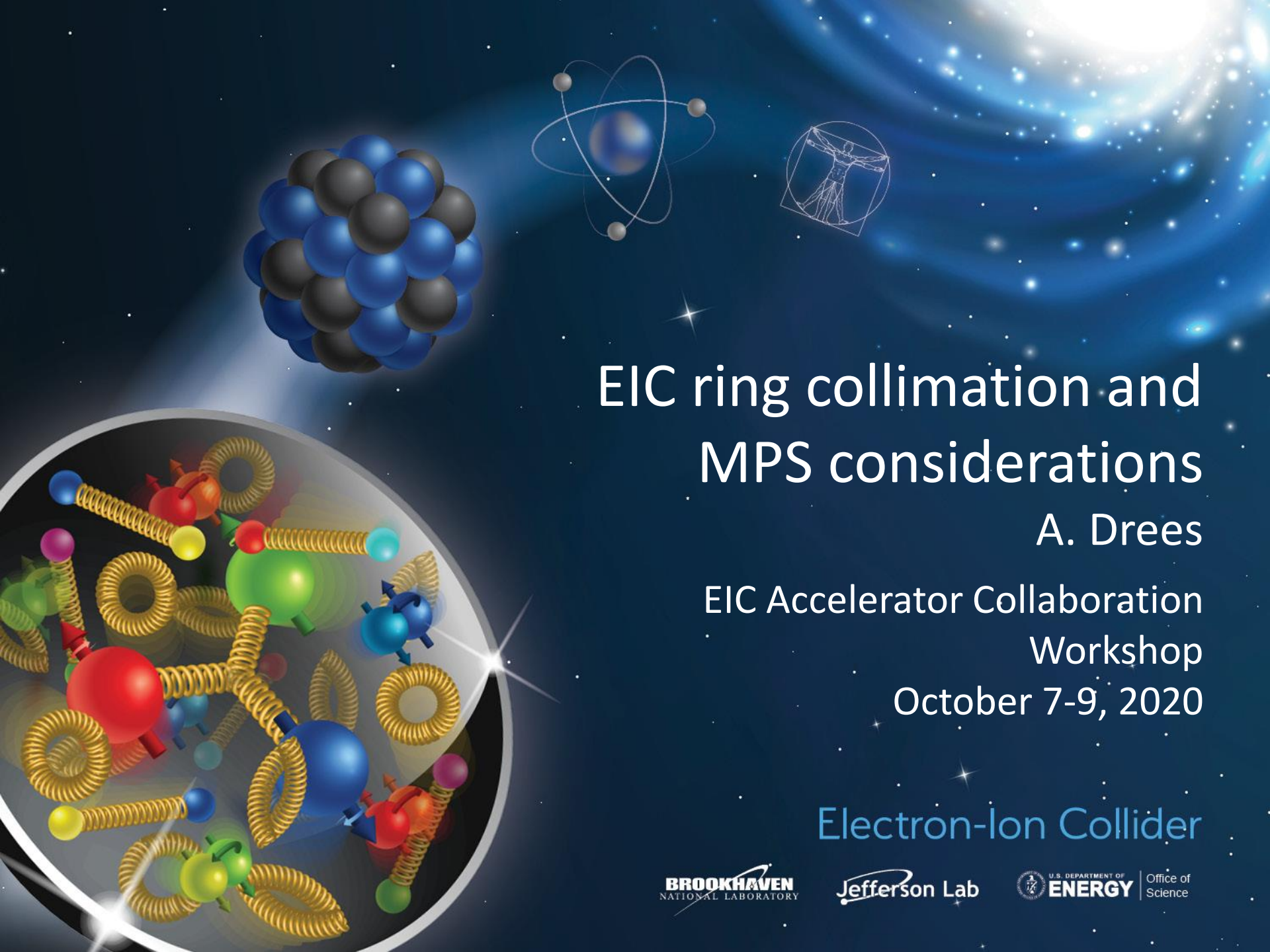

EIC ring collimation and MPS considerations

A. Drees

EIC Accelerator Collaboration Workshop

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Electron-Ion Collider

BROOKHAVEN NATIONAL LABORATORY
Jefferson Lab
U.S. DEPARTMENT OF ENERGY | Office of Science

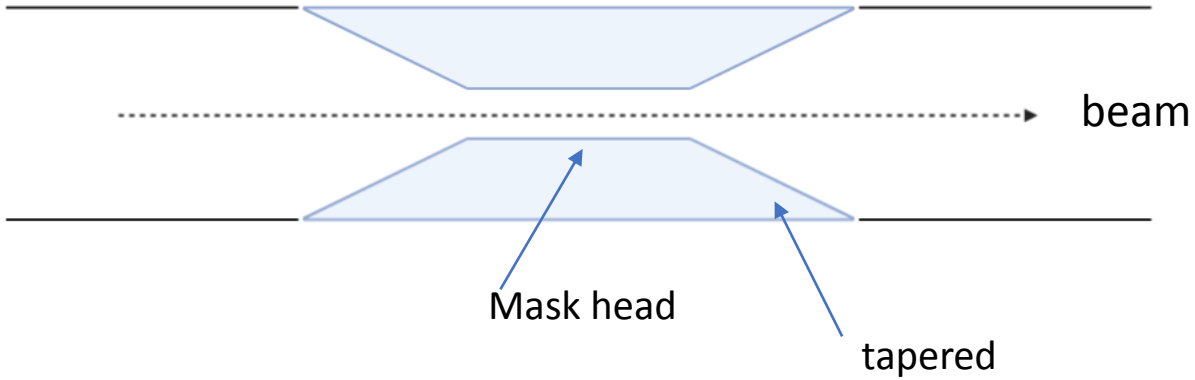
Introduction:

Task: define and design collimation and machine protection systems including emergency dumps for the three rings: RCS, ESR and HSR.

Ring	β Collimators	mom. collimators	MPS	Dump/abort
RCS	tbd	No	Yes	No
ESR	Yes	Yes	Yes	Yes
HSR	Yes	Yes	Yes	Yes

- ring by ring details on the following slides
- work in progress!

collimator requirements:



- 2 stage system for ESR and HSR
- Two sided design for flexibility
- Total length ~ 2m/collimator (expected)
- For impedance purposes the collimators should be symmetric & tapered
- Jaw material of primaries and secondaries should be different
- Collimators will need cooling
- Choices of collimator material and design could be part of a collaborative effort

RCS

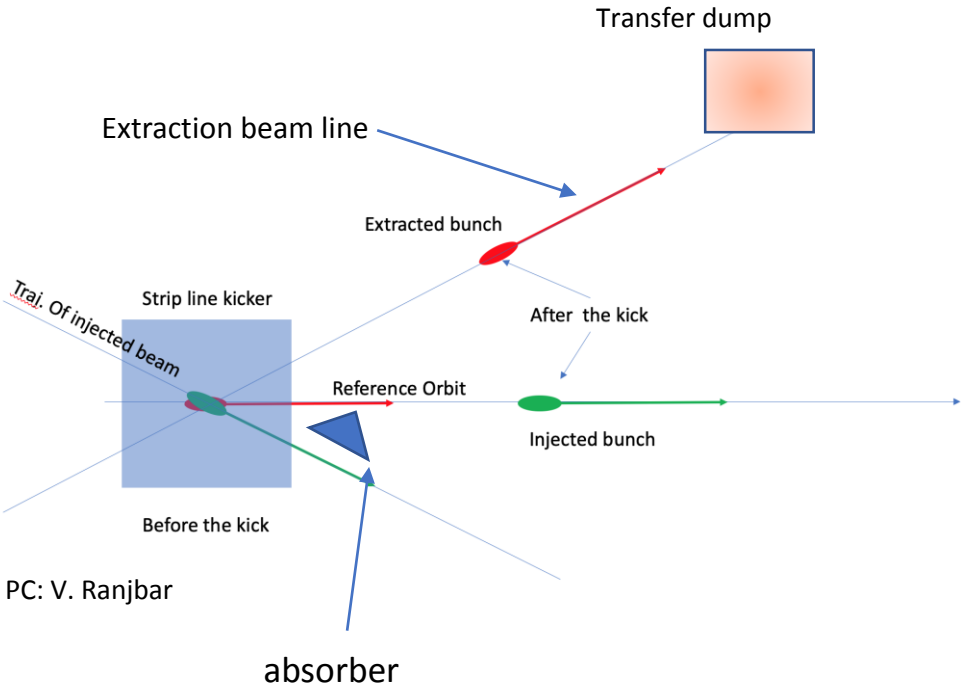
- 1 Hz cycle, fast ramping, only 2 bunches circulating at a time, transfer into the ESR at IR12
- Dedicated MPS abort system needed
  - Need to prevent e-beam hitting components at normal angle
  - Grazing angles not a problem but failures should inhibit the RCS-ESR injection cycle
- MPS/abort reaction time determined by:
  - Insertion devices (beam instrumentation or vacuum valves etc.)
  - Drop of bending field (ps failures etc.)
  - a few 10 ms
- MPS monitoring needed for insertion devices, vacuum, bending magnets
- No dedicated dump required

ESR

- Variety of lattices: 5 GeV, 10 GeV and 18 GeV operation
- High beam current: up to 1160 bunches, 17 10^{10} e/bunch (@10 GeV), 2.5 A total
- small emittance beam (20/1.2) nm (H/V)

  - Need a flexible collimation system to support variety of lattices
    - protect accelerator components
    - and EIC detectors
  - 2-stage system, with low density primary collimators
    - First step: need to be placed in the beam lines/lattices ✓
  - Need MPS
  - Need dumps for
    - transfer (1 Hz, 2 bunches at a time), location IR12
    - AND abort dump, location TBD

RCS to ESR transfer



- Crotch absorber needed to protect from potential kicker failure
- Transfer dump for 2 bunches, 1 Hz
- Transfer line to dilute beam sizes upstream of dump

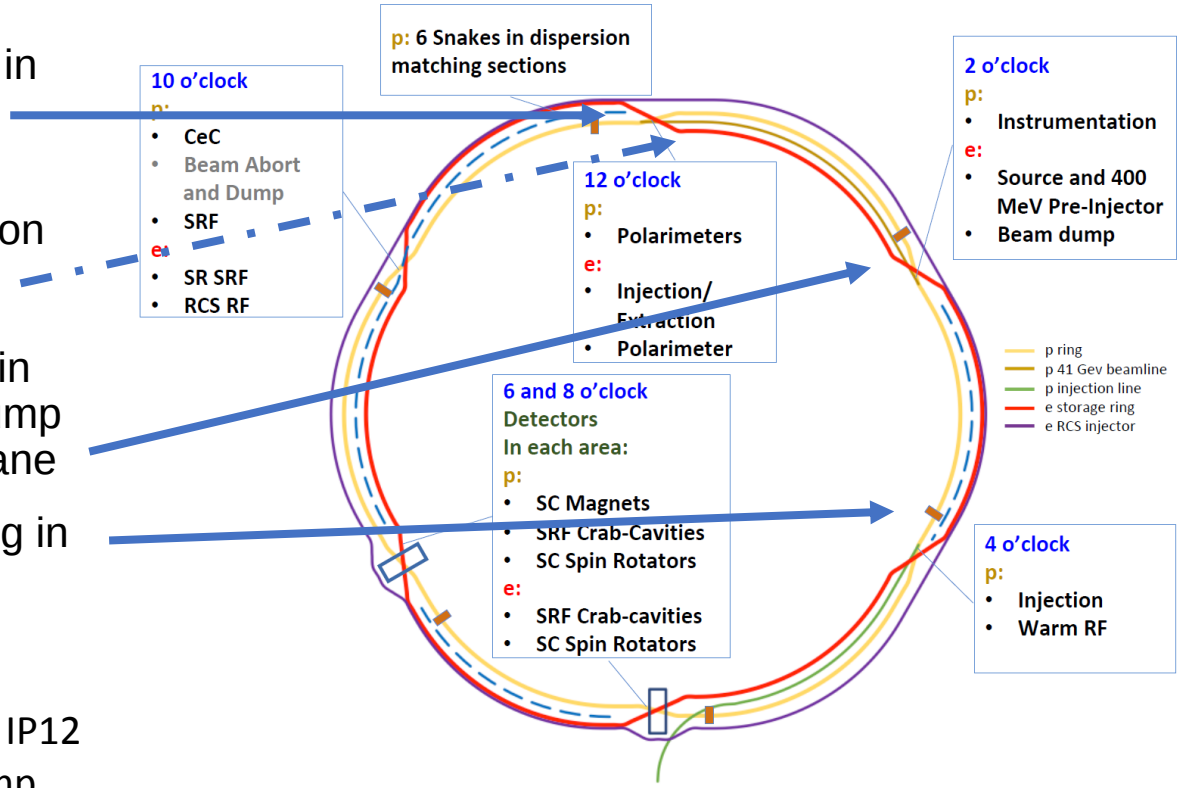
ESR MPS and abort

- Input:
  - BPMs
  - BLMs
  - Beam current
  - Vacuum, valves
  - Magnet current
  - PS
  - EIC detector background
  - RF
  - Other
- Potential for collaboration: dedicated instrumentation (fast BLMs, diamond LM …)

- Reaction time: several revolutions (tens of μs)
- Remove entire beam in one turn
- Abort kickers
- Needs dedicated extraction line to blow up beam size
- Dump is only needed for emergency aborts
- Absorber to protect from kicker failure
- Location: TBD

ESR: summary of proposed collimators & dumps

- Vertical collimation in IR12 upstream of injection
- Horizontal collimation downstream of injection (not ideal with dispersion) or in IR2 upstream of dump in the horizontal plane
- Momentum cleaning in IR4



Abort & dump:

- Transfer dump: IP12
- Emergency dump (abort): necessary, but no location yet (tbd)

Phase advance from injection => x coll => experiment might have to be reviewed for new releases of optics

Hadrons: HSR

- Variety of lattices: 41 GeV – 275 GeV
  - 41 GeV operation might require duplication of some collimators
- Operation with a radial shift
- High intensity: 7 10^{10} p/bunch, up to 1160 bunches, 1 A total
- Smaller than RHIC emittances (9.6/1.5) nm (H/V)
- Existing RHIC systems for collimation, dump and MPS

HSR collimators

Betatron collimators

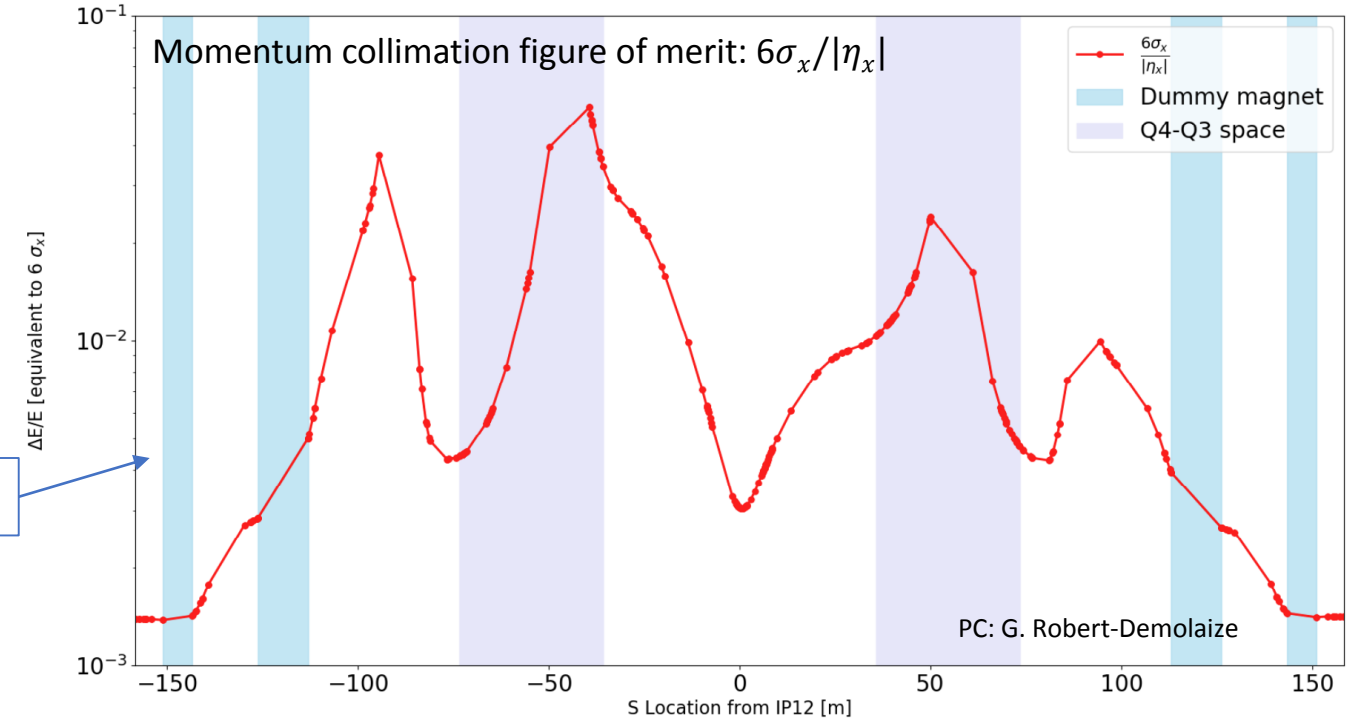
- Needed for machine protection as well as detector background, ramp collimation, transition crossing
  - Existing RHIC system is not suitable
  - Needs redesign and relocation
  - 2-stage system
  - Growing β fct from primaries to secondaries
  - IR12 location chosen
  - Exact placement may need several iterations
  - Tracking and code bench marking ongoing effort -> collaborative effort?
  - Radiation shielding at new location needs to be addressed
  - Mechanical design and radiation shielding could be collaborative effort

Momentum collimators

- Needed for ramp development and commissioning
- Debunched beam (HI), recombined ions and radial shift operation
- RHIC has no momentum collimator:
  - New design needed
  - 1 stage only
- The only suitable location is inside a cryostat and will need a cryo-bypass

HSR momentum collimator

- Momentum collimators need
  - large dispersion
  - small beta
  - Warm area outside cryostat (not readily available)



D9 half cell

HSR MPS and abort

MPS

- Existing system needs to be updated
- Input (existing):
  - BLMs: 20 y old
  - BPMs (BPM MPS system is currently upgraded and tested for EIC purposes)
  - Vacuum
  - RF
  - Corrector supplies
  - Quench detection
  - Detector magnets
- Input (to be added):
  - All PS
  - dedicated fast BLMs, bunch by bunch signals, abort gap beam, EIC detector backgrounds etc.
  - Dedicated instrumentation (detector and accelerator) could be a collaborative effort

Abort & dump

- Existing system at IP10 needs upgrade
- RHIC has had ”pre-fire” issues, i.e. asynchronous spontaneous firing of 1(5) abort modules (with detrimental effect for detectors and magnets)
- One potential solution (serial mechanical switches) is currently under testing in RHIC but might not be good enough for EIC
- Studying other solutions (solid state?) could be a collaborative effort
- Radiation shielding of the existing dump needs to be verified and perhaps upgraded -> collaborative effort possible

Summary

Ring	β Collimators	mom. collimators	MPS	Dump/abort
RCS	tbd If required for clean transfer into the ESR	No	Yes	No Tens of ms, no dedicated dump/abort area (spread beam along beam pipe)
ESR	Yes MPS, exp. Background Location: IR2, IR12	Yes IR4	Yes	dump: transfer (2 Hz, IR12) Abort: fast (one turn), location tbd Extraction line for abort
HSR	Yes Transition crossing, ramp collimation, MPS, exp. Background IR12	Yes Ramping Exp. Bkgd. D9 half-cell IR12	Yes	Yes Dump & abort: fast (one turn), trigger time as in RHIC, same dump for aborts and regular store ends, sector 9 side of IR10 (existing RHIC yellow dump)