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Baseline Injection/Extraction Configuration

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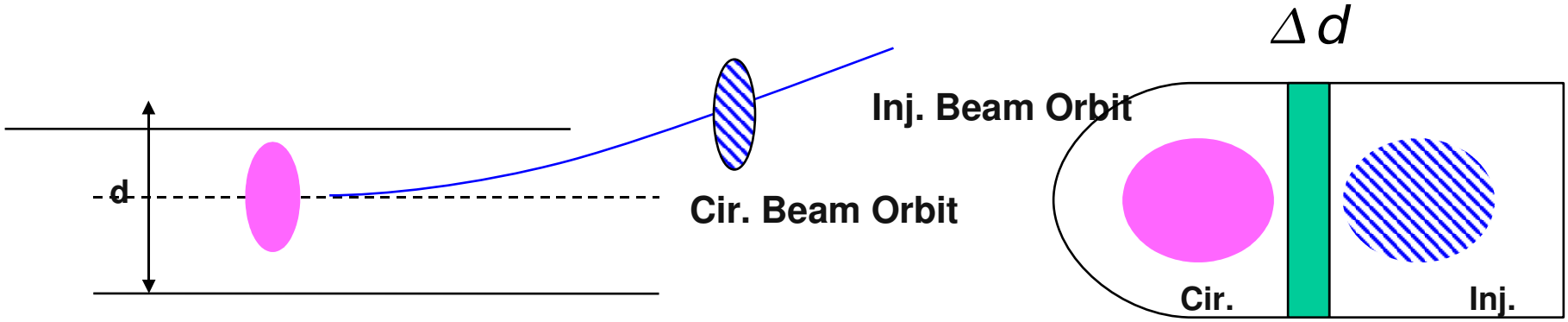
Fast Strip-Line Kicker

- Technical specification (section 4.1.2 of Baseline Document) :
  - Length L=300 mm
  - Gap d=30 mm
  - Pulse V=10 kV
  - Need maximum beam acceptance $A_{x,max}$= 0.09 m-rad
- Kicking angle of kicker is 0.04 mrad $\Delta\theta = 2g\frac{eV}{E}\frac{L}{d}$
- Acceptance and aperture sets the maximum beta functions at strip-line kicker:

$$2\sqrt{\beta_0 \frac{A_{x,max}}{\gamma}} \le d \;\rightarrow\; \beta_0 \le 25\,m$$

Including room for orbit excursion, say, 2 mm: $\beta_0 \le 16\,m$

Optical Requirement of Fast Strip-Line Kicker



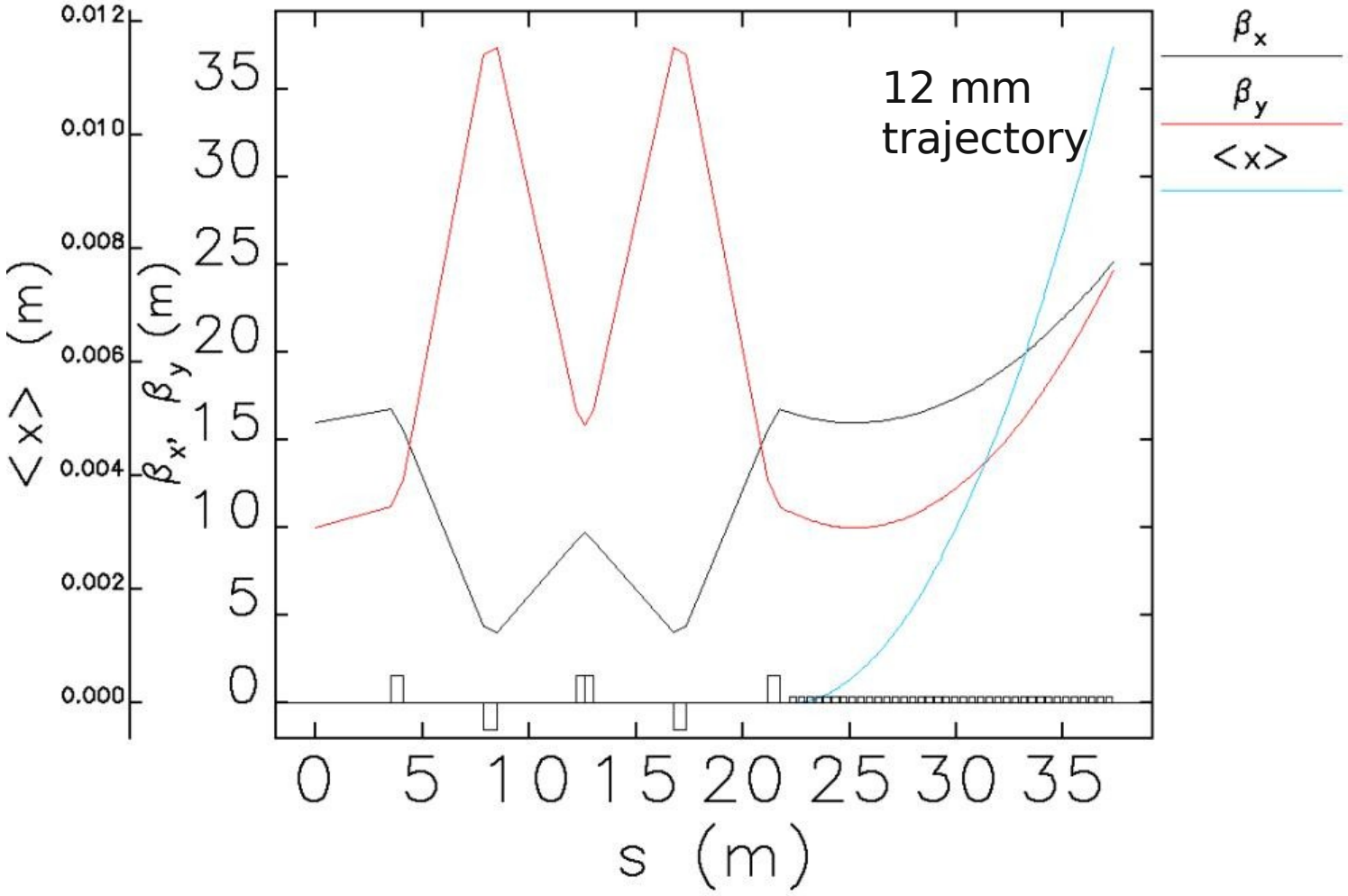
- Trajectory after kicks $\Delta x(s) = \sqrt{\beta_{x,0}\beta_x(s)}\,\theta\,\sin(\Delta\phi)$
- Required beam separation at septum

$$\Delta x_{min} = 2\sqrt{\beta_{x,septum}(A_{x,max}/\gamma)} + \Delta d$$

- Neglecting septum thickness, assume sin $\Delta\varphi$ = 1, the minimum number of strip-line kicker is about 38.

$$\theta_{min} = 2\sqrt{\frac{A_{x,max}}{\gamma}\frac{1}{\beta_{x,0}}}$$

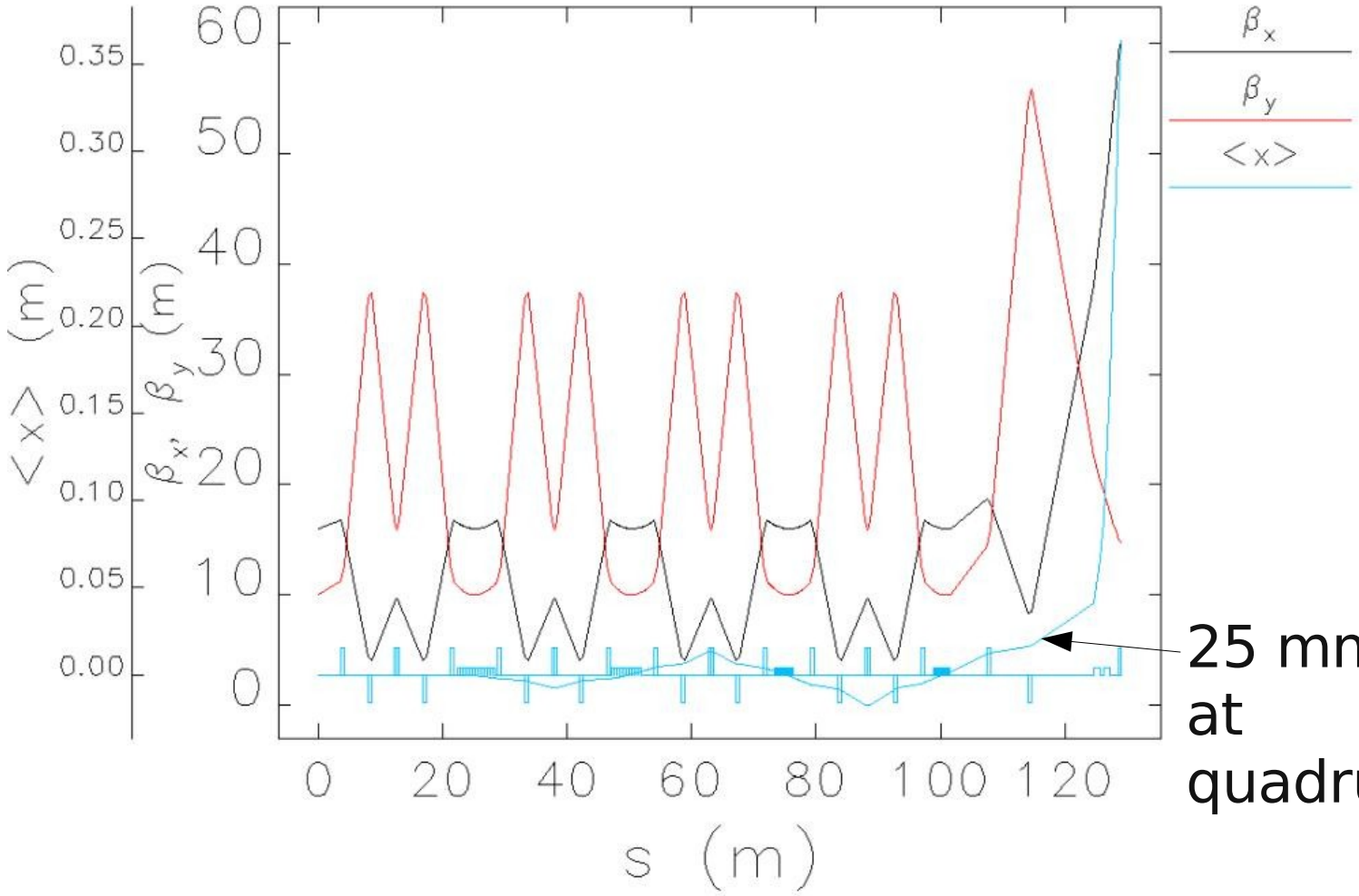
Injection Section – If we put all strip-line kickers in one drift space



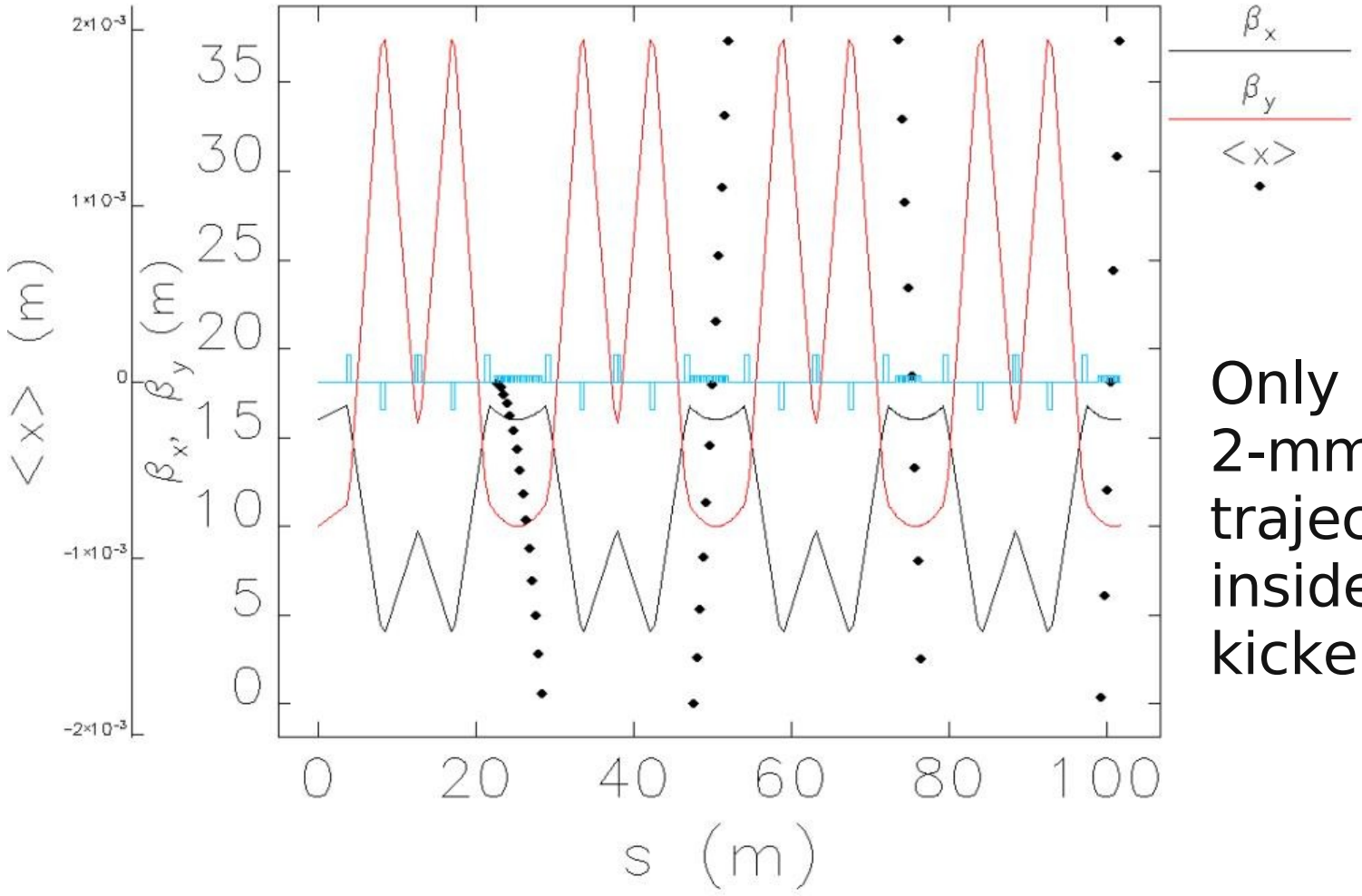
Distributed Kicker Scheme

π-phase advance cells

Entire injection line optics



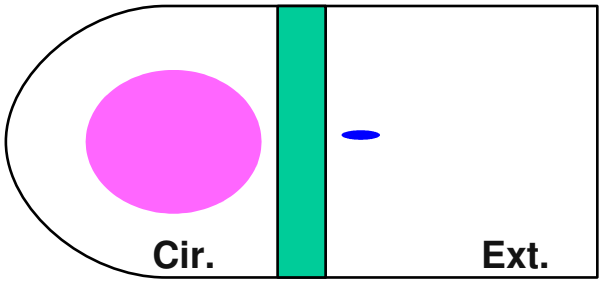
Distributed Injection Scheme



Only 2-mm trajectory inside kickers

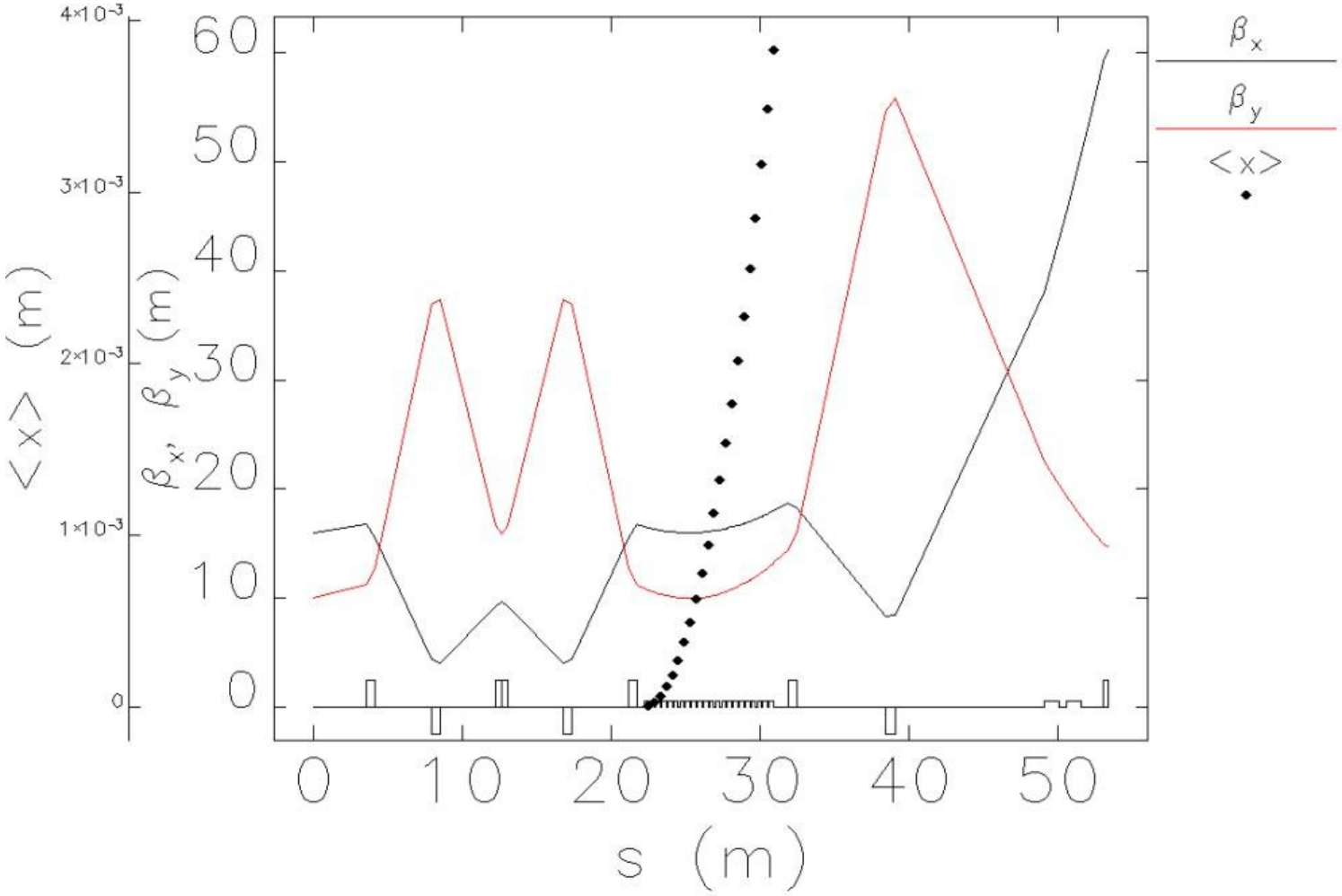
Extraction Section

- Similar to injection except the extracted beam size is much smaller
- Required kicker angle in about half of that of injection
- The tolerance on the beam orbit excursion can be large

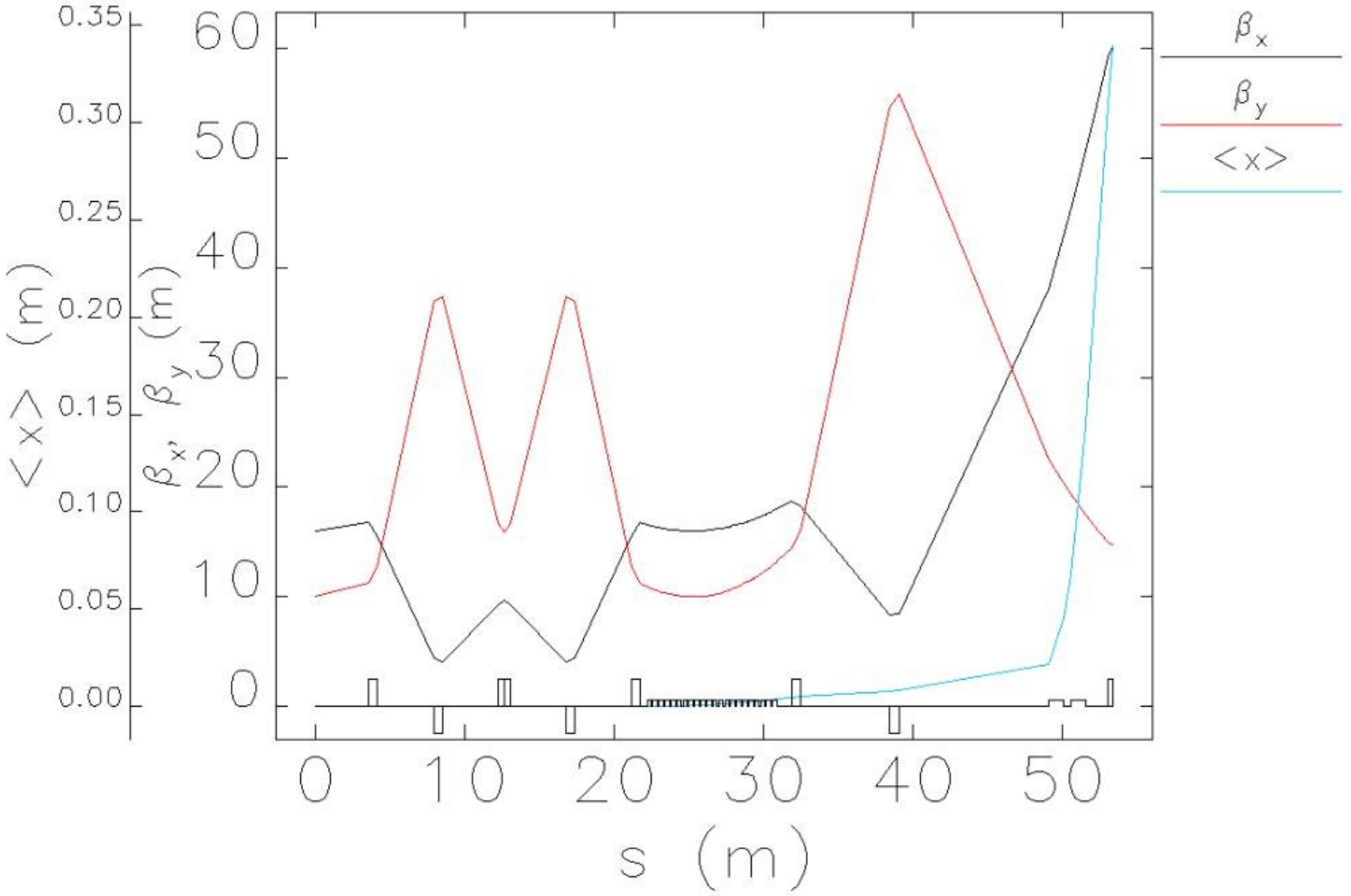


Extraction Section

4 mm trajectory



Lattice of Extraction Scheme

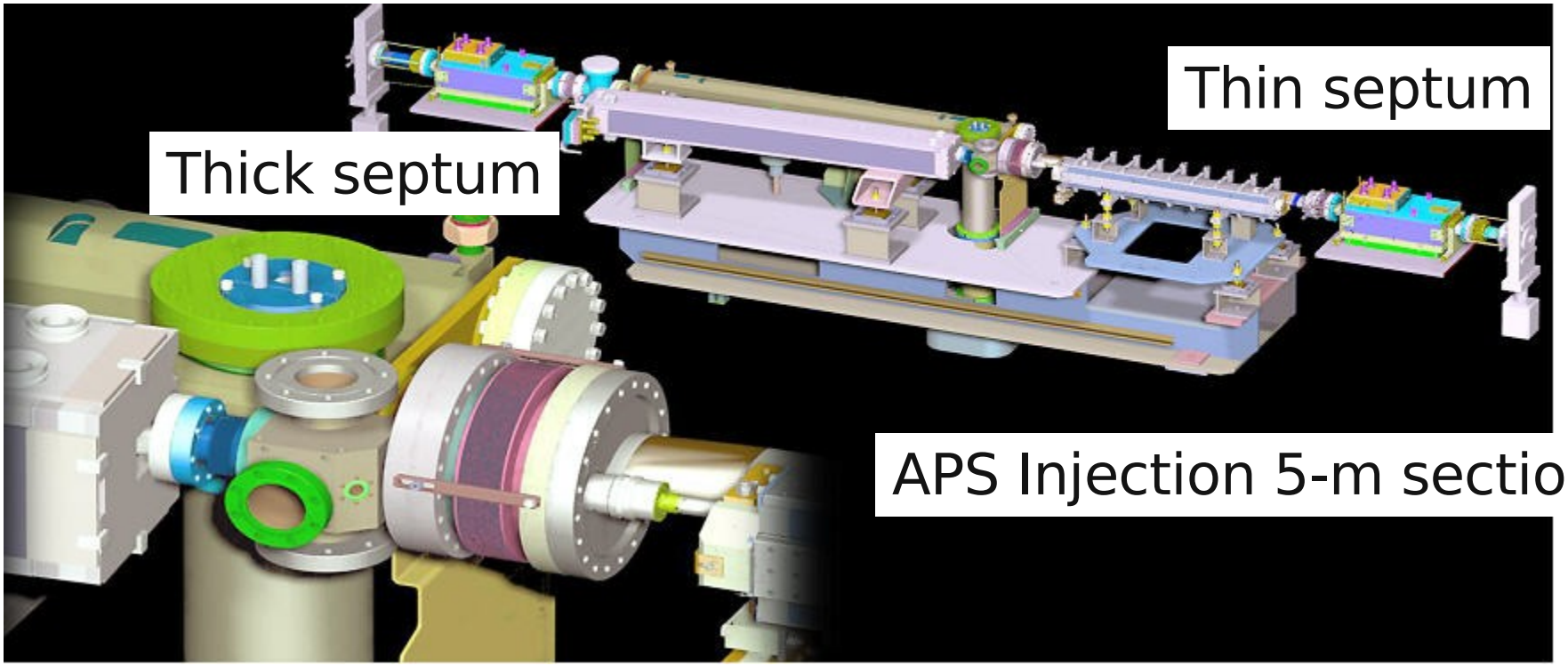


Possible Pulsed Septum Magnet

- Inspired by APS injection septum magnets that run at 7 GeV
  - Pulsed with 10 ms sine wave instead of DC because of heating (80 kW peak power)
- Thick septum, 70 mrad, 1T, 700 A, N=36, 10 ms half-sine
- Thin septum, 33 mrad, 0.7 T, 14000A, N=1, uses 3:1 transformer

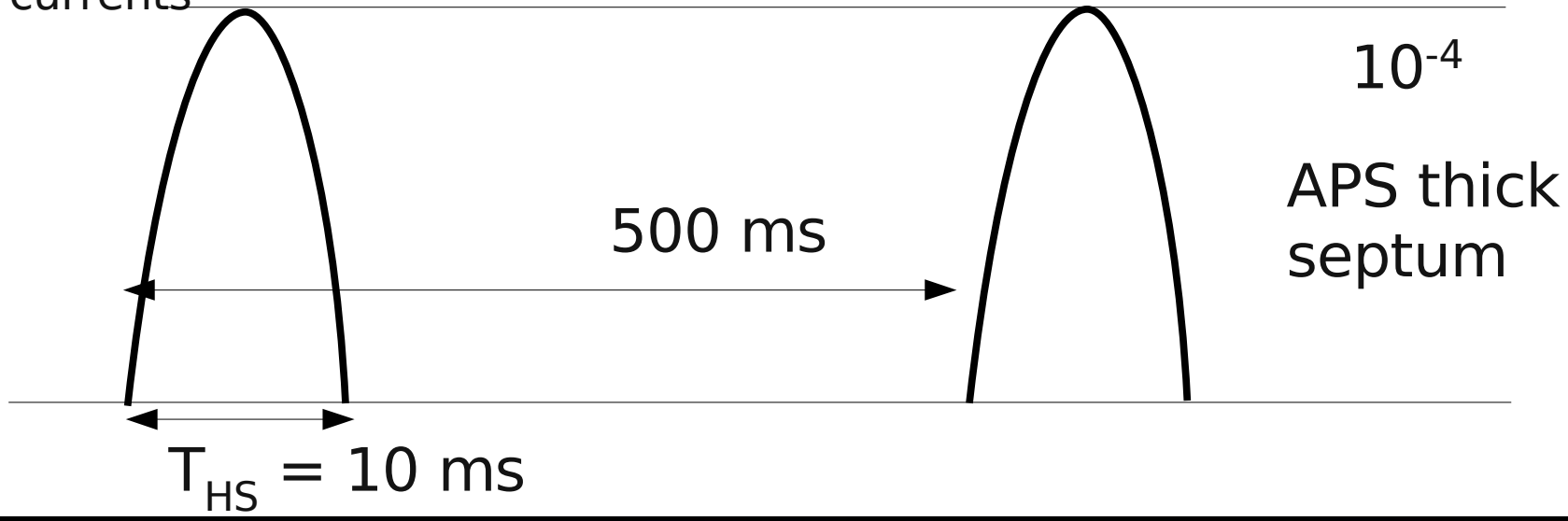
Need sufficient large angle to clear the closest quadrupole

Layout of injection at APS



Pulse requirements

- APS septums discharge capacitors into the magnet inductance
  - Charge supply is controlled to 10^{-4} using 20 kHz (?) pulse injection just before discharging
  - Resulting trajectory angle jitter is 0.01 mrad
  - For a 1 ms period thick septum variation is $\pm 60 \times 10^{-4}$, too large!
    - *Thin septum pulse is already shorter than 1 ms!*
- To control the flat top, one must regulate during 1 ms of the discharge period, which is harder because of the much higher currents



Pulsed Magnet Flat Top Regulation

- APS engineers think regulation may be possible for thick septum
  - Spring-8 booster ramp 100 ms flat-top regulation of 1500 A to 10^{-4} (Fukami)
- Thin septum design requires a short pulse for reduction of leakage fields using eddy currents, so a 1 ms pulse may defeat this feature.