# Introduction

Sebastien Murphy, Marco Zito Dual phase far detector meeting November 30th 2015



- Where are we in the DUNE structure?
- Overall task of the group
- Work package structure
- Meetings
- Goal of today meeting







### WA105 ~ DUNE

# The six high level organisation

**DEEP UNDERGROUND NEUTRINO EXPERIMENT** 

WA105 <</



# **FD working group**



DAQ, HV, photon detector are in the scope of other working groups



\* prove the feasibility of having (at least) one 10kt module with Dual phase technology at SURF. It will be the only module that can achieve:

 $\star$ readout with gain

\*readout with 3 mm pitch

\*decouple from risks that may cripple your signal such as unforeseen noise, lower than expected purity (difficult to predict what the level of noise will be on a 12x60x12 m TPC).

\*guaranteed reach of low energy events.

★ worth exploring two different technologies (Dual/Single) each having their own advantages and risks. Both require proof of operation on the large scale => WA105 & protoDUNE.



★ The design of the dual phase TPC will be performed in close contact with the WA105 demonstrator program at CERN, with important milestones in 2016 (construction and operation of the 3x1x1 m3 detector) and 2017-18, with the installation, commissioning and beam data-taking of the 6x6x6 m3 detector. We would like to take advantage of the lesson learned on these detectors for the DUNE design.

The dual phase TPC WG will work in tight coordination with the light readout, the electronics, the HV, and the DAQ WGs

★Work packages: see later



#### \*\*\*PROPOSAL\*\*\* DUNE dual phase far detector work packages conveners: Marco Zito, Sebastien Murphy

| WP1<br>Chimneys<br>& Feedthroughs   | WP2<br>CRP mechanical   | WP3<br>CRP sensor   | WP4<br>Drift cage &<br>cathode   | WP5<br>Slow control<br>& calibration   | WP6<br>det. installation<br>and integration   |
|---|---|---|--|--|---|
| <ul> <li>signal + slow<br/>control<br/>feedthroughs</li> <li>all crossing pipes<br/>including cryo<br/>services</li> <li>pressure relief<br/>devices</li> <li>tight collab. with<br/>the group<br/>constructing the<br/>tank to ensure<br/>adequate<br/>placement of<br/>chimneys</li> <li>manholes and<br/>accesses</li> <li>check for<br/>sufficient<br/>clearance of<br/>services inside<br/>tank from the drift<br/>cage</li> </ul> | <ul> <li>mechanical<br/>design of 3x3 m<sup>2</sup><br/>CRPs frames.</li> <li>ensure rigidity<br/>and stability in<br/>cold according to<br/>tolerances</li> <li>motorised<br/>suspension<br/>system</li> <li>extraction grid<br/>with sufficient<br/>tensioning and<br/>minimum dead<br/>space between<br/>modules</li> <li>field lines<br/>simulations to<br/>guide design<br/>especially at the<br/>junction between<br/>CRPs</li> <li>mounting<br/>sequences</li> </ul> | <ul> <li>purchase &amp; QA<br/>of large amounts<br/>of LEMs +<br/>anodes</li> <li>logistics for<br/>cleaning, testing<br/>and storage of<br/>LEM+ anodes</li> <li>adequate HV<br/>connections for<br/>all devices (up to<br/>10 kV for<br/>extraction grid)</li> <li>ensure of non<br/>sparking for<br/>connections in<br/>GAr</li> <li>mounting<br/>sequence on 3x3<br/>m2 CRPs</li> </ul> | <ul> <li>design and<br/>assembly<br/>sequence of<br/>large drift cage</li> <li>drift cage<br/>suspended to<br/>cryostat roof</li> <li>design of<br/>cathode based<br/>on field line<br/>simulation &amp;<br/>ensure<br/>mechanical<br/>rigidity</li> <li>spark protection<br/>device around<br/>cathode</li> <li>voltage divider<br/>chain</li> <li>connection of<br/>cathode to HV<br/>feedthrough</li> </ul> | <ul> <li>complete list of<br/>what we want to<br/>monitor and for<br/>which purpose</li> <li>construction and<br/>calibration of<br/>purity monitors,<br/>temperature,<br/>pressure,voltage<br/>s and currents<br/>monitoring, level<br/>meters, cameras<br/>etc</li> <li>includes also low<br/>voltage (&lt;= 10<br/>kV) connections<br/>in Gar or LAr</li> <li>cabling and<br/>connection to<br/>racks near the<br/>tank.</li> </ul> | <ul> <li>construction the detector taking into account the underground environment and limited shaft space + TCO.</li> <li>All safety related aspects</li> <li>Ventilation &amp; accesses</li> <li>clean room(s)</li> <li>cavern layout and space for racks and detector/tank services</li> <li>Insure of non conflicts between subsystems</li> <li>cavern layout and space for racks and detector/tank services</li> </ul> |



#### plan to share most of the information on this webpage

https://web.fnal.gov/collaboration/DUNE/SitePages/FD%20Dual-Phase%20TPC%20Working%20Group.aspx



The final Dual phase module is developed following an incremental approach. Design optimised at each steps





- December: assembly structure ready
- February: top-cap delivered.
- March-April-May: detector installation and cabling in assembly structure + testing.
- June: move top-cap with detector to cryostat and install internal cryo-piping.
- July: setup ready for GAr test
- Aug 1st. cryo-installation complete.
- Sept: setup ready for LAr test

| Activity Name   | Duration<br>(Days)  | Stat Date Final Date Resource Assignal   | Mill (1)         Mill (1) |
|---|---|--|---|
| NA105-182 v7 24/11/15 / AR  |   |  |   |
| Detector integration Big 182<br>Detector assembly parton mady   | 100   | 101515 101515 Deepu  |   |
| Top cap delivered at CERN<br>Fix top cap on platform  | \$100<br>\$100  | 21/4 21/18<br>21/4 25/8  |   |
| Top cap ready for detector installation<br>More & weld top-cap on prostat   | 1.00<br>5.00  | 2514 2515  |   |
| Finalise installation inside cryostat<br>Setup ready for DAr level  | 14.00   | 7674 72218<br>12214 72218  |   |
| Perform lest in GAr<br>GAr purity achieved inside the cryostat  | 15.00   | 12516 81216<br>51316 51316   |   |
| Ar-002 run<br>Setup ready for LAr test  | 21.00   | 81514 81215<br>51214 51215   |   |
| Perform test in UAr<br>UAr purity achieved in side crycelal.  | 81.00   | \$1514 1517<br>\$1514 \$1517   |   |
| Coamic tracks recorded  | 1.00  | \$1514 \$1515  |   |
| Slow control<br>bring 5 DC3 + 1 LAPP racks to 8: 152  | 207.00  | 8/18/15 7/4/16<br>2618 2515 Cosino Cantra  |   |
| Net area near TAS<br>acidening connectors on cables,<br>insection in SCFT and test (CERN  | 15.00   | 22514 31915 Colino Centre  | ++++++++++++++++++++++++++++++++++++++  |
| FSU)<br>cebling of DC3 "subside tenk" Le from<br>Range to derivation boxes to nacks on  | 21.00   | 51716 41916 Coalto Carteri   |   |
| cable Insys (CERN FSU) and testing<br>with PEC<br>Minn ( ADP rack to A. 21 for internation  | -1.00   | 12214 2519   |   |
| with DCS and leat in 5-21   |   |  |   |
| procure coax level meters<br>install coax level meters  | 30.00   | 62814 63015 Coalto Cartin  |   |
| Site control ready  | 5.00  | 7414 1918 Coeno Cartin<br>7414 1918 Coeno Cartin   |   |
| Chimneys and feedthrough  | 49.00   | 1/25/16 3/31/16  |   |
| Next SGFT inside the crossing pipes   | 7.00  | 2814 21918   |   |
| Inaart electronic cards inside SGF7   | 5.00  | 217/4 225/8  |   |
| 3 SPFT fixedon on chimneys + leading<br>without CRP   | 18.00   | 2/114 20176  |   |
| CRP   | 207.00  | 81/15 6/15/16  |   |
| Select line LEMs for CMP<br>Test new LEMs in cold with pusht rings  | 14.00<br>14.00<br>14.00   | 112/15 1122/15<br>2014 100216<br>112/15 1125/15  |   |
| Procure Shall LDMs for CRP<br>LDMs mady   | 8525<br>0.00  | 42218 42218<br>42218 42218   |   |
| dignal cables ready<br>Anodes ready   | 0.00  | 1019/15 1019/15  |   |
| sistration got when ready<br>Level meters ready<br>(302 ecoeptic  | 6.00  | 12/15/18 12/1/18<br>4/2014 6/11/18   |   |
| CRIP many<br>CRIP many  | -100  | 51018 51018<br>51018 51018   |   |
| to the three suspenation cables   | -   | 50574 50574  |   |
| rescent or movement  Install extraction grids  Connect ender to 50000 - 10000   | 400   | 52978 52578<br>52878 5775  |   |
| Annual answer to burn + electrical<br>heat<br>Connect alow control aeraors to SCFT<br>a decidied but  | 5.00  | 6216 6818  |   |
| <ul> <li>electrical test</li> <li>Complete test of CMP (movement, MV, DCS, putsing anode)</li> </ul>  | 5.00  | 89/16 675/15   |   |
| Light readout system  | 15.00   | 82115 10915  |   |
| PMT installation acquerce for   | 15.00   | 92115 10915 DENAT  |   |
| Suspension system   | 2.00  | 2/24/16 2/25/16  |   |
|   |   |  |   |
| Drift cage<br>Field cage delivered at CERN  | 171,00  | 11/2/15 6/27/16<br>11/2/15 11/2/15   |   |
| Hang field cage from top cap<br>Insert HVPT and connect   | 2.00  | 61614 61918<br>61314 62916   |   |
| Install PMTs and connect<br>Complete test of Drift Cage (divident,<br>rationite. HV1  | 5.00  | 67376 62275<br>62376 62278   |   |
| Drift sage + detector ready   | 0.00  | 62716 62716  |   |
| HV system<br>300 KV power supply  | 158.00  | 9/1/15 4/7/16<br>9/3/15 9/15   |   |
| HVFT order<br>HVFT procement  | 9100  | 101515 101515<br>101516 22916  |   |
| 300 KV teat with Rogowski<br>Installation on detector   | 25.00   | 3114 4415<br>4514 4015   |   |
| Front-end electronics   | 152.00  | 11/2/15 6/1/16   |   |
| Procurement of components for Betlet<br>(ADC, FPGA,)<br>Procurement PCB of 10 digitization  | 1.00  | 11015 11015  |   |
| cards (540 channels) - two mounted for<br>tests<br>Susceedul test of 2 cards  | 21.00   | 11214 2010   | * · · · · · · · · · · · · · · · · · · ·   |
| Completed 10 full cards<br>Procurement 110 cards for Sefet  | 1.00  | 3114 2115<br>31814 42818   |   |
| Mounted 10 cards on 3x1x1<br>Mounted all cards on 3x1x1   |   | 403 453  |   |
| DAQ   |   |  |   |
| 505   |   |  |   |
| ProvinityExternal Cryogenics  | 330.00  | 6/1/15 9/5/16<br>9/175 9/5/16  |   |
| Corplation of the definition of<br>specifications and required performance  | 1.00  | 4115 8175  |   |
| clashibor of the controls interface<br>Completion of the design   | 0.00  | 87875 \$3075<br>87875 \$7875   |   |
| Design reviewed and approved for<br>procurement/fabrication<br>Contract(s) awarded for fabrication  | 1.00  | 11215 11215  |   |
| WR105 supply of cryo items (LND/GN2<br>delivery ine to SGFT)  | 0.00  | 2114 2115  |   |
| Completion of acceptance leafs at<br>vendor's facility<br>Subassembles delivered to CHEM  | 1.00  | 71/4 21/8  |   |
| and ready for installation<br>Installation at CERN complete   | 0.00  | 8176 8776<br>8578 8578   |   |
| Acceptance tests completed and<br>systems ready for commissioning   |   |  |   |
| Proximity Cryogenics (Non-Cryogenic<br>part shared ETH2+CERN)<br>Completion of the definition of  | 296.38  | 4703 75878<br>4555 6575  |   |
| specifications and required performance<br>Completion of the definition of the<br>sectorial interface   | 6.00  | 101513 101115  |   |
| Completion of the design<br>Design reviewed and approved for  | 100   | 93015 93015<br>93015 102015  |   |
| procurement/fabrication<br>Contract(s) awarded for fabrication  | 0.00  | 1021/18 1021/15  |   |
| Completion of procurement/flabrication<br>Rems delivered and ready for<br>Installation  | 1.00  | 11415 11415  |   |
| Procumental by WA105 of GAr warm<br>heras (GAr purit PUD, PDH, MPC-1,<br>PMT, PMS, VP.1 - 1   | 1.00  | 11015 11015  |   |
| Installation of warm pipes for pas  | 12.00   | 26/4 2/9/6   |   |
| (But see as   |   |  |   |
| Internal Cryogenics (by WA105)  | 58.3  | 81155 70216<br>81175 81175   |   |
| Internal Crysgenics (by WA105)<br>Completion of the definition of<br>apecifications and required performance<br>Completion of the definition of the   | 346.08<br>0.00<br>0.00  | 4115 52218<br>6115 6115<br>93015 83015   |   |
| International<br>Internal Cryagenics (by WK100)<br>Completion of the technics of<br>apachications and regulard performance<br>Completion of the solutions of the<br>control interface<br>Completion of the season<br>Design revisioned and account if the   | 386.38<br>0.00<br>0.00<br>0.00<br>15.00   | 4115 72218<br>6125 6115<br>93015 83015<br>83013 83015<br>10215 93215   |   |
| Internal Cysopenics (by WA10)<br>Comparison of the shift-lates of<br>approximation of the shift-lates of<br>Comparison of the shift-lates of the<br>controls interface<br>Comparison of the shift-lates of the<br>control interface<br>Comparison of the shift-lates of<br>Comparison of the shift-lates of<br>Comparison of the shift-lates of<br>Comparison of the shift-lates of<br>Comparison of the shift-lates of the<br>Comparison of the shift-lates of the shift-lates of the shift-lates of the<br>comparison of the shift-lates of the shift-lates of the shift-lates of the<br>comparison of the shift-lates of the shift-lates of the shift-lates of the<br>comparison of the shift-lates of the shift-                                       | 346.38<br>5.00<br>5.00<br>15.00<br>5.00   | 8/18         72216           6/17         6/115           6/30/5         8/30/5           6/30/5         8/30/5           6/30/5         8/30/5           6/30/5         8/30/5           6/30/5         8/30/5           6/30/5         8/30/5           6/30/5         8/30/5           6/30/5         8/30/5           6/30/5         8/30/5  |   |
| International Copyspectra (by HA118)<br>Destination (Copyspectra) (b) HA118)<br>Destination (b) Hang and Hagenberg and Hagenberg<br>paraditations of the photosets of the<br>control internation of the always.<br>Desting investment and aggregation (b)<br>Desting investment and aggregation (b)<br>Desti  | 388.38<br>0.00<br>0.00<br>15.00<br>0.00<br>55.00<br>0.00  | 40.55         762/16           40.15         60.15           40.15         80.15           50.15         80.15 |   |
| Increases<br>Internal Cryptachis (b) 484-10(1)<br>Convolution of the pelotitism of<br>specifications are the pelotitism of<br>constrain tarking<br>Comparison of the datapoint<br>Comparison of the datapoint<br>Reserve and the datapoint<br>R            | 386.84<br>6.00<br>6.00<br>6.00<br>75.00<br>6.00<br>95.00<br>6.00<br>6.00<br>6.00  | 4713         52016           4715         4715           47015         47015           47017         47015           47017         47015           47017         47015           47017         47015           47017         47015           47017         47015           47017         47016           47017         47016           47017         47016   |   |
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## 3x1x1 layout b.182



#### **3x1x1 layout b. 182**



# Detector

- Drift cage ready.
- CRP: mechanical frame ready.
- PMTs ready.
- Feedthroughs:
- HV arrives in December- testing beg. of next year.
- Signal: one proto delivered since spring. Remaining 5 arrive in December
- Slow control: delivered
- suspension: ready
- racks for slow control: last ones been cabled. Almost ready.
- cable routing being finalised.
- Detector assembly begins
   February. Lots of work ahead!





# Cryostat

lots of progress and ongoing work on measuring the tightness of the membrane (local test) and the outer structure (accumulation test).









Tendering document is been sent out to companies. Expect replies in January. Request ready for cryo operation in September.







Based on the experience gained with the 3x1x1m3 master schedule ->includes feedback from real experience on building the 3x1x1

- September 2016: start cryostat construction
- April 2017: start detector installation
- December 2017: seal TCO & cryostat
- January 2018: start cryogenic operation

(cooldown+filling)

• March 2018: ready to collect beam





### **Recent progress on the 6x6x6**

#### **DEEP UNDERGROUND NEUTRINO EXPERIMENT**

Lots of recent progress on finalising the detector aspects linked to the cryostat design (chimney layout, PMT fixation, TCO, ...). Lots of progress also on the beam steering and reduction of the muon background.











# **Recent progress on the 6x6x6**

The 6x6x6 is also of primary importance for testing the DUNE dual phase integration scheme. Both detectors have exact same modularity (3x3 m2 CRPs). They will be installed with the same procedure.

#### Common to WA105 & DUNE

CRP box: 3100x3100x500 that contains the CRP fully assembled. The box enters the TCO located in the pit through the roof



many email exchanges, thank you for all the feedback. Work is ongoing (but no dedicated presentations today).



### Latest detector drawing

Same chimney layout as the for 6x6x6 modules.



## **Integration & shaft**

Ross



|                   | Length 'L' (ft.) | Width 'W' (ft.) |
|-------------------|------------------|-----------------|
| Cage Compartment  | 12' 10 ½"        | 5′              |
| South Skip Compt. | 5′ 7 ¼″          | 4' 7"           |
| North Skip Compt. | 5′ 7 ¼″          | 4' 7"           |

We are investigating how many CRPs we can fit in the cage and how fast it can be lowered.

3 per cage would obviously make installation quicker. Anyhow main message is that at least one is possible.

Also investigating the CAD of the tunnels.



- Most of the team is already in place since LAGUNA, LAGUNA-LBNO and WA105 projects
- •The core of the activity is the WA105 preparation, construction and tests.
- •However we will also make progress in parallel with the DUNE FD that has a longer timescale. A large part (most) of the engineering for the DUNE-DPFD is now been tested in the 3x1x1 and even more so in the 6x6x6 that has the same modularity and integration scheme.
- •We have therefore decided to limit the number of meetings to 1-2 in between DUNE CM.

6x6x6: bi weekly meetings on Wednesdays.

3x1x1: bi weekly meeting on Thursdays

| LAGUNA-LBNO General Meetings 10 events                        |
|---|
| LBNE-LBNO joint meetings 1 event                              |
| LBNO Near Detector meetings 3 events                          |
| BNO prototype (WA105) meetings 111 events (protected)         |
| LBNO-DEMO/WA105 Executive Board meetings 6 events (protected) |
| LBNO-DEMO/WA105 General Meetings 6 events                     |
| LBNO-DEMO/WA105 Institution Board 1 event (protected)         |
| LBNO-DEMO/WA105 LRO subgroup meetings 1 event (protected)     |
| BNO-DEMO/WA105 Science Board 17 events (protected)            |
| BNO-DEMO/WA105 Technical Board 19 events (protected)          |
| Workshops 1 event   |



### extra slides





#### Common to WA105 & DUNE

CRP box: 3100x3100x500 that contains the CRP fully assembled. The box enters the CRB located in the pit through the roof



a) insert CRP box into clean room buffer (CRB)

- b) fix on rails in CRB and slide into the clean room via the TCO.
- c) once inside the tank need a tool to rotate and lay flat to unpack (requires that the rails extend into the tank and a platform inside tank too)

WA105 <~

# **Double phase TPC layout**

Underground installation studied in details during LAGUNA, we are just translating it to the DUNE environment. Same remark for the field cage.

80 CRPs



#### One 10 kt FD module:

- 3x3m2 CRP modules placed at the gas-liquid interface
- 2 perpendicular "collection" views, 3mm readout pitch
- 80 CRPs / 10 kton
- 153,600 ionisation readout channels
- Accessible cold electronics
- Hanging field cage and cathode@600 kV for 0.5 kV/cm
- Decoupled PD system (w/ no. 720 8" PMT)
- Active mass 12'096 tons (10'643 fiducial) for 12m drift



WA 105

## external assembly structure

#### **DEEP UNDERGROUND NEUTRINO EXPERIMENT**





if everybody agrees with this position we go ahead (~2 weeks from now)



