Injection Schemes for Diamond-II

~~Jonas Kallestrup~~
Ian Martin

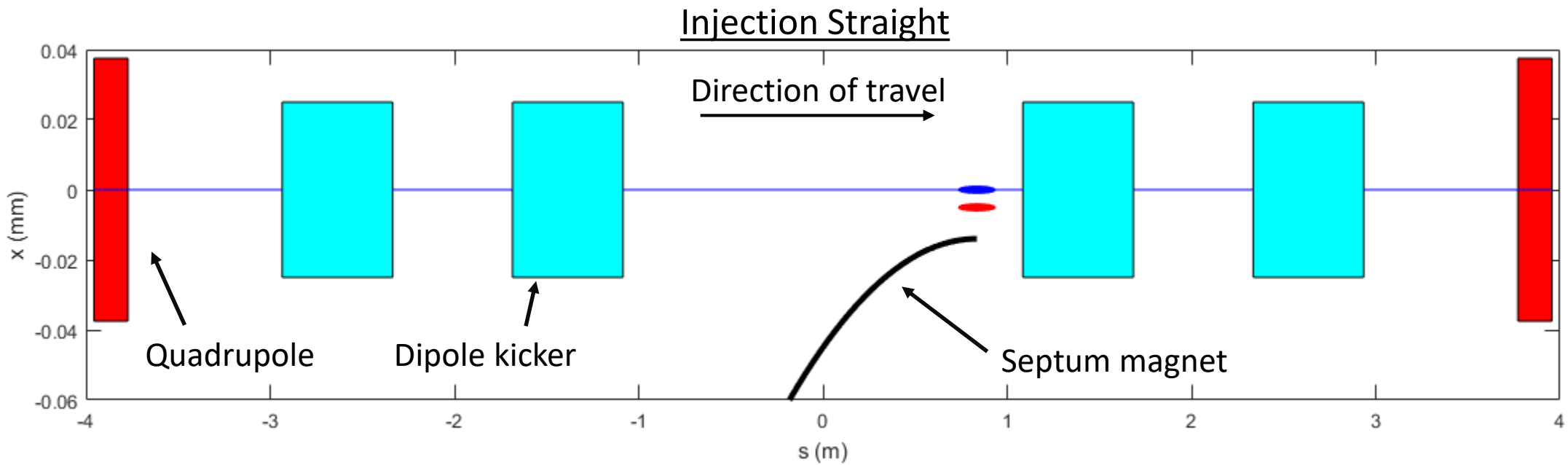
IoP PABG Annual Conference
26/07/2022

Standard Off-axis Injection Scheme

Before injection: - all four kickers and septum magnet are off
- stored beam (blue) travels on a straight line

During injection: - kicker magnets fire, bumping the stored beam towards the septum magnet
- injected beam is deflected by the septum magnet and exits parallel to stored beam

After injection: - kicker magnets and septum are switched off
- injected beam is inside storage ring but displaced
- radiation damping causes the injected bunch to damp down over few 10s ms



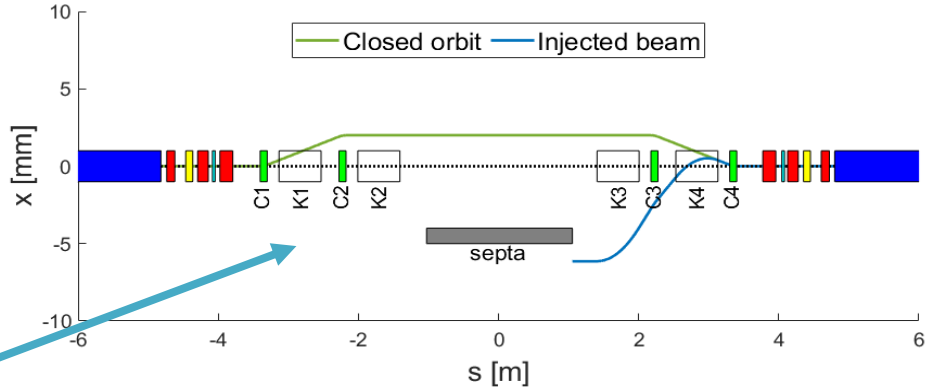
Standard Off-axis Injection Scheme

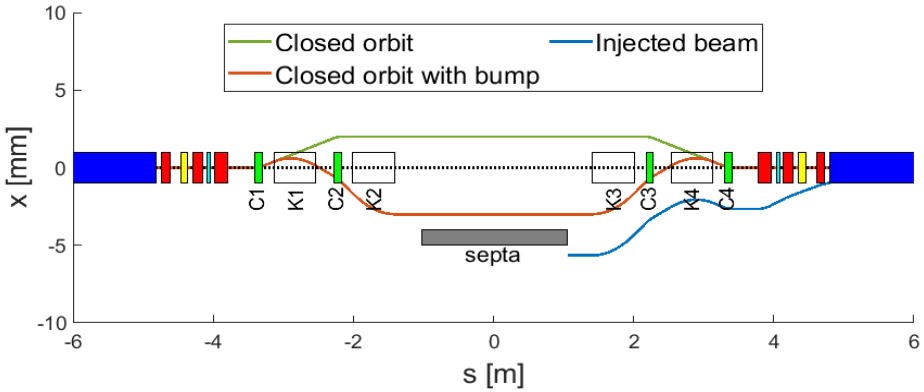
The four-kicker bump is a robust and reliable method of injection:

- Proven technology, used at Diamond >15 years
- Can be used to inject single bunches or trains of bunches
- Very flexible in terms of on or off-axis injection

Four-kicker bump will be used for commissioning:

1) On-axis injection for beam-threading and first-turns
2) Off-axis accumulation with unclosed bump (better efficiency)
3) Off-axis accumulation with closed bump

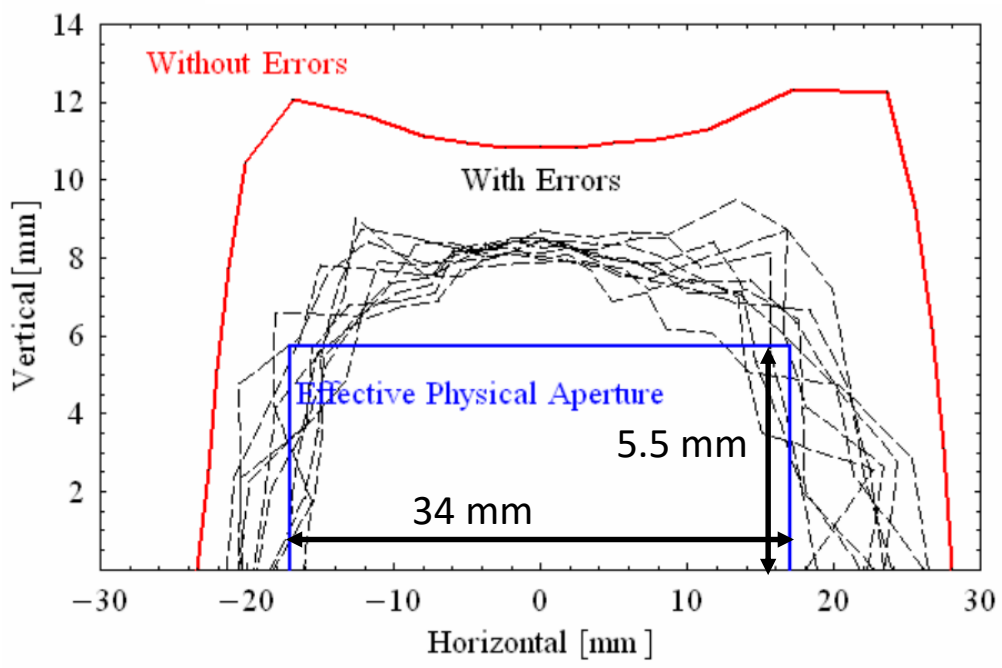




Dynamic Aperture Reduction for Diamond-II

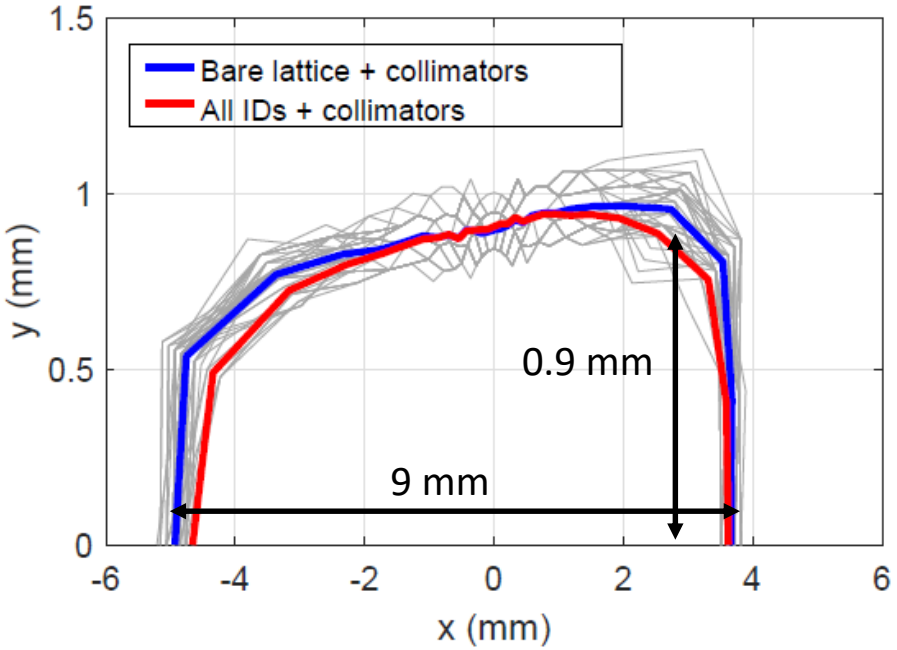
Diamond

S. Smith, J. Jones, H. Owen, EPAC'02



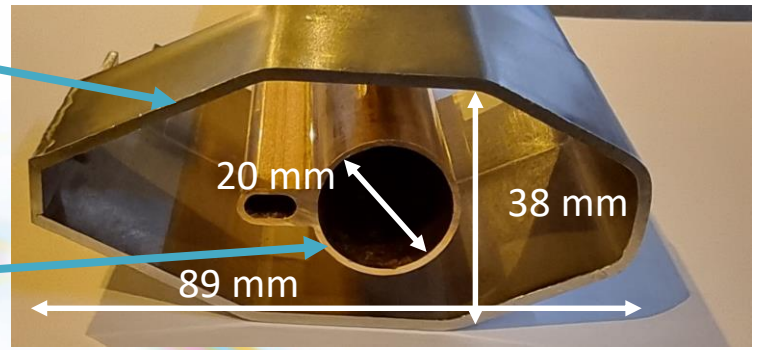
Diamond-II

H.C. Chao, Diamond-II TDR, 2022



Diamond

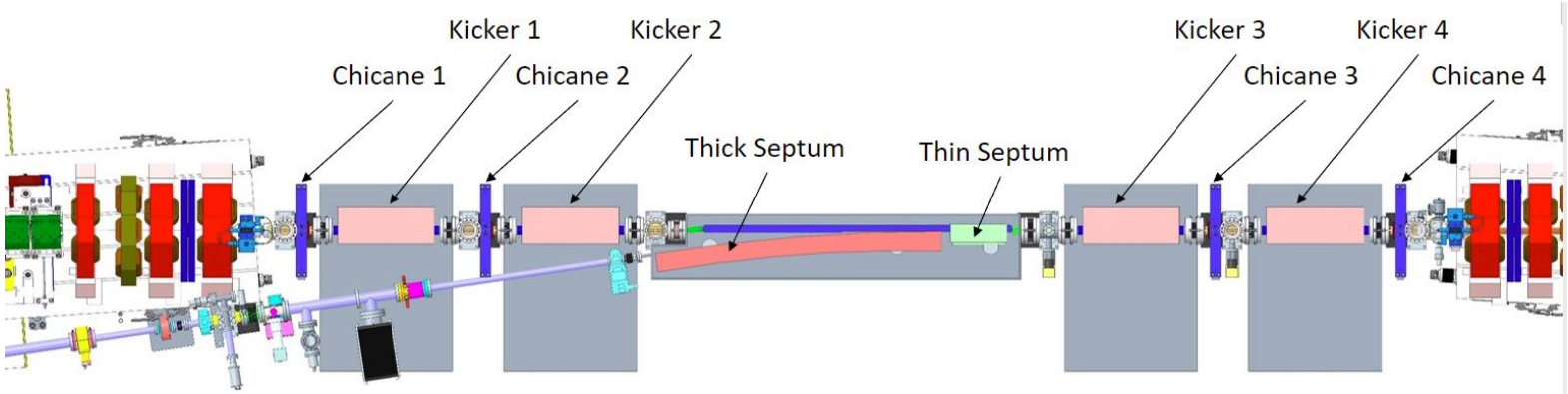
Diamond-II



⇒ Factor 4 reduction in available aperture horizontally

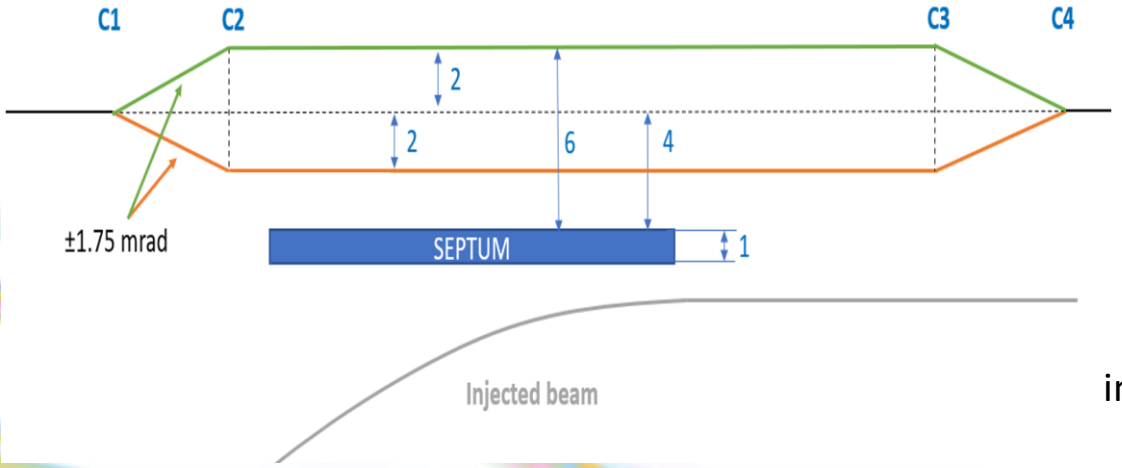
⇒ Factor 6 reduction in available aperture vertically

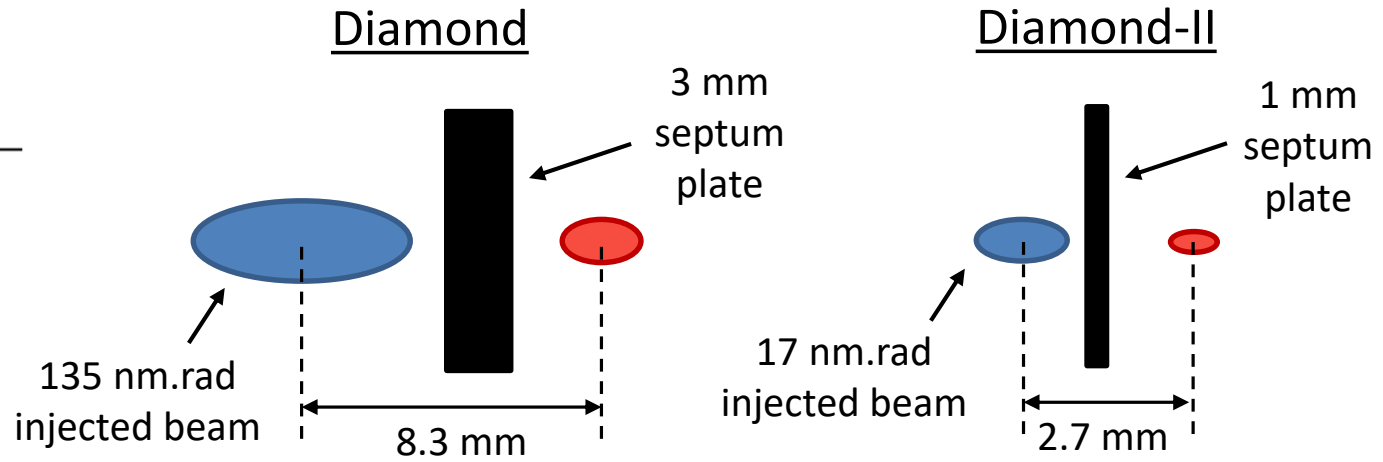
Injection Straight for Diamond-II



Injection Straight Components

- Combined thick and thin septum magnets to steer the injected beam (new)
- Four dipole kickers to bump the stored beam towards the septum magnet during injection (reuse existing)
- Four DC chicane magnets (adjust position and angle of stored beam separately from injected beam)



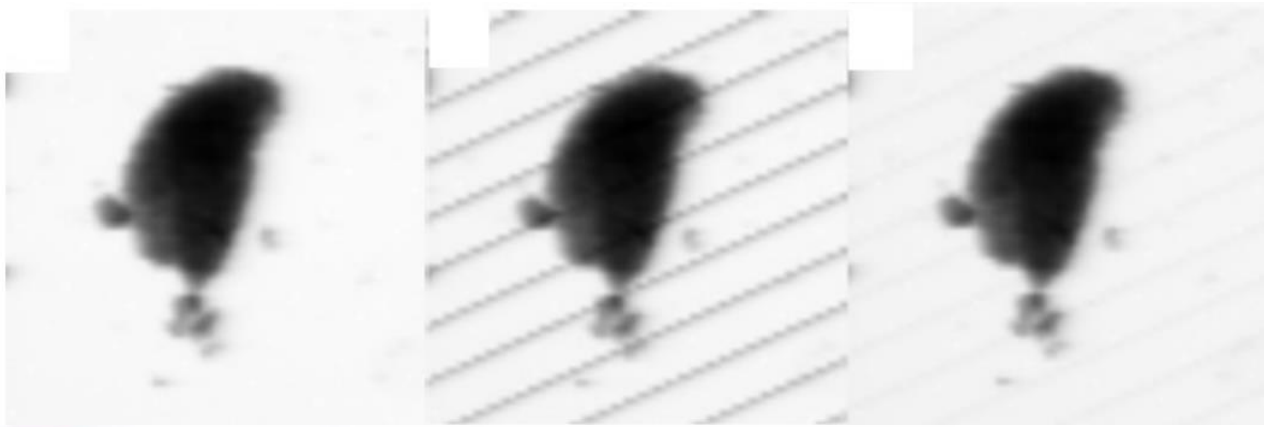


Injection Transparency

Unfortunately, not perfectly transparent ….

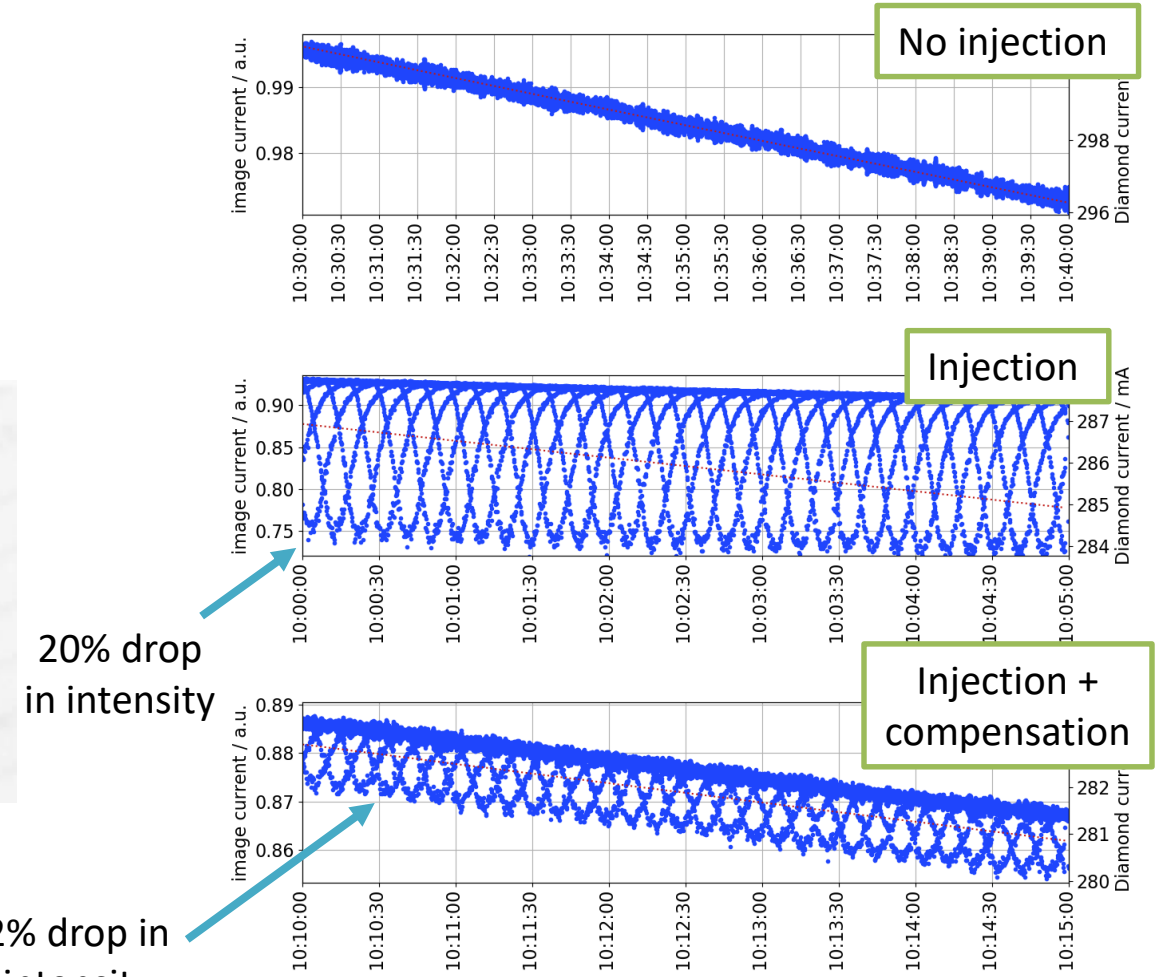
Data taken at Diamond on I08

Continuous raster scan, 10 ms/pixel exposure



Data taken at Diamond on I13-2

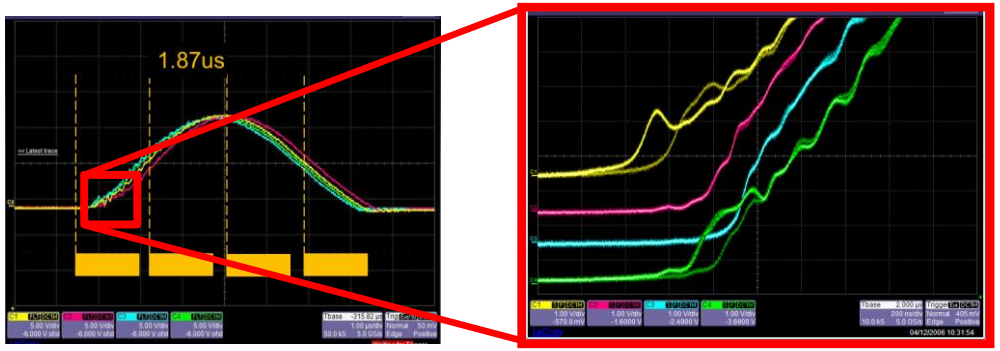
Image current on final mirror



Injection Transparency

There are a number of reasons why injection is not transparent in reality

1) The kicker magnets **may be rolled slightly**, transferring some of the horizontal kick into the vertical
2) The kickers have independent power supplies which **may not be matched in shape, amplitude or timing**
3) The **titanium coating** on the ceramic vessels **could be damaged** or non-uniform
4) The stored beam may not be completely shielded from the septum magnet field



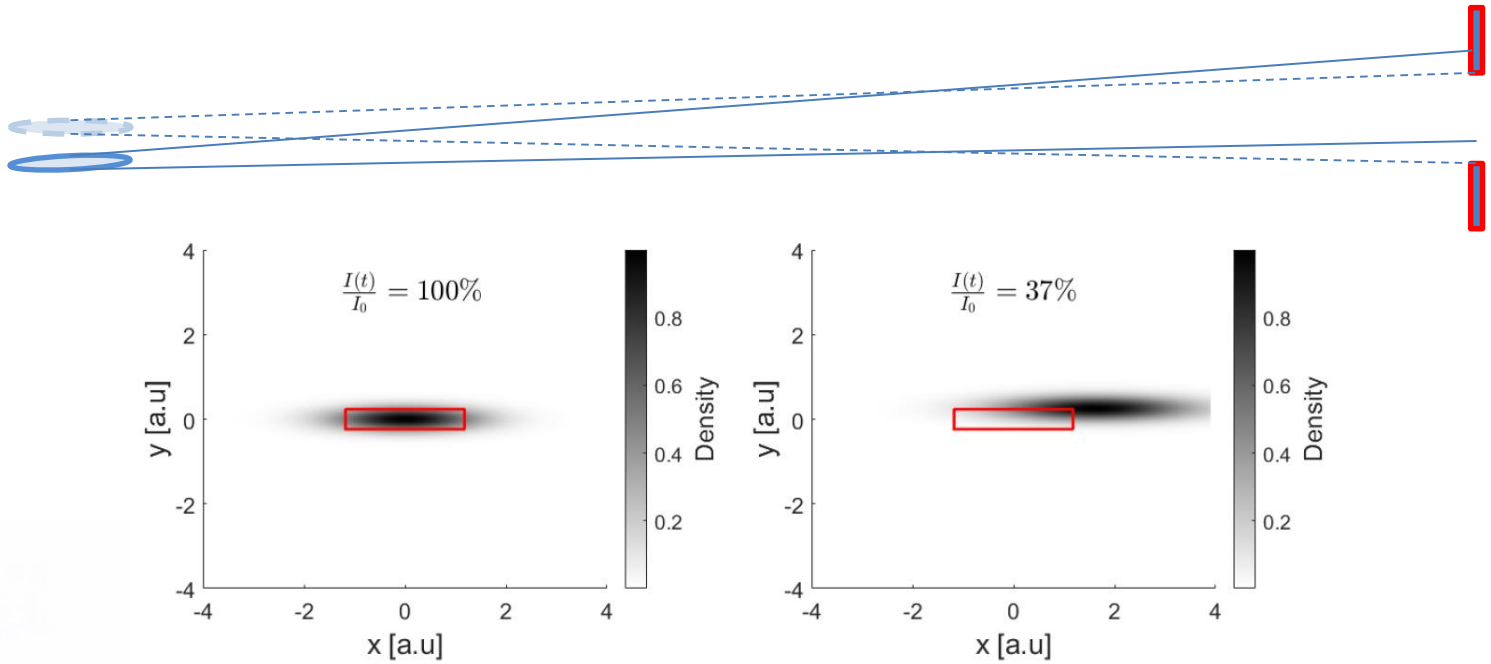
Damage to vessel coating

Injection Transparency

Goal for Diamond-II is to make injection transparent to users.

Diamond-II Figure of Merit (FoM) definition of “transparent” injection:

“Intensity integrated over 100 μs through 2D FWHM slit 45 meter downstream from source point must remain above 99% of nominal at all times at all beamlines”



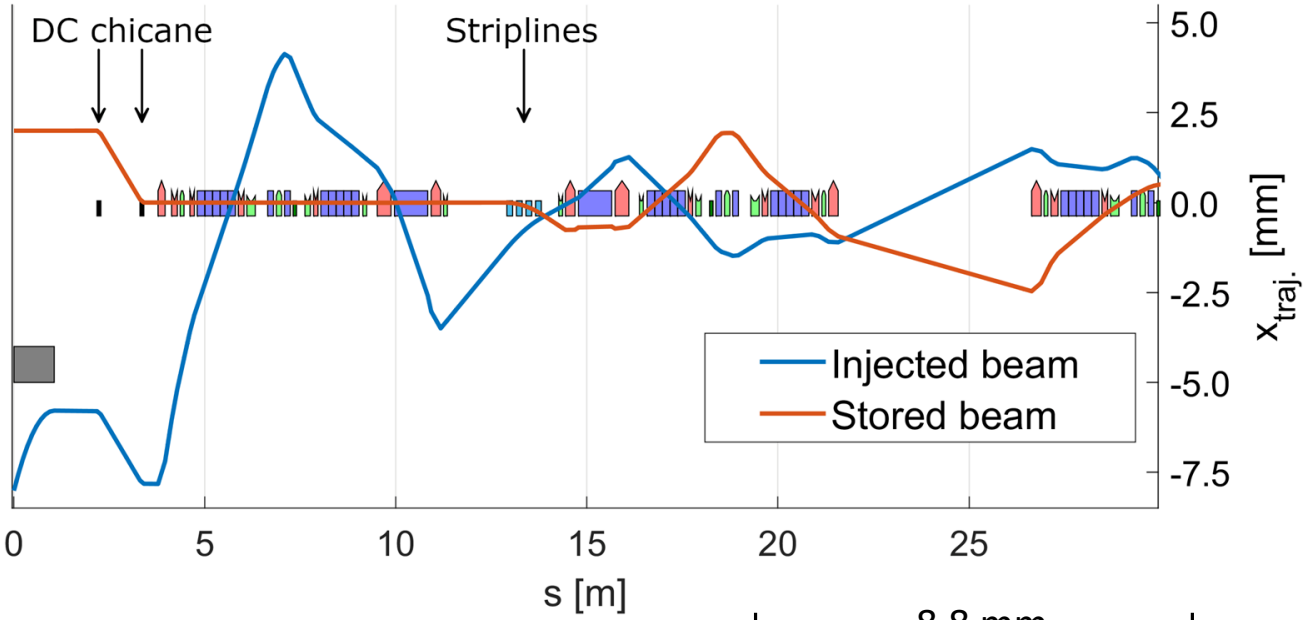
How can we improve transparency during top-up?

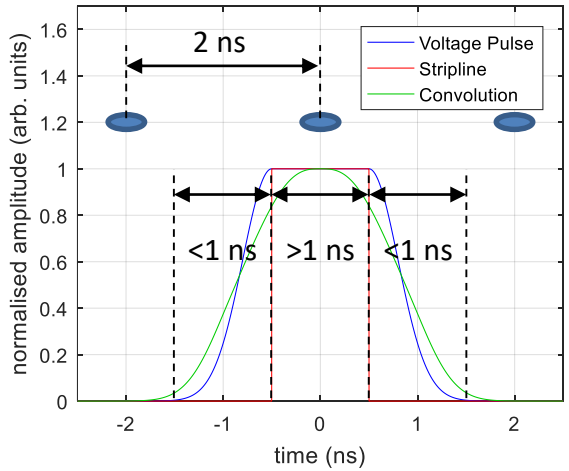
⇒ Transparency improves as the number of kicked bunches is reduced

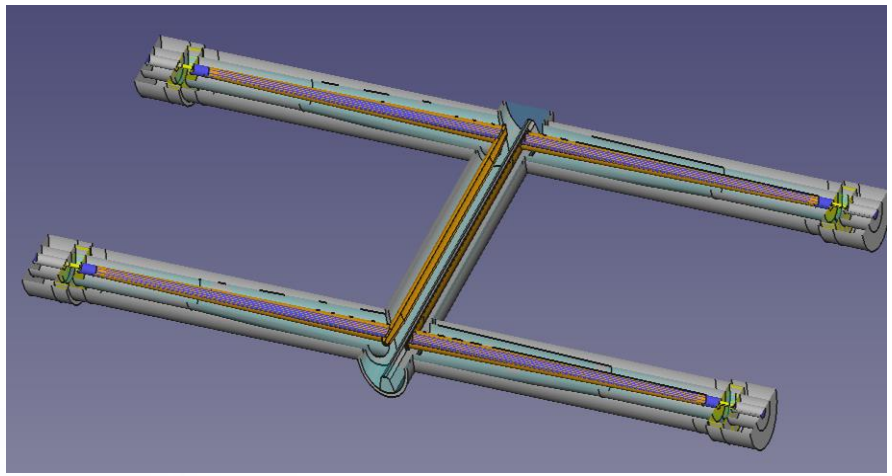
Single Bunch Injection with Stripline Kickers

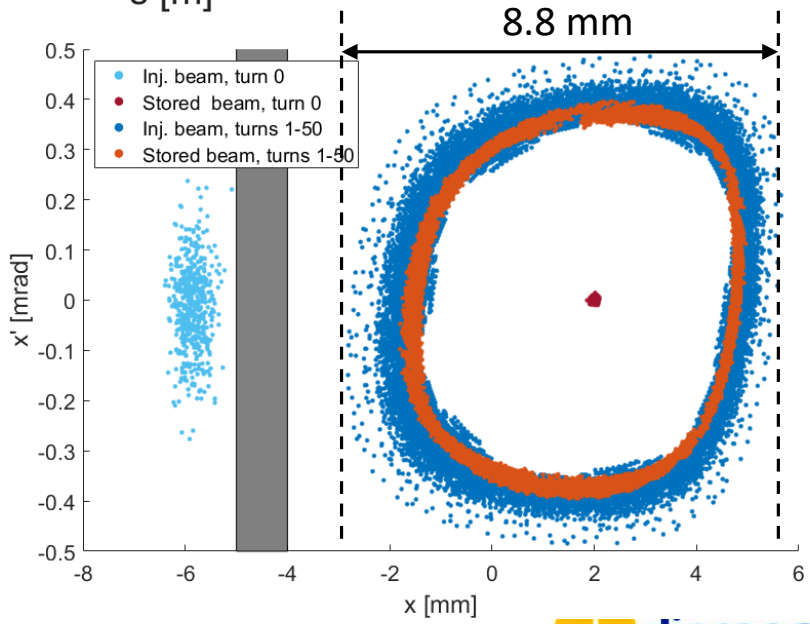
Top-up injection will use ‘aperture sharing’

- Four × 0.15 m long striplines in first mid straight
- Pulse length <3 ns full width, >1 ns flat-top
- Single bunch injection only
- 1 bunch in 899 will be disturbed
- Much improved transparency!



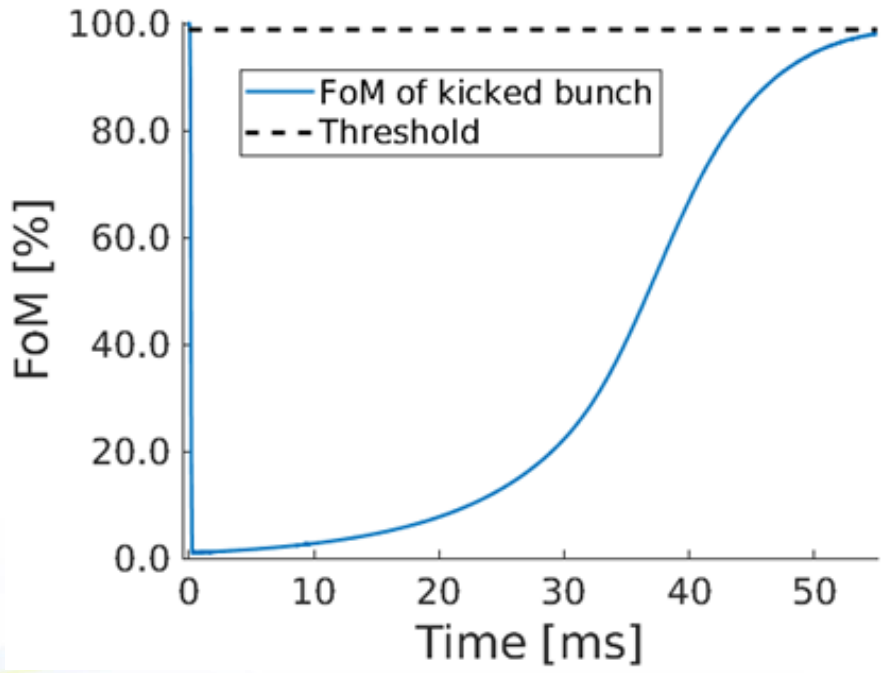




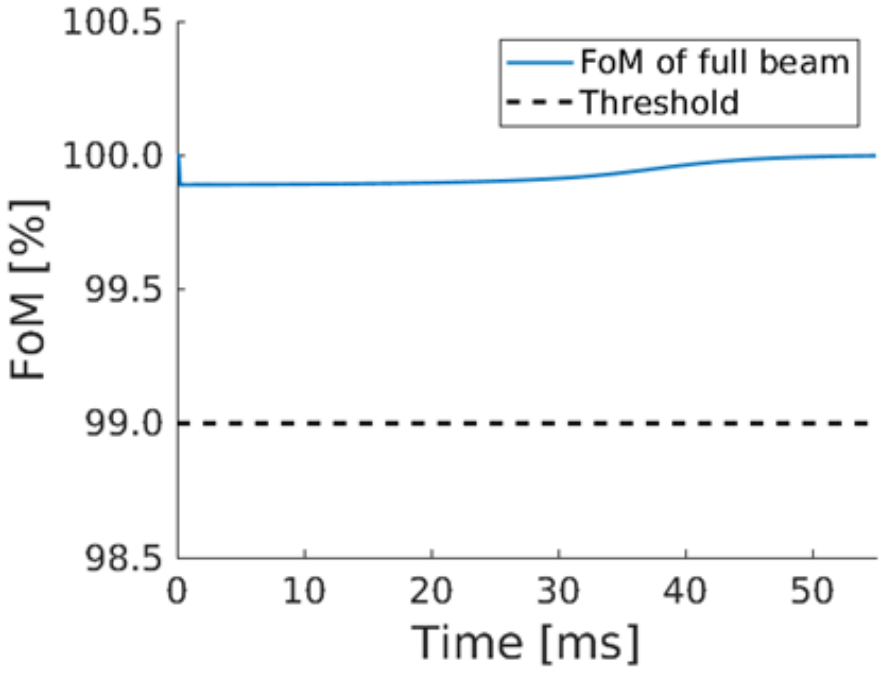


Single Bunch Injection with Stripline Kickers

Intensity for the kicked bunch drops to zero but recovers in ~50-60 ms



Intensity for the beam as a whole stays above 99.9% during injection

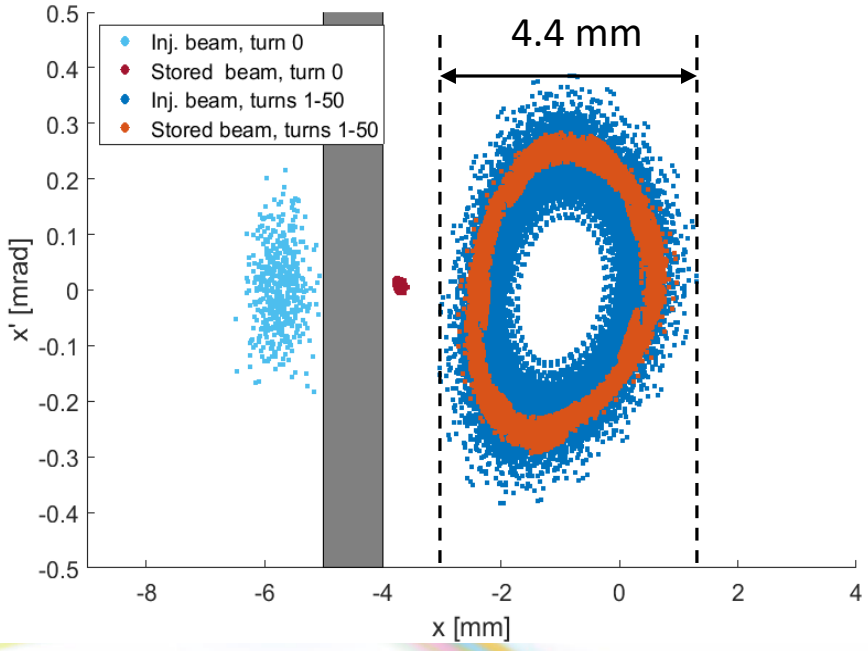


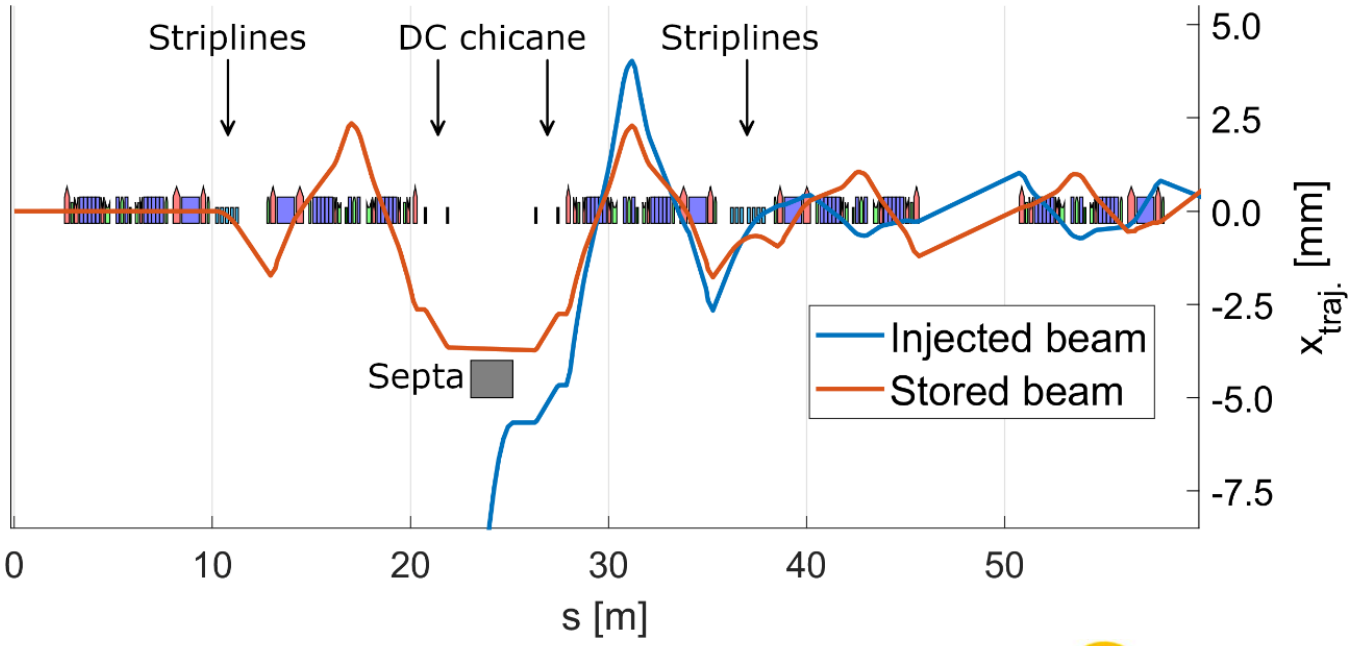
‘Enhanced’ aperture sharing

Concept:

Try to combine closed-orbit bump for stored beam with single-bunch kickers for transparency

1) Striplines in mid-straight upstream of septum
2) Kick stored bunch close to septum
3) Stored and injected beam kicked back in downstream mid-straight





Summary

Two injection schemes developed for Diamond-II

Updated ‘classic’ four-kicker bump scheme for commissioning:

- Flexibility & adjustability
- Can be single or multi-bunch injection (reduces fill-time and/or number of injection shots per cycle)
- Risk minimization: maintains fallback options; robust, proven technology

Transparent injection possible using single-bunch ‘aperture-sharing’ injection:

- Only 1 bunch in 900 is kicked
- Can be installed / tested / developed separately from basic injection scheme
- Upgrade path for injection into potential future ‘high-brightness’ lattices

Several key technologies under development:

- In-vacuum thick-thin eddy current septa
- 150 mm striplines
- Few nanosecond pulsers from industry

Stage	Scheme	
Commissioning	Traditional 4-kicker bump	Multi/single bunch
User mode	Single-bunch aperture sharing	single-bunch
High-brightness	Enhanced aperture sharing	single-bunch