TDI redesign: materials, beam parameters and impact scenarios

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TDI upgrade meeting

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Updated material list

Material	Chem. F.	Density	Used in device	λ
Graphite and carbon compounds				
CfC (low density)	C	1.4 g/cm^3	TCDS, TDE	58.2 cm
AC150 C/C	C	1.65 g/cm^3	TCLIB, TCSG, TCP	49.4 cm
CfC (high density)	C	$>$1.7 g/cm^3	TCDS, TDE, TPSG	$<$48.0 cm
Graphite	C	$>$1.77 g/cm^3	TCDQ, TCDS, TPSG, TED, TCDI, TCLIA	$<$46.1 cm
Boron compounds				
Boron nitride (BN5000)	BN	1.92 g/cm^3	TDI	42.9 cm
Boron nitride	BN	2.21 g/cm^3	–	37.3 cm
Boron carbide	B_4C	2.50 g/cm^3	–	31.6 cm
Silicon compounds				
Silicon carbide	SiC	3.16 g/cm^3	–	30.3 cm
Silicon nitride	Si_3N_4	3.2 g/cm^3	–	29.8 cm
Aluminium and aluminium compounds				
Aluminium	Al	2.699 g/cm^3	TDI, TED	37.9 cm
Aluminium nitride	AlN	3.25 g/cm^3	–	29.3 cm
Alumina	Al_2O_3	3.34/3.76 g/cm^3	–	28.5/25.3 cm
Copper and copper compounds				
Copper	Cu	8.96 g/cm^3	TDI, TED, TCDD	14.6 cm
Copper-Diamond Composite	CuB-CD	5.4 g/cm^3	–	19.7 cm
Glidcop AL-15	$CuAl_2O_3$	8.9 g/cm^3	–	14.7 cm
Molybdenum and molybdenum compounds				
Molybdenum	Mo	10.2 g/cm^3	–	14.4 cm
Moly-Graphite Composite type 2	Mo-GRCF	3.7 g/cm^3	–	31.7 cm
Moly-Graphite Composite type 1	Mo-GR	5.6 g/cm^3	–	21.9 cm
Moly-Copper-Diamond Composite	MoCu-CD	6.7 g/cm^3	–	18.4 cm
Other high-density materials				
Titanium	Ti	4.5 g/cm^3	TCDS, TPSG	26.7 cm
Inermet 180	WCuNi	18.0 g/cm^3	–	9.7 cm

Beam parameters and impact scenarios

LIU parameters for 25 nsec (by courtesy of Brennan)

	LIU beta function @TDI entrance
β_x	107.7 m
β_y	47.9 m

	ϵ_n	I_{bunch} (I_{total})	σ_x^{TDI}	σ_y^{TDI}
LIU (nominal)	1 μm	1.15×10^{11} (3.31×10^{13})	0.47 mm	0.32 mm
LIU (maximum)	2.5 μm	2.5×10^{11} (7.20×10^{13})	0.75 mm	0.50 mm
Current nominal	3.75 μm	1.15×10^{11} (4.90×10^{13})	0.90 mm	0.51 mm

Beam impact scenarios

	Full impact (maximum impact parameter) (injection timing error)	**Grazing** (MKI erratic, flashover)
Load on D1 (&triplet)	• Drives $N_\lambda = \sum_i l_i/\lambda$: energy deposition in downstream magnets due to particles escaping downstream TDI surface • LIU maximum specs more demanding (due to higher I_{total}; beam size not so important for D1 load) • Functional design requires no damage, but with suffently large N_λ (∼13-14?) once can stay probably below quench limit	• $N_\lambda = \sum_i l_i/\lambda_i$ not so important if N_λ reasonably high (>10): secondary particles escaping from gap between jaws dominate (hadrons) • LIU maximum specs more demanding (due to higher I_{total}) • Quench cannot be avoided, without TCDD probably above damage limit
Load on TDI	• Important to consider both LIU specs when assessing material blocks: higher energy density in one case, higher gradient in the other	• Diluted impact on leading blocks: likely less energy density than for full impact case • Direct impact on high-density materials needs to be avoided (offset wrt lighter materials)

Open points and outlook

- Collect more ideas on:
  - **Number of individual modules**
    - more modules better for TDI load as shower opens up, but impedance issues
    - impact on downstream magnets (to be evaluated)
  - **Total length on blocks** (between 4.2 and 5 m seems logical choice)
  - Material availability, suitability for vacuum operation
- Material specifications:
  - Material data for ANSYS calculations is not always available
- Proposed next steps (until next meeting):
  - More (systematic) iterations on energy density calculations (FLUKA) and evaluation of corresponding temperatures and stresses (ANSYS) for different candidate material sandwiches
- Later:
  - Incorporate TDI model in FLUKA beam line and study different impact scenarios (load on D1)
  - At this point, we would need to know impact distributions for different cases (impact parameter, angle, distribution for grazing impact)