Global Alliance
for Genomics & Health

Genome Data for Personalised Medicine

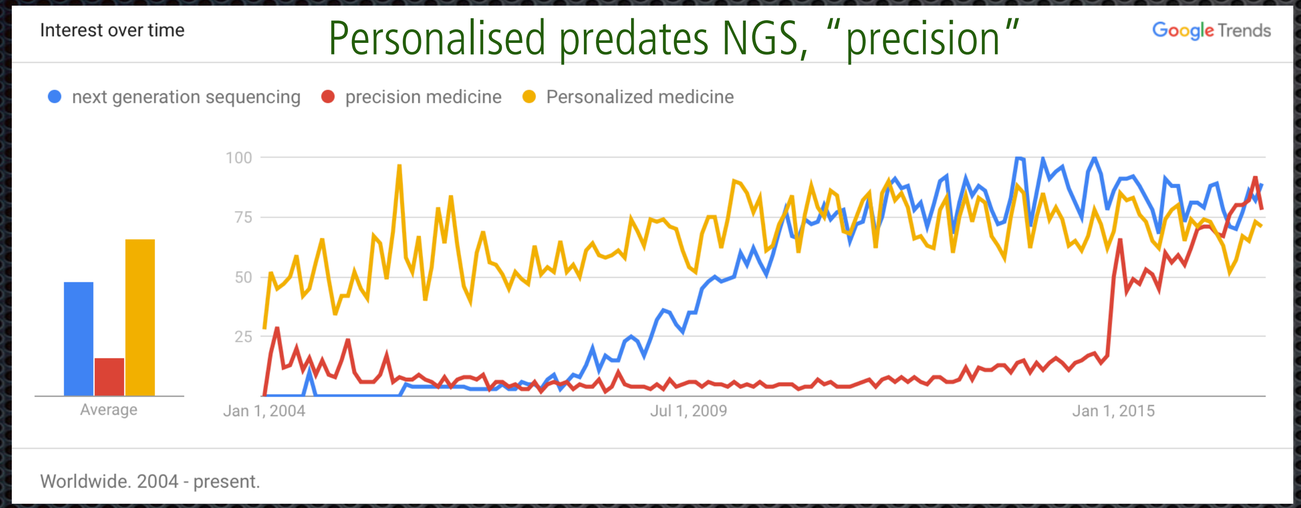
Advancing the Global Alliance for Genomics and Health data schemas through *data-driven* implementations

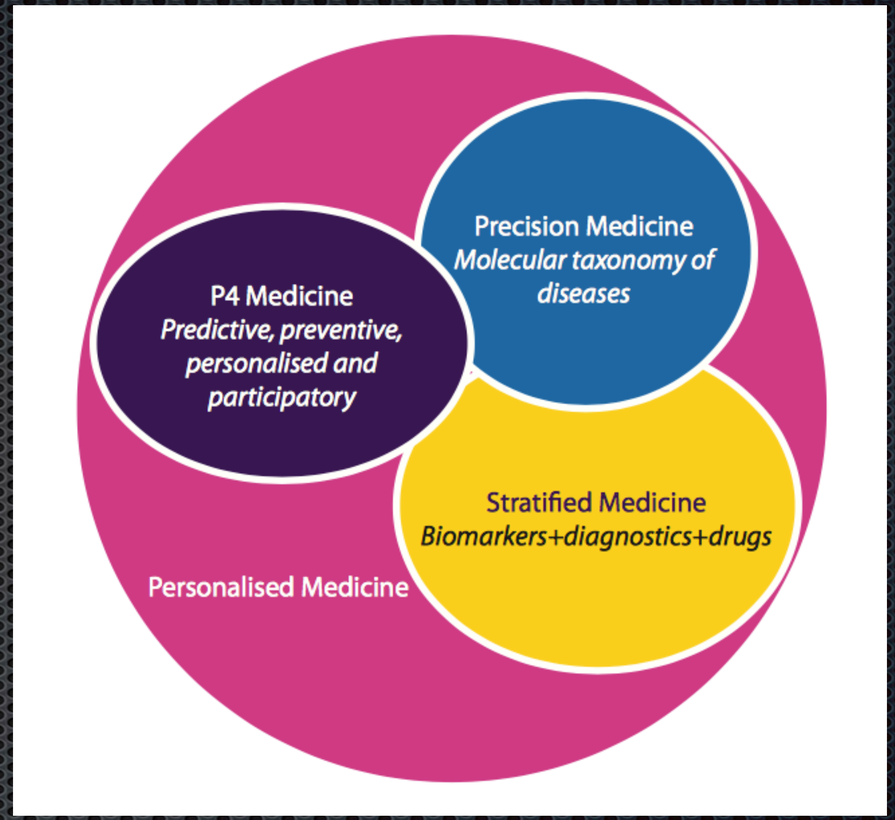
Michael Baudis - [BC]² 2017

University of Zurich[UZH]

Genomic Background + Disease Parameters

Personalised Medicine
Precision Medicine
...



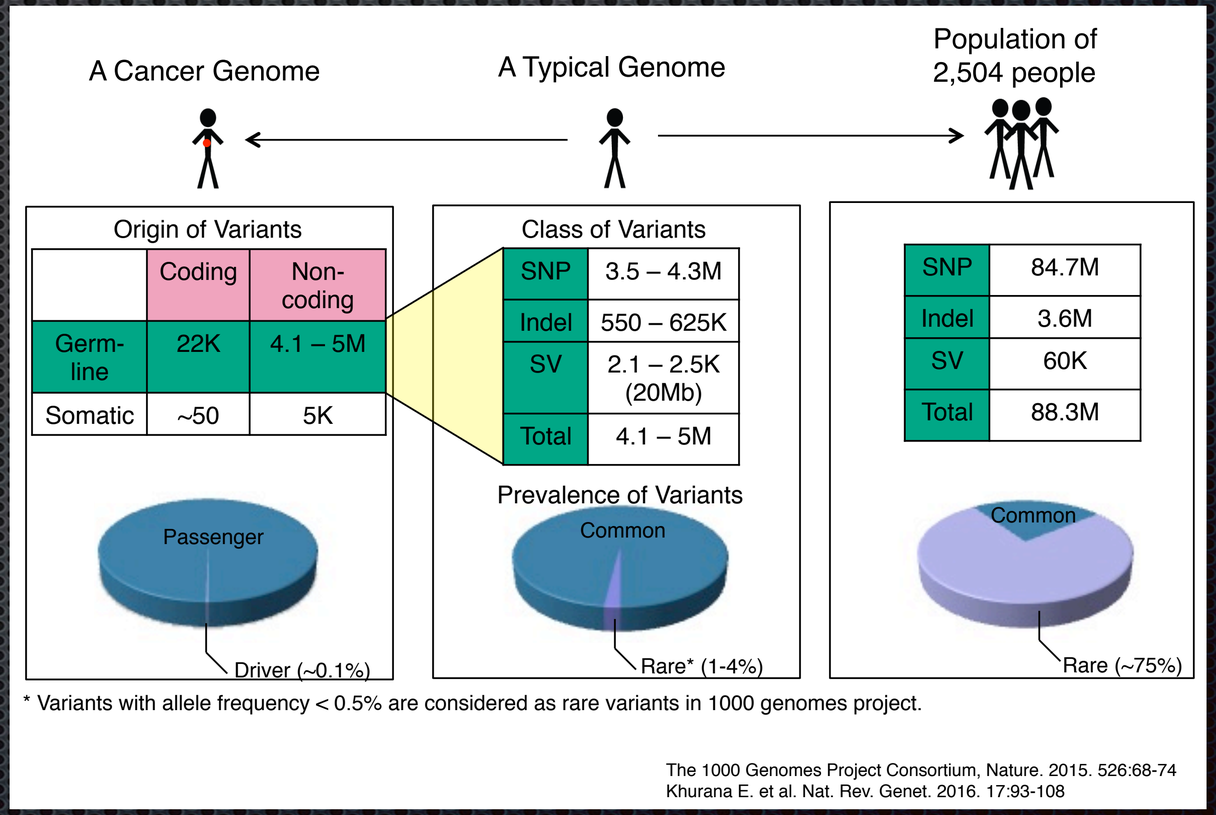


Source: PHG Foundation

While medicine has always been "personal" and "precise" in the given context of available knowledge and technologies, the concept of "**Personalised Medicine**" describes **the use of individual genome information and individually targeted therapies**.

Finding Somatic Mutations In Cancer:
Many Needles in a Large Haystack

- a typical humen genome (~3 billion base pairs) has ~5 million variants
- most of them are "rare"; i.e. can only be identified as recurring when sequencing thousands of people
- cancer cells accumulate additional variants, only **few** of which ("**drivers**") are relevant for the disease



The 1000 Genomes Project Consortium, Nature. 2015. 526:68-74
Khurana E. et al. Nat. Rev. Genet. 2016. 17:93-108

Graphic adapted from Mark Gerstein (GersteinLab.org; @markgerstein)

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Genomes Everywhere

Large Genome Data Generation, Analysis & Sharing Initiatives

Organization / Initiative: Name	Organization / Initiative: Category	Cohort
100K Wellness Project	Research Project	107 unaffected individuals (scaling up to 100,000)
23andMe	Organization	>1 million customers (>80% consented to research)
Actionable Cancer Genome Initiative (ACGI)	Data-Sharing Project	Goal: 100,000 individuals
Ancestry.com	Organization	1.4 million customer DNA samples (what % consented to research?)
BioBank Japan	Repository	Specimens from >200,000 patients and unaffected controls
Cancer Moonshot2020	Consortium	Phase 1: 20,000 cancer patients
Children's Hospital of Philadelphia Biorepository	Repository	Capacity for 8.6 million samples
China Kadoorie Biobank	Repository	>512,000 participants (general population, China). Genotyping data available for ~100,000.
CIMBA	Consortium	>15,000 BRCA1 carriers, >8,000 BRCA2 carriers
Clinical Sequencing Exploratory Research (CSER)	Consortium	~4,000 patients and healthy controls
DECIPHER	Repository	19,014 patients (international)
deCode Genetics	Organization	500,000 participants (international)
East London Genes & Health	Research Project	100,000 unaffected individuals (East London, Pakistani or Bangladeshi heritage)
Electronic Medical Records and Genomics (eMERGE) Network	Repository, Consortium, Research Project	55,028 patients
European Network for Genetic and Genomic Epidemiology (ENGAGE)	Research Project	80,000 GWAS scans, and DNA and serum/plasma from >600,000 individuals
Exome Aggregation Consortium (ExAC)	Consortium	60,706 individuals
GENIE/AACR	Data-Sharing Project	>17,000 cancer patients (international)
Genome Asia 100K	Consortium	Goal: 100,000 individuals (Asia)
Genomics England	Organization	Goal: 100,000 genomes from 70,000 individuals (rare disease & cancer patients, and their relatives)
GoT2D	Consortium, Data-Sharing Project	Multiple case-control cohorts
International Cancer Genome Consortium (ICGC)	Consortium	currently data from >16'000 samples
International Genomics of Alzheimer's Project (IGAP)	Consortium	40,000 patients with Alzheimer's disease
International Multiple Sclerosis Genetics (IMSG) Consortium	Consortium	Goal: >50,000 patients with MS
Kaiser Permanente: Genes, Environment, and Health (RPGEH)	Repository, Research Project	200,000 DNA samples (scaling up to 500,000)
Leiden Open Variation Database (LOVD)	Repository	>170,000 individuals
Million Veteran Program	Research Project	Goal: 1 million individuals; first 200,000 is complete.
MyCode® Community Health Initiative	Repository, Research Project	Goal: >250,000 patients
Precision Medicine Initiative	Research Project	Goal: >1 million participants, starting in 2016 (US)
Psychiatric Genomics Consortium (PGC)	Consortium	>170,000 subjects
Resilience Project	Research Project	589,306 individuals
Saudi Human Genome Program	Research Project	Goal: ~100,000 patients and controls (Saudi Arabia)
Scottish Genomes Partnership (SGP)	Research Project	>3,000 individuals (Scotland)
T2D-GENES	Consortium, Data-Sharing Project	10,000 patients and controls (five ethnicities); 600 individuals (Mexican American)
TBResist	Consortium	>2,600 samples
UK Biobank	Repository, Consortium, Research Project	500,000 individuals (age 40-69 years; UK)
UK10K	Research Project	10,000 participants (6,000 patients and 4,000 controls)
Vanderbilt's BioVU	Repository	>215,000 samples

>1'000'000

100'000

20'000+

17'000+

16'000+

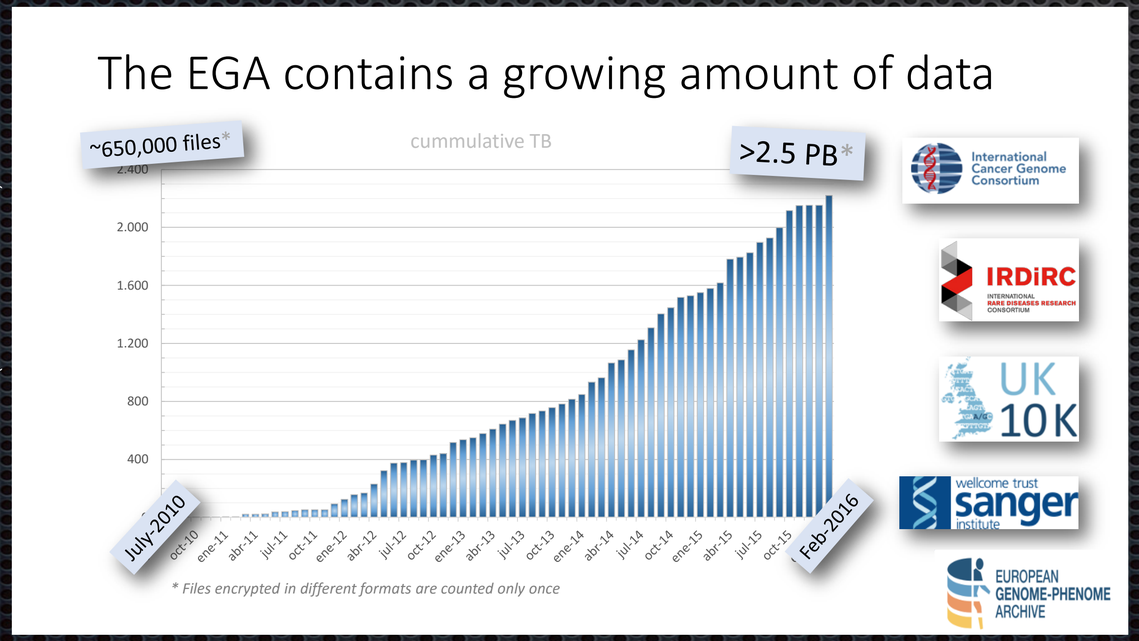
>2-500'000

>1'000'000

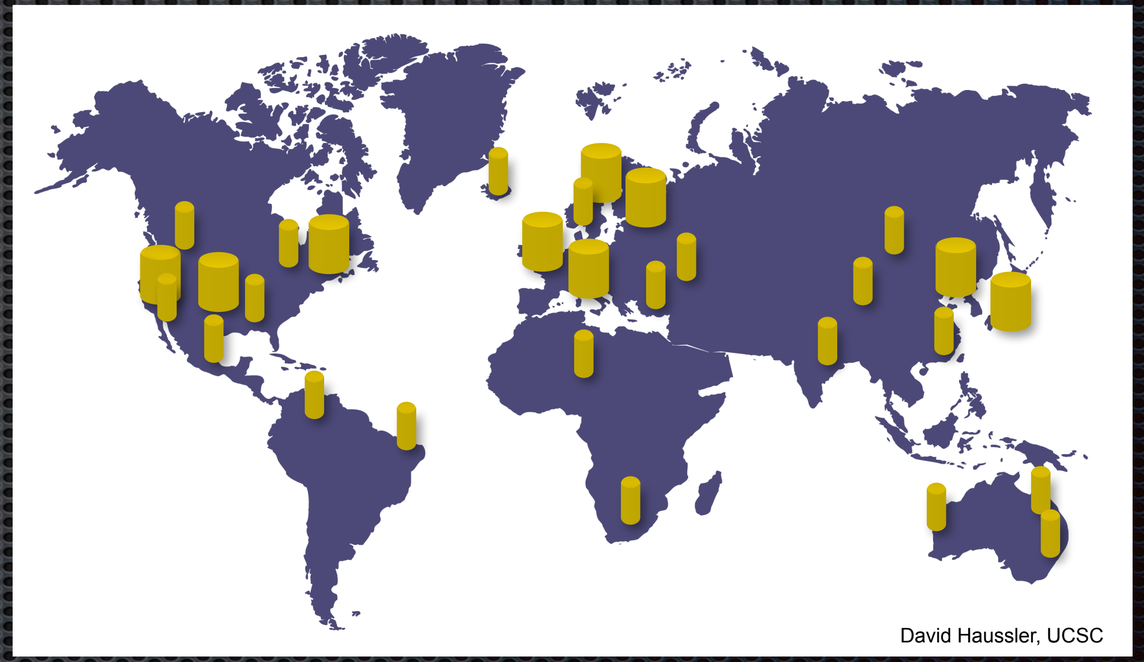
500'000

Genome Datasets: Rapid Growth, Limited Access

population based and cancer research studies produce a rapidly increasing amount of genome sequence data



Source: Jordi Rambla (CRG Barcelona) 2016



genome data is stored in an increasing number of institutional and core repositories, with **incompatible data** structures and **access** policies

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GA4GH to solve genome data access…

GA4GH HISTORY & MILESTONES

- January - June 2013 - Meeting & White Paper, over next year signed by 70 “founding” member institutions (e.g. SIB, UZH)
- March 2014 - **Working groups** established in Hinxton & 1st plenary in London
- October 2014 - Plenary meeting, San Diego; interaction with ASHG meeting
- June 2015 - 3rd Plenary meeting, Leiden
- September 2015 - GA4GH at ASHG, Baltimore
- October 2015 - DWG / New York Genome Centre
- April 2016 - Global Workshop @ ICHG 2016, Kyoto
- October 2016 - 4th Plenary Meeting, Vancouver
- May 2017 - Strategy retreat, Hinxton
- October 2017: 5th Plenary Meeting, Orlando

  ➡ “GA4GH II”: **Work Streams** && **Driver Projects**


GENOMICS

A federated ecosystem for sharing genomic, clinical data

Silos of genome data collection are being transformed into seamlessly connected, independent systems

The Global Alliance for Genomics and Health*

SCIENCE 10 JUNE 2016 • VOL 352 ISSUE 6291

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GA4GH API promotes sharing

GENOMICS

A federated ecosystem for sharing genomic, clinical data

Silos of genome data collection are being transformed into seamlessly connected, independent systems

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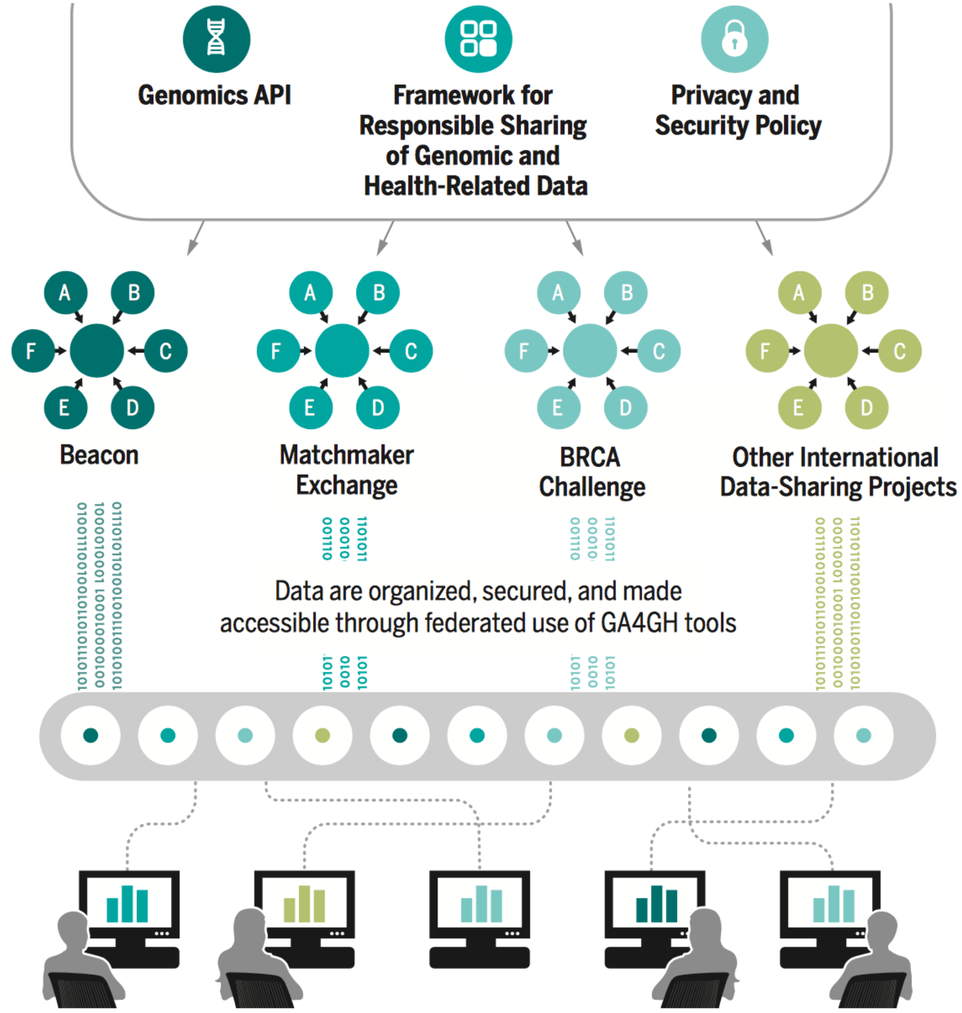
A federated data ecosystem. To share genomic data globally, this approach furthers medical research without requiring compatible data sets or compromising patient identity.



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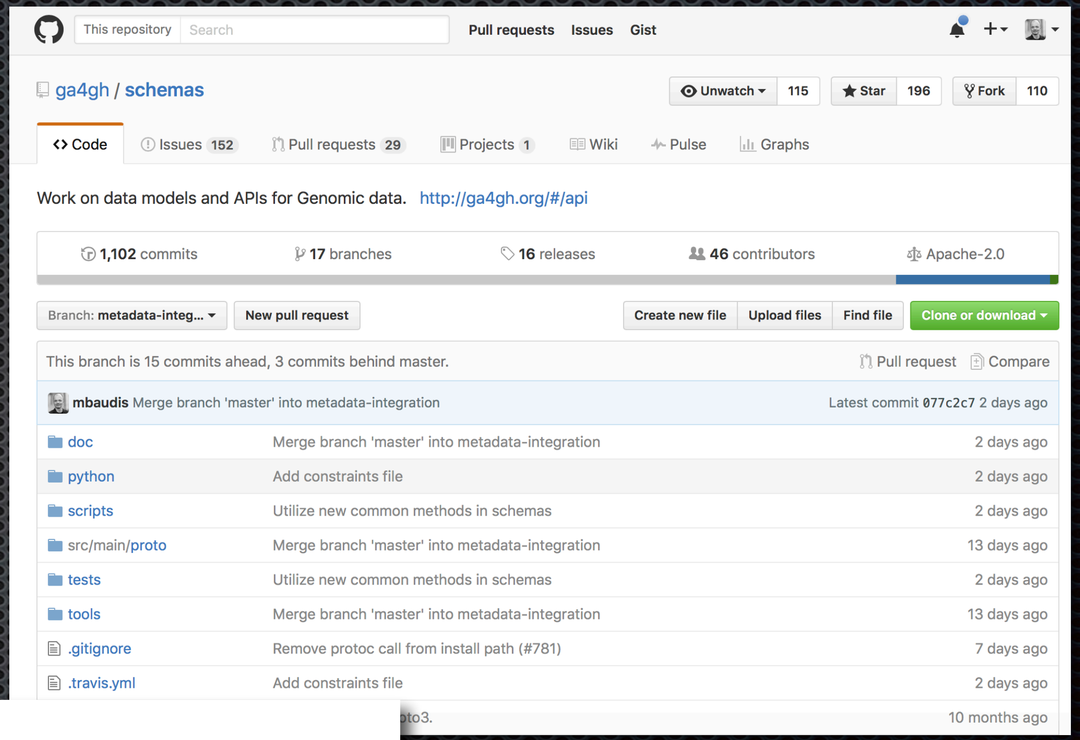
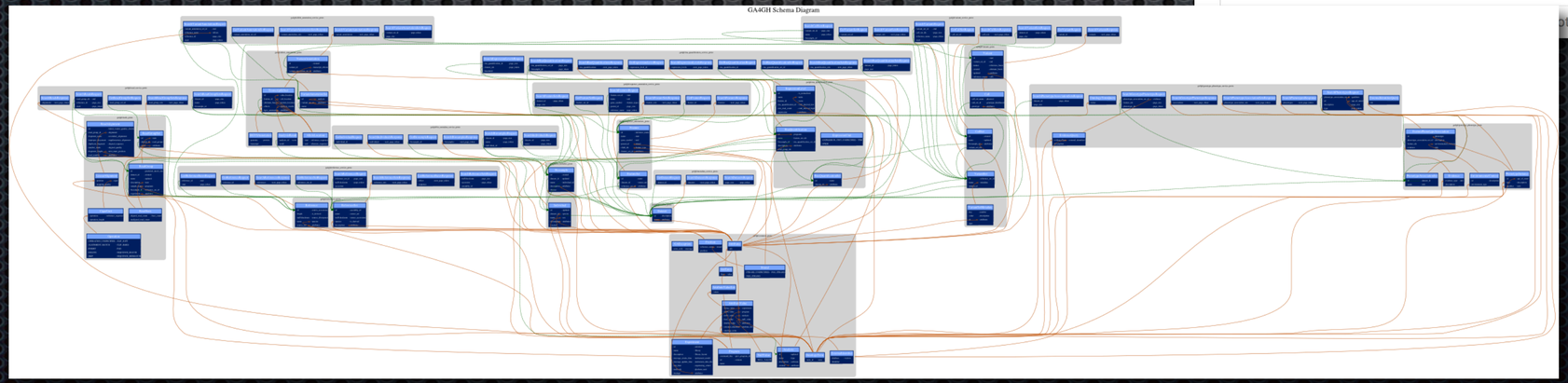
GA4GH Data **Working Group**

- development of schemas for genome data & metadata representation
- reference server, documentation
- “all in one” master schema





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GA4GH **Driver Projects**

BRCA Challenge
The BRCA Challenge aims to advance understanding of the genetic basis of breast and other cancers using data from around the world.

Beacon Project
Beacon Project is an open web service that tests the willingness of international sites to share genetic data. It is being implemented on the websites of the world's top genomic research organizations.

Matchmaker Exchange
Matchmaker Exchange is a federated network of databases whose goal is to find genetic causes of rare diseases by matching similar phenotypic and genotypic profiles.

The Cancer Gene Trust
proposes to aggregate somatic cancer mutation data and some clinical data in order to improve the genomic landscape of actionability in some cancers and to enable greater personalized clinical care for individuals with rare cancer mutations.

BRCA CHALLENGE

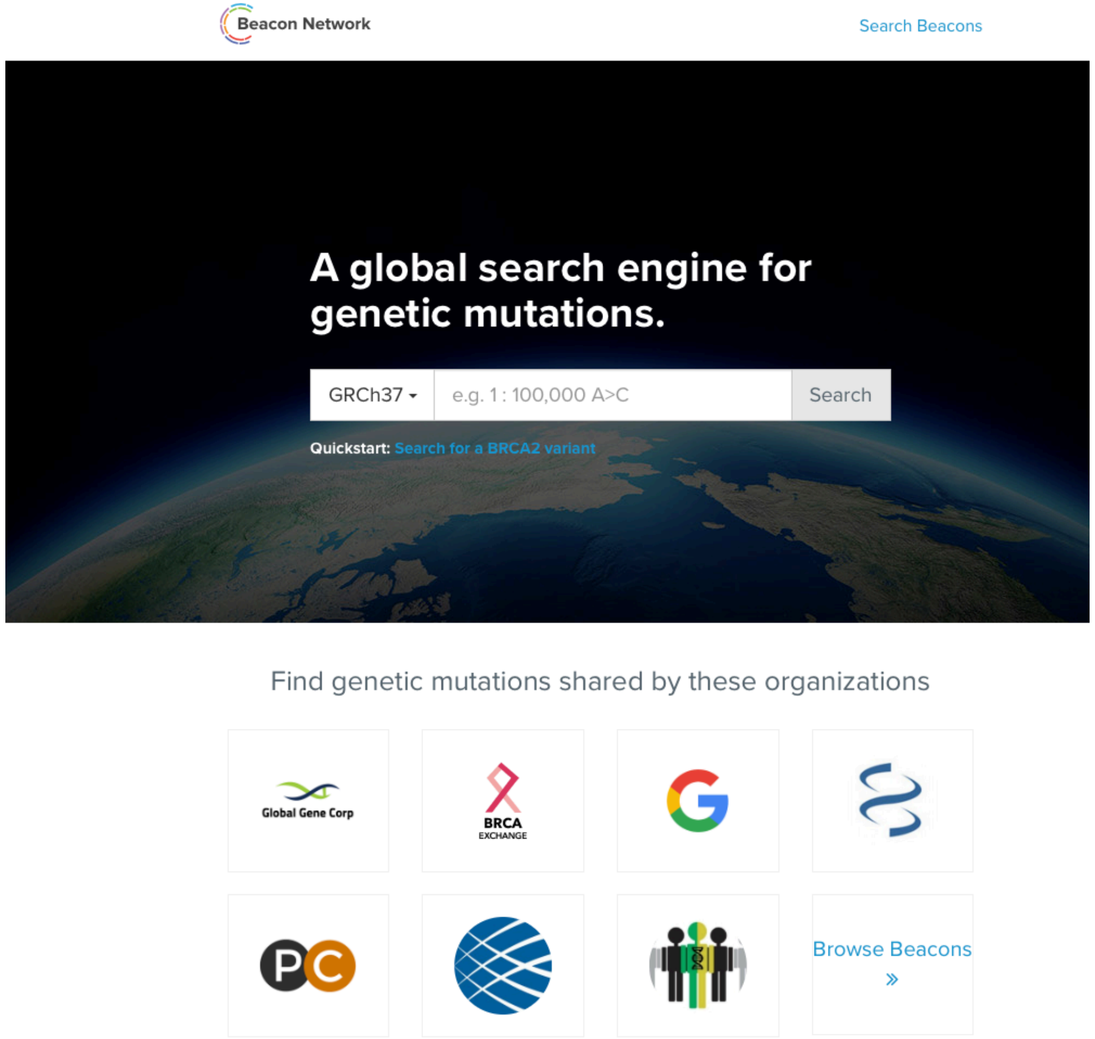
Beacon

Matchmaker Exchange

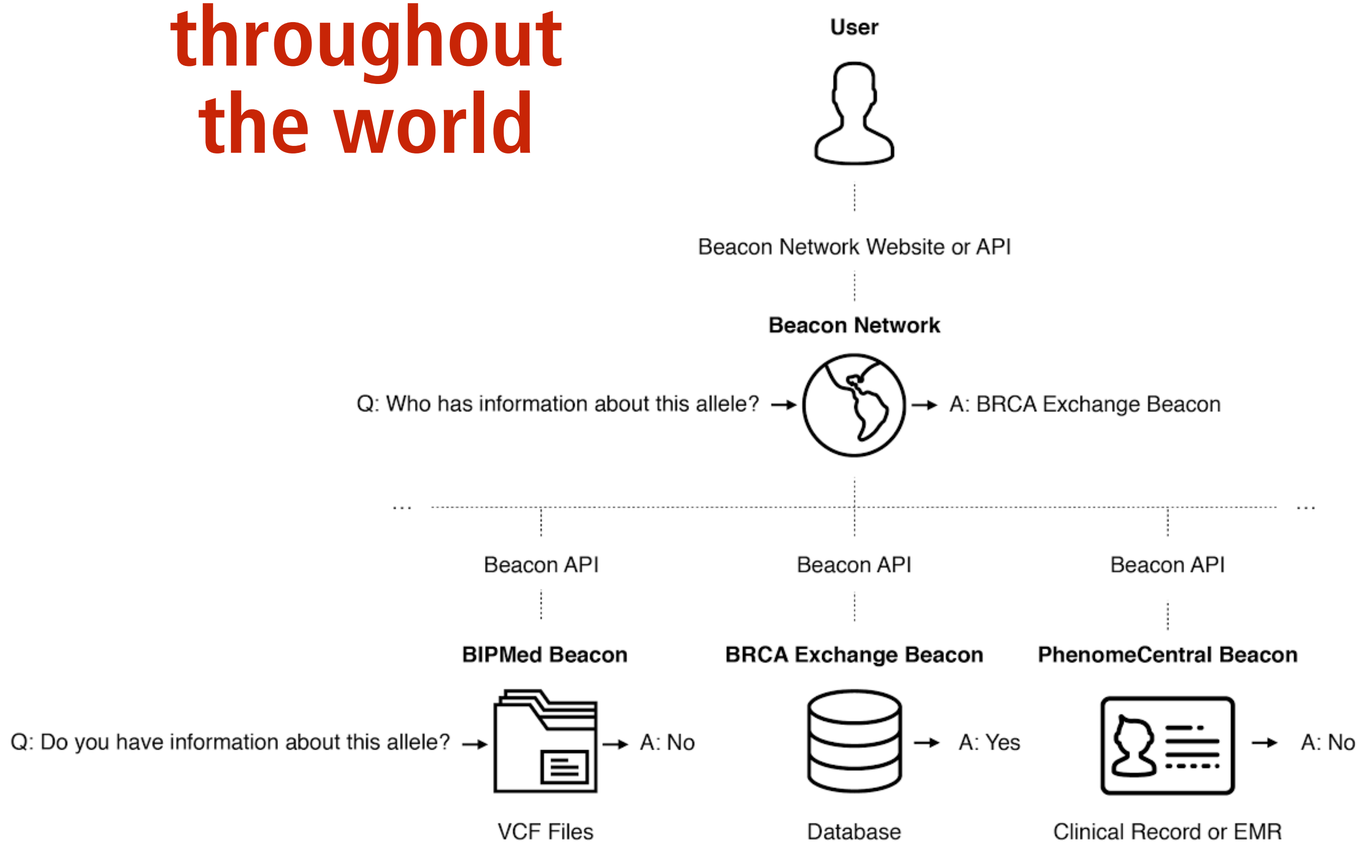
Cancer Gene Trust

Beacon Project

An open web service that tests the willingness of international sites to share genetic data.



> 50 Beacons throughout the world



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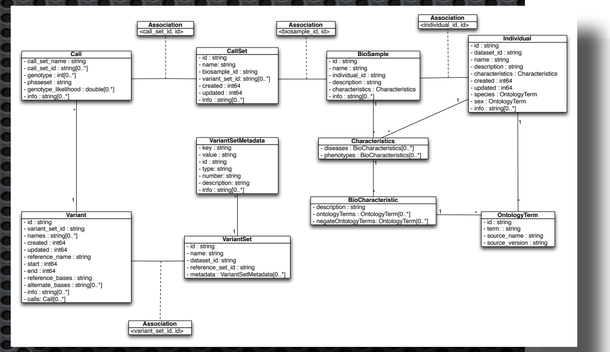
Developing the GA4GH **Metadata** Schema

- arrayMap for GA4GH
  - metadata schema development through implementation of arrayMap resource data
  - OntologyTerm objects for biodata
  - implementation w/ ontology services



Driving **Beacon** Development

- Beacon+
  - CNV/CNA as first type of structural variants
  - disease specific queries
  - quantitative reporting

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EMBL-EBI

arrayMap

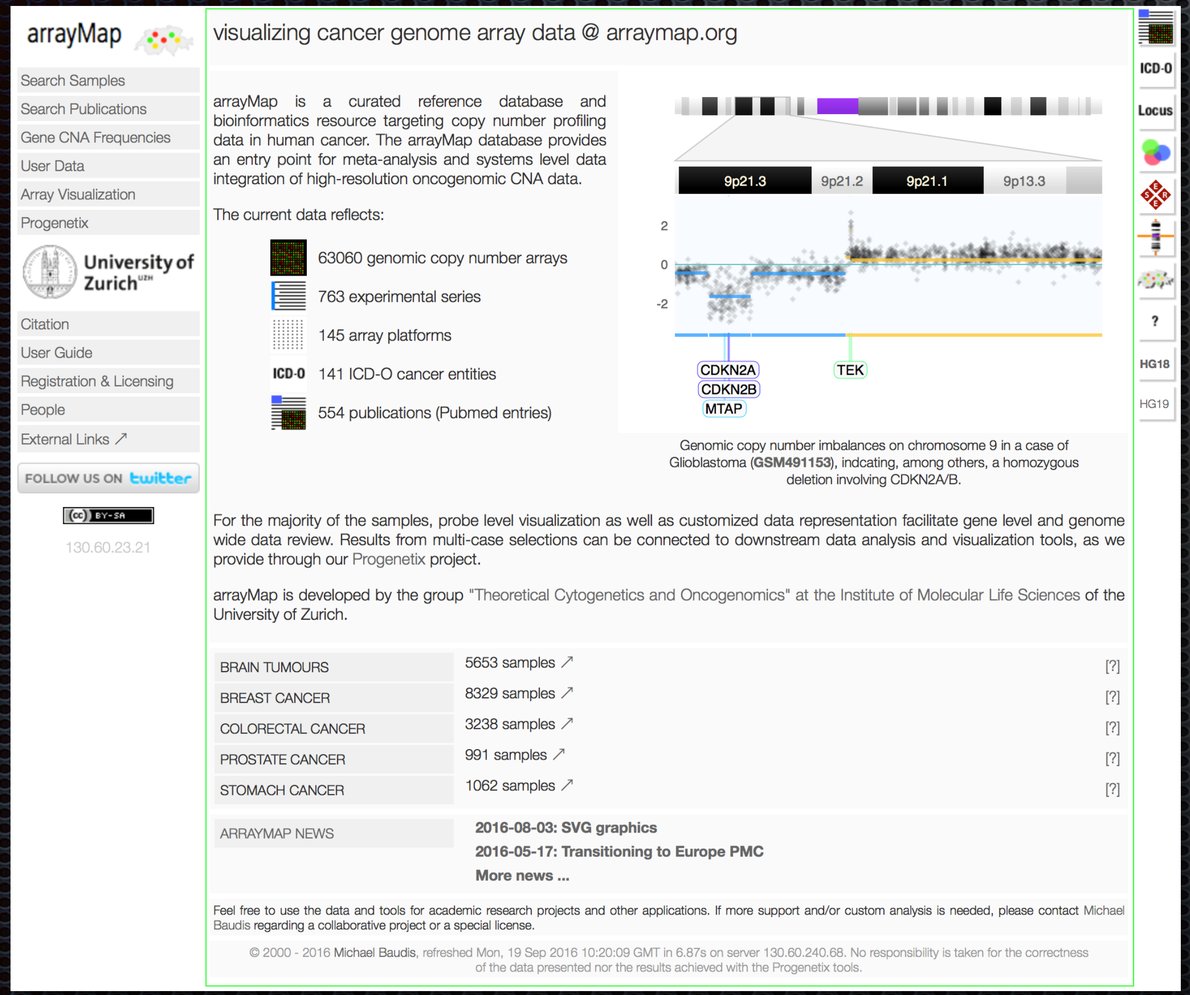
elixir

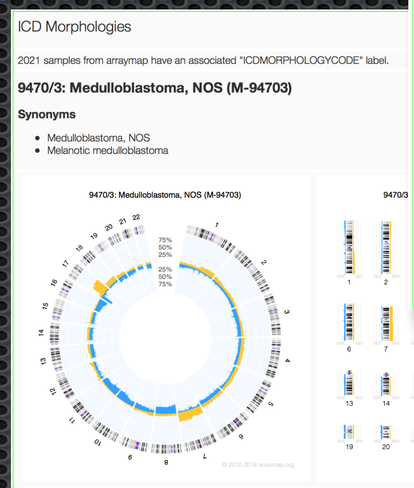
SIB Swiss Institute of Bioinformatics

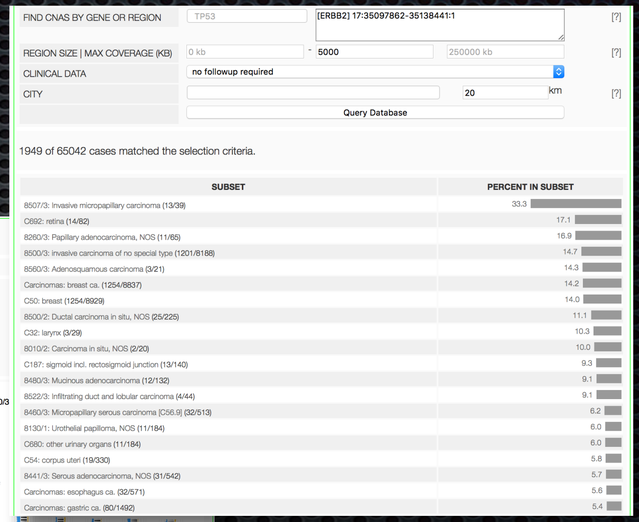

```
"_id" : ObjectId("58297ca32ca4591e5a0df054"),
"id" : "AM_V_1778741",
"variant_set_id" : "AM_VS_HG18",
"reference_name" : "10"
"start" : 579049,
"end" : 17236099,
"alternate_bases" : "DUP",
"reference_bases" : ".",
"info" : {
  "svlen":16657050,
  "cipos":[
      -1000,
      1000
  ],
  "ciend":[
      -1000,
      1000
  ]
},
"calls" : [
        {
                "genotype" : [
                        ".",
                        "."
                ],
                "call_set_id" : "AM_CS_TCGA-61-1917-01A-01D-0648-01",
                "info" : {
                        "segvalue" : 0.5491
                }
        }
],
"created" : ISODate("2016-11-14T08:33:58.202Z"),
"updated" : ISODate("2016-11-14T08:33:58.202Z"),
}
```

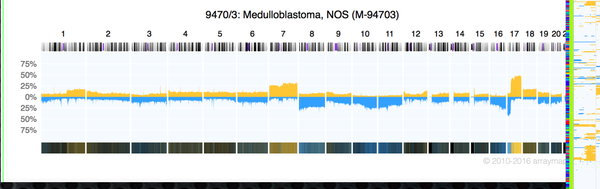
arrayMap

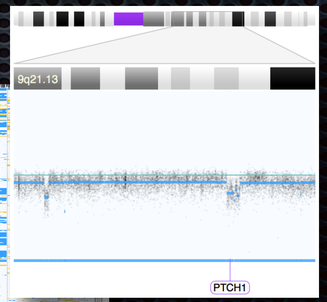
Resource for copy number variation data in cancer











UID	SERIESID	PMID	ICDMORPHOLOGYCODE	ICDTOPOGRAPHYCODE
GSM1000061	GSE36942	23457519	8070/3	C10
GSM1000062	GSE36942	23457519	8070/3	C10
GSM1001316	GSE40777	23571474	8070/3	C53
GSM1001317	GSE40777	23571474	8010/3	C34
GSM1001318	GSE40777	23571474	8070/3	C09
GSM1001319	GSE40777	23571474	8010/3	C34
GSM1002668	GSE40834	24047479	9823/3	C42
GSM1002669	GSE40834	24047479	9823/3	C42
GSM1002670	GSE40834	24047479	9823/3	C42
GSM1002671	GSE40834	24047479	9823/3	C42
GSM1002672	GSE40834	24047479	9823/3	C42
GSM1002673	GSE40834	24047479	9823/3	C42
GSM1002674	GSE40834	24047479	9823/3	C42
GSM1002675	GSE40834	24047479	9823/3	C42
GSM1002676	GSE40834	24047479	9823/3	C42
GSM1002677	GSE40834	24047479	9823/3	C42
GSM1002678	GSE40834	24047479	9823/3	C42
GSM1002679	GSE40834	24047479	9823/3	C42
GSM1002680	GSE40834	24047479	9823/3	C42

arrayMap

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- object model instead of columnar
- referencing of ontologies instead of text descriptors

- need for ontologies & mappings
- these are no "real" open ontologies

- data standards use (e.g. ISO)

- fallback to generic object map for unassigned data; this should disappear over time

GA4GH DWG Metadata Task Team: Schema Wranglers

```
"id" : "PGX_AM_BS_GSM510730",
"individual_id" : "PGX_IND_GSM510730",
"name" : "PGX_AM_BS_GSM510730",
"description" : "breast carcinoma",
"bio_characteristics" : [
   {
      "description" : "breast carcinoma",
      "ontology_terms" : [
         {
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            "term_label" : "Ductal Breast Carcinoma"
         },
         {
            "term_id" : "pgx:icdom:8500_3",
            "term_label" : "invasive carcinoma of no special type"
         },
         {
            "term_id" : "pgx:icdot:C50",
            "term_label" : "breast"
         },
         {
      ],
      "negated_ontology_terms" : [ ],
   }
],
"individual_age_at_collection" : "P47Y",
"attributes" : {
   "tnm" : {
      "values" : [
         { "string_value" : "T1N0M0" }
      ]
   },
"location" : {
   "geo_label" : "Oslo, Norway",
   "latitude" : 59.91,
   "longitude" : 10.75,
   "geo_precision" : "city"
},
"external_identifiers" : [
   {
      "database" : "Pubmed",
      "identifier" : "20592421",
      "relation" : "part_of"
   },
],
"updated" : ISODate("2017-03-20T08:37:07.771Z"),
```

Do classifications & ontologies need an Einstein to sort them out?!

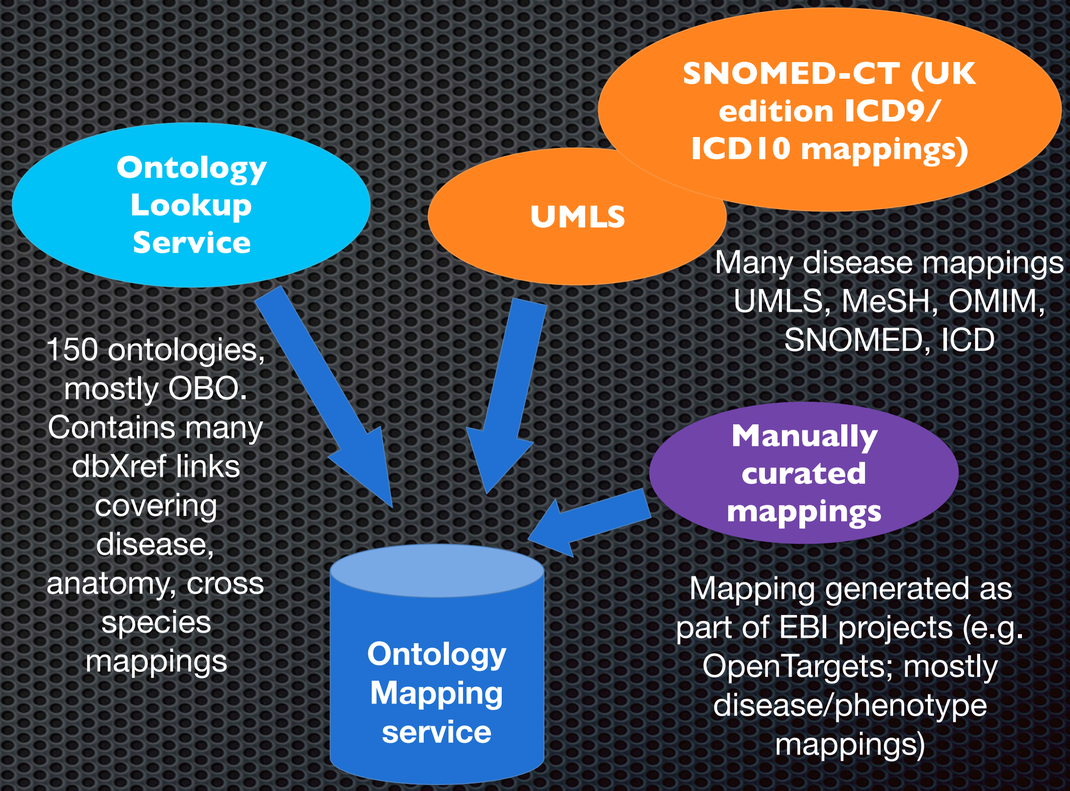
University of Zurich[UZH]

ARRAYID	NCIT:CODE	NCIT:TERM	ICD-MORPHOLOGY-CODE	ICD-TOPOGRAPHY-CODE
GSM393758	C2753	Acute Myeloid Leukemia Not Otherwise Specified	9861/3	C42
GSM302275	C2852	Adenocarcinoma	8140/3	C34
GSM918983	C3222	Medulloblastoma	9470/3	C716
GSM551398	C4017	Ductal Breast Carcinoma	8500/3	C50
GSM412374	C3163	Chronic Lymphocytic Leukemia	9823/3	C42
GSM121826	C4017	Ductal Breast Carcinoma	8500/3	C50
GSM714412	C2852	Adenocarcinoma	8140/3	C569
GSM110923	C9306	Soft Tissue Sarcoma	8800/3	C499
GSM711848	C2852	Adenocarcinoma	8140/3	C25
GSM746794	C89476		8077/2	C53
GSM198158	C4017	Ductal Breast Carcinoma	8500/3	C50
GSM271399	C7949		8500/2	C50
GSM533469	C9349	Plasmacytoma	9731/3	C42

Making Ontologies Work for GA4GH Implementation Studies

- biomedical "metadata" in different resources frequently follows incompatible classification systems
- medical coding systems are driven by different paradigms compared to biological ontologies (e.g. for cross-species comparisons)
- frequently used classifications (ICD, Snomed…) are either not “ontologised” or cannot be referenced in open resources

Federated queries across resources need **curated mappings** of classifications/ ontologies

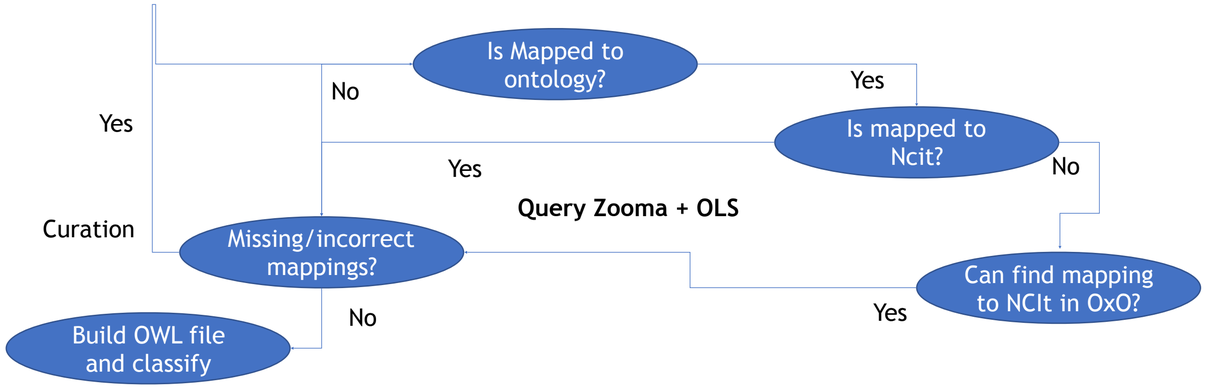


Ontology Mapping Service

Working towards ontologies w/ arrayMap: Mapping >55'000 samples from ICD-O to NCIt neoplasm core

ICDM	ICDMORPHOLOGY	NCItcode	NCItlabel	ICDT	ICDTOPOGRAPHY	NCItcode	NCItlabel	NCIt_mapp	NCIt_mapped_ICDM_T_label
8021/3	Carcinoma anaplastic type			C739	thyroid gland	C12400	thyroid gland	C3878	Thyroid Gland Undifferentiated (Anaplastic) Carcinoma
9451/3	Oligodendroglioma anaplastic	C4326	anaplastic oligodendroglioma	C719	Brain	C12439	brain	C4326	Anaplastic Oligodendroglioma
9051/3	Desmoplastic mesothelioma	C6747		C499	connective and soft tissue			C6747	Desmoplastic Mesothelioma
9732/3	Plasma cell myeloma	C3242	multiple myeloma	C42	hematopoietic and reticuloendothelial systems			C3242	Plasma Cell Myeloma
8070/3	Squamous cell carcinoma	C2926	non-small cell lung carcinoma	C140	pharynx			C102872	Pharyngeal Squamous Cell Carcinoma
8380/3	Endometrioid adenocarcinoma	C3769	endometrioid carcinoma	C54	corpus uteri	C12316		C6287	Endometrial Endometrioid Adenocarcinoma
8070/3	Squamous cell carcinoma	C2926	non-small cell lung carcinoma	C44	skin	C12470	zone of skin	C4819	Skin Squamous Cell Carcinoma
8430/3	Mucoepidermoid carcinoma	C45544	pulmonary mucoepidermoid carcinoma	C089	salivary gland	C12426	saliva-secreting gland	C5953	Minor Salivary Gland Mucoepidermoid Carcinoma
9680/3	Diffuse large B-cell lymphoma	C8851	diffuse large B-cell lymphoma	C42	hematopoietic and reticuloendothelial systems			C8851	Diffuse Large B-Cell Lymphoma
8800/3	Sarcoma	C9118	sarcoma	C559	uterus nos			C9306	Soft Tissue Sarcoma
8441/3	Serous adenocarcinoma	C7550	ovarian serous adenocarcinoma	C570	fallopian tube	C12403	fallopian tube	C40101	Serous Adenocarcinoma
9689/3	splenic marginal zone lymphoma nos			C422	spleen	C12432	spleen	C4663	Splenic Marginal Zone Lymphoma
8077/2	Squamous intraepithelial neoplasia grade III			C53	cervix uteri	C12311		C89476	Grade III Vaginal Intraepithelial Neoplasia
8140/0	Adenoma	C4196	adenoma	C189	large intestine excl. rectum and rectosigmoid junction			C4349	Colon Adenocarcinoma
8272/3	Pituitary carcinoma	C4536	Pituitary carcinoma	C751	pituitary gland	C12399	pituitary gland	C4536	Pituitary Gland Carcinoma
8500/2	Ductal carcinoma in situ	C3641	ductal carcinoma in situ	C50	breast	C12971	breast	C2924	Ductal Breast Carcinoma In Situ
8200/3	Adenoid cystic carcinoma	C2970	adenoid cystic carcinoma	C32	larynx	C12420	larynx	C2970	Adenoid Cystic Carcinoma
9370/3	Chordoma	C2947	Chordoma	C419	bone	C13076	bone tissue	C2947	Chordoma
9717/3	Enteropathy type T-cell lymphoma			C17	small intestine	C12386	small intestine	C4737	Enteropathy-Associated T-Cell Lymphoma
9698/3	Follicular lymphoma grade 3			C42	hematopoietic and reticuloendothelial systems			C3460	Grade 3 Follicular Lymphoma
9863/3	Chronic myeloid leukemia	C3177	chronic myelogenous leukemia	C42	hematopoietic and reticuloendothelial systems			C3174	Chronic Myelogenous Leukemia BCR-ABL1 Positive
8852/3	Liposarcoma myxoid	C3735	myxoid liposarcoma	C499	connective and soft tissue			C27781	Myxoid Liposarcoma
9080/3	Teratoma malignant			C809	unknown	C35882	Hereditary elliptocytosis	C3403	Tetratoma
8530/3	Inflammatory carcinoma	C4872	breast carcinoma	C50	breast	C12971	breast	C4001	Inflammatory Breast Carcinoma
8140/3	Adenocarcinoma	C27745	lung adenocarcinoma	C809	unknown	C35882	Hereditary elliptocytosis	C2852	Adenocarcinoma
						C12762	oropharynx	C2970	Adenoid Cystic Carcinoma
						C12415	kidney	C3158	Leiomyosarcoma
						C12499	internal ear	C2970	Adenoid Cystic Carcinoma
						C12683	bronchus	C2923	Bronchioloalveolar Carcinoma
						C12343	retina	C3224	Melanoma
					ial systems			C8459	Hepatosplenic T-Cell Lymphoma
						C12393	pancreas	C8294	Pancreatic Adenocarcinoma
					ial systems			C3996	Monoclonal Gammopathy of Undetermined Significance
								C4817	Ewing Sarcoma
								C3288	Oligodendroglioma
						C12422	tongue	C4648	Tongue Squamous Cell Carcinoma
					ial systems			C2862	Primary Myelofibrosis
								C4833	Oral Cavity Squamous Cell Carcinoma
						C12390	rectum	C9383	Rectal Adenocarcinoma
								C3158	Leiomyosarcoma
					ial systems			C3898	Extranodal Marginal Zone Lymphoma of Mucosa-Associate
						C12404	female gonad	C4512	Ovarian Mucinous Cystadenoma

- From 456 pairs of ICD-O terms Morphology and Topography representative of cancer entities in arrayMap
- Develop Python script to take ICD-O Morphology and Topography labels separately QUERY ZOOMA, OxO and OLS to find mapping to NCIt



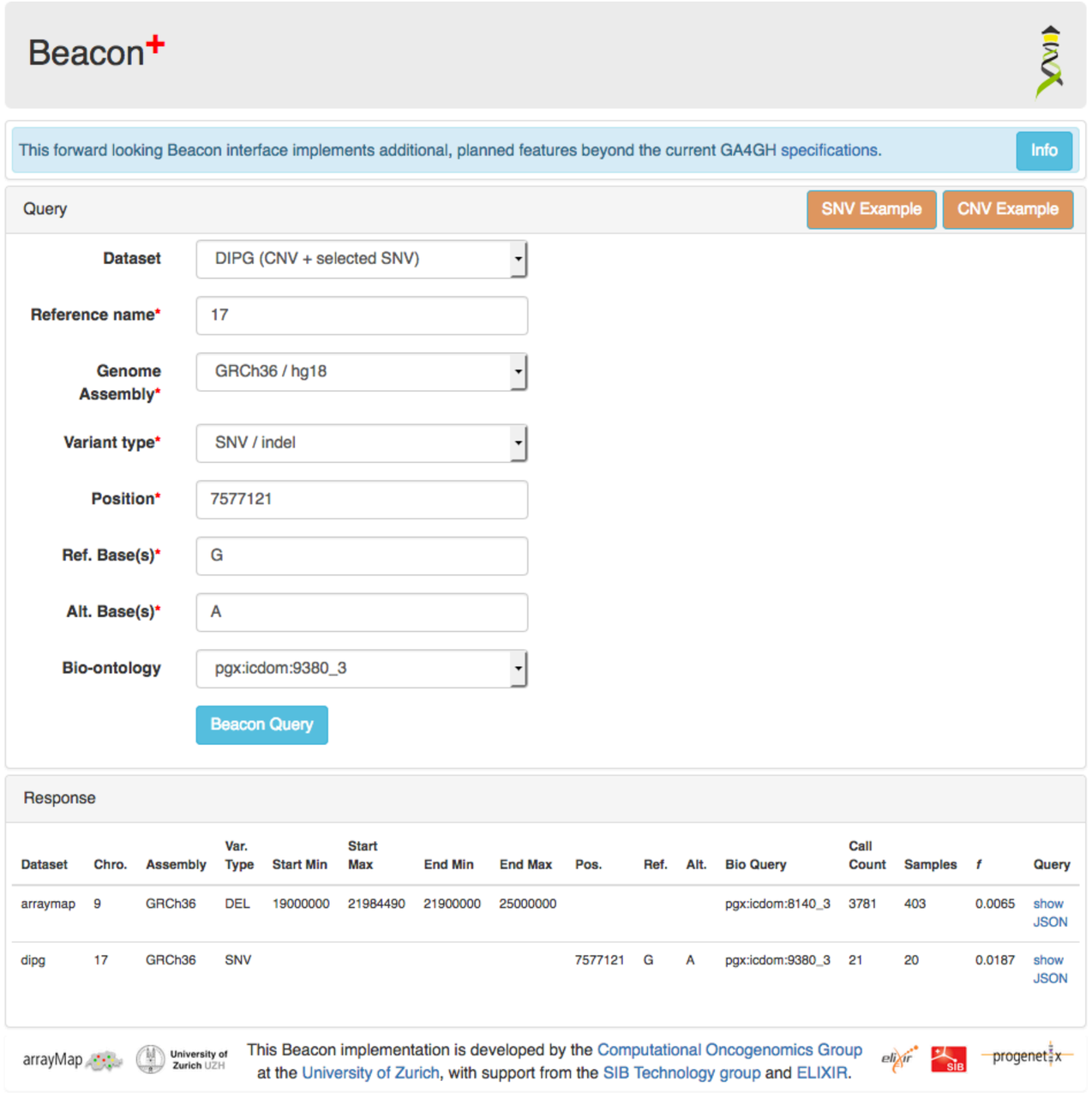
From 456 pairs of ICD-O
70% ICD-O Morphology - NCIt
65% ICD-O Topography - NCIt

45% ICD-O-3 Pairs mapped to NCIt terms

=> MANUAL CURATION of >50%

Beacon+ Concept

- Implementation of cancer beacon prototype, backed by arrayMap and DIPG data set (MacKay *et al.*, Cancer Cell 2017, in print)
- structural variations (DUP, DEL) in addition to SNV
- diagnosis queries using ontology codes (NCIT, ICD-O)
- quantitative responses
- current version uses **GA4GH schema compatible** database



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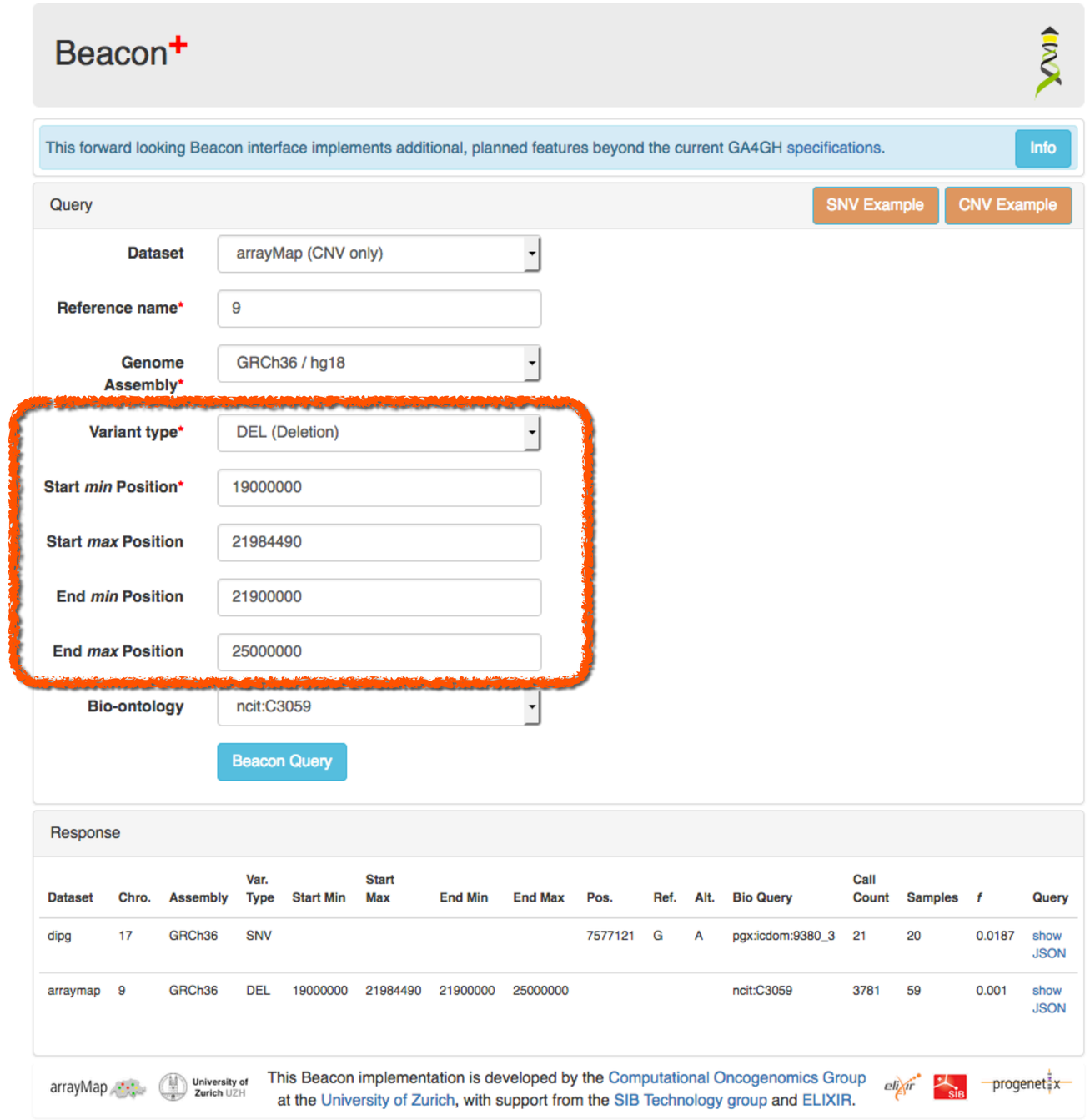
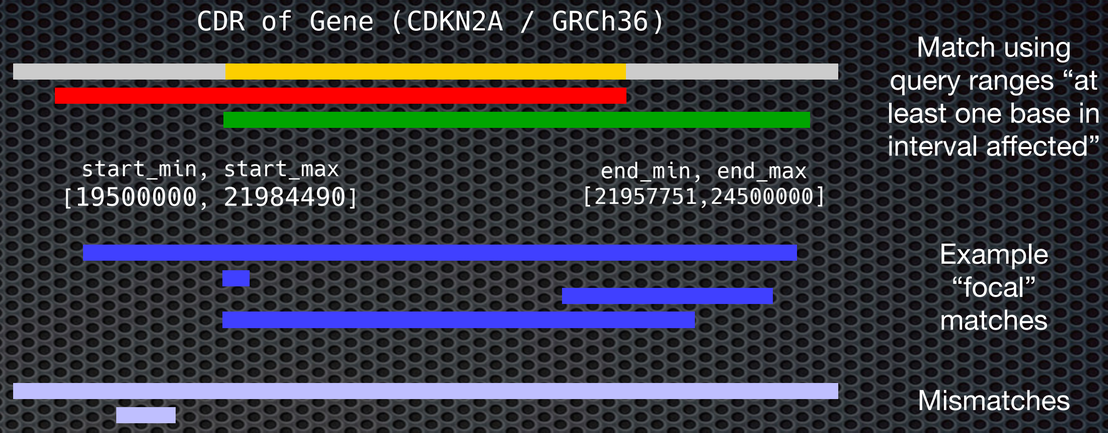


```
        { "variant_type" : “DEL" },
        { "start" : { "$gte" : 19500000 } },
        { "start" : { "$lte" : 21984490 } },
        { "end" : { "$gte" : 21957751 } },
        { "end" : { "$lte" : 24500000 } }
      ]
    },
    "api_version" : "0.4",
    "beacon_id" : "org.progenetix.progenetix.beacon",
    "exists" : true,
    "info" : {
      "query_string" :
"dataset_id=arraymap&variants.reference_name=chr9&assembly_id=GRCh36&va
riants.variant_type=DEL&variants.start_max=19000000&variants.start_min=
21984490&variants.end_min=21900000&variants.end_max=25000000&biosamples
.bio_characteristics.ontology_terms.term_id=pgx:icdom:9440_3",
      "version" : "Beacon+ implementation based on a development branch
of the beacon-team project: https://github.com/ga4gh/beacon-team/pull/
94"
    },
    "url" : “http://progenetix.org/beacon/info/“,
    "dataset_allele_responses" : [
      {
        “dataset_id" : "arraymap",
        "error" : null,
        "exists" : true,
        "external_url" : “http://arraymap.org",
        "sample_count" : 584,
        "call_count" : 3781,
        "variant_count" : 3244,
        "frequency" : 0.0094,
        "info" : {
          "description" : "The query was against database
\"arraymap_ga4gh\", variant collection \"variants_cnv_grch36\". 3781 /
59428 matched callsets for 3602919 variants. Out of 62105 biosamples in
the database, 2047 matched the biosample query; of those, 584 had the
variant.",
          "ontology_ids" : [
            "ncit:C3058",
            "pgx:icdom:9440_3",
            "pgx:icdot:C71.9",
            "pgx:icdot:C71.0"
```

- Beacon+ **range queries** allow the definition of a genome region of interest, containing a specified variant or potentially other position related feature
- “fuzzy” matching of region ends essential for inexact features
- current Beacon implementation addresses CNV (<DUP>, <DEL>), as are specified in VCF && GA4GH variant schema

```
        { "reference_name" : "9" },
        { "variant_type" : "DEL" },
        { "start" : { "$gte" : 19500000 } },
        { "start" : { "$lte" : 21984490 } },
        { "end" : { "$gte" : 21957751 } },
        { "end" : { "$lte" : 24500000 } }
      ]
    },
    "api_version" : "0.4",
    "beacon_id" : "org.progenetix:progenetix-beacon",
    "exists" : true,
    "info" : {
      "query_string" :
"dataset_id=arraymap&variants.reference_name=chr9&assembly_id=GRCh36&va
riants.variant_type=DEL&variants.start_max=19000000&variants.start_min=
                                                              biosamples
.bio_characteristics.ontology_terms.term_id=pgx:icdom:9440_3"
                                                              ent branch
of the beacon-team project: https://github.com/ga4gh/beacon-team/pull/
94"
    },
    "url" : "http://progenetix.org/beacon/info/",
    "dataset_allele_responses" : [
      {
        "dataset_id" : "arraymap",
        "error" : null,
        "exists" : true,
        "external_url" : "http://arraymap.org",
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            "pgx:icdot:C71.9",
            "pgx:icdot:C71.0"
```


Beacon+ Concept

Testing Beacons for Data Discovery

- standard Beacon payload (e.g. “exists”)
- testing GA4GH metadata “biocharacteristics” ontology term ids
- multiple datasets can be returned (only one shown here)
- quantitative reporting
- additional information about query & dataset(s)

Driving GA4GH Schema Development and Implementation Studies: The Road Ahead

Global Alliance for Genomics & Health

- GA4GH will be restructured (**work streams**; “real-world” **driver projects**) - to be announced at GA4GH plenary in Orlando, October 15-17, 2017
- developing, distributing and harmonising (meta-)data schema among different driver projects and implementations (clinical/phenotypic data - Phenopackets, genome standards…)
- Beacon as part of “**discovery**” work stream will be expanded, with ELIXIR as project driver
- GA4GH discovery work stream to harmonise APIs, possibly based on Beacon
- We will contribute to both Beacon & schema development, including implementation of necessary tools & examples:
  - example datasets
  - implement OxO ⇔ arrayMap ontology searches (using the Beacon+ as test/implementation case)
  - schema extension for metagenomic data representation
  - implementing more bio- and other metadata (geolocation data, complex time …)

University of Zurich[UZH]

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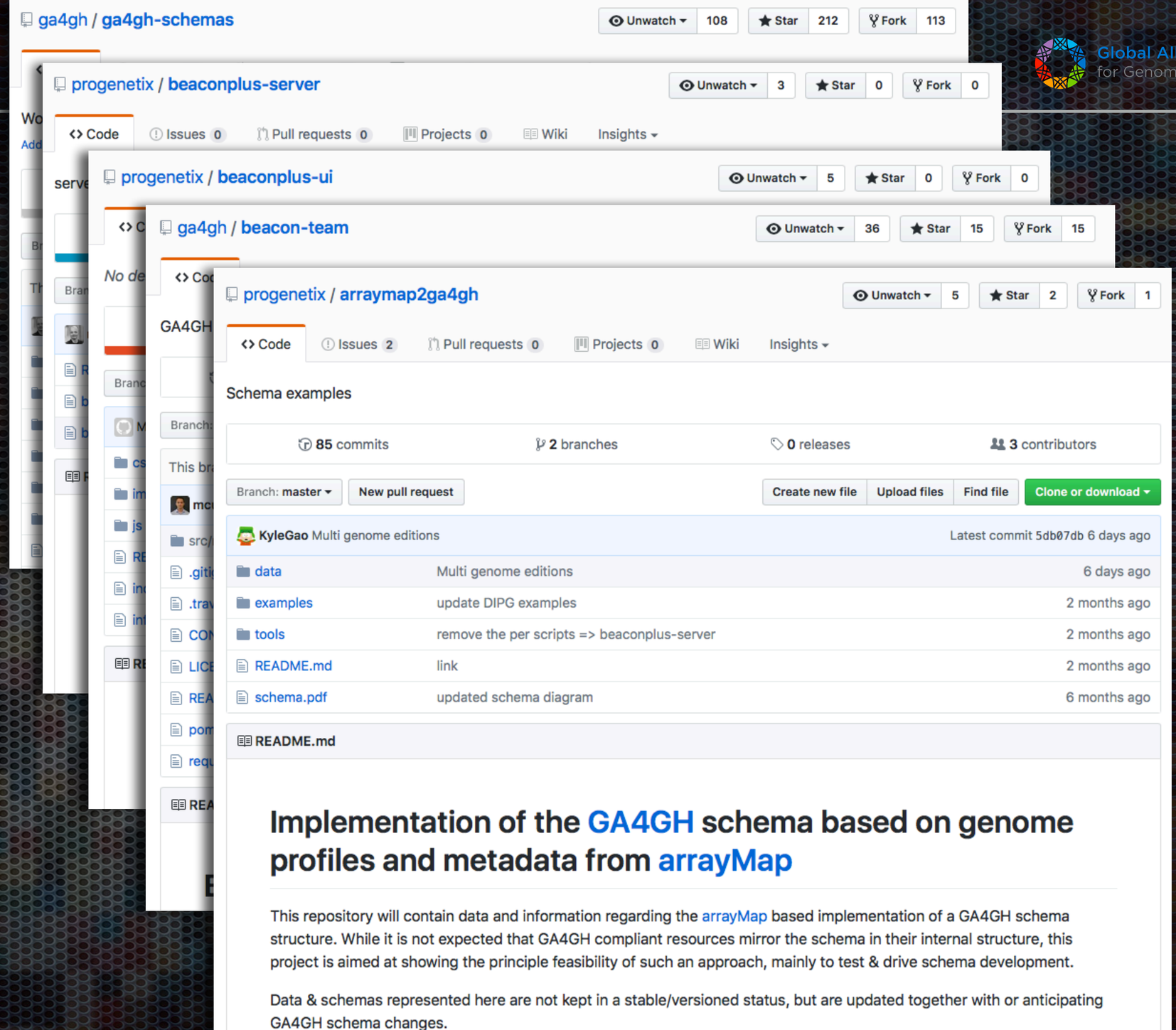
elixir

Check it Out!

- managed, participation driven projects living on Github: ***ga4gh***
- test datasets & code available through our ***progenetix*** repositories
  - ➡ test
  - ➡ comment
  - ➡ suggest
  - ➡ propose
  - ➡ complain …



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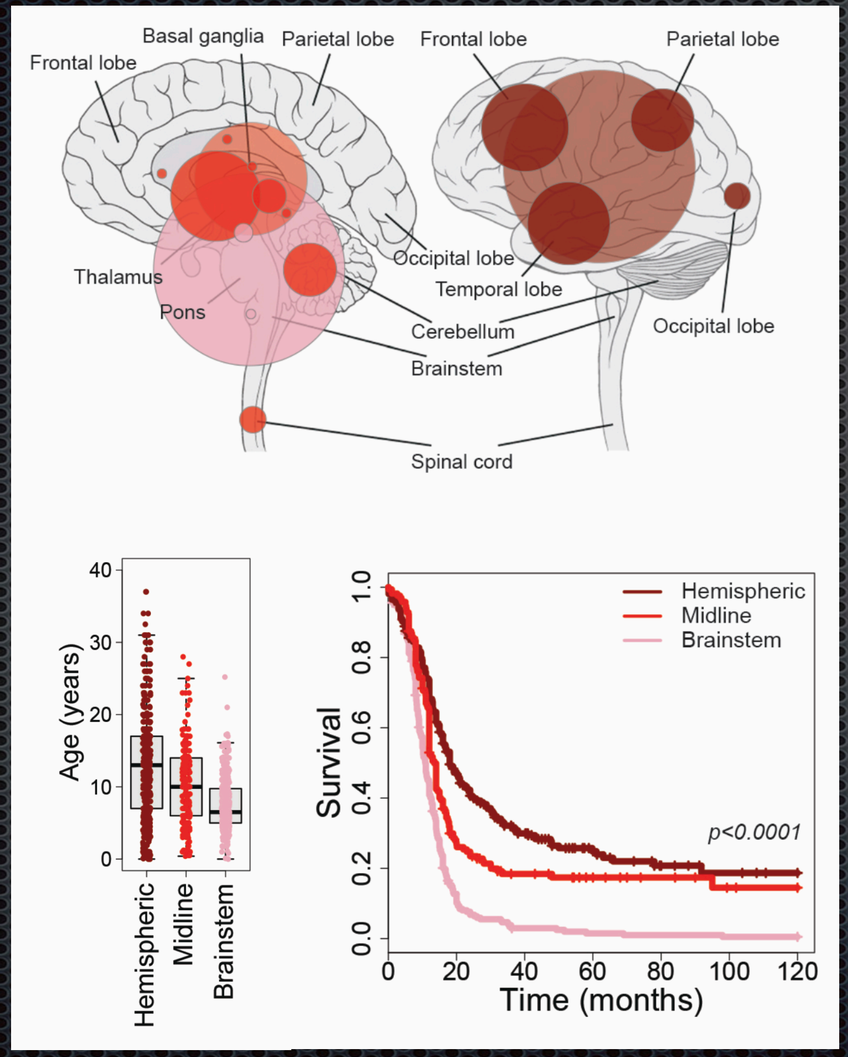
Implementing real-world datasets for federated access using GA4GH schema specifications: pHGG

Mackay A, Jones C, Baudis M and many, many others: Integrated molecular meta-analysis of 1000 paediatric high grade and diffuse intrinsic pontine glioma (2017, Cancer Cell, in press)




```
"_id" : ObjectId("591eb73709d374421fc0b2a"),
"individual_id" : "DIPG_IND_0809",
"id" : "DIPG_BS_0809",
"name" : "pHGG_META_0809",
"description" : "glioma, paediatric, high grade",
"individual_age_at_collection" : {
   "age_class" : {
      "term" : "Adult onset",
      "term_id" : "HP:0003581"
   },
   "age" : "P17Y0M"
},
"bio_characteristics" : [
   {
      "ontology_terms" : [
         {
            "term_label" : "Glioma",
            "term_id" : "ncit:C3059"
         },
         {
            "term_label" : "Brain NOS",
            "term_id" : "pgx:icdot:C71.9"
         }
      ],
      "description" : "Juvenile high grade glioma",
   }
],
"external_identifiers" : [
   {
      "database" : "Pubmed",
      "identifier" : "25752754",
      "relation" : "reported_in"
   }
],
"attributes" : {
   "grade" : { "values" : [ { "string_value" : "4" } ] },
   "histone" : { "values" : [ { "string_value" : "wt" } ] },
}
```

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