muEDM Roma Status Report

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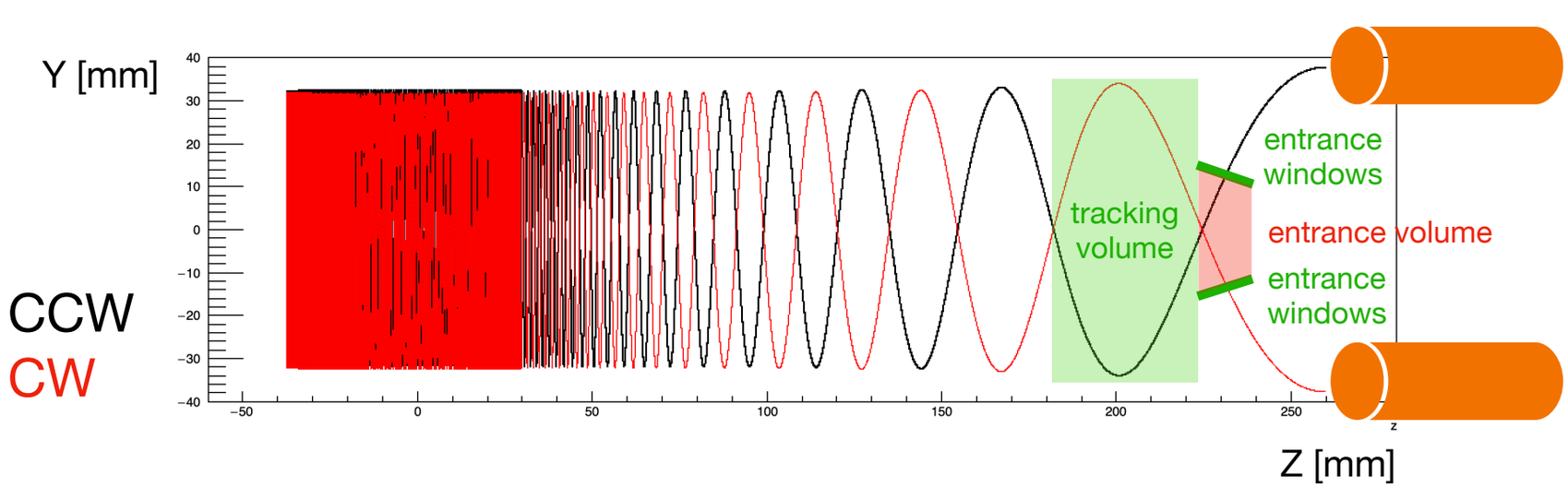
INFN Roma

The muTPC project

- Determination of the muon momentum difference between clockwise (CW) and counter-clockwise (CCW) injection within 0.5% precision —> ***essential for the control of the systematic uncertainties***
- Determination of the phase space at the entrance of the magnet —> ***cross-check the alignment of beam, injection channels and magnet***



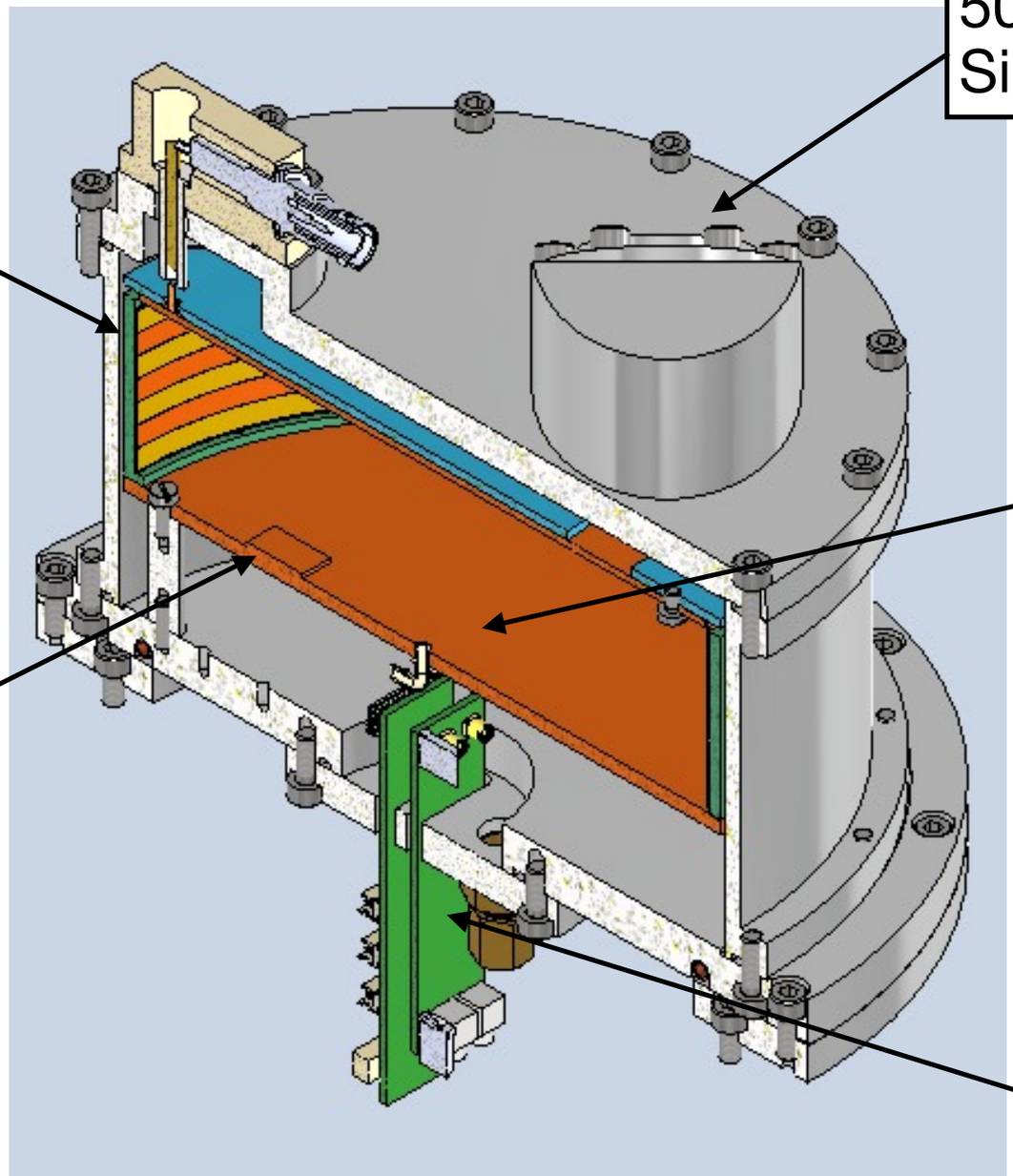
- Small TPC (few cm drift) with GridPix readout
- Main challenges:
  - extremely light material budget:
  - miniaturization effort to fit in the limited space at the entrance of the solenoid

muTPC Design

Cutting edge technologies in a miniature detector

Field cage
Flexible PCB on 3D-printed support

Entrance window
500 nm, vacuum-proof Silicon Nitride



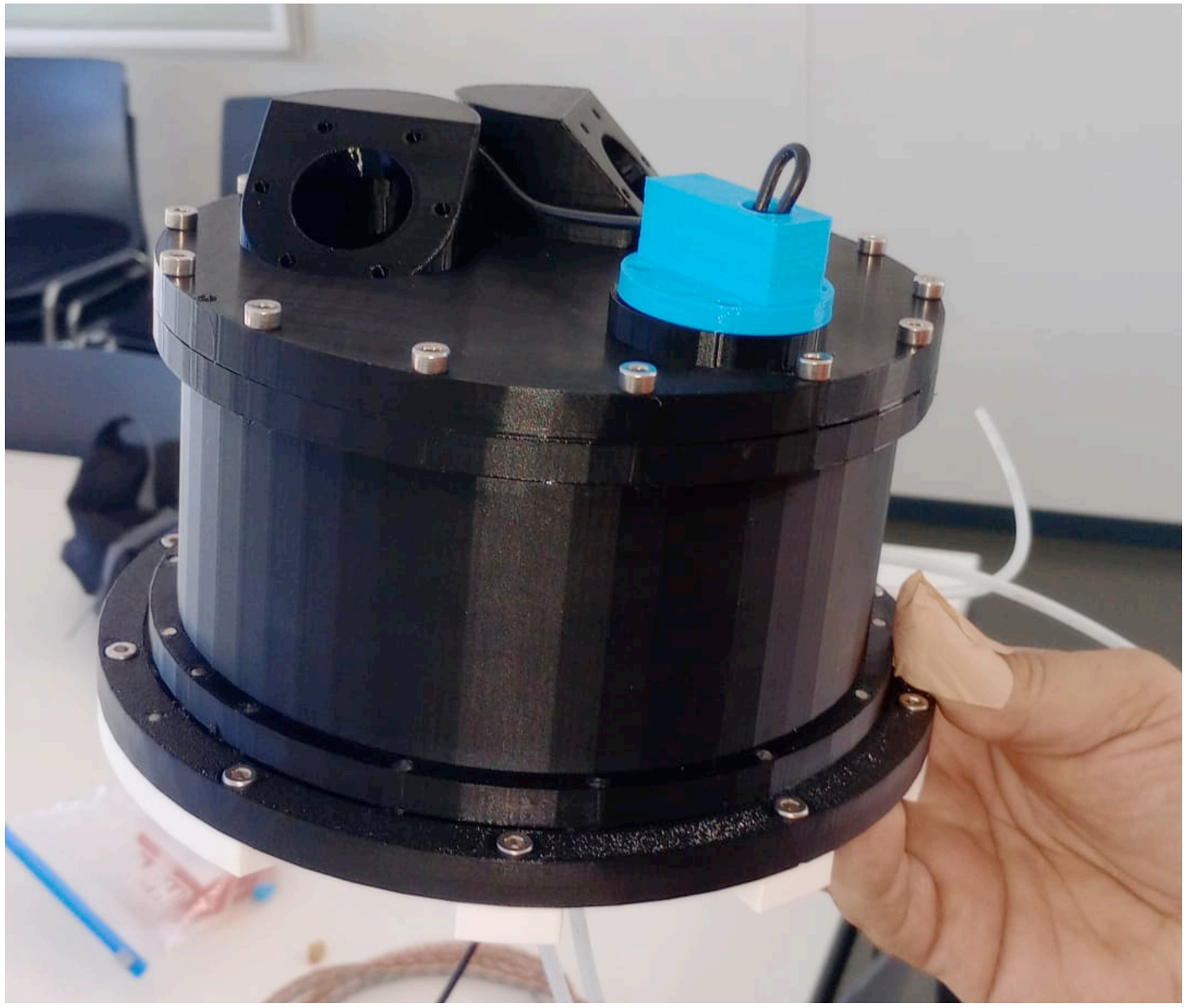
Readout
GridPix MPGD in Helium-Isobutane mixture

Trigger
Coated scintillator integrated in the anode plane

Signal transport
Cables and PCBs custom-designed for high-speed LVDS communication

muTPC Design

Cutting edge technologies in a miniature detector



Entrance windows

- Requirements: << 1 μm thickness, good coverage of the beam phase space, vacuum tight and capable of sustaining up to 1 bar gas pressure

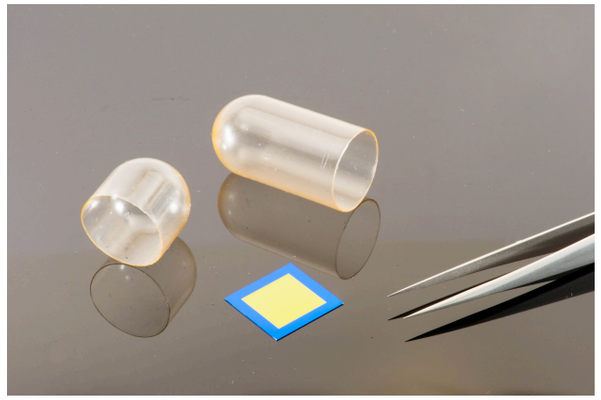
- Custom design by Silson Ltd. (UK)

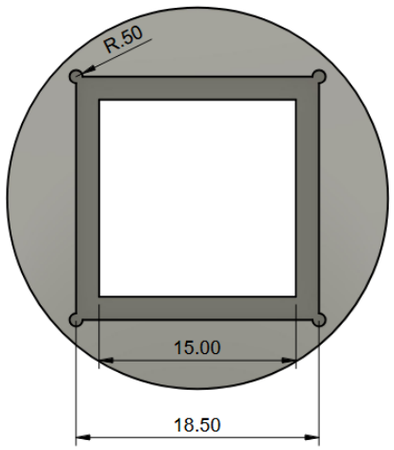
  - 3 x 3 matrix of 4.5 x 4.5 mm² Silicon Nitride windows on a 300 μm silicon frame

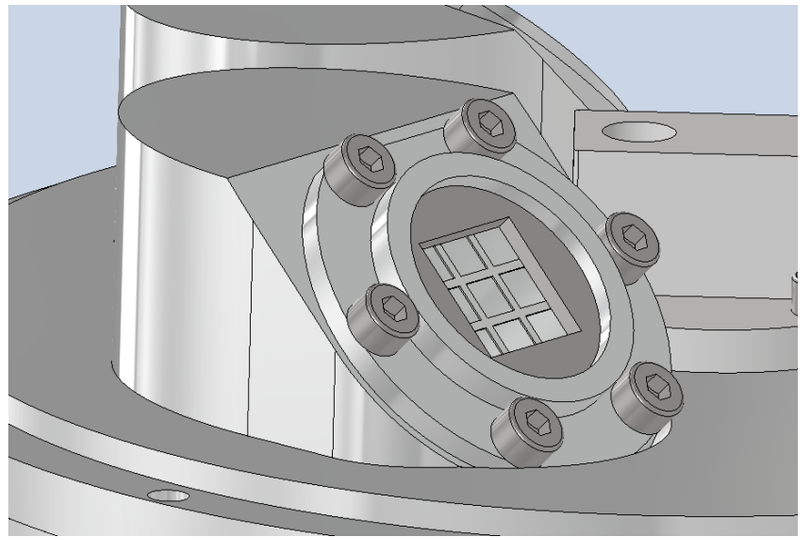
- Simulations to optimize window orientation for optimal measurement of the phase space parameters

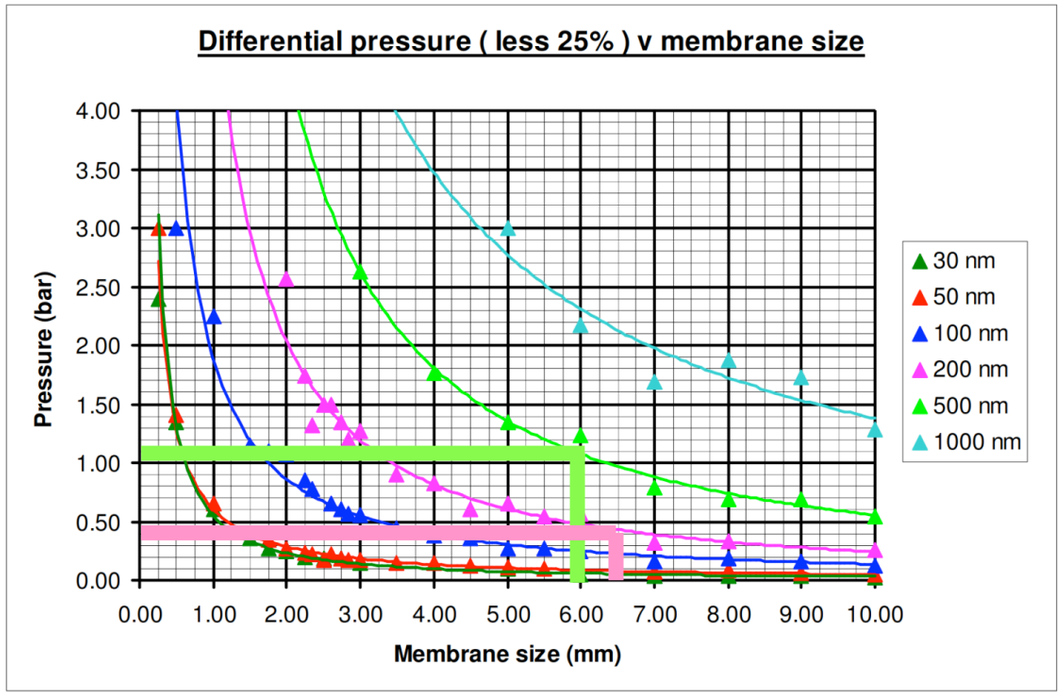
- 2025: order placed for 500 nm windows (with a safe margin on max. sustainable pressure) for the Dec. beam time

- 2026: if we demonstrate operations at << 1 bar, we could consider reducing the thickness to 400 nm or less





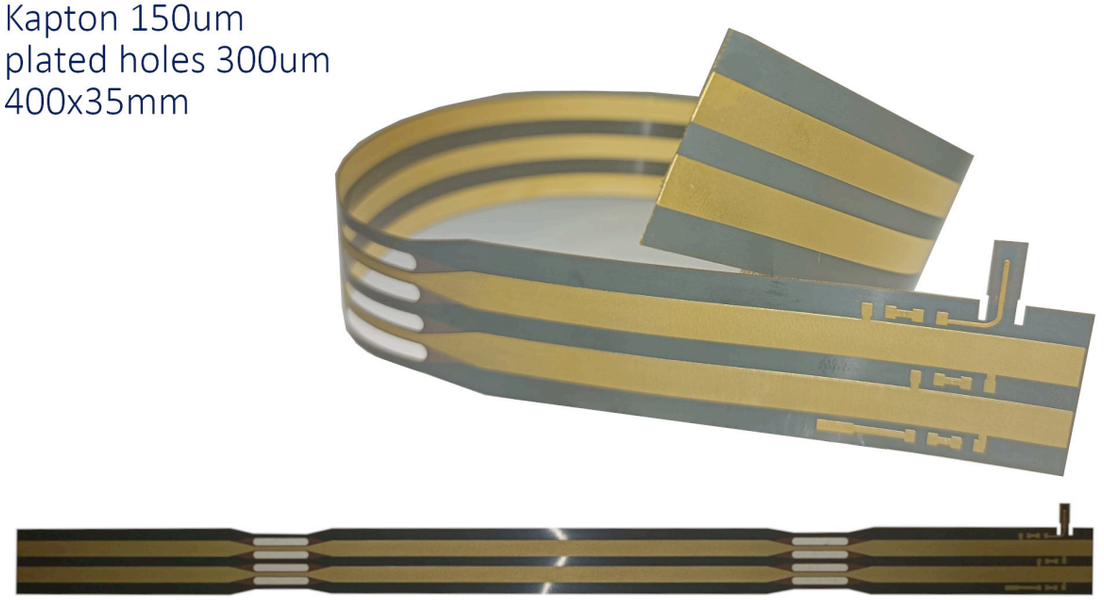


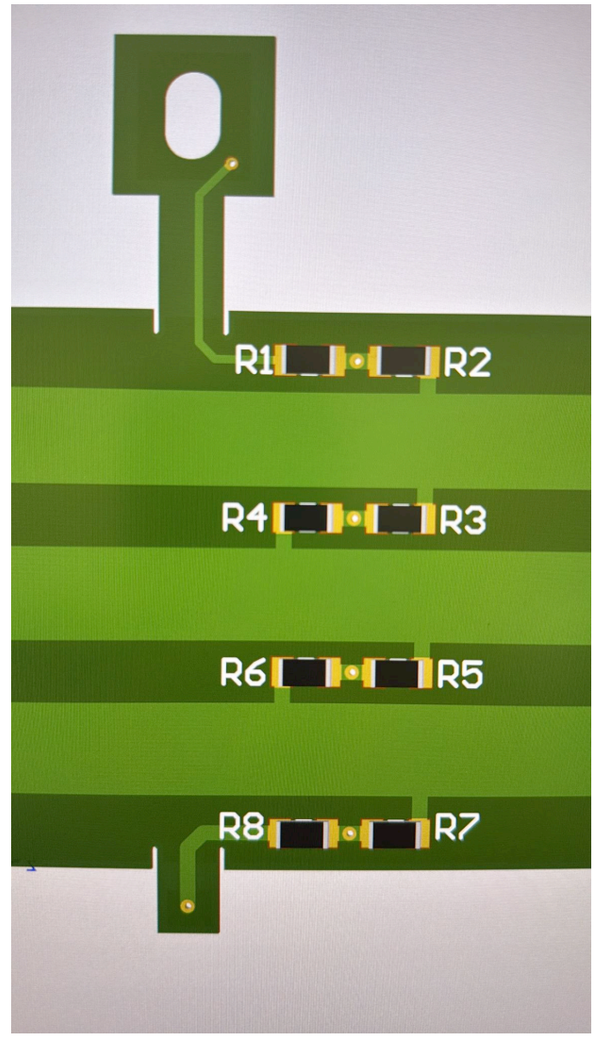


Field cage

- Based on a prototype tested in 2024
- Flexible PCBs with electrodes on both sides for optimal shaping of the drift field in high-ionization conditions
- Mounted on 3D-printed support (under design)

Kapton 150um
plated holes 300um
400x35mm





Blum, Riegler, Rolandi, *Particle Detection with Drift Chambers*

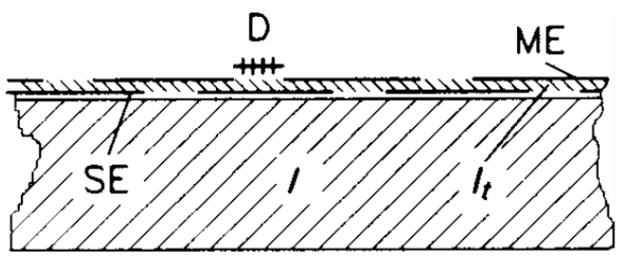
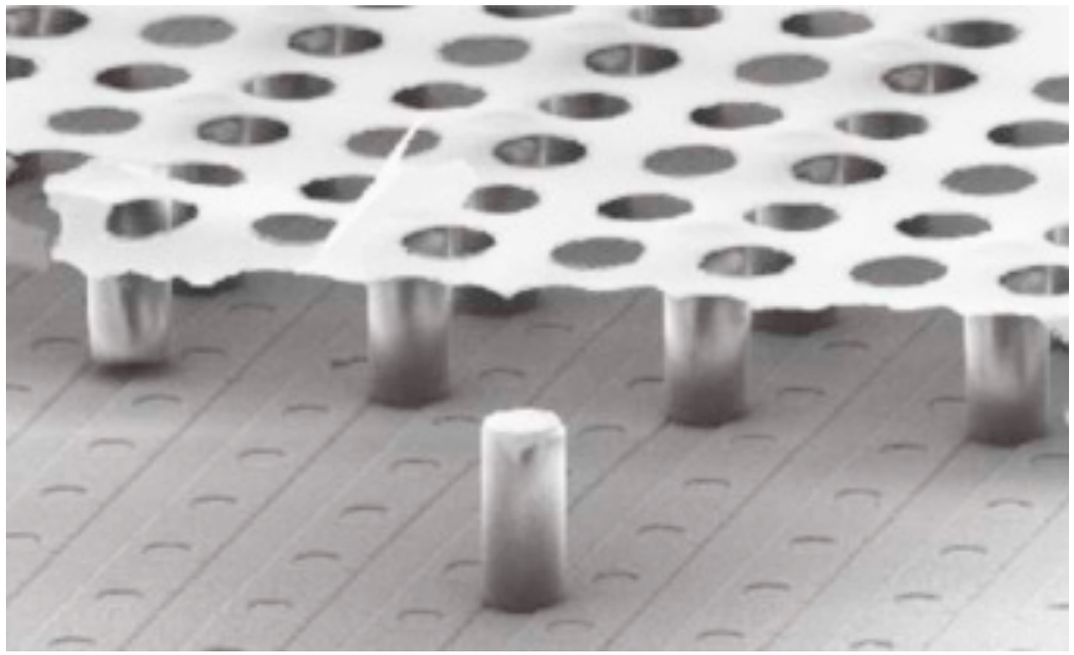
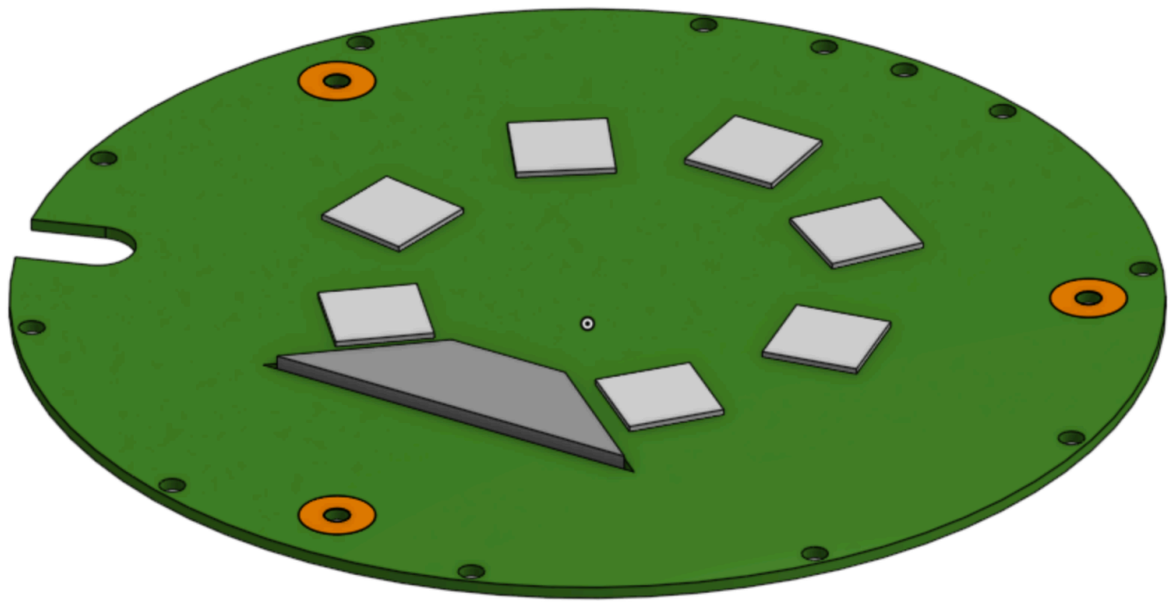


Fig. 3.17 Field-cage electrode configuration with secondary electrode strips (SE) covering the gaps between the main electrode strips (ME) behind a thin insulator foil (It). D: drift space; I: insulator

GridPix

- Miniaturized Micromegas
  - Mesh built on top of a TimePix pixelated sensor, with holes precisely aligned on top of the readout pixels
- Collaboration with University of Bonn, which will provide 8 GridPixes mounted on a custom PCB
  - PCB under design
  - delivery promised by October
- Trigger scintillator integrated on the readout plane



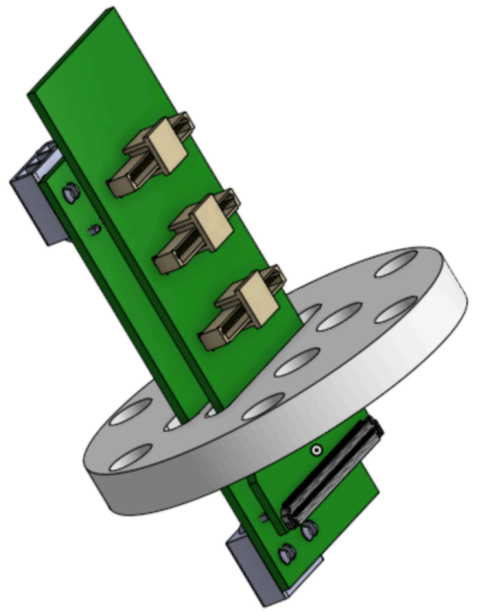


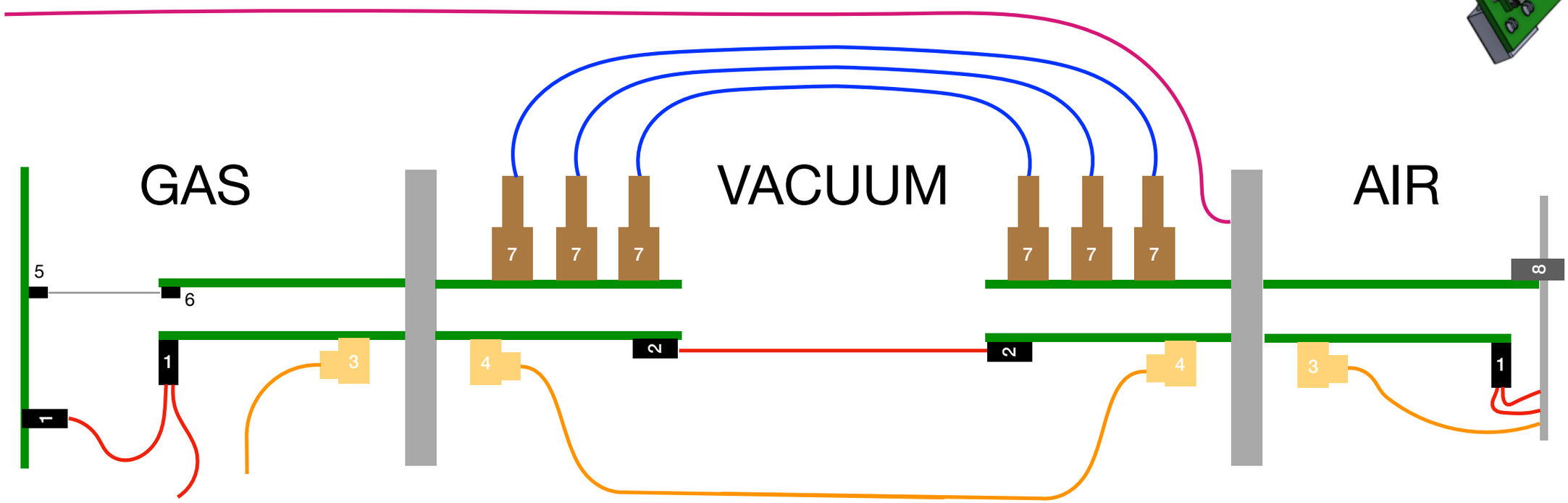
Signal transport and Services

- Vacuum compatible cabling and feedthroughs for high-speed LVDS communication + services (HV, LV, temperature sensors, gas distribution)
  - custom feedthrough boards under design
  - procurement of connectors and cables ongoing (higher cost than expected, try to economize on other componenst)

Molex 0150260660

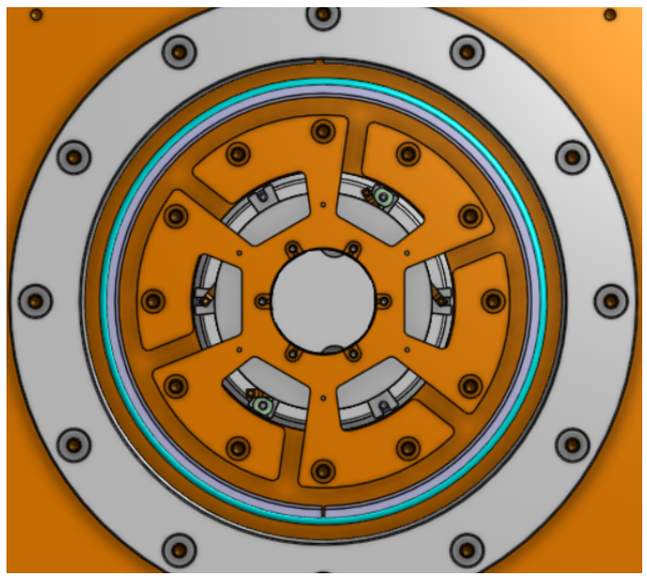
Cicoil CL-1000

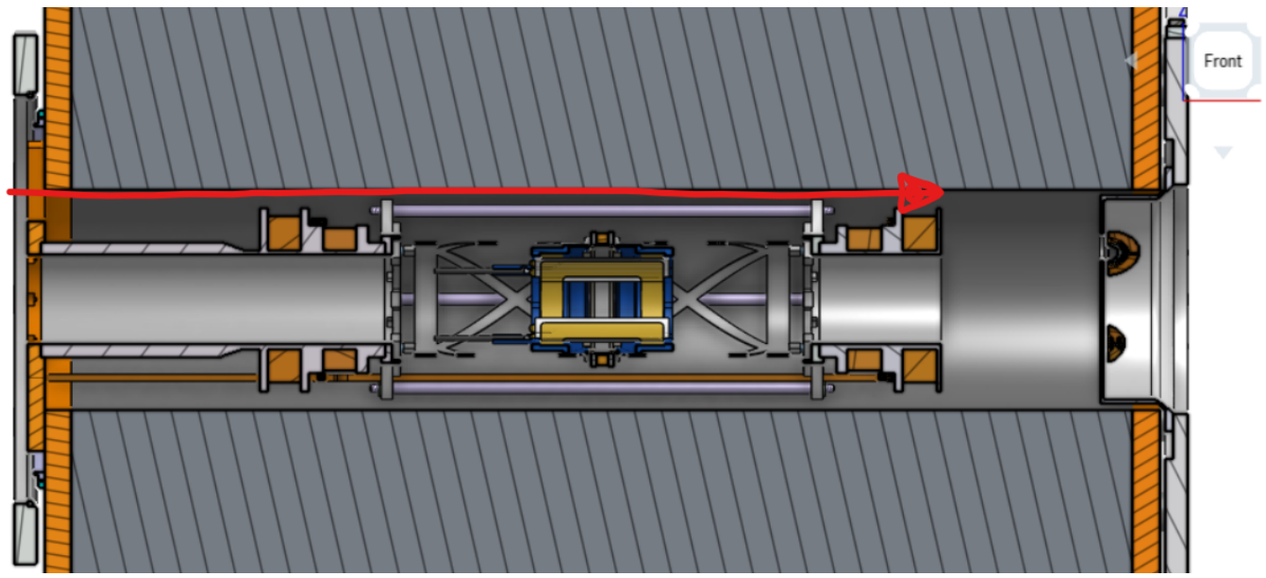




Alignment

- Any misalignment of the detector relative to the magnet translates into a bias in the measurement of the beam phase space:
  - sub-mm alignment inside the magnet is critical to preserve the functionality of the system
- Instrumentation for the inner muTPC alignment in the 2025 budget
- For global alignment, crowded environment in the magnet bore:
  - almost no line of sight from outside to the muTPC
  - necessity of installing **miniaturized alignment targets** (hollow retroreflectors) on the muTPC





2025 Schedule

- Currently, we are almost in standby, waiting for the finalization of the magnetic field design by the PSI group (expected within September)

	July		August		September		October		November		December	
Definition of the magnetic field (PSI)												
Finalization of the design												
Procurement												
Production of custom parts												
Assembly												
Tests @ INFN Roma												
Beam time												

2026 Plan

- The muTPC construction will be completed in 2025
- Based on the results of the 2025 beam time, we could consider implementing some corrections/upgrades of the design:
  - thinner entrance window
  - improved electrode geometry
- Systematic calibrations of the detector @ INFN Roma
- Development of the alignment system

Anagrafica 2026

	Ruolo	**FTE**
Francesco Renga	Primo Ric.	0.3
Cecilia Voena	Prof. Ass.	0.1
Daniele Pasciuto	Tecnologo	0.15

1 laureando (D. D’Ignazio)

Richieste 2026

APPARATI (9 kEURO + 4 kEURO S.J.)

- Entrance windows: 3 kEURO (S.J.) — vd. quotazione in backup
- Elettrodi: 1 kEURO (S.J.)
- 3 + 1 (spare) retroreflettori miniaturizzati: 8 kEURO — vd. quotazione in backup
- Meccanica di precisione per posizionamento retroreflettori: 1 kEuro

MISSIONI (17 kEURO)

- 2 settimane x 2 persone per commissioning + presa dati + decomissioning della muTPC: 6 kEURO
- 4 settimane per turni di collaborazione: 6 kEURO
- 3 meeting x 2 persone: 5 kEURO

Backup

1.9 kGBP + IVA + sdoganamento ~ 3kEuro

Quotation

Customer Information **Quote number:** #02504124

Name:	Philipp Schmidt-Wellenburg	**Date:**	29th April 2025
Address:	Paul Scherrer Institute PSI WBWA/231 Forschungsstrasse 111 5232 Villigen PSI Switzerland	**Contact:**	Peter Anastasi
		Account No:	PSI0176
		Terms:	30 days
		Delivery:	approx 3 weeks from receipt of purchase order
Email:	francesco.renga@roma1.infn.it		
Tel:			
Fax:			

Item	Description	Quantity	Unit Price	Total
1	silicon nitride membranes: frame: 17.5 mm x 17.5 mm, 200 µm thick membrane: 4.5 mm x 4.5 mm, 500 nm thick membrane array: 3 x 3 product code: to be confirmed	5	£244.80	£1,224.00
2	supply and mounting of membranes in 1) above into Silson standard mount F10001	5	£120.00	£600.00
			Goods Total	£1,824.00
			Insurance	£18.24
			Carriage	£40.00
			Total	£1,882.24

1. Prices shown are in UK Pounds
2. Quotation valid for 60 days
3. Inco Terms: DAP
4. Please submit orders to sales@silson.com

EORI No: GB623760251000 **Vat No: GB 623 7602 51**

PLX Inc.
40 West Jefryn Blvd.
Deer Park NY 11729

Website: www.plxinc.com
Email: sales@plxinc.com

Phone: 631-586-4190
Fax: 631-586-4196

Int Phone: 001-1-631-586-4190
Int Fax: 001-1-631-586-4196

Quote Number: 23347

QUOTE

Quote To:	
Istituto Nazionale di Fisica Nucleare	**Date:** 6/25/2025
	Expires: 7/25/2025
	Reference: MO-VPWTY
	Sales Person: Jessica Dare sales@plxinc.com
	Fax:
	FOB: PLX - DEER PARK
Phone: Fax:	**Terms:** PAY IN ADVANCE

We are pleased to quote on your request as follows:
PLX shall not disclose any information that the company deems proprietary.

Shipipng lead time begins after receipt of formal order and payment.

USD

Line	Part Description	Rev Drawing	Expected Qty	Unit Price	Ext. Price
1	OW-008-30D O/W 0.08"X30SEC UV Enhanced Aluminum Coating		1.00 EA	1,784.00	1,784.00

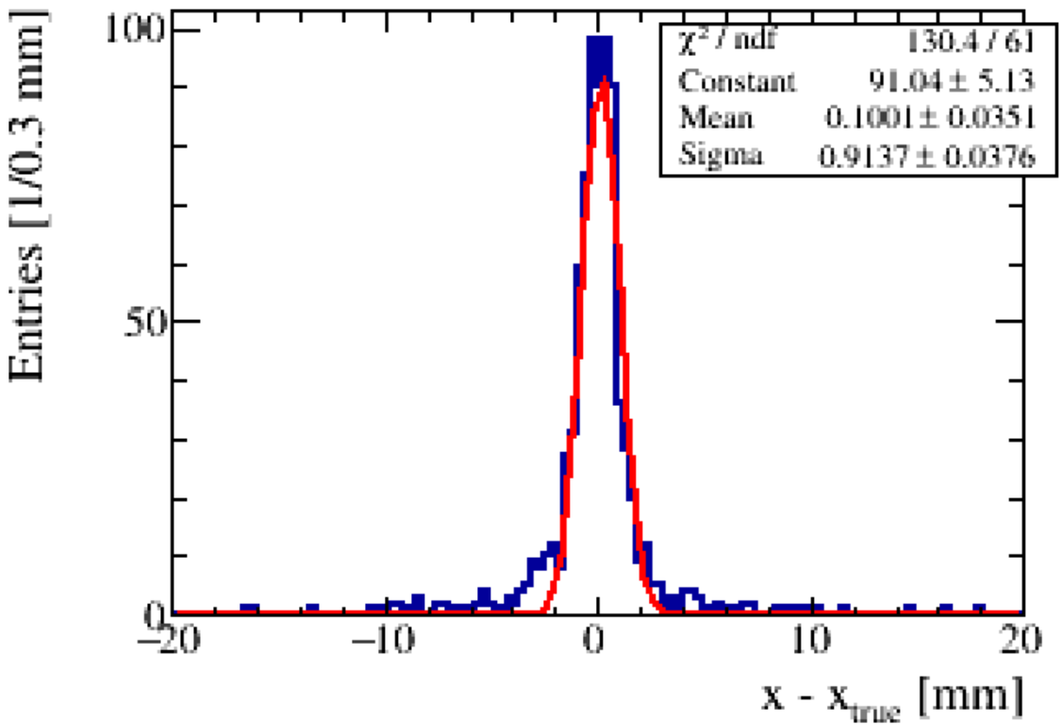
- QUANTITY BREAKS -

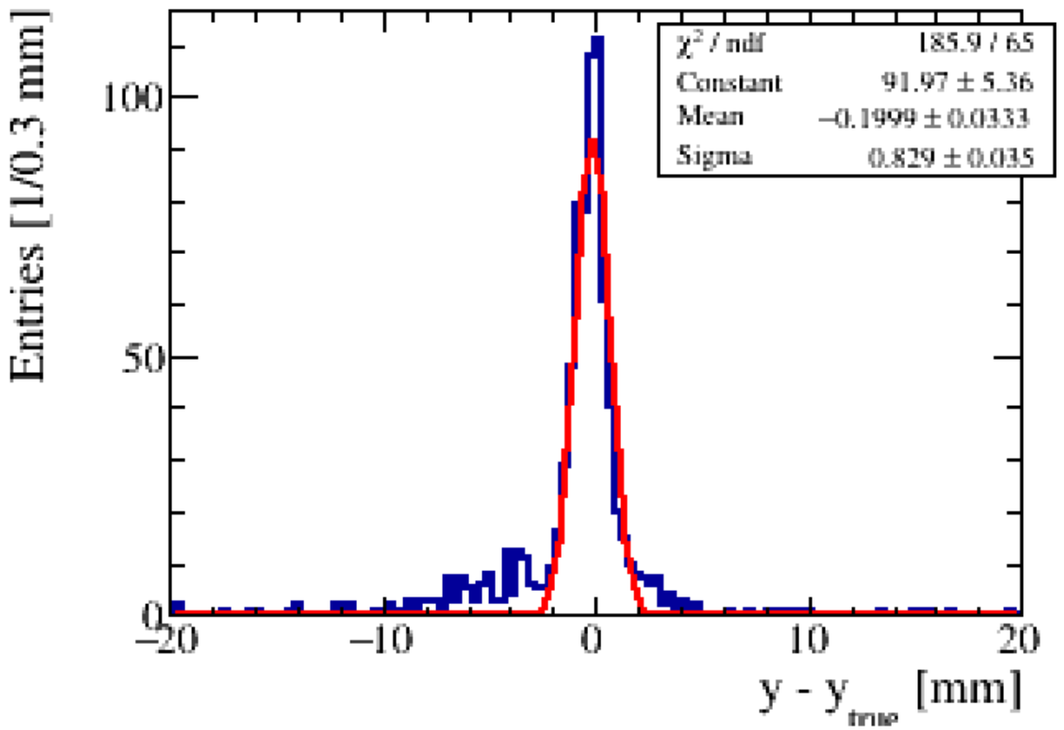
Quantity	Unit Price	Ext. Price	Lead Time
1.00 EA	1,784.00 /1	1,784.00	1-2 weeks
5.00 EA	1,734.48 /1	8,672.40	1-2 weeks

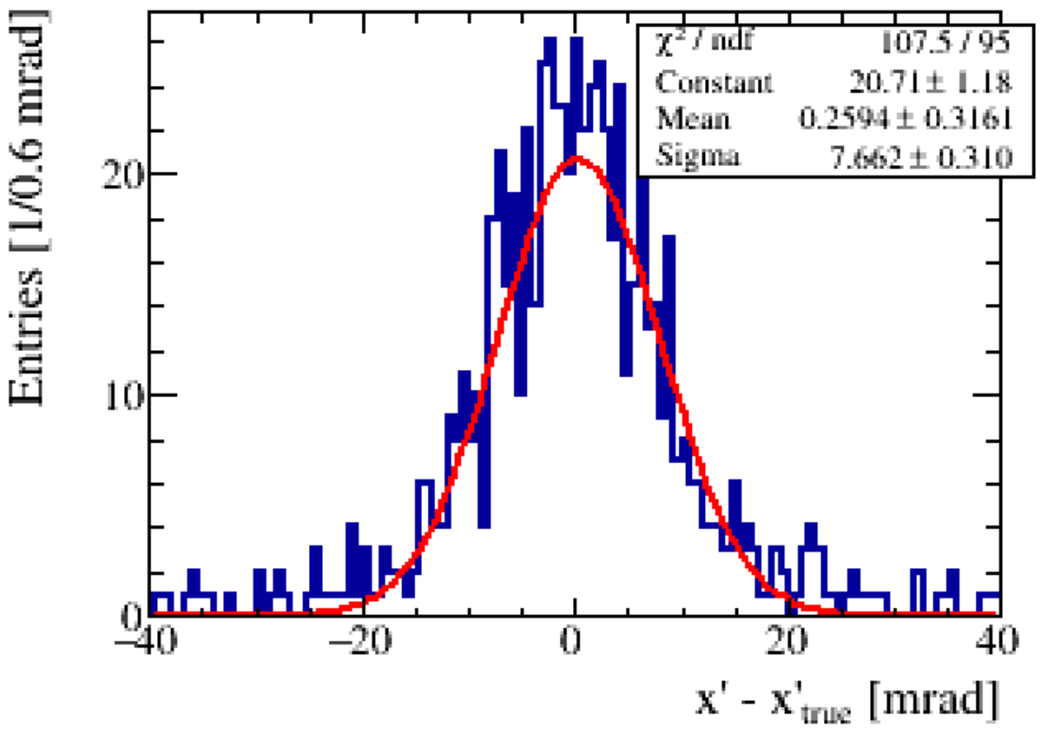
Lines Total	1,784.00
Total Taxes	0.00
Line Miscellaneous Charges	0.00
Quote Miscellaneous Charges	0.00
Quote Total	**1,784.00**

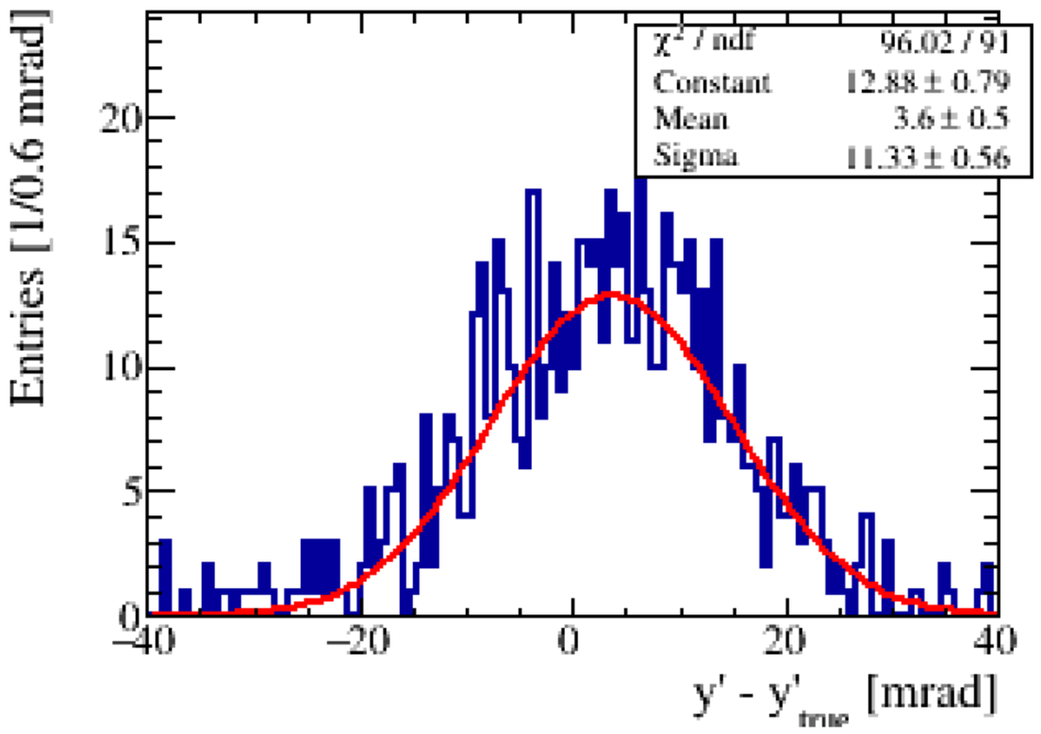
QuotForm:001:00

3 + 1 (spare) x 1.8kUSD + IVA + sdoganamento ~ 8 kEURO


Entries [1/0.3 mm]
100
50
0
−20
−10
0
10
20
x - x_true [mm]
χ² / ndf 130.4 / 61
Constant 91.04 ± 5.13
Mean 0.1001 ± 0.0351
Sigma 0.9137 ± 0.0376


Entries [1/0.3 mm]
100
50
0
−20
−10
0
10
20
y - y_true [mm]
χ² / ndf 185.9 / 65
Constant 91.97 ± 5.36
Mean −0.1999 ± 0.0333
Sigma 0.829 ± 0.035


Entries [1/0.6 mrad]
20
10
0
−40
−20
0
20
40
x' - x'_true [mrad]
χ² / ndf 107.5 / 95
Constant 20.71 ± 1.18
Mean 0.2594 ± 0.3161
Sigma 7.662 ± 0.310


Entries [1/0.6 mrad]
20
15
10
5
0
−40
−20
0
20
40
y' - y'_true [mrad]
χ² / ndf 96.02 / 91
Constant 12.88 ± 0.79
Mean 3.6 ± 0.5
Sigma 11.33 ± 0.56