

WP7 Timing

DRD1 work package project preparation

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WP7 Outline

The role of detectors featuring timing capability will become crucial in the future experiments in High Energy Physics (HEP) field as well as in nuclear and hadronic physics. In many of these future experiments the **time information will play a major role** in studying the interaction of particles in more precise way by providing 4D information. Their role has recently been **emphasized in the LHC upgrade** towards high luminosity where high interaction rate created by the pileup at the interaction point configurations can only be mitigated by a precise time information.

The long-term plans of this projects aims to match the requirements highlighted in the 2021 ECFA detector research and development roadmap. The relevant parts in terms of facilities requirements and recommendation are reported here. The proposed activities are covering the Detector Research and Development Themes **DRDT 1.1 (Improve time and spatial resolution for gaseous detectors with long-term stability)** and **DRDT 1.3 (Develop environmentally friendly gaseous detectors for very large areas with high-rate capability)**.

Two technology specific projects

- WP7 Project A - High-rate, high-granularity precise timing with MPGDs
 - WP7 Project B - High-rate, large, precise timing RPC/MRPC
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- 9 institutes participating in MPGD activities
 - 17 institutes participating in RPC/MRPC activities

WP7

Work package table represents well tasks being worked on / considered by institutes

Synergies with all DRD1 WGs

Additional information on DRD1 website:

<https://drd1.web.cern.ch/wp/wp7>

#	Task	Performance Goal	DRD1 WGs	ECFA DRDT	Milestones/Deliverable			Institutes
					12M	24M	36M	
T1	Optimize the amplification technology towards large-area detectors	- Uniformity over m ² (time resolution, rate capability, efficiency)	WG1,		M1.1 Prototypes review (proof of concept, enhancing time resolution, active area of about 100 cm ²): status and perspectives. [T1, T2, T5, T10] M1.2 Common activities and material studies: Support and development of modelling and simulation (time resolution, rate capabilities) tools and testing facilities (time resolution, rate capability, space resolution, gas and material studies). [T3, T4, T6, T7, T8, T11]	M2.1 Prototypes suitable for large area coverage systems review: status and perspectives. [T1, T3, T10] M2.2 Multichannel readout electronics: evaluation (on small prototypes, 100 cm ² active area) of different multichannel readout solutions. [T9]	D Prototypes with time resolution below 200 ps based on RPC/MRPC and MPGD technologies: demonstrate the scalability of the technologies targeting m ² size coverage. Prototypes will be characterized in terms of time resolution, rate capability, space resolution, efficiency and multi-hit response. Different examples of multichannel readout electronics will be provided. [T1, T3, T4, T5, T9, T10] Guidelines for future developments: At the end of the three years, development directions will be summarized based on future facilities' requirements and the achievable performances of the studied solutions. Status and strategies towards the use of sustainable gas mixtures will be given. [T7]	AUTH , CERN, CIEMAT, CNRS-IN2P3/Omega, DGIST, GWNU, HYU, HIP, INFN-BA, UniBA, PoliBA, INFN-PV, UniPV, UniBG, INFN-RM2, UniRomaTOV, IRFU/CEA, IP2I, JLab, LIP-Coimbra, MPP, RBI, SIAT, SJTU, U Heidelberg, U Kyoto, U Tsinghua, USTC, VUB and UGent
T2	Enhance timing performance	- Time resolution < 50 ps up to 30 kHz/cm ²	WG2, WG3,	1.1, 1.3				
T3	Enhance rate capability	- Time resolution < 200 ps up to 100-150 kHz/cm ²	WG4, WG5,					
T4	Spatial resolution and readout granularity	- Spatial resolution of mm with low number of readout channels	WG6, WG7					
T5	Stability, robustness and longevity	- IBF <1% with <100 ps time resolution for single photoelectrons - Stable, high-gain operation						
T6	Material studies	- Radiation-hardness - Longevity						
T7	Gas studies for precise timing applications	- Eco-friendly mixtures - Recuperation - Ageing mitigation - CO ₂ -based mixture with geometrical quenching						
T8	Modelling and simulation of timing detectors	- Accurate modelling of charge transport and signal induction processes in precise timing detector geometries						
T9	Readout electronics for precise timing	- Low-noise FEE - High input capacitance - Large dynamic range - Fast rise time - Sensitivity to small charges - Multi-channel readout solution for timing detectors						
T10	Precision mechanics and construction techniques	- Precise mechanics (μm) over relatively large active areas (hundreds of cm ²)						
T11	Common framework and test facilities for precise timing R&D	- Test bench for precise timing studies						

WP7 Tasks

- T1: Optimize the amplification technology towards large-area detectors -> **WG1**
- T2: Enhance timing performance
- T3: Enhance rate capability
- T4: Spatial resolution and readout granularity -> **WG6, WG5**
- T5: Stability, robustness and longevity
- T6: Material studies -> **WG3**
- T7: Gas studies for precise timing applications -> **WG3**
- T8: Modelling and simulation of timing detectors -> **WG4**
- T9: Readout electronics for precise timing -> **WG5**
- T10: Precision mechanics and construction techniques -> **WG6**
- T11: Common framework and test facilities for precise timing R&D -> **WG7**

Tasks addressed by both MPGD and RPC/MRPC projects

WP7 Project A - Detailed deliverables

Project A					
Number	Title	Description	Start date	End date	Institutions
D7A.1	Prototypes with time resolution below 200 ps based on MPGD technology	Demonstrate the scalability of the technologies targeting m2 size coverage. Prototypes will be characterized in terms of time resolution, rate capability, space resolution, efficiency and multi-hit response. Different examples of multichannel readout electronics will be provided. [T1, T3, T4, T5, T9, T10]	0	36M	CN-USTC, HR-RBI, FI-HIP, FR-IRFU-CEA, GR-GSRLAUTH, IT-INFN.PV, CH-CERN, US-TJNAF-JLAB
M7A.1.1	Prototypes review	(proof of concept, enhancing time resolution, active area of about 100 cm2): status and perspectives. [T1, T2, T5, T10]	0M	12M	

M7A.1.2	Common activities and material studies	Support and development of modelling and simulation (time resolution, rate capabilities) tools and testing facilities (time resolution, rate capability, space resolution, gas and material studies). [T3, T4, T6, T7, T8, T11]	0M	12M	
M7A.1.3	Prototypes suitable for large area coverage systems	review: status and perspectives. [T1, T3, T10]	12M	24M	
M7A.1.4	Multichannel readout electronics	evaluation (on small prototypes, 100 cm2 active area) of different multichannel readout solutions. [T9]	12M	24M	
D7A.2	Guidelines for future developments	At the end of the three years, development directions will be summarized based on future facilities' requirements and the achievable performances of the studied solutions. Status and strategies towards the use of sustainable gas mixtures will be given. [T7]	30M	36M	CN-USTC, HR-RBI, FI-HIP, FR-IRFU-CEA, GR-GSRLAUTH, IT-INFN.PV, CH-CERN, US-TJNAF-JLAB

Project A

High-rate, high-granularity precise timing with MPGDs

WP7 Project A - Participating institutes

WP7 MPGD activities focus currently on PICOSEC MM developments

Participating members mostly from PICOSEC MM collaboration

- Aristotle University of Thessaloniki (AUTH)
- IRFU, CEA, University Paris-Saclay (IRFU/CEA)
- European Organisation for Nuclear Research (CERN)
- INFN, Pavia (INFN-PV)
- Jefferson Lab (JLab)
- Ruđer Bošković Institute (RBI)
- University of Science and Technology of China (USTC)
- Laboratory of Instrumentation and Experimental Particles Physics, Lisbon (LIP)
- Helsinki Institute of Physics (HIP)

WP7 Project A - Detailed deliverables

- D A.1 **Large area** detector modules with scalable readout chain
- D A.2 Precise timing detector prototype with **improved spatial resolution**
- D A.3 **Robust** detector prototype and **photocathodes** for long-term operation
- D A.4 **Scalable readout** chain maintaining high time resolution
- D A.5 **Calorimeter embedded** precision timing-tracking
- D A.6 Evaluation of techniques for **minimising material budget**
- D A.7 **Improved simulation model** of PICOSEC precise timing detector
- D A.8 Comparison and optimisation of timing performance of **ecofriendly gas mixtures**

Eight deliverables, most of them currently addressed by multiple institutes

Institute	Deliverables							
	D A.1	D A.2	D A.3	D A.4	D A.5	D A.6	D A.7	D. A.8
A.1: AUTH				X	X		X	
A.2: IRFU/CEA			X	X		X		
A.3: CERN	X		X					
A.4: INFN-PV	X							X
A.5: JLab	X	X	X					
A.6: RBI			X	X				
A.7: USTC	X							
A.8: LIP							X	
A.9: HIP	X		X					

WP7 Project A - Status

Dedicated kick-off meeting for WP7 Project A

No regular dedicated work package meetings but frequent meetings among Picosec collaborators

Collected list of funding agencies and existing resources

Minor resource modifications since last presentation of WP7-A resources

Prepared to proceed for endorsement

WP7

Organising common RPC-MPGD projects meeting to discuss possible synergies and shared interests

The screenshot displays a Zoom meeting agenda for 'DRD1 - WP7 Timing Detectors' on Monday, July 15, 2024, from 09:00 to 13:10 in the Europe/Zurich time zone. The agenda includes the following items:

- 09:00 → 09:30 Introduction**
- 09:30 → 11:00 Precise Timing Electronics**
- 11:00 → 11:20 Coffee break** (20m)
- 11:20 → 12:50 Mechanics for Precise Timing**
- 12:50 → 13:00 Discussion on common developments** (10m)

Each item has a corresponding edit icon. A 'Join' button is visible in the top right of the agenda section.