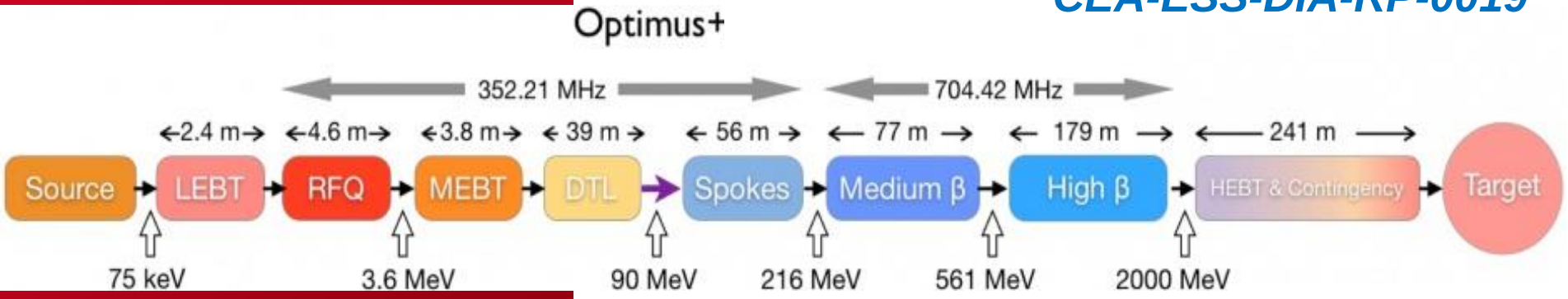
DE LA RECHERCHE À L'INDUSTRIE

CEA – Saclay

# STUDY OF THE ELECTRIC FIELD UNIFORMITY OF THE IPM

**ESS-0092070**

***CEA-ESS-DIA-RP-0019***





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Study done by **Anna Vnuchenko**, during 6 months internship period

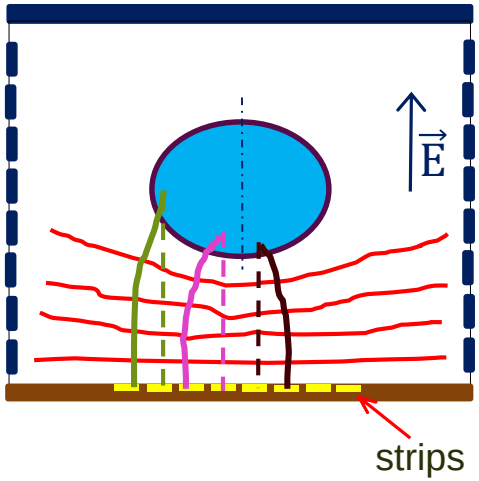
## $\vec{E}$ uniformity

- Why, how…
- simulation results for parameter optimization
- Experimental checking

## Summary

# UNIFORMITY, WHY?

Mirage effects



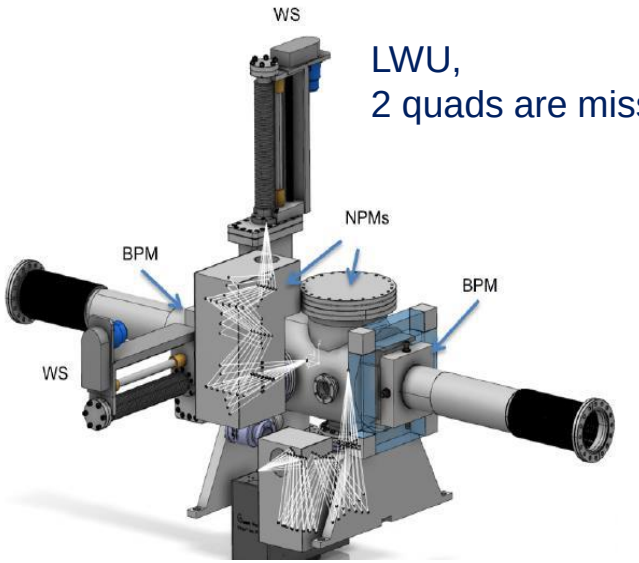

## Uniformity of the electric field

- most importance for avoiding distortion on measured profile
- no addition of spurious effects, SC is enough!

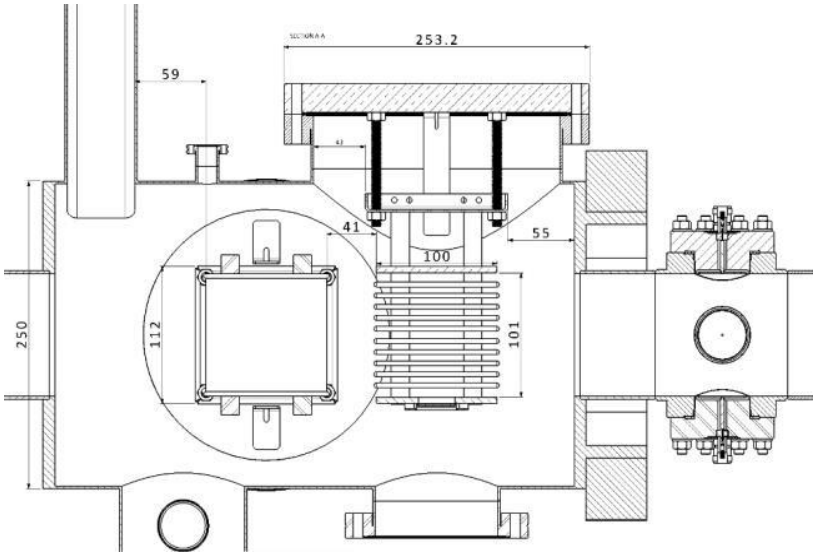
## Specificity

- 2 IPMs (X & Y) → interferences
- insertion of the 2 IPMs in the vacuum chamber

## Goal: check compliance with geometric constraints for validation (no stopping points)



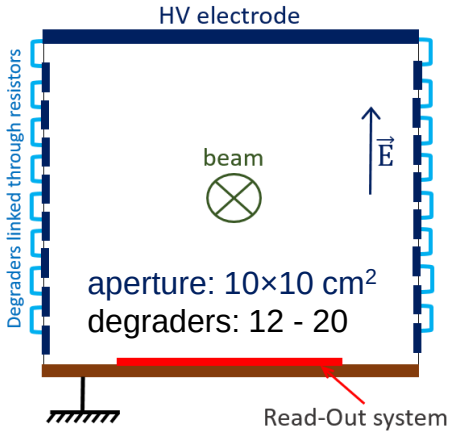

LWU,
2 quads are missing



# UNIFORMITY STUDY, HOW?

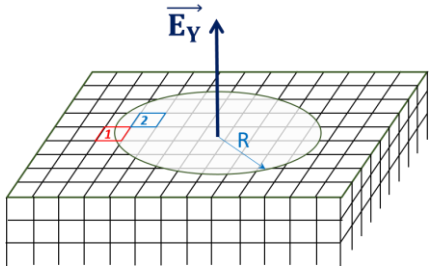
## Tools and Procedures

- COMSOL (https://www.comsol.fr/)
  → geometry description and meshing
- Analysis done with Cern Root software (https://root.cern.ch/)
  → extracted data are analyzed and reprocessed for optimization

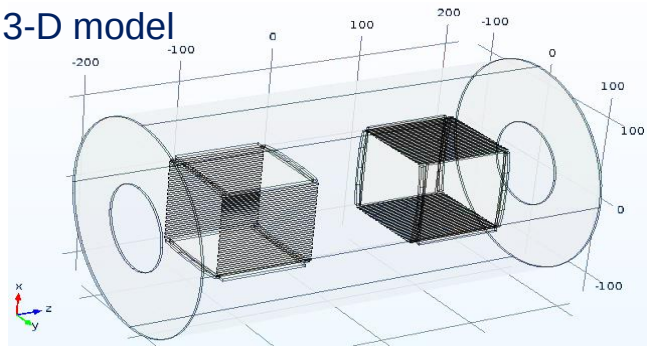



## Electric field uniformity criterion

- hypothesis: applied field electric $E_Y \neq 0$, $E_X = E_Z = 0$
- $\sigma = \sqrt{\sum_i^N E_{X,i}^2} / N$
  → $\sigma$ is calculated over the disk surface
- Relative non-uniformity = $\sigma$ / $E_Y$




3-D model



# DEPTH STUDY (BEAM DIRECTION) OF THE IPM

Vacuum chamber length: 456 mm

VC diameter: 250 mm

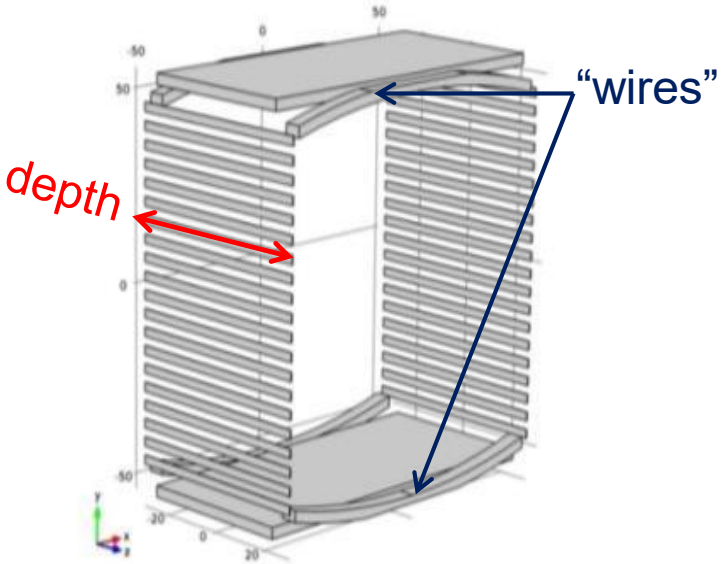
Beam pipe diameter: 100 mm

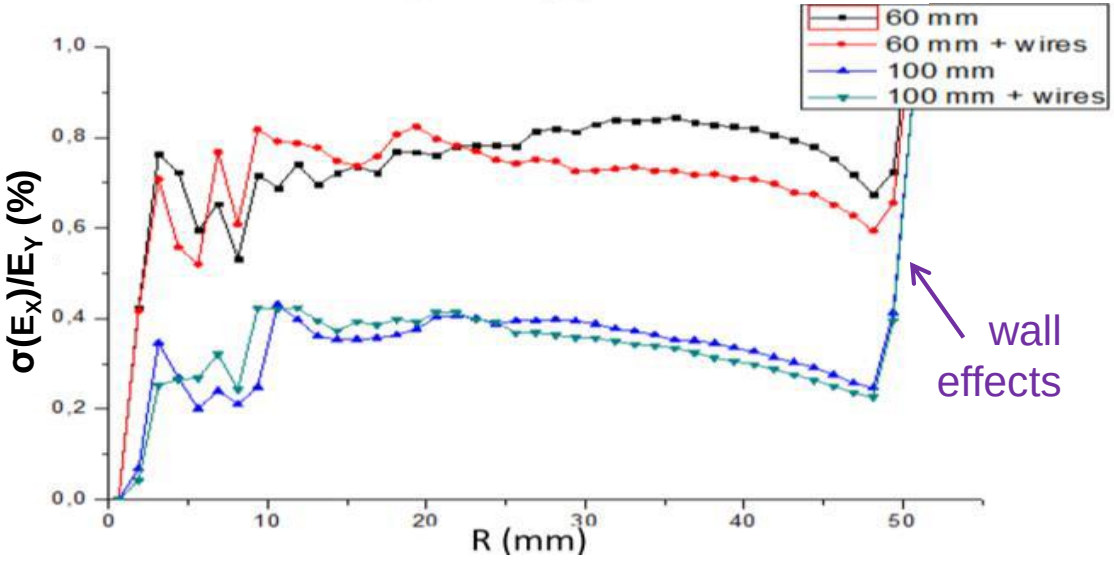
"wires": very efficient for LIPAc project

- ➢ not here, abandoned

IPM depth

- ➢ the larger, the better



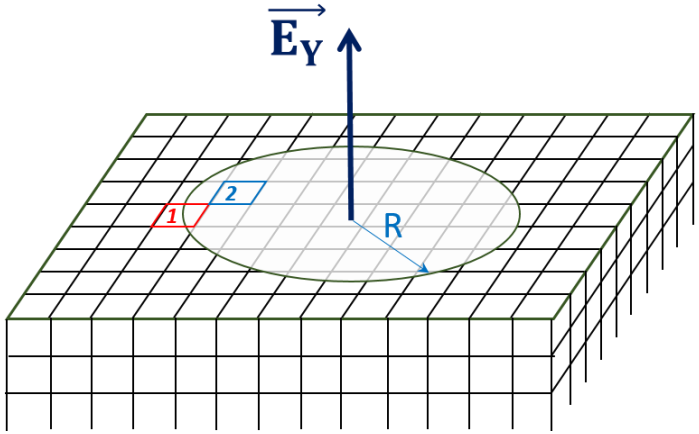



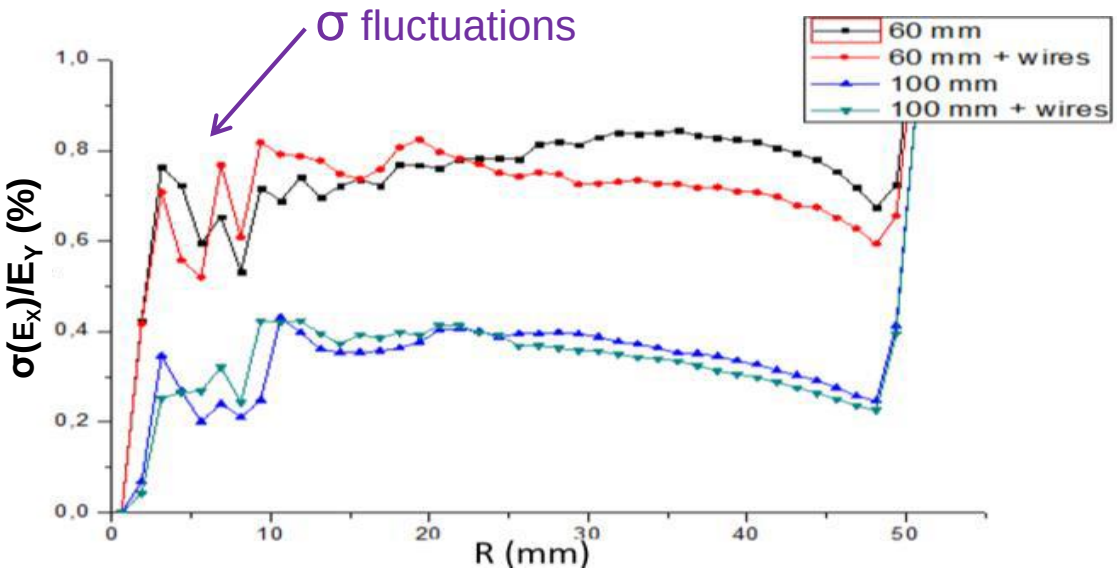
# SIGMA FLUCTUATIONS

due to fluctuations on overlapping between cells

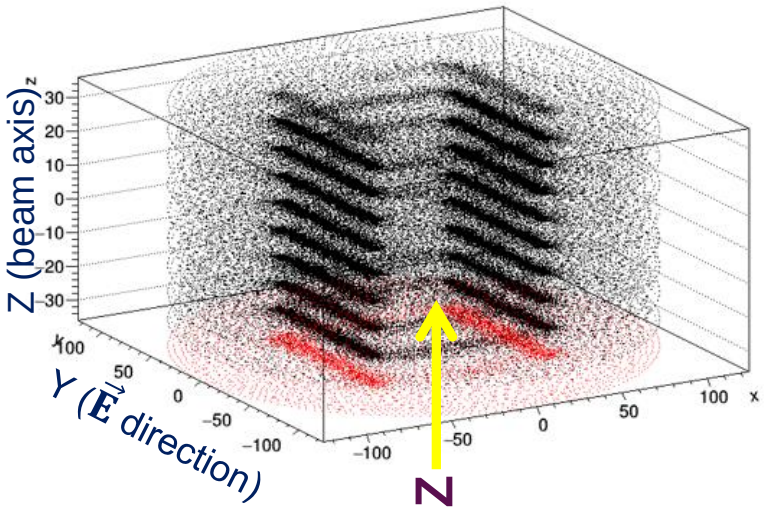
→ may explain the behavior at low radius

→ to be taken into account in the final electric field uniformity studies



# ELECTRIC FIELD UNIFORMITY INSIDE THE IPM

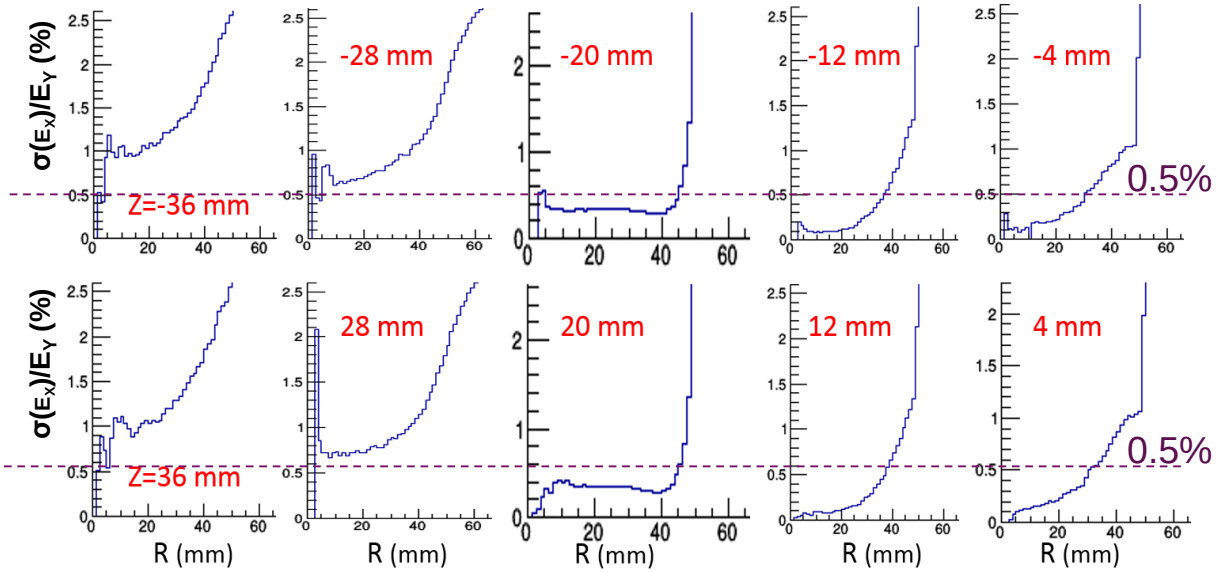



notes

- Border effects at 50 mm
- For central R<40 mm
  - σ < 0.5% for -20 < Z < 20
  - σ < 1% for -28 < Z < 28

Read-Out spread

- length in the beam direction can spread over ±20mm (40 mm)



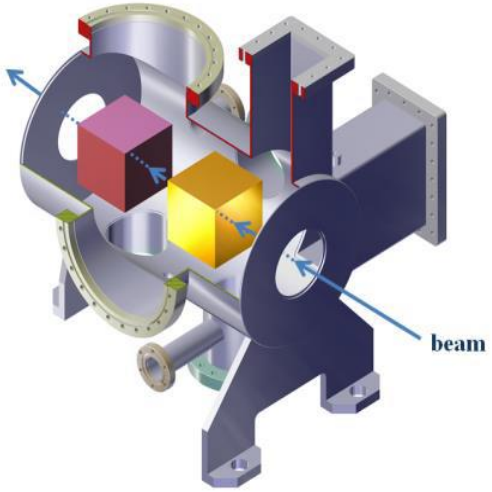
# INTERFERENCES BETWEEN BOTH IPMs

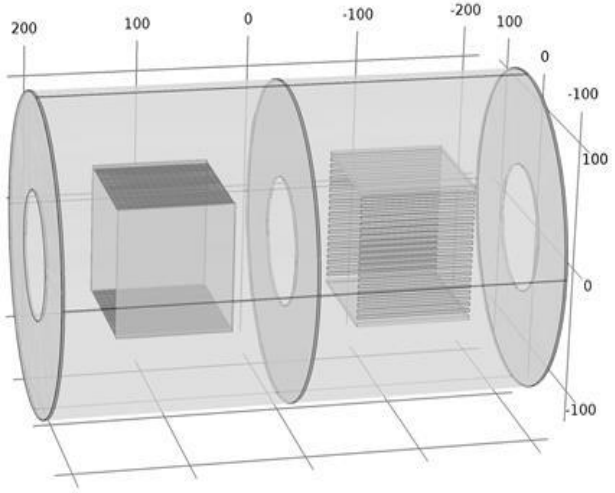
conductive disk separating IPMs

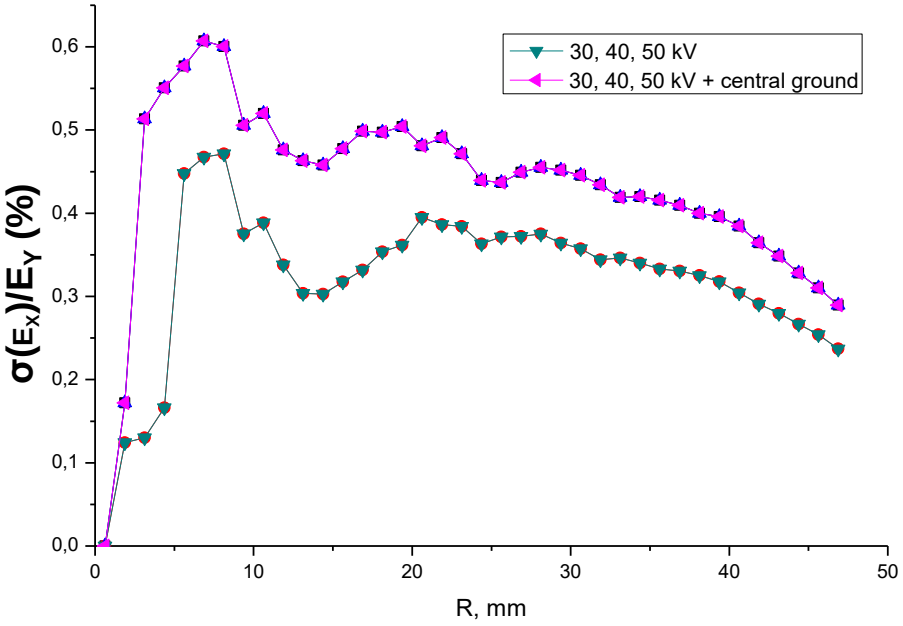
- works nice at LIPAc, not here

interference

- σ < 0.5%, good uniformity → Ok



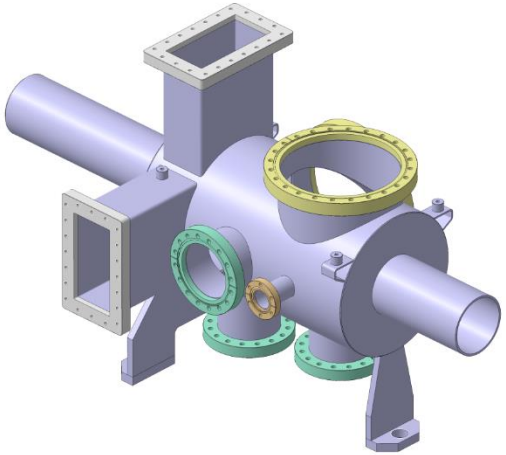



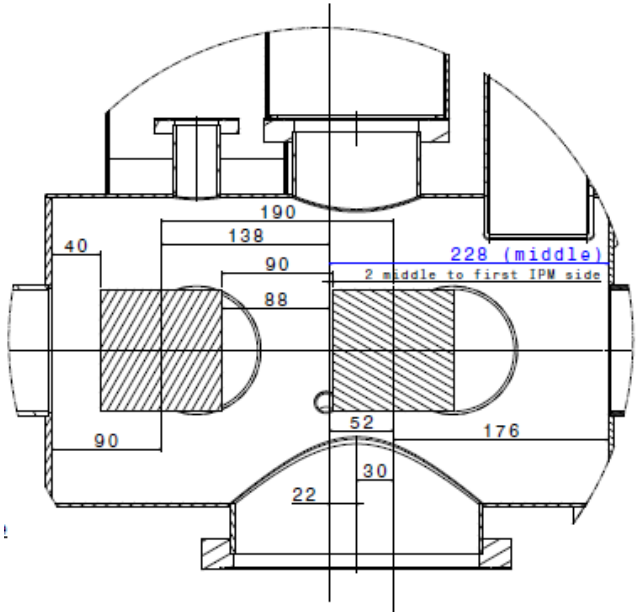
# ELECTRIC FIELD UNIFORMITY INSIDE THE IPMs

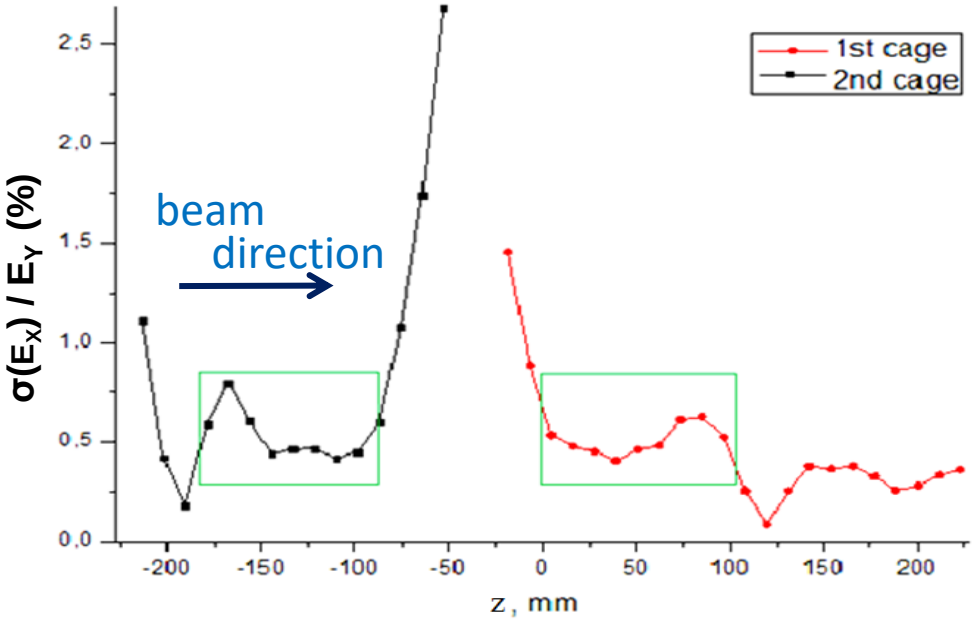
IPM size: 102×102×100 $mm^3$
Degrader numbers: 20 / side
Gap between IPMs: 90 mm

Results

- σ ≤ 0.5%, good uniformity → Ok





# EXPERIMENTAL $\vec{E}$ UNIFORMITY CHECKING

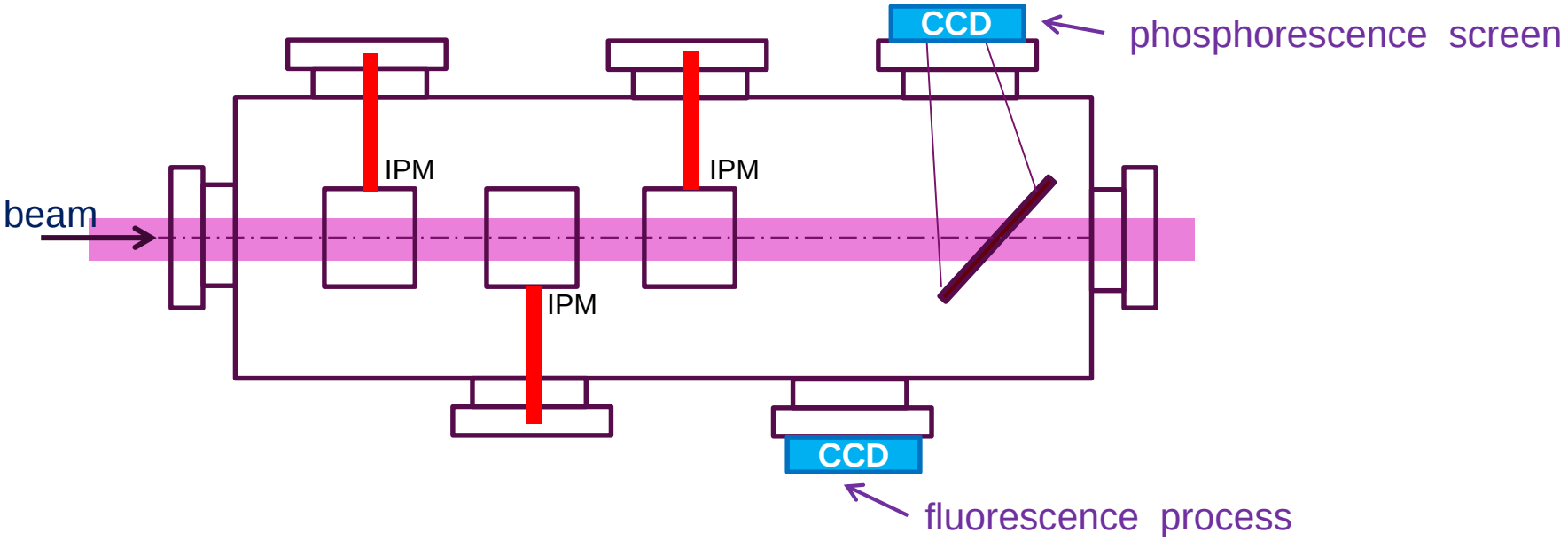
Test done with 3 IPMs equipped of different Read-Out

→ roughly “same” beam profile measurements

Profile measured without electric field

→ beam profiles with NO electric field

Comparisons between them!




Wait for talk about “IPM test bench design and beam test strategy”

# SUMMARY

Conclusions of the **preliminary** study of the electric field uniformity

- at first sight, $\vec{E}$ uniformity seems to be compliant with the vacuum chamber of the LWU
- $\sigma(E_X)/E_Y < 0.5\%$ with no needs of
  - extra electrodes
  - insertion of a conductive disk between IPMs

But, for the prototype, more realistic VC as well as IPM have to be considered

- Read-Out systems
- reduce the degrader number (about 12) with realistic resistors (few tens of MΩ, 500 MΩ/side → I=0.24 mA for 60 kV)
- VC shape

Experimental validation of the $\vec{E}$ uniformity procedure