GZK-40
May 17, 2006

SUPPRESSING ARTIFICIAL FLUCTUATIONS IN SIMULATED AIR SHOWERS

Sergey Troitsky (INR)

ARTIFICIAL fluctuations in SIMULATED showers

WELCOME TO THE REAL WORLD!

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SUPPRESSING ARTIFICIAL FLUCTUATIONS IN SIMULATED AIR SHOWERS

Sergey Troitsky (INR)

- FLUCTUATIONS DUE TO THINNING
- ECONOMIC WAYS TO SUPPRESS THEM

ARTIFICIAL FLUCTUATIONS DUE TO THINNING

- SHOULD BE SMALLER THAN PHYSICAL FLUCTUATIONS
- MAY BE IMPORTANT FOR COMPOSITION STUDIES

ARTIFICIAL FLUCTUATIONS DUE TO THINNING

- NORMALLY SMALLER THAN PHYSICAL FLUCTUATIONS
- MAY BE IMPORTANT FOR COMPOSITION STUDIES
- MAY BE STUDIED
  (USE THE LIBRARY OF SHOWERS SIMULATED WITHOUT THINNING!)

ARTIFICIAL FLUCTUATIONS DUE TO THINNING

SEPARATION OF PHYSICAL FLUCTUATIONS FROM ARTIFICIAL ONES

- PHYSICAL FLUCTUATIONS ARE DOMINATED BY THE FIRST INTERACTION
- APPROXIMATION: NO OTHER SOURCES OF PHYSICAL FLUCTUATIONS
- VALIDITY: DEPENDS ON THE MULTIPLICITY OF THE FIRST INTERACTION

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WANT TO QUANIFY ARTIFICIAL FLUCTUATIONS FOR OBSERVABLES:

- $S(600)$
- $\rho_\mu(1000)$
- $X_{\max}$

ARTIFICIAL FLUCTUATIONS DUE TO THINNING

- SIMULATE A SHOWER WITHOUT THINNING

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- RECONSTRUCT $S(600)_{\rm true}, \;\; \rho_\mu(1000)_{\rm true}, \;\; X_{\rm max,true}$

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- FIX THE SAME FIRST INTERACTION

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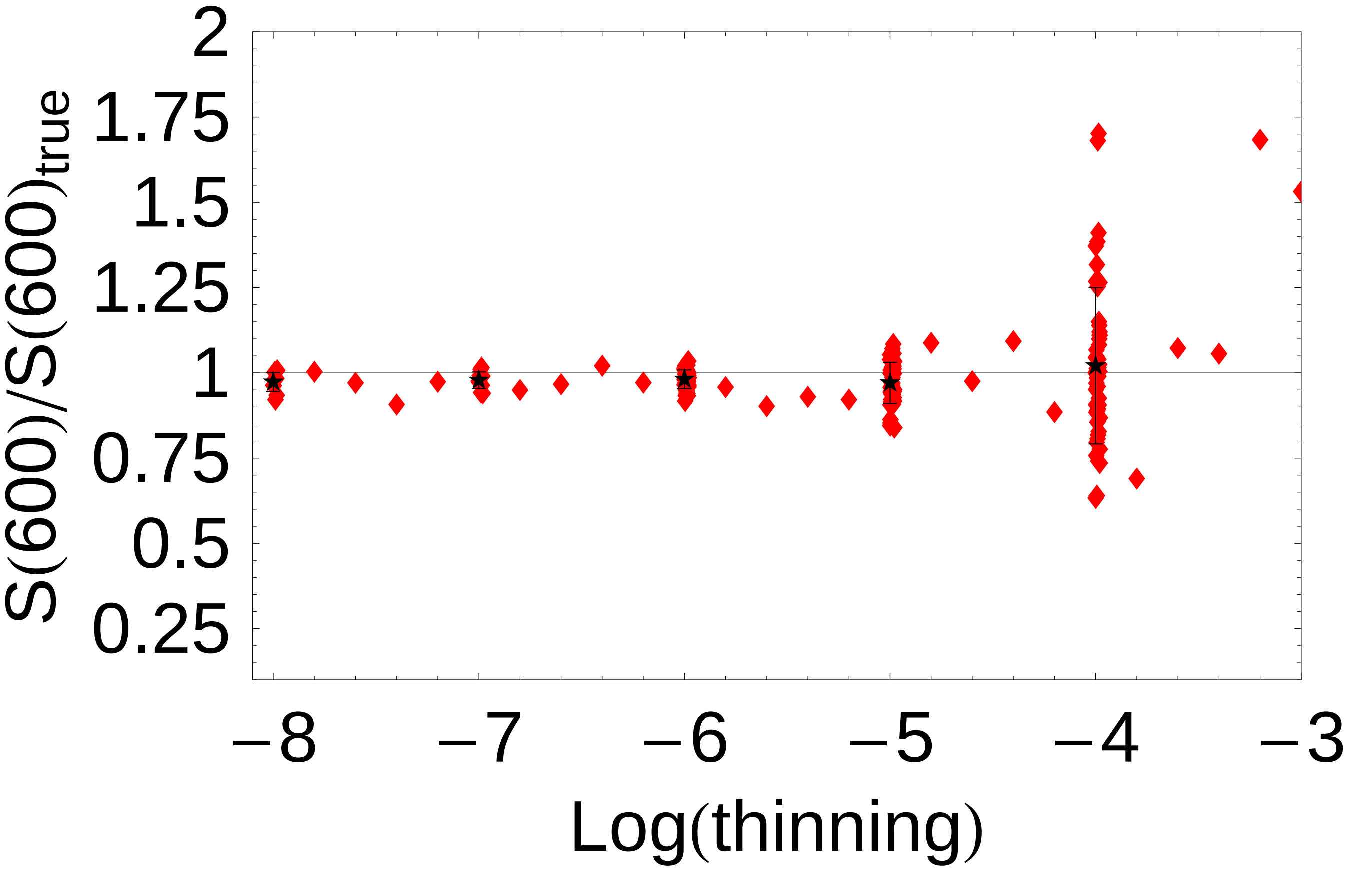
- FIX THE SAME FIRST INTERACTION
- SIMULATE SHOWERS WITH THINNING
- RECONSTRUCT $S(600)$, $\rho_\mu(1000)$, X_{max}
- LOOK AT THE DISTRIBUTIONS OF

$$\frac{S(600)}{S(600)_{\mathrm{true}}}, \quad \frac{\rho_\mu(1000)}{\rho_\mu(1000)_{\mathrm{true}}}, \quad \frac{X_{\mathrm{max}}}{X_{\mathrm{max,true}}}$$

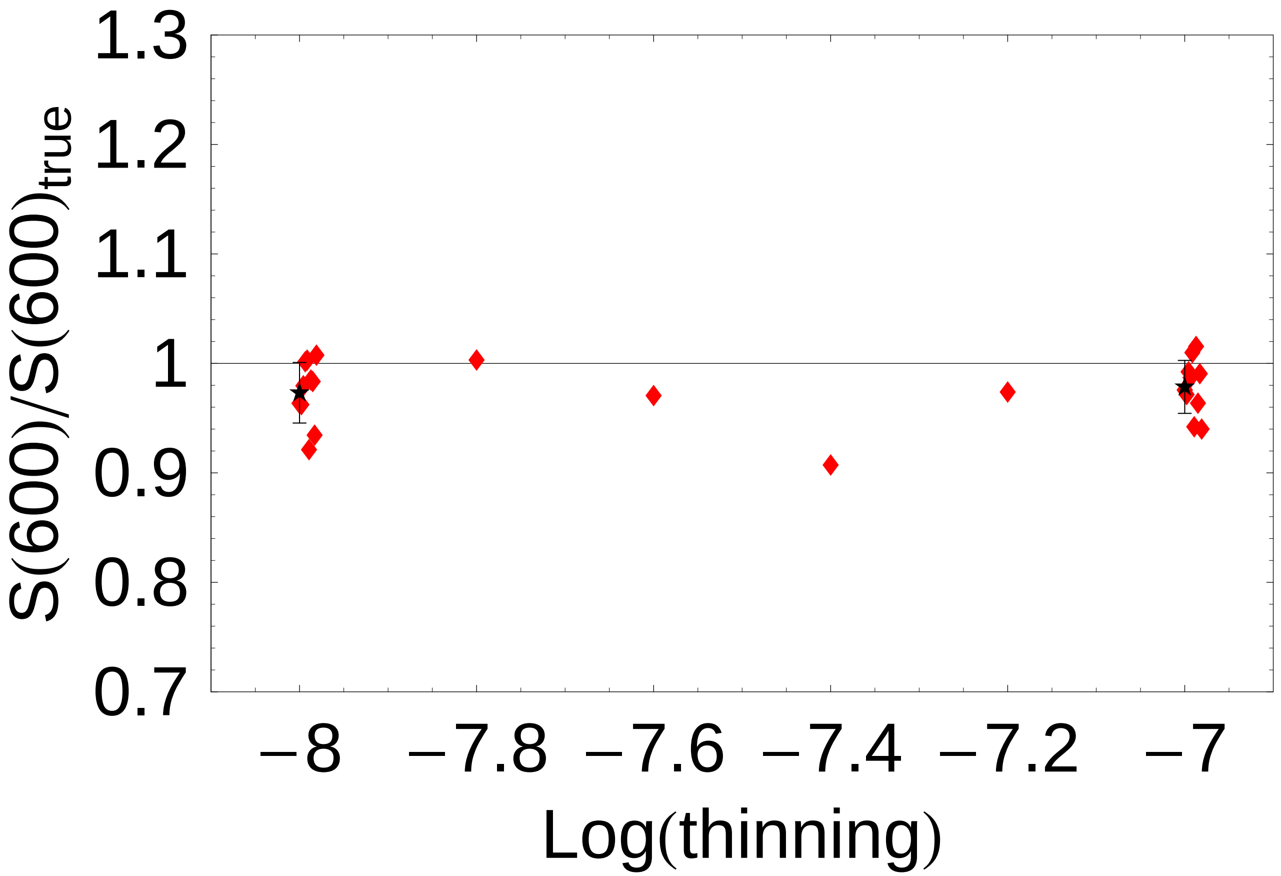
ARTIFICIAL FLUCTUATIONS DUE TO THINNING

FLUCTUATIONS IN $S(600)$



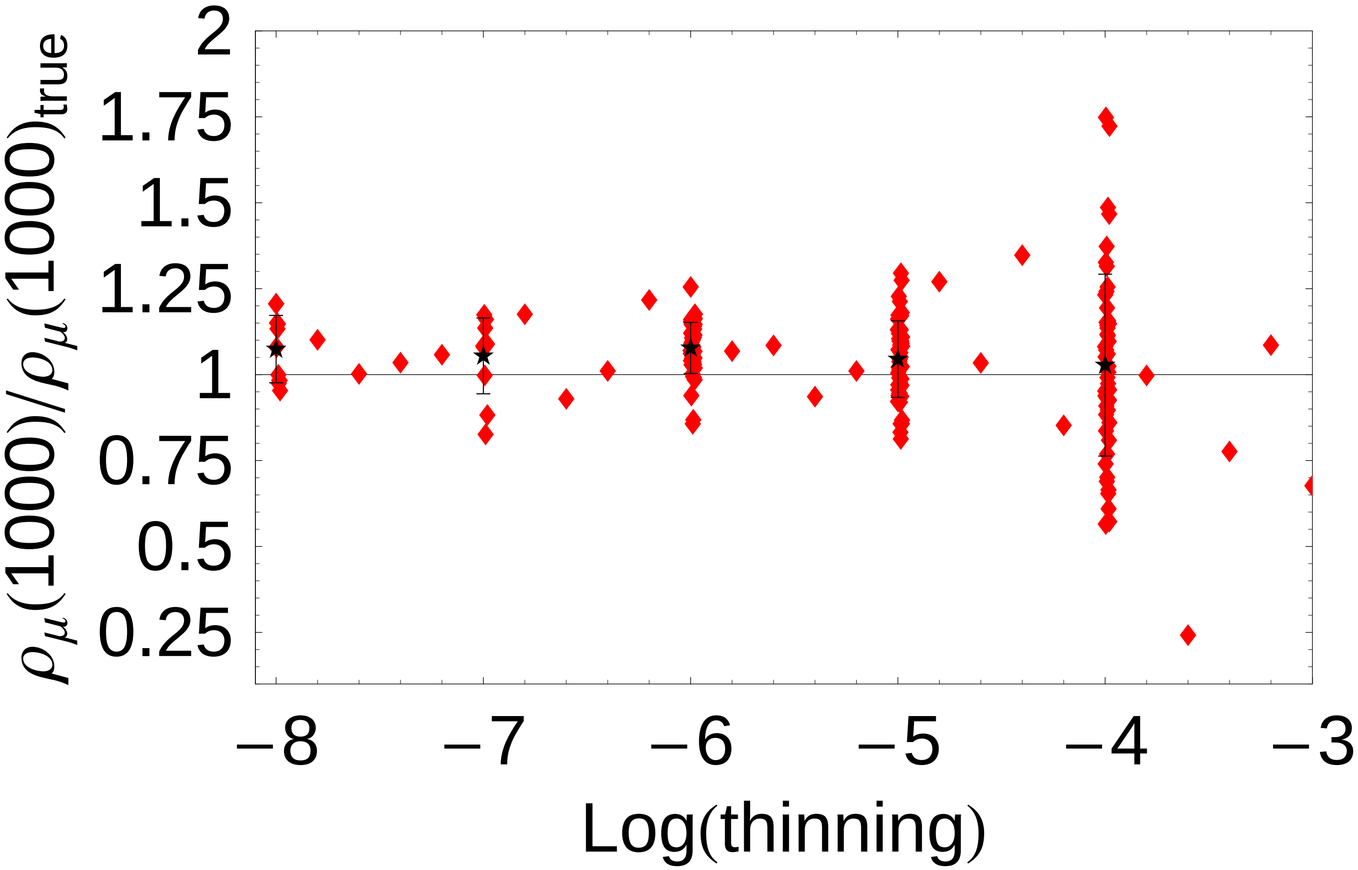
ARTIFICIAL FLUCTUATIONS DUE TO THINNING

FLUCTUATIONS IN $S(600)$: ZOOM IN



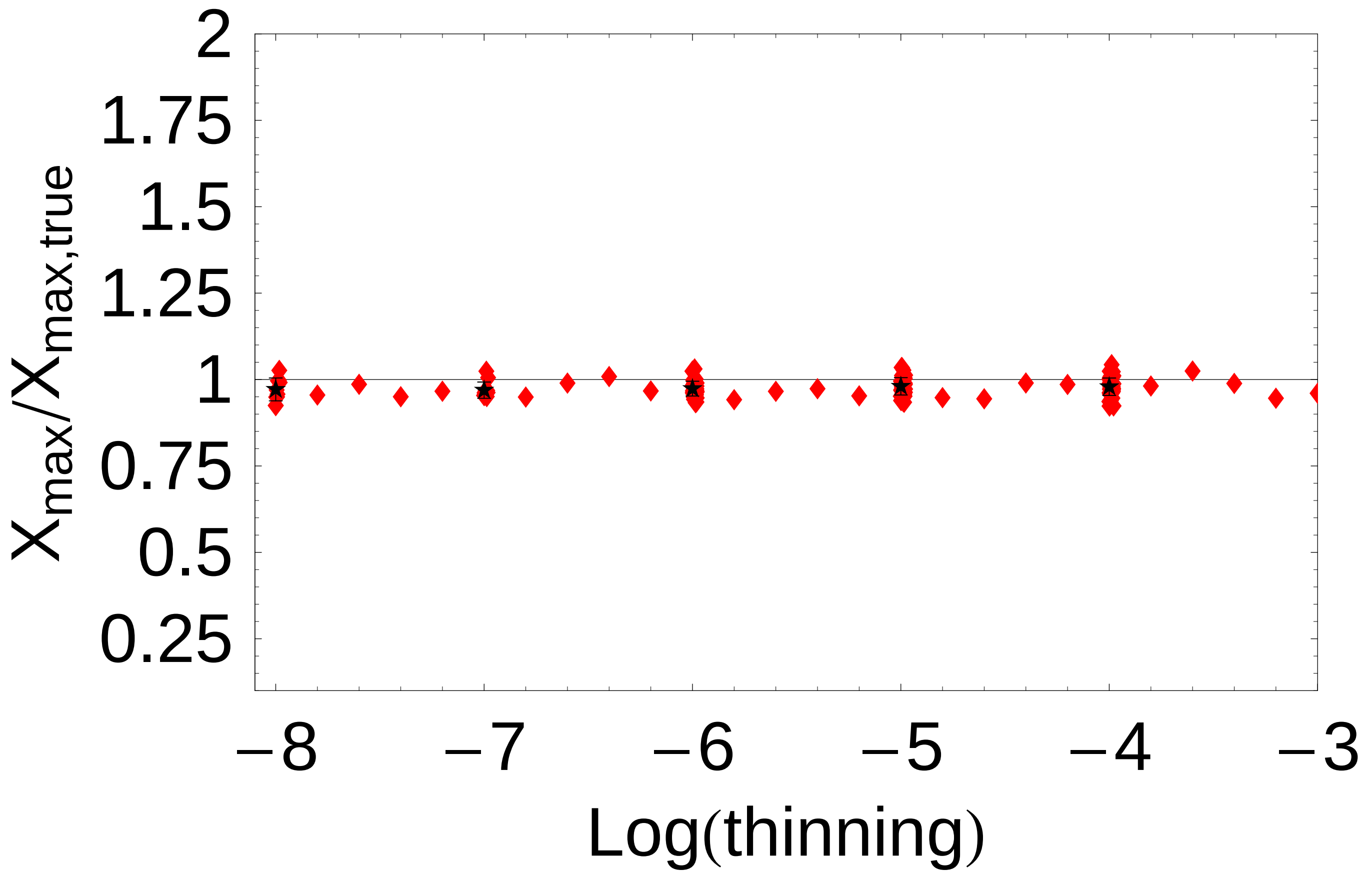
ARTIFICIAL FLUCTUATIONS DUE TO THINNING

FLUCTUATIONS IN $\rho_\mu(1000)$

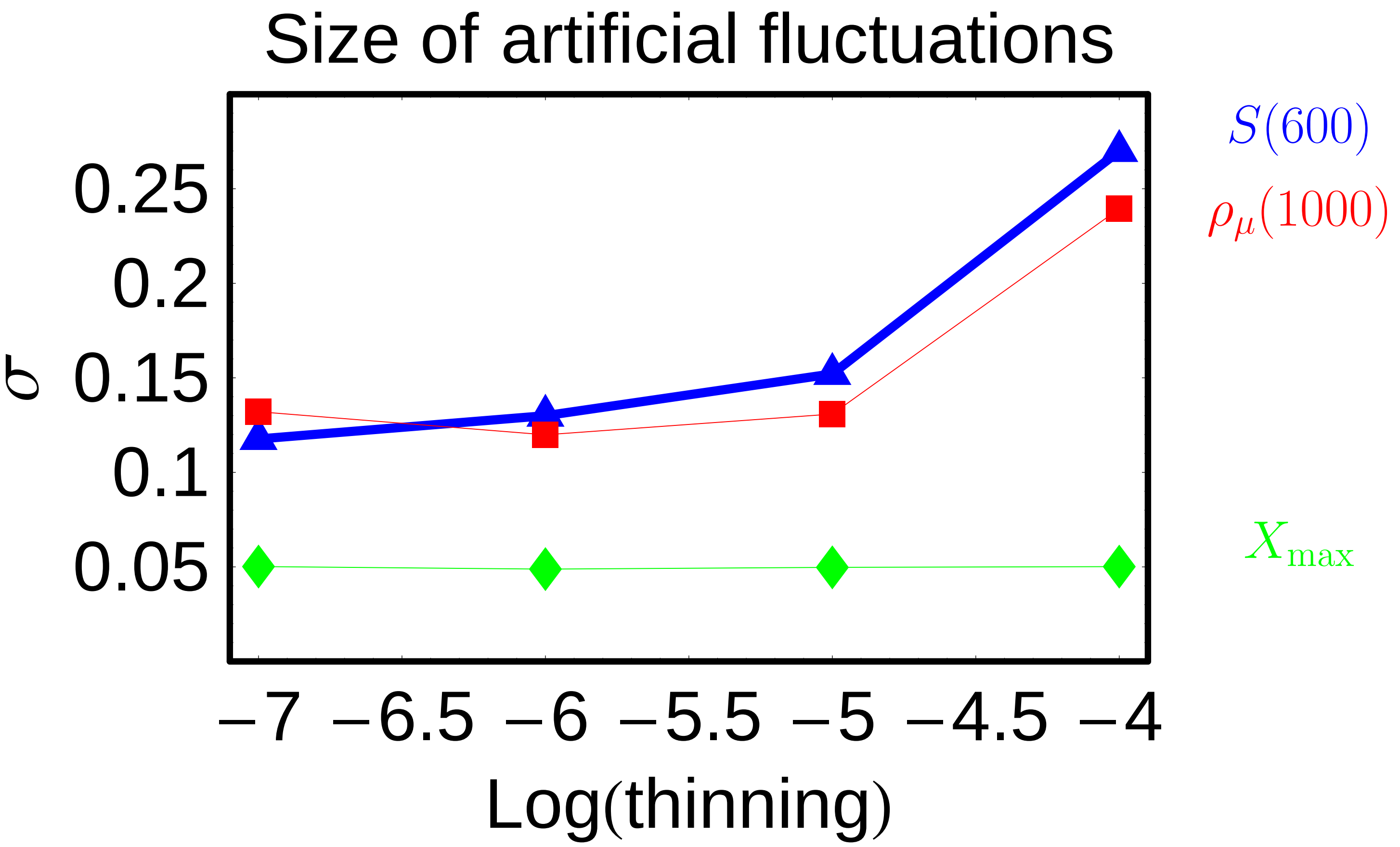


ARTIFICIAL FLUCTUATIONS DUE TO THINNING

FLUCTUATIONS IN $X_{\max}$



ARTIFICIAL FLUCTUATIONS DUE TO THINNING



SUPPRESSION OF ARTIFICIAL FLUCTUATIONS

- REDUCE THINNING? ENORMOUS COMPUTING TIME/RESOURCES

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- LET US INVENT SOMETHING ELSE...

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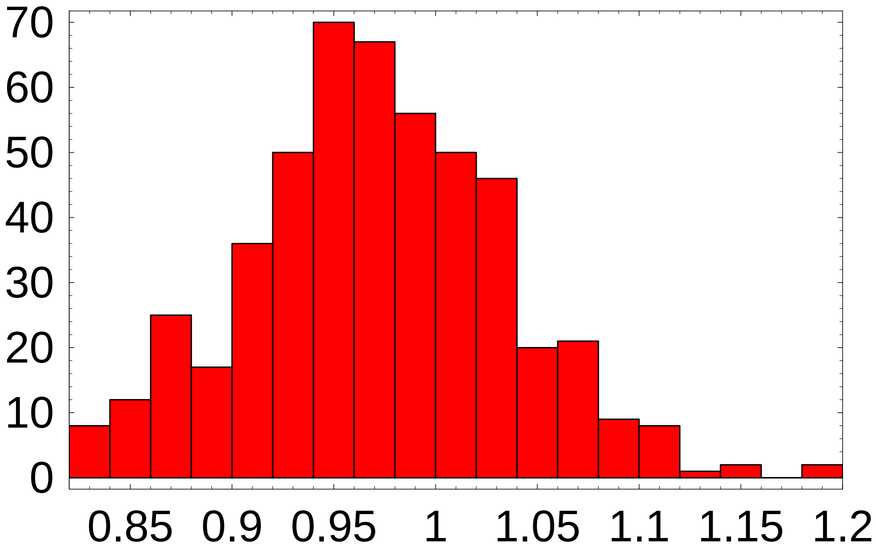
- LET US INVENT SOMETHING ELSE...
- LOOK AT THE DISTRIBUTION OF $S(600)/S(600)_{\mathrm{true}}$ FOR A GIVEN THINNING LEVEL:



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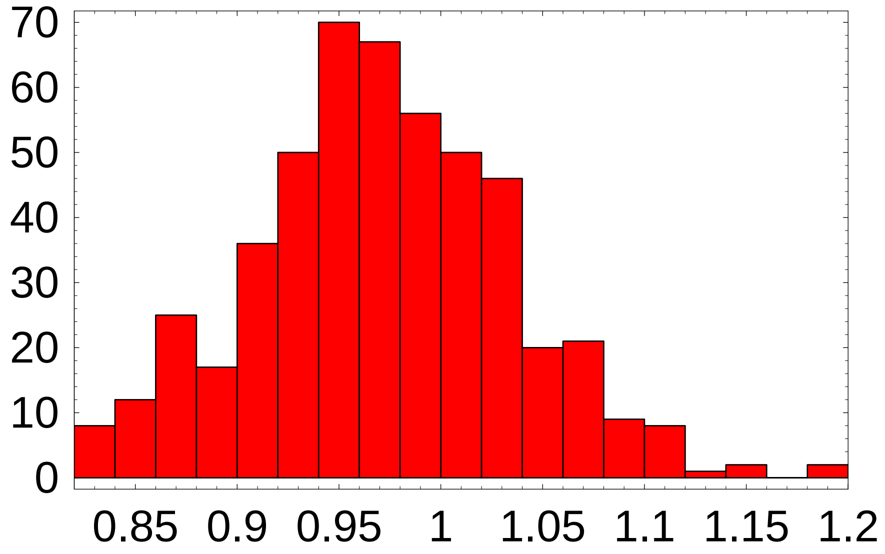

- SUPPOSE IT IS GAUSSIAN WITH THE WIDTH σ

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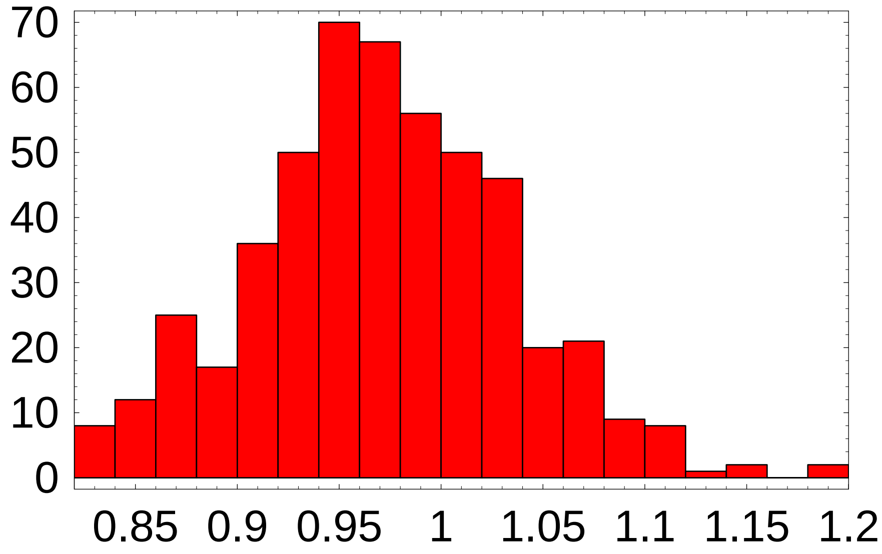
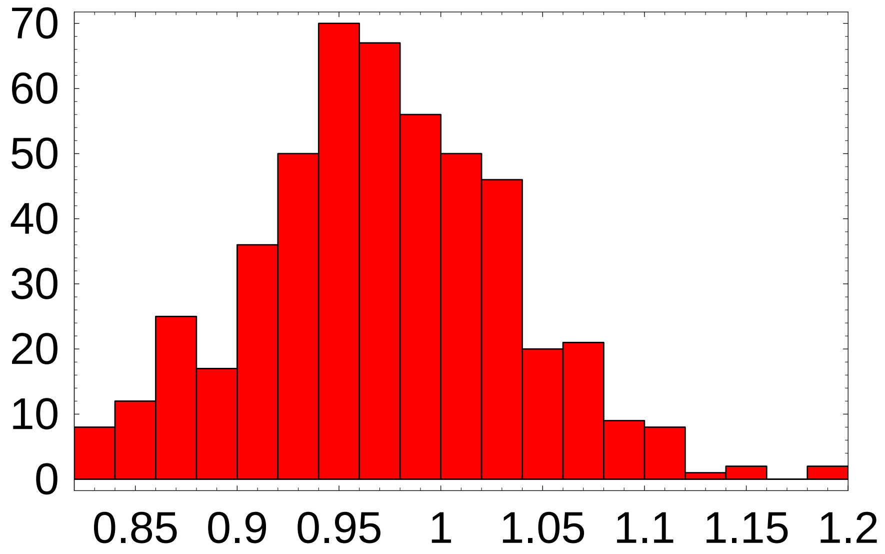


- SUPPOSE IT IS GAUSSIAN WITH THE WIDTH σ
- MAKE N MEASUREMENTS

SUPPRESSION OF ARTIFICIAL FLUCTUATIONS

- REDUCE THINNING? **ENORMOUS** COMPUTING TIME/RESOURCES
- LET US INVENT SOMETHING ELSE...
- LOOK AT THE DISTRIBUTION OF $S(600)/S(600)_{\rm true}$ FOR A GIVEN THINNING LEVEL:



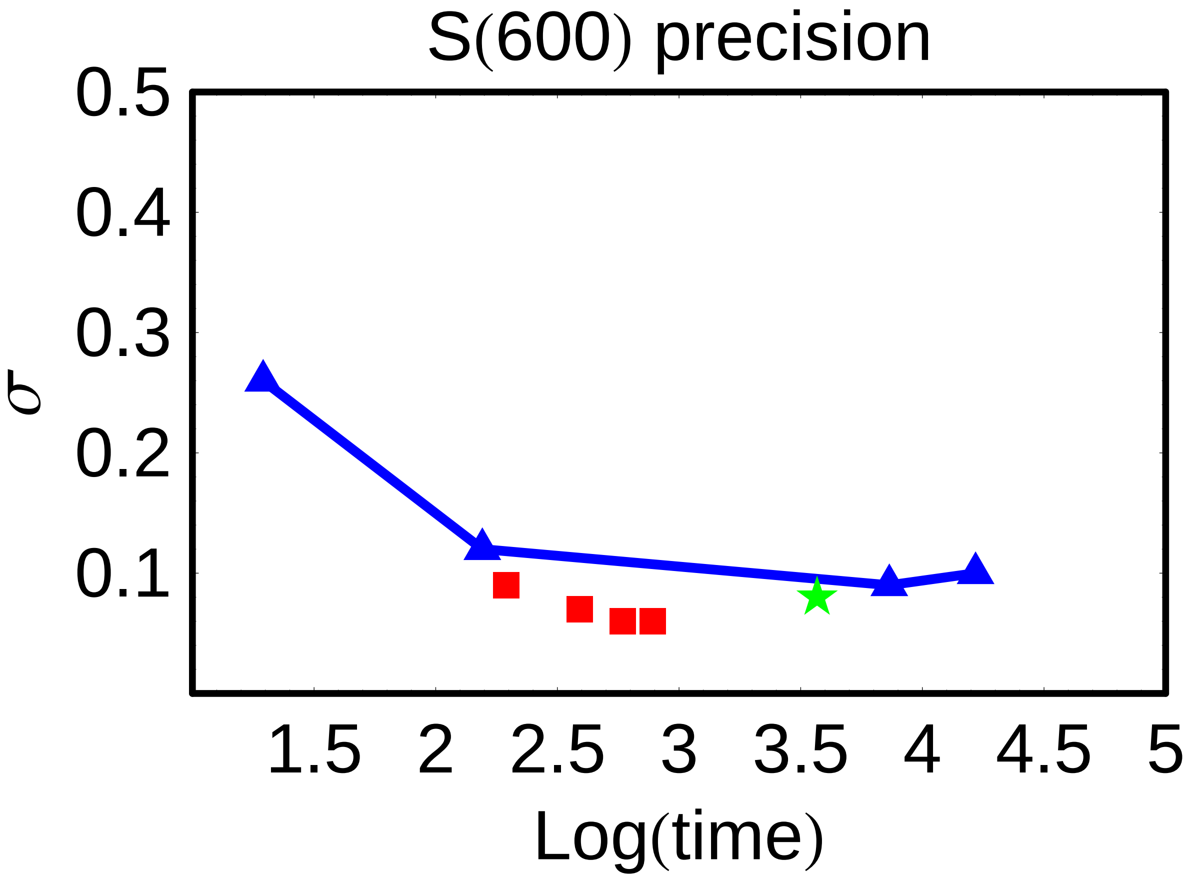
- SUPPOSE IT IS GAUSSIAN WITH THE WIDTH σ
- MAKE N MEASUREMENTS
- YOU KNOW THE MEAN WITH THE PRECISION $\sigma/\sqrt{N}$

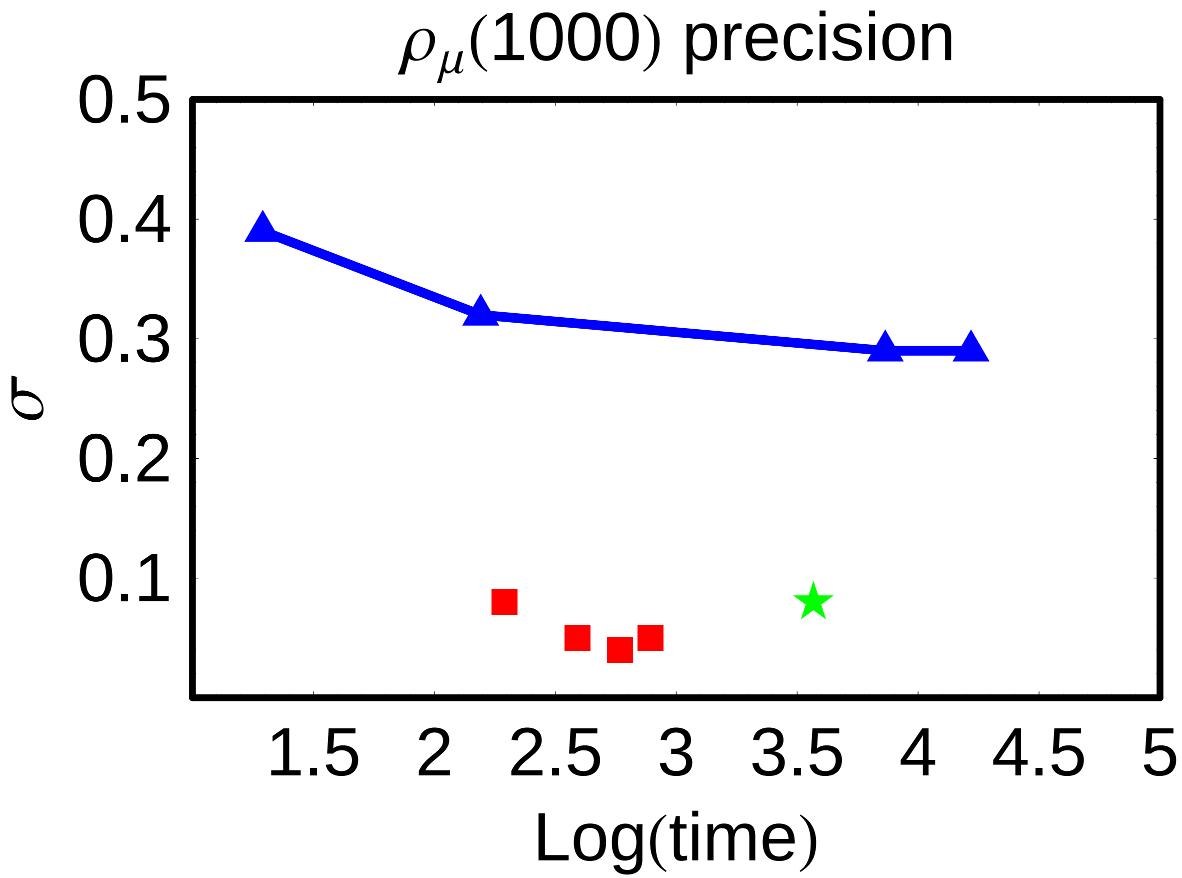
SUPPRESSION OF ARTIFICIAL FLUCTUATIONS

MULTISAMPLING:

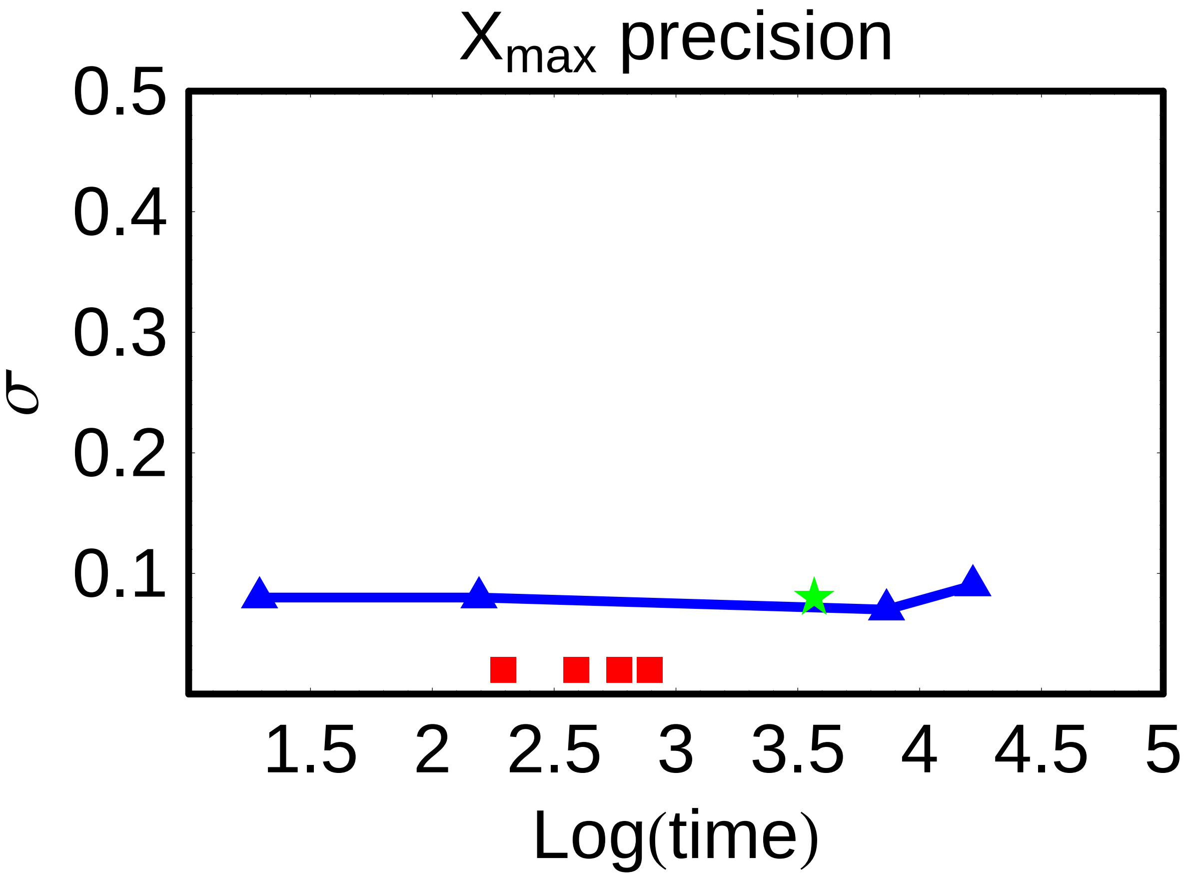
- SIMULATE N SHOWERS WITH STRONG THINNING (LARGE σ)
- MAY BE BETTER THAN ONE SHOWER WITH SMALL σ

COMPARE THE RESOURCES REQUIRED TO OBTAIN A GIVEN PRECISION


S(600) precision
0.5
0.4
0.3
0.2
0.1
σ
1.5
2
2.5
3
3.5
4
4.5
5
Log(time)


$\rho_\mu(1000)$ precision
0.5
0.4
0.3
0.2
0.1
σ
1.5
2
2.5
3
3.5
4
4.5
5
Log(time)

RESOURCES



CONCLUSIONS

- ARTIFICIAL FLUCTUATIONS CAUSED BY THINNING ARE LARGE
- *MULTISAMPLING* IS A WAY TO IMPROVE PRECISION
- COMPARED TO "OPTIMAL THINNING":
  - FACTOR OF 10 GAIN IN TIME
  - FACTOR OF 30 GAIN IN RESOURCES
  - BETTER PRECISION FOR COMPOSITION–DEPENDENT PARAMETERS

ARTIFICIAL fluctuations in SIMULATED showers ARE OVERCOME

WELCOME BACK TO THE WORLD OF REAL SHOWERS!

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- RECEPTION STARTS IN SOME 10 MINUTES

ARTIFICIAL fluctuations in SIMULATED showers ARE OVERCOME

WELCOME BACK TO THE WORLD OF REAL SHOWERS!

- RECEPTION STARTS IN SOME 10 MINUTES
- THE PROGRAM FOR TOMORROW HAS BEEN CHANGED!