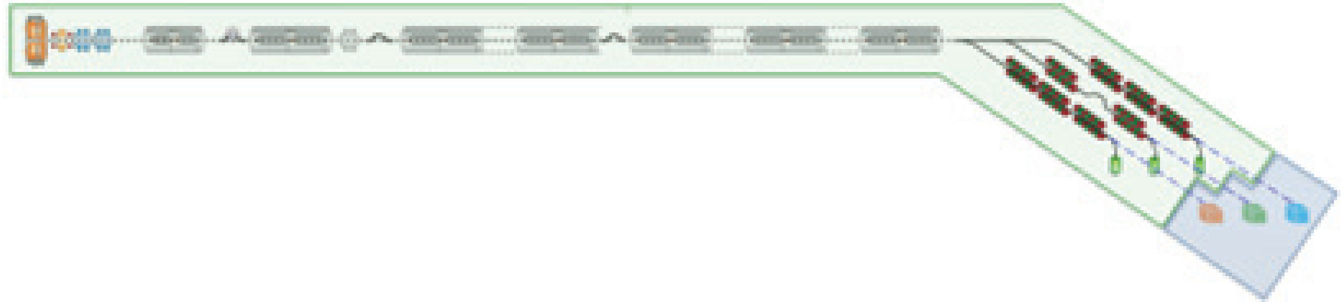

Design Concept of an RF Deflecting Cavity Based Spreader System for a Next Generation Light Source (NGLS)

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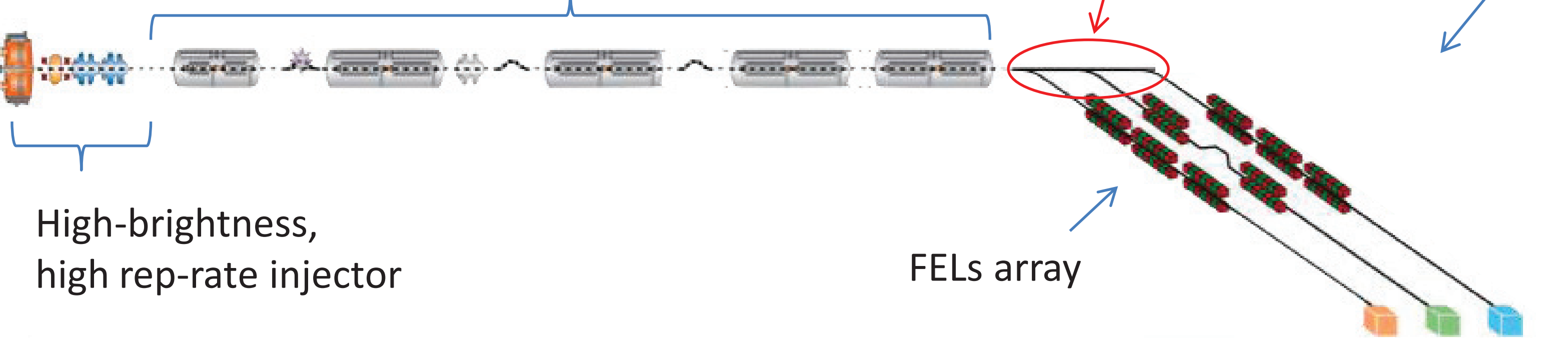
BERKELEY LAB
Lawrence Berkeley National Laboratory

NGLS
next generation light source

Outline

- ❑NGLS and its spreader system
- ❑Fast kicker approach
- ❑RF deflection cavity approach
  - o Advantages
  - o Design concept
  - o Transport line optics
  - o Gun and Cavity timing
  - o Two color capability
- ❑Summary

Next Generation Light Source (NGLS)



NGLS: An x-ray FELs array powered by a CW superconducting linear accelerator

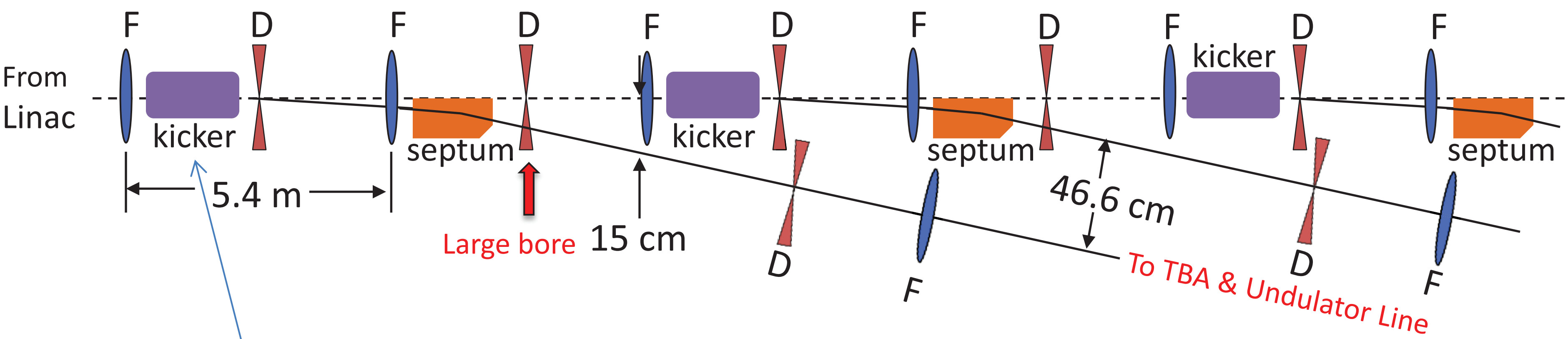
- High repetition rate 1 MHz
- Maximum bunch charge 300 pC
- Nominal energy 2.4 GeV to cover soft x-ray photon energy range
- Upgradable to high energy to cover hard x-ray
- Independently configurable FEL beamlines
- Expandable to increase capacity and capability

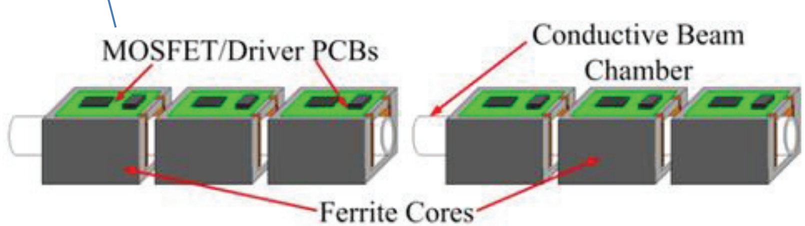
More in the afternoon talk by John Corlett "Design concepts for a NGLS at LBNL", TUOCNO05

Basic Requirements of Spreader System Design

- ❑ Divide 1MHz electron bunch train into multiple FEL lines
- ❑ Flexible bunch repetition rates
  - Seeded FEL lines maybe initially limited to 100kHz rep. rate
  - SASE/SS lines can receive the full incoming bunch rate of 1MHz
- ❑ Fast Switching
  - Pulse spacing <1μs
- ❑ Preserve beam quality
  - <10% emittance degradation
  - Trajectory stability <5% beam size
  - Achromatic and isochronous transport line
- ❑ Keep each transport line optics as "identical" as possible
- ❑ Maintain about 5.4 m separation between FEL lines
- ❑ Offer site-compatible footprint
  - 36 deg bending angle to fit LBNL's site

Fast Kicker Scheme





Ferrite loaded kicker magnet driven by MOSFET switches

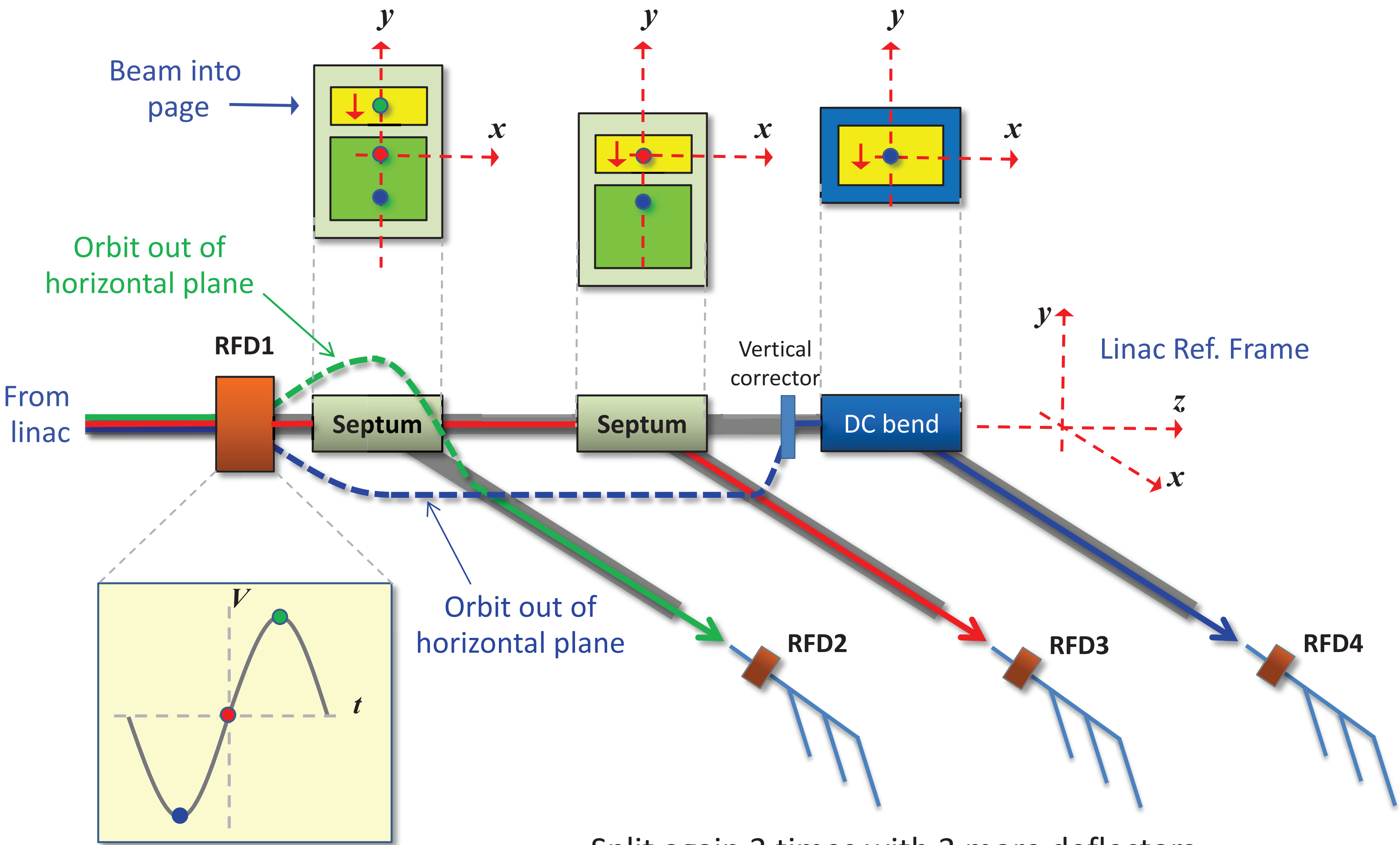
Advantage : Simpler technology; Easier optics design; Allows for variable bunch pattern

Disadvantage: Limited repetition rate (≤150kHz); Stability (~10 $^{-4}$)

RF Deflecting Cavity Approach

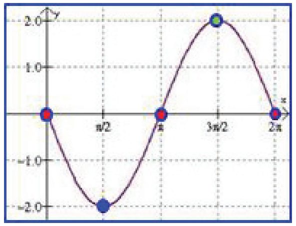
- **MOTIVATION**
  - Removes repetition rate limitation from kicker (~150KHz)
  - Flexible bunch repetition rate
  - Offers more stable operation
  - Opens to future upgrades

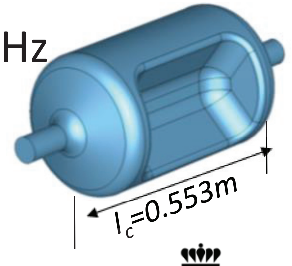
Three-Ways Vertical Deflection Concept



Split again 3 times with 3 more deflectors

Main Components





❑ Vertical Deflection Cavity (RFD)

- Divides incoming bunch train into three lines (2 “on crest” + 1 straight)
- Emittance dilution for zero X-ing beam requires freq < 400MHz
- Phase jitter tolerances (146fs) for zero X-ing beam requires freq = 139 MHz
- Kick amplitude tolerance ($1.3\text{x}10^{-4}$) requires kick angle = 1.14 mrad
- Based on SRF cavity development at ODU. However, room temperature deflectors are also considered.

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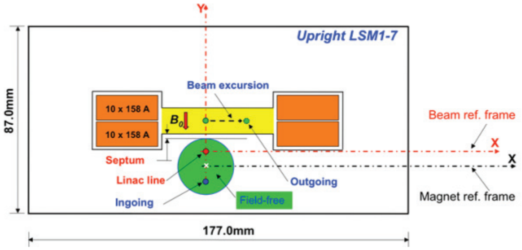
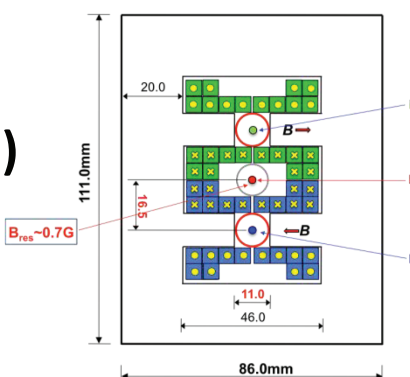
❑ Lambertson Septum Magnet (LSM)

- Horizontally right-deflects “on-crest” lines to respective arc
- Allows other lines to go straight

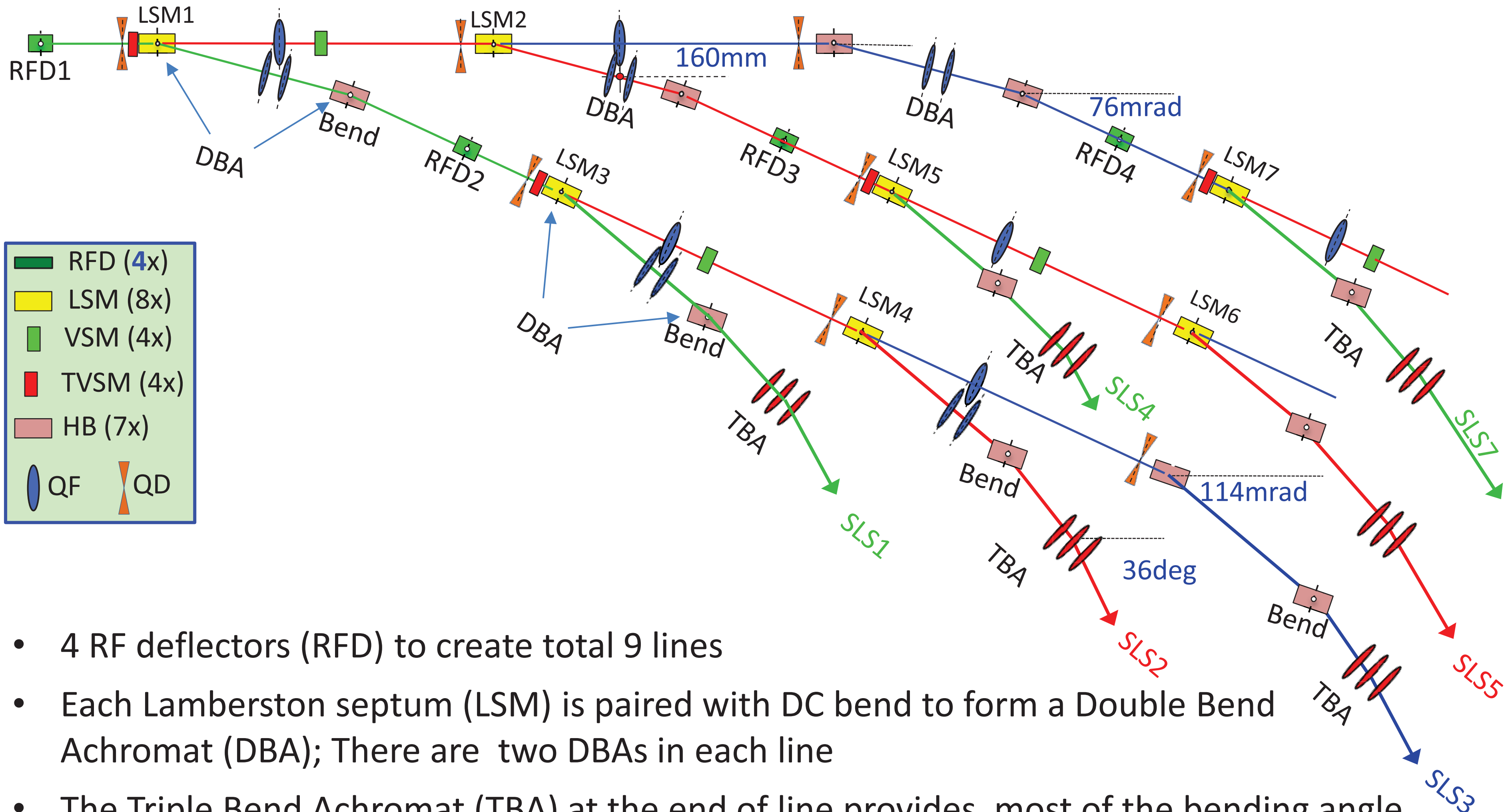




❑ Vertical Septum Magnet and Corrector (VSM)

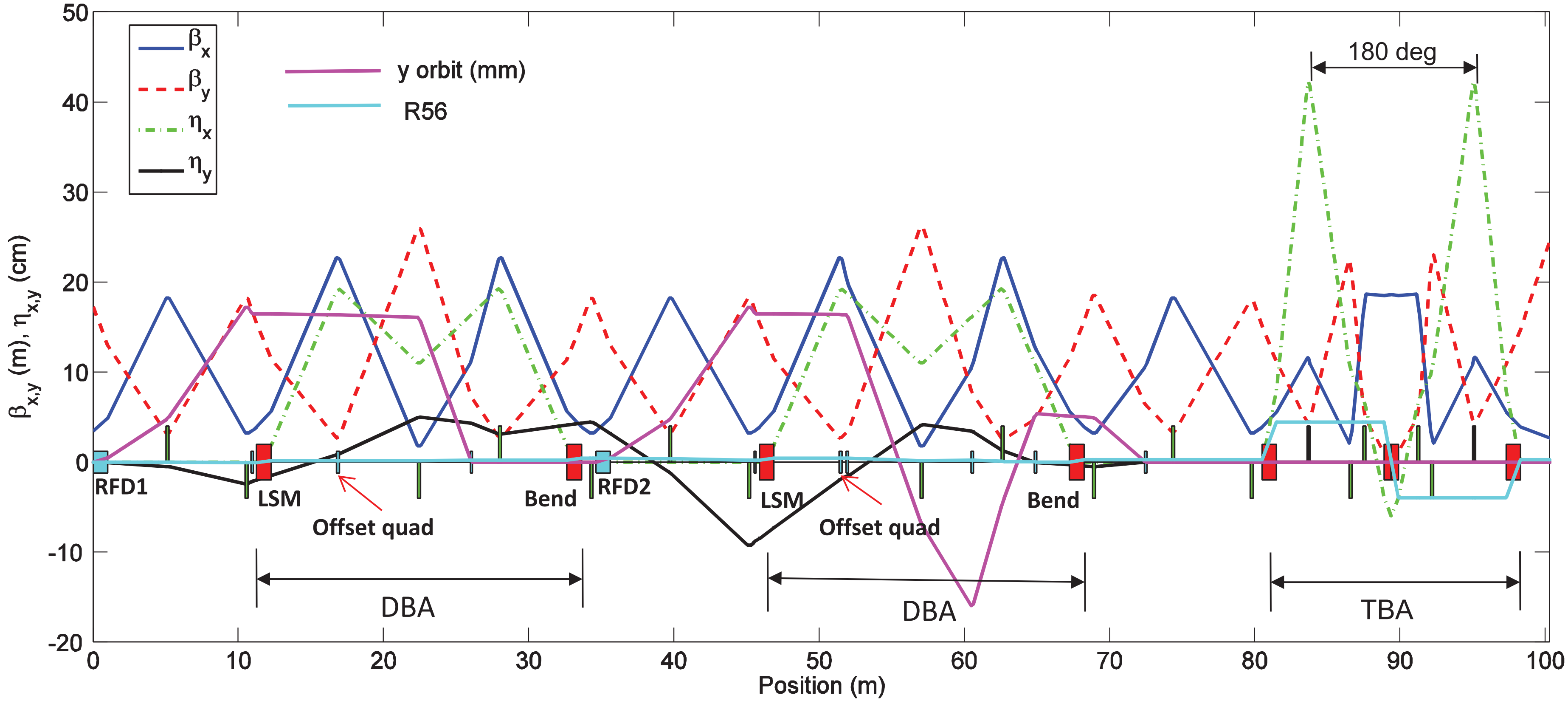
- Control and correct vertical orbit offset

Nine Lines Layout (top view)



- 4 RF deflectors (RFD) to create total 9 lines
- Each Lamberston septum (LSM) is paired with DC bend to form a Double Bend Achromat (DBA); There are two DBAs in each line
- The Triple Bend Achromat (TBA) at the end of line provides most of the bending angle 27 deg out of total 36 deg; The TBA is designed to be isochronous and the CSR effects are also minimized
- All bending elements (RFD, LSM, VSM, Bend) are imbedded in FODO lattice

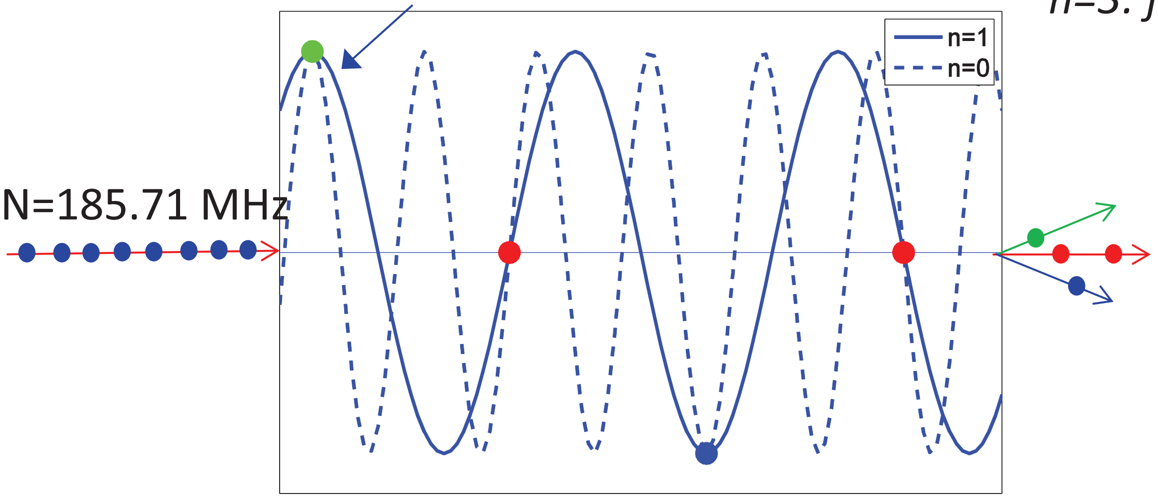
Twiss Function & Vertical Orbit of the Line SLS1



- Each LSM is paired with a DC bend to form a Double Bend Achromat (DBA).
- 1st quad in the DBA is vertically offset to allow beam pass through the quad center
- Several vertical correctors are used to correct vertical orbit and dispersion functions
- Vertical orbit offset are controlled under 20 mm and the dispersion functions are corrected to zero at end of the beamline
- The TBA has a mirror symmetric structure and designed to be isochronous

Bucket Rates and Gun Timing

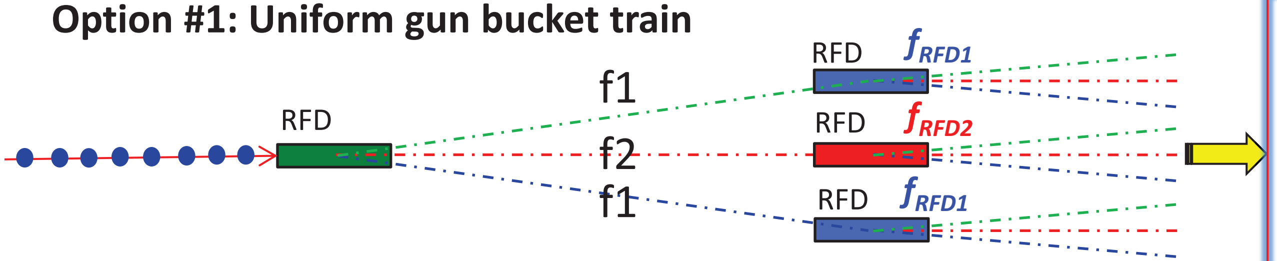
$f_{RFD}=f_{GUN}(n/2 + ¼)$, n=0, 1, 2... → $n=1: f_{RFD} = 139.28MHz$; $n=3: f_{RFD} = 324.99MHz$



f_1=f_GUN/4=46.43 MHz
f_2=f_GUN/2=92.86 MHz
f_1=f_GUN/4=46.43 MHz

Flexible bunch repetition rate for each line:

Option #1: Uniform gun bucket train

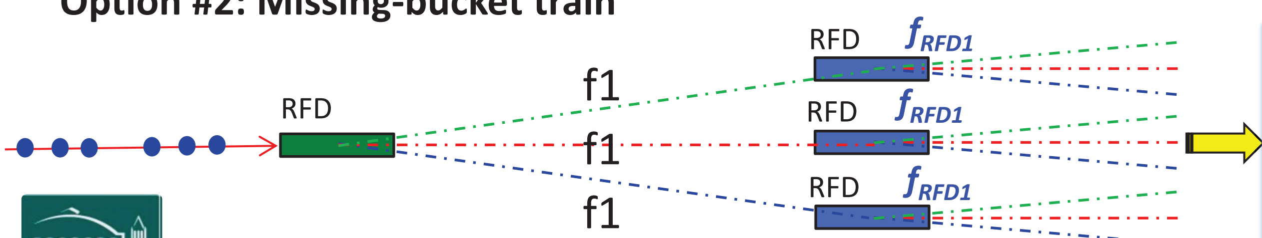


4 lines, $f = f_{GUN}/16$=11.61MHz

4 lines, $f = f_{GUN}/8$=23.22MHz

1 line, $f = f_{GUN}/4$=46.43MHz

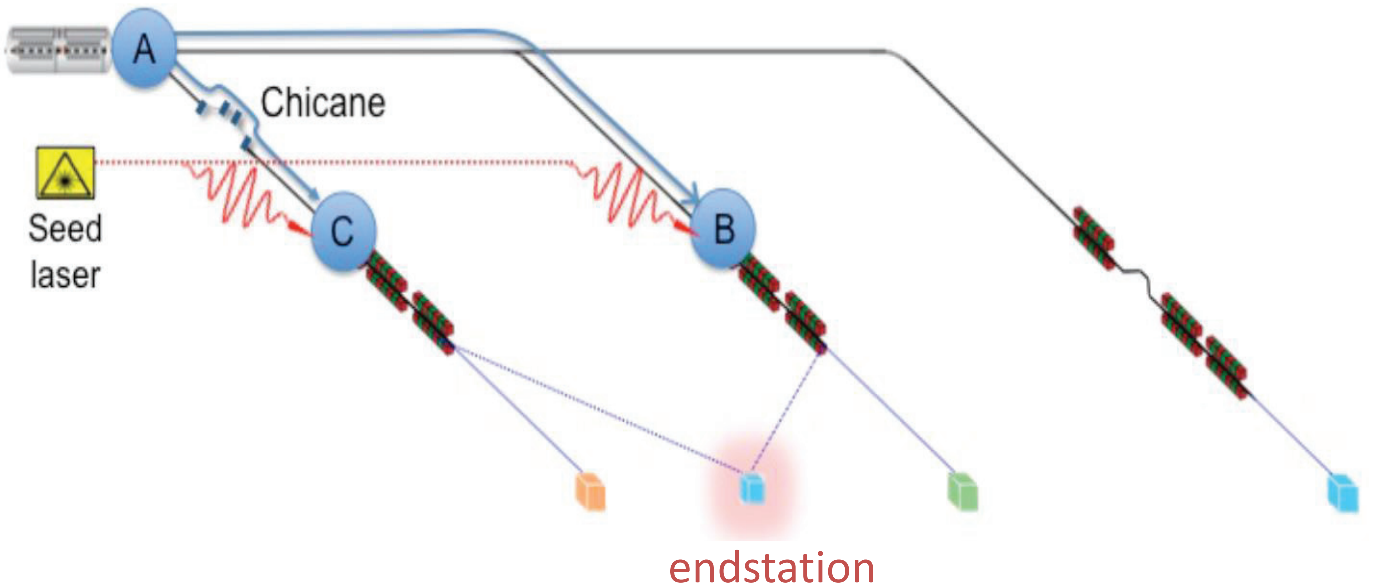
Option #2: Missing-bucket train



6 lines, $f = f_{GUN}/16$=11.61MHz

3 lines, $f = f_{GUN}/8$=23.22MHz

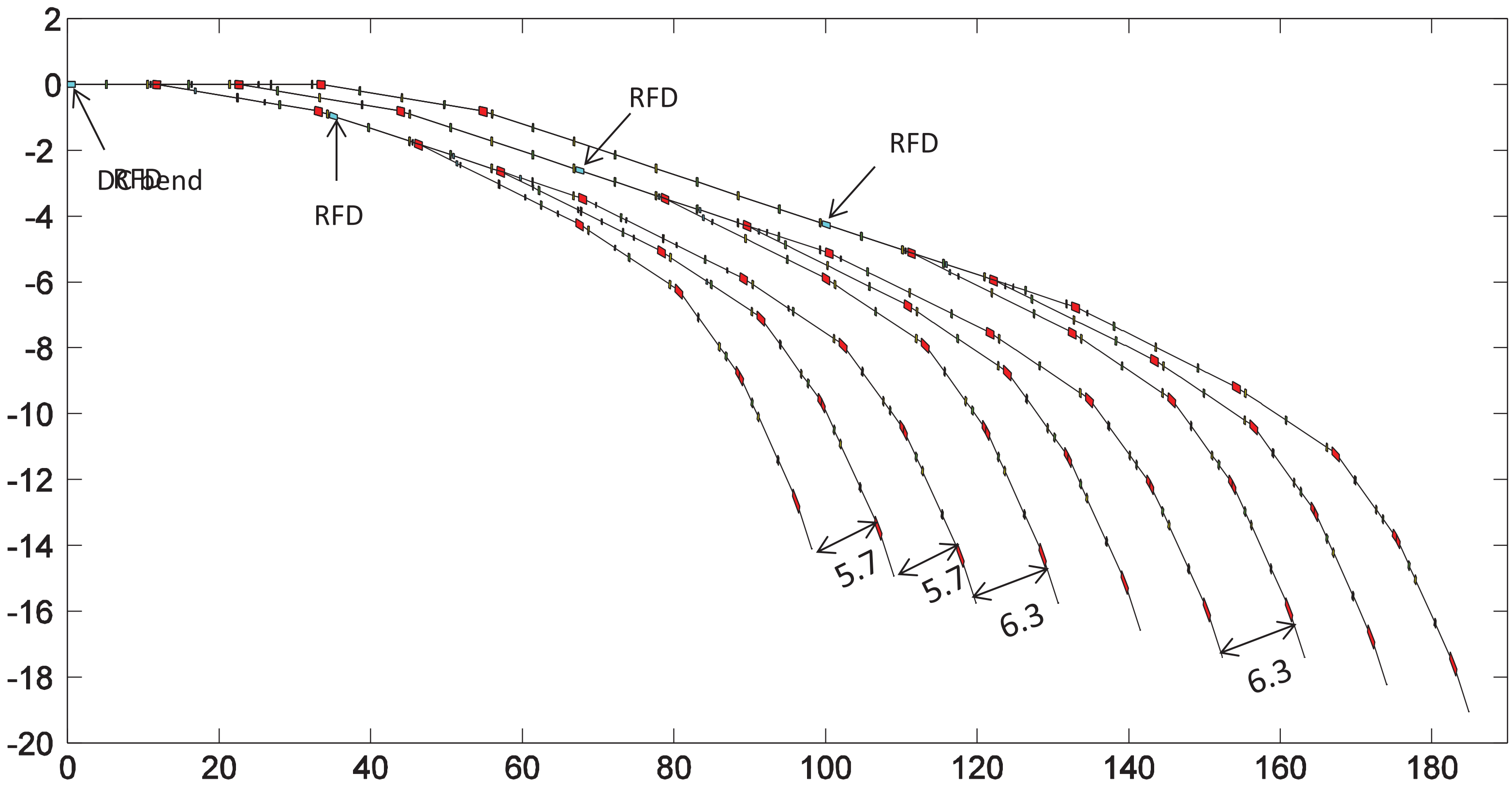
"Two-color" X-ray Pulse Capability



- "Two-color" capability is realized by synchronizing two independent FELs
- The bunch travel times difference between two lines (A->C and A->B) is made equal to the bunch spacing at the photocathode gun, and additional timing adjustment will be provided by a chicane
- Two consecutive bunches arrive at the end station at the same time

The design of the spreader system allows us to have this capability!!!

Footprint



Unit: meter

Summary

- At LBNL, we are developing a design concept of a spreader system based on three-way vertical deflection cavity for a Next Generation Light Source (NGLS)

- This system meets our design requirements
  - Provide flexible and high repetition rates for each FEL line
  - Better deflection stability
  - Offer site-compatible footprint
  - Open to future upgrades

- This system can be configured to fit a wide choice of beam switchyard topologies including arrays of beamlines symmetrically split at both sides of the linac

ACKNOWLEDGEMENTS

Thanks for the supports and encouragements of the LBNL's NGLS design beam

Thanks for your attention!!!