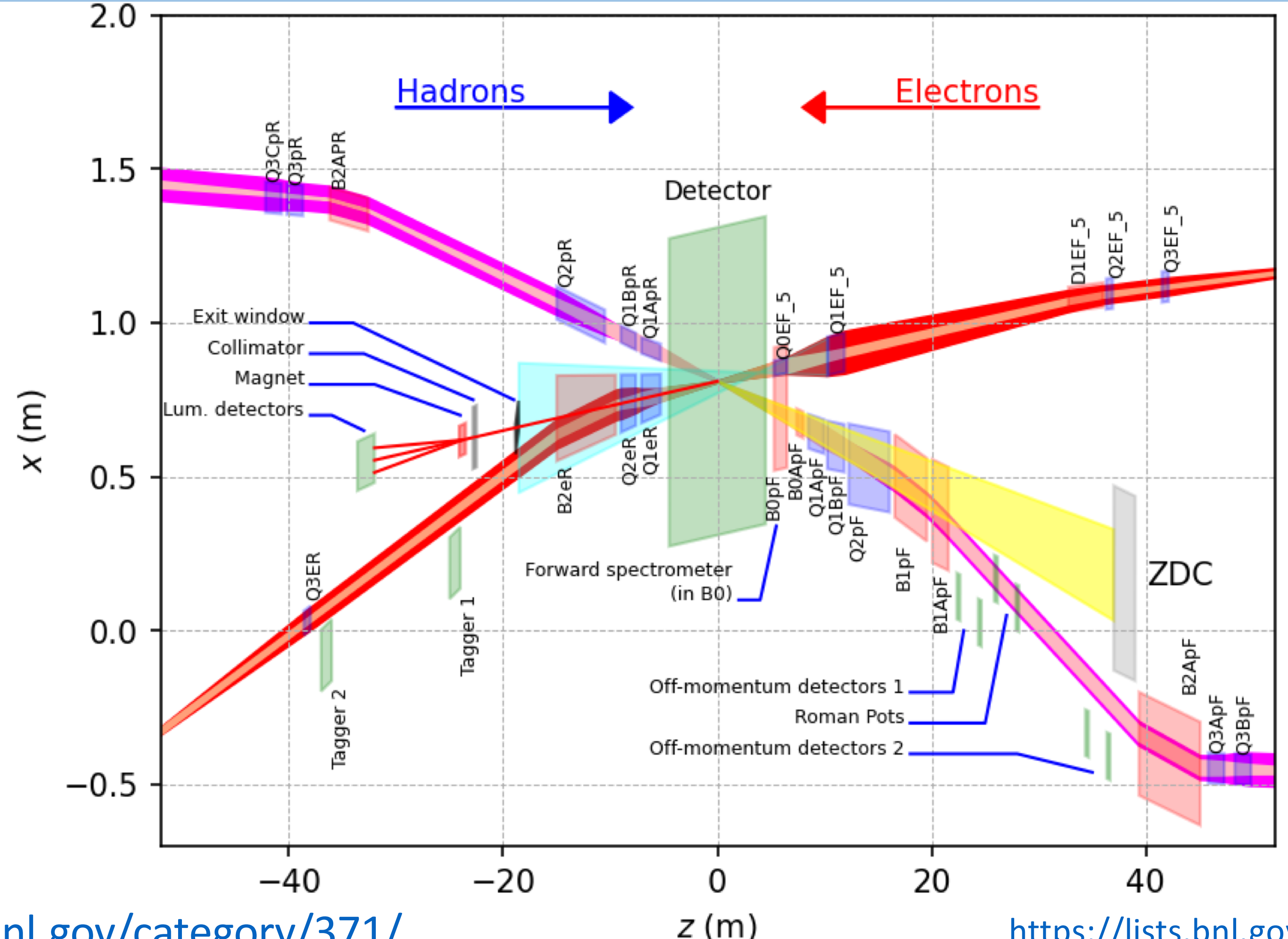
Athena FarBackward Working Group:

Proposal for luminosity detectors



Top view of the IR6

in Athena coordinates

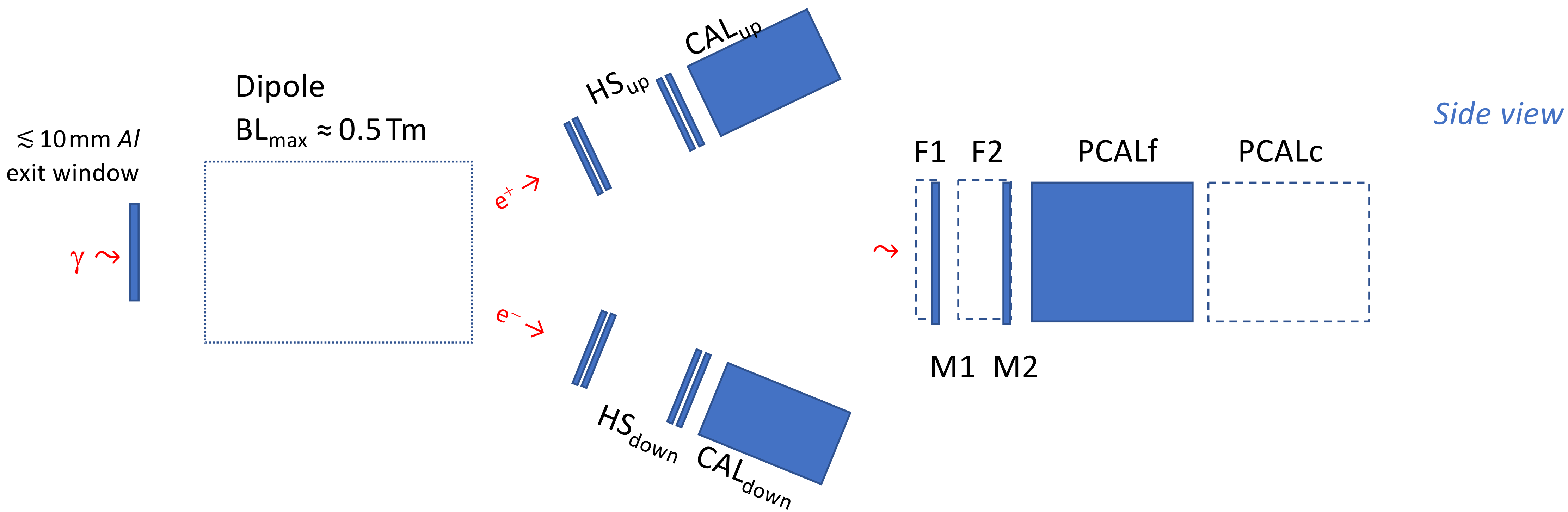
https://indico.bnl.gov/category/371/

https://lists.bnl.gov/mailman/listinfo/eic-ip6-det-back-l (21)

FarBackward WG: need for three luminosity methods

Luminosity measurements at the EIC are very challenging: huge event rates + wide electron beam energy range (5… 10… 18 GeV) + large spectrum of nuclei species (from *p* to *Au*) ⇒ there is no unique best solution – one needs to use 3 largely complementary bremsstrahlung measurements**:

1. *Reference* measurement – photon **counting** with a (movable) calorimeter PCALc, only at *low L*
2. Photon conversion **counting** using $CAL_{up/down}$ + $HS_{up/down}$ (outside SR fan)
3. Photon **energy flow**, or $\langle E_{PCALf} \rangle$, using a movable calorimeter PCALf, with SR filters/monitors in front

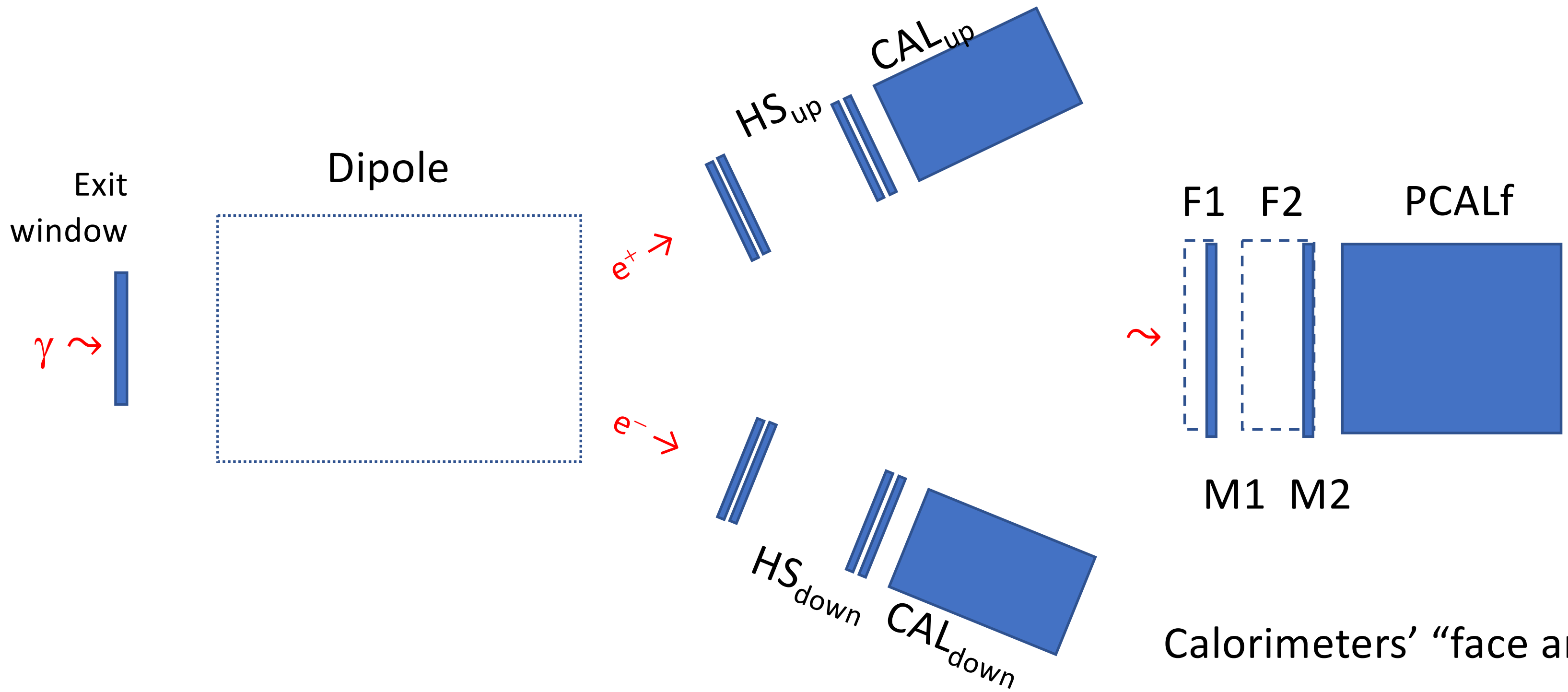


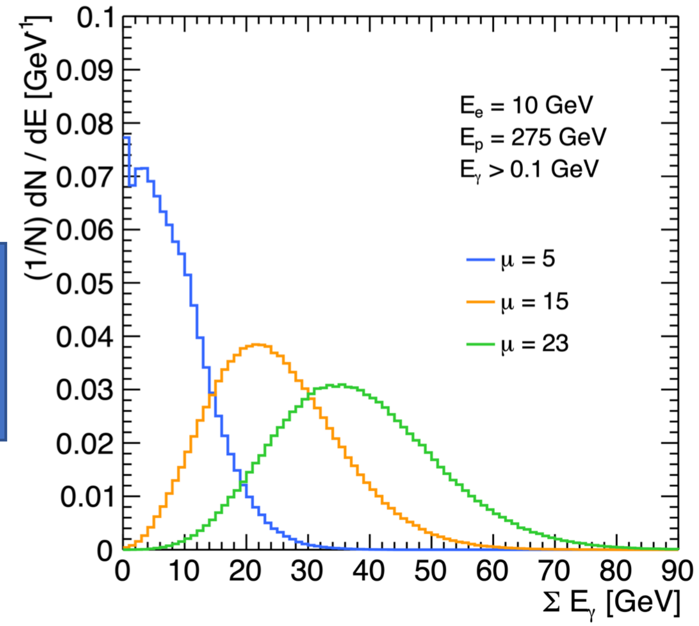
**) arxiv.org/abs/2106.08993

FarBackward proposal: PCALf & SR filters/monitors

PCALf – **Luminosity (online) Monitor**: for 10 × 275 GeV *ep* **⟨E_{PCALf}⟩ ≈ 40 GeV** at the nominal *L* ⇒ huge detector irradiation ≈ 100 Mrad per 100 fb^{-1} for *ep* ⇒ proposed solution – movable tungsten (or lead) spaghetti calorimeter with fused quartz (silica) fibers readout by SiPMs (or fast PMTs)

F1/2 + M1/2: at 18 GeV SR is hard and needs strong filtering/suppression ⇒ proposed solution – two movable tungsten /graphite filters 0.5 X_0 and 1 X_0 thick, equipped with fused silica fibers + SiPMs as SR monitors



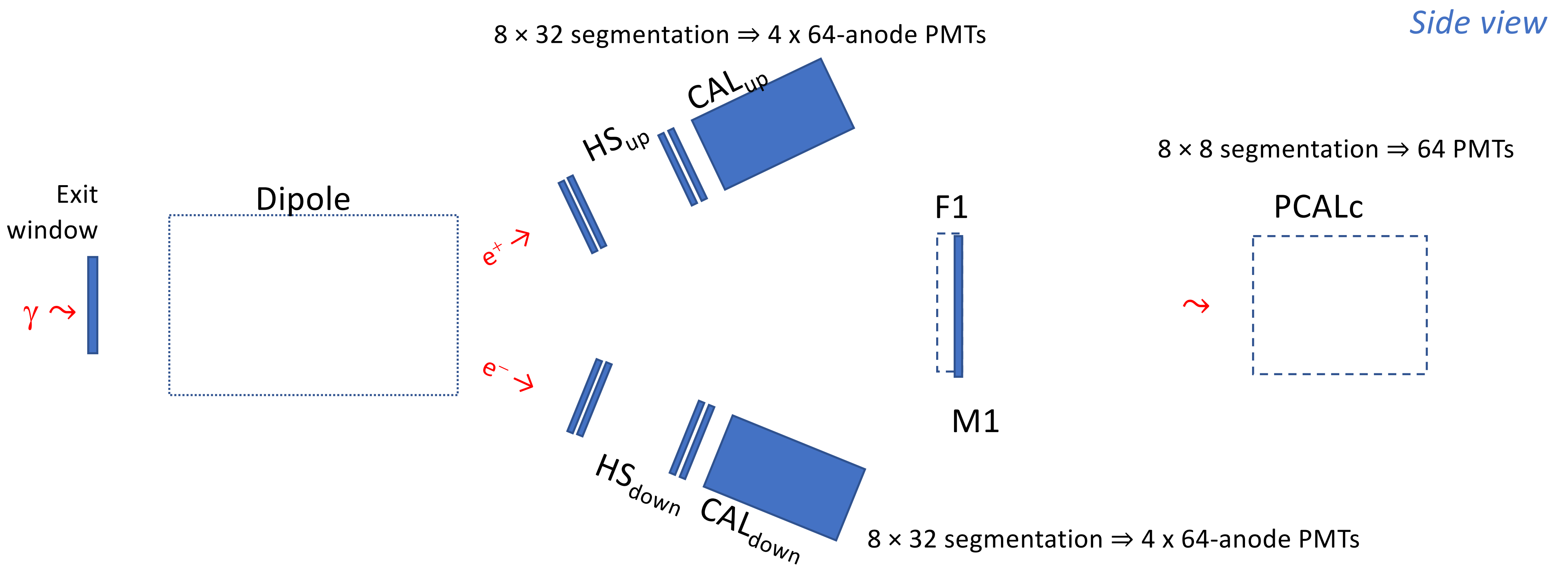


Calorimeters' “face area” circa 100 cm^2

FarBackward proposal: $CAL_{up/down}$ + PCALc

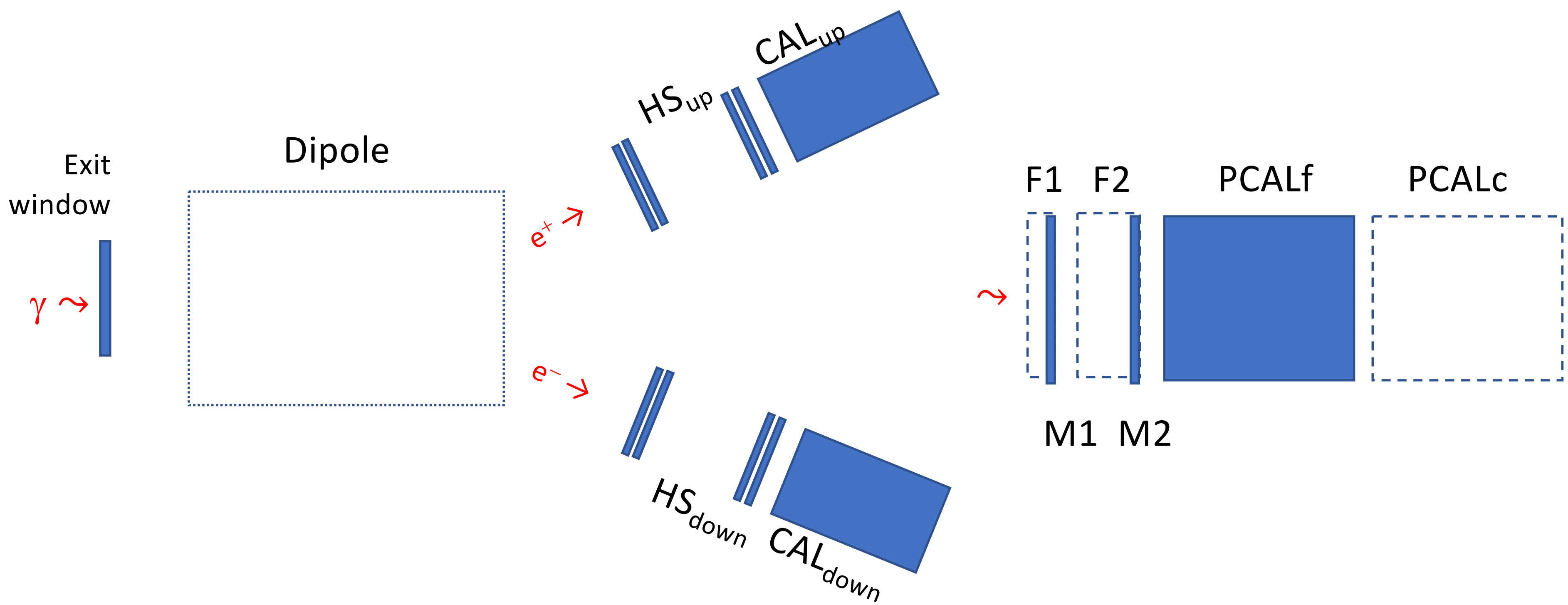
A similar energy resolution of about 10%/√E should be required for the three calorimeters **PCALc + $CAL_{up/down}$** + a very good linearity well below 0.1 GeV for PCALc and higher segmentation for $CAL_{up/down}$

Event rates for $CAL_{up/down}$ are around 100 MHz, and the expected maximal irradiation is less than 1 Mrad per 100 fb^{-1} for *ep* collisions – proposed solution: tungsten (lead) *spaghetti calorimeter* with radhard scintillator fibers + PMTs



FarBackward proposal: Hodoscopes

HS_{up} + HS_{down}: ”spectrometer” method has to deal, at the nominal *L*, with a significant *event pileup* ≈ 0.1 for *ep* and about 2 for *eAu; hodoscopes* are also essential for calibrations/systematics ⇒ proposed solution – 2 × two parts: with 4 front planes of 1 mm square, straight scintillating fibers + 4 back planes of 2 mm fibers, all read out by SiPMs – **about 800 channels** in total.

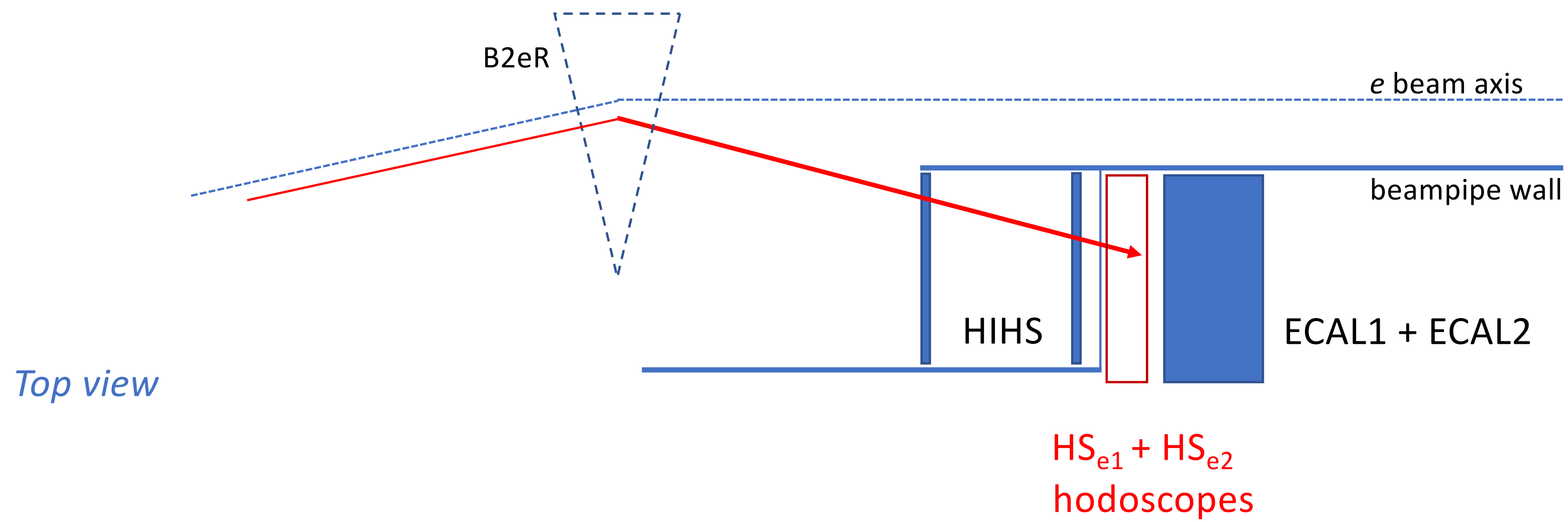


Side view

FarBackward Proposal: Bremsstrahlung electrons (& photoproduction tagging)

Two electron calorimeters $ECAL_{1/2}$ (or just one) have different geometries from $CAL_{up/down}$ but same technology – the event pileup in ECAL is **large**, especially for *eAu* collisions, and in addition events are strongly "collimated" in the EIC plane ⇒ even higher radiation resistance is required – Sci fibers should be sufficient (later, might swap or use fused quartz?).

Initially, "copies" of HS_{up} + HS_{down} could be used for the electron tracking ⇒ **HS_{e1} + HS_{e2};** but later, a very high resolution hodoscope HIHS could be considered (using Timepix?) – necessary for the photoproduction tagging in *eAu* collisions. *Note:* HS_{up} + HS_{down} is sufficient for the relevant checks of luminosity systematics.



FarBackward Proposal: 0^{th} order inventory

Four similar calorimeters: ECAL1, ECAL2 + $CAL_{up/down}$ – small **tungsten spaghetti calorimeters with Sci fibers + 4 fast multi-anode PMTs** (as H12428) – each about 250 channels in total

PCALc – movable small **tungsten spaghetti calorimeter with Sci fibers + fast PMTs** – about 64 channels

PCALf – movable **small tungsten spaghetti calorimeters with fused quartz fibers + SiPMs** – about 500 channels

Four hodoscopes: HS_{up} + HS_{down} and HS_{e1} + HS_{e2} **– in total about 1600 SiPM channels reading out Sci fibers**

Movable SR filters and monitors + a small **dipole magnet**

Dedicated luminosity ASICs with **100 MHz sampling** and signal preprocessing – in two versions: 4- and 10-bit resolution with 2100 and 1100 channels, respectively.

Large data volume expected: small detectors but huge event rates – data volume driven mostly by the **electron data** (photoproduction tagging) – at least 40 Gb/s at the nominal *L* for *ep*.