

LUXE



LUXE DIPOLE MAGNETS

LOUIS HELARY - DESY - FTX

LUXE SIMULATION MEETING - MAY 18TH 2021

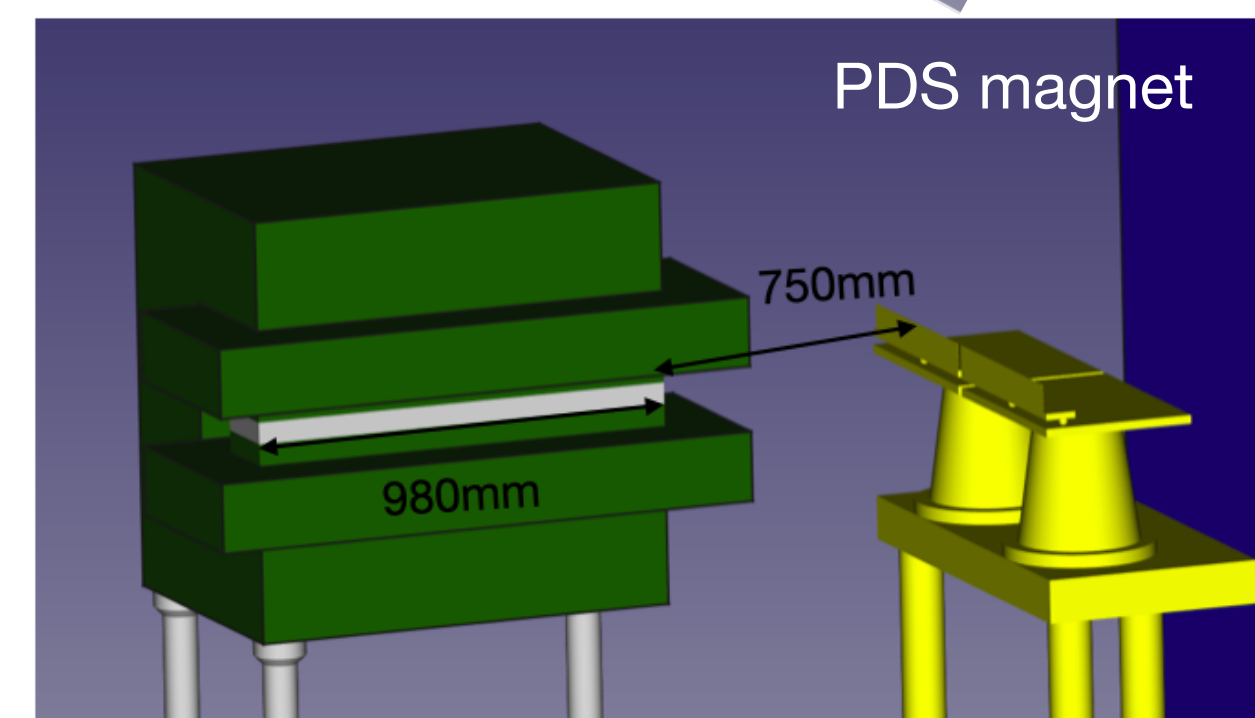
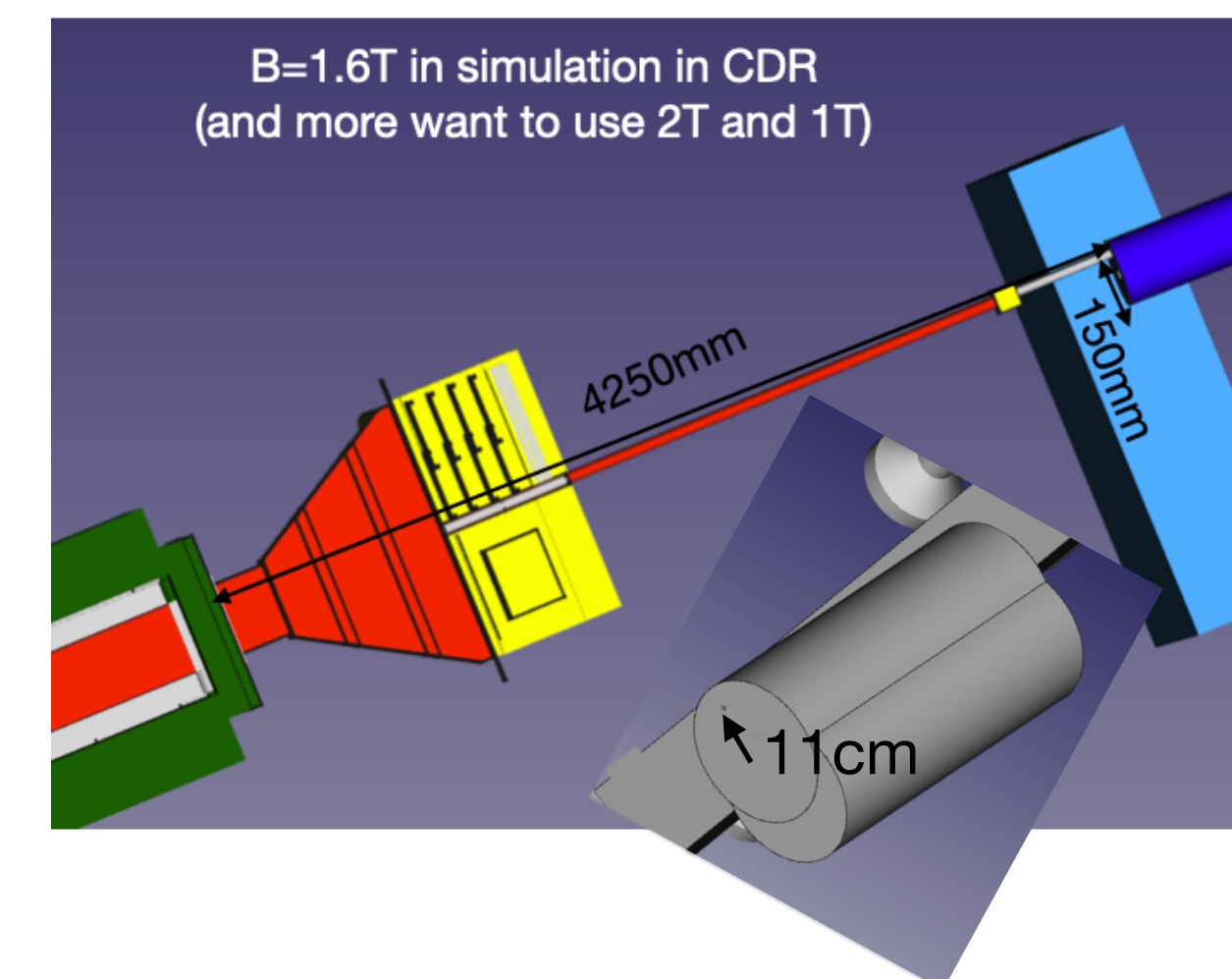
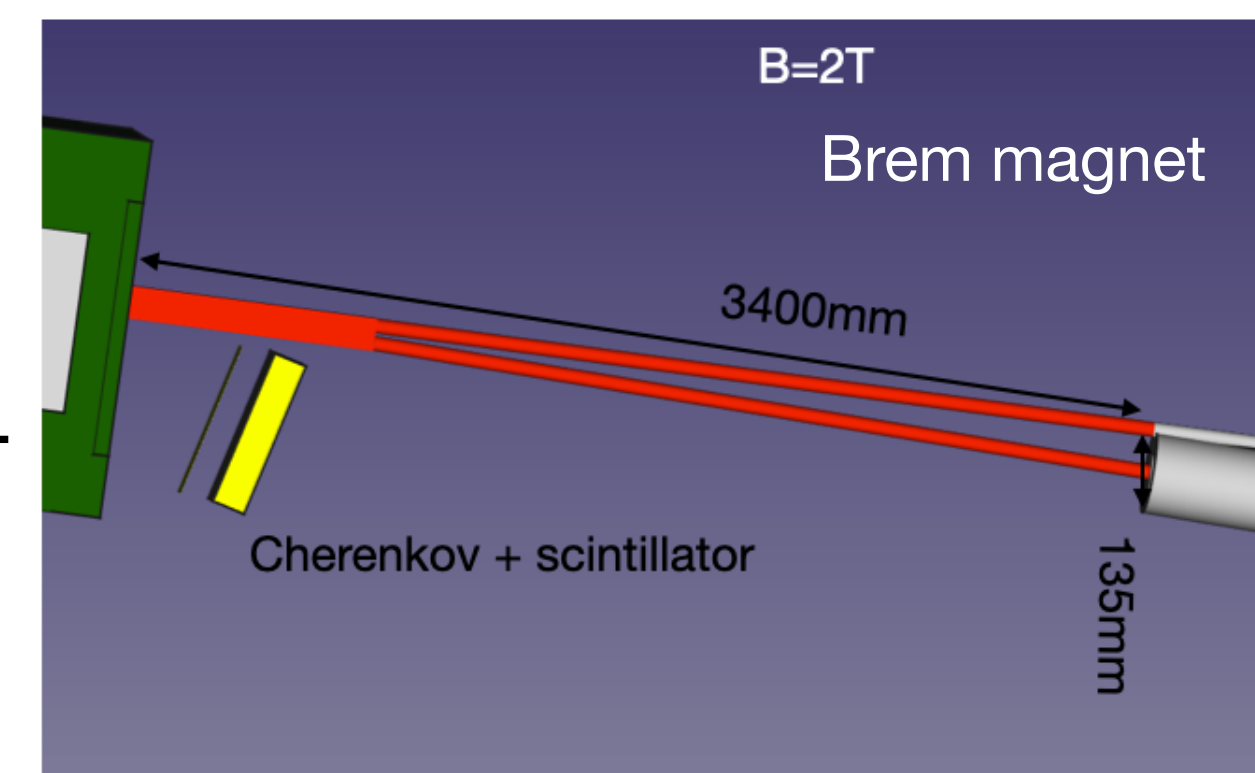


ONE WORD ABOUT THE EXPERIMENT MAGNET

Some consideration to design magnets:

- Buying multiple time same magnet save 1/3 price for 2nd, 3rd...
- Magnets are always only designed for a single field value
 - If need more has to be specified and need to understand what is most important value
- Magnets $>1.5\text{T}$ are complicated to design not superconducting because Iron saturate $>1.8\text{ T}$
- Decide to fix the displacement of e^- at dump as the distance to keep

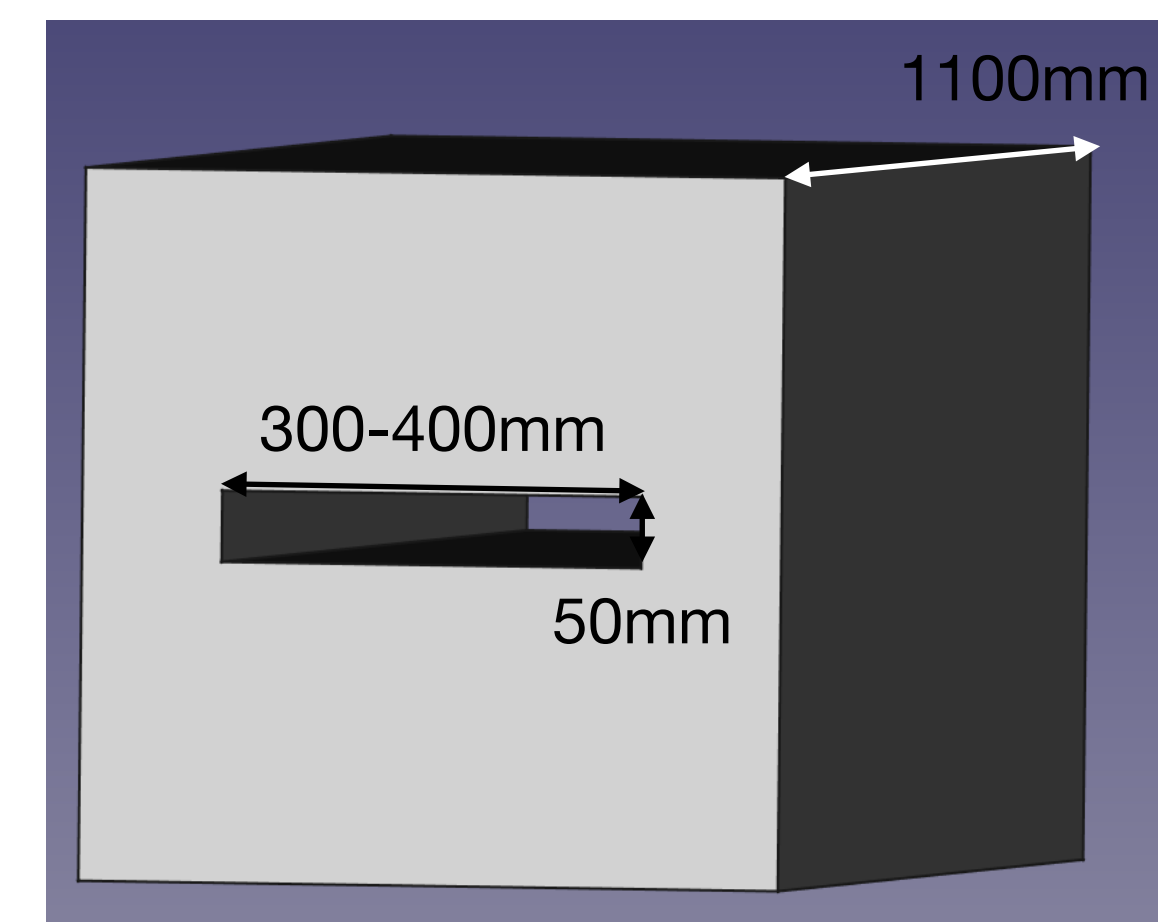
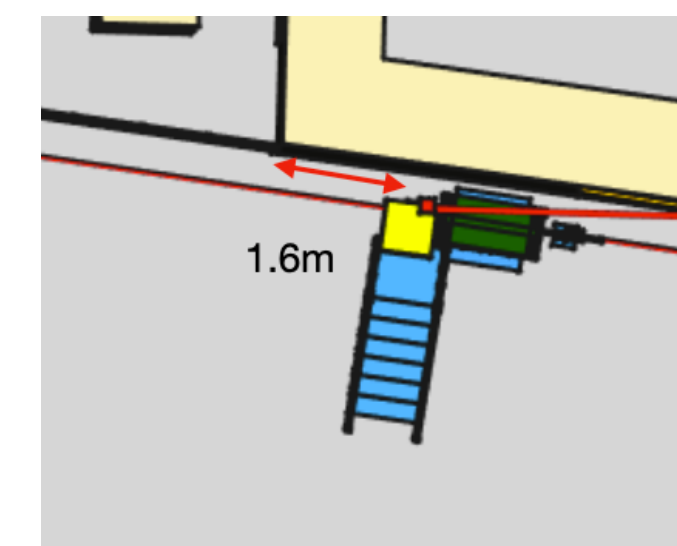
Magnet	Brem	IP high Xi	IP low Xi	IP g-laser	PDS
max e^- energy [GeV]	16.5	16.5	16.5	16.5	12
Magnetic field [T]	1.8	1.0	2.0	1.6	1.4
Magnetic length [mm]	1029	1029			980
Distance to object [mm]	3448	4435			750
Displacement [mm]	135	180	90	148	42
Goal	Dump XFEL e^-	dump XFEL e^- , measure e^+e^- paires from IP		measure e^+e^- paires from IP	Measure e^+e^- paires in PDS



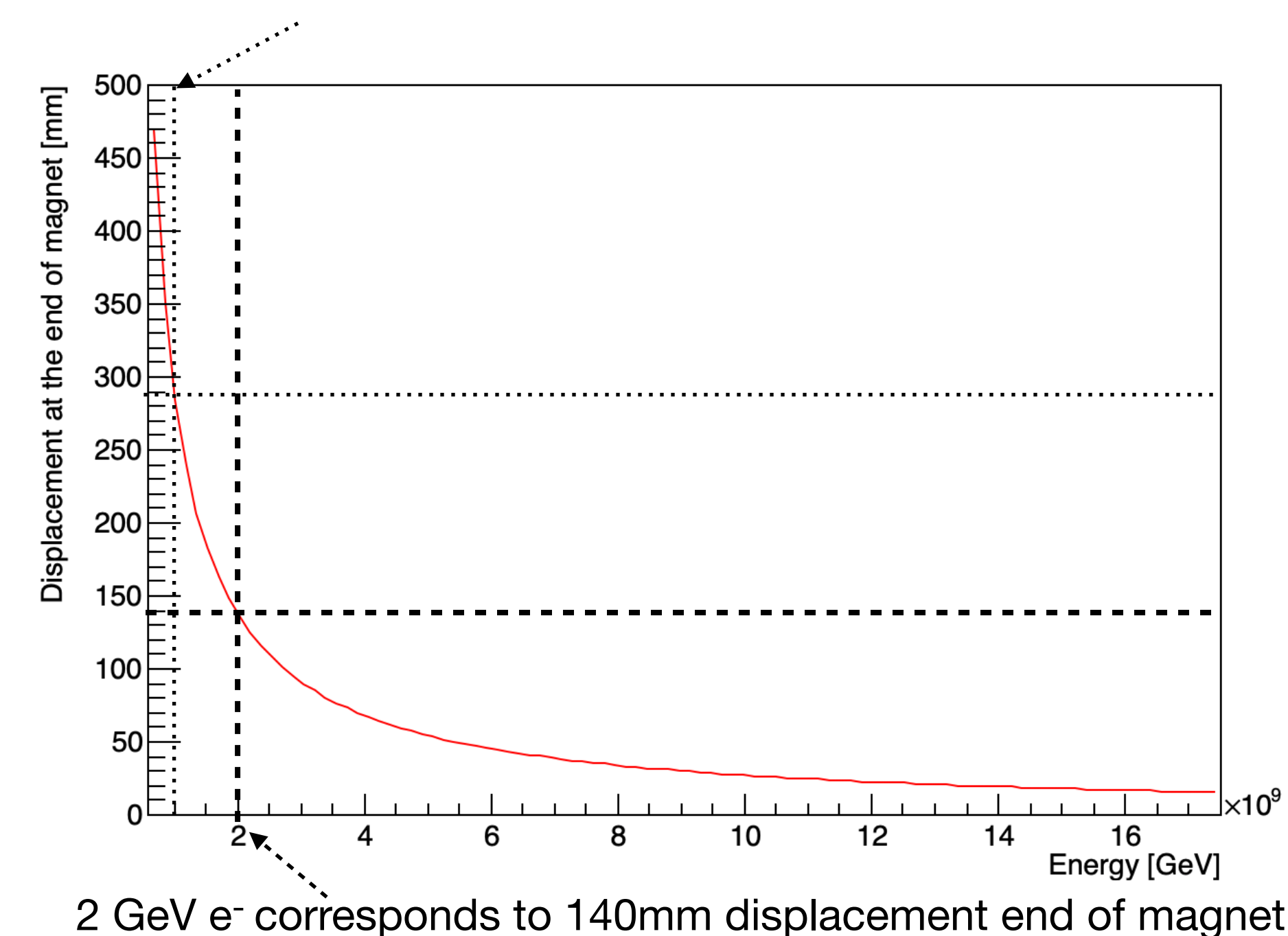
NEW NEED

- Try to make single magnet that could fit all the needs:
 - Aperture: 300-400mm limit lower energy range of particles that can be measured
 - Height: 50-60mm to host beam pipe (and or vacuum chamber)
 - Length: 1-1.2m (same as MB)
 - Field: 1.4-1.6T
 - HV-current: use system defined for CDR (quote from CAEN - 400A - 100V).
 - Need to define cooling capabilities

Magnet	Brem	IP	PDS
min e ⁻ energy [GeV]	1.5 (off axis)	2	2
max e ⁻ energy [GeV]	16.5		12
Magnetic field [T]	1.5		
Magnetic length [mm]	1100		
Distance to object [mm]	3950	4450	750
Delta Z position CDR [mm]	500	15	0
Displacement e ⁻ _{max} [mm]	135	150	65
Goal	Dump XFEL e ⁻	dump XFEL e ⁻ , measure e ⁺ e ⁻ paires from IP	Measure e ⁺ e ⁻ paires in PDS

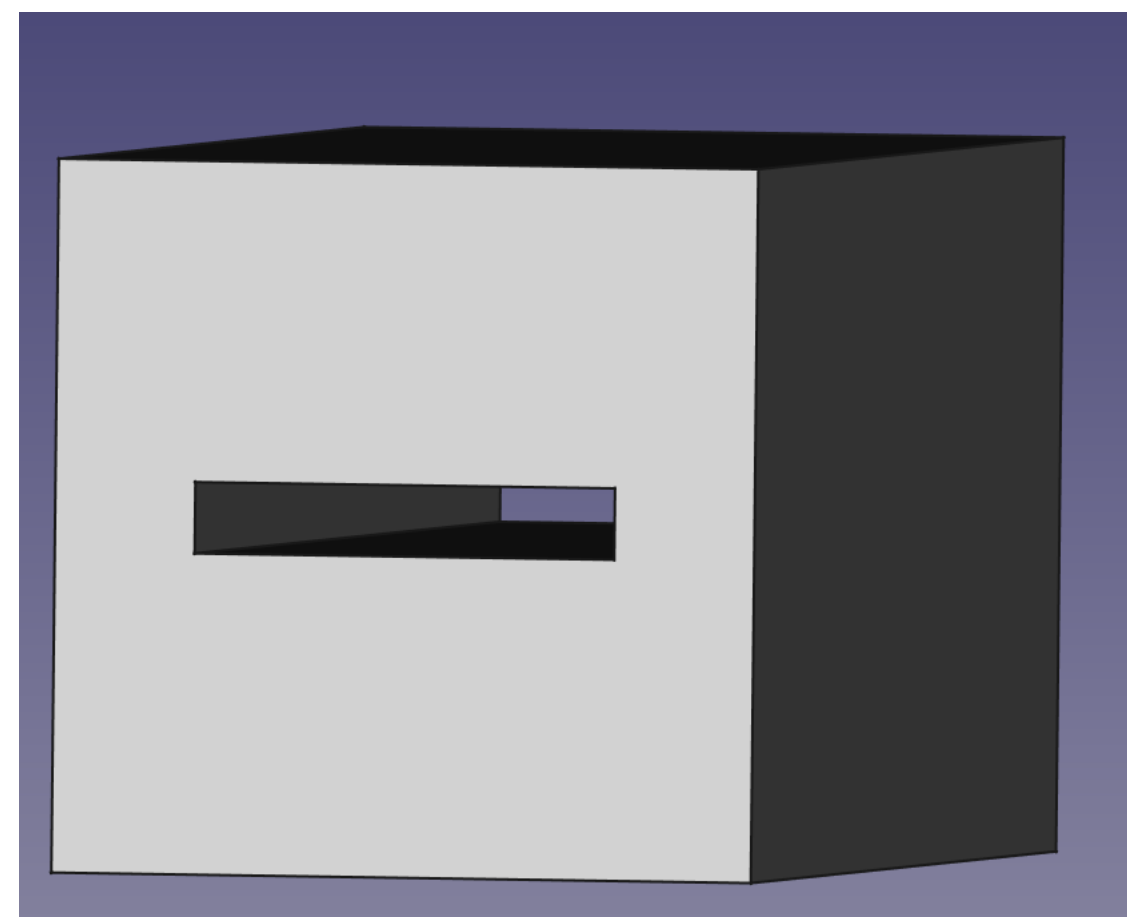
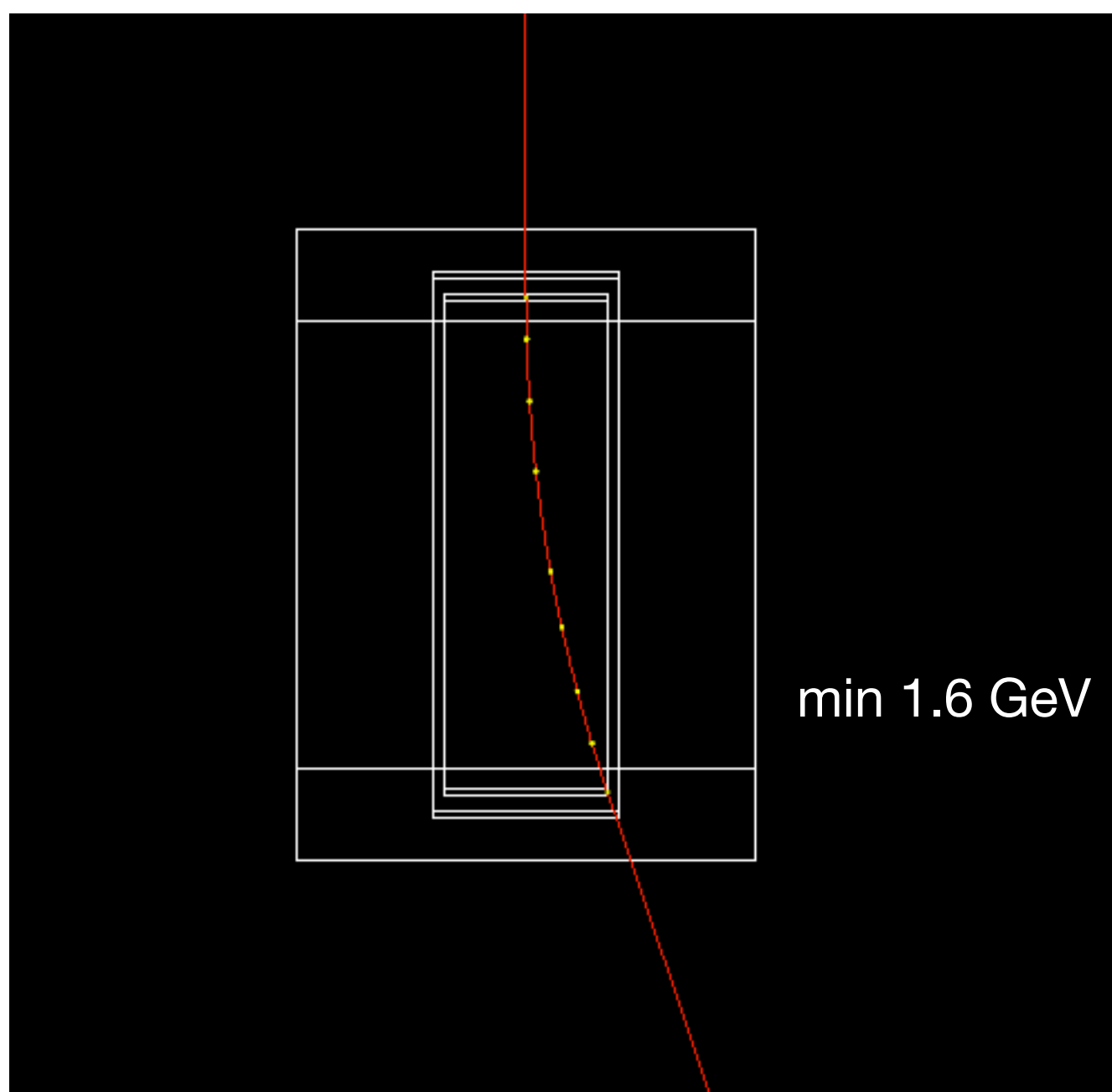


1 GeV e⁻ corresponds to 290mm displacement end of magnet



SPECIFICATIONS

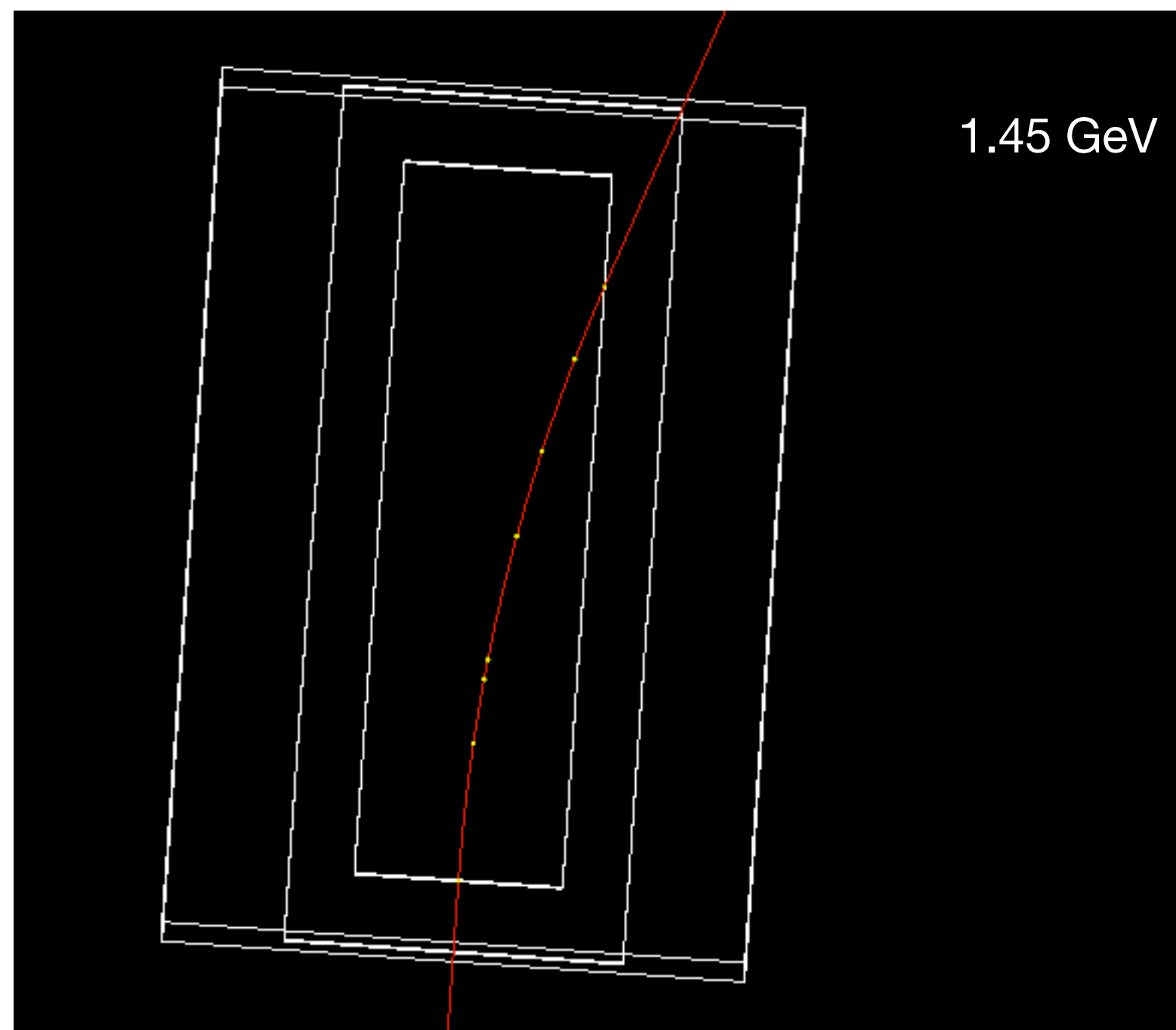
- Try to make single magnet that could fit all the needs:
 - Aperture: 350 (good field)-400 (aperture)mm limit lower energy range of particles that can be measured
 - Height: 50 (good field)- 55mm to host vacuum chamber
 - Length: 1.1m good field 1.2m out (~same as MB)
 - Field: 1.5T
 - Max delta 55cm upstream at brem site (there is 1.6m space left)
 - Still need to define voltage-current and cooling



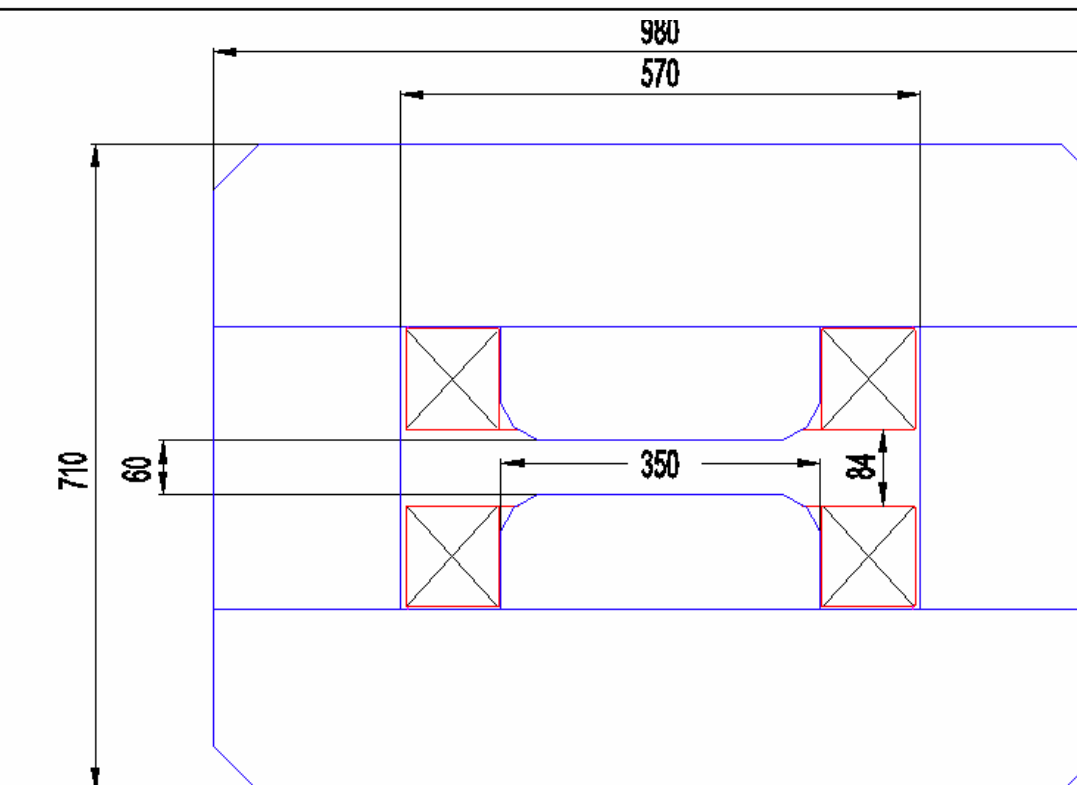
Parameter	Specification
Nominal magnetic field	1.5 T
Air gap	55 mm
Magnetic field quality	<1 e-3 (??)
Integrated magnetic field	55 T.m
Bending angle	2. ° (for e- @16.5 GeV)
Good field region (HxW)	50 mm * 350 mm (wrt air gap)
Distance from Yoke in beam direction that field drops to 0T	< 500 mm
Nominal current	400 A (CAEN system quote used in CDR)
Nominal voltage	< 100 V (CAEN system quote used in CDR)
Water pressure Drop	xx bar (??)
Water temperature rise	< xx° (??)
Maximum geometric size LxW	1600 mm * 1200 mm

ALTERNATIVE WITH EXISTING DESIGN - FLASH TDC

- If we want to reuse one magnet design we should use this one:
 - Aperture: 570mm (350 good field), down to 1.5 GeV
 - Aperture is really huge!
 - Height: 60mm to host beam pipe (or vacuum chamber)
 - Length: 1.2m (bit longer than MB), but x,y much smaller
 - Perfectly fit the current design
 - Field: 1.6T
 - Delta: (-15cm at brem (shorter distance), -75 cm IP to dump),
 - Voltage amperage and cooling are already defined.
 - Uses about 30 kW, ~6 Tonnes.
 - CDR estimate of HV system made for this magnet.



Technische Daten			
	Hauptspule	Korrekturspule	
Nennstrom	372	15	A
Spulen (Anzahl, Querschnitt)	2 (6048)	2 (564.86)	mm ²
Leiterquerschnitt (Cu)	60.48 (9 x 9 ; ø5)	8.826 (2.5 x 3.75)	mm ²
Windungszahl n/Spule	100	64	
Magnetwiderstand bei 20°C	200	440	mΩ
Induktivität	41		mH
Frequenz	DC	DC	
Max. Stromdichte	6.15	1.7	A/mm ²
Verlustleistung	28.1	0.09	kW
Anzahl der Kühlkreise	10		
Kühlwassermenge	14.4		l/min
Δt Kühlwasser	29		°C
Differenzdruck	7		bar
Prüfdruck der Spulen	25		bar
Prüfspannung der Spulen	2.0		kV (eff.)
Spulengewicht (pro Spule)	190	10	kg
Feld		1.6	T
Luftspalt		60	mm
Eisenlänge		1200	mm
Magnetlänge (eff.)		1300	mm
Gesamtlänge		1440	mm
Gesamtgewicht		6000	kg
Hersteller Fertigungszeichnung	Efremov – Institute , St. Petersburg (Russia)		
Hersteller Eisenjoch/Spule	Efremov – Institute , St. Petersburg (Russia)		
Bearbeitet: A. Jantzen-Stenzel	Geändert		
MEA Tel. 8998–3271 / 3327			



Backup

Dipolmagnet MB



Power

Water cooling
flow needed

Weight

Nennstrom	1500	A
Spulen (Anzahl, Querschnitt)	2 / 4007	mm ²
Leiterquerschnitt (Cu)	57.25 (9 x 9 ; ø 5.5)	mm ²
Windungszahl n/Spule	70	
Magnetwiderstand bei 20°C	165	mΩ
Induktivität		mH
Frequenz	DC	
Max. Stromdichte	26.2	A/mm ²
Verlustleistung	400	kW
Anzahl der Kühlkreise	28	
Kühlwassermenge	146	l/min
Δt Kühlwasser	40	°C
Differenzdruck	9.0	bar
Prüfdruck der Spulen		bar
Prüfspannung der Spulen		kV (eff.)
Feld	2.24	T
Luftspalt	108	mm
Eisenlänge	1080	mm
Magnetlänge (eff.)	1029	mm
Gesamtlänge	1520	mm
Gesamtgewicht	7500	kg
Spulengewicht (pro Spule)		kg

Dipolmagnet DORIS III



Power

Water cooling
flow needed

Weight

	Hauptspule	Korrekturspule	
Nennstrom	940	~17	A
Spulen (Anzahl, Querschnitt)	4 / 6000	4 / 140	mm ²
Leiterquerschnitt (Cu)	300 (21 x 16.5 ; ø 7.7)	10 (4.5 x 2.3)	mm ²
Windungszahl n/Spule	20	14	
Magnetwiderstand bei 50°C	15	350	mΩ
Induktivität			mH
Frequenz	DC	DC	
Max. Stromdichte	2.84	1.7	A/mm ²
Verlustleistung	13.2	0.1	kW
Anzahl der Kühlkreise	2		
Kühlwassermenge	5.6		l/min
Δt Kühlwasser	40		°C
Differenzdruck	3		bar
Prüfdruck der Spulen			bar
Prüfspannung der Spulen			kV (eff.)
Spulengewicht (pro Spule)	325	6.5	kg
Feld		1.4	T
Luftspalt		60	mm
Eisenlänge		1020	mm
Magnetlänge (eff.)		1071	mm
Gesamtlänge			mm
Gesamtgewicht		5200	kg

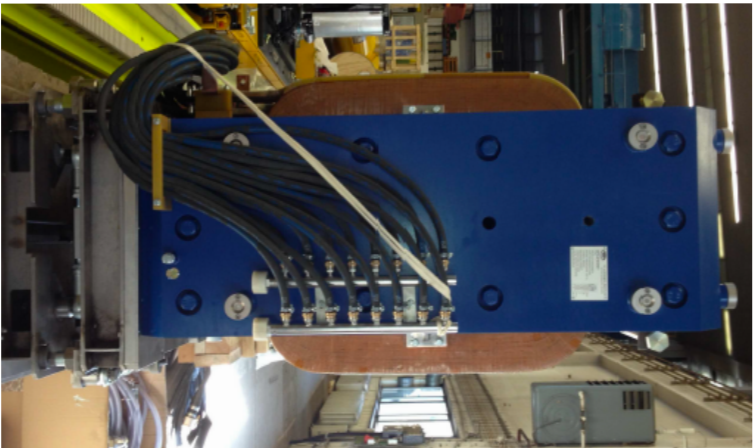
Why we can not use the MB (DORIS) magnets? It consumes too much power and cooling.

New TD20 line magnets

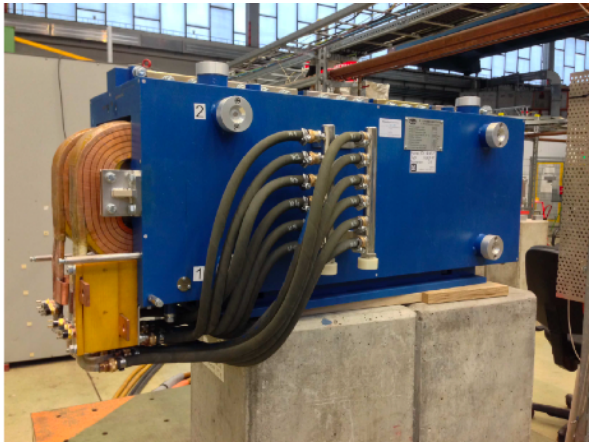
Type	Number
Dipole BD vertical	2
Dipole BD horizontal	9
Septum BZ short	4
Quadrupole QH	10
Corrector CHX	5
Corrector CHY	5

Magnet	Number	Power	Cooling	Tot Pow	Tot Cooling
XBZ	4	3kW	8.7l/min	12kW	35l/min
XBD	11	7.2kW	12.6l/min	80kW	139l/min
XQH	10	5.6kW	4.6l/min	56kW	46l/min
XCH	10	0.13kW	-	1.3kW	-
total	35	-	-	146 kW	220l/min

XBZ



XBD



XQH



XCH



TD20 line require ~150 kW and 220l/min of water.

Full XFEL is about 1.5MW total.

Technische Daten		
Nennstrom	1500	A
Spulen (Anzahl, Querschnitt)	2 / 4007	mm ²
Leiterquerschnitt (Cu)	57.25 (9 x 9 ; ø 5.5)	mm ²
Windungszahl n/Spule	70	
Magnetwiderstand bei 20°C	165	mΩ
Induktivität		mH
Frequenz	DC	
Max. Stromdichte	26.2	A/mm ²
Verlustleistung	400	kW
Anzahl der Kühlkreise	28	
Kühlwassermenge	146	l/min
Δt Kühlwasser	40	°C
Differenzdruck	9.0	bar
Prüfdruck der Spulen		bar
Prüfspannung der Spulen		kV (eff.)
Feld	2.24	T
Luftspalt	108	mm
Eisenlänge	1080	mm
Magnetlänge (eff.)	1029	mm
Gesamtlänge	1520	mm
Gesamtgewicht	7500	kg
Spulengewicht (pro Spule)		kg