HL-LHC HEL BPM

Preliminary design considerations

Outline

- Specifications
- First ideas
- Beam signals
- LF system
- HF system
- Acquisition system
- Summary

Specifications:

	Proton beam	Electron beam	Comments
Intensity	? - 2.5E11 (63A)	? - 5A	
Bunch / Pulse length	1ns	86us	P=4σ; E_beam off 3us; tr = 200ns
Relativistic β	1	0.2	E_{Beam} Low β = 5* charge density
Resolution	5um	5um	
Relative accuracy	30um	30um	
Time resolution	1s	1s	TBD

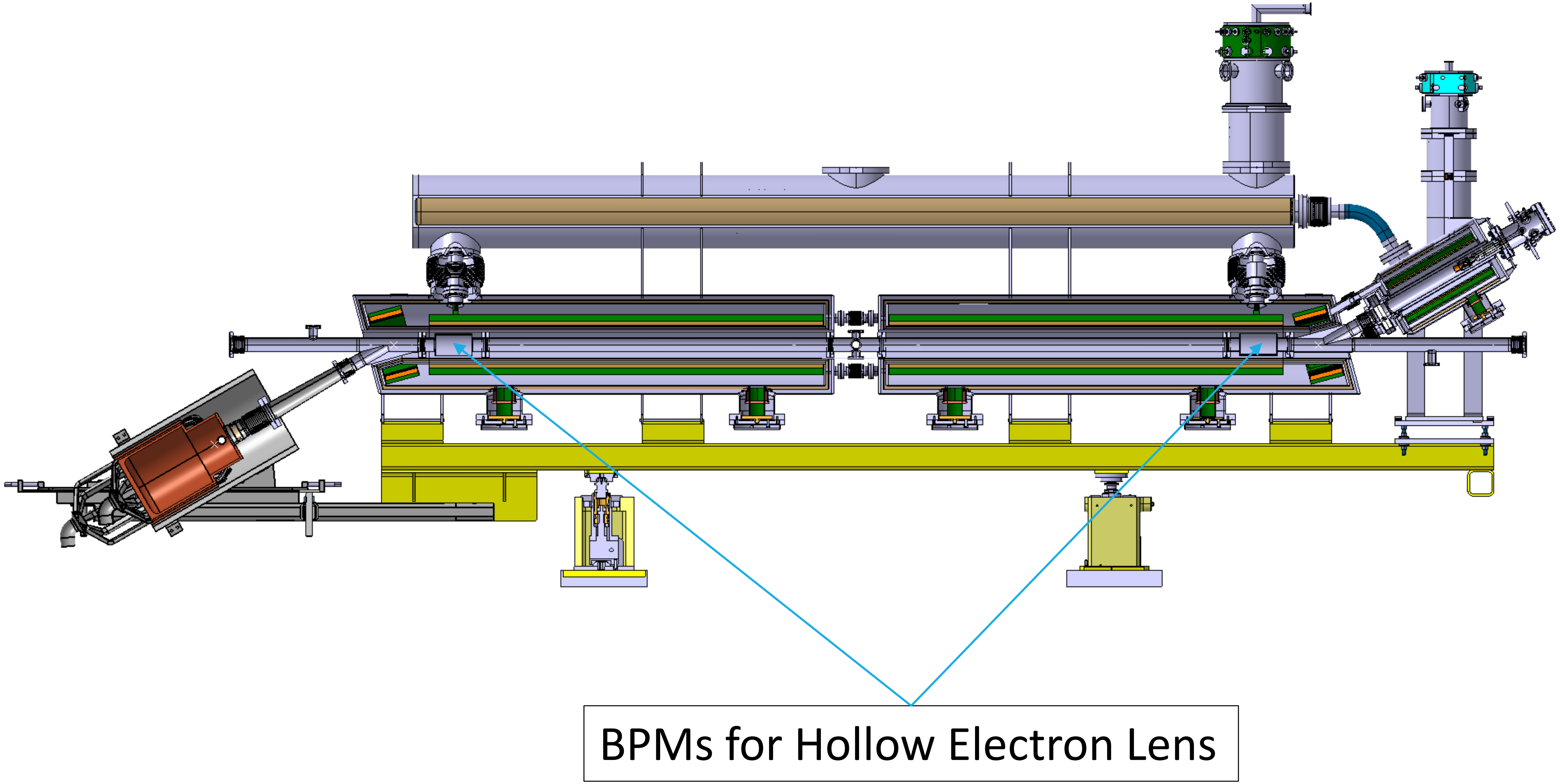
- Functional specifications not so clear (to me):
  - E_beam on continuously and only off in abort gap?
  - Injection and / or only stable beams?
  - Pilots, batches, full machine…

First ideas

- Same BPMs for the two beams
  - **Minimize mechanical offsets**

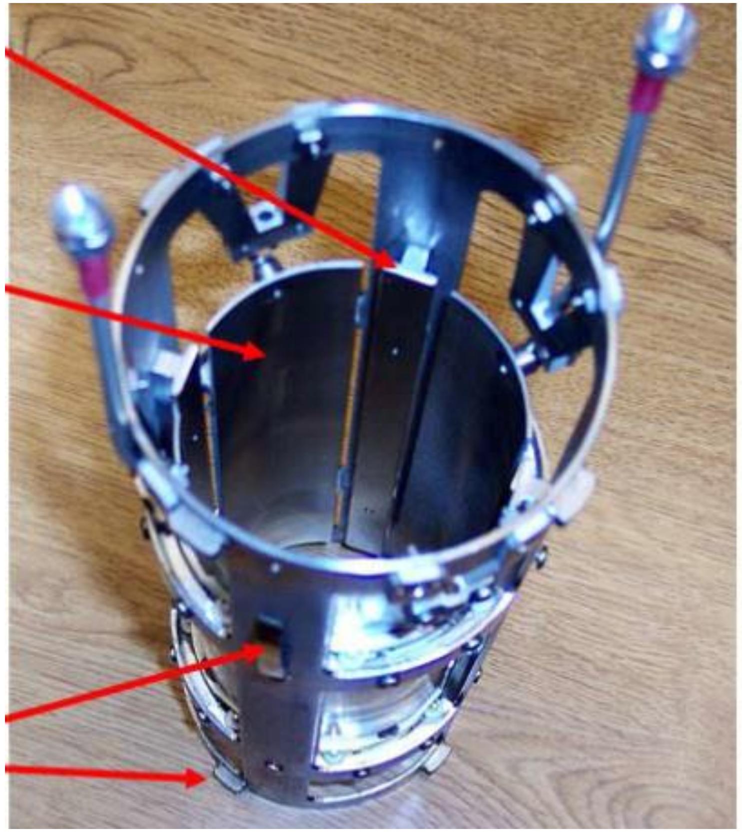
- Same electronics for the two beams to minimize electrical offsets
  - **Frequency separation**
    - Different electronics for the two beams. Bigger offsets
    - A lot of 11kHz lines will make it very difficult
  - **Time separation**
    - Measure E_{Beam} in abort gap and P_{Beam} outside, **using same part of spectrum**
    - Same electronics for two beams, **<u>if same amplitude range</u>**

- Low frequency (< 40MHz) or High frequency (40MHz++)
  - Depends if E_{Beam} modulation is possible?


BPMs for Hollow Electron Lens

BPMs considered

FNAL TEL 2 BPM



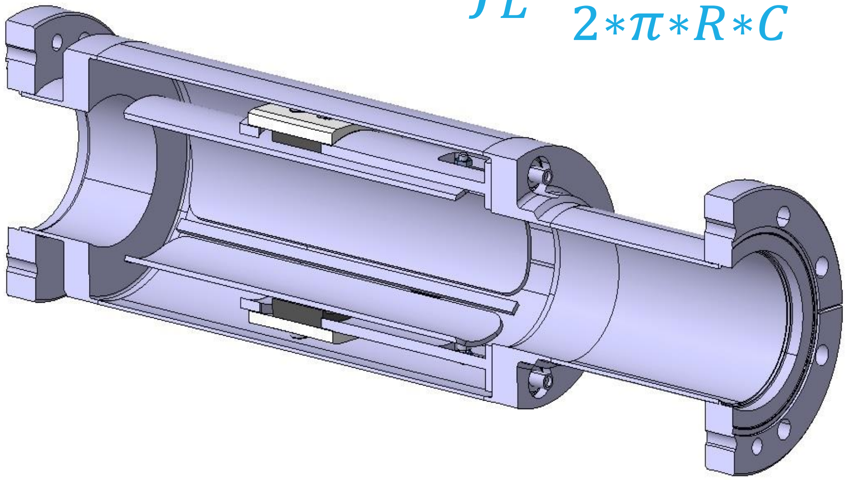
Present HEL BPM design

L= 100mm, φ=75°; C=20pF, R=50Ω

Z_{coup_E} = **15.9 ohms**

Z_{coup_P} = **3.1 ohms**

$$f_L = \frac{1}{2*\pi*R*C}$$



Button BPM

D= 20mm; C=20pF; R=50Ω

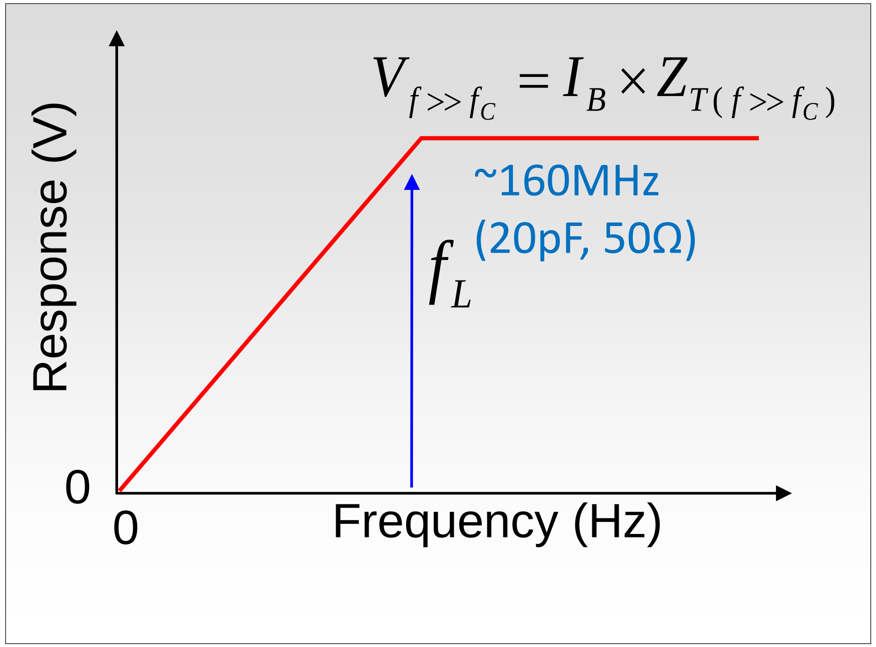
Z_{coup_E} = **1.1Ω**

Z_{coup_P} = **0.2Ω**

Wide band Beam signals with electrostatic BPM

Zcpl_E = **15.9 ohms**

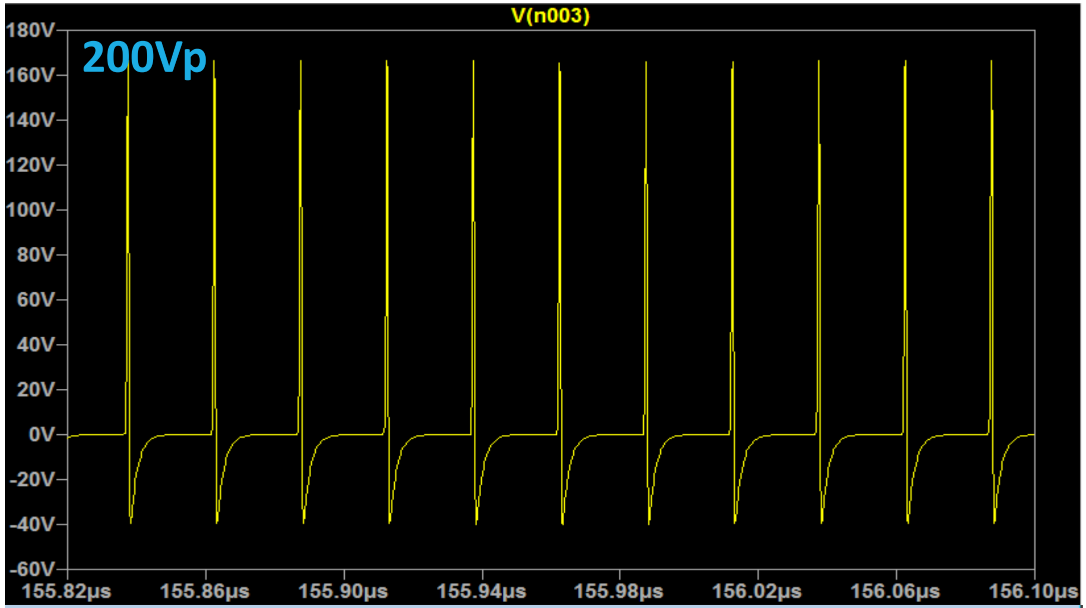
Zcpl_P = **3.1 ohms**



E_{Beam} spectrum heavily filtered

Protons :

I= 63A, 25ns

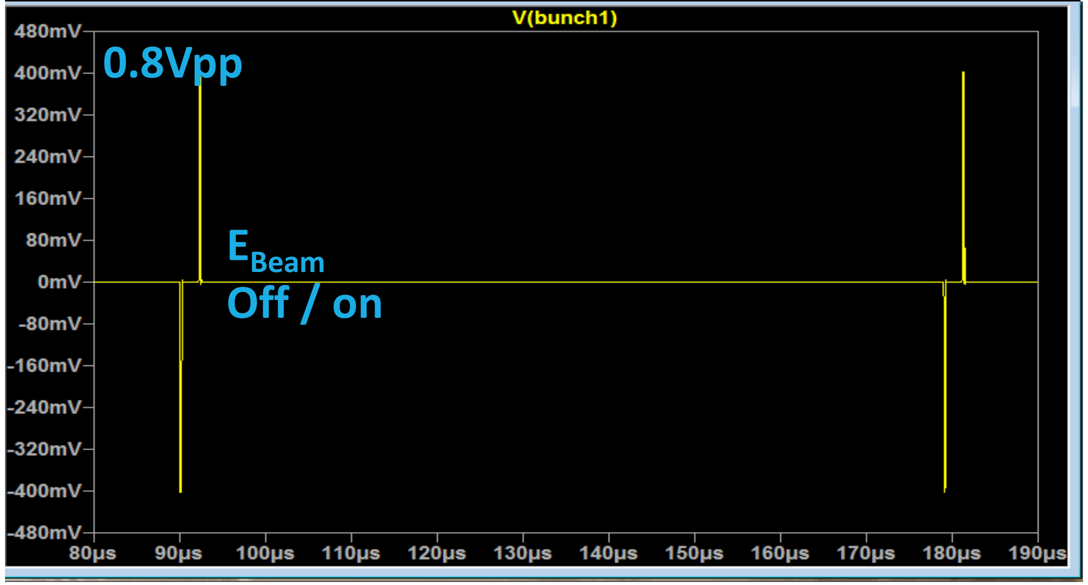


Electrons :

I= 5A,

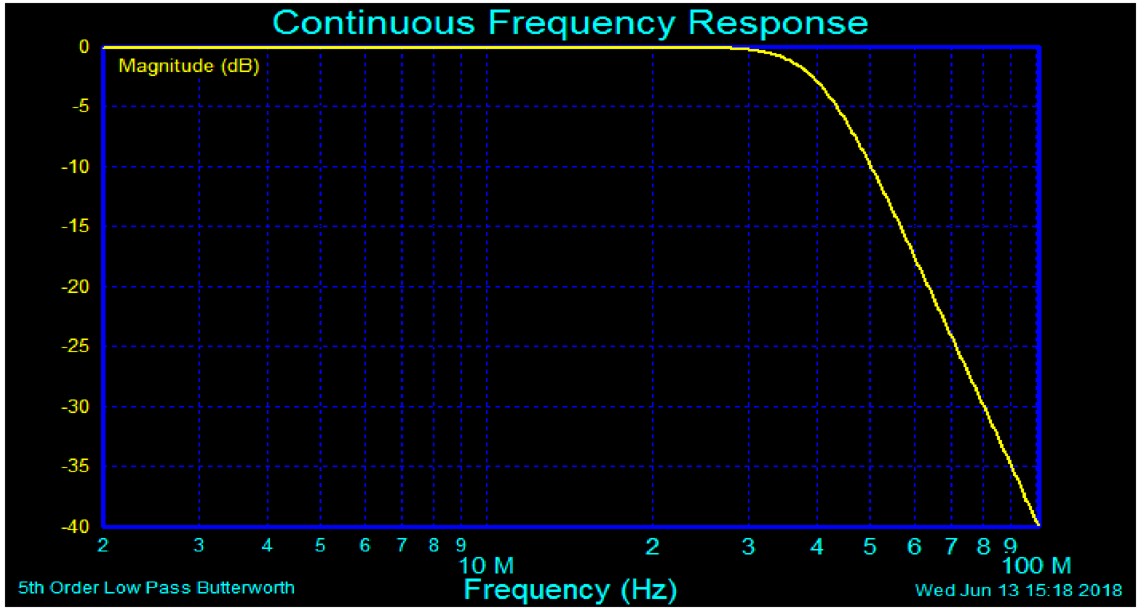
Tr=200ns,

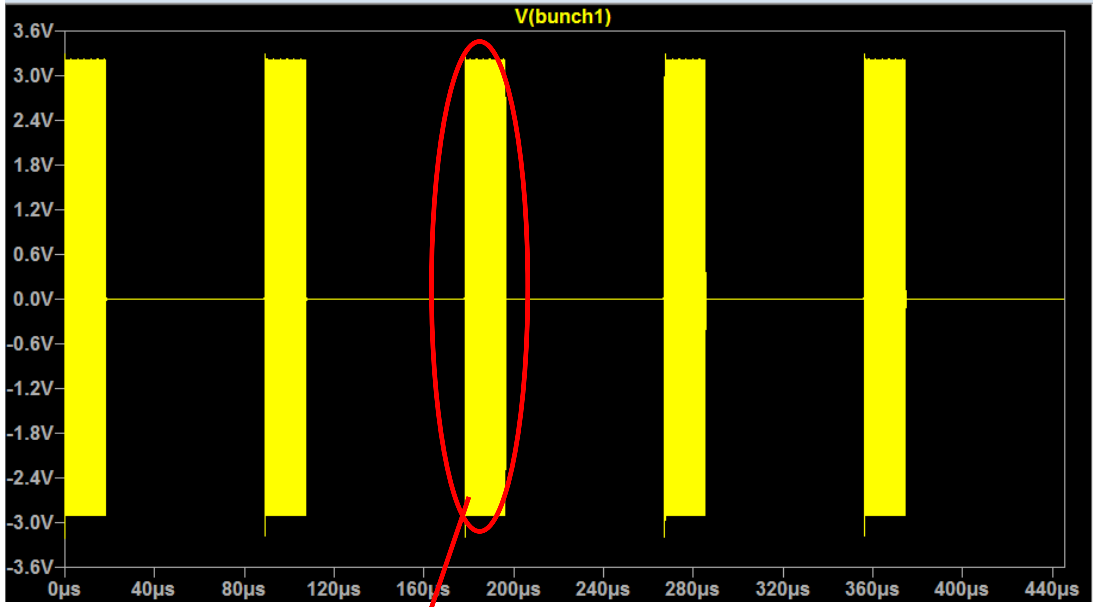
off 2us

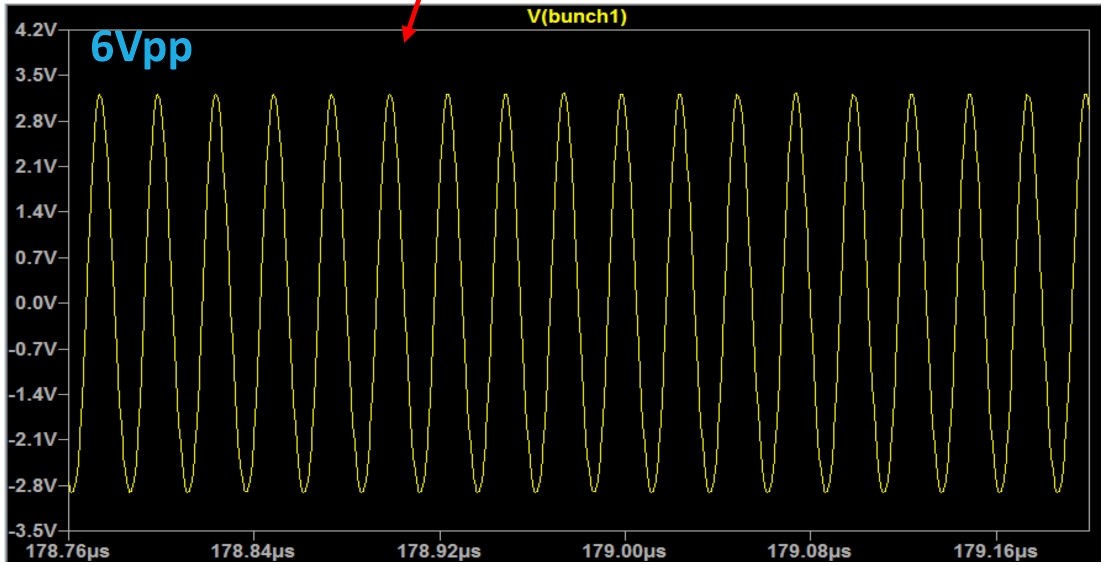


Low frequency: P_{Beam} signals with electrostatic BPM

With 40MHz LP filter





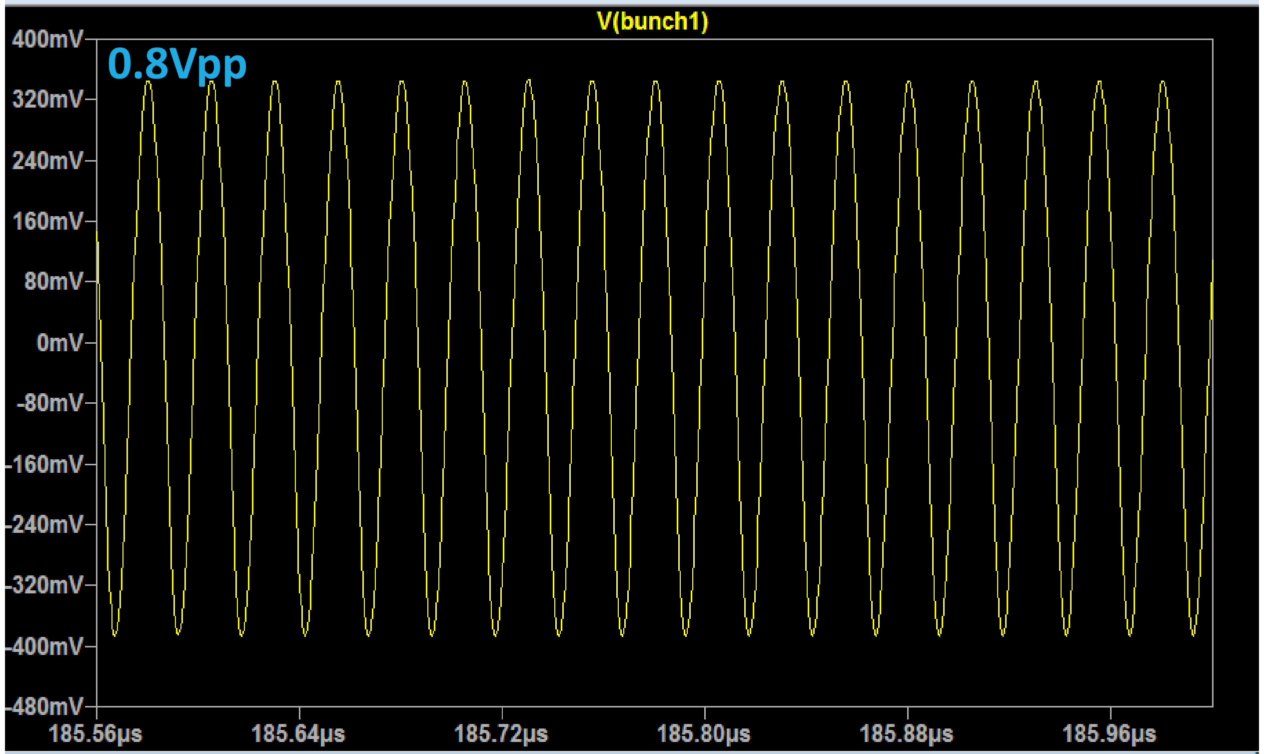


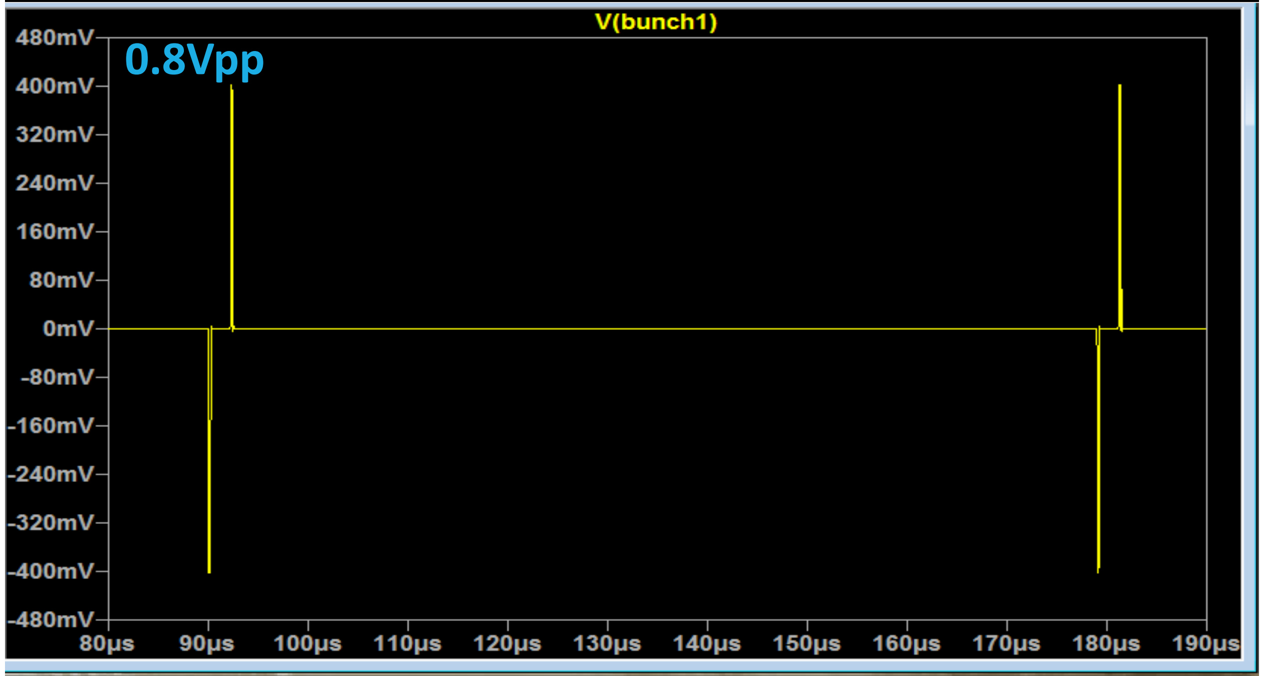
Still a factor ~10 too high

With 25MHz LP filter

- With button BPM signal levels would be 15 times smaller ~25mV.
- Electrostatic BPM seems better suited for the LF version
- BP filter should be considered to minimize noise and offsets
- Amplitudes shown for max currents

BPM coupling impedance for E_{Beam} = 15.9Ω.
20% modulation @20MHz, 1A = ±8V/10=0.8V
(Factor ~10 less signal due to BPM high pass)

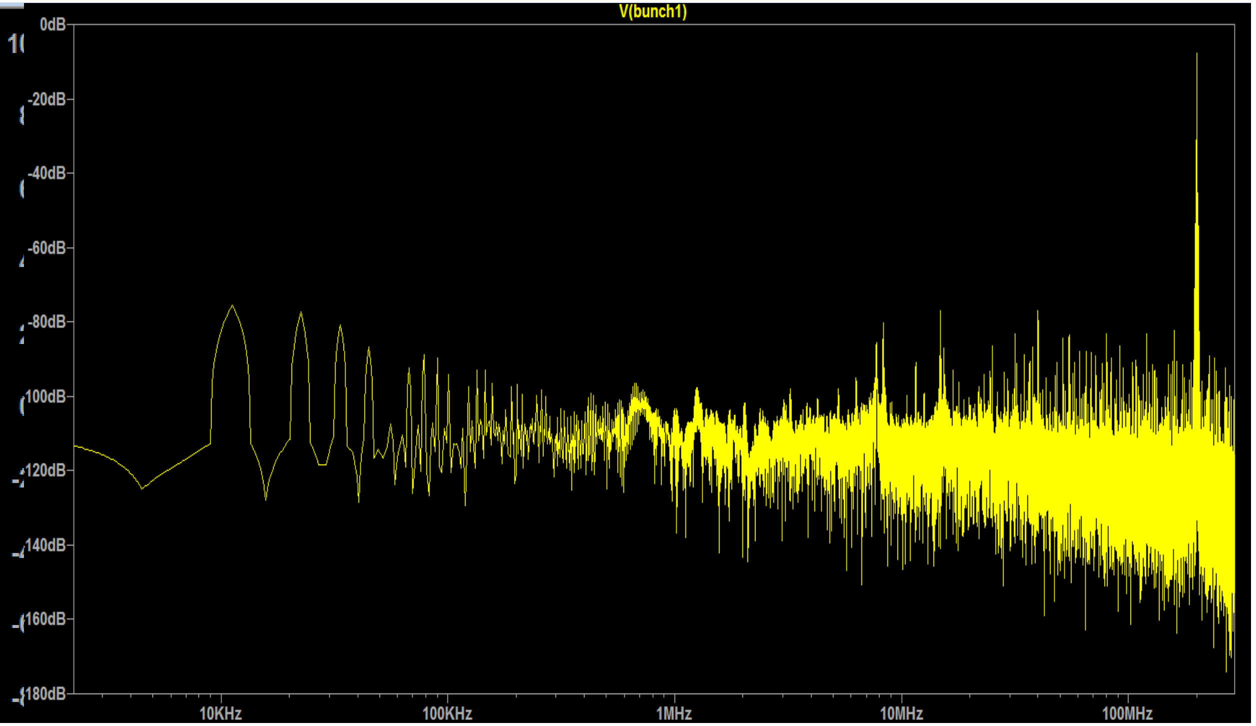




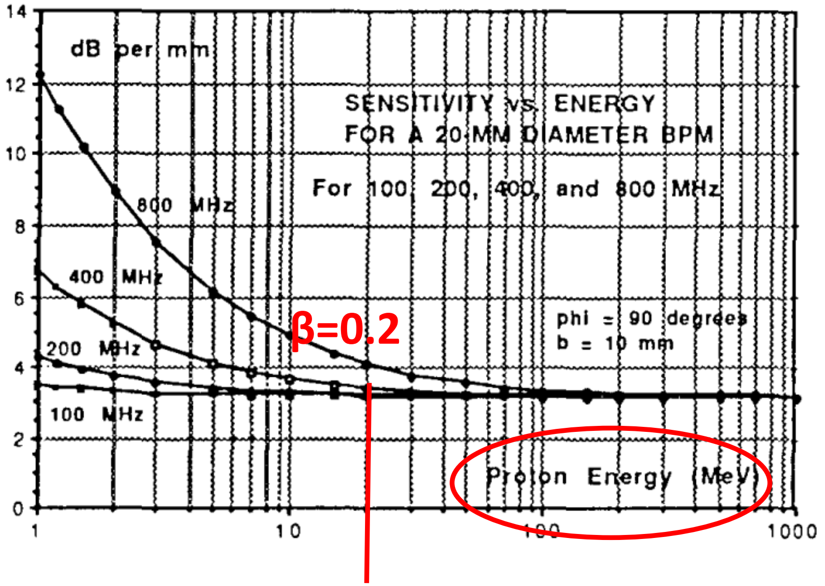
High Frequency: With E_{Beam} modulation @ 200MHz

- Working in BPM pass band
- Electrostatic BPM coupling impedance for E_{Beam} = 15.9Ω.
- **20%** sinewave modulation 1A = ±8V
- Button BPM amplitudes ~ 500mVp

- NEED 20% modulation
- Higher resolution on E_{Beam}
  - Number of 5ns periods in 2us : 40
  - 20*higher amplitudes

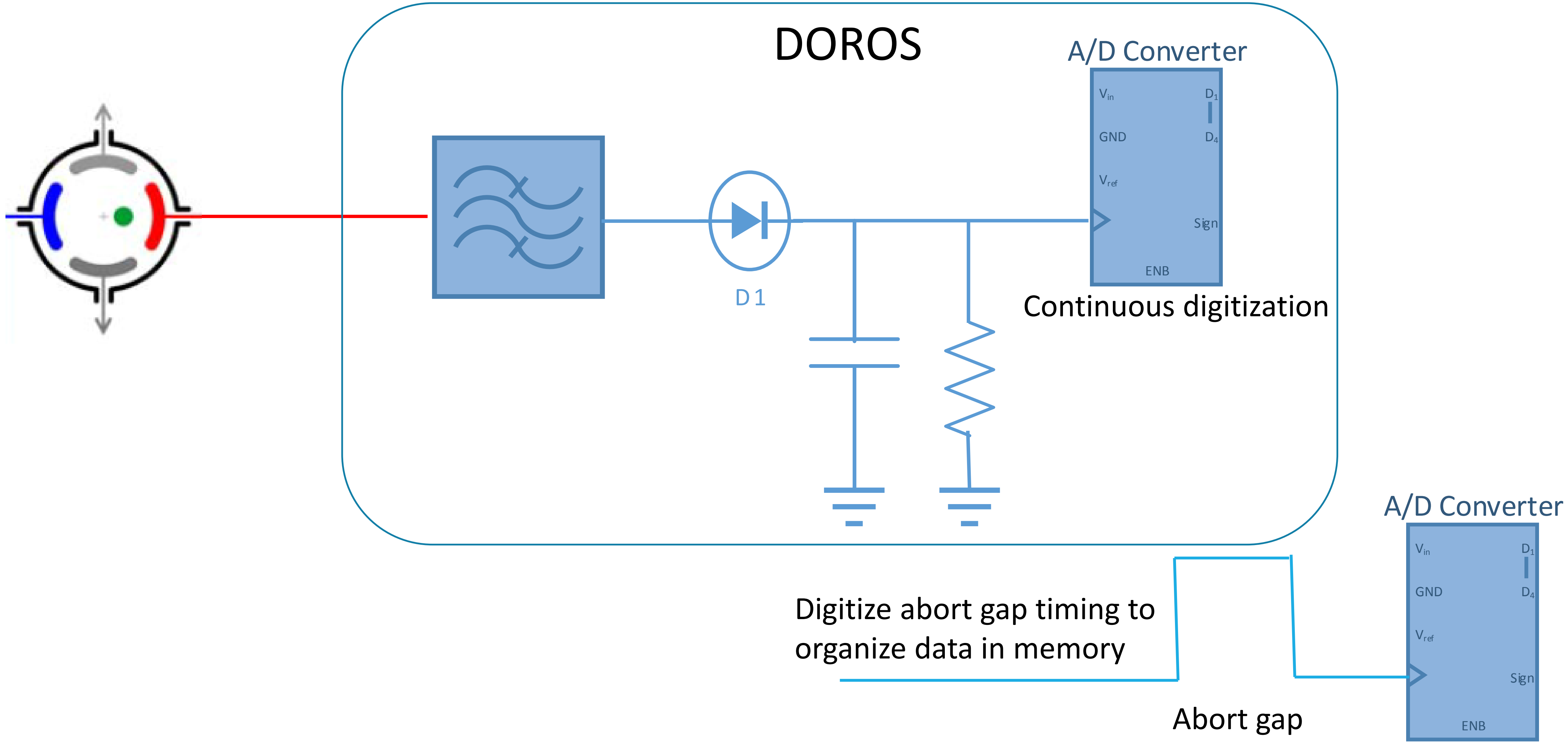


100MHz no sensitivity change @ β=0.2



Proton beam with 200MHz, 5MHz BP, 5^{th} order, 2.5E11, σ= 0.25ns

Possible acquisition system



Summary:

- We can tailor the signal conditioning (filter) to have only one acquisition system for the 2 beams, ADC included.
- Low frequency system:
  - Electrostatic BPM needed to get sufficient signal levels
  - Resolution still to be estimated but ~100* worse than high frequency system
  - Resolution can be significantly improved with high load resistance, but electrode charging could be a serious issue
- High Frequency system
  - In BPM passband > 200MHz
  - 20% Modulation is needed
  - Can be very narrow band around harmonic / modulation frequency
  - Low beta effect on BPM sensitivity to be verified. 100MHz seems OK
- Acquisition system
  - DOROS type seem a very good option