Crossing angle @ the EIC

YR Integration / Complementarity WG meeting   October 21, 2020

Topics

- Accelerator:
  - Crab crossing: why is it needed and how is it implemented (Christoph)
  - Solenoid field compensation for the hadron beam (Vasiliy)
  - Crossing angle and EIC IR magnet design challenges (Holger)

- Detector performance:
  - Case study #1: crossing angle and far forward detectors (Alex)
  - Case study #2: σ_p/p azimuthal asymmetry in the hadron endcap (Rey)

We assume ~10'+5' talks, with a few crystal-clear messages and a minimum of low-level technical details … and as many questions from the audience as needed, at any time

Slides are uploaded here: https://indico.bnl.gov/event/9887/

-> if this meeting format works, there are other topics to consider (like **picosecond timing for EIC**: bunch length, t_0 issues, time of flight prospects and why are they different in the forward / mid-rapidity / backward acceptances)

A pseudo-rapidity with a crossing angle "quiz"

HERA was an "easy" case: head-on ep-collisions, therefore a *unique* beam line axis in the laboratory frame

Pseudo-rapidity is kind of an artificial variable, but we obviously use it to quantify the detector acceptance (say [-4.0 .. 4.0]) -> would be great to agree on how we calculate it

- $\eta = -\ln(\tan(\theta/2))$, we all know this … but what is θ in the lab. frame?!
  - let's say η=-infinity is the *outgoing electron direction*; then what is the η=+infinity direction? Well, must be the *outgoing hadron direction,* right?

-> but then:

  - Is η calculation different on the left and on the right side with respect to the outgoing hadron beam line? And if yes, where is my continuous coverage from 0^0 to 180^0 in these two cases?
  - Is η=0 sitting at $\theta=90^0$, and if yes, with respect to which direction?
  - Does η calculation (and therefore η acceptance of the detector) depend on the *beam energy combination*? On the *scattered* particle momentum? Or perhaps even on its mass?

One practical example

- It is intuitively clear that one needs to find an "equivalent" head-on kinematic configuration in the lab. frame:
  - So take an (ep) initial system at some $\sqrt{s}$ in a 25mrad crossing configuration (and some secondary particle scattered at a small angle in either electron or hadron endcap direction), and:

boost to (ep) CMS → **rotate (align with the boost)** → **boost back**

Now the initial state particles are in a head-on collision configuration in the lab. frame, the secondary track 4-vector is also modified accordingly, and one can calculate η in a "usual" way

It turns out that for all practical purposes the η value in this *transformed (head-on) configuration* is indeed numerically very close to the one obtained via $\eta = -\ln(\tan(\theta/2))$ ansatz in the *initial (crossing angle) configuration* if one uses secondary track θ with respect to the (A) electron beam line direction in case of scattering in the the electron-going endcap, and θ with respect to the (B) hadron beam line direction in case of scattering in the hadron-going endcap