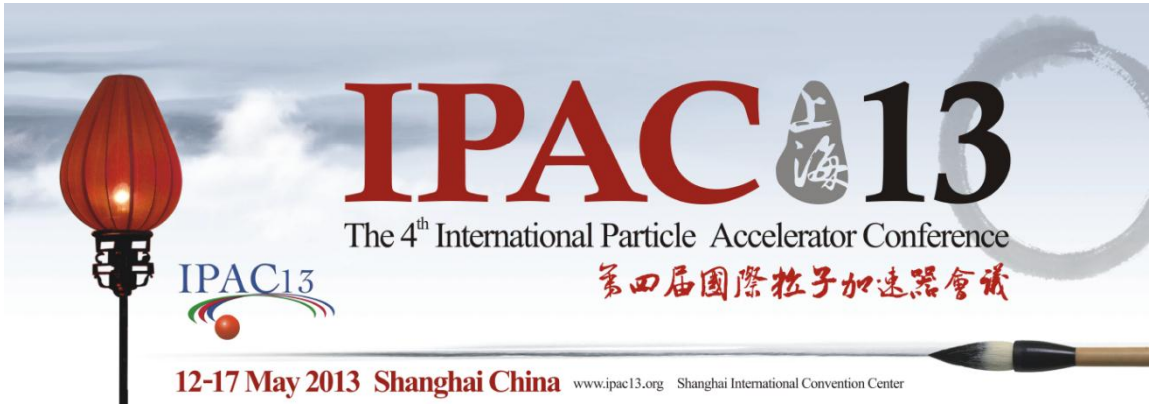
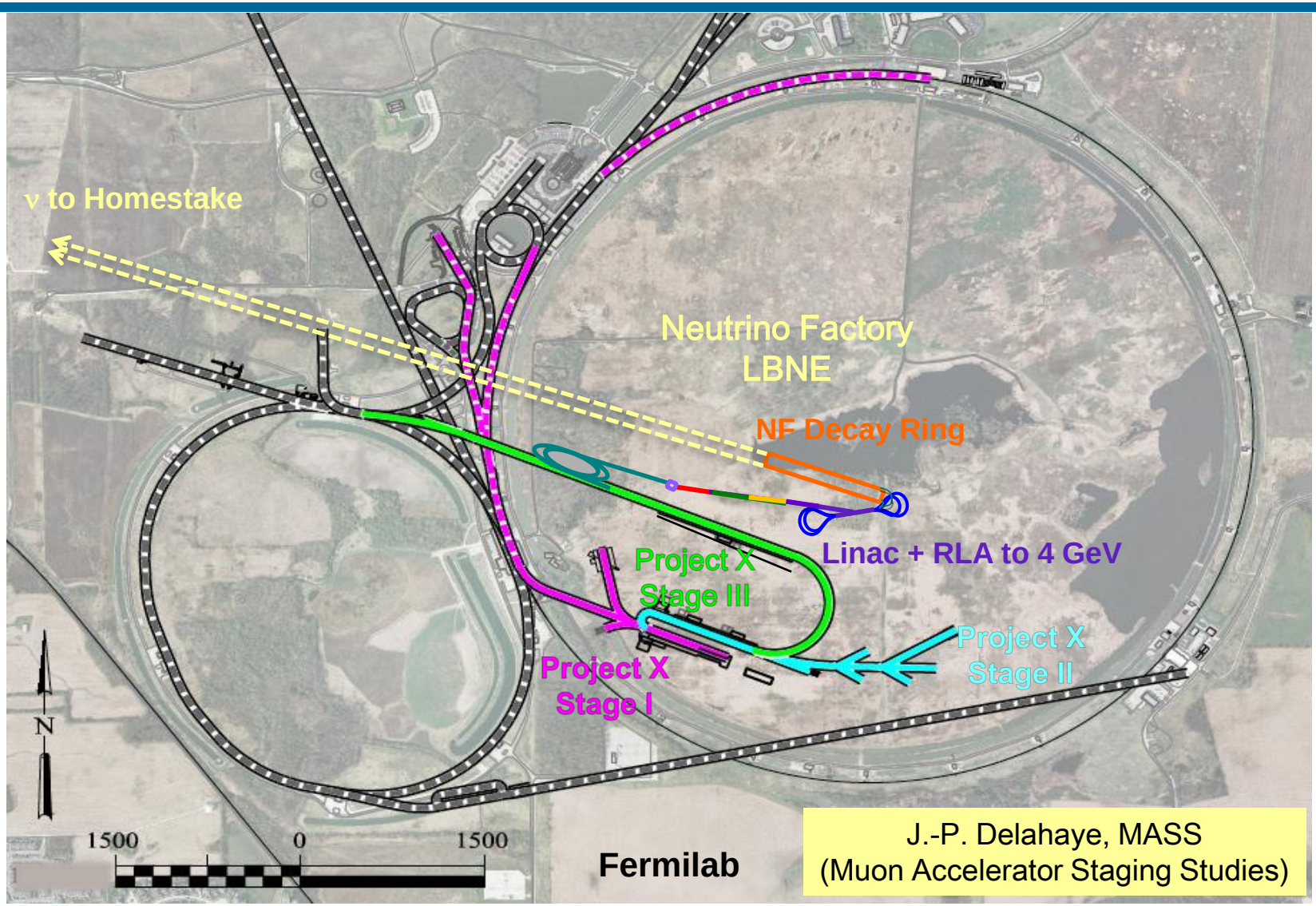
JEMMRLA – Electron Model of Muon RLA with Multi-pass Arcs

Alex Bogacz

G.A. Krafft, V.S. Morozov, Y.R. Roblin

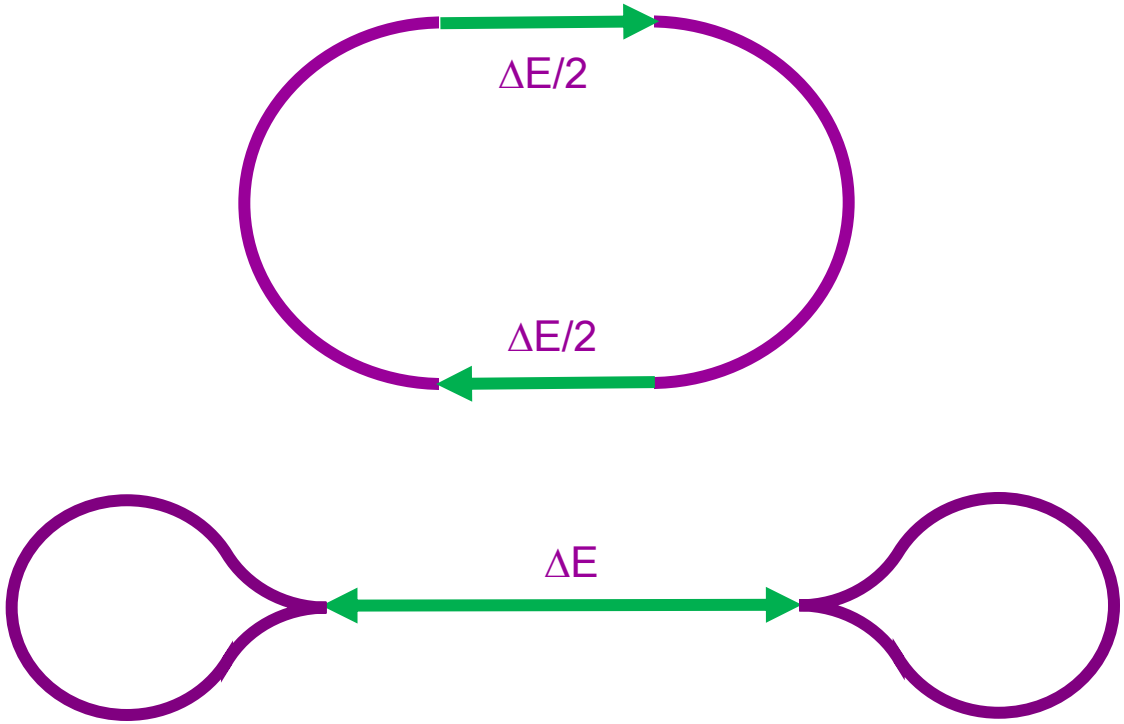


Future Muon Facilities – Muon Acceleration



‘Racetrack’ vs ‘Dogbone’ RLA

short-lived muons (τ = 2.2 μsec.) ➔ rapid acceleration (fixed-field)



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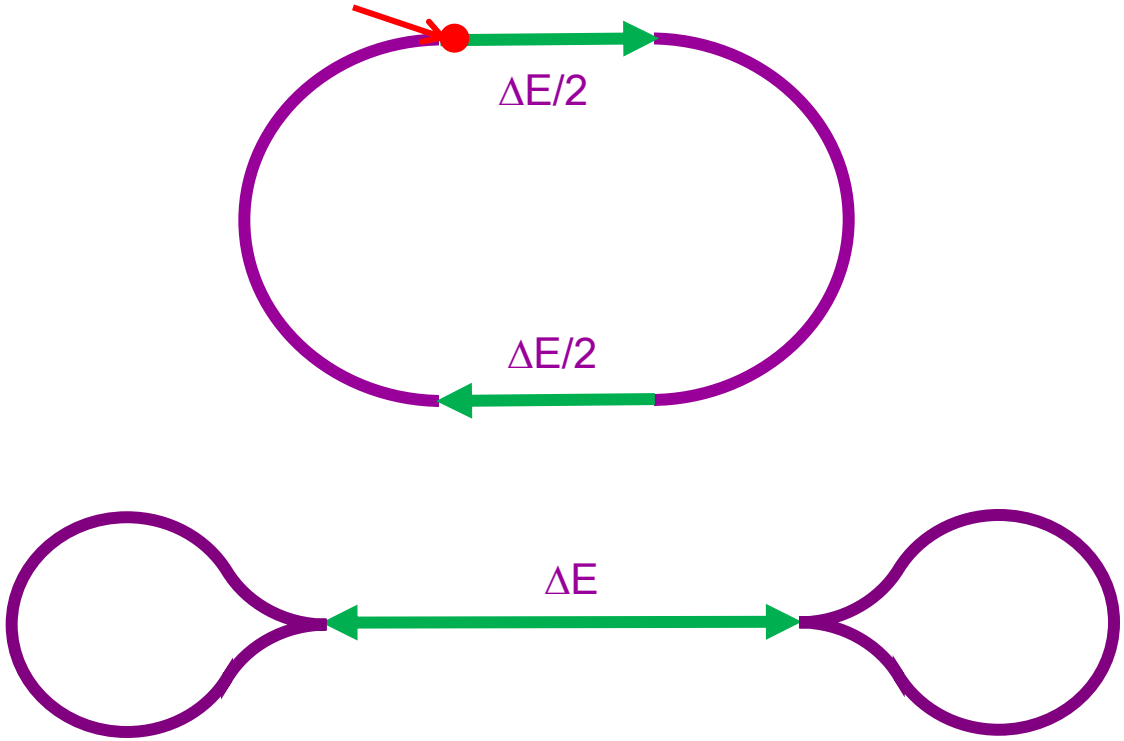

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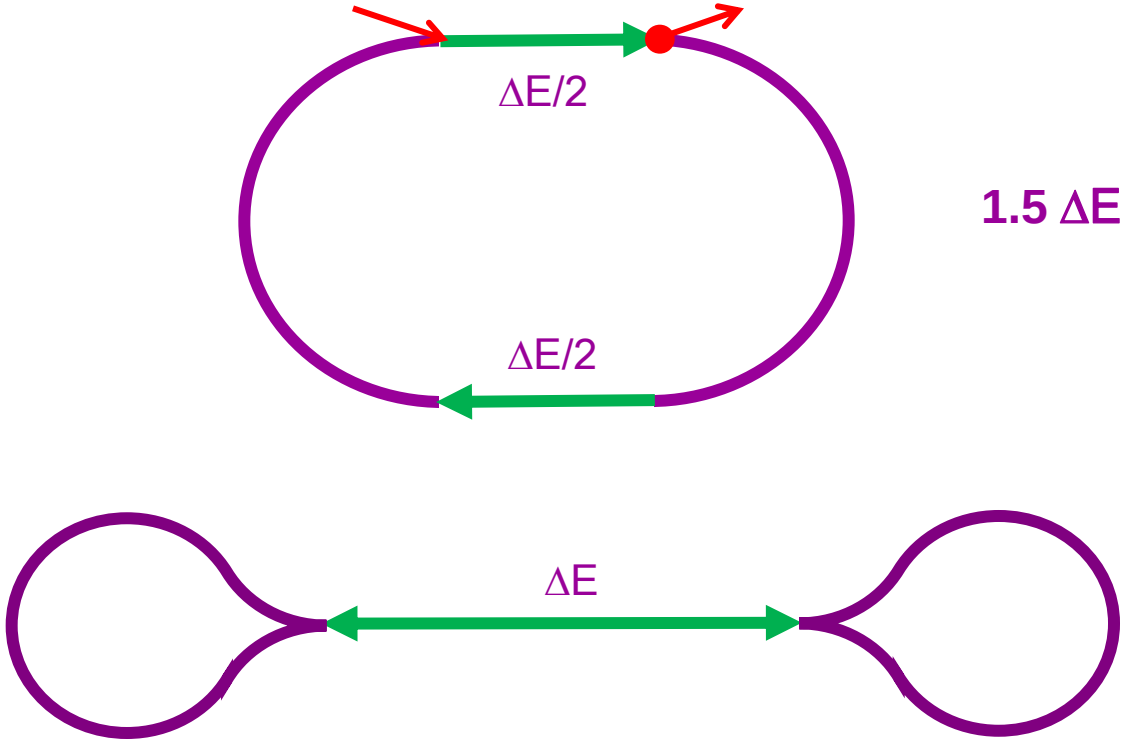

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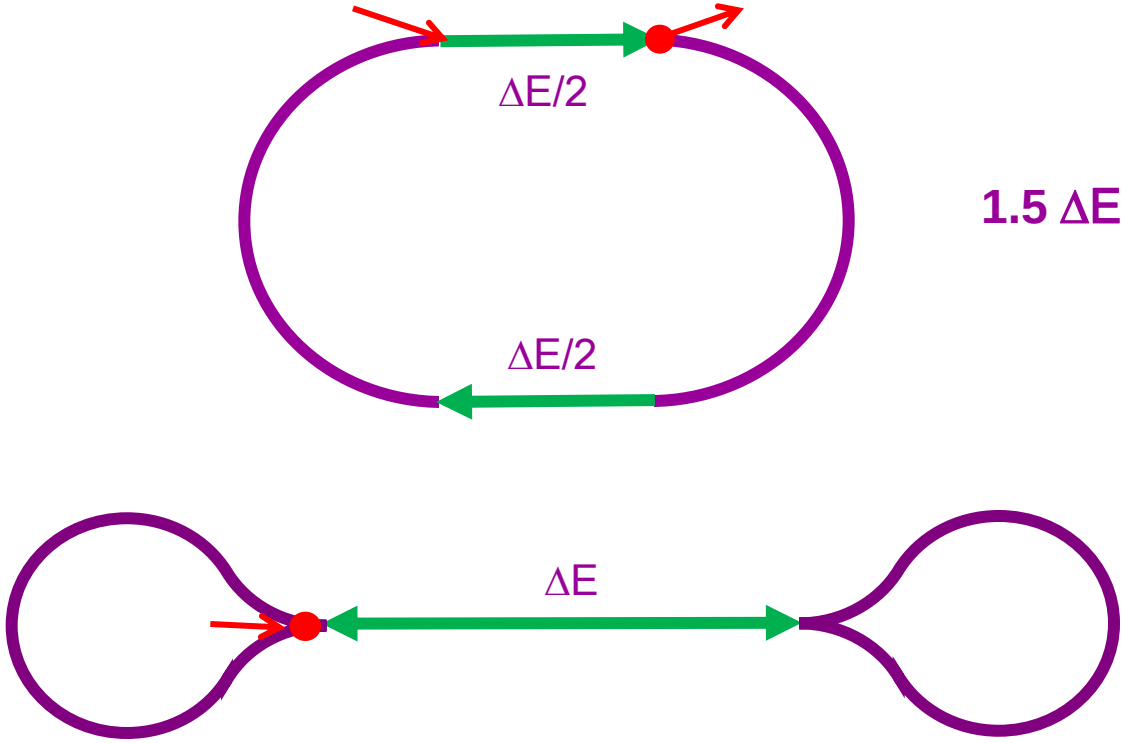

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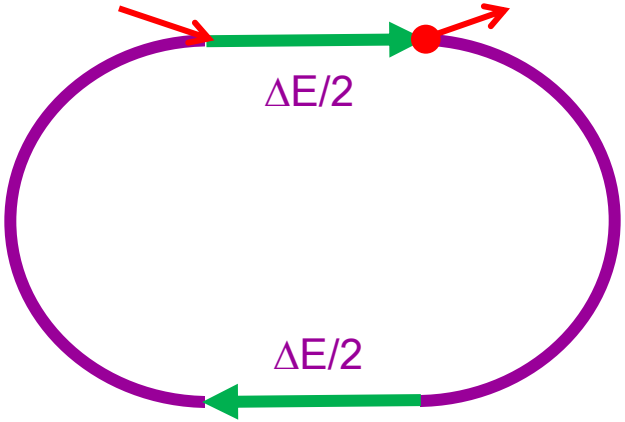

1.5 ΔE

3 ΔE

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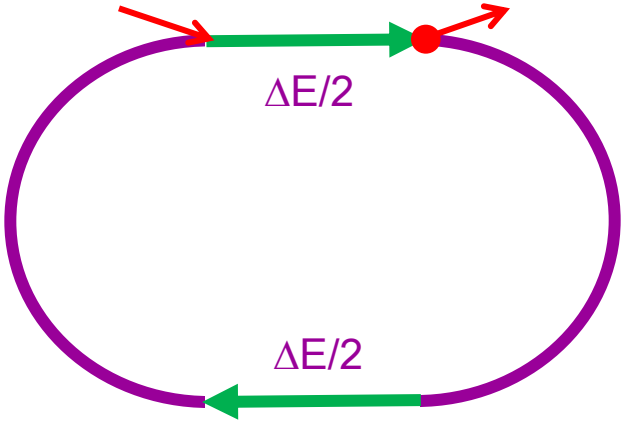

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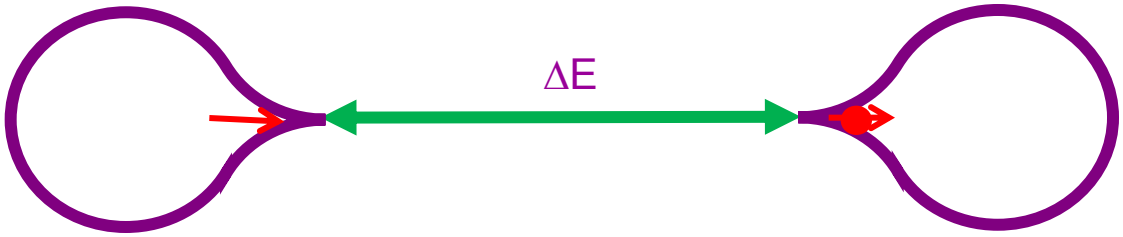
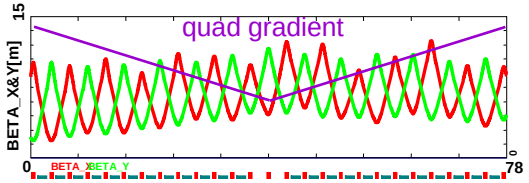
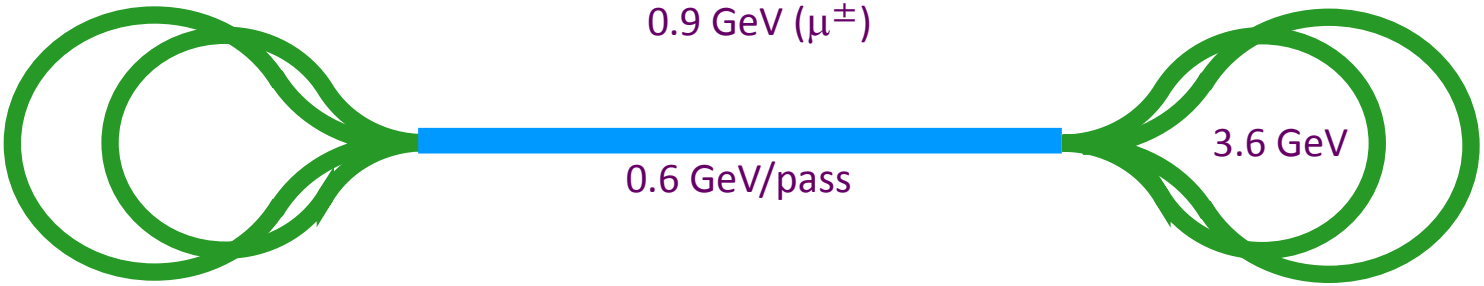


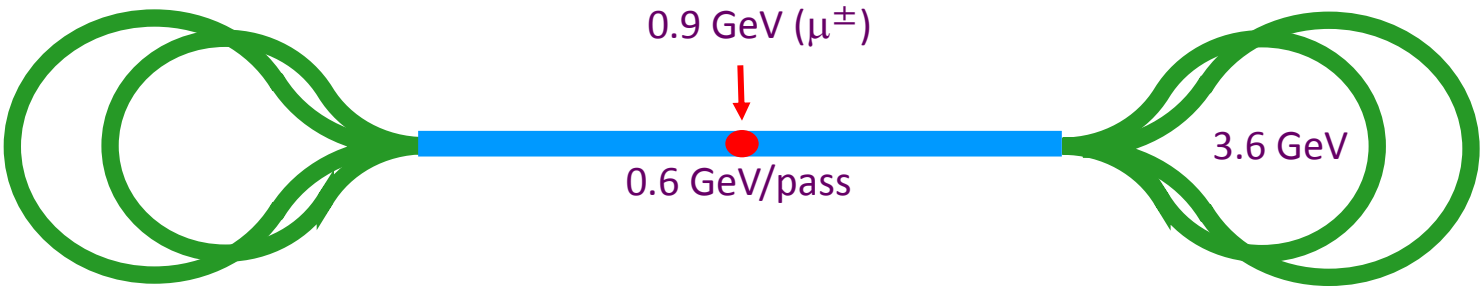
3 ΔE



Multi-pass Arc Muon RLA



Multi-pass Arc Muon RLA



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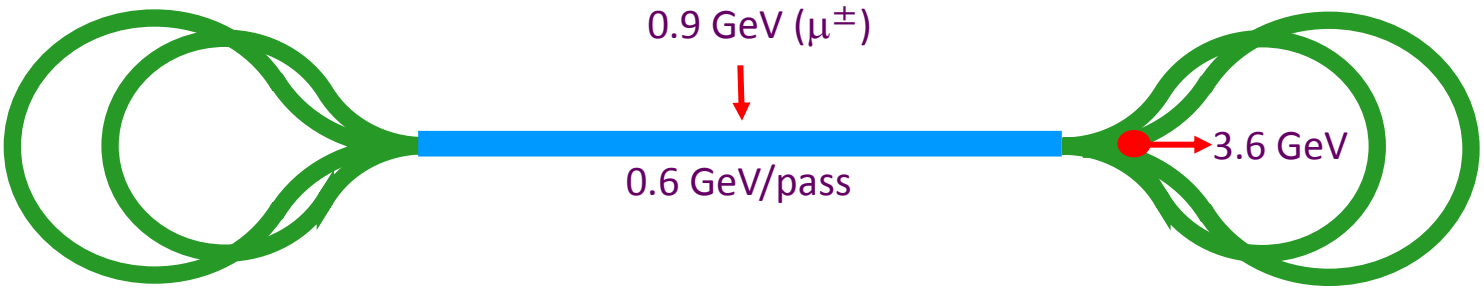

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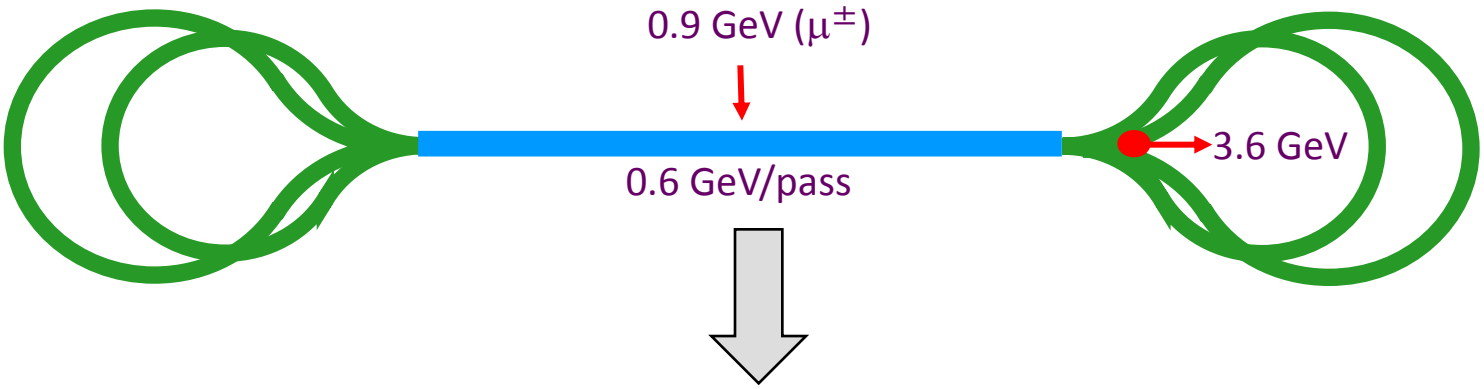

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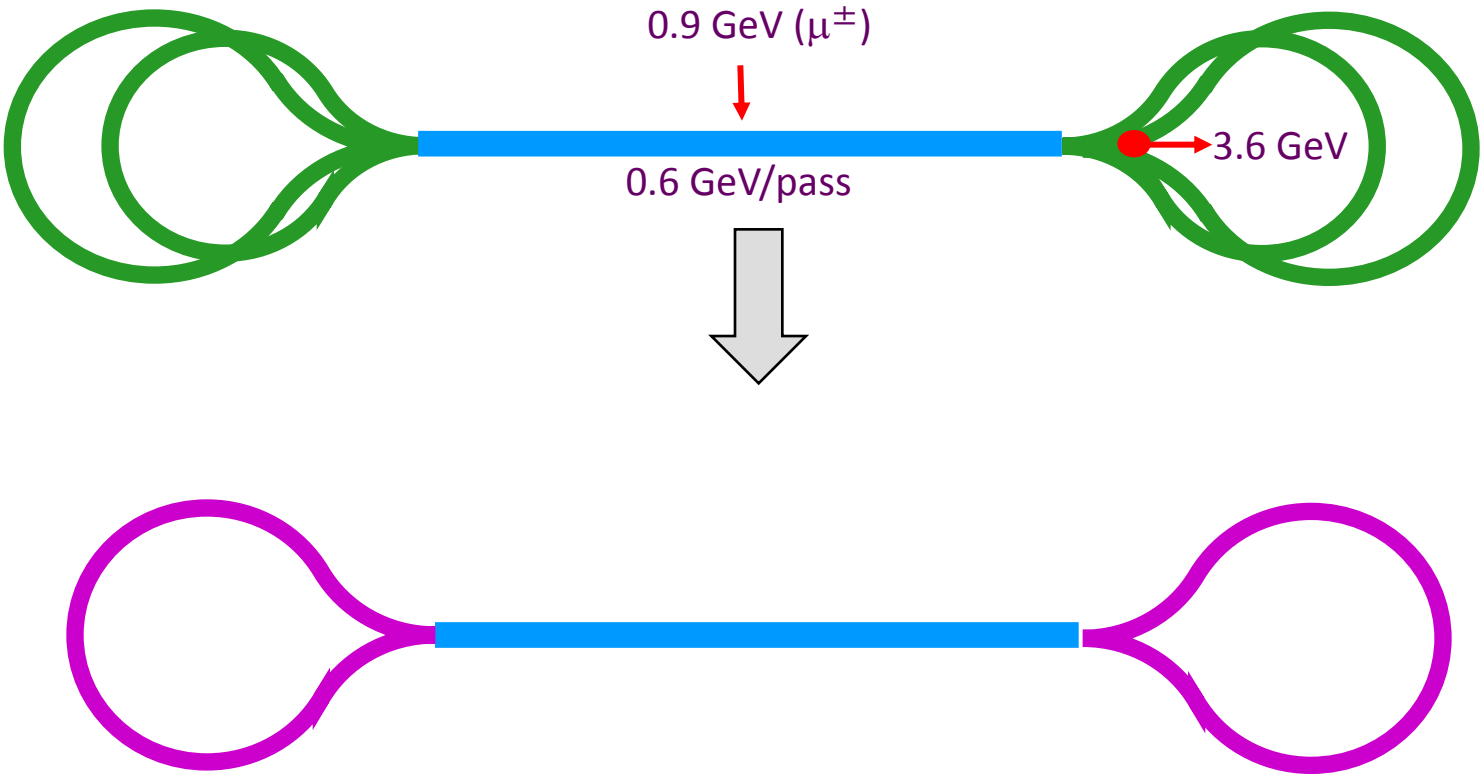
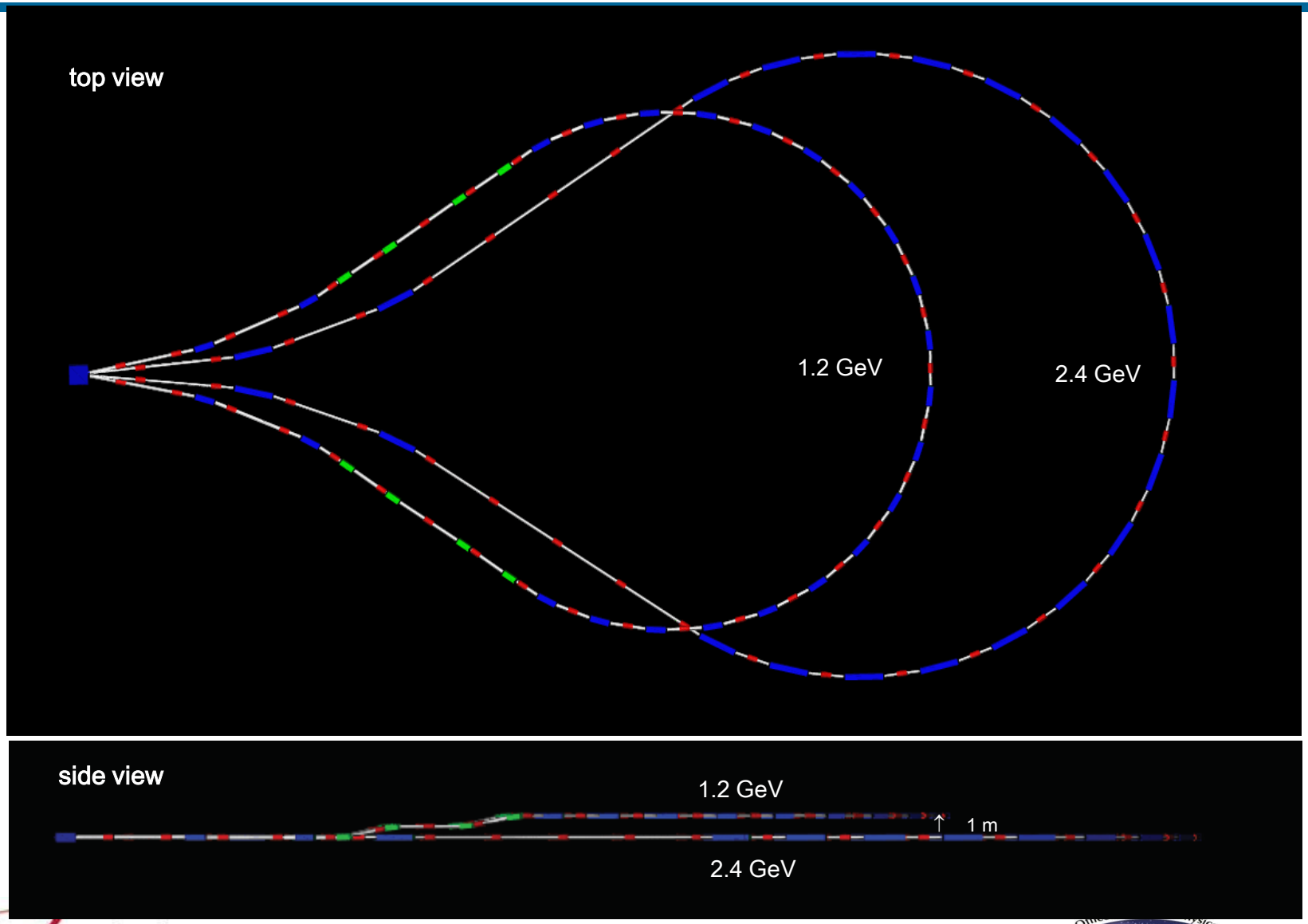


Conventional Single-pass Droplet Arcs



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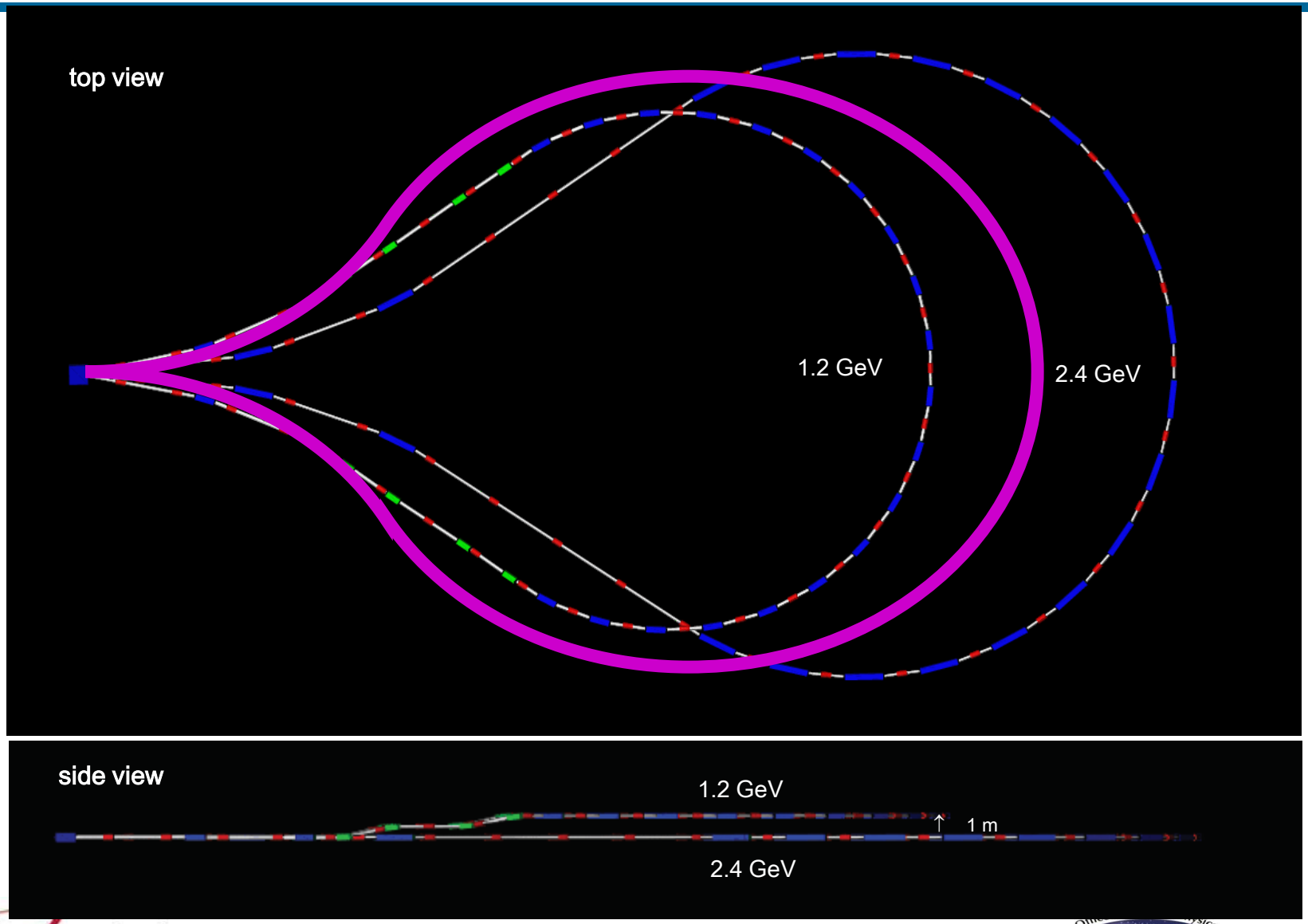
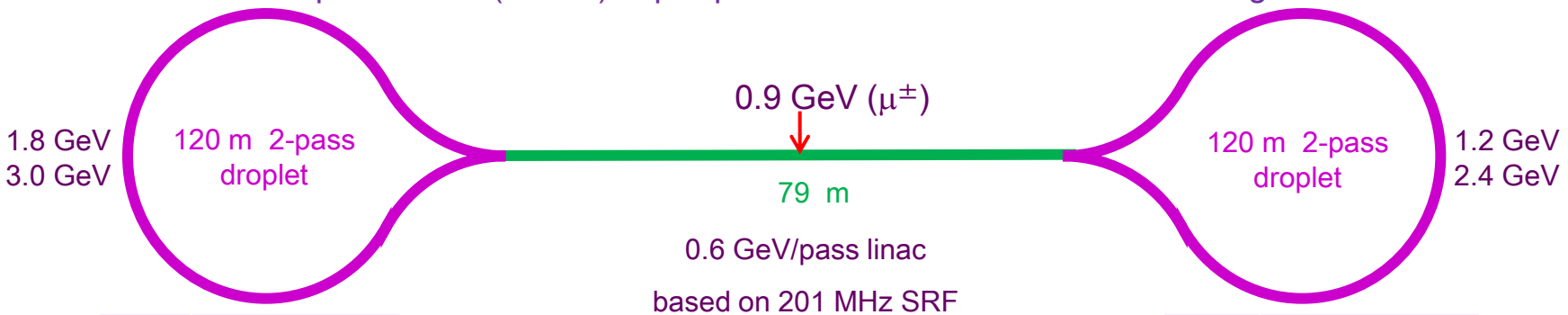


Size-down: Electron Model of Muon RLA

Droplet Arcs: 7 (1+5+1) super-periods × 24 combined function magnets



B	2.6 Tesla
G	45 Tesla/m

B	1 .7 Tesla
G	28 Tesla/m

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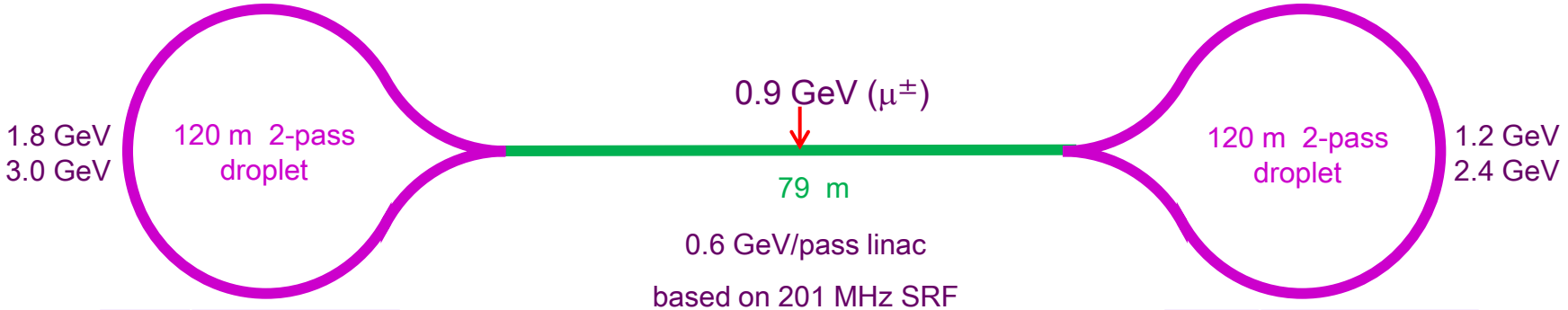

B	2.6 Tesla
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energies reduced by factor of ~200 (m_μ/m_e)

size reduced by factor of ~7.5 (1497/201)

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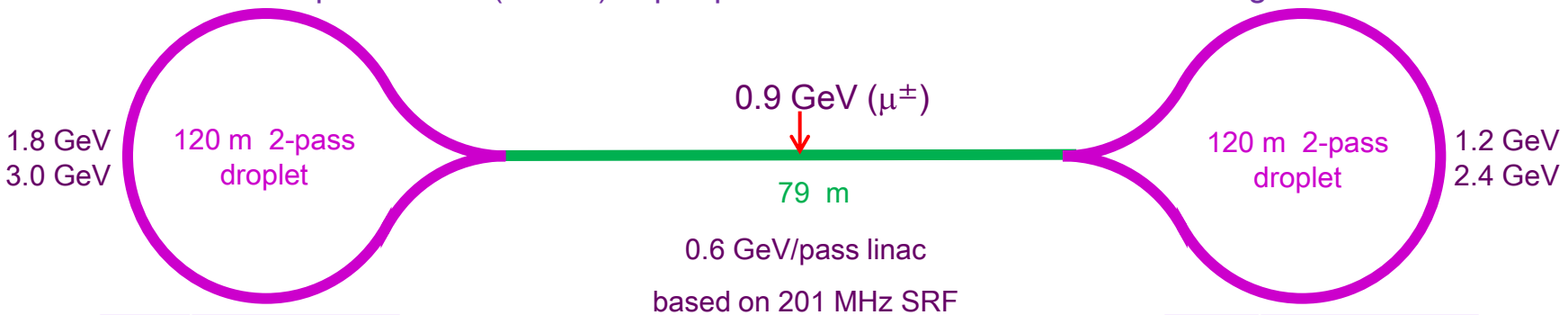

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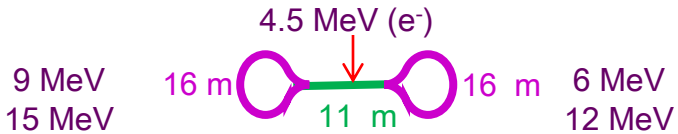
B	975 Gauss
G	1275 Gauss/cm



3 MeV/pass linac based on 1497 MHz SRF

B	638 Gauss
G	825 Gauss/cm

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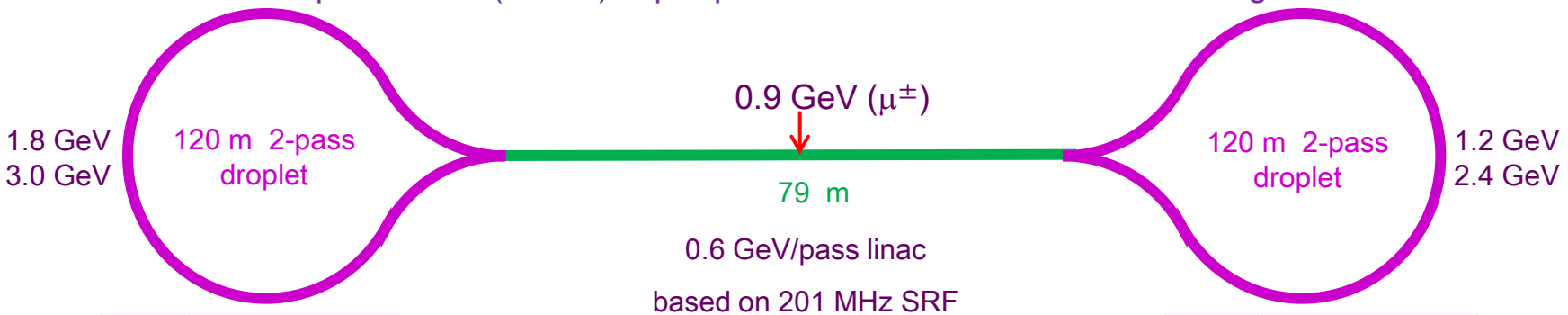

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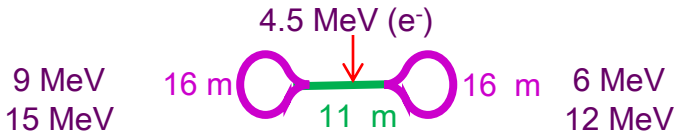

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Fits in 25m × 7m

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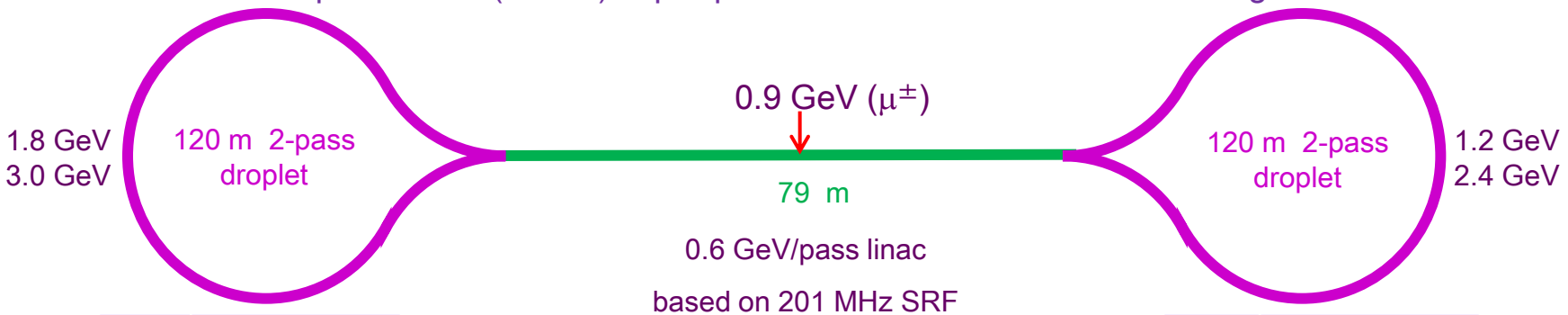

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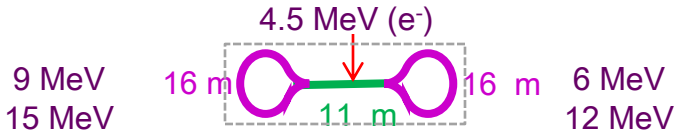

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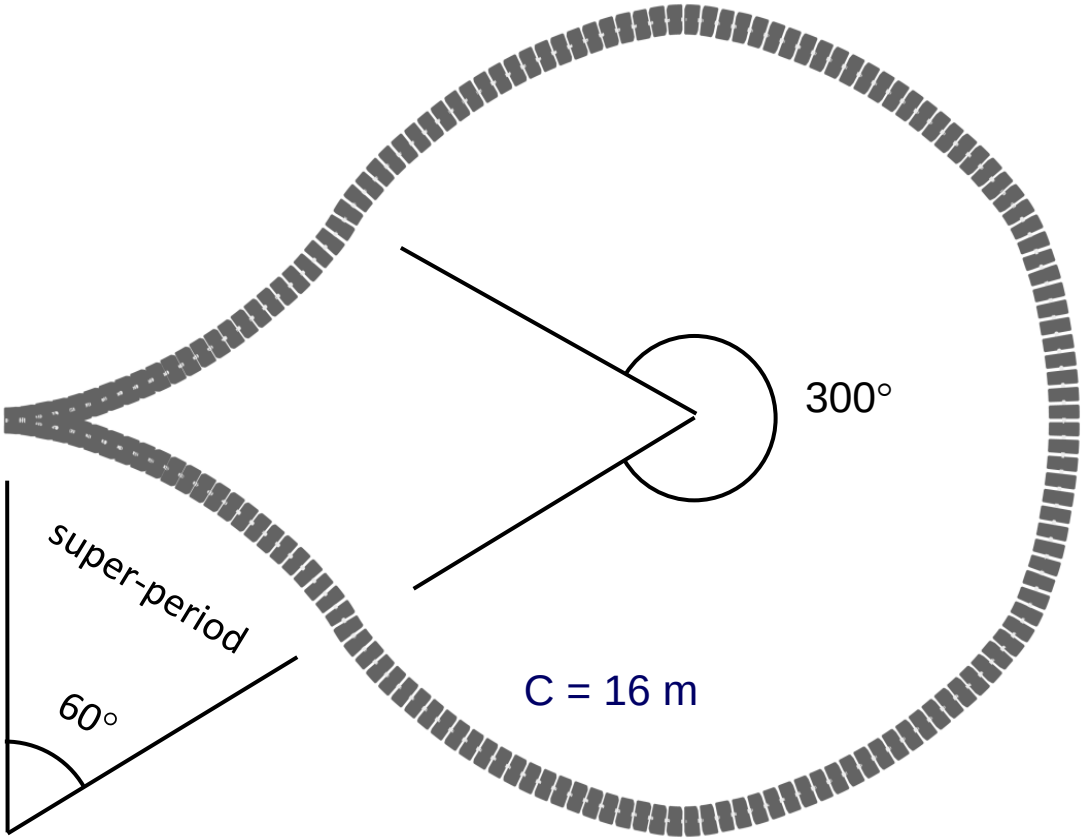
Fits in 25m × 7m

Droplet Arc Architecture (6/12 MeV/c)

7 super-periods (1 out + 5 in + 1 out)



B	~ 650 Gauss
G	~ 800 Gauss/cm

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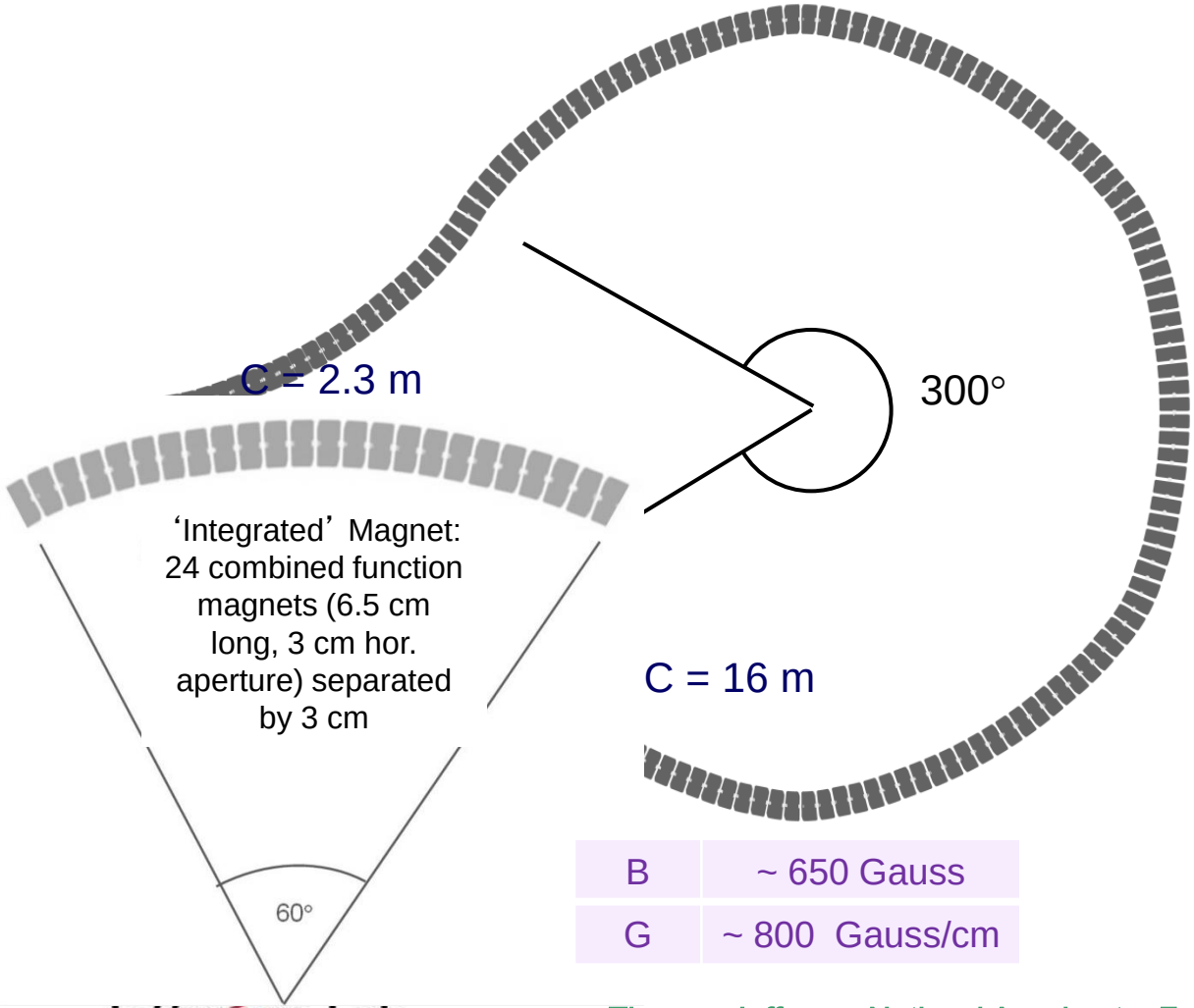

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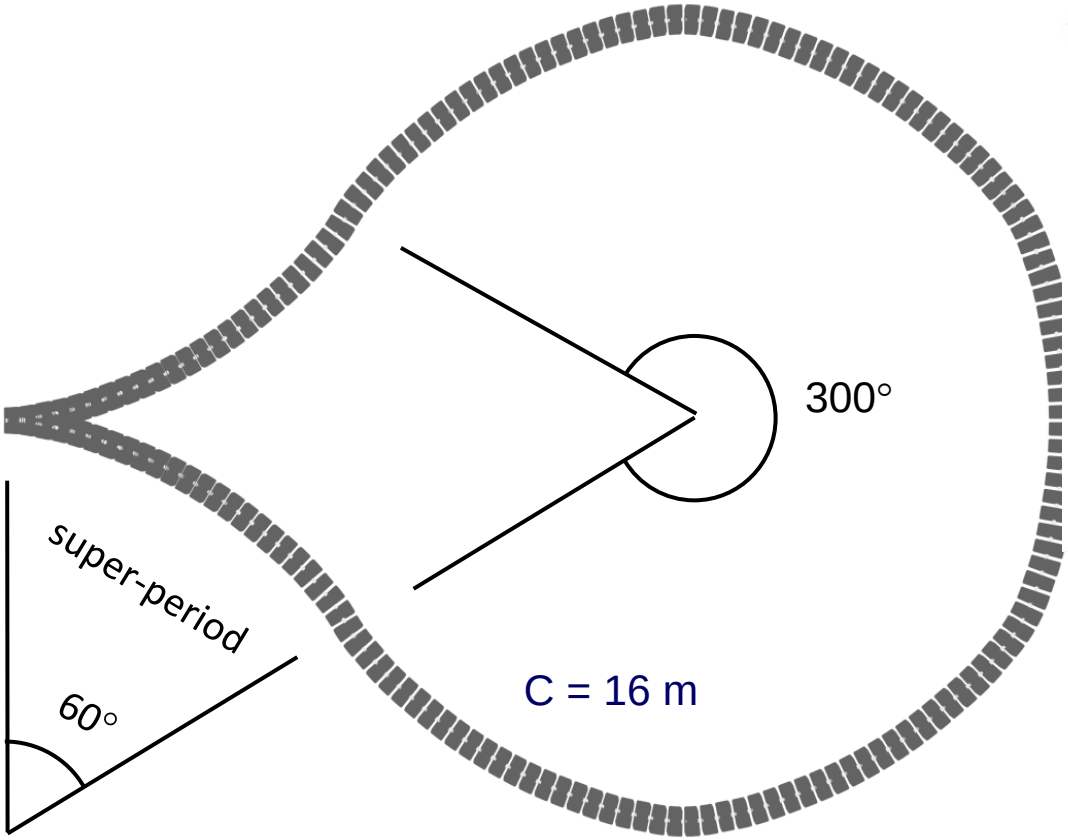
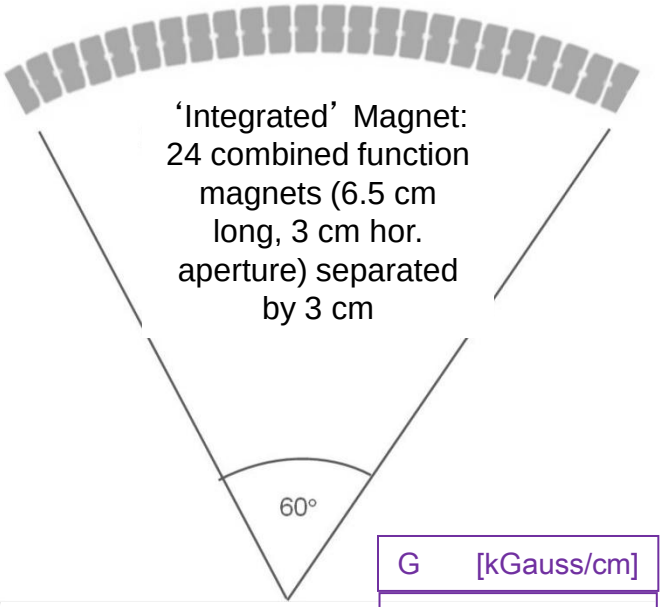


C = 2.3 m



2 × 7 ×

G	[kGauss/cm]
BO01	0
BO02	0
BO03	0.549
BO04	-0.691
BO05	0.796
BO06	-0.627
BO07	0.596
BO08	-0.597
BO09	0.653
BO10	-0.777
BO11	0.690
BO12	-0.523

B	~ 650 Gauss
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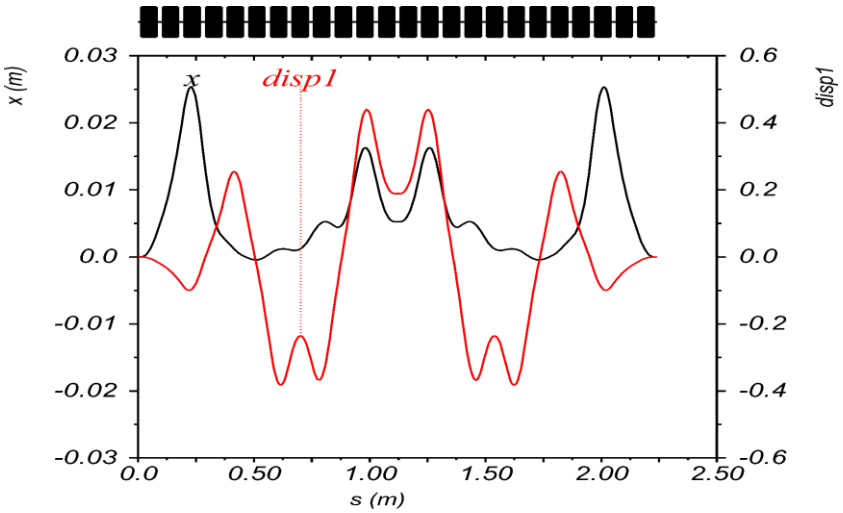
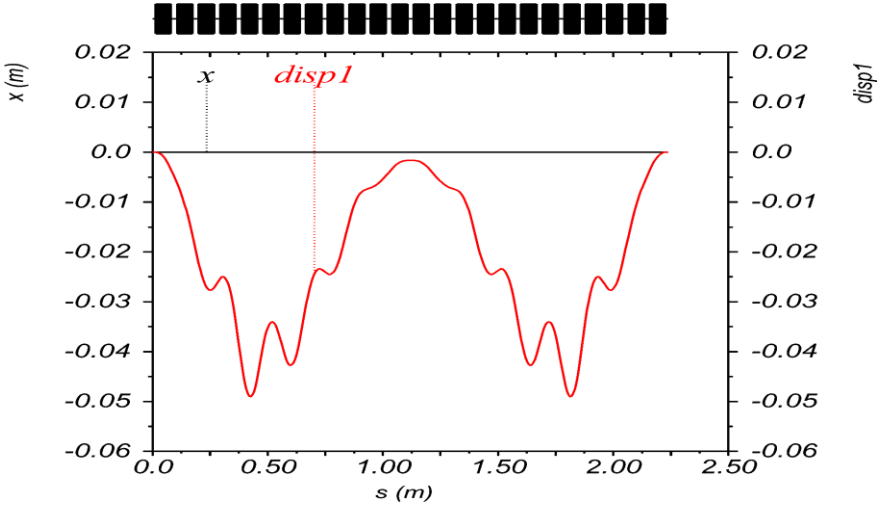
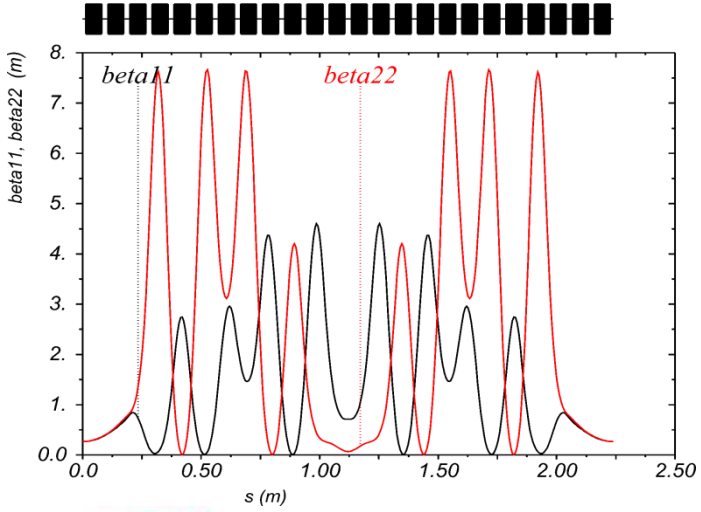
Super-period Optics for $P_2 / P_1 = 2$

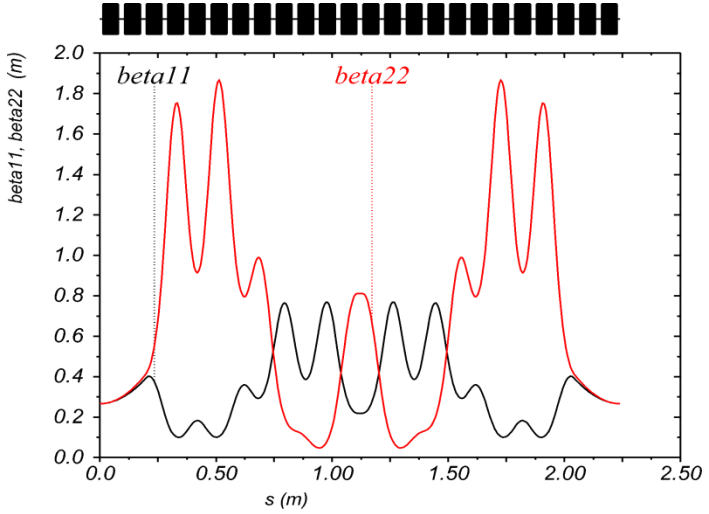
P_1 (6 MeV/c)



P_2 (12 MeV/c)





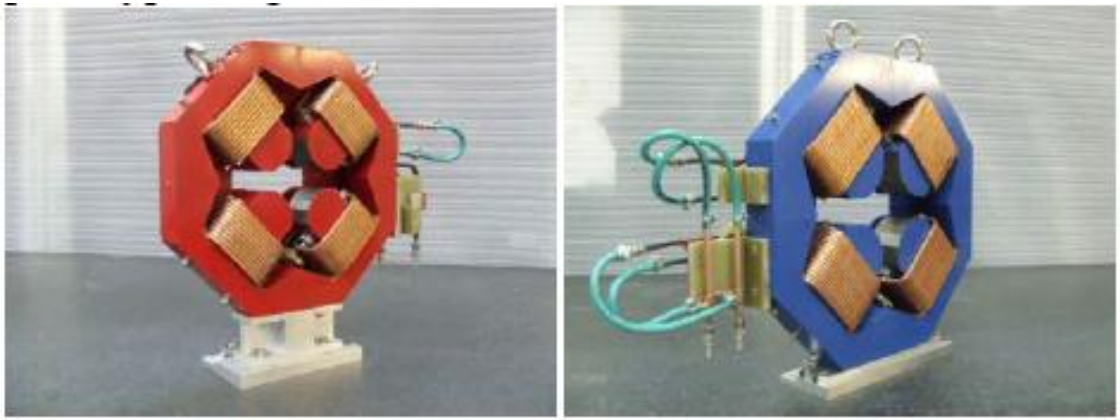


Displaced Coil EMMA Quads

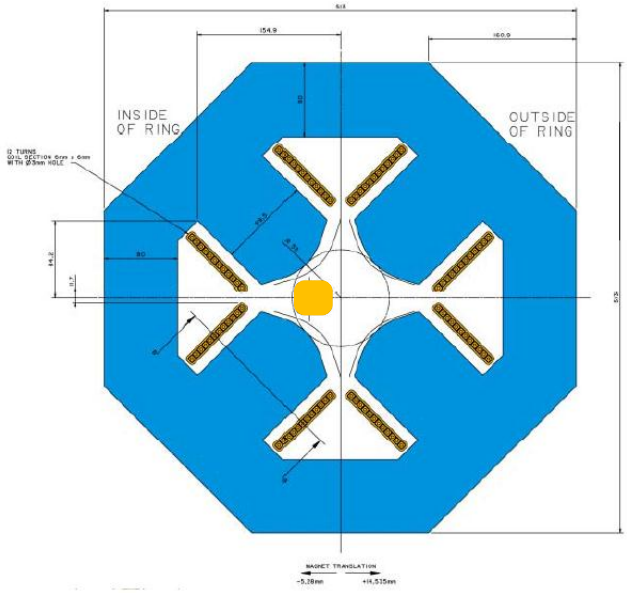
WEPC156 Proceedings of EPAC08, Genoa, Italy

DEVELOPMENT AND ADJUSTMENT OF THE EMMA QUADRUPOLES

N.Marks, B.J.A.Shepherd, ASTeC / Cockcroft Institute, STFC Daresbury Laboratory, Warrington, UK
B. Leigh, F. Goldie, M.J.Crawley, Tesla Engineering, Storrington, Sussex, UK



Parameter	F magnet	D magnet	Units
Integrated gradient	-0.387	0.347	T
Inscribed radius	37	53	mm
Current	213.4	263.5	A
Turns in coil	11	11	
Yoke thickness	55	65	mm
Pole width	73	100	mm
Horizontal movement range	-2.711 +2.604	-5.28 +14.535	mm
Offset from magnetic centre	7.507	34.025	mm
Required good field region	-32…+16	-56…-10	mm



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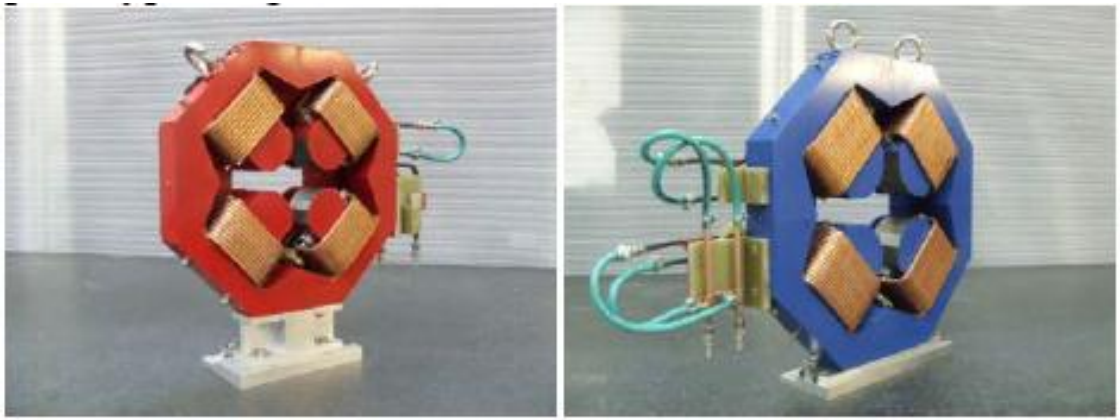

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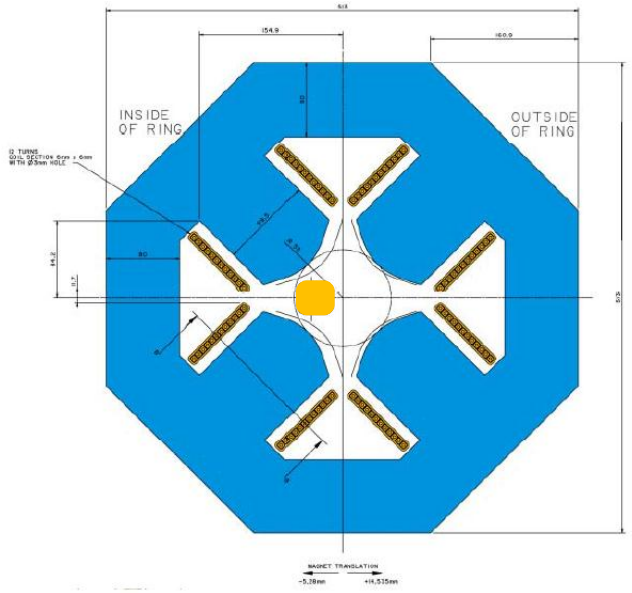
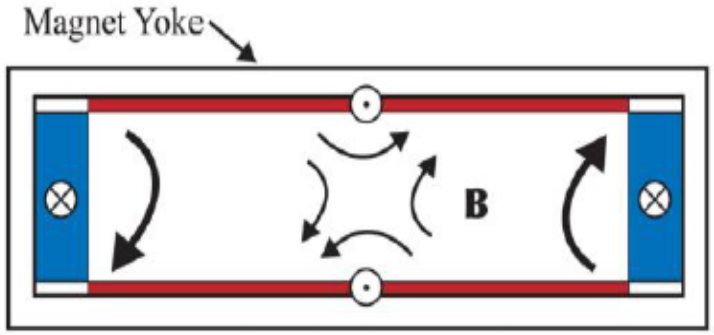


Three-coil Panofsky Quad

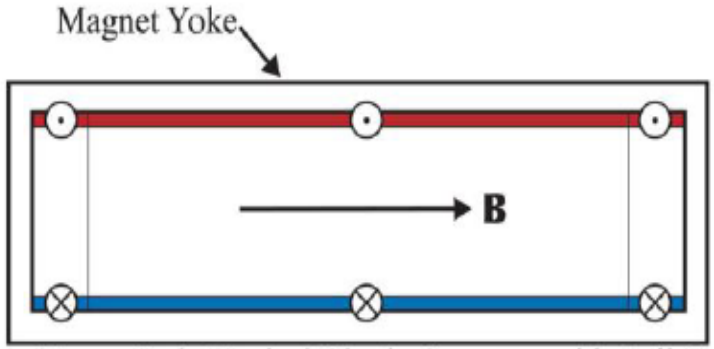
PAC 20007 Proceedings

COMBINED PANOFSKY QUADRUPOLE & CORRECTOR DIPOLE *

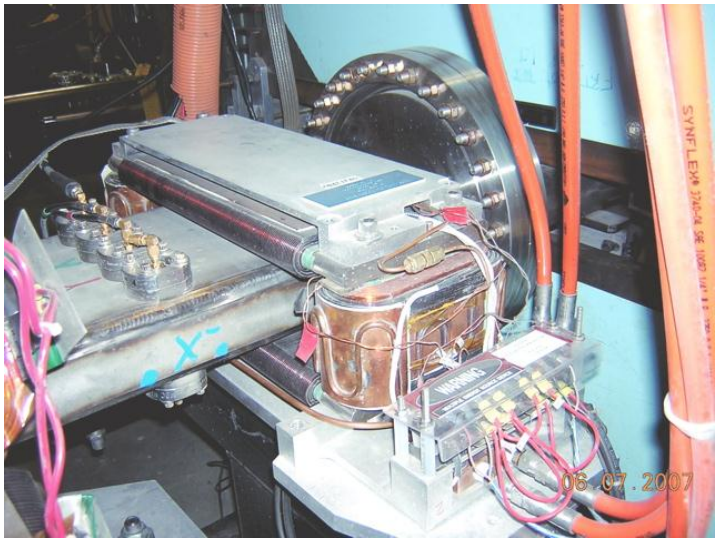
George H. Biallas#, Nathan Belcher, David Douglas, Tommy Hiatt, Kevin Jordan, Jefferson Lab,



Rectangular Panofsky Quadrupole with Coil Currents
(Looking Downstream, Focusing Electrons)

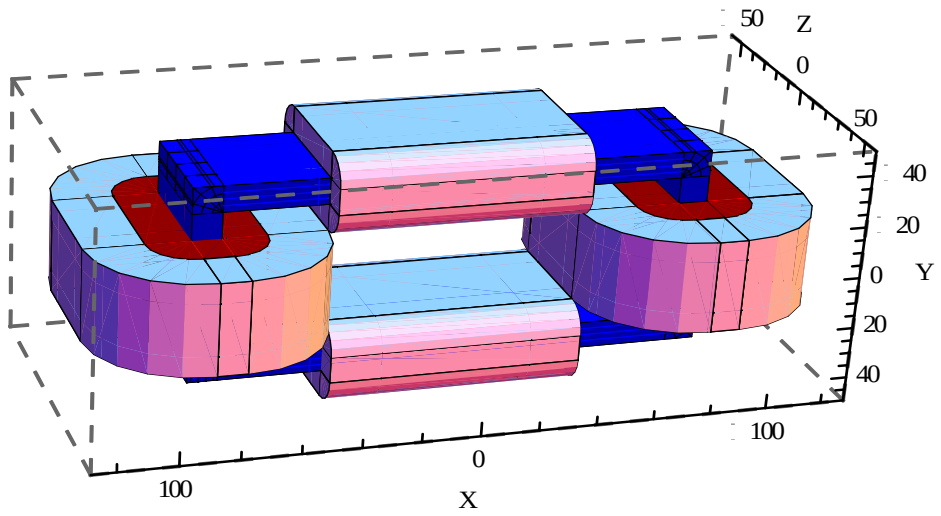


Window Frame Style Vertical Dipole Corrector with Coil Currents
(Looking Downstream, Bending Electrons Up)



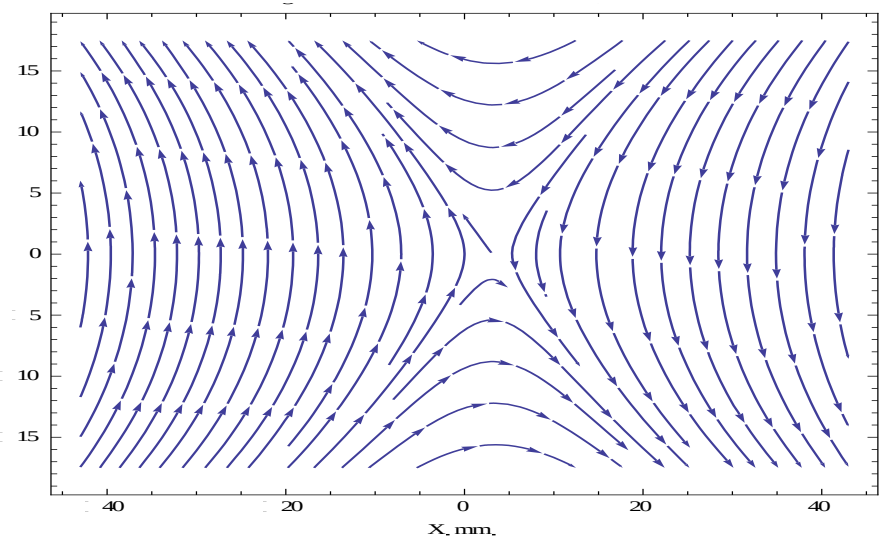
Preliminary Magnet Modeling

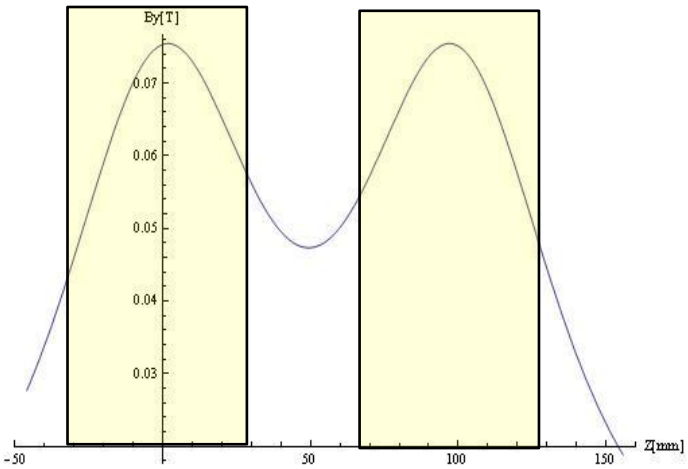
Radia (ESRF)



TOSCA will be used for detailed studies and generation of field maps

Field affected by neighboring magnets





R. Roussel

Error Sensitivity – Monte-Carlo Study

- Mis-alignment:

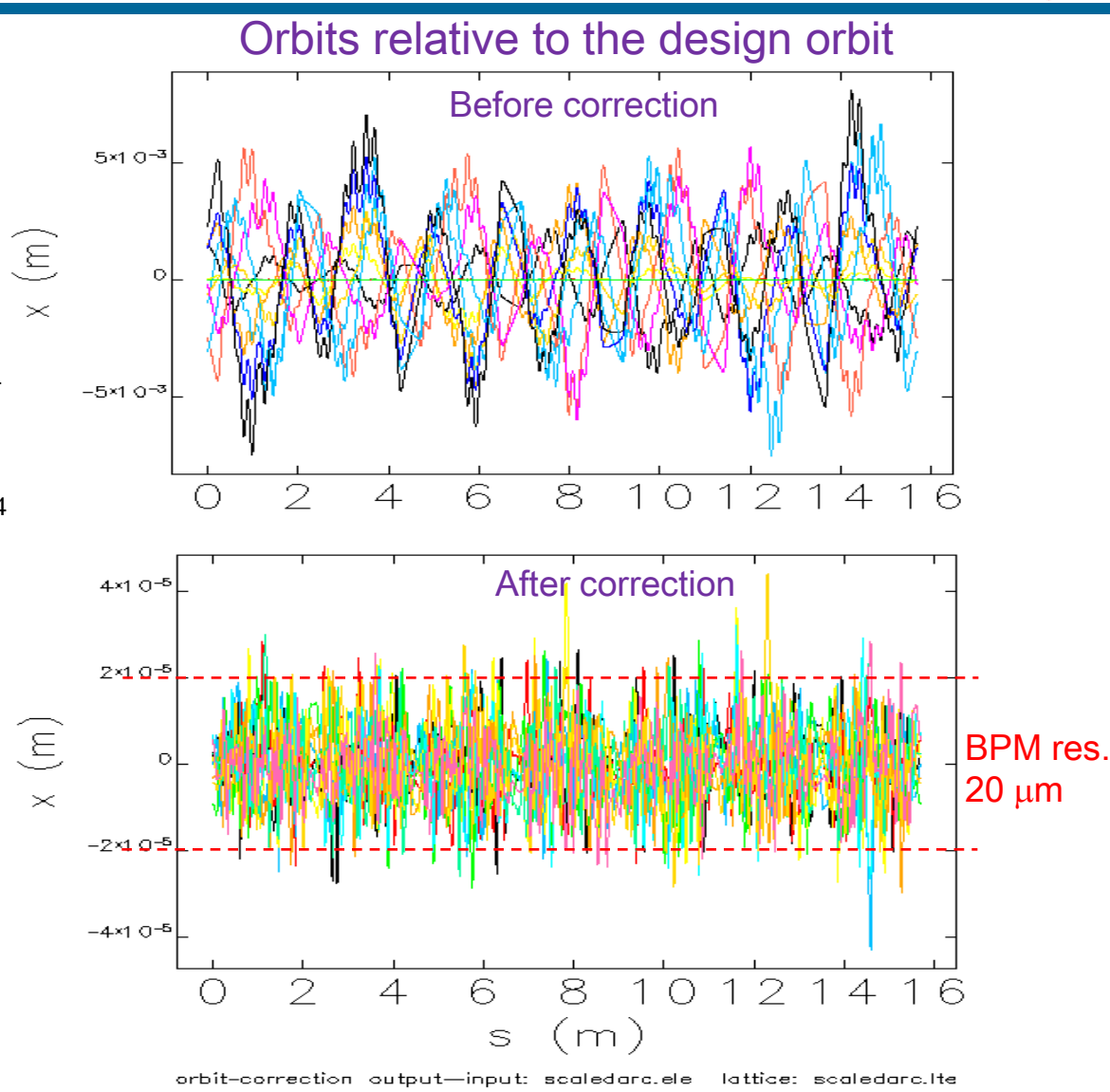
$$\sigma_{x/y} = 200\mu m$$

- Mis-powering:

$$\frac{\Delta B}{B} = 10^{-4}$$

$$\frac{\Delta k_1}{k_1} = 10^{-4}$$

- 25 random machines, corrected with X/Y correctors located after each dipole. BPMs between each dipole, with 20 μm resolution.



Conclusions

- **JEMMRLA (JLab Electron Model of Muon RLA)**
  - Proof-of-concept for novel RLA with multi-pass arc
    - Efficient use of RF (4.5 passes)
    - No switchyard – single droplet arc on each side of the linac

V.S. Morozov, S.A Bogacz et al, 'Linear Fixed-field Multipass Arcs for Recirculating Linear Accelerators', PRST-AB **15**, 060101 (2012)

- Demonstration of a new kind of fixed field accelerator
  - Rapid acceleration of muons for the Next Generation Muon Facilities: Neutrino Factory, Higgs Factory and energy frontier Muon Collider
- Proof-of-principle for multi-pass arcs based on combined function magnets
  - Possible medical application for gantry design

D. Trbojevic, V.S. Morozov et al, 'Non-scaling fixed field alternating gradient permanent magnet cancer therapy accelerator', IPAC'11, San Sebastian, Spain, September (2011)