A Little Background on Background Radiation

In NE MO where I live and have the Home Lab, background radiation runs around 10 uR/H from natural sources, mostly K-40. This radiation field will give far different counts on various probes, depending on their overall sensitivity and their sensitivity to the specific energies in the local radiation. For example K-40 has a Gamma radiation energy of 1460 keV, which is just above the normal range for GM tubes, therefore a GM tube will not give a totally accurate reading if K-40 is the main isotope. On the other hand, the low energies given off by U will be exaggerated by a good GM probe. On average though, GM tubes give very acceptable and particularly repeatable results.

By far the most common radioactive materials are the ones found in the soil and rocks in most every state of the Union in one form or another, and to a more or less degree.

Almost all of the many isotopes represented in this group, are the decay products or daughters of U235, U238 or Th-232. These include all the Radium's, Thorium's, Radon's, Polonium, all the way down to the radioactive Leads. They all start out as one of the 3 parents listed above, and here are a few excellent links that we continually refer to which give all the details.

See: Natural Decay Series Charts by Argonne National Laboratory, in the reference section.

Background (B/G) is gamma rays, they travel far in air. Betas do travel a distance too though and shouldn't be overlooked, but are easily shielded out. Figure 12 feet per MeV in air for betas. Alphas not a problem, only travel an inch or two in air.

Technically speaking, no amount of shielding will *stop* gamma rays. Practically speaking, we refer to

Half Value Layer HVL, the amount that cuts it in half. Then you figure the Tenth Value Layer or TVL as the most that can be achieved under practical terms. The TVL depends on the energy of the gammas, but 2" is TVL for a 1.5 MeV gamma. You can't have a 2 inch lead shield in a handheld probe, so they are usually anywhere from 1/8" to 1/2" of lead.

In nature there are 3 decay chains headed by Uranium 235, Uranium 238 and Thorium. U 235 in low abundance but U 238 and Thorium are everywhere. Each of the decay chains have the long lived parent element and many shorter lived daughters present in a stable mix called equilibrium. Sometimesequilibrium is disturbed by natural means, but usually undisturbed ore has a good mix. Keeping in mind that all U238 ores will have a similar "signature", be it yellow cake or Torbernite, because it is all Uranium after all. Many different types of U samples are not needed, but interesting nonetheless.

Other radioactive isotopes also exist in nature but do not have a decay chain, that is, their decay products themselves are not radioactive, but stable. Potassium is a very common element, and a portion of all K in nature is radioactive K-40, which is a large part of natural background radiation. For home lab use, we can get samples of K-40 in N0-Salt, Potassium Chloride salt for water softeners, fertilizer and many other household items.

The USGS has some cool maps that show distribution of radon throughout the US as well as similar maps showing background Gamma radiation. See:

http://energy.cr.usgs.gov/radon/radonhome.html

and

http://energy.cr.usgs.gov/radon/rnus.html

One of the first questions we hear on this board from a new member is "How hot is this if I get a reading of XXX?).

Well, the answer depends on a lot of factors, namely the distance you are from the radiation source, the size and shape of the radiation source, what is between you and the source (including the source itself, can have large self-absorption), and most importantly, what is the source material Quality Factor "QF" (i.e. what type, energy, and abundance of radiations does it emit?)

In the field, one seldom encounters a single source of radiation, rather a mixture of NORM (naturally occurring radioactive material) which has an array of different Gamma energies. Chief among the NORM are Uranium, Thorium and K-40.

A portion of all background (B/G) radiation detected will be from Cosmic Rays.

I've seen references that claim as much as 1/3 of all B/G is from Cosmic Rays, although I personally cannot corroborate this. (My experiments on bodies of water yield very low residual counts, being well away from soil/rock and soil/rock spawned radon).

From the lab standpoint, where shields can remove most of the B/G, individual isotopes may be measured and formulae employed to ascertain the needed data.

One formula, taken from the Health Physics Handbook is shown here:

R (@1 ft)= 6 x CE

Or

R (@ 1 cm)= 5.6 x10^3 x CE

Where

R= RADs/H

C= activity in Curies

E= Gamma energy in MEV

x= multiplication symbol

Fortunately for us, the US Gov't has worked all this out for some usefulisotope, and an excerpt is included below. For a full read and printout , refer to the source document at:

http://www-rsicc.ornl.gov

Here the "inverse square law" applies, so halving the distance will X4 the intensity.

Exposure Rate Constants

The "Specific Exposure Rate Constant", sometimes known as the "Gamma Factor", is the exposure rate at a specific distance from a given amount of a photon-emitting radionuclide. These constants are used frequently for radiation protection purposes. The following is a listing of Specific Exposure Rate Constants for a variety of radionuclides, in units of Roentgens per hour (R/hr) at a distance of one (1) meter from a one (1) curie point source of that radionuclide.

Actinium

Ac-225 - 0.191364

Ac-227 - 0.0087468

Ac-228 - 0.84397

Aluminum

Al-26 - 1.49739

Al-28 - 0.88208

Americium

Am-241 - 0.313723

Am-242 - 0.202612

Am-242m - 0.18315

Am-243 - 0.312872

Am-244 - 1.17216

Am-245 - 0.086617

Am-246 - 0.079513

Antimony

Sb-117 - 0.304103

Sb-122 - 0.304251

Sb-124 - 1.06671

Sb-125 - 0.38036

Sb-126 - 1.7982

Sb-126m - 1.04488

Sb-127 - 0.444

Sb-129 - 0.85655

Argon

Ar-41 - 0.69597

Arsenic

As-72 - 1.16476

As-73 - 0.140008

As-74 - 0.54464

As-76 - 0.274096

As-77 - 0.0062863

Astatine

At-211 - 0.22644

At-217 - 0.000160247

Barium

Ba-131 - 0.46028

Ba-133 - 0.45547

Ba-133m - 0.124764

Ba-135m - 0.110038

Ba-137m - 0.39997

Ba-139 - 0.0285529

Ba-140 - 0.164502

Ba-141 - 0.57794

Ba-142 - 0.56869

Berkelium

Bk-250 - 0.67858

Beryllium

Be-7 - 0.0343804

Bismuth

Bi-206 - 2.5234

Bi-207 - 1.33311

Bi-208 - 1.5207

Bi-211 - 0.047138

Bi-212 - 0.194768

Bi-213 - 0.11618

Bi-214 - 0.83916

Bromine

Br-77 - 0.71151

Br-80 - 0.080142

Br-80m - 0.703

Br-82 - 1.61949

Br-83 - 0.0051837

Br-84 - 0.88504

Br-85 - 0.039183

Cadmium

Cd-109 - 0.184371

Cd-111m - 0.313131

Cd-115 - 1505160000

Cd-115m - 0.0127021

Cd-117 - 0.6438

Cd-117m - 1.08595

Calcium

Ca-45 - 2.98664E-08

Ca-47 - 0.58497

Ca-49 - 1.33755

Californium

Cf-248 - 0.045473

Cf-249 - 0.41403

Cf-250 - 0.044844

Cf-251 - 0.42994

Cf-252 - 0.041847

Cf-253 - 0.0007696

Cf-254 - 4.8507E-08

Carbon

C-11 - 0.71669

Cerium

Ce-139 - 0.205498

Ce-141 - 0.073223

Ce-143 - 0.255041

Ce-144 - 0.0233174

Cesium

Cs-126 - 0.80142

Cs-129 - 0.359825

Cs-131 - 0.124431

Cs-132 - 0.57572

Cs-134 - 0.99937

Cs-134m - 0.070448

Cs-136 - 1.34384

Cs-137 - 0.38184

Cs-138 - 1.26614

Cs-139 - 0.15762

Chlorine

Cl-38 - 0.71854

Chromium

Cr-49 - 0.75073

Cr-51 - 0.023384

Cobalt

Co-56 - 1.92585

Co-57 - 0.151219

Co-58 - 0.61383

Co-58m - 9.7569E-05

Co-60 - 1.37011

Co-60m - 0.00335109

Co-61 - 0.084582

Copper

Cu-61 - 0.56832

Cu-62 - 0.7067

Cu-64 - 0.131942

Cu-67 - 0.087431

Curium

Cm-242 - 0.072113

Cm-243 - 0.47582

Cm-244 - 0.064417

Cm-245 - 0.4514

Cm-246 - 0.057387

Cm-247 - 0.267029

Cm-248 - 0.045399

Cm-249 - 0.0148259

Dysprosium

Dy-157 - 0.309209

Dy-165 - 0.0229141

Dy-166 - 0.05735

Einsteinium

Es-253 - 0.0256077

Es-254 - 0.5513

Es-254m - 0.56203

Es-255 - 0.00315573

Erbium

Er-169 - 1.26022E-06

Er-171 - 0.29637

Europium

Eu-152 - 0.74444

Eu-152m - 0.212602

Eu-154 - 0.75554

Eu-155 - 0.066748

Eu-156 - 0.73704

Fermium

Fm-254 - 0.041477

Fm-255 - 0.322677

Fluorine

F-18 - 0.69523

Francium

Fr-221 - 0.044141

Fr-223 - 0.33041

Gadolinium

Gd-153 - 0.172383

Gd-159 - 0.039183

Gd-162 - 0.308617

Gallium

Ga-66 - 1.29648

Ga-67 - 0.111148

Ga-68 - 0.66193

Ga-72 - 1.45632

Germanium

Ge-68 - 0.060458

Ge-71 - 0.061161

Ge-77 - 0.71558

Gold

Au-194 - 0.66008

Au-195 - 0.087394

Au-195m - 0.152884

Au-196 - 0.369704

Au-198 - 0.291634

Au-199 - 0.069042

Hafnium

Hf-181 - 0.39257

Holmium

Ho-166 - 0.023199

Ho-166m - 1.0619

Indium

In-111 - 0.50172

In-113m - 0.242979

In-114 - 0.0230251

In-114m - 0.150738

In-115m - 0.197173

In-116m - 1.3542

In-117 - 0.50283

In-117m - 0.11322

Iodine

I-122 - 0.70337

I-123 - 0.276686

I-124 - 0.7585

I-125 - 0.274984

I-126 - 0.39035

I-128 - 0.059792

I-129 - 0.125837

I-130 - 1.40267

I-131 - 0.282939

I-132 - 1.42746

I-133 - 0.40885

I-134 - 1.57287

I-135 - 0.86099

I-136 - 1.26429

Iridium

Ir-190 - 0.99197

Ir-190m(1.2h) - 2.2644E-07

Ir-190m(3.2h) - 0.055463

Ir-192 - 0.59163

Ir-193m - 0.00037629

Ir-194 - 0.061901

Ir-194m - 1.61764

Iron

Fe-52 - 0.52281

Fe-59 - 0.66193

Krypton

Kr-79 - 0.60347

Kr-81 - 0.43364

Kr-83m - 0.118733

Kr-85 - 0.00156584

Kr-85m - 0.160136

Kr-87 - 0.43253

Kr-88 - 1.02453

Kr-89 - 0.97162

Kr-90 - 0.76701

Lanthanum

La-141 - 0.0226144

La-142 - 1.35272

Lead

Pb-203 - 0.67636

Pb-204m - 1.3505

Pb-205 - 0.251193

Pb-210 - 0.251637

Pb-211 - 0.0363932

Pb-212 - 0.273393

Pb-214 - 0.323454

Pd-103 - 0.230103

Pd-109 - 0.0004847

Lutetium

Lu-177 - 0.0282532

Lu-177m - 0.78144

Magnesium

Mg-27 - 0.53613

Mg-28 - 0.87875

Manganese

Mn-52 - 2.0091

Mn-52m - 1.44411

Mn-54 - 0.51134

Mn-56 - 0.92352

Mn-57 - 0.112147

Mercury

Hg-197 - 0.069338

Hg-197m - 0.076183

Hg-203 - 0.253117

Molybdenum

Mo-101 - 0.88467

Mo-91 - 0.70226

Mo-93 - 0.293632

Mo-99 - 0.112924

Neodynium

Nd-147 - 0.139453

Nd-149 - 0.300144

Neptunium

Np-235 - 0.258223

Np-236 - 1.04821

Np-236m - 0.23643

Np-237 - 0.46287

Np-238 - 0.55389

Np-239 - 0.51282

Np-240 - 1.41562

Np-240m - 0.42328

Nickel

Ni-56 - 1.08817

Ni-57 - 1.07707

Ni-65 - 0.297406

Niobium

Nb-90 - 2.44089

Nb-91 - 0.326784

Nb-91m - 0.26492

Nb-92 - 1.26318

Nb-92m - 0.89281

Nb-93m - 0.052577

Nb-94 - 0.97976

Nb-94m - 0.202797

Nb-95 - 0.48026

Nb-95m - 0.23643

Nb-96 - 1.5244

Nb-97 - 0.43475

Nb-97m - 0.46694

Nitrogen

N-13 - 0.71706

N-16 - 1.47408

Osmium

Os-185 - 0.4847

Os-190m - 1.11666

Os-191 - 0.067969

Os-191m - 0.0053613

Os-193 - 0.052318

Oxygen

O-15 - 0.7178

Platinum

Pt-191 - 0.243756

Pt-193m - 0.0172013

Pt-195m - 0.075073

Pt-197 - 0.0208939

Pt-197m - 0.071447

Plutonium

Pu-236 - 0.088985

Pu-237 - 0.38443

Pu-238 - 0.078995

Pu-239 - 0.0301365

Pu-240 - 0.07511

Pu-242 - 0.062308

Pu-243 - 0.092833

Pu-244 - 0.054094

Pu-245 - 0.38702

Polonium

Po-209 - 0.00363007

Po-210 - 5.2688E-06

Po-211 - 0.0049136

Po-213 - 1.90402E-05

Po-214 - 5.1726E-05

Po-215 - 0.000105857

Po-216 - 8.9688E-06

Potassium

K-40 - 0.081696

K-42 - 0.143153

K-43 - 0.67007

Praseodynium

Pr-142 - 0.0299922

Pr-143 - 5.6388E-09

Pr-144 - 0.01702

Pr-144m - 0.0367521

Promethium

Pm-143 - 0.266992

Pm-144 - 1.09446

Pm-145 - 0.089466

Pm-146 - 0.54094

Pm-147 - 2.67584E-06

Pm-148 - 0.330669

Pm-148m - 1.31979

Pm-149 - 0.0085729

Pm-151 - 0.262182

Protactinium

Pa-230 - 0.88319

Pa-231 - 0.37407

Pa-233 - 0.49395

Pa-234 - 1.98172

Pa-234m - 0.0102712

Radium

Ra-222 - 0.0078255

Ra-223 - 0.325193

Ra-224 - 0.0109779

Ra-225 - 0.154068

Ra-226 - 0.0121138

Radon

Rn-218 - 0.00050579

Rn-219 - 0.052503

Rn-220 - 0.000359751

Rn-222 - 0.00027343

Rhenium

Re-182 - 1.13886

Re-182m - 0.73778

Re-183 - 0.157509

Re-184 - 0.58201

Re-184m - 0.284086

Re-186 - 0.0181633

Re-188 - 0.040478

Rhodium

Rh-103m - 0.0255744

Rh-105 - 0.058756

Rh-105m - 0.157287

Rh-106 - 0.138158

Rubidium

Rb-81 - 0.83768

Rb-82 - 0.77848

Rb-83 - 0.77145

Rb-84 - 0.86062

Rb-86 - 0.053946

Rb-88 - 0.321937

Rb-89 - 1.0952

Rb-90 - 0.94276

Rb-90m - 1.63873

Ruthenium

Ru-103 - 0.33189

Ru-105 - 0.51689

Ru-97 - 0.44178

Samarium

Sm-151 - 9.0354E-05

Sm-153 - 0.09028

Scandium

Sc-44 - 1.33274

Sc-46 - 1.16735

Sc-46m - 0.066933

Sc-47 - 0.08029

Sc-48 - 1.89329

Sc-49 - 0.00052059

Selenium

Se-73 - 1.09853

Se-75 - 0.85951

Silicon

Si-31 - 0.00048322

Silver

Ag-106m - 1.93769

Ag-108 - 0.0162763

Ag-108m - 1.27132

Ag-109m - 0.100714

Ag-110 - 0.0205646

Ag-110m - 1.65242

Ag-111 - 0.0197173

Sodium

Na-22 - 1.3394

Na-24 - 1.93769

Strontium

Sr-82 - 0.39405

Sr-85 - 0.75924

Sr-85m - 0.222148

Sr-87m - 0.29637

Sr-89 - 8.1585E-05

Sr-91 - 0.41366

Sr-92 - 0.72002

Sr-93 - 1.35605

Tantalum

Ta-182 - 0.77182

Technetium

Tc-101 - 0.255892

Tc-95 - 0.77404

Tc-95m - 0.71743

Tc-96 - 1.81263

Tc-96m - 0.16391

Tc-97 - 0.281052

Tc-97m - 0.193621

Tc-98 - 0.8991

Tc-99 - 4.5954E-07

Tc-99m - 0.122729

Tellurium

Te-121 - 0.53835

Te-121m - 0.248011

Te-123 - 0.099419

Te-123m - 0.194657

Te-125m - 0.228216

Te-127 - 0.00348836

Te-127m - 0.073149

Te-129 - 0.067821

Te-129m - 0.073889

Te-131 - 0.298775

Te-131m - 0.90724

Te-132 - 0.279313

Te-133 - 0.58608

Te-133m - 1.36493

Te-134 - 0.64047

Terbium

Tb-157 - 0.0089762

Tb-160 - 0.66156

Tb-162 - 0.71188

Thorium

Th-226 - 0.067266

Th-227 - 0.42365

Th-228 - 0.079254

Th-229 - 0.73593

Th-230 - 0.068857

Th-231 - 0.54501

Th-232 - 0.068376

Th-233 - 0.095719

Th-234 - 0.075406

Thullium

Tm-170 - 0.0061901

Tm-171 - 0.00096089

Tin

Sn-113 - 0.179228

Sn-117m - 0.251452

Sn-119m - 0.103193

Sn-123 - 0.0039294

Sn-125 - 0.172938

Sn-126 - 0.126096

Titanium

Ti-200 - 0.83361

Ti-201 - 0.087764

Ti-202 - 0.349206

Ti-204 - 0.00111518

Ti-207 - 0.00130388

Ti-208 - 1.70385

Ti-209 - 1.29352

Ti-210 - 1.70237

Ti-44 - 0.144633

Ti-45 - 0.61161

Ti-51 - 0.26381

Tungsten

W-181 - 0.051393

W-185 - 2.02205E-05

W-187 - 0.328782

W-188 - 0.00133755

Uranium

U-230 - 0.091131

U-231 - 0.7844

U-232 - 0.088911

U-233 - 0.0291042

U-234 - 0.077589

U-235 - 0.338883

U-236 - 0.073704

U-237 - 0.58793

U-238 - 0.065231

U-239 - 0.13431

U-240 - 0.284382

Vanadium

V-48 - 1.70126

V-52 - 0.76109

Xenon

Xe-122 - 0.180079

Xe-123 - 0.52392

Xe-125 - 0.356014

Xe-127 - 0.345247

Xe-129m - 0.228105

Xe-131m - 0.093721

Xe-133 - 0.102971

Xe-133m - 0.112258

Xe-135 - 0.189477

Xe-135m - 0.320087

Xe-137 - 0.123802

Xe-138 - 0.62123

Ytterbium

Yb-169 - 0.326969

Yb-175 - 0.0304621

Yttrium

Y-86 - 2.32804

Y-87 - 0.68857

Y-88 - 1.78303

Y-90m - 0.48692

Y-91 - 0.00199911

Y-91m - 0.38036

Y-92 - 0.146927

Y-93 - 0.051652

Zinc

Zn-62 - 0.33263

Zn-65 - 0.330188

Zn-69 - 4.3216E-06

Zn-69m - 0.295371

Zirconium

Zr-86 - 0.88171

Zr-88 - 0.6327

Zr-89 - 0.98494

Zr-95 - 0.46546

Zr-97 - 0.108114

****Listing partially extracted from ORNL/RSIC-45, "Specific Gamma-Ray Dose Constants for Nuclides Important to Dosimetry and Radiological Assessment", 1981**

Taking a Radiation Reading" is a simple matter. Understanding that reading may be a little more complex. Yes you can point your CDV700 at something, and get a reading. The next question is "what does that reading mean?".

The passage that follows is a direct quote from a book, so that the details are preserved. My comments at the conclusion.

QUOTE:

"To be effective in your radiological work, you must get a first grasp on the ways radiation is measured. "Radiation", like "distance" is a general concept. You would have a weak understanding of distance if you were vague about "foot", "inch", "mile", "kilometer", "light year", and the other ways by which distance is measured. The same is true for radiation.

The Curie (Ci) is the unit used to measure the activity of all radioactive substances. It is a measurement of rate of decay or nuclear disintegration that occurs within the radioactive material. The Curie initially established the activity (that is, decay rate) of Radium as the standard with which the activity of any other substance was compared.

By using a formula that takes into account the number of atoms per gram and the value of the half-life in seconds, scientists have determined that the activity of Radium is equal to 3.7 X 10E10 nuclear disintegrations per gram per second. This value is now the standard of comparison. A Curie of ANY radioactive isotope, therefore, is the amount of that isotope that will produce 3.7 X 10E10 nuclear disintegrations per second. Since the measure is based on number of disintegrations, the weight of the radioisotope will vary from that of Radium. A Curie of pure CO60 would weigh less than .9 milligrams, while a Curie of U238 would weigh over two metric tons.

The Curie is a large unit. In training, a milliCurie, mCi (one-thousandth Curie) and the microCurie, uCi (one millionth Curie) are common units in use. At the opposite extreme, the Curie is too small a unit for convenient measurement of the high-order activity produced by the nuclear explosion. For this purpose, he MegaCurie (one million Curies) is used.

The Roentgen,(R) by definition measures exposure to Gamma and X-rays.

It is an expression of the ability of Gamma or X-ray to ionize air.

One R will produce 2.083 X 10E9 ion pairs per cubic centimeter in air.

The Curie measures Radioactivity

The Roentgen measures X or Gamma rays"

END QUOTE

My comment:

Armed with the above information, consider the added confusion when you include the fact that every radioisotope puts out a different type of radiation mixture. Some have Alphas and Betas(Betas

themselves which have a range, not a discrete energy). Then the Gamma rays are of different energies. This soup of different radiations would be difficult enough to quantify in a perfect world, but our

probes are far from perfect. Some respond way differently than others, some over respond to certain radiation, or under respond. The probe housing also has a big affect on the final readings..........

some being "compensated", some "uncompensated. Throw in the distance, geometry and other geotropic factors, shielding, and it would be very difficult indeed to say "this material is 20 mCi" First you would have to know exactly what the material was in the first place, so you could analyze which radiations the probe was (or was not) reading.

Since the R is a unit of field charge and not of radioactivity, it is perfectly valid to use a CDV700 to make these measurements (shield closed). It is also valid to use a Beta check source to "calibrate" a probe/meter combination and have that "calibration" apply to the Gamma response as well*. That reading is valid for the location of the probe. It offers no help as to the quantity or energy level of

the material producing the Gamma Rays, or the distance it is from the probe. It does not matter in this context, the ionization field isbeing produced by whatever quantity and energy mix that exists, and

the distance factor is automatically integrated into the reading. R is a measure of the effects of Gamma rays, only valid with the Beta shield close.

That's fine from a health-physics or CD standpoint, as far as it goes.

*** the idea here is that the characteristics of the QPL 6993 probe are so well known, both Beta and Gamma, that exposure to a know Beta source (shield open) will give a reasonable expectation of a know**

Gamma response (shield close). This is the basis of the QPL or Quality Product List classification on the 6993 tubes. In the case of the radioactive check source that comes with the CDV700 set, there has been a considerable time elapse since these were installed, and in some cases at least, they have been replaced or refreshed. Also it is indicated that the material itself is of different compositions, between makers. All this affects the present day strength of he sample. Since we have a "standard" radioactive source readily available, long half-life, namely the radioactive lantern mantles, assuming them to be from the same batch lot (mine are), it would seem that anyone could measure his probe/meter against the mantle, then apply a K factor to the onboard test spot. All we would need is a representative measurement made with a new or know good tube at the specified high voltage. A suggestion is to leave the mantle in the plastic bag, with the red side towards the probe, and wrapped around the open Beta window with a rubber band. Perhaps someone out there has an actual assayed or calibrated lab sample that could provide the NIST trace to legitimize the project.

My personal interest goes in another vector. I want to know quantitatively (assay) and qualitatively (is it Alpha?, Beta?, Gamma?, and what energy levels). I continue to give reading as CPM, with probe and other conditions listed.

Geologists have a keen interest in radioactivity, as it can foretell the nature of the earth in the vicinity. Some even use the small differences to detect the probable presence of petroleum. Others use it to prospect for minerals.

In practice the 3 main of interest are Potassium, Uranium and Thorium. By knowing the concentration and relationship of these three, the geologist can make many conclusions.

A small percentage (.12%)of all natural Potassium is a radioactive isotope K-40 which has only one Gamma decay product, a ray of 1.461 MeV. This can be measured directly by the instrument.

Uranium itself is an strong Alpha emitter and it's gamma rays are unsuitable for direct measurement in this field, so a daughter of unique properties, Bismuth-214 is used instead, where the 1.76 MeV Gamma can easily be distinguished.

Thorium has similar difficulties in direct measurement, so in this instance the daughter - Thallium-208 with it's 2.62 MeV gamma are chosen for scrutiny.

We you see prospectors with their PRI's clicking away in the movies, the real science of today has moved way beyond that. Grids are set up for a routine survey and many measurements of the 3 minerals mentioned above are made. Sometimes the detector is winched down a well drill hole to take measurements (other methods of radioactive investigation are also used in well logging). Airborne and carborne surveys can easily be made too.

In all these cases, the 3 different energy level gammas are measured separately by means of a gamma spectrometer. Some instruments are more complex than others, thereby giving readings that are easier to understand.

Some even use isotope stabilized probes to prevent temperature variations form affecting readings (NaI(Tl) - PMT scintillators sensitivity drifts with temperature, about 1% for each 2 degrees). A closed feedback loop measures the Alphas given off by Am-241 which is actually inside the crystal, and the high voltage is adjusted for a standard reading automatically.

As you should know if you read the Primer in GCE message 266, scintillator detectors put out pulses that vary in height, according to the energy level of the radiation that caused the pulse. In the Gamma Ray Spectrometer, those pulses are sorted out and dealt with on a case by case basis.

In the simple self-contained (probe is inside the instrument) units like the DISA 300, there is often only a LLD (Lower Level Discriminator) sometimes called a threshold control. It can be preset for the different channels of interest, but basically it will ignore all the energy pulses BELOW a certain point, and count all the ones above that. The K channel (Potassium) will ignore all below 1.46 but count all above that, which of course includes the U and Th channels. Similarly the U (Uranium) channel will

include the Th energies., so to get an individual picture of each, some readings are taken, and mathematical subtraction employed.

In the case of the more complicated Scintrex, there is also a Upper Limit control or "window" applied which ignores all the pulses ABOVE a certain level, so that the counter only recognizes the pulses above the LLD but below the Window.

These same controls exist on all SCA's (Single Channel Analyzers) except that in the geologists special unit there a 4 different ones that are simply preset, then switch selected (K-U-Th and the 4th channel is wide open or Total Counts).

Rather large scintillators must be utilized for good sensitivity and reasonable count rates. Even though the count rate "wide open" will be huge, when all the random pulses are screened out, the actual reading can become quite small for the energy levels of interest.

Have fun

Geo