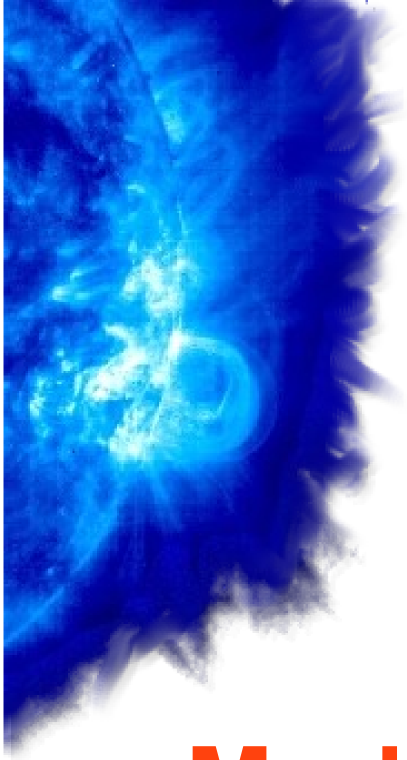


Modeling the Energy Resolution of Xenon with NEST

Sergey Uvarov
University of California, Davis

APS Meeting
April 12, 2013

Introduction

Noble Element Detectors

- ➔ Dark Matter Detectors (LUX, Xenon100, DarkSide, etc...)
- ➔ Neutrino-less double-beta decay (EXO, NEXT, etc...)

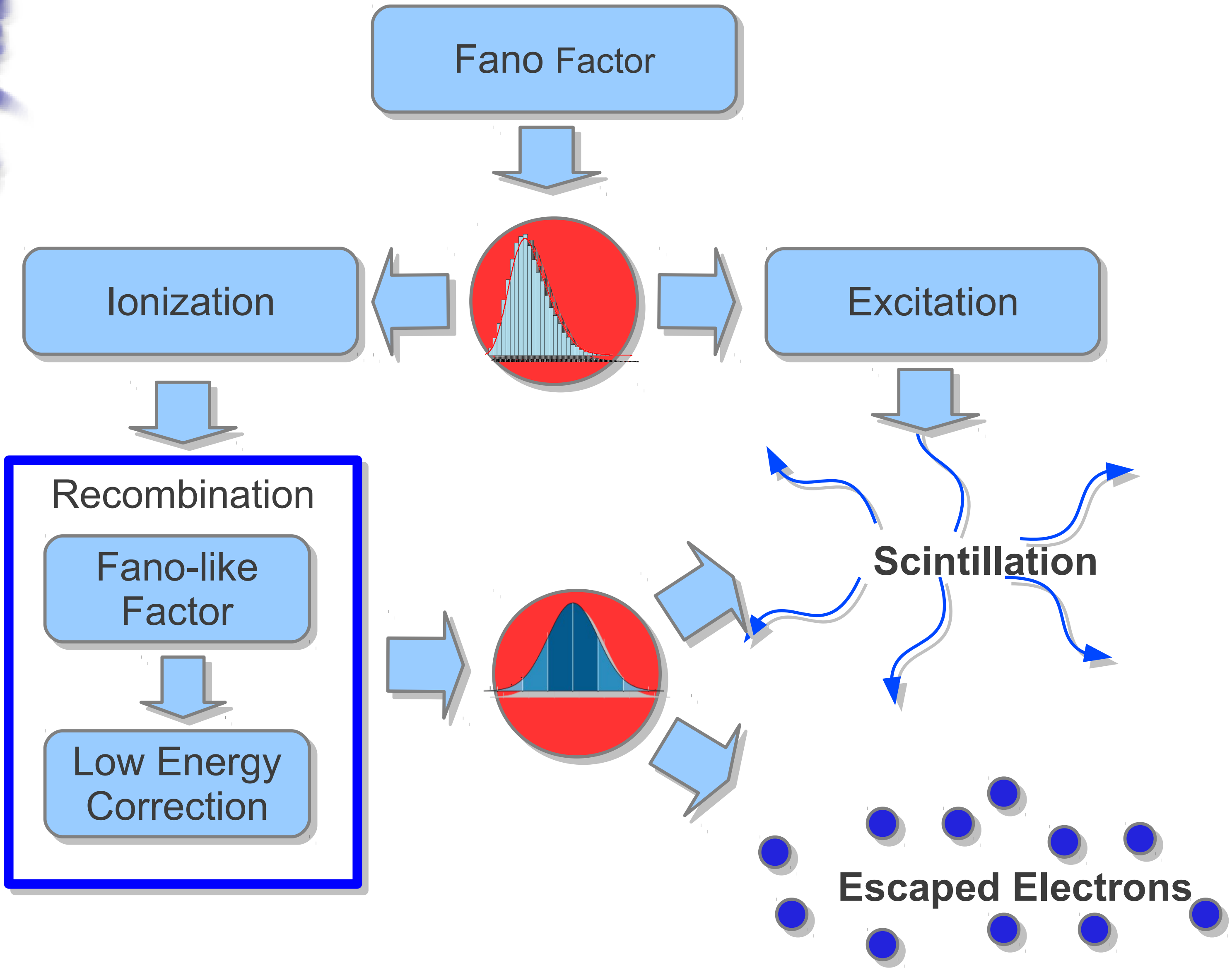
Light yield is non-monotonic at low energies

- ➔ Incident particle type
- ➔ dE/dx
- ➔ Electric field

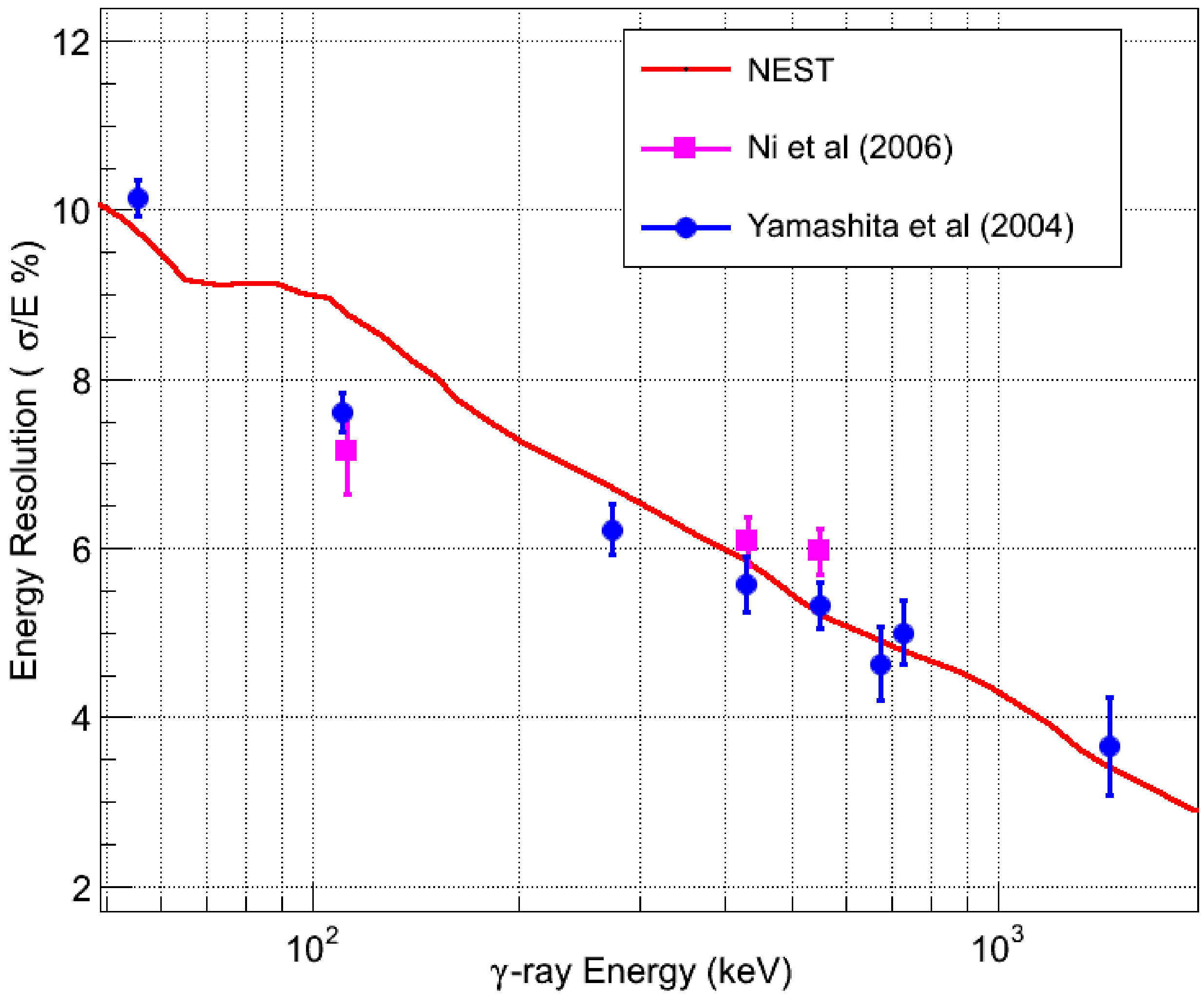
Discrimination

- ➔ Stochastic variations

Adding Stochastic Variation

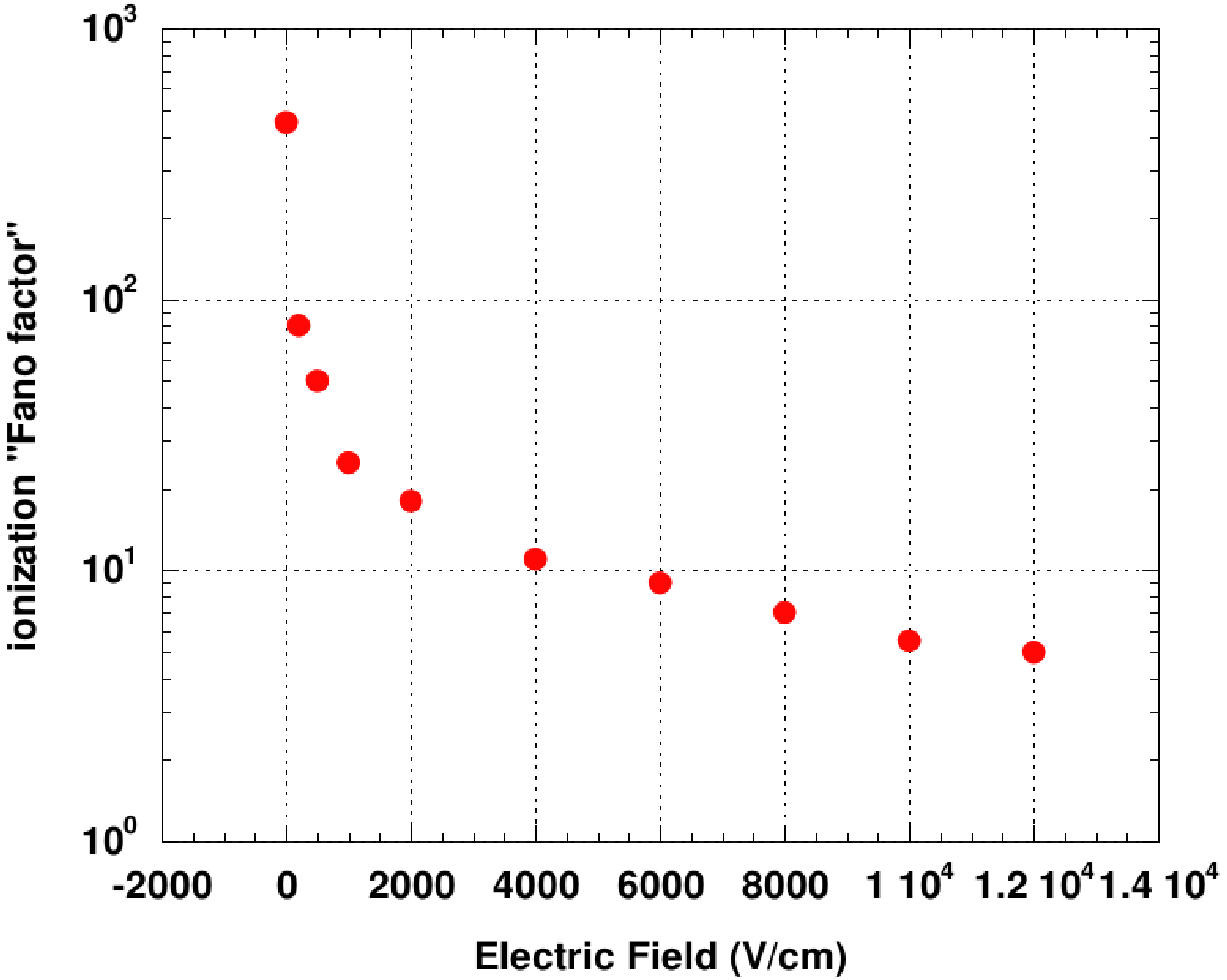


At Zero Electic Field



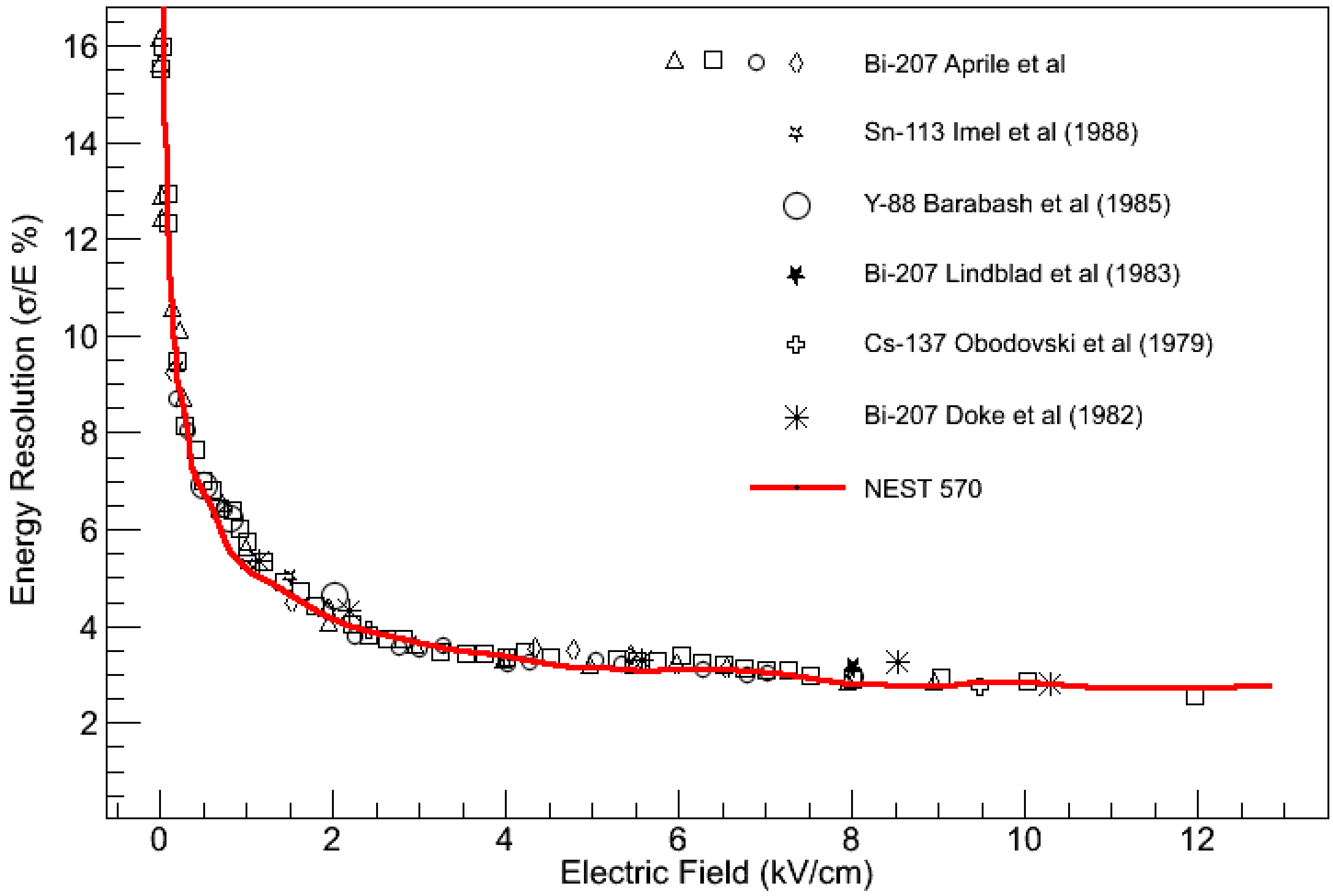
- ➔ Non-monotonic behavior
- ➔ Rich features emerge
- ➔ Matches zero electric field data

Electric Field Dependence



- Regular Fano factor left alone
- Recombination fluctuations have been modeled as a bounded Gaussian, with a sigma of sqrt(F_e*N_e), per interaction site
- Field-dependent but energy-independent

Non-Zero Electric Field

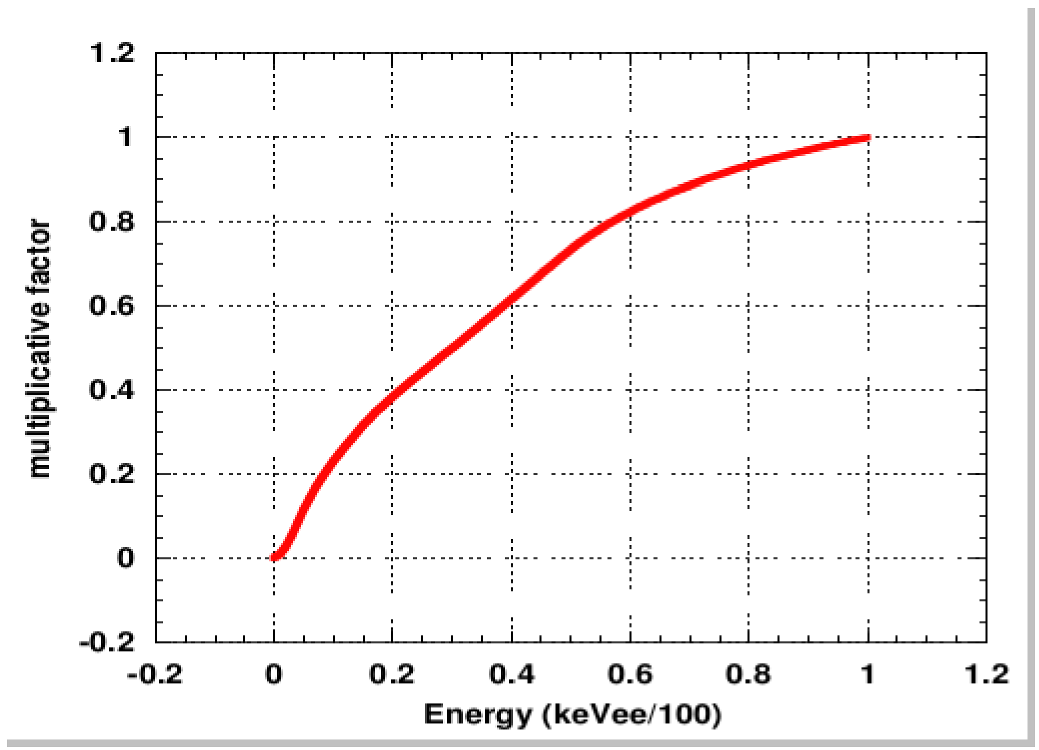


Good simulated resolution will allow us to predict the discriminati on power of any detector as a function of field and energy

Low Energy Corrections

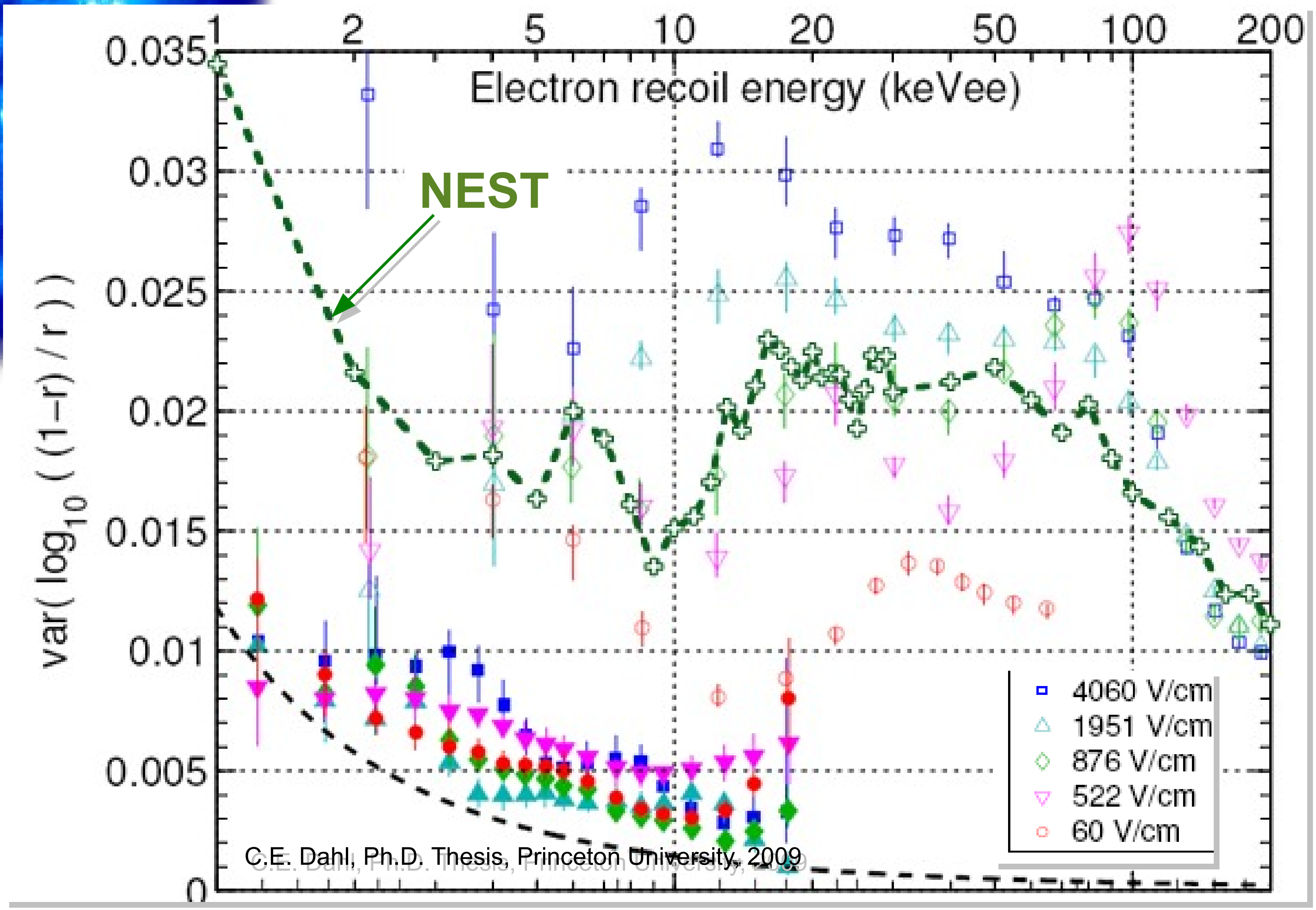
At low energies, the recombination probability depends on the energy, via the number of ions, and not on dE/dx

➔ Required a switch from Doke-Birks to Thomas-Imel model



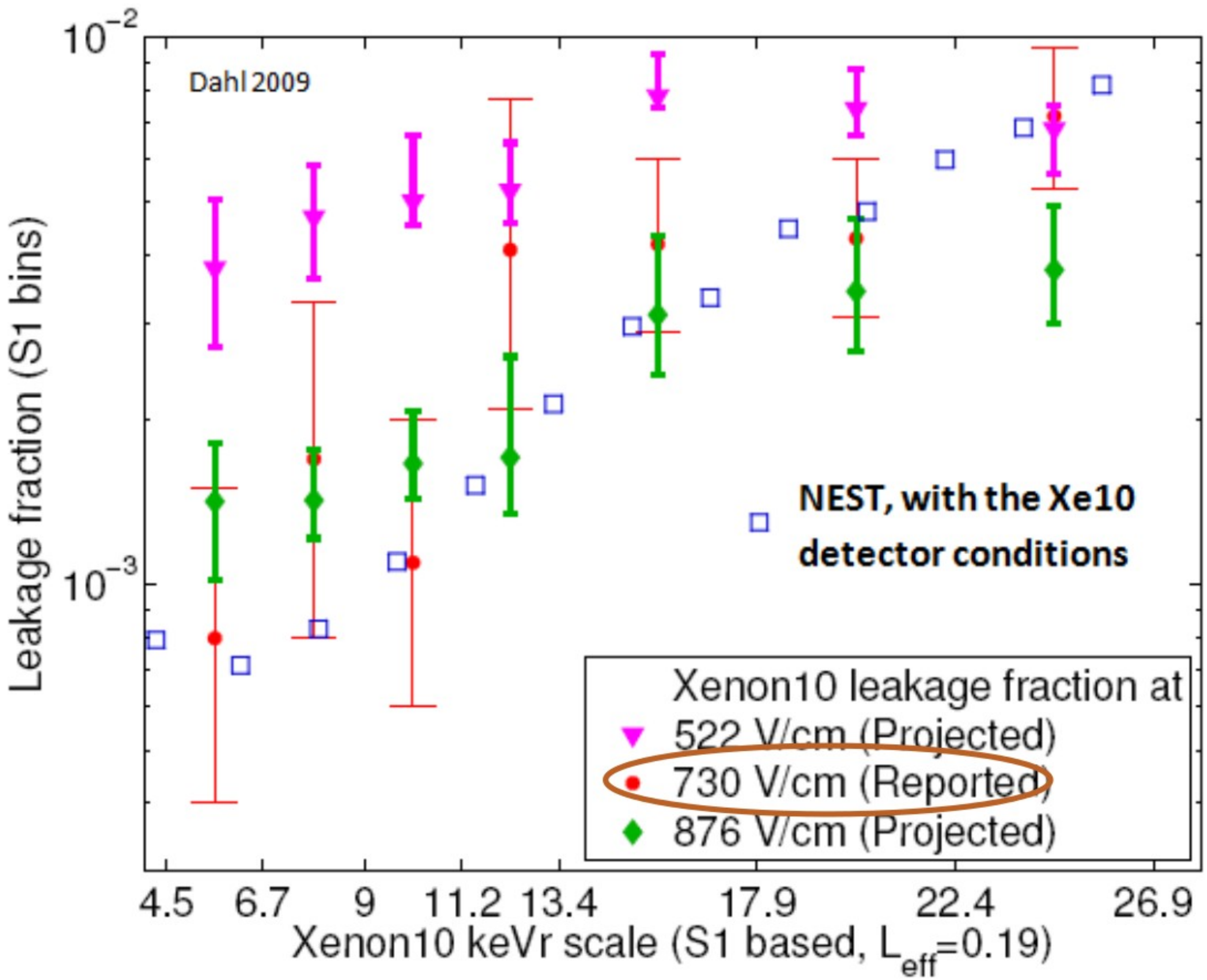
- ➔ Introduce an empirically derived multiplicative factor, sqrt(a*F_e*N_e)
- ➔ Used 876 V/cm data to ground the NEST model
- ➔ The anomalously high (F_e ~ 10-100) recombination fluctuations at high energies are smoothly extrapolated down to 0

Low Energy



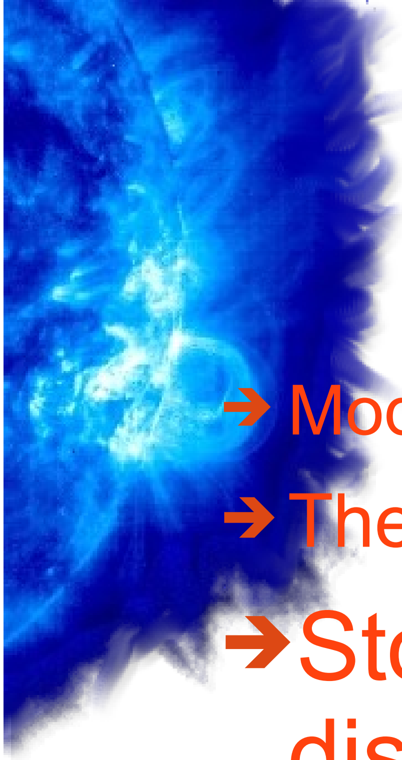
The undulations are an “emergent property” of NEST, caused by the “battle” between the increasing energy and the increasing variance

ER vs NR Discrimination



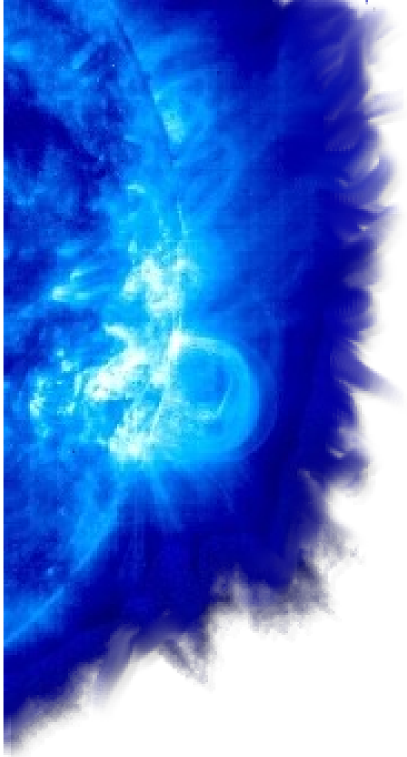
After the improvements to the recombination model

- NEST exhibits the correct behavior for low-E discrimination!
- Can make general predictions for present and future detectors of differing light collection efficiencies and electric fields



Summary

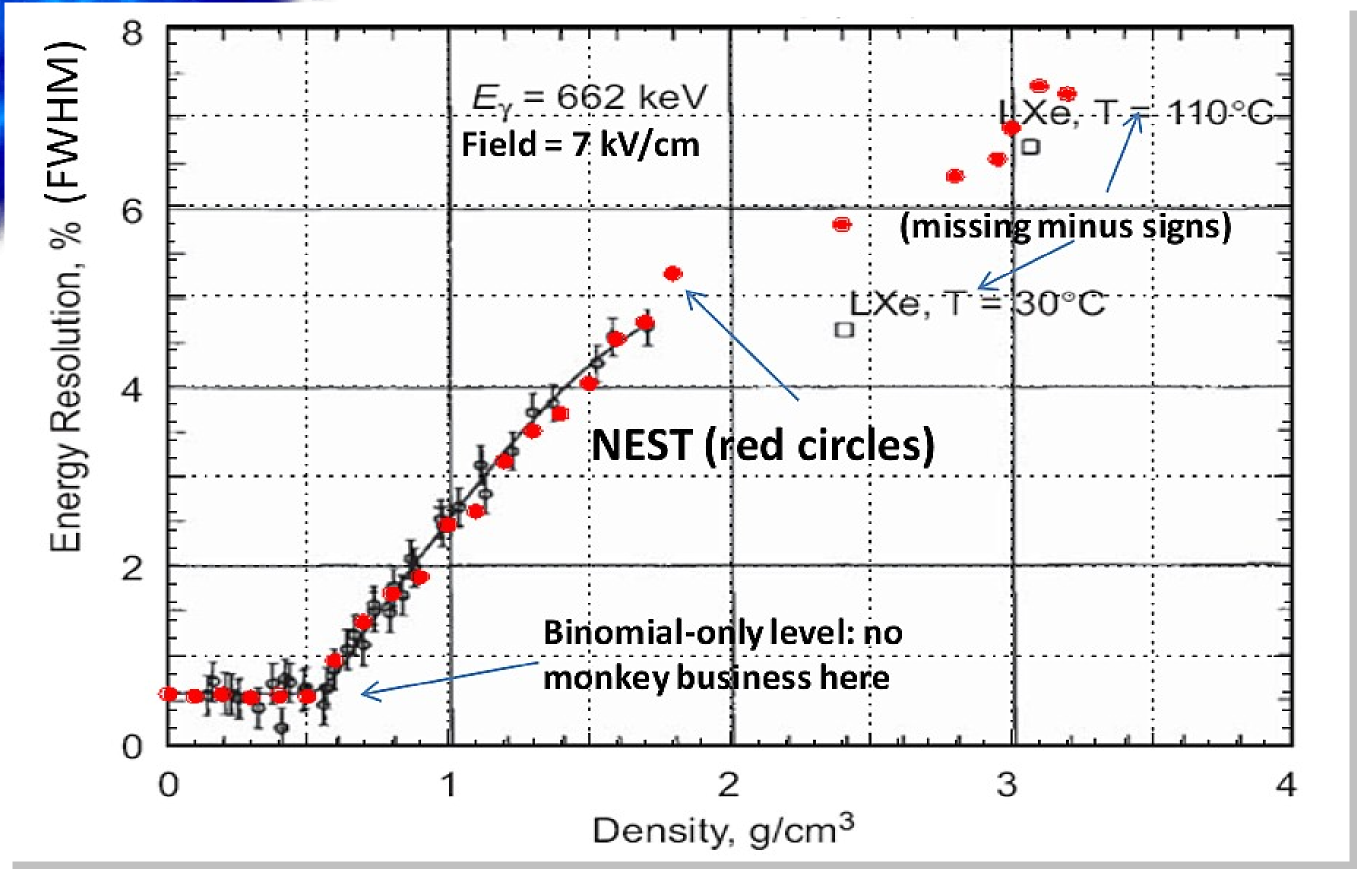
- ➔ Model behavior from 0 to high electric fields
- ➔ The emergent properties match real data
- ➔ Stochastic variations properly models discrimination power
- ➔ Reproduces correct energy dependence at low and high energies



Back Up Slides

Gaseous Xenon

We can generalize our field-dependent model to be density-dependent, and use it to fit gas data effectively



The plot at bottom left from Bolotnikov 1997 and Nygren 2009 was considered a bit mysterious: we now have a model to explain it (though it still needs more physical motivation quantitatively)

NEST has ever-broader applications (double beta decay in this case)