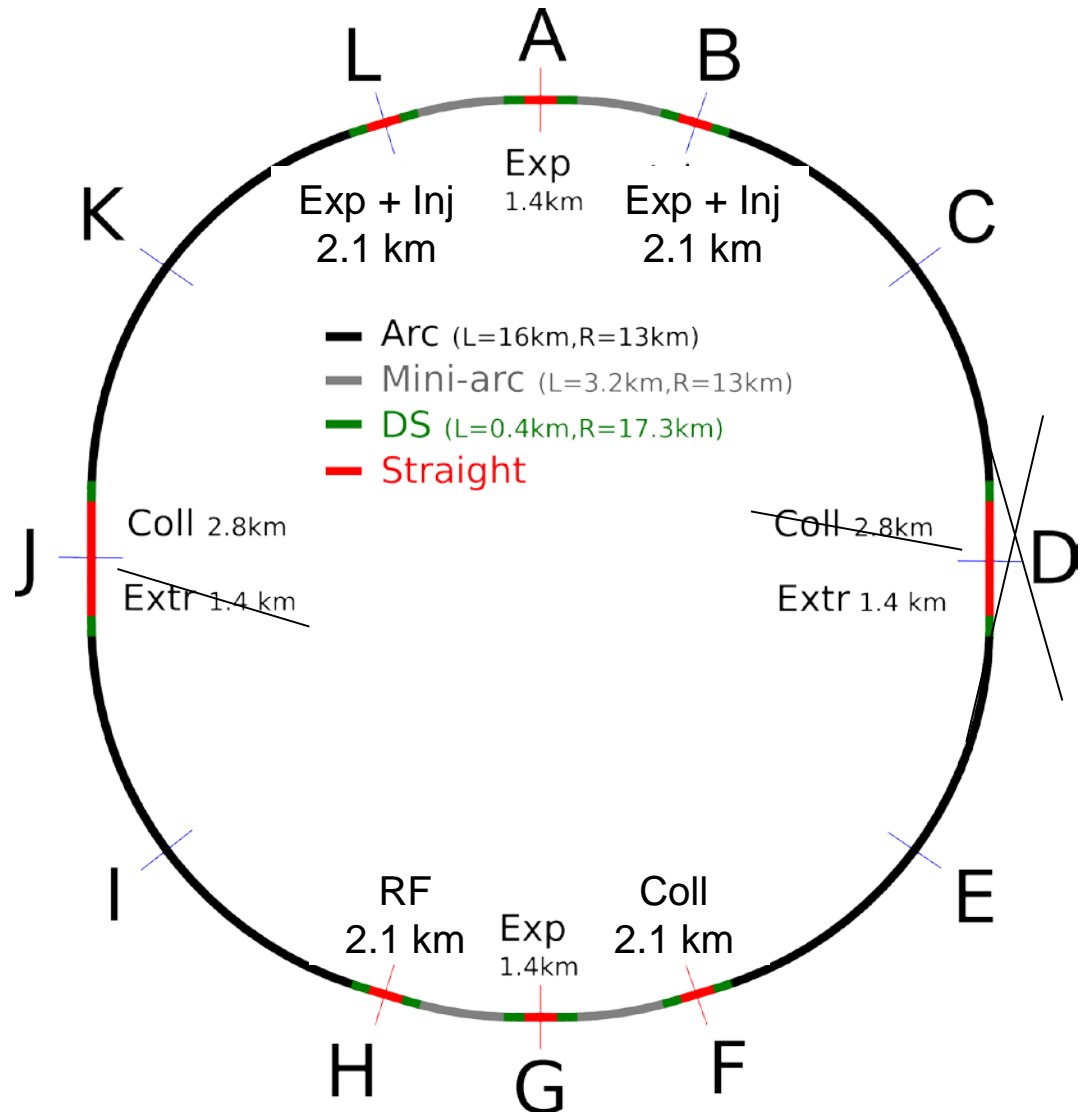








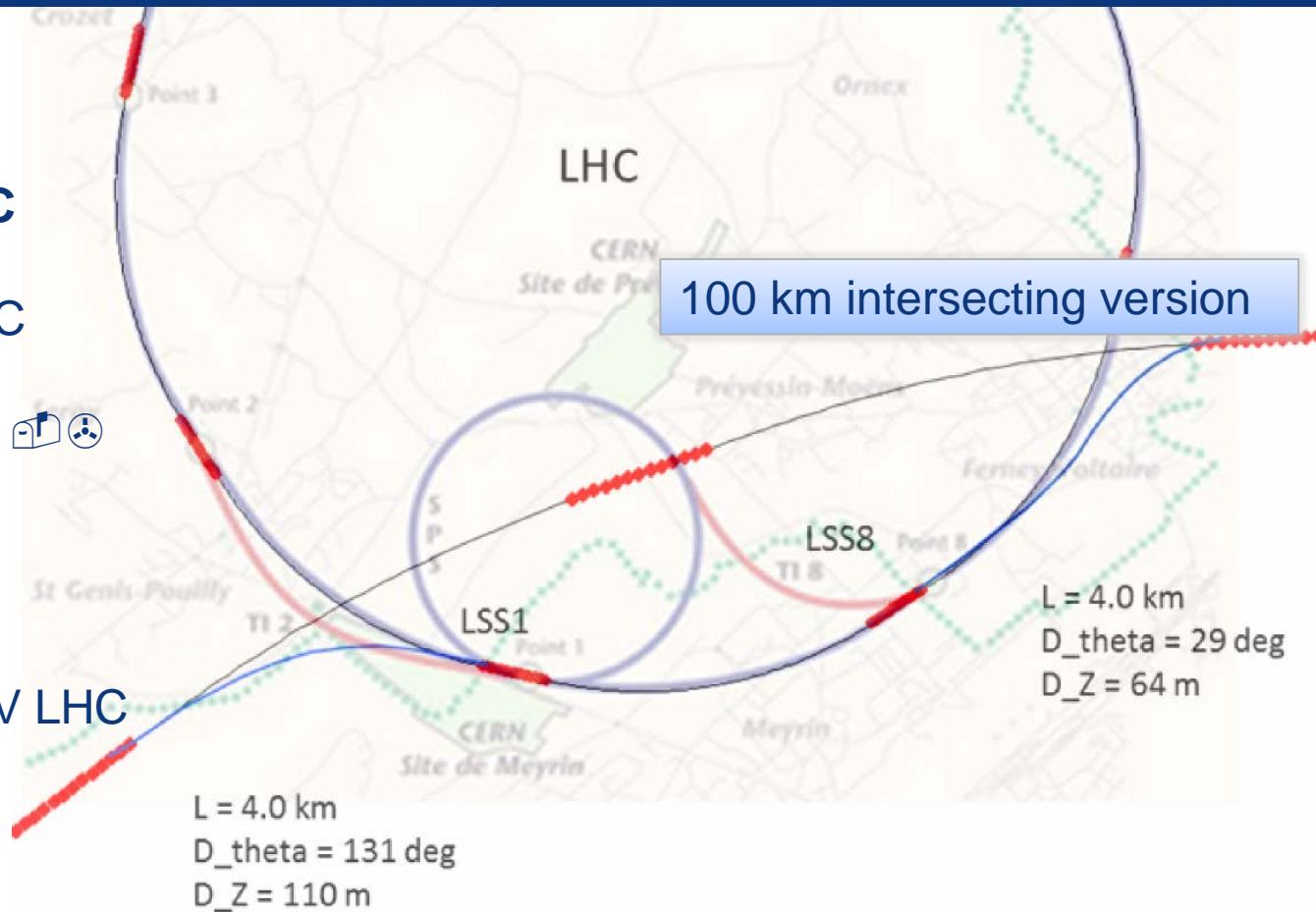
FCC-hh beam instruments

- Two high-luminosity experiments (A and G)
- Two other experiments (B and L):
 - Injection through experiments!
- One collimation insertions in J
- Extraction insertion in D
- One insertions with RF
- One insertion with energy collimation
- Circumference 100km
- Can use LHC or SPS as injector



Injector options:

- SPS => LHC   FCC
- SPS/SPS_{upgrade}   FCC
- SPS -> FCC booster  
FCC



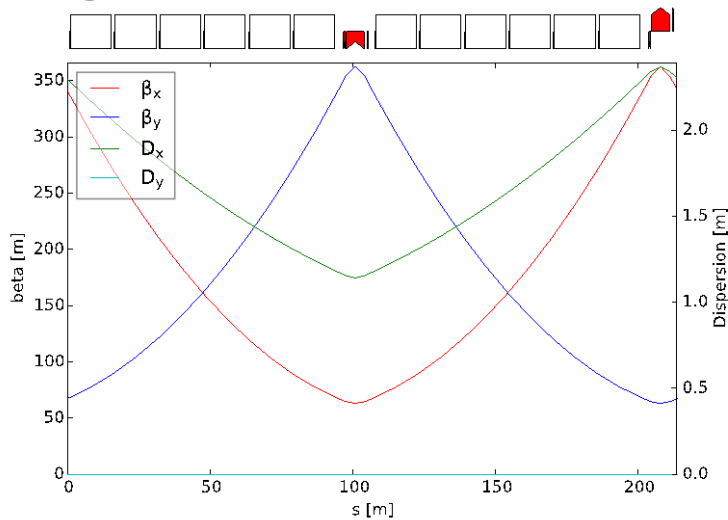
Current baseline:

- injection energy 3.3 TeV LHC
- confirmed by review

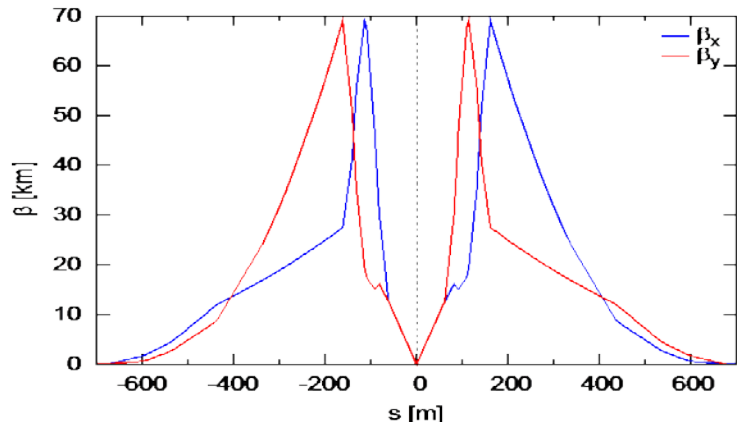
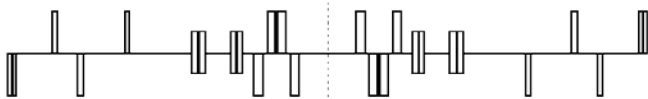
Alternative options:

- Injection around 1.5 TeV
- compatible with: SPS_{upgrade}, LHC, FCC booster

Regular arc cell



Interaction region



Parameters

Parameter		Value
Energy	TeV	50
Circumference	km	100.171
β^*	m	0.3
L^*	m	45
α	10^{-4}	1.008
γ_{tr}	-	99.580
Q_x	-	111.31
Q_y	-	108.32
Q'_x	-	2
Q'_y	-	2
# dipoles MB	-	4616
MB field	T	15.93
# quadrupoles MQ	-	846
Max grad MQ	T/m	370 ^a
# sextupoles MS	-	710
Max grad MS	T/m ²	18670

a. in the arcs

	(HL)-LHC	FCC-hh baseline	FCC-hh ultimate
Collision energy [TeV]	14	100	100
Dipole field [T]	8.3	16	
Luminosity L [10^{34} cm ⁻² s ⁻¹]	(5) 1	5	20-30
Normalized emittance [μ m]	(2.5) 3.5	2.2 (0.44)	
Bunch intensity [10^{11}]	(2.2) 1.15	1 (0.2)	
Bunch spacing [ns] (option)	25	25 (5)	
Beta* [m]	(0.15) 0.55	1.1	0.3
Number of bunch	2808	10600 (53000)	
IP beam size [μ m]	16.7	6.8 (3)	3.5 (1.6)
Rms bunch length [cm]		8	
Stored energy/beam [GJ]	(0.7) 0.36	8.4	
Synchrotron rad. [W/m/beam]	(0.35) 0.18	30	
Dipole coil aperture [mm]	56	40	

List of instruments:

- beam position + AC-dipole + k-modulation+ **coupling**
- tune, chromaticity
- beam intensity (DC, bunch to bunch), lifetime
- beam losses
- transverse profiles
- **abort gap population**
- longitudinal profiles
- specific instrumentation for machine protection:
(aka interlocked BPMs, beam presence flags...)

- In LHC, used to measure:
 - ✓ *Injection trajectories, closed orbits, dispersion, coupling, optics (via phase advance), resonance driving terms etc*

Functionality:

- Measurement of the **closed orbit**
 - provide **turn-by-turn data** for injection oscillations, optics measurements...
 - Closed orbit used for Orbit and radial position real-time feedback
 -
 - Machine protection, Interlocked BPM?
 - A few special BPMs should provide high resolution (μm) **bunch-by-bunch** and **turn-by-turn data** for special purposes (instability observations etc).
-
- Alignment tolerance comparable to LHC:
 - 100 μm in the arc
 - 50 μm in IR
-
- => **LHC-like BPM system but Synchrotron Radiation!**



Beam Loss Monitor



- ❑ Based on LHC BLM system:
 - Quench protection → beam loss scenarios needed
 - UFO detection
 - Vacuum spike detection?
- ❑ Continuous/discrete measurements?
- ❑ Simulation needed

Functionality:

- ❑ Tune measurement
 - ❑ Cohabitation with transverse feedback
- ❑ Transverse profiles:
 - ❑ SR in the arc: critical photon energy 0.575 keV (0.044 keV in LHC)
- ❑ Beam intensity : DC, bunch by bunch, lifetime
 - ❑ Same dynamic range as LHC: from 5×10^9 to $1 \cdot 10^{11}$
- ❑ Abort gap population
- ❑ Longitudinal profiles
- ❑ Obs Box