CMIDAQ DEVELOPMENT: TINE + PYTHON.

- WHY WE GO FOR PYTHON.

- TINE CLIENT - GUI IN PYTHON

IGOR RUBINSKIY, CFEL/UHH/CUI CONTROLLED MOLECULE IMAGING GROUP

8.06.2015, DESY, TINE USERS MEETING

WHAT DO WE NEED ON THE CMI DAQ SIDE 1/2

- Full (remote) control over the Hardware Units:
    - Digitiser (upto 400 MB/s uncompressed)
        - data reduction on CPU/server: pedestal substraction, peak finder (Time, Signal Integral)
    - Pixel Camera (1 Mpixel, 12 bit, 120 fps - 180 MB/s uncompressed)
        - data reduction on CPU/server: blob finder, centroiding (x,y, amplitude)
    - plenty of “slow” devices: Delay Generator, Translation/Rotation stages, Temperature, Humidity, Vacuum sensors.
    - quick-device-implementation interface
- Easy device selection, configuration, and data storage/access, tree structure:
    - practical need: prepare a list of “step-by-step” instructions = how the group of detectors can do a multi-dimensional scan over two (standard scan) or more parameters - a la “shoot-and-forget”
    - data storage format and mechanism is not critical (preference to HDF5), but we want to move high level analysis tools as close as possible to the beginning of the data acquisition chain - rich graphics (!)

WHAT DO WE NEED ON THE CMI DAQ SIDE 2/2

- centralised control system over many experiments in the labs
  - safety nets and provisions for device moves without cross-talks between setups, but not being "difficult"
- 1 user friendly GUI for a variety of experiments
  - plenty high-level data analysis including graphical input and output
  - 2D and nD histograms, projections, slices
  - gates, signal expressions (math),
- user defined scans:
  - multi-dimenstional scans (iterative acquisition, small increments of single parameter)
  - user extensibility (should be easy for students to add new functional)
  - secondary analysis

PYTHON:

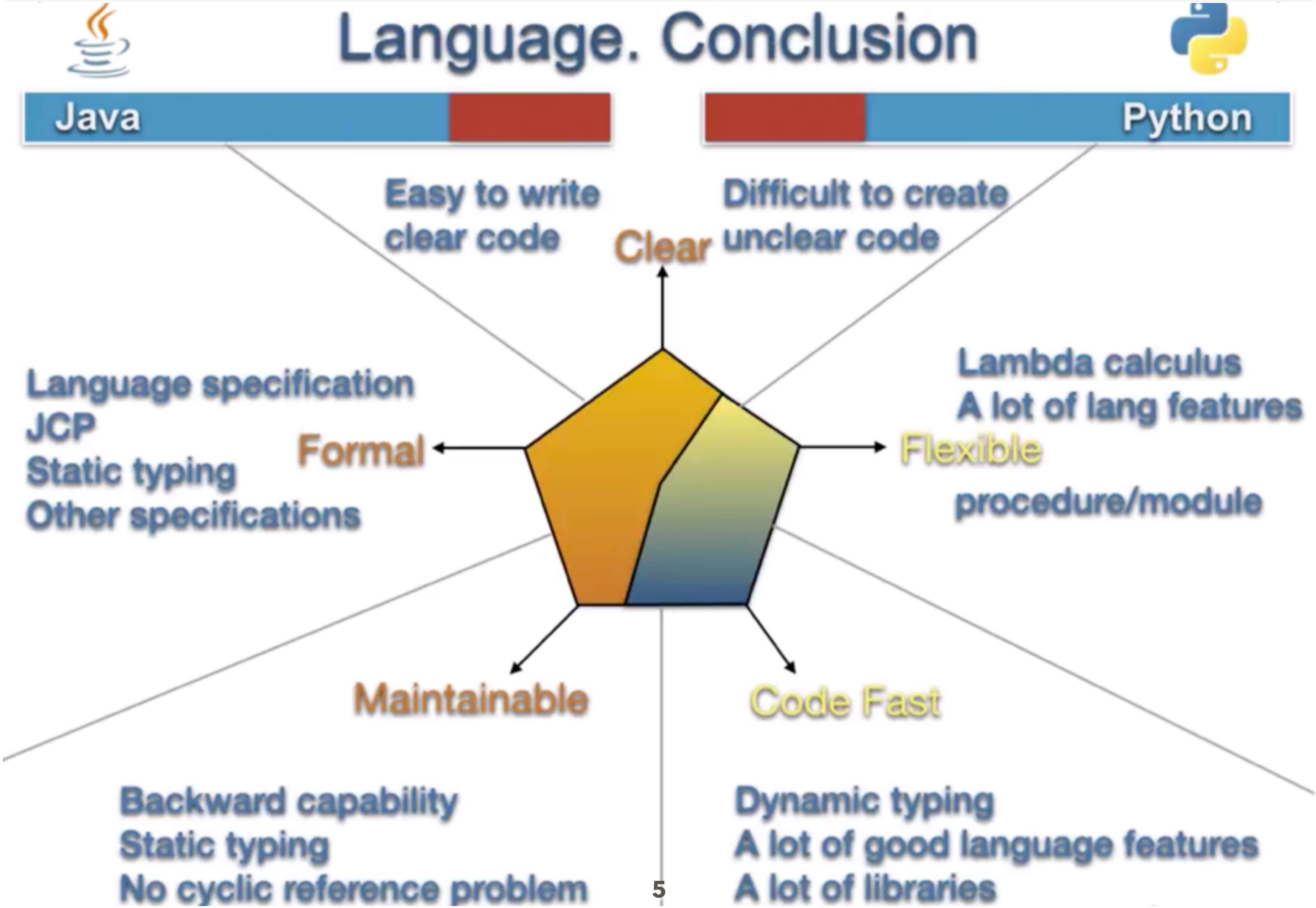
Interpreted & Object oriented,
High-level built-in data structures
Dynamic typing & dynamic binding
- is acknowledged for Prototyping, Rapid Application Development, scripting, and "glue" language to bring different components together

In general the syntax is simple and easy to learn (good for students!)
The syntax rules force one to write clear and readable code
- reduces the maintenance cost

Python code is built around modules and packages
- encourages program modularity and code re-use

Exception-based error handling
Extensive standard libraries and large variety of third-party modules for virtually every task
Embeddable within applications as a scripting/interactive interface

NEXT FEW SLIDES FROM
ALEXANDR BYKOVSKY “JAVA VS PYTHON PLATFORMS COMPARISON”



Coding. Crawler

Java

```java
public class CrawlerExample {

    public static void main(String[] args) throws IOException {
        PrintWriter textFile = null;
        try {
            textFile = new PrintWriter("result.txt");
            System.out.println("Enter the URL you wish to crawl..");
            System.out.print("@> ");
            String myUrl = new Scanner(System.in).nextLine();

            String response = getContentByUrl(myUrl);

            Matcher matcher = Pattern
              .compile("href=[\"'](.[^\"']+)[\"']").matcher(response);
            while (matcher.find()) {
                String url = matcher.group(1);
                System.out.println(url);
                textFile.println(url);
            }
        } finally {
            if(textFile != null) {
                textFile.close();
            }
        }
    }

    private static String getContentByUrl(String myUrl)
              throws IOException {
        URL url = new URL(myUrl);
        URLConnection urlConnection = url.openConnection();
        BufferedReader in = null;
        StringBuilder response = new StringBuilder();
        try {
            in = new BufferedReader(new InputStreamReader
              (urlConnection.getInputStream()));
            String inputLine;
            while ((inputLine = in.readLine()) != null) {
                response.append(inputLine);
            }
        } finally {
            if(in != null) {
                in.close();
            }
        }
        return response.toString();
```

Python

```python
if __name__ == '__main__':
    with open("result.txt","wt") as textFile:
        print("Enter the URL you wish to crawl..")
        myUrl = input("@> ")
        for i in re.findall("href=[\"'](.[^\"']+)[\"']",
            urllib.request.urlopen(myUrl).read().decode(), re.I):
            print(i)
            textFile.write(i+'\n')
```

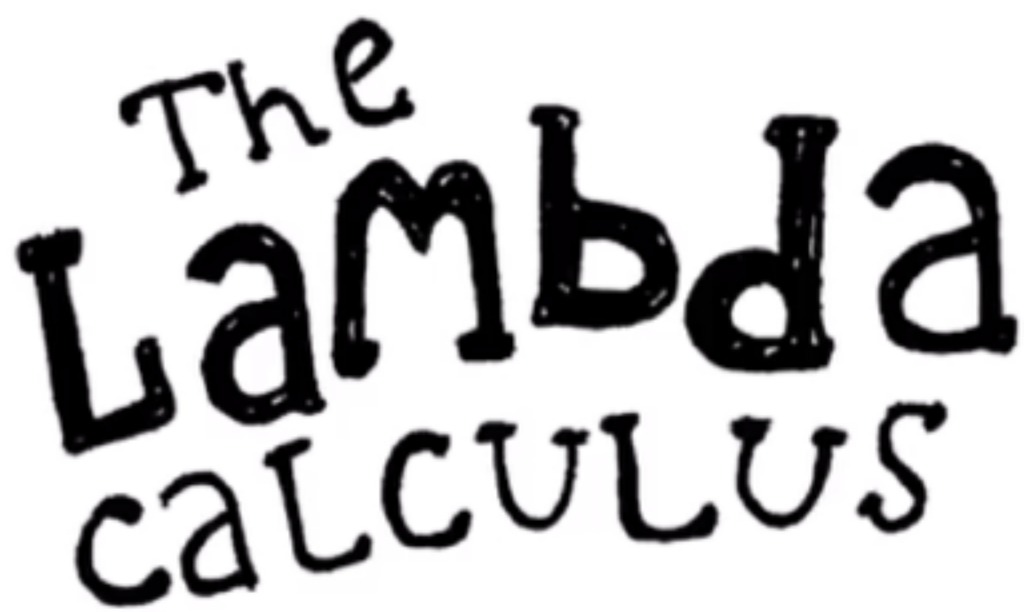
Coding. Functional programming

Java

```java
public class CommandPatternExample {

    public static void main(String[] args) {
        Executor executor = new Executor();
        executor.execute(new Command() {
            @Override
            public void execute(int parameter) {
                System.out.println(parameter + parameter);
            }
        });
    }
}

class Executor {
    private int parameter = 100;
    public void execute(Command command) {
        if(command != null) {
            command.execute(parameter);
        }
    }
}

interface Command {
    public void execute(int parameter);
}
```

Python

```python
class Executor:
    parameter = 100
    def execute(self, command):
        if command is not None:
            command(self.parameter)

if __name__ == '__main__':
    executor = Executor()
    executor.execute(lambda parameter: print(parameter + parameter))
```



Coding. Functional programming

Java

```
def win(arr):
    chars = list(set(arr))
    if len(chars) == 1 and chars[0] != '.':
            return chars[0]
    return '.'

def checkio(game_result):
    game_lines = []

    for i in range(3):
        horizontal_line = game_result[i]
        game_lines.append(horizontal_line)

    for i in range(3):
        vertical_line = [game_result[x][i] for x in range(3)]
        game_lines.append(vertical_line)

    diagnoal_right = [game_result[0][0], game_result[1][1],
       game_result[2][2]]
    game_lines.append(diagnoal_right)

    diagnoal_left = [game_result[2][0], game_result[1][1],
       game_result[0][2]]
    game_lines.append(diagnoal_left)

    for line in game_lines:
        w = win(line)
        if w != '.': return w

    return 'D'
```

Python

```
checkio=lambda r,j="".join:"DOX"[sum(m*3in[j(r[::e])[::4]for e
in(1,-1)]+r+list(map(j,zip(*r)))for m in"XOX")]
```

Solutions for "Xs and Os Referee". Lambda hell like RegEx

Coding. Functional programming

Java

```java
for(Iterator<Product> iter = list.iterator(); iter.hasNext();) {
    Product product = iter.next();
    if(product.isDeleted()) {
        iter.remove();
    }
}

double price = 0.0;
for (Product product : productList) {
    price += product.getPrice() * product.getQuantity();
}

Point[] f = new Point[]{new Point(1,2), new Point(3,4), new Point(5,6)};
double h = 0.0;
for (Point p : f) {
    h += Math.sqrt(p.x*p.x+p.y*p.y);
}
```

Python

```python
filter(lambda product: product.deleted == False, productList)

reduce((lambda p1, p2: p1 + p2),
       map(lambda product: product.price*product.qty, productList))

f = [(1,2), (3,4), (5,6)]
h = reduce(lambda x,y: x+y, [math.sqrt(x*x+y*y) for x,y in f])
```

Look ma, no loop!

Parallelism. Multiprocessing

Java

```
final BlockingQueue<SomeObject> queue
     = new LinkedBlockingQueue<>();

new Thread(new Runnable() {
    @Override
    public void run() {
        queue.add(new SO(42, null, "hello"));
    }
}).start();

try {
    System.out.println(queue.take());
} catch (InterruptedException e) {
    throw new RuntimeException(e);
}
```

Python

```
def f(q):
    q.put([42, None, 'hello'])

if __name__ == '__main__':
    q = Queue()
    p = Process(target=f, args=(q,))
    p.start()
    print(q.get())
    p.join()
```

Output:

```
[42, None, 'hello']
```

```
[42, None, 'hello']
```

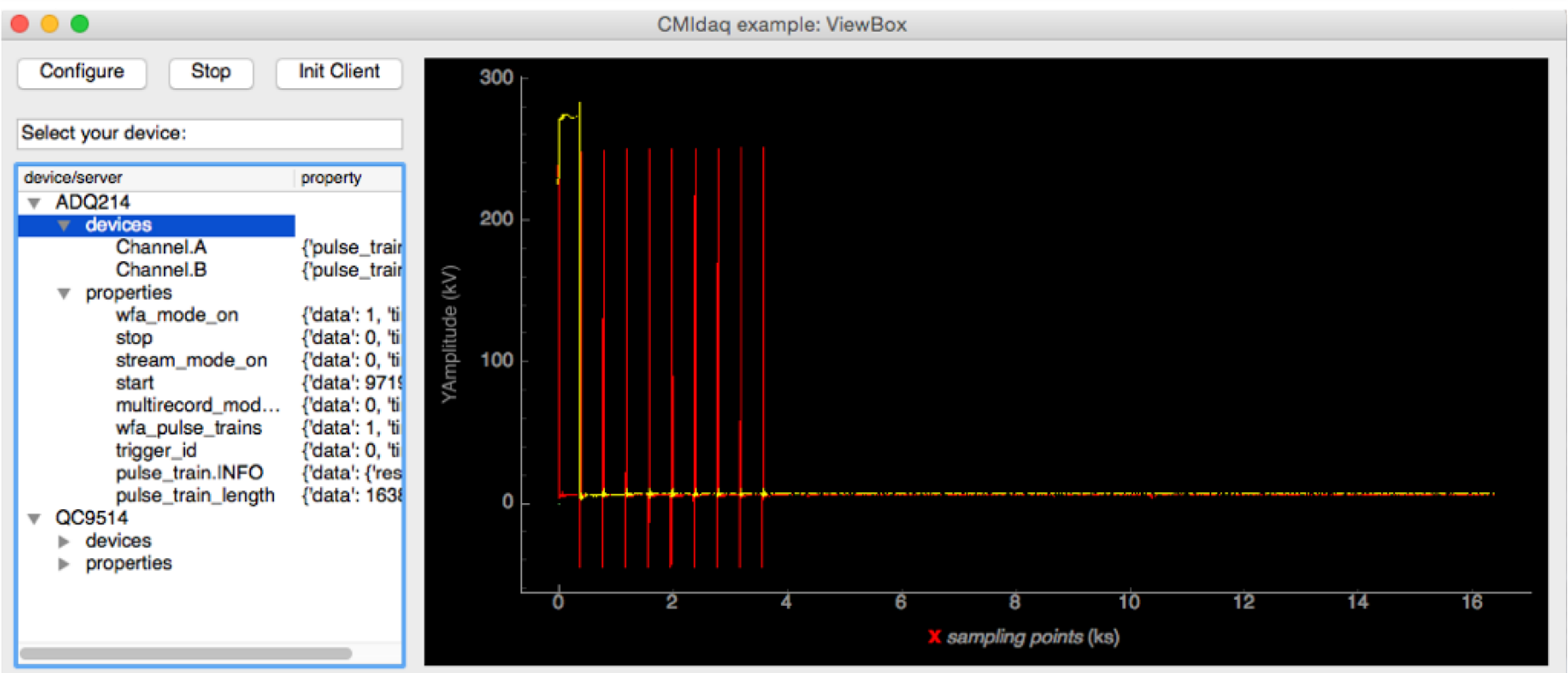
PYQTGRAPH

PURE PYTHON
GUI AND GRAPHICS
BASED ON QT AND NUMPY

SUPPORTED ON:
WINDOWS
LINUX
MACOS

GUI USING PYQTGRAPH / VIRTUAL SCOPE

- Digitiser TineServer at 10 Hz (two channels) are sending a pulse 16384 (x4 byte, x2 channels) 128 KB/s
  - Python GUI manages fine, target data stream x10^3
  - this GUI realisation has 702 lines of code (including comments and redundant code)



GUI USING PYQTGRAPH / CODE EXAMPLES

```
#!/usr/bin/env python
# -*- coding: utf-8 -*-
### Local Variables:
### fill-column: 100
### truncate-lines: t
### End:

import initExample ## Add path to library (just for examples; you do not need this)

import pyqtgraph as pg
import pyqtgraph.exporters
from pyqtgraph.Qt import QtCore, QtGui
from PyQt4.QtCore import QObject, pyqtSignal, pyqtSlot

import threading
lock = threading.Lock();

import os
import ctypes as C

import h5py
import numpy as np

import PyTine as tine
tine.debug("set debug=1")

import time

# ---------------------------------------------------------- #
context_name    = "CFEL.CMI"
experiment_name = "FEL-2-simulator"
run_name        = "run000001"
servers={}
```

```
# ---------------------------------------------------------- #
app   = QtGui.QApplication([])
p_A   = pg.PlotDataItem(pen='r')
p_B   = pg.PlotDataItem(pen='y')
vb    = pg.ViewBox()
model = QtGui.QStandardItemModel()
tw    = QtGui.QTreeView()
# ---------------------------------------------------------- #
```

```
## Always start by initializing Qt (only once per application)
def startApplication():
  mw = QtGui.QMainWindow()
  mw.setWindowTitle('CMIdaq example: ViewBox')
  mw.show()
  mw.resize(1000, 400)

  ## Define a top-level widget to hold everything
  w = QtGui.QWidget()
  mw.setCentralWidget(w);

  ## Create some widgets to be placed inside
  btn_init = QtGui.QPushButton('Init Client')
  btn_init.clicked.connect( initialise );

  btn_configure = QtGui.QPushButton('Configure')
  btn_configure.clicked.connect( configure_btn_clicked);

  btn_stop = QtGui.QPushButton('Stop')
  btn_stop.clicked.connect( stop_btn_clicked);

  text = QtGui.QLineEdit('Select your device:')
  listw = QtGui.QListWidget()
  plot = pg.PlotWidget()

  ## Create a grid layout to manage the widgets size and position
  layout = QtGui.QGridLayout()
  w.setLayout(layout)

  ## Add widgets to the layout in their proper positions
  layout.addWidget(btn_configure, 0, 0)   #
  layout.addWidget(btn_stop, 0, 1)    #
  layout.addWidget(btn_init, 0, 2)    #
  layout.addWidget(text, 1, 0, 1, 3)  #

  # operation on global tw:
  addTreeWidget()
  layout.addWidget(tw, 2, 0, 1, 3)  # list widget goes in bottom-left

  ## Display the widget as a new window
  w.show()
```

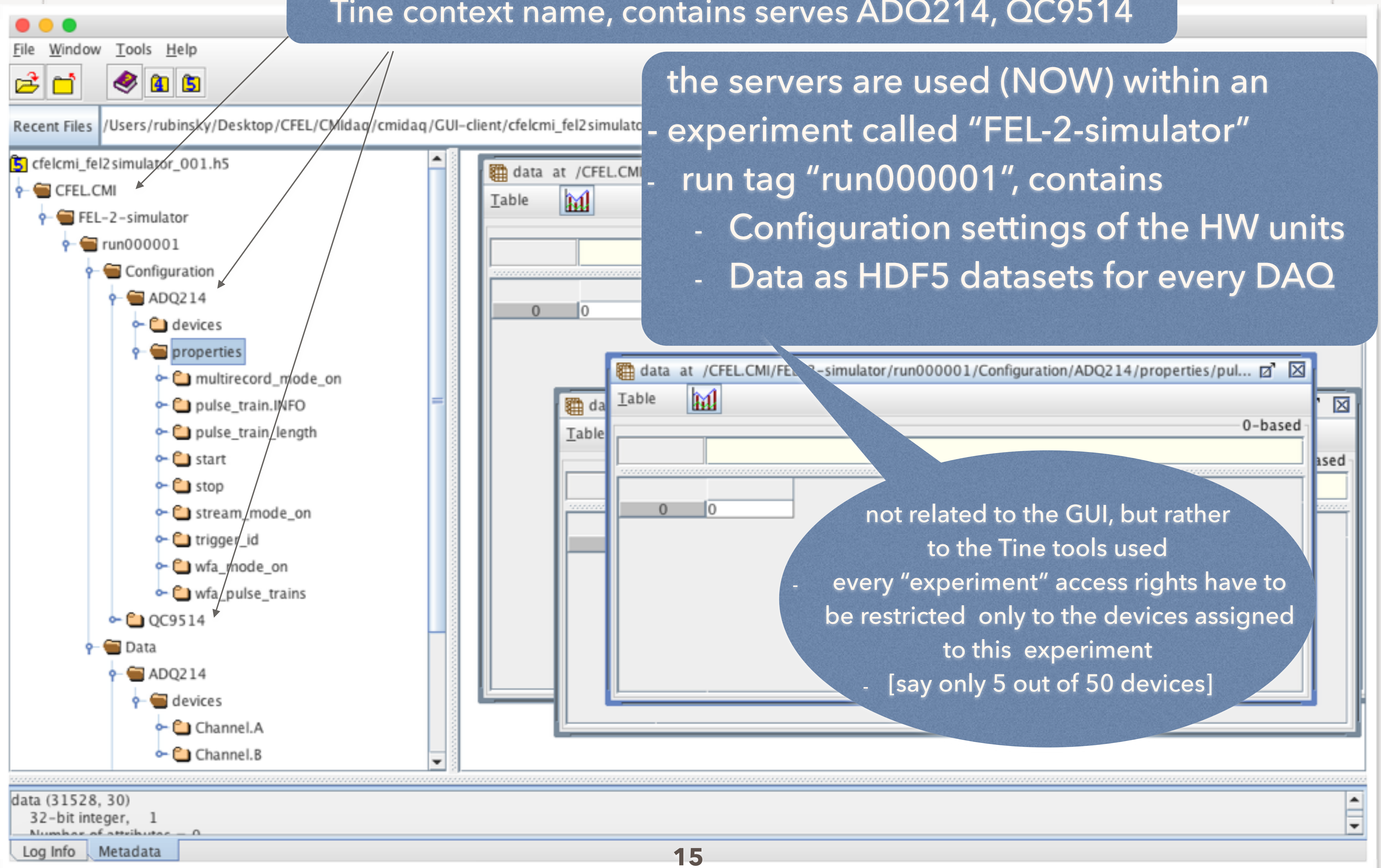
```
gv = pg.GraphicsView()
layout.addWidget(gv, 0, 3, 3, 1)  # plot goes on right side, spanning 3 rows

l = QtGui.QGraphicsGridLayout()
l.setHorizontalSpacing(0)
l.setVerticalSpacing(0)


vb.addItem(p_A)
vb.addItem(p_B)

rect = movableRect(QtCore.QRectF(0, 0, 1, 1))
rect.setPen(QtGui.QPen(QtGui.QColor(100, 200, 100)))
vb.addItem(rect)

l.addItem(vb, 0, 1)
gv.centralWidget.setLayout(l)

xScale = pg.AxisItem(orientation='bottom', linkView=vb)
l.addItem(xScale, 1, 1)
yScale = pg.AxisItem(orientation='left', linkView=vb)
l.addItem(yScale, 0, 0)

xScale.setLabel(text="<span style='color: #ff0000; font-weight: bold'>X</span> <i>sampling points</i>", units="s")
yScale.setLabel('<span>Y</span>Amplitude', units='V')

app.exec_();
```

CMIDAQ HDF5 DATA MODEL (STANDARD TOOL "HDF5VIEW" IN JAVA)

Tine context name, contains serves ADQ214, QC9514

the servers are used (NOW) within an
- experiment called "FEL-2-simulator"
- run tag "run000001", contains
  - Configuration settings of the HW units
  - Data as HDF5 datasets for every DAQ

not related to the GUI, but rather to the Tine tools used
- every "experiment" access rights have to be restricted only to the devices assigned to this experiment
- [say only 5 out of 50 devices]



```
# ------------------------------------------------------------ #
context_name    = "CFEL.CMI"
experiment_name = "FEL-2-simulator"
run_name        = "run000001"
servers={}


def get_tine_property(device_name, channel_name, prop_name):
    addr = "/" + context_name + "/" + device_name + "/" + channel_name
    print("get tine prop: ", addr, " ", prop_name)
    return tine.get(address = addr, property = prop_name)


def get_device_structure(device):
    global servers

    print("get_device_structure for %s and device %s " % (context_name,device));
    try:
        t=tine.list(context_name,device)
    except:
        print("device %s does not exist in the context %s " %(device, context_name) )
        return -1
    servers[device]={}

    servers[device]["devices"]={}
    for i in t["devices"]:
        servers[device]["devices"][i]= {}
        if "ADQ" in device:
            servers[device]["devices"][i]["pulse_train"] = 0 ; # get_tine_property( device, i, "pulse_train")

    servers[device]["properties"]={}
    for i in t["properties"]:
        if "pulse_train" !=  i:
            servers[device]["properties"][i]=get_tine_property(device, "Channel.A", i)

    return 0

def get_context_structures():
    print("get_context_structures")
    context_servers = tine.list(context_name)
    print("opening Context: ",context_name,"\n list of registered servers:\n",context_servers,"\n")
    for device in context_servers["servers"]:
            if "ADQ" in device:
                get_device_structure(device);
            if "QC" in device:
                get_device_structure(device);
```

```python
def create_file(fname):
    print("create_file")
    # Create a new file using defaut properties.
    #
    file = h5py.File(fname,'w')
    #
    # Create a dataset under the Root group.
    #
    #print( "Creating a group Configuration in the file...")
    group_configuration_name = "/" + context_name + "/" + experiment_name + "/" + run_name + "/Configuration/"
    group_configuration = file.require_group( group_configuration_name )
    print( "Creating dataset ADQ214 in group [", group_configuration_name, "] for file: ", file)

    for i0 in servers:
        group0 = group_configuration.require_group(i0)
        for i1 in servers[i0]:
            group1 = group0.require_group(i1)
            for i2 in servers[i0][i1]:
                group2 = group1.require_group(i2)
                for i3 in servers[i0][i1][i2]:
                    if "pulse_train" not in i3:
                        #group2 = group1.require_group(i3)
                        value = 0
                        try:
                            value = servers[i0][i1][i2][i3]['data']
                        except:
                            value = servers[i0][i1][i2][i3]
                        value_len = 1
                        try:
                            value_len = len(value)
                            print( i3, " / ", value[0:10] )
                        except:
                            # print("value :",i3, " is not an array, set its length to 1")
                            print( i3, " / ", value )
                        print("require_dataset for ", i3, " shape: " , (value_len,), " dtype:", get_type(value)  )
                        dataset = group2.require_dataset(name=i3, shape=(value_len,), dtype=  get_type(value) )
                        dataset = value
```

Many Thanks!

to Philip Duval and Mark Lomperski for the introductory course to TINE and helping me to sort out several not really obvious problems in the implementation and possibly misuse of the framework.

to-do:

- user & experiment & server restriction rules

- existing Tine services are not used by us a lot yet (wish to use as much as applicable in our case)

Comments and advices are welcome and will be highly appreciated.

Thank you!