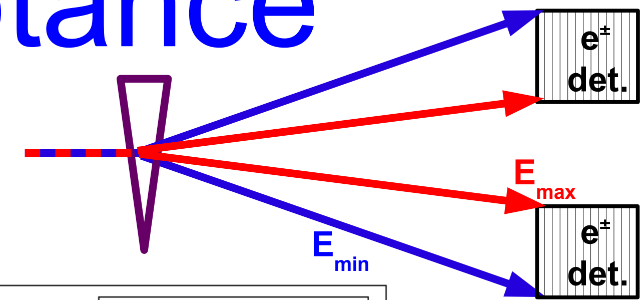
LUMI pair spectrometer: some considerations

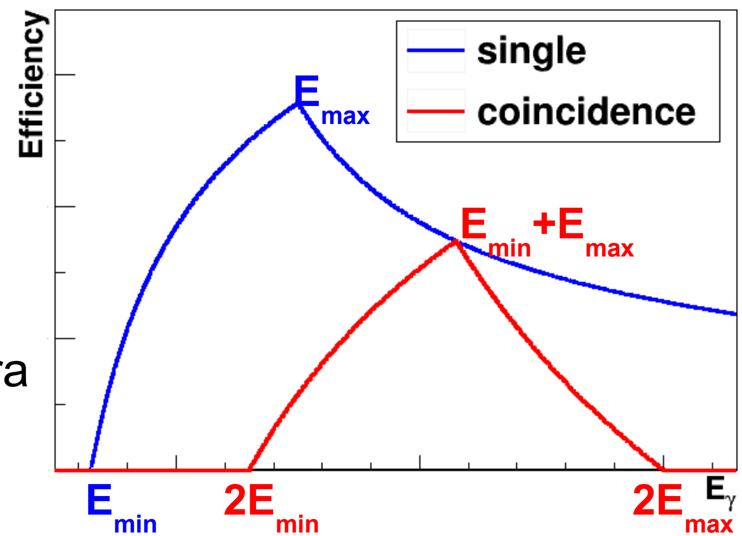
ePIC/project LUMI mtg.
16.05.23

- Calorimeters resolution requirements: reminders
- Photon path line considerations, need technical advice, including
  - converters $\leftrightarrow$ sync. rad. viability
  - dipole magnet strengths

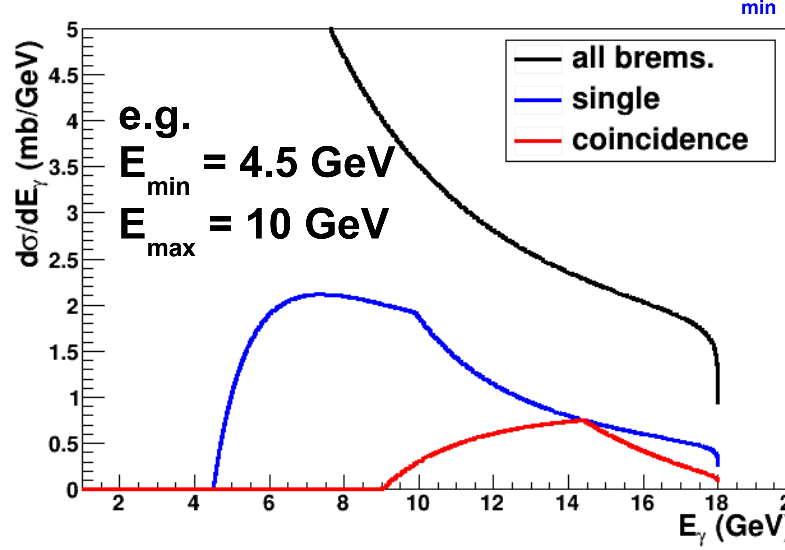
Spectrometer acceptance

- Spec. acceptance fully determined by min./max. energies (E_{min},E_{max}) of $e^{\pm}$ that can hit detector:

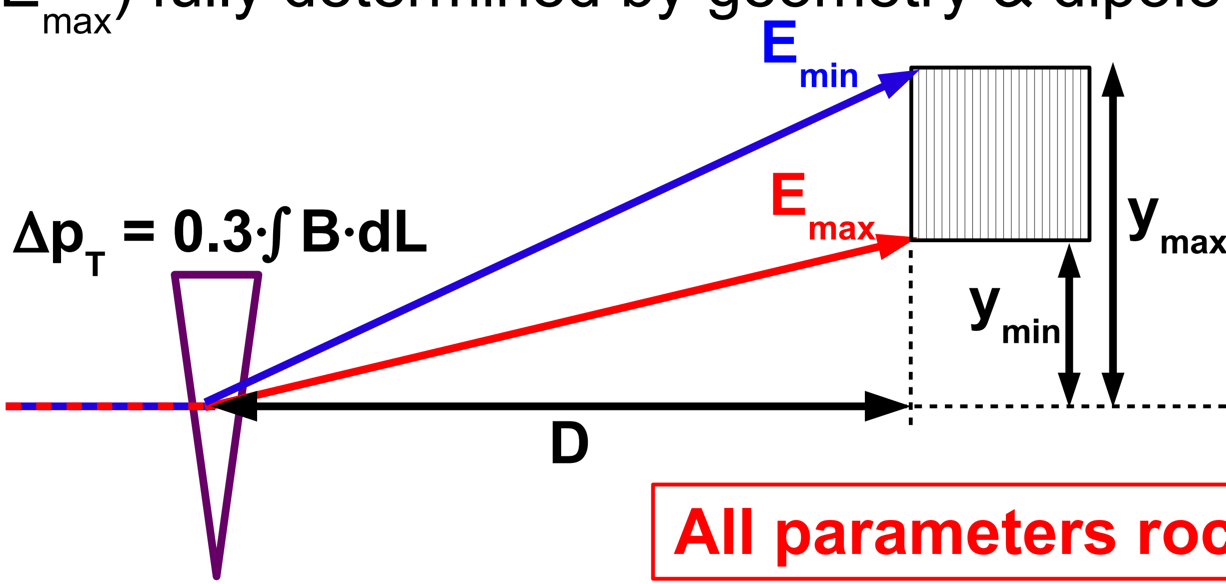




details on extra slides



- (E_{min},E_{max}) fully determined by geometry & dipole:



$E_{min} = \Delta p_T \cdot D / y_{max}$

$E_{max} = \Delta p_T \cdot D / y_{min}$

All parameters rock-solid stable

Calorimeter resolutions

- Acceptance determined by geometry, dipole;
  do not need event-by-event photon energy

- Calorimeter energy resolution not very important;
  just need to decide **'hits'** or **'no hits'** in a bunch ×ing

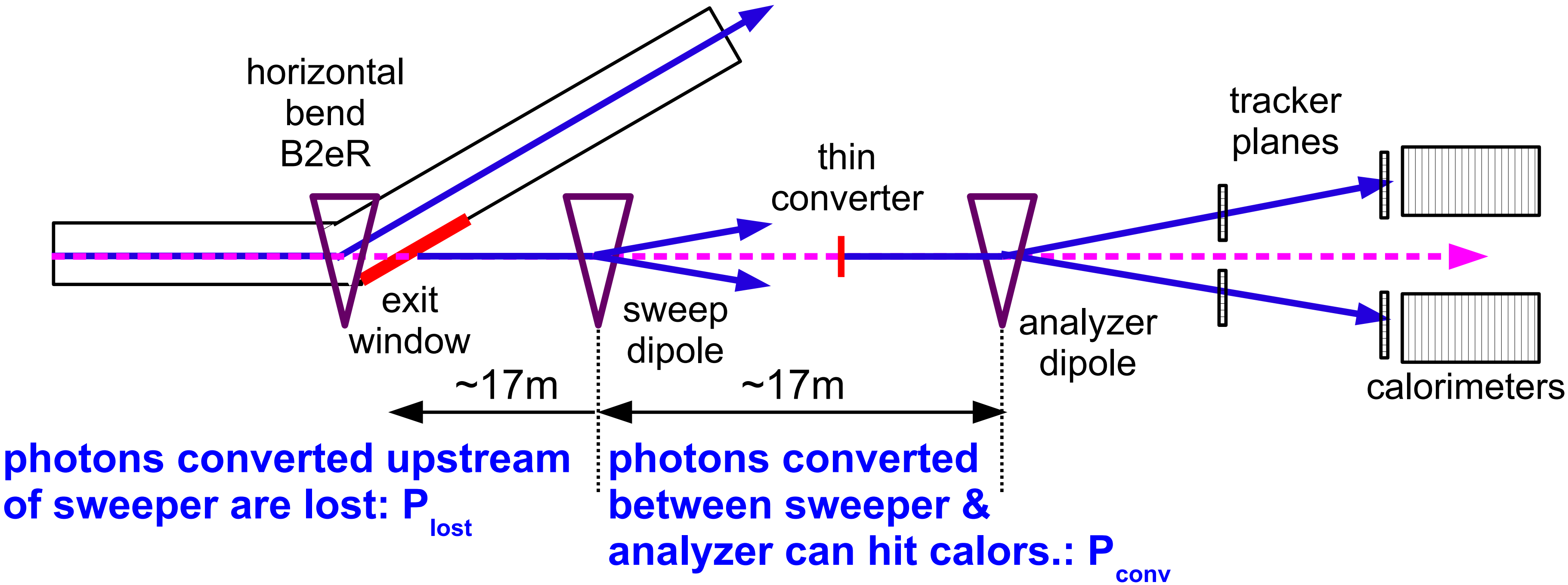
- <u>More important:</u> signals must be isolated to one bunch ×ing
  otherwise pileup correction very complicated

<u>But good E-resolution is helpful</u>

- Acceptance correction requires faithful simulation,
  factors not in simple calculation, e.g.:
  - photon aperture
  - finite length dipoles
  - beam spread vertically, varying E_{min},E_{max}
  - 'fuzzy' edges of calorimeter acceptance
    try to map out with $e^{\pm}$ trackers

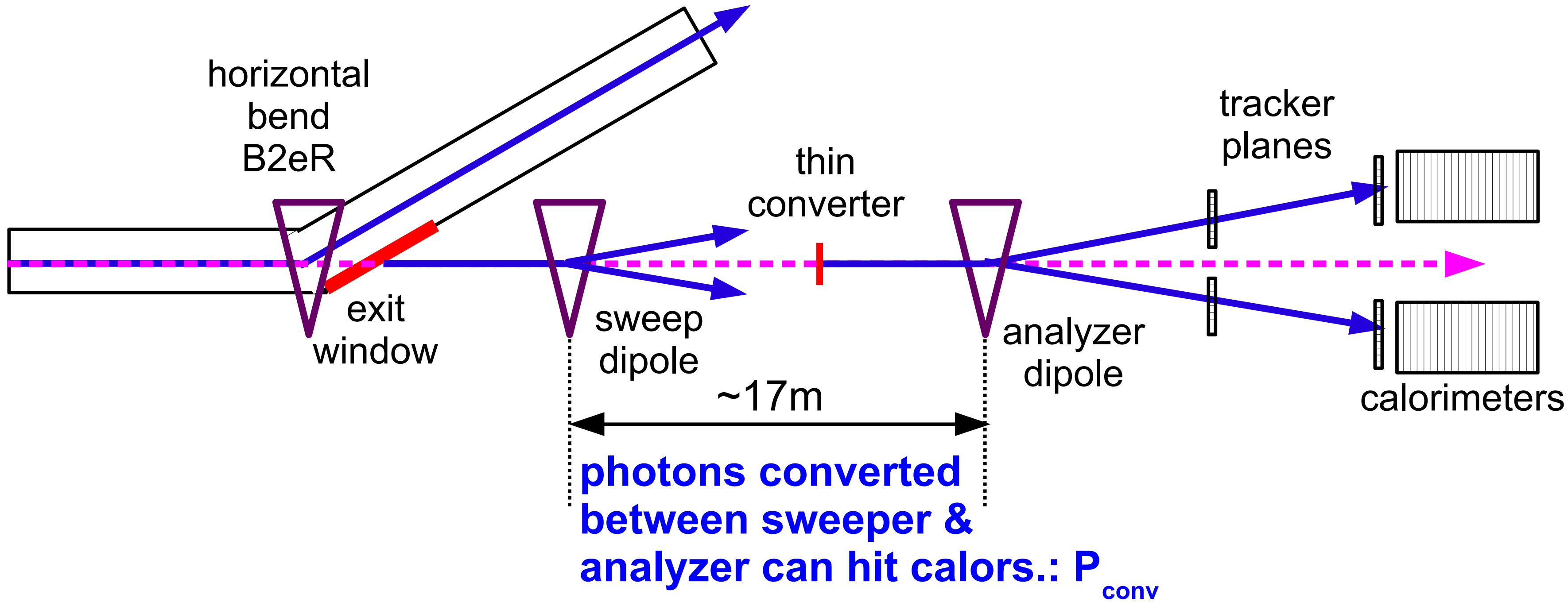
- Need to verify: simulation ↔ data comparison
  as many variables as we can plot
  better resolutions ⇒ better simulations

Lost / converted photons



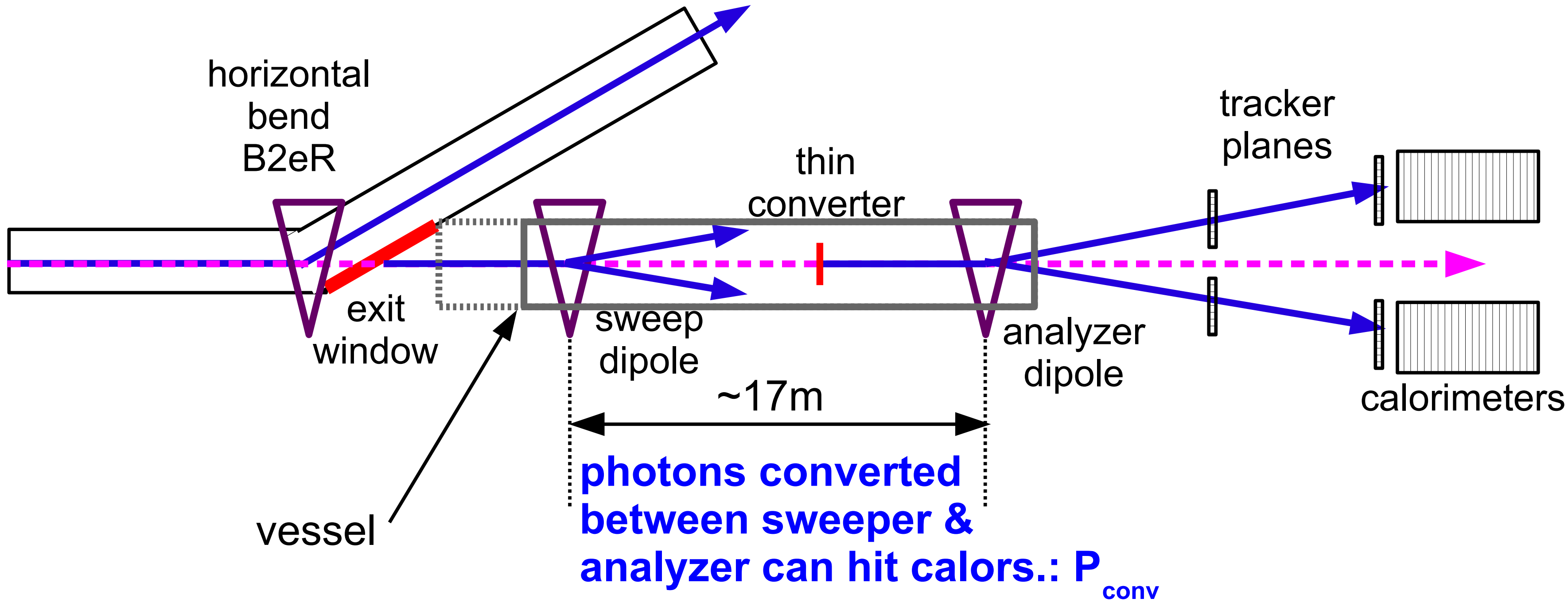
- # calor. hits: $N_{hits} \propto (1-P_{lost}) \cdot P_{conv} \cdot L$
- P_{lost} ~ 10% (~1 cm Al exit window); also ~17m air...
  uncertainty of e.g. 5% on P_{lost} gives 0.55% uncert. on L
- Can measure P_{lost}:
  - turn off sweeper $N_{hits} \propto P_{lost} \cdot P_{conv} \cdot L$
  - measure sweeper on/off rates tagged by low-Q^2 brems. electrons

Converted photons



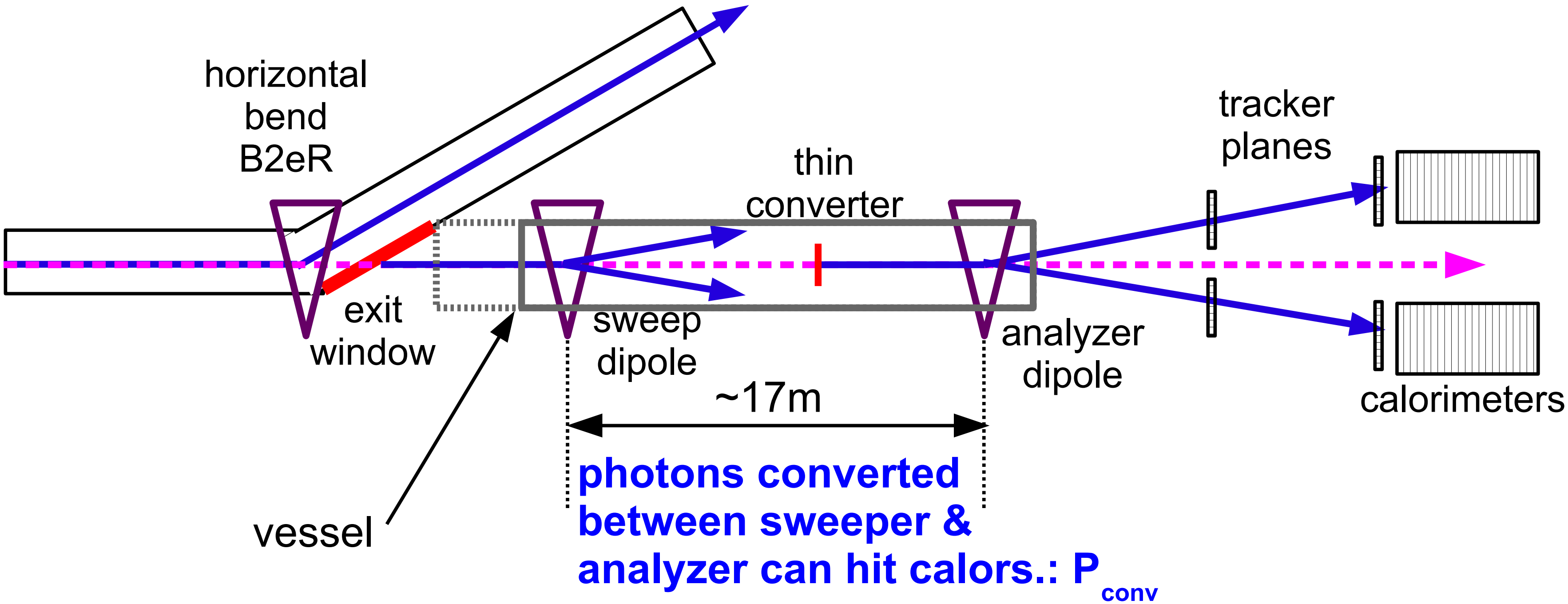
- Want P_{conv} as small as possible, hopefully ~1% (1mm Al)
- Need guidance: **how thin a converter can withstand sync. rad.?**
- But there is ~17m air between sweeper/analyzer
  - dry air, 20° C 1 atm, radiation length L_{rad} = 304m
  - 17m air adds ~5.6% to P_{conv}
- Too many conversions in air. Similar contribution to P_{lost}...

Converted photons



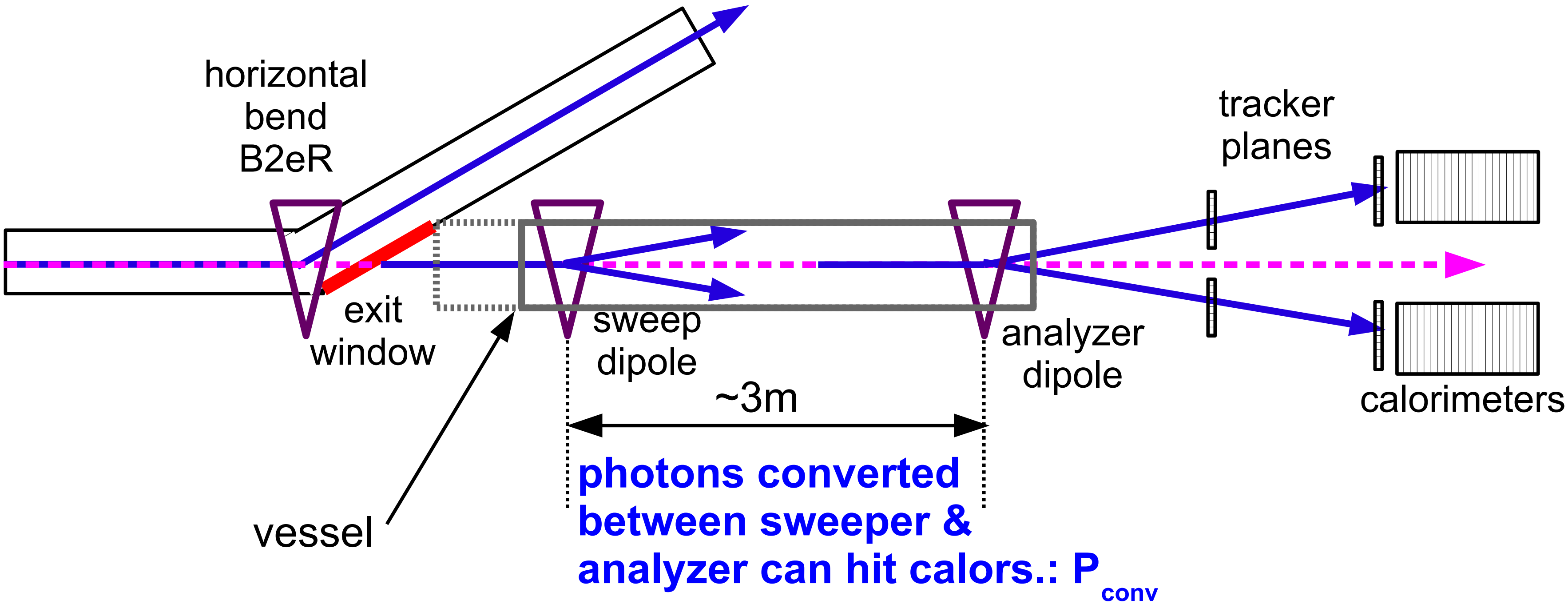
- Add vessel with controlled content between sweeper↔analyzer,
  or exit window↔analyzer
  - conversions in entrance window swept, exit window not tagged
  - **thin converter must be inside vessel**
- Contents Helium:
  - He, 20° C 1 atm, radiation length L_{rad} = 5.7km
  - 17m He adds ~0.3% to P_{conv}
- He @ 1 atm: entrance/exit windows can be thin

Converted photons



- Vessel contents ~vacuum: adds ~nothing to P_{conv}
- Entrance/exit windows must support 1 atm: thick multiple scattering in exit window degrades tracker $e^{\pm}$ energy resolution, how much?
- Thin converter inside vacuum vessel

Converted photons



Alternatively:

can we make a much stronger sweeper? from 0.4 T-m → 2 T-m?

need guidance: **how strong can sweeper be?**

- Shorten sweeper→analyzer distance to ~3m
- 3m air, P_{conv} = 1% eliminate thin converter, vessel

How stable is the weather in EIC (RHIC) tunnel?

- Or: 3m vessel w/ dry N_2 as converter?

no problems from: no sync. rad., temp/humidity (fixed closed volume)

We are still seeking best solution

Extras

Radiation lengths (from PDG)

- helium gas (He) 20° C, 1 atm

Radiation length 5.671E+05 cm

- nitrogen gas (N_2) 20° C, 1 atm

Radiation length 3.260E+04 cm

- air (dry) 20° C, 1 atm

Radiation length 3.039E+04 cm

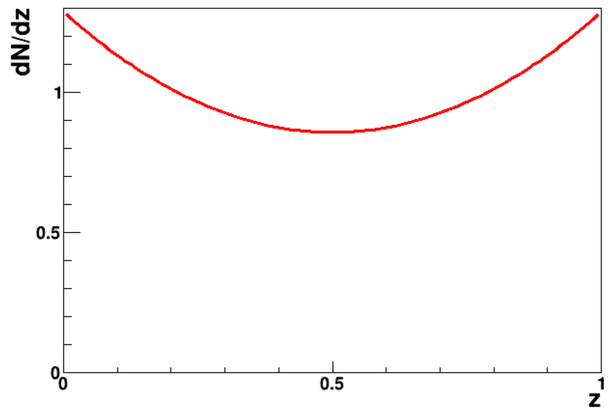
- aluminum (Al)

Radiation length 8.897 cm

Spec. acceptance vs E_γ

- Energy sharing for $\gamma \to e^+e^-$: $z = E_{e+}/E_\gamma$, $0<z<1$
- Distribution $dN/dz \propto 1 - (4/3)\cdot z\cdot(1-z)$

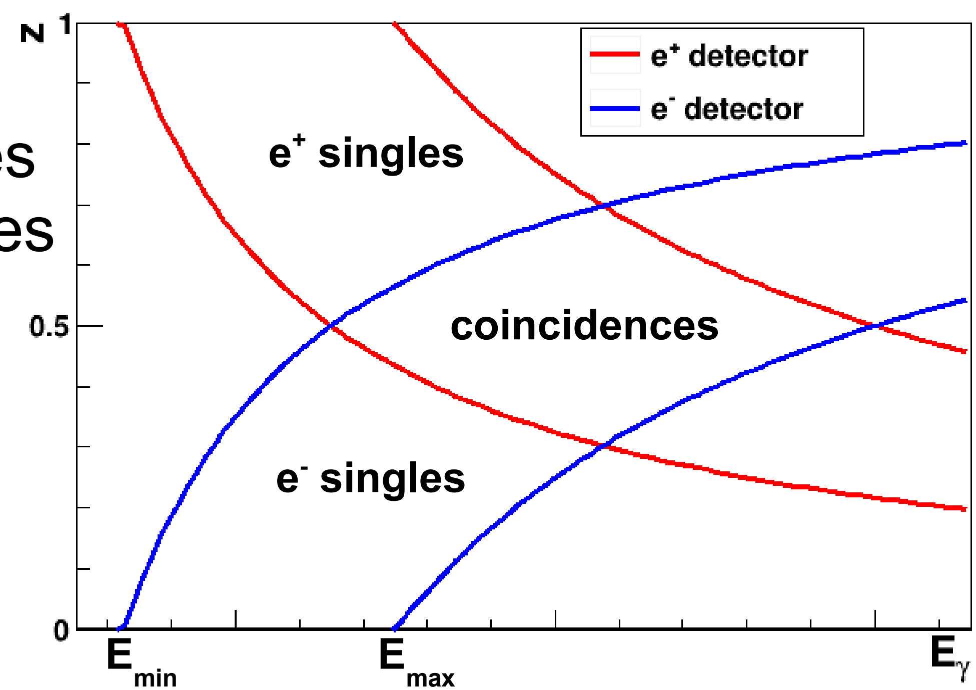
[PDG eq. 34.31]



- Energy range of spec. det. (E_{min},E_{max}) defines z ranges:

$z_{min,max} = E_{min,max}/E_\gamma$ for e^+ det. & $(1-z_{max}, 1-z_{min})$ for e^- det. $(0<z<1)$

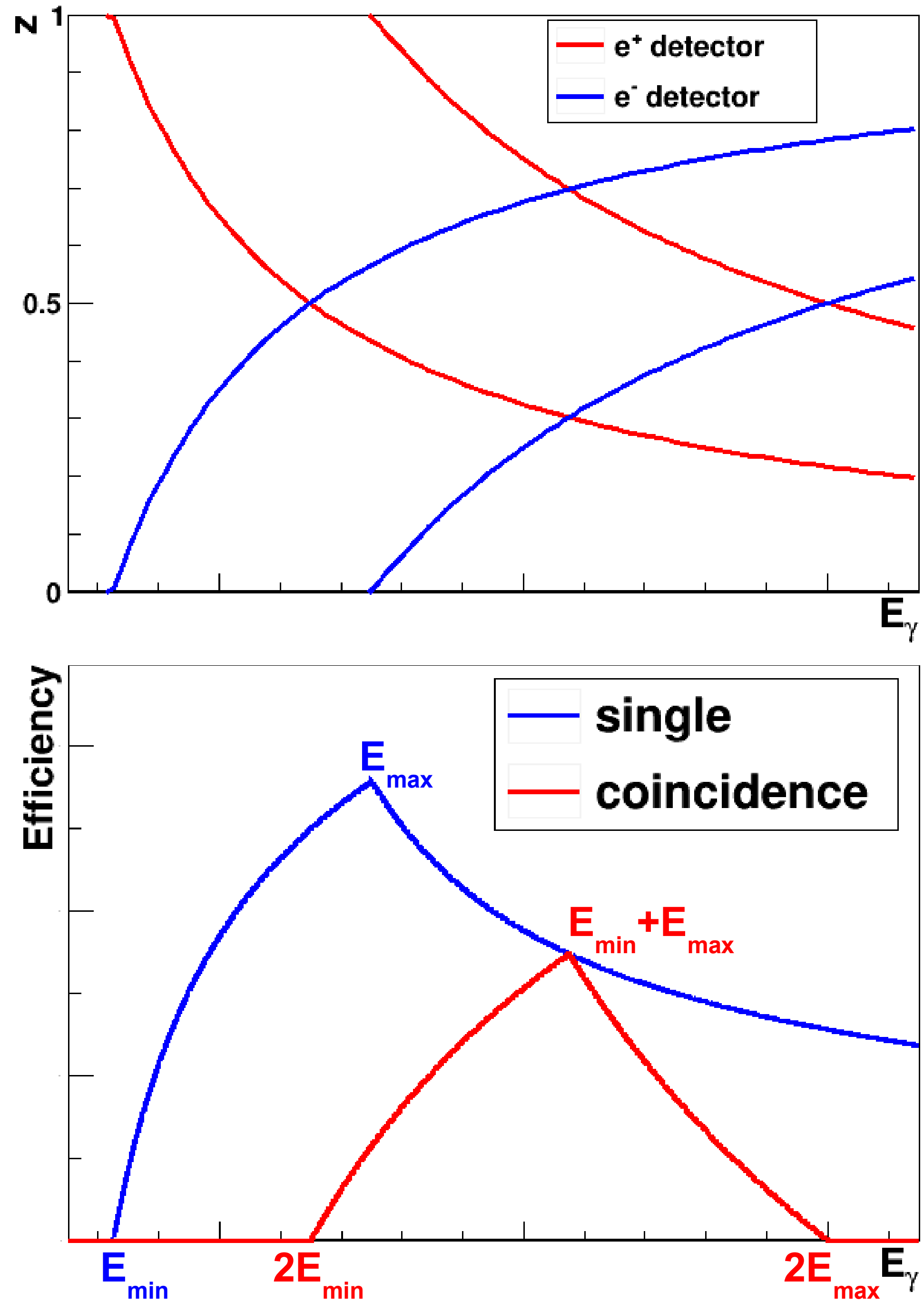
- Acceptance in E_γ-z plane:
  - e^+ singles between red curves
  - e^- singles between blue curves
  - coincidence in diamond shaped region



Spec. acceptance vs E_γ

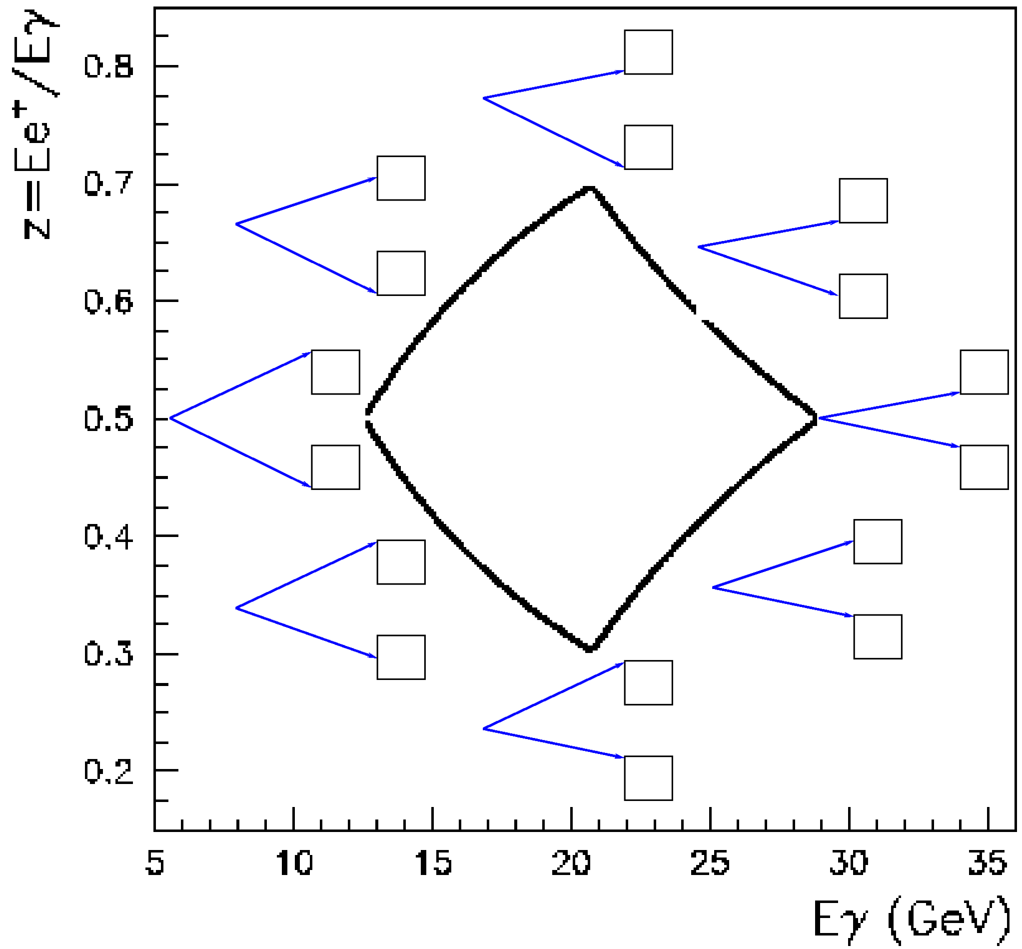
$acc(E_\gamma) = \int dz \cdot dN/dz$

- single:
  integrate between red/blue curves
- coincidence:
  integrate in diamond shaped region



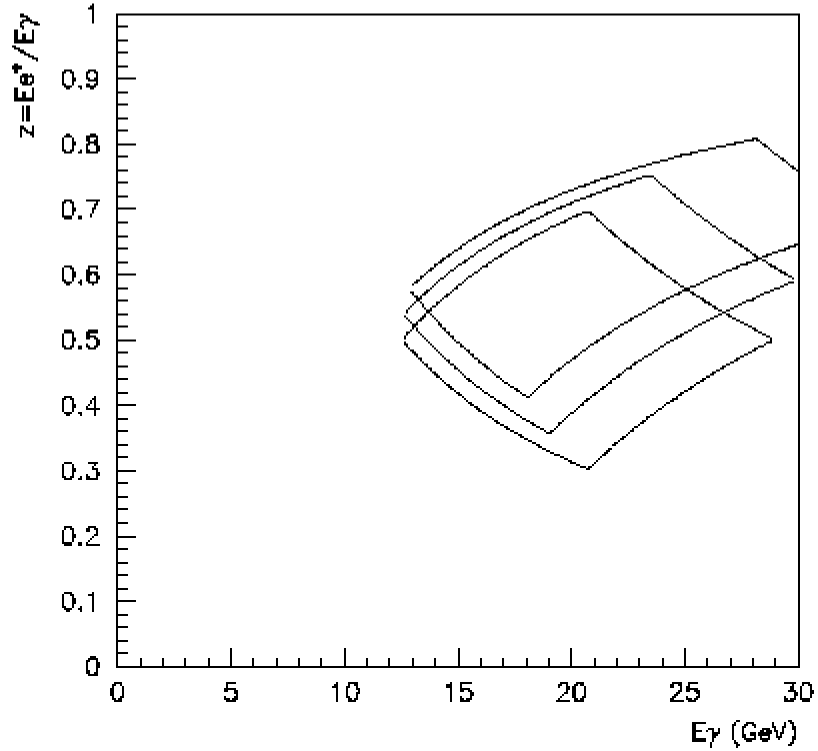
Coincidence region E_γ-z plane

- Insets show pair detector configurations at edges, corners of acceptance region



Spec. acceptance vs y_γ

- Coincidence region in γ-z plane varies with γ vertical position
- Shown here for 0,1,2 cm above spec. midpoint



- Prescription previous slides outlines acceptance for a given γ vertical position y: acc(E_γ,y)
- γ vertical position distribution due beam divergence: Gaus(y)
- Then overall acceptance acc(E_γ) = $\int$dy·Gaus(y)·acc(E_γ,y)
- Easily evaluated numerically as in previous examples, providing estimates including beam divergence