Ohmic Loss Minimization and Trapped Modes Analysis

- Trapped resonance modes lead to the heating and beam impedance.
- Main resonance modes excited in a gap between button and housing hole.
- Narrowing the gap simply reduces the resonance strength.
- It requires tighter machining tolerance to avoid electric short.
- We selected the same gap of 0.5 mm as the electrode of the present SPRing-8.
- Button thickness 5 mm was optimized to minimize the total ohmic loss \( P_{loss} \).

Assumed bunch fill pattern of 0.25 mA/bunch * 406 gave the maximum heat load among the equally spaced bunch fill patterns for a total stored current of 100 mA. Bunch lengthening due to potential well distortion was taken into account. The bunch length \( s_b \) is 14 ps for the bunch current of 0.25 mA.

**Frequency spectrum of trapped modes**

\[ R(\omega; \sigma_b) = 2 \text{Re} \left[ \frac{1}{\omega^2 - \omega_0^2} \right] \]

**Magnetic field distributions**

11.48 GHz (TE110)  15.09 GHz (TE111)

**Heat input condition**

- For a temporary bunch filling pattern: 0.25 mA/bunch * 406 @ Total current 100 mA, bunch length 14 ps (rms)
- The total heat input to the whole of the BPM head -> 1.1 W
- Estimation of heat input to the button surface, center pin and the inside of housing hole.
- We computed a temperature distribution of the BPM head.

**Signal Intensity**

Required signal voltage \( V > \frac{k_{x,y}}{2\sigma_v} \cdot \sigma_v \)

0.38 mV -> -55 dBm

Sensitivity coefficients: \( k_x = 6.8 \text{ mm, } k_y = 7.7 \text{ mm} \)

Demanded resolution: \( \sigma_v = 100 \mu\text{m (rms)} \)

Equivalent input noise power: -87 dBm (\( \sigma_v = 10 \mu\text{V} \))

Thermal - 101 dBm

NF of BPM electronics including cable loss 14 dB

**Heating of the BPM Electrode and the Block**

- Block (stainless steel)

**Mechanical Design**

- BPM block
- Water cooling channel
- Reverse polarity SMA female
- Outer flange (Stainless steel)
- Button (Mo) ±0.03
- Insulator (Ceramic Al(OH)3)
- Brazing
- Step for the vertical support
- Center pin (Mo)

**Materials**

- Water-cooled BPM block, Outer flange of the electrode
  - Stainless steel (316L)
- Button and center pin -> Molybdenum (Mo)
  - Suppression of the trapped mode heating
- Mo: High electric and thermal conductivity
- Insulator -> Alumina ceramic (Al2O3)
  - Thermal conductivity 18 W/m/K close to that of stainless steel

**Required Performances for the BPM system**

1) Resolution
   - Single-Pass (SP) mode COD mode: 100 \( \mu \text{m rms} \) @ 100 pC single bunch, 0.1 \( \mu \text{m rms} \) @ 100 mA 1 kHz b.w.

2) Accuracy
   - Single-Pass (SP) mode COD mode: 100 \( \mu \text{m rms} \) (±200 \( \mu \text{m max.} \)) before BBA

3) Stability
   - Drift of BPM offset < 5 \( \mu \text{m/month} \)