Measurement of low energy Electronic Recoil Response and Electronic/Nuclear Recoils Discrimination in XENON100

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On behalf on XENON Collaboration

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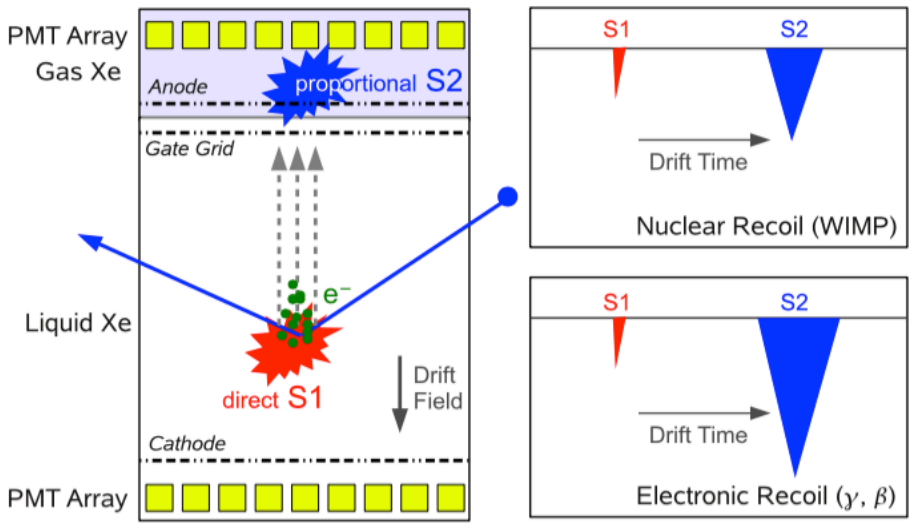
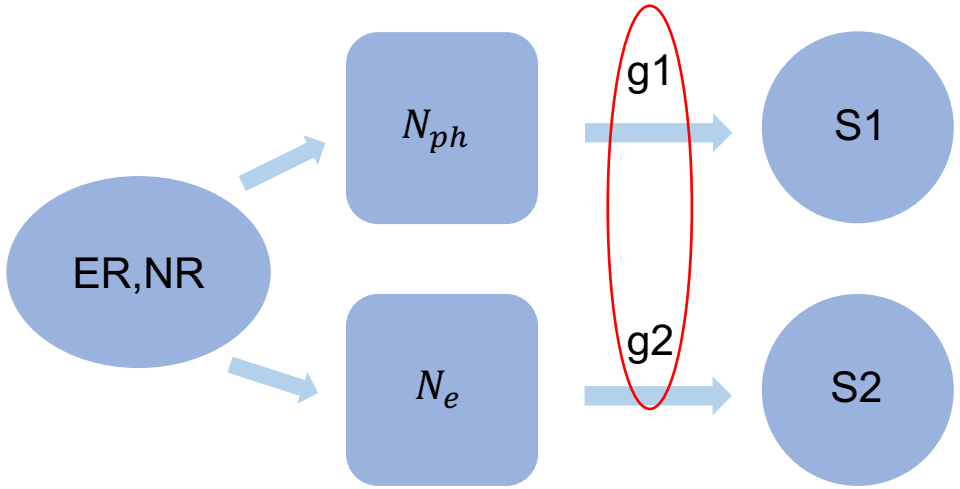
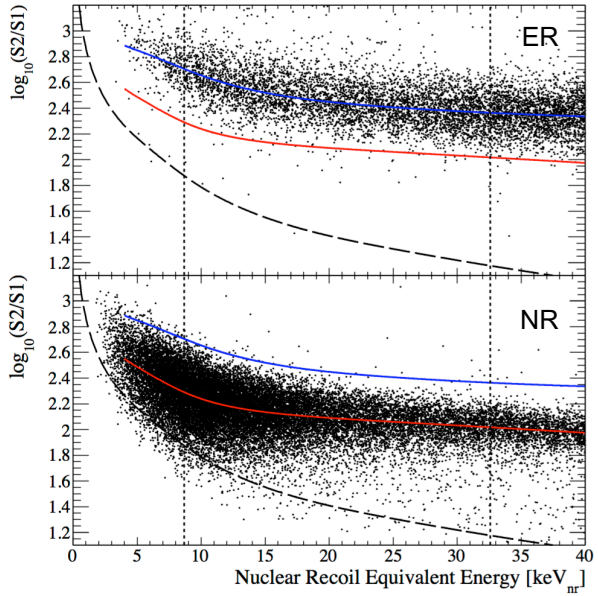
Introduction





- Scintillation signal S1
- Charge signal S2
- Different S2/S1 for ER/NR



$$g_1 = \frac{S_1}{N_{ph}}, g2 = \frac{S_2}{N_e}$$

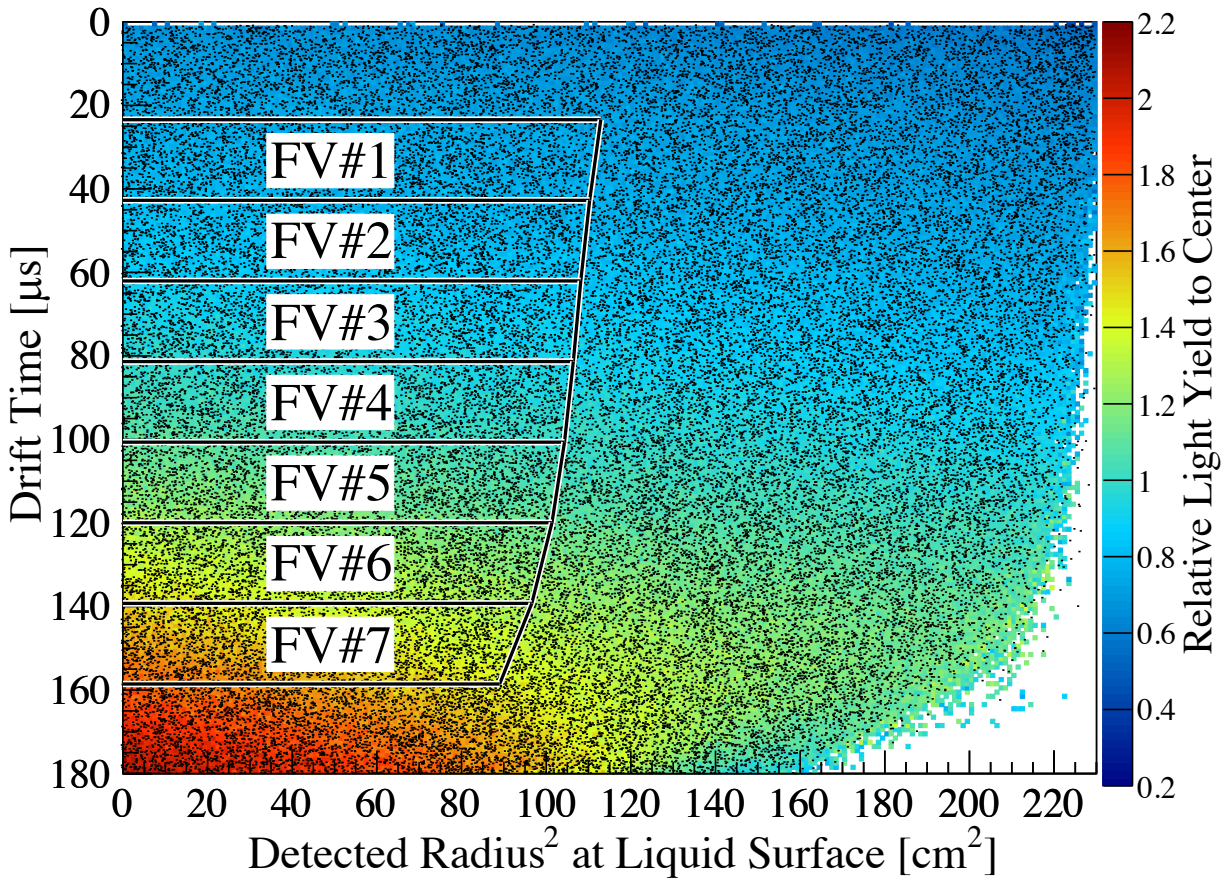
- Primary scintillation gain g1
- Secondary scintillation gain g2
- g1 is proportional to photon detection efficiency(PDE)

Data Extraction

Calibration source & detector condition:

- CH_3T calibration (<18.6 keVee, ER)
- AmBe calibration(NR)
- 3 different drift and extraction fields

	Drift field(V/cm)	Extraction field(kV/cm)	Electron lifetime(us)	Max drift time(us)	Events in sub-FV(10^4)
CH3T	400	10.0	1470 ± 190	182	43.4
CH3T	167	8.2	390 ± 160	202	11.9
CH3T	100	8.2	590 ± 30	220	8.9
AmBe	400	10.0	1490 ± 100	182	3.5
AmBe	167	8.2	490 ± 130	202	3.6
AmBe	100	8.2	550 ± 60	220	6.5



To compare with different PDE:

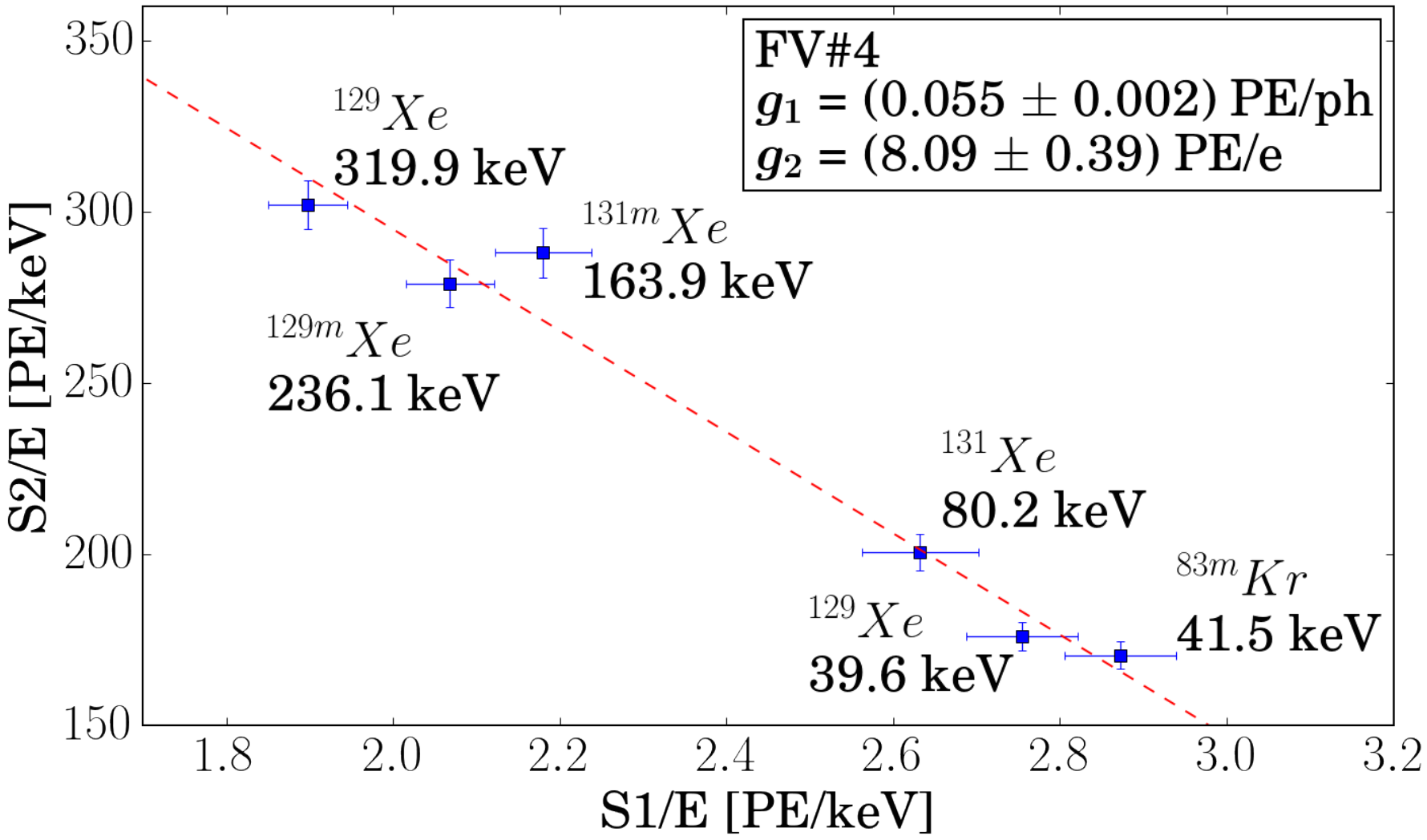
- 7 sub-FVs('small detector')
  - 50% quantile in R^2direction, equal in drift time
  - Enough statistics in each sub-FV
  - Avoid strong field distortion in top and bottom region
- No position dependent correction of S1 and S2
  - Small S1 and S2 variation in each sub-FV(6% for S1, 5% for S2)
  - PDE increases from top part to bottom part

Detector calibration(g1, g2)

Calibration principle:
Doke method

$$E = W \cdot (\frac{S_1}{g_1} + \frac{S_2}{g_2}), W = 13.7eV$$

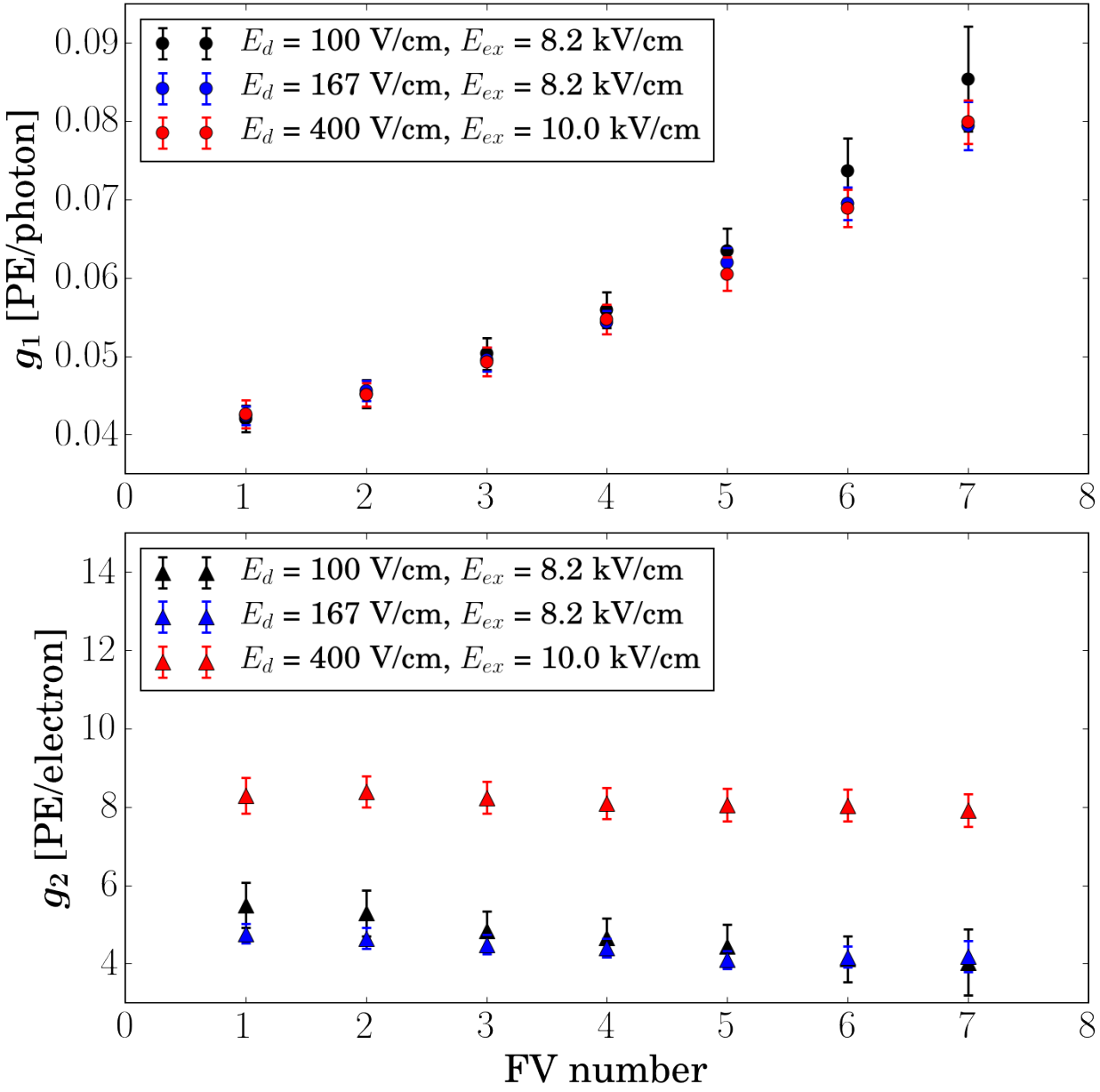
$$\frac{S_2}{E} = -\frac{g_2}{g1}\frac{S_1}{E} + \frac{g_2}{W}$$



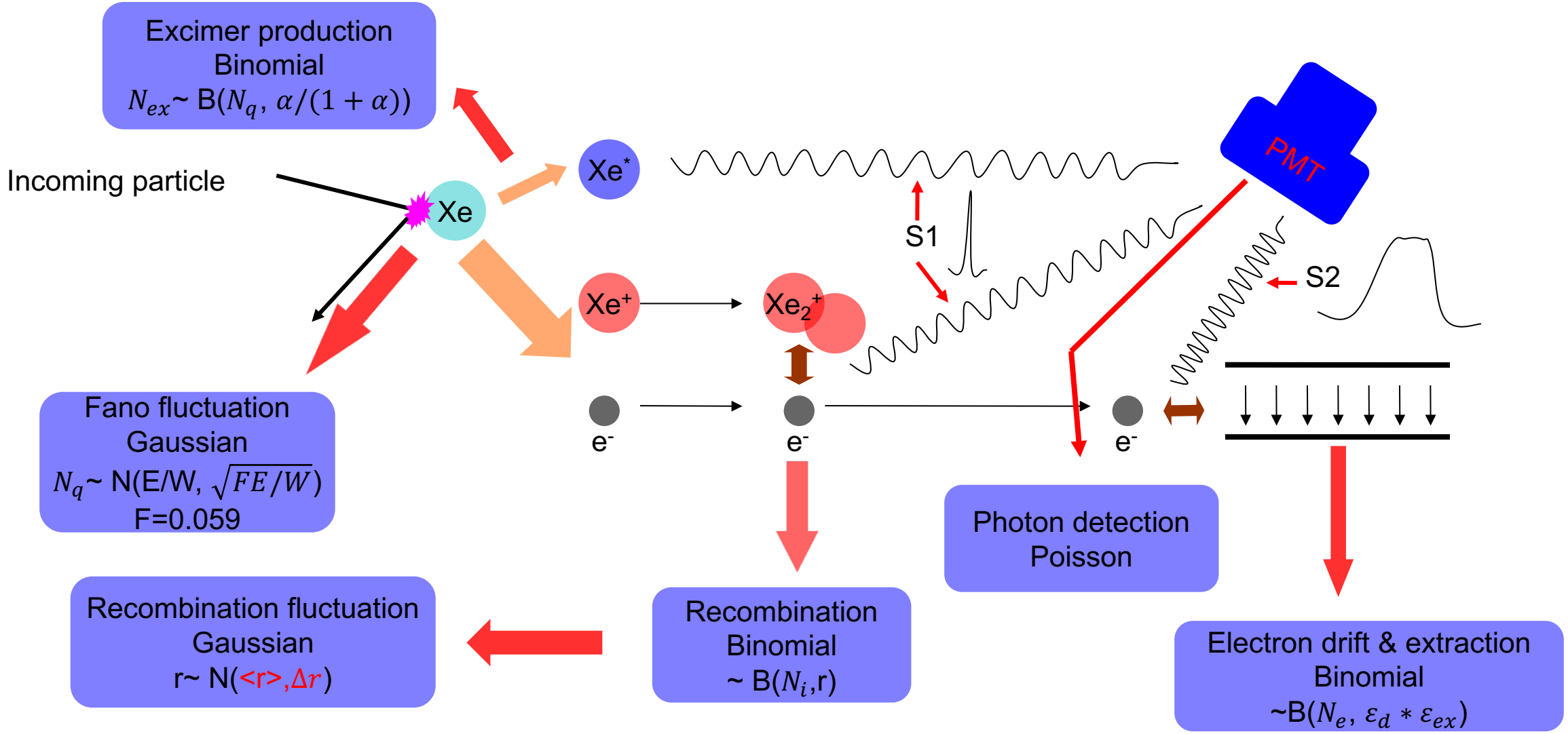
Detector calibration(g1, g2)

Calibration result:

- g1 z dependence due to geometry effect
- g2 z dependence due to electron lifetime
- g1 is consistent under different drift fields
- g2 increases with larger extraction field



Simulation model



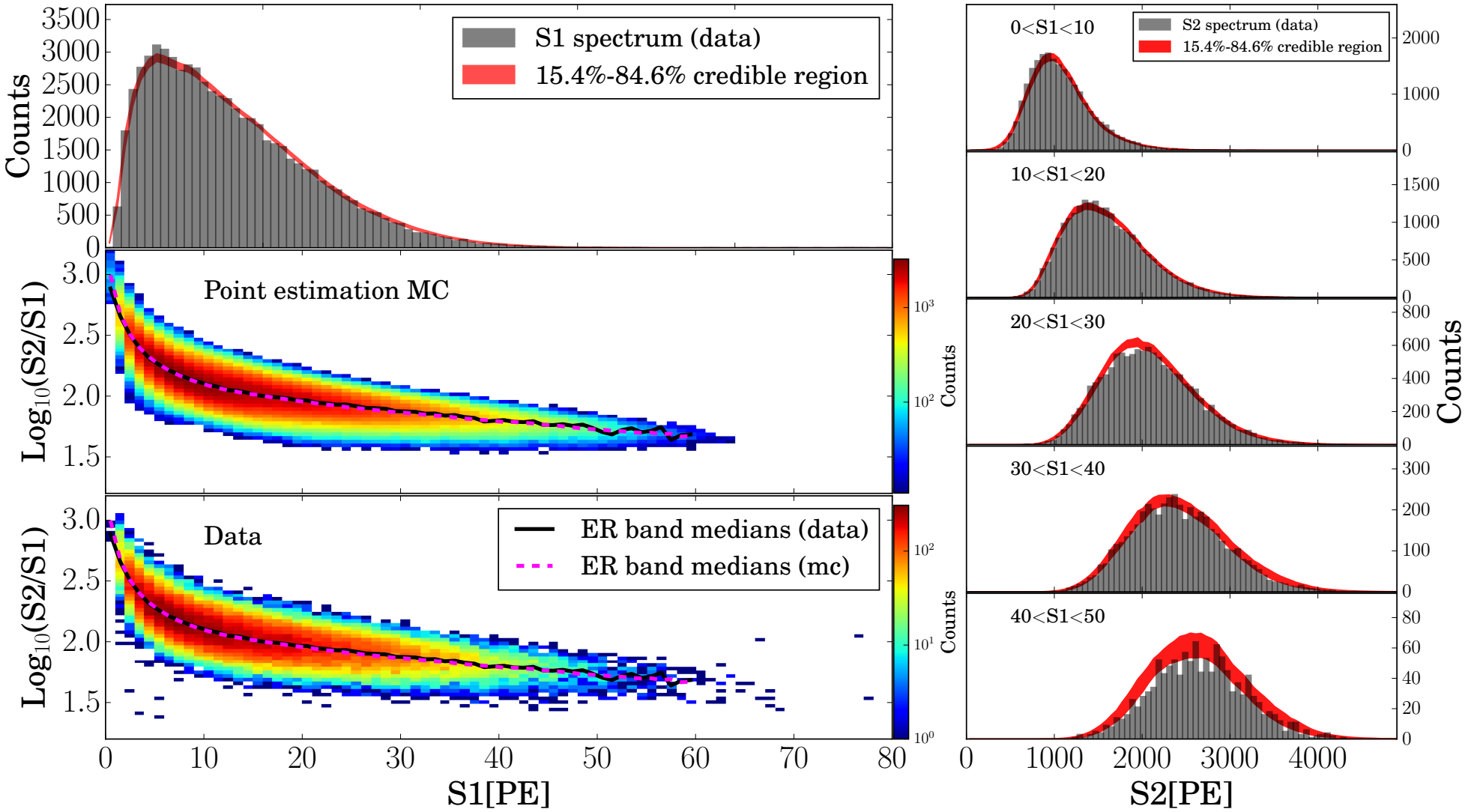
r: recombination factor

<r>: average recombination fraction(<r> is tuned)

Δr: recombination fluctuation(Δr/<r> is tuned)

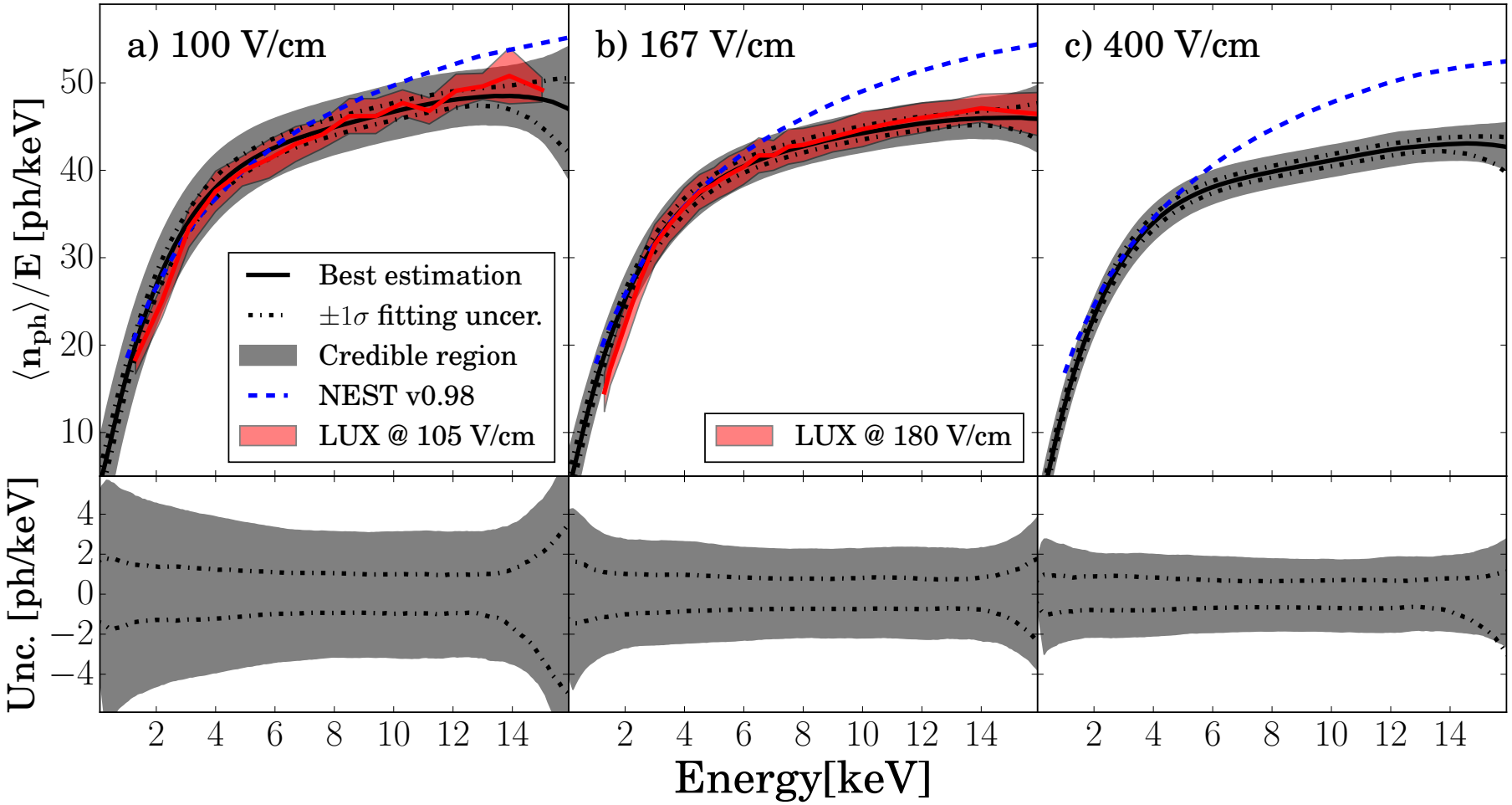
MC-data matching

Use Binned Maximum Likelihood Estimation(MLE) in Log10(S2/S1) vs S1 space to extract ER response



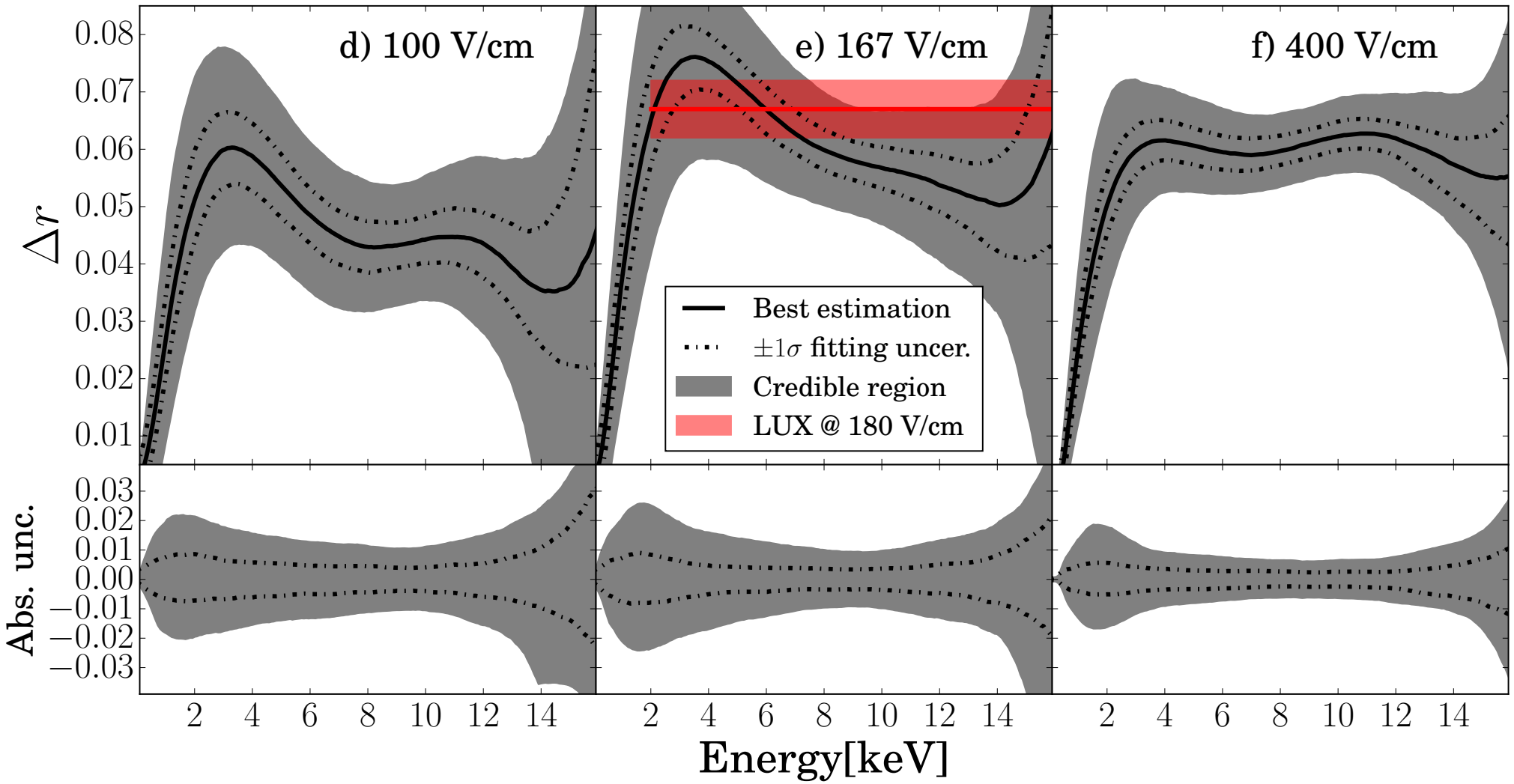
Light yield

- Lower light yield at higher drift field as expected
- Consistent with LUX measurement
- Light yield deviates from NEST at high energy, especially at high drift fields



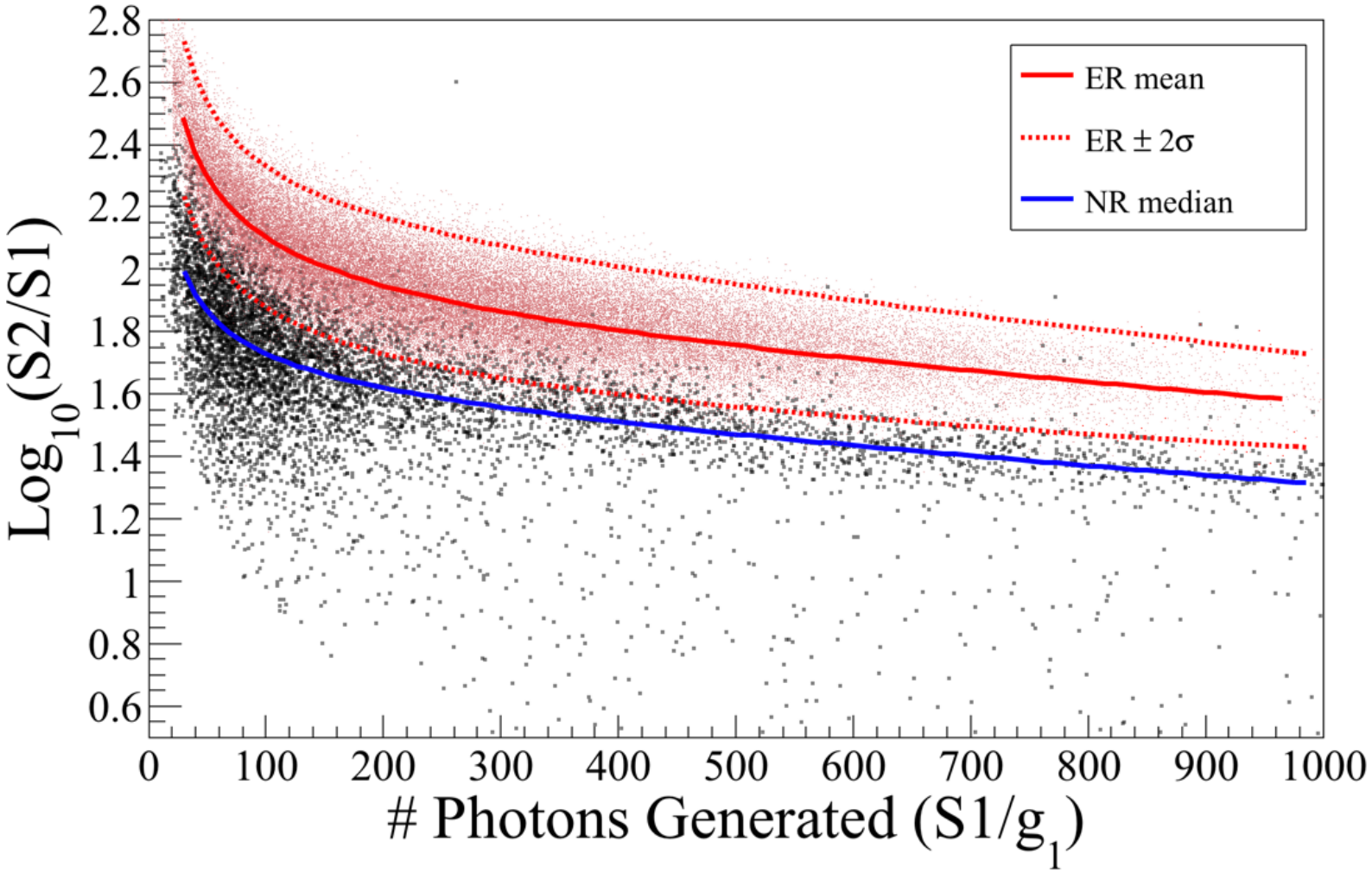
Recombination fluctuation

No significant change observed between different drift fields



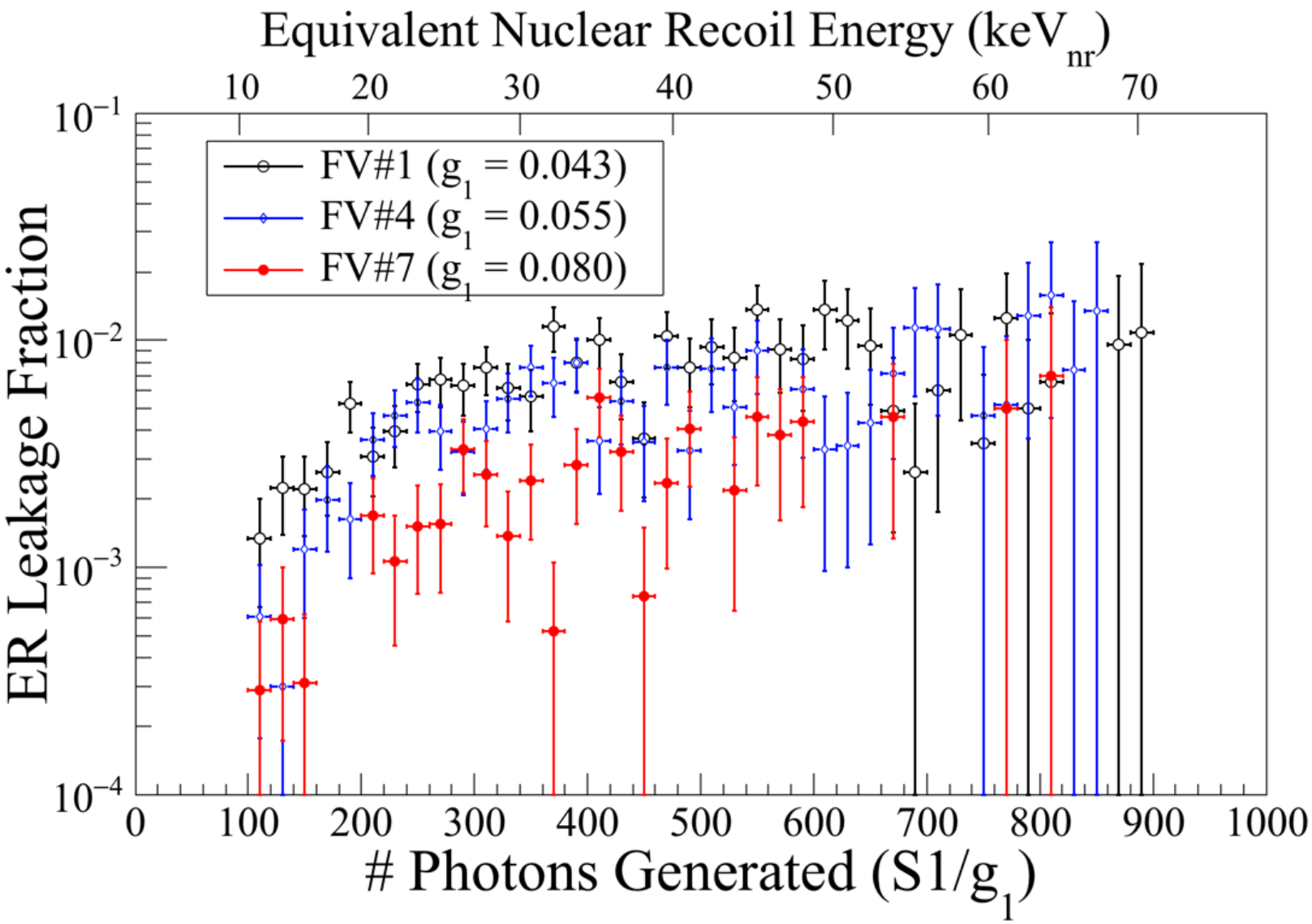
ER/NR discrimination

- Normalize S1 to photons generated to compare ER leakage under different g1
- S2 is corrected for electron lifetime



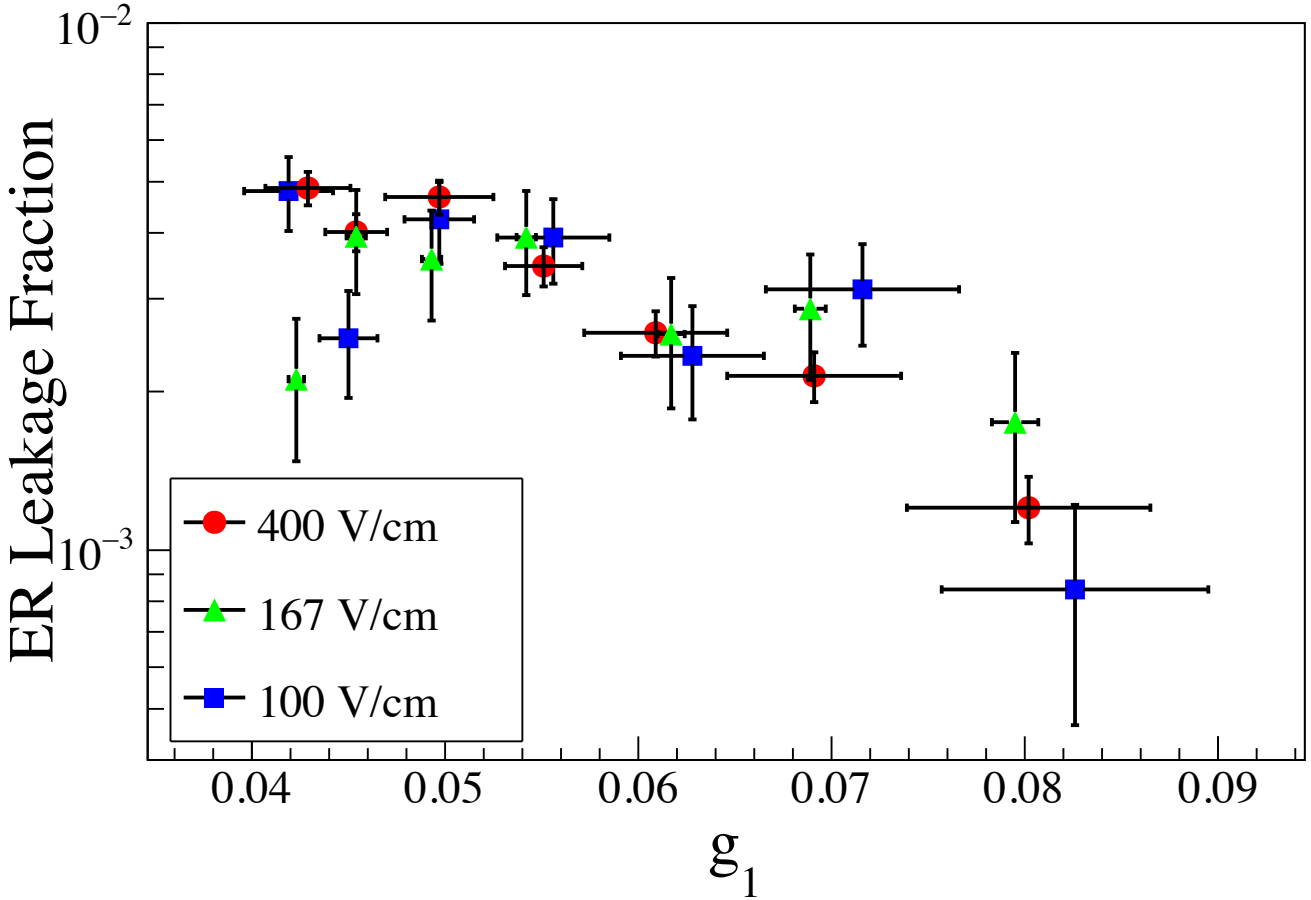
ER/NR discrimination

ER leakage is smaller at larger g1



ER/NR discrimination for different g1 and drift fields

- S1 range(100-400 photons), energy range(11-34 keVnr)
- ER leakage is smaller at larger g1
- No significant difference for ER leakage between 100 V/cm and 400 V/cm drift field

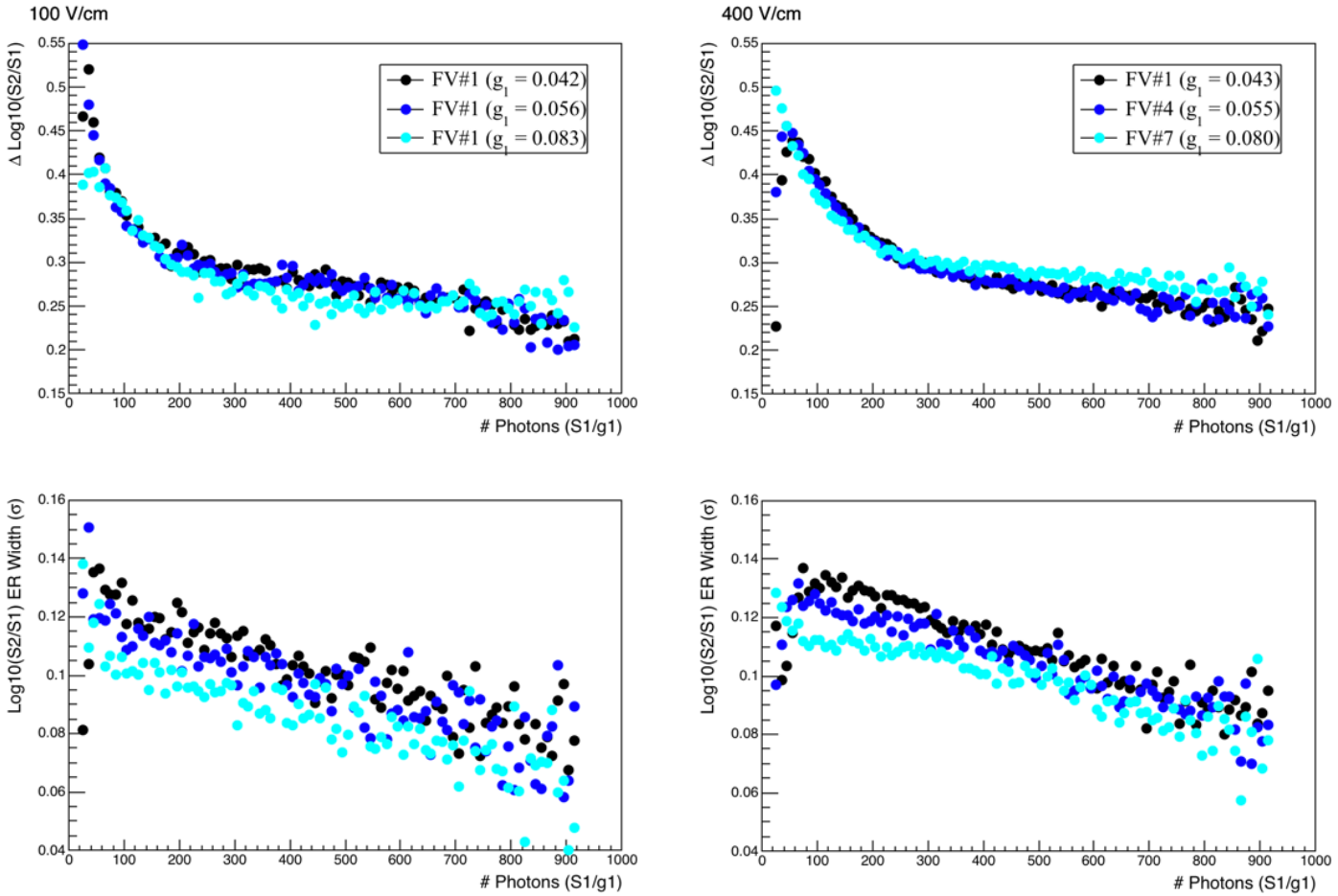


Summary

- Light yield and recombination fluctuation for low energy under three drift field are measured
  - Light yield under 100 and 167 V/cm are consistent with LUX measurement
- ER leakage is smaller for larger photon detection efficiency
- No significant difference in ER leakage is observed between 100 V/cm and 400 V/cm drift field
- The paper will be available on arXiv next week

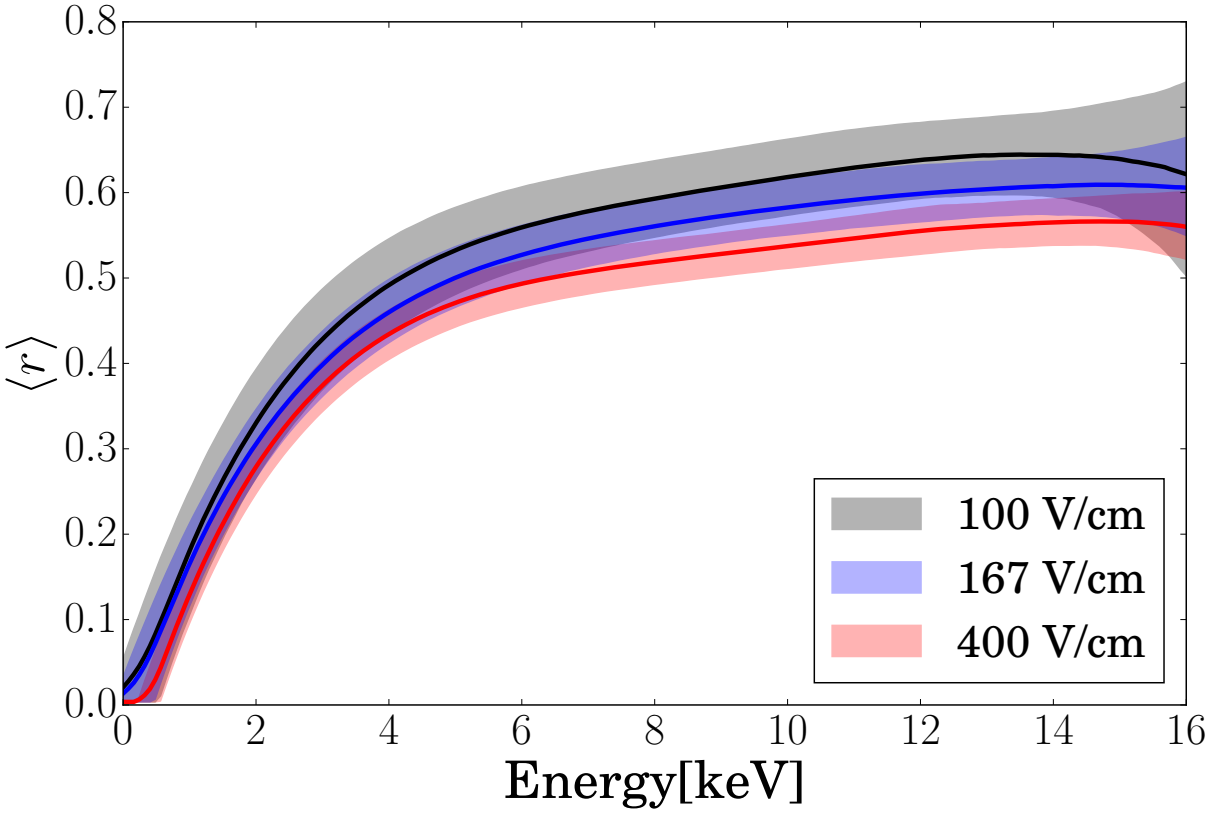
Back up

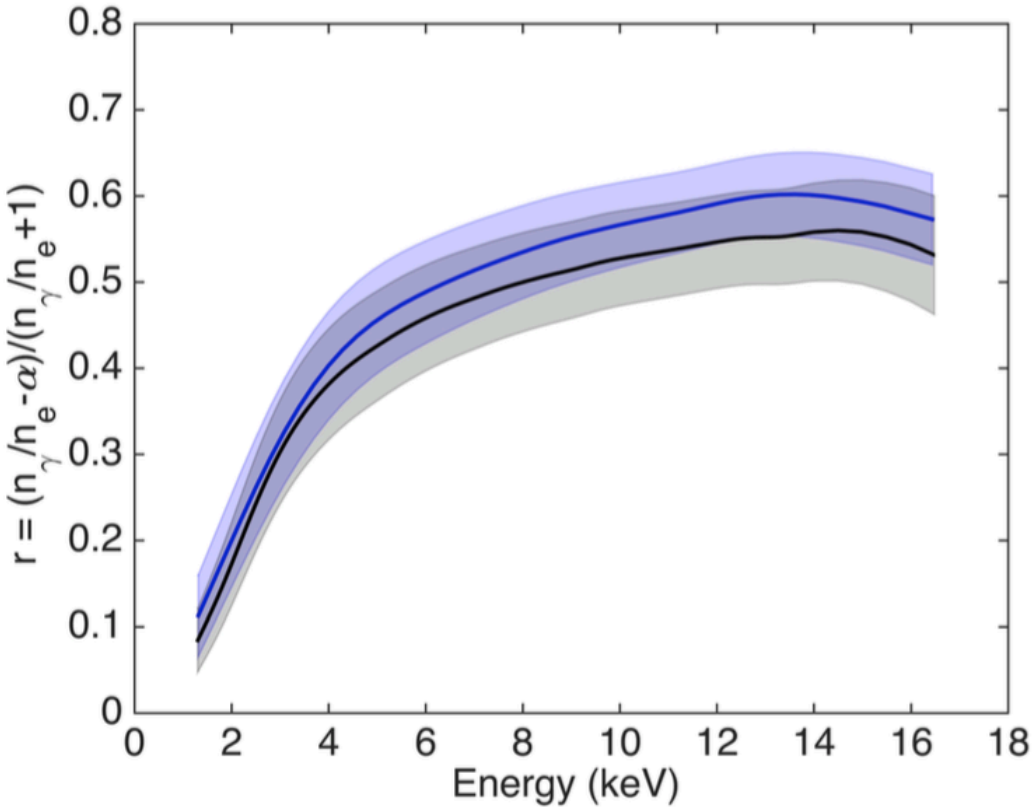
- Drift field increases:
  - ER/NR separation increases
  - ER band width increases
- g1 increases:
  - ER/NR separation doesn't change significantly
  - ER band width decreases



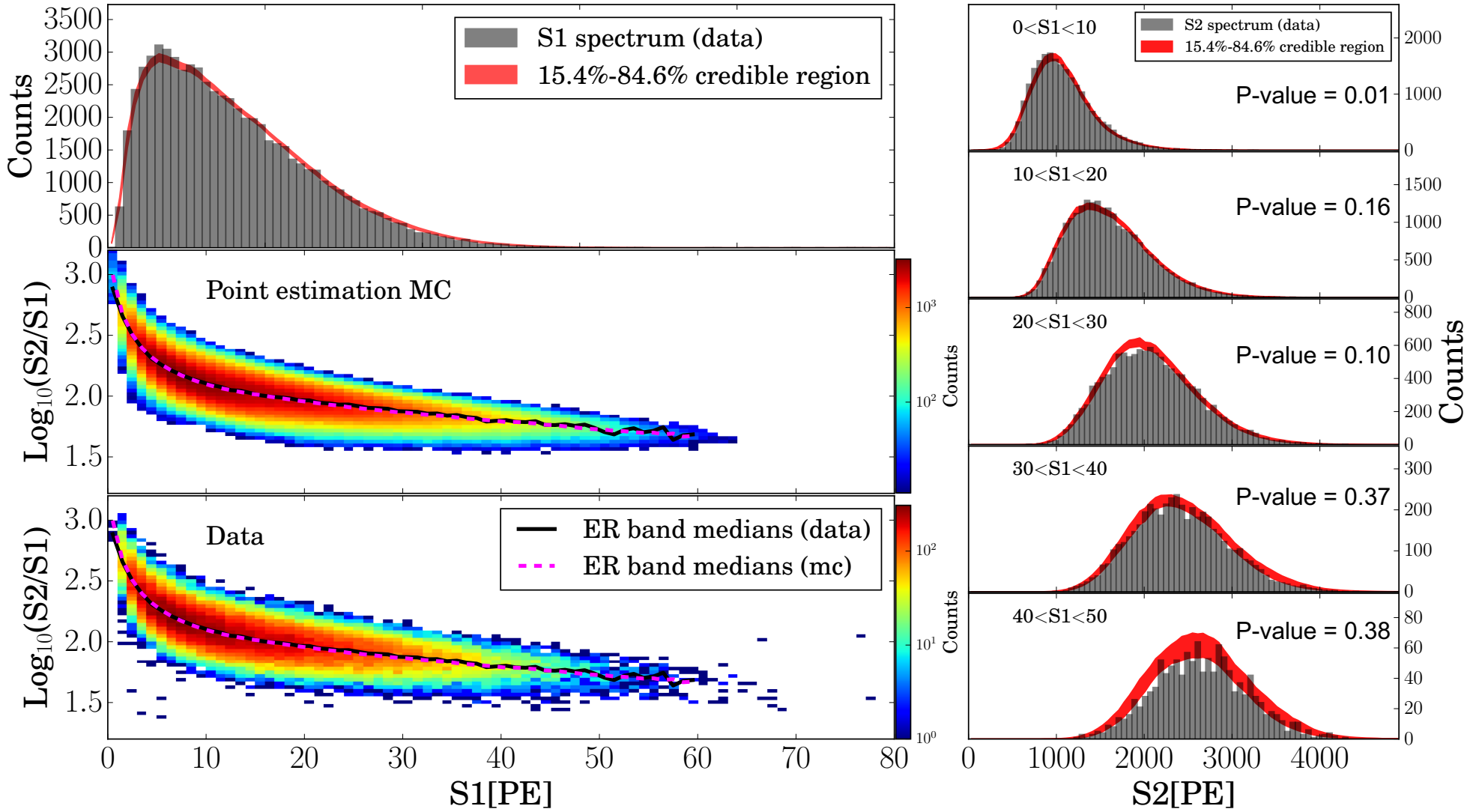
Recombination factor

LUX Collaboration
arXiv: 1512.03133





Black: 180 V/cm
Blue: 105 V/cm


S1 spectrum (data)
15.4%-84.6% credible region
Counts
Point estimation MC
Log10(S2/S1)
Data
ER band medians (data)
ER band medians (mc)
S1[PE]
0<S1<10
10<S1<20
20<S1<30
30<S1<40
40<S1<50
S2 spectrum (data)
15.4%-84.6% credible region
P-value = 0.01
P-value = 0.16
P-value = 0.10
P-value = 0.37
P-value = 0.38
S2[PE]