IDEA drift chamber

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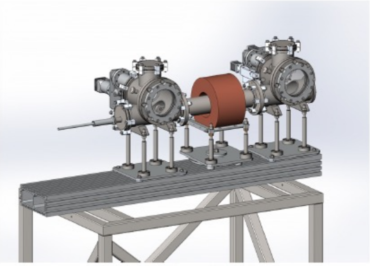
on behalf of the INFN Bari and Lecce teams

Challenges for large-volume drift chambers

- **Electrostatic stability** condition: $\frac{\lambda^2}{4\pi\varepsilon}\frac{L^2}{w^2} < wire\ tension < YTS \cdot \pi r_w^2$

λ = linear charge density (gas gain)
L = wire length, r_w wire radius, w = drift cell width
YTS = wire material yield strength



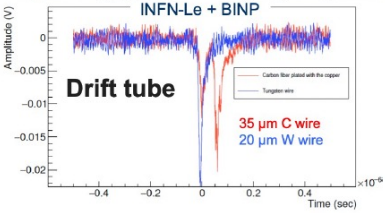
The proposed drift chambers for FCC-ee and CEPC have lengths **L = 4 m** and plan to exploit the cluster counting technique, which requires gas gains **~5×10^5**.
This poses serious constraints on the drift cell width (**w**) and on the wire material (**YTS**).

⇒ new wire material studies

- **Non-flammable gas / recirculating gas systems**

Safety requirements (**ATEX**) demands stringent limitations on flammable gases;
Continuous increase of **noble gases cost**

⇒ gas studies

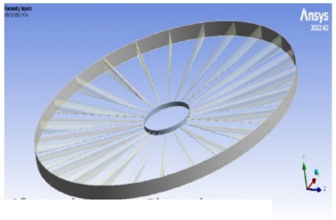


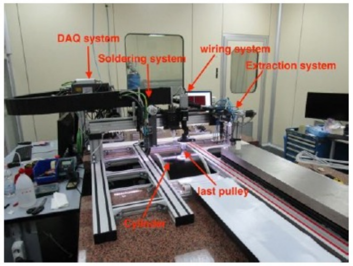
- **Data throughput**

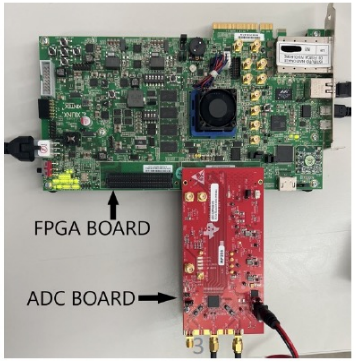
Large number of channels, high signal sampling rate, long drift times (slow drift velocity), required for cluster counting, and high physics trigger rate (Z_0-pole at FCC-ee) imply data transfer rates in excess of **~1 TB/s**

⇒ on-line real time data reduction algorithms

- **New wiring systems for high granularities / / new end-plates / new materials**

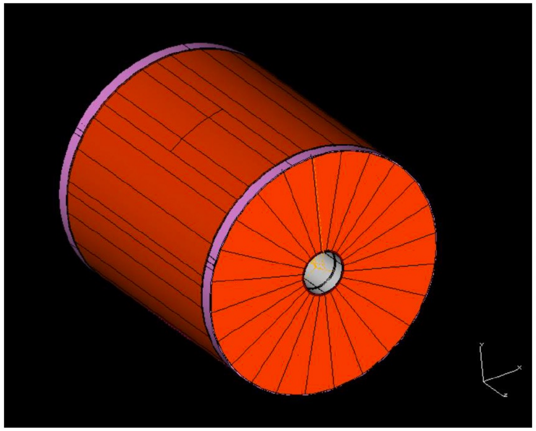






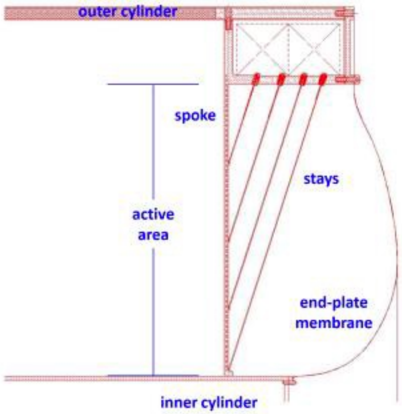
Mechanical structure of the DCH

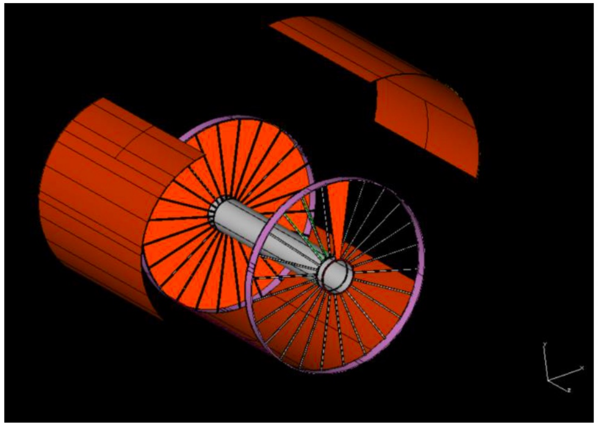
IDEA Drift Chamber



- Inner radius R_{in} = **35 cm**, outer radius R_{out} = **200 cm**
- Length **L = 400 cm**
- Inner wall thickness **200 μm** Carbon fiber
- Outer wall thickness **2cm** composite material sandwich (honeycomb structure)

tension recovery system



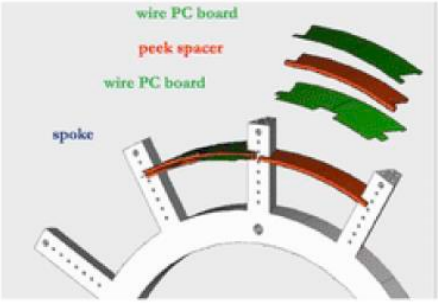


- **Inner cylinder** and **Outer cylinder** are connected with 48 **Spokes** (24 per endcap) forming 24 azimuthal sectors.
- Each spoke is supported by 15 **Cables.**
- Spoke length **l =** 165cm

IDEA Drift Chamber: wire cage

- **343968 wires** in total:
  - 56448 sense wires – 20 μm diameter W(Au)
  - 229056 field wires – 40 μm diameter Al(Ag)
  - 58464 field and guard wires – 50 μm diameter Al(Ag)

- The **Wires** are soldered to the PCB and inserted between the spokes.
- **112 co-axial layers** (grouped in 14 superlayers of 8 layers each) **of para-axial wires**, at alternating-sign stereo angles, arranged in 24 identical azimuthal sectors.
- **Stereo configuration:** one sector is connected with the second corresponding sector in the opposite endcap (hyperbolic profile).



MEG2 drift chamber

Mechanical structure with FEM

Big Problems to manage!

- σ_{xy} < **100 μm** → accuracy on the position of the anodic wires < **50 μm**.
- The anodic and cathodic wires should be parallel in space to preserve the constant electric field.
- A 20 μm tungsten wire, 4 m long, will bow about 400 μm at its middle point, if tensioned with a load of approximately 30 grams.

30 gr tension for each wire → **10 tonnes** of total load on the **endcap**

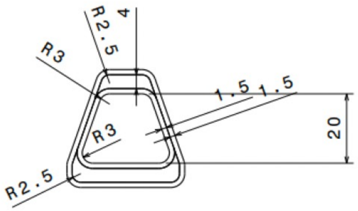
Load on spokes (24 sectors): 416 Kg/spoke => 2.5 Kg/cm average

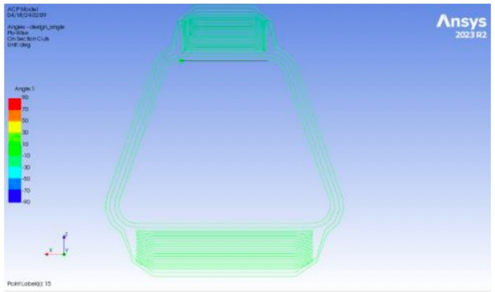
Load on stays (14 stays/spoke) - 416 Kg/14/sin 8.6° = 200 Kg/stay

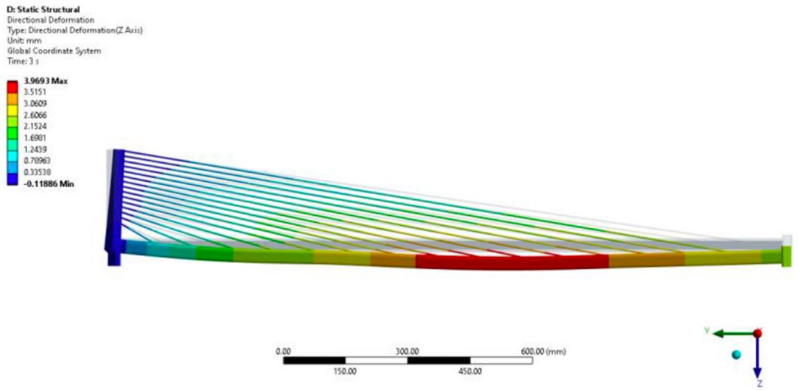
Mechanical structure: FEM simulation studies

Everything supported by the EURIZON project

Simulation studies: progress about the final design of the cross section of the spoke

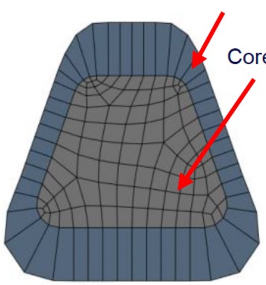






Statical structure simulation:

deformation along r



Our main goal is to limit the deformation of the spokes to **200 μm**, while ensuring the structural integrity

- Including **prestressing of spokes**
- Investigate more **composite structures**
- **Buckling** analysis on outer cylinder

Studi di progettazione meccanica DCH per IDEA con calcoli FEM analysis (EnginSoft, pagati con Eurizon)

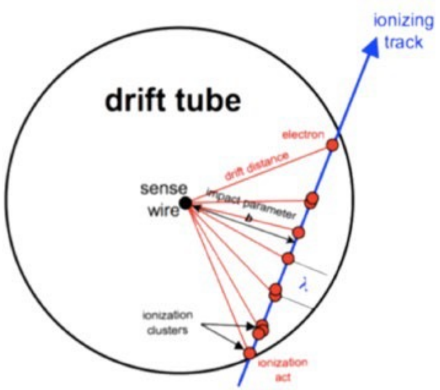
- definita la sezione degli spokes,
- si sta lavorando sulla struttura del composito con cui realizzarli e sul comportamento sotto stress, è partita l'analisi di stabilità del cilindro esterno

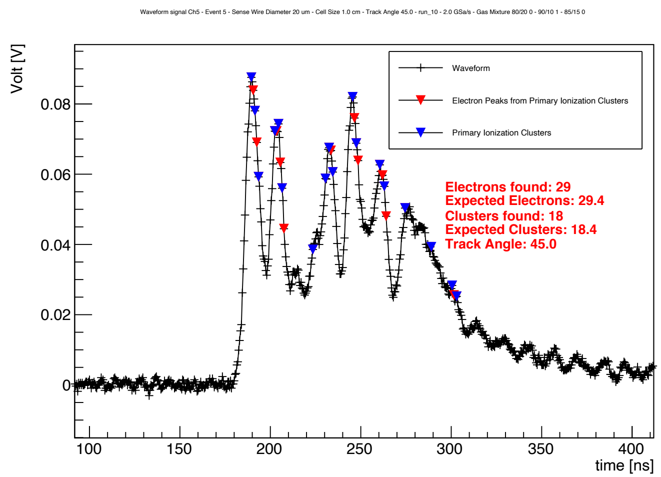
Testbeam data analysis

The Drift Chamber: Cluster Counting/Timing and PID

Principle: In He based gas mixtures the signals from each ionization act can be spread in time to few ns. With the help of a fast read-out electronics they can be identified efficiently.

- By counting the number of ionization acts per unit length (dN/dx), it is possible to identify the particles (P.Id.) with a better resolution w.r.t the dE/dx method.





- collect signal and identify peaks
- record the time of arrival of electrons generated in every ionisation cluster
- reconstruct the trajectory at the most likely position

- Landau distribution of dE/dx originated by the mixing of primary and secondary ionizations, has large fluctuations and limits separation power of PID → primary ionization is a Poisson process, has small fluctuations
- The cluster counting is based on replacing the measurement of an ANALOG information (the [truncated] mean dE/dX) with a DIGITAL one, the number of ionisation clusters per unit length:

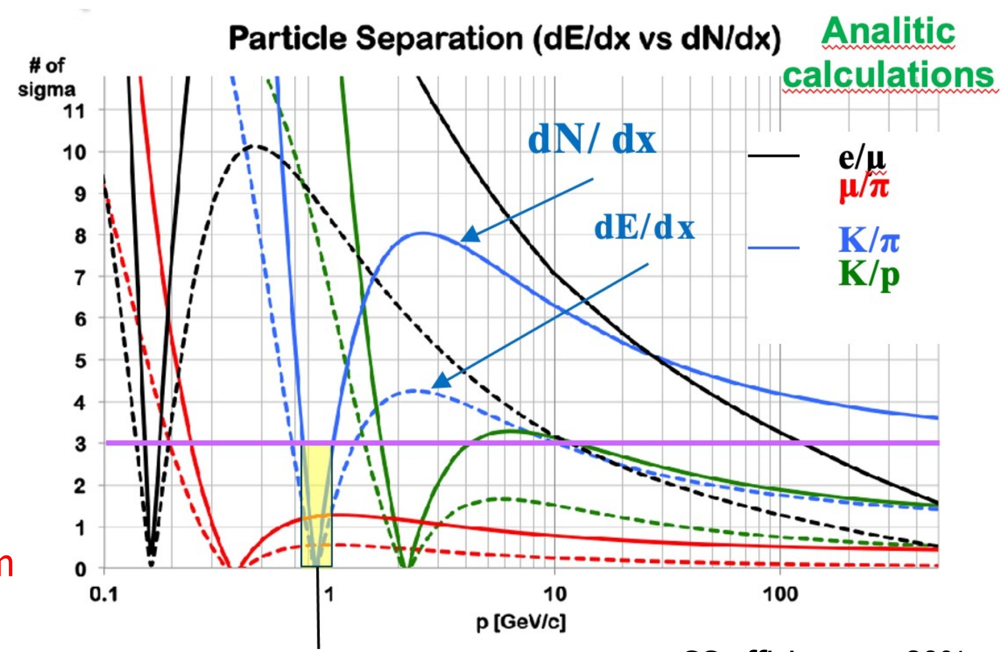
dE/dx: truncated mean cut (70-80%), with a 2m track at 1 atm give $\sigma \approx 4.3\%$

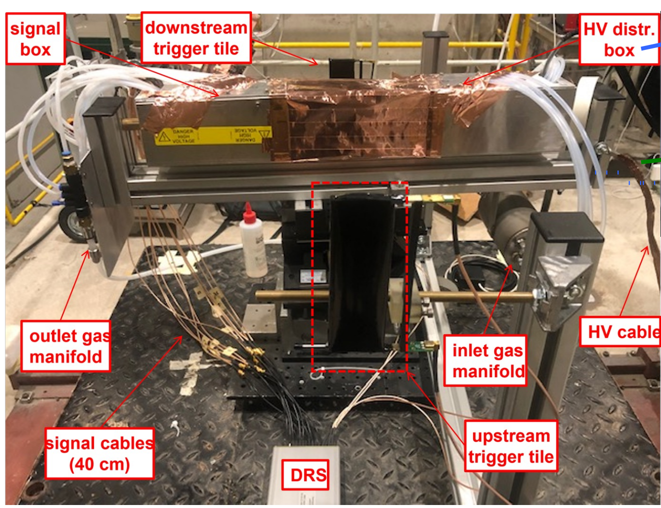
dN_{cl}/dx: for He/iC_4H_{10}=90/10 and a 2m track gives $\sigma_{dNcl/dx} / (dN_{cl}/dx) < 2.0\%$

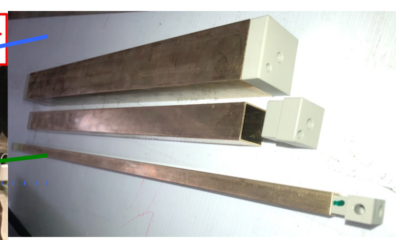
The Drift Chamber: Cluster Counting/Timing and PID

- Analitic calculations: Expected excellent K/π separation over the entire range except 0.85<p<1.05 GeV (blue lines)

- Simulation with Garfield++ and with the Garfield model ported in GEANT4:
  - the particle separation, both with dE/dx and with dN_{cl}/dx, in GEANT4 found considerably worse than in Garfield
  - the dN_{cl}/dx Fermi plateau with respect to dE/dx is reached at lower values of βγ with a steeper slope
  - finding answers by using real data from beam tests

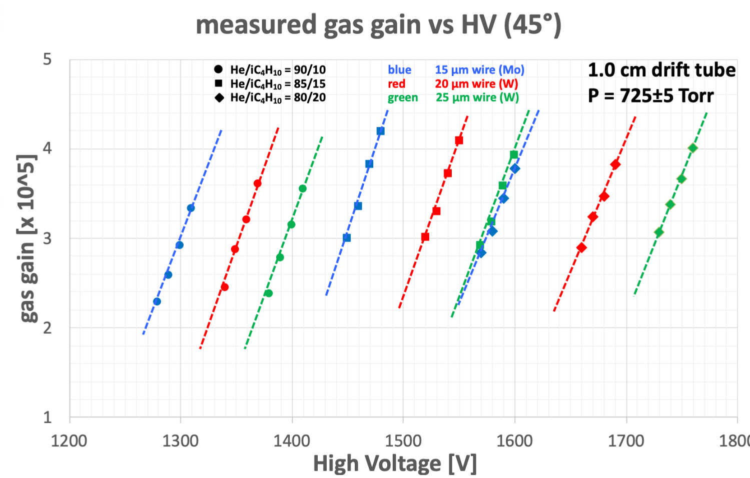






90%He-10%iC_4H_{10} nominal HV+20, 45°, Gas gain ~ $2 \cdot 10^5$, 165 GeV/c

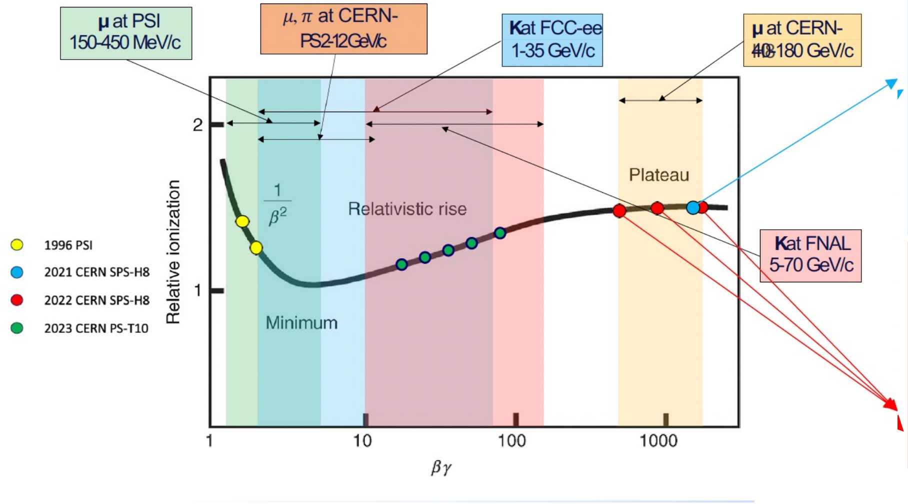
CC efficiency ≈ 80%

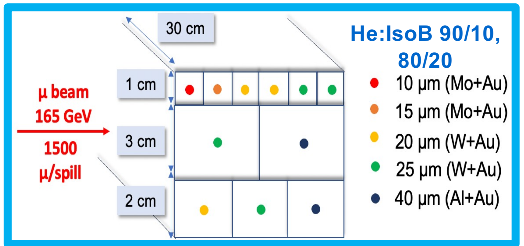


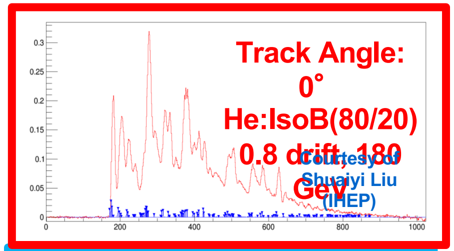
Beam tests in 2021,2022, 2023 and 2024

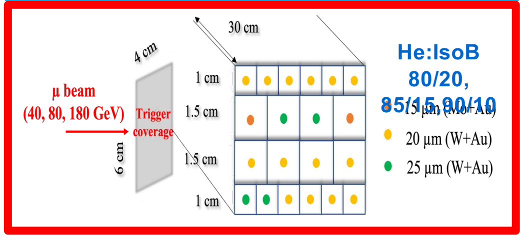
Beam tests to experimentally asses and optimize the **performance of the cluster counting/timing** techniques:

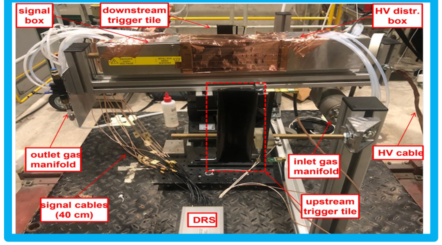
- Two **muon beam tests** performed at **CERN-H8 (βγ > 400)** in Nov. 2021 and July 2022 (p_T = 165/180 GeV).
- A **muon beam test** (from 4 to 12 GeV momentum) in 2023 performed at **CERN**. Just completed a testbeam with the same configuration, July 10-24, 2024 ← **large participation (BA, LE, BNL, FSU)**
- Ultimate test at **FNAL-MT6** in 2025 with π and **K (βγ = 10−140)** to fully exploit the relativitic rise.







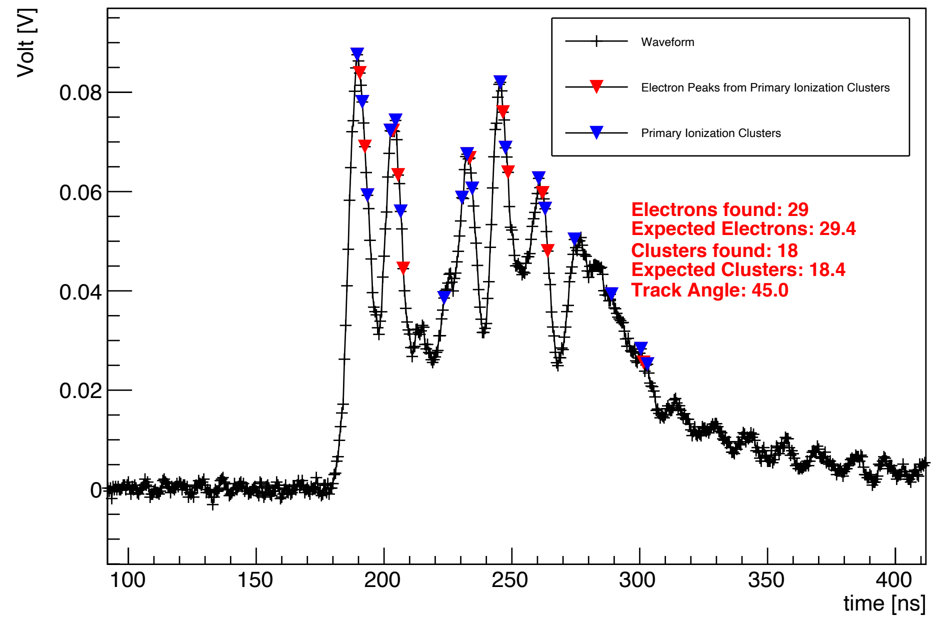




2021/2022 beam test results: performance plots

- Several algorithms developed for electron peak finding:
  - ✓ Derivative Algorithm (DERIV)
  - ✓ and Running Template Algorithm (RTA)
  - ✓ NN-based approach (developed by IHEP)
- Clusterization algorithm to merge electron peaks in consecutive bins
- Poissonian distribution for the number of clusters as expected
- Different scans have been done to check the performance: (HV, Angle, gas gain, template scan)

Sense Wire Diameter 15 μm; Cell Size 1.0 cm
Track Angle 45; Sampling rate 2 GSa/s
Gas Mixture He:IsoB 80/20

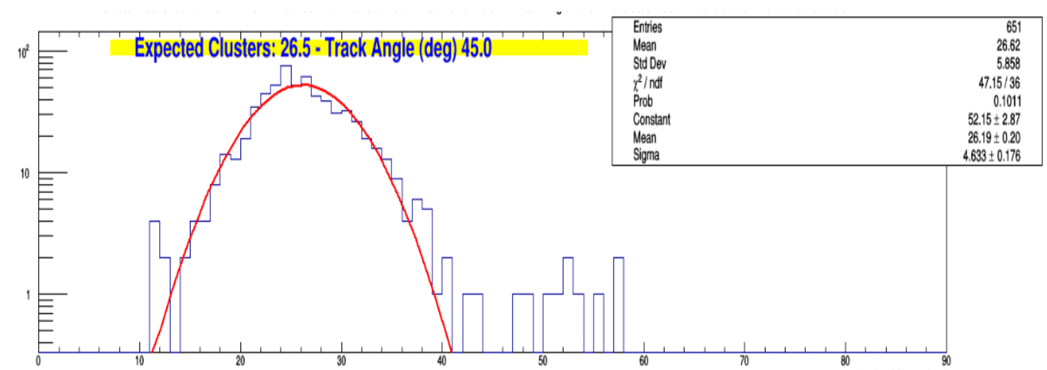


Expected number of electrons =
δ cluster/cm (M.I.P.) * drift tube size [cm] * 1.3 (relativistic rise)* 1.6 electrons/cluster * 1/cos(α)

- α = angle of the muon track w.r.t. normal direction to the sense wire
- δ cluster/cm (M.I.P) changes from 12, 15, 18 respectively for He:IsoB 90/10, 85/15 and 80/20 gas mixtures.
- drift tube size are 0.8, 1.2, and 1.8 respectively for 1 cm, 1.5 cm, and 2 cm cell size tubes.

[1] H. Fischle, J. Heintze and B. Schmidt, Experimental determination of ionization cluster size distributions in counting gases, NIMA 301 (1991)

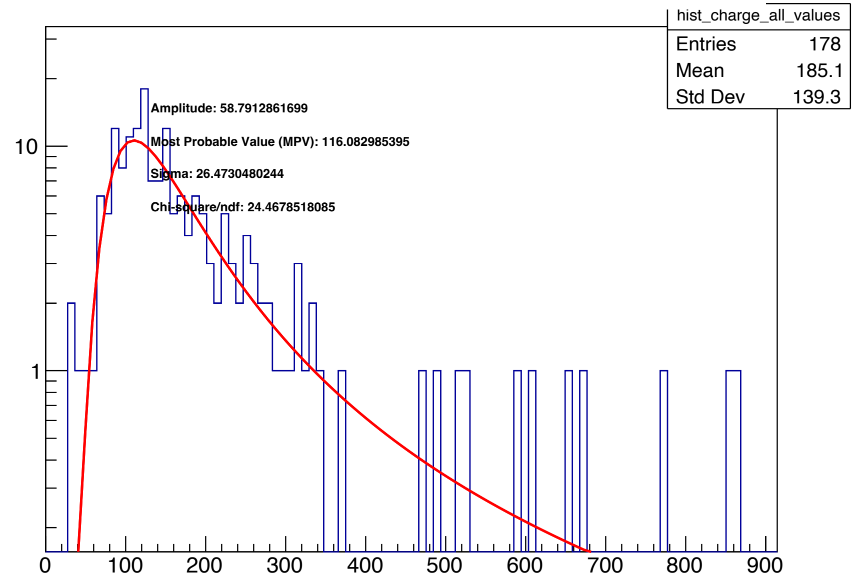
Poissonian distribution for the number of clusters



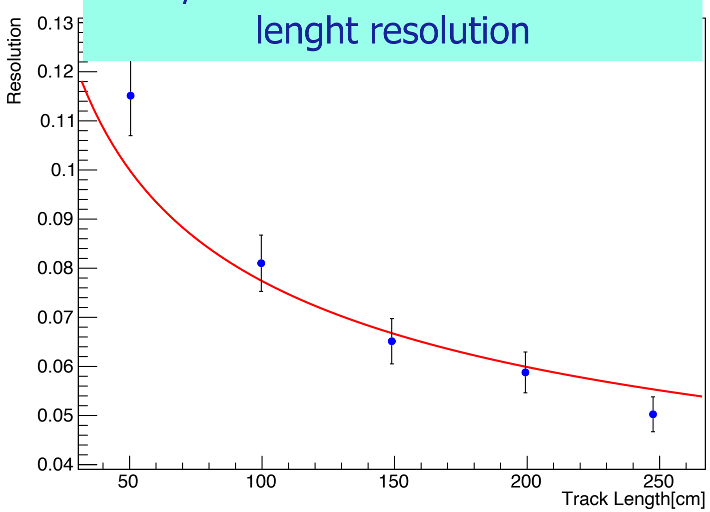
2021/2022 beam test results: resolutions

- **Landau distribution** for the charge along a track
- Selected the distribution with 80% of the charges for the dE/dx truncation, to be compared with dN/dx
- **NEW results**

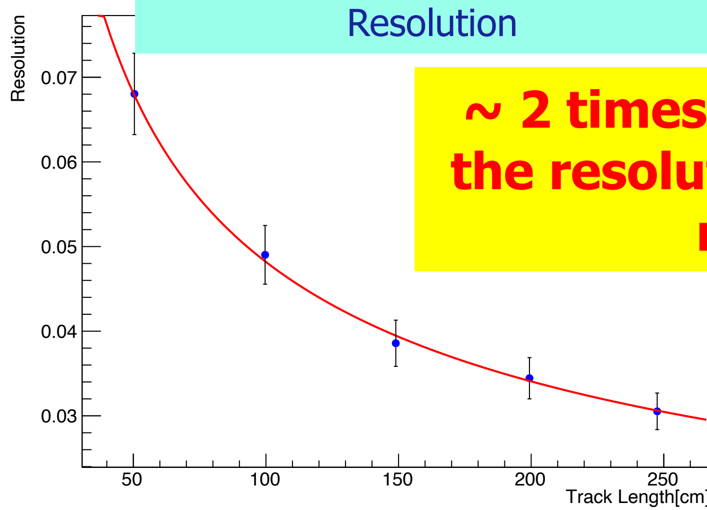
Integral charges along a 2 m track length



dE/dx Resolution scan vs track lenght resolution



dN/dx scan vs track lenght Resolution



~ 2 times improvement in the resolution using dN/dx method

A complete report to be given at ICHEP last week

Overview delle attività di RD_FCC Bari nel 2025

Hardware (in forte sinergia con INFN Lecce):

- setup tubi a drift per testbeam 2025 a Fermilab
- **inizio costruzione di un prototipo «full length» della DCH per IDEA**
- proposta di ristrutturazione di una **camera pulita** per assemblaggio/filatura

Simulazione e progettazione:

- f*ull simulation (***digi+ tracking algorithms***)* della camera a drift per IDEA FCC-ee
- studi di beam related background in connessione con il gruppo CERN e Frascati
- progettazione meccanica di un nuovo prototipo in scala di camera a drift per IDEA FCC-ee per studi di tracking performance

Analisi dati/Fisica:

- finalizzazione analisi dati del testbeam 2023 e 2024 (in sinergia con INFN Lecce), paper
- Analisi di fisica Higgs per FCCee e FCC-hh

Attività di coordinamento: software, fisica e calcolo per FCC Italia

Partecipazione a workshop/conferenze/meeting FCC

Partecipazione a DRD1 per gas detector (WP2)

Overview delle attività di RD_FCC Lecce nel 2025

Hardware (in forte sinergia con INFN Bari):

- setup tubi a drift per testbeam 2025 a Fermilab
- **inizio costruzione di un prototipo «full lenght» della DCH per IDEA**
- **Implementazione su FPGA di algoritmi di peak finding** per il processamento parallelo delle waveforms da molti canali di ADC → riduzione del trasferimento dati (completamento attivita' su AIDAInnova)

Analisi dati

- Finalizzazione analisi dati del testbeam 2023 (in sinergia con INFN Bari), note e paper, analisi dati del TB 2024

Partecipazione a workshop/conferenze/meeting FCC

Partecipazione a DRD1 per gas detector (WG2)

2025 full-length prototype: Goals

- **Check the limits of the wires' electrostatic stability at full length and at nominal stereo angles**

- **Test different wires**: uncoated Al, C monofilaments, Mo sense wires, …, of different diameters
  - Test different wire anchoring procedures (soldering, welding, gluing, crimping, …) to the wire PCBs
  - Test different materials and production procedures for spokes, stays, support structures and spacers
  - Test compatibility of proposed materials with drift chamber operation (outgassing, aging, creeping, …)

- Validate the **concept of the wire tension recovery scheme** with respect to the tolerances on the wire positions
  - Optimize the layout of the wires' PCBs (sense, field and guard), according to the wire anchoring procedures, with aim at minimizing the end-plate total material budget

- Starting from the new concepts implemented in the MEG2 DCH robot, **optimize the wiring strategy**, by taking into account the 4m long wires arranged in multi-wire layers

- Define and validate **the assembly scheme** (with respect to mechanical tolerances) of the multi-wire layers on the end plates
  - Define the front-end cards channel multiplicity and their location (cooling system necessary?)

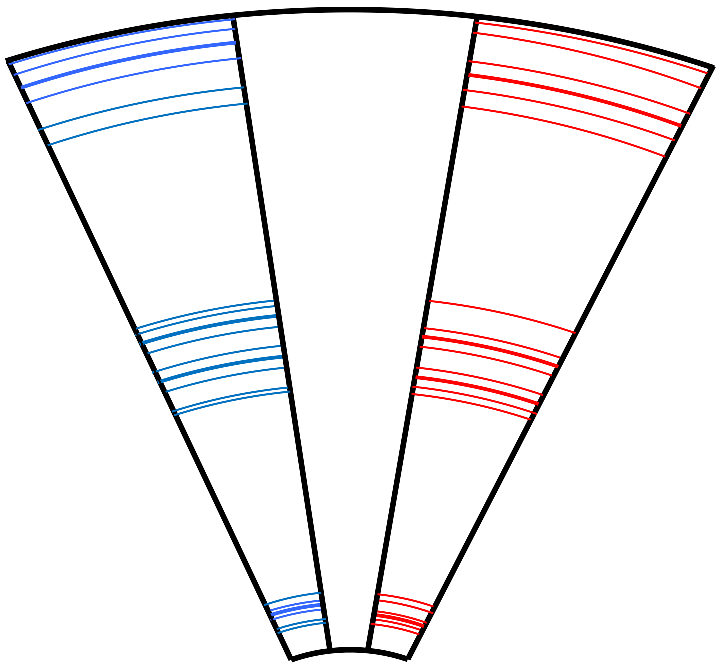
- **Optimize the High Voltage and signal distribution** (cables and connectors)

- Test performance of **different versions of front-end, digitization and acquisition chain**

▸ ***Full-length prototype necessary*** ○ ***Can be done in parallel on small prototypes***

2025 full-length prototype: Wiring

Target: a full length DCH prototype with 3 sectors per endcap



- 8 spokes (4 per endcap)
- Internal ring
- part of the outer ring
- part of the cylindrical panel

First two layers of superlayer #1
- V and U guard layers (2 x 9 guard wires)
- V and U field layers (2 x 18 field wires)
- U layer (8 sense + 9 guard)
- U and V field layers (2 x 18 field wires)
- V layer (8 sense + 9 guard)
- V and U field layers (2 x 18 field wires)
- V and U guard layer (2 x 9 guard wires)

Last two layers of superlayer #7
- V and U guard layers (2 x 21 guard wires)
- V and U field layers (2 x 42 field wires)
- U layer (20 sense + 21 guard)
- U and V field layers (2 x 42 field wires)
- V layer (20 sense + 21 guard)
- V field layer (42 field wires)

First two layers of superlayer #8
- U field layer (46 field wires)
- U layer (22 sense + 23 guard)
- U and V field layers (2 x 46 field wires)
- V layer (22 sense + 23 guard)
- V and U field layers (2 x 46 field wires)
- V and U guard layer (2 x 23 guard wires)

Last two layers of superlayer #14
- V and U guard layers (2 x 35 guard wires)
- V and U field layers (2 x 70 field wires)
- U layer (34 sense + 35 guard)
- U and V field layers (2 x 70 field wires)
- V layer (34 sense + 35 guard)
- V and U field layers (2 x 70 field wires)
- V and U guard layer (2 x 35 guard wires)

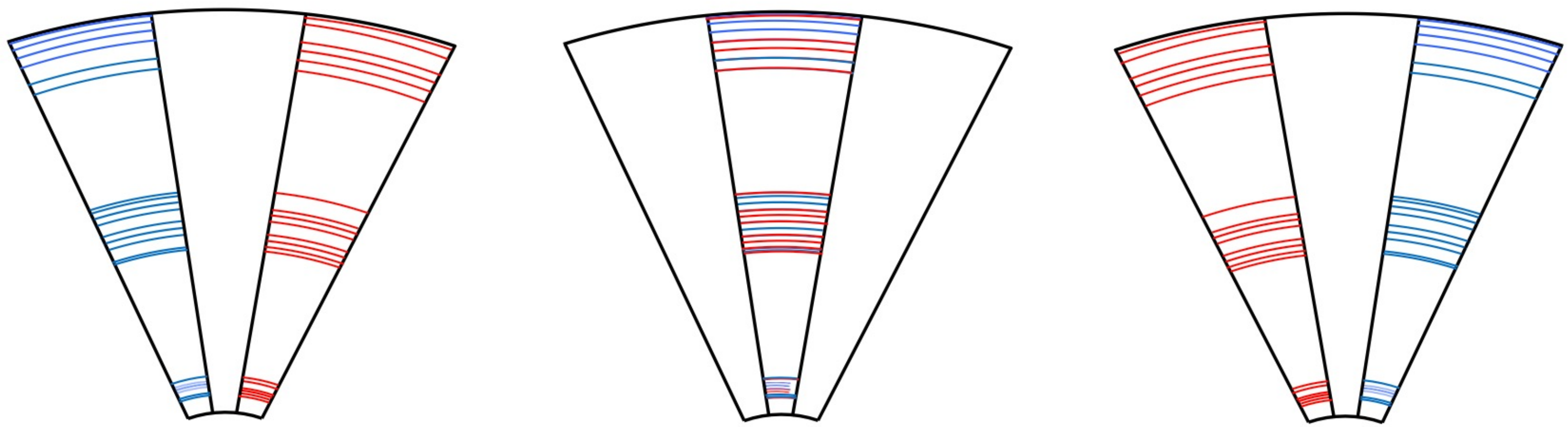
TOTAL LAYERS: 8
Sense wires: 168
Field wires: 965
Guard wires: 264

PCBoards wire layers: 42
Sense wire boards: 8
Field wire boards: 22
Guard wire boards: 12
HV values: 14

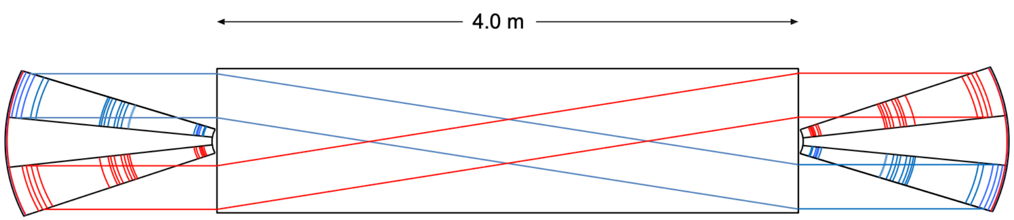
Readout channels: 8+8 +16+16+16+16 + 16+16 = 112

2025 full-length prototype: Coverage

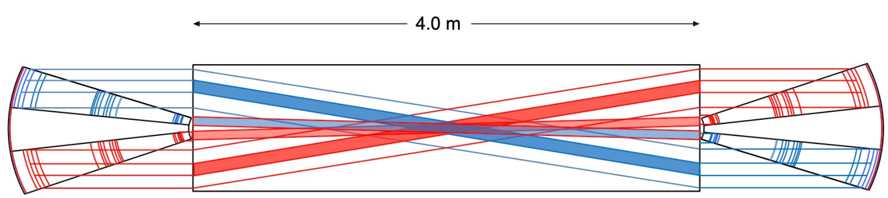
z = − 2.0 m | z = 0 | z = + 2.0 m



MAX COVERAGE



ELECTRONICS COVERAGE



Minimum stereo angle	50 mrad
Maximum stereo angle:	250 mrad

2025 full-length prototype: Schedule

- First phase of conceptual design of full chamber completed as of today by a collaboration of EnginSoft and INFN-LE mechanical service (+ a PhD student from Bari Politecnico): final draft of technical report ready
- Full design of full-scale prototype completed by summer 2024 by EnginSoft (purchase order issued) with INFN-LE mechanical service
- Preparation of samples of prototype components (molds and machining) ready by fall 2024 by CETMA consortium
- All mechanical parts (wires, wire PCBs, spacers, end plates) ready by end of 2024
- MEG2 CDCH2 Wiring robot transported from INFN-PI (being used for MEG2 CDCH2 until May 2024) to INFN-LE/BA, refurbished and re-adapted, to be operational by spring 2025
- Wiring and assembling clean rooms:
  - INFN-LE clean room currently occupied by ATLAS ITK assembly (until 2026 ?)
  - Investigating the possibility of renovate a clean room at INFN-BA or at CNR-LE (subject to agreement between INFN and CNR)
- Wiring and assembling operations would occur during second half of 2025
- Prototype built by end of 2025/beginning 2026 and ready to be tested during 2026

N. B. Aggressive schedule strongly depending on the INFN funding

2025 full-length prototype: Costs

- Drift Chamber conceptual design (20 k€ from EURIZON-LE, invoice paid to EnginSoft)
- Full-Scale Prototype design (20 k€ from EURIZON-LE, purchase order issued to EnginSoft)
- Full-Scale Prototype design and material tradeoffs (molds and machining) (20 k€ from EURIZON-LE, purchase order issued to CETMA)
- Full-Scale Prototype components (inner cylinder and 8 spokes) (20 k€ from EURIZON-LE, purchase order issued to CETMA)
- Wires from CFW: 10 Km of 50 μm Al for field and guard; 1 Km of 20 μm W for sense (15 k€ from EURIZON-BA)
- Wires from Specialty Materials: 900 m of 35 μm C monofilament (5 k€ from EURIZON-LE)
- Wiring robot from MEG2 CDCH CSN1 funds to INFN-LE (estimated 100 k€)

Everything supported by the EURIZON project and not CSN1

Costs to be borne (late 2024 and 2025)

- Additional wires
- Wire PCBs
- Peek spacer
- Wiring robot refurbishing
- Mechanical support and gas envelope
- Front-end, digitizers and acquisition electronics

2025 full-length: additional arguments

- Tre settori sono il minimo per le due viste stereo.
- E’ necessario testare il layer più interno, con le celle più piccole, il layer più esterno col massimo angolo stereo e due layer intermedi alla transizione di due superlayer, dove cambia il passo dei fili per l’incremento di celle da un superlayer al successivo. Dunque, 4 layer per due viste, ovvero 8 layer.
- E’ necessario coprire in azimuth con i fili l’intero settore per distribuire il campo elettrico in modo da testare la stabilità elettrostatica con le configurazioni stereo. Ridurre ulteriormente il numero di fili di campo comporterebbe l’introduzione di effetti di bordo che influirebbero sui fili di sense più interni.
- E’ necessario coprire in azimuth con i fili l’intero settore per controllare la filatura su pcb che diventano circa 50 cm lunghe al layer più esterno con ovvie difficoltà di mantenimento delle tolleranze geometriche.
- Per quanto riguarda il numero di canali di lettura, leggiamo le due viste interne (tutti gli 8+8 canali), le quattro viste intermedie (16+16+16+16 canali su 20+20+22+22 fili di sense) e le due viste esterne (16+16 canali su 34+34). Il tutto ci offre una copertura di un paio di decimetri quadrati per i raggi cosmici verticali.
- I 112 canali → richiesta delle due schede NALU da 64 canali oltre ai due digitizzatori CAEN VX2751 da 16 canali per confronto e per testare la lettura divisione di corrente e la differenza di tempo fra le due estremità dei fili

Anagrafica 2025: INFN Bari

INFN- Bari	2025
N. De Filippis (Assoc. Prof.)	30%
M. Abbrescia (Assoc. Prof.)	20%
M. Louka (PhD)	100%
B. D’Anzi (PhD)	100%
M. Barbieri (PhD)	0%
M. Anwar (PhD)	20%
W. Elmetenawee (Postdoc INFN)	30%
D. Diacono (Tecn. INFN)	10%
F. Procacci (PhD)	100%
G. Pappalettera (Assoc. Prof.)	20%
F. Loddo (Tecn. INFN)	20%
TOT	**4,5 FTE**

Anagrafica 2025: INFN Lecce

INFN- Lecce	2025
M. Primavera (INFN I ricer)	20% + + 10% su sigle sinergiche (AIDAInnova 7.4.1, 10%)
E. Gorini (Full prof.)	30%
A. Ventura (Assoc. Prof.)	30%
M. Panareo (Assoc. Prof.)	10%
F.G. Gravili. (RTDA)	30%
S. Grancagnolo (RTDB)	30%
A. Miccoli (Tecnologo INFN)	20% + 10% su sigle sinergiche (AIDAInnova 7.3.1, 10%)
F. De Santis (PHD)	10%
F. Grancagnolo (retired)	0%
TOT	**2.0 FTE**

Responsabile: M. Primavera

Totale: 1.8 (+0.20 su sigle sinergiche) → 2.0 FTE

→ apertura nuova sigla

Personale tecnico:
A. Corvaglia
C. Veri

Funding 2024: sub-judice INFN Bari

Linear stage (aka «slitta micrometrica>): fundamental to test the tensioning schema/limitations of different wire prototypes and materials

- **stress-strain curve**
- **elastic limit**
- **breaking load**
- **elongation (Young module)**

→ wire qualification chain to be implemented

Motorized Linear Stage, Linear Motor, 100 mm Travel, 100 N Load, M4 and M6

MODEL: **XMS100-S**

CHF11,436

2 Weeks

1 | Add to Cart

https://www.newport.com/p/XMS100-S

— Specifications

Travel Range	100 mm	Compliance in Pitch	2.5 μrad/Nm
Maximum Speed	300 mm/s	Yaw, Typical	±10 μrad
Minimum Incremental Motion[1]	1 nm	Yaw, Guaranteed	±25 μrad
Continuous Motor Force	25 N	Compliance in Yaw	3.5 μrad/Nm
Peak Motor Force	100 N	Compliance in Roll	2.0 μrad/Nm
Centered Load Capacity	100 N	Drive Type	Linear Motor
Accuracy, Typical	±0.3 μm	Origin Repeatability	±0.025 μm
Accuracy, Guaranteed	±0.75 μm	Thread Type	M4 and M6
Bi-directional Repeatability, Typical	±0.030 μm	Weight	3.5 kg
Bi-directional Repeatability, Guaranteed	±0.040 μm	MTBF	20,000 h (25% load, 30% duty cycle)
Flatness Typical (Guaranteed)	±0.37 (±0.75) μm	Maximum Power Consumption	70 W
Straightness Typical (Guaranteed)	±0.37 (±0.75) μm	Compliance	RoHS 3, CE
Pitch, Typical	±12 μrad		
Pitch, Guaranteed	±25 μrad		

Funding 2024: sub-judice INFN Lecce

For the readout of the prototype we need **112 channels**, so we need 2 boards with 64 channels equipped with FPGA.

CAEN Technologies Inc.

On the Edge of Discovery

QUOTATION

CAEN
Tools for Discovery

Our Reference: QUO138233
Date of Quotation: July 18, 2024

From: CAEN Technologies Inc.
1 Edgewater Street - Suite 101
Staten Island, NY 10305

Phone: (718) 981-0401
Email: sales@caentechnologies.com

To: **INFN - Lecce**
VIA PER ARNESANO 1
LECCE, LE 73100
Italy

Attn: Carlo Veri

Item	Product code	Description	U. P.	Qty.	Disc.%	Subtot.
1	WTNHDSOCEVAA	Testboard for Nalu HDSoC chip	$ 3,800.00	1.00	5.00	$ 3,610.00
2	WVARIEYAAAAA	Nexys Artix-7 FPGA KIT	$ 550.00	1.00		$ 550.00
					Total	**$ 4,160.00**

Funding request 2025: INFN Bari

Consumi/Inventariabile:

- strumentazione per tubi a drift e prototipo full size:
  - lastre di peek (spaziatori e costi di lavorazione): 10k
  - filatura su piano: sistema di trasporto dei fili su 4m + saldatura a infrarossi + motori passo passo delle National instruments, scheda di controllo, decoder → 12k€ per modificare il robot usato da MEG
  - trigger: tile di scintillatori (24 tile 30x30) con SiPM 8k → 12k€ con elettronica con schede + support
  - rotating table per testbeam – 2k€
  - costi ulteriori per testbeam @ FNAL (gas+servizi): 2k€
  - Costo di 3km di sense wire in molibdeno da 20 micron con rivestimento in oro): 3k€

Totale: 41 k€

Facility per costruzione prototipi → camera pulita

- individuata area disponibile da attrezzare con filtri, condizionamento, rivestimento pareti adeguato, certificazione 10000 -> preventivo di circa 208k€ (richiesta da valutare successivamente)

Richieste missioni per RD_FCC 2025 - Bari

- Testbeam al Fermilab a luglio/settembre 2025:
  - missioni per 2 settimane, 3 persone: 10k€
- missioni a INFN Lecce – 5k€
- missioni per meeting, workshop, trasferte (4.5 FTE) 5.5k€

Totale: 20.5 k€

Funding request 2025: INFN Lecce

Consumi

- 200 PCB + componenti elettronica per prototipo → 15 keuro
  stays + sistemi di ancoraggio e regolazione+misuratori di tensione per prototipo —> 5 keuro
- Materiale (profilati) per realizzazione sistema di sostegno per prototipo → 5 keuro
- costi per testbeam Fermilab (gas+servizi) → 2 keuro
- pannello strutturale esterno prototipo e lavorazioni pannelli laterali e frontali → 15 keuro

Inventario

- Controller misuratori di tensione per prototipo→ 2 keuro

Trasporti

- Trasporto del robot di filatura da Pisa a Lecce → 3 keuro
- Trasporto del setup di test a Fermilab → 5 keuro

Totale: 52 k€

Richieste missioni per RD_FCC 2025 - Lecce

- Testbeam al Fermilab a luglio/settembre 2025:
  - missioni per 2 settimane, 3 persone: 10k€
- missioni per meeting, workshop, trasferte (2.0 FTE) 2.5k€

Totale: 12.5 k€

Attività DRD1

N. De Filippis:

WP2 convener:
«Inner and Central Tracking with Particle Identification Capability – Drift Chambers»

Technological representative in the DRD
Management Board

M. Panareo:

Lecce IR in DRD1 Collaboration Board

M. Primavera:

Secretariat of DRD1 Collaboration Board

#	Task	Performance goal	DRD1 WGs	ECFA DRDT	Milestones/Deliverable 12M	24M	36M	Institutes
T1	Front-end ASIC for cluster counting	- High bandwidth - High gain - Low power - Low mass	WG5, WG7.2	1.1 1.2	M1: **Achieving efficient cluster counting and cluster timing** performances by using FPGA based architecture → prototype of the front-end ASIC for cluster counting [T1]	M2: **Completion of a cylindrical sector** of a full length drift chamber prototype aimed at testing all mechanical properties [T3]	D: **Performance of K-pi separation** in the momentum range from 2 to 30 GeV/c based on a scalable front-end/digitizer/DAQ electronics chain for cluster counting.[T2]	INFN-BA, INFN-LE, INFN-RM BNL, FIT, U. Mass Amherst, U. Michigan, Irvine, Tufts U., U. Florida, U. Wisconsin IHEP-CAS, Nankai U., Tsinghua U.. USTC, IMP-CAS, Wuhan U, Jilin U., IJCLab-IN2P3. Bose.
T2	Scalable multichannel DAQ board	- High sampling rate - Dead-time-less - DSP and filtering - Event time stamping - Track triggering	WG5 WG7.2	1.1 1.2				
T3	Mechanics: wiring procedures New endplate concepts	- feed-through-less wiring procedures - More transparent endplates (< 5% X_0) - transverse geometry	WG3 3.1C	1.1 1.3				
T4	High rate High granularity	- smaller cell size and shorter drift time - higher field-to-sense ratio	WG3 3.2E, WG7.2	1.3				
T5	New wire materials and wire metal coating	- Electrostatic stability - High YTS - Low mass, low Z - High conductivity - Aging	WG3 3.1C	1.1 1.2				
T6	Ageing of new wire types	- Establish charge collection limits for carbon wires as field and sense wires	WG3 3.2B WG7.3,4	1.1 1.2				
T7	Gas mixing, recuperation, purification and recirculation systems	- Non-flammable gas - High quenching power - Low-Z - High radiation length - High primary ions	WG3 3.1B 3.2C WG4, WG7.4	1.3				

Richieste finanziarie per DRD1-WP2 - Bari

- Prototipo di camera a drift per tracciamento: 20k€
- Elettronica di lettura per prototipo per tracciamento: digitizer VX2751 CAEN: 25k€
- Missioni al CERN per organizzazione meeting DRD1 WP2: 2k€

VX2751 ★ Coming Soon

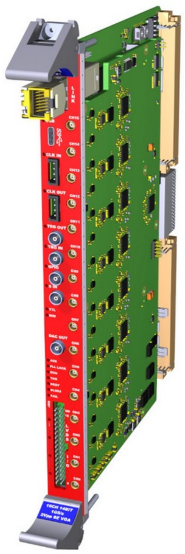
16 Channel 14 bit 1 GS/s Digitizer with programmable Input Gain

Request a quote

Features

- 14 bit @ 1 GS/s ADC
- 16 single-ended analog inputs on MCX connectors
- 2Vpp input range with software selectable analog gain
- Open FPGA programming through the graphical tool SCI-Compiler
- Wide range of applications (from Nuclear and Particle Physics to High Timing Resolution, Fast Neutron Spectroscopy, Dark Matter and Astroparticle, Fusion Plasma diagnostic, and Homeland Security)
- Suited for signals from fast organic, inorganic and liquid scintillators coupled to PMTs or SiPMs, Diamond detectors and others
- On-board live selection between scope mode (common trigger) and DPP mode (independent channel self-trigger)

More info



Richieste finanziarie per DRD1-WP2 - Lecce

- Prototipo di camera a drift per tracciamento: 20k€
- Elettronica di lettura per protipo per tracciamento: digitizer VX2751 CAEN: 25k€
- Missioni al CERN per CB meeting DRD1 (M. Primavera)? : 2k€ (non richieste nei preventivi!)

Summary/Conclusions

Good progress reported on:

- mechanical structure design
- on going effort to build a full-length prototype next year
- testbeam data analysis → NEW and quite conclusive results

Plenty of areas for collaboration:

- detector design, construction, beam test, performance
- local and global reconstruction, full simulation
- physics performance and impact
- etc.

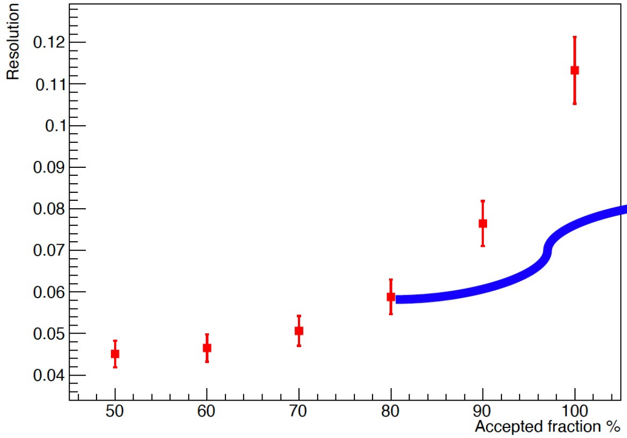
Effort to build a international collaboration enforced

- started to collaborate with US people from BNL
- significative participation of BNL to the 2024 testbeam

Backup

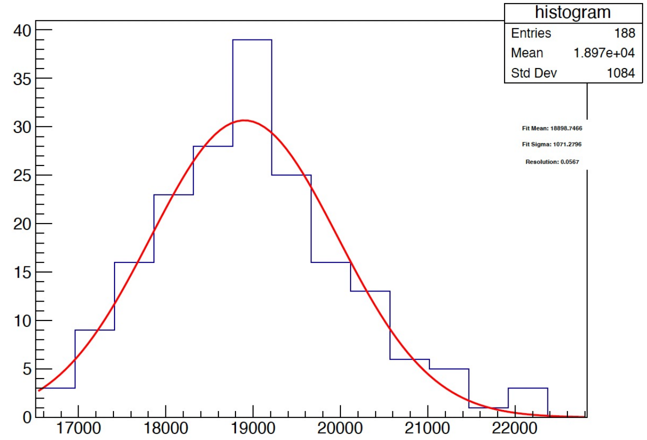
TestBeam 2021 and 2022: resolution studies

dE/dx Resolution Scan Vs accepted fraction of charge



dE/dx resolution varies from 4.5% - 11% for 2 m track length relying on the accepted fraction of the charges.

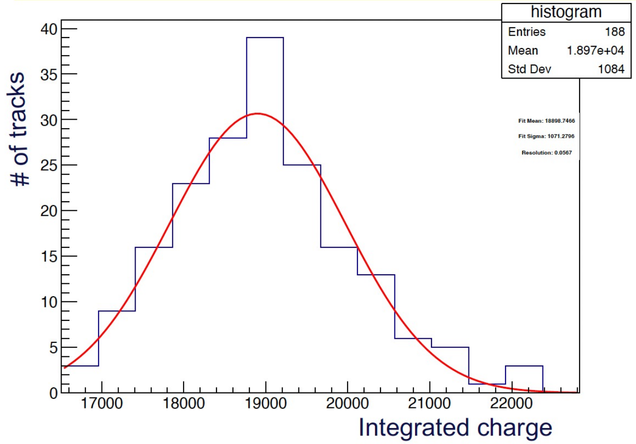
dE/dx Resolution (remove 20% higher charges for each track)



@2m long track we have dE/dx resolution 5.7%

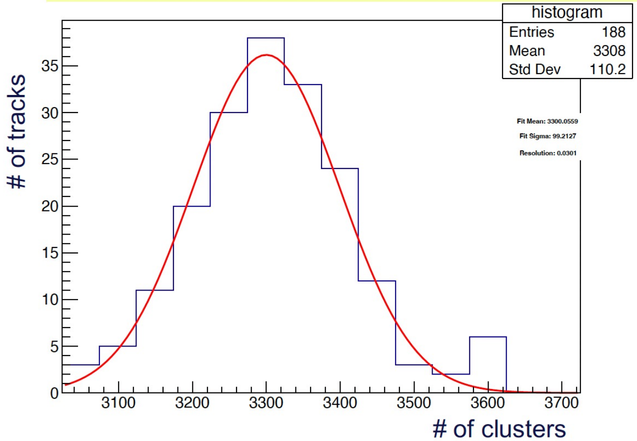
Study done using same tracks (2 m track length) made of the same hits.

dE/dx Resolution (remove 20% higher charges)



@2m long track we have dE/dx resolution 5.7%

dN/dx Resolution



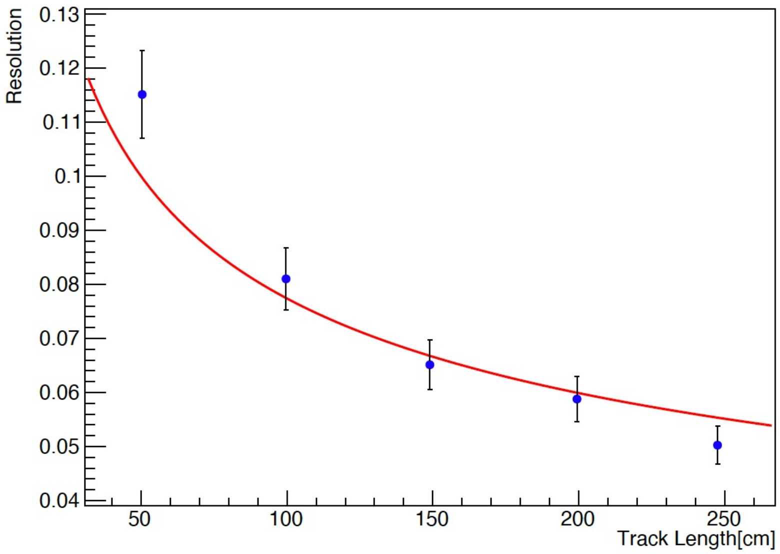
@2m long track we have dN/dx resolution 3%

~ **2 times** improvement in the resolution using dN/dx method

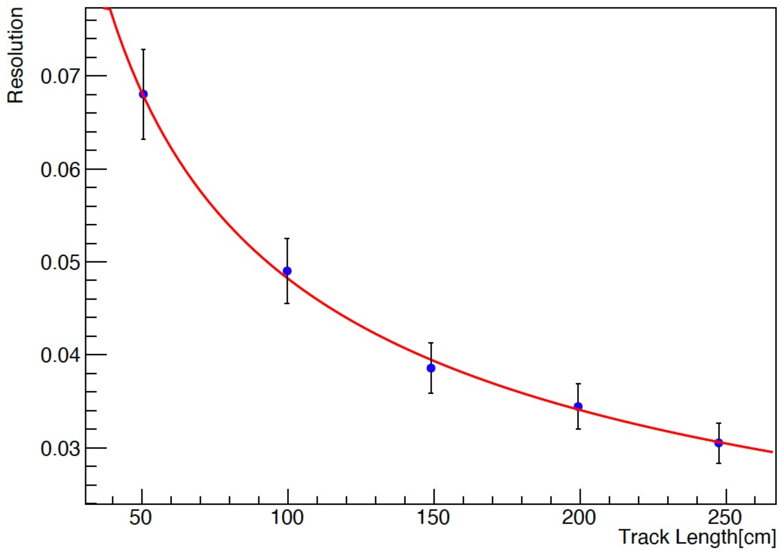
TestBeam 2021 and 2022: resolution studies

2m tracks length

dE/dx Resolution



dN/dx Resolution



dE/dx resolution dependence on the track length $L^{-0.37}$ dN/dx resolution dependence on the track length $L^{-0.5}$

~ **2 times** improvement in the resolution using dN/dx method

Funding request 2025: clean room @INFN Bari

Class 10000

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Preventivo
n. 86/2024 del 29/05/2024

Destinatario	Destinazione
I.N.F.N. Via Orabona,4 70126 Bari (BA) Italy Cod. Fisc. 84001850589	I.N.F.N. Via Orabona,4 70126 Bari (BA) Italy

Codice	Descrizione	Quantità	Prezzo	Sconto	Importo	Iva
	Oggetto Realizzaione impianto condizionamento presso Clean room , vs sede Bari					
	Fornitura e posa in opera di pannelli da assemblare come rivestimento di pareti e soffitto in pannello sandwiches coibentato con chiusura ad agganci e con porta a battente.	1	€ 29.000,00		€ 29.000,00	22
	Fornitura e posa in opera di quadrotti per pavimento sopraelevato dimensione 600x600 con rivestimento linoleum antistatico incluso lo smmontaggio e smaltimento di quello esistente	40 mq	€ 160,00		€ 6.400,00	22
	Fornitura e posa in opera di unita di trattamento aria del tipo a sezioni componibili completa di quadro elettrico e termoregolazione tipo Tecnair o similare ,versione orizzontale, per installazione all'esterno. Portata d'aria 3200mc/h. Struttura in lamiera saldata e sigilalta a perfetta ternuta d'aria, pannellatura autoportante di tipo sandwich a doppia parete in lamiera di acciaio zincato interna e lamiera di acciaio preverniciato esterna in bianco epossidico, dello spessore di 50 mm con interposto isolamento termoacustico in lana di roccia. Filtro piano G4, filtro a tasche rigide F9, batteria di riscaldamento, batteria raffrescamento, separatore di gocce, umidificatore a vapore, batteria di postriscaldo ventilatore di mandata plug fan 3200mc/h, ventilatore di espulsione 3200mc/h, recuperatore di calore. Incluso trasporto, attacchi idraulici ed elettrici.	1	€ 51.500,00		€ 51.500,00	22
	Fornitura e posa in opera di pompa di calore reversibile monoblocco con condensazione ad aria e ventilatori elicoidali. Serie a compressori ermetici rotative DC Inverter e gas refrigerante R32 . Versione con pompa a bordo e serbatoio	2	€ 26.000,00		€ 52.000,00	22

Pag. 1 Segue >>>

Codice	Descrizione	Quantità	Prezzo	Sconto	Importo	Iva
	inerziale 100l. Resa frigorifera circa 29kW. Incluso trasporto e montaggio, allacci irdaulici.					
	Adeguamento del sistema di canalizzazioni aria esistente incluso lo montaggio dei vecchi diffusori, la sigillatuira dei passaggi inutilizzati, la modifica del canale di mandata e ripresa incluso la fornitura di due griglie in alluminio	1	€ 8.000,00		€ 8.000,00	22
	Diffusore quadrato vorticoso ad alta induzione, in acciaio verniciato con vite di fissaggio nascosta, per diffusione dell'aria con flusso elicoidale e deflettori regolabili in materiale plastico, posto in opera a soffitto completo di serranda di taratura regolabile dall'ambiente e plenum interno, delle seguenti dimensioni: dimensione esterna 600 x 600 mm, 550mc/h, Incluso cannister porta filtro con imbocco circolare, filtro H14	6	€ 800,00		€ 4.800,00	22
	Ripristino dell'impianto elettrico esistente da adeguare al nuovo layout che include la sostituzione dei gruppi presee il montagiio sulle nuove contropareti, il rifacimento parziale delle tubzioni, nuovi cavi ove necessari, N.6 panel led per ambienti sterili, N.1 plafoniera di emergenza, N.1 quadro elettrico completo di interrruttori a servizio delle utenze del condizionamento	1	€ 16.000,00		€ 16.000,00	22
	Rimozione parziale dell'impianto esistente e trasporto a discarica	1	€ 2.500,00		€ 2.500,00	22

Pag. 2 Segue >>>

Modalità di pagamento **Acconto**
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Tot. Iva	€ 37.444,00
Tot. documento	**€ 207.644,00**

Pag. 3

Summary and conclusions (2)

- PID with a cluster counting technique is under study by using simulations and beam-test data
- Several algorithms for peak finding under development show agreement in data
- Results demonstrate the capability to count cluster with high efficiency at a fixed βγ
- Limiting conditions for an efficient cluster counting established:
  - gas gain saturation
  - cluster density (by changing the gas mixture)
  - space charge (gas gain, sense wire diameter, track angle)
  - recombination effects and electron attachment

Short term prospects:

- Finalization of Mechanical Structure and DAQ of the Drift Chamber
- Continuation of Beam Tests
- Construction of a prototype of a full scale wedge of the drift chamber:
  - to verify the electrostatic stability of different wire types (aluminum, titanium and carbon monofilamets for field and guard wires and tungsten, molybdenum for sense wires) of different diameters
  - to optimize the wire tension compensation scheme proposed to minimize the end-plates budget material

Notes in preparation:

- IDEA drift chamber proposal
- Results from cluster counting beam test
- Data acquisition system for cluster counting
- Preliminary studies on the IDEA drift chamber mechanical structure
- Preliminary estimate of the IDEA drift chamber costing