Preliminary result of FCC conventional positron source simulation

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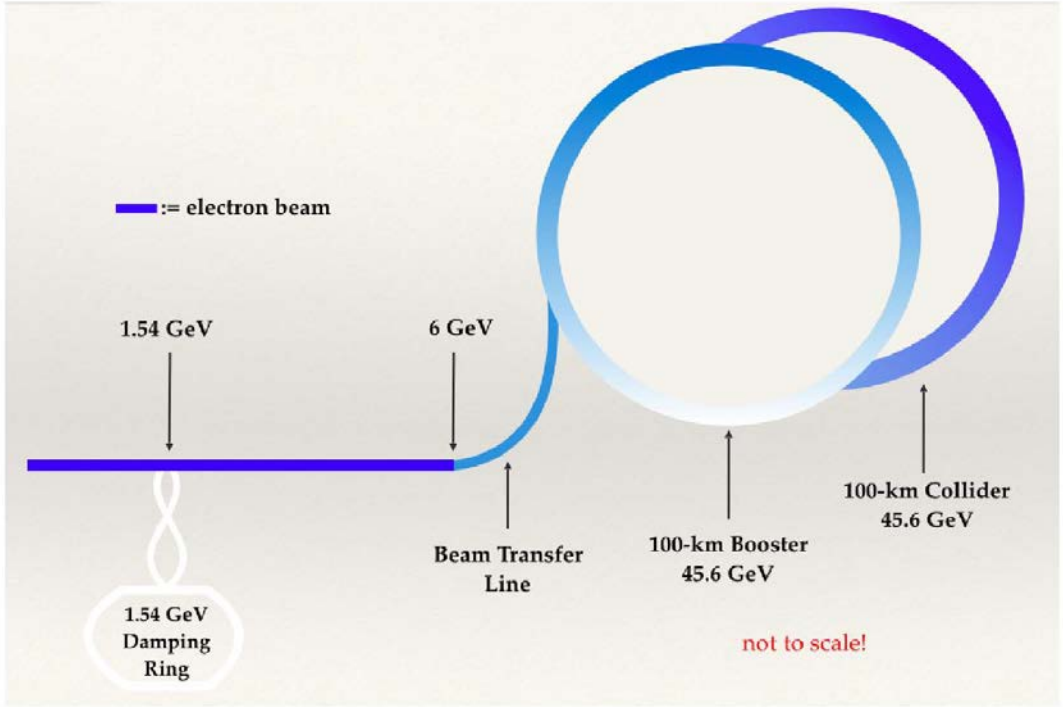
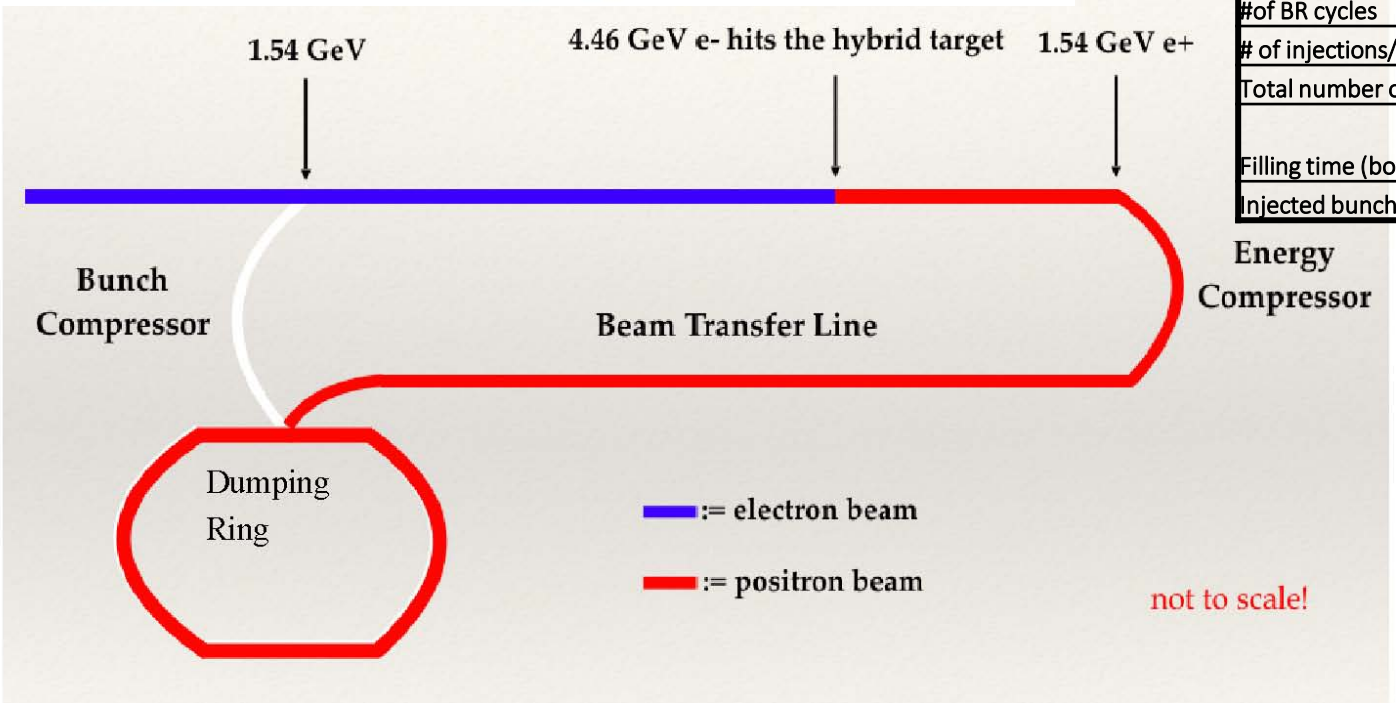


FCC-ee electron flow scheme for Z-pole operation

FCC-ee injector parameters

Accelerator	FCCee-Z		FCCee-W		FCCee-H		FCCee-tt	
Energy [GeV]	45.6		80		120		175	
Type of filling	Full	Top-up	Full	Top-up	Full	Top-up	Full	Top-up
LINAC # bunches, **with 2.8 GHz RF**	2		1					
LINAC repetition rate [Hz]	200		100					
LINAC/SPS bunch population [10^{10}]	2.06	0.20	1.88	0.15	0.77	0.20	2.12	0.43
# of LINAC injections	610	1525	263		60		81	
SPS bunch spacing [ns]	2.5		50		380		280	
# SPS cycles	10	15	20		13		1	
SPS # of bunches	1220	3050	263		60		81	
SPS cycle time [s]	3.55	8.13	3.13		1.10		1.31	
SPS duty factor	0.86	0.95	0.91		0.15	0.70	0.18	
BR # of bunches	12200	45750	5260		60	780	81	
BR cycle time [s]	39.5	125.9	68.6		7.1	20.3	7.31	
#of BR cycles	15	2	4	1	13	1	10	1
# of injections/collider bucket	2	1	4	1	13	1	10	1
Total number of bunches	91500		5260		780		81	
Filling time (both species) [sec]	1185	503.5	548.8	84.6	527.8	40.6	146.2	14.6
Injected bunch population [10^{10}]	3.3	0.16	6.0	0.12	8.0	0.16	16.9	0.34



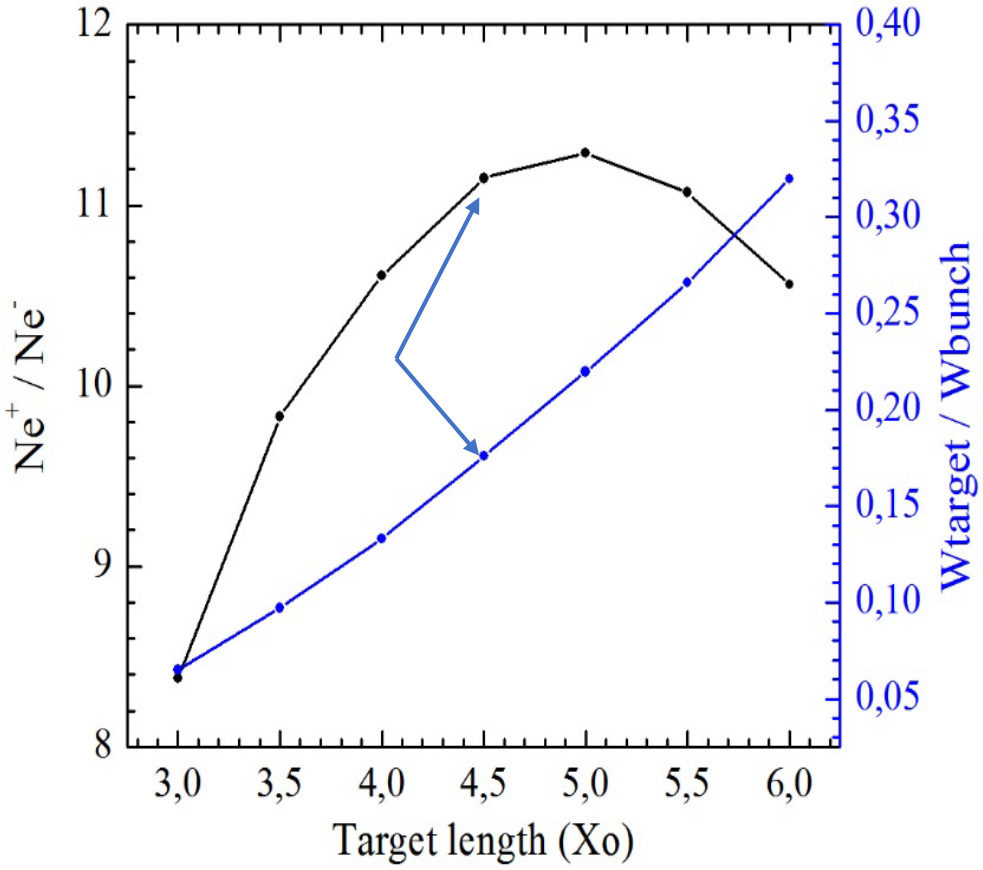
required DR e+ bunch population 2.5×10^{10}

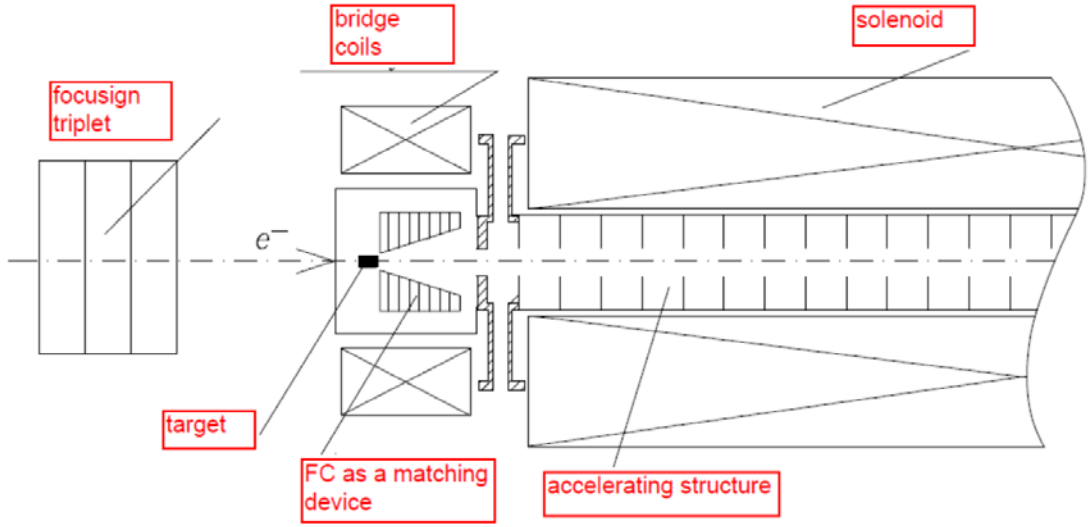
FCC-ee positron flow scheme for Z-pole operation

1. Target parameters and computation
   - optimum target thickness and total conversion ration
   - total target deposition energy, peak energy deposition density
   - target design, cooling and size
2. Flux Concentrator parameters
   - peak field optimization
   - optimal FC total length
   - optimization of a longitudinal magnetic field profile
3. Bridge coil & solenoid
   - solenoid field optimization
   - optimization of a total longitudinal magnetic field profile
     FC + Bridge coil + Solenoid

FCC Conventional Positron Source

e+ production target optimization

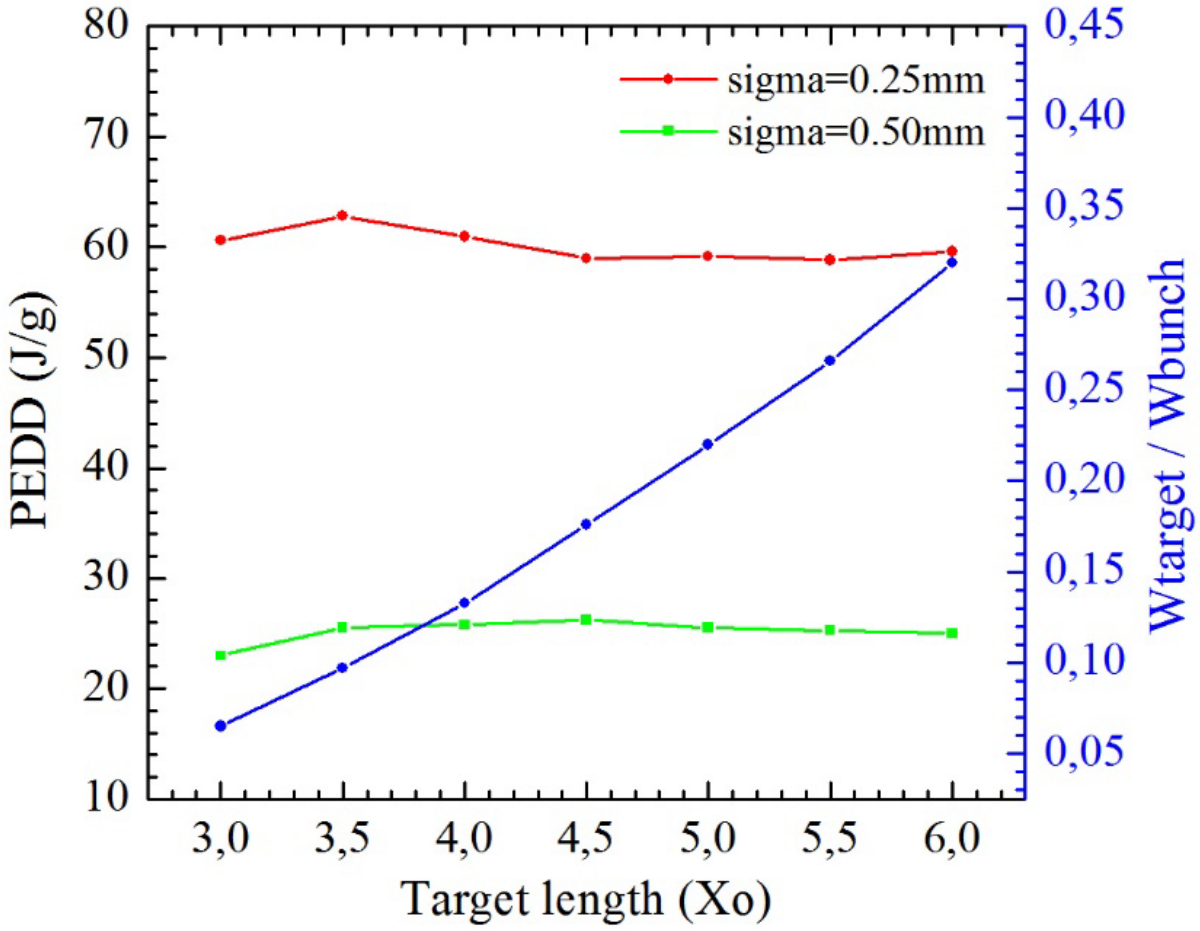


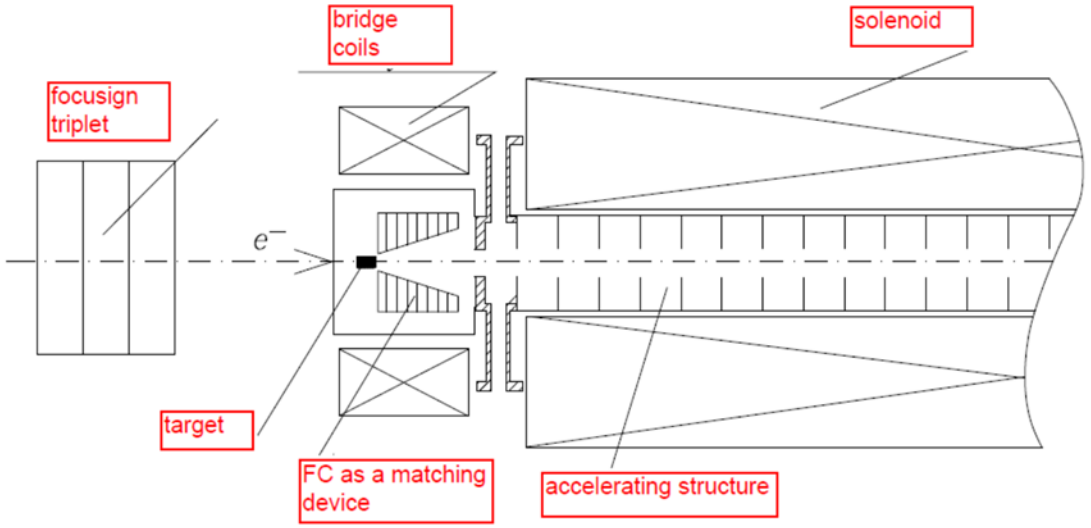


Positron total production rate for electron beam energy of 4.5 GeV (left).
Total energy deposition in tungsten target normalized by total energy of electron bunch (right).
Tungsten radiation length Xo is 0.35 cm.

e^- bunch charge	e^- bunch population	energy of e^- bunch	Target power Deposition (4.5Xo)
2x10 nC	$2x6.25 \cdot 10^{10}$	45 J	790 W
2x8.8 nC	$2x5.53 \cdot 10^{10}$	40 J	700 W

FCC Conventional Positron Source

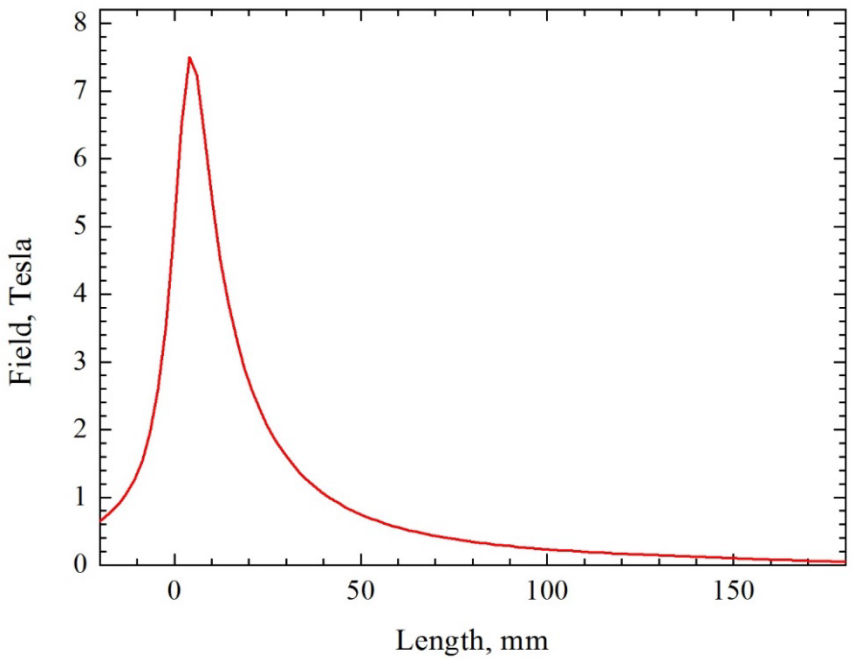




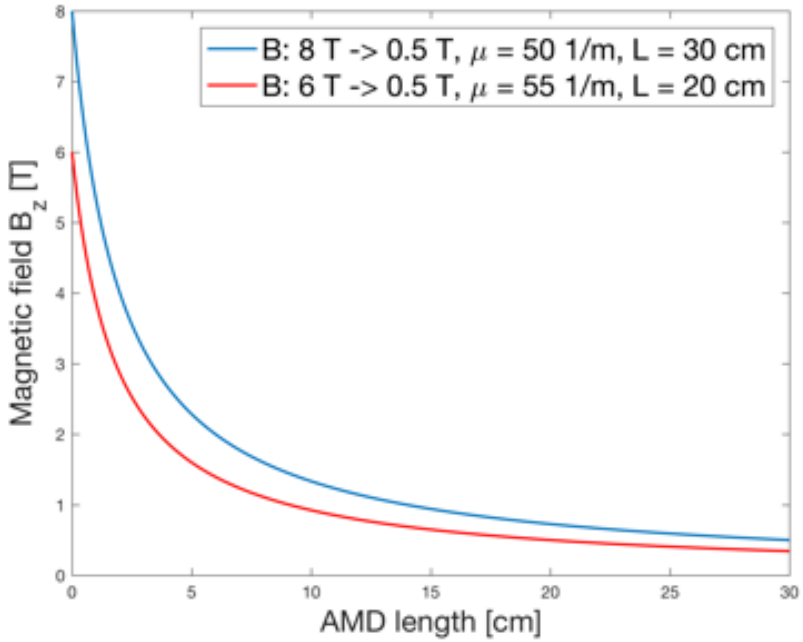
Peak energy deposition density 2x10nC (left).
Total energy deposition in tungsten target normalized by total energy of electron bunch (right).
Tungsten radiation length Xo is 0.35 cm.
W74Re26 target alloy has a PEDD limit of 35 J/g

FCC Conventional Positron Source

Flux Concentrator longitudinal field profile



AMD device longitudinal field profile



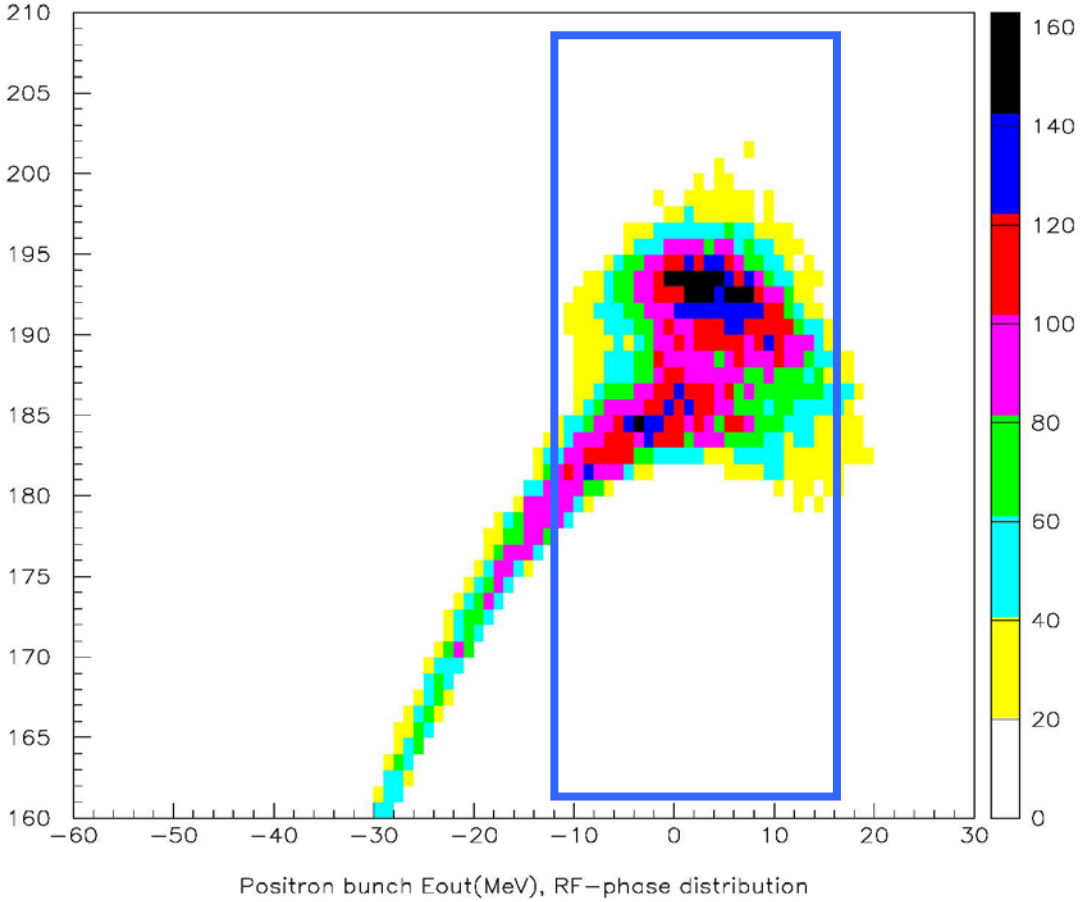
FC parameters

- simple conical cavity shape
- front aperture is 10 mm
- rear aperture is 70 mm
- FC length is 150 mm

Non-adiabatic field decreasing

FCC Conventional Positron Source

Energy(MeV) ─ length(RF-phase degrees) distribution of positron bunch after 2 accelerating section
Initial RF phase of accelerating structure is 5 degrees



- accelerating gradient is 30 MeV/m
- 2 section with length of 3m
- section aperture diameter is 20 mm

- FC peak field is 7.5 Tesla
- solenoid uniform field is 0.5 Tesla
- FC length is 150 mm
- Offset between target and FC peak field position is 7 mm

- Damping Ring energy 1.54 GeV
- Damping Ring energy acceptance is ±6÷8% (±92 MeV)

Envelope applying for a positron yield estimation
(±2σ ≈ 27º RF phase).

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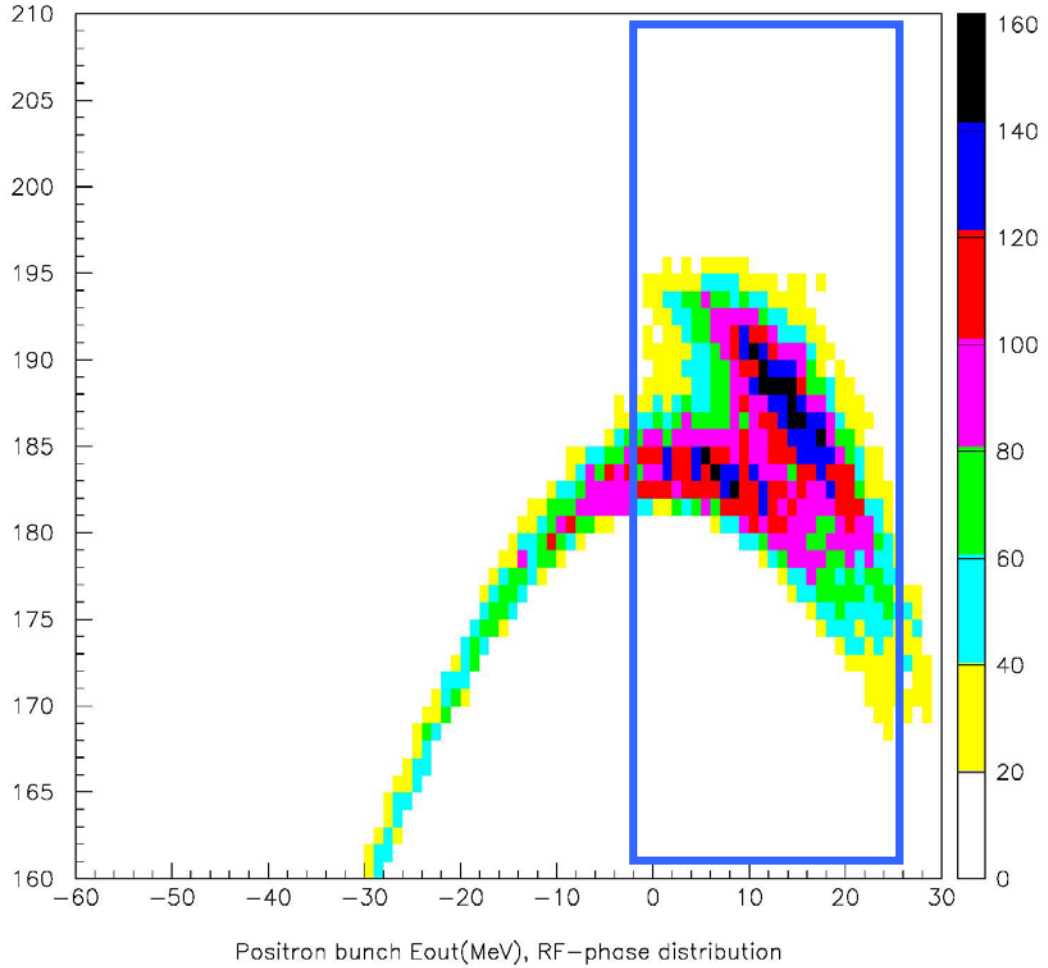

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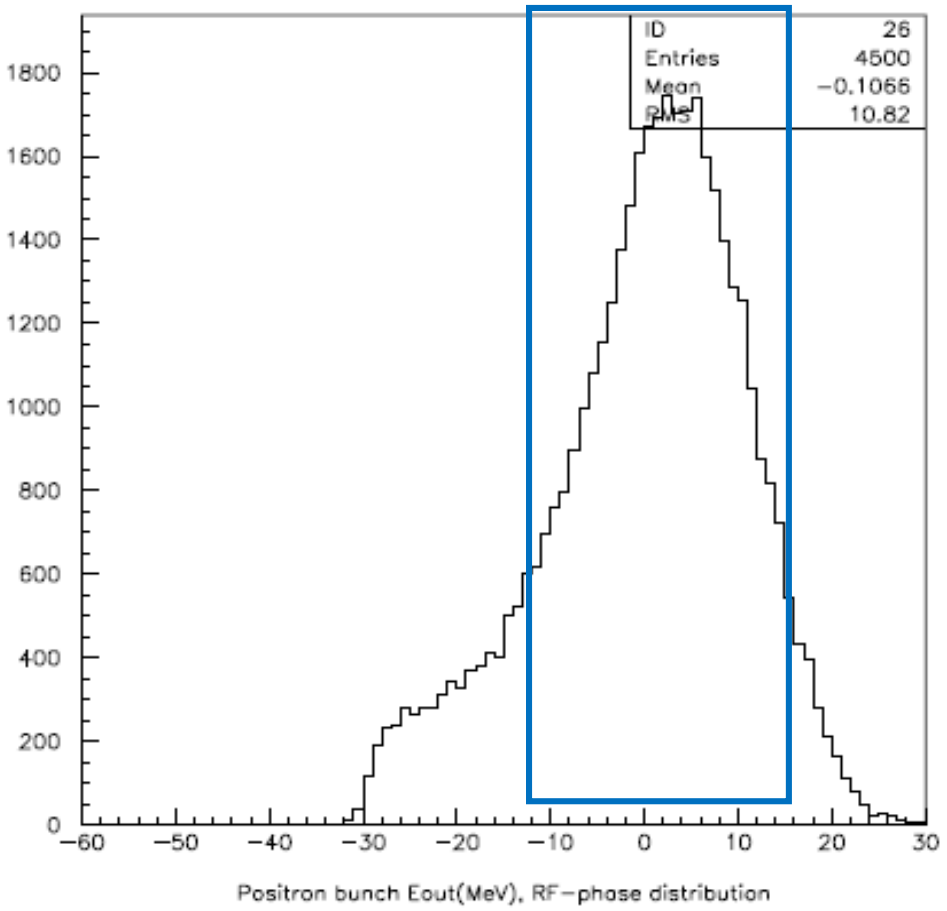

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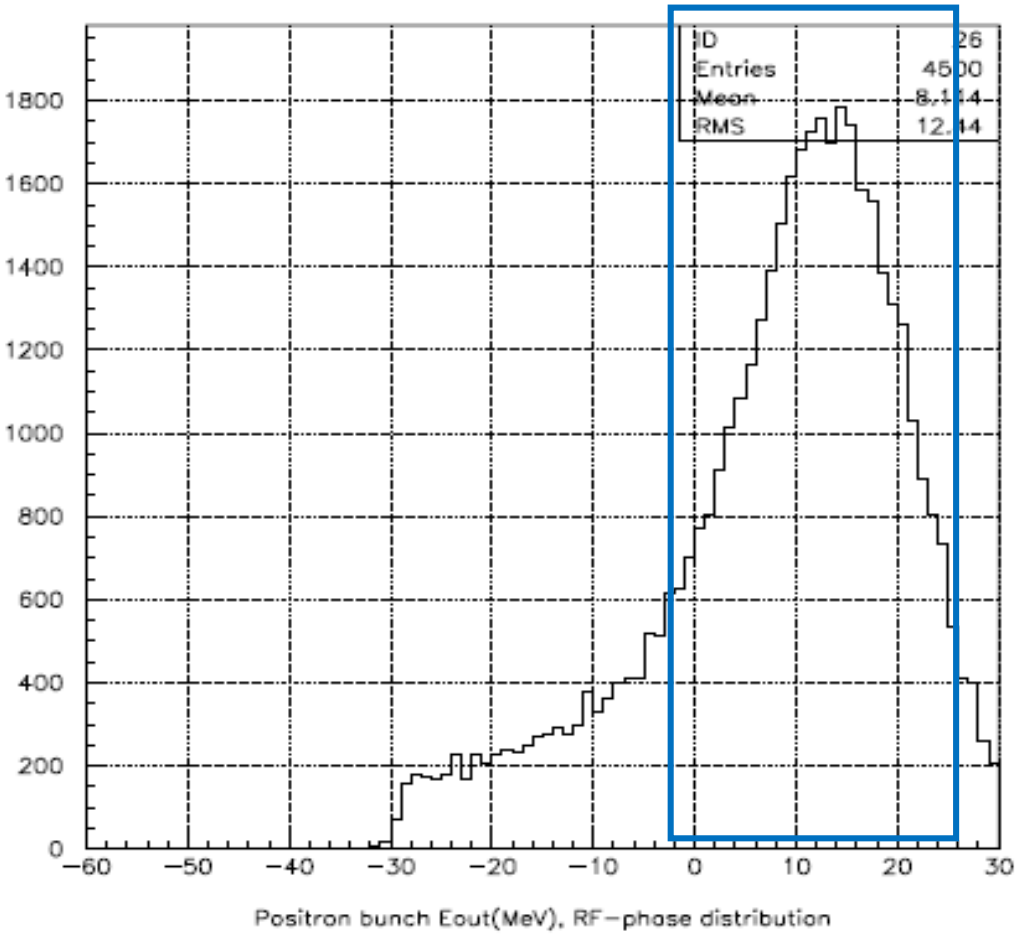
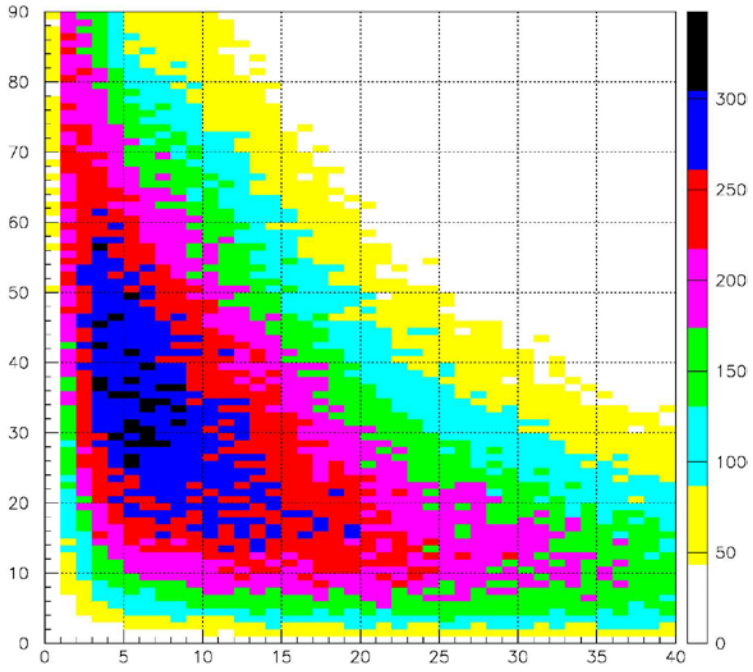


FCC Conventional Positron Source

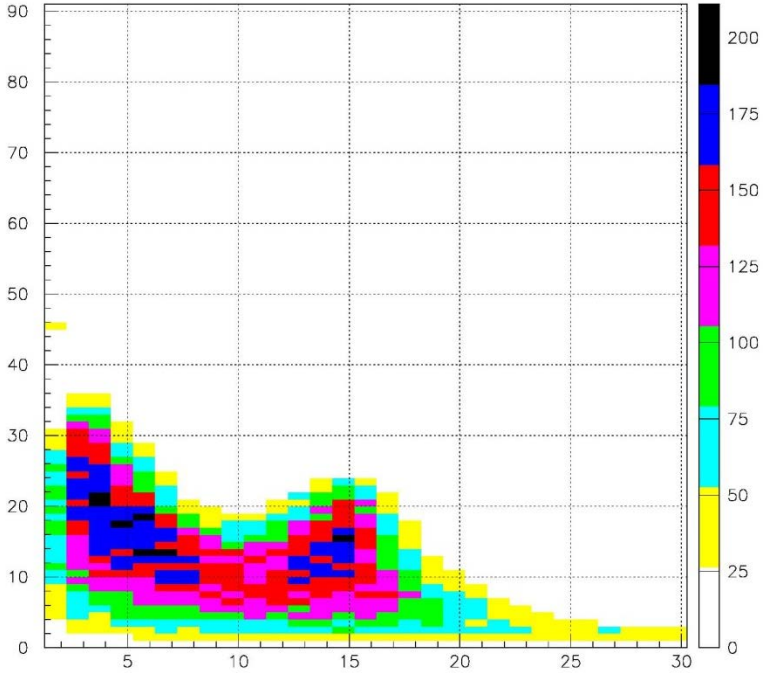
FC peak field is 7.5Tesla solenoid field is 0.5Tesla

e+ energy [MeV] vs. transverse divergence [deg.] at the production



Energy (MeV)

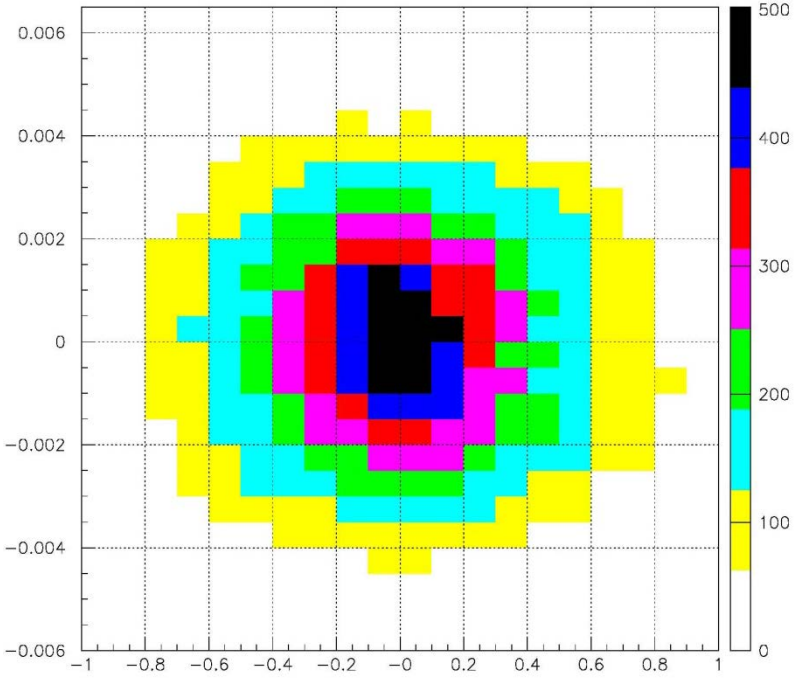
e+ energy [MeV] vs. transverse divergence [deg.] at the production within the e+ capture system acceptance



Energy (MeV)

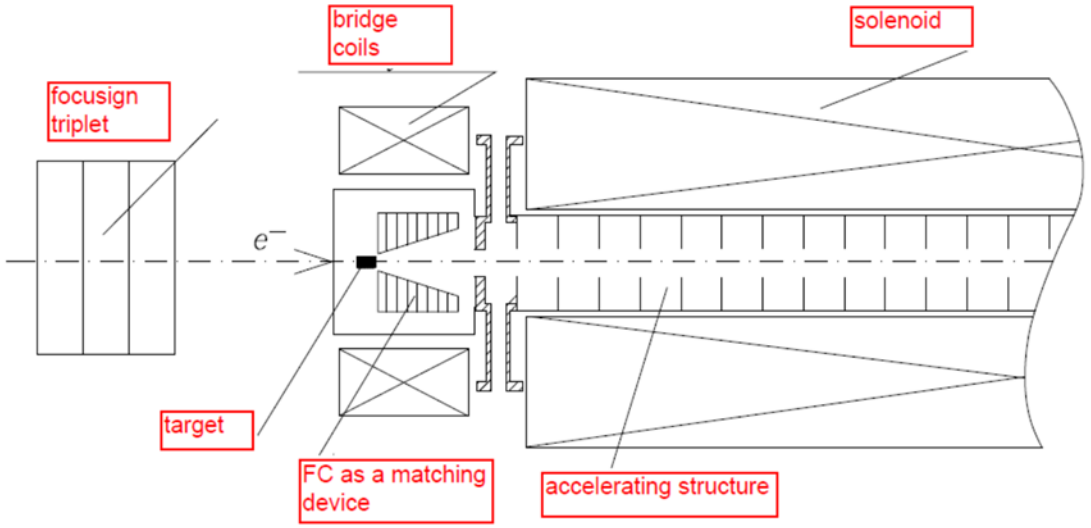
e+ transv. distribution x [cm] vs. px [rad] @~190 MeV after 2nd Acc. Section

X-RMS emittance is ≈ 8.5 μm



X (cm)

FCC Conventional Positron Source



Positron yield and emittance estimation without channel transmission parameter

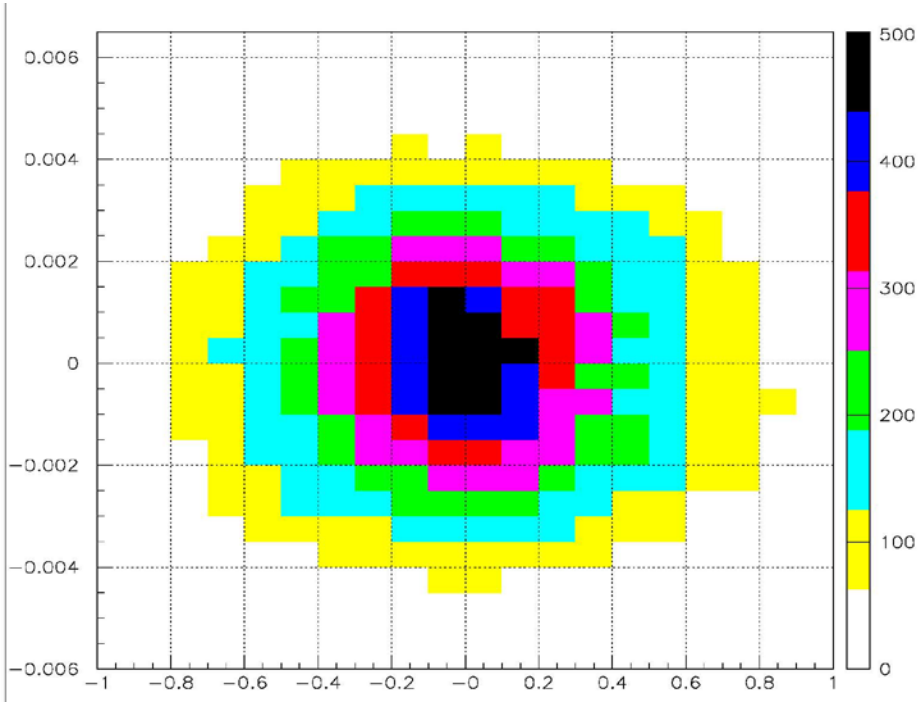
	FC field 7.5 Tesla solenoid field 0.5 Tesla		FC field 7.5 Tesla solenoid field 0.7 Tesla	
Acc. Structure diameter	20 mm	30 mm	20 mm	30 mm
Positron yield Ne^+/Ne^-	0.7	1.1	0.92	1.44
Emittance, μm	8.5	15	10.5	18.8

required e+ bunch population 2.5×10^{10}

channel transmission parameter can be not higher of 60÷70%

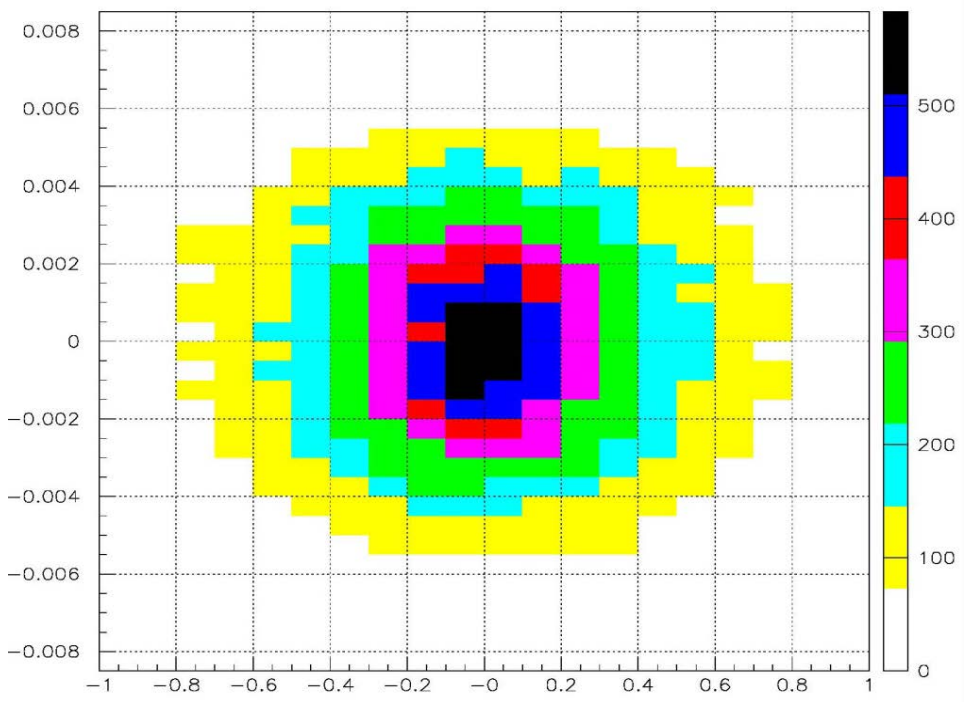
FCC Conventional Positron Source

- FC peak field is 7.5 Tesla
- Solenoid field is 0.5 Tesla
- RMS emittance is ≈ 8.5 μm
- Acc. structure diameter is 20 mm



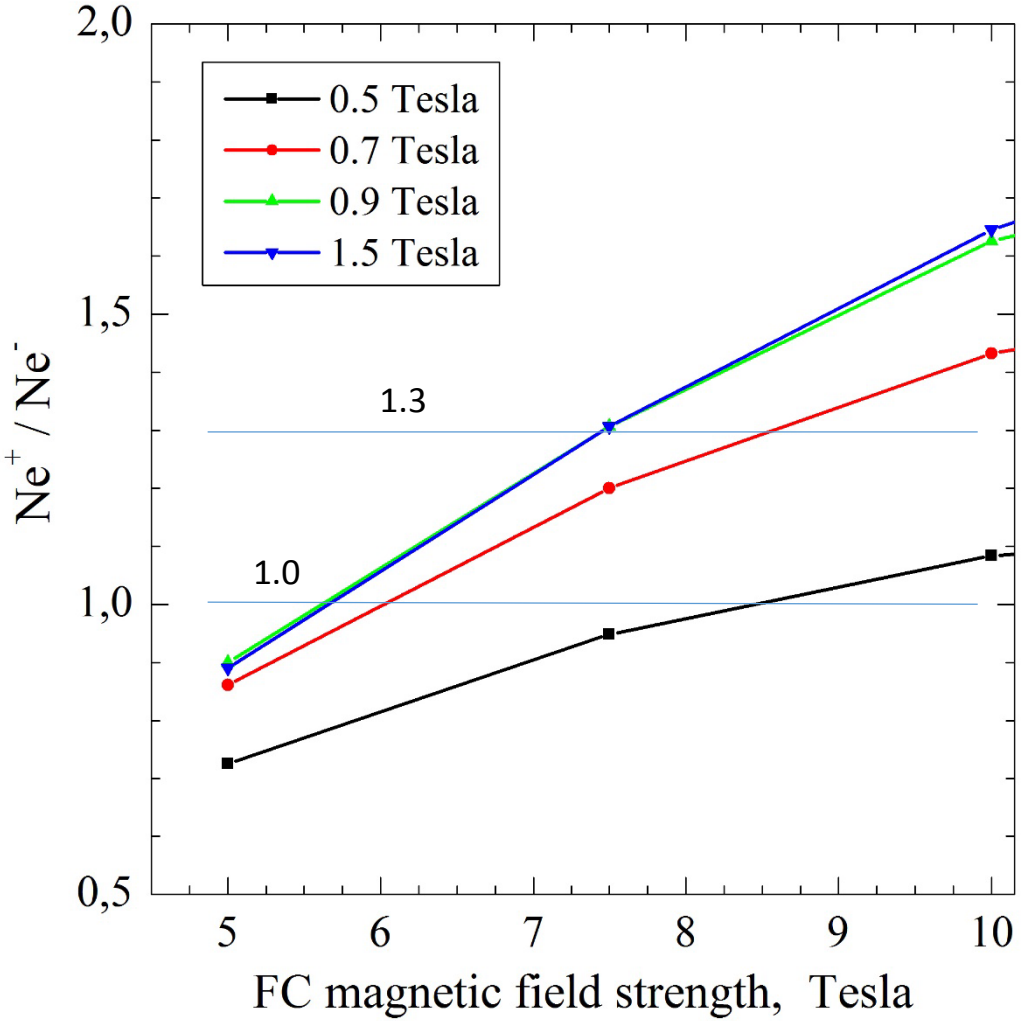
Positron X-emittance rad*cm

- FC peak field is 7.5 Tesla
- Solenoid field is 0.7 Tesla
- RMS emittance is ≈ 10.5 μm
- Acc. structure diameter is 20 mm



Positron X-emittance rad*cm

The last presentation slide

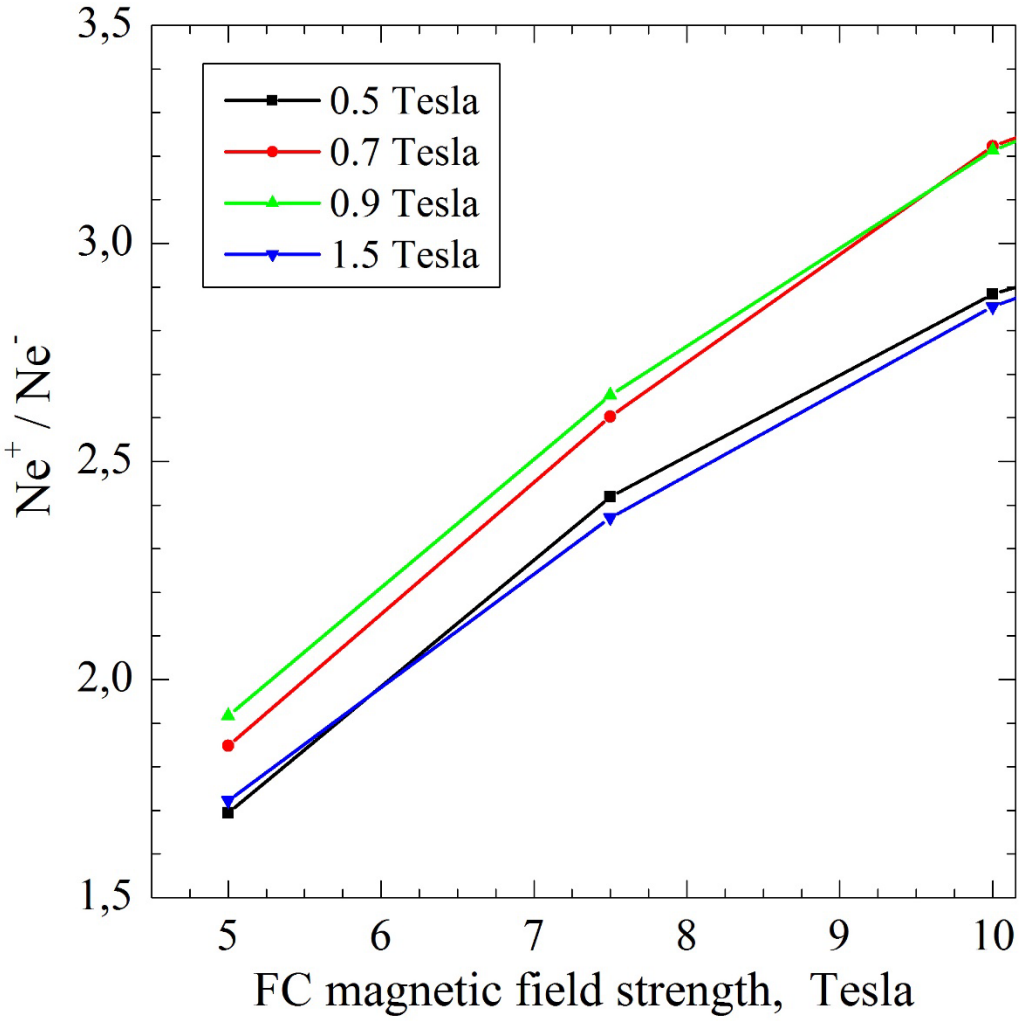


S-band structure linac positron yield after solenoid focusing (250 MeV, with conversion electron bunch energy of 6 GeV) vs Flux Concentrator peak field and solenoid field

Positron bunch population injected to main ring $3.3 \cdot 10^{10}$
Safety factor is ~ 2.

Yield should be (taking safety factor) for electron bunch charge:

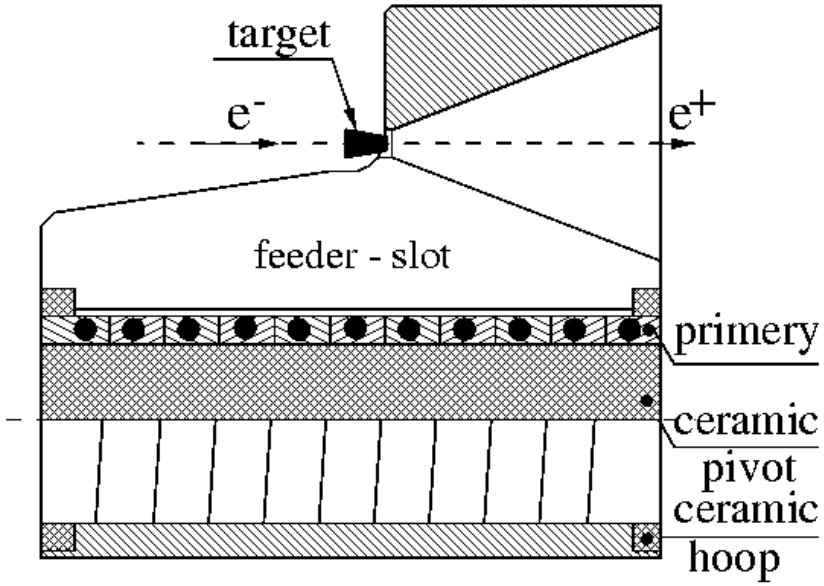
8 pC	~ 1.3 Ne^+/Ne^-
10 pC	~ 1.0 Ne^+/Ne^-

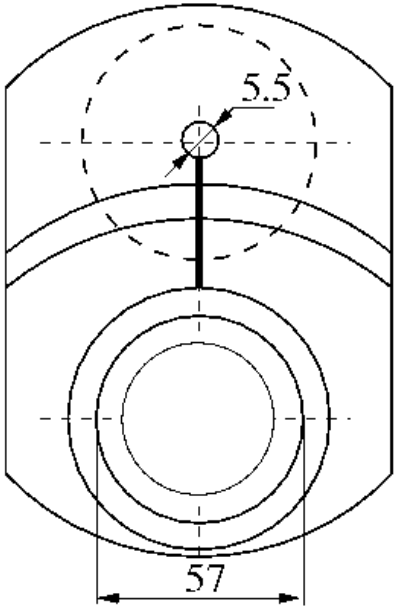


L-band structure linac positron yield after solenoid focusing (250 MeV, with conversion electron bunch energy of 6 GeV) vs Flux Concentrator peak field and solenoid field

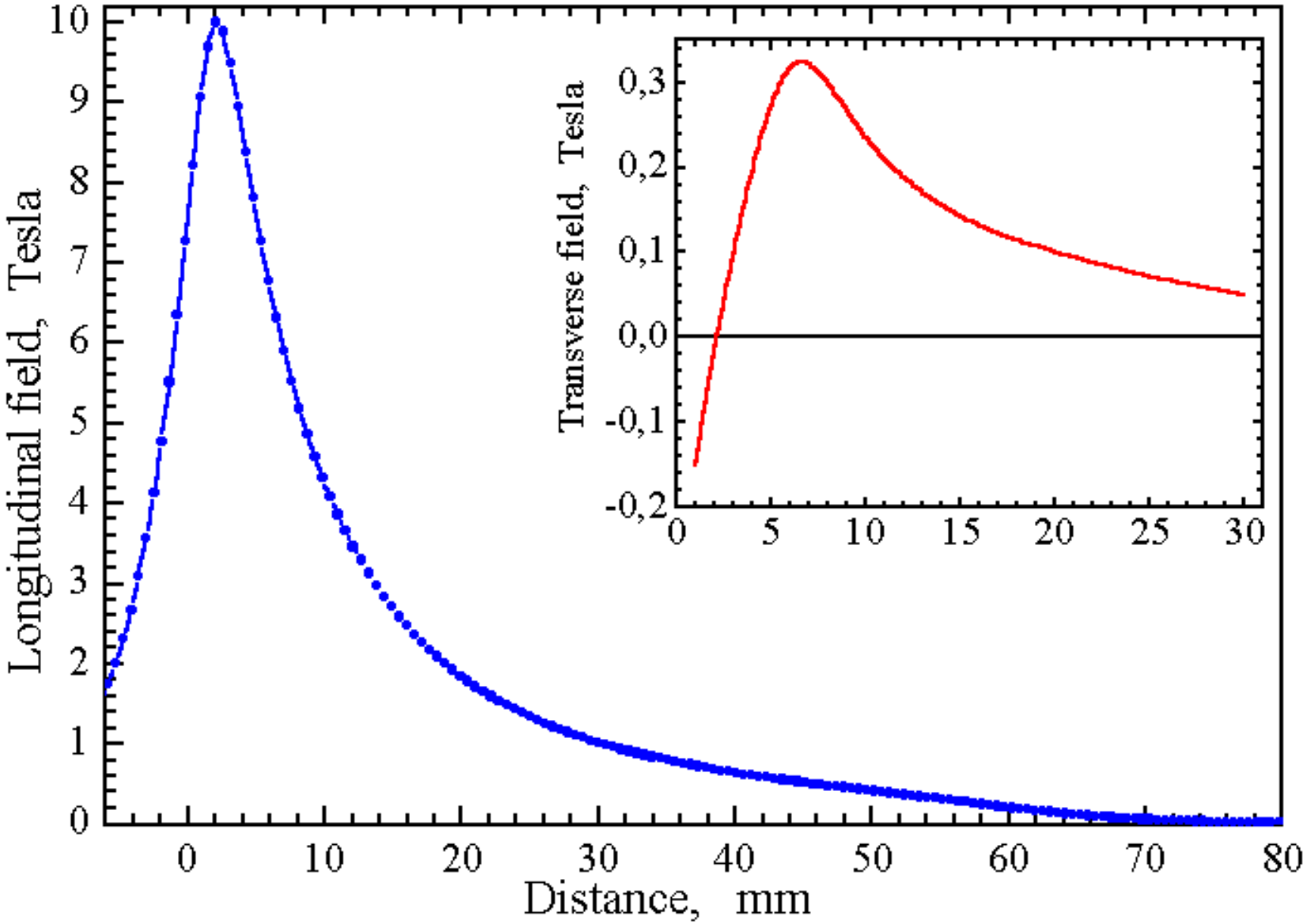
L-band linac has 2 time higher of a positron yield in comparison with S-band.

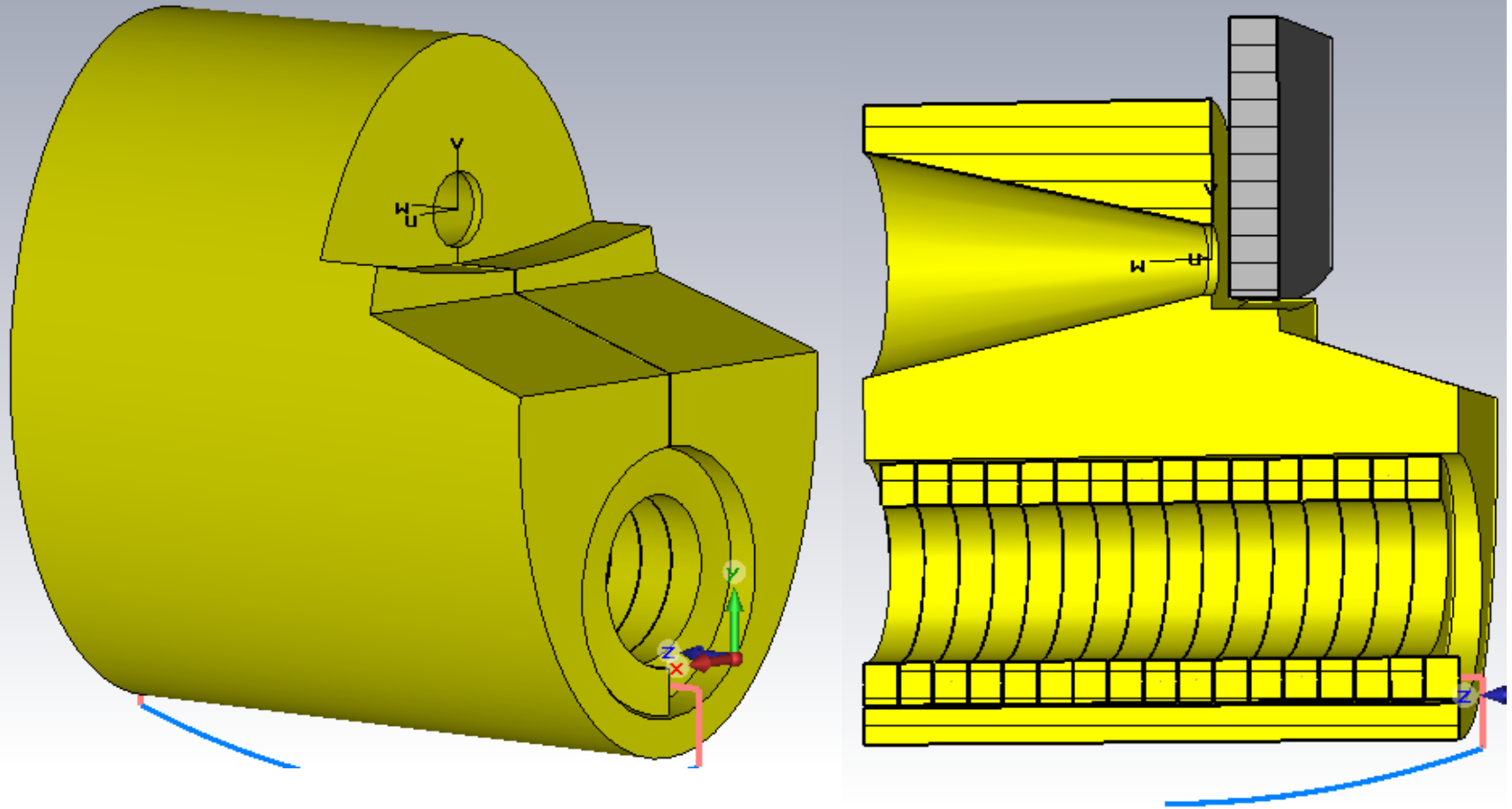
VEPP-5 Flux Concentrator





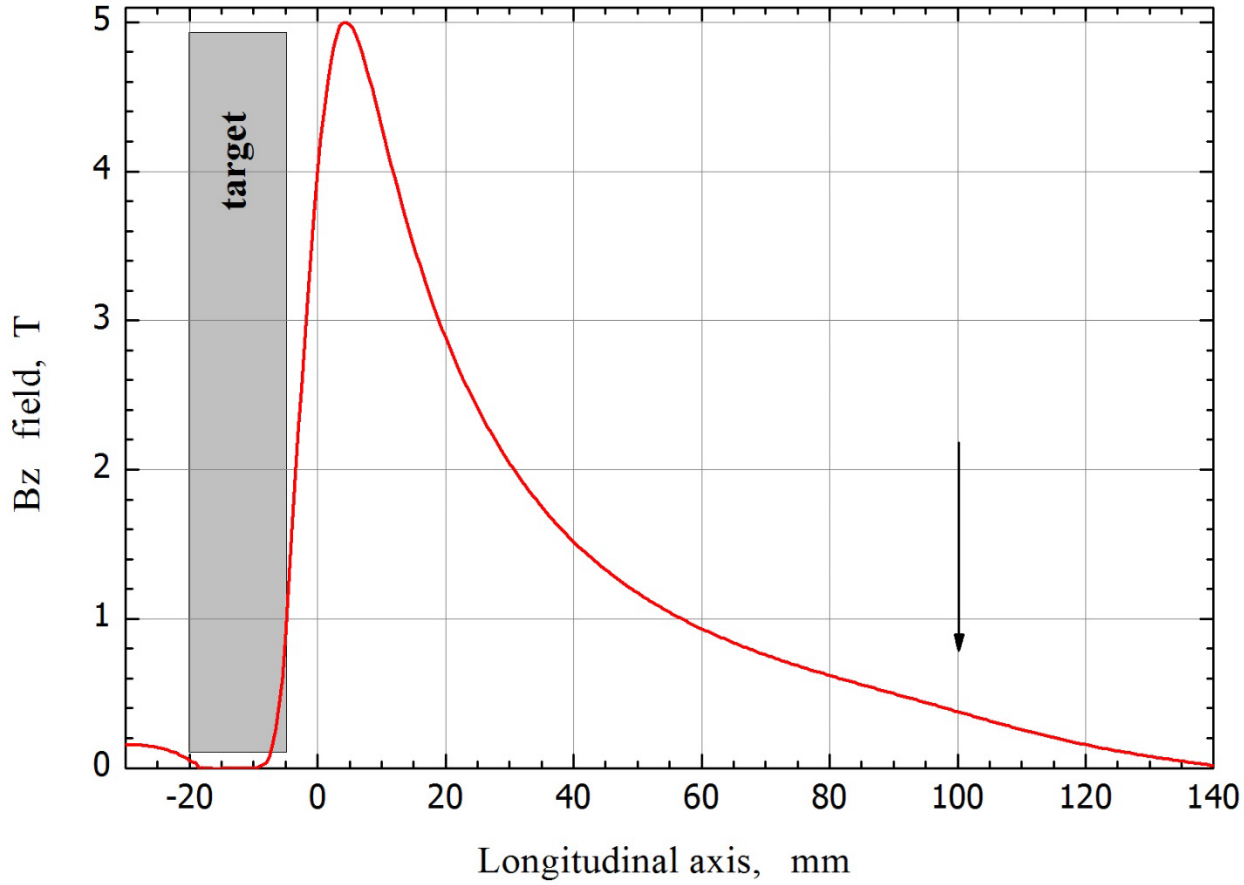
VEPP-5 forinjector FC magnetic field





Single turn Flux Concentrator for ILC positron source

Size	Elliptical cylinder 120x180 mm
Total length	170 mm
Conical part length	100 mm
Min cone diameter	16 mm
Max cone diameter	63 mm
Cone angle	26 degrees
Turns number	16 (9,6x12 mm)
Cylindrical hole diameter	70 mm

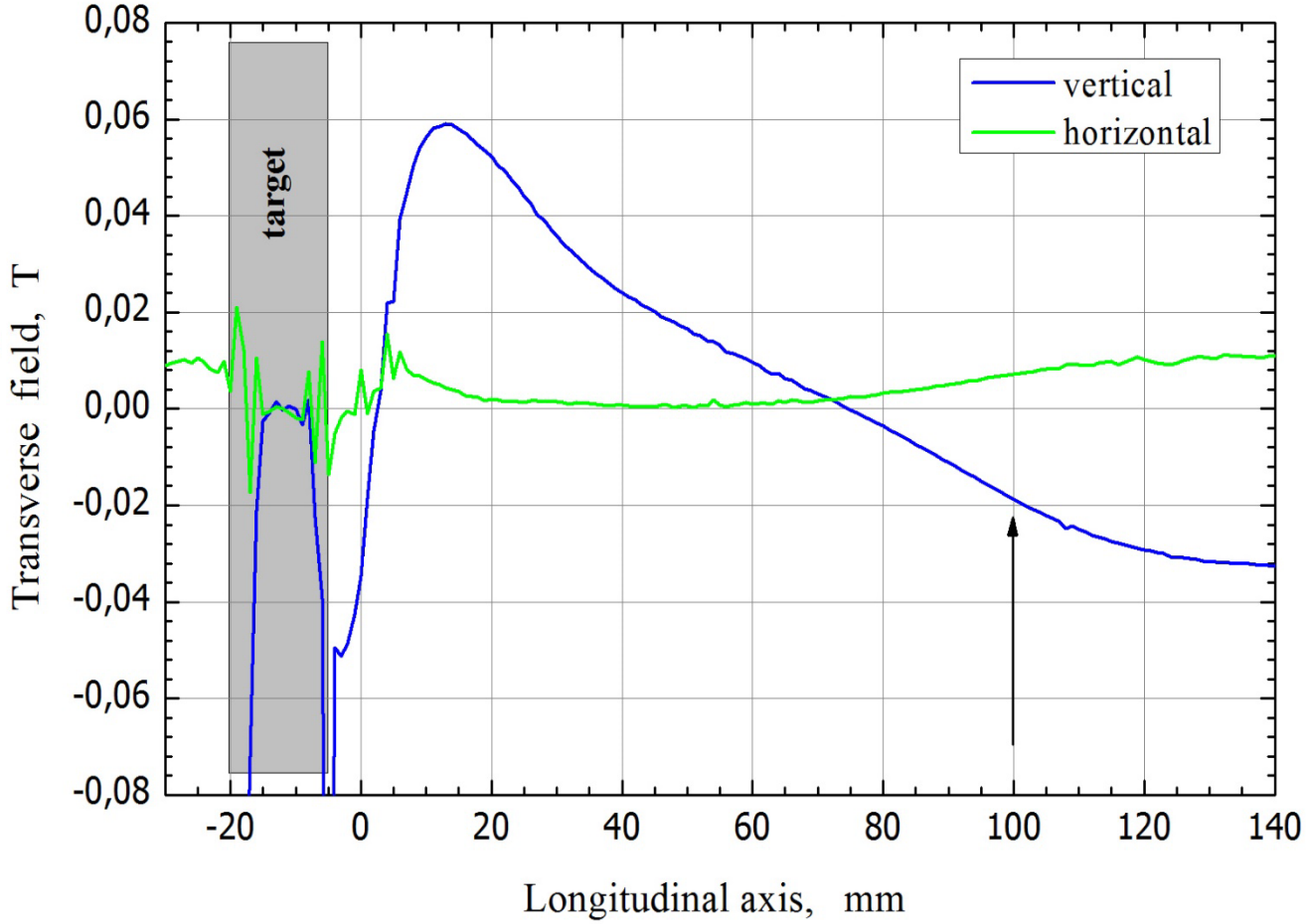


Longitudinal magnetic field component
on a longitudinal (top)

Peak current 25 kA
Pulse duration 25 μs
Target ohmic losses 10 J/pulse
FC ohmic losses 160 J/pulse

Minimal Cone diameter is 16 mm

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



1. Target computation
    - positron production rate vs an electron bunch energy
    - total deposited power in a target material defines target type, target cooling, target size
    - PEDD peak energy deposition density (W74Re26 material has a PEDD limit of 35 J/g)

2. FC magnetic field simulation with a target close setup

3. Positron yield for S-band and L-band structure with a real FC magnetic field
    - FC magnetic field peak optimization
    - solenoid field optimization
    - bridge coils field profiles optimization

DR ring energy acceptance, positron bunch length?