



KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY



„Signal processing”

**Prezentacja multimedialna współfinansowana przez
Unię Europejską w ramach
Europejskiego Funduszu Społecznego w projekcie pt.
*„Innowacyjna dydaktyka bez ograniczeń - zintegrowany
rozwój Politechniki Łódzkiej - zarządzanie Uczelnią,
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do zatrudniania osób niepełnosprawnych”***



Politechnika Łódzka

Politechnika Łódzka, ul. Żeromskiego 116, 90-924 Łódź, tel. (042) 631 28 83
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Medical diagnosis as a binary decision

Medical diagnosis, in many cases can be viewed as the task of taking a binary decision about patient status:

0 – patient healthy

1 – patient ill

This decision is taken on the basis of some diagnostic parameter derived from the patient (e.g. body temperature, ECG record, X-ray, mammography, CT, MRI, USG scans, blood pressure measurement, other symptoms).

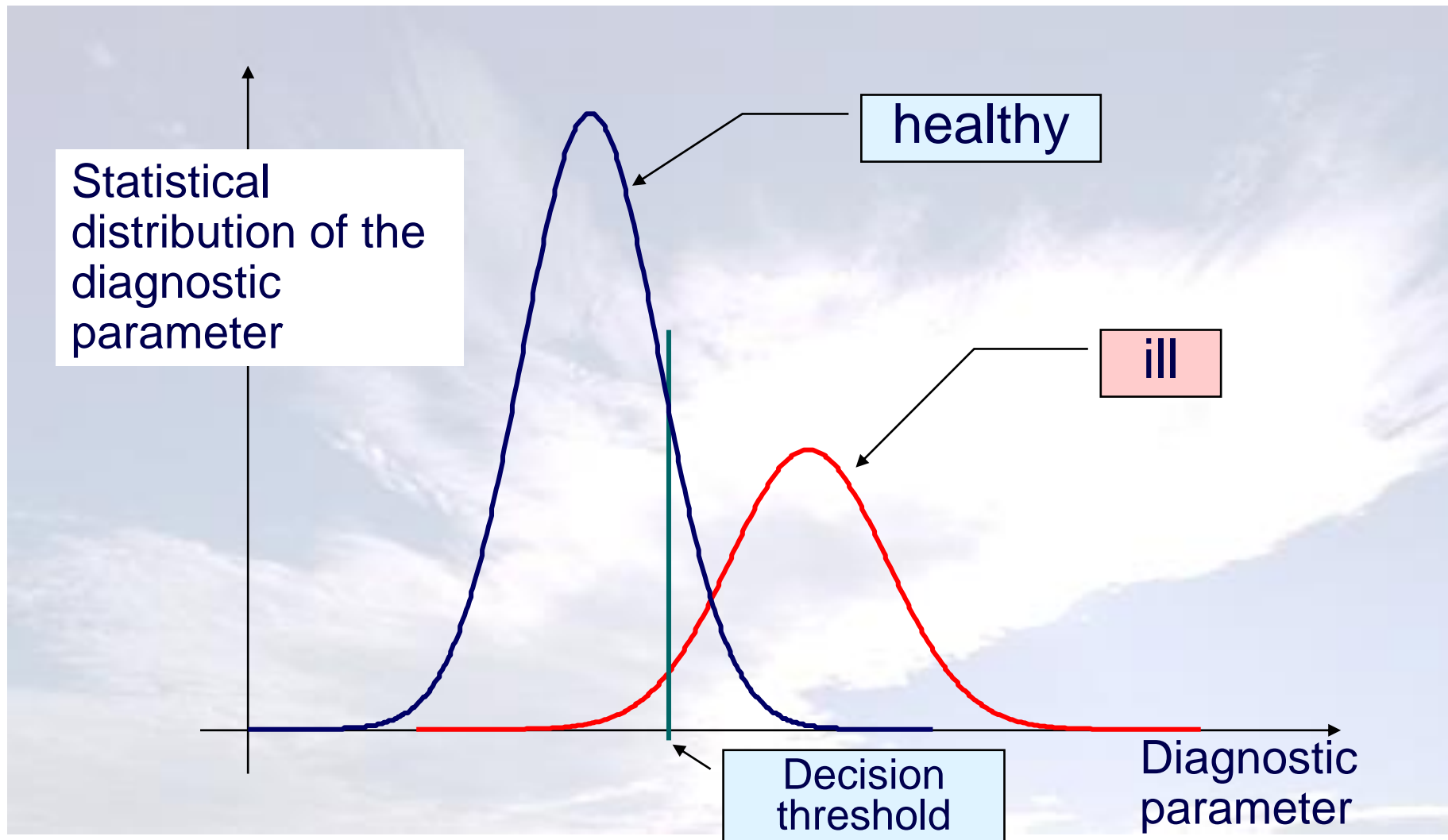
Unfortunately, due to many factors (e.g. imprecise data measurement, poor skills of the medical personnel) the diagnosis decision proves wrong, e.g. healthy patient is rendered ill, or even worse ill patient is rendered healthy

How to evaluate the quality of the diagnoses?



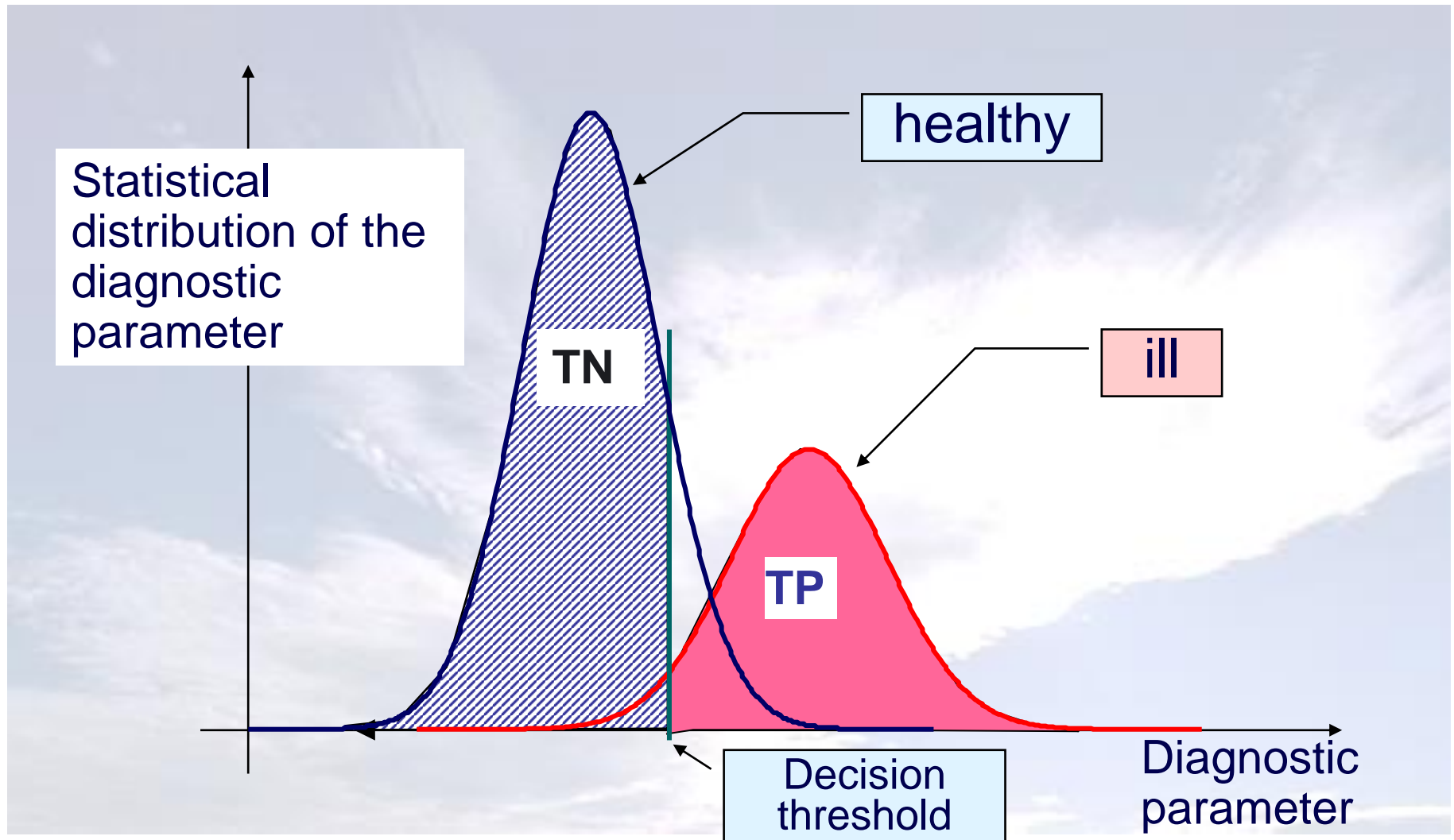


Evaluation of a diagnostic test



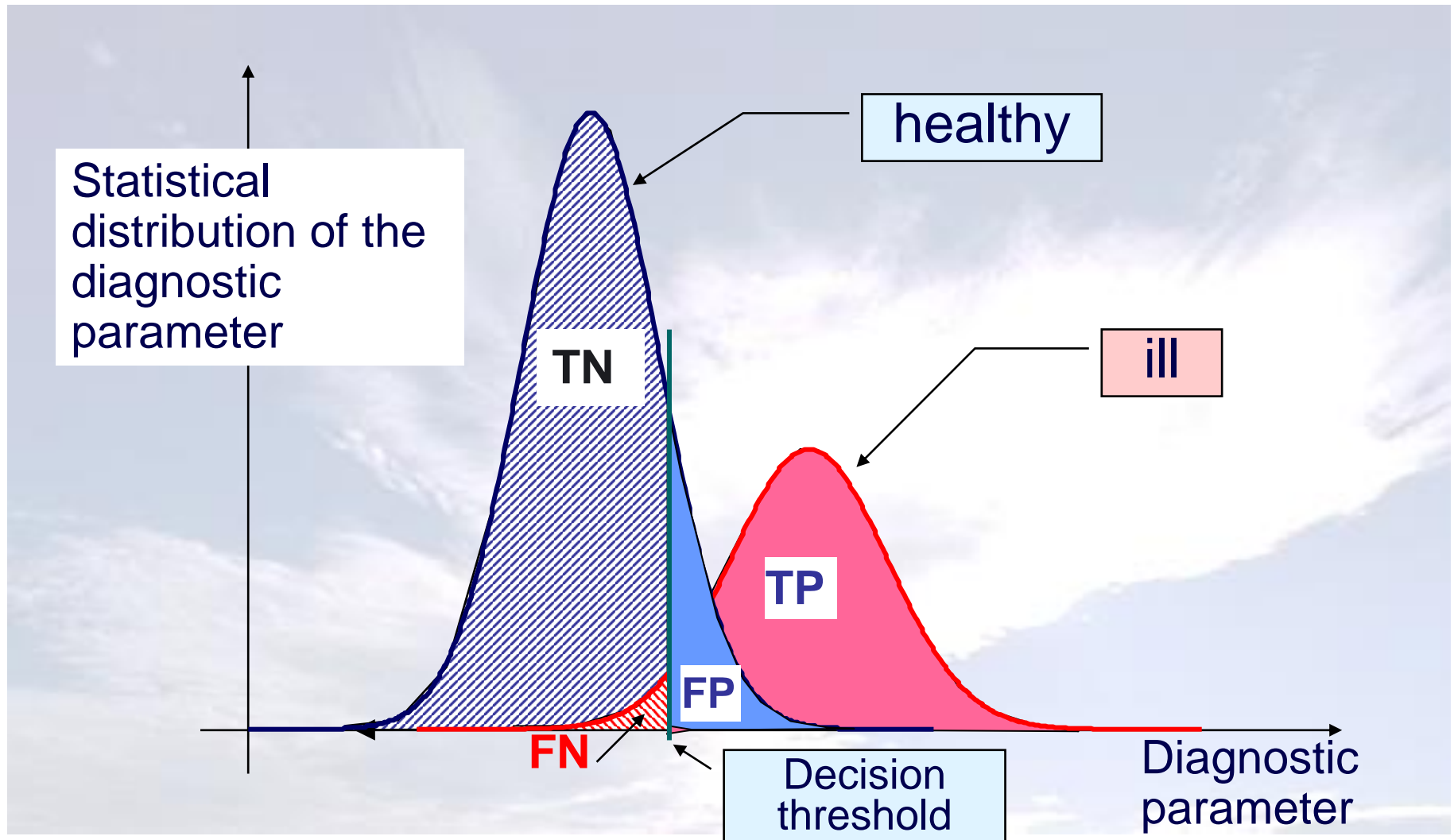


Evaluation of a diagnostic test





Evaluation of a diagnostic test

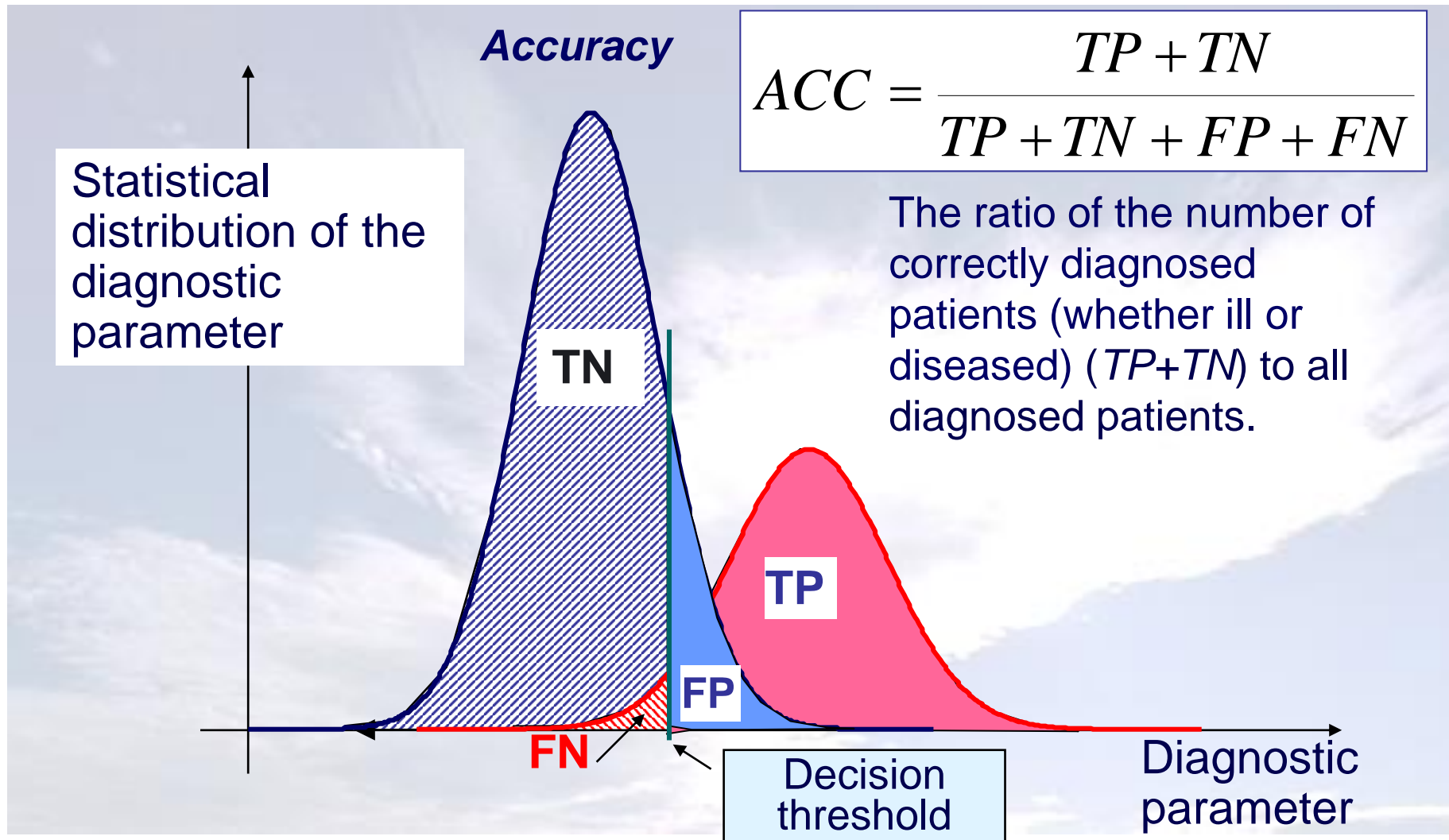


Evaluation of a diagnostic test

The confusion matrix

		Ground truth (real health status)	
		ill patients	healthy patients
Diagnosis result	ill patients	TP (<i>true-positive</i>) – <i>correct hit</i>	FP (<i>false-positive</i>) - false alarm
	healthy patients	FN (<i>false-negative</i>) - missed	TN (<i>true-negative</i>) - correct rejection

Evaluation of a diagnostic test



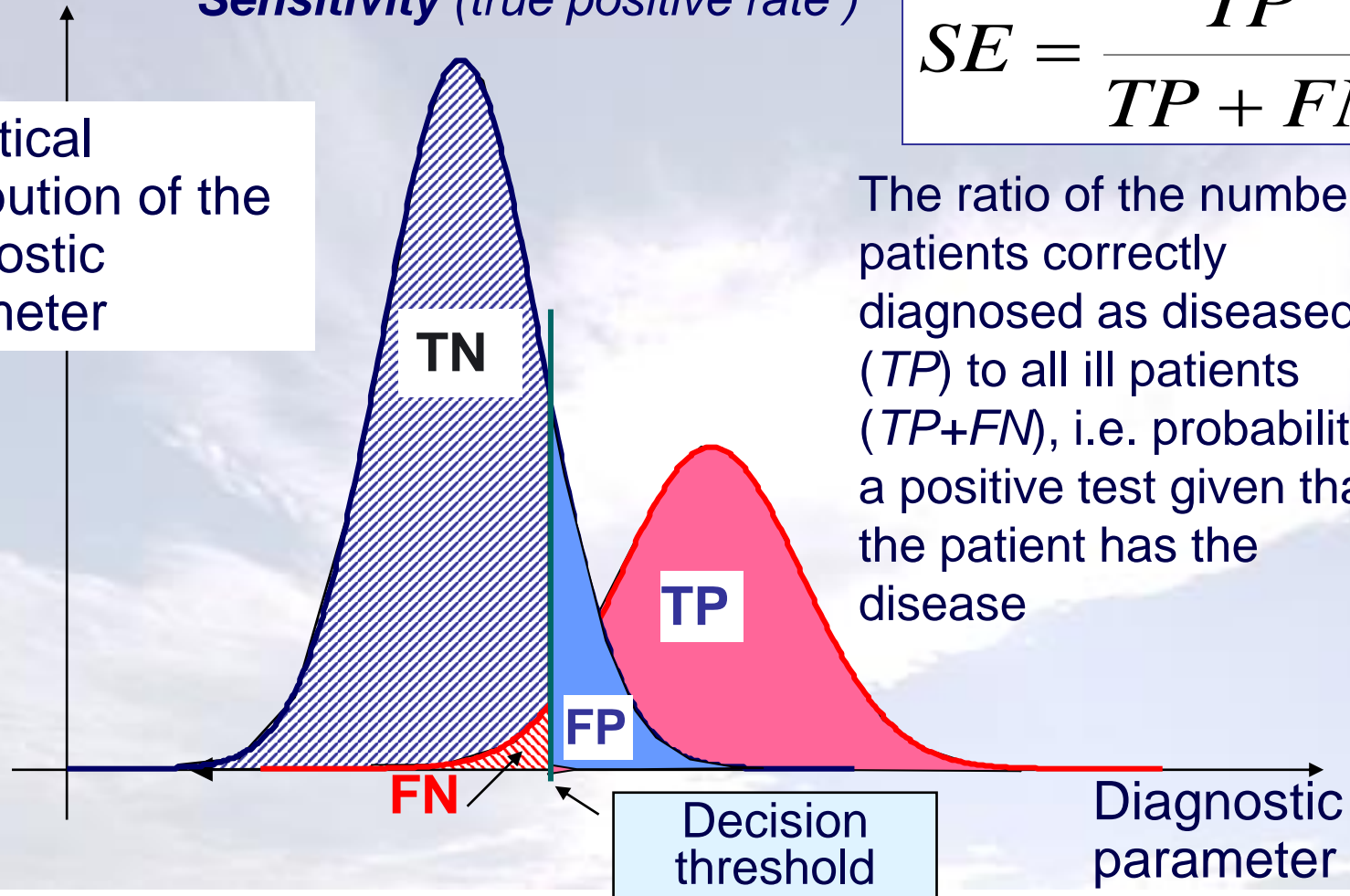
Evaluation of a diagnostic test

Sensitivity (true positive rate)

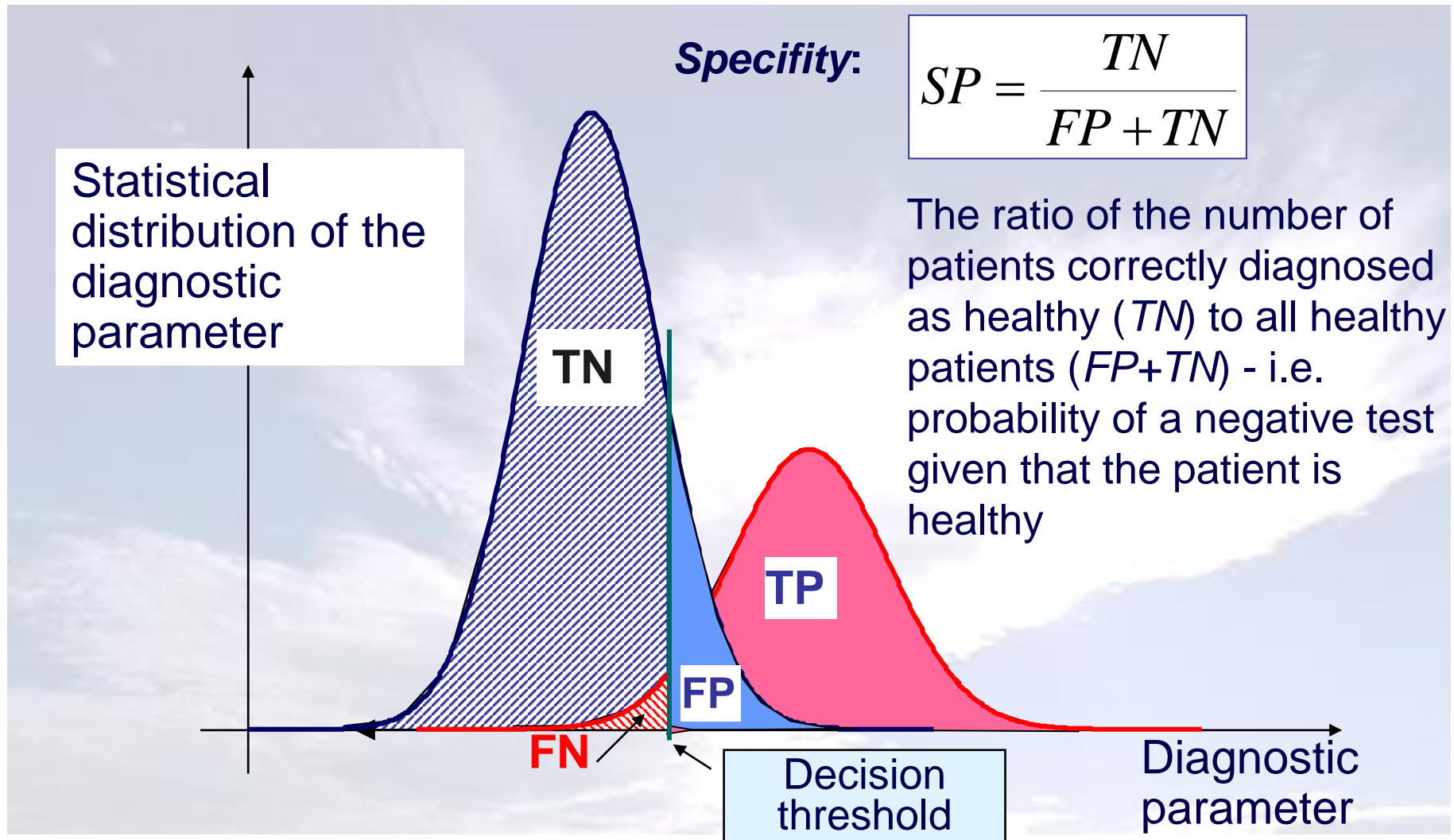
$$SE = \frac{TP}{TP + FN}$$

The ratio of the number of patients correctly diagnosed as diseased (TP) to all ill patients ($TP+FN$), i.e. probability of a positive test given that the patient has the disease

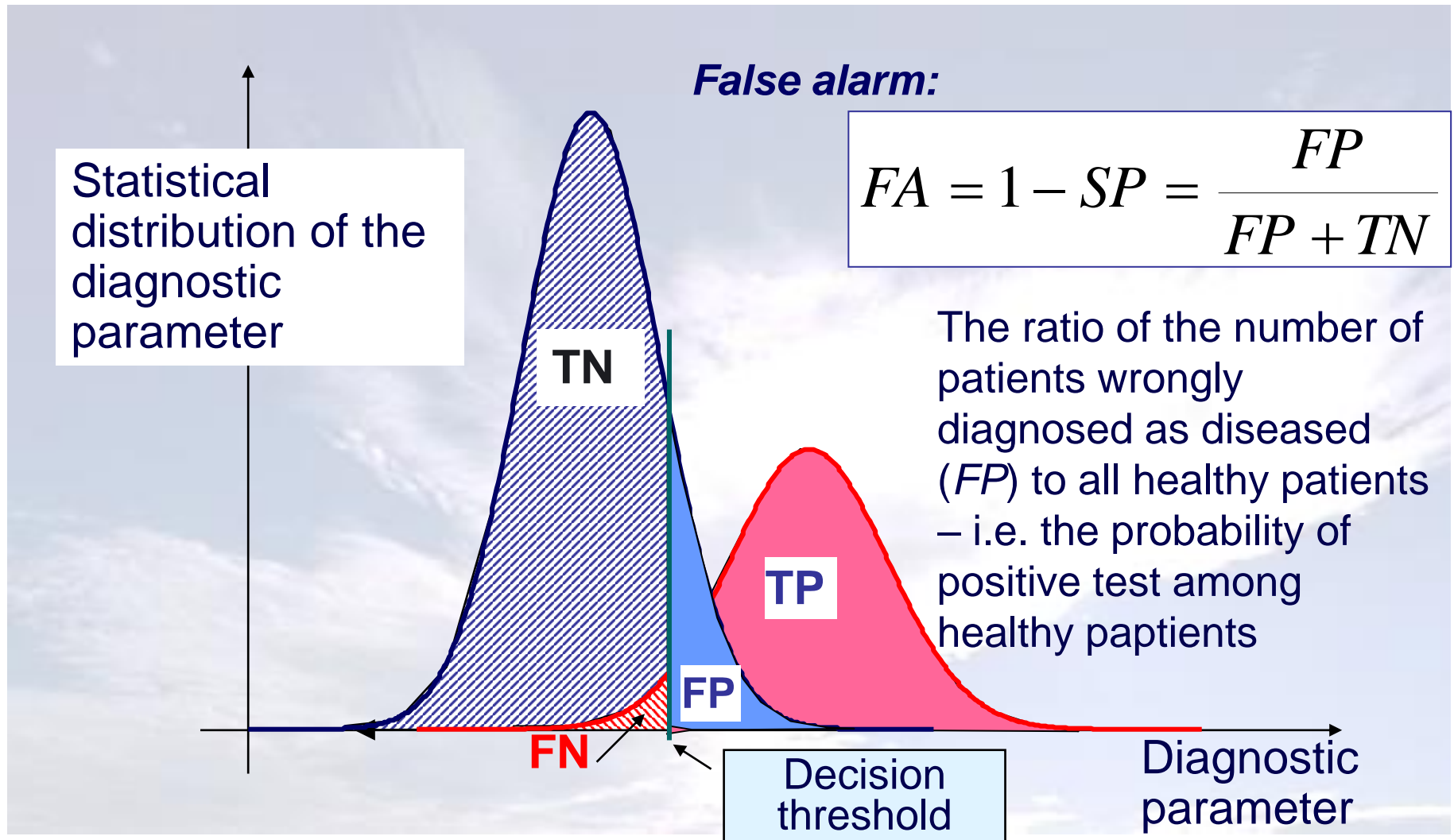
Statistical distribution of the diagnostic parameter



Evaluation of a diagnostic test



Evaluation of a diagnostic test



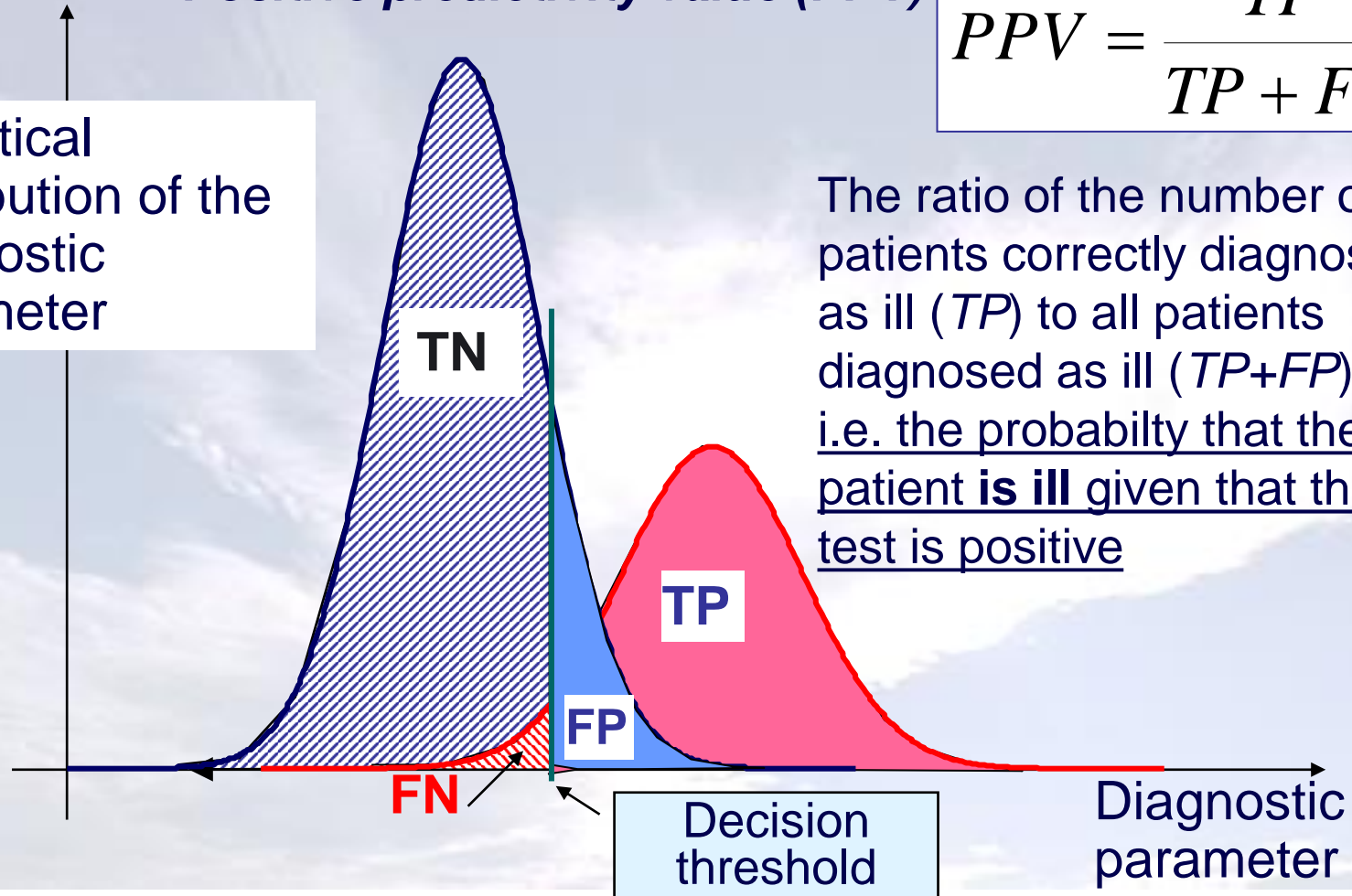
Evaluation of a diagnostic test

Positive predictivity value (PPV)

$$PPV = \frac{TP}{TP + FP}$$

Statistical
distribution of the
diagnostic
parameter

The ratio of the number of patients correctly diagnosed as ill (TP) to all patients diagnosed as ill ($TP+FP$).
i.e. the probability that the patient **is ill** given that the test is positive

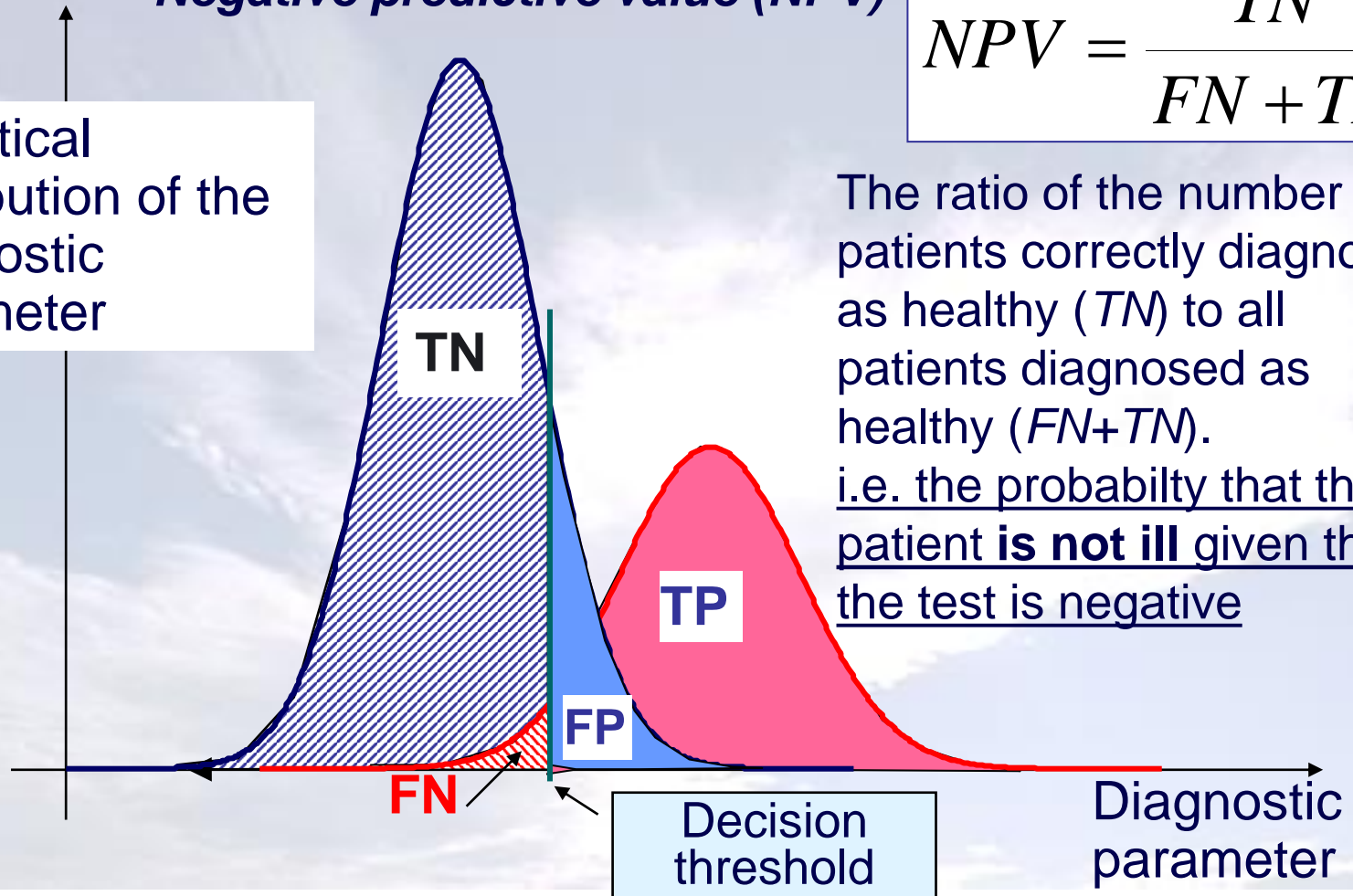


Evaluation of a diagnostic test

Negative predictive value (NPV)

$$NPV = \frac{TN}{FN + TN}$$

Statistical
distribution of the
diagnostic
parameter





Measures for valuation of a diagnostic test – case study

Case study: *In a hypothetical emergency department **100** patients were admitted with heart attack symptoms. The doctor on duty, working under pressure, from all admitted patients has diagnosed **30** patients as suffering from heart attack and the rest as having other benign disorders.*

*All patients underwent long term medical observation that has confirmed that only **25** patients had heart attack. Also from **70** patients, that were sent home in fact **6** suffered from heart attack and nearly died.*

Build a confusion matrix for this case study and compute measures evaluating the performance of doctors decisions.

Case study

Confusion matrix for our case study

		Real heath status		
		Heart attack	Other benign illness	
Diagnosis result	Heart attack	TP=?	FP=?	TP+FP=30
	Other benign illness	FN=6	TN=?	FN+TN=70
		TP+FN=25		



Case study

← Compute these parameters

Accuracy:

Sensitivity:

Specificity:

False alarm rate:

Positive predictive value:

Negative predictive value:

Please try to explain why we need these many measures for evaluating medical tests

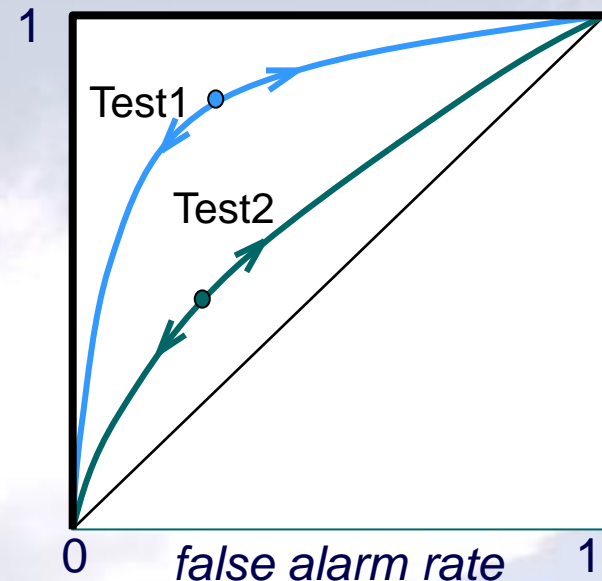
The Receiver Operator Characteristic (ROC)

The concept of ROC curve was first used to evaluate radar operators decisions during World War II (detection of enemy planes).

In medicine the ROC curve is used to evaluate diagnostic decisions and tests.

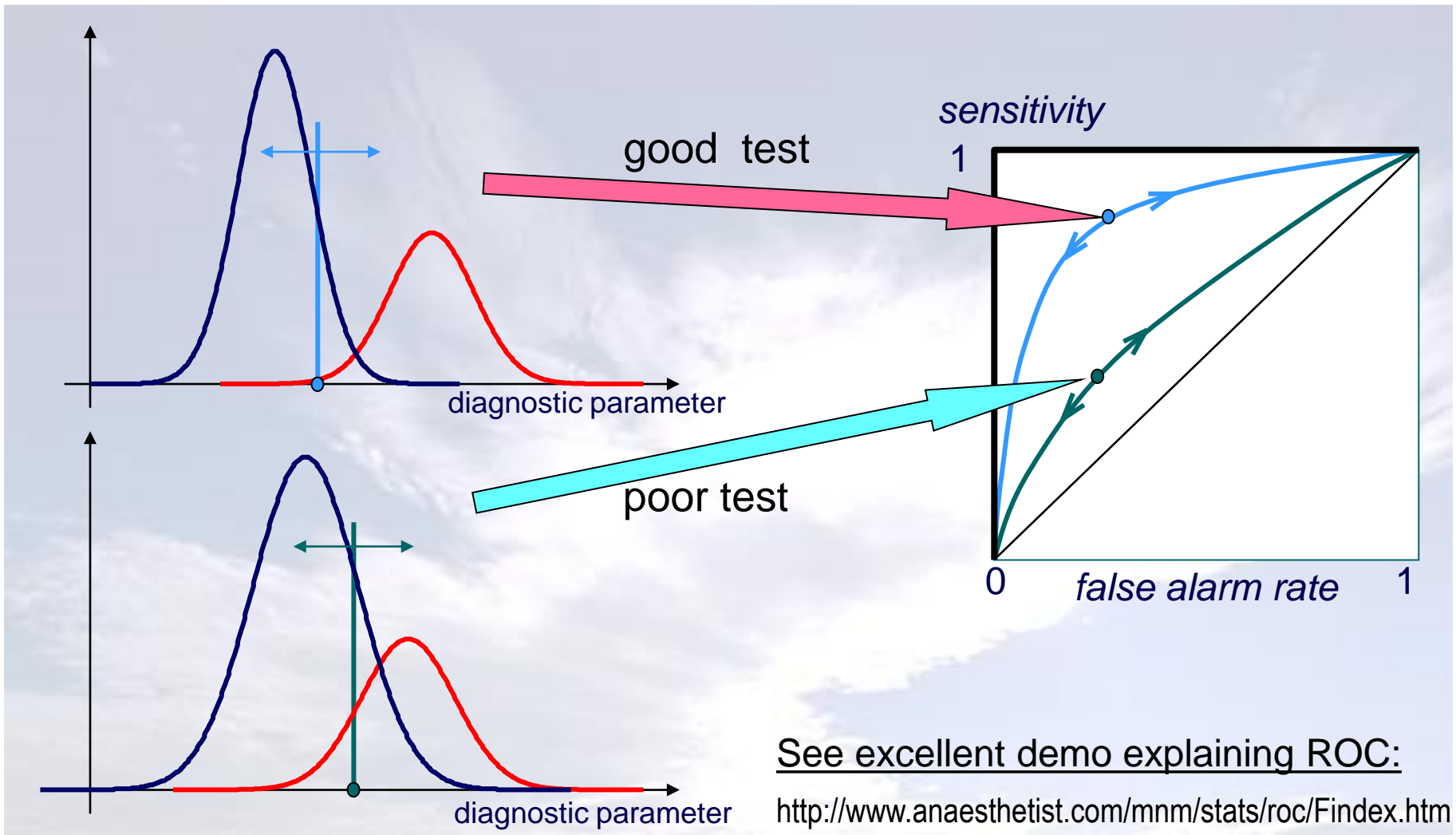
The ROC is a plot showing the trade-off between specificity („goodnes of illness detection”) and false alarm rate of the test while the decision threshold is changed.

sensitivity

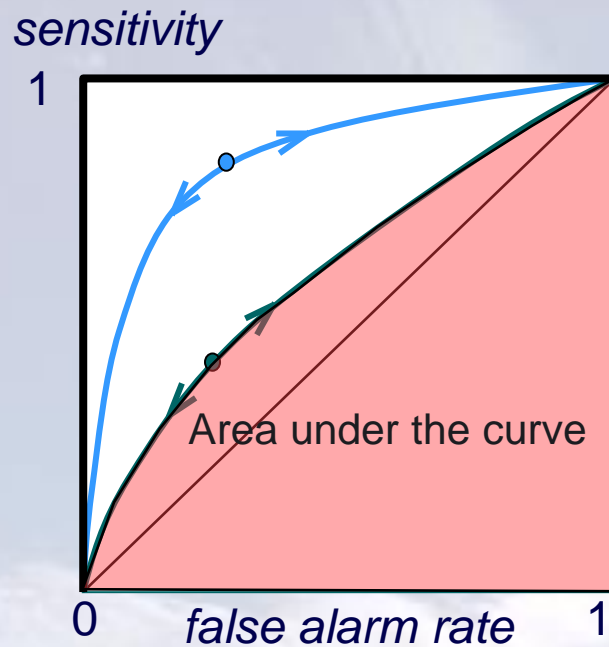


Test1 is better than Test 2, as it yields higher sensitivity at lower false alarm rates.

Receiver Operator Characteristic (ROC)



Area under the ROC curve as a measure of test goodness



The accuracy of a diagnostic test is evaluated according to the following measures:

- 0.90-1.00 = excellent test
- 0.80-0.90 = good test
- 0.70-0.80 = fair test
- 0.60-0.70 = poor test
- 0.50-0.60 = worthless test

ROC - example

Case study:

Patients with suspected hypertension (high blood pressure) had their systolic blood pressure measured.

Measurements for healthy and ill patients are shown in the table.

Build the ROC curve for this test.

Plot statistical distribution of blood pressure for each of the patients groups.

Blood pressure (mmHg)	Patients with normal blood pressure	Patient with hypertension
90	5	0
100	15	1
110	20	2
120	25	5
130	15	10
140	10	15
150	5	25
160	2	30
170	0	20
180	0	15



ROC - example

$$SE = \frac{TP}{TP + FN}$$

$$FA = 1 - SP = \frac{FP}{FP + TN}$$

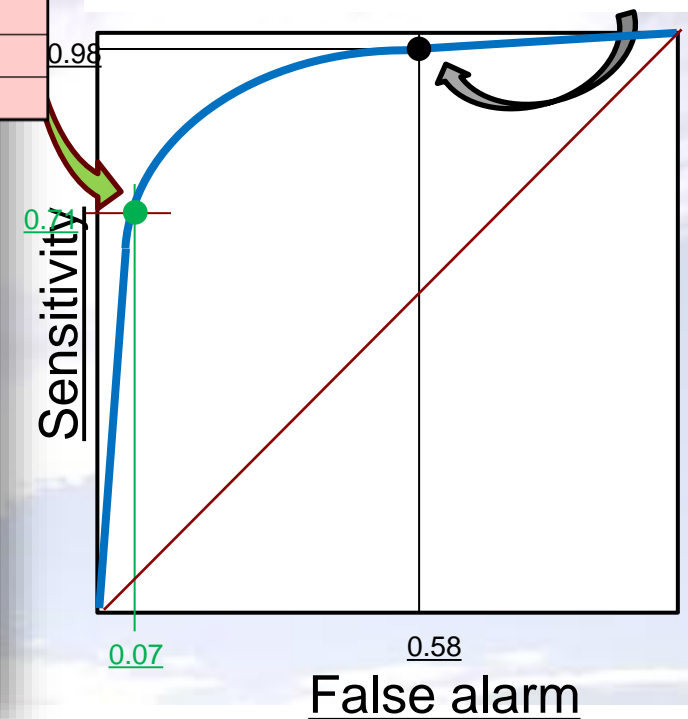
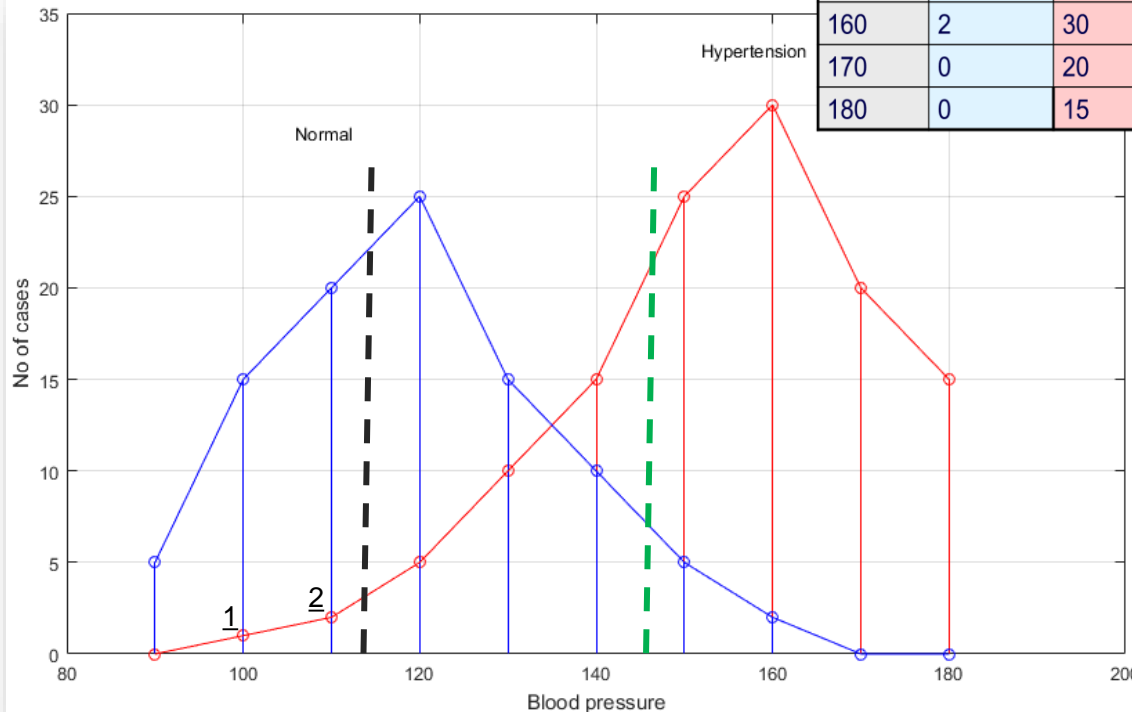
Ciśnienie krwi (mmHg)	Pacjenci o normalnym ciśnieniu krwi	Pacjenci o podwyższonym ciśnieniu krwi
90	5	0
100	15	1
110	20	2
120	25	5
130	15	10
140	10	15
150	5	25
160	2	30
170	0	20
180	0	15

$$SE = TP / (TP + FN) = 90 / (90 + 37) = 0.71$$

$$FA = FP / (FP + TN) = 7 / (7 + 90) = 0.07$$

$$SE = TP / (TP + FN) = 120 / (120 + 3) = 0.98$$

$$FA = FP / (FP + TN) = 57 / (57 + 40) = 0.58$$





Receiving operating curve (ROC) - summary

1. Medical diagnosis as binary data classification problem
2. The confusion matrix summarizes diagnosis performance
3. Definition of measures for evaluating medical tests
4. Understanding the ROC curve
5. Case studies





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