Answers to Questions for LArIAT ORR

13 October 2015

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for the LArIAT collaboration

Question 1

- The LArIAT collaboration is responsible for operating the experiment in a safe manner. Describe how that is accomplished. Include a discussion of the relevant organization, functional roles, and personnel. Cover the installation, commissioning, steady-state running, and repair conditions.

Operating Safely: (Re)installation

- Run Coordinator & Deputies are responsible for coordination of installation activities
  - Responsible parties are identified for each installation task, and these parties coordinate work through Run Coordinator
- During installation period, daily toolbox meetings are held before beginning work, to make sure that everyone knows roles and tasks, understands hazards, and communicates concerns
  - For tasks that are not routine, Job Hazard Analyses are prepared, approved by ES&H, and signed by workers
  - e.g., Procedure for opening cryostat in MC7
- We also coordinate activities with FTBF personnel who have oversight (JJ Schmidt & Mandy Rominsky) and technical services/expertise (FTBF technicians)

Operating Safely: Commissioning

- Run Coordinator & Deputies are responsible for coordination of commissioning activities, with toolbox meetings when appropriate
- Re-commissioning of the beamline detectors will be done in the same way as for Run-I
  - Initial commissioning (pre-beam) checks: power-up and readback of each system, check delays, thresholds, gate widths
  - Timing-in is done manually once beam is delivered, but we don't expect this to have changed significantly from Run-I to Run-II
- Commissioning TPC will also be done in same manner as Run-I
  - Before closing cryostat, send calibration pulses to each channel to check for good connections, low noise, look for swapped cables

Safety: Steady State Running

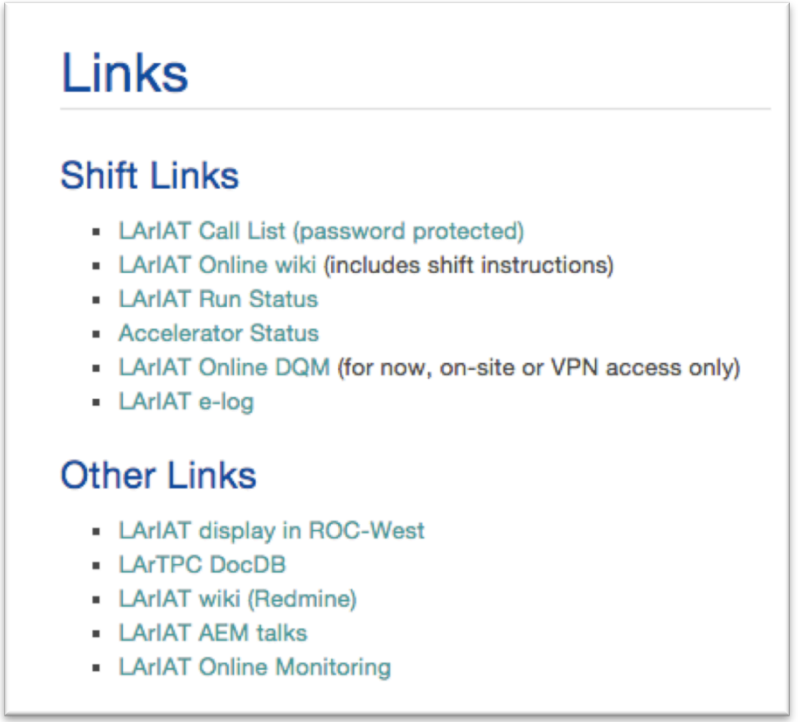
- ES&H for safe operations is coordinated by spokesperson (JLR)
  - ITNA for new collaborators is updated/created when they join the experiment
    - For shift-taking, require: “FTBF Hazard Awareness” training
    - For work in MC7 enclosure, require:
      - FTBF Hazard Awareness
      - Rad Worker
      - Controlled Access
  - MC7 is classified as ODH-0
    - Requires ODH monitoring system, including ODH exhaust fan to maintain this classification
    - ODH monitoring system and exhaust fan were implemented before beginning of run in order to meet this requirement

Operating Safely: Routine Repairs

- Decision for how to proceed depends on what is broken and what time of day it is
  - If middle-of-the-night critical component breaks, Run Coordinator calls in experts to make Controlled Access (minimum 2 people required)
  - If non-critical component, data-taking continues until morning without that detector in the data stream

Operating Safely: Emergency Repairs

- Emergency call-list with well-defined areas of responsibility
  - There are at least 2 experts for each system
  - Cryo & cryo controls system are the only major areas where we rely on non-LArIAT collaborators for emergency support
    - Technician on-call
    - Emergency contact info for Cryo Engineers & Cryo Controls Eng.
  - ODH system is connected to FIRUS. Experts are notified in case of alarm



Emergency Repair Example

- Torrential rains in mid-June caused extensive flooding in MCenter enclosure late one evening
  - Water killed UPS that supports cryo controls rack. When rack power died, “ODH Trouble” alarm (indicating equipment problem) was sent to FIRUS
  - Main switchboard operator saw FIRUS alarm and started calling down ODH phone list, but misreported alarm as just “ODH Alarm” (indicating hazardous environment)
  - At the same time, shifter found all cryo-related monitors were in alarm and phoned cryo experts and Run Coordinator
  - Under direction of RunCo, shifter notified MCR of alarm, and asked for beam to be shut off, and to help us investigate problem
  - MCR sent emergency crew with self-rescuers and monitors, who entered the MCenter enclosure and found that environment was not oxygen deficient
  - As we could not (at the time) identify the cause of the alarm, and since we had no way to monitor the system overnight since the cryo rack was not reporting monitor values, we chose to turn off the TPC HV, PMTs, and TPC wire bias for the night. Cryo engineer could still control cryo system through IFIX, and so was able to put system into stable state for the night (not supplying new argon to cryostat, but still allowing the boil-off argon to vent safely to outside)
  - In the light of day, a team of cryo experts investigated the situation, and identified the source of the problem (dead UPS)
  - System was put back into operation late that morning

Hardware-related ES&H

- ES&H related to getting the detectors operating is well-addressed by the FTBF Operational Readiness Clearance process
  - Documents for this are available in our DocDB:
    - Cryogenic Safety documentation http://lartpc-docdb.fnal.gov/cgi-bin/ShowDocument?docid=1213
    - HV System ORC documentation http://lartpc-docdb.fnal.gov/cgi-bin/ShowDocument?docid=1472
    - Full System ORC documentation http://lartpc-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=1644

Question 2

- Clarify your (prioritized) physics goals and the required statistics and tools per physics goal. Discuss your run plan in the context of meeting these goals.

Prioritized Physics Goals

- $\pi^{\pm}$ total inclusive cross section (current top priority)
- π exclusive cross sections:
  - Charge Exchange: $\pi^- + p\ (\rightarrow\ \Delta^0) \rightarrow\ \pi^0 + n$

    $\pi^+ + n\ (\rightarrow\ \Delta^+) \rightarrow\ \pi^0 + p$
  - Absorption: e.g., π^+ (np) → p p
- Kaon ID (decay channels and interaction channels)
- μ sign determination without magnetic field (capture vs. decay)
- e-shower vs γ-shower separation
- ***p:*** recombination of ionization charge vs electric field

Required Statistics

- $\pi^{\pm}$ total cross section
  - Need 5000 π events (for each sign) to achieve measurement at 10% stat error in 50 MeV bins from 100 MeV to 1 GeV kinetic energy.
  - Estimate made by scaling from current analysis (~400 events, which is ~10% of available stats, and with very tight cuts). **Statistics from Run-I expected to be sufficient to match the goal.**
- π exclusive cross sections
  - $\sigma_{chgx} \simeq 0.15 \times \sigma_{Tot} \Rightarrow$ to achieve measurement at 10% stat error, need ~ 30,000 π events **(i.e. requirement for Run-II: 6 times statistics from Run-I)**
  - $\sigma_{abs} \simeq 0.30 \times \sigma_{Tot} \Rightarrow$ **requirement for Run-II: 6 times statistics from Run-I** will be more than sufficient

Required Statistics, cont'd

- Kaon ID
  - Kaon production is ~2% of pion production

  ⇒ **Requirement for Run-II: 6 times statistics from Run-I**
    - This will provide ~600 kaon events, sufficient for kaon ID studies
- μ sign determination
  - Muon production is ~5% of pion production

  ⇒ **Requirement for Run-II: 6 times statistics from Run-I**
    - This will provide ~1500 μ events, sufficient for μ sign determination studies
- ***p*** recombination study
  - Proton production is ~10% of pion production

  ⇒ **Requirement for Run-II: 6 times statistics from Run-I**
    - This will provide ~3000 p events, sufficient for recombination studies
- e-shower vs. γ-shower separation
  - Required statistics for this goal not yet determined. Under study.

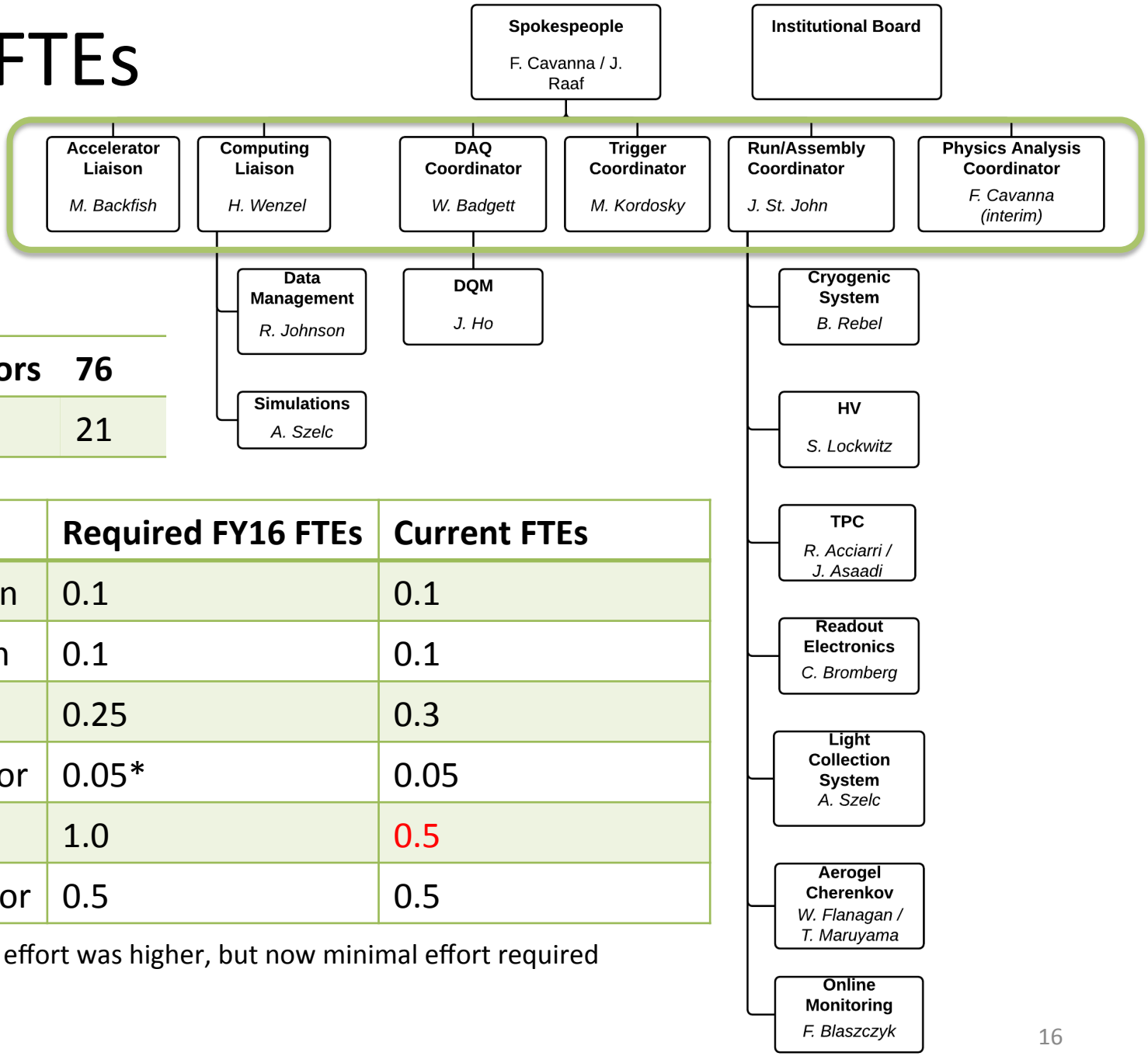
Run plan in context of meeting goals

- **Requirement for Run-II: Collect (at least) 6 times statistics of Run-I**
  - Physics goals appear achievable with Run-II time of 10 - 14 weeks (IF beam muon halo suppression is approved and implemented)
  - At this time, we have no reason to expect that halo suppression will not be implemented
- **Additional Run-II plan: Run secondary pion beam (on tertiary target) at 64 GeV to improve kaon production**
  - Muon range stack upgraded to better discriminate muon to pion at higher energies

Question 3

- Please provide an estimate of your FTE needs for FY16 and compare it to your FTE resources. Break out technical resources provided from the lab. Include a discussion of availability when competing experiments are simultaneously running (e.g. MicroBooNE). Comment on the existence of formal agreements (TSW, SOW, MOU) with relevant lab divisions and collaborating Institutions.

LArIAT FTEs

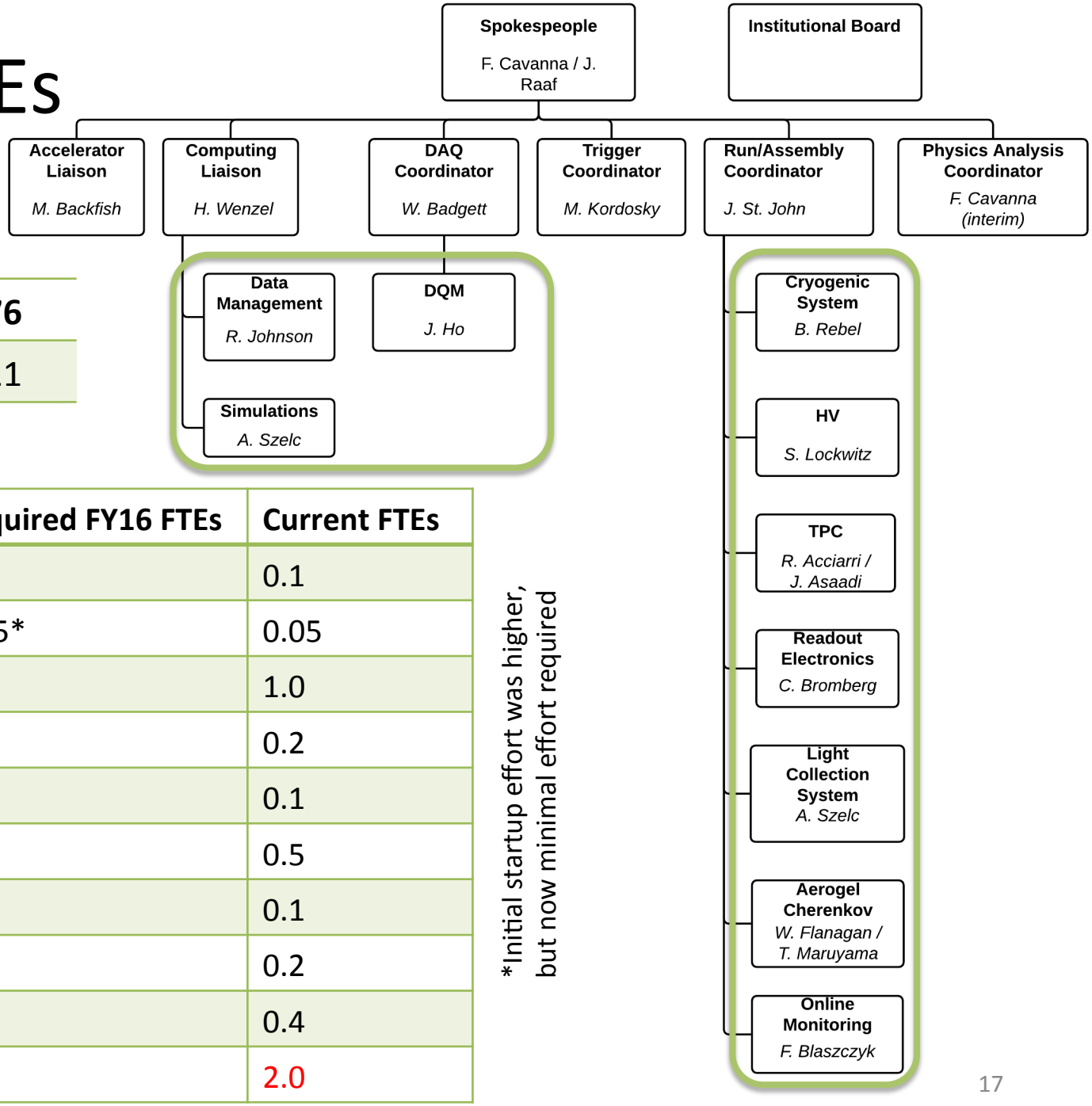


Total # collaborators	**76**
Total # FTEs	21

Role	Required FY16 FTEs	Current FTEs
Accelerator Liaison	0.1	0.1
Computing Liaison	0.1	0.1
DAQ Coordinator	0.25	0.3
Trigger Coordinator	0.05*	0.05
Run Coordinator	1.0	0.5
Physics Coordinator	0.5	0.5

*Initial startup effort was higher, but now minimal effort required

LArIAT FTEs



Total # collaborators	**76**
Total # FTEs	21

Role	Required FY16 FTEs	Current FTEs
Cryogenic System	0.1	0.1
HV	0.05*	0.05
TPC	0.5	1.0
Readout Electronics	0.2	0.2
Light Collection	0.1	0.1
Aerogel	0.1	0.5
Online Monitoring	0.1	0.1
Data Management	0.2	0.2
DQM	0.4	0.4
Simulations	4.0	2.0

*Initial startup effort was higher, but now minimal effort required

Technical Resources from Lab

- On-call cryo controls engineer & cryo engineer
  - All relevant cryo monitor values are fed from IFIX to ACNET, where shifter monitors them
  - After initial startup period, there were very few times that we had to call in the engineers. System is very stable.
- ND Technical Ops Dept. (Bill Badgett): 0.3 FTE
- FTBF Technicians (available by request to FTBF coordinators, when needed)

Competing Resources (e.g. uBooNE)

- **Federal University of ABC, Brazil (UFABC)** Célio A. Moura, Laura Paulucci
- **Federal University of Alfenas, Brazil (UNIFAL-MG)** Gustavo Valdiviesso
- **Boston U.** Flor de Maria Blaszczyk, Dan Gastler, Ryan Linehan, Ed Kearns, Daniel Smith
- **U. Campinas, Brazil (UNICAMP)** Cesar Castromonte, Carlos Escobar, Ernesto Kemp, Ana Amelia B. Machado, Bruno Miguez, Monica Nunes, Lucas Santos, Ettore Segreto, Thales Vieira
- **U. Chicago** Ryan Bouabid, Will Foreman, Johnny Ho, Dave Schmitz
- **U. Cincinnati** Randy Johnson, Jason St. John
- **Fermilab** Roberto Acciarri, Michael Backfish, William Badgett, Bruce Baller, Flavio Cavanna† (also INFN, Italy), Alan Hahn, Doug Jensen, Hans Jostlein, Mike Kirby, Tom Kobilarcik, Paweł Kryczyński (also Institute of Nuclear Physics, Polish Academy of Sciences), Sarah Lockwitz, Alberto Marchionni, Irene Nutini, Ornella Palamara (also INFN, Italy), Jon Paley, Jennifer Raaf†, Brian Rebel‡, Michelle Stancari, Sam Zeller
- **Federal University of Goiás, Brazil (UFG)** Tapasi Ghosh, Ricardo A. Gomes, Ohana Rodrigues
- **Istituto Nazionale di Fisica Nucleare, Italy (INFN)** Flavio Cavanna (also Fermilab), Ornella Palamara (also Fermilab)
- **KEK** Eito Iwai, Takasumi Maruyama
- **Louisiana State University** William Metcalf, Andrew Olivier, Martin Tzanov
- **U. Manchester, UK** Justin Evans, Pawel Guzowski, Colton Hill, Andrzej Szelc
- **Michigan State University** Carl Bromberg, Dan Edmunds, Dean Shooltz
- **U. Minnesota, Duluth** Rik Gran, Alec Habig
- **U. Pittsburgh** Steve Dytman, Matthew Smylie
- **Syracuse University** Jessica Esquivel, Greg Pulliam, Mitch Soderberg
- **U. Texas, Arlington** Jonathan Asaadi, Animesh Chatterjee, Amir Farbin, Sepideh Shahsavarani, Jae Yu
- **U. Texas, Austin** Will Flanagan, Karol Lang, Dung Phan, Brandon Soubasis (also Texas State University)
- **University College London** Anna Holin, Ryan Nichol
- **William & Mary** Mike Kordosky‡, Matthew Stephens
- **Yale University** Bonnie Fleming, Elena Gramellini

22 of our 76 collaborators are also on MicroBooNE

Based on Run-I experience, LArIAT requires minimal effort to operate/maintain.

“Local” Resources

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34 of our 76 collaborators are local/on-site

Formal Agreements

- A TSW for LArIAT and FTBF exists, as required by standard FTBF procedures
  - This also includes signatures by division heads from: AD, PPD, CS, ESH&Q. (Note: at the time, ND did not exist)
- A TSW for LArIAT and Fermilab Computing exists
- There are no formal MOUs or SOWs with other divisions or with collaborating institutions
  - However, several of our institutions have agency funding specifically granted for LArIAT work

Safety: (Re)Installation

- Run Coordinator & Deputies are responsible for coordination of installation activities.
- During installation, daily toolbox meetings are held before beginning work, to make sure that everyone knows roles and tasks
  - Reseal cryostat flanges (done by technicians) and put downstream collimator back in place
  - Place beamline detectors back in position (TOF, Beam Halo, MWPC, scintillators, cosmic paddle)
    - Beamline detector stands were initially surveyed, and then bolted to floor of MC7
    - Detectors have not moved within stands, so installation is just a matter of moving the stands back into place (there are fiducial marks on them to return to original alignment)
    - Reconnect power and signal cables. These were carefully labeled before we moved the detectors in July.
  - Reconnect cables from TPC feedthrough to D2S boards (also carefully labeled before we detached them)
- We also coordinate with FTBF personnel who have oversight (JJ Schmidt) and technical services/expertise (technicians).

Question 4

- Discuss your plan for completing the Run 2 improvements. Include a discussion of the implications if they are not all completed or come late.

Run 2 Improvement Task	Status	Expected duration of task	Implication/Impact
Cryo-system modification	Just started	4 weeks	• If late: Run-II starts later than expected • If not completed: No physics impact, just continued Run-I level of operations cost
Modify bias voltage card	Completed	2 hours	N/A
Change base of Hamamatsu PMT	In progress	1 day	• If late: Run-II starts later than expected • If not completed: Some impact on analyses using light collection system, since, as in Run-I, we would not be able to operate the PMT again
Add 2 small SiPMs to LCS	In progress	2 days	• If late: could choose to not implement, or could choose to delay Run-II start • If not completed: No impact to physics, only impact to R&D
Muon halo suppression	Under evaluation by AD	1 day	• Positive impact if installed: reduction of muon halo will give more good quality events in each spill → shorten run duration

Run 2 Improvement Task	Status	Expected duration of task	Implication/Impact
Increase TOF coincidence window	Not started	1 day	Can be done even after start of Run-II. Physics impact: better tagging for slow particles
Muon range stack X-Y scintillators installation	In progress	3 days	Improved ability to distinguish muons from pions with X-Y positioning in MRS If not completed: no negative impact to physics, since existing system is operational and allows physics analyses

Question 5

- Discuss your fallback plans if you have a failure in a system with no spares.

Item	Spares	# used in LArIAT	Anticipated purchases FY16	Comments
CAEN V1740 digitizers	0	9		
CAEN V1751 digitizers	0	2		
CAEN V2718 VME master	0	1		
CAEN V1495 FPGA trigger	0	1		
CAEN A3818 PCI-to-VME bridge	1	1		
CAEN VME crate and PS	1	1		
MWPCs	3	4		FTBF-owned
ASIC boards	2	9		
Glassman HV PS	1	1		
LV PS	1	2		
Wiener VME chassis	1	1		
Wiener power supply	0	1		

CAEN V1740 digitizers

- We don't know of anyone else on site who uses these (DarkSide-50 uses V1720's)
- Contingency plan: The ninth V1740 would be put into service for the TPC. That takes us from 96 extra channels to 32, which would require triage in selecting which to salvage. At the end of Run-I we were only using 38 spare channels, with an eye on expanding the muon range stack 16 or more channels. Most likely, we would choose to not digitize the six muon halo counters, and future MRS channels would be eliminated for that time.

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LV PS	1	2		
Wiener VME chassis	1	1		
Wiener power supply	0	1		

CAEN V1751 digitizers

- V1751 loss would be harder to triage. Channels in use:
  - 4 x TOF
  - 4 x AeroGel
  - 5 x Cryo LCS
  - 2 x Beam halo
  - 1 x AeroGel cosmic
- Last 3 (2x halo + 1x AG cosmic) are obvious candidates to eliminate, then it gets harder…

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Glassman HV PS	1	1		
LV PS	1	2		
Wiener VME chassis	1	1		
Wiener power supply	0	1		

CAEN V2718 VME master

- Contingency plan: borrow a spare from AD, SeaQuest, or DarkSide-50 (but need to verify that they're using this particular module)

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Wiener VME chassis	1	1		
Wiener power supply	0	1		

CAEN V1495 FPGA trigger

- Contingency plan: borrow a spare from AD, SeaQuest, or DarkSide-50, all of whom use this card. The DS-50 V1495 is in their test stand.
- Expect long repair time at CAEN: ~2-3 months
- 2nd option is to FedEx V1495 from W&M

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MWPCs	3	4		FTBF-owned
ASIC boards	2	9		
Glassman HV PS	1	1		
LV PS	1	2		
Wiener VME chassis	1	1		
Wiener power supply	0	1		

Wiener VME power supply

- Contingency plan: borrow one from AD until it can be repaired; last repair was ~ 2 weeks total turn-around

Question 6

- What mechanisms do you have to receive feedback from the relevant LAr stakeholders (e.g. future neutrino experiments)? How are the various R&D possibilities prioritized? How are the R&D possibilities coordinated across the LAr community?

- Coordination and prioritization of R&D efforts is a hot topic in the entire LAr community
  - A workshop is planned for January, to discuss exactly this
  - Output of workshop is expected to be a more clear/coordinated picture of the global LAr R&D efforts
- Feedback from other stakeholders:
  - On Friday (this week!) we have been invited by DUNE to report on LArIAT with the idea of finding all common aspects and maybe plans for future tests
  - MicroBooNE has requested that we run at lower E field to measure recombination at a value never precisely studied
  - SBND is asking us to explore light collection solutions in view of implementation in that detector (and to give feedback on their currently implemented solution)
  - Further electronics tests were discussed at BNL recently
    - MicroBooNE and LArIAT are the first experiments to implement the BNL preamplifier ASIC in a full detector readout, and thorough evaluation of operation and performance is crucial to both
    - The possibility of quick-turnaround with changes to the LArIAT detectors makes it an excellent testing ground for alternative cold electronics options, such as those under consideration for SBND and DUNE
- Mechanism for feedback has been informal discussions