RFQ couplers test stand

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## Requirements

### RFQ parameters (from RFQ FRS)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ion type</td>
<td>H-</td>
</tr>
<tr>
<td>Beam current</td>
<td>1-10 mA</td>
</tr>
<tr>
<td>Beam input energy</td>
<td>0.03 keV</td>
</tr>
<tr>
<td>Beam output energy</td>
<td>2.1 MeV</td>
</tr>
<tr>
<td>Frequency</td>
<td>162.5 MHz</td>
</tr>
<tr>
<td>Duty factor (CW)</td>
<td>100%</td>
</tr>
<tr>
<td>Total RF power</td>
<td>≤ 130 kW</td>
</tr>
<tr>
<td>Number of couplers</td>
<td>2</td>
</tr>
</tbody>
</table>

### Coupler requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>162.5 MHz</td>
</tr>
<tr>
<td>Operating power (SWR: 1 ÷ ∞)</td>
<td>75 kW</td>
</tr>
<tr>
<td>Coupling type</td>
<td>Loop</td>
</tr>
<tr>
<td>Output port diameter</td>
<td>~3&quot;</td>
</tr>
<tr>
<td>Input impedance</td>
<td>50 Ohm</td>
</tr>
</tbody>
</table>
Documentation is ready for bidding. We can hope to have couplers in half of year.
Possible configurations of test

Two RF sources
Couplers can be test in TW and SW modes with any phase of reflected power.

One RF source
TW mode

SW mode
Choosing of coupling cavity

Two approach is possible:

1. Make a model of RFQ cavity (one quarter)
   - **Pros:** couplers will be tested close to operating conditions.
   - **Cons:** big size of cavity (~ 1m), narrow bend (tuning mechanism is needed), not clear issue with multipactor - expensive.

2. Make cavity as simple is possible.
   - **Pros:** less expensive, can control / suppress multipactor.
   - **Cons:** fields around coupling loop is different from operating field. Only geometry before loop can be tested (ceramic window, etc.). We cannot test loop cooling.

We chose second approach.
Several options were investigated:

Cavity with mechanical contact between loops

Cavity without mechanical contact between loops
The chosen geometry

~3"

~280 mm
Sectional views of coupling cavity
Passband of coupling cavity

\[ Q = 5.4 \]
Temperature rise estimation. $P \sim 232W$

Cooling at right end only

Cooling through long channel in center

Water cooling: flow $\sim 70 - 100\ g/s$, $dT$ (max – water T) $\sim 40\ C$
Cavity tuning by gap size changing.
Sensitivity to the gap between loops

Resonant frequency is not sensitive to gap size
Multipactor in the cavity

- P = 0.78 KW
- P = 3.1 KW
For interesting range of power the multipactor is localized in coaxial end.
Multipactor can be suppressed by magnetic field

Geometry for multipactor simulations:

Geometry for magnetic field calculation:
RF = 12.5 kW
Solenoid -> 0 A x turn
RF = 12.5 kW  
Solenoid -> 790 A x turn
RF = 12.5 kW  Solenoid -> 1185 A x turn
RF = 12.5 kW  Solenoid -> 1580 A x turn
RF = 6.5 kW  Solenoid -> 1185 A x turn
RF = 6.5 kW  Solenoid -> 1580 A x turn

Material – copper:

Material - Aluminum

Conclusion:
Solenoid with ~ 2000 A x turn will suppress multipactor in coaxial part of cavity.
(H ~ 1.4E+4 A/m, ~ 0.017 T)
3-D model of RFQ coupler test stand
3-D model of RFQ coupler test stand
Coupling cavity

- Cavity body
- O-ring
- RF spring
- Coupler loop
- Coupler flange
- Solenoid
- Pumping holes
- Removable cover for tuning
- Water cooling
- Internal conductor
Block diagram of RFQ coupler test

Control signals:

• Direct / Reflected RF power
• Temperature around window
• Vacuum level
Questions we have to answer:
When? Where? Who?

When:
We expect that couplers will be produced within 0.5 year. In nearest days documentation will be ready for bidding. DC blocks are under production. Test stand (test cavity) can be produced within 3-4 months. It seems infrastructure (RF sources, waveguide system, etc) will determine the time of test.

Where:
Probably most practical place is place close to future RFQ position. It will allow to use RFQ infrastructure (RF source, waveguides, etc.)

Who:
Somebody should take care about infrastructure.