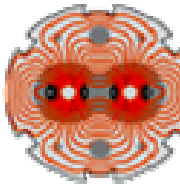
TCDS DILUTER TO PROTECT MSD SEPTUM MAGNETS



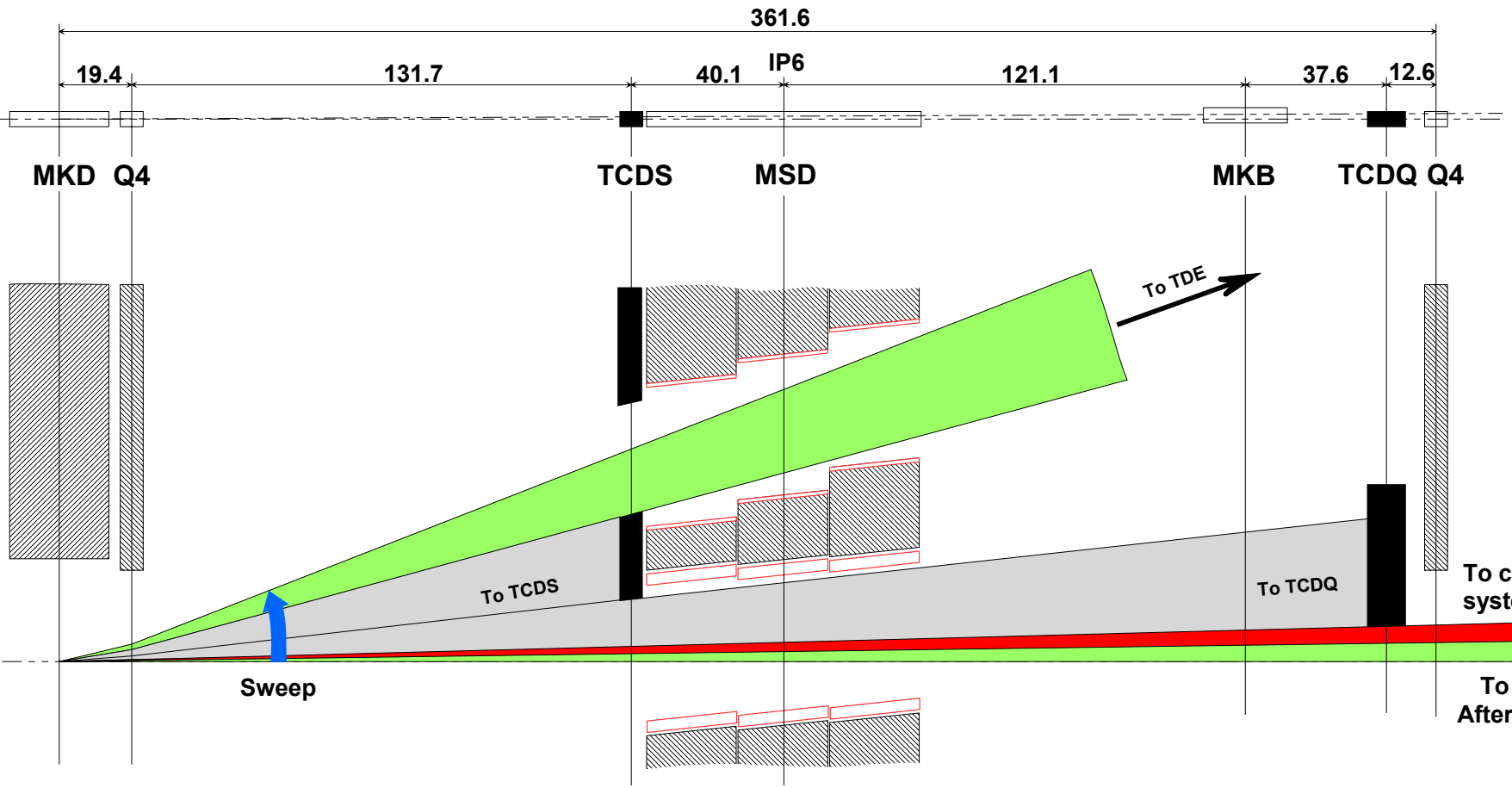
FUNCTIONAL SPECIFICATION
LHC-TCDS-ES-0001

W. Weterings [AB/BT]

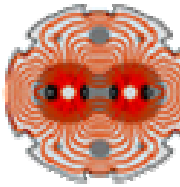
With contributions from :

M. Sans Merce [AB/ATB]
L. Bruno [AB/ATB]
B. Goddard [AB/BT]
M. Gyr [AB/BT]
J.M. Jimenez [AT/VAC]

INTRODUCTION



OPERATION CONDITIONS



LHC BEAM INTENSITY AND ENERGY [1]

- 7 TeV Proton Beam Energy
- 2808 Bunches, 24.95 ns spacing, 1.1 10^{11} Particles/Bunch
- 350 MJ stored Energy

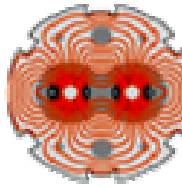
PERFORMANCE OBJECTIVE TCDS [2]

- **What:** dilute about 6.1 MJ, ~ 1.7% of LHC beam energy.
- **When:** Event of an unsynchronised beam abort of the MKD kickers at baseline luminosity and 1.2μs delay.

EXTRACTION PARAMETERS

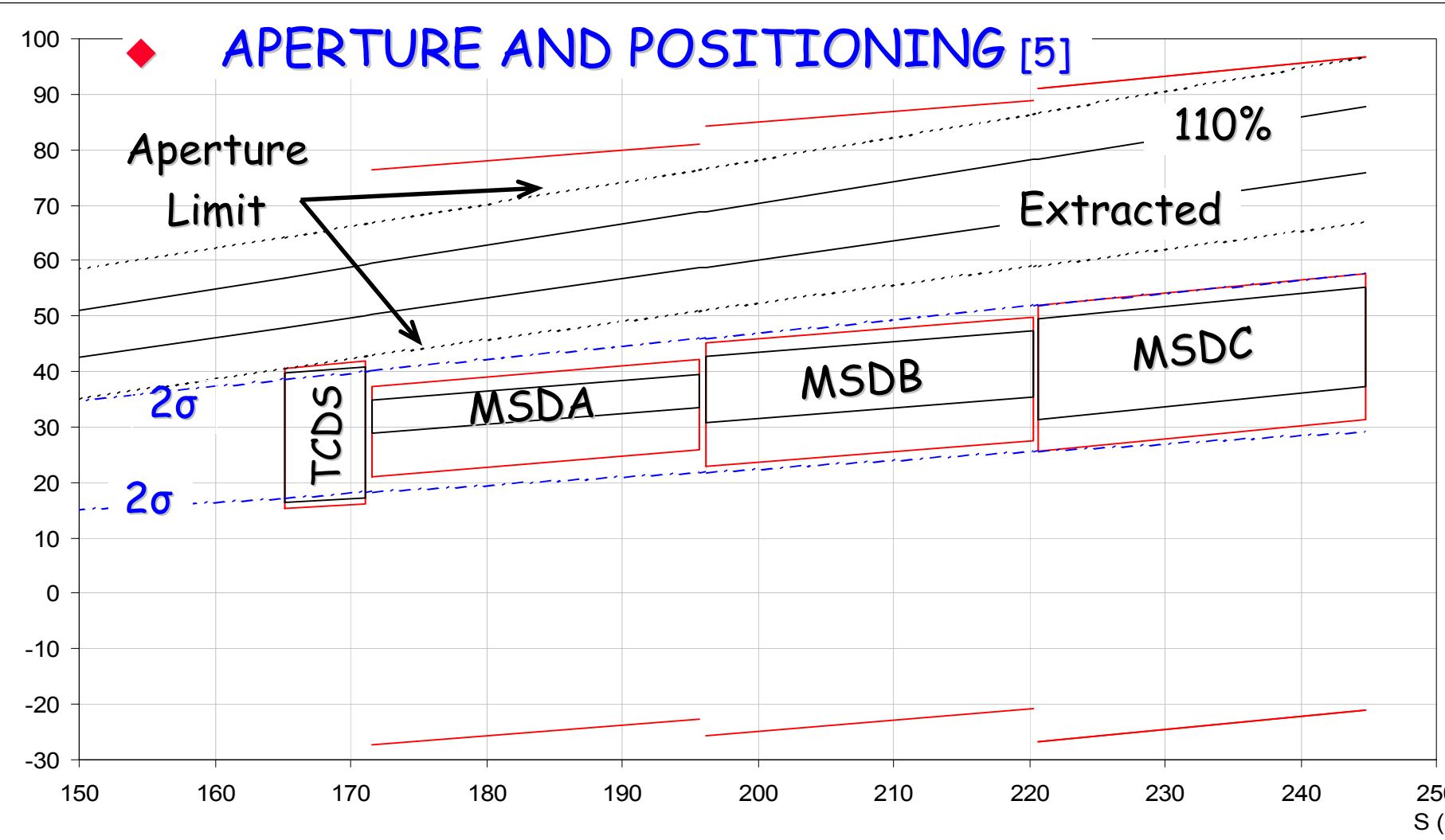
- Bunch is deflected proportionally to the kicker strength.
- Kicker waveform consisting of a linear ramp of 2.76μs rise time, bunch separation of 24.95ns.
- The distance between bunch hits is calculated using:
  - The extreme orbit trajectories at the TCDS position,
  - The dimensions and position of the TCDS in the IP6 line,
  - The kicker strength and parameters.

DESIGN REQUIREMENTS AND CONSTRAINTS - 1

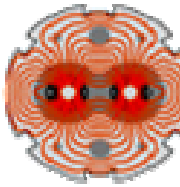


- MATERIALS
  - Thermal, Mechanical, Impedance, Vacuum, Radiological and Environmental constraints.
- VACUUM SYSTEM [3]
  - Compatible with room temperature beam vacuum system of the LHC LSS
  - Nominal pressure of $<10^{-8}$ Pa, Leak tested $1 \cdot 10^{-11}$ Pa.m^3/s.
  - Compatible with an *in-situ* bake-out to at least 250°C for 24 hours.
- IMPEDANCE [4]
  - Low electrical resistivity -> low transverse machine impedance.
  - The surface resistance Rs $< 3.906\ 10^{-11}\ d^3\ W$. (d = beam screen ID)

DESIGN REQUIREMENTS AND CONSTRAINTS - 2



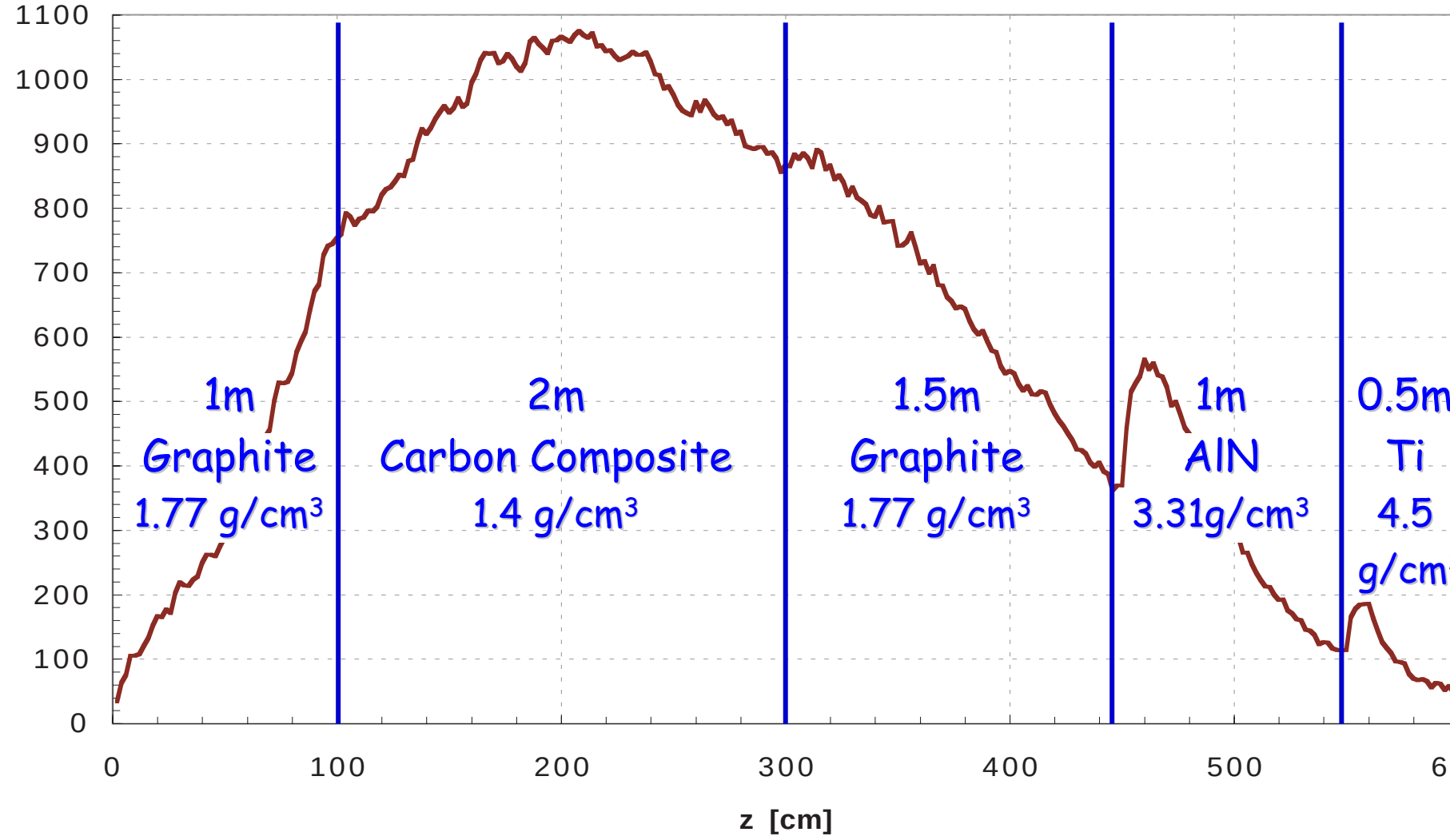
CONCEPTUAL DESIGN - 1



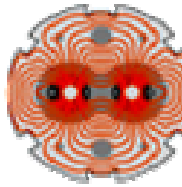
- CONFIGURATION
  - **Considering:**
    - Choice of Absorber materials and

      Maximum Temperatures:
    - MSD Vacuum chamber (300°C)
    - MSD Steel Yoke (100°C)
  - **Baseline Solution [6]:**
    - 1m C, 2m C-C, 1.5m C, 1m AlN, 1m Ti
  - **Alternative Solution (pending tests):**
    - 1m C, 2m C-C, 1.5m C, 1m SiN, 1m Ti
    - 4.5m C-C , 1m AlN, 1m Ti
    - 4.5m C-C , 1m Al, 1m Ti

CONCEPTUAL DESIGN - 2

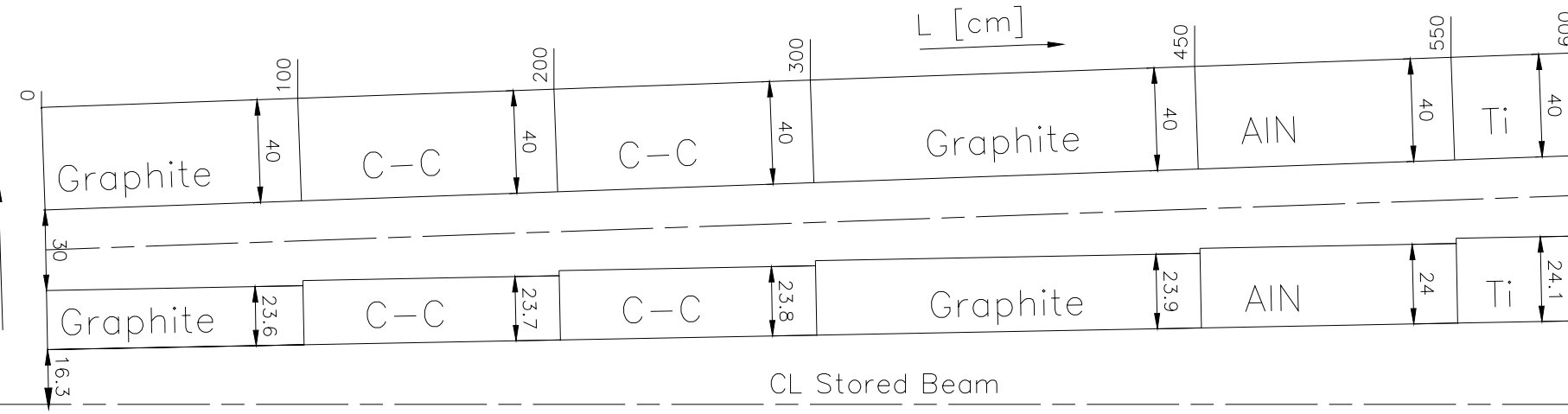


CONCEPTUAL DESIGN - 3

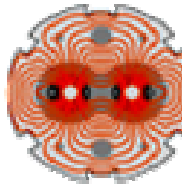


DIMENSIONS

- The ideal TCDS configuration is wedge-shaped.
- To avoid manufacture, assembly and alignment difficulties an approximate configuration with increasing thickness is proposed.
- A 2nd jaw, giving a clear aperture of 30mm, to protect the MSD from particles outside the aperture.

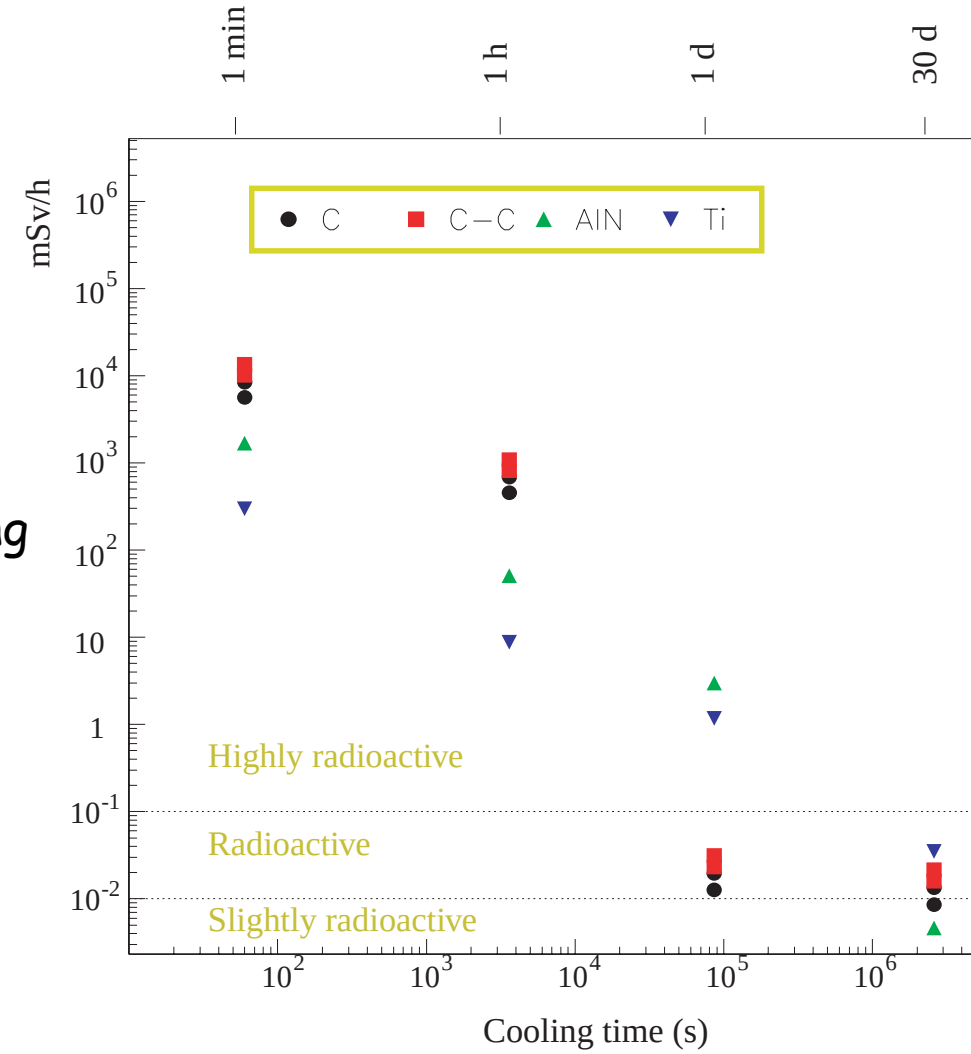


CONCEPTUAL DESIGN - 4

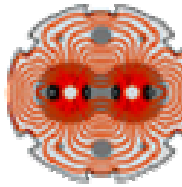


RADIOLOGICAL AND ENVIRONMENTAL ISSUES

- Dose rate at 30cm from the object after one unsynchronised beam abort.
- After impact and 1 day cooling period ~3mSv/h.
- After impact and of 30 days cooling period ~0.035mSv/h.



CONCEPTUAL DESIGN - 5



COOLING REQUIREMENTS

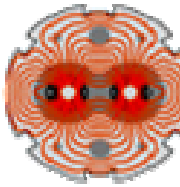
- A 500W cooling system to absorb the estimated 40W/m power deposited by the beam [7]. (.....is factor 2 safety enough?)

THERMO MECHANICAL STRESSES AND DILATATION

- Thermal behaviour and stresses analyses is treated in a separate technical specification [8].
- The design must take into account the estimated thermal expansion of the TCDS absorber elements due to bake-out and beam impact.

Material	ΔL Impact [mm]	ΔL 250°C [mm]
Graphite	0.2 (80°C)	0.9
C-C Composite	0.6 (190°C)	0.8
Graphite	0.9 (185°C)	1.3
Aluminium Nitride	0.6 (130°C)	1.2
Titanium	0.2 (50°C)	1.2

MECHANICAL DESIGN - 1



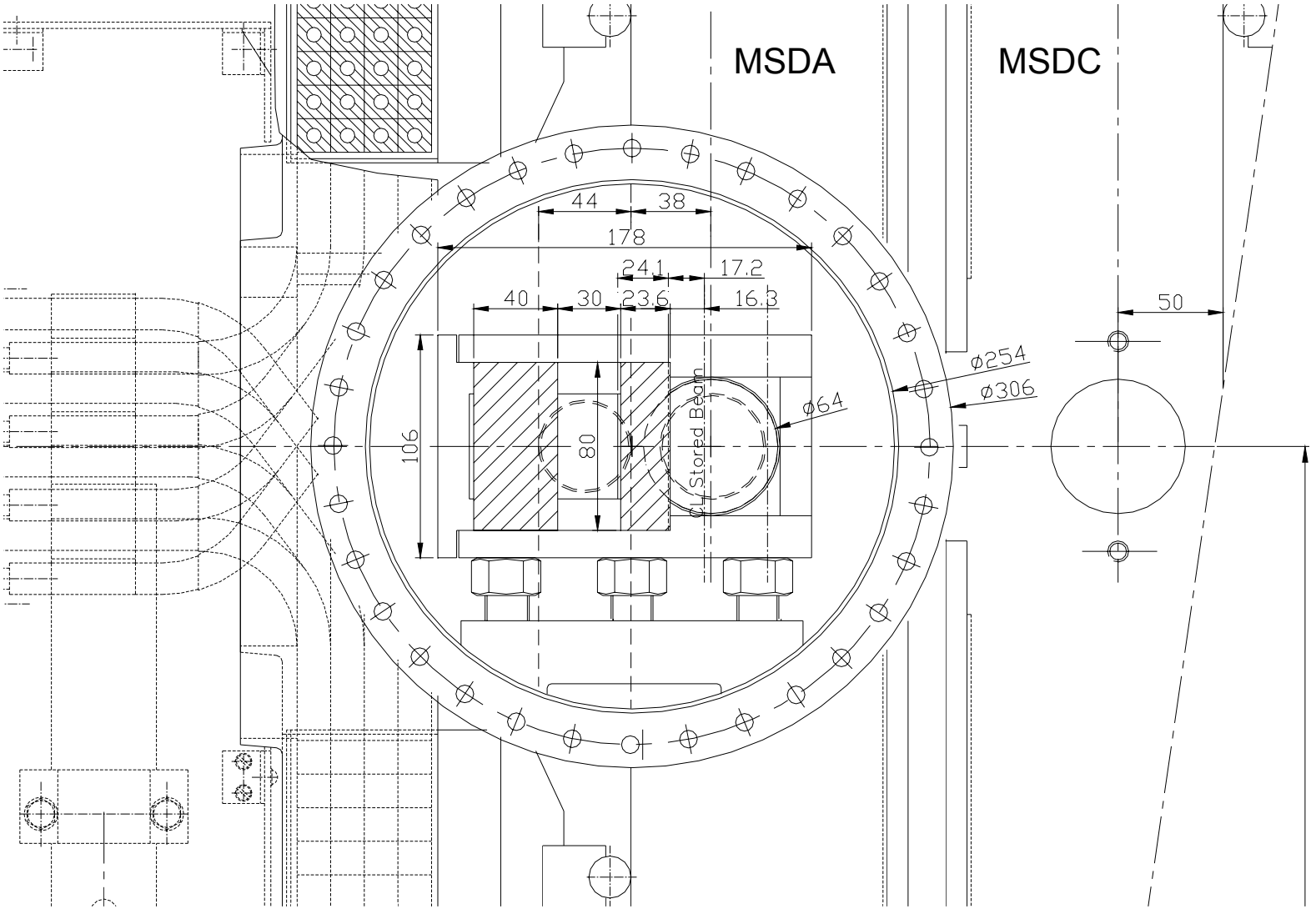
VACUUM VESSEL/EQUIPMENT

- Maximum OD Ø350mm (interference adjacent LHC vacuum tube), Maximum length <7.18m (compatibility CERN cleaning baths)
- Manufacture, assembly & alignment tolerances. of ±1mm.
- No use of halogen containing brazing flux (corrosion) and *In-situ* welding must be avoided. (Cleaning and Conditioning problems).
- Interconnection bellows (thermal expansion/contraction) shall assure continuity of electrical conductivity.
- Two 400 l/s ion-pumps and two sublimators (CO and CH families) [9].
- The vacuum vessel of 316 L(N) (300°C external bake by heating jackets).

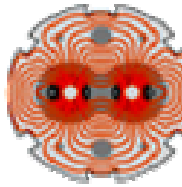
BEAM SHIELDING

- Beam screen for LHC stored beam with a minimum clear aperture of 48.4mm (MSDA).
- All cavities, should be shielded with transitions angles <15°, surface roughness <200 um[4].
- Bellows shielded with impedance of ≤0.1mΩ. Contact resistance between chambers <100 mΩ [3].
- Pumping slots with a surface area of up to 20%, rounded corners and their major axis is in the beam direction.

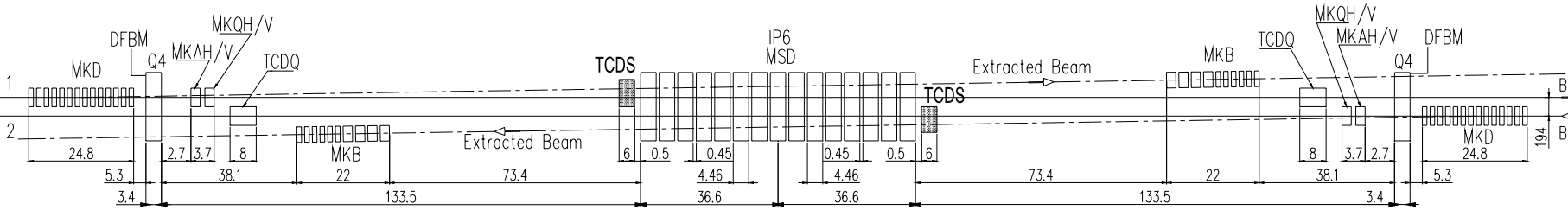
MECHANICAL DESIGN - 2



LAYOUT AND INTEGRATION

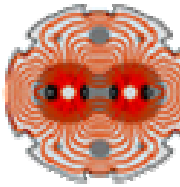


SCHEMATIC LAYOUT

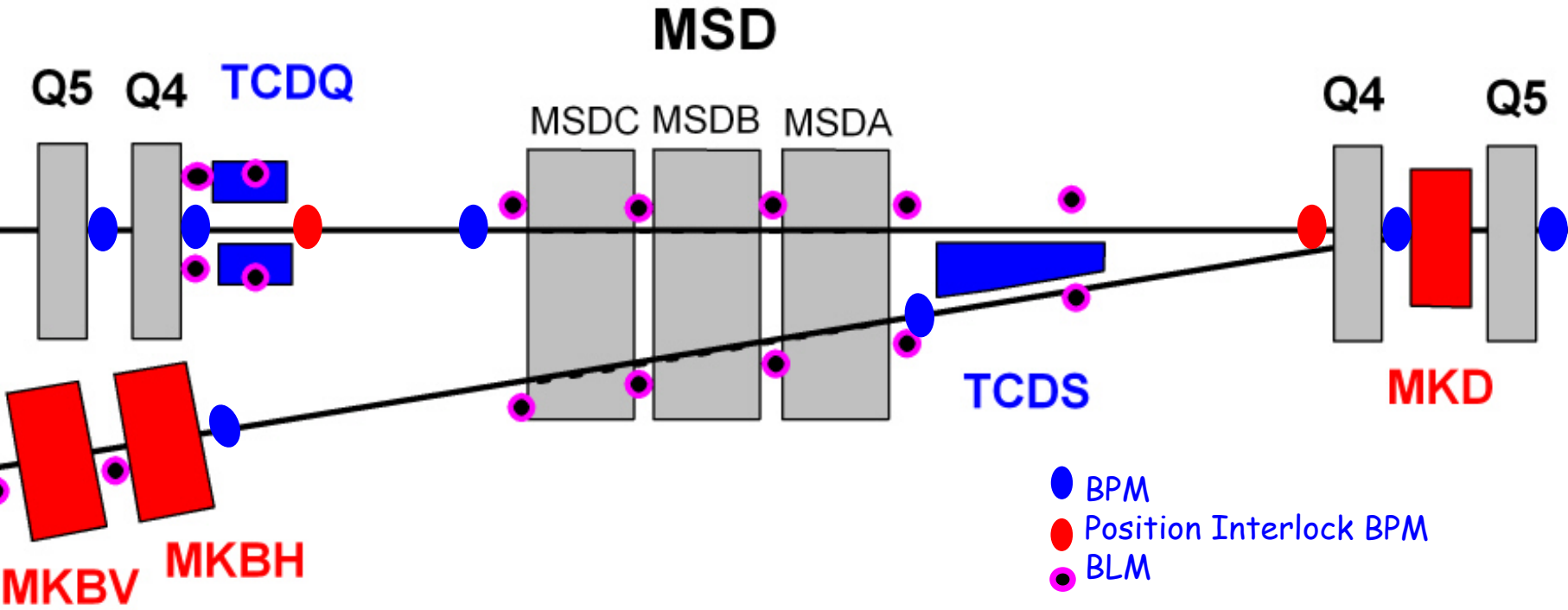


- The TCDS vacuum vessel will be fitted with DN250 conflat flanges at each end for connection to the LHC room temperature beam vacuum system and to the MSD pumping module.
- The TCDS will not be isolated from the other equipment by special sector valves.

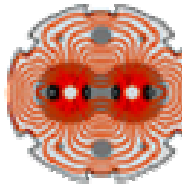
INSTRUMENTATION



- Temperature sensors to monitor the temperature profile.
- Flow-meters and temperature gauges to monitor the cooling system.
- Beam position monitors (BPM) (horizontal and vertical plane) to monitor the position of the extracted and circulating beams [10].
- Loss monitors (BLMs) around the TCDS diluter blocks.



REFERENCES



[1] LHC Design performance, Nominal Beam Parameters, accessed November 2002 on http://edmsoraweb.cern.ch/.

[2] N.V. Mokhov et al., Further Studies On Protecting LHC Components Against Radiation Resulting From An Unsynchronized Beam Abort, FERMILAB-FN-724, 2003-04-21.

[3] I. Collins, Room temperature Beam Vacuum System for LHC Long Straight Section, Functional Specification, EDMS LHC-LVW-ES-0001 rev 0.2, 2002-03-04.

[4] L. Vos, Tentative Impedance Specification for the Warm Pipes in the Long Straight Sections of the LHC, 2001-08-10

[5] B. Goddard, M. Gyr, The aperture and layout of the extraction septa of the LHC beam dumping system, LHC Project Note, to be published, 2003.

[6] M. Sans, Simulations of energy deposition and adiabatic temperature rise in the TCDS, LHC Project Note, to be published, 2003.

[7] Private discussion with L. Vos, AB/ABP group, 2003-04-07.

[8] M. Sans, Study of the Thermal Behavior of the TCDS Target unit, Technical Specification, to be published, 2003.

[9] Electronic mail communication from J.M. Jimenez, AT/VAC group, 2003-06-19.

[10] J. Wenninger et al., Instrumentation for the LHC beam dump lines, Functional Specification, EDMS LHC-DC-ES-0002, 2002-06-03.