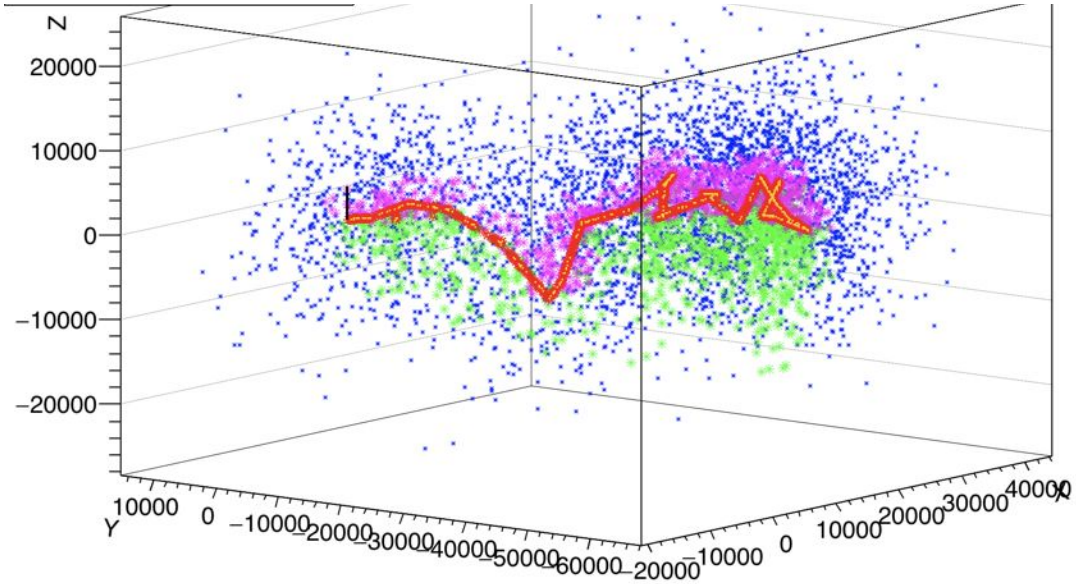
Hello Everybody!

RCX: ReCombination in liquid Xenon
Microscopic Model of Light Production



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RCX: ReCombination in liquid Xenon

1. Motivation

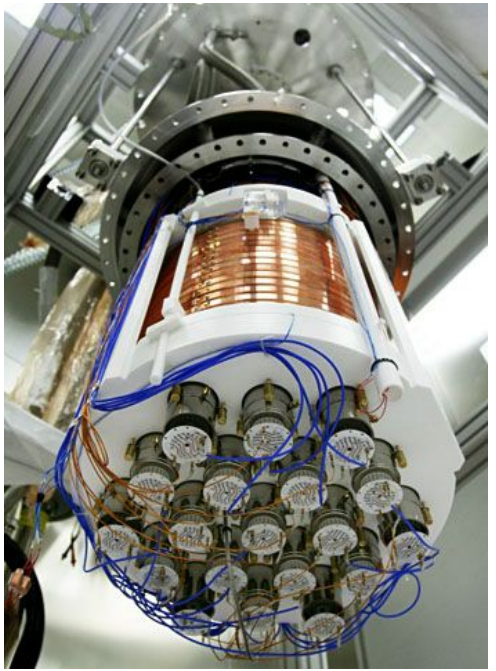
Liquid Noble Gas Detectors → cutting edge of particle physics!
→ typically use liquid Argon or Xenon as detection medium
→ particles deposit energy in medium, we measure this

<u>Time Projection Chamber</u> (TPC)

Some experiments around the world:

EXO - neutrinoless double beta decay, xenon
darkside - dark matter, argon
XENON - dark matter
LUX - dark matter, xenon
ICARUS, DUNE, MicroBOONE - neutrinos, argon
PandaX 2 - dark matter, neutrinoless double beta, xenon

and many more...



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2. What is measured

Particles deposit their energy by colliding with xenon atoms resulting in ion/electron pairs and excited states

A) Excited states

Various states relax → **light**

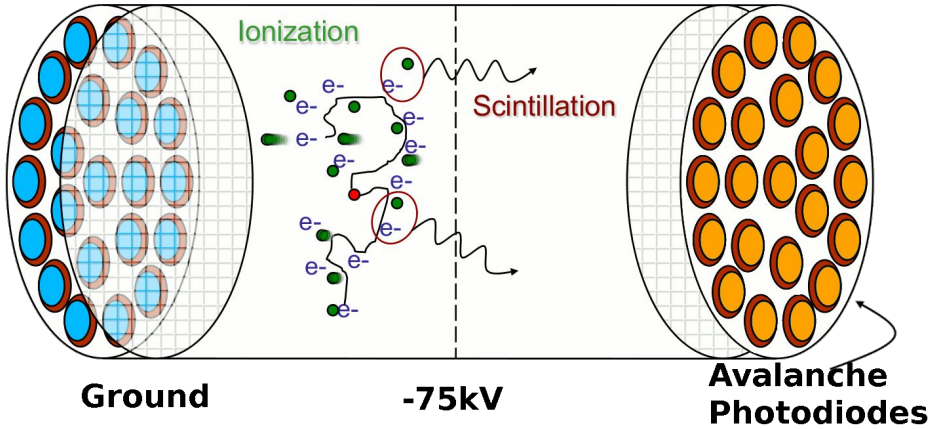
B) Ion/electron pairs

Some e^- recombine with ions → **light**

Others escape to cathode → **charge**

TPCs measure **light** and **charge**

TPCs have an applied electric field



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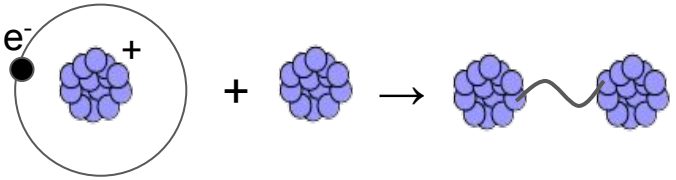
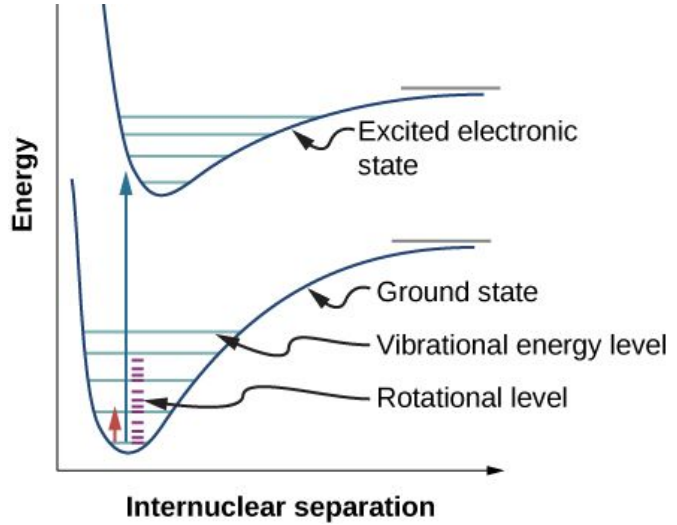
3. Chemistry of recombination

A) Excited states relaxation (*self-trapped exciton luminescence*)

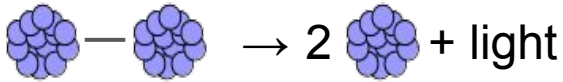
1. $Xe^* + Xe \rightarrow (Xe_2^*)_{exc}$



2. $(Xe_2^*)_{exc} \rightarrow Xe_2^* + Q^A$



3. $Xe_2^* \rightarrow 2Xe + \gamma + Q_{split}$



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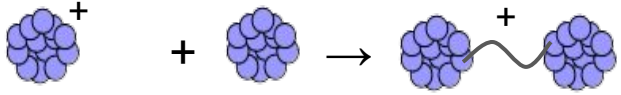
4. Chemistry of recombination

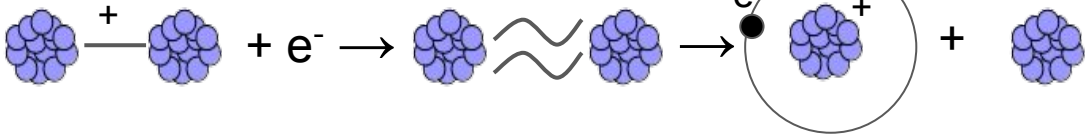
B) Excited states recombining (*recombination luminescence)*

1. $Xe^+ + Xe \rightarrow Xe_2^+$



e^- escapes due to E field
charge collected

2. $Xe_2^+ + e^- \leftrightarrow (Xe_2^*)_u \rightarrow Xe^* + Xe + Q_{diss}$



Back to previous process
light

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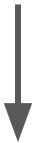
5. Application (Recombination Monte Carlo)

Application

perform recombination on
tracks produced by Daniel

Advantages of this simulation

- Detailed time structure of light signal
- Charge collection vs. field orientation
- Heat deposition in detector



1. Better experimental understanding
2. More discrimination power
3. More chance for discovery!

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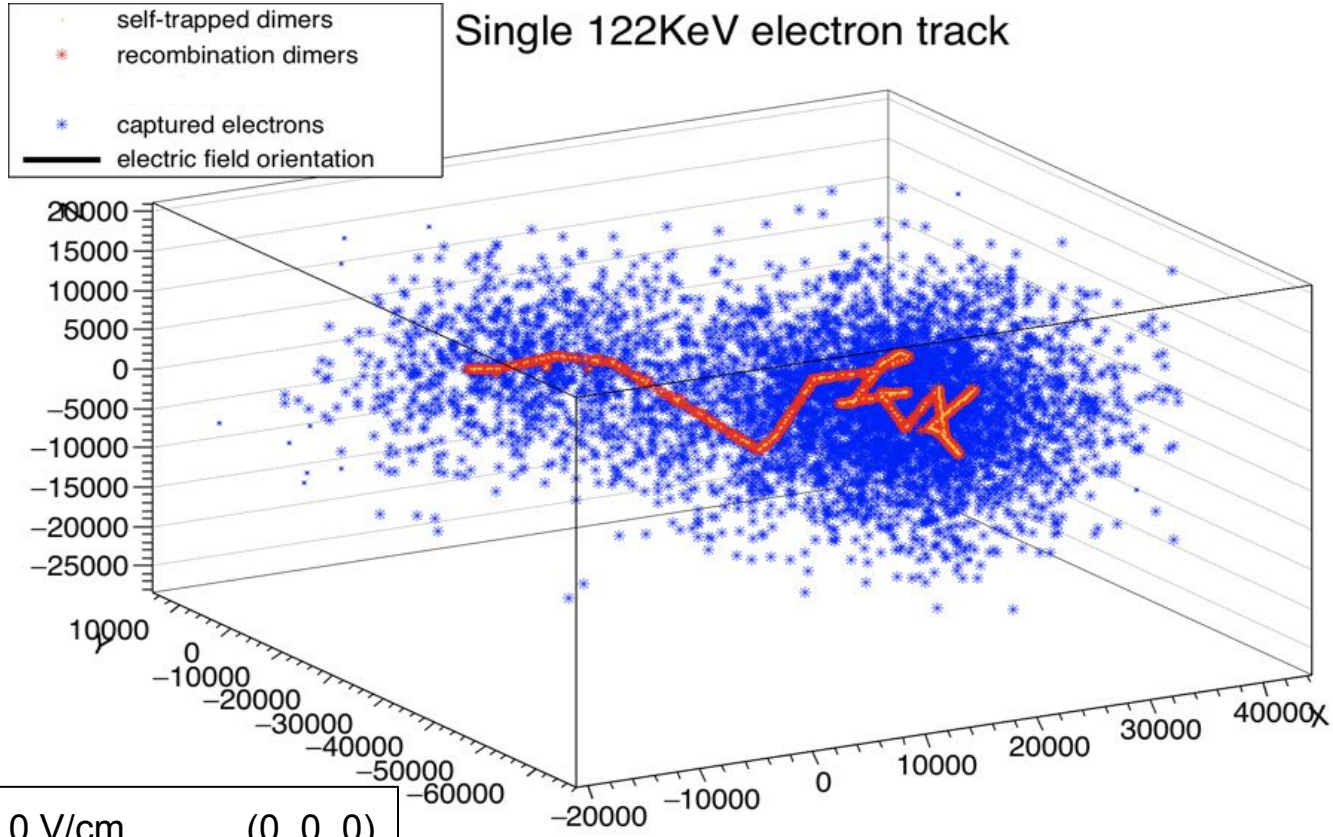
6. Plot: zero field



N events = 8695

Detector sees:

100% light

0% charge

E field = 0 V/cm (0, 0, 0)

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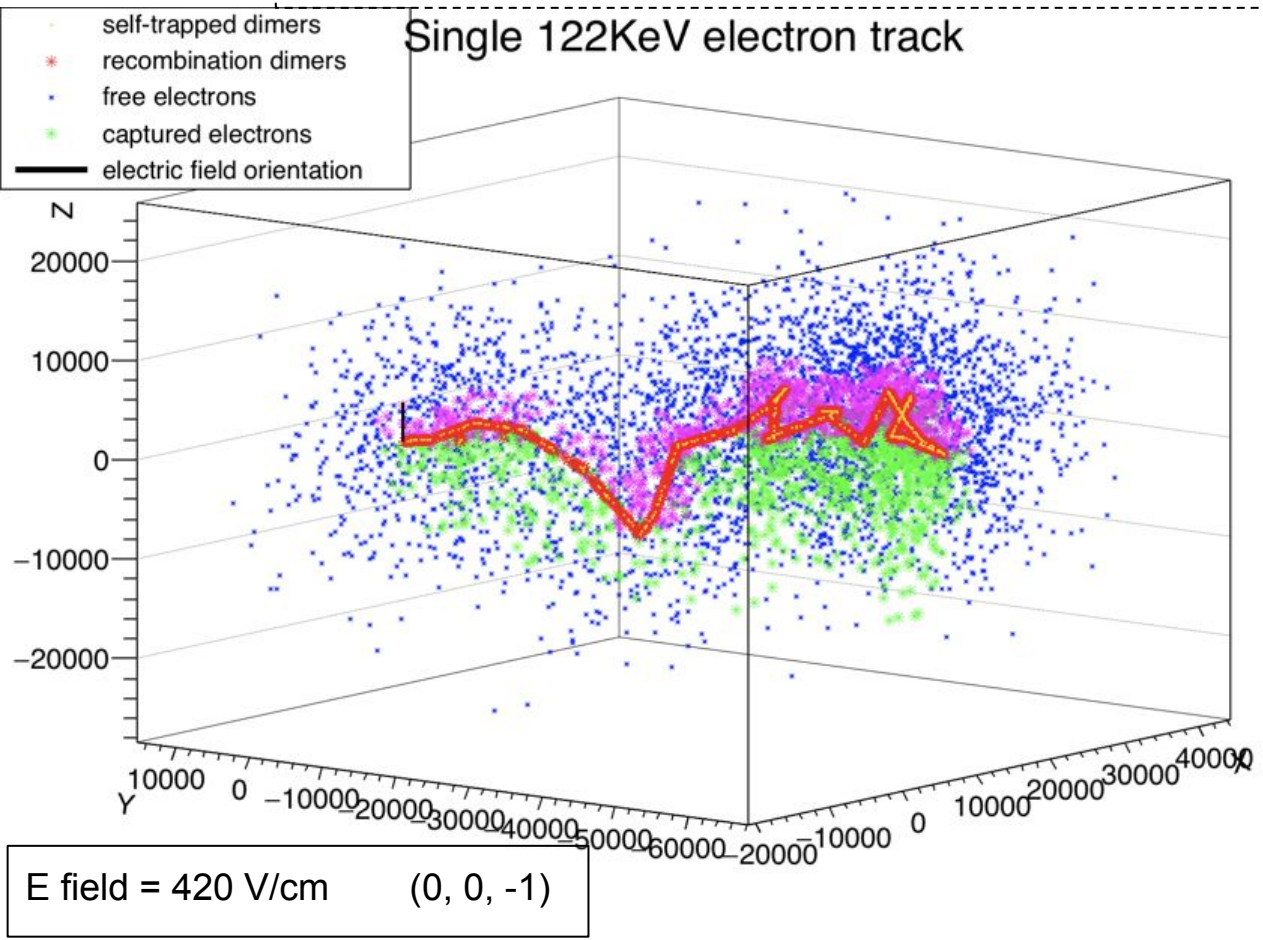
7. Plot: medium field



N events = 8695

Detector sees:

~59% light

~41% charge

E field = 420 V/cm (0, 0, -1)

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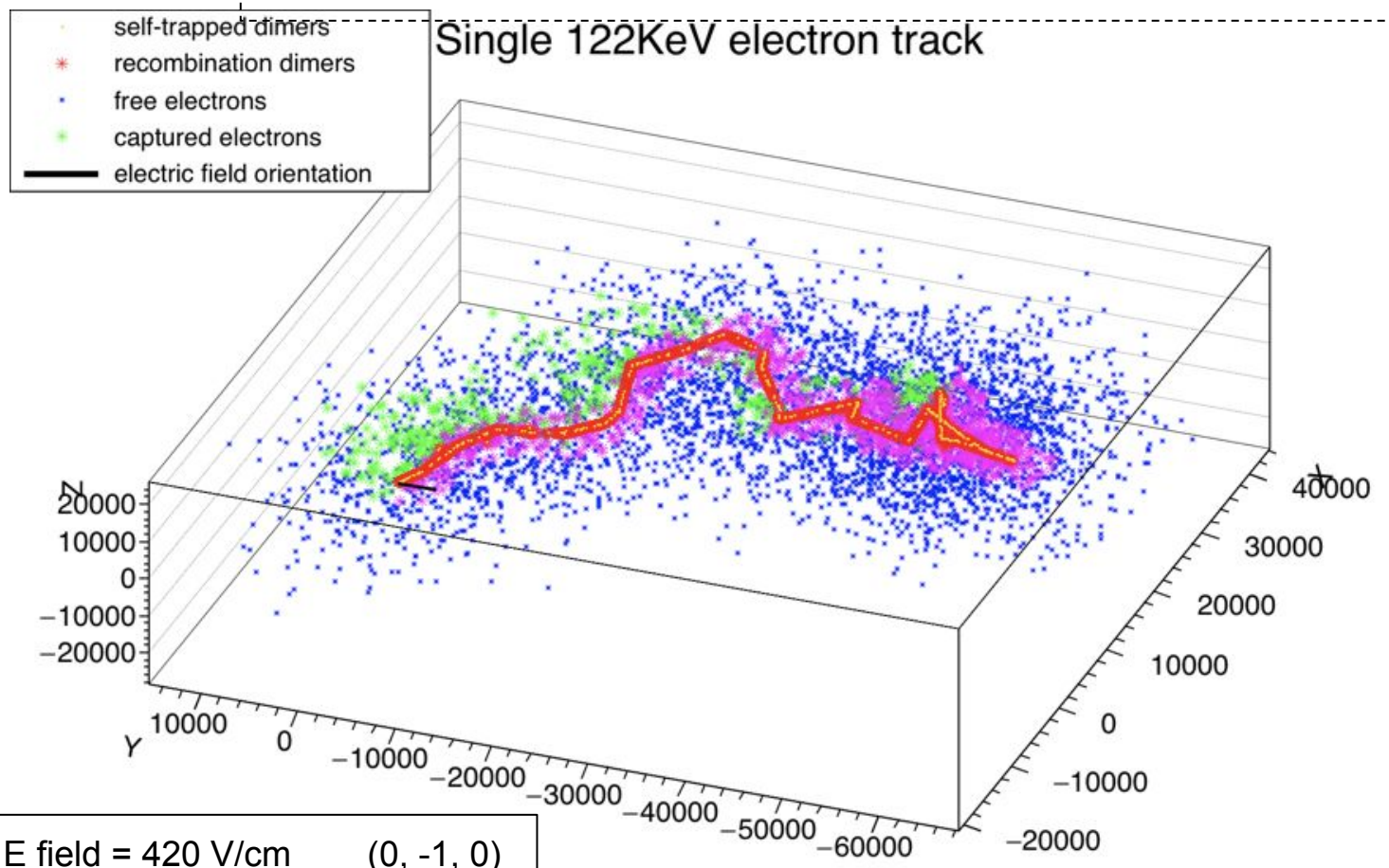
7. Plot: medium field



N events = 8695

Detector sees:

~56% light

~44% charge

E field = 420 V/cm (0, -1, 0)

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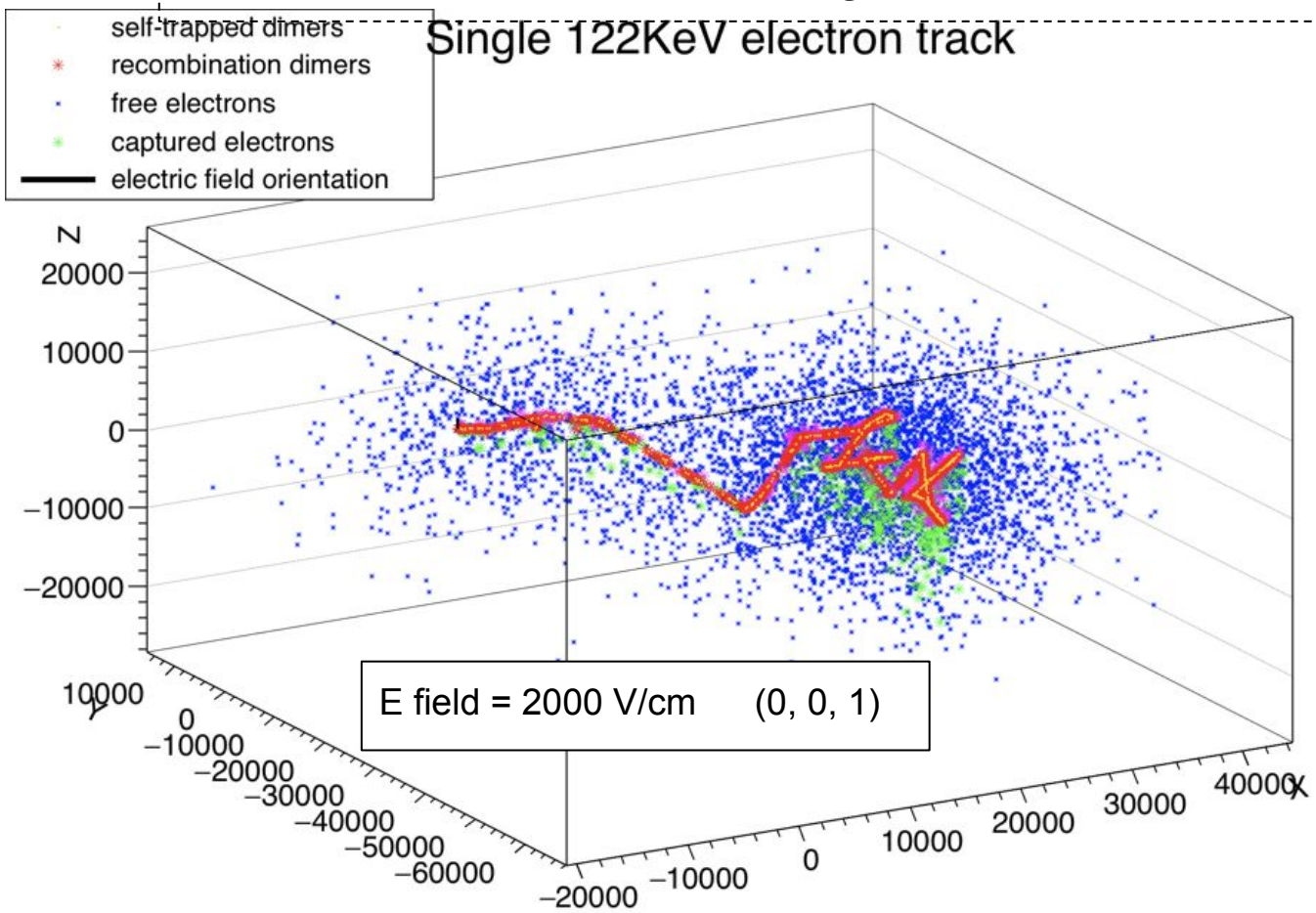
8. Plot: high field



N events = 8695

Detector sees:

~45% light

~55% charge

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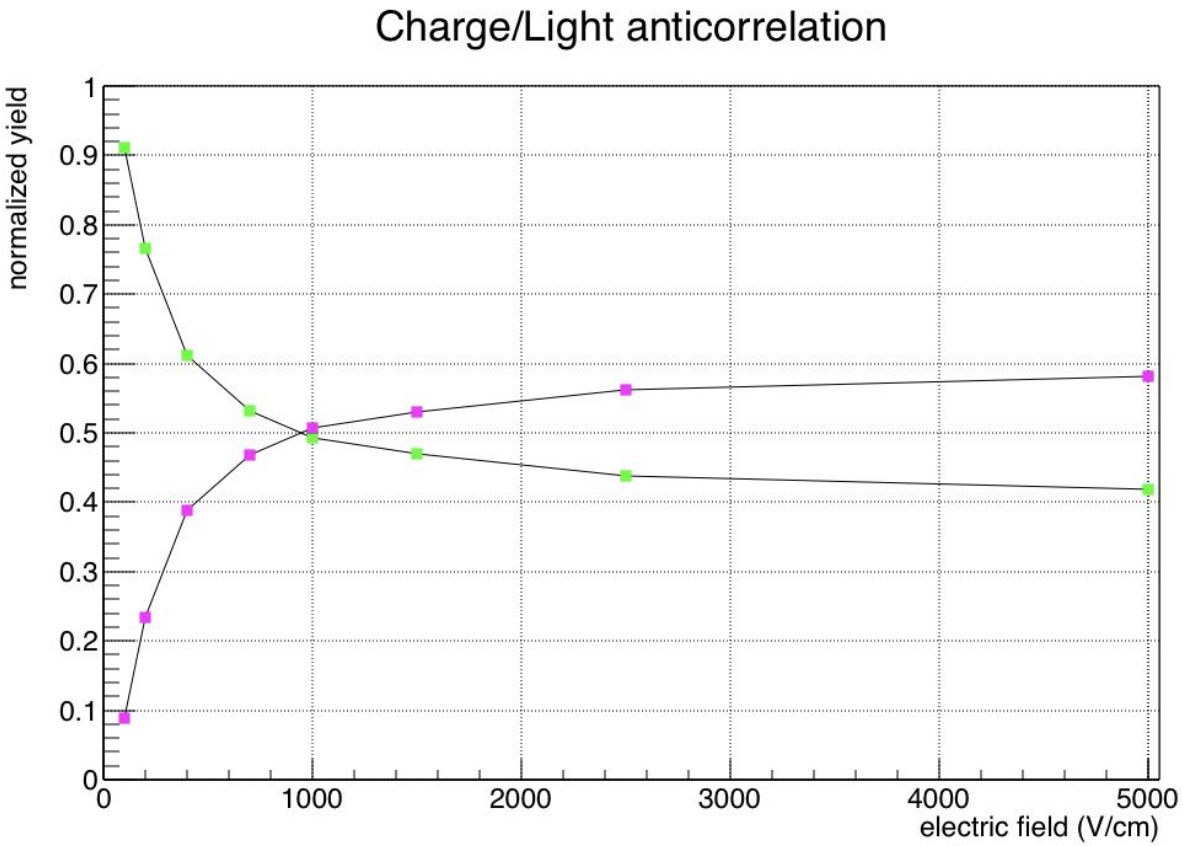
9. Plot: many data points



Green - light
Pink - charge

Compared to literature: crossing occurs at too high a field

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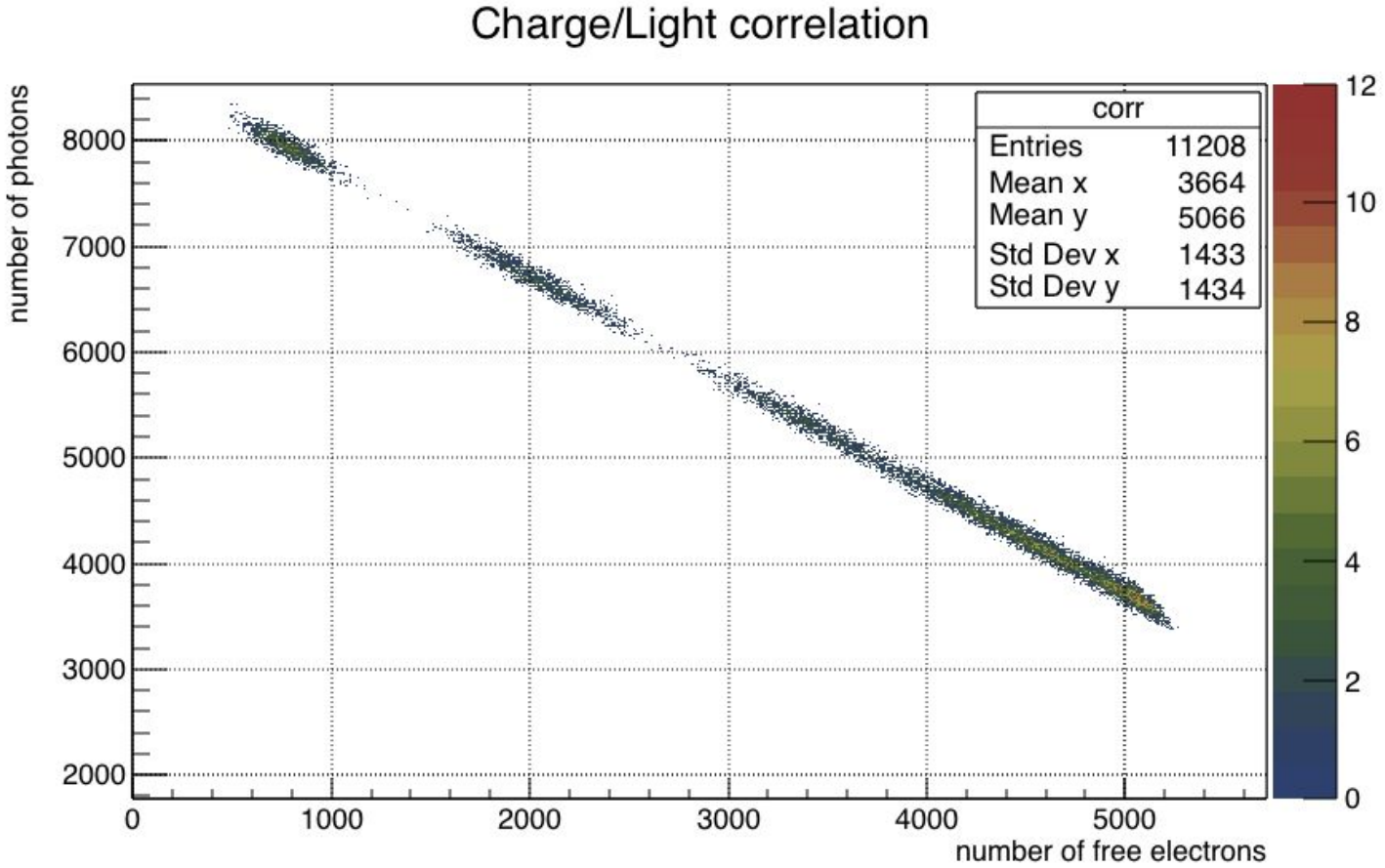
10. Plot: many data points



Appears to be too much variance for given field strength

100, 200, 400, 700, 1000, 1500, 2500, 5000 V/cm

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11. Improvements, whats next

Improvements

- Change implementation to handle high charge density of track core → ie more realistic physics

- Investigate screening of charge in LXe

Further work (aside from above changes)

- Investigate heat deposition in detail
- Analyze larger data sets, various particles and energies
- Study dependance of field direction vs. charge collection
- Investigate timing structure → see if can use as further discrimination tool

- Apply to Argon (once the track's are also simulated)

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12. Learning

Learned

- How to perform a proper literature review/study, become knowledgeable in a specific field
- Co-operate with a partner on a complex project (working with Daniel Mayer)
- MORE coding skills (c++, ROOT, compiling and general library implementation knowledge)
- Mentorship skills and planning (supervising Benjamin Weiser's summer research)
- How to disagree with other scientists (and still be cool afterwards)

PEACE!