U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U

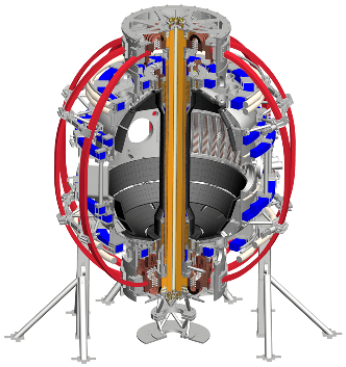
Analysis of Beam Blips

W. Heidbrink, D. Liu, D. Darrow and the NSTX-U Team

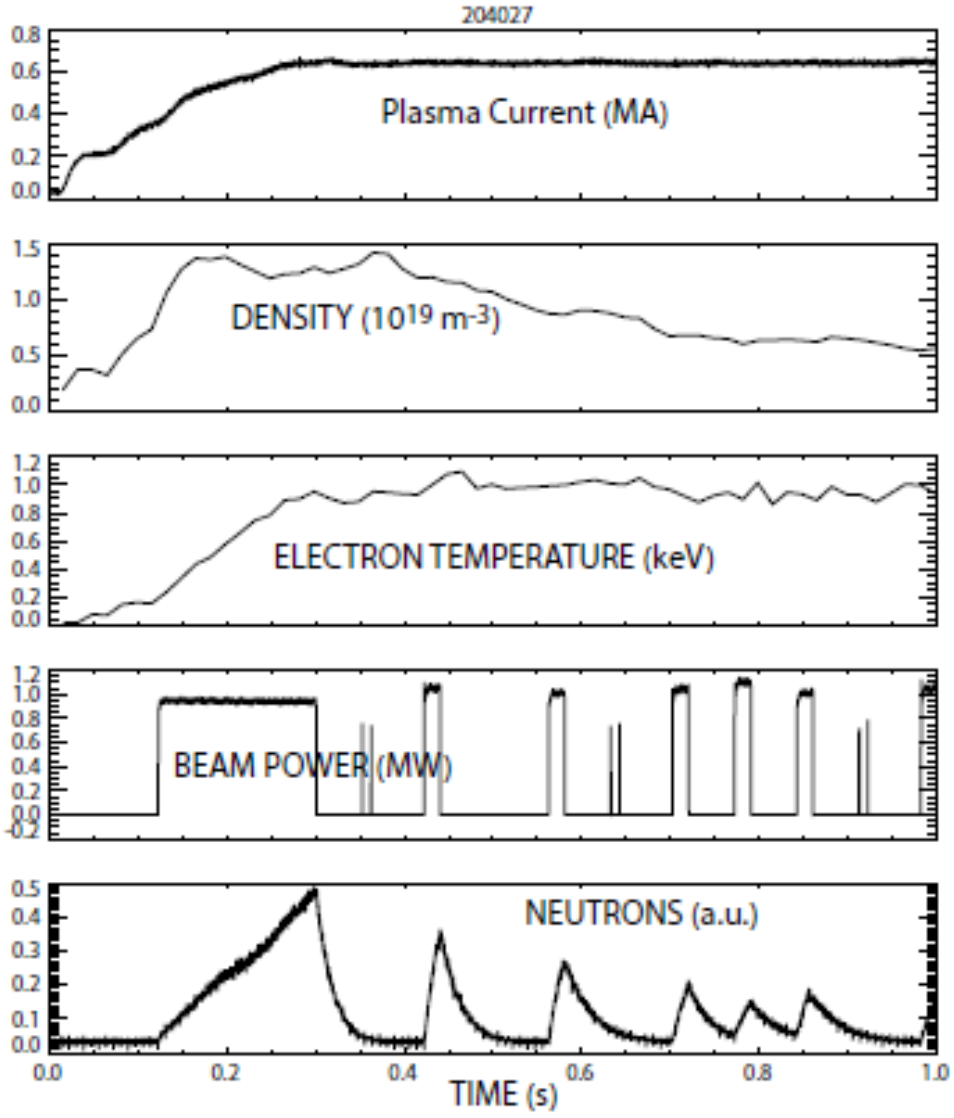
Monday Physics Meeting
4/25/2016

UCIrvine
University of California, Irvine

PPPL

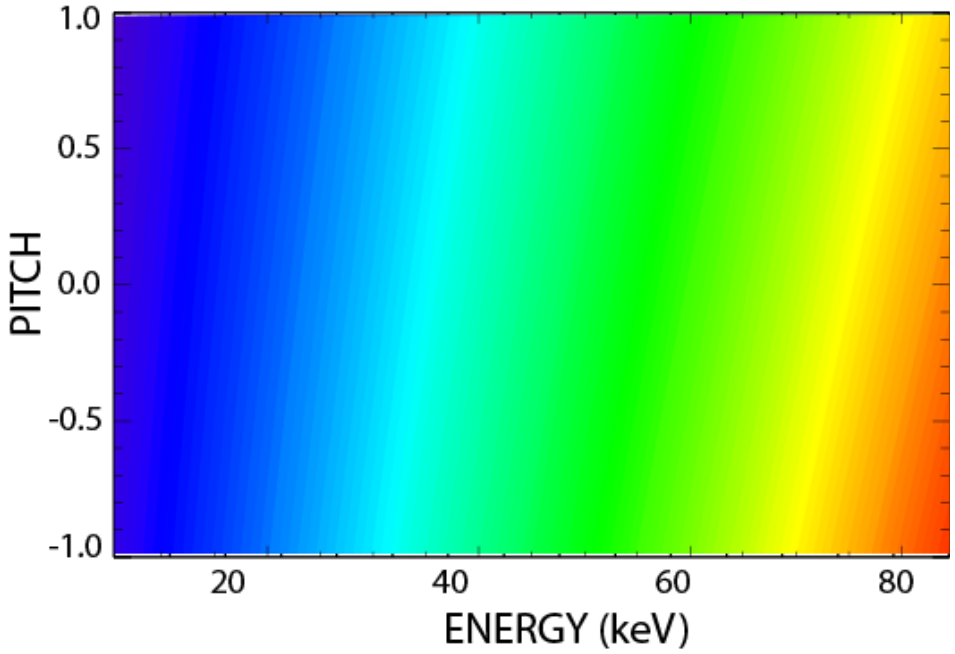


Inject beam blips in a low-density, L-mode plasma



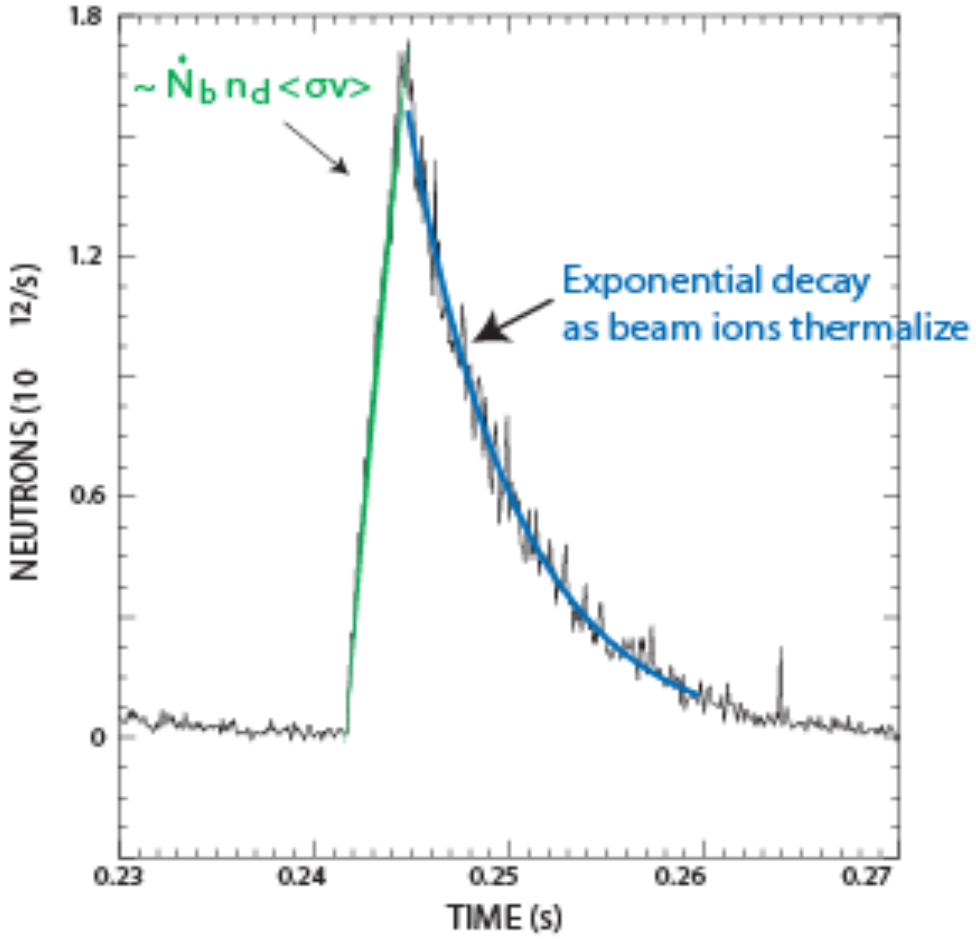
- **Low voltage on the beams**
- **Inner wall limiter**
- **Not much MHD**
- **Use scintillator signal for time evolution**
- **Cross calibrate to absolutely calibrated fission detector**

Neutrons measure the total number of high-energy beam ions



- **Beam-target reactions dominate in all of these discharges**

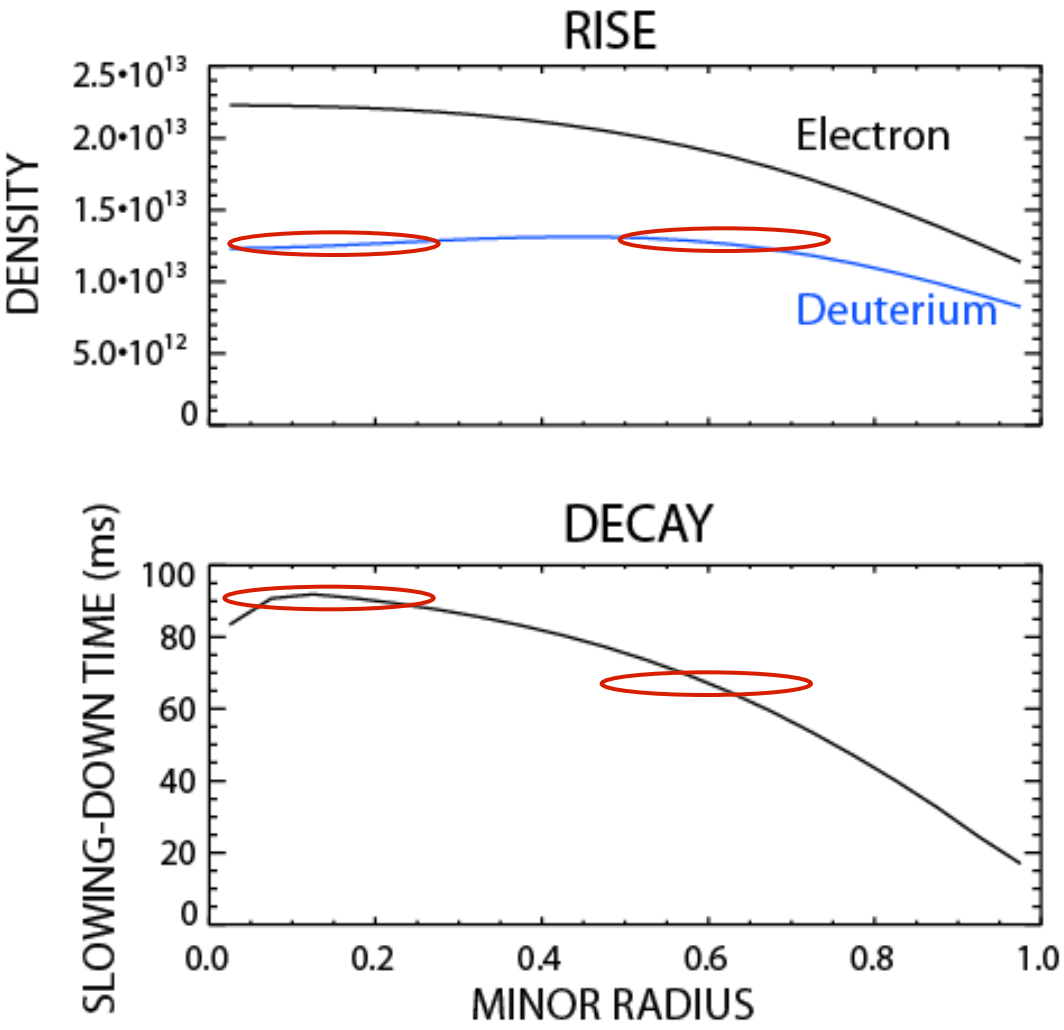
Beam-Blip Technique Measures Prompt & Delayed Losses



Nucl. Fusion 43 (2003) 883.

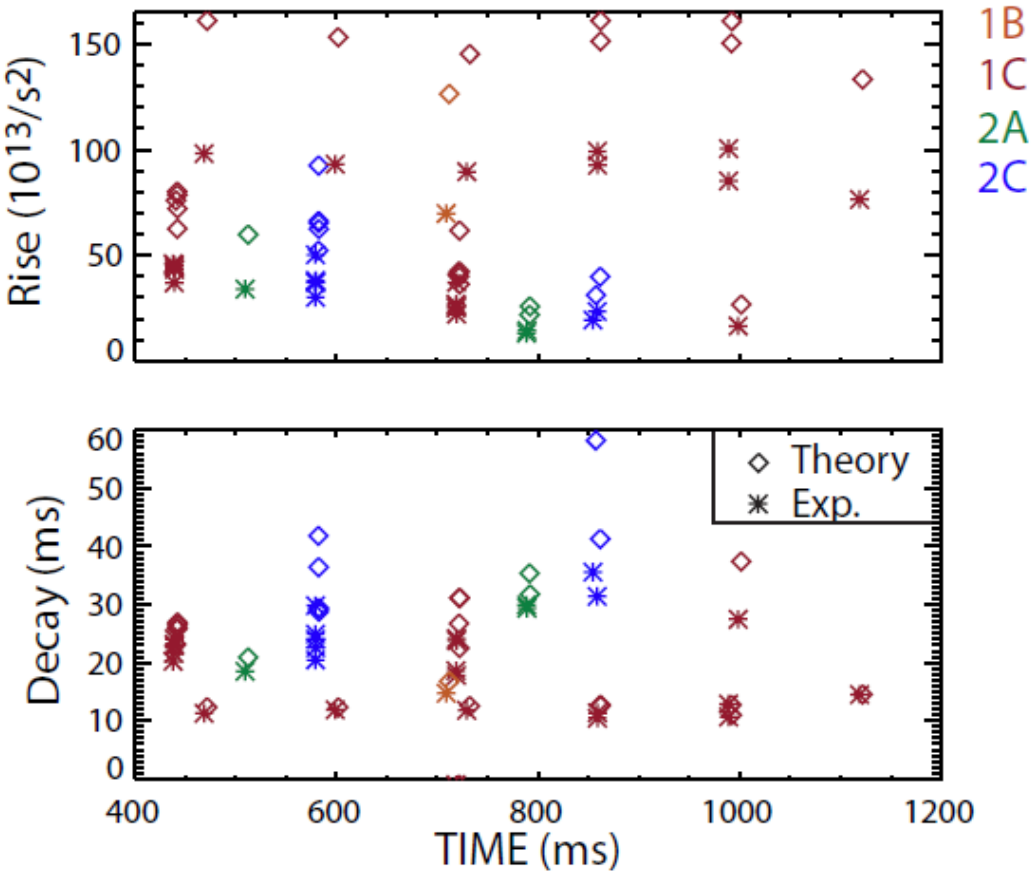
- Rise depends on number of confined beam ions injected
- Decay depends on slowing down & losses on t_s timescale
- Excellent fits to model equations for all of these data

Rise depends on n_d profile; decay depends on t_s profile



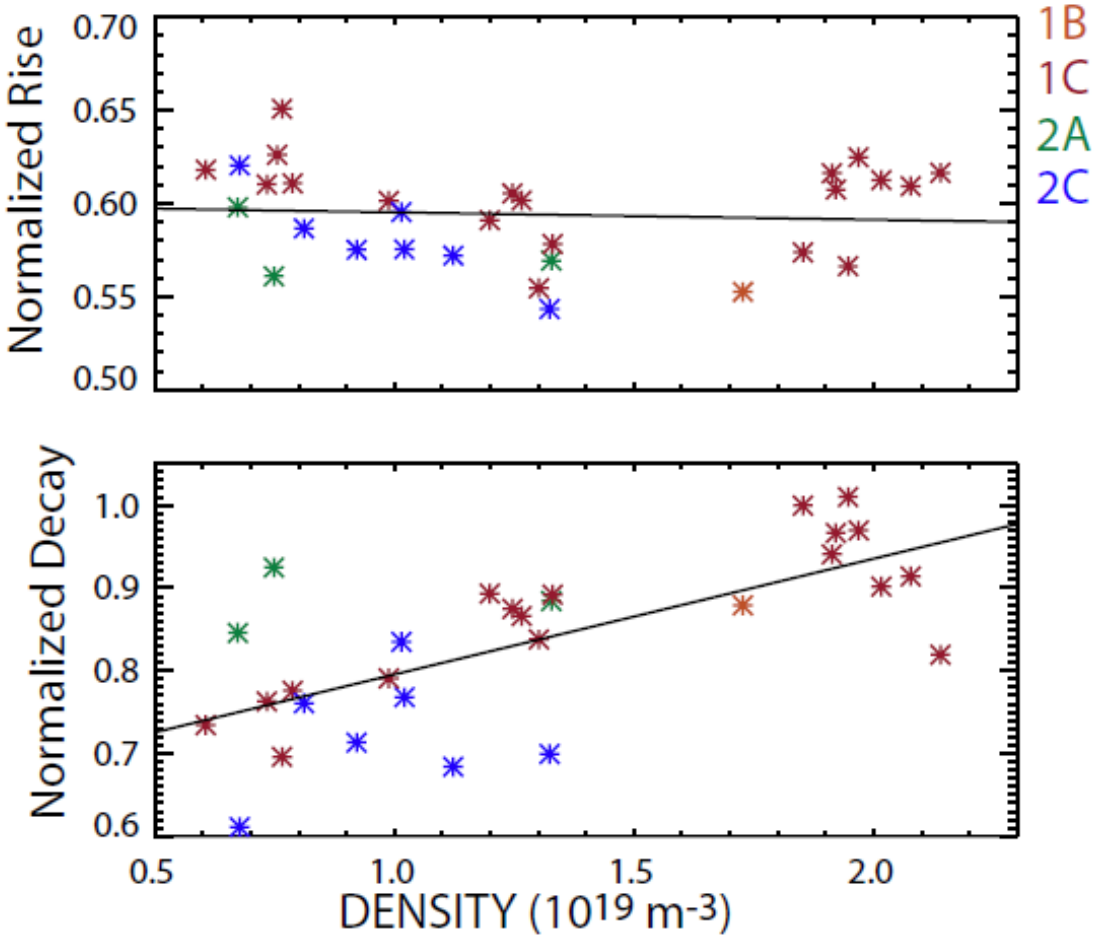
- Expect small difference between beams in normalized rise
- Expect off-axis decay time to be shorter for beams with orbits in outer part of plasma
- TRANSP should account for these variations

The rise is smaller and the decay is faster than predicted



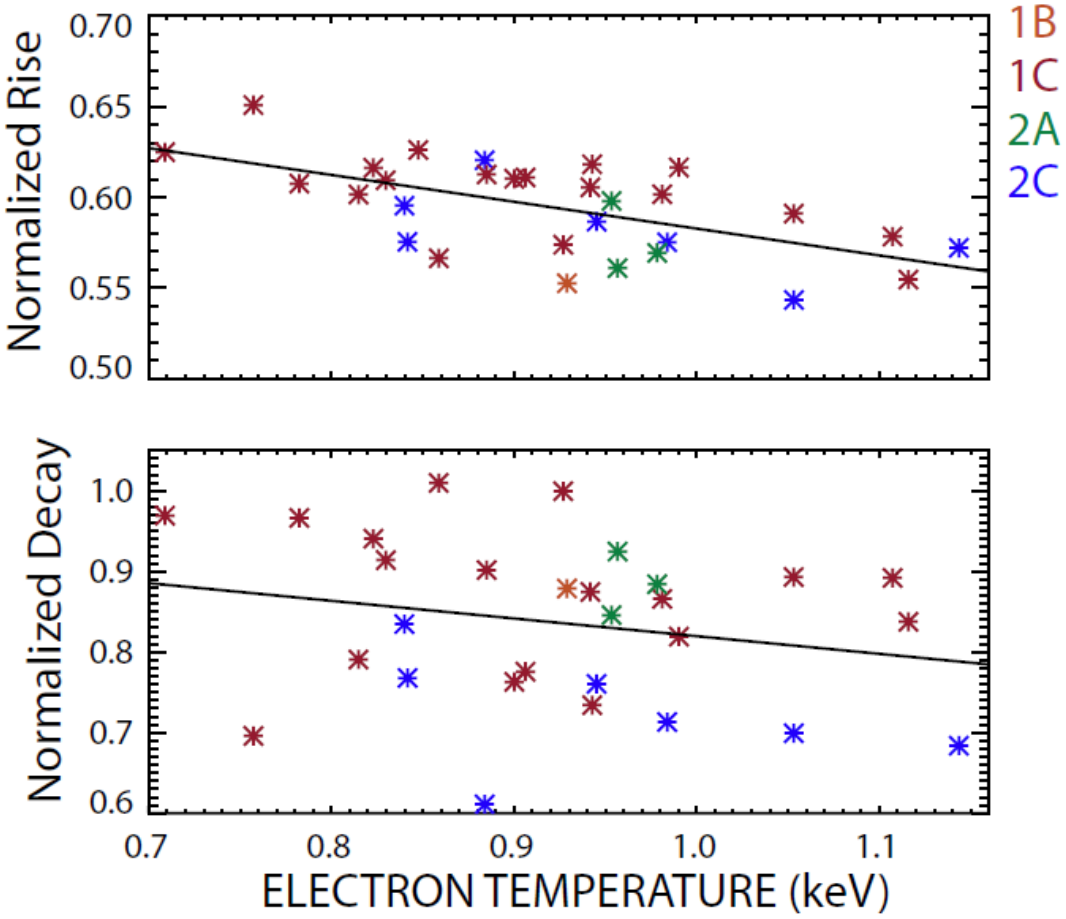
- **Experimental rise is smaller than TRANSP predicts**
- **Experimental decay is usually shorter than TRANSP predicts**
- **Assumed Zeff=1.5 in all TRANSP runs**
- **Classical simulations (no *ad hoc* fast-ion diffusion)**
- **T_i=T_e (no effect)**
- **EFIT01**
- **Namelist options have weak effect**

The decay agrees better when the decay time is short



- **Weak dependence of normalized rise on density**
- **Strong correlation of normalized decay with density (r = 0.68)**
- **A density calibration error can <u>not</u> explain the discrepancy**
- **Bigger decay discrepancy for large $\tau \downarrow s$ -- could be cause by anomalous losses**

The rise has an unexpected temperature dependence



- **Weak dependence of decay on T_e**
- **Strong dependence of normalized rise on T_e (r = -0.60)**

Similar results for all 4 sources

Source	Rise	Decay
1B	0.55	0.88
1C	0.60	0.88
2A	0.58	0.88
2C	0.58	0.72

- **Suggests TRANSP modeling of beam physics is OK**
- **Suggests a common source of rise discrepancy**

What causes the rise discrepancy?

Source	Rise	Decay
1B	0.55	0.88
1C	0.60	0.88
2A	0.58	0.88
2C	0.58	0.72

- **Zeff But assuming Zeff=1.5 → n_d/n_e= 0.9**
- **Density But increasing n_e makes decay discrepancy worse**
- **Neutron Calibration Need ~40% increase**
- **Full-energy Injected Current i.e., Beam power or species mix**
- **Large "Prompt" Fast-ion Losses Waveform shape in excellent agreement with model → ions must escape in < 1 ms**
- **Equilibrium**

What causes the decay discrepancy?

Source	Rise	Decay
1B	0.55	0.88
1C	0.60	0.88
2A	0.58	0.88
2C	0.58	0.72

- **Density** But decreasing n_e makes rise discrepancy worse
- **Electron Temperature** Unlikely since short $\tau\downarrow s$ agrees
- **Equilibrium**
- **Fast-ion Losses on 10 ms timescale** Huge edge neutral density, error fields, MHD, ...

Tentative Conclusions

- **Triple check neutron calibration**
- **Blips from all sources and at full voltage (species mix more reliable at 90 keV)**
- **Correlation with MHD, error fields, ...**
- **Agree with Kaye's conclusion: Something is wrong.**