

Development of a ChDR BPM for the AWAKE experiment - Status

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... with many thanks to CLEAR OP for the support !



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Outline

- Outlook on the tests
- Test of $\varnothing 6$ and $\varnothing 15$ mm buttons
- Horn antennas vs waveguide transitions
- Waveguide transition tests & status
- Lessons learned
- Transition design status
- ▼ Conclusions

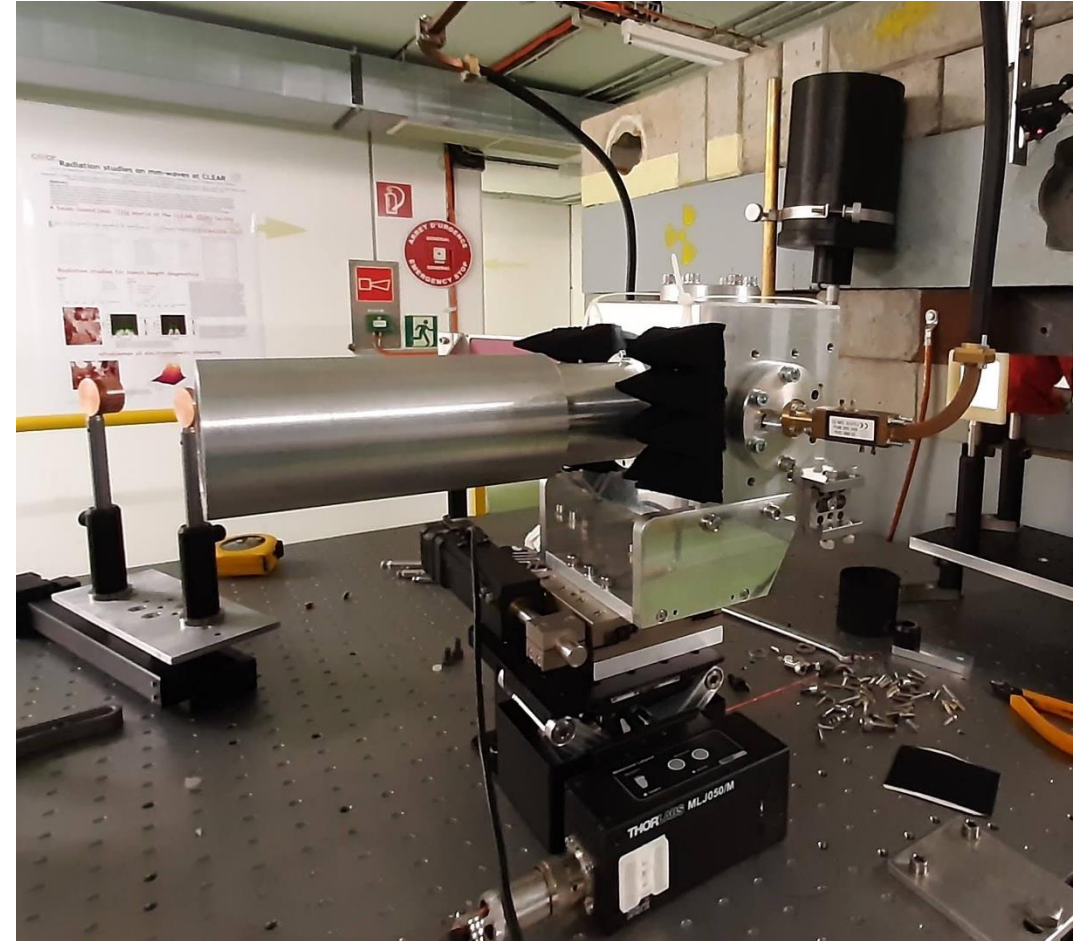
April 2021 test campaign at CLEAR

The initial plan

Detection in the bunker

PRO: short waveguides

CON: inaccessible



April 2021 test campaign at CLEAR

~~The initial plan~~

~~Detection in the bunker~~

~~PRO: short waveguides~~

~~CON: inaccessible~~

Too difficult to
access and fix

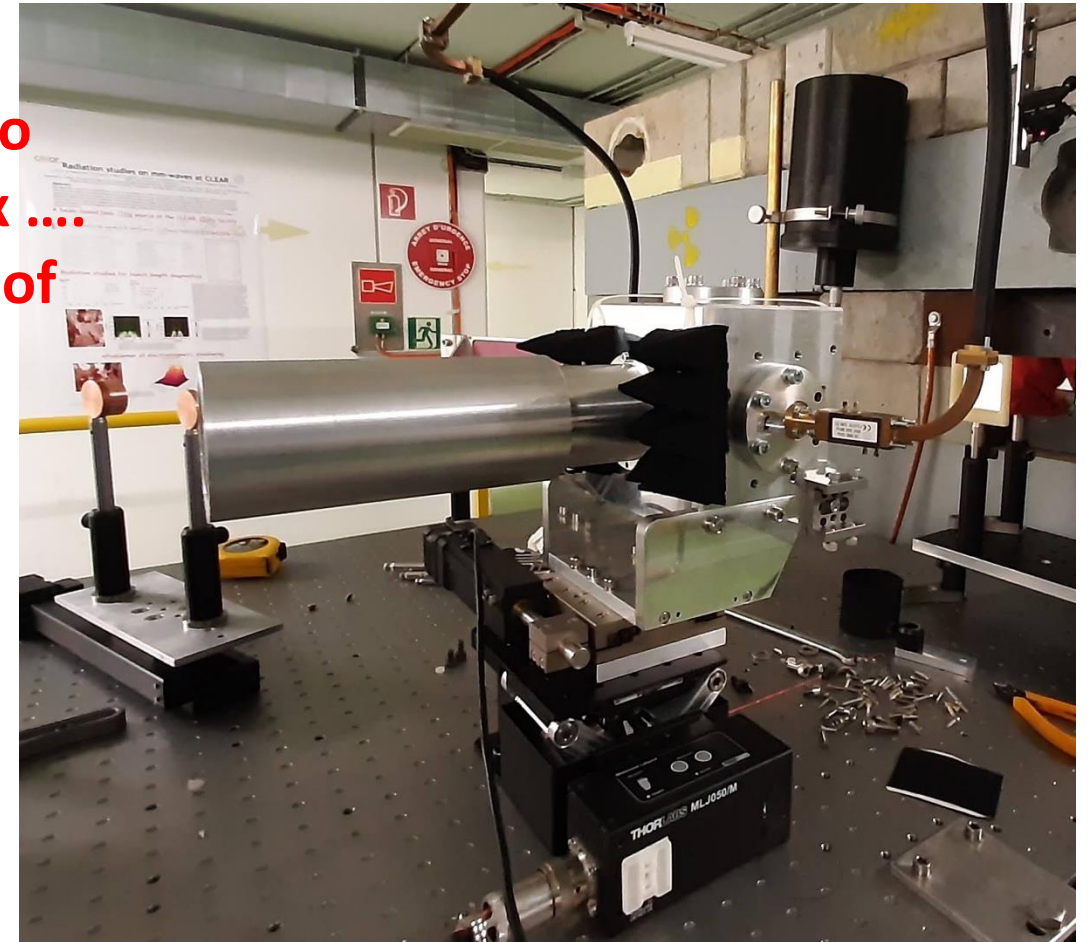
Needed a lot of
fixing ...

Final solution

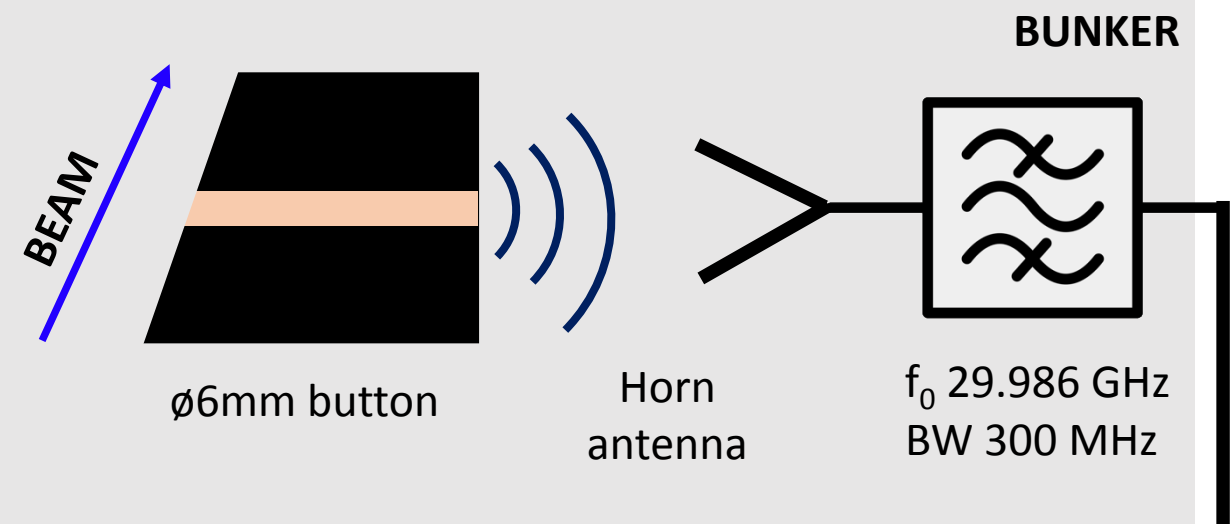
Detection in the klystron gallery

PRO: accessible, troubleshootable

CON: >10 dB attenuation

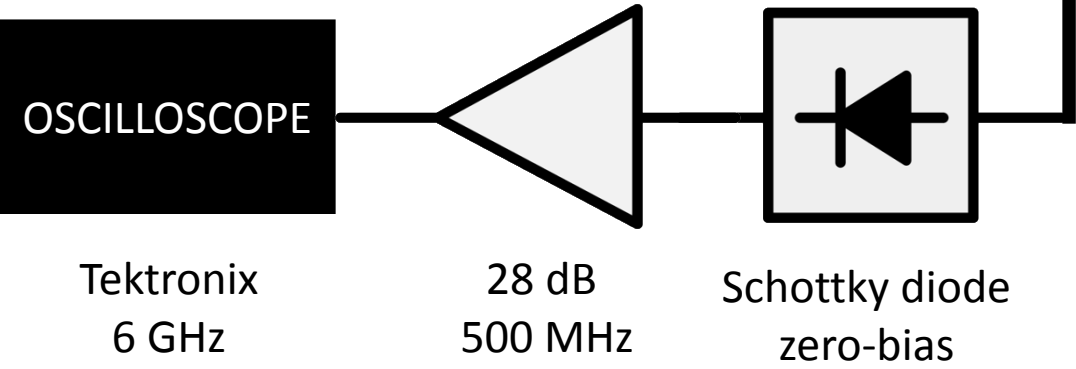


Detection scheme: horns



Detection with horn antennas

- PRO:** - Simple(r)
- CON:** - Hard to align
- Requires RF shielding



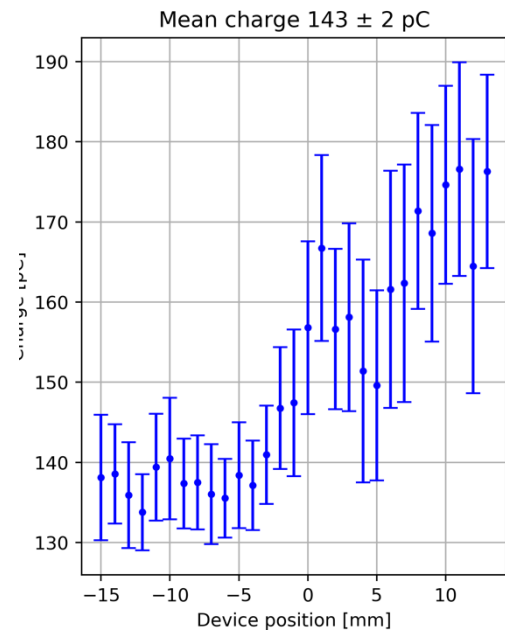
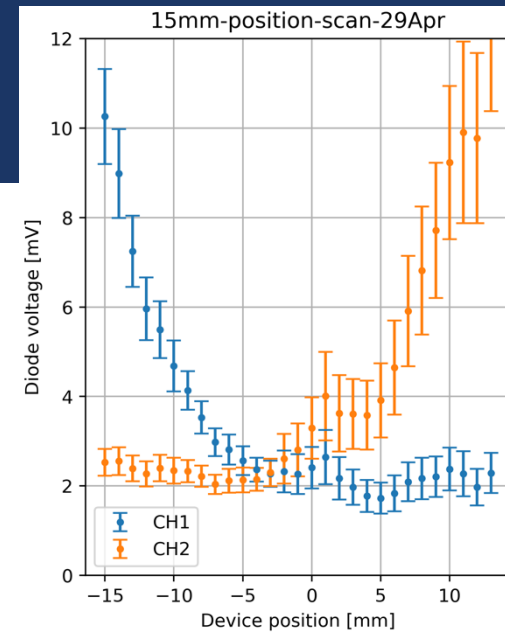
Waveguide network
15m
10 dB



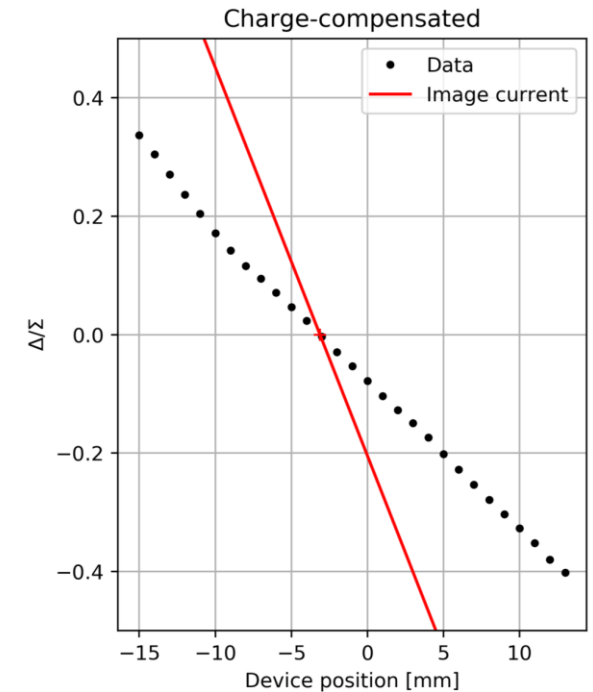
Test description

- Both $\varnothing 6$ and $\varnothing 15$ mm radiators were tested
- Mostly charge 80-140 pC
- Different bunch lengths
- Very different attenuations from the two buttons
 - 0.3 dB difference @30GHz in WG
 - Buttons, transitions ...
 - Diodes ...
- A 'sweet spot' in the configuration exists ... however charge drift is also a problem

~3 dB total



$\sigma = 3.8$ ps
 143 ± 2 pC



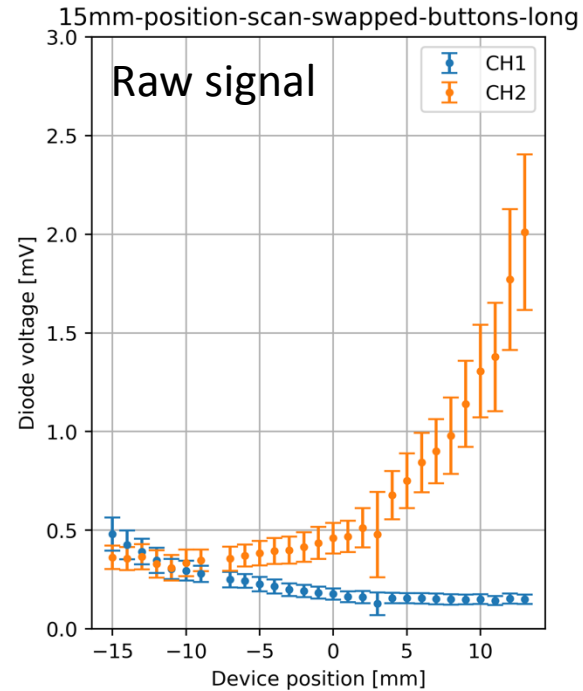
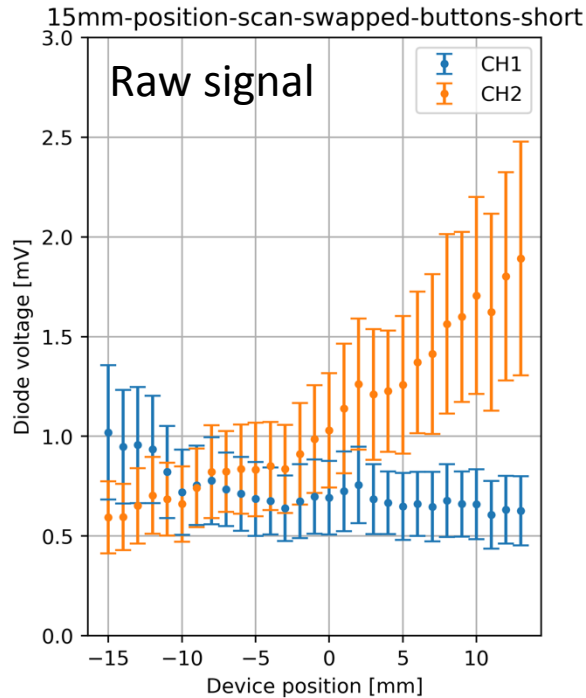
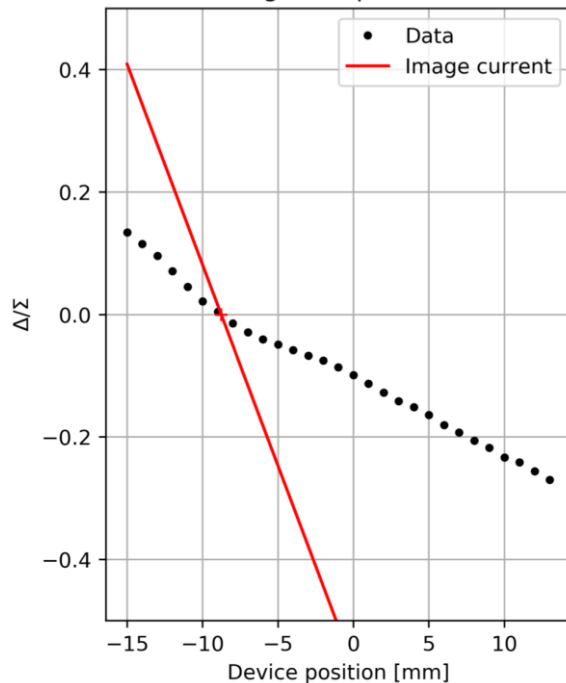
Response after charge compensation

Response to long and short bunches

SHORT BUNCH RESPONSE

$\sigma = 1.1$ ps
 81 ± 3 pC

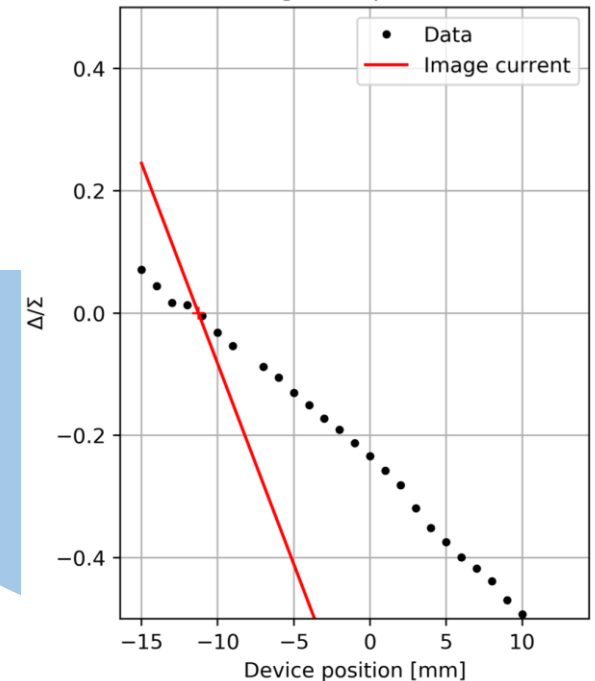
Charge-compensated



LONG BUNCH RESPONSE

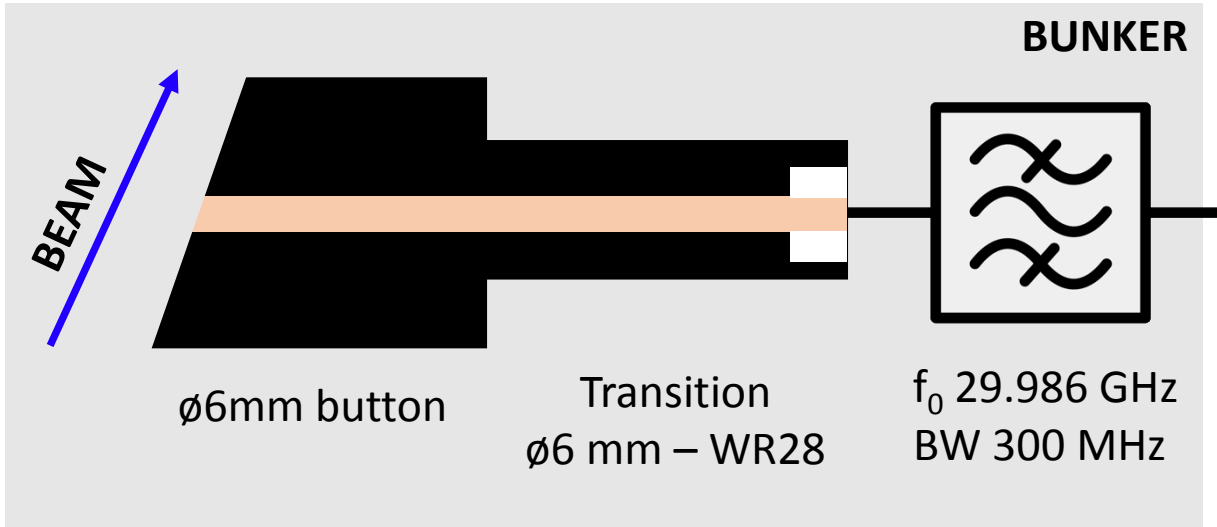
$\sigma = 4.8$ ps
 89 ± 3 pC

Charge-compensated



15 mm buttons.
Expectation for Gaussian bunches
- 32% signal for long bunch

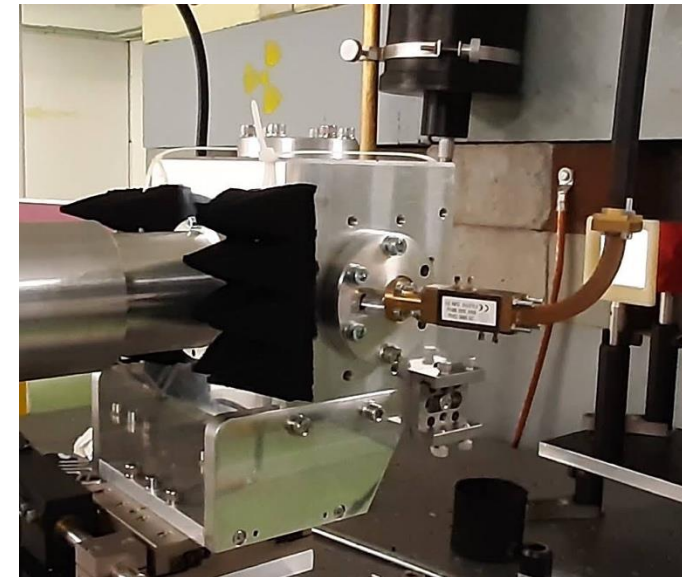
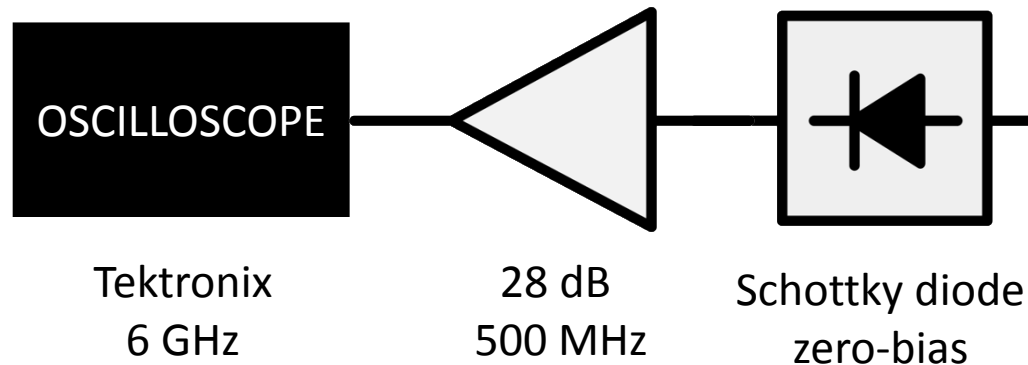
Detection scheme: transitions



Detection with transitions

- PRO:**
- Intrinsically shielded
 - Couples larger signal
- CON:**
- Custom part
 - Early prototype

Waveguide network
15m
10 dB



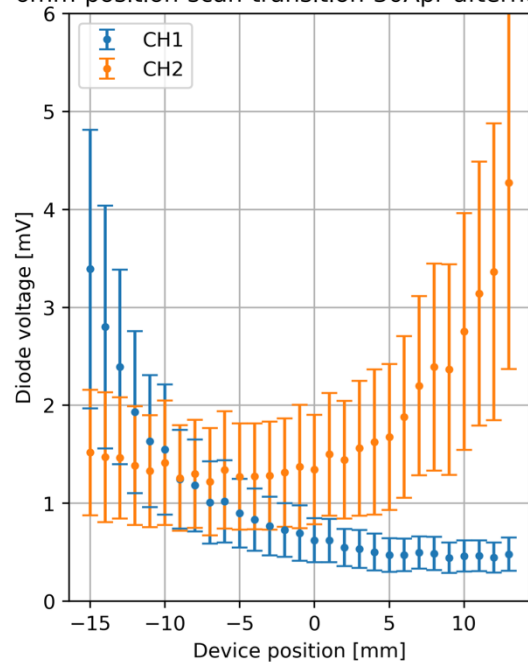
Alumina-loaded circular waveguide ø6 mm to WR 28 transition

Test description

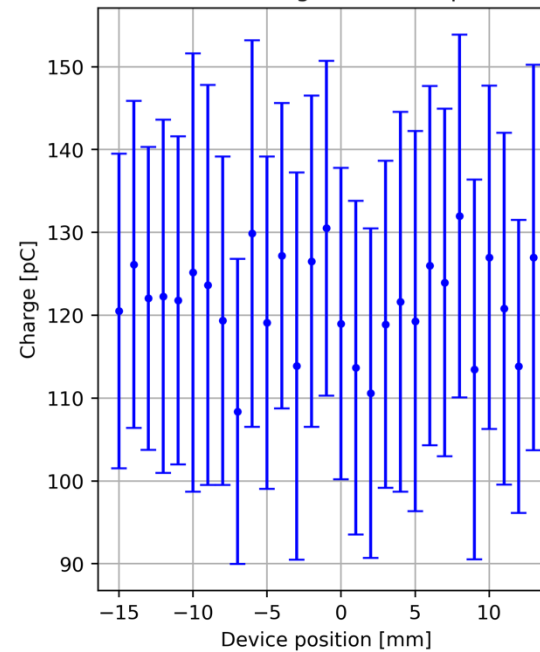
- Transition available only for radiators $\varnothing 6$ mm
- Mostly charge 80-120 pC

$\sigma = 3.8$ ps
 121 ± 15 pC

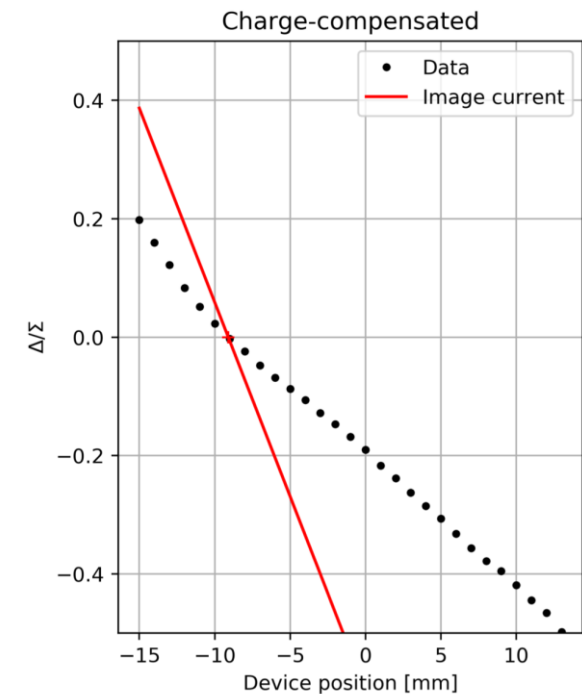
6mm-position-scan-transition-30Apr-afternoon2



Mean charge 121 ± 15 pC

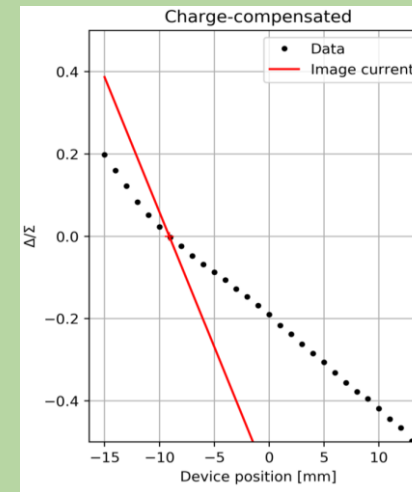
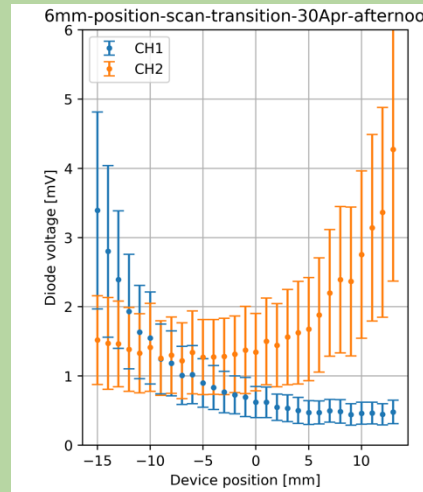
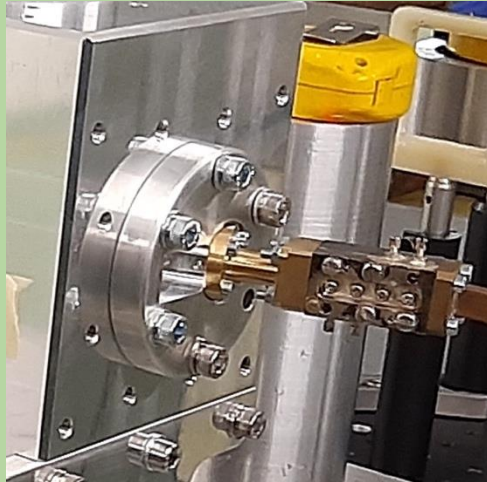


Response after charge compensation



Horn antenna vs transition

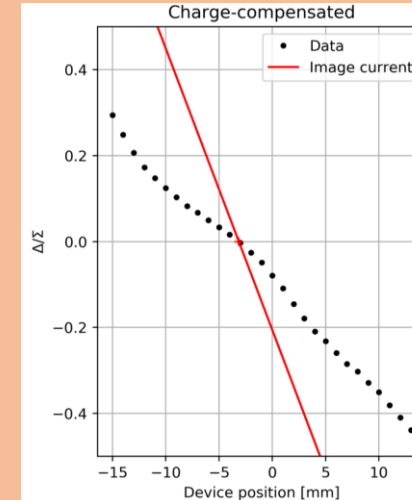
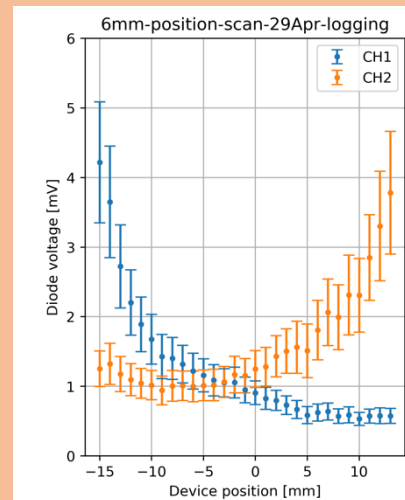
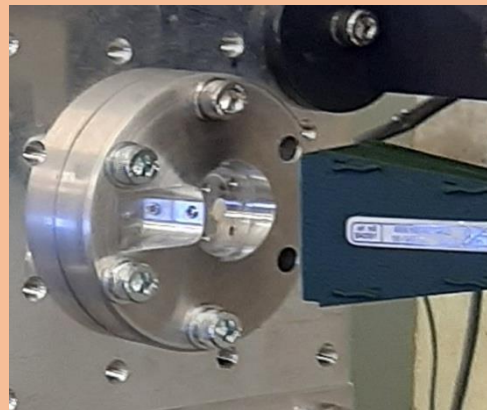
WAVEGUIDE
TRANSITION



To get similar
output voltage

121 ± 15 pC

HORN
ANTENNA



429 ± 65 pC

Lessons learned



Different channels might present rather large attenuation differences

- Buttons asymmetry
- Transitions asymmetry
- Waveguide length difference
- Unknown assembly tolerances



Reduced dependence on bunch length

- Expected 32% difference in power
- Bunch shape might play a role



Dramatic signal increase with transitions

- Compared to horn antennas, same signal with factor ~ 4 charge difference
- Early transition prototype, still reflecting $\sim 40\%$ of the power

Transition designs

➤ Large simulation work done by **Collette**

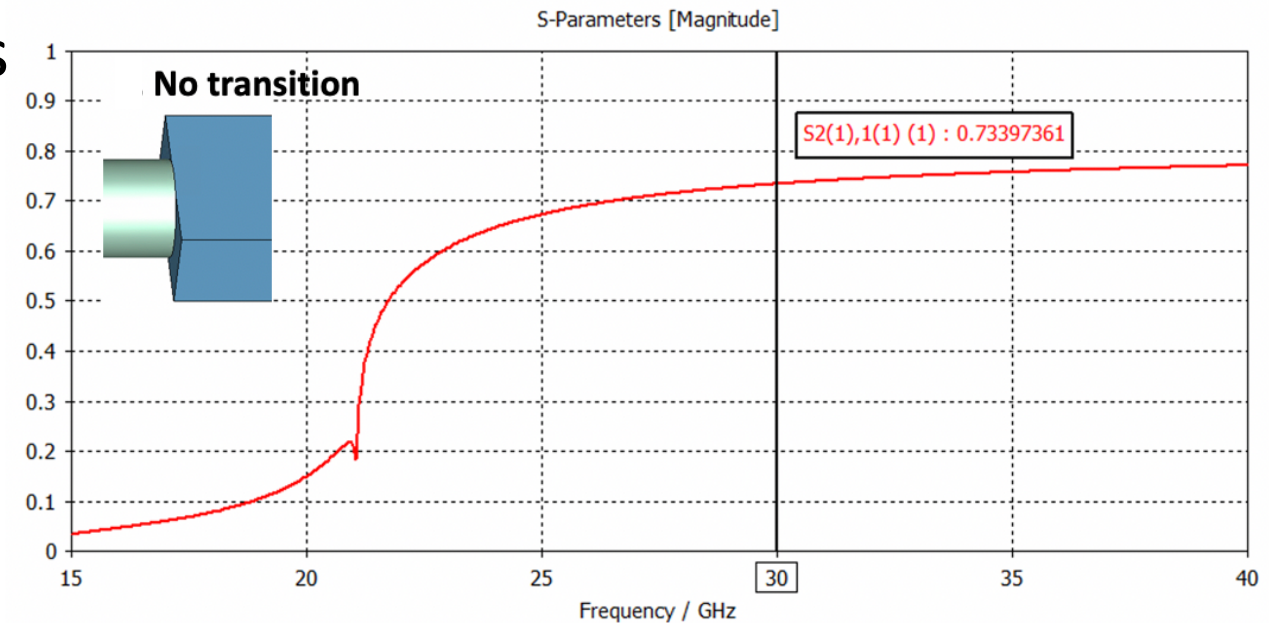
➤ Just showing worst case, details in a separate talk of Collette

Level

0 No transition $P_{\text{tra}} = 53\%$

1 Single dielectric $P_{\text{tra}} = 64\%$

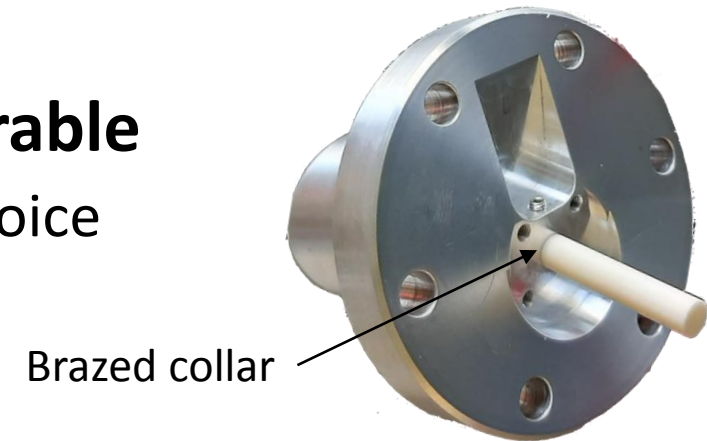
2 Multiple dielectrics $P_{\text{tra}} = 99\%$



Conclusions

A design with waveguide transition is desirable

- Alumina buttons $\varnothing 6$ mm are the preferred choice
- Button + alumina is vacuum tight



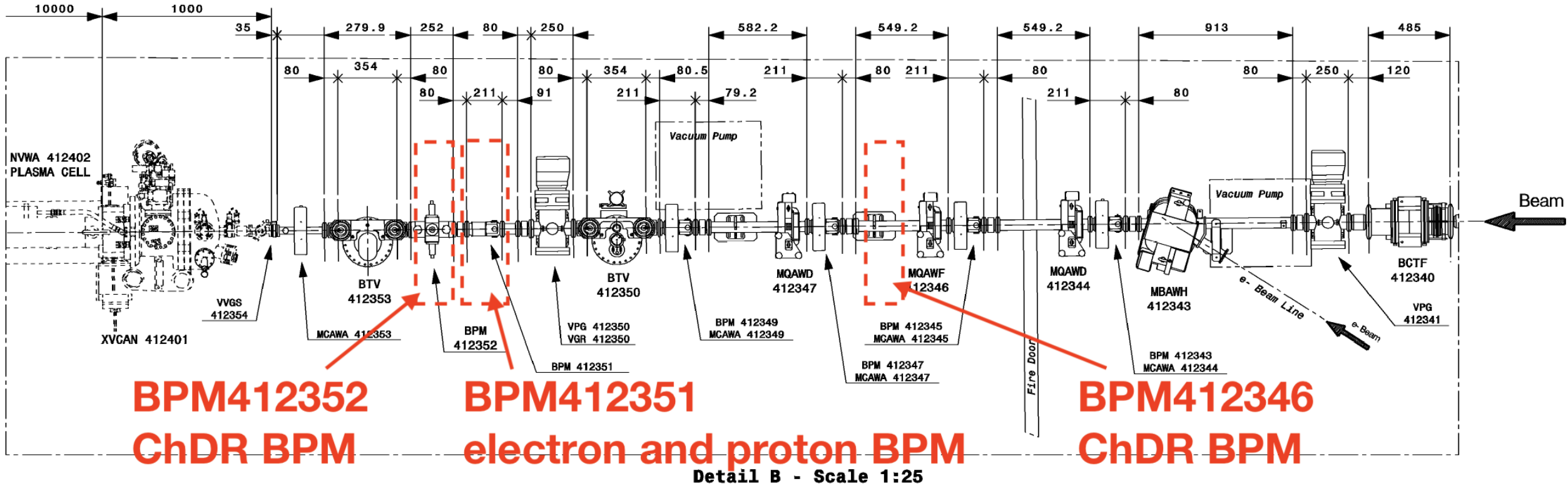
Important effort in transition R&D

- Modular design: the transition slides onto the alumina, outside the vacuum
- Large efforts to understand the impact of tolerances

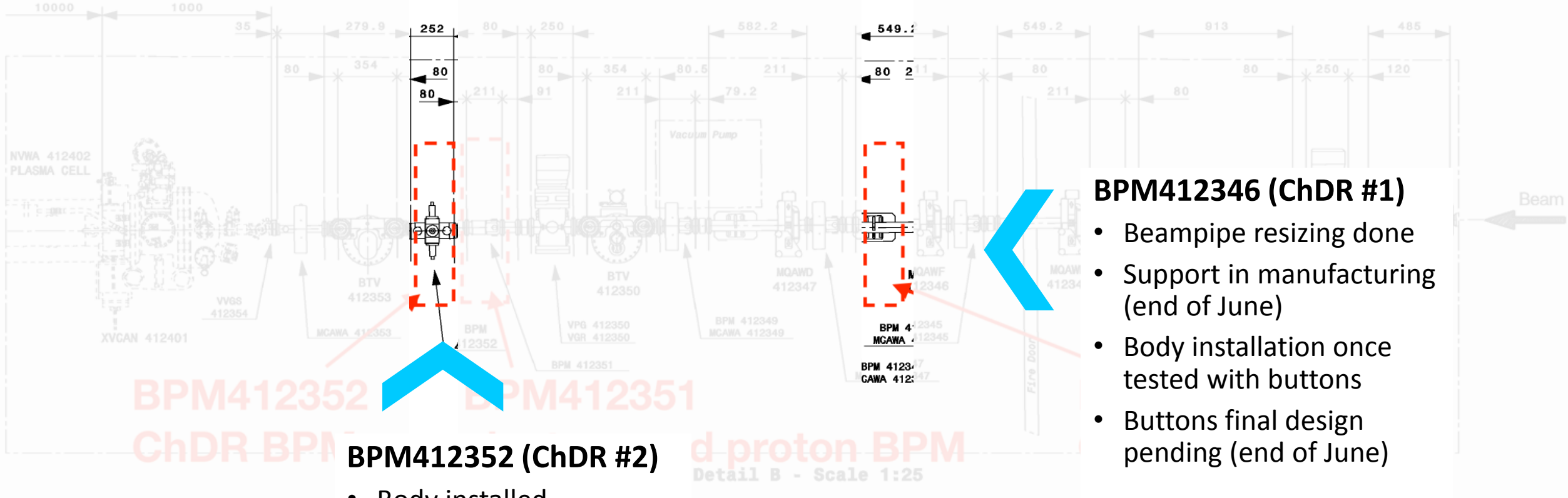
Studies pending

- Possible additional test campaign at CLEAR for stability studies

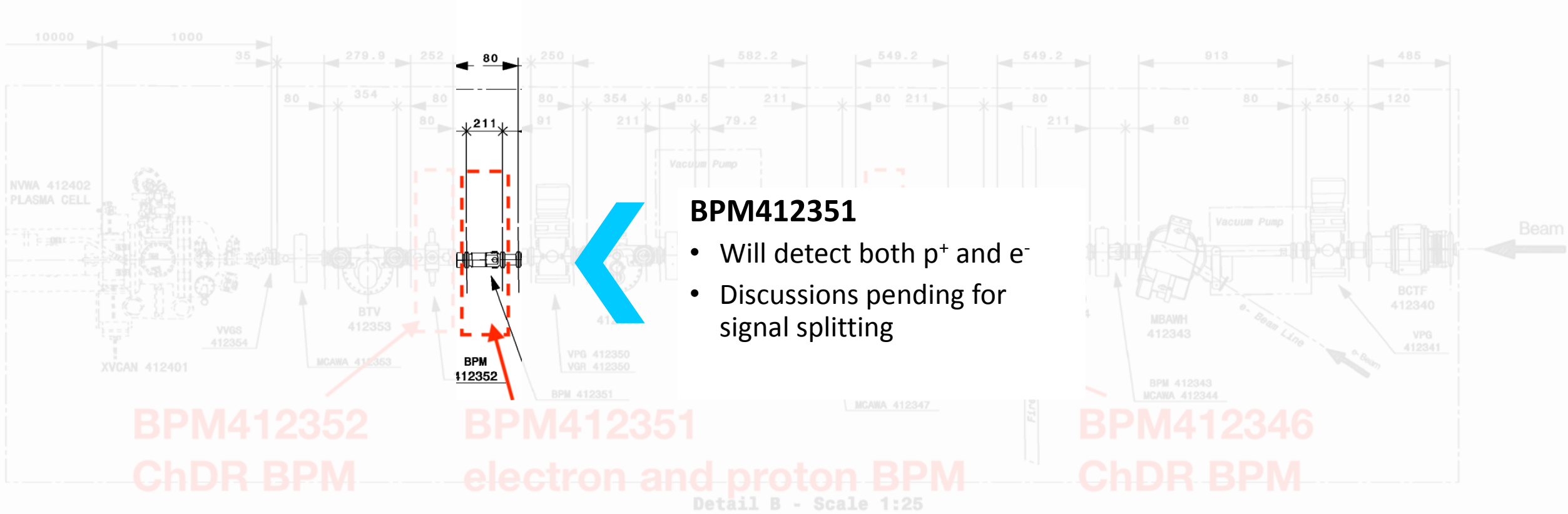
ChDR BPM project summary



ChDR BPM project summary



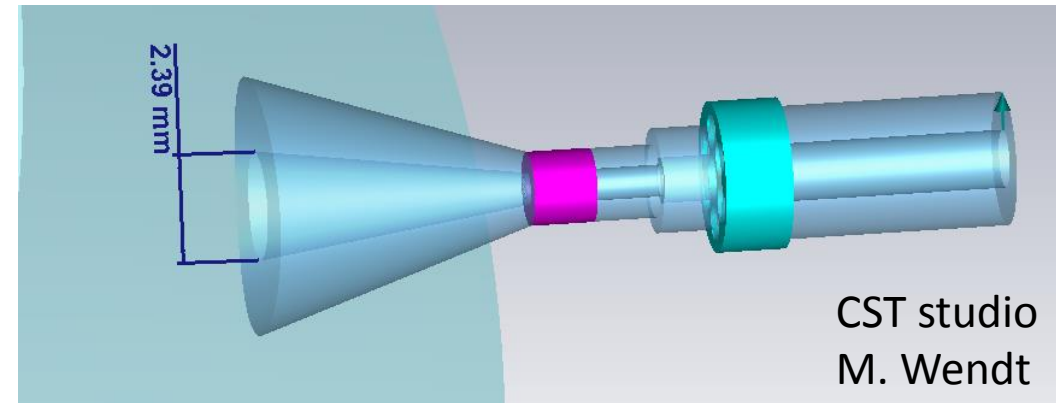
ChDR BPM project summary



40 GHz buttons option

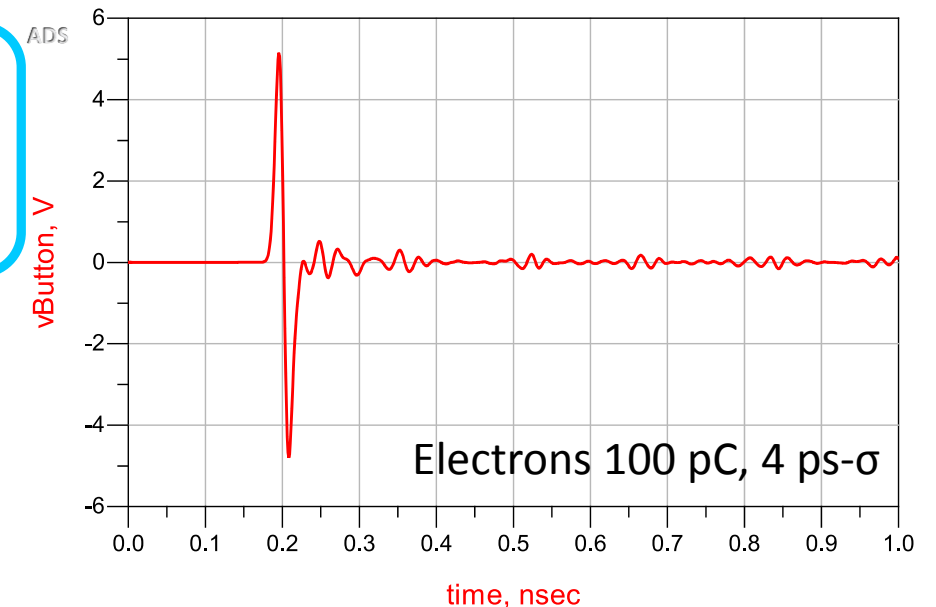
In the past the use of high frequency buttons was discussed

➤ CST simulations showed satisfactory performance with respect to ChDR BPM



➤ **This is an alternative, additional R&D project, and not a fallback solution**

- Mitigate the risk on ChDR BPM project
- Compare the two technologies



40 GHz buttons option

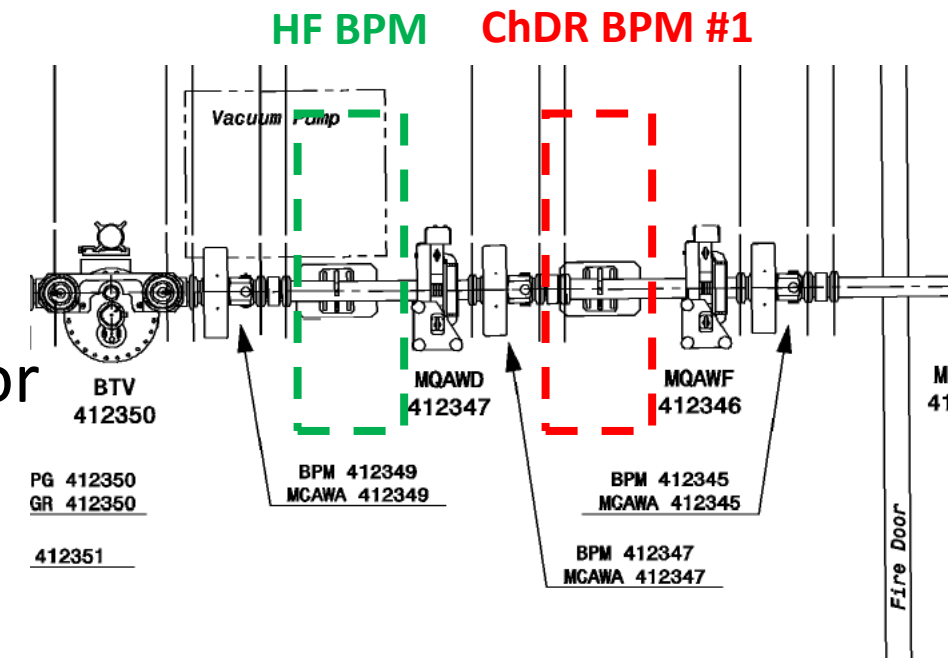


This is an alternative, additional R&D project, and not a fallback solution

- Valid quote for the buttons for 2 more weeks
- Body to be designed

Proposal:

- Procure min 5 buttons and 1 body
- Install in the other free drift close to fire door
- Cost in the order of 50kCHF
- Minimum 12 months before installation



Thanks for your attention !