IR8 Status

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Electron-Ion Collider

BROOKHAVEN NATIONAL LABORATORY

Jefferson Lab

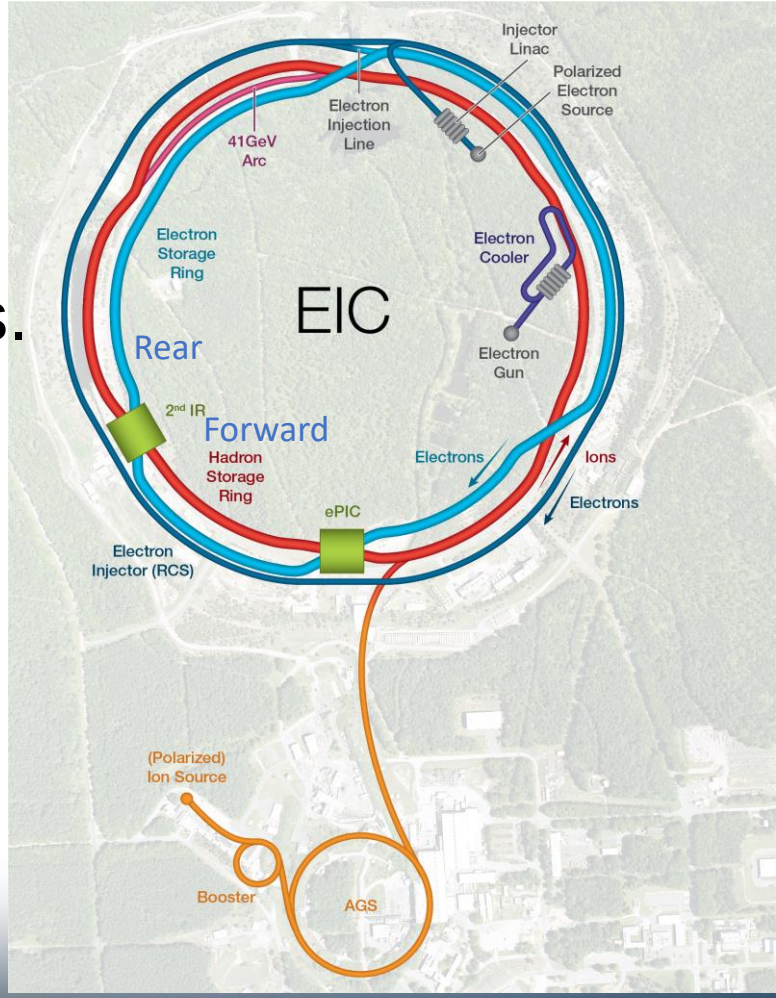
U.S. DEPARTMENT OF ENERGY | Office of Science

IR requirements & parameters

	1st IR		2nd IR	
	proton	electron	proton	electron
Detector occupied region	-4.5 m +5.0 m Beam elements < 1.5° in main detector		-4.5 m +5.0 m Beam elements < 1.5° in main detector	
Polarimetry	Yes (IR4)	local	Yes (IR4)	local
2nd focus	No		yes	
β^* @ 275 GeV (h), 10 GeV (e)	β^*_x = 80 cm β^*_y = 7.2 cm	β^*_x = 45 cm β^*_y = 5.6 cm	β^*_x = 80 cm β^*_y = 7.2 cm	β^*_x = 45 cm β^*_y = 5.6 cm
ZDC	0.6m x 0.6m x 2m @ s≅30m n: ± 4 mrad		0.6m x 0.6m x 2m @ s≅ 40m n: ± 4 mrad	
Roman Pots	1-5 mrad, @s≅30m		0-5 mrad, @s≅30-45m	
Scattered particle acceptance	p: 0.18 GeV/c < p_T < 1.3 GeV/c		p: 0 GeV/c < p_T < 1.3 GeV/c	
Q^2 tagger		Q^2< 0.1 GeV		
Crossing angle	25 mrad		35 mrad	

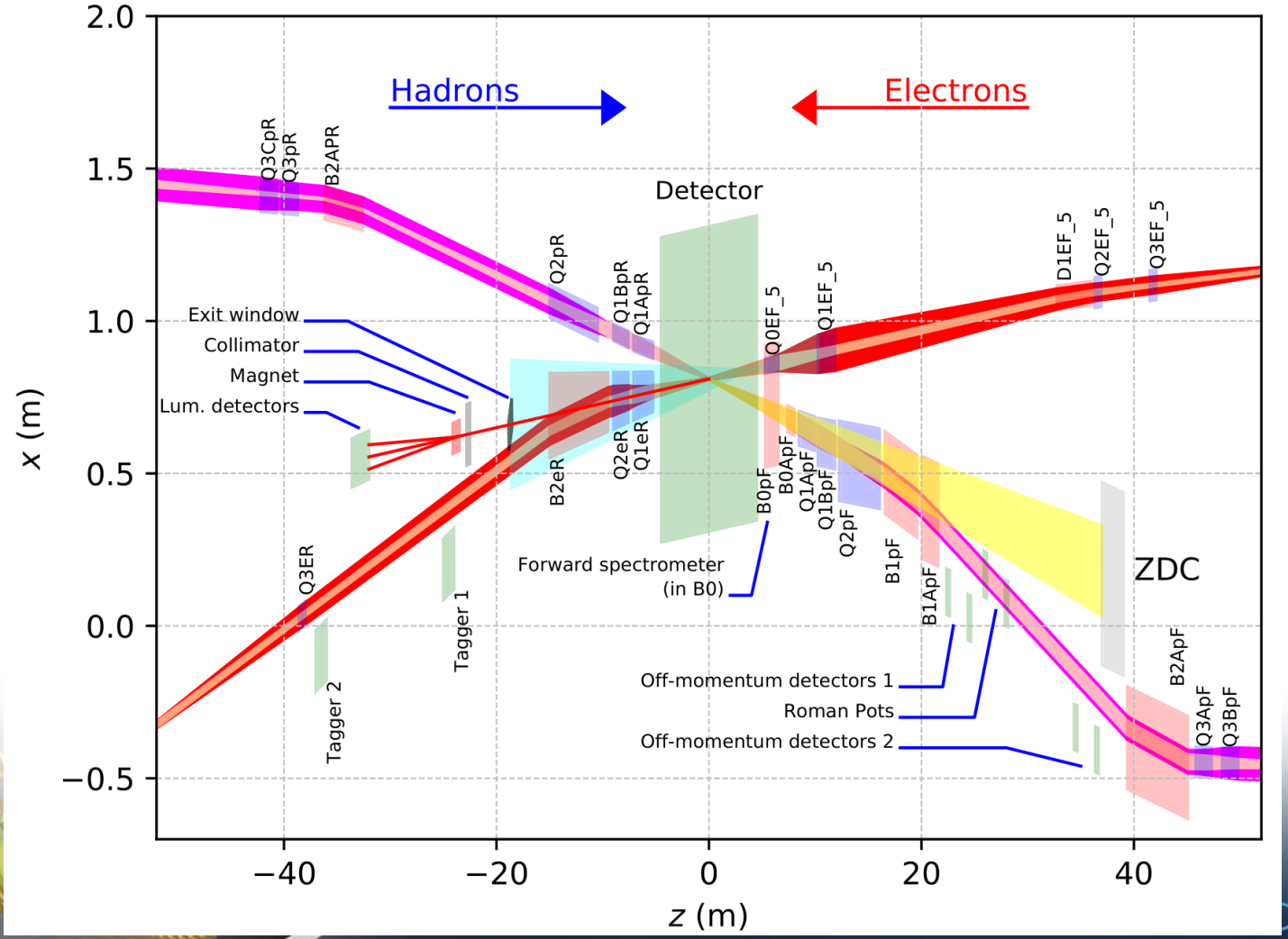
Requirements/Constraints

- Fit into the existing RHIC IR8 experimental hall between arcs 7 and 9.
- Preference for a secondary focus.
- Same accelerator equipment as in IR6 (spin rotators, snake and crab cavities).
- Second colliding IR and detector not in project, but the ability to have one is in the project scope.



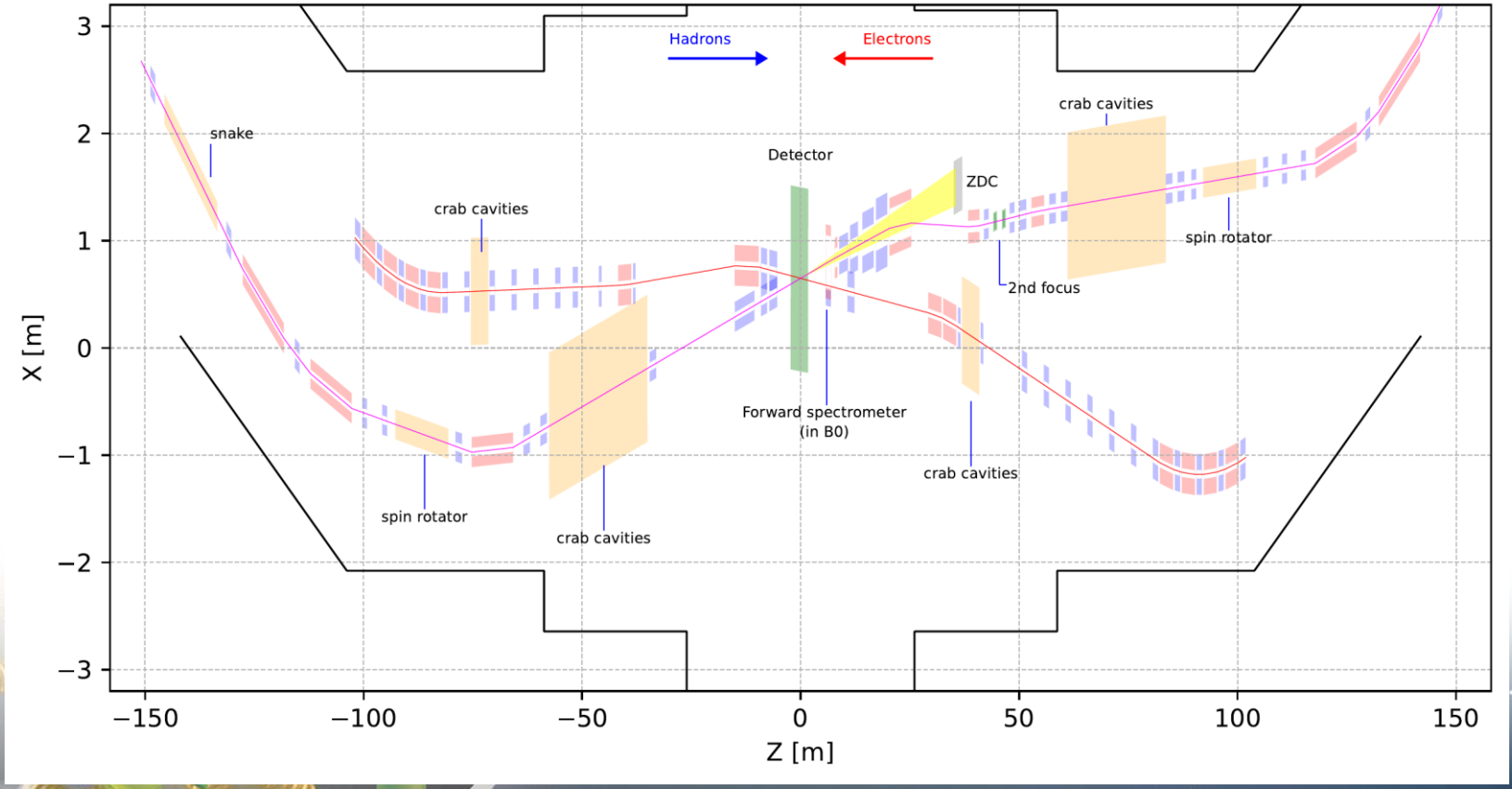
IR6 layout

- 25 mrad crossing angle



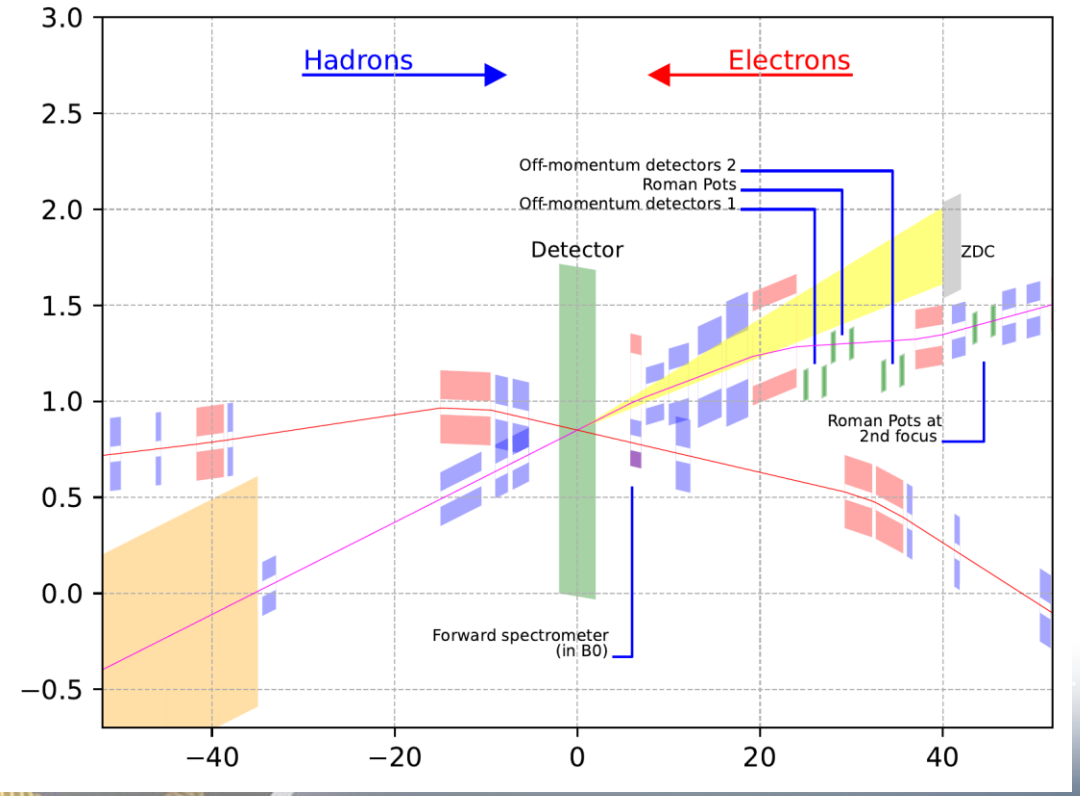
IR8 full layout (colliding)

- 35 mrad crossing angle (driven by accelerator geometry).
- Second focus point at ~45m.
- Space for similar accelerator equipment as IR6.



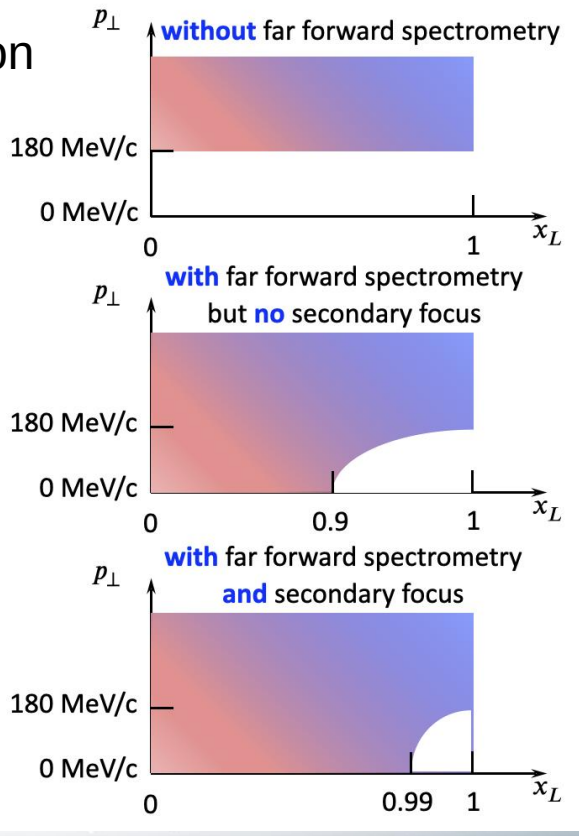
IR8 near IR layout

- Space available for luminosity monitor, low Q2 tagger etc..
- All ancillary detectors in outgoing hadron beam side (Forward) integrated



Acceptance as a function of x_L and p_T

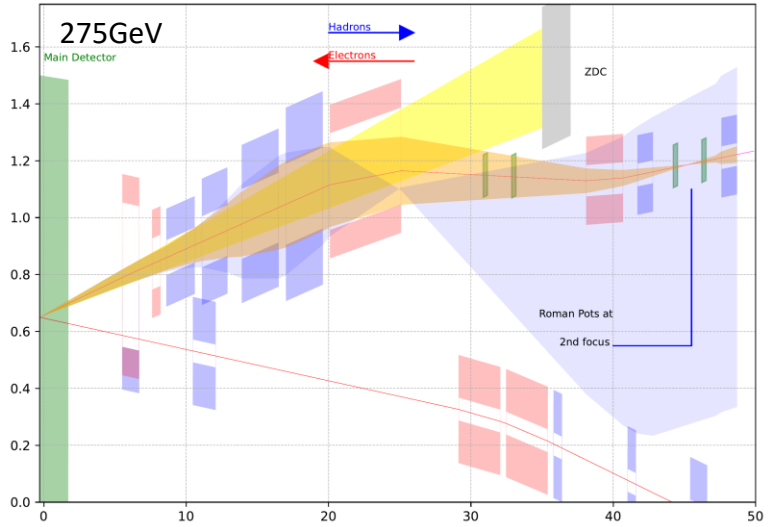
- x_L - fraction of the longitudinal momentum relative to hadron beam
- p_T - fraction of the transverse momentum relative to hadron beam (θ)
- p_T acceptance at $x_L = 0$
  - $p_T^{min} > 10 p_0 \theta_{IP} = 10 p_0 \sqrt{\frac{\epsilon}{\beta^*}}$
- x_L acceptance at $p_T = 0$
  - $x_L < 1 - 10\frac{\sigma_x}{D} = 1 - 10\frac{\sqrt{\beta_x^{2nd}\epsilon_x + D_x^2\sigma_\delta^2}}{D}$
- Secondary focus allow for $|D\sigma_\delta| \gg \sqrt{\beta\epsilon}$
- Can reach the fundamental limit
  - $x_L < 1 - 10\sigma_\delta$

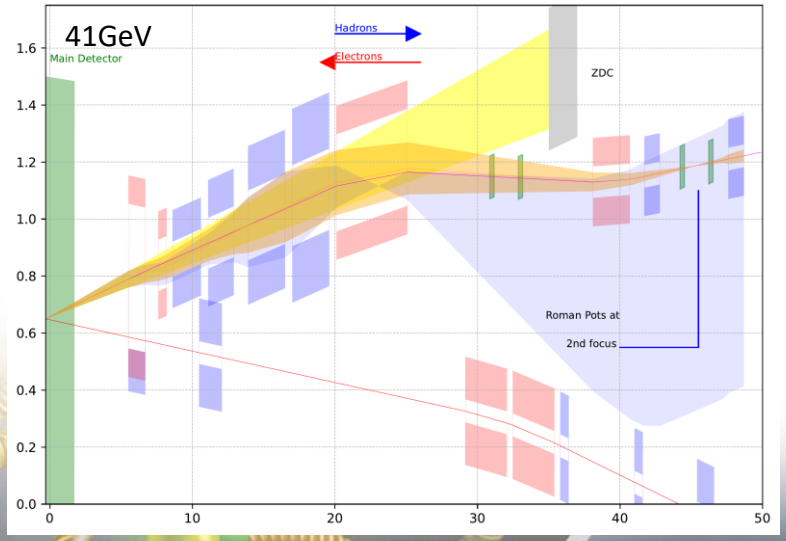


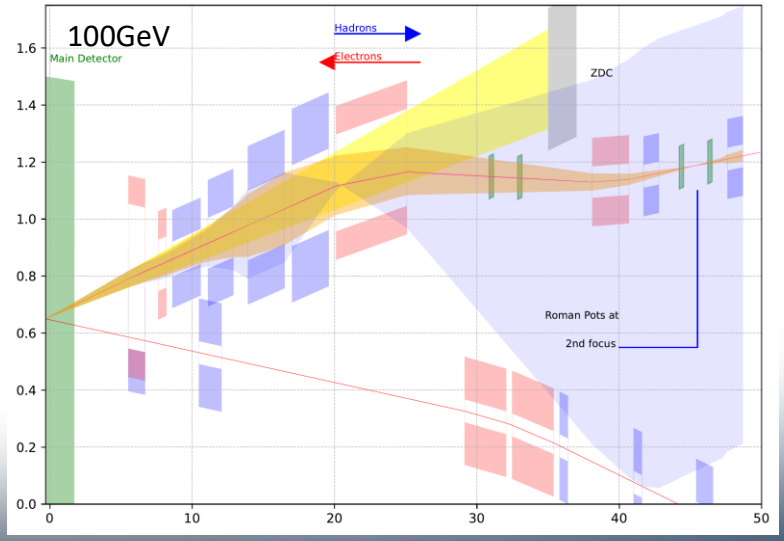
IR8 forward acceptance

Neutrons ± 5 mrad
Protons ± 5 mrad
$x_L = 1$
Protons ± 5 mrad

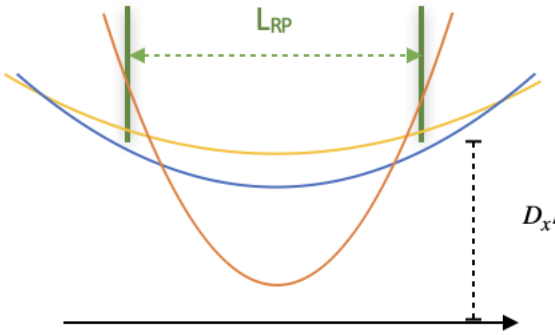
- This is using NbTi magnets.
- Final focusing quads and the dipoles properties (apertures, lengths etc..) was optimized for forward scattering neutron and proton acceptance.



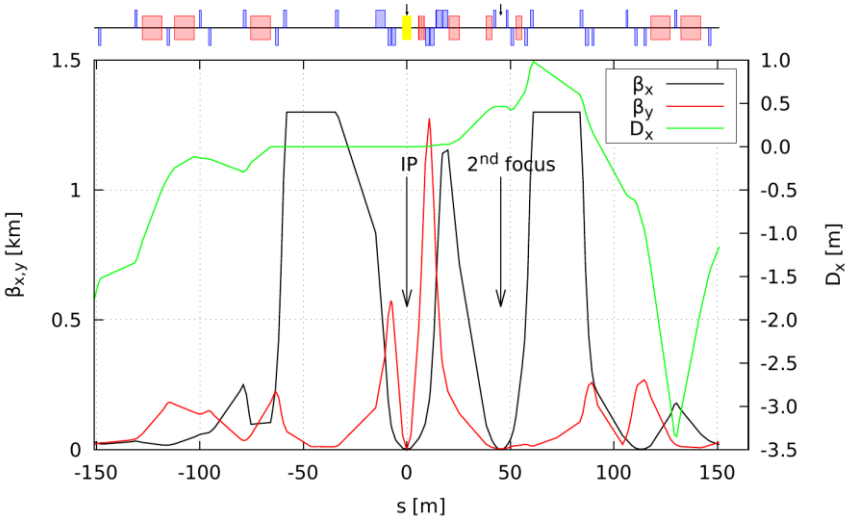




IR8 second focus



$$D_x\Delta > 10\sigma_x = 10\sqrt{\epsilon_x\left(\beta_x + \frac{L_{RP}^2}{4\beta_x}\right) + D_x^2\delta^2}$$



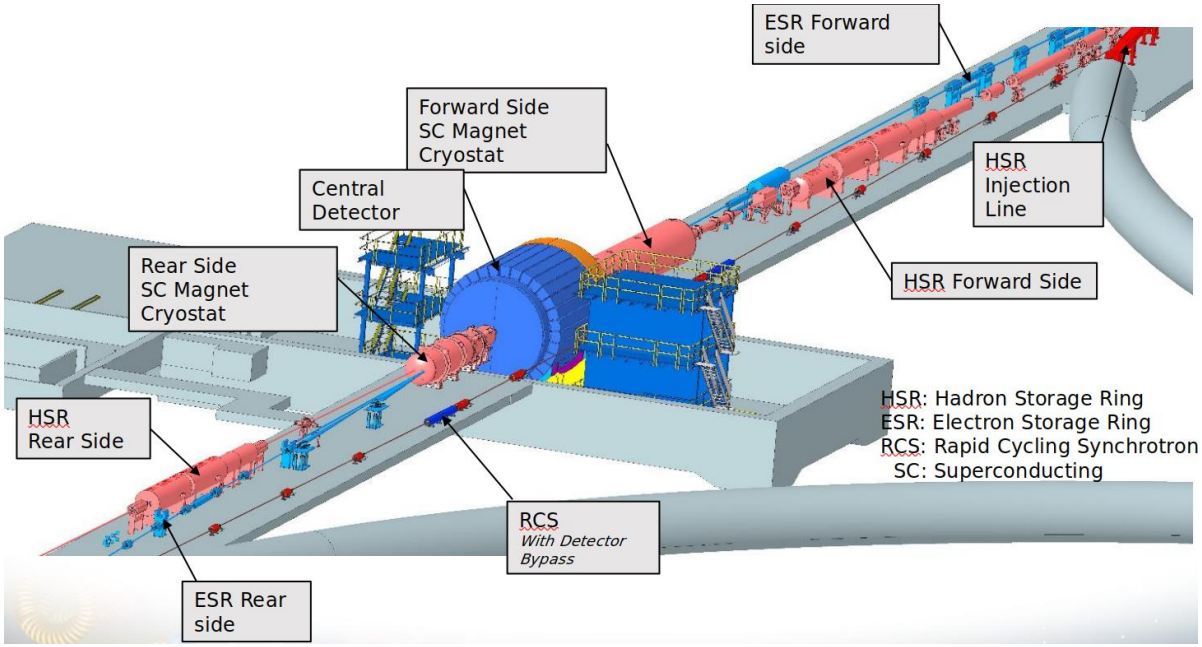
- Optimal $\beta_x^{2nd} = \frac{L_{RP}}{2}$
- For the current design, $x_L < 0.9930$
- Limit of x_L for the given momentum spread is 0.9932 at 275GeV

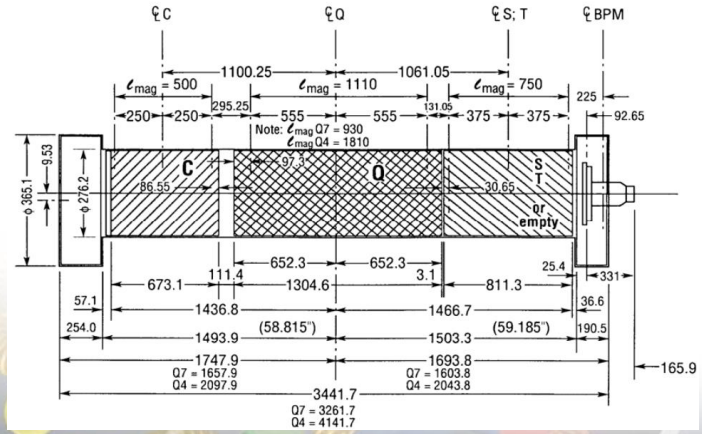
Parameters at the 2nd focus for different energies

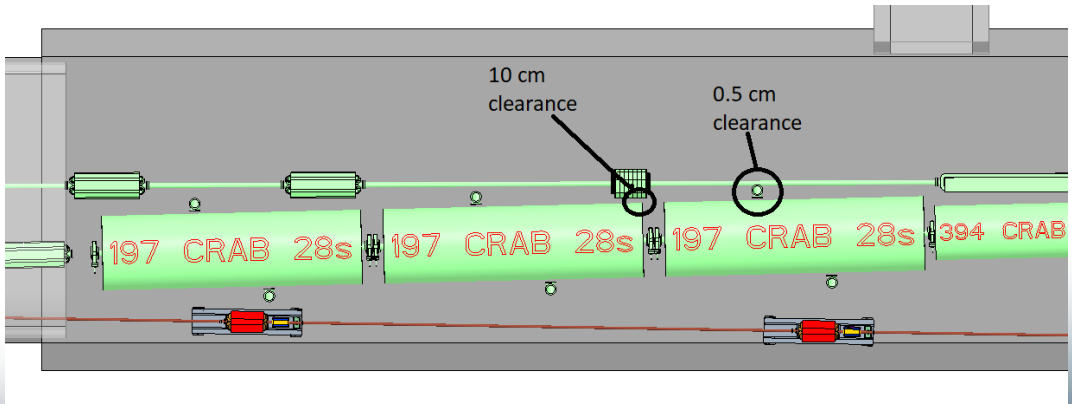
Parameter	Value at 41 GeV	100 GeV	275 GeV	Units
β_x	0.85	0.8	0.5	m
D_x	0.48	0.48	0.47	m
ϵ_x	44	30	11.3	nm
σ_δ (10^{-4})	10.3	9.7	6.8	-
$1 - x_L$ (10^{-3})	4.16	10.2	7	-

Constraints

- Space for magnets.
- Geometry of the experimental hall.
- Optics requirements for specific regions (eg: crab cavities)



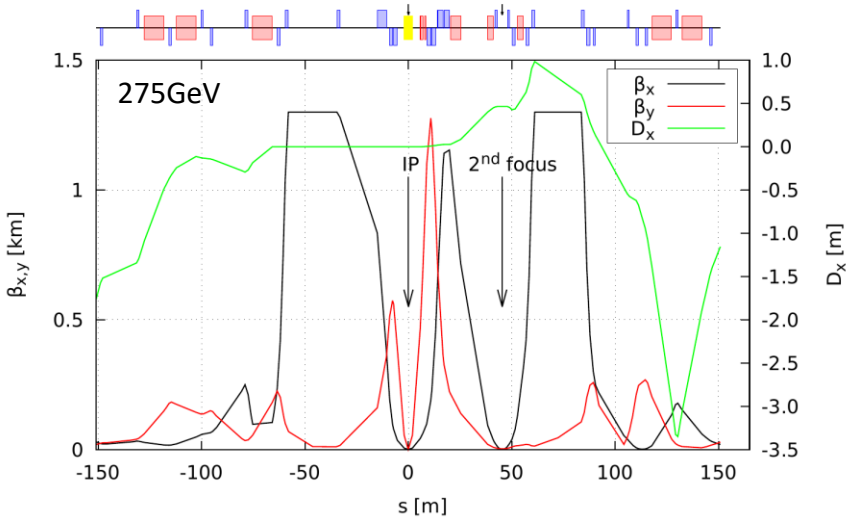


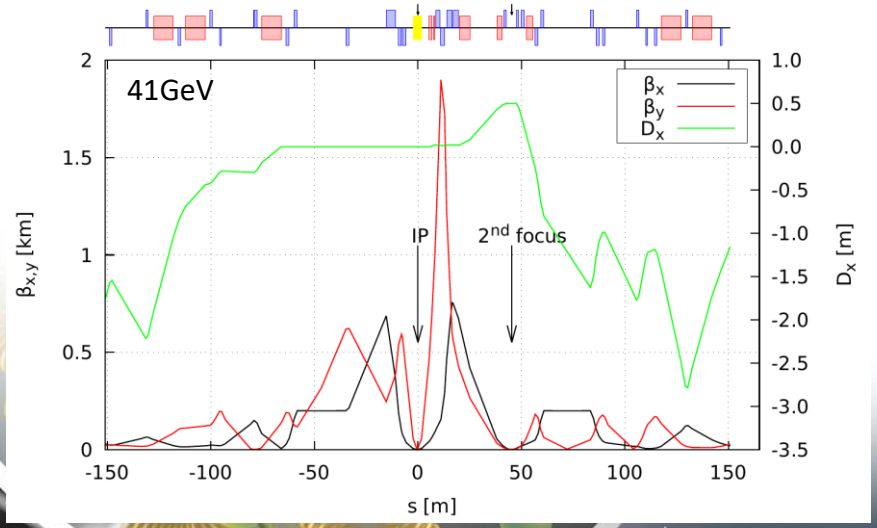


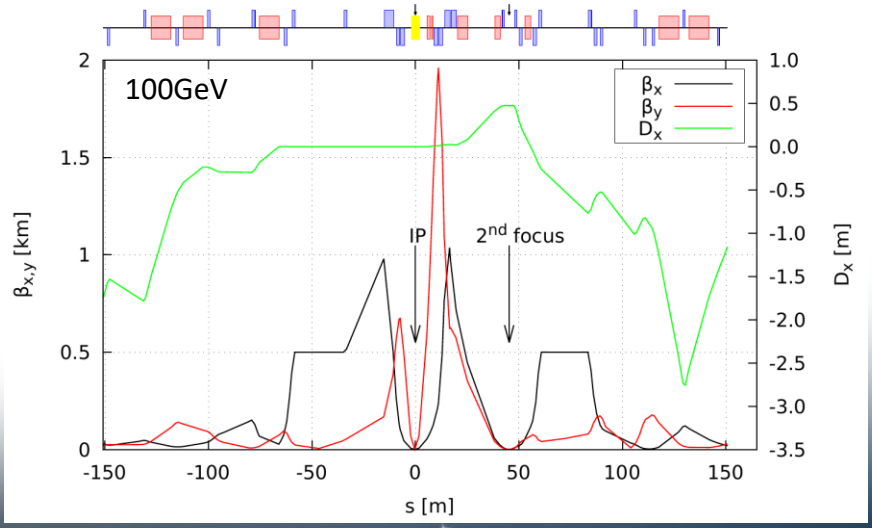
IR8 hadron optics

- Limited matching space requires some high gradient magnets (quadrupoles) than what is available from existing RHIC magnets.
- Near IR magnet include 7 FFQs, 2 Dipoles, 1 corrector and B0.
- All magnets are assumed to be NbTi

Magnets	RHIC	New
Quadrupoles	11	11
Dipoles	5	0

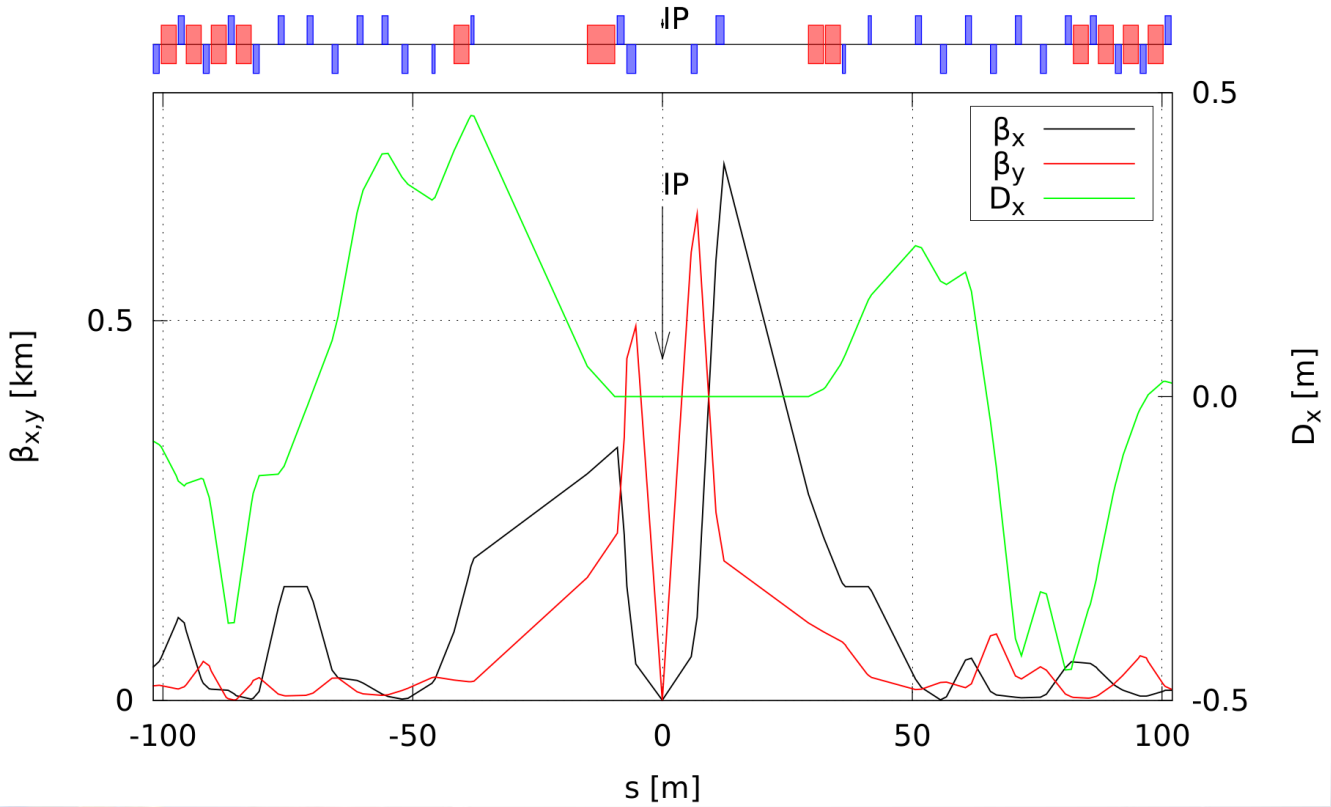






IR8 electron optics

- Optics and design similar to IR6



Summary 2nd IR (IR8)

- Second colliding IR and detector not in project, but the ability to have one is in the project scope.
- This is a Pre-conceptual design.
- The IR8 with the second focus adds complementarity to IR6.
- Work to be done includes,
  - ~~Crab cavity space requirement for the 35 mrad crossing angle.~~
  - ~~Clearance check for the RCS (Rapid Cycling Synchrotron) bypass.~~
  - ~~Account for luminosity sharing by moving the IP by 0.2975m away from IR6.~~
  - ~~Low energy lattices (41,100 for protons and 5,10 for electrons)~~
  - Further study needed for the feasibility of the IR magnets.
  - Nb3Sn magnets are being evaluated as an option.
  - Chromaticity compensation with two IR's

Thank you!