Beam Pipe Meeting Introduction

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Goal of the Meeting

- The beam pipe area is critical for the FHC design
  - Magnet aperture is a main cost driver
  - Beam aperture is a main beam performance factor
  - Thickness of shielding gap is critical to link the two
  - Beam screen cooling is one of the main power consumption sources
- Beam pipe area design interacts with many expertises
  - Magnet design
  - Cooling and power efficiency
  - Wakefields, impact beam stability, optics and feedback
  - Electron cloud, impacts the time structure and background in the experiments
  - Vacuum design
- Need an integrated task force/working group
  - Define baseline beam aperture, magnet aperture and shielding gap
  - Develop strategies for alternative solutions
  - Later also touch field quality at injection
- This meeting should kick-start the technical discussion of this task force

Synchrotron Radiation Load

- Main difference between LHC and FHC
- Synchrotron radiation is 25 to 44 W/m per beam averaged over the arc for (15T and 20T)
  - Important to avoid heating of magnets
- Total radiation is 4.4 to 5.8 MW for both beams
  - Total cooling efficiency is critical
  - Cooling needs to be done at relatively high temperature due to Carnot inefficiency -> Philippe
- Four approaches
  - Conventional beam screen -> Philippe, Nicolas
  - Conventional beam screen with high temperature superconductor
  - Photon stops -> Nicolas
  - Open midplane magnet
  - Are there more?

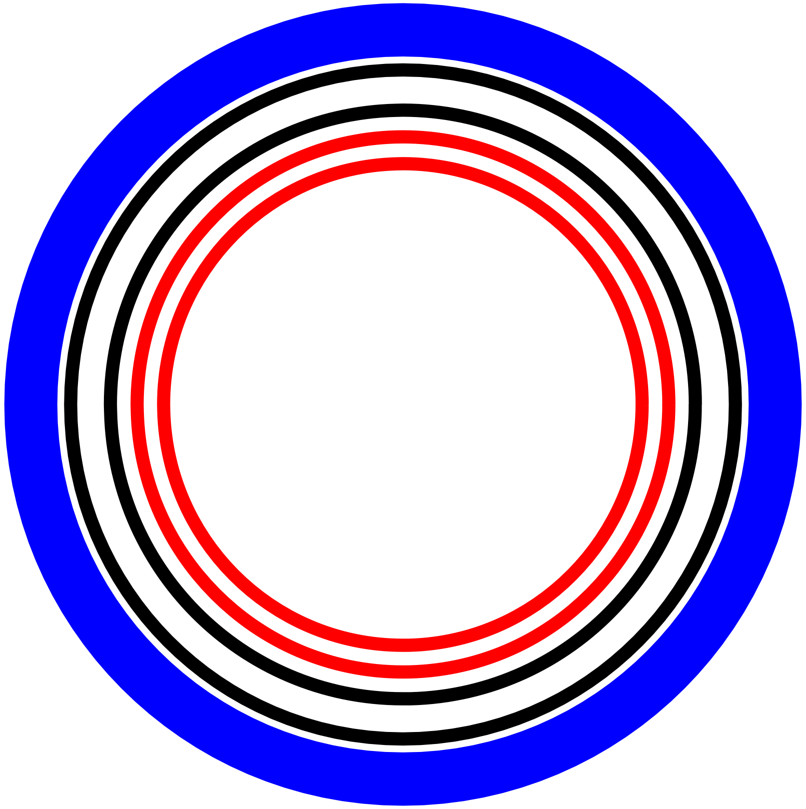
Beam Screen

- Current draft baseline
  - beam aperture: 2x13mm
  - magnet aperture; 2x20mm
  - Space for shielding etc: 7mm
  - Needs to be reviewed

- Impedance effects
  - Strong dependence on radius
  - Field dependent
  - increase above approx. 20K

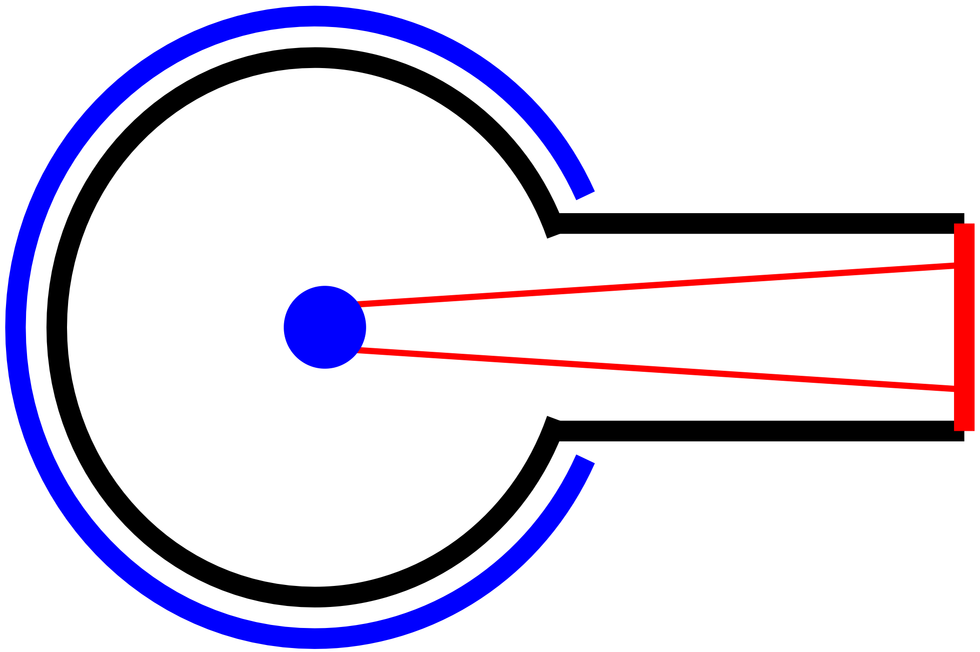
- Potential cures
  - Increase of aperture
  - Superconducting coating
    - Amorphous carbon coating against ecloud (Gijs De Rijk, Roberto Kersevan)

Simplified sketch

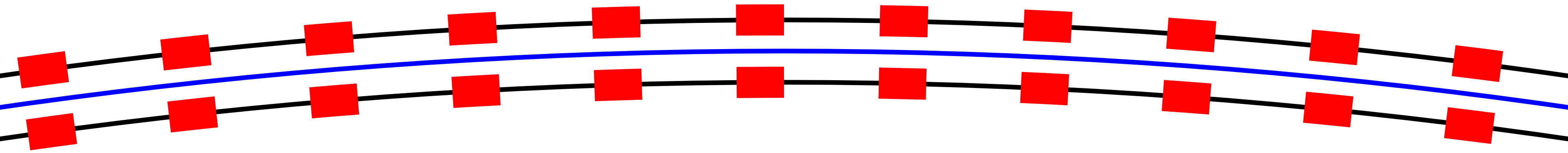


Open Midplane

- Less impact of warm surface impedance on beam
- Could also help against electron cloud
- Maybe easier to shield magnet
  - Could reduce space between beam screen and magnet
- But very difficult magnet design
  - Likely reduced field
- Similar studies for muon collider



Photon Stops



- Photon stops could take most of the heat load and be cooled at a higher temperature
- Photons travel for approx 12-21m at injection and around 14.5m at full energy (20T design)
  - For 13mm beam pipe radius 10mm radius for photon stops requires 1.8m spacing
  - Would need very short magnets or have to integrate the stops into the dipoles
  - Maybe space between beam and magnet aperture can be reduced
- Reflectivity of photons (4keV critical energy) might be OK

Conclusion

- Beam pipe design is very critical
  - Magnet cost
  - Power consumption
  - Beam stability
  - Electron cloud

- Consider four different approaches
  - All have advantages and disadvantages
  - Need to explore them to some level
  - Will require R&D

- Will form an integrated working group
  - Experts from the different fields
  - Meet regularly
  - To work out details
  - To come up with novel ideas

- Will need to find a time slot and make sure that each field can be represented

Potential Next Steps

- Define conventional solution
  - Temperature of beam screen
  - Design of screen and inner kryostat
  - Probably thickness is independent of the inner aperture
  - Can then define inner aperture from beam dynamics

- Define strategy with high temperature superconductor coating
  - Material
  - Electron cloud mitigation
  - Inner kryostat/beam screen
  - Aperture

- Define a strategy for photon stops
  - Integration of stops into dipoles
  - Required shielding gap thickness
  - Determine impedance effects

- Define strategy toward open midplane magnets
  - Is it worth exploring?