Development of a ChDR BPM for the AWAKE experiment - Status

Eugenio Senes
for the BI AWAKE & Cherenkov teams

... with many thanks to CLEAR OP for the support!
Outlook on the tests
Test of ø6 and ø15 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

Final solution
Detection in the klystron gallery

- PRO: accessible, troubleshootable
- CON: >10 dB attenuation

Too difficult to access and fix....
Needed a lot of fixing ...
Detection with horn antennas

**PRO:**
- Simple(r)

**CON:**
- Hard to align
- Requires RF shielding

Horn antenna
- $f_0 = 29.986 \text{ GHz}$
- BW = 300 MHz

Waveguide network
- Length 15m
- 10 dB

OSCILLOSCOPE
- Tektronix 6 GHz
- 28 dB
- 500 MHz

Schottky diode
- Zero-bias
Test description

- Both $\varnothing6$ and $\varnothing15$ 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

$\sigma = 3.8 \text{ ps}$

143 $\pm$ 2 pC

~3 dB total
Response to long and short bunches

SHORT BUNCH RESPONSE
\[ \sigma = 1.1 \text{ ps} \]
\[ 81 \pm 3 \text{ pC} \]

LONG BUNCH RESPONSE
\[ \sigma = 4.8 \text{ ps} \]
\[ 89 \pm 3 \text{ pC} \]

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

OSCILLOSCOPE
- Tektronix 6 GHz
- 28 dB
- 500 MHz
- Schottky diode zero-bias

Waveguide network
- 15 m
- 10 dB

Alumina-loaded circular waveguide Ø6 mm to WR 28 transition
Test description

- Transition available only for radiators Ø6 mm
- Mostly charge 80-120 pC

\[ \sigma = 3.8 \text{ ps} \]
\[ 121 \pm 15 \text{ pC} \]
Horn antenna vs transition

To get similar output voltage

Horn antenna: 429±65 pC

Waveguide transition: 121±15 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 ~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  $P_{tra} = 53\%$

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

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

A design with waveguide transition is desirable
- Alumina buttons Ø6 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

BPM412352     BPM412351     BPM412346
ChDR BPM       electron and proton BPM       ChDR BPM
ChDR BPM project summary

BPM412346 (ChDR #1)
- Beampipe resizing done
- Support in manufacturing (end of June)
- Body installation once tested with buttons
- Buttons final design pending (end of June)

BPM412352 (ChDR #2)
- Body installed
- Buttons final design pending (end of June)
BPM412351
- Will detect both $p^+$ and $e^-$
- Discussions pending for signal splitting
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

Electrons 100 pC, 4 ps-σ
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!