PAUL SCHERRER INSTITUT

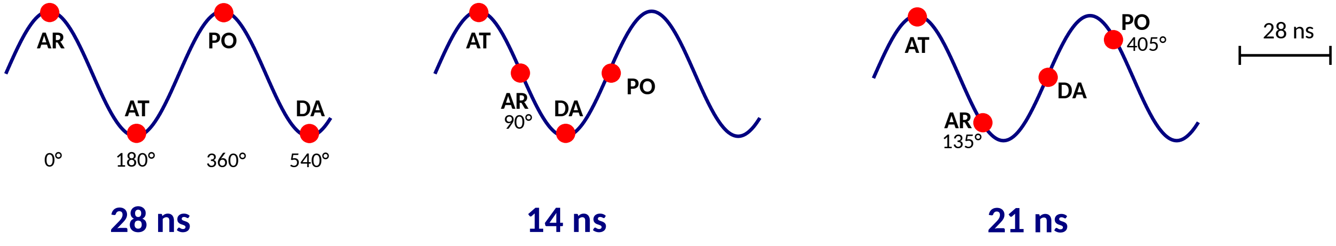
Thomas Schietinger, Martin Paraliev :: Paul Scherrer Institut

Porthos: kicker options

Porthos Machine Working Group Meeting, 15 December 2020

Kicker options I: no RK upgrade

- Assume that the first kicker remains the same, delivering a sine curve with 56 ns period.
- There are different ways to place the bunches along this sine curve, leading to different bunch spacings:

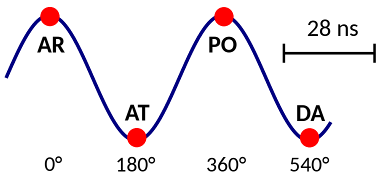


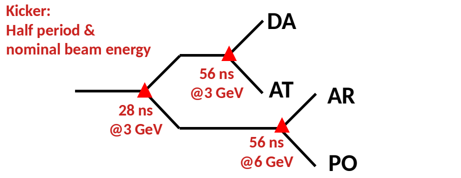
- Bunches placed on the zero crossing of the kicker voltage will suffer from voltage jitter.
- Swapping the bunches we can select which bunches profit from the highest stability (on-crest kicker voltage) – but this leads to weird septum designs and the need to remerge beams.
- Here's an overview of the possible combinations and their implications / complications:

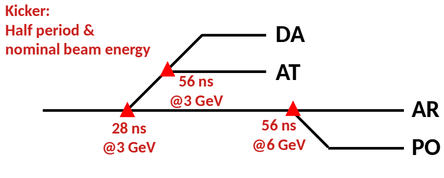
Bunch spacing / allocation	Bunch placement at first kicker	Topology	Actual layout (schematic)

28 ns

Status quo with four bunches, all on-crest

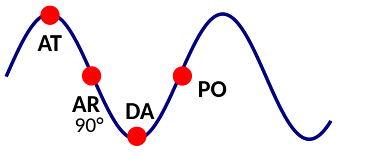


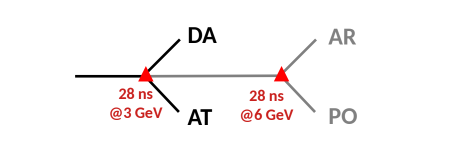


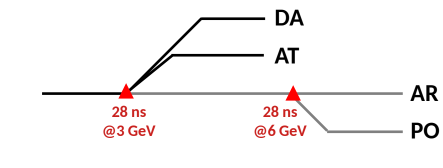


14 ns

Additionally using zero crossings to go straight.

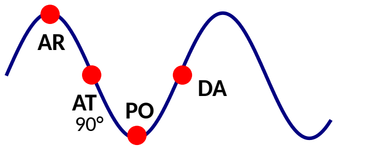


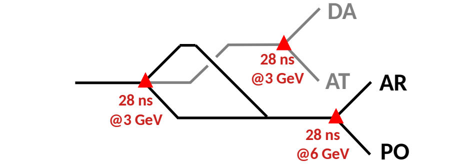


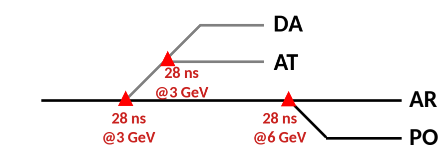


14 ns, swapped

Additionally using zero crossings to go into the soft-X-ray branch

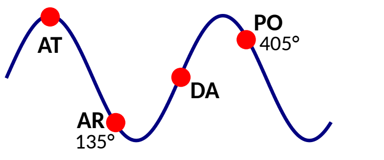


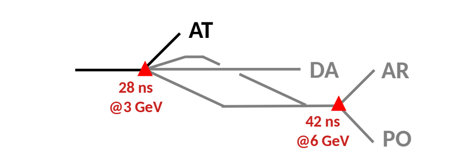


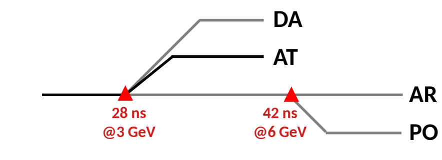


21 ns

Compromise:
one line on-crest, two lines close to on-crest (HXR), one line in the zero-crossing

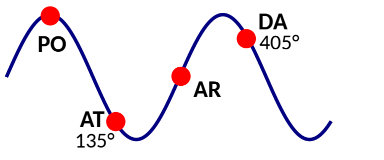


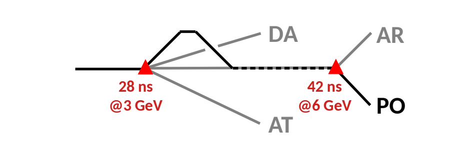


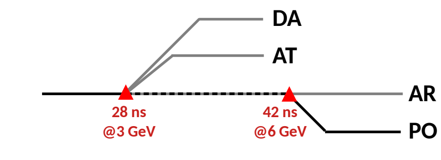


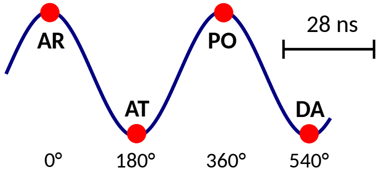
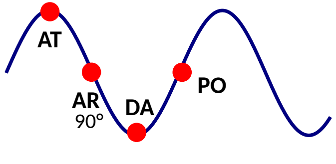
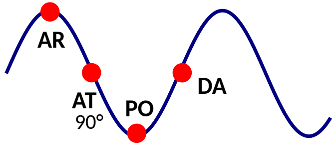
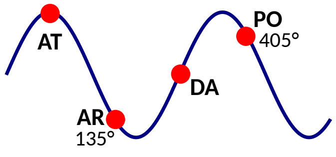
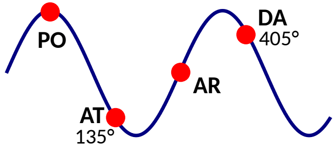
21 ns, swapped

Compromise:
one line on-crest, two lines close to on-crest (SXR), one line in the zero-crossing





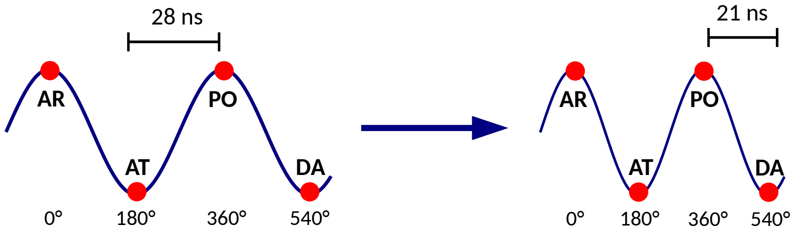


Bunch spacing / allocation	Bunch placement at first kicker	Evaluation (pulsed magnets, RF, other)
28 ns Status quo with four bunches, all on-crest		• Maximum stability for all bunches. • 6 GeV kicker doable (twice stronger but twice lower frequency). • New kicker and electronics need to be designed. • Other diagnostics and (LLRF) control systems will not suffer. • High (unacceptable?) loss of RF power at 84 ns separation. • Maximum RF tunability, minimum wakefield effects.
14 ns Additionally using zero crossings to go straight.		• Doable from pulsed magnets point of view. • Separating at 6 GeV will require (most likely) 4 more kickers identical to the existing ones – no new development needed. • Other systems suffer (less separation). • Minimal loss of RF power. • Minimum RF tunability, maximum wakefield effects. • Dual septum needs to be designed (feasible?). • Poorest stability for AR and PO.
14 ns, swapped Additionally using zero crossings to go into the soft-X-ray branch		• Special septum that deflects the bunches at zero crossing while the others remain on straight orbit? (Feasible? Resonant kicker for remerging?)
21 ns Compromise: one line on-crest, two lines close to on-crest (HXR), one line in the zero-crossing		• 21 ns is a good compromise for all systems that need upgrading. (But may be difficult for laser systems…) • Jitter induced by resonant kicker is reduced, but only by √2… • Triple septum that can separate 4 different beams to be designed (feasible?). • May have to involve dogleg in the separation (gradient septum? defocusing quad?) – space requirements to be evaluated. • Semi-merge AR and PO (on two crossing trajectories), then separate them later with a thin septum (without kicker, to be designed…)? • Swapped version to be preferred to have the highest-demand beam (PO) on crest (but poor stability for AR). • Acceptable loss of RF power(?) • Acceptable RF tunability, wakefield effects (?) …to be evaluated!
21 ns, swapped Compromise: one line on-crest, two lines close to on-crest (SXR), one line in the zero-crossing		

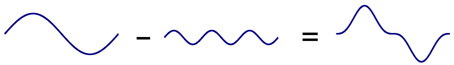
Kicker options II: with RK upgrade

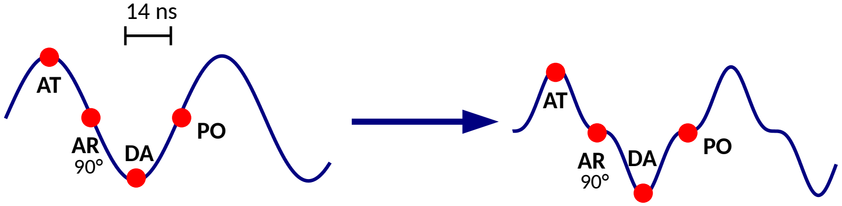
Two possibilities to upgrade the kicker to avoid or mitigate the problems associated with shorter bunch separations:

- **Faster oscillation**
  - The emergence of GaN transistors means that higher voltages are now possible than 10 years ago (our current system is based on Si MOSFET and pushed that technology to the limit).
  - A faster kicker with the same active length will be challenging but should be possible (Martin).



- **Addition of higher-harmonic oscillation**
  - Can we create a two-resonance system with coupled resonators?





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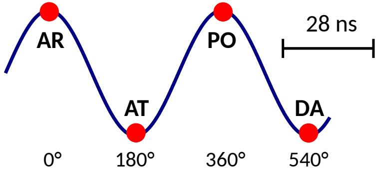
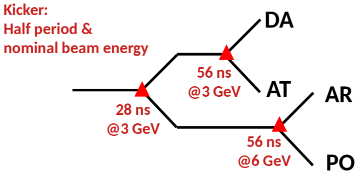
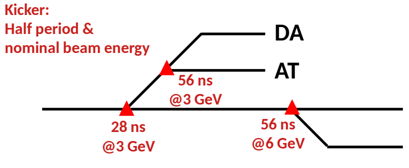
Status quo with four bunches, all on-crest</td><td>
</td><td>
</td><td>
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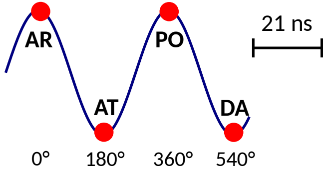
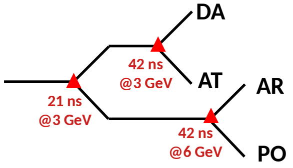
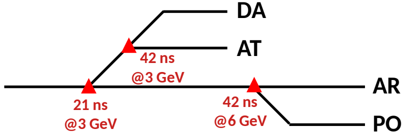
Status quo with four bunches, but faster kicker</td><td>
</td><td>
</td><td>
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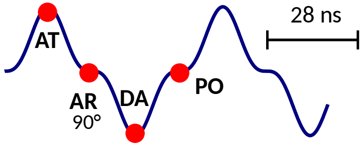
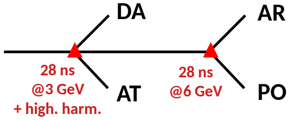
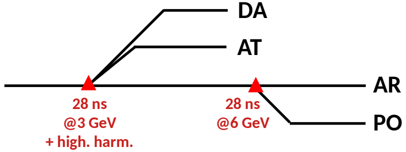
Using inflection points at zero crossings to go straight.</td><td>
</td><td>
</td><td>
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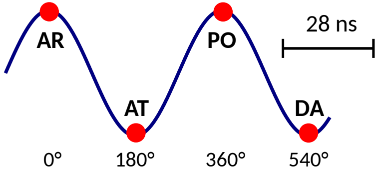
Status quo with four bunches, all on-crest</td><td>
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• 6 GeV kicker doable (twice stronger but twice lower frequency).
• New kicker and electronics need to be designed.
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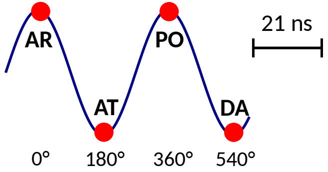
Status quo with four bunches, but faster kicker</td><td>
</td><td>• 21 ns is a good compromise for all systems that need upgrading. (Laser???)
• Maximum stability for all bunches
• Normal septa – we can keep the first as it is.
• No complications from remerging beams.
• Acceptable loss of RF power(?)
• Acceptable RF tunability, wakefield effects (?) …to be evaluated!</td></tr>
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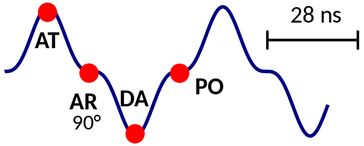
Using inflection points at zero crossings to go straight.</td><td>
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• Separating at 6 GeV will require (most likely) 4 more kickers identical to the existing ones – no new development needed.
• Other systems suffer (less separation).
• Minimal loss of RF power.
• Minimum RF tunability, maximum wakefield effects.</td></tr>
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21 ns bunch spacing – a problem for the laser?

Discussion about feasibility of 21 ns bunch spacing for laser systems (summarized by Martin):

- 21 ns spacing (or other separation that is not a multiple of 14 ns) is possible only if:
  - There is a separate laser for each beamline.
  - The timing and synchronization system is capable of reliably positioning the pulses at the required timing positions (including those of the other lasers) so the lasers could be easily interchangeable.
- Limitations and drawbacks:
  - In general one laser will not be able to simultaneously serve two or more arbitrary beamlines (loss of this backup solution). It might be possible for bunches that are separated with multiples of 14 ns but this will increase system complexity and will require additional effort. (For example in case of 4 bunches separated with 21 ns theoretically one laser could serve simultaneously only 1st and 3rd or 2nd and 4th – separation between 1st and 3rd is 2x 21 ns = 42 ns = 3x 14 ns.)
  - We will lose the possibility to setup the timing by simply jump to next n-th laser train pulse keeping the exact RF phasing.
  - A second cathode transfer line is required. Combining 4 separate lasers in one transfer line will result in too large light losses. (Not specific to 21 ns spacing but common to all solutions with 4 separate lasers)