IDEA concept
Status Report

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INFN – Lecce

WG11
CERN, October 4, 2019

Disclaimer

- All transparencies are stolen from recent presentations of different authors.
- No software developments.
- No magnet updates.

Outline

- IDEA detector: a few reminders
- Current activities on
  - Vertex detector
  - Drift Chamber
  - Calorimeter
  - Preshower and Muons

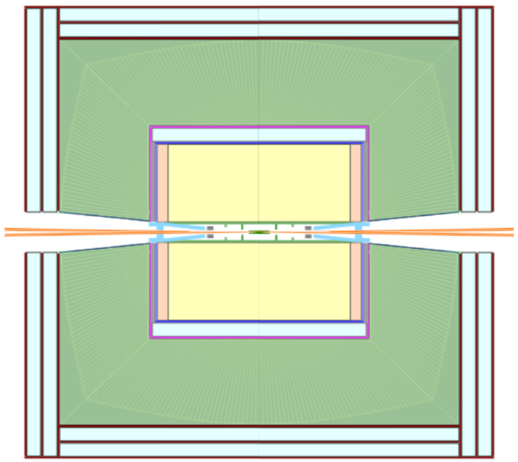
FCCee IDEA Detector

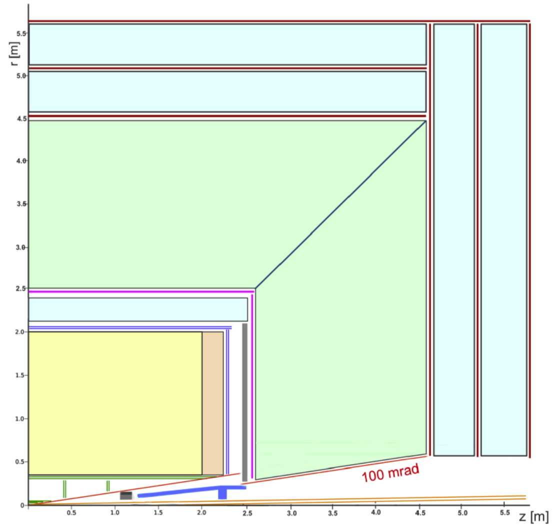
Beam pipe: r ~1.5 cm

Vertex: 5 MAPS layers
r = 1.7-34 cm

Drift Chamber: 4 m long, r = 35-200 cm

Outer Silicon Layers: strips





Superconducting solenoid coil: 2 T, r ~ 2.1-2.4 m
0.74 X_0, 0.16 λ @ 90°

Preshower: ~1 X_0 µ-RWELL MPGD

Dual-Readout Calorimeter: 2 m / 8 λ_{int}

Yoke + Muon chamber: µ-RWELL MPGD

Vertex detector

Exploring CMOS technologies, since they have the potential for low cost/high throughput

- VTX: Depleted Monolithic Active Pixels
  - – Fast signal
  - – Possibility for very thin detectors (low material)
  - – Small pitches already realized
  - – INFN/CSN5 developments: SEED-ARCADIA
    - One AIDA++ EoI submitted
  - – INFN/(CSN5+CSN1) developments: HVR_CCPD-ATLAS
    - One AIDA++ EoI submitted
- Outer tracker:
  - – Proposing passive CMOS sensor (productions by ATLAS/CMS on going, part of the ATLAS pixel detector market surveys)
    - One AIDA++ EoI submitted

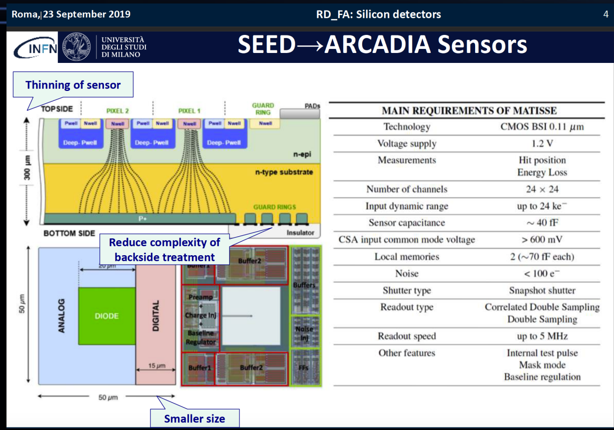
ARCADIA
(Advanced CMOS Architectures with Depleted Integrated sensor Arrays)
INFN CSN5 Call Project targeting a full-size system-ready demonstrator of a low-power high density pixel matrix CMOS monolithic sensor featuring:

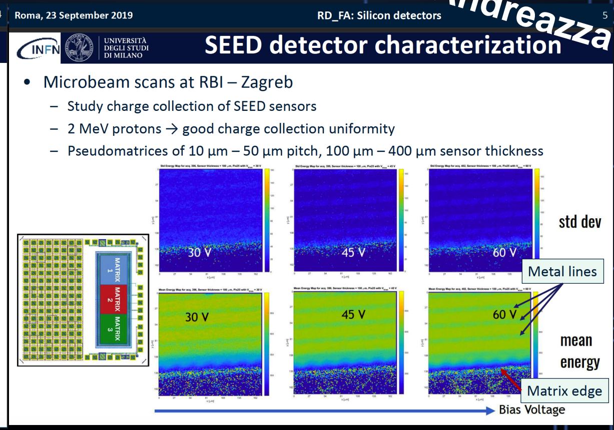
1. Active sensor thickness in the 50-500 μm range
2. Operating in full depletion fast charge collection by drift
3. Scalable readout architecture with ultra-low power capability O(10 mW/cm^2)

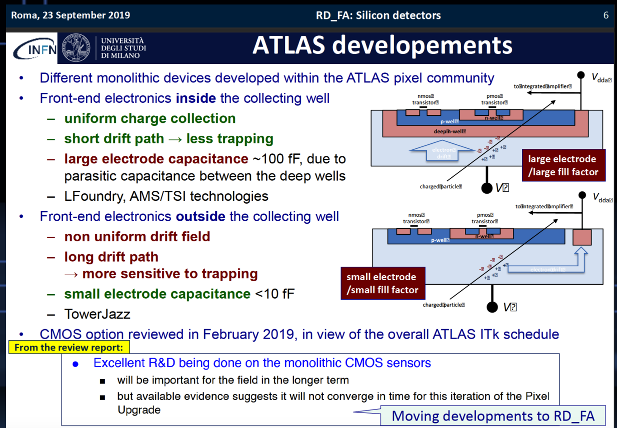
Vertex detector

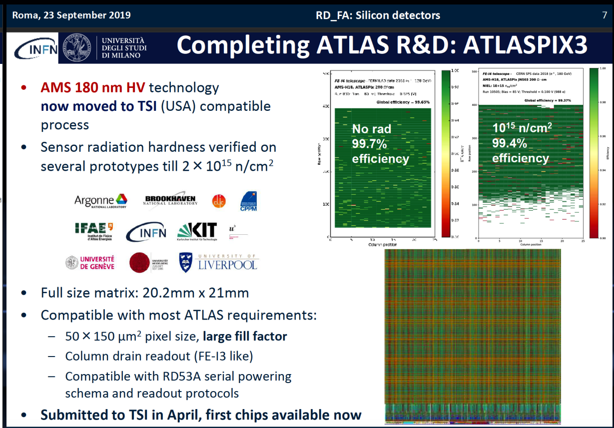
from Attilio Andreazza

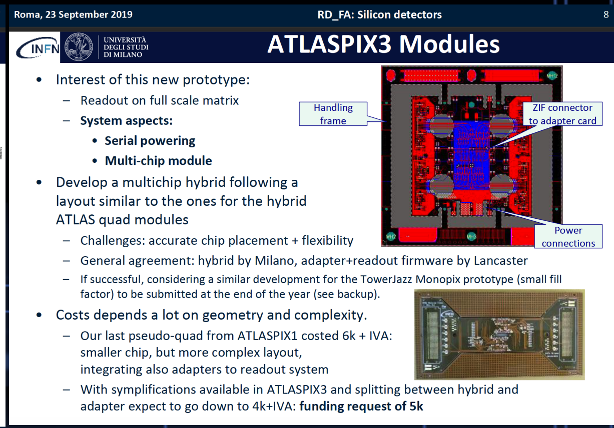
- Silicon package till now mainly concentrated on application of CMOS technologies
- Assess multi-chip performance of the detectors developed for ATLAS
- Technology of great interest for INFN
- Submitted 5 (3 from IDEA) AIDA++ EoI on CMOS related technologies







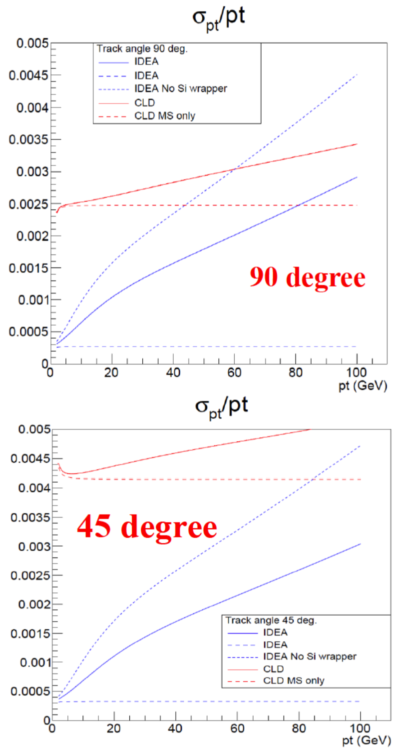




Drift Chamber performance

from Lorenzo Pezzotti

Full tracking performances (vertex + drift chamber + Si wrapper)



@ 90°, asymptotic behavior

IDEA

$$\sigma_{p_t}/p_t \simeq 2.2 \times 10^{-5} p_t$$

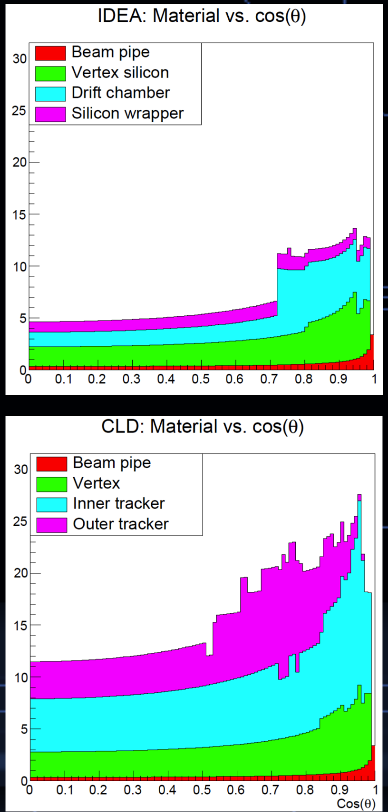
IDEA no Si wrapper

$$\sigma_{p_t}/p_t \simeq 5.7 \times 10^{-5} p_t$$

+

Cluster counting
for improved particle identification:
$dN_{cl}/dx \sim 2\%$ vs $dE/dx \sim 4\%$

No ion back-flow & short drifting time.

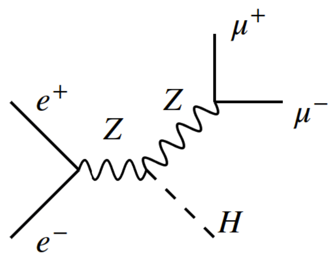


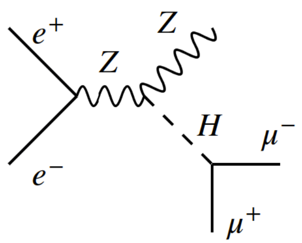
Drift Chamber performance

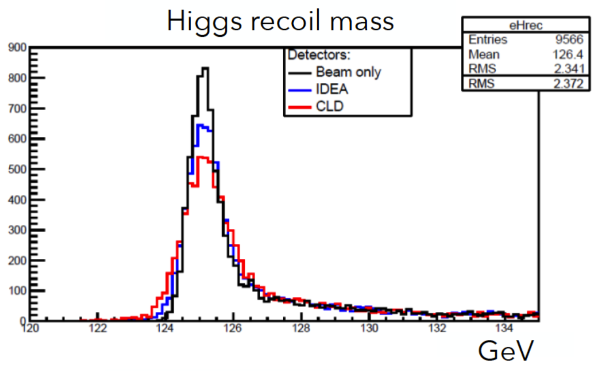
from Lorenzo Pezzotti

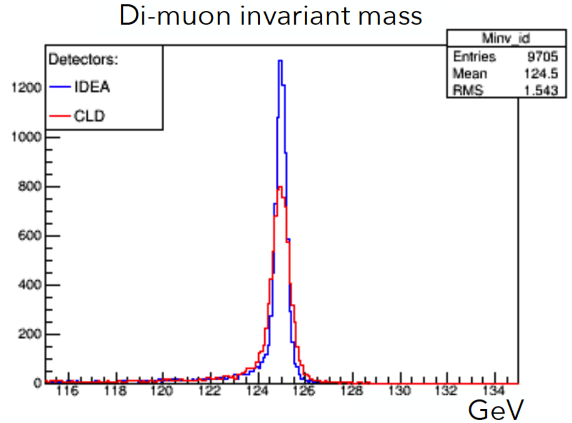
IDEA/CLD Comparison

Run @Higgs pole, assuming 0.136% beam spread

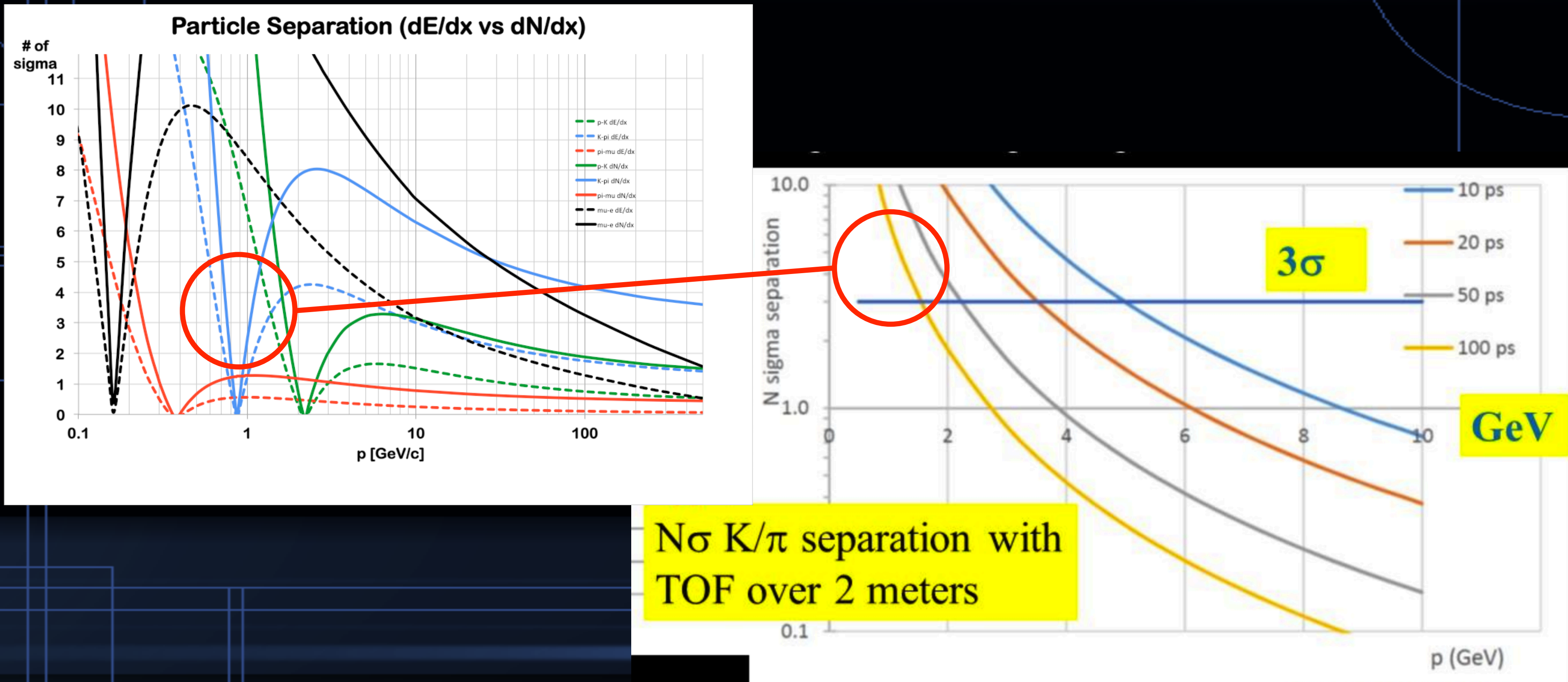








Drift Chamber performance



Drift Chamber R&D: wire length

Electrostatic stability condition $T > \frac{C^2 V_0^2 L^2}{4\pi\varepsilon w^2}$

T = wire tension
C = capacitance per unit length
V_0 = anode-cathode voltage
L = wire length, w = cell width

IDEA Drift Chamber: **C = 10 pF/m, V_0 = 1500 V, L = 4.0 m, w = 1.0 cm**

T > 0.32 N

- 20 µm W sense wire (Y.S. ≈ 1200 MPa): **T_{max} = 0.38 N** (marginal)
- 40 µm Al field wire (Y.S. ≈ 300 MPa): **T_{max} = 0.38 N** (marginal)

=> **shorten chamber** (loss of acceptance)
=> **widen cell size** (increase occupancy)
=> **increase wire diameter** (increase multiple scattering and endplate load)

or,

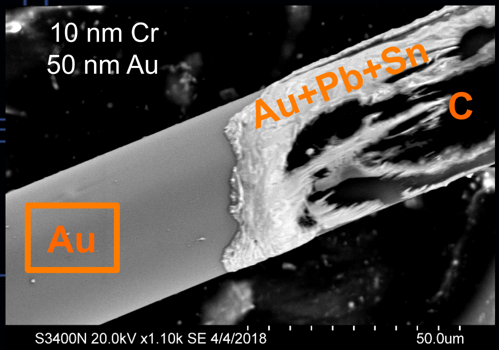
=> replace 40 µm Al with **35 µm Carbon monofilament**
(Y.S. > 860 MPa): **T_{max} > 0.83 N**

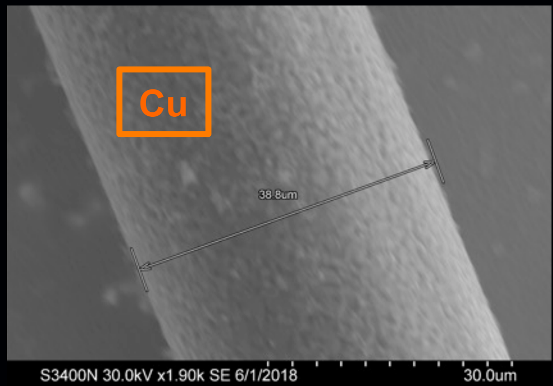
Drift Chamber R&D: C wire

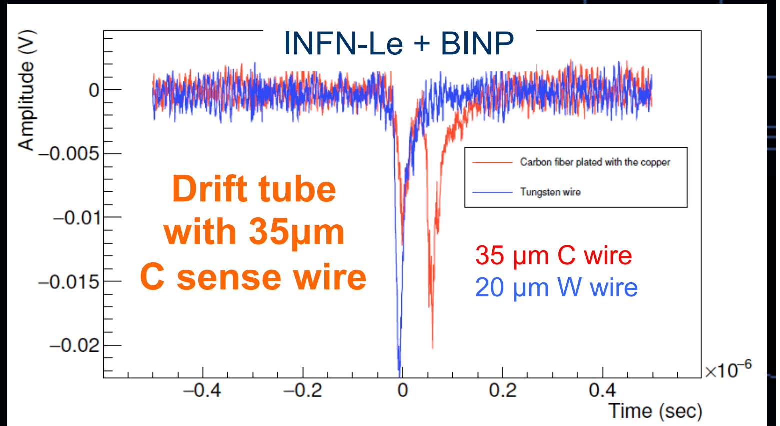
BINP
A. Popov
V. Logashenko

HiPIMS: High-power impulse magnetron sputtering

physical vapor deposition (PVD) of thin films based on magnetron sputter deposition (extremely high power densities of the order of kW/cm^2 in short pulses of tens of microseconds at low duty cycle <10%)

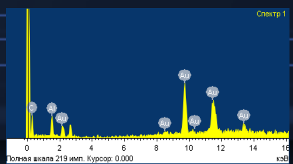




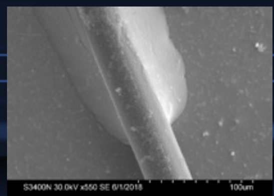


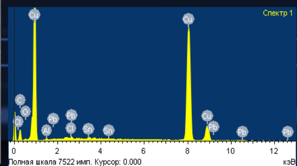
soldering attempt

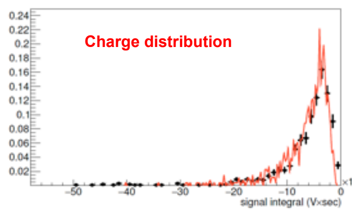
Lead forms intermetallic compound with gold and completely dissolves the 50 nm Au layer.

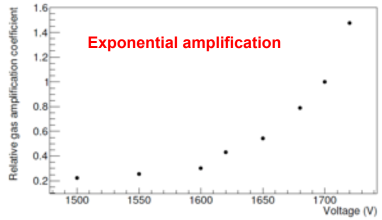


good solder wettability on Cu







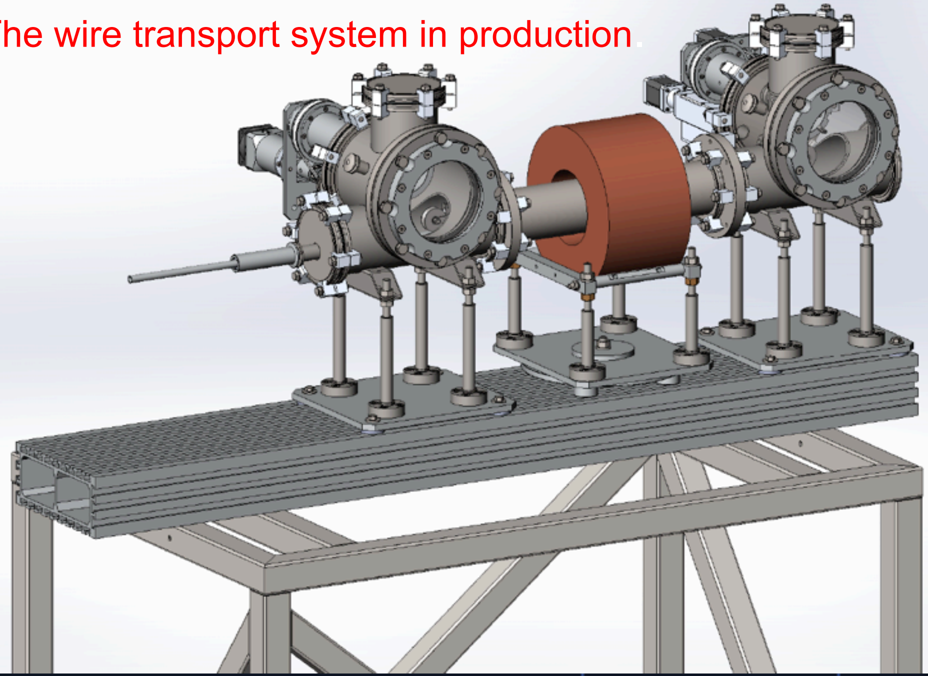


Drift Chamber R&D: C wire

BINP
A. Popov
V. Logashenko

- Cu coating test of 35 μm carbon monofilament very successful on short samples with HiPIMS at BINP, Novosibirsk
- Investigation of magnetron sputtering facilities elsewhere
- Industrialization of process for coating continuous spooled monofilament ongoing
- **Different alternatives?**

Cylindrical magnetron completed at BINP.
Stable discharge obtained.
The wire transport system in production



C wire soldering **without** metal coating

Soldering of Carbon Materials Using Transition Metal Rich Alloys

Published online August 09, 2015
10.1021/acsnano.5b02176

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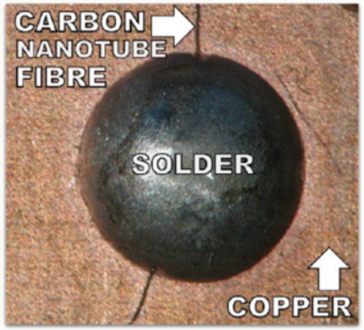
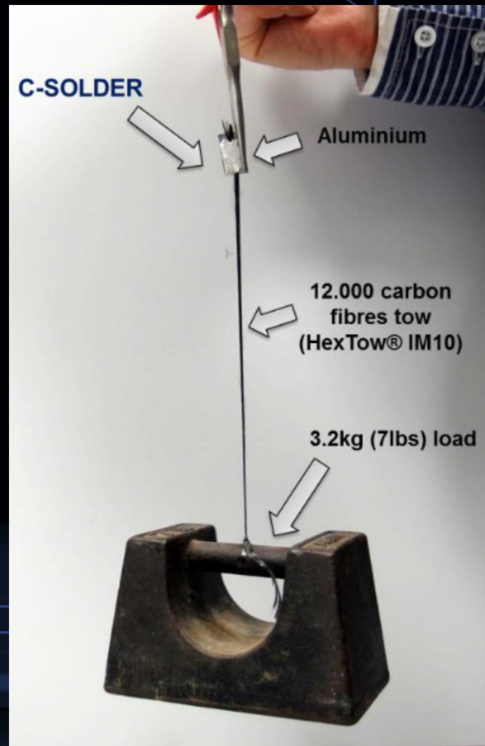
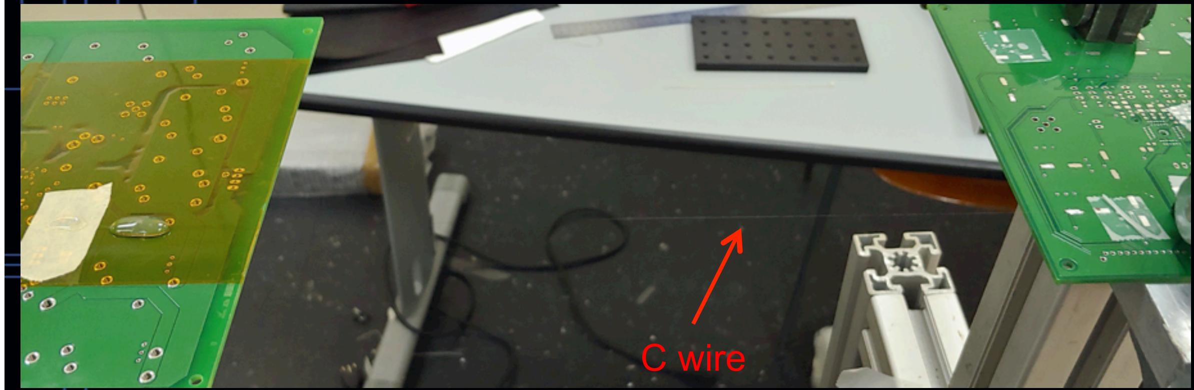
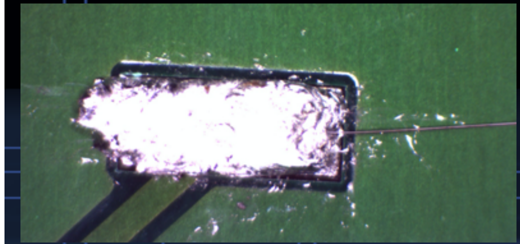
ABSTRACT Joining of carbon materials *via* soldering has not been possible up to now due to lack of wetting of carbons by metals at standard soldering temperatures. This issue has been a severely restricting factor for many potential electrical/electronic and mechanical applications of nanostructured and conventional carbon materials. Here we demonstrate the formation of alloys that enable soldering of these structures. By addition of several percent (2.5−5%) of transition metal such as chromium or nickel to a standard lead-free soldering tin based alloy we obtained a solder that can be applied using a commercial soldering iron at typical soldering temperatures of approximately 350 °C and at ambient conditions. The use of this solder enables the formation of mechanically strong and electrically conductive joints between carbon materials and, when supported by a simple two-step technique, can successfully bond carbon structures to any metal terminal. It has been shown using optical and scanning electron microscope images as well as X-ray diffraction patterns and energy dispersive X-ray mapping that the successful formation of carbon−solder bonds is possible, first, thanks to the uniform nonreactive dispersion of transition metals in the tin-based matrix. Further, during the soldering process, these free elements diffuse into the carbon−alloy border with no formation of brazing-like carbides, which would damage the surface of the carbon materials.





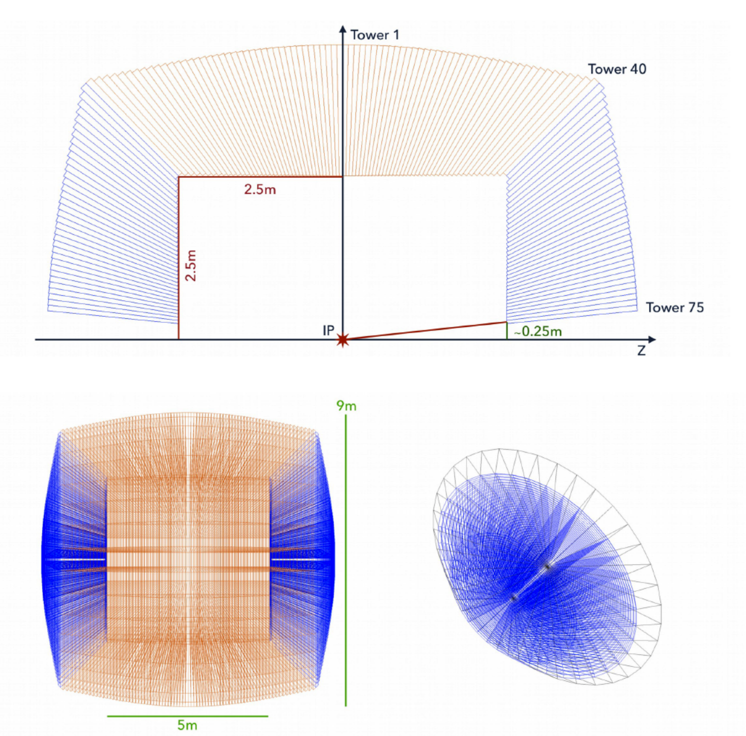
C wire **without** metal coating: **manual** soldering





DR Calorimeter: 4π simul.

from Lorenzo Pezzotti



Cu absorber

1 mm fibres

1.5 mm pitch

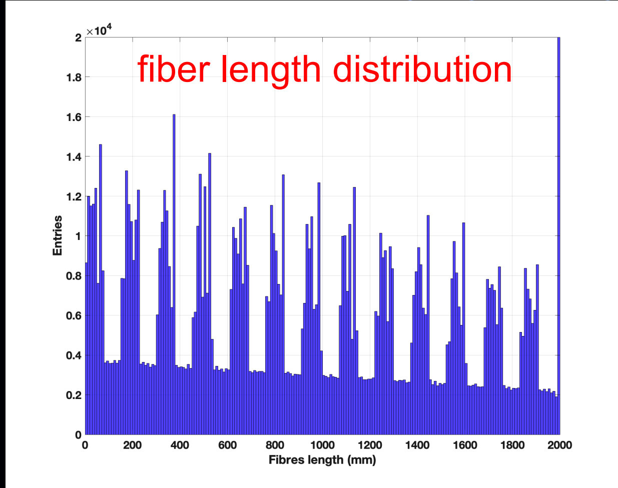
75 projective towers × 36 slices

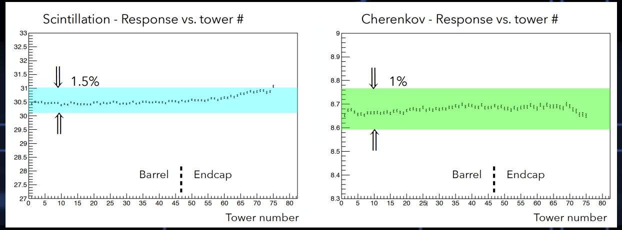
Δθ = 1.125°

Δφ = 10°

~130 M fibres

constant sampling fraction

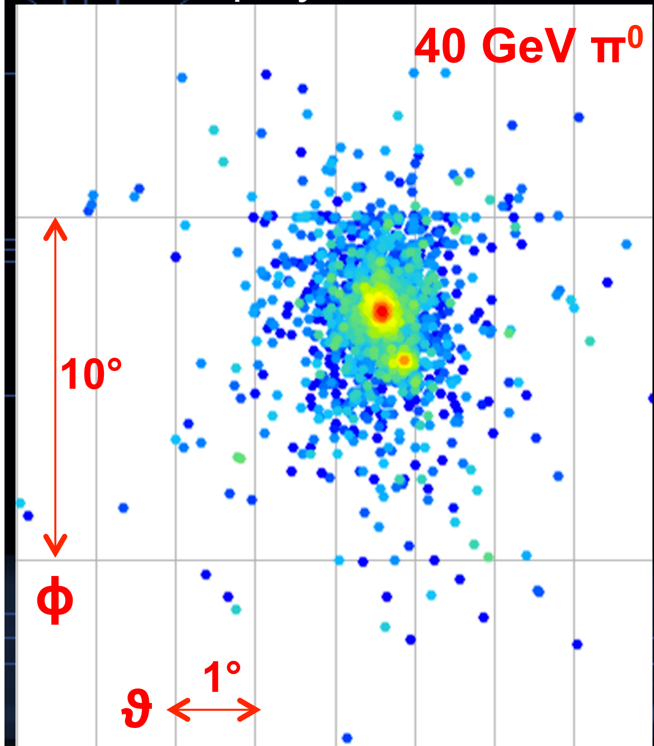




DR Calorimeter: resolutions

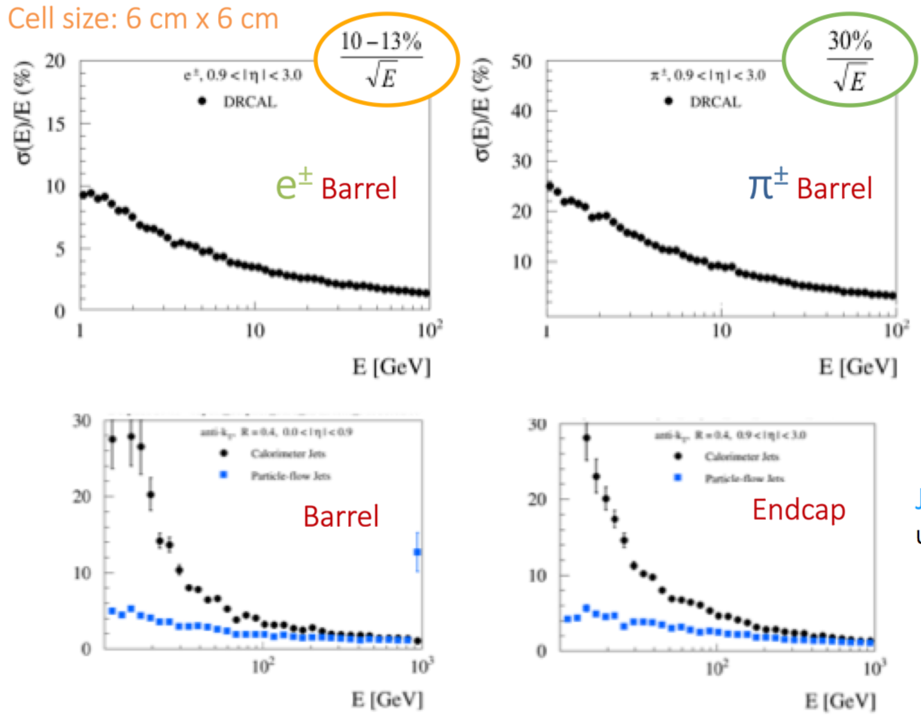
from Roberto Ferrari

event display



Delphes simulation

Cell size: 6 cm x 6 cm

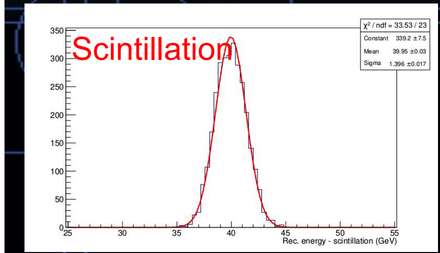


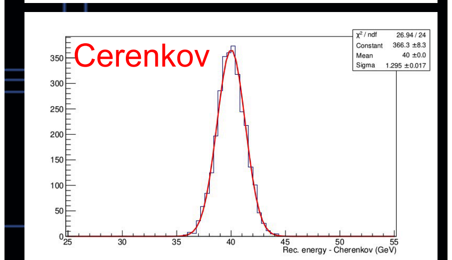
Energy resolution for reconstructed objects (both had and em particles) considering two different regions of pseudorapidity (η) with particle gun events (electrons and pions)

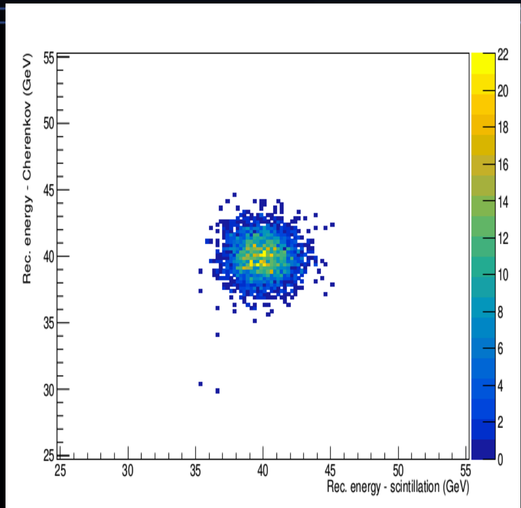
Jet Energy resolution using PF reconstruction

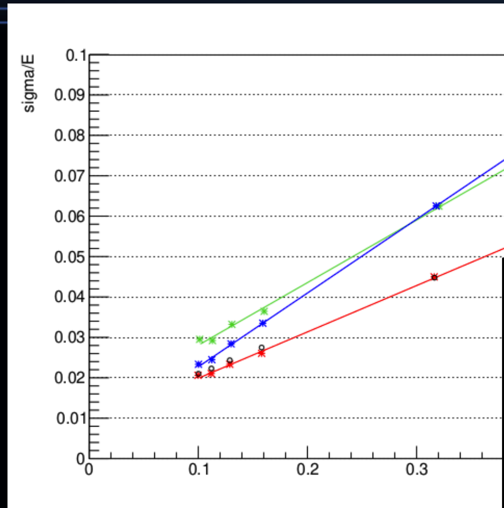
DR Calorimeter: resolutions

from Roberto Ferrari





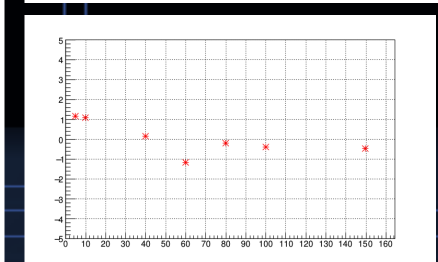


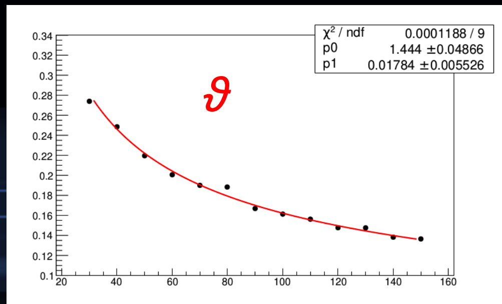


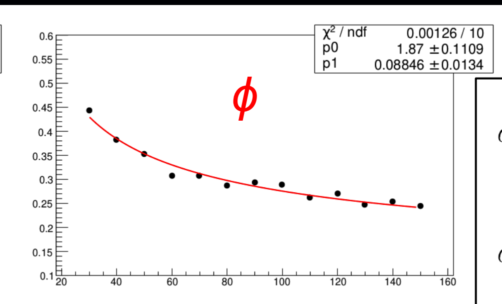
S $\quad \frac{\sigma}{E} = \frac{15.5\%}{\sqrt{E}} + 1.2\%$

Č $\quad \frac{\sigma}{E} = \frac{18.3\%}{\sqrt{E}} + 0.5\%$

S + Č $\quad \frac{\sigma}{E} = \frac{11.0\%}{\sqrt{E}} + 0.8\%$







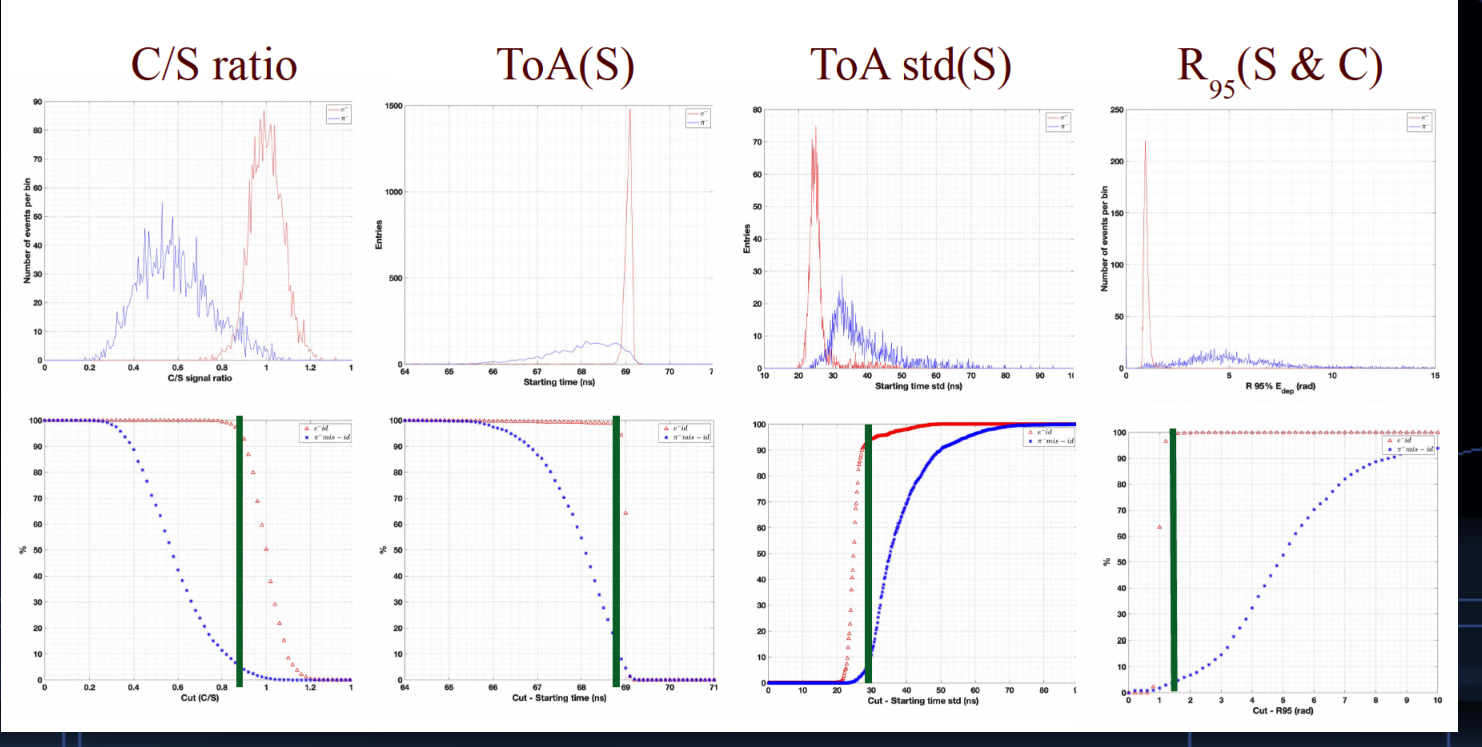
$$\sigma_\theta = \frac{1.4\%}{\sqrt{E}} + 0.02 \quad (mrad)$$

$$\sigma_\phi = \frac{1.8\%}{\sqrt{E}} + 0.09 \quad (mrad)$$

DR Calorimeter: resolutions

from Roberto Ferrari

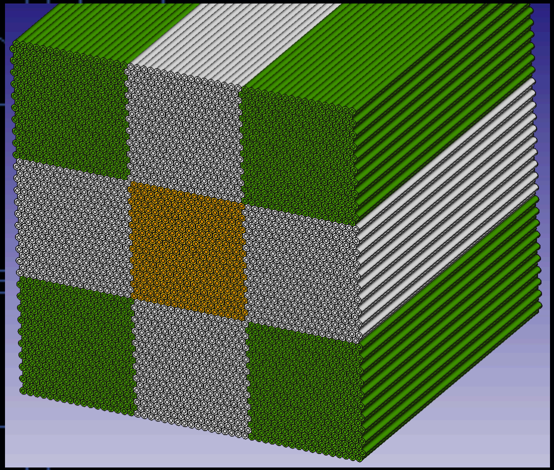
PID for single particles with timing

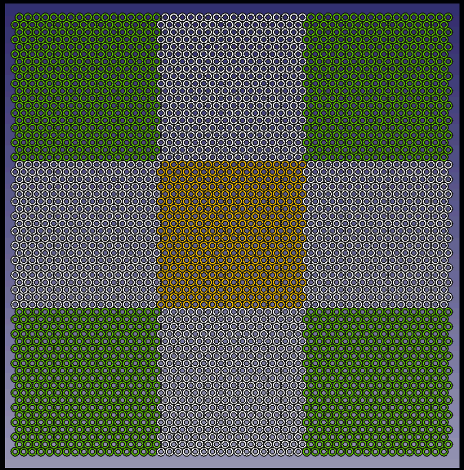


DR Calorimeter: tubelets

from Roberto Ferrari

Zagreb RBI proposal





2.0 mm OD, 1.1 mm ID and 1000 mm Length
ID tolerance: + 0.1 mm and - 0.0 mm
Material: CuZn37, 170 VPN Hardness

RBI Zagreb : select, test and assembly tubelets study fibre insertion
INFN Pavia : study and produce mechanics for fibre gathering and distribution, study fibre insertion
U. of Sussex : select and qualify S and Č fibres attenuation length, light yield, numerical aperture
INFN Milano (Insubria) : SiPM selection and readout chain

Muon detector

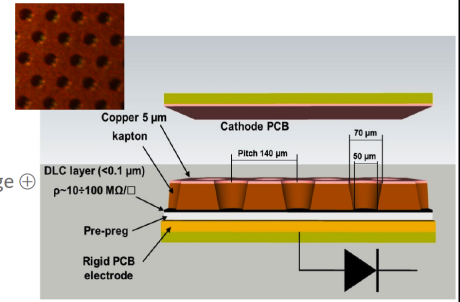
from Paolo Giacomelli

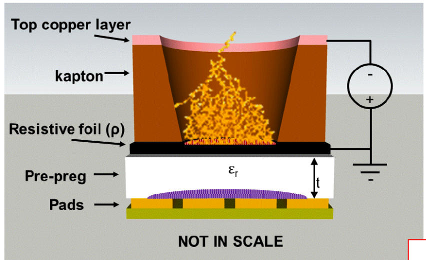
The µ-RWELL architecture

The µ-RWELL is composed of only two elements:

- µ-RWELL_PCB
- drift/cathode PCB defining the gas gap

µ-RWELL_PCB = amplification-stage ⊕ resistive stage ⊕ readout PCB





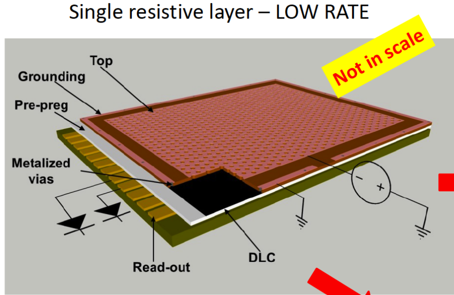
- The "WELL" acts as a multiplication channel for the ionization produced in the gas of the drift gap
- The charge induced on the resistive layer is spread with a time constant, τ ~ ρ×C

$$C = \varepsilon_0 \times \varepsilon_r \times \frac{S}{t} \cong 50\ pF/m \text{ (pitch-width 0,4 mm)}$$

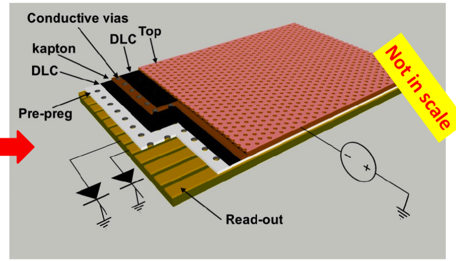
G. Bencivenni e P. Giacomelli, RD_FA WP7: µ–RWELL R&D 3

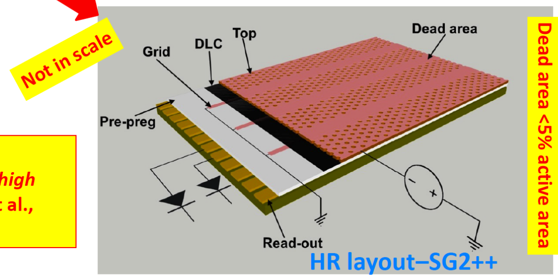
Detector Layouts

Single resistive layer – LOW RATE



Double resistive layer – HIGH RATE



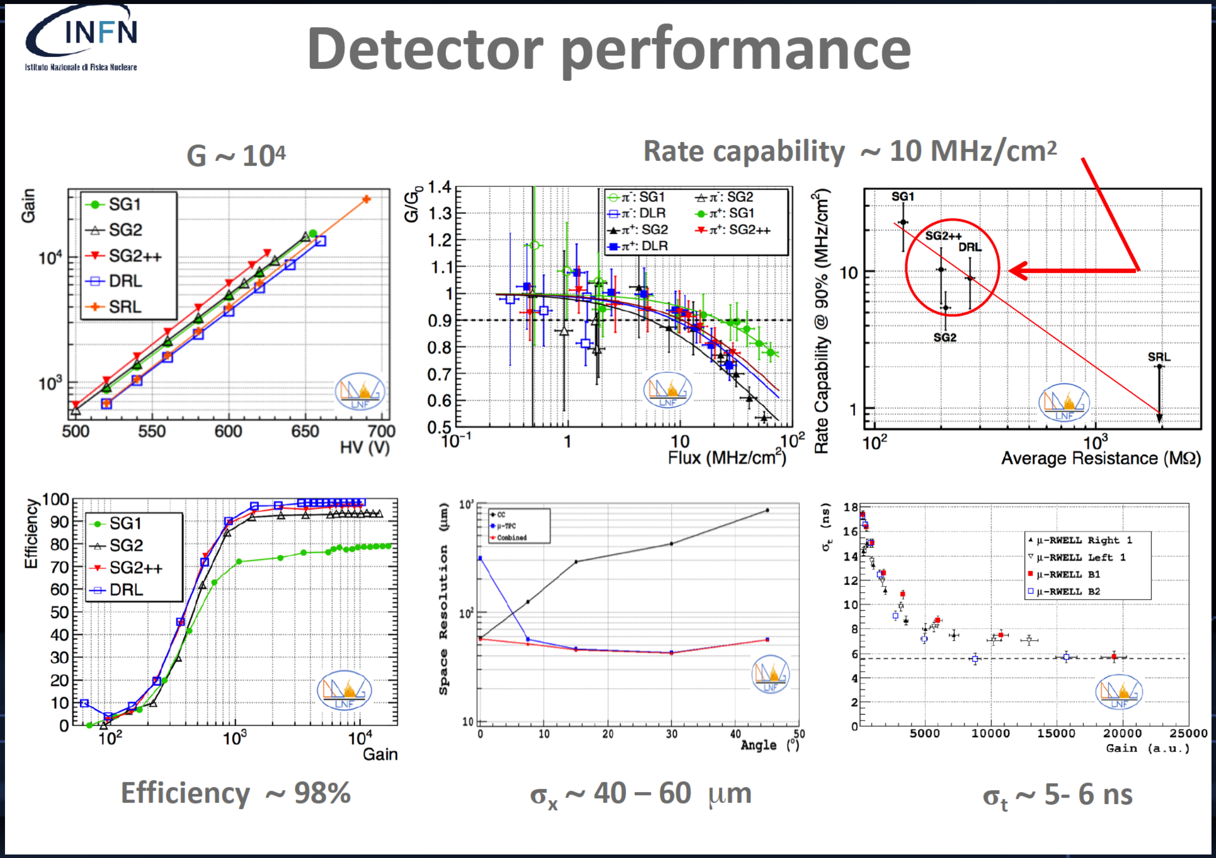


Detailed description in:
***The micro-RWELL layouts for high particle rate*, G. Bencivenni et al., 2019_JINST_14_P05014.**

Single resistive layer with dense grid grounding – SIMPLIFIED HIGH RATE

Muon detector

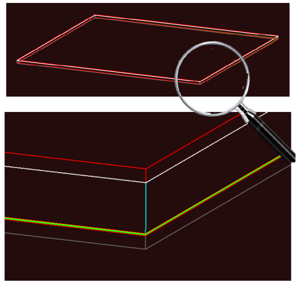
from Paolo Giacomelli



Preshower detector

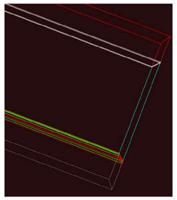
from Paolo Giacomelli

Full simulation of IDEA's Preshower



Chamber thickness: 9.4601mm
- Cathode thickness: 1.635mm
- Driftgap: 6mm
- µ-RWELL+readout thickness: 1.8251mm

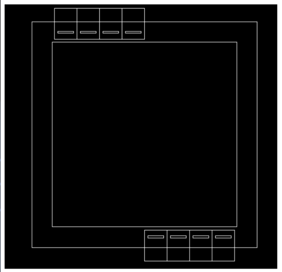
The cathode points to the IP



All the materials and dimensions of a HR µ-RWELL HR-SG2++ have been considered

Full simulation of IDEA's Preshower

First considered chamber size:
500 mm x 500 mm

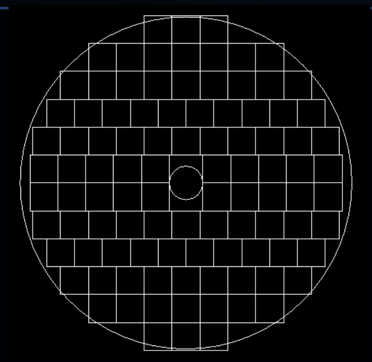


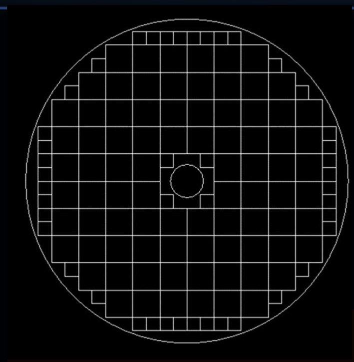
Need to evaluate the realistic ACTIVE AREA of the detector:
- HV cables
- 8 APV25 (128 channels):
  50 mm x 68 mm x 1.6 mm
- Panasonic connectors (perpendicular to strips):
  35 mm x 4.2 mm x 7mm

ACTIVE AREA = 410 mm x 410 mm

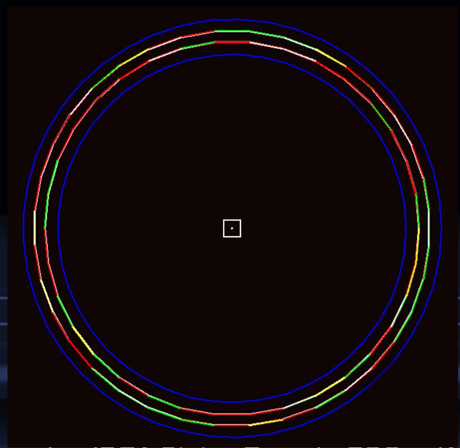
Pitch: 400 µm=> 1025 strip
(they will be reduced to 1024,so that they can be read by 8 APV25 (128 channels)

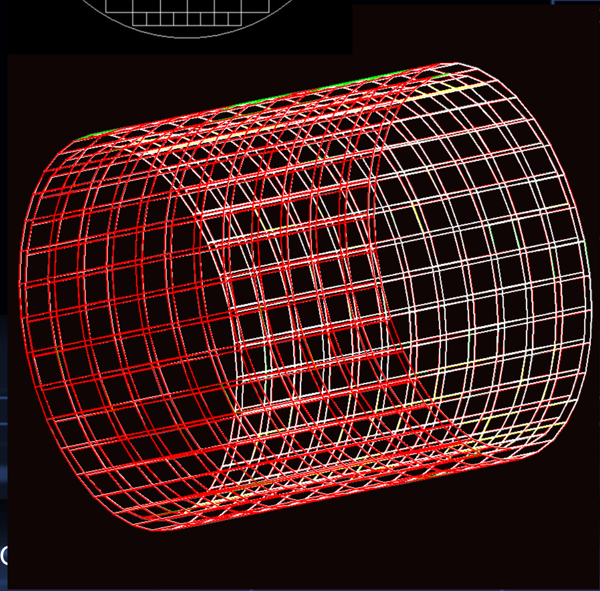
Description of a µ-RWELL (**HR layout–SG2++**) detector implemented





two options for endcap





IDEA EoI's

- Dual readout calorimeter
  - Detector design and construction (Pi, Pv, Mi, Sussex, Korea, USA, Zagreb)
    - Choice of materials (absorber and fibres)
    - Production of the elements
    - Assembly, Quality control
  - Light sensors and Readout (Pv, Mi, Sussex, USA)
    - SiPM, ASIC, FPGA, signal processing and feature extraction
- Drift Chamber
  - Cluster Counting/Timing (Le, Ba, BINP)
    - Data reduction and pre-processing of drift chamber signals sampled at high rates
  - A prototype of an ultra-light drift chamber (Le, Ba, BINP)
    - With new materials for the next generation of lepton colliders

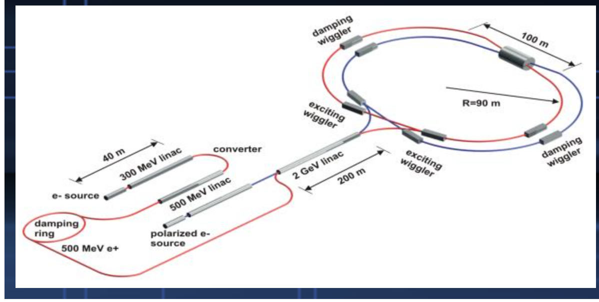
IDEA EoI's

- Preshower and Muon detector
  - Innovative ML-based algorithms for tracking in MPGDs (Bo, Fe, LNF)
    - Improve particle tracking (for any incident angle) in modern MPGDs (μRWELL, GEM, MicroMegas, etc.)
  - Industrial engineering of high-rate μRWELL detectors with bi-dimensional readout (Bo, Fe, LNF, CERN, Eltos)
  - Development and characterisation of integrated electronics for the readout of pixellated μRWELL detectors (Bo, Fe, To, LNF)
- Vertex detector
  - Sensor development, ARCADIA-based solution (To, Mi, Tn, Pd, Pv, Bo, Pg)
  - Senior development HV-CMOS (Mi, Pv, Pi, Bonn, Strasbourg)
  - Optimisation of detector mechanics and cooling (Mi, To, Pd, Tn)

An ultra-low mass Tracking Chamber with Particle Identification capabilities for SCTF at BINP

presented at "Joint Workshop on future tau-charm factory" LAL, Orsay, Dec. 2018

CREMLIN+ Proposal



F. Grancagnolo

INFN – Lecce

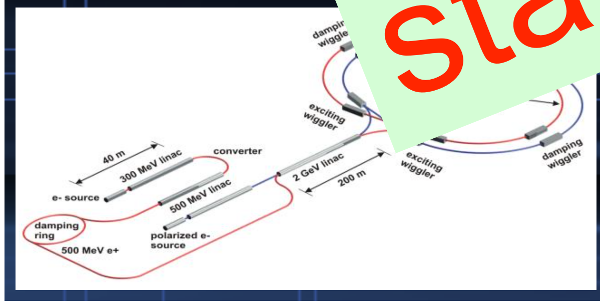
Istituto Nazionale di Fisica Nucleare

An ultra-low mass Tracki… …ber with Particle Identifi… …ies for …

presented at "Jo… …, Orsay, Dec. 2018

Approved
starts Feb. 1, 2020

…F Proposal



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