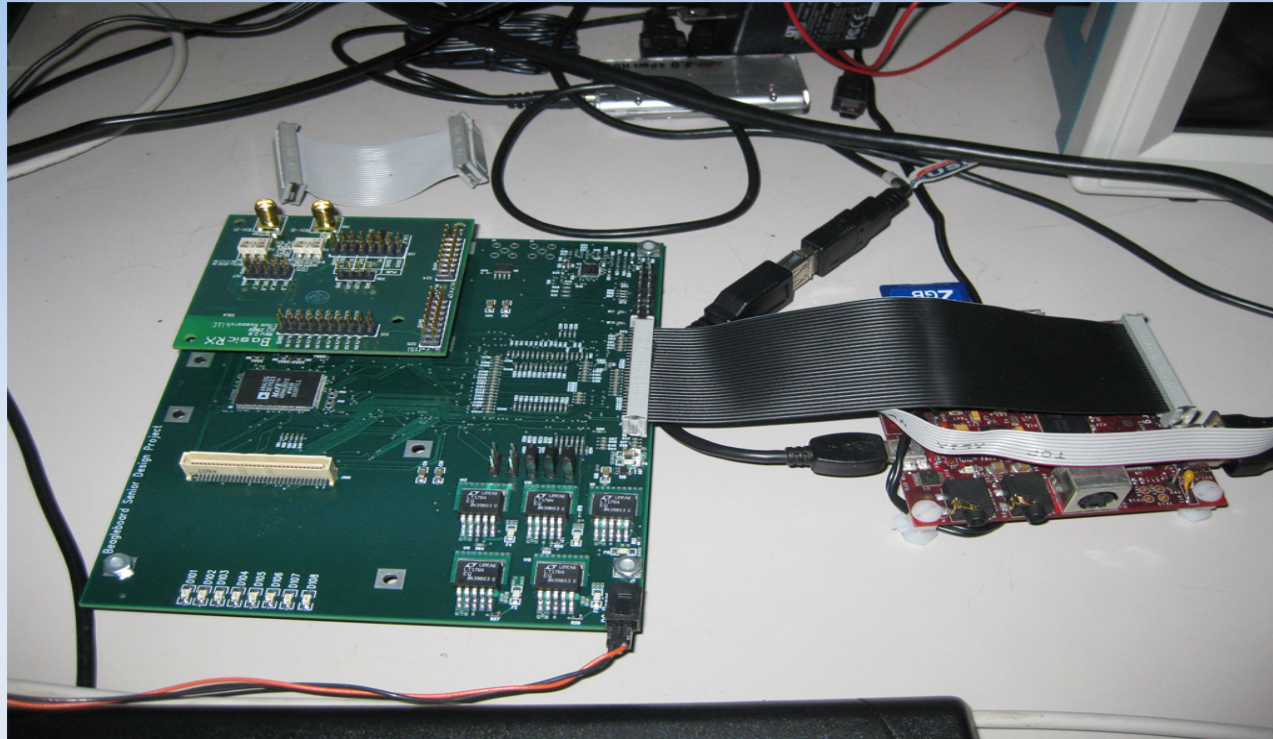


# Adapted GNU Radio Setup



<http://www.flickr.com/photos/32615155@N00/3447696549/>

USRP daughterboard (\$75-500): RF gain/filtering

Custom board (<\$500): ADC, down-conversion

BeagleBoard (\$200)

# Modifications



Port GNU Radio to BeagleBoard

ARM Cortex-A8 with NEON FP extensions

Poorly supported by GCC

Create new signal source/sink block

Uses SPI interface instead of USB

Lower overhead, latency

Must still control USRP daughterboards

Patch bootloader, Linux kernel to expose SPI port on BeagleBoard's expansion header

# SPI Signal Source Block



<200 lines of C++

Uses Linux's spidev userspace API

Implemented as a class `gr_spi_source_s`

`work()`: poll FPGA, return 0 or more samples

`send_spi_command()`: buffer a command to send to the board

# Command Set



- Start/stop streaming
- Set DDC frequency
- Set decimation rate
- Tune analog front-end

# Testing



Before working board or Verilog delivered:

Capture waveform data using oscilloscope

Simulate FPGA's processing offline

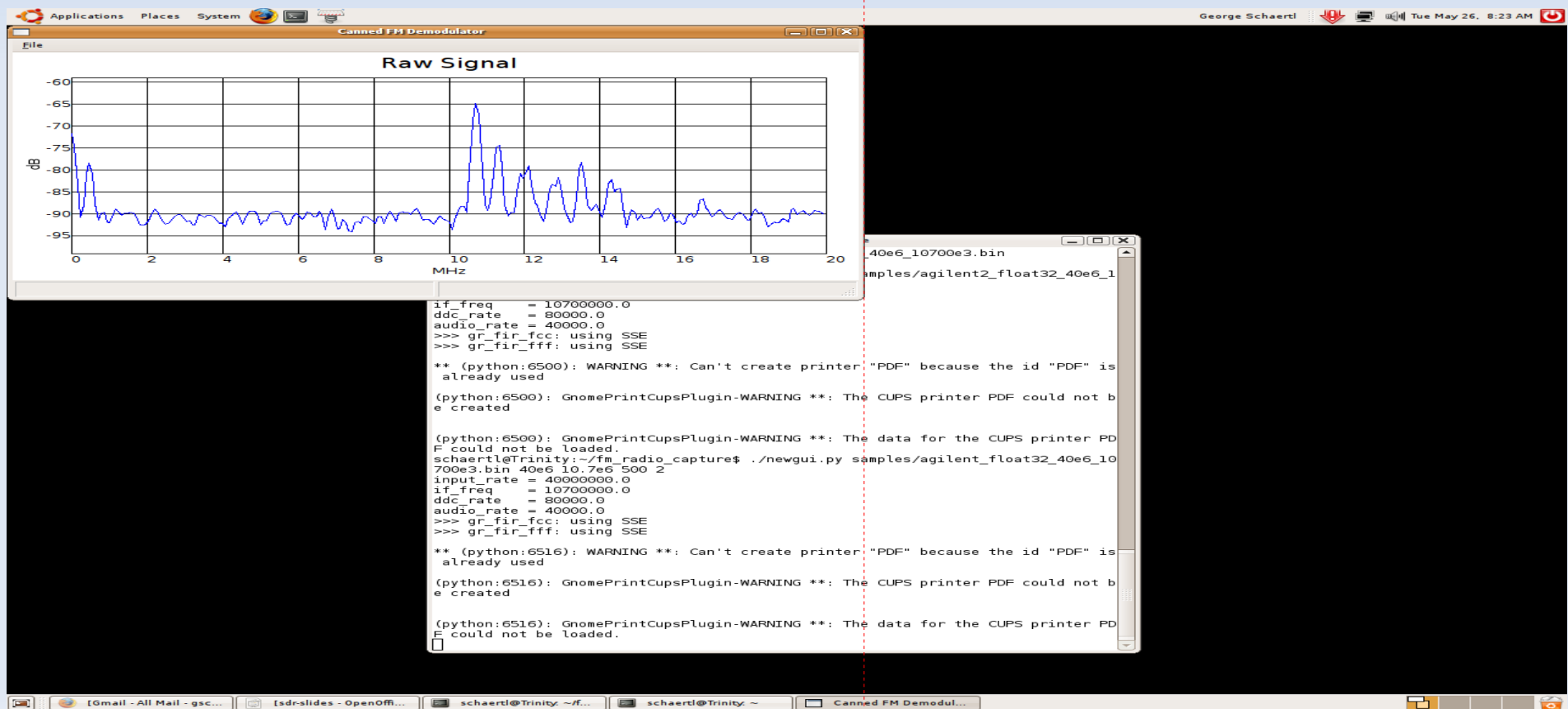
Use file source instead of SPI source

# Signal Capture



Radio set with 10.7 MHz IF output

DSO samples at 40 MHz, captures 0.2 sec



# Signal capture



iPod → signal generator → 10.7 MHz FM signal  
DSO samples at 1 MHz, captures 10 sec  
Signal aliased to 300 kHz

The screenshot displays a BeagleBoard Linux desktop environment. A presentation window titled "Canned FM Demodulator" is open, showing slides 13 through 16. Slide 13 is titled "Processing on BeagleBoard" and lists tasks: "MATLAB converts scope's bin format to wav", "Copy to BeagleBoard file system", "Use flograph downconverts to baseband (offline)", and "Use flograph demodulates signal (realtime)". Slide 14 is also titled "Processing on BeagleBoard" and lists: "IPIC is flow graph for QI subdemodulate FM (sharing flograph.py, second\_half.py)". Slide 15 is titled "Q&A" with a "Click to add an outline" button. Slide 16 is titled "Demo FM demod on Beagle".

In the foreground, a terminal window shows the following commands and output:

```
>>> gr_fir_fff: using SSE
** (python:6516): WARNING **: Can't create printer "PDF" because the id "PDF" is
already used
(python:6516): GnomePrintCupsPlugin-WARNING **: The CUPS printer PDF could not b
e created
(python:6516): GnomePrintCupsPlugin-WARNING **: The data for the CUPS printer PD
F could not be loaded.
schaertle@Trinity:~/fm_radio_capture$ ls samples
agilent1.png          bleh.bin
agilent2_float32_40e6_10700e3.bin  lecroy2_float32_le6_300e3.bin
agilent2_wav          lecroy2_uint32_le6_300e3.bin
agilent_float32_40e6_10700e3.bin  lecroy_float32_le6_300e3.bin
agilent_wav          lecroy_uint32_le6_300e3.bin
aisl-250k.cfile
schaertle@Trinity:~/fm_radio_capture$ ./newgui.py samples/lecroy_float32_le6_300e
3.bin le6_300e3 3 2
input_rate = 1000000.0
if_freq = 300000.0
ddc_rate = 393333.393333333331
audio_rate = 166666.666666666666
>>> gr_fir_ffc: using SSE
>>> gr_fir_fff: using SSE
** (python:6554): WARNING **: Can't create printer "PDF" because the id "PDF" is
already used
(python:6554): GnomePrintCupsPlugin-WARNING **: The CUPS printer PDF could not b
e created
(python:6554): GnomePrintCupsPlugin-WARNING **: The data for the CUPS printer PD
F could not be loaded.
```

# Processing on BeagleBoard



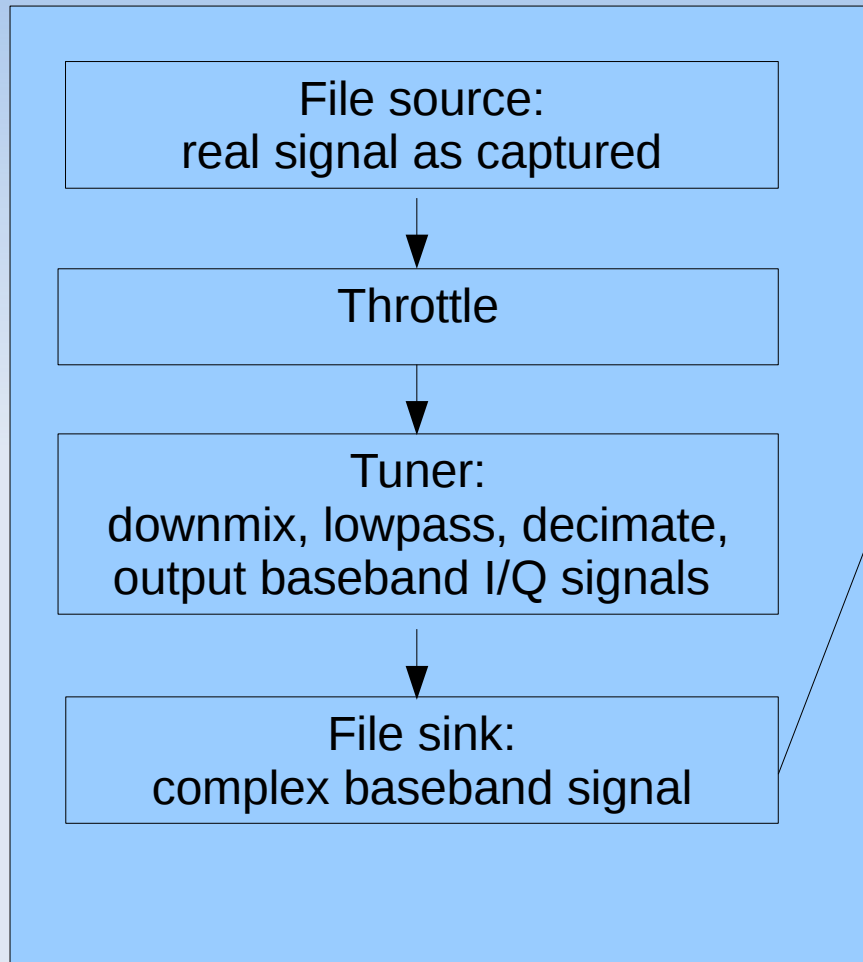
MATLAB converts scope's .bin format to .wav

Copy to BeagleBoard filesystem

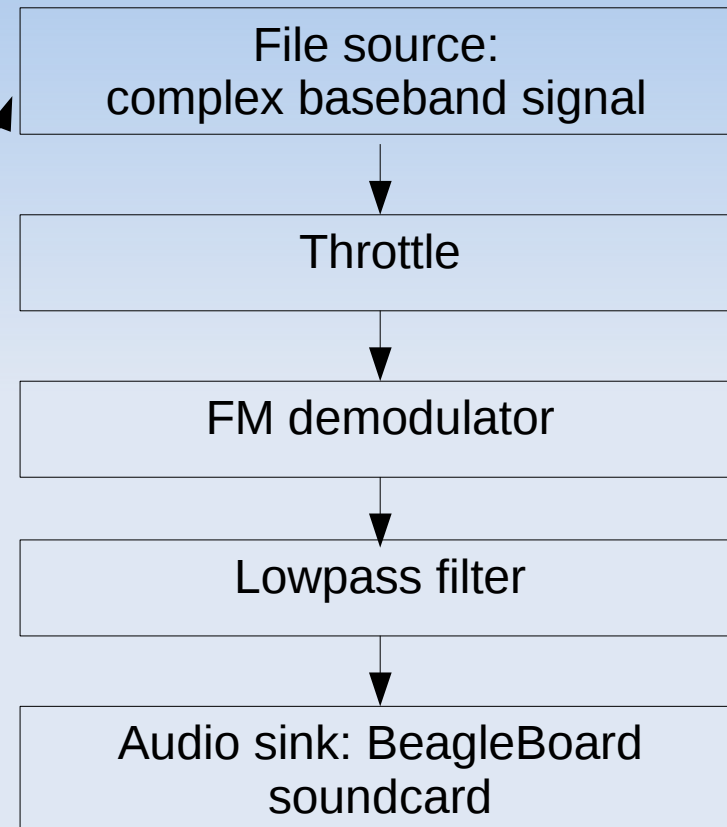
One flowgraph downconverts to baseband  
(offline)

One flowgraph demodulates signal (realtime)

# Processing on BeagleBoard



Offline:  
to be replaced by FPGA  
Uses unoptimized FIR filter



Realtime

# Building under OE with BitBake



## Install OpenEmbedded

<http://elinux.org/BeagleBoardAndOpenEmbeddedGit>

Add GNU Radio and your project to local.conf

## Create .bb file for your project

Points to sources, dependencies, build commands

## Patch kernel & bootloader to expose SPI port

<http://groups.google.com/group/beagleboard/msg/816397901ec999c4>

bitbake your-project

# Q&A



# Tutorial Overview



Introduction and Overview – Chris Anderson

Overview of the OMAP3 – Philip Balister

Hardware Design – Chris Anderson

Break

FPGA Interfacing – Philip Balister

GNU Radio on the Beagle – George Schaertl

**System Demonstrations – Schaertl/Balister**

# Demo FM demod on Beagle



# Demo SPI RX on Beagle



# Q&A

