PH101 LAB 1

UNCERTAINTY ANALYSIS STATISTICS

Sciencing

- So you have an idea.
- This idea must be *testable* ... or it is not science
- So we test it.

- How good is our test? How well did it work?
  - a measure of the result & accuracy
  - does it make any sense? predict something else ...

Example

- Your reaction time is better than mine ...
- Every time? By how much?
- What is the variability?
- How good is the measurement anyway?

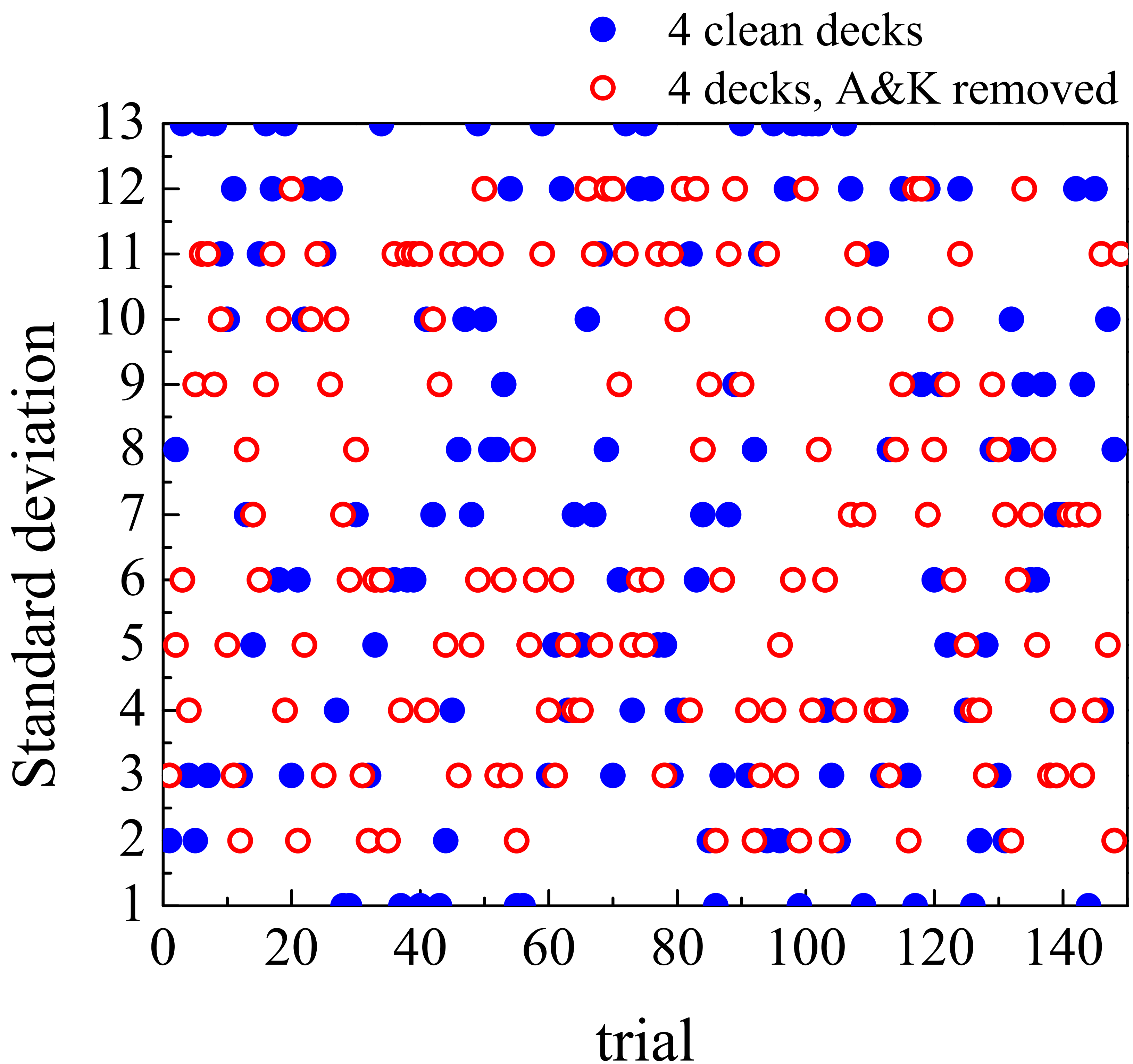
Today: is the deck loaded?

- one measurement vs. many
- how does accuracy improve?
- how to measure accuracy?
- statistical measures of uncertainty & dispersion

The experiment: picking cards

- give each one a number
- Ace = 1, 2 = 2 ... Jack = 11 ... King = 13
- what is the average card?
  - we expect it must be 7 ...
- what is the spread? how to define this?

150 trials ...

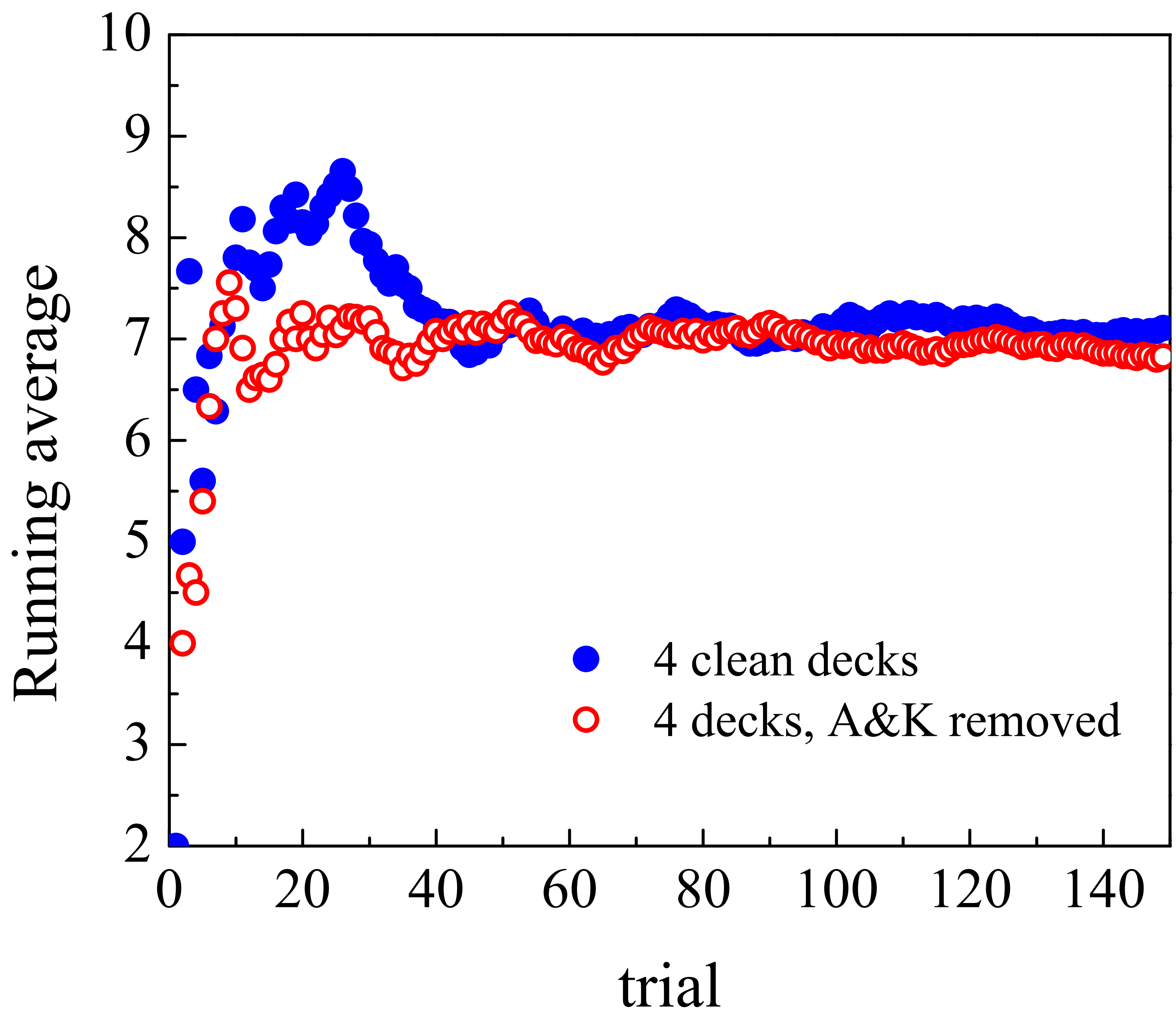


4 clean decks
4 decks, A&K removed
Standard deviation
trial
13
12
11
10
9
8
7
6
5
4
3
2
1
0
20
40
60
80
100
120
140

equal number of each

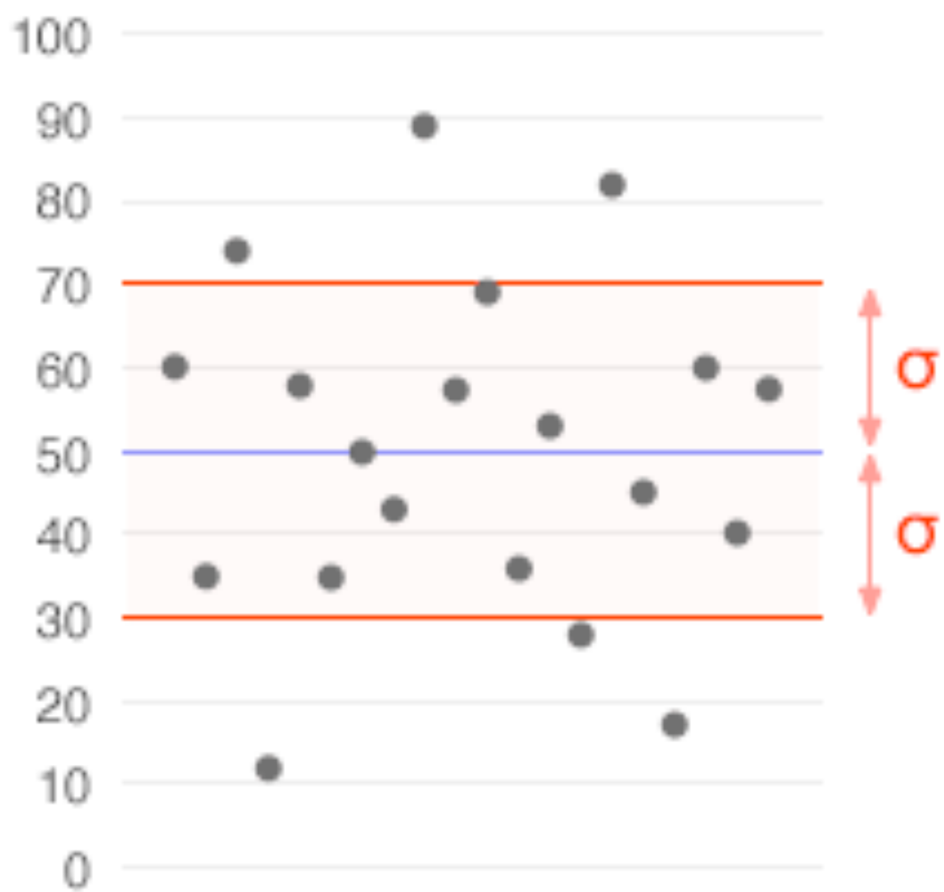
average must be 7, if one chooses enough cards

takes ~50 before ‘luck’ is irrelevant!

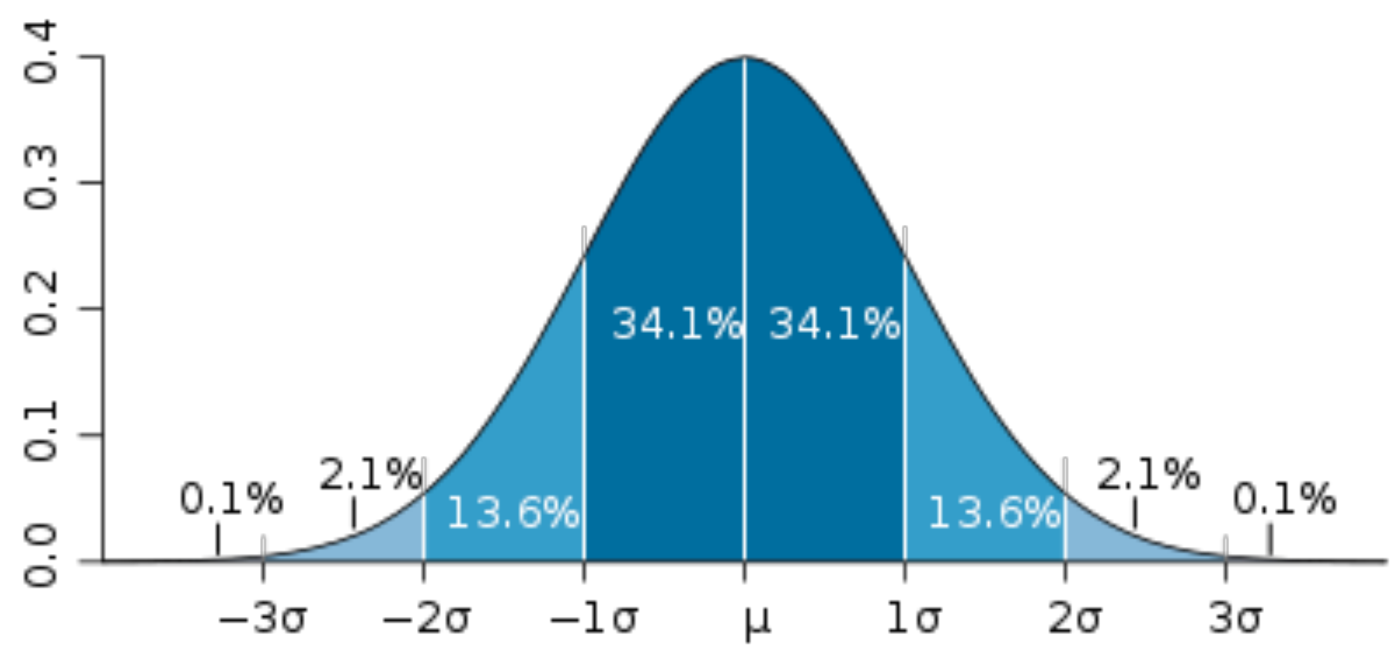


standard deviation is a measure of the variability dispersion in a population or data set

low standard deviation: data tends to lie close to the average (mean)
high standard deviation: data spread over a large range



data set: data clustered about average



many trials: follow a *distribution*

~68% within +/- 1 standard deviation
~95% within +/- 2 standard deviations
~99.7% within +/- 3 ...

so what?

- knowing the standard deviation tells you
  - if subsequent measurements are outliers
  - what to expect next
  - *accuracy* of a set of data
  - variability in a large batch
- "six sigma" - quality control
  - means one out of 500 million!

so what?

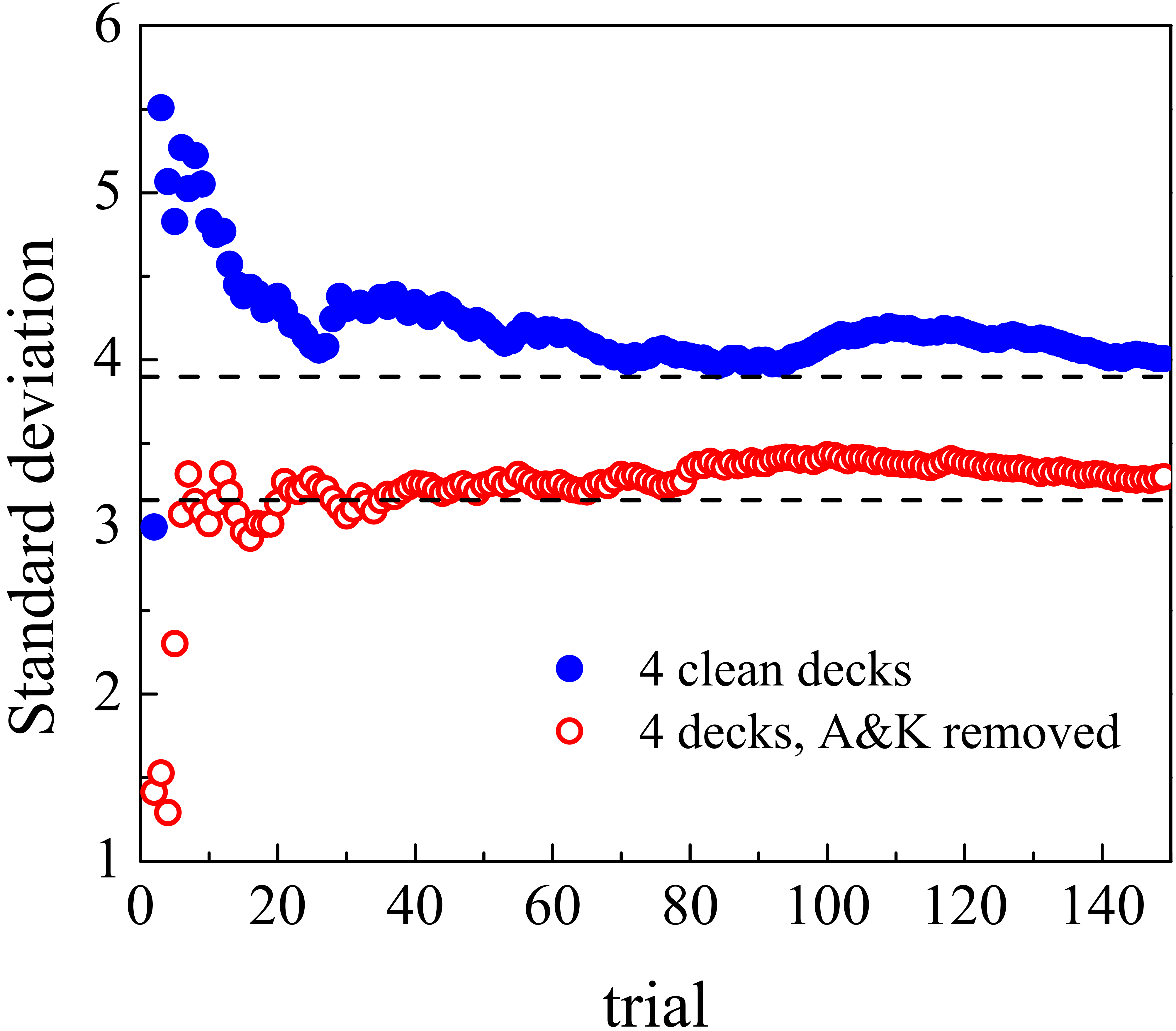
if the mean of the measurements is too far away from the prediction, then the theory being tested probably needs to be revised!

particle physics: 3-sigma standard typical

more than that ... probably a new effect!

$$(\text{quantity}) = (\text{mean}) \pm (\text{systematic error}) \pm (\text{statistical error})$$

or $$x = \overline{x} \pm \delta x \pm \sigma$$



Standard deviation
trial
4 clean decks
4 decks, A&K removed
0
20
40
60
80
100
120
140
1
2
3
4
5
6

expect 75% of cards within 2 standard deviations of average

or, 75% are within about 4 cards from the average after 100 trials

or, 75% of cards should be between 3 and Jack (inclusive)

It works!

flip side: we could estimate the distribution of cards without prior knowledge
(e.g., remove all 2’s and 3’s ... we could tell!)

what else?

- standard deviation gives accuracy of average
- if you do n measurements, average is better for higher n

$$\sigma_{\overline{x}} = \frac{\sigma}{\sqrt{n}}$$

$$(\text{best value of } x) = \overline{x} \pm \sigma_{\overline{x}}$$

detailed explanation & examples in lab procedure

... so read it first

excel example included too

draw	card	running average	running standard deviation	
1	2	2.00		
2	8	5.00	4.24	
3	13	7.67	5.51	
4	3	6.50	5.07	
5	2	5.60	4.83	

	A	B	C	D	E
1	draw	card	running average	running standard deviation	
2	1	2	2.00		
3	2	8	=AVERAGE($B$2:B3)	=STDEV($B$2:B3)	
4	3	13	^ drag down	^ drag down	
5	4	3	6.50	5.07	
6	5	2	5.60	4.83	
7					