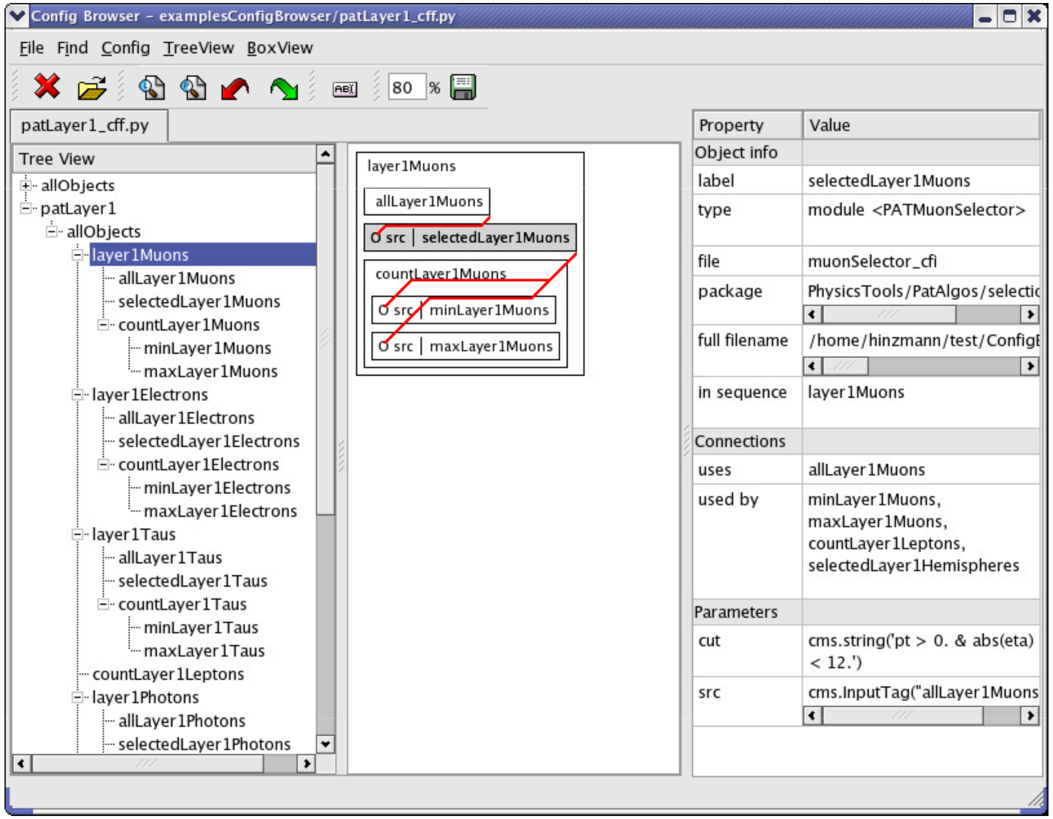
Visualization of the CMS Python Configuration System



Property	Value
Object info	
label	selectedLayer1Muons
type	module <PATMuonSelector>
file	muonSelector_cfi
package	PhysicsTools/PatAlgos/selectic
full filename	/home/hinzmann/test/ConfigE
in sequence	layer1Muons
Connections	
uses	allLayer1Muons
used by	minLayer1Muons, maxLayer1Muons, countLayer1Leptons, selectedLayer1Hemispheres
Parameters	
cut	cms.string('pt > 0. & abs(eta) < 12.')
src	cms.InputTag("allLayer1Muons

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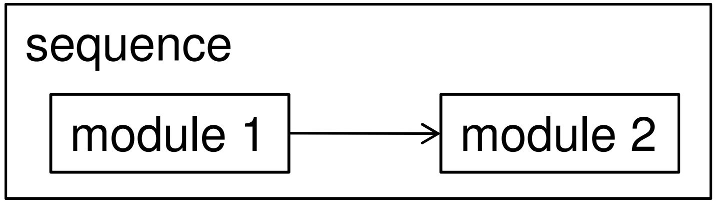
B. Hegner (CERN)

CMS software framework

- CMS has **common software framework** for simulation, high level trigger, reconstruction and analysis

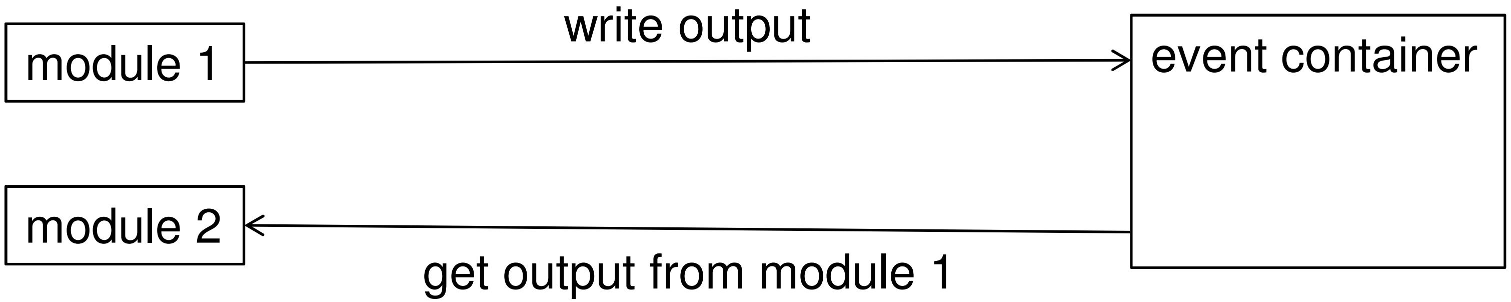
- **Modular FW:** Modules organized in sequences, defining order of execution



sequence

module 1 → module 2

- **Information flow** between modules only via a data container:



module 1 → write output → event container

event container → get output from module 1 → module 2

CMS python configuration system

- **Python configuration** system used for **steering of the C++ based FW**
- Python configuration
  - **defines** the **sequences** and the **parameters** of the modules
  - defines the setup: geometry, conditions, etc.
  - in principle contains all information on the processing flow except for the algorithms
  - **spread over many files** connected **via python import**

```
import FWCore.ParameterSet.Config as cms
from PhysicsTools.PatAlgos.producers.muonProducer_cfi import *
from PhysicsTools.PatAlgos.selection.muonSelector_cfi import *
from PhysicsTools.PatAlgos.selection.muonCountFilter_cff import *

Muons = cms.Sequence(allMuons * selectedMuons * countMuons)
```

Aims of visualization

- Problems:
  - Configuration spread over many files
    → difficult to find/edit certain modules/parameters
  - Indirect information flow between modules
    → difficult to understand dependencies

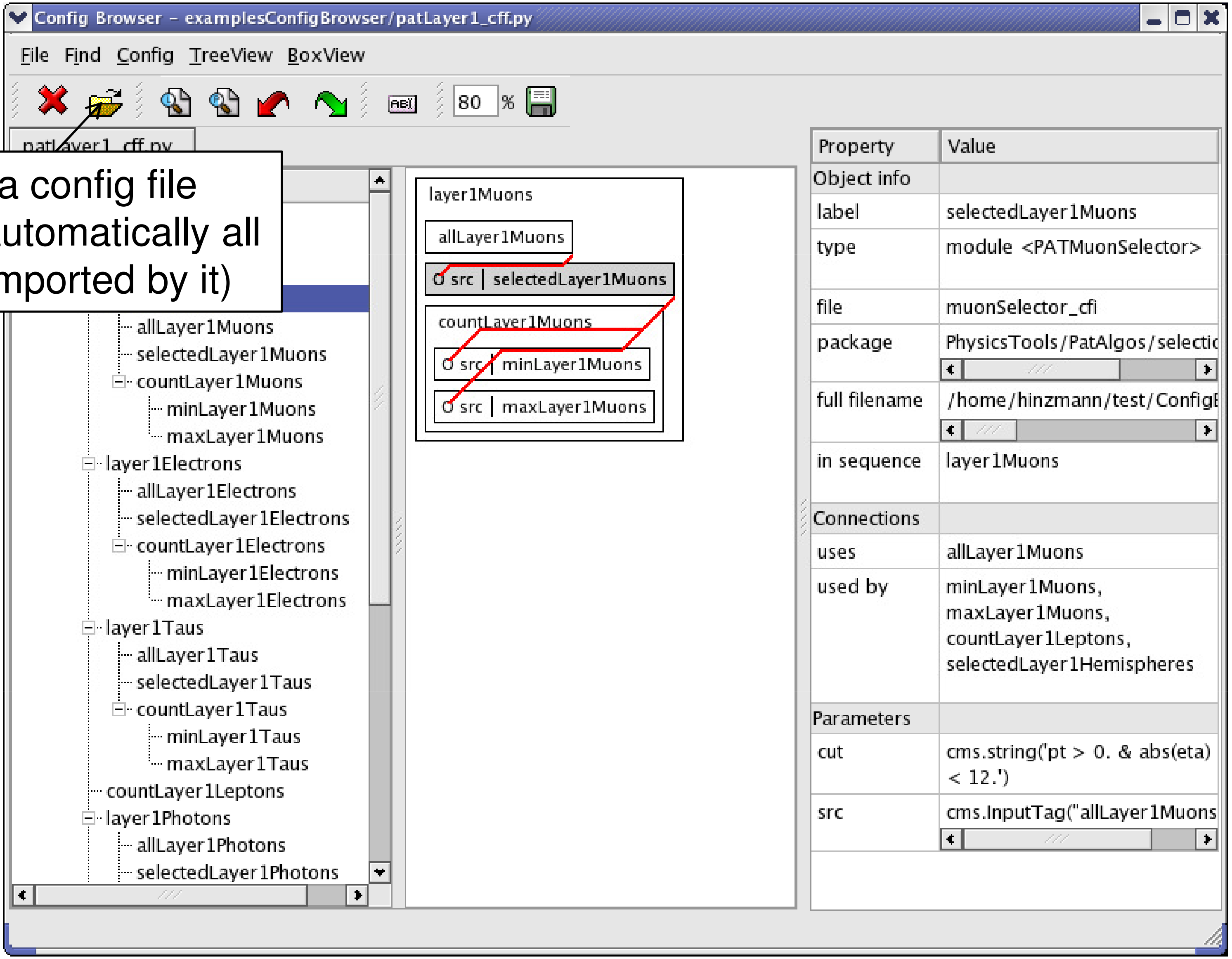
- Requirements for a browsing tool for the configuration system
  - Give **quick but detailed overview** over simulation / trigger / reconstruction / analysis
  - Allow **debugging** / **verification** of configuration files
  - Allow **documentation** of simulation / trigger / reconstruction / analysis

⇨ CMS Configuration Browser

Key functionality

- Visualization of the **sequence structure**
- Visualization of the **information flow** between modules
- **Locating module definitions** in configuration files
- **Interactive editing** of the configuration
- **Exporting graphical representations** of the configuration structure

CMS Configuration Browser



1. Open a config file (and automatically all files imported by it)

- allLayer1Muons
- selectedLayer1Muons
- countLayer1Muons
  - minLayer1Muons
  - maxLayer1Muons
- layer1Electrons
  - allLayer1Electrons
  - selectedLayer1Electrons
  - countLayer1Electrons
    - minLayer1Electrons
    - maxLayer1Electrons
- layer1Taus
  - allLayer1Taus
  - selectedLayer1Taus
  - countLayer1Taus
    - minLayer1Taus
    - maxLayer1Taus
- countLayer1Leptons
- layer1Photons
  - allLayer1Photons
  - selectedLayer1Photons

Property	Value
Object info	
label	selectedLayer1Muons
type	module <PATMuonSelector>
file	muonSelector_cfi
package	PhysicsTools/PatAlgos/selectic
full filename	/home/hinzmann/test/ConfigE
in sequence	layer1Muons
Connections	
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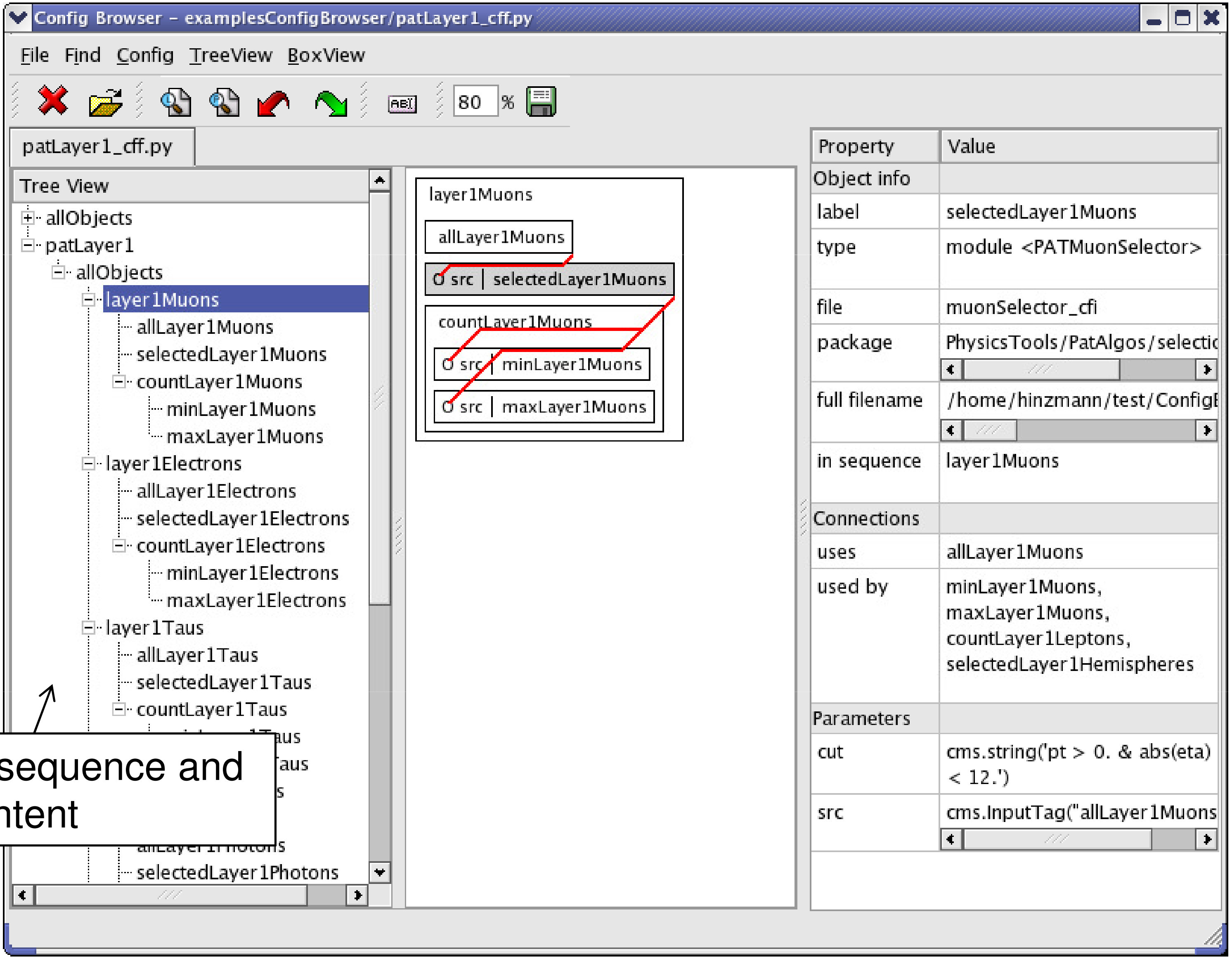
used by	minLayer1Muons, maxLayer1Muons, countLayer1Leptons, selectedLayer1Hemispheres
Parameters	
cut	cms.string('pt > 0. & abs(eta) < 12.')
src	cms.InputTag("allLayer1Muons

CMS Configuration Browser

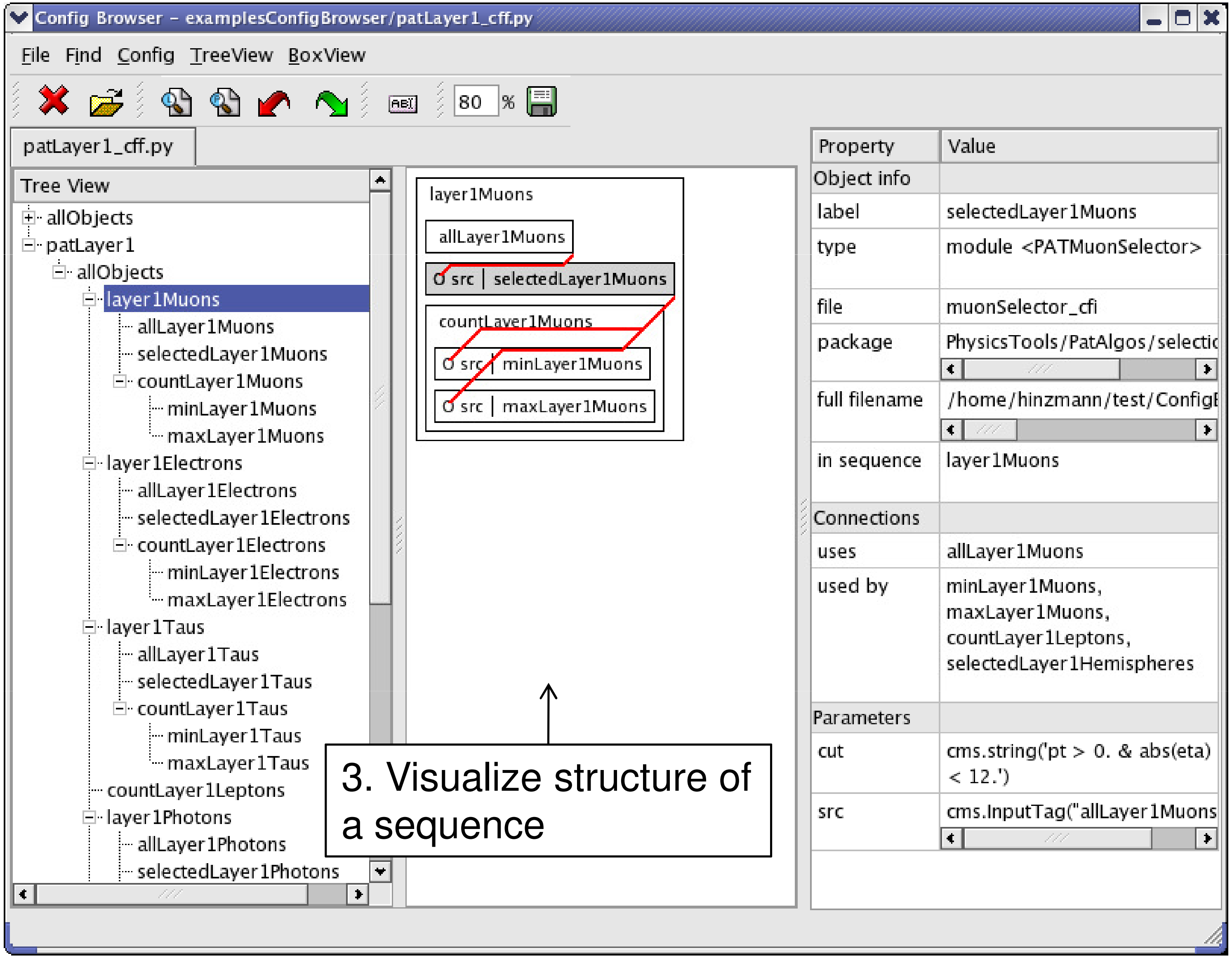


```
+ allObjects
- patLayer1
  - allObjects
    - layer1Muons
        allLayer1Muons
        selectedLayer1Muons
      - countLayer1Muons
          minLayer1Muons
          maxLayer1Muons
    - layer1Electrons
        allLayer1Electrons
        selectedLayer1Electrons
      - countLayer1Electrons
          minLayer1Electrons
          maxLayer1Electrons
    - layer1Taus
        allLayer1Taus
        selectedLayer1Taus
      - countLayer1Taus
          aus
          aus
        s
        allLayer1Photons
        selectedLayer1Photons
```

Property	Value
Object info	
label	selectedLayer1Muons
type	module <PATMuonSelector>
file	muonSelector_cfi
package	PhysicsTools/PatAlgos/selectic
full filename	/home/hinzmann/test/ConfigE
in sequence	layer1Muons
Connections	
uses	allLayer1Muons
used by	minLayer1Muons, maxLayer1Muons, countLayer1Leptons, selectedLayer1Hemispheres
Parameters	
cut	cms.string('pt > 0. & abs(eta) < 12.')
src	cms.InputTag("allLayer1Muons

2. Browse sequence and module content

CMS Configuration Browser


Config Browser - examplesConfigBrowser/patLayer1_cff.py
File Find Config TreeView BoxView
80 %
patLayer1_cff.py
layer1Muons
allLayer1Muons
O src | selectedLayer1Muons
countLayer1Muons
O src | minLayer1Muons
O src | maxLayer1Muons

Tree View

- allObjects
- patLayer1
  - allObjects
    - layer1Muons
      - allLayer1Muons
      - selectedLayer1Muons
      - countLayer1Muons
        - minLayer1Muons
        - maxLayer1Muons
    - layer1Electrons
      - allLayer1Electrons
      - selectedLayer1Electrons
      - countLayer1Electrons
        - minLayer1Electrons
        - maxLayer1Electrons
    - layer1Taus
      - allLayer1Taus
      - selectedLayer1Taus
      - countLayer1Taus
        - minLayer1Taus
        - maxLayer1Taus
    - countLayer1Leptons
    - layer1Photons
      - allLayer1Photons
      - selectedLayer1Photons

Property	Value
Object info	
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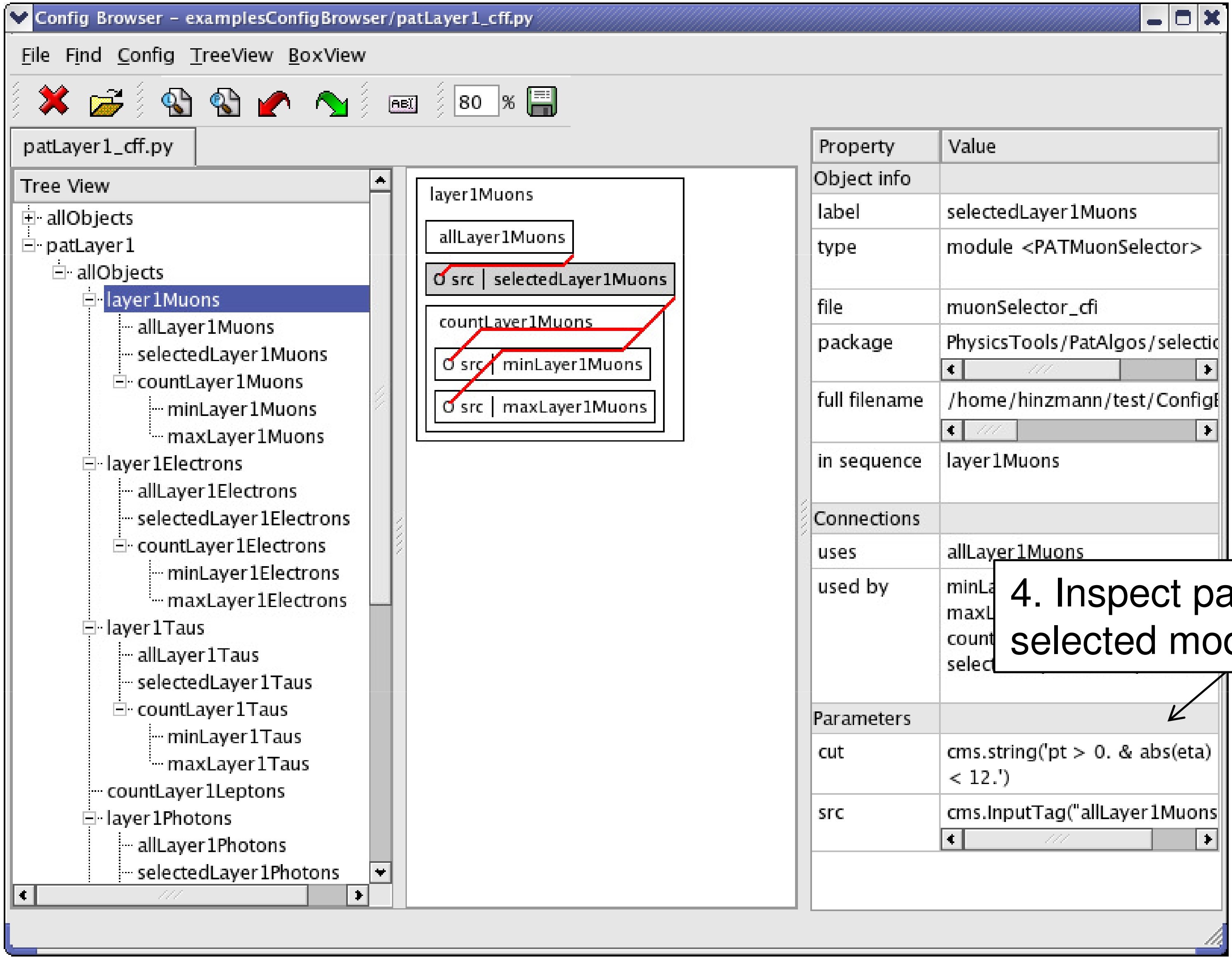
file	muonSelector_cfi
package	PhysicsTools/PatAlgos/selectic
full filename	/home/hinzmann/test/ConfigE
in sequence	layer1Muons
Connections	
uses	allLayer1Muons
used by	minLayer1Muons, maxLayer1Muons, countLayer1Leptons, selectedLayer1Hemispheres
Parameters	
cut	cms.string('pt > 0. & abs(eta) < 12.')
src	cms.InputTag("allLayer1Muons

3. Visualize structure of a sequence

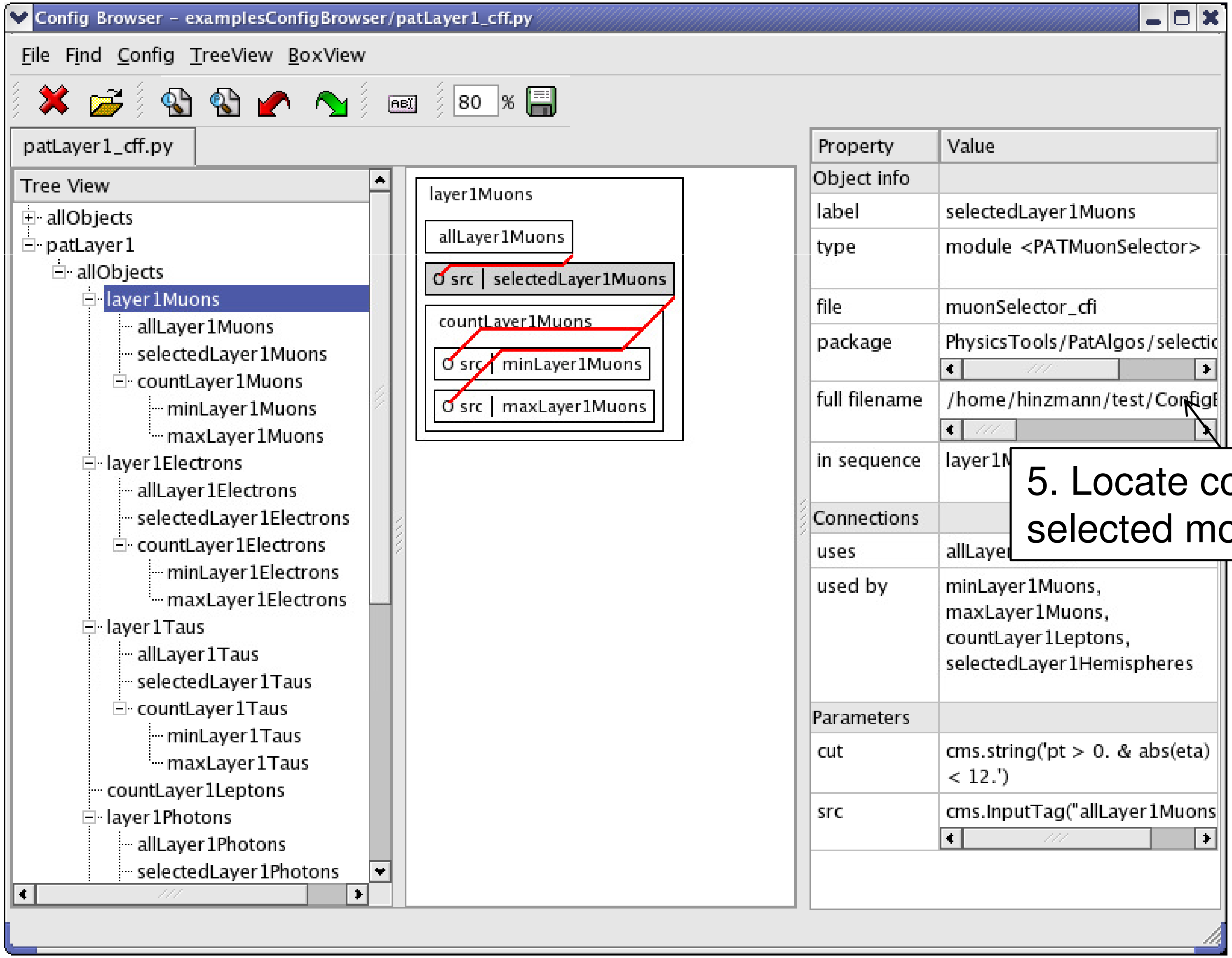
CMS Configuration Browser



Property	Value
Object info	
label	selectedLayer1Muons
type	module <PATMuonSelector>
file	muonSelector_cfi
package	PhysicsTools/PatAlgos/selectio
full filename	/home/hinzmann/test/ConfigE
in sequence	layer1Muons
Connections	
uses	allLayer1Muons
used by	minLa maxL count selec
Parameters	
cut	cms.string('pt > 0. & abs(eta) < 12.')
src	cms.InputTag("allLayer1Muons

4. Inspect parameters of selected module

CMS Configuration Browser

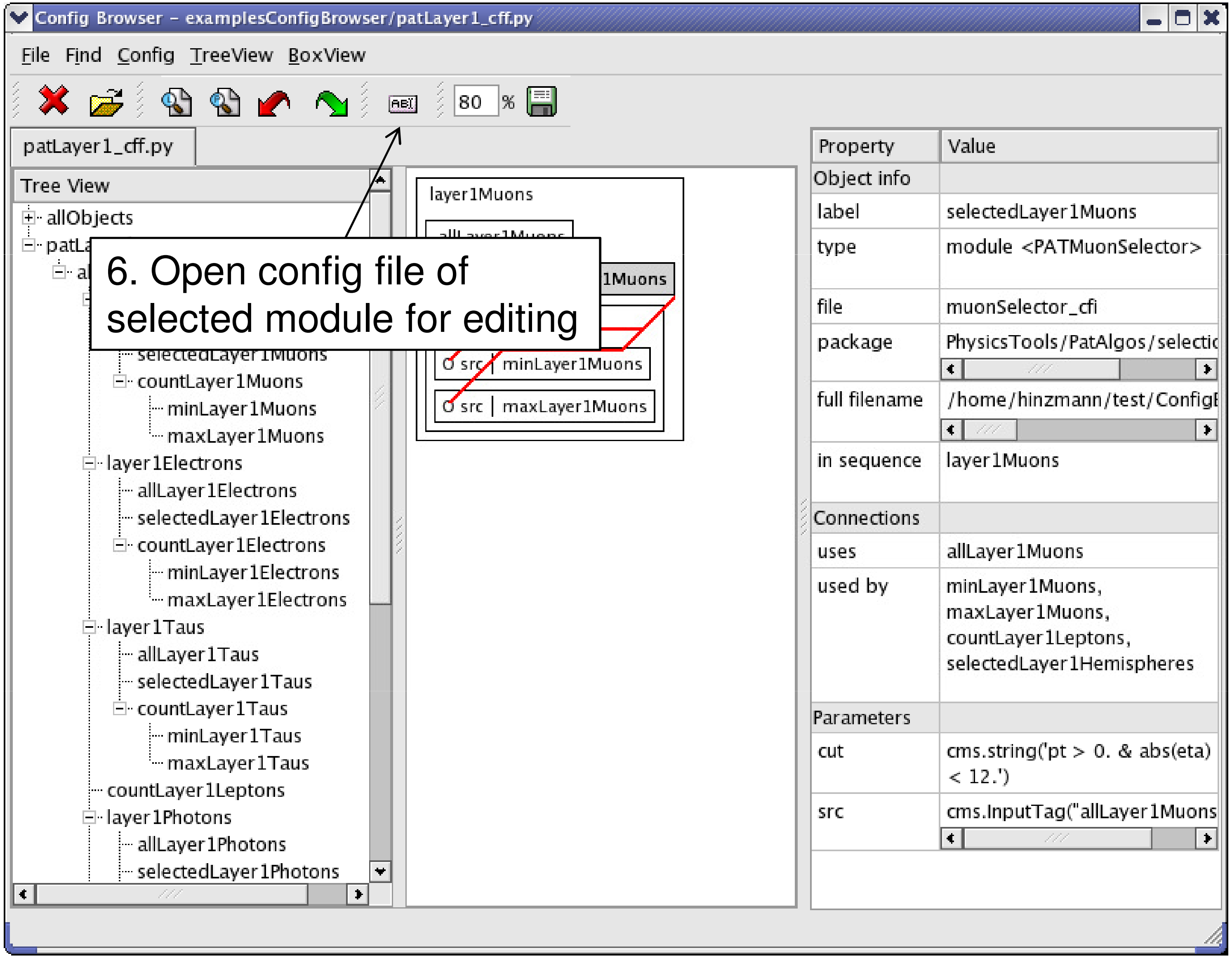


```
+ allObjects
- patLayer1
  - allObjects
    - layer1Muons
        allLayer1Muons
        selectedLayer1Muons
      - countLayer1Muons
          minLayer1Muons
          maxLayer1Muons
    - layer1Electrons
        allLayer1Electrons
        selectedLayer1Electrons
      - countLayer1Electrons
          minLayer1Electrons
          maxLayer1Electrons
    - layer1Taus
        allLayer1Taus
        selectedLayer1Taus
      - countLayer1Taus
          minLayer1Taus
          maxLayer1Taus
      countLayer1Leptons
    - layer1Photons
        allLayer1Photons
        selectedLayer1Photons
```

Property	Value
Object info	
label	selectedLayer1Muons
type	module <PATMuonSelector>
file	muonSelector_cfi
package	PhysicsTools/PatAlgos/selectic
full filename	/home/hinzmann/test/ConfigE
in sequence	layer1M
Connections	
uses	allLayer
used by	minLayer1Muons, maxLayer1Muons, countLayer1Leptons, selectedLayer1Hemispheres
Parameters	
cut	cms.string('pt > 0. & abs(eta) < 12.')
src	cms.InputTag("allLayer1Muons

5. Locate config file of selected module

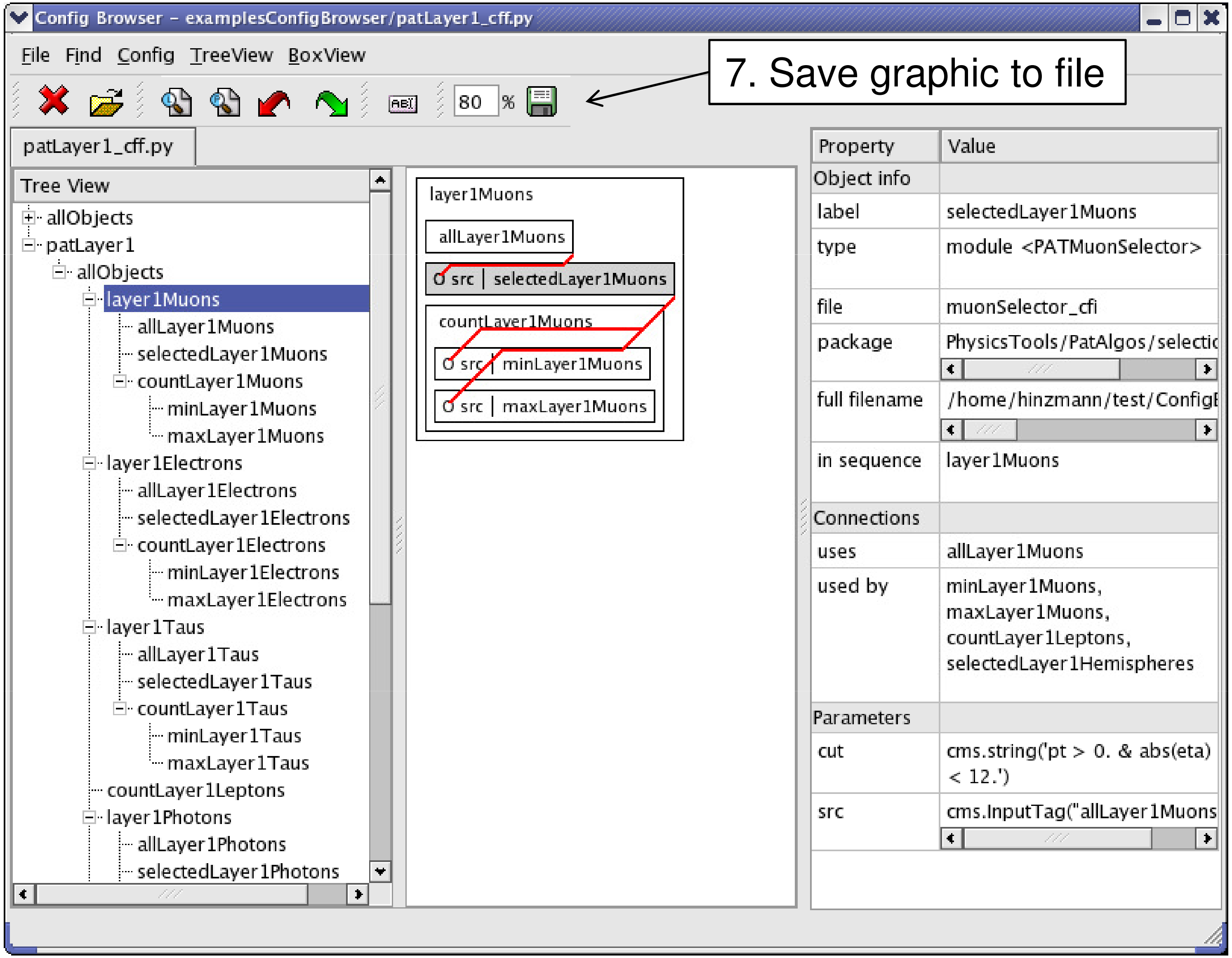
CMS Configuration Browser



6. Open config file of selected module for editing

Property	Value
Object info	
label	selectedLayer1Muons
type	module <PATMuonSelector>
file	muonSelector_cfi
package	PhysicsTools/PatAlgos/selectic
full filename	/home/hinzmann/test/ConfigE
in sequence	layer1Muons
Connections	
uses	allLayer1Muons
used by	minLayer1Muons, maxLayer1Muons, countLayer1Leptons, selectedLayer1Hemispheres
Parameters	
cut	cms.string('pt > 0. & abs(eta) < 12.')
src	cms.InputTag("allLayer1Muons

CMS Configuration Browser



Config Browser - examplesConfigBrowser/patLayer1_cff.py

7. Save graphic to file

- allObjects
- patLayer1
  - allObjects
    - layer1Muons
      - allLayer1Muons
      - selectedLayer1Muons
      - countLayer1Muons
        - minLayer1Muons
        - maxLayer1Muons
    - layer1Electrons
      - allLayer1Electrons
      - selectedLayer1Electrons
      - countLayer1Electrons
        - minLayer1Electrons
        - maxLayer1Electrons
    - layer1Taus
      - allLayer1Taus
      - selectedLayer1Taus
      - countLayer1Taus
        - minLayer1Taus
        - maxLayer1Taus
    - countLayer1Leptons
    - layer1Photons
      - allLayer1Photons
      - selectedLayer1Photons

Property	Value
Object info	
label	selectedLayer1Muons
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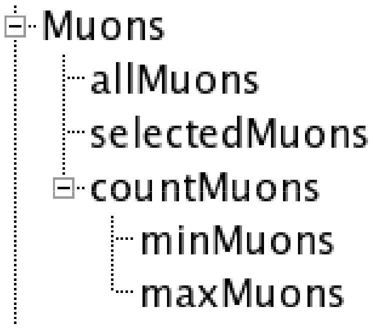
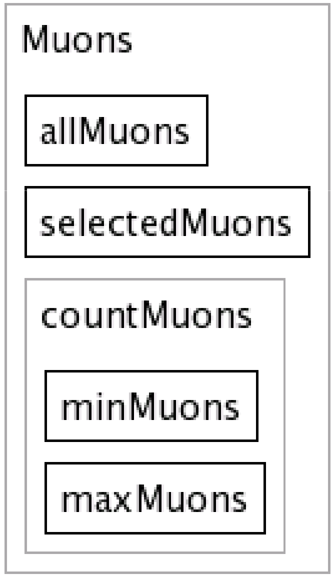
file	muonSelector_cfi
package	PhysicsTools/PatAlgos/selectic
full filename	/home/hinzmann/test/ConfigE
in sequence	layer1Muons
Connections	
uses	allLayer1Muons
used by	minLayer1Muons, maxLayer1Muons, countLayer1Leptons, selectedLayer1Hemispheres
Parameters	
cut	cms.string('pt > 0. & abs(eta) < 12.')
src	cms.InputTag("allLayer1Muons

Visualization of sequence structure

- Sequence structure of a config file visualized
  - in form of a tree
  - as a block diagram



```
Muons
    allMuons
    selectedMuons
    countMuons
        minMuons
        maxMuons
```



Muons

allMuons

selectedMuons

countMuons

minMuons

maxMuons

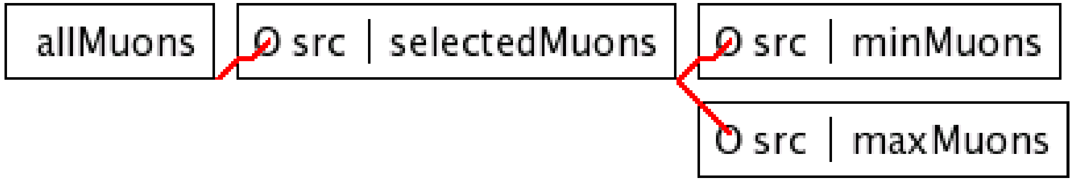
```
countMuons = cms.Sequence(minMuons * maxMuons)

Muons = cms.Sequence(allMuons * selectedMuons * countMuons)
```

- Sequence structure visualizes the **full chain of modules** in a config file

Visualization of information flow

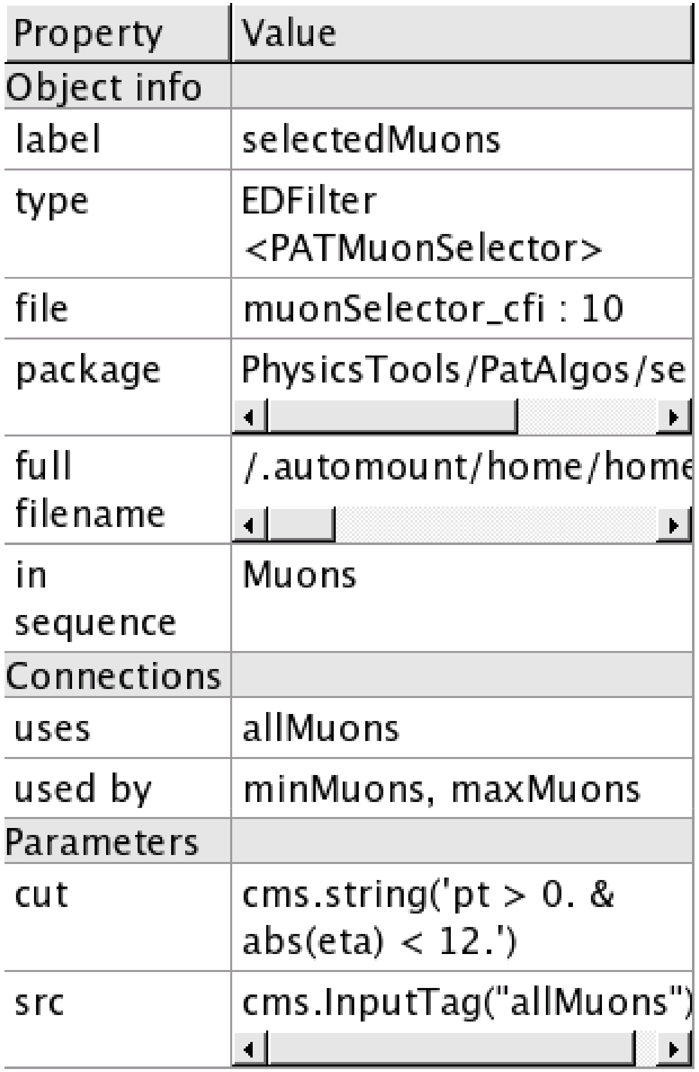
- Input from other modules visualized by **connecting lines**

- Arrange modules according to information flow



- Modules which depend on the output of selected module **listed in properties**

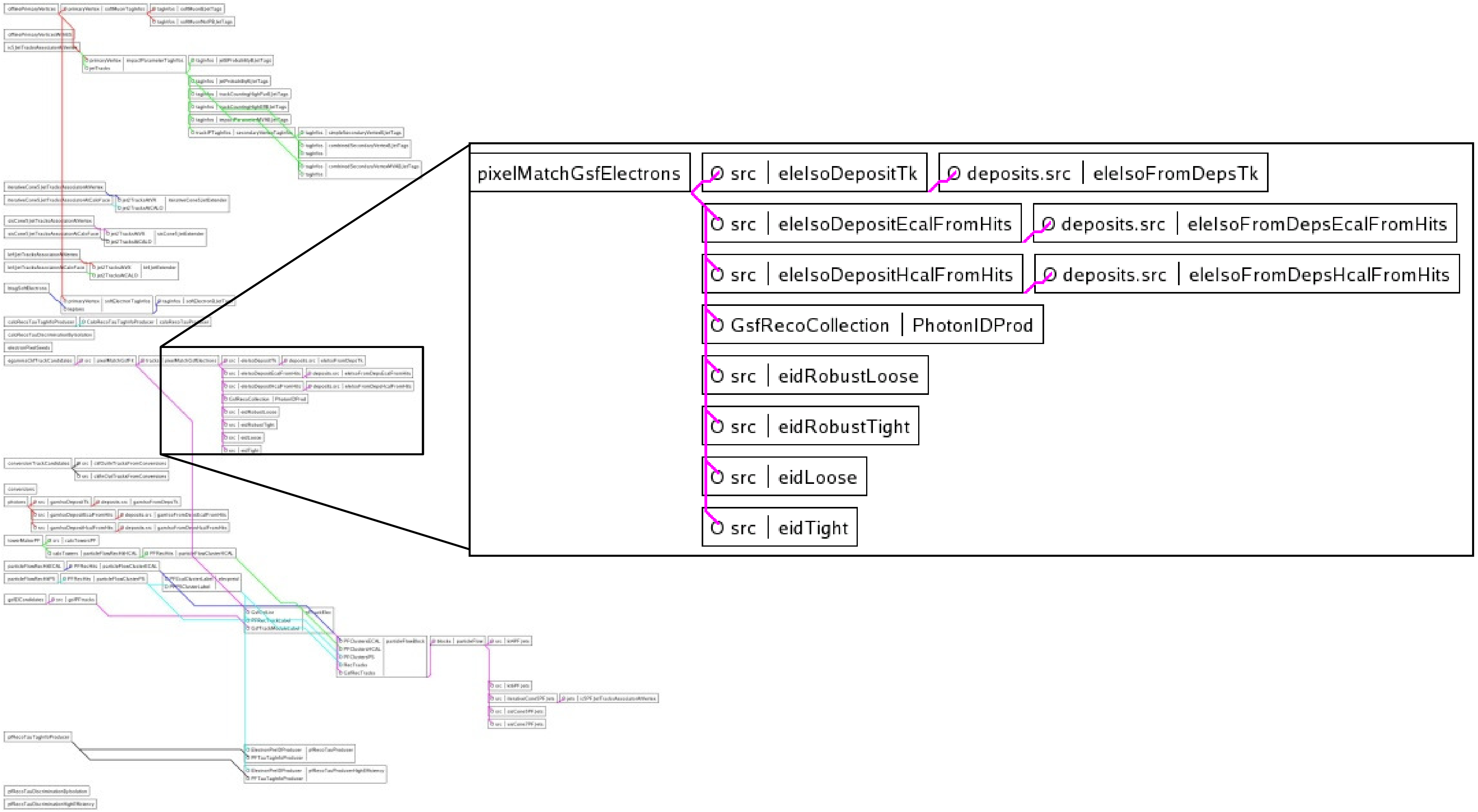
- Allows user to understand the dependencies between modules



Property	Value
Object info	
label	selectedMuons
type	EDFilter <PATMuonSelector>
file	muonSelector_cfi : 10
package	PhysicsTools/PatAlgos/se
full filename	/.automount/home/home
in sequence	Muons
Connections	
uses	allMuons
used by	minMuons, maxMuons
Parameters	
cut	cms.string('pt > 0. & abs(eta) < 12.')
src	cms.InputTag("allMuons")

A more sophisticated example

- Graphical representation of the high-level reconstruction in CMS


pixelMatchGsfElectrons
src | eleIsoDepositTk
deposits.src | eleIsoFromDepsTk
src | eleIsoDepositEcalFromHits
deposits.src | eleIsoFromDepsEcalFromHits
src | eleIsoDepositHcalFromHits
deposits.src | eleIsoFromDepsHcalFromHits
GsfRecoCollection | PhotonIDProd
src | eidRobustLoose
src | eidRobustTight
src | eidLoose
src | eidTight

Information in the configuration

- Sequence structure is contained **directly** in python configuration
- Information flow structure however contained only **unidirectional**
  - Input from another module is indicated in the parameters of module by the name of module whose output is used

module 1

module 2
parameter “src”=“module 1“

  - Names are mapped to the modules themselves
  - Entire configuration is scanned in order to calculate “usedby“ dependency

module 1
“usedby” = “module 2”

module 2
“uses” = “module 1”

The underlying software concept

- Configuration Browser programmed in Python, using Qt for the GUI

- Python:
  - Python configuration can be **directly analyzed via import and introspection**
  - **Fast development turnaround** due to dynamic typing, automatic memory management

- Qt:
  - Widely spread cross-platform application development framework
  - Other usage in CMS (Iguana event display)

The underlying software concept

- Configuration Browser is a plug-in of an underlying software framework
  - **designed for maximum reusability**

- New browsers / editors can be added to the application using a **plug-in mechanism**

- Plug-ins **share graphical compounds**: tree view, center view, properties view, etc.

- Example for further plug-ins:
  - Event browser for the CMS data files (EdmBrowser)
    Browses entire content of CMS data files event by event using introspection

- Common code of the two browsers 2000 lines, individual 1000 each

Summary

- Key features of CMS Configuration Browser
  - Visualization of the sequence structure and information flow of CMS configuration files
  - Interactive editing and documentation of the configuration
  - Implementation in Python gives direct access to the configuration
  - GUI designed for maximum reusability