

# Channel Finder

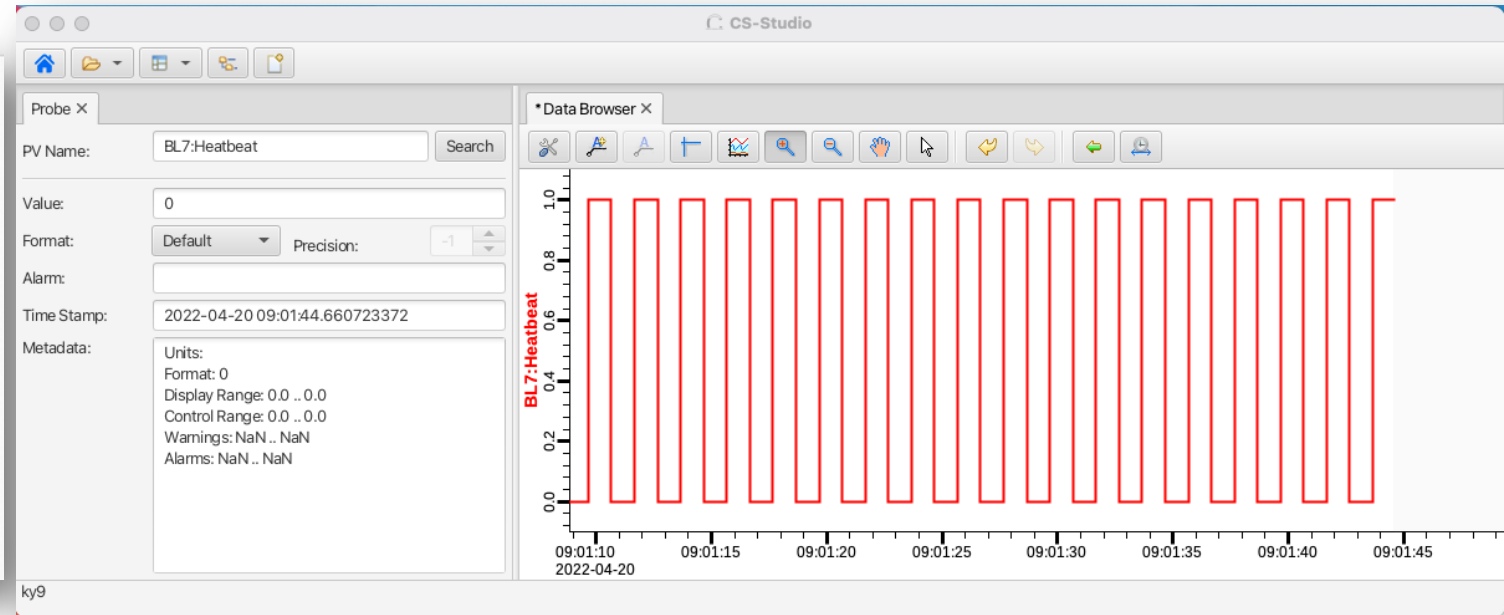
Kay Kasemir  
Aug. 2022

ORNL is managed by UT-Battelle, LLC for the US Department of Energy

# EPICS: Distributed & loosely coupled

```
[ky9@bl7-dassrv1 ~]$ cat new.db
record(calc, "BL7:Heatbeat")
{
  field(SCAN, "1 second")
  field(CALC, "!IVAL")
}

[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

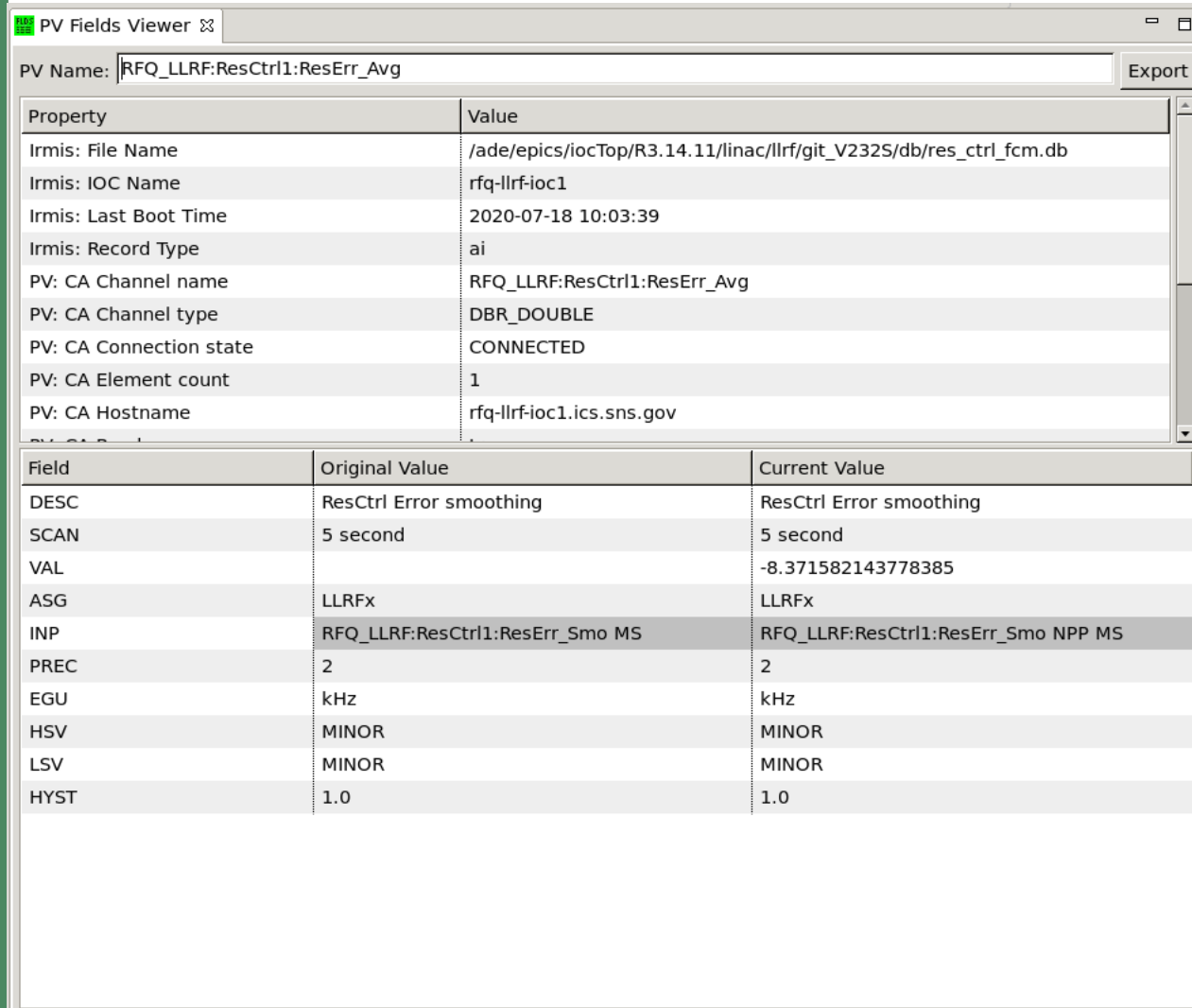
Start IOC → PVs are online

- No spell checker
- No “list all IOCs”, “list all PVs”

Like internet

- Chaos!
- Likely need some level of control...

# History: APS 'IRMIS', 'crawler'



The screenshot shows a window titled "PV Fields Viewer" with a search bar containing "RFQ\_LLRF:ResCtrl1:ResErr\_Avg" and an "Export" button. Below the search bar is a table of properties and values. At the bottom of the window is a table with three columns: "Field", "Original Value", and "Current Value".

Property	Value
Irmis: File Name	/ade/epics/iocTop/R3.14.11/linac/lrf/git_V232S/db/res_ctrl_fcm.db
Irmis: IOC Name	rfq-llrf-ioc1
Irmis: Last Boot Time	2020-07-18 10:03:39
Irmis: Record Type	ai
PV: CA Channel name	RFQ_LLRF:ResCtrl1:ResErr_Avg
PV: CA Channel type	DBR_DOUBLE
PV: CA Connection state	CONNECTED
PV: CA Element count	1
PV: CA Hostname	rfq-llrf-ioc1.ics.sns.gov

Field	Original Value	Current Value
DESC	ResCtrl Error smoothing	ResCtrl Error smoothing
SCAN	5 second	5 second
VAL		-8.371582143778385
ASG	LLRFx	LLRFx
INP	RFQ_LLRF:ResCtrl1:ResErr_Smo MS	RFQ_LLRF:ResCtrl1:ResErr_Smo NPP MS
PREC	2	2
EGU	kHz	kHz
HSV	MINOR	MINOR
LSV	MINOR	MINOR
HYST	1.0	1.0

- 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

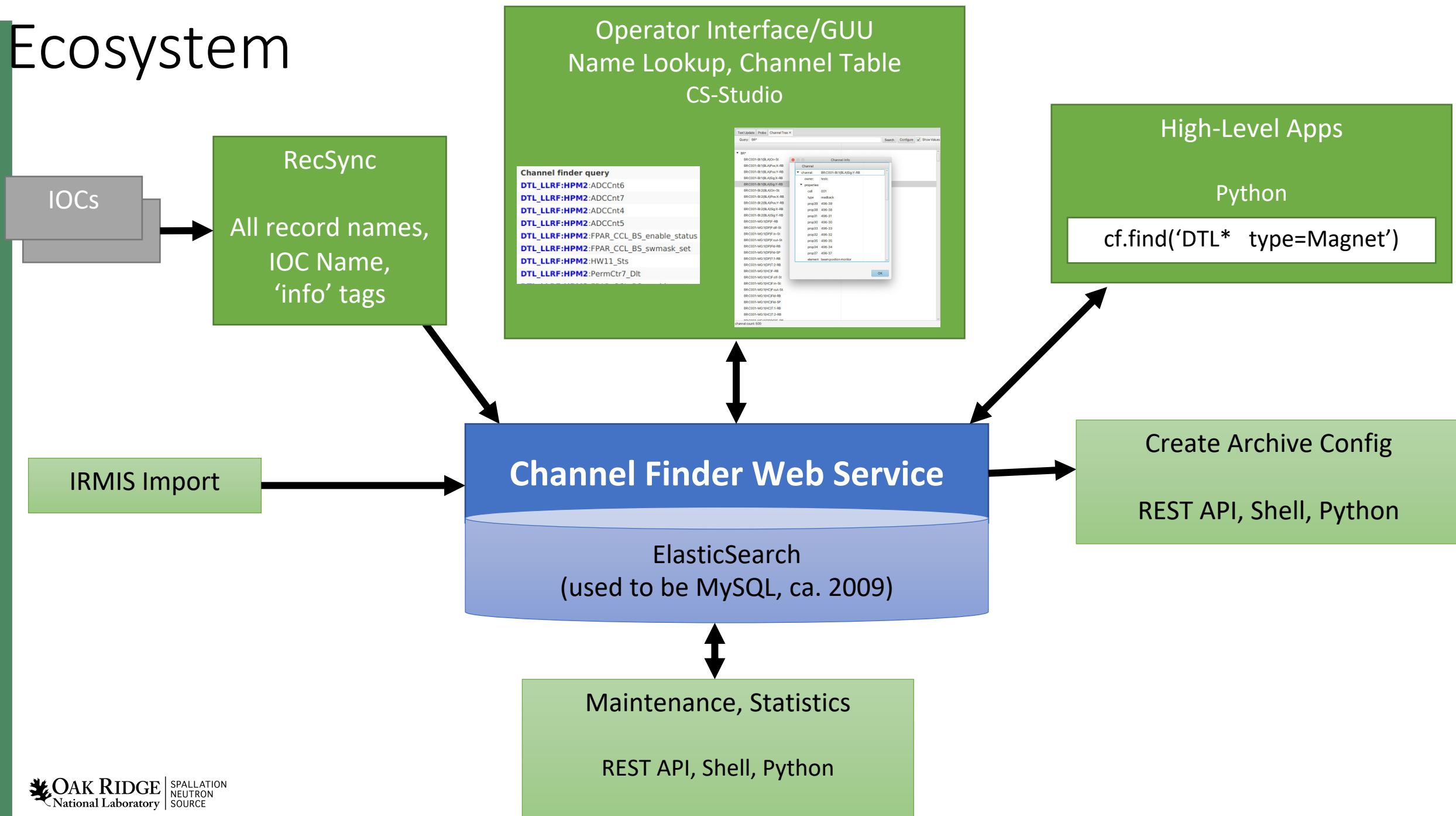
# Channel Finder 101

- 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



# 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 Receiver
4. Instrument IOCs to publish their records

In training setup, see [/ics/examples/26\\_ChannelFinder](/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

Probe X

PV Name: cf\_

Value: cf\_demo:ramp

Format: Local PV  
loc://name<VType>(initial value...)

Alarm: PV Access PV

Time Stamp: pva://cf\_

Metadata: pva://cf\_/subfield  
pva://cf\_/subfield/subelement

Formula  
=2\*`pv\_name`

Channel finder query  
cf\_demo:ramp

PVs from example IOC

Probe X

PV Name: SR:

Value: loc://name<VType>(initial value...)

Format: Formula  
=2\*`pv\_name`

Alarm: Channel finder query

Time Stamp: SR:C001-PS:2 {QDP:D} F-St

Metadata: SR:C001-PS:1 {DP} Gnd-St  
SR:C001-VA:2 {IPC} I-RB  
SR:C001-PS:2 {QDP:D} Val-St  
SR:C001-PS:3 {QDP:D} OK-St  
SR:C001-PS:4 {QDP:D} OK-St  
SR:C001-PS:1 {QDP:S} Rst-Cmd  
SR:C001-PS:5 {QDP:D} OK-St  
SR:C001-VA:4 {VGC} P-RB  
SR:C001-BI:4 {BLA} Pos:Y-RB  
SR:C001-MG:2 {VC:F} T-RB  
SR:C001-PS:4 {HC:S} Acc-St  
SR:C001-PS:5 {HC:S} Gnd-St  
SR:C001-PU:T36 {TC} T:2-RB  
SR:C001-BI:2 {BHS} Pos:Y-RB  
SR:C001-PS:5 {HC:S} Acc-St  
SR:C001-MG:1 {HC:S} Fld-RB  
SR:C001-MG:2 {HC:S} Fld-RB  
SR:C001-PS:3 {QDP:F} Acc-St  
SR:C001-PS:4 {QDP:D} I-RB

Channel Finder demo channels



# CS-Studio: Channel 'Table'

More elaborate demo data from BNL

Channel Table x

Query: \*

Search

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	1	100	100	500	200	500	500	200	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 quadrupole	2	100	100	500	200	500	500	200	500	500	0	booster	inside	103-20	103-21	103-22	103-23
SR:C001-VA:2{IPC}I-RB	testc	001	pump	vacuum	2	20	100	500	200	500	500	200	500	500	0	storage ring	center	721-20	721-21	721-22	721-23
SR:C001-PS:2{QDP:D}Val-St	testc	001	power supply	defocusing quadrupole	2	500	500	100	500	50	500	500	200	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 quadrupole	3	500	500	100	500	50	500	500	200	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 quadrupole	4	200	500	100	500	50	500	500	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	1	500	500	100	500	50	500	500	200	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 quadrupole	5	500	500	100	500	50	500	500	200	500	0	storage ring	center	74-20	74-21	74-22	74-23
SR:C001-VA:4{VGC}P-RB	testc	001	gauge	vacuum	4	20	100	500	200	500	500	200	500	500	0	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	4	0	0	500	200	500	500	200	500	500	0	storage ring	center	987-20	987-21	987-22	987-23
BR:C001-PS:2{QDP:D}F-St	testc	001	power supply	defocusing quadrupole	2	200	500	100	500	50	500	500	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 corrector	2	50	200	500	200	500	500	200	500	500	0	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 corrector	4	500	500	200	500	200	500	200	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 corrector	5	100	500	200	500	200	500	200	500	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	36	0	50	500	200	500	500	200	500	500	0	storage ring	inside	815-20	815-21	815-22	815-23
BR:C001-VA:1{TMP}P-RB	testc	001	pump	vacuum	1	500	500	200	500	200	500	200	500	500	0	booster	center	432-20	432-21	432-22	432-23
SR:C001-BI:2{BHS}Pos:Y-RB	testc	001	bpm	high stability BPM	2	0	0	500	200	500	500	200	500	500	0	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 corrector	5	100	500	200	500	200	500	200	500	500	0	storage ring	center	429-20	429-21	429-22	429-23
SR:C001-MG:1{HC:S}Fld-RB	testc	001	magnet	horizontal slow corrector	1	500	500	200	500	200	500	200	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 corrector	2	100	500	200	500	200	500	200	500	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	3	500	500	100	500	500	500	100	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	3	500	500	100	500	500	500	20	500	500	200	storage ring	center	464-20	464-21	464-22	464-23
SR:C001-PS:4{QDP:D}I-RB	testc	001	power supply	defocusing quadrupole	4	200	500	100	500	50	500	500	200	500	0	storage ring	center	167-20	167-21	167-22	167-23
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

Channel Info

Channel

- channel: SR:C001-VA:4{VGC}P-RB
- owner: testc
- properties:
  - cell: 001
  - type: readback
  - prop39: 703-39
  - prop38: 703-38
  - prop31: 703-31
  - prop30: 703-30
  - prop33: 703-33
  - prop32: 703-32
  - prop35: 703-35
  - prop34: 703-34
  - prop37: 703-37
  - element: vacuum
  - prop36: 703-36
  - group8: 100
  - group7: 20
  - group9: 500
  - group4: 500





# Integration

Mode: BOTH  
Ion Source: 60.0

FTS  
Rate: 45.0  
Beam Gate Width: 1000 turns  
Diag Request: -1 cycle  
Diag Laser: 30 p/s

Delay: 2 Ramp Up: 0 turns Ramp Down: 0 turns Waveform Width: 738 turns

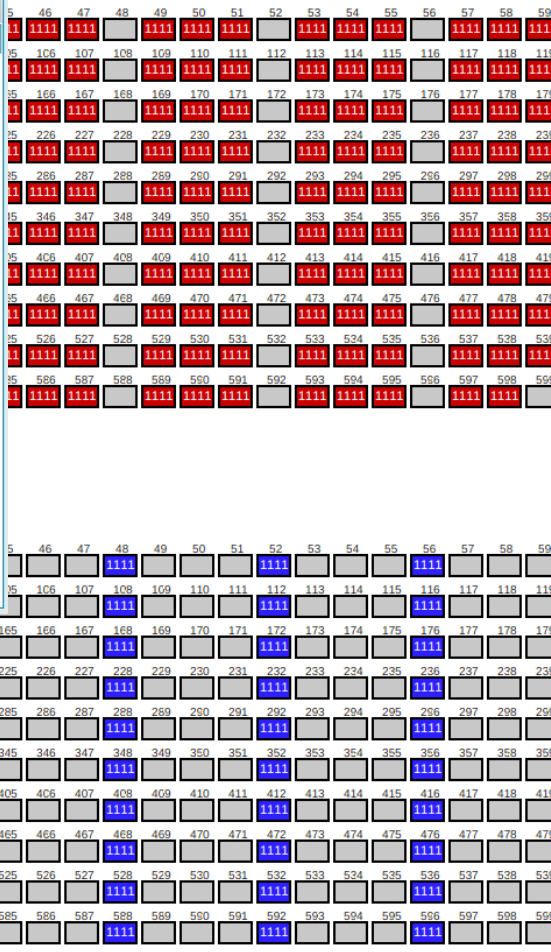
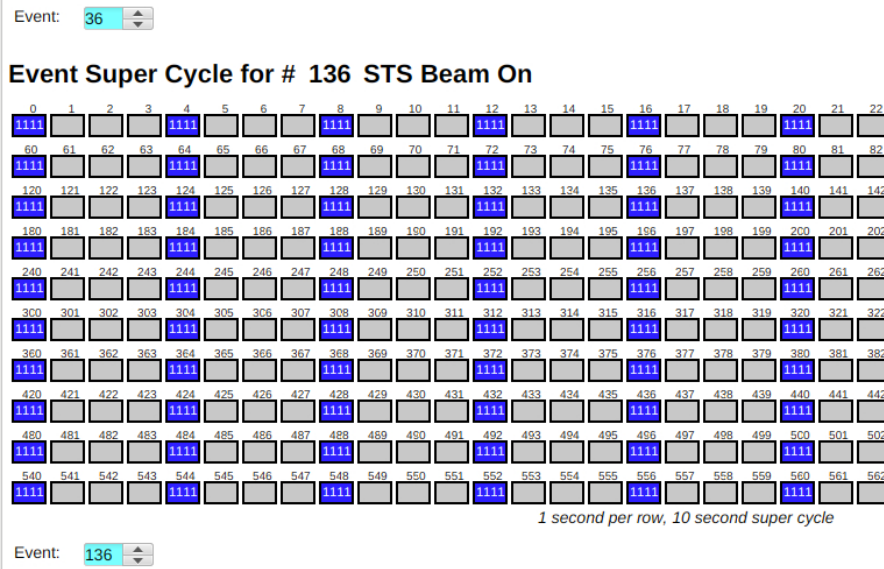
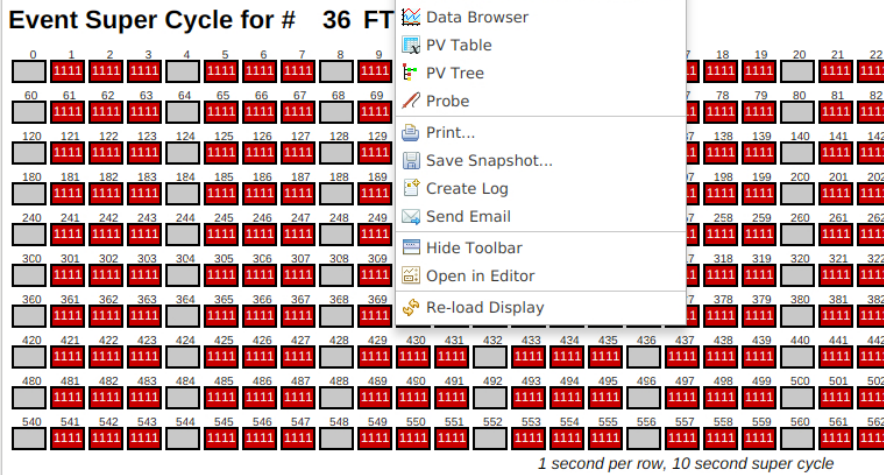
STS  
Rate: 15.0  
Beam Gate Width: 1000 turns  
Diag Request: -1 cycle

Delay: 2 Ramp Up: 98 turns On: 640 turns Ramp Down: 0 turns Waveform Width: 738 turns

- 'Spinner1' Information
- 'Event Schedule' Information
- Alarm History
- Channel Info
- Copy PV to Clipboard
- Copy PV to Clipboard with Value
- Data Browser
- PV Table
- PV Tree
- Probe
- Print...
- Save Snapshot...
- Create Log
- Send Email
- Hide Toolbar
- Open in Editor
- Re-load Display

### Channel Info

Channel	
channel:	Demo:Schedule:FtsRate
owner:	admin
properties:	
EpicsVersion	/home/controls/common/base/main
hostName	sts-icsdev2.ornl.gov
WorkingDirectory	/home/controls/accel/RunPermit/BucketList/main
iocid	127.0.0.1:34080
Engineer	ky9
recordType	ao
iocName	EventSchedule
archive	Monitor, 00:01:00, VAL HOPR
time	2022-05-13 15:45:31.590293
pvStatus	Active
Location	VM





# Especially useful for Disconnected Channels

The screenshot shows a window titled "PV Tree X" with a search bar containing "PV: cf\_demo:ramp". Below the search bar, a red bar indicates the status: "PV 'cf\_demo:ramp' (unknown) [DISCONNECTED]". A context menu is open over this entry, showing three options: "Alarm History", "Channel Info", and "Copy PV to Clipboard".

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

The "Channel Info" dialog box displays the following information:

Channel	
channel:	cf_demo:ramp
owner:	Bob
properties:	
EpicsVersion	/ics/tools/base-7.0.6
hostName	training-VirtualBox
WorkingDirectory	/ics/examples/26_ChannelFinder/example_ioc/iocBoot/iocexample
iocid	127.0.0.1:54812
Engineer	Bob
recordDesc	Example record
recordType	calc
iocName	TrainingIOC
time	2022-08-26 15:51:51.634681
pvStatus	Inactive

# Create you own tools

```
[ky9@sts-icsdev2 css]$ ./list_iocs.py
# IOC PV Count
-----
1 ics-gen-ioc-vacuum 28964
2 scl-cryo-ioc-lxalarm-all 8555
3 ics-opns-ioc-linux01 7709
4 ics-hprf-ioc-linux-pwrlmt 5882
5 tgt-he-iocl 5623
6 chl-ioc-lxalarm-all 5591
7 rtbt-diag-ioc-blm1 5212
8 ccl-vac-iocl 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-iocl
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-iocl 3430
28 scl-hprf-ioc15 3393
29 scl-hprf-ioc21 3389
30 dtl-rccs-iocl 3363
31 scl-hprf-ioc01 3325
32 scl-llrf-ioc01c 3255
33 scl-llrf-ioc03c 3255
```

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

```
[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

The screenshot shows the Elastic Search Profiler interface. The top navigation bar includes the Elastic logo, a search bar, and user icons. Below the navigation bar are tabs for Console, Search Profiler (active), Grok Debugger, Painless Lab, and BETA. The main content area is divided into two sections: a query editor on the left and a query profile on the right.

**Index:** `_all`

```
1 {
2   "query":
3   {
4     "nested":
5     {
6       "path": "properties",
7       "query": { "match": { "propertie
8     }
9   },
10  "size": 0,
11  "aggs":
12  {
13    "IOCs":
14    {
15      "nested": { "path": "properties"
16      "aggs":
17      {
18        "filter_ioc":
19        {
20          "filter": { "bool": { "filte
21          "aggs": { "ioc": { "terms":
22        }
23      }
24    }
25  }
26 }
```

**Query Profile** | **Aggregation Profile**

**Index: channelfinder** Cumulative time: 73.618ms

▼ `[piDdWd-URpCjo_wyZNV6yw][0]`

Type and description

▼ **BoostQuery** 73.618ms

`(ConstantScore(properties.name:iocName))^0.0`

Self time	Total time	Percentage	Action
33.4ms	50.2ms	68.22%	<a href="#">View details</a>
16.8ms	16.8ms	22.84%	<a href="#">View details</a>

● **TermQuery**

`properties.name:iocName`

[Profile](#)

Aggregate IOC names for 500k channels: 0.075 seconds



# Python: Loop over all Channels, catalog IOCs, ...

```
# 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
```

Loops over 500k PVs in about 10 seconds.

Nested structure

# Questions

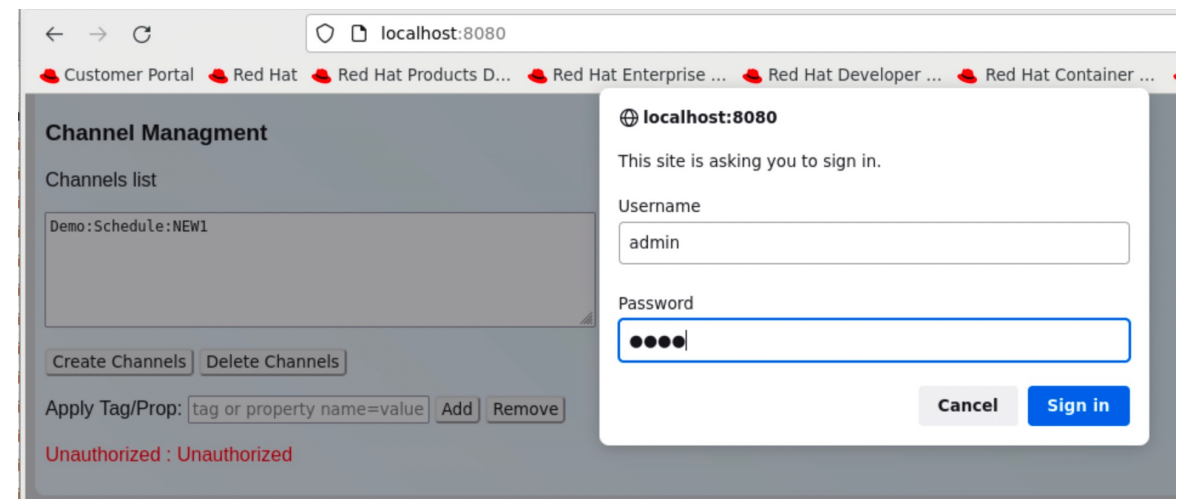
- What happens when a record is removed from an IOC?
  - It remains in the channel finder but as “Inactive”

Channel Table X

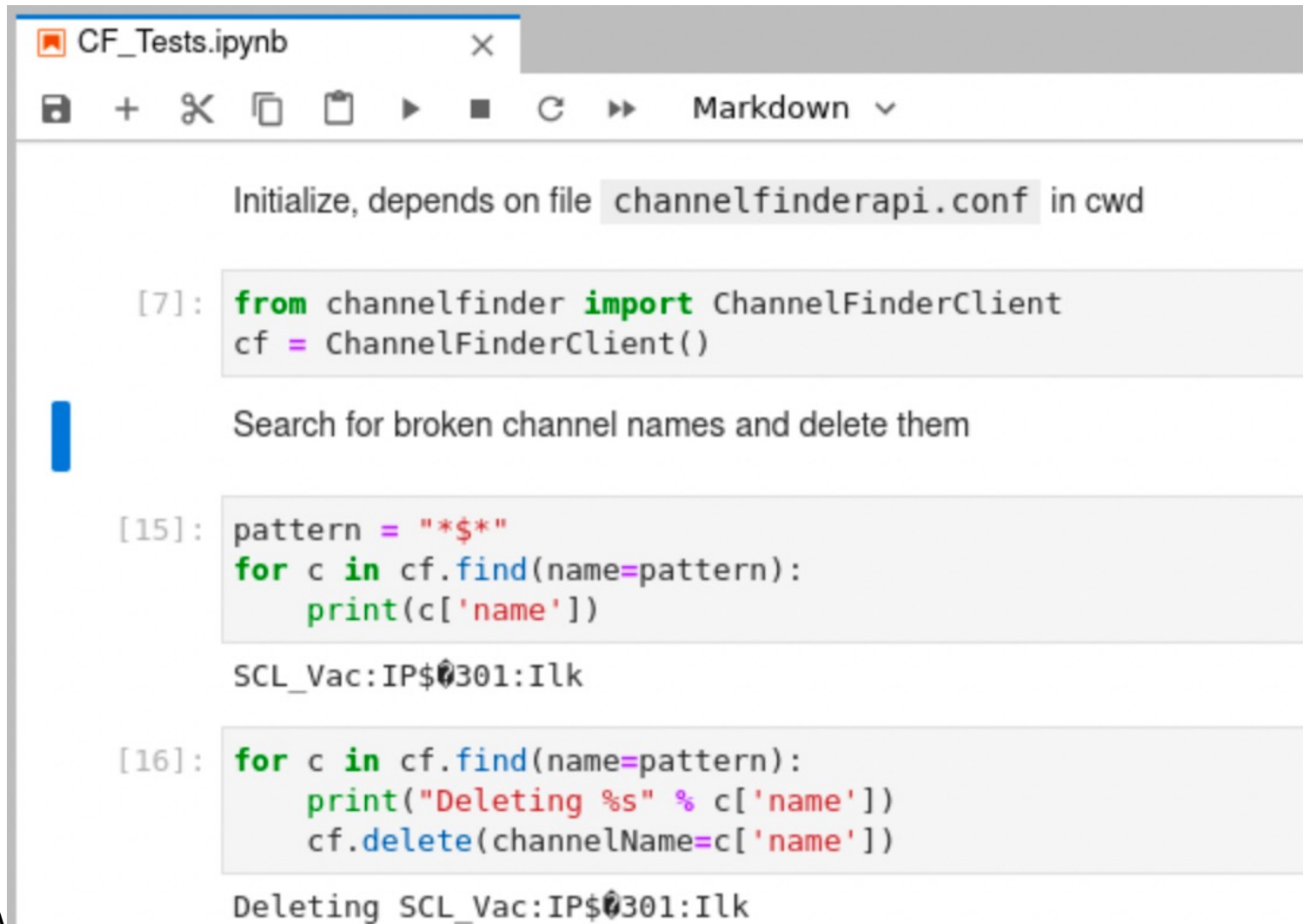
Query: Demo:\* recordType=\*

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



```
CF_Tests.ipynb x
+ ✂ 📄 ▶ ■ ↻ ⏩ Markdown v

Initialize, depends on file channelfinderapi.conf in cwd

[7]: from channelfinder import ChannelFinderClient
     cf = ChannelFinderClient()

Search for broken channel names and delete them

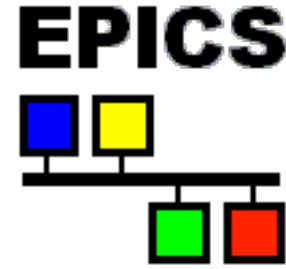
[15]: pattern = "$*"
      for c in cf.find(name=pattern):
          print(c['name'])

SCL_Vac:IP$0301:Ilk

[16]: for c in cf.find(name=pattern):
      print("Deleting %s" % c['name'])
      cf.delete(channelName=c['name'])

Deleting SCL_Vac:IP$0301:Ilk
```

# Channel Finder



- ✓ Database of channels
- ✓ IOCs can publish their records
  - ✓ With host name, contact person, ..
  - ✓ "Receiver" tracks Active/Inactive PV status
  
- Easy name lookup in CS-Studio
- You may add other information and use in python scripts