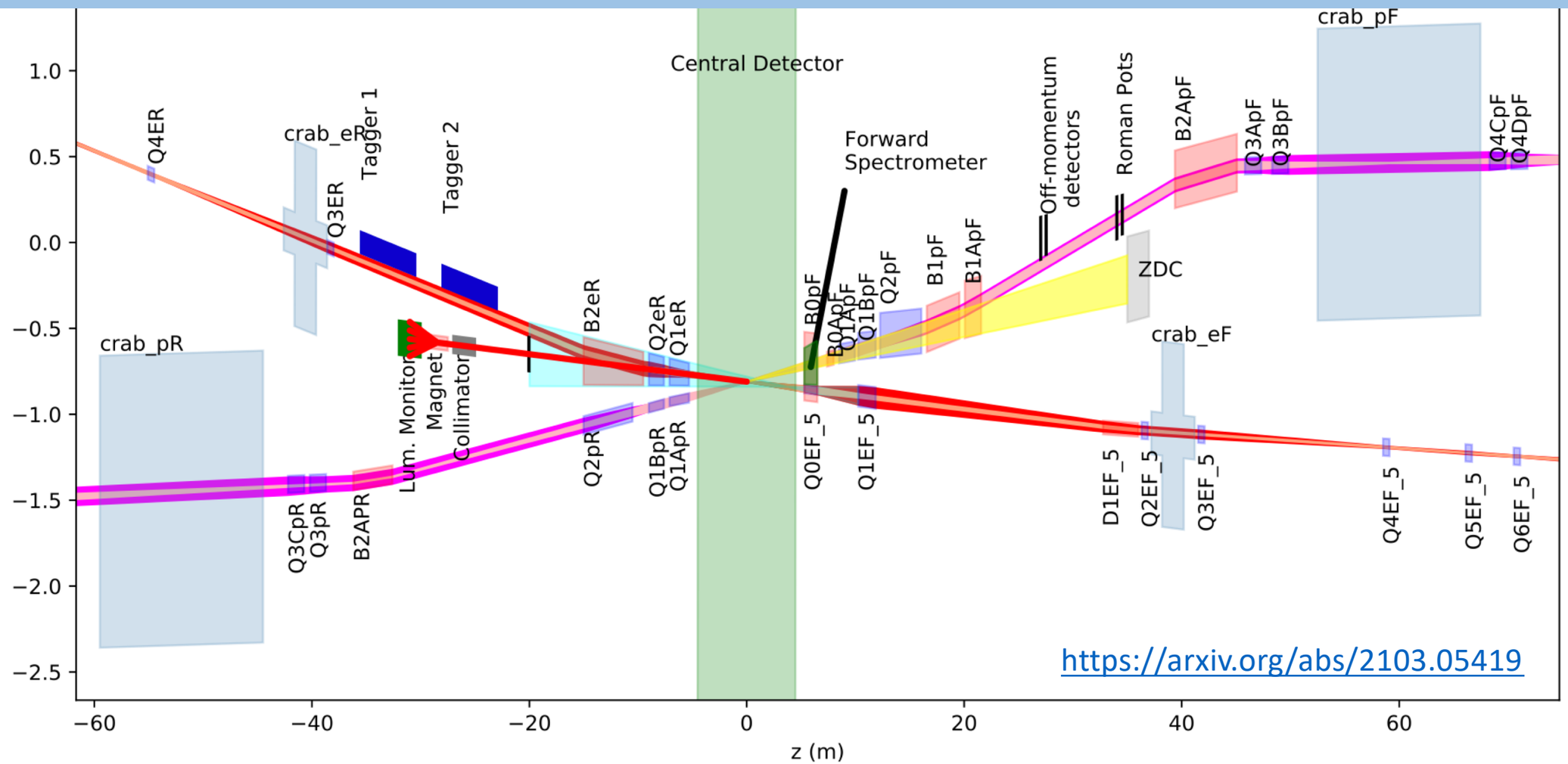
Welcome to the FarBackward Working Group:

Luminosity measurement and low-Q^2 tagging in ATHENA



https://arxiv.org/abs/2103.05419

Welcome to the FarBackward Working Group:

Luminosity measurement and low-Q^2 tagging in ATHENA

FarBackward WG kick-off

Wednesday 26 May 2021, 12:00 → 13:00 US/Eastern

Jaroslav Adam (BNL) , Krzysztof Piotrzkowski (UCLouvain & AGH UST)

Description Join ZoomGov Meeting
https://bnl.zoomgov.com/j/1606097140?pwd=bXpOOS95VGQzaExrOVVTbThlYW5Qdz09

Meeting ID: 160 609 7140
Passcode: 893548
One tap mobile
+16692545252,,1606097140#,,,,*893548# US (San Jose)
+16468287666,,1606097140#,,,,*893548# US (New York)

12:00 → 12:20 **Introduction and outlook** ¶
Speakers: Jaroslav Adam (BNL) , Krzysztof Piotrzkowski (UCLouvain & AGH UST)

12:20 → 12:40 **Discussion**

12:40 → 13:00 **Synchrotron radiation and design of beam-pipe exit windows**
Speaker: Charles Hetzel (BNL)

We will meet weekly, at noon BNL time on Wednesdays:

This is important not only for “formal” presentations and topical discussions but also to ensure proper information flow as well as just to keep in touch – our project is very challenging and we need to prepare a strong proposal in short time

https://lists.bnl.gov/mailman/listinfo/eic-ip6-det-back-l (17)

FarBackward WG: First four meetings

Our first three meetings on **May 26th, June 2nd and 9th** will be dedicated to gathering all “up-to-date” information about ”boundary conditions” for this project.

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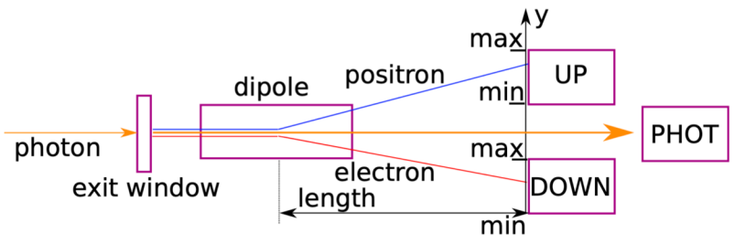
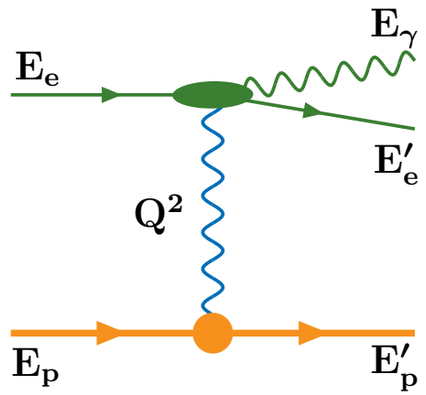


On June 16th we plan to hold a meeting where the outline of the Far-Backward project will be discussed and a very first workplan towards the FarBackward proposal presented



May 26:

Introduction

June 2:

Synchrotron radiation and beampipe design

Event pileup issues and mitigations

June 9:

Framework for the FarBackward simulations (fast vs. full MC)

Summary of the infrastructure/available space for our detectors

Short summary of first ideas regarding the “spectrometer dipole”

FarBackward WG: First organizational steps

FarBackward ATHENA detectors are very challenging and contributors to this project are very welcome – there are many important aspects to be covered!

Three candidates for representatives of the FarBackward WG to the ATHENA Proposal Group are proposed:

- Costing: Mariusz Przybycien (AGH)
- Integration: Jaroslav Adam (BNL)
- Editing: Krzysztof Piotrzkowski (AGH)

Open list of participants in various areas of the Far-Backward proposal

Integration with the EIC – J. Adam (BNL)

Electronics – Marek Idzik (AGH)

FarBackward system integration/technical coordination – Leszek Hajduk (IFJ)

Dipole magnet – NN (BNL), TBD

Spectrometer detectors – NN (BNL), TBD

Photon calorimeter – K. Piotrzkowski (AGH)

Tagging – Bill Schmidke (BNL) and K. Piotrzkowski (AGH)

Online data flow & processing – J. Adam (BNL) and K. Piotrzkowski (AGH)

Software – J. Adam (BNL), Janusz Chwastowski (IFJ) and M. Przybycien (AGH)

FarBackward WG: Luminosity measurement challenge

We plan to use the definition of a cross-section:

Event rate = Luminosity × σ

where colliding particles are represented by plane waves – but this *assumption* **breaks down** when **both** lateral beam sizes are comparable to relevant impact parameter in bremsstrahlung

⇒ *Beam-Size Effect* (BSE)

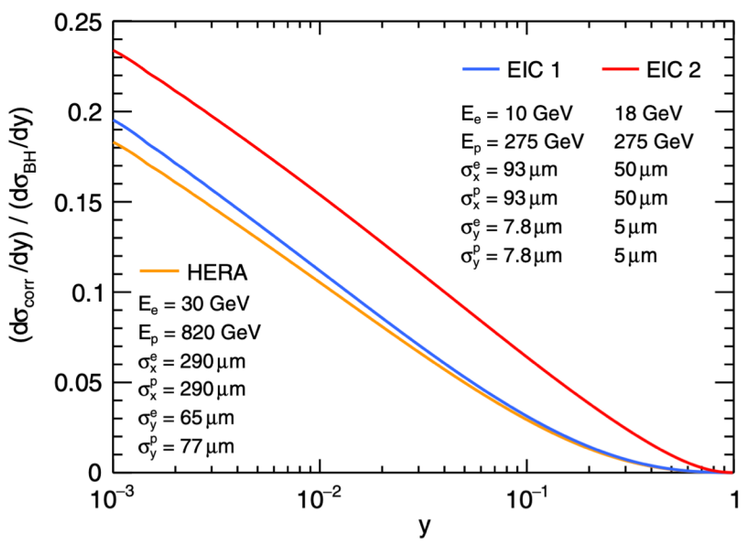


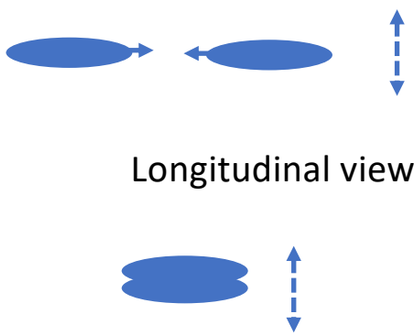
FIG. 2. Relative corrections to the standard Bethe-Heitler cross sections due to the beam-size effect. Relative suppression due to the beam-size effect $(d\sigma_{corr}/dy)/(d\sigma_{BH}/dy)$ is shown as a function of $y = E_\gamma/E_e$ for three cases of electron-proton bremsstrahlung.

At HERA the *electron-gas* bremsstrahlung was measured to agree with the Bethe-Heitler LO formula but a significant **suppression** of *electron-proton* bremsstrahlung was observed at low photon energies – it was found to agree at 30% level with the BSE calculations by G. Kotkin *et al.*, Z. Phys. C **39**, 61 (1988): https://arxiv.org/abs/hep-ex/9504003

At the EIC the BSE will be strong (at 18 GeV) and needs to be carefully studied – at HERA the high energy part was weakly constrained ⇒ a **dedicated, high resolution photon calorimeter** is necessary to measure the FULL bremsstrahlung spectrum while displacing laterally one of the beams ⇒

… and to provide a regular, absolute luminosity reference/normalization.

Using *Van der Meer scans*:



https://doi.org/10.1103/PhysRevD.103.L051901

FarBackward WG: Luminosity measurement concept

The precise luminosity measurement at the EIC is VERY challenging and to achieve that goal **two independent techniques** (not just two technologies) are required + two auxiliary detectors:

- *Bremsstrahlung (converted) event counting* method is relatively **complex** but is not sensitive to SR and has **low** event pileup for *ep,* though **large** for *eAu*
- *Bremsstrahlung energy flow* method is (in principle) very **simple** and independent (apart from the common but large geometrical acceptance) but is more sensitive to the BSE and at 18 GeV (only!) **suffers** from the direct SR
- + need for a precise absolute calibration detector – movable, used in special, low event rate runs for regular BSE/x-sec/energy scale verifications + electron detectors as discussed below

Key EIC design parameters: huge direct SR (only at 18 GeV) and the resulting exit window designs (affecting both techniques) – what options are possible? See today's talk.

We need to make proper studies of various contributions to the luminosity error for numerous detector/running scenarios and based on a wide set of (fast) simulations

FarBackward WG: Electronics and online data flow

- In luminosity detectors **the event pileup scales roughly as Z^2/A** hence for the *eAu* case instead of 10 hard photons every 10 ns more than 100 will hit the FarBackward detectors, what corresponds to > 10 GHz total event rate!
- Event pileup will affect strongly also the spectrometer measurement as well as the photoproduction tagging
- Finely segmented and radiation hard detectors have to be used
- Precise measurements will require developing dedicated detector technologies and specialized electronics – **100 MHz sampling rate** and, given > 10 GHz event rates, a near-detector signal (pre-)processing is necessary:

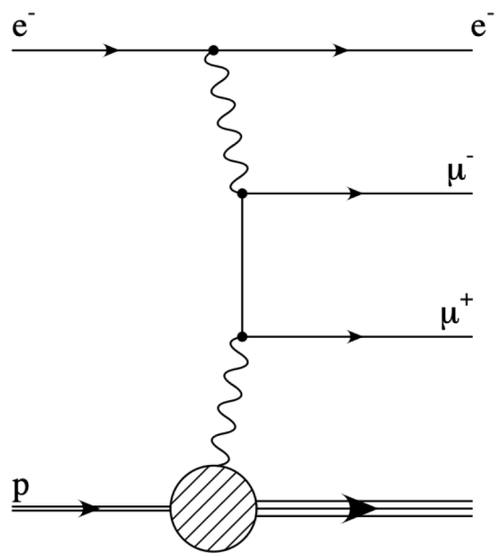
A simple zero-suppression still results in huge data streams – for example: 100 B × 100 MHz = **10 GB/s**! We need to very carefully design the *dedicated* DAQ electronics, so it is capable AND flexible in handling these huge data flows

FarBackward WG: Low-Q^2 tagging challenges

Efficient detection of very forward scattered electrons is a very powerful tool, effectively turning the EIC into a high energy photon-ion collider – and it is **especially important for ion beams** when very forward hadron detectors have limited acceptance: to cope with high electron event pileup (to be discussed on June 2nd) **fast hodoscopes** seem mandatory

At the same time, a precise measurement of bremsstrahlung electrons is very useful for the luminosity determination as it provides a data-driven photon acceptance verification.

The electron detectors will also provide an excellent data-driven energy calibration – two-photon production of lepton pairs can be used for that:



To achieve the optimal electron detector designs we need to carefully study the best electron momentum reconstruction techniques

FarBackward WG: Next three weeks

- Time to learn about the EIC design status and FarBackward “detectors’ environment/constrains”
- And to prepare for **June 16th** the task list and workplan towards the FarBackward proposal

Remember about 1-2 slides to be presented by your group at tomorrow’s ATHENA biweekly meeting:

1. which is the contributions you can bring to the FarBackward activity towards the proposal in the next months?

2. what are the most relevant and urgent questions in the FarBackward sector?

3. how do you see globally FarBackward project for Detector 1?

Questions?