INTEGRATING BPMS IN ACC. STRUCTURES

T. Lefevre, CERN, 7th October 2020

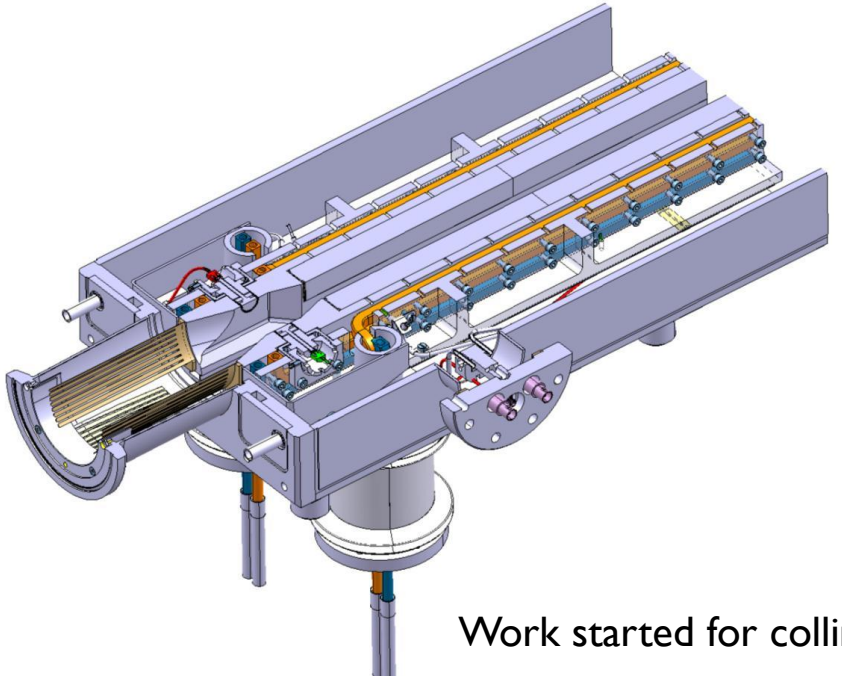
AS ALTERNATIVE TO
WAKEFIELD MONITORING
IF ……NECESSARY

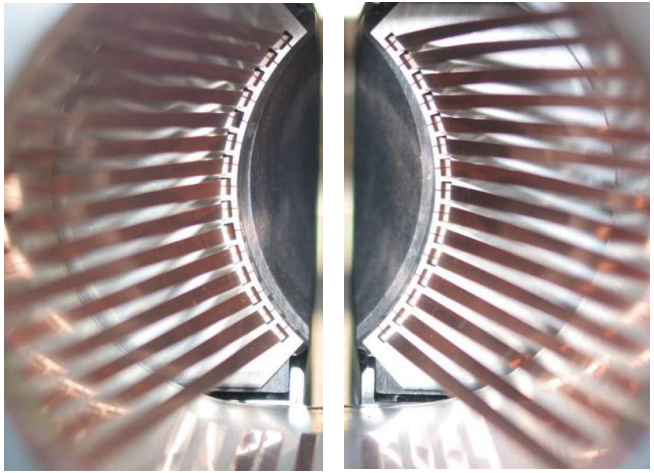
OUTLINE

- 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

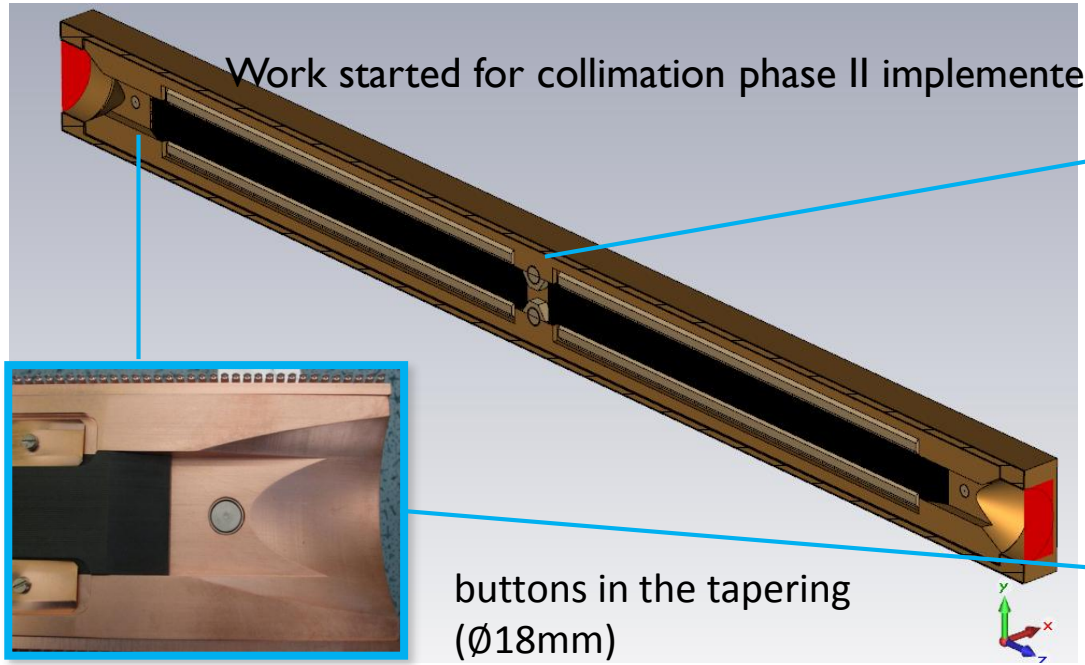


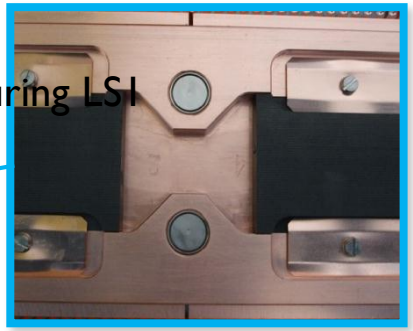


Work started for collimation phase II to help centering jaws around the beam

COLLIMATOR BPM @ LHC

First prototype in 2011





Center pair of buttons
(Ø18mm)

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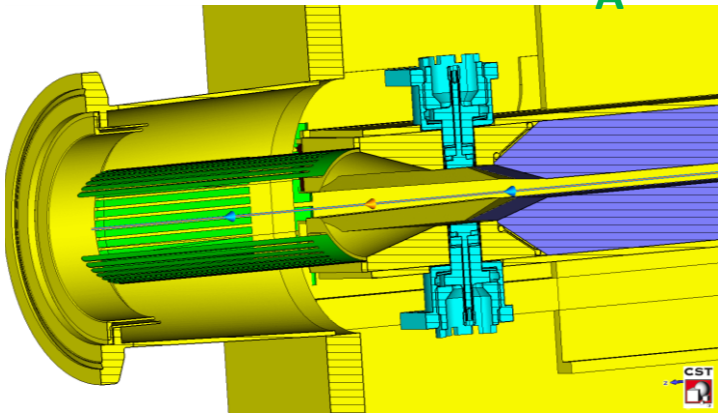
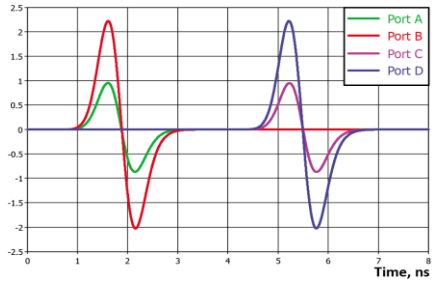
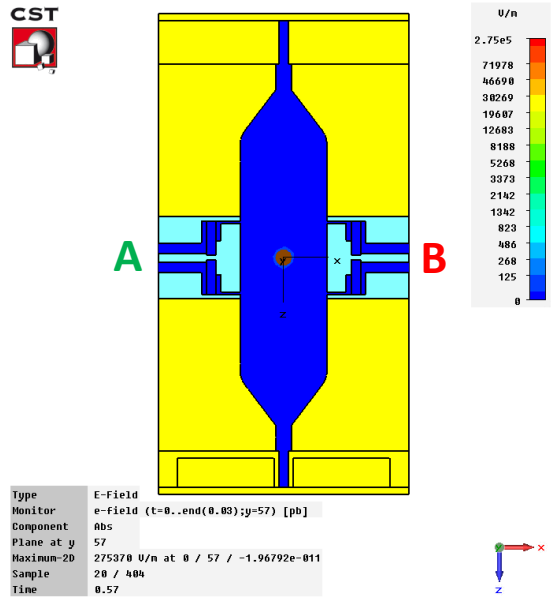




Typical up and downstream time signals with beam offset



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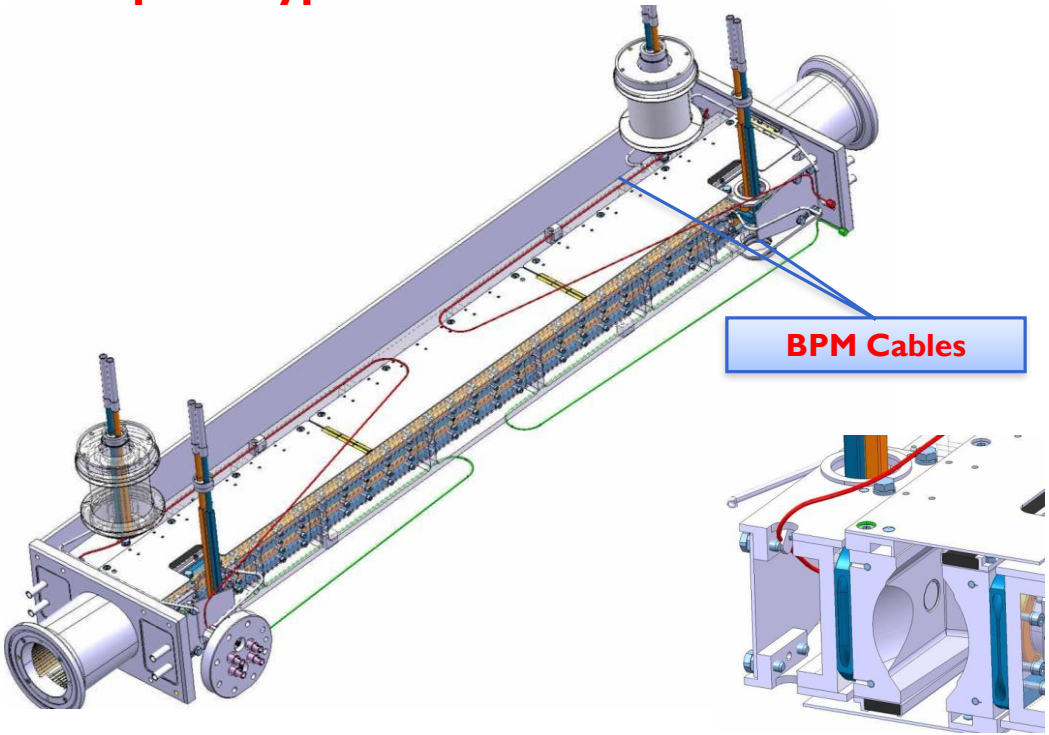
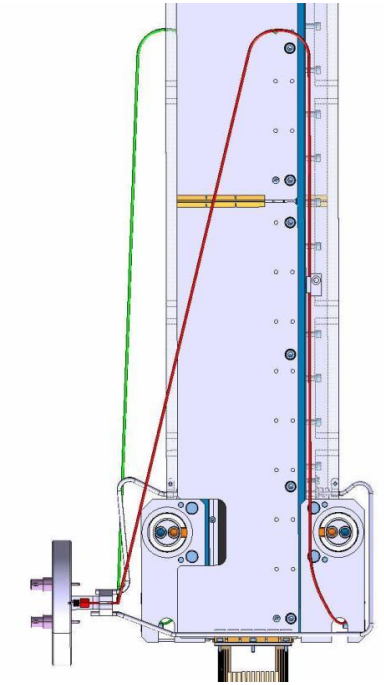


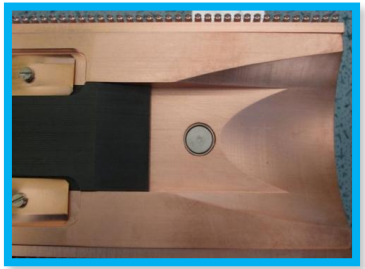


COLLIMATOR BPM @ LHC

- 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
- During LS2 a new serie of collimators with BPMs is being installed
- Plan is to have almost all collimators equipped with BPMs for LS3 (> 70)

SIMILAR CONCEPT FOR ACC. CAV.

- Incorporating PU's in the mechanical body of accelerating structures
  - Installed at the extremety of the cavities or module ?
  - Button with smaller size (~Ø1mm)
  - Pre-alignment of the BPMs with respect to the structure done in metrology to ensure a good position accuracy (<20um)
  - BPM read-out systems based on CLIC BPM technology
    - Designed resolution of 5um for single shot measurement



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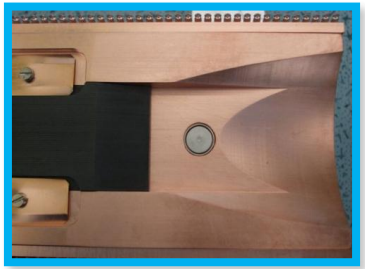
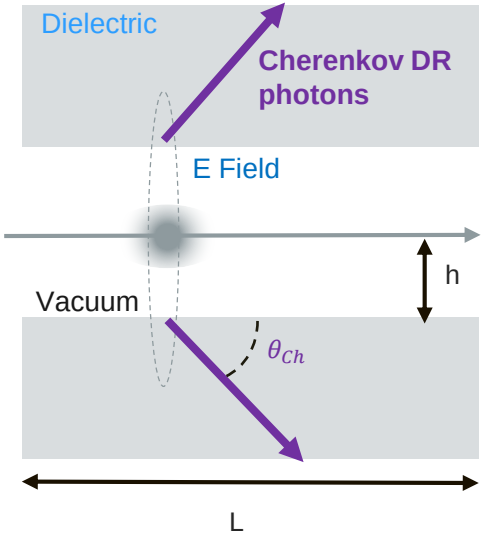


Possible issue with the use of electrostatic PU's due to presence of 12GHz high power

SIMILAR CONCEPT FOR ACC. CAV.

- Possible solution using dielectric Buttons producing Cherenkov radiation



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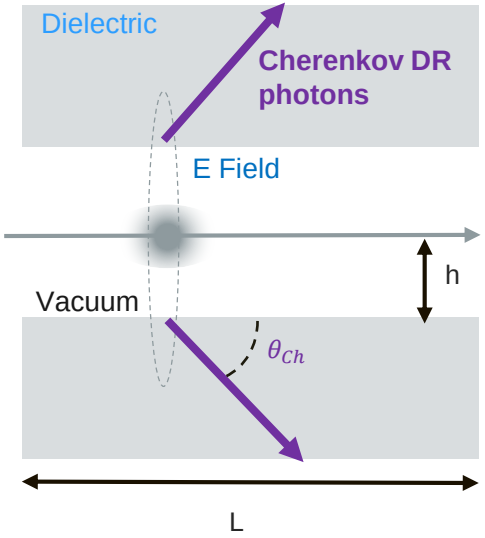
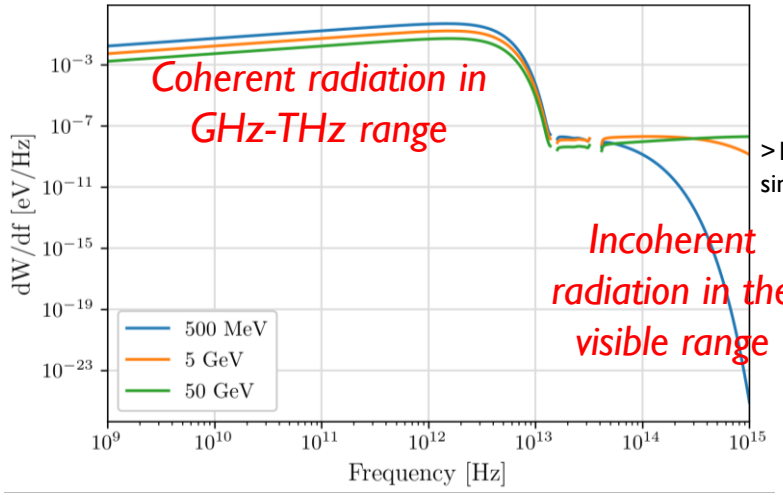


Typical Radiation spectrum for short bunches



>10E6 photons for single bunch

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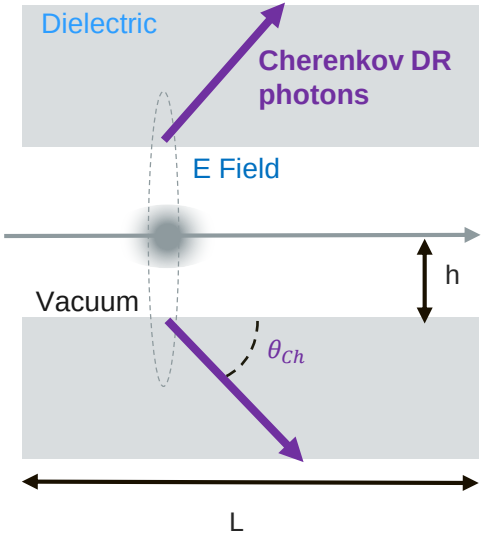
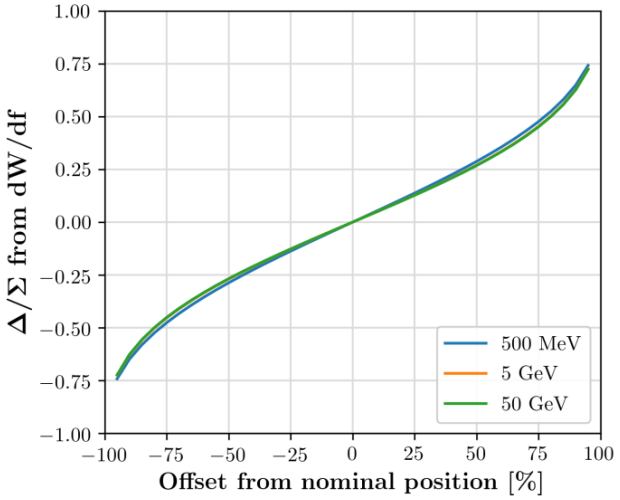


Typical BPM response curve

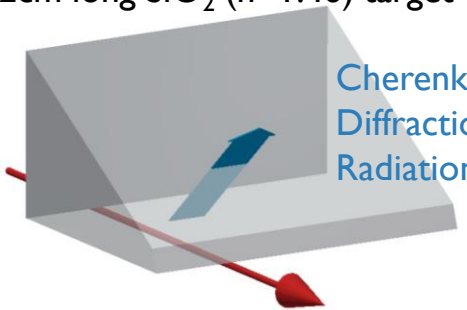


SIMILAR CONCEPT FOR ACC. CAV.

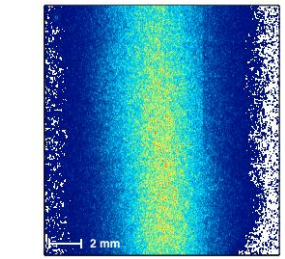
- Tested dielectric Buttons producing incoherent radiation at Cornell

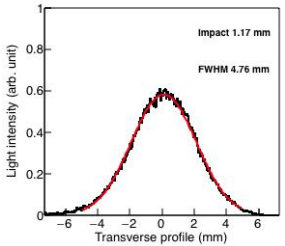
*R. Kieffer et al., "Direct Observation of Incoherent Cherenkov Diffraction Radiation in the Visible Range", PRL **121** (2018) 054802*
*R. Kieffer et al., "Generation of Incoherent Cherenkov Diffraction Radiation in Synchrotrons", PRAB **23** (2020) 042803*

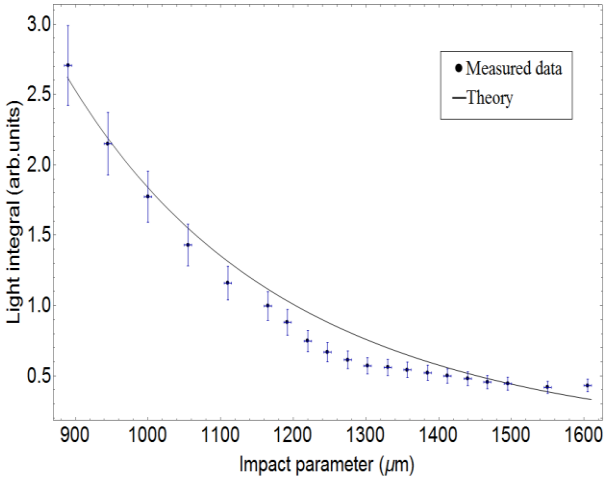
2cm long SiO_2 (n=1.46) target



5.3GeV positron Beam



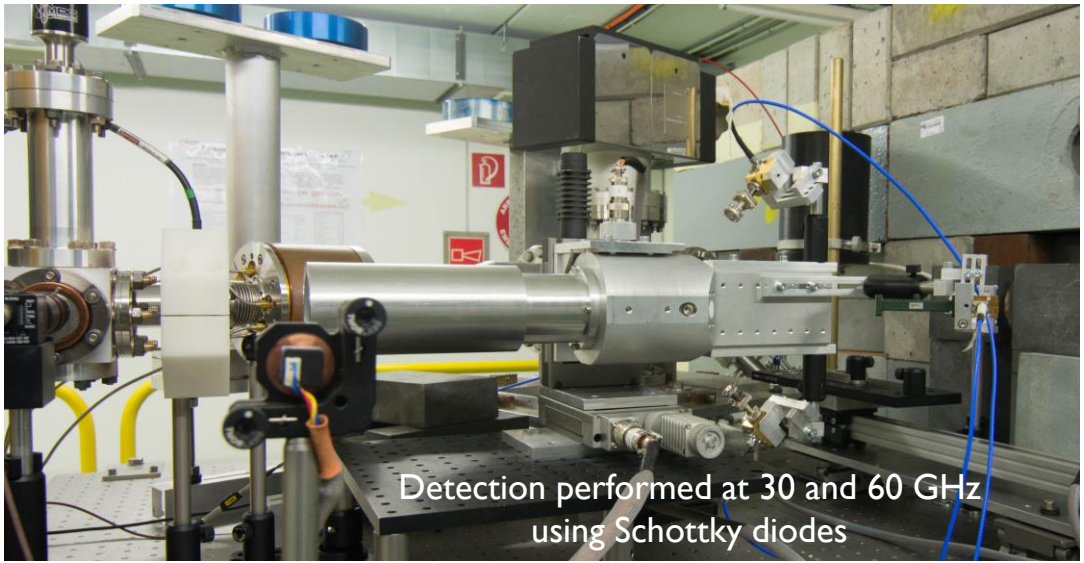


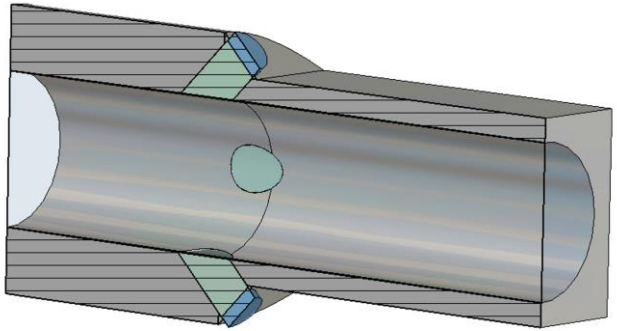


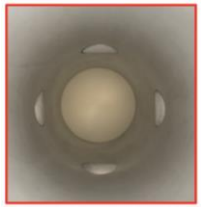
SIMILAR CONCEPT FOR ACC. CAV.

- Tested dielectric Buttons producing Coherent radiation at CLEAR

  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", to be submitted







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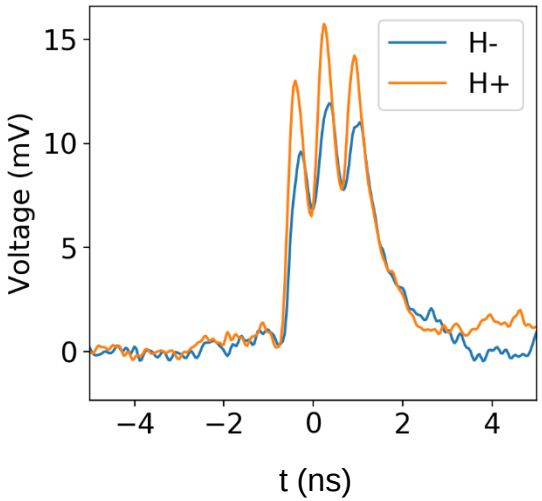

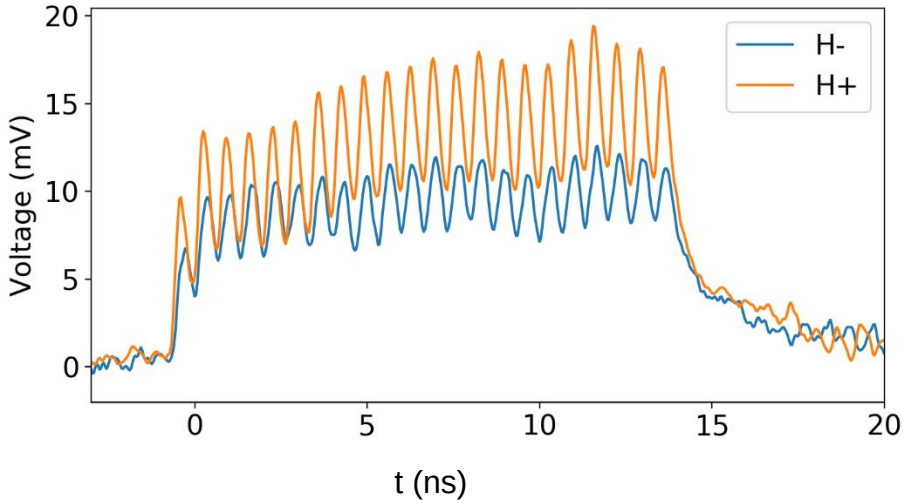

Bunch by bunch time resolution possible

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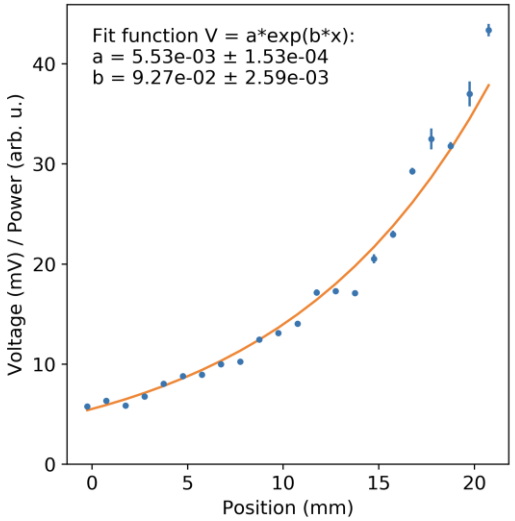
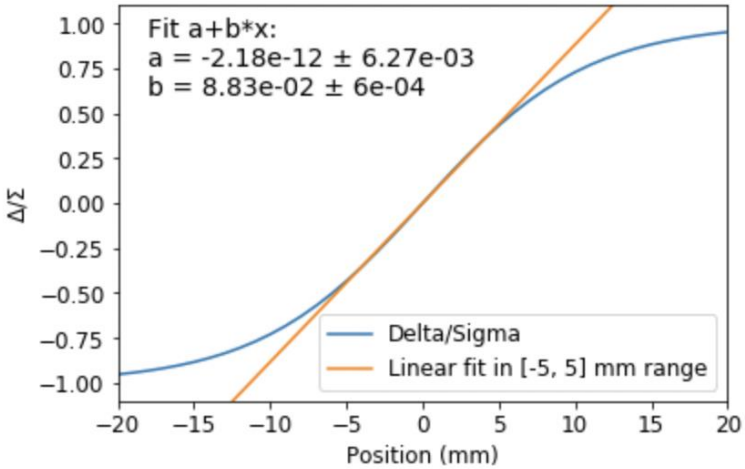


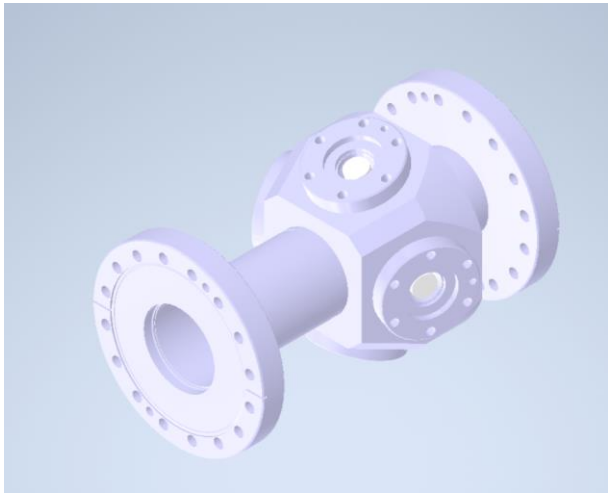
Measured position sensitivity

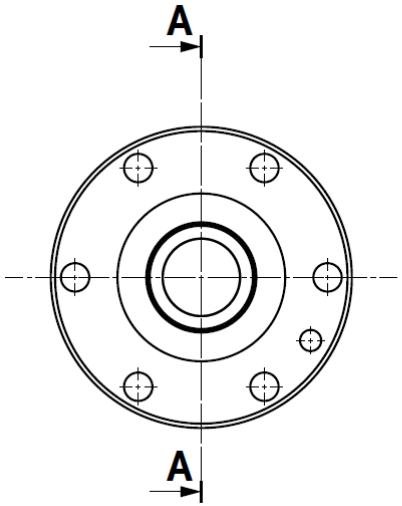


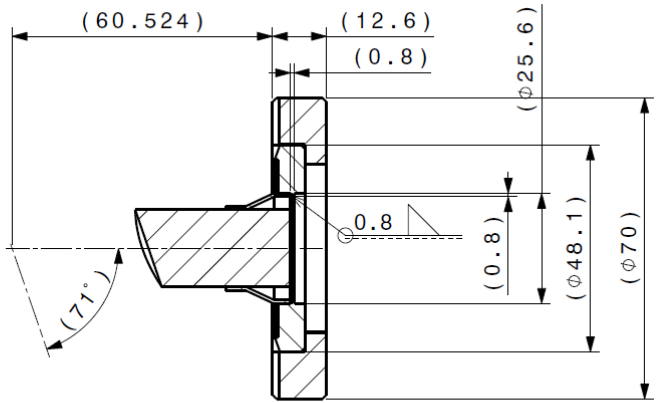
Similar resolution as for normal electrostatic PU's – but working at higher frequencies

SIMILAR CONCEPT FOR ACC. CAV.

- UHV prototypes (AWAKE / LHC) to be tested by the end of the year at CLEAR (Ø4mm - Ø38 mm)







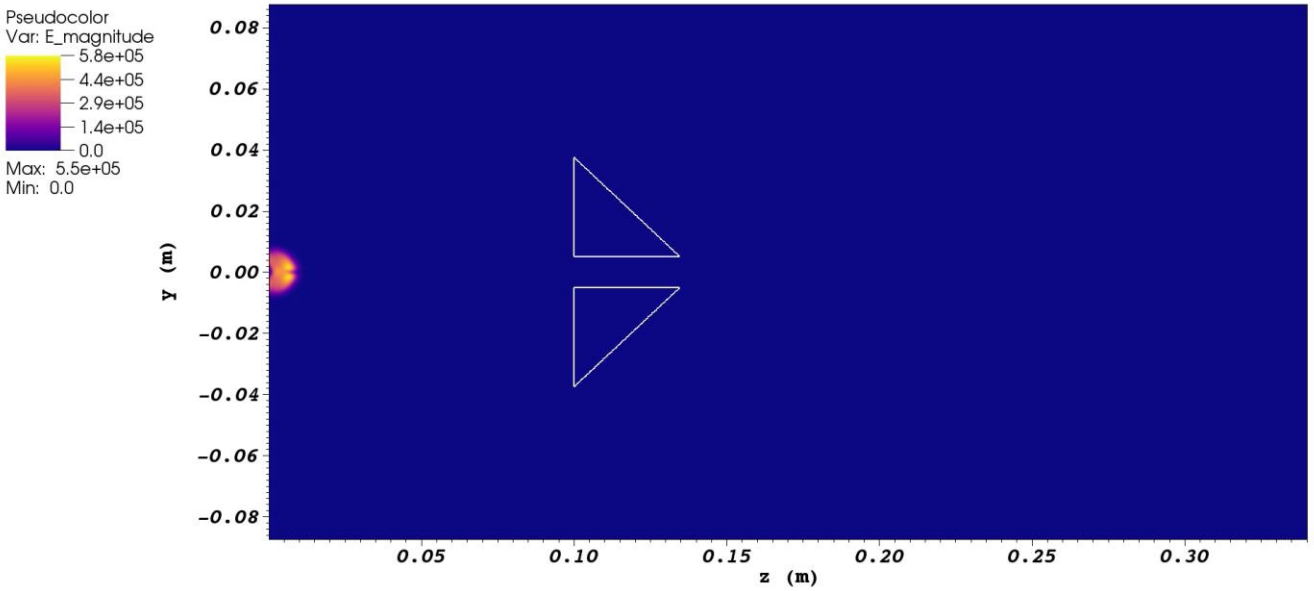
CONCLUSIONS

- BPMs embedded in collimators have already proven their capabilities to centre 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
- Expected resolution / accuracy compatible with the general requirements for wakefield monitoring at CLIC
- Same technology will be naturally used in dielectric acc. Cavities.

Thanks for your attention

MODELLING AND SIMULATIONS

Simulations of a short bunch in a Teflon target using VSIM



from K. Lekomtsev