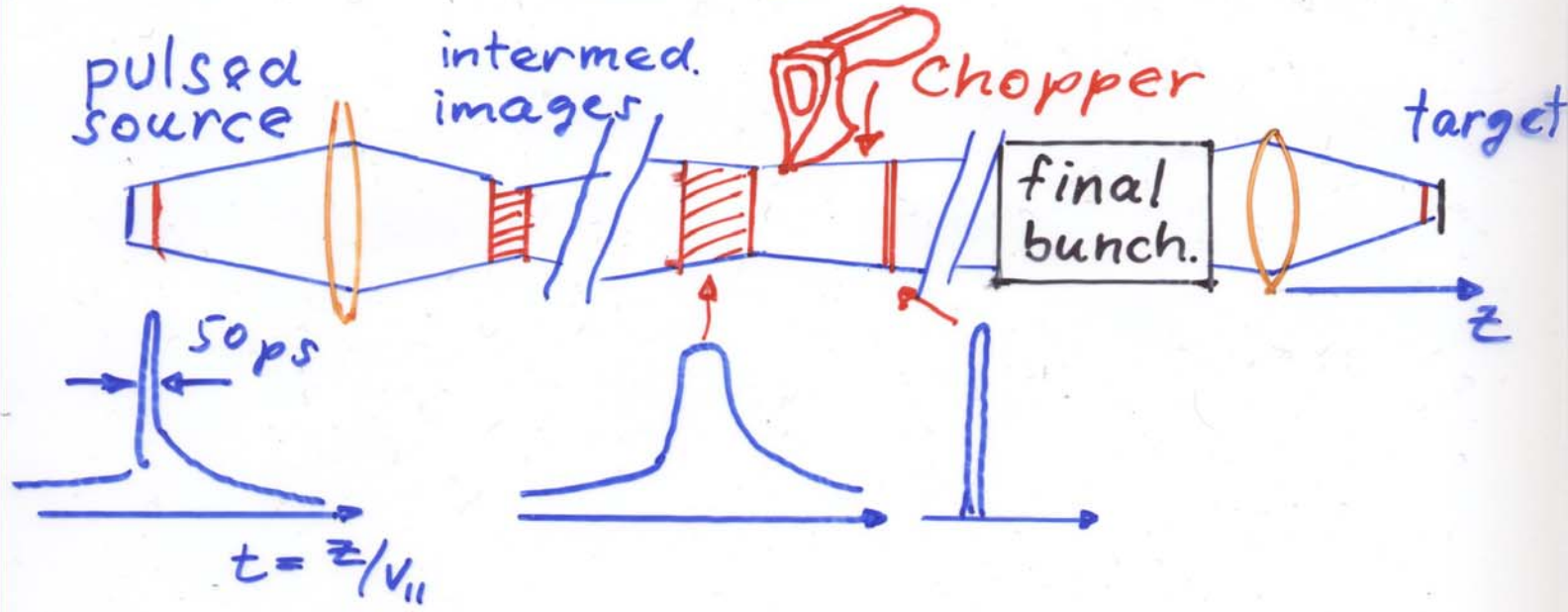
CHOPPER



NEVER FORGET LIOUVILLE:

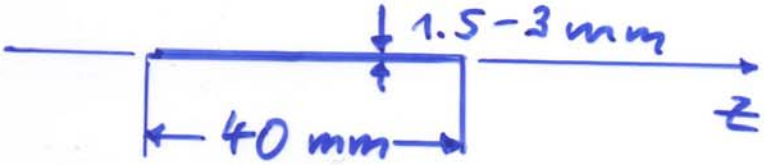
$$\frac{d}{dz}\left(\underbrace{\Delta E_{\parallel}\,\Delta t}_{\text{longit}} \cdot \underbrace{\Delta E_{\perp}\,\Delta x\,\Delta y}_{\text{transverse}}\right) \geq 0$$

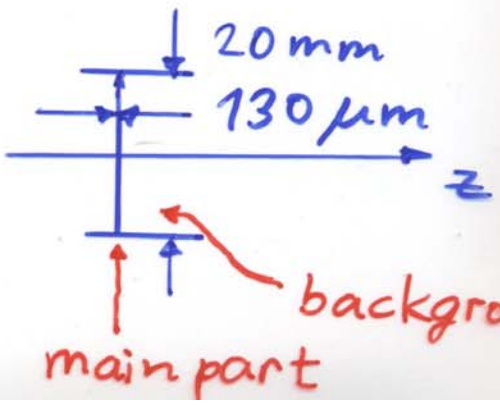
Interchange of $\parallel$ and $\perp$ at chopper

Occupied phase space at source:

	PLEPS	EPOS (optimistic)
$\Delta E_{\parallel} \cdot \Delta t$	1eV · 15ns	1eV · 50ps
$\Delta E_{\perp} \cdot \Delta x \Delta y$	30 meV · 8 mm² (SPM: 2 mm²)	1eV · 300 mm²

pulse shape at $E_{\parallel} = 20$eV



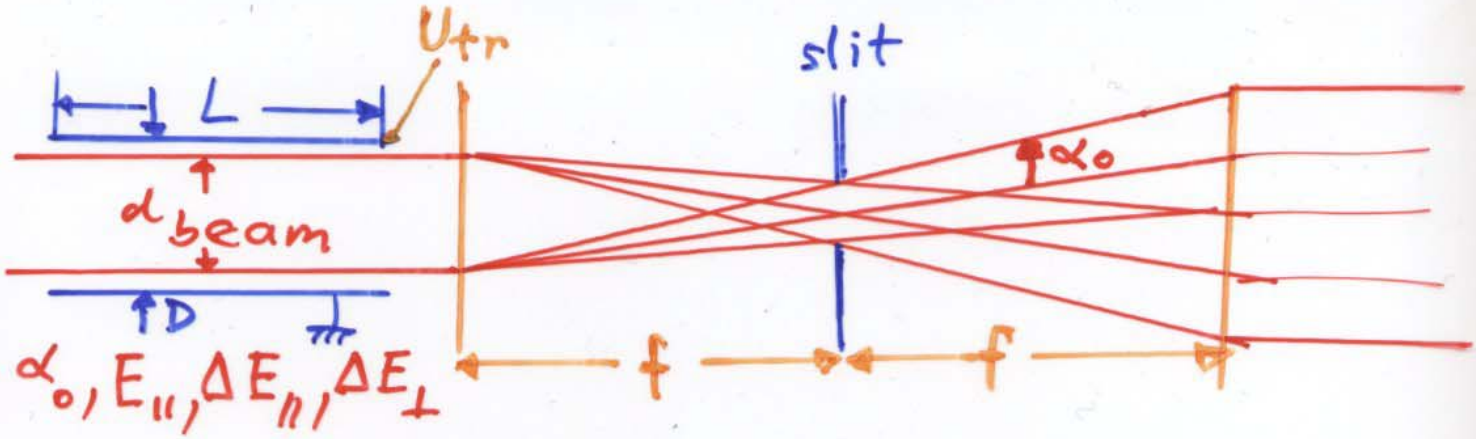


- Simple results on deflection by a transient field

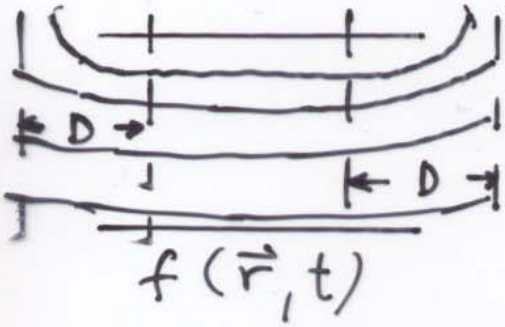
- Overview: EPOS and well-established choppers:
  - deflection plate (SPM, Munich)
  - deflection plates in a magnetic guiding field (PLEPS III, Munich)
  - Schödlbauer's chopper (PLEPS I, Munich)
  - Suzuki's gate (Tsukuba)

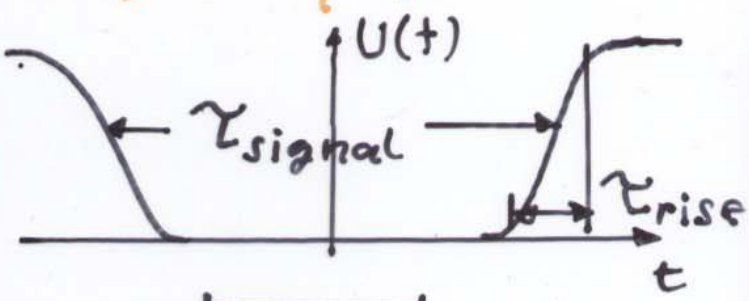
- Alternatives for EPOS
  - Remoderation
  - Phase space shifter
  - Split beam

Deflection by transient field (1. order)



$$U_{tr}(\vec{r},t) = U(t)\cdot f(\vec{r},t)$$





$$\tau_{transit} = \frac{L}{v_{\parallel}}$$

$$\tau_{signal} \geq \tau_{transit}$$

Gate closed if deflection $\alpha \geq 2\alpha_0 = 2\sqrt{\frac{\Delta E_\perp}{E_\parallel}}$

$$\alpha = \frac{eU}{m v_{\parallel}^2}\cdot\frac{L}{D} = \frac{eU}{2E_{\parallel}}\cdot\frac{L}{D} \geq 2\sqrt{\frac{\Delta E_\perp}{E_\parallel}}$$

Chopped beampulses:

$$FWHM \geq \tau_{signal} \geq \frac{L}{v_{\parallel}}$$

$$\text{rise time} \geq Max(\tau_{rise},\ D/v_{\parallel})$$

$$\Delta E_{\parallel} = eU$$

⇝ effects of chopper

	chopped beam		incoming beam
(1)	$\Delta E_{\parallel} \approx eU$	$\geq$	$4 \frac{D}{L} \sqrt{\Delta E_{\perp} E_{\parallel}}$
(2)	$\Delta E_{\perp}$	$\geq$	$4 \Delta E_{\perp}$
(3)	FWHM τ_{chop}	$\geq \tau_{signal} \geq$	$\frac{L}{v_{\parallel}}$
(4)	risetime	$\geq$	$\mathrm{Max}\left(\frac{D}{v_{\parallel}}, \tau_{rise}\right)$

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(3) in (1) ⇝

$$(5) \quad \Delta E_{\parallel} \cdot \tau_{chop} \geq 4 \sqrt{d_{beam}^2 \cdot \Delta E_{\perp}} \cdot \sqrt{\frac{E_{\parallel}}{v_{\parallel}^2}}$$

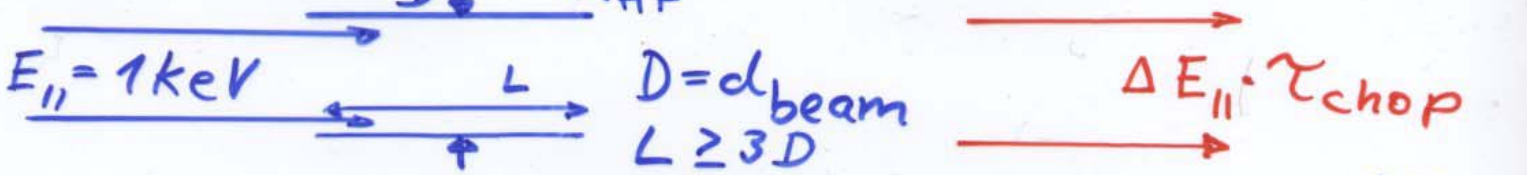
$$[eV \cdot ns] \qquad = 6.74 \, \frac{d_{beam}}{mm} \sqrt{\frac{\Delta E_{\perp}}{eV}}$$

new invariants: $d_{beam}^2 \Delta E_{\perp}$, $\Delta E_{\parallel} \cdot \tau_{chop}$

invariants of incoming beam

Overview: Performance at EPOS (SPM)

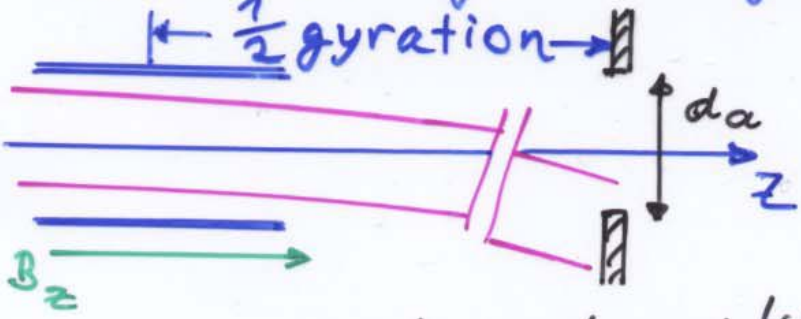
1) Single deflection stage

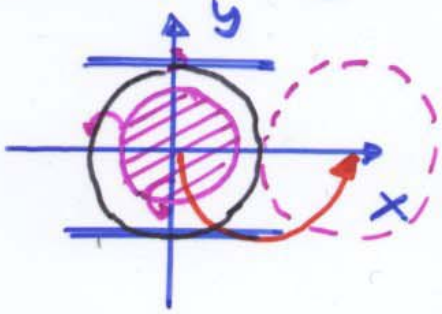


	$\frac{\Delta E_\perp \cdot D^2}{mm^2 \cdot eV}$	$\frac{\Delta E_\parallel \cdot \tau_{chop}}{ns \cdot eV}$	U_{HF}/V	FWHM at target	$\Delta E_{\parallel}$ (target)
SPM	0.06	1.65	5	400 ps	4 eV
EPOS	300	117	30	50 ps	2.3 keV

↝ at Epos acceptable only at target energies ≥ 23 keV

2) Defl. stage in magnetic field B_z





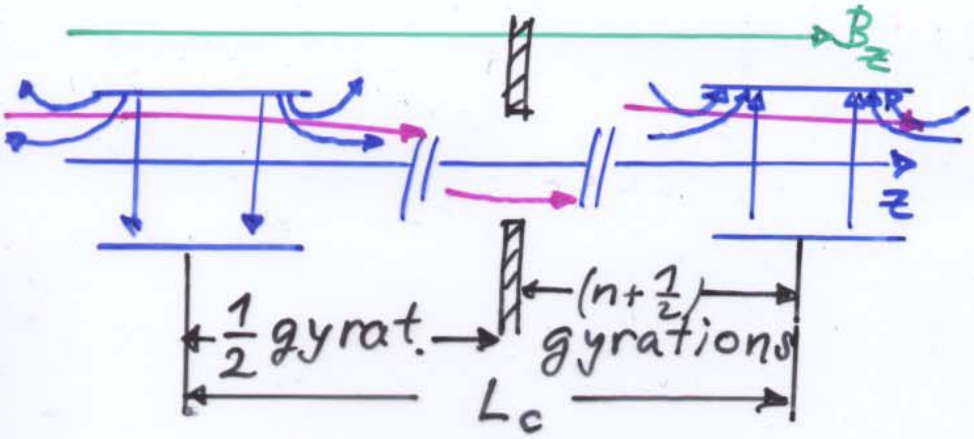
$$d_a \approx d_{beam} + 4 r_{g,0}$$

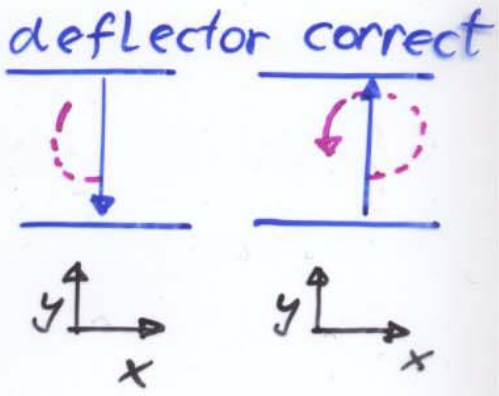
gate closed, if induced $r_g \geq \frac{d_{beam}}{2} + 2 r_{g,0}$

$$\rightsquigarrow v_\perp \geq \frac{e}{m} B_z \frac{d_{beam}}{2} + 2 v_{\perp,0}$$

$$\alpha_{defl} = \frac{v_\perp}{v_\parallel} \geq \underbrace{\frac{e B_z}{2 m v_\parallel} \cdot d_{beam}}_{\approx 5\alpha_0 \text{ for EPOS}} + 2\alpha_0$$

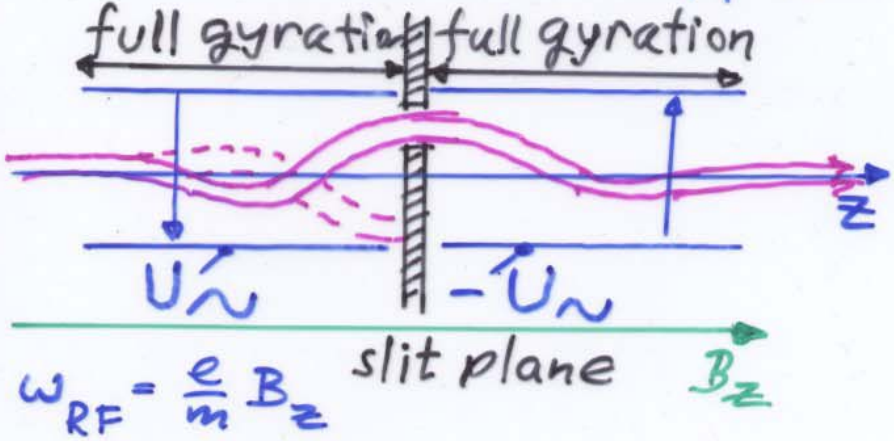
Short defl. plates with corrector (PLEPS III)

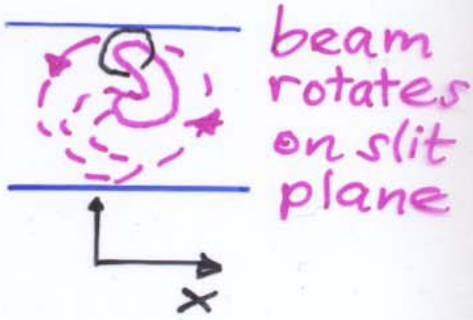




- corrector signal reversed and delayed by time of flight $L_c/v_{\parallel}$
- to 1. order full correction; 2. order effects remain (visible in PLEPS III)

Schödlbauer's chopper (PLEPS I, 1985)



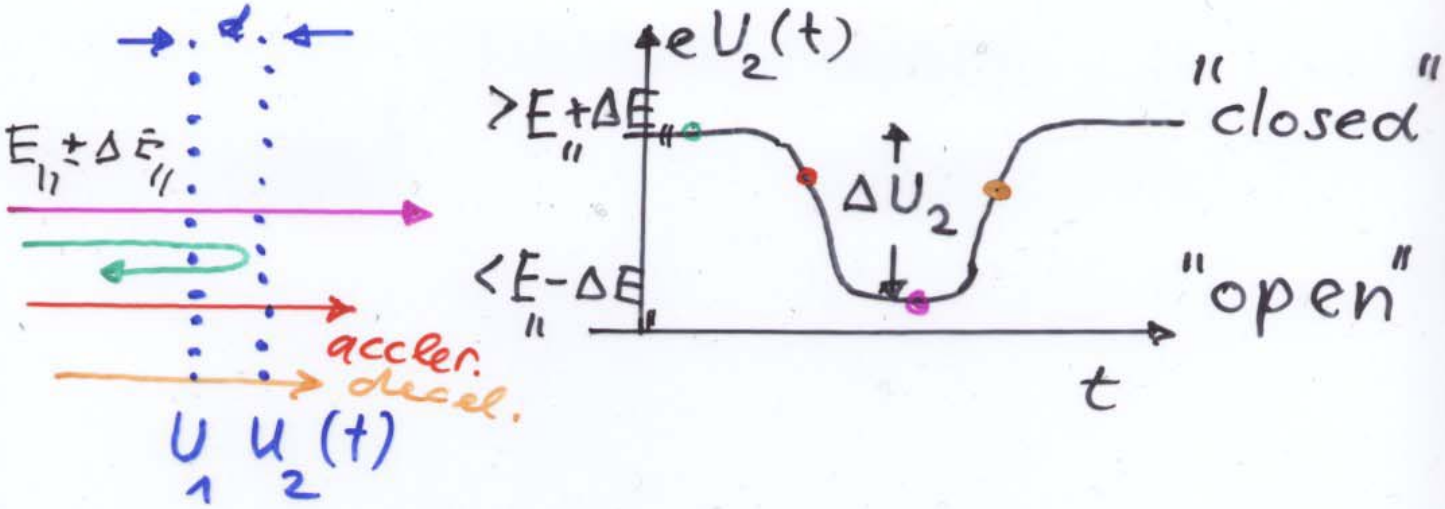


Abandoned because of critical adjustment and large 2. order effects

$\Delta E_{\parallel} \cdot \tau_{chop} \approx 10\ ns \cdot eV$ (PLEPS I).

Requires high RF-amplitude.

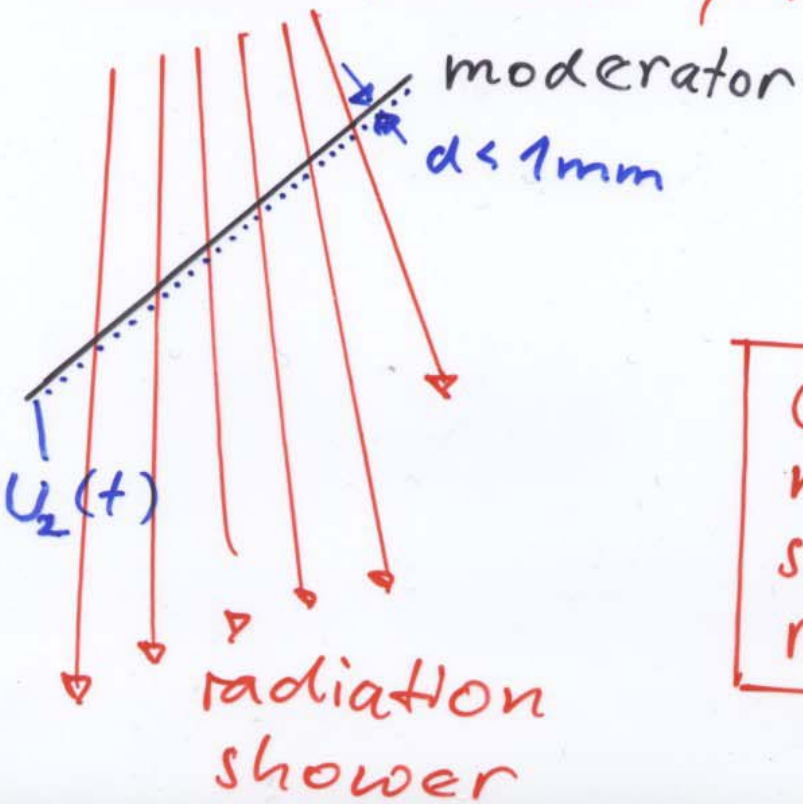
Suzuki's chopper (Tsukuba, ~1990)



advantage for EPOS: gate independent on beam diameter

disadvantages: needs grids. Transmitted fraction strongly influenced, $\Delta E_{\parallel} \approx 2 \Delta U_2$. Grids induce $\Delta E_{\perp} \approx \Delta U_2$.

out of all proven choppers, best (?) choice for EPOS, if located at source!

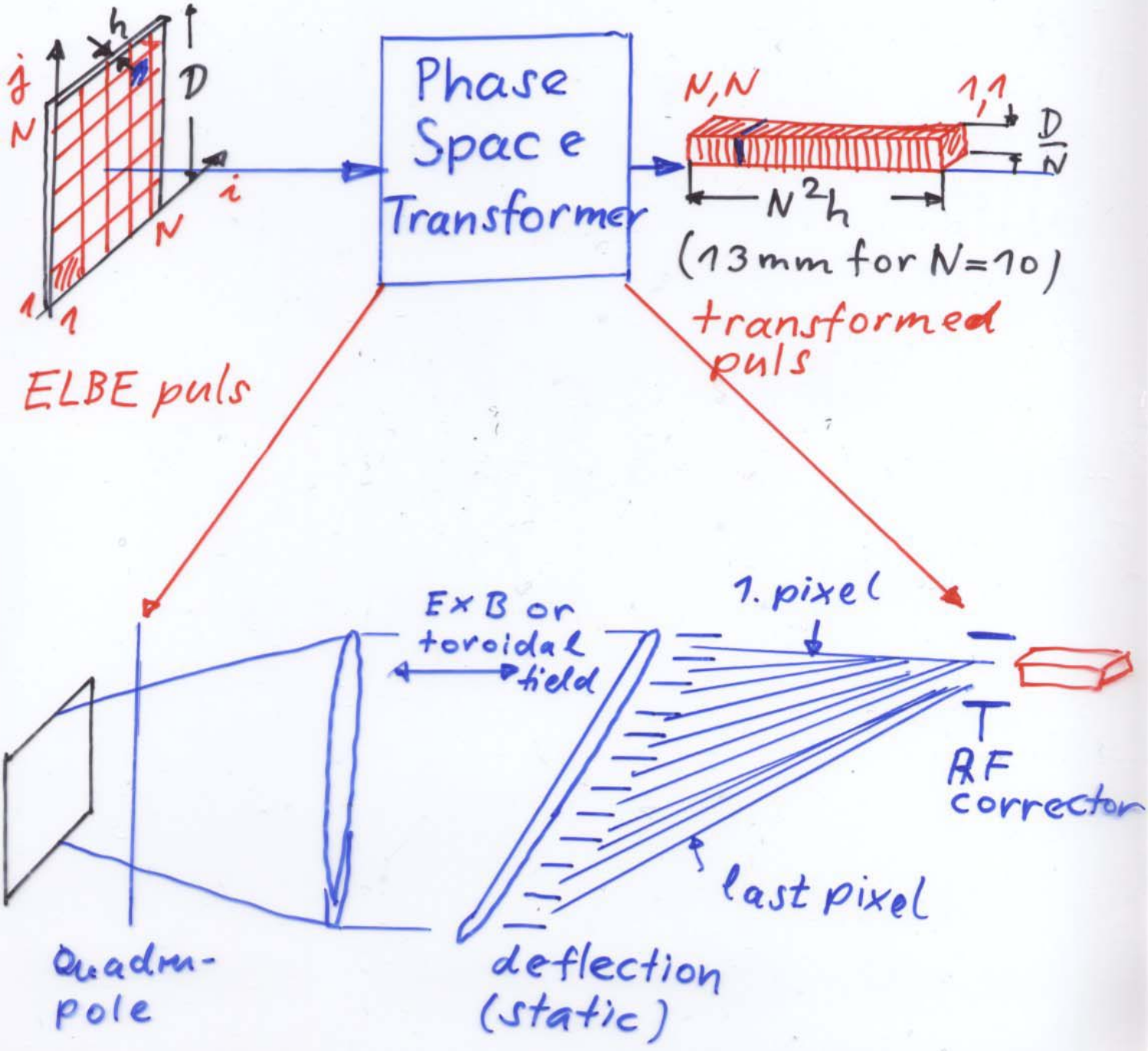


$\Delta U_2 = 10\,V$
$d < 1\,mm$
$\rightsquigarrow \tau_{chop} \gtrsim 1\,ns$

Careful numerical simulations required

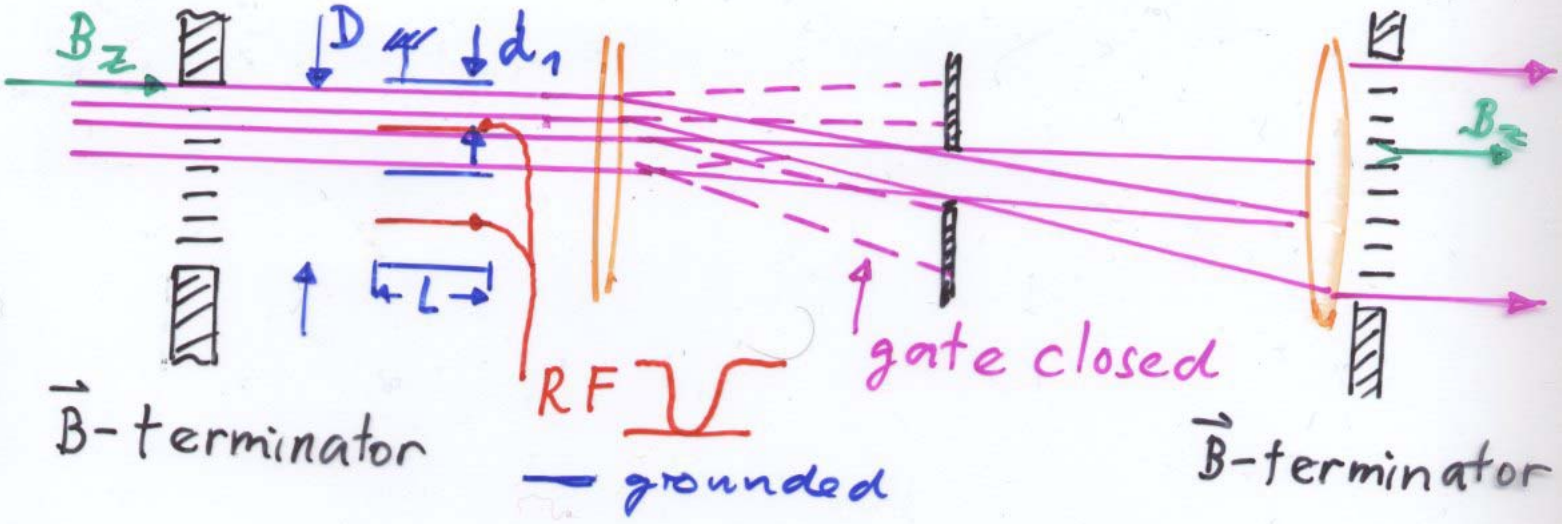
Alternative solutions for EPOS

1. All troubles are removed by a remoderation stage (intensity loss 80%)
2. Transform the problematic disc-shaped e^+-pulse from the ELBE e^+-source into the usual needle-shaped pulse:



exciting, but never tried

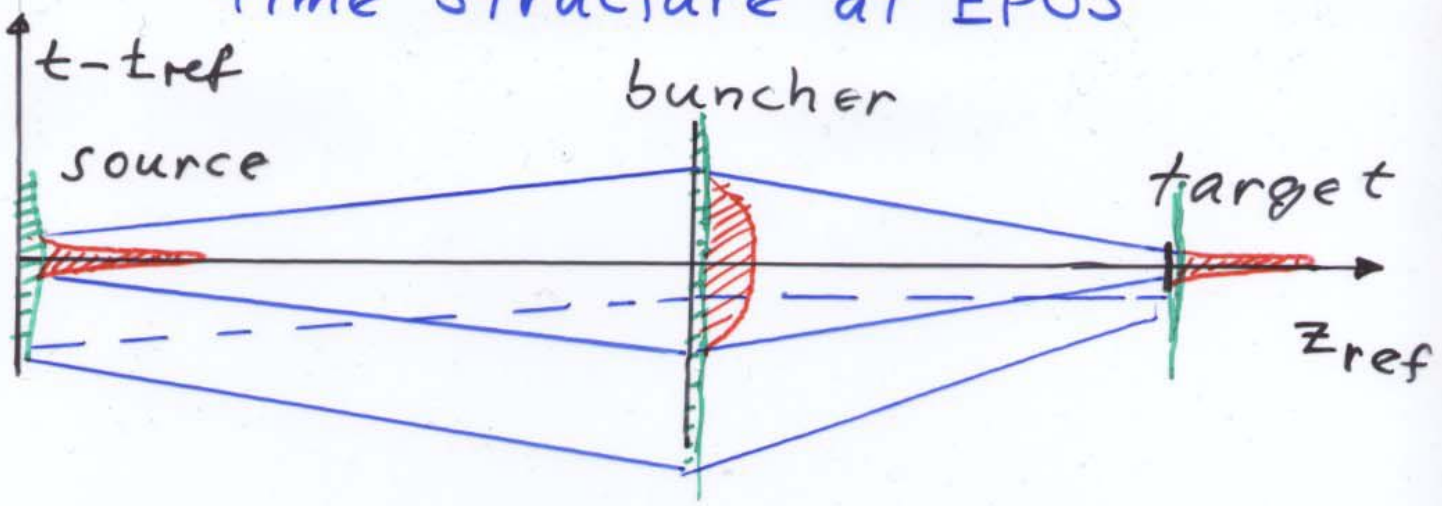
3. "Split-beam" chopper



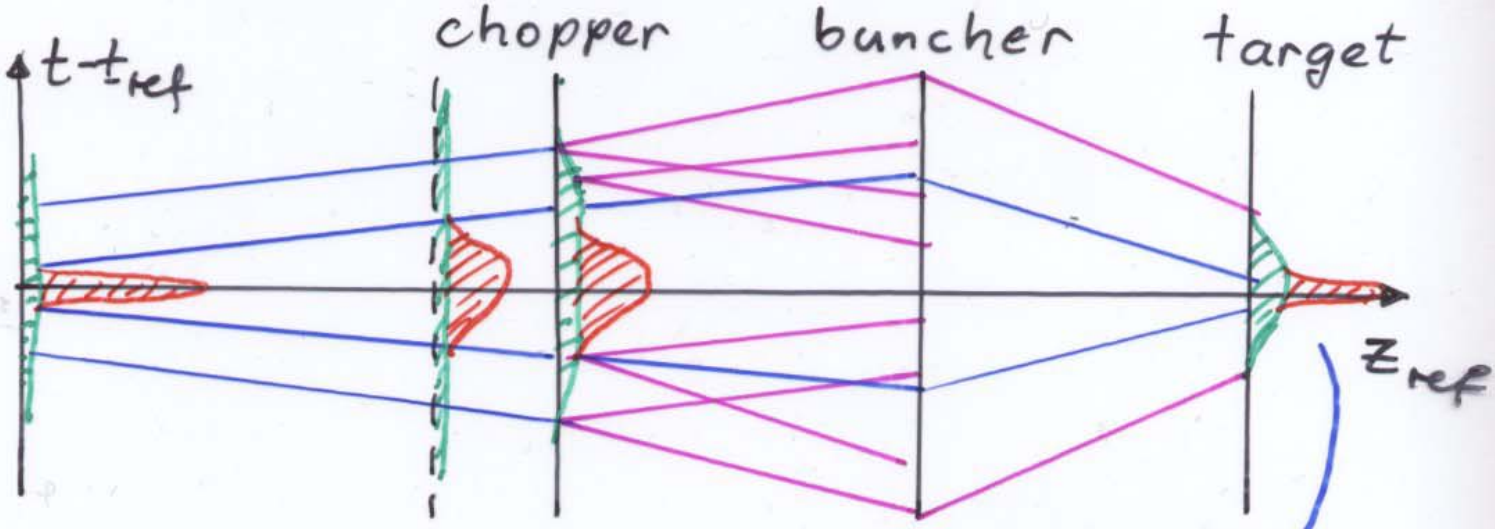
Main advantage:
Diameter d_1 of individual slices independent of beam diameter
↝ perturbations by chopper can be reduced by any amount (at least in principle)

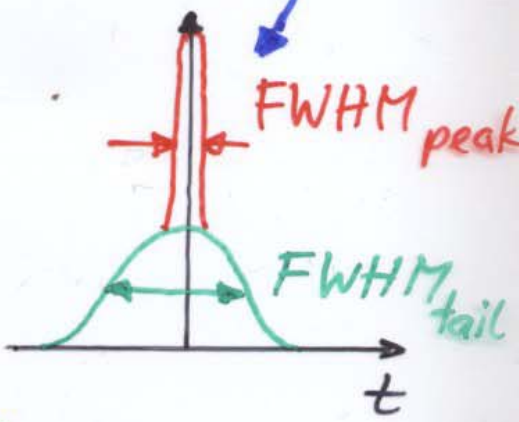
Disadvantages: So far never tried, intensity loss by interception

Concluding remarks on the predicted time structure at EPOS



z_{ref} refers to the position of the reference particle. Graph must be drawn for any point on the source.





Personal experience from PLEPS and SPM:

Minimum of $FWHM_{peak}$ and $FWHM_{tail}$ at different settings of system parameters