RD_FA WP5
Drift Chamber
Status e Richieste 2018

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Status

Che cosa è stato fatto:

- Sviluppo del concetto generale di un tracciatore per colliders e^+e^- con Pid
- Ottimizzazione del disegno di camera a drift per FCC-ee
- Ottimizzazione del disegno di camera a drift per CEPC
- Adattamento dei due disegni per IDEA
- Sviluppo del pacchetto di *full simulation* in GEANT4 della camera a drift di IDEA
- Integrazione nella simulazione di un *dummy* VXD e un *dummy* preshower: inizio ottimizzazione del detector

Status

Che cosa è stato fatto: *Presentazioni*

An ultra-light drift chamber with particle identification capabilities
CEPC-SppC Study Group Meeting, 2-3 September 2016, Beihang University - https://indico.ihep.ac.cn/event/6149/timetable/

Wire Chamber at FCC-ee
WG11 Detector Design Meeting, 17 Oct 2016, CERN - https://indico.cern.ch/event/558137/

A Drift Chamber Option for the CEPC
IAS Program on High Energy Physics, 9-26 January 2017, Hong Kong HKUST - iasprogram.ust.hk/hep/2017/conf.html

IDEA Tracking Highlights
CEPC Study Group Meeting, 19-21 Apr 2017, Wuhan - http://indico.ihep.ac.cn/event/6433/overview

"Full" Simulation of the IDEA Drift Chamber at FCC-ee
WG11 Detector Design Meeting, 11 May 2017, CERN - https://indico.cern.ch/event/628428/

Preliminary results on a full simulation of the drift chamber
WG11 Detector Design Meeting, 19 June 2017, CERN - https://indico.cern.ch/event/638354/

Update on the integration of the simulation packages of the IDEA detector
WG11 Detector Design Meeting, 31 July 2017, CERN - https://indico.cern.ch/event/650053/

Status

Che cosa stiamo facendo:

Co-convener (FG) WG11 di FCC-ee Detector Design Meeting al CERN

Integrazione della *full simulation* di IDEA nei framework di FCC-ee e di CEPC (GT)

Ottimizzazione della geometria e del layout della camera a drift di IDEA

Definizione degli algoritmi di *track finding* e *fitting*

Beam test di un prototipo (144 canali, circa 1000 fili) al PSI (piM1 100-400 MeV/c) per studi di *Cluster Timing/Counting*

Beam Test at PSI

- **September 13 – 27 piM1 beam (e/μ/π 100÷400 MeV/c)**
  - supported by MEG2 and FIRB (Renga-Tassielli)
  - **cluster timing** for spatial resolution (impact parameter bias)
  - **cluster counting** for particle identification

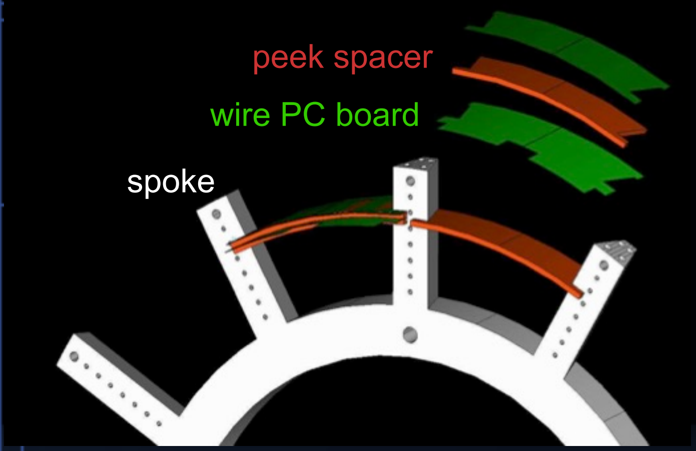
Status

Che cosa vorremmo fare nel 2018:

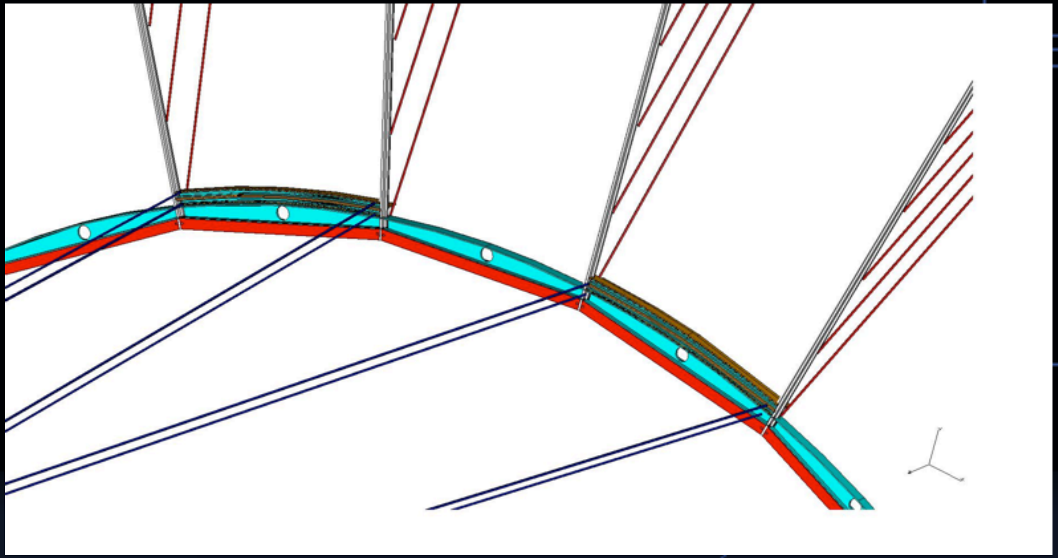
1.	Studi su componentistica camera • wirePCB, spaziatori, spokes, • schema recupero deformazioni, • strategie di sostituzione fili)	3 Keuro
2.	Studi su fili di differenti materiali	3 Keuro
3.	Studi su materiali nanocompositi trifasici	4 Keuro
4.	Prototipo scheda FPGA multicanale	5 Keuro

1. Componentistica Camera a Drift

MEG2



IDEA (from Mu2e I-Tracker Proposal)



2. Studi su Fili di differenti materiali

sagitta due to electrostatic forces on sense wire displaced by Δ from central symmetry position

$$\delta = \frac{C^2 V_0^2 L^2}{4\pi\varepsilon T W^2}\Delta$$

C = wire capacitance per unit length
V_0 = wire voltage
L = wire length
T = wire mechanical tension
w/2 = wire distance from ground plane
R = sense wire radius

$$C = \frac{2\pi\varepsilon}{\ln\left(\frac{\{2\}w}{2R}\right)}$$

stability condition

$$\boxed{T \geq \frac{\pi\varepsilon V_0^2 L^2}{w^2\left(\ln\frac{w}{R}\right)^2}}$$

MEG2 drift chamber: *L = 2 m, w = 7 mm*
T ≥ 0.12 N
(MEG2 wires are strung at ***T = 0.25 N***)

For IDEA Drift Chamber, *L = 4 m, w = 12 mm*,
(same gas gain and same sense wire radius):

$\boxed{T \geq 0.16N}$ **or, for *T = 0.25 N*,** $\boxed{L \leq 4.9m}$

2. Studi su Fili di differenti materiali

Suppose that occupancy imposes a reduction of the cell size for the inner layers from w = 12 mm to 7 mm.

Stability condition requires $T \geq 0.47$ N (1500 MPa): **above W wire YS!**

$$\delta = \frac{\pi r^2 \delta}{8}\left(\frac{g}{T}\right)L^2$$

Possible solutions:

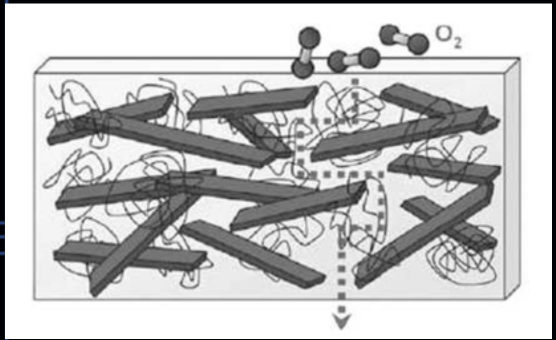
- shorten wire length for inner layers from L = 4 m to 2.3 m ⇒ **loss of solid angle**
- increase wire radius R = 20 μm to 35 μm ⇒ **increment of X_0, end plate tension, grav. sag**
- **find new materials: higher YS and lower density** ⇒ **reduction of X_0, grav sag, ep tension**

wire material	**W**	**Mo**	**Ti**	**Al**	**C**
δ [g/cm^3]	19.3	10.2	4.5	2.7	2.2
X_0 [cm]	0.35	0.96	3.6	8.9	19.3
X_0 [g/cm^2]	6.8	9.8	16.2	24.0	42.7
Y.S. [MPa]	1500	550	800	240	6000

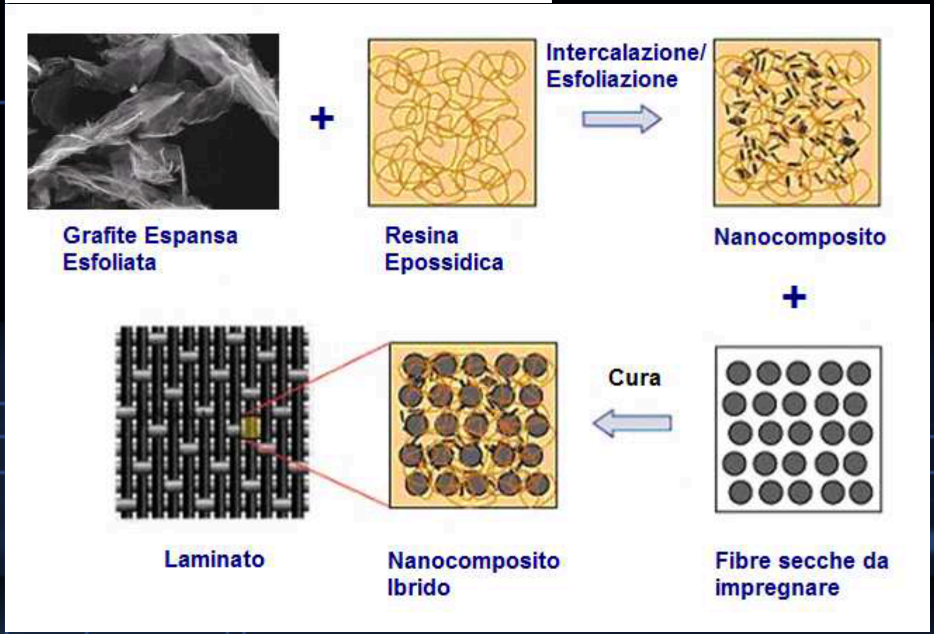
wire coating	**Au**	**Ag**	**Sn**	**Cr**
δ [g/cm^3]	19.3	10.5	7.2	7.2
X_0 [cm]	0.33	0.85	1.2	2.1
X_0 [g/cm^2]	6.5	9.0	8.8	14.9

- Large diameters C wires can be obtained with bundled 6-8 μm filaments (tow) – **to be studied**
- C wires cannot be crimped (transverse fragility) or soldered, unless metal coated
- Metal coating processes **to be studied** (need at least 2 μm skin depth for 1-2 GHz bandwidth, depending on metal)

3. Studio su Materiali Nanocompositi Trifasici



I **nanocompositi grafene-polimero** riducono la **permeabilità ai gas** grazie all'elevato rapporto di forma delle lamelle, alla loro orientazione e alla frazione volumetrica di grafene, aumentando la tortuosità del cammino delle molecole di gas nella loro diffusione attraverso il polimero (modello di Nielsen).
Inoltre, grazie alle proprietà del grafene, aumentano la conducibilità elettrica e, quindi, lo **schermaggio elettrostatico e a radiofrequenza**, limitando, così, gli spessori di eventuali rivestimenti metallici.



Graphene Properties:

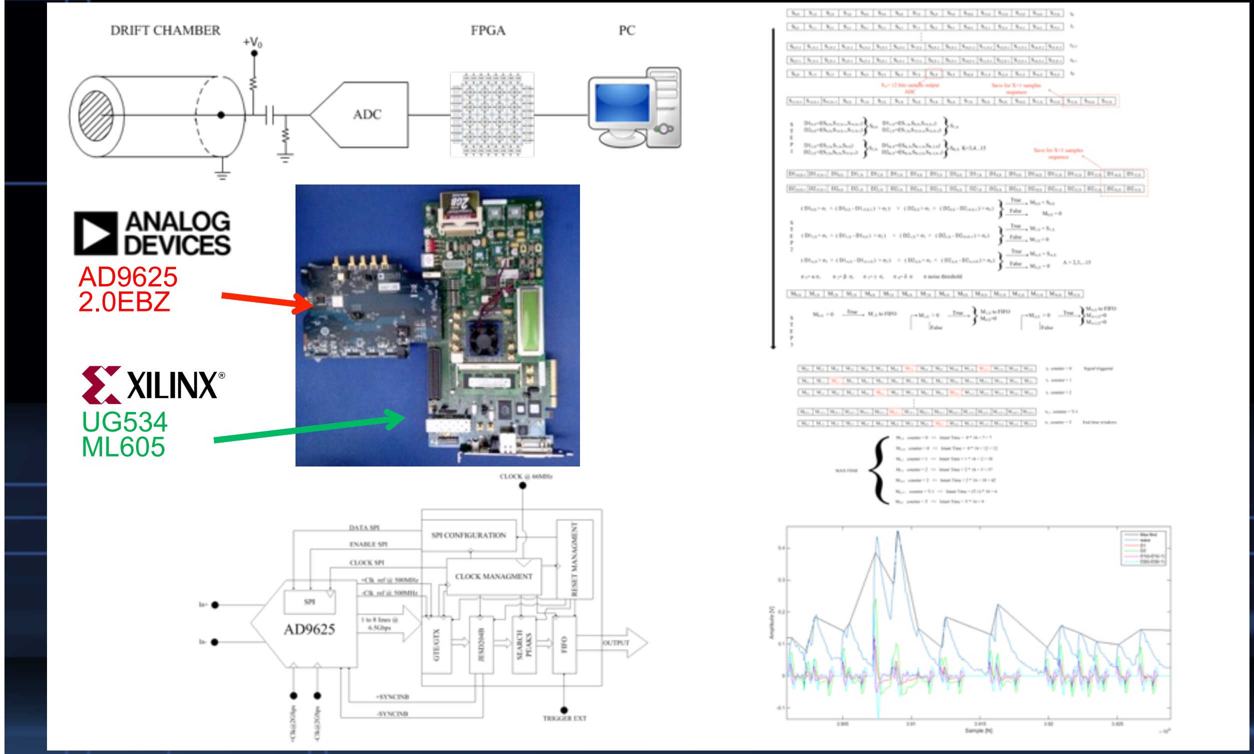
Young modulus ≈ 1100 GPa
Breaking strength ≈ 130 GPa
Thermal conductivity > 2500 W/m·K
Electrical conductivity ≈ 10^6 S/m

da A. L'Erario
Definizione e caratterizzazione dei materiali costituenti rivelatori traccianti ad alta trasparenza, 2014, Tesi di Dottorato in Ingegneria dei Materiali e delle Strutture. Università del Salento, Lecce.

4. Prototipo Scheda FPGA multicanale

Suppose a trigger rate of 10 kHz, an average occupancy of 10% over the 56,000 drift cells, a maximum drift time of 500 ns readout at 2 GSa/s => **500 GB/s !** (**unsustainable!**)

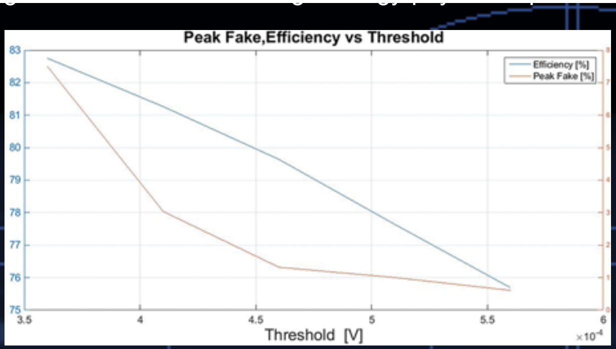
Solution: analyze in real time the signal waveform: find the ionization peaks; register and transfer only the time and amplitude of each peak with a short relative delay with respect to the trigger. This represents a data reduction of about 50, equivalent to a data transfer of **10 GB/s** (**manageable today!**)



Proof of principle demonstrated for one FPGA per single channel on evaluation boards.

publ. in Vol. "Field - Programmable Gate Array," ISBN 978-953-51-3208-0

http://www.intechopen.com/articles/show/title/the-use-of-fpga-in-drift-chambers-for-high-energy-physics-experiments



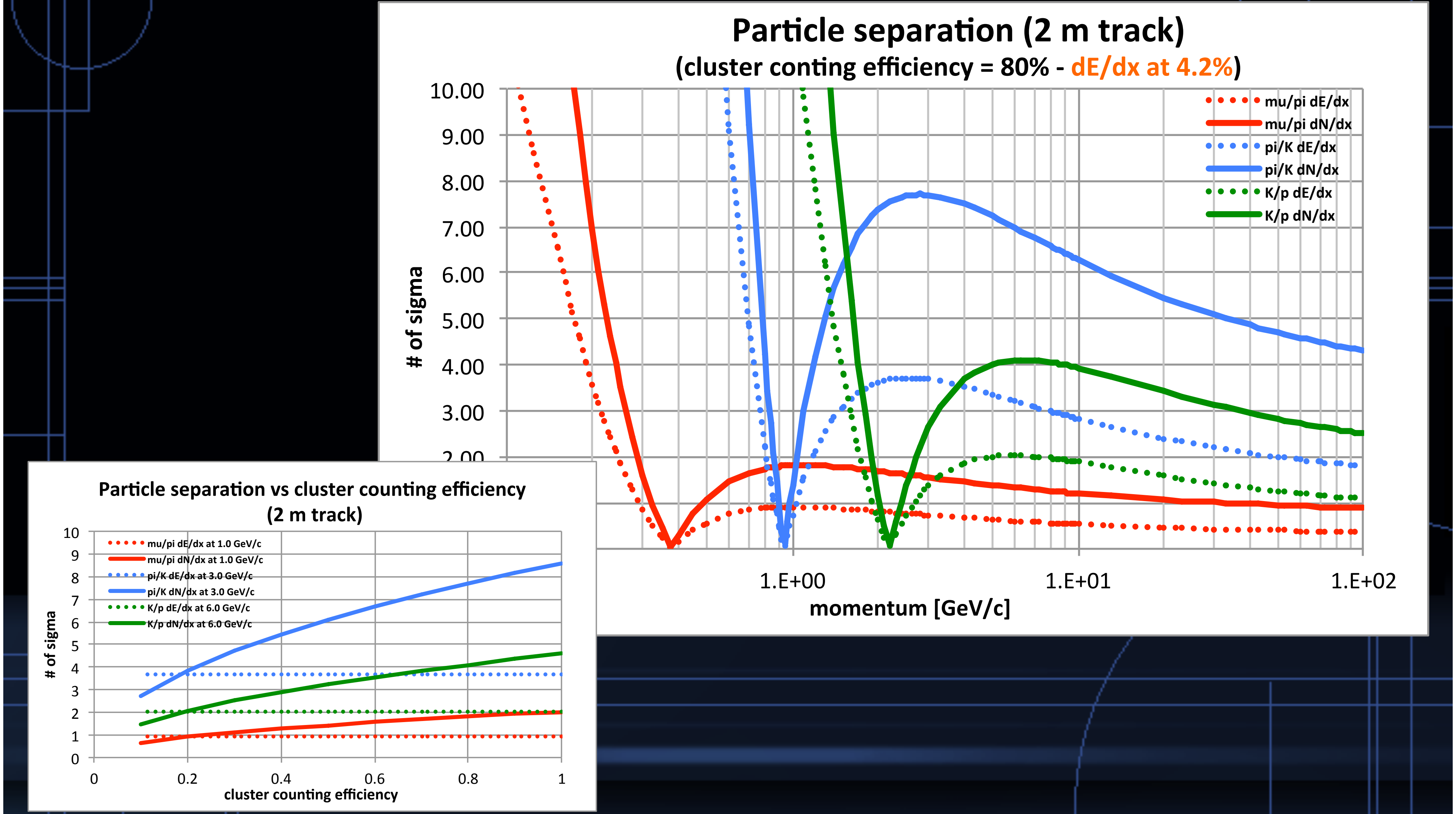
Need to implement it on a multi-ch board with a single FPGA.

Status

Che cosa resta da fare in futuro:

- Beam test of drift chamber prototype at CERN (π/K separation)
- IDEA Slice test: drift chamber + preshower + dual readout
- Full length prototype (≥ 4 m, few (25?) cells, C (?) wires)
  - test electrostatic stability
  - cosmic ray tests
  - longitudinal coord. measurement

Drift Chamber Particle Id.



Particle separation (2 m track)

(cluster conting efficiency = 80% - dE/dx at 4.2%)

Particle separation vs cluster counting efficiency (2 m track)