OAK RIDGE National Laboratory

Channel Finder

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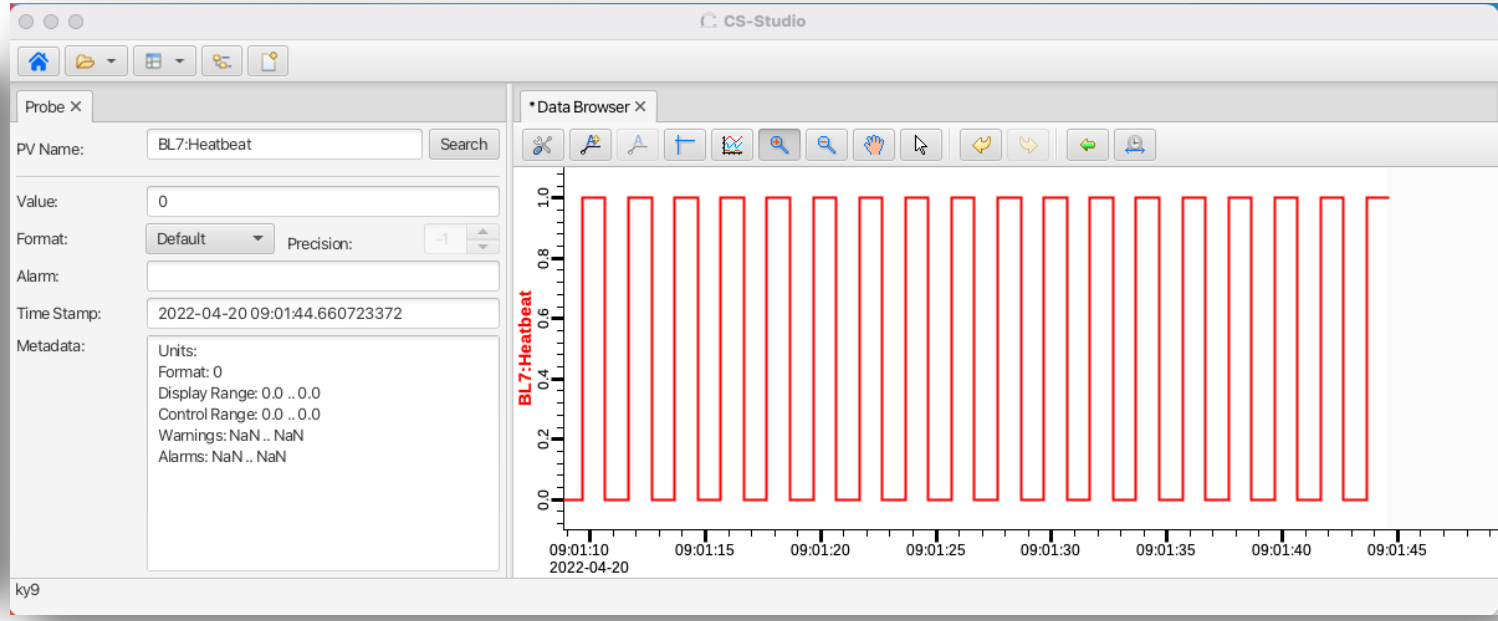
U.S. DEPARTMENT OF ENERGY

EPICS: Distributed & loosely coupled

```
[ky9@bl7-dassrv1 ~]$ cat new.db

record(calc, "BL7:Heatbeat")
{
    field(SCAN, "1 second")
    field(CALC, "!VAL")
}

[ky9@bl7-dassrv1 ~]$ /home/controls/epics/base/master/bin/linux-x86_64/softIoc -d new.db
Starting iocInit
################################################################################
## EPICS R3.14.12.6
## EPICS Base built Jun  6 2017
################################################################################
cas warning: Configured TCP port was unavailable.
cas warning: Using dynamically assigned TCP port 45216,
cas warning: but now two or more servers share the same UDP port.
cas warning: Depending on your IP kernel this server may not be
cas warning: reachable with UDP unicast (a host's IP in EPICS_CA_ADDR_LIST)
The CA server's beacon address list was empty after initialization?
iocRun: All initialization complete
epics>
```



Start IOC → PVs are online

- No need to register IOC
- No need to reserve PV names

Like internet

- Flexibility!
- Few central bottlenecks

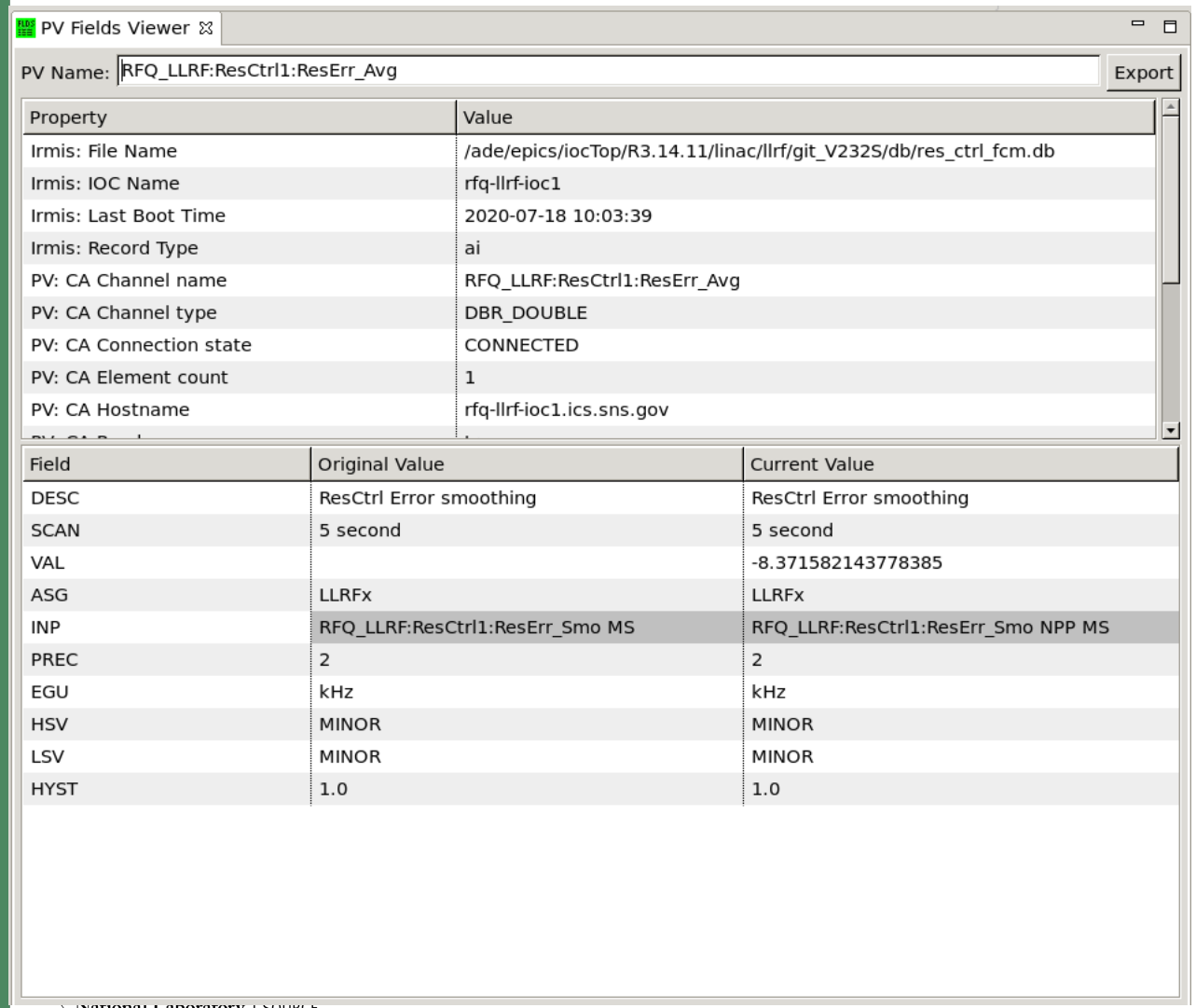
Start IOC → PVs are online

- No spell checker
- No "list all IOCs", "list all PVs"

Like internet

- Chaos!
- Likely need *some* level of control…

History: APS 'IRMIS', 'crawler'



- Resulting info
  - ✓ Which IOC last held that record?
  - ✓ When did it last boot? Where?
  - ✓ Initial value of fields?
  - ✓ Current value of fields?

- SNS: Abandoned
  - Parsing st.cmd, *.db, following 'cd' commands and macros is hard!

IRMIS=Integrated Relational Model of Installed Systems

Channel Finder 101

- Searchable list of “Channels”
- Optional “Tags”
  - ‘Magnet’ ?!
  - ‘ImportantSetting’
- Optional “Properties”
  - iocNAME = ‘NameOfIOC’
  - Type=‘Magnet’ ?!
  - Section=‘Front End’
  - Archive=‘Monitor, 00:01:00’
  - Zpos = ‘10m’ (position from start of accelerator)
  - Readback=‘NameOfAssociatedReadbackPV’

- ✓ Find iocName for a PV
- ✓ List all ‘Magnet’ channels
- ✓ List all PVs with iocName=‘someIOC’
- ✓ Get ‘archive’ settings for PVs
- ✓ Locate Readback for some setpoint

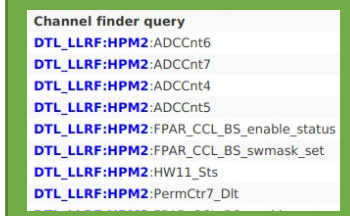
Ecosystem

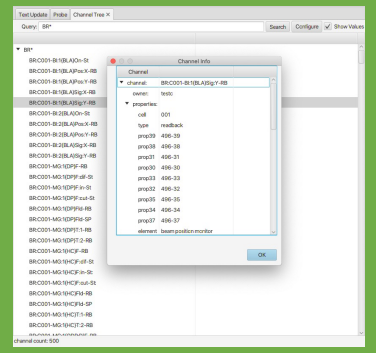
IOCs

RecSync

All record names,
IOC Name,
'info' tags

Operator Interface/GUU
Name Lookup, Channel Table
CS-Studio





High-Level Apps

Python

cf.find('DTL* type=Magnet')

IRMIS Import

Channel Finder Web Service

ElasticSearch
(used to be MySQL, ca. 2009)

Create Archive Config

REST API, Shell, Python

Maintenance, Statistics

REST API, Shell, Python

Initial Setup

1. Install & run Elasticsearch
   → Open web browser to http://localhost:9200
2. Install & run ChannelFinder
   → Open web browser to http://localhost:8080
3. Install & run Recceiver
4. Instrument IOCs to publish their records

In training setup, see /ics/examples/26_ChannelFinder

Instrumenting an IOC

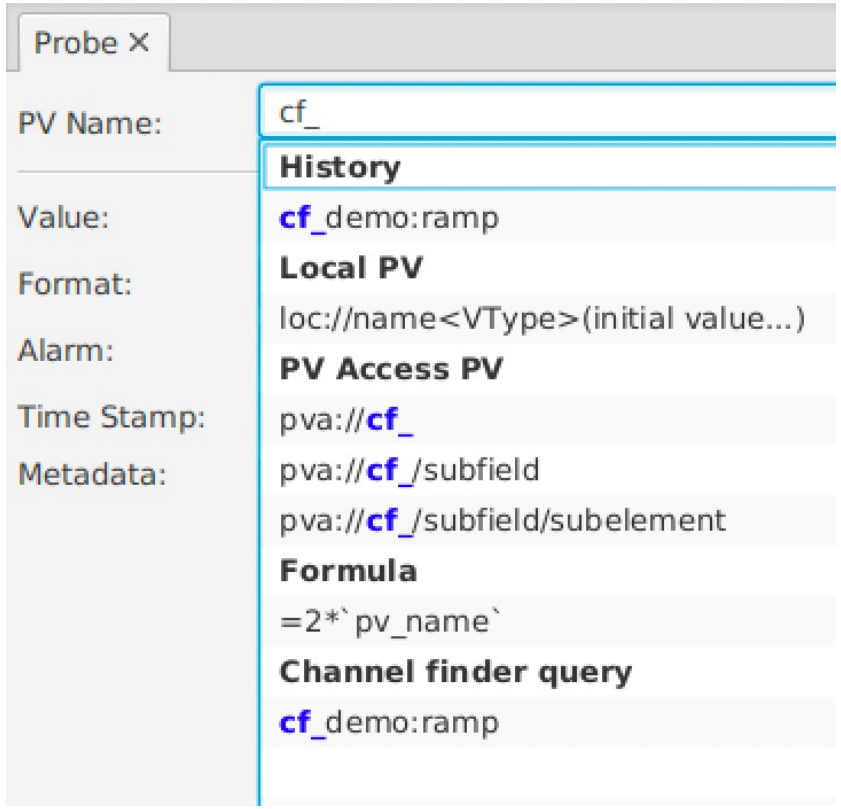
abcApp/src/Makefile

```
ABC_DBD += reccaster.dbd
ABC_LIBS += reccaster
```

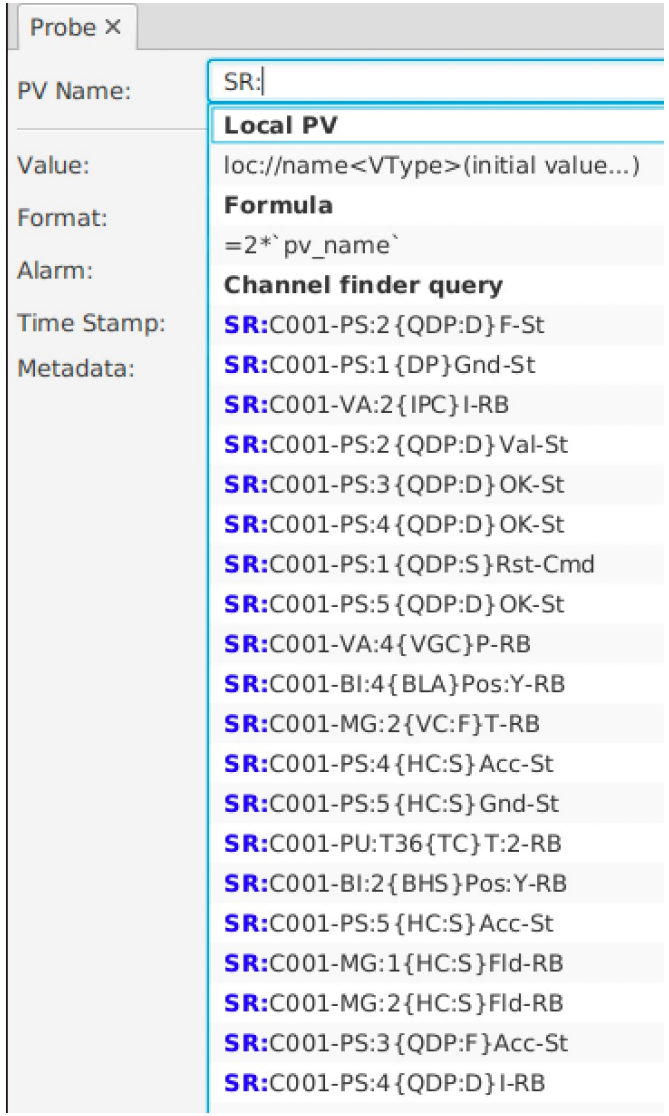
iocBoot/iocAbc/st.cmd

```
# Nice, but optional
epicsEnvSet("IOCNAME", "abc-ioc1")
epicsEnvSet("ENGINEER", "Fred")
epicsEnvSet("LOCATION", "Rack 123")
```

CS-Studio: PV Name Completion



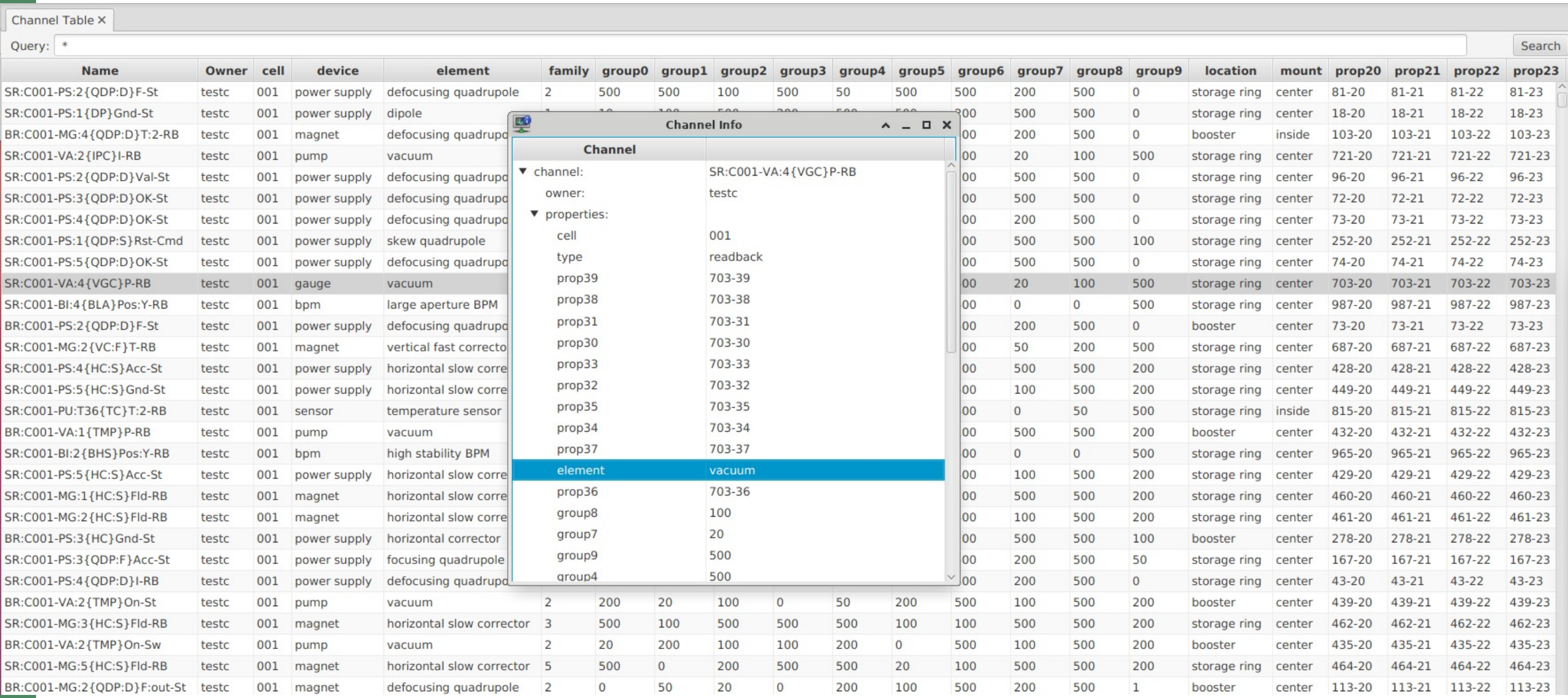
PVs from example IOC



Channel Finder demo channels

CS-Studio: Channel 'Table'

More elaborate demo data from BNL



Name	Owner	cell	device	element	family	group0	group1	group2	group3	group4	group5	group6	group7	group8	group9	location	mount	prop20	prop21	prop22	prop23
SR:C001-PS:2{QDP:D}F-St	testc	001	power supply	defocusing quadrupole	2	500	500	100	500	50	500	500	200	500	0	storage ring	center	81-20	81-21	81-22	81-23
SR:C001-PS:1{DP}Gnd-St	testc	001	power supply	dipole								300	500	500	0	storage ring	center	18-20	18-21	18-22	18-23
BR:C001-MG:4{QDP:D}T:2-RB	testc	001	magnet	defocusing quadrupo								00	200	500	0	booster	inside	103-20	103-21	103-22	103-23
SR:C001-VA:2{IPC}I-RB	testc	001	pump	vacuum								00	20	100	500	storage ring	center	721-20	721-21	721-22	721-23
SR:C001-PS:2{QDP:D}Val-St	testc	001	power supply	defocusing quadrupo								00	500	500	0	storage ring	center	96-20	96-21	96-22	96-23
SR:C001-PS:3{QDP:D}OK-St	testc	001	power supply	defocusing quadrupo								00	500	500	0	storage ring	center	72-20	72-21	72-22	72-23
SR:C001-PS:4{QDP:D}OK-St	testc	001	power supply	defocusing quadrupo								00	200	500	0	storage ring	center	73-20	73-21	73-22	73-23
SR:C001-PS:1{QDP:S}Rst-Cmd	testc	001	power supply	skew quadrupole								00	500	500	100	storage ring	center	252-20	252-21	252-22	252-23
SR:C001-PS:5{QDP:D}OK-St	testc	001	power supply	defocusing quadrupo								00	500	500	0	storage ring	center	74-20	74-21	74-22	74-23
SR:C001-VA:4{VGC}P-RB	testc	001	gauge	vacuum								00	20	100	500	storage ring	center	703-20	703-21	703-22	703-23
SR:C001-BI:4{BLA}Pos:Y-RB	testc	001	bpm	large aperture BPM								00	0	0	500	storage ring	center	987-20	987-21	987-22	987-23
BR:C001-PS:2{QDP:D}F-St	testc	001	power supply	defocusing quadrupo								00	200	500	0	booster	center	73-20	73-21	73-22	73-23
SR:C001-MG:2{VC:F}T-RB	testc	001	magnet	vertical fast correcto								00	50	200	500	storage ring	center	687-20	687-21	687-22	687-23
SR:C001-PS:4{HC:S}Acc-St	testc	001	power supply	horizontal slow corre								00	500	500	200	storage ring	center	428-20	428-21	428-22	428-23
SR:C001-PS:5{HC:S}Gnd-St	testc	001	power supply	horizontal slow corre								00	100	500	200	storage ring	center	449-20	449-21	449-22	449-23
SR:C001-PU:T36{TC}T:2-RB	testc	001	sensor	temperature sensor								00	0	50	500	storage ring	inside	815-20	815-21	815-22	815-23
BR:C001-VA:1{TMP}P-RB	testc	001	pump	vacuum								00	500	500	200	booster	center	432-20	432-21	432-22	432-23
SR:C001-BI:2{BHS}Pos:Y-RB	testc	001	bpm	high stability BPM								00	0	0	500	storage ring	center	965-20	965-21	965-22	965-23
SR:C001-PS:5{HC:S}Acc-St	testc	001	power supply	horizontal slow corre								00	100	500	200	storage ring	center	429-20	429-21	429-22	429-23
SR:C001-MG:1{HC:S}Fld-RB	testc	001	magnet	horizontal slow corre								00	500	500	200	storage ring	center	460-20	460-21	460-22	460-23
SR:C001-MG:2{HC:S}Fld-RB	testc	001	magnet	horizontal slow corre								00	100	500	200	storage ring	center	461-20	461-21	461-22	461-23
BR:C001-PS:3{HC}Gnd-St	testc	001	power supply	horizontal corrector								00	500	500	100	booster	center	278-20	278-21	278-22	278-23
SR:C001-PS:3{QDP:F}Acc-St	testc	001	power supply	focusing quadrupole								00	200	500	50	storage ring	center	167-20	167-21	167-22	167-23
SR:C001-PS:4{QDP:D}I-RB	testc	001	power supply	defocusing quadrupo								00	200	500	0	storage ring	center	43-20	43-21	43-22	43-23
BR:C001-VA:2{TMP}On-St	testc	001	pump	vacuum	2	200	20	100	0	50	200	500	100	500	200	booster	center	439-20	439-21	439-22	439-23
SR:C001-MG:3{HC:S}Fld-RB	testc	001	magnet	horizontal slow corrector	3	500	100	500	500	500	100	100	500	500	200	storage ring	center	462-20	462-21	462-22	462-23
BR:C001-VA:2{TMP}On-Sw	testc	001	pump	vacuum	2	20	200	100	100	200	0	500	100	500	200	booster	center	435-20	435-21	435-22	435-23
SR:C001-MG:5{HC:S}Fld-RB	testc	001	magnet	horizontal slow corrector	5	500	0	200	500	500	20	100	500	500	200	storage ring	center	464-20	464-21	464-22	464-23
BR:C001-MG:2{QDP:D}F:out-St	testc	001	magnet	defocusing quadrupole	2	0	50	20	0	200	100	500	200	500	1	booster	center	113-20	113-21	113-22	113-23

Search Options: “*Pattern* tag prop=*value*”

Channel Table ×

Query: SR:* element=vacuum

Search

Name	Owner	cell	device	element	family	group0	group1	group2	group3	group4	group5	group6	group7	group8	group9	location	mount	prop20	prop21	prop22	prop23	prop24	prop25	pro
SR:C001-VA:1{IPC}On-Sw	testc	001	pump	vacuum	1	50	200	500	500	500	500	20	500	100	500	storage ring	center	724-20	724-21	724-22	724-23	724-24	724-25	724
SR:C001-VA:2{TCG}P-RB	testc	001	gauge	vacuum	2	200	50	0	100	200	500	500	20	100	500	storage ring	center	711-20	711-21	711-22	711-23	711-24	711-25	711
SR:C001-VA:1{IPC}On-St	testc	001	pump	vacuum	1	200	500	0	50	500	0	20	500	100	500	storage ring	center	728-20	728-21	728-22	728-23	728-24	728-25	728
SR:C001-VA:2{IPC}I-RB	testc	001	pump	vacuum	2	500	0	0	0	200	10	500	20	100	500	storage ring	center	721-20	721-21	721-22	721-23	721-24	721-25	721
SR:C001-VA:2{VGC}OK-St	testc	001	gauge	vacuum	2	500	500	0	100	500	200	20	500	100	500	storage ring	center	706-20	706-21	706-22	706-23	706-24	706-25	706
SR:C001-VA:1{VGC}P-RB	testc	001	gauge	vacuum	1	500	0	500															700-25	700
SR:C001-VA:1{IPC}OK-St	testc	001	pump	vacuum	1	500	500	500															726-25	726
SR:C001-VA:1{TMP}P-RB	testc	001	pump	vacuum	1	500	500	200															732-25	732

Channel Table ×

Query: SR:* element=vacuum device=pump

Search

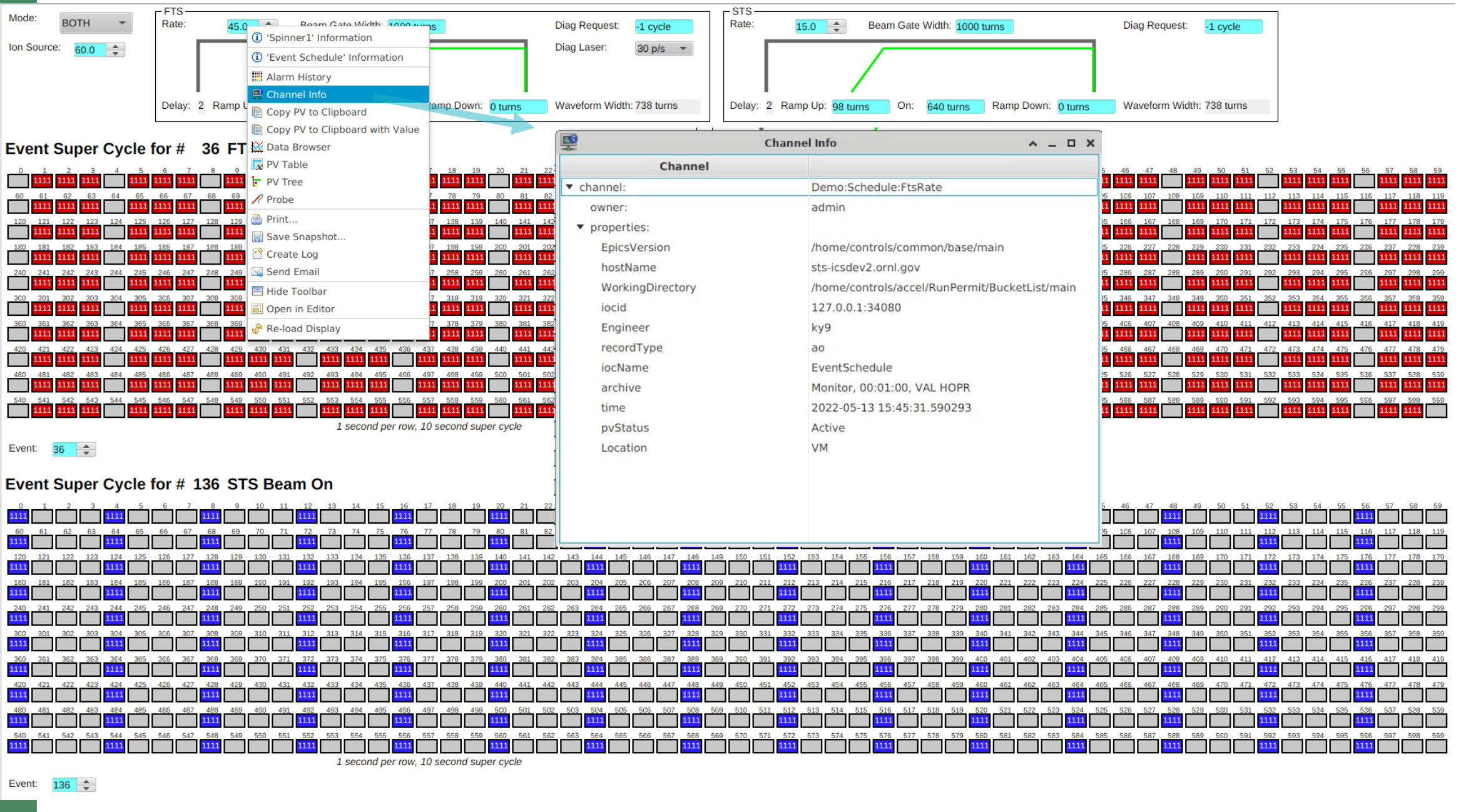
Name	Owner	cell	device	element	family	group0	group1	group2	group3	group4	group5	group6	group7	gr
SR:C001-VA:1{TMP}I-RB	testc	001	pump	vacuum	1	500	200	100	500	500	500	20	500	100
SR:C001-VA:1{IPC}On-Sw	testc	001	pump	vacuum	1	50	200	500	500	500	500	20	500	100
SR:C001-VA:2{TMP}OK-St	testc	001	pump	vacuum	2	5	100	500	20	0	100	500	20	100
SR:C001-VA:1{IPC}On-St	testc	001	pump	vacuum	1	200	500	0	50	500	0	20	500	100
SR:C001-VA:2{IPC}I-RB	testc	001	pump	vacuum	2	500	0	0	0	200	10	500	20	100
SR:C001-VA:1{TMP}On-Sw	testc	001	pump	vacuum	1	500	500	100	100	500	500	20	500	100
SR:C001-VA:2{IPC}OK-St	testc	001	pump	vacuum	2	500	500	50	500	0	200	500	20	100
SR:C001-VA:1{IPC}P-RB	testc	001	pump	vacuum	1	200	500	500	0	200	100	20	500	100
SR:C001-VA:1{IPC}I-RB	testc	001	pump	vacuum	1	500	50	500	100	500	100	20	500	100
SR:C001-VA:1{TMP}On-St	testc	001	pump	vacuum	1	500	500	500	500	100	500	20	500	100
SR:C001-VA:2{IPC}P-RB	testc	001	pump	vacuum	2	20	0	500	0	100	100	500	20	100
SR:C001-VA:1{IPC}OK-St	testc	001	pump	vacuum	1	500	500	500	100	0	500	20	500	100
SR:C001-VA:1{TMP}P-RB	testc	001	pump	vacuum	1	500	500	200	500	50	200	20	500	100
SR:C001-VA:2{TMP}I-RB	testc	001	pump	vacuum	2	500	50	100	500	500	200	500	20	100
SR:C001-VA:2{TMP}On-Sw	testc	001	pump	vacuum	2	100	500	50	500	200	500	500	20	100
SR:C001-VA:2{TMP}On-St	testc	001	pump	vacuum	2	0	500	0	500	100	500	500	20	100
SR:C001-VA:1{TMP}OK-St	testc	001	pump	vacuum	1	200	500	100	200	500	500	20	500	100
SR:C001-VA:2{IPC}On-Sw	testc	001	pump	vacuum	2	500	500	500	500	500	20	500	20	100
SR:C001-VA:2{IPC}On-St	testc	001	pump	vacuum	2	0	500	500	200	500	0	500	20	100
SR:C001-VA:2{TMP}P-RB	testc	001	pump	vacuum	2	500	500	0	500	200	500	500	20	100

Channel Table ×

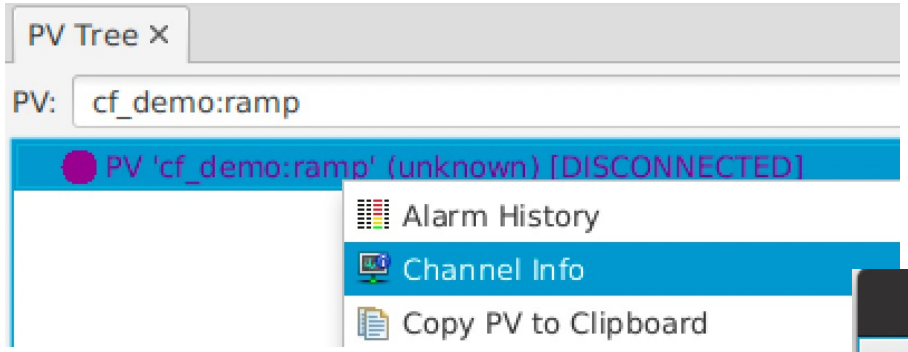
Query: SR:* device=pump

Name	Owner	cell	device	element	family	group0	group1	group2	group3	group4	group5	gr
SR:C001-VA:1{TMP}I-RB	testc	001	pump	vacuum	1	500	200	100	500	500	500	20
SR:C001-VA:1{IPC}On-Sw	testc	001	pump	vacuum	1	50	200	500	500	500	500	20
SR:C001-VA:2{TMP}OK-St	testc	001	pump	vacuum	2	5	100	500	20	0	100	50
SR:C001-VA:1{IPC}On-St	testc	001	pump	vacuum	1	200	500	0	50	500	0	20
SR:C001-VA:2{IPC}I-RB	testc	001	pump	vacuum	2	500	0	0	0	200	10	50
SR:C001-VA:1{TMP}On-Sw	testc	001	pump	vacuum	1	500	500	100	100	500	500	20
SR:C001-VA:2{IPC}OK-St	testc	001	pump	vacuum	2	500	500	50	500	0	200	50
SR:C001-VA:1{IPC}P-RB	testc	001	pump	vacuum	1	200	500	500	0	200	100	20
SR:C001-VA:1{IPC}I-RB	testc	001	pump	vacuum	1	500	50	500	100	500	100	20
SR:C001-VA:1{TMP}On-St	testc	001	pump	vacuum	1	500	500	500	500	100	500	20
SR:C001-VA:2{IPC}P-RB	testc	001	pump	vacuum	2	20	0	500	0	100	100	50
SR:C001-VA:1{IPC}OK-St	testc	001	pump	vacuum	1	500	500	500	100	0	500	20
SR:C001-VA:1{TMP}P-RB	testc	001	pump	vacuum	1	500	500	200	500	50	200	20
SR:C001-VA:2{TMP}I-RB	testc	001	pump	vacuum	2	500	50	100	500	500	200	50
SR:C001-VA:2{TMP}On-Sw	testc	001	pump	vacuum	2	100	500	50	500	200	500	50
SR:C001-VA:2{TMP}On-St	testc	001	pump	vacuum	2	0	500	0	500	100	500	50
SR:C001-VA:1{TMP}OK-St	testc	001	pump	vacuum	1	200	500	100	200	500	500	20
SR:C001-VA:2{IPC}On-Sw	testc	001	pump	vacuum	2	500	500	500	500	500	20	50
SR:C001-VA:2{IPC}On-St	testc	001	pump	vacuum	2	0	500	500	200	500	0	50
SR:C001-VA:2{TMP}P-RB	testc	001	pump	vacuum	2	500	500	0	500	200	500	50

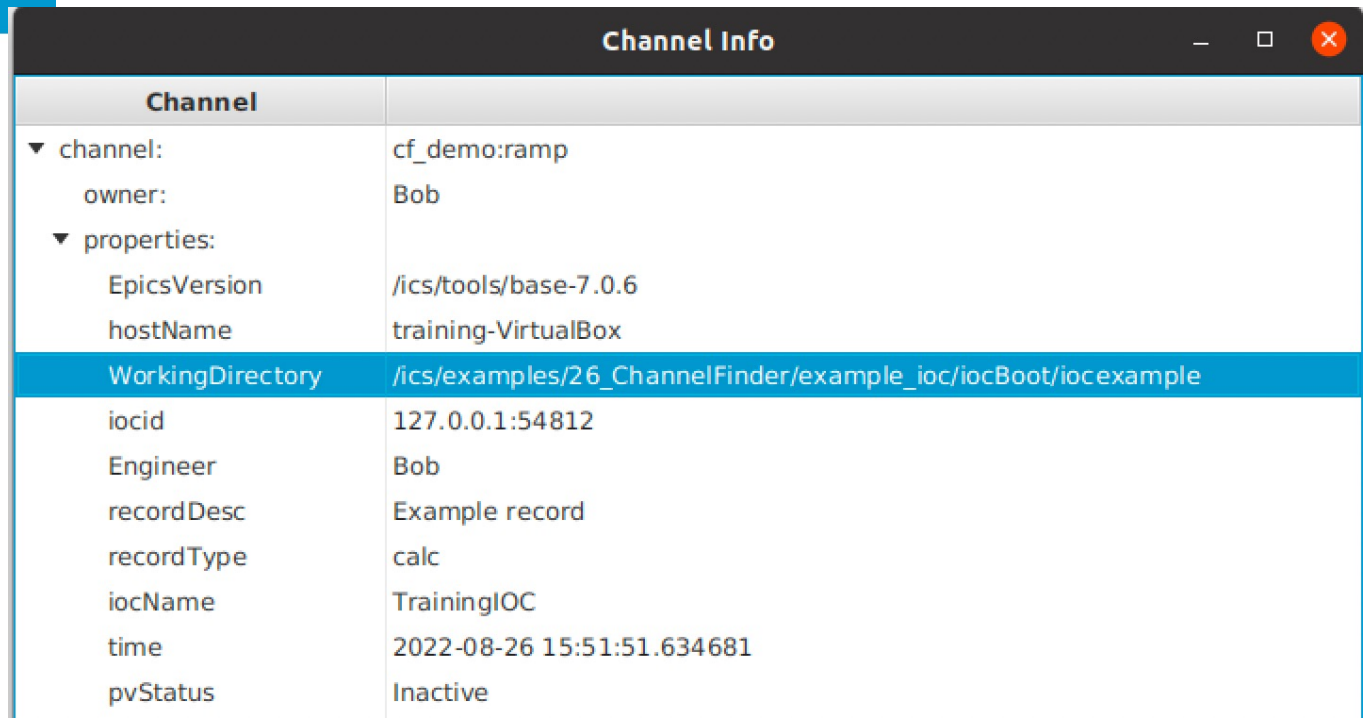
Integration



Especially useful for Disconnected Channels



- What IOC is supposed to provide this channel?
- When was IOC last seen?
- Who to contact?
- What host? Where on that host?



Create you own tools

- List all IOCs and their PV counts
- Create archive config

```
[ky9@sts-icsdev2 css]$ ./list_iocs.py
#   IOC                          PV Count
-----------------------------------------
  1 ics-gen-ioc-vacuum             28964
  2 scl-cryo-ioc-lxalrm-all         8555
  3 ics-opns-ioc-linux01            7709
  4 ics-hprf-ioc-linux-pwrlmt       5882
  5 tgt-he-ioc1                     5623
  6 chl-ioc-lxalrm-all              5591
  7 rtbt-diag-ioc-blm1              5212
  8 ccl-vac-ioc1                    5159
  9 ring-diag-ioc-blm4              5125
 10 ring-diag-ioc-blm3              5071
 11 ring-diag-ioc-blm1              5035
 12 ring-diag-ioc-blm2              4995
 13 ccl-diag-ioc-blm2               4601
 14 ccl-diag-ioc-blm1
 15 hebt-diag-ioc-blm2
 16 dtl-diag-ioc-blm1
 17 scl-diag-ioc-blm4
 18 dtl-hprf-ioc3
 19 scl-diag-ioc-blm1
 20 ring-hprf-ioc1
 21 scl-diag-ioc-blm2
 22 hebt-diag-ioc-blm1
 23 scl-diag-ioc-blm3
 24 scl-hprf-ioc09                  3458
 25 scl-hprf-ioc05                  3451
 26 scl-hprf-ioc12                  3432
 27 rfq-hprf-ioc1                   3430
 28 scl-hprf-ioc15                  3393
 29 scl-hprf-ioc21                  3389
 30 dtl-rccs-ioc1                   3363
 31 scl-hprf-ioc01                  3325
 32 scl-llrf-ioc01c                 3255
 33 scl-llrf-ioc03c                 3255
```

```
[ky9@sts-icsdev2 css]$ ./create_archive_config.py -ioc EventSchedule
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<engineconfig>
  <!-- IOC 'EventSchedule', name pattern '*' -->
  <group>
    <name>EventSchedule</name>
    <channel> <name>Demo:Schedule:FtsRate</name> <monitor/> <period>00:01:00</period> </channel>
    <channel> <name>Demo:Schedule:FtsRate.HOPR</name> <monitor/> <period>00:01:00</period> </channel>
    <channel> <name>Demo:Schedule:StsRate.</name> <scan/> <period>00:01:00</period> </channel>
  </group>
</engineconfig>
```

Elasticsearch: Count PVs

```
curl http://localhost:9200/channelfinder/_count?pretty
```

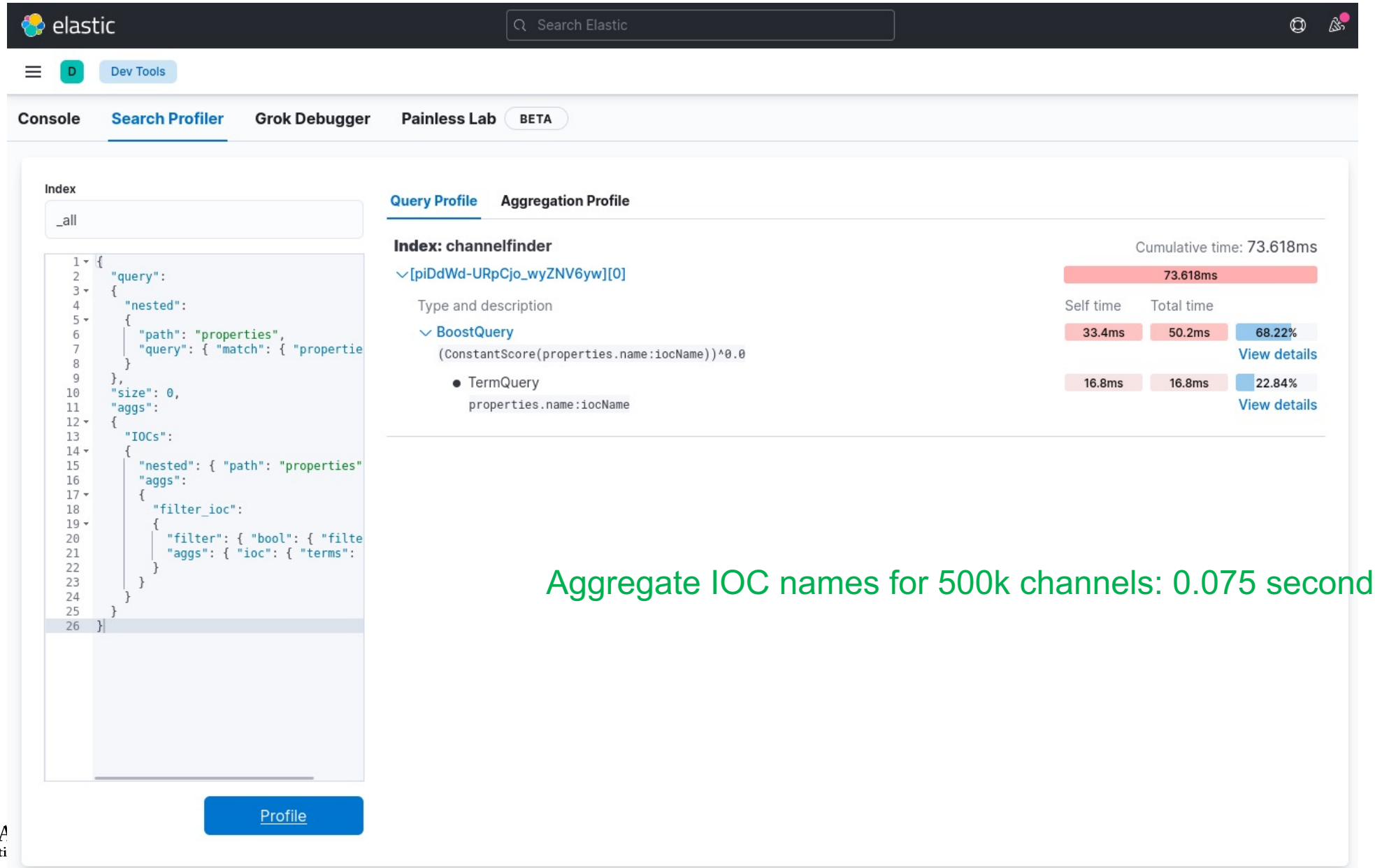
```
OK..
```

Elasticsearch: List IOCs

```
curl -XGET "http://localhost:9200/channelfinder/_search" -H 'Content-Type: application/json' -d'
{
  "query":
  {
    "nested":
    {
      "path": "properties",
      "query": { "match": { "properties.name": "iocName" } }
    }
  },
  "size": 0,
  "aggs":
  {
    "IOCs":
    {
      "nested": { "path": "properties" },
      "aggs":
      {
        "filter_ioc":
        {
          "filter": { "bool": { "filter": [ { "term": { "properties.name": "iocName" } } ] } },
          "aggs": { "ioc": { "terms": { "field": "properties.value", "size": 500 } } }
        }
      }
    }
  }
}'
```

Well…

But it's fast



Aggregate IOC names for 500k channels: 0.075 seconds

Python: Loop over all Channels, catalog IOCs, …

```python
# PV counts per IOC
iocs = dict()

# Hosts of IOCs
hosts = set()

# PV count
pvs = 0

# Helper for batching more than 10000 results
batch = None

while True:
    # Default result 'size' is 10, maximum 10000.
    # To get all results, keep fetching the next batch
    # via 'search_after', which is only supported when
    # using 'sort'. The pseudo-sort option "_doc" uses
    # the natural index order.
    result = es.search(index="channelfinder",
                       size=10000,
                       sort="_doc",
                       search_after=batch)
    batch = None
    for hit in result['hits']['hits']:
        data = hit['_source']
        name = data['name']
        ioc = getProperty(data, 'iocName')
        if ioc:
            if ioc in iocs:
                iocs[ioc] = iocs[ioc] + 1
            else:
                iocs[ioc] = 1
            pvs += 1
        host = getProperty(data, 'hostName')
        if host:
            hosts.add(host)
        # Does result include a token for 'search_after'?
        if "sort" in hit:
            batch = hit['sort']
    # Continue with the last batch token, or quit
    if batch is None:
        break
```

Nested structure

Loops over 500k PVs in about 10 seconds.

Questions

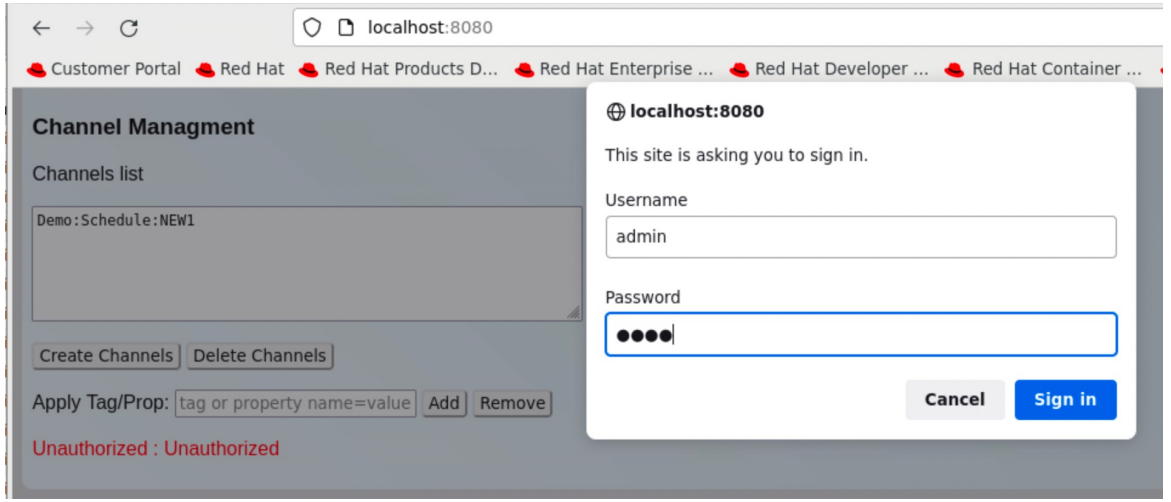
- What happens when a record is removed from an IOC?
  - It remains in the channel finder but as “Inactive”

Channel Table ×

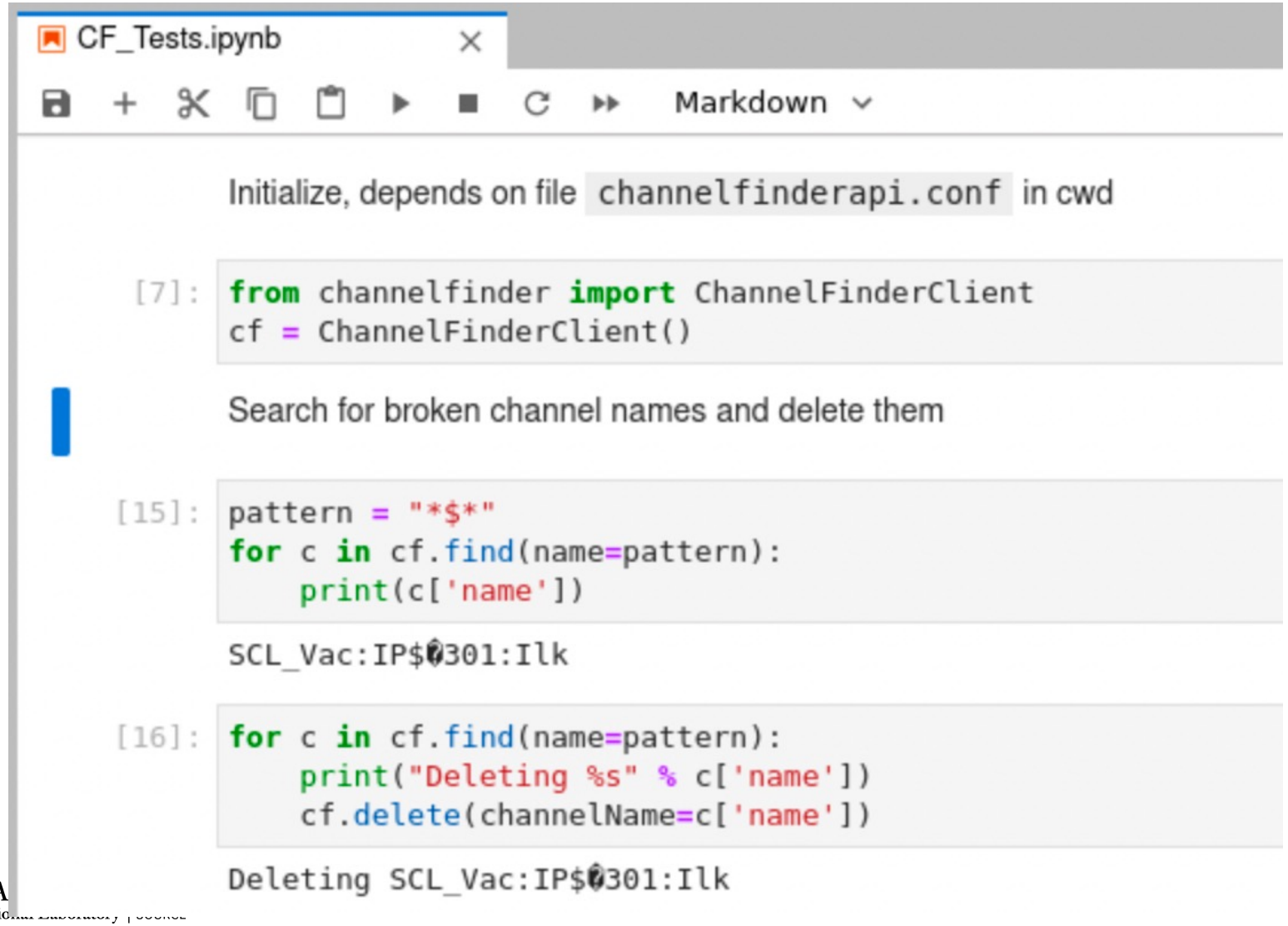
Query: Demo:* recordType=*

Name	iocName	pvStatus	Owner	Engineer	iocid
Demo:Schedule:FtsDiagLaserRate	EventSchedule	Active	admin	ky9	127.0.0.1:33536
Demo:Schedule:StsChopperRampDown	EventSchedule	Active	admin	ky9	127.0.0.1:33536
Demo:Schedule:FtsChopperProfileWidth	EventSchedule	Active	admin	ky9	127.0.0.1:33536
Demo:Schedule0:SelectedEventName	EventSchedule	Active	admin	ky9	127.0.0.1:33536
Demo:Schedule:StsChopperProfileWidth	EventSchedule	Active	admin	ky9	127.0.0.1:33536
Demo:Schedule:FtsDiagRequest	EventSchedule	Active	admin	ky9	127.0.0.1:33536
Demo:Schedule:StsChopperRampUp	EventSchedule	Active	admin	ky9	127.0.0.1:33536
Demo:Schedule0:EventCycle	EventSchedule	Active	admin	ky9	127.0.0.1:33536
Demo:Schedule:NEW1	EventSchedule	Inactive	admin	ky9	127.0.0.1:33282
Demo:Schedule:StsRate	EventSchedule	Active	admin	ky9	127.0.0.1:33536
Demo:Schedule1:SelectedEvent	EventSchedule	Active	admin	ky9	127.0.0.1:33536

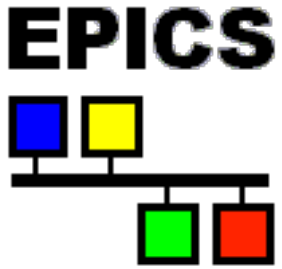
- How to really delete channel?
  - Web interface, …



Python Notebook Example



Channel Finder



- ✓Database of channels
- ✓IOCs can publish their records
  - ✓ With host name, contact person, ..
  - ✓ "Recceiver" tracks Active/Inactive PV status

→Easy name lookup in CS-Studio

→You may add other information and use in python scripts