Flux Concentrator Design Study for the ILC Conventional e+ Source

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ILC-CLIC e+ studies

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Length of electron beam mini-train is ~ 1 μs (flat current pulse part)

Peak of magnetic field is 5 Tesla

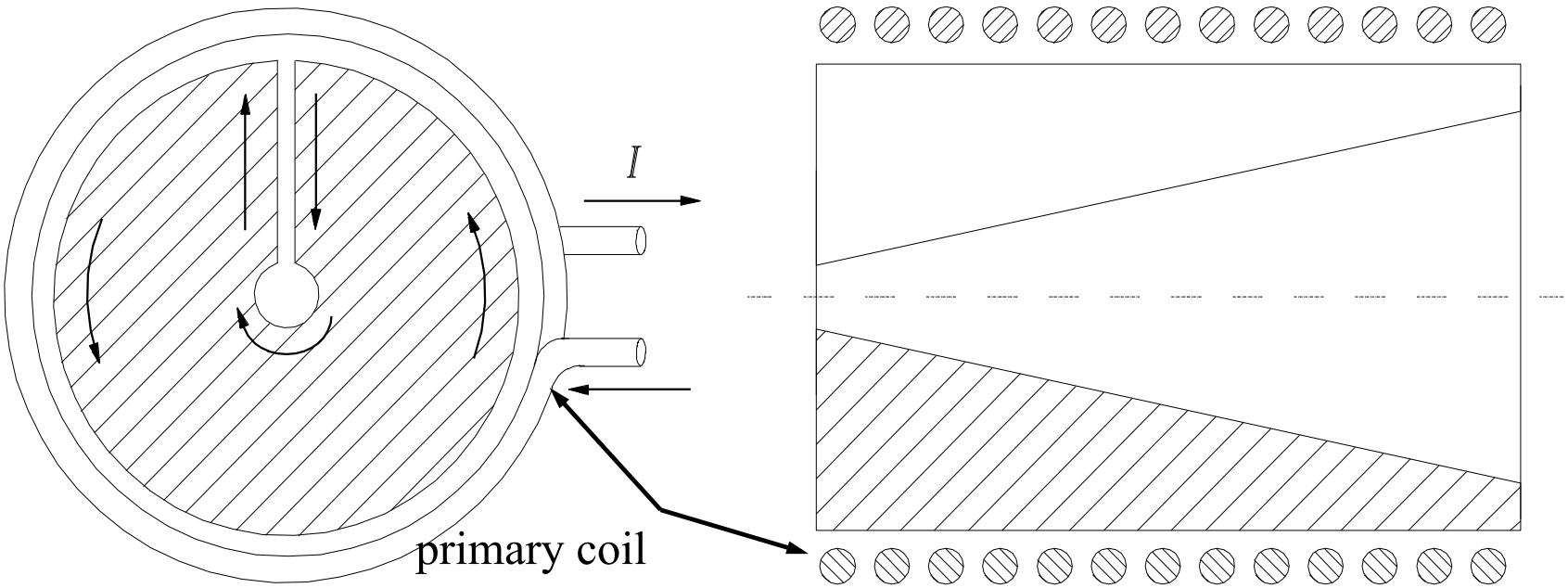
Electron beam size on a target σ is 4 mm
(to provide of target surviving limit PEDD of 35 J/g)

AMD device front aperture is 20 mm

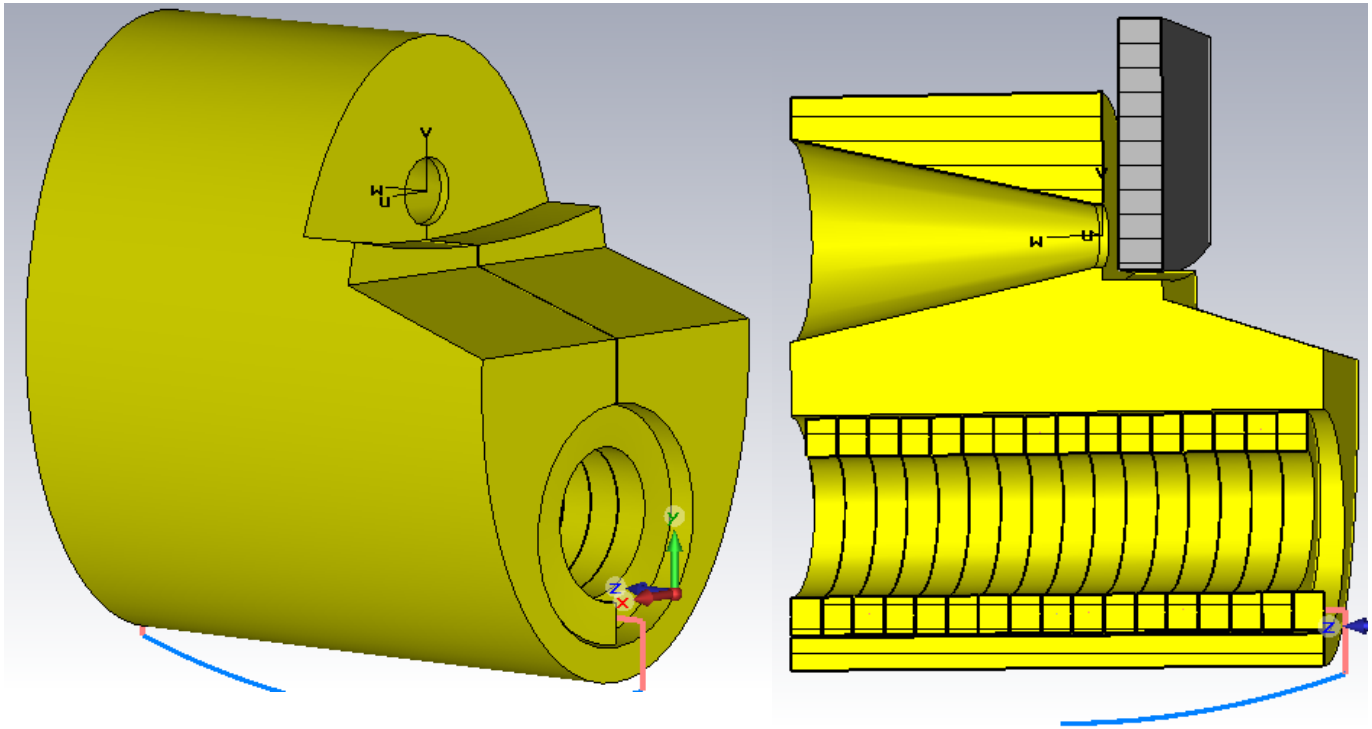
Flux Concentrator should be used as AMD

- classical flux concentrator
- spiral flux concentrator
- singe-turn flux concentrator

Classical Flux Concentrator

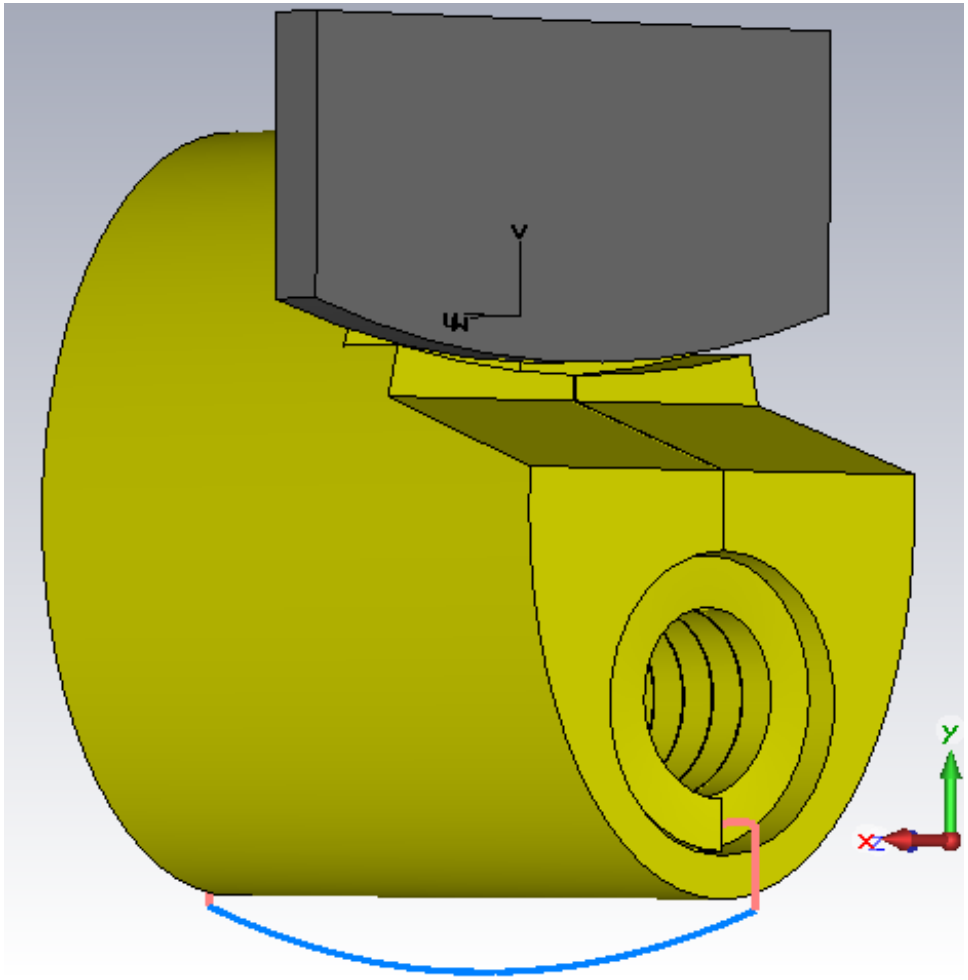


Peak magnetic field and Tapering field parameter are defined by a diameter value of a small hole and angle of conical cavity.



Size	Elliptical cylinder 120x180 mm
Total length	170 mm
Conical part length	100 mm
Min cone diameter	20 mm
Max cone diameter	63 mm
Cone angle	24 degrees
Turns number	16 (9,6x12 mm)
Cylindrical hole diameter	70 mm

FC Computer model with part of positron production target



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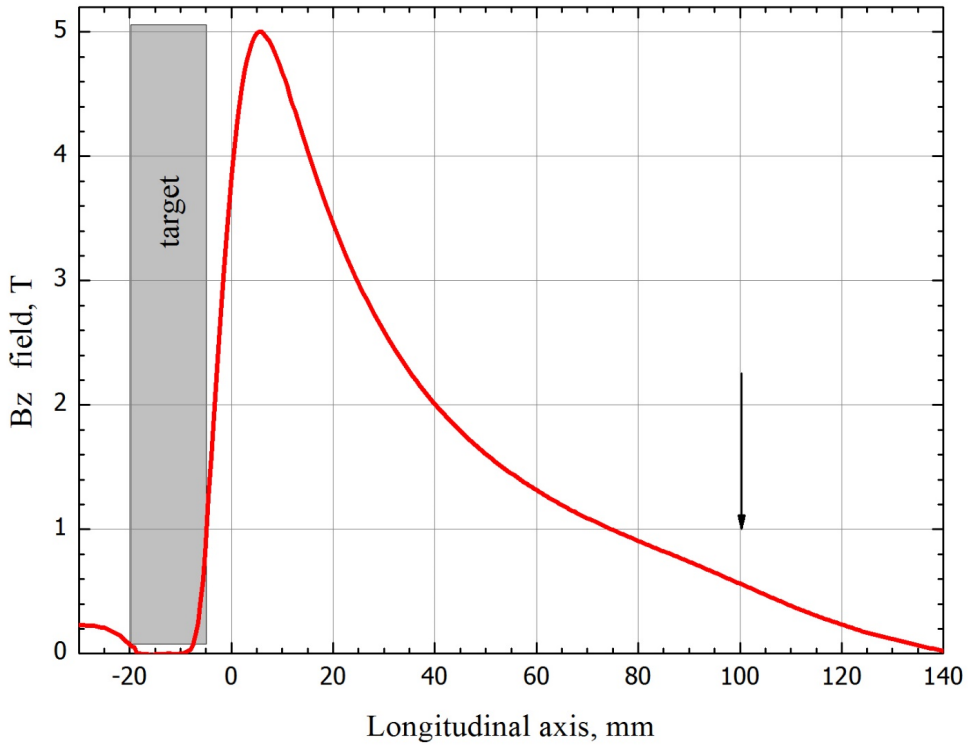
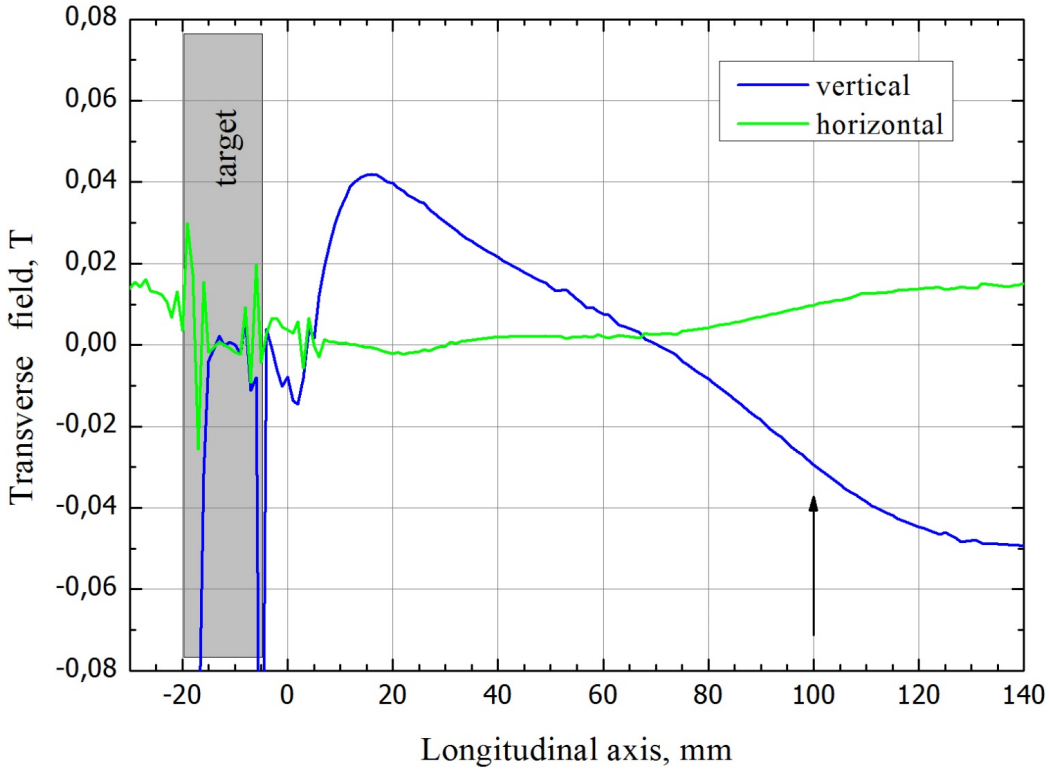
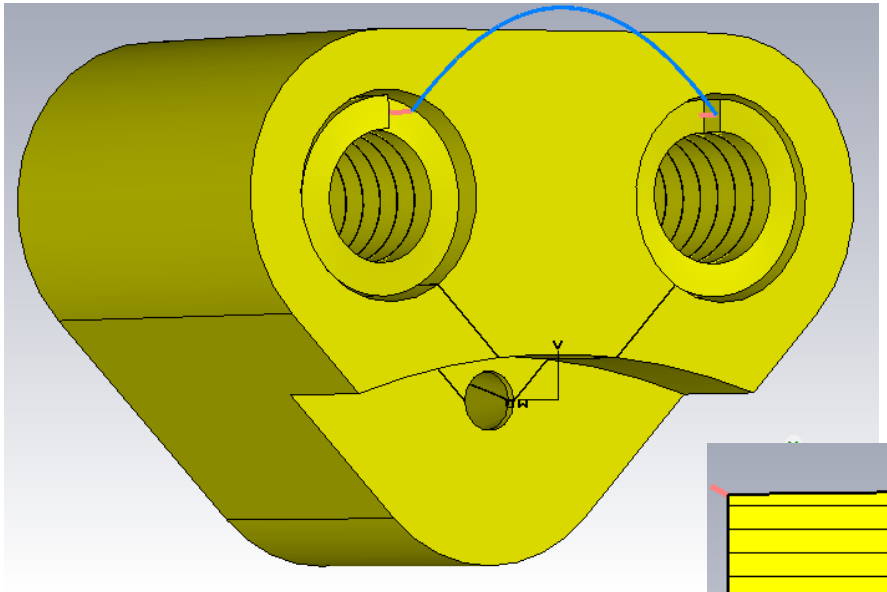


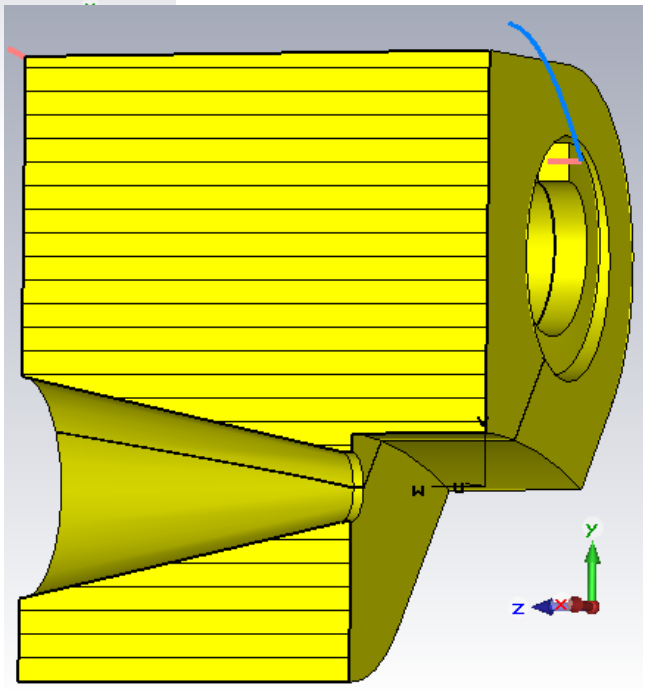
Longitudinal magnetic field component
on a longitudinal (top)

Peak current 34 kA
Pulse length 25 μs
Target ohmic losses 24 J/pulse
FC ohmic losses 245 J/pulse

Transverse magnetic field components
on a longitudinal axis of
Flux Concentrator (bottom)
Peak vertical component value is about 43 mTesla



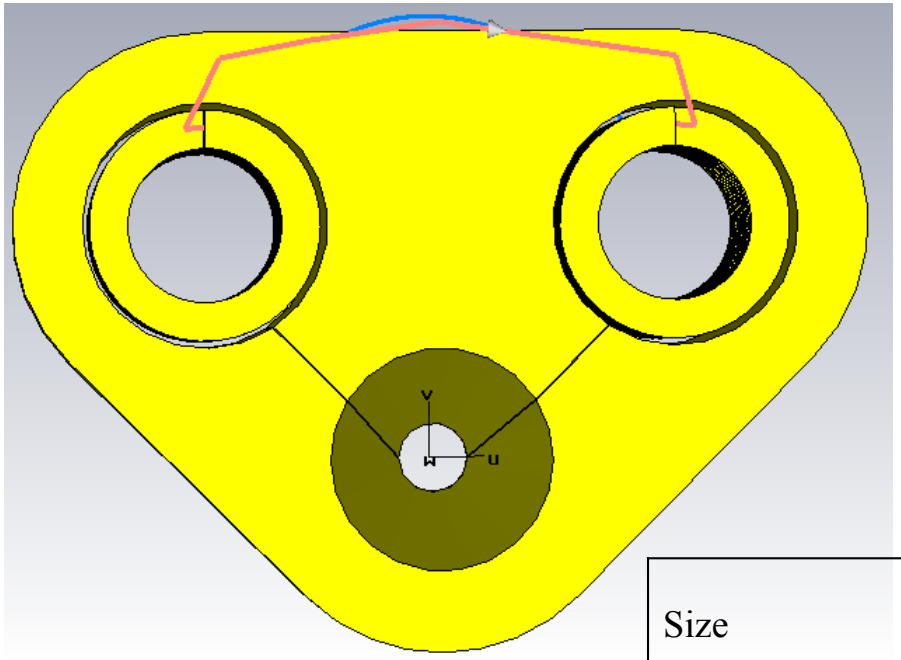


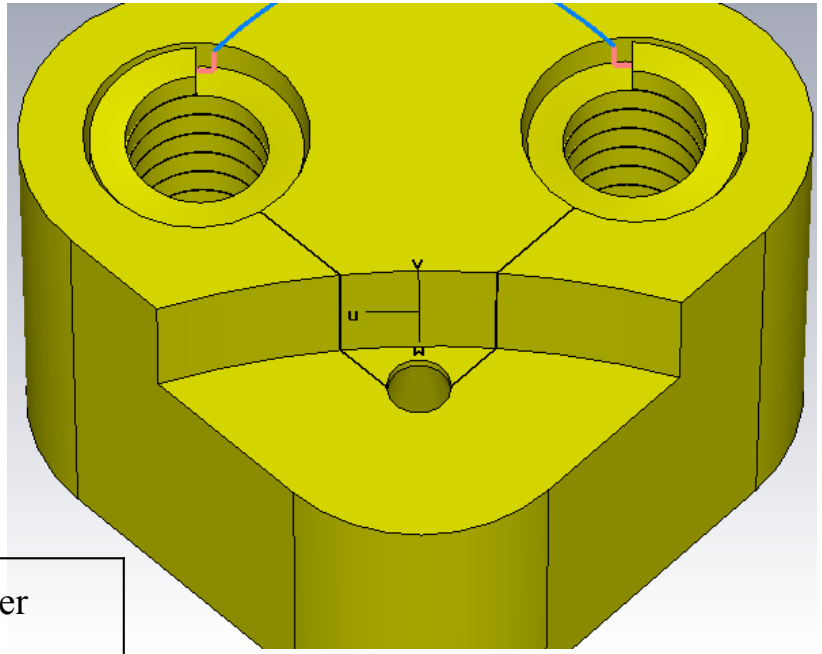


Size	190x122 mm (w x h)
Total length	140 mm
Cone length	100 mm
Min cone diameter	20 mm
Max cone diameter	64 mm
Cone angle	25 degrees
Number of turns	13x2 (9,6x12 mm)
Cylindrical hole diameter	70 mm

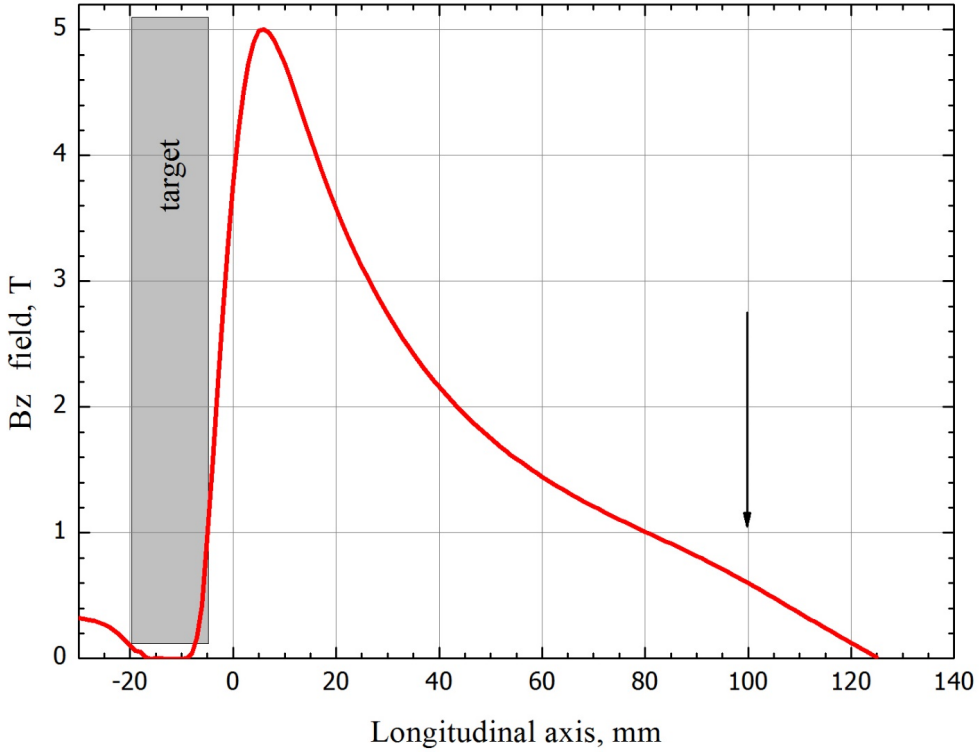
Pseudo symmetrical geometry from eddy current topology point of view

FC with 2 primary hole





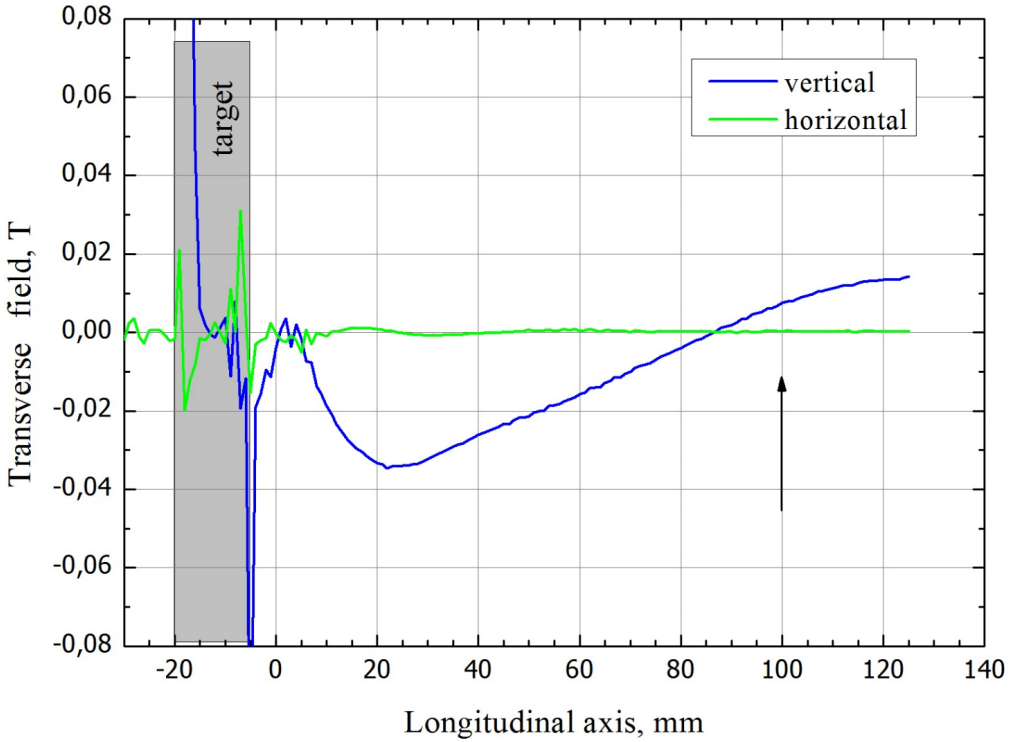
Size	Elliptic cylinder 120x240 mm
Length	140 mm
Min cone diameter	20 mm
Max cone diameter	64 mm
Cone starting angle	54 degrees
Number of turns	13x2 (9.6x12 mm)
Cylindrical hole diameter	75 mm

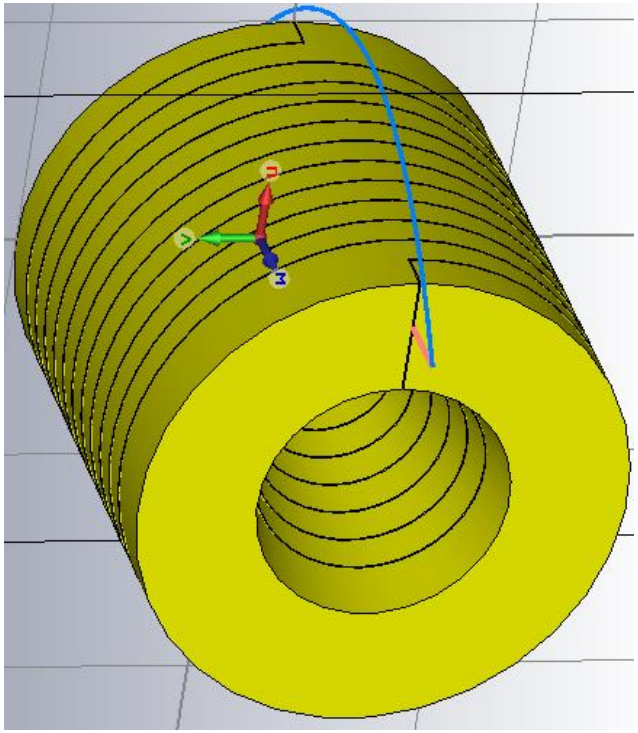


Longitudinal magnetic field component on a longitudinal axis of 2 primary hole Flux Concentrator (top)

Peak current 39 kA
Pulse length 25 μs
Target ohmic losses 27 J/pulse
FC ohmic losses 530 J/pulse

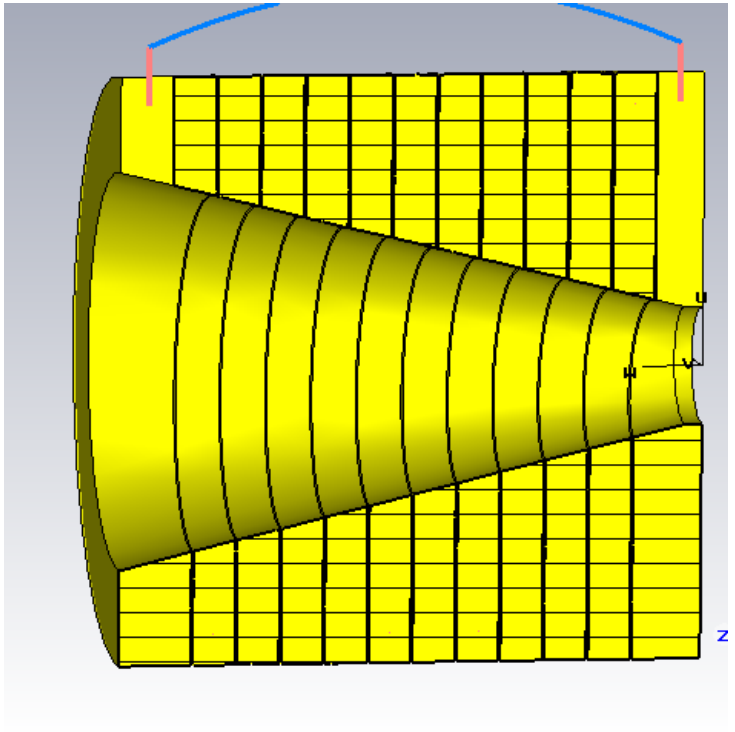
Transverse magnetic field components on a longitudinal axis of 2 primary hole Flux Concentrator (bottom)
Peak vertical component value is about 31 mTesla



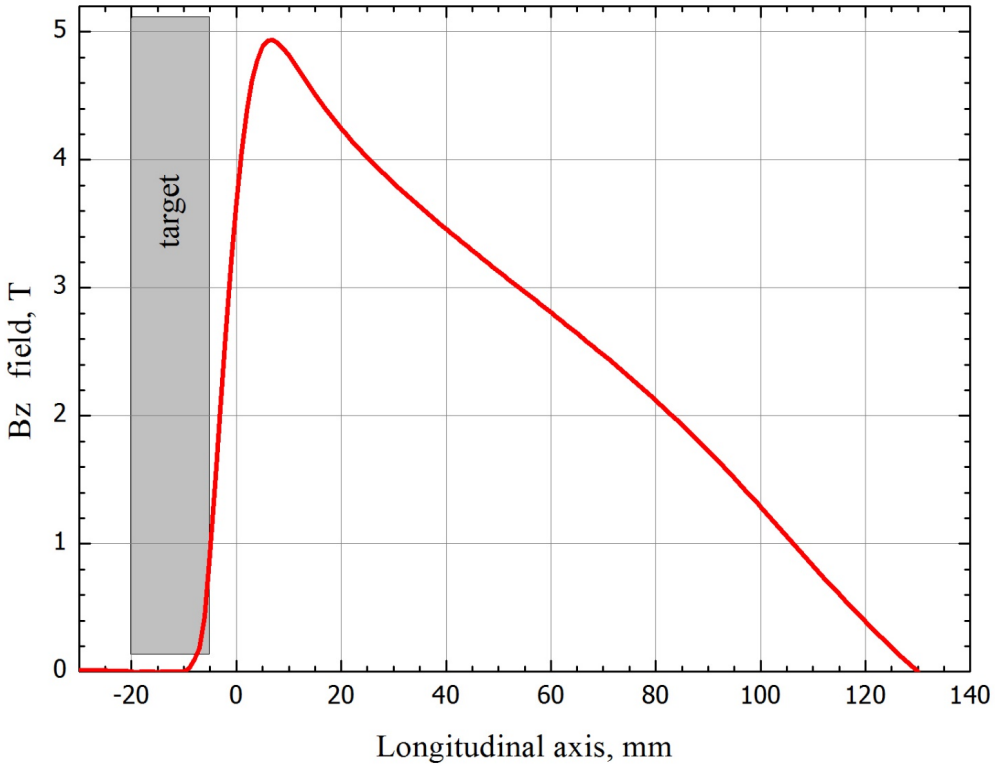


KEK SFC parameters

Spiral Flux Concentrator (SFC)



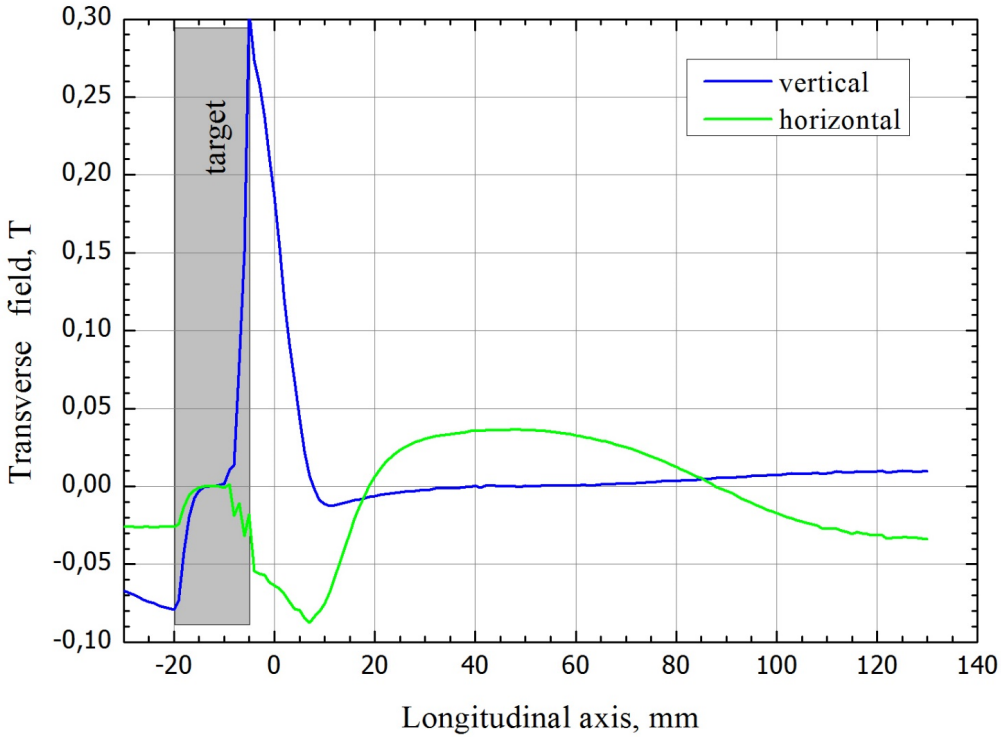
- SFC diameter is 100mm
- SFC length is 100mm
- Min cone diameter is 7mm → 20mm
- Max cone diameter is 52 mm → 64mm
- 12 turns with thickness ≈ 8.1 mm
- Current is 12 kA
- Current profile is a half of sine with a pulse length is 6 μs →25 μs

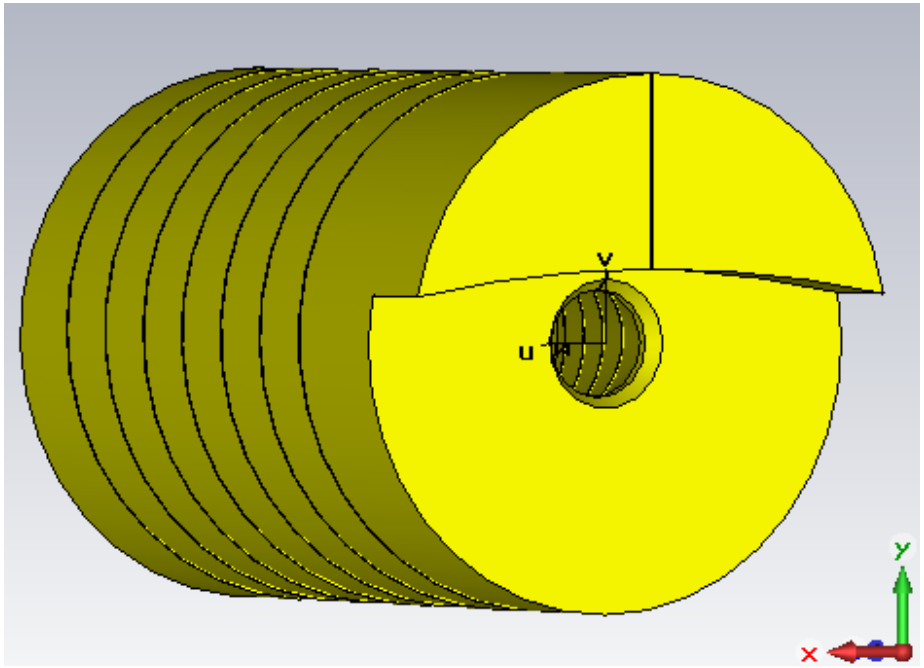


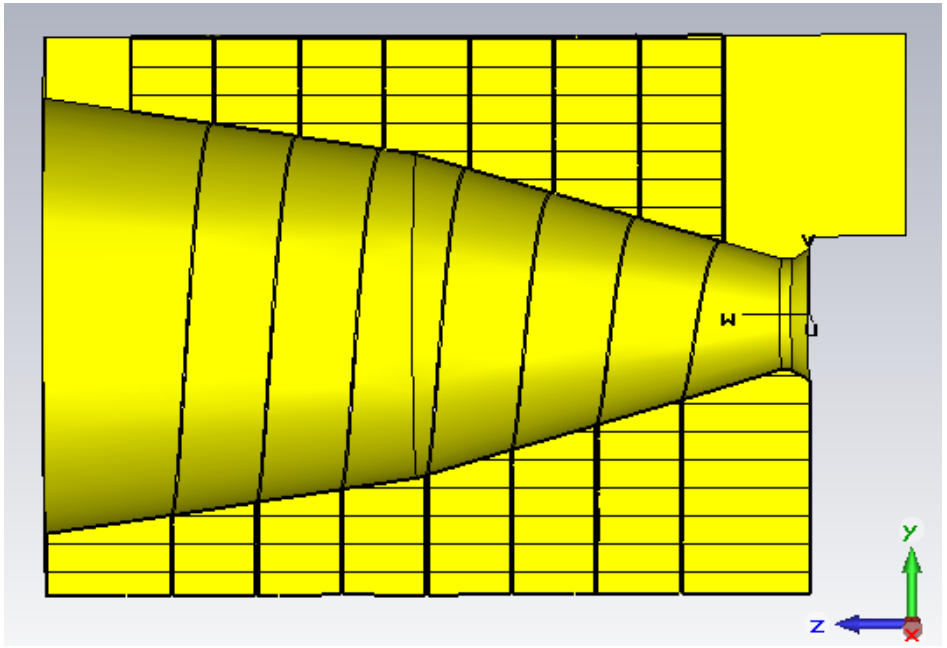
Longitudinal magnetic field component
on a longitudinal (top)

Peak current 45 kA,
pulse length 25 μs
Target ohmic losses 24 J/pulse

Transverse magnetic field component
on a longitudinal axis of
Flux Concentrator (bottom)

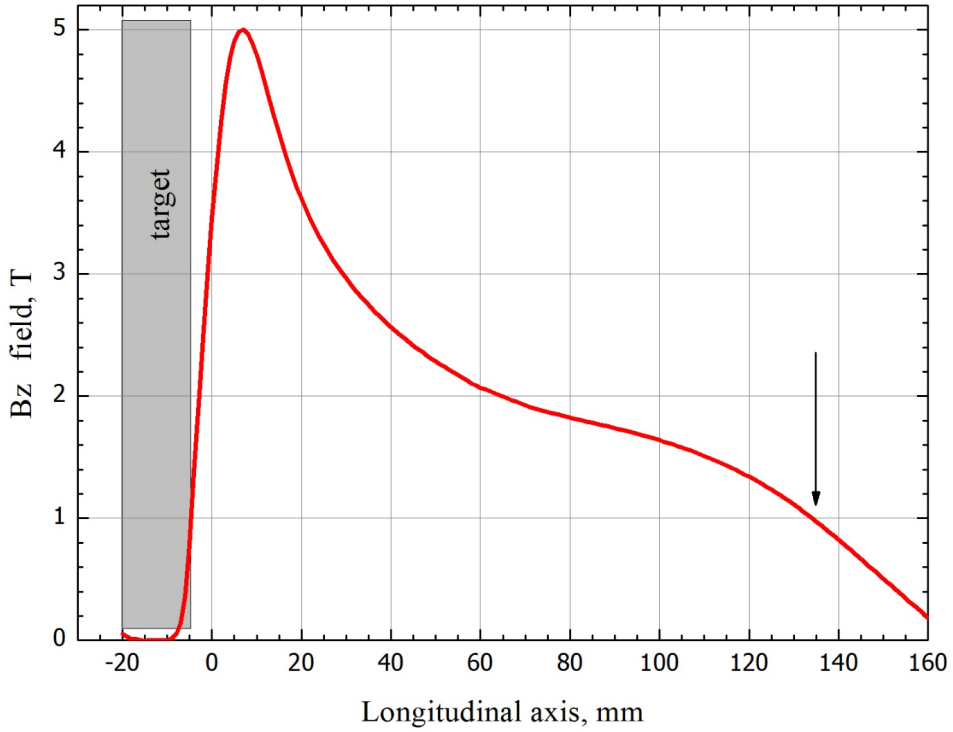






Spiral Flux Concentrator (SFC)

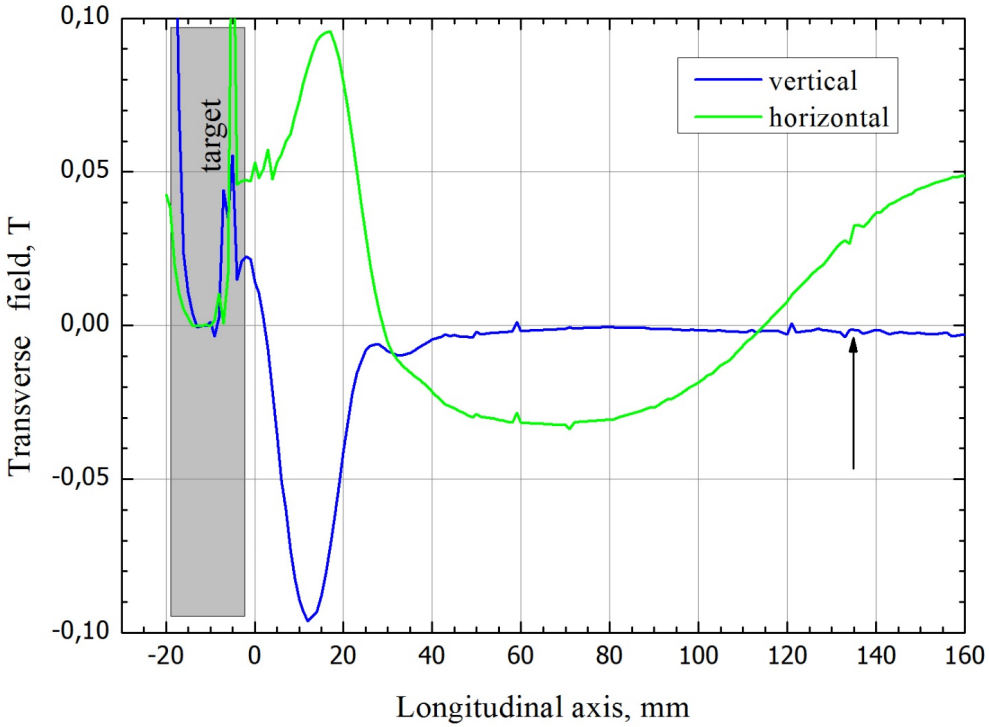
- SFC diameter 100 mm
- FC length 136 mm
- Min cone diameter 20 mm
- Max cone diameter 72 mm
- 8 turns with thickness 9.6 mm
- Current 49 kA
- Current profile is a half of sine with a pulse length 25 μs



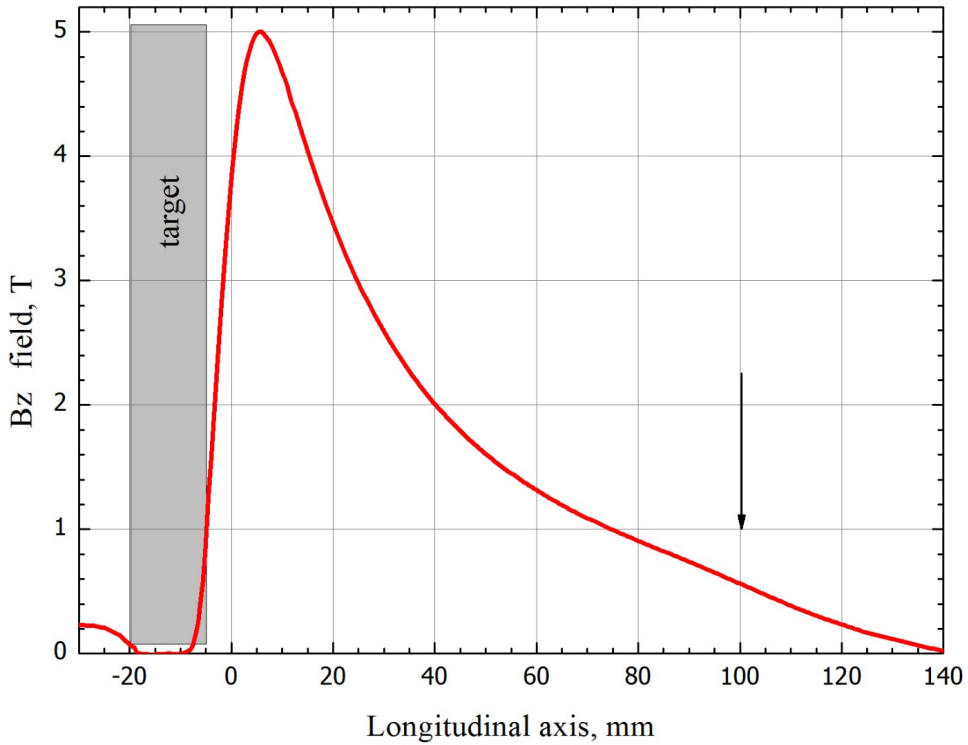
Longitudinal magnetic field component
on a longitudinal (top)

Peak current 49 kA
Pulse length 25 μs
Target ohmic losses 24 J/pulse
FC ohmic losses 395 J/pulse

Transverse magnetic field component
on a longitudinal axis of
Flux Concentrator (bottom)
Peak vertical component value is about -95 mTesla
Peak horizontal component value is about 95 mTesla



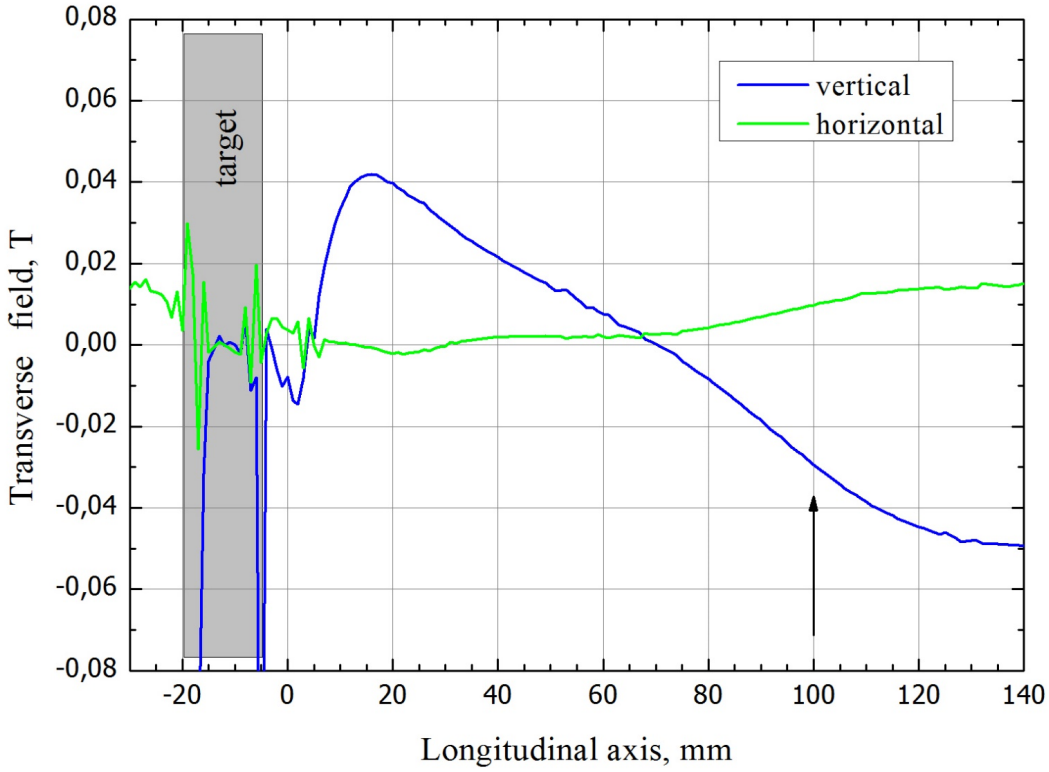
Cone diameter is 20 mm (Nose FC)

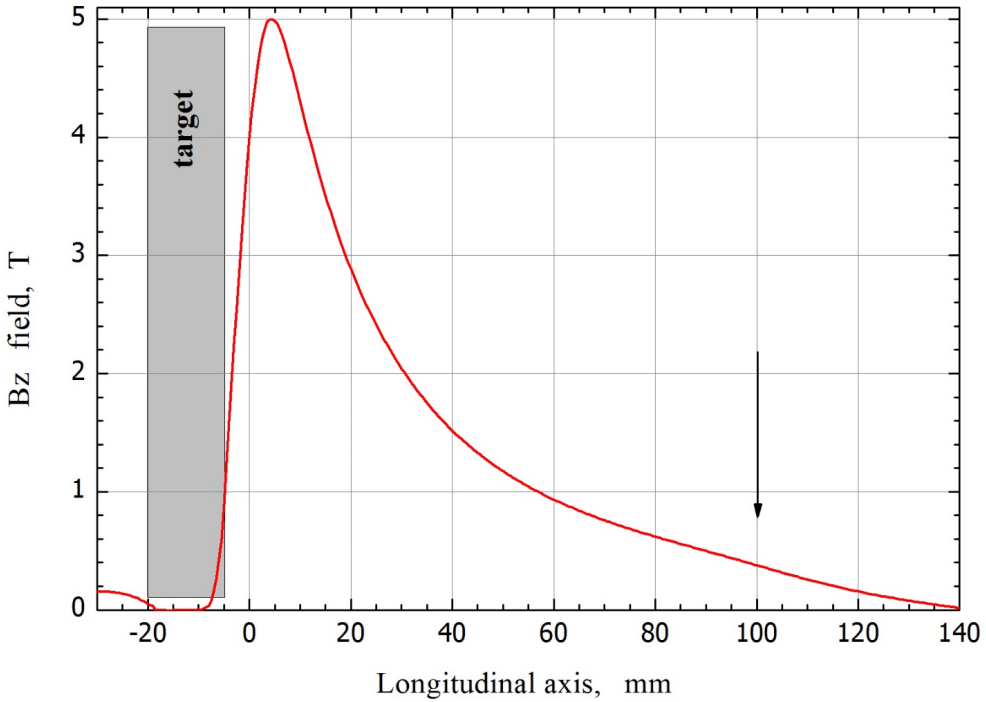


Longitudinal magnetic field component
on a longitudinal (top)

Peak current 34 kA
Pulse length 25 μs
Target ohmic losses 24 J/pulse
FC ohmic losses 245 J/pulse

Transverse magnetic field components
on a longitudinal axis of
Flux Concentrator (bottom)



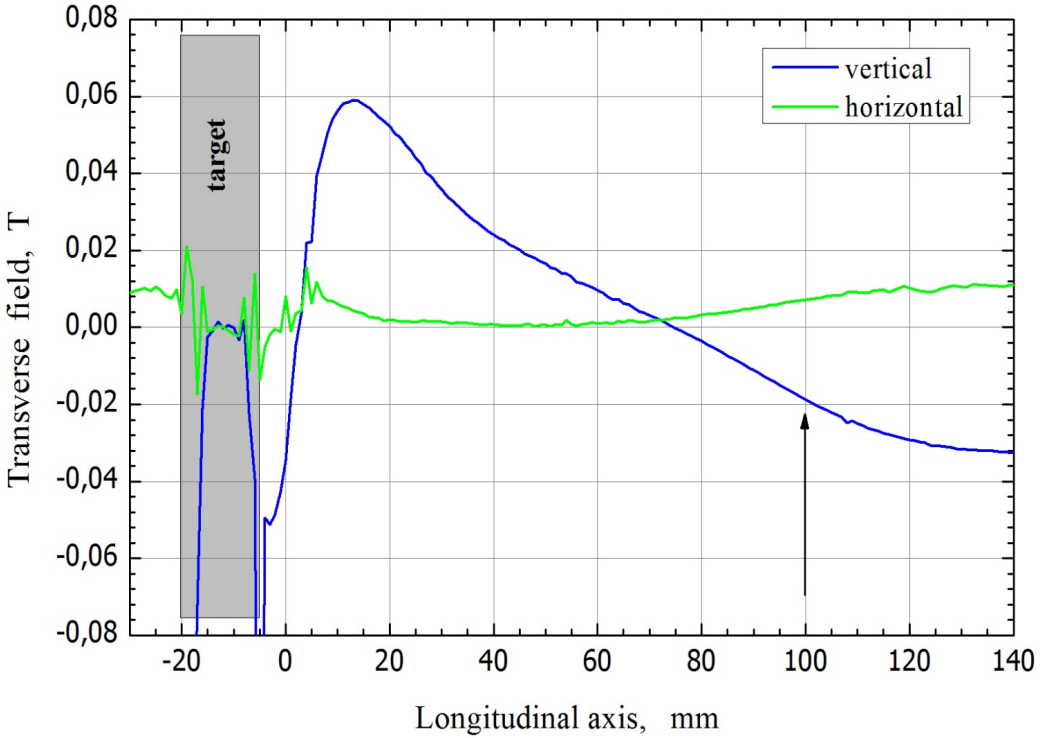


Longitudinal magnetic field component
on a longitudinal (top)

Peak current 25 kA
Pulse length 25 μs
Target ohmic losses 10 J/pulse
FC ohmic losses 140 J/pulse

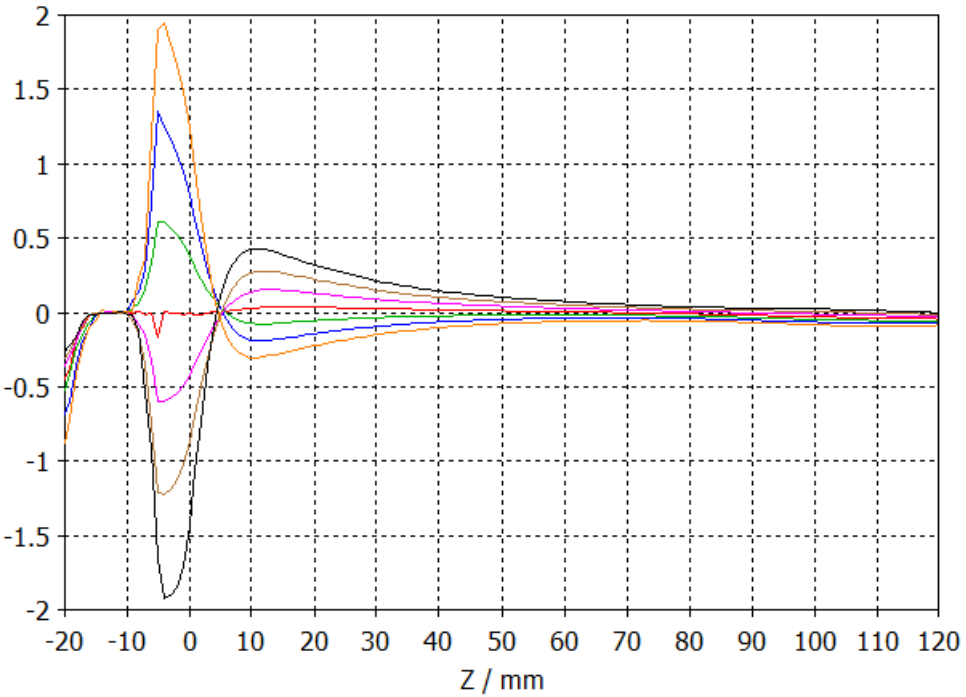
Cone diameter is 16 mm (Nose FC)

Transverse magnetic field components
on a longitudinal axis of
Flux Concentrator (bottom)



	2 holes FC type2	Nose FC type D 20 mm	Nose FC type D 16 mm	Spiral FC
Peak current	39 kA	34 kA	25 kA	49 kA
Peak field	5 Tesla	5 Tesla	5 Tesla	5 Tesla
Peak transverse field	≈31 mTesla	40-50 mTesla	50-60 mTesla	95 mTesla (X,Y component)
Current shape	half of sine	half of sine	half of sine	half of sine
Current pulse length	25 µs	25 µs	25 µs	25 µs
Target ohmic loss	≈ 27 J/pulse	≈ 24 J/pulse	≈ 10 J/pulse	≈ 24 J/pulse
FC ohmic loss	≈ 530 J/pulse	≈ 245 J/pulse	≈ 140 J/pulse	≈ 395 J/pulse
Repetition rate 100 pps (=300 pps/s)				
Target losses	2.7 kW	2.3 kW	1 kW	2.3 kW
FC losses	**52 kW**	**25 kW**	**14 kW**	**40 kW**

- Nose FC type with front aperture of 16 mm looks mostly acceptable as ILC matching device.
- Power supply draft design.
- Additional positron yield computation with real field is required
  adiabatic decreasing of longitudinal profile
  transverse component field value on axis.
- Shape profile of conical cavity (simple geometry).
- Current pulse length may be shorter of 25 μs.
- Mean FC ohmic losses power 14 kW is regular value.

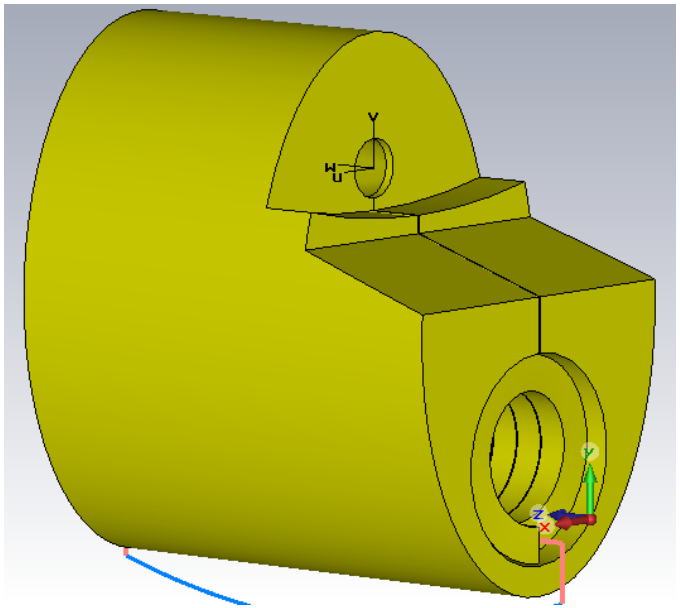


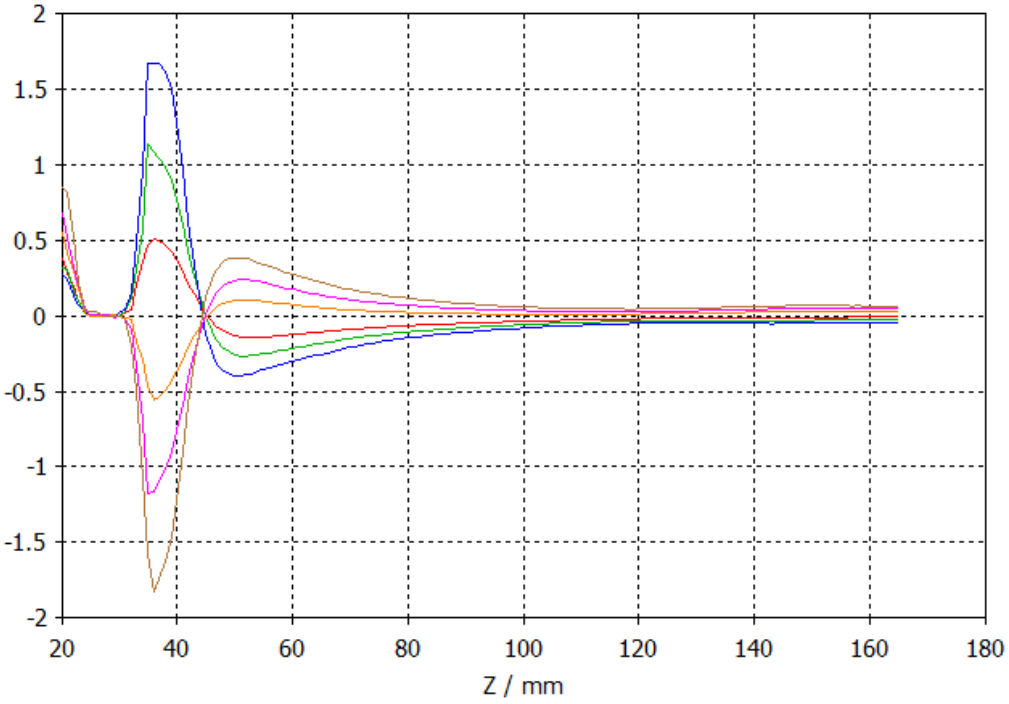
nose FC

Vertical component of magnetic field

y= 0 mm
y= -2 mm
y= -4 mm
y= -6 mm

y= 2 mm
y= 4 mm
y= 6 mm

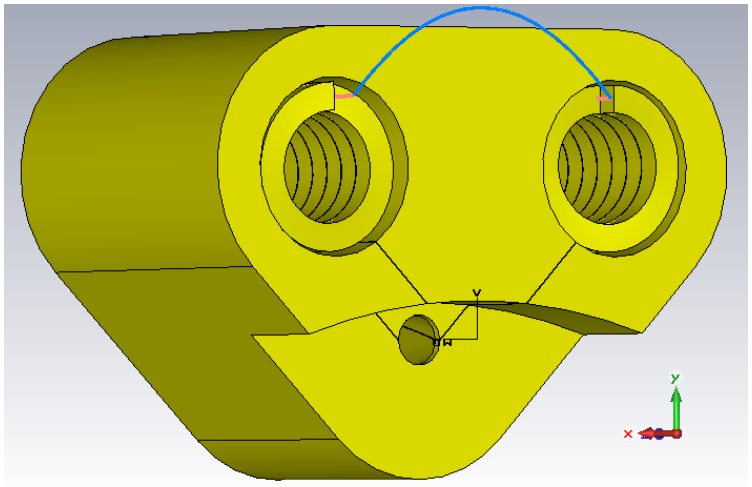


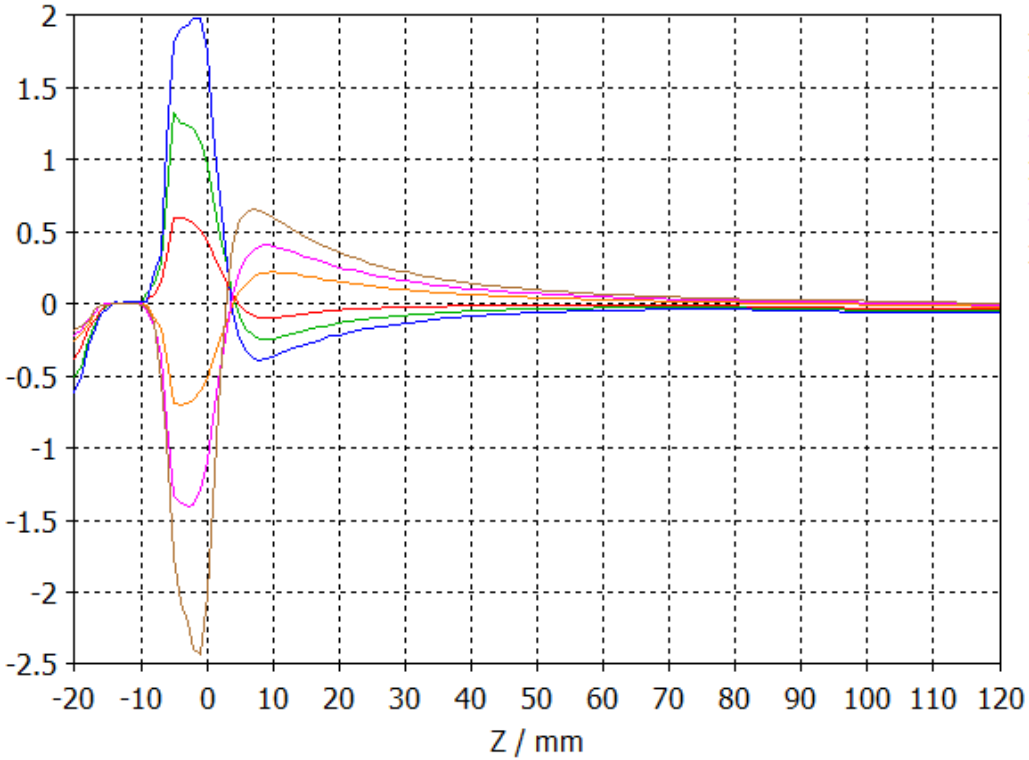


2 hole FC
Vertical component of magnetic field

y= -2 mm
y= -4 mm
y= -6 mm

y= 2 mm
y= 4 mm
y= 6 mm



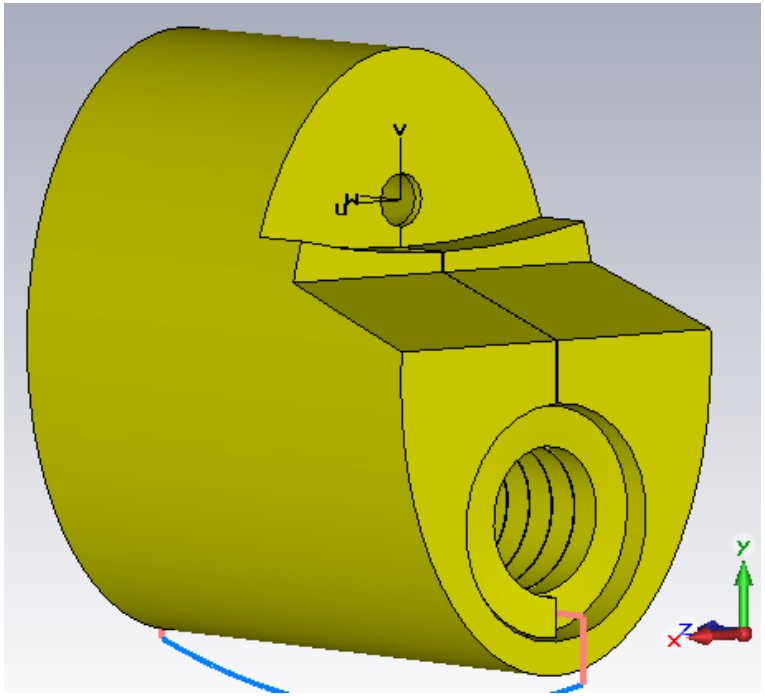


nose FC

Vertical component of magnetic field

y= -2 mm
y= -4 mm
y= -6 mm

y= 2 mm
y= 4 mm
y= 6 mm



Cone diameter is 16 mm