

```
1 "D:\Program Files\Python\python.exe" D:\
  PyCharmProjects\KRNN-G\main_pipeline.py
2
3 [Phase 0] Initializing Pipeline & Checking Data...
4 2025-12-22 18:27:56,917 [INFO] Global Seed set to 42
5 2025-12-22 18:27:56,920 [INFO] Data files found.
  Skipping download.
6
7 [Phase 1] Loading Data Module (RAM Cache)...
8 2025-12-22 18:27:57,540 [INFO] Dataset loaded to cuda
  . Usage: 326.43 MB
9 2025-12-22 18:27:57,593 [INFO] Dataset loaded to cuda
  . Usage: 56.84 MB
10 2025-12-22 18:27:57,677 [INFO] Dataset loaded to cuda
  . Usage: 130.85 MB
11
12 [Phase 2] Training K-Parallel KRNN (Heteroscedastic
  - Overfit Mode)...
13 2025-12-22 18:28:02,823 [INFO] Epoch 1/100 | Train
  GNLL: -0.0989 | Val GNLL: -2.5453
14 2025-12-22 18:28:06,961 [INFO] Epoch 2/100 | Train
  GNLL: -2.0157 | Val GNLL: -2.1712
15 2025-12-22 18:28:11,007 [INFO] Epoch 3/100 | Train
  GNLL: -2.3373 | Val GNLL: -2.7839
16 2025-12-22 18:28:15,143 [INFO] Epoch 4/100 | Train
  GNLL: -2.4868 | Val GNLL: -2.1105
17 2025-12-22 18:28:19,306 [INFO] Epoch 5/100 | Train
  GNLL: -2.5552 | Val GNLL: -3.0187
18 2025-12-22 18:28:23,445 [INFO] Epoch 6/100 | Train
  GNLL: -2.6086 | Val GNLL: -2.5504
19 2025-12-22 18:28:27,578 [INFO] Epoch 7/100 | Train
  GNLL: -2.7194 | Val GNLL: -3.0991
20 2025-12-22 18:28:31,725 [INFO] Epoch 8/100 | Train
  GNLL: -2.5705 | Val GNLL: -2.5473
21 2025-12-22 18:28:35,889 [INFO] Epoch 9/100 | Train
  GNLL: -2.4268 | Val GNLL: -2.8726
22 2025-12-22 18:28:40,052 [INFO] Epoch 10/100 | Train
  GNLL: -2.9212 | Val GNLL: -3.2251
23 2025-12-22 18:28:44,199 [INFO] Epoch 11/100 | Train
  GNLL: -2.2906 | Val GNLL: -1.1670
24 2025-12-22 18:28:48,345 [INFO] Epoch 12/100 | Train
```

```
24 GNLL: -2.6091 | Val GNLL: -3.0832
25 2025-12-22 18:28:52,477 [INFO] Epoch 13/100 | Train
   GNLL: -2.9169 | Val GNLL: -3.0755
26 2025-12-22 18:28:56,602 [INFO] Epoch 14/100 | Train
   GNLL: -3.0211 | Val GNLL: -3.1298
27 2025-12-22 18:29:00,733 [INFO] Epoch 15/100 | Train
   GNLL: -3.0273 | Val GNLL: -3.1636
28 2025-12-22 18:29:04,877 [INFO] Epoch 16/100 | Train
   GNLL: -3.0290 | Val GNLL: -3.1882
29 2025-12-22 18:29:09,013 [INFO] Epoch 17/100 | Train
   GNLL: -3.0359 | Val GNLL: -3.1721
30 2025-12-22 18:29:13,133 [INFO] Epoch 18/100 | Train
   GNLL: -2.9612 | Val GNLL: -3.1005
31 2025-12-22 18:29:17,266 [INFO] Epoch 19/100 | Train
   GNLL: -2.9876 | Val GNLL: -3.1884
32 2025-12-22 18:29:21,404 [INFO] Epoch 20/100 | Train
   GNLL: -2.9892 | Val GNLL: -3.2668
33 2025-12-22 18:29:25,550 [INFO] Epoch 21/100 | Train
   GNLL: -3.0025 | Val GNLL: -3.1889
34 2025-12-22 18:29:29,695 [INFO] Epoch 22/100 | Train
   GNLL: -3.0038 | Val GNLL: -3.0586
35 2025-12-22 18:29:33,999 [INFO] Epoch 23/100 | Train
   GNLL: -3.0088 | Val GNLL: -3.1120
36 2025-12-22 18:29:38,153 [INFO] Epoch 24/100 | Train
   GNLL: -3.0119 | Val GNLL: -3.2346
37 2025-12-22 18:29:42,285 [INFO] Epoch 25/100 | Train
   GNLL: -3.0125 | Val GNLL: -3.2909
38 2025-12-22 18:29:46,428 [INFO] Epoch 26/100 | Train
   GNLL: -3.0114 | Val GNLL: -3.2373
39 2025-12-22 18:29:50,604 [INFO] Epoch 27/100 | Train
   GNLL: -3.0176 | Val GNLL: -3.0396
40 2025-12-22 18:29:54,783 [INFO] Epoch 28/100 | Train
   GNLL: -3.0138 | Val GNLL: -3.1287
41 2025-12-22 18:29:58,960 [INFO] Epoch 29/100 | Train
   GNLL: -3.0119 | Val GNLL: -3.2319
42 2025-12-22 18:30:03,133 [INFO] Epoch 30/100 | Train
   GNLL: -3.0241 | Val GNLL: -3.2829
43 2025-12-22 18:30:07,287 [INFO] Epoch 31/100 | Train
   GNLL: -3.0036 | Val GNLL: -3.1530
44 2025-12-22 18:30:11,491 [INFO] Epoch 32/100 | Train
   GNLL: -3.0903 | Val GNLL: -3.2892
```

```
45 2025-12-22 18:30:15,685 [INFO] Epoch 33/100 | Train
    GNLL: -3.1221 | Val GNLL: -3.3133
46 2025-12-22 18:30:19,849 [INFO] Epoch 34/100 | Train
    GNLL: -3.1222 | Val GNLL: -3.3188
47 2025-12-22 18:30:24,041 [INFO] Epoch 35/100 | Train
    GNLL: -3.1221 | Val GNLL: -3.2719
48 2025-12-22 18:30:28,359 [INFO] Epoch 36/100 | Train
    GNLL: -3.1209 | Val GNLL: -3.3270
49 2025-12-22 18:30:32,558 [INFO] Epoch 37/100 | Train
    GNLL: -3.1180 | Val GNLL: -3.2878
50 2025-12-22 18:30:36,794 [INFO] Epoch 38/100 | Train
    GNLL: -3.1259 | Val GNLL: -3.2625
51 2025-12-22 18:30:41,034 [INFO] Epoch 39/100 | Train
    GNLL: -3.0968 | Val GNLL: -3.3162
52 2025-12-22 18:30:45,218 [INFO] Epoch 40/100 | Train
    GNLL: -3.1281 | Val GNLL: -3.3160
53 2025-12-22 18:30:49,407 [INFO] Epoch 41/100 | Train
    GNLL: -3.1281 | Val GNLL: -3.3242
54 2025-12-22 18:30:53,891 [INFO] Epoch 42/100 | Train
    GNLL: -3.1301 | Val GNLL: -3.3130
55 2025-12-22 18:30:58,100 [INFO] Epoch 43/100 | Train
    GNLL: -3.1235 | Val GNLL: -3.3295
56 2025-12-22 18:31:02,330 [INFO] Epoch 44/100 | Train
    GNLL: -3.1304 | Val GNLL: -3.3323
57 2025-12-22 18:31:06,897 [INFO] Epoch 45/100 | Train
    GNLL: -3.1334 | Val GNLL: -3.3341
58 2025-12-22 18:31:11,118 [INFO] Epoch 46/100 | Train
    GNLL: -3.1315 | Val GNLL: -3.3169
59 2025-12-22 18:31:15,257 [INFO] Epoch 47/100 | Train
    GNLL: -3.1313 | Val GNLL: -3.3228
60 2025-12-22 18:31:19,406 [INFO] Epoch 48/100 | Train
    GNLL: -3.1318 | Val GNLL: -3.3421
61 2025-12-22 18:31:23,606 [INFO] Epoch 49/100 | Train
    GNLL: -3.1241 | Val GNLL: -3.3263
62 2025-12-22 18:31:27,847 [INFO] Epoch 50/100 | Train
    GNLL: -3.1288 | Val GNLL: -3.3191
63 2025-12-22 18:31:32,034 [INFO] Epoch 51/100 | Train
    GNLL: -3.1304 | Val GNLL: -3.3558
64 2025-12-22 18:31:36,231 [INFO] Epoch 52/100 | Train
    GNLL: -3.1217 | Val GNLL: -3.2792
65 2025-12-22 18:31:40,435 [INFO] Epoch 53/100 | Train
```

```
65 GNLL: -3.1305 | Val GNLL: -3.3236
66 2025-12-22 18:31:44,886 [INFO] Epoch 54/100 | Train
    GNLL: -3.1296 | Val GNLL: -3.3418
67 2025-12-22 18:31:49,217 [INFO] Epoch 55/100 | Train
    GNLL: -3.1318 | Val GNLL: -3.3264
68 2025-12-22 18:31:53,347 [INFO] Epoch 56/100 | Train
    GNLL: -3.1308 | Val GNLL: -3.3412
69 2025-12-22 18:31:57,533 [INFO] Epoch 57/100 | Train
    GNLL: -3.1325 | Val GNLL: -3.3301
70 2025-12-22 18:32:01,665 [INFO] Epoch 58/100 | Train
    GNLL: -3.1353 | Val GNLL: -3.3339
71 2025-12-22 18:32:05,873 [INFO] Epoch 59/100 | Train
    GNLL: -3.1340 | Val GNLL: -3.3248
72 2025-12-22 18:32:10,087 [INFO] Epoch 60/100 | Train
    GNLL: -3.1317 | Val GNLL: -3.3322
73 2025-12-22 18:32:14,319 [INFO] Epoch 61/100 | Train
    GNLL: -3.1315 | Val GNLL: -3.3324
74 2025-12-22 18:32:18,456 [INFO] Epoch 62/100 | Train
    GNLL: -3.1335 | Val GNLL: -3.3386
75 2025-12-22 18:32:22,610 [INFO] Epoch 63/100 | Train
    GNLL: -3.1330 | Val GNLL: -3.3403
76 2025-12-22 18:32:26,771 [INFO] Epoch 64/100 | Train
    GNLL: -3.1341 | Val GNLL: -3.3210
77 2025-12-22 18:32:30,982 [INFO] Epoch 65/100 | Train
    GNLL: -3.1346 | Val GNLL: -3.3324
78 2025-12-22 18:32:35,157 [INFO] Epoch 66/100 | Train
    GNLL: -3.1340 | Val GNLL: -3.3371
79 2025-12-22 18:32:35,157 [INFO] Early stopping
    triggered.
80 2025-12-22 18:32:35,168 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
81 2025-12-22 18:32:35,179 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
82 Training Complete. Final Val GNLL: -3.
    3558453798294066
83
84 [Phase 3] Running Systematic Portfolio Selection &
    Robust Risk Analysis...
85     Scanning assets for alpha...
86 2025-12-22 18:32:35,190 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
```

```
87 2025-12-22 18:32:35,200 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
88 2025-12-22 18:32:35,210 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
89 2025-12-22 18:32:35,221 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
90 2025-12-22 18:32:35,232 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
91 2025-12-22 18:32:35,243 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
92 2025-12-22 18:32:35,253 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
93 2025-12-22 18:32:35,263 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
94 2025-12-22 18:32:35,274 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
95 2025-12-22 18:32:35,285 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
96 2025-12-22 18:32:35,296 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
97 2025-12-22 18:32:35,306 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
98 2025-12-22 18:32:35,317 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
99 2025-12-22 18:32:35,327 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
100 2025-12-22 18:32:35,339 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
101 2025-12-22 18:32:35,351 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
102 2025-12-22 18:32:35,363 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
103 2025-12-22 18:32:35,375 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
104 2025-12-22 18:32:35,388 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
105 2025-12-22 18:32:35,400 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
106 2025-12-22 18:32:35,413 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
107 2025-12-22 18:32:35,424 [INFO] Dataset loaded to
```

```
107 cuda. Usage: 0.57 MB
108 2025-12-22 18:32:35,437 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
109 2025-12-22 18:32:35,449 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
110 2025-12-22 18:32:35,462 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
111 2025-12-22 18:32:35,474 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
112 2025-12-22 18:32:35,485 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
113 2025-12-22 18:32:35,496 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
114 2025-12-22 18:32:35,506 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
115 2025-12-22 18:32:35,517 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
116 2025-12-22 18:32:35,528 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
117 2025-12-22 18:32:35,539 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
118 2025-12-22 18:32:35,549 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
119 2025-12-22 18:32:35,560 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
120 2025-12-22 18:32:35,572 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
121 2025-12-22 18:32:35,584 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
122 2025-12-22 18:32:35,596 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
123 2025-12-22 18:32:35,608 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
124 2025-12-22 18:32:35,621 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
125 2025-12-22 18:32:35,633 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
126 2025-12-22 18:32:35,645 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
127 2025-12-22 18:32:35,657 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
```

```
128 2025-12-22 18:32:35,669 [INFO] Dataset loaded to
    cuda. Usage: 0.50 MB
129 2025-12-22 18:32:35,681 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
130 2025-12-22 18:32:35,691 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
131 2025-12-22 18:32:35,702 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
132 2025-12-22 18:32:35,712 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
133 2025-12-22 18:32:35,722 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
134 2025-12-22 18:32:35,733 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
135 2025-12-22 18:32:35,743 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
136 2025-12-22 18:32:35,753 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
137 2025-12-22 18:32:35,764 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
138 2025-12-22 18:32:35,774 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
139 2025-12-22 18:32:35,786 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
140 2025-12-22 18:32:35,798 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
141 2025-12-22 18:32:35,810 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
142 2025-12-22 18:32:35,823 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
143 2025-12-22 18:32:35,836 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
144 2025-12-22 18:32:35,848 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
145 2025-12-22 18:32:35,860 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
146 2025-12-22 18:32:35,873 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
147 2025-12-22 18:32:35,885 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
148 2025-12-22 18:32:35,897 [INFO] Dataset loaded to
```

```
148 cuda. Usage: 0.57 MB
149 2025-12-22 18:32:35,908 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
150 2025-12-22 18:32:35,919 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
151 2025-12-22 18:32:35,930 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
152 2025-12-22 18:32:35,941 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
153 2025-12-22 18:32:35,951 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
154 2025-12-22 18:32:35,961 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
155 2025-12-22 18:32:35,972 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
156 2025-12-22 18:32:35,982 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
157 2025-12-22 18:32:35,994 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
158 2025-12-22 18:32:36,006 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
159 2025-12-22 18:32:36,019 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
160 2025-12-22 18:32:36,031 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
161 2025-12-22 18:32:36,044 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
162 2025-12-22 18:32:36,056 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
163 2025-12-22 18:32:36,068 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
164 2025-12-22 18:32:36,080 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
165 2025-12-22 18:32:36,091 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
166 2025-12-22 18:32:36,102 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
167 2025-12-22 18:32:36,112 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
168 2025-12-22 18:32:36,122 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
```



```
169 2025-12-22 18:32:36,133 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
170 2025-12-22 18:32:36,143 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
171 2025-12-22 18:32:36,153 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
172 2025-12-22 18:32:36,163 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
173 2025-12-22 18:32:36,174 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
174 2025-12-22 18:32:36,184 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
175 2025-12-22 18:32:36,195 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
176 2025-12-22 18:32:36,207 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
177 2025-12-22 18:32:36,218 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
178 2025-12-22 18:32:36,229 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
179 2025-12-22 18:32:36,241 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
180 2025-12-22 18:32:36,254 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
181 2025-12-22 18:32:36,266 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
182 2025-12-22 18:32:36,278 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
183 2025-12-22 18:32:36,290 [INFO] Dataset loaded to
    cuda. Usage: 0.57 MB
184     Selected Top 10 Candidates.
185
186 3. Risk Filter: Analyzing Heavy Tails (EVT) & Bounds
    (Naumova DCMF)...
187     - GEHC: Gamma=0.26 | Gap=-1.59
188     - ADBE: Gamma=0.51 | Gap=-4.27
189     - AMD: Gamma=0.43 | Gap=-3.76
190     - ABNB: Gamma=0.33 | Gap=-1.97
191     - GOOGL: Gamma=0.34 | Gap=-1.85
192     - GOOG: Gamma=0.44 | Gap=-2.71
193     - AMZN: Gamma=0.46 | Gap=-3.67
```

```
194 - AEP: Gamma=0.45 | Gap=-2.59
195 - AMGN: Gamma=0.48 | Gap=-2.38
196 - ADI: Gamma=0.29 | Gap=-1.75
197
198 4. Optimization: Mean-CVaR (Long/Short)...
199
200 [Phase 4] Out-of-Sample Evaluation...
201
202 [Phase 5] Running Out-of-Sample Portfolio Backtest
    ...
203 2025-12-22 18:32:37,829 [INFO] Saved comprehensive
    text report to ./reports\comprehensive_summary.txt
204
205 === OUT-OF-SAMPLE RESULTS (2024+) ===
206 Metric                Strategy          Benchmark
207 -----
208 Total Return           0.59             % 0.60             %
209 Volatility              0.48             % 0.41             %
210 Sharpe Ratio            0.6215           0.7465
211
212 Pipeline Complete. Reports generated in ./reports
213
214 Process finished with exit code 0
215
```