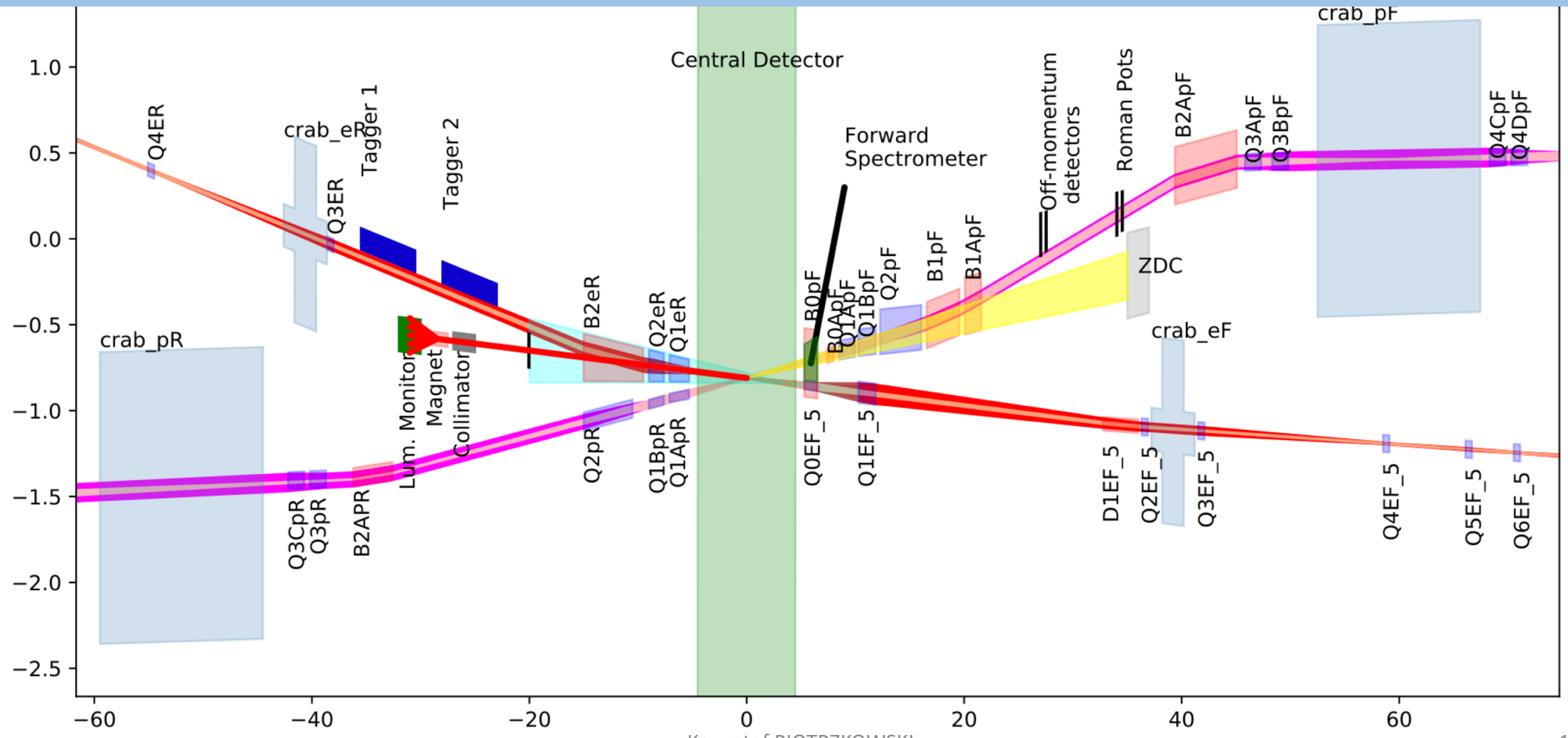
FarBackward Working Group:

Luminosity measurement and low-Q^2 tagging in ATHENA



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

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

FarBackward WG: reminder

Open list of participants in various areas of the FarBackward proposal

Integration with the EIC – J. Adam (BNL): presentation by Charlie Hetzel https://indico.bnl.gov/event/12026/ , followed by very fruitful discussions and by G4 exit window results from Jarda https://indico.bnl.gov/event/12137/

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): Bill presented 1st considerations regarding event pileup in FB taggers

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

Software – J. Adam (BNL), Janusz Chwastowski (IFJ) and M. Przybycien (AGH): "Preparing a ['very fast simulation'] framework for evaluation of the expected luminosity errors, as well as the tagging performance, **for different running scenarios and as a function of detector parameters and configurations**"

FarBackward WG: next meetings etc

On June 16th we hold a FB WG meeting where the outline of the FarBackward luminosity detectors is discussed and a very first workplan towards the FarBackward proposal presented

On June 18th a presentation by KP on photoproduction taggers (= FB electron detectors) at the *Exclusive Physics* WG

On June 23rd we should have a big "follow-up" discussion + planning for Summer + start **planning for R&D**

---------- switching to summertime biweekly pace.

On July 7th ?? (very) fast vs. full simulation needs and workplan + first (luminosity) data flow discussions

On July 21st , August 4th and 18th – series of updates on SR and designs of window + various detector components

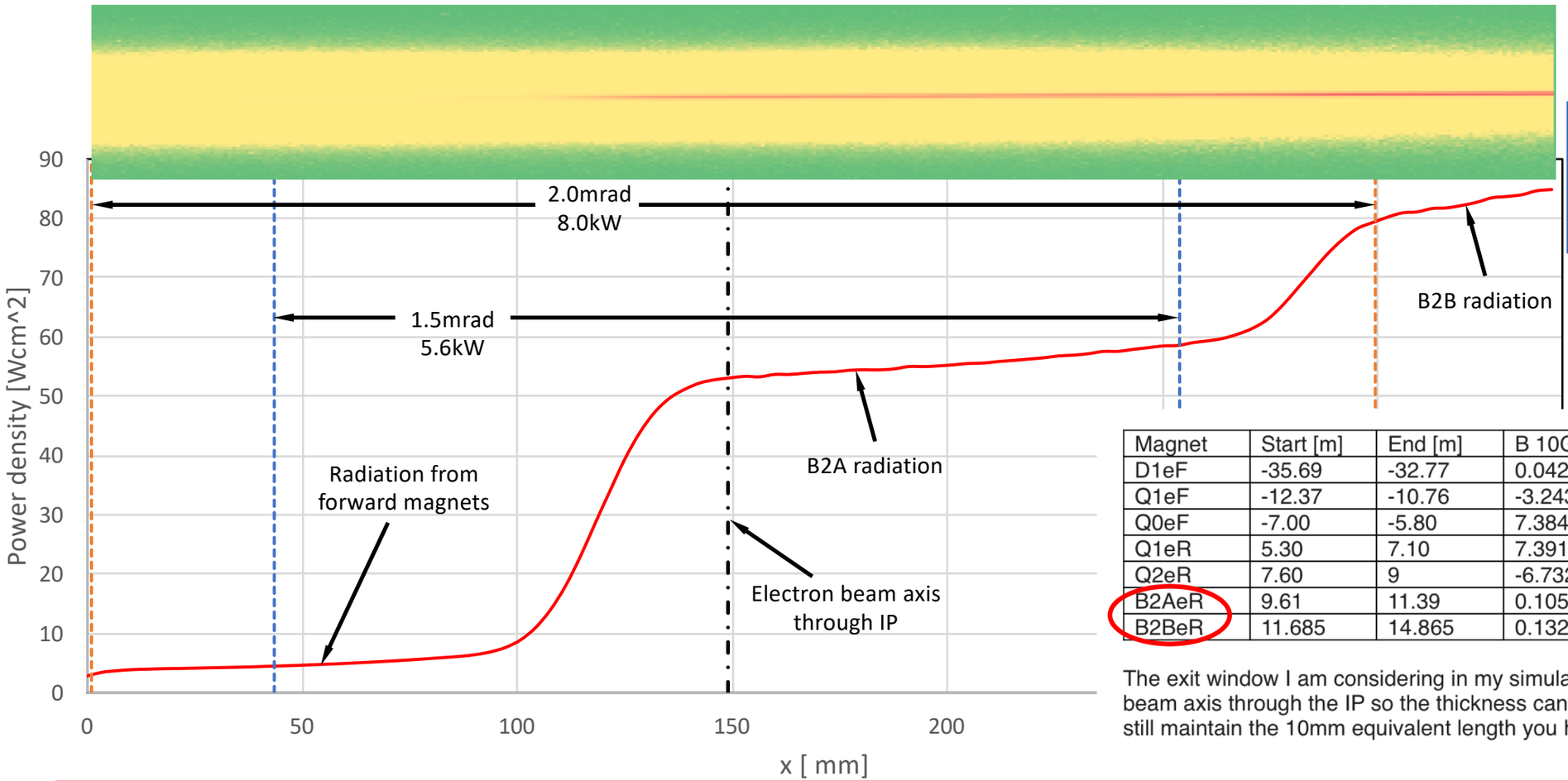
---------- switching back

On Sep 1st we are back to weekly pace and should **freeze** the FarBackward detector setup + start serious discussions about "detectors' and tunnel **infrastructure**" aspects and overall **costing** + start writing up for Proposal

Three representatives of the FarBackward WG to the ATHENA Proposal Group were proposed:

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

Power on Exit Window (10GeV) – Ch. Hetzel



1st design iteration made, and a lot of room for improvement

Magnet	Start [m]	End [m]	B 10Gev [T or T/m]	B 18Gev [T or T/m]
D1eF	-35.69	-32.77	0.04214	0.07585
Q1eF	-12.37	-10.76	-3.24387	-5.85089
Q0eF	-7.00	-5.80	7.3846	13.1289
Q1eR	5.30	7.10	7.39198	13.3153
Q2eR	7.60	9	-6.73288	-12.0595
B2AeR	9.61	11.39	0.105	0.192
B2BeR	11.685	14.865	0.132	0.238

The exit window I am considering in my simulation is tilted at 250mrad to the electron beam axis through the IP so the thickness can be increased from 1mm to 2.6mm and still maintain the 10mm equivalent length you have been using.

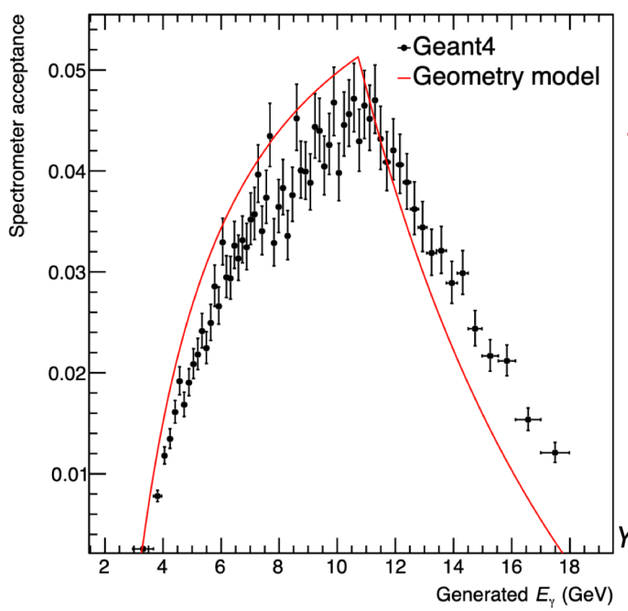
Direct synchrotron radiation levels in *FarBackward* region is the major "defining" condition to properly start designing the FB detector systems – we are on a good track to arrive to an **optimal** EIC beamline/exit window design, in that respect **splitting the B2eR dipole into two parts** is a huge step in this direction!

Direct Synchrotron Radiation – challenge nr. 1

***Direct* SR fan**, originating mostly in the *B2eR* dipole, poses two major experimental challenges:

1. As it cannot be avoided, it requires strong SR filtering, which **compromises** BS photon energy measurements in calorimeters due to passive absorbers in front of them – it is mostly relevant at 18 GeV, where the BSE is maximal.

2. BS exit window has to withstand high SR power – for example, 10 mm thick *Al* window (equivalent to ≈ 11% X_0)

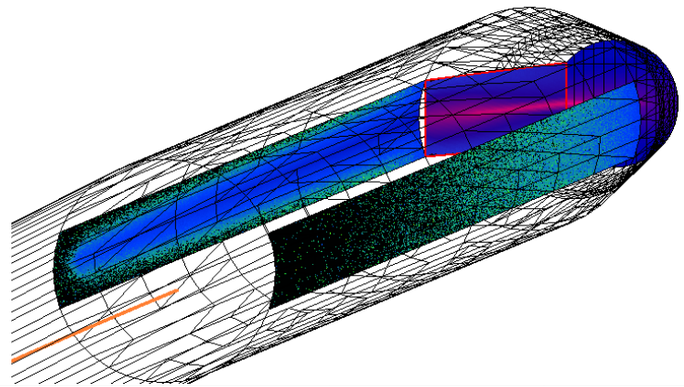


⇐ **significantly deteriorates** energy resolution of e^+e^- spectrometer + induce significant event pileup

Yellow Report 2021

Figure 11.114: Luminosity spectrometer acceptance as a function of the bremsstrahlung photon energy E_γ. The acceptance includes a photon to pair conversion probability of ∼8%.

1st iteration for γ exit window design (*Ch. Hetzel*)



	10 GeV	18 GeV
Total Power [kW]	25.6	24.7
Window Power [kW]	10.2	9.91
Total Flux [ph/s]	6.32×10^{19}	1.12×10^{19}
Window Flux [ph/s]	2.68×10^{19}	4.77×10^{18}

Note, at 18 GeV the SR critical energy ≈ 6 times bigger!

Need for **optimization of *B2eR* magnet design** – split in two parts where *B2AeR* should be as weak as possible.

Aim at **6% X_0** window thickness (≈ 4% BS conversion)?

FarBackward WG: “proposal”

Prepared for submission to JINST

https://indico.bnl.gov/event/12197/contributions/50977/attachments/35265/57394/eic-lumi.pdf

“The challenges for precise determination of the absolute luminosity at the EIC are huge, much bigger than at HERA. This is why it is proposed here to **significantly extend the dedicated instrumentation** to well control all the relevant systematic biases and to maximally exploit high statistics data-driven powerful calibration techniques.”

Challenging luminosity measurements at the Electron-Ion Collider

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Abstract: A precise determination of absolute luminosity, using the bremsstrahlung process, at the future Electron-Ion Collider (EIC) will be very demanding, and its three major challenges are discussed herein. First, the bremsstrahlung rate suppression due to the so-called beam size effect has to be well controlled. Secondly, the impact of huge synchrotron radiation fluxes should be mitigated. Thirdly, enormous bremsstrahlung event rates, in excess of 10 GHz, have to be coped with. A basic layout of the luminosity measurement setup at the EIC, addressing these issues, is proposed, including preliminary detector technology choices.

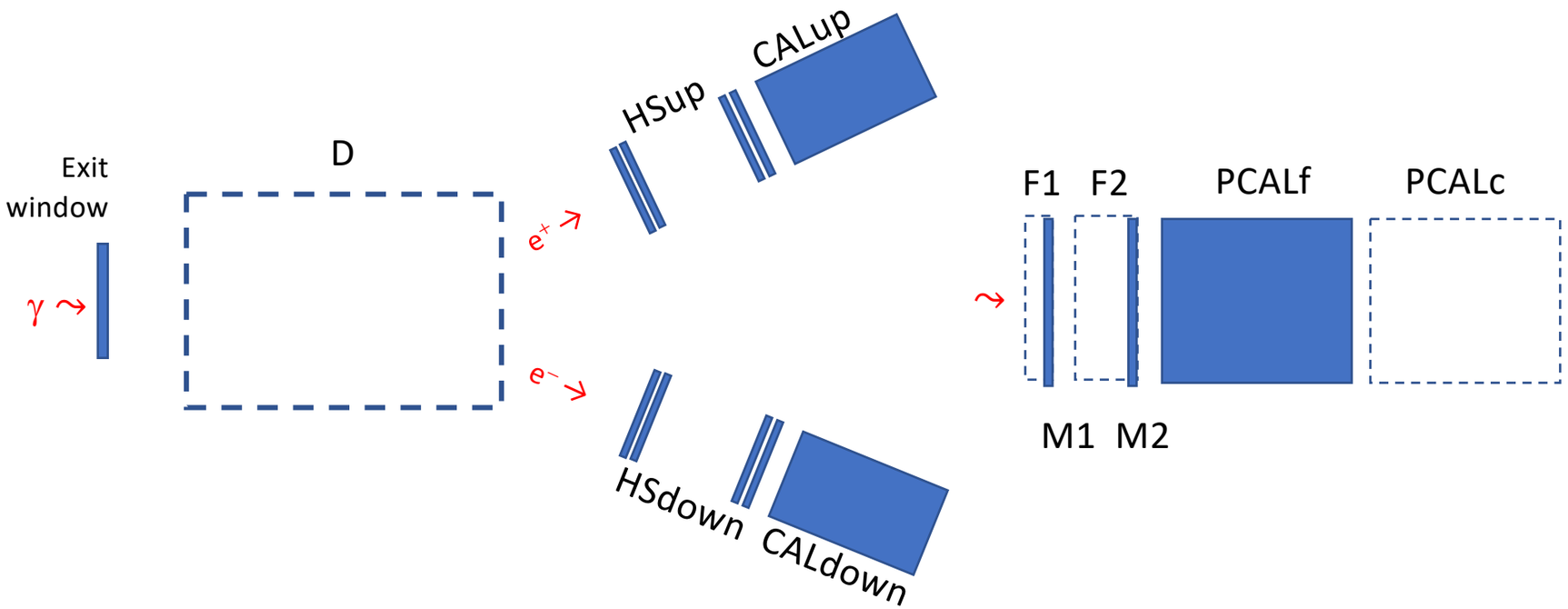
Keywords: Instrumentation for particle accelerators and storage rings - high energy, Calorimeters, Particle tracking detectors

comments/corrections most welcome

FarBackward WG: photon energy *flow*

"…in case of eAu (Z = 79) collisions at 10 GeV the expected bremsstrahlung **event pileup** is almost **350**, corresponding to the event rate above **30 GHz**. These extreme event rates will result in significant power deposited in the middle of PCAlf – of about **15 W** for the eAu case, and about **1 W** for the ep one." -- truly a *calorimetric* measurement

At nominal luminosities (at 10 GeV): average energies in **PCALf** ≈ 1 TeV (*eAu*) or 60 GeV (*ep*) $\propto L$

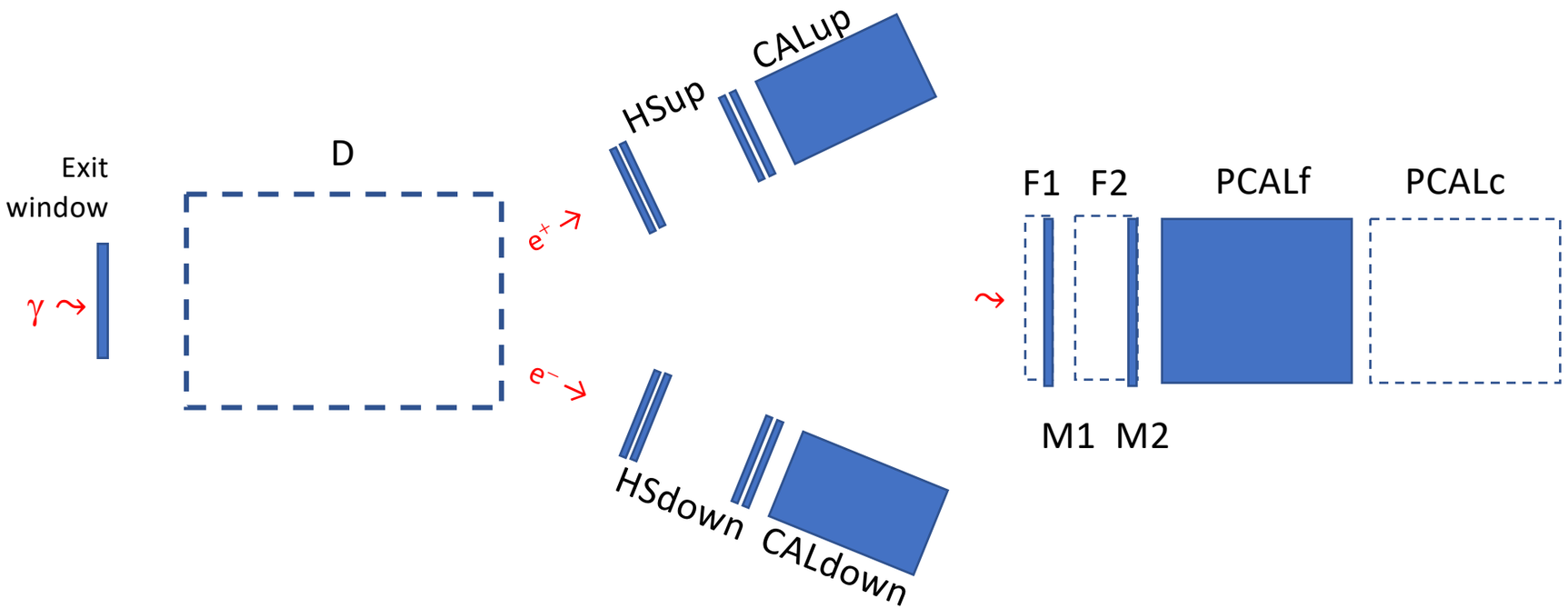


FarBackward WG: energy flow vs. conversion counting

EF formula: Average photon energy (per bunch) = Luminosity × $\int_{Emin} E_\gamma \, d\sigma \times A_\gamma \times (1–CF^*)$

Note: geometrical $A_\gamma > 99\%$ and $CF^* = CF - \varepsilon$, where $CF \approx 4\%$ and $\varepsilon \ll CF$

CC formula: Photon conversion rate = Luminosity × $\Delta\sigma \times A_\gamma \times CF \times A_{selection} \times Corr_{pileup}$



FarBackward WG: technology choice

"…it is proposed to assume for PCALf a **tungsten spaghetti calorimeter with fused silica fibers**. The Cerenkov light is read out separately from each fiber with **SiPMT**s, where the expected number of fibers is of the order of 2000… In addition, the synchrotron radiation flux should be monitored using the dedicated detectors behind the SR filters (M1 and M2)… The other four calorimeters (that is PCALc, CALup, CALdown and ECAL) should be built using the same technology, as **tungsten spaghetti calorimeters with scintillating fibers**, read out by SiPMTs, for example…

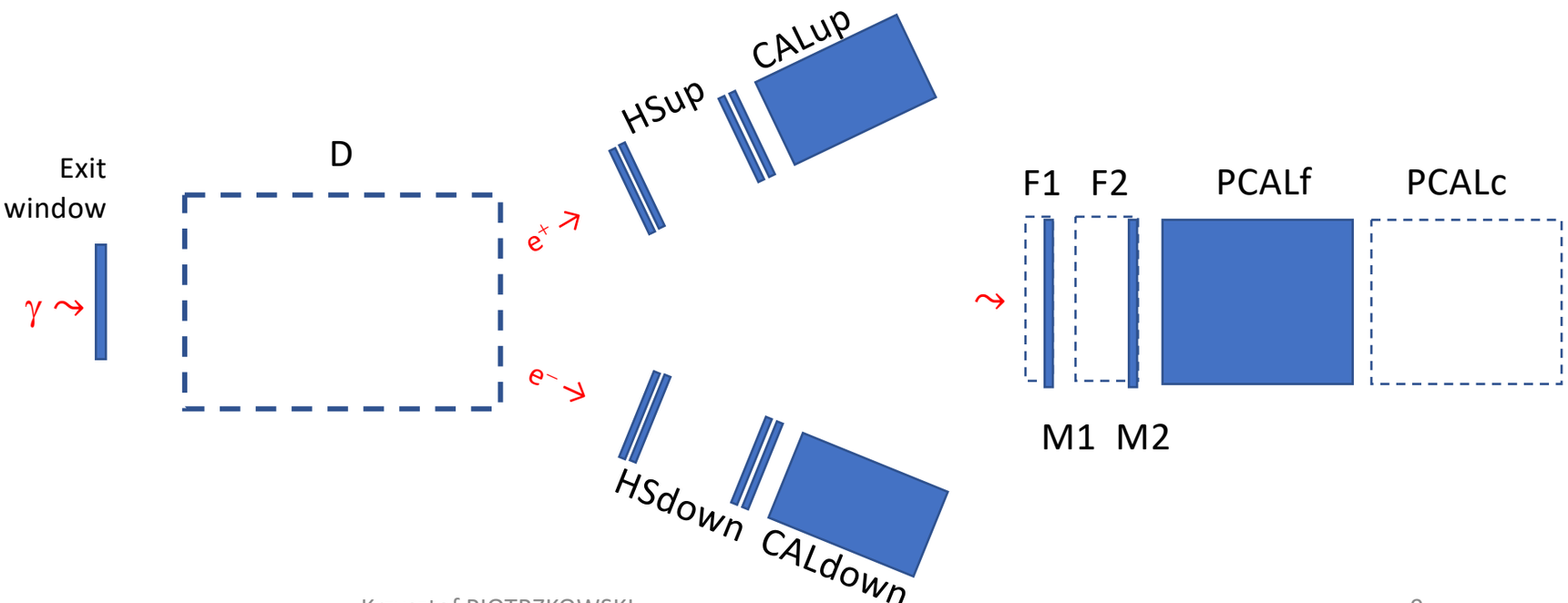
The spectrometer hodoscopes, HSup and HSdown, will not face very large event rates, and as only the vertical track position has to be determined, just **several simple planes of about 1 mm square, straight scintillating fibers read out by SiPMTs** are proposed for that purpose…"

Do you agree?

Who works on what?
(for Proposal)

PCALf ⇒ AGH UST

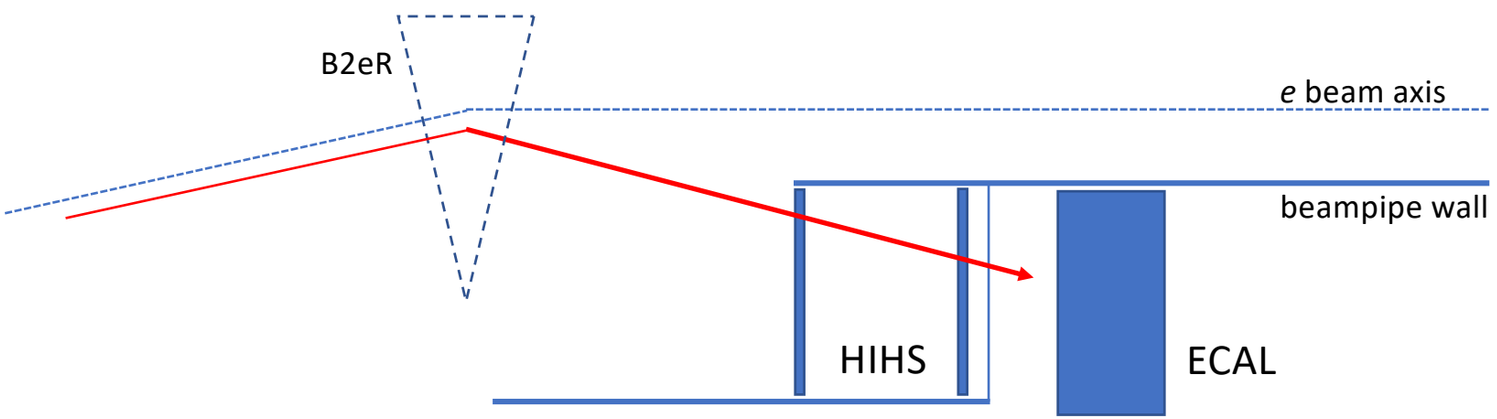
… ?



FarBackward WG: tagging

"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 due to very high event pileup due to bremsstrahlung – if one assumes the tagging range equal to the third selection in table 1 (that is $0.4 > E_\gamma/E_e > 0.1$) 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."



More on HIHS this Friday