Pandora Deep Learning Pull Requests

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LArSoft Coordination Meeting

DEEP UNDERGROUND NEUTRINO EXPERIMENT

WARWICK

DL library in Pandora

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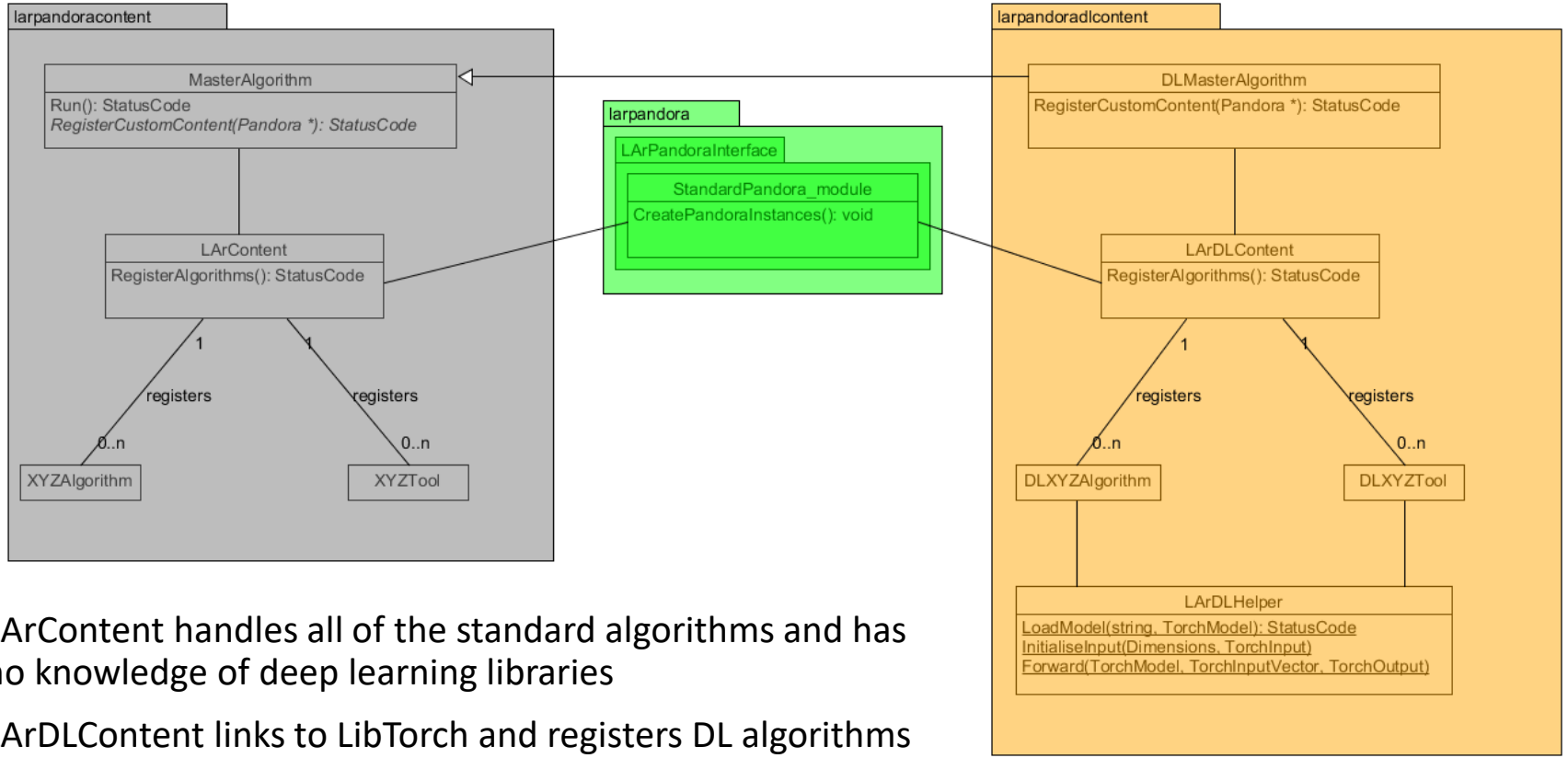
- Active pull requests for larpandoracontent and larpandora add LibTorch support to Pandora
  - The relevant libraries can be optionally built/linked with cmake/mrb option –DPANDORA_LIBTORCH=ON/OFF to larpandoracontent/larpandora respectively, but also checks for the presence of LibTorch and falls back to standard build if missing
  - By default, this option is set to ON (more on what this actually means later)
- Within the larpandoracontent product, there are now larpandoracontent and larpandora**dl**content libraries

```
[phrdqd@nevoso lib]$ ldd libLArPandoraDLContent.so | grep libtorch
        libtorch.so => /cvmfs/larsoft.opensciencegrid.org/products/libtorch/v1_5_1a/Linux64bit+3.10-2.17-e19-eigen/lib/libtorch.so (0x00007f12aad0e000)
        libtorch_cpu.so => /cvmfs/larsoft.opensciencegrid.org/products/libtorch/v1_5_1a/Linux64bit+3.10-2.17-e19-eigen/lib/libtorch_cpu.so (0x00007f12a70eb000)
        libc10.so => /cvmfs/larsoft.opensciencegrid.org/products/libtorch/v1_5_1a/Linux64bit+3.10-2.17-e19-eigen/lib/libc10.so (0x00007f12a6ea6000)
[phrdqd@nevoso lib]$
```

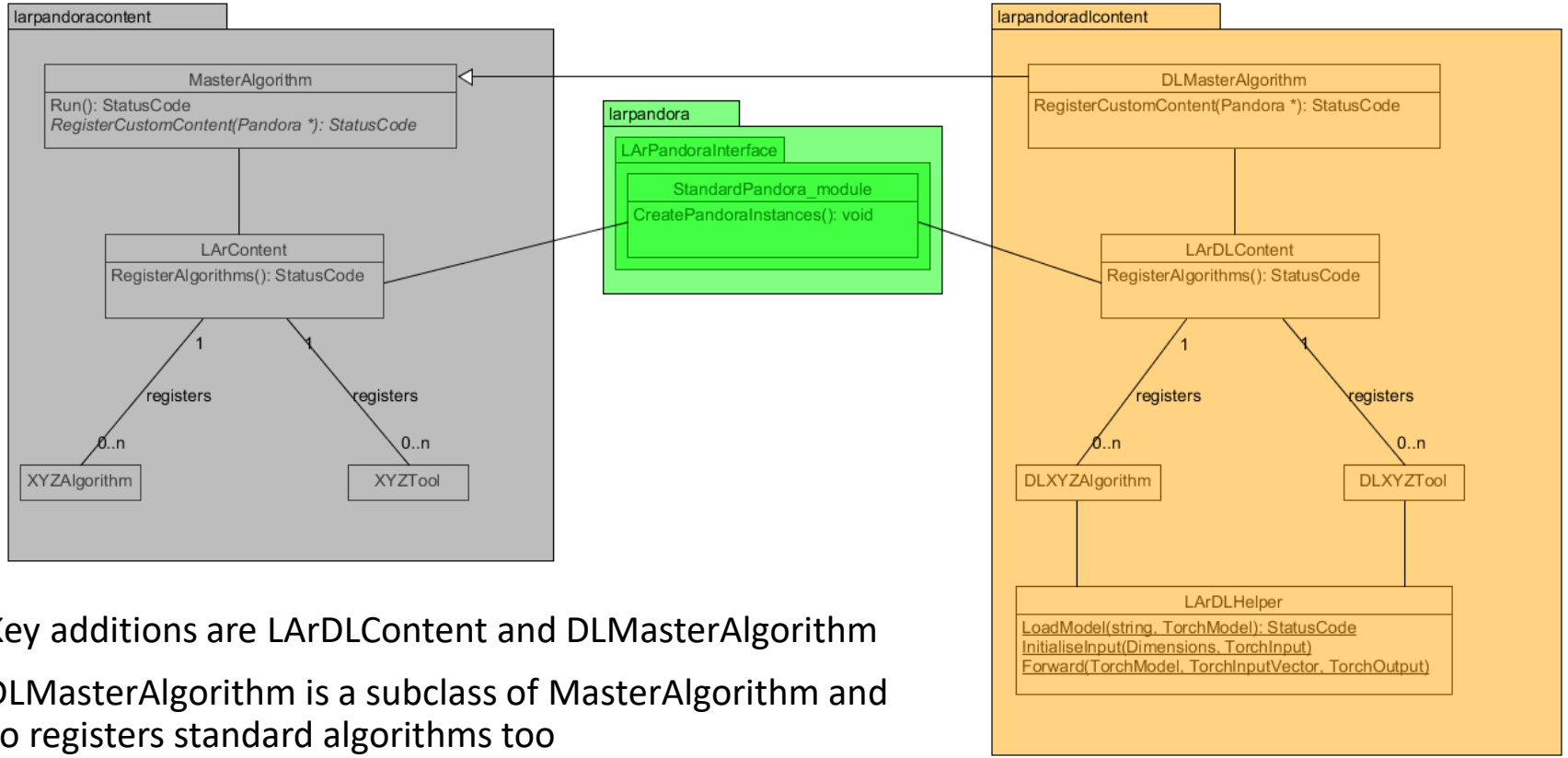
```
[phrdqd@nevoso lib]$ ldd liblarpandora_LArPandoraInterface.so | grep Content
        libLArPandoraDLContent.so => /storage/epp2/phrdqd/Pandora.repos/LArSoftPyTorch/DUNE_v09_06_00/build_slf7.x86_64/larpandoracontent/lib/libLArPandoraDLContent.so (0x00007fbcbf28b000)
        libLArPandoraContent.so => /storage/epp2/phrdqd/Pandora.repos/LArSoftPyTorch/DUNE_v09_06_00/build_slf7.x86_64/larpandoracontent/lib/libLArPandoraContent.so (0x00007fbcbe96c000)
[phrdqd@nevoso lib]$
```

DL library in Pandora



- LArContent handles all of the standard algorithms and has no knowledge of deep learning libraries
- LArDLContent links to LibTorch and registers DL algorithms

DL library in Pandora



- Key additions are LArDLContent and DLMasterAlgorithm
- DLMasterAlgorithm is a subclass of MasterAlgorithm and so registers standard algorithms too

Using the LArDLContent library

- When there is no need of LibTorch functionality, Pandora can be used entirely unchanged, but to use LibTorch functionality in the context of the master algorithm, an alternative master algorithm is employed:

```
<algorithm type = "LArDLMaster">   <!-- <algorithm type = "LArMaster">   -->
   <CRSettingsFile>PandoraSettings_Cosmic_DUNEFD.xml</CRSettingsFile>
   <NuSettingsFile>PandoraSettings_Neutrino_DUNEFD.xml</NuSettingsFile>
   <SlicingSettingsFile>PandoraSettings_Slicing_Standard.xml</SlicingSettingsFile>
   …
```

- If this is the only change made to XML files, everything will run as if the LArMaster algorithm was still in use
  - Useful for validating the build mechanics in LArSoft, while leaving all outputs unchanged
  - When built with –DPANDORA_LIBTORCH=ON larpandora registers DL algorithms, which can then be included (or not) in top-level XML as well
- To use a LibTorch-based algorithm, the algorithm should live in the larpandoradlcontent branch of the larpandoracontent repository (in the `lar_dl_content` namespace), and then added to the appropriate worker XML (e.g. PandoraSettings_Neutrino_DUNEFD.xml) in the usual way

LibTorch performance implications

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- Investigation into LibTorch performance issues is ongoing, so it's clearly undesirable to have non-performant DL algorithms running in the LArSoft stack right now
- As such, although the DL functionality is included by default in these pull requests, no DL algorithms run by default, so no performance hit is expected while the LibTorch performance issues are investigated
  - Any inclusion of DL algorithms moving forward will, of course, be discussed with the relevant experiments
- Main aim for the Pandora team is to make the functionality available for ongoing development and testing purposes
  - In the near-term, we have track/shower discrimination and vertexing networks which can be tested within the existing reconstruction chain
  - Longer-term we will be investigating the use of networks across different areas of the reconstruction, from clustering through to algorithm selection
- I'm also in the early stages of investigating GPUaaS

Summary

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- Issued PRs providing LibTorch deep-learning support for Pandora
- Goal is the provision of the functionality for development and testing purposes
- Expect no performance hit from current LibTorch issues