RING-RING LATTICE

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Acknowledgements: O.S. Brüning, S. Fartoukh,
B. Holzer, J.M. Jowett

Layout and Geometry

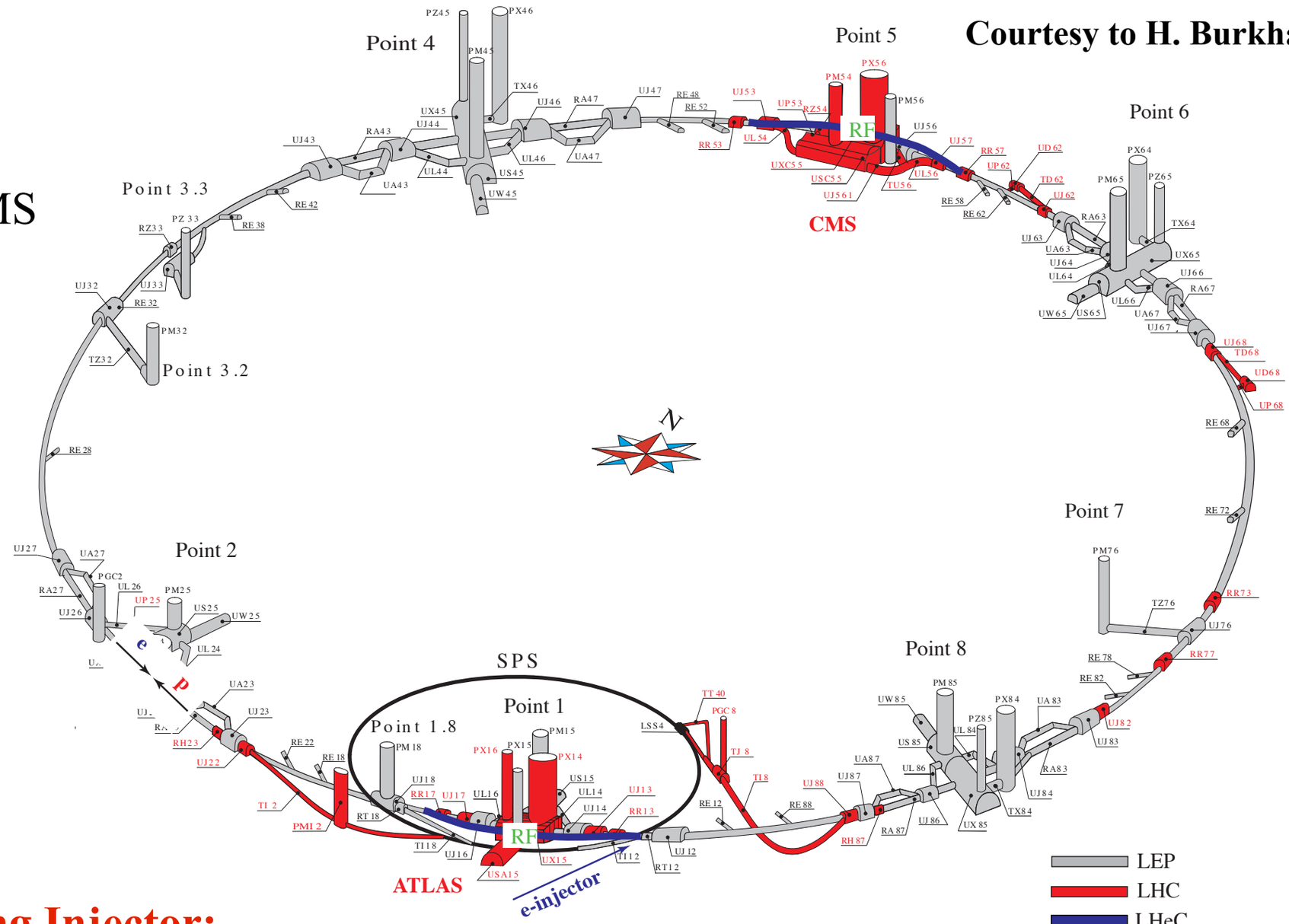
Courtesy to H. Burkhardt

Bypasses:

- around ATLAS and CMS
- host the RF

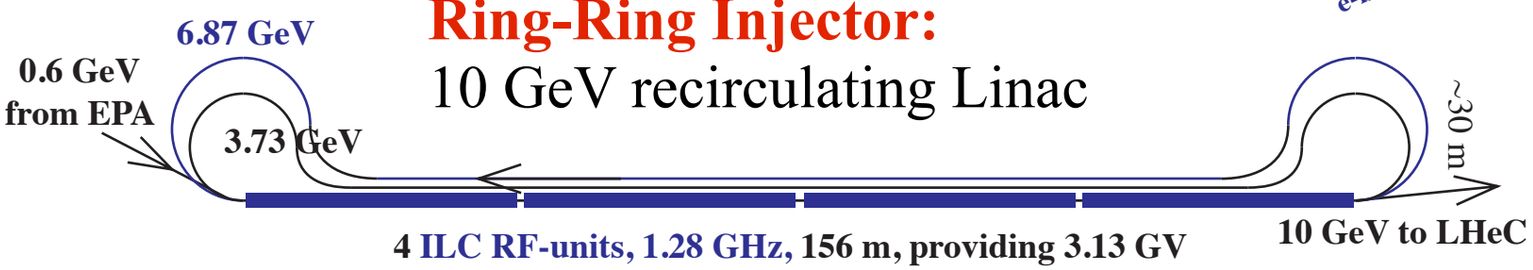
Interaction region:

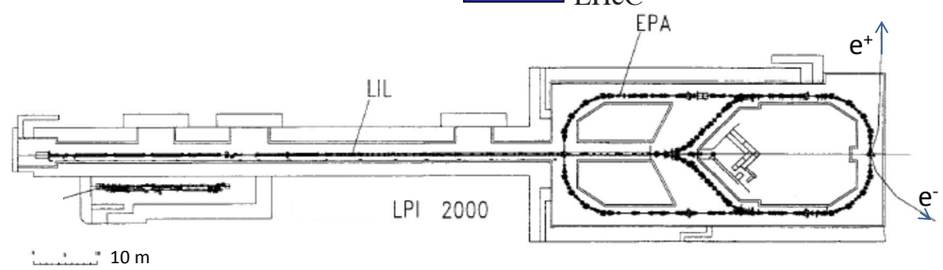
- in Point 2
- two options: High Acceptance (HA) and High Luminosity (HL)



Ring-Ring Injector:

10 GeV recirculating Linac

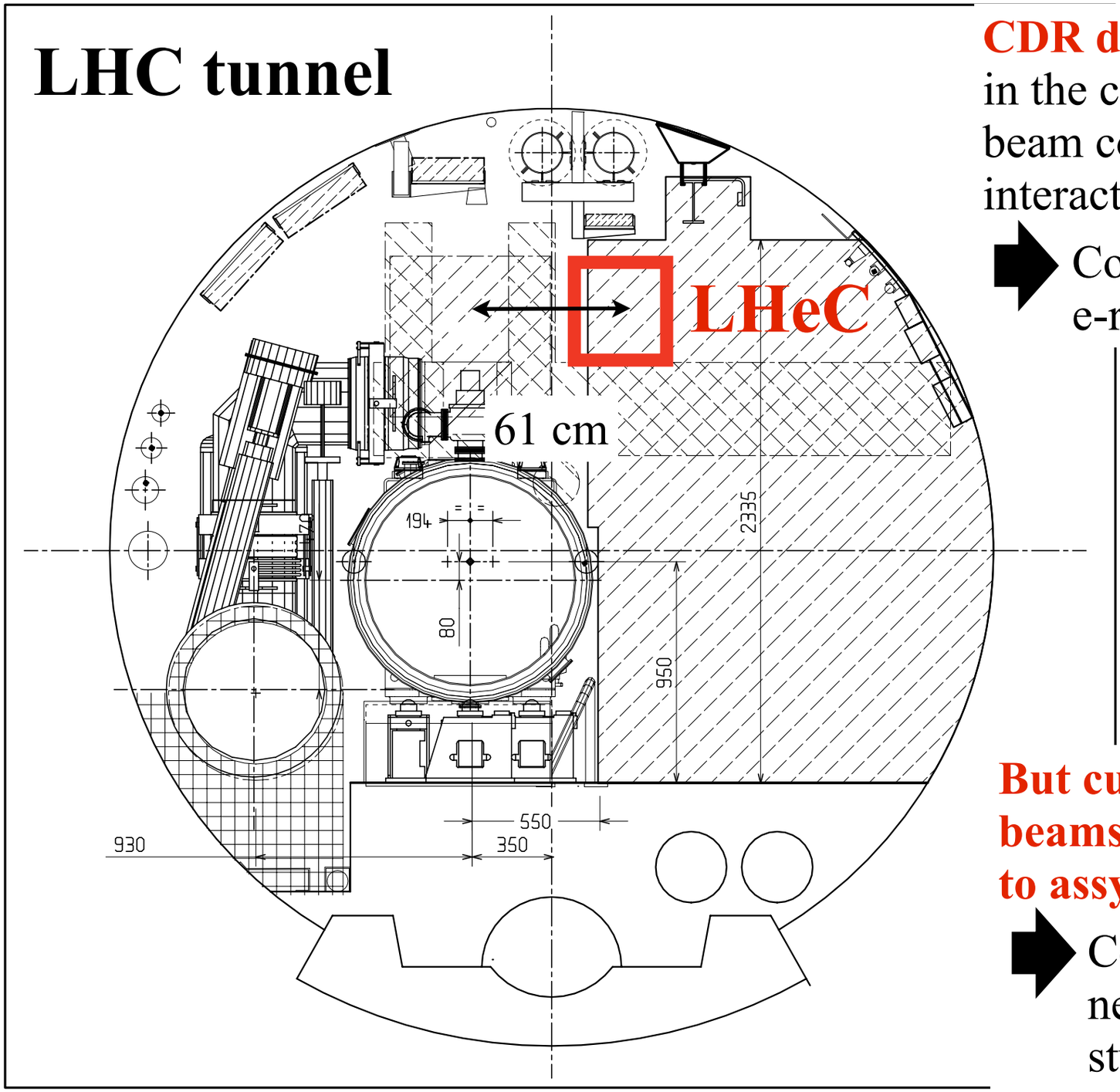




Courtesy to H. Burkhardt

e-Ring Circumference

LHC tunnel



CDR design assumes equal circumferences, as in the case of different circumferences the proton beam could become unstable due to beam-beam interactions with the electrons.

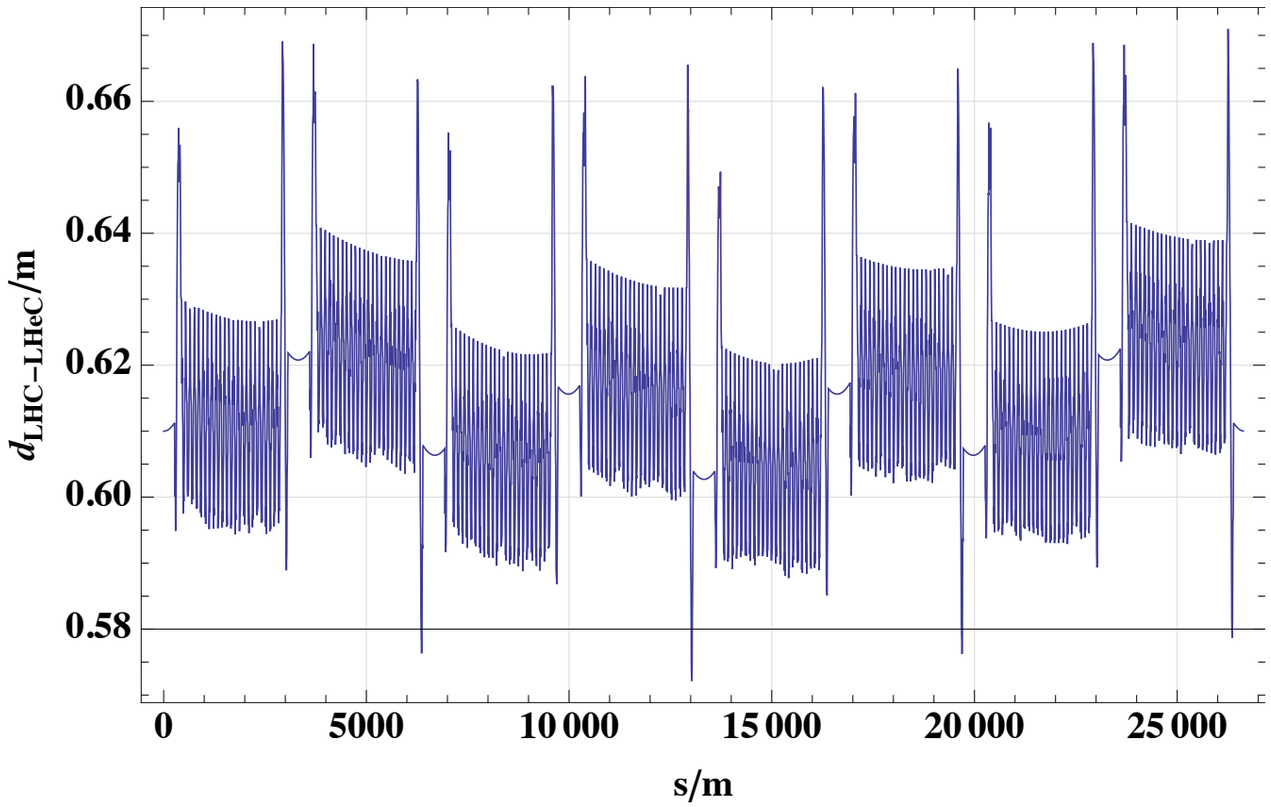
➡ Compensation of the bypasses by placing the e-ring to the inside of the LHC

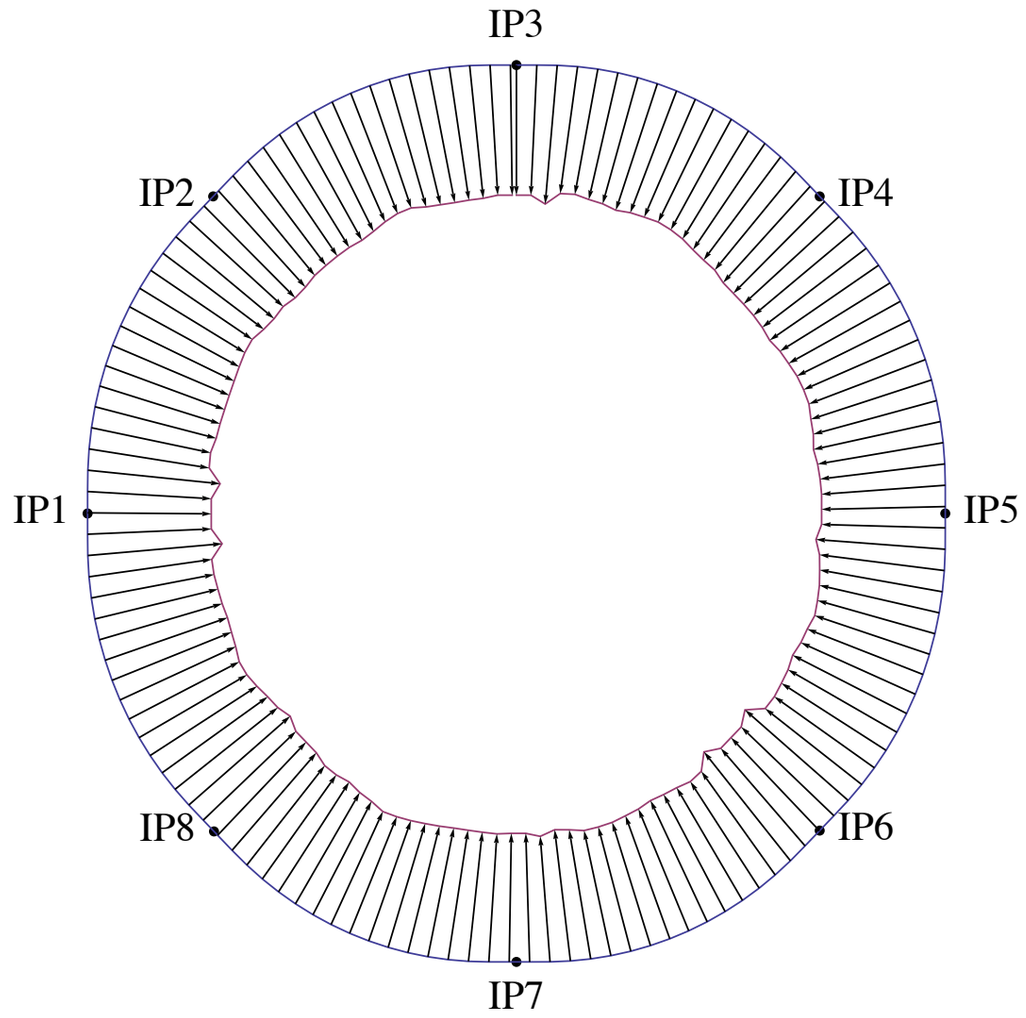
But current experiences at the LHC show that beams do not necessarily become unstable due to assymetry

➡ Compensation of the bypasses probably not needed, but to be confirmed by detailed studies

Courtesy to K.H. Mess

Geometry





Distance between the LHC and LHeC:

Bypass Design

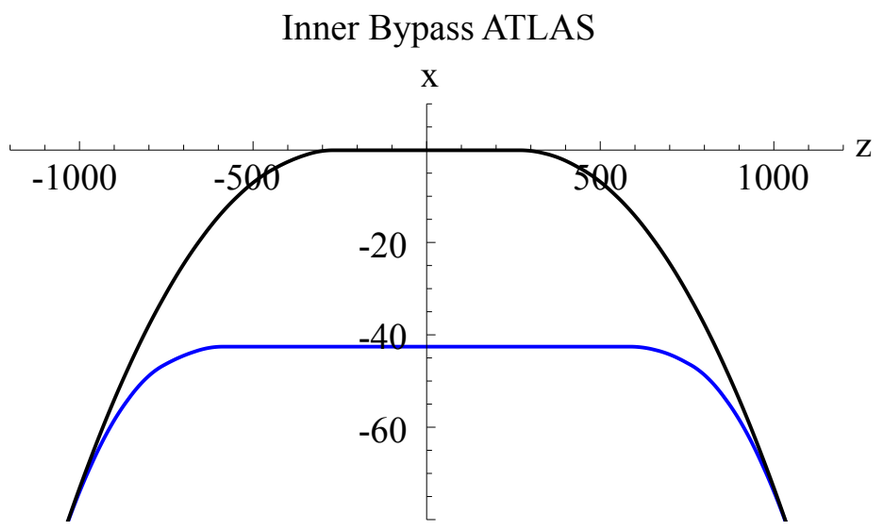
Design options:

- **Vertical bypass** has to be vertically upward in order not to cross the LHC magnets and would require 20-25 m separation. This can only be achieved by strong vertical bending.

  ➧ **integration, increase of synchrotron radiation losses and decrease of polarization**

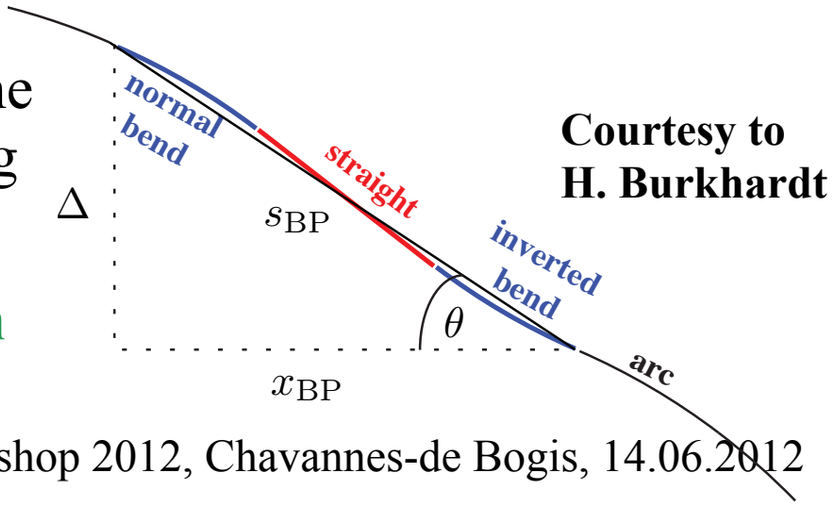
- **Horizontal inner bypass** can be constructed by decreasing the bending radius of the main bends, but has to cross the inner side of the LHC tunnel

  ➧ **integration, increase of synchrotron radiation, but possible to compensate circumference increase of a horizontal outer bypass**



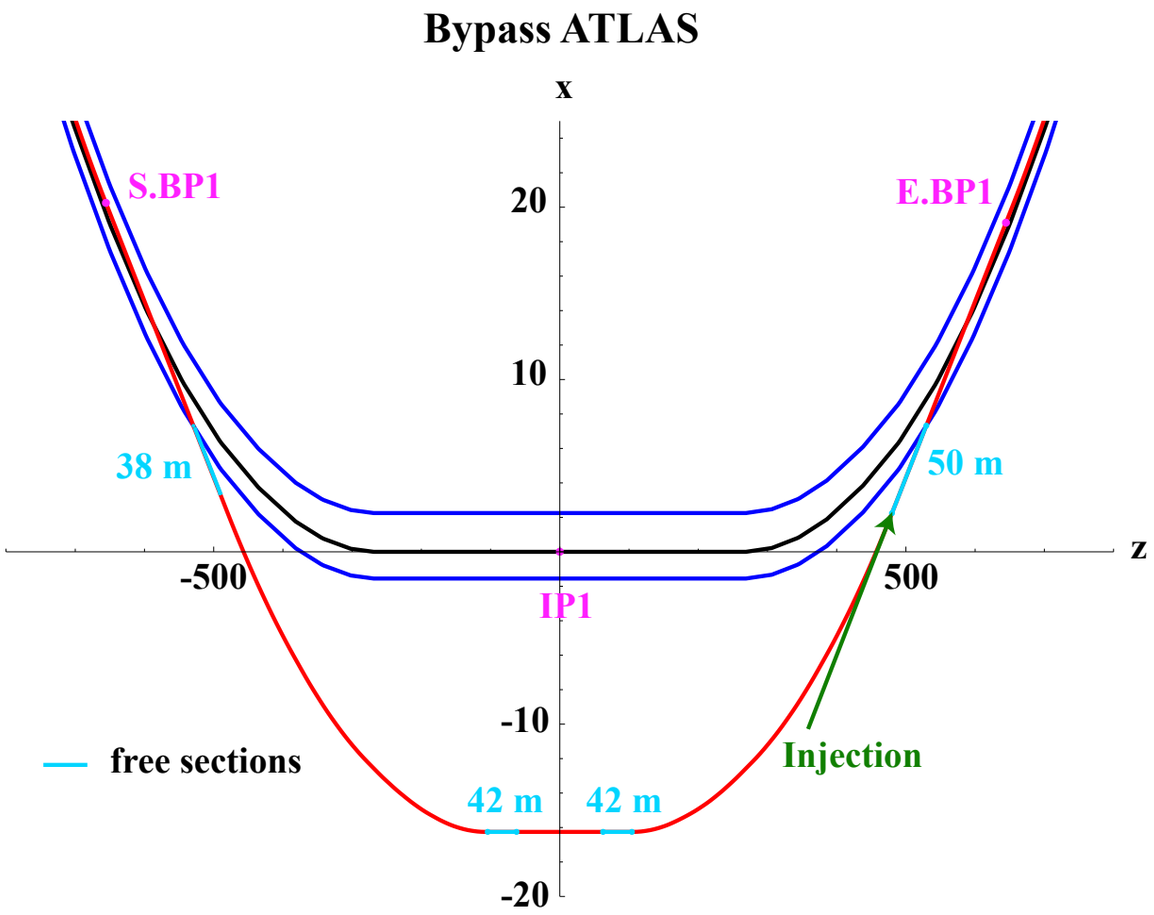
- **Horizontal outer bypass** uses the existing curvature of the ring. The separation is achieved by simply inserting a straight section of adequate length

  ➧ **no additional synchrotron radiation**



Courtesy to H. Burkhardt

Bypass Point 1 and 5

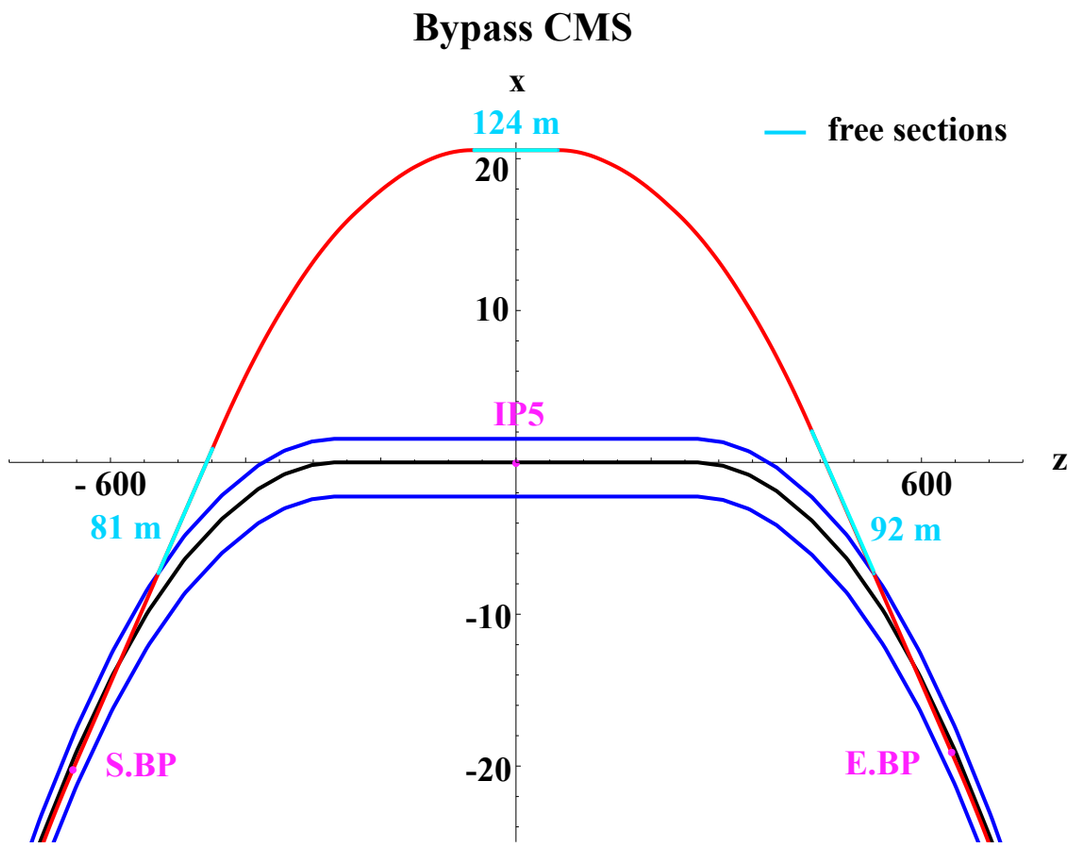


Bypass Point 1:

- **Injection** on the right side of the bypass
- long part of the straight section lies inside the tunnel
- straight sections used for installation of the RF

Bypass Point 5:

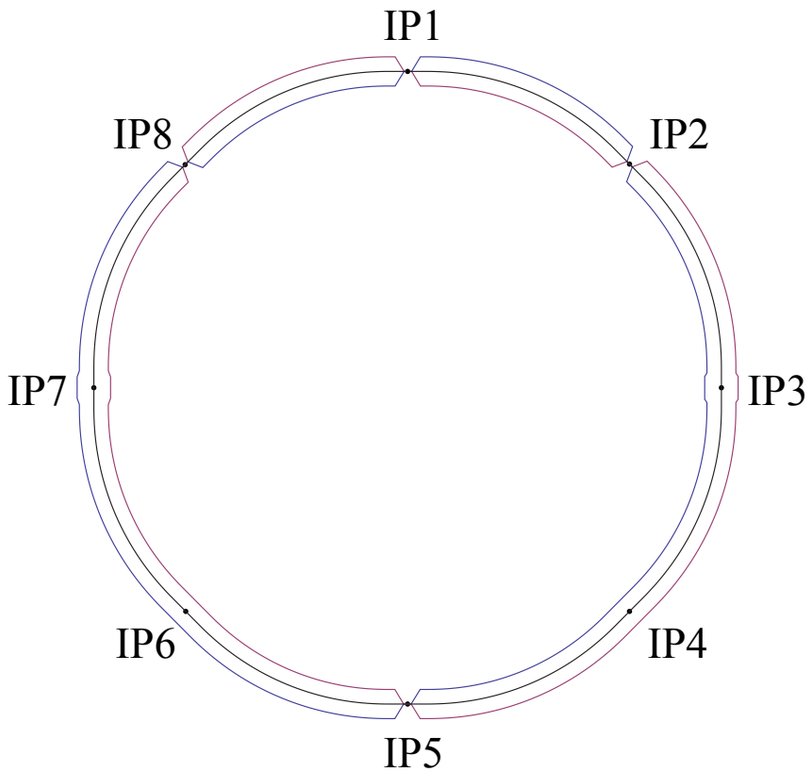
- long straight section used for the installation of the RF

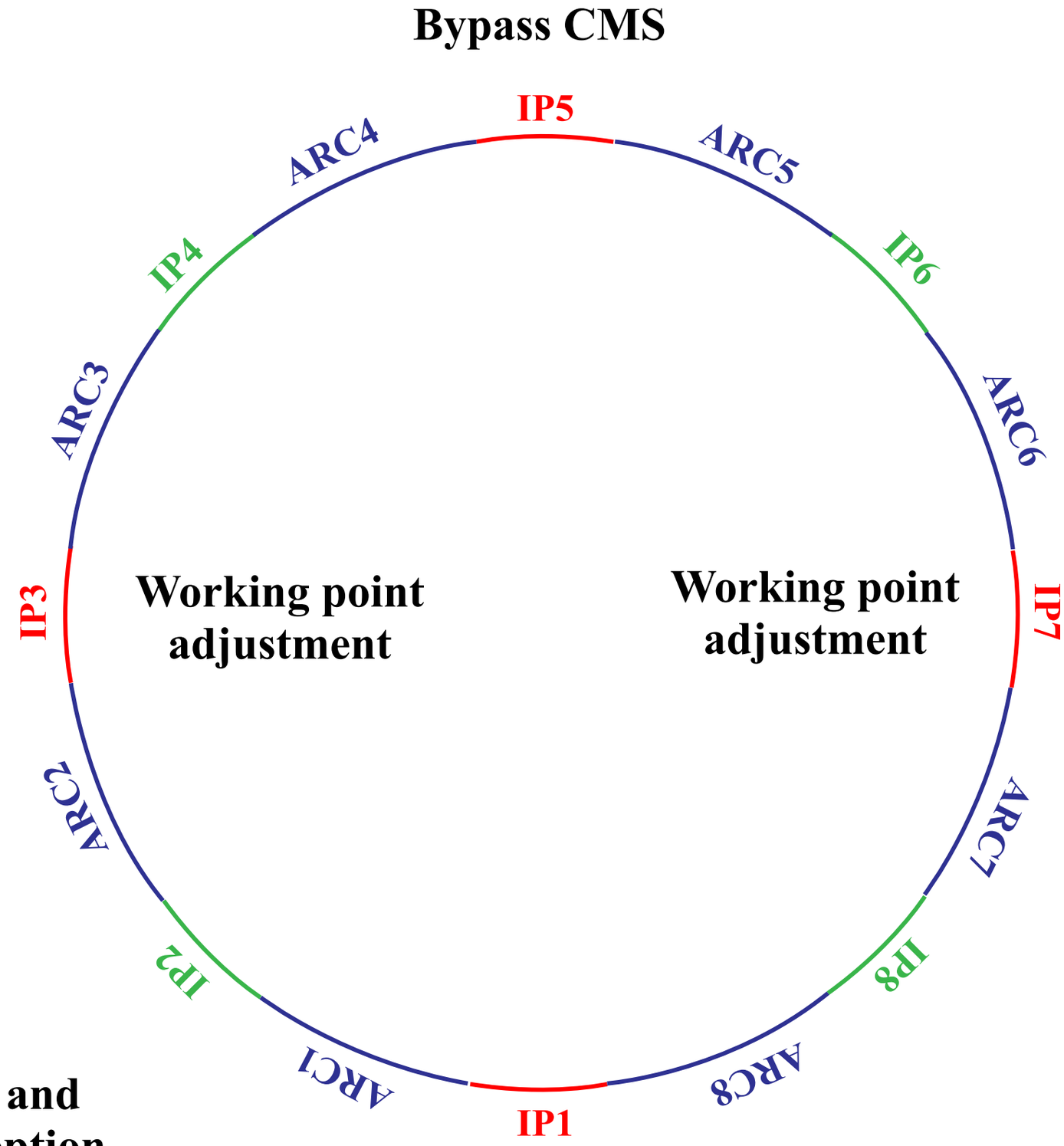


Bypass parameters

	ATLAS	CMS
L_{BP}	1303.3 m	1303.7 m
Δ_{BP}	16.25 m	20.56 m
$L_{tot,\ straight\ sections}$	172 m	297 m

Optics





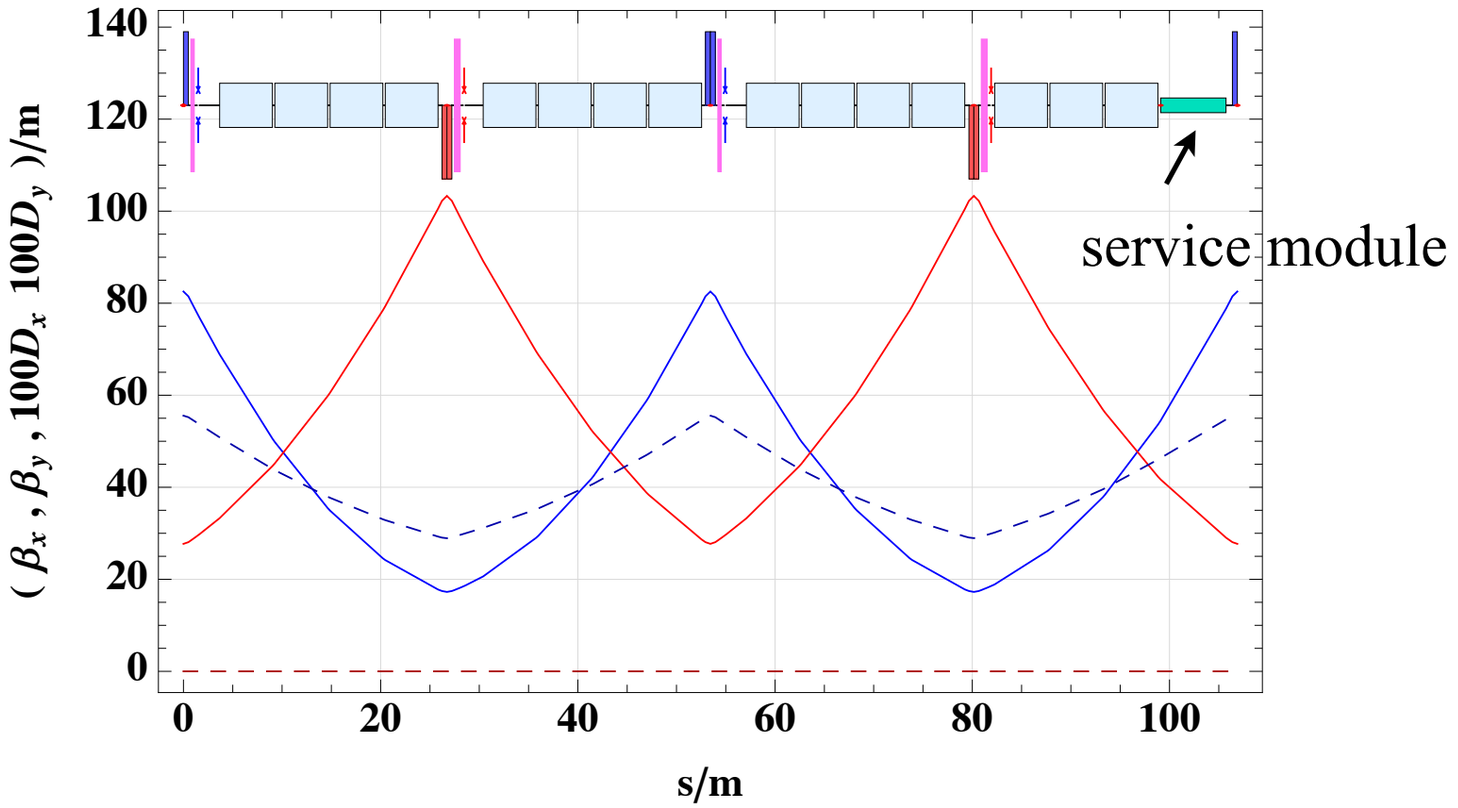
Interaction Point:
High Acceptance (HA) and
High Luminosity (HL) option

Arc Cell Optics

- multiple of the LHC cell length as the LHC service modules are placed at the beginning of each LHC FODO cell
- emittance increases with the cell length

➧ asymmetric double FODO cell with $L_{LHeC,\,FODO} = 1/2\ L_{LHC,\,FODO} = 106.881$ m and 90°/60° phase advance

- dipoles must be shortened in order to meet the LHC geometry



Insertion Optics

Insertions

Geometry and Layout:

- dipole configuration adopted to follow the LHC geometry
- FODO cell in the straight section (would have to be adapted to meet all integration constraints in the straight sections)

Optics:

- DS with 8 matching quadrupoles
- FODO cell with 90˚/60˚ phase advance

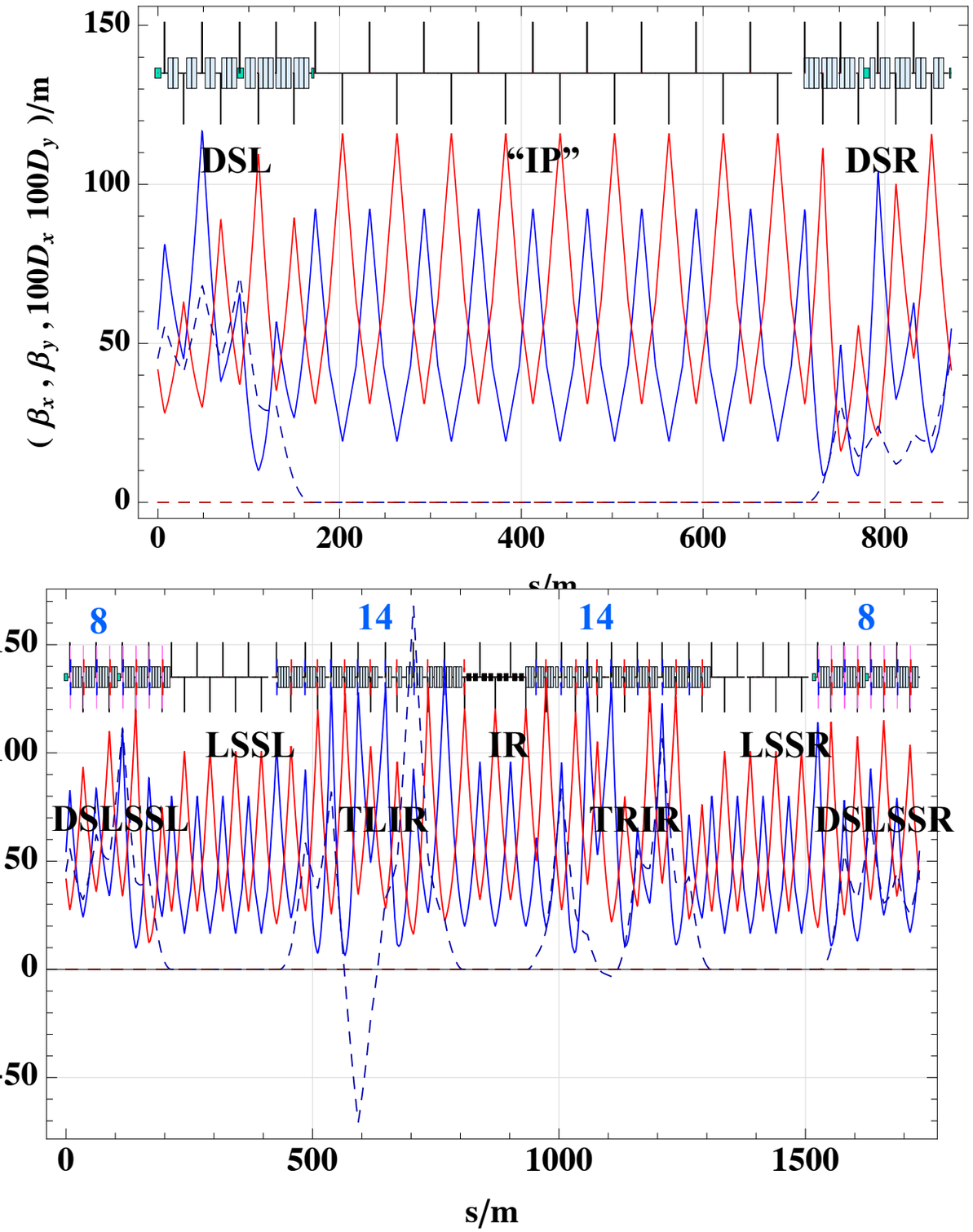
Bypasses

Geometry and Layout:

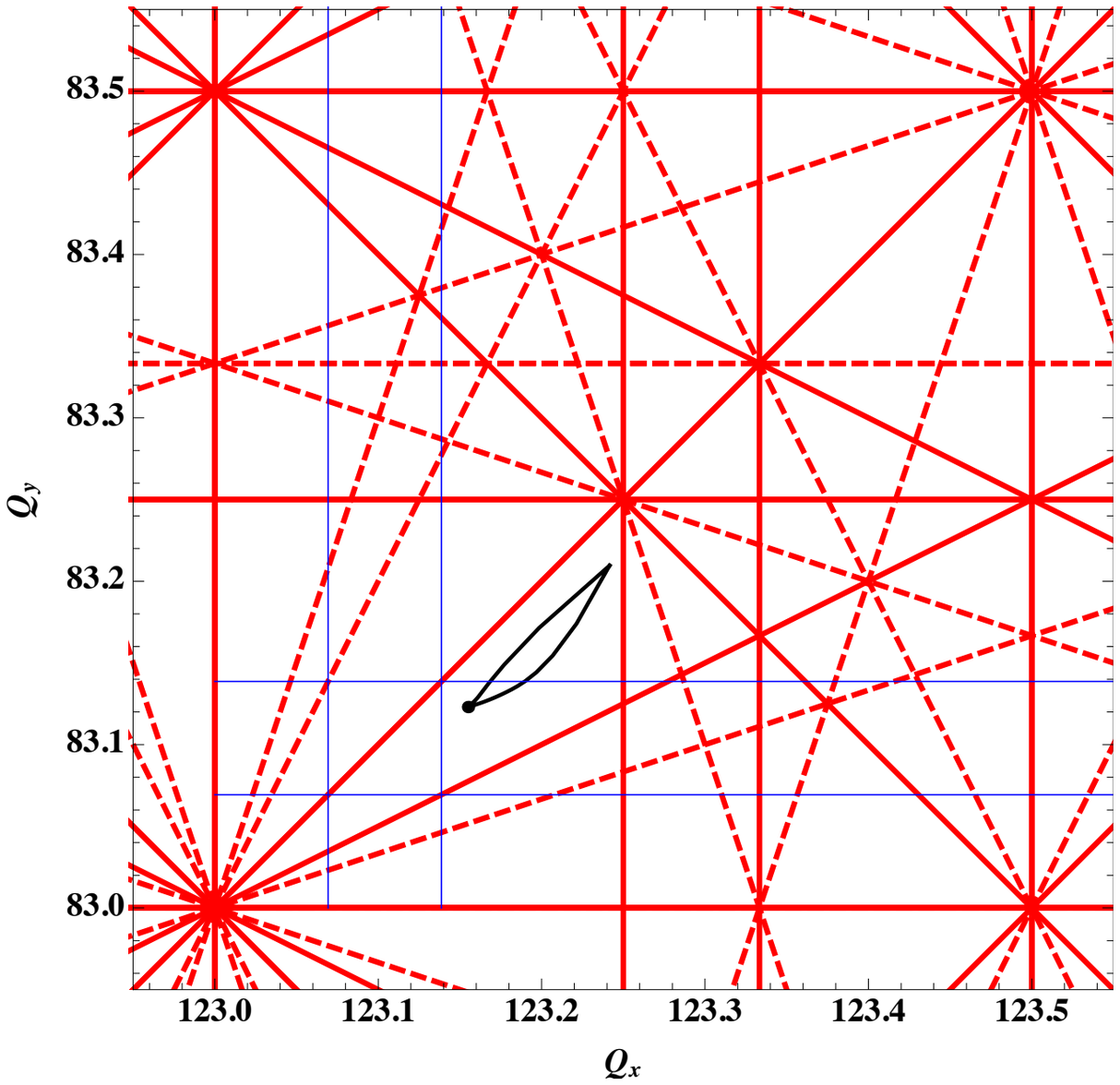
- dipole configuration same as in the arc cells respectively DS

Optics:

- individual quadrupoles for matching
- FODO cell with 90˚/60˚ phase advance



Working Point



Choice of WP:

- lattice symmetry 1
- avoid the first synchrotron side band of the integer resonance
- below diagonal [4]
- beam-beam tune shift of approx. 0.09 (for HA and HL option)

➡ $Q_{x/y}$ = 123.55/83.123

[4] J. Jowett: Choice of a working point for LEP, CERN-LEP-Note-493, 1984

WP adjustment:

- small changes over the main arc quadrupoles
- larger changes over IP3 and IP7 by changing the phase advance of the FODO cells and rematching the dispersion suppressor

Chromaticity Correction

Karlsruhe Institute of Technology

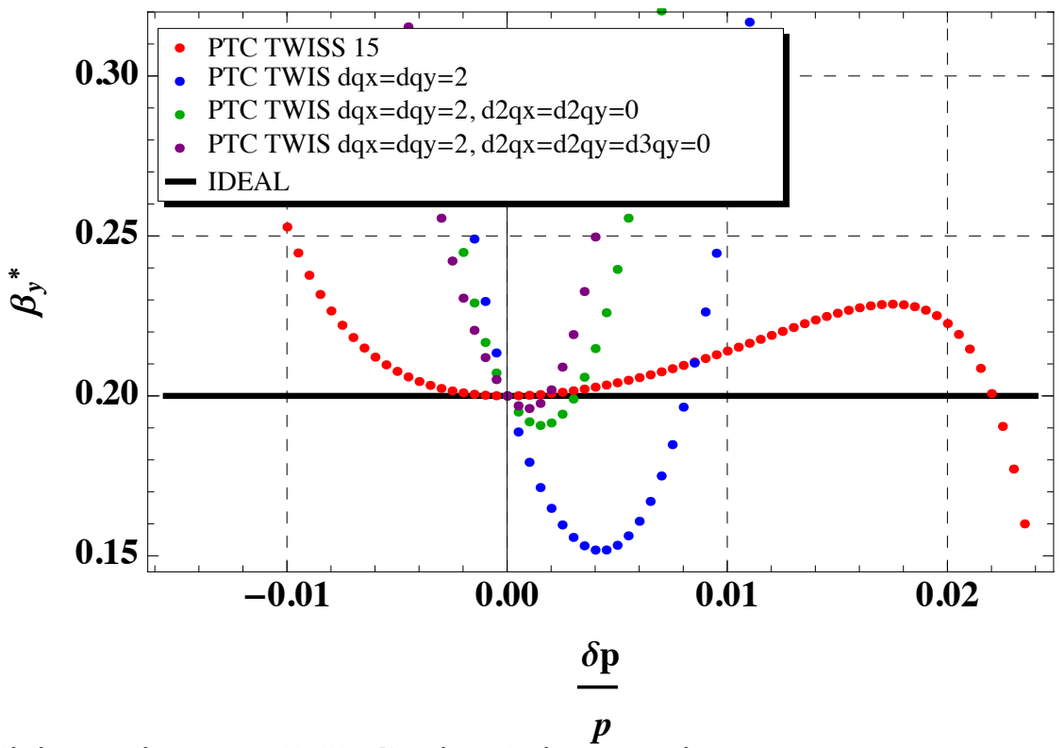
In general:

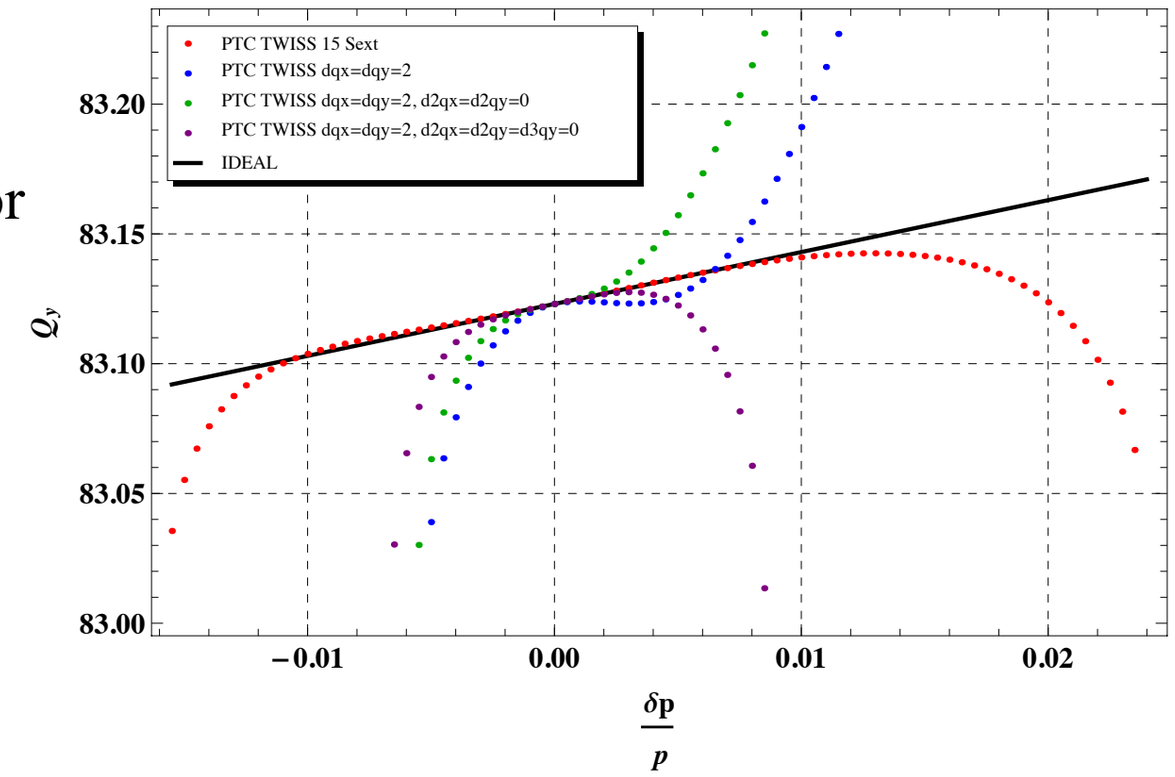
- 90°/60° fodo cell phase advance suggest 2 sextupole families in the hor. and 3 in the vert. plane
- eventually local correction of the off-momentum beta-beating arising mainly from the interaction region with the adjacent arcs

HL option:

- local contribution of the IR to the chromaticity is **not considerably** higher than from the bypasses or insertions
- no large chromatic aberrations

➡ global correction



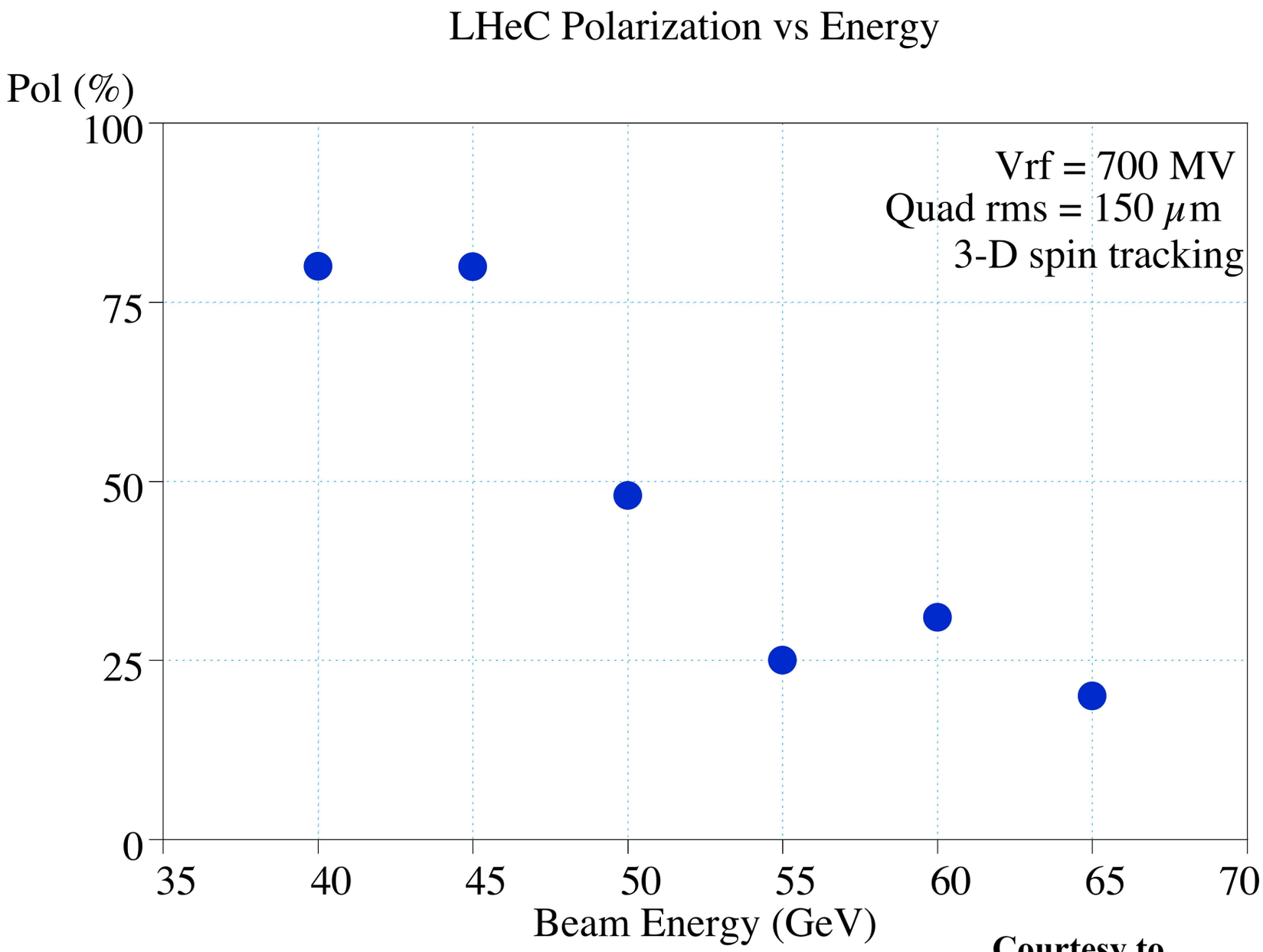


HA option:

- local contribution of the IR to the chromaticity is **considerably** higher than from the bypasses or insertions

➡ local correction with the arcs adjacent to the IP

Polarization



Courtesy to
D. Barber, U. Wienands

- Polarization of 25% to 40% at 60 GeV can be reasonably aimed for with harmonic closed orbit spin matching
- precision alignment of the magnets to better of 150 μm rms needed to achieve a high polarization level
- option of having siberian snakes

Summary

- **layout** meeting the integration constraints (experiments, service modules, DFBs)
- **optics** meeting the design parameters
- **chromaticity correction** scheme for both IR options

THANK YOU FOR YOUR ATTENTION