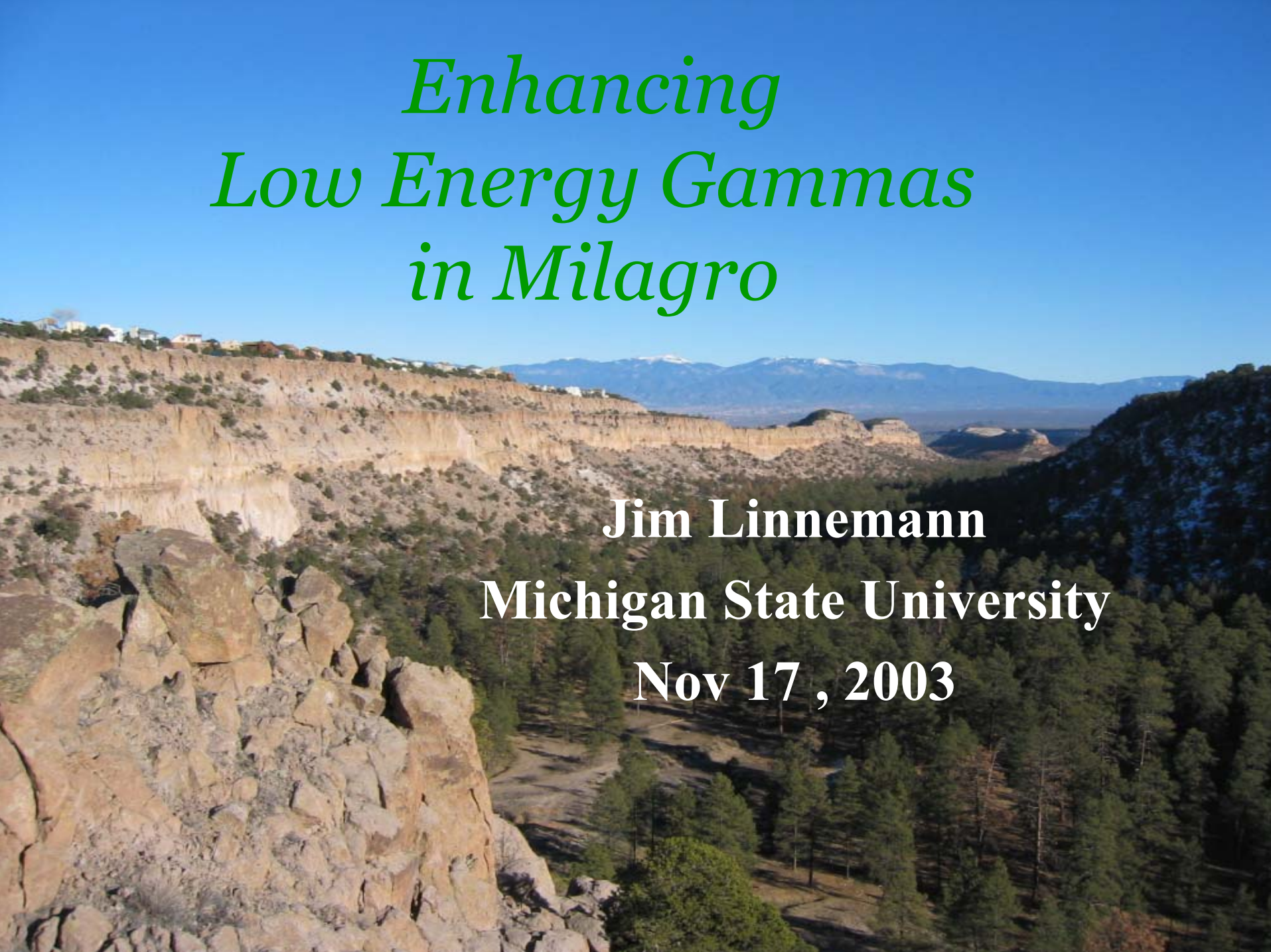
Enhancing Low Energy Gammas in Milagro



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Michigan State University
Nov 17 , 2003

A Few Updates

- **NSF grant for 50% on Milagro** submitted
- Graduate student **Aws Abdo** recruited
  - Learning Root now—reproducing old plots so far
- MSU has a Solar Surface MHD expert—interest?
- Next Semester: Yale AGN expert seminar?
- MSU theorist Mark Voit may be interested
- Statistics: Significance paper written
  - Alexandreas method =
    - Bayes, flat prior in Noff
    - Buzzwords: "predictive inference" for Non | Noff
      And then "Bayesian p-value" for ≥ Noff observed
    - Amazingly, **proven identical to Binomial**
      Frequentist UMPU test for ratio of Poisson means
- These absorbed my fall "Milagro time"
- **But I'll report on July 12-31, 2003**

Executive Summary

- X2 doesn't work well for low-E gammas
  - Especially T20 (20 tubes, risetime < 50ns)
  - **Q = 0.5 for X2 > 2.5 (standard cut)**
- X2 strongly correlated with Nas
  - Parameterize <X2> vs. Nas
    - Nas directly related to triggering (before risetime…)
  - Hope cut efficiency has less Nas dependence
- **Cut on λ ⟨X2(Nas)⟩ improves to Q = 1.1 for T20**
  - **Correlation is strong but noisy**
  - **Not clear X2 *shape* independent of Nas**
  - **Maybe: Q 1.76 to 2.19 for 50 tube trigger (different tunings)**
- **Pemax less powerful discriminator at Low Nas**
  - **Nas a proxy for energy? For Nb2? Cut on pemax/Nb2**
- **Cut Nb2< cut for 20 tube triggers**
  - **Q = 1.37**

Which Gammas?

- E < 300 GeV (non-attenuated GRB's)
- T20, since that's the new kind of data
  - With T20 as is: use existing sample
    - 25 tubes in real data
- Hardest Case, so may help others, too

Noise Reduces T20 Efficiency

Default Uncorrelated MC Noise

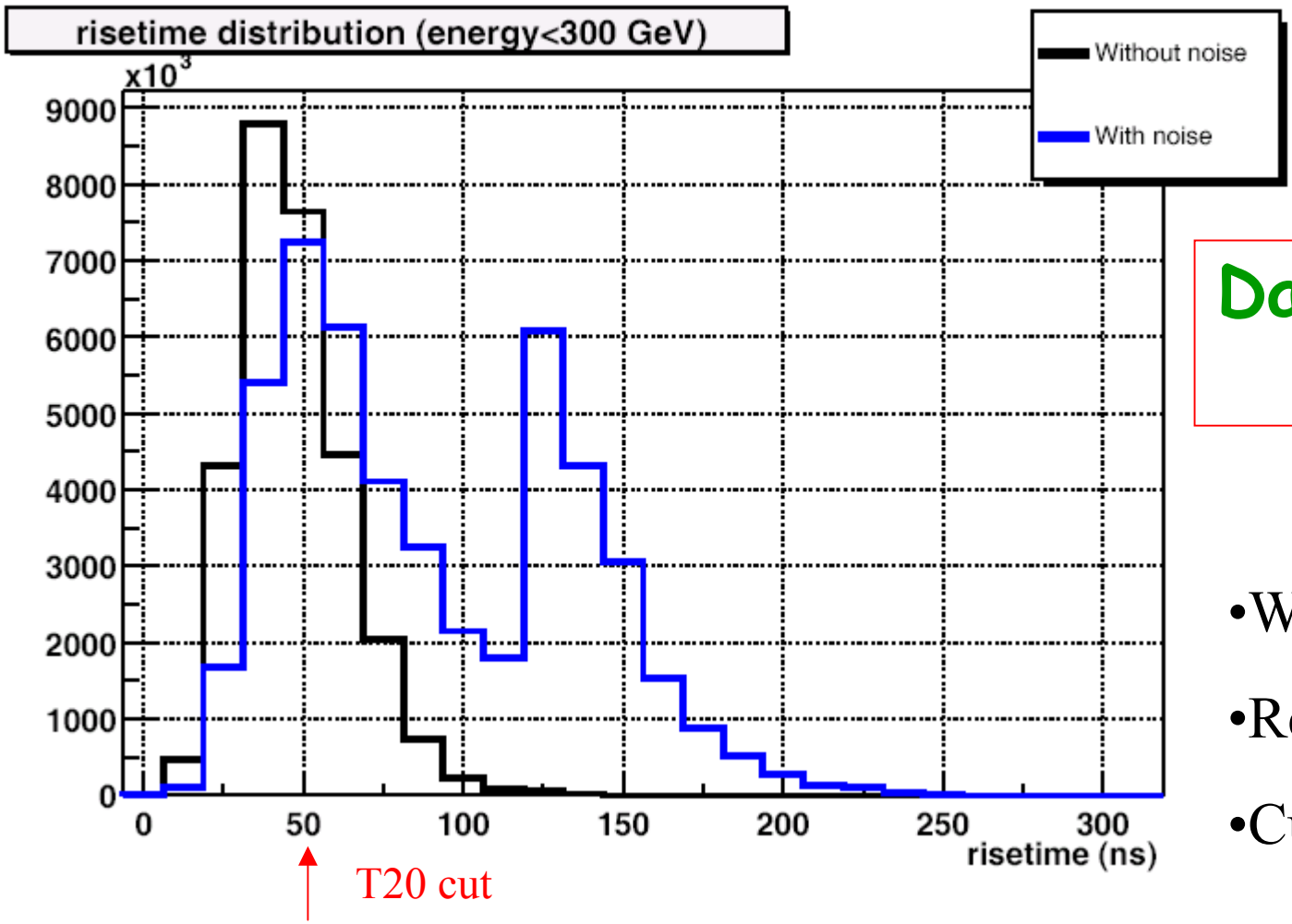
		Eγ< 300 GeV	> 300 GeV
All Triggers	No noise	3294	15971
	Noise	2341 (-29%)	13182 (-17%)
Exclude T20	No Noise	902 2/3 are in T20	9491
	Noise	999 (+11%)	9973 (+5%)

50% loss in T20!

Should T20 be Changed from Risetime to something else???

Would a better Noise model change this conclusion?

Why?
Noise Increases Risetime

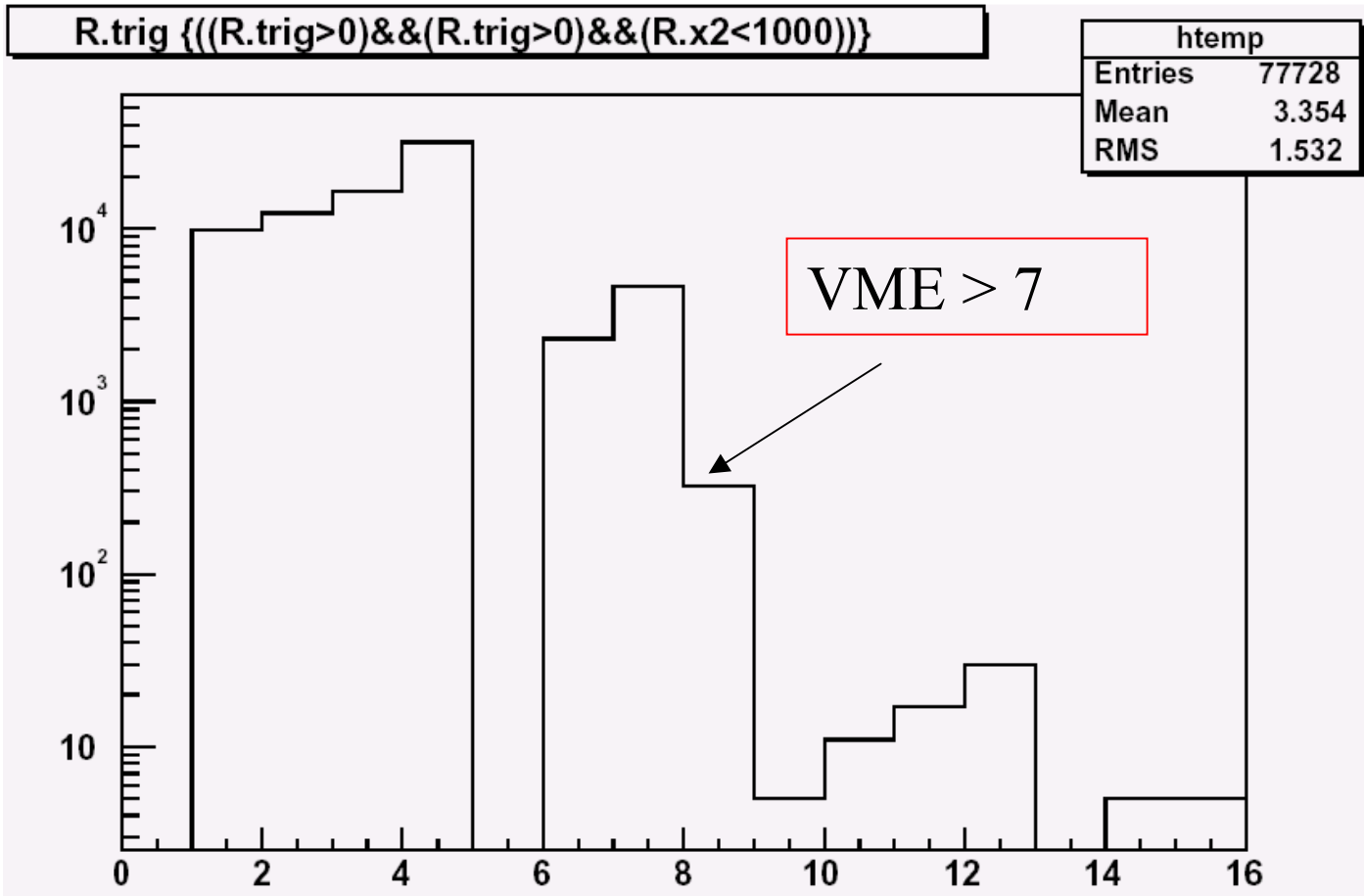


David Noyes Plot

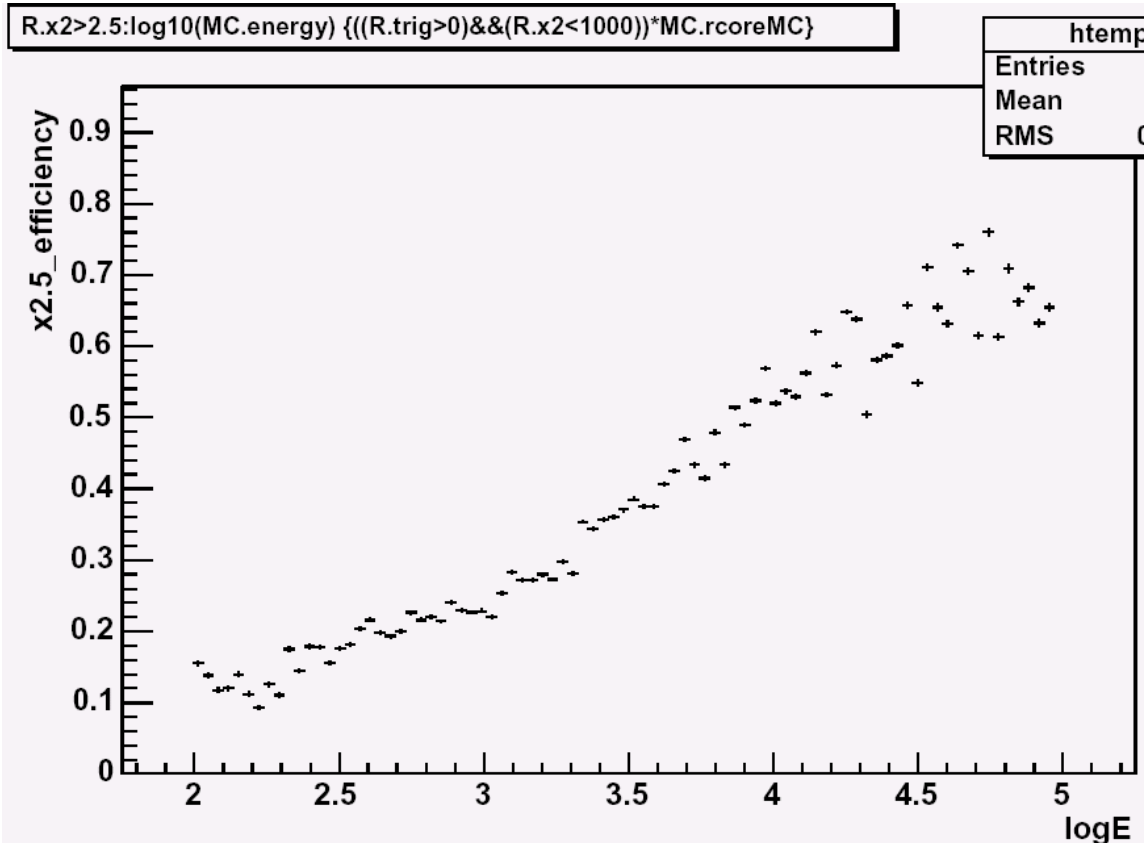
- Why 2 lumps?
- Real or bogus MC?
- Cut at peak of dist!

Trigger 8 surprise
T20 / 1000, with no risetime cut

- risetime rejection is about x 10
- 0.5% of events
- not in MC
- remove from your sample with t != 8
- remove t=4 also?
- Time dep thresh



X2 diagnosis: efficiency vs. E



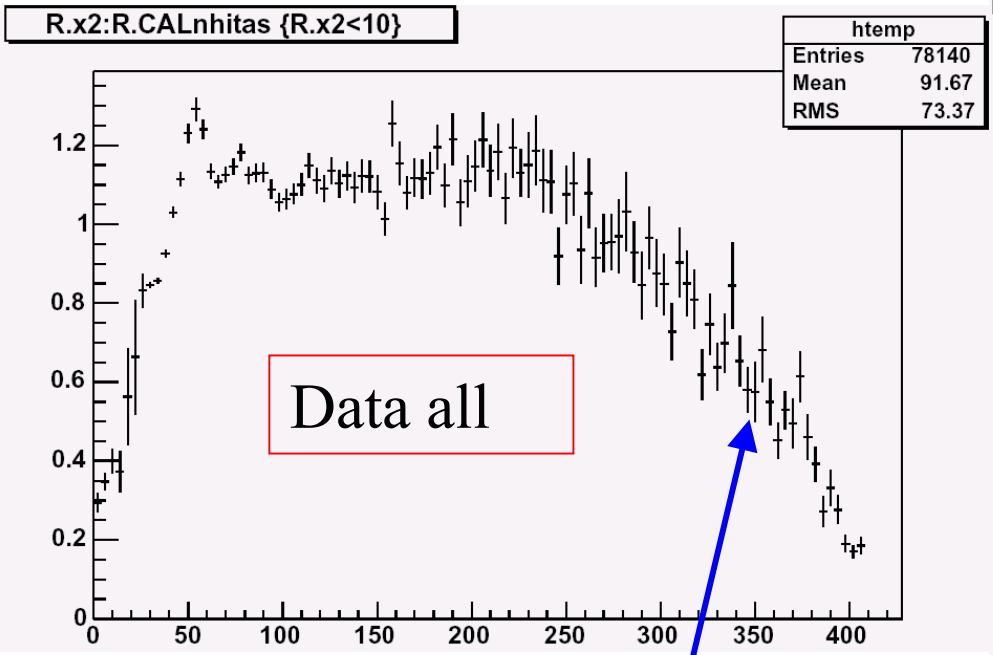
- Decided to plot <X2> vs. Nas
  - X2 efficiency a function of E
  - Nas a weak E proxy?
  - Nas strongly related to trigger

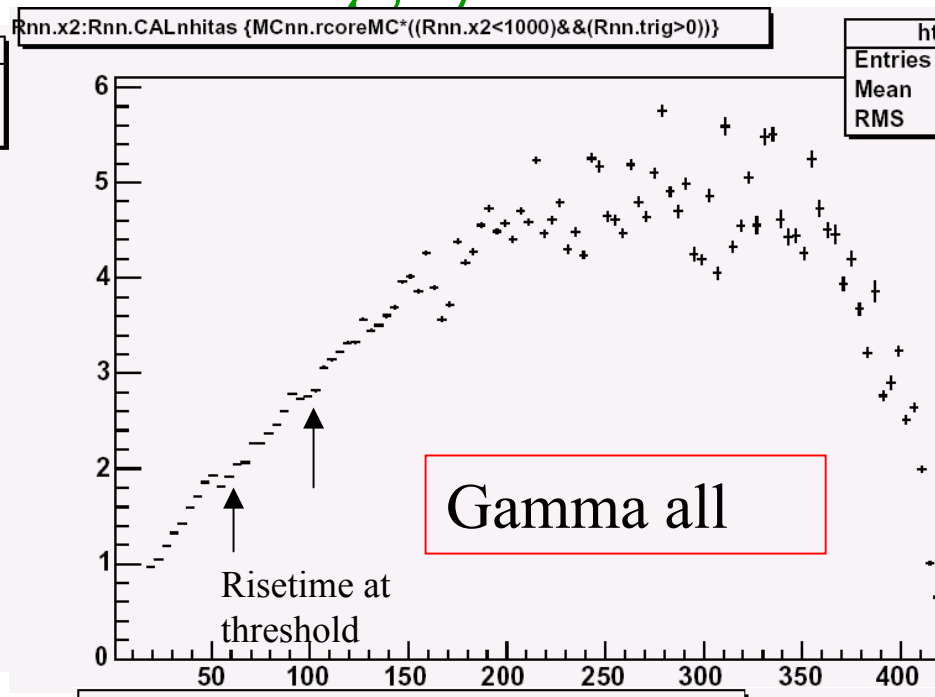
X2>2.5 has poor γ efficiency T20, or low Eγ

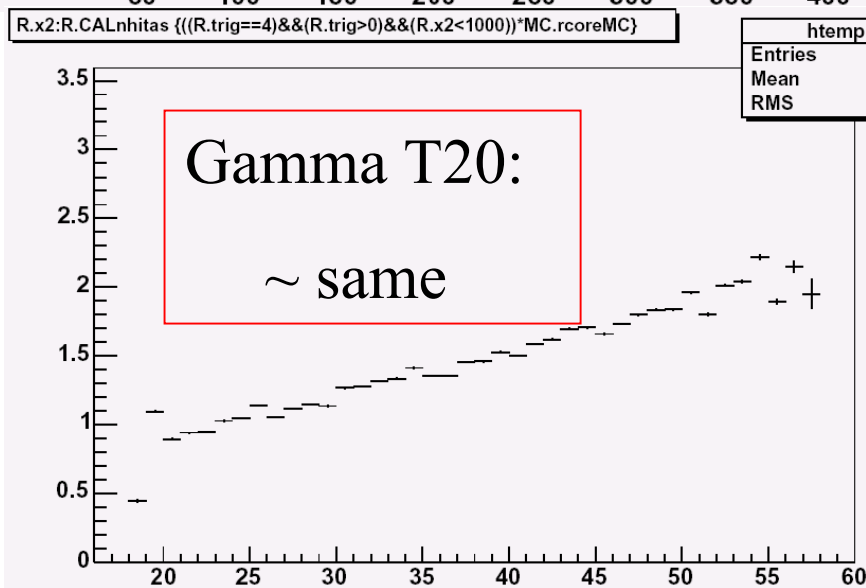
- **11%** for T20, all Eγ >100 Data: 4.1%, **Q=.5**
  Same for 100 < Eγ < 300
- 17% for all triggers, Low Eγ
  100 < Eγ < 300
- 31% for all triggers, all Eγ >100
- 53% for all triggers excluding T20 (Crab paper)
-

To check: try lowering X2 cut

<X2> depends strongly on Nas







High Nas: More events with X2 ~ 0

drive down average

Nb2 ~ saturates; but…

crazy tube(s) more probable:

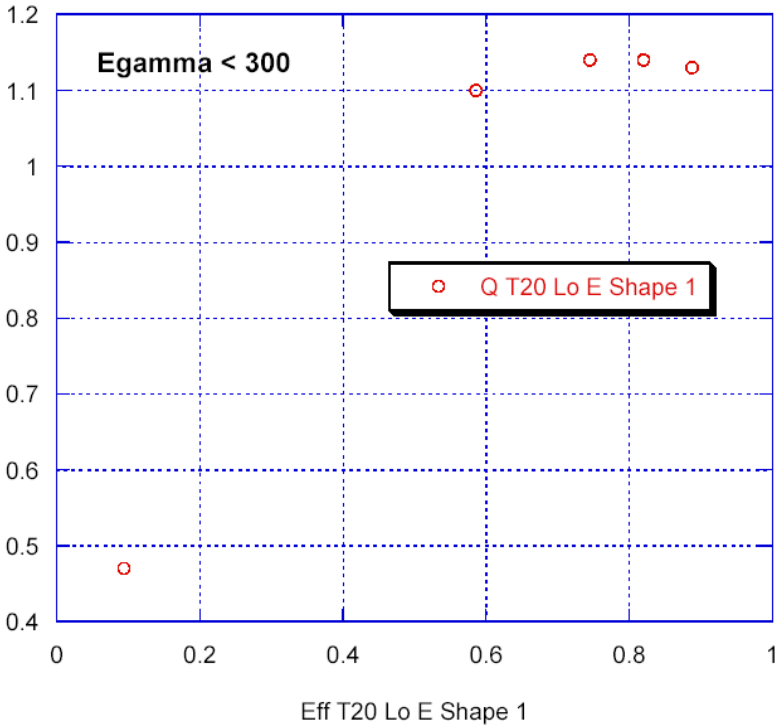
PEMax > 10000 Why?

Parameterize ⟨X2(Nas)⟩

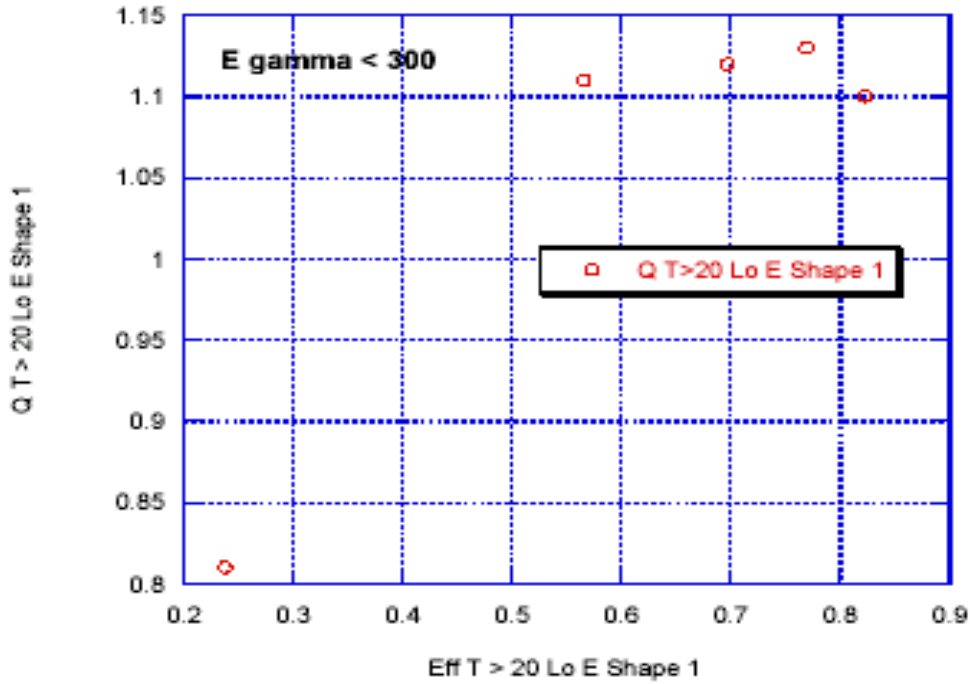
- Guess: shape independent of ⟨X2⟩ so scale cut to mean?
  - Cut on X2 > λ ⟨X2(Nas)⟩
- Hope: ε ⟨X2⟩ cut less E dependent
  - Does succeed in making less Nas dependent
- Spectacular improvement: Q > 2.0 !
  - Alas, starting from Q=0.5
- **Net result: Q = 1.1 for E<300 T20, T>20**
- **Maybe Q = 1.75 for T > 20**

Q vs Efficiency E < 300

T20



T>20

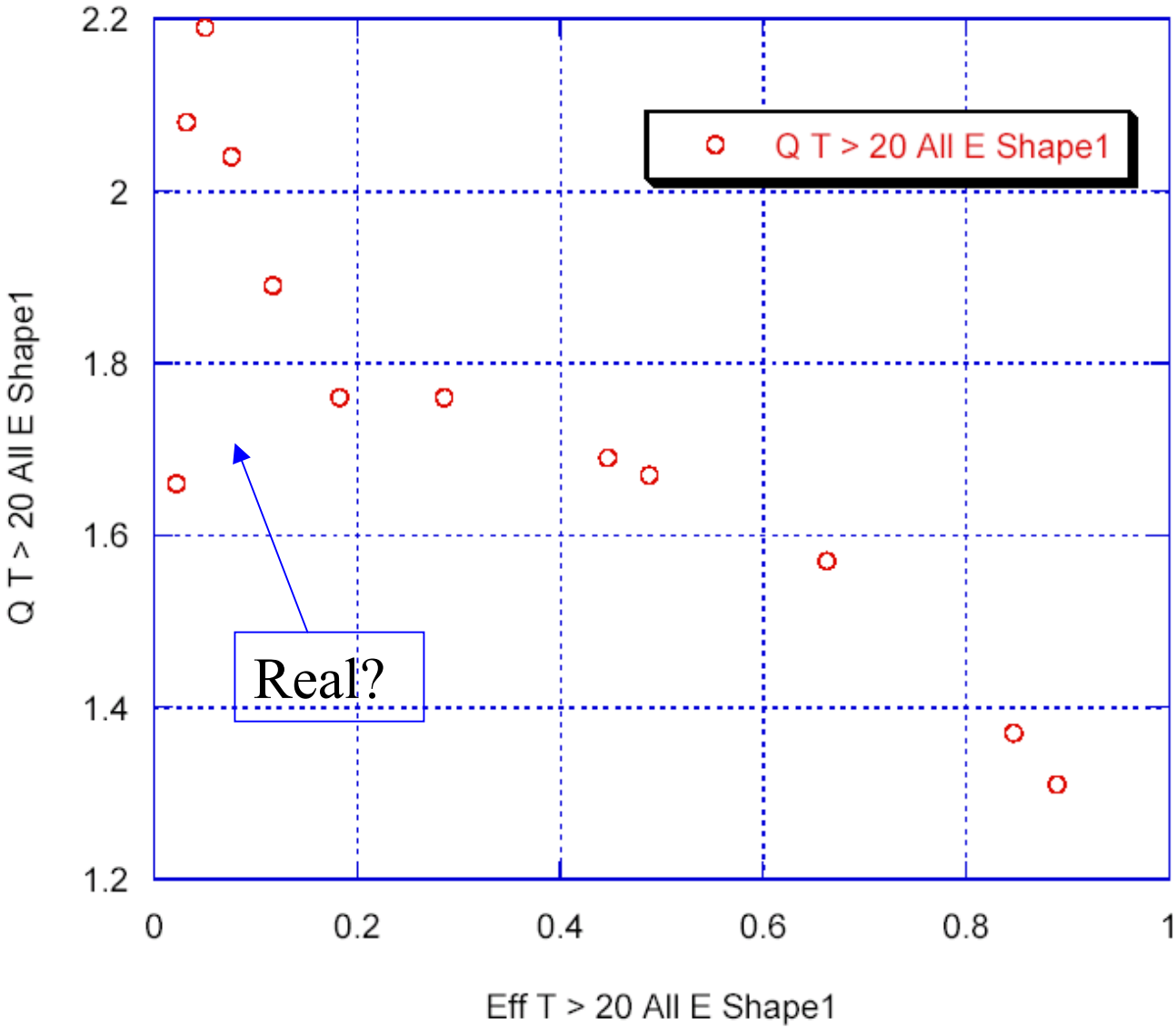


T20 Qo = .47

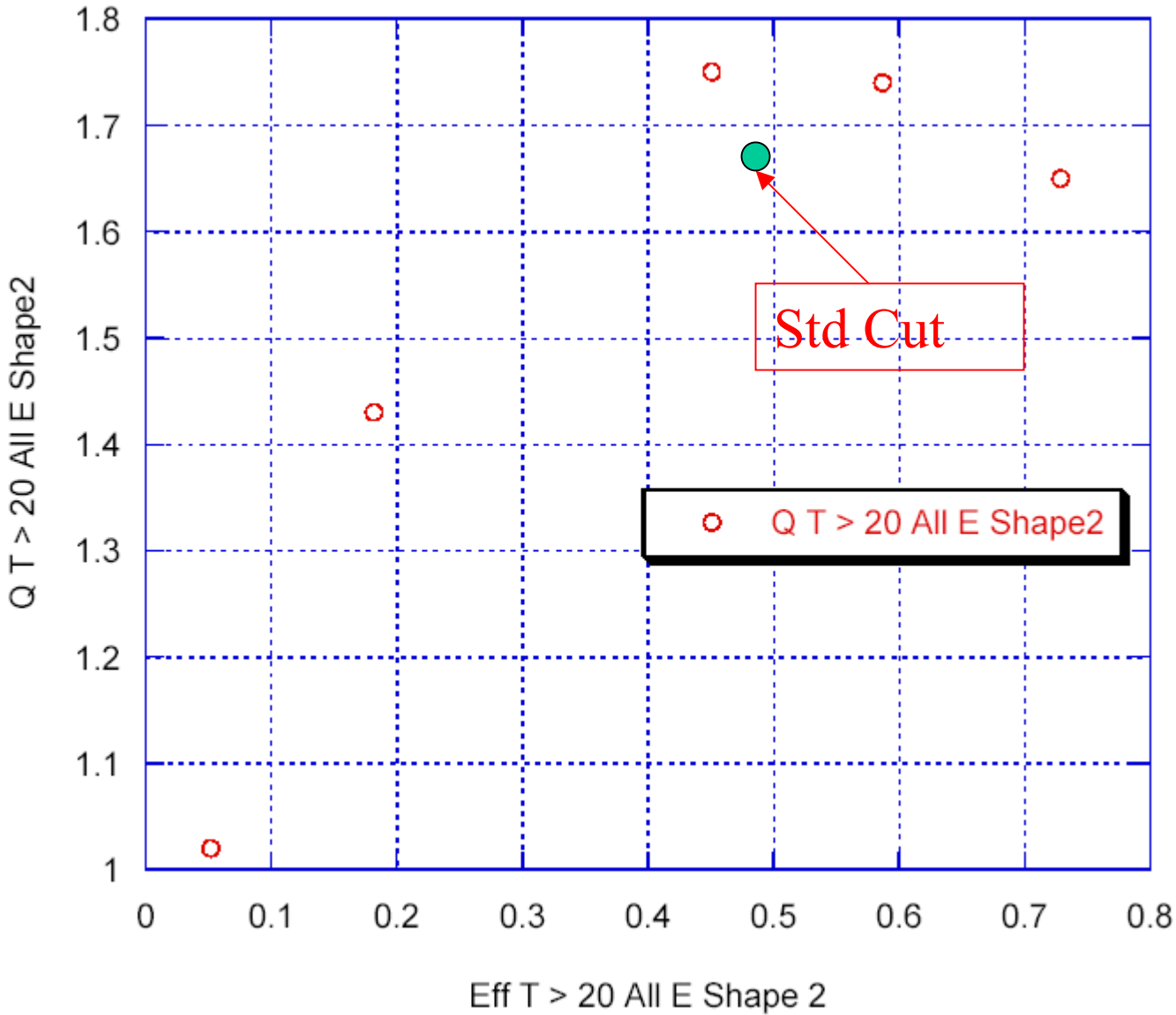
T>20 Qo = .81

Q vs. Efficiency, E > .1 TeV

Q > 2 for 10% efficiency?



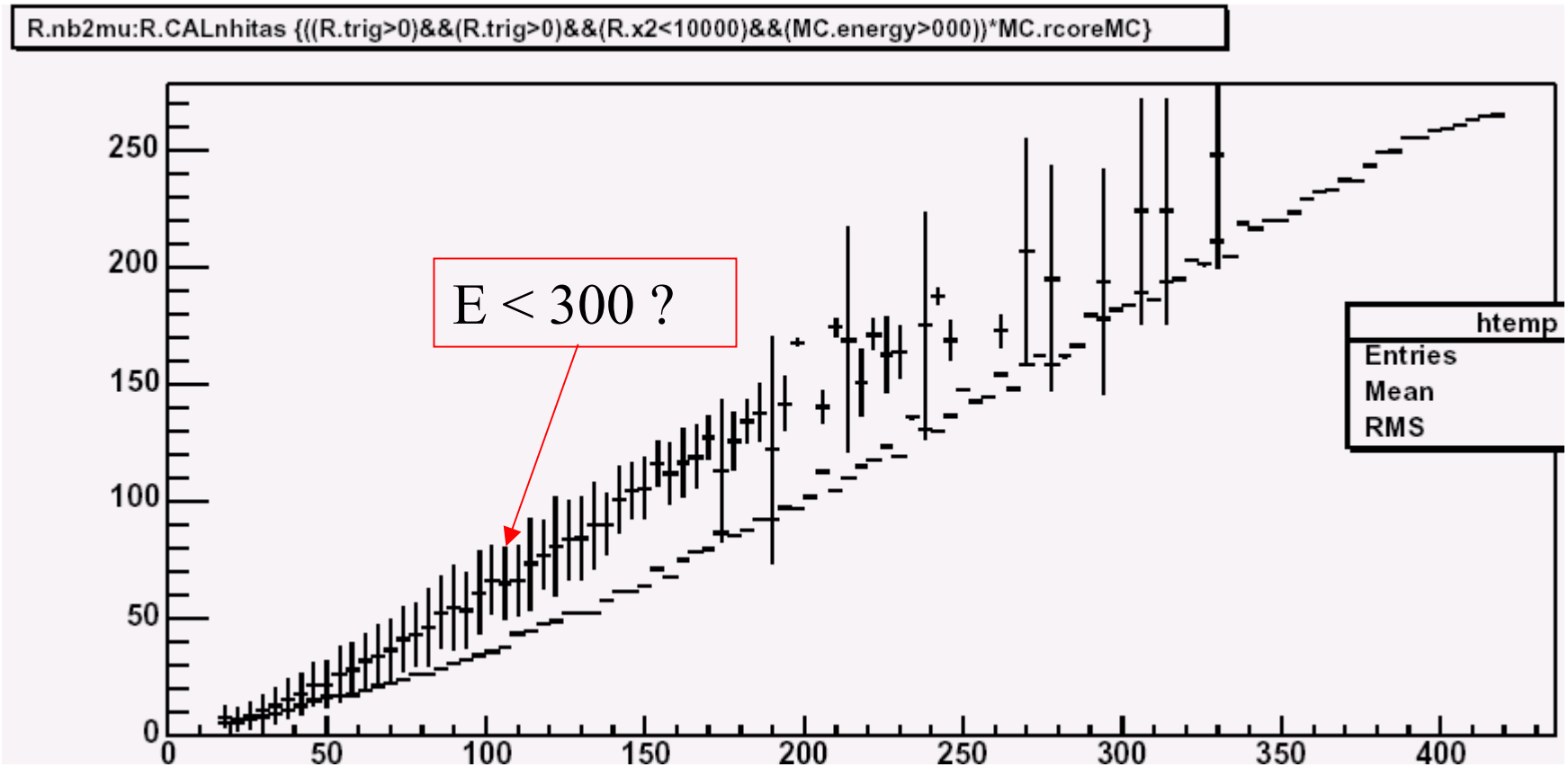
Q vs Efficiency, All-E Shape
Qmax 1.76, Efficiency 50%



Deconstructing X2 for T20

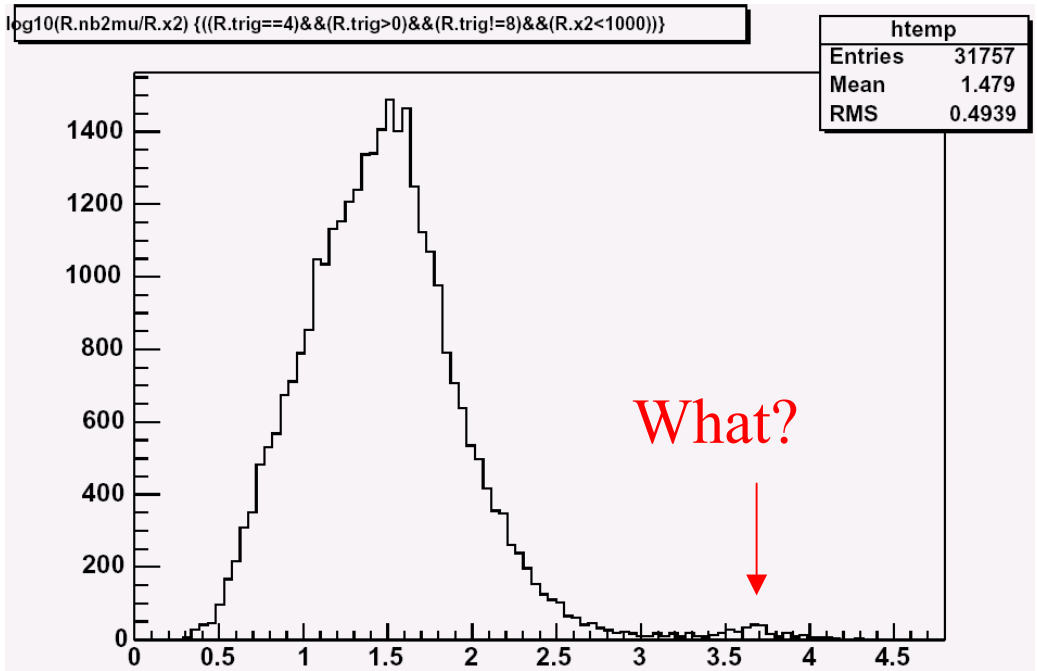
- Disappointed with X2(Nas) rejection
- Nas and Nb2 correlated
- X2 = Nb2/Pemax>cut
- So X2 cut is Nb2 > Pemax × cut
  - Nb2(Nas) > Pemax(Nas) × cut
  - Think of as Pemax cut depending on Nb2
- Plot Nb2, Pemax separately
  - Find better separation than X2

Nb2 correlated with Nas (Gamma MC)



Log10 PeMax for T20

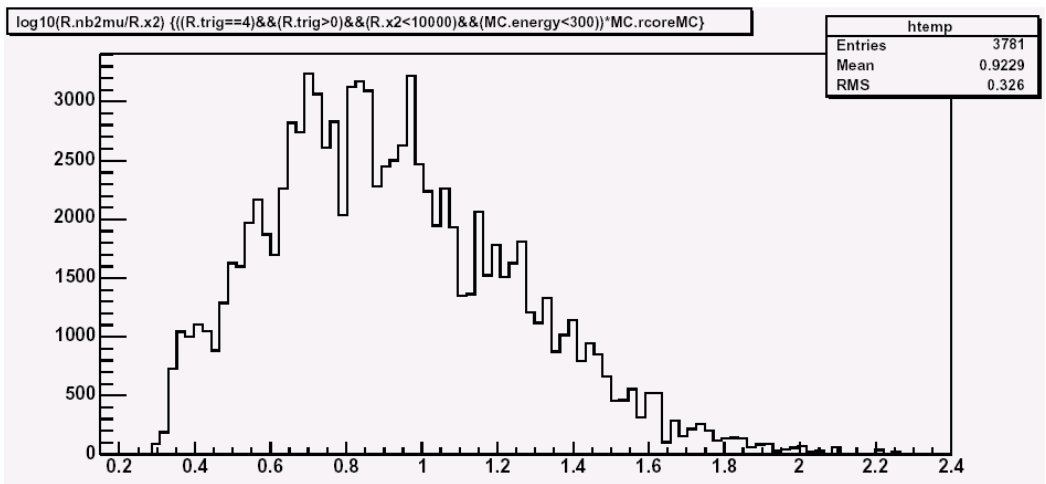
Data 1.5 (.5 rms)



Gamma .9 (.3 rms)

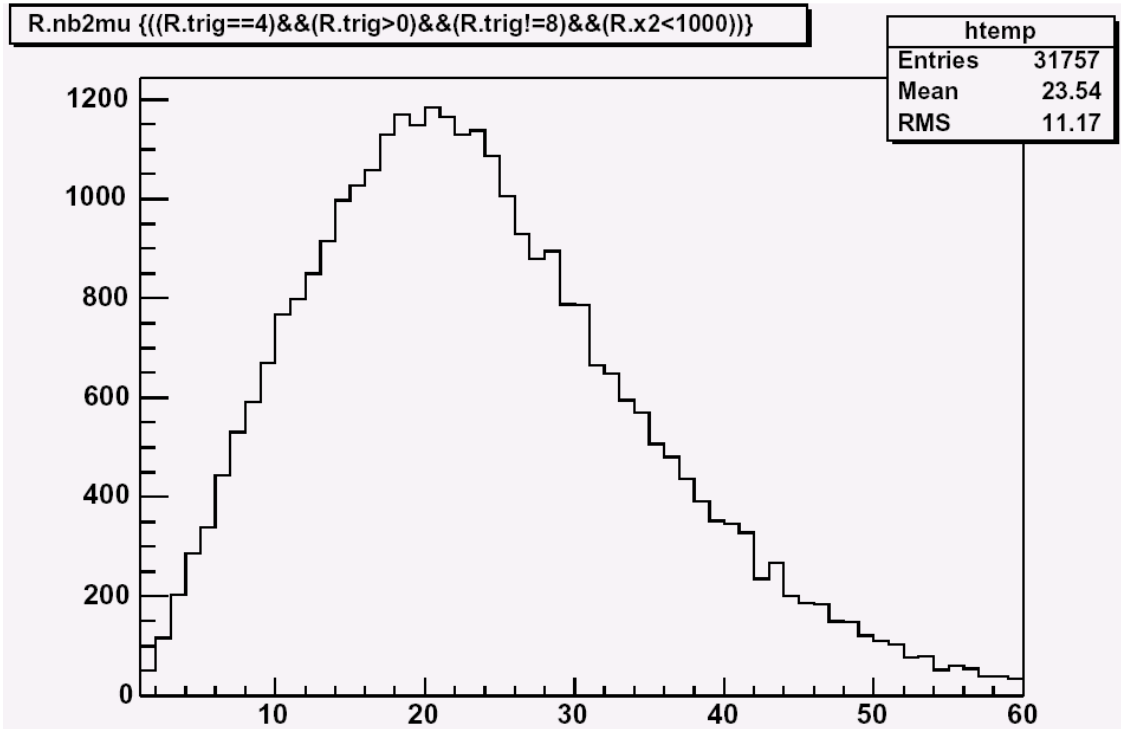
lower than data

ratio: 1.59 (.5 σ/μ)



Nb2 for T20

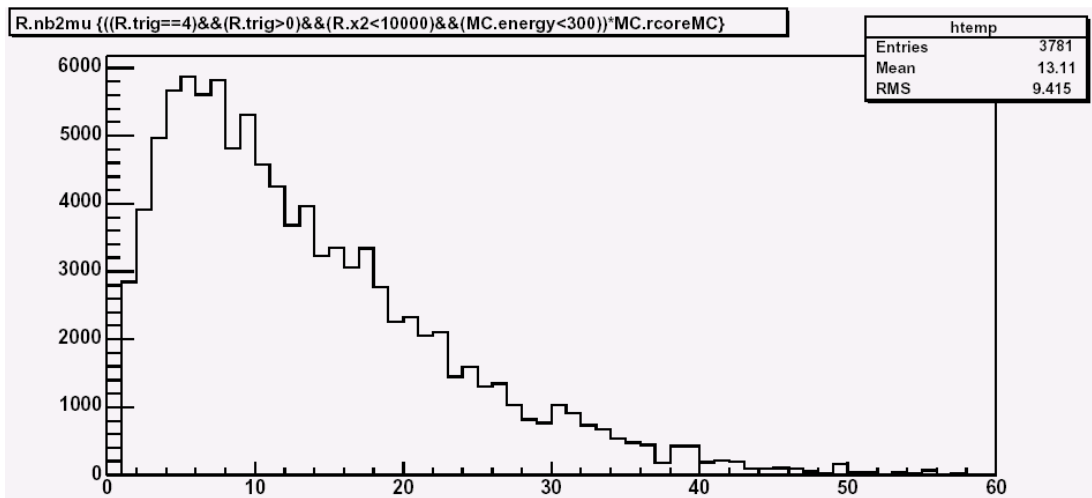
Data: 24 (11 rms)



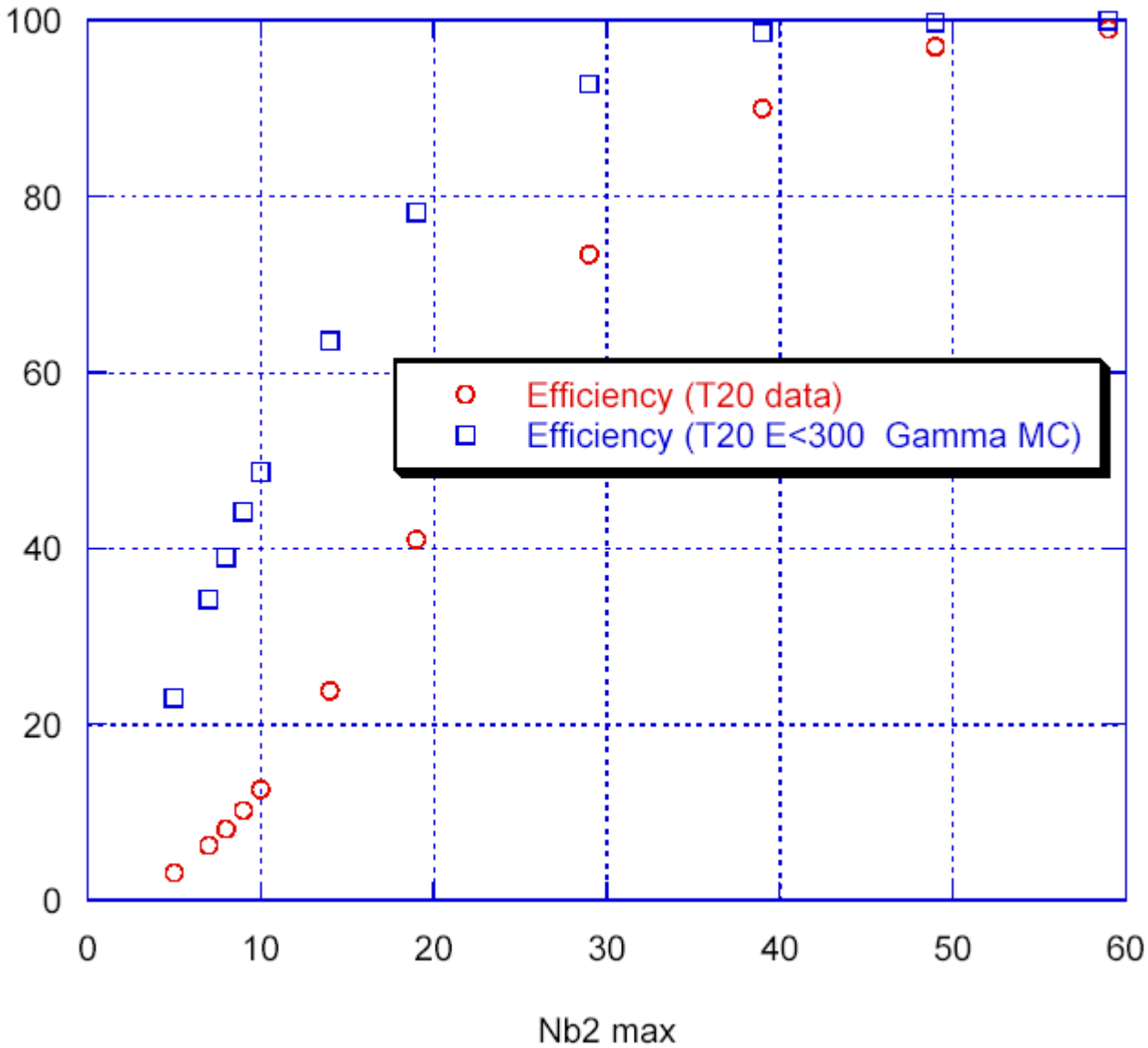
Gamma: 13 (9 rms)

also lower than data

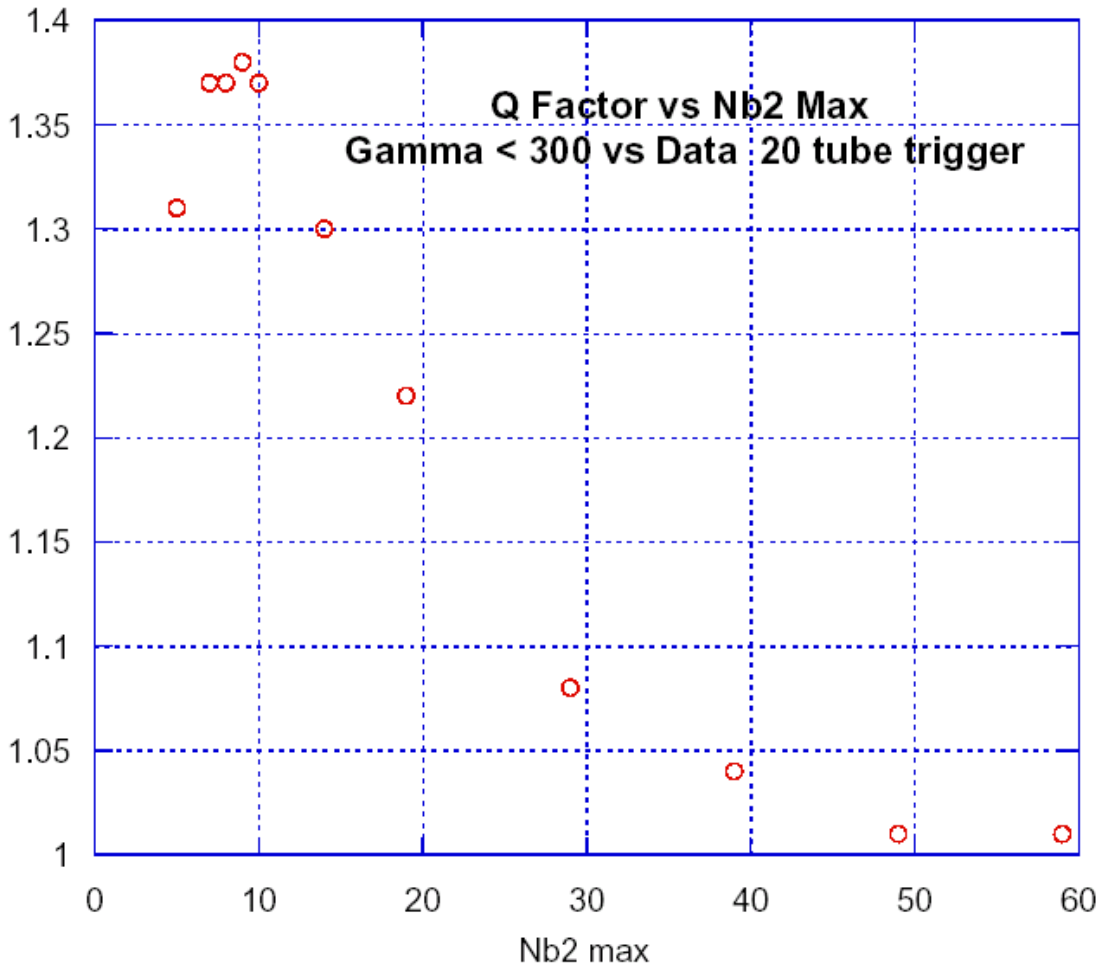
ratio: 1.79 (.9 σ/μ)

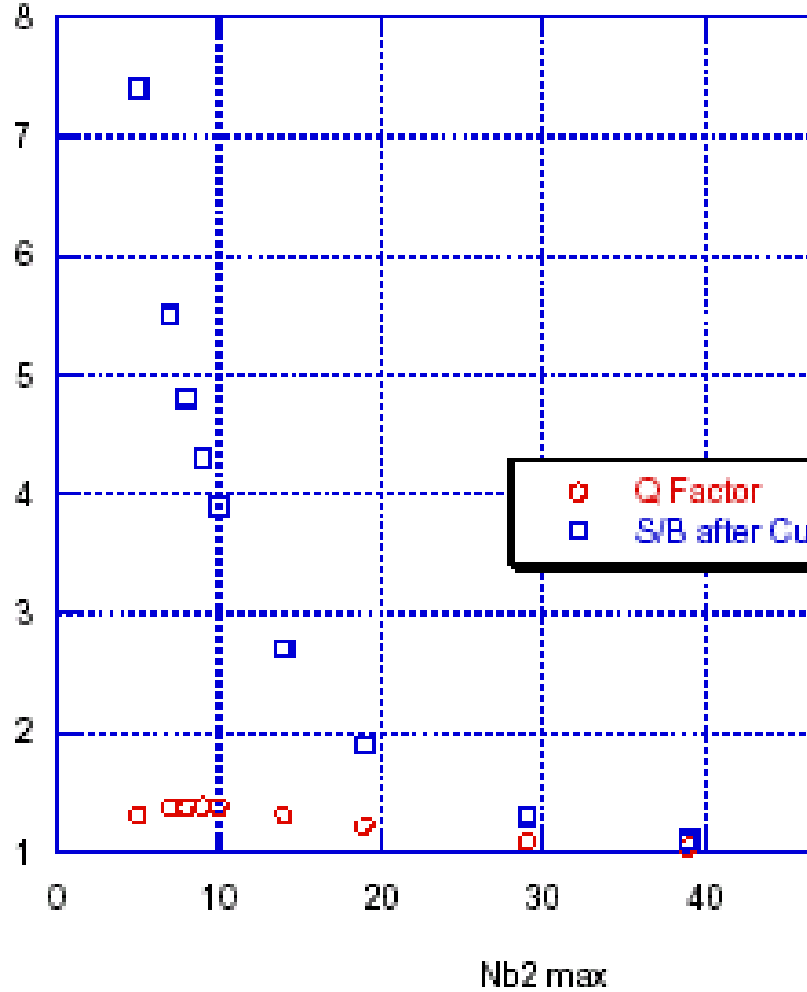


Efficiency for Data, MC: Nb2 < cut



Q up to 1.37; purity enhanced 3-7



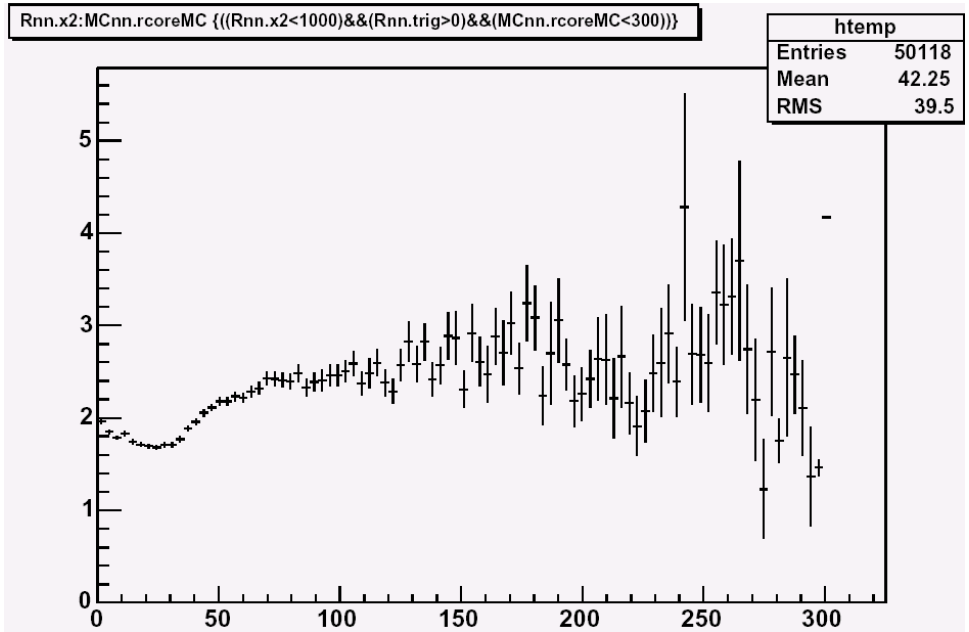


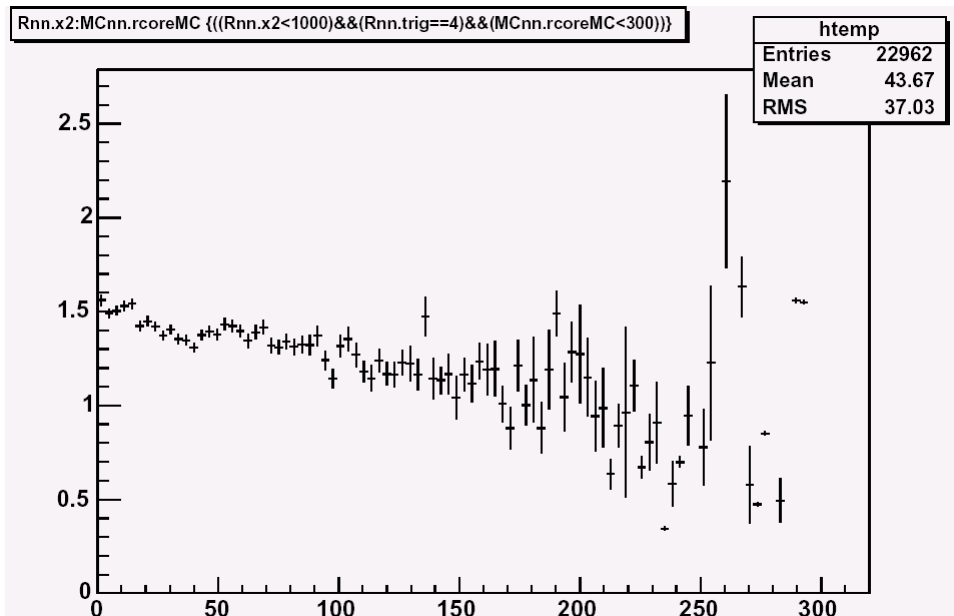
What next?

- Need to remake trees w/ new calibration, MC scale?
  - **Hadron MC must reproduce data: must check**
  - Is Nb2 a better variable than PEMax?
    - Larger ratio h/γ than Pemax, but average σ/μ smaller
    - Should look at Pemax separately as well, but I trust it less in MC
      - Vulnerable to calibration error on a single tube
  - How about Nb8
- Bad news: what if lost all 30% of events w/ muons:
  - Worst case: .7 * Q=1.3 = .91(lose gamma, not hadrons…)
    - Try again with nb8 cut instead of nb2?
- Gus's bright idea:
  - **tight timing cuts** on muon layer before **any** hadron ID
    - Eliminates muon background 20ns/400ns = 5% x 30% = 1.5%
    - A concern with 1-layer detector: can we still do that?

X2 vs. Rcore MC

- Weak dependence
  - When look at all triggers
- X2 largest for Rcore=0, >150





- trig=T20 Lowers <X2> by > .5
- And monotonic decrease now
- Risetime cut drives this?

Rejection from Veto on Number of Outriggers for T20?

- Idea: T20 requires gamma on pond; p's leak off?
  - Maybe group the outriggers by distance from pond edge?
- Cut on <= 1 Calibrated Outrigger hit
  - Data efficiency: 18%
  - MC gamma: 53%
  - **Q = 1.37**
- **A long shot: dubious variable in MC**
  - **Not absolutely sure I rcore-weighted**
- **should re-try with Nb2, Nb:** **but looks less promising**
- **cal >2 >8 outriggers**
  - **Data: 4.3 2.7 1.4**
  - **MC γ : 1.8 1.5 0.9 < 300, T20, std noise…**
  - **Ratio 2.4 1.8 1.6**

Other Avenues for rejection

- **Clustering** in muon layer: better shape analysis?
  - Not obvious from T20 event displays, so quantitative…
- **Extra, early light** for hadrons
  - from upper layer projected to muon layer
    - **Concern is Dt ~ uncertainty in plane tilt**
    - **Did Magda rule out usefulness of early light?**
  - Again not for a 1-layer detector
- **Rcore** dependence from outriggers
  - sMilagro: need fiducial volume cut?
- Must push to understand Milagro had rejection
  - So understand what can simplify in sMilagro

Some Queries

- Physics meetings more regularly?

- Does anyone understand MC of risetime?
- Time dependent trigger threshold (T25)
- Selection of trig bits for crab (bit 8)
- Events with data vme word = 0?
- Sum pe's in event display