Baseline Lattice Design for PERLE

Alex Bogacz

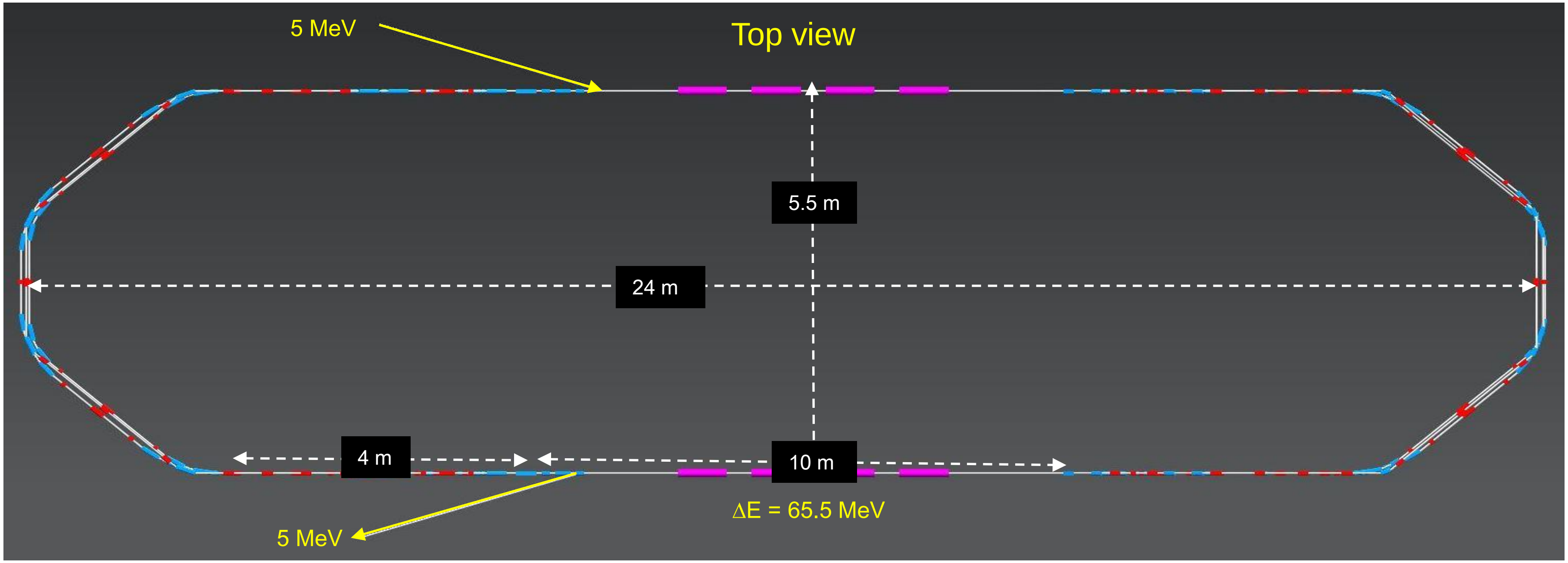
Outline

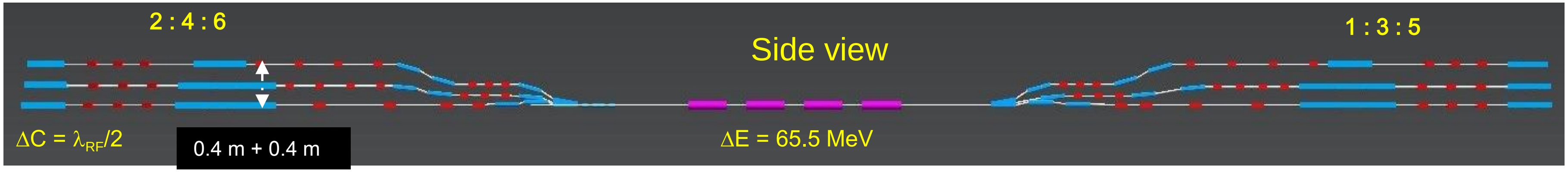
- What is unique about PERLE?
- Baseline Design, Lattices
  - PERLE@Orsay – Layout
  - Multi-pass linac Optics in ER mode
  - Arc Optics Architecture
    - ‘Six bend’ arc configuration
  - Switchyard Options
    - Compact ’two step’ Spr/Rec with a second B-com magnet
    - ‘Single step’ vs ’Two step’ Spr/Rec’ configurations
- Summary and Outlook

Why is PERLE Unique?

- **PERLE** originated as the LHeC Test Facility is a sub-GeV-scale accelerator system invoking a unique combination of parameters, technology, and design choices
  - Very high ‘virtual’ beam power (~10 MW)
  - Moderately high current and bunch charge (20 mAmp, 500 pC)
  - Conventional accelerator transport system design
  - Common beam transport for acceleration and recovery
  - Extremely large dynamic range (ratio of full to initial/final energy ~ 100)
  - Multiple passes (3)
- PERLE offers unique opportunity to controllably study of virtually every effect of interest in the next generation of ERL design

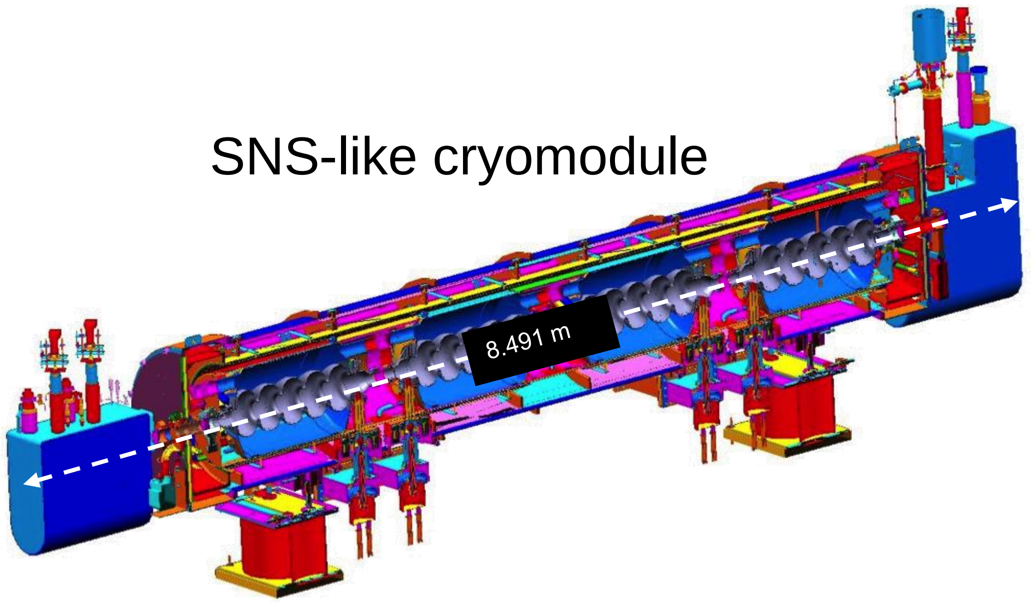
PERLE@Orsay – Baseline Layout





Linac, Cryo-module - Layout

SNS-like cryomodule



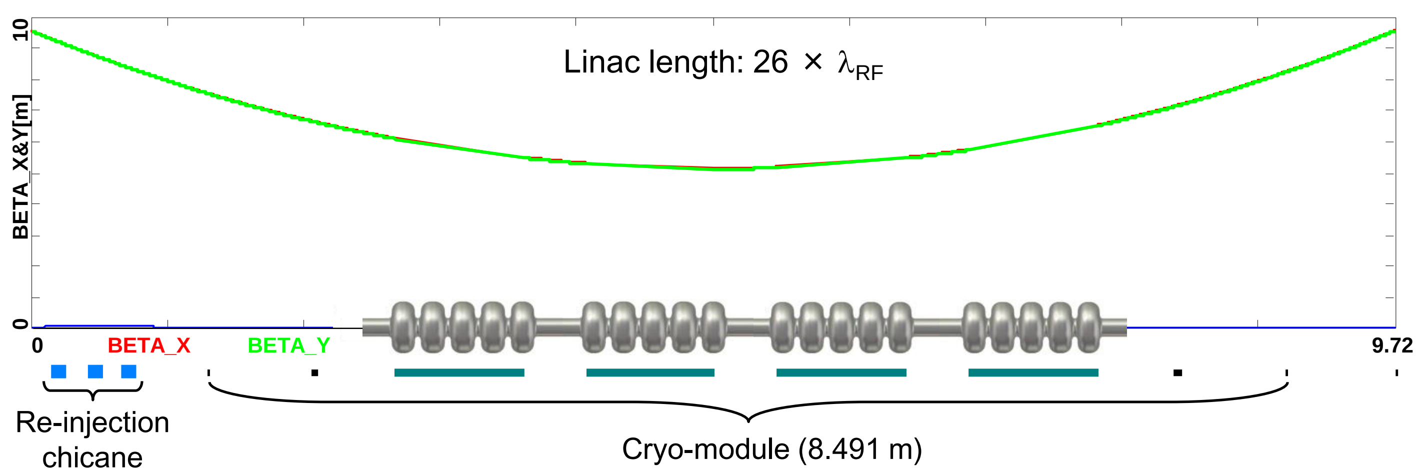
801.58 MHz RF, 5-cell cavity:

λ = 37.40 cm

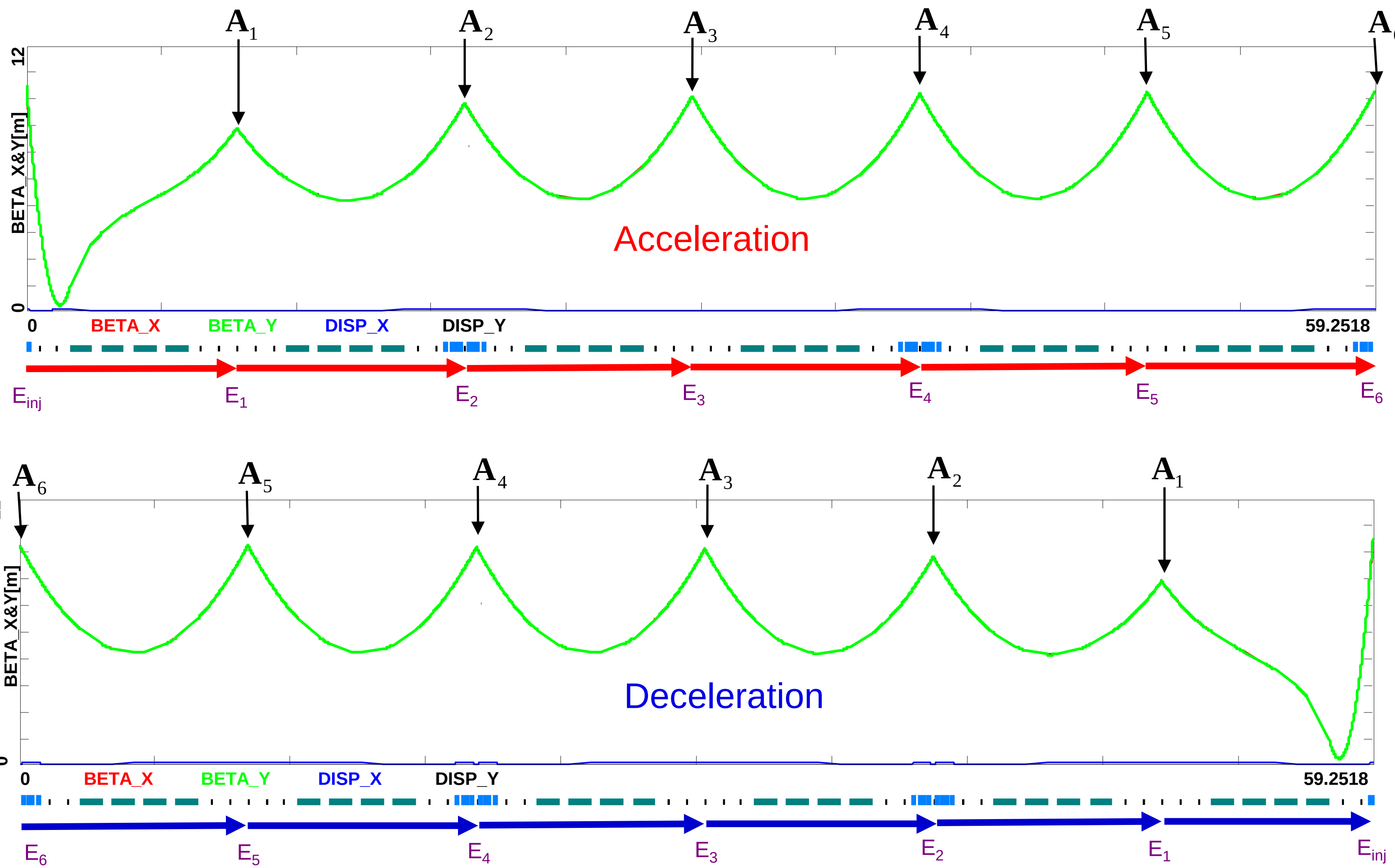
$L_c = 5\lambda/2 = 93.50$ cm

Grad = 17.5 MeV/m (16.4 MeV per cavity)

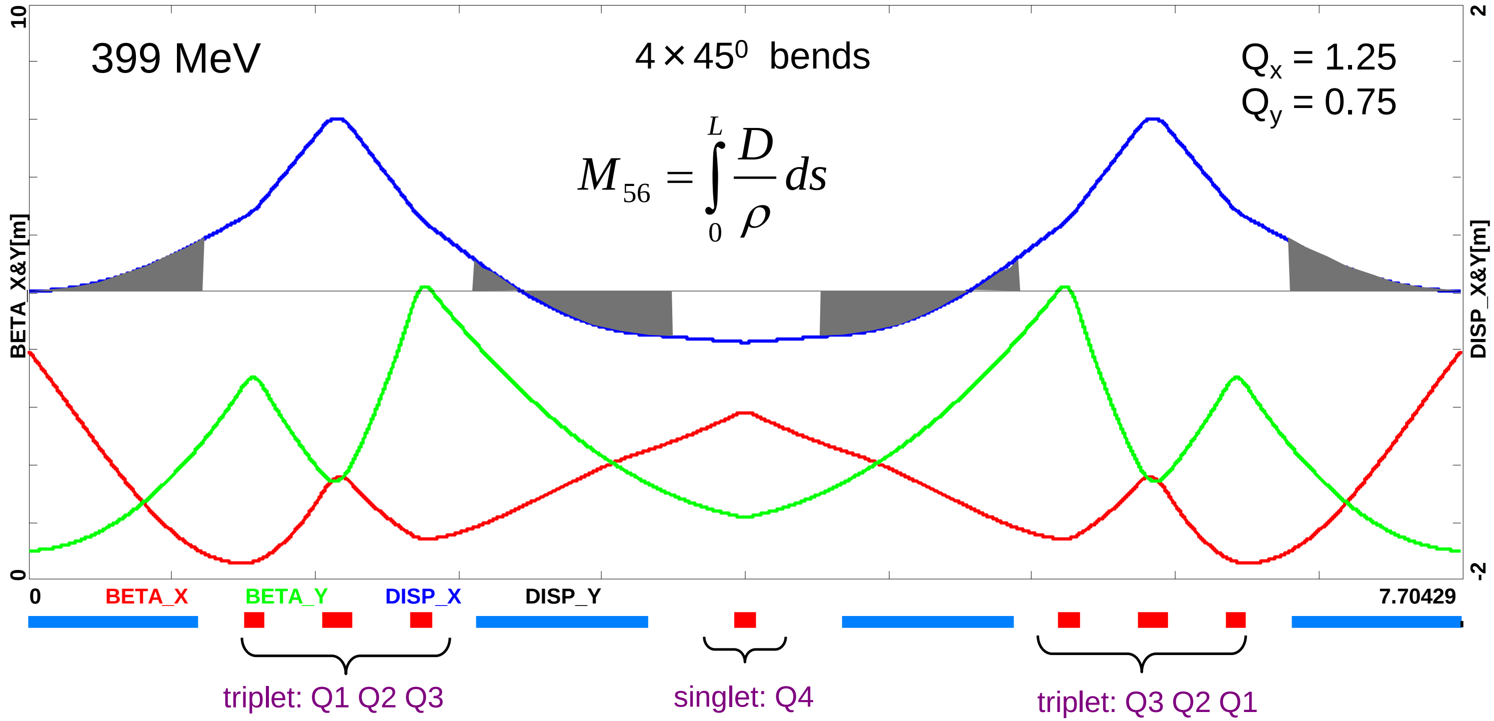
ΔE= 65.5 MeV per Cryo-module



Multi-pass ER Optics



Arc 6 (5,4) Optics – ‘Four-Bend’ Lattice



Dipoles: (91.2 cm long)

B = 1.2 Tesla

Quadrupoles:

Q1	L[cm] =10	G[T/m] = - 23.6
Q2	L[cm] =15	G[T/m] = 28.2
Q3	L[cm] =10	G[T/m] = - 22.4
Q4	L[cm] =10	G[T/m] = 8.6

Benefits of 'Six-Bend' vs 'Four-Bend' Arc

- Smaller bend angle of individual dipoles (30^0 vs 45^0)
  - Alleviates strong edge focusing effects of the bends
  - Results in a better balanced optics with smaller alphas
- Optics more resilient to CSR (micro bunching)
  - Larger number of periods (3 vs 2) – Smaller M_{56} variance.
  - Lattices with smaller variation in M_{56} generate lower CSR gain*, ideally, lattices that are composed of multiple super-periods, each period being achromatic and isochronous.

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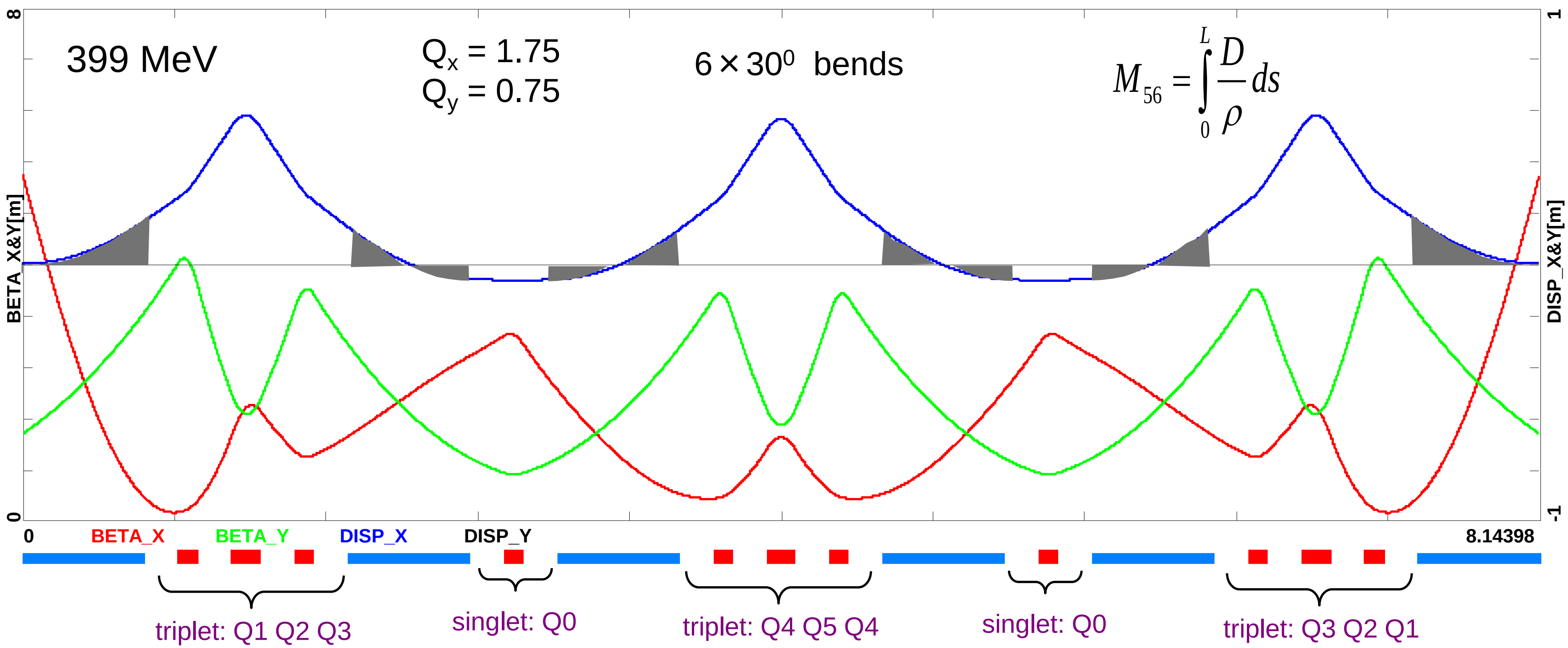
Conditions for coherent-synchrotron-radiation-induced microbunching suppression in multibend beam transport or recirculation arcs

C.-Y. Tsai,[1,*] S. Di Mitri,[2] D. Douglas,[3] R. Li,[1,3] and C. Tennant[3]

Arc 6 (5,4) Optics – ‘Six-Bend’ Lattice



Dipoles: (66 cm long)

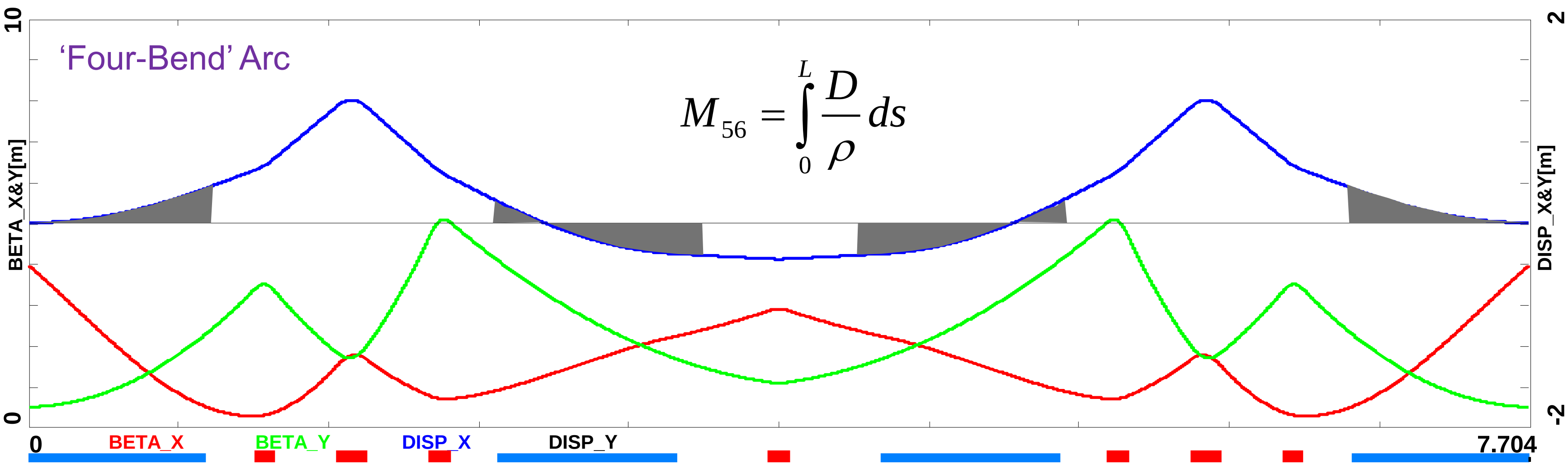
B = 1.2 Tesla

(1.0 Tesla, 0.8 Tesla)

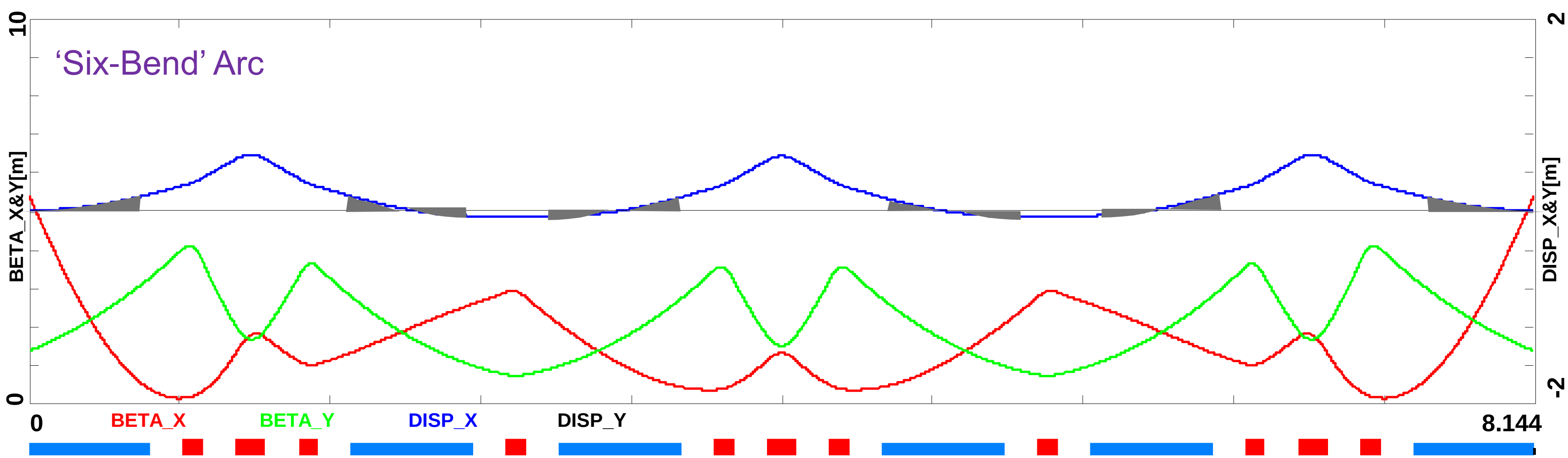
Quadrupoles:

qQ0	L[cm] = 10	G[T/m] = 16.6
qQ1	L[cm] = 10	G[T/m] = -30.1
qQ2	L[cm] = 15	G[T/m] = 39.2
qQ3	L[cm] = 10	G[T/m] = -29.6
qQ4	L[cm] = 10	G[T/m] = -31.1
qQ5	L[cm] = 15	G[T/m] = 40.6

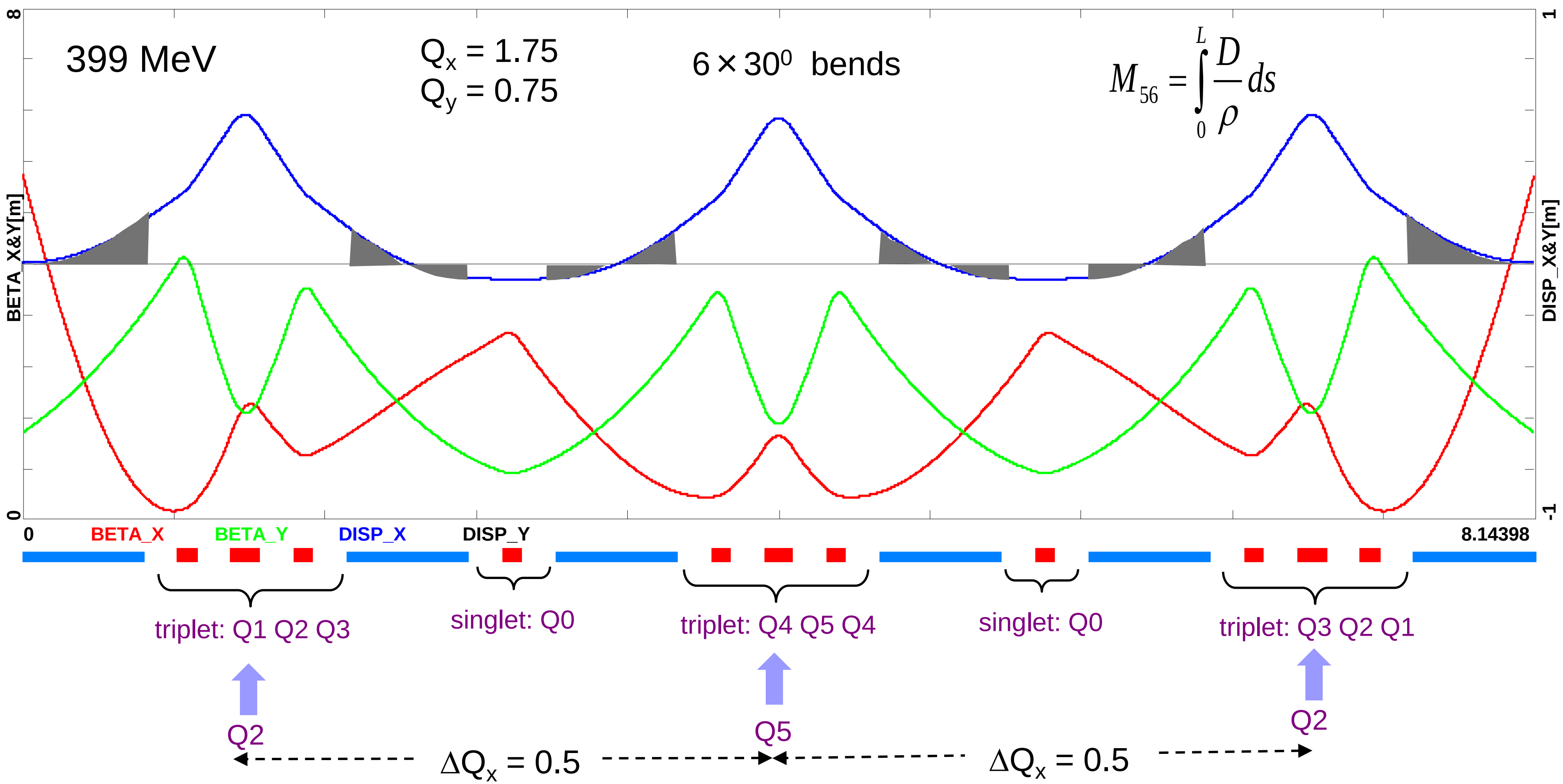
M_{56} Variance Across Arcs



$$M_{56} = \int_0^L \frac{D}{\rho} ds$$



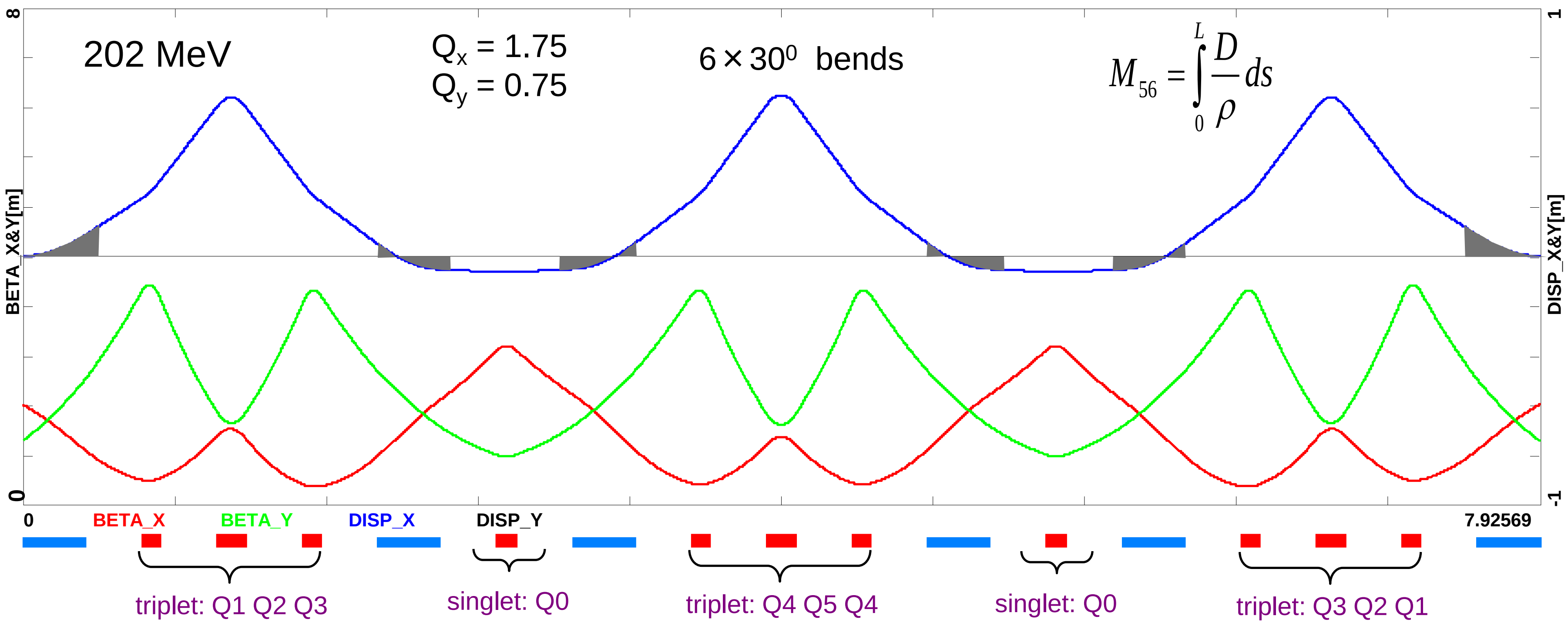
Arc 6 (5,4) Optics – Dispersion/M_{56} Control



Independent Control of Dispersion and M_{56}

'Orthogonal Knobs': Q2 Q5 Q2

Arc 3 (2,1) Optics – 'Six-Bend' Lattice



Quadrupoles:

qQ0	L[cm] = 10	G[T/m] = 9.1
qQ1	L[cm] = 10	G[T/m] = -14.7
qQ2	L[cm] = 15	G[T/m] = 16.6
qQ3	L[cm] = 10	G[T/m] = -13.8
qQ4	L[cm] = 10	G[T/m] = -13.9
qQ5	L[cm] = 15	G[T/m] = 16.8

Dipoles: (33 cm long)

B = 1.2 Tesla

(0.8 Tesla, 0.4 Tesla)

PERLE Magnet Design (dipoles and quads)

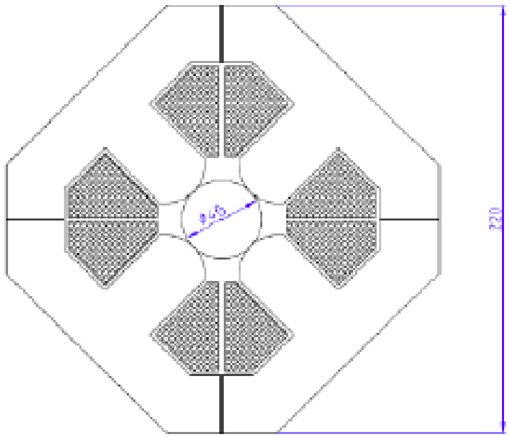
70 dipoles 0.45-1.29 T Two varieties of bends: (66 cm and 33 cm long)

+- 20 mm aperture, l=200,300,400 mm

May be identical for hor+vert bend

7A/mm2 (in grey area) water cooled

DC operated

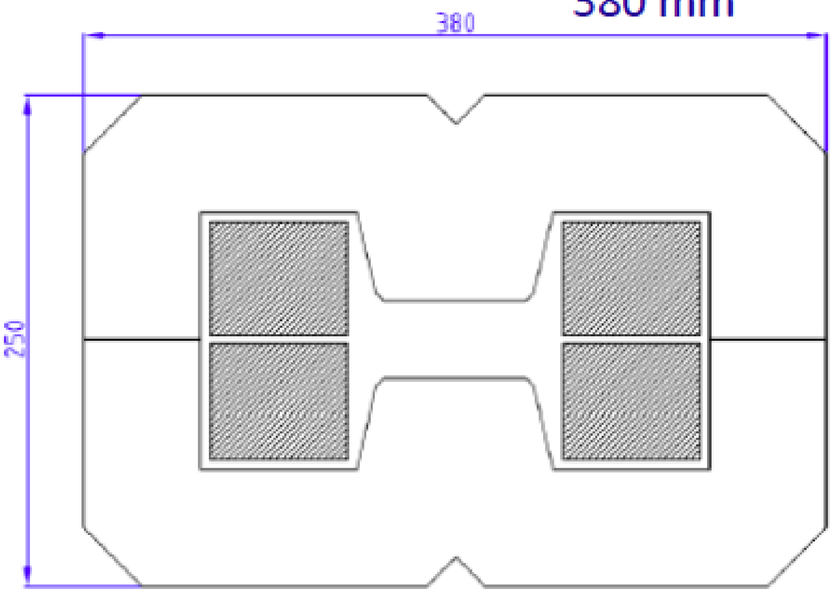


220 mm

1.2 Tesla
1.0 Tesla
0.8 Tesla

380 mm

250 mm



114 quadrupoles max 28T/m

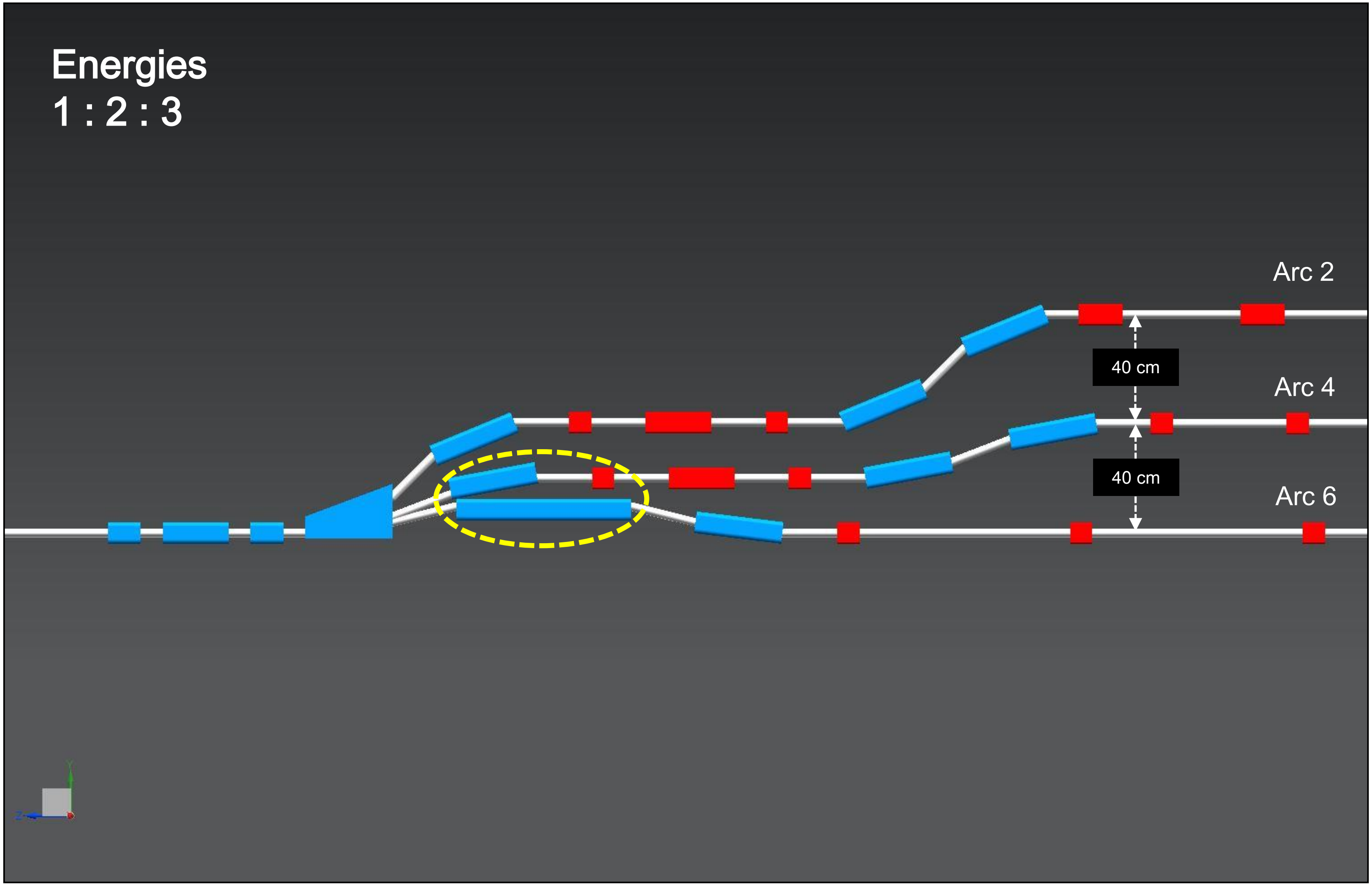
Common aperture of 40mm all arcs

Two lengths: 100 and 150mm

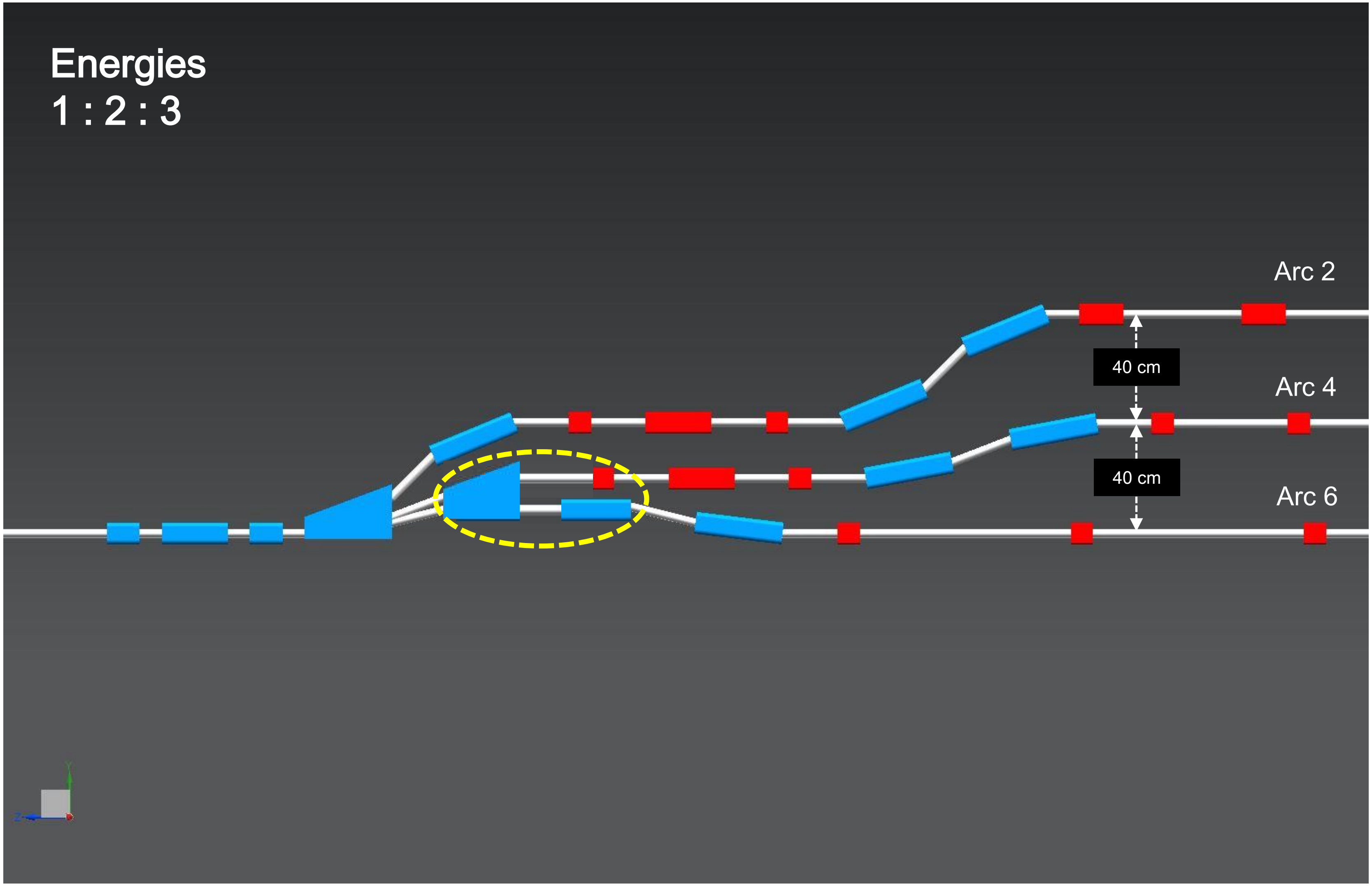
1.2 Tesla
0.8 Tesla
0.4 Tesla

P Thonet, A Milanese (CERN), C Vallerand (LAL), Y Pupkov (BINP)

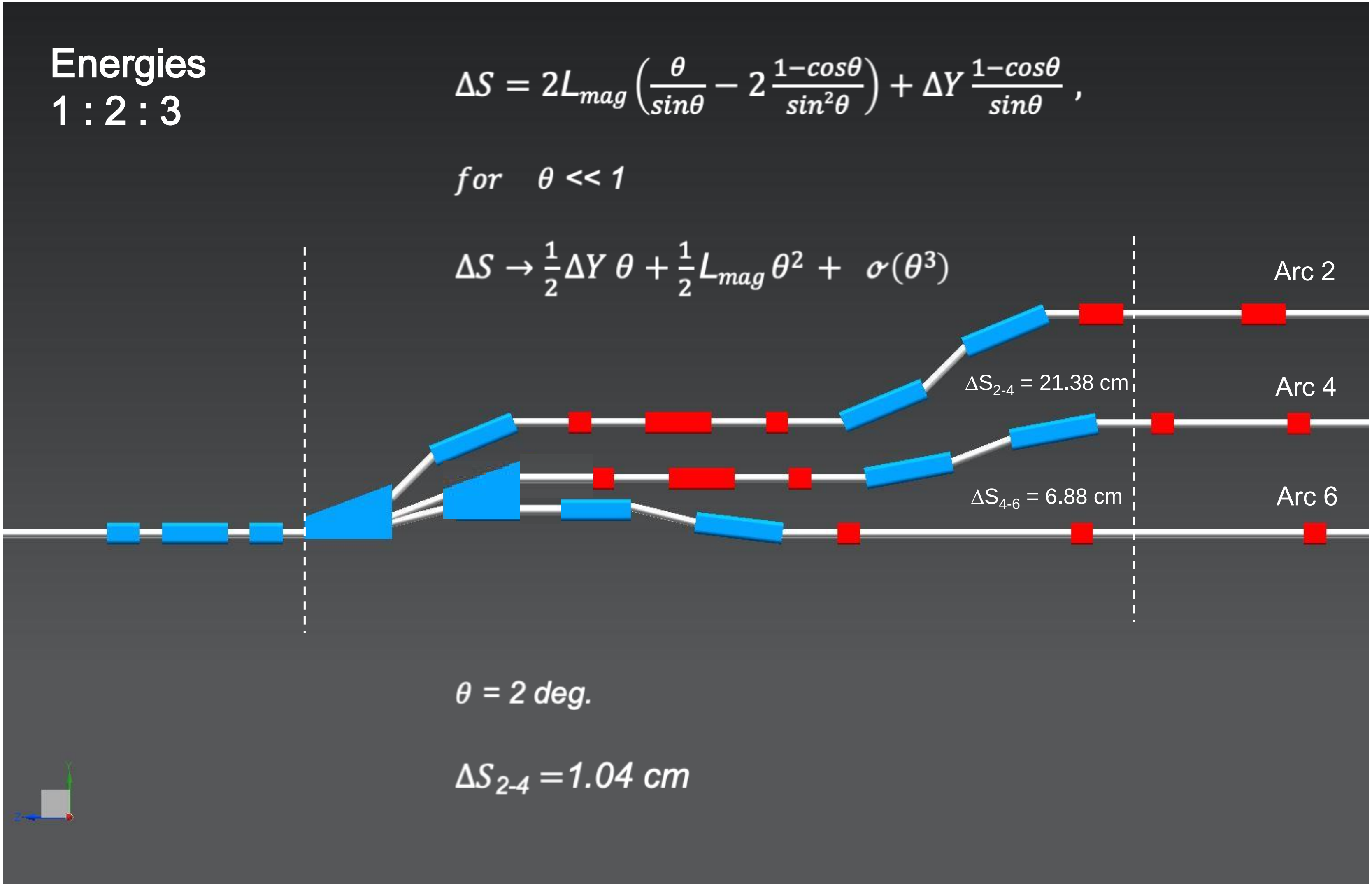
Switchyard Layout with a Single B-com



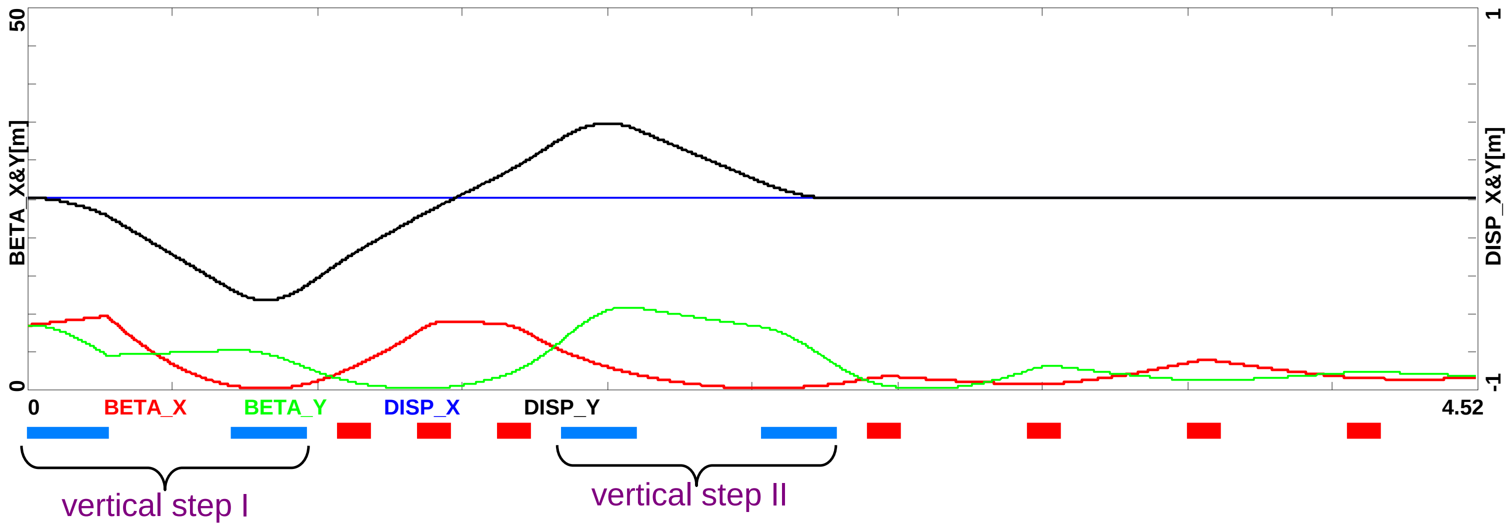
Switchyard Layout with Two B-coms

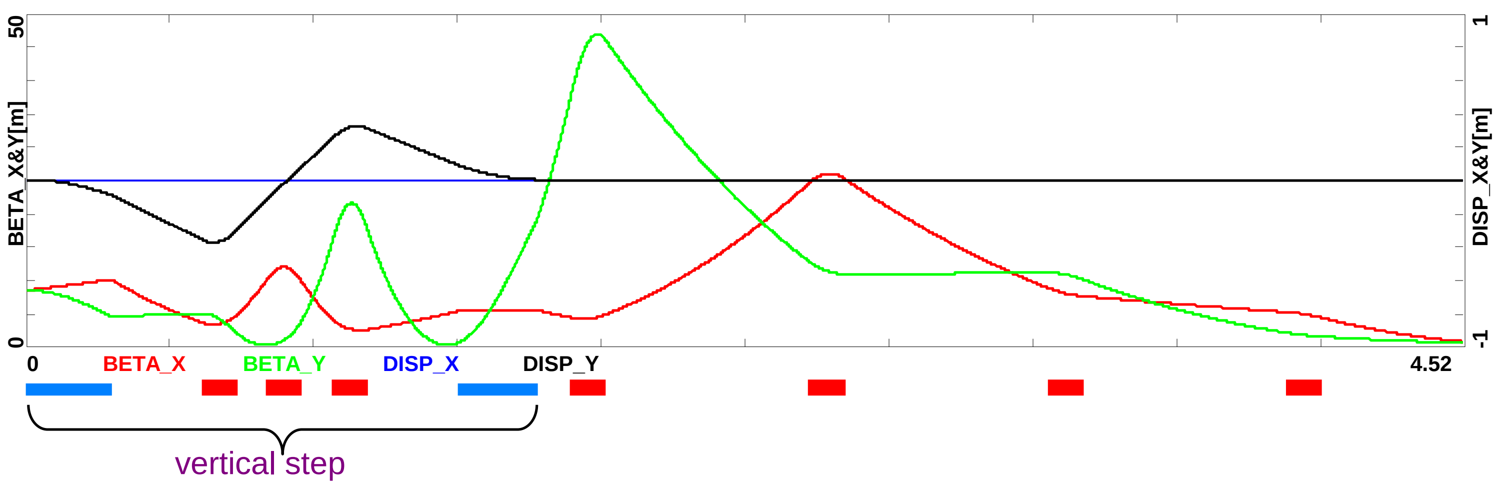


Switchyard – Pathlength Differences

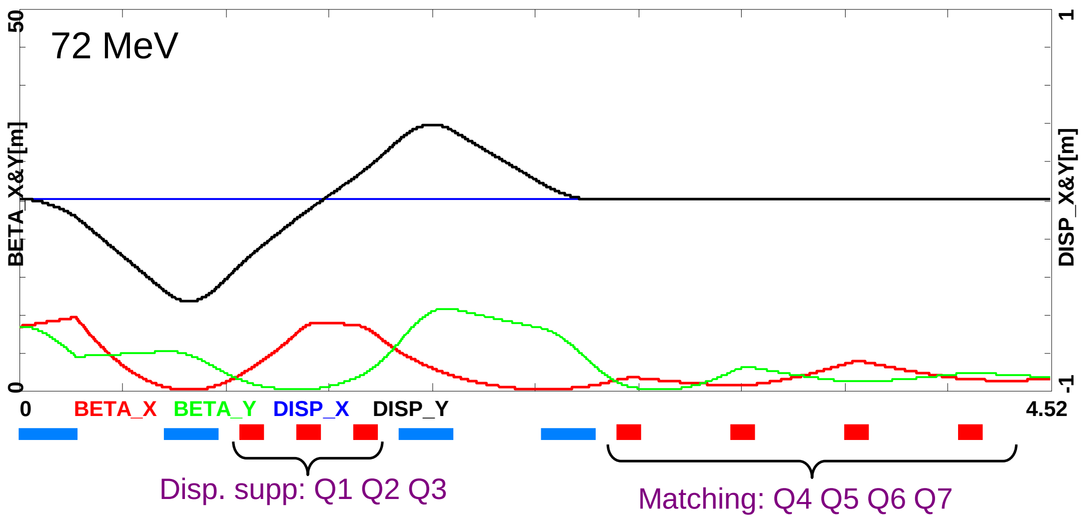


‘Two-step’ vs ‘Single-step’ Spreader



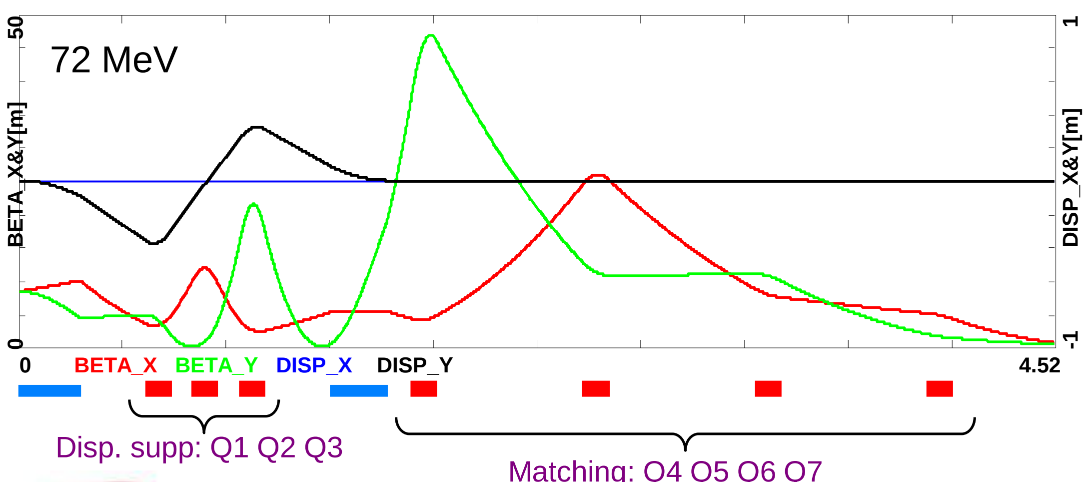


'Two-step' vs 'Single-step' Spreader



L[cm]=10

Q1	G[T/m] = 1.96
Q2	G[T/m] = 5.03
Q3	G[T/m] = 3.89
Q4	G[T/m] = 10.50
Q5	G[T/m] = -10.30
Q6	G[T/m] = 6.01
Q7	G[T/m] = -3.34



L[cm]=10

Q1	G[T/m] = -22.90
Q2	G[T/m] = 18.92
Q3	G[T/m] = -24.44
Q4	G[T/m] = -9.36
Q5	G[T/m] = 4.30
Q6	G[T/m] = -2.49
Q7	G[T/m] = 2.91

Summary, Outlook

- PERLE Baseline Design, Refinements
  - New arc architecture
    - ‘Six bend’ rather than ‘Four bend’ arc configuration
    - Present ‘Curved Dipole’ design with shorter bends (66 cm, 33 cm)
  - Explored switchyard options
    - Compact ’two step’ Spr/Rec with a second B-com magnet
    - ‘Single step’ vs ’two step’ Spr/Rec’ configurations
- Next steps …. new Baseline?

Thank you!

Special Thanks to:

Max Klein

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and

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