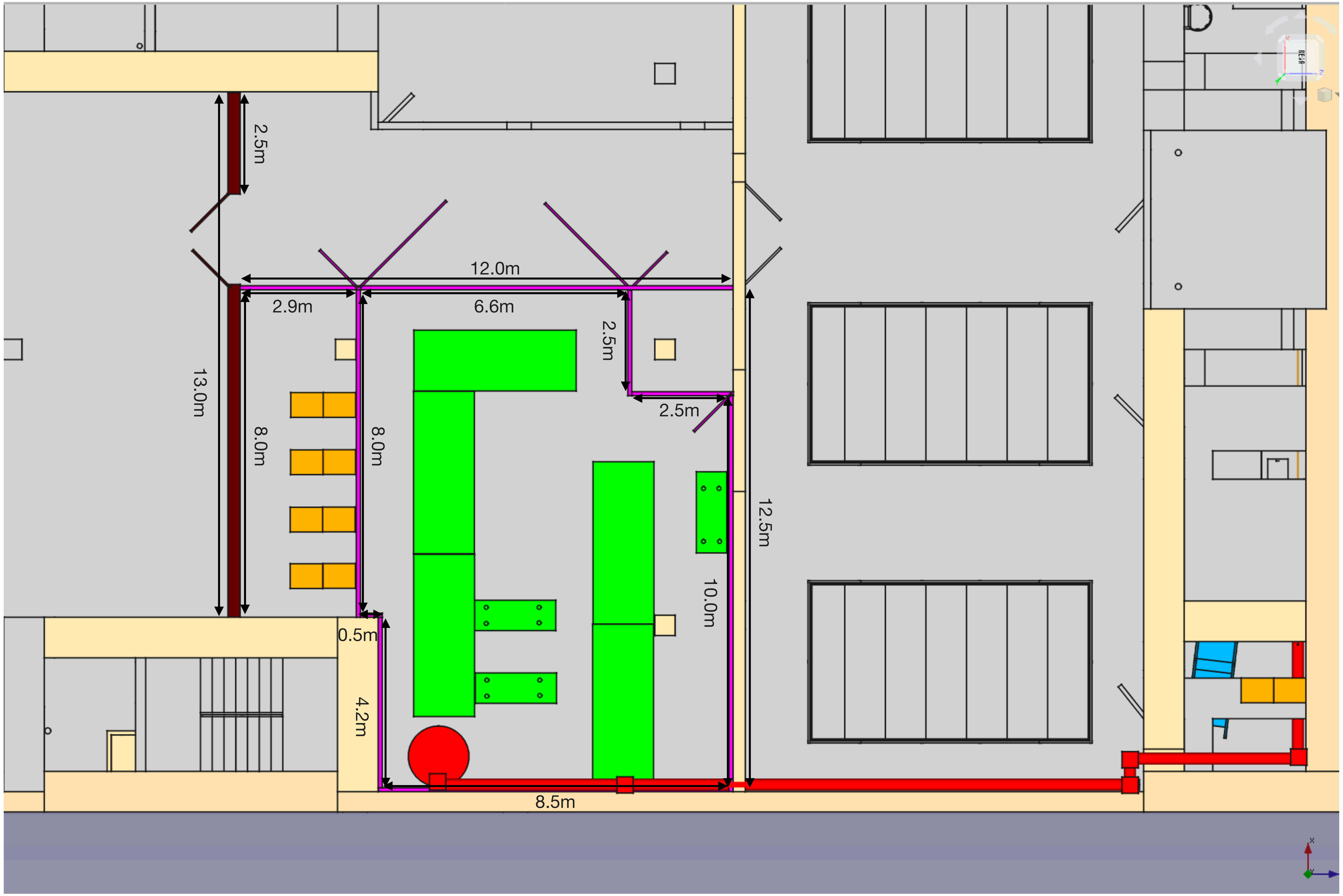
DIFFERENT TOPICS (CLEAN ROOM, MAGNETS, POWER CONSUMPTION)

LOUIS HELARY - DESY

12/11/2020

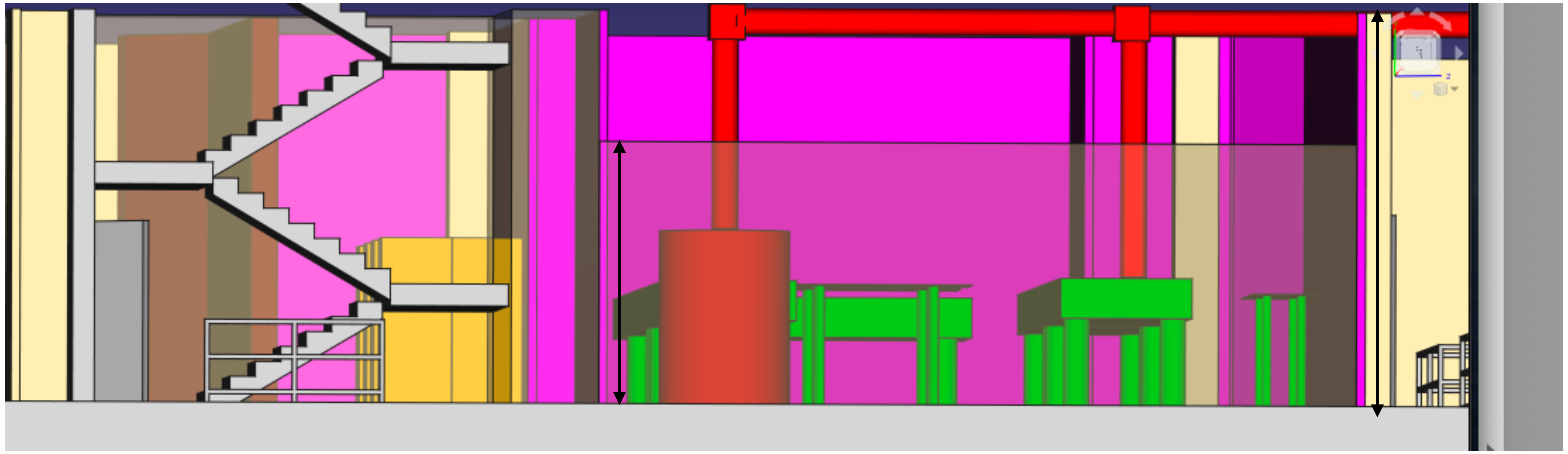
Laser clean room update


Fire resistant wall
and doors
(REI90 rating)
Laser service room
Equipment entrance to clean room
Entrance to changing room
Isolation panels rating
A1 (non flammable) or
B1 (difficult to ignit)
XFEL magnets
HVPS
Entrance to clean room
Detector service room



2.5m
12.0m
2.9m
6.6m
2.5m
13.0m
8.0m
8.0m
2.5m
12.5m
10.0m
0.5m
4.2m
8.5m

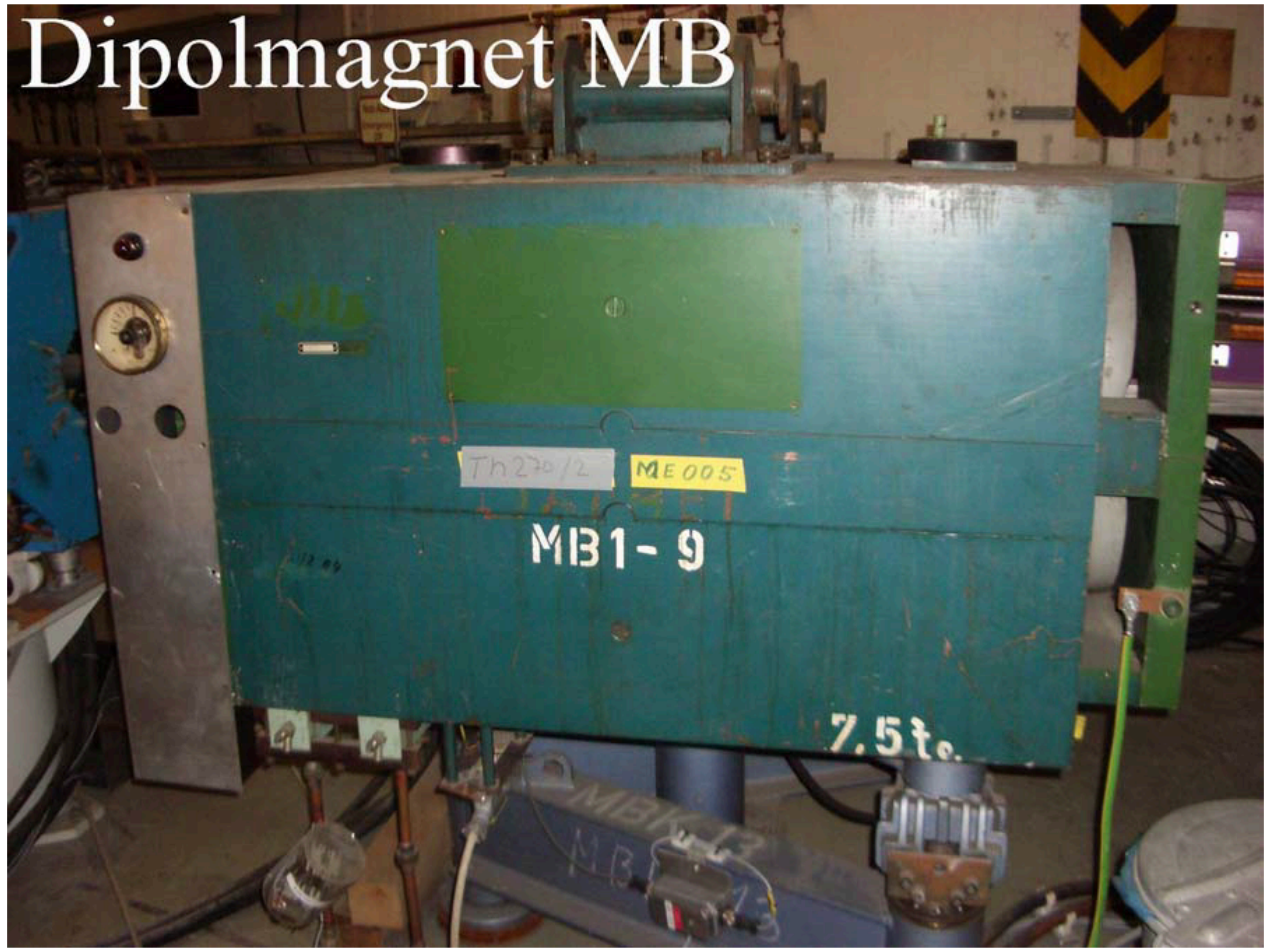
Total floor height is 4.5m



Clean room height 3m

Magnets

Why we can not use the MB (DORIS) magnets?



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
Power	Verlustleistung	400	kW
	Anzahl der Kühlkreise	28	
Water cooling flow needed	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
Weight	Gesamtgewicht	7500	kg
	Spulengewicht (pro Spule)		kg

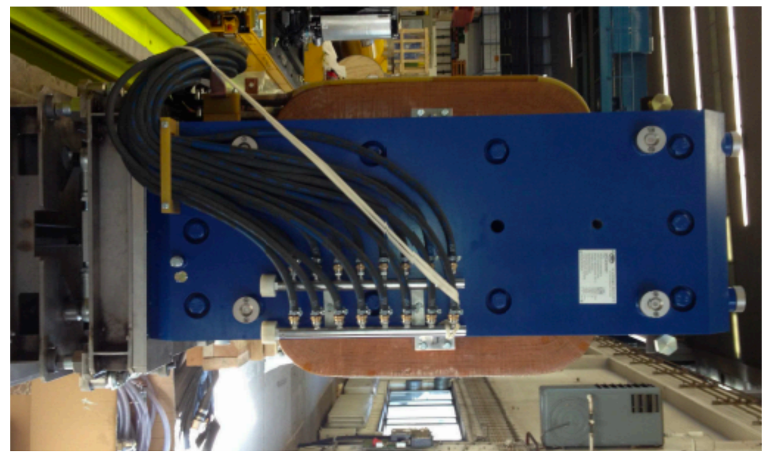
Why we can not use the MB (DORIS) magnets? It consumes too much power and cooling.

New TD20 line magnets

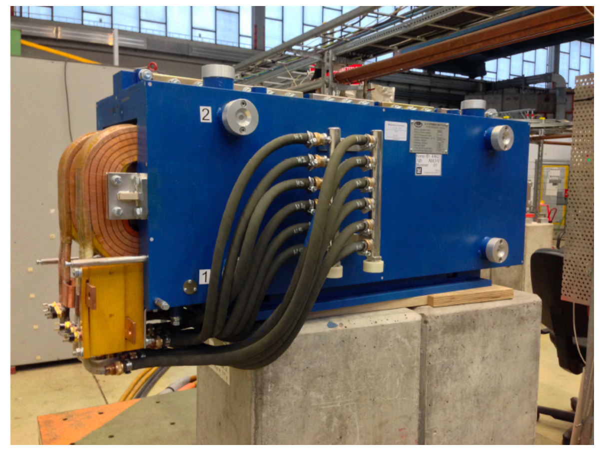
Type	Number
Dipole BD vertical	2
Dipole BD horizontal	9
Septum BZ short	4
Quadrupole QH	10
Corrector CHX	5
Corrector CHY	5

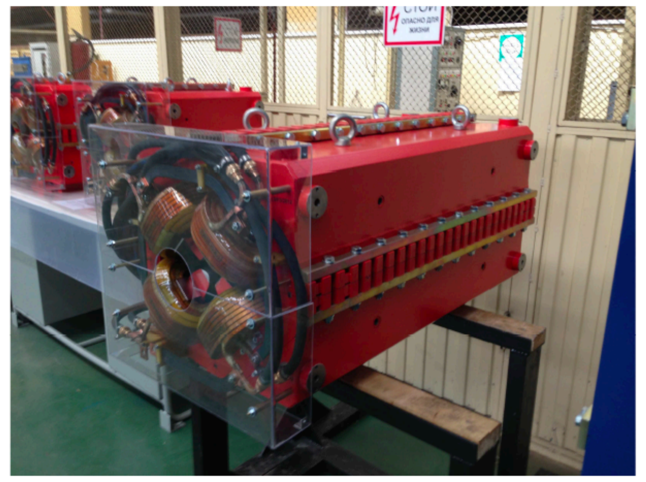
Magnet	Number	Power	Cooling	Tot Pow	Tot Cooling
XBZ	4	3kW	8.7l/min	12kW	35l/min
XBD	11	7.2kW	12.6l/min	80kW	139l/min
XQH	10	5.6kW	4.6l/min	56kW	46l/min
XCH	10	0.13kW	-	1.3kW	-

XBZ



XBD





XQH

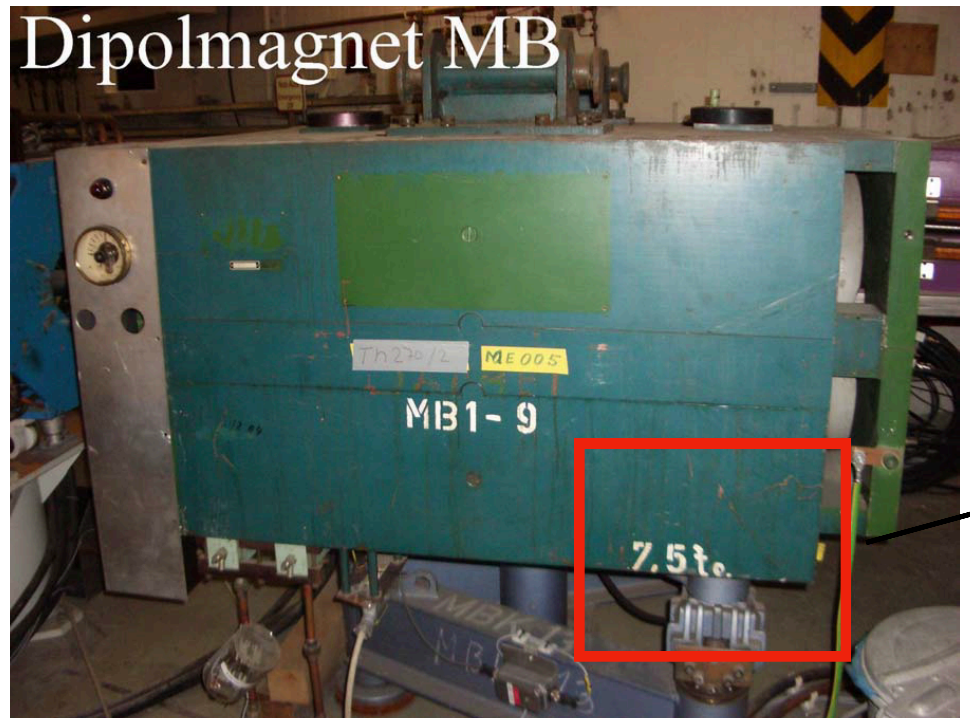
XCH

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

Why we can not use the MB (DORIS) magnets? It's too heavy…



(9.88*7500)/(0.883*1.540)=53KN/m2

50 kN/m²
20 kN/m²
10 kN/m²
5,0 kN/m²

What about the blue (DORIS 3) magnet?

Technische Daten			
	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

There were 3 in storage, 1 was reserved for flash forward and another one was damaged.

Refurbishment of an old magnet allow to save the price of the iron yoke roughly.

Buying a new magnet?

- MEA strongly advised to design magnet according to our needs.
- Once filled following sheet, they will submit it to different companies.
- Need to think about power consumption, as it impact the power converter we need to buy ($$$).
- Buying multiple time the same magnet allow to save 1/3 of price for 2nd, 3rd…
- The magnets are always only thought for a single field value.
  - If we need more than 1 field this as to be specified, and we need to understand what value is the most important.
- Simulation can be done (there is a specialist in DESY for that), however MEA said that measurements are much more precise, they only rely on them.
- Magnet come naked from company (1-1.5 year time scale).
- Need to buy power supply, installation is done by MKK.
- Initial estimate for 3 2T dipole was 200k, with an extra 50k for power supply.
- After discussion with Matthew thought that this might be underestimated 350k for 3 2T dipole, with 150k for power supplies.
- We should try to decide what we need for the following parameters.

Parameter	Specification
Nominal magnetic field	xx T
Air gap	xx mm
Magnetic field quality	<1 e-3
Integrated magnetic field	xx T.m
Bending angle	xx°
Good field region (HxW)	xx mm * yy mm (wrt air gap)
Distance from Yoke in beam direction that field drops to 0T	< xx mm
Nominal current	xx A
Nominal voltage	< xx V
Water pressure Drop	xx bar
Water temperature rise	< xx°
Maximum geometric size LxW	xx mm * yy mm

From John slides

R = E / Bc

(Energy in eV)

The incidence of these particles on a detector plane orthogonal to a beampipe is described by this equation:

$$x = R(1 - cos(sin^{-1}(\frac{z_m}{R}))) + tan(sin^{-1}(\frac{z_m}{R}))z_d$$

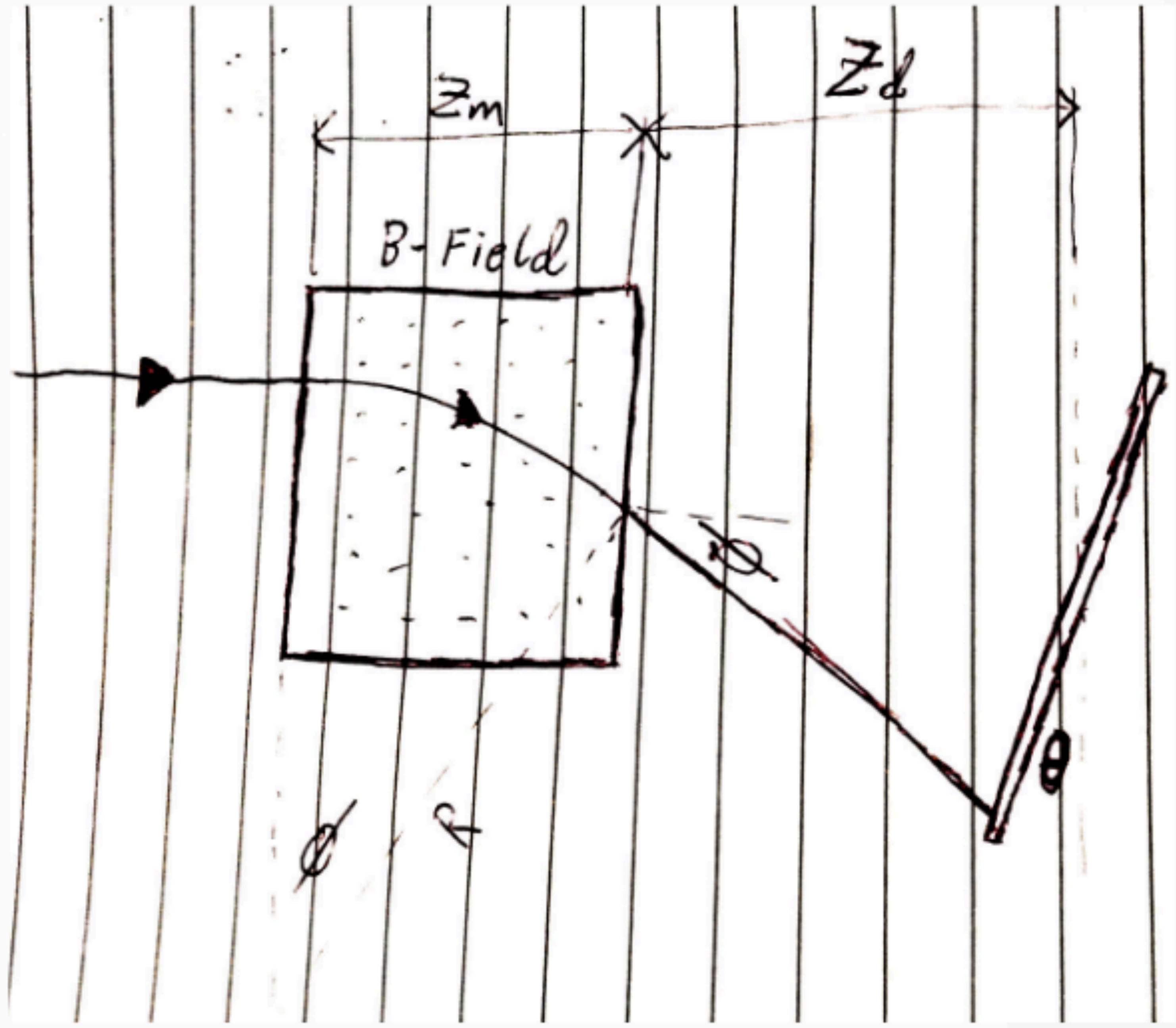
We also must create a provision to account for the possible rotation of the detector in the Y axis by an angle of θ. Separating the components of the final x value into x_1, x_2 and x_3, we sum them to obtain the 'global' x-value of the hit.

$$x_1 = R(1 - cos(\phi))$$

$$x_2 = tan(\phi)z_d$$

$$x_3 = \frac{tan(\theta)tan(\phi)(x_{detector} - x_1 - x_2)}{1 + tan(\theta)tan(\phi)}$$

Where $\phi = sin^{-1}(\frac{z_m}{R})$. From there mapping to the detector's 'local' x coordinates is elementary: $x_{local} = x_{global} - x_{detector}/cos(\theta)$



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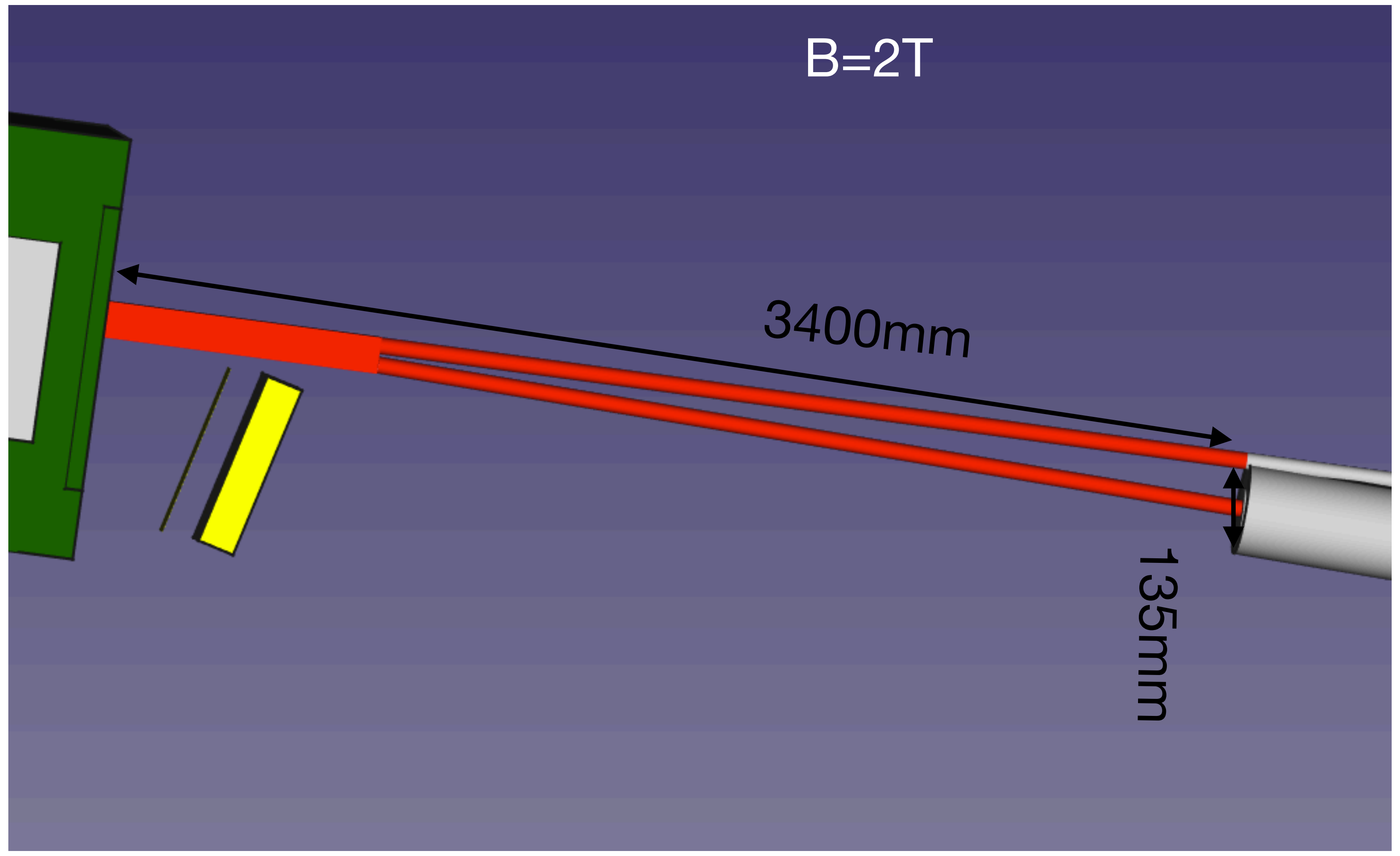
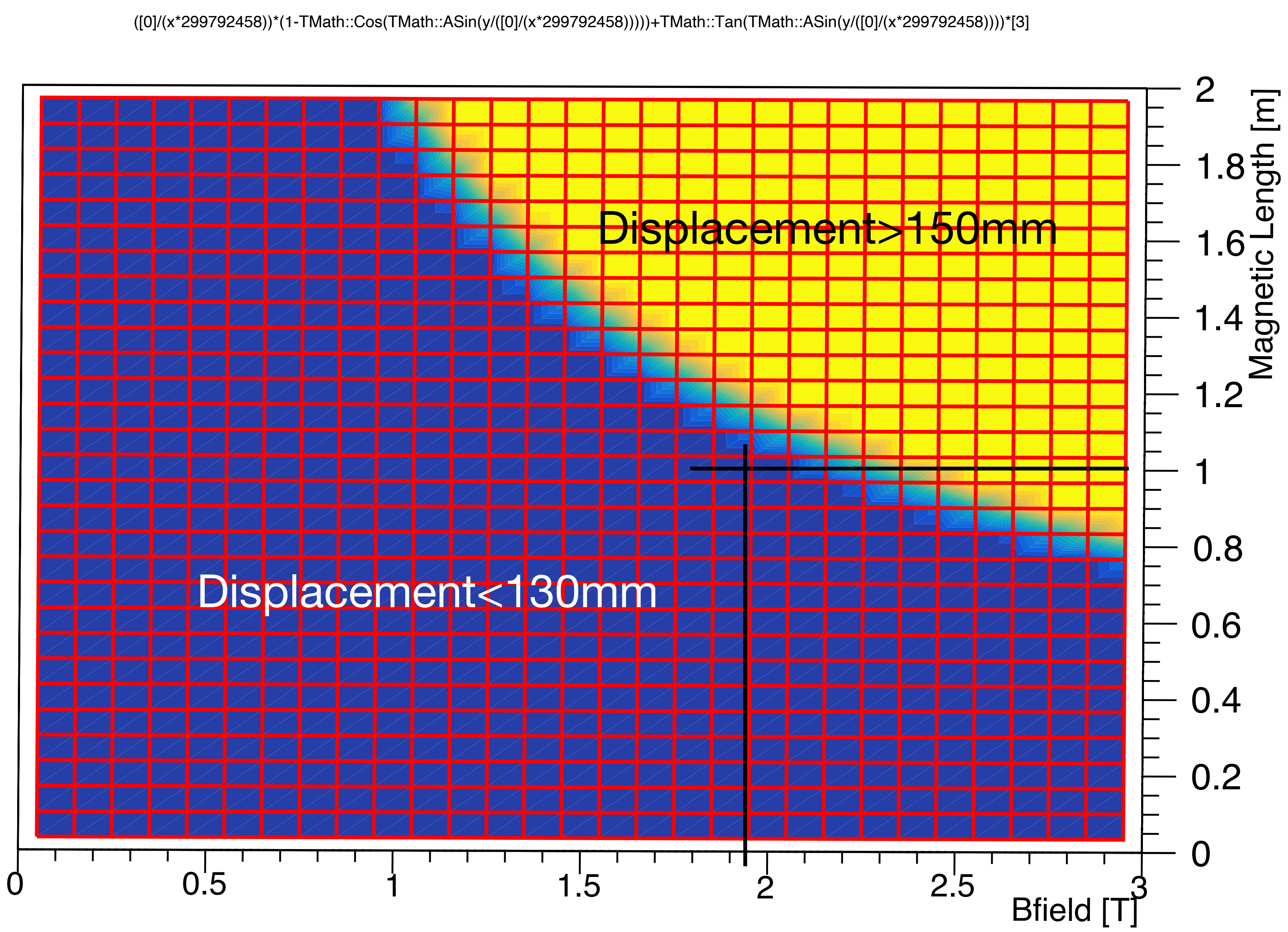
Use this formula to emulate magnet behavior

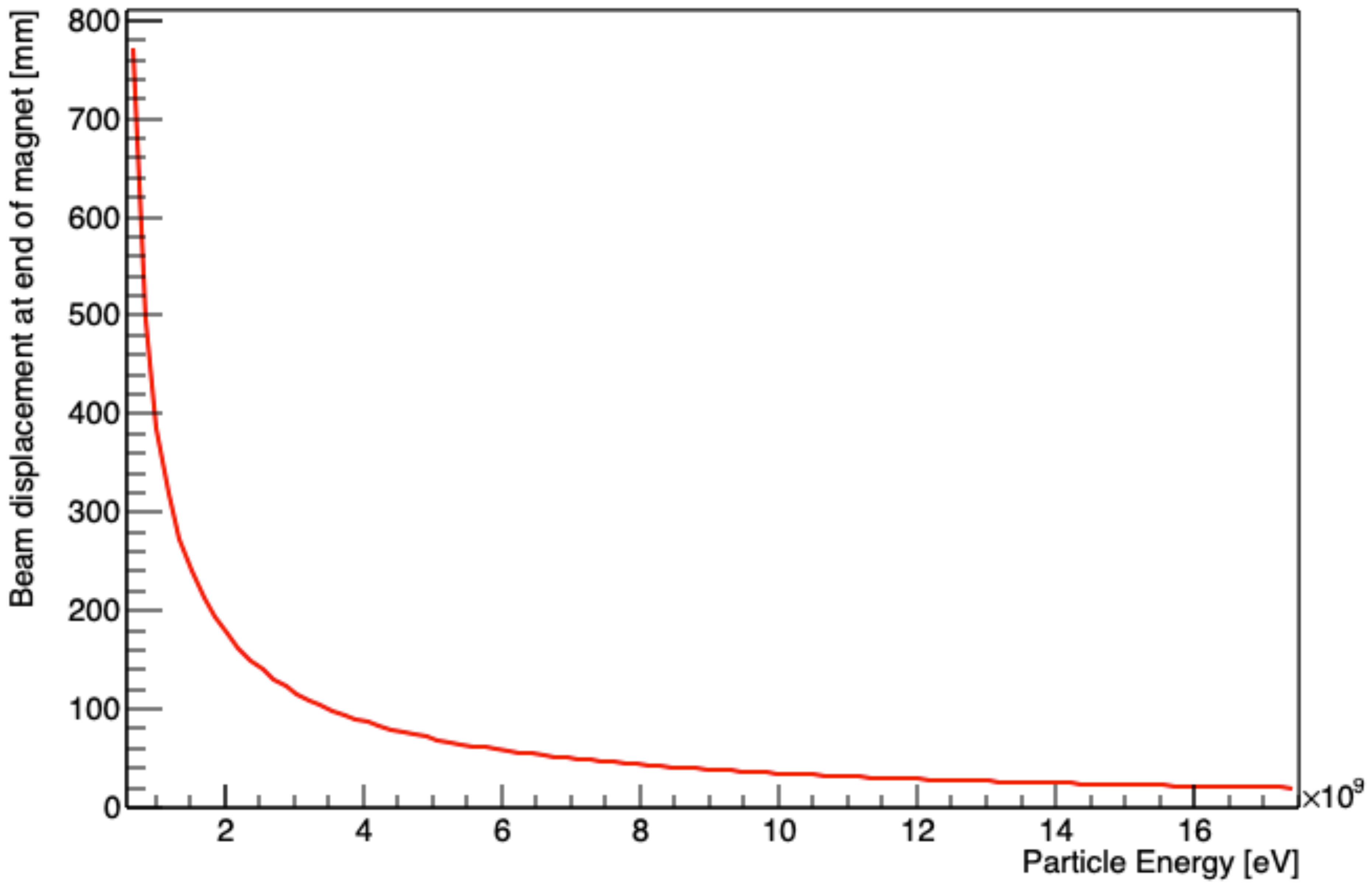
Brehm magnet



Field	2.0T
Magnetic length	1080 mm
Distance to dump	3400mm
Displacement of 16.5 GeV beam to dump	135mm

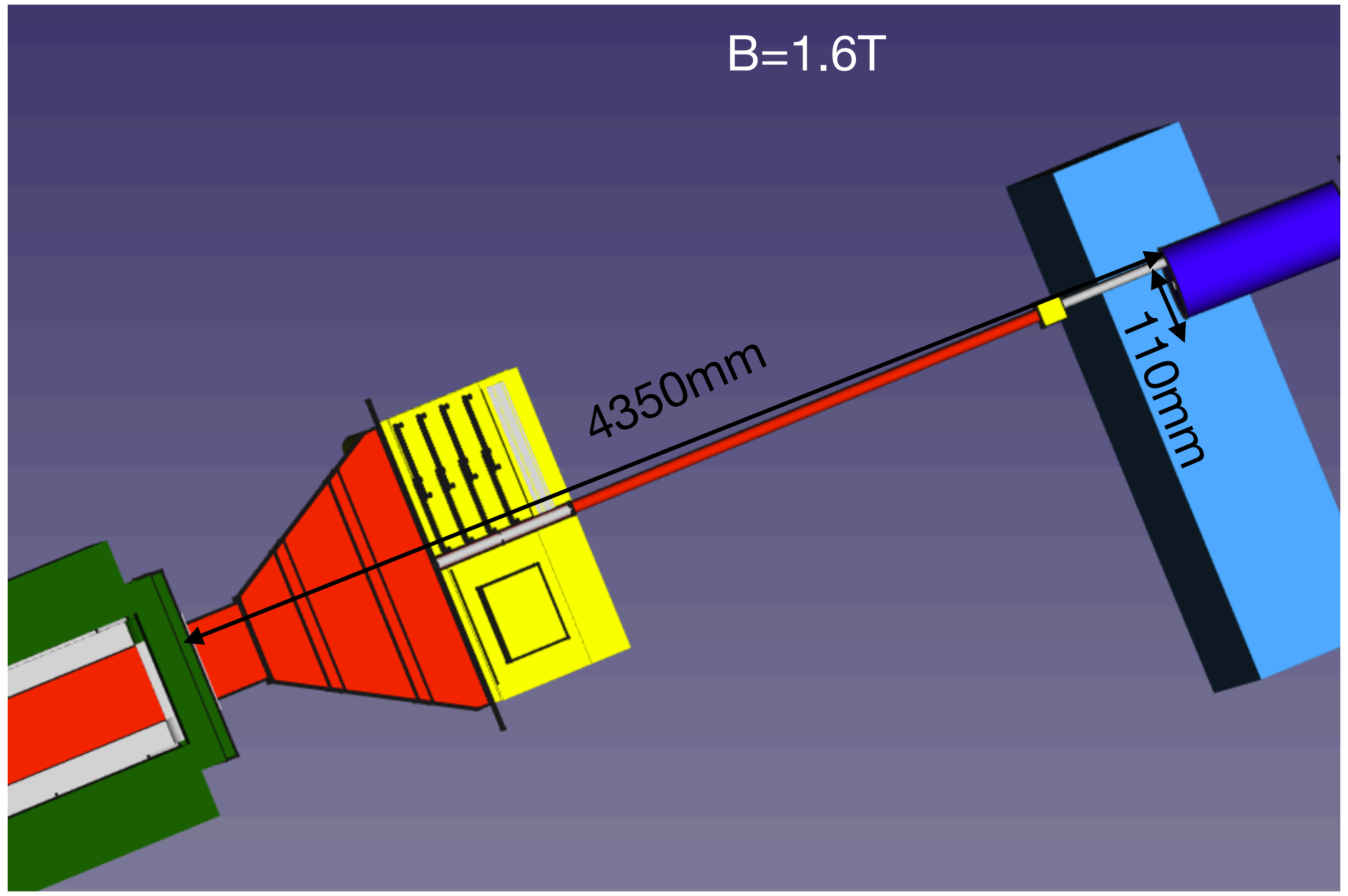


Fixing distance to dump

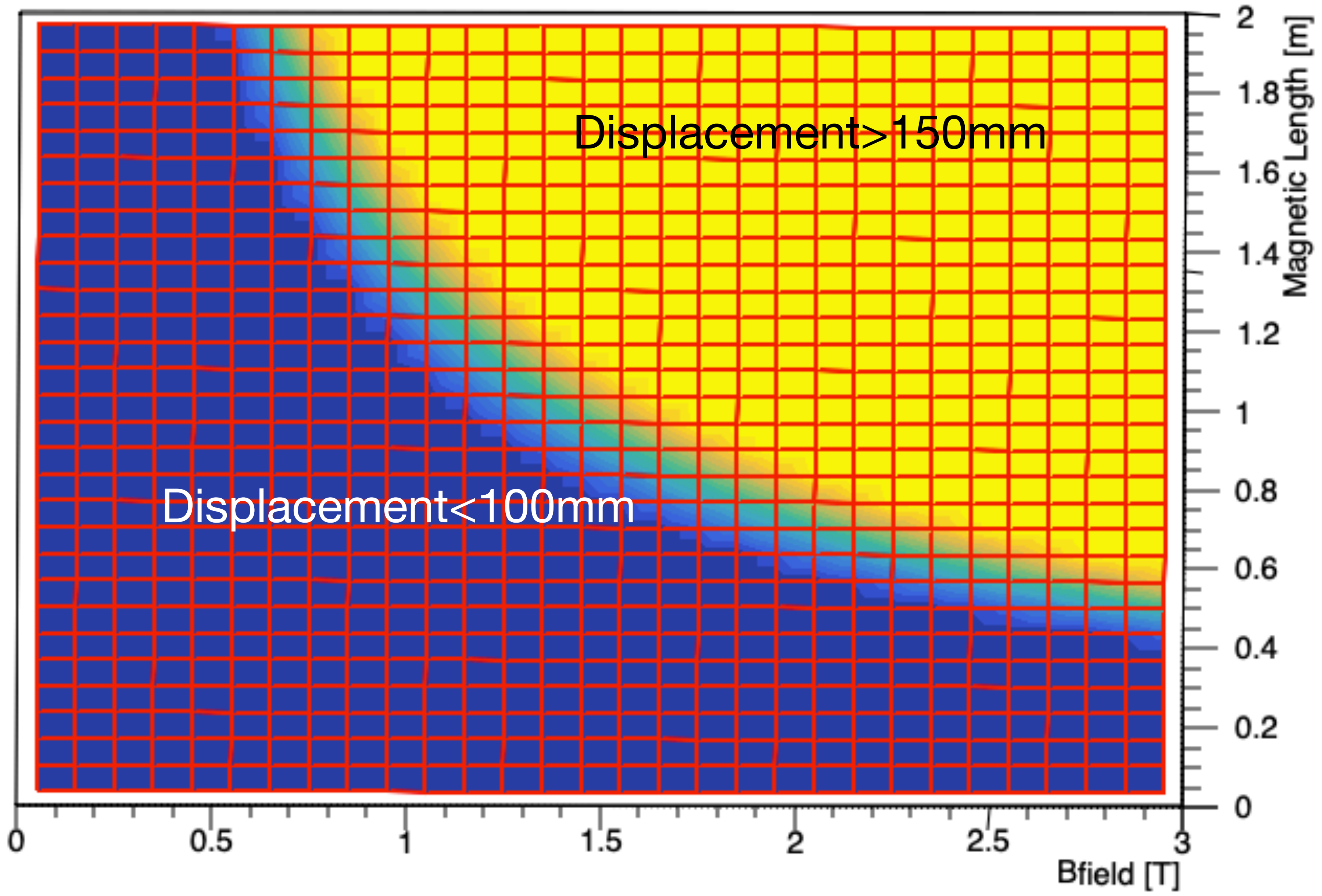


Beam displacement after magnetic length (emulate magnet aperture)

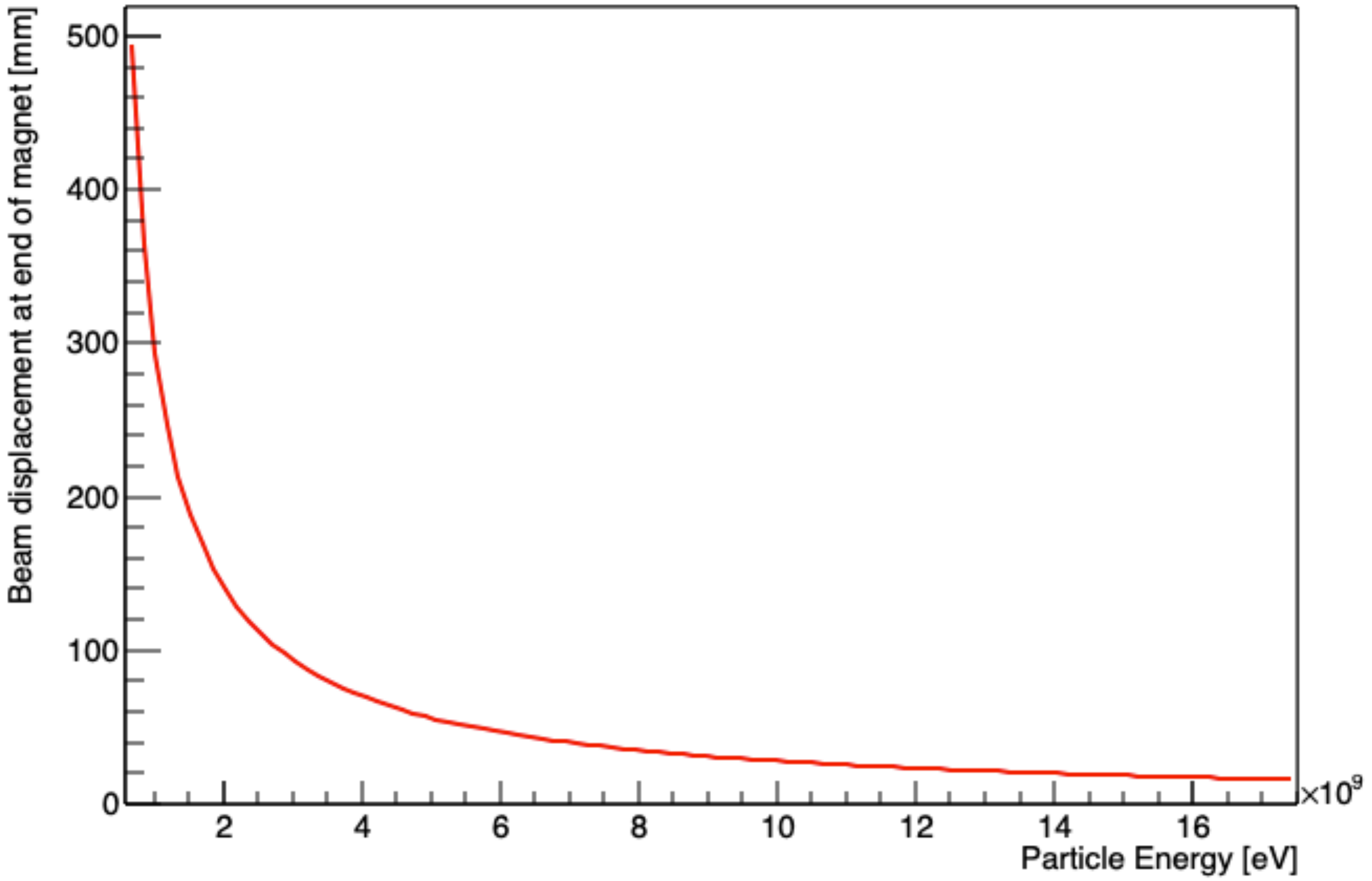
IP magnet



Field	1.6T
Magnetic length	1080 mm
Distance to dump	4350mm
Displacement of 16.5 GeV beam to dump	110mm

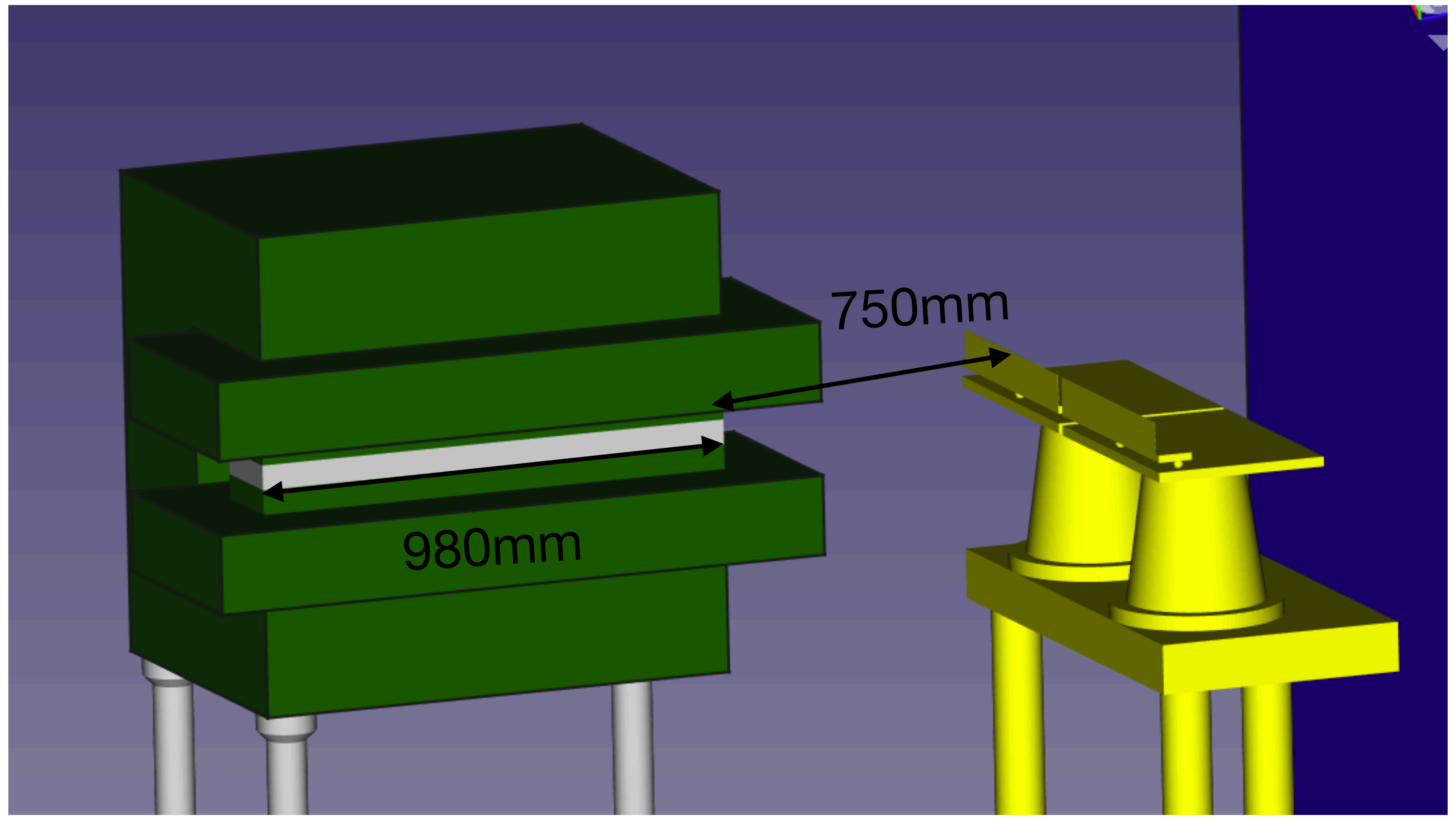


Fixing distance to dump



Beam displacement after magnetic length (emulate magnet aperture)

Forward magnet

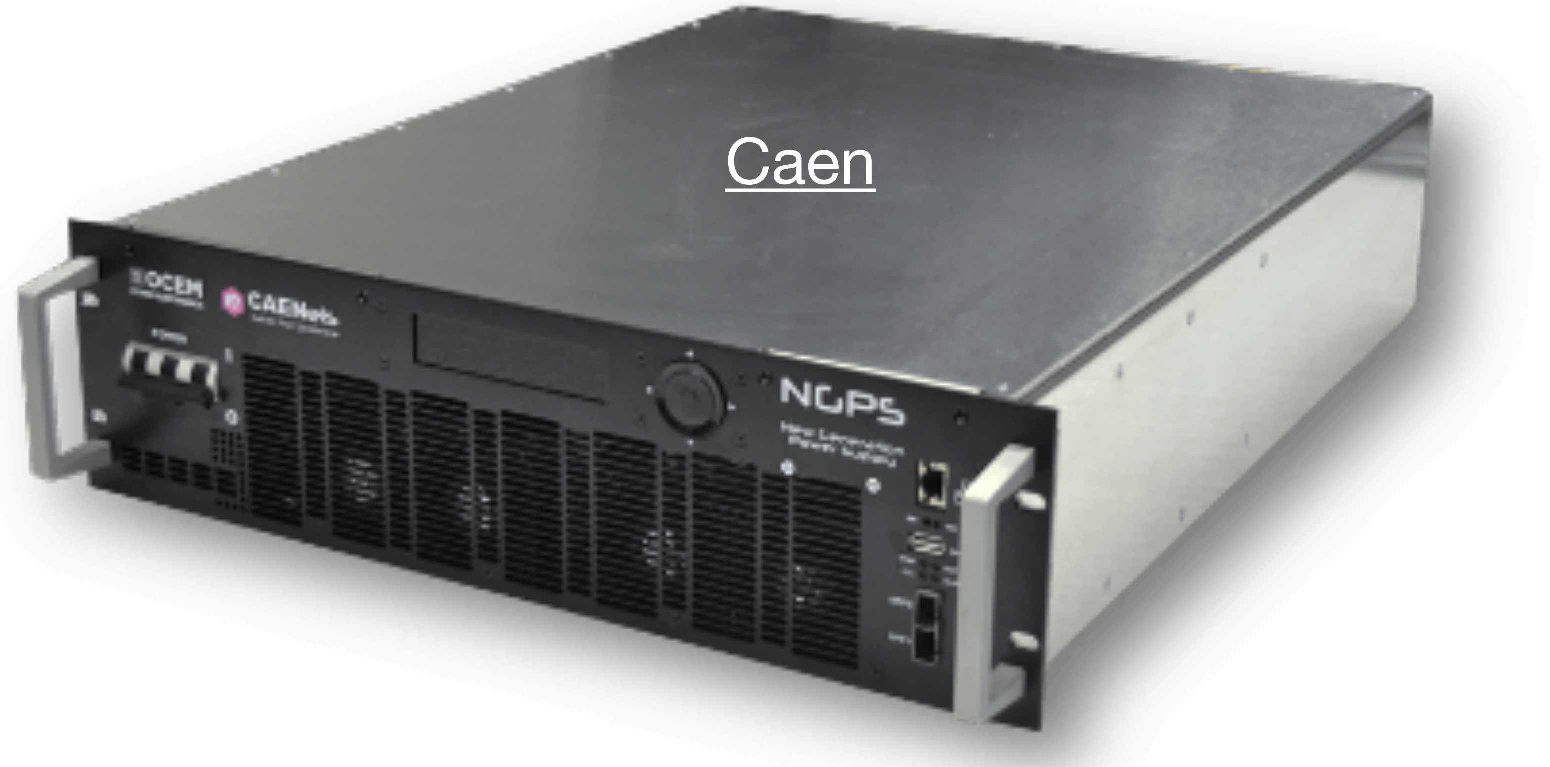


Field	1.4T
Magnetic length	980 mm
Distance to screen	750mm

Power supplies

DeltaElectronics

TDK



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I have asked quotes for power supplies to the these companies.

The characteristics of the magnets we need to feed are:
*Magnet 1 (2T),   Intensity nominal= 464A, Resistance=0.079 ohm, max voltage: 40V, max intensity: 500A, max power: 20kW.
*Magnet 2 (1.6T), Intensity nominal =372A, Resistance=0.2 ohm   , max voltage: 80V, max intensity: 400A, max power: 30 kW.
*Magnet 3 (1.4T), Intensity nominal=940 A, Resistance=0.015 ohm, max voltage: 15V, max intensity: 1000A, max power: 15kW.

The magnets will be in operation for about 10 months per year, 7 days a week, 24h a day for about 10 years. And we will probably turn them off and on once a month.

Each magnet will function at nominal amperage all the time once it has been ramped. Each power converter needs to be high precision with high accuracy, and tracking capabilities. And we need to be able to operate it remotely with a regular ethernet interface. I need to understand if multiple power supplies could work in parallel to feed a single magnet, and if it is possible to easily switch its polarity? Could you tell me what are the precision on the intensity? And what is the stability of the this number over time? Are your power supply also coming with a diode protection circuit to avoid damaging the magnets?

The power converters can be cooled with air or water, and they will be racked in electrical cabinets.

Power consumption

Power consumption

	Phase 1	Phase 2
Clean room klima	10	10
Laser frontend	5	5
Laser power amplifier+pump	25	50
Laser pulse compressor	3	5
Laser additional flow box	5	5
Laser computers, owis controller, etc..	5	5
Laser beam-line (pumps)	2	2
IP Box (pumps)	1	1
Target chamber (pumps)	0	1
Electron beam-line (pumps)	2	2
Detector front end electronic	30	30
Tracker chiller	1	1
Magnet power supplies	60	60
Magnet vacuum chamber pump	1	1
Total in kW	150	178
Magnets for TD20 lines	146kW	

Main Change from Phase 1 to Phase 2
- Laser upgrade (~27kW).
- Addition of a pump for Brehm target chamber (1kW).

Rough estimate for detectors
(took the total power consumption of 3 server shelves full, and at full occupancy).

Decided to limit magnet consumption at 20kW per magnet.

Sent a mail to MKK to understand if there is enough resources for these sort of power in XS1.

Time needed to reach vacuum in the different elements (from Rajendra)

rough vacuum (<1mbar)							
parts	volume (in l)	volume to be evacuated(m3)	scroll pump speed (m3/h)	scroll pump speed (m3/s)	initial vac (mbar)	final vac (mbar)	Pump time (min)
Laser beamline(IP)	5025	5.025	20	0.005555	1000	0.1	138.8458811
Laser beamline(ics)	130	0.13	20	0.00555	1000	0.1	3.592032745
IP	1626	1.626	20	0.00555	1000	0.1	44.92804033
target chamber	343	0.343	20	0.005555	1000	0.1	9.477440242
magnet vacuum chamber	128	0.128	20	0.00555	1000	0.1	3.536770702
ele beamline	131	0.131	20	0.00555	1000	0.1	3.619663766

high vacuum(<10^{-4} mbar)						
parts	Volume (in l)	turbo speed (l/s)	turbo speed (m3/s)	initial vac (mbar)	final vac (mbar)	Pump time(min)
Laser beamline(IP)	5025	2100	2.1	0.1	1E-06	0.459146432233932
Laser beamline(ics)	130	2100	2.1	0.1	1.00E-06	0.011878415162271
IP	1626	2100	2.1	0.1	1E-06	0.148571561952711
target chamber	343	2100	2.1	0.1	1.00E-06	0.03134074154353
magnet vacuum chamber	128	2100	2.1	0.1	1E-06	0.011695670313621
ele beamline	131	2100	2.1	0.1	1.00E-06	0.011969787586596

- Rough vacuum takes most time to reach.
- IP box with a single turbo pump takes about ~1h.
  - Might be a problem in real life commissioning.
- Laser beamline is also long, but can be isolated.