INTEGRATING BPMS IN ACC. STRUCTURES

UPDATES FROM PAST PRESENTATION IN JUNE 2020

T. Lefevre, CERN, 14th June 2023

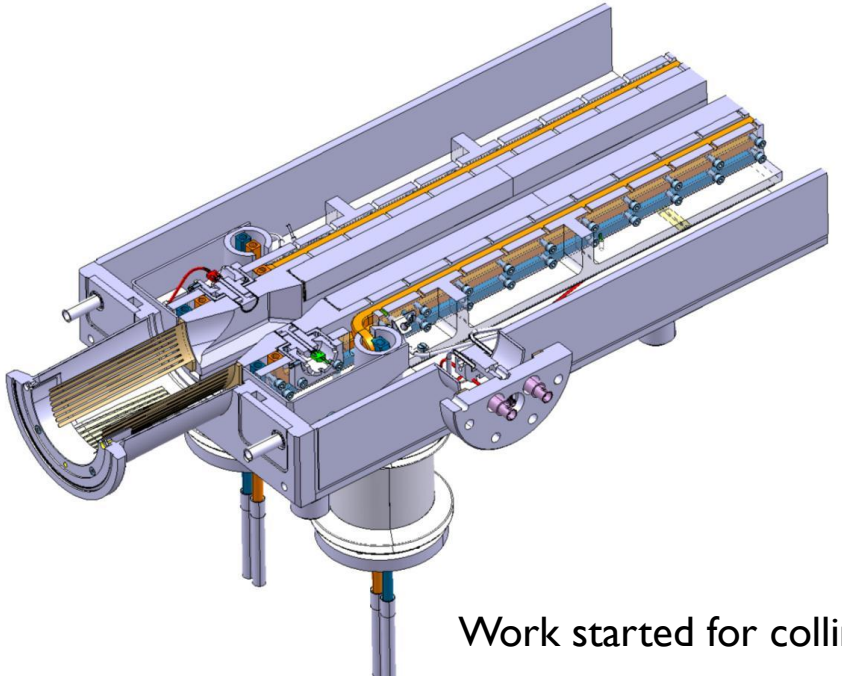
AS AN ALTERNATIVE TO
WAKEFIELD MONITORING
IF ……NECESSARY

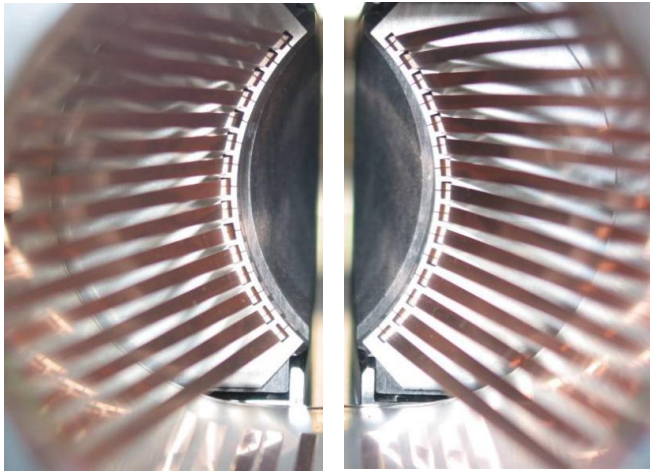
OUTLINE

- On the use of BPMs for centring collimator jaws
- Possible designs for acc. structures
- Conclusions and Perspectives

COLLIMATOR BPM @ LHC

Electrostatic Button PUs embedded in collimators jaws for LHC

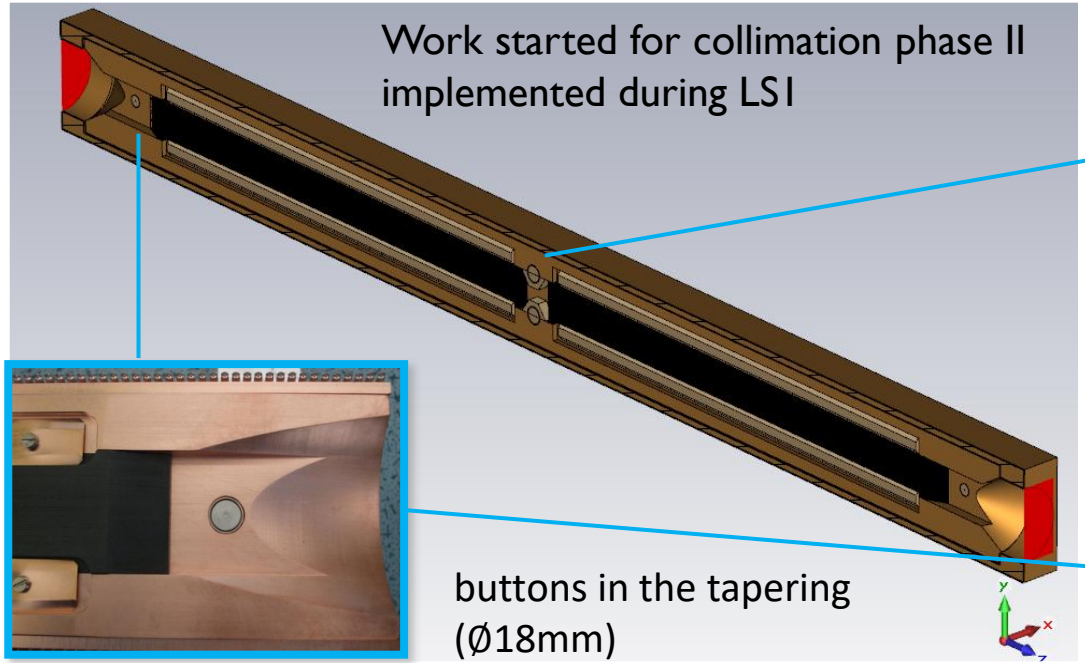


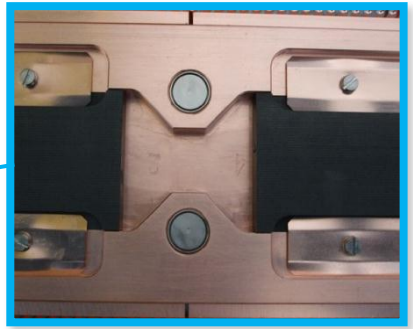


Work started for collimation phase II to help centering jaws around the beam

COLLIMATOR BPM @ LHC

First prototype in 2011





Center pair of buttons
(Ø18mm)

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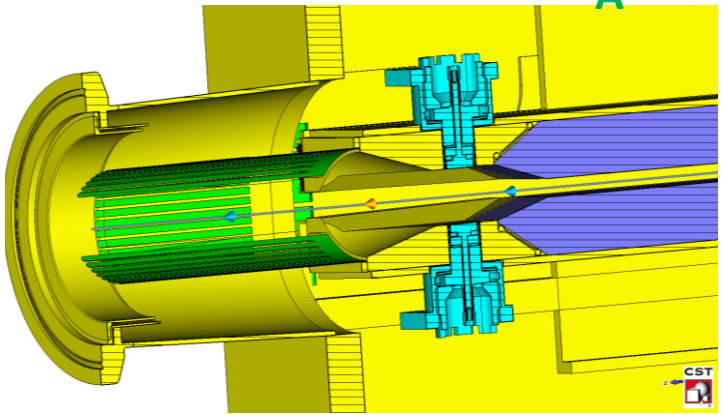
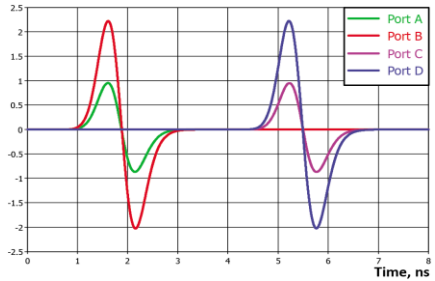
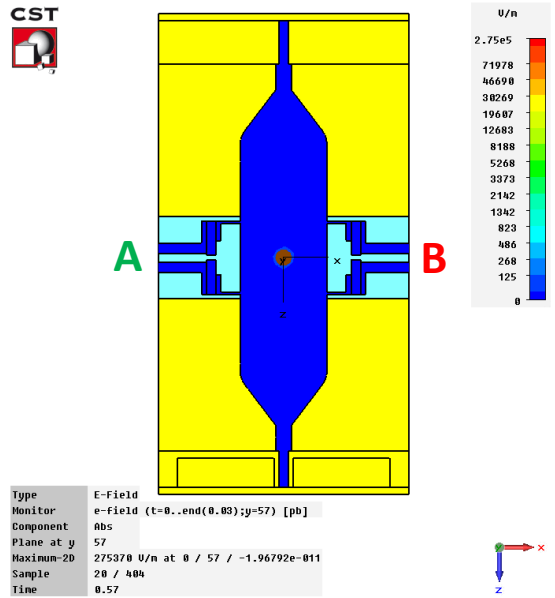




Typical up and downstream time signals with beam offset



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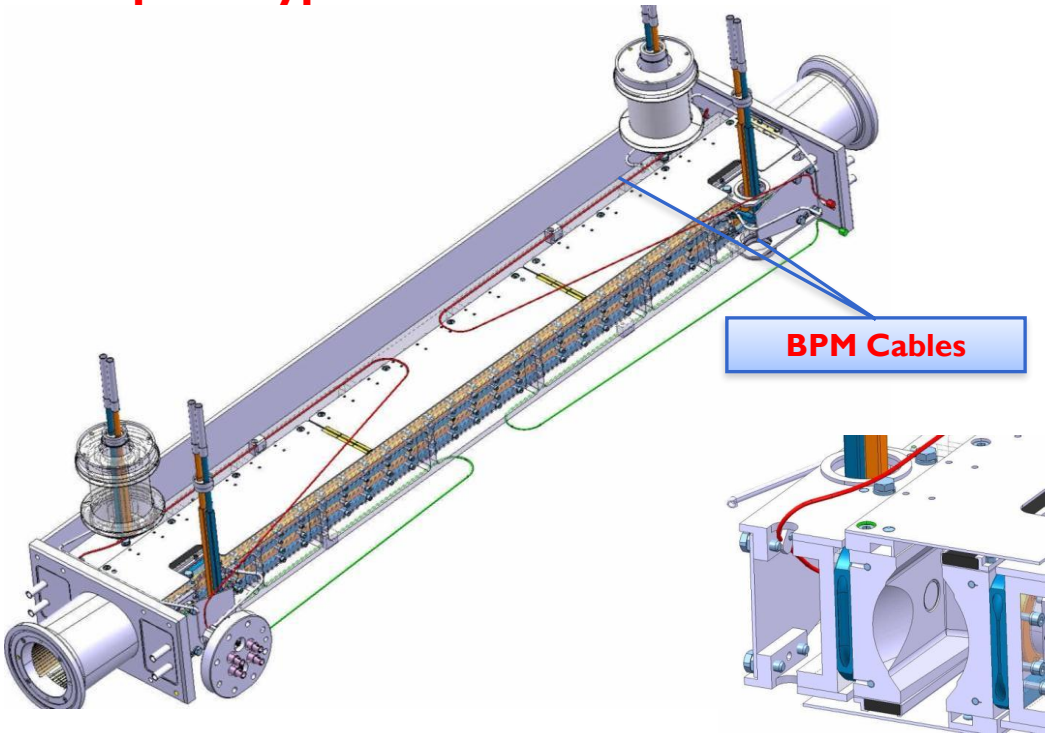
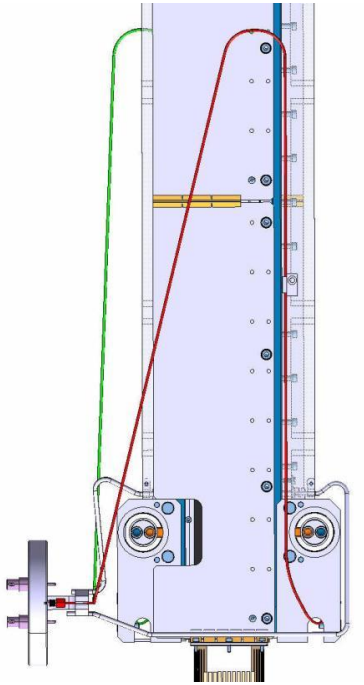


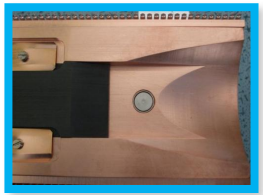


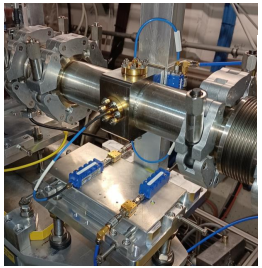
COLLIMATOR BPM @ LHC

- 20 collimators equipped with embedded BPMs installed during LS1 (2012-14)
- Made operational during LHC run 2 (2015-18) showing sub-micron resolution and enabling to set-up collimators in minutes compared to hours without BPMs
- Installed another 20 collimators with BPMs during LS2, using an improved version of electronics (slow acquisition rate but resolution better than 100nm)
- With next consolidation foreseen during LS3, we will have > 70 collimators equipped with BPMs for Run4

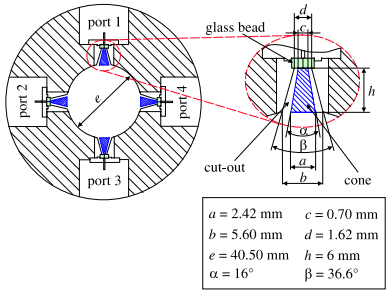
SIMILAR CONCEPT FOR ACC. CAV.

- Incorporating PU's in the mechanical body of accelerating structures
- To be installed at the extremety/middle of the cavities or module
- Pre-alignment of the BPMs with respect to the structures done in metrology to ensure a good position accuracy (<10um)
- Small size button tested at AWAKE high frequency button (MHz-40GHz) BPM





Device	Plane	Detection band
HF-BPM	x	11.375 ± 0.250 GHz
HF-BPM	y	26.25 ± 0.900 GHz



*See A. Angelovski et al., Phys. Rev. ST Accel. Beams **15**, 112803 (2012)*

SIMILAR CONCEPT FOR ACC. CAV.

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Broadband PU adapted to fit in the 60mm beam pipe diameter @ AWAKE

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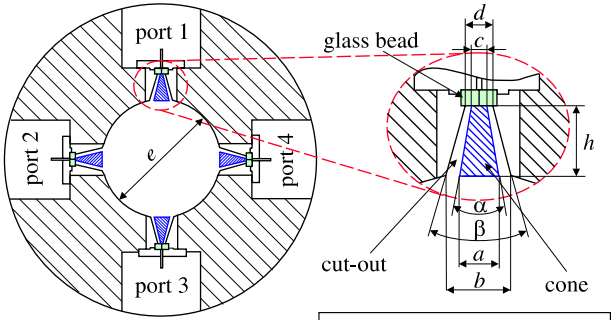

a = 2.42 mm	c = 0.70 mm
b = 5.60 mm	d = 1.62 mm
e = 40.50 mm	h = 6 mm
α = 16°	β = 36.6°

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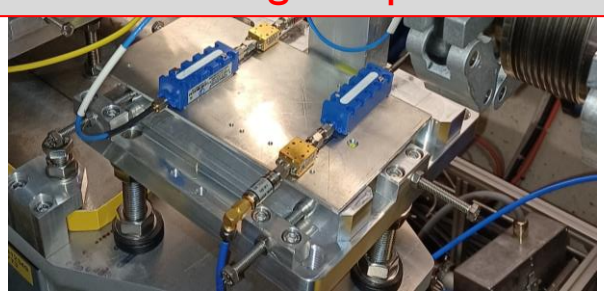

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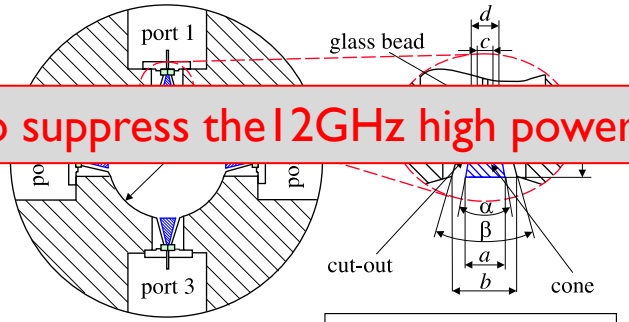

a = 2.42 mm	c = 0.70 mm
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Works well but would need strong low pass filtering to suppress the12GHz high power

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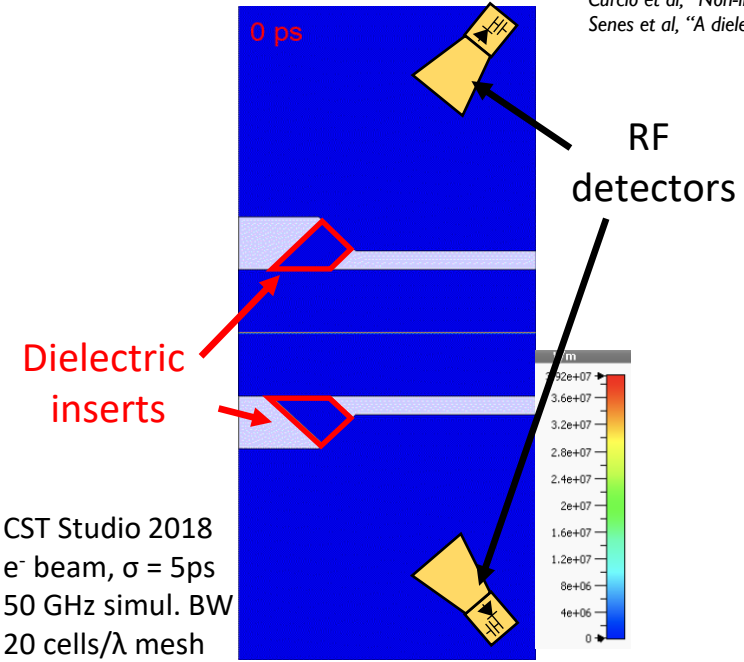
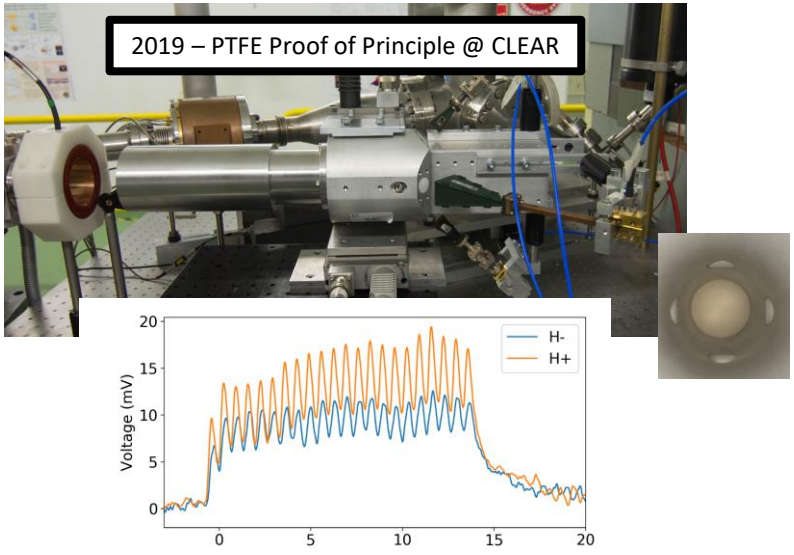
SIMILAR CONCEPT FOR ACC. CAV.

- Since 2019, developing dielectric Button BPM based on Cherenkov radiation

Curcio et al, "Non-invasive bunch length measurements exploiting Cherenkov diffraction radiation, PRAB 23, 022802 (2020)
Senes et al, "A dielectric beam position monitor for short bunches of charged particles", Ph. D thesis

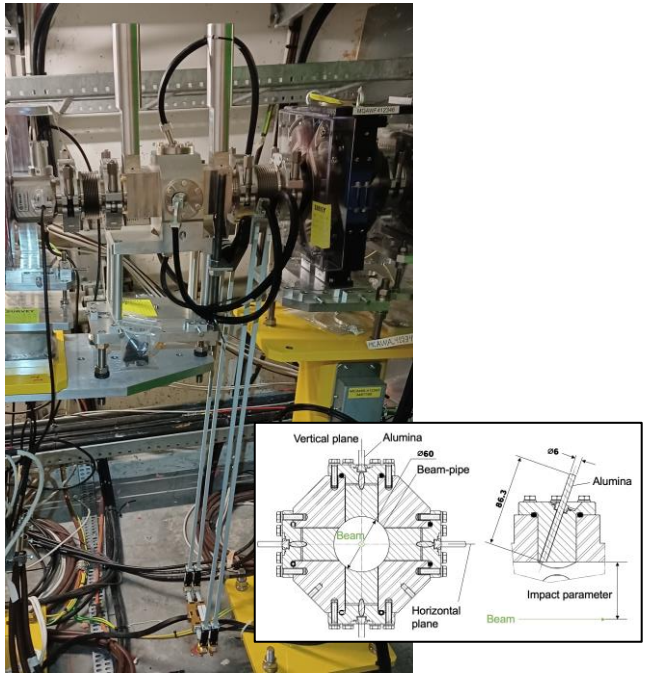


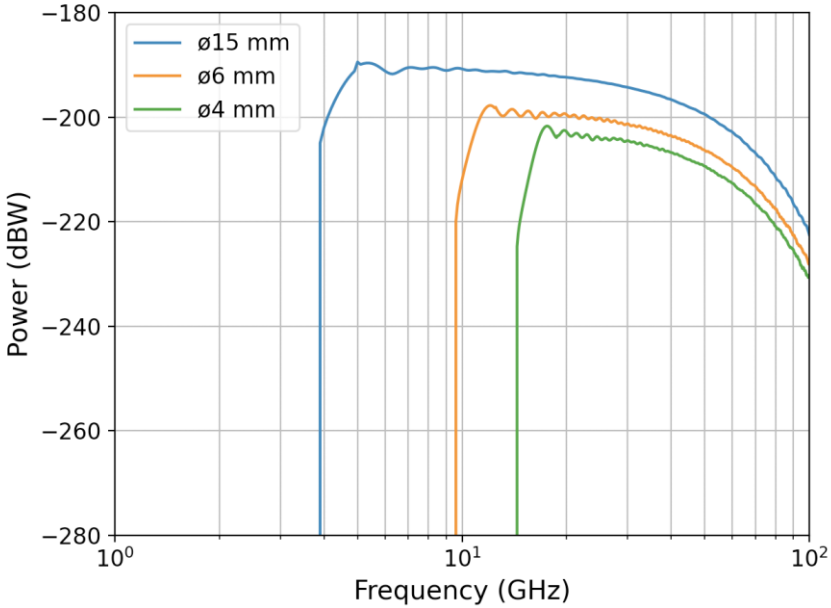
CST Studio 2018
e^- beam, σ = 5ps
50 GHz simul. BW
20 cells/λ mesh



SIMILAR CONCEPT FOR ACC. CAV.

- Vacuum compatible pick-ups using brazed alumina at AWAKE





Courtesy of E. Senes

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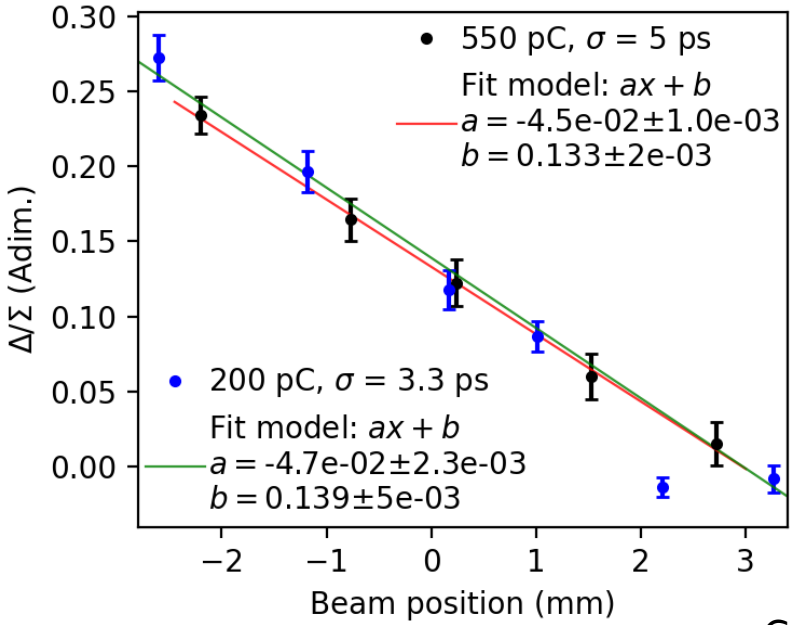
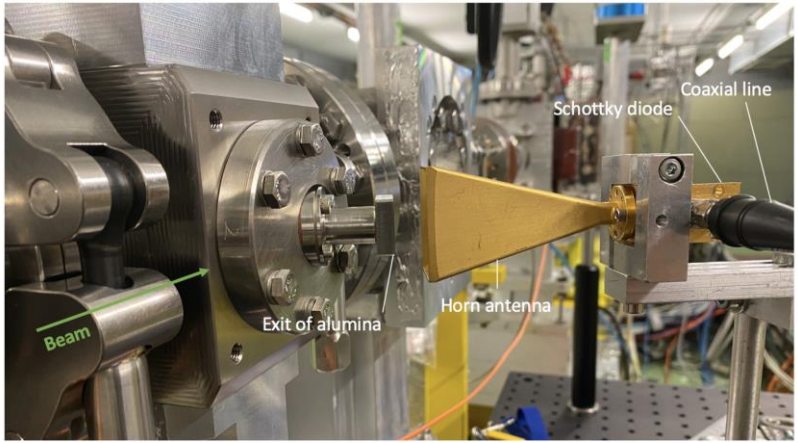
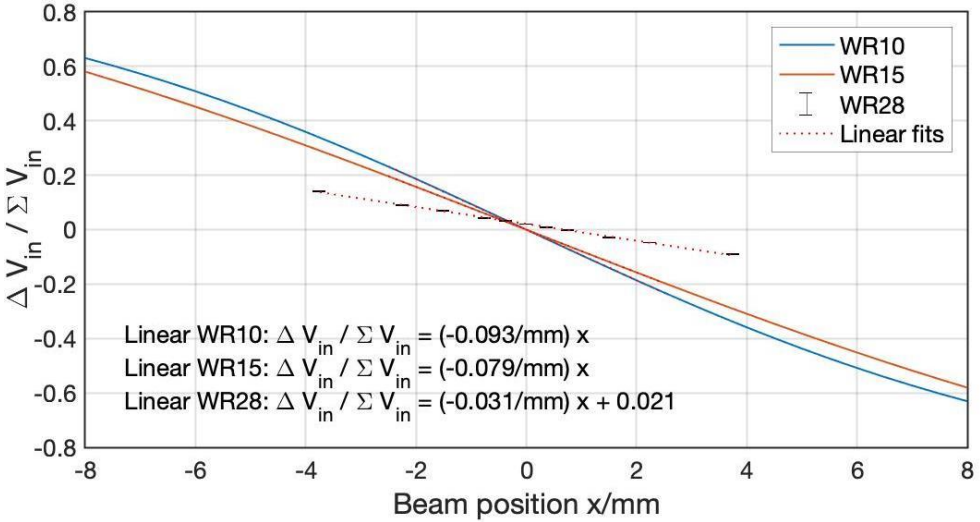


Courtesy of E. Senes

SIMILAR CONCEPT FOR ACC. CAV.

- Vacuum compatible pick-ups using brazed alumina at CLEAR





Similar position sensitivity compared to normal electrostatic PU's – but working at higher frequencies

Courtesy of C. Pakuza

CONCLUSIONS

- BPMs embedded in collimators have already proven their capabilities to centre / align collimators around beam with good precision and accuracy
- For Acc. Structures, a similar concept could be adapted but with different PU technology compatible with the presence of high power at 12 GHz
  - small electrostatic button or dielectric button
- Expected resolution / accuracy (1um/5um) challenging but not very far with the general requirements for wakefield monitoring at CLIC
- Same technology will be naturally used in dielectric acc. Cavities.

Thanks for your attention