HELMHOLTZ ZENTRUM BERLIN
für Materialien und Energie

TRANSVERSE EMITTANCE EXCHANGE BY DYNAMIC COUPLING

P. Kuske, BESSY

Motivation:

improvement of injection efficiency

The Physics of Transverse Emittance Exchange:

static in transfer lines
dynamic in synchrotron

Will it Work?

vertical acceptance of the storage ring

Next Steps:

injection tests with a fully coupled beam

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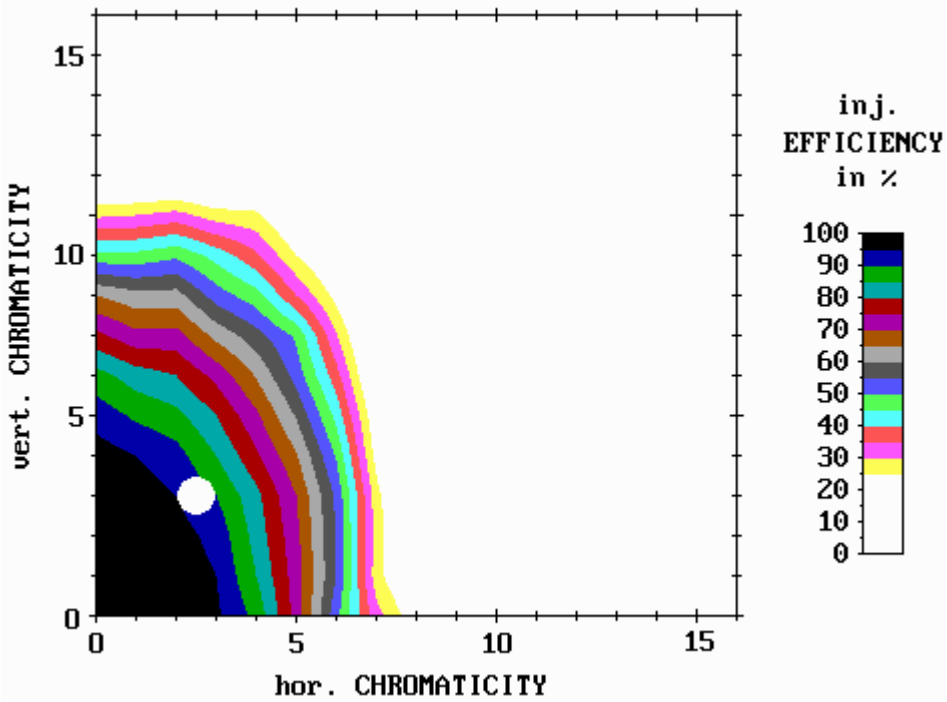
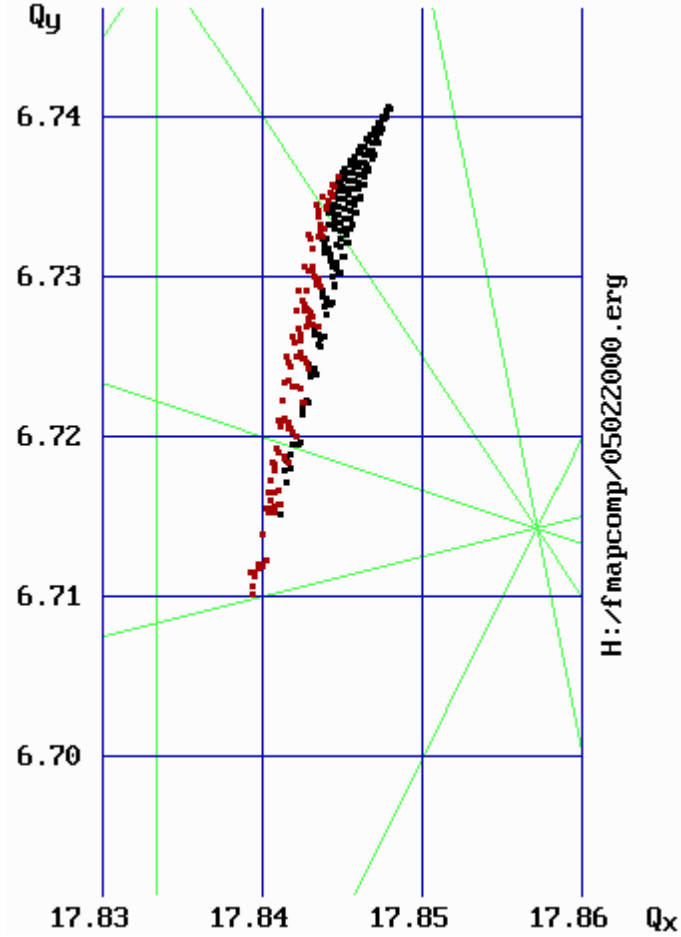
Injection Efficiency vs. Chromaticity

harmonic sextupole settings for optimized lifetime





operating conditions: ξ_x=2.5 and ξ_y=3.0

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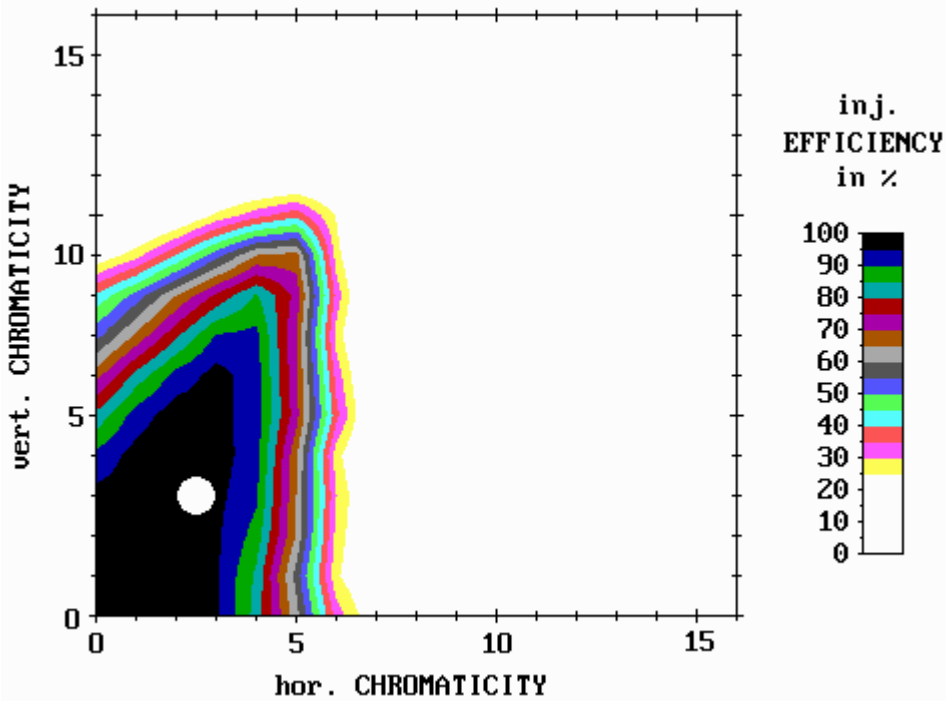
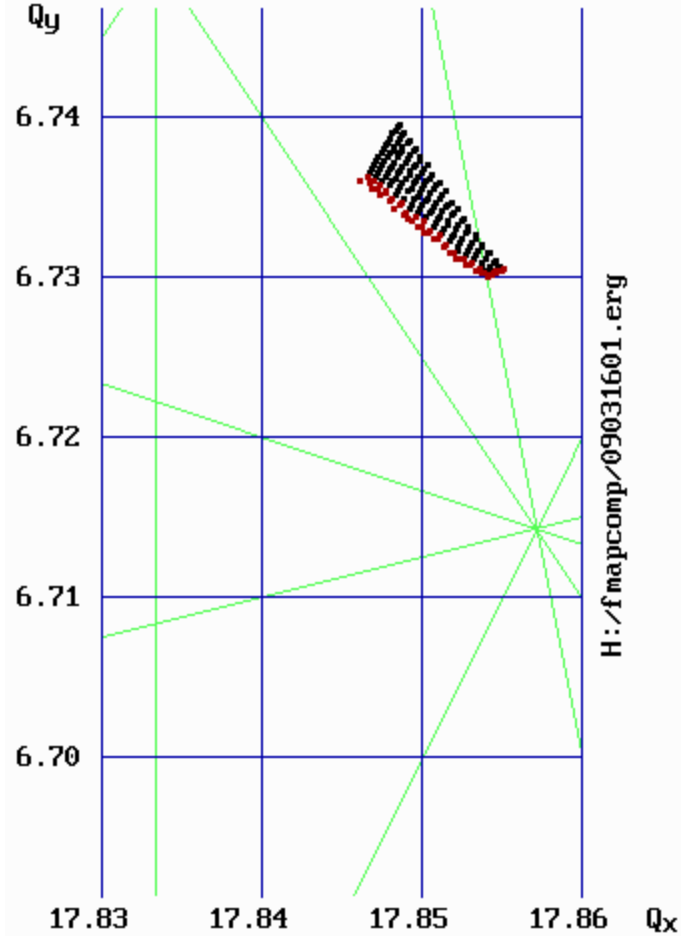
Injection Efficiency vs. Chromaticity

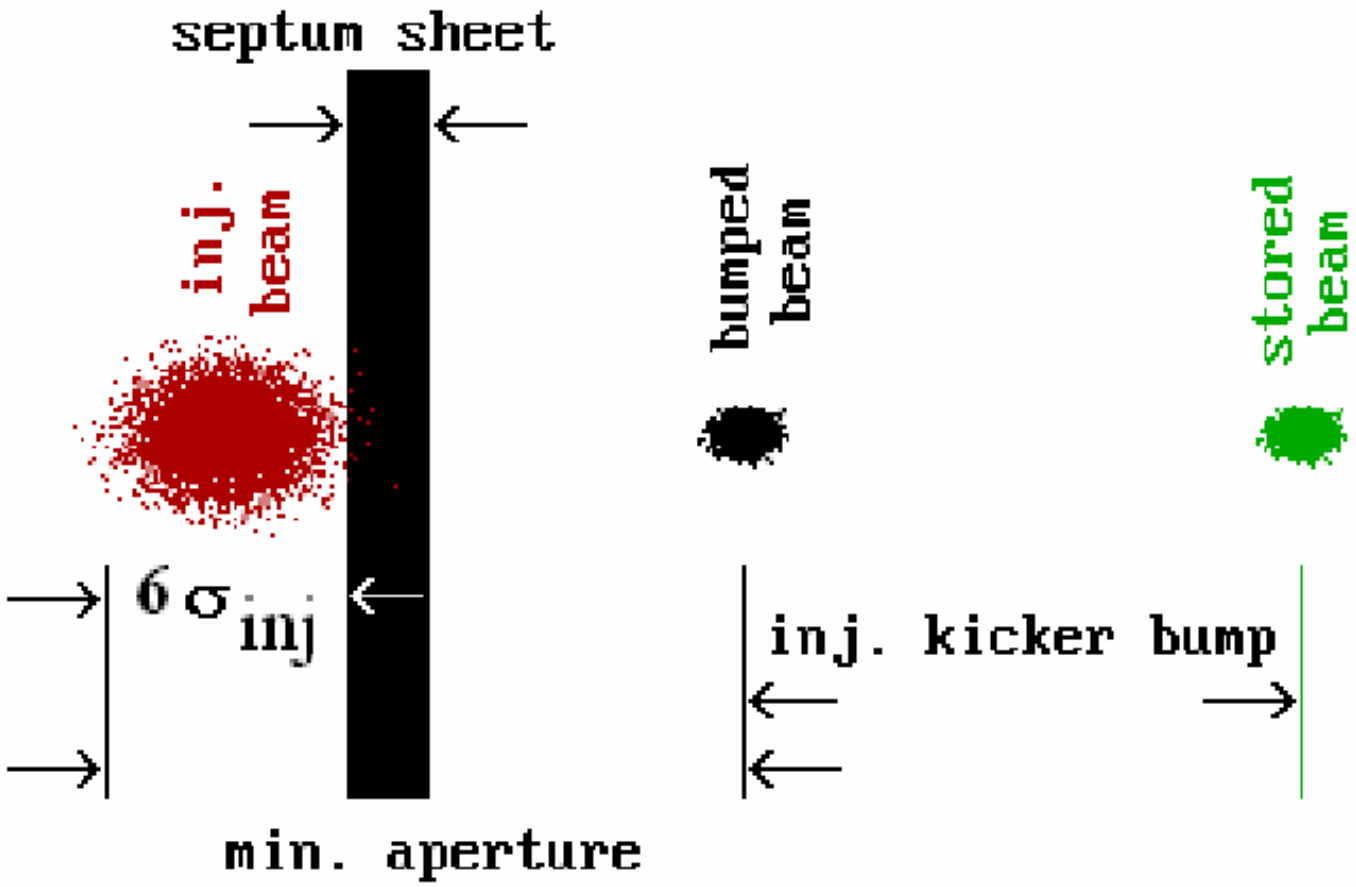
harmonic sextupole optimized for injection efficiency





operating conditions: ξ_x=2.5 and ξ_y=3.0

Injection Efficiency and Injection Geometry



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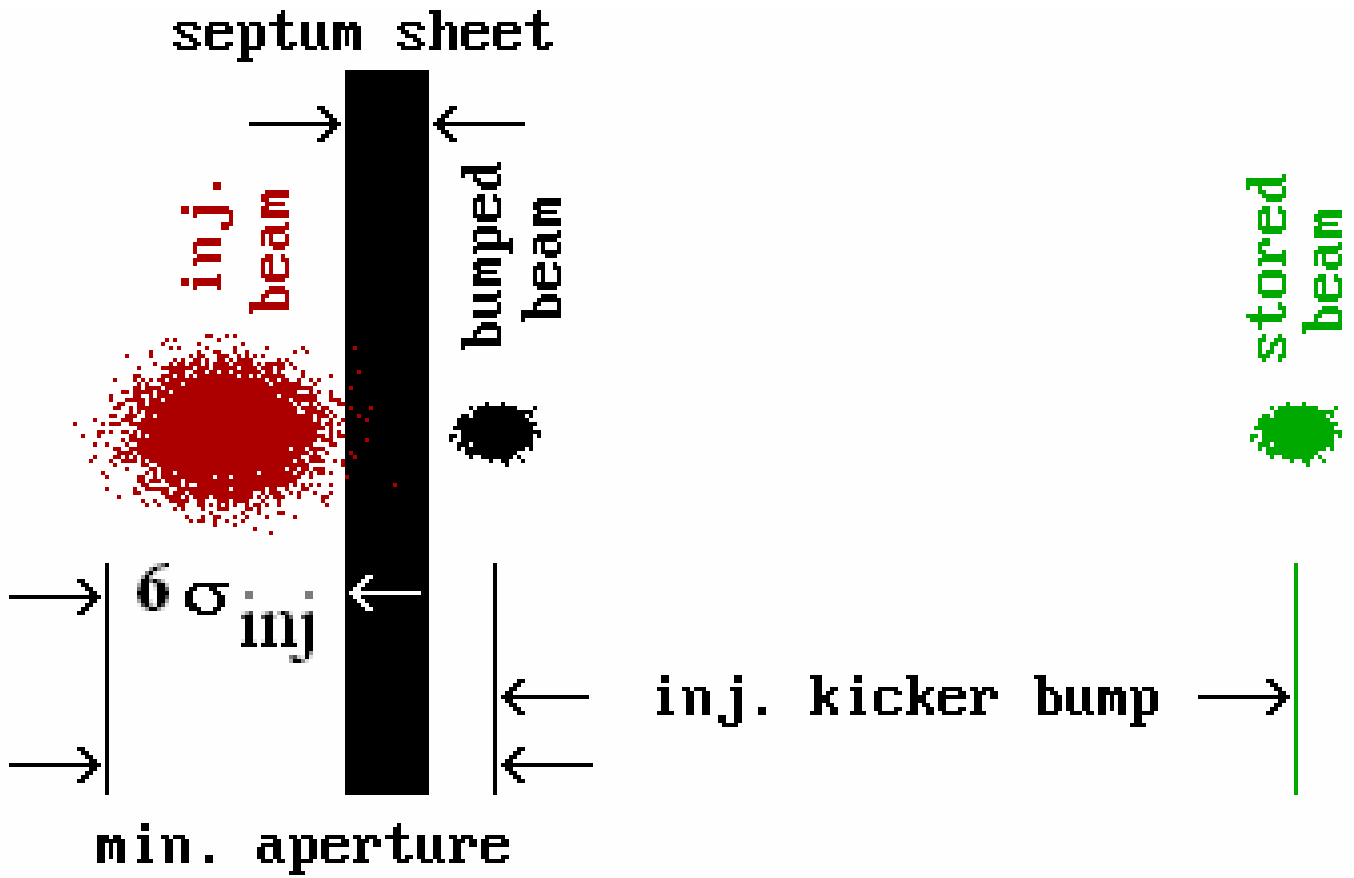
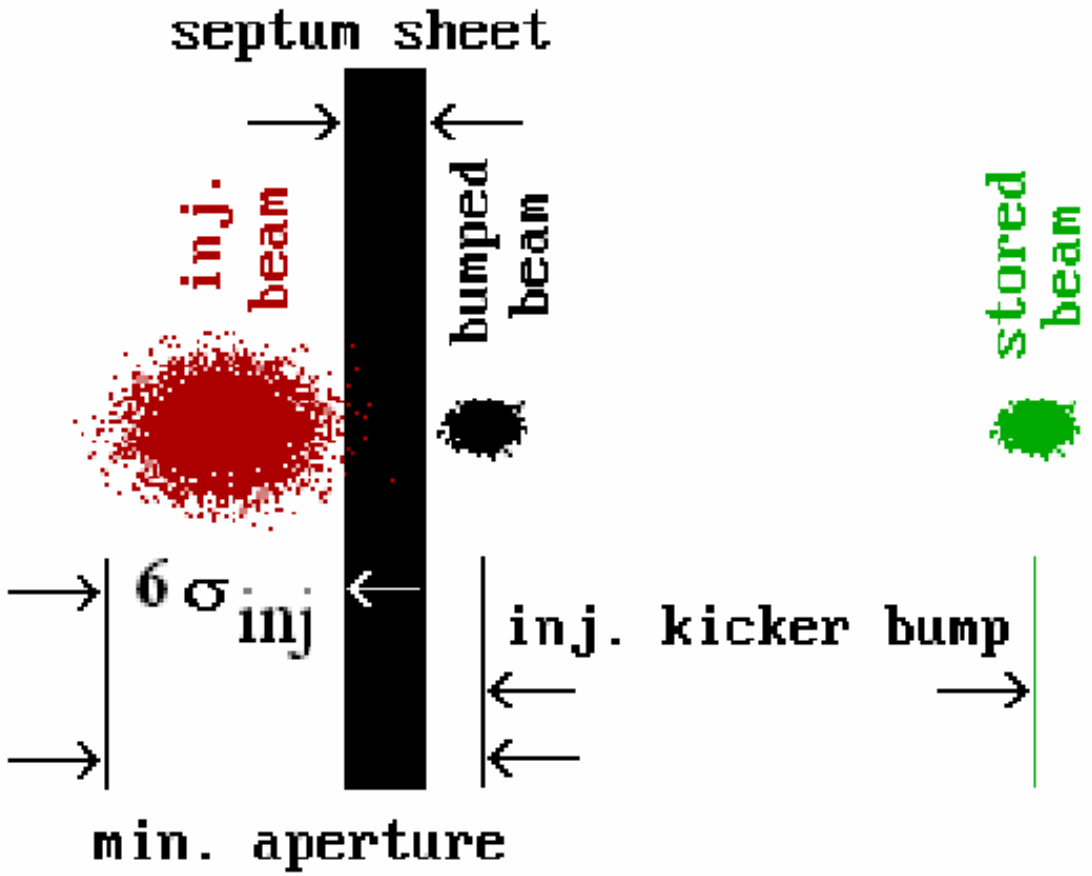


Injection Efficiency and Injection Geometry



OPTIMIZED INJECTION EFFICIENCY

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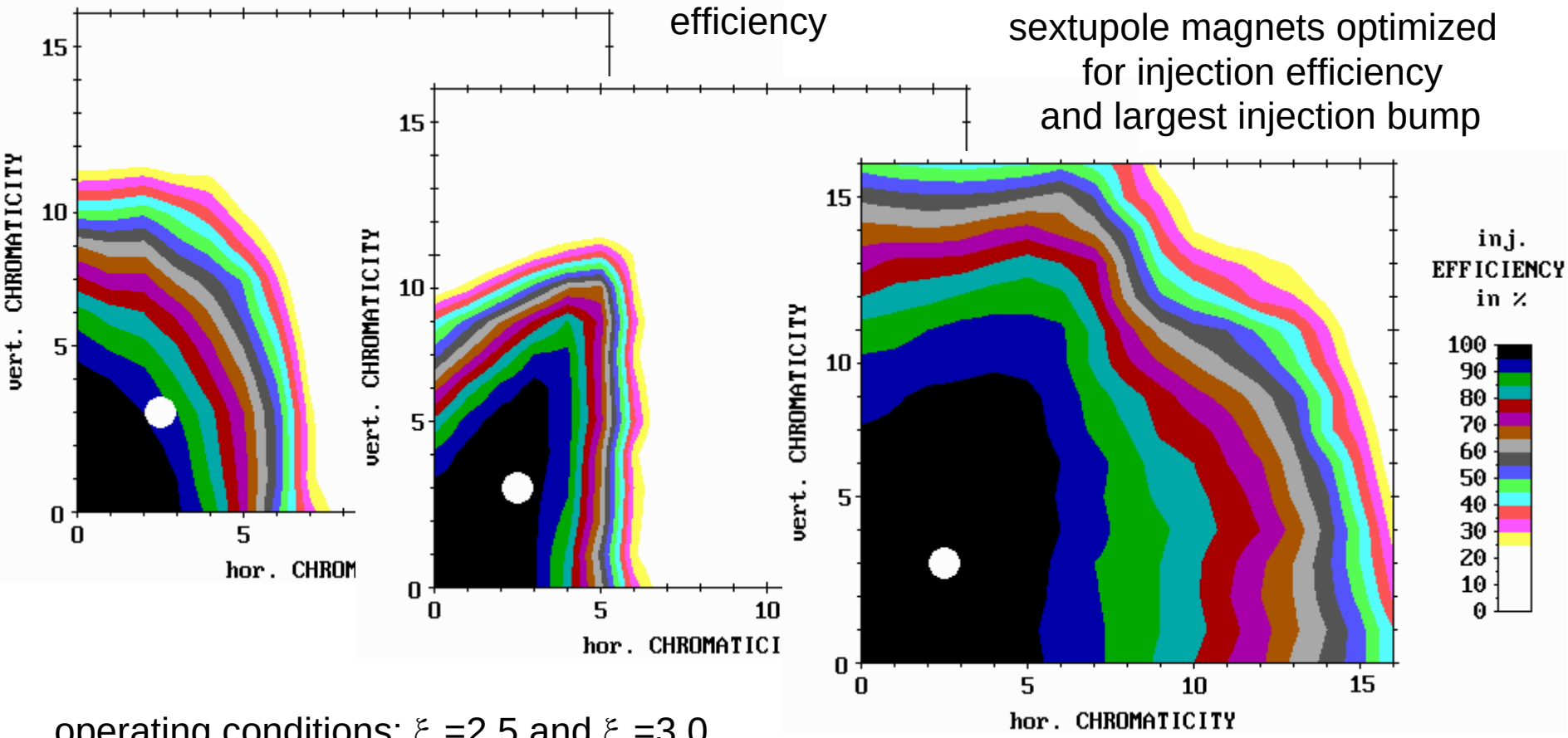
Injection Efficiency vs. Chromaticity

harmonic sextupole settings for optimized lifetime

optimized for injection efficiency

sextupole magnets optimized for injection efficiency and largest injection bump



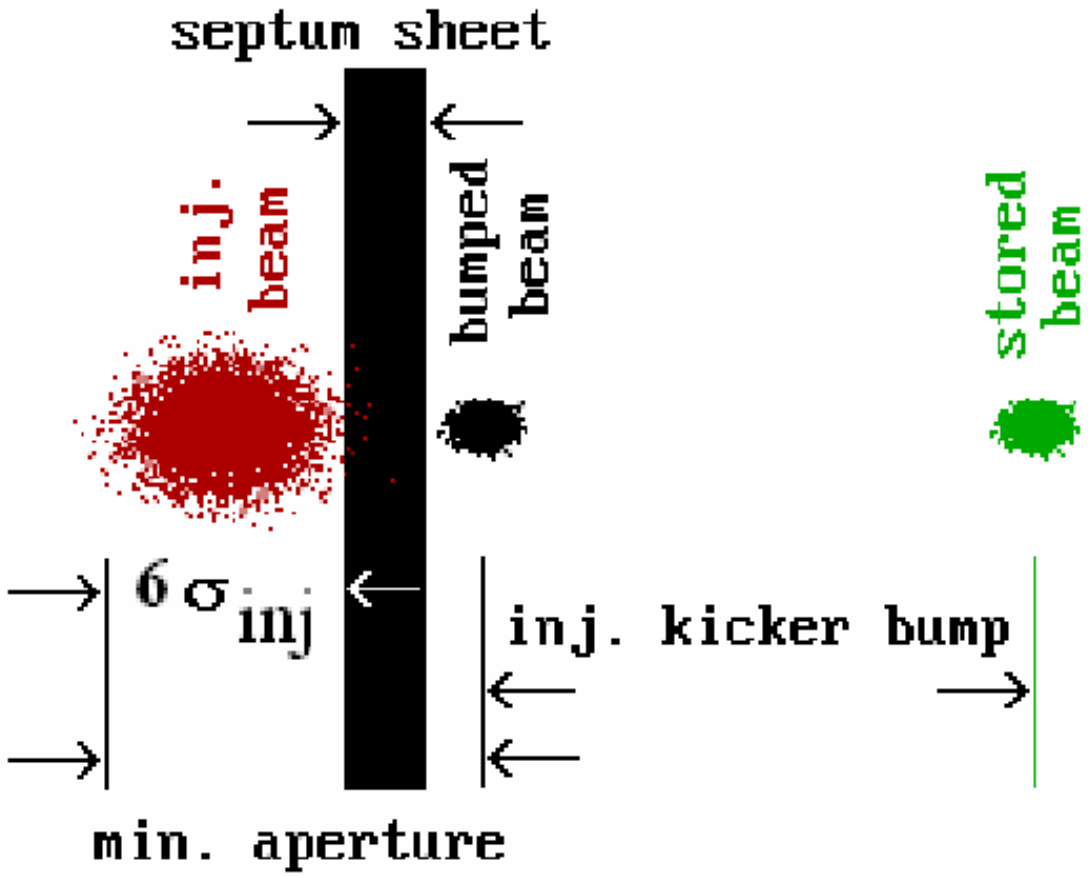
operating conditions: ξ_x=2.5 and ξ_y=3.0

overcome technical limitations!

Injection Efficiency and Injection Geometry

How to achieve a smaller emittance of the injected beam?

Usually the vertical emittance is much smaller than the horizontal emittance.



Injection Efficiency and Injection Geometry

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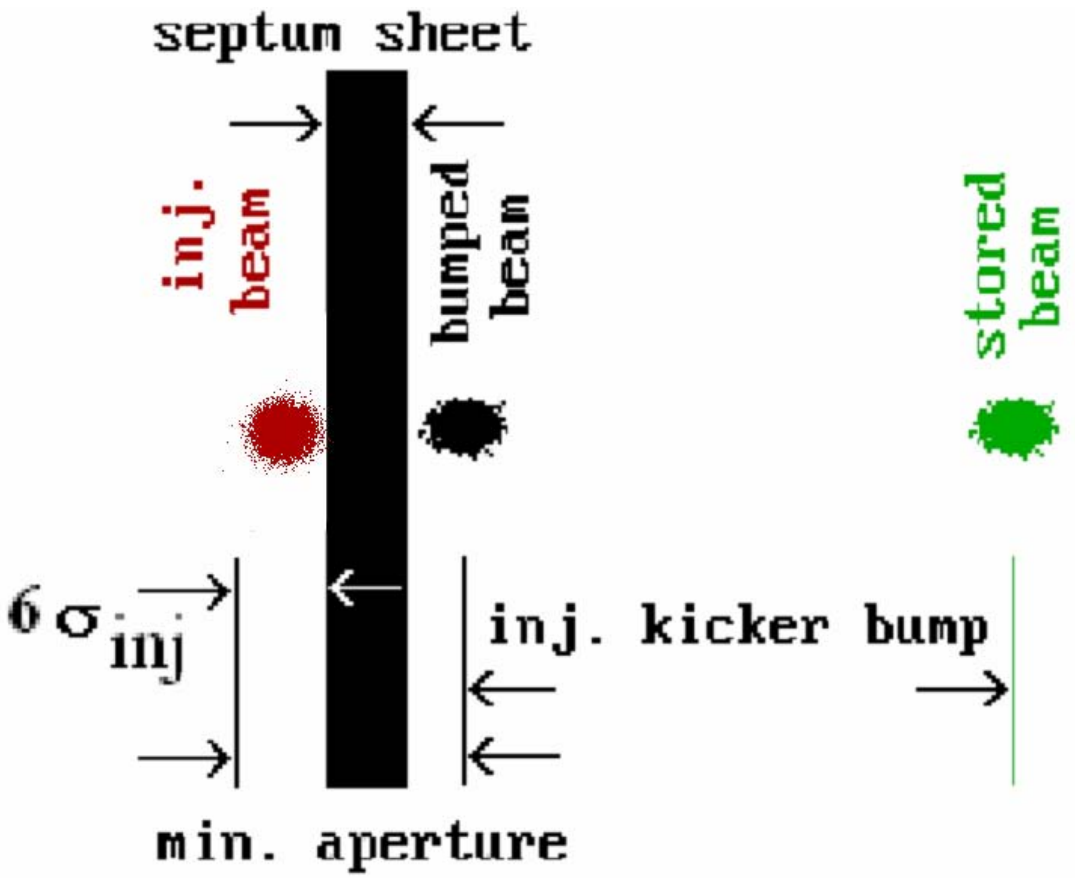
horizontal emittance reduction through transverse emittance exchange



Static Transverse Emittance Exchange

P. J. Bryant in „Beam Transfer Lines“ proc. CAS, CERN 85-19

„A complete exchange of the transverse phase planes requires a transformation of the form,

$$\begin{pmatrix} x \\ x' \\ y \\ y' \end{pmatrix}_1 = \left(\begin{array}{cc|cc} 0 & 0 & m_{13} & m_{14} \\ 0 & 0 & m_{23} & m_{24} \\ \hline m_{31} & m_{32} & 0 & 0 \\ m_{41} & m_{42} & 0 & 0 \end{array}\right) = \begin{pmatrix} x \\ x' \\ y \\ y' \end{pmatrix}_0$$

This can be achieved by using skew quadrupole lenses.“

At least 4 skew quadrupole magnets are needed.

Dynamic Transverse Emittance Exchange

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1.switched skew quadrupole field

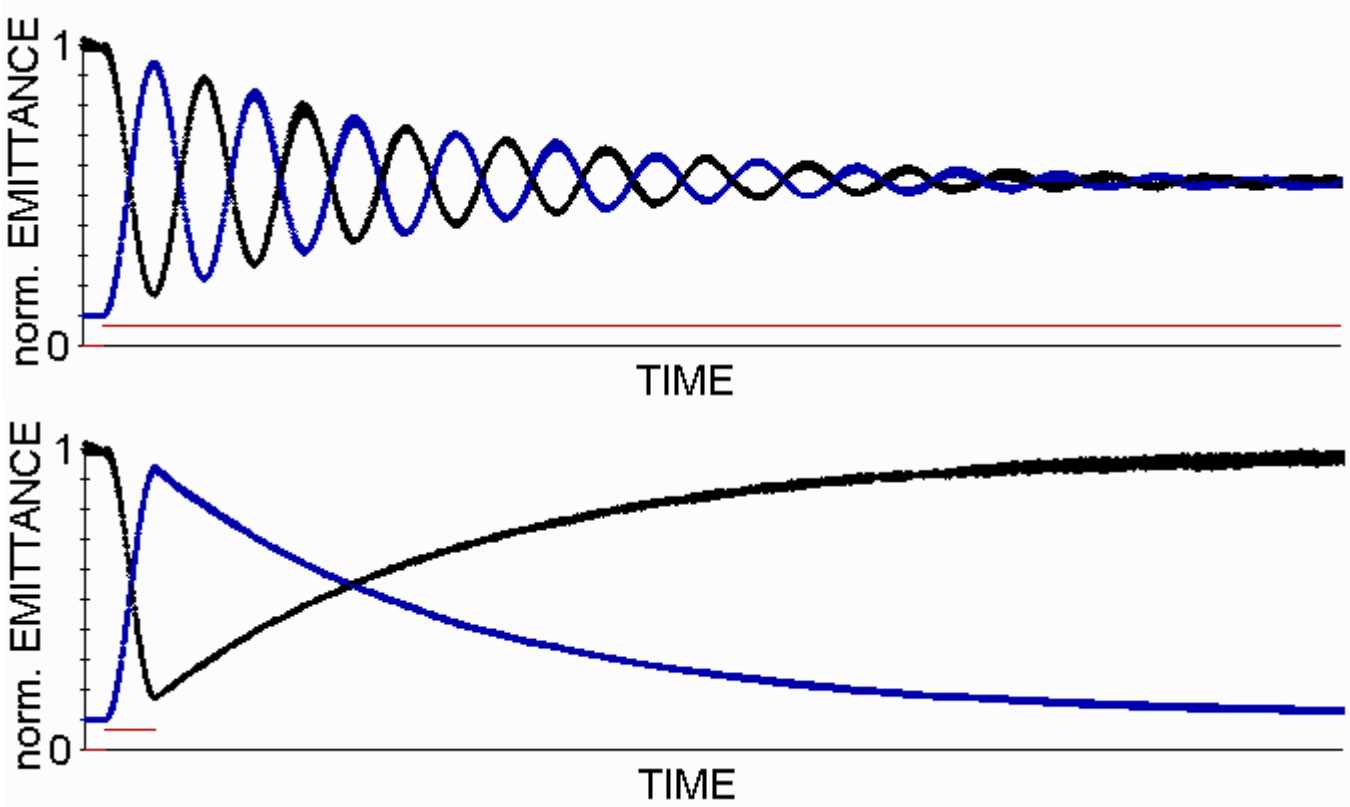
2.tune switching

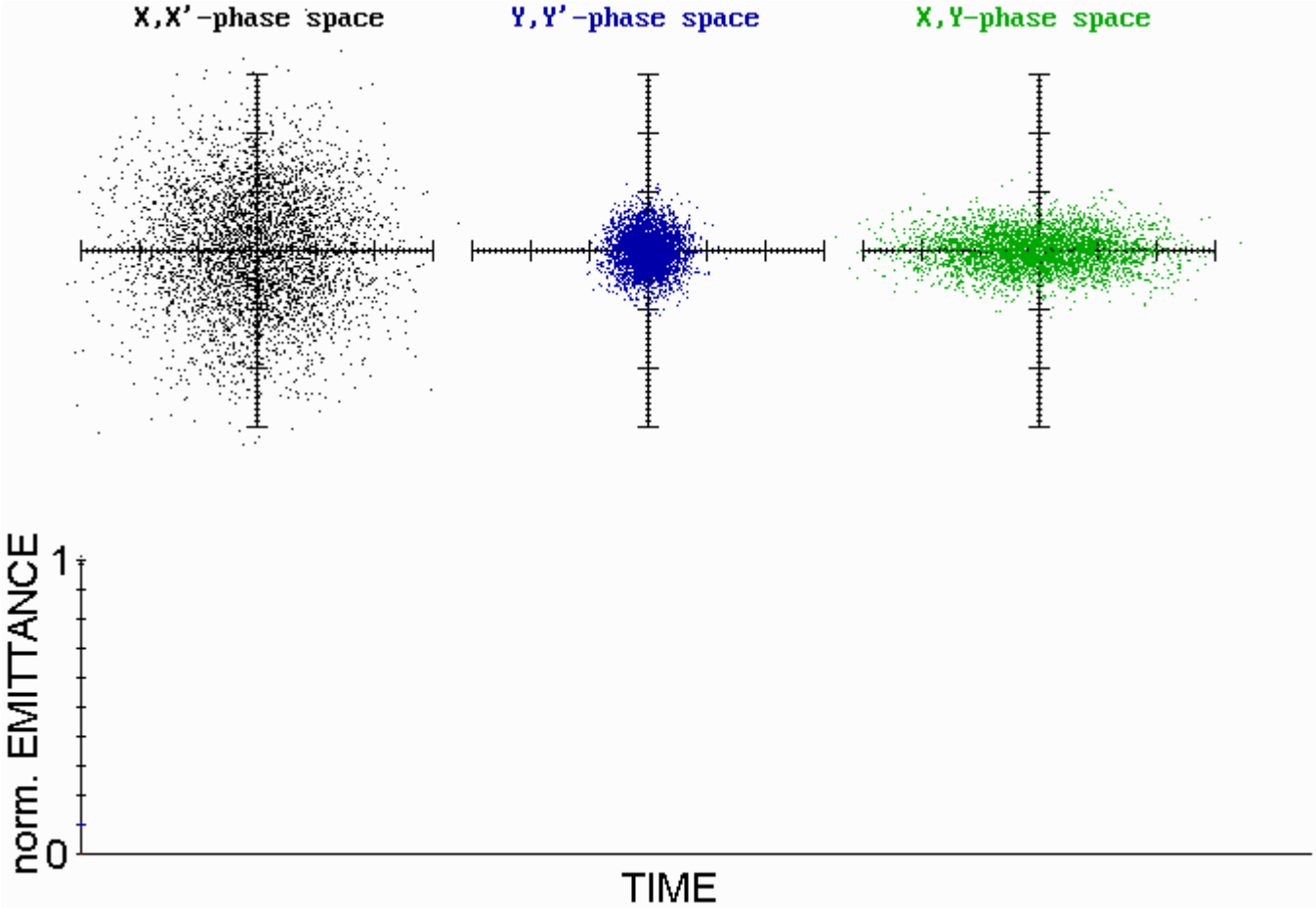
3.time dependent and resonant skew quadrupole field

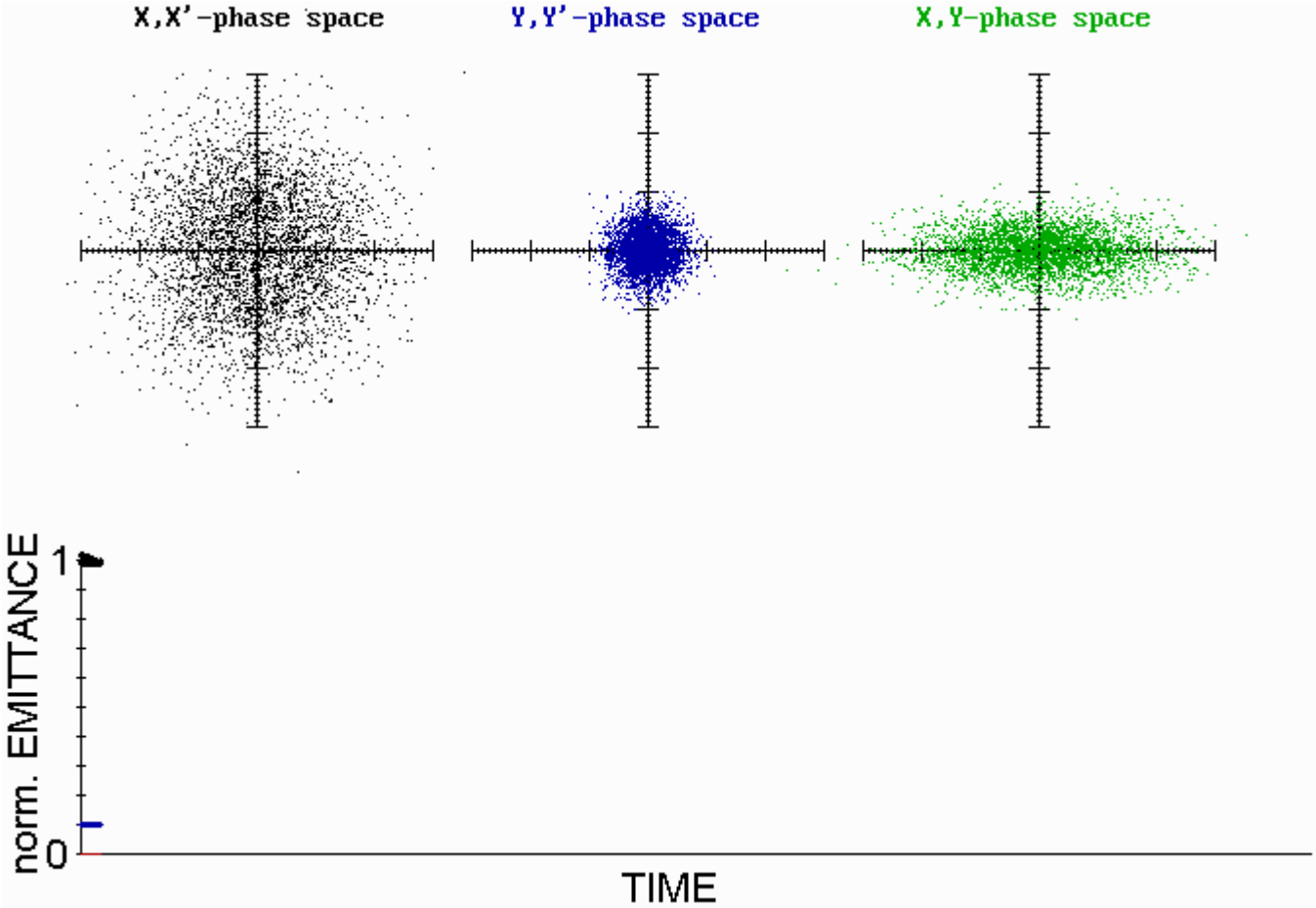
C. Carli, et al.,"Emittance Exchange by Crossing a Coupling Resonance", EPAC 2002

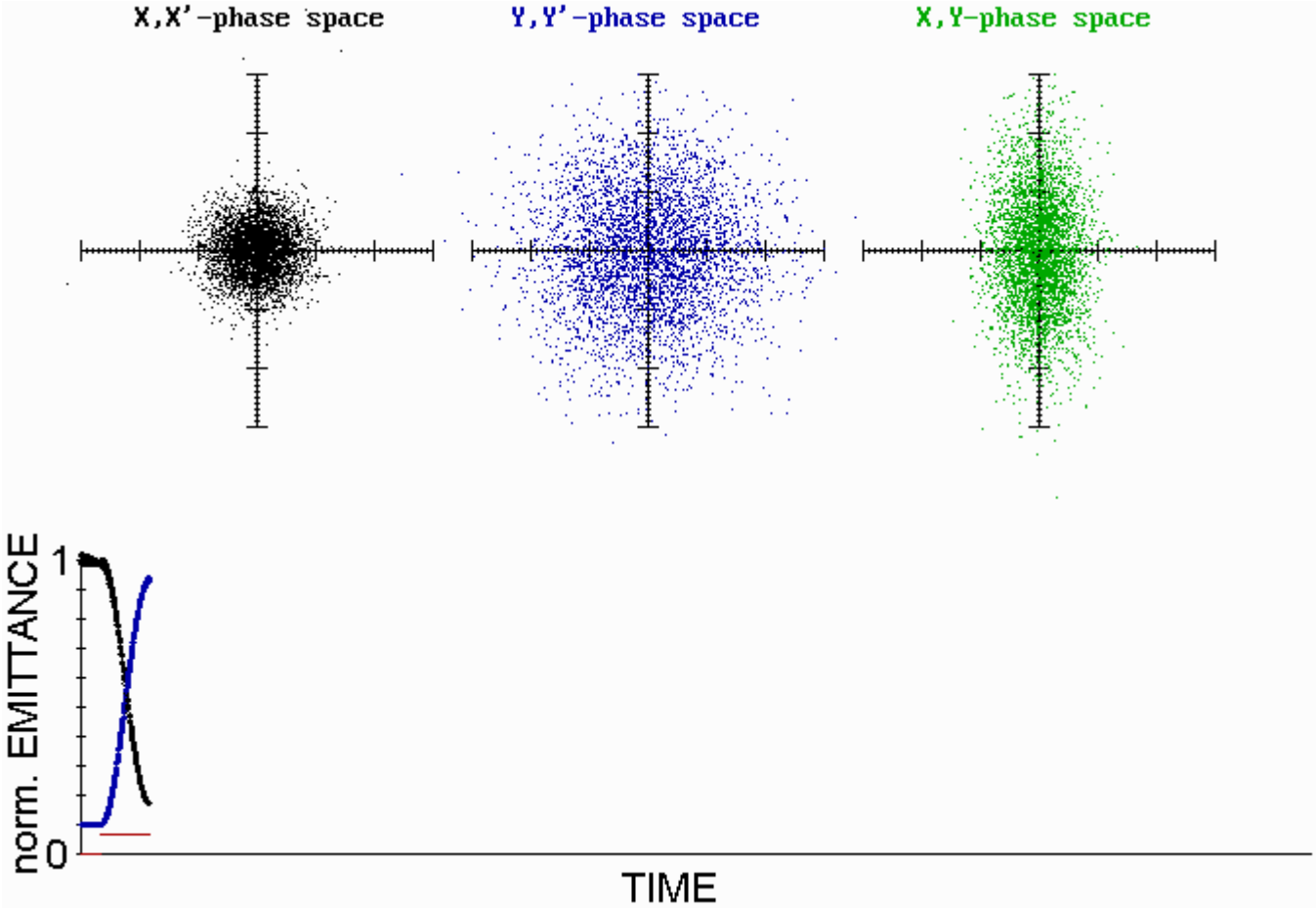
results of multi particle tracking with time dependent coupling:

horizontal and vertical EMITTANCE vs. TIME




X,X'-phase space
Y,Y'-phase space
X,Y-phase space
norm. EMITTANCE
1
0
TIME


X,X'-phase space
Y,Y'-phase space
X,Y-phase space
norm. EMITTANCE
1
0
TIME


X,X'-phase space
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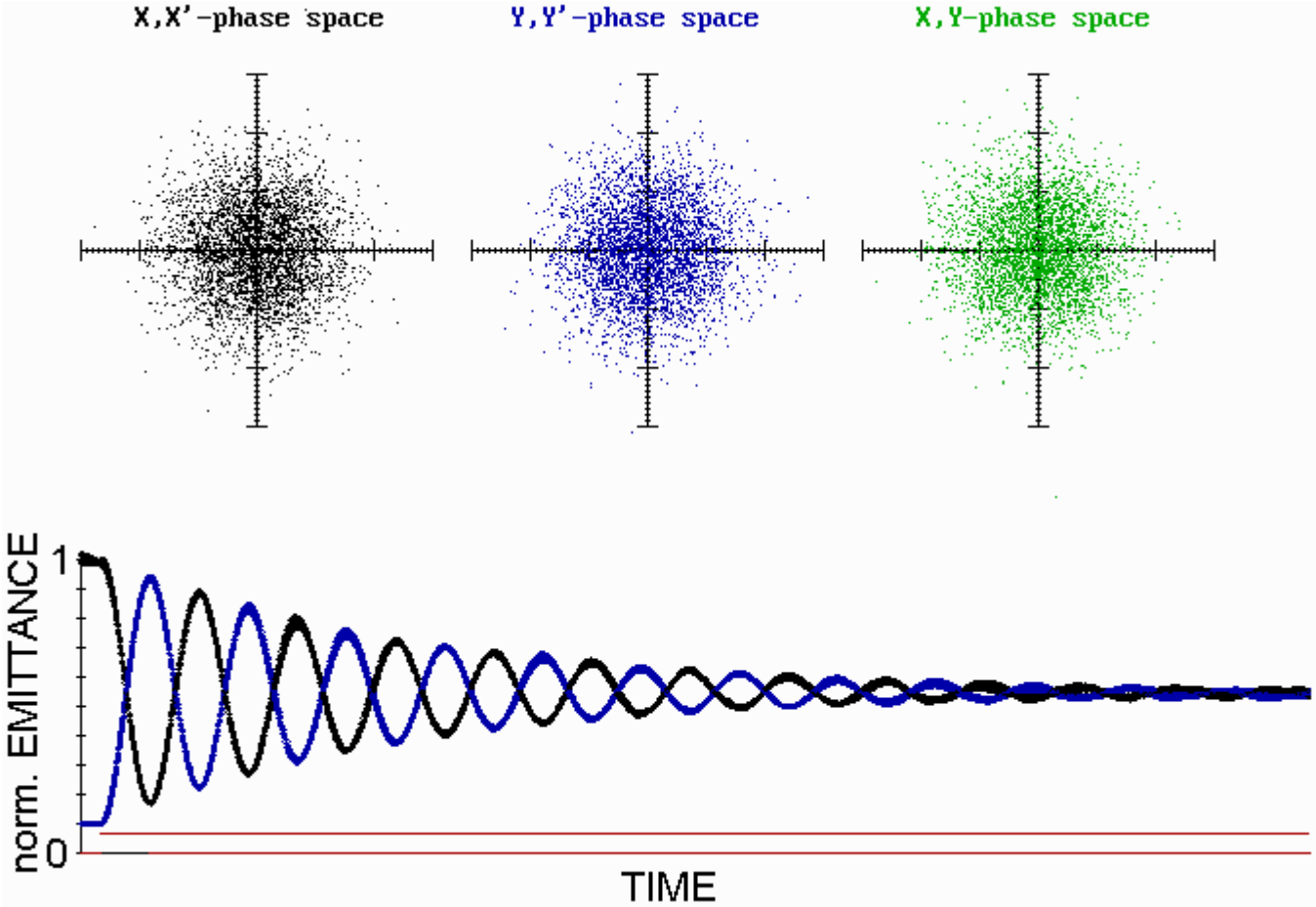
TIME


X,X'-phase space
Y,Y'-phase space
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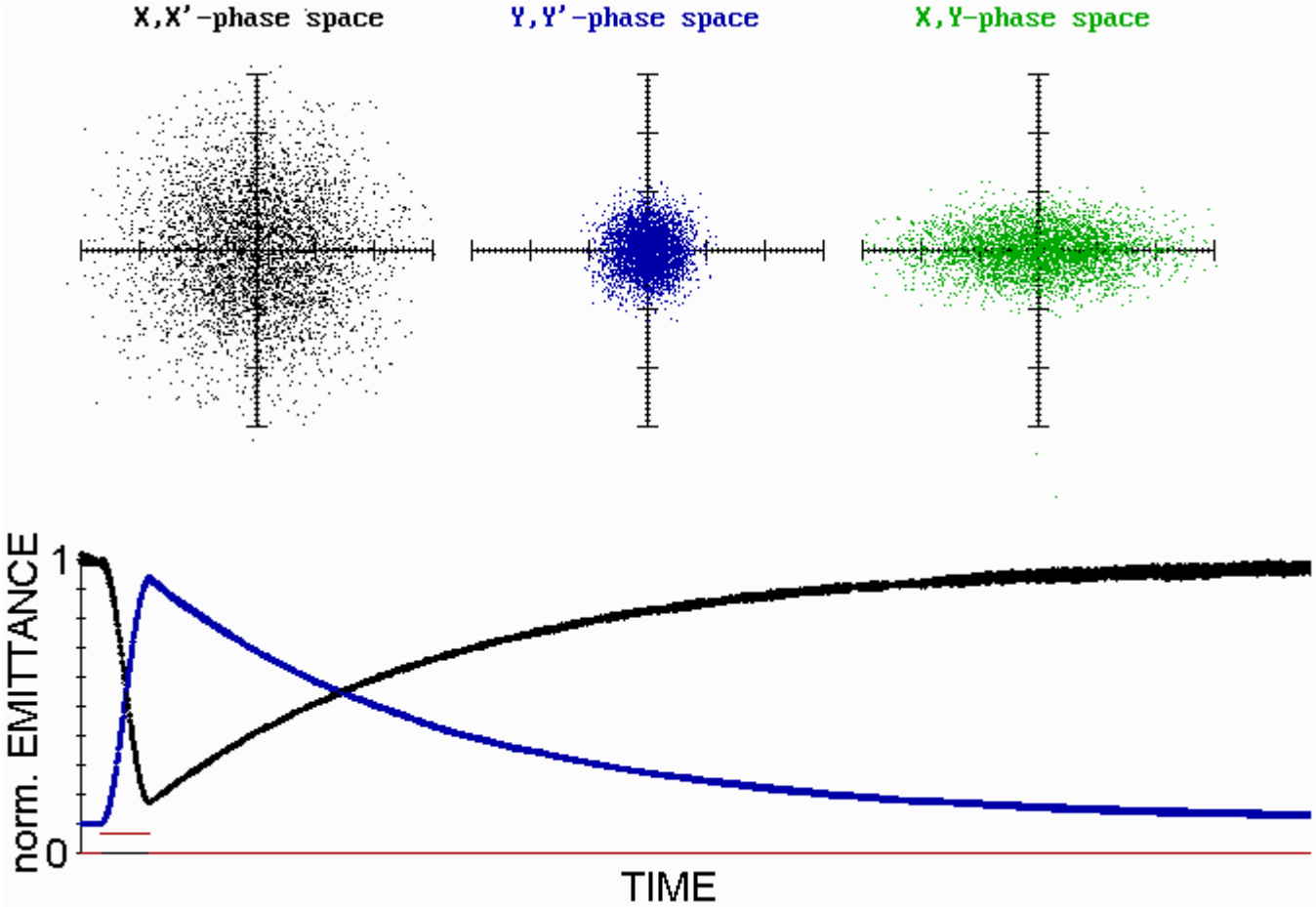
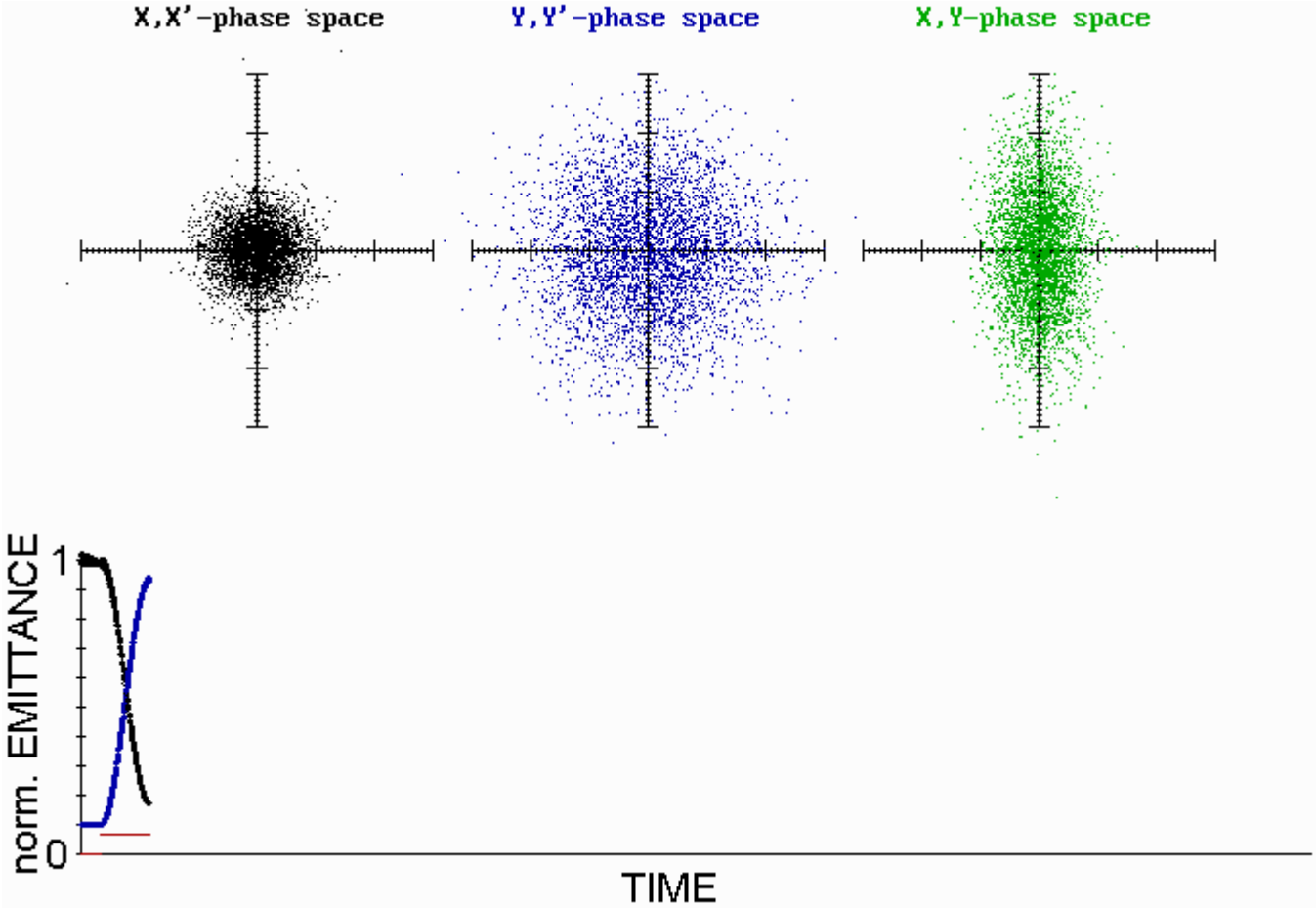

X,X'-phase space
Y,Y'-phase space
X,Y-phase space
norm. EMITTANCE
1
0
TIME


X,X'-phase space
Y,Y'-phase space
X,Y-phase space
norm. EMITTANCE
1
0
TIME

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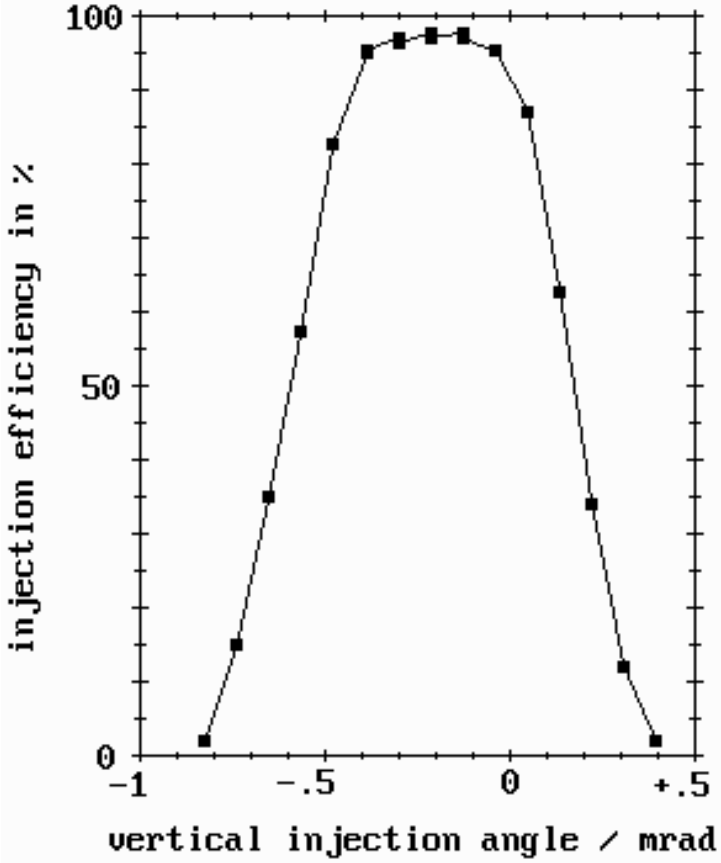
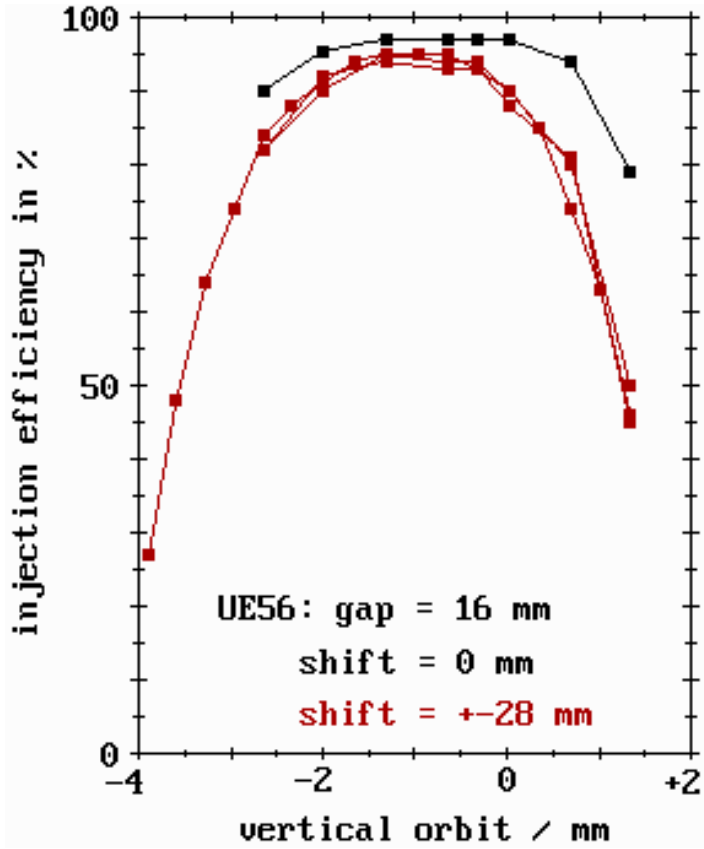
Vertical acceptance of the storage ring:





vertical acceptance ~100 nm·rad > hor. ε_{syn}

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Injection tests with a fully coupled beam

adjust tunes in the synchrotron: Q_x-Q_y=n

small natural coupling and tune jitter - may require installation of a skew quadrupole magnet

could reduce the amplitude of the injected beam by 1.8 mm

For MAX IV: **thickness of the septum sheet will dominate the amplitude of the injected beam**

emittance of the injected beam < stored beam < 0.5 nm·rad

Can we reduce the septum sheet thickness by a smaller injection channel?