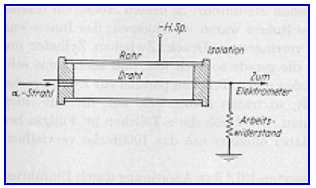
WP7 - Gaseous detectors

WP COORDINATORS:

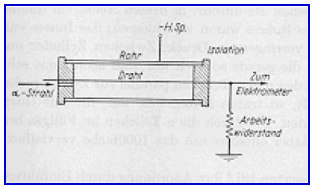
Silvia Dalla Torre, Burkhard Schmidt



OUTLOOOK

- **Task 7.1: Coordination and Communication** (S. Dalla Torre, Burkhard Schmidt)
- **Task 7.2: RPC sector** **3 tasks**
  - 7.2.1: Multi-gap RPCs (MRPCs) for fast timing (C. Williams)
  - 7.2.2: Shower development in SDHCAL (Mary-Cruz Fouz)
  - 7.2.3: Eco-friendly gas mixtures for RPCs (B. Mandelli, D. Piccolo)
- **Task 7.3: MPGD sector, Technology and engineering** **2 tasks**
  - 7.3.1: Development of resistive electrodes for MPGDs (P. Verwilligen)
  - 7.3.2: Industrial engineering of high-rate μ-RWELLs (G. Bencivenni)
- **Task 7.4: Large volume gaseous detectors** **2 tasks**
  - 7.4.1: A 4-channel electronic board for cluster counting (F. Grancagnolo)
  - 7.4.2: High pressure gas TPC for neutrino physics (A. Deisting) → (Xianguo Lu)
- **Task 7.5: PID sector** **1 task**
  - Photon detectors for hadron particle identification at high momenta (S. Dalla Torre)

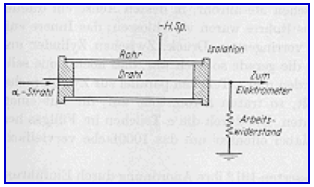
WP7, partners



		Beneficiaries							Associated Partners				
Tasks	7.1	CERN	INFN-Trieste										
	7.2.1	INFN-Bologna	LIP-Coimbra	Univerity of Clermont-Ferrand	PICOTECH SAS				Tsinghua University	Shenzhen Institute of Advanced Technology	Seoul National University Bundang Hospital	IRIS Co.	Benemérita Universidad Autónoma de Puebla
	7.2.2	CNRS - IP2I	CNRS - LPC	CNRS - OMEGA	CIEMAT								
	7.2.3	CERN-EPDT	INFN-Frascati	INFN-Roma2	INFN-Bologna	INFN-Bari	INFN-Torino	Ghent University					
	7.3.1	INFN-Pavia	INFN-Bari	INFN-Lecce									
	7.3.2	INFN-Frascati	INFN-Bologna	INFN-Ferrara	CERN	ELTOS							
	7.4.1	INFN-Lecce	CAEN										
	7.4.2	RHUL	UOXF	INFN-Bari	USC	CERN	CSIC-IFIC						
	7.5.1	INFN-Trieste	INFN-Bari	INFN-Bologna	Charles University				USTC	INCOM			

- Strong collaboration with industry (yellow boxes)
- Wide and solid links also outside Europe

Task 7.1 – Activity in the last year

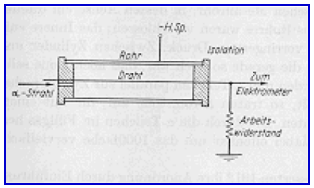


Coordination activity during the 3rd year

- 3 WP7 meetings: 7/7/23; 4/12/23; 19/3/24
- 2 WP7 reports to the SC: #10 (12/7/23); #12 (7/12/23)
- "Help-line" always open
  - *So far, only used to postpone by 3 months Deliverable D7.3 and the related Milestone MS28: discussed and approved at the SC # 12*

DELIVERABLES & MILESTONES

GAS DETECTORS



Tasks	Description	Year 1												Year 2												Year 3												Year 4												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
WP7: Gaseous detectors																																																		
7.1	Coordination and Communication																																																	
7.2	Multigap RPCs for fast timing and Eco-friendly gas mixtures for RPCs																																			D										D					
7.3	Development of resistive electrodes for MPGDs and Industrial engineering of high-rate μ-RWELL detector																							M						D					M														
7.4	A 4-channel prototype electronic board for cluster counting and Hybrid readout high pressure gas TPC for neutrino physics																																			M										D	M				
7.5	Photon detectors for hadron particle identification at high momenta																																												D					

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DELIVERABLE REPORT

PRODUCTION WITH INDUSTRY OF SMALL-SIZE μ-RWELLS

DELIVERABLE: D7.3

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MILESTONE REPORT

IDENTIFICATION OF A GAS MIXTURE FOR NEUTRINO PHYSICS IN AN OPTICAL TPC

MILESTONE: MS27

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CHARACTERISATION OF SMALL SIZE MRPC PROTOTYPES FOR FAST TIMING AND HIGH RATES

Deliverable: D7.2

Date: Xx/03/2024

Grant Agreement No: 101004761

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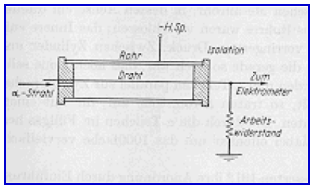
DELIVERABLE REPORT

CHARACTERISATION OF SMALL SIZE MRPC PROTOTYPES FOR FAST TIMING AND HIGH RATES

DELIVERABLE: D7.2

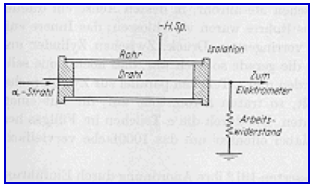


In the following:

Highlights of the WP7 activity in period

April 2023 - March 2024

More attention dedicated to
3rd year Deliverables and milestines

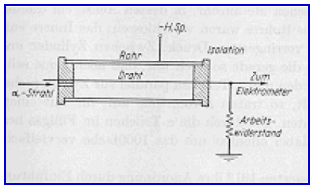


RPCs

tasks 7.2.1, 7.2.2, 7.2.3

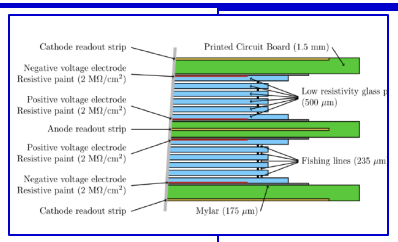
Task 7.2.1 – DELIVERABLE (M36)

MRPCs for high-rate applications

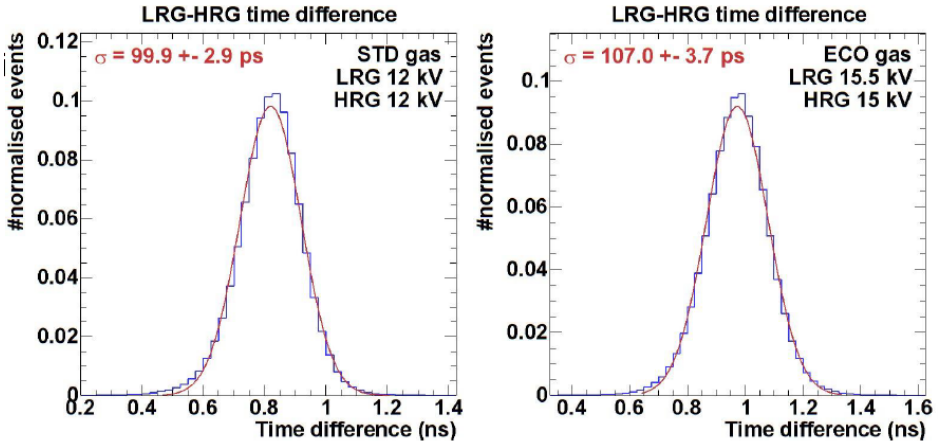


Beam test :

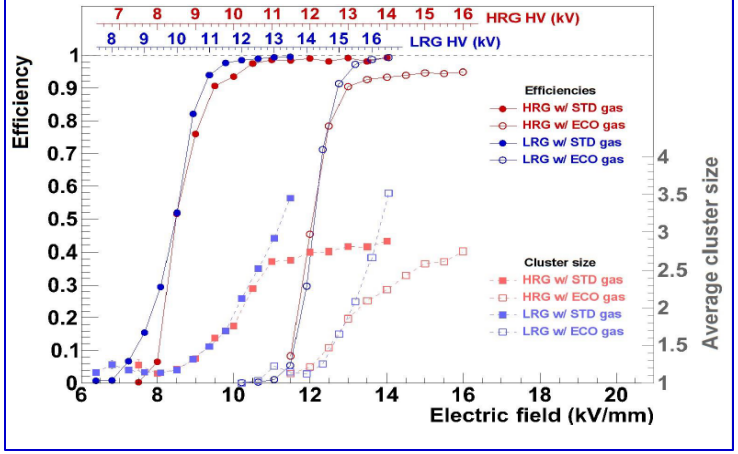
- T10 line at PS CERN
- Two MRPC tested :
  - 8-gap (2 stacks of 4-gaps) chamber **(HRG)**
  - 10-gap (2 stacks of 5 gaps) chamber **(LRG)**
- Two mixtures of gas tested :
  - 98% $C_2F_4H_2$ and 2% SF_6
  - **100% HFO-1234ze**



Time resolution

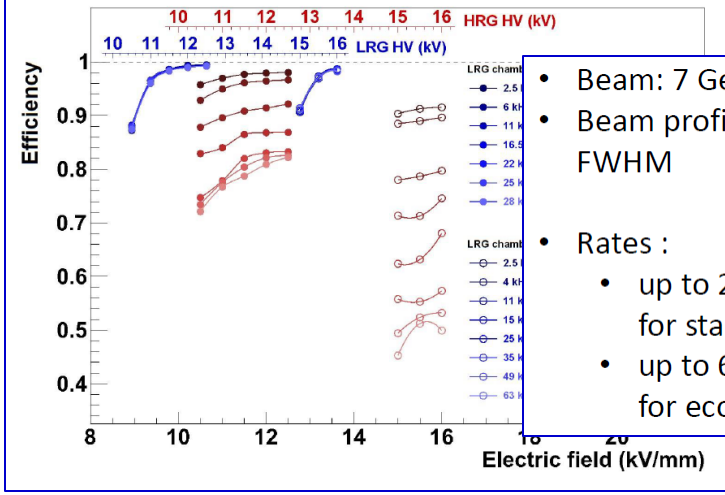


Efficiency/Multiplicity



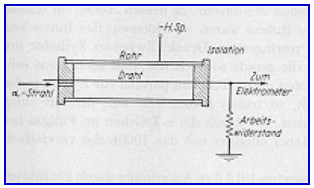
Eco-gas: 4 kV more to reach the plateau

Rate performance



- Beam: 7 GeV pions
- Beam profile : 1.3 cm FWHM
- Rates :
  - up to 28 kHz/cm2 for standard gas
  - up to 63 kHz/cm2 for eco gas

Task 7.2.1 – DELIVERABLR (M36)



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CHARACTERISATION OF SMALL SIZE MRPC PROTOTYPES FOR FAST TIMING AND HIGH RATES

Deliverable: D7.2

Date: Xx/03/2024

Grant Agreement No: 101004761

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Advancement and Innovation for Detectors at Accelerators

Horizon 2020 Research Infrastructures project AIDAINNOVA

DELIVERABLE REPORT

CHARACTERISATION OF SMALL SIZE MRPC PROTOTYPES FOR FAST TIMING AND HIGH RATES

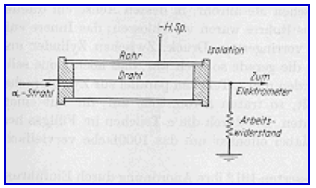
DELIVERABLE: D7.2

Conclusion

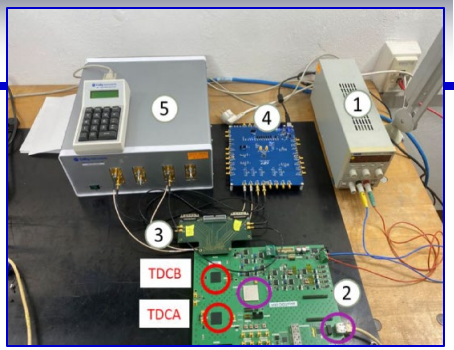
- HRG vs. LRG
  - A distinct difference in the rate capability at high rate flux
- Ecological gas vs. Standard gas
  - No conspicuous difference in efficiency and timing performance

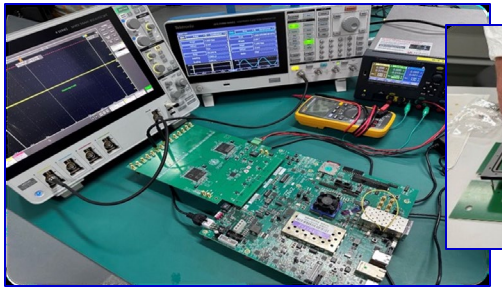
- A realistic test on the rate capability needs to be carried out in the further test by irradiating the larger detector area instead of a focused beam on a small spot.

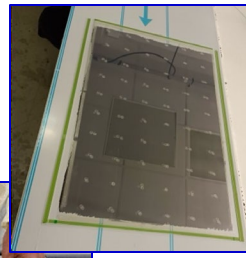
More from RPCs

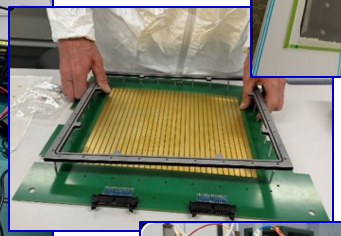


- **Task 7.2.1 - MRPCs for fast timing at high rates**
  - Progress for the picoTDC card (128 ch.s)
- **Task 7.2.2 – SDHCAL for 5D-calorimetry (space, amplitude & timing)**
  - Fine time-resolution FE needed → in use PETIROC (~50ps), DAQ under development
  - Test of various MRPC prototypes
- **Task 7.2.3 – ECO-gasses**
  - Enriching the setup at GIF++: Humidifier, gas mixture OMRON sensors to monitor the gas flow
  - Ageing test with ECO-gas 2 ongoing

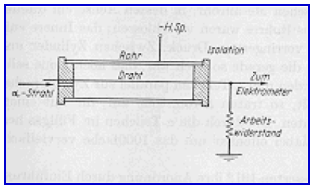








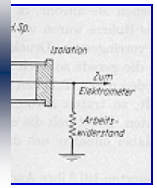
Humidifier Mixer



MPGD technologies

tasks 7.3.1, 7.3.2

Task 7.2.1 – DELIVERABLR (M30→M33)



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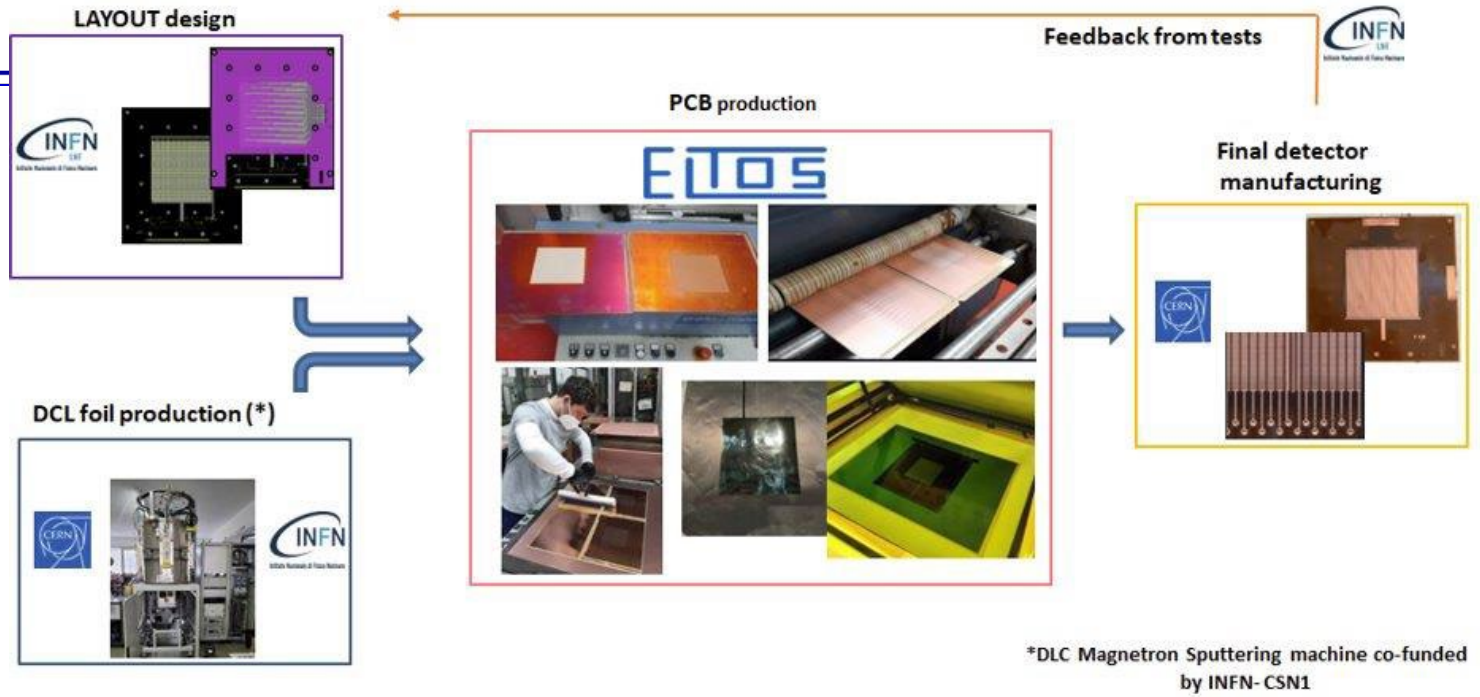
DELIVERABLE REPORT

PRODUCTION WITH INDUSTRY OF SMALL-SIZE μ-RWELLS

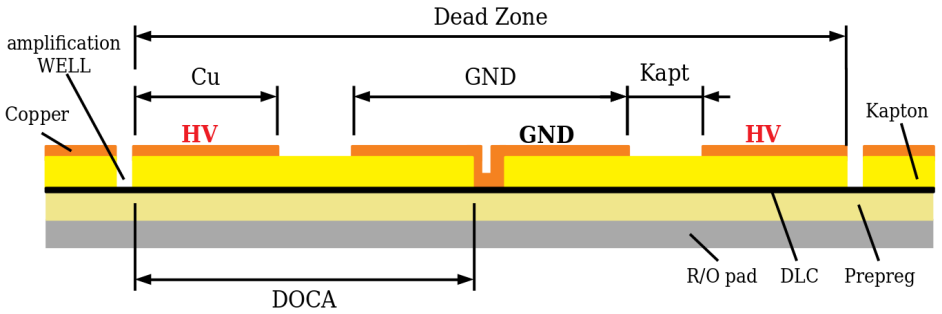
DELIVERABLE: D7.3

This report addresses the technology transfer of the micro-RWELL detector to ELTOS SpA, an industry specialized in Printed Circuit Board manufacturing.

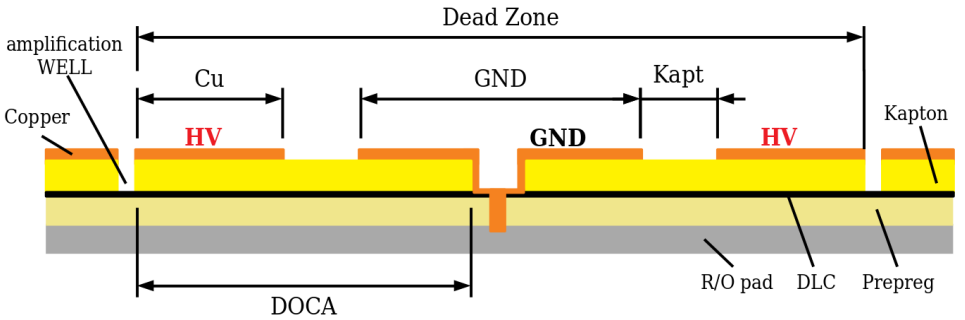


Task 7.2.1 – DELIVERABLE (M30→M33)

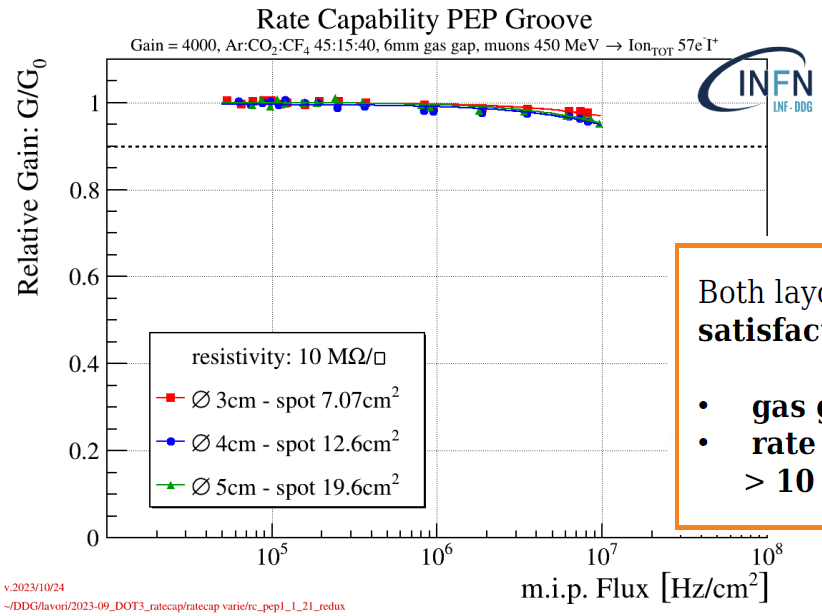
2 high rate configuration realized and satisfactory tested



PEP-grove layout

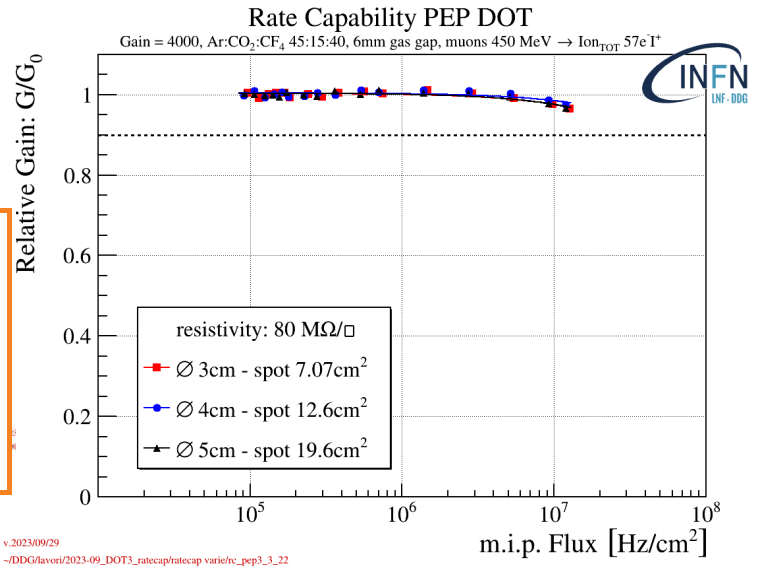


PEP-DOT layout

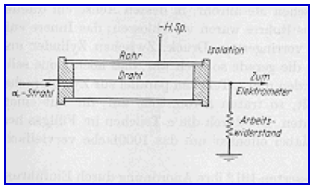


Both layouts exhibit **satisfactory performance:**

- **gas gain** of up to **10^4**
- **rate capability** (@ 90% drop) **> 10 MHz/cm²**



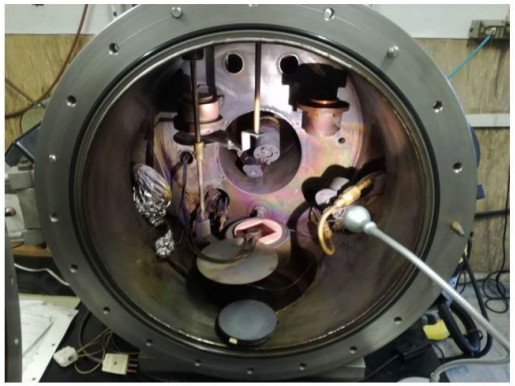
MPGD TECHNOLOGIES, more



Task 7.3.1 - resistive detectors for MPGDs

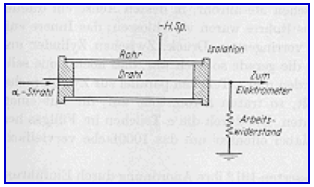
- **Comparing DLC foils produced with different approaches**
  - **Ion beam deposition**
  - **Pulsed laser deposition**

  } **Original approaches**



  - **Magnetron Sputtering (MS) @ CERN**
  - **also used to produce the DLC foils of the previously discuss TT effort**

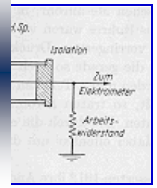
- **On going studies: the investigation of the Investigate structural properties DLC (Resistivity ∝ sp3/sp2 ratio)**



Large Volume Gaseous Detectors

tasks 7.4.1, 7.4.2

Task 7.4.2 – MILESTONE (M36)



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MILESTONE REPORT

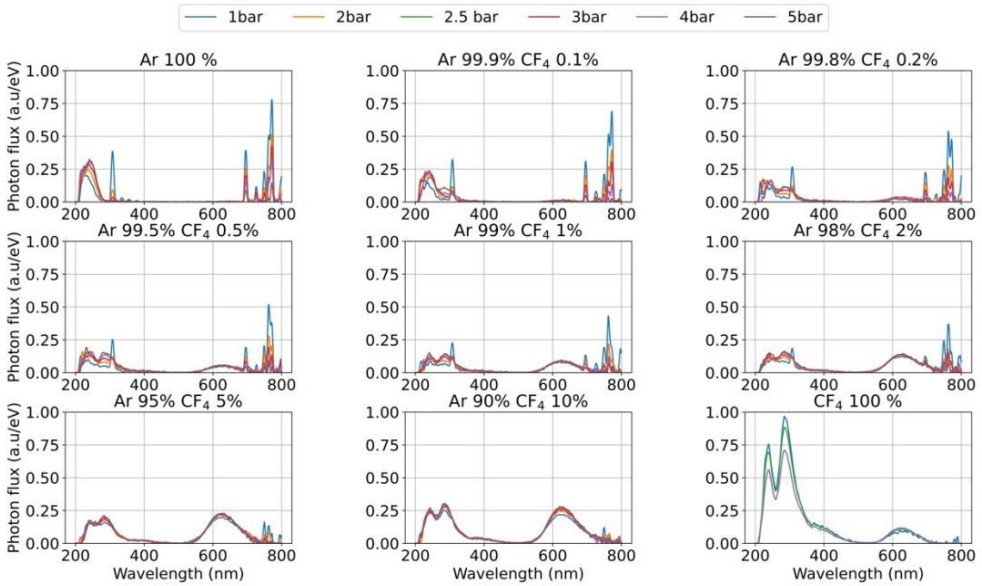
IDENTIFICATION OF A GAS MIXTURE FOR NEUTRINO PHYSICS IN AN OPTICAL TPC

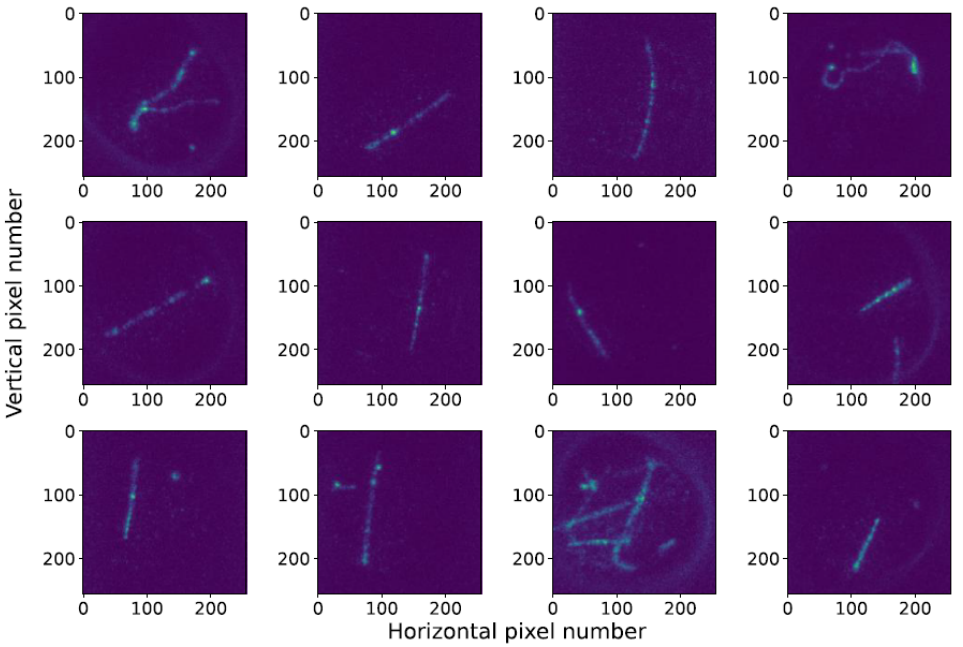
MILESTONE: MS27

Demonstrated: the possibility of doing **time-tagging** and **accurate particle tracking**, simultaneously, in next-generation neutrino experiments in high pressure TPCs

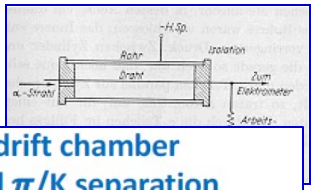
Cosmic rays detected from luminescent light in by a CCD camera (Ar: CF4 = 99 : 1)

PRIMARY SCINTILLATION



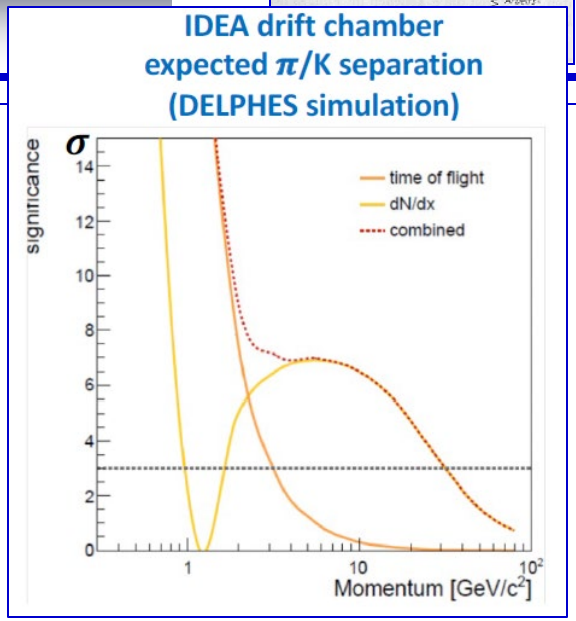


Large Volume Gaseous Detectors, more

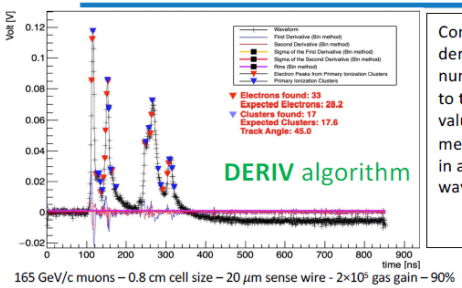


Task 7.4.1 - Electronics for cluster counting

- **Cluster counting in gaseous drift chambers for PID**
- **Needed: fine time-resolution electronics with local intelligence to reduce at an early stage the data bandwidth**

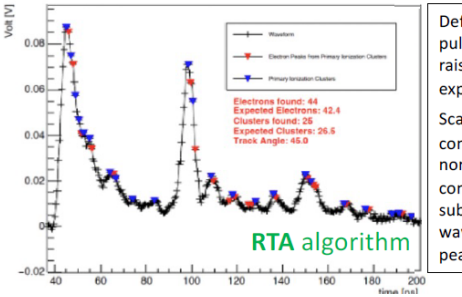


Peak finding algorithms

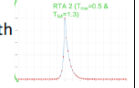


Compute the first and second derivative over a pre-defined number of bins and compare them to thresholds in terms of a r.m.s. value, where. r.m.s. is a measurements of the noise level in a control region of the waveform.

165 GeV/c muons – 0.8 cm cell size – 20 μm sense wire - 2×10^5 gas gain – 90% He/10% iC_4H_{10} (m.i.p.: 12 clusters/cm) - 45° track angle –12 bits at 1.2 Gsa/s

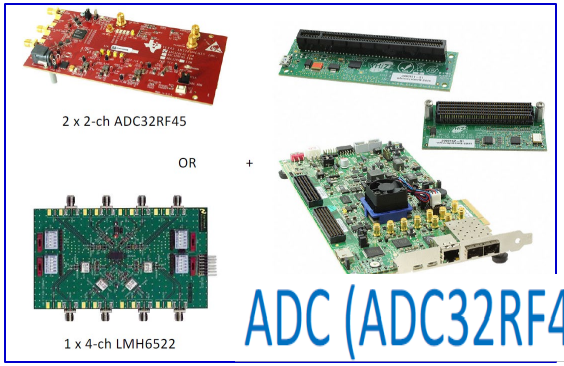


Define a digitized pulse template with raising and falling exponentials.

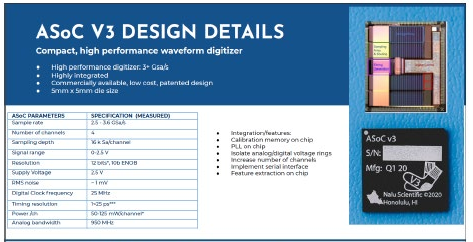


Scan the data waveform by comparing it to the template, normalized to the amplitude, and construct a χ^2. If above threshold, subtract the found peak from the waveform and iterate until no new peaks are found.

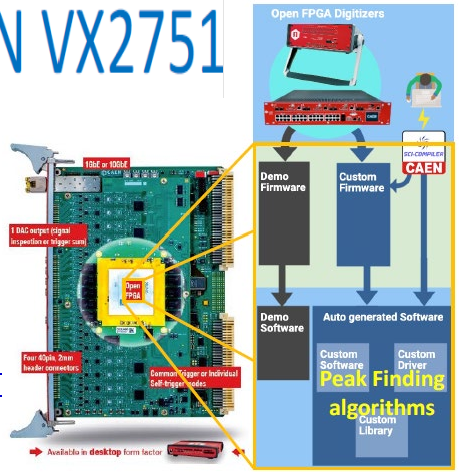
Hardware Configurations

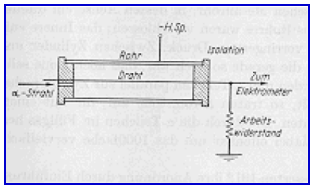


ADC (ADC32RF45 or LMH6522) + FPGA KCU105



CAEN VX2751



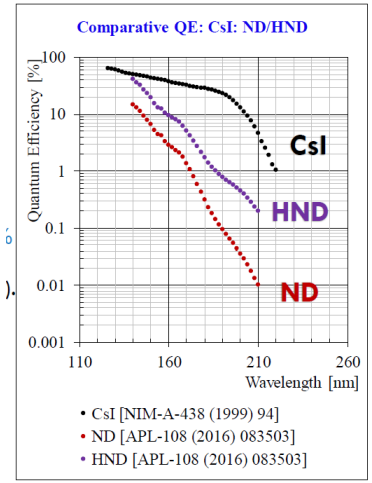


Photon Detection for PID

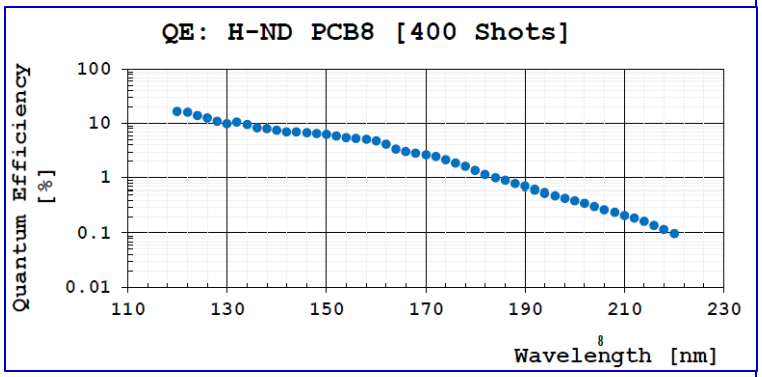
task 7.5.1

MPGD-based PDs – novel photoconverters for operation in gas

Nanodiamond photocathodes for MPGD based single photon detectors



Photoconverter QE



VUV SENSITIVE PHOTOCATHODES

CsI

> Low electron affinity > 0.1 eV

> Wide band gap > 6.2 eV

> Typical Quantum Efficiency > 35 – 50% @ 140 nm

> CsI has hygroscopic nature

> Aging > Ion Accumulation > Degradation in QE of PC

The only one used so far

Nanodiamond (ND)

> Low electron affinity > 0.35 – 0.5 eV

> Wide band gap > 5.5 eV

> Preliminary measured QE > 30 – 40% @ 140 nm for Hydrogenated ND. (We meas 7.7% after one year H-ND in H_2O).

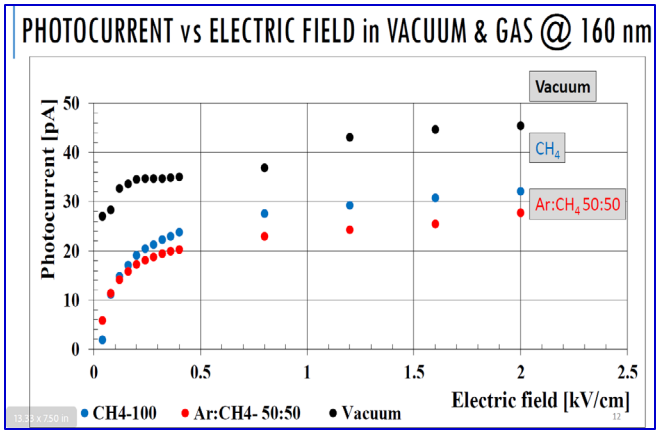
> Chemically inert

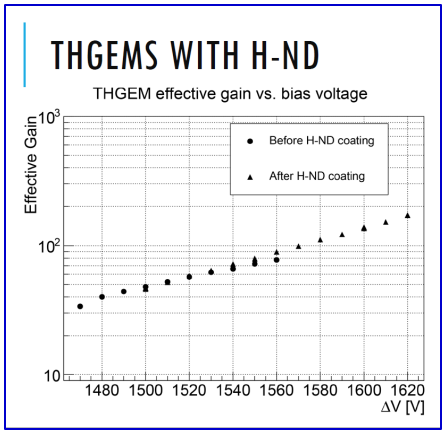
> Radiation hard

> Good thermal conductivity

The novel option

Qualifying the photoconverter for gaseous PD

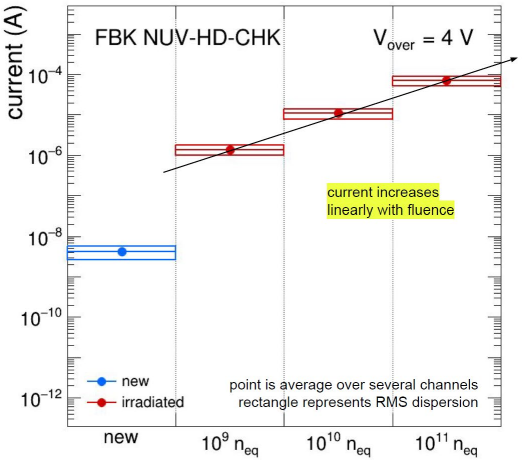


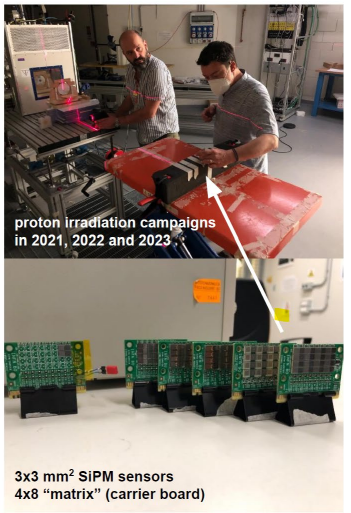


Task 7.5.1, R&D activity

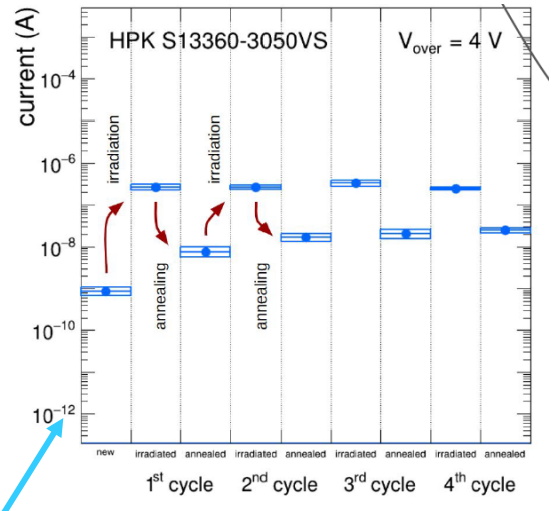
Si PMs

Studies of radiation damage on SiPM

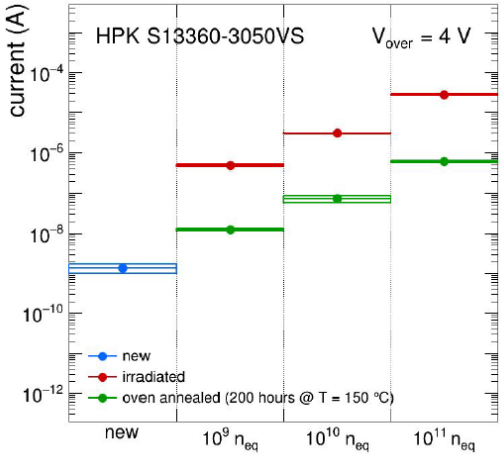




Repeated irradiation/ annealing cycles

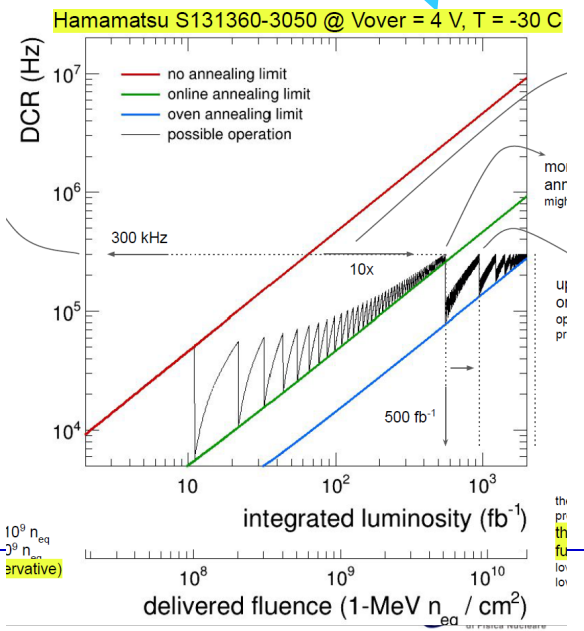


High-temperature annealing recovery



"Online" self-induced annealing

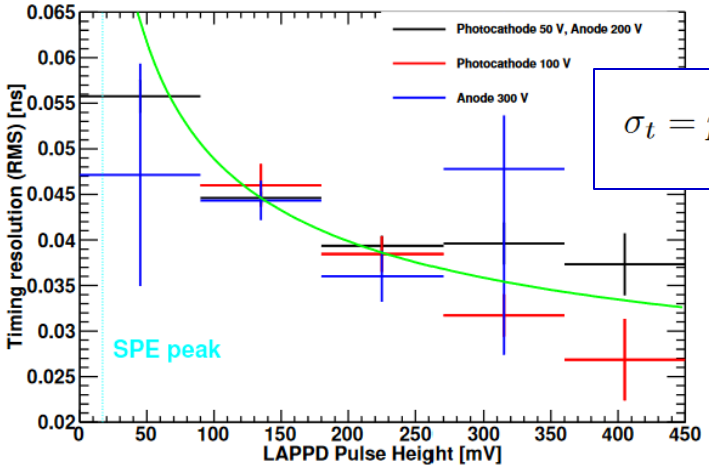
Ageing model



Task 7.5.1, R&D activity

LAPPD – large-size MCP-PMTs

finalization and publication (NIMA) of the timing studies

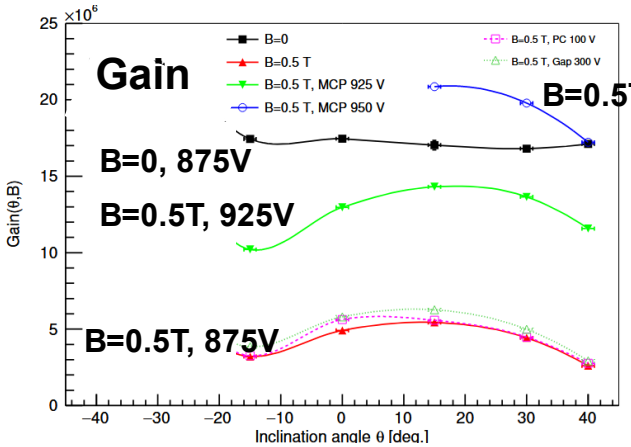


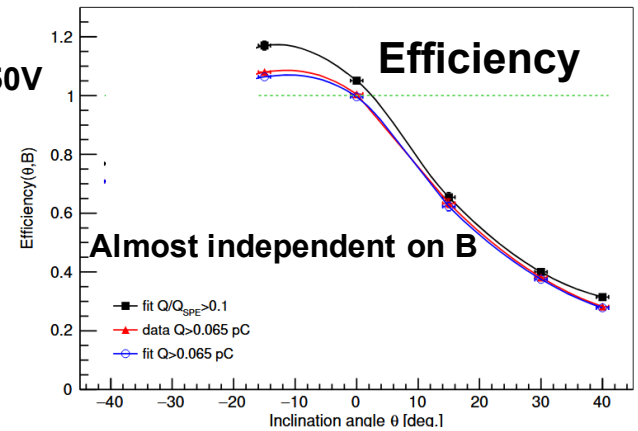
$$\sigma_t = p_0 + \frac{p_1}{\sqrt{V_{peak}/1V}}$$

Performance in magnetic field, also vs. orientation

SPE time resolution: 75 ps

Asymptotic limit for large amplitude (multiple PE events) : 18 ps

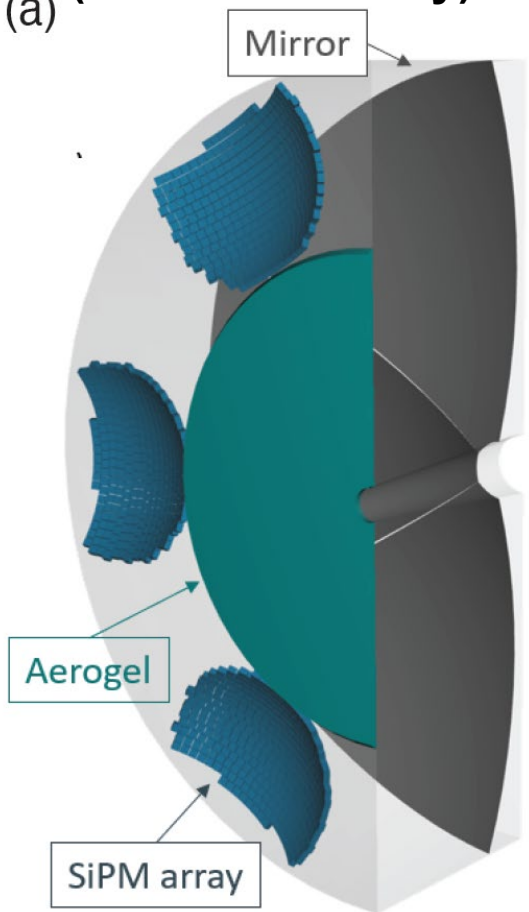


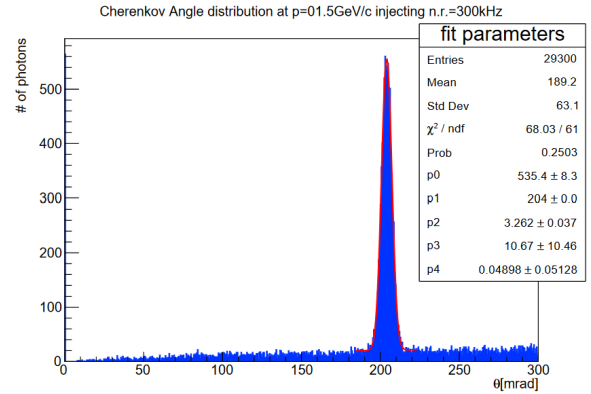


Task 7.5.1, R&D activity

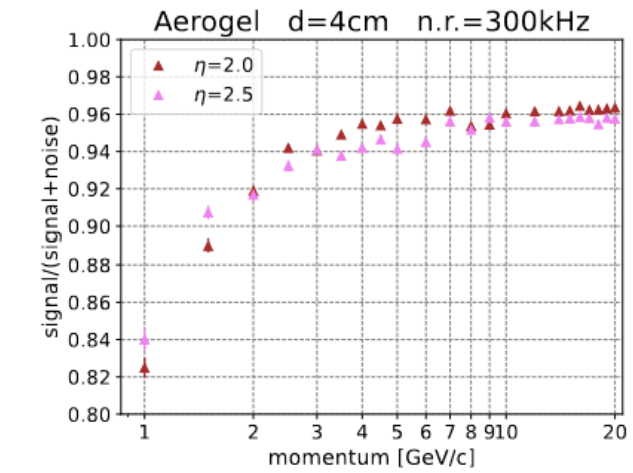
Simulation – Impact of the SiPM dark noise

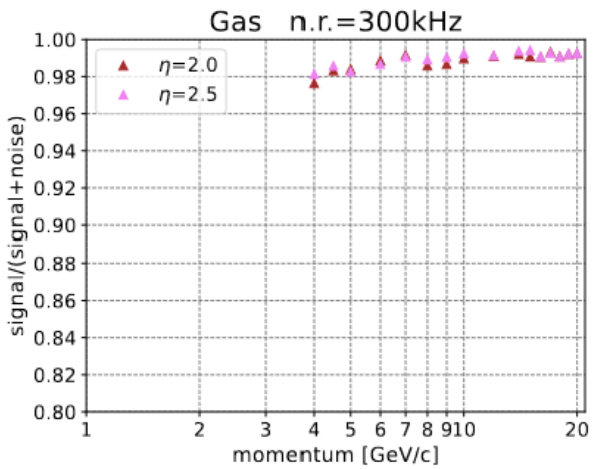
ePIC (at EIC) dRICH (as case of study)



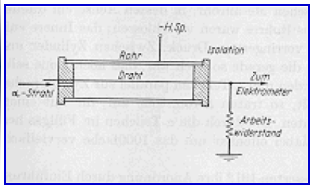


Purity = signal / (signal+noise)





SUMMARIZING



SUBSTANTIAL PROGRESS IN ALL THE TASKS

OF WP 7