Exact Calculation of Disconnected Loops

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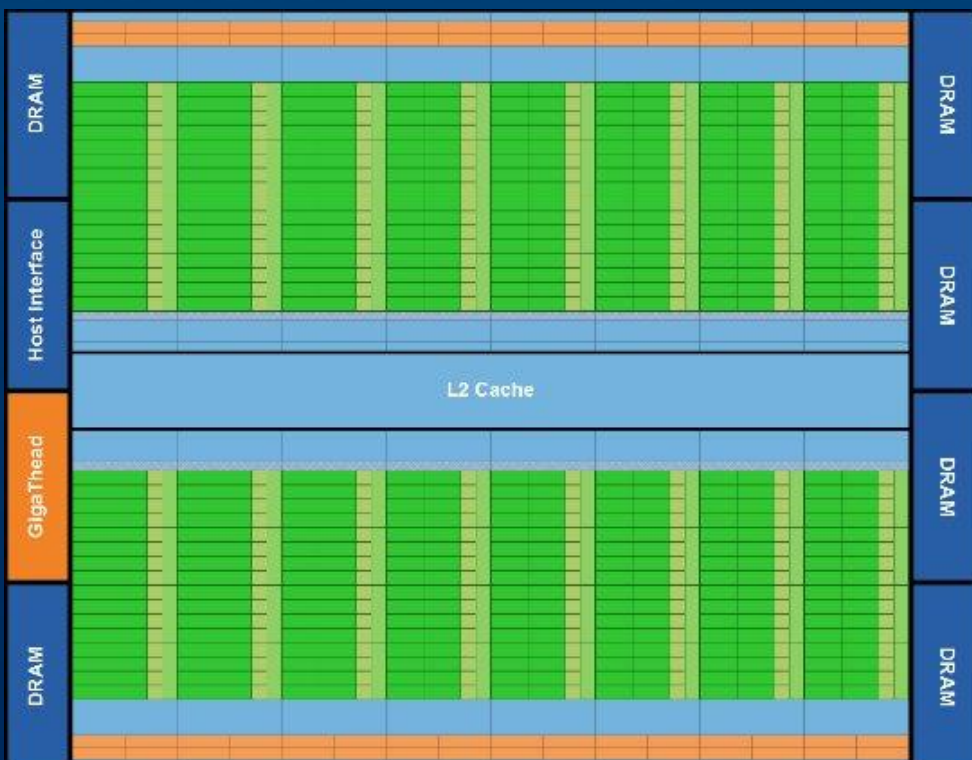
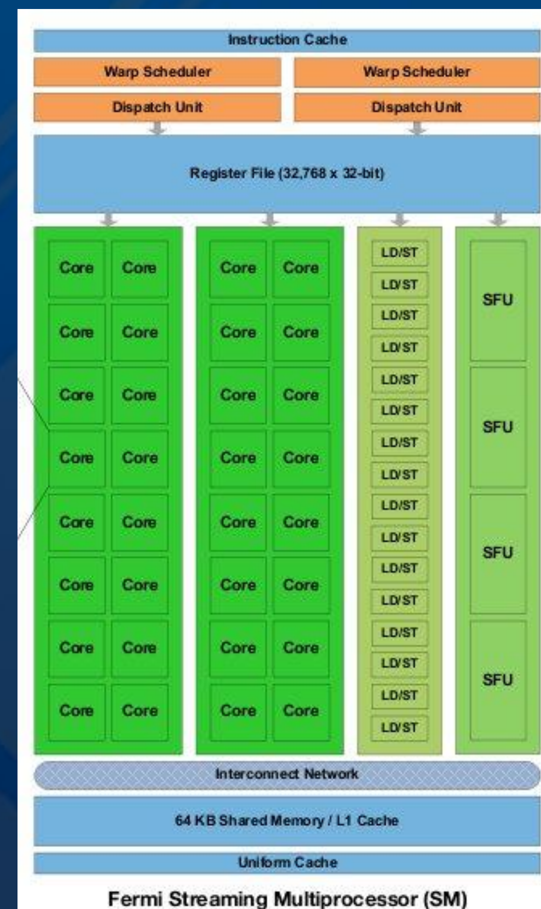
Outline

- “Past”, current and future accelerating coprocessors
- Setup
- Results

GPU Computing

- Technology driven by gaming market
- Huge performance (per €)





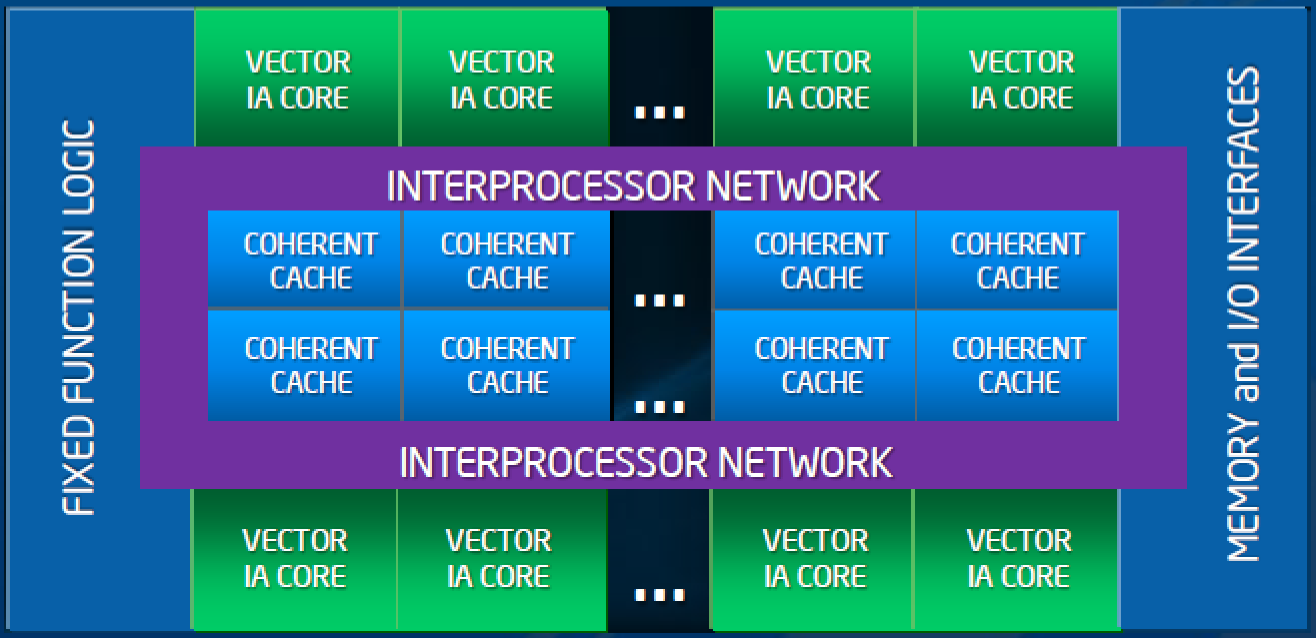
Fermi GPU

- Advancement focus on HPC
- ECC GDDR5 Memory
- 512 cores
- Cache hierarchy
- Greatly improved double precision performance

But…

- Cumulative latencies make device to device communication a challenge

MIC Architecture



- Common CPU/co-processor compiler
- Common optimization techniques
- “100”s of threads

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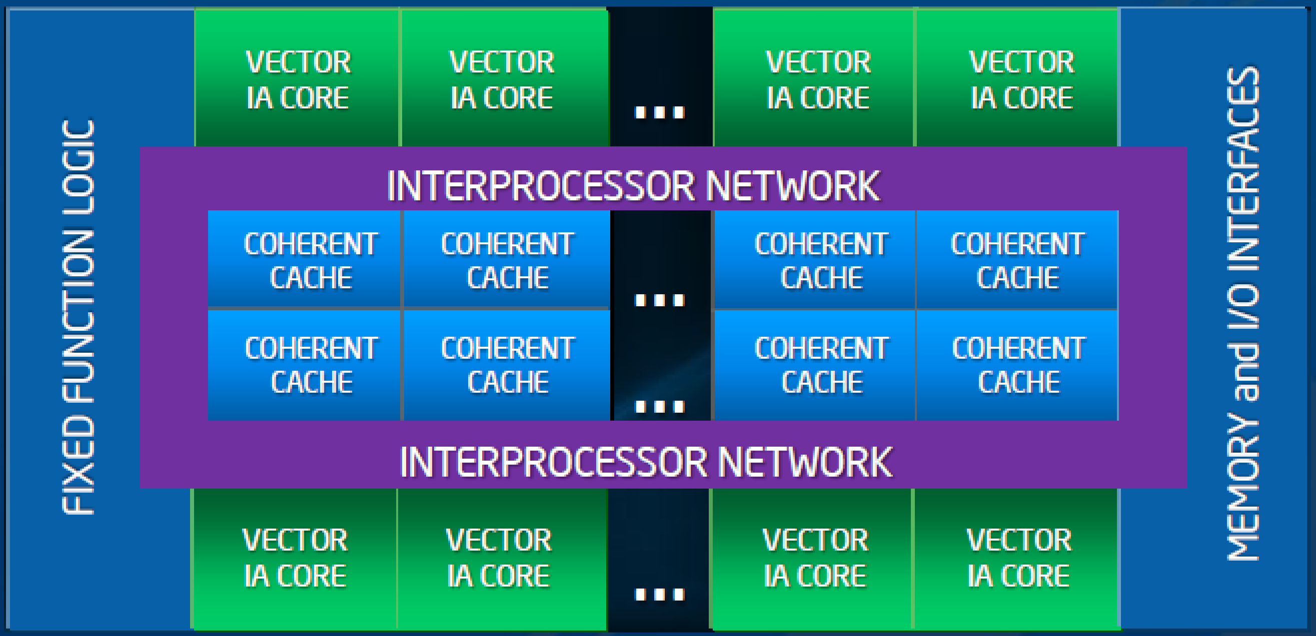
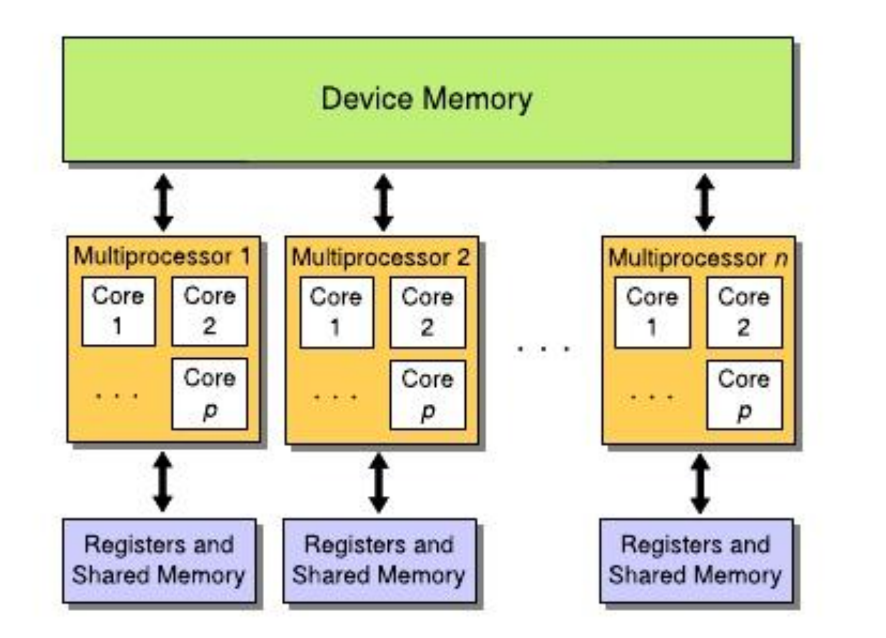
MIC Architecture



- Common CPU/co-processor compiler
- Common optimization techniques
- “100”s of threads…thread-based programming model

Tesla



- 30 multiprocessors consisting of a total of 240 cores
- 4GB RAM
- Compute Unified Device Architecture (CUDA)

Lattice Setup

- 16^3 X 32 lattice volume, ensemble of 53 configs
- SESAM 2 flavour dynamical lattices
- Pion mass of ~880MeV
- Wilson action
- Stoutlink smeared gaugefields
- Jacobi smearing on quarkfields
- QUDA package for inversions
- ~50000 inversions per timeslice

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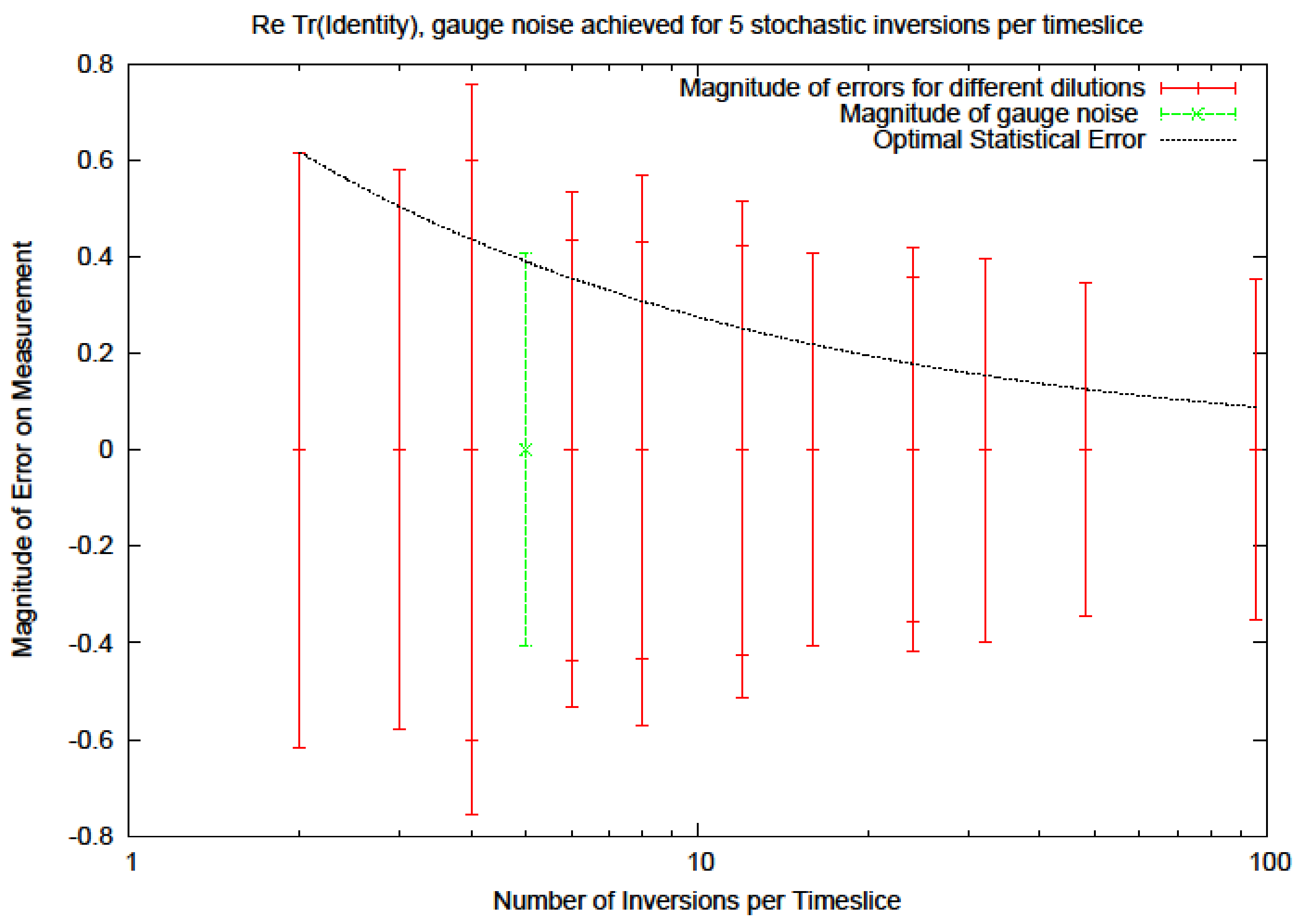
QUDA Hacking

- Modified memory management
- Dynamic algorithm switching

Lattice size	16^3 * 32							
Solver tolerance	1.00E-10							
Algorithm type:	BiCG	CG	BiCG	CG	BiCG	CG	BiCG	CG
CPU gauge field precision:	D	D	D	D	D	D	D	D
GPU gauge field precision:	D	D	D	D	D	D	D	D
Reconstruct type:	8	8	12	12	8	8	12	12
GPU gauge field sloppy precision:	H	H	H	H	S	S	S	S
Sloppy reconstruct type:	12	12	12	12	8	8	12	12
CPU spinor precision:	D	D	D	D	D	D	D	D
GPU spinor precision:	D	D	D	D	D	D	D	D
GPU spinor sloppy precision:	H	H	H	H	S	S	S	S
Avr full time, sec.:	2.11	n/a	2.06	n/a	2.42	4.19	2.47	4.36
Avr inv time, sec.:	0.94	n/a	0.87	n/a	1.24	3.01	1.29	3.18
Avr Gflops for inversion (on GPU)	87.51	n/a	93.86	n/a	64.34	70.56	62.12	66.74


Re Tr(Identity), gauge noise achieved for 5 stochastic inversions per timeslice
Magnitude of errors for different dilutions
Magnitude of gauge noise
Optimal Statistical Error
Magnitude of Error on Measurement
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
1
10
100
Number of Inversions per Timeslice

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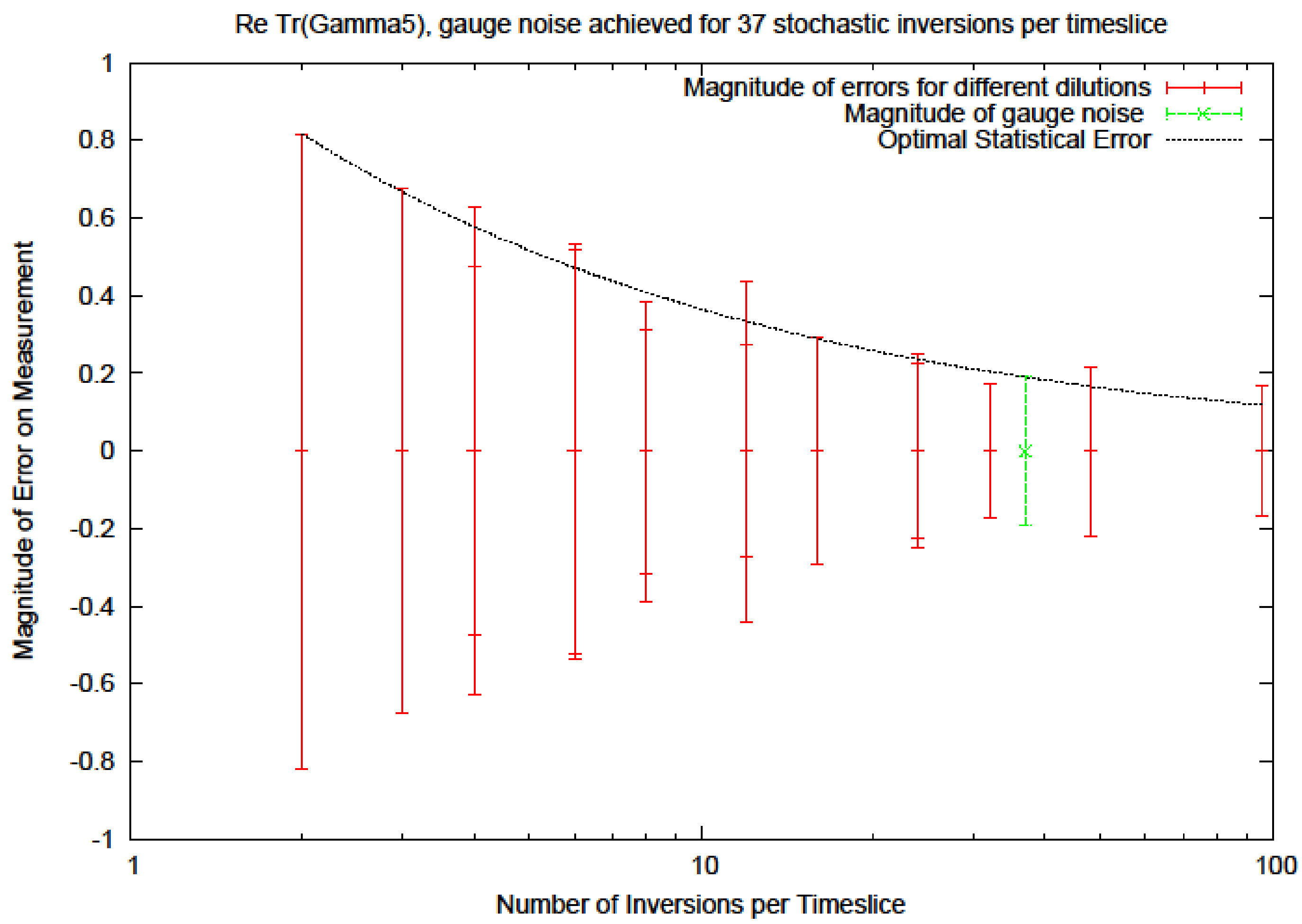

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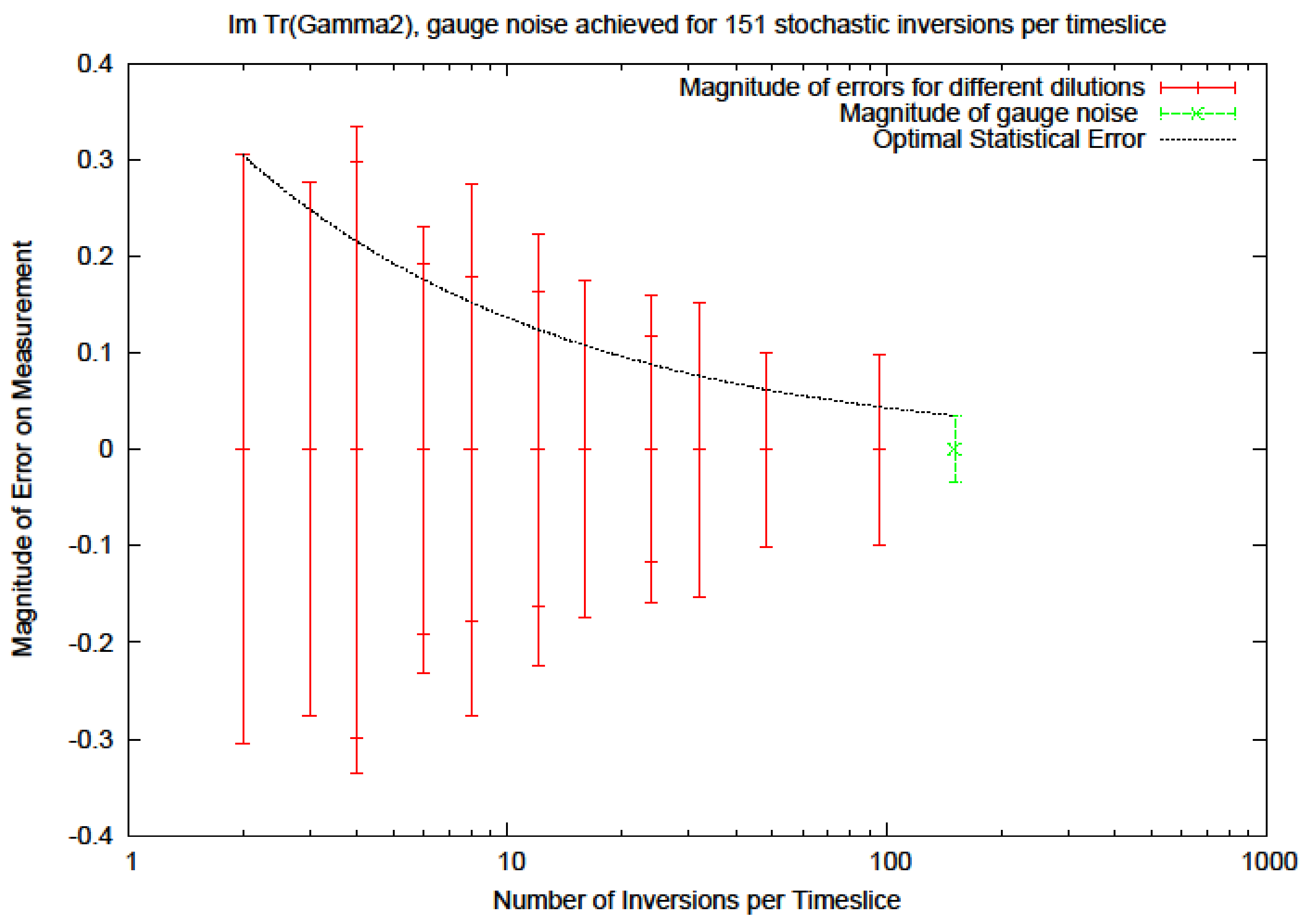
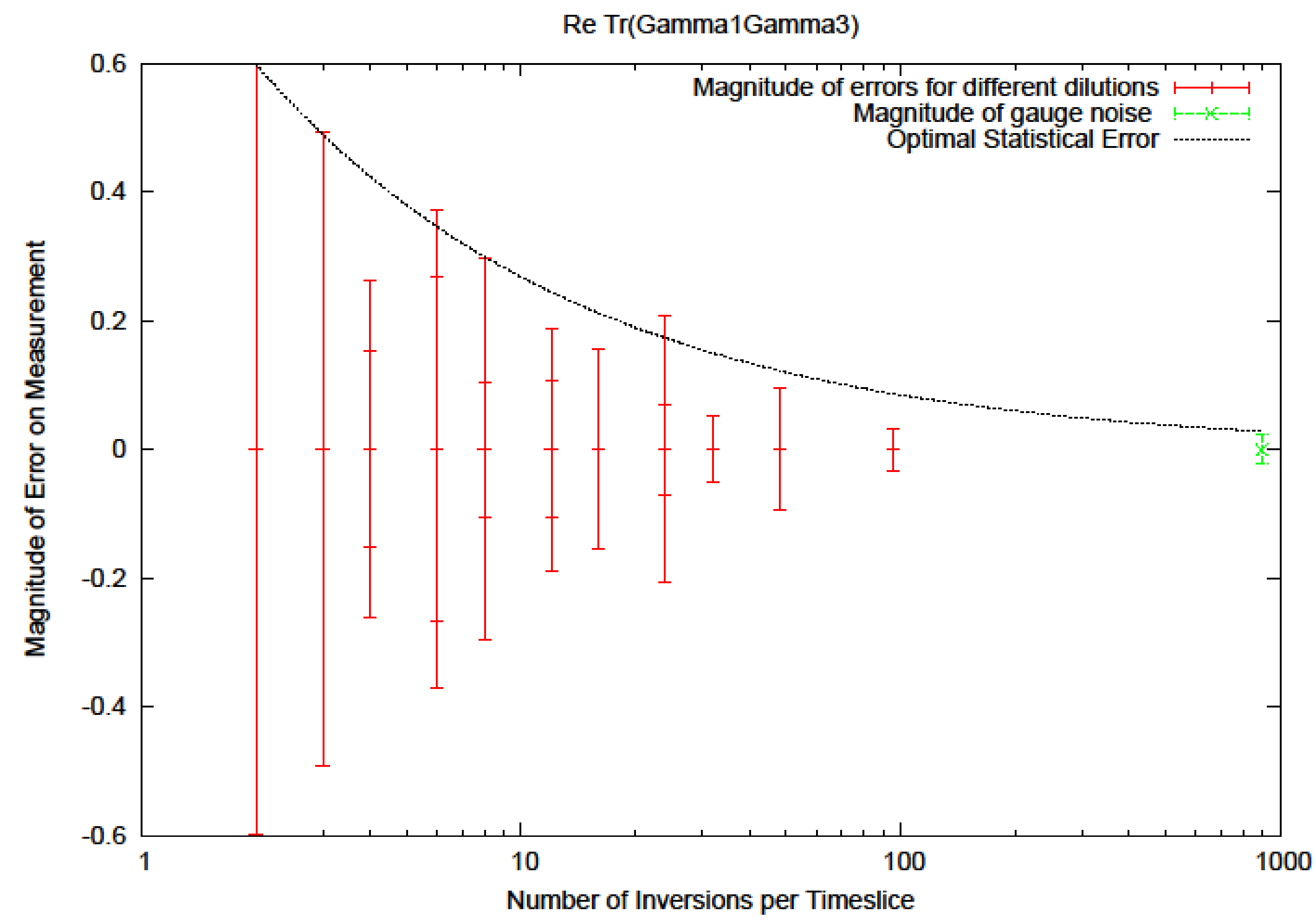
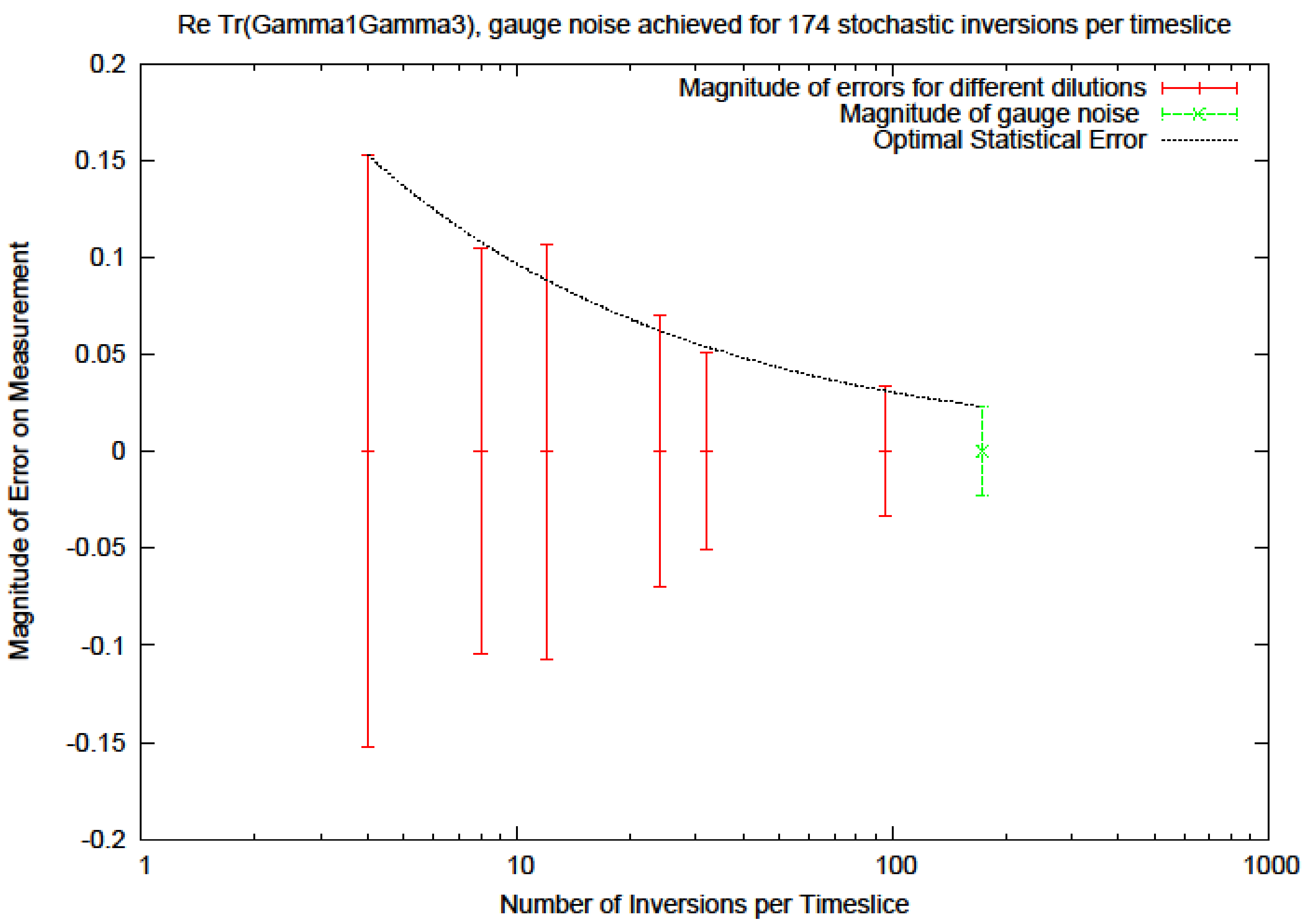
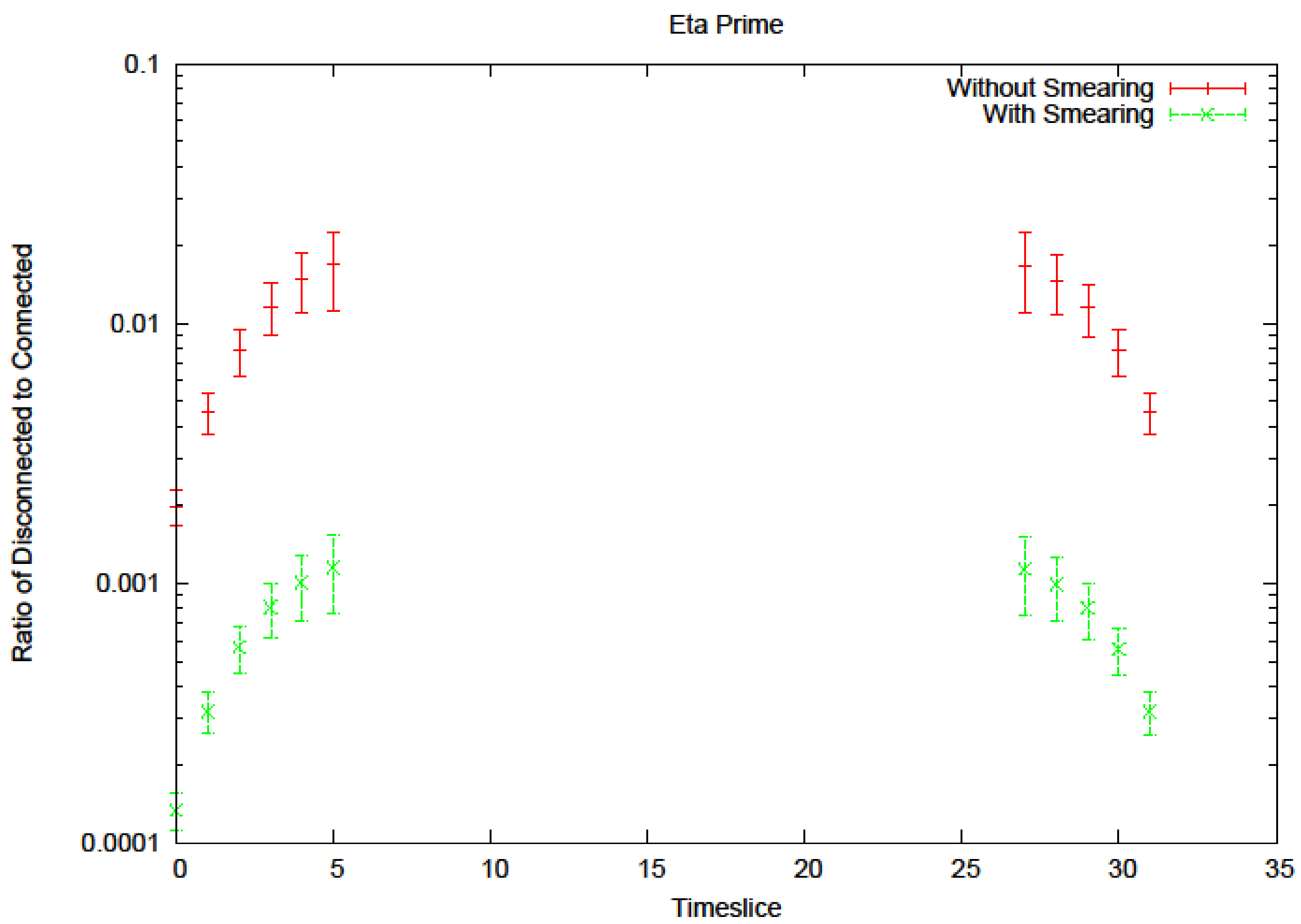



Re Tr(Gamma1Gamma3)
Magnitude of errors for different dilutions
Magnitude of gauge noise
Optimal Statistical Error
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1
10
100
1000
Magnitude of Error on Measurement
Number of Inversions per Timeslice


Re Tr(Gamma1Gamma3), gauge noise achieved for 174 stochastic inversions per timeslice
Magnitude of errors for different dilutions
Magnitude of gauge noise
Optimal Statistical Error
Magnitude of Error on Measurement
Number of Inversions per Timeslice
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
1
10
100
1000


Eta Prime
Without Smearing
With Smearing
Ratio of Disconnected to Connected
Timeslice
0.1
0.01
0.001
0.0001
0
5
10
15
20
25
30
35

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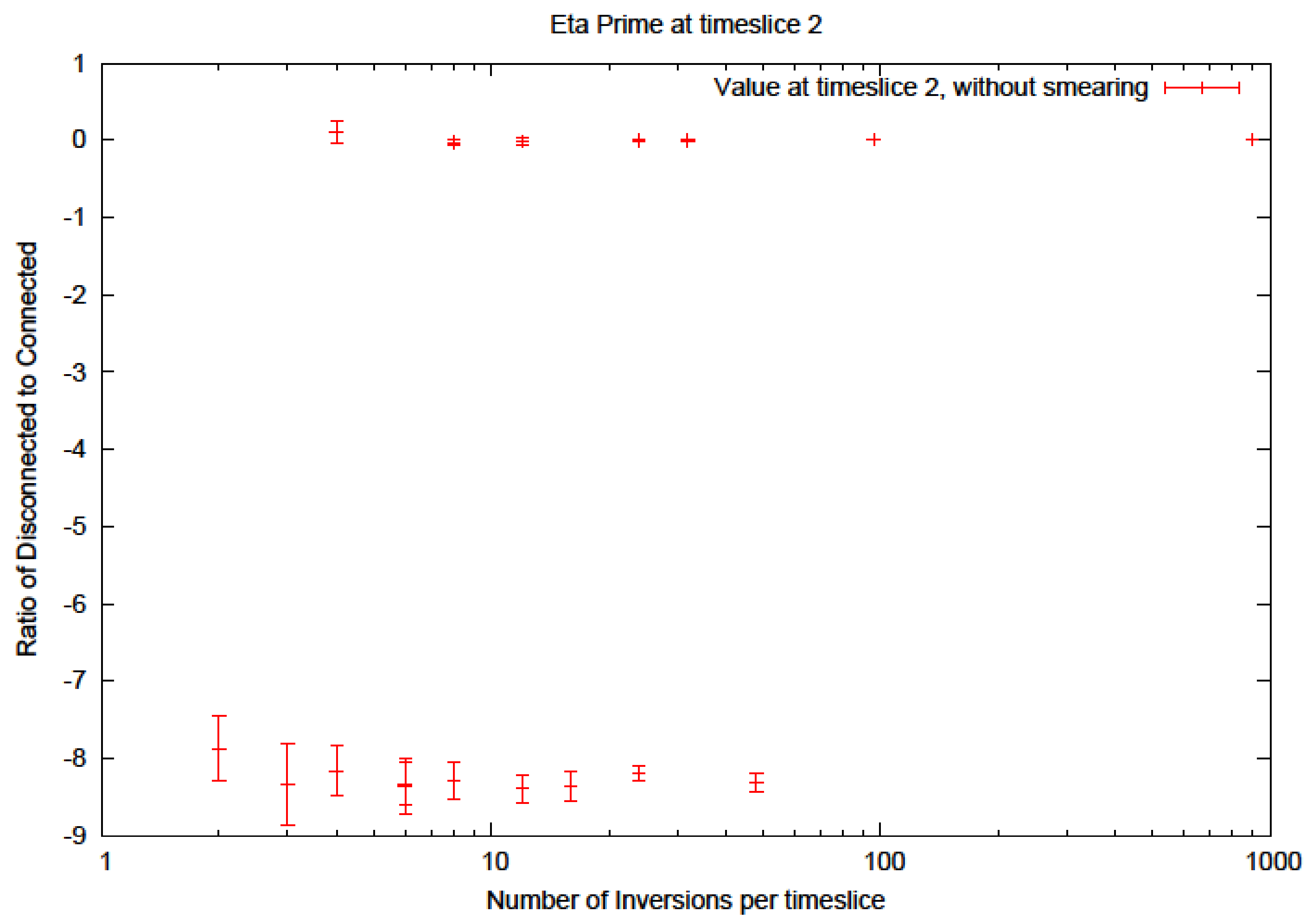
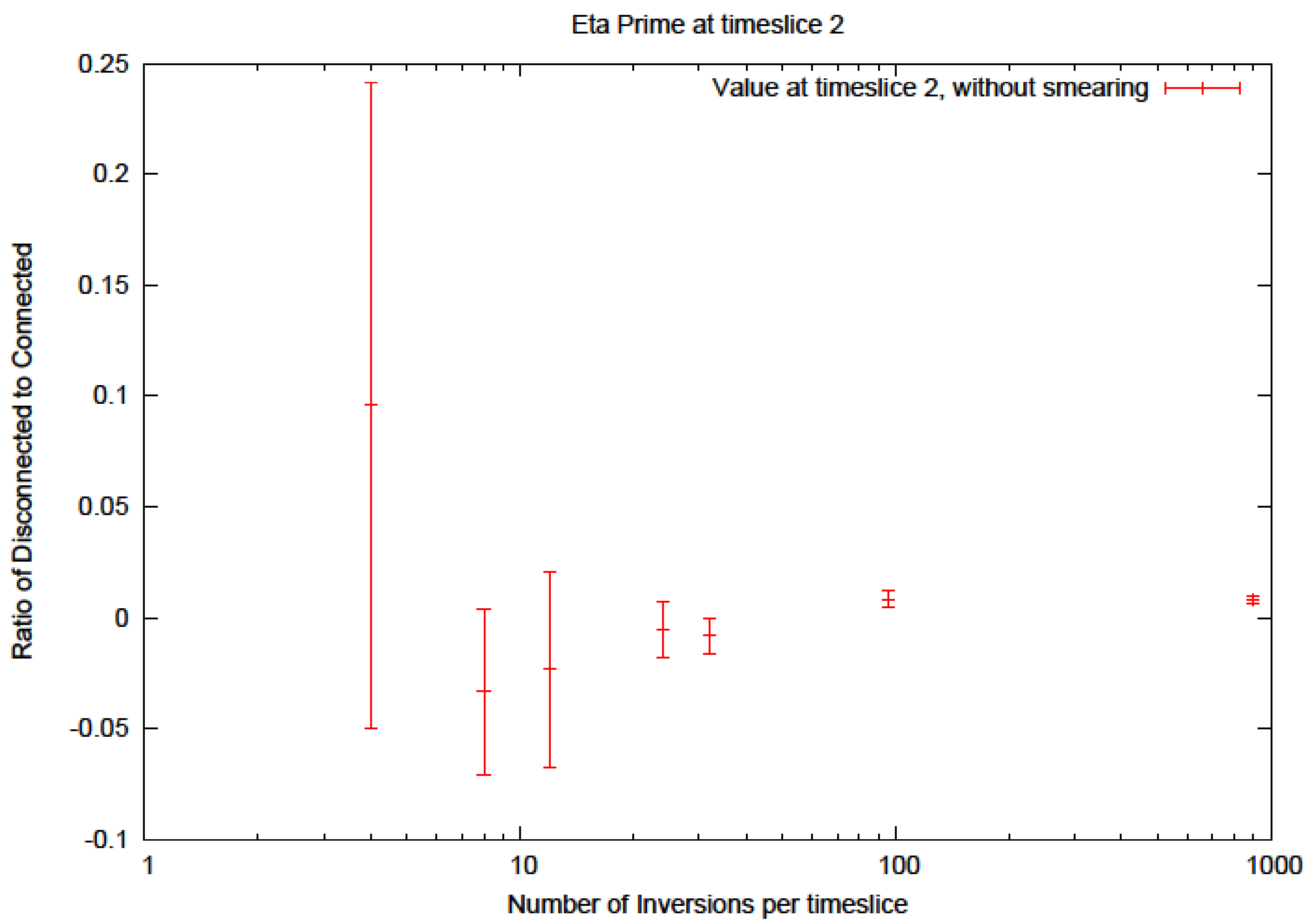
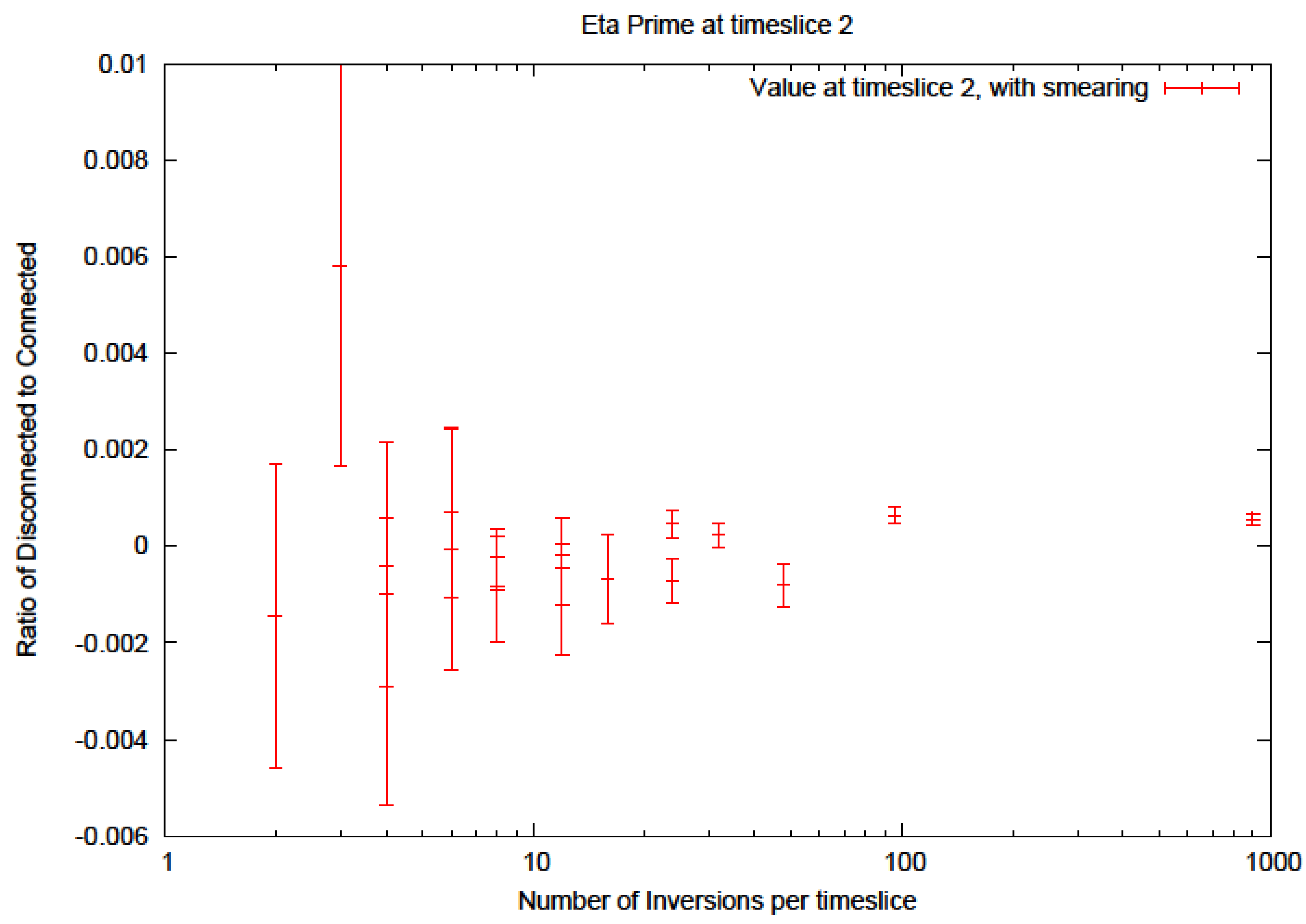



Eta Prime at timeslice 2
Value at timeslice 2, without smearing
Ratio of Disconnected to Connected
Number of Inversions per timeslice
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
1
10
100
1000


Eta Prime at timeslice 2
Value at timeslice 2, with smearing
Ratio of Disconnected to Connected
Number of Inversions per timeslice
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
1
10
100
1000

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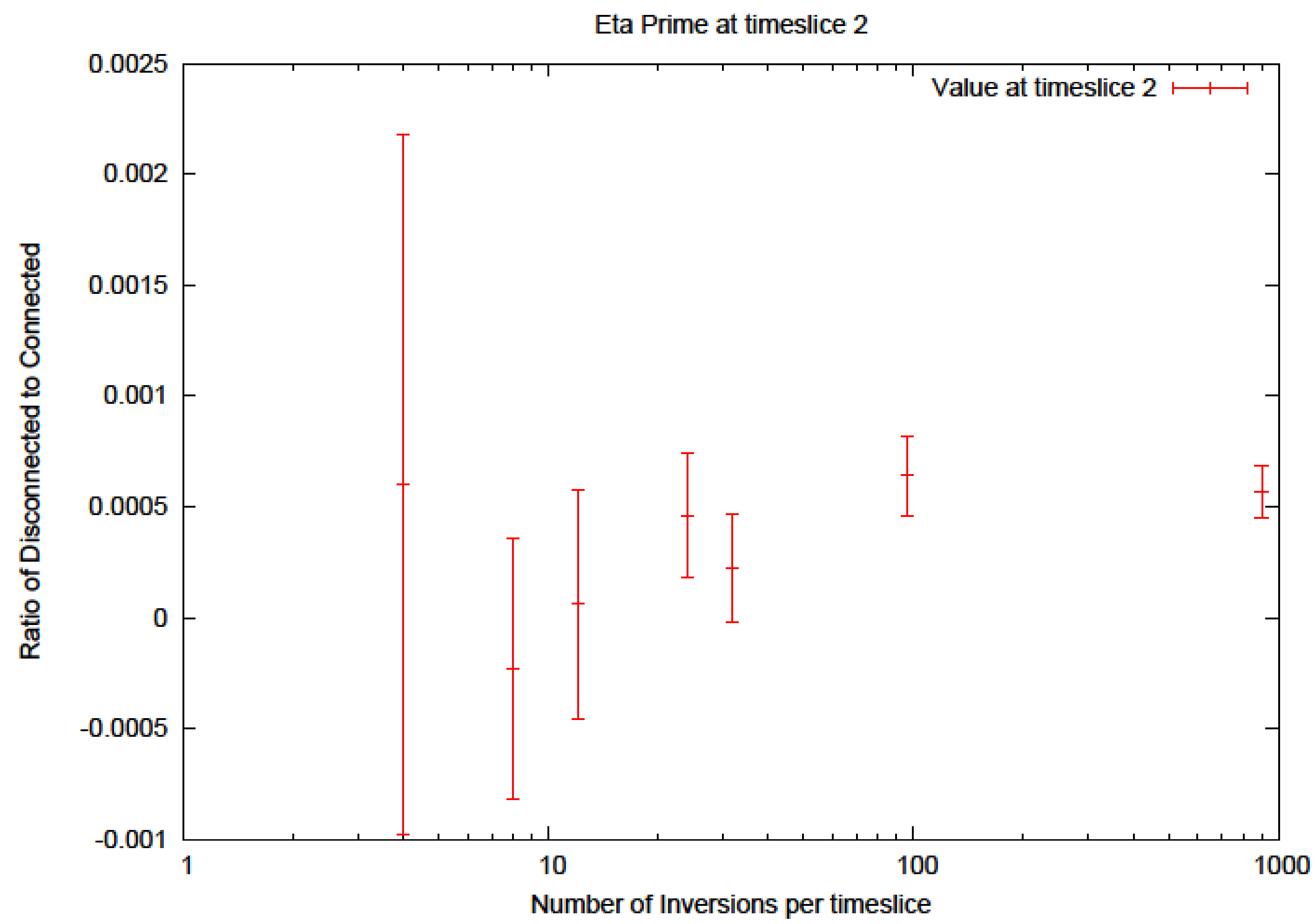

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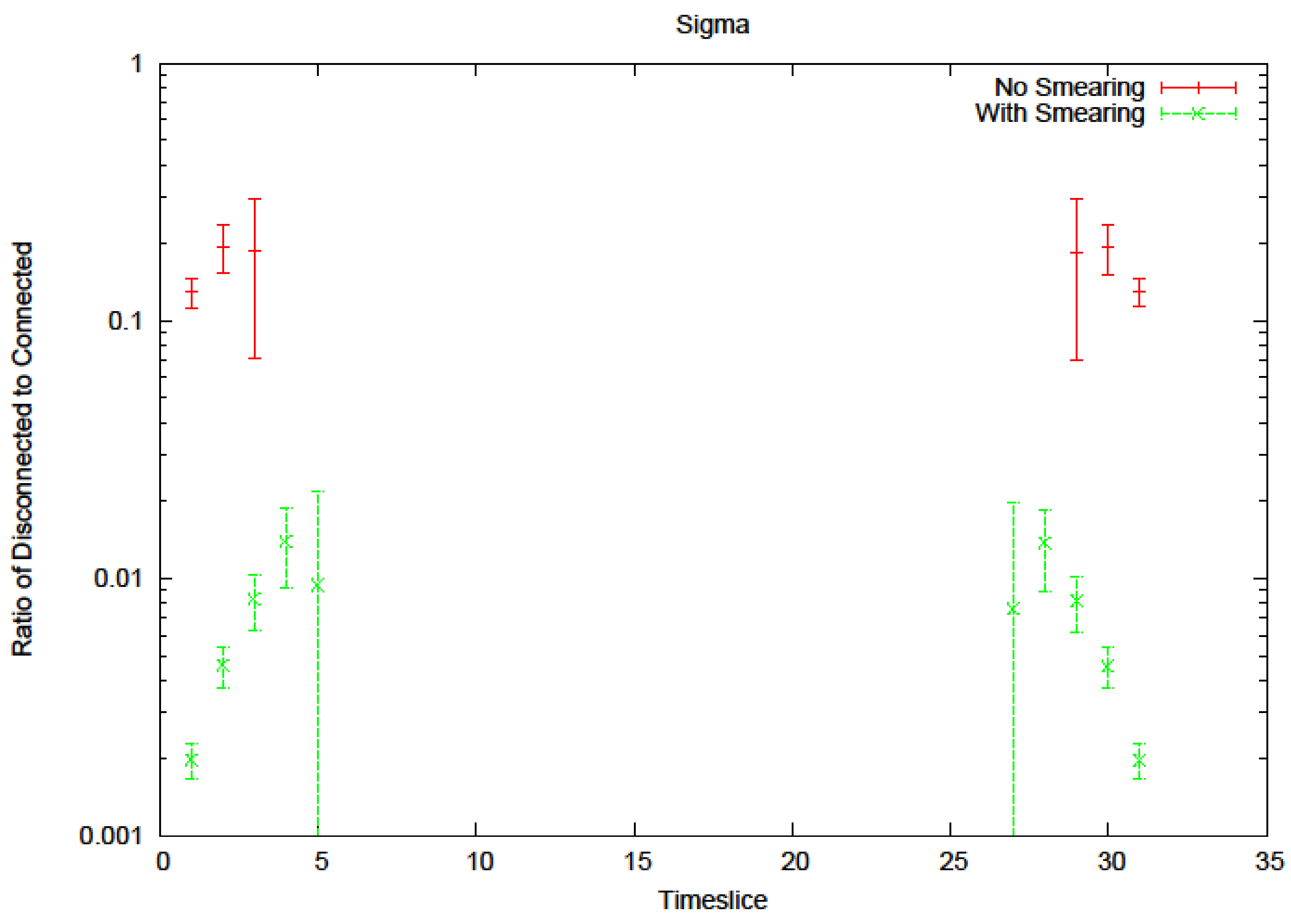
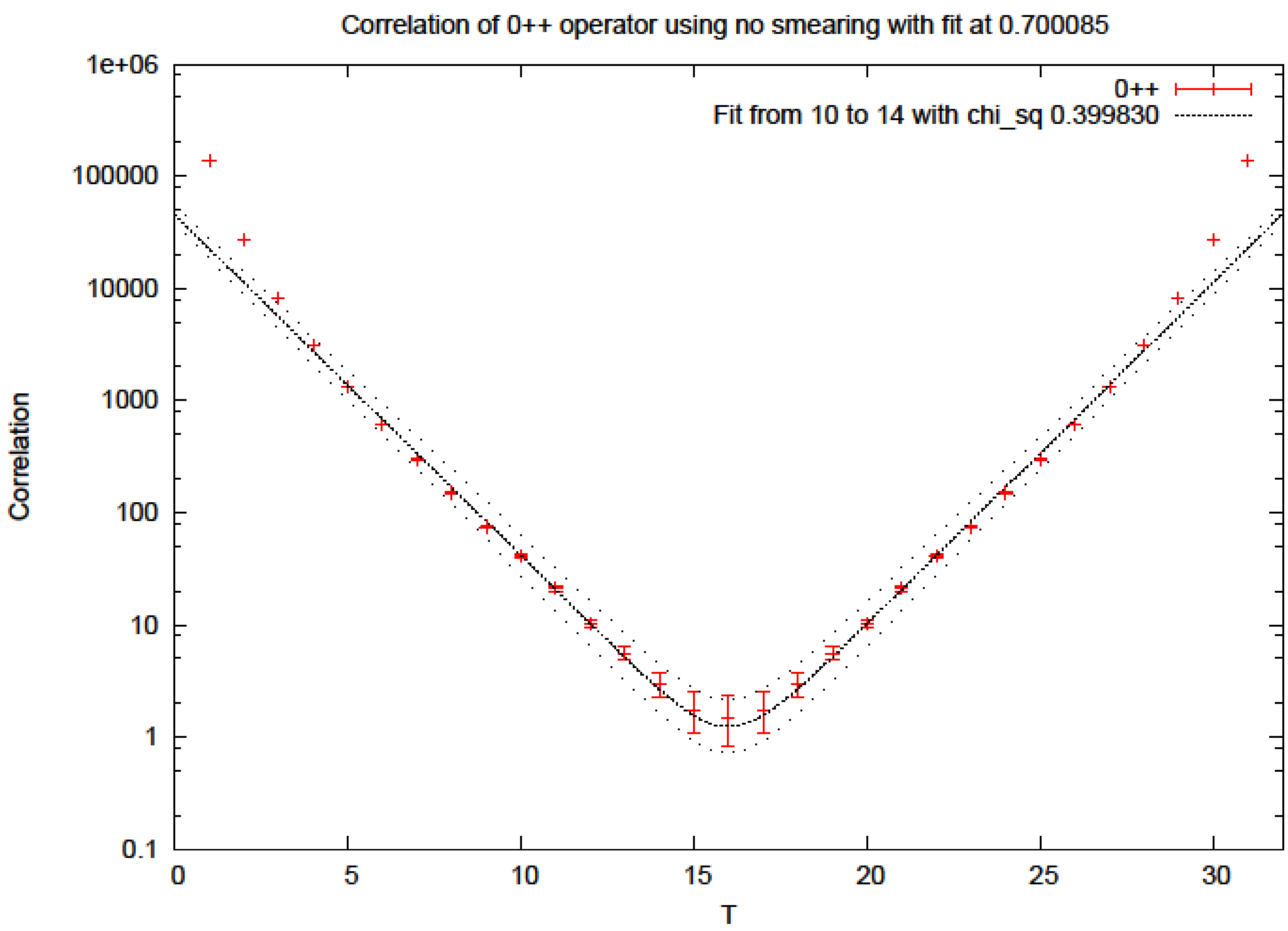
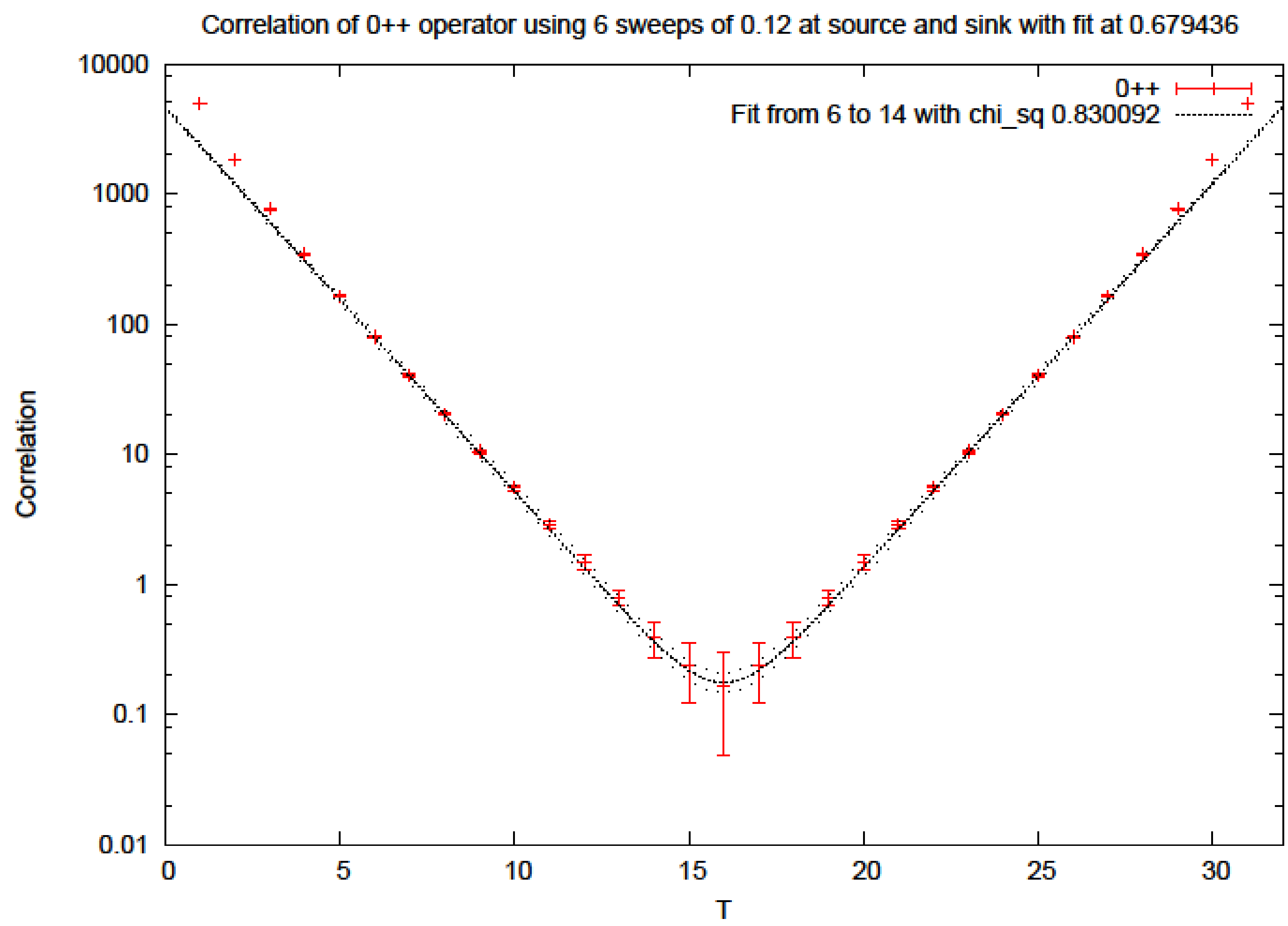
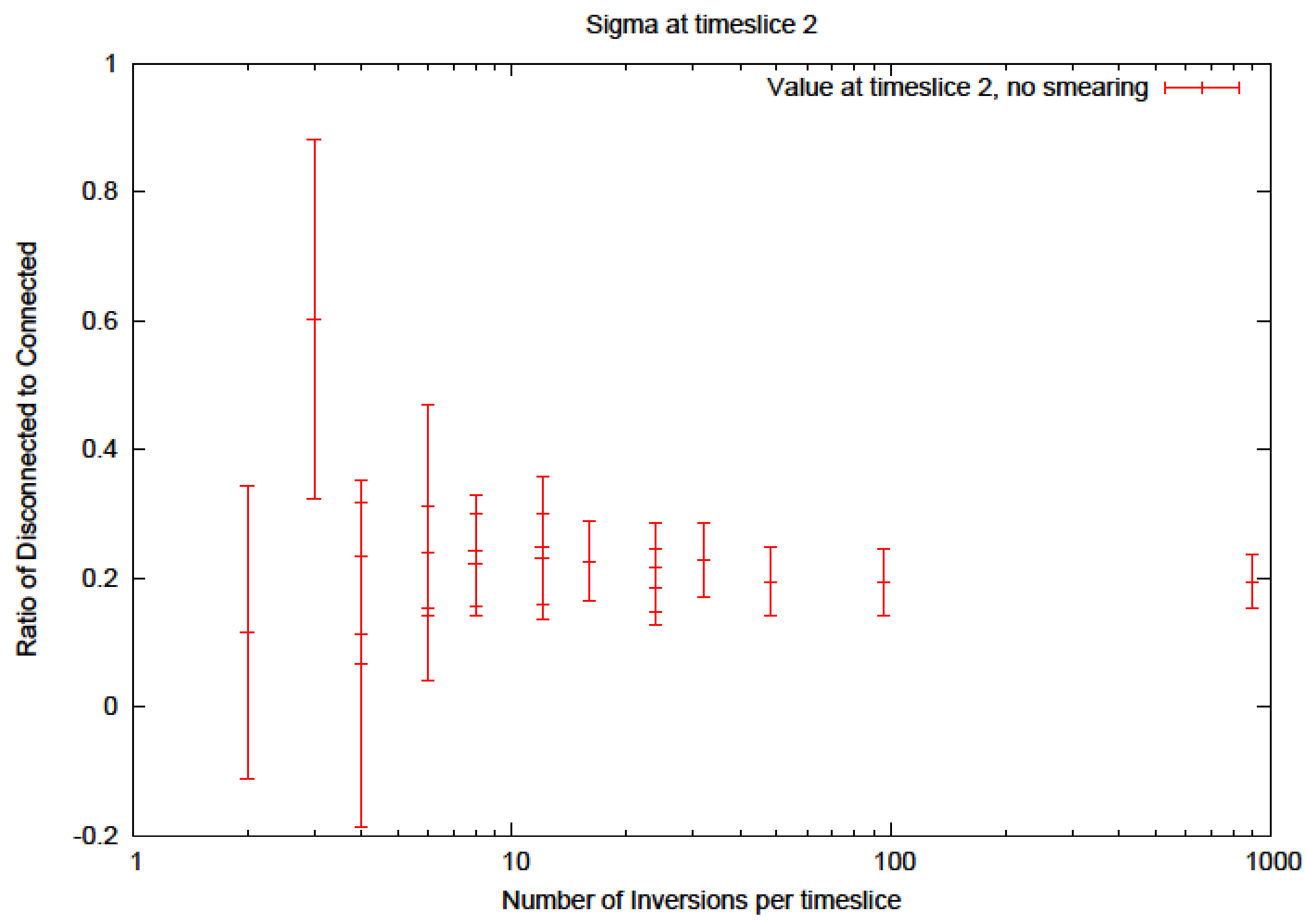
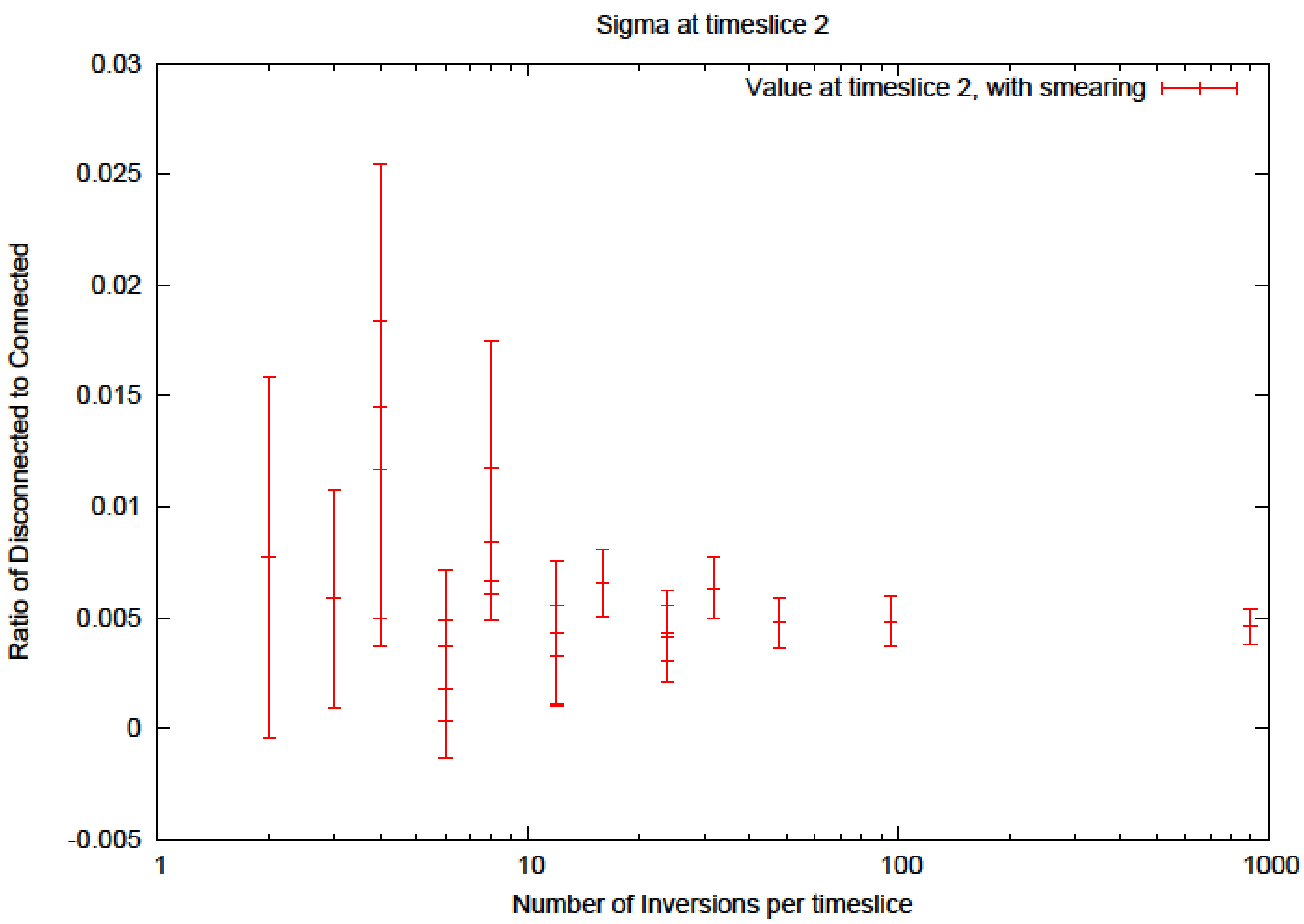
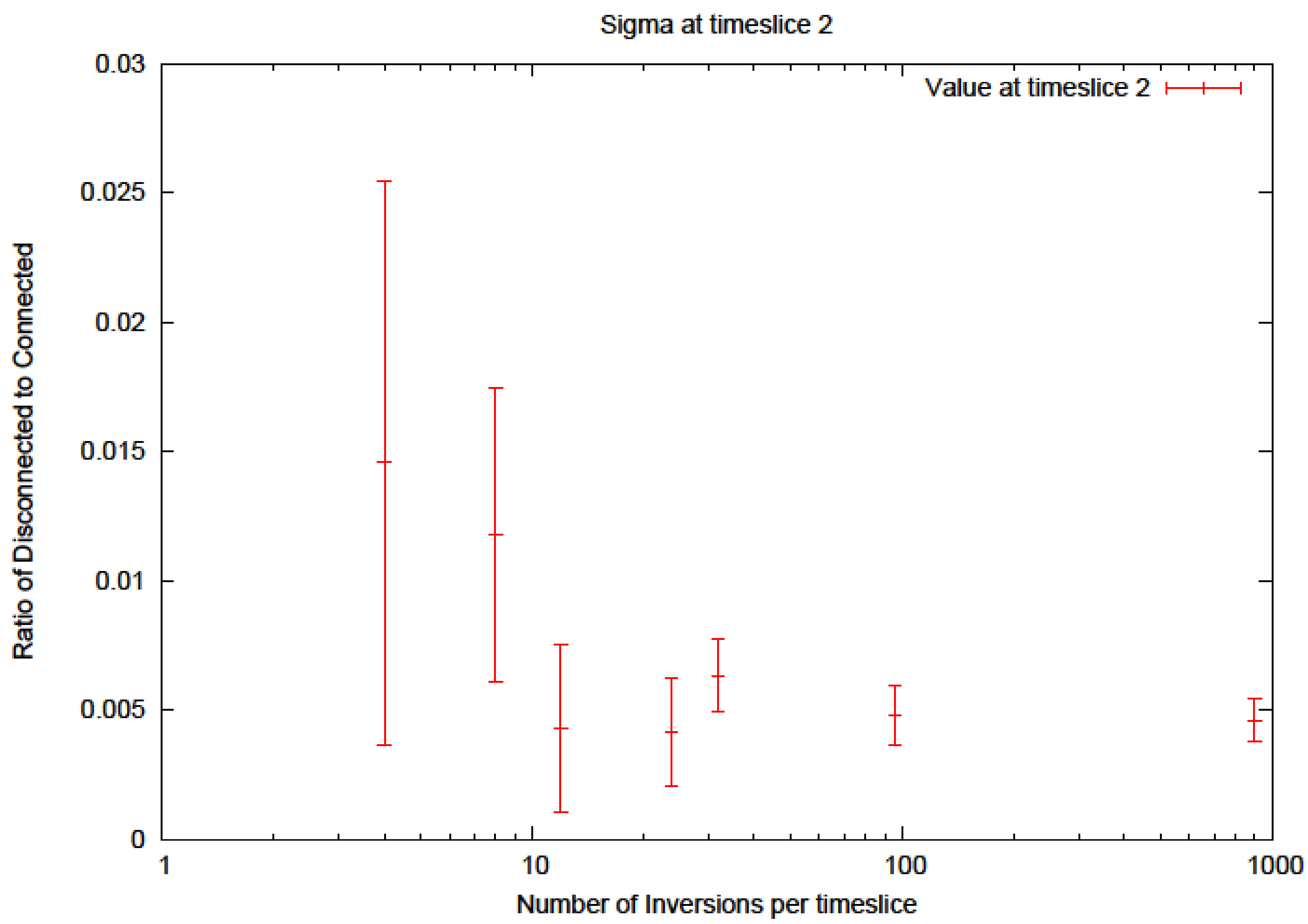



Correlation of 0++ operator using no smearing with fit at 0.700085
0++
Fit from 10 to 14 with chi_sq 0.399830
Correlation
T
1e+06
100000
10000
1000
100
10
1
0.1
0
5
10
15
20
25
30


Correlation of 0++ operator using 6 sweeps of 0.12 at source and sink with fit at 0.679436
10000
1000
100
10
1
0.1
0.01
Correlation
0
5
10
15
20
25
30
T
0++
Fit from 6 to 14 with chi_sq 0.830092


Sigma at timeslice 2
Value at timeslice 2, no smearing
Ratio of Disconnected to Connected
Number of Inversions per timeslice
1
0.8
0.6
0.4
0.2
0
-0.2
1
10
100
1000


Sigma at timeslice 2
Value at timeslice 2, with smearing
Ratio of Disconnected to Connected
Number of Inversions per timeslice
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
1
10
100
1000


Sigma at timeslice 2
Value at timeslice 2
Ratio of Disconnected to Connected
Number of Inversions per timeslice
0.03
0.025
0.02
0.015
0.01
0.005
0
1
10
100
1000

Conclusions

- Exact inversion is of course not feasible on large (most!) lattices

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- Gauge noise is quantity dependent and its size varies significantly

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- Gauge noise is quantity dependent and its size varies significantly
- Smearing is an integral part of the operator and can have a large effect on correlated quantities both in terms of the measurement and the quality of the signal estimation

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Conclusions

- Exact inversion is of course not feasible on large (most!) lattices
- Gauge noise is quantity dependent and its size varies significantly
- Smearing is an integral part of the operator and can have a large effect on correlated quantities both in terms of the measurement and the quality of the signal estimation
- Spin dilution has significant influence but smearing *may* wash out the effects of utilising different stochastic methods

The End