ULTRASAT camera development

Status update and next steps

APC meeting, 11th November 2020 The ULTRASAT camera team UC-1200-PT022-01

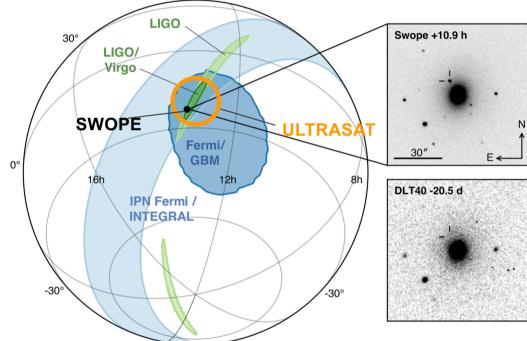
DESY.

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

ULTRASAT camera development

Status update and next steps

APC meeting, 11th November 2020 The ULTRASAT camera team UC-1200-PT022-01





HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Overview

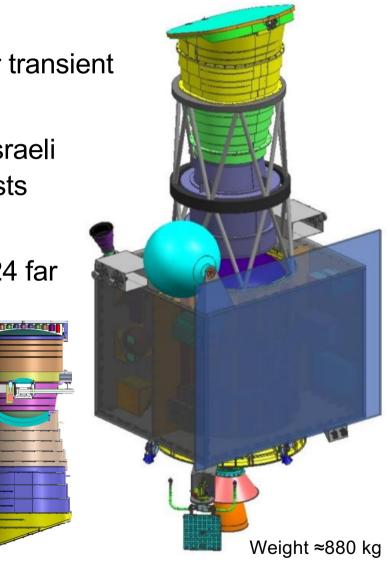
- Wide-field UV telescope (220-280 nm, FOV~200 deg²) for transient astronomy (GW, SN, etc.).
- Mission led by Weizmann Institute of Science and Israeli Space Agency; DESY provides camera. Mission costs O(100M€), ≈ 5% for DESY.
- Kick off Sep. 2019, launch agreement NASA for 2024 far advanced.

≈1.6m

• Launcher to GTO orbit, satellite will fly to GEO.

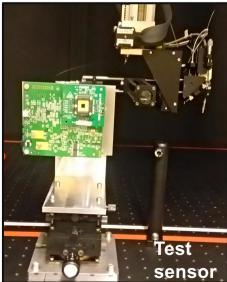
Current phase:

- Telescope (ELOP) PDR in Oct. 20.
- $_{\circ}$ Satellite (IAI) ΔSDR Nov. 20.
- Camera (DESY) PDR 14 & 15 Dec. 20.



Main advances since last meeting

- Group build-up (QA, Firmware).
- Significant gain in expertise and understanding (DLR cooperation).
- Sensor contracted, designed and taped in imminent.
- Test sensors characterized (lead to important design changes).
- Electronics and structure design advanced for PDR.
- Sensor package contracted and ongoing design.
- Heat pipe design contracted and ongoing.
- Laboratories and TVAC approved (but not yet contracted).
- Small TVAC procured and on site.



Group and facilities



Photon Science DESY Hamburg

> Cornelia Wunderer Alessandro Marras

> > Electronic workshop

Mechanics workshop

Administration purchasing / legal

Francesco Zappon Electronics



David Berge Project PI Gamma group



Rolf Bühler Project Manager



Marek Kowalski Ice-cube group



Gianluca Giavitto System engineer

Group

Photon Science DESY Hamburg

> Cornelia Wunderer Alessandro Marras

> > Electronic workshop

Mechanics workshop

Administration purchasing / legal

Nirmal Kaipachery AIV

Full-time



Francesco Zappon Electronics



David Berge Project PI Gamma group



Merlin Barschke System engineer

Rolf Bühler



and thermal



Julian Schliwinski **Project Manager** Testing & science



Marek Kowalski Ice-cube group



Steve Worm Detector lab.



Shrinivasrao

R. Kulkarni

Arooj Asif

Firmware

QA

Gianluca Giavitto System engineer

Benjamin Bastian Testing

Vasilev

Electronics

Nicola de

Simone

Firmware





Sebastian Philipp Mechanical and thermal



Jason Watson EGSE



7

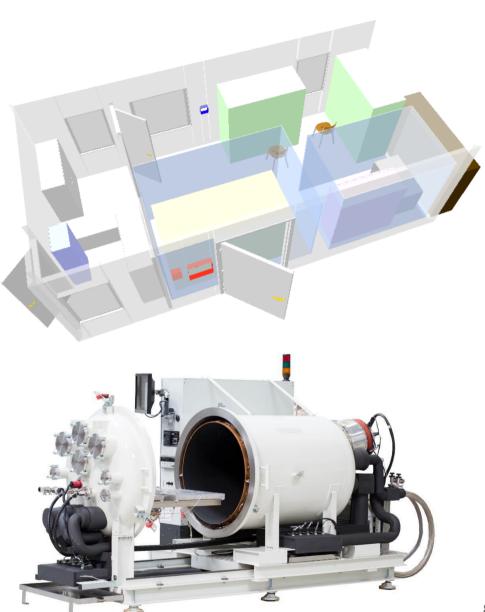
Laboratory setup

Obtained directorate approval for laboratory investment, tender being prepared.

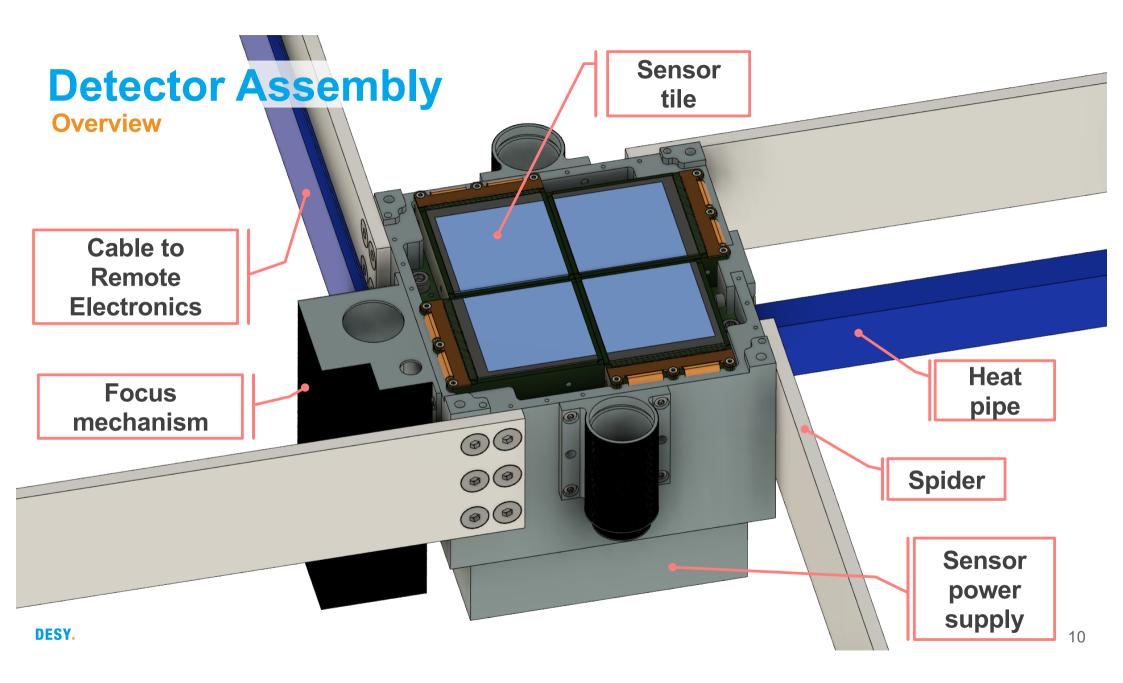
- One ISO 7 laboratory with ISO 5 areas of 35m².
- Large 170 L TVAC.

Small 27L TVAC procured and working.



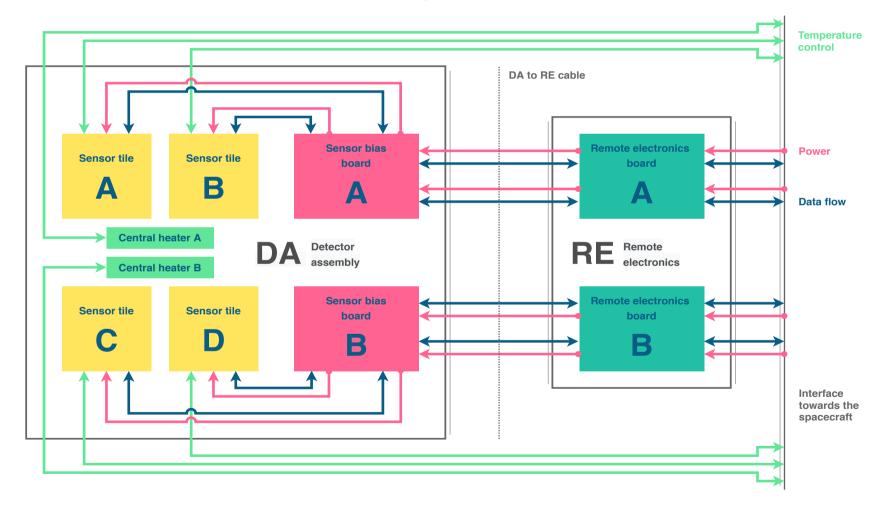


Design status and timeline



Camera layout

Remote Electronics and Detector Assembly



Time line

Delivery of EMs 30 months and PFM 35 months after kick off.

Time line "close to best case", communicated from the start. Electronics, structure, sensor and laboratories all in parallel, no buffers.

However, delay could endanger the mission. Risk mitigation focus of advisory board next week.

				2020	2021	2022	2023
Name	Begin date	End date	Duration	08 09 10 11	12 01 02 03	3 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09	10 11 12 01 02 0
■ • 2500: Sensor	30.09.20	24.03.22	376			08.08.21	
Sensor development - Tower	30.09.20	29.06.21	187				
CDR	30.09.20	30.09.20	0	•			
 Tape in 	10.11.20	10.11.20	0	•			
 Mask arrival & wafer split 1 	01.12.20	01.12.20	0	I 🔹	•		
 Wafer split 2 	18.12.20	18.12.20	0	1	•		
 Pad-wafer delivery 	31.03.21	31.03.21	0			♦	
 FSI die delivery 	16.04.21	16.04.21	0	1		 له 	
 BSI die delivery split 1 	14.06.21	14.06.21	0	1		•	
 BSI die delivery split 2 	30.06.21	30.06.21	0	1		•	
Sensor package - STA	25.11.20	12.11.21	245		_		
• PDR	25.11.20	25.11.20	0	1	•		
• CDR	14.01.21	14.01.21	0		•		
Prototype	03.05.21	03.05.21	0	1	· · · ·	•	
 Die tests setup - Sensor connect & debugg 	16.04.21	10.08.21	80	1		······································	
 Die sorting (room temp.) 	11.08.21	07.09.21	20				
 Package delivery (every ~2 weeks) 	14.09.21	12.11.21	43	I			<u></u>
 Sensor characterization 	02.06.21	24.03.22	208				<u> </u>
Dark test	21.09.21	01.12.21	50				<u></u>
Optical tests	05.10.21	29.12.21	60				<u> </u>
Radiation TID testing	30.12.21	27.01.22	20			¥	<u> </u>
Radiation TED testing Radiation SEE testing	28.01.22	24.03.22	40				<u></u>
• Sensor test milestones	02.06.21	04.10.21	88	I			1
	02.08.21	03.12.21					<u> </u>
2400: Firmware & EGSE			319				<u></u>
• 3100: Laboratories	06.11.20	20.08.21	198	1			<u></u>
2300: Electronics	01.09.20	31.01.22	359				<u> </u>
■ • 2200: Structure	31.08.20	17.01.22	350				
■ • 3000: AIV	18.01.22	12.04.23	310	I			
◎ • Cam_EMs	18.01.22	28.03.22	50				
Cam_EMs: assembly	18.01.22	14.02.22	20				1
 Cam_EMs: Physical and functional test 	01.02.22	28.03.22	40			<u></u>]	1
□ • Cam_PFM	15.02.22	23.08.22	130				
 Cam_PFM: assembly 	15.02.22	28.03.22	30				
• Cam_PFM: TRR	29.03.22	04.04.22	5	I			<u></u>
 Cam_PFM: functional 	05.04.22	20.04.22	10				1
 Cam_PFM: physical propertie tests 	21.04.22	04.05.22	10				
 Cam_PFM: EMC tests 	05.05.22	18.05.22	10			<mark></mark>	
 Cam_PFM: Structural tests 	19.05.22	02.06.22	10				1
 Cam_PFM: Thermal tests 	03.06.22	18.07.22	30				1
 Cam_PFM: Bake out 	19.07.22	23.08.22	25				
 Cam_PFM: Review (TRB&DRB) 	19.07.22	08.08.22	15				1
 Cam_FS: Populate & bake boards, fine tuning 	24.08.22	19.10.22	40				<u> </u>
□ • Cam_FS	20.10.22	12.04.23	120				-
 Cam_FS: assembly 	20.10.22	05.12.22	30				
 Cam_FS: TRR 	06.12.22	12.12.22	5				L,
 Cam_FS: functional 	13.12.22	27.12.22	10				_
 Cam_FS: physical propertie tests 	28.12.22	11.01.23	10				<u> </u>
 Cam_FS: Structural tests 	12.01.23	25.01.23	10				<u>_</u>
Cam_FS: Thermal tests	26.01.23	08.03.23	30				
• Cam_FS: Bake out	09.03.23	12.04.23	25				
 Cam FS: Review (TRB&DRB) and delivery 	09.03.23	29.03.23	15				

Risks

High-level risks

Despite great support from DESY so far, delays compared to the ambitious time line are likely. The main risks are (concrete example):

A) Sensor:

- Performance below specifications (dark current).
- Connecting Readout Electronics (voltages or interface debugging).
- B) Readout electronics design delay (too high workload).
- C) Structure design delay (problems in DM tests, too high workload).
- D) Procurement delays (electronic components and boards).
- E) Laboratory availability delayed (no vendor builds in time).
- F) Large TVAC delayed (TVAC not working "out of the box").

Risk mitigation

For A, B, C)

 Additional experienced DESY engineers for structural and thermal design would significantly reduce risks; will also lead to better 'DESY integration'.
 Additional experienced postdoc for sensor testing.

For D, E, F)

 More support on infrastructures: Typical DESY process times too slow for ULTRASAT. Laboratory, TVAC and components procurement work intensive. Infrastructure group already overloaded, consider external support company
 Laboratory alternative as backup in case of E) (~25 m² ISO-5 area within ISO 7 room).

3) Dedicated ULTRASAT laboratory in Zeuthen DM/EM work (room with clean benches sufficient, currently using desk in particle physics lab.).

4) TVAC alternative through DLR (already contacted, application required, which needs our time).

Summary and outlook

Summary and outlook

ULTRASAT group built up and achieved great progress:

- PDR on December 14th, design almost ready.
- Key long-lead items procured (sensor and package).

No surprise that the project is more complex than expected (2 years ago). The schedule remains the single major challenge, despite great support from DESY so far.

The risk can be significantly reduced (but not eliminated) with:

- Additional manpower support, particularly from experienced DESY engineers.
- Support on laboratories and procurement.

Backup

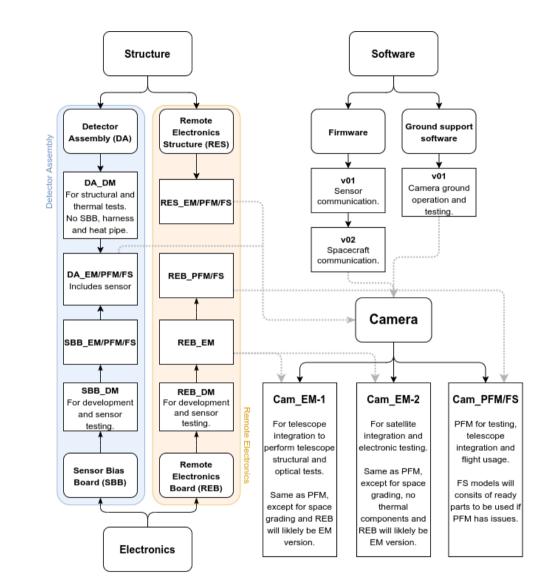
Camera models

We will build 3 full cameras:

- Two engineering models (EM).
- One Proto-Flight Model (PFM).

One Flight Spare (FS). First tests will be done on a Development Models (DMs).

Environmental tests on the PFM, in line with the "fast but riskier approach" ULTRASAT philosophy.



DM: Development Model EM: Engineering Model PFM: Proto Flight Model FS: Flight Spare

Time line sensor, package, laboratories and firmware

				2020	1	2021			2022
Name	Begin date	End date	Duration	08 09 10	11 12	01 02 03 04	05 06 07 0	8 09 10 11	12 01 02 0
□ • 2500: Sensor	30.09.20	24.03.22	376	F				2.08.21	
Sensor development - Tower	30.09.20	29.06.21	187	F					
CDR	30.09.20	30.09.20	0	•					
Tape in	10.11.20	10.11.20	0		•				
 Mask arrival & wafer split 1 	01.12.20	01.12.20	0						
 Wafer split 2 	18.12.20	18.12.20	0						
 Pad-wafer delivery 	31.03.21	31.03.21	0			•			
 FSI die delivery 	16.04.21	16.04.21	0			•			
 BSI die delivery split 1 	14.06.21	14.06.21	0				•		
 BSI die delivery split 2 	30.06.21	30.06.21	0				•		
Sensor package - STA	25.11.20	12.11.21	245						
• PDR	25.11.20	25.11.20	0		•				
• CDR	14.01.21	14.01.21	0			♦			
 Prototype 	03.05.21	03.05.21	0				•		
 Die tests setup - Sensor connect & debugg 	16.04.21	10.08.21	80			<u>7</u>		1	
 Die sorting (room temp.) 	11.08.21	07.09.21	20				1		
 Package delivery (every ~2 weeks) 	14.09.21	12.11.21	43		-				
Sensor characterization	02.06.21	24.03.22	208		-		,		
 Dark test 	21.09.21	01.12.21	50]
 Optical tests 	05.10.21	29.12.21	60					•	
 Radiation TID testing 	30.12.21	27.01.22	20						
 Radiation SEE testing 	28.01.22	24.03.22	40						
 Sensor test milestones 	02.06.21	04.10.21	88						
 Thermal cycle & optical tench 	02.06.21	02.06.21	0				•		
 Functionality at room temp. 	18.08.21	18.08.21	0						
 Dark current operational temp. 	05.10.21	05.10.21	0		-				
 2400: Firmware & EGSE 	01.09.20	03.12.21	319	, 1	-				1
• FW V1.0	01.09.20	01.04.21	149						<u>.</u>
• FW V2.0	05.04.21	03.12.21	170			Y_			
 E-GSE simulator 	01.09.20	27.05.21	186						-
 3100: Laboratories 	06.11.20	20.08.21	198		, — — — — — — — — — — — — — — — — — — —				
 Laboratory tender out 	06.11.20	18.12.20	30						
Laboratory contract	21.01.21	21.01.21	0			•			
Laboratory build	30.07.21	30.07.21	0						
TVAC tender out	06.11.20	18.12.20	30						
TVAC contract	28.01.21	28.01.21	0			•			
TVAC installed	23.08.21	23.08.21	0						

Time line electronics and structure

				2020 2021	2022
Name	Begin date	End date	Duration	08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 1	2 01 02 03 0
• 2500: Sensor	30.09.20	24.03.22	376		_
 2400: Firmware & EGSE 	01.09.20	03.12.21	319	, , , , , , , , , , , , , , , , , , ,	
 3100: Laboratories 	06.11.20	20.08.21	198		
 2300: Electronics 	01.09.20	31.01.22	359		
□ • RE_DM	29.10.20	09.04.21	112		
 RE_DM: dev. board and interfaces 	29.10.20	09.04.21	112		
 RE_DM: P&P dev. board 	23.12.20	19.02.21	40		
■ • RE_EMs	01.09.20	21.09.21	268		
□ • RE_PFM-FS	22.09.21	31.01.22	91		
• RE_PFM-FS: redisign	22.09.21	19.11.21	41		
 RE_PFM-FS: P&P (coat and bake) 	22.11.21	17.01.22	40		
 RE_PFM-FS: functional test 	18.01.22	31.01.22	10		
□ • SBB_DM	01.09.20	16.06.21	199		
 SBB_DM: component selection 	01.09.20	30.11.20	64		
 SBB_DM: schematic 	01.12.20	18.01.21	32		
 SBB DM: layout 	19.01.21	04.03.21	33		
• SBB_DM-EM-PFM-FS: P&P	01.12.20	09.04.21	90		
 SBB DM: functional test 	12.04.21	16.06.21	45		
□ • SBB EMs-PFM-FS	17.06.21	11.10.21	83		
 SBB_EMs-PFM-FS: schematic 	17.06.21	15.07.21	21		
 SBB_EMs-PFM-FS: SBB layout 	16.07.21	16.08.21	22		
 SBB_EMs-PFM-FS: P&P (coat and bake) 	17.08.21	27.09.21	30		
 SBB_EMs-PFM-FS: funtional test 	28.09.21	11.10.21	10		
 2200: Structure 	31.08.20	17.01.22	350		-
🗉 • DA DM	31.08.20	30.06.21	210		
 DA_DM: design 	31.08.20	30.11.20	65		
 DA DM: mechanical sim. 	01.10.20	07.12.20	47		
 DA_DM: thermal simulations 	07.10.20	29.12.20	58		
 DA_DM: P&P Structure 	01.12.20	23.04.21	100		
 DA_DM-EMs-PFM-FS: P&P Straps 	01.12.20	25.03.21	80		
• DA_DM: MGSE	15.01.21	09.04.21	60		
 DA_DM: Assembly 	03.05.21	17.05.21	10		
• DA_DM: Structural	18.05.21	01.06.21	10		
• DA_DM: Thermal	02.06.21	30.06.21	20		
□ DA_EMs-PFM-FS	01.12.20	17.01.22	285		
■ DA_EMs-PFM-FS: design	01.07.21	08.09.21	50		
• DA_EMs-PFM-FS: mechnical sim.	22.07.21	15.09.21	40		
 DA_EMs-PFM-FS: thermal sim 	29.07.21	22.09.21	40		
 DA_EMs-PFM-FS: P&P structure 	23.09.21	17.01.22	80		
■ DA_EMs-PFM-FS: P&P HP design	01.12.20	25.03.21	80		
• DA EMs-PFM-FS: P&P HP	26.02.21	11.11.21	180		

GANTT project				2020 2021	2022	2023
Name	Begin date	End date	Duration	08 09 10 11 12 01 02 03 04 05 0	6 07 08 09 10 11 12 01 02 03 04 05 06 07 0	8 09 10 11 12 01 02 03 04
• 2500: Sensor	30.09.20	24.03.22	376	21.01.21		
 2400: Firmware & EGSE 	01.09.20	03.12.21	319			
 3100: Laboratories 	06.11.20	20.08.21	198			
 2300: Electronics 	01.09.20	31.01.22	359	J		
2200: Structure	31.08.20	17.01.22	350	ļ		
• 3000: AIV	18.01.22	12.04.23	310			
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 Cam_EMs: assembly 	18.01.22	14.02.22	20			
 Cam_EMs: Physical and functional test 	01.02.22	28.03.22	40		Π	
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 Cam_PFM: assembly 	15.02.22	28.03.22	30			
 Cam_PFM: TRR 	29.03.22	04.04.22	5		Ĺ,	
 Cam_PFM: functional 	05.04.22	20.04.22	10			
 Cam_PFM: physical propertie tests 	21.04.22	04.05.22	10			
 Cam_PFM: EMC tests 	05.05.22	18.05.22	10			
 Cam_PFM: Structural tests 	19.05.22	02.06.22	10			
 Cam_PFM: Thermal tests 	03.06.22	18.07.22	30			
 Cam_PFM: Bake out 	19.07.22	23.08.22	25			П
 Cam_PFM: Review (TRB&DRB) 	19.07.22	08.08.22	15			-
 Cam_FS: Populate & bake boards, fine tuning 	24.08.22	19.10.22	40			
□ • Cam_FS	20.10.22	12.04.23	120			
 Cam_FS: assembly 	20.10.22	05.12.22	30			
 Cam_FS: TRR 	06.12.22	12.12.22	5			Ļ
 Cam_FS: functional 	13.12.22	27.12.22	10			
 Cam_FS: physical propertie tests 	28.12.22	11.01.23	10			
 Cam_FS: Structural tests 	12.01.23	25.01.23	10			i i i i i i i i i i i i i i i i i i i
 Cam_FS: Thermal tests 	26.01.23	08.03.23	30			
 Cam_FS: Bake out 	09.03.23	12.04.23	25			
 Cam_FS: Review (TRB&DRB) and delivery 	09.03.23	29.03.23	15			
 Project Milestones 	14.12.20	12.04.23	586			
• PDR	14.12.20	14.12.20	0	•		
 Cam_DM: delivery ELOP/IAI 	01.07.21	01.07.21	0		♦	
 Cam_EMs: delivery ELOP/IAI 	05.04.22	05.04.22	0			•
 Cam_PFM: delivery ELOP 	31.08.22	31.08.22	0			♦
 Cam FS: delivery ELOP 	13.04.23	13.04.23	0			

Time line -AIV

Advisory board schedule

Торіс	Duration	Speaker				
Introduction, group, model plan	8+2 min	@ Rolf Buehler				
Camera system overview	8+2 min	@ Merlin Barschke				
Mechanical & thermal design	8+2 min	@ Juan Maria Haces Crespo				
Electronic design	8+2 min	@ Francesco Zappon				
Scouts	5+2 min	@ Nirmal Kaipachery @ Julian Schliwinski				
Firmware and EGSE	5+2 min	@ Arooj Asif				
QA, cleanliness, V&V, laboratories	8+2 min	@ Shrinivasrao Ramarao Kulkarni				
Time line and risk management	20 min	@ Rolf Buehler				
Discussion	~45 min					
Closed session	~45 min					

Advisory board



Norbert Kappelmann Uni-Tübingen, UV astronomy and detectors.



Maria Fürmetz OHB thermal and mechanical.



Olivier Limousin CEA, sensors and electronics.



Chris Tenzer Uni-Tübingen, management, electronics.





Harald Michaelis DLR Adlershof, management and sensors.



Nick Waltham RAL space, management electronics, sensors.



Achim Peters HU-Berlin electronics, lasers.

Jörn Wilms Uni Erlangen Adlershof X-ray missions APC member 24

