The Beryllium Anomaly with the MEGII experiment

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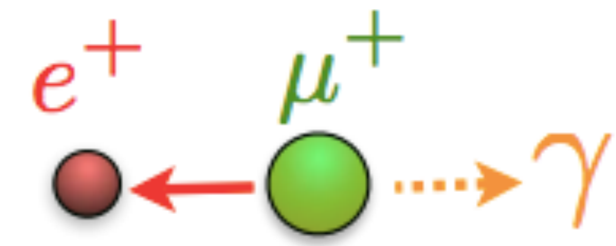
The MEG-II experiment

SIGNAL

- 28 MeV/c μ continuous beam stopped on a 130 μm polyethylene slanted target (15°)
- Paul Scherrer Institut (Switzerland) has the most intense DC muon beam in the world: up to 10^8 μ/s
- 5 kinematic variables: $E_e, E_\gamma, t_{e\gamma}, \theta_{e\gamma}$ $e\gamma$



$E_\gamma = E_e = 52.8$ MeV

$\theta_{e\gamma} = 180°$

$t_{e\gamma} = 0$ s

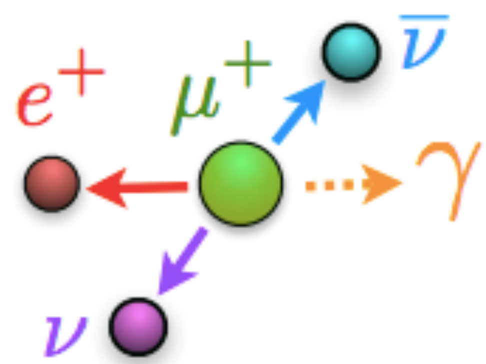
BACKGROUNDS

$E_\gamma < 52.8$ MeV

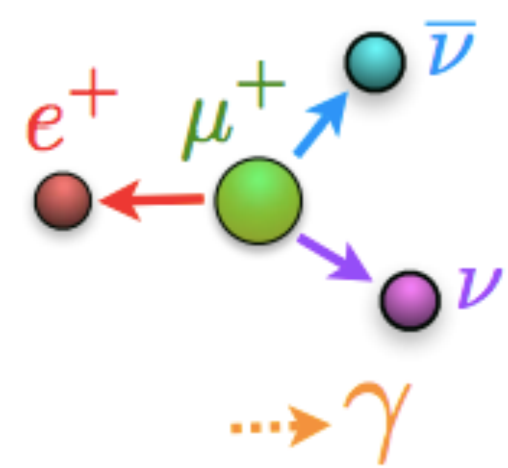
$E_e < 52.8$ MeV

$\theta_{e\gamma} < 180°$

$t_{e\gamma} = 0$ s



- Radiative muon decay (RMD)



$E_\gamma < 52.8$ MeV

$E_e < 52.8$ MeV

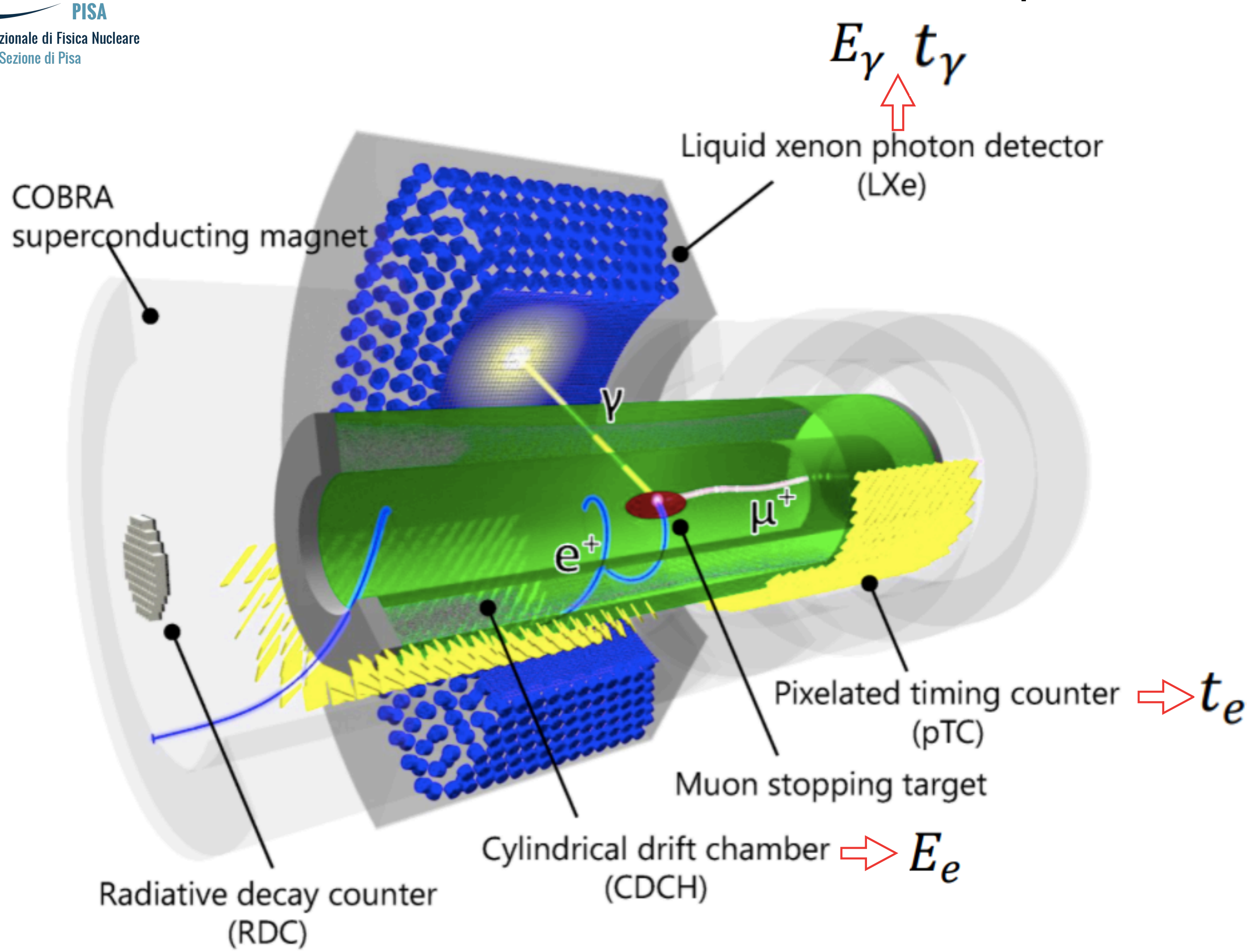
$\theta_{e\gamma} < 180°$

$t_{e\gamma} = \text{flat}$

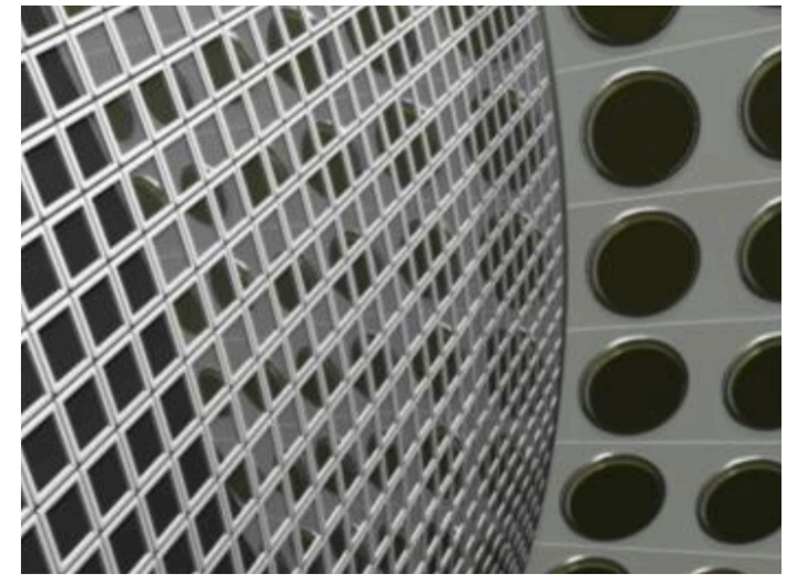
- Accidental background
  —> Michel decay + Gamma from RMD, AIF or bremsstrahlung

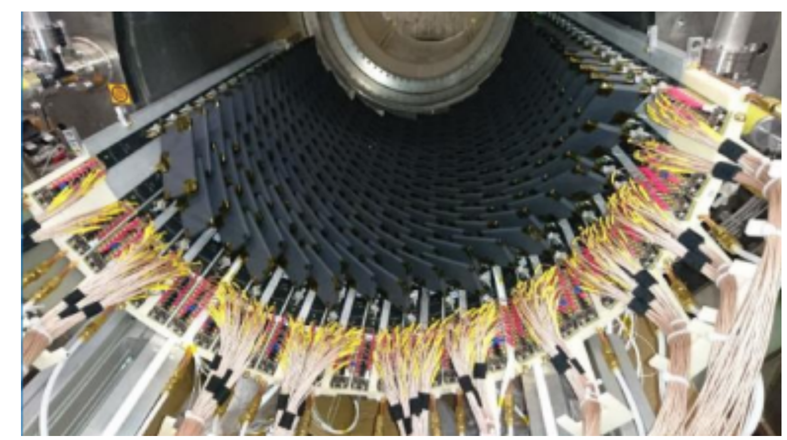
$N_{\text{acc}} \propto R_{\mu^+}^2 \times \Delta E_\gamma^2 \times \Delta p_{e^+} \times \Delta\Theta_{e^+\gamma}^2 \times \Delta t_{e^+\gamma} \times T$ —> Accidental bkg dominant at high rates

The MEG-II experiment

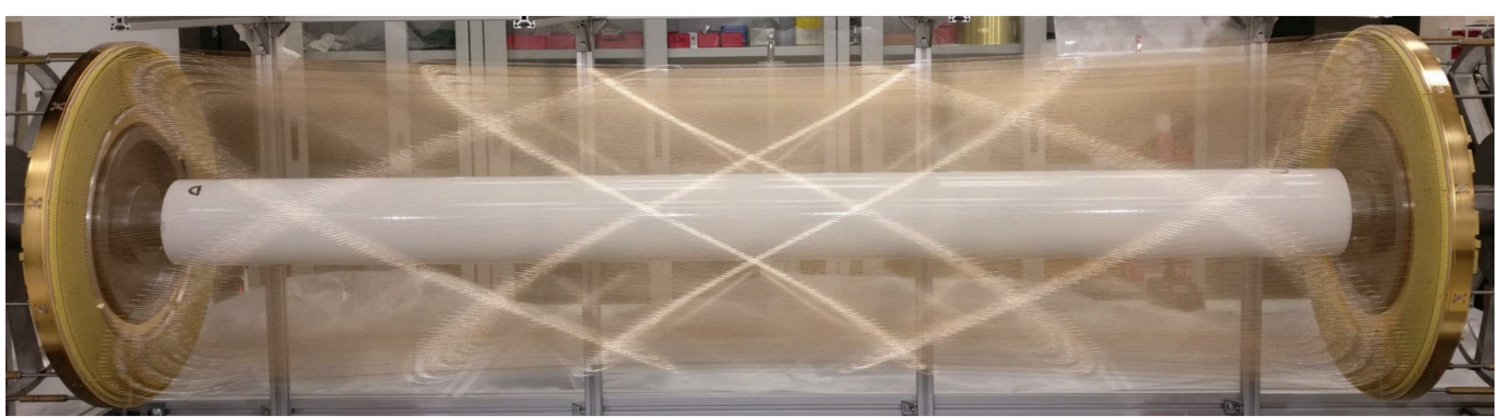


900L of LXe readout by 4092 SiPMs and 668 PMTs





pTC - 2 x 256 of scintillator plates readout by SiPMs



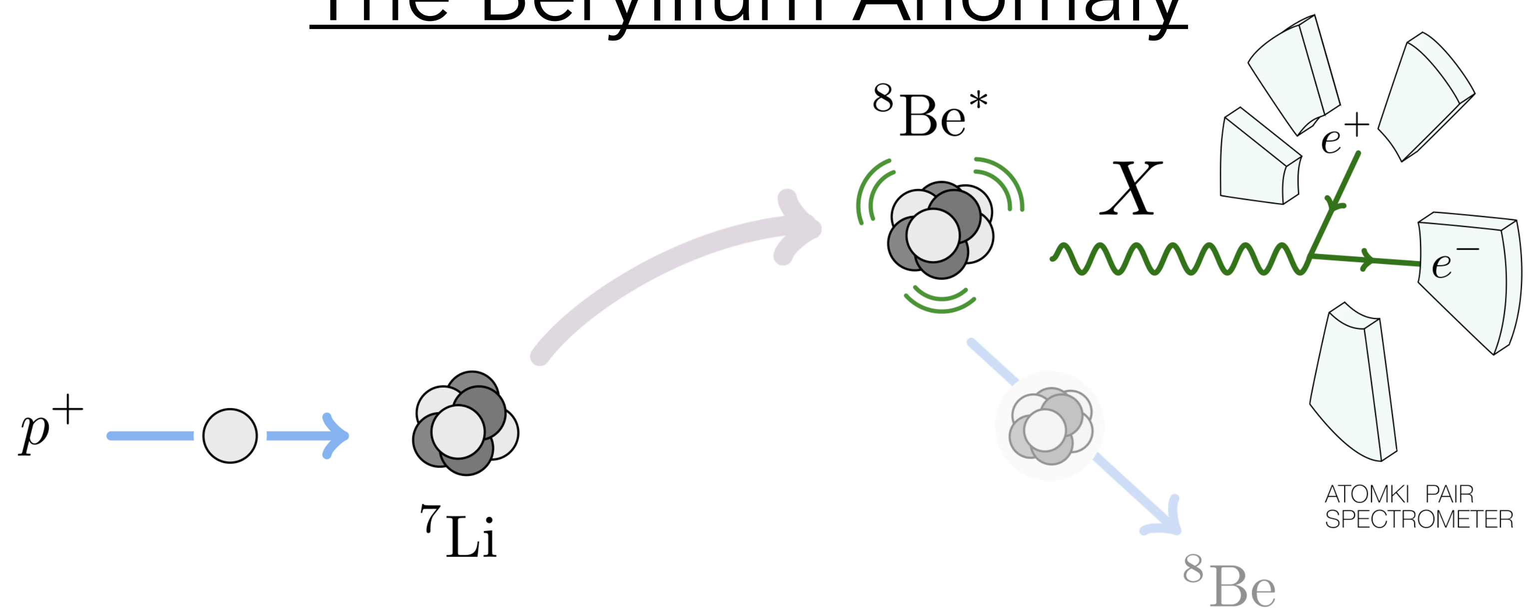
Low-mass single volume detector with high granularity
—> 9 concentric layers of 192 drift cells defined by 11904 wires

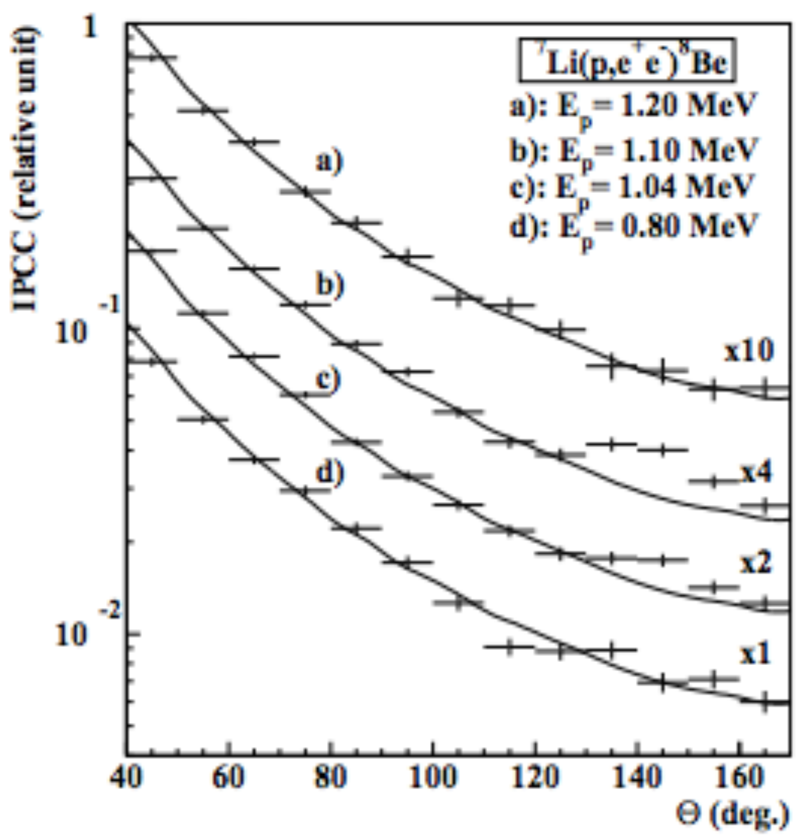
Resolutions	MEG	MEG II
p_e (keV)	306	130
ϑ_e(mrad)	9.4	5.3
φ_e(mrad)	8.7	4.8
e^+ efficiency (%)	40	88

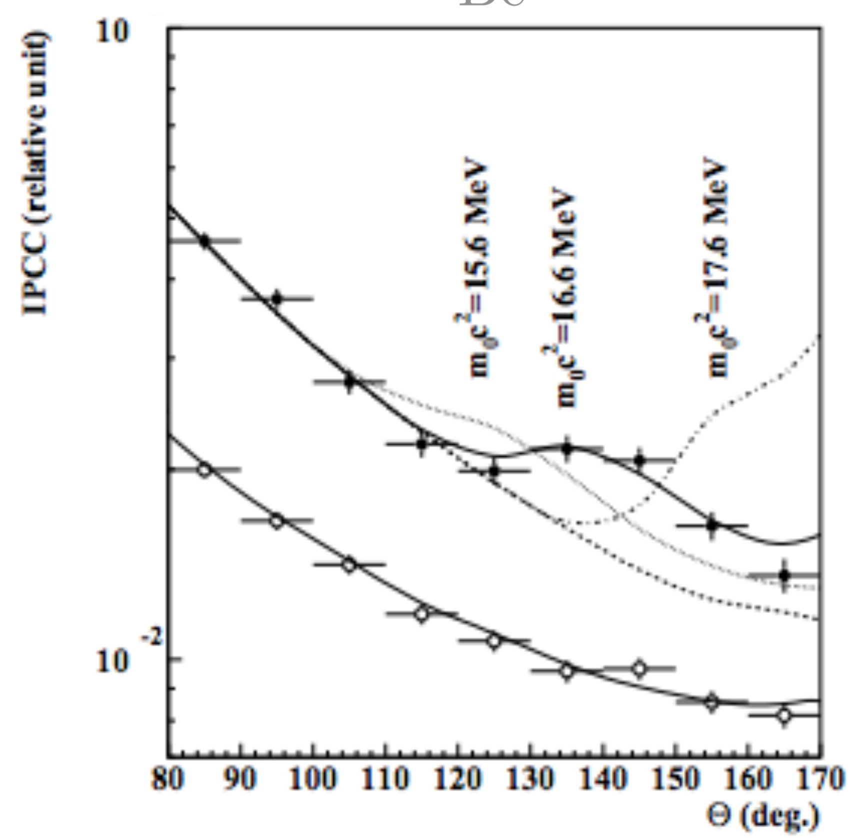
x2 resolution compared to MEG

Beryllium Anomaly investigation

The Beryllium Anomaly







—> potential light boson X17 (17 MeV)

—> main background: Internal Pair Conversion (IPC), e+/e- pair creation by the excited nucleus

The Beryllium Anomaly with MEG-II

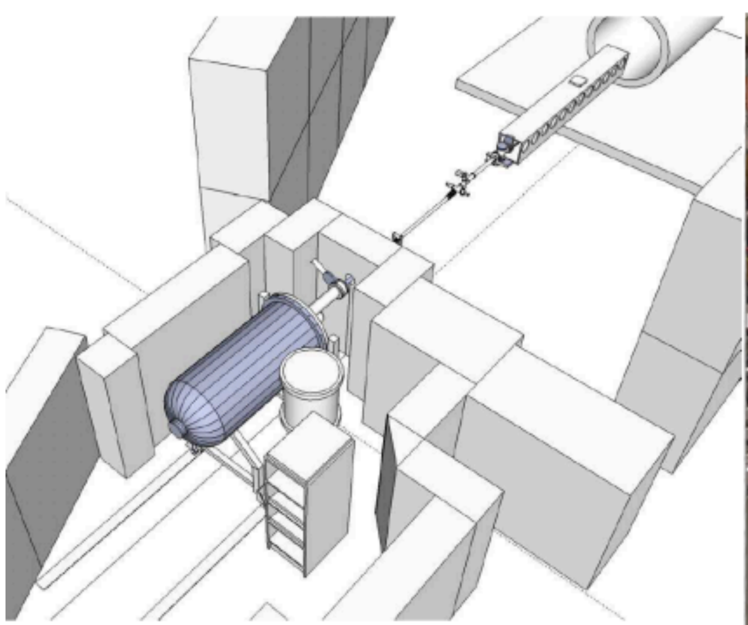
- Objective: performing the same measurement with a different setup and improved detector resolutions

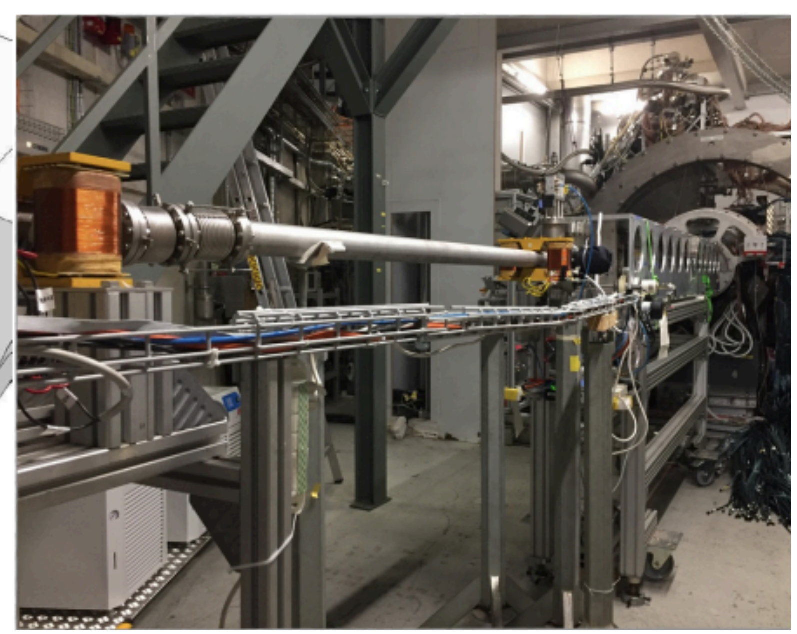
- Three key elements:

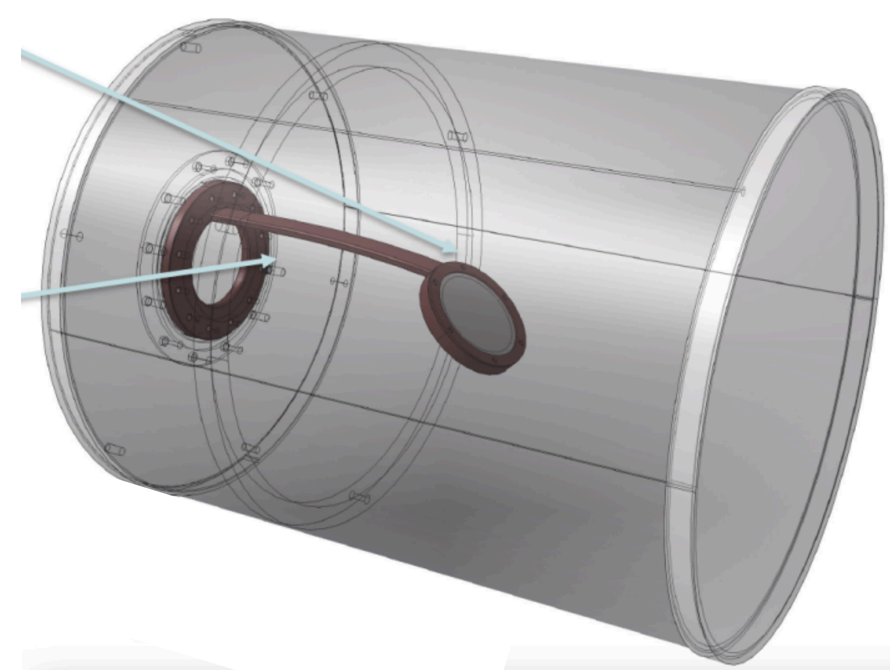
—> Cockroft-Walton accelerator which produces 1.05MeV protons with 1uA current

—> lithium target optimized for the X17 search, 5um LiF on 25um copper substrate with copper arm (heat dissipation)

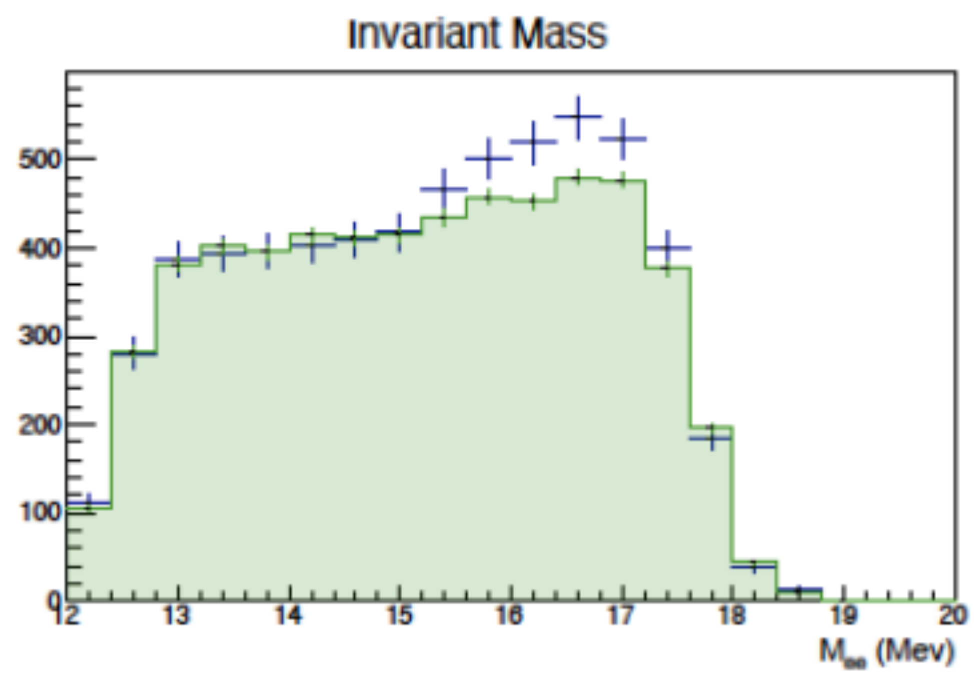
—> the MEG-II drift chamber with reduced magnetic field allows to detect the e+/e- pair (momentum ~ 9MeV)

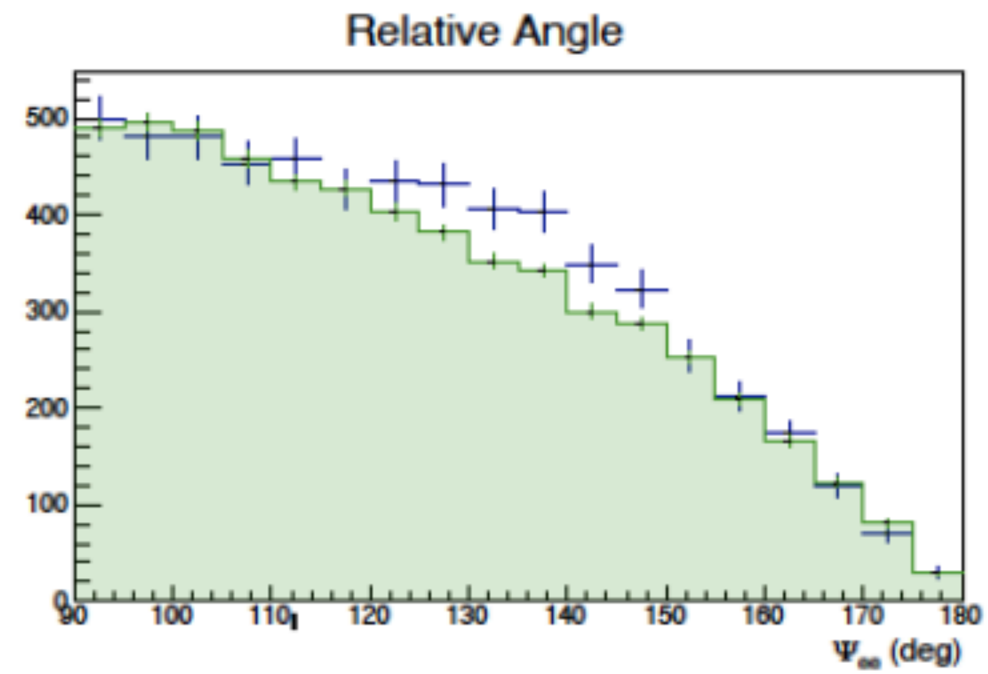


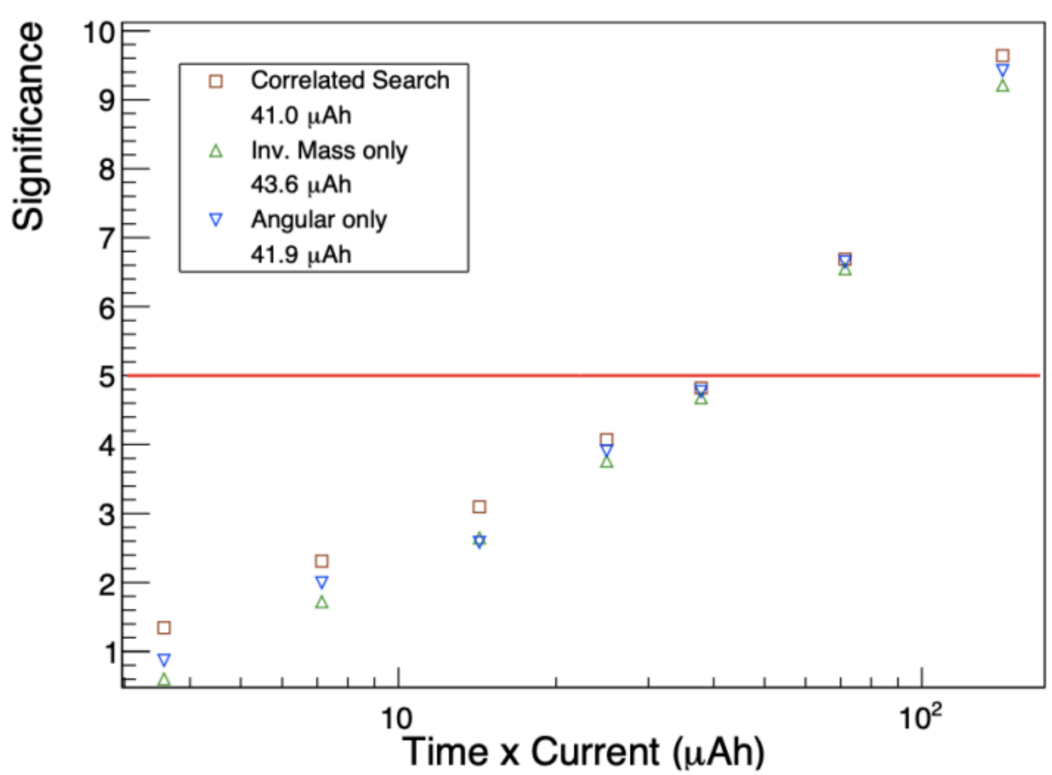




The Beryllium Anomaly with MEG-II







- Two observables: invariant mass and opening angles
- Data were taken for 2 weeks in February
- Analysis currently being carried out: main challenge is to reconstruct both the positron and the electron track
- e+ tracking ready from MEG search but e- tracking needs to be achieved

e+/e- pair tracking in the MEG-II drift chamber

Track finder efficiency

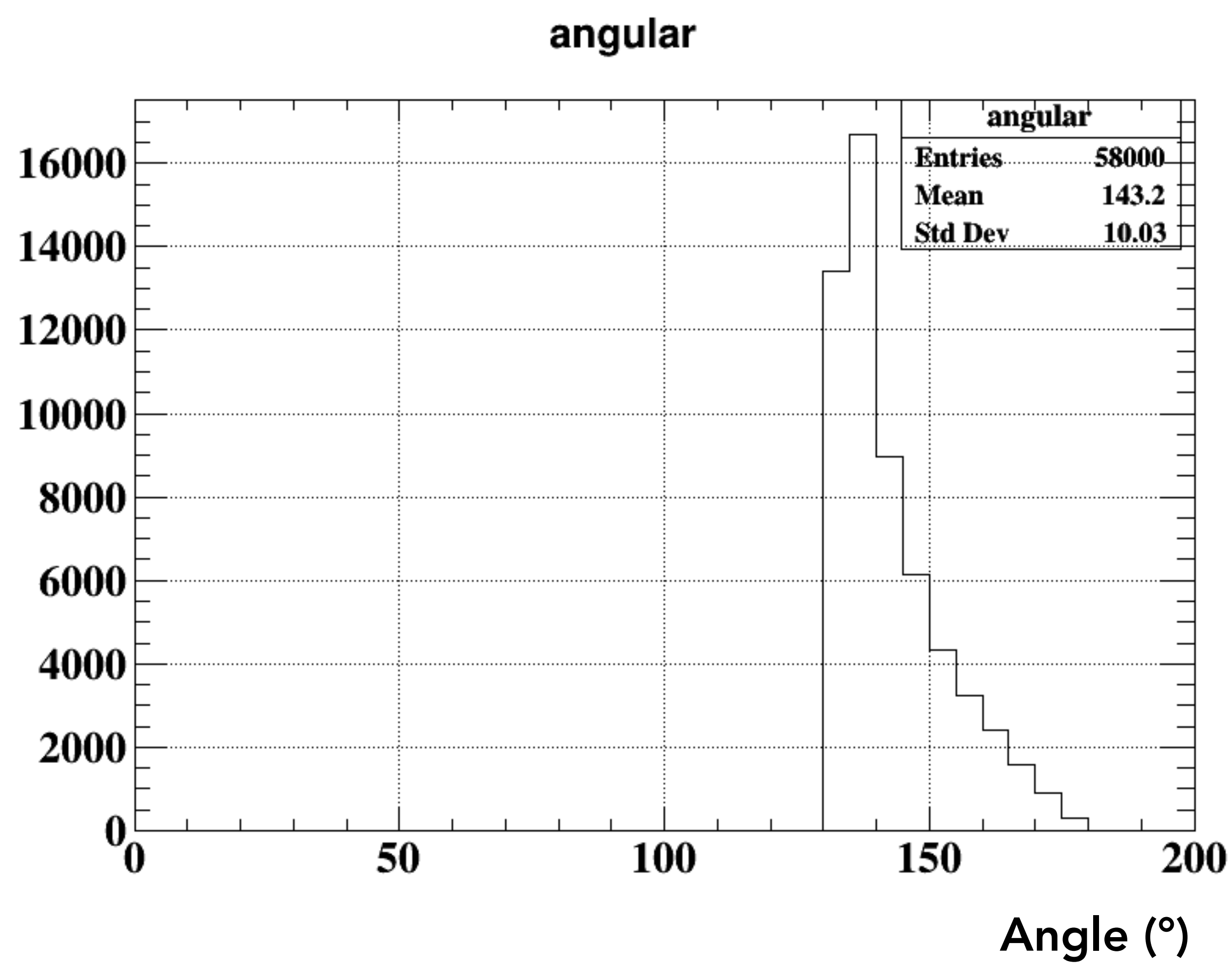
Simulated	2k XBoson positrons —> condition: **events with 1+ track**	2k XBoson electrons —> condition: **events with 1+ track**	2k XBoson pairs —> condition: **2+ tracks/event (1+ e+, 1+ e-)**	2K IPC pairs —> condition: **2+ tracks/event (1+ e+, 1+ e-)**
Track finder MC	920 e+ 17 e-	44 e+ 670 e-	469	208
Track finder PR	223 e+ 6 e-	59 e+ 110 e-	43	16
Ratio PR/MC	24 %	16 %	9 %	8 %

- lots of « **false e+** » but very few « **false e-** » —> very few « **false pairs** »
- reconstruction for **e-** 2x worse than for **e+** —> actual loss in efficiency
- an idea could be to try fitting all tracks with both e+ and e- assumptions and keep the best fit
- how good are the reconstructed pairs?

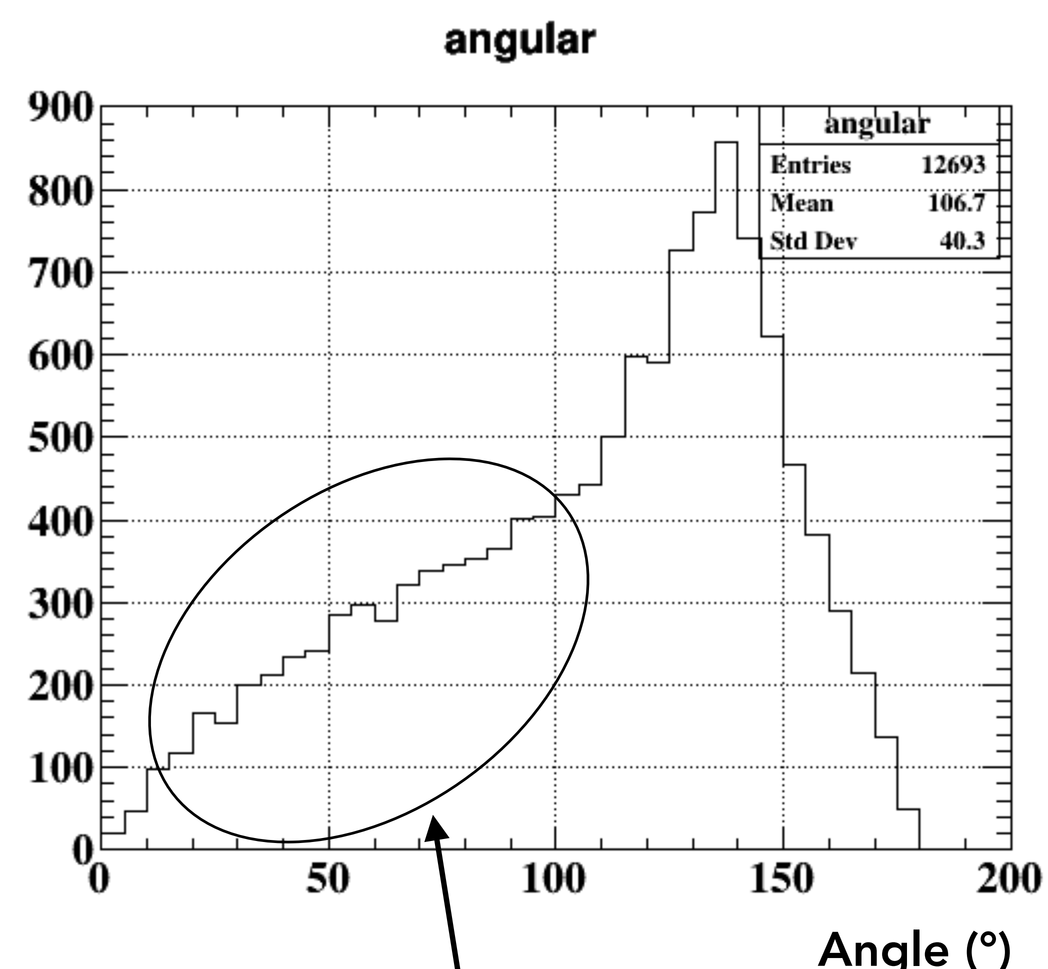
Angular correlation

—> For each event with 1+ positron and 1+ electron, best tracks chosen by minimizing chi2/dof (XBoson simulation - 60k events)
—> Angular correlation was calculated with the best positron track and the best electron track

simulation level



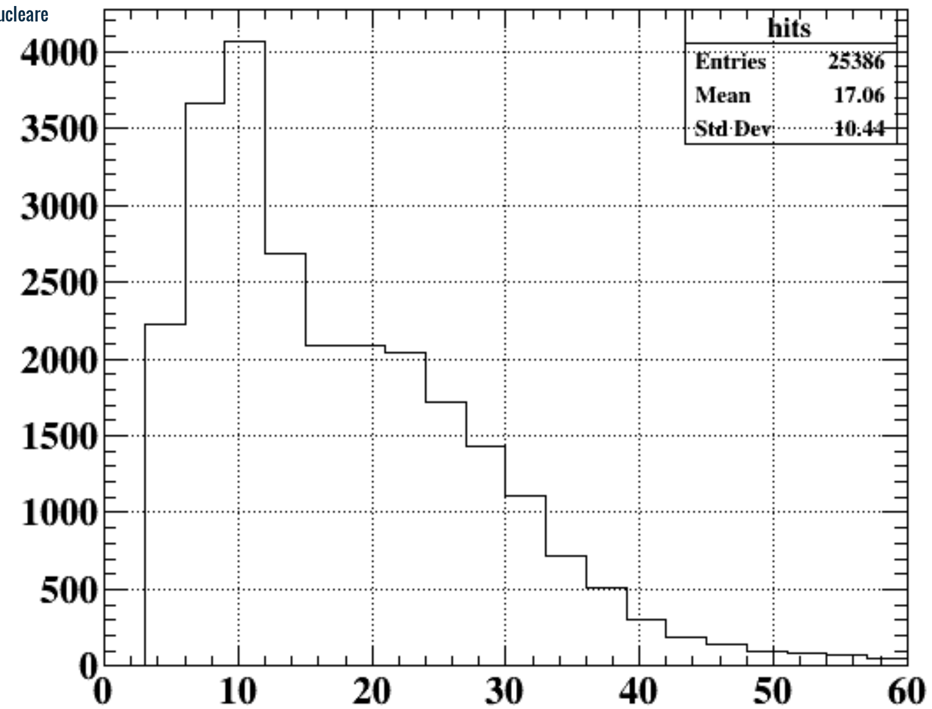
reconstructed level



Large tail at low angles
—> pairs badly reconstructed

Hits study

Number of hits per track

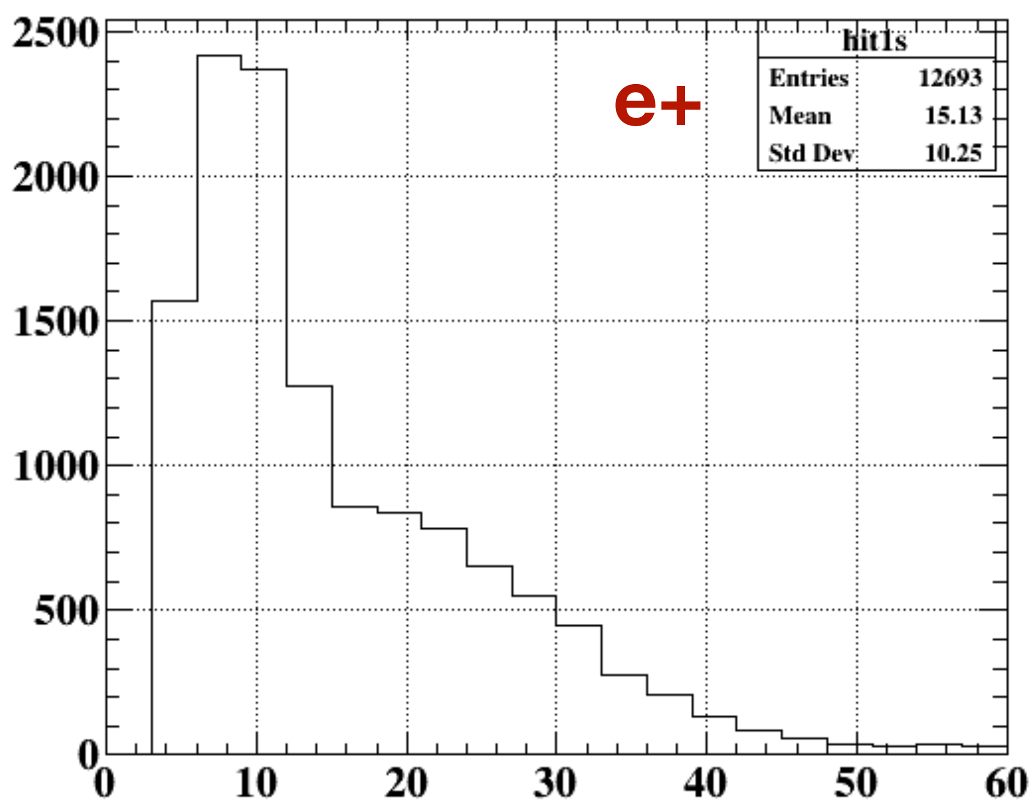


—> hits distributions for reconstructed pairs

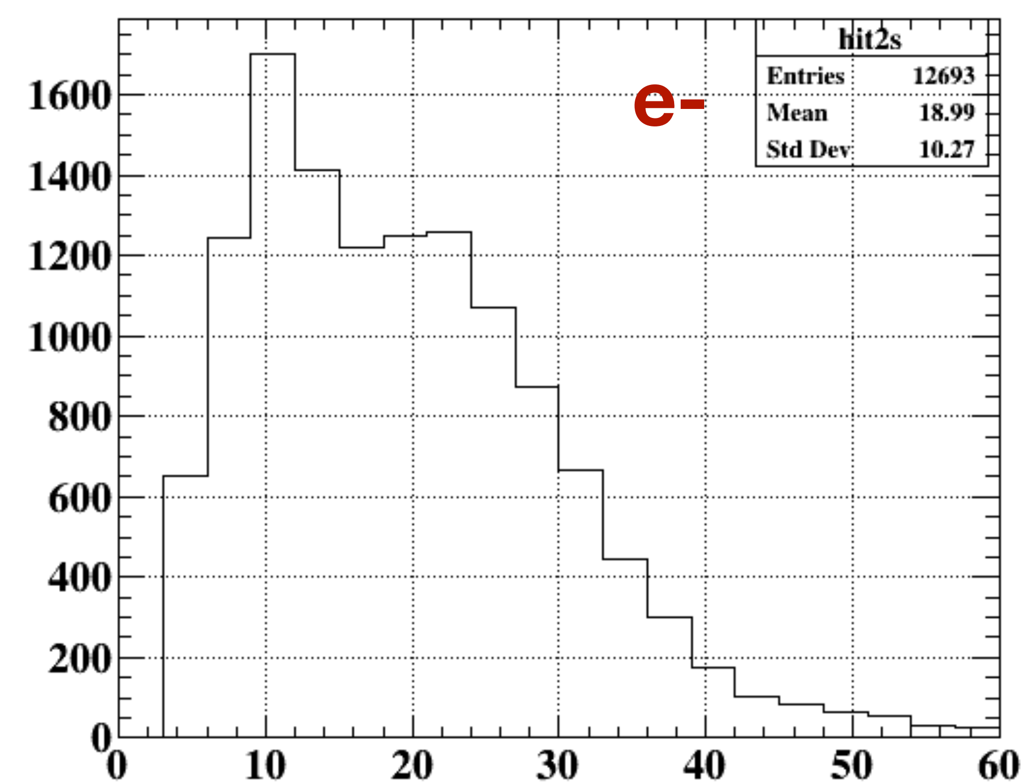
—> peaks at **10 hits**

—> in average, **17 hits per track**, twice less than for MEG

Number of hits per e+ track



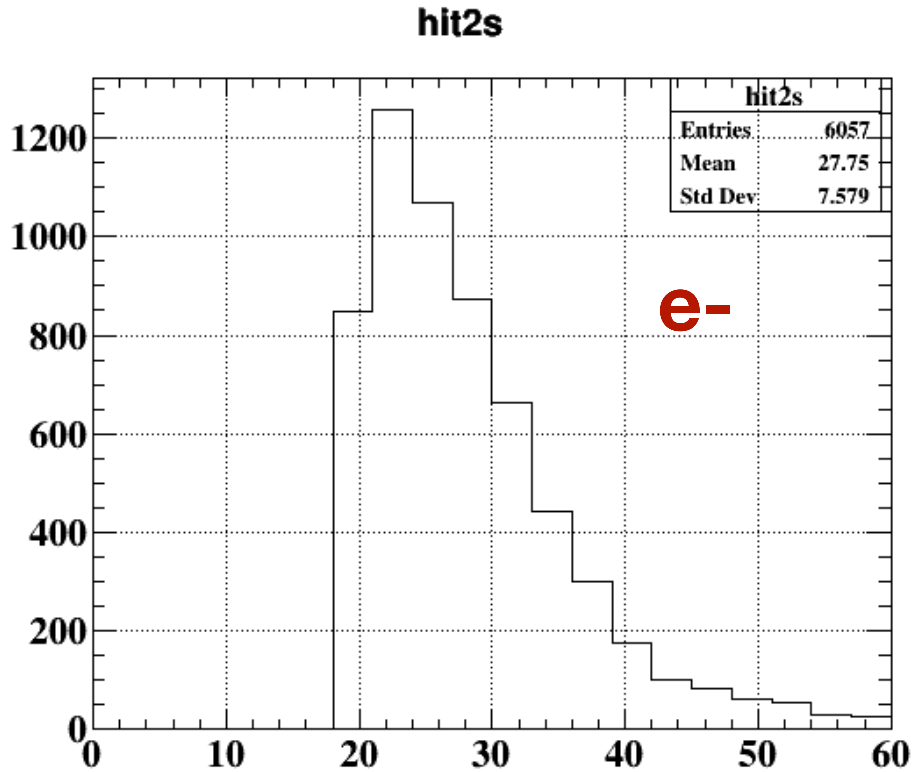
Number of hits per e- track

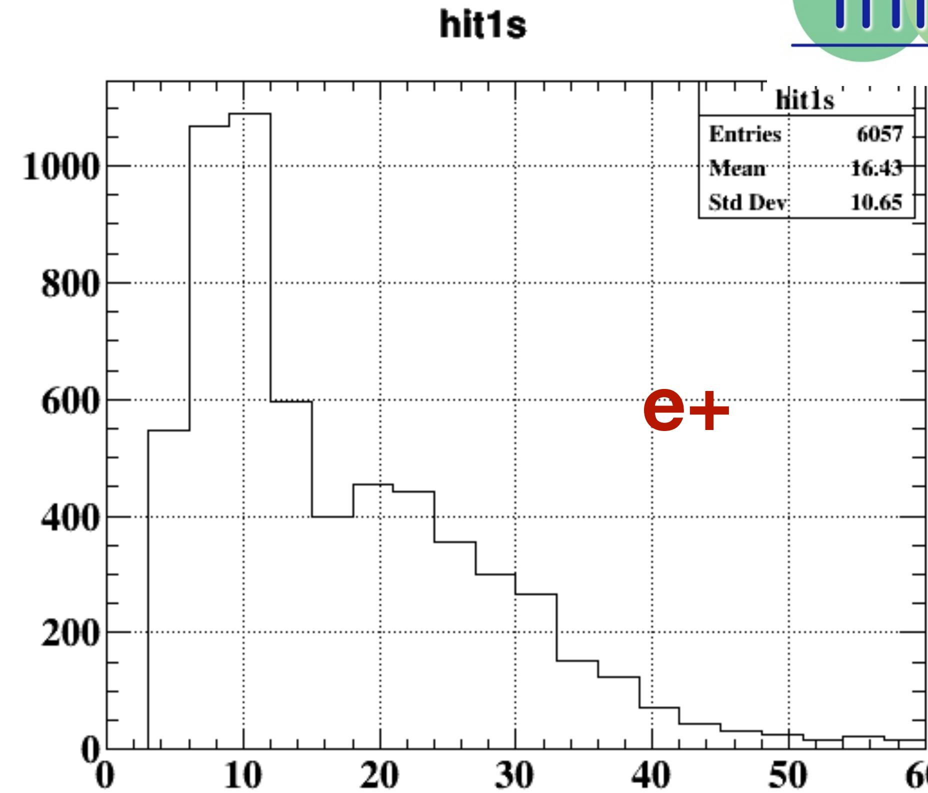


—> in average 4 more hits from the electron track: Kalman needs more e- hits to reconstruct? asymmetry of the TC?

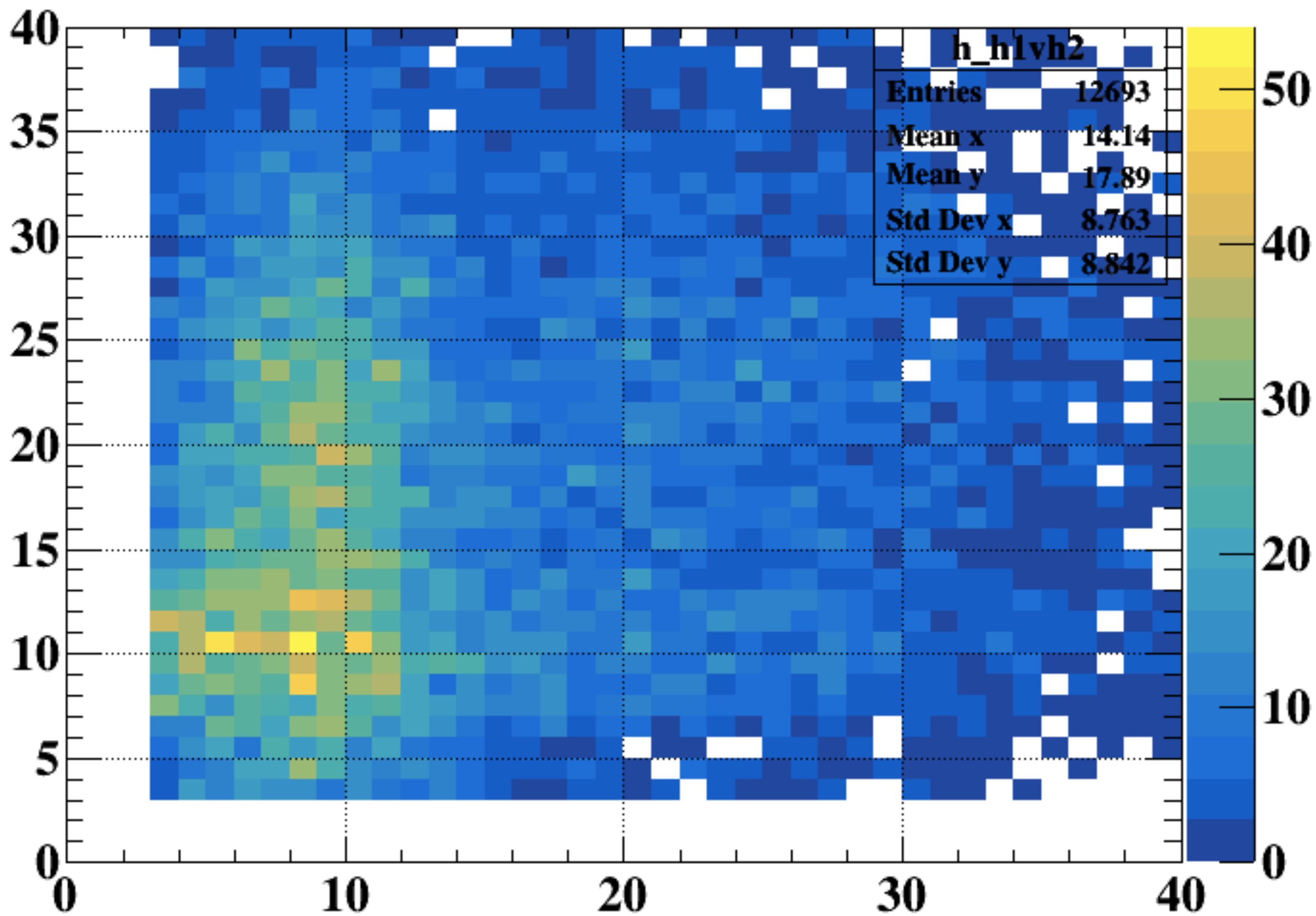
—> second peak around **25 hits**

Hits study: correlation between e+ and e- hits?



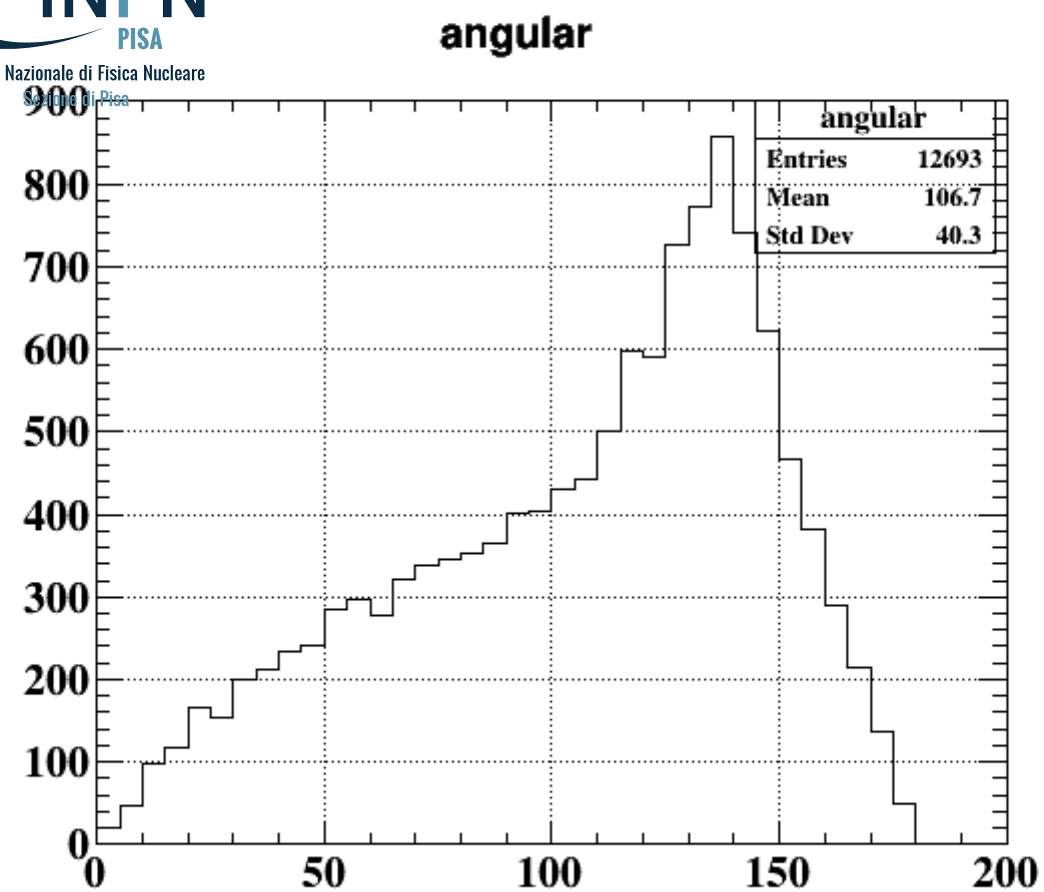


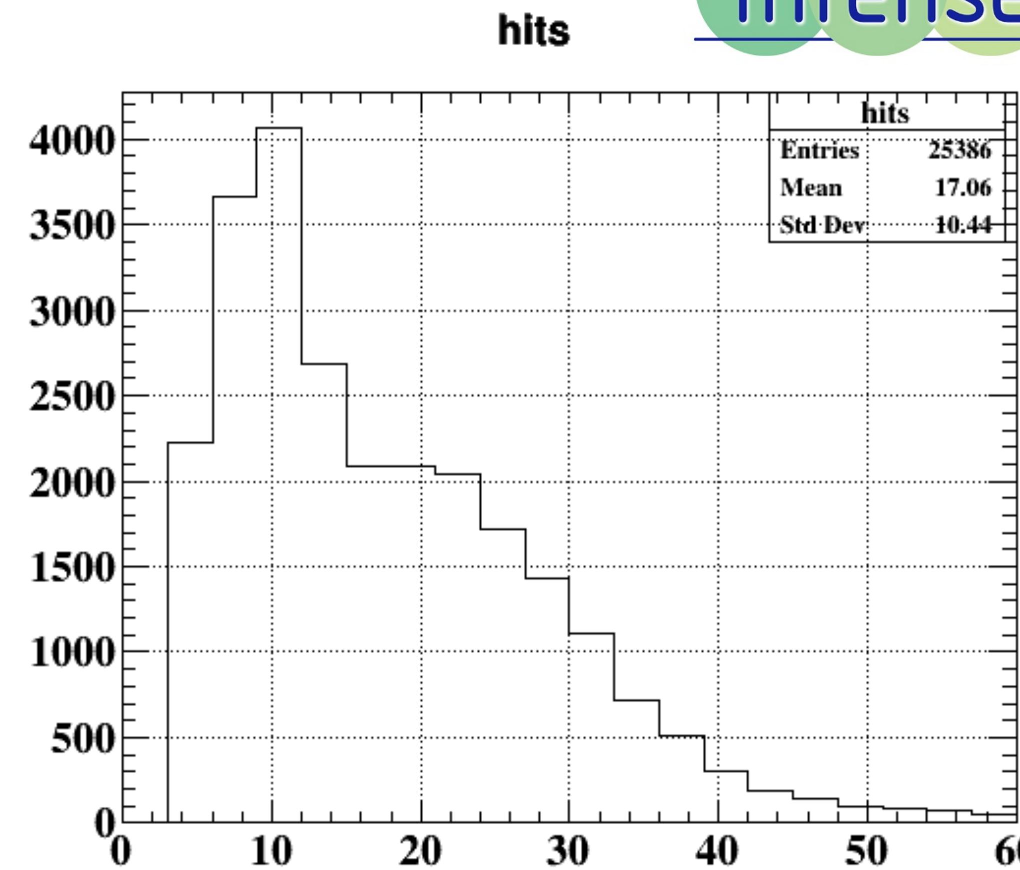
cut: **nhits>18** on **e-** → no significant impact on **e+ nhits**



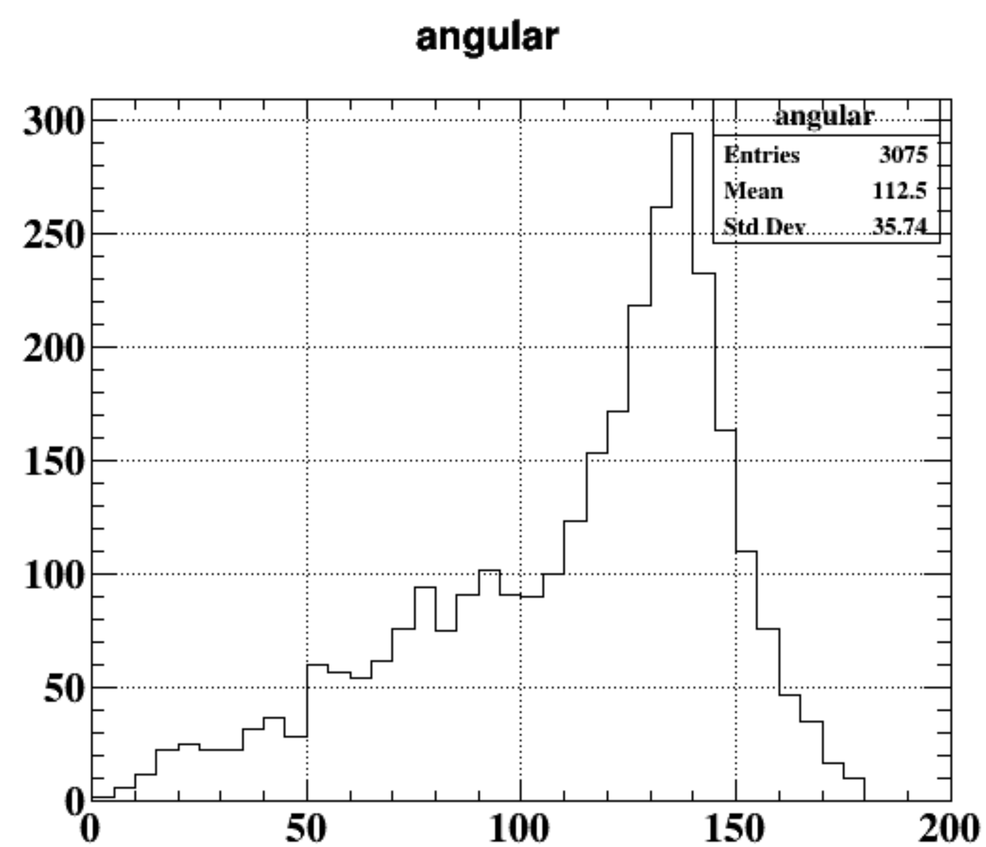
—> no strong correlation between e+ and e- nhits

Impact of hits on angular correlation tail

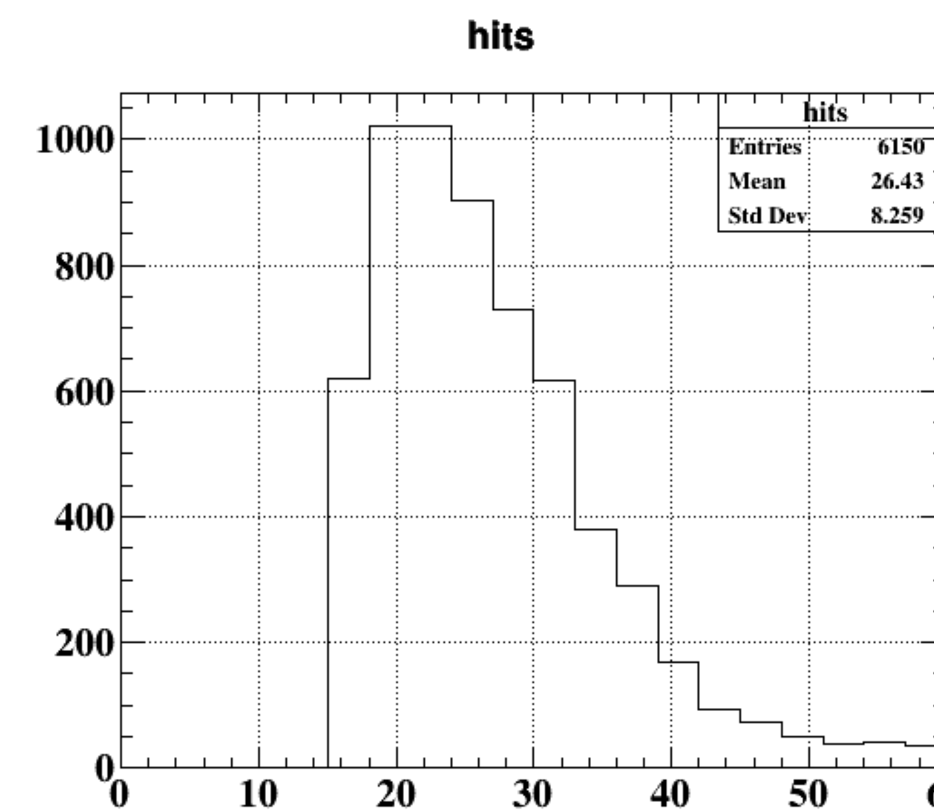




no cut on nhits

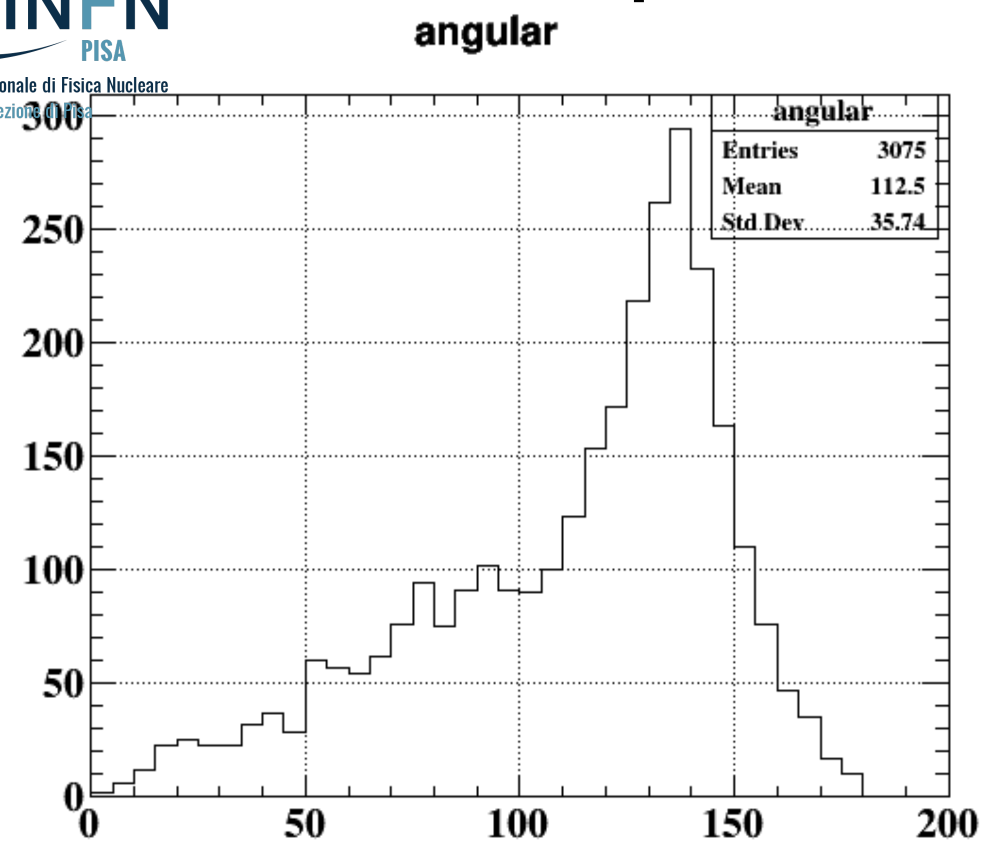


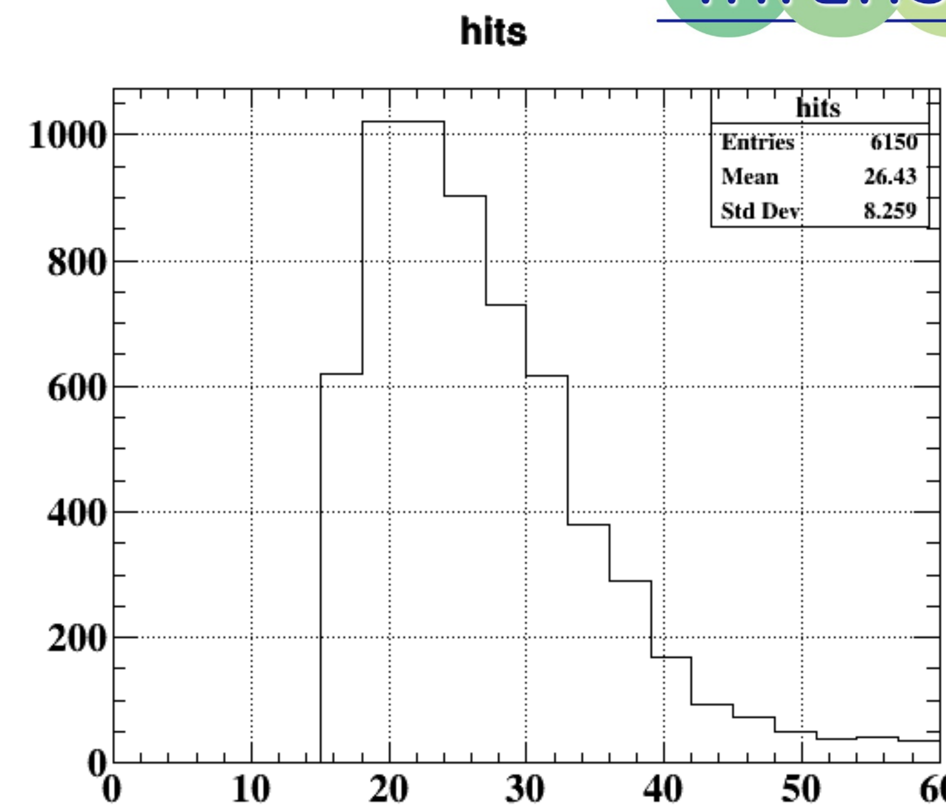
nhits>15



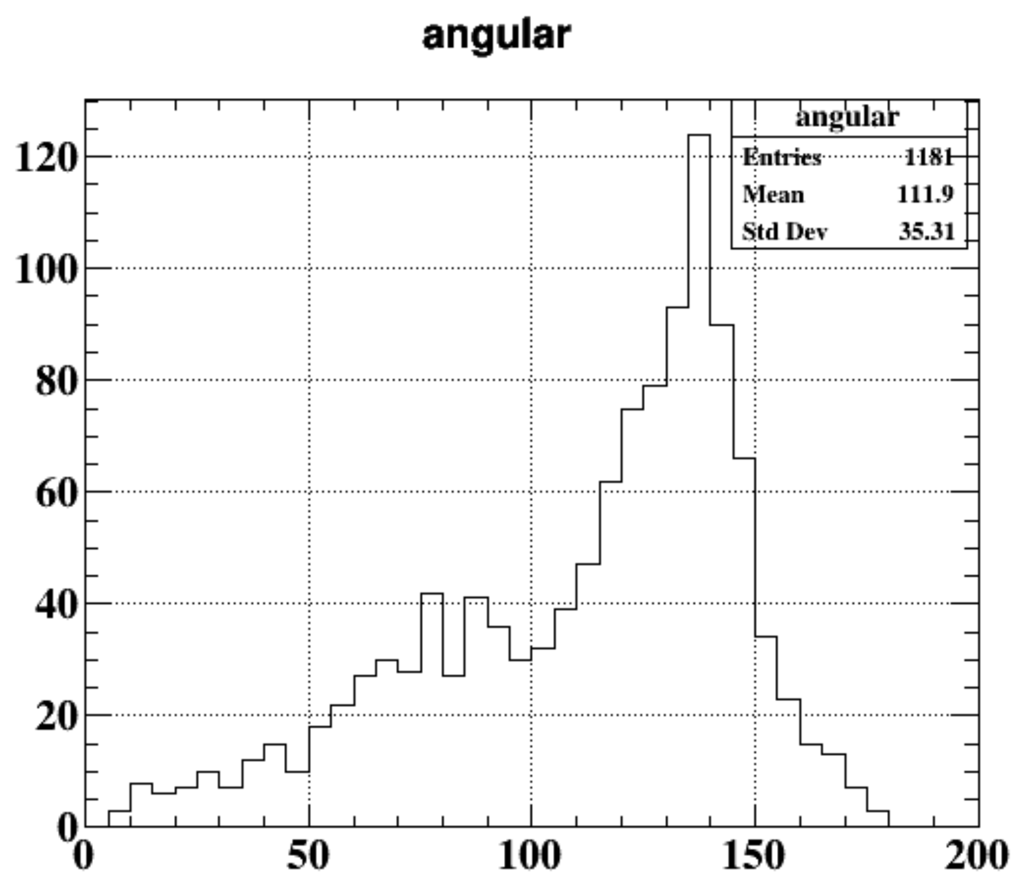
Impact of hits on angular correlation tail

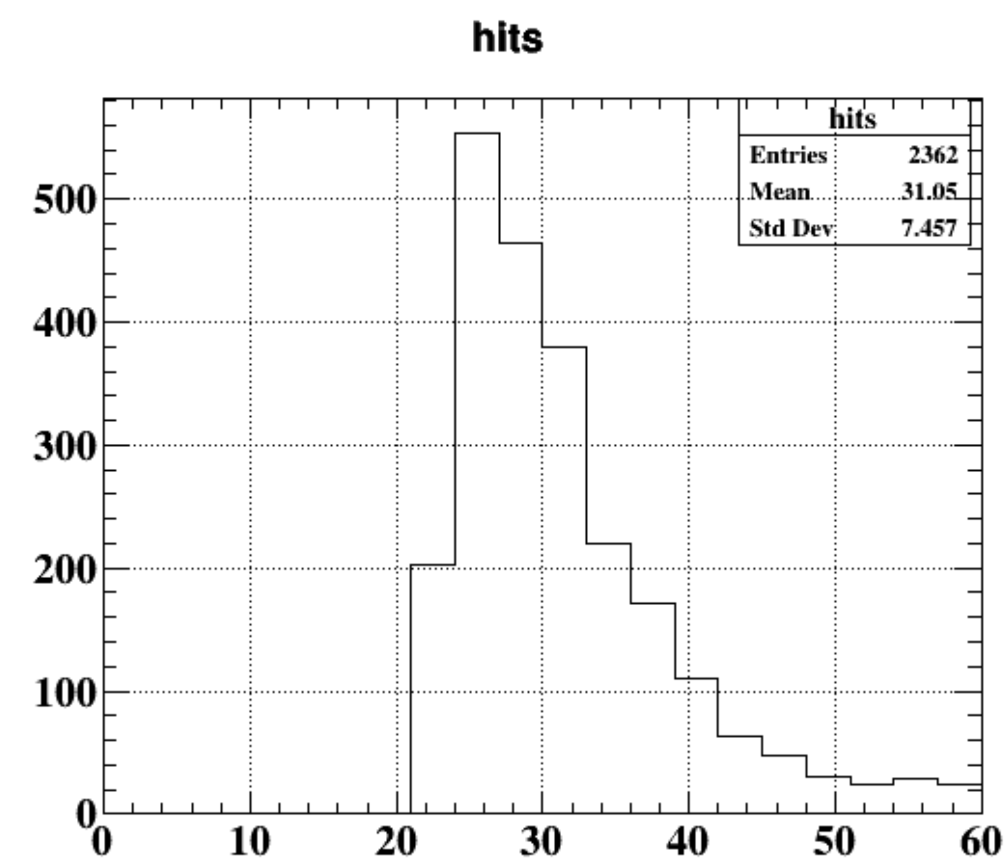
nhits>15





nhits>22

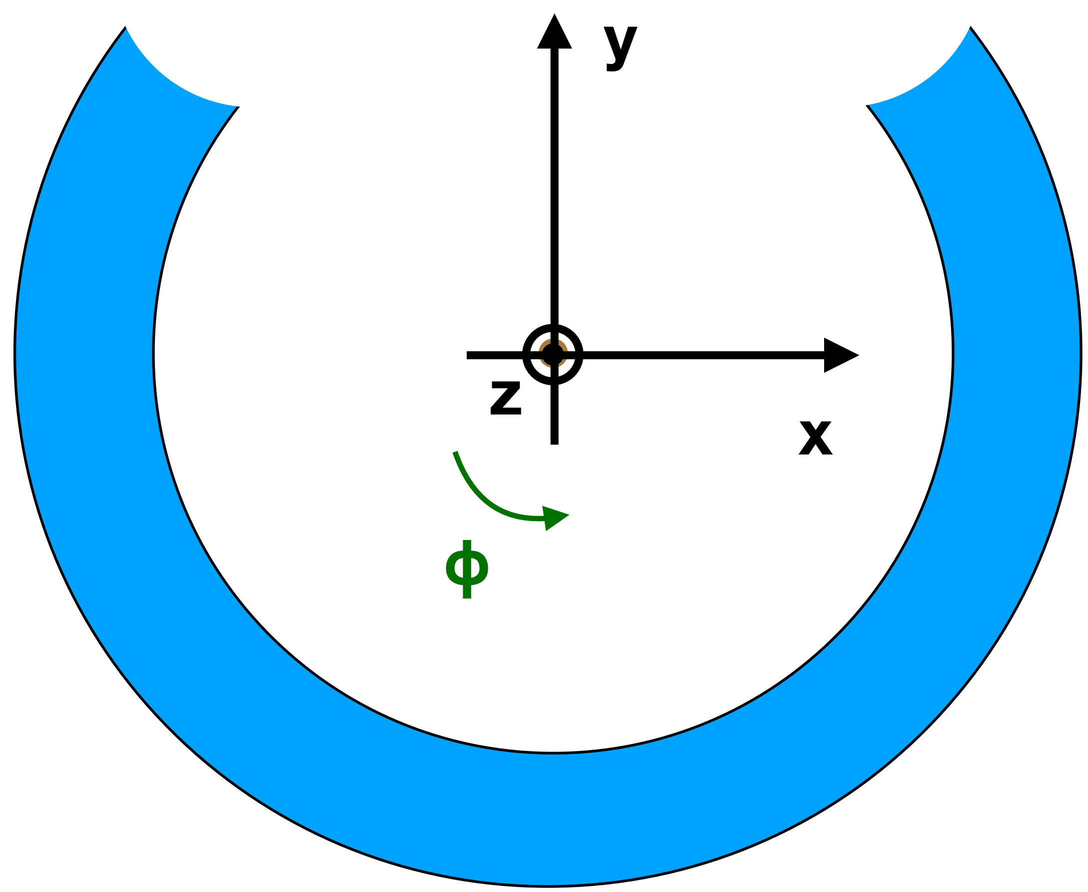




—> badly reconstructed events particularly at **low nhits**

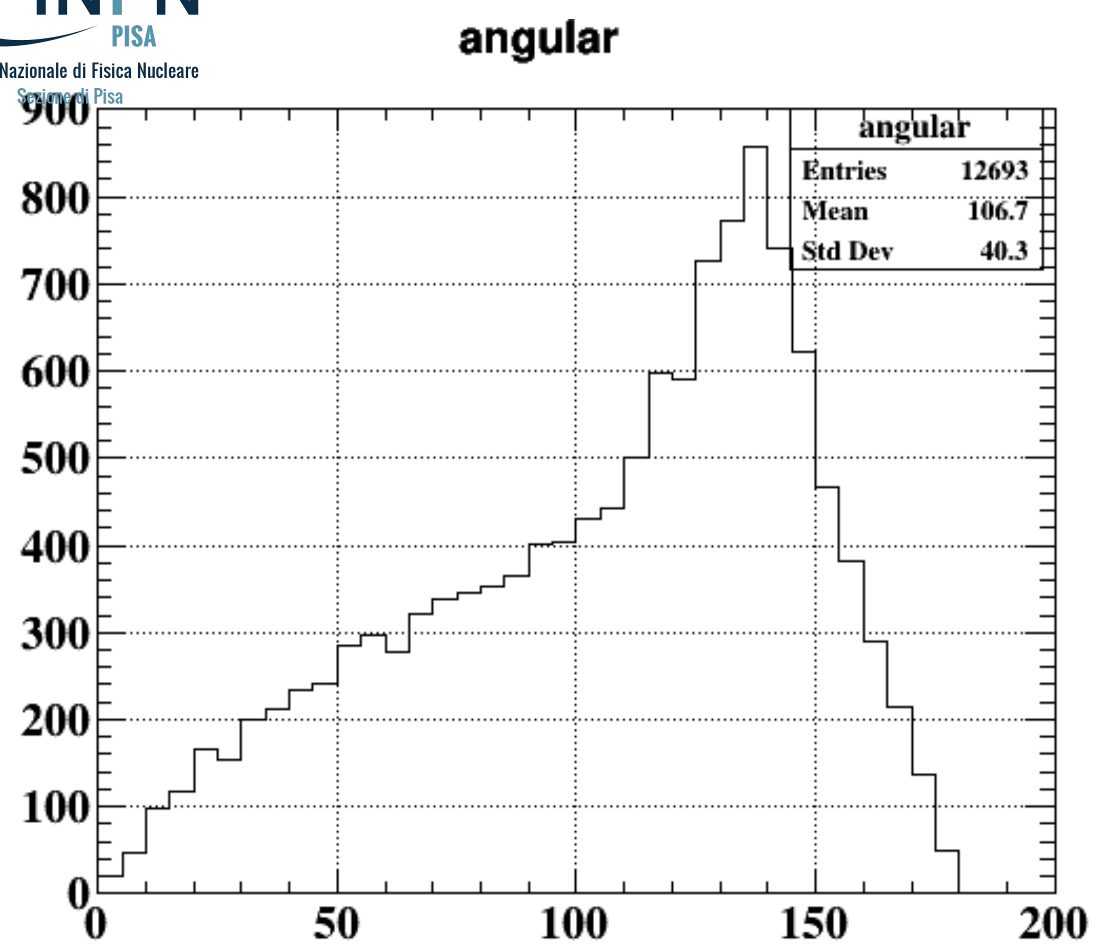
—> what are the characteristics of these events?

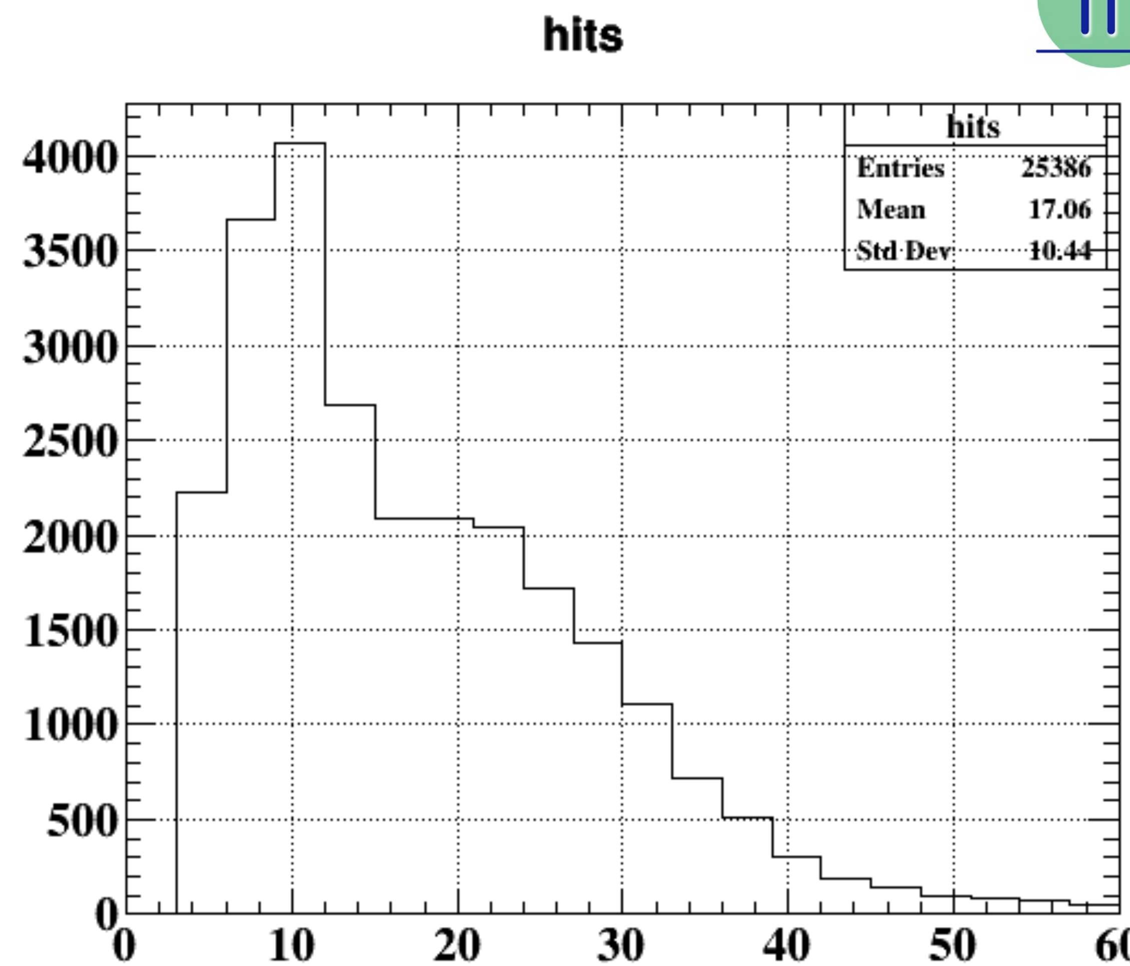
Study of badly reconstructed pairs



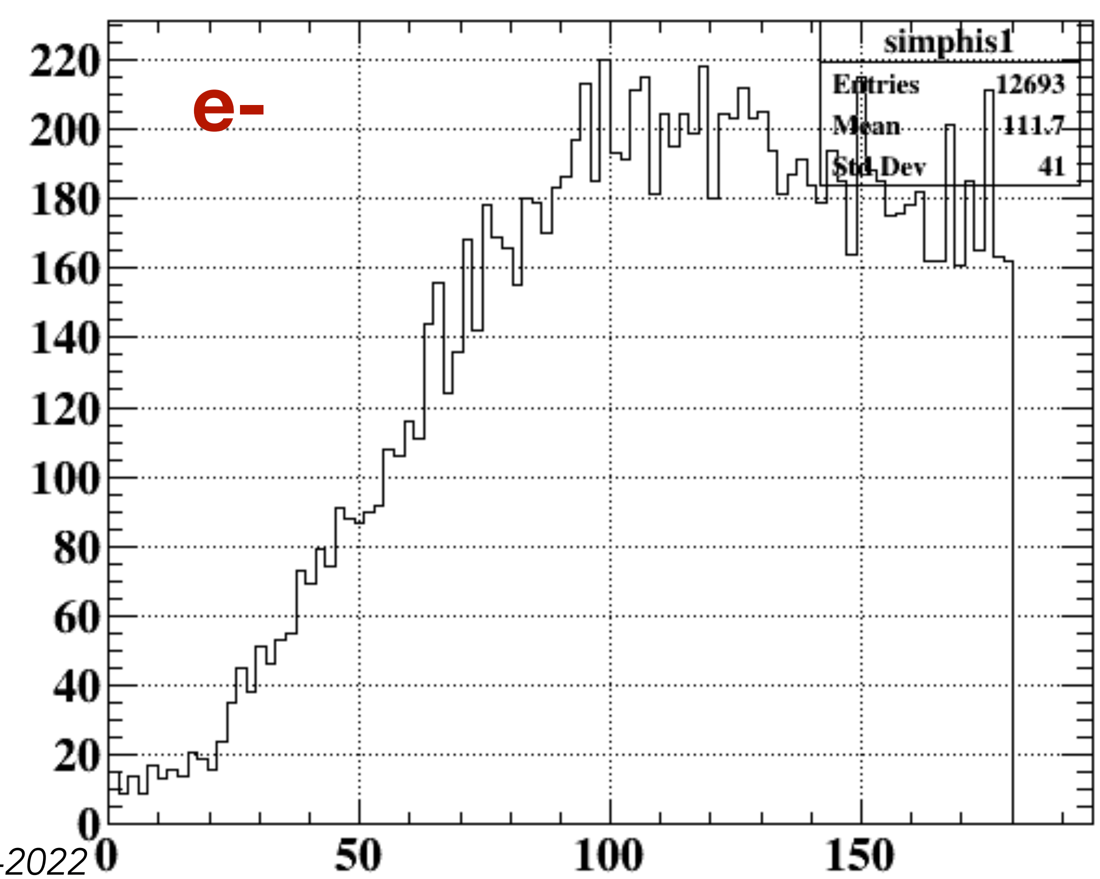
—> could the badly reconstructed events be due to the unread section of the CDCH?

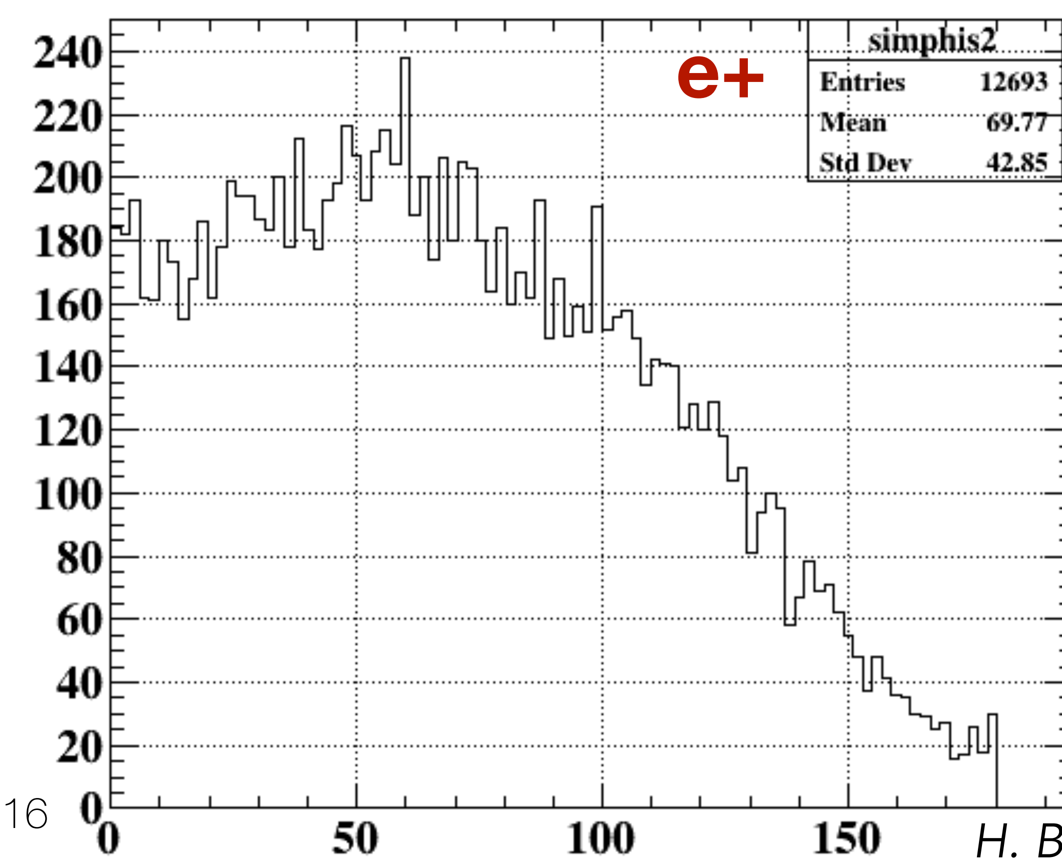
Study of badly reconstructed pairs





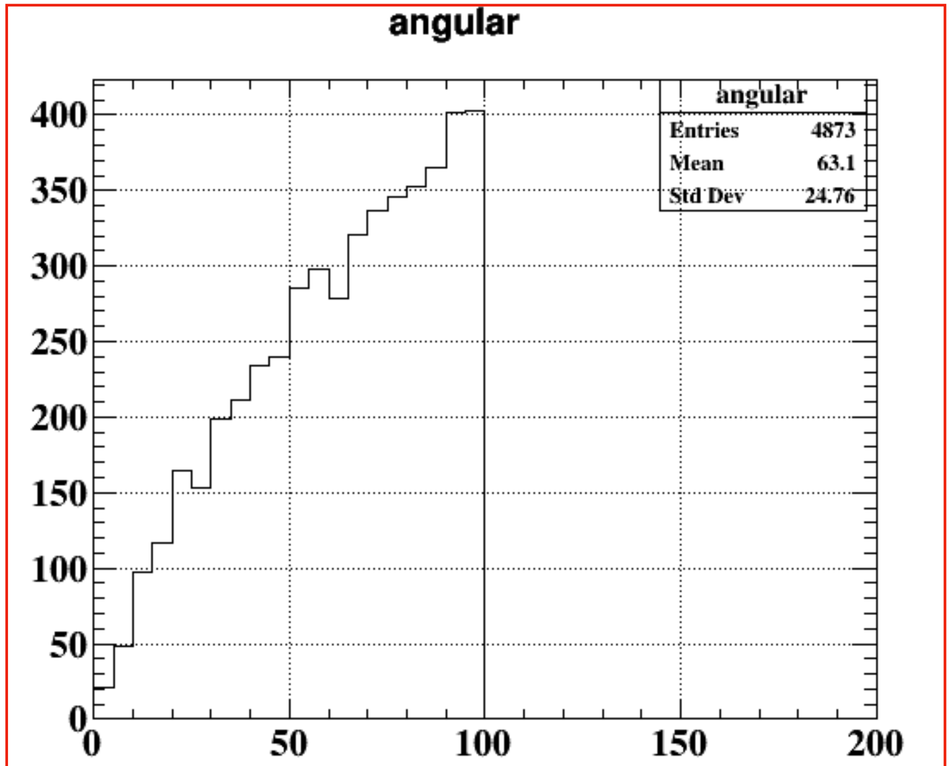
Phi distribution of the GENERATED e+ and e- tracks (sim level)

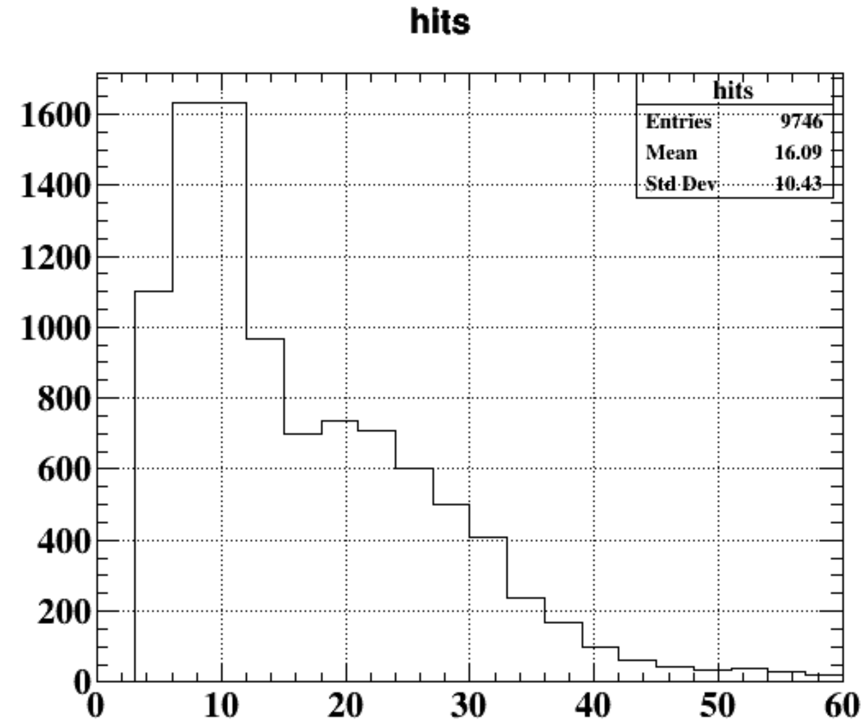


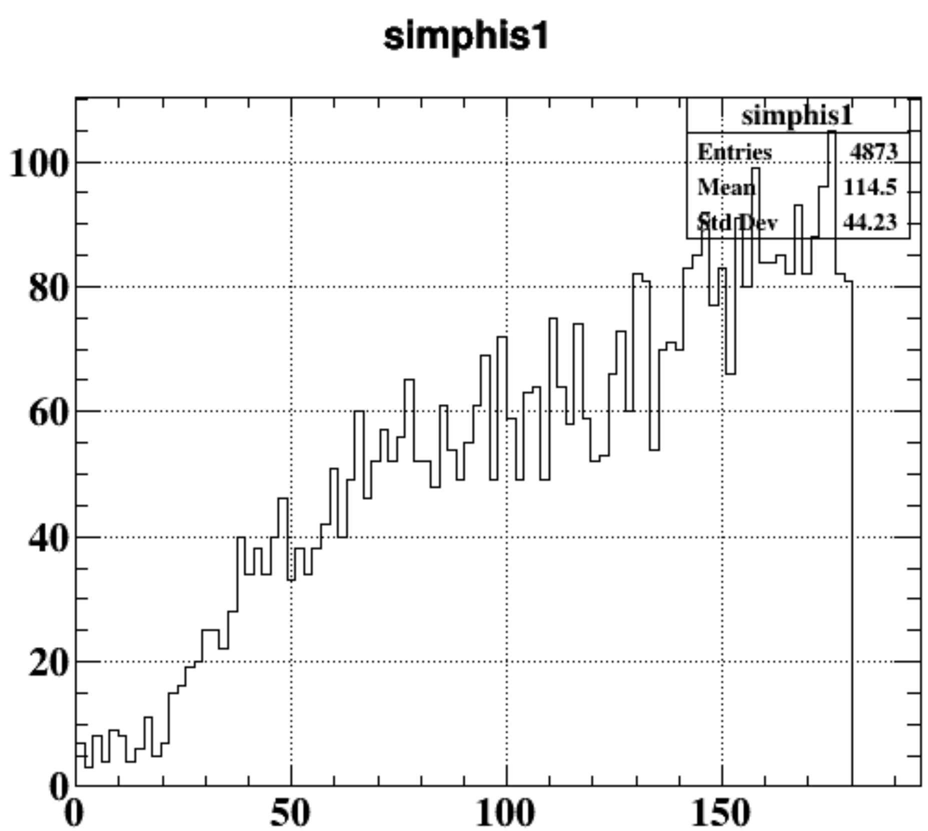


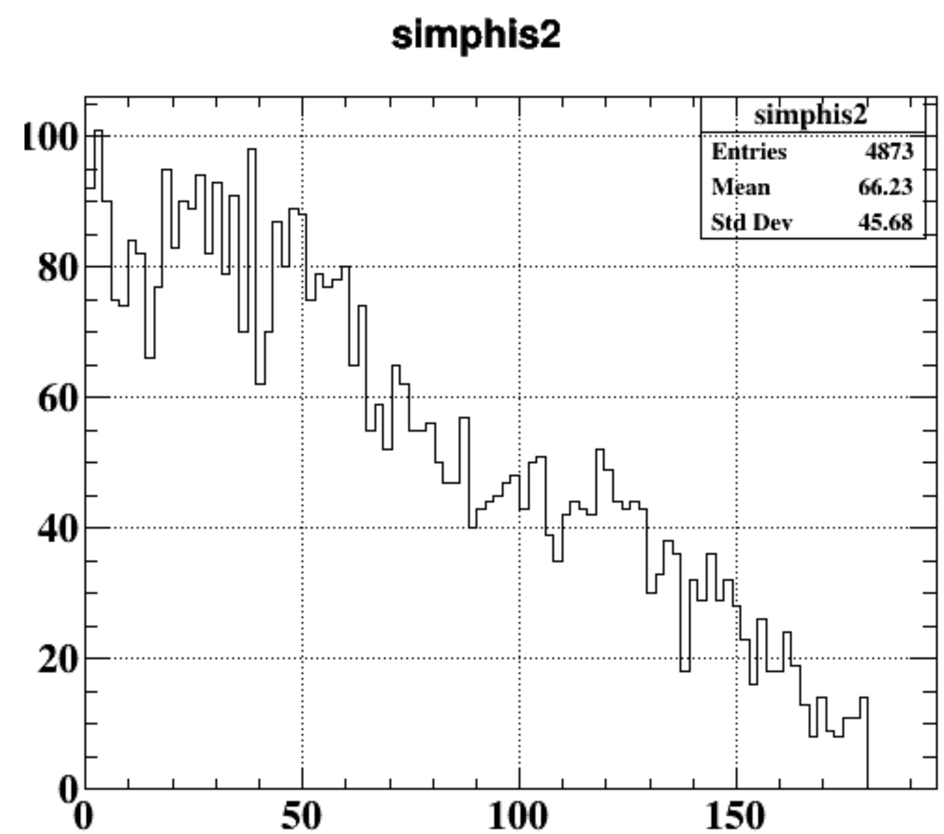
Study of badly reconstructed pairs

—> cut on the tail events from the angular correlation distribution: **angle < 100°**





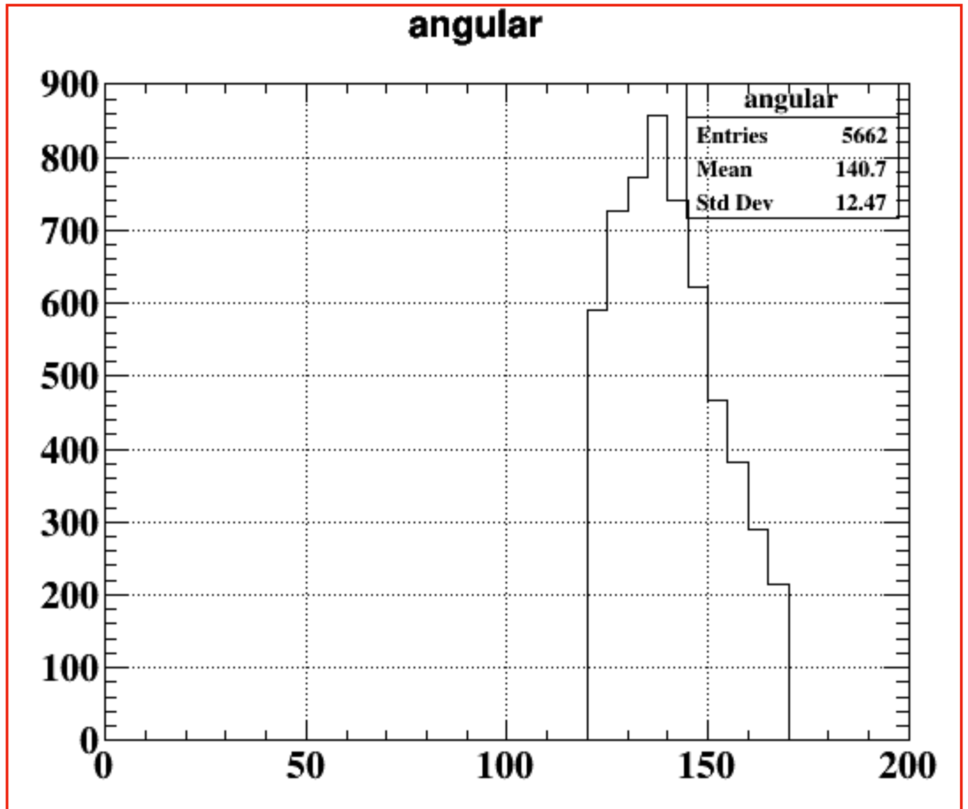


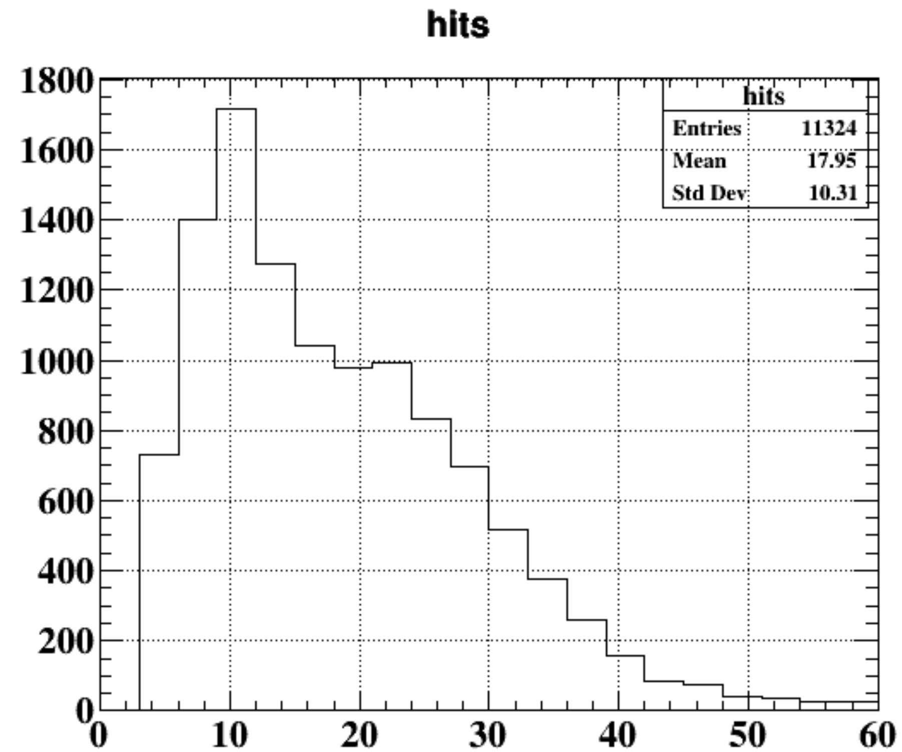


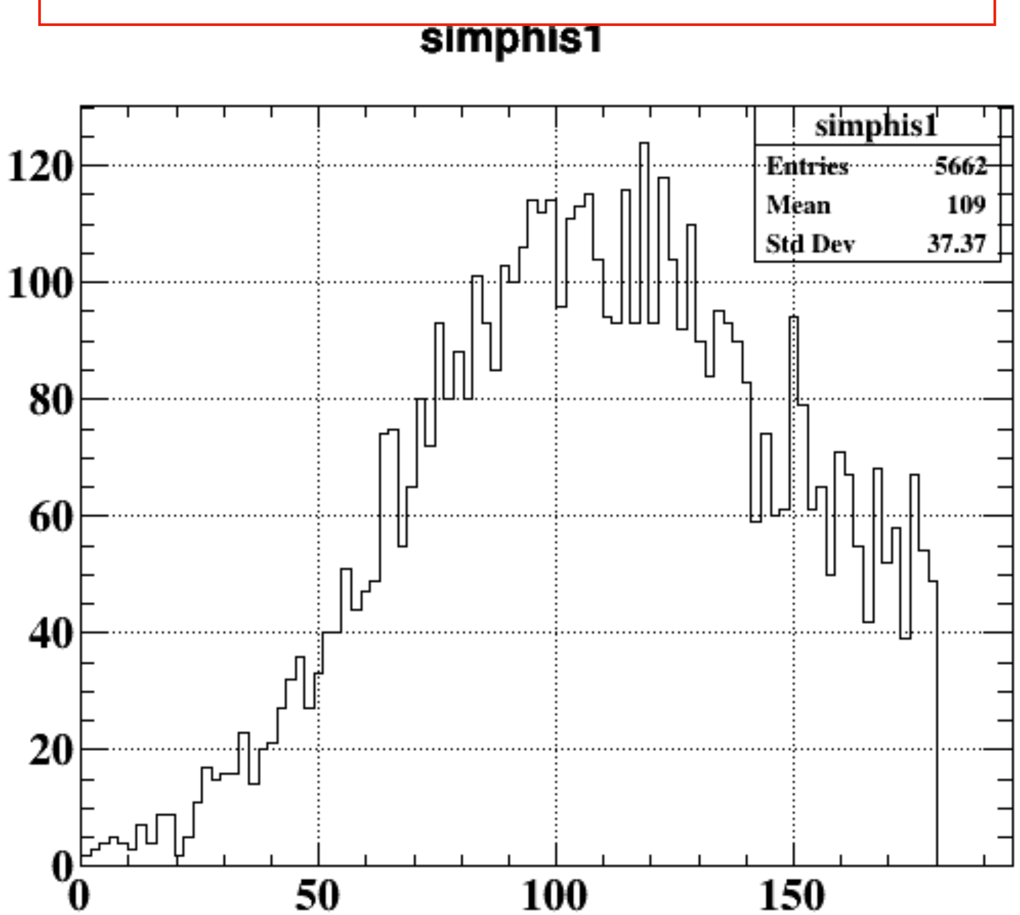
—> badly reconstructed events correspond mainly to pairs emitted **// to x axis**

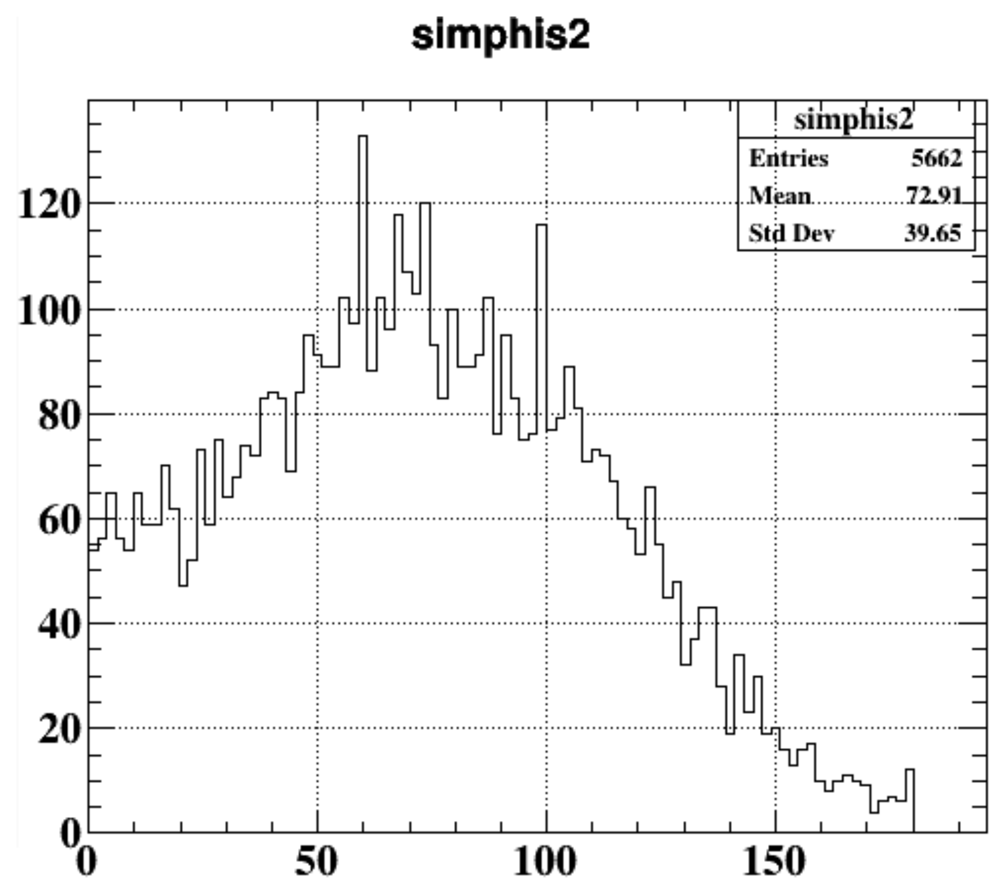
Study of badly reconstructed pairs

—> cut on the tail events from the angular correlation distribution: **angle > 120°**







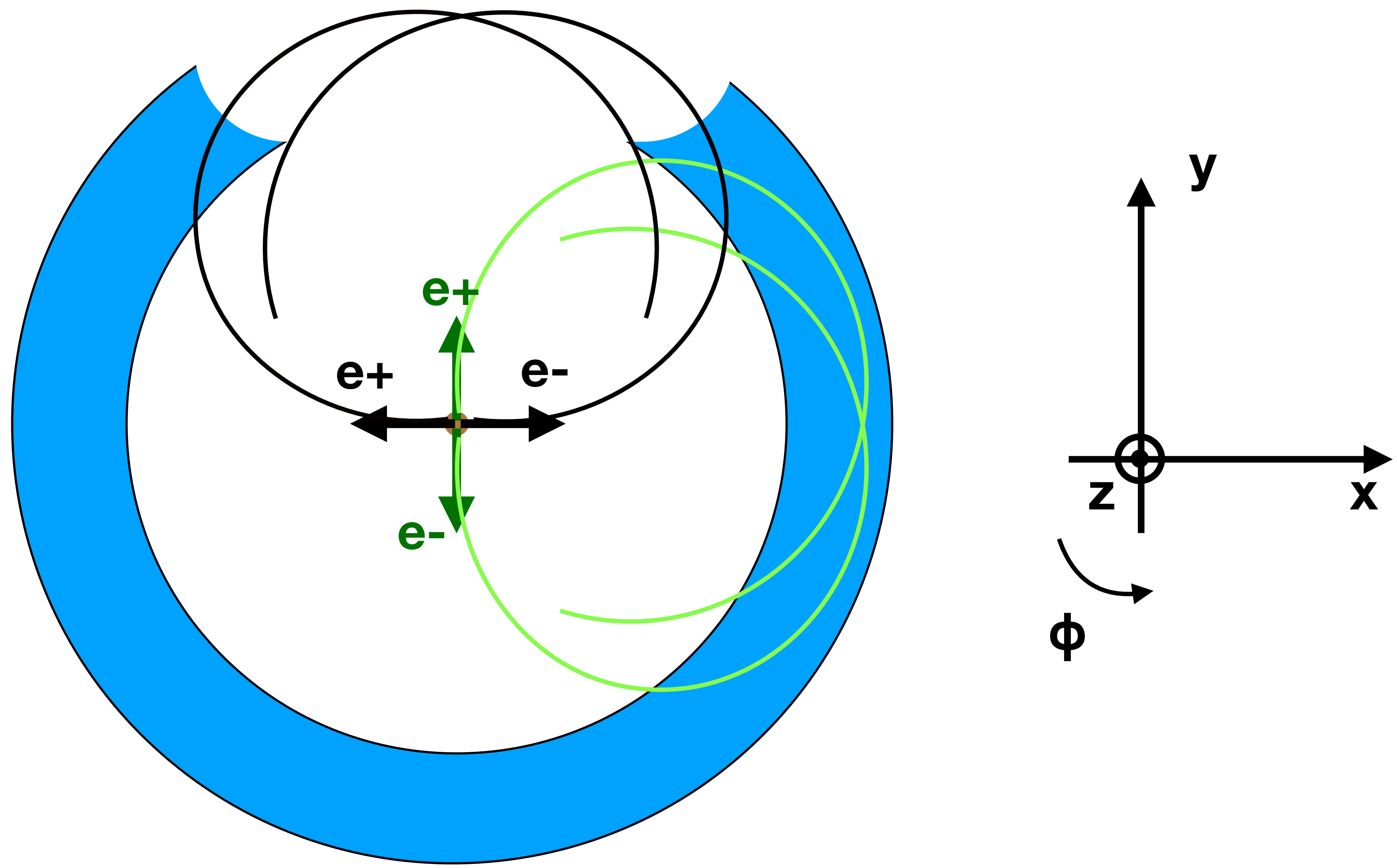


—> well reconstructed events correspond mainly to pairs emitted **// to y axis**

Study of badly reconstructed pairs: interpretation

—> not reconstructed events correspond mainly to pairs emitted **// to x axis directed towards the unread section** (low number of hits)

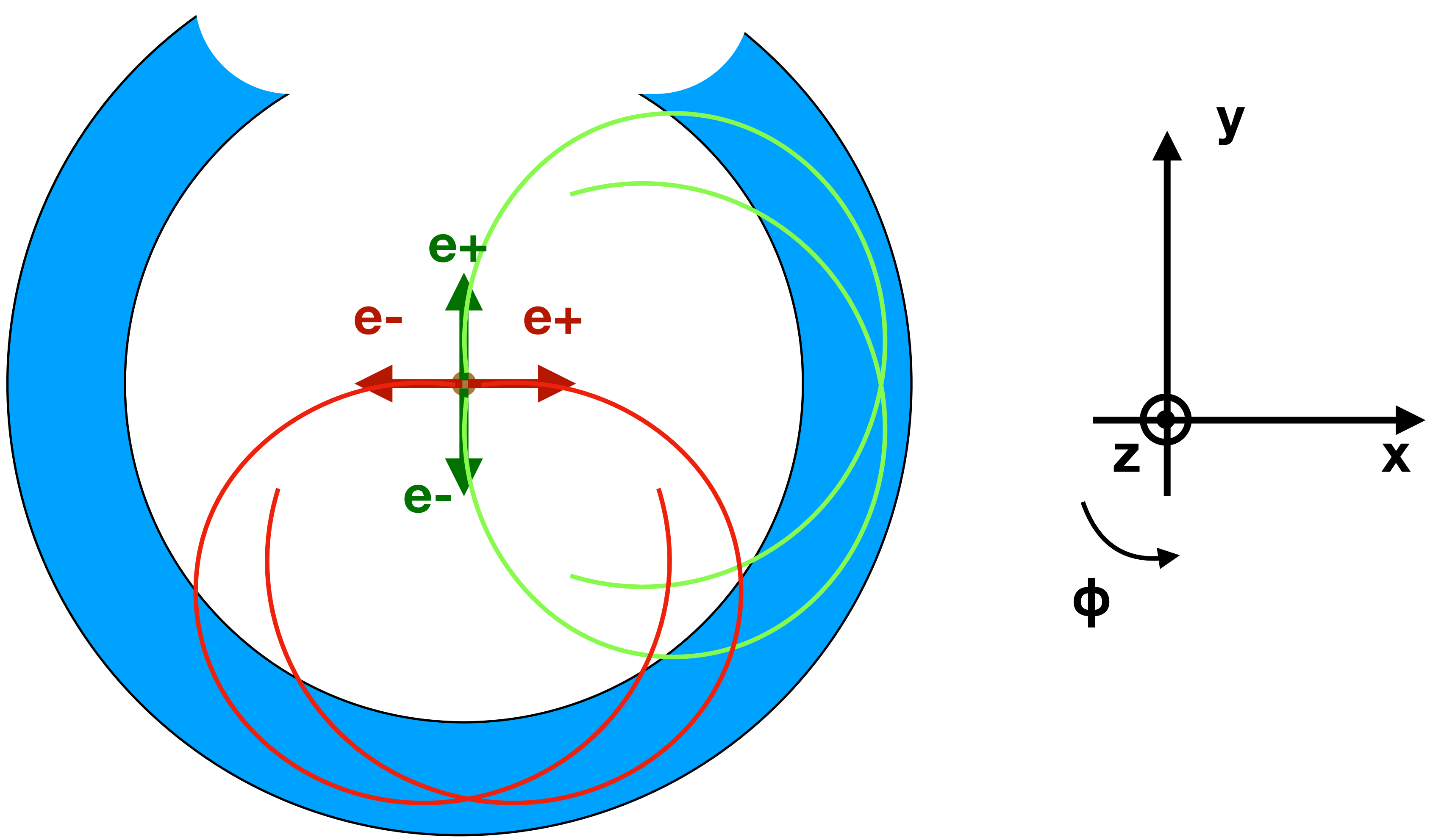
—> well reconstructed events correspond mainly to pairs emitted **// to y axis**



Study of badly reconstructed pairs: interpretation

—> badly reconstructed events correspond mainly to pairs emitted **// to x axis**

—> well reconstructed events correspond mainly to pairs emitted **// to y axis**



—> badly reconstructed seem to be the one emitted // to the x axis
—> many of these must not be reconstructed at all

Conclusion

—> reconstruction efficiency for e+ **x2 lower** than MEG e+

—> reconstruction efficiency for e- **x2 lower** than e+

—> pair reconstruction efficiency 8-10%

—> asymmetry in e+ and e- average nhits

—> a significant fraction of the pairs are badly reconstructed: they correspond to pairs emitted ~// to the x axis, they lead to tracks with low number of hits

Next steps

—> try fitting each track with both e+ and e- assumption

—> confirm interpretation of badly reconstructed events by cutting on phi at the sim level