Total Quality Management & Use of Running Averages in Milling Operation

2nd Annual IAOM Southeast Asia District Conference & Expo

Bali, Indonesia

J. A. Gwirtz, Ph.D.

Five Precepts of Total Quality

- All work is a process
- Processes can be improved continually
- Ultimate Judge of Quality-Customers
- Variation is endemic
- Minimize variation improve quality

Important Questions

- Is it necessary?
- Is there a simpler way?
- Can this task be combined with others?

Customer-Satisfaction-Oriented Benefits

- Product Quality
- Product Design
- Production Flow
- Employee Moral/Quality Consciousness
- Product Service
- Marketplace Acceptance

Economic Improvements

- Operating Cost
- Operating Losses
- Field Service Cost
- Liability Exposure

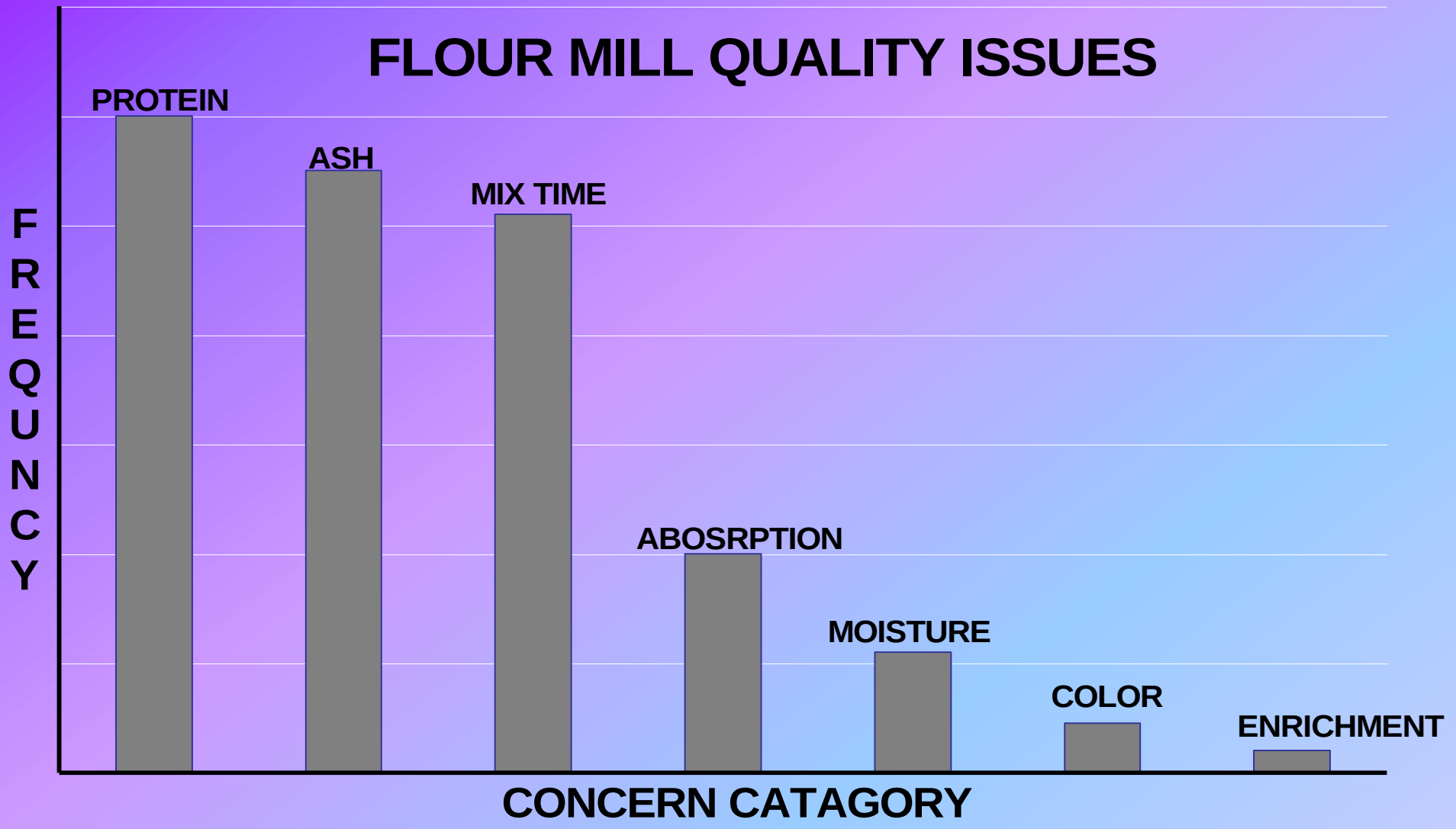
Steps to TQM Implementation

- Identify Key Problem Areas
- Measure Control Capability
- Identify Sources of Variation
- Experimental Design
- Economic Study
- Implementation
- Re-evaluation

Problem (Opportunity) Identification

- Recognize a difference between where you are and where you want to be!
- Focus on the critical few rather than the trivial many!
- Can be driven by forces beyond your control!

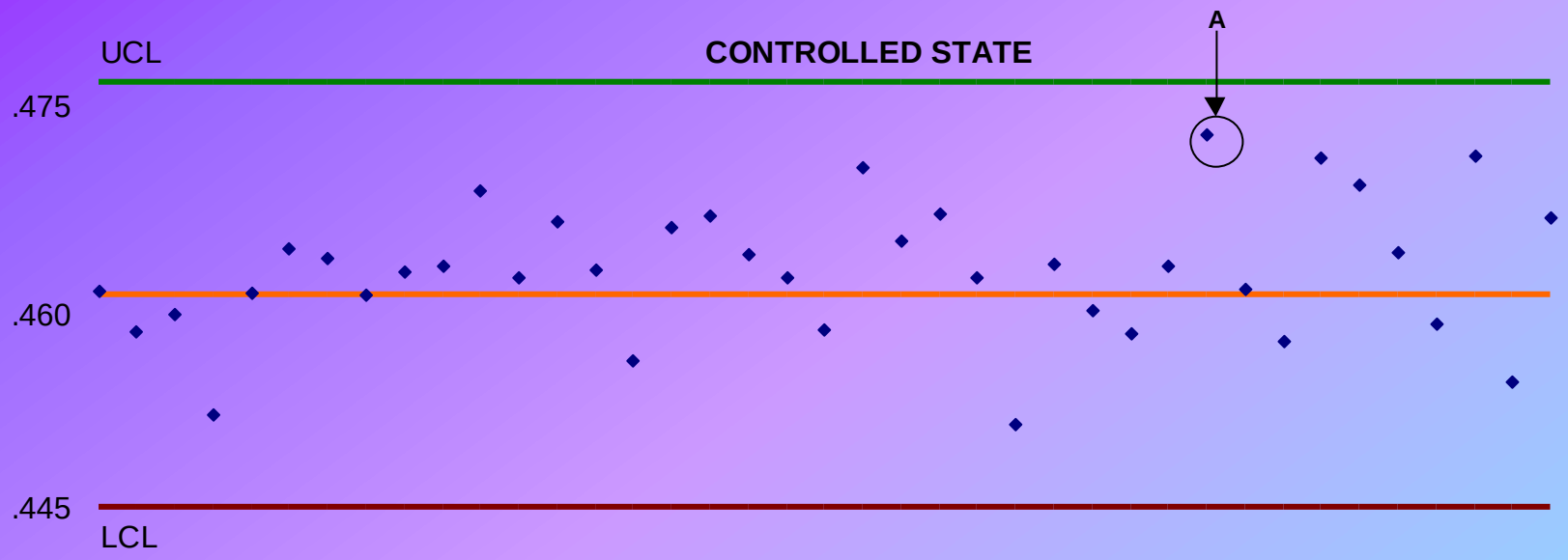
Pareto Chart



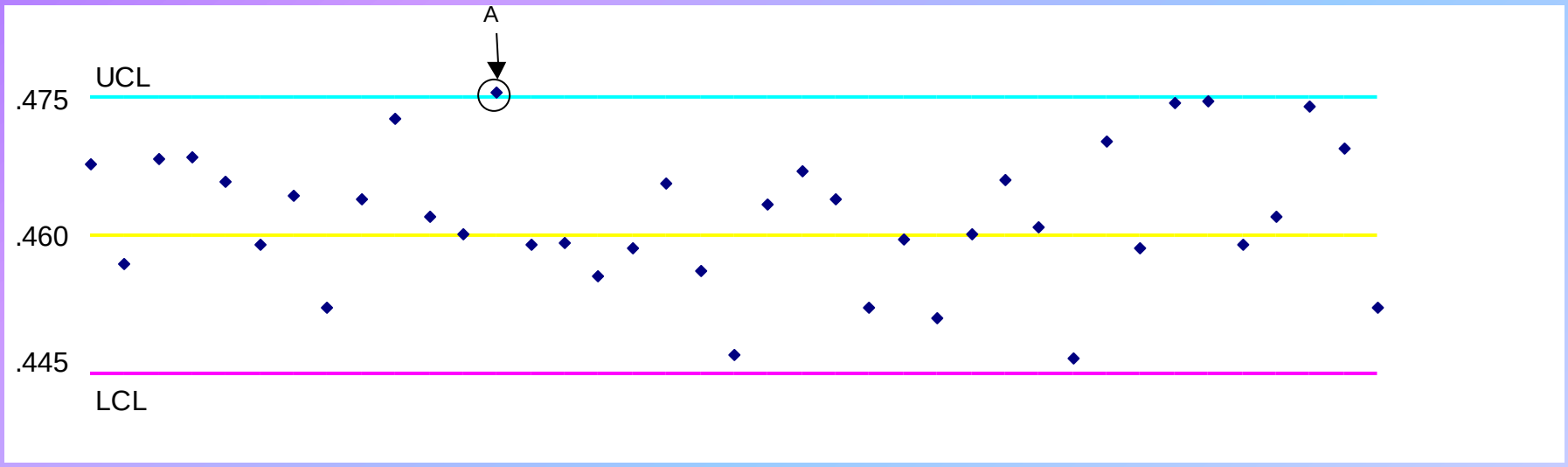
SPC Concepts

- Prevent rather than simply identify defects
- Sources of Variation
  - Random
  - Assignable

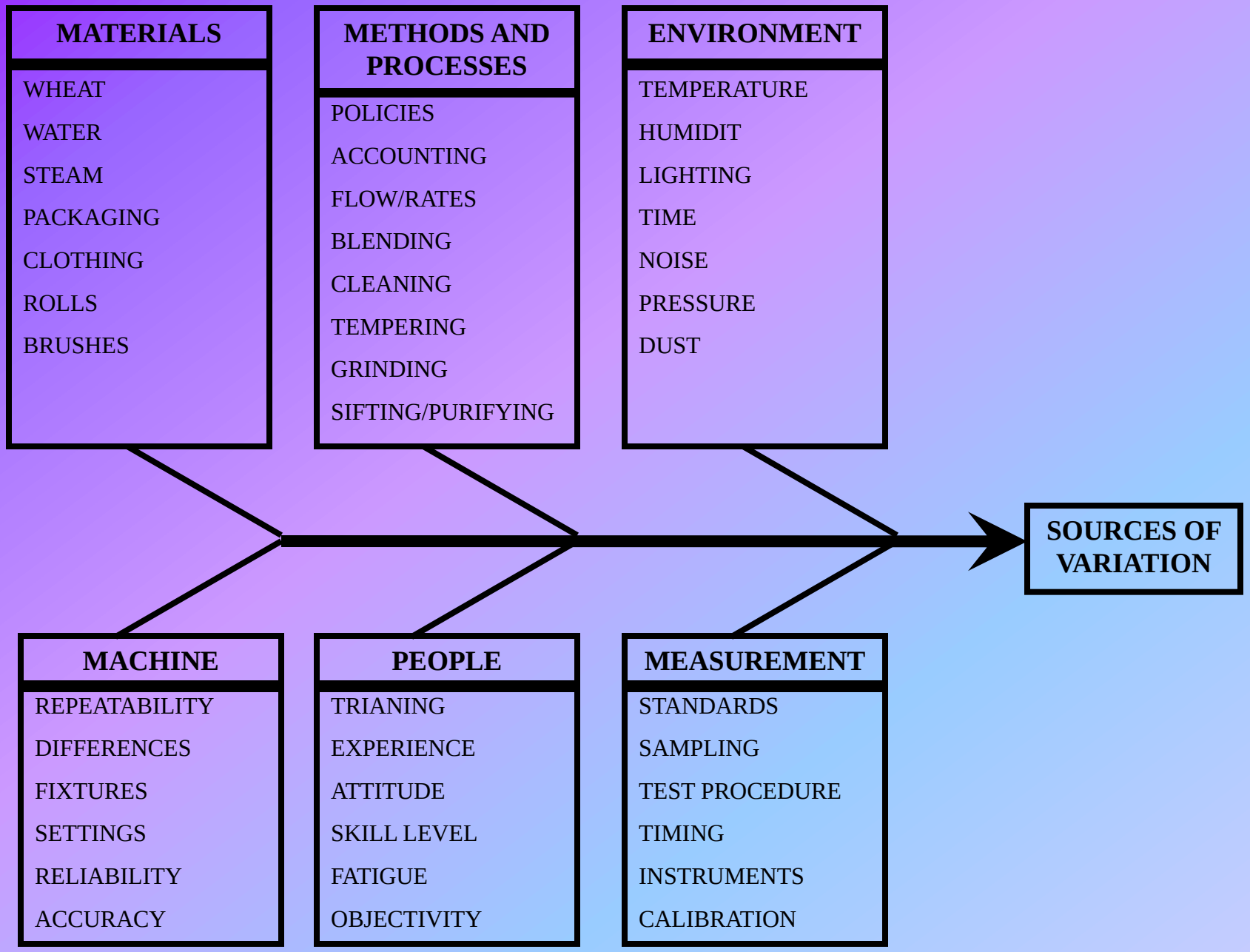
SHEWHART CONTROL CHART
FLOUR MILL ASH



UNCONTROLLED STATE



SIMPLIFIED FISHBONE DIAGRAM



X-BAR, R Chart Analysis

- Basic process control methodology

X-BAR, R Chart Analysis

- Requires grouping of replications into sets (group size of N)
- Measure of central tendency or “average” x-bar
- Measure of variability or “range” R
- Establish upper and lower control limits UCL and LCL

$\bar{X}$ Control Chart:

$$\text{Central Line} = \bar{\bar{X}}$$

$$\text{Lower Control Limit} = \bar{\bar{X}} - A_2\bar{R}$$

$$\text{Upper Control Limit} = \bar{\bar{X}} + A_2\bar{R}$$

R Control Chart:

$$\text{Central Line} = \bar{R}$$

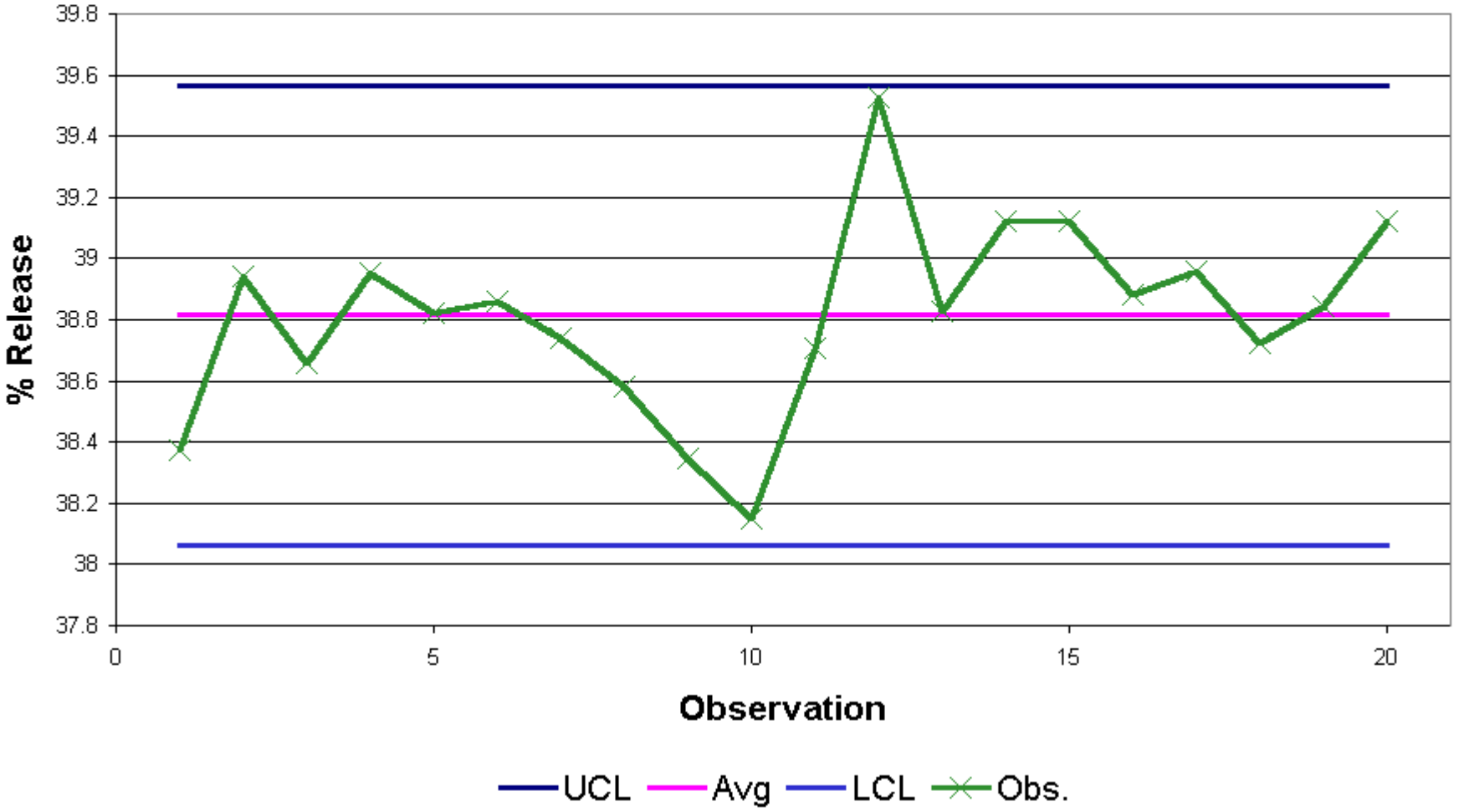
$$\text{Lower Control Limit} = D_3\bar{R}$$

$$\text{Upper Control Limit} = D_4\bar{R}$$

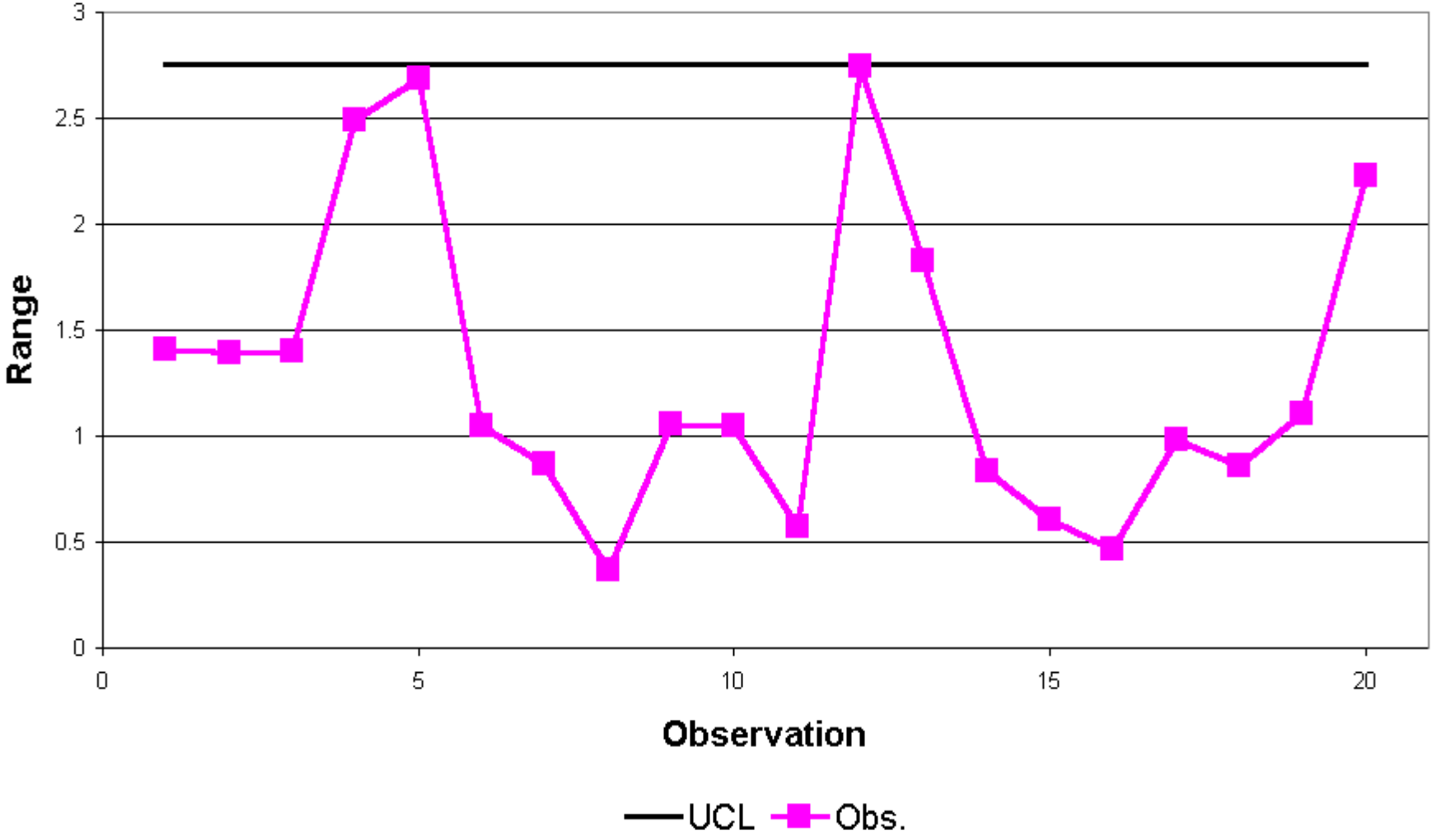
Values for Setting Control Limits

n	A_2	D_4	D_3
2	1.880	3.267	0.000
3	1.023	2.575	0.000
4	0.729	2.282	0.000
5	0.577	2.115	0.000
6	0.483	2.004	0.000
7	0.419	1.924	0.076

Second Break Release
X-Bar



Second Break Release Range



Process is in control when….

- Both statements below **ARE TRUE**!
- Average within upper and lower control limits
- Range within groups within upper and lower control limits

Simple Keys for Out of Control

1. Points beyond UCL or LCL
2. Long run (5-7 points) above or below the center line
3. Two out of 3 consecutive points are in the third standard deviation zone
4. Obvious trend or shift

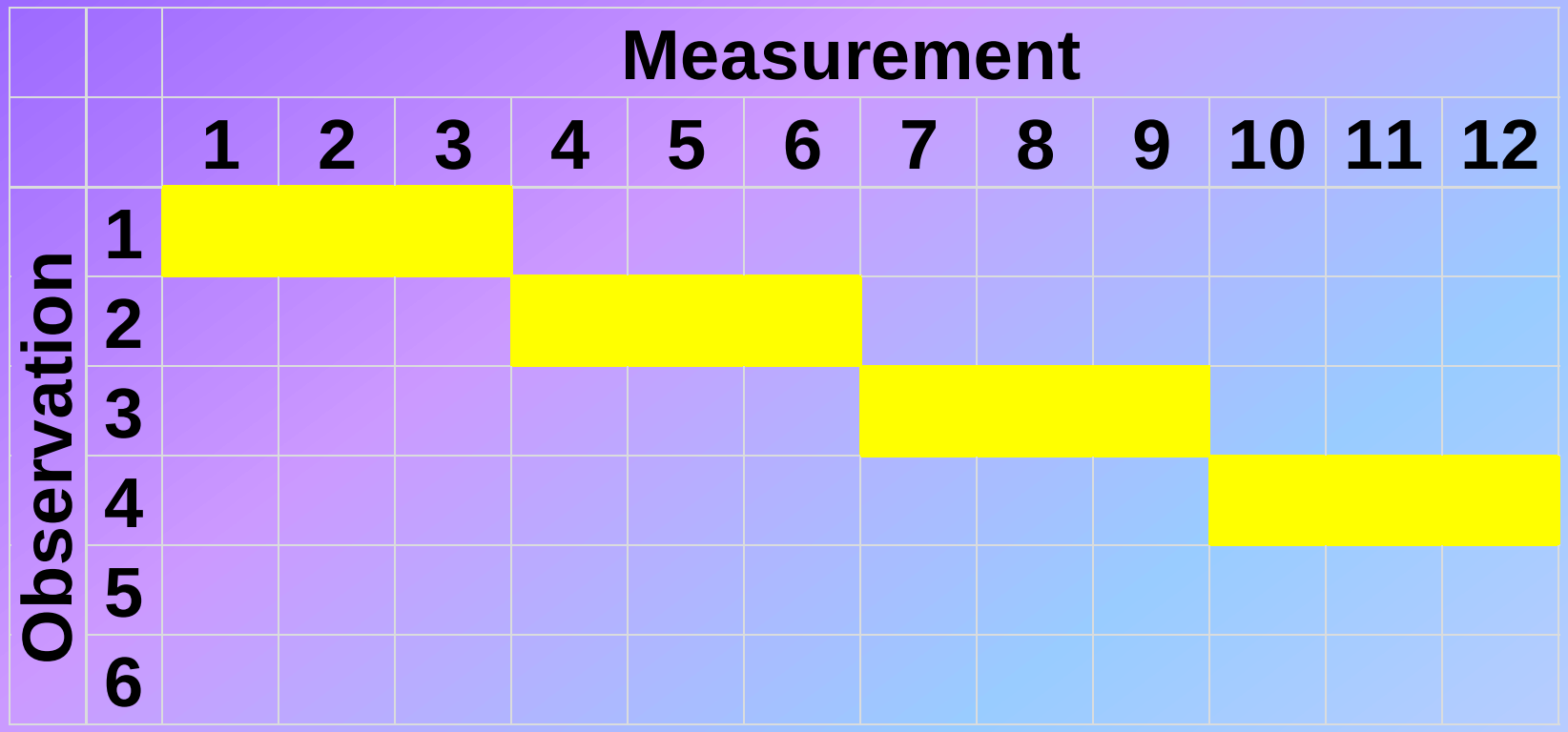
More Complex Keys

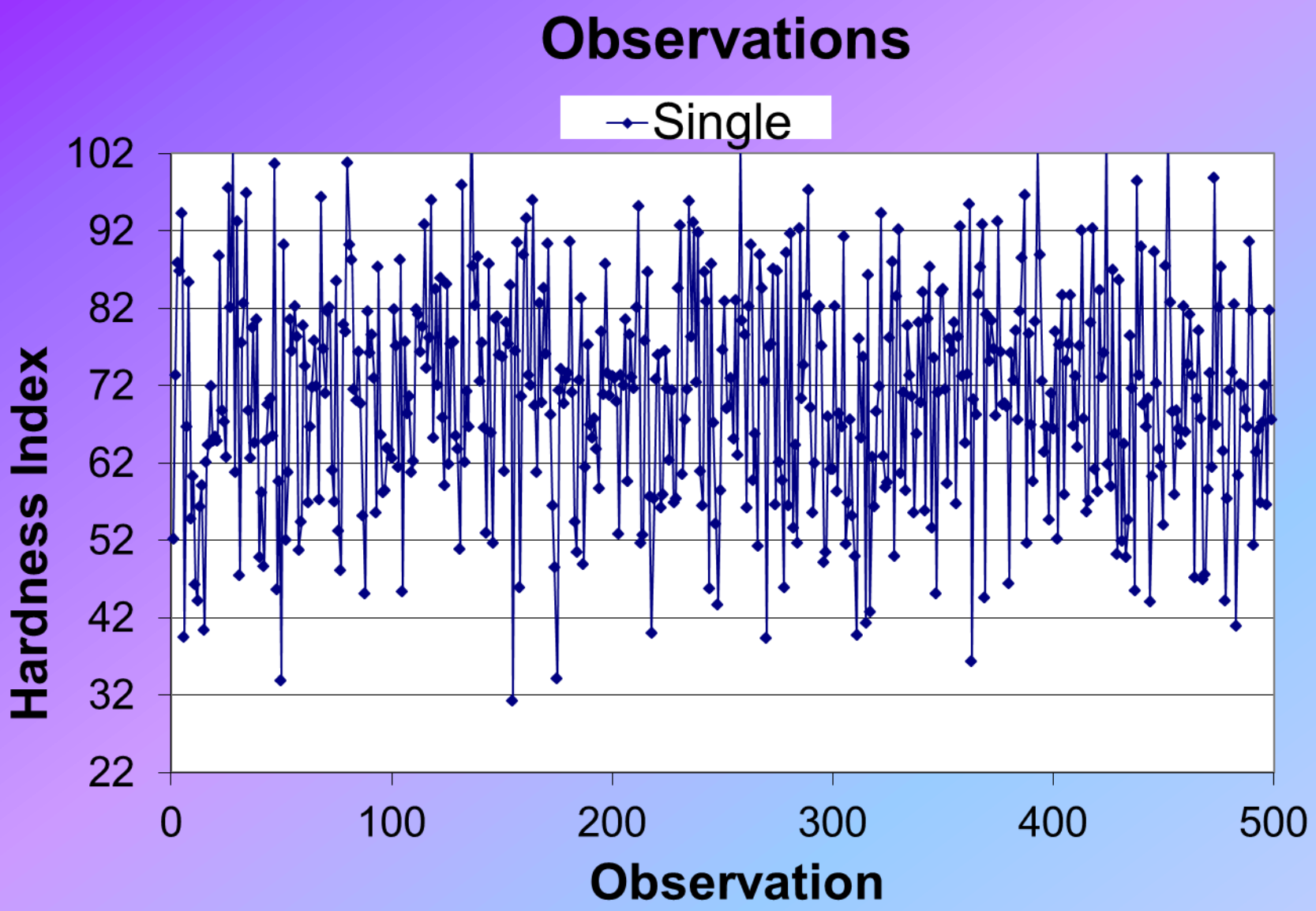
1. A point beyond the sixth standard deviation
2. Two of 3 consecutive points in the third standard deviation
3. Four of 5 successive points are in the second standard deviation zone or beyond
4. Eight successive points in the first standard deviation zone or beyond

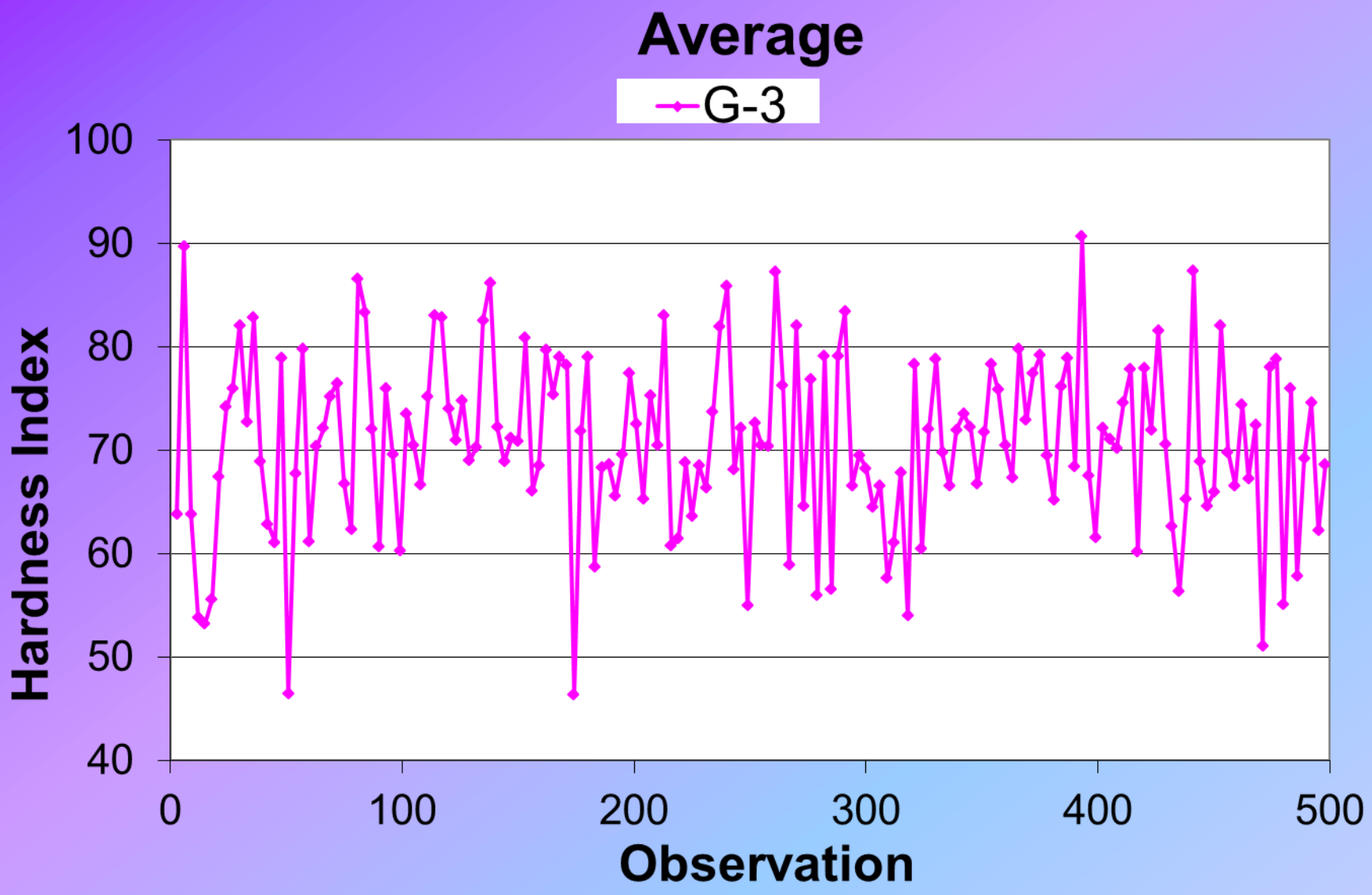
More Complex Keys Cont'd

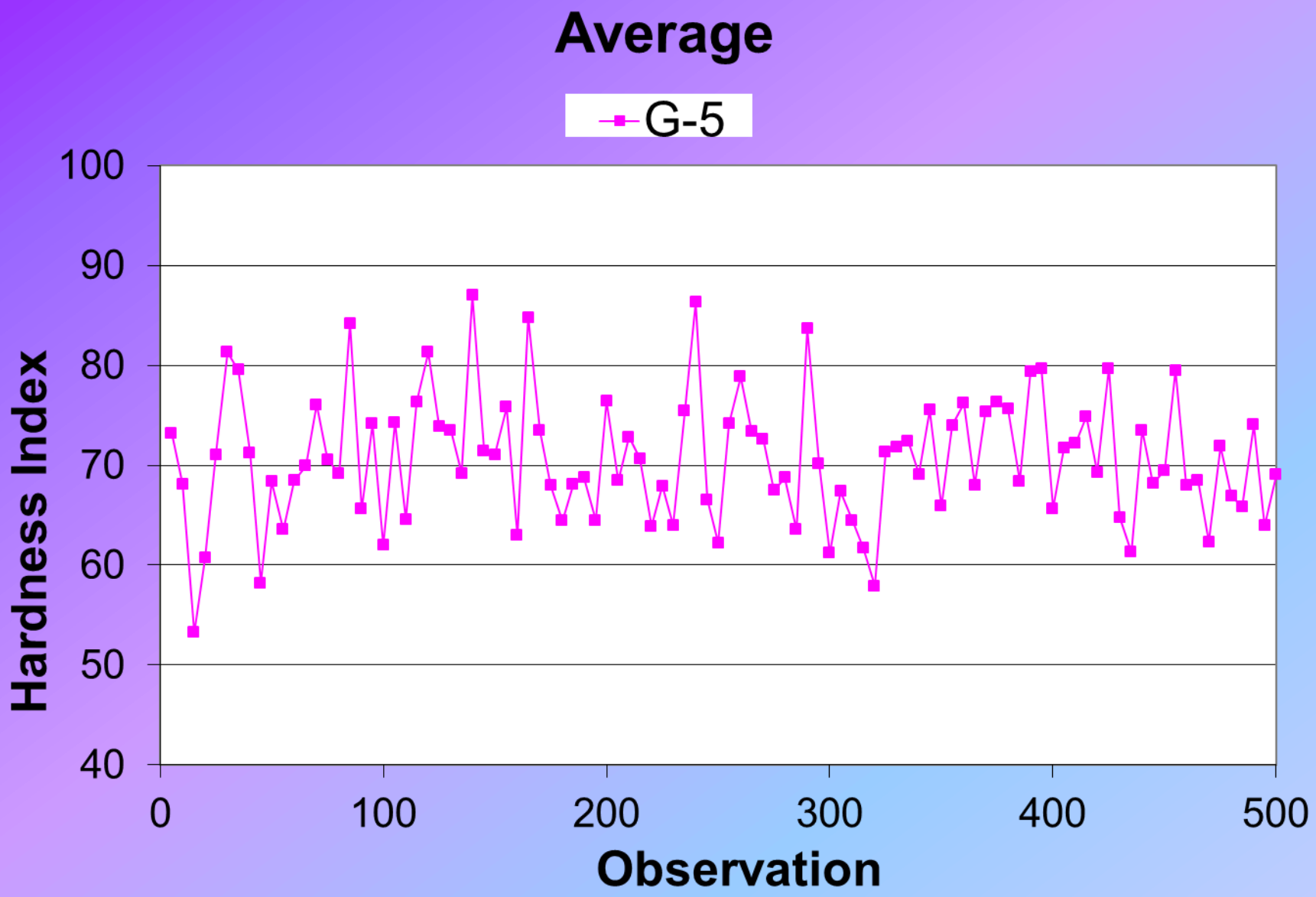
5. One or more points fall beyond the upper or lower control limits
6. A run of 7 or more points lies above or below the center line
7. Cycle or non-random patterns
8. 8 successive points on the same side
9. 11 of 12 successive points on the same side
10. 13 of 15 successive points on the same side

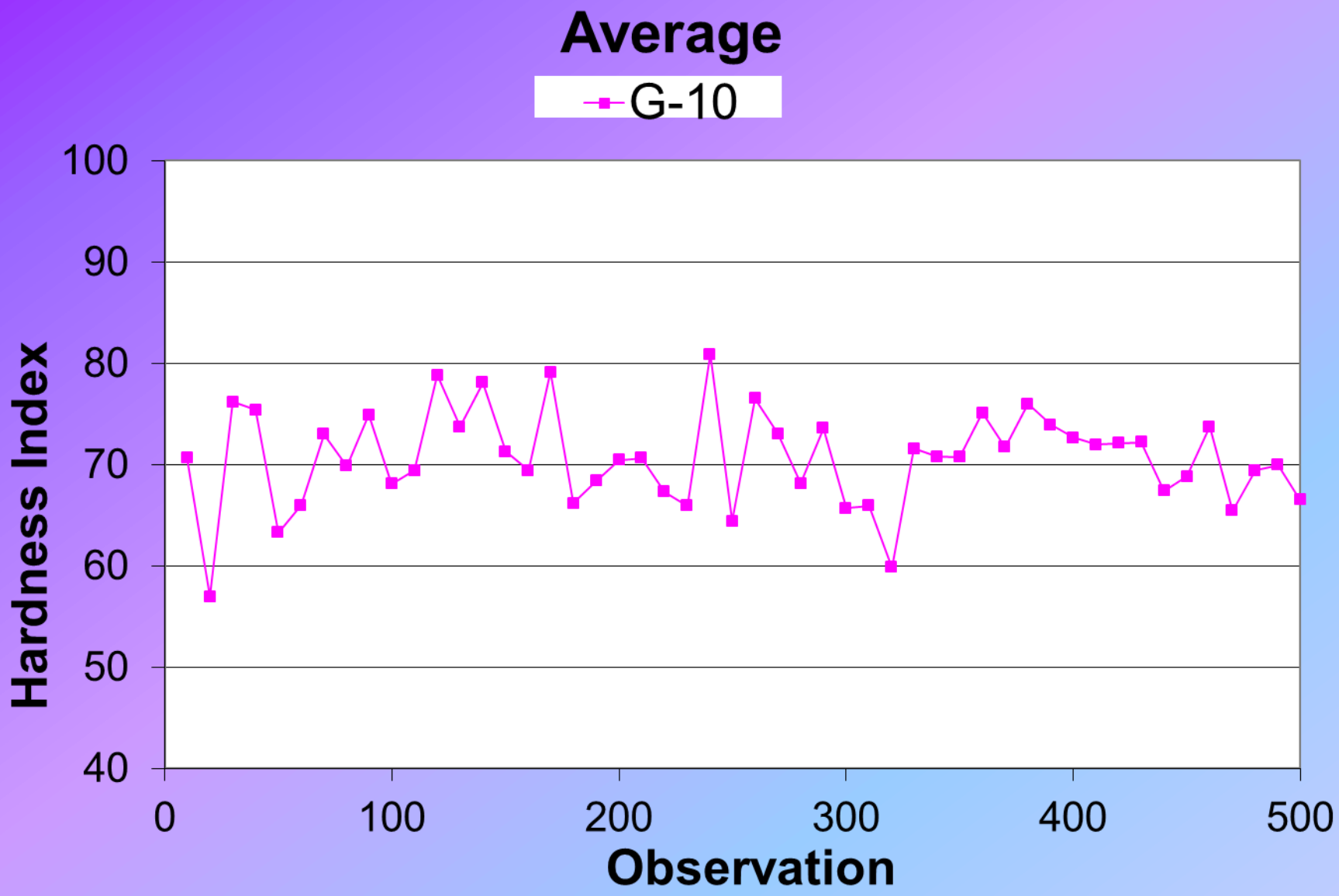
Grouping




Observations
Single
Hardness Index
102
92
82
72
62
52
42
32
22
0
100
200
300
400
500
Observation


Average
G-3
100
90
80
70
60
50
40
Hardness Index
0
100
200
300
400
500
Observation


Average
G-5
Hardness Index
100
90
80
70
60
50
40
0
100
200
300
400
500
Observation


Average
G-10
100
90
80
70
60
50
40
Hardness Index
0
100
200
300
400
500
Observation

How Many is Enough?

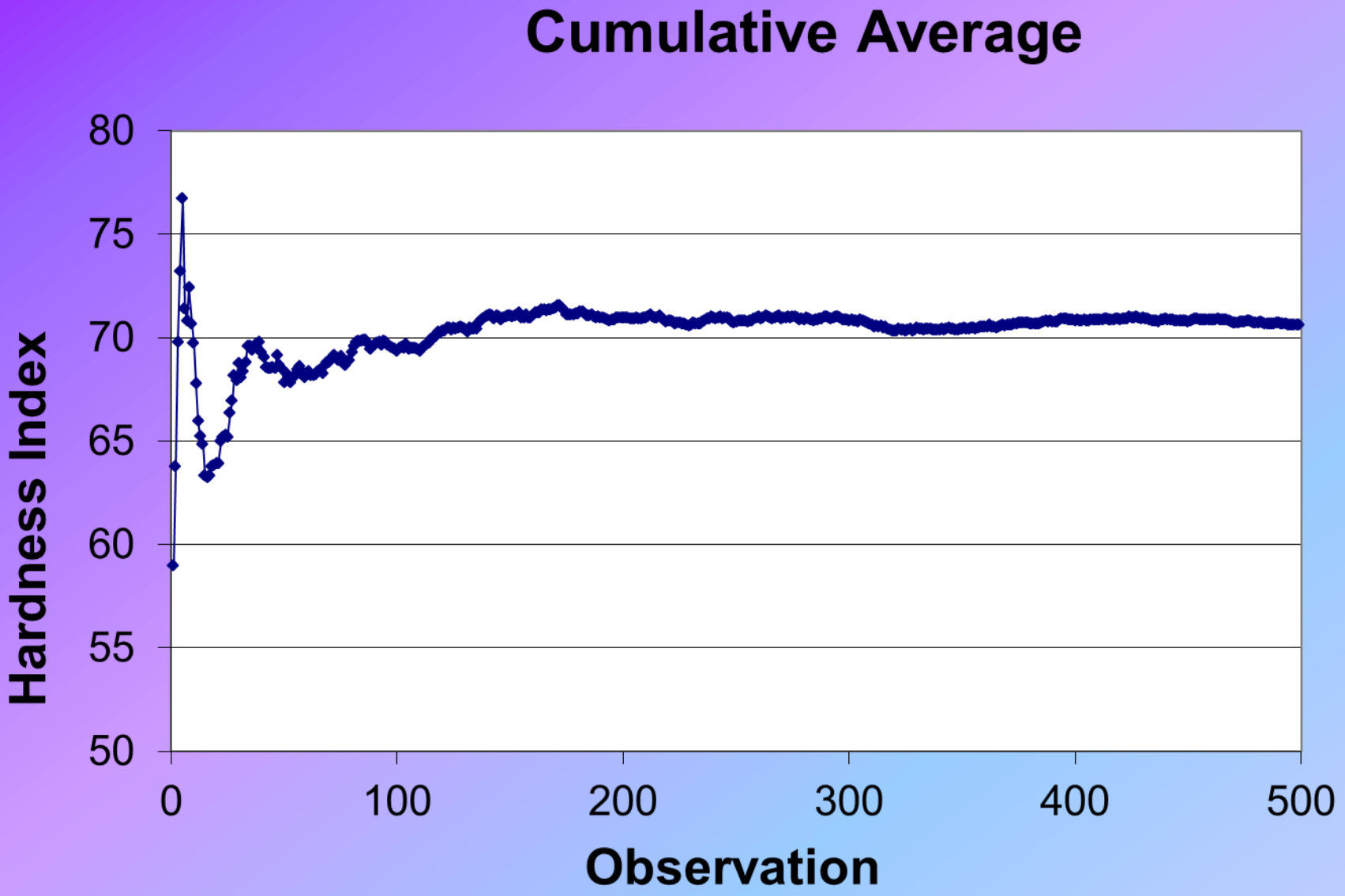
- Reflect of Reality
  - Average
  - Variation
- Risk of Overstating
- Risk of Understating

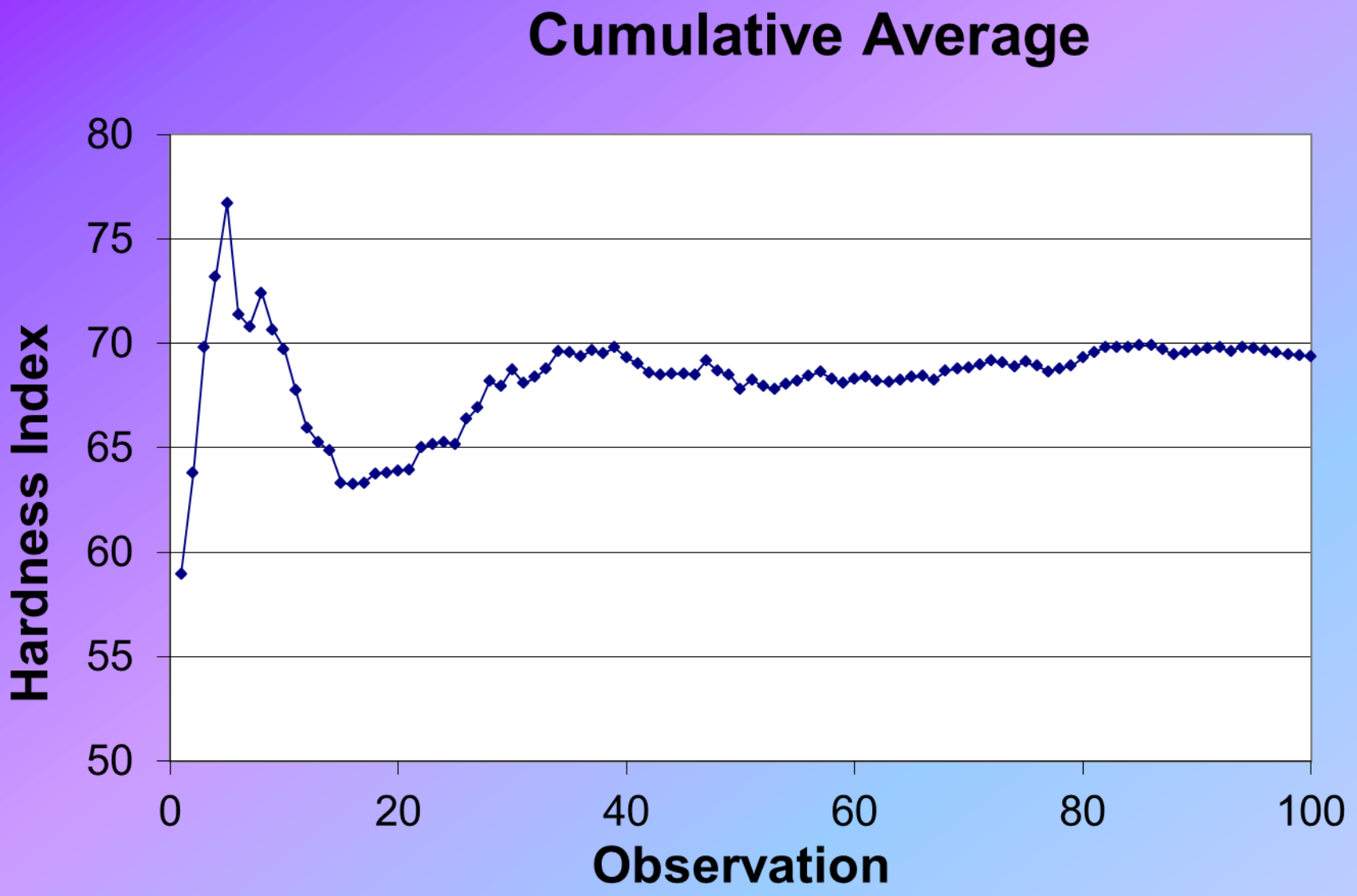
How Many is Enough?

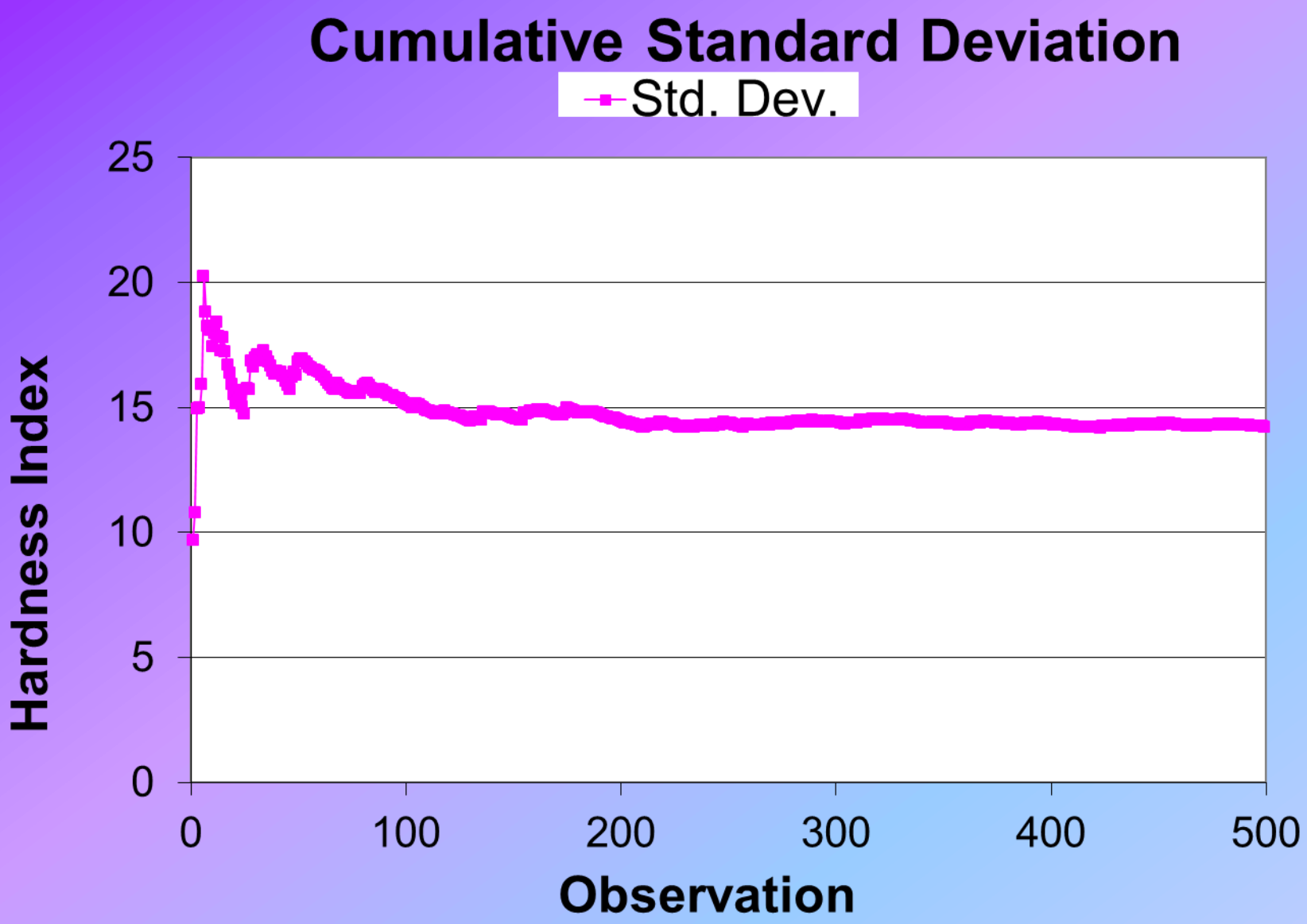
- Reflect of Reality
  - Average
  - Variation
- Risk of Overstating
- Risk of Understating

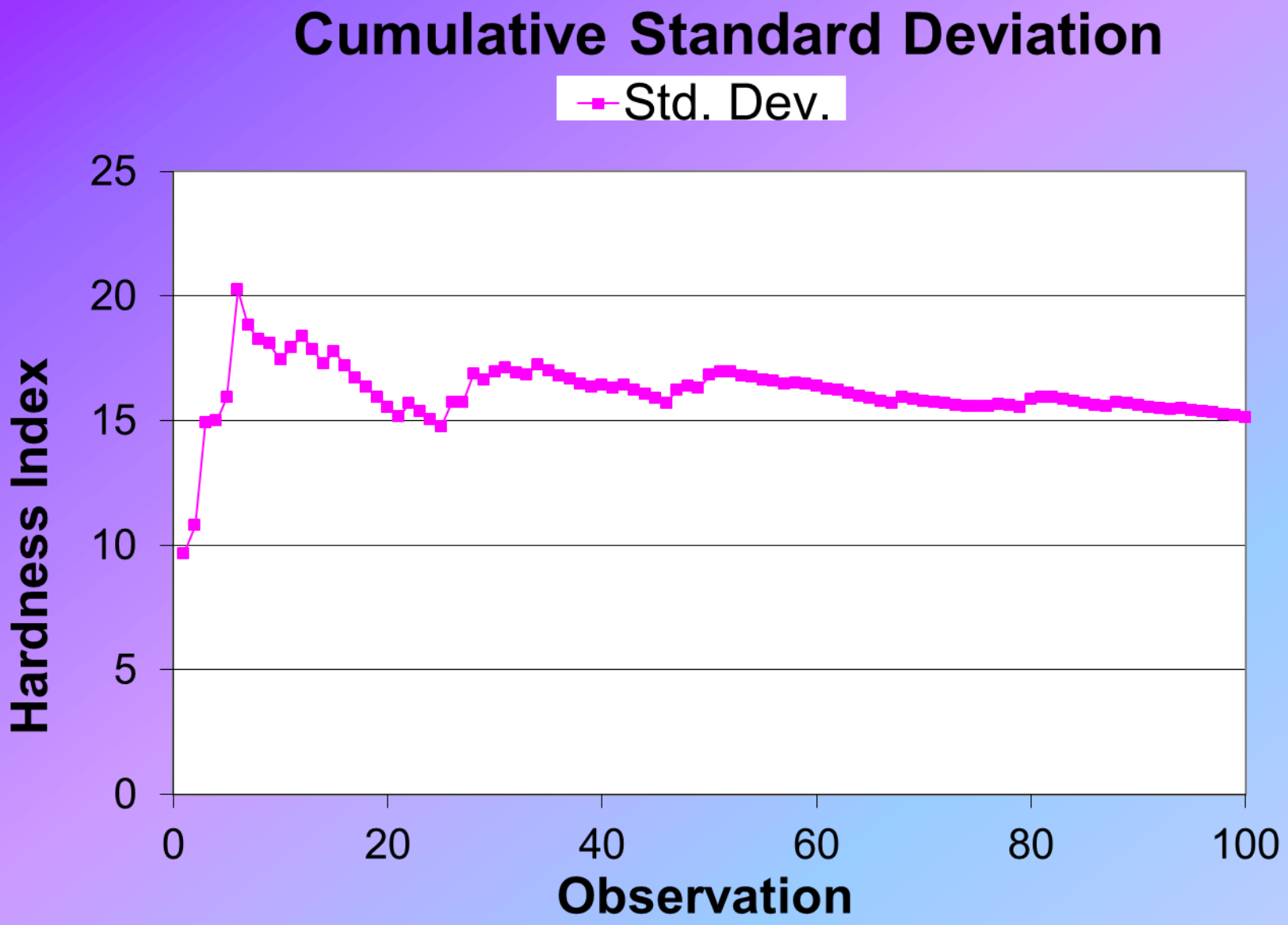
Numbers

- **Average**
- **Standard Deviation**
- **Time period**

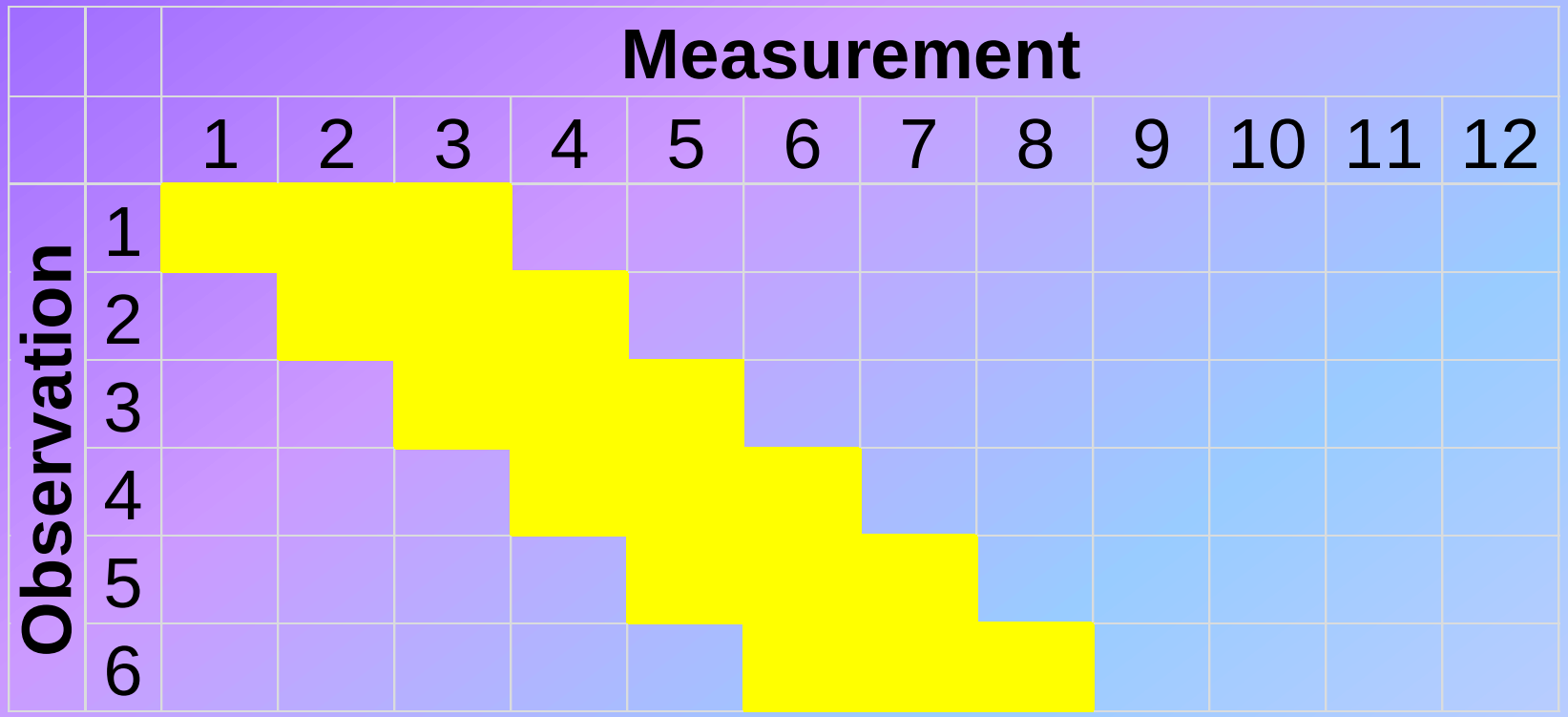

Cumulative Average
Hardness Index
80
75
70
65
60
55
50
0
100
200
300
400
500
Observation

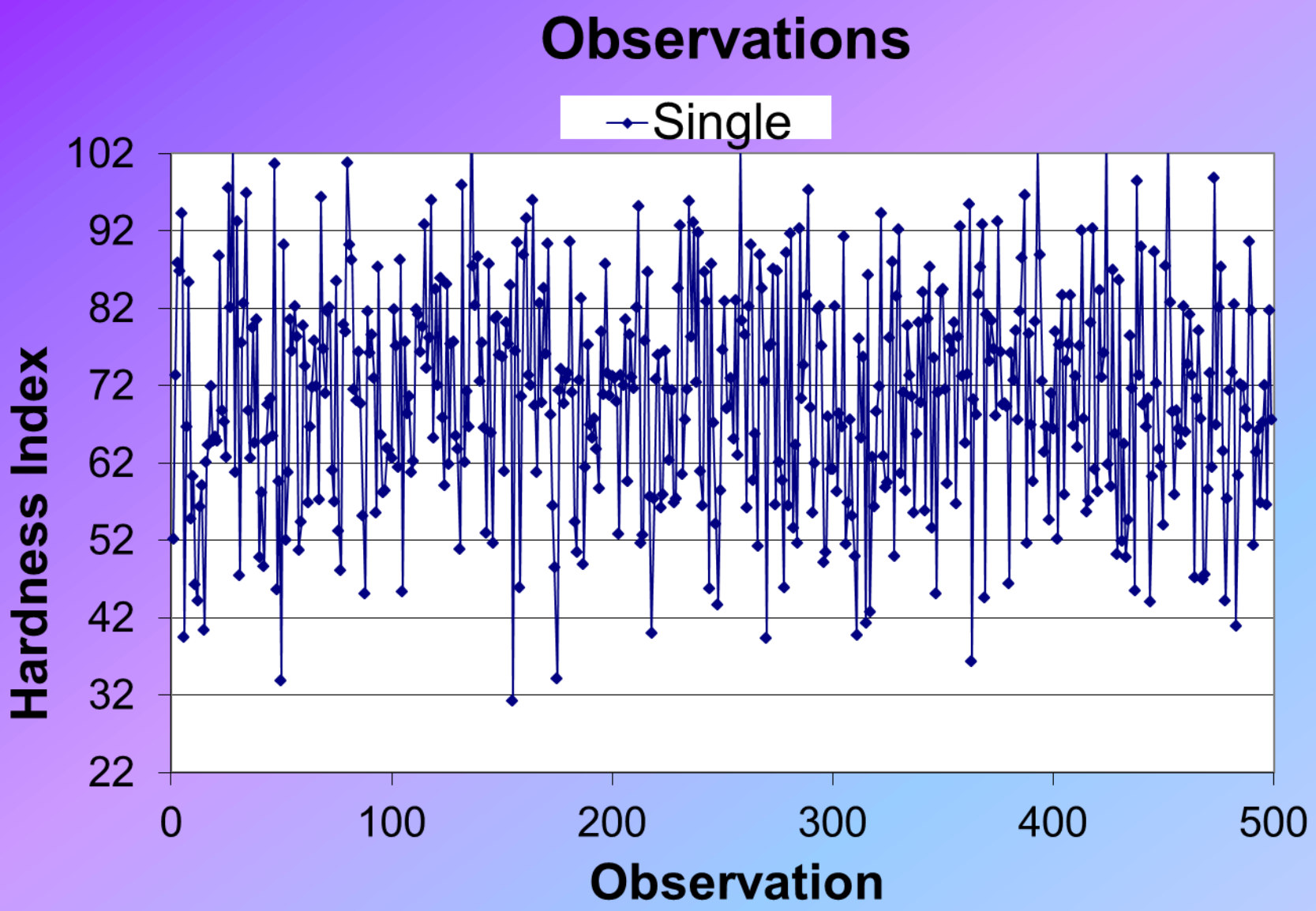

Cumulative Average
Hardness Index
80
75
70
65
60
55
50
0
20
40
60
80
100
Observation

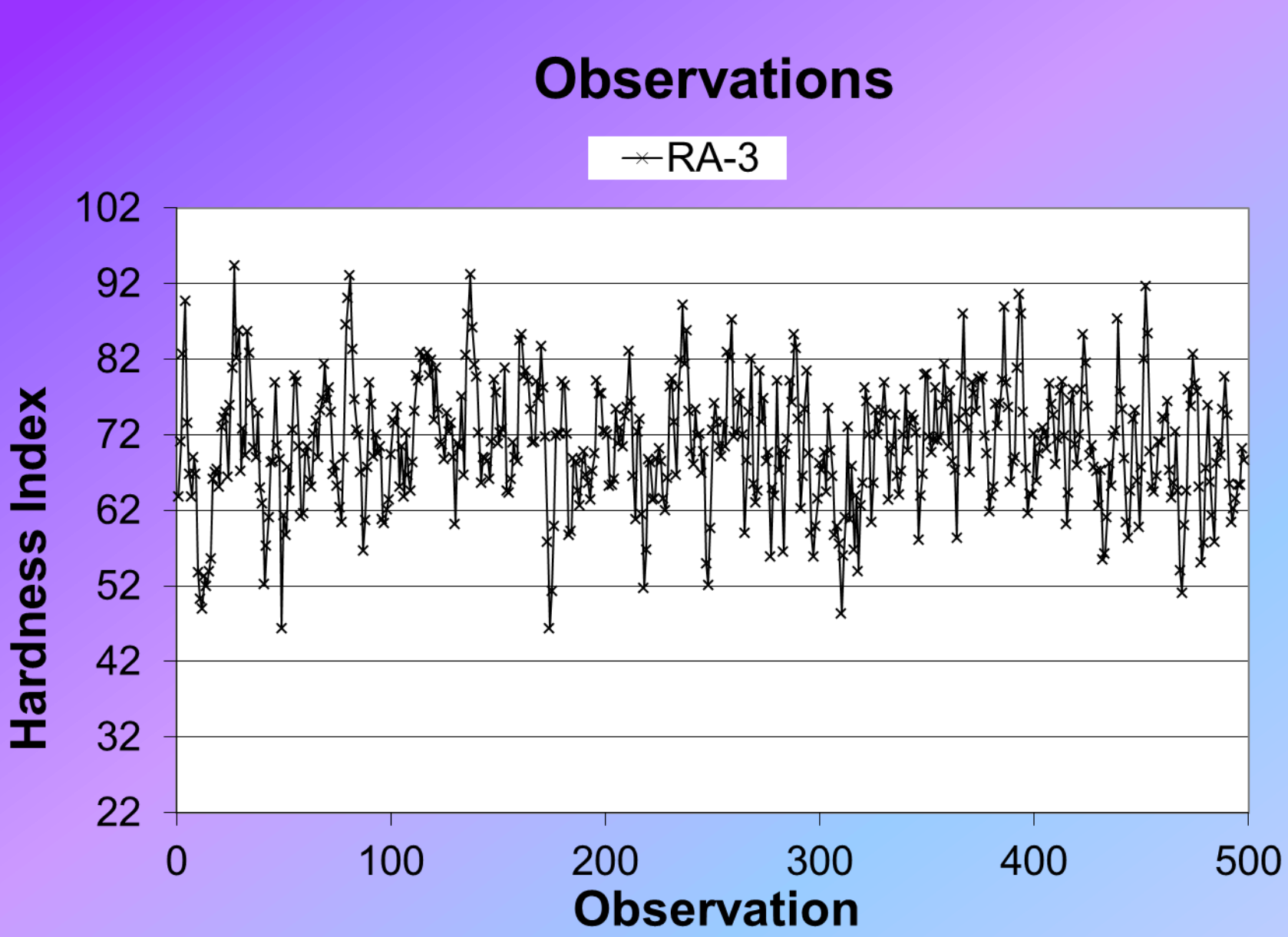

Cumulative Standard Deviation
Std. Dev.
Hardness Index
25
20
15
10
5
0
0
100
200
300
400
500
Observation

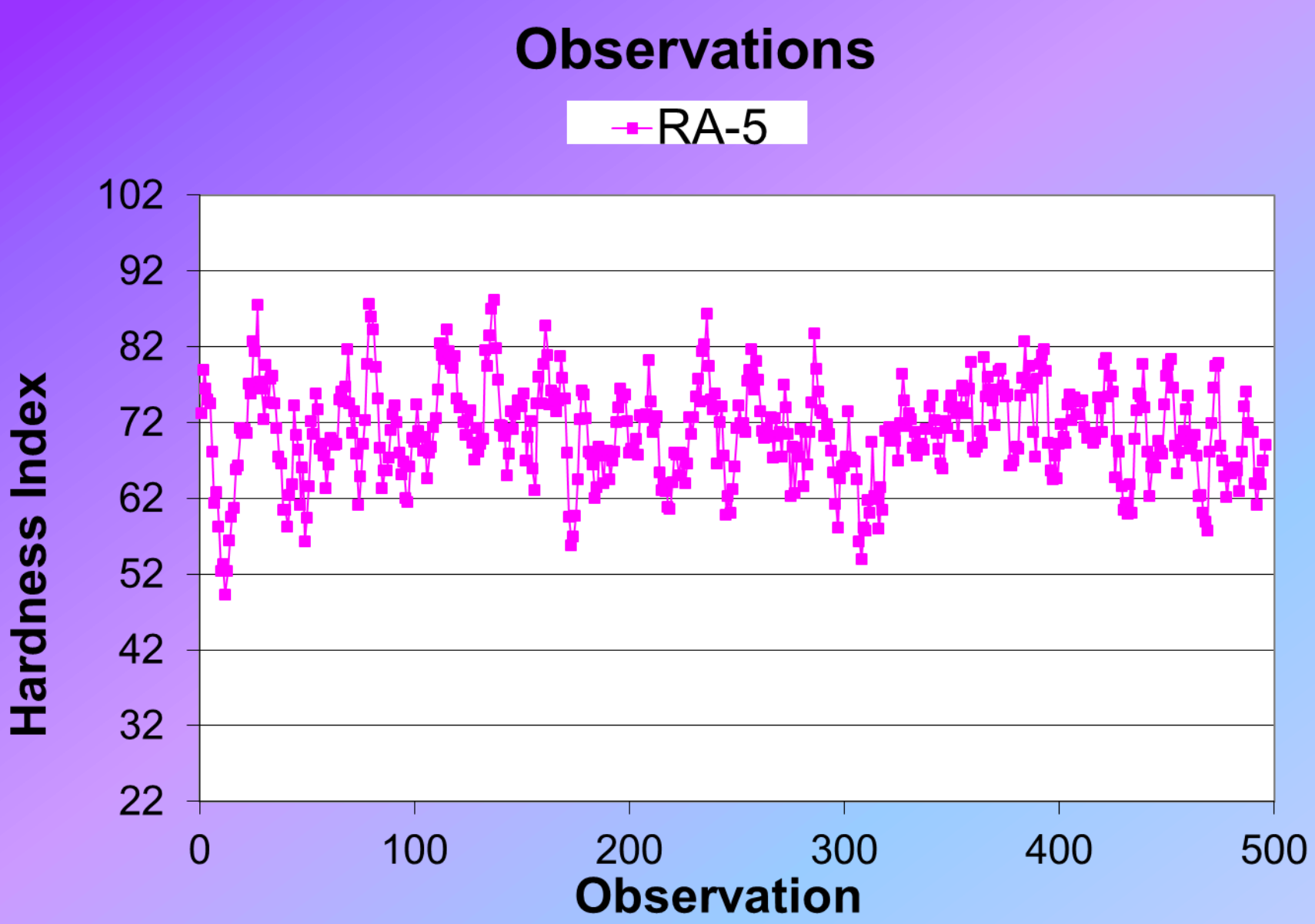

Cumulative Standard Deviation
Std. Dev.
Hardness Index
25
20
15
10
5
0
0
20
40
60
80
100
Observation

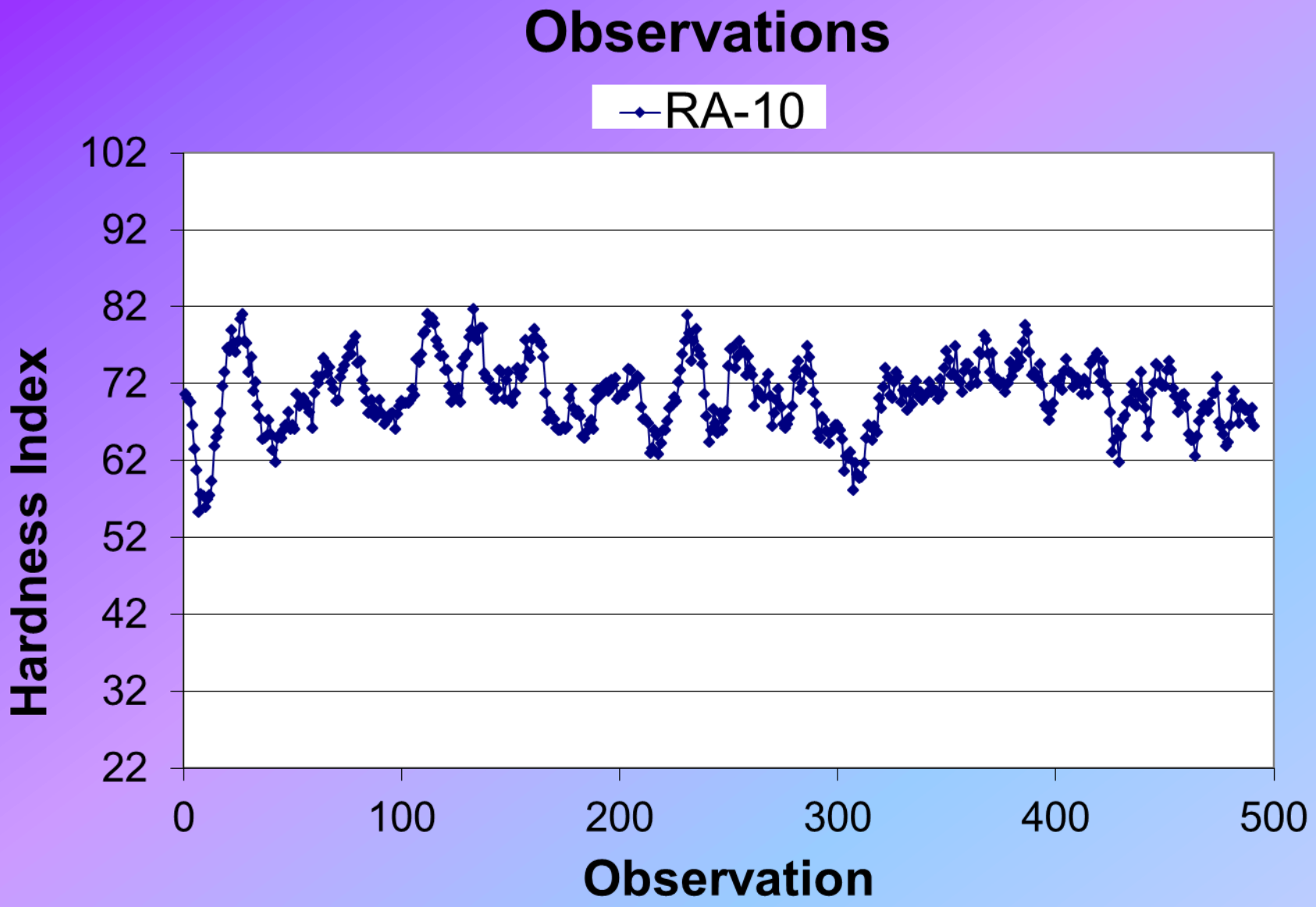
Running Average




Observations
Single
Hardness Index
102
92
82
72
62
52
42
32
22
0
100
200
300
400
500
Observation

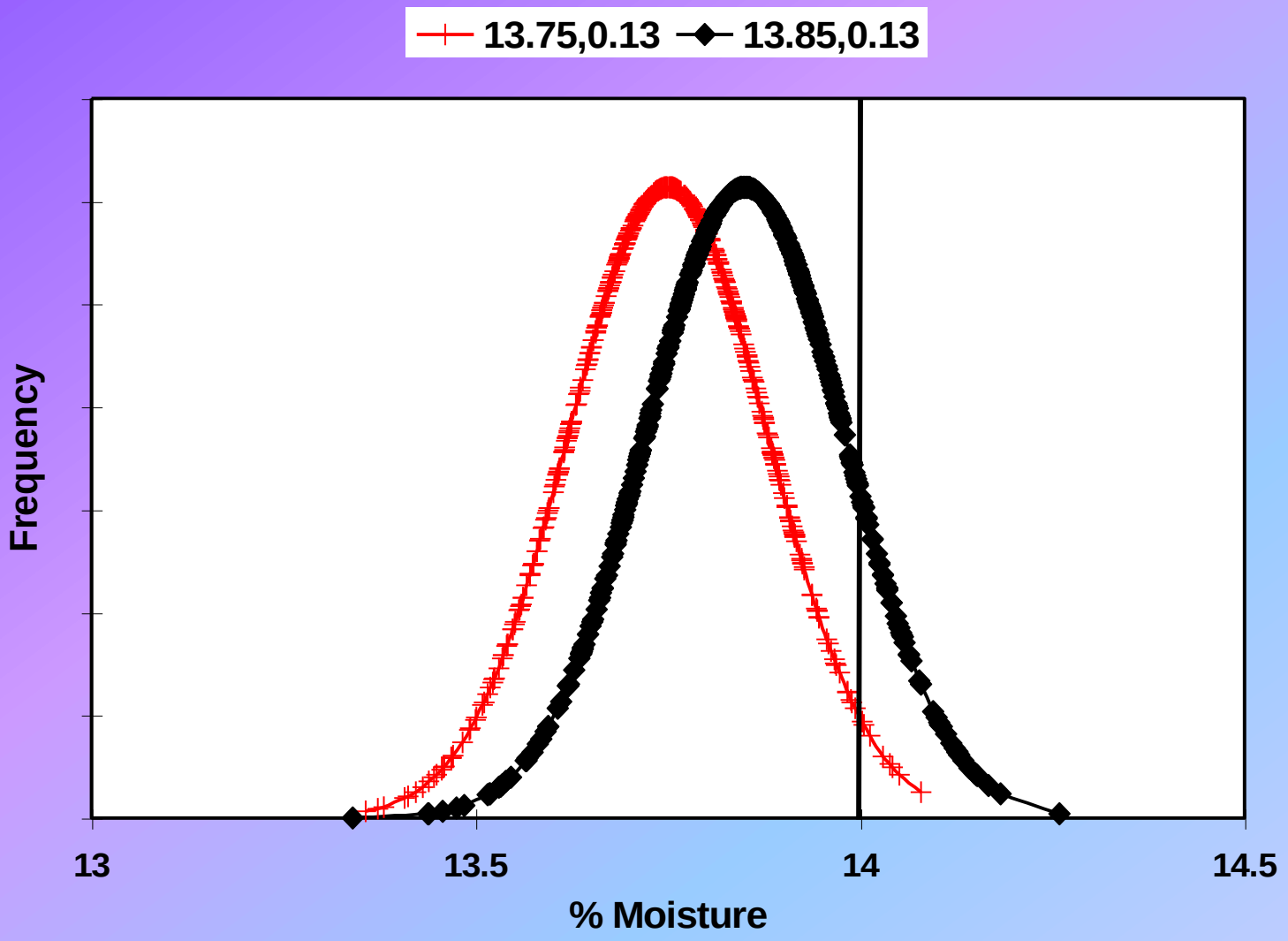

Observations
RA-3
Hardness Index
102
92
82
72
62
52
42
32
22
0
100
200
300
400
500
Observation


Observations
RA-5
Hardness Index
102
92
82
72
62
52
42
32
22
0
100
200
300
400
500
Observation


Observations
RA-10
102
92
82
72
62
52
42
32
22
Hardness Index
0
100
200
300
400
500
Observation

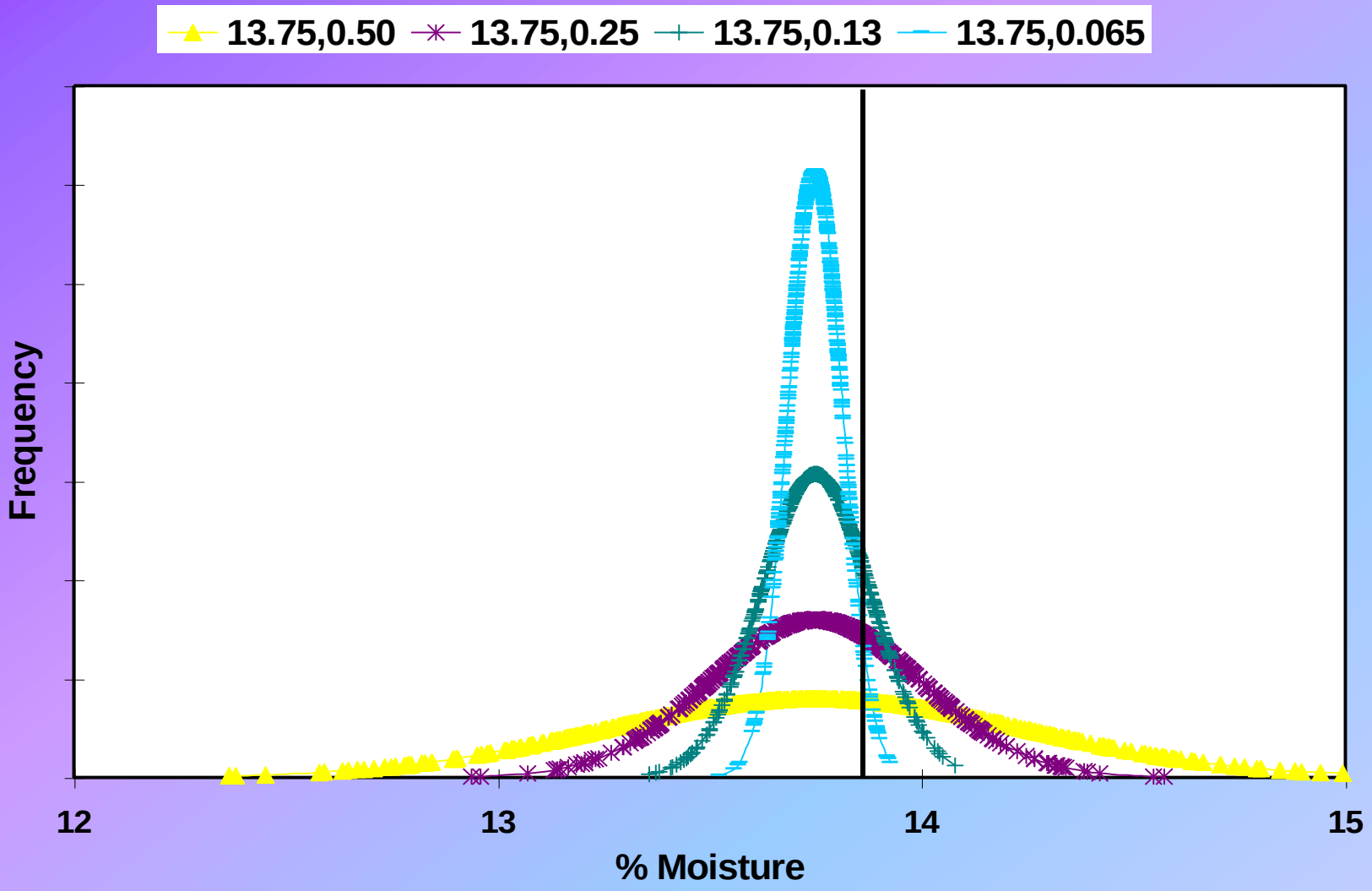
Where Do You Want To Be?

Flour Moisture Distribution



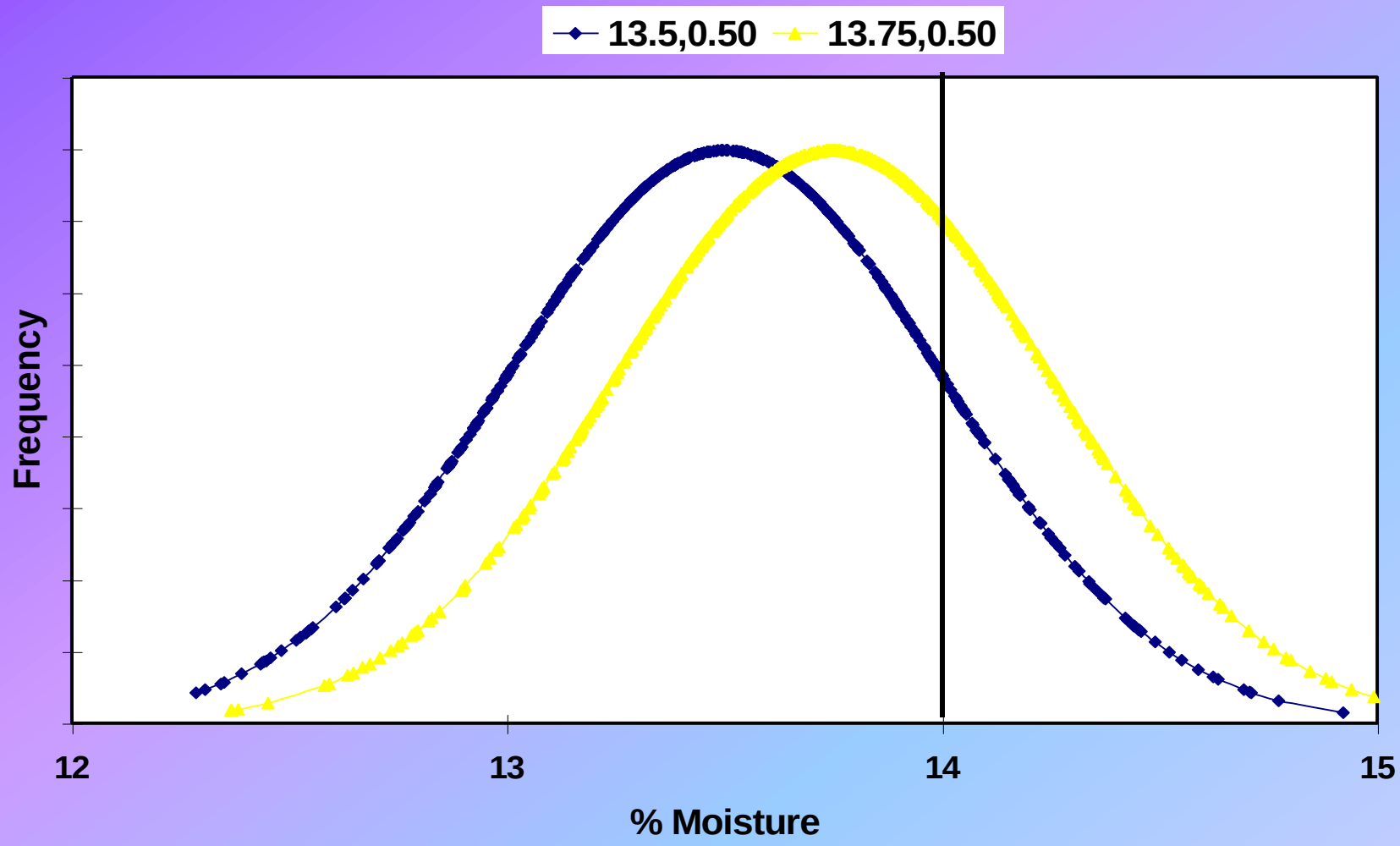
Changing the Standard Deviation

Flour Moisture Distribution



Changing the Average

Flour Moisture Distribution



Designing the experiment…Why Repeated Measures?

- Measure of Variability
- Risk of Understating
- Risk of Overstating
- Estimate Probability of Achieving Goals

Statistical Experiment

Group 1		Group 2		
Mean	Std. Dev.	Mean	Std. Dev.	Difference
60	0.87	59	1.05	1
60	0.87	58	1.05	2
60	0.87	57	1.05	3
60	0.87	56	1.05	4
60	0.87	55	1.05	5

Mean Difference of Five

	Group Size									
Range	1	2	3	4	5	6	7	8	9	10
<4	23%	16%	11%	7%	5%	3%	2%	2%	1%	0%
>6	24%	15%	11%	8%	7%	4%	2%	1%	1%	1%
N	500	499	498	497	496	495	494	493	492	491
Total	47%	31%	22%	16%	12%	7%	4%	3%	2%	1%

Mean Difference of Four

	Group Size									
Range	1	2	3	4	5	6	7	8	9	10
<3	20%	13%	8%	5%	4%	3%	2%	1%	1%	1%
>5	26%	16%	13%	10%	8%	7%	5%	4%	3%	2%
Total	46%	29%	21%	15%	12%	10%	7%	5%	4%	3%
N	500	499	498	497	496	495	494	493	492	491

Mean Difference of Three

	Group Size									
Range	1	2	3	4	5	6	7	8	9	10
<0	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%
<2	23%	17%	11%	8%	5%	4%	4%	3%	2%	2%
>4	21%	15%	9%	5%	3%	1%	0%	1%	0%	0%
Total	44%	32%	20%	12%	8%	6%	4%	4%	2%	2%
N	500	499	498	497	496	495	494	493	492	491

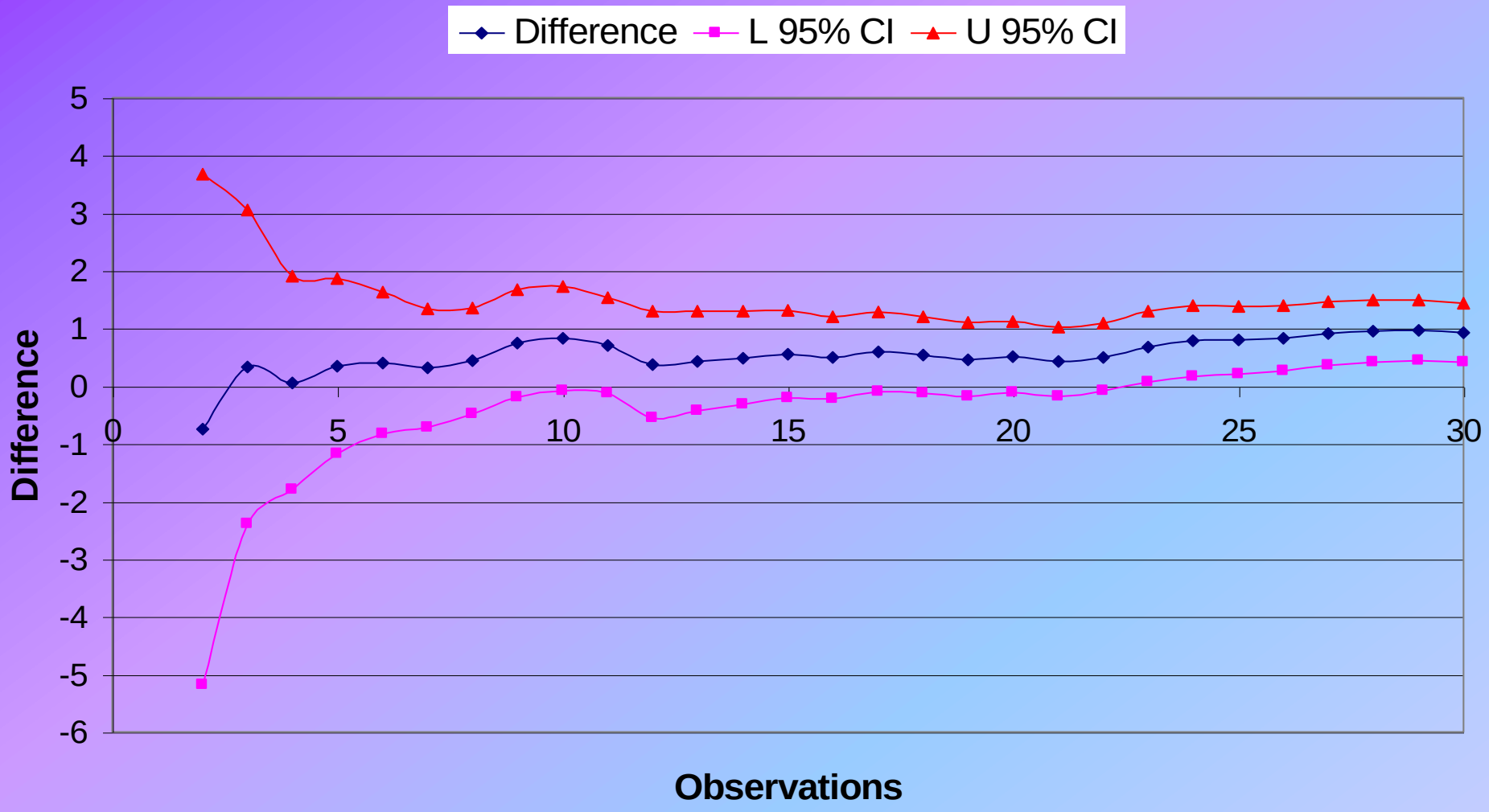
Mean Difference of Two

	Group Size									
Range	1	2	3	4	5	6	7	8	9	10
<0	6%	3%	1%	0%	0%	0%	0%	0%	0%	0%
<1	20%	14%	11%	7%	5%	2%	1%	0%	0%	0%
>3	25%	16%	12%	7%	6%	4%	4%	3%	2%	1%
Total	45%	30%	23%	14%	10%	7%	5%	4%	2%	1%
N	500	499	498	497	496	495	494	493	492	491

Mean Difference of One

	Group Size									
Range	1	2	3	4	5	6	7	8	9	10
<0	19%	11%	9%	4%	3%	2%	1%	1%	0%	0%
>2	27%	21%	15%	10%	8%	7%	6%	5%	4%	4%
Total	46%	32%	24%	15%	11%	9%	7%	6%	5%	4%
N	500	499	498	497	496	495	494	493	492	491

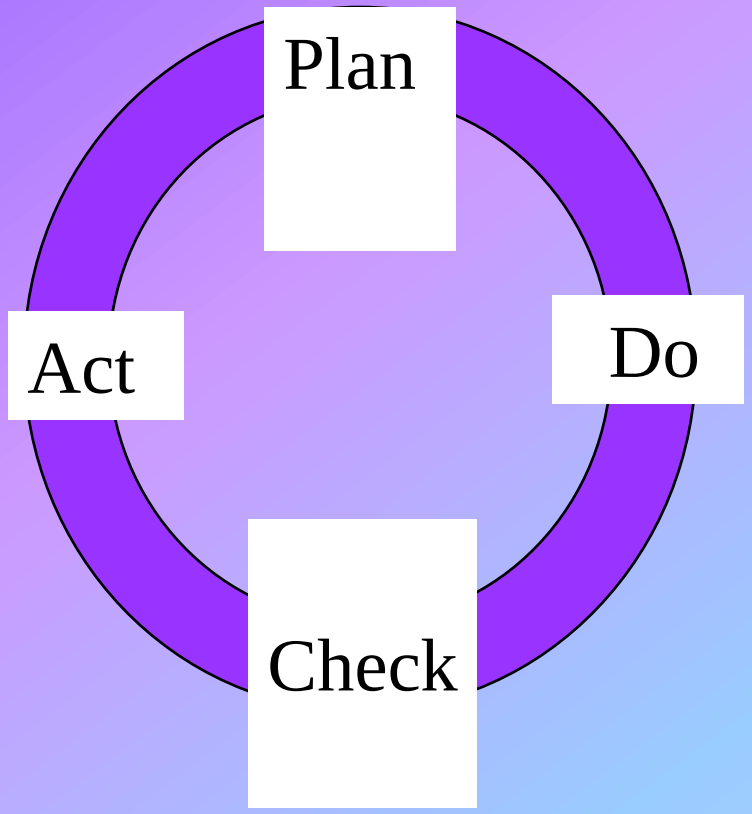
Effect of Observations on Difference Estimates



Simple Payback Analysis

ΔYield (%)	Initial Invest. ($Million)	Year 1	2	3	4	5	6	7	8	9	10
0	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
1	(0.4)	(0.2)	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6
2	(0.8)	(0.6)	(0.4)	(0.2)	0.0	0.2	0.4	0.6	0.8	1.0	1.2
3	(1.2)	(1.0)	(0.8)	(0.6)	(0.4)	(0.2)	0.0	0.2	0.4	0.6	0.8
4	(1.6)	(1.4)	(1.2)	(1.0)	(0.8)	(0.6)	(0.4)	(0.2)	0.0	0.2	0.4

PDCA Cycle



Final Thoughts

- Identify Key Problem Areas
- Measure Control Capability
- Identify Sources of Variation
- Experimental Design
- Economic Study
- Implementation
- Re-evaluation

Thank You!