STATUS of BBC DESIGN and ENGINEERING : PRELIMINARY RESULTS

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Outline

Beam-Beam compensator:

Decreasing the influence of a beam on the other using electrified wire in some TCTP collimators

Specifications:

- Re-use nearly 100% of existing TCTP design
- Electrified wire as close as possible to the beam axis: distance the center of the wire - the surface of the jaw <3mm
- Maximum diameter of the copper 2mm
- Maximum input current: 350A DC
- If possible, 2 wires (1 working – 1 spare)
1 Wire Design

- Cooling Pipes (Cu Ni)
- Tungsten Jaw (Inermet)
- Glidcop Jaw (Glidcop)
- Back-Stiffener (Glidcop)

17mm
3mm

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2 Wires Design

Cooling Pipes (Cu Ni)

Tungsten Jaw (Inermet)

Glidcop Jaw (Glidcop)

Back-Stiffener (Glidcop)

3mm

11.4mm

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1 Wire Design
2 Wires Design
Thermocoax wire

3 Layers
Total diameter : 3.6mm

Stainless Steel – Thickness 0.3mm
Magnesium oxide – Thickness 0.5mm
Copper – Diameter 2mm

Electrical properties :

Magnesium Oxide layer → perfect electrical insulator
Copper → very good electrical conductor

Maximum admissible temperature (estimated by Thermocoax, not tested): ≈400ºC
(under testing by A. Ravni)
TCTP Thermal Load

TCTP without BBC

1h Beam Life Time (8.6e8 p/s) on each Jaw : 418.4W

TCTP with BBC

Heat generation due to Joule effect in the wire with 350 A :

\[ 2.11 \times 10^8 \text{ W/m}^3 \] (at 300ºK)

Total thermal power dissipation:

1 Wire design at 300ºK : \( 940 \text{ W} + 418 \text{W from beam} \)

2 Wires design at 300ºK : \( 986 \text{ W} + 418 \text{W from beam} \)

BBC : adds more than twice the 1h BLT thermal load optimistically assuming RT Cu electric resistivity
Thermal simulation : wire cooled only in Jaw

Calculation for both designs: 1 and 2 wires
Only electric load considered: 350A DC current

To achieve numerical convergence, electric load applied through internal heat generation

Power calculated from Joule heating 350A DC at 27ºC = 2.11e8 W/m³

Thermal interfaces

Heat sink : convection inside cooling pipes 13000 W/(m²K)
Temperature max
- Inermet Jaw: 101.1°C
- Wire: 15800°C

Average temperature
- Inermet Jaw: 34°C
- Glidcop Jaw: 31.4°C
2 Wires

Temperature max
- Jaw: 116.8°C
- Wire: 19600°C

Average temperature
- Inermet Jaw: 36.6°C
- Glidcop Jaw: 31°C
Additional thermal bridge system

- Glidcop
- Stainless Steel

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**1 Wire – Optimized Cooling system**

**Temperature max**
- Tungsten Jaw: 42.1°C
- **Wire: 440°C**

**Average temperature**
- Inermet Jaw: 32.5°C
- Glidcop Jaw: 30°C
2 Wires - Optimized Cooling system

Temperature max
- Tungsten Jaw: 49.2°C
- Wire: 431°C

Average temperature
- Inermet Jaw: 34.6°C
- Glidcop Jaw: 29.7°C

350A DC not compatible with present design
Thermal issues

Electric resistivity not constant over temperature: the hotter, the higher the heat generation

Electric resistivity at 400ºC = 2.5 times the one at 27ºC

Temperatures reached are clearly underestimated
Preliminary conclusion: Thermal issues

Both designs not acceptable (yet!)

Challenge: must cool the wires in the hottest zones!

350 A DC with constant electric resistivity at RT

Taking into account dependancy in T:
Strong increase of the final temperature

350 A DC with T-dependant electric resistivity
Back-up slide
Back-up slide

2 Wires design - Thermal load: 350 A with constant electric resistivity (at 400°C)
Back-up slide

2 Wires design - Thermal load: 300 A with constant electric resistivity (at 27°C)