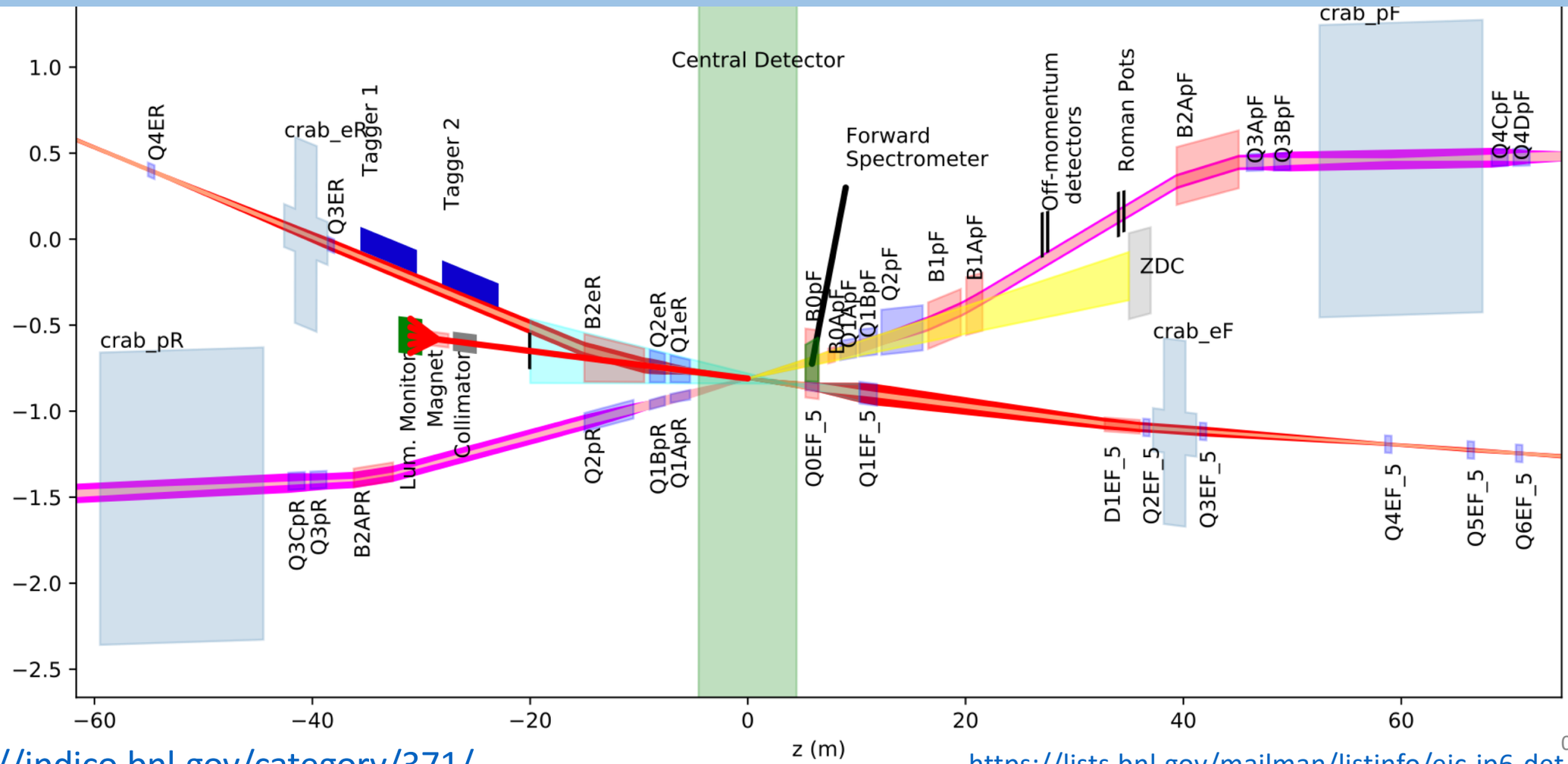
(Exclusive) photoproduction tagging:
from HERA to the EIC



https://indico.bnl.gov/category/371/

https://lists.bnl.gov/mailman/listinfo/eic-ip6-det-back-l (20)

Exclusive photoproduction @ HERA: personal view

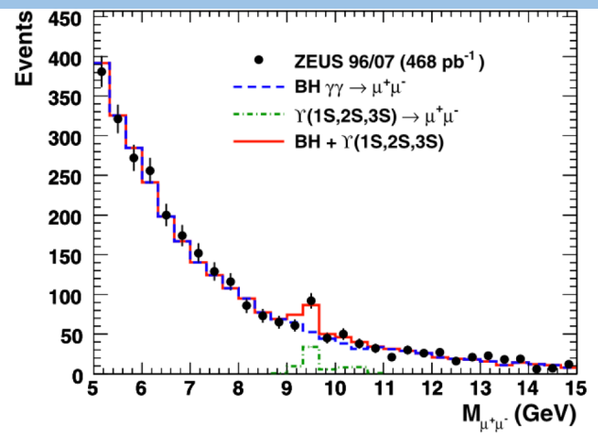


Fig. 2. Invariant mass distribution of $\mu^+\mu^-$ pairs. The dashed line shows the simulated Bethe–Heitler (BH) (exclusive and proton dissociative) distribution, normalised to the data points in the range [5.0–15.0] GeV excluding the [9.0–11.0] GeV mass window. Simulated contributions of the $\Upsilon(1S)$, $\Upsilon(2S)$ and $\Upsilon(3S)$ resonances are shown as a histogram on the mass axis (dashed-dotted line). The solid line shows the sum of all contributions.

https://doi.org/10.1016/j.physletb.2012.01.009

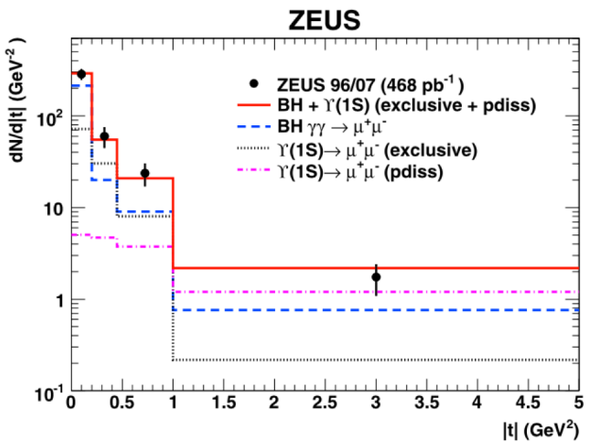


Fig. 3. Measured $|t|$ distribution (full dots) with error bars denoting statistical uncertainties. Fitted distributions for simulated events are shown for the Bethe–Heitler (dashed line), exclusive $\Upsilon(1S)$ (dotted line) and proton dissociative $\Upsilon(1S)$ (dashed-dotted line) processes. The solid line shows the sum of all contributions.

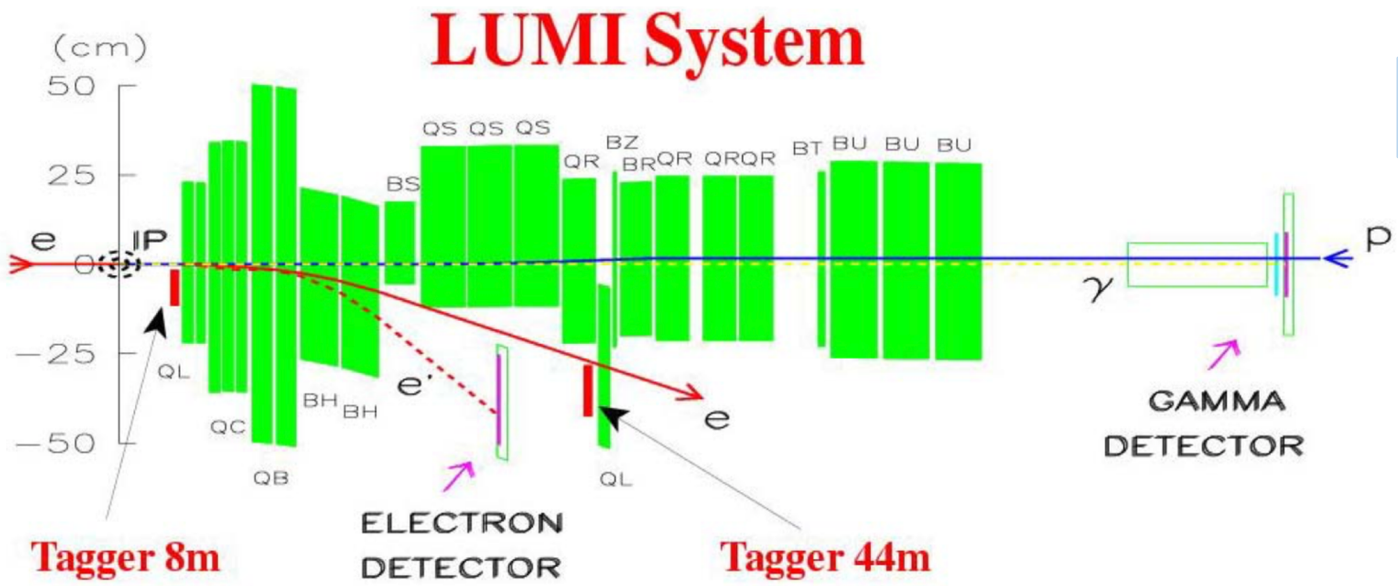
- Poor exclusive statistics – all data @ HERA I + II = 0.5 fb^{-1}
- Pretty poor track resolution (by modern collider standards):

⇒ Could not resolve *Upsilon 1S, 2S, 3S* + big BH background

- Because of low statistics **no** photoproduction tagging was used here, resulting in poor t resolution as Q^2 was limited up to 1 GeV^2 , but the meson p_T resolution was not great anyway…

In contrast, tagging was used for $\sigma_{\gamma p}^{tot}$ measurements, but tagging efficiencies/resolutions rather poorly understood

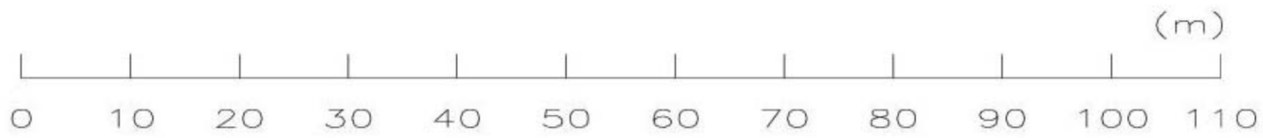
Photoproduction tagging in ZEUS @ HERA I



27.5 GeV e × 820 GeV p

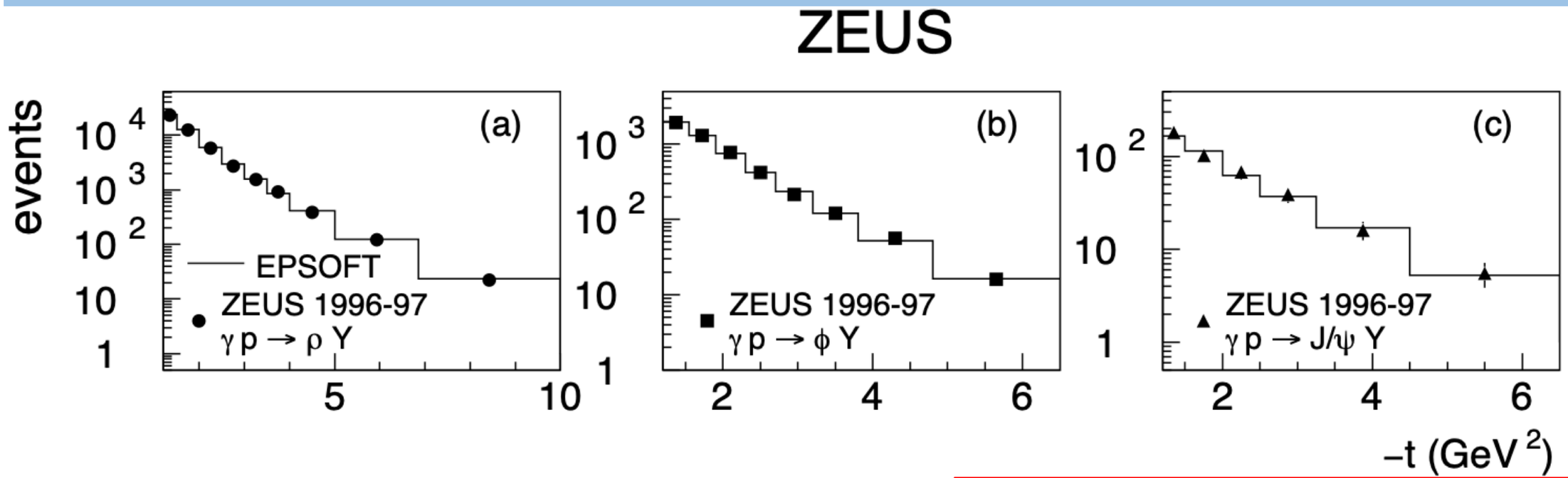
Tagging at HERA was very tricky due to **complex** beam optics, and tagging at HERA II was **not** successful at all…

ZEUS@HERA: TOP view



(H1 used similar detectors but no 44 m tagger)

Semi-exclusive photoproduction @ HERA: personal view



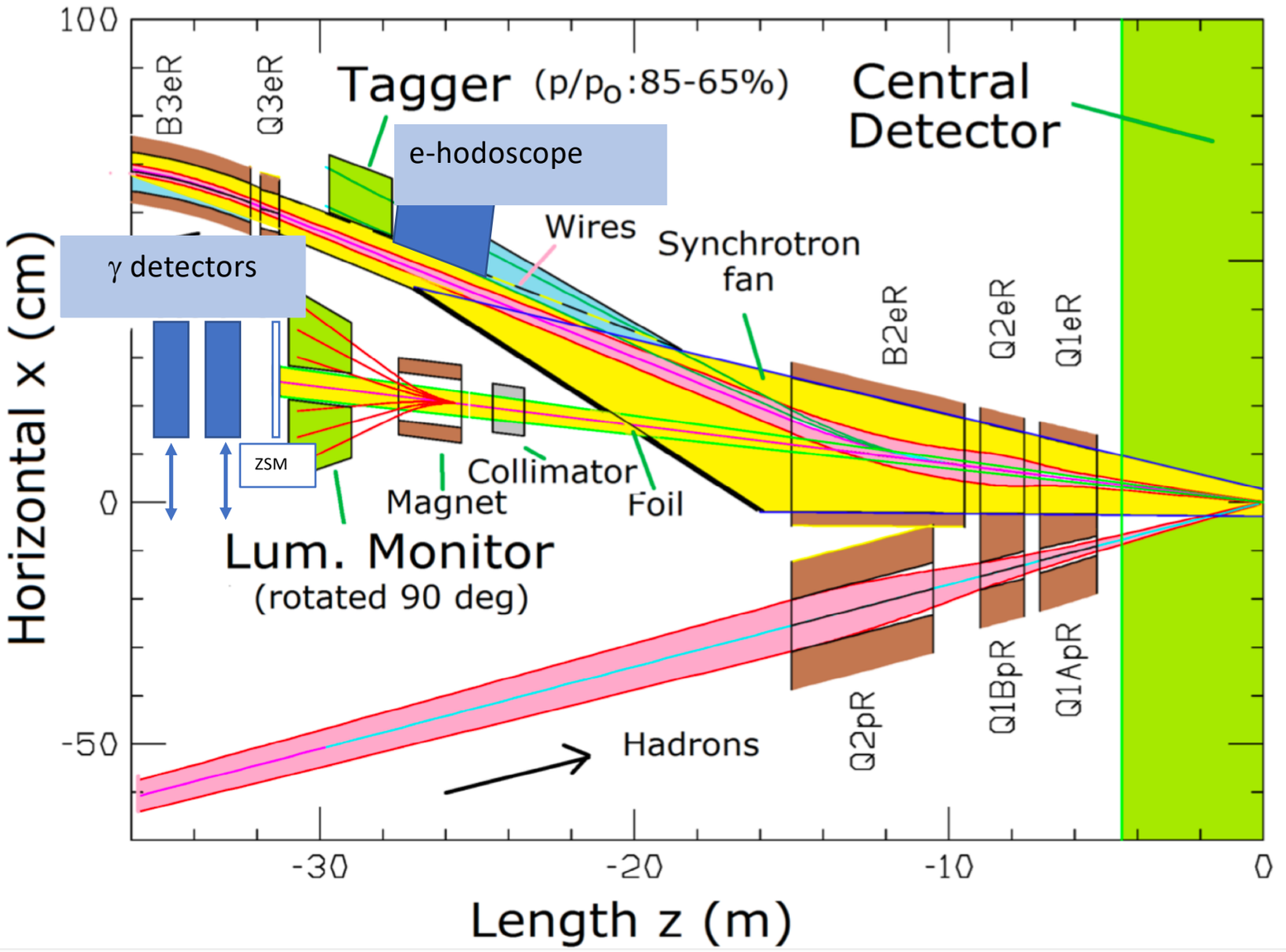
"The photoproduction tagger (PT) [10] is a small electromagnetic calorimeter located close to the beam-pipe at Z = −44 m. It detects positrons of energy between 21 and 26 GeV scattered under very small angles (less than a few mrad). The positron measured in the PT is used **to tag** photoproduction events with a photon-beam energy in the 1.5–6.5 GeV range."

https://dx.doi.org/10.1140/epjc/s2002-01079-0

ZEUS used a special and very simple detector to tag only – it was not used for any reconstruction and effectively provided simply ***yes/no*** signal (for trigger!)

Tagging was essential to make sure that Q^2 does not spoil t reconstruction from meson's p_T

Exclusive photoproduction @ EIC: personal view



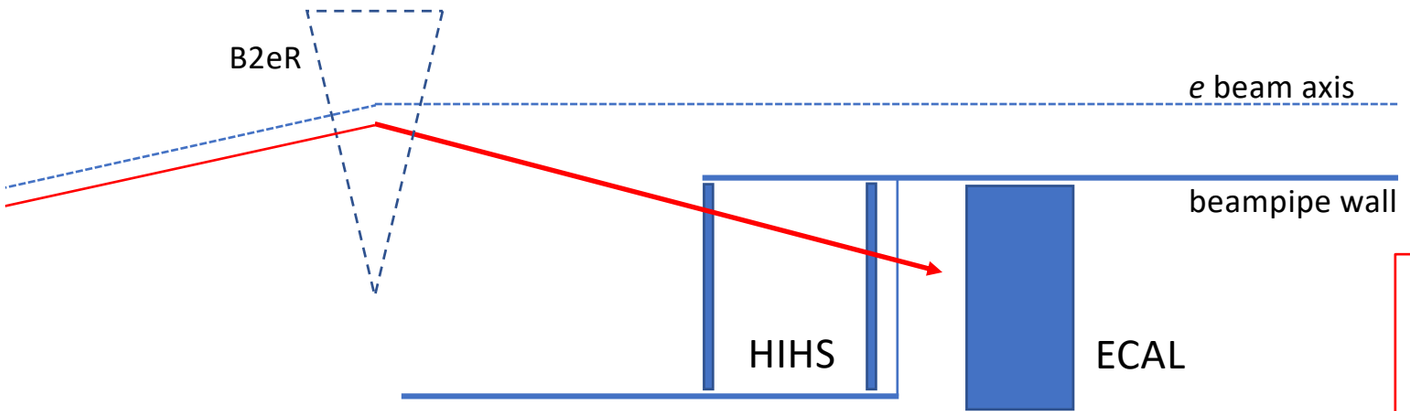
- Conditions at the EIC are much more **favorable** for exclusive physics:
- Luminosity > 100 higher + wide range of hadron beam types
- *e* beam optics much simpler for photoproduction tagging! Almost "perfect" – very **high electron resolutions are feasible**, in principle

But… there is a (high) price to pay.

FarBackward WG: tagging (huge) challenge

"Regarding the luminosity measurements only, **ECAL is more or less sufficient**, provided its good energy and spatial resolutions, as it will serve there primarily to cross check the bremsstrahlung photon energy scales as well the acceptance corrections, including the photon conversion factor.

However, this is highly **insufficient** for the photoproduction tagging at the EIC because of a very high event pileup due to bremsstrahlung – if one assumes the tagging range equal to the third selection in table 1 (that is $\mathbf{0.4 > E_\gamma/E_e > 0.1}$) then for 10 GeV electron beams the average number of simultaneous bremsstrahlung electrons in this range is **6.3 for the ep** collisions, and almost **100 for the eAu** ones, at the nominal luminosities. Clearly, even highly segmented calorimeters cannot cope with it and a dedicated hodoscope is needed."



https://arxiv.org/abs/2106.08993

"The experimental conditions are very different for *HIHS* – the track rates and densities can be very high in this case, therefore **highly pixelized and thin semiconductor detectors** seem to be mandatory. "

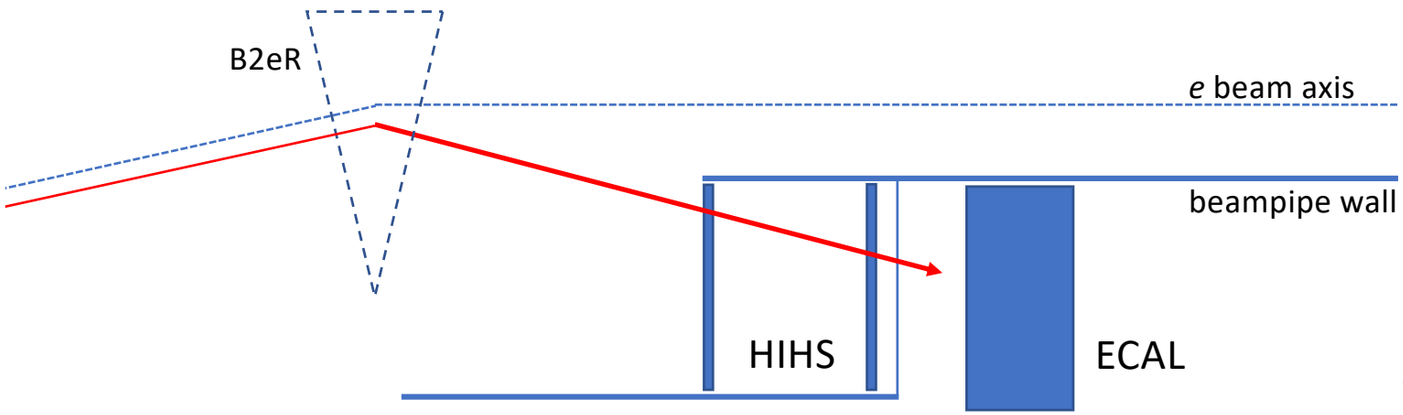
FarBackward WG: tagging (huge) challenge

Building a detector like HIHS (in the beam primary vacuum) is a major challenge and if Athena wants to go for it a big effort must start **now**.

However, before, we have to understand what is needed – what are specific physics motivations for the FB tagging?

- What energy range we need to tag – remember we have anyway 5/10/18 GeV electron menu, so it seems only the lowest tagged energy counts here – do we need it for some **threshold scans?**
- What int. luminosity is needed – always 100 fb^{-1}, or there are cases when **cleanly** tagged 1 fb^{-1} sample is interesting?
- Is photoproduction tagging particularly interesting for *eAu*?

The answers will tell whether we need HIHS at all, that is the ultimate resolutions on scattered electrons – resulting not only in **excellent *t* resolution** – but maybe also a **1% tagged photon resolution** is possible (for example opening a possibility of the missing mass method).



Need to answer these questions soon…

https://arxiv.org/abs/2106.08993

FB WG (and Athena) needs urgently your input/involvement/advice/etc on photoproduction tagging:

BOTH in defining physics needs/motivations and in tagging detectors' development ("HIHS" case)

Thanks!