Calorimetry and Timing with Gaseous detectors in DRD1

I. Laktineh

DRD1 Scientific organization: Working groups

- Structure in Working Groups, forum for scientific discussions, coordinated by conveners:
 - aligned with the scientific program of the ECFA roadmap through the applications related to future facilities challenges, outlined by R&D Themes (DRDTs*), but also to the GSRs



DRD1, DRD4 and DRD6 were the first to be approved by DRDC ion 6th of December 2023

Strategic R&D = Work Package

Strategic R&Ds (according to ECFA Detector R&D Roadmap) organized in Work Packages

 group activities of the Institutes with shared research interests around Applications with a focus on a specific task(s) devoted to a specific DRDT challenge, typically related to specific Detector
 Technologies and to the development of specific tool or infrastructure



WP1

(Trackers)

- Atsuhiko Ochi
- Gabriella Pugliese
- Giulio Aielli
- Mauro lodice
- Riccardo Farinelli

WP2

(Drift chambers)

Francesco Grancagnolo

WP3

(Straw tubes)

• Peter Wintz

WP4

(Tracking TPCs)

- Diego Gonzalez Diaz
- Esther Ferrer Ribas
- Francisco Ignacio Garcia Fuentes
- Jochen Kaminski
- Piotr Gasik

WP5

(Calorimeters)

• Imad Laktineh

WP6 (Photodetectors)

- Fulvio Tessarotto
- Florian Brunbauer
- Piotr Gasik

WP7

(Timing)

- Diego Gonzalez Diaz
- Florian Brunbauer
- Imad Laktineh
- Ingo Deppner

WP8

(Reaction/Decay TPCs)

- Diego Gonzalez Diaz
- Esther Ferrer Ribas
- Francisco Ignacio Garcia Fuentes
- Jochen Kaminski
- Piotr Gasik

WP9

(Beyond HEP)

- Jona Bortfeldt
- Gabriele Croci
- Dezso Varga

Innovative gaseous detectors for calorimetry

- > To develop precise gaseous detectors as active media for future calorimeters
- Several technologies are of interest : (M)RPC, MPGD
- > The boundaries with DRD6 are well defined

#	Teelr	Barformones Cosl	DRD1	ECFA	Milestones/Deliverable			Institutes
#	Task	Performance Goar	WGs	DRDT	12M	24M	36M	Institutes
T1	Conception, construction and charac-	 High efficiency with thin large detectors Compactness of the ac- 	WG1,	1.1,	M1.1	M2.1	D1.1	IP2I,
	terization of large sampling	tive unit including cas- settes and possible cool-	WG2,	1.3	Construction of	Uniformity study	Performance and	CIEMAT,
	elements for calorimeters	ing system - Uniformity in terms of	WG4,		gaseous detector	and cluster size	of the large and thin	VUB and UGent,
		thickness, resistivity and gas circulation	WG7		ments on efficiency	medium-size de-	technologies. Perfor-	GWNU,
					[T1].	timing performance	of:	SJTU,
T2	Timing per-	- Timing performance				the case of MPGD, 0.7 ps for PPC and	mity: < 10% in	MPP,
	formance of gaseous	of different technologies - Uniformity of the				0.15 ns for MRPC with 4 gaps [T2]	an in terms of cluster	WIS,
	detectors for calorimeters	detector response in terms of timing				with 4 gaps [12].	- time resolution below few ns [T2]	INFN-BA, UniBA PoliBA
						M2.2	- high detection rate	INFN-RM3
						Construction of large and thin (few	few kHz/cm ² [T4],	INFN-NA
T3	Readout elec-	- Low-jitters readout				mm) detectors of different technolo-	different kinds of gas	
	tronics for calorimeter	electronics - Low power consump-				gies (MRPC, RPC, MM uRWELL	D1.2	
	gaseous detec- tors	tion per channel - Active Sensitive Unit				RPWELL) with small dead zones	The readout	
		(ASU) of large size with good flatness				(< 2% dead zone). We propose to build	electronics [T3]	
						detectors larger than $50 \text{ cm} \times 50 \text{ cm}$ in	pickup pads of the order of 1 cm ² :	
T4	High-rate	- High-rate capability				the case of MPGD and larger than 100	- threshold down to a few fC for MPGD	
	capability gaseous de-	exceeding a few KHz in case of (M)RPC and				$cm \times 100$ cm for (M)RPC, featuring	and tens of fC for (M)RPC	
	tectors for cir- cular collider	tens of KHz in case of MPGD				dead zones $< 2\%$. The detectors should	- time resolution better than 100 ps	
	calorimeters	- Impact of high particle rate on the detector				feature an efficient gas circulation to		
		performance (efficiency, spatial resolution, tim-				be used as active layers in granular		
		ingetc)				calorimeters [T1].		
			1	1				

Uniformity, efficiency, high-rate and timing

How the WP covers the topics in the ECFA roadmap

DRDTs

DRDT 1.1 - Precise timing detectors with rate capability, spatial resolution.

DRDT 1.3 – Study eco-friendly solutions for gaseous timing detector

Challenges

-Realization of thin and large surface detectors with high efficiency, excellent uniformity and high-rate capabilities operated with eco-friendly gases

- Very good time resolution

-Embedded readout electronics

Goals

To provide high granular hadronic calorimeters with active media made of gaseous detectors to efficiently apply the PFA techniques and at the same time provide good energy resolution

1	_			DBDI	DODA		M'1		
	#	Task	Performance Goal	WC	ECFA	1014	Milestones/Denverable	2614	Institutes
	T1	Conception, construction	- High efficiency with thin large detectors - Compactness of the ac-	WG1,	1.1,	M1.1	M2.1	D1.1	IP2I,
		terization of large sampling	tive unit including cas- settes and possible cool-	WG2,	1.3	Construction of medium-sized	Uniformity study including efficiency	Performance and uniformity studies	CIEMAT,
		calorimeters	- Uniformity in terms of	WG4,		gaseous detector fulfilling the require-	and cluster size distribution with	of the large and thin detectors of different	VUB and UGent,
			gas circulation	WG7		ments on efficiency and small dead zones	medium-size de- tectors. Expected	technologies. Perfor- mance goals in terms	GWNU,
						[T1].	timing performance	of:	SJTU,
	T2	Timing per-	- Timing performance				the case of MPGD,	mity: < 10% in	MPP,
		formance of gaseous	of different technologies - Uniformity of the				0.15 ns for MRPC with 4 gaps [T2]	an in terms of cluster	WIS,
		detectors for calorimeters	detector response in terms of timing				with F Bups [12].	- time resolution below few ns [T2]	INFN-BA, UniBA PoliBA
							M2.2	- high detection rate	INFN-RM3
							Construction of	few kHz/cm ² [T4],	INFN NA
	Т3	Desdout alac	Low jitters readout				mm) detectors of	different kinds of gas	INTIVIA
	15	tronics for	electronics				gies (MRPC, RPC,	mixtures.	
		gaseous detec-	tion per channel				MM, µRWELL, RPWELL) with	D1.2	
		tors	 Active Sensitive Unit (ASU) of large size with 				small dead zones (< 2% dead zone).	The readout electronics [T3]	
			good flatness				We propose to build detectors larger than	associated with pickup pads of the	
							50 cm × 50 cm in the case of MPGD	order of 1 cm ² : - threshold down to	
	T4	High-rate capability gaseous de-	 High-rate capability exceeding a few KHz in case of (M)RPC and 				and larger than 100 cm \times 100 cm for (M)RPC, featuring	a few fC for MPGD and tens of fC for (M)RPC	
		cular collider calorimeters	MPGD - Impact of high particle				dead zones < 2%. The detectors should feature an efficient	- time resolution better than 100 ps	
			rate on the detector performance (efficiency, spatial resolution tim-				gas circulation to be used as active		
			ingetc)				calorimeters [T1].		

Strategy: One project associating different technologies

Two Deliverables

D1.1- Performance and uniformity study of **large detectors built** with different technologies ((M)RPC, MPGD) : **Uniformity** (efficiency&cluster size), **high rate**, **time** resolution.

D1.2 – Production of panels equipped with low-noise, low time-jitter readout

electronics to read out large detectors of different technologies in collaboration with **DRD6**

Two milestones

- M1.1 : Performance and uniformity study with prototypes of medium size
- M1.2: Conception and construction of large surface detectors

#	Tack	Parformance Coal	DRD1	ECFA		Milestones/Deliverable		Institutes
"	IdSK	renomance Ooar	WGs	DRDT	12M	24M	36M	msututes
T1	Conception, construction and charac-	 High efficiency with thin large detectors Compactness of the ac- 	WG1,	1.1,	M1.1	M2.1	D1.1	IP2I,
	large sampling	settes and possible cool-	WG2,	1.3	Construction of medium-sized	Uniformity study including efficiency	Performance and uniformity studies	CIEMAT,
	elements for calorimeters	ing system - Uniformity in terms of	WG4,		gaseous detector	and cluster size	of the large and thin detectors of different	VUB and UGent,
		thickness, resistivity and gas circulation	WG7		ments on efficiency	medium-size de-	technologies. Perfor-	GWNU,
					[T1].	timing performance	of:	SJTU,
Т?	Timing per-	- Timing performance				the case of MPGD,	- detector unifor- mity: < 10% in	MPP,
12	formance	of different technologies				0.7 ns for RPC and 0.15 ns for MRPC	an in terms of cluster	WIS,
	detectors for	detector response in terms of timing				with 4 gaps [T2].	size [T1], - time resolution	INFN-BA,
	calorinicaers	terms of unning				M2.2	below few ns [T2], - high detection rate	UniBA, PoliBA,
						Construction of	capabilities up to a few kHz/cm ² [T4],	INFN-RM3,
						large and thin (few mm) detectors of	to be obtained with different kinds of gas	INFN-NA
13	readout elec- tronics for	 Low-jitters readout electronics 				different technolo- gies (MRPC, RPC,	mixtures.	
	calorimeter gaseous detec-	 Low power consump- tion per channel 				MM, µRWELL, RPWELL) with	D1.2	
	tors	 Active Sensitive Unit (ASU) of large size with 				small dead zones (< 2% dead zone).	The readout electronics [T3]	
		good flatness				We propose to build detectors larger than	associated with	
						50 cm × 50 cm in the case of MPGD	order of 1 cm ² :	
T4	High-rate capability gaseous de- tectors for cir-	 High-rate capability exceeding a few KHz in case of (M)RPC and tens of KHz in case of 				and larger than 100 cm \times 100 cm for (M)RPC, featuring dead zones < 2%.	a few fC for MPGD and tens of fC for (M)RPC - time resolution	
	cular collider calorimeters	MPGD - Impact of high particle rate on the detector performance (efficiency.				The detectors should feature an efficient gas circulation to	better than 100 ps	
		spatial resolution, tim- ingetc)				layers in granular calorimeters [T1].		
I I			1	1				

• Institutes

- ightarrow 10 institutes from 8 countries
- \rightarrow Most of all are also involved in DRD6 (calorimetry)
- → Most of them have already worked together on a given technology but in this proposal common studies will be an essential feature

- Institut de la physique des 2 infinis (IP2I)
- Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT)
- Vrije Universiteit Brussel (VUB)
- Gangneung-Wonju National University (GWNU)
- Shanghai Jiao Tong University (SJTU)
- Max-Planck Institute for Physics (MPP)
- Weizmann Institute of Science (WIS)
- Bari INFN & University (INFN-ba)
- ROME3 University (ROME3)
- Naples INFN (INFN-Na)

RPC-based HCAL is much more advanced than the MPGD-based ones

SDHCAL prototype was exposed to beam particles at CERN PS, SPS in 2012, 2015, 2017,2018 and 2022









RPC-based SDHCAL→ (M)RPC-based HCAL

- Better time resolution leading to better PFA performance with better energy and PID
- Higher rate capabilities (less charge) and possibility to have low resistivity glass plates











Electronics:

We need new electronics to read out (M)RPC and exploit the timing performance.

PETIROC was proposed for iRPC@CMS. Excellent performances are obtained with doublet RPC using pickup strips \rightarrow A good candidate to start with

Gaussian Fitting

7.3998



The problem with PETIROC TDC is the deadtime (12.5 μ s) Within DRD6 a new ASIC (CALOROC) will be developed and a variant adapted to MRPC readout



MPGD-based SDHCAL

The activities started in 2012 with the DHCAL-ANR where in addition to the 48 RPC chambers, 4 large MICROMEGAS conceived by LAPP and equipped with similar electronics were inserted in the SDHCAL prototype.

Groups from Italy and Israel have started similar activities including other MPGD technologies such that MICROMEGAS, μ WELL and RPwell





- detector size: 20x20 cm2
- ~6 mm drift gap

• Common readout board: $1x1cm2 pad \rightarrow 384 pads$



- Data

- MC

Good efficiency for all technologies

Uniformity is better for μ Megas than for the μ well and Rpwell. Some X-talk issues....



First results at PS



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

• 9 institutes participating in MPGD activities

• 21 institutes participating in RPC/MRPC activities

	77 J		DRD1	ECFA		T at a		
ŦF	Task	Performance Goal	WGs	DRDT	12M	24M	36M	Institutes
T1	Optimize the amplification technology towards large-	- Uniformity over m ² (time resolution, rate capability, efficiency)		Diddi			0011	
	area detectors		WG1,		M1.1	M2.1	D	AUTH ,
T2	Enhance timing perfor-	- Time resolution < 50 ps up to 30 kHz/cm ²	WG2,	1.1,	Prototypes re-	Prototypes suit- able for large area	Prototypes with time resolution	CERN,
	mance		WG3,	1.3	concept, enhancing	coverage systems	below 200 ps based	CIEMAT,
	Each and an and a	Time monthing	WCA		time resolution,	review. status and	MDCD to book	CNIDE
15	Ennance rate	- Time resolution <	WG4,		active area of about	perspectives. [11,	MPGD technolo-	CINKS-
	capability	200 ps up to $100-$	NUCE		100 cm ²): status and	13, 110]	gies: demonstrate	IN2P3/Omega,
		130 KHZ/CIII-	wG5,		T2, T5, T10]	M2.2	the technologies	DGIST,
T4	Spatial resolu- tion and read-	- Spatial resolution of mm with low number of	WG6,		M1.2	Multichannel	targeting m ² size coverage. Prototypes	GWNU,
	out granularity	readout channels	WG7		Common activi-	readout electronics: evaluation (on small	will be characterized in terms of time	HYU.
T5	Stability, ro-	- IBF <1% with <100 ps	t		ties and material	prototypes, 100 cm ²	resolution, rate	
	bustness and longevity	time resolution for sin- gle photoelectrons			studies: Support and development	active area) of dif- ferent multichannel	capability, space resolution efficiency	HIP,
	gy	- Stable, high-gain oper-			of modelling and	readout solutions	and multi-hit re-	INFN-BA
		ation			simulation (time	[T 9]	sponse. Different	UniBA, PoliBA,
					resolution, rate		examples of mul-	
T6	Material stud-	 Radiation-hardness 			capabilities) tools		tichannel readout	INFN-PV, UniPV,
	ies	- Longevity			and testing facilities		electronics will be	UniBG,
T7	Gas studies for	Eco friandly mixtures			rate conspility space		T4 T5 T0 T10	INEN PM2
11	precise timing	- Recuperation			resolution gas and		14, 13, 19, 110]	UniPomaTOV
	applications	- Ageing mitigation			material studies)		Guidelines for	Chirkomarov,
	applications	- CO ₂ -based mix-			[T3, T4, T6, T7, T8,		future develop-	IRFU/CEA,
		ture with geometrical quenching			111]		the three years, de-	IP2I,
тв	Modelling and	- Accurate modelling					velopment directions will be summarized	JLab,
	simulation of timing detec-	of charge transport and signal induction pro-					based on future facil- ities' requirements	LIP-Coimbra,
	tors	cesses in precise timing detector geometries					and the achievable performances of the	MPP
	Baadout alaa						studied solutions.	BBI
12	tronics for pre-	– High input capaci-					towards the use	KDI,
	cise timing	tance					of sustainable gas	SIAT,
		 – Large dynamic range – Fast rise time 					given. [T7]	SJTU,
		 Sensitivity to small charges 						U Heidelberg,
		- Multi-channel readout solution for timing de-						U Kyoto,
		tectors						U Tsinghua
T10	Precision me-	- Precise mechanics						USTC
	construction	(μm) over relatively large active areas (hun-						0510,
	techniques	dreds of cm ²)						VUB and UGent
T11	Common	- Test bench for precise	l I					
	framework and	timing studies						
	test facilities							
	for precise							
	timing R&D							

Timing , readout electronics, high-rate with eco-friendly gases

• How the WP covers the topics in the ECFA roadmap

- DRDTs:
 - DRDT 1.1 Precise timing detectors with rate capability, spatial resolution.
 - DRDT 1.3 Study eco-friendly solutions for gaseous timing detector
- Challenges
 - Eco-friendly gases: decreasing availability, increasing cost of GH gases
 - Detector ageing: operational instabilities/ageing in harsh environments,
 - Front end electronics: timing performance, low power, robustness
- Goals
 - Development of scalable precise timing detector with operational stability and long term robustness
 - High-rate capability and spatial resolution with suitable FE electronics for the required readout granularity

#	Took	Parformance Coal	DRD1	ECFA		Milestones/Deliverable		Institutes
π	IdSK	renormance Goar	WGs	DRDT	12M	24M	36M	msututes
T1	Optimize the amplification technology towards large- area detectors	 Uniformity over m² (time resolution, rate capability, efficiency) 	WG1,		M1	M2	D	AUTH ,
T2	Enhance timing perfor-	- Time resolution < 50 ps up to 30 kHz/cm ²	WG2,	1.1,	Prototypes re- view (proof of	Prototypes suit- able for large area	Prototypes with time resolution	CERN,
	mance	oo po up to oo minoom	WG3,	1.3	concept, enhancing time resolution,	coverage systems review: status and	below 100ps based on RPC/MRPC and	CIEMAT,
T3	Enhance rate capability	- Time resolution < 200 ps up to 100- 150 kHz/cm ²	WG4,		active area of about 100 cm ²): status and	perspectives. [T1, T3, T10]	MPGD technolo- gies: demonstrate	CNRS- IN2P3/Omega,
Г4	Spatial resolu-	- Spatial resolution of	WG5, WG6.		[T1, T2, T5, T10]	Multichannel readout electronics:	the technologies targeting m ² size	DGIST,
	tion and read- out granularity	mm with low number of readout channels	WG7		Common activi- ties and material	Evaluation (on small prototypes, 100 cm ²	coverage. Prototypes will be characterized	GWNU,
Т5	Stability, ro-	- IBF <1% with <100 ps			studies: Support and development	active area) of dif- ferent multichannel	in terms of time resolution, rate	HYU,
	longevity	gle photoelectrons - Stable, high-gain oper-			simulation (time resolution, rate	[T9]	resolution, efficiency and multi-hit re-	INFN-BA,
		ation			capabilities) tools and testing facilities		sponse. Different examples of mul-	UniBA, PoliBA,
16	Material stud- ies	- Radiation-hardness - Longevity			(time resolution, rate capability, space resolution gas and		tichannel readout electronics will be provided	INFN-PV, UniPV, UniBG,
T7	Gas studies for precise timing applications	Eco-friendly mixtures Recuperation Ageing mitigation CO ₂ -based mix- ture with geometrical			material studies). [T3, T4, T6, T7, T8, T11]		[T1, T3, T4, T5, T9, T10] At the end of the three years,	INFN-RM2, UniRomaTOV, IRFU/CEA,
TO	Madall'an and	quenching					guidelines for future developments will be	IP2I,
10	simulation of timing detec-	of charge transport and signal induction pro-					on future facilities' requirements and	LIP-Coimbra,
	tors	detector geometries					the achievable per- formances of the studied solutions.	MPP,
T9	Readout elec- tronics for pre-	 Low-noise FEE High input capaci- 					Status and strategies towards the use	RBI,
	cise timing	 Large dynamic range Fast rise time 					of sustainable gas mixtures will be given [T7]	SIAT,
		 Sensitivity to small charges 					a	U Heidelberg,
		 Multi-channel readout solution for timing de- tectors 						U Kyoto,
T10	Precision me-	- Precise mechanics						U Tsinghua,
	chanics and construction	(µm) over relatively large active areas (hun-						USTC,
T11	techniques	dreds of cm ²)						VUB and UGent
111	framework and test facilities for precise timing R&D	timing studies						

• Two projects based on different technologies:

- Project A High-rate, high-granularity precise timing with MPGDs
- Project B High-rate, large, precise timing (M)RPC

• Deliverables in WP7

Project A:

- 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 longterm 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

Project B:

- D B.1: Production and comparison of full large (> 1 m2) MRPC built with different techniques
- D B.2: Production of large PCB equipped with precise timing electronics
- D B.3: Production of a stable single cell MRPC with very high-rate and timing capability
- D B.4: Construction of large-area double-gap RPC with a time resolution better than 200ps
- D B.5: Timing and spatial resolution studies versus different gas mixtures

#	Took	Parformance Goal	DRD1	ECFA		Milestones/Deliverable		Institutes
π	IdSK	Ferformance Goai	WGs	DRDT	12M	24M	36M	monutes
T1	Optimize the amplification technology towards large-	 Uniformity over m² (time resolution, rate capability, efficiency) 						
	area detectors		WG1,		М1	M2	D	AUTH ,
T2	Enhance timing perfor- mance	- Time resolution < 50 ps up to 30 kHz/cm ²	WG2, WG3,	1.1, 1.3	Prototypes re- view (proof of concept, enhancing time resolution	Prototypes suit- able for large area coverage systems	Prototypes with time resolution below 100ps based on PPC/MPPC and	CERN, CIEMAT,
Т3	Enhance rate capability	- Time resolution < 200 ps up to 100- 150 kHz/cm ²	WG4, WG5,		active area of about 100 cm ²): status and perspectives. [T1, T2, T5, T10]	perspectives. [T1, T3, T10] Multichannel	MPGD technolo- gies: demonstrate the scalability of the technologies	CNRS- IN2P3/Omega, DGIST,
T4	Spatial resolu- tion and read- out granularity	 Spatial resolution of mm with low number of readout channels 	WG6, WG7		Common activi- ties and material studies: Support	readout electronics: Evaluation (on small prototypes, 100 cm ² active area) of dif-	targeting m ² size coverage. Prototypes will be characterized in terms of time	GWNU, HYU,
T5	Stability, ro- bustness and longevity	- IBF <1% with <100 ps time resolution for sin- gle photoelectrons - Stable, high-gain oper- ation			and development of modelling and simulation (time resolution, rate capabilities) tools and testing facilities	ferent multichannel readout solutions. [T9]	resolution, rate capability, space resolution, efficiency and multi-hit re- sponse. Different examples of mul-	HIP, INFN-BA, UniBA, PoliBA,
Т6	Material stud- ies	 Radiation-hardness Longevity 			(time resolution, rate capability, space resolution, gas and		tichannel readout electronics will be provided.	INFN-PV, UniPV, UniBG,
T7	Gas studies for precise timing applications	Eco-friendly mixtures Recuperation Ageing mitigation CO ₂ -based mix- ture with geometrical quenching			material studies). [T3, T4, T6, T7, T8, T11]		[T1, T3, T4, T5, T9, T10] At the end of the three years, guidelines for future development will be	INFN-RM2, UniRomaTOV, IRFU/CEA, IP2I,
T8	Modelling and simulation of timing detec- tors	 Accurate modelling of charge transport and signal induction pro- cesses in precise timing detector geometries 					developments will be summarized based on future facilities' requirements and the achievable per- formances of the studied solutions	JLab, LIP-Coimbra, MPP,
T9	Readout elec- tronics for pre- cise timing	- Low-noise FEE - High input capaci- tance - Large dynamic range - Fast rise time - Sensitivity to small charges - Multi-channel readout solution for timing de- tectors					Status and strategies towards the use of sustainable gas mixtures will be given. [T7]	RBI, SIAT, SJTU, U Heidelberg, U Kyoto,
T10	Precision me- chanics and construction techniques	 Precise mechanics (μm) over relatively large active areas (hun- dreds of cm²) 						U Tsinghua, USTC, VUB and UGent
T11	Common framework and test facilities for precise timing R&D	- Test bench for precise timing studies						

WP7-B

Timing Detectors- B High-rate, large, precise timing (M)RPC

(M)RPC are still the reference in time resolution when large detectors are needed

- Trigg, ToF, PFA-based Calorimetry
- Some applications need few hundreds of ps resolution other a few tens of ps

WP7-B

17 institutes from 3 continents with expertise in RPCs/MRPCs and its readout electronics

- > Institut de la physique des 2 infinis de Lyon (IP2I)
- > Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT)
- Vrije Universiteit Brussel (VUB)
- Gangneung-Wonju National University (GWNU)
- Shanghai Jiao Tong University (SJTU)
- > Organisation de Micro-Électronique Générale Avancée (OMEGA)
- Physikalisches Institut, Heidelberg University (HDU)
- Kyoto University (KU)
- > Laboratório de Instrumentação e Física Experimental de Partículas (LIP)
- Tsinghua University (TSU)
- Shenzhen Institute of Advanced Technology (SIAT)
- Daegu Gyeongbuk Institute of Science and Technology (DGIST)
- Max-Planck Institute for Physics (MPP)
- ➤ INFN-BARI
- Roma Ter Vergata
- Hanyang University
- CERN EP-DT gas team



D B.1: Production and comparison of full large (> 1 m2) MRPC detectors with different techniques (24M).

M B.1: production of small detector O(10 cm) of 4-8 gaps prototypes using different technologies.

D B.2: Production of large PCB of strip and PAD-based pickup configuration equipped with electronics able to reach better than 100 ps time resolution (36 M)

M B.2: Review of the needed electronics components to achieve 100 ps for strips and pad-like and performance comparison between direct and differential readout techniques.

WP7-B

D B.3: Production of a stable single cell MRPC with very high-rate capability (> 50 kHz/cm2) and time resolution better than 100 ps (36M).

M B.3: High-rate tests with small detector prototypes (24M)

D B.4: Construction of large-area double-gap RPC with a time resolution better than 200 ps (36M).

M B.4: Construction of small prototype (50x50 cm2) reaching 200 ps (24M).

D B.5: Timing and spatial resolution studies versus different gas mixtures (48M). M B.4: Construction of small prototype (50x50 cm2) reaching 200 ps (24M).

M B.5: preliminary results of timing and spatial resolution with standard gas Mixture (36)

Multigap Resistive Plate Chamber



stack of equally-spaced resistive plates with voltage applied to external surfaces (all internal plates electrically floating)

pickup electrodes on external surfaces (resistive plates transparent to fast signal)

internal plates take correct potential – initially due to electrostatics but kept at correct potential by flow of electrons and positive ions - feedback principle that ensures equal gain in all gas gaps



Excellent time resolution could be obtained with many gas gaps

Two technologies and different gas mixtures are being tested



Conclusion

- DRD1 is very robust collaboration that succeeds to gather different technologies ensuring a very smooth passage from RD51
- 8 Working Groups (forums) and 9 WP that include important tasks to prepare the future collider experiments
- WP5 (gaseous detectors for calorimetry) and WP9 (timing gaseous detectors) have started with very promising results
- > The WG as WP7 are open to new groups that want to join the adventure