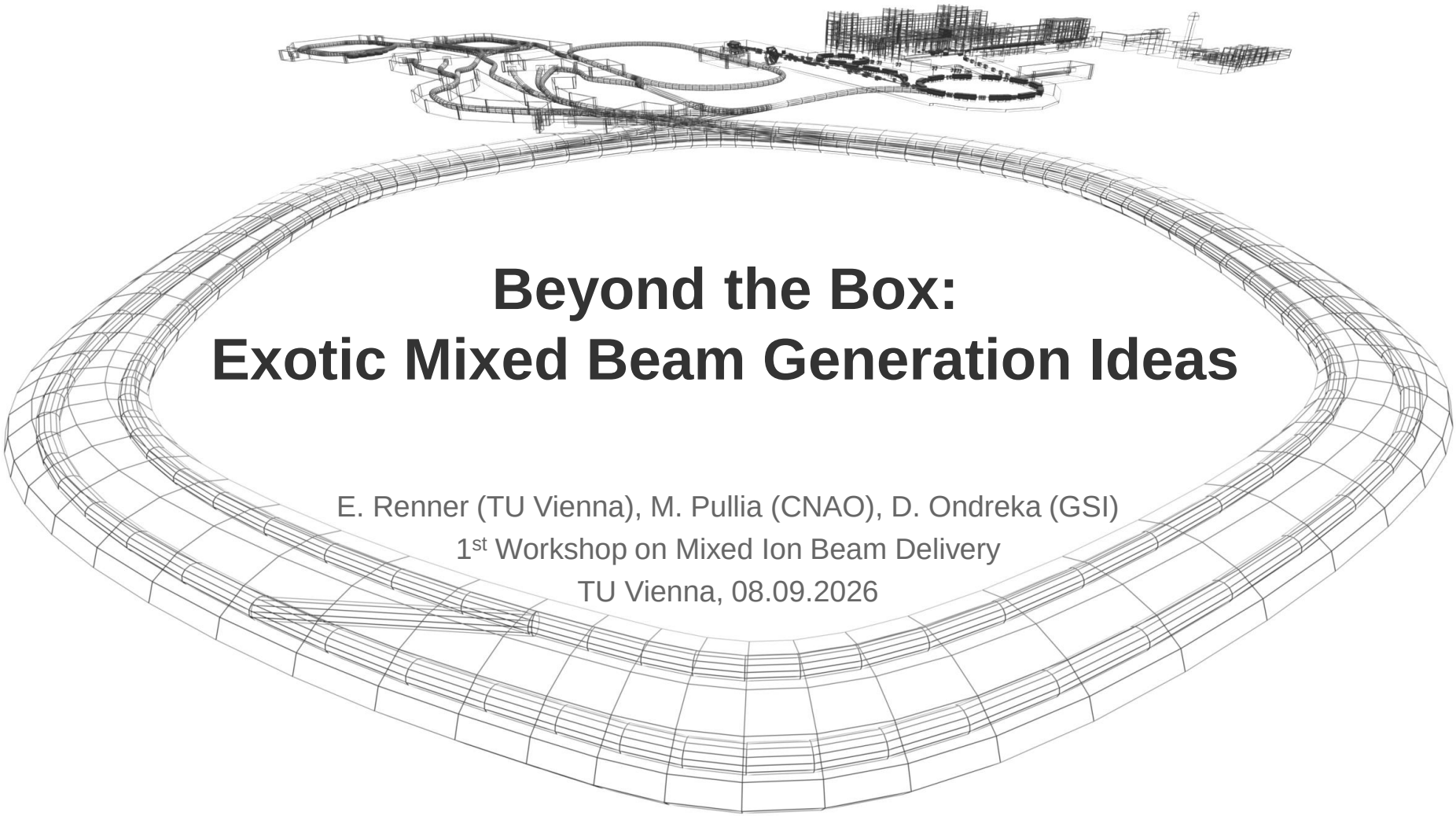

Beyond the Box:
Exotic Mixed Beam Generation Ideas

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1st Workshop on Mixed Ion Beam Delivery
TU Vienna, 08.09.2026

What's in the box

- Delivery of mixed C/He with constant fraction well established
- Generation
  - Present gold standard: sequential multiturn injection from two sources
  - Alternative option (with issues): generation in the same source
- Extraction
  - KO extraction makes extracting a constant He fraction simple
- *What more do we need?*

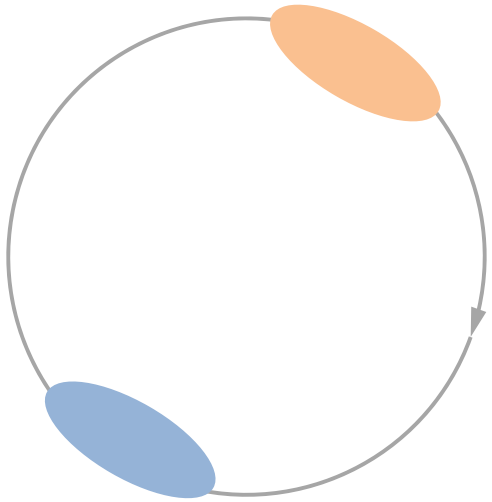
Beyond the box

- Possible additional or alternative requirements
  - Independent control over extraction rate of each ion
  - Temporal separation of extracted ions
  - Same transverse phase space for both ions
  - …

- Potential applications
  - Variation of He fraction per energy slice (compatible with multi-E extraction)
  - Two-ion dose delivery within same cycle
  - Detection of He without C fragment background
  - …

Beyond the box:
Ions in separate bunches

- Goal: have each ion in a separate bunch
- Advantages
  - Rate control for each ion with bunch-by-bunch KO
  - Temporal separation of C and He at the target
- Potential applications
  - Variation of He fraction per energy slice (compatible with multi-energy extraction)
  - Two-ion dose delivery within same cycle
  - Detection of He without C fragment background
- Possible generation schemes
  - Slip stacking
  - Ring-RF synchronized ion source switching

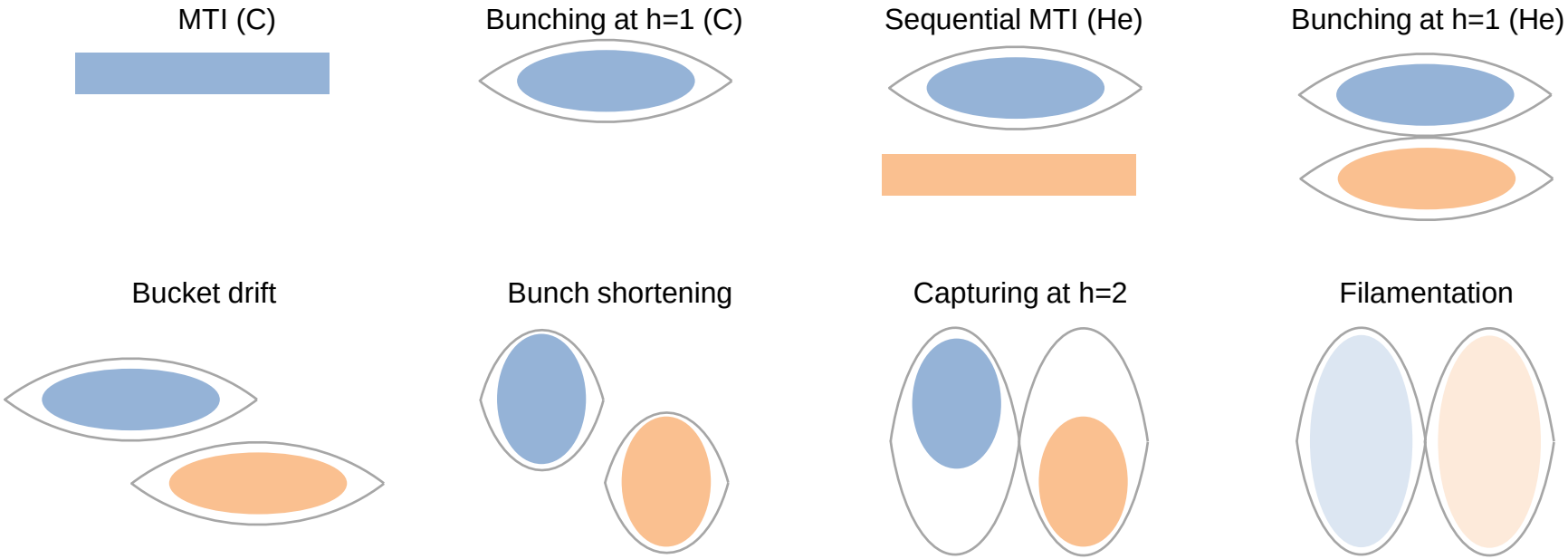


Slip stacking

Mentioned in: M. Kausel et al., Phys. Rev. Accel. Beams 28, 111001 (2025)

- Phase drift of two series of buckets with a momentum relative to each other
- Pioneered by Fermilab to increase intensity
- CERN: reduction of bunch spacing for lead

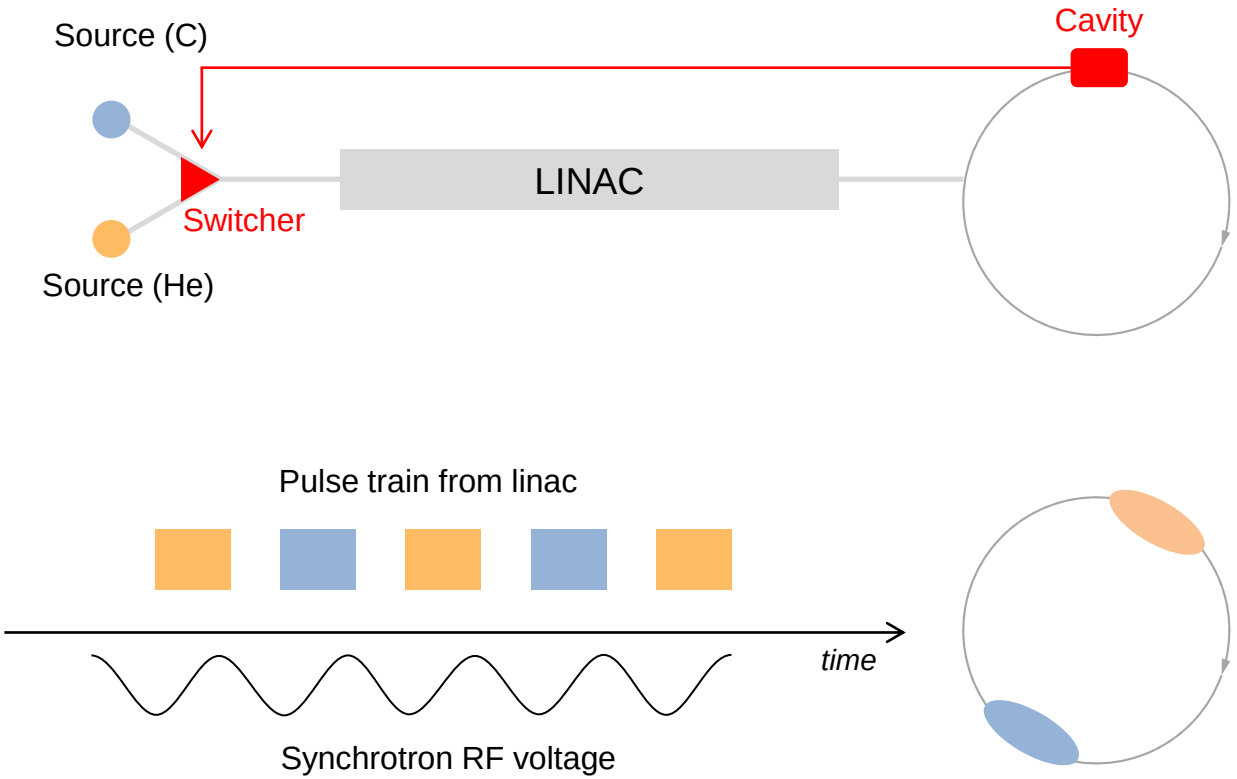
- Crucial points for mixed beams
  - Requires larger momentum acceptance
  - Details need to be worked out with simulations



Bunch-to-bucket injection

Mentioned in: M. Kausel et al., Phys. Rev. Accel. Beams 28, 111001 (2025)

- Perform MTI into buckets
- Requires same M/Q in linac

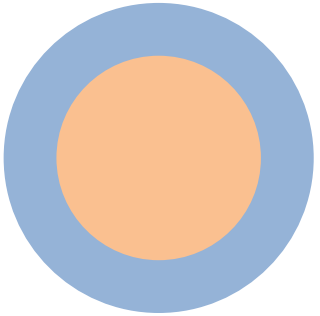


Beyond the box:
Same transverse phase space

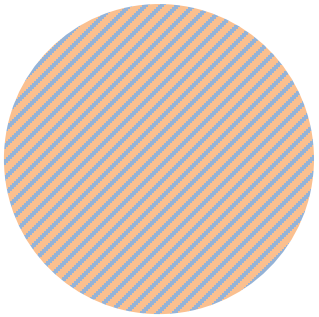
- Goal: have both ions occupy same transverse phase space

- Possible generation schemes
  - Generation in a single ion source (if contamination can be avoided)
  - Longitudinal stacking

Nested phase space after sequential MTI



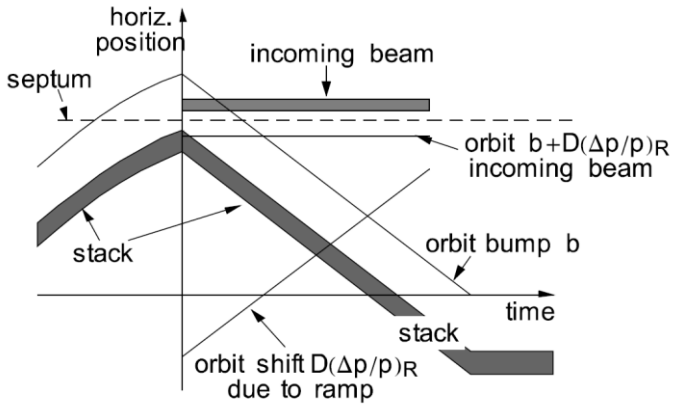
Shared phase space



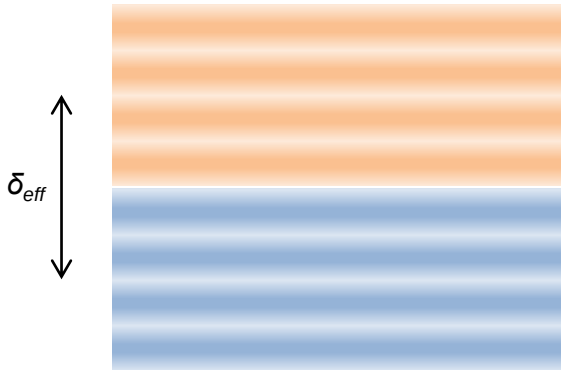
Longitudinal stacking

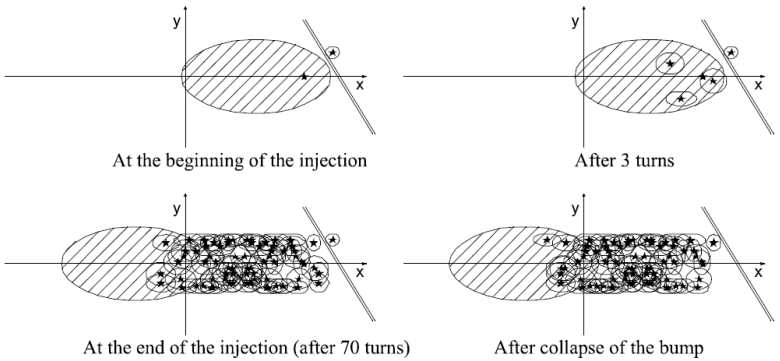
Mentioned in: M. Kausel et al., Phys. Rev. Accel. Beams 28, 111001 (2025)

- Example: LEIR lead ion injection
  - Linac energy ramped over pulse
  - Orbit bump synchronized with energy ramp
- Key features
  - Longitudinal stacking, same transv. phase space
  - Requires large norm. dispersion $D \cdot \beta^{1/2}$
  - Favors small momentum spread of injected beam



Possible stacking of C and He





LHC Design Report Vol 3, 2004, pp. 284ff.

Beyond the box

Your ideas go here!