Gaia MPS Summary

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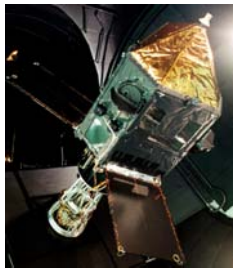
Gaia mission objectives

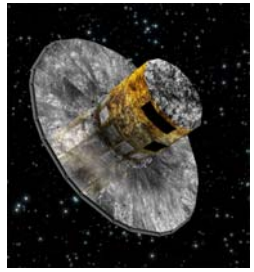
- To create the largest and most precise 3D chart of our Galaxy by providing positional and velocity measurements for about one billion stars

- Astrometry and Photometry for at least one billion stars (1% of the stars in the Milky Way)
- Spectroscopy for about 150 million stars
- One billion objects observed on the average 70 times over 5 years mission is 40 million stars a day (400 million measurements a day)
- Orders of magnitude improvement w.r.t. Hipparcos

From Hipparcos to Gaia

	Hipparcos	GAIA
Magnitude limit	12	20 mag
Completeness	7.3 – 9.0	~20 mag
Bright limit	~0	~3-7 mag
Number of objects	120 000	26 million to V = 15 250 million to V = 18 1000 million to V = 20
Effective distance limit	1 kpc	1 Mpc
Quasars	None	~5×10^5
Galaxies	None	10^6 - 10^7
Accuracy	~1 milliarcsec	4 μarcsec at V = 10 10-15 μarcsec at V = 15 200-300 μarcsec at V = 20
Broad band	2-colour (B and V)	5-colour to V = 20
Medium band	None	11-colour to V = 20
Radial velocity	None	1-10 km/s to V = 16-17
Observing programme	Pre-selected	Complete and unbiased





Gaia science performances

	V mag	EOM Performance [μas]	Specification
B1V	< 10.0	8.3	< 7
	15.0	26.2	< 25
	20.0	326.3	< 300
G2V	< 10.0	8.5	< 7
	15.0	24.2	< 24
	20.0	290.2	< 300
M6V	< 10.0	10.4	< 7
	15.0	9.2	< 12
	20.0	96.6	< 100

End of mission astrometry performances

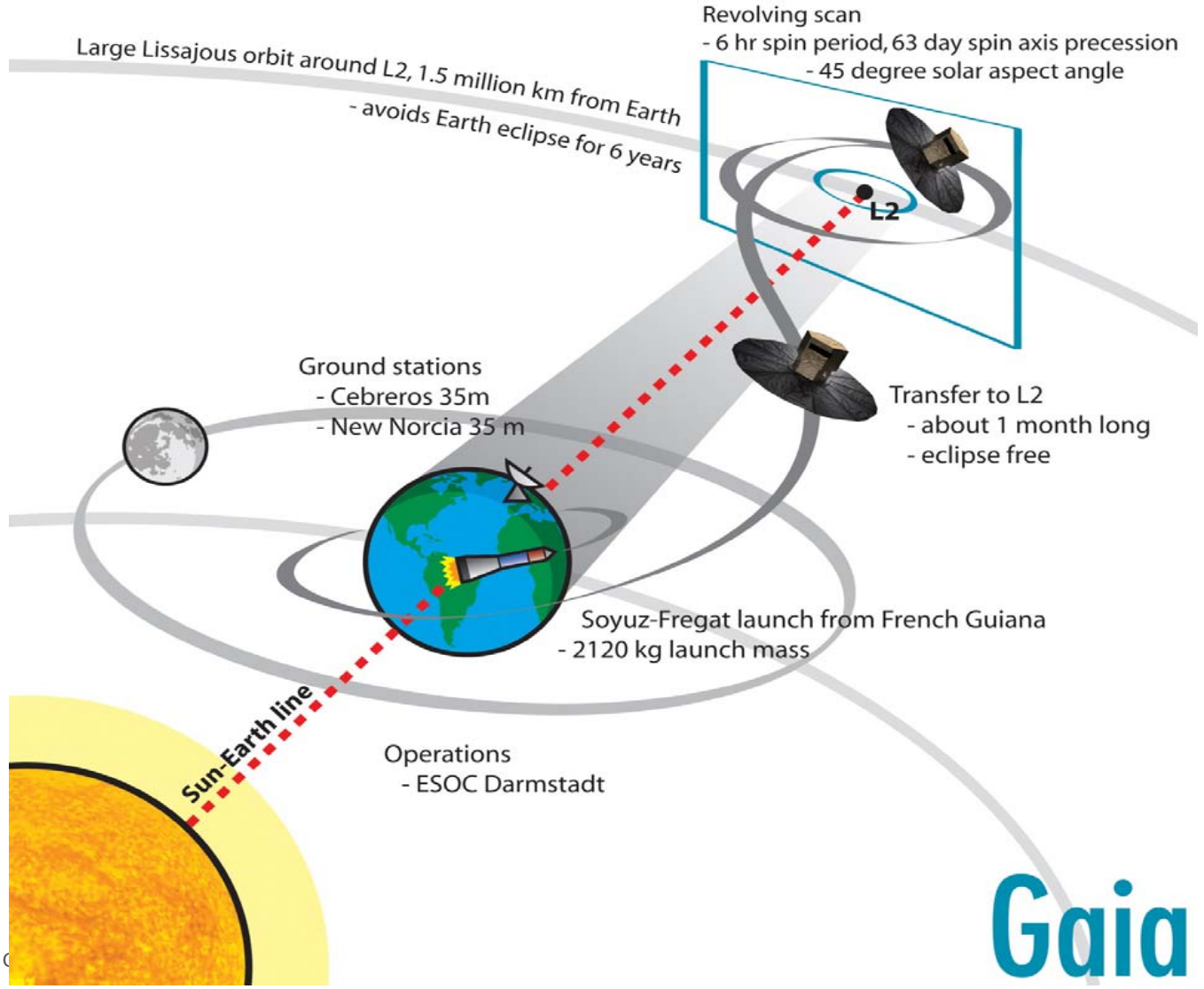
	Band	EOM Performance [mmag]	Specification
B1V - V=15	C1M410	5	< 10
	C1M549	5	< 8
	C1M965	8	< 20
G2V - V=15	C1M410	6	< 10
	C1M549	5	< 8
	C1M965	6	< 10
M6V - V=15	C1M410	16	< 20
	C1M549	5	< 8
	C1M965	4	< 10

End of mission photometry performances

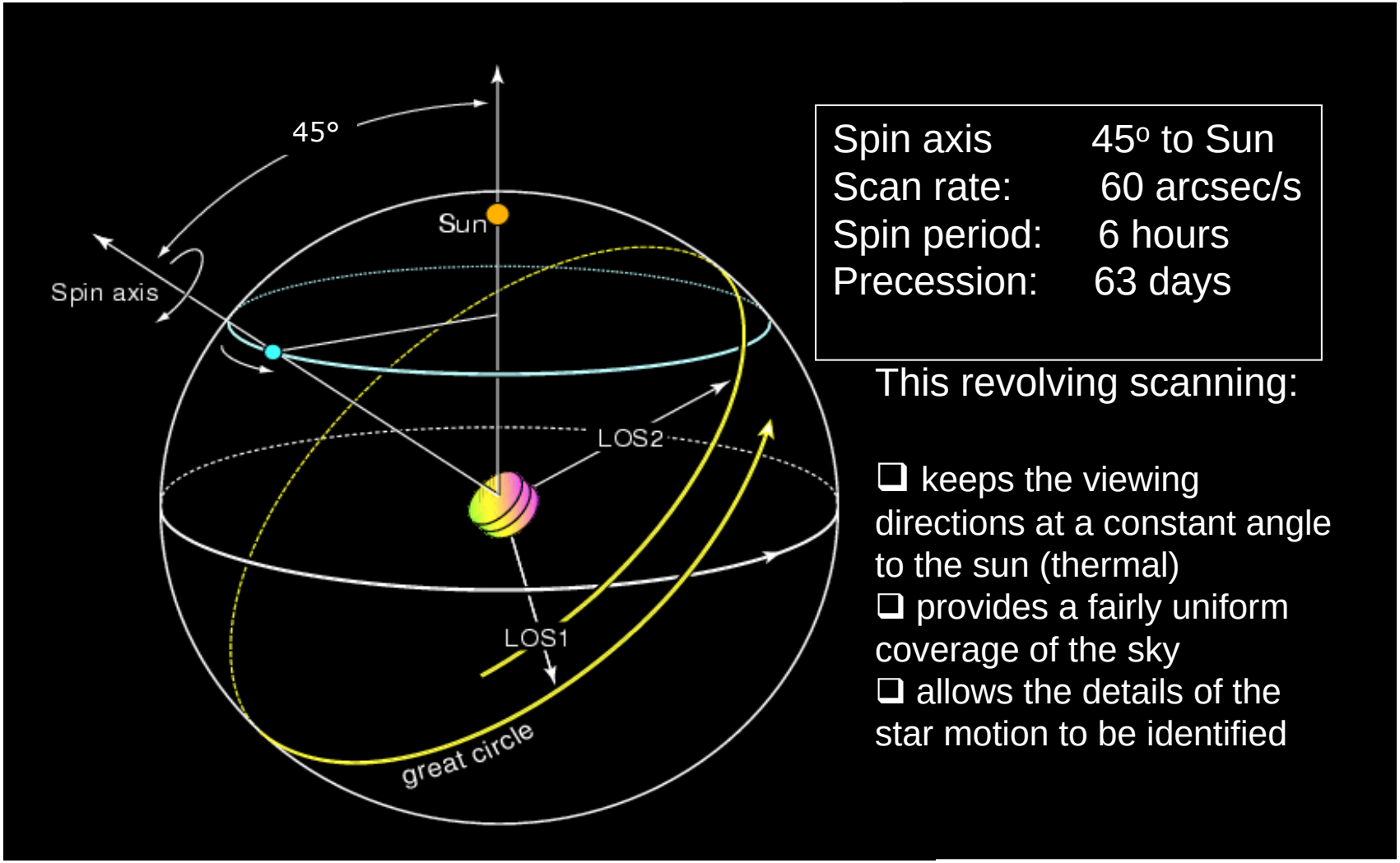
	V mag	EOM Performance [km/sec]	Specification
B1V	7.0	0.6	< 1
	12.0	8.5	< 15
G2V	13.0	0.6	< 1
	16.5	12.8	< 15
K1IIIMP	13.5	0.6	< 1
	17.0	13.3	< 15

End of mission radial velocity spectrometry performances

Launch and operations



Gaia sky scanning principle



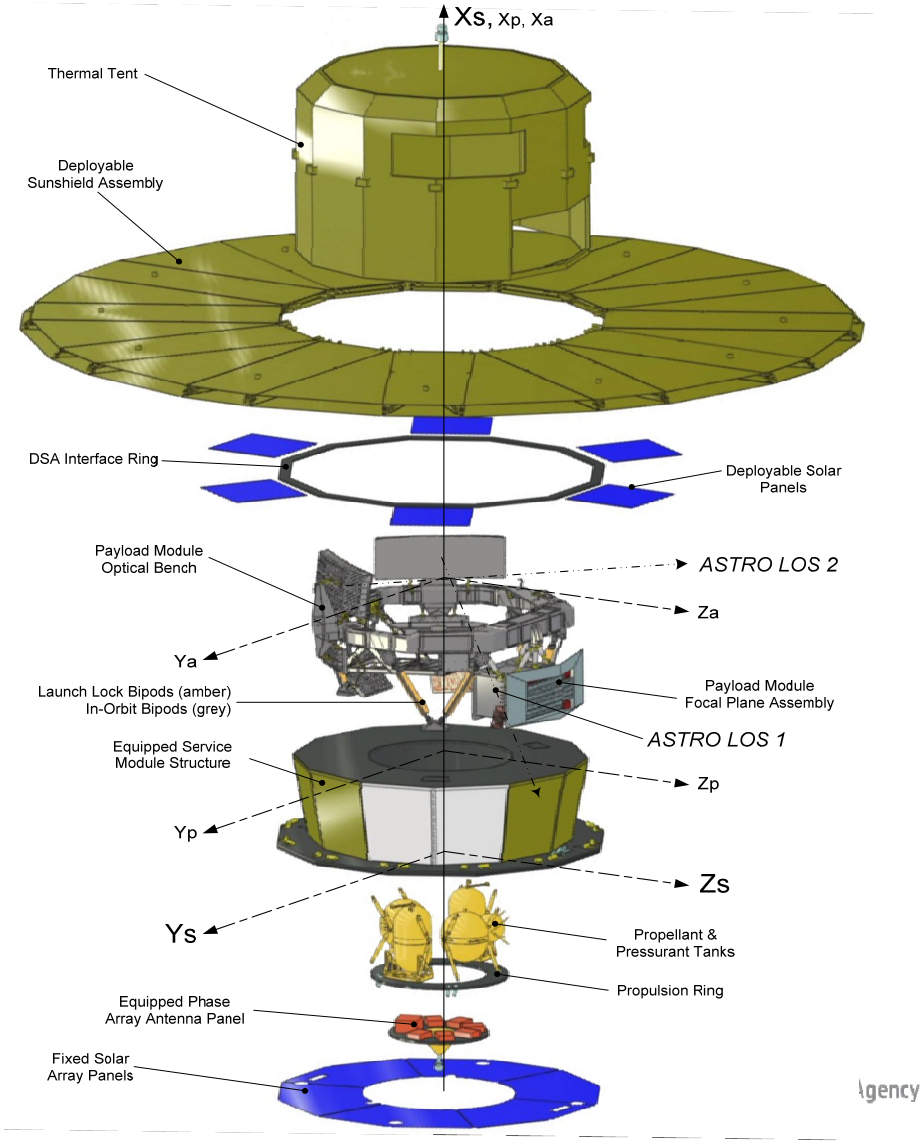
Spin axis	45º to Sun
Scan rate:	60 arcsec/s
Spin period:	6 hours
Precession:	63 days

This revolving scanning:

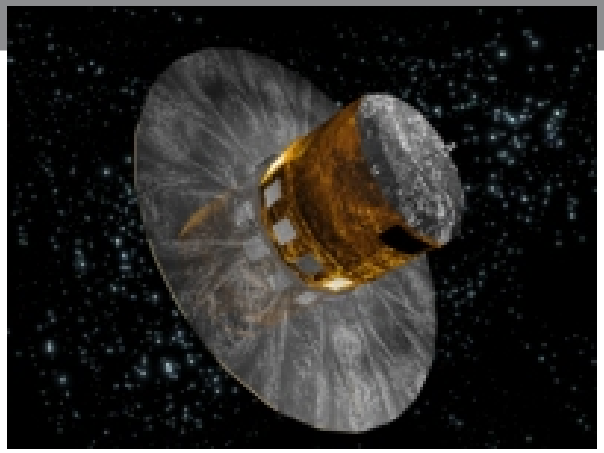
- ❑ keeps the viewing directions at a constant angle to the sun (thermal)
- ❑ provides a fairly uniform coverage of the sky
- ❑ allows the details of the star motion to be identified

Overview of the spacecraft

- Mass
  - S/C launch mass 2100 kg
  - Bi-propellant mass 250 kg
  - Cold gas propellant mass 60 kg
- Power
  - 1.9 kW
- Data management
  - Data rate up to 7.5 Mbps
  - Data storage 1 Terabit
  - Atomic clock 1 s drift in 250000 y
- Optical payload
  - Two telescopes
  - Entrance pupil 1.45 x 0.5 m^2
  - Focal length 35 m
  - Field of View 1.58 x 0.69 deg
  - Focal plane size 1 Gpixels



Gaia MPS requirements



The Gaia Cold Gas MicroPropulsion System (MPS) is being devloped and produced by TAS-I

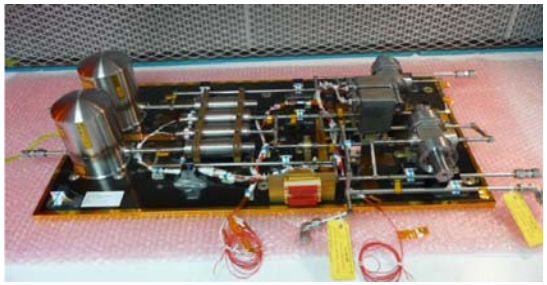
Gaia MPS must provide a fine control of the generated thrust using proportional operation, with innovative and challenging thrust requirements:

1. dynamic range (commanded thrust ranging in 1 to 500 µN , 0.1 µN steps)
2. very low noise (1 µN/√Hz from 0.01 Hz to 1 Hz and 0.045 µN/√Hz above 1 Hz) and thrust bias (≤0.5 µN)
3. low time response (< 300 ms @63% of the new commanded thrust level, at a command frequency of 1 Hz))
4. high accuracy (scale factor knowledge error < 1% of thrust) resolution (< 1 µN)
5. specific Impulse (>60 sec @20°C) to be achieved throughout the whole thrust range
6. Lifetime of 6.5 years; 153 million on/off cycles and1.23 billion thrust command changes

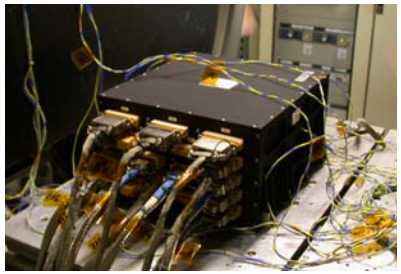
Gaia MPS Architecture

The Gaia MPS is composed by 3 main units:

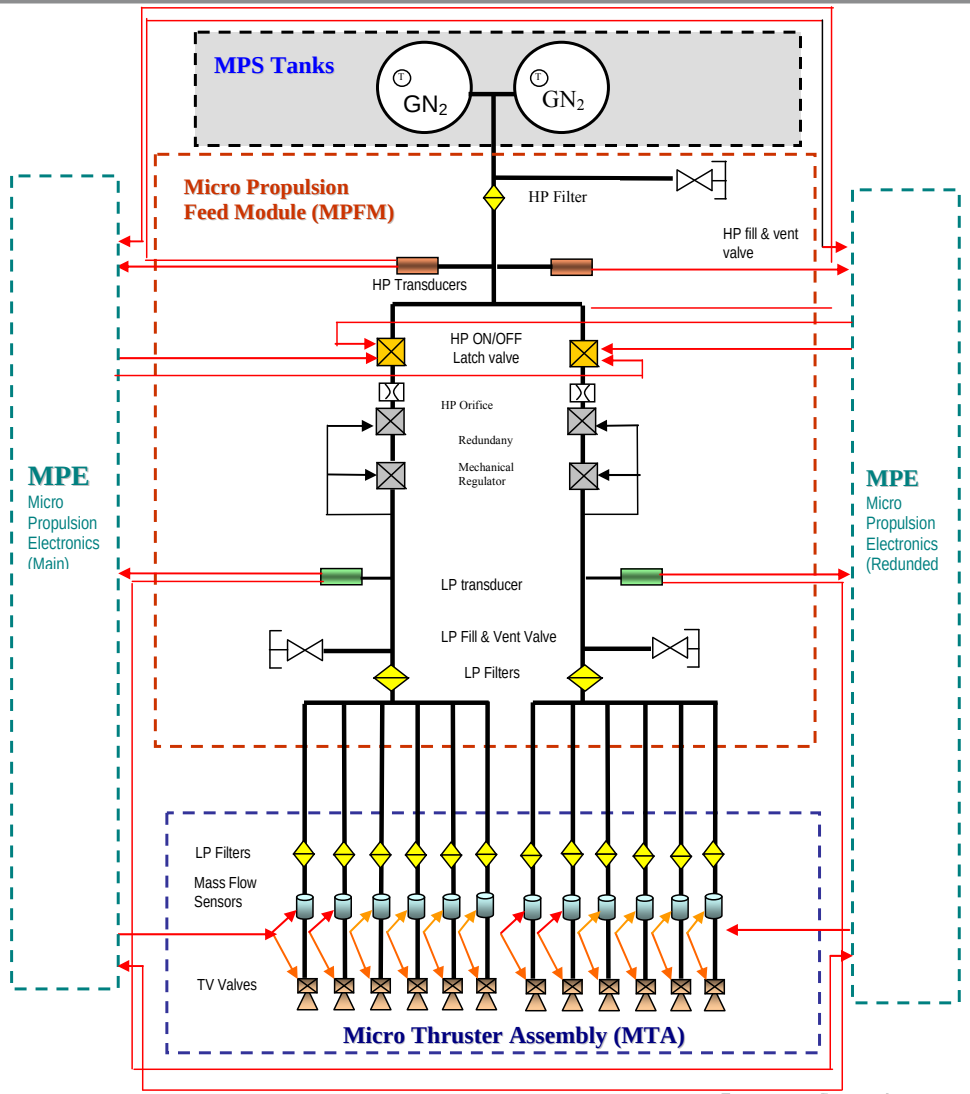
- **MPFM** – Micro Propulsion Feed Module (nominal and redundant branches)



- **MPE** – Micro Propulsion Electronics (nominal and redundant sections)



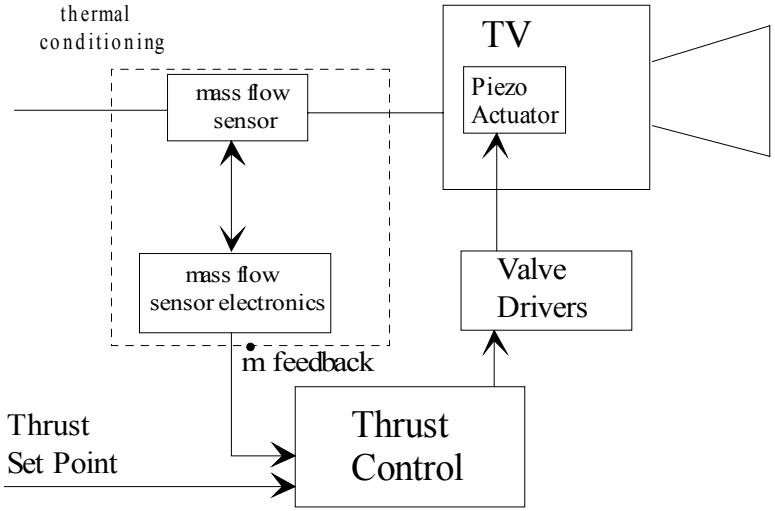
- **MTA** – Micro Thruster Assembly (6 nominal and 6 redundant sets)

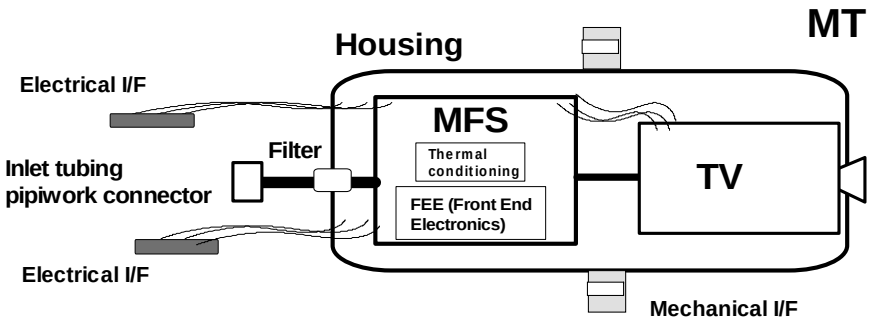


Micro Thruster Assembly (MTA)

MTA (6+6 MT's) functions (each MT) are :

- to generate and finely throttle the thrust
- to provide insulation (closure of the nozzle throat) with very low leakage
- to provide monitor of the propellant mass flow





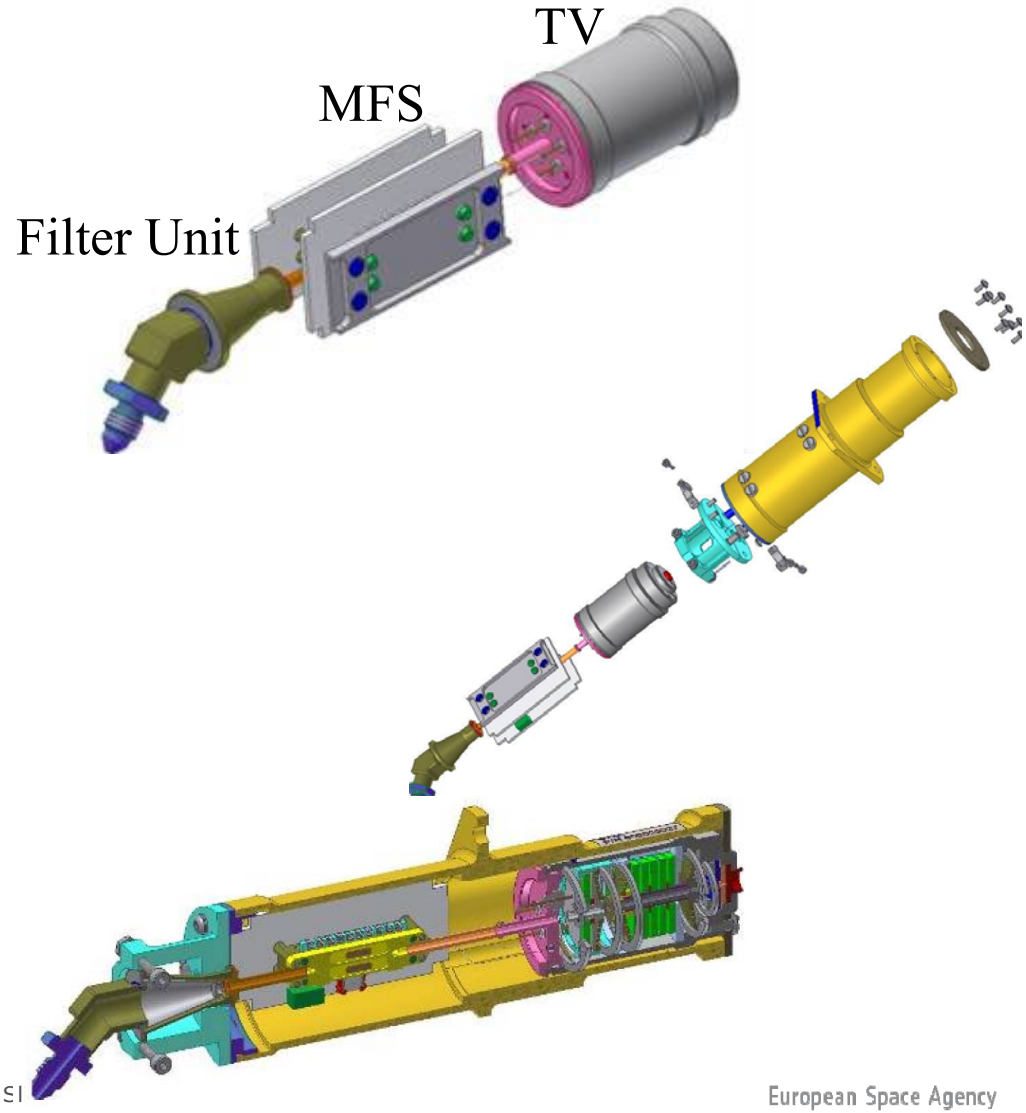
The MT design takes into account :

- Hysteresis behavior of piezo actuator
- Working tolerances and materials CTE
- Operational temperature range
- Leakage
- Thrust noise requirements
- Flow regulation dynamics
- Wear/lifetime aspects
- Mechanical environment

MTA key elements

The MT unit includes:

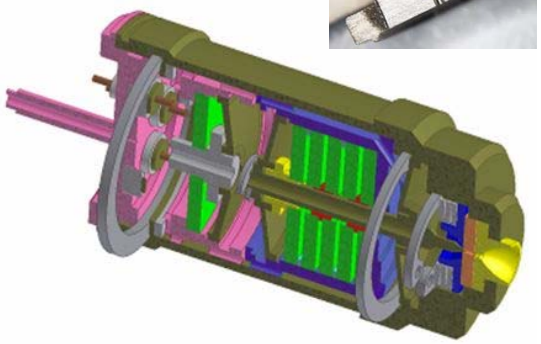
- Mechanical Housing and inlet pipeline
- **TV (Thruster Valve)**
  MFS assembly including the FEE & Electrical connectors (x 2)
- **MFS (Mass Flow Sensor)**
  - Mass flow sensing through thermal conditioning
  - Inlet **Low Pressure Filter**
  - Internal Pipe work



TV and MFS (including FEE)

TV unit includes:

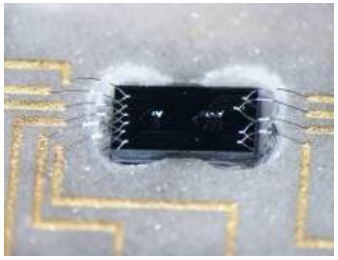
1. Piezo-electric actuator
2. Plunger, connected to the piezo-ceramic actuator
3. Antagonist S-shaped spring which pushes the plunger against the orifice (power off)
4. Micro Nozzle integrated in the valve body,
5. Mechanical Housing & pipeline connections

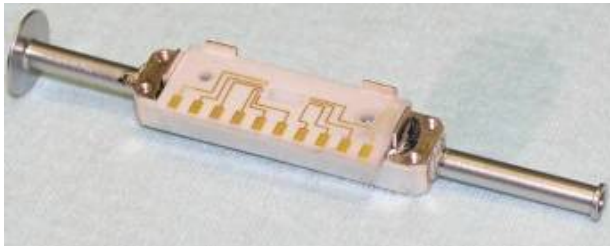


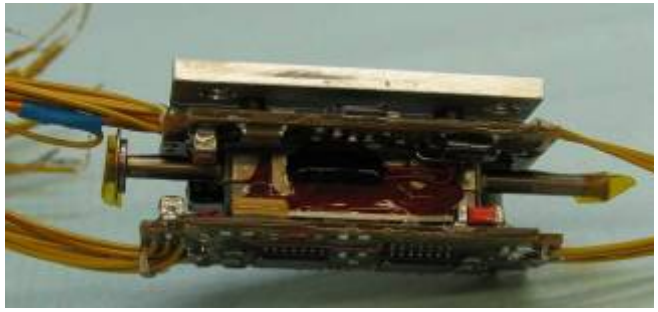
Φ=30 mm
L=64.3 mm
M= 100g

MFS assembly includes:

1. Si chip
2. Al_2O_3 support, metalized to allow brazing to the fluidic assembly
3. Fluidic assembly (brazed on support)
4. Input/output connections
5. Double Board FEE for the MFS conditioning







Gaia MPS Budgets

Components	*No. of items*	*Envelope (mm)*	*Item Mass wt. contingency (Kg)*
MT's + cables & brackets	**6+6**	**184,3 x 62 x 52,5 each**	**=0.37 x 12 = 4.4**
MPE (nom+red.)	**1 box**	**250x150x120**	**4.9**
Electrical Harness	**1 set**		**5.2**
MPFM (2 branches), with Piping, fittings & brackets	**1 ass.y**	**650 x 340 x 200 (mounted on a panel)**	**8,0**
TOTAL MPS Dry			**23.8**

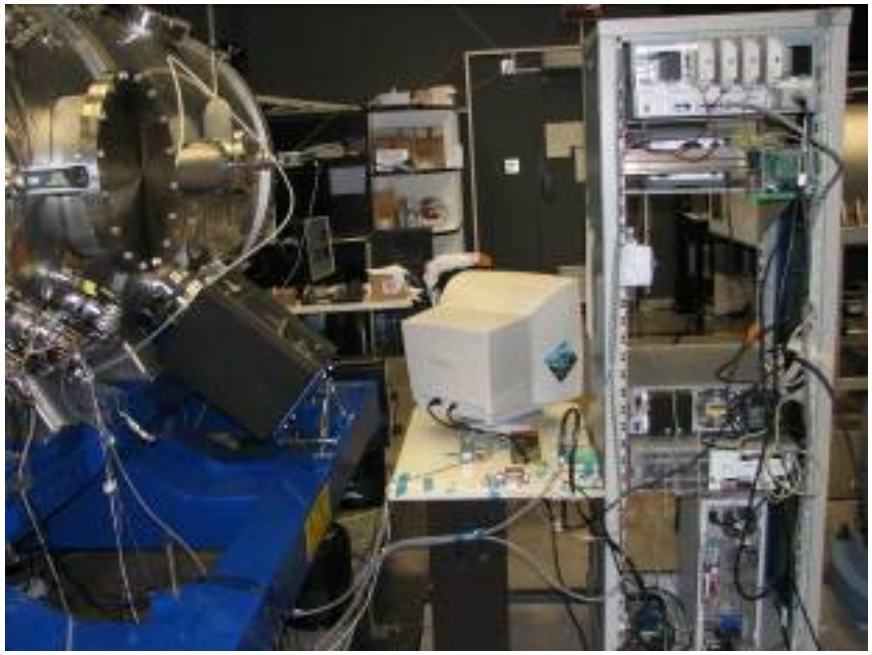
Power consumption	*Idle*	*Warm-up*	*Typical*	*Peak*
Power at primary bus plus as measured on the EQM unit	**8.0 W (incl.3 W margin)**	**30.3 W (incl. 2.6 W margin)**	**25.6 W (incl. 2.2 W margin)**	**47.1 W (incl. 2.7 W margin)**

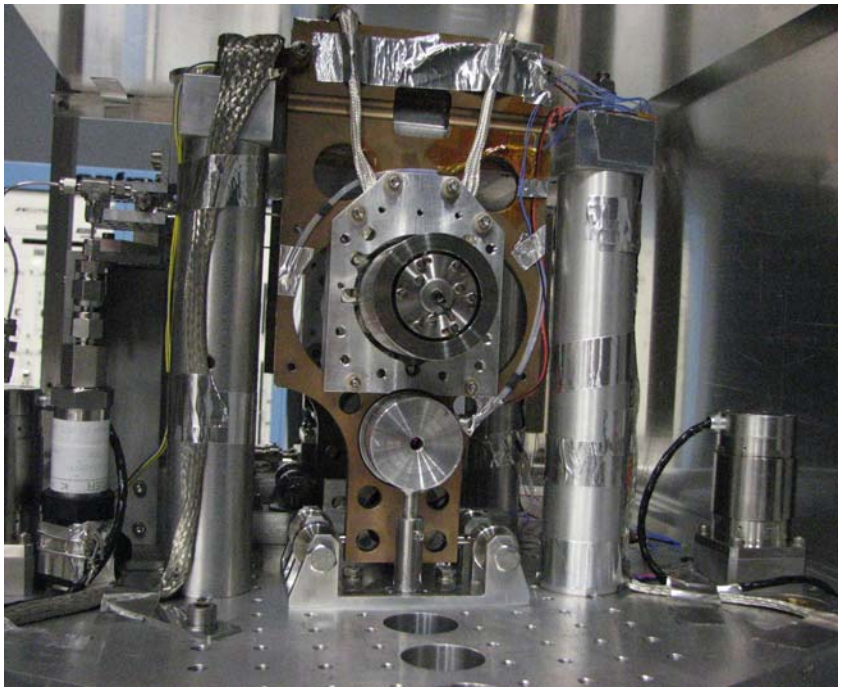
Flow Rate Resolution Test

resolution of 0.08 scc/m around 1 scc/m. Tamb.

- *Blue plot: MFS signal*
- *violet plot: set point,*
- *green plot: Vreg*

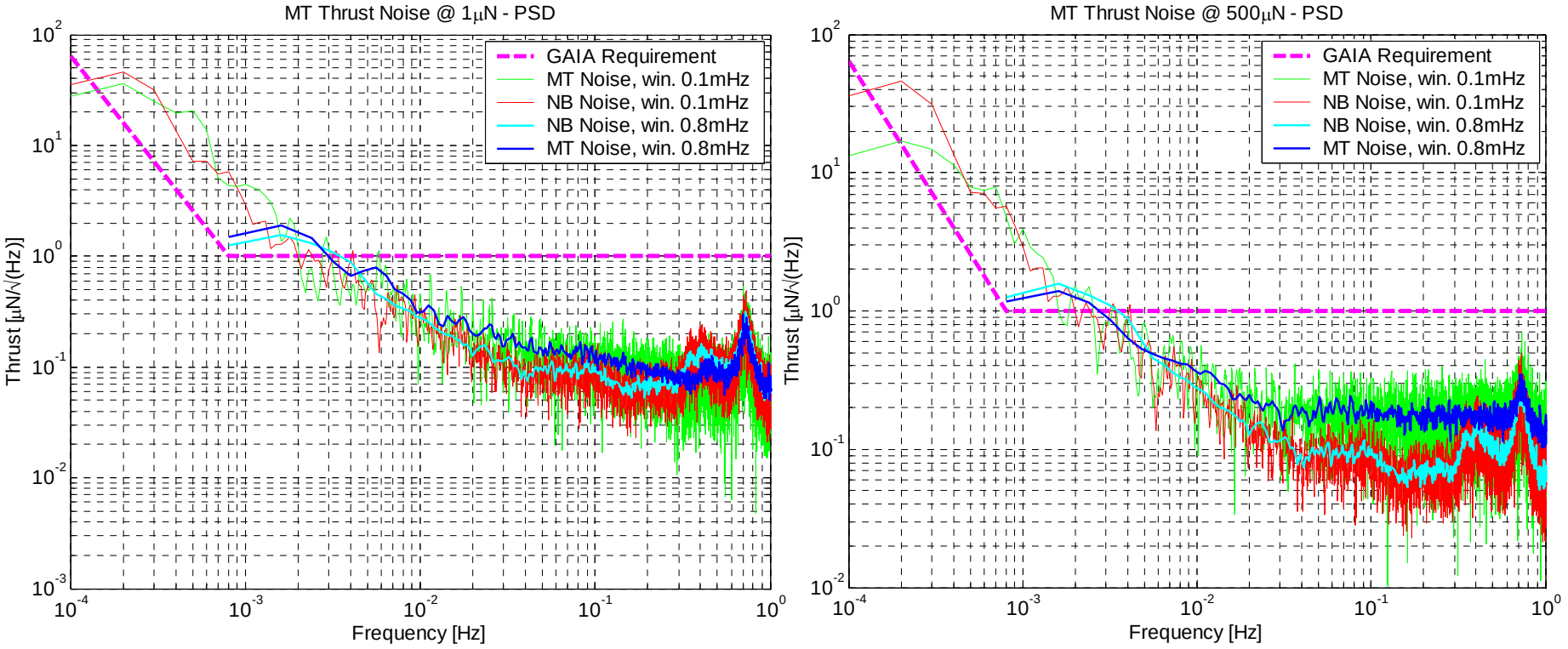
MT Qualification at the ONERA Nanobalance Facility (1/4)





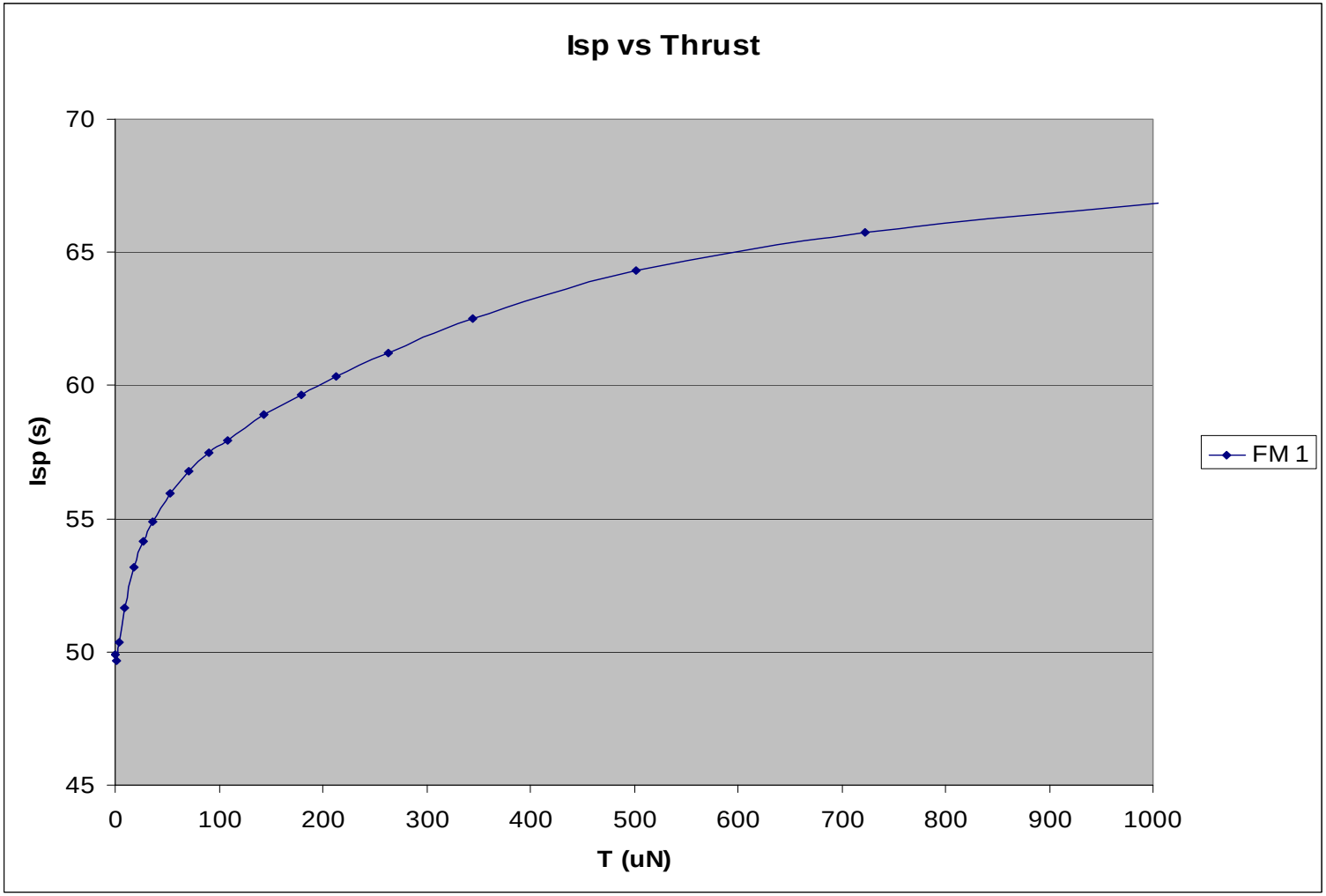
MT Qualification at the ONERA Nanobalance Facility (2/4)

Thrust noise



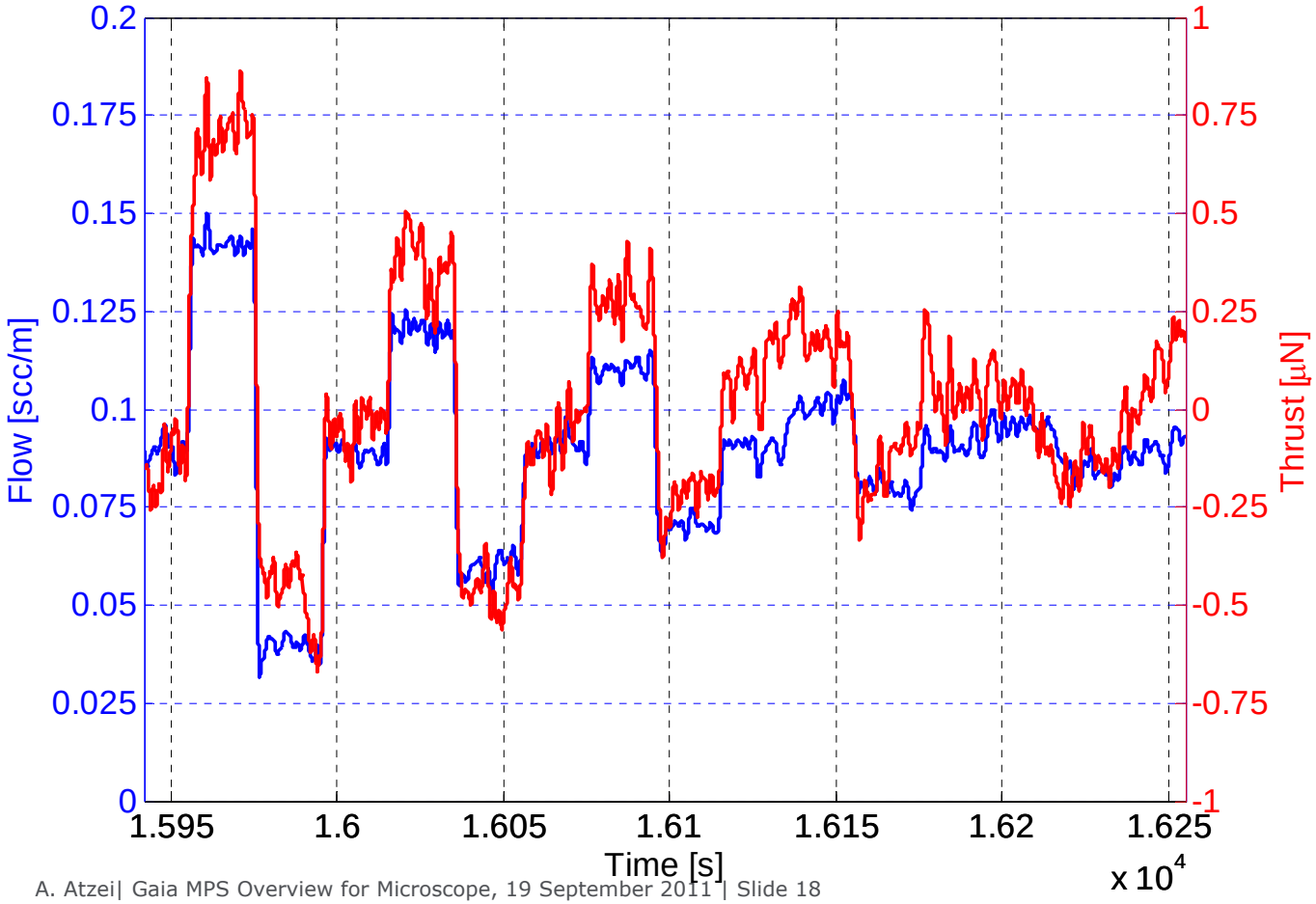
MT Qualification at the ONERA Nanobalance Facility (3/4)

Specific Impulse vs. Flow Rate



MT Qualification at the ONERA Nanobalance Facility (4/4)

Thrust resolution

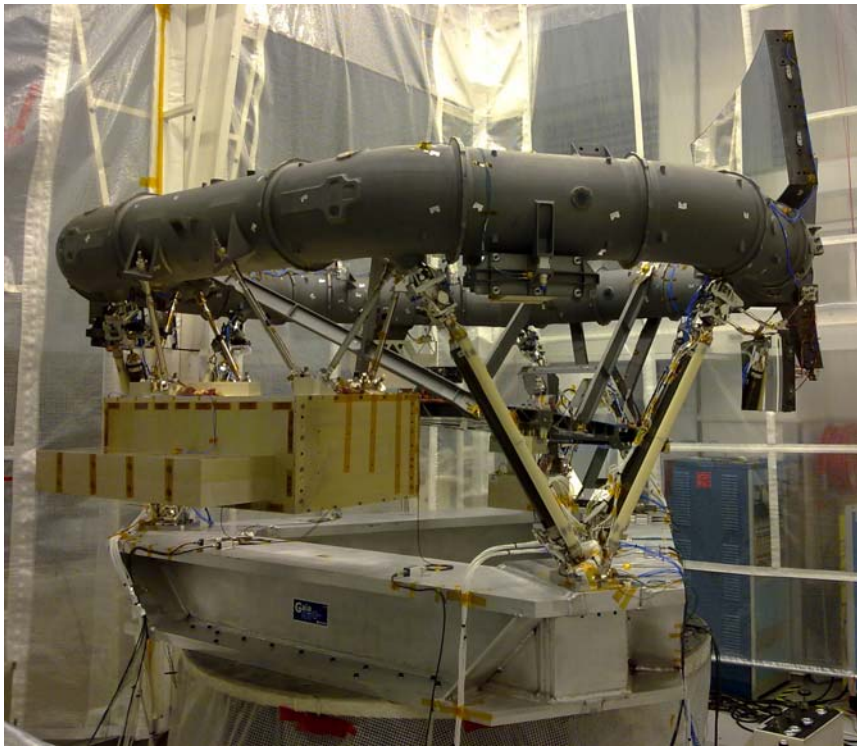


Conclusion

- The development phase of the Gaia MPS system is finished
- The first flight models have been successfully produced and delivered
- The performance test in ONERA has shown that the performance in terms of performance, noise, response time, resolution, etc. is compatible with the Gaia requirements
- With limited adaptations to the MPS electronics, the Gaia MPS system is compatible with the Microscope requirements

Any Questions?

Gaia FM Service Model



Gaia FM Payload Model