Collimation Efficiency Versus Collimation Depth

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5.11.2001

Problem: “Nominal” aperture studies
(Primary: 7 σ. Secondary: 8.2 σ.)

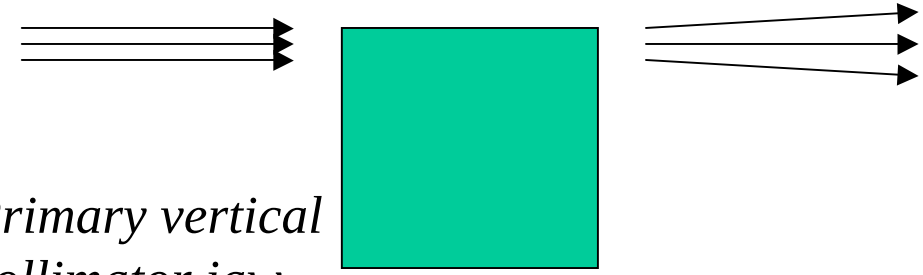
“Nominal” collimation studies
(Primary: 6 σ. Secondary: 7 σ.)

Should we enforce consistency?

Remark: Secondary must protect machine aperture!

Simulation: Consider betatron cleaning system
20 collimators (4 primary, 16 secondary)
7 TeV
Design emittance: 0.5 nm
Design beta functions
No imperfections for this study

Efficiency for vertical halo:



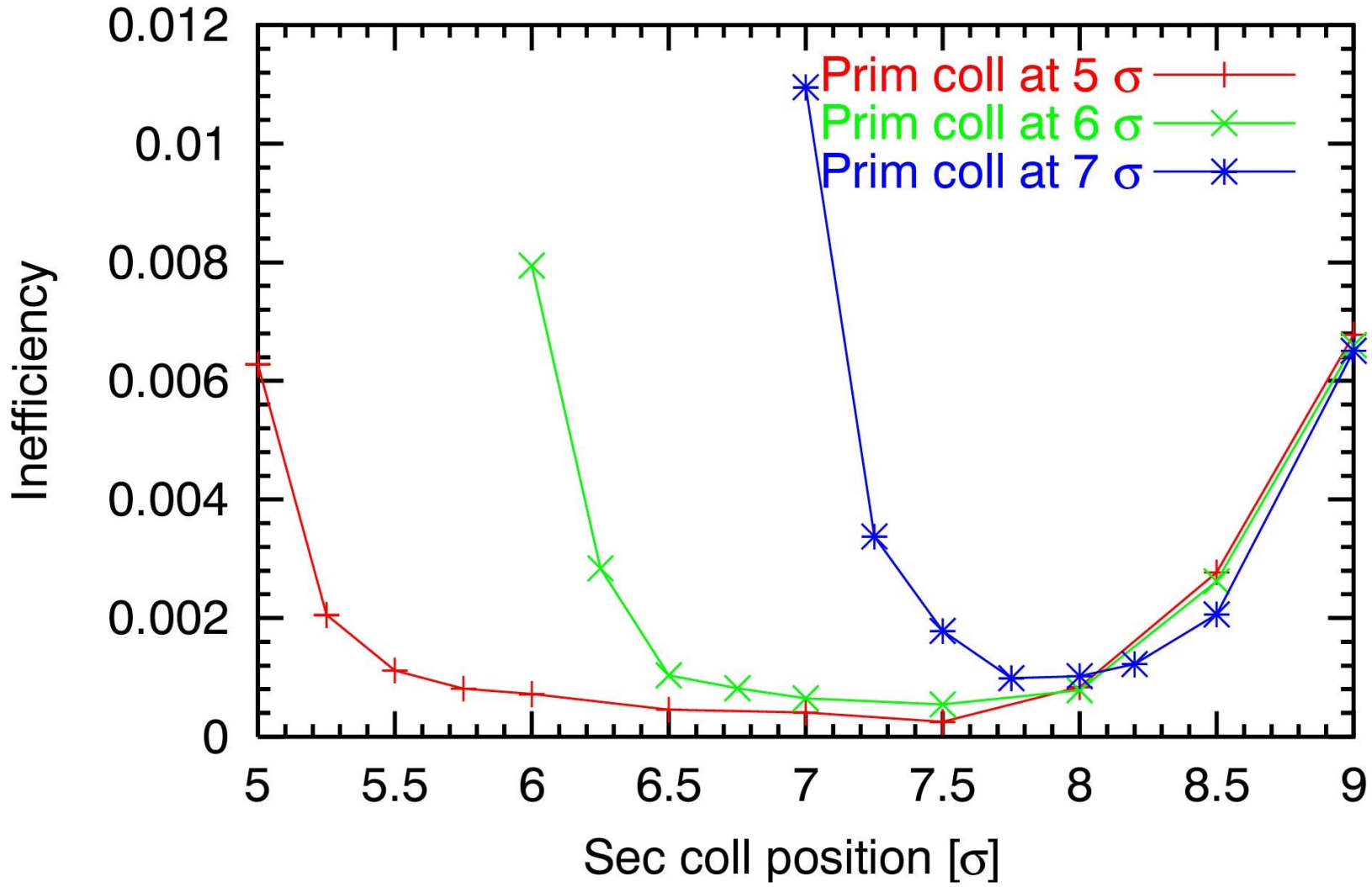
Primary vertical collimator jaw

Look only at particles scattered at primary vertical jaw.

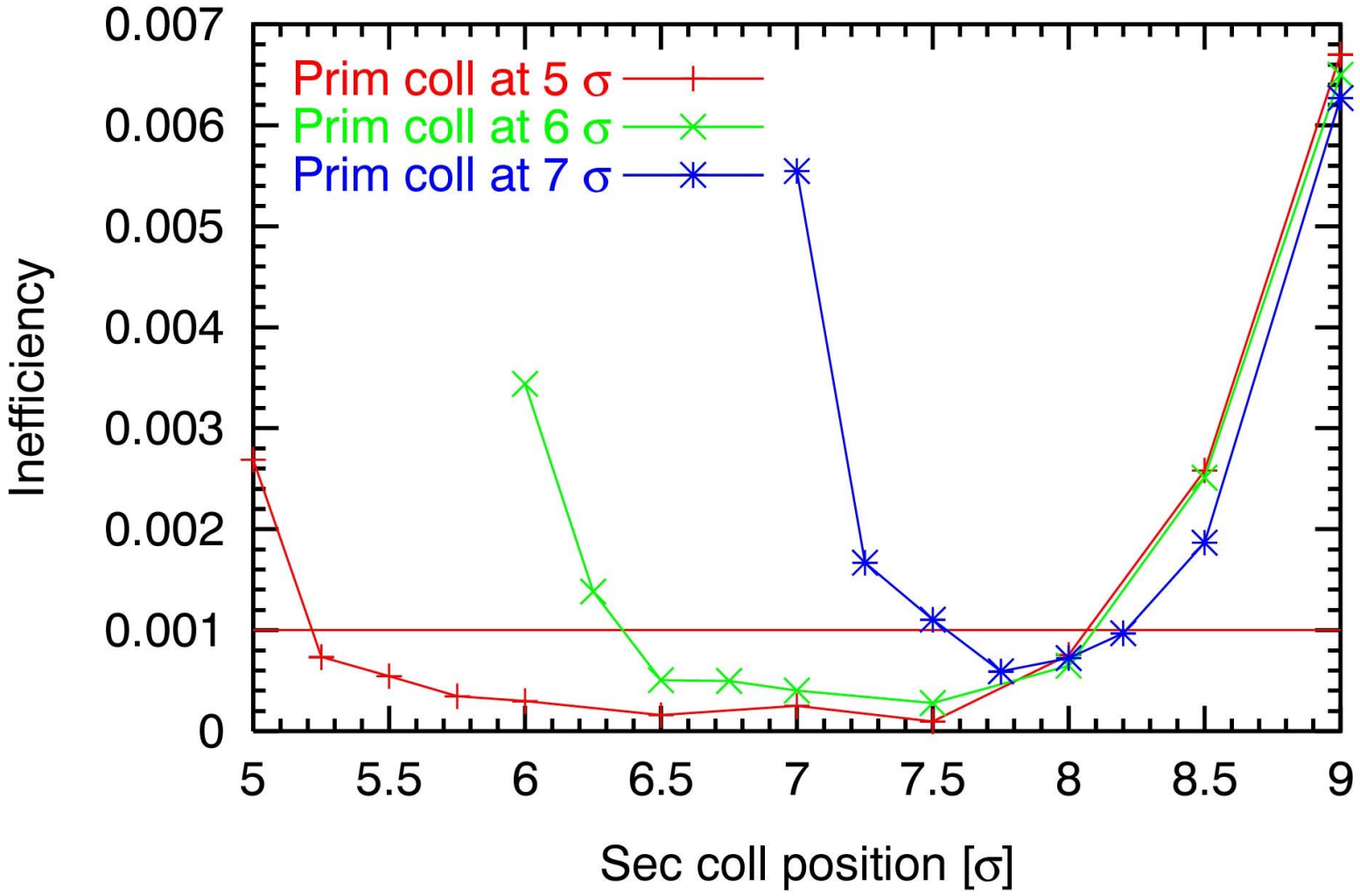
~ 100000 particles
track on for 20 turns
~80% absorbed

$$\text{Inefficiency } (N\,\sigma_r) = \frac{\#\text{ Particles } (A_r > N\,\sigma_r)}{\#\text{ cleaned particles}}$$

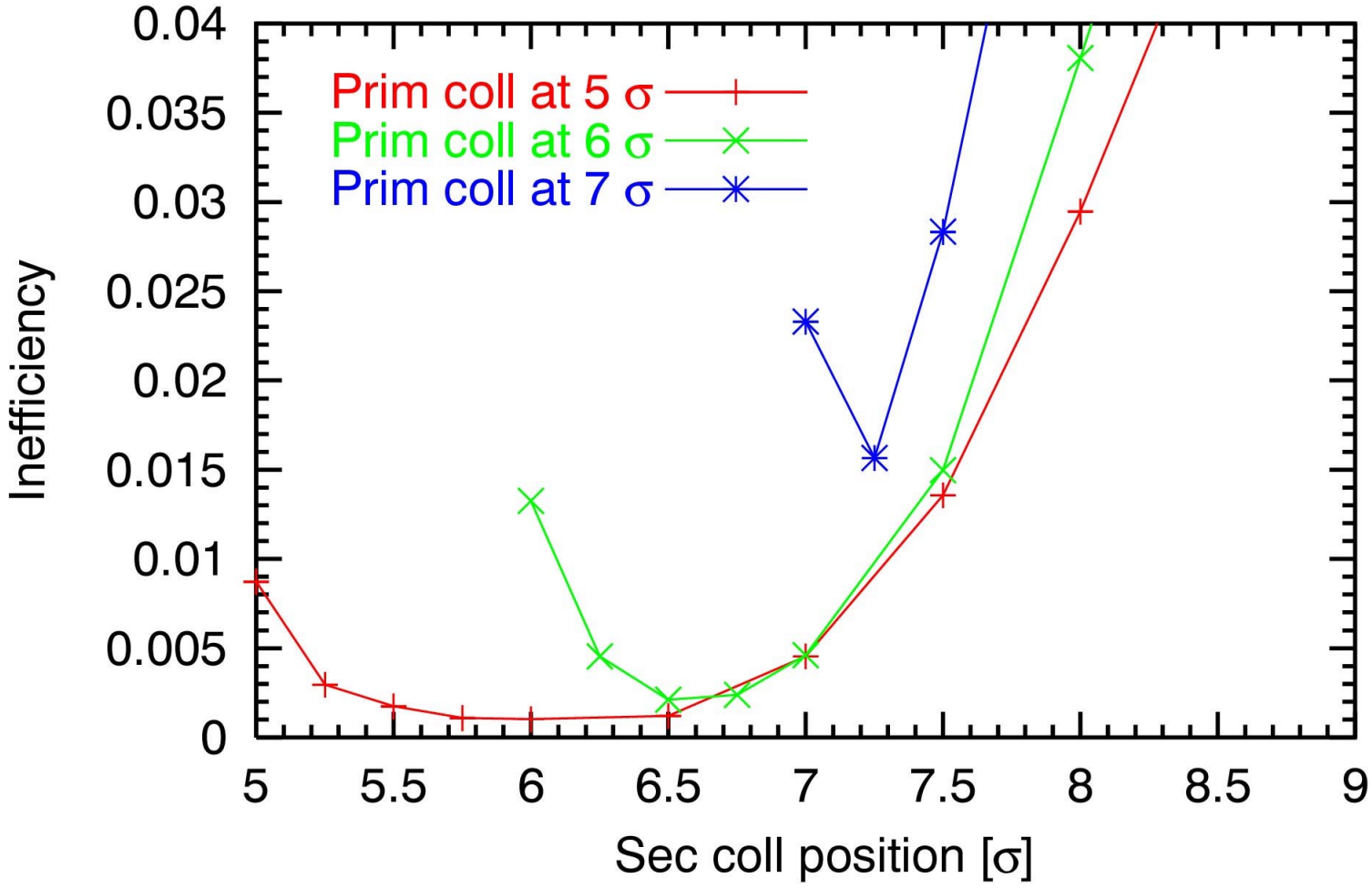
Assume: Mechanical aperture at 10 σ.



Assume: Mechanical aperture at 10 σ, but particles at amplitudes above 15 σ lost shortly after collimation section (warm).



Assume: Mechanical aperture at 8 σ.



Different minimum than for 10 σ aperture!

Rule of thumb (ideal system, nominal σ's):

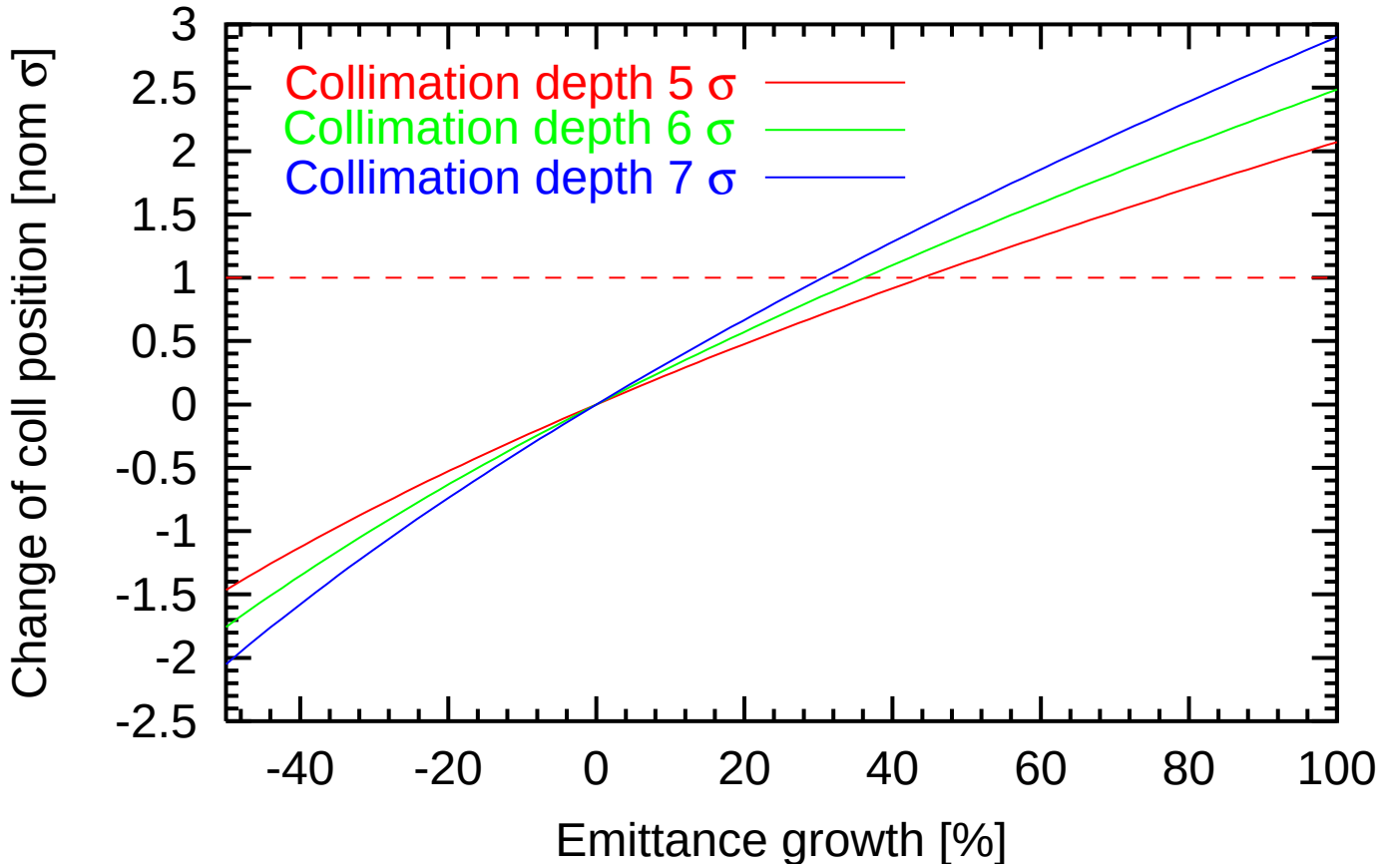
Put primary collimator at (mechanical aperture – 3 σ)
Put secondary collimator at (mechanical aperture – 2 σ)

Smaller collimation depth helps:

- Lower inefficiencies achievable (close to limit anyway).
- Smaller mechanical apertures can be protected.
- More insensitive positioning of secondary collimators.
- Larger retraction of secondaries relaxes some tolerances.

What limits minimum collimator opening:

- Don't cut into beam core (3.5-4 σ).
- Beam σ can be larger than nominal σ! (emittance blow-up)


Collimation depth 5 σ
Collimation depth 6 σ
Collimation depth 7 σ
Change of coll position [nom σ]
Emittance growth [%]
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-40
-20
0
20
40
60
80
100

Example:

Protect aperture at 10 σ (nominal).

Put collimators at 7 σ (primary) and 8 σ (secondary), nominal.

Emittance ~ 60 % larger than design value.

Collimators sit at ~ 5 σ and ~ 6 σ (real sigma).

Conclusion:

Not clear to me whether we should define “nominal” collimation depth.

Instead: Adjust collimators to the machine condition.

In particular: Collimators follow the machine aperture.

Trivial: Keep mechanical aperture as big as possible.

Trade-off: Emittance - Intensity