

## AUTHOR INDEX

- Abramovitz, M., 169  
Anderson, B. D. O., 305  
Arvidson, B. E., 15  
Athans, M., 306  
Auguston, R. M., 14  
Bar-Ilan, A., 14, 83  
Barrett, P. B., 16, 166  
Bellman, R., 169, 305, 306  
Ben-Haim, A., 14  
Ben-Haim, Y., 80, 81, 166,  
256, 296, 306  
Berger, C. O., 167  
Berger, J. O., 296  
Betel, D., 15  
Bevan, R., 168  
Black, R. C., 16  
Bondar, L., 83  
Boster, T. A., 168  
Boyce, I. S., 168  
Brain, J. D., 167  
Bram, J., 305  
Bristow, Q., 226  
Cameron, J. F., 168  
Cejnar, F., 79  
Chagaray, J., 296  
Chernoff, H., 256  
Chrysochoides, N., 168  
Claisse, F., 15  
Clayton, C. G., 227  
Coderld, A., 15  
Cohn, D. L., 225  
Cohn, S. H., 15  
Coop, K. L., 256  
Costello, D. G., 80  
Cottral, M. F., 15  
Cowart, J. B., 226  
Craig, A. T., 256  
Cramer, H., 255  
Cunningham, J. B., 168  
Dell'Oro, P., 84  
Despres, M., 83  
Dickerson, M. H., 167  
Dirac, P. A. M., 166  
Diu, C. K., 167  
Doob, J. L., 225  
Dragnev, T., 83  
Dudley, R. A., 14  
Elias, E., 15, 168  
Falb, P. L., 306  
Fanger, H.-U., 15  
Fehlau, P. E., 256  
Feller, W. F., 79, 82  
Fisher, R. A., 255  
Fomin, S. V., 80  
Foster, K. T., 167  
Friedman, A., 167  
Fry, F. A., 15, 224  
Gardner, R. P., 15  
Gettings, J. F., 83  
Goans, R. E., 14, 167, 224  
Good, W. M., 14, 224  
Gozani, T., 15, 45, 79, 80,  
81, 168  
Green, B. M. R., 224  
Greene, R. T., 167  
Gudiksen, R. H., 167  
Gunnick, R., 82  
Hardy, G. H., 225

- Harlan, R. A., 14, 84  
Harmuth, H., 168  
Hayano, N., 83  
Hernandez, D., 296  
Hogg, R. V., 256  
Holden, N. E., 80  
Holynska, B., 15  
Howsley, R., 83  
Humphreys, D. R., 227  
Ingman, D., 16  
Ivanovich, M., 226  
James, D. B., 83  
Karpf, E., 81  
Kehler, P., 16, 166  
Kelly, P., 80  
Killeen, P. G., 227  
Knight, A., 224  
Knoll, A., 14, 83  
Knoll, G., 79  
Kolmogorov, A. N., 80  
Kormuth, J. W., 83  
Kovar, I., 79  
Kushelevsky, A., 296  
Lahey, R. T., 16  
Lando, J., 14  
Lane, R. C., 296  
Lay, S. R., 80  
Lees, E. W., 83  
Lieblein, J., 82  
Littlewood, J. E., 225  
Lubecki, A., 15  
Luenberger, D. L., 306  
Malm, H., 296  
Markin, J. T., 256  
Melsa, J. L., 225  
Menlove, H. O., 84  
Michaelis, W., 15  
Mizushita, S., 296  
Moore, J. B., 305  
Morsy, S. M., 167  
Newton, D., 14  
Nixon, K. V., 256  
Notea, A., 14, 78, 83  
Nutter, J. D., 79  
O'Connell, M. E. A., 15  
O'Hara, F. A., 79  
Ong, L. D. Y., 82  
Osmond, J. K., 226  
Oyedele, J. A., 168  
Packer, T. W., 83  
Panasyuk, I. S., 81  
Papoulis, A., 82  
Parker, J. L., 83  
Parker, T. W., 226  
Parkinson jr., W. W., 14,  
224  
Pau, L. F., 306  
Perez-Griffo, M., 16, 166  
Pieters, W., 168  
Pipes, D., 168  
Polya, G., 225  
Pomroy, C., 296  
Rahola, T., 296  
Rao, C. R., 255  
Rasmussen, E. B., 15  
Reilly, T. D., 14  
Rice, S. O., 82  
Righetti, M., 296

- Rimsaite, J., 227  
Robell, A. J., 224  
Rodenburg, W. W., 79  
Saaty, T. L., 305  
Sampson, T. E., 82  
Samson, C., 15  
Sandstrom, B., 15  
Segal, E., 78  
Segal, Y., 14, 78, 83  
Shenhav, N., 14, 78, 80, 81,  
83  
Shope, L. A., 227  
Slaughter, G. G., 14  
Stegun, I., 169  
Tauxe, W. N., 15  
Taviv, E., 16  
The, H. L., 15  
Thorpe, M. M., 84  
Tong, Y. L., 256  
Trott, M. G., 15  
Tzafestas, S., 168  
Umiatowski, K., 16  
Valberg, P. A., 167  
Van Trees, H. L., 226  
Vergheese, K., 15  
Wald, A., 296  
Wasilewska, M., 15  
Weinstock, E. V., 83  
Weiss, M. L., 80  
Well, D. G., 15  
Wheeler, A., 224  
White, D. R., 224  
Wilhelmova, L., 79  
Williams, M. M. R., 82  
Willsky, A. S., 306  
Wormald, M. R., 227  
Yom-Tov, Z., 168  
Yu, C. P., 167  
Zucker, M. S., 14, 80, 81, 83

## SUBJECT INDEX

- ABSORPTION coefficient,  
  path-integrated, 154–5
- Active assay, 2, 19
- Adaptive assay, 5, 12, 165,  
  257ff, 305  
  comparison with non-adap-  
  tive, 294–5  
  components of, 258  
  information flow in, 258
- Adaptive control, 302
- Aerosol dispersion in respira-  
  tory tract, 116, 119, 168
- Air pollution, 111
- Alloy, assay of, 8
- Alternative hypothesis, 260
- $^{241}\text{Am}$ , assay with, 137
- Analyte, definition, 13
- a posteriori* estimate, 273
- a priori* estimate, 273
- a priori* probability density,  
  186, 209, 213
- Arithmetic–Geometric mean  
  inequality, 50
- Assay of material, stages of, 1,  
  2, 112, 257–9
- Asymptotic design, 13, 299
- Auxiliary parameters, 86, 149  
  and spatial uncertainty, 158ff
- BACKGROUND radiation,  
  116, 219
- Barrel assay, 270ff
- Batch assay, 264
- Bayes' decision theory, 12, 195
- Bayes' rule, 181
- $^{214}\text{Bi}$ , in U assay, 2
- Biased quadratic cost function,  
  203
- Binary decisions  
  in Bayes theory, 199  
  in Neyman-Pearson theory,  
  208  
  in sequential analysis, 264
- Bore-hole logging, 8, 216
- Boundedness, uniform, 99
- Bubble detection, 9
- CALIBRATION, probabilistic,  
  195, 202, 212ff, 229
- Cauchy–Schwarz inequality,  
  101
- Characteristic function, 171
- Chebyshev inequality, 225
- Chi-squared distribution, 266
- Closed-boundedness, 29, 166
- Closed set, 21, 79
- $^{57}\text{Co}$ , assay of, 7
- $^{60}\text{Co}$ , assay with, 137
- Coal assay, 8, 127, 137
- Coincidence measurement, 38ff
- Collimation of detectors, 165
- Compactness, 91, 166  
  of complete response set, 102  
  of set of constrained distribu-  
  tions, 102  
  relative, 100
- Compact set, extrema on, 97,  
  133
- Conditional mean, 207
- Conditional probability, 181
- Constrained spatial distribu-  
  tion, 86, 93

- Continuous functions, 100  
 Continuous parameters,  
     Bayes estimation of, 206  
     Neyman-Pearson estimation  
     of, 211  
 Control, adaptive, 302  
 Convex combination, 105  
 Convex hull, 24, 53, 56, 89, 93,  
     298  
 Convexity, 22, 79  
     local, 299  
     of complete response set, 99,  
     299  
     of set of constrained distribu-  
     tions, 99  
 Convexity theorem, 25, 38, 39,  
     44, 63, 85, 297  
     generalization of, 89  
 Convex set, extrema on, 97,  
     133  
 Conveyor belt, assay of mate-  
     rial on, 127  
 Cost function  
     biased quadratic, 203  
     differential, 197  
     in Bayes theory, 195  
     quadratic, 201, 206  
     squared-error, *see* quadratic  
<sup>51</sup>Cr, assay of, 7  
 Criterion of distinguishability,  
     28, 94, 166  
 Critical values  
     inequalities for, 264  
     in sequential analysis, 260,  
     261, 263  
     positivity of, 211  
<sup>137</sup>Cs,  
     assay of, 7  
     assay with, 137  
<sup>67</sup>Cu, assay of, 7  
 DAWSON'S integral, 155  
 Decision probabilities  
     in Neyman-Pearson theory,  
     209  
     in sequential analysis, 262-4  
 Decision regions, 198, 208, 260  
 Decision rule, 257  
     in Bayes theory, 196, 198  
     in Neyman-Pearson theory,  
     209, 210  
     in sequential analysis, 261  
 Decision theory, 11  
     Bayes, 12, 195  
     Neyman-Pearson, 12, 208  
 Delta function, 90, 164  
 Density thickness, assay of, 127  
 Design algorithm in adaptive  
     assay, 259  
 Design, asymptotic, 13, 299  
 Design parameters, 258  
 Differential cost, 197  
 Dirac delta function, 90, 164  
 Direct probabilistic calibration,  
     195, 202, 212ff, 229  
 Distance from origin, 54  
 Distinguishability  
     criterion of, 28, 94, 166  
     lines of, 140  
 Doubles rate in coincidence  
     measurement, 45

- Drugs, toxicity of, 7  
Duration of measurement, 4,  
13, 259  
Dynamic optimization, 276,  
302  
Dynamic programming, 133,  
136, 169  
ENRICHMENT assay, 141ff  
Equicontinuity, 100  
Equivalent detectors, 57  
Error function, 155  
Error propagation, 82  
Estimation theory, 11  
Euclidean metric, 100  
Expansion, 28, 29, 35, 53, 55,  
57, 85, 90, 93, 151  
probabilistic, 244ff  
Exponential integral, 218  
Extremal plane, 56, 94  
<sup>59</sup>Fe, ASSAY OF, 7  
Filter for malfunction isolation,  
301  
Fisher information matrix, 240,  
279, 280  
Fission assay, 38  
Flow rate measurement, 8, 163,  
267  
Flow regime determination, 9  
Fluid, multiphase, assay of, 127  
Foils, thickness of, 127  
Fundamental spatial distribu-  
tion, 97, 103  
GAMMA distribution, 243, 264  
Generality in design and inter-  
pretation, 297  
Geological prospecting, 1, 2, 8,  
22, 216, 229  
Geometric mean, 50  
Geomorphology of uranium,  
216, 284  
Global optimization, 303  
HALF-THICKNESS of  $\gamma$  radi-  
ation in lung, 116  
Health-safety monitoring, 115  
*h*-moment, 88  
Hyperplane, supporting, 94  
Hypothesis, statistical, 260  
<sup>131</sup>I, ASSAY OF, 7  
Induction, mathematical, 136  
Inequality  
arithmetic-geometric mean,  
50  
Cauchy-Schwarz, 101  
Chebyshev, 225  
Critical values, 264  
Rao-Cramer, 12, 239, 279ff  
Reduction theorem, 247,  
249ff  
Information flow in material  
assay, 257  
Information matrix, Fisher,  
240, 279–80  
Inner iteration, 58–60, 63  
Inner product, 53  
Integrable functions, 88  
Interpretation algorithm in  
adaptive assay, 259  
*In Vivo* radionuclides, assay of,  
6, 21, 296  
Isolation of malfunction, 13,

- 300ff
- Iterations, inner and outer, 58–60, 63
- $^{40}\text{K}$ , ASSAY OF, 7, 176
- Kalman filter, 301
- LAGRANGE multiplier, optimization by, 124, 210
- Leached fuel hulls, assay of, 6
- Lebesgue integral, 224
- Likelihood function, 183  
and probability density of mass, 184, 191, 225ff
- Likelihood ratio, 183, 211, 225, 260, 305
- Limit point, 79
- Linearity in mass, 19, 21, 24, 63, 87, 298
- Linearity in time, 19, 21, 63, 298
- Lines of distinguishability, 140
- Local convexity, 299
- Local optimization, 303
- Logging, bore-hole, 8, 216
- Lung burden of Pu, 116
- Lung clearance mechanisms, 116
- MALFUNCTION isolation, 13, 300ff
- Marginal detector, utility of, 52, 147, 152, 299
- Marginal probability density, 181
- Mathematical induction, 136
- Matrix material, 4, 14, 40  
variable structure of, 149, 152ff
- Maximization *see* optimization
- Maximum likelihood estimation  
in Bayes theory, 201, 281  
in Neyman-Pearson theory, 211
- Mean, conditional, 207
- Mean free path, 19, 22, 79, 216
- Measurement duration, 4, 13, 259
- Measurement vector, 88
- Measure of performance, 4, 90, 257,  
*see also* relative mass resolution  
algorithm for, 11, 18  
deterministic, 10, 11, 17, 76, 85  
probabilistic, 11, 12
- Medical assay, 1, 3, 6, 22
- Meteorological measurements, 1, 111
- Metric  
uniform, 100  
Euclidean, 100
- Minimization *see* optimization
- Minimum probability of error, 200, 202
- Minimum variance, 12, 237ff  
comparison with relative error, 238
- Min-max algorithm, 58, 92, 94, 96, 98, 298
- Modelling in assay system design, 257

- Model parameters, 258
- Moisture content, assay of, 9
- Moment assay, 8, 9, 85–6
- Multinomial distribution, 120
- Multiphase fluid, assay of, 127
- Multiplication of sets by
  - scalars, 25, 88
- Muscle mass, assay of, 7
- NEUTRON activation, 3, 9, 68
- Neutron multiplicity, 40
- Neyman-Pearson decision theory, 12, 208
- Non-linearity in mass, 13, 298
- Non-uniform random distribution, 172, 194
- Normal distribution, 105
- Nuclear safeguards, 1, 3, 5, 22
  - leached fuel hulls, 6
  - process waste, 6
  - spent fuel, 6
- Null hypothesis, 260
- OPPOSITELY ordered sequences, 225
- Optimality in design and interpretation, 297
- Optimization
  - by dynamic programming, 133, 136
  - by LaGrange multipliers, 124, 210
  - dynamic, 276, 302
  - global/local, 303
- Ordering of response sets, 104
- Ore, assay of, 8
- Orthogonal functions representing spatial distributions, 128
- Outer iteration, 58–60, 63
- Overlap function
  - asymmetry of, 253
  - definition, 245
  - inequalities for, 249
  - tails of, 251
- PARAMETER, statistical definition of, 239
- Particle size, effects in assay, 8, 179
- Passive assay, 2, 68
- Passive gamma assay, 29
- Phoswich detector, 116
  - comparison with Ge, 296
- Planes
  - definition, 54
  - extremal, 56, 94
  - supporting, 55
- Poisson distribution, 182, 188, 217, 226, 231, 268, 278
- Poisson process, 182, 185
- Poisson statistics, 2, 64, 215
- Probabilistic calibration, 195, 202, 212ff, 229
- Probability density, *a priori*
  - 186, 209, 213
- Probability density of measurement
  - calculation of, 170ff, 187
  - convolutions, 174
  - multiple measurement, 174
  - single measurement, 170
- Probability density of source

- mass
  - and likelihood function, 184, 191, 225ff
  - calculation, 179ff, 185
- Probability distribution
  - convolutions of, 251
  - symmetrical, 252
- Probability of error
  - in Neyman-Pearson theory, 209
  - in sequential analysis, 262-4
- Probability ratio, 260
- Process waste in nuclear fuel cycle, 6
- Proportionality
  - and ordering of response sets, 104
  - property of, 88, 92, 94-6, 299
- Prospecting, geological, 1, 2, 8, 22, 216, 229
- <sup>239</sup>Pu, assay of, 29, 34, 44, 59, 67, 115, 185, 193, 204, 276
- Pulmonary aerosol, 7, 115ff, 168, 172, 192, 276
- QUADRATIC cost function, 201, 206
- RADEMACHER functions, 128, 169
- Random variable, statistical
  - definition of, 239
- Rao-Cramer inequality, 12, 239, 279ff
- Rao-Cramer lower bound, 239
- Realizability in design and interpretation, 297
- Reduction theorems, 247, 249ff
- Relative error, 12, 189, 220ff, 229ff, 286
  - comparison with minimum variance, 238
- Relatively compact, 100
- Relative mass resolution, 10, 17, 26, 29, 34, 39, 45, 50, 85, 270
  - algorithm for, 53ff, 58ff, 76, 85, 92
  - asymptotic, 33, 147, 299
  - conservatism of, 170, 190
  - graphical evaluation of, 34, 49, 156
  - multi-detector, 11, 51, 65, 70ff
  - statistical uncertainty and, 64, 67, 77
  - symmetry and, 53, 57ff
- Relative resolution, 90, 93
  - algorithm for, 92-3
- Resolving power, 78
- Respiratory tract, regions of, 116
- Response functions, 18-20, 29, 40, 87, 180
  - continuity of, 224
  - ensemble variation of, 153, 158
  - fundamental, 154
  - probabilistic calibration and, 213
  - probability distribution and, 172

- smoothness of, 224
- symmetric, 57, 60
- time-varying, 162
- Response of detector
  - average, 214
  - spatial variance of, 214
  - statistical variance of, 215
- Response set
  - complete, 24, 29, 30, 34, 49, 53, 57, 85, 298
  - complete, for  $h$ -moment, 89, 92–4, 97
  - fundamental, 97
  - multiplication of, 25
  - non-convex, 299
  - ordering of, 95, 104
  - point-source, 21–2, 30, 34, 47, 85, 298
  - point-source, for  $h$ -moment, 89, 93, 97
- Response space, 46
- Risk in Bayes theory, 196
- SAMPLE size, 4, 22, 30
- Self-expansion, 29, 90
- Separable set, 159
- Sequences, oppositely ordered, 225
- Sequential analysis, 13, 259, 305
- Shadowing by analyte, 20
- Signal to noise ratio, 116
- Singles rate in coincidence
  - measurement, 45
- Slurry, assay of, 8, 127
- Source material, 14, 40
- Spatial distributions
  - constrained, 86, 93
  - fundamental, 97, 103
  - non-uniform random, 172, 194
  - time-varying, 7, 162
  - unconstrained, 88
  - uniform random, 171–2
- Spatial randomness, xii, 9, 17, 38
- Spatial uncertainty, 2, 4, 7, 65, 278, 285
- Spent fuel, assay of, 6
- Squared-error cost function, 201, 206
- $^{90}\text{Sr}$ , assay of, 7
- Statistic
  - definition, 239
  - efficiency of, 243
  - unbiased, 239
- Statistical confidence, 64
- Statistical uncertainty, 2, 4, 17, 63ff, 72, 78, 82, 98, 184, 285
- Sub-symmetry, 252
- Supporting hyperplane, 94
- Supporting plane, 55
- Surface assay, 21
  - assay of fractional, 141ff
- Symmetrically equivalent detectors, 57
- TEA-LEAF effect, 172
- Temperature, assay sensitivity to, 149
- $^{232}\text{Th}$  in uranium assay, 219

- Thickness measurement, 127ff  
 Thickness profile, 127  
 Threshold detection  
   in Neyman-Pearson theory, 208  
   in sequential analysis, 264  
 Time-varying spatial distribution, 7, 162  
<sup>208</sup>Tl in uranium assay, 219  
 Tomography, 10  
 Tracer, radioactive, 8, 164, 267  
 Transmission of radiation, thickness measurement, 127  
 Turbulence estimation, 9  
<sup>235</sup>U, ASSAY OF, 44, 141, 284  
<sup>238</sup>U, 2, 44, 217  
 Unbiased estimate  
   definition, 239  
   variance of 240  
 Uncertainty  
   spatial, 2, 4, 17, 65, 278, 285  
   statistical, 2, 4, 17, 63ff, 72, 78, 82, 98, 184, 285  
 Unconstrained spatial distribution, 88  
 Uniformly bounded, 99  
 Uniform metric, 100  
 Uniform random distribution, 171-2  
 Uranium  
   geomorphology of deposits, 216, 284  
   hexafluoride, 141  
   prospecting, 2, 8, 216, 229, 284  
 VECTOR RESPONSE FUNCTION, 20  
   *see also* reponse function  
 Voltage to detector, assay sensitivity to, 149  
 WALL THICKNESS, assay sensitivity to, 149  
 Walsh functions, 169  
 Weighted sum  
   algorithm for expansion, 58, 60-1, 81  
   sign of, 57  
   standard deviation of, 66  
 Whole-body assay, 7, 176  
 Wind flow pattern, 111  
<sup>65</sup>Zn, ASSAY OF, 7