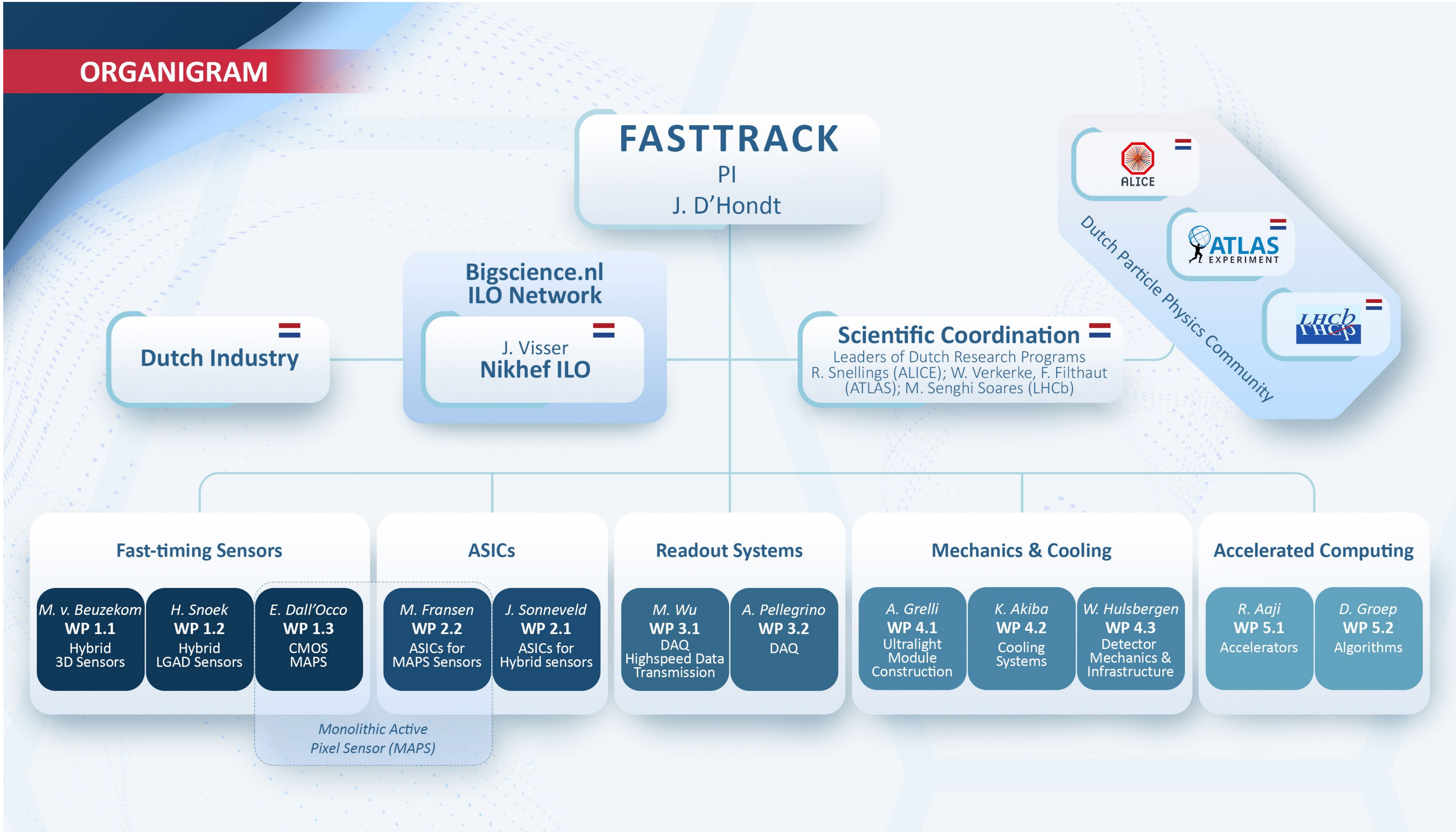
Work Packages and WP Leads



WP Deliverables

WP1.1: fully validated hybrid 3D sensors with 50 ps time resolution and non-uniform radiation profile

WP1.2: fully validated LGAD sensors with 50 ps time resolution and improved radiation tolerance

WP1.3: fully validated CMOS MAPS architecture, with 2.5 µm space resolution and 50 ps time resolution

WP2.1: ASIC design for hybrid sensors towards full ASIC production, meeting the extreme radiation requirement of 1.2 Grad, capable of sustaining data rates above 80 Gbit/s/cm^2 and of achieving time-stamping with a target resolution of 35 ps

WP2.2: final design of the logic circuitry for CMOS MAPS for full production, capable of achieving time-stamping with 50 ps resolution, sustaining a hit rate of 35 MHz cm^{-2} and a per-link data rate of 14 Gbit/s and with a power consumption below 100 mW cm^{-2}

WP3.1: fully validated fast link hardware capable of speeds in excess of 10.24 Gb/s

WP3.2: hardware and firmware of state-of-the-art FPGA boards for control, data acquisition and processing, capable of sustaining the throughput of up to 48 fast data links and a total throughput of 480 Gbit/s

WP4.1: fully completed modular structures integrating sensors/ ASIC with state-of-the-art cooling substrates, like 3Dprinted titanium, aluminum, ceramic, or printed silicon carbide

WP4.2: last-generation cooling systems ready to be integrated in the operating detectors, capable of reaching stable temperatures below −40 °C

WP4.3: the components of the detector mechanical infrastructure, ready for the final assembly at the experimental site, with minimal material (less than 0.07% of a radiation length) between the beam line and the detector, and novel solutions for powering scheme (serial or optical powering)

WP5.1: facility (8 host servers connected through a fast network) to validate and scale up data-processing pipelines that integrate commercial GPU and FPGA accelerator boards with AI inference engines

WP5.2: deep-learning-based pattern recognition algorithms optimized to run on computing on large accelerator systems integrated in the experiments processing pipelines

Schedule & Milestones

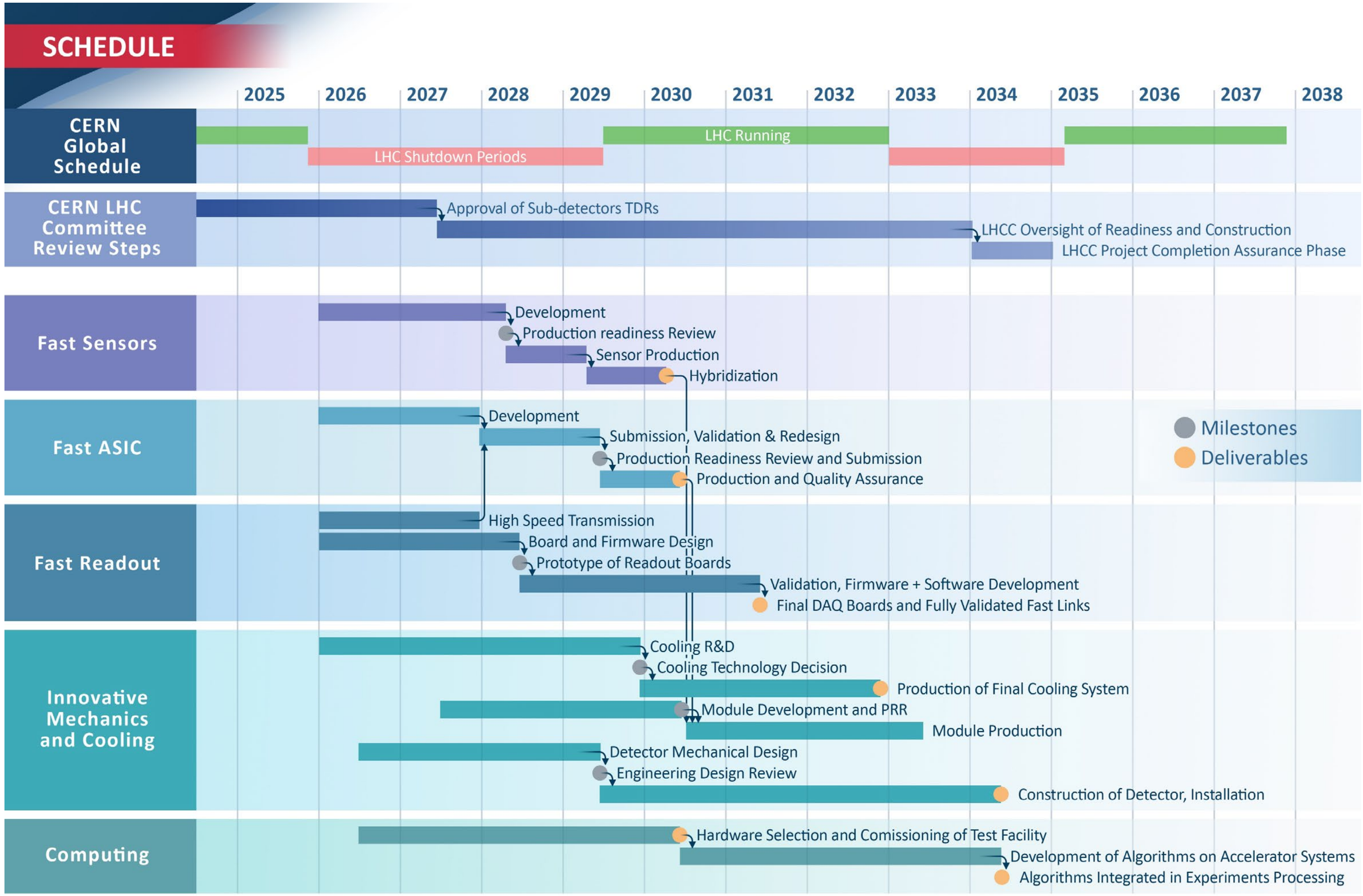
Milestones – The most relevant milestones to realize the deliverables of the project are shown in the Gantt chart in fig. 21. They have been matched to the overall project schedules for the realization of the ALICE, ATLAS and LHCb tracking systems, shown at the top of the Gantt chart. The overall LHC schedule alternates data-taking periods and long shutdowns to increase the luminosity. The LHC is currently in a data-taking period, with two long shutdowns planned for 2026-2028 and 2033-2034, respectively. In the first shutdown, the new ATLAS inner tracking system (ITk) and the HGTD detector will be installed; in the second shutdown, the innermost ring of HGTD sensors will be replaced and the new LHCb and ALICE tracking systems will be installed. The harvesting of physics results will continue until 2041.

In sect. 5 (technical aspects) these are further worked out, e.g.:

The main WP1.1 **deliverable** is the production of sensors for the LHCb VELO detector. In total, 700 sensors are needed. The production schedule takes into account that sensors must be ready in an early phase of the project, in time to be installed in the modular mechanical structures (see section 5.1.4). An important **milestone** of WP1.1 is the sensor Production Readiness Review (PRR) expected by the end of 2026.

Currently, Nikhef and CERN participate in prototyping a test ASIC as a proof-of-concept to achieve time-stamping with a target resolution of 35 ps. The main **milestone** of WP2.1 is the ASIC design submission by early 2027. After a full validation and irradiation campaign, the final ASIC, which is the WP2.1 **deliverable**, will be produced by 2028.

cm^{-2} or below. The main **milestone** of WP2.2 is the submission of the ASIC by the beginning of 2027. After a full validation and irradiation campaign, the final ASICs will be produced by 2028. This is the WP2.2 **deliverable**.



Financial Overview

Table 2: Total project costs to the Netherlands.

Total project costs (€)			
	Capital investment (€)	Running costs (€)	Total (€)
Requested NWO contribution	21,737,333	0	**21,737,333**
In kind contribution consortium	*26,053,474*	*5,500,000*	***31,553,474***
Cash contribution consortium	*0*	*0*	***0***
Total contribution consortium	26,053,474	5,500,000	**31,553,474**
Total project costs	47,790,807	5,500,000	**53,290,807**

Table 3: Overview of the Netherlands' share of personnel costs, split by work packages. All costs are capital investments (no running costs), contributed by Nikhef.

Personnel costs (€)					
Description	Contributor	Capital investment (€)	Running costs (€)	Total (€)	Year(s)
WP1.1 3D Hybrids	*Nikhef*	*709,062*	*0*	*709,062*	*2026-2035*
WP1.2 LGAD Hybrids	*Nikhef*	*164,898*	*0*	*164,898*	*2026-2035*
WP1.3 Monolithic	*Nikhef*	*205,573*	*0*	*205,573*	*2026-2035*
WP2.1 Hybrid ASICs	*Nikhef*	*2,663,377*	*0*	*2,663,377*	*2026-2035*
WP2.2 Monolithic	*Nikhef*	*199,253*	*0*	*199,253*	*2026-2035*
WP3.1 High-Speed Transmission	*Nikhef*	*3,134,490*	*0*	*3,134,490*	*2026-2035*
WP3.2 Data Acquisition	*Nikhef*	*2,522,372*	*0*	*2,522,372*	*2026-2035*
WP4.1 Module Construction	*Nikhef*	*3,861,094*	*0*	*3,861,094*	*2026-2035*
WP4.2 Cooling	*Nikhef*	*1,799,630*	*0*	*1,799,630*	*2026-2035*
WP4.3 Mechanics & Infrastructure	*Nikhef*	*8,467,720*	*0*	*8,467,720*	*2026-2035*
WP5.1 Accelerators	*Nikhef*	*664,708*	*0*	*664,708*	*2026-2035*
WP5.2 Algorithms	*Nikhef*	*1,137,297*	*0*	*1,137,297*	*2026-2035*
	Total contribution NWO	0	0	**0**	
	Total contribution Nikhef	25,529,474	0	**25,529,474**	
	Total personnel costs	25,529,474	0	**25,529,474**	

Table 4: Overview of the Netherlands' share of material costs, split by work packages.

Non-personnel costs (€)					
Description	Contributor	Capital investment (€)	Running costs (€)	Total (€)	Year(s)
WP1.1 3D Hybrids	*NWO*	*2,230,000*	*0*	*2,230,000*	*2026-2035*
WP1.2 LGAD Hybrids	*NWO*	*1,000,000*	*0*	*1,000,000*	*2026-2035*
WP1.3 Monolithic	*NWO*	*2,400,000*	*0*	*2,400,000*	*2026-2035*
WP2.1 Hybrid ASICs	*NWO*	*3,460,000*	*0*	*3,460,000*	*2026-2035*
WP2.2 Monolithic	*NWO*	*600,000*	*0*	*600,000*	*2026-2035*
WP3.1 High-Speed Trans.	*NWO*	*1,000,000*	*0*	*1,000,000*	*2026-2035*
WP3.2 Data Acquisition	*NWO*	*1,740,000*	*0*	*1,740,000*	*2026-2035*
WP4.1 Module Construction	*NWO*	*1,838,000*	*0*	*1,838,000*	*2026-2035*
WP4.2 Cooling	*NWO*	*1,050,000*	*0*	*1,050,000*	*2026-2035*
WP4.3 Mechanics & Infrastruct.	*NWO*	*2,780,000*	*0*	*2,780,000*	*2026-2035*
WP5.1 Accelerators	*NWO*	*3,139,333*	*0*	*3,139,333*	*2026-2035*
WP5.2 Algorithms	*NWO*	*500,000*	*0*	*500,000*	*2026-2035*
Travel costs	*Nikhef*	*524,000*	*0*	*524,000*	*2026-2035*
Membership fees (M&O cat. A)	*Nikhef*	*0*	*3,500,000*	*3,500,000*	*2026-2035*
Membership fees (M&O cat. B)	*Nikhef*	*0*	*2,000,000*	*2,000,000*	*2026-2035*
	Total contribution NWO	21,737,333	0	**21,737,333**	2026-2035
	Total contribution Nikhef	524,000	0	**6,024,000**	2026-2035
	Total material costs	22,261,333	5,500,000	**27,761,333**	2026-2035

Table 5: Estimated total cost for the entire FASTTRACK lifespan (science harvesting costs are not included).

Lifespan cost (k€)					
Description	**Contributor**	**Yr 1-10 (k€)**	**Yr 11-16 (k€)**	**Yr 17 (k€)**	**Total (k€)**
Overview of all costs to the Netherlands for the entire lifespan of ALICE/ATLAS/LHCb					
FASTTRACK material costs	*NWO*	*21,737*			***21,737***
FASTTRACK personnel costs	*Nikhef*	*25,530*			***25,530***
FASTTRACK travel costs	*Nikhef*	*524*	*122*		***646***
FASTTRACK maintenance costs	*Nikhef*		*1,200*		***1,200***
FASTTRACK dismantling costs	*Nikhef*			*47*	***47***
Membership fees ALICE/ATLAS/LHCb	*Nikhef*	*5,500*	*3,300*		***8,800***
Total costs to the Netherlands		53,291	4,622	47	**57,960**
Core costs for ALICE/ATLAS/LHCb upgrade - does not include personnel, travel and membership fees					
Material costs to upgrade ALICE/ATLAS/LHCb for the HL-LHC	All ATLAS/ALICE/ LHCb institutions	570,000			**570,000**