Sim Integration of Position Dependent Fields

Shaun Alsum
Wei Ji

Recap: what is Plan A?

Use full field dependent functionality of NEST

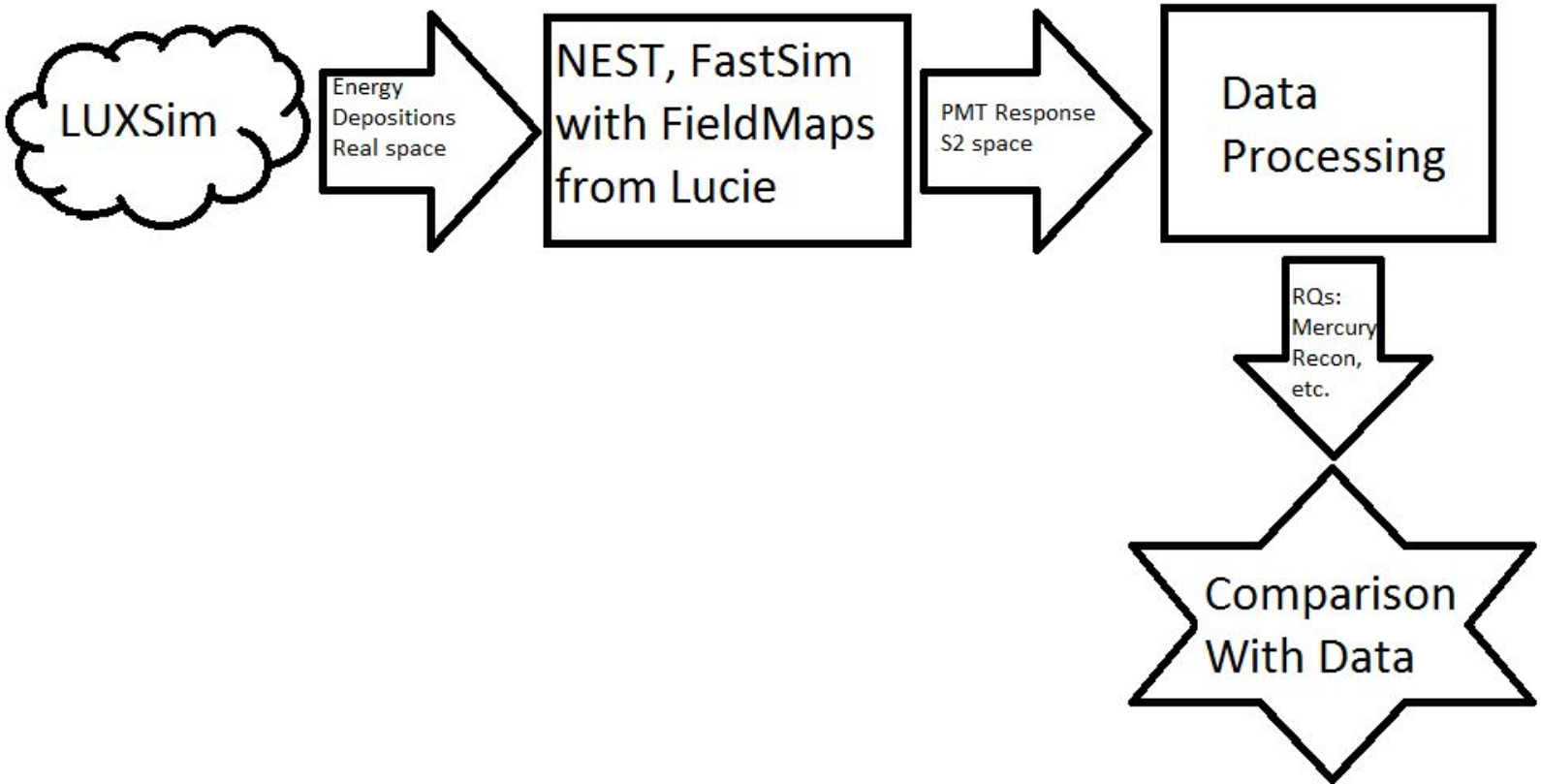
Every location/time will have field dependence

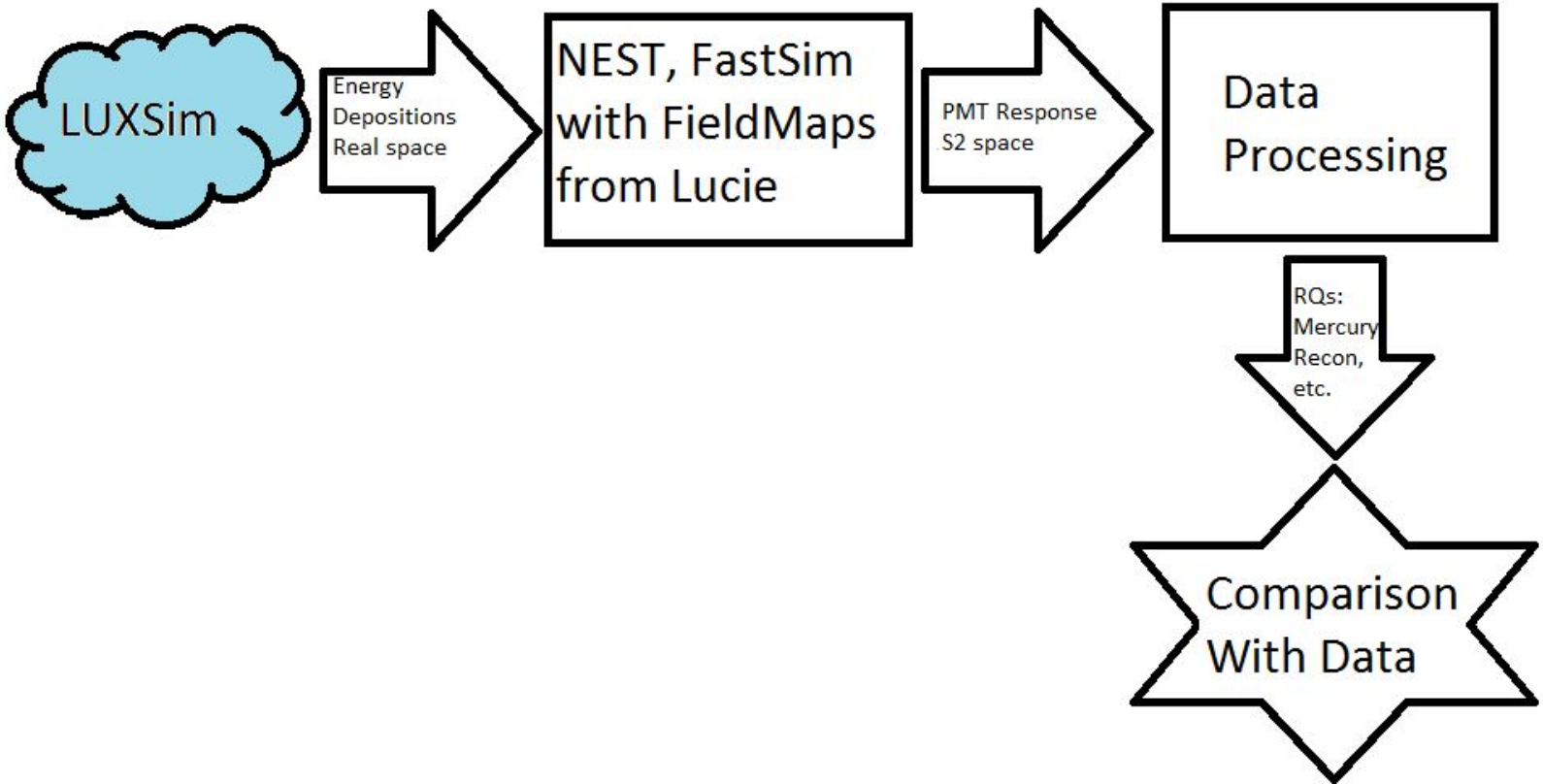
Contrasts with plan B which uses some single field for all locations and times.

Goals Required for Plan A background model

- Correctly simulate the positional response of the detector, taking into account changes in the electric field.
- Correctly simulate the S1 and S2 response in the detector as a function of the changing electric field at various locations.

This will also be used for tritium and dd calibration studies.


LUXSim
Energy Depositions Real space
NEST, FastSim with FieldMaps from Lucie
PMT Response S2 space
Data Processing
RQs: Mercury Recon, etc.
Comparison With Data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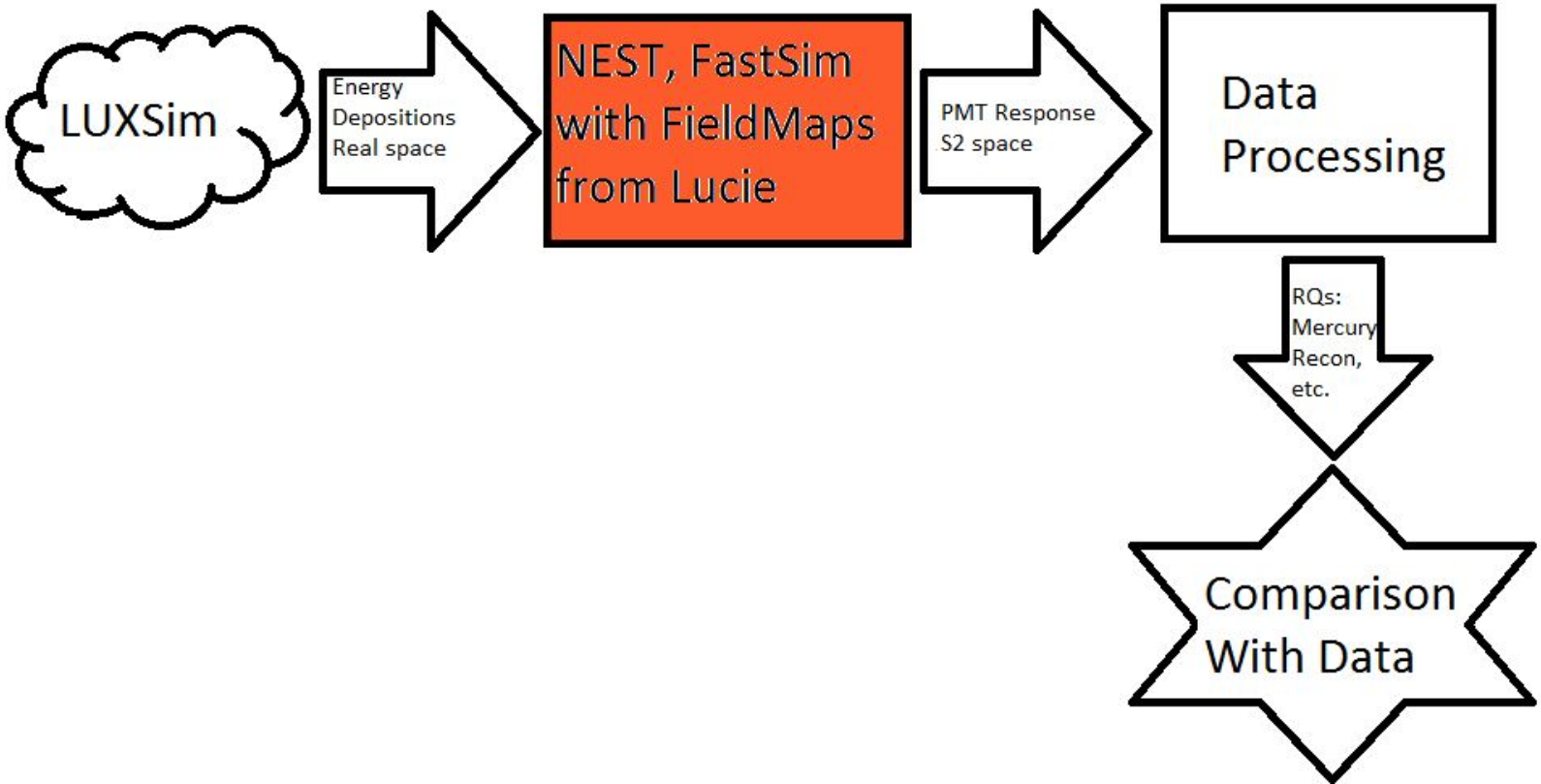
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The Field Maps

The Field maps contain eight values for each entry. The entries form a cubic lattice in real space.

X, Y, and Z: real space coordinates (denoted as Xi, Yi, Zi in the map).

E : the electric field magnitude at real (X, Y, Z)

X_S2, and Y_S2: the location electrons will drift to if they originate at real (X, Y, Z). (denoted as S2x, S2y in the map).

drift: the time it takes for an electron to drift from real (X, Y, Z) to (X_S2, Y_S2) at the surface.

Event classification: flags the fate of the electron. Made it to the surface, eaten by

wall, eaten by grid, etc.

Implementation approach

Interpolate E, X_S2, Y_S2, and drift using surrounding Field Map entries.

Feed these into NEST and FastSim

Throw edge data away: If not all of the grid points making up the cube immediately surrounding the event have values for E, X_S2, Y_S2, and drift, chuck out the event.

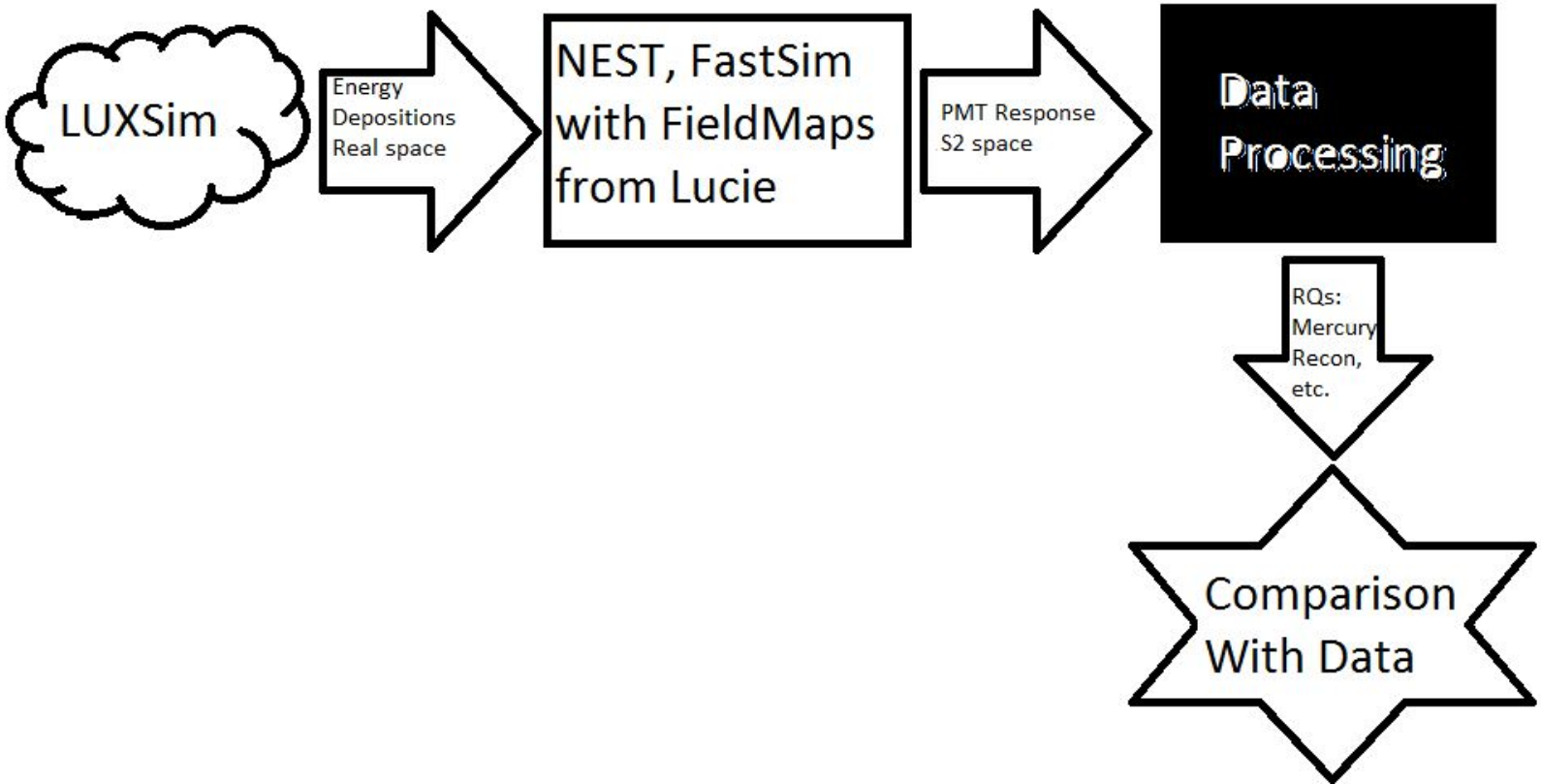
Updated the ER portion of NEST

Using a the run03 FastSim hitmap but in S2 space

For Users

In order to utilize the updates to LUXSim, use the following commands.

- /LUXSim/detector/EFieldFromFile true
  - Activates the portion of the code that uses an external field map
- /LUXSim/detector/EFieldFile [path-to-file]
  - This tells the simulation which file to use
- /LUXSim/physicsList/s1gain [value <1]
  - This sets the value of g1 and must be <1 in order for FastSim to be used
- /LUXSim/physicsList/s2gain [value <1]
  - This sets the value of the extraction efficiency and must be <1 in order for FastSim to be used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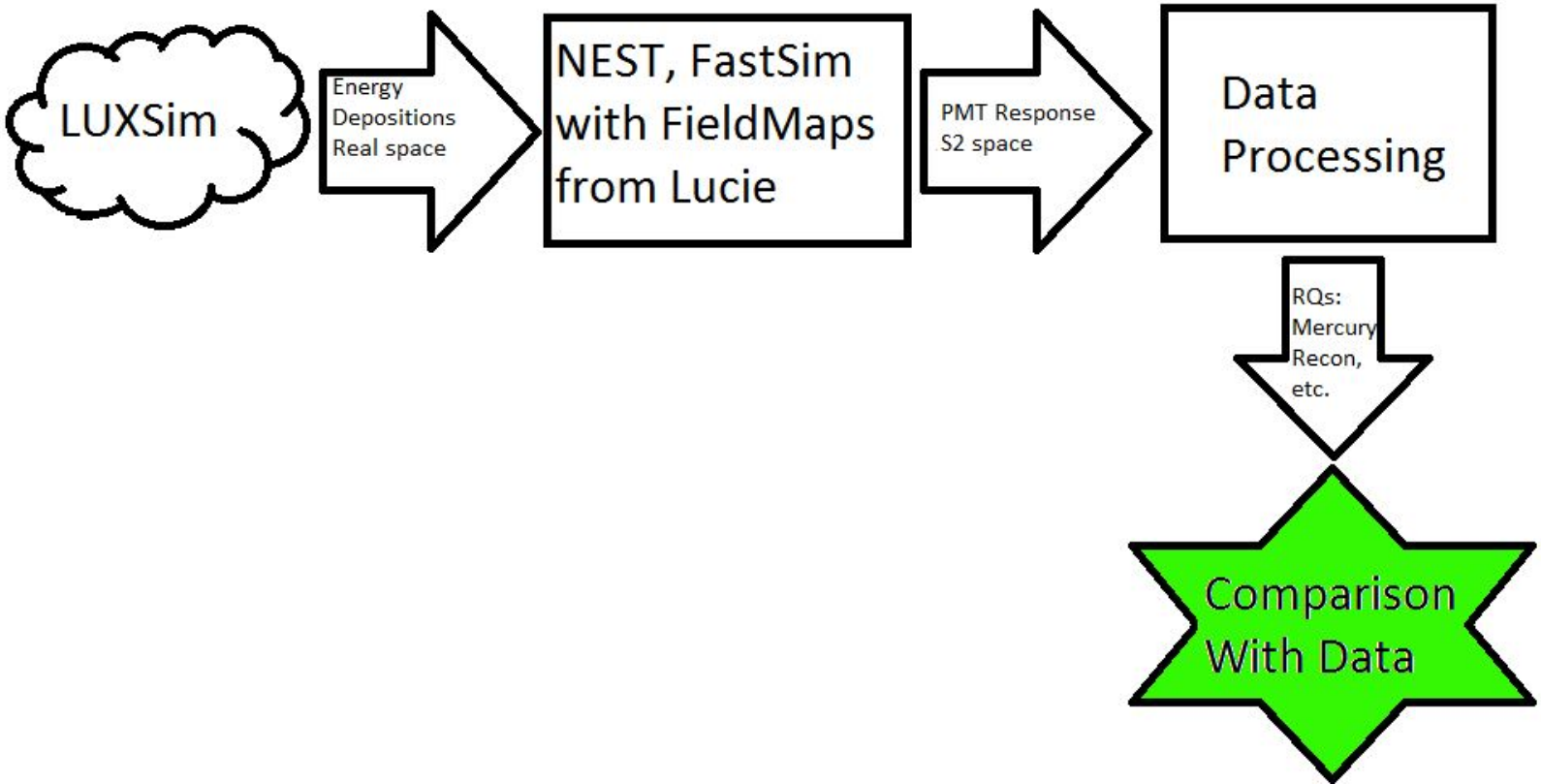
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Verification: Selected data

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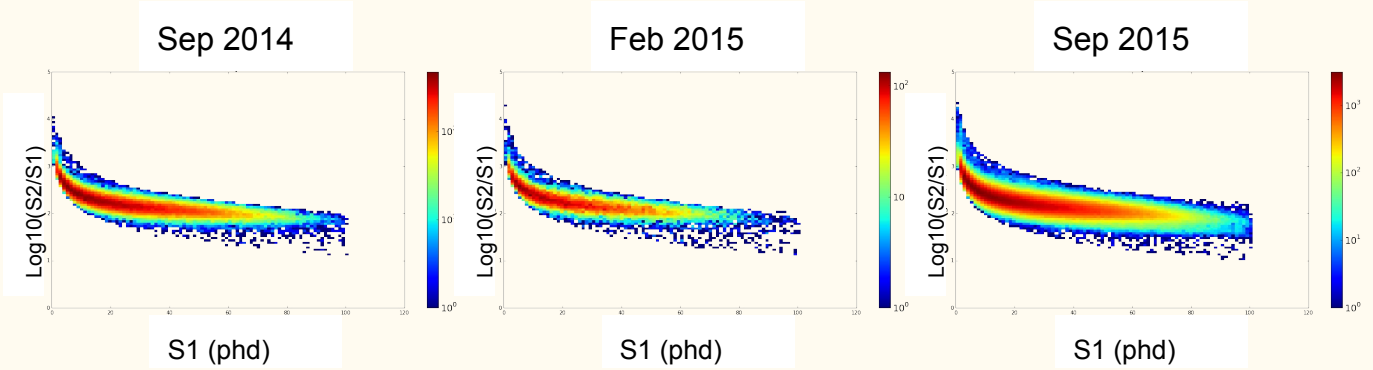
- Also made cuts on S1, and S2 to isolate the tritium band.



Sep 2014:
- $\log(S1) < 2.0$
- $3.1 < \log(S2) < 4.0$

Feb 2015:
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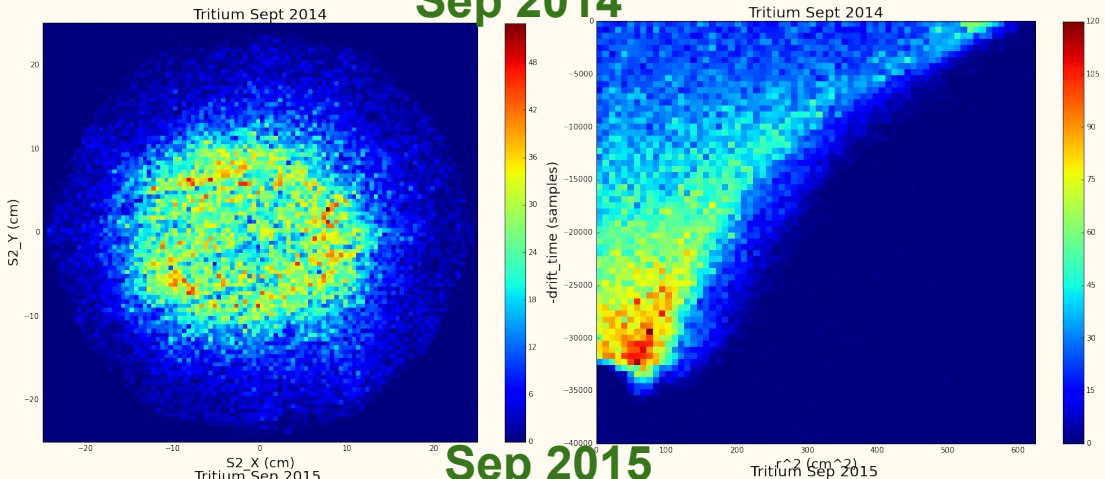
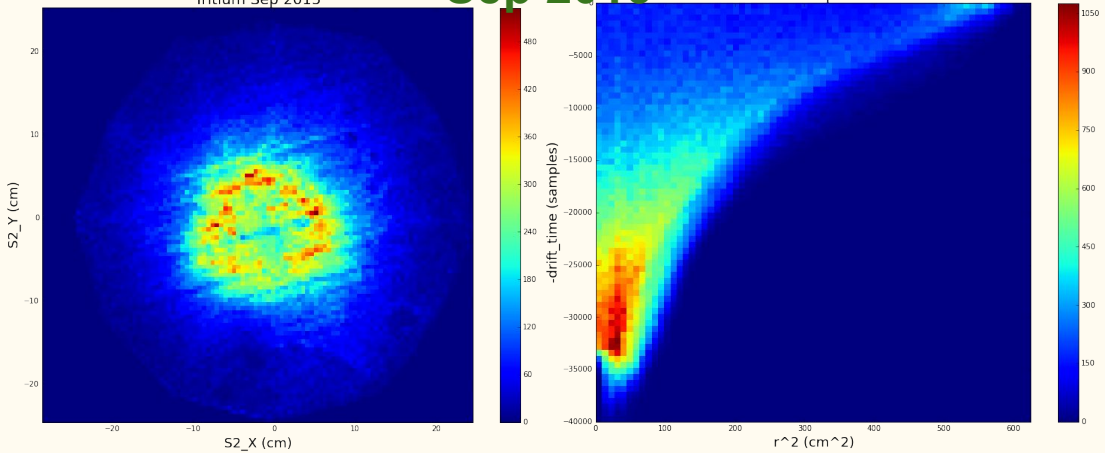
Verification: positional response

Sep 2014



Sep 2015

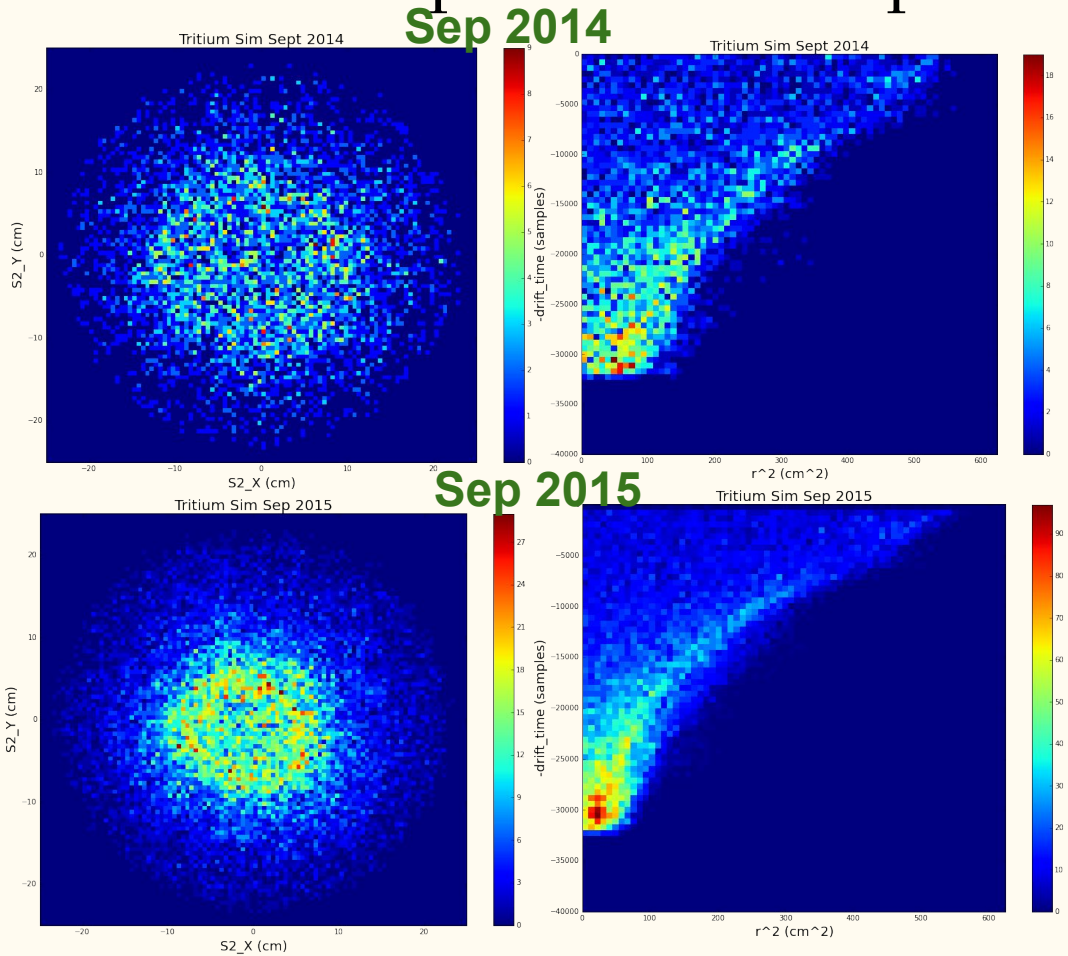


Data

Sim

- XY response good.
- Drift time has problems
  - missing the bulge.

Verification: positional response



Simulation

Sim

- XY response good.
- Drift time has problems
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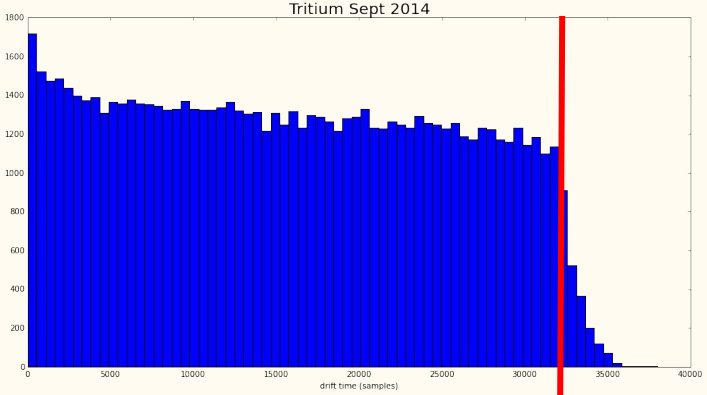
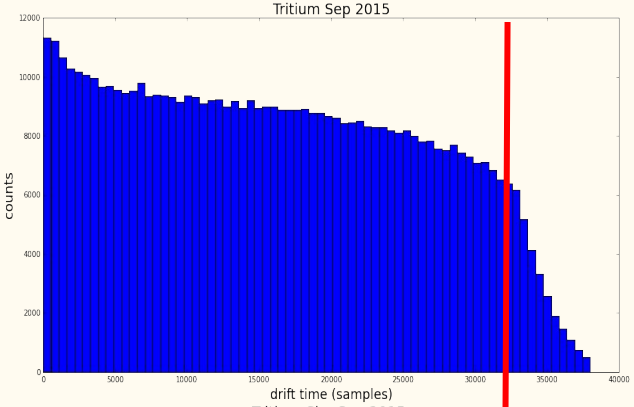
Verification: drift time samples histogram

2014

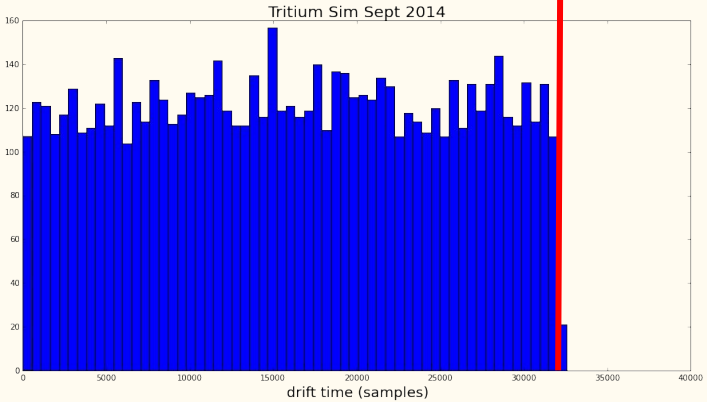


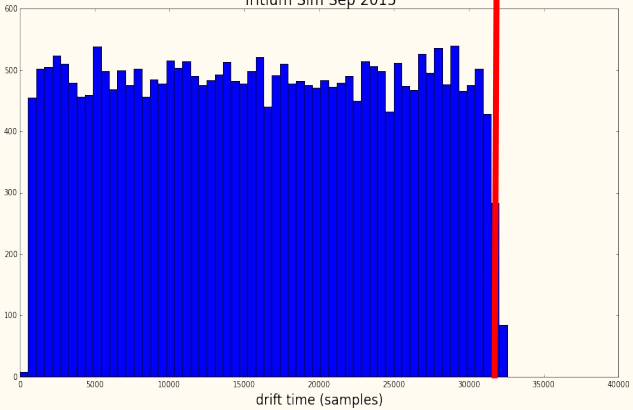
2015



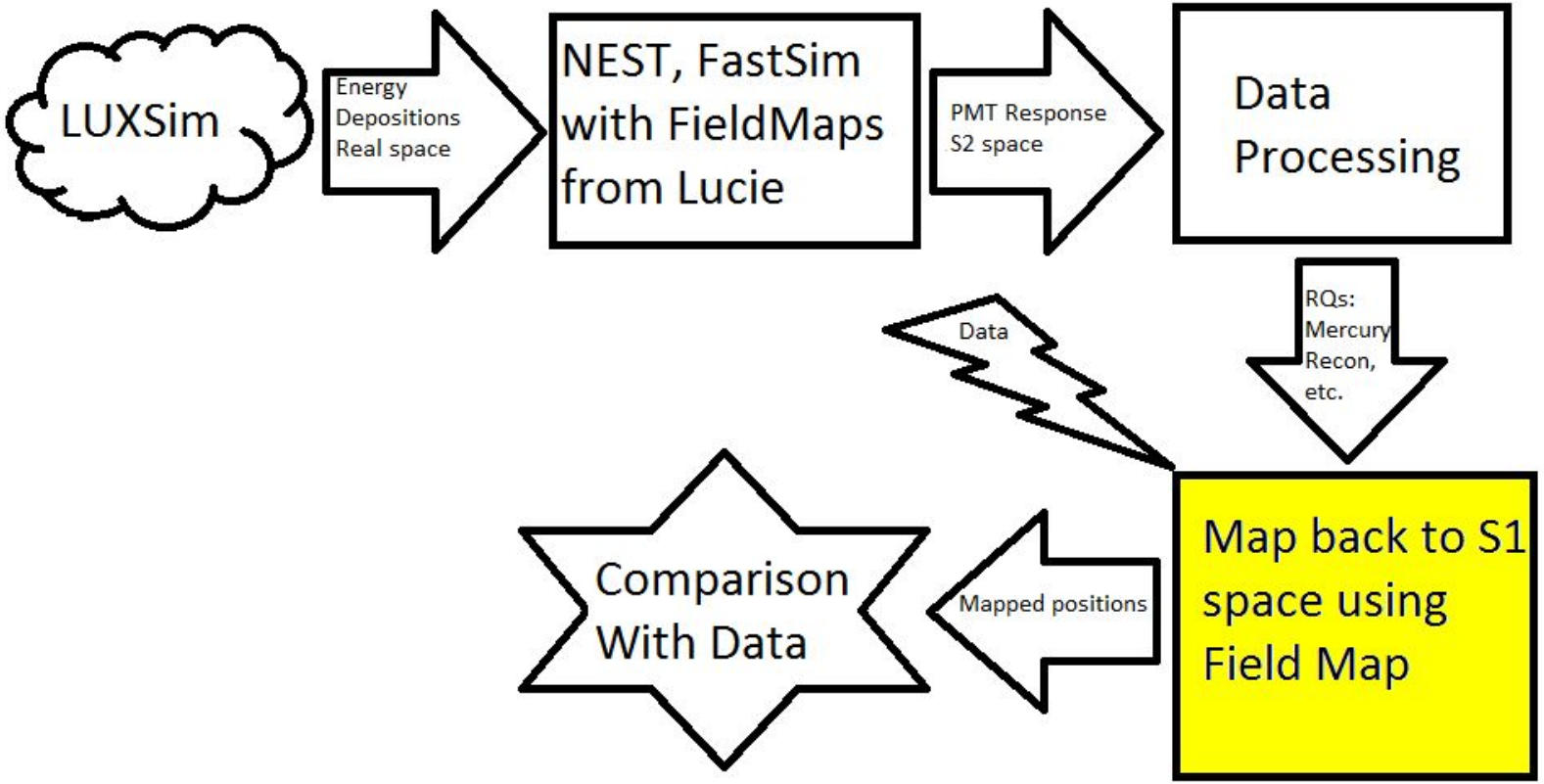
Data

- Missing tail
- Missing slope
- Confirms drift time problem





Sim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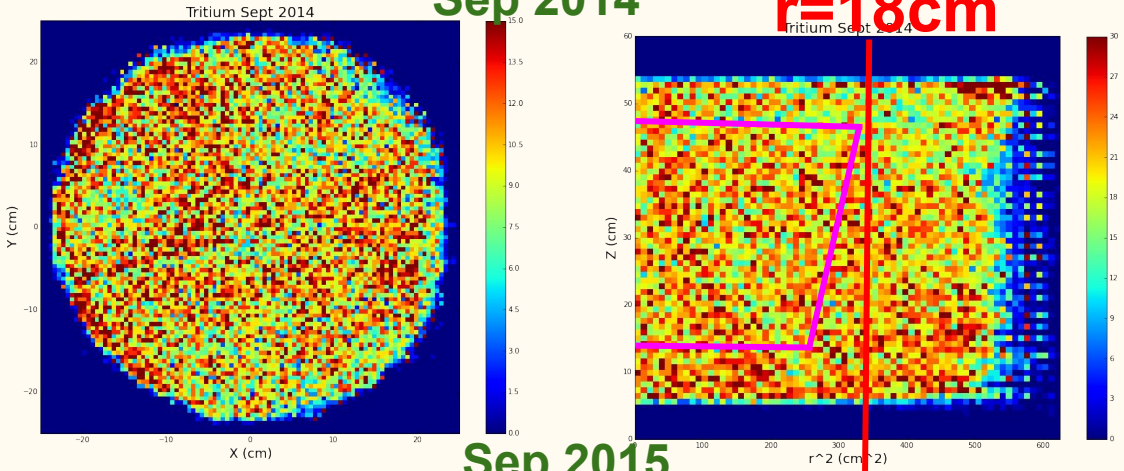
Data
Map back to S1 space using Field Map
Mapped positions
Comparison With Data

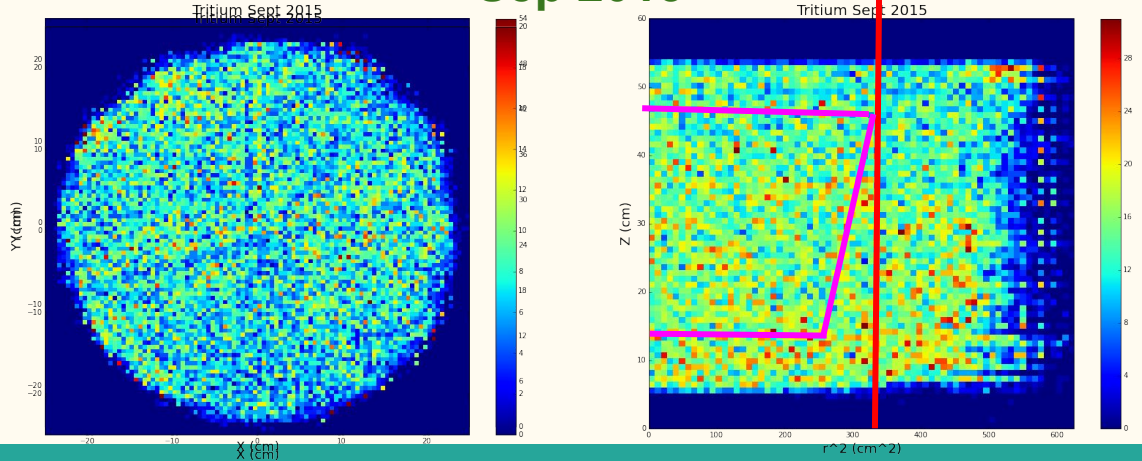
Verification: data back to real xyz space

Sep 2014

r=18cm



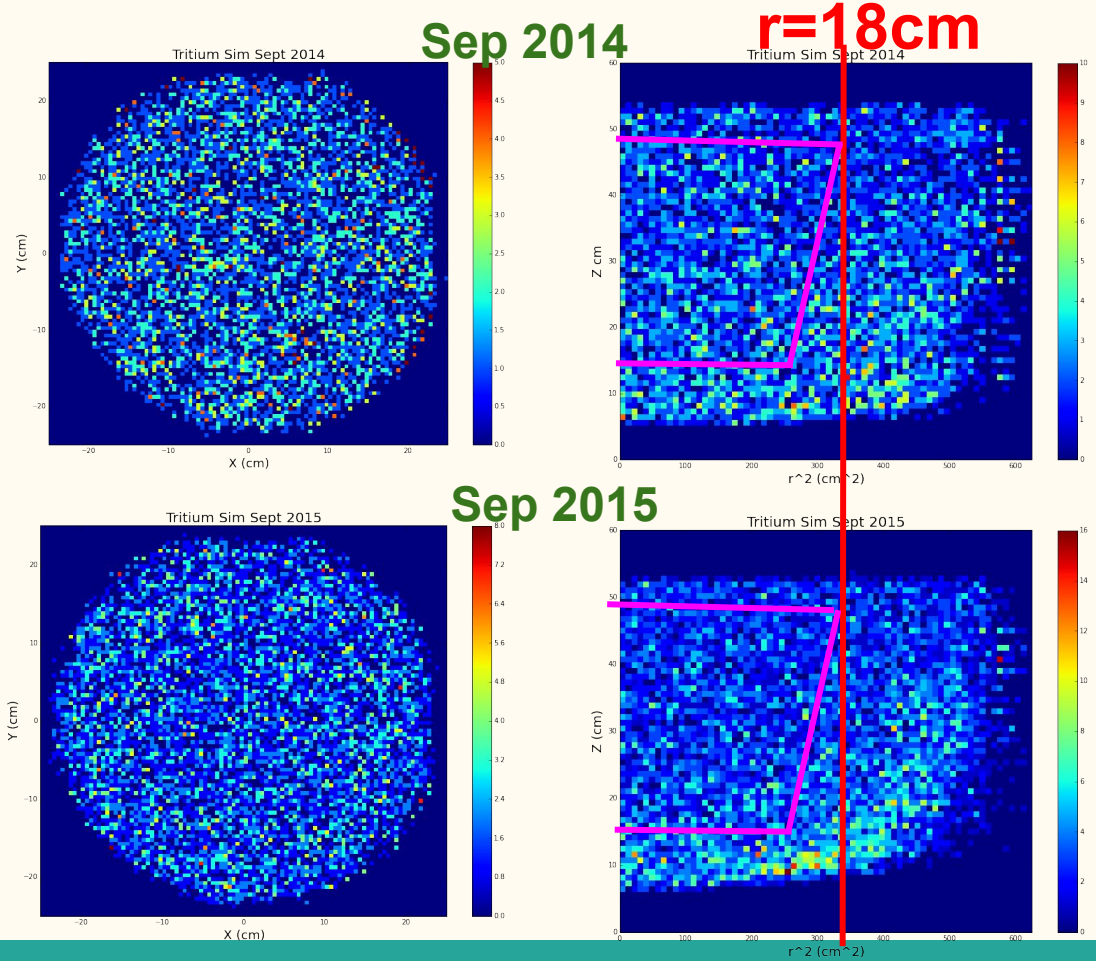
Sep 2015



Data

- event in XYZ space is uniformly distributed.

Verification: data back to real xyz space

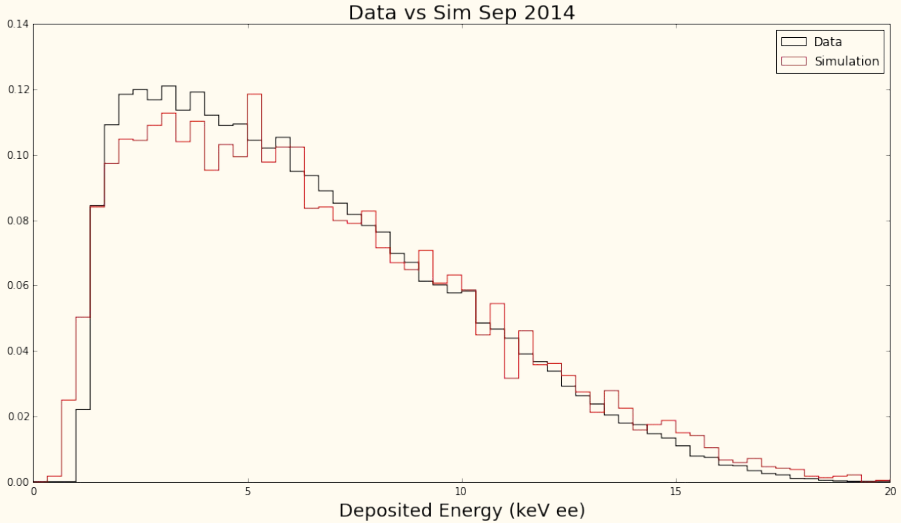


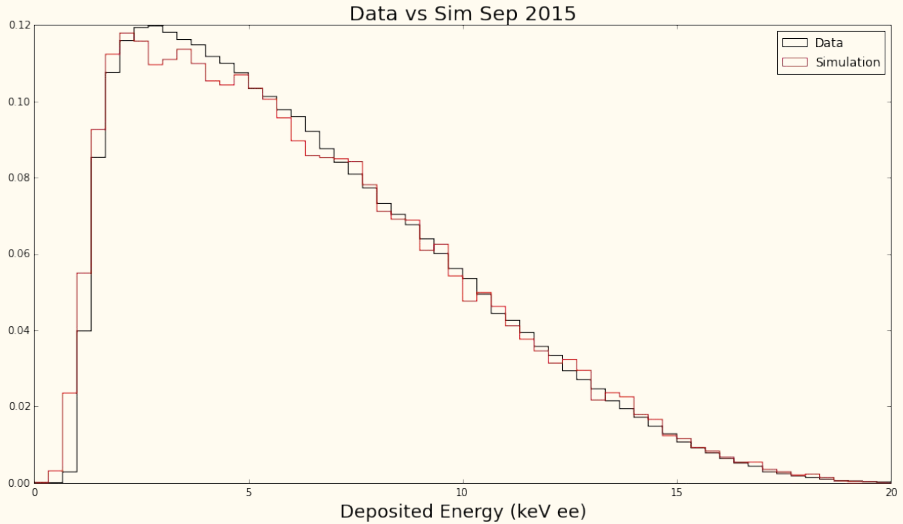
Simulation

- XY distribution is close to uniformity.
- Drift time has problems
  - missing the cathode corner.

Energy Spectra

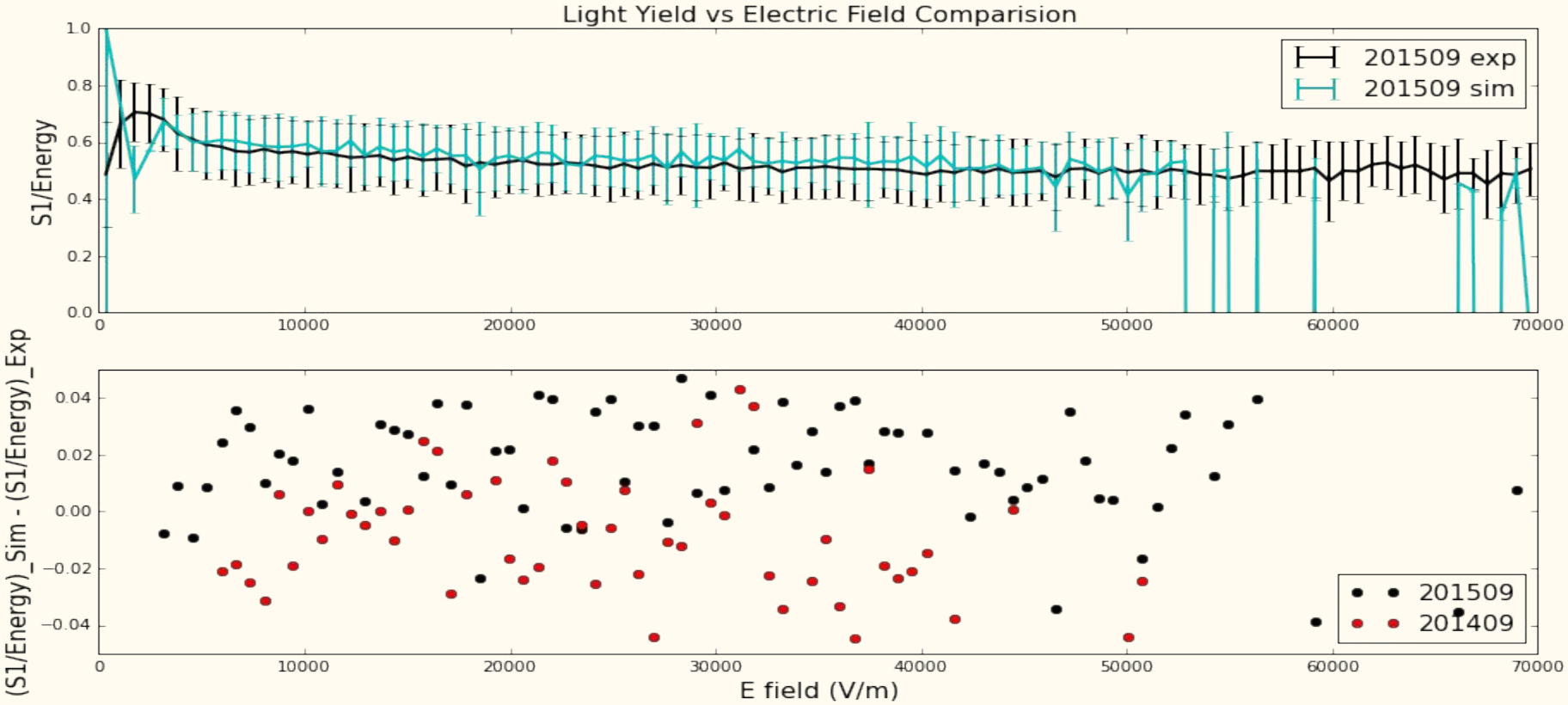
Comparing the energy spectrum from Data and Simulation. Both are obtained via W(S1/g1 + S2/g2)

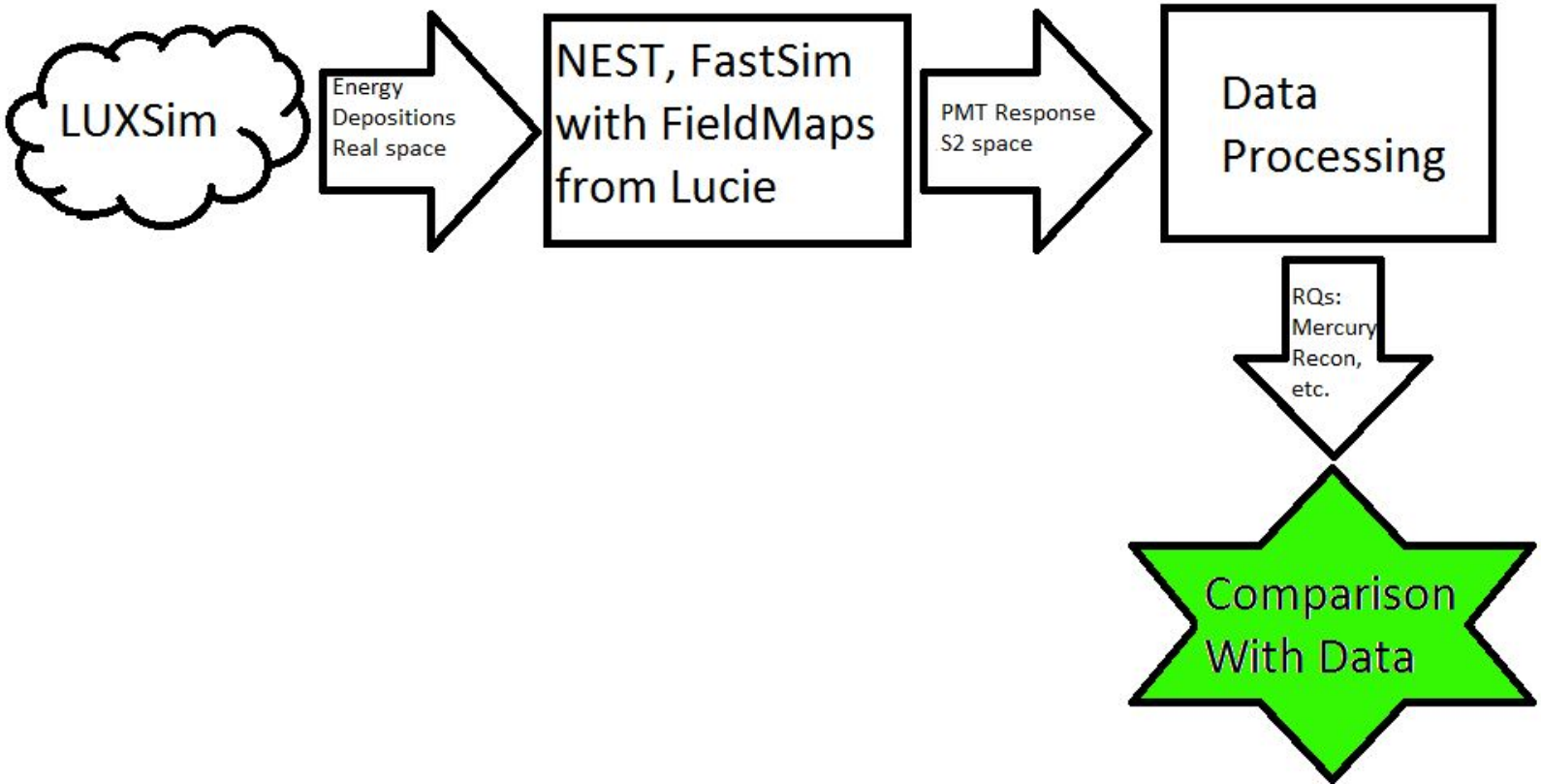




- Low energy rise in simulation
- Sim underpredicts around 3-4 and 6-7 keVee

Light Yield vs Electric field Comparison:

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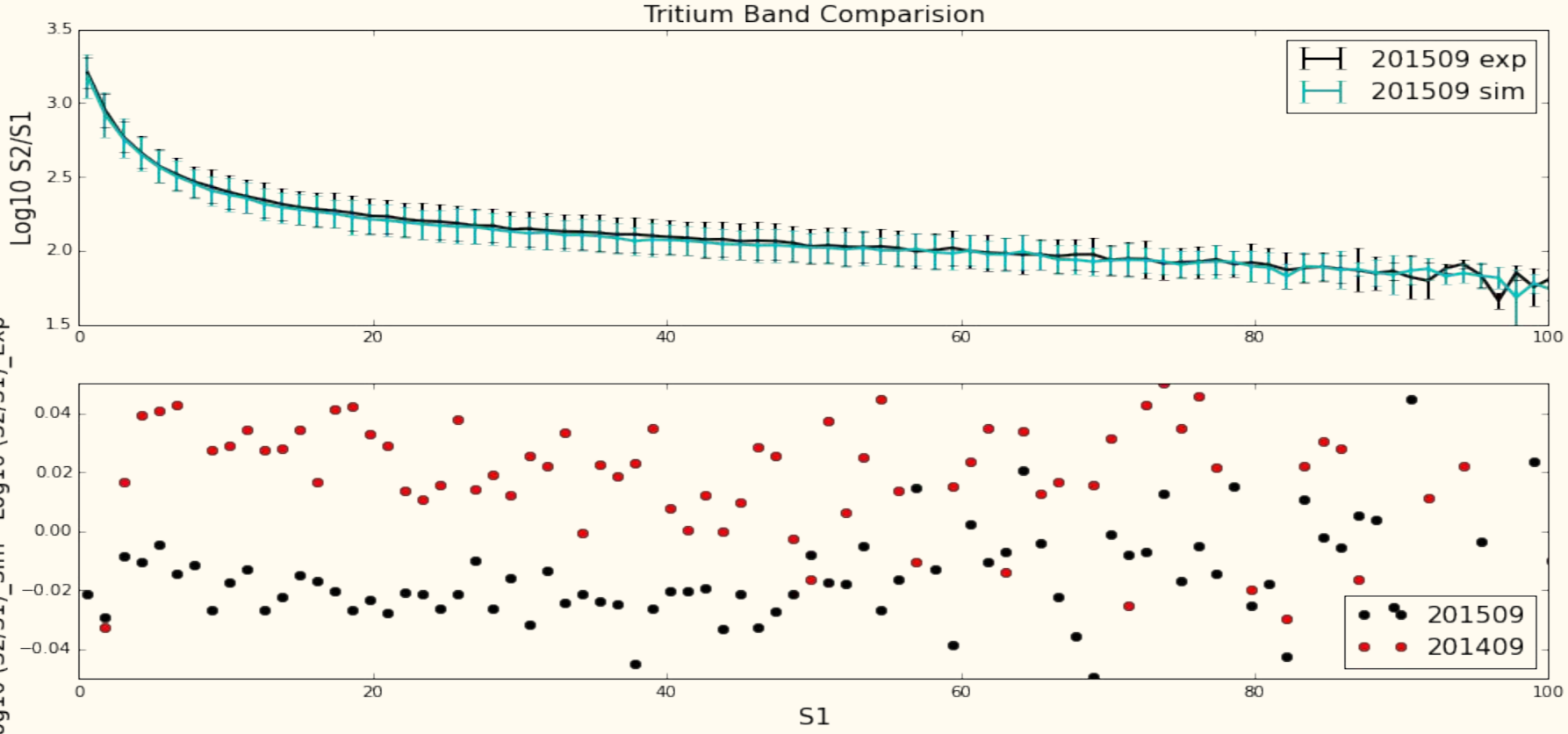
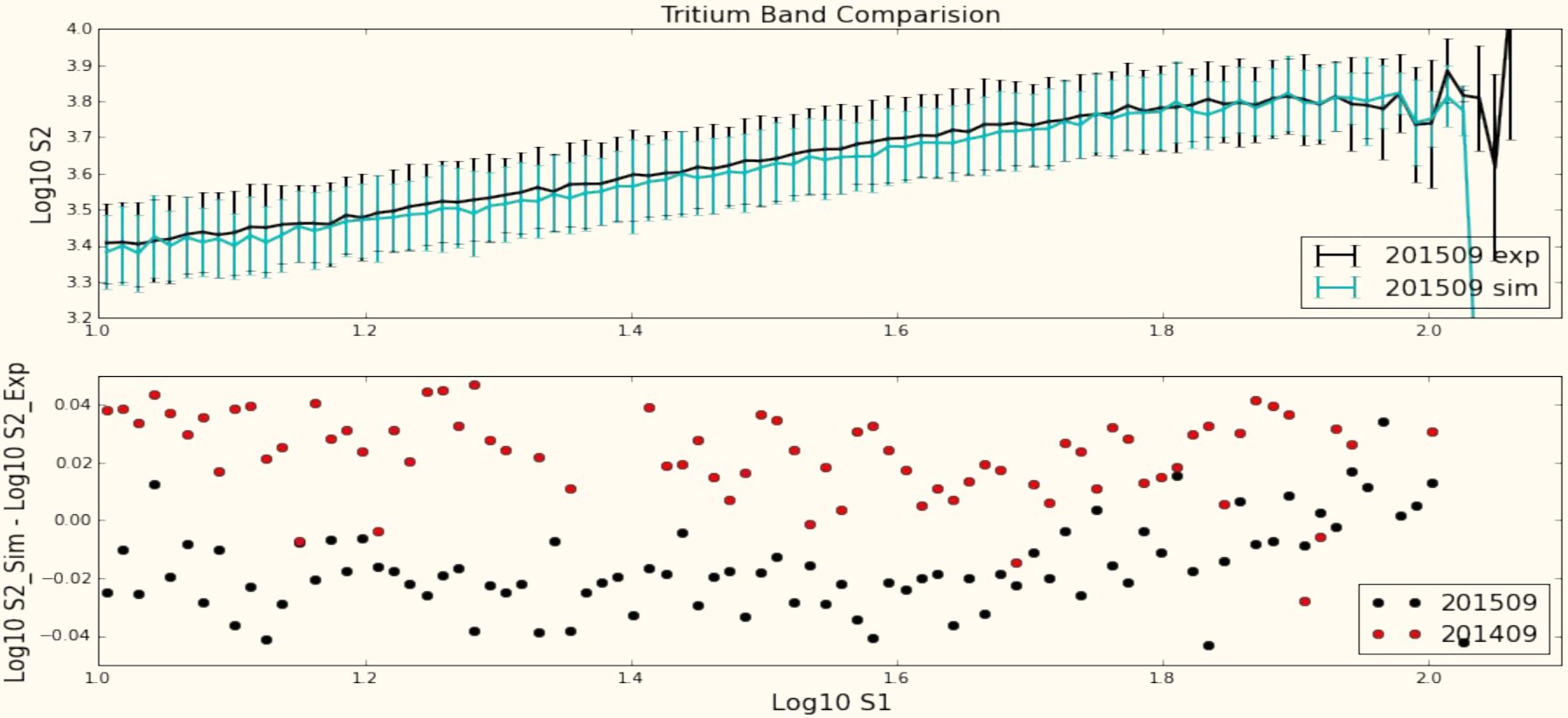
Log S2/S1 vs S1 band:



Log S2 vs Log S1 band:



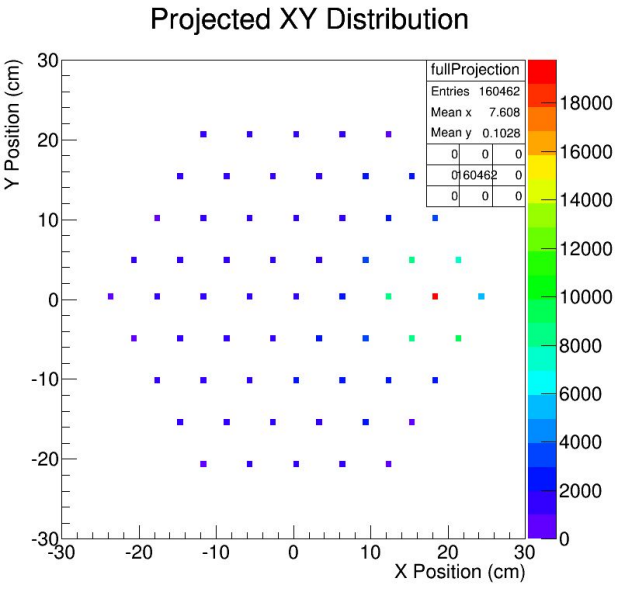
Conclusion

- Simulation machinery in place
- Many aspects work well
  - XY position
  - S1 yield trends with field as it should
- Some aspects don’t
  - Drift time
  - Bands and energies don’t quite match up all the time

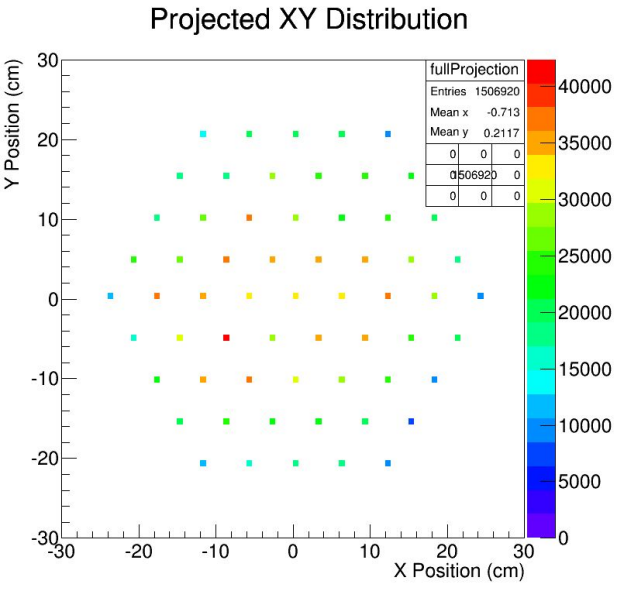
Backup

Verification: positional response

To test that the alterations to positional response we directly altered columns S2x and S2y in one of Lucie's field maps (September 2014) to be 20 cm and 0 cm respectively. We then ran the same simulation on both the altered and unaltered versions to compare the results.



Altered field map



Lucie's map

As expected, the signal is centered around (20, 0) in the altered case, The real map is more isotropic.

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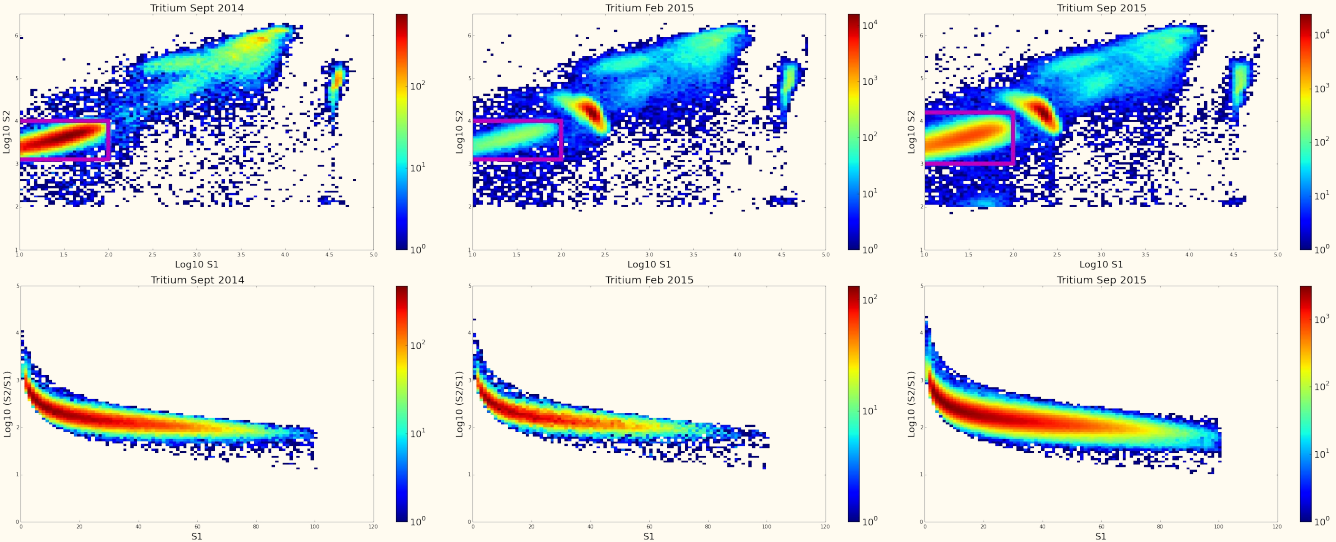

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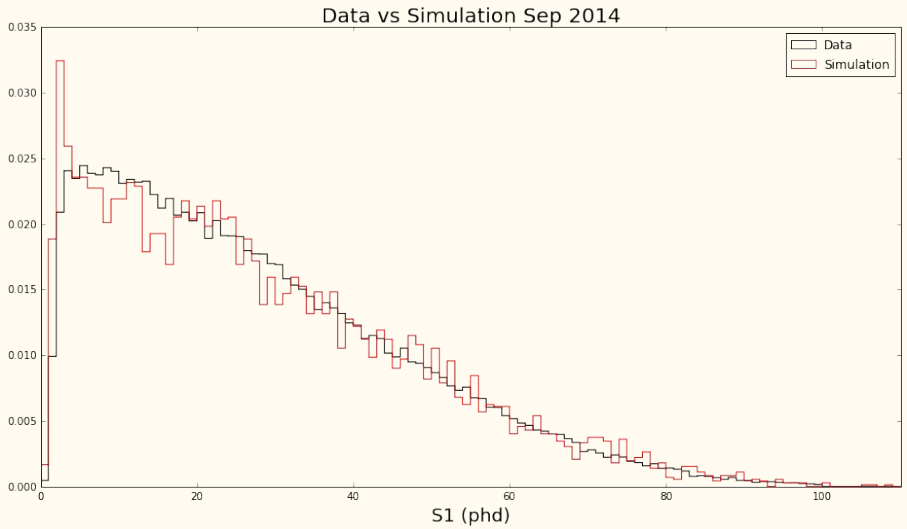
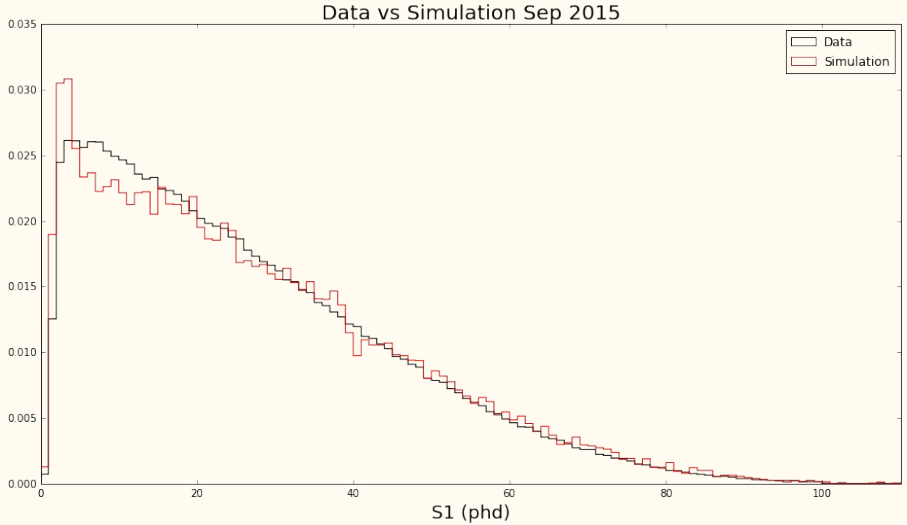
S1


Data vs Simulation Sep 2014
Data
Simulation
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
20
40
60
80
100
S1 (phd)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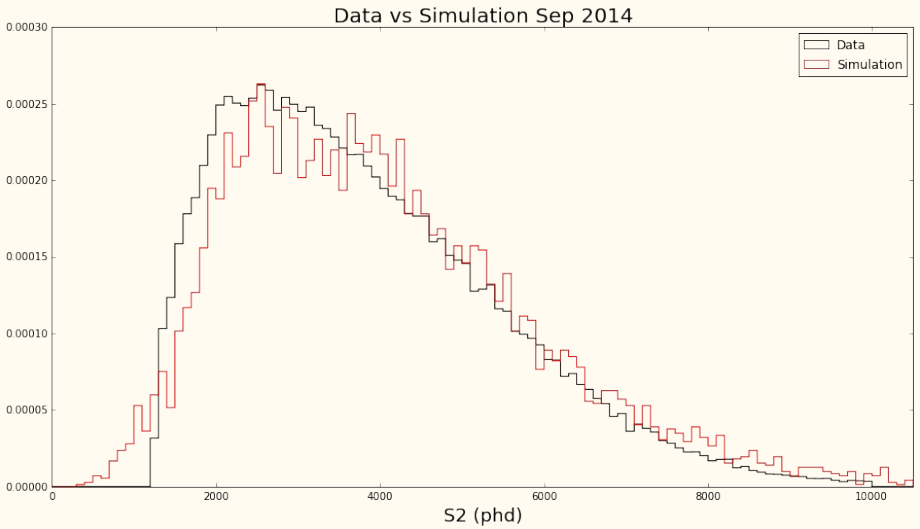
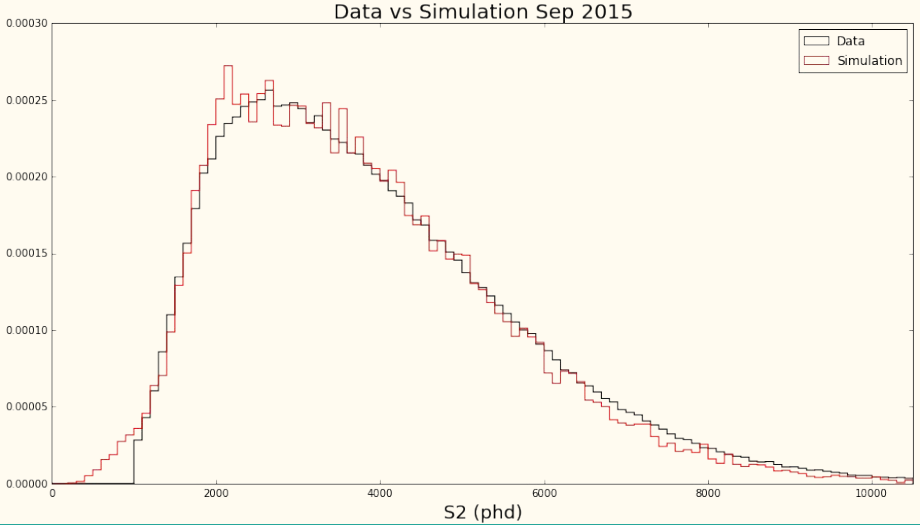
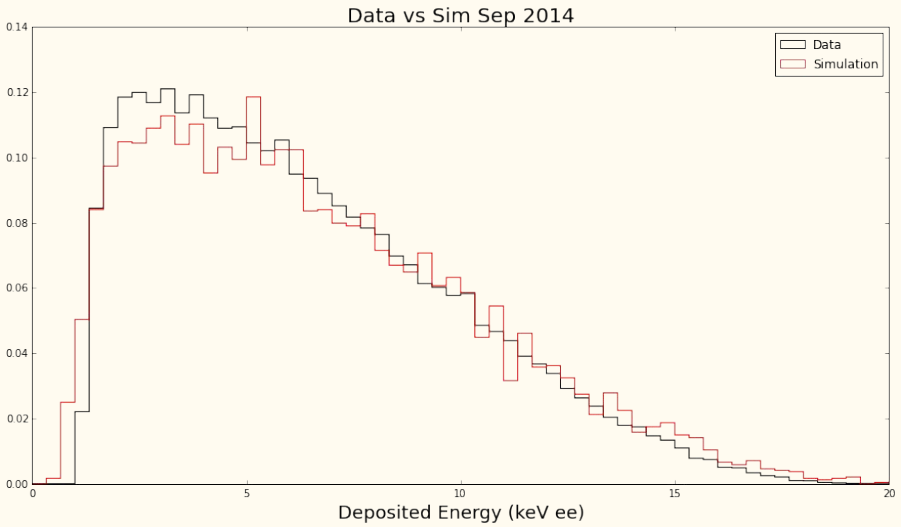
Data
Simulation
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
20
40
60
80
100
S1 (phd)

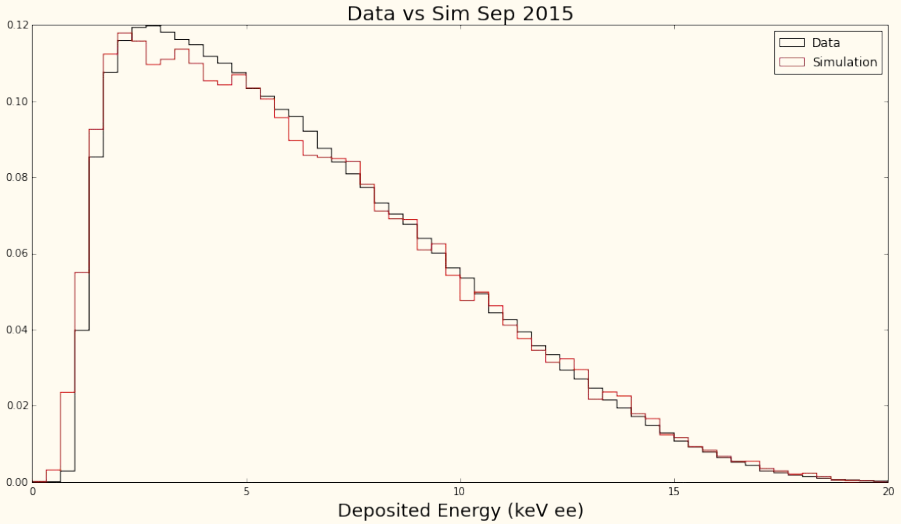
S2


Data vs Simulation Sep 2014
Data
Simulation
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
0
2000
4000
6000
8000
10000
S2 (phd)


Data vs Simulation Sep 2015
Data
Simulation
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
0
2000
4000
6000
8000
10000
S2 (phd)

Energy


Data vs Sim Sep 2014
Data
Simulation
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
5
10
15
20
Deposited Energy (keV ee)


Data vs Sim Sep 2015
Data
Simulation
0.12
0.10
0.08
0.06
0.04
0.02
0.00
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5
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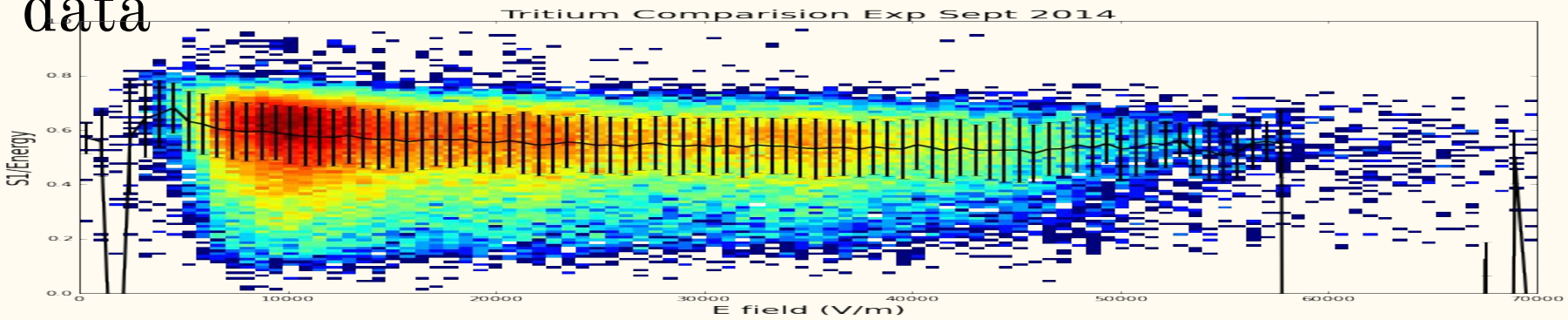
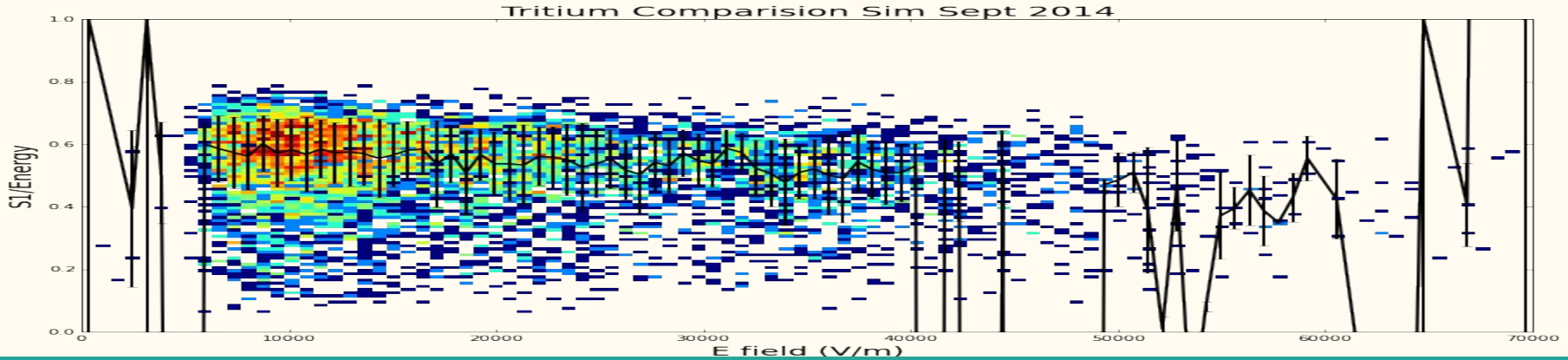
15
20
Deposited Energy (keV ee)

Verification: Compare light yield vs ESep 2014 data





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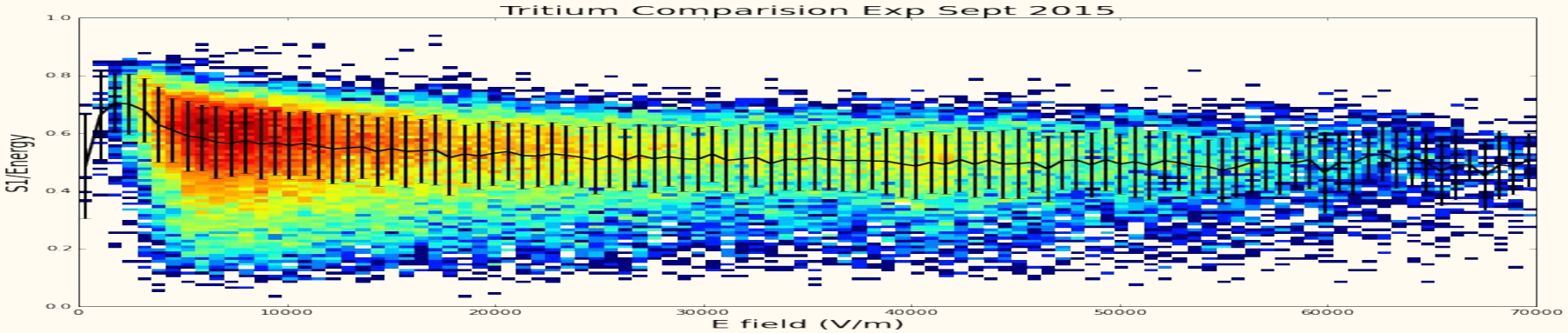
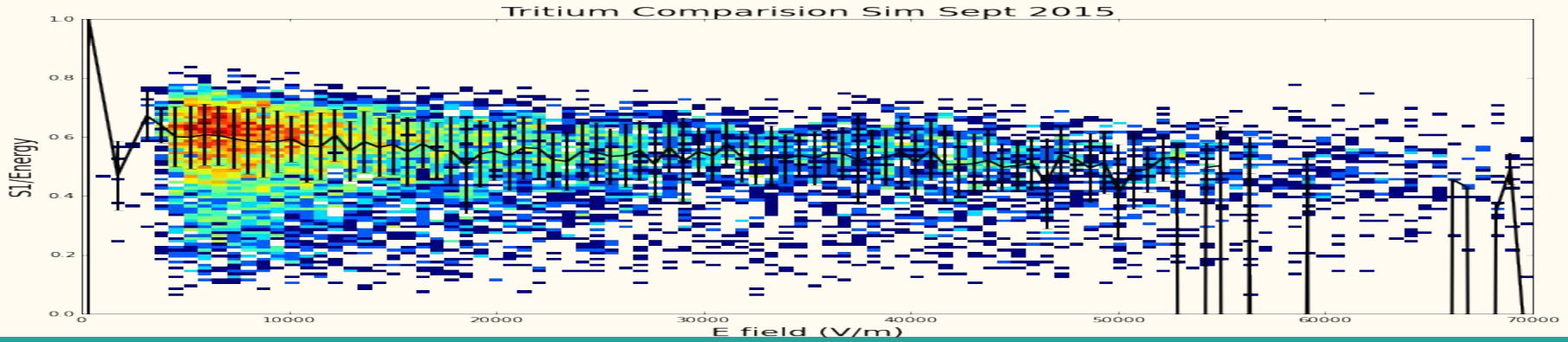
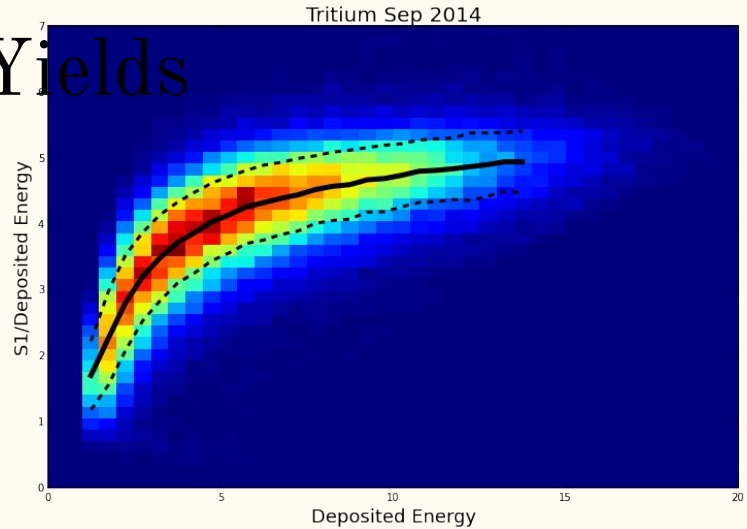
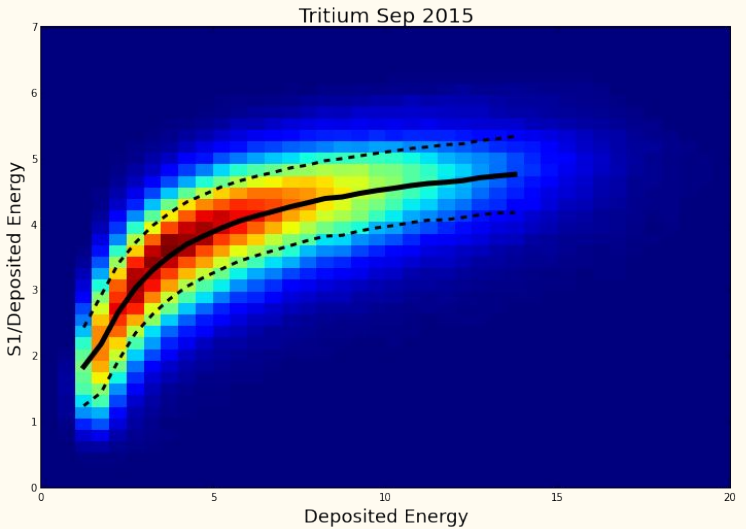
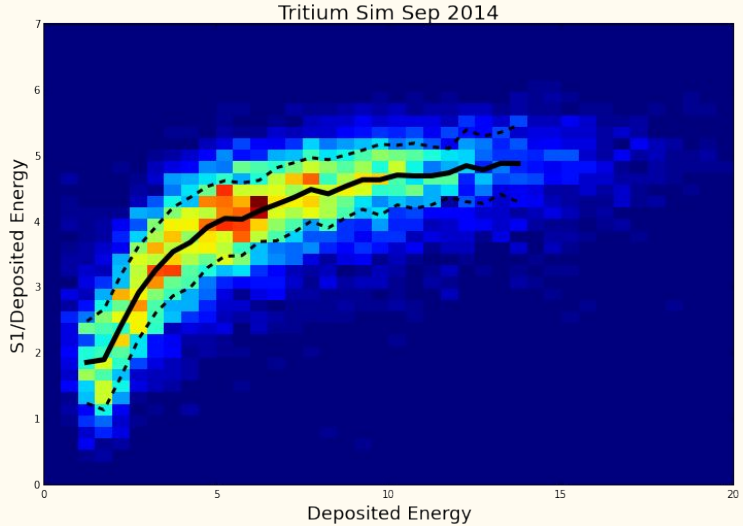


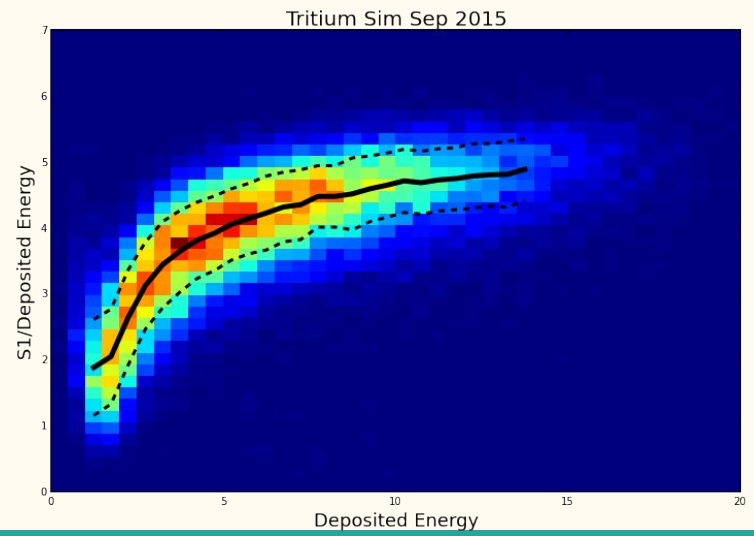


Light Yields

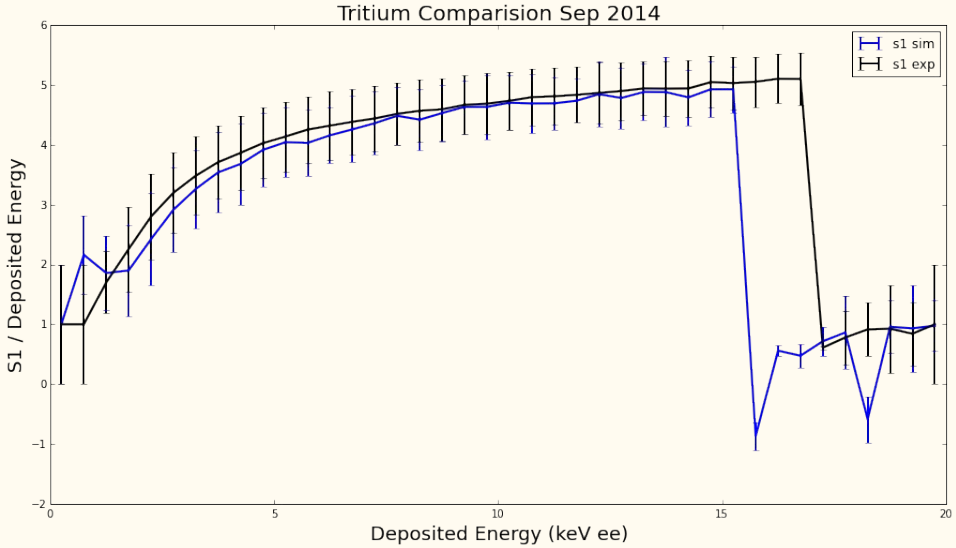


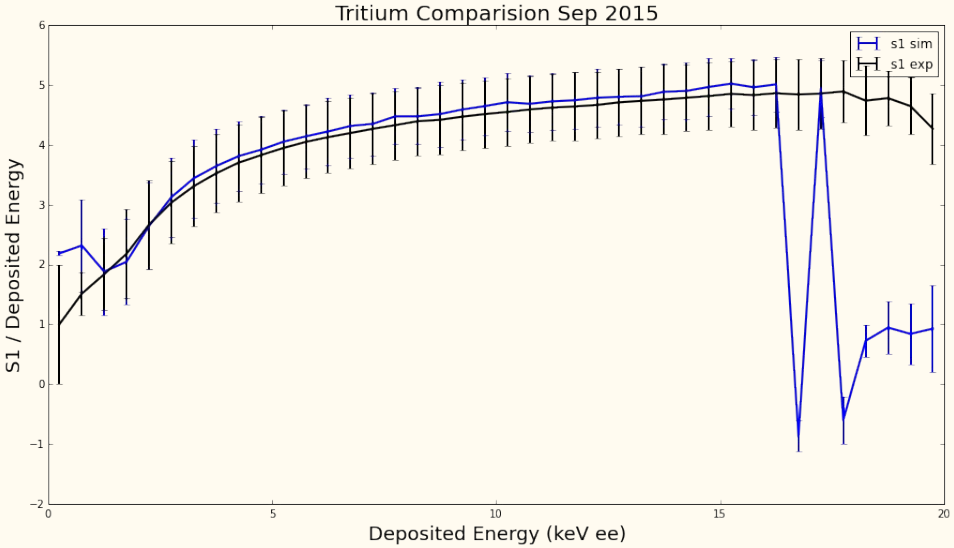




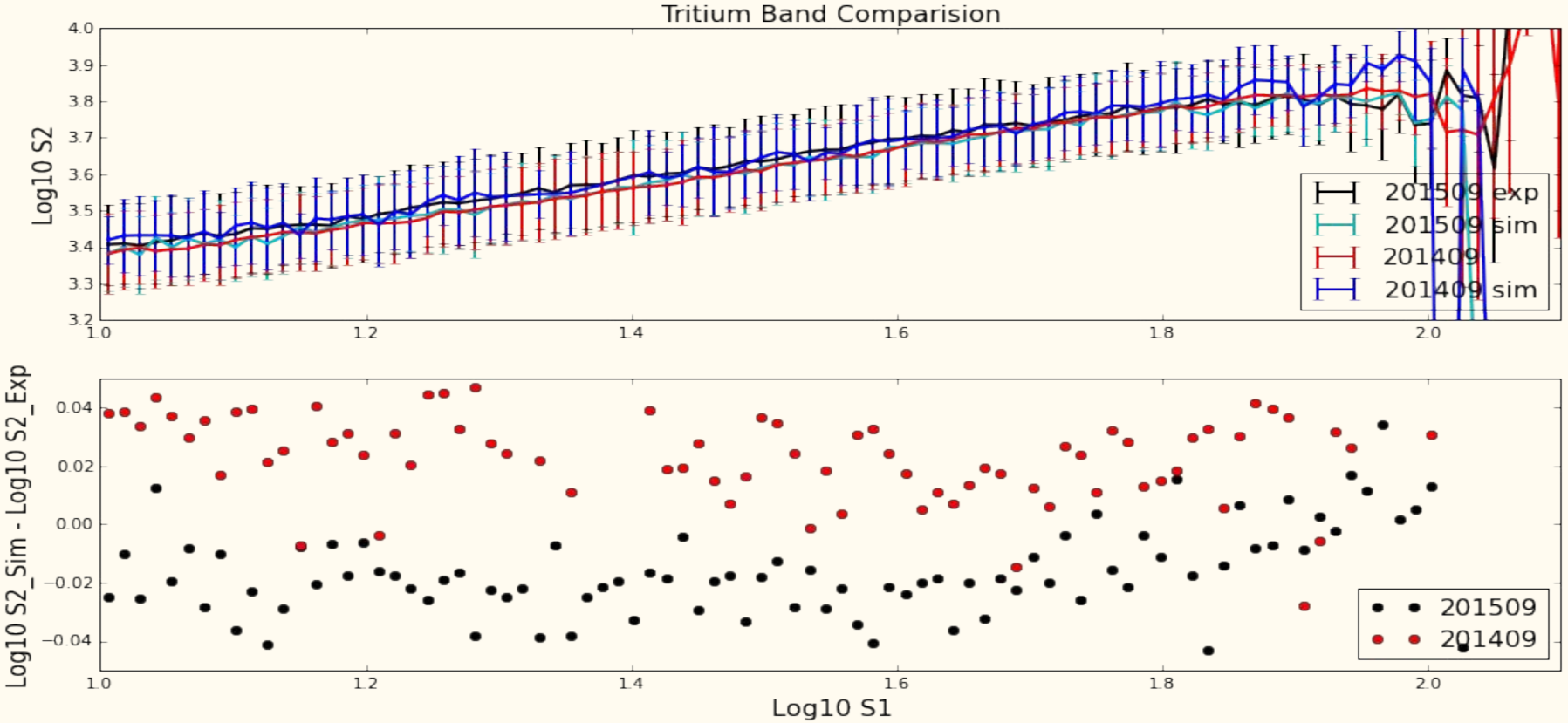


Light Yields Comparison

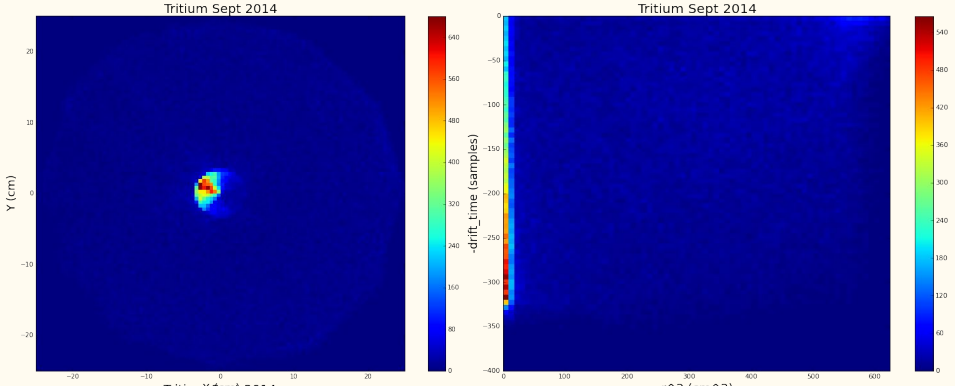




Bands With Means



x_del, y_del



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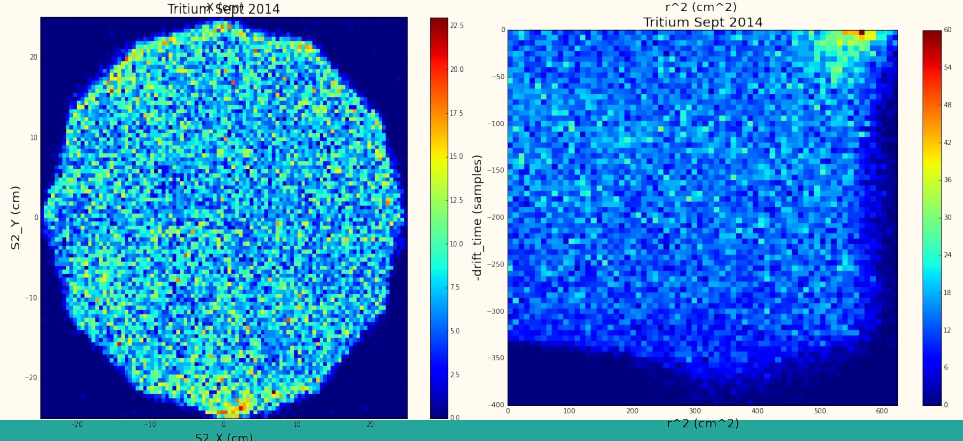

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