Au-Au ion collider

Concept design for JAS Dubna 2019

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Initial data

Parameter	Rings (1==2)
Circumference [m]	800
Ions	$^{197}Au^{79+}$
Ion energy [GeV/u]	1.0-5.0
Luminosity [$cm^{-2}s^{-1}$]	$1 \cdot 10^{27}$
Emittance [$\pi \cdot mm \cdot mrad$]	$\varepsilon_x = \varepsilon_y = 1$
Beta function [m]	$B_x = B_y = 0.6$

Proposed collision scheme is head-on.

Luminosity

$$L = \frac{n_{\text{bunch}} N_1 N_2 f_0}{4\pi\sqrt{\varepsilon_x \varepsilon_y} B^*} \Phi_{\text{HG}}$$

$$\Phi_{\text{HG}}(\alpha) = \frac{2}{\sqrt{\pi}} \int_0^{\infty} \frac{e^{-u^2} du}{1 + (\alpha u)^2} \qquad \alpha = \frac{\sigma_s}{B^*} \qquad \Phi_{\text{HG}}(1) = 0{,}7578$$

CONDITIONS

$$v_1 = -v_2, \quad V = 2, \quad B^*_{x1} = B^*_{x2} \equiv B^*_x, \quad B^*_{y1} = B^*_{y2} \equiv B^*_y,$$

$$\sigma_{s1} = \sigma_{s2} \equiv \sigma_s, \quad \varepsilon_{x1} = \varepsilon_{x2} \equiv \varepsilon_x, \quad \varepsilon_{y1} = \varepsilon_{y2} \equiv \varepsilon_y.$$

$\sigma_s \ll l_D$ - detector length

$\sigma_s = B^*(\alpha = 1)$ σ_s - longitudinal bunch length HG - Hourglass effect

Beam-beam and Laslett parameters estimations

$$\Delta q_x = -\frac{Z^2 N r_p}{2\pi\beta^2\gamma^3 A}\frac{\sqrt{B_x}}{\sqrt{\varepsilon_x}\left(\sqrt{\varepsilon_x\langle B_x\rangle}+\sqrt{\varepsilon_y\langle B_y\rangle}\right)}\frac{C_{ring}}{\sqrt{2\pi}\sigma_s} = -\frac{Z^2}{A}\frac{N r_p}{4\pi\beta^2\gamma^3\varepsilon}\frac{C_{ring}}{\sqrt{2\pi}\sigma_s}$$

Z - gold charge state
N - particles per bunch
r_p - classic proton radius
B_x - beam envelope
C_{ring} - ring circumference

β - reduced beam velocity
ɣ - Lorentz factor
A - gold mass
σ - longitudinal beam size
ε - emittance

Beam-beam and Laslett parameters estimations

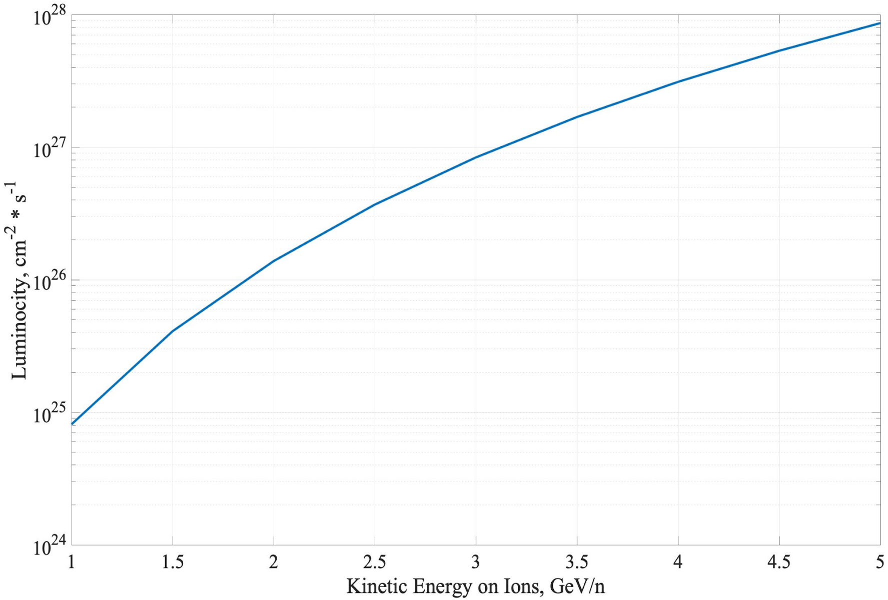
$$\xi\ (\eta) = \frac{Z^2}{A}\frac{r_p N_2}{4\pi\varepsilon}\frac{1+\beta^2}{\beta^2\gamma}\Phi_x(\eta) \qquad \Phi_{x,y12}\,(\eta = 0\ \alpha = 1) = 0{,}913$$

ξ - beam-beam effect
η - distance between IP and bunch center
ϕ - relative function

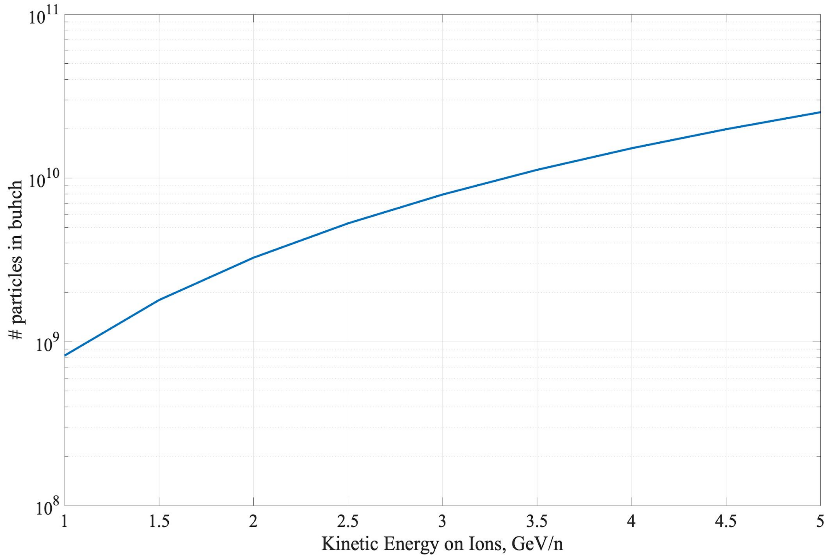
Collider luminosity optimization for NICA collider

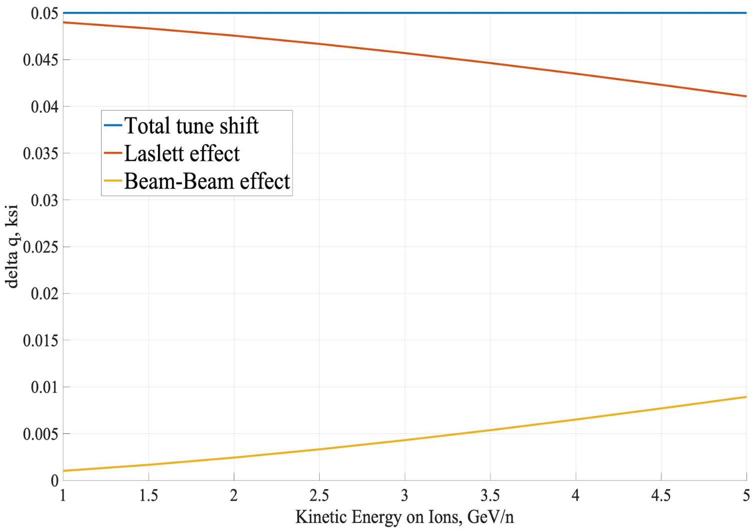
$$|\Delta q| + |\xi| \leq \Delta Q_{max}$$

$$\Delta Q \leq 0.05$$

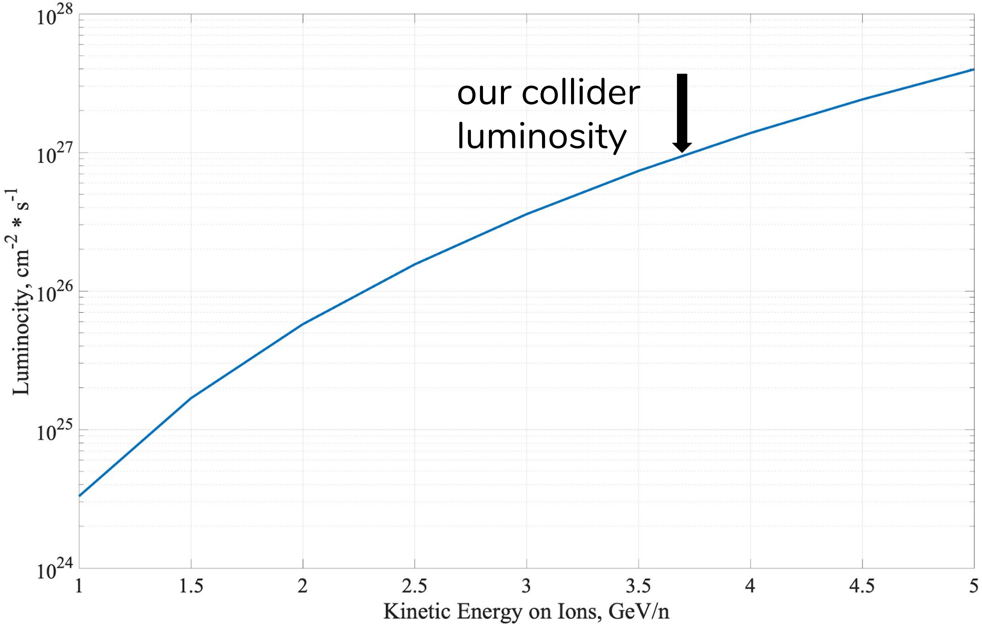


Collider luminosity optimization for NICA collider





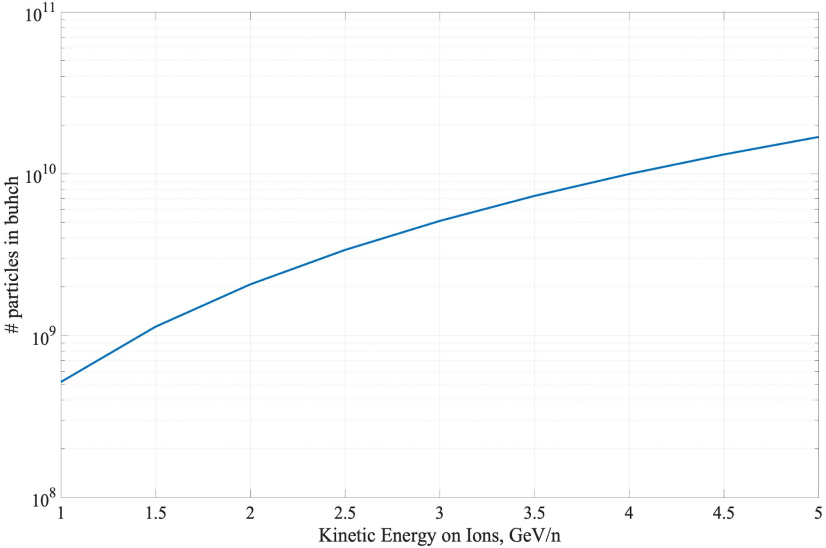
Collider luminosity optimization for our collider

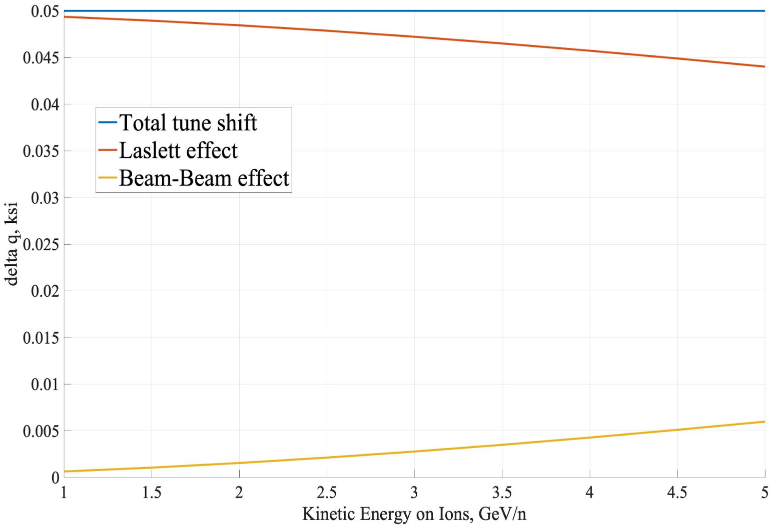


Target luminosity is achieved at

3,7 GeV/u vs. 3 GeV/u for NICA

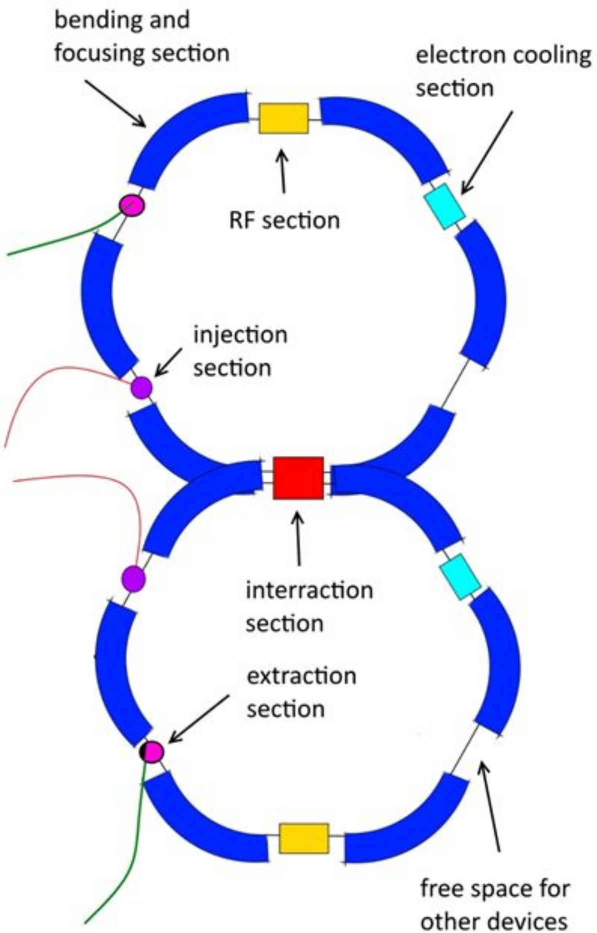
Collider luminosity optimization for our collider



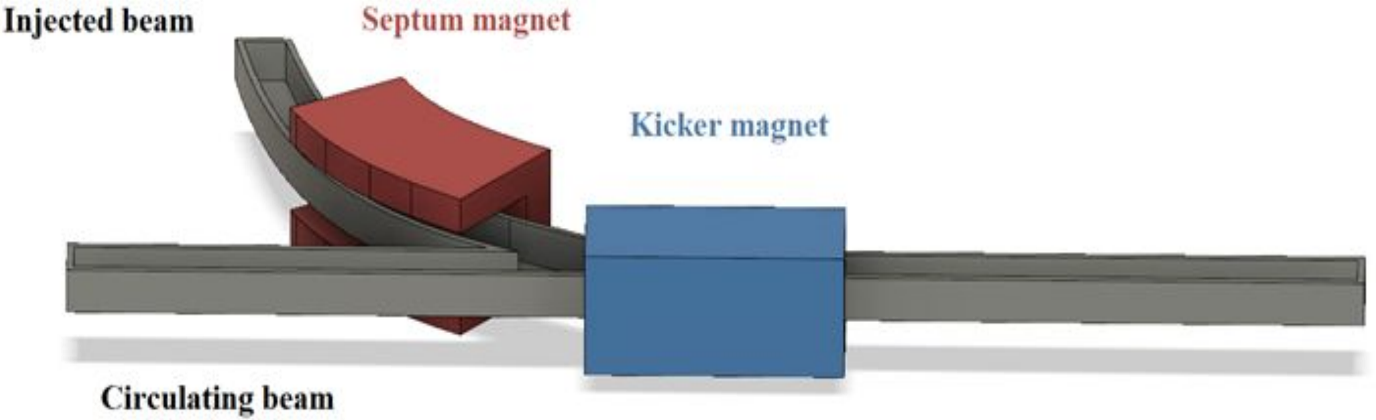


Magnetic system configuration

Energy per nucleon [GeV]	1	5
Magnetic rigidity [T · m]	14.048	48.688
Bending radius [m]	38.197	
Bending field [T]	0.368	1.275
Number of bending magnets	120	
Length of magnet [m]	2	
Number of FODO sections	120	
Length of FODO section [m]	3	



Injection system



Field of septum magnet: 0.5 T
Bending angle: 198 mrad

Field of kicker magnet: 0.1 T
Bending angle: 4 mrad

$$B = \mu_0 \frac{I}{g}$$

$$L = \mu_0 \frac{W}{g}$$

Injection system calculations

$N_{1GeV} = 3.4 \cdot 10^{8}$

$N_{5GeV} = 3.2 \cdot 10^{9}$

$\rho = 0.9 \cdot 10^{19} \frac{Atom}{cm^2}$

$\sigma_{5GeV} = 800 \text{ barn}$

$\sigma_{1GeV} = 2000 \text{ barn}$

$$\frac{\Delta N}{N}(5\ GeV) = \sigma_{5GeV} \cdot \rho = 0.72 \cdot 10^{-2}$$

$$\frac{\Delta N}{N}(1\ GeV) = \sigma_{1GeV} \cdot \rho = 1.8 \cdot 10^{-2}$$

$$\Delta N(5\ GeV) = 2.3 \cdot 10^{7}$$

$$\Delta N(1\ GeV) = 2.1 \cdot 10^{7}$$

Thank you

I never expected this to happen in my lifetime and shall be asking my family to put some champagne in the fridge.

- Peter Higgs