MeRHIC Design

V.Ptitsyn

on behalf of MeRHIC Design team:

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Talk Outline

MeRHIC

- MeRHIC layout and general description
- Design beam parameters and luminosity
- Design components:
  - Electron linac
  - Recirculation passes
  - Interaction region
  - Injector
- Summary

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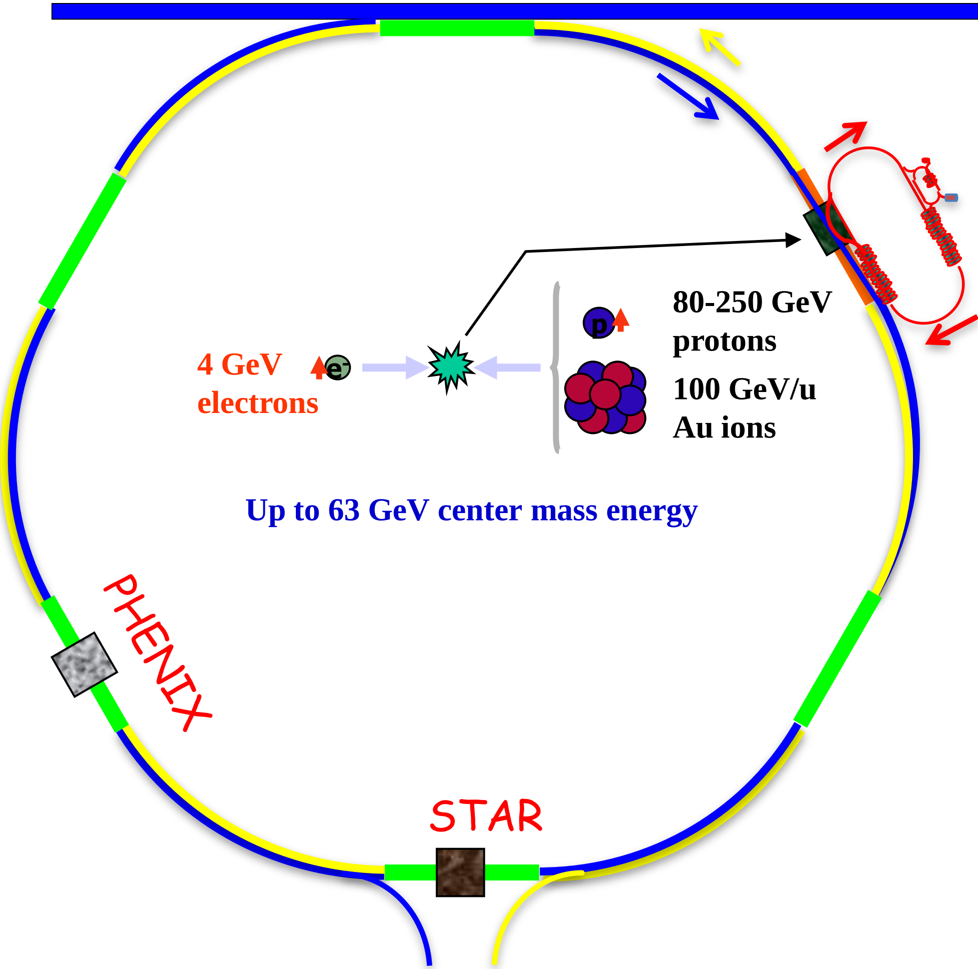
RHIC and MeRHIC

MeRHIC



- MeRHIC – Medium energy eRHIC . **First stage of the electron-ion collider at BNL.**
- Electron acceleration is based on energy-recovery linacs.
- Electrons collide with protons and ions from RHIC Blue ring. Only minimal modifications of existing RHIC rings at IR region.
- Polarized electron and proton beams. Longitudinal polarization orientation at the collision point for both beams.
- Parallel operation with the p-p (or ion-ion) collisions at PHENIX and STAR detectors.

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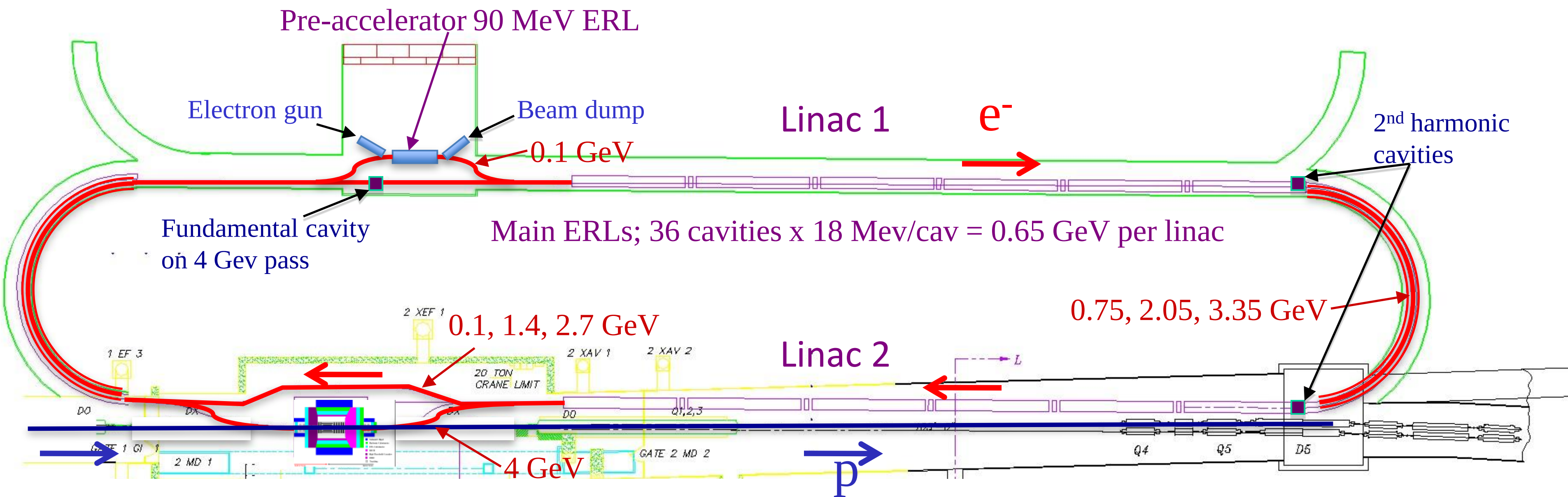
MeRHIC at IR2 region



IR2 region features:

- asymmetric detector hall (appropriate for asymmetric detector for e-p collisions)
- long wide (7.3m) tunnel on one side from the IR (enough space to place energy recovery linac(s))

Main components:

-100 MeV injector on the basis of polarized electron gun (50 mA) and pre-accelerator ERL.

-Two main ERLs (one of them in the RHIC tunnel) with maximum 0.65 GeV energy gain per linac.

-Recirculation passes: warm magnets, acceptable synchrotron radiation power.

Proton and ion beam for MeRHIC

MeRHIC

- Goal: modifications for proton (ion) beam have to be minimal
- IR design: use of existing triplets and D0 magnets, removal of IR2 DX magnets, addition of warm dipole magnets.
- Addition of two spin rotators in Blue ring.
- Required proton beam parameters are either already achieved or planned to be achieved in 2-3 years for RHIC operation.
- MeRHIC will take advantages of planned improvements in RHIC (for RHIC operation): 56 MHz SRF, stochastic cooling (for ions) …

MeRHIC parameters for e-p collisions

MeRHIC

	Baseline design (no cooling)		Pre-cooled at the injection energy		With high energy cooling (CEC)	
	p	e	p	e	p	e
Energy, GeV	250	4	250	4	250	4
Bunch repetition time, ns	105	105	105	105	105	105
Bunch intensity, 10^{11}	2.0	0.31	2.0	0.31	2.0	0.31
Bunch charge, nC	32	5	32	5	32	5
Normalized emittance, 1e-6 m, 95% for p / rms for e	15	73	6	29	1.5	7.3
rms emittance, nm	9.4	9.4	3.8	3.8	0.94	0.94
beta*, cm	50	50	50	50	50	50
rms bunch length, cm	20	0.2	20	0.2	5	0.2
beam-beam for p /disruption for e	1.5e-3	3.1	3.8e-3	7.7	0.015	7.7
Peak Luminosity, 1e32, $cm^{-2}s^{-1}$	0.93		2.3		9.3	

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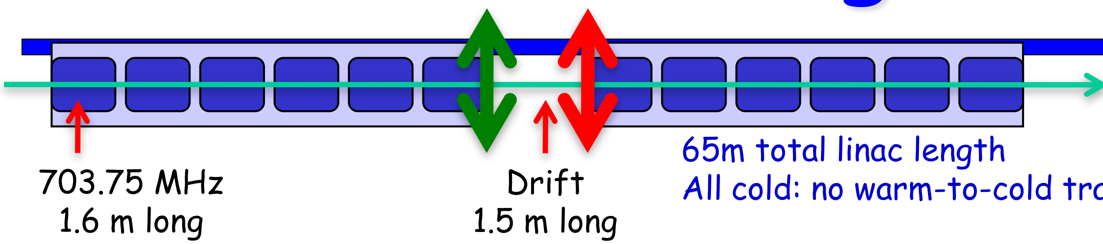
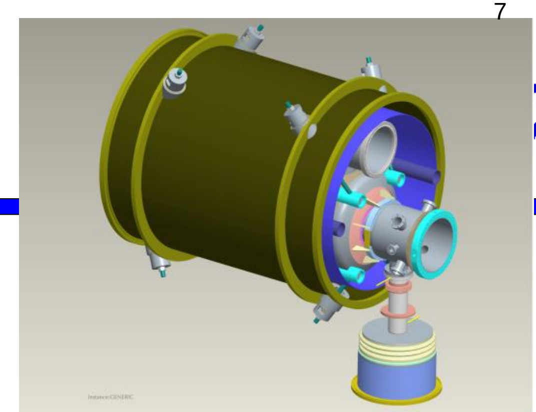
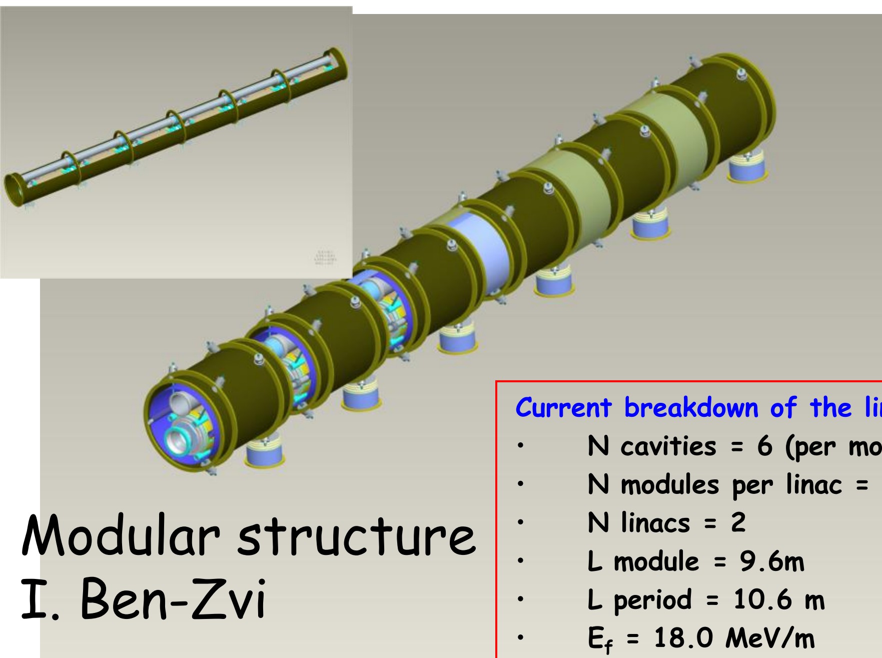
MeRHIC Linac Design



65m total linac length
All cold: no warm-to-cold transition





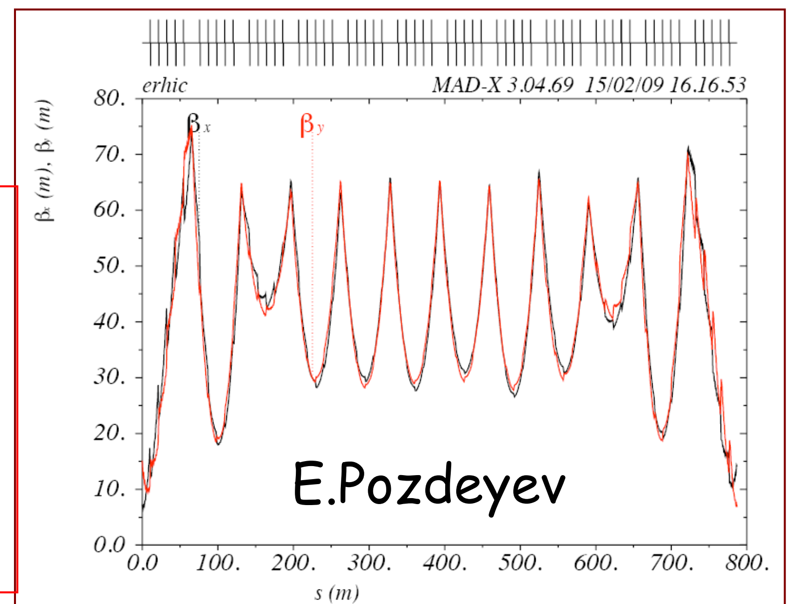
Modular structure
I. Ben-Zvi

Current breakdown of the linac

- N cavities = 6 (per module)
- N modules per linac = 6
- N linacs = 2
- L module = 9.6m
- L period = 10.6 m
- E_f = 18.0 MeV/m
- ⟨dE/ds⟩ = 10.2 MeV/m

Based on BNL SRF cavity with fully suppressed HOMs
Critical for high current multi-pass ERL

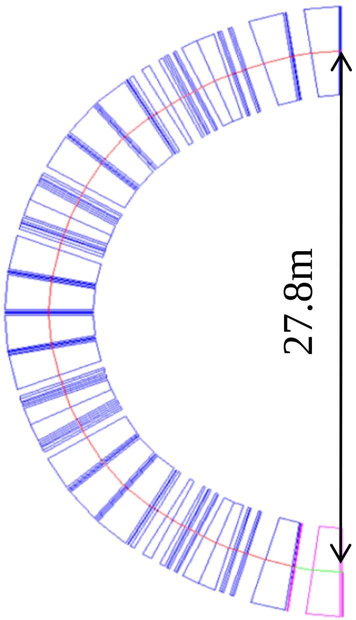
100 MeV → 4 GeV → 100 MeV

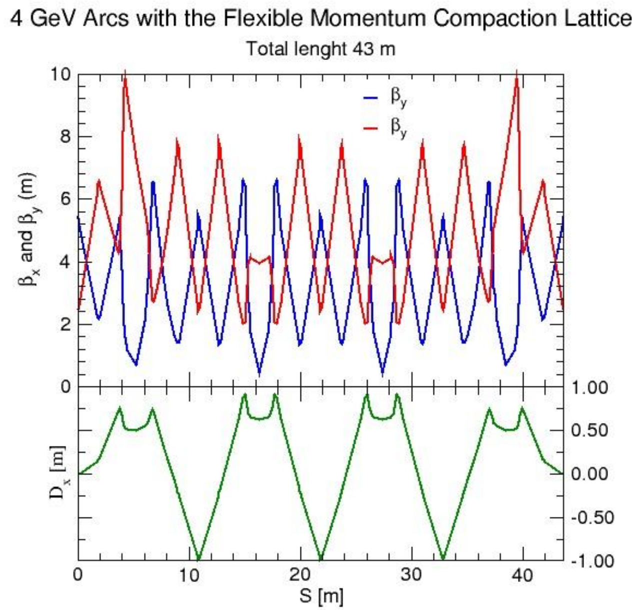


Recirculation pass lattice

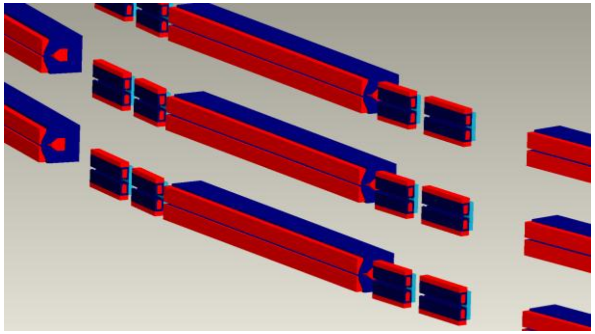
- Achromatic and isochronous arc design
- Flexible Momentum Compaction Lattice-> adjustable M_{56} parameter
- Large dipole filling factor (64%) -> reduced synchrotron radiation (< 2kW/m)
- Initial dipole and quadrupole magnet design has been developed

D. Trbojevic, N. Tsoupas



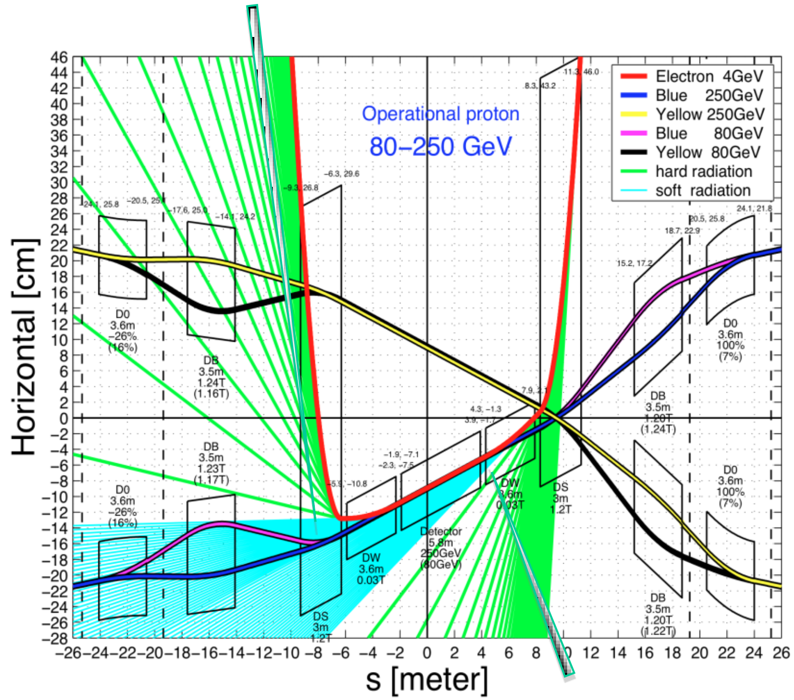


Vertical arrangement of recirculation passes



IR Design Features

MeRHIC



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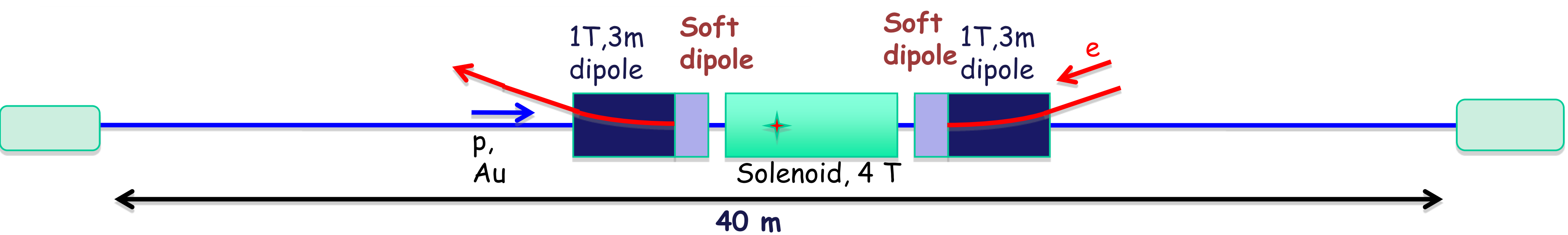
- Provides the integration of detector dipole magnets into the beam separation scheme
- Provides the ability to vary the proton beam energy from 80 to 250 GeV at constant electron beam energy.
- Provides effective SR protection:
  soft bend (~0.05T) is used for final bending of electron beam
- Focusing elements are located far from the IP (first electron quad at 11m)



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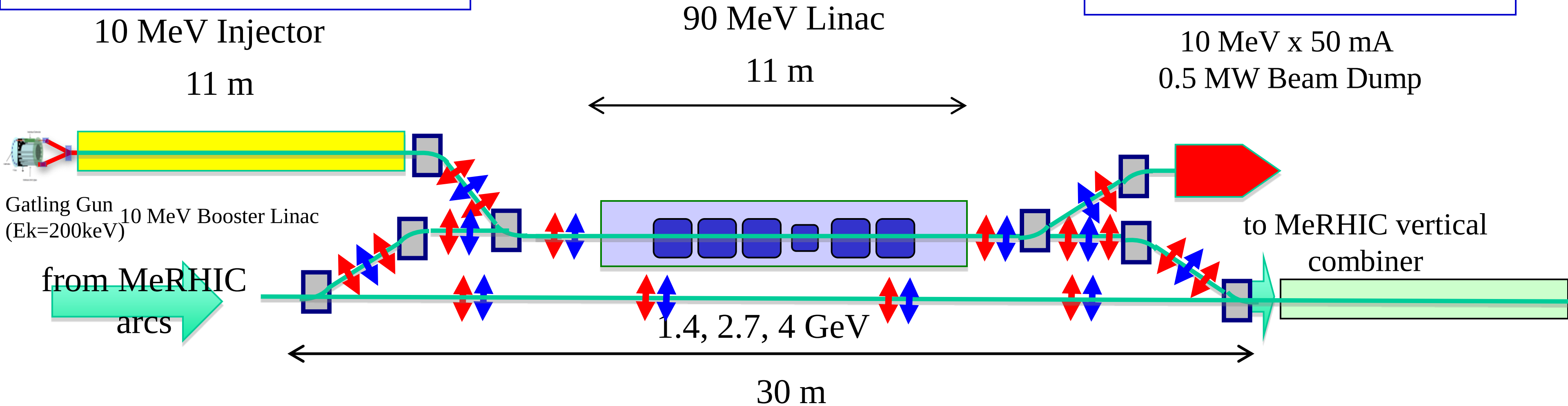
Injector and Pre-accelerator Design

X. Chang and D. Kayran

<u>Injector Parameters:</u>
Polarized Gun (200kV)
Cathode GaAs,
Laser 780nm
Emax= 10 MeV
Iavr =50 mA,
Q per bunch =5nC
Design realizes bunch compression and spin direction control

<u>Pre-accelerator linac:</u>
Standard MeRHIC linac cryomodule (~10m) with 5x703 MHz 5-cell cavities and one 3rd harmonic 2.11 GHz inside.
Two transition sections (0.5 m each) attached from both ends
Energy gain 90 MeV

<u>Output beam parameters :</u>
E=100 MeV
Iavr=50 mA
Ipeak=500 A
Reprate = 9.8 MHz
Emittance =70 mm-mrad
Bunch length = 3 mm
dE/E = 1E-3



Summary: MeRHIC Design Status

MeRHIC

- The lattices of all machine components (injector, recirculation passes, linac, interaction region, mergers/splitters) have been developed.

- The interaction region with the detector fully integrated into the accelerator environment has been designed.

- The most important beam dynamics effects, defining achievable beam parameters and machine luminosity, has been studied. No show-stoppers had been found. *(See Y. Hao's talk)*

- Conceptual designs of superconducting linac and its cryomodule have been done.

- Detailed cost estimate of MeRHIC has been completed for all machine systems, civil construction and utilities. In early October 2009, an Internal BNL Committee reviewed the MeRHIC cost estimate and is preparing its conclusions.