PAUL SCHERRER INSTITUT

PSI

Paolo Craievich on behalf of the collaboration team :: Paul Scherrer Institut

FCC-ee injector update & (Future) Positron source test at PSI

FCC November Week 2020, 10th November 2020

Premise

- Recently the *Swiss Accelerator Research and Technology* (CHART II) collaboration approved to finance the FCC-ee Injector update studies and a proof of principle for a positron source at PSI/SwissFEL facility
  - Collaboration between PSI and CERN with several external partners (IJCLab, INFN-LNF, BINP, KEK…)
  - Duration 4 years (from September 2020) + to be considered 1 year extension 😂
  - Goals:
    - review of the actual CDR0/Injector and write a CDR+/Injector with cost estimate
    - Proof of principle of the positron source at PSI/SwissFEL

Credits

The ideas/outcomes presented in this contribution has been carried out in the last months. An acknowledgment goes to all the colleagues who contribute to it: I hope, cited in a right way here and in the talk

I. Chaikovska, A. Faus-Golfe – IJCLab

K. Oide, Y. Enomoto, K. Furukawa – KEK

P. Martyshkin – BINP

C. Milardi – INFN-LNF

R. Zennaro, M. Pedrozzi, H. Braun, J.-Y. Raguin, S. Sanfilippo – PSI

A. Grudiev, F. Zimmermann, S. Ogur, M. Benedikt, S. Gilardoni, A, Latina, S. Doebert, T. Gilles, P. Hilser – CERN

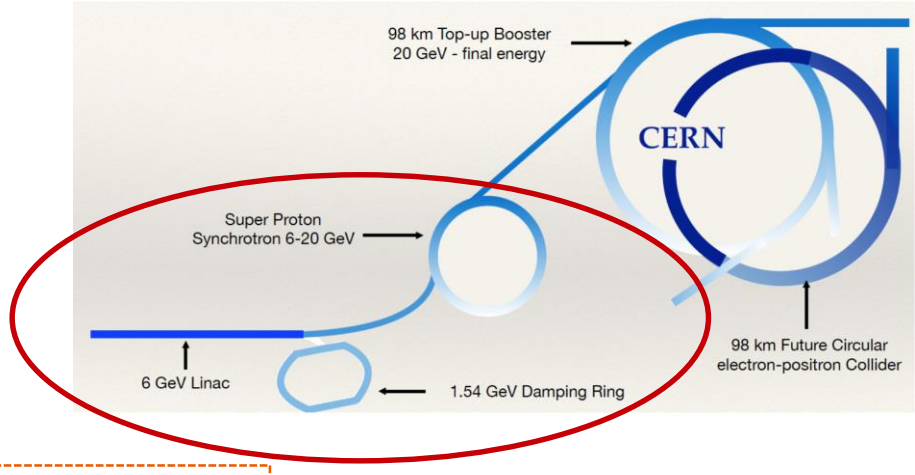
B. Dalena, A. Chance - CEA

Outline

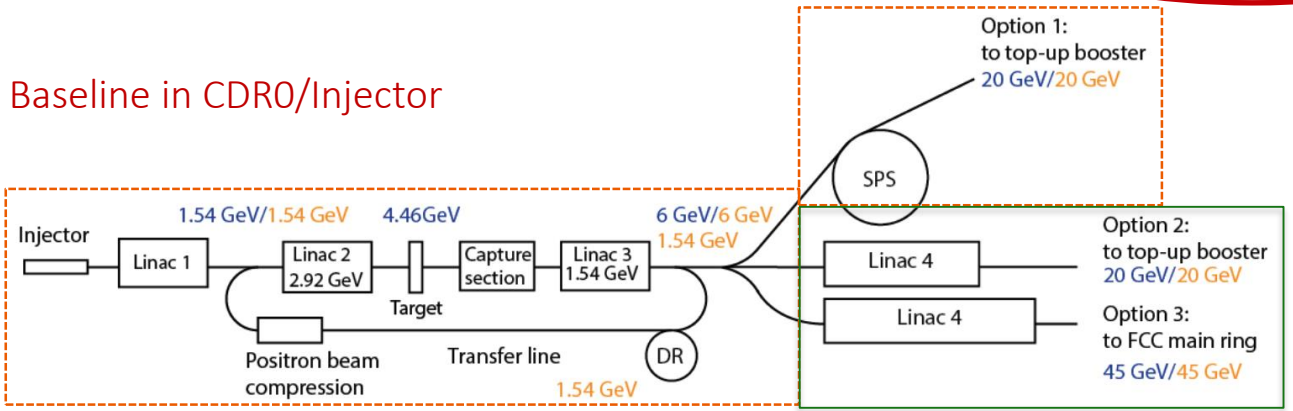
- Introduction to the FCC-ee Injector Complex Update
- Layout of the Injector 6 GeV (20 GeV)
- Positron source experiment at Paul Scherrer Institut
  - Introduction to SwissFEL
  - Location of the experiments
  - Status of the positron sources studies
  - Options for the experiments

Introduction (FCC-ee Injector Complex Updated)

- e-/e+ linac up to 6 GeV, 1.54 GeV Damping Ring
- SPS as a Pre-Booster Damping Ring (6 - 20GeV)
- Booster Ring (20 → 45 GeV)
- The main 6 GeV linac hosts the e+ source. The positrons are produced with 4.46 GeV e- beam

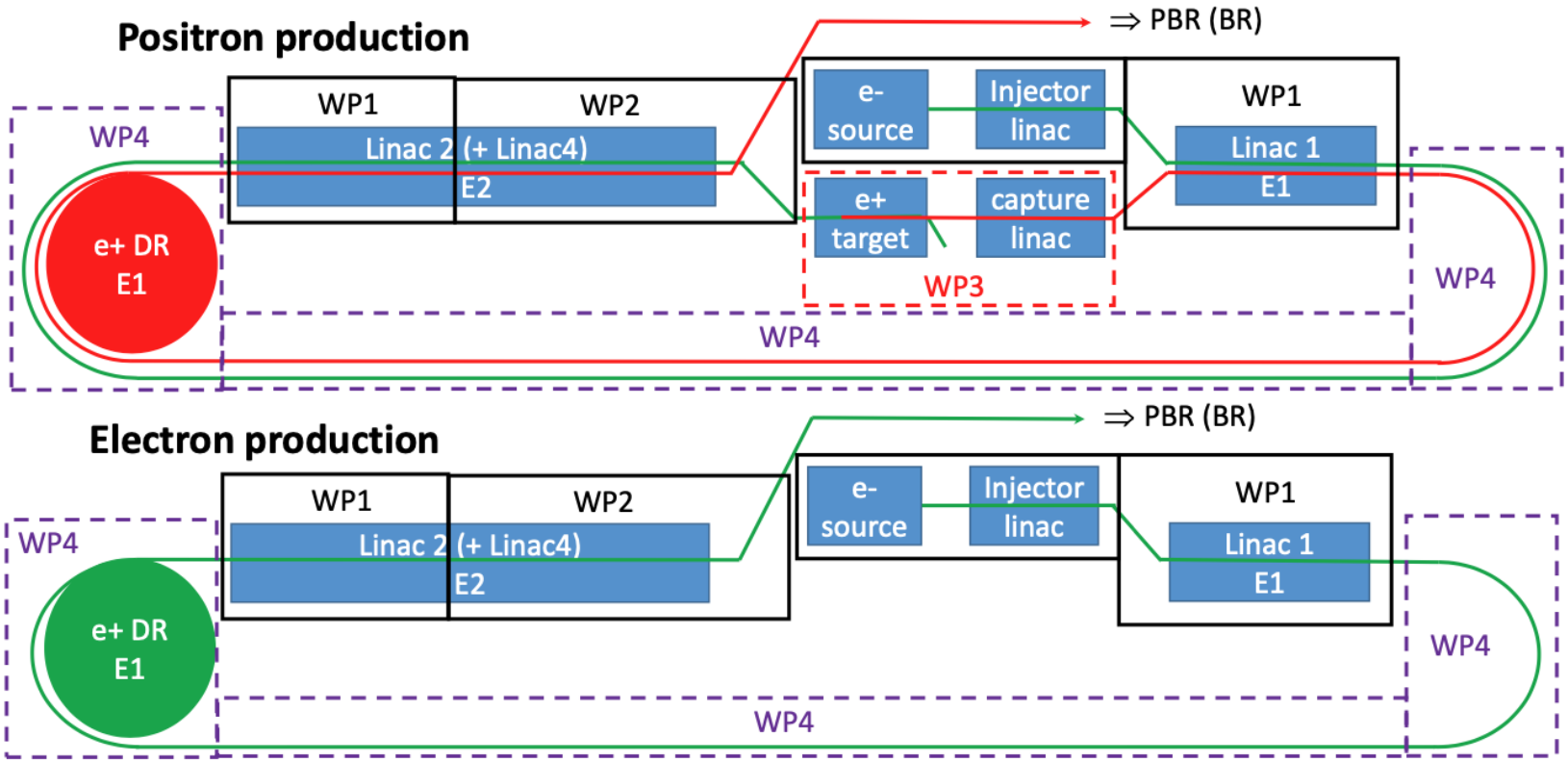


Baseline in CDR0/Injector



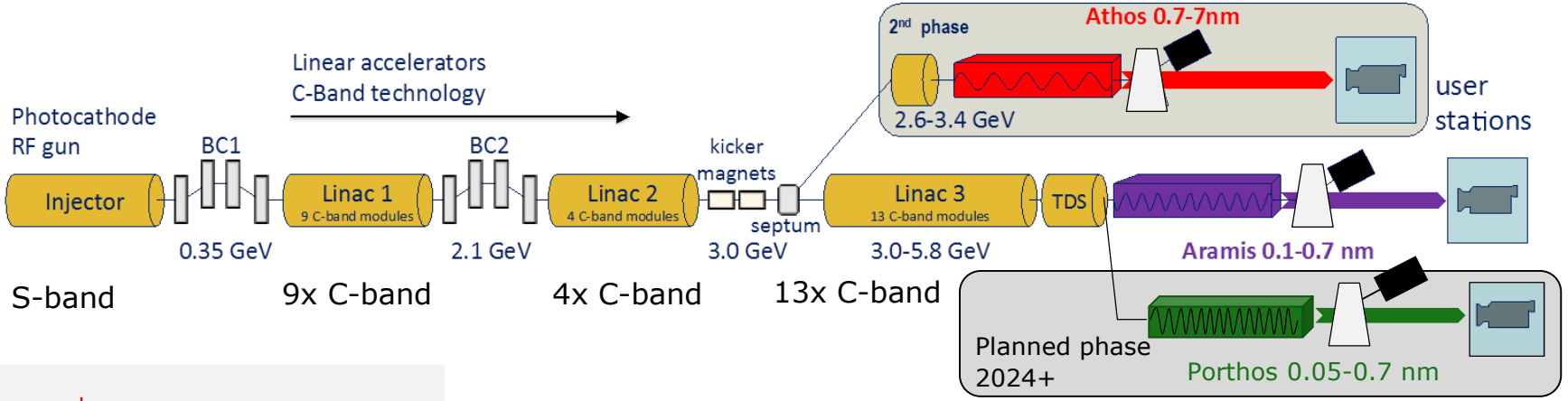
As alternative options for the FCC-ee Injector, a 20 GeV or a 40 GeV linacs are proposed to provide the direct injection into the main booster or main ring

Layout of the injector 6 GeV (20GeV)



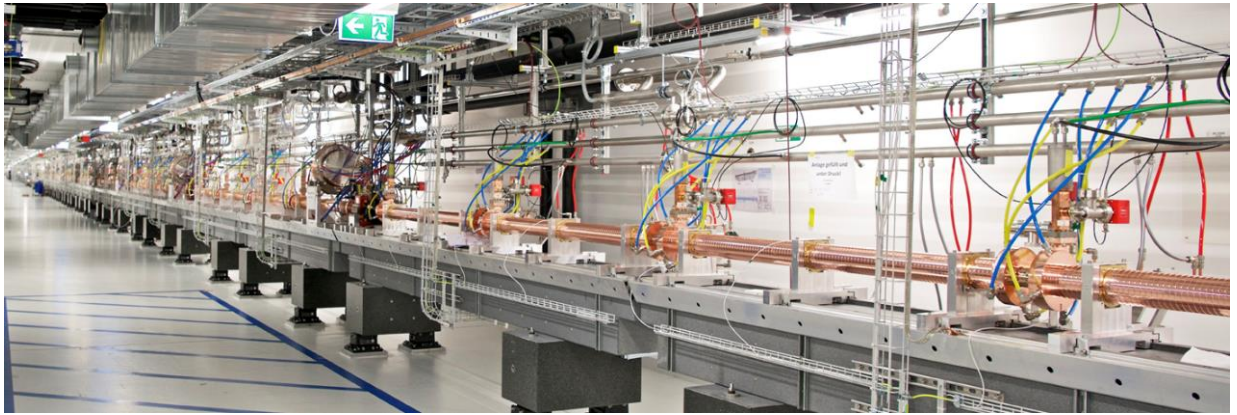
Outcome from WP0.2 meetings leading by A. Grudiev

Introduction to the SwissFEL



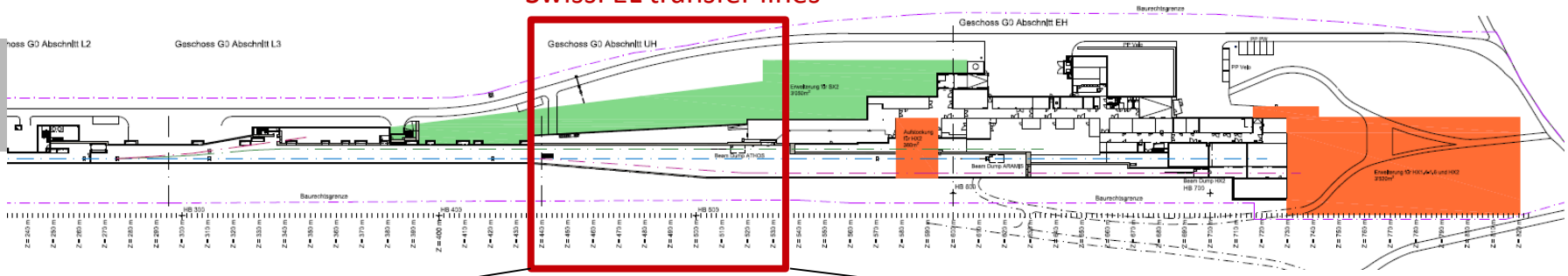
Main parameters

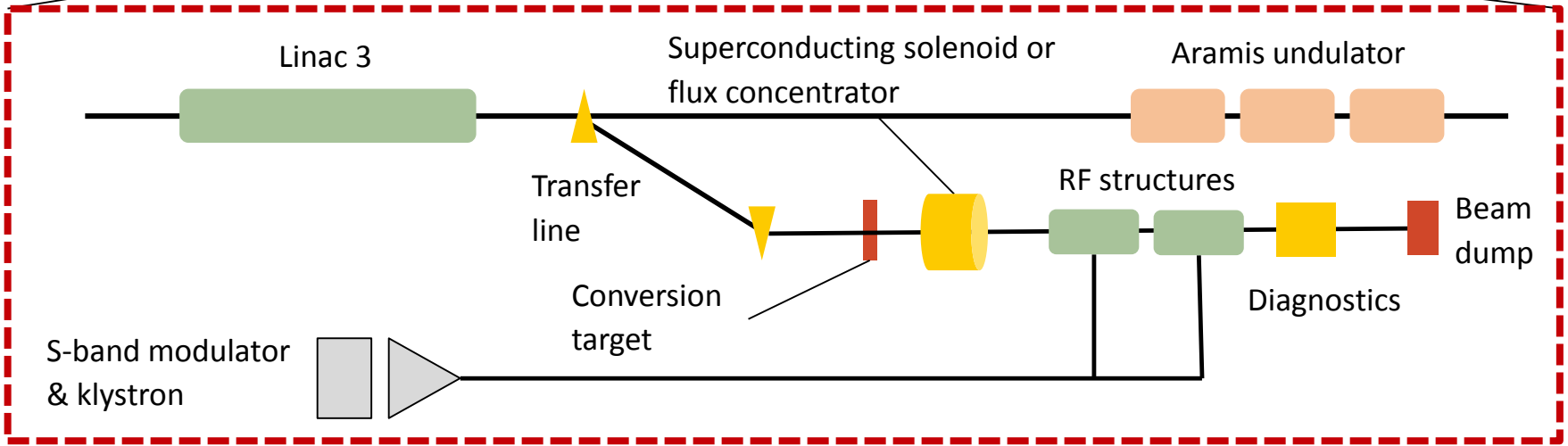
Beam energy	6.2 GeV
Bunch charge	10-200 pC
Repetition rate	up to 100 Hz
Pulse duration	<1 fs – 3 ps (rms)
Norm. emittance	400 nm
Overall length	740 m



WP6: Positron source in SwissFEL

SwissFEL transfer lines



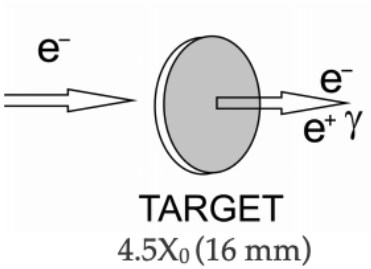


Transfer line to the e^+ experiment and to future Porthos beamline

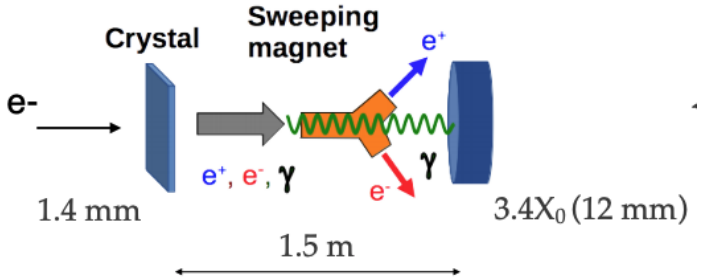
- Transfer line at the linac end: we are thinking to use a 2 degree dipole at the linac end to have a simple outcoupling and a double bend achromat layout to close the dispersion in the straight line
- Beam dump into outcoupling direction with the idea to keep it for the tune-up of the future Porthos beamline (work in progress).

...positron sources... schemes under investigatiomn

1) Conventional target

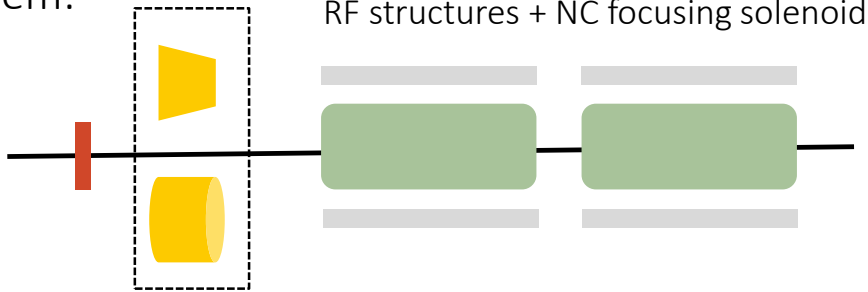


2) Hybrid target



Capture system:

RF structures + NC focusing solenoids



2 options to be considered for the Adiabatic Matching Device (AMD):

a. Flux concentrator (Pulsed magnet)

b. Superconducting solenoids

Studies on the positron production (work in progress)

Electron beam energy 4.46 GeV (FCC-ee Injector baseline)

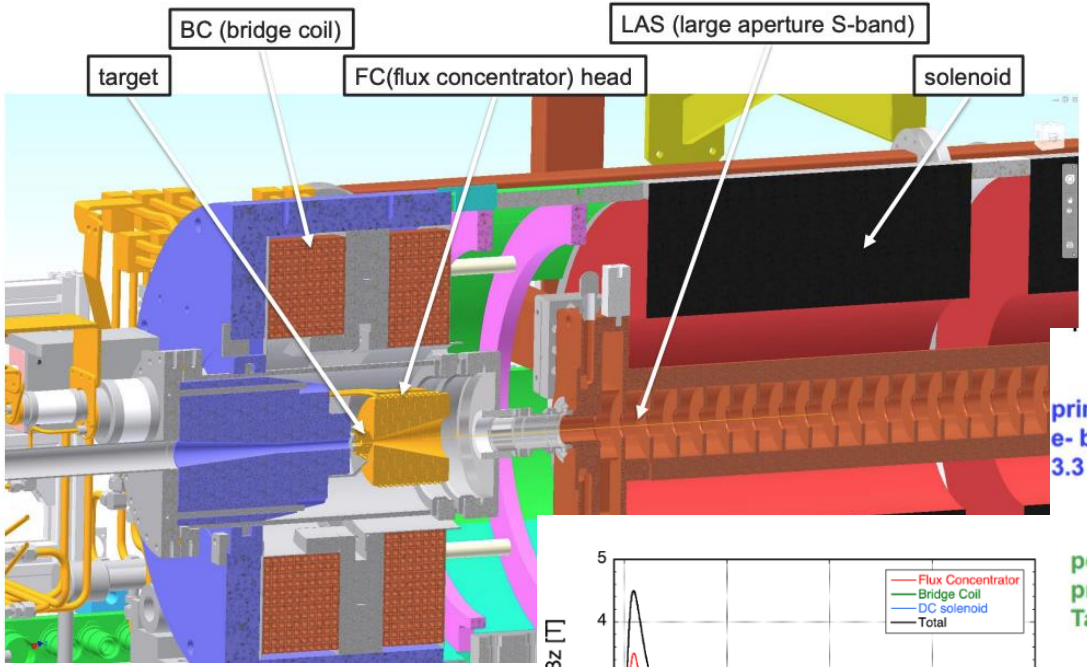
Beam Parameter	CLIC-like Hybrid	Absorber Hybrid	Conventional	18.5 GeV	SuperCon.
Target thickness	**0.4 X_0/ 3.4X_0**	**0.4X_0/ 3.4X_0**	**4.5X_0**	**6.3X_0**	**4.5X_0**
e+ yield @ Target	6.5 e+/e-	6.5 e+/e-	10.5 e+/e-	38.6 e+/e-	10.5 e+/e-
PEDD (Target)	2.1 J/g	2 J/g	24 J/g	80 J/g	24 J/g
Power deposited (Target)	1.5 kW	1.5 kW	2.6 kW	13.2 kW	2.6 kW
AMD Field	7 T	7 T	7 T	7 T	8 T
AMD length	7.4 cm	7.4 cm	7.4 cm	7.4 cm	-
AMD aperture ⌀	8/44 mm	8/44 mm	8/44 mm	8/44 mm	-
e+ yield @ AMD	2.4 e+/e-	~2.4 e+/e-	5.6 e+/e-	21 e+/e-	10.2
DC Solenoid Field	0.7 T	0.7 T	0.7 T	0.7 T	0.8 T
RF frequency	2 GHz	2 GHz	2 GHz	2 GHz	2.856 GHz
AS length (TW)	1.5 m	1.6 m	1.6 m	1.6 m	3.2 m
Axial E-field	16 MV/m	16 MV/m	16 MV/m	16 MV/m	20 MV/m
Aperture	40 mm	40 mm	40 mm	40 mm	30 mm
e+ yield @ 200 MeV	1.30 e+/e-	1.4 e+/e-	3 e+/e-	11.5 e+/e-	4.6 e+/e-
Accepted e+ yield @ 200 MeV	0.74 e+/e-	0.67 e+/e-	1.4 e+/e-	8.2 e+/e-	1.8 e+/e-

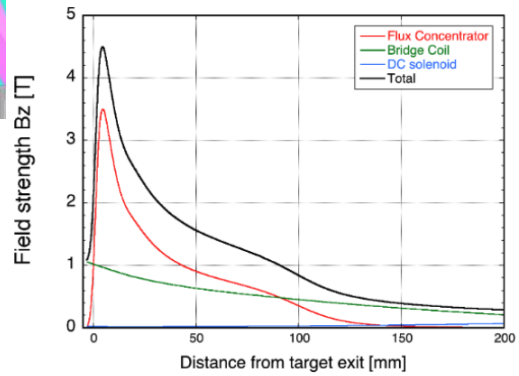
Option a

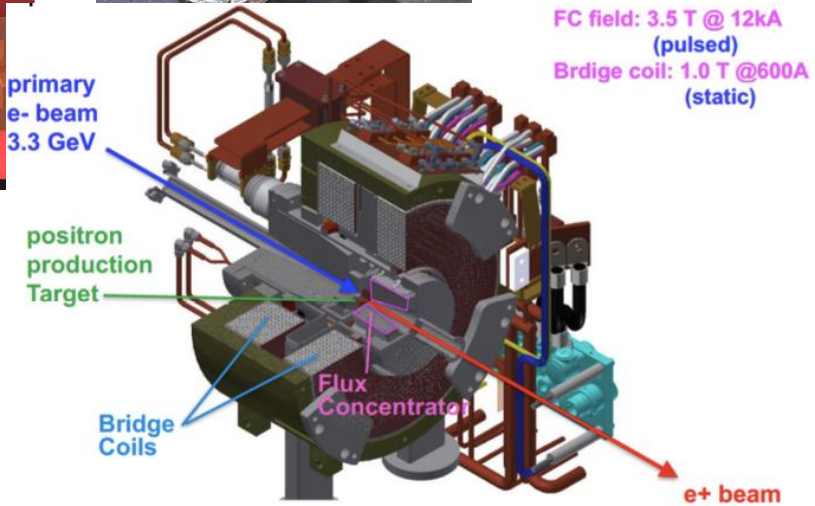
Option b

Courtesy of Iryna Chaikovska and Yanliang Han (IJCLab)

a. Flux concetrator (Super KEKB Positron)

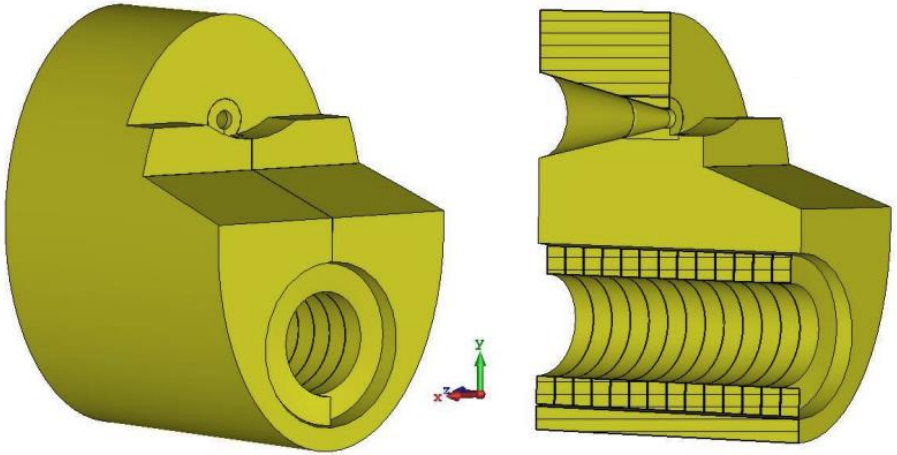






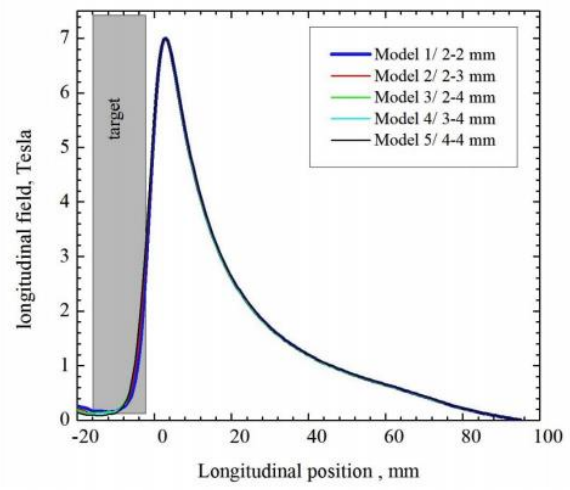
Courtesy of Y. Enomoto (SuperKEKB)

a. Flux concetrator – FCC design (presently)



- Elliptical cylinder 120x180 mm-
- Total length is140 mm-
- Conical part length is 70 mm-
- Min cone diameter is 8 mm-
- Max cone diameter is 44 mm-
- Cone angle is ≈29 degrees-
- Cylindrical hole diameter is 70 mm-
- Coil has 13 turns

- Electron beam energy 4.46 GeV
- Peak field: 7 T
- DC solenoid: 0.5-0.7 T (uniform profile)
- Field on target: ~3 T
- 3D field map is provided
- *Also studies for a 5 Tesla peak field*
- *DC Solenoid: 0.5 T (uniform field)*



Courtesy of Pavel Martyshkin Budker Institute of Nuclear Physics, Novosibirsk

b. Superconducting solenoid – FCC

$$B(z) = B_W + \frac{B_t - B_w}{(1 + (z/R_s)^2)^{1.5}}$$

- Bw = 0.8 T
- Bt = 8.8 T

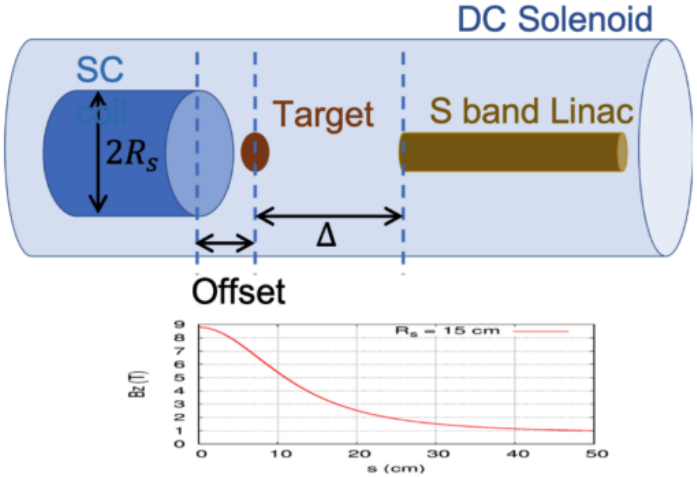
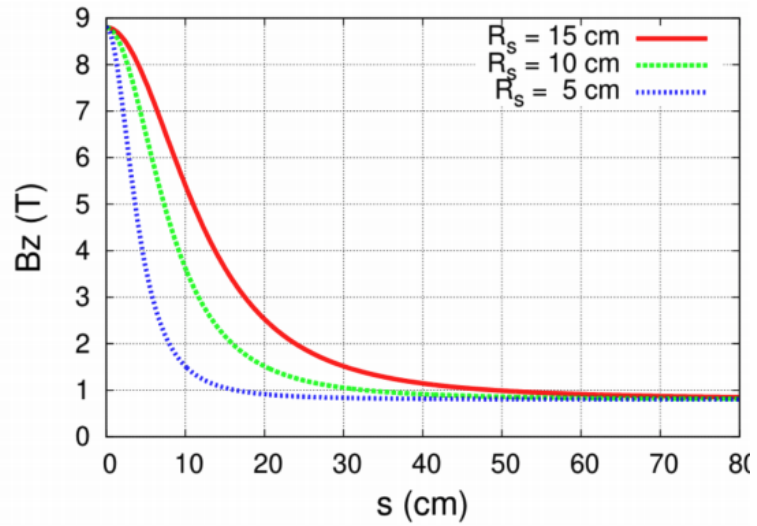
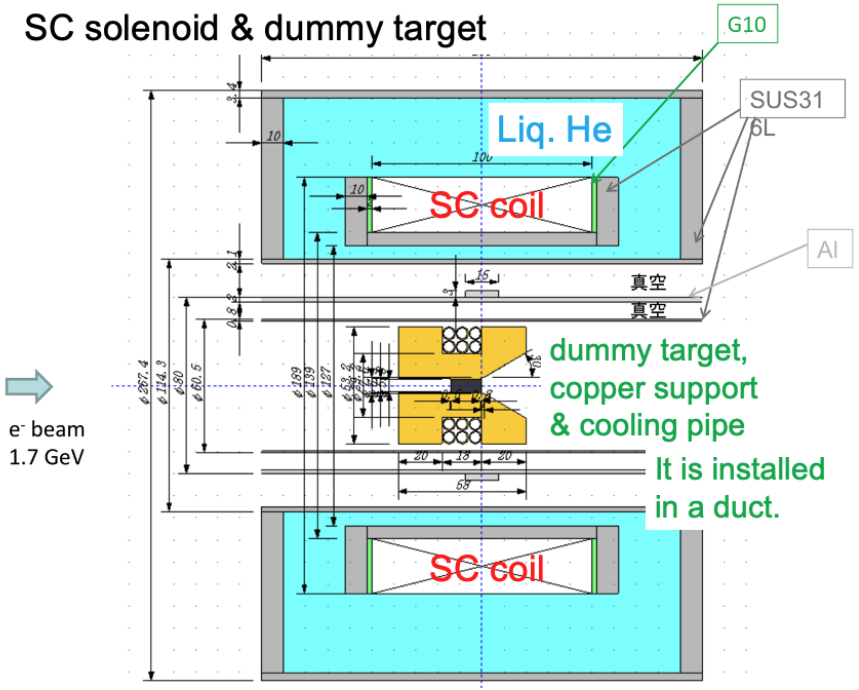


Figure 3: The sketch of the simulation environment.



Courtesy of Y. Han and I. Chaikovska (IJCLab Orsay)

b. Superconducting solenoid – SuperKEK



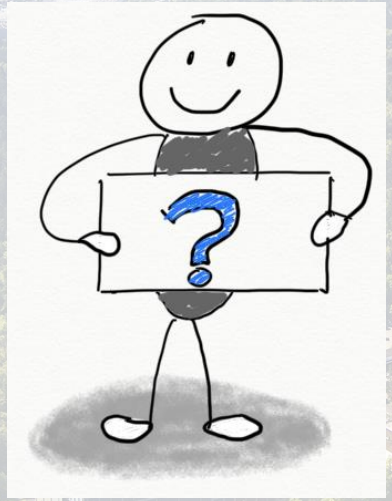
Experiment: 7 nC x 2 electron beams on target, field 3.2 T, 50 Hz

Courtesy of T. Kamitani (KEK)

Wir schaffen Wissen – heute für morgen

Thank you for the attention!

Any questions?



The Future Circular Collider Innovation Study (FCCIS) project has received funding from the European Union's Horizon 2020 research and innovation programme under grant No 951754