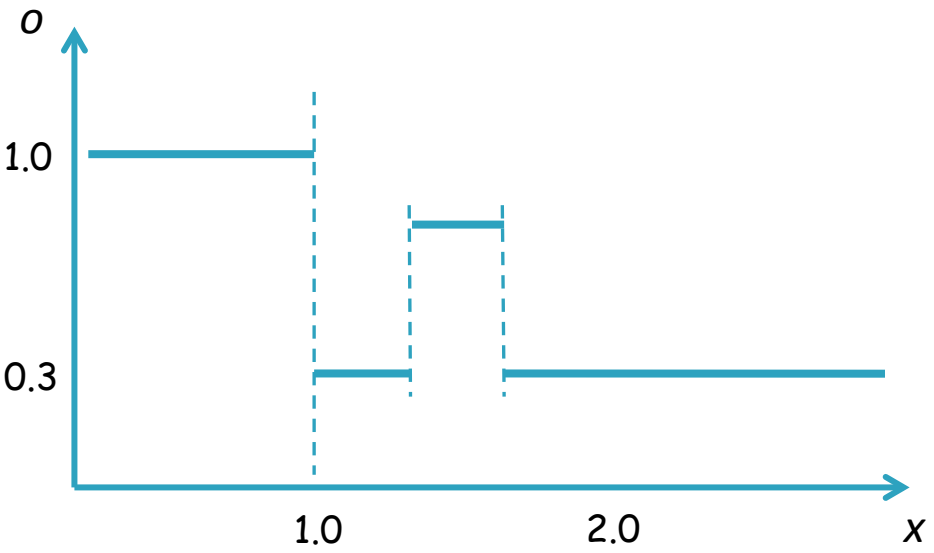
Discrete Factors

```
1    x = sample(1.5);
2    y = (int) x;
3    if (x < 1.0)
4      o = 1 + y;
5    else
6      if (t(x) > 0.3)
7        o = 0.3;
8      else
9        o = 0.75;
```



- *Discrete factors:*
  real value -> discrete value
  - predicate
  - type cast
  - discrete mathematical library functions

Theorem 1: Given two sample executions, if all of their DFs produce the **same** discrete values, they must have the **same** mathematical output function.

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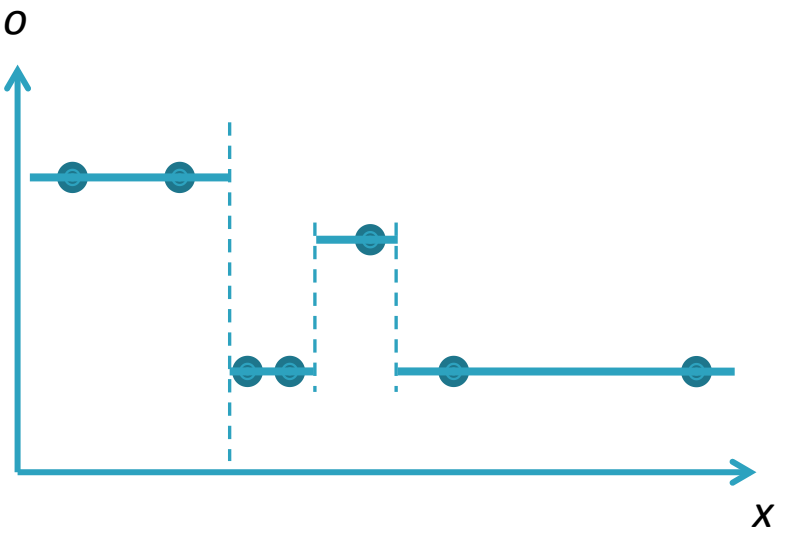
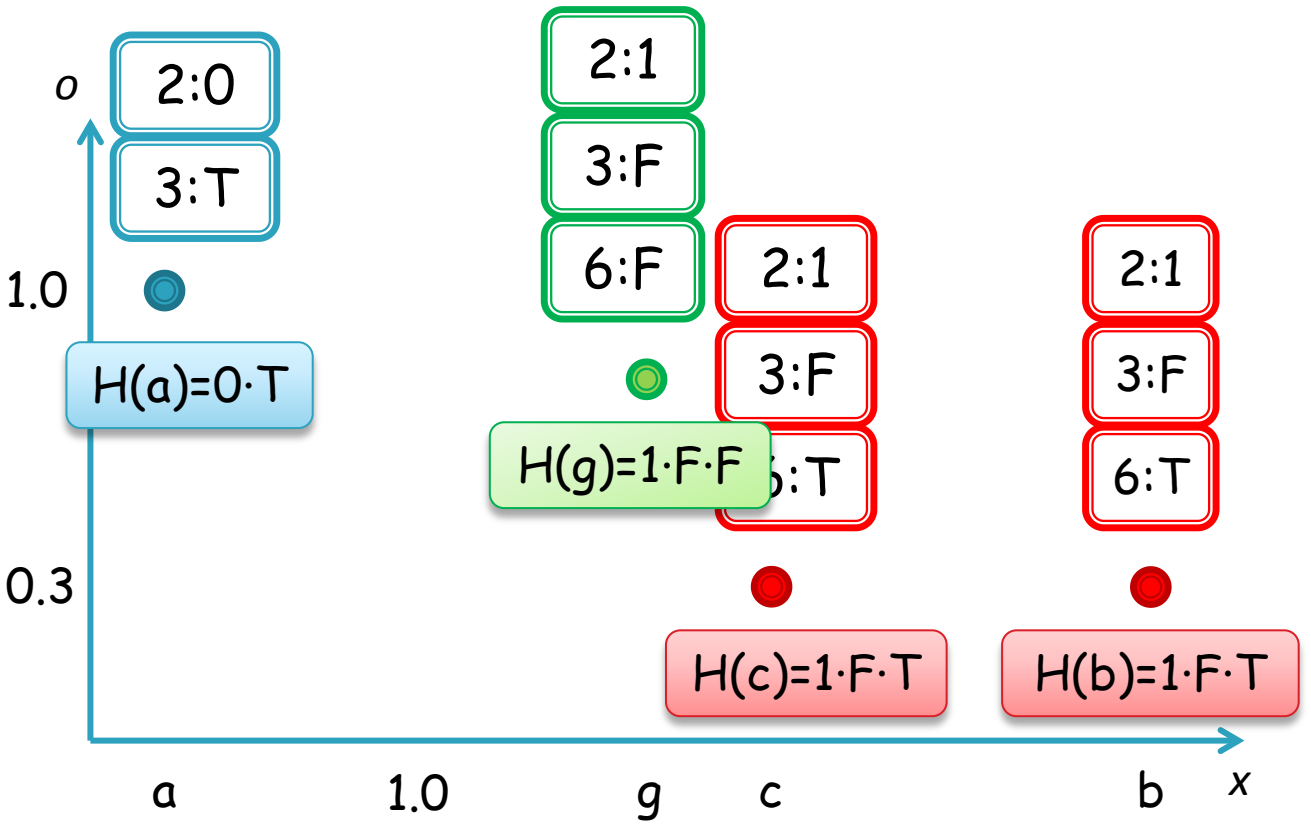
~~Tracing~~ the DFs

Hashing

```
1   x = [illegible];
2   y = (int) x;
3   if (x < 1.0)
4     o = 1 + y;
5   else
6     if (t(x) > 0.3)
7       o = 0.3;
8     else
9       o = 0.75;
```





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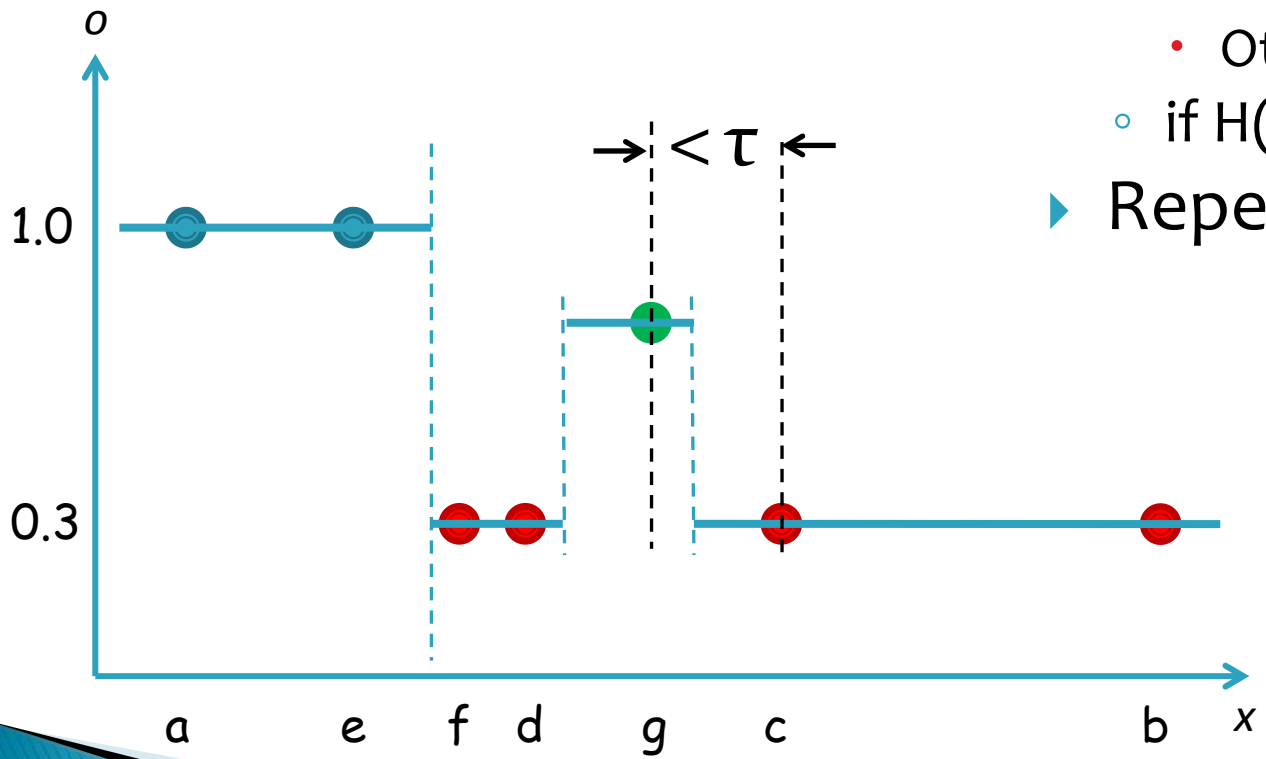
White-box Sampling Algorithm



- To sample region [a, b]:
  - if H(a) ≠ H(b)
    - if |a-b|≥ τ, take another sample at c = (a+b)/2;
    - Otherwise, stop.
  - if H(a) = H(b), then stop
- Repeat the process

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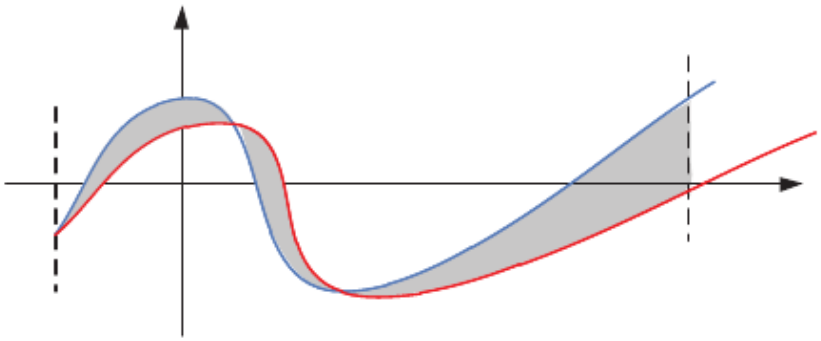
Experiments: Efficiency

program	native	white-box	overhead	# of samples †
168.wupwise	2.05	2.14	4%	2
171.swim	0.15	0.15	1%	2
172.mgrid	3.31	3.32	0%	2
173.applu	0.06	0.07	6%	2
178.galgel	0.69	0.70	10%	416
183.equake	0.20	0.21	6%	66
187.facerec	1.23	1.25	2%	117
188.ammp	2.72	2.73	0%	2
191.fma3d	0.02	0.02	0%	2
200.sixtrack	2.22	2.27	2%	2
301.apsi	1.75	1.77	1%	167
deisotope	0.02	0.02	0%	55
AVERAGE			2.67%	

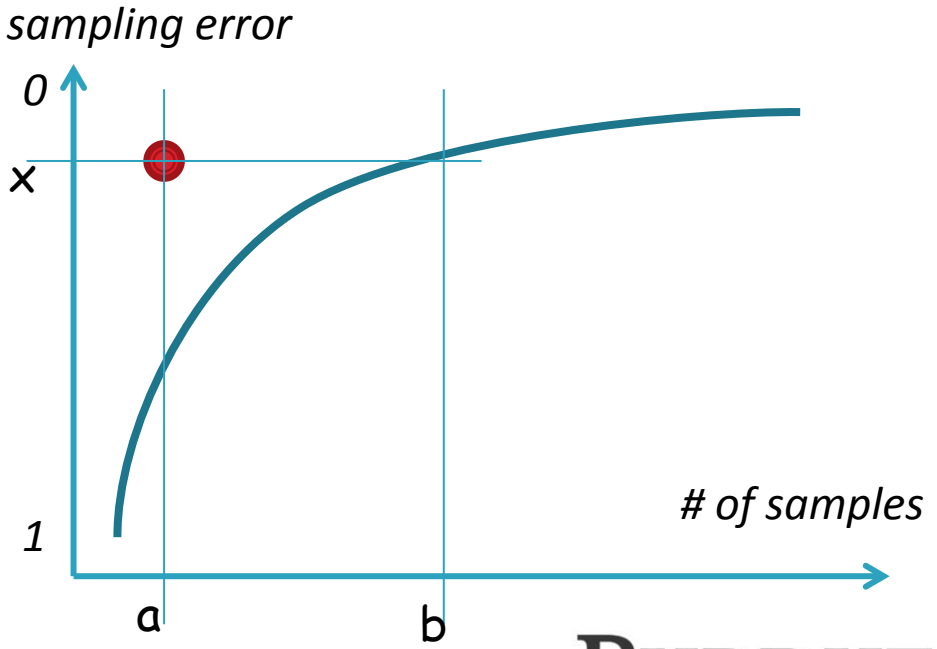
† Regular MC: 1000 samples

Experiments: Effectiveness

- Measuring the sampling quality
  - Comparing against the *ideal* curve.



- Goal
  - To achieve the precision of a high sampling rate with the cost of a low sampling rate.



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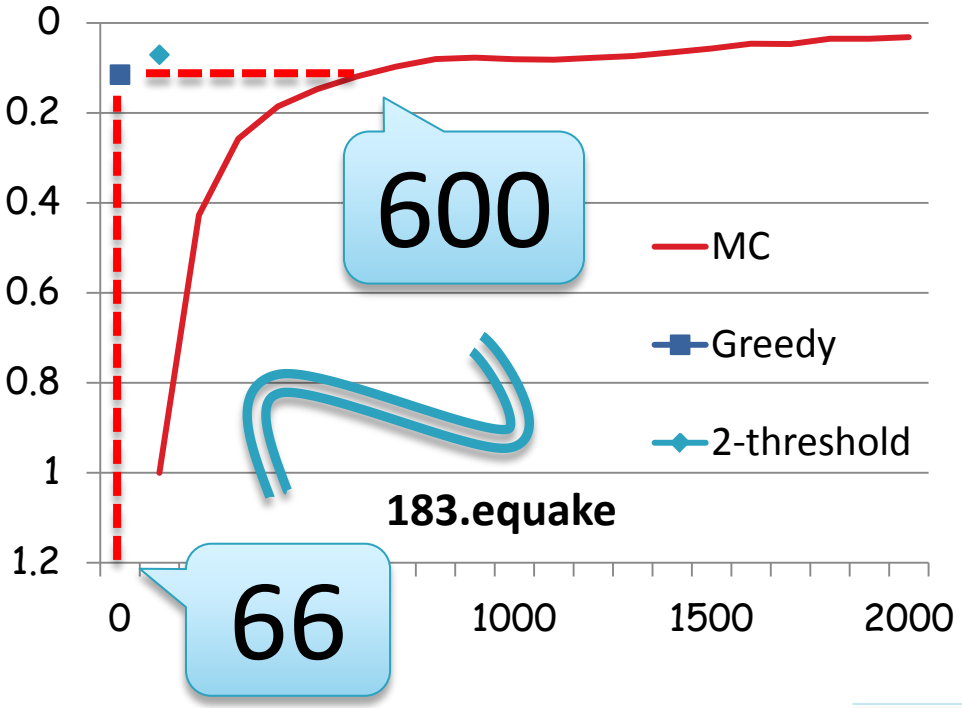

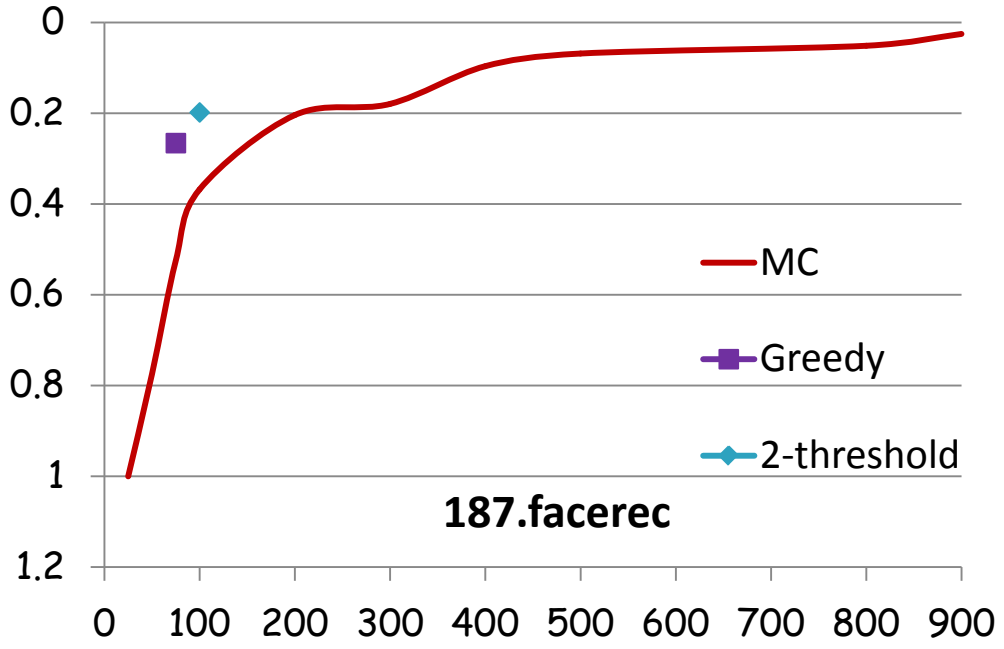

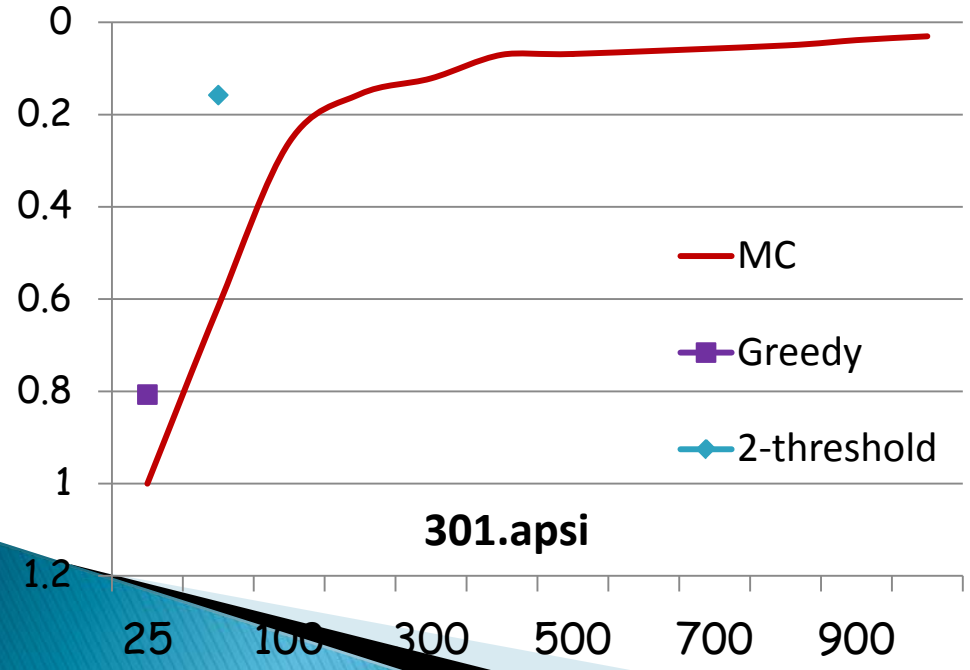

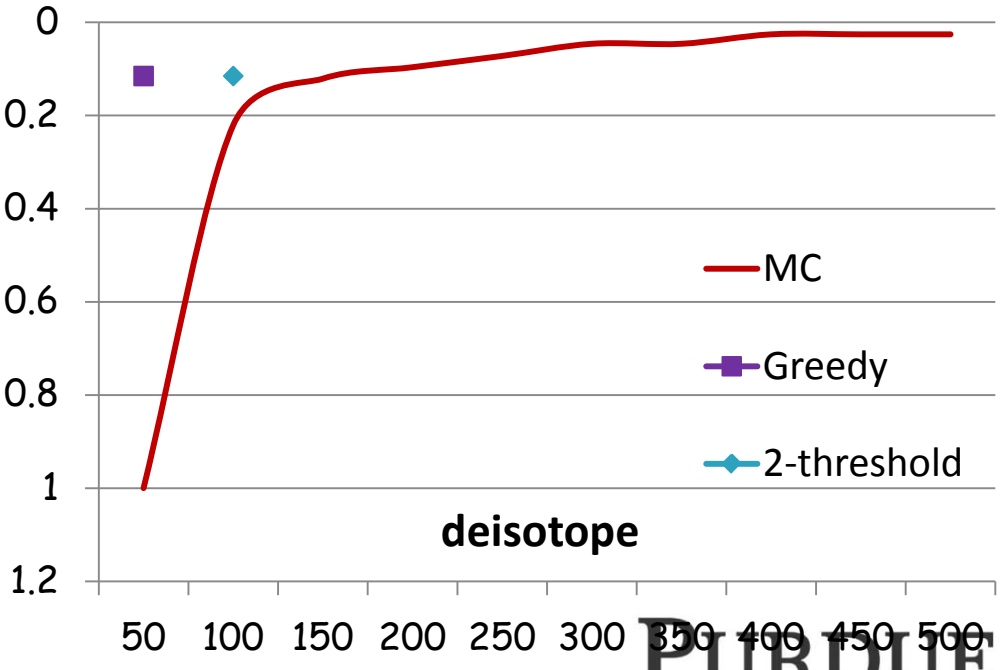

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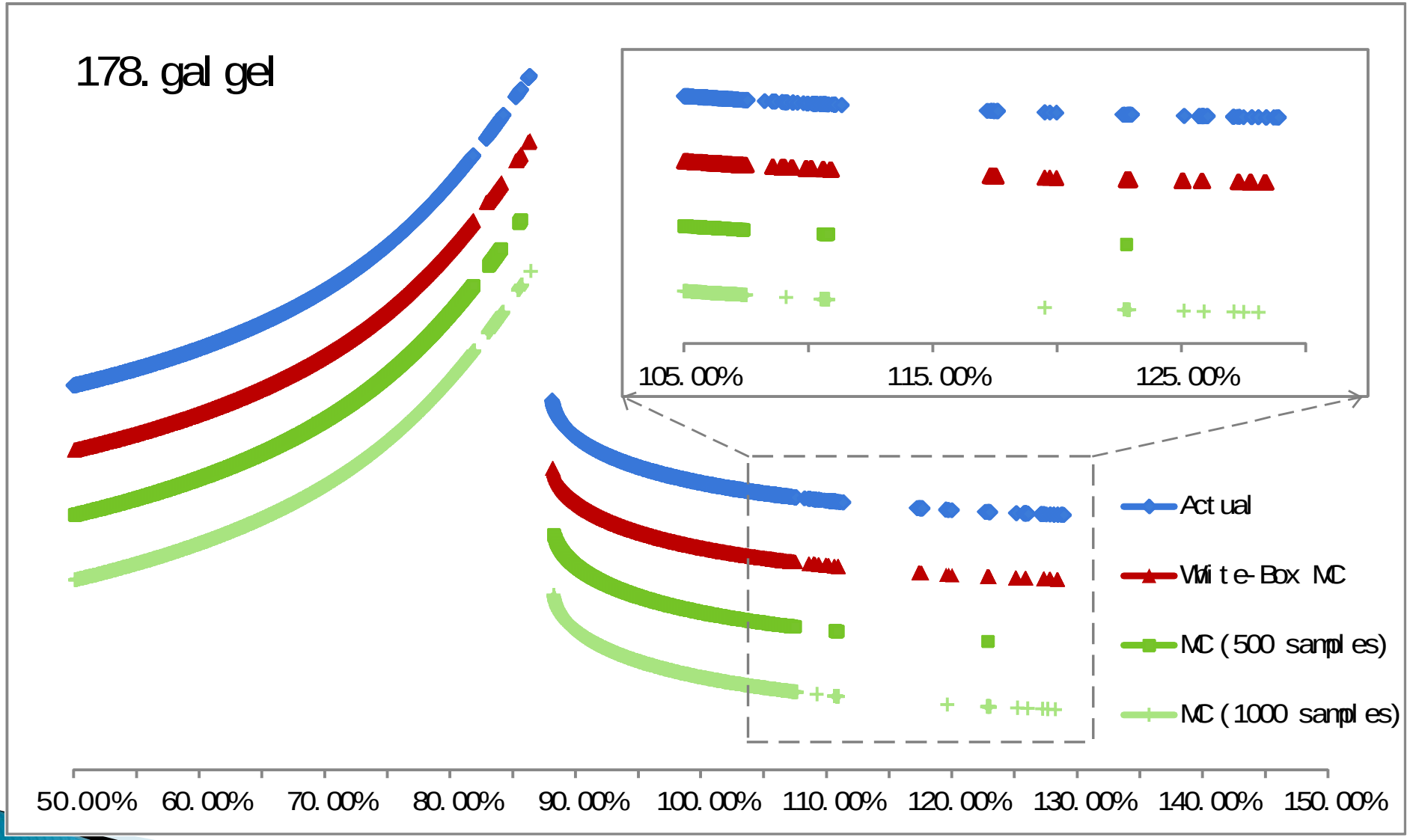
Case study: 178.galgel



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Outline

- Overview
- External Errors
  - White-box Sampling (OOPSLA 2012)
- Internal Errors
  - On-the-fly detection of instability problems (OOPSLA 2013)

Internal Errors

```
1  float x, z;
2  x = input();
3  z = f(x);

4  if (z > 0.5)
5     printf ("hit");
6  else
7     printf ("miss");
```

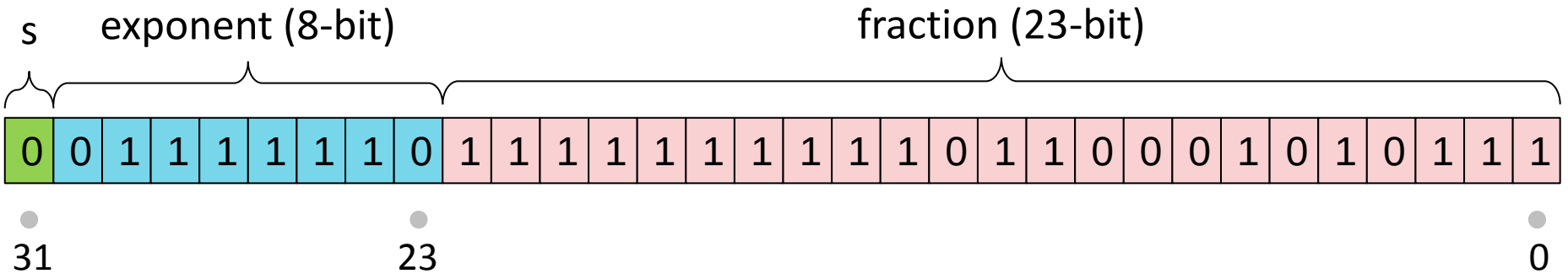
x = 100.0;

2. Are the computed results reliable?

miss

Floating-Point Representation

- IEEE 754-1985



- 0.9997_{10} => 0x3F7FEC57
  - $0.9997_{10} \approx 1.11111111110110001010111_2 * 2^{-1}$
  - 0.9997 = 0.999700009822 + (-0.000000009822)

ideal represented

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