

Subject index

- Absolute responsivity, 161, 164
- Absorption cross section, 81–3
- Absorption length, 81–3, 275
- Accelerator, 93–102
- Acceptance, 26, 328
- Accidentals, 139, 307
- Acoustic radiation, 74–5
- Active target, 129
- Aerogel, 193
- Afterpulsing, 164–5
- Albedo events, 299
- Alignment, 19
- Analog/digital converter (ADC) (*see also* Flash ADC), 143–4, 171, 248, 316
- Analog methods for wire chambers, 228
- Analyzing power, 373
- Angular distribution, 87–91
- Annihilation, 46, 53–4
- Anti-(veto) counter, 167–8, 304, 337
- Antineutron, 315
- Antiparticle, 4, 5, 10
- Antiproton
 - beam, 102, 107
 - interactions, 82, 85, 87
 - multiple scattering, 71
 - trigger, 312
- Antiproton–proton collider, 101–2, 115
- Arrival time method, 231
- Atomic properties of common materials, 84
- Atomic properties of elements, 83
- Atomic shell, 42, 56
- Attachment in gases, 211, 215, 223, 253, 268, 290
- Attenuation coefficient, 392
- Attenuation length, 155, 159
- Auger electron, 56
- Axial field magnet, 331–2, 346
- Axial field spectrometer (AFS), 346–7
- Background, 17, 307, 374
- Bargmann–Michel–Telegdi equation, 362
- Barium flouride, 333–4
- Barn, 391
- Baryon, 3, 9
- Baryon quantum number, 7
- Beam–beam events, 367
- Beam dump, 120, 130
- Beam monitor, 74, 115, 207
- Beam profile, 113–14
- Beam transport, 108–15, 329
- Bending magnet (*see* Dipole magnet)
- Betatron oscillation, 97
- Bethe–Bloch formula, 35–41
- BGO, 149–50, 333–4
- Bhabha scattering, 46, 65–6, 115, 299
- Binding energy, 274–5
- Binomial distribution, 389
- Biological effectiveness, 120
- Booster, 97
- Bragg peak, 33
- Branching ratio, 10, 366
- Bremsstrahlung
 - coherent, 73–4
 - ordinary, 47–53, 59, 260
- Brookhaven, AGS, 95, 376
- Bubble chamber, 4, 16, 23, 25, 129, 285–8, 333, 367
- Burst guard discriminator, 136–7
- Calibration, 17, 19
- Calorimeter
 - continuous, 259, 266, 333–4
 - electromagnetic, 266–74, 337–9, 341–5, 347–8, 379
 - hadron, 74, 278–9, 315–6, 337–9, 342–7, 379–80
 - liquid argon, 268–71, 275, 277–8, 316

- particle identification, 280
- PWC, 268–9, 272, 349–50
- readout, 266–8
- resolution, 269–72, 279–81
- scintillator, 152, 267–9, 273, 315–16
- uranium, 278–81
- CAMAC, 19, 141–2, 227–8
- Cascade particle, 9, 312–15, 365
- Cathode pad (strip), 228–30, 256
- Center of momentum (CM) frame, 11–13
- Central detector, 333, 379
- Cerenkov angle vs velocity, 180
- Cerenkov counter
 - absorption, 201–3
 - aerogel, 193–6, 346
 - differential, 184, 196–201, 349
 - efficiency, 191–2, 194–5
 - gas, 186–90, 193–5
 - intensity monitor, 115
 - particle identification, 335
 - radiator, 183
 - threshold, 184, 190–6, 310–1, 346, 377
 - total internal ref, 190–1
 - (*see also* DISC, Lead–glass, Ring imaging counters)
- Cerenkov effect, 42, 178–83
- CERN
 - ISR, 100–2
 - LEAR, 102
 - LEP, 102–3
 - PS, 95, 102
 - SPS, 95, 100, 102, 107
- Channeling (radiation), 73–4
- Characteristic energy, 238
- Characteristic length, 113
- Charge, measurement of, 358–9
- Charge coupled device (CCD), 248, 257
- Charge division, 230–1, 346
- Charge exchange in gases, 211
- Charged current interaction, 88
- Charged hadron beam, 107
- CHARM spectrometer, 246, 337–8, 340
- Chord, 326
- Clearing field, 290
- Clipping, 146
- Clusters, ionization, 255, 296–7
- Coaxial cable, 144–6
- Cockcroft–Walton accelerator, 94
- Coincidence curve, 138, 140, 329–30
- Coincidence overlap, 137
- Coincidence unit, 137–41
- Coincidence width, 137–8
- Colliding beam accelerator, 99–102
- Collimator, 103
- Collision length, 81
- Collision time, 32, 395
- Compton effect, 56–8
- Computer, online, 17, 352
- Constant fraction discriminator, 136
- Constants, physical, 385
- Cooling, phase space, 101–2
- Coplanarity, 305, 307
- Cornell, CESR, 100
- Cosmic rays, 14, 74, 118–19, 349
- Coulomb interference cross section, 370
- Coulomb scattering, 64–7, 370
- Coupling, electronic, 134–5
- Crate controller, 141
- Crazing, 153
- Critical angle
 - channeling, 72–3
 - internal reflection, 157
- Critical energy, 52–3, 260
- Critical pressure, 187–8
- Critical temperature, 187–8
- Cross section and probability, 391–2
- Cryogenic liquids, 126
- Crystal Ball spectrometer, 347–9
- Curvature, 23, 326
- Cyclotron frequency, 363
- Dalitz plot, 26
- Dark current, 165
- Data acquisition, 351–4
- Data analysis, 18–26
- Deadtime, 15, 316
- Decay length, 7
- dE/dx
 - in liquid or solid, 35–6, 286, 288
 - in gases, 41, 239, 254
 - measurement of, 167, 169, 252–5, 286, 288, 359
 - particle identification, 252–7, 335
- Delay curve (*see* Coincidence curve)
- Delay line, 230, 249
- Delta ray (knock-on electron), 42, 44–5, 192–3, 208, 224, 288
- Density effect, 40–1, 44
- Depolarizing resonance, 99
- DESY
 - DORIS, 100
 - HERA, 102–3
 - PETRA, 100–1
- Detailed balance, 362
- Detector uses, 17
- Differential cross section, 392
- Diffraction scattering, 85, 368
- Diffusion, 212–13, 236–9, 249–50, 256
- Dipole magnet, 96, 108–11, 331–2, 339, 344
- Dirac theory, 37, 59, 362
- Direct pair production, 53
- Direct photon, 309–10, 315
- DISC Cerenkov counter, 197–9, 314

- Discriminator, 134–7
- Dispersion, 178–9, 197
- Distribution function, 388
- Double nuclear scattering, 129, 372
- Double pulse resolution, 135
- Drift chamber
 - construction, 241–6, 251
 - cylindrical, 18, 242–5
 - dE/dx , 252–7
 - degradation, 252
 - efficiency, 239, 245
 - electronics, 247–9, 251, 341
 - gas, 234–40, 243, 256, 345
 - high voltage, 245
 - magnetic field, 235–7
 - monitor, 249
 - planar, 241–2, 345
 - principle, 234–5
 - space-time relation, 234, 242, 252
 - spatial resolution, 234, 236–7, 239, 249–52
 - time response, 333
 - tubes (PDT), 245–6, 340–1
 - (*see also* Time projection chamber)
- Drift space, 108, 110
- Drift velocity, 212–13, 235–40
- Duty cycle, 93

- $E \times B$ correction, 20, 225, 235, 241
- Effective mass, 6, 7, 320–1, 365
- Elastic scattering
 - coherent, 81–2
 - electromagnetic, 64–7
 - hadronic, 80, 368–72
 - luminosity, 115
 - quasi-, 81–2
 - spectrometer, 328–9, 371–2
 - TOF, 172
 - trigger, 305–7, 318
- Electromagnetic shower, 14, 16, 46, 259–66, 270–1, 273
- Electromagnetic shower detector (*see* Calorimeter)
- Electron
 - annihilation, 53–4
 - beam, 96, 106, 330, 375
 - bremsstrahlung, 47–53
 - channeling, 74
 - detection, 201–2, 266–74, 279, 286, 294, 335, 375–80
 - energy loss to radiation, 51–3
 - energy spectrum, 270–1, 273
 - ionization loss, 41, 46–7
 - magnetic moment, 8, 9, 363
 - mass, 8, 9
 - multiple scattering, 71
 - pair production, 59–63
 - polarized scattering, 88, 374
 - pulse height spectrum, 45
 - radius, 38
 - range, 47
 - relativistic rise, 47
 - shower, 259–66
 - spectrometer, 375, 377, 380
 - spin, 362
 - trigger, 308, 310–11
- Electron affinity, 211
- Electron–positron collider, 100–2, 115
- Electron–electron interactions, 85, 87
- Electroweak interaction, 3
- EMC spectrometer, 246, 249, 319, 336, 340
- Emittance, 113
- Empty target correction, 72, 369, 372
- Emulator, 317, 352
- Emulsion, 16–17, 288–9
- Energy deposition of 10 GeV proton, 275
- Energy loss (*see* dE/dx , Ionization energy loss)
- Energy transfer, maximum, 13–14
- European Hybrid Spectrometer (EHS), 202
- Excitation, 208
- Expectation value, 388
- External muon identifier, 286

- Fan in/out, 142–3
- FASTBUS, 142
- Fermi momentum, 126, 128
- Fermi plateau, 40–1
- Fermilab
 - main ring, 95, 97–8, 106–7, 130
 - Tevatron I, 102–3
- Filter, event, 20
- Fission compensation, 278–81
- Fixed target accelerator, 94–9
- Flash ADC, 248, 255
- Flash tube detector, 266, 298, 333
- Flat top, 98
- Fluorescence, 56, 148
- Fluorescent converter, 157
- Flux monitors, 115–17
- Foam limit, 287
- Foil, radioactive, 115–17
- Form factor, 370
- Forward particle, 10–11, 87–8
- Four-vector, 6
- Frank–Condon principle, 151
- FREJUS spectrometer, 349–50
- Frequency function, 388

- g factor, 362
- g factor anomaly, 362
- g -2 experiments, 359
- Gas Cerenkov radiator, 188, 193
- Gas jet target, 15, 130–1

- Gases, fundamental processes, 208–15
- Gate generator, 143
- Gauge boson, 3, 5, 8, 89
- Gaussian distribution, 389–90
- Geiger mode, 206–7, 268
- Geometrical fitting, 22–4
- Giant resonance, 55
- Gluon, 5
- Gravitational force, 2, 5
- Graviton, 5

- Hadron, 3, 79
- Hadronic shower, 274–8, 281
- Hall probe, 328
- Heavy ions, 74, 120
- Helical trajectory, 22–4, 325
- High voltage system, 165–6
- Hodoscope, 168–9
- Holography, 288
- Horn, neutrino, 105–6
- Huyghens construction, Cerenkov, 181
- Hybrid bubble chamber, 286
- Hydrogen atom, radius, 49
- Hydrogen, liquid, 36, 101, 125–7, 287
- Hydrophone, 74
- Hyperon, 3
 - beam, 108
 - decay, 90–1

- Impact parameter, 30–2
- Inclusive production, 85–7
- Index of refraction, 178–9, 182–3, 187–8, 190, 193, 202
- Inefficiency, 22, 307
- Interaction length, 392
- Interferometer, 190
- Ionization chamber, 115, 206–7
- Ionization energy loss
 - classical, 30–4
 - fluctuations, 42–6
 - quantum, 34–42
- Ionization in gases, 208–10
- Ionization potential, 37–41, 208–9

- J particle, 376–9
- Jet, 4, 316, 381

- K + detector, 298
- Kaon
 - beam, 107
 - detection, 298
 - interactions, 82, 85
 - ionization loss, 35–6
 - mass, 8, 359
 - multiple scattering, 71
 - production, 86–7
 - properties, 8
 - range, 35–6, 298
 - TOF, 172–4
 - trigger, 306, 308, 312, 318
- Kaonic atom, 359
- KEK
 - synchrotron, 95
 - TRISTAN, 102–3
- Kinematic fitting, 25–6

- Laboratory (LAB) frame, 10–12
- Lagrangian multiplier, 26
- Lambda particle
 - decay distribution, 363
 - magnetic moment, 9, 363–4
 - polarization, 363
 - precession angle, 364
 - production, 86–7
 - properties, 9
 - trigger, 309, 313
- Landau distribution, 43–4, 53, 210
- Large pt production, 88, 309, 316, 346
- Larmor precession frequency, 236
- Lead–glass counter, 156, 202–3, 315
- Leading particle, 88
- Left–right ambiguity, 241, 318
- Lepton, 3, 8
- Lepton number, 88
- Lifetime, 364–6
- Light collection, 156–61, 185–6, 197
- Light guide, 157, 159–60
- Limited streamer mode, 268
- Linear accelerator (Linac), 94–6
- Linear attenuation coefficient, 54, 63
- Linear energy transfer, 120
- Liouville theorem, 112, 160
- Liquid hydrogen (*see* Hydrogen, liquid)
- Logic levels, 134
- Lookup table, 317
- Lorentz invariant, 11–12
- Lorentz transformation, 5, 6
- Lorenz–Lorentz law, 187
- Luminosity, 99, 101

- Magic gas, 216, 220
- Magnetic field
 - configurations, 331–3
 - measurement, 328, 360, 364
- Magnetic moment, 10, 362–4
- Magnetic shield, 165
- Magnetostriction, 293
- MARK III spectrometer, 175
- Mark-J spectrometer, 341, 345
- Marx generator, 293
- Mass, measurement of, 359–61
- Mass attenuation coefficient, 63
- Mean free path, 81
- Meson, 3, 8

- Minimum bias trigger, 304
- Minimum ionization, 38
- Missing mass, 26
- Mobility, 212
- Moliere radius, 264
- Moliere theory of multiple scattering, 69–73
- Moller scattering, 46, 65, 375
- Momentum resolution, 326–7, 329, 332
- Momentum transfer, 14
- Monitoring, 17, 169, 175, 202, 249, 351, 354
- Monte Carlo technique, 26
- Motion of ions in E and B fields, 235–7, 394–5
- Mott scattering, 65, 375
- Multiparticle spectrometer (BNL), 241–2, 320
- Multiple scattering, 67–73, 197, 239, 327
- Multiplication, charge, 214–20, 268
- Multiplicity, 85–7, 89
- Multistep avalanche chamber, 225
- Multiwire Proportional Chamber (MWPC)
 - construction, 218–22
 - deadtime, 224
 - efficiency, 220–4, 226, 295
 - electronics, 225–31
 - electrostatic force, 219–20
 - energy resolution, 220
 - field distribution, 218–9
 - gas, 221, 268, 295
 - in magnetic field, 224–5
 - spatial resolution, 218, 223, 228, 231, 268
 - time resolution, 224, 337
 - trigger, 226
 - wire clusters, 223, 227
 - (*see also* Proportional chamber)
- Muon
 - beam, 107, 336
 - bremsstrahlung, 47
 - decay, 8, 361
 - detection, 279, 298, 332, 336, 341, 359
 - ionization loss, 35–6
 - lifetime, 8, 10
 - magnetic moment, 8, 363
 - mass, 8, 359
 - momentum in pion decay, 359–61
 - production, 85, 88
 - range, 35–6, 298
 - trigger, 298, 308, 311–12, 315, 319–21, 337
- NA1 spectrometer, 230
- NA3 spectrometer, 222, 227
- NaI scintillator, 149–50, 167, 333–4, 348
- Neutral current interaction, 88–9
- Neutral hadron beam, 107–8
- Neutrino
 - beam, 105–6, 341
 - detection, 129, 279, 282–3, 285, 336, 379
 - fission, 118
 - interactions, 88–91, 201
 - mass, 10, 359–61
 - solar, 118, 349
 - trigger, 303, 341
- Neutron
 - beam, 107–8
 - detection, 152, 167, 201, 280–2, 313–14
 - interactions, 79–83
 - lifetime, 9, 10
 - production, 55
 - properties, 9
 - trigger, 306, 308, 313
- NIM electronics, 133–4, 142
- Noise, 22
- Novosibirsk, VEPP-4, 100
- Nuclear magnetic resonance (NMR), 131–2, 328, 360–1, 364, 375
- Nuclear shadowing, 129
- Nucleon, 3
- Nucleon decay, 3, 14, 117, 193, 349–51
- Nucleus, radius, 83
- Offline analysis chain, 19
- Omega particle, 3, 4, 9, 313–15, 365–6
- Omega spectrometer, 104, 318
- Optical theorem, 370
- Pair production, 42, 59–63, 260
- Parity, 88, 363
- Particle identification, 16–17, 25, 252–7, 280, 335
- Particle physics, 1, 2
- Pattern recognition, 20–2, 318, 381
- Pedestal, 144
- Penning effect, 210
- Periodic table, 387
- Phase space ellipse, 113–14
- Phosphorescence, 148
- Photoelectric effect, 54–6
- Photomultiplier tube (PMT), 159, 161–5, 172, 174, 182, 186, 193–4
- Photon
 - annihilation, 53–4
 - beam, 104–5, 115
 - bremsstrahlung, 47–52
 - channeling, 73–4
 - Compton effect, 55–8
 - detection, 152, 167, 200–3, 266–74, 279, 286, 341, 347
 - hadronic interactions, 84–5
 - pair production, 55, 59–63
 - photoelectric effect, 55–6
 - shower, 259–66
 - trigger, 308–10, 349

- Photonuclear absorption, 55
- Physics analysis, 26
- Pickup electrode, 115
- Pileup, 270, 336
- Pion
 - beam, 107, 360, 369
 - channeling, 72–3
 - decays, 8, 202, 360, 366, 378
 - detection, 279, 315
 - energy spectrum, 273
 - interactions, 82, 85–6
 - ionization loss, 35–6, 41
 - mass, 8, 359
 - multiple scattering, 71–3
 - production, 86–8, 107
 - range, 35–6, 298
 - shower, 273–5
 - spin, 362
 - TOF, 172–4
 - trigger, 308–11
- Pionic atom, 359
- Plasma frequency, 41
- Poisson distribution, 389
- Polarization, 12, 372–6
- Polarized target, 15, 131–2, 337, 374–6
- Positron
 - annihilation, 53–4
 - bremsstrahlung, 48
 - channeling, 74
 - ionization loss, 46–7
 - pair production, 59–63
 - shower, 259–66
- Positronium, 54
- Potential energy vs atomic spacing, 151
- Preprocessing, 19–20
- Pretrigger, 304
- Primary ionization, 208–9
- Primary ionization rate, 43
- Probability, 388–92
- Projected space angle, 69, 70
- Proper time, 6
- Proportional chamber
 - gases, 45, 216–18, 281
 - principles, 16, 205–8
 - pulse height, 45
 - (*see also* Drift chamber, Multiwire Proportional Chamber)
- Proton
 - beam, 93–4, 107
 - channeling, 72–3
 - detection, 279
 - hadronic energy loss, 274–5
 - interactions, 80–2, 85–7
 - ionization loss, 35–6, 41, 45
 - magnetic moment, 9, 363
 - mass, 9
 - multiple scattering, 71, 73
 - range, 33–6, 298
 - recoil mass distribution, 372
 - spin, 9, 362
 - TOF, 173
 - trigger, 308, 312–13
 - (*see also* Nucleon decay)
- Proton–proton collider, 100–1, 115
- Proton–proton interactions, 367
- Punch through, 311
- Quadrupole magnet, 94, 97, 109–15
- Quality factor, 120
- Quantum chromodynamics (QCD), 4, 5, 376
- Quantum efficiency, 161, 163–4
- Quantum electrodynamics (QED) 3, 29, 48, 59, 65, 85, 107
- Quark model, 4, 91, 117, 359
- Quasistable particle, 8, 10
- Quenching
 - gases, 211, 239
 - scintillator, 150–2
- Radiation length, 52, 260
- Radiation protection, 120–2
- Radiation sickness, 121
- Radiative corrections, 372
- Radio frequency quadrupole (RFQ), 94
- Radioactive source, 119
- Radioactivity, 115–17, 119, 122
- Raether criterion, 215, 290
- Range, 33–6, 45–6
- Rayleigh scattering, 55
- Recoil particle, 10–11
- Recombination in gases, 206–7, 210–11, 293
- Reflection, 157–9, 184–5
- Register (latch), 143
- Relativistic rise, 39–41, 253–5
- Relativity, 5
- Residual, 19
- Resolving time, 137–8
- Resonance, 3, 4, 80, 85, 89
- Response time, 15
- RF cavity, 94, 96
- RF structure, 93–4
- Ring imaging Cerenkov counter (RICH), 193, 198–200
- Risetime method, 231
- Rossi–Greisen equation, 69
- Rutherford scattering, 64–6
- Sagitta, 326
- Sample mean, 388
- Sampling calorimeter, 16, 259
- Saturated avalanche mode, 268
- Scaler, 143
- Scattering, 10–14
- Scintillation, 148

- Scintillation counter
 - construction, 16, 148
 - deadtime, 333
 - dE/dx , 167, 341, 360
 - efficiency, 167–8
 - energy resolution, 168
 - intensity monitor, 115
 - response time, 333
 - spatial resolution, 168–9
 - timing, 169–75
 - trigger, 165, 341
- Scintillation efficiency, 150
- Scintillator
 - decay time, 150–2
 - fibers, 155
 - glass, 156
 - inorganic, 148–9
 - liquid, 152
 - noble gas, 155–6
 - organic, 149–55
 - plastic, 153–5, 167, 174–5
- Screening, 40, 48–50, 59–61
- Secondary beams, 103–8
- Secondary emission monitor, 115
- Self-absorption, 151
- Semiconductor detector, 16, 129–30, 296–8, 360–1
- Separated beam, 112–3
- Separator, electrostatic, 103–4
- Serpukov, 95, 103
- Shower (*see* Electromagnetic or Hadronic shower)
- Sigma particle, 9, 10, 313–14
- Silicon detector (*see* Semiconductor)
- SLAC
 - linac, 94–6, 115, 286, 374
 - SLC, 102–3
 - SPEAR, 100, 347
- Slewing, 135–6
- Sokolov–Ternov effect, 99
- Solenoid magnet, 331–2
- Source, accelerator, 93–4, 99
- Space, charge repulsion, 213–14, 217
- Space–time relation, 234, 252
- Spark chamber, 289–93
- Spark counter, 298–300
- Spatial resolution, 15
- Spectrometer
 - colliding beam, 329, 341–9, 367, 379–80
 - design criteria, 329–36
 - fixed target, 328–9, 336–41, 360, 363–5, 369, 371, 375–7
 - magnetic relations, 325–7
 - nucleon decay, 349–50
- Spin
 - measurement of, 361–2
 - quantum number, 3, 38
- Spline fit, 24
- Split field magnet, 331–2
- Standard deviation, 389
- Statistics, 388–90
- Straggling, 45
- Strangeness quantum number, 3, 7
- Streamer chamber, 16, 210, 293–4, 336–7
- Strong interaction, 2, 3, 79–88
- Structural materials, 397
- SU(3) model, 3
- Synchrotron, 96
- Synchrotron oscillation, 97
- Synchrotron radiation, 47, 98–9, 335
- t distribution, 12, 26
- Target, 125–32
- TASSO spectrometer, 174, 193–6, 244–5, 268
- Termination, cable, 145–6
- Thin lens approximation, 111
- Thomas–Fermi model of atom, 39, 49, 65
- Thomson cross section, 58
- Thyratron, 290
- Time/digital convertor (TDC), 144, 171, 247–8
- Time dilation, 6, 7, 363
- Time of flight (TOF), 172–5, 298–300, 335
- Time projection chamber (TPC), 242, 256–7
- Toroidal magnet, 331–2, 337–40
- Total cross section, 79–85, 89, 367–9, 391–2
- Total specific ionization, 208–9
- Townsend's ionization coefficient, 214
- Track length, 262
- Track sensitive target, 286
- Tracking, 15, 19, 333
- Transition radiation, 42, 294–7, 335
- Transmission, optical, 185–6
- Transmission measurement, 368–9
- Transport coefficient, 237–8
- Transverse momentum, 88
- Trigger
 - beam, 303–4
 - data acquisition, 336, 351–3
 - deposited energy, 315–7, 379
 - final state, 304–7
 - general properties, 16–17, 303–7
 - higher level, 316–21, 371
 - identified particle, 307–15
 - multiplicity, 305
- Truncated mean technique, 253–4
- Two body scattering, LAB frame, 393
- UA1 spectrometer, 18, 379–80
- Ultraviolet light, (UV), 159, 161, 179, 183–6, 200–1

- Updating discriminator, 136
- Uranium calorimeter, 279–81, 347

- Vacuum, beam, 101, 130
- Van de Meer method, 368
- Variance, 388–9
- Vee, 25
- Velocity, measurement of, 172, 196
- Vertexing, 25

- Villari effect, 293
- Virtual particle, 11

- W gauge boson, 3, 5, 18, 88, 379–81
- Waist, 113–14
- Wavelength shifter, 153–4, 157, 186, 267
- Weak interaction, 2, 3, 88–91
- Winston cone, 160–1

- Z gauge boson, 3, 5, 89

