DUNE FD Calibrations Consortium

José Maneira (LIP), Kendall Mahn (MSU)

December 20, 2018

Outline

- Welcome!
  - List of institutes/members
- Consortium organization
  - General meetings and tools
  - Sub-groups
- Discussion
  - Calibration system requirements
- Main tasks ahead
  - TDR
  - prepare prototypes for tests at proto-DUNE and elsewhere
  - funding proposals

Welcome!

- Univ. of Bern
  - Igor Kreslo, Michele Weber
- Boston Univ.
  - Chris Grant
- Colorado State Univ.
  - Mike Mooney
- Univ. of California at Davis
  - Bob Svoboda, Jingbo Wang
- Univ. of Hawaii
  - Jelena Maricic
- Univ. of Iowa
  - Jane Nachtman, Yasar Onel
- LIP, Portugal
  - Lisbon: Sofia Andringa, Fernando Barão, Nuno Barros, José Maneira, Amélia Maio, Gersende Prior
  - Coimbra: Francisco Neves, Vladimir Solovov
- Michigan State University
  - Kendall Mahn
- Univ. of Pittsburgh
  - Donna Naples, Vittorio Paolone
- South Dakota Sch. Mines Tech.
  - Juergen Reichenbacher
- Univ. of Tenessee, Knoxville
  - Sowjanya Gollapinni

Calibration Mandate

- "The initial goals of this new Consortium will be the design and prototyping of a **laser calibration** system, a **neutron generator**, and a possible **radioactive source** system in preparation for the TDR. "
- This means
  - 3 sub-systems: laser, neutron source, radioactive source
  - Initial goals: design and prototyping, TDR
  - Later goals: building the systems for DUNE
- Calibration Task Force
  - CTF is maintained at least through to the TDR
  - Close collaboration in setting specifications/goals

Organization

Organization

- Initial appointment by Spokespeople of
  - Consortium Leader (CL): J. Maneira
  - Technical Leader (TL): K. Mahn
- Consortium management rules are stated in the DUNE management plan DocDB-2145
- Consortium Board
  - one member per institution (please indicate)
  - for now: no CB meetings, only mailing list
- Project Management Board
  - CL + TL + TC (E. James) + lead national project managers
  - propose to set up after TDR

Working Groups

- Form a Working Group for each sub-system
  - can have dedicated meetings, tools, etc…
  - CL/TL nominated WG leaders

Working Group	Leader
Laser	S. Gollapinni
Pulsed Neutron Source	J. Wang
Radioactive Source	J. Reichenbacher

Online Tools

- Consortium mailing list:
  - dune-fd-clbrt-cnsrt@fnal.gov
- Wiki:
  - https://wiki.dunescience.org/wiki/Joint_Far_Detector_CLBRT
- Indico
  - https://indico.fnal.gov/category/925/

Requirements →

Specifications/goals

Specifications/goals

- An important component of the TDR will be the setting of requirements.
- Stefan SR:
  - "LBNC has emphasized the importance of requirements at several of the past meetings and its recommendations."
  - "We are moving away from requirements to newly defined 'goals' and 'specifications', which better fit the problem."

- Specification: This is the intended value for the parameter or, more often, the upper or lower limit for the parameter.
- Goal: This is an improved value that offers some benefit, and the collaboration aims to achieve this value where it is cost effective to do so.

- See DocDB 11074 and 11431

Top level specifications

(under discussion)

Parameter	Specification	Goal
Drift field	>250 V/cm	500 V/cm
Electron lifetime	>3 ms	10 ms
System noise	<1000 enc	ALARA
Light yield	>0.5 p.e./MeV	5 p.e./MeV
Time resolution	<1 μs	100 ns

TABLE I: Summary of high-level design specifications.

(ALARA: As Low As Reasonably Achievable)

Other scientific specs

Parameter	Specification	Goal
Gaps between APAs		
on same support beams	<15 mm	ALARA
on different support beams	<30 mm	ALARA
Field non-uniformity throughout volume		ALARA
due to component alignement	<1%	ALARA
due to HV system	<1%	ALARA
APA wire angles		
X and G	0°	
U and V	±35.7°	
APA wire spacing		
X and G	4.669 mm	
U and V	4.790 mm	
APA wire position tolerance	±0.5 mm	ALARA
HV PS ripple contribution to system noise	<100 enc	ALARA
Front-end peaking time	1 μs	adjustable
Signal saturation level	~500,000 electrons	
LAr nitrogen contamination	<25 ppm	ALARA
Detector down time	<0.5%	ALARA

TABLE II: Summary of other scientific design specifications.

(under discussion)

Engineering design specs

Parameter	Specification	Goal
Cathode resistivity	>1 MΩ/cm^2	1 GΩ/cm^2
Cryogenic monitoring devices	see text	
ADC sampling frequency	∼2 MHz	
Number of ADC bits	12	
Cold electronics power	<50 mW/channel	ALARA
Data rate to tape	<30 PB/year	
Supernova trigger efficiency	>90% for dist<100 kpc	
Local electric fields	<30 kV/cm	ALARA
Non-FE noise contributions	≪1000 enc	ALARA
LAr impurities from components	≪30 ppt	ALARA
Introduced radioactivity	below ^{39}Ar	ALARA
Dead channels	<1%	ALARA

TABLE III: Summary of engineering design specifications.

(under discussion)

Calibration specs

- Level 2 are the high level Scientific and Engineering specifications
  - Need to identify them and discuss with EB
- Level 3 are the consortium-owned specifications
  - To be listed in the TDR, but up to CTF and us.
- Need input from consortium on
  - what is important, what should be our specifications/ goals?
  - once we identify those, which to make L2 ?
- Consider
  - 3 systems: laser, neutrons, source
  - 4 categories: physics, DAQ, interferences, safety

1. Physics/Detector perf.

- "Scientific" (or High Level)
  - From IDR, vol. 1, p. 4-47
    - "…calibration information needs to provide approximately 1-2% understanding of normalization, energy, and position resolution within the detector."
  - How well do we need to measure Efield distortions?
    - Recombination studies indicate: 4% Efield distortions lead to 1% bias in energy
    - Existing EB spec: Distortion due to HV/APA shifts <1%
    - Shall our calibration spec be 4% Efield knowledge? more studies?
  - In what fraction of the fiducial volume?
    - How well can we extrapolate from boundary cond.?
    - Corners vs. middle
  - Low energy scale/resolution/trigger efficiency
    - ~20% energy should be good (SN studies ongoing)

1. Physics/Detector perf.

- "Engineering" (or Lower Level)
  - Laser:
    - Length of track in LAr, or beam divergence
    - Accuracy of knowledge of beam direction
  - Neutrons:
    - Effective attenuation length of neutrons from filter > x
    - Pile-up vs. pulse width settings
    - Activation of cryostat materials
- Source
  - Efficiency to create 9 MeV gammas (or, how well will we know the 9 MeV gamma rate)
  - Contamination from residual source neutrons

2. DAQ/data taking

- Scientific
  - Noise: EM shielding of DD generator and laser
  - Impact of calibrations on detector down time
    - what is down time when we use triggered sources ?
    - laser run plan: one drift volume at a time. turn PDS off?
    - neutron source: for how long after the pulse trigger are do we create a background for SN? (not blind, though)
- Interlock: stop laser or DD generator in case of SN trigger
- With current limits on data volume, can we calibrate to required precision?

3. Interference w/ other systems

- Laser
  - E field distortion from FC penetration ?
    - collision with non-uniformity spec of < 1%
  - Degradation of detector components ?
    - interlock to turn off PDS? Can SiPMs take the hit?
    - long terms effects on scint seem low.
- Neutrons
  - If we don't use manhole or feedthrough, how big a hole can be made in cryo insulation?
  - Weight of system, support on cryo and other structures
- Source and Laser
  - Impact on LAr purity
- All: installation logistics constraints

4. Detector and personnel safety

- Laser
  - Class 4 laser.
    - Closed box, operator training
    - Special conditions for initial alignment
- Neutrons + source
  - Radiological safety. Dose specs @ SURF ?
  - Design of shielding, storage, DD gen. locking
- Laser + source
  - pressure rating of feedthrough flanges

Next steps on req.

- Please comment!
  - What did we forget?
  - Help us to quantify any of these issues:
    - values for specifications AND goals
  - Which ones should be level 2 specs?

Tasks ahead

TDR

- Kendall and Sowjanya taking the lead on this
- Physics TDR
  - https://docs.google.com/document/d/1ohDorJxncQrBPq16ZUiBDBluLtr27efcYy5YJBtHoHQ/edit
    - Comments deadline: Jan 2nd.
- Detector TDR (SP)
  - Draft 1: March 1, 2019
- Detector TDR (DP)
  - Draft 2: May 10, 2019

Technical Coordination

- We need to identify consortium points-of-contact with TC on:
  - Quality Assurance/Quality Control
  - Electrical Safety & Hazards

proto-DUNE

- Design prototypes
- Plan for
  - differences between DUNE and proto-DUNE
  - safety issues at CERN (laser and radiation)
- Organize
  - link tasks to institutes
  - coordinate funding proposals

funding

- group/institute base/startup funds
- MRI call for neutron source
- Early career awards?
- Portugal funding agency call next year
  - plan to ask for (parts of) construction of laser + neutron prototype
  - not includng laser + DD gen itself.

AOB ?