# INFN Frascati contributions to CTF3-002:

## Monitors and Kickers for Drive Beam Phase Feed-forward

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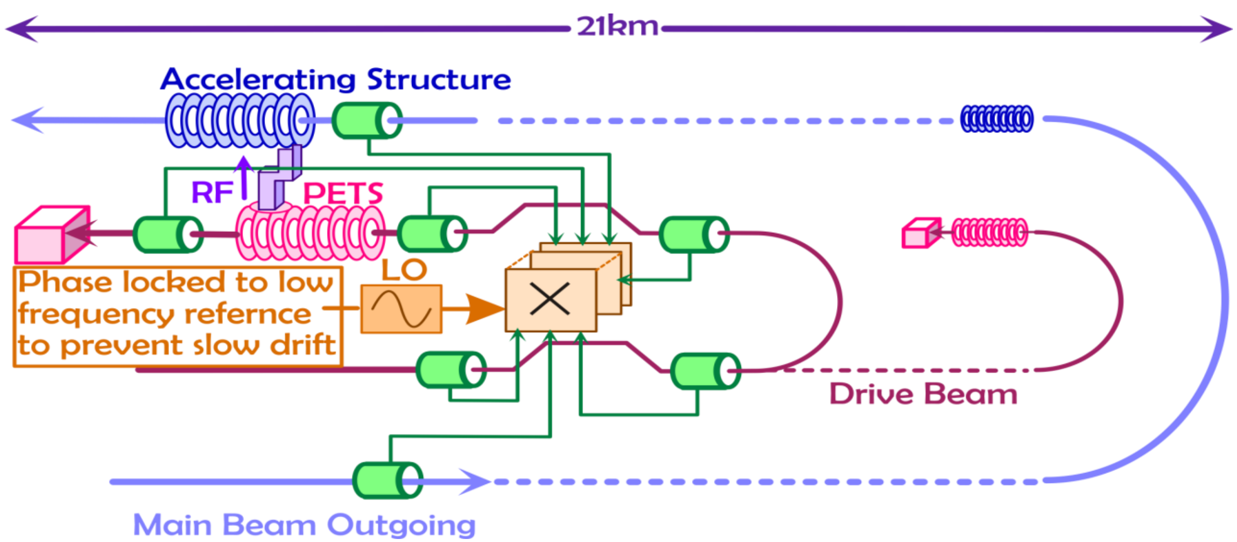
# Phase error control

- In the two beam acceleration scheme is important to synchronize precisely the Main Beam with respect to the RF power produced by the Drive Beam.
- Timing errors lead to energy variations in the Main Linac and would have an impact on the collider performance (luminosity reduction).




*Overall CLIC layout and the placement of the detectors (green cylinders) in the turnarounds.*

- Control of the drive beam phase errors within about 0.1° (23fs @ 12GHz).
- Feedback and/or feed-forward systems needed.

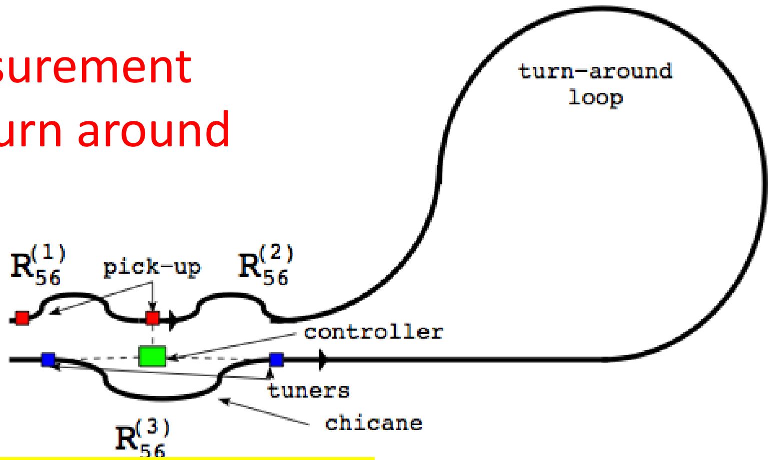
## Phase monitor main requirements

- Resolution of the order of 20 fs.
- Very low coupling impedance due to the high beam current.
- Rejection, by means of proper designed filters, of RF noise and weak fields in the beam pipe that otherwise could affect the measurements.
- Detection is done at 12 GHz.
- $\tau_f$ monitor ≈ 10ns=2Q/ω →Q ≈380, BW ≈30MHz.

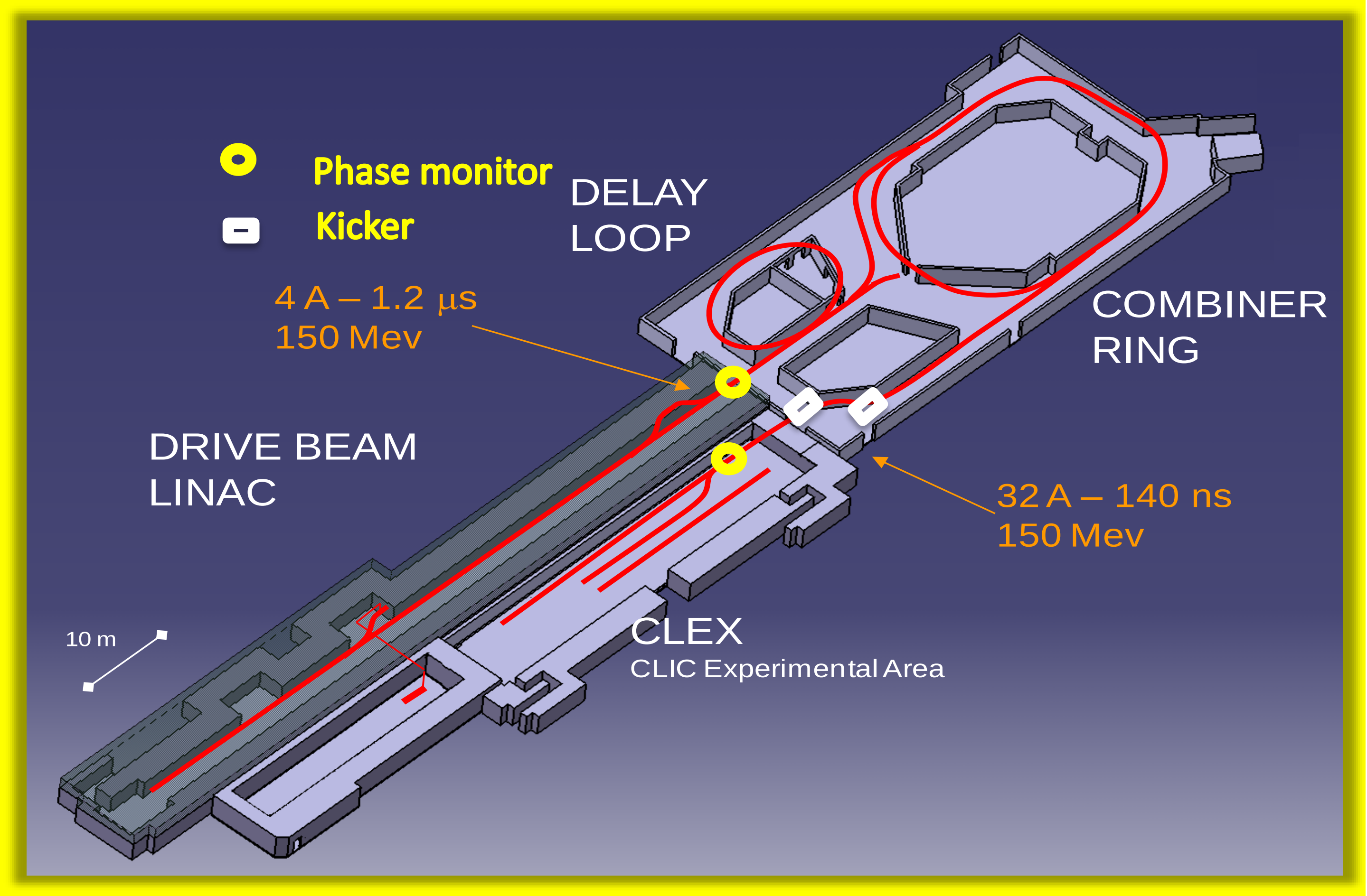
## Pick-up design

- A prototype could be tested in the CTF3 and installed in the chicane region, before the Delay Loop, where the vacuum pipe diameter is 40mm.
- At 12 GHz, 6 modes can propagate in a Ø=40mm pipe,
- A smaller pipe cross section would be useful to reduce the no. of modes.
- Reducing the pipe diameter at Ø=23mm, only 2 modes have a cut-off frequency lower than 12 Ghz.

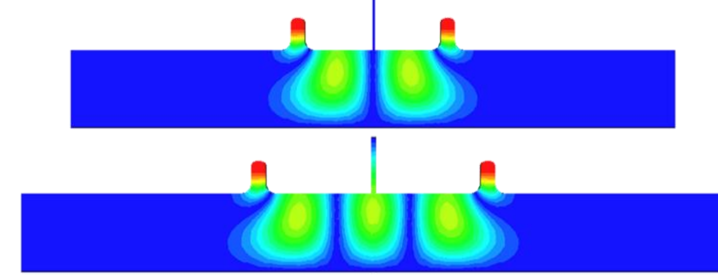
# Drive Beam phase measurement and correction in CLIC turn around

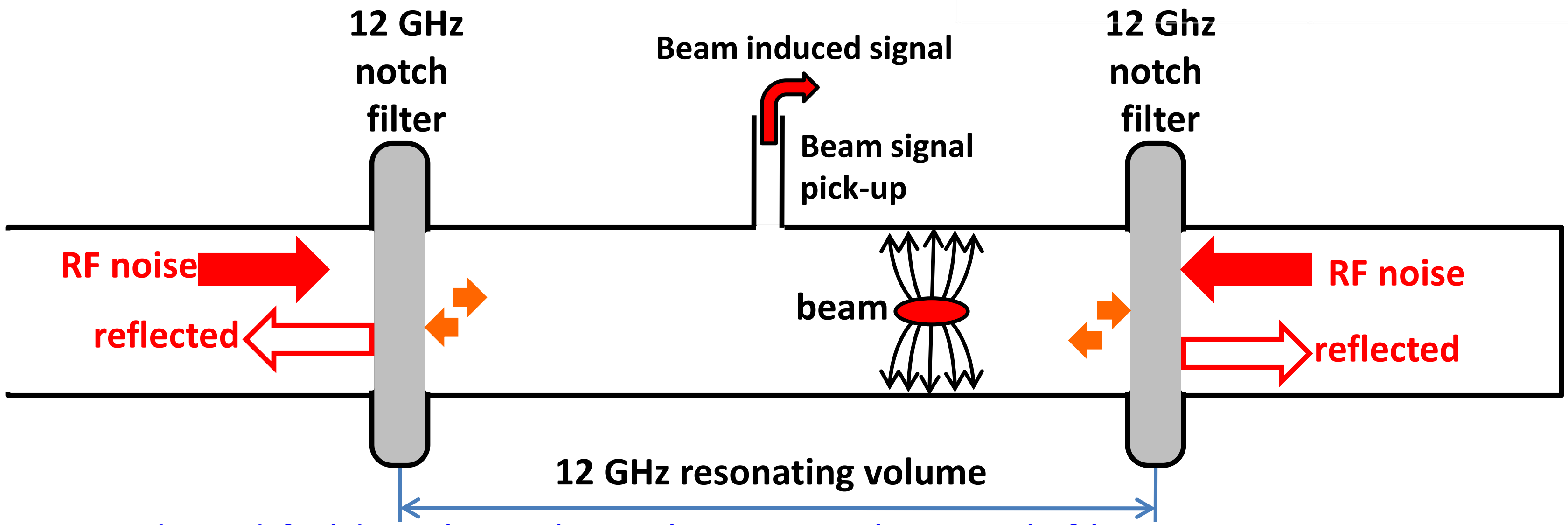



# Feed-forward experiment in CLIC Test Facility CTF3



# How the pick-up works

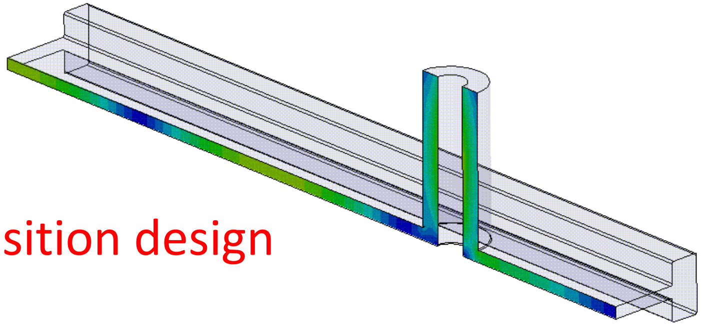





- Beam induced field in the volume between the notch filters.
- 12 GHz component of beam generated field after the first filter could be reflected back by the second filter and detected again.
- Unless the distance between the filters is chosen to define a volume resonating at 12 GHz. The pick-up is positioned in correspondence of zero crossing standing wave field.
- RF noise has to be filtered at both the pick-up sides.

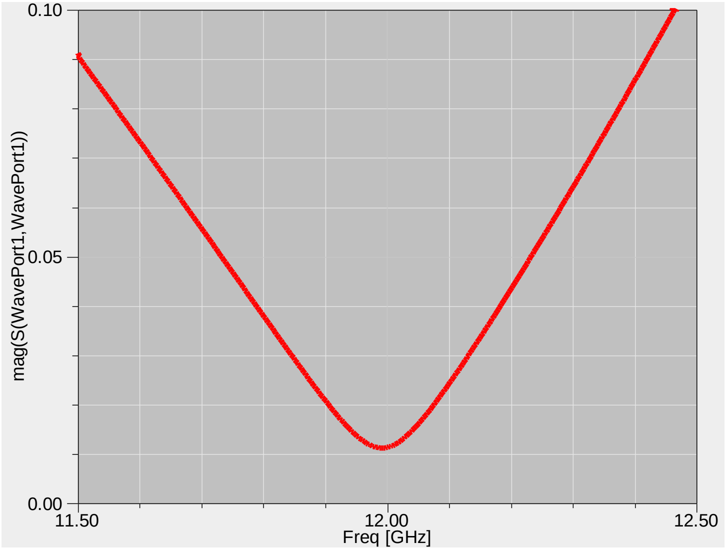
# Pick-up design

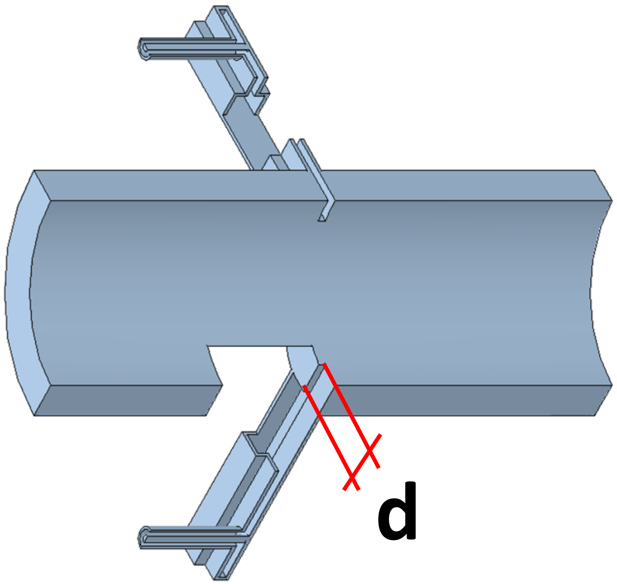
- The beam induced signal is coupled out of the beam pipe through a rectangular slot in a double ridged waveguide
- The thickness of the slot defines the coupling level
- The ridged waveguide has a transition to 50 Ω coaxial where a commercial vacuum feedthrough (MSSI part #853872) is placed



Transition design

Reflection coefficient at the input port



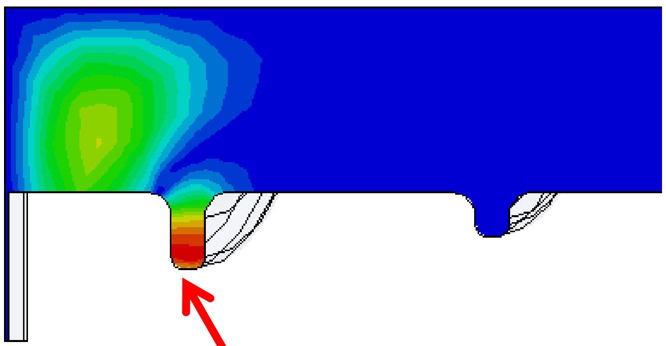




Cut view of the waveguide pick-ups

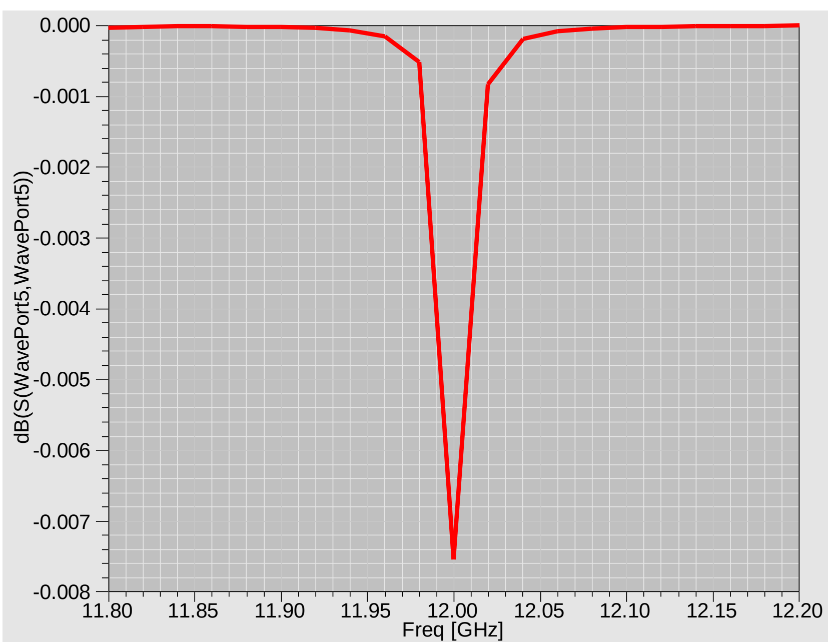
# Pick-up elettromagnetic design

**TM01**

**Resonating volume tuning @12 GHz**

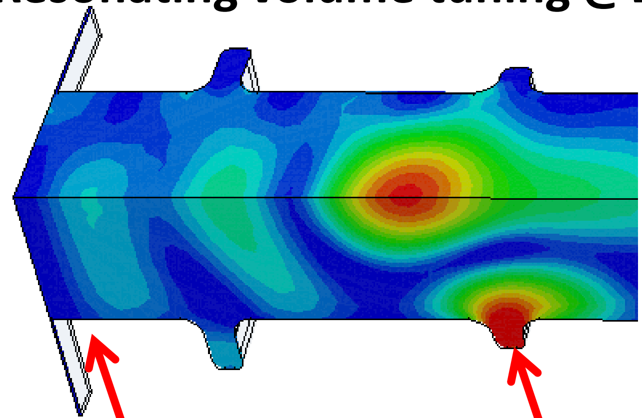


Notch for the TM01



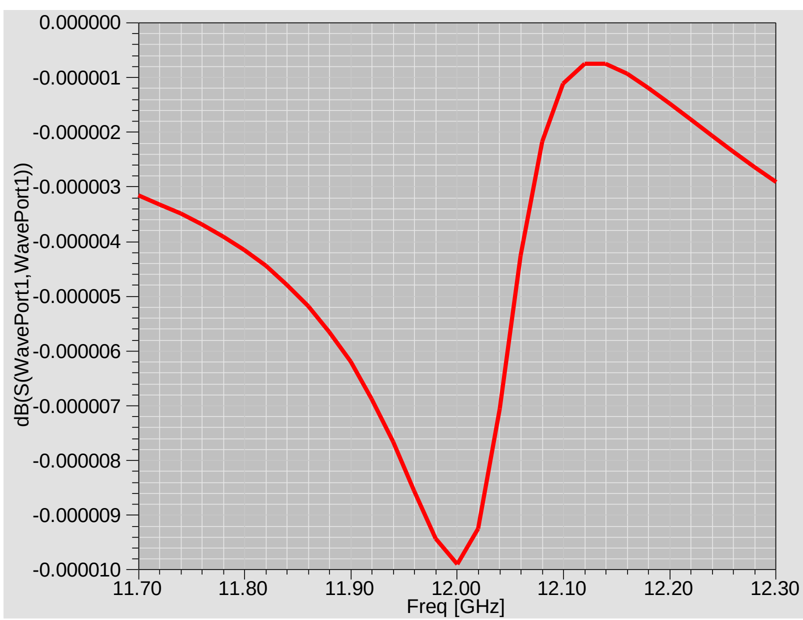

**TE11**

**Resonating volume tuning @12 GHz**



No coupling with the waveguide

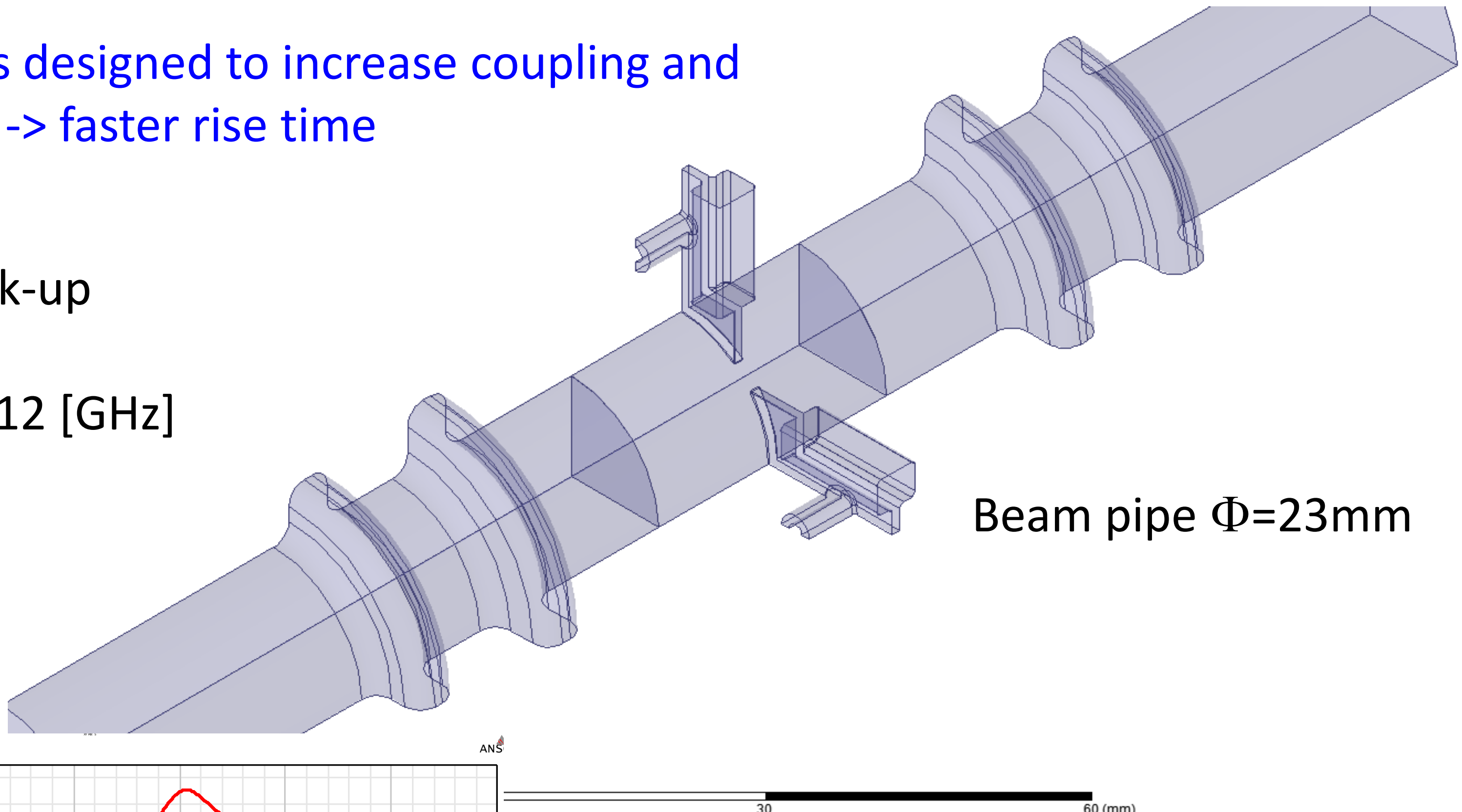
Notch for the TE11



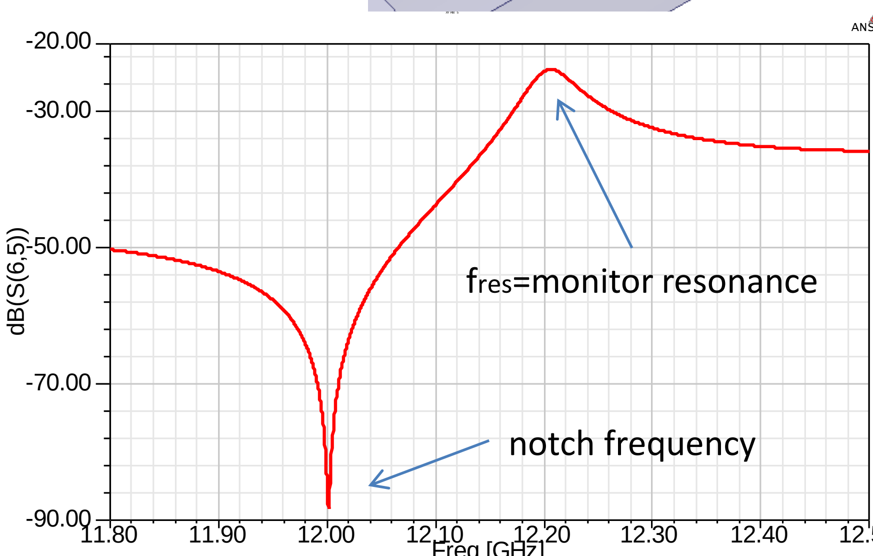
# CTF3 phase pick-up prototype

- Waveguides designed to increase coupling and decrease Q -> faster rise time

Tuned pick-up
Q=41
fres=fRF=12 [GHz]




Beam pipe Φ=23mm

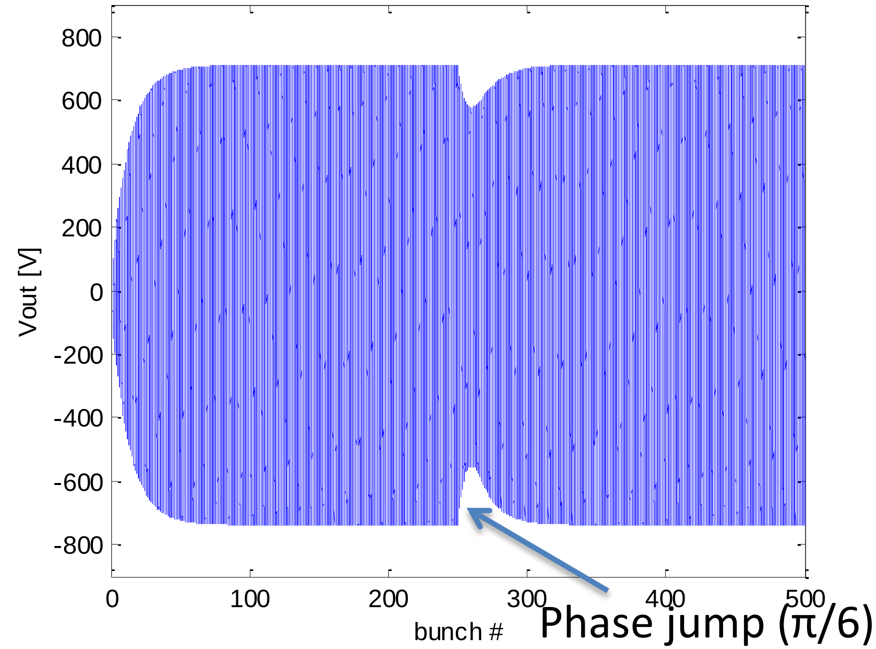



Detuned pick-up to decrease the voltage
Q=42
$f_{res}$=≠$f_{RF}$=12.22 [GHz]

# Tuned version $f_{res}$=12 GHz

- Time response signal, in bunch number, of the monitor precisely tuned at the bunch frequency

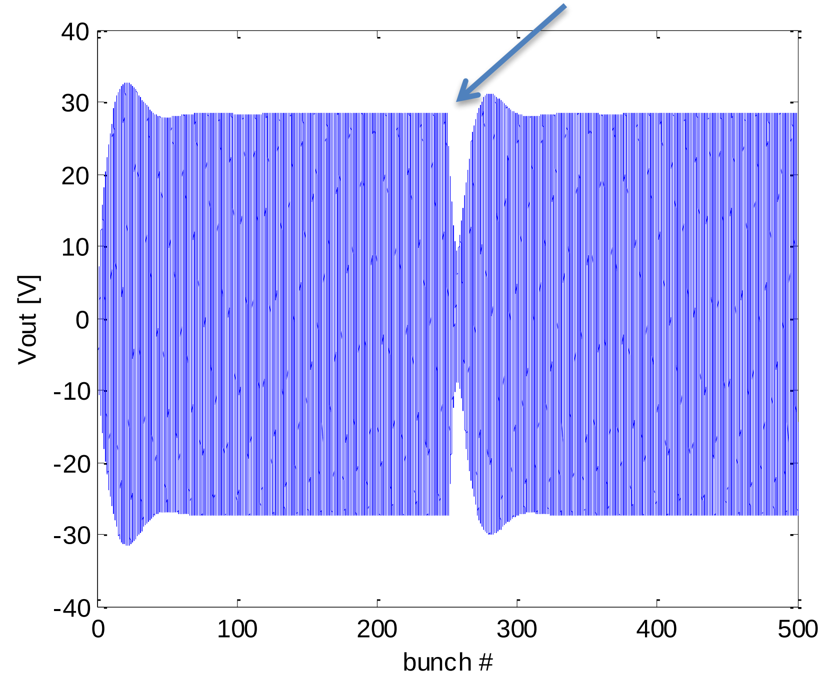
  Qb=2.33e-9 [C]  (bunch charge)
  $f_{RF}$=12 [GHz]
  Bunch separation: 1/$f_{RF}$
  I=28 [A]
  Vout=710 V




# Detuned version $f_{res}$=12.2 GHz

- same pick-up with the notch filter with slightly different distance that gives the detuned

  Qb=2.33e-9 [C]  (bunch charge)
  $f_{RF}$=12[GHz]
  Bunch separation: 1/$f_{RF}$
  I=28 [A]
  Vout=28 V

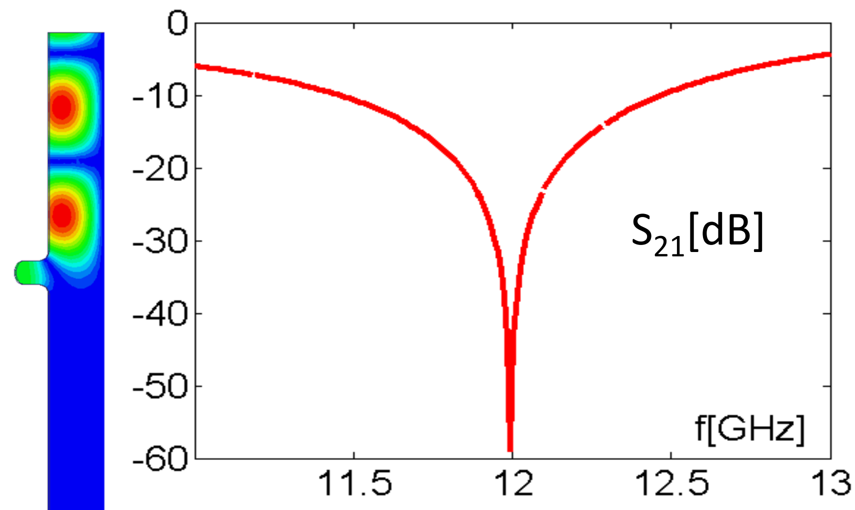



The response time is approximately 50 bunches on 2100 bunches of the train

# Rejection of RF noise and wakefield

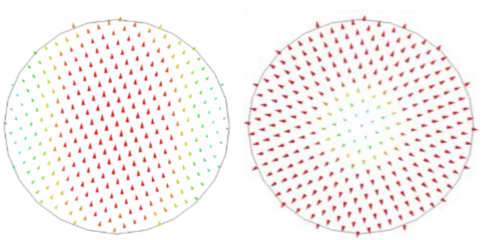
- Rejection of RF noise and beam generated wake fields, in the detection frequency range, is done by notch filters.

  The notch filter is realized as a bump in the beam pipe. The dimensions of this bump are chosen to reject the 12GHz frequency component of the noise.

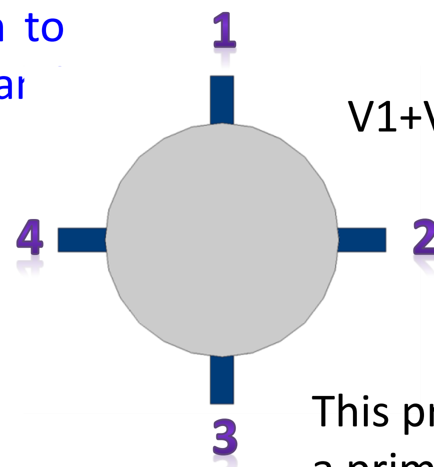



Transmission response of stop-band filter for the $TM_{01}$ mode

- Installation of the monitor prototype is foreseen before the CTF3 Delay Loop.
  The pipe radius has been reduced down to 11.5 mm, to limit to only 2 modes ($TE_{11}$ ar $TM_{01}$) propagation at 12 GHz.



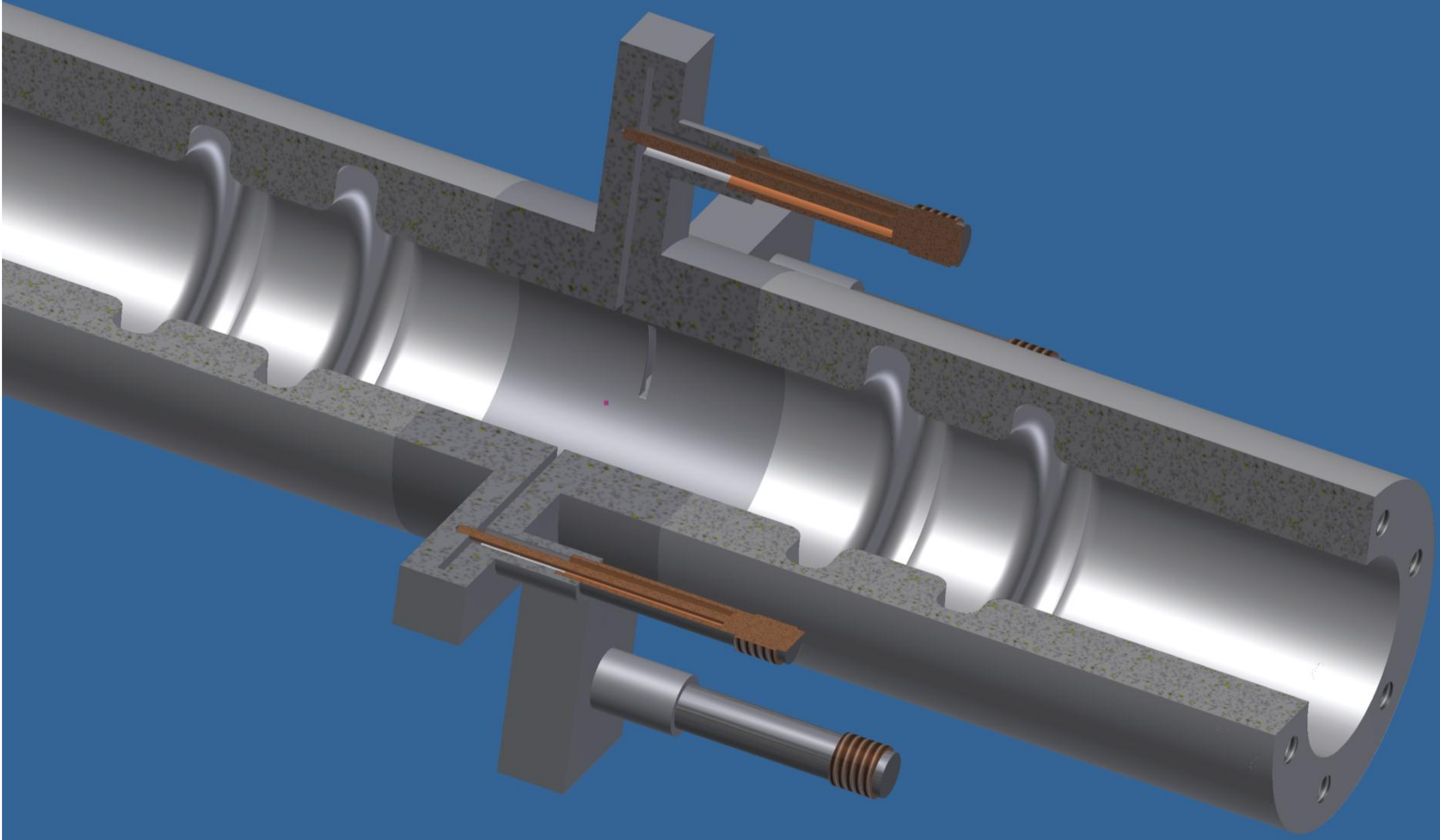
TE11 TM01




$$V1+V2+V3+V4 \begin{cases} \neq 0, \text{TM01} \\ = 0, \text{TE11} \end{cases}$$

This property can be used as a primary mean to reject $TE_{11}$

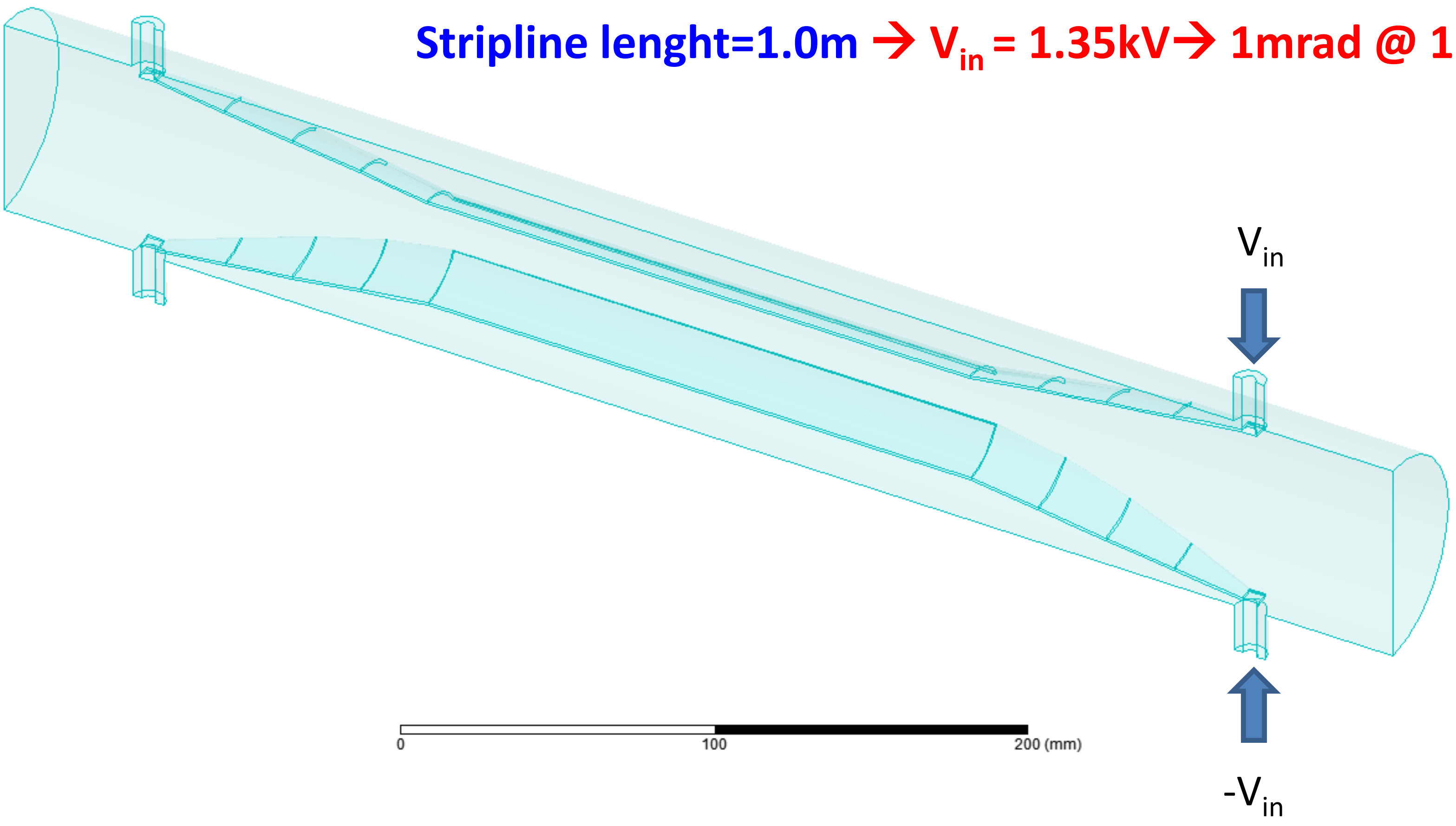
# Pick-up mechanical design



# Phase-forward system kicker

**Stripline lenght=0.4m → $V_{in}$ = 3. 9 kV→ 1mrad @ 150MeV**

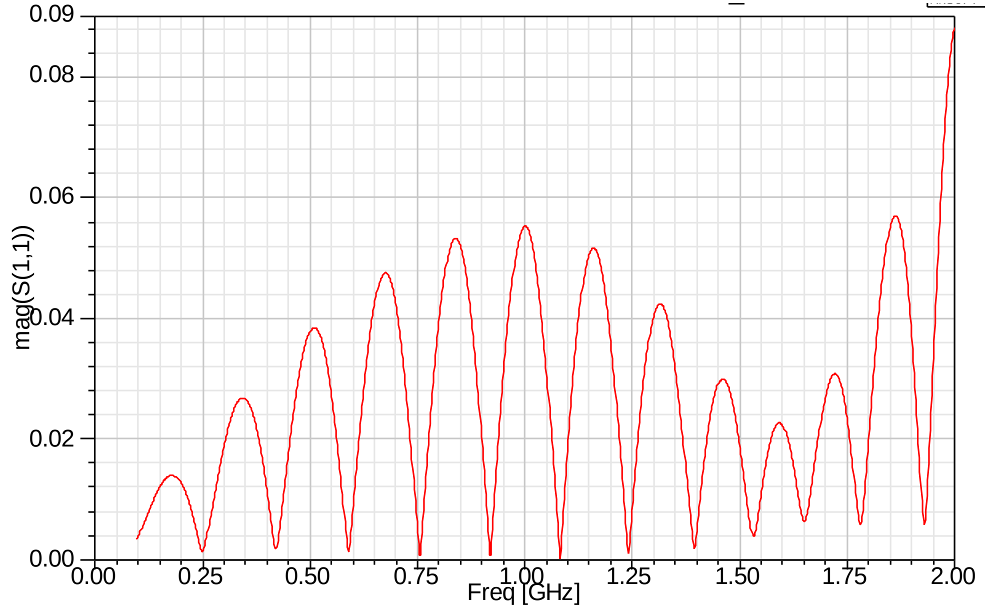
**Stripline lenght=1.0m → $V_{in}$ = 1.35kV→ 1mrad @ 150MeV**



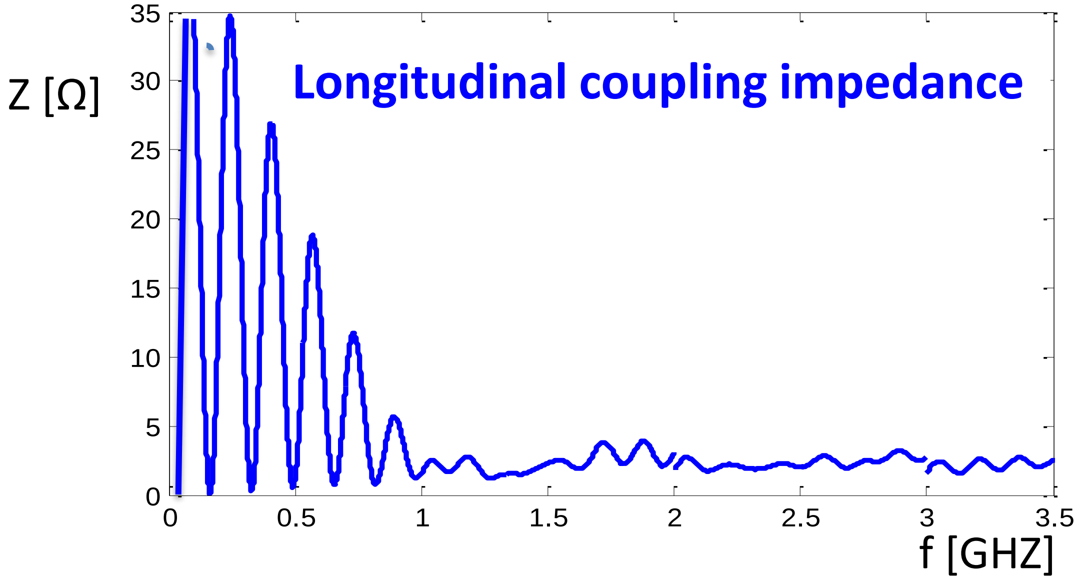
# Stripline lenght = 1m

The striplines ends are tapered in order to reduce the beam coupling impedance and to have good 50 Ω matching to the amplifiers

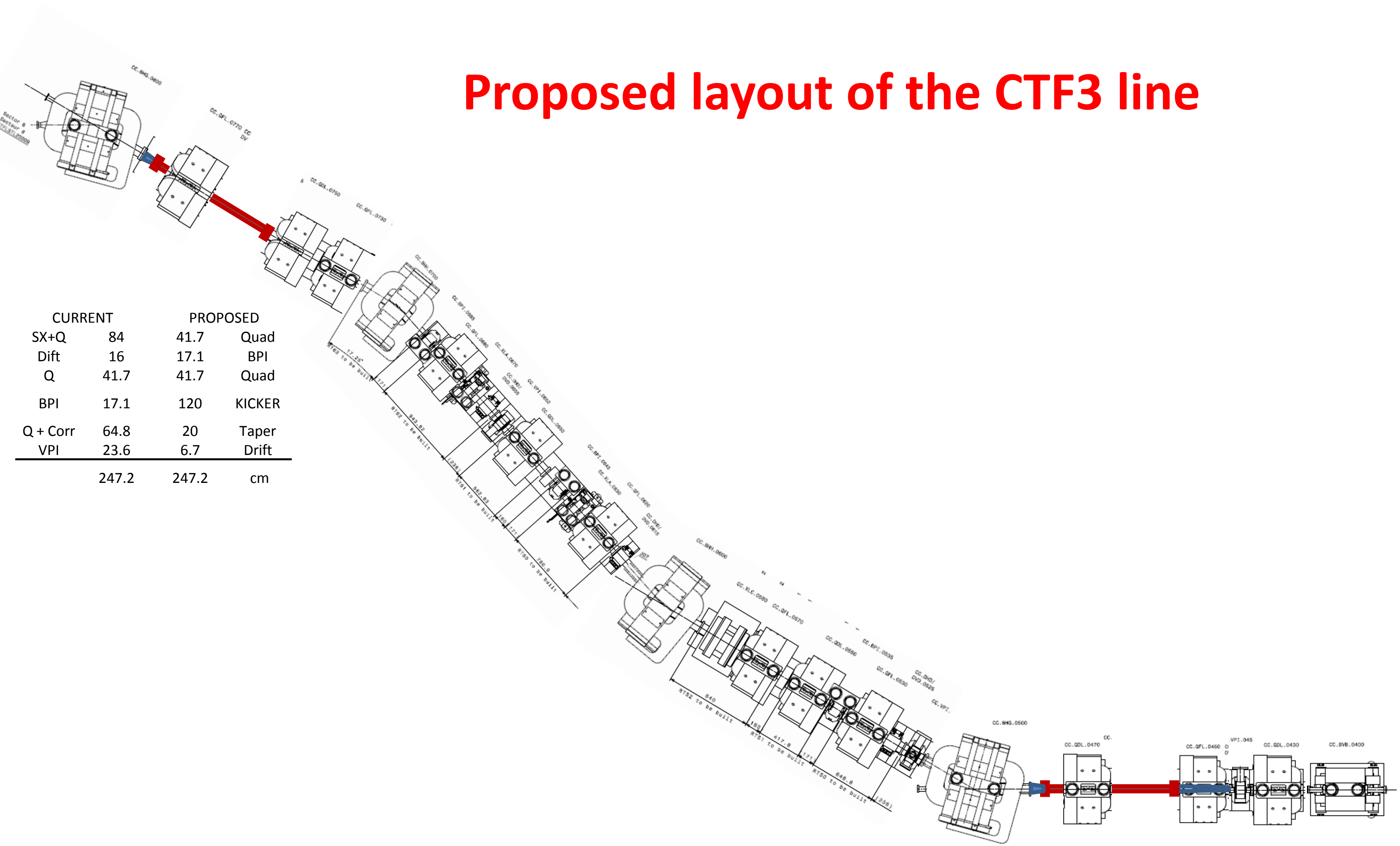
**Reflection coefficient from stripline input port**




Simulations of the kicker with stripline 80 cm long + 2x10 cm tapers

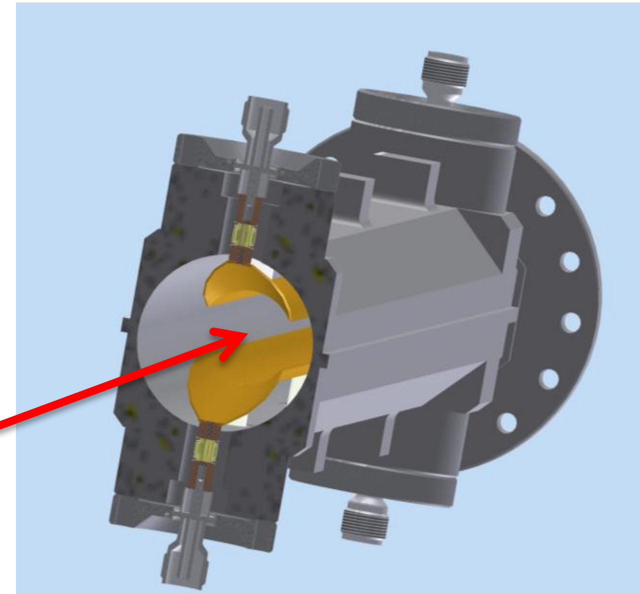


# Proposed layout of the CTF3 line

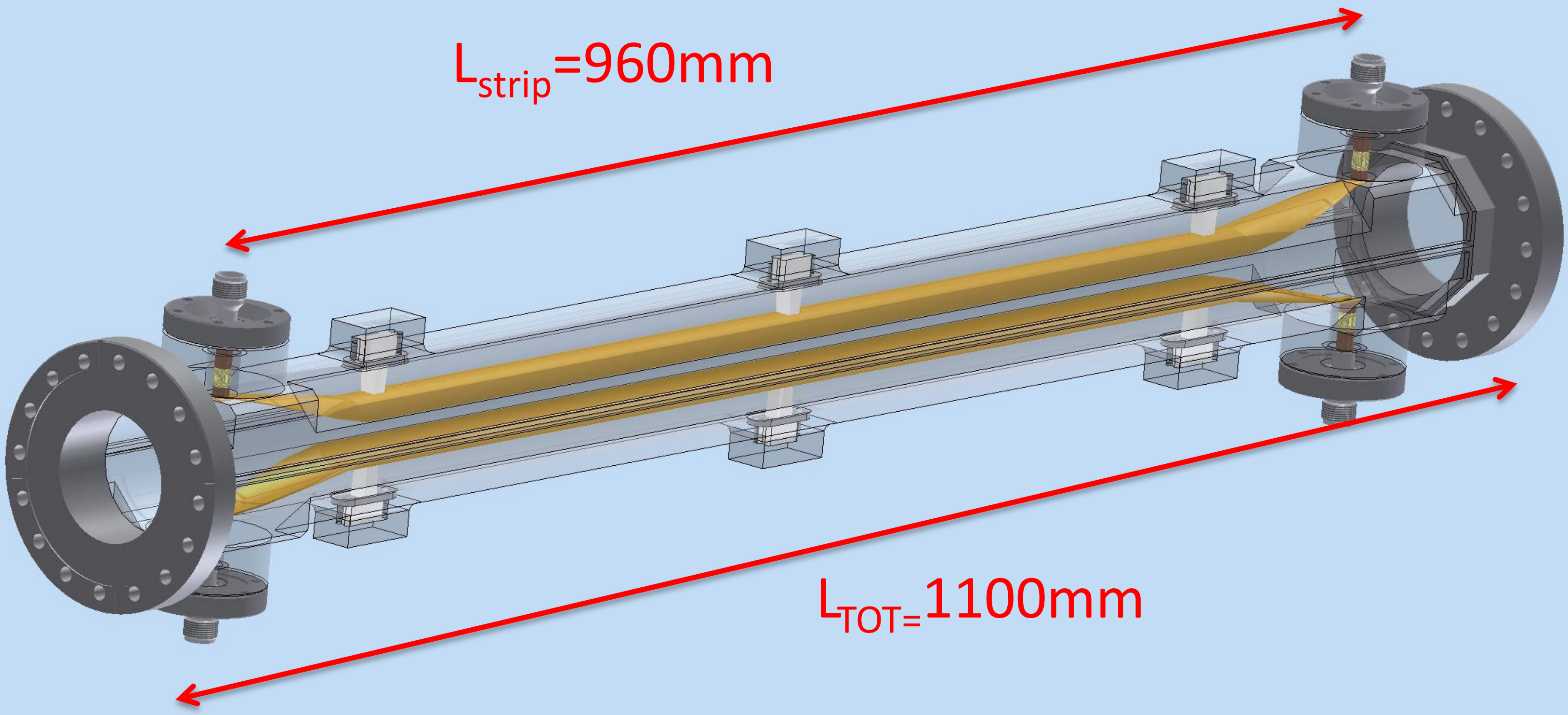


| CURRENT | | PROPOSED | |
|---|---|---|---|
| SX+Q | 84 | 41.7 | Quad |
| Dift | 16 | 17.1 | BPI |
| Q | 41.7 | 41.7 | Quad |
| BPI | 17.1 | 120 | KICKER |
| Q + Corr | 64.8 | 20 | Taper |
| VPI | 23.6 | 6.7 | Drift |
| | 247.2 | 247.2 | cm |

# Kicker mechanical design



Strip-line Internal Diameter=40mm



# WP CTF3-002 INFN Contribution