# Prompt processing and Data Quality Monitoring in the protoDUNE-SP experiment

M.Potekhin

NPPS Meeting - May 24th 2019



#### **Overview**

- Please look at the "Backup Slides" at your leisure, there is interesting material there
- Lots of graphics here which I'm going to quickly go through
- The Deep Underground Neutrino Experiment: DUNE
  - the experiment and its Liquid Argon TPC (LArTPC)
- protoDUNE
  - experimental program at CERN involving two large LArTPC prototypes
- Prompt processing and Data Quality Monitoring in protoDUNE-SP (single phase)
  - motivation, scale and requirements
  - general design
  - components, deployment
  - operation and experience with the system



#### **DUNE components**



DUNE has been conceived around three central components:

- an intense 1.2MW wide-band neutrino beam originating at FNAL
- a capable fine-grained near neutrino detector close to the neutrino source
- a massive 40kT Liquid Argon time-projection chamber deployed as a far neutrino detector 1,300 km from FNAL and 1.5km underground



#### protoDUNE-SP in numbers

- Includes full-scale elements of the DUNE LArTPC: 2.3×6.2m<sup>2</sup> each
- TPC volume: 7.3×7.4×6.2m<sup>3</sup>
- External cryostat dimensions: ~11×11×11m<sup>3</sup>
- TPC channel count: 15,360
- Channel readout operating at 87K (inside the cryo)
- Digitization frequency: 2MHz
- Nominal readout window: 5ms
- Nominal beam trigger rate: 25Hz
- Single readout size: 230MB
- Lossless compression factor: 4
- Post-compression peak data rate: 1.4GB/s
- Nominal 20Gbps network bandwidth from the experiment to CERN central storage
- ~3PB of data has been collected so far





#### Data Quality Monitoring (DQM)

- The experiment has many moving parts (e.g. Argon purity, the condition of the "cold electronics" and the readout chain, general sanity/formatting of the data, DAQ etc)
- The operators need to obtain actionable information in real time or "near time"
- Some of the monitoring functionality fits well within the DAQ monitor capability and mode of operation ...but some does not:
  - DQM activity is very agile and the software is updated often not good for DAQ
  - DQM jobs are typically more complex than DAQ monitoring and take a lot longer (channel/group level FFT, basic track finding, a lot of histogramming etc) see next slide
  - may need more cores than locally available in the experiment's data room
  - it is beneficial to validate the data already committed to disk (to check the format)



## The protoDUNE-SP data flow





#### **DQM** payloads

- "Monitoring" plethora of histogramming for channel signals at various level of aggregation, FFTs and metrics, O(1000) entries per run
- Front End Motherboard (FEMB) health check
- 2D event display on raw data
- Data preparation for the 3D event display (rendered remotely at BNL)
- Argon purity estimator (based on cosmic ray track candidates)
- A few other experimental items coming from the working groups in various stages of development



#### **Design considerations**

- The process is data-driven and the processing needs to be elastic with regards to resources
  - and flexible as to what sort computing resource is utilized
  - ...indeed went through a few iterations of hardware/clustering solutions
- Need to automate, manage and orchestrate execution of DQM jobs and their output data
  - provide infrastructure for ingesting the data and triggering processing
  - workflow management capability is desirable (e.g. DAG)
  - must have efficient monitoring of the workload and job/data states
- Need functional UI for accessing the DQM data products



#### The design

- There are two separate systems working in tandem
  - workload management (p3s)
  - DQM user interface
- Both are designed as Django-based Web services
  - Applications written in Python 3.+ (as required by Django 2.+)
  - Separate Apache Web servers... both CLI/HTTP and Web interfaces available
  - PostgreSQL DB
  - Google Charts were used to generate dynamic graphs
- Overall emphasis on simplicity and ease of installation and maintenance
  - frugal but clean and efficient UI



### The p3s pilot framework

- The pilot-based approach was chosen, inspired by PanDA and Dirac
  - allows considerable flexibility in interfacing the computing resources, efficient error handling and data stage in/out, can use multiple clusters at once
  - reduces latency of job submission in case of a batch system being the computing back-end
  - the database back-end is a solid tool for system monitoring, brokerage and other logic
- Flexibility was demonstrated when the system was deployed with minimal effort
  - on a stack of old laptops
  - a cluster at CERN made of consigned old ATLAS TDAQ servers
  - the Ixbatch facility
- p3s is experiment-agnostic and can run any kind of payloads



### p3s

- Queue priority and queue depth for each job class
- Workflows managed using a graph analysis package (NetworkX)
  - DAGs formatted in a standard XML schema GraphML with 3rd party support



- Individual job descriptions in JSON format
- User-friendly CLI to submit and managed ad-hoc jobs and pilots, and manage the system
- Service and error events are stored in a central log in the database accessible from the GUI
- A suite of service scripts to automate data discovery and job generation, manage pilot population, pilot and job timeouts etc
  - Kerberized crontab on CERN lxplus



#### The p3s dashboard

Shifter Manual p3s Home@localhost:8008 DQM Home@localhost:8009



Jobs Pilots Data Services

For experts ⇒ Workflows DAGs Data Types Sites

p3s on server "p3s-web.cern.ch"

Refresh: Never V Submit

Last updated at 16:54:09 09/29/18 CET.

Load: 0.21 0.30 0.26 1/176 14740

#### System Summary

Pilots		Jobs		Jobs Timeline of Job States				Finished Jobs Types					Defined Jobs Types							Type limits			
State 🗠	Count 🛆	State 🗠	Count 🛆	Туре 🛆	1min 🗠	10min 🛆	1hr 🗠	2hrs 🛆	24hrs 🛆	Туре 🛆	1min 🗠	10min 🛆	1hr 🛆	2hrs 🗠	24hrs 🛆	Туре 🛆	1min 🗠	10min 🛆	1hr 🗠	2hrs 🛆	24hrs 🛆	Туре 🛆	Limit 🗠
Total	351	Total	6740	defined	0	19	73	147	1029	evdisp	0	1	18	37	294	evdisp	0	5	20	40	298	evdisp	20
no jobs	294	defined	0	started	0	19	73	147	1029	monitor	0	2	17	34	230	monitor	0	4	18	37	241	monitor	20
running	57	running	57	finished	0	8	71	135	1002	crt	0	0	0	0	0	crt	0	0	0	0	0	crt	20
active	0	finished	6432	pilotTO	0	0	0	0	0	beam	0	0	0	0	0	beam	0	0	0	0	0	beam	20
timeout	0	pilotTO	0	timelimit	0	0	0	0	6	femb	0	2	22	38	291	femb	0	5	20	40	296	femb	20
				error	0	1	7	8	46	purity	0	3	14	26	181	purity	0	5	15	30	194	purity	20

#### Parameter Checklist

System Parameter 🛆	Nominal 🛆	Actual 🛆	Status 🛆	Action 🗠
Total Pilots	350	351	ОК	( <b>5</b> )
Pilot Lifetime : Bad Pilots	90000	89964:322	ОК	-





#### One of the p3s monitor pages - the job monitor

		p3s home @"p3s-web.cern.ch"					DQM @"p3s-content	05/07/18 21:30:18 CET										
	Jobs			Pilots		Workfle	<u>ows</u>	DAGs Data			Data Ty	<u>(pes</u>		Services		Site	25	
								job : Total in DB:14, selected:14 on server "p3s-w	eb.cern	.ch"								
lob S	<ul> <li>All</li> <li>Template</li> <li>Defined</li> <li>Running</li> <li>Finished</li> <li>Pilot Timed Ou</li> <li>Time Limit</li> </ul>	<b>User</b> :	All	Type: All	• # ŗ	ber page: 25	5 V Su	ibmit										
	Uuid 🛆	llear 🔿	Site \land	Host A	Name 🔿	Wfuuid 🔿 t	vpe 🛆	Pavload	Params A	Pri.	t.limit 🛆	State 🛆	defined \land	started 🛆	stonned 🔿	Pid 🔿	Errcode @	
1112200		0301 -	DITC -	1103L Gui	TACULC -	errorard	1		i birburro -			ouno -	dennied		propped	1 14		Directive
0609	6a4baa72-4fad-11e8-bd99-fa163e69d62c	gechrist	bxvm	b62d79dd7e.cern.ch	Monitor:Main	— п	nonitor	/afs/cern.ch/work/g/gechrist/public/monitor_main.sh	-	1	1000	finished	20180504 17:11:26	20180504 17:11:26	20180504 17:14:47	76	0	<ul> <li>Directive</li> </ul>
609	6a4baa72-4fad-11e8-bd99-fa163e69d62c cb398984-4fa9-11e8-8e95-fa163e69d62c	gechrist gechrist	bxvm bxvm	b62d79dd7e.cern.ch b616c5b70d.cern.ch	Monitor:Main Monitor:Main	— п — п	nonitor	/afs/cern.ch/work/g/gechrist/public/monitor_main.sh /afs/cern.ch/work/g/gechrist/public/monitor_main.sh	-	1	1000 1000	finished finished	20180504 17:11:26 20180504 16:45:31	20180504 17:11:26 20180504 16:45:31	20180504 17:14:47 20180504 16:50:32	76 76	0	<ul> <li>Directive</li> <li>—</li> </ul>
609 608 607	6a4baa72-4fad-11e8-bd99-fa163e69d62c cb398984-4fa9-11e8-8e95-fa163e69d62c b927cbb4-4fa6-11e8-98ea-fa163e69d62c	gechrist gechrist gechrist	bxvm bxvm bxvm	b62d79dd7e.cern.ch b616c5b70d.cern.ch b6e1da905a.cern.ch	Monitor:Main Monitor:Main Monitor:Main	— п — п	nonitor nonitor nonitor	/afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh	_ 	1 1 1	1000 1000 1000	finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:23:32	20180504 17:11:26 20180504 16:45:31 20180504 16:23:33	20180504 17:14:47 20180504 16:50:32 20180504 16:30:19	76 76 76	0 1 1	<ul> <li>Directive</li> <li>-</li> <li>-</li> <li>-</li> </ul>
609 608 607 606	6a4baa72-4fad-11e8-bd99-fa163e69d62c cb398984-4fa9-11e8-8e95-fa163e69d62c b927cbb4-4fa6-11e8-98ea-fa163e69d62c 6a9fd2e8-4d80-11e8-aada-fa163e953a6b	gechrist gechrist gechrist mxp	bxvm bxvm bxvm bxvm	b62d79dd7e.cem.ch b616c5b70d.cem.ch b6e1da905a.cem.ch b67dec01e4.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main	n	nonitor nonitor nonitor nonitor	/afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/wser/n/np04dgm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh	- - -	1 1 1 1	1000 1000 1000 1000	finished finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:23:32 20180501 22:44:17	20180504 17:11:26 20180504 16:45:31 20180504 16:23:33 20180501 22:44:18	20180504 17:14:47 20180504 16:50:32 20180504 16:30:19 20180501 22:54:24	76 76 76 76 76	0 1 1 1	<ul> <li>Directive</li> <li></li> <li></li> <li></li> <li></li> <li></li> </ul>
609 608 607 606 605	6a4baa72-4fad-11e8-bd99-fa163e69d62c cb398984-4fa9-11e8-8e95-fa163e69d62c b927cbb4-4fa6-11e8-98ea-fa163e69d62c 6a9fd2e8-4d80-11e8-aada-fa163e953a6b 4e7e2662-4d7d-11e8-8217-fa163e953a6b	gechrist gechrist gechrist mxp mxp	bxvm bxvm bxvm bxvm bxvm	b62d79dd7e.cem.ch b616c5b70d.cem.ch b661da905a.cem.ch b67dec01e4.cem.ch b62a6ccd95.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main	n	nonitor nonitor nonitor nonitor nonitor	/afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/wser/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh	-	1 1 1 1 1 1	1000 1000 1000 1000 1000	finished finished finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:23:32 20180501 22:44:17 20180501 22:22:01	20180504 17:11:26 20180504 16:45:31 20180504 16:23:33 20180501 22:44:18 20180501 22:22:02	20180504 17:14:47 20180504 16:50:32 20180504 16:30:19 20180501 22:54:24 20180501 22:30:25	76 76 76 76 76 76 76	0 1 1 1 0	<ul> <li>Directive</li> <li></li> <li></li></ul>
609 608 607 606 605 604	6a4baa72-4fad-11e8-bd99-fa163e69d62c cb398984-4fa9-11e8-8e95-fa163e69d62c b927cbb4-4fa6-11e8-98ea-fa163e69d62c 6a9fd2e8-4d80-11e8-aada-fa163e953a6b 4e7e2662-4d7d-11e8-8217-fa163e953a6b 304c7cca-4d7d-11e8-bb15-fa163e953a6b	gechrist gechrist gechrist mxp mxp mxp	bovm bovm bovm bovm bovm bovm	b62d79dd7e.cem.ch b616c5b70d.cem.ch b61da905a.cem.ch b67dec01e4.cem.ch b62a6ccd95.cem.ch b600350b92.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main	n	nonitor nonitor nonitor nonitor nonitor nonitor	Jaścem.ch/work/gigechrist/public/monitor_main.sh Jaśscem.ch/work/gigechrist/public/monitor_main.sh Jaśscem.ch/work/gigechrist/public/monitor_main.sh Jaśscem.ch/wser/n/np04dqm/public/p3s/p3s/inputs/Jarsoft/monitor/monitor_main.sh Jaśscem.ch/user/n/np04dqm/public/p3s/p3s/inputs/Jarsoft/monitor/monitor_main.sh	-	1 1 1 1 1 1	1000 1000 1000 1000 1000 1000	finished finished finished finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:23:32 20180501 22:44:17 20180501 22:22:01 20180501 22:21:11	20180504 17:11:26 20180504 16:45:31 20180504 16:23:33 20180501 22:44:18 20180501 22:22:02 20180501 22:21:12	20180504 17:14:47 20180504 16:50:32 20180504 16:30:19 20180501 22:54:24 20180501 22:30:25 20180501 22:32:55	76 76 76 76 76 76 76 76	0 1 1 1 0 1	Directive
609 608 607 606 605 604 603	Ga4baa72-4fad-11e8-bd99-fa163e69d62c cb396984-4fa9-11e8-8e95-fa163e69d62c b927cbb4-4fa6-11e8-8ees-fa163e69d62c Ga9fd2e8-d480-11e8-aada-fa163e953a6b 4e7e2662-4d7d-11e8-8217-fa163e953a6b 3047cca.4d7d-11e8-b915-fa163e953a6b 7d265aee-4d6d-11e8-9b59-fa163e953a6b	gechrist gechrist gechrist mxp mxp mxp mxp	bovm bovm bovm bovm bovm bovm bovm bovm	b62d79dd7e.cem.ch b616c5b70d.cem.ch b6e1da905a.cem.ch b67dec01e4.cem.ch b67dec01e4.cem.ch b62a6ccd95.cem.ch b6600350b92.cem.ch b63b14eaa1.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main	- n - n - n - n - n - n - n - n	nonitor nonitor nonitor nonitor nonitor nonitor nonitor	Asicem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh		1 1 1 1 1 1 1 1 1	1000 1000 1000 1000 1000 1000 1000	finished finished finished finished finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:45:31 20180504 16:23:32 20180501 22:44:17 20180501 22:22:01 20180501 22:21:11 20180501 20:28:48	20180504 17:11:26 20180504 16:45:31 20180504 16:23:33 20180501 22:44:18 20180501 22:22:02 20180501 22:21:12 20180501 20:28:48	20180504 17:14:47 20180504 16:50:32 20180504 16:50:32 20180504 16:30:19 20180501 22:54:24 20180501 22:30:25 20180501 22:32:55 20180501 20:35:31	76 76 76 76 76 76 76 76 76 76	0 1 1 1 0 1 0	Directive
609 608 607 606 605 604 603 602	6a4baa72.4fad.11e8-bd99.fa163e69d62c cb398984.4fa9.11e8-8e95.fa163e69d62c b927cbb4.4fa6.11e8-8ees.fa163e69d62c 6a9fd2e8.4d00.11e8-aada.fa163e6953a6b 4e7e2662.4d7d.11e8-8217.fa163e953a6b 304c7cca.4d7d.11e8-bb15.fa163e953a6b 6854d9dc.4d64.11e8-9556.fa163e953a6b	gechrist gechrist gechrist mxp mxp mxp mxp mxp	bxvm bxvm bxvm bxvm bxvm bxvm bxvm bxvm	b62d79dd7e.cem.ch b61c5b70d.cem.ch b61c5b70d.cem.ch b62d6905a.cem.ch b62a6ccd95.cem.ch b600350b92.cem.ch b63b14eaa1.cem.ch b632a7bdb1.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main		nonitor nonitor nonitor nonitor nonitor nonitor nonitor nonitor	Asicem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh		1 1 1 1 1 1 1 1 1 1 1	1000 1000 1000 1000 1000 1000 1000 100	finished finished finished finished finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:45:31 20180504 16:23:32 20180501 22:44:17 20180501 22:22:01 20180501 22:22:11 20180501 20:28:48 20180501 19:23:47	20180504 17:11:26 20180504 16:45:31 20180504 16:23:33 20180501 22:44:18 20180501 22:22:02 20180501 22:21:12 20180501 20:28:48 20180501 19:23:48	20180504 17:14:47 20180504 16:50:32 20180504 16:50:32 20180501 46:30:19 20180501 22:54:24 20180501 22:30:25 20180501 22:32:55 20180501 20:35:31 20180501 19:30:32	76 76 76 76 76 76 76 76 76 76	0 1 1 1 0 1 0 0	<ul> <li>Directive</li> <li></li> <li></li></ul>
609 608 607 606 605 604 603 602 601	6a4baa724fad-11e8-bd99-fa163e69d62c cb3989844fa9-11e8-8e95-fa163e69d62c b927cbb4-4fa6-11e8-98ea-fa163e69d62c 6a9fd2e8-d400-11e8-anda-fa163e953a6b 4e7c2662-dd7d-11e8-3217-fa163e953a6b 304c7cca-4d7d-11e8-9b15-fa163e953a6b 7d265aee-d464-11e8-959-fa163e953a6b 6854d9d-c464-11e8-9c0f-fa163e953a6b 0667d0c4-472b-11e8-9c7c-fa163e853a6b	gechrist gechrist gechrist mxp mxp mxp mxp np04dqm	bxvm bxvm bxvm bxvm bxvm bxvm bxvm bxvm	b62d79dd7e.cem.ch b616c5b70d.cem.ch b6e1da905a.cem.ch b62da905a.cem.ch b62da905a.cem.ch b600350b92.cem.ch b63b14eaa1.cem.ch b63b214eaa1.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main HitDump		nonitor nonitor nonitor nonitor nonitor nonitor nonitor nonitor nonitor nonitor	Als/cem.ch/work/g/gechrist/public/monitor_main.sh /als/cem.ch/work/g/gechrist/public/monitor_main.sh /als/cem.ch/work/g/gechrist/public/monitor_main.sh /als/cem.ch/work/g/gechrist/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /als/cem.ch/work/n/p04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /als/cem.ch/work/n/p04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /als/cem.ch/work/n/p04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /als/cem.ch/work/n/p04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /als/cem.ch/work/n/p04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh		1 1 1 1 1 1 1 1 1 1 1 1	1000 1000 1000 1000 1000 1000 1000 100	finished finished finished finished finished finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:45:31 20180504 16:23:32 20180501 22:44:17 20180501 22:22:01 20180501 22:22:01 20180501 20:28:48 20180501 19:23:47 20180423 21:17:55	20180504 17:11:26 20180504 16:45:31 20180504 16:23:33 20180501 22:44:18 20180501 22:22:02 20180501 22:21:12 20180501 20:28:48 20180501 19:23:48 20180501 19:23:48	20180504 17:14:47 20180504 16:50:32 20180504 16:50:32 20180501 22:54:24 20180501 22:30:25 20180501 22:30:25 20180501 20:35:31 20180501 19:30:32 20180501 19:30:32	76 76 76 76 76 76 76 76 76 76 76 76	0 1 1 1 0 1 0 0 0 0	Directive
609 608 607 606 605 605 604 603 602 601 600	6a4baa724fad-11e8-bd99-fa163e69d62c cb3989844fa9-11e8-8e95-fa163e69d62c b927cbb4-4fa6-11e8-98ca-fa163e69d62c 6a9fd2e8-4d90-11e8-anda-fa163e953a6b a7c26524d7d-11e8-8d17-fa163e953a6b 304c7cca-4d7d-11e8-9b51-fa163e953a6b 6854d9dc-4d64-11e8-9c76-fa163e953a6b 685fd9dc-4d64-11e8-9c76-fa163e953a6b	gechrist gechrist gechrist mxp mxp mxp mxp mxp np04dqm np04dqm	bxvm bxvm bxvm bxvm bxvm bxvm bxvm bxvm	b62d73dd7e.cem.ch b616c5b70d.cem.ch b616c5b70d.cem.ch b67dec01e4.cem.ch b62a6ccd95.cem.ch b630a50b92.cem.ch b630a7bdb1.cem.ch b632a7bdb1.cem.ch b632a7bdb1.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main HitDump HitDump		nonitor nonitor nonitor nonitor nonitor nonitor nonitor nonitor nonitor nonitor nonitor	Asicem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/monitor_main.sh /afs/cem.ch/work/g/gechrist/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /afs/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/motif/dumptest.sh		1 1 1 1 1 1 1 1 1 1 1 1 1 1	1000 1000 1000 1000 1000 1000 1000 100	finished finished finished finished finished finished finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:45:31 20180504 16:23:32 20180501 22:24:01 20180501 22:22:01 20180501 22:22:01 20180501 22:22:11 20180501 20:28:48 20180501 19:23:47 20180423 21:17:55 20180423 21:17:55	20180504 17:11:26 20180504 16:45:31 20180504 16:45:31 20180501 22:44:18 20180501 22:22:02 20180501 22:22:12 20180501 22:22:12 20180501 20:28:48 20180501 19:23:48 20180423 21:17:55	20180504 17:14:47 20180504 17:14:47 20180504 16:50:32 20180504 16:30:19 20180501 22:54:24 20180501 22:30:25 20180501 22:30:25 20180501 20:35:31 20180501 19:30:32 20180423 21:39:40 20180423 21:34:42	76 76 76 76 76 76 76 76 76 76 76 76 76	0 1 1 1 0 1 0 0 0 0 0 0	Directive
609 608 607 606 605 605 603 602 601 600 609	6a4baa724fad-11e8-bd99-fa163e69d62c cb3989844fa9-11e8-8e95-fa163e69d62c b927cbb4-4fa6-11e8-98ca-fa163e69d62c 6a9fd2c8-4df80-11e8-aada-fa163e953a6b d47cc8624df7d-11e8-8217-fa163e953a6b 7d265ace-4df6d-11e8-959-fa163e953a6b 6854d9dc-4d64-11e8-9c7-fa163e953a6b 6867d9c4-472b-11e8-9c7-fa163e28fa79 0667c750-472b-11e8-9c7-fa163e28fa79 bdd937324728-11e8-b931-fa163e28fa79	gechrist gechrist gechrist mxp mxp mxp mxp mxp np04dqm np04dqm	bxvm bxvm bxvm bxvm bxvm bxvm bxvm bxvm	b624794047e.cem.ch b616c5b70d.cem.ch b616c5b70d.cem.ch b67dec01e4.cem.ch b63a6ccd95.cem.ch b63a14eaa1.cem.ch b632a7bdb1.cem.ch b65d289b81.cem.ch b65d289b81.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main HitDump HitDump EvDisp:Main		nonitor nonito	Ads/cem.ch/work/g/gechrist/public/monitor_main.sh Ads/cem.ch/work/g/gechrist/public/monitor_main.sh Ads/cem.ch/work/g/gechrist/public/monitor_main.sh Ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/moti/midumptest.sh Ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/moti/midumptest.sh		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1000 1000 1000 1000 1000 1000 1000 100	finished finished finished finished finished finished finished finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:45:31 20180504 16:23:32 20180501 22:44:17 20180501 22:22:01 20180501 22:22:01 20180501 22:24:17 20180501 19:23:47 20180423 21:17:55 20180423 21:17:55	20100504 17:11:26 20180504 16:45:31 20180504 16:45:31 20180501 22:44:18 20180501 22:21:22 20180501 22:21:22 20180501 20:28:48 20180501 20:28:48 20180521 21:17:56 20180423 21:17:56	20180504 17:14:47 20180504 16:50.32 20180504 16:30.19 20180501 22:54:24 20180501 22:55 20180501 22:30:25 20180501 22:32:55 20180501 20:35:31 20180501 20:35:31 20180501 19:30:32 20180423 21:39:40 20180423 21:43:21	76 76 76 76 76 76 76 76 76 76 76 76 76 7	0 1 1 0 1 0 0 0 0 0 0 0 0 0	Directive
06009 0608 0607 0606 0605 0605 0604 0603 0602 0600 0600 0599	6a4baa72-4fad-11e8-bd99-fa163e69d62c cb398984-4fa9-11e8-8e95-fa163e69d62c b927cbb4-4fa6-11e8-98ea-fa163e69d62c 6a9fd2e8-4d80-11e8-aada-fa163e953a6b 4a7c2662-4d7d-11e8-8217-fa163e953a6b 03dc7cca-4d7d-11e8-b15-fa163e953a6b 6854d9dc-4d64-11e8-950-fa163e953a6b 06667d0c4-4d64-11e8-9c7c-fa163e28fa79 06667c50-472b-11e8-9c7c-fa163e28fa79 0bd93732-472b-11e8-b31-fa163e28fa79	gechrist gechrist gechrist mxp mxp mxp mxp mxp np04dqm np04dqm np04dqm	bxvm bxvm bxvm bxvm bxvm bxvm bxvm bxvm	b624794047e.cem.ch b616c5b70d.cem.ch b616c5b70d.cem.ch b67dec01e4.cem.ch b630350b92.cem.ch b630350b92.cem.ch b63047b4b1.cem.ch b65d289b81.cem.ch b65d289b81.cem.ch b612c657ca.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main HitDump HitDump EvDisp:Main HitDump		nonitor nonito	Ads/cem.ch/work/g/gechrist/public/monitor_main.sh Ads/cem.ch/work/g/gechrist/public/monitor_main.sh Ads/cem.ch/work/g/gechrist/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/moti/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/moti/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/moti/mitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/moti/monitor_main.sh /ads/cem.ch/user/n/np04dqm/public/p3s/p3s/inputs/larsoft/moti/monitor_main.sh		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1000 1000 1000 1000 1000 1000 1000 100	finished finished finished finished finished finished finished finished finished finished finished	20180504 17:11:26 20180504 17:11:26 20180504 16:45:31 20180504 16:23:32 20180501 22:24:17 20180501 22:22:01 20180501 22:22:11 20180501 22:24:17 20180423 21:17:55 20180423 21:17:55 20180423 21:10:34	20100504 17:11-26 20180504 16:45:31 20180504 16:45:31 20180501 22:44:18 20180501 22:24:02 20180501 22:24:12 20180501 20:28:48 20180501 19:23:48 20180423 21:17:55 20180423 21:01:34 20180423 21:01:34	20180504 17:14:47 20180504 16:50.32 20180504 16:50.32 20180504 16:30.19 20180501 22:54:24 20180501 22:30.25 20180501 22:30.25 20180501 20:30.31 20180501 20:30.32 20180423 21:30:40 20180423 21:43:21 20180423 21:43:21	76 76 76 76 76 76 76 76 76 76 76 76 76 7	0 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	Directive
0609 0608 0607 0606 0605 0605 0604 0603 0603 0603 0602 0600 0599 0598	6a4baa72.4fad.11e8.bd99.fa163e69d62c cb398984.4fa9.11e8.8e95.fa163e69d62c bb927cbb4.4fa6.11e8.98ea.fa163e69d62c 6a9fd2e8.4d80.11e8.aada.fa163e953a6b 4e7e2662.4d7d.11e8.b315.fa163e953a6b 7d265aee.4d6d.11e8.9b59.fa163e953a6b 6854d9dc.4d64.11e8.9b59.fa163e953a6b 0667d0c4.472b.11e8.9c7.fa163e953a6b 0667d0c4.472b.11e8.9c7.fa163e28fa79 0667c750.472b.11e8.9c7.cfa163e28fa79 0d493732.4728.11e8.ba32.fa163e28fa79 6d94256.4726.11e8.ab32.fa163e28fa79	gechrist gechrist gechrist mxp mxp mxp mxp np04dqm np04dqm np04dqm	bxvm bxvm bxvm bxvm bxvm bxvm bxvm bxvm	b62279407c.cem.ch b6216307c.cem.ch b616c5b70d.cem.ch b626cc01c4.cem.ch b620350b92.cem.ch b600350b92.cem.ch b600350b92.cem.ch b632a7bdb1.cem.ch b6524290811.cem.ch b650246ba3c.cem.ch b660246ba3c.cem.ch	Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main Monitor:Main HitDump HitDump EvDisp:Main HitDump		nonitor nonito	Jalscem.ch/work/g/gechrist/public/monitor_main.sh Jals/cem.ch/work/g/gechrist/public/monitor_main.sh Jals/cem.ch/work/g/gechrist/public/monitor_main.sh Jals/cem.ch/work/g/gechrist/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/monitor/monitor_main.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/test/hidumptest.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/test/hidumptest.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/test/hidumptest.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/test/hidumptest.sh Jals/cem.ch/work/mp04dqm/public/p3s/p3s/inputs/larsoft/test/hidumptest.sh		1 1 1 1 1 1 1 1 1 1 1 1 1 1	1000 1000 1000 1000 1000 1000 1000 100	finished finished finished finished finished finished finished finished finished finished finished finished	20180504 17:11:26 20180504 16:45:31 20180504 16:45:31 20180504 16:23:32 20180501 22:24:17 20180501 22:22111 20180501 22:22131 20180501 22:24:84 20180423 21:17:55 20180423 21:17:55 20180423 21:07:55 20180423 20:45:02 20180423 00:45:623	20180504 17:11:26 20180504 16:45:31 20180504 16:23:33 20180501 22:44:18 20180501 22:21:02 20180501 22:21:12 20180501 22:24:8 20180501 19:23:48 20180423 21:17:56 20180423 21:17:55 20180423 21:01:55 20180423 20:45:05	2018050417:14.47 2018050416:50.32 2018050416:50.32 2018050416:50.32 2018050122:54.24 2018050122:3025 2018050122:3025 2018050120:3531 20180423 21:30.32 20180423 21:39.40 20180423 21:43.22 20180423 21:33.22 20180423 21:13.32	76 76 76 76 76 76 76 76 76 76 76 76 76 7	0 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	Directive

**13** M Potekhin | *prompt processing and DQM in protoDUNE-SP* | NPPS meeting - May 2019



DUNE

#### p3s in protoDUNE data challenges



**14** M Potekhin | *prompt processing and DQM in protoDUNE-SP* | NPPS meeting - May 2019



DUNE

#### **DQM content service**

- The salient feature of the system design is self-describing data
- Jobs are expected to generate JSON-formatted descriptions of categories of their output and list of plots in each category, as well as some summary metrics
- GUI elements, web pages and links are generated automatically by the server with no code changes required to match the constantly chaging software
- This was an important enabling feature of DQM which contributed to its success

Back to DQM Home@localhost:8009 Run: 4828, fileIdx: 58, dl: 1, type: monitor													
Profiled number of hits	run004828_0058_sps_event21715	FFT Channel	SSP Raw Decoder Plots	Timing Raw Decoder Plots	Channel stuck code off								
Profiled hit RMS	Beam particle - run004828_0058_sps_event21740	Waveform for Channel			Mean of channel ADC from slot								
Hit Charge distribution per APA per view	run004828_0058_sps_event21708	Hit times			Profiled FFT Fiber								
Number of hits per APA per view	run004828_0058_sps_event21740	Peak Amplitude			RMS of ADC per view per APA and per channels								
Profiled hit charge	Beam particle - run004828_0058_sps_event21708	Peak Area			Mean of ADC per view per APA for all channels								
Hit peak time distribution per APA per view	Beam particle - run004828_0058_sps_event21715	ADC values			Persistent FFT Fiber								
Hit RMS distribution per APA per view		Persistent Waveform			Mean and RMS of ADC for all channels								
					RMS of ADC per view per APA for all channels								
					RMS of channel ADC from slot								
					Number of Ticks in TPC channels								
					Bit values								
					FFT								
					Channel stuck code on								
					Number of noisy channels								
					Moon of ADC per view per ADA and per ehappele								

Produced by job fc0b2426-c3eb-11e8-a208-fa163e513824 at 09/29/18 14:54:21

**15** M Potekhin | *prompt processing and DQM in protoDUNE-SP* | NPPS meeting - May 2019

BROOKHAVEN NATIONAL LABORATORY



#### p3s and DQM interfaces (data)







#### DQM - LAr purity graphs displayed in the control room



**17** M Potekhin | *prompt processing and DQM in protoDUNE-SP* | NPPS meeting - May 2019



DUNE

#### DQM - the LAr purity timeline (based on muon tracks candidates)





#### **DQM - the hits timeline**





#### **DQM - channel FFT plots**









#### **DQM - first tracks seen in protoDUNE**





#### p3s/DQM deployment in OpenStack (CentOS 7 VMs)

CERN Accelerating science Signed in as: mpotekhi Sign out Directory													
🖸 openstack	■ DUNE +										Tools •		
Project				11	ISTANCE ID = +			FILTER	A LAUNCH INSTAN	ICE DELETE INSTAN	CES MORE ACTIONS -		
API Access	Displaying 10 items												
Compute	Instance Name	Image Name	IP Address	Flavor	Key Pair	Status	Availability Zone	e Task	Power State	Time since created	Actions		
Overview	protodune-fts	SLC6 - x86_64 [2018-03-16]	137.138.76.234 2001:1458:d00:1c::ea	m2.xlarge	steve-openstack	Active	cern-geneva-a	None	Running	1 month	CREATE SNAPSHOT +		
Instances Images	protodune-ftslight2	SLC6 - x86_64 [2018-01-12]	137.138.152.177 2001:1458:d00:13::ae	m2.medium	steve-openstack	Active	cern-geneva-a	None	Running	1 month, 3 weeks	CREATE SNAPSHOT +		
Key Pairs	protodune-fts2	SLC6 - x86_64 [2018-01-12]	137.138.31.189 2001:1458:d00:19::b9	m2.xlarge	steve-openstack	Active	cern-geneva-b	None	Running	1 month, 3 weeks	CREATE SNAPSHOT +		
Volumes	protodune-ftslight1	SLC6 - x86_64 [2018-01-12]	137.138.120.127 2001:1458:d00:16::18c	m2.medium	steve-openstack	Active	cern-geneva-c	None	Running	2 months	CREATE SNAPSHOT +		
Container Infra	dune-vm-build-03	مع SLC6 - x86_64 [2017-04-06]	188.185.113.233 2001:1458:d00:a::100:1e3	m2.xlarge	Ixplus	Active	cern-geneva-a	None	Running	9 months	CREATE SNAPSHOT +		
Identity	dune-vm-build-02	SLC6 - x86_64 [2017-04-06]	188.185.112.32 2001:1458:d00:a::100:1a	m2.large	Ixplus	Active	cern-geneva-a	None	Running	9 months	CREATE SNAPSHOT +		
Workflow	np04-webgw1	CC7 - x86_64 [2017-04-06]	188.185.71.29 2001:1458:d00:7::100:317	m2.large	Ixplus	Active	cern-geneva-c	None	Running	10 months	CREATE SNAPSHOT +		
	p3s-content	CC7 - x86_64 [2017-04-06]	188.185.77.72 2001:1458:d00:9::100:142	m2.medium	2	Active	cern-geneva-a	None	Running	10 months, 1 week	CREATE SNAPSHOT *		
	p3s-db	CC7 - x86_64 [2017-04-06]	188.185.85.205 2001:1458:d00:f::100:1c7	m2.medium	5	Active	cern-geneva-a	None	Running	10 months, 1 week	CREATE SNAPSHOT +		
	p3s-web	CC7 - x86_64 [2017-04-06]	188.185.85.175 2001:1458:d00:f::100:1a9	m2.medium	2	Active	cern-geneva-a	None	Running	10 months, 1 week	CREATE SNAPSHOT +		
	Displaying 10 items												



#### **Experience with p3s/DQM and future plans**

- Motivations for the system and its design proved to be correct
- Server logs demonstrate that the system was used regularly by the shifters and DRA team members throughout the run with hundreds of hits per day
- Since the beginning of the run, there was a good engagement with the reco team and other experts
- Stephen Pordes: "My concern is essentially that the DQM continue to be available; the DQM is by far our best source of information to guide us as we perform this crucial part of the prototyping"
- Operation of the p3s and DQM services has largely been smooth, running and continuously updated since mid-2017 and underwent two data challenges in the workup to the run
  - virtually no interventions required
- Docker images are being prepared to further facilitate installation and maintenance
- The p3s workload management system will be migrated to a VM with a higher core count currently just 2 cores so the load may be not trivial



## **Backup Slides**





#### **DUNE: the Primary Science Program**

- Precision measurement of neutrino oscillation parameters
- Search for proton decay in several modes, for example  $p \rightarrow Kv$
- Detection and measurement of the neutrino flux from core-collapse supernovae in our galaxy (should any occur during the lifetime of the experiment)



#### Single-Phase LArTPC (DUNE and protoDUNE)

- Liquid Argon serves as both the target and the sensitive medium. LArTPC is essentially an ionization chamber with multiple sets of electrodes (wires)
- Planar arrays of sensor wires are grouped in the **anode assembly**, including two *induction planes* with wires at a **stereo angle** and the *collection* plane.
- Two coordinates (in the plane) are determined via stereo projections on three planes, and the third (along the drift) via the time measurement





#### The scale of the DUNE LArTPC

- Four 10kt TPC modules (each 58m long)
- 1,536,000 TPC channels
- Integrated photon detector



27 M Potekhin | prompt processing and DQM in protoDUNE-SP | NPPS meeting - May 2019



DUNE

#### The protoDUNE program at CERN

- Prototypes of Single- and Dual-Phase LArTPCs (CERN designation NP04 and NP02)
- Purpose-built test-beam facility in the extension of the North Area Hall, with a tertiary beam from the SPS (H4) providing various particle types
- In addition to validating the design of the detectors, the progeam provides a unique opportunity for detector characterization and evaluation of reconstruction techniques in controlled test-beam conditions and with varying event types. Beam and cosmic ray triggers.





#### **Construction of the Anode Plane Assembly (the APA) - 6m across**



29 M Potekhin | prompt processing and DQM in protoDUNE-SP | NPPS meeting - May 2019



DUNE

#### **Building the cryostat**







#### View from the control room (top of the cryostat)





