# VD PHOTON DETECTION SYSTEM -REQUIREMENTS

*ETTORE SEGRETO*

***University of Campinas - UNICAMP - Brazil***

UNICAMP

FAPESP

CNPq

Conselho Nacional de Desenvolvimento Científico e Tecnológico

# Basic Considerations

- We believe that the PD of HD and VD versions of the far detector should have the same minimal physics requirements
- This means that the VD module should be able to do at least the same physics as the HD module

# PD HD Physics and Detector Requirements

| Label | Description | Specification (Goal) | Rationale | Validation |
|---|---|---|---|---|
| SP-FD-3 | Light yield | $>$ 20 PE/MeV (avg), $>$ 0.5 PE/MeV (min) | Gives PDS energy resolution comparable to that of the TPC for 5-7 MeV SN $\nu$s, and allows tagging of $>$ 99 % of nucleon decay backgrounds with light at all points in detector. | Supernova and nucleon decay events in the FD with full simulation and reconstruction. |
| SP-FD-4 | Time resolution | $<$ 1 µs ($<$ 100 ns) | Enables 1 mm position resolution for 10 MeV SNB candidate events for instantaneous rate $<$ 1 $m^{-3}ms^{-1}$. | |

# PD HD Physics Requirements

| Label | Description | Specification (Goal) | Rationale | Validation |
|---|---|---|---|---|
| SP-FD-3 | Light yield | > 20 PE/MeV (avg), > 0.5 PE/MeV (min) | Gives PDS energy resolution comparable to that of the TPC for 5-7 MeV SN $\nu$s, and allows tagging of > 99 % of nucleon decay backgrounds with light at all points in detector. | Supernova and nucleon decay events in the FD with full simulation and reconstruction. |
| SP-FD-4 | Time resolution | < 1 µs (< 100 ns) | Enables 1 mm position resolution for 10 MeV SNB candidate events for instantaneous rate < 1 $m^{-3}ms^{-1}$. | |

# PD HD Detector Requirements

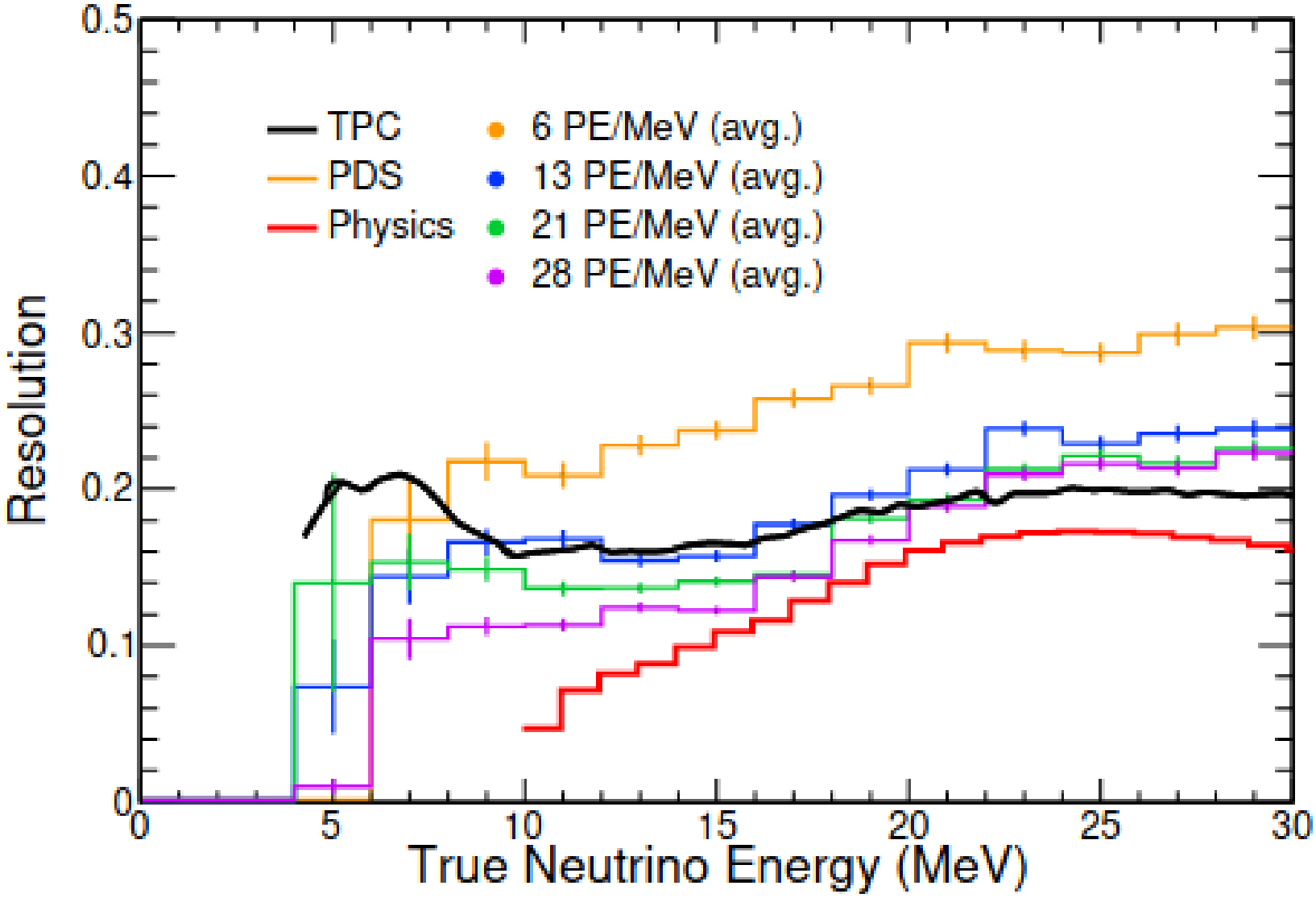
| Label | Description | Specification (Goal) | Rationale | Validation |
|---|---|---|---|---|
| SP-FD-3 | Light yield | > 20 PE/MeV (avg), > 0.5 PE/MeV (min) | Gives PDS energy resolution comparable to that of the TPC for 5-7 MeV SN $\nu$s, and allows tagging of > 99 % of nucleon decay backgrounds with light at all points in detector. | Supernova and nucleon decay events in the FD with full simulation and reconstruction. |
| SP-FD-4 | Time resolution | < 1 µs (< 100 ns) | Enables 1 mm position resolution for 10 MeV SNB candidate events for instantaneous rate < 1 $m^{-3}ms^{-1}$. | |

***The Physics requirements have been translated into detector requirements through detailed (and very time consuming) full simulations of the SP HD far detector and of large samples of Supernova and nucleon decay events***

# Rationale of PD HD Detector Requirements

- The **detector requirements** of an **average LY of 20 phel/MeV** inside the TPC comes directly from the **physics requirement** of being able to obtain, with the HD PD, **a similar energy resolution for Supernova neutrinos as that achievable with the detection of the charge with the TPC**

- The **detector requirement** of a **minimum LY of 0.5 phel/MeV** comes from the **physics requirement** of being able to measure the **$T_0$ for nucleon decay background events everywhere inside the active volume**. *This translates into an active mass of 10 kT of LAr for proton decay searches, which corresponds to a certain level of sensitivity in terms of proton decay time*


TPC
PDS
Physics
6 PE/MeV (avg.)
13 PE/MeV (avg.)
21 PE/MeV (avg.)
28 PE/MeV (avg.)
Resolution
True Neutrino Energy (MeV)
0
0.1
0.2
0.3
0.4
0.5
0
5
10
15
20
25
30

# Path towards PD VD Detector Requirements

- Assuming for the VD, the same minimal physics requirements of the HD, the derivation of the detector requirements needs to follow  the same procedure:
  - Large samples of Supernova neutrinos and nucleon decay complete simulation (in terms of detector description and backgrounds)
- The Physics and Simulation WG of the PD Consortium is working at full speed in the development of the simulation. Most of the software in place (inside the same framework used for the HD - LArsoft), *but we still need time to finalize it and run large sample of data*

# Path towards PD VD Detector Requirements

- The work done for the HD represents ***a solid starting poin***t and can allow us to make *some educated guesses for the VD requirements*
- It is reasonable to think that the requirement on the average LY, related to the ***average energy resolution*** of the PD, **will be similar to the HD - around 20 phel/MeV**
- The requirement ***on the minimum light yield could be different***, because the active masses of the HD (10 kt) and VD (14.7 kt) TPCs are different.
  - ***Example***: In the case of Cathode mounted PD in order to be able to tag with $T_0$ proton decay background events in a 10 kt mass of LAr, we should have a minimum light yield of 0.5 phel/MeV at 4.5 meters from the cathode (2 meters from the anode)
  - ***Obs***: It would be unfortunate to have 4 kton of LAr which can not be used for proton decay searches
- Conservatively, **it looks appropriate** at this point assuming also the **minimum LY requirement of 0.5 phel/MeV everywhere in the TPC also for the VD**

# Optimized X-ARAPUCAs for Xe shifted light

- The OPTO Company was still not able to develop a design for a Xe optimized dichroic filter
- We plan to involve other Companies. We had contacts with Asahi and Leybold Optics