DRDT 4.3 Theme

Develop RICH and imaging detectors with low mass and high timing resolution

$\longrightarrow$ Work-Package

Develop RICH and imaging detectors for next-generation experiments.

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						WG						DRD4 - DRDT					approx. number of JP with double-counting			
TOTALS					27	18	17	12	10		22	12	13	9	1	28	15	21	10
Submitter	Name of PI	JP?	COUNTRY	Group name	4.1 - Ph	4.2 - Pa	4.3 - Te	4.4 - So	4.5 - Sci		4.1	4.2	4.3	4.4	4.0	# of 4.1	# of 4.2	# of 4.3	# of 4.4
Roger Forty	Roger Forty	YES	CERN	ARC (a compact RICH detector)	YES	YES	NO	YES	NO		YES	NO	YES	NO	NO	1		3	
Eugenio Nappi	Eugenio Nappi	YES	IT	INFN Bari(2)	YES	YES	NO	NO	NO		NO	NO	YES	YES	NO			1	1
Gregory Hallewell	Gregory D Hallewell	NO	FR	CPPM(2)	NO	NO	YES	NO	NO		NO	NO	NO	NO	NO				
Do-Won Kim	Do-Won Kim	LATER	KR	Seoul National University Bunda	NO	NO	NO	NO	YES		NO	NO	NO	NO	NO				
Zhenyu Ye	Zhenyu Ye	YES	US	University of Illinois at Chicago	NO	NO	NO	NO	NO		YES	YES	NO	YES	NO	1	1		1
Florin Maciuc	Florin Maciuc	YES	RO	IFIN-HH Bucharest Romania	YES	YES	YES	NO	NO		YES	NO	YES	NO	NO	2		2	
Yuekun HENG	Yuekun Heng	YES	CN	IHEP Detector Group 3	YES	YES	YES	NO	YES		YES	NO	NO	NO	NO	1			
Matthieu Heller	Matthieu Heller	NO	CH	DPNC UNIGE	YES	NO	YES	YES	YES		NO	NO	NO	NO	NO				
Jonas Rademacker	Jonas Rademacker	YES	UK	University of Bristol	YES	YES	YES	YES	NO		YES	NO	YES	YES	NO	1		2	2
Ulrik Egede	Ulrik Egede	YES	AU	Monash University	YES	YES	NO	YES	NO		YES	NO	NO	NO	NO	1			
Imad Laktineh	Imad Laktineh	YES	FR	IP2I Lyon /IN2P3	YES	NO	NO	NO	YES		YES	NO	NO	NO	NO	1			
Jochen Schwiening	Jochen Schwiening	NO	DE	GSI	YES	YES	YES	YES	NO		NO	NO	NO	NO	NO				
Amur Margaryan	Amur Margaryan	YES	AM	AANL / Yerevan	YES	NO	NO	NO	YES		YES	NO	NO	YES	NO	1			1
Christian Pauly	K H Kampert	NO	DE	Wuppertal University	NO	NO	YES	NO	NO		NO	NO	NO	NO	NO				
Viatcheslav Sharyy	Viatcheslav Sharyy	YES	FR	CaLIPSO IRFU-CEA	YES	NO	NO	YES	YES		NO	NO	NO	YES	NO				1
Nicola Mazziotta	Nicola Mazziotta	YES	IT	INFN Bari(1)	YES	YES	NO	NO	YES		YES	YES	NO	NO	YES	1	1		
Carmelo D'Ambrosio	Carmelo D'Ambrosio	YES	CERN	CERN-EP	YES	YES	YES	NO	NO		YES	NO	YES	NO	NO	1		2	
Timothy Gershon	Gary Barker	LATER	UK	University of Warwick	YES	YES	NO	YES	NO		NO	NO	NO	NO	NO				
Claudio Gotti	Claudio Gotti	LATER	IT	University and INFN Milano-Bic	YES	NO	NO	NO	NO		NO	NO	NO	NO	NO				
Sara MARCATILI	Sara Marcatili	YES	FR	LPSC Grenoble	YES	NO	NO	NO	NO		YES	NO	NO	YES	NO	1			1
David Gascon	David Gascon	YES	ES	ICCUB	YES	NO	YES	NO	YES		YES	YES	YES	YES	NO	1	1	1	1
Yasar Onel	Yasar Onel	YES	US	University Iowa	YES	YES	YES	NO	YES		YES	YES	NO	NO	NO	1	1		
Roberto Calabrese	Roberto Calabrese	YES	IT	INFN Ferrara	YES	YES	YES	NO	NO		YES	YES	YES	NO	NO	2	2	1	
Phillip Urquijo	Phillip Urquijo	YES	AU	The University of Melbourne	YES	YES	YES	YES	NO		NO	YES	NO	YES	NO		1		1
Roberto Preghenella	Alessandro Montanari	YES	IT	INFN Bologna	YES	YES	NO	NO	NO		YES	YES	YES	NO	NO	1	1	1	
Antonello Di Mauro	Antonello Di Mauro	NO	CERN	CERN ALICE	YES	YES	YES	NO	NO		NO	NO	NO	NO	NO				
Sen Qian	QIAN Sen	YES	CN	IHEP-CAS-FPMT	YES	NO	NO	NO	NO		YES	NO	NO	NO	NO	1			
Antonis Papanestis	Antonis Papanestis	LATER	UK	STFC - RAL	YES	NO	NO	YES	NO		NO	NO	NO	NO	NO				
Michael Mccann	Michael McCann	YES	UK	Imperial College London	NO	NO	YES	NO	NO		NO	NO	YES	NO	NO			1	
Stephen Wotton	Paula Alvarez Cartelle	YES	UK	University of Cambridge	NO	NO	YES	YES	NO		NO	NO	YES	NO	NO			3	
Mauro Piccini	Mauro Piccini	YES	IT	INFN Perugia	YES	YES	YES	NO	NO		YES	NO	YES	NO	NO	1		1	
Roberta Cardinale	Roberta Cardinale	YES	IT	University and INFN Genova	YES	YES	YES	YES	NO		YES	YES	YES	NO	NO	2	2	2	
Rok Pestotnik	Rok Pestotnik	YES	SI	Jožef Stefan Institute	YES	YES	NO	YES	YES		YES	YES	NO	NO	NO	2	1		
Angela Romano	Angela Romano	LATER	UK	University of Birmingham	YES	NO	NO	NO	NO		NO	NO	NO	NO	NO				
Claudia Hoehne	Claudia Hoehne	LATER	DE	Justus Liebig University Giessen	NO	NO	YES	NO	NO		NO	NO	NO	NO	NO				
Etiennette Auffray	Etiennette Auffray	LATER	CERN	CERN	YES	NO	NO	NO	YES		NO	NO	NO	NO	NO				
Fulvio Tessarotto	Fulvio Tessarotto, Silvia I	YES	IT	INFN Trieste	YES	YES	YES	YES	NO		NO	NO	YES	NO	NO			1	
Peter Hobson	Jon Hays	YES	UK	Queen Mary University of Lond	YES	YES	NO	NO	NO		NO	YES	NO	NO	NO		1		
Franz Muheim	Silvia Gambetta	YES	UK	University of Edinburgh	YES	YES	YES	NO	NO		YES	YES	NO	NO	NO	1	1		
Peter Dendooven	Alexander Gerbershagen	NO	NL	UMCG PARTREC Groningen	YES	NO	YES	NO	NO		NO	NO	NO	NO	NO				
Ezio Torassa	Ezio Torassa	YES	IT	INFN Padova(1)	YES	YES	NO	NO	NO		YES	NO	NO	NO	NO	2			
Gabriele Simi	Gabriele Simi	YES	IT	INFN Padova(2)	YES	YES	YES	NO	NO		YES	YES	NO	NO	NO	2	2		
Christian Morel	Morel	YES	FR	CPPM	NO	NO	NO	YES	NO		NO	NO	NO	YES	NO				1
Guy Wilkinson	Guy Wilkinson	LATER	UK	University of Oxford	YES	YES	YES	NO	NO		NO	NO	NO	NO	NO				

On the proposed proto-tasks

- Many task proposals appear to be a list of "to-do".
- Some task proposals have a **well-defined target**; others have **very broad targets**.
- There are hints of (either known or unknown) **proto-collaborations** to build synergies among different groups.
- There is no time-scale and no information on the number of full-time equivalent. So far, difficult to judge how realistic the task is.
- Many task proposals are **interdisciplinary** among two (or more) WP/WG. We should find a way to **keep alive strong links wherever required**.
- We shall **try to involve other missing expert and/or interested people**.
- We are checking that any path to [?whatever] is fully covered.
- We are looking forward hearing from you about the range of themes proposed. **Any comment/suggestion is always welcome**.

Tentative Task and sub-Tasks architecture. 1

1. **New Materials, Radiators and Components for RICH detectors**:
   - 1.1 **study of radiator gases**;
   - 1.2 **aerogel**;
   - 1.3 **solid radiators**;
   - 1.4 **low mass mirrors**;
   - 1.5 **materials and mechanical solutions**;
   - 1.6 **instrumentation**.
2. **Next RICH detectors (less than ten years)**:
   - 2.1 **new detector concepts**;
   - 2.2 **f/e**;
   - 2.3 **detector development and design**;
   - 2.4 **ancillary systems for characterization/calibration/alignment/monitoring**.
3. **Far future (more than ten years), Blue-Sky**; after the next RICH detectors.
4. **Software and Performance**.

Tentative Task and sub-Tasks architecture. 2

- We need **strong contacts from/to**:
  - SiPM, MCP and other sensors for RICH / **interface with DRDT4.1/DRDT4.2**.
  - similar projects for TOF / **interface with DRDT4.4**.
- Boundaries with other DRDs: we understand that we deal with
  - electronics/mechanical/thermal engineering for testing/prototyping/laboratory/development;
  - specific work targeting one precise experiment requirement is not in;
  - large scale design, engineering and production is not in;
  - DRD7 and DRD8 deal with generic advanced R&D on new concepts;
  - we need close integration with sensors, and targeting detector requirements.

TASK-1 New Materials, Radiators and Components 1

DRAFT abstract.
A variety of technological aspects concerning physical, chemical and optical properties of materials used as radiators, mirrors, windows, supports, etc. require dedicated studies to face the challenges of next generation PID detectors.
Specific instrumentation and techniques for testing, commissioning and monitoring the components also need to be developed.
This WP-task aims at addressing the most critical elements, in a collaboration between groups interested in different applications and with different background.

Proponents or potentially interested groups:
CERN, Bari, Ferrara, Genova, GSI, Marseille, Oxford, Trieste, ...

TASK-1 New Materials, Radiators and Components 2

The goals are divided in six sub-tasks:

- 1.1 **Study of radiator gases** alternative to per-fluorocarbons. Circulation and purification gas systems with minimal environmental impact. Specific gas mixing and separation systems.
- 1.2 **Aerogel** optimization: transparency, refractive index tuning, large size, chemical compatibility, thermal properties.
- 1.3 **Solid radiator** material quality (fused silica and alternative radiators). Gluing, optical coupling, wavelength filtering. Support system optimization.
- 1.4 **Low mass mirrors** materials, production methods, coating, robustness, chemical compatibility, support and alignment systems.
- 1.5 **Materials and mechanical solutions** for windows, low mass vessels, sealing, thermal isolation, low out-gassing, high stability, radiation hardness.
- 1.6 **Instrumentation** and techniques for precise control of refractive index, pressure, temperature, purity, transparency, etc.

TASK-2 Next RICH (and other PID) detectors 1

Next ten years.

The goals are divided in four sub-tasks.

TASK-2 Next RICH (and other PID) detectors 2

- 2.1 **New RICH detector concepts for improved performance**.

  DRAFT abstract.

  Development of a proximity focusing RICH detector with TOF capability.
  Concept: use of Cherenkov light for TOF within an aerogel + SiPM proximity focusing RICH with a thin, transparent solid radiator layer in front of the SiPMs..
  Development of a compact RICH using high-pressure noble gas radiator.
  Concept: exploit the low chromaticity of light noble gases and the tunability of refractive index by pressure for a compact RICH with innovative, low mass vessel materials and MCP/SiPM sensors.
  Program: investigate performance limits of component materials, compare different configurations, design and build prototypes, perform systematic studies of all elements of the new technologies.

  proposed by: Bari, Trieste.

TASK-2 Next RICH (and other PID) detectors 3

- 2.2 **RadHard fast scalable f/e for single-photon counters; vertical integration**.

  DRAFT abstract.

  This project is planned in different phases in collaborations with other groups. It is planned to collaborate with other groups to study existing integrated electronics for the fast readout of PMT/MCP/SiPM targeting single-photon counters, in particular PID detectors. Vertical integration of dedicated SiPM arrays to the readout electronics will be studied, to optimize timing resolution by means of reducing the parasitic inductances and capacitances of the interconnections. Low-temperature and cryogenics operation will be studied, to be able to operate in harsh radiation environments. Scalability will be an essential requirement for future systems.

  Tasks proposed by: Barcelona, Bucharest, Milano-Bicocca.
  Dealing also with electronics engineering aspects, DRD7 interface.

TASK-2 Next RICH (and other PID) detectors 4

- 2.3 **Prototype Solid-State Single-Photon Sensitive Module for Imaging Arrays**. Including thermo-mechanical engineering aspects: *DRD8 Integration* is in standby.

  DRAFT abstract.

  Next RICH and imaging detectors will typically have common challenging requirements.

  The housing of the sensors is a complex task, regardless of the sensor choice, due to the large number of sensors/channels and the many requirements, typically including most, if not all, the following: close-packing on a large surface; large and uniform filling factor; ease of access for repair and maintenance; constraints of volume, mass and power; mechanical robustness and stability; active cooling and thermal control; electrical connections and insulation; (electro-)magnetic shielding; radiation shielding.

  The first challenge will be to include some sort of active cooling into the module, together with the other ancillary services.

  Tasks proposed by: Cambridge, CERN, Genova.

TASK-2 Next RICH (and other PID) detectors 5

- 2.4 **Prototype characterization/calibration/alignment/monitoring systems**.

  DRAFT abstract.

  On detector Calibration/Monitoring/Alignment are crucial aspects of the detector design, and critical ones. A careful design is needed, in order not to end up with sub-optimal systems having a not-good-enough control of systematic effects. On detector Calibration/Monitoring/Alignment tasks are often staged, in detector projects, to prioritize other tasks. The future RICH detectors are challenging ones: typically, the targeted angular precision and accuracy, the high-density of tracks and hits, the large event rates, the large, often physical, background, will make them unique and will require a very fine control of systematic effects in order to extract high-quality results from the challenging conditions. The experiments will be sailing unexplored lands, when aiming to sub-0.1 mrad angular precision and accuracy on the track Cherenkov angle with O(100ps) timing precision and accuracy. The challenges can be only mitigated by providing the detector with independent and redundant tools for control of systematic effects. ...

  Tasks proposed by: Genova, Perugia.

TASK-3 Far Future and Blue-Sky

Beyond ten years.

So far, only one well-defined cluster of interests.

- New solid radiators and MetaMaterials.

TASK-4 Software and Performance 1

DRAFT abstract.
Next-generation RICH and imaging detectors will face new challenges in terms of events/hits multiplicity, rate, amount of data and background/noise levels, calling for new approaches and/or new implementations to detector simulations and analysis. The accuracy and precision, necessary for control of statistical and systematic uncertainties, calls for in-depth validation of simulations, and larger volumes of simulated data. Novel reconstruction algorithms for RICH PID will face large multiplicities and combinatorial, calling for faster and more efficient algorithms. The variety of different applications would benefit from the establishment of general software frameworks and tools, dedicated to PID and other imaging detectors. Fast data simulation/analysis tools, preliminary to fulland more accurate/precise algorithms, are required to establish directions before using full algorithms. Finally, dedicated external tools, for satellite applications producing parameterized results to be feed into the main detectors simulation analyse tools, have to be mapped and investigated, including dedicated SW for simulation and analysis of the internal working of sensors, optical CAD SW to optimize geometrical and physical optics design (ray tracing, reflections/refractions, filters, coatings,...), electrical predictions, ... Standardization/definition of tools/benchmarks for estimating (on sim) and evaluation (on real data) the performance of RICHes are necessary.

TASK-4 Software and Performance 2

- Projects explicitly proposed in the survey, possibly covered, TBC:
  - Novel Architectures For RICH PID: Development Of A Test-bench/Framework.
  - Novel Reconstruction Algorithms For RICH PID: Development Of A Detector-Agnostic Software Framework.
  - Fast Pattern Recognition For RICH In High-Multiplicity Environment.
  - Fast Optical Photon Tracing In RICH.
- Missing topics, to be covered:
  - definition of benchmarks for evaluation and comparison of RICH performance;
  - tools for evaluation of systematic uncertainties in simulation and analysis SW;
  - validation of simulation against real data;
  - common framework for tracing of optical photons;
  - satellite SW;
  - ML algorithms.
- Keep in mind:
  - link to 4.4
  - link to GEANT4 and other SW developers.

What next?

- Many other groups have expressed interest in the above items,
  but not (yet) readiness to commit: **borders are not so clear**, at this stage,
  and therefore we may have understood it wrong. **Please send your feedback asap!**
- Fine-tune the architecture using feedback from groups.
- Propose **coverage of essential but missing topics**
  and try to rationalize and optimize.
- **Enlarge** and **extend** proto-collaborations out the perimeter of existing experiments,
  in order to build synergy, exchange information, knowledge, ideas,
  (and possibly instruments and infrastructure)
  and to contaminate groups with each other.
- Here we need a to build a three/four years project,
  with **deliverables**, **milestones**, **FTE** and **money**....
  You have to do it **in agreement with your funding agency**.
- Help is welcome, needed and invited...

END