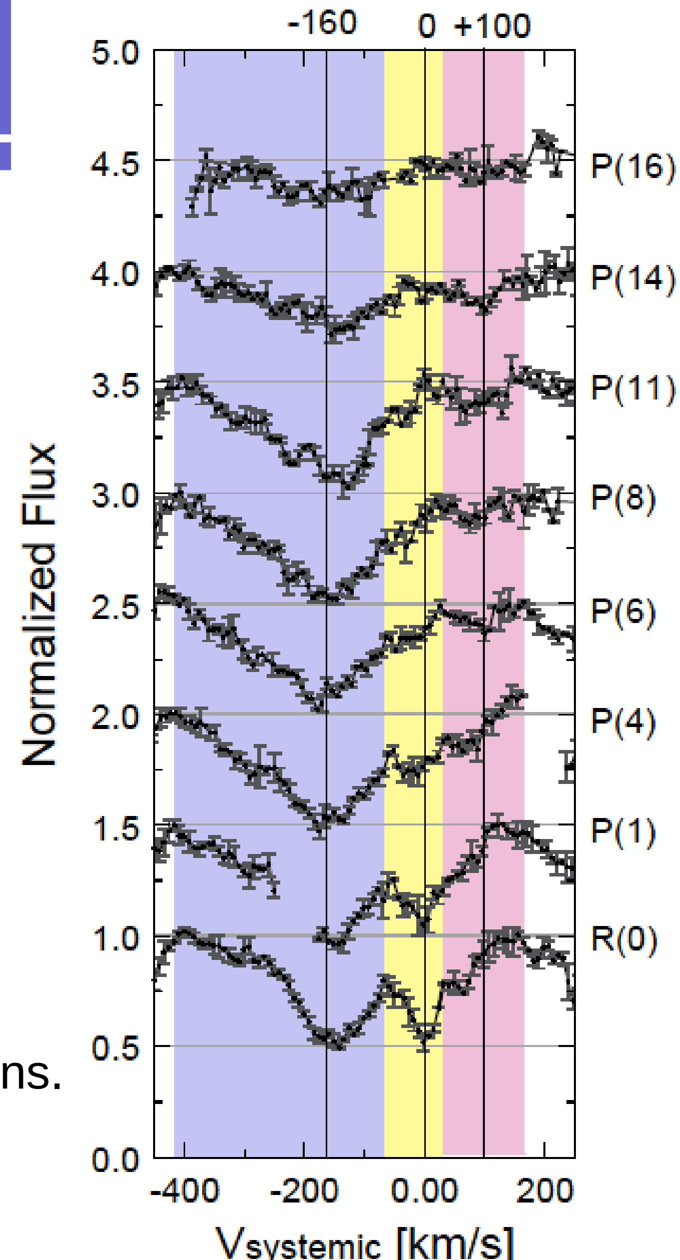
- Herschel
  - OH ground state
  - V_peak ~-700 km/s
  - T_gas ~ 100K (Fischer)



Sturm + 11

- AKARI/Subaru
  - CO ro-vibrational trans.
  - V_peak ~-160 km/s
  - T_gas ~ 300K

Shirahata, Nakagawa + 13



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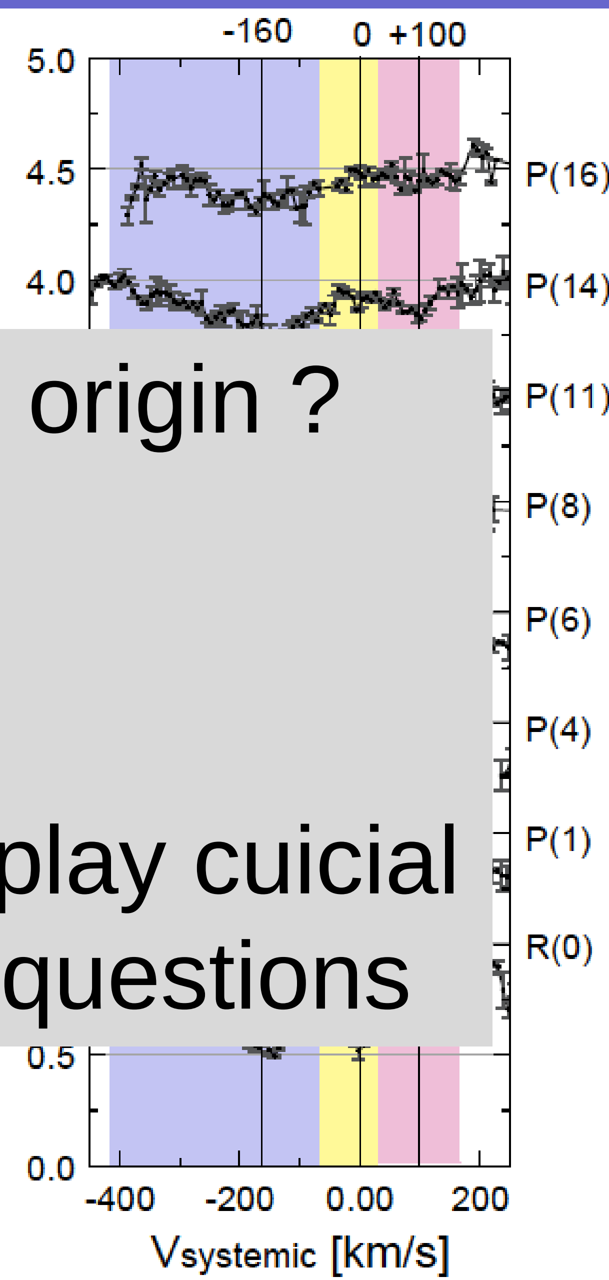
Two types of molecular flow ?

- Herschel
  - OH ground state

Do the have the same origin ?
AGN feedback ?
Positive or negative ?

SPICA is expected to play cuicial roles to answer these questions

Sturm + 11



- CO ro-vibrational trans.
- V_peak ~-160 km/s
- T_gas ~ 300K

Shirahata, Nakagawa + 13

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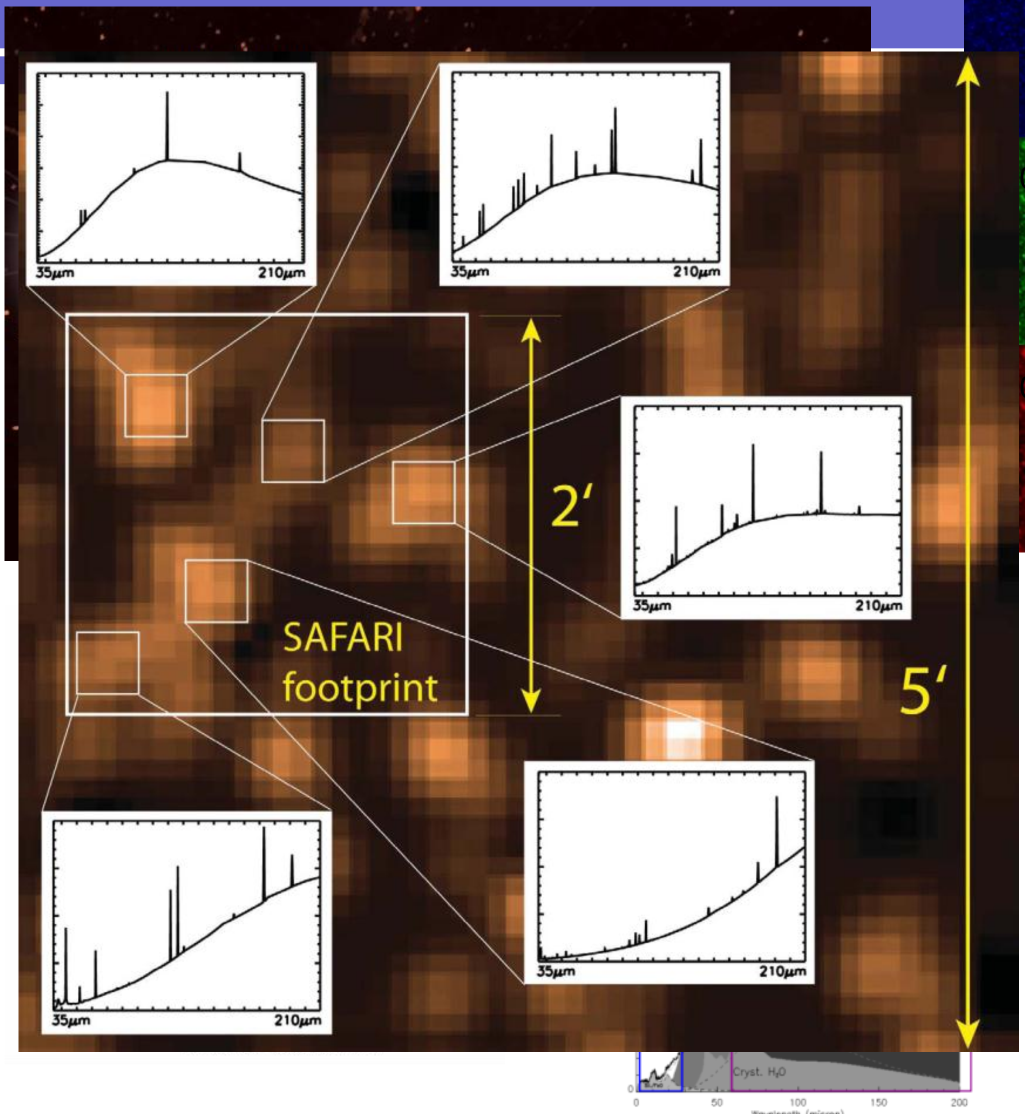
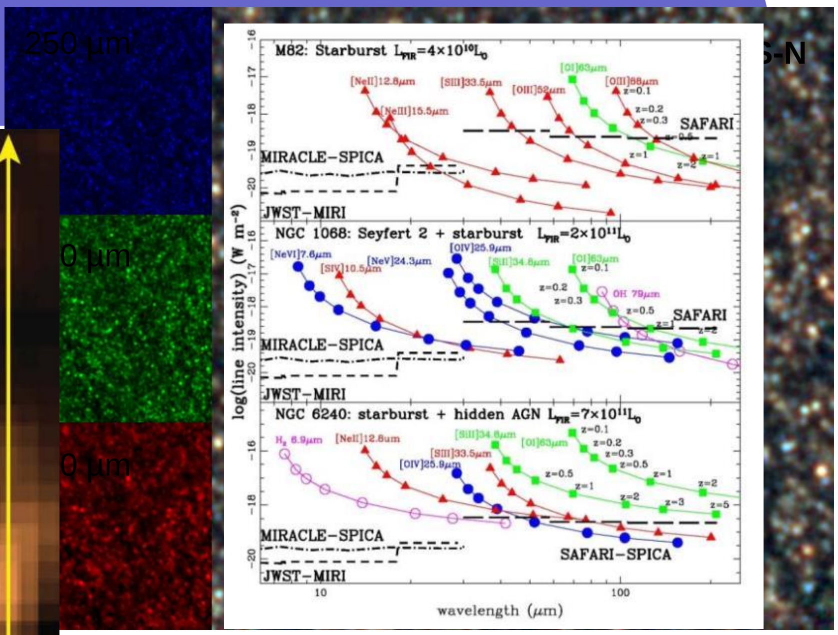
Herschel Heritage to SPICA

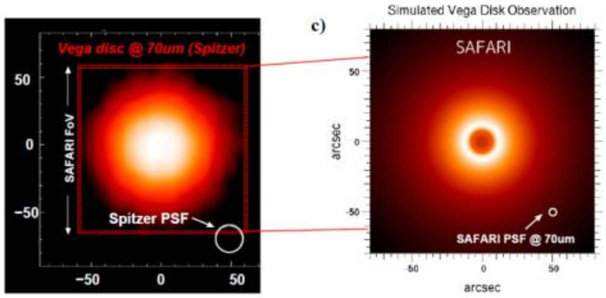
- Herschel has opened a new era of far-infrared and sub-mm astronomy.
- Herschel has provided many surprises, related with fundamental questions, such as:
  - AGN feedback
  - Star-formation modes at low- and high-z
  - Filaments to star-formation
  - Interstellar chemistry, water and other species
  - Cool TNOs with low albedo
  - …..
- To answer the questions raised by Herschel, we need a mission with much better sensitivity: SPICA

In summary: SPICA's science issues





…most will need imaging spectroscopy with superior sensitivity



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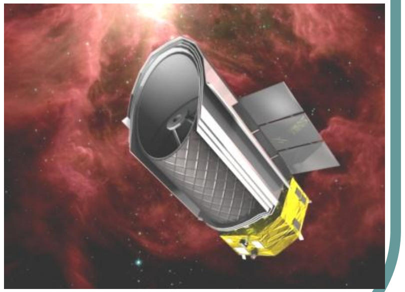
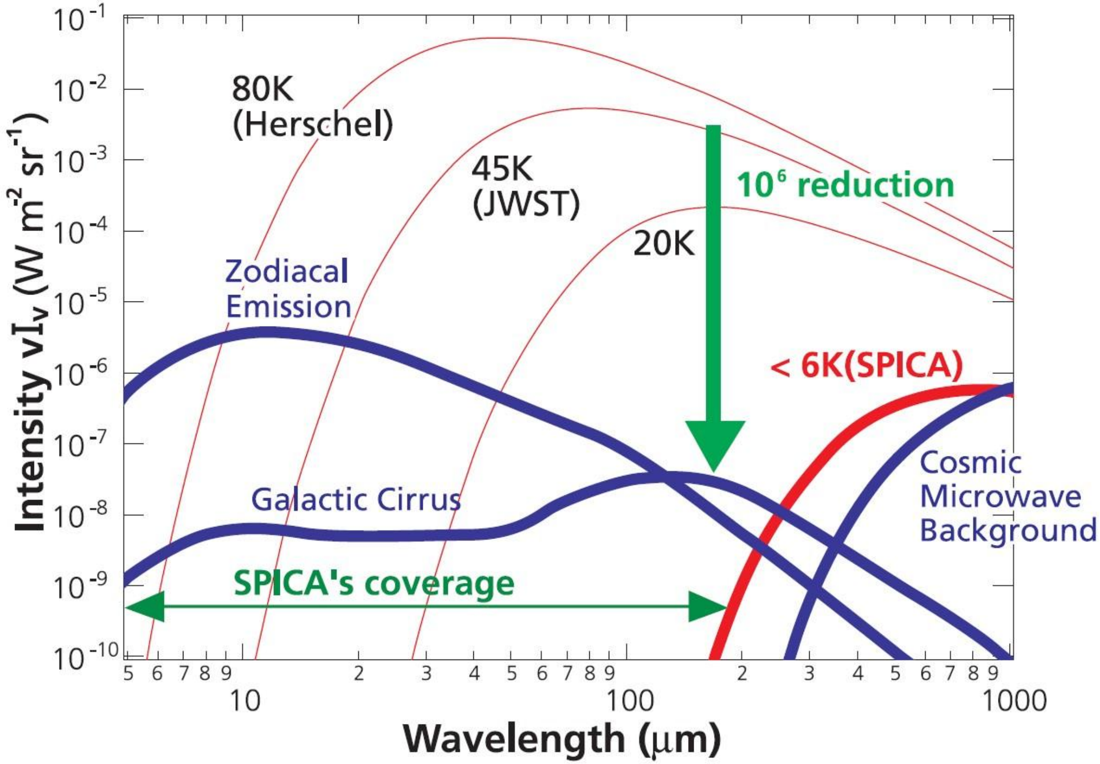
Mission Overview



Requirements: Cooled Telescope

- T<10 K is required to improve sensitivity
  - Background Radiation can be reduced by a factor of one million ! -> Huge gain of sensitivity



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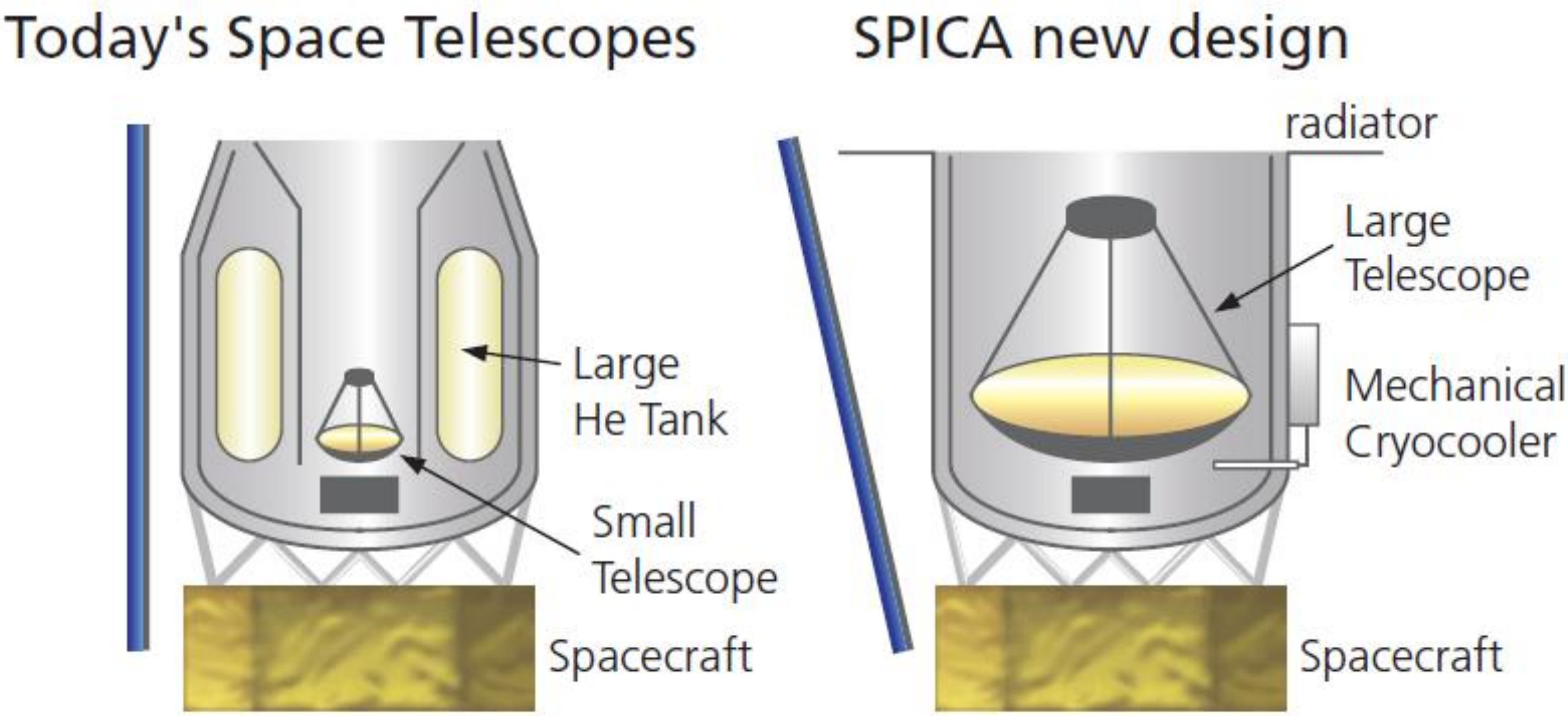
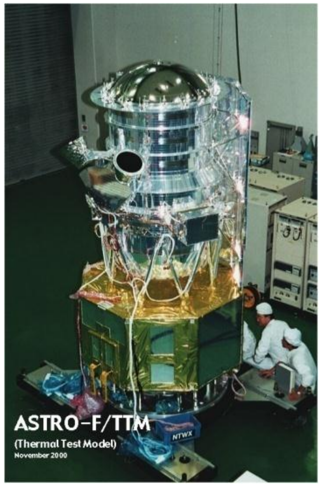
Cryogen-free mission

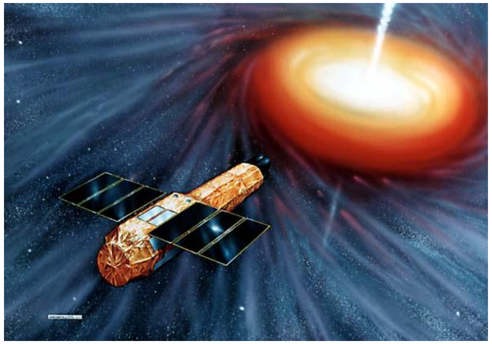


Lighter and Larger

Heritage of Mechanical Cryocoolers

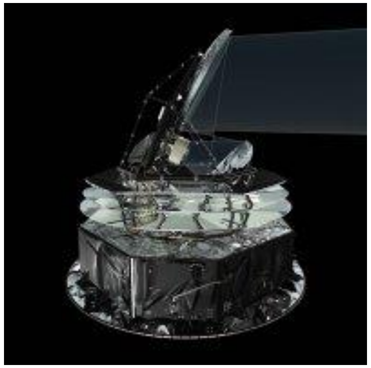
- AKARI(JAXA)
  - Hybrid system with Liq He and 2-stage Stirling 2006





- ASTRO-H (JAXA)
  - 2ST, 4He JT, ADR
  - 2015

- Planck (ESA)
  - Cryogen-free system
  - 2009



- Both ESA and JAXA have good technical heritage.

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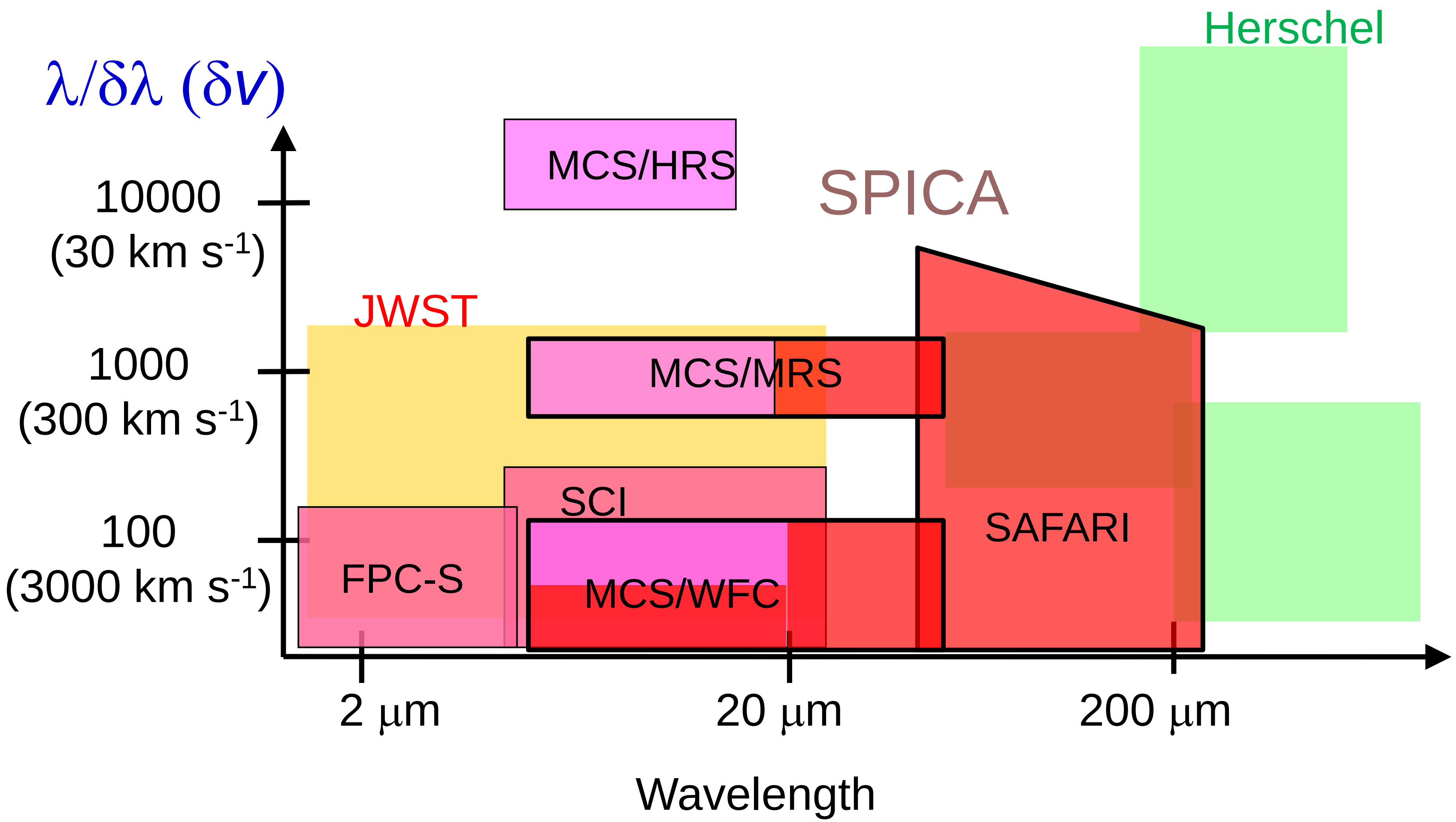
SPICA Telescope Assembly

- 3.2m Ritchey Chretien telescope
- Cryogenic telescope (T<6K): background limited over core wavelength range.
- ESA contribution:
  - Building on European Industrial Heritage (Herschel)
  - SiC or Carbon fibre reinforced SiC
    - Lightweight, low thermal expansion

Focal Plane Instruments: original baseline

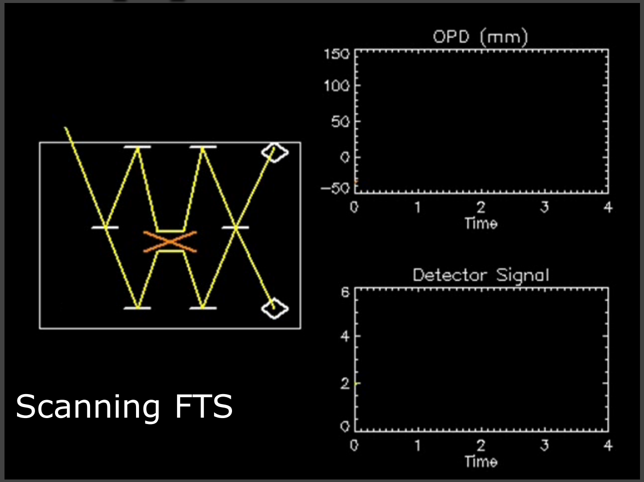


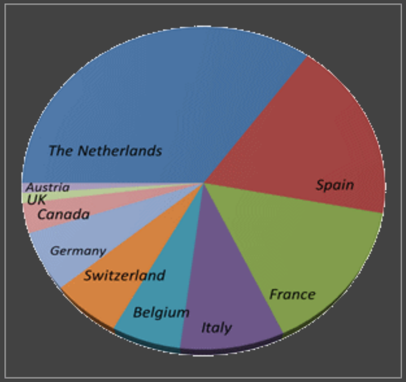
Original Baseline: being revisited

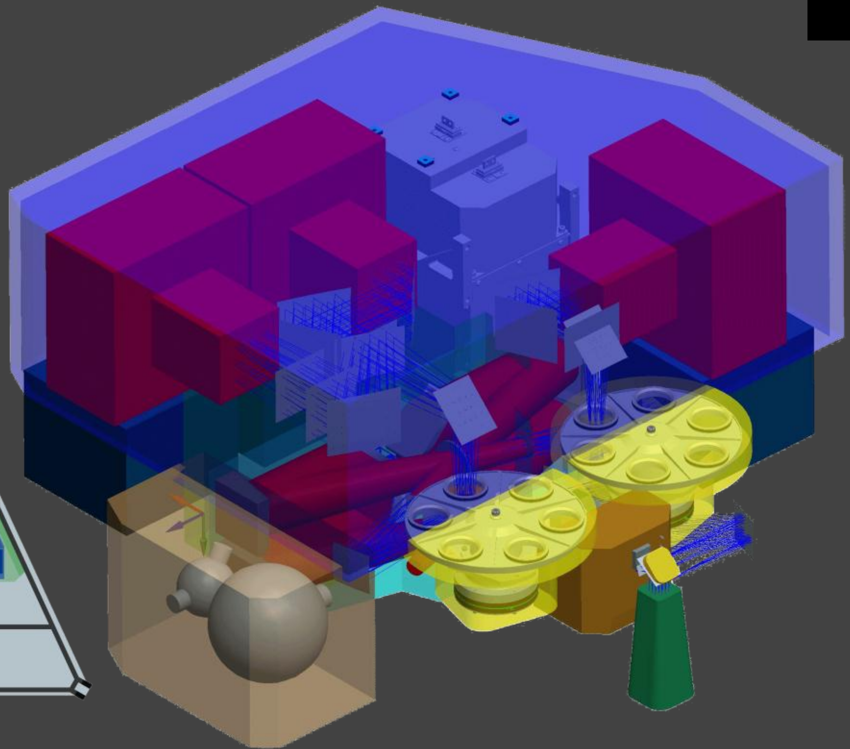
SAFARI – Imaging spectroscopy

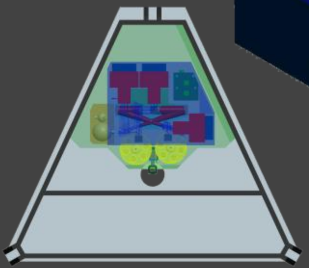
- Scanning Fourier Transform Spectrometer with 2’x2’ FoV
- Simultaneously observing in 3 bands (34-210μm)
- Ultra sensitive TES detectors/SQUID read out at 50 mK

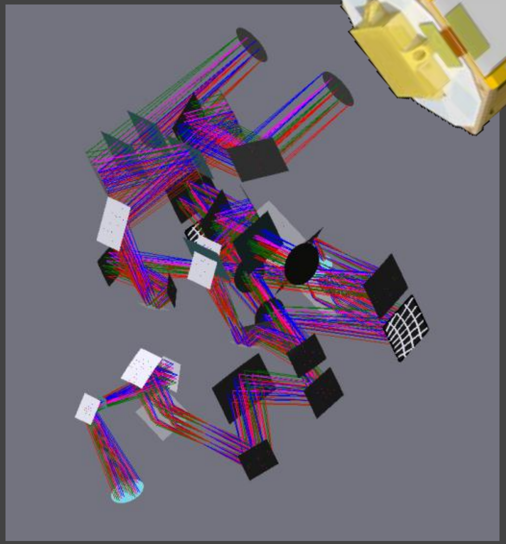
  → almost ***200 times*** more sensitive than Herschel
- Frequency Domain Multiplexing
- To be built by an SRON-led consortium
  - ~15 institutes in Europe, Canada, Japan - cost ~170M€

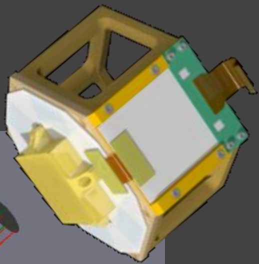












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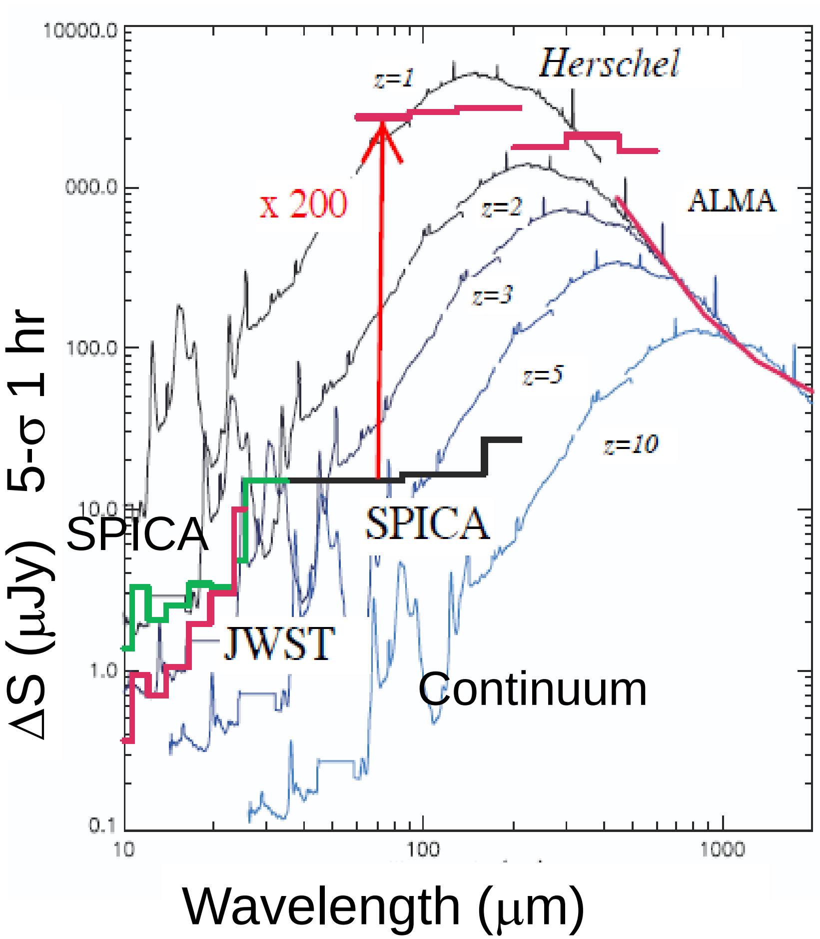
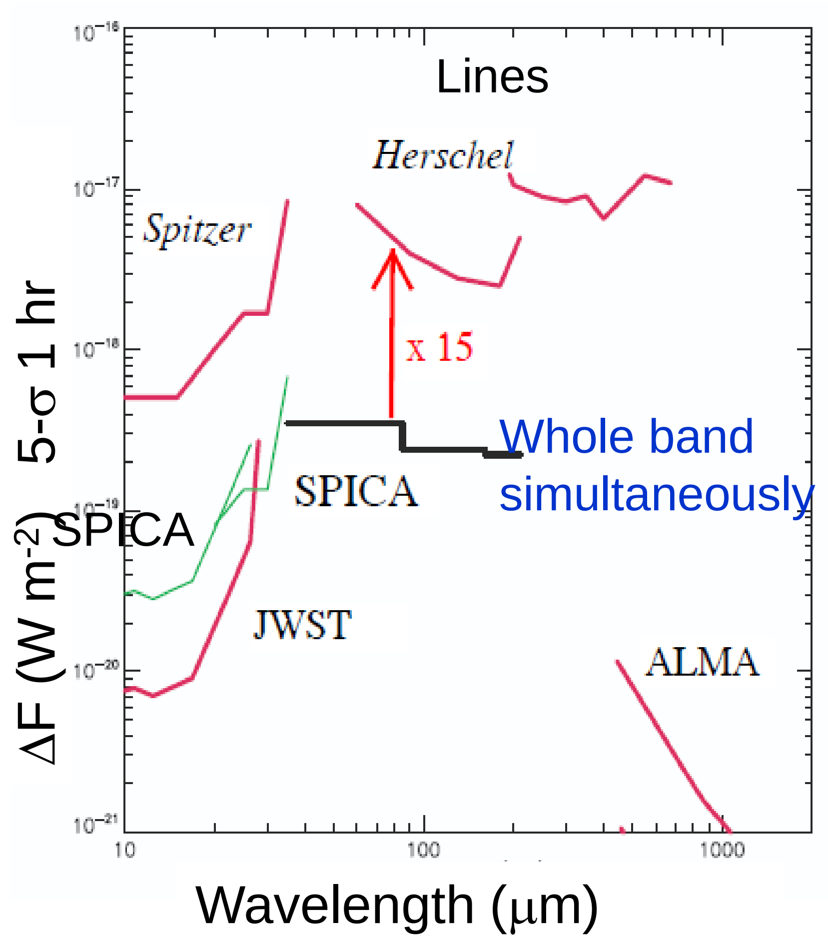
SPICA Sensitivity

Photometry



Spectroscopy



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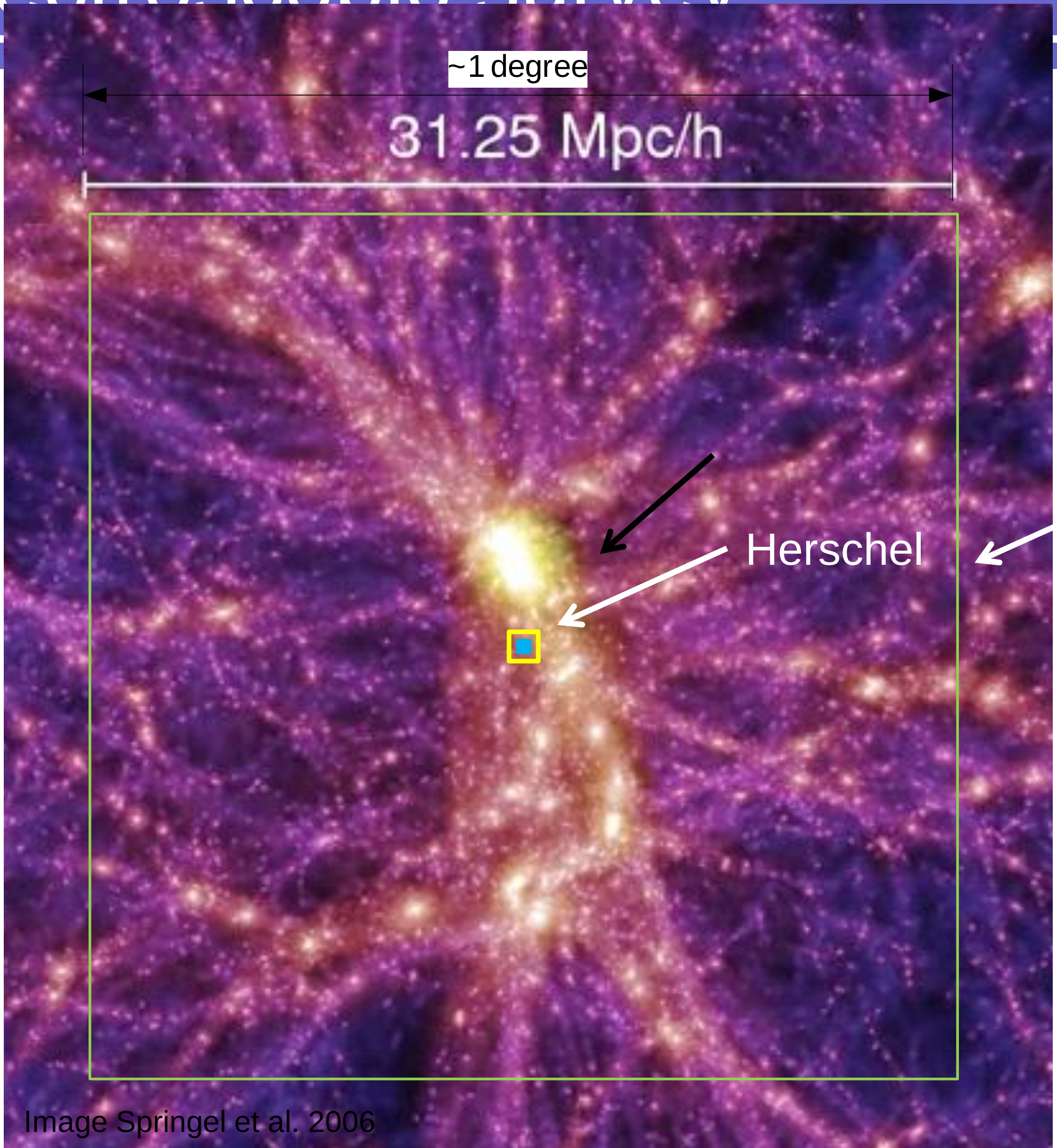
The first cosmological spectroscopic survey

900 hours
Of Obs.

Gain of 1000 relative to Herschel



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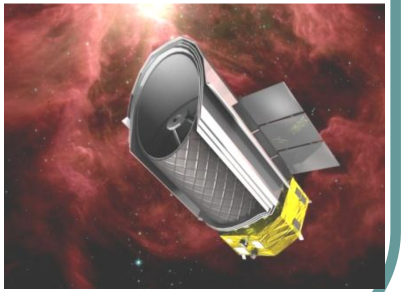
JAXA Japan Aerospace Exploration Agency

New Framework and Schedule



New framework proposed

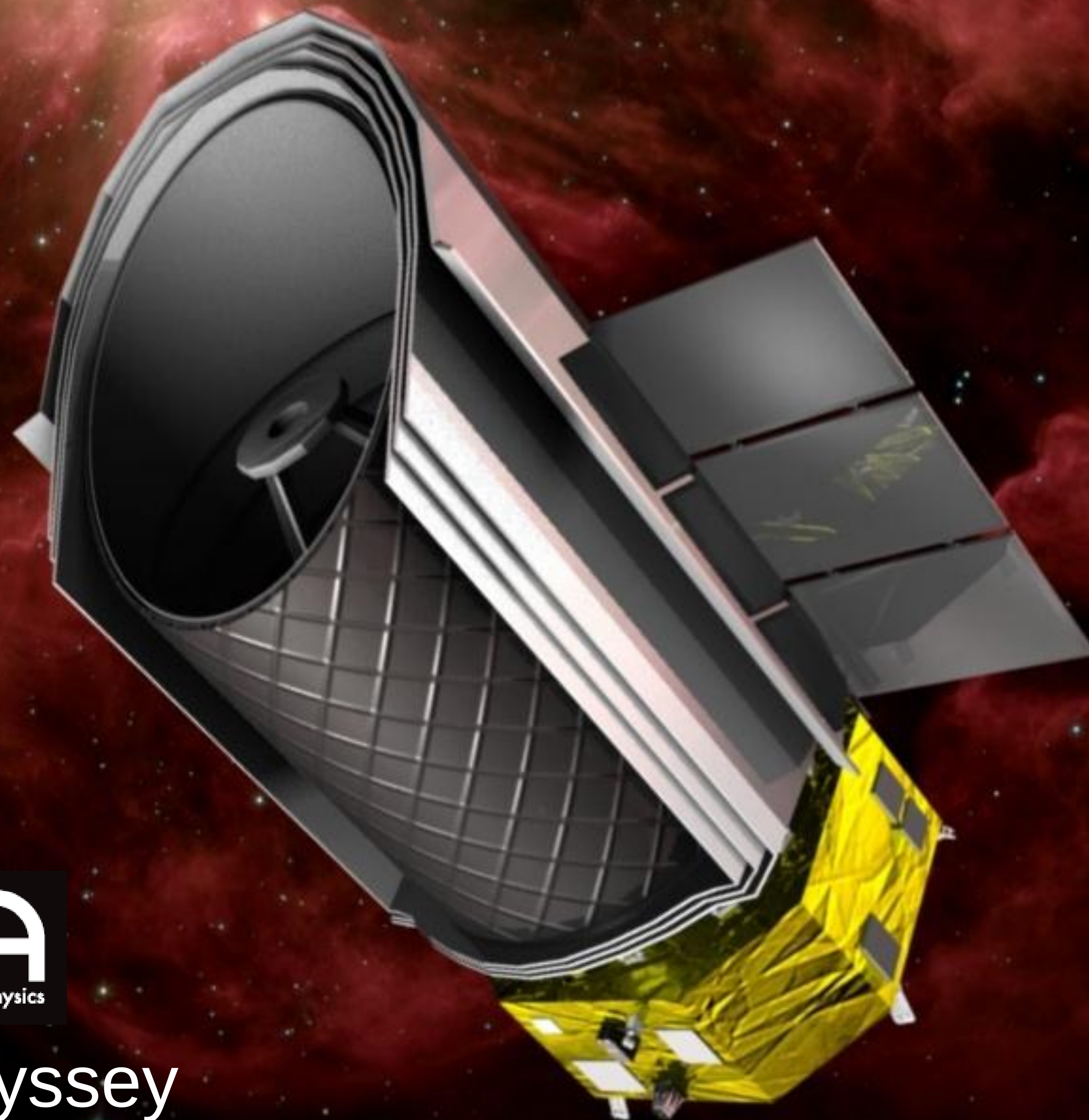
- Original Plan
  - JAXA preproject since 2008
  - ESA CV MoO candidate since 2007
  - Approval in 2014 by JAXA and ESA for the launch in 2023.
- SPICA FY 2014 budgetary proposal in Japan
  - R&D activity going on, but difficulty for the whole project.
  - SPICA has the top priority among the future science missions in Japan, .
- Discussion on new framework started
  - To establish a more feasible plan (programmatic & technical)
  - To increase the role of European contribution, while keeping SPICA as a JAXA-led project.
    - ESA will be in charge of the Payload Module integration in addition to the procurement of the Telescope.

Implications

- SPICA will be re-optimized for mid- and far-infrared with a cryogenically cooled, 3m-class mirror.
- Major changes in roles of international partners, approval processes, and schedule.
  - Re-entering open competition in the ESA Cosmic Vision program (4th M-class mission, M4)
  - Science cases to be revised in a post-Herschel, ALMA, JWST era
  - Expected Launch in 2026

Towards the future

- SPICA is an excellent opportunity for the whole far-infrared community.
  - X1000 gain over Herschel in spectroscopic mapping
- Schedule
  - JAXA: As a JAXA preproject, to go through approval processes in the new framework.
  - ESA: open competition in the Cosmic Vision M4
- Science case is being revisited for the post-Herschel, ALMA, JWST era.



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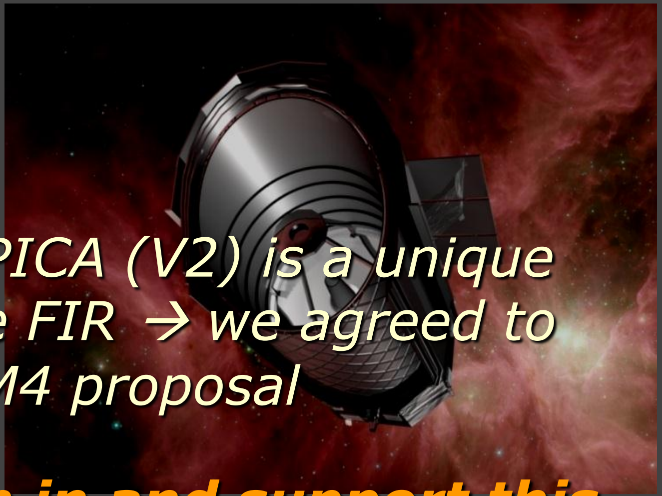
New Space Odyssey
Beyond Herschel

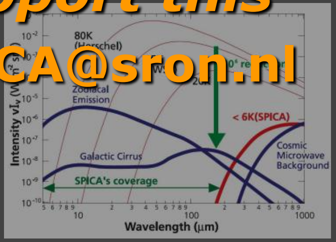
Towards a SPICA M4 proposal



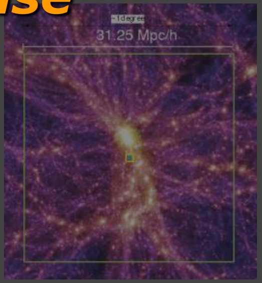
The SAFARI consortium is convinced that SPICA (V2) is a unique observatory, and the logical next step in the FIR → we agreed to take the lead in the work towards a SPICA M4 proposal

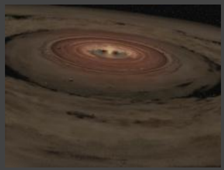
We invite all who are interested to join in and support this

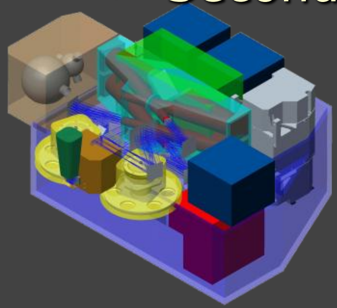
contact point – **SPICA@sron.nl**



- What does an M4 mission proposal entail
  - First and foremost a ***detailed and convincing science case***
    …this where we need the community – ***you*** – to join in
  - Secondly an instrument complement and mission concept







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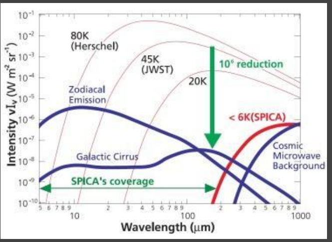
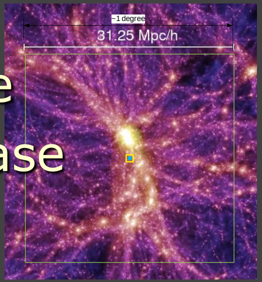
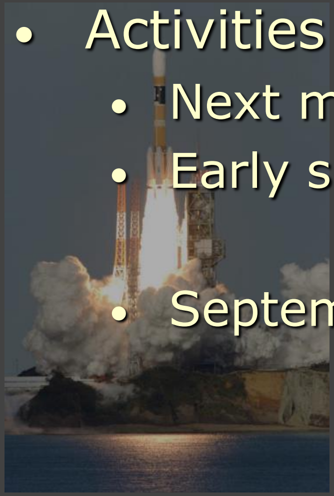
An M4 proposal – timeline

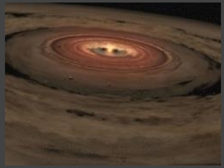
- Spring 2014 – M4 call issued
- ***September 2014 -*** mission proposals due
- November 2014 - candidate mission selection
- 2015-2017 - mission analysis
  - mission and instrument development
- Summer 2017 - final consolidated instrument proposal
- Fall 2017 - final mission selection







- Activities in 2013/2014
  - Next months - core team to establish skeleton science case
  - Early spring - open workshop to discuss/develop science case date and location TBA
  - September – proposal submission



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