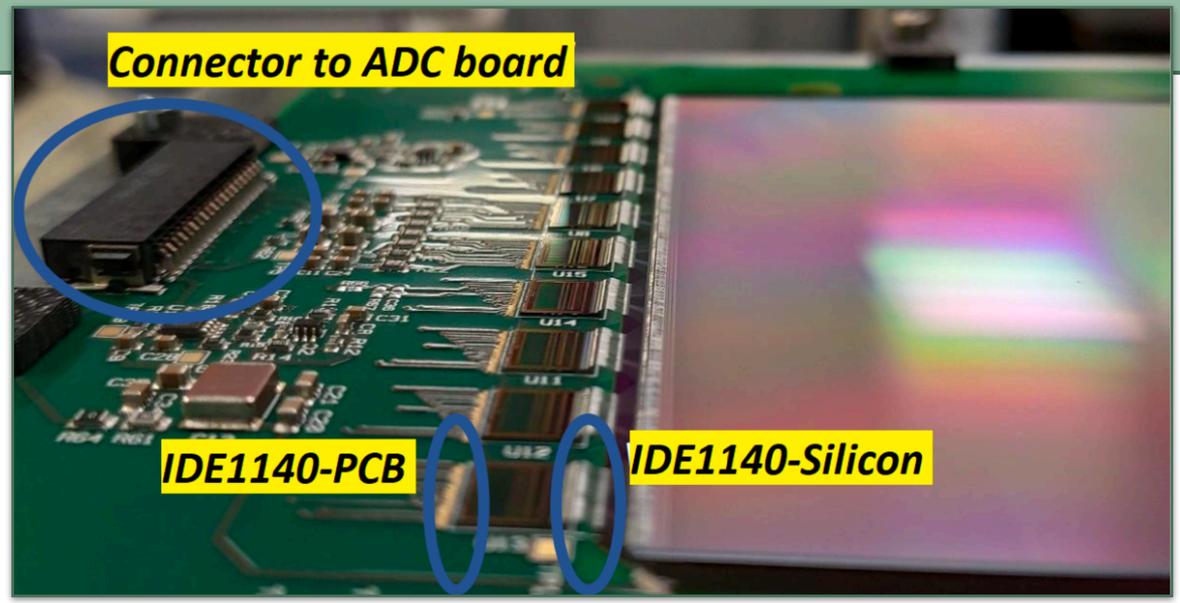
The MSD detector: Recap

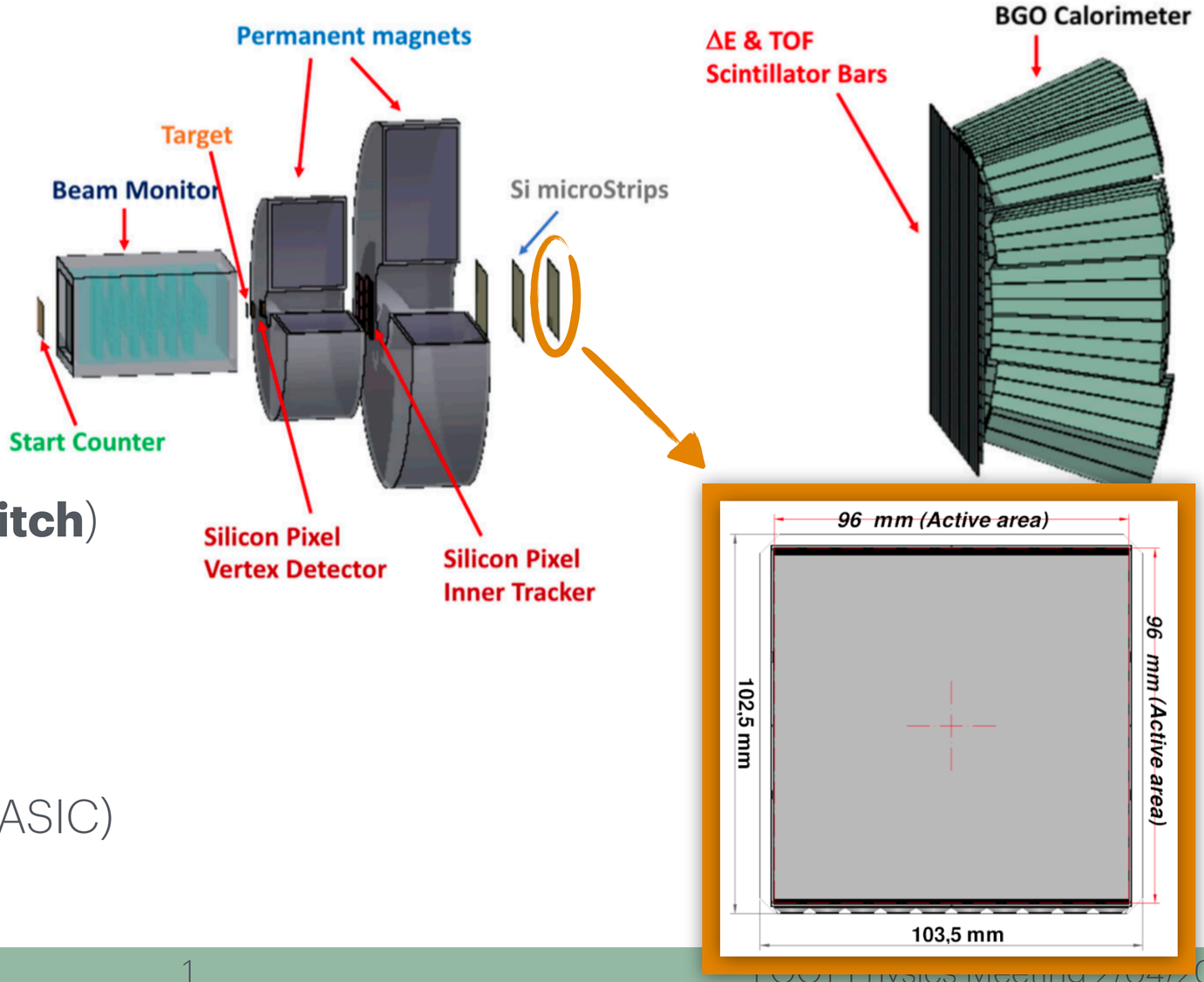
FOOT Physics Meeting 2/04/2025

Ilaria Mattei on behalf of the MSD group



The MSD detector geometry

- **3 planes**
- **2 sensors per plane (X-Y)**
- Each microstrip silicon sensor:
  ~ 10 x 10 cm^2 , 150 μm thickness
- 1920 strips per sensor (**50 μm implant pitch**)
- **640 read strips per sensor**
  (1 readout strip - 2 floating strips)
- **Each sensor read by 10 chips** (IDE1140 ASIC)
  => **each chip read 64 strips**



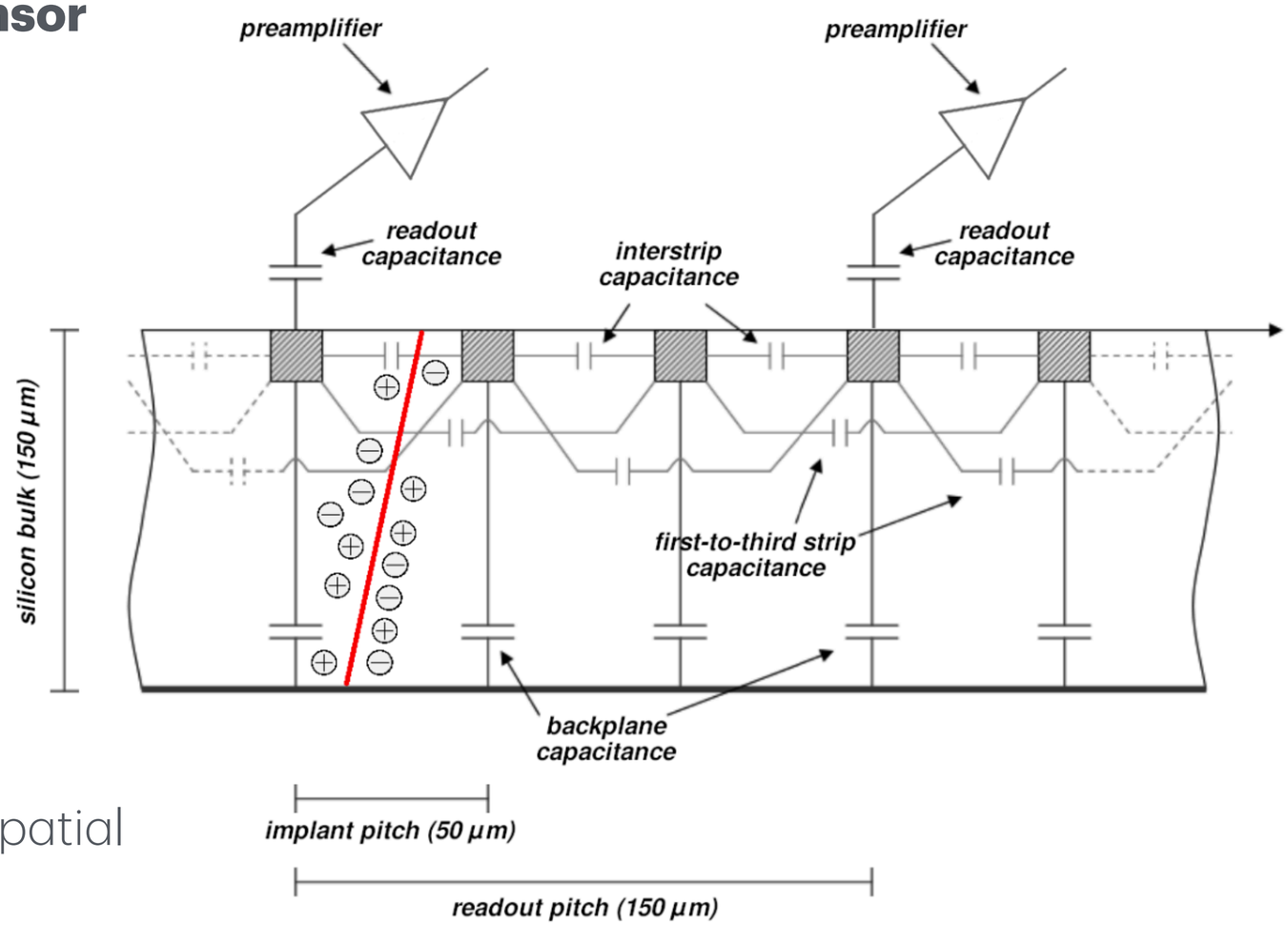
The Silicon Strip operation

- **Charged particle passes through Si sensor**
  => e-h pairs drifting towards electrods
  (MIP: ~ 11800 e-h pairs in 150μm)

- **Intrinsic Voltage ~ 20V**
  => complete depletion

- **Bias Voltage = 50 V**
  => over depletion regime:
  - highest charge collection efficiency
  - highest possible signal

- **Read-out pitch = 150*μ*m**
  => costs optimization without reducing spatial resolution

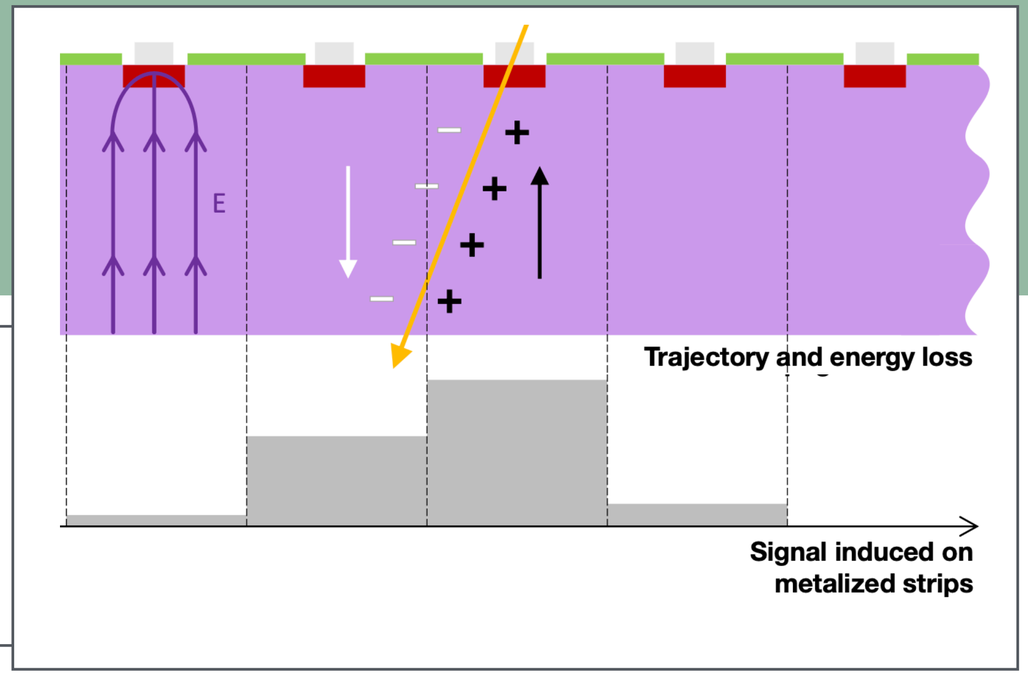


Gianluigi Silvestre et al 2022 JINST 17 P12012

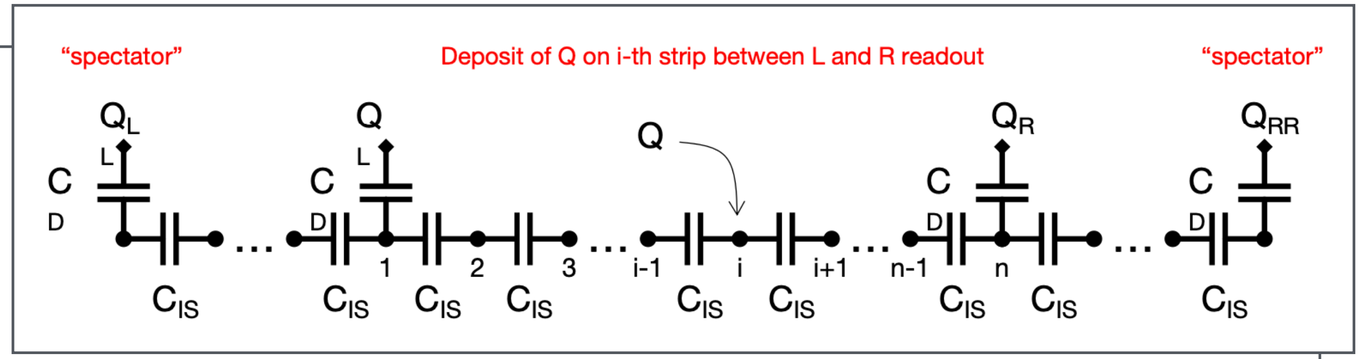
The Read-Out

Slides from A. Oliva

- Devices with **implantation pitch of tens of microns** or less
  => **intrinsic better position resolution**
  (diffusion "charge sharing" between strips)



- The signal produced on strips by drift-diffusion can be injected to a Silicon sensor equivalent circuit: **CAPACITIVE NET**



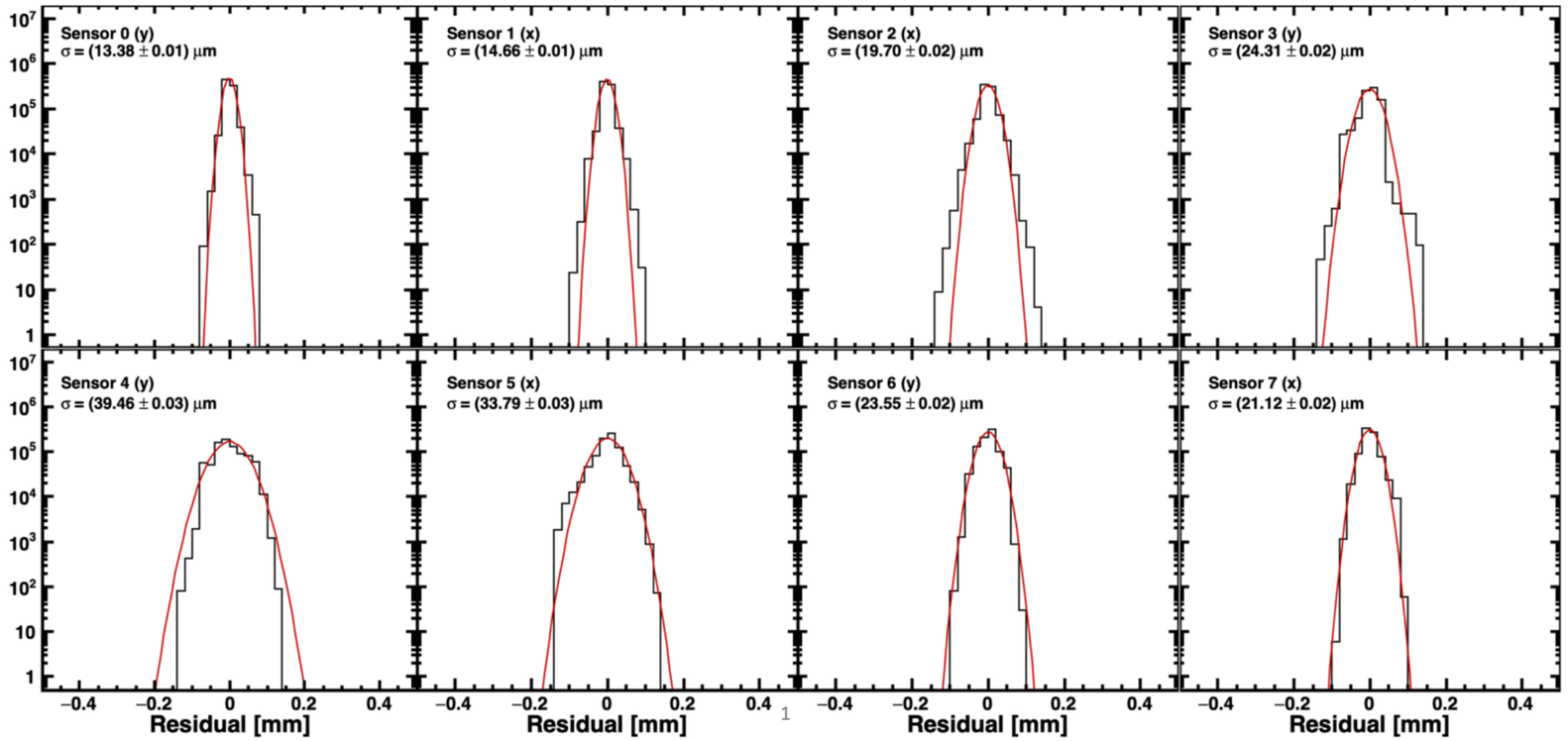
<u>Position estimation:</u>
Signal is distributed proportionally to the Edep location
=> **redistribution of charge** onto the capacitive net
=> **better position resolution** than the readout pitch

<u>Charge estimation:</u>
Spectator strips take a fix amount of charge of the closest strip
=> **fighting saturations**

Performances

- **Digital spatial resolution** of the readout pitch:
  150 μm/sqrt(12) **~ 43 *μ*m**
  (event with energy release in a single strip)
- With analog readout: gain of at least a factor 2 on spatial resolution
  => ~ **12-14 *μ*m** when more than 1 strip is fired (e.g. **carbon ions**)
  (from Gianluigi Silvestre analysis)

Fragments from Pb (150 A GeV/c or 379 GV/c) + Be (40 mm) target



Slide of A. Oliva

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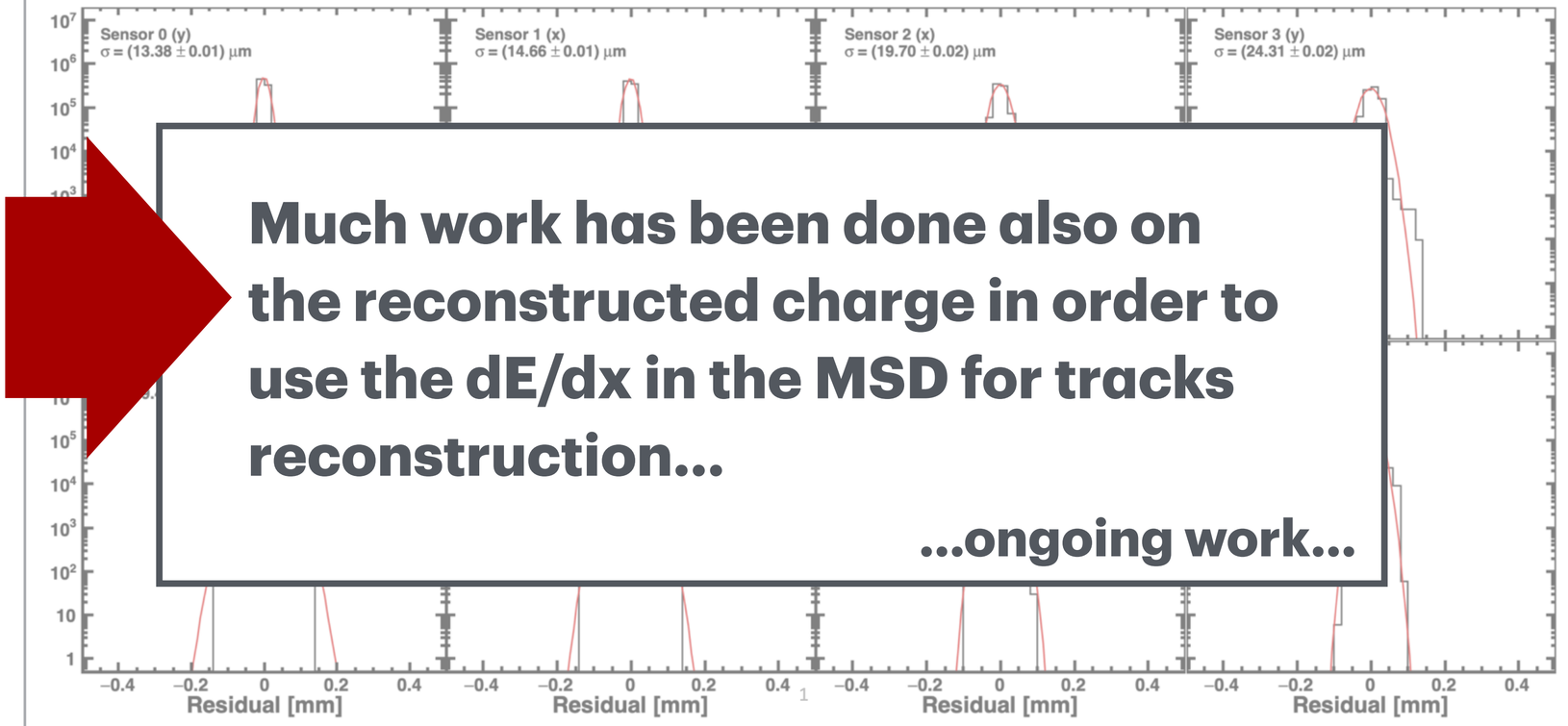
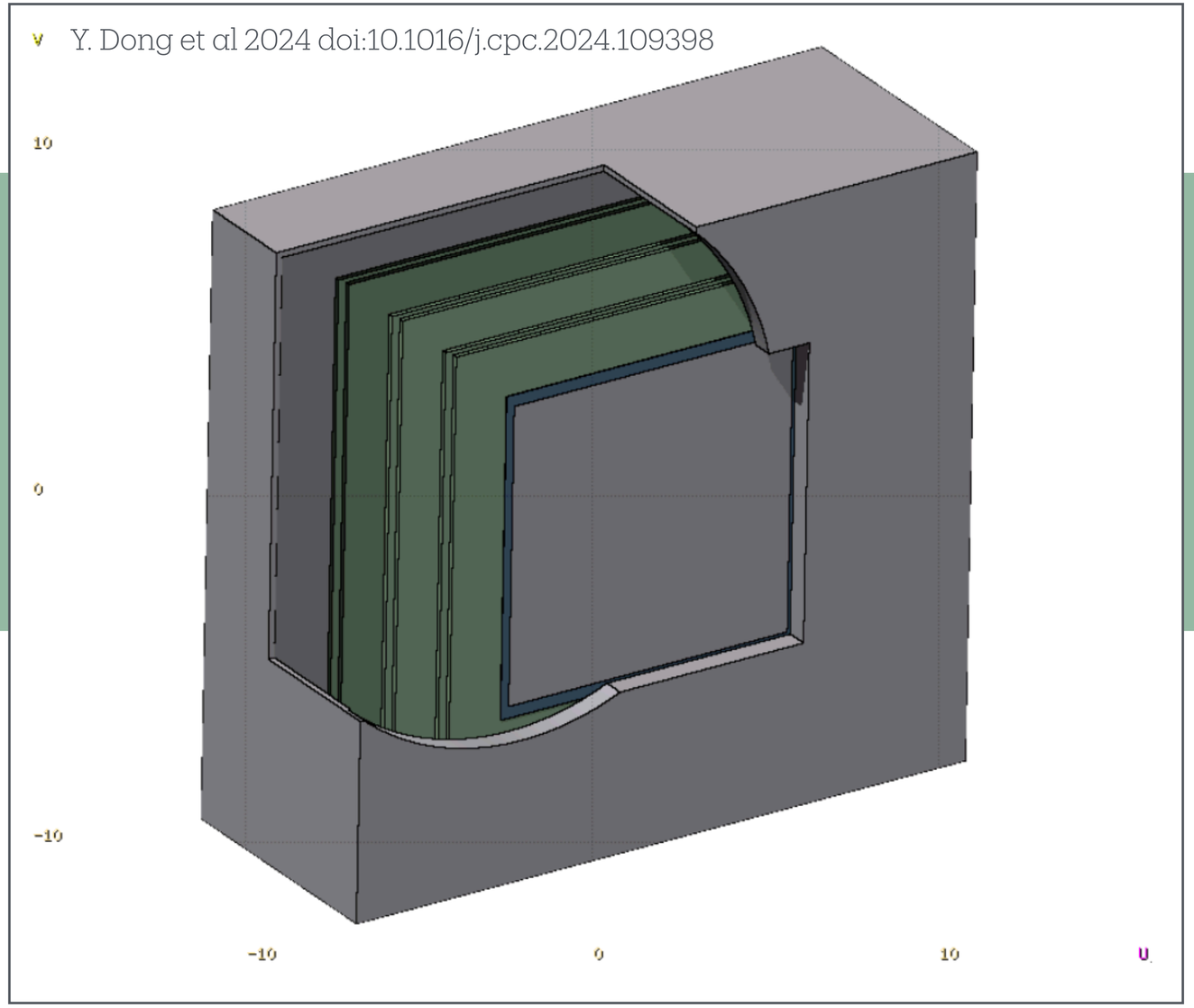


Much work has been done also on the reconstructed charge in order to use the dE/dx in the MSD for tracks reconstruction...

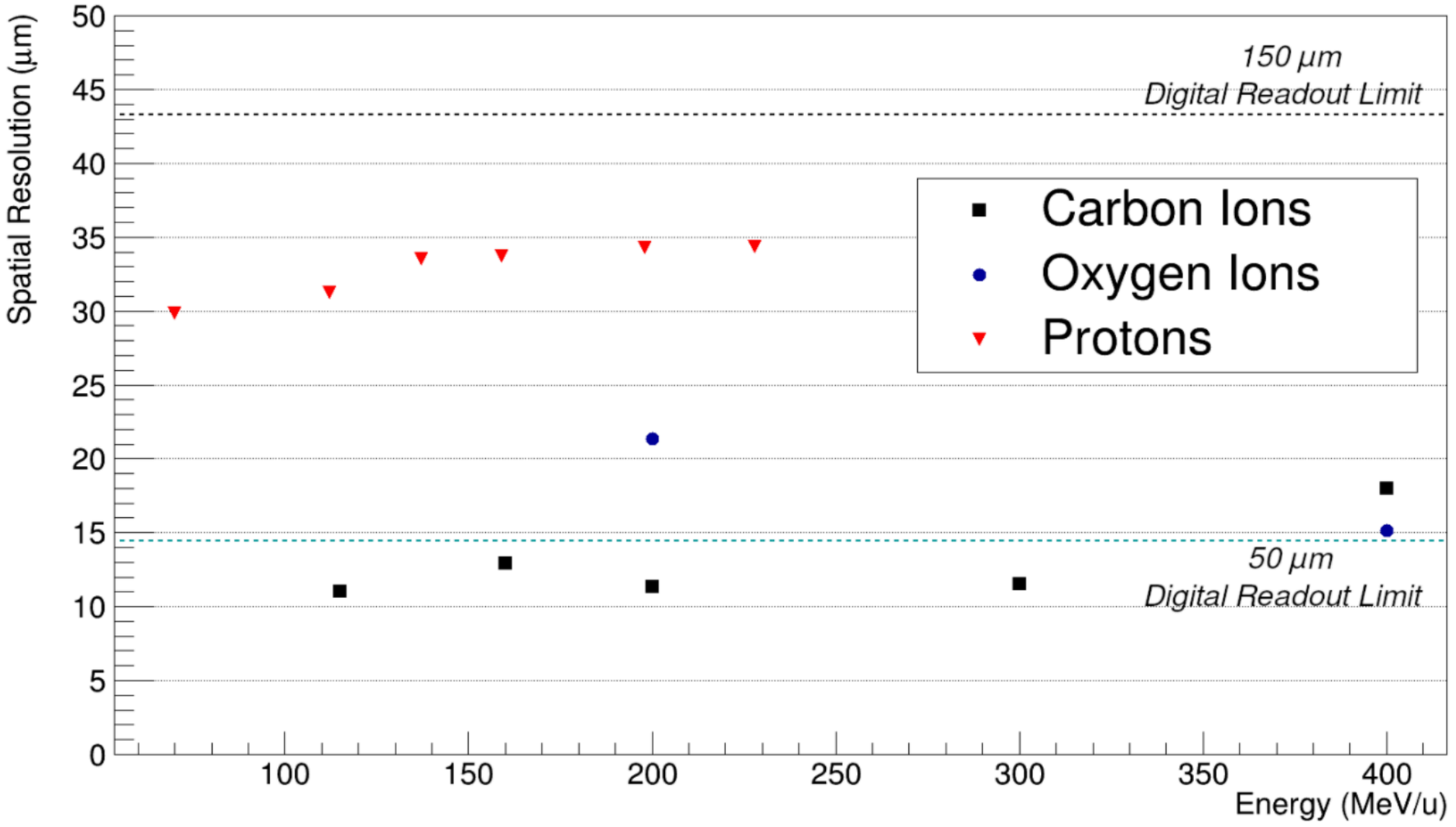
...ongoing work...

Slide of A. Oliva

Thank You



BACKUP


Spatial Resolution (μm)
50
45
40
35
30
25
20
15
10
5
0
100
150
200
250
300
350
400
Energy (MeV/u)
150 μm
Digital Readout Limit
50 μm
Digital Readout Limit
Carbon Ions
Oxygen Ions
Protons