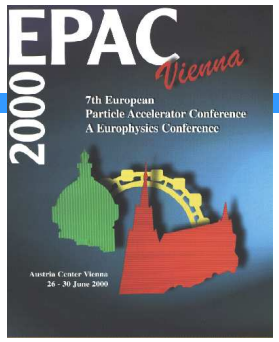

EPAC00, Vienna, 26. June 2000

Future Possibilities for HERA

G. H. Hoffstaetter

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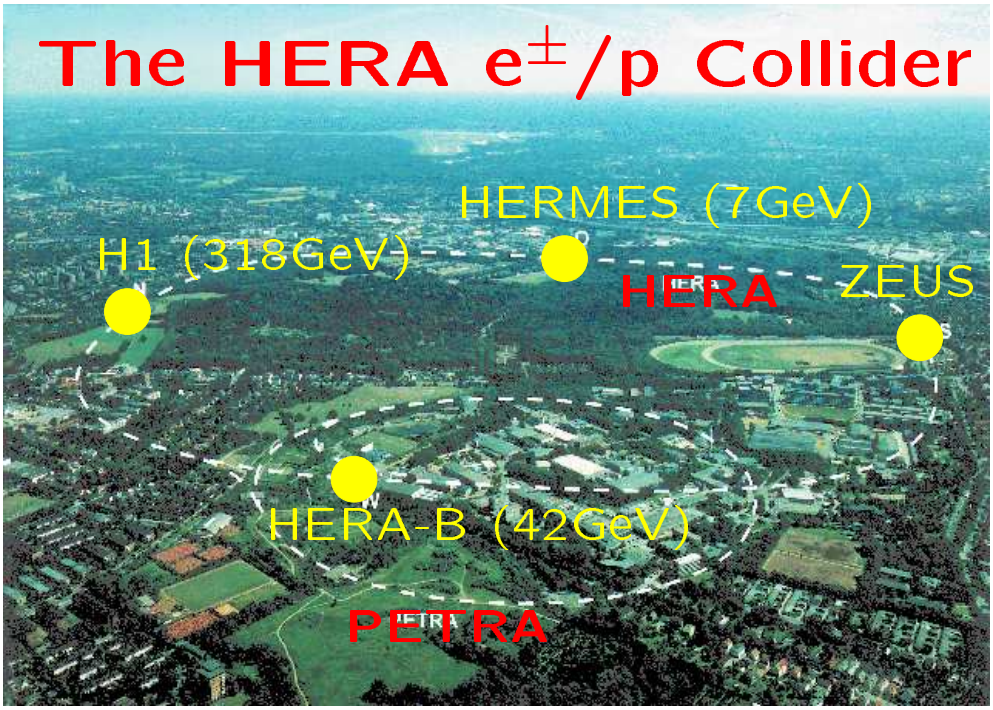

The Future

- Short term future plans:

  The luminosity upgrade from Sep.00 to Jun.01 should increase the luminosity from $1.5 \cdot 10^{31}$ to $7.6 \cdot 10^{31} \mathrm{cm}^{-2}\mathrm{s}^{-1}$.

- Long term future options:

  - $\star$ $e \Leftrightarrow \vec{p}$
    Polarized proton acceleration
  - $\star$ $e \Leftrightarrow \vec{d}$
    Polarized deuteron acceleration
  - $\star$ $e \Leftrightarrow A$
    Ion acceleration
  - $\star$ e–Cooling
    For protons and other ions

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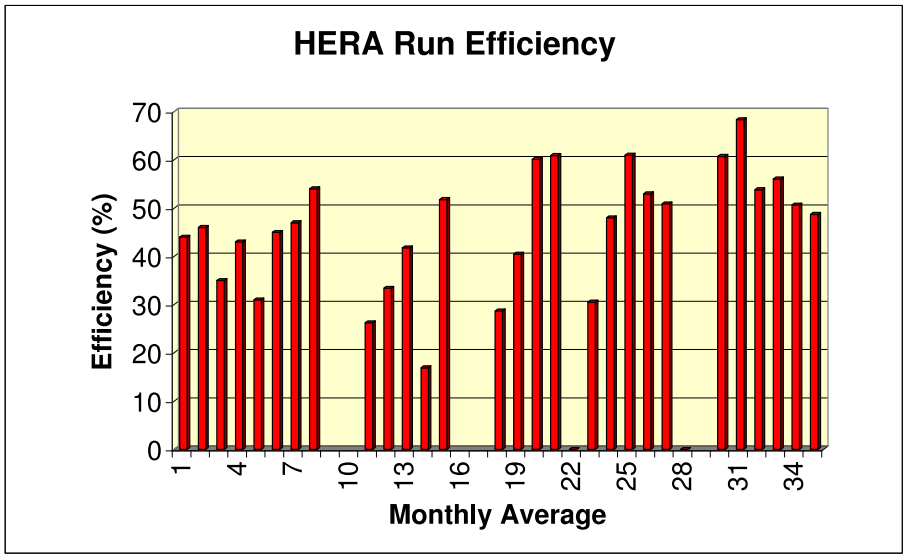

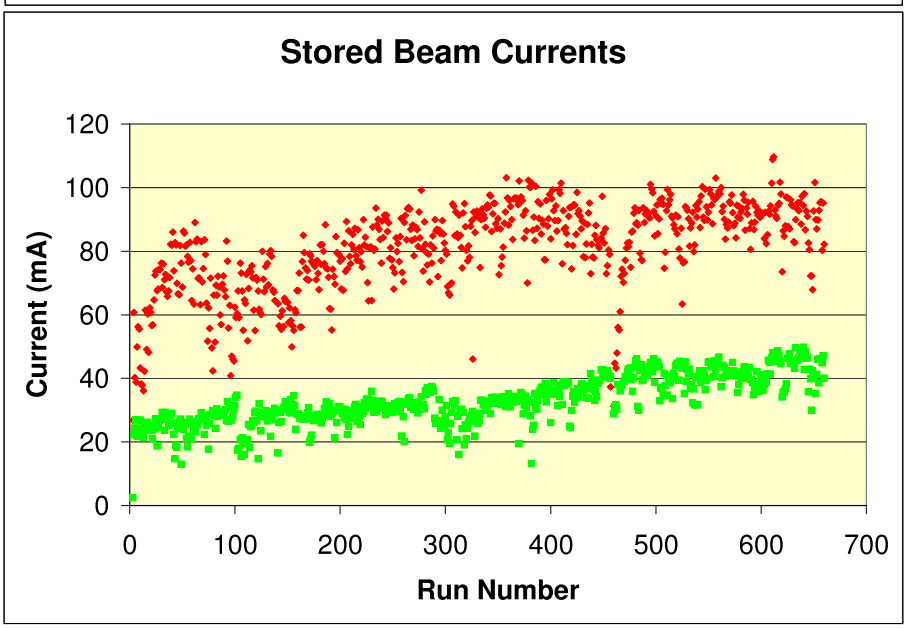

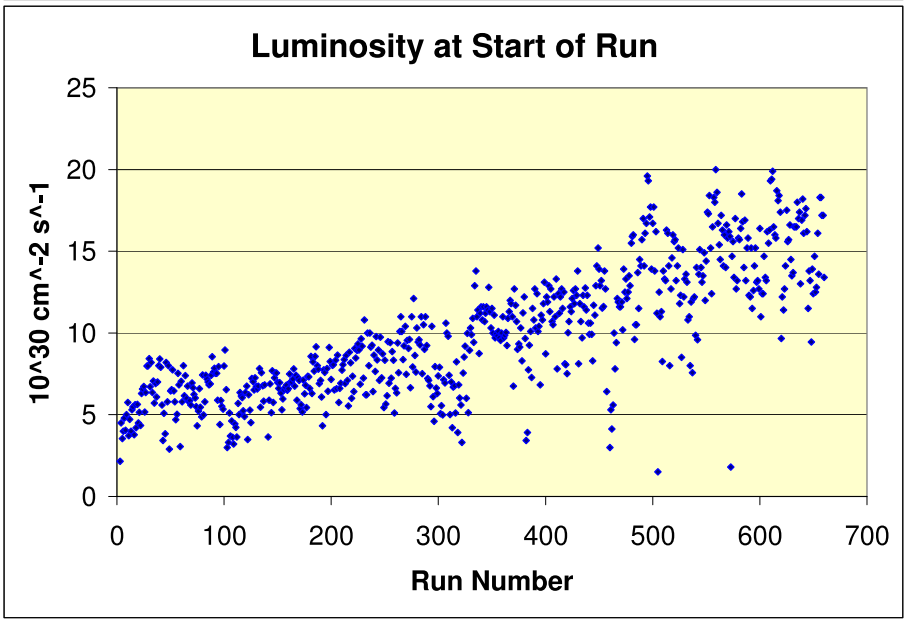

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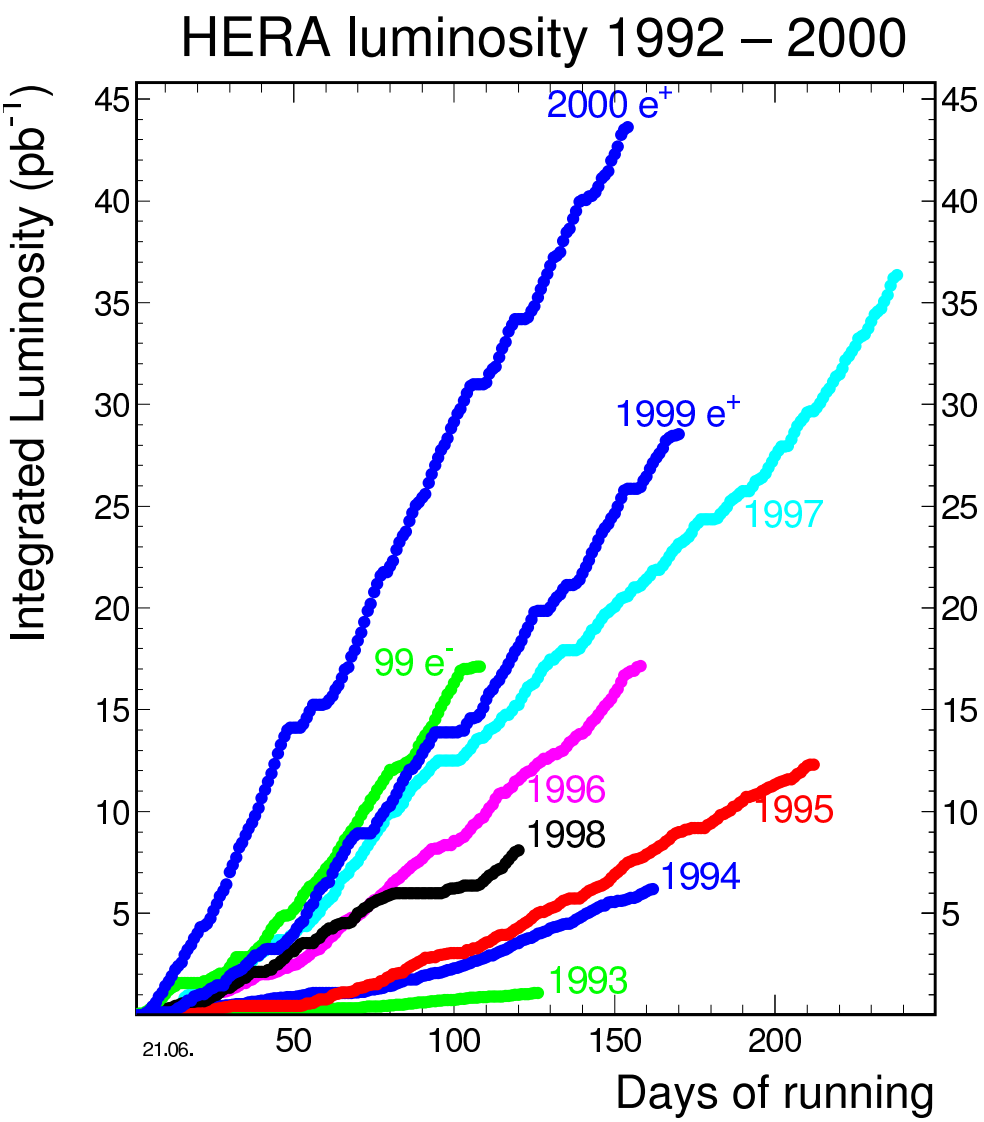
Luminosity of HERA

- Increased reliability
- Higher currents



$\Rightarrow$ It is time for a luminosity upgrade

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HERA $\mathcal{L}$–Upgrade

$$\mathcal{L} = \frac{N^p_{ppb} \cdot I^e}{4\pi \cdot e \cdot \epsilon_p} \frac{1}{\sqrt{\beta_{px} \cdot \beta_{py}}} \quad , \quad \begin{pmatrix} \sigma_e = \sigma_p \\ \epsilon_{px} = \epsilon_{py} \end{pmatrix}$$

In HERA the β_{px} and β_{py} will be decreased:

- reduced distance of proton IP quads (26m $\rightarrow$ 11m)
- needs most importantly early separation of e–p beams
- separation is simpler for reduced electron emittances (41$\rightarrow$20nm)

Limitations to the beamsize reduction are:

- beam beam tune shift for e and p
- hourglass effect for protons
- background due to synchrotron radiation and scattered electrons
- dynamic aperture of electrons

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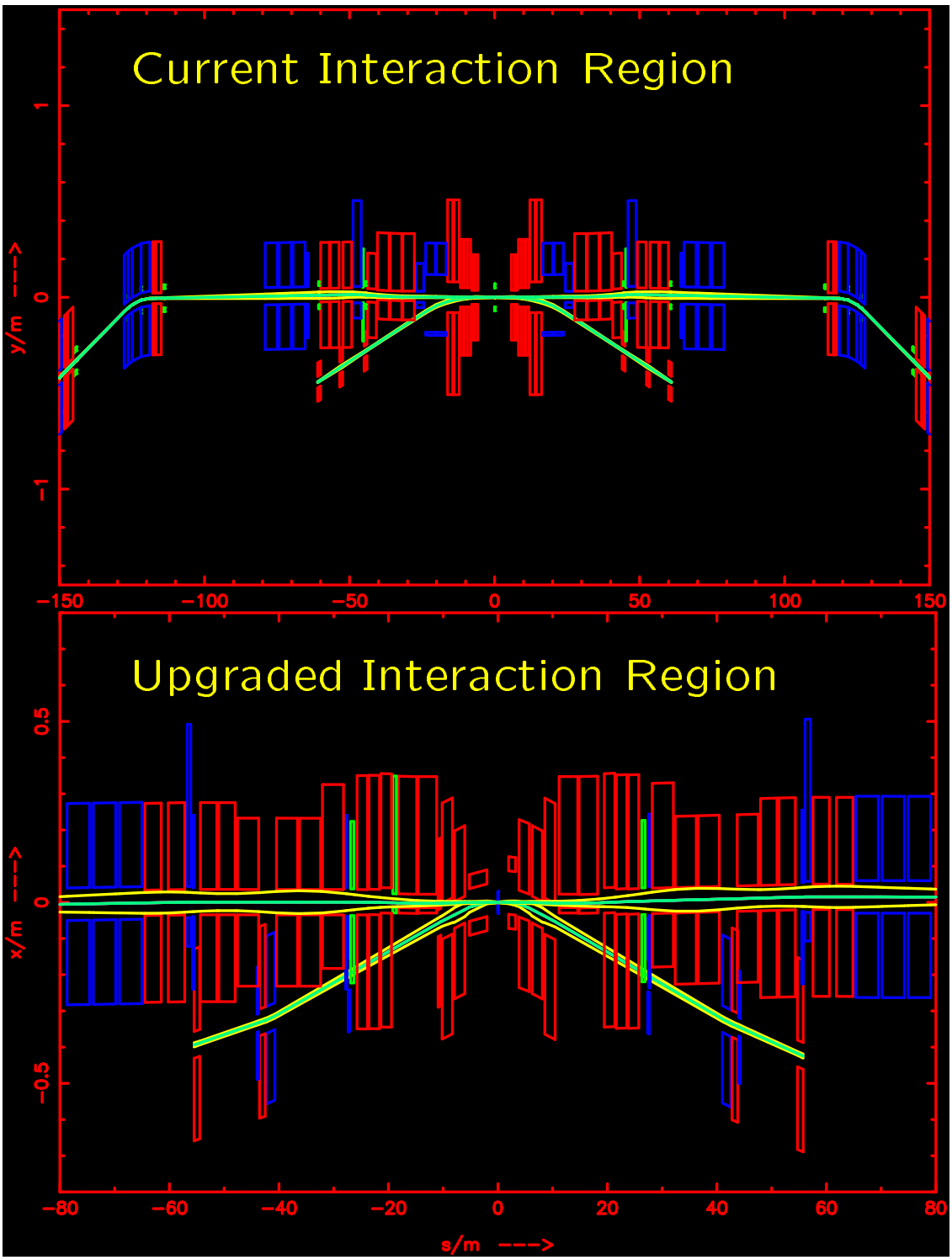
Changes of HERA–IRs



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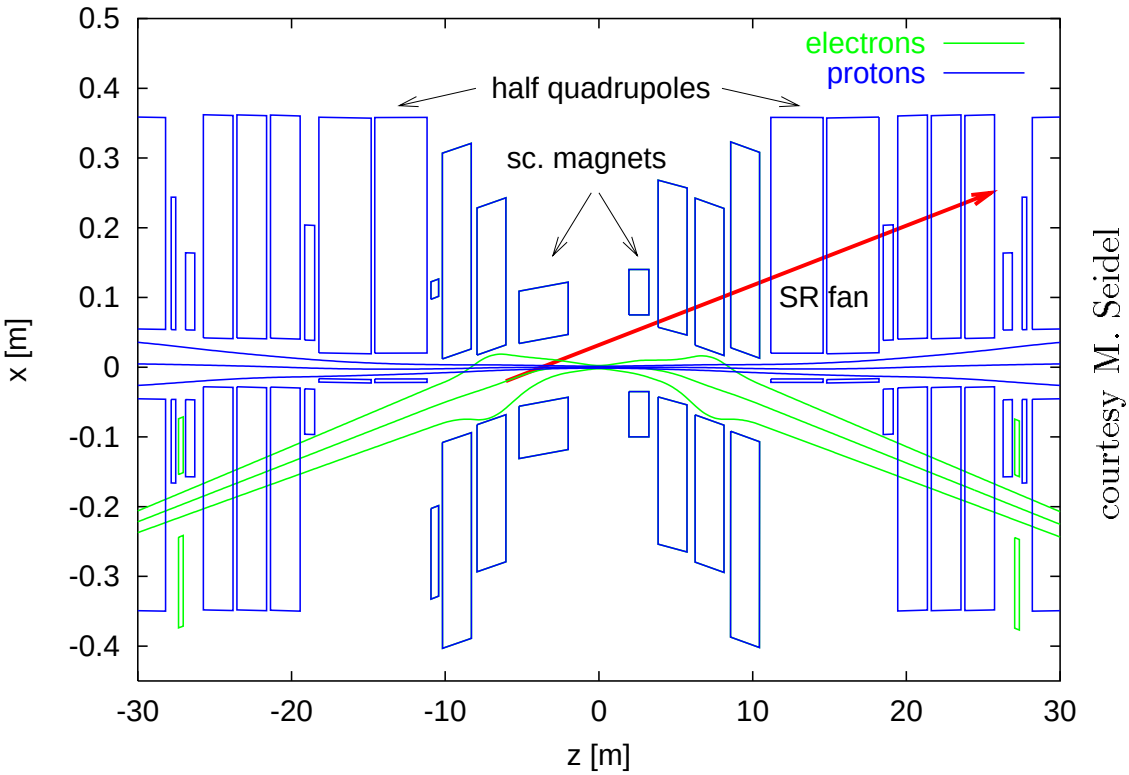
Concepts of IRs



courtesy M. Seidel

- Beam separation by superconducting magnets in the detectors
- e–curvature ($\frac{1}{1200\text{m}} \rightarrow \frac{1}{400\text{m}}$) leads to more radiated power (28kW, $E_{critical} = 150\text{keV}$)
- Radiation passes the detector and is absorded 11, 19, and 26m behind.

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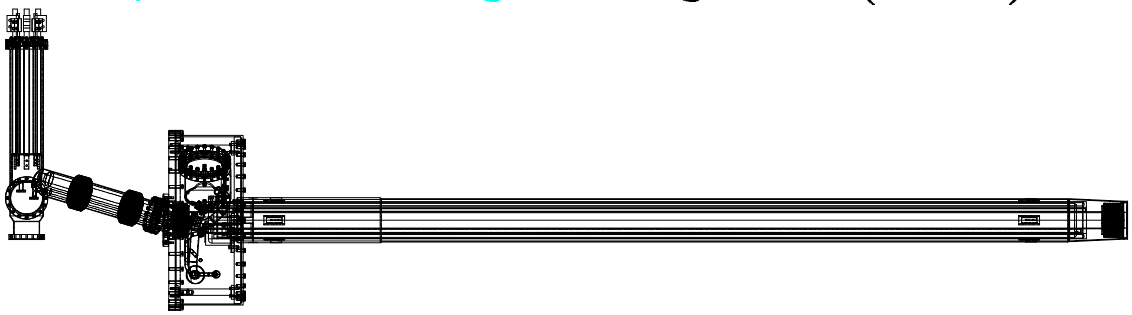
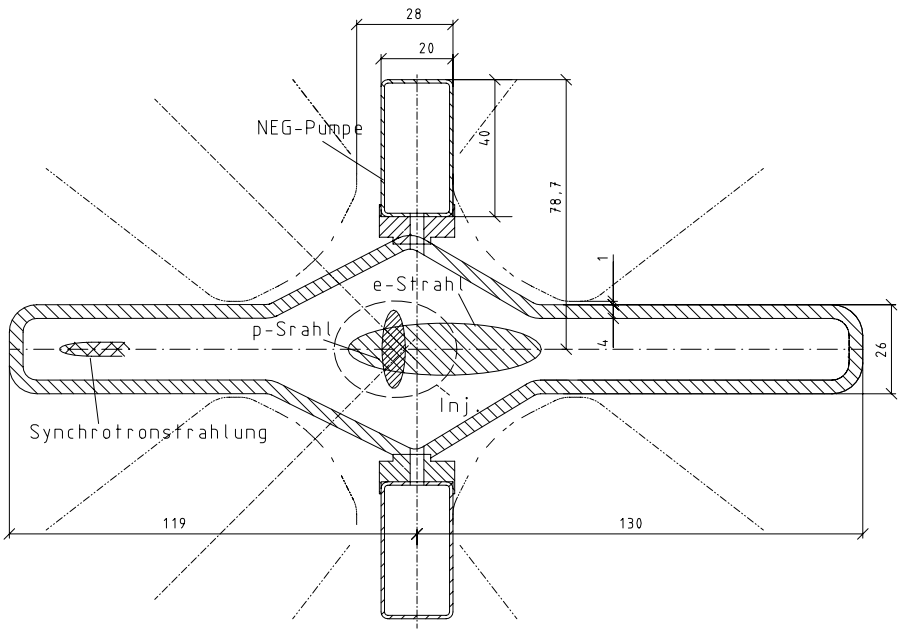
New Components

- 4 superconducting mamgnets (BNL)



- 56 normalconducting magnets (Eframov Inst.)
- 448m UHVacuum system



- Absorbers, instrumentation, controls, ...

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Parameters	currently		after the Upgrade	
	HERA-e	**HERA-p**	**HERA-e**	**HERA-p**
E(GeV)	27.5	920	27.5	920
I(mA)	50	100	58	140
$N_{ppb}(10^{10})$	3.5	7.3	4.0	10.3
n_{tot}/n_{col}	189/174	180/174	189/174	180/174
$\beta_x^\star/\beta_y^\star$(m)	0.90/0.60	7.0/0.5	0.63/0.26	2.45/0.18
ϵ_x(nm)	41	$\frac{5000}{\beta\gamma}$	20	$\frac{5000}{\beta\gamma}$
ϵ_y/ϵ_x	10%	1	17%	1
$\sigma_x/\sigma_y(\mu$m)	192/50	189/50	112/30	112/30
σ_z(mm)	11.2	191	10.3	191
$2\Delta\nu_x$	0.024	0.0026	0.068	0.0031
$2\Delta\nu_y$	0.061	0.0007	0.103	0.0009
Polarization	60%	0%	?%	0%
$\mathcal{L}(\mathrm{cm}^{-2}\mathrm{s}^{-1})$	$16.9{\cdot}10^{30}$		$75.7{\cdot}10^{30}$	
$\mathcal{L}_s(\mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{mA}^{-2})$	$0.66{\cdot}10^{30}$		$1.82{\cdot}10^{30}$	

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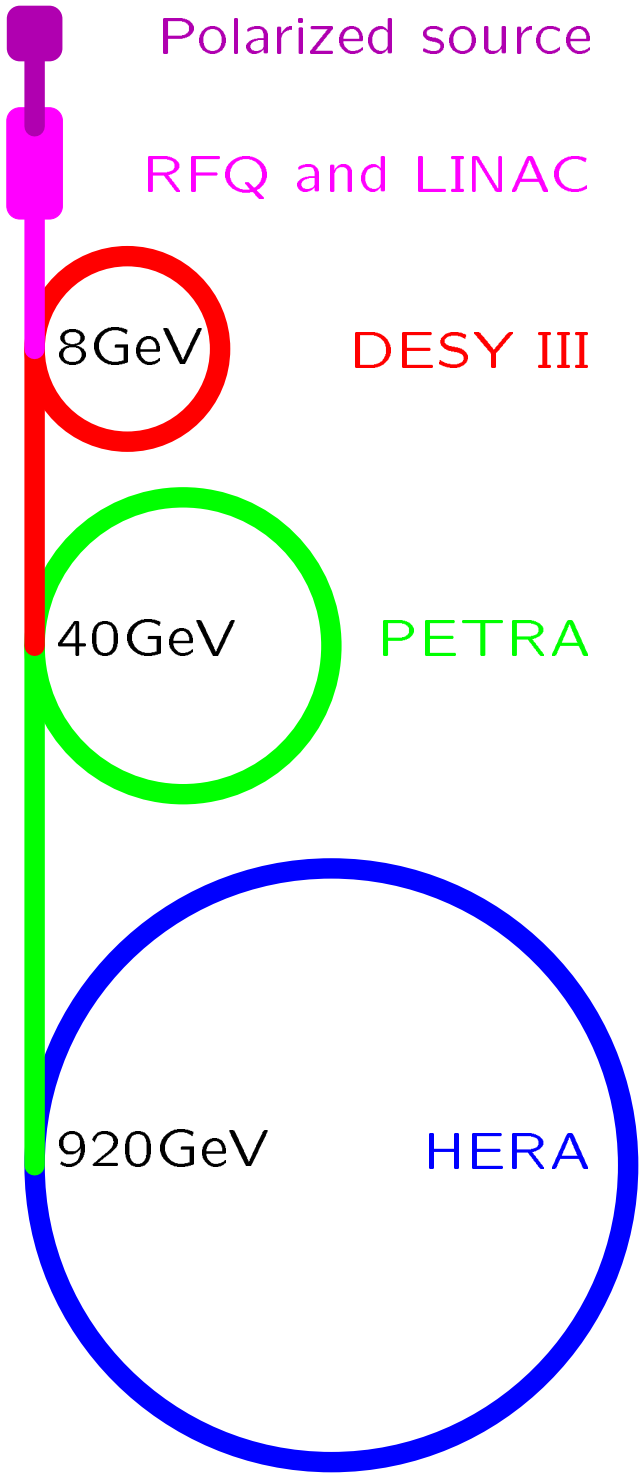
Polarized protons at DESY



Challenges:

- Polarized 20mA H^- source
- Acceleration
- Storage at 920 GeV
- Polarimetry

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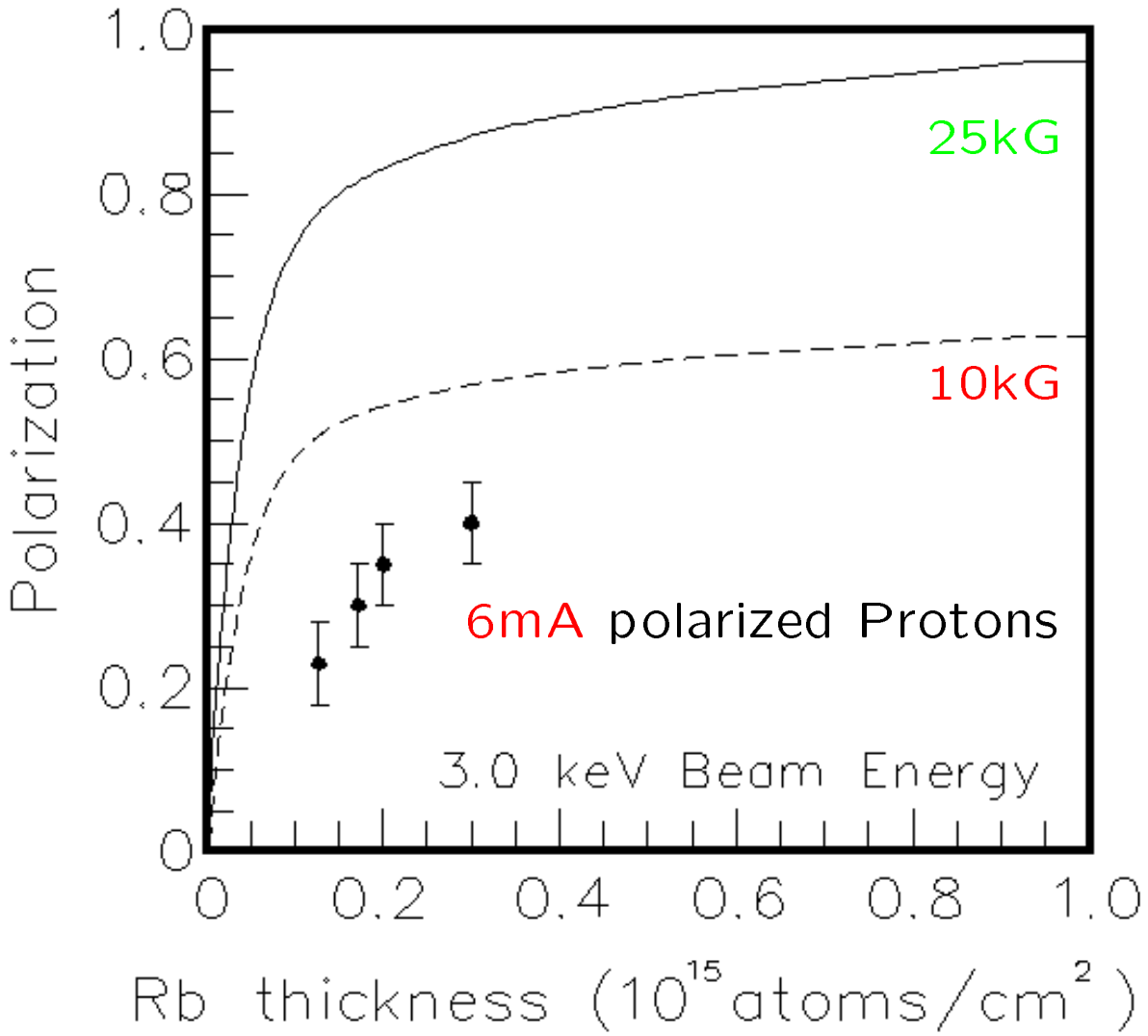
Polarized H^- source



Potential for higher polarization and for higher current.

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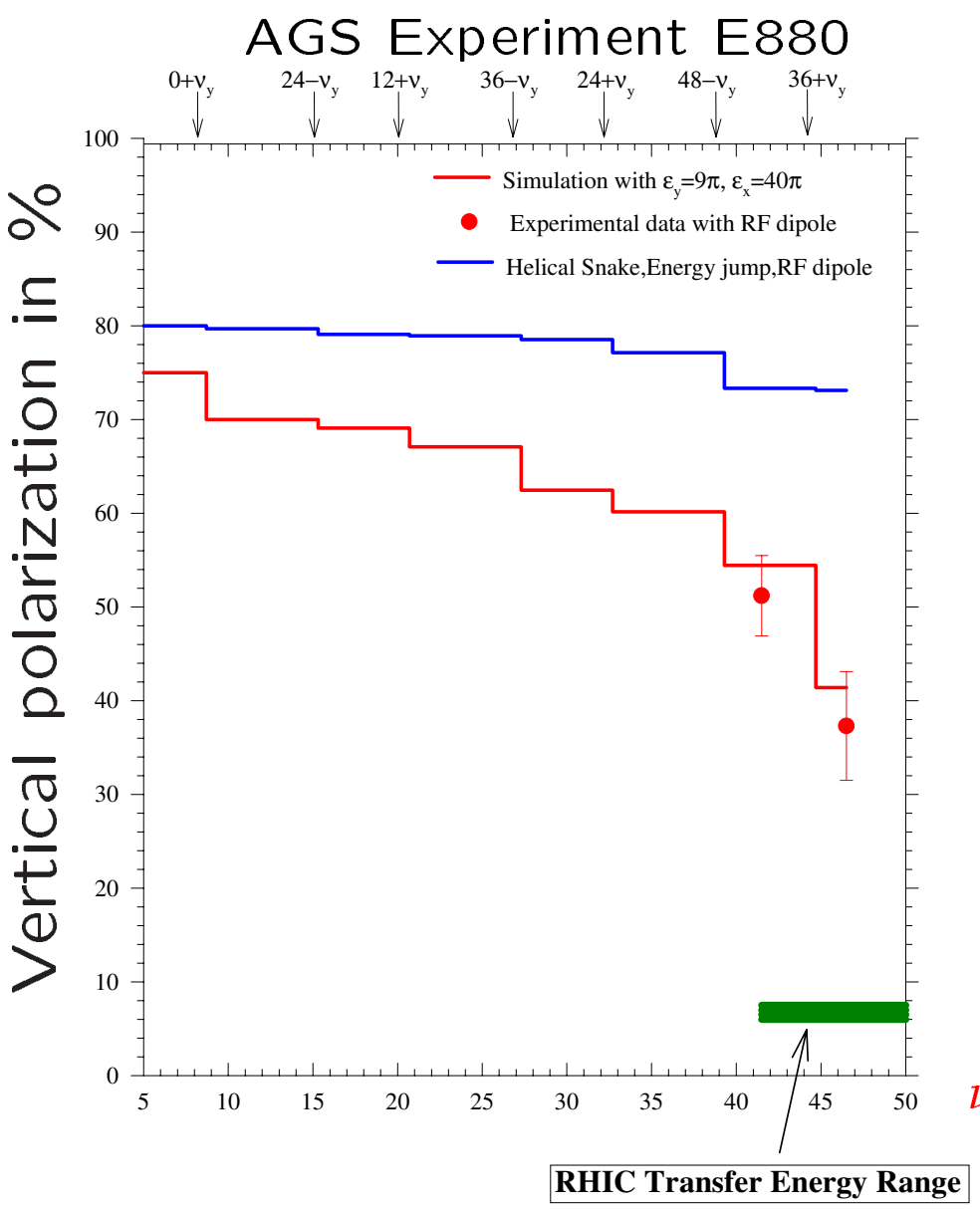
Crossing resonances

Remedy for DESY III: Tune jump, Energy jump, and RF dipole excitation



courtesy T. Roser

$\nu = G\gamma$

Remedy for PETRA and HERA: Fixing the spin tune $\nu = \frac{1}{2}$ by Siberian Snakes.

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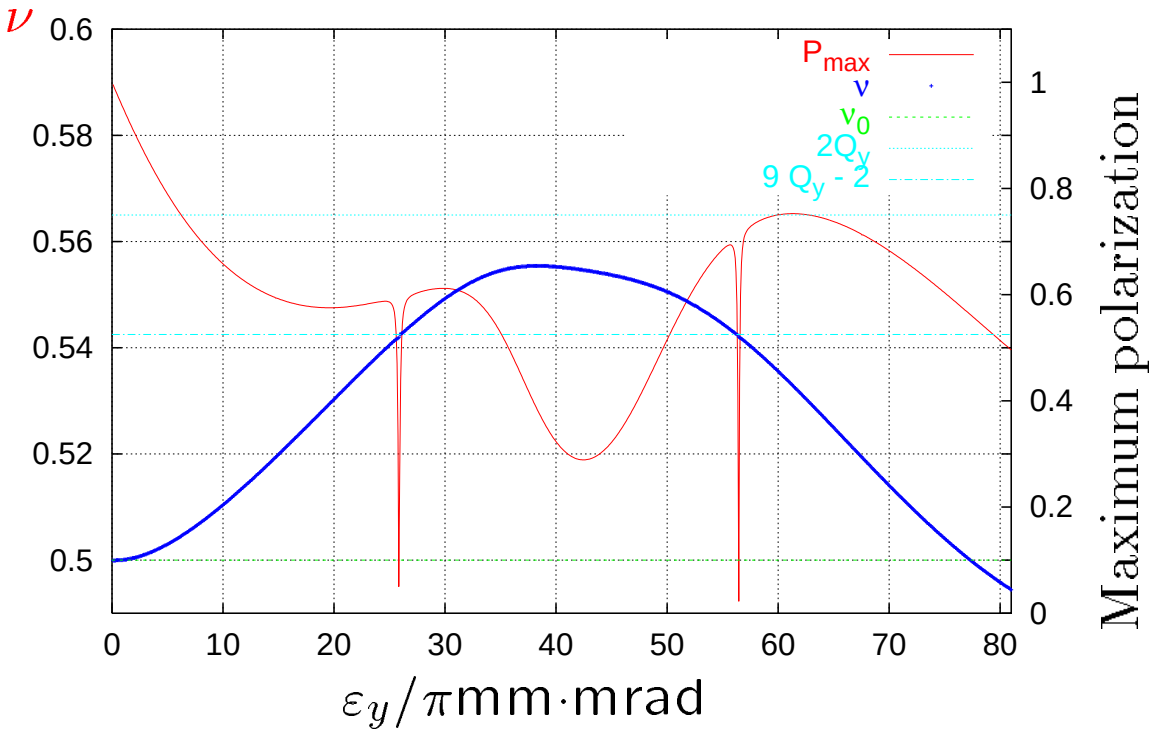
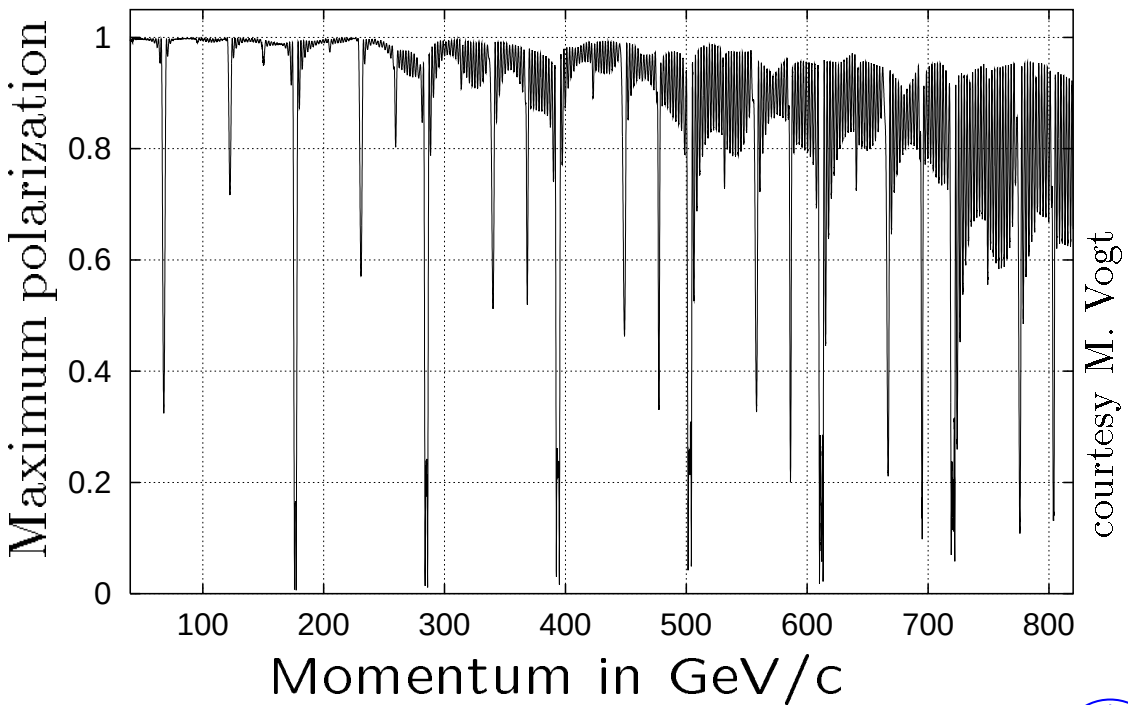
Amplitude dependend spin orbit resonances



Acceleration of $2\sigma_x/2\sigma_y/2\sigma_\tau$



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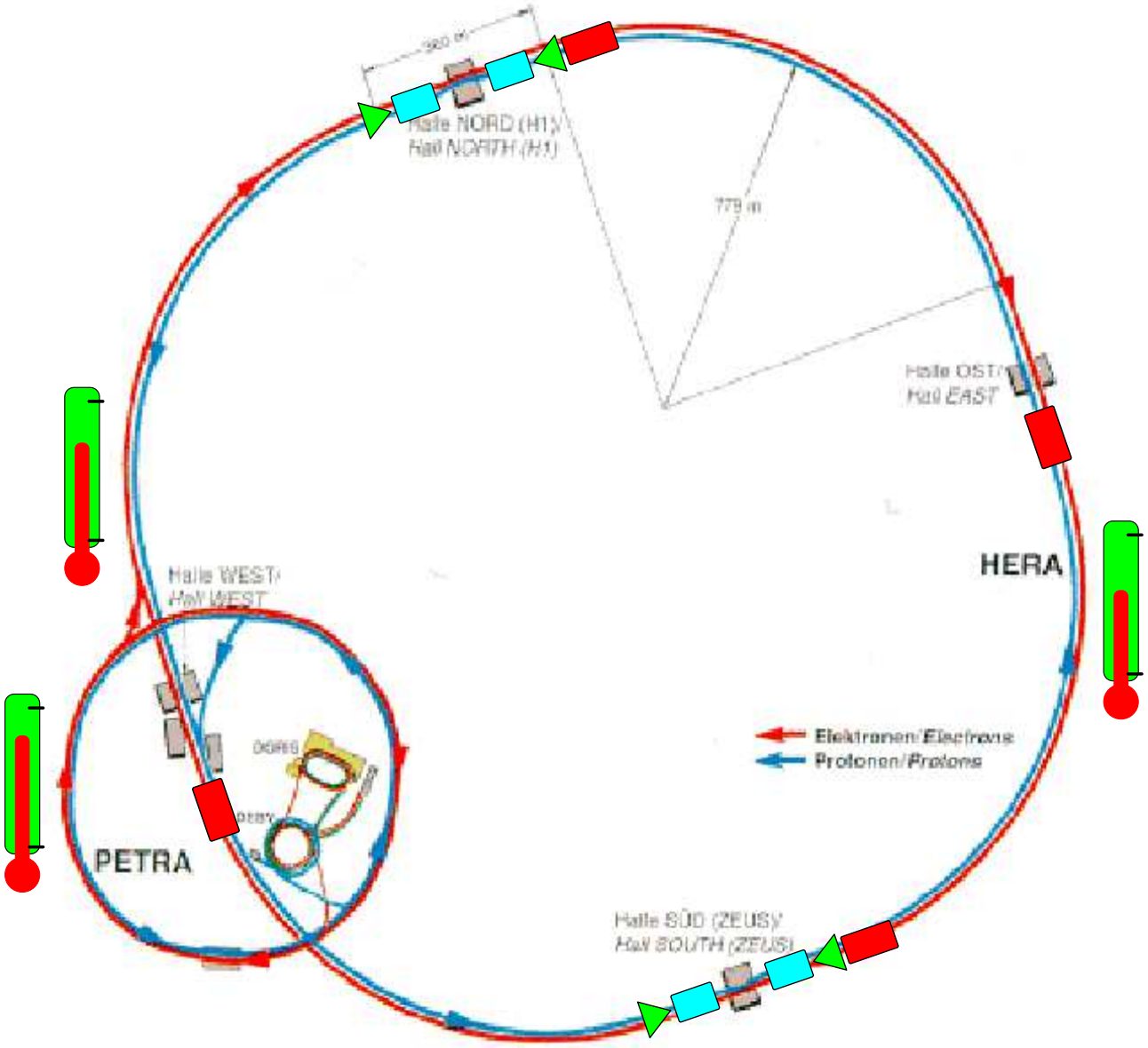
Required instalations in HERA



- Polarimeters
- Flattening Snakes
- Spin rotators
- At least 4 Siberian Snakes

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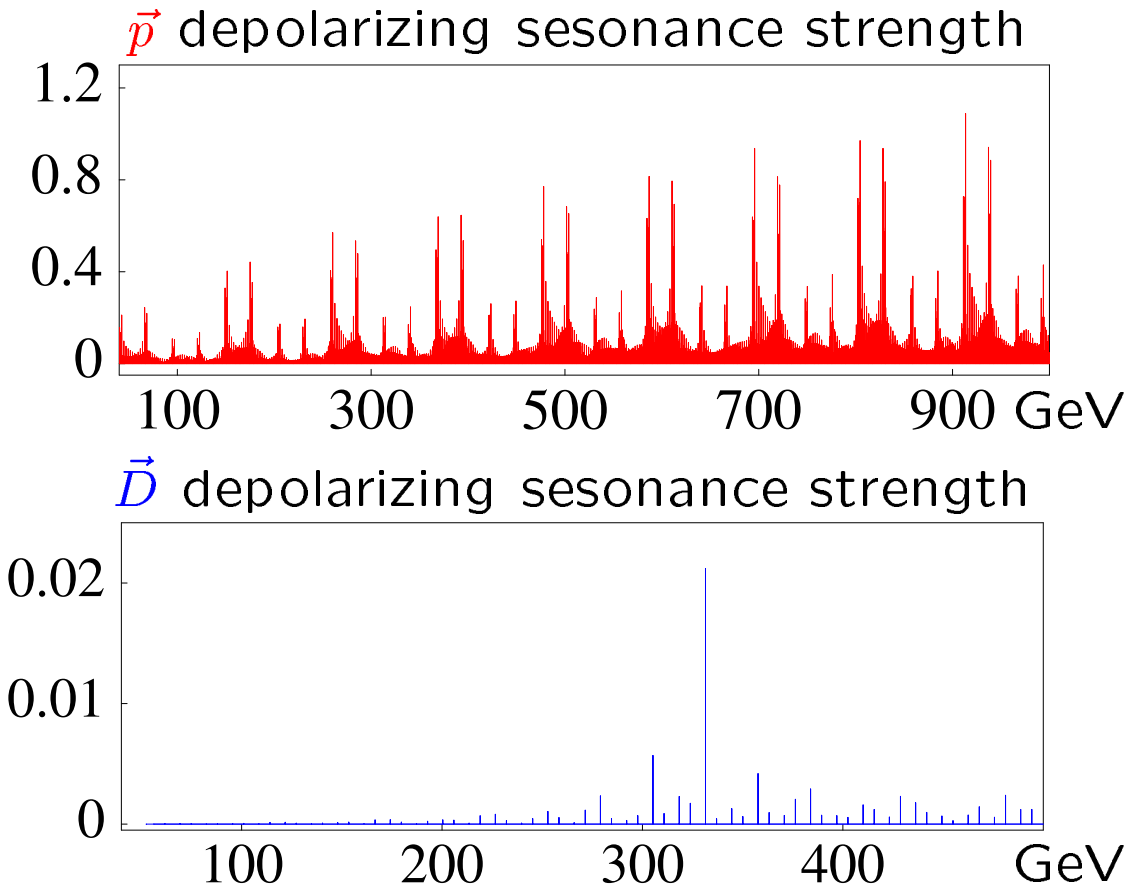
Polarized Deuterons



- Resonances are 25 times weakerand 25 times rarer for $\vec{D}$ than for $\vec{p}$
- Transverse polarization could be achieved without Siberian Snakes
- Transverse RF dipoles could be used to rotate and stabilize longitudinal polarization

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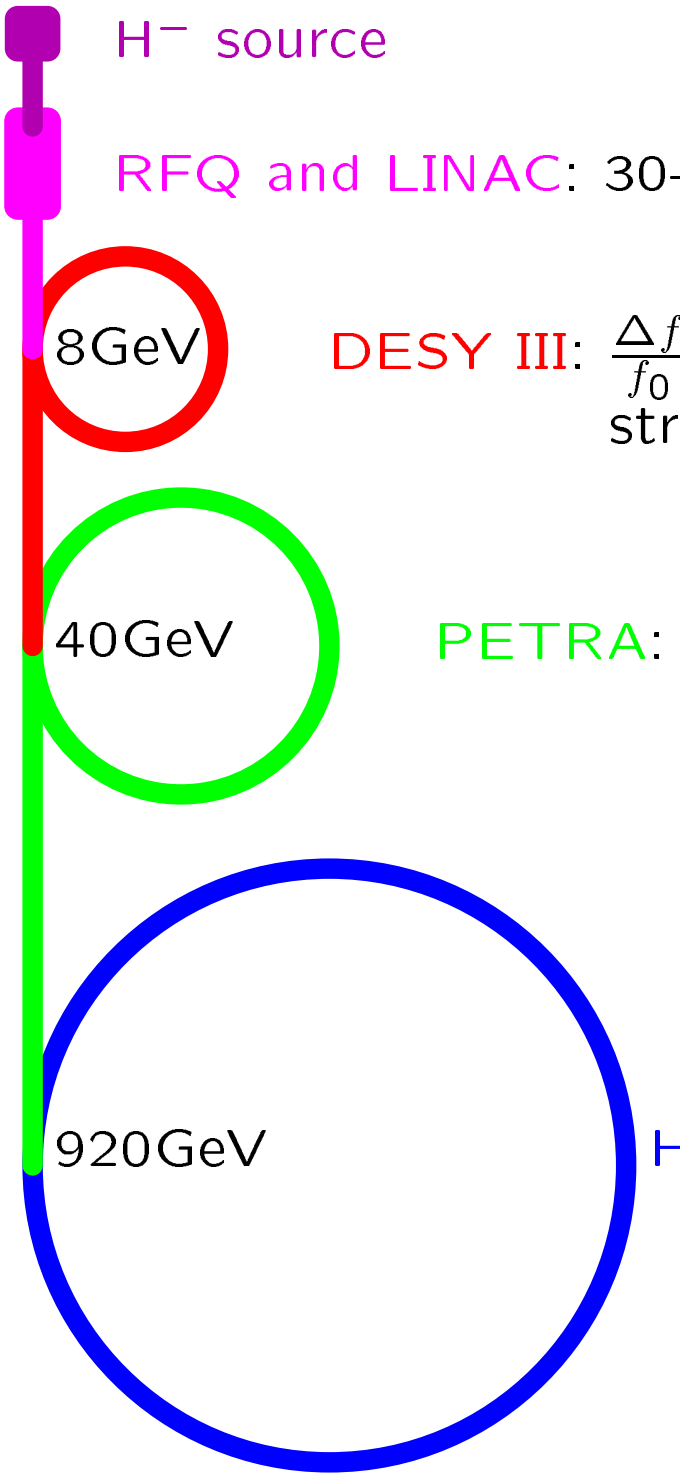
Ions in HERA



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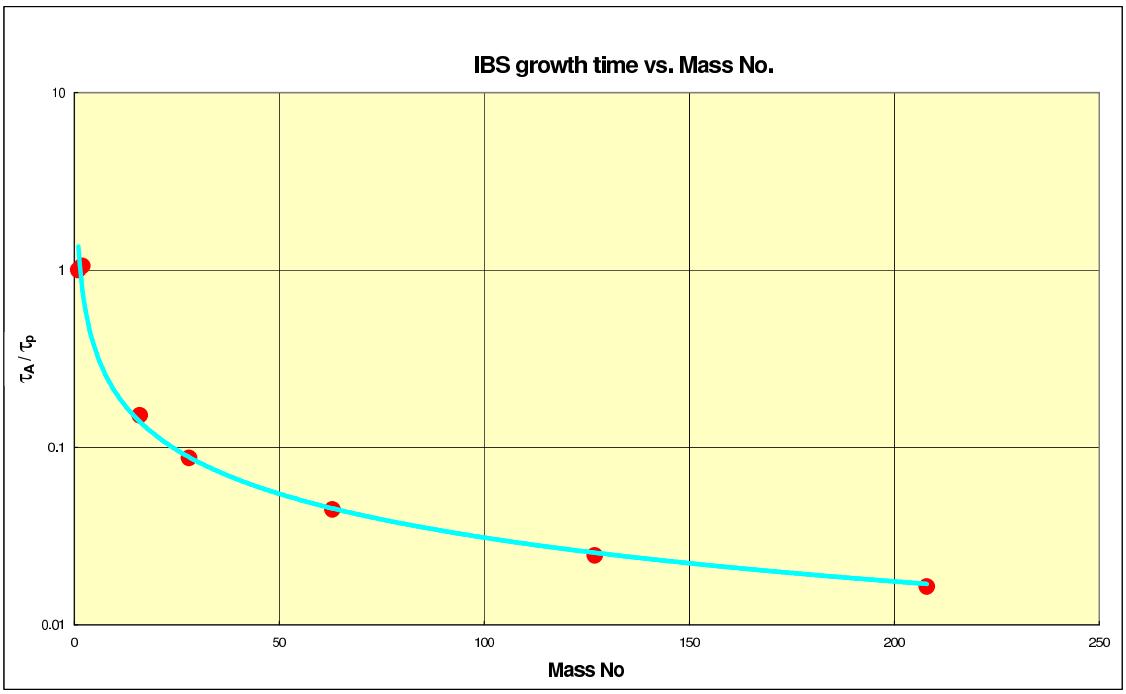
Problem: IBS in HERA

$$\frac{1}{\tau_{IBS}} \propto I_{bunch} \cdot (\frac{Z}{A})^2 \cdot \frac{1}{\gamma^3} \cdot Z$$

	Deuteron	$^{16}O^{8+}$	$^{208}Pb^{82+}$
ϵ_N	2.5μm	2.5μm	2.0μm
N_{ppb}	$5.0 \cdot 10^{10}$	$6.0 \cdot 10^{9}$	$4.8 \cdot 10^{8}$
$\mathcal{L}$	$3.5 \cdot 10^{31}$	$4.4 \cdot 10^{30}$	$3.4 \cdot 10^{29}$
$\sum_{xyz} \tau_{IBS}$	140min	20min	2.5min

Ion99.3 Chart 5



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Summary on $e \Leftrightarrow A$

- Deuteron acceleration:
  technical solutions seem possible

- Heavy ions: $\mathcal{L}_A \approx \mathcal{L}_p/A$
  does not seem possible

- e–Cooling could counter balance Intra Beam Scattering and lead to the required emittances and
  Luminosity $\mathcal{L}_A \approx \mathcal{L}_p/A$

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e–Cooling for HERA

- $e \Leftrightarrow A$: balance IBS
- $e \Leftrightarrow \vec{p}$: reduce p–emittance to a polarizable size
- $e \Leftrightarrow p$: double luminosity

$$\tau_{long} \propto \frac{A}{Z} \cdot \gamma^4 \cdot \sqrt{\epsilon_p}^2 \cdot \frac{1}{Z}$$

$$\tau_{trans} \propto \frac{A}{Z} \cdot \gamma^3 \cdot \sqrt{\epsilon_p}^3 \cdot \frac{1}{Z}$$

- Cooling PETRA ($\gamma \approx 19$):
  ϵ_{px}: 5→3.3mm mrad
  ϵ_{py}: 5→0.8mm mrad
- Cooling HERA: preserve ϵ_p against IBS
  ϵ_{px}: 3.8mm mrad
  ϵ_{py}: 0.9mm mrad

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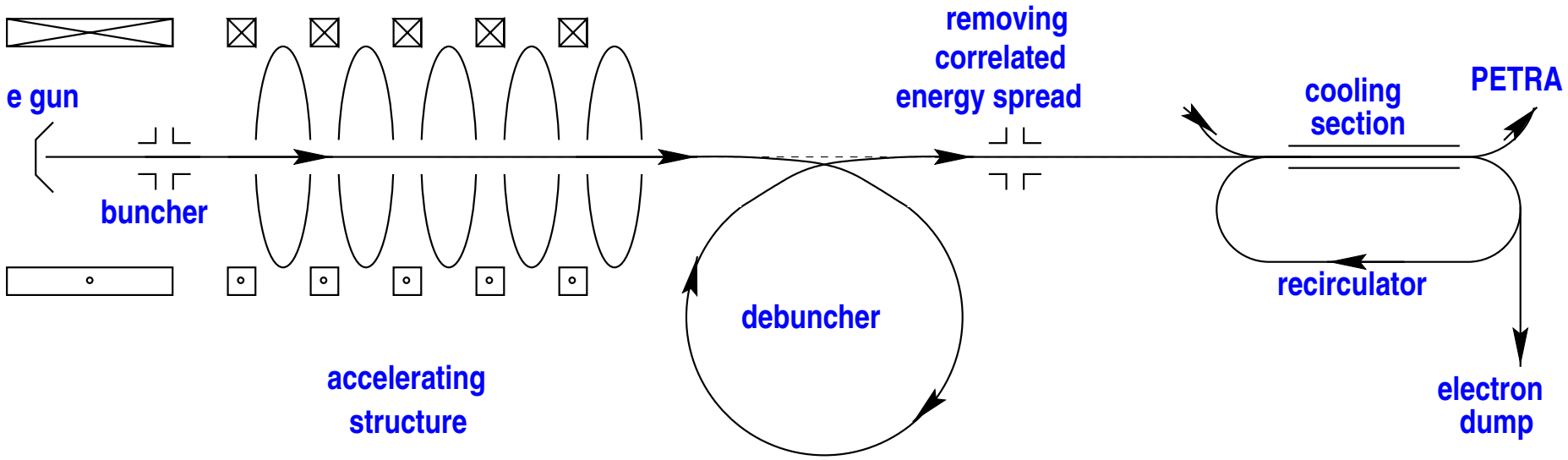
Electron Cooling in PETRA



B_z	$= 0.3\mathrm{T}$
N^e_{ppb}	$= 3 \cdot 10^{10}$

E	$= 9.8 MeV$
$\frac{\Delta p}{p}$	$= 30 \cdot 10^{-4}$
σ_z	$= 0.017$

B_z	$= 0.06\mathrm{T}$
$\frac{\Delta p}{p}$	$= 3 \cdot 10^{-4}$
σ_z	$= 0.5$

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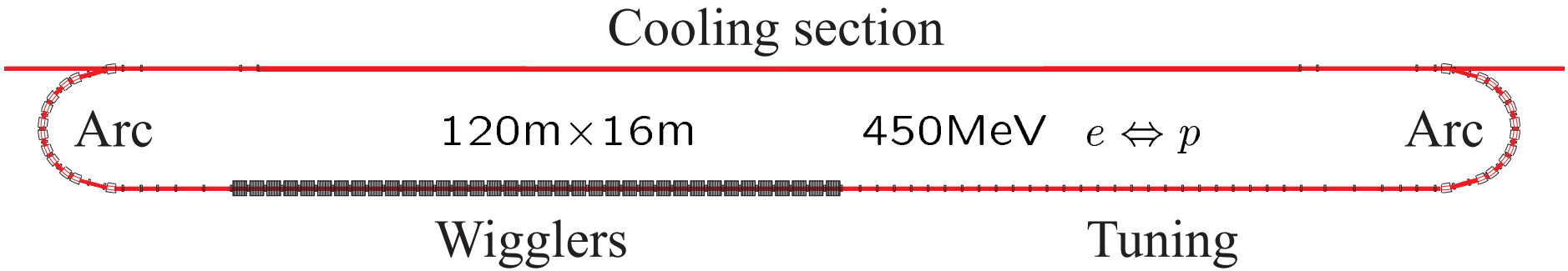
Electron Cooling in HERA



- Width limit: dynamic aperture from sextupoles required due to strong focusing (tunnel has 5.2m)
- 37 wigglers section: $D = 0,\ D' = 0,\ B = 1\mathrm{T}$
- Tuning section: tune control, decoupling, RF cavities

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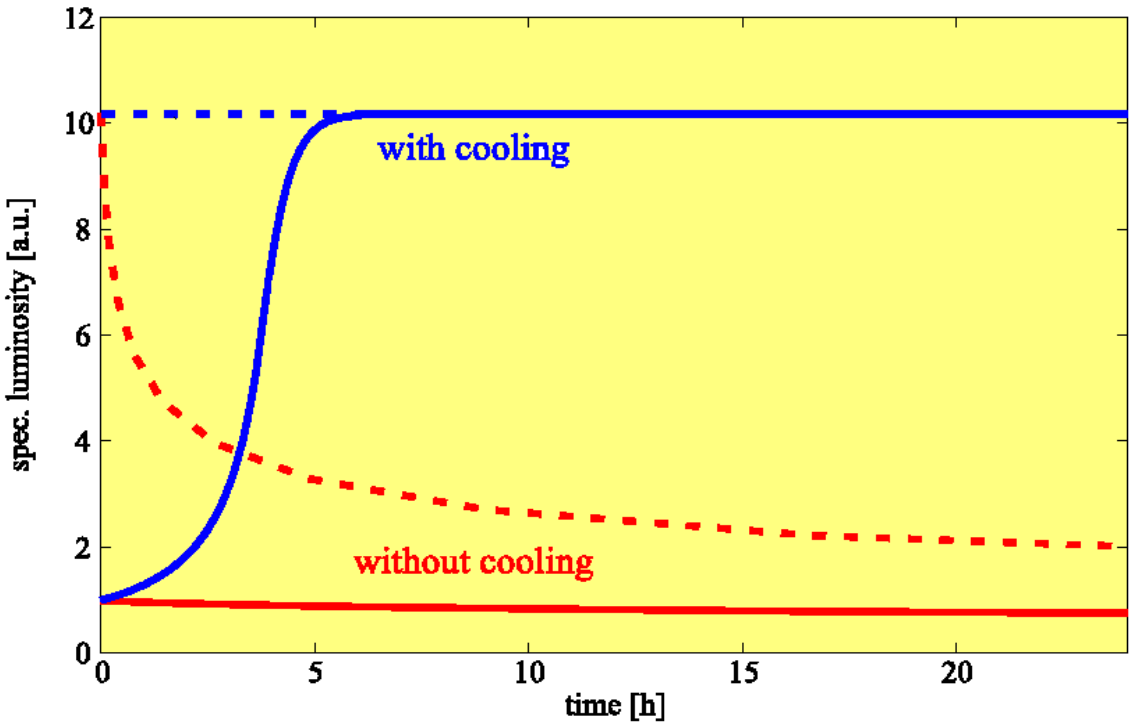
Cooling for $e \Leftrightarrow A$

$^{197}\mathrm{A}^{79+}$: $E = 330 \frac{\mathrm{GeV}}{\mathrm{u}}$

$\epsilon_x = 1\mu\mathrm{m},\ \epsilon_y = 0.25\mu\mathrm{m}$



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hori. $\tau_{IBS} = \tau_{cool} = 30\mathrm{min}$

long. $\tau_{IBS} = \tau_{cool} = 18\mathrm{min}$

$$\mathcal{L}_A = \mathcal{L}_p \frac{1}{A}$$

$$\mathcal{L}_p = 0.76 \cdot 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$$

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HERA after TESLA

HERA will be around for many more years

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