Working Group 4.2 (draft)

Working Group 4.2 deals with Particle Identification techniques, in particular with Cherenkov imaging techniques (RICH, DIRC) and time of flight (TOF, TOP, TORCH)

WGs follow the forum principle. Collaboration members (institutes) participate in and contribute to one or several WGs. The main purpose of a WG is to exchange information, train younger people, expose problems, ask for advice and agree on best practices, common standards etc. WGs agree on a loose work programme without agreed milestones and deliverables. WGs can be joined or left without formalities. The WG is led by an expert in the relevant field facilitating and promoting the activities. The involved resources are marginal.

1. Particle Identification Techniques

- Cherenkov Imaging techniques (RICH, DIRC) achieve the highest PID performance by the efficient detection of single photons with sub-mm position and optical focusing. The current generation of Cherenkov detectors is based on (MA-)PMT and MCP-PMT. The use of SiPM if operated in a low temperature regime and read out by fast FR electronics promises a significant performance increase.
- Time of flight methods can achieve pion/kaon separation in the 10 GeV/c range provided pathlength variations can be measured and corrected photon by photon. TOP and TORCH counters rely on ultrafast photodetectors and can be integrated in a detector system requiring minimal volume.

2. List of Partners: including industries

1. QMU London
2. Trieste
3. Padova
4. Giessen
5. Ljubljana
6. Genova
7. Perugia
8. IC London
9. CERN
10. Bologna
11. Melbourne
12. Ferrara
13. Iowa
14. CERN
15. Bari
16. GSI
17. Monash

18. Bristol
19. HPK
20. IHEP Beijing
21. Bucharest
22. Chicago
23. Warwick
24. Wuppertal
25. Bari
26. CERN
27. Oxford
28. Padova
29. Edinburgh

RICH design	time resolved RICH/DIRC	self triggered RO	hi rate / radiation RICH	TOF design	TORCH design
1	2	3	4	5	6
Trieste	Padova	Giessen	Ferrara	Mel-bourne	Monash
Genova	CERN ALICE				University of Oxford
Perugia	Bari				
Cavendish Laborator	Wuppertal				
Imperial College London	Bari				
GSI	Padova				
Bucharest					
ARC (a compact RICH detector)					

Quite a few replies which require further discussions and perhaps a transfer to another WG

Queen Mary University of London	>> SW	4.2 Development of fast, efficient ML techniques.
Jožef Stefan Institute	>> 4.1	4.2 - Long term photon sensor stability in future PID experiments
CERN-EP	>> SW	4.2: Simulations and software for Time-resolved RICH Detectors designs.
University of Bristol	>> 4.1	4.1: PMTs/MCP-PMTs with diamond films as electron multipliers
IHEP Detector Group 3	>>4.1	photon detector, high precision time measurement, Semiconductor detector
University of Illinois at Chicago	>> DRD3??	4.2 improve AC-LGAD performance (timing resolution and radiation hardness)
University of Warwick	>> ???	4.2 - optimising physics research for future flavour physics experiments

3. Short description of the work programme (approx. 20 lines)

WG 4.2 brings together groups interested in various Particle ID techniques, in particular Cherenkov Imaging based techniques such as RICH and DIRC, as well as Time Of Flight and Time Of Propagation Techniques including TORCH. Groups in WG work on concepts, designs and performance characterisation in view of future applications of these techniques in new experiments or major upgrades. These applications comprise upgrades (e.g. LHCb-II, BELLE-II), new experiments currently under study (e.g. ALICE-3, EIC, FCC, Linear Collider detectors) or approved experiments at different levels of design and construction phases (PANDA, CBM). Higher luminosity or interaction rates pose new challenges in terms of pile-up, readout speed, event complexity and size, but lead to even harsher radiation environments in which the PID systems have to work and maintain their performance.
The activities of the participating groups cover new concepts, geometries, readout schemes incl. fast timing. R&D on new photodetectors is covered by WG 4.1 and is therefore not in the focus of WG 4.2. An active exchange between the two WGs is maintained by joint meetings during the DRD4 events. SImilarly, the development of new materials, be it for Cherenkov radiators or for structural purposes, optical components (filers, mirrors, lenses) belongs to WG 4.3. The groups in WG 4.2 will rely a lot on advances in simulation and analysis software which will mainly be developed by groups in WG 4.4.

The main goals of WG 4.2 is to optimise the performance, longevity and cost of future PID systems by

- ❖ an open exchange on concepts and ongoing developments
- ❖ forming teams for studies and performance evaluation of new devices
- ❖ sharing samples, tools, equipment, infrastructure and organising joint test beams
- ❖ exchanging personnel, in particular students and post-docs to widen scope and experience
- ❖ avoiding duplication of efforts and uncoordinated parallel developments

WG 4.2 serves also as a learning platform for groups that are new in the field and that can join at a later stage a Joint Project in order to take responsibility for a larger development.

● Spin-off (if any)

With the focus on new Particle ID methods it is less likely that WG 4.2 will produce a lot of output that can be used outside high energy physics. However, the demanding requirements of PID such as detection of single photoelectrons, light-weight designs, fast readout of very small signal amplitudes, may have a driving impact on developments in other fields, e.g. gaseous photosensors in DRD 1 and advanced mechanics.