TCS Trigger

TCS signals from calorimeters
Beam background rates

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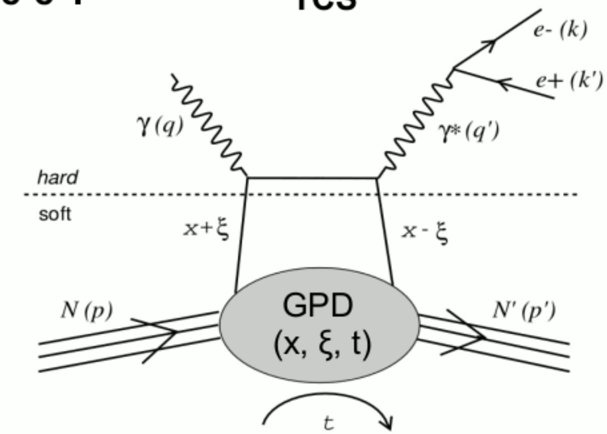
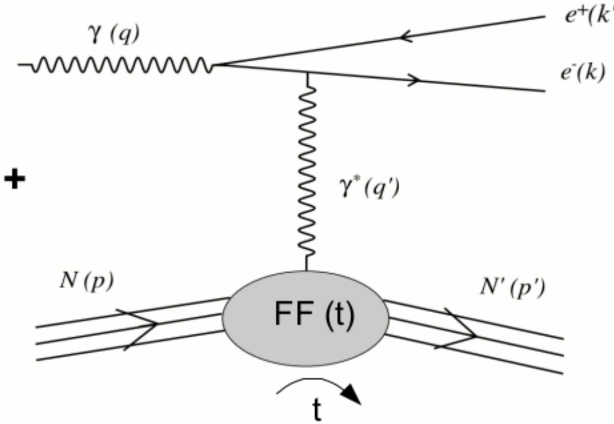
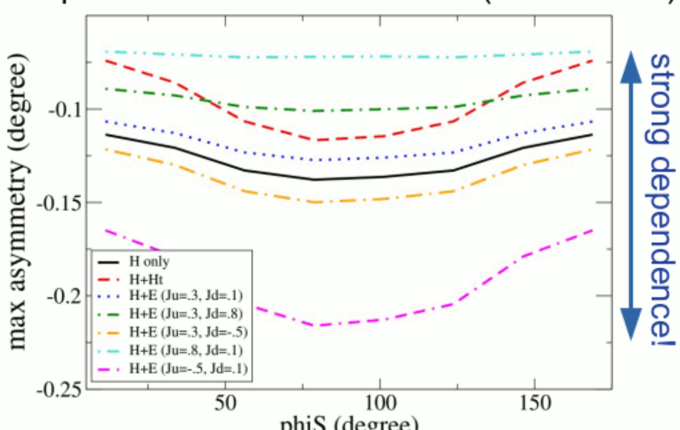
Physics goals

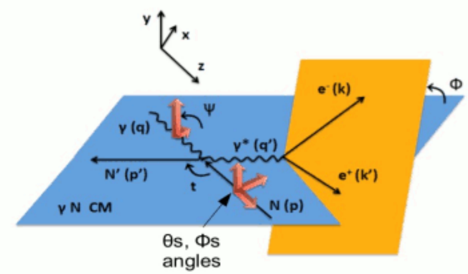
γ P → e⁺e⁻ P' = **TCS** **+** **Bethe-Heitler**





Sin(φ) moment of transverse spin asymmetry vs φ_S,
Dependence in GPD E and $J^{u,d}$ (VGG model)





TSA as a function of φ and φ_s

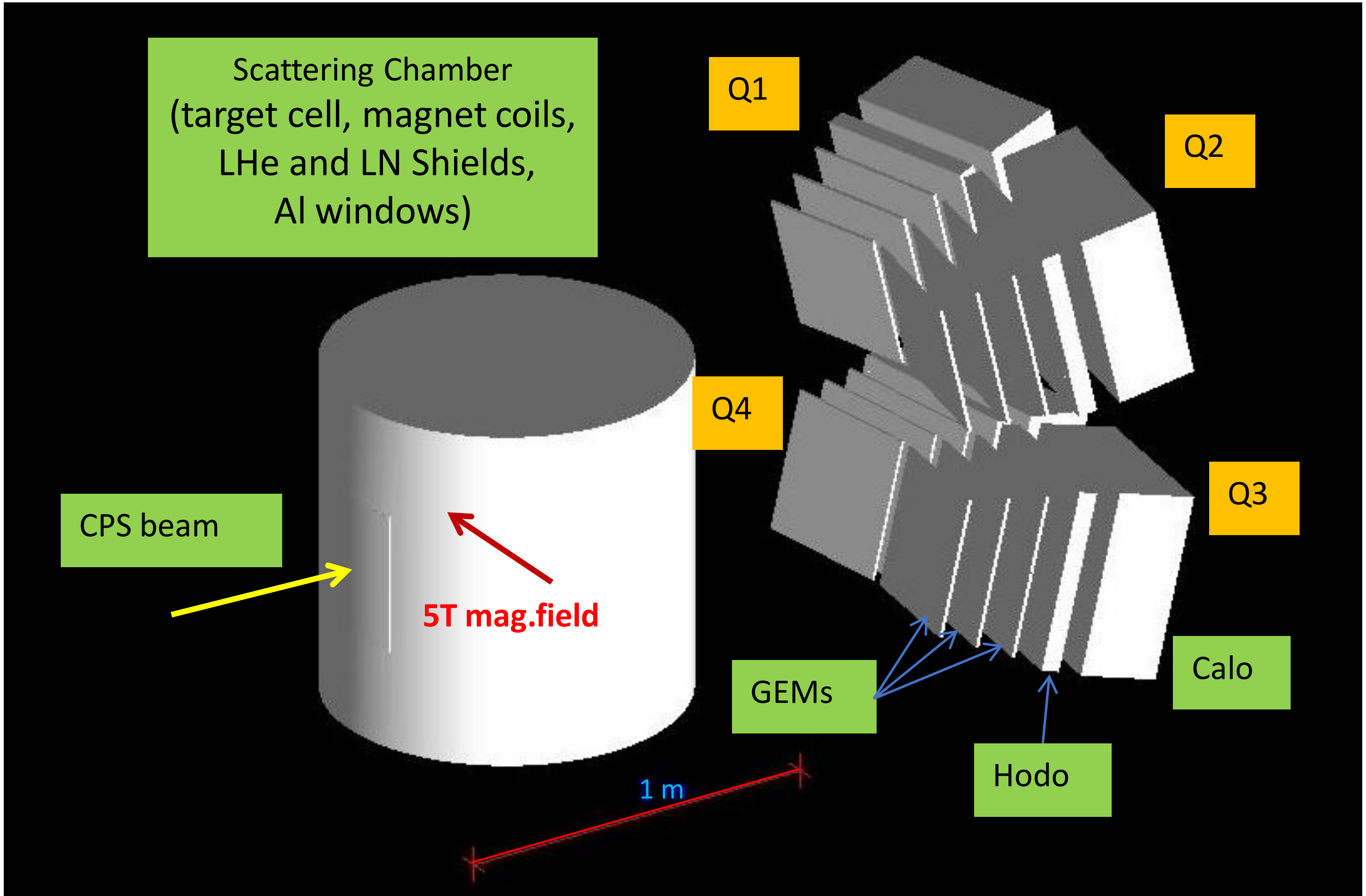
- Sensitive to Im(interference), BH cancels
- Strong dependence in angular momenta,

Sensitivity to GPD E (also to H, Ht)

Courtesy M.Boer

Proposed TCS setup

$$\gamma + p \rightarrow \gamma^* (e^+ + e^-) + p'$$



- Detect e^+, e^-, recoil p' in coincidence
- UVA/Jlab NH_3 target, transversely polarized
- Detectors arranged in 4 quarters, oriented to target
- Triple-GEMs for e^+, e^-, p tracking
- Hodoscopes for recoil proton detection/PID
- $PbWO_4$ calorimeters for e^+, e^- detection/PID

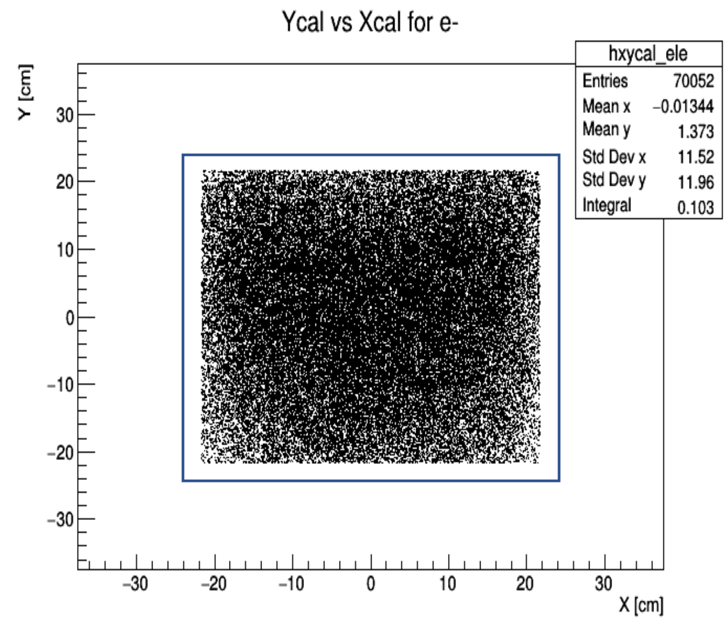
TCS event sampling and analysis

TCS event generation:

- From DEEPGen generator
- Sampling phase space:
  1) 5.5 GeV < E_γ < 11 GeV (Bremsstrahlung spectrum)
  2) 4 GeV^2 < Q^2 < 9 GeV^2
  3) 0 GeV^2 < -t < 1 GeV^2

Selection and analysis of TCS events:

- Select e+, e- tracks within acceptance of a quadrant (passing through GEMs and hitting calorimeter);
- Select recoil proton within acceptance of a quadrant (passing through GEMs);
- Select the e-, e+ tracks inside calorimeter (inside of the outer rim of 1 module width (~20mm, 1 Moliere radius);
- Calculate energy depositions in the calorimeters from e+,e-.



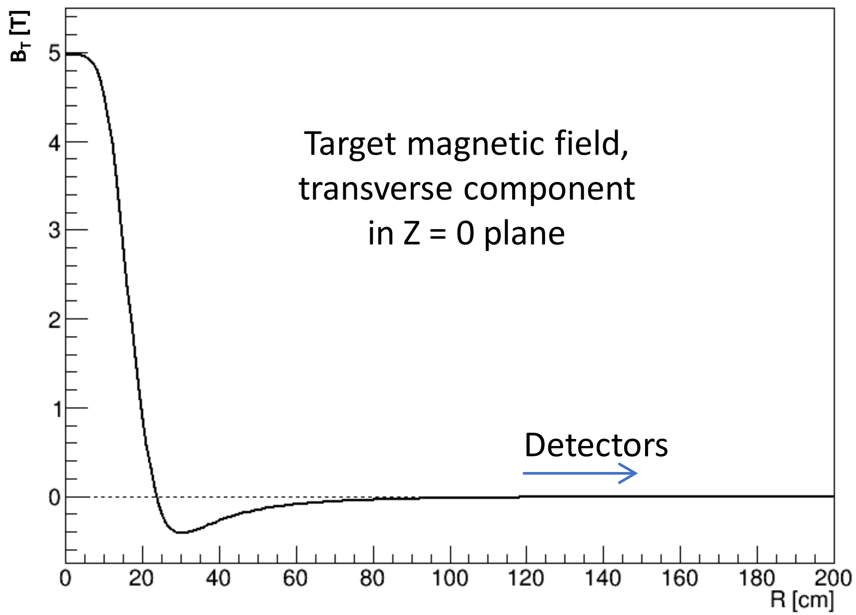
Beam background simulations

<u>CPS beam</u>

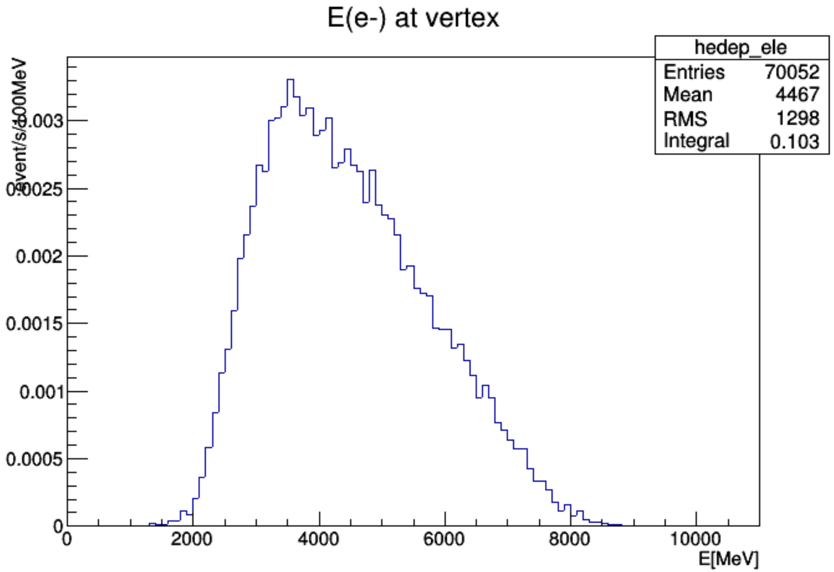
- 2 mm rastered collinear bremsstrahlung photon beam , E_{MAX} = 11 GeV
- Energy range: 10 MeV -- 11 GeV
- Intensity: $2x10^{13}$ γ/s

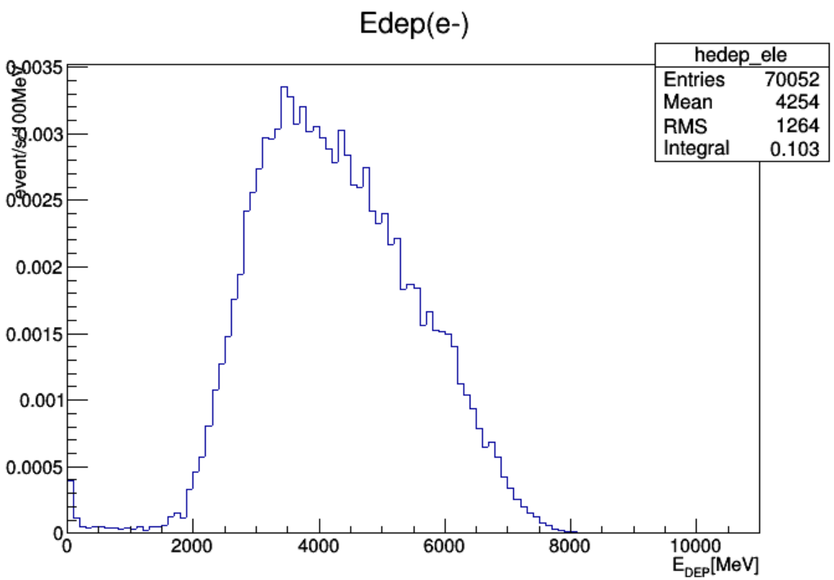
<u>Target assembly</u>

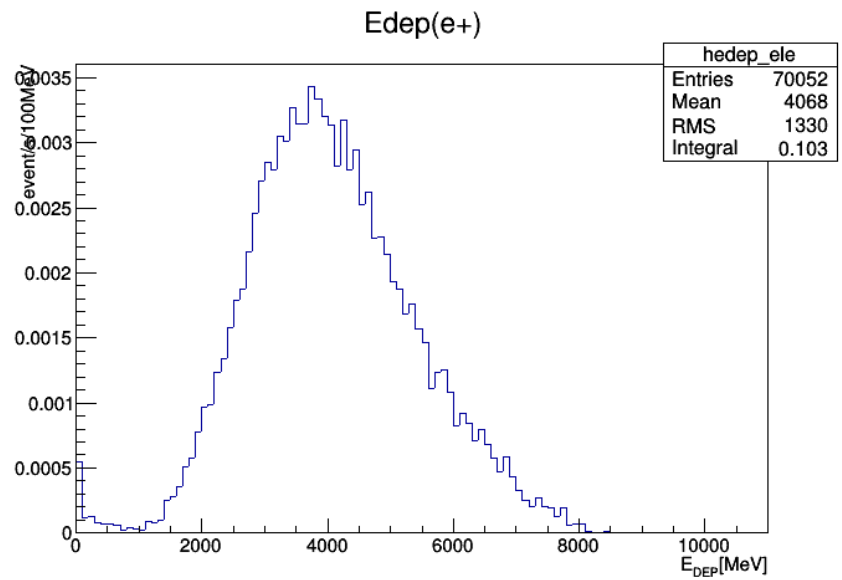
- 3 cm diam., 3 cm long target cell of 0.9 mm thick Kel-F (C_2ClF_3, ρ=2.13 g/cm^3)
- 0.7 mil Al cell entrance and exit windows
- Ammonia in LHe (at ~4^{o}K), 0.6 packing fraction
- Scattering Chamber with 20 mil Al windows
- Magnet coils, LHe and LN Shields
- Chamber & magnet rotated 90^o
- Transverse magnetic field, 5T at center



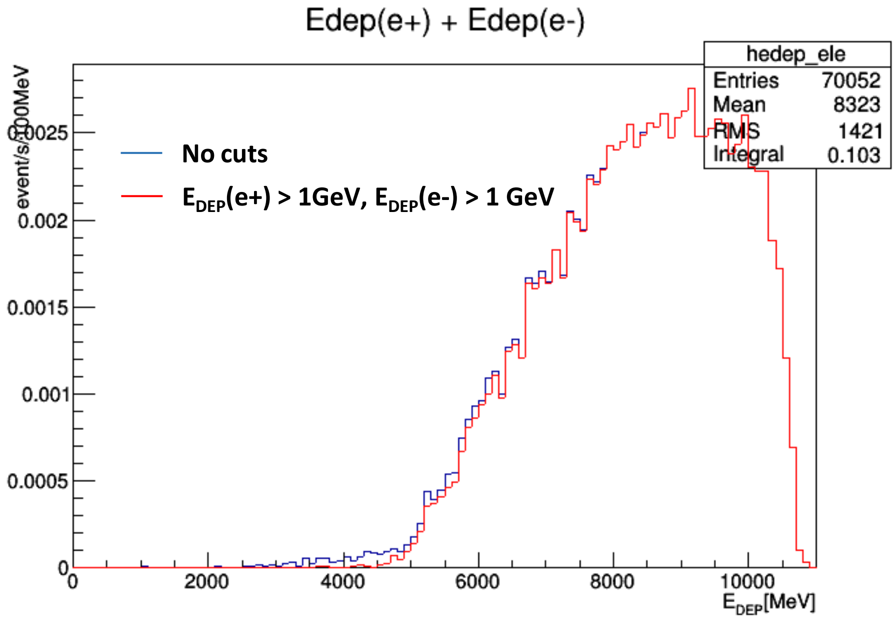
TCS events

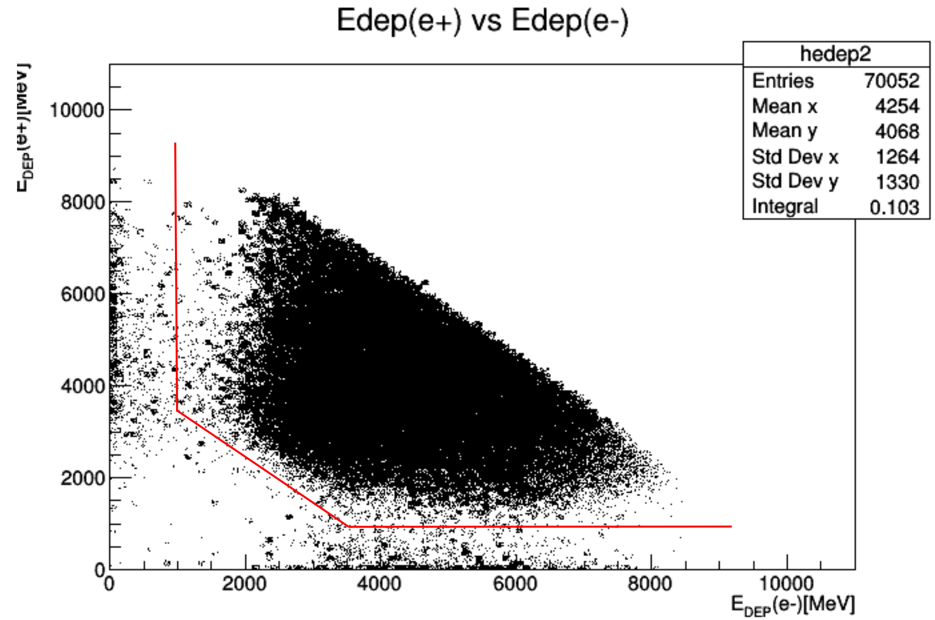

E(e-) at vertex
hedep_ele
Entries 70052
Mean 4467
RMS 1298
Integral 0.103
event/s/100MeV
E[MeV]

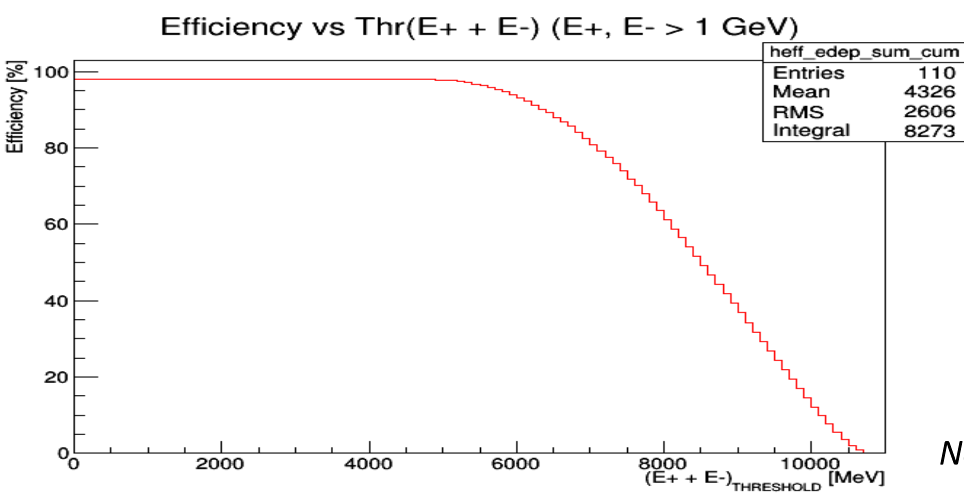

Edep(e-)
hedep_ele
Entries 70052
Mean 4254
RMS 1264
Integral 0.103
event/s/100MeV
E_DEP[MeV]


Edep(e+)
hedep_ele
Entries 70052
Mean 4068
RMS 1330
Integral 0.103
event/s/100MeV
E_DEP[MeV]

TCS events



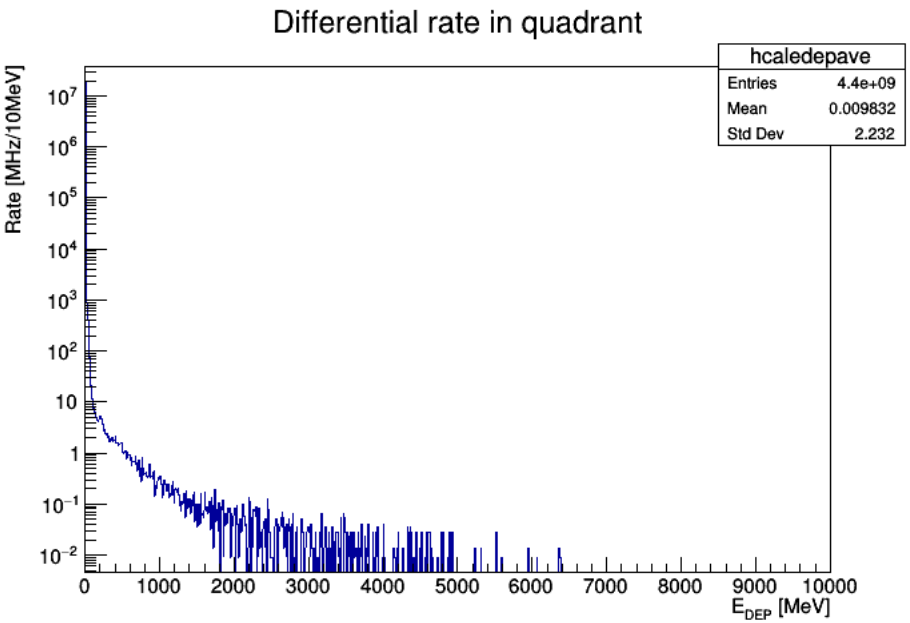


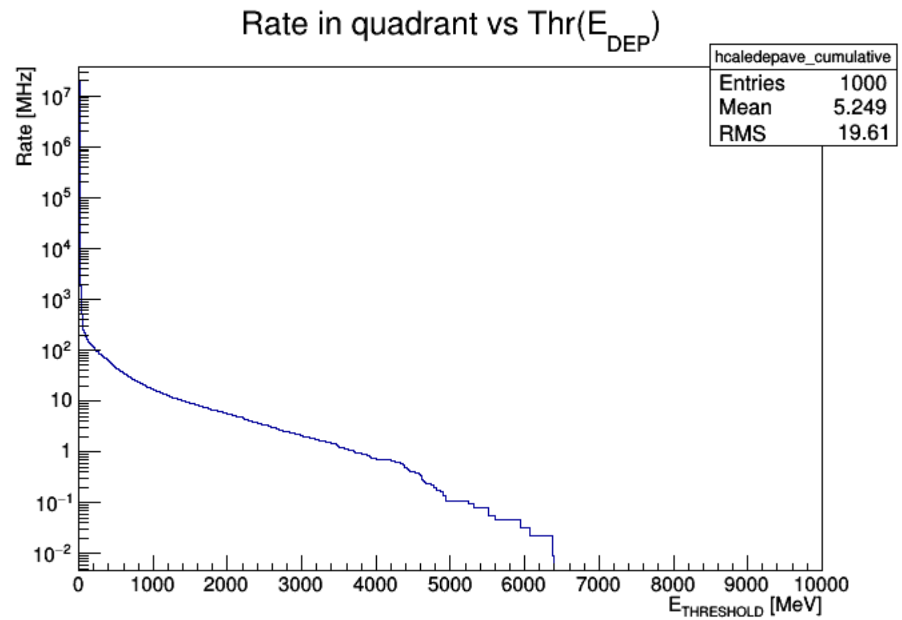


E_{DEP}(e-), E_{DEP}(e+) thr.[GeV]	E_{DEP}(e-) + E_{DEP} (e+) thr.[GeV]	Efficiency [%]
1.	5.	97.7 ± 0.1
1.5	5.	97.1 ± 0.1
1.	4.5	98.0 ± 0.1

Note: e- & e+ tracks in opposite quadrants in ~99.5% of cases.

Beam background

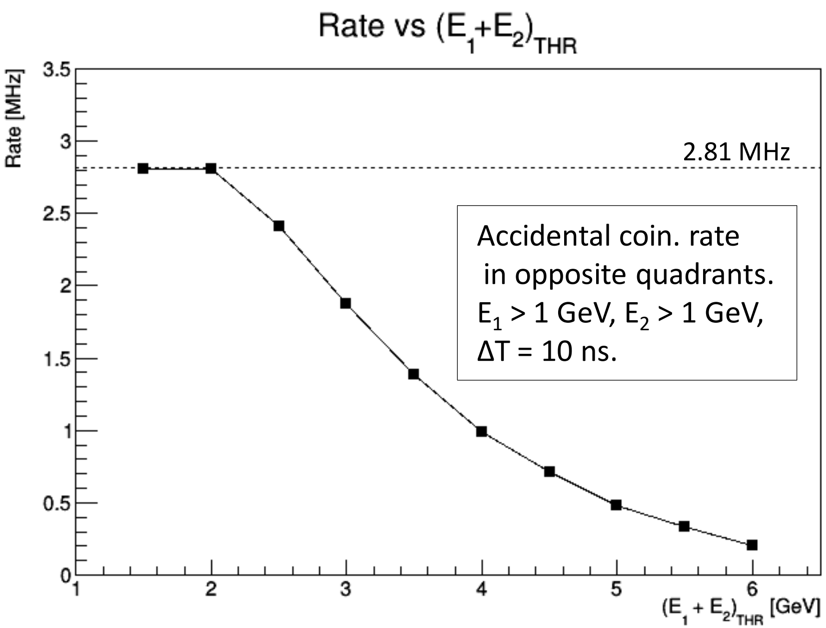


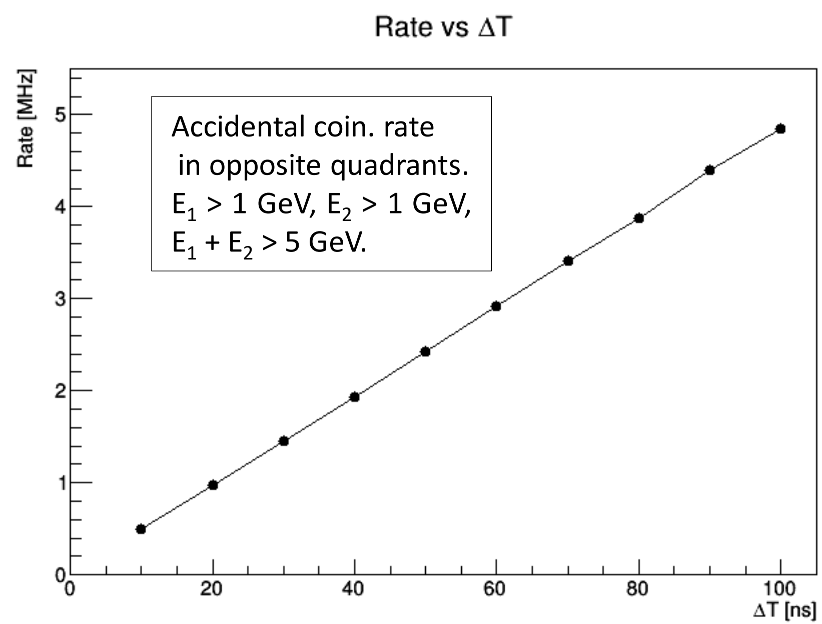


Rate ~ 17 MHz in a quadrant for Edep > 1 GeV.

Accidental coincidence rate in opposite quadrants for ΔT=10ns: $16.77 \cdot 10^{6} \times 16.77 \cdot 10^{6} \times 10 \cdot 10^{-9}$ = ***2.81 MHz***

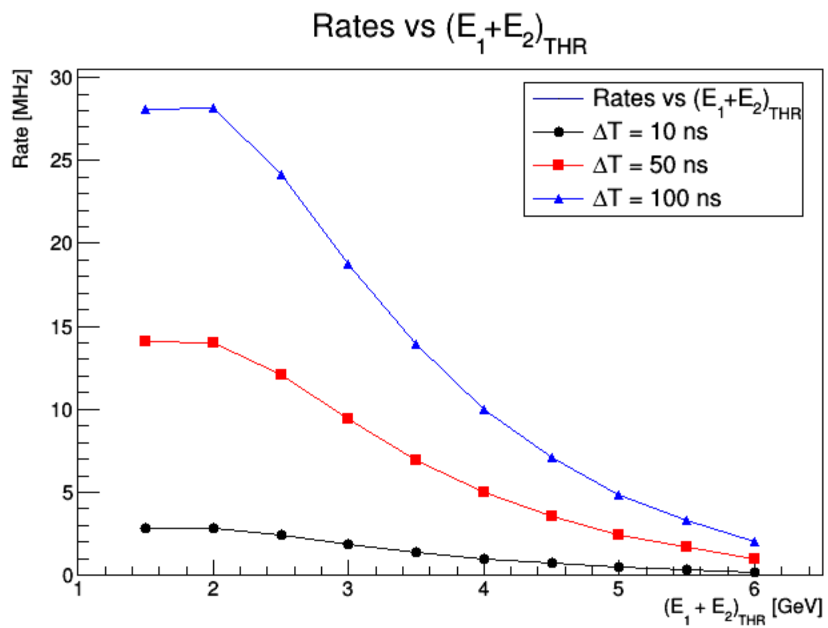
Beam background





Accidental coincidence rates in opposite quadrants, for $E_1 > 1$ GeV, $E_2 > 1$ GeV.

Beam background

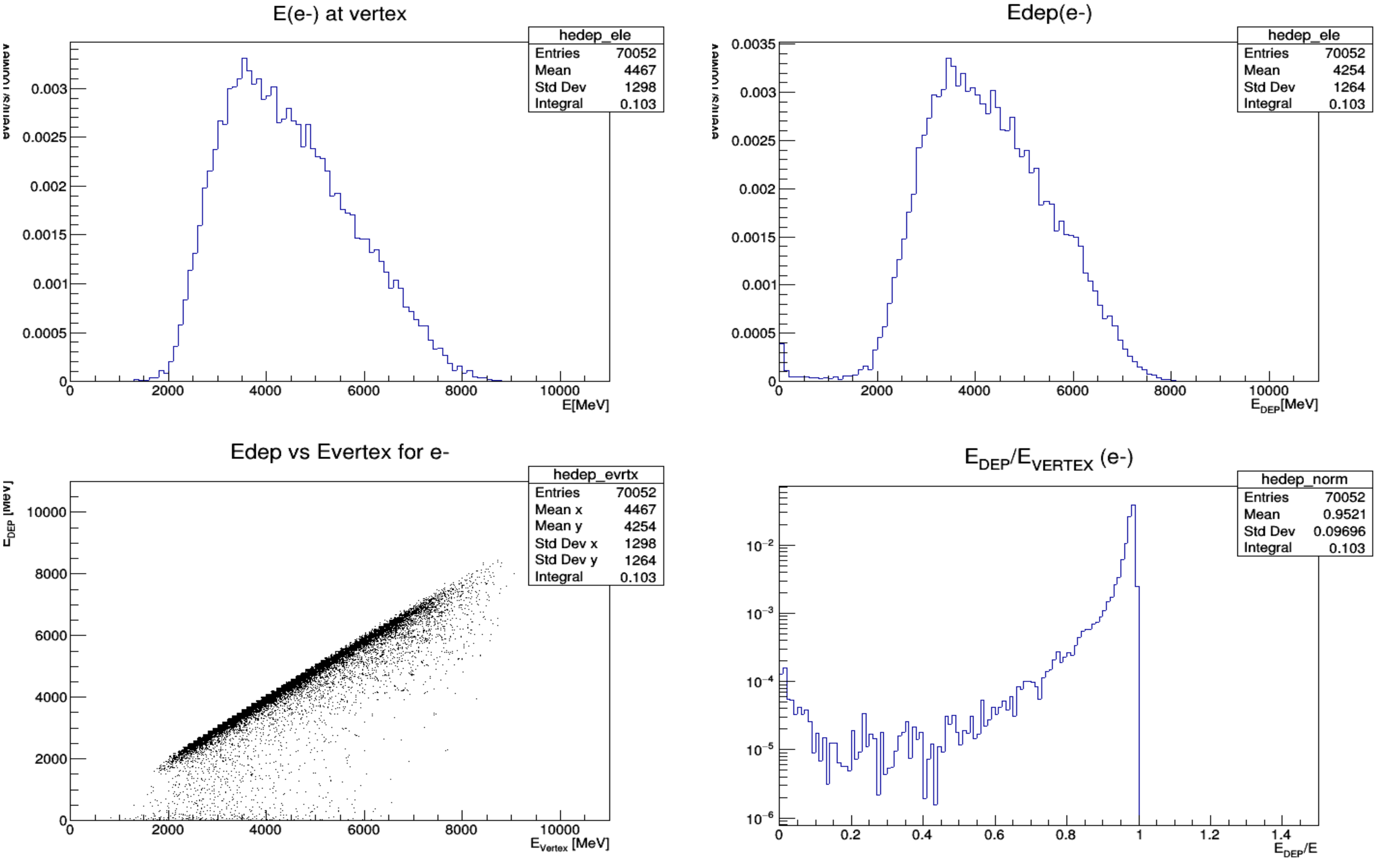


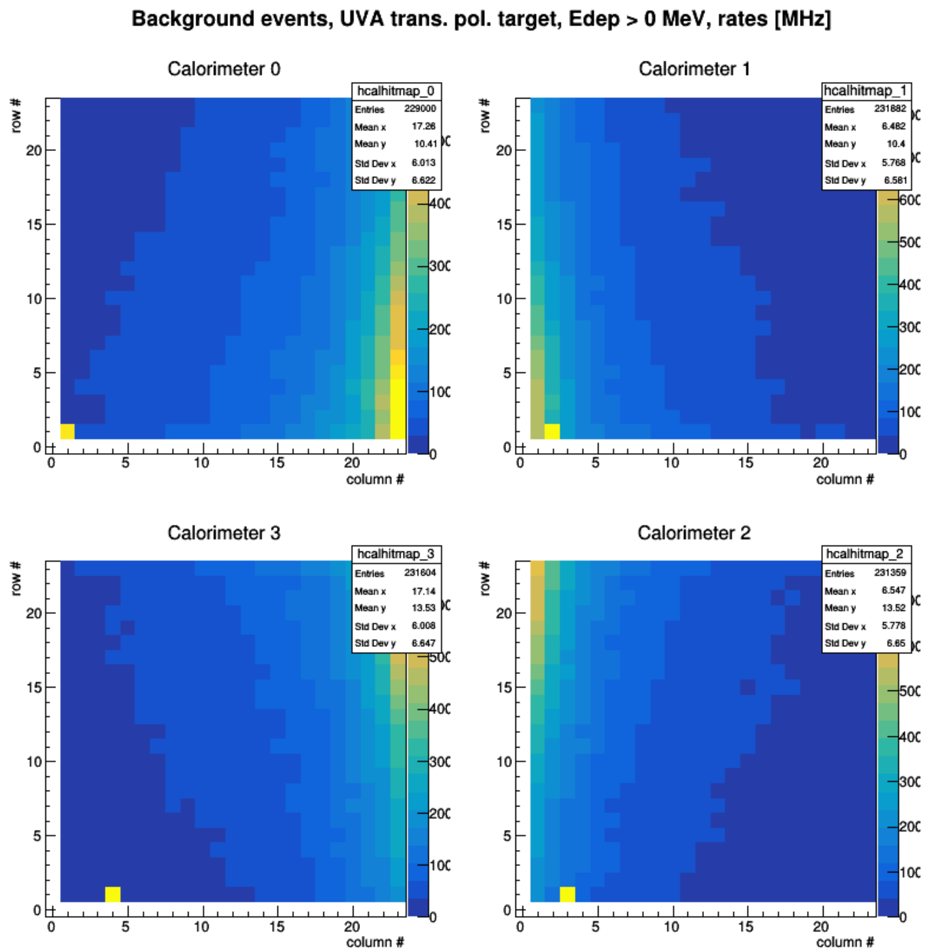
Accidental coincidence rates in opposite quadrants for E_1 > 1 GeV, E_2 > 1 GeV. Rate reduction by several times due to cut on the summed deposited energy at ~ 5 GeV.

Conclusion

- For TCS events, e- and e+ tracks are in opposite quadrants in ~99.5% of cases.
- For TCS events, E_1>1GeV, E_2>1GeV, E_1+E_2>5GeV cuts are ~98% efficient.
- Accidental coincidence rate in opposite quadrants from beam background is ~2.8 MHz, for time window ΔT = 10 ns and E_1>1GeV, E_2>1GeV, linear in ΔT.
- The accidentals can be reduced by 5 – 6 times with E_1+E_2>5GeV cut implementation.
- Note: estimates are for full quadrants. Significant reduction of the accidental rates is expected with elimination of the "hot" channels in the calorimeters.

Backup slides


E(e-) at vertex
hedep_ele
Entries 70052
Mean 4467
Std Dev 1298
Integral 0.103
E[MeV]
Edep(e-)
hedep_ele
Entries 70052
Mean 4254
Std Dev 1264
Integral 0.103
E_DEP[MeV]
Edep vs Evertex for e-
hedep_evrtx
Entries 70052
Mean x 4467
Mean y 4254
Std Dev x 1298
Std Dev y 1264
Integral 0.103
E_Vertex [MeV]
E_DEP [MeV]
E_DEP/E_VERTEX (e-)
hedep_norm
Entries 70052
Mean 0.9521
Std Dev 0.09696
Integral 0.103
E_DEP/E



Beam background hit pattern in the calorimeters.

Material before the calorimeters

Item	Material	Density[g/cm^3]	Rad.Length[cm]	Thickness[cm]	Thick./RadL[%]
Half of target	NH_3, Lhe	0.5482	78.685	1.5	1.906
Target end cap	Al	2.7	8.893	0.001778	0.020
LHe shield	Al	2.7	8.893	0.00381	0.043
LN2 scr. Window	Al	2.7	8.893	0.00381	0.043
Scat. Cham. window	Al	2.7	8.893	0.0508	0.571
GEMs (3 layers)					
Hodoscope	Polystyrene	1.06	41.313	5.	12.103
Case window	Al	2.7	8.893	0.1	1.124
Air		0.00129	28511.3	~100.	~0.351
Total					16.161

GEMs thick./RL is expected to be small.

Calculation of accidental coincidence rate in opposite quadrants

Take rate R1 for E_{THR} > 1 GeV in a quadrant from cumulative distribution (16.8 MHz)
Calculate average number of events in time interval ΔT: Nave = R x ΔT (0.17 for ΔT=10ns)

For each event:

- Sample E1 > 1 GeV in a quadrant (from cumulative distribution);
- Sample number of hits in the opposite quadrant N2, from Poisson distribution for Nave

  Ncoin = 0
  For each hit in 2-nd quadrant:
    - Sample E2 > 1 GeV (from cumulative distribution)
    - If (E1 + E2 > 5 GeV) Ncoin++

End:

- F = Ncoin/Nevents
- Rcoin = R1 x F