Columnar recombination

Kiseki Nakamura (Kobe Univ.)

2009-2013 (student) : NEWAGE experiment

Maybe everyone here knows

2014- (PD) : AXEL experiment

Developing high pressure xenon gas TPC for 0nbb search

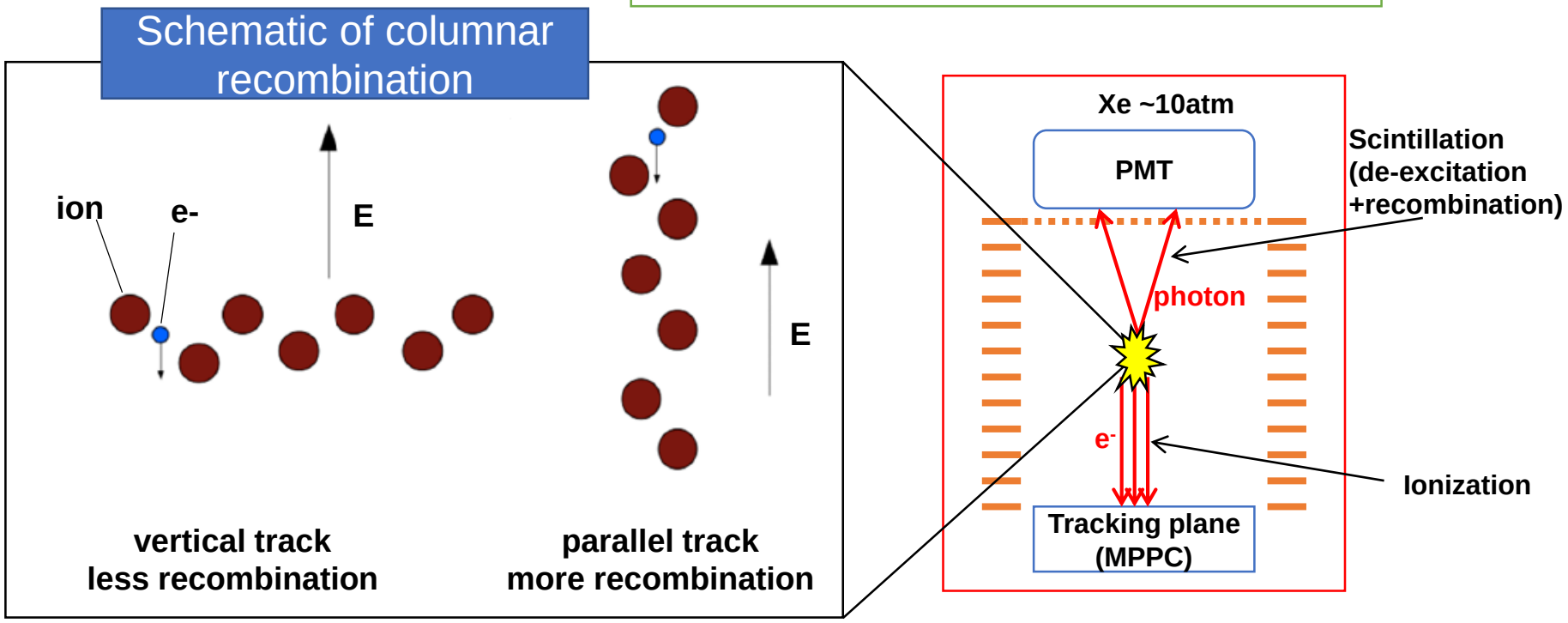
My interest is direction-sensitive DM search

arXiv:1803.00752

Columnar recombination

- High pressure xenon gas TPC
  = directionality + mass + SI sensitivity

D. Nygren J Phys. Conf. Ser. 460 (2013) 012006

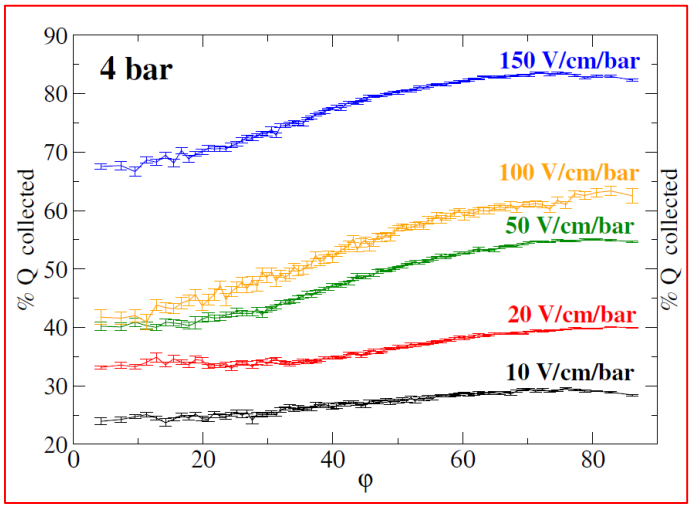


Previous research by NEXT

- Xe + TMA (penning effect)
- Ionization have angular dependence
- Scintillation was suppressed

PoS (TIPP2014) 057

J. Phys. Conf. Ser. 650 (2015) 012012



5MeV alpha-ray

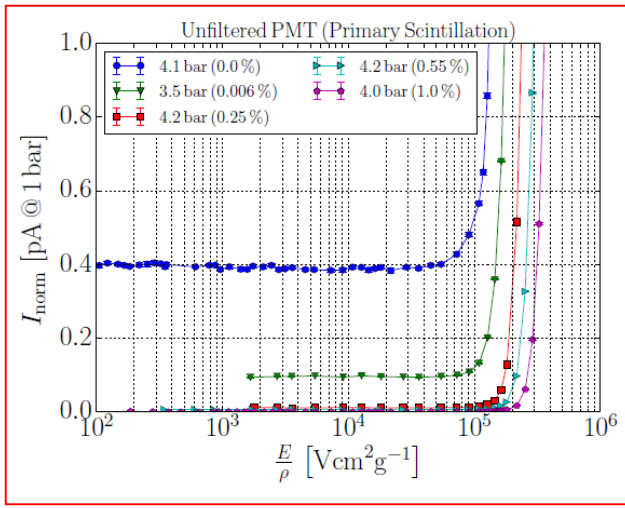
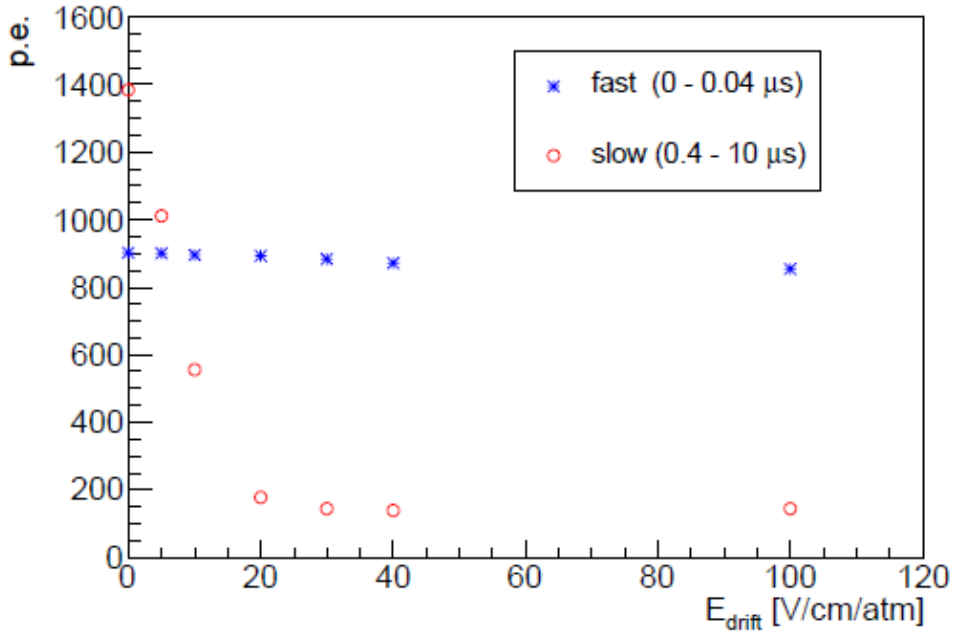
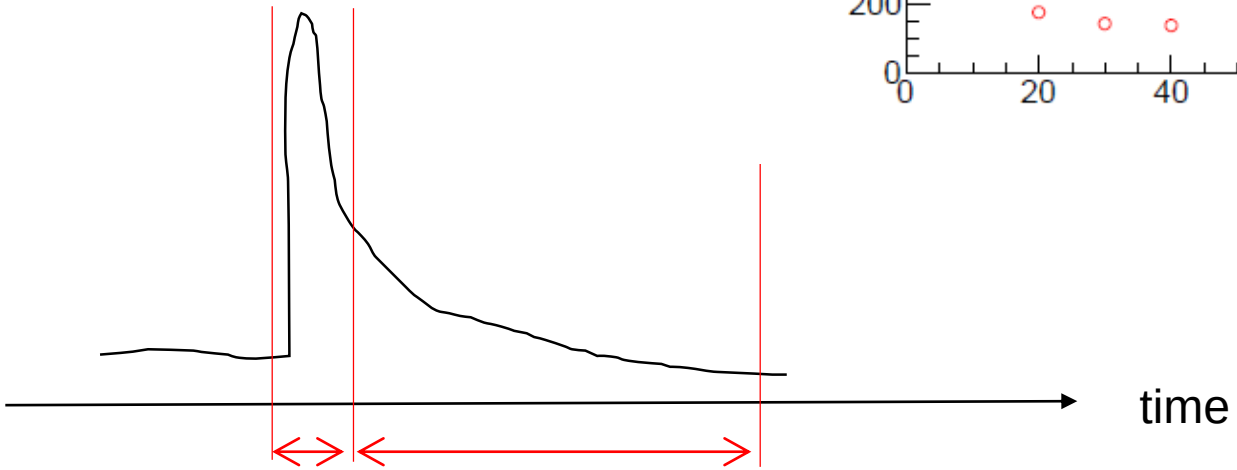


Figure 8. Primary scintillation light yield with Xe+TMA gas mixture, measured at approximately 4 bar total pressure and various TMA concentration.

Time profile of scintillation

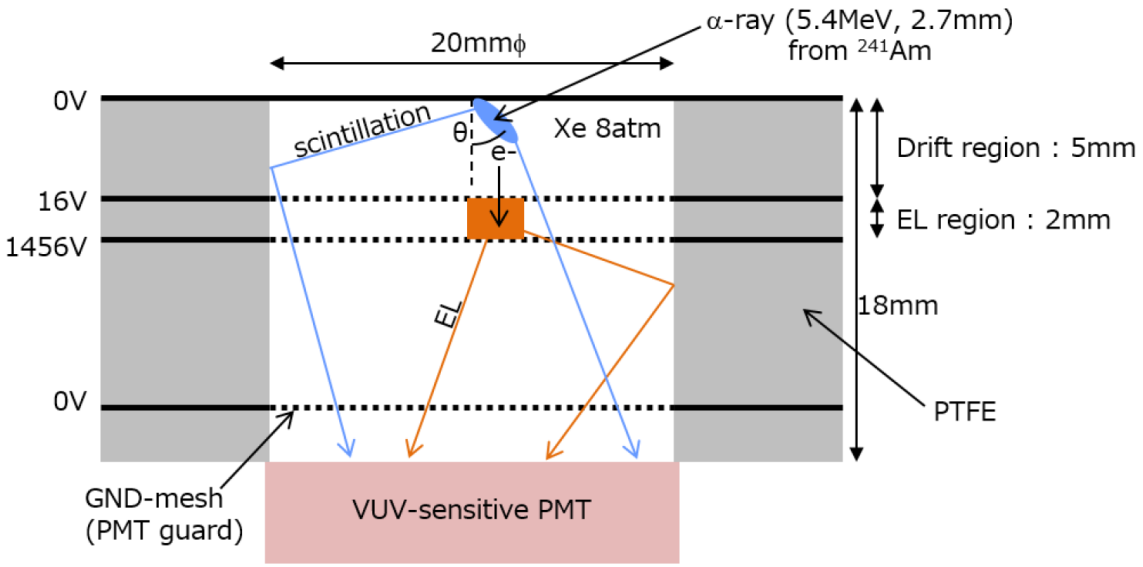
- slow is mainly recombination
- slow may have angular dependence

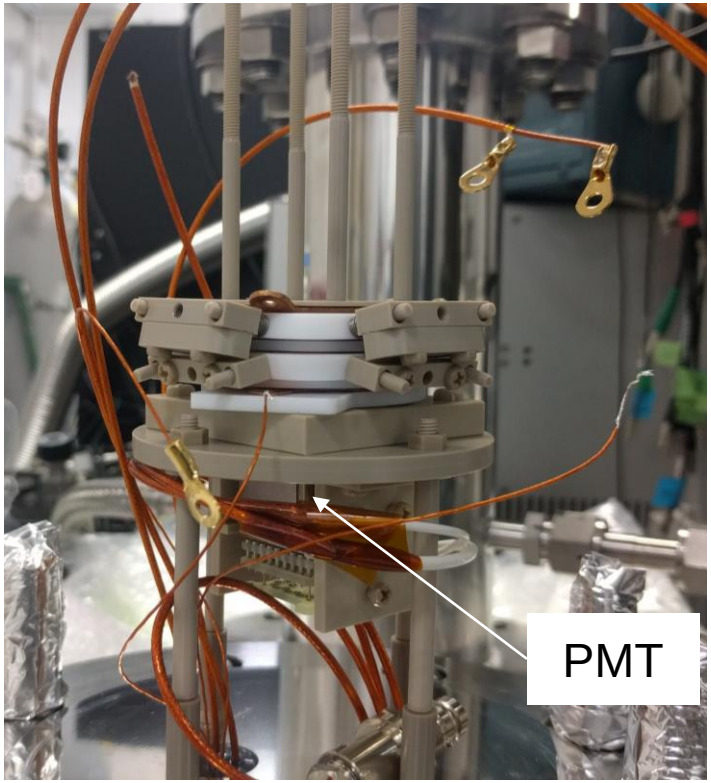




Principle demonstration detector

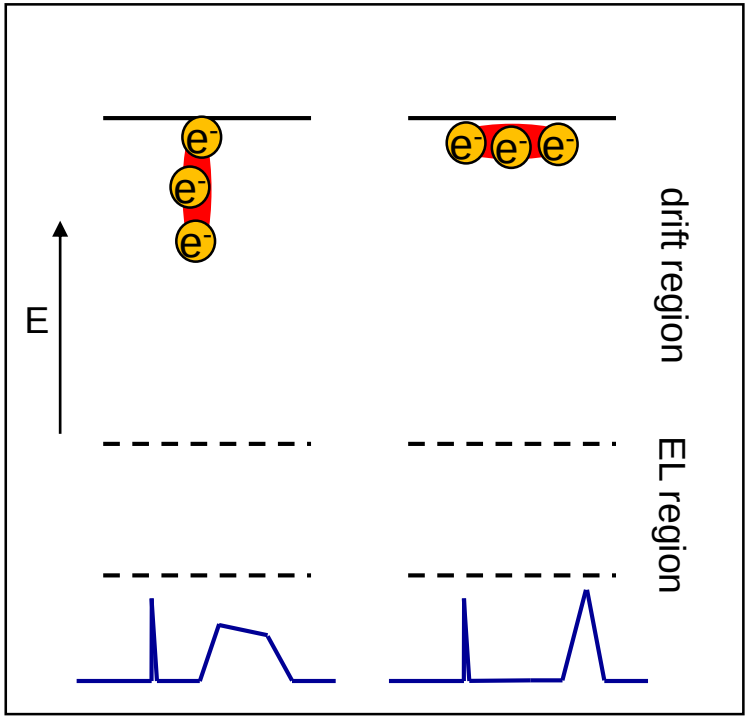
- PMT detect both scintillation and EL(ionization)
- 5MeV alpha-ray





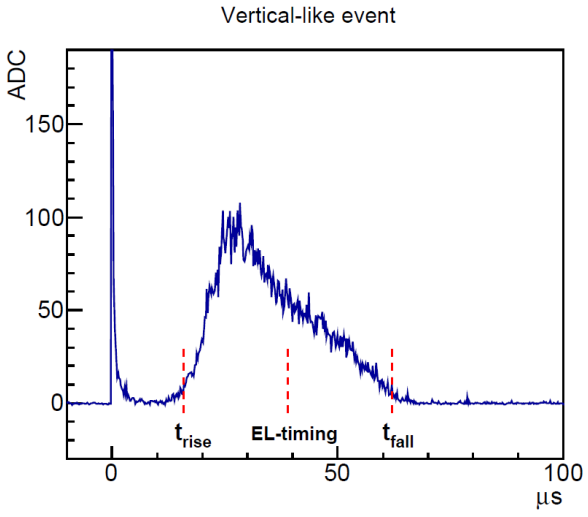
Signal waveform

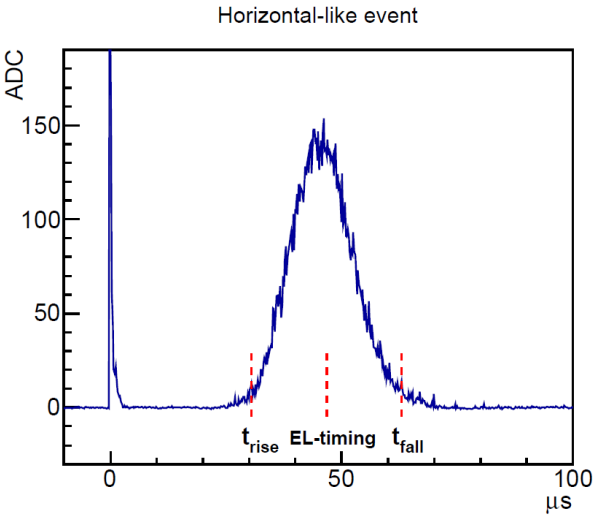
- EL-timing ∝ cosθ
- Initial angle can be known

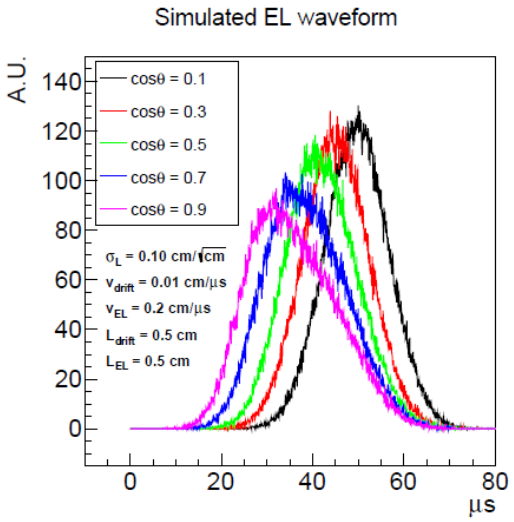


$$EL\text{-}timing = \frac{t_{rise} + t_{fall}}{2}$$

8atm Xe
E_{drift}=6.6V/cm/atm
E_{EL}=900V/cm/atm

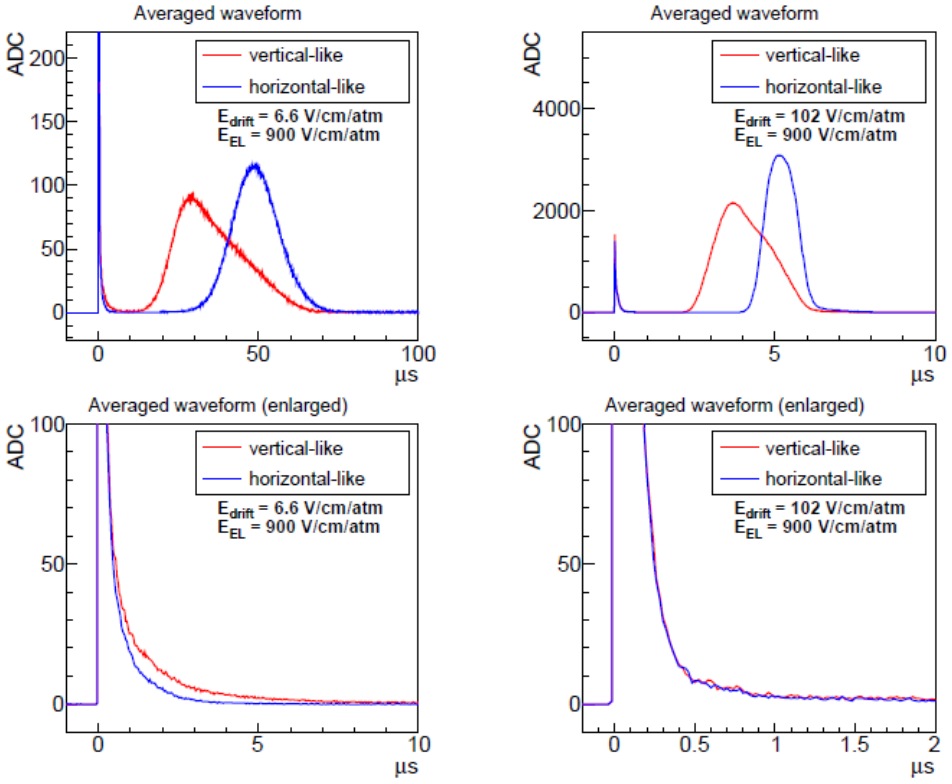






Averaged waveform

- Low E (6.6V/cm/atm): columnar recombination
- High E (102V/cm/atm): no difference

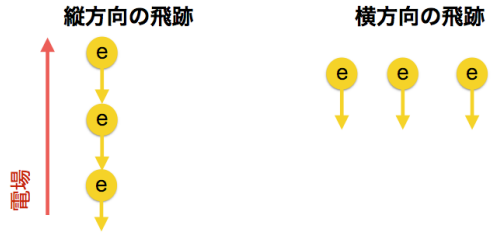


E_{drift}=6.6V/cm/atm

Angular dependence of yield

- fast (de-excitation): const.
- slow (recombination): neg. relation
- EL (ionization): pos. relation

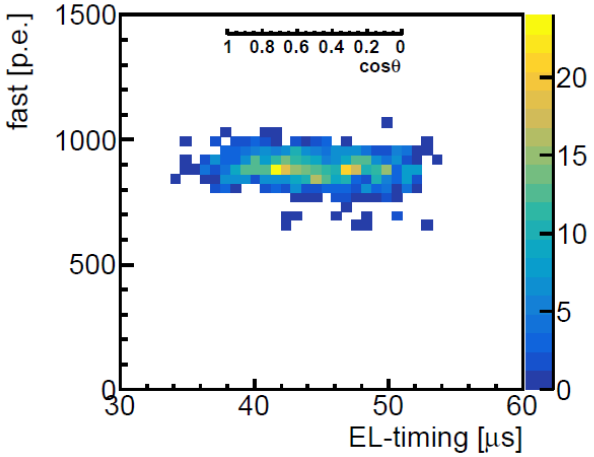
  --> Columnar recombination !



cosθ=1 ⟷ cosθ=0

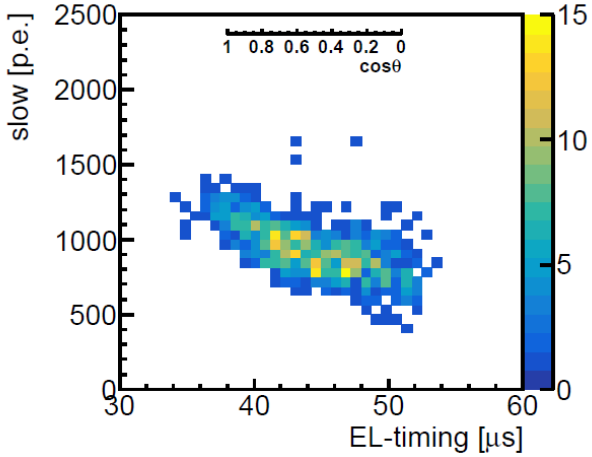
θ=0° ⟷ θ=90°

fast : de-excitation



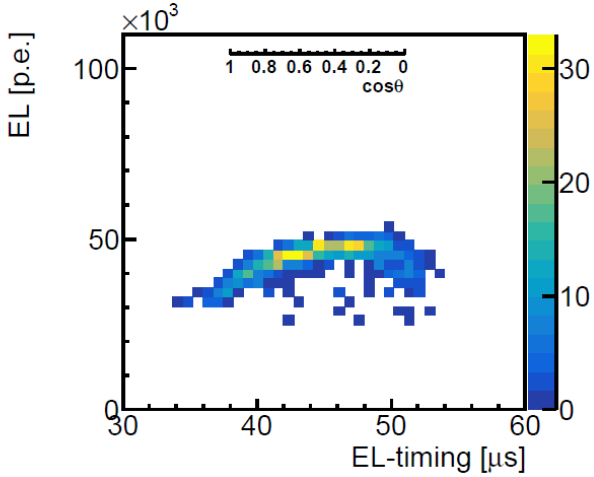
vertical ⟷ horizontal

slow : recombination



vertical ⟷ horizontal

EL : ionization



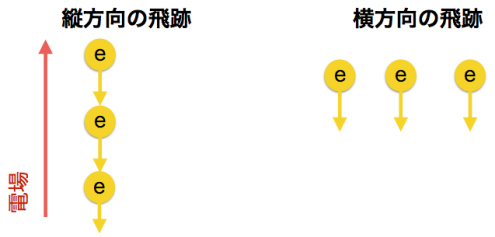
vertical ⟷ horizontal

E_{drift}=102V/cm/atm

High electric field

- fast (de-excitation): const.
- slow (recombination): decreased
- EL (ionization): increased

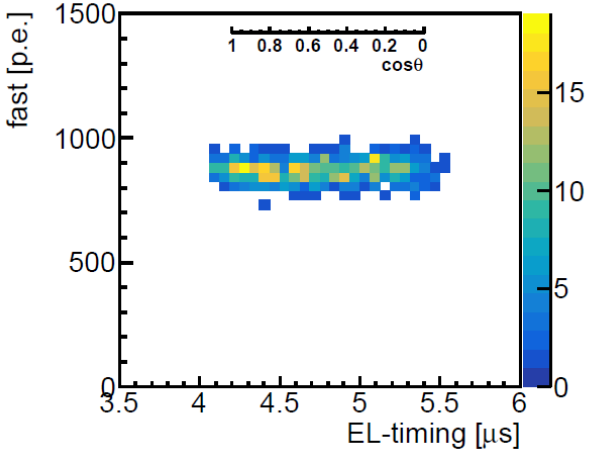
  --> No angular dependence



cosθ=1 ⟷ cosθ=0

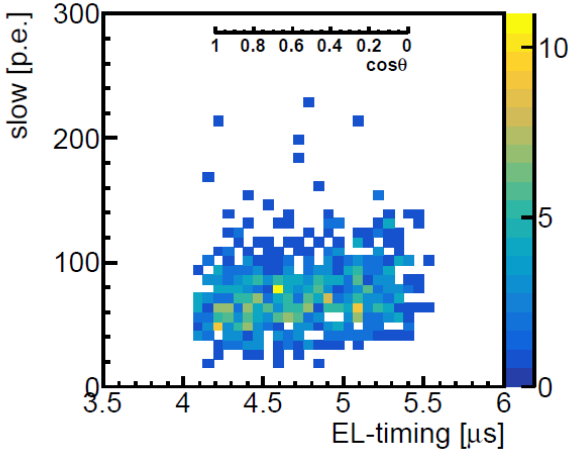
θ=0° ⟷ θ=90°

fast : de-excitation



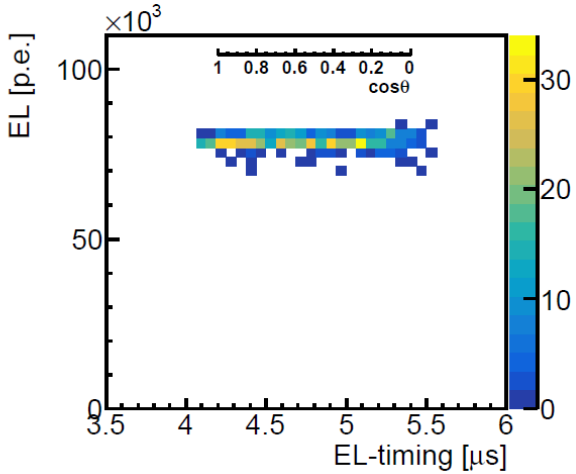
vertical ⟷ horizontal

slow : recombination



vertical ⟷ horizontal

EL : ionization



vertical ⟷ horizontal

arXiv:1803.00752

Conclusion

- Angular dependence of columnar recombination was observed in both photon and charge signal
  - gas: 8atm Xe 100%
  - particle: 5MeV alpha-ray
- Low electric field is needed (6.6V/cm/atm this time)
- Paper have been submitted to JINST
  - I expect it will be accepted soon.
- Next plan: Low energy study (252Cf)