

# Pipeline Report

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# 1 Metadata information

## 1.1 Constants

The following information is not automatically updated in the report:

Build: b38 (hg38)

## 1.2 Dynamic

The following information is gathered dynamically when a report is generated:

Library	Sample	Preparation	Gbp
HALB3002753	NA12878	PCR-free-illumina	181.14
HALB3002754	HG002	PCR-free-illumina	145.87
HALB3002755	HG003	PCR-free-illumina	149.77
HALB3002756	HG004	PCR-free-illumina	138.30
HALB3002757	HG005	PCR-free-illumina	159.85
HALB3003200	NA12878	PCR-free-illumina	167.53
HALB3003201	HG002	PCR-free-illumina	129.81
HALB3003222	HG003	PCR-free-illumina	156.20
HALB3010451	NA12878	PacBio-CCS-high	77.46
HALB3010452	HG002	PacBio-CCS-high	166.22
HALB3010453	HG003	PacBio-CCS-high	129.52
HALB3010454	HG004	PacBio-CCS-high	123.81
HALB3010455	HG005	PacBio-CCS-high	145.34
HALB3010456	HG006	PacBio-CCS-high	122.17
HALB3010457	HG007	PacBio-CCS-high	113.30

## 2 Summarized Small Variant Comparison

This section contains the summarized results of the small variant analysis. For each aligner-caller pair, we ran RTG on the Genome in a Bottle (GIAB) high confidence truth set ( $\approx 3.6$ M variants). The following results are gathered from the RTG ‘summary.txt’ file using the final row (i.e. “None” indicating no variants were filtered) and with the `--all-records` option enabled.

### 2.1 Preparation: “PCR-free-illumina”

Reference	Aligner	Caller	N	Precision	Sensitivity	F-measure
clinical	sentieon-201808.07	strelka-2.9.10	8	0.9923+-0.0014	0.9920+-0.0008	0.9922+-0.0010
hg38_GIAB_masked	dragmap-1.2.1	clair3-0.1-r9	8	0.9976+-0.0003	0.9924+-0.0006	0.9950+-0.0004
hg38_GIAB_masked	dragmap-1.2.1	deepvariant-1.2.0	8	0.9989+-0.0002	0.9928+-0.0006	0.9959+-0.0004
hg38_GIAB_masked	dragmap-1.2.1	dnascope-0.5-202010.04-PO	8	0.9984+-0.0002	0.9924+-0.0007	0.9954+-0.0004
hg38_GIAB_masked	dragmap-1.2.1	dnascope-1.0-202112.01-PO	8	0.9984+-0.0003	0.9942+-0.0008	0.9963+-0.0005
hg38_GIAB_masked	dragmap-1.2.1	octopus-0.7.4	8	0.9962+-0.0003	0.9899+-0.0008	0.9931+-0.0005
hg38_GIAB_masked	dragmap-1.2.1	sentieon_gatk4-202010.04	8	0.9913+-0.0008	0.9924+-0.0009	0.9918+-0.0008
hg38_GIAB_masked	dragmap-1.2.1	strelka-2.9.10	8	0.9893+-0.0039	0.9922+-0.0009	0.9907+-0.0023
hg38_GIAB_masked	sentieon-202010.04	clair3-0.1-r9	8	0.9974+-0.0003	0.9936+-0.0006	0.9955+-0.0004
hg38_GIAB_masked	sentieon-202010.04	deepvariant-1.2.0	8	0.9988+-0.0003	0.9937+-0.0006	0.9963+-0.0003
hg38_GIAB_masked	sentieon-202010.04	dnascope-0.5-202010.04-PO	8	0.9980+-0.0002	0.9927+-0.0006	0.9953+-0.0003
hg38_GIAB_masked	sentieon-202010.04	dnascope-1.0-202112.01-PO	8	0.9983+-0.0003	0.9944+-0.0007	0.9963+-0.0005
hg38_GIAB_masked	sentieon-202010.04	octopus-0.7.4	8	0.9946+-0.0004	0.9903+-0.0008	0.9924+-0.0005
hg38_GIAB_masked	sentieon-202010.04	sentieon_gatk4-202010.04	8	0.9865+-0.0009	0.9934+-0.0007	0.9899+-0.0007
hg38_GIAB_masked	sentieon-202010.04	strelka-2.9.10	8	0.9869+-0.0039	0.9931+-0.0007	0.9900+-0.0022
hg38_GIAB_masked	sentieon-202010.04-recal	clair3-0.1-r9	8	0.9974+-0.0003	0.9926+-0.0007	0.9950+-0.0004
hg38_GIAB_masked	sentieon-202010.04-recal	deepvariant-1.2.0	8	0.9987+-0.0002	0.9935+-0.0005	0.9961+-0.0003
hg38_GIAB_masked	sentieon-202010.04-recal	dnascope-0.5-202010.04-PO	8	0.9983+-0.0002	0.9912+-0.0009	0.9948+-0.0005
hg38_GIAB_masked	sentieon-202010.04-recal	dnascope-1.0-202112.01-PO	8	0.9986+-0.0002	0.9932+-0.0009	0.9959+-0.0005
hg38_GIAB_masked	sentieon-202010.04-recal	octopus-0.7.4	8	0.9947+-0.0004	0.9902+-0.0007	0.9925+-0.0005
hg38_GIAB_masked	sentieon-202010.04-recal	sentieon_gatk4-202010.04	8	0.9888+-0.0005	0.9931+-0.0008	0.9909+-0.0005
hg38_GIAB_masked	sentieon-202010.04-recal	strelka-2.9.10	8	0.9905+-0.0016	0.9930+-0.0007	0.9918+-0.0011
hg38_GIAB_masked	snap-2.0.0	clair3-0.1-r9	8	0.9966+-0.0003	0.9928+-0.0005	0.9947+-0.0004
hg38_GIAB_masked	snap-2.0.0	deepvariant-1.2.0	8	0.9984+-0.0002	0.9937+-0.0005	0.9960+-0.0003
hg38_GIAB_masked	snap-2.0.0	dnascope-0.5-202010.04-PO	8	0.9973+-0.0002	0.9932+-0.0006	0.9953+-0.0003

Reference	Aligner	Caller	N	Precision	Sensitivity	F-measure
hg38_GIAB_masked	snap-2.0.0	dnascope-1.0-202112.01-PO	8	0.9976+-0.0003	0.9942+-0.0007	0.9959+-0.0004
hg38_GIAB_masked	snap-2.0.0	octopus-0.7.4	8	0.9938+-0.0003	0.9907+-0.0007	0.9922+-0.0004
hg38_GIAB_masked	snap-2.0.0	sentieon_gatk4-202010.04	8	0.9849+-0.0009	0.9939+-0.0007	0.9893+-0.0007
hg38_GIAB_masked	snap-2.0.0	strelka-2.9.10	8	0.9861+-0.0042	0.9934+-0.0007	0.9897+-0.0024
hg38_asm5_alt	dragmap-1.2.1	clair3-0.1-r9	8	0.9975+-0.0002	0.9705+-0.0008	0.9838+-0.0004
hg38_asm5_alt	dragmap-1.2.1	deepvariant-1.2.0	8	0.9986+-0.0002	0.9709+-0.0008	0.9846+-0.0004
hg38_asm5_alt	dragmap-1.2.1	dnascope-0.5-202010.04-PO	8	0.9983+-0.0002	0.9710+-0.0011	0.9844+-0.0006
hg38_asm5_alt	dragmap-1.2.1	dnascope-1.0-202112.01-PO	8	0.9978+-0.0002	0.9735+-0.0010	0.9855+-0.0006
hg38_asm5_alt	dragmap-1.2.1	octopus-0.7.4	8	0.9969+-0.0002	0.9681+-0.0011	0.9823+-0.0006
hg38_asm5_alt	dragmap-1.2.1	sentieon_gatk4-202010.04	8	0.9935+-0.0006	0.9702+-0.0011	0.9817+-0.0008
hg38_asm5_alt	dragmap-1.2.1	strelka-2.9.10	8	0.9902+-0.0038	0.9699+-0.0011	0.9800+-0.0023
hg38_asm5_alt	parabricks-3.5.0	germline	1	0.9909+-0.0000	0.9944+-0.0000	0.9927+-0.0000
hg38_asm5_alt	parabricks-3.6.0	deepvariant	1	0.9986+-0.0000	0.9945+-0.0000	0.9965+-0.0000
hg38_asm5_alt	sentieon-202010.04	clair3-0.1-r9	8	0.9977+-0.0002	0.9926+-0.0007	0.9951+-0.0004
hg38_asm5_alt	sentieon-202010.04	deepvariant-1.2.0	8	0.9988+-0.0002	0.9927+-0.0006	0.9957+-0.0003
hg38_asm5_alt	sentieon-202010.04	dnascope-0.5-202010.04-PO	8	0.9980+-0.0002	0.9921+-0.0007	0.9950+-0.0004
hg38_asm5_alt	sentieon-202010.04	dnascope-1.0-202112.01-PO	8	0.9983+-0.0002	0.9938+-0.0007	0.9961+-0.0004
hg38_asm5_alt	sentieon-202010.04	octopus-0.7.4	8	0.9958+-0.0002	0.9893+-0.0008	0.9926+-0.0004
hg38_asm5_alt	sentieon-202010.04	sentieon_gatk4-202010.04	8	0.9899+-0.0005	0.9924+-0.0007	0.9912+-0.0006
hg38_asm5_alt	sentieon-202010.04	strelka-2.9.10	8	0.9890+-0.0038	0.9921+-0.0007	0.9906+-0.0022
hg38_asm5_alt	sentieon-202010.04-recal	clair3-0.1-r9	8	0.9978+-0.0002	0.9916+-0.0007	0.9947+-0.0004
hg38_asm5_alt	sentieon-202010.04-recal	deepvariant-1.2.0	8	0.9986+-0.0002	0.9925+-0.0006	0.9956+-0.0004
hg38_asm5_alt	sentieon-202010.04-recal	dnascope-0.5-202010.04-PO	8	0.9983+-0.0002	0.9907+-0.0009	0.9945+-0.0005
hg38_asm5_alt	sentieon-202010.04-recal	dnascope-1.0-202112.01-PO	8	0.9986+-0.0002	0.9926+-0.0008	0.9956+-0.0005
hg38_asm5_alt	sentieon-202010.04-recal	octopus-0.7.4	8	0.9960+-0.0002	0.9893+-0.0008	0.9926+-0.0004
hg38_asm5_alt	sentieon-202010.04-recal	sentieon_gatk4-202010.04	8	0.9922+-0.0002	0.9922+-0.0008	0.9922+-0.0004
hg38_asm5_alt	sentieon-202010.04-recal	strelka-2.9.10	8	0.9923+-0.0014	0.9920+-0.0008	0.9922+-0.0010
hg38_asm5_alt	snap-2.0.0	clair3-0.1-r9	8	0.9967+-0.0003	0.9927+-0.0005	0.9947+-0.0004
hg38_asm5_alt	snap-2.0.0	deepvariant-1.2.0	8	0.9984+-0.0002	0.9936+-0.0005	0.9960+-0.0003
hg38_asm5_alt	snap-2.0.0	dnascope-0.5-202010.04-PO	8	0.9973+-0.0002	0.9932+-0.0006	0.9953+-0.0003
hg38_asm5_alt	snap-2.0.0	dnascope-1.0-202112.01-PO	8	0.9976+-0.0003	0.9941+-0.0006	0.9959+-0.0004
hg38_asm5_alt	snap-2.0.0	octopus-0.7.4	8	0.9944+-0.0003	0.9905+-0.0007	0.9925+-0.0004
hg38_asm5_alt	snap-2.0.0	sentieon_gatk4-202010.04	8	0.9867+-0.0008	0.9937+-0.0007	0.9902+-0.0007

Reference	Aligner	Caller	N	Precision	Sensitivity	F-measure
hg38_asm5_alt	snap-2.0.0	strelka-2.9.10	8	0.9868+-0.0042	0.9932+-0.0007	0.9900+-0.0024

## 2.2 Preparation: “PacBio-CCS-high”

Reference	Aligner	Caller	N	Precision	Sensitivity	F-measure
hg38_GIAB_masked	minimap2-2.23	clair3-0.1-r9	7	0.9980+-0.0013	0.9987+-0.0006	0.9983+-0.0010
hg38_GIAB_masked	minimap2-2.23	deepvariant-1.2.0	7	0.9976+-0.0018	0.9976+-0.0014	0.9976+-0.0016
hg38_GIAB_masked	minimap2-2.23	dnascope_hifi-0.4-202010.04	7	0.9986+-0.0008	0.9986+-0.0006	0.9986+-0.0007
hg38_GIAB_masked	minimap2-2.23	peppermargindv-r0.7	7	0.9983+-0.0009	0.9984+-0.0006	0.9983+-0.0007
hg38_GIAB_masked	pbmm2-1.7.0	clair3-0.1-r9	7	0.9984+-0.0013	0.9987+-0.0006	0.9985+-0.0009
hg38_GIAB_masked	pbmm2-1.7.0	dnascope_hifi-0.4-202010.04	7	0.9987+-0.0008	0.9987+-0.0005	0.9987+-0.0007
hg38_GIAB_masked	pbmm2-1.7.0	peppermargindv-r0.7	7	0.9986+-0.0008	0.9983+-0.0006	0.9985+-0.0007
hg38_GIAB_masked	sentieon_mm2-202010.04	clair3-0.1-r9	7	0.9980+-0.0013	0.9987+-0.0006	0.9983+-0.0010
hg38_GIAB_masked	sentieon_mm2-202010.04	deepvariant-1.2.0	7	0.9976+-0.0018	0.9976+-0.0014	0.9976+-0.0016
hg38_GIAB_masked	sentieon_mm2-202010.04	dnascope_hifi-0.4-202010.04	7	0.9986+-0.0008	0.9986+-0.0006	0.9986+-0.0007
hg38_GIAB_masked	sentieon_mm2-202010.04	peppermargindv-r0.7	7	0.9983+-0.0009	0.9984+-0.0006	0.9983+-0.0007
hg38_noalt	sentieon_mm2-202010.04	dnascope_hifi-0.4-202010.04	7	0.9986+-0.0008	0.9986+-0.0006	0.9986+-0.0007

### 3 Summarized SNP/Indel Comparison

This section contains the summarized results of the small variant analysis when stratified by SNP/Indel. Files were filtered using `bcftools filter` to pair down to SNPs or Indels only. For each aligner-caller pair, we ran RTG on the Genome in a Bottle (GIAB) high confidence truth set ( $\approx 3.6$ M variants). The following results are gathered from the RTG ‘summary.txt’ file using the final row (i.e. “None” indicating no variants were filtered) and with the `--all-records` option enabled.

#### 3.1 Preparation: “PCR-free-illumina”

Reference	Aligner	Caller	Type	N	Precision	Sensitivity	F-measure
clinical	sentieon-201808.07	strelka-2.9.10	SNP	8	0.9912+-0.0016	0.9922+-0.0007	0.9917+-0.0010
			Indel	8	0.9885+-0.0009	0.9839+-0.0018	0.9862+-0.0013
hg38_GIAB_masked	dragmap-1.2.1	clair3-0.1-r9	SNP	8	0.9976+-0.0003	0.9925+-0.0006	0.9950+-0.0003
			Indel	8	0.9949+-0.0006	0.9896+-0.0011	0.9922+-0.0008
hg38_GIAB_masked	dragmap-1.2.1	deepvariant-1.2.0	SNP	8	0.9989+-0.0002	0.9927+-0.0007	0.9958+-0.0004
			Indel	8	0.9964+-0.0004	0.9915+-0.0008	0.9940+-0.0006
hg38_GIAB_masked	dragmap-1.2.1	dnascope-0.5-202010.04-PO	SNP	8	0.9987+-0.0002	0.9923+-0.0006	0.9955+-0.0003
			Indel	8	0.9966+-0.0004	0.9926+-0.0009	0.9946+-0.0006
hg38_GIAB_masked	dragmap-1.2.1	dnascope-1.0-202112.01-PO	SNP	8	0.9986+-0.0002	0.9940+-0.0008	0.9963+-0.0005
			Indel	8	0.9968+-0.0005	0.9946+-0.0008	0.9957+-0.0006
hg38_GIAB_masked	dragmap-1.2.1	octopus-0.7.4	SNP	8	0.9961+-0.0003	0.9850+-0.0012	0.9905+-0.0007
			Indel	8	0.9476+-0.0027	0.9612+-0.0024	0.9543+-0.0024
hg38_GIAB_masked	dragmap-1.2.1	sentieon_gatk4-202010.04	SNP	8	nan+-nan	0.0000+-0.0000	nan+-nan
			Indel	8	nan+-nan	0.0000+-0.0000	nan+-nan
hg38_GIAB_masked	dragmap-1.2.1	strelka-2.9.10	SNP	8	0.9878+-0.0045	0.9924+-0.0008	0.9900+-0.0025
			Indel	8	0.9883+-0.0010	0.9841+-0.0019	0.9862+-0.0014
hg38_GIAB_masked	sentieon-202010.04	clair3-0.1-r9	SNP	8	0.9973+-0.0003	0.9938+-0.0007	0.9955+-0.0004
			Indel	8	0.9948+-0.0006	0.9900+-0.0012	0.9924+-0.0009
hg38_GIAB_masked	sentieon-202010.04	deepvariant-1.2.0	SNP	8	0.9988+-0.0003	0.9937+-0.0006	0.9963+-0.0003
			Indel	8	0.9963+-0.0004	0.9918+-0.0009	0.9940+-0.0006
hg38_GIAB_masked	sentieon-202010.04	dnascope-0.5-202010.04-PO	SNP	8	0.9981+-0.0002	0.9927+-0.0006	0.9954+-0.0003
			Indel	8	0.9964+-0.0004	0.9926+-0.0008	0.9945+-0.0006
hg38_GIAB_masked	sentieon-202010.04	dnascope-1.0-202112.01-PO	SNP	8	0.9984+-0.0002	0.9942+-0.0007	0.9963+-0.0004
			Indel	8	0.9968+-0.0005	0.9946+-0.0008	0.9957+-0.0006

Reference	Aligner	Caller	Type	N	Precision	Sensitivity	F-measure
hg38_GIAB_masked	sentieon-202010.04	octopus-0.7.4	SNP	8	0.9944+-0.0004	0.9854+-0.0011	0.9899+-0.0006
			Indel	8	0.9469+-0.0026	0.9612+-0.0023	0.9540+-0.0023
hg38_GIAB_masked	sentieon-202010.04	sentieon_gatk4-202010.04	SNP	8	nan+-nan	0.0000+-0.0000	nan+-nan
			Indel	8	nan+-nan	0.0000+-0.0000	nan+-nan
hg38_GIAB_masked	sentieon-202010.04	strelka-2.9.10	SNP	8	0.9852+-0.0045	0.9934+-0.0007	0.9893+-0.0025
			Indel	8	0.9870+-0.0010	0.9844+-0.0018	0.9857+-0.0014
hg38_GIAB_masked	sentieon-202010.04-recal	clair3-0.1-r9	SNP	8	0.9974+-0.0003	0.9928+-0.0007	0.9951+-0.0004
			Indel	8	0.9942+-0.0008	0.9891+-0.0013	0.9916+-0.0010
hg38_GIAB_masked	sentieon-202010.04-recal	deepvariant-1.2.0	SNP	8	0.9986+-0.0003	0.9934+-0.0005	0.9960+-0.0003
			Indel	8	0.9963+-0.0004	0.9921+-0.0008	0.9942+-0.0006
hg38_GIAB_masked	sentieon-202010.04-recal	dnascope-0.5-202010.04-PO	SNP	8	0.9986+-0.0002	0.9915+-0.0007	0.9950+-0.0004
			Indel	8	0.9961+-0.0006	0.9889+-0.0021	0.9925+-0.0014
hg38_GIAB_masked	sentieon-202010.04-recal	dnascope-1.0-202112.01-PO	SNP	8	0.9987+-0.0002	0.9931+-0.0009	0.9959+-0.0005
			Indel	8	0.9967+-0.0006	0.9927+-0.0014	0.9947+-0.0010
hg38_GIAB_masked	sentieon-202010.04-recal	octopus-0.7.4	SNP	8	0.9944+-0.0003	0.9854+-0.0011	0.9899+-0.0006
			Indel	8	0.9476+-0.0025	0.9613+-0.0023	0.9544+-0.0022
hg38_GIAB_masked	sentieon-202010.04-recal	sentieon_gatk4-202010.04	SNP	8	nan+-nan	0.0000+-0.0000	nan+-nan
			Indel	8	nan+-nan	0.0000+-0.0000	nan+-nan
hg38_GIAB_masked	sentieon-202010.04-recal	strelka-2.9.10	SNP	8	0.9893+-0.0018	0.9932+-0.0007	0.9913+-0.0012
			Indel	8	0.9870+-0.0010	0.9844+-0.0018	0.9857+-0.0014
hg38_GIAB_masked	snap-2.0.0	clair3-0.1-r9	SNP	8	0.9964+-0.0003	0.9928+-0.0005	0.9946+-0.0004
			Indel	8	0.9943+-0.0006	0.9903+-0.0012	0.9923+-0.0009
hg38_GIAB_masked	snap-2.0.0	deepvariant-1.2.0	SNP	8	0.9984+-0.0002	0.9936+-0.0005	0.9960+-0.0003
			Indel	8	0.9961+-0.0004	0.9921+-0.0009	0.9941+-0.0006
hg38_GIAB_masked	snap-2.0.0	dnascope-0.5-202010.04-PO	SNP	8	0.9974+-0.0002	0.9932+-0.0005	0.9953+-0.0003
			Indel	8	0.9961+-0.0004	0.9930+-0.0008	0.9946+-0.0006
hg38_GIAB_masked	snap-2.0.0	dnascope-1.0-202112.01-PO	SNP	8	0.9977+-0.0002	0.9941+-0.0007	0.9959+-0.0004
			Indel	8	0.9962+-0.0004	0.9945+-0.0007	0.9953+-0.0005
hg38_GIAB_masked	snap-2.0.0	octopus-0.7.4	SNP	8	0.9936+-0.0003	0.9858+-0.0011	0.9897+-0.0006
			Indel	8	0.9463+-0.0025	0.9609+-0.0023	0.9535+-0.0023
hg38_GIAB_masked	snap-2.0.0	sentieon_gatk4-202010.04	SNP	8	nan+-nan	0.0000+-0.0000	nan+-nan
			Indel	8	nan+-nan	0.0000+-0.0000	nan+-nan
hg38_GIAB_masked	snap-2.0.0	strelka-2.9.10	SNP	8	0.9845+-0.0048	0.9937+-0.0007	0.9891+-0.0026

Reference	Aligner	Caller	Type	N	Precision	Sensitivity	F-measure
			Indel	8	0.9853+-0.0009	0.9849+-0.0018	0.9851+-0.0014
hg38_asm5_alt	dragmap-1.2.1	clair3-0.1-r9	SNP	8	0.9975+-0.0002	0.9700+-0.0008	0.9836+-0.0004
			Indel	8	0.9949+-0.0006	0.9714+-0.0014	0.9830+-0.0010
hg38_asm5_alt	dragmap-1.2.1	deepvariant-1.2.0	SNP	8	0.9986+-0.0002	0.9703+-0.0008	0.9842+-0.0004
			Indel	8	0.9962+-0.0004	0.9732+-0.0011	0.9846+-0.0008
hg38_asm5_alt	dragmap-1.2.1	dnascope-0.5-202010.04-PO	SNP	8	0.9985+-0.0002	0.9704+-0.0011	0.9842+-0.0006
			Indel	8	0.9967+-0.0005	0.9748+-0.0011	0.9856+-0.0008
hg38_asm5_alt	dragmap-1.2.1	dnascope-1.0-202112.01-PO	SNP	8	0.9980+-0.0002	0.9728+-0.0010	0.9853+-0.0006
			Indel	8	0.9966+-0.0006	0.9776+-0.0010	0.9870+-0.0007
hg38_asm5_alt	dragmap-1.2.1	octopus-0.7.4	SNP	8	0.9968+-0.0002	0.9628+-0.0016	0.9796+-0.0008
			Indel	8	0.9482+-0.0027	0.9436+-0.0024	0.9459+-0.0024
hg38_asm5_alt	dragmap-1.2.1	sentieon_gatk4-202010.04	SNP	8	nan+-nan	0.0000+-0.0000	nan+-nan
			Indel	8	nan+-nan	0.0000+-0.0000	nan+-nan
hg38_asm5_alt	dragmap-1.2.1	strelka-2.9.10	SNP	8	0.9886+-0.0044	0.9696+-0.0011	0.9790+-0.0026
			Indel	8	0.9894+-0.0009	0.9656+-0.0021	0.9773+-0.0015
hg38_asm5_alt	parabricks-3.5.0	germline	SNP	1	0.9905+-0.0000	0.9943+-0.0000	0.9924+-0.0000
			Indel	1	0.9929+-0.0000	0.9941+-0.0000	0.9935+-0.0000
hg38_asm5_alt	parabricks-3.6.0	deepvariant	SNP	1	0.9985+-0.0000	0.9945+-0.0000	0.9965+-0.0000
			Indel	1	0.9966+-0.0000	0.9930+-0.0000	0.9948+-0.0000
hg38_asm5_alt	sentieon-202010.04	clair3-0.1-r9	SNP	8	0.9976+-0.0002	0.9927+-0.0007	0.9952+-0.0004
			Indel	8	0.9950+-0.0005	0.9895+-0.0012	0.9922+-0.0009
hg38_asm5_alt	sentieon-202010.04	deepvariant-1.2.0	SNP	8	0.9988+-0.0002	0.9926+-0.0007	0.9957+-0.0003
			Indel	8	0.9963+-0.0004	0.9913+-0.0009	0.9938+-0.0006
hg38_asm5_alt	sentieon-202010.04	dnascope-0.5-202010.04-PO	SNP	8	0.9982+-0.0002	0.9920+-0.0007	0.9951+-0.0003
			Indel	8	0.9964+-0.0005	0.9923+-0.0008	0.9944+-0.0006
hg38_asm5_alt	sentieon-202010.04	dnascope-1.0-202112.01-PO	SNP	8	0.9984+-0.0002	0.9936+-0.0007	0.9960+-0.0004
			Indel	8	0.9970+-0.0004	0.9943+-0.0007	0.9957+-0.0006
hg38_asm5_alt	sentieon-202010.04	octopus-0.7.4	SNP	8	0.9957+-0.0002	0.9844+-0.0012	0.9900+-0.0006
			Indel	8	0.9478+-0.0025	0.9608+-0.0023	0.9543+-0.0023
hg38_asm5_alt	sentieon-202010.04	sentieon_gatk4-202010.04	SNP	8	nan+-nan	0.0000+-0.0000	nan+-nan
			Indel	8	nan+-nan	0.0000+-0.0000	nan+-nan
hg38_asm5_alt	sentieon-202010.04	strelka-2.9.10	SNP	8	0.9874+-0.0043	0.9924+-0.0007	0.9899+-0.0024
			Indel	8	0.9884+-0.0008	0.9839+-0.0018	0.9861+-0.0013
hg38_asm5_alt	sentieon-202010.04-recal	clair3-0.1-r9	SNP	8	0.9978+-0.0002	0.9918+-0.0007	0.9948+-0.0004



Reference	Aligner	Caller	Type	N	Precision	Sensitivity	F-measure
			Indel	8	0.9945+-0.0008	0.9887+-0.0013	0.9916+-0.0010
hg38_asm5_alt	sentieon-202010.04-recal	deepvariant-1.2.0	SNP	8	0.9986+-0.0002	0.9924+-0.0006	0.9955+-0.0004
			Indel	8	0.9963+-0.0004	0.9917+-0.0008	0.9940+-0.0006
hg38_asm5_alt	sentieon-202010.04-recal	dnascope-0.5-202010.04-PO	SNP	8	0.9986+-0.0001	0.9909+-0.0008	0.9947+-0.0004
			Indel	8	0.9961+-0.0007	0.9886+-0.0020	0.9923+-0.0014
hg38_asm5_alt	sentieon-202010.04-recal	dnascope-1.0-202112.01-PO	SNP	8	0.9988+-0.0001	0.9925+-0.0008	0.9956+-0.0004
			Indel	8	0.9968+-0.0006	0.9923+-0.0014	0.9946+-0.0010
hg38_asm5_alt	sentieon-202010.04-recal	octopus-0.7.4	SNP	8	0.9958+-0.0002	0.9844+-0.0012	0.9901+-0.0006
			Indel	8	0.9486+-0.0024	0.9609+-0.0023	0.9547+-0.0022
hg38_asm5_alt	sentieon-202010.04-recal	sentieon_gatk4-202010.04	SNP	8	nan+-nan	0.0000+-0.0000	nan+-nan
			Indel	8	nan+-nan	0.0000+-0.0000	nan+-nan
hg38_asm5_alt	sentieon-202010.04-recal	strelka-2.9.10	SNP	8	0.9912+-0.0016	0.9922+-0.0007	0.9917+-0.0010
			Indel	8	0.9885+-0.0009	0.9839+-0.0018	0.9862+-0.0013
hg38_asm5_alt	snap-2.0.0	clair3-0.1-r9	SNP	8	0.9966+-0.0003	0.9927+-0.0005	0.9946+-0.0003
			Indel	8	0.9944+-0.0006	0.9902+-0.0011	0.9923+-0.0008
hg38_asm5_alt	snap-2.0.0	deepvariant-1.2.0	SNP	8	0.9984+-0.0002	0.9936+-0.0005	0.9960+-0.0003
			Indel	8	0.9961+-0.0004	0.9920+-0.0009	0.9940+-0.0006
hg38_asm5_alt	snap-2.0.0	dnascope-0.5-202010.04-PO	SNP	8	0.9974+-0.0002	0.9932+-0.0006	0.9953+-0.0003
			Indel	8	0.9960+-0.0004	0.9930+-0.0008	0.9946+-0.0006
hg38_asm5_alt	snap-2.0.0	dnascope-1.0-202112.01-PO	SNP	8	0.9977+-0.0002	0.9939+-0.0006	0.9958+-0.0004
			Indel	8	0.9963+-0.0004	0.9944+-0.0007	0.9953+-0.0005
hg38_asm5_alt	snap-2.0.0	octopus-0.7.4	SNP	8	0.9942+-0.0003	0.9856+-0.0011	0.9899+-0.0006
			Indel	8	0.9467+-0.0026	0.9608+-0.0023	0.9537+-0.0023
hg38_asm5_alt	snap-2.0.0	sentieon_gatk4-202010.04	SNP	8	nan+-nan	0.0000+-0.0000	nan+-nan
			Indel	8	nan+-nan	0.0000+-0.0000	nan+-nan
hg38_asm5_alt	snap-2.0.0	strelka-2.9.10	SNP	8	0.9852+-0.0048	0.9935+-0.0006	0.9894+-0.0026
			Indel	8	0.9860+-0.0009	0.9848+-0.0018	0.9854+-0.0013

### 3.2 Preparation: “PacBio-CCS-high”

Reference	Aligner	Caller	Type	N	Precision	Sensitivity	F-measure
hg38_GIAB_masked	minimap2-2.23	clair3-0.1-r9	SNP	7	0.9978+-0.0003	0.9994+-0.0001	0.9986+-0.0002
			Indel	7	0.9880+-0.0089	0.9858+-0.0063	0.9869+-0.0076
hg38_GIAB_masked	minimap2-2.23	deepvariant-1.2.0	SNP	7	0.9984+-0.0003	0.9991+-0.0001	0.9988+-0.0001
			Indel	7	0.9822+-0.0127	0.9787+-0.0116	0.9805+-0.0121
hg38_GIAB_masked	minimap2-2.23	dnascope_hifi-0.4-202010.04	SNP	7	0.9993+-0.0003	0.9993+-0.0001	0.9993+-0.0001
			Indel	7	0.9935+-0.0049	0.9932+-0.0050	0.9934+-0.0049
hg38_GIAB_masked	minimap2-2.23	peppermargindv-r0.7	SNP	7	0.9981+-0.0002	0.9991+-0.0002	0.9986+-0.0001
			Indel	7	0.9896+-0.0057	0.9855+-0.0059	0.9875+-0.0058
hg38_GIAB_masked	pbmm2-1.7.0	clair3-0.1-r9	SNP	7	0.9987+-0.0002	0.9993+-0.0002	0.9990+-0.0001
			Indel	7	0.9903+-0.0087	0.9913+-0.0059	0.9908+-0.0073
hg38_GIAB_masked	pbmm2-1.7.0	dnascope_hifi-0.4-202010.04	SNP	7	0.9994+-0.0003	0.9993+-0.0001	0.9994+-0.0001
			Indel	7	0.9940+-0.0046	0.9940+-0.0045	0.9940+-0.0046
hg38_GIAB_masked	pbmm2-1.7.0	peppermargindv-r0.7	SNP	7	0.9989+-0.0002	0.9990+-0.0002	0.9990+-0.0001
			Indel	7	0.9918+-0.0056	0.9909+-0.0055	0.9913+-0.0056
hg38_GIAB_masked	sentieon_mm2-202010.04	clair3-0.1-r9	SNP	7	0.9979+-0.0003	0.9994+-0.0002	0.9986+-0.0002
			Indel	7	0.9880+-0.0088	0.9859+-0.0063	0.9870+-0.0075
hg38_GIAB_masked	sentieon_mm2-202010.04	deepvariant-1.2.0	SNP	7	0.9984+-0.0003	0.9991+-0.0001	0.9988+-0.0001
			Indel	7	0.9822+-0.0127	0.9787+-0.0116	0.9805+-0.0121
hg38_GIAB_masked	sentieon_mm2-202010.04	dnascope_hifi-0.4-202010.04	SNP	7	0.9993+-0.0003	0.9993+-0.0001	0.9993+-0.0001
			Indel	7	0.9935+-0.0049	0.9932+-0.0050	0.9934+-0.0049
hg38_GIAB_masked	sentieon_mm2-202010.04	peppermargindv-r0.7	SNP	7	0.9981+-0.0002	0.9991+-0.0002	0.9986+-0.0001
			Indel	7	0.9895+-0.0057	0.9855+-0.0060	0.9875+-0.0058
hg38_noalt	sentieon_mm2-202010.04	dnascope_hifi-0.4-202010.04	SNP	7	0.9993+-0.0003	0.9993+-0.0001	0.9993+-0.0001
			Indel	7	0.9935+-0.0049	0.9932+-0.0049	0.9934+-0.0049

## 4 CMRG Comparison

GIAB recently released a pre-print describing Challenging Medically-Relevant Autosomal Genes (CMRG) benchmark. These regions are harder to capture than the typical GIAB benchmarks. This section contains the summarized results of the small variant analysis, specifically on the CMRG regions. For each aligner-caller pair, we ran RTG on the CMRG high confidence truth set (currently only for HG002 samples). The following results are gathered from the RTG ‘summary.txt’ file using the final row (i.e. “None” indicating no variants were filtered) and with the `--all-records` option enabled.

### 4.1 Preparation: “PCR-free-illumina”

Reference	Aligner	Caller	N	Precision	Sensitivity	F-measure
clinical	sentieon-201808.07	strelka-2.9.10	2	0.9542+-0.0031	0.9512+-0.0007	0.9527+-0.0019
hg38_GIAB_masked	dragmap-1.2.1	clair3-0.1-r9	2	0.9708+-0.0001	0.9596+-0.0002	0.9652+-0.0002
hg38_GIAB_masked	dragmap-1.2.1	deepvariant-1.2.0	2	0.9878+-0.0004	0.9601+-0.0005	0.9738+-0.0000
hg38_GIAB_masked	dragmap-1.2.1	dnascope-0.5-202010.04-PO	2	0.9876+-0.0005	0.9616+-0.0010	0.9744+-0.0007
hg38_GIAB_masked	dragmap-1.2.1	dnascope-1.0-202112.01-PO	2	0.9753+-0.0001	0.9668+-0.0006	0.9710+-0.0004
hg38_GIAB_masked	dragmap-1.2.1	octopus-0.7.4	2	0.9804+-0.0006	0.9633+-0.0008	0.9718+-0.0008
hg38_GIAB_masked	dragmap-1.2.1	sentieon_gatk4-202010.04	2	0.9514+-0.0025	0.9527+-0.0008	0.9521+-0.0016
hg38_GIAB_masked	dragmap-1.2.1	strelka-2.9.10	2	0.9405+-0.0033	0.9561+-0.0008	0.9482+-0.0021
hg38_GIAB_masked	sentieon-202010.04	clair3-0.1-r9	2	0.9696+-0.0005	0.9604+-0.0001	0.9650+-0.0002
hg38_GIAB_masked	sentieon-202010.04	deepvariant-1.2.0	2	0.9870+-0.0002	0.9617+-0.0001	0.9743+-0.0001
hg38_GIAB_masked	sentieon-202010.04	dnascope-0.5-202010.04-PO	2	0.9848+-0.0002	0.9615+-0.0008	0.9730+-0.0005
hg38_GIAB_masked	sentieon-202010.04	dnascope-1.0-202112.01-PO	2	0.9750+-0.0009	0.9660+-0.0014	0.9705+-0.0012
hg38_GIAB_masked	sentieon-202010.04	octopus-0.7.4	2	0.9735+-0.0017	0.9640+-0.0015	0.9687+-0.0016
hg38_GIAB_masked	sentieon-202010.04	sentieon_gatk4-202010.04	2	0.9406+-0.0014	0.9567+-0.0010	0.9486+-0.0012
hg38_GIAB_masked	sentieon-202010.04	strelka-2.9.10	2	0.9357+-0.0045	0.9607+-0.0005	0.9481+-0.0025
hg38_GIAB_masked	sentieon-202010.04-recal	clair3-0.1-r9	2	0.9707+-0.0005	0.9574+-0.0000	0.9640+-0.0002
hg38_GIAB_masked	sentieon-202010.04-recal	deepvariant-1.2.0	2	0.9885+-0.0007	0.9614+-0.0005	0.9748+-0.0005
hg38_GIAB_masked	sentieon-202010.04-recal	dnascope-0.5-202010.04-PO	2	0.9876+-0.0005	0.9569+-0.0008	0.9720+-0.0006
hg38_GIAB_masked	sentieon-202010.04-recal	dnascope-1.0-202112.01-PO	2	0.9767+-0.0015	0.9625+-0.0015	0.9695+-0.0015
hg38_GIAB_masked	sentieon-202010.04-recal	octopus-0.7.4	2	0.9738+-0.0000	0.9634+-0.0007	0.9686+-0.0004
hg38_GIAB_masked	sentieon-202010.04-recal	sentieon_gatk4-202010.04	2	0.9477+-0.0002	0.9560+-0.0007	0.9518+-0.0002
hg38_GIAB_masked	sentieon-202010.04-recal	strelka-2.9.10	2	0.9451+-0.0026	0.9604+-0.0006	0.9526+-0.0017
hg38_GIAB_masked	snape-2.0.0	clair3-0.1-r9	2	0.9645+-0.0015	0.9601+-0.0002	0.9623+-0.0008

Reference	Aligner	Caller	N	Precision	Sensitivity	F-measure
hg38_GIAB_masked	snap-2.0.0	deepvariant-1.2.0	2	0.9869+-0.0009	0.9615+-0.0003	0.9741+-0.0003
hg38_GIAB_masked	snap-2.0.0	dnascope-0.5-202010.04-PO	2	0.9830+-0.0010	0.9629+-0.0008	0.9729+-0.0009
hg38_GIAB_masked	snap-2.0.0	dnascope-1.0-202112.01-PO	2	0.9704+-0.0012	0.9654+-0.0006	0.9679+-0.0009
hg38_GIAB_masked	snap-2.0.0	octopus-0.7.4	2	0.9672+-0.0015	0.9652+-0.0007	0.9663+-0.0004
hg38_GIAB_masked	snap-2.0.0	sentieon_gatk4-202010.04	2	0.9343+-0.0011	0.9575+-0.0001	0.9457+-0.0007
hg38_GIAB_masked	snap-2.0.0	strelka-2.9.10	2	0.9269+-0.0055	0.9606+-0.0006	0.9435+-0.0031
hg38_asm5_alt	dragmap-1.2.1	clair3-0.1-r9	2	0.9750+-0.0001	0.8511+-0.0002	0.9088+-0.0002
hg38_asm5_alt	dragmap-1.2.1	deepvariant-1.2.0	2	0.9854+-0.0003	0.8513+-0.0006	0.9134+-0.0002
hg38_asm5_alt	dragmap-1.2.1	dnascope-0.5-202010.04-PO	2	0.9827+-0.0004	0.8520+-0.0012	0.9126+-0.0008
hg38_asm5_alt	dragmap-1.2.1	dnascope-1.0-202112.01-PO	2	0.9780+-0.0001	0.8656+-0.0008	0.9183+-0.0004
hg38_asm5_alt	dragmap-1.2.1	octopus-0.7.4	2	0.9747+-0.0000	0.8539+-0.0012	0.9103+-0.0007
hg38_asm5_alt	dragmap-1.2.1	sentieon_gatk4-202010.04	2	0.9587+-0.0018	0.8417+-0.0010	0.8964+-0.0014
hg38_asm5_alt	dragmap-1.2.1	strelka-2.9.10	2	0.9430+-0.0029	0.8447+-0.0010	0.8911+-0.0019
hg38_asm5_alt	sentieon-202010.04	clair3-0.1-r9	2	0.9777+-0.0002	0.9517+-0.0000	0.9646+-0.0001
hg38_asm5_alt	sentieon-202010.04	deepvariant-1.2.0	2	0.9882+-0.0006	0.9528+-0.0002	0.9702+-0.0002
hg38_asm5_alt	sentieon-202010.04	dnascope-0.5-202010.04-PO	2	0.9835+-0.0004	0.9527+-0.0005	0.9679+-0.0004
hg38_asm5_alt	sentieon-202010.04	dnascope-1.0-202112.01-PO	2	0.9831+-0.0005	0.9622+-0.0012	0.9726+-0.0009
hg38_asm5_alt	sentieon-202010.04	octopus-0.7.4	2	0.9738+-0.0010	0.9551+-0.0014	0.9643+-0.0012
hg38_asm5_alt	sentieon-202010.04	sentieon_gatk4-202010.04	2	0.9512+-0.0013	0.9480+-0.0014	0.9496+-0.0013
hg38_asm5_alt	sentieon-202010.04	strelka-2.9.10	2	0.9449+-0.0050	0.9516+-0.0007	0.9483+-0.0028
hg38_asm5_alt	sentieon-202010.04-recal	clair3-0.1-r9	2	0.9789+-0.0002	0.9486+-0.0000	0.9636+-0.0001
hg38_asm5_alt	sentieon-202010.04-recal	deepvariant-1.2.0	2	0.9884+-0.0009	0.9526+-0.0003	0.9702+-0.0006
hg38_asm5_alt	sentieon-202010.04-recal	dnascope-0.5-202010.04-PO	2	0.9859+-0.0007	0.9484+-0.0009	0.9667+-0.0008
hg38_asm5_alt	sentieon-202010.04-recal	dnascope-1.0-202112.01-PO	2	0.9847+-0.0012	0.9589+-0.0010	0.9717+-0.0011
hg38_asm5_alt	sentieon-202010.04-recal	octopus-0.7.4	2	0.9748+-0.0001	0.9550+-0.0013	0.9648+-0.0007
hg38_asm5_alt	sentieon-202010.04-recal	sentieon_gatk4-202010.04	2	0.9587+-0.0002	0.9471+-0.0008	0.9528+-0.0005
hg38_asm5_alt	sentieon-202010.04-recal	strelka-2.9.10	2	0.9542+-0.0031	0.9512+-0.0007	0.9527+-0.0019
hg38_asm5_alt	snap-2.0.0	clair3-0.1-r9	2	0.9724+-0.0010	0.9520+-0.0002	0.9621+-0.0006
hg38_asm5_alt	snap-2.0.0	deepvariant-1.2.0	2	0.9869+-0.0007	0.9533+-0.0004	0.9698+-0.0001
hg38_asm5_alt	snap-2.0.0	dnascope-0.5-202010.04-PO	2	0.9825+-0.0009	0.9546+-0.0008	0.9684+-0.0008
hg38_asm5_alt	snap-2.0.0	dnascope-1.0-202112.01-PO	2	0.9802+-0.0010	0.9583+-0.0003	0.9691+-0.0006
hg38_asm5_alt	snap-2.0.0	octopus-0.7.4	2	0.9666+-0.0018	0.9575+-0.0011	0.9620+-0.0003
hg38_asm5_alt	snap-2.0.0	sentieon_gatk4-202010.04	2	0.9431+-0.0007	0.9493+-0.0003	0.9462+-0.0005

Reference	Aligner	Caller	N	Precision	Sensitivity	F-measure
hg38_asm5_alt	snap-2.0.0	strelka-2.9.10	2	0.9335+-0.0053	0.9525+-0.0008	0.9429+-0.0031

## 4.2 Preparation: “PacBio-CCS-high”

Reference	Aligner	Caller	N	Precision	Sensitivity	F-measure
hg38_GIAB_masked	minimap2-2.23	clair3-0.1-r9	1	0.9668+-0.0000	0.9925+-0.0000	0.9795+-0.0000
hg38_GIAB_masked	minimap2-2.23	deepvariant-1.2.0	1	0.9792+-0.0000	0.9886+-0.0000	0.9839+-0.0000
hg38_GIAB_masked	minimap2-2.23	dnascope_hifi-0.4-202010.04	1	0.9876+-0.0000	0.9894+-0.0000	0.9885+-0.0000
hg38_GIAB_masked	minimap2-2.23	peppermargindv-r0.7	1	0.9854+-0.0000	0.9908+-0.0000	0.9881+-0.0000
hg38_GIAB_masked	pbmm2-1.7.0	clair3-0.1-r9	1	0.9701+-0.0000	0.9905+-0.0000	0.9802+-0.0000
hg38_GIAB_masked	pbmm2-1.7.0	dnascope_hifi-0.4-202010.04	1	0.9882+-0.0000	0.9889+-0.0000	0.9886+-0.0000
hg38_GIAB_masked	pbmm2-1.7.0	peppermargindv-r0.7	1	0.9821+-0.0000	0.9888+-0.0000	0.9854+-0.0000
hg38_GIAB_masked	sentieon_mm2-202010.04	clair3-0.1-r9	1	0.9671+-0.0000	0.9927+-0.0000	0.9797+-0.0000
hg38_GIAB_masked	sentieon_mm2-202010.04	deepvariant-1.2.0	1	0.9792+-0.0000	0.9886+-0.0000	0.9839+-0.0000
hg38_GIAB_masked	sentieon_mm2-202010.04	dnascope_hifi-0.4-202010.04	1	0.9876+-0.0000	0.9894+-0.0000	0.9885+-0.0000
hg38_GIAB_masked	sentieon_mm2-202010.04	peppermargindv-r0.7	1	0.9854+-0.0000	0.9908+-0.0000	0.9881+-0.0000
hg38_noalt	sentieon_mm2-202010.04	dnascope_hifi-0.4-202010.04	1	0.9857+-0.0000	0.9845+-0.0000	0.9851+-0.0000

## 5 Summarized Haplotyper Comparison

This section contains the summarized results of the haplotype analysis. For each aligner-haplotyper pair, we attempted to run the haplotyper and gather the resulting prediction. “Output” is the percentage that generated an output file. This is most commonly below 100% when a tool crashes while trying to run. “Computed” is the percentage that generated a prediction in the output file. This is most commonly below 100% when a tool successfully runs, but it does not generate a prediction in the output file (e.g. “None”). “Matching” is the percentage that generated the correct haplotype prediction based on our lookup table. These haplotyping tools often assume a particular data type, and are not designed to work under all of the conditions tested by this benchmark.

### 5.1 Preparation: “PCR-free-illumina”

Reference	Aligner	Haplotyper	N	Output (%)	Computed (%)	Matching (%)
hg38_GIAB_masked	dragmap-1.2.1	cyrius-1.1.1	8	100.0	75.0	75.0
hg38_GIAB_masked	sentieon-202010.04	cyrius-1.1.1	8	100.0	87.5	87.5
hg38_GIAB_masked	sentieon-202010.04-recal	cyrius-1.1.1	8	100.0	87.5	87.5
hg38_GIAB_masked	snap-2.0.0	cyrius-1.1.1	8	100.0	87.5	87.5
hg38_asm5_alt	dragmap-1.2.1	cyrius-1.1.1	8	25.0	0.0	0.0
hg38_asm5_alt	sentieon-202010.04	cyrius-1.1.1	8	100.0	100.0	100.0
hg38_asm5_alt	sentieon-202010.04-recal	cyrius-1.1.1	8	100.0	100.0	100.0
hg38_asm5_alt	snap-2.0.0	cyrius-1.1.1	8	100.0	87.5	87.5

### 5.2 Preparation: “PacBio-CCS-high”

Reference	Aligner	Haplotyper	N	Output (%)	Computed (%)	Matching (%)
hg38_GIAB_masked	minimap2-2.23	cyrius-1.1.1	5	100.0	20.0	20.0
hg38_GIAB_masked	sentieon_mm2-202010.04	cyrius-1.1.1	5	100.0	20.0	20.0

## 6 Summarized Deletion Comparisons

This section contains the summarized results of the deletion variant analysis. For each aligner-caller pair, we ran Truvari on the corresponding truth set with these options: “--pctsim 0.0 --sizemax 1000000000”. The following results are gathered from the Truvari “summary.txt” file.

### 6.1 Restricted calls

These evaluations are **RESTRICTED**, meaning that a BED file was used to limit the analysis regions, typically to “high-confidence” regions associated with the benchmark. This corresponds to the “--includebed” option in Truvari. As a result, benchmark sets that were not released with a corresponding BED file are excluded from this analysis. At this time, only the HG002 GIAB v0.6 benchmark is included in this analysis.

#### 6.1.1 Preparation: “PCR-free-illumina”

Reference	Aligner	Caller	N	precision	recall	f1
hg38_GIAB_masked	dragmap-1.2.1	dysgu-1.3.4	2	0.4321+-0.2749	0.7240+-0.0096	0.4848+-0.2258
hg38_GIAB_masked	dragmap-1.2.1	dysgu-1.3.4-PO	2	0.9088+-0.0190	0.7067+-0.0041	0.7950+-0.0047
hg38_GIAB_masked	dragmap-1.2.1	manta-1.6.0	2	0.9561+-0.0011	0.6679+-0.0185	0.7862+-0.0124
hg38_GIAB_masked	sentieon-202010.04	dysgu-1.3.4	2	0.4688+-0.2847	0.6689+-0.0042	0.4977+-0.2086
hg38_GIAB_masked	sentieon-202010.04	dysgu-1.3.4-PO	2	0.9030+-0.0196	0.6499+-0.0005	0.7557+-0.0066
hg38_GIAB_masked	sentieon-202010.04	manta-1.6.0	2	0.9524+-0.0012	0.6906+-0.0153	0.8006+-0.0099
hg38_GIAB_masked	sentieon-202010.04-recal	dysgu-1.3.4	2	0.4735+-0.2874	0.6698+-0.0060	0.5005+-0.2086
hg38_GIAB_masked	sentieon-202010.04-recal	dysgu-1.3.4-PO	2	0.9011+-0.0186	0.6520+-0.0038	0.7565+-0.0040
hg38_GIAB_masked	sentieon-202010.04-recal	manta-1.6.0	2	0.9518+-0.0009	0.6905+-0.0147	0.8003+-0.0096
hg38_GIAB_masked	snap-2.0.0	dysgu-1.3.4	2	0.6995+-0.0516	0.6604+-0.0050	0.6783+-0.0217
hg38_GIAB_masked	snap-2.0.0	dysgu-1.3.4-PO	2	0.9409+-0.0038	0.6236+-0.0013	0.7501+-0.0003
hg38_GIAB_masked	snap-2.0.0	manta-1.6.0	2	0.9490+-0.0008	0.6802+-0.0128	0.7924+-0.0084
hg38_asm5.alt	dragmap-1.2.1	dysgu-1.3.4	2	0.4355+-0.2775	0.7088+-0.0097	0.4825+-0.2235
hg38_asm5.alt	dragmap-1.2.1	dysgu-1.3.4-PO	2	0.9146+-0.0191	0.6927+-0.0040	0.7882+-0.0045
hg38_asm5.alt	dragmap-1.2.1	manta-1.6.0	2	0.9616+-0.0007	0.6550+-0.0169	0.7791+-0.0117
hg38_asm5.alt	sentieon-202010.04	dysgu-1.3.4	2	0.4756+-0.2901	0.6647+-0.0055	0.4995+-0.2090
hg38_asm5.alt	sentieon-202010.04	dysgu-1.3.4-PO	2	0.9048+-0.0198	0.6446+-0.0010	0.7527+-0.0062
hg38_asm5.alt	sentieon-202010.04	manta-1.6.0	2	0.9563+-0.0018	0.6899+-0.0149	0.8015+-0.0094
hg38_asm5.alt	sentieon-202010.04-recal	dysgu-1.3.4	2	0.4787+-0.2911	0.6655+-0.0079	0.5014+-0.2079
hg38_asm5.alt	sentieon-202010.04-recal	dysgu-1.3.4-PO	2	0.9038+-0.0190	0.6459+-0.0042	0.7533+-0.0037
hg38_asm5.alt	sentieon-202010.04-recal	manta-1.6.0	2	0.9547+-0.0018	0.6896+-0.0140	0.8007+-0.0088

Reference	Aligner	Caller	N	precision	recall	f1
hg38_asm5_alt	snap-2.0.0	dysgu-1.3.4	2	0.7062+-0.0531	0.6590+-0.0077	0.6805+-0.0207
hg38_asm5_alt	snap-2.0.0	dysgu-1.3.4-PO	2	0.9430+-0.0048	0.6225+-0.0043	0.7500+-0.0016
hg38_asm5_alt	snap-2.0.0	manta-1.6.0	2	0.9509+-0.0022	0.6791+-0.0127	0.7923+-0.0079

### 6.1.2 Preparation: “PacBio-CCS-high”

Reference	Aligner	Caller	N	precision	recall	f1
hg38_GIAB_masked	minimap2-2.23	dysgu-1.3.4	1	0.8958+-0.0000	0.9808+-0.0000	0.9364+-0.0000
hg38_GIAB_masked	minimap2-2.23	dysgu-1.3.4-PO	1	0.9415+-0.0000	0.9729+-0.0000	0.9570+-0.0000
hg38_GIAB_masked	minimap2-2.23	pbsv-2.8.0	1	0.9463+-0.0000	0.9847+-0.0000	0.9651+-0.0000
hg38_GIAB_masked	minimap2-2.23	sniffles-2.0.2	1	0.9492+-0.0000	0.9808+-0.0000	0.9647+-0.0000
hg38_GIAB_masked	pbbmm2-1.7.0	dysgu-1.3.4	1	0.8877+-0.0000	0.9760+-0.0000	0.9298+-0.0000
hg38_GIAB_masked	pbbmm2-1.7.0	dysgu-1.3.4-PO	1	0.9601+-0.0000	0.1849+-0.0000	0.3101+-0.0000
hg38_GIAB_masked	pbbmm2-1.7.0	pbsv-2.8.0	1	0.9423+-0.0000	0.9863+-0.0000	0.9638+-0.0000
hg38_GIAB_masked	pbbmm2-1.7.0	sniffles-2.0.2	1	0.9453+-0.0000	0.9815+-0.0000	0.9631+-0.0000
hg38_GIAB_masked	sentieon_mm2-202010.04	dysgu-1.3.4	1	0.8957+-0.0000	0.9806+-0.0000	0.9362+-0.0000
hg38_GIAB_masked	sentieon_mm2-202010.04	dysgu-1.3.4-PO	1	0.9413+-0.0000	0.9727+-0.0000	0.9567+-0.0000
hg38_GIAB_masked	sentieon_mm2-202010.04	pbsv-2.8.0	1	0.9463+-0.0000	0.9847+-0.0000	0.9651+-0.0000
hg38_GIAB_masked	sentieon_mm2-202010.04	sniffles-2.0.2	1	0.9490+-0.0000	0.9808+-0.0000	0.9646+-0.0000

## 6.2 Unrestricted calls

These evaluations are **UNRESTRICTED**, meaning that there is no BED file used to limit the analysis to a subset of the genome (e.g. no high-confidence region applied). As a result, precision results are skewed downwards and should be considered a lower-bound on precision with respect to the full benchmark dataset. However, this allows us to add benchmarks that were not released with a BED file, specifically HG001/NA12878’s Personalis benchmark set.

### 6.2.1 Preparation: “PCR-free-illumina”



Reference	Aligner	Caller	N	precision	recall	f1
hg38_GIAB_masked	dragmap-1.2.1	dysgu-1.3.4	4	0.2645+-0.0967	0.8001+-0.1599	0.3828+-0.0987
hg38_GIAB_masked	dragmap-1.2.1	dysgu-1.3.4-PO	4	0.5677+-0.0903	0.7861+-0.1648	0.6375+-0.0066
hg38_GIAB_masked	dragmap-1.2.1	manta-1.6.0	4	0.5694+-0.0968	0.7414+-0.1496	0.6223+-0.0078
hg38_GIAB_masked	sentieon-202010.04	dysgu-1.3.4	4	0.2469+-0.0790	0.7531+-0.1556	0.3599+-0.0782
hg38_GIAB_masked	sentieon-202010.04	dysgu-1.3.4-PO	4	0.5698+-0.0915	0.7366+-0.1599	0.6201+-0.0080
hg38_GIAB_masked	sentieon-202010.04	manta-1.6.0	4	0.5405+-0.0989	0.7585+-0.1441	0.6098+-0.0173
hg38_GIAB_masked	sentieon-202010.04-recal	dysgu-1.3.4	4	0.2487+-0.0790	0.7531+-0.1552	0.3620+-0.0780
hg38_GIAB_masked	sentieon-202010.04-recal	dysgu-1.3.4-PO	4	0.5689+-0.0920	0.7373+-0.1589	0.6198+-0.0069
hg38_GIAB_masked	sentieon-202010.04-recal	manta-1.6.0	4	0.5395+-0.0979	0.7583+-0.1448	0.6092+-0.0166
hg38_GIAB_masked	snap-2.0.0	dysgu-1.3.4	4	0.2762+-0.0463	0.7288+-0.1519	0.3894+-0.0253
hg38_GIAB_masked	snap-2.0.0	dysgu-1.3.4-PO	4	0.6048+-0.0974	0.6876+-0.1457	0.6213+-0.0135
hg38_GIAB_masked	snap-2.0.0	manta-1.6.0	4	0.4962+-0.0946	0.7500+-0.1470	0.5759+-0.0216
hg38_asm5.alt	dragmap-1.2.1	dysgu-1.3.4	4	0.2714+-0.1009	0.7780+-0.1539	0.3868+-0.0999
hg38_asm5.alt	dragmap-1.2.1	dysgu-1.3.4-PO	4	0.5745+-0.0922	0.7646+-0.1573	0.6345+-0.0063
hg38_asm5.alt	dragmap-1.2.1	manta-1.6.0	4	0.5851+-0.1027	0.7227+-0.1442	0.6242+-0.0073
hg38_asm5.alt	sentieon-202010.04	dysgu-1.3.4	4	0.2165+-0.0638	0.7449+-0.1533	0.3261+-0.0661
hg38_asm5.alt	sentieon-202010.04	dysgu-1.3.4-PO	4	0.5621+-0.0898	0.7260+-0.1554	0.6120+-0.0082
hg38_asm5.alt	sentieon-202010.04	manta-1.6.0	4	0.5502+-0.1032	0.7555+-0.1427	0.6147+-0.0183
hg38_asm5.alt	sentieon-202010.04-recal	dysgu-1.3.4	4	0.2179+-0.0638	0.7456+-0.1532	0.3278+-0.0656
hg38_asm5.alt	sentieon-202010.04-recal	dysgu-1.3.4-PO	4	0.5624+-0.0905	0.7272+-0.1550	0.6125+-0.0061
hg38_asm5.alt	sentieon-202010.04-recal	manta-1.6.0	4	0.5492+-0.1020	0.7550+-0.1432	0.6140+-0.0174
hg38_asm5.alt	snap-2.0.0	dysgu-1.3.4	4	0.2781+-0.0471	0.7273+-0.1529	0.3908+-0.0252
hg38_asm5.alt	snap-2.0.0	dysgu-1.3.4-PO	4	0.6027+-0.0977	0.6877+-0.1472	0.6198+-0.0121
hg38_asm5.alt	snap-2.0.0	manta-1.6.0	4	0.4999+-0.0970	0.7476+-0.1463	0.5773+-0.0224

### 6.2.2 Preparation: “PacBio-CCS-high”

Reference	Aligner	Caller	N	precision	recall	f1
hg38_GIAB_masked	minimap2-2.23	dysgu-1.3.4	2	0.2508+-0.0756	0.9539+-0.0153	0.3906+-0.0938
hg38_GIAB_masked	minimap2-2.23	dysgu-1.3.4-PO	2	0.4146+-0.1333	0.9433+-0.0199	0.5616+-0.1262

Reference	Aligner	Caller	N	precision	recall	f1
hg38_GIAB_masked	minimap2-2.23	pbsv-2.8.0	2	0.3678+-0.1155	0.9559+-0.0066	0.5202+-0.1203
hg38_GIAB_masked	minimap2-2.23	sniffles-2.0.2	2	0.3764+-0.1180	0.9470+-0.0189	0.5264+-0.1187
hg38_GIAB_masked	pbbmm2-1.7.0	dysgu-1.3.4	2	0.2590+-0.0755	0.9505+-0.0086	0.4008+-0.0928
hg38_GIAB_masked	pbbmm2-1.7.0	dysgu-1.3.4-PO	2	0.6144+-0.0612	0.4064+-0.2471	0.4285+-0.1707
hg38_GIAB_masked	pbbmm2-1.7.0	pbsv-2.8.0	2	0.3812+-0.1208	0.9590+-0.0080	0.5337+-0.1234
hg38_GIAB_masked	pbbmm2-1.7.0	sniffles-2.0.2	2	0.3838+-0.1203	0.9486+-0.0168	0.5341+-0.1202
hg38_GIAB_masked	sentieon_mm2-202010.04	dysgu-1.3.4	2	0.2497+-0.0747	0.9536+-0.0152	0.3893+-0.0928
hg38_GIAB_masked	sentieon_mm2-202010.04	dysgu-1.3.4-PO	2	0.4147+-0.1334	0.9431+-0.0198	0.5616+-0.1263
hg38_GIAB_masked	sentieon_mm2-202010.04	pbsv-2.8.0	2	0.3676+-0.1161	0.9557+-0.0068	0.5198+-0.1210
hg38_GIAB_masked	sentieon_mm2-202010.04	sniffles-2.0.2	2	0.3761+-0.1178	0.9470+-0.0189	0.5262+-0.1185