FCC IS WP2 Closeout

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FCC IS WP2 Workshop, December 10, 2021

U.S. DEPARTMENT OF ENERGY | Stanford University

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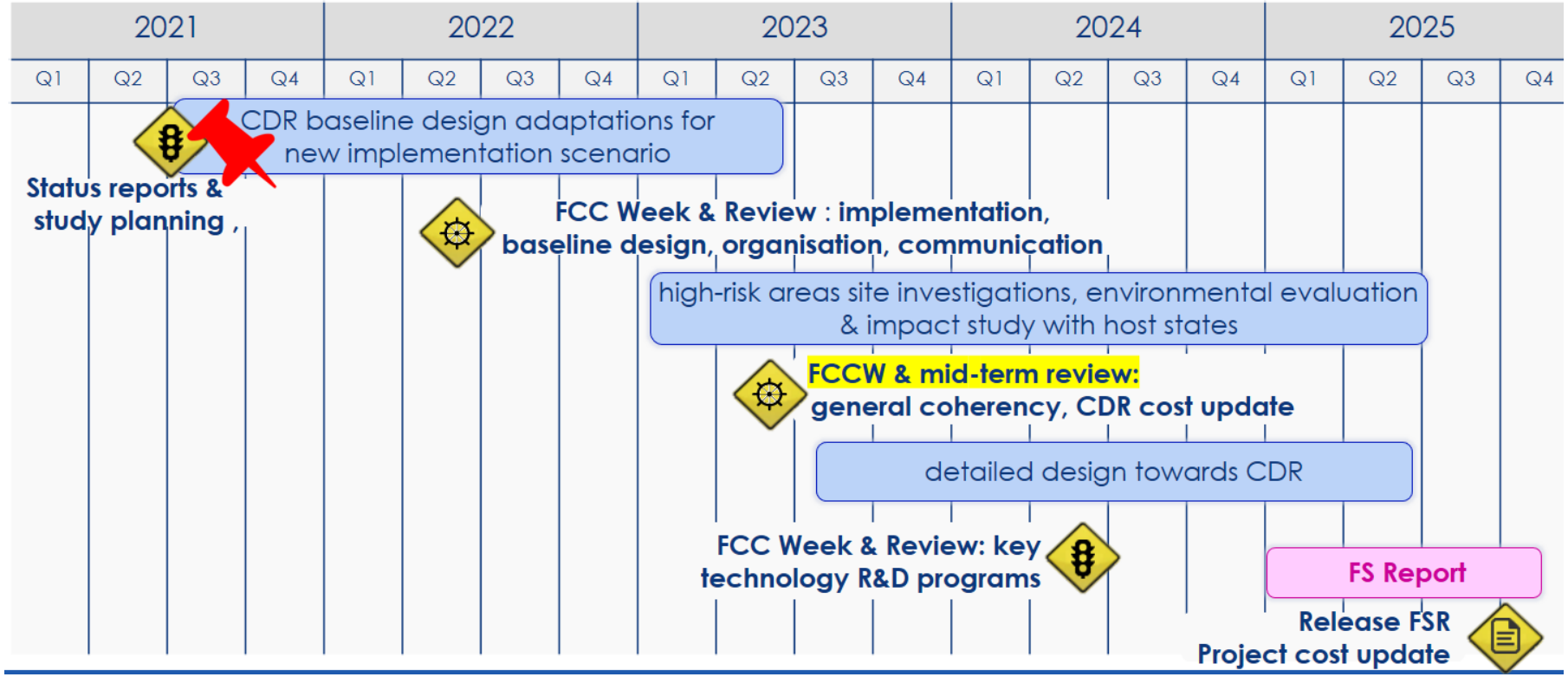
Goals for the FCC

The FCC CDR was developed for the 2020 European Strategy (ESPP)

Now push the design further with detailed placement options to a pre-TDR level for the next ESPP in 2026.

Focus on the FCC-ee to address Z, W, Higgs, and t-tbar before an FCC-hh



Accelerator Development Goals and Timeline

- Self-consistent Baseline configuration for Feasibility Study by end of 2025
- Support mid-term and final costing exercises in June 2023 and December 2025
  - Complete beam optics aligned to the present tunnel placement and initial component specification by January 2023 to allow cost development through May 2023 **for mid-term FCC review in June 2023**
    - Optics specifications with correction elements, RF, collimation and injection systems
    - Beam dynamics calculations to include initial studies: tuning and correction; dynamic aperture with errors; beam-beam with errors; collective effects.
    - FCCee Injector and Booster optics and layouts completed with tradeoff studies documented
    - FCChh optics layout in consistent layout
    - Technology R&D specification with milestones
- Iterate to support the Feasibility Study costing exercise from January 2025 through December 2025

FCC Accelerator Status

Placement updated with slightly smaller footprint (91 km) and 8 accesses

Updating main ring optics for 4 IPs with new placement for 4 energies

Selected baseline high-level parameters (mostly)

Working on MDI, RF layout, collimation, and injection/extraction

Many outstanding physics and tuning questions

Developing Booster and Injector configurations

Working to ensure compatibility with FCC-hh

Technical R&D program is prioritizing tasks

Energy calibration and polarization studies beginning – critical for Z physics

Parameters

To be updated in **January**

Will provide parameter ranges and dependencies to clarify interactions

Beam energy	[GeV]	45.6	80	120	182.5
Layout		PA31-1.0			
# of IPs		4			
Circumference	[km]	91.174117		91.174107	
Bending radius of arc dipole	[km]	9.937			
Energy loss / turn	[GeV]	0.0391	0.370	1.869	10.0
SR power / beam	[MW]	50			
Beam current	[mA]	1280	135	26.7	5.00
Bunches / beam		9600	880	248	36
Bunch population	[10^{11}]	2.53	2.91	2.04	2.64
Horizontal emittance ε_x	[nm]	0.71	2.16	0.64	1.49
Vertical emittance ε_y	[pm]	1.42	4.32	1.29	2.98
Arc cell		Long 90/90		90/90	
Momentum compaction α_p	[10^{-6}]	28.5		7.33	
Arc sextupole families		75		146	
$\beta^*_{x/y}$	[mm]	150 / 0.8	200 / 1.0	300 / 1.0	1000 / 1.6
Transverse tunes/IP $Q_{x/y}$		53.563 / 53.600		100.565 / 98.595	
Energy spread (SR/BS) σ_δ	[%]	0.039 / 0.130	0.069 / 0.154	0.103 / 0.185	0.157 / 0.229
Bunch length (SR/BS) σ_z	[mm]	4.37 / 14.5	3.55 / 8.01	3.34 / 6.00	2.02 / 2.95
RF voltage 400/800 MHz	[GV]	0.120 / 0	1.0 / 0	2.08 / 0	4.0 / 7.25
Harmonic number for 400 MHz		121648			
RF freuqeuncy (400 MHz)	MHz	399.994581		399.994627	
Synchrotron tune Q_s		0.0370	0.0801	0.0328	0.0826
Long. damping time	[turns]	1168	217	64.5	18.5
RF acceptance	[%]	1.6	3.4	1.9	3.1
Energy acceptance (DA)	[%]	±1.3	±1.3	±1.7	-2.8 +2.5
Beam-beam ξ_x/ξ_y [a]		0.0040 / 0.152	0.011 / 0.125	0.014 / 0.131	0.096 / 0.151
Luminosity / IP	[10^{34}/cm^{2}s]	189	19.4	7.26	1.33
Lifetime (q + BS)	[sec]	–		1065	2405
Lifetime (lum)	[sec]	1089	1070	596	701

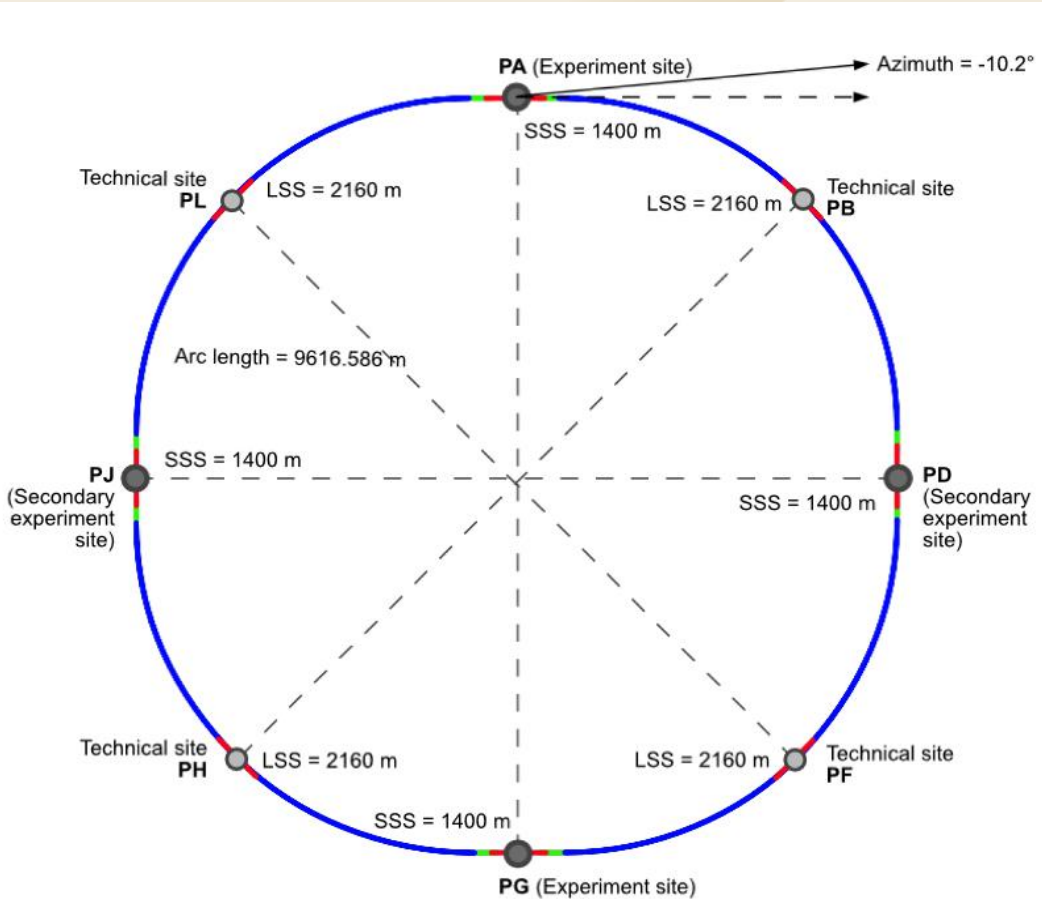
Main Ring Optics
new placement with 4 IPs

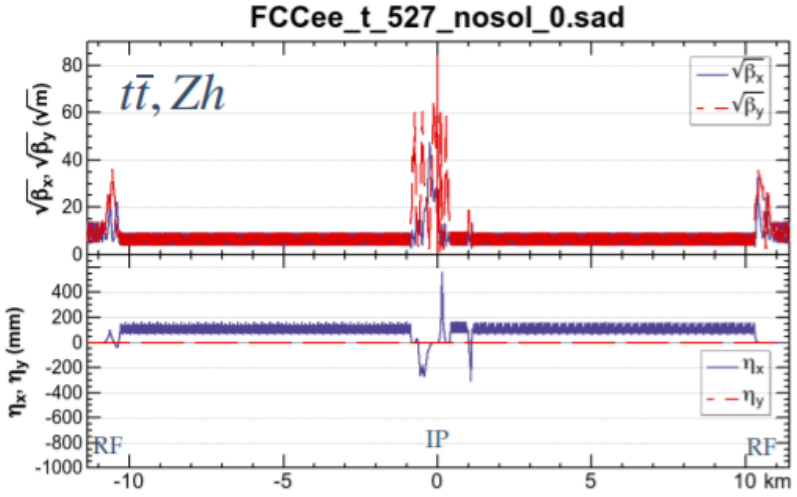
First new optics developed in September 2021

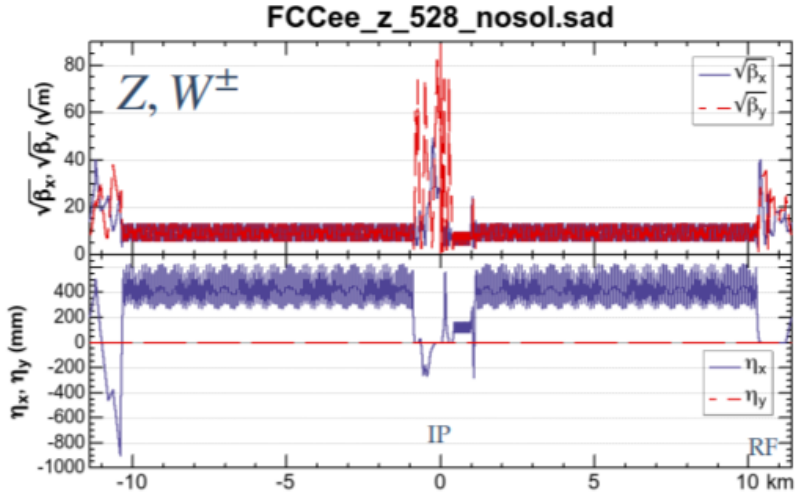
2 main optics configurations: Z, W and Zh, ttbar

Aim to ‘release’ optics with correct harmonic number and circumference by February

Using September optics to develop tuning algor







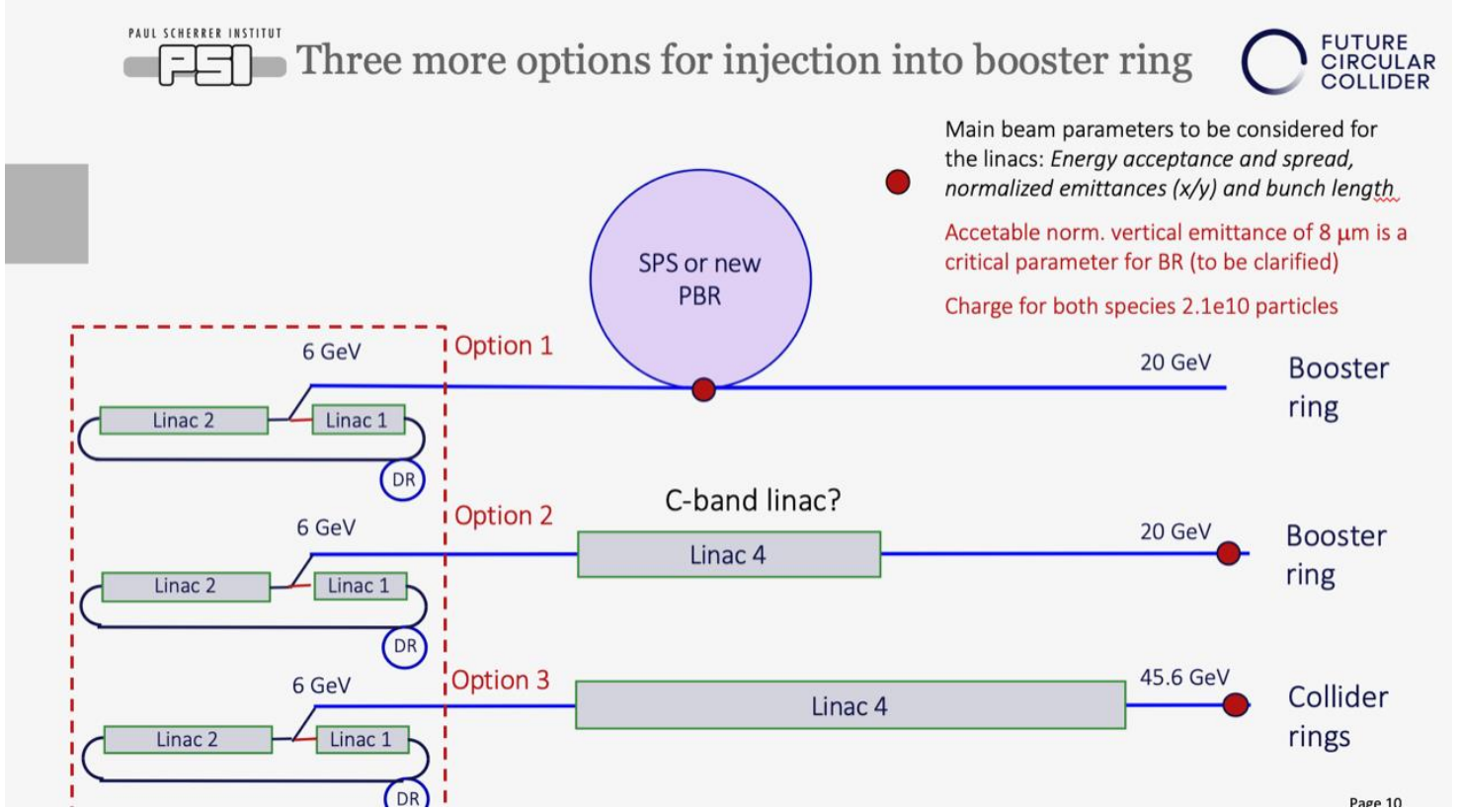
Subsystem Definitions

Along with the main ring placement, major subsystems are being defined and layouts started:

RF, injection/extraction, beam collimation, polarization meas/control, …..

Booster, Injector, Transfer lines

Need iterations on all of these by June 2022 to understand the preliminary civil and infrastructure requirements



Summary

- Personally, FCCIS Workshop was wonderful!
- Tons of work has been accomplished and is excellent work is ongoing
- Large number of people engaged, especially young people!
- The accelerator will operate in a new regime with very high luminosity at high energy (a merger of the B-factories and LEP) **with new** physics challenges
- Detailed studies are beginning to understand the placement, infrastructure, and civil engineering as well as the beam physics and accelerator components
- Very exciting time with lots to do to define this new collider!