Time Projection Chambers

Future facilities will have increased needs for new generation of TPCs, which can accommodate requirements such as: good dE/dX resolution partly driven by the uniformity of the gain, very low gain times Ion Back flow to drastically reduce distortions, highly readout granularity to cope with the particle rate, an increased amount of channels to be read out with low power dissipation electronics, large area coverage and relative low cost, mounted on light-weight mechanical structures based on composite materials. As an example, such future electron collider facilities can be listed as the ILC, FCC-ee, CEPC for targeting such types of detectors. A work package WP4 addressing the main R&D challenges for TPC developments is presented below, in Table 4.

Table 4: WP4 - a work package on Time Projection Chambers. Area of application: future electron colliders (ILC, FCC-ee, CEPC). Timeline: 2035-2040, most of the R&D goals should be reached by 2030 to allow for timely construction.

#	Task	Performance goal	DRD1 WGs	ECFA DRDT	Main developments covered	Deliverables next 3 y	Institutes
T1	IBF reduction	G*IBF ~ 1-2	WG4	1.2	• Hybrid stacks • Gating GEM • Distortion corrections • SPace charge monitoring • Development of simulation tools	- Provide a large-area prototype with a uniform IBF distribution of G*IBF=5 keeping the energy resolution at the tolerable level - present a structure with stable settings for G*IBF of 1-2 - Determin the ion blocking power of a GEM-based gate - provide systematic studies and simulations of IBF performance of the most common structures in (high) magnetic fields • IBF calculator (Garfield-based) for optimisation of the HV parameters	- GSI - Uni BOnn CEA Saclay - USTC - IHEP - KEK - DESY - NIKHEF
T2	Pixel TPC development	- 50000-60000 GridPixes to readout full TPC → 109 pixel pads - d*N*/d*x* < 4 %	WG5	1.1	• InGrids (grouping of channels) • Low-power FEE - Optimisation of pixel size (>200µm) or cost reduction	- Provide a large-area pixel-based (InGrid) readout module - measuring IBF for Gridpix. Reduction with double-mesh - Present dN/dx measurement in beam	- Uni Bonn - NIKHEF

		achievable			•		
T3	Optimisation of the amplification stage and its mechanical structure. Low X/X0 FC	- Uniform response across the full readout unit area. - Keep σdE/dx ~4% -Point resolution of <100 µm - minimize static distortions by minimizing insensitive areas - minimise ExB - E-field homogeneity at ~10-4 level	WG1 WG4 WG6	1.1 1.2	Static distortions minimisation: • Algorithms for distortion corrections - Field shaping wires - Minimise GEM frame area (usr thicker GEMs) Main ampl. stages: - Encapsulated Resistive Anode MMG • Multiple GEM • GridPix • Hybrids FC - high quality strips, suspended strips - module flatness	- Provide a solution for a large-volume TPC with 1e6 pad raodut by means of pre-production of several reaodut modules of comparable quality	- CEA Saclay - Uni Bonn - IHEP CAS
T4	Low-power FEE	• < 5 mW/ch for >1e6 pad TPC - ASIC development in 65 nm CMOS	WG5	1.3	• continuous vs. pulsed	- Present stable operation of a multi-channel TPC prototype with a low-power ASIC	- IHEP CAS
T5	FEE Cooling	10^6 channels per endplate	WG5	1.2	• 2-phase CO2 cooling • Micro-channel cooling with 300 µm pipes in carbon fiber tubes • 3D printing → complex structures, performance optimization, material	- Present a cooling system prototype for the 1e6 pad TPC option	- CEA Saclay - Lund Univeristy - INFN Pisa
T6	Longevity	Define discharge rate, collected doses	WG1, WG3, WG4	1.1	Discharge probability, aging	- lower the discharge probability of reaodut units by 1-2 order to ~1e-14 per fadron - avoid secondary discharges at operational fields in MPGD stacks	- GSI - TUM