Why Consider a Toroid Spectrometer Built Around Existing Hardware?

Potentially a cleaver / faster / cheaper solution for going after “some” of the physics than the proposed ~50 M$s “wish list” worth of post upgrade hardware?

+ Using G^0 toroid in a “Qweak” style focusing geometry may have lower backgrounds – as the target is upstream and can be shielded and collimated to an arbitrarily high level. No activation of magnet issues (no iron!)

+ Suitable power supply exists (I am told) in JLab storage.

+ Fe free Toroid(s) can easily operate in either polarity (in- or out-focus) depending on measurement needs with no hysteresis issues.

+ Target to magnet distance can be varied straightforwardly depending on measurement acceptance / kinematics requirements.

Why Consider a Toroid Spectrometer Built Around Existing Hardware?

+ No polarization of the targets in PVDIS or other PV measurements. No magnetic forces on the target assembly. Qweak target system (LH_2, LD_2, Solid targets) can probably be reused!

+ Core sub-systems 100% separated in Z (not inside each other). Makes assembly / tolerances and maintenance much easier.

+ Much more room for detectors allowing use of conservative lower technology (cheaper) systems. Also, much easier to reconfigure.

+ Detectors should be better intrinsically protected from backgrounds because of distance, collimation and magnetic field between them and the target.

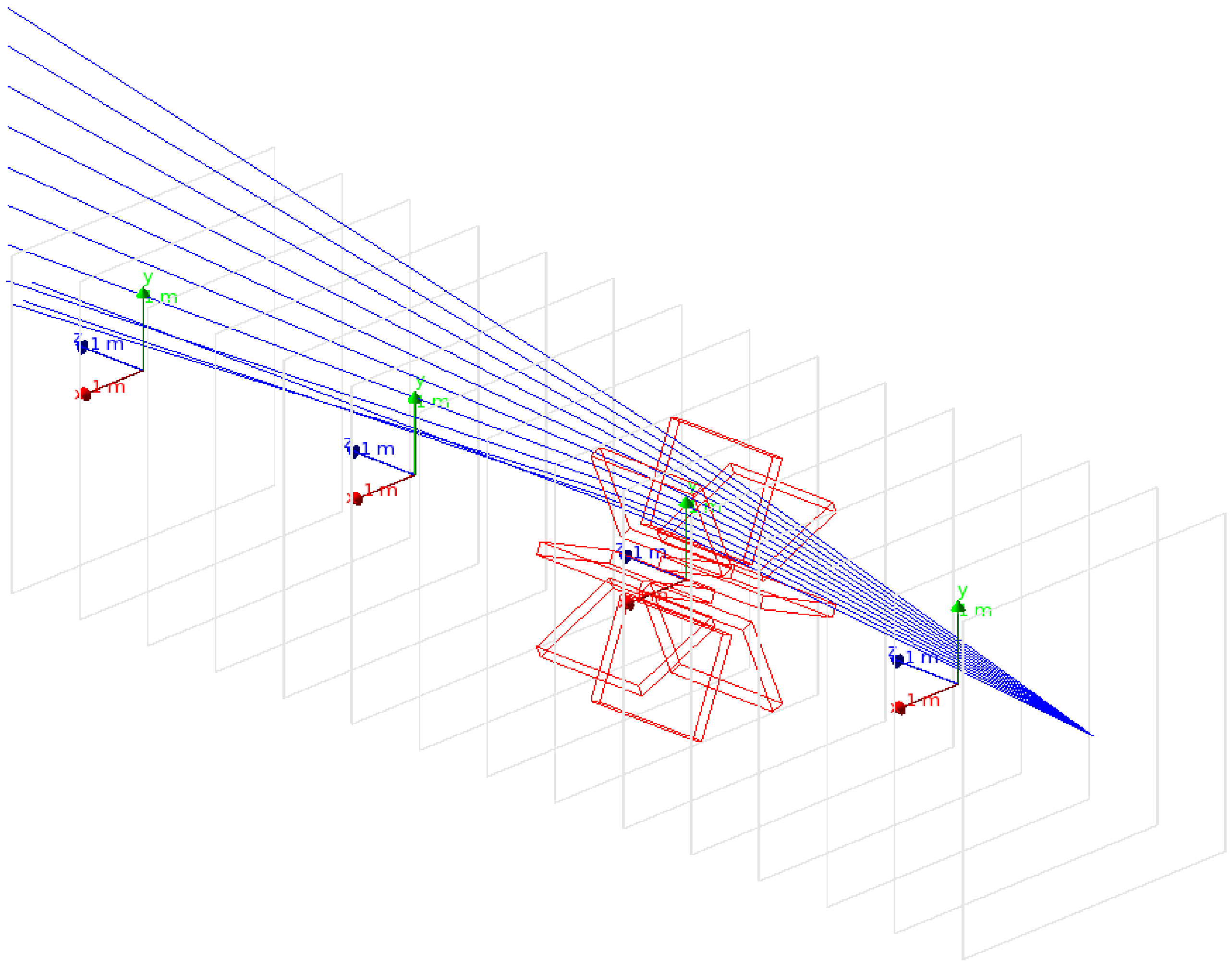
Why Consider a Toroid Spectrometer Built Around Existing Hardware?

- Require some rework of the G^0 superconducting magnet (believe this should be straightforward). Move an internal cryo-line and put exit windows on the downstream side. Needs to be investigated further!

- Field limitations will reduce the accessible physics phase space.

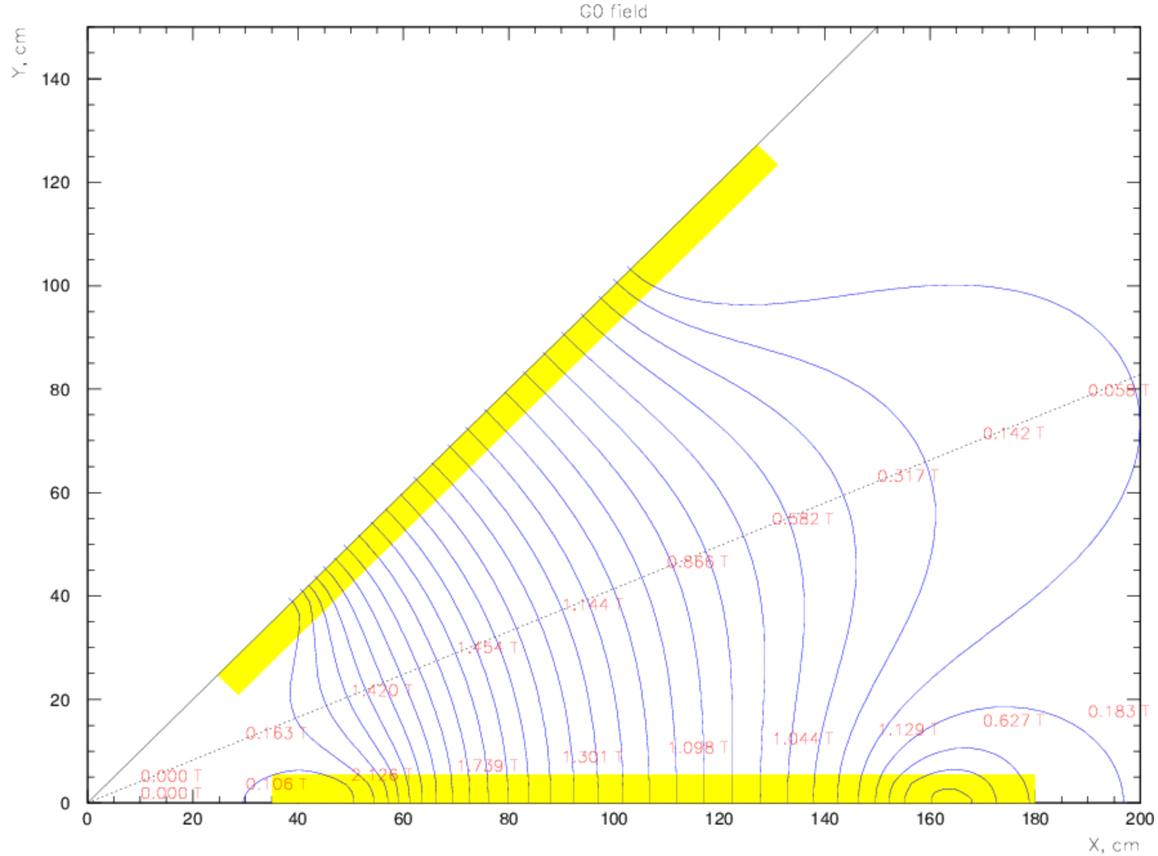
++ Potentially a fraction of the cost / construction time of “wish list” hardware.

Exploration of Ideas for a “New” Toroidal Spectrometer



Idle Thought: What if we re-use G^0 Superconducting Toroid?

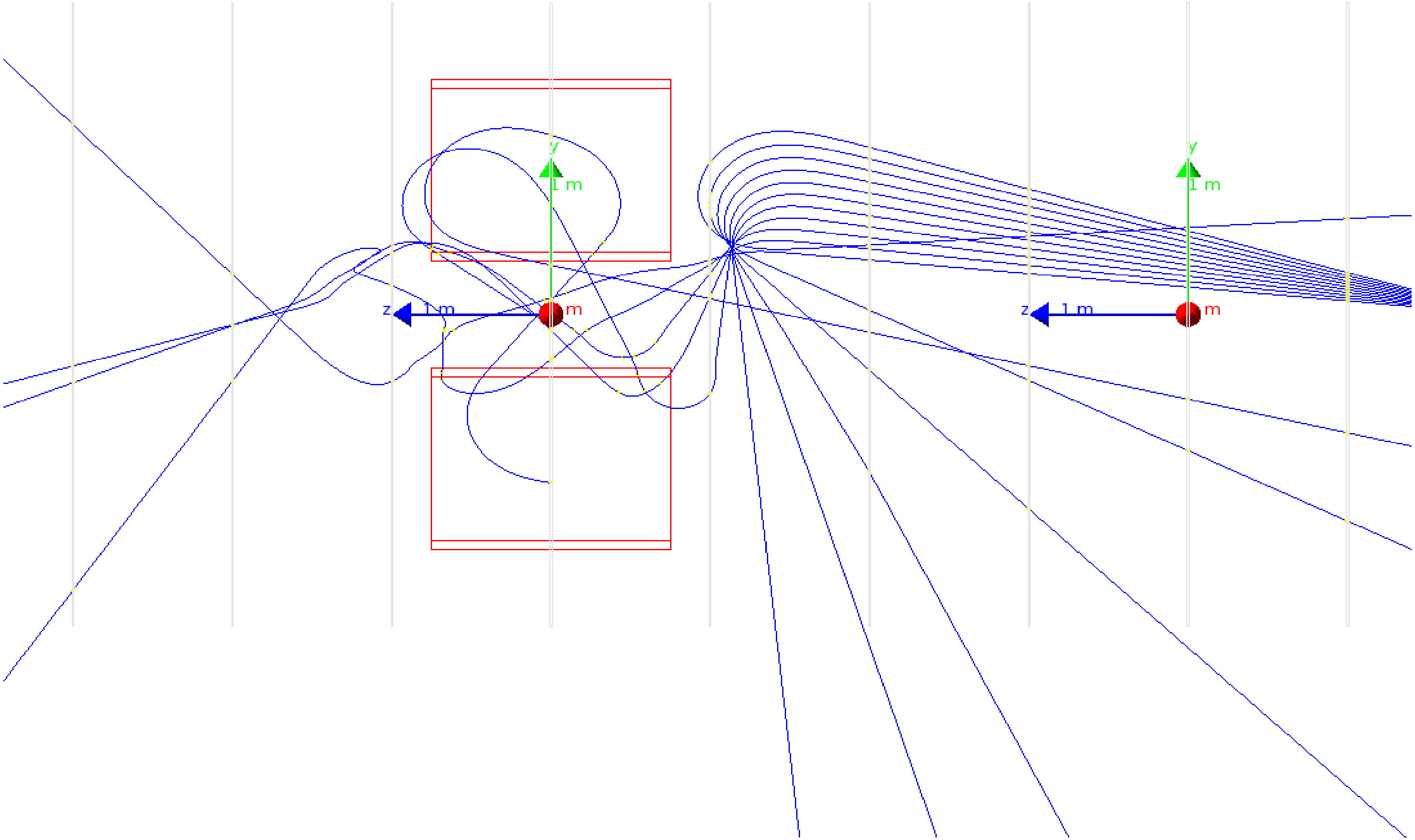
Parameter	G0
Number of coils	8
Full current along Z at R=0.4 m	5.76 MA
Full current along Z at R=1.5 m	5.76 MA
Superconductor cable	20 strands
Cross section of the copper support cable	20×5 mm²
Current density	5000 A/cm²
Cable layers per coil	4
Coil cross section, at R=0.4 m	8×18 cm²
Full coil thickness in φ	15 cm
B_φ at ≅0.4 m	1.44 T
B_φ at 1.5 m	0.77 T
B_{max}	-
Full current density dI/dR at R=0.4-1.5 m	none
Cables per unit length in R, at R=0.4-1.5 m	none
Coil cross section, at R_{max}≅1.5 m	8×18 cm²
Full number of turs per coil	-
Stored energy, MJ	7.6



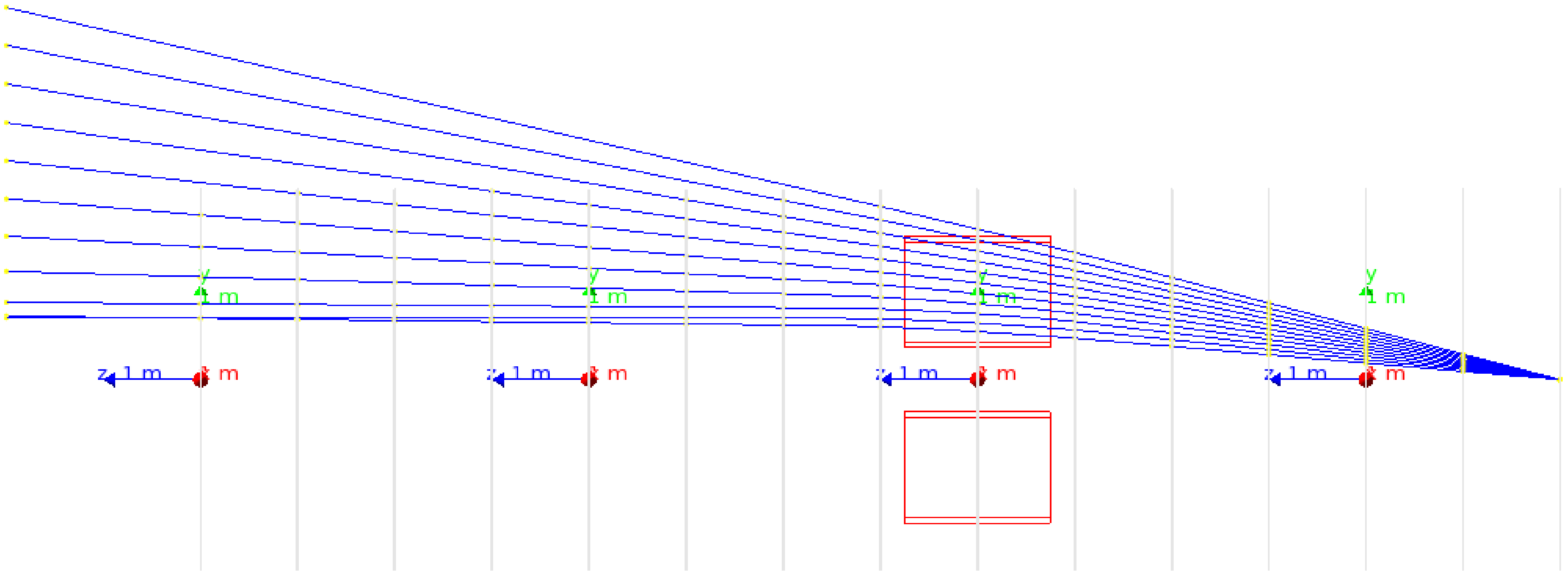
* From Eugene Chudakov's 2008 study:
https://userweb.jlab.org/~gen/jlab12gev/tor_sim/

What can this magnet do with a doubled beam energy?

150—200 MeV particles bounce



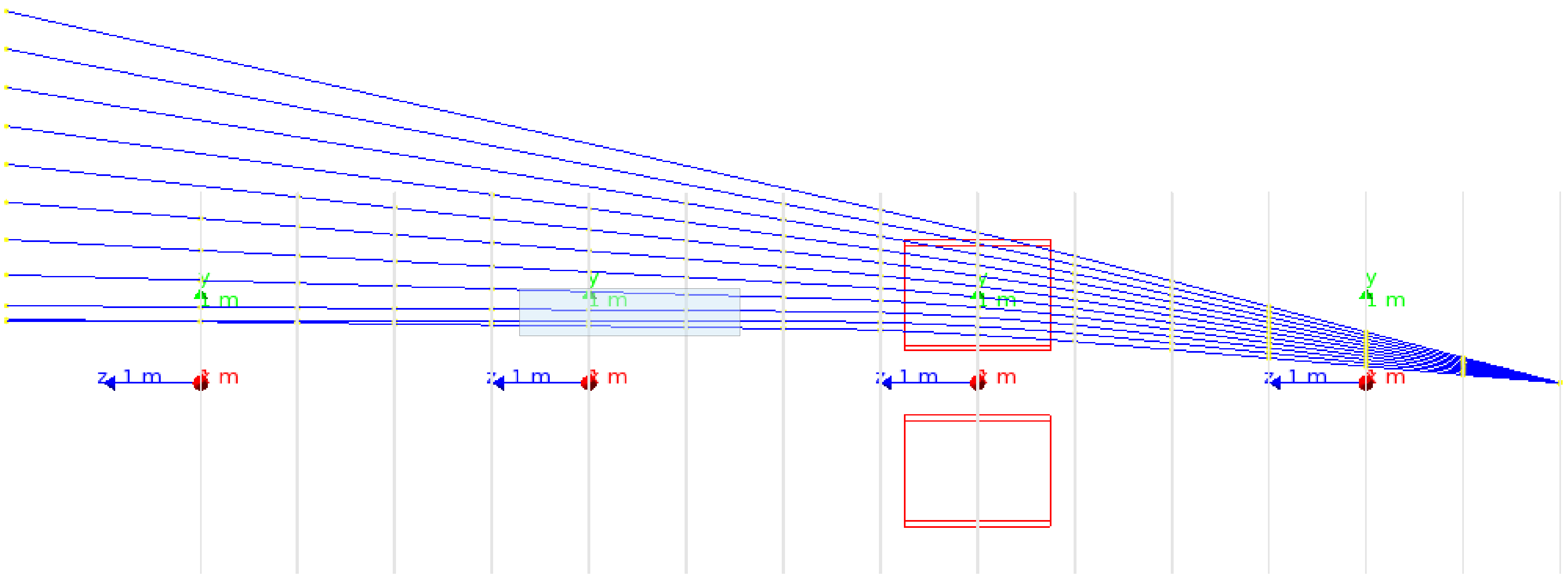
11 GeV/c, 5—15º Tracks



Gray lines are fiducials at 1m intervals

Axes pictograms have arms 1m long

11 GeV/c, 5—15º Tracks

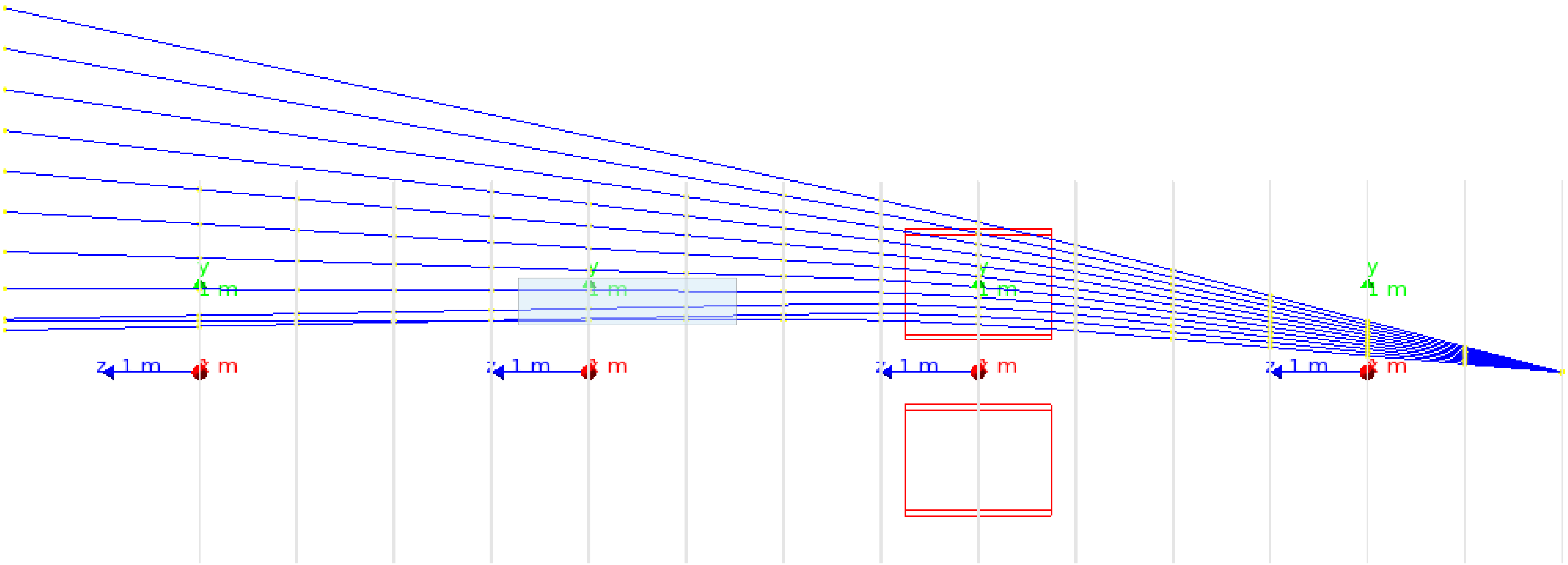


Gray lines are fiducials at 1m intervals

Axes pictograms have arms 1m long

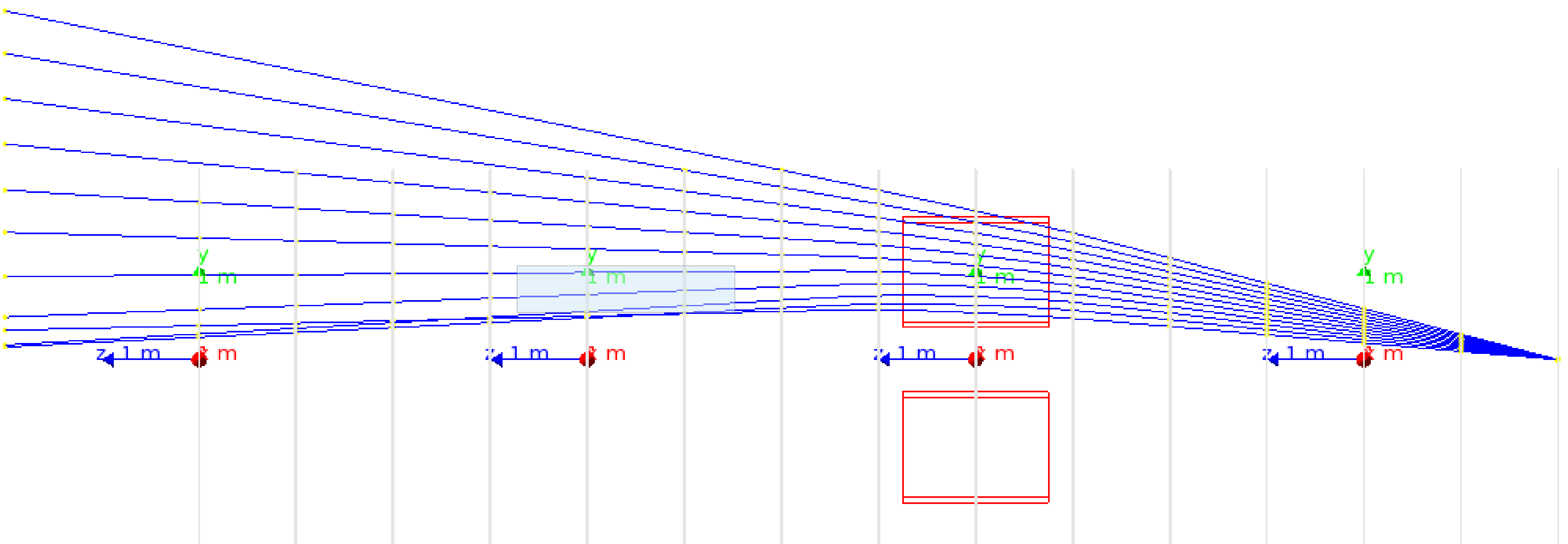
Each track corresponds to different theta.

9 GeV/c, 5—15º Tracks



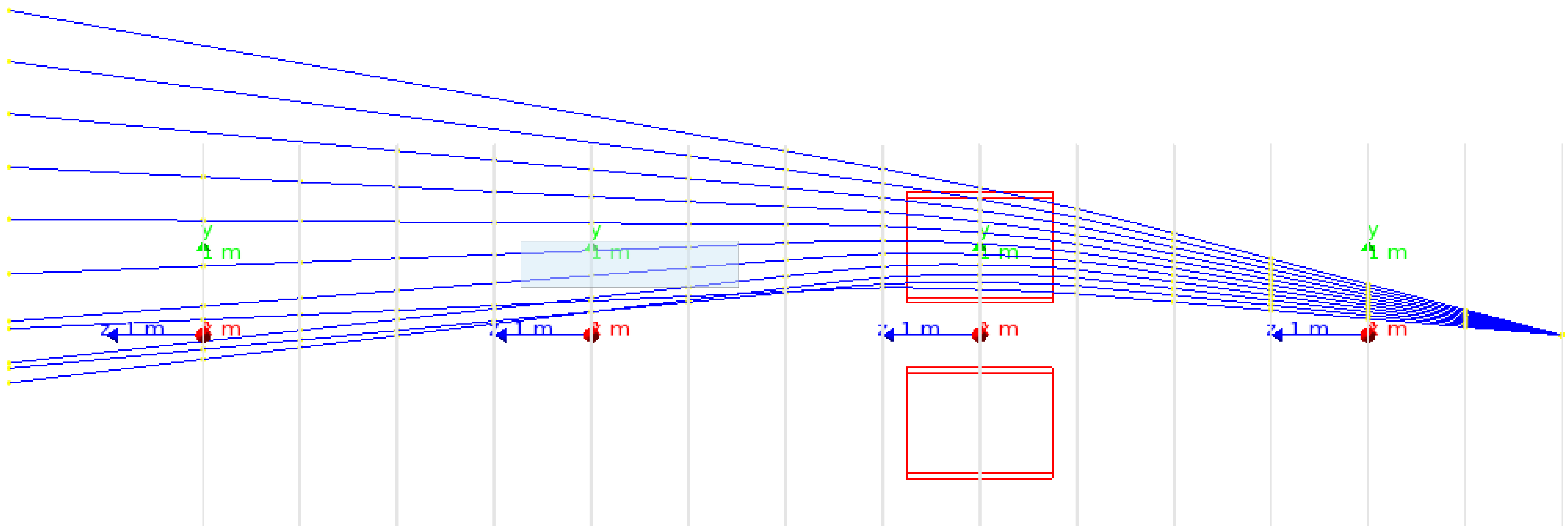
- Instrument near beamline (polar angle: 5—8º)
  - No line of sight to target

7 GeV/c, 5—15º Tracks



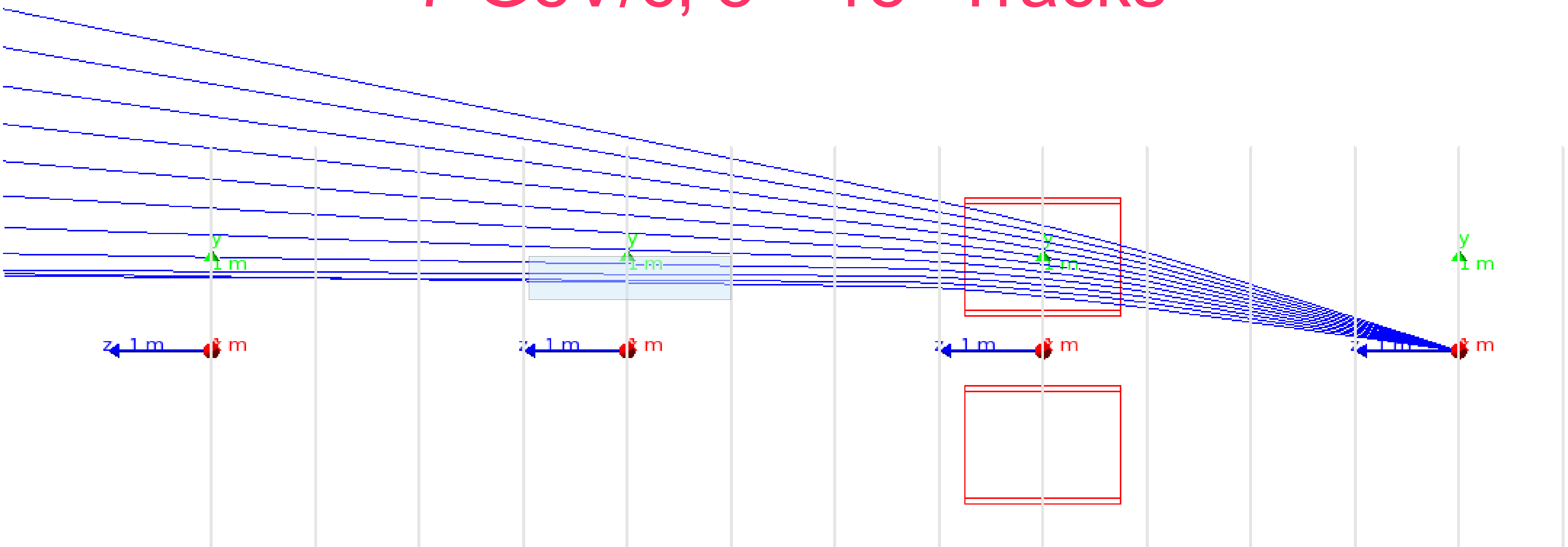
- Instrument near beamline (polar angle: 5—8º)
  - No line of sight to target

5 GeV/c, 5—15º Tracks



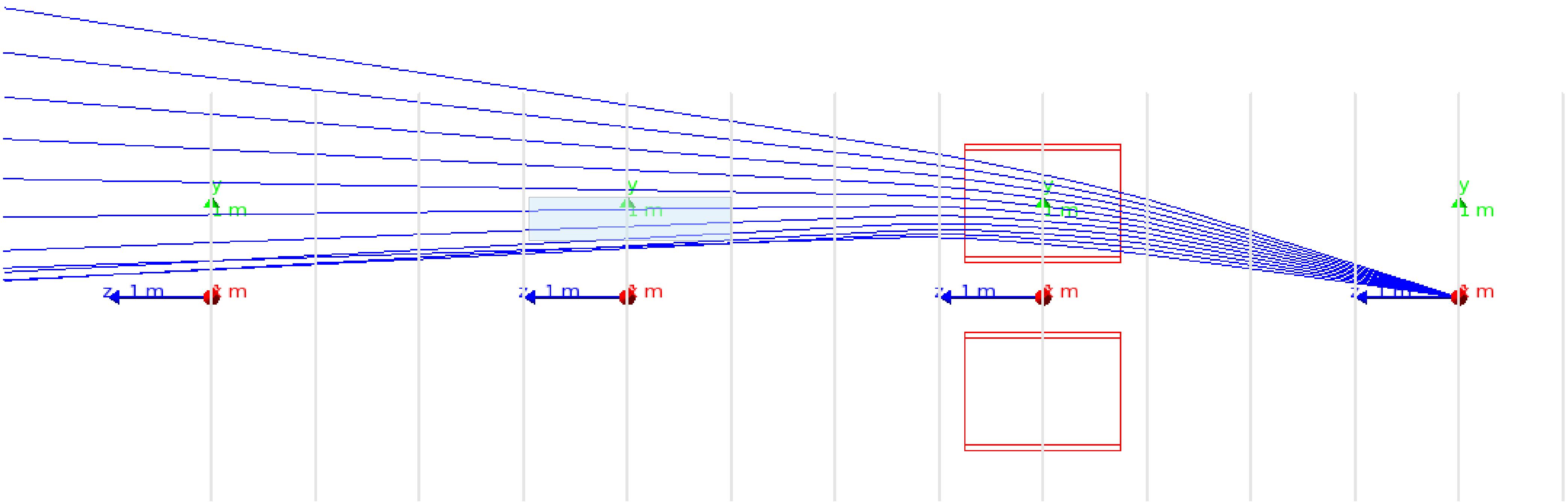
- Instrument near beamline (polar angle: 5—8º)
  - Bending through beamline at 5 GeV, dial back the magnet field (ie. different kinematic setting)

Move Magnet Closer to Target to Reach (somewhat) Larger Angles 7 GeV/c, 8—18º Tracks



- Instrument near beamline (polar angle: 8—11º)
  - No line of sight to target
  - Reduced momentum reach (not enough Bdl to bend higher momentum particles)

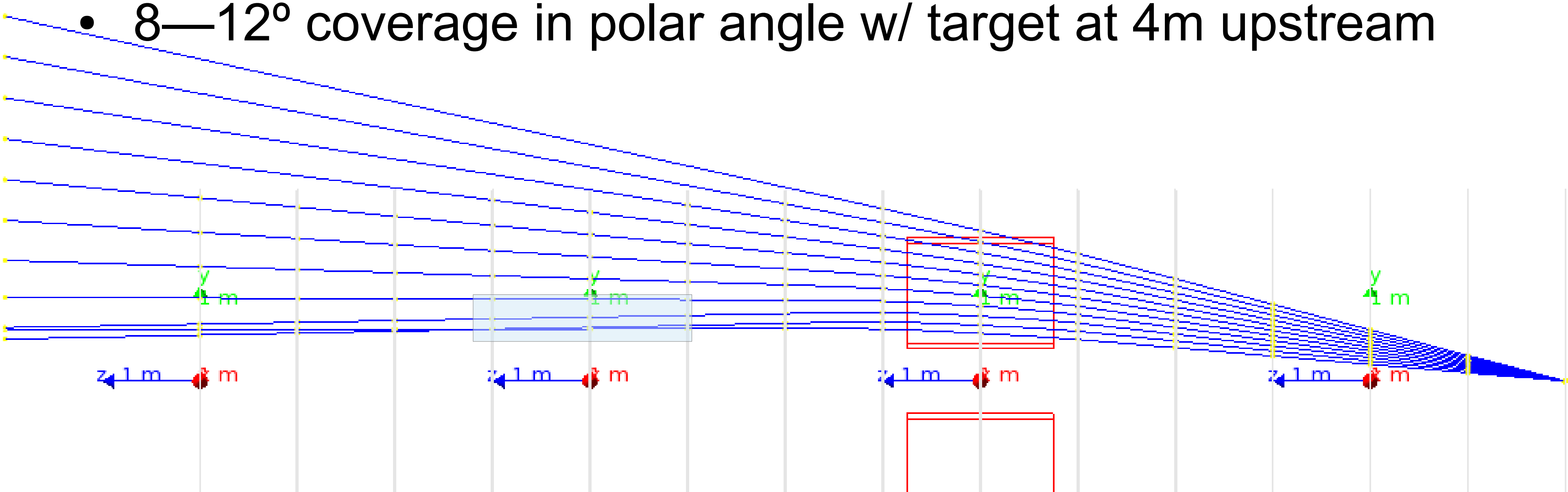
Move Magnet Closer to Target to Reach (somewhat) Larger Angles 7 GeV/c, 8—18º Tracks



- Instrument near beamline (polar angle: 8—11º)
  - No line of sight to target
  - Reduced momentum reach (not enough Bdl to bend higher momentum particles)

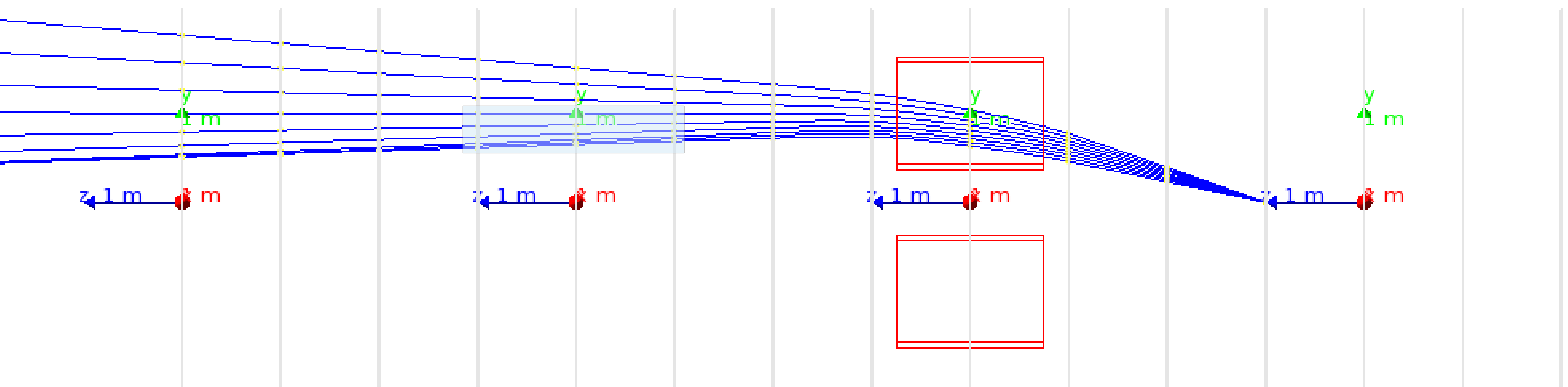
Possible Applications?

- High-energy, "High" luminosity
  - bend-in mode
  - 7—11 GeV momentum bite with highest field
  - no line-of-sight to the target
  - detectors well downstream, "Q-weak" like collimation
- 5 — 8º coverage in polar angle w/ target at 6m upstream
- 8—12º coverage in polar angle w/ target at 4m upstream



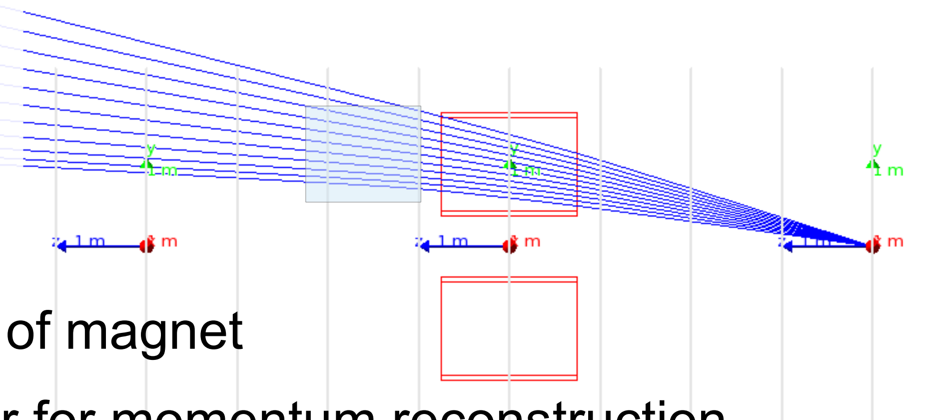
Possible Applications?

- Low-energy, "High" luminosity
  - bend-in mode
  - no line-of-sight to the target
  - detectors well downstream, "Q-weak" like collimation
- 11—17° coverage in polar angle w/ target at 3m upstream, and E' < 4 GeV

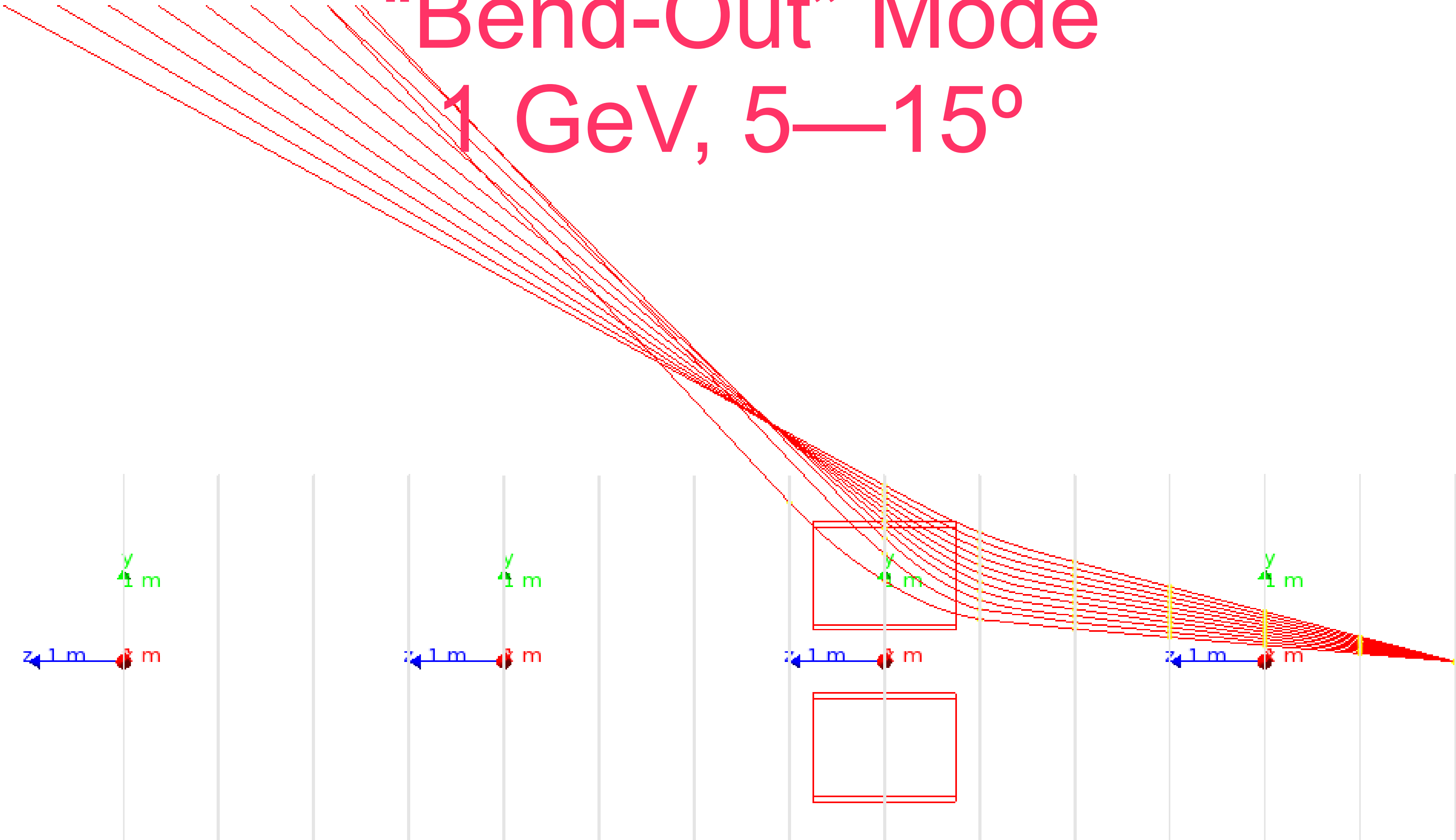


Possible Applications?

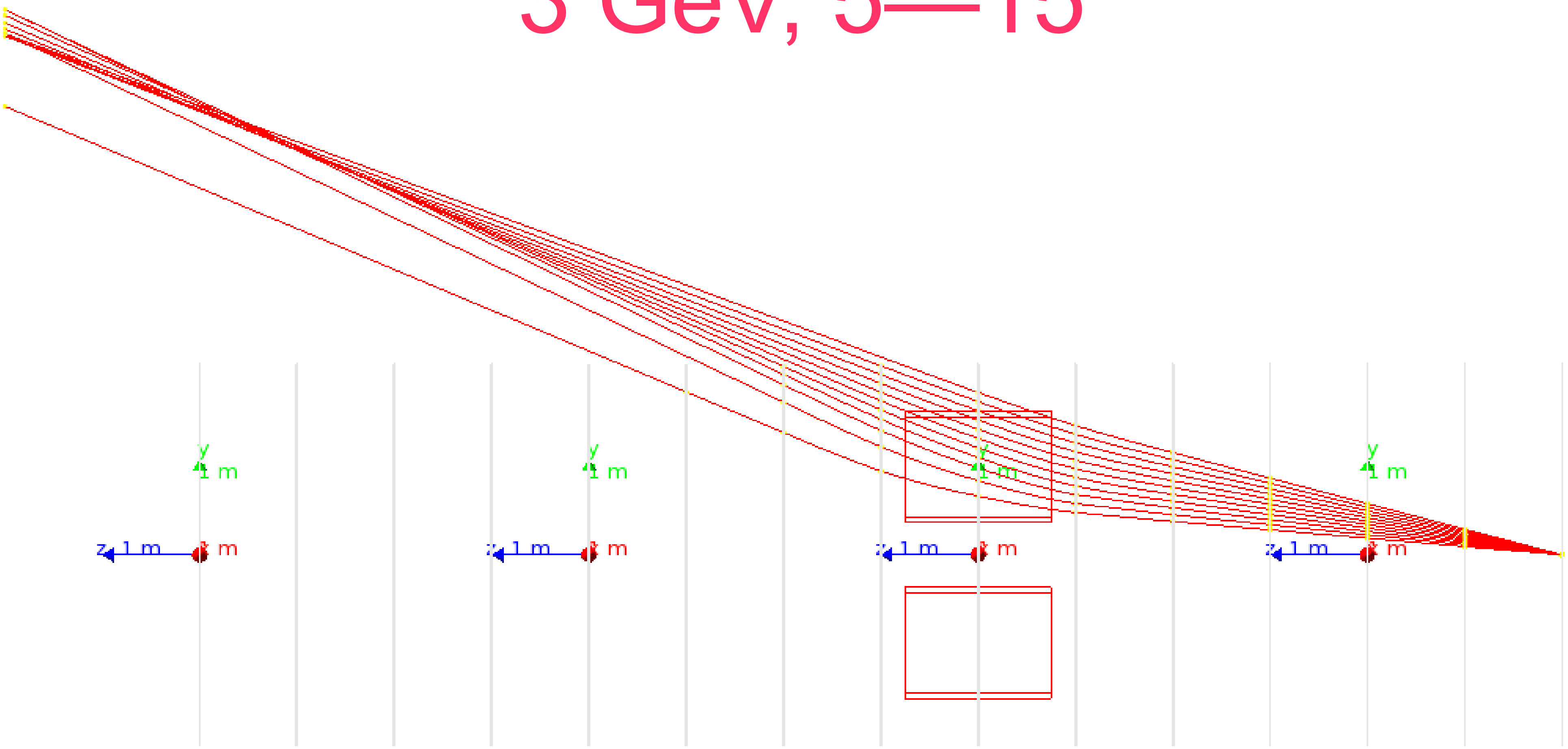
- Medium—High energy, large acceptance, modest luminosity (mid 10^{35} range")
  - ie. "6 GeV BigBite x 8"   "*OctoBite*"
  - bend-in mode
  - instrument detectors just downstream of magnet
    - would really want a forward tracker for momentum reconstruction
  - there <u>will</u> be a line-of-sight to the target
    - field is there to analyze momentum (event-mode tracking), and to bounce < 200 MeV charged background
  - SIDIS "modes" (ie. Transversity acceptances seems "doable")
    - single device configuration (multi-sector coincidence)
    - G0 magnet could be placed reasonably far downstream to make room for second arm: SHMS, BETA, LAD, (S).BigBite, ???
  - Inclusive (d_2, g_2, ...) may be feasible too



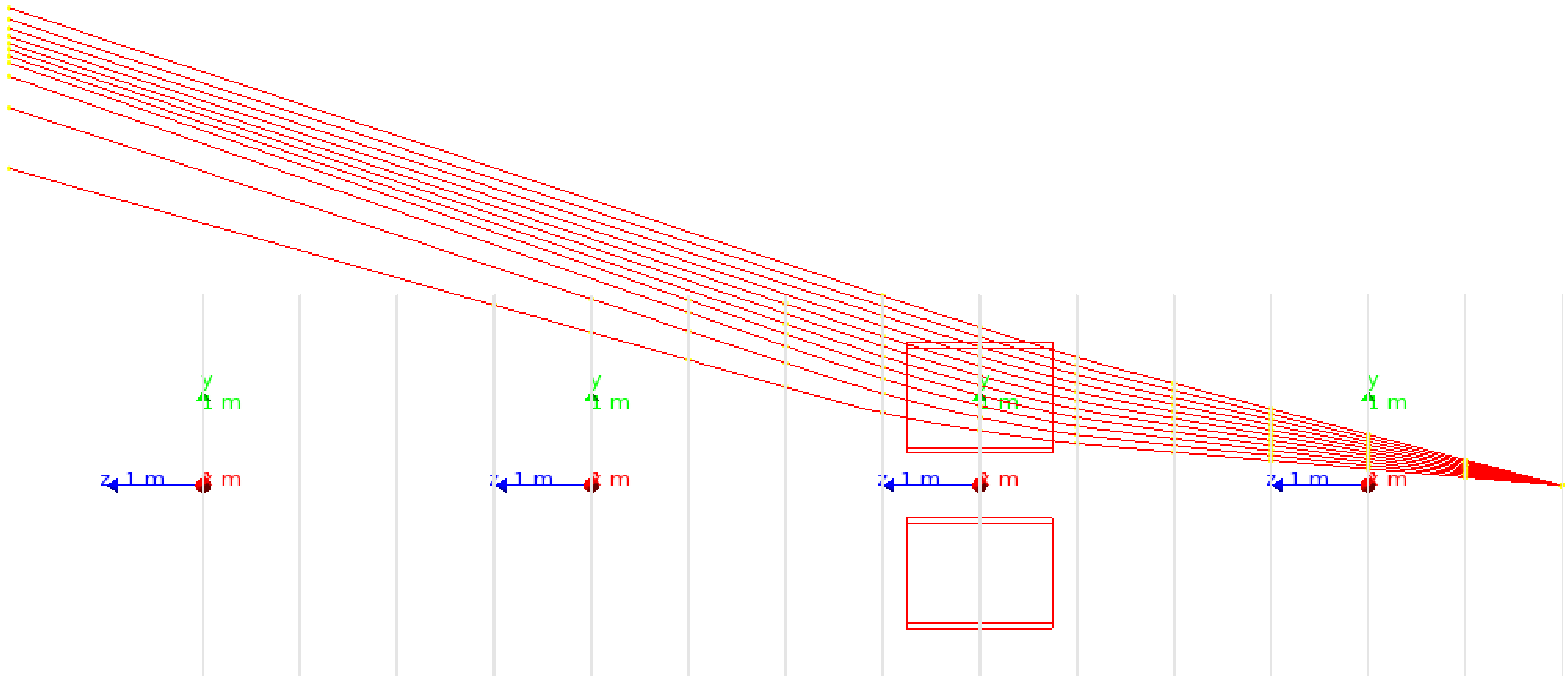
“Bend-Out” Mode
1 GeV, 5—15°



"Bend-Out" Mode
3 GeV, 5—15º

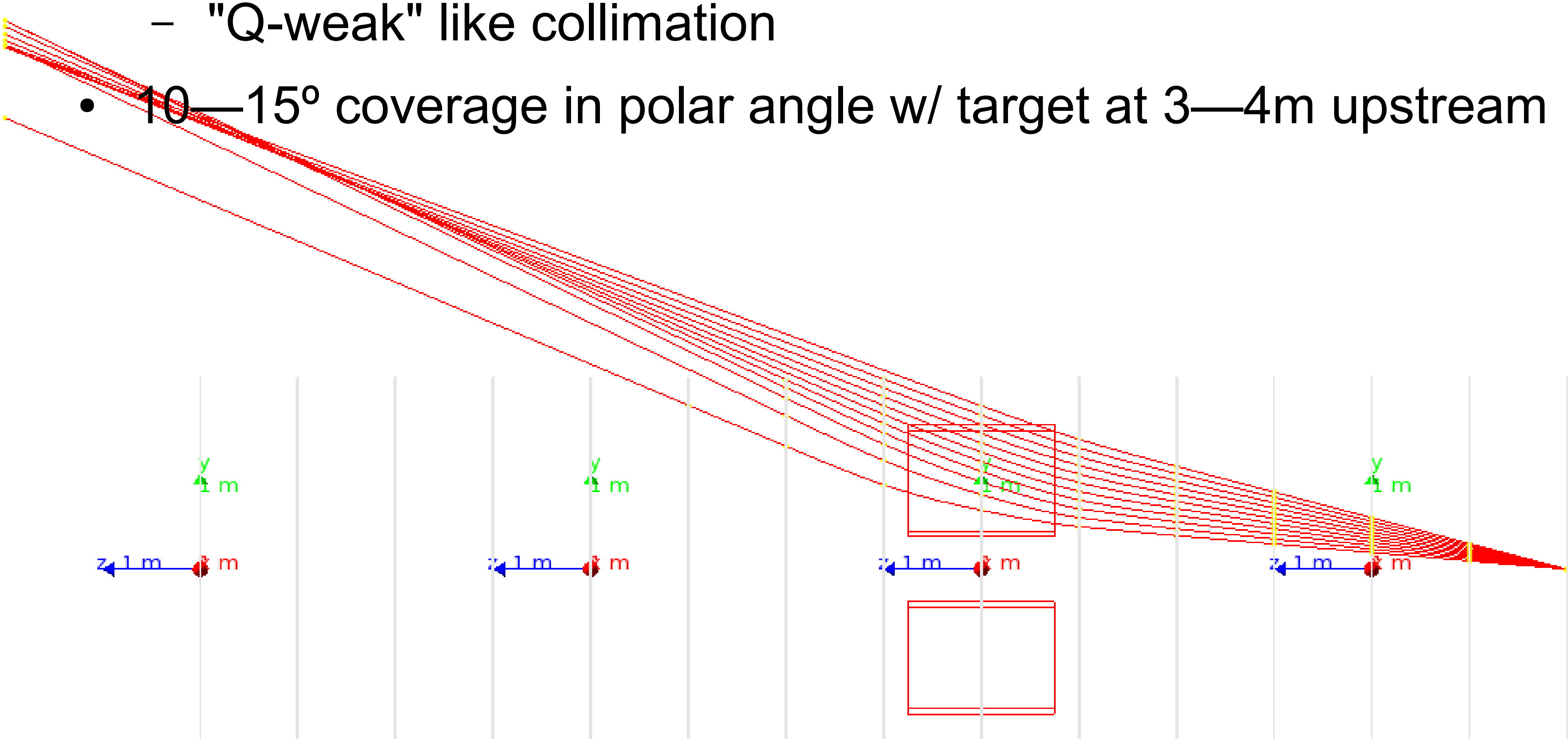


“Bend-Out” Mode
5 GeV, 5—15°

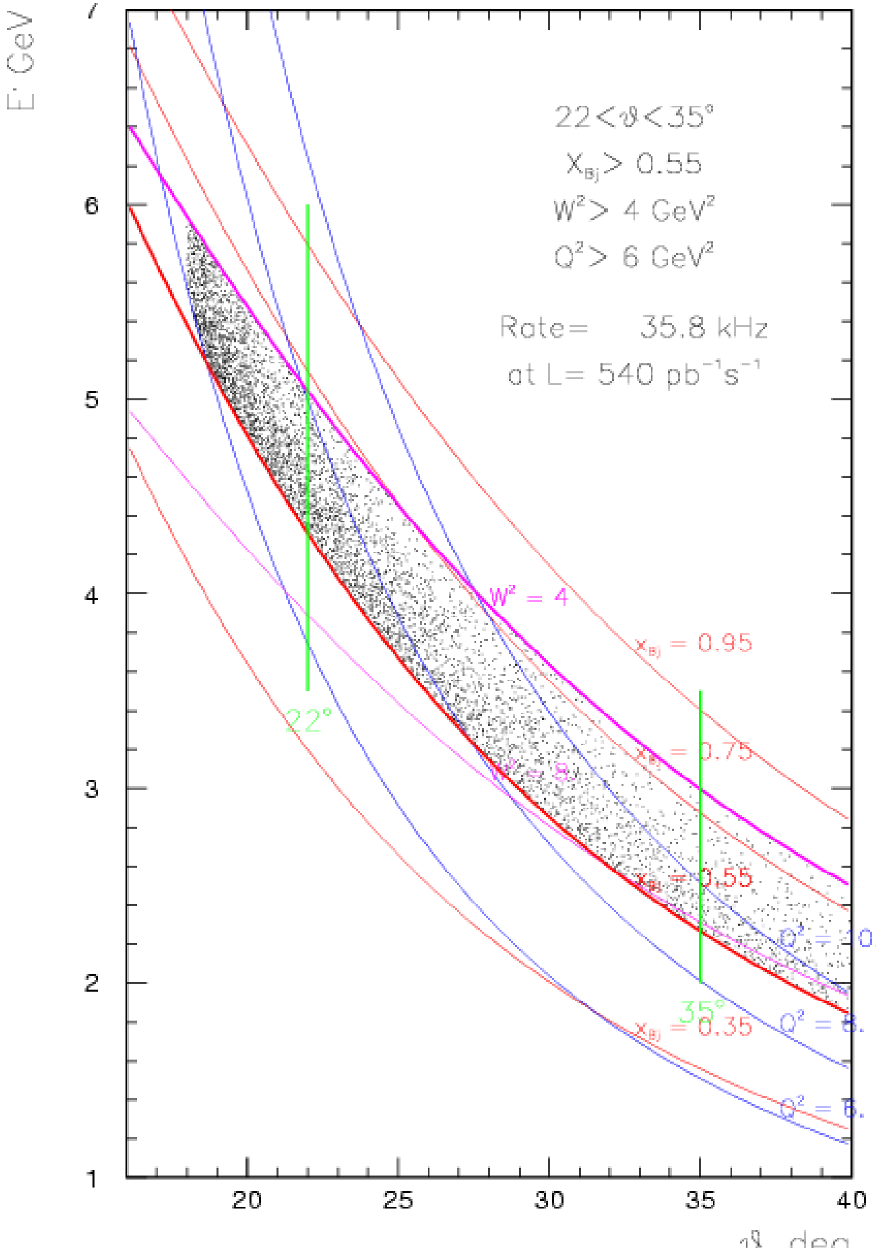


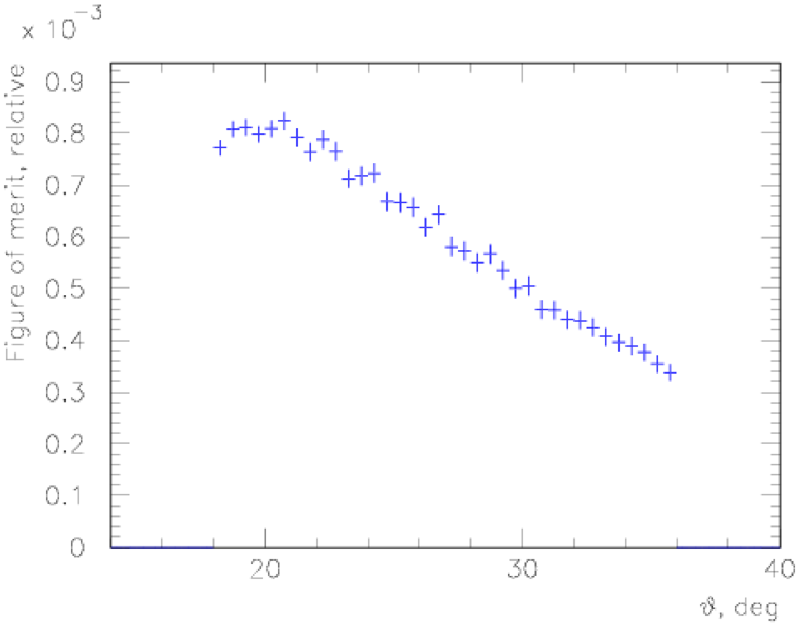
Possible Applications for “Bend-Out”?

- Low/Mid-energy, "High" luminosity
  - No line-of-sight to the target
  - Nice momentum focus can be obtained for E <= 3 GeV
  - "Q-weak" like collimation
- 10—15º coverage in polar angle w/ target at 3—4m upstream



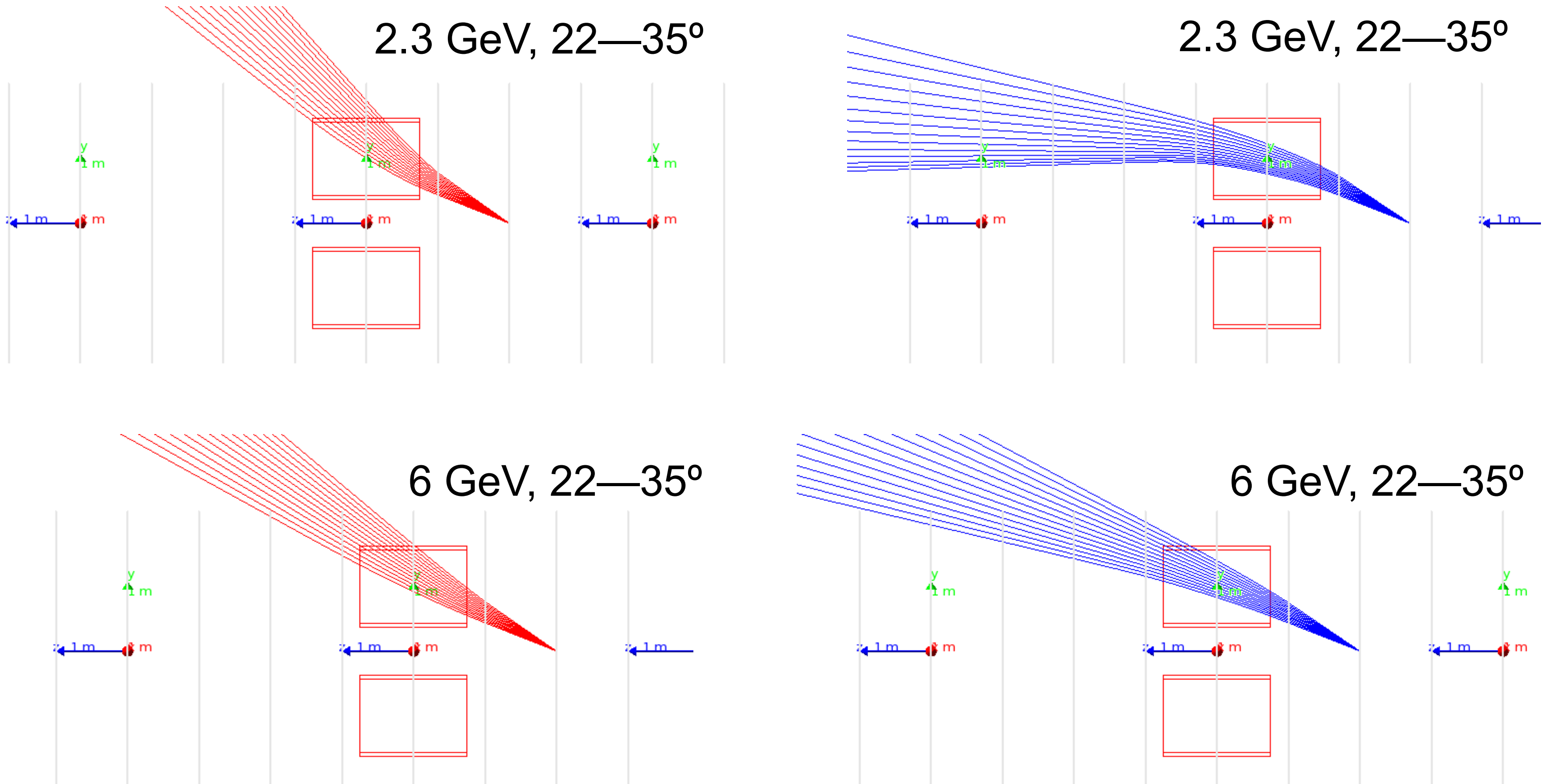
PVDIS • SOLID kinematics





- Figure of merit rises as you go to forward angles, BUT so does backgrounds
- Proposed SOLID luminosity: 10^{38}
  - kinematic selection for SOLID and 2008 Chudakov study shown on left

PVDIS • SOLID kinematics



- Low momentum side OK, can shield away target
- High momentum not so good
  - Would need to revisit kinematics and evaluate acceptances better suited to this device...

Issues / Open Questions

- Backgrounds, backgrounds, backgrounds
  - All the usual stuff, plus keep in mind that low-E charged particles will want to cross through beamline and striking detectors at phi+180
  - Shielding options
    - collimation, lintels (ie. Qweak), etc
  - forward tracker requirements
  - feasibility of instrumenting near beamline (R ~ 50cm) downstream of target
- Real acceptances targeted at specific physics
  - actual G0 magnet apertures need to be established
  - extended target acceptances not addressed
    - and one or two other "details" ... <cough>cost?<cough>
- *Crazier ideas:*
  - stack G0 magnet with QTOR for more BdL
  - use QTOR as a low-enegy sweep magnet?