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Transitioning MSc Physics Teaching to LabVIEW NXG 2.0: From Drills to DAQ-First

NI Academic Users Forum 2018

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MSc teaching at Cardiff University School of Physics and Astronomy

- MSc Physics
- MSc Data-Intensive Physics
- MSc Compound Semiconductor Physics

- MSc Astrophysics
- MSc Data-Intensive Astrophysics

- Two new MScs for 2019/20

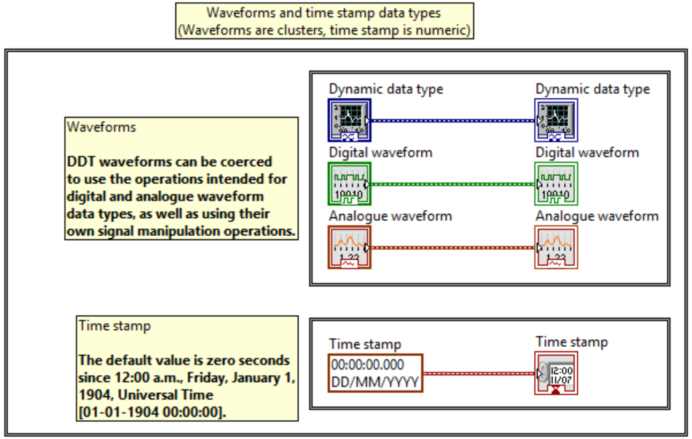
Modules with LabVIEW in MSc Physics, DIP, and CSP:

- Advanced Experimental Techniques in Physics (core)
- Advanced LabVIEW Programming for Physicists

LabVIEW content of PXT101 “Advanced Experimental Techniques in Physics”

- PXT101 core for MSc Physics, DIP, CSP
- PXT101 is 20cr, 10cr of which is LabVIEW 2015
- Other 10cr are student-lead micro projects
- *Ab initio* to approximately CLAD standard in 11 weeks
- Very high staff to student ratio
- Stable, mature materials, examples, and projects

- Average student satisfaction score of 93%
- Exceptionally positive student feedback
- Exceptionally positive external examiner feedback
- Engineering Impact Award 2016 (NE, Education)
- Excellence in Engineering Education Award 2017



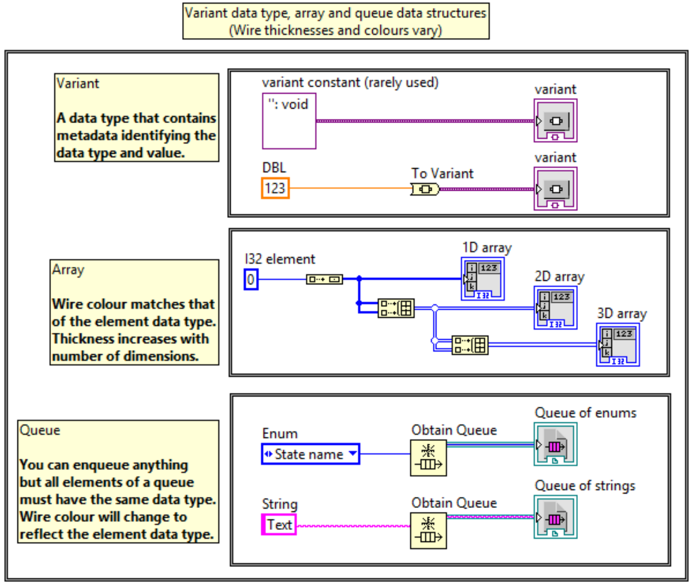
Waveforms and time stamp data types
(Waveforms are clusters, time stamp is numeric)

Waveforms

DDT waveforms can be coerced to use the operations intended for digital and analogue waveform data types, as well as using their own signal manipulation operations.

Time stamp

The default value is zero seconds since 12:00 a.m., Friday, January 1, 1904, Universal Time [01-01-1904 00:00:00].



Variant data type, array and queue data structures
(Wire thicknesses and colours vary)

Variant

A data type that contains metadata identifying the data type and value.

Array

Wire colour matches that of the element data type. Thickness increases with number of dimensions.

Queue

You can enqueue anything but all elements of a queue must have the same data type. Wire colour will change to reflect the element data type.

Example MSc Physics student feedback

- “The way the LabVIEW language was explained definitely improved the total progress I made”
- “Excellent quality teaching supported by good module resources. Good hands-on programming experience.”
- “The coding aspects of the MSc have been insanely useful for my new job.”
- “[LabVIEW] has proved extremely useful throughout my MSc course”

Why would we want to change anything?!

Pedagogy

- LabVIEW 2015’s quirks **define** the order of instruction rather than **supporting** it
- Students get to really useful, interesting applications **only in the last third** of the semester
- Interruptions or issues early on can potentially cascade through (**strong scaffolding**)

Logistics

- High demands on staff time makes scaling difficult
- Highly tailored examples make sharing and scaling very time- and effort- intensive

Cohort composition

- PXT101 will be core for all MScs from 2018/19 onwards (including MSc Astrophysics, MSc DIA)

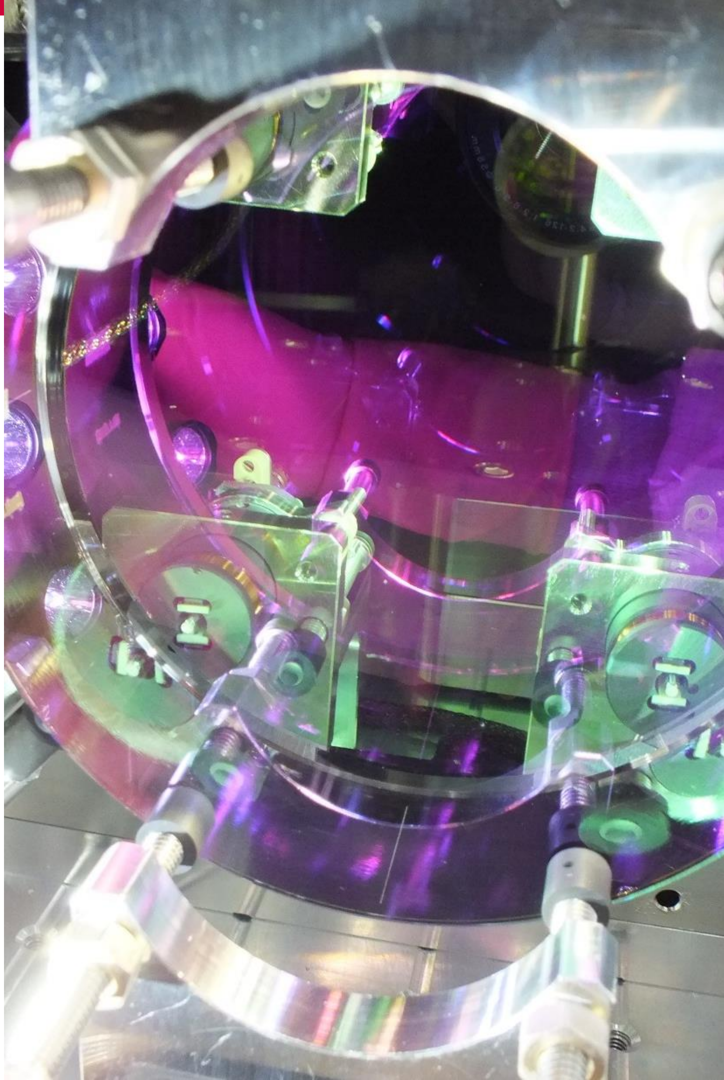
Why NXG 2.0? Why not 2017?

Pedagogy (strongly favours NXG)

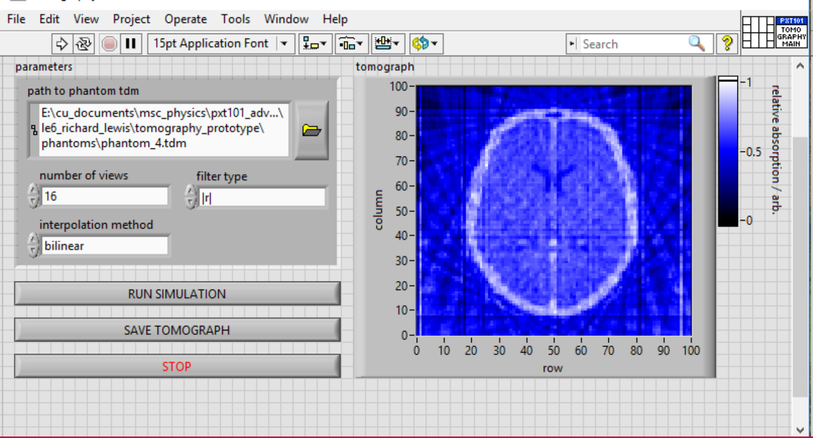
- NXG allows a gentler, more logical learning curve
- NXG starts useful and remains useful
- Supporting materials are excellent
- The NXG interface is (much) better
- Language improvements (e.g. G Types)
- Good style is (much) easier to enforce, projects mandatory

Logistics (no major advantage for NXG over 2017)

- Most issues here are solved by curriculum design
- Primary requirement is to be relevant and useful
- NXG starting and staying useful allows real-world applications to be tackled throughout
- Possible NXG license / mass install issues?



Pedagogical rationale for transitioning to LabVIEW NXG 2.0



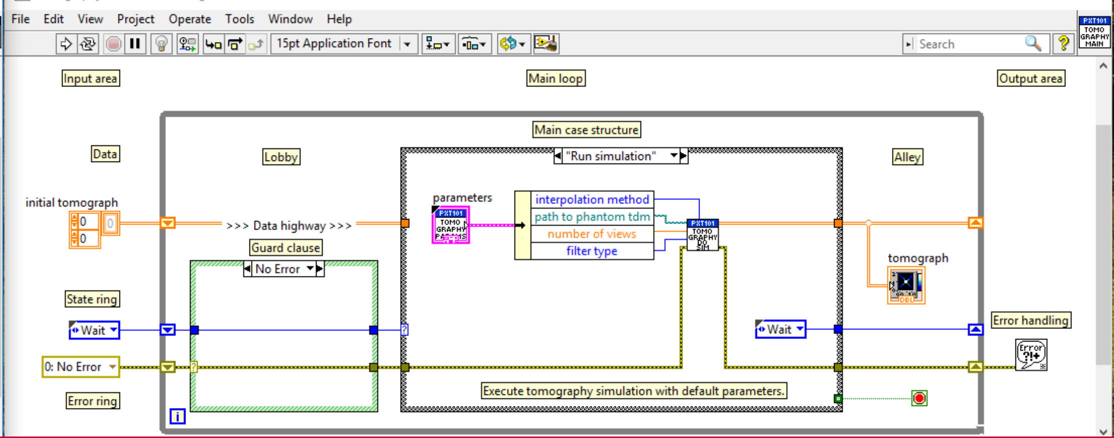
parameters

path to phantom tdm: E:\cu_documents\msc_physics\pxt101_adv...\le6_richard_lewis\tomography_prototype\phantoms\phantom_4.tdm

number of views: 16

filter type: |r|

interpolation method: bilinear



LabVIEW 2015: drills to application

Week 1: projects, front panel, block diagram, dataflow, Express VIs, AAP

Week 2: arrays, clusters, file I/O, case structures, loops, sub VIs, errors, style

Week 3: functional specifications, efficient VI engineering

Week 4: interfacing with hardware, MAX, VISA, AAP with hardware

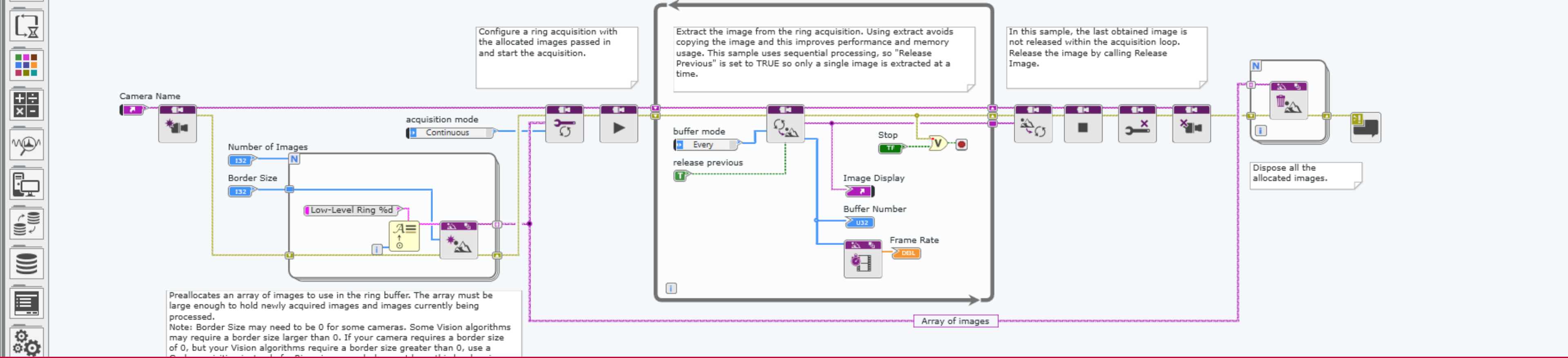
Week 5: development paradigms, type definitions, DAQmx

Week 6: error handling, tunnels, shift registers, classic state machines

Week 7: event structure, event-driven state machines, functional global variables

Week 8: queues, queued state machines

Weeks 9 to 11: applying LabVIEW to micro-projects



Configure a ring acquisition with the allocated images passed in and start the acquisition.

Extract the image from the ring acquisition. Using extract avoids copying the image and this improves performance and memory usage. This sample uses sequential processing, so "Release Previous" is set to TRUE so only a single image is extracted at a time.

In this sample, the last obtained image is not released within the acquisition loop. Release the image by calling Release Image.

Dispose all the allocated images.

Preallocates an array of images to use in the ring buffer. The array must be large enough to hold newly acquired images and images currently being processed.
Note: Border Size may need to be 0 for some cameras. Some Vision algorithms may require a border size larger than 0. If your camera requires a border size of 0, but your Vision algorithms require a border size greater than 0, use a

LabVIEW NXG 2.0: DAQ-first, applications throughout (draft)

Week 1: a guided tour of LabVIEW NXG, establishing common and linked contexts

Week 2 (AAV and IO I): no coding required, NXG functionality, DAQ on 1 and 2 channels

Week 3 (AAV and IO II): coding drag and drop, DAQ on 1 and 2 channels, images

Week 4 (AAV and IO III): coding from scratch, DAQ on 1 and 2 channels, images

Week 5 (looping and iteration I): looping and iteration, looping AAV code

Week 6 (looping and iteration II): : classic state machines

Week 7 (looping and iteration III): : event-driven state machines

Week 8 (looping and iteration IV): : queued state machines

Weeks 9 to 11: continuing to apply LabVIEW to micro-projects

How will NXG support MSc learning?

- LabVIEW NXG is useful from day one
- Students can apply NXG throughout
- Concepts are introduced to directly support the learning, rather than being first assembled in abstract form and applied later

Week 1 (tour)

- DAQ from myDAQ and cameras, projects
- Explicitly showing how NXG is relevant and useful

Weeks 2-4 (AAV and IO)

- Drag-and-drop coding, modifying code, data types, dataflow, sub VIs, flow control, mastering AAV

Weeks 5-8 (looping and iteration)

- Loops, spanning arrays, streaming data, open-act-close paradigm, automation, UI-driven apps

Common and linked concepts in practice: example weekly themes (draft)

MSc Physics (1 to N channel focus)

Week 1: FFT analysis of photodiode data (reaction rate)

Week 2: compensating data for temperature variation
Week 3: gated fluorescence acquisition, integration
Week 4: consolidate into from-scratch AAV applications

Week 5: streaming acquisition of IV data, limits of AAV
Week 6: stepping (V,T), streaming I data
Week 7: UI-driven version, dealing with errors
Week 8: advanced automation and scripting of (V,T)

Weeks 9-11: students concentrate on micro-projects

MSc Astrophysics (1 to N channel focus)

Week 1: FFT analysis of light curve data (variable stars)

Week 2: compensating data for temperature variation
Week 3: gated photometric acquisition, integration
Week 4: consolidate into from-scratch AAV applications

Week 5: streaming acquisition of photometric data
Week 6: stepping (θ,ϕ), streaming photometric data
Week 7: UI-driven version, dealing with errors
Week 8: advanced automation and scripting of (θ,ϕ)

Weeks 9-11: students concentrate on micro-projects

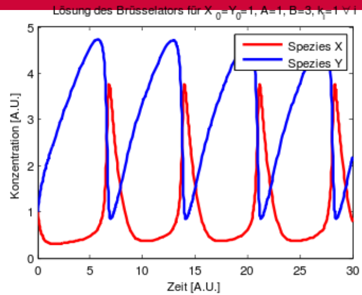
Key ideas

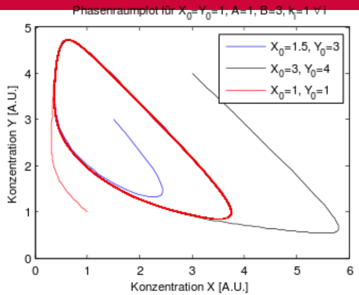
- Make LabVIEW NXG useful from day one, re-use techniques throughout
- Use real-world techniques / tackle real-world problems each week
- Use linkable concepts from each discipline for each week’s activities
- **<u>Explicitly make the links across disciplines</u>**
- **1 to N channel focus** and **image focus** run in parallel

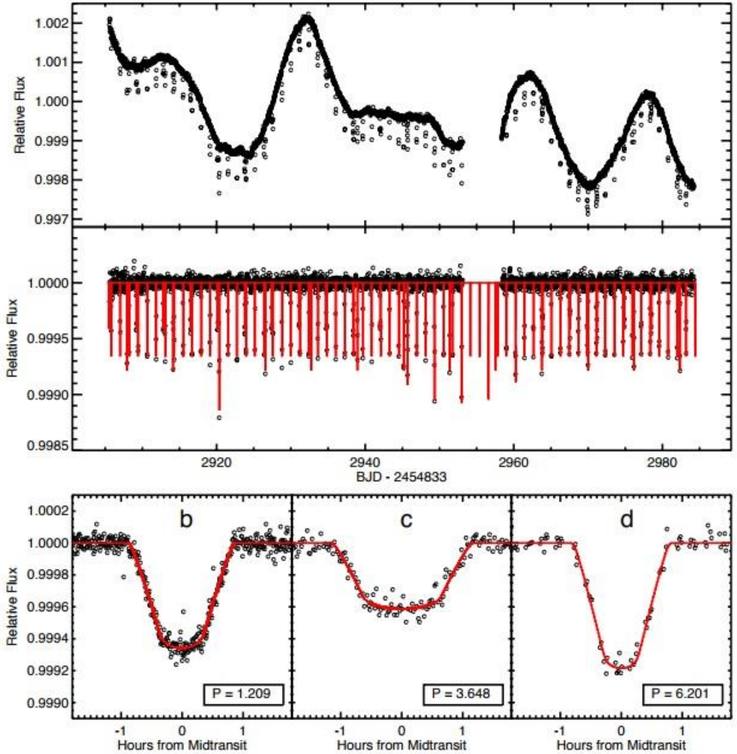
Logistical rationale for transitioning to LabVIEW NXG 2.0

Common and linked contexts

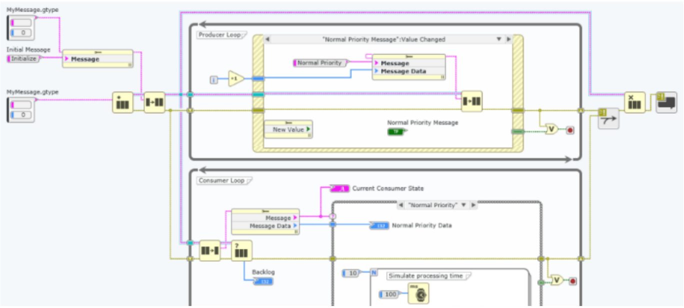
- Transition from per-student customisation to per-discipline customisation is very scalable
- Possible to address very closely related (or identical) skills and concepts for each discipline at the same time (same assessment)
- Maintains “bespoke” feel for minimum additional organisational effort
- Inherently multidisciplinary: supports peer-learning, collaborative projects, etc.



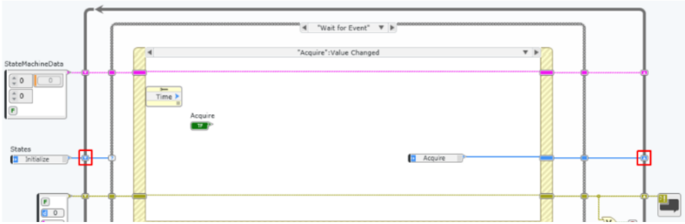




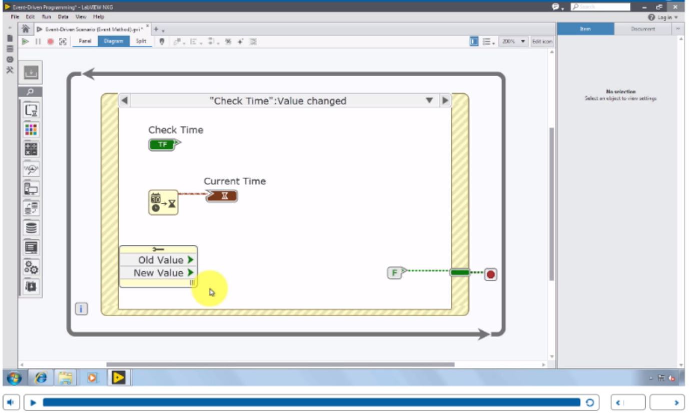
Message Implementation – Producer/Consumer (Events)



Event-Driven State Machine



Event Data Node



Use of Core 1, 2 materials, assessment design

Core 1 and 2 on-line materials

- Specify sections of Core 1 and 2 as pre-reading
- Weekly questionnaires linked to the pre-reading
- Aids scalability, reduces assessment load
- NXG Core 3 coming soon?

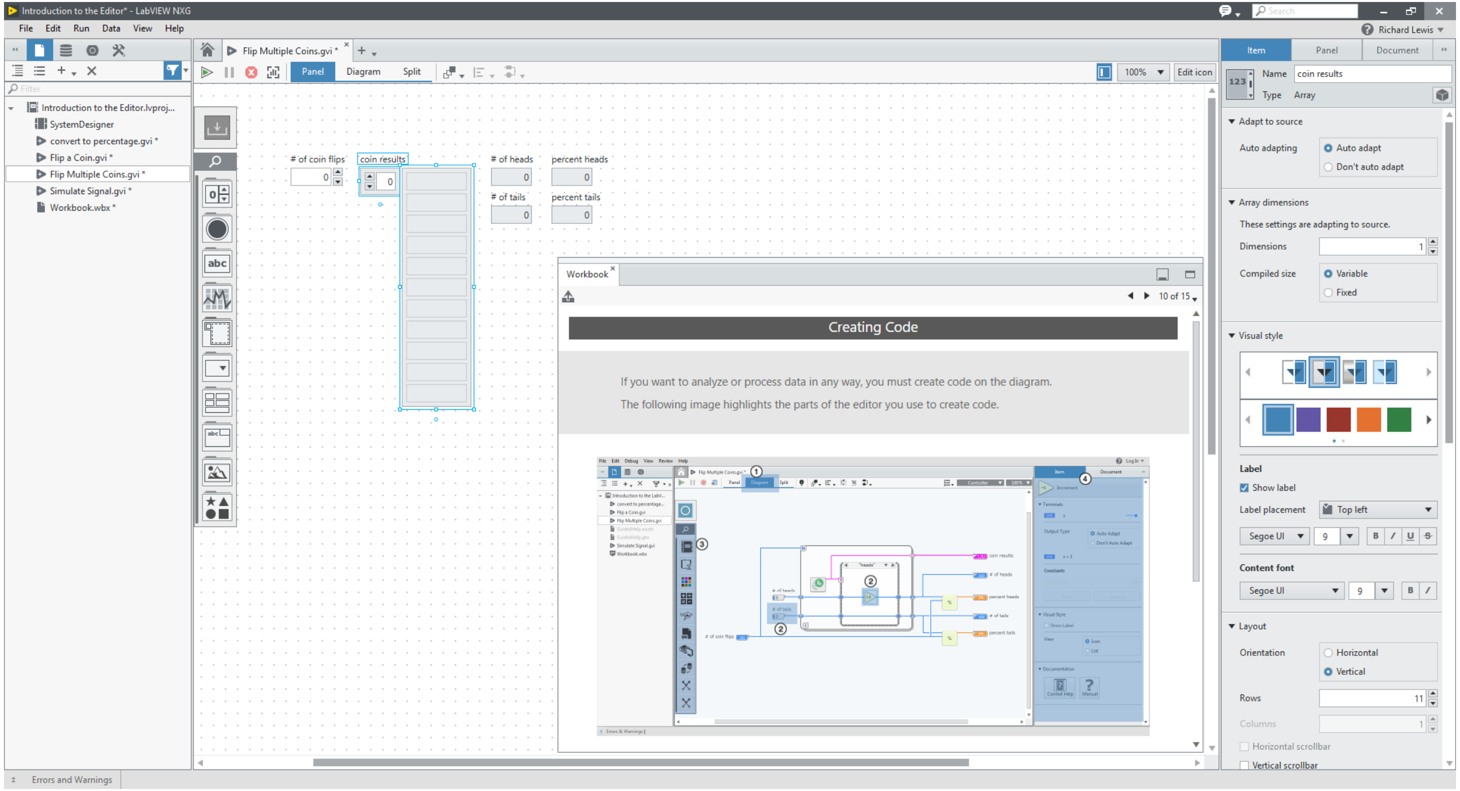
Other assessment

- Laboratory exercises retained, but now will all be group submissions

Weighting?

- Direct LabVIEW material currently 30% of the course mark – scope for increasing this?

LabVIEW NXG workbooks (embedded in the NXG editor)



Creating Code

If you want to analyze or process data in any way, you must create code on the diagram.

The following image highlights the parts of the editor you use to create code.

Name: coin results

Type: Array

Adapt to source

Auto adapting: ● Auto adapt ○ Don't auto adapt

Array dimensions

These settings are adapting to source.

Dimensions: 1

Compiled size: ● Variable ○ Fixed

Visual style

Label

☑ Show label

Label placement: Top left

Segoe UI 9

Content font

Segoe UI 9

Layout

Orientation: ○ Horizontal ● Vertical

Rows: 11

Columns: 1

□ Horizontal scrollbar

□ Vertical scrollbar

These are great – educators really need access to edit these!

Contingency planning and summary

What could go wrong? What's Plan B?

Potential major issues (showstoppers)

- Split of LabVIEW and NXG licences?
- Issues with NXG mass install / licensing

Short-term pain

- A **lot** of materials need to be generated
- Need to revise Advanced LabVIEW elective
- Delay / issues with edit access to workbooks?
- No RIO support in 2.0, coming soon? ☹

Plan B

- Adapt PXT101 materials to LabVIEW 2017
- Implement customisation at per-discipline level

Summary: from drills to DAQ-first

- Transitioning from LabVIEW 2015 to LabVIEW NXG 2.0
- Fundamental change to course structure keeps applications central throughout
- Aiming to solve multiple pedagogical and logistical issues simultaneously

- Potential technical issues such as mass installs, split licences, RIO support,
- Workbooks might not become available in time for 2018/19 :(
- Comments, criticism, etc., welcome! :)

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Case studies, presentations

Bringing the Research Group Ethos into Taught Masters Learning (VICE/PHEC 2016)

MSc Physics Students Take Ownership of their Learning with LabVIEW (NI EIA 2016)

LabVIEW as a Common Language for Community and Skill Building (NI AUF 2016, NIWeek 2017)

Reflections on LabVIEW as a Common Language for Community and Skill Building (NIDays 2017)