T_0 via fluorescence tag in HPgTPC

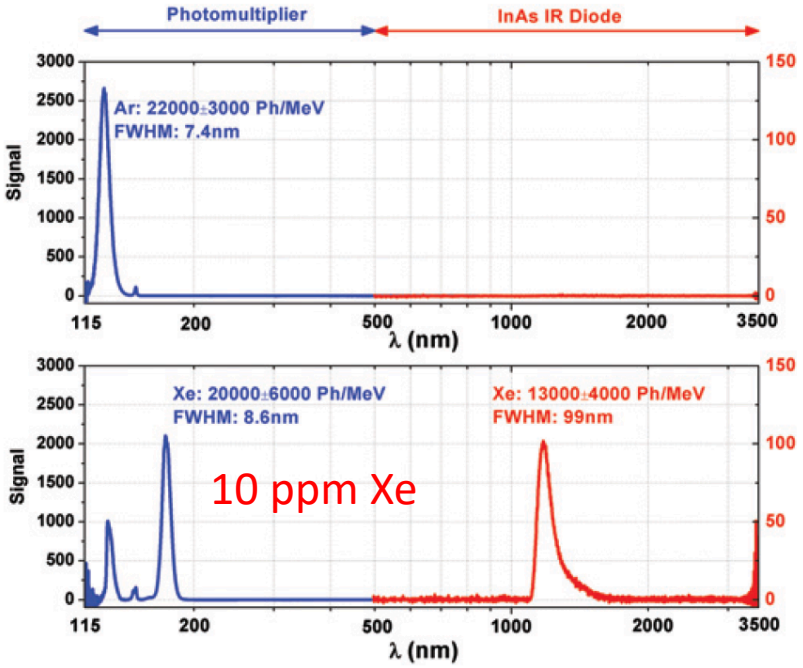
Fluorescence tagging in HPgTPC

- The TPC is an inherently slow device
  - Drift over 2.5m ~ 50 μs (for vdrift = 5cm/μs)
- 10 μs spill
  - Yields ~ 50 cm uncertainty w/r to where the vertex is.
    - Not an issue for any event with a charge track leaving the TPC and entering the ECAL - ~ 1ns time tag.
  - Having a time stamp would help with the rest
    - Matching to ECAL hits then becomes straightforward
- This is a bit tricky, since conventional gas mixtures, P10 for example, quench all fluorescence.
- Promising ternary systems:
  - Ar + Xe + CH4, Ar + Xe + CF4, Ar + N2 + CF4
  - Quench all of most of the deep UV fluorescence while producing light in the visible?

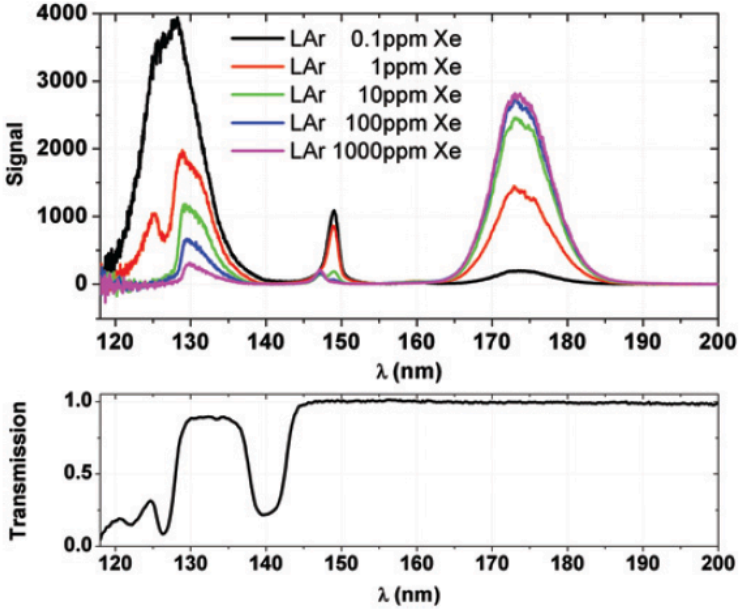
Near-IR emission in LAr + Xe

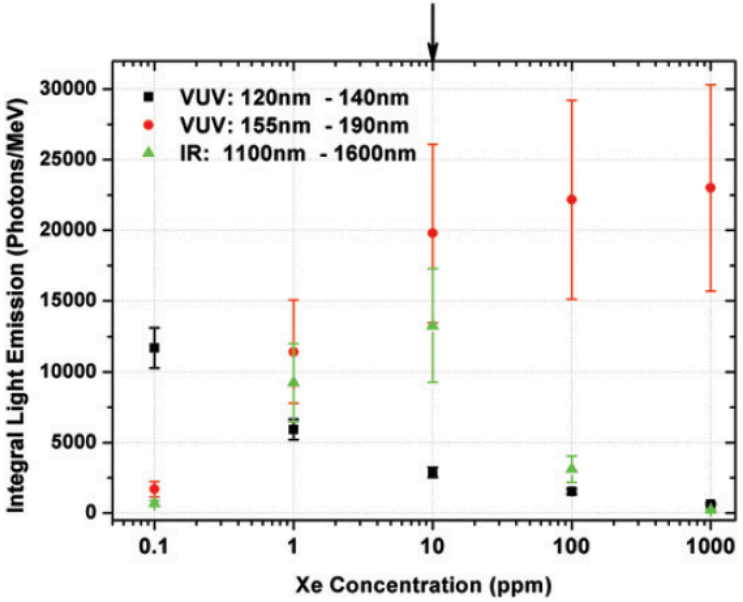
- There has been recent work in LAr to measure and use NIR fluorescence for light detection in order to vastly reduce Rayleigh scattering.
  - http://iopscience.iop.org/article/10.1209/0295-5075/106/32001
- From IOP article

Neumeier et al.



Emission in IR

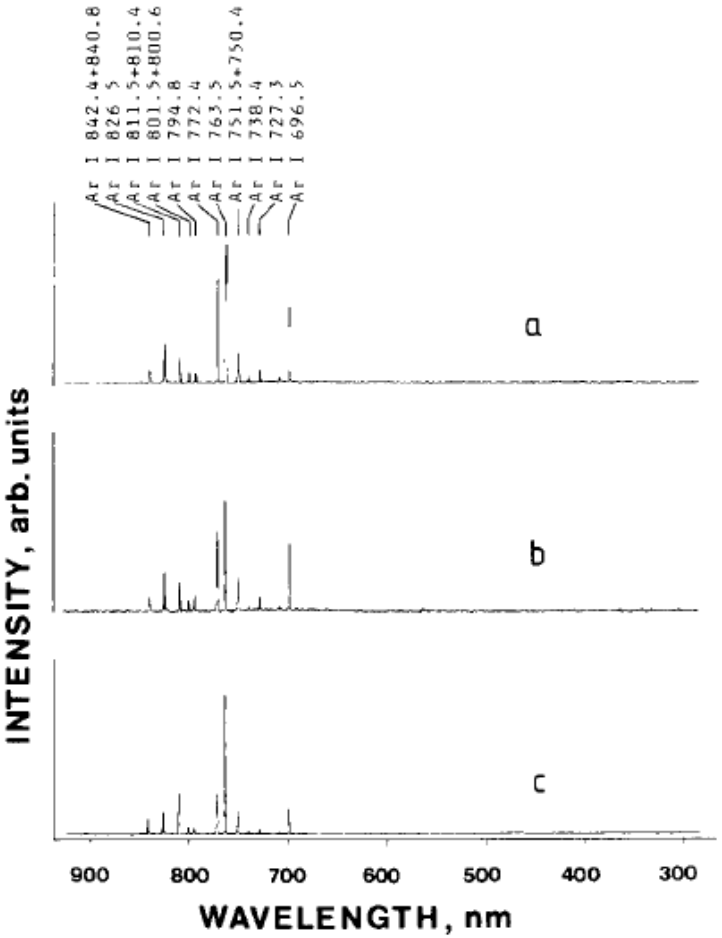




Emission in IR reaches intensity ≅ intensity @ 127nm

What about in gas?

- Very little in the literature regarding this process

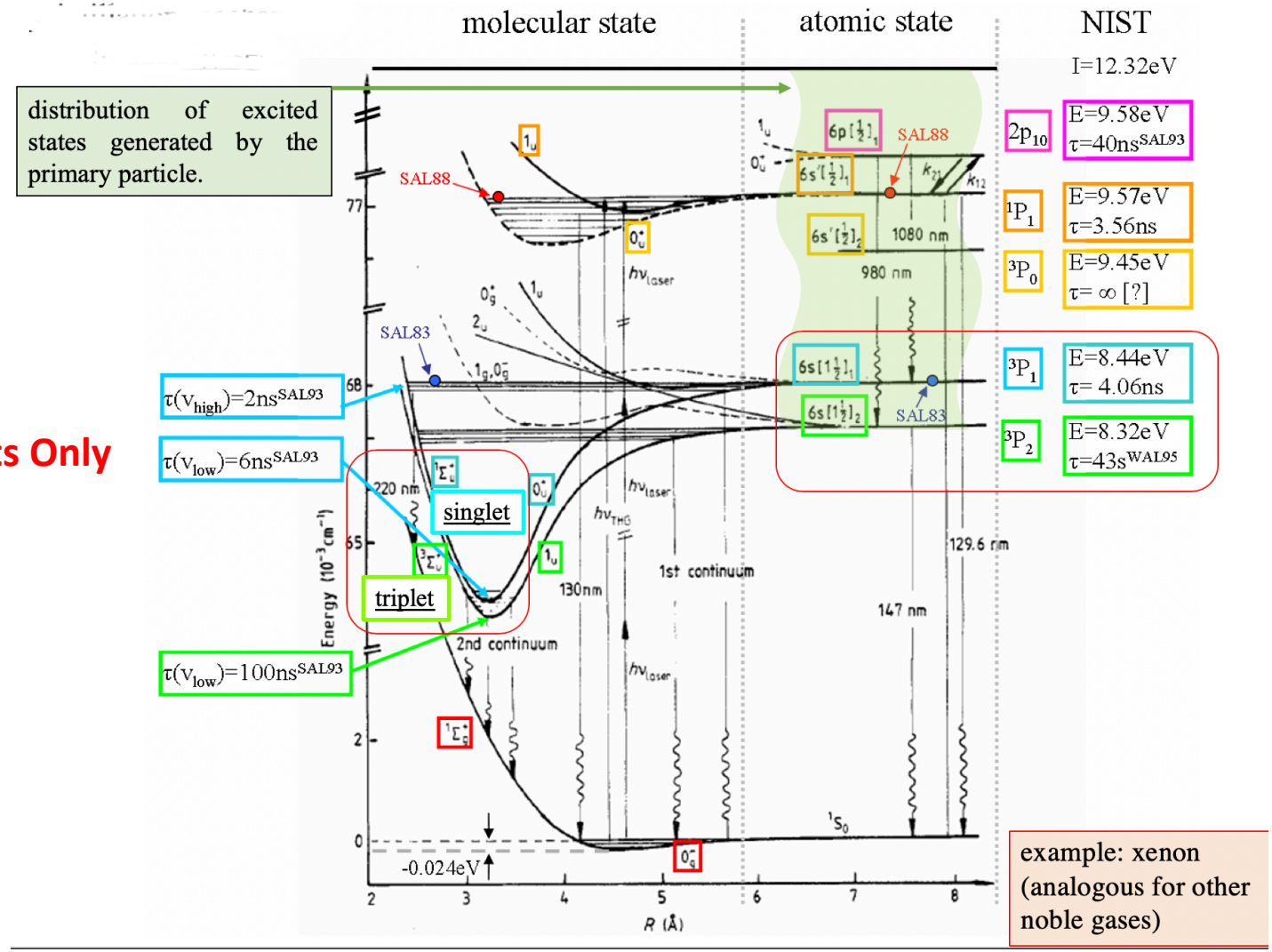


- Pure Ar
- 2 Atm
- Electron beam excitation
- Quite faint
- What if Xe is added?
- 10 Atm?

Lindbloom and Solin, NIMA 268, 1988, 204-208

Gas dynamics are complicated

Experts Only

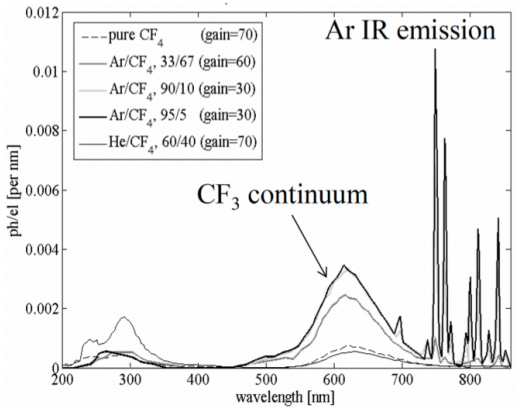


example: xenon (analogous for other noble gases)

Numerous WLS options

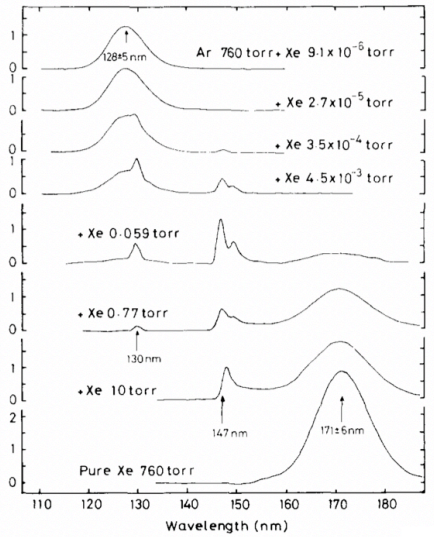
wavelength-shifting

128nm->600nm (Ar/CF_4)

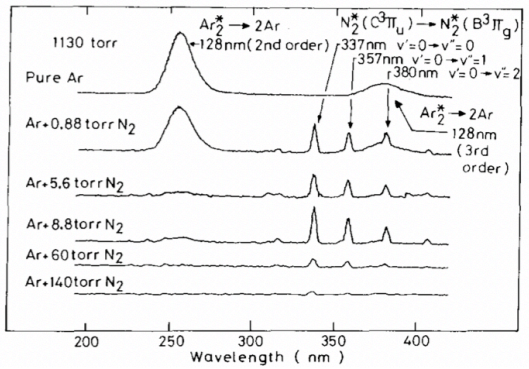


Fraga&Fraga (2002)
(secondary scint.)

128nm->172nm (Ar/Xe)

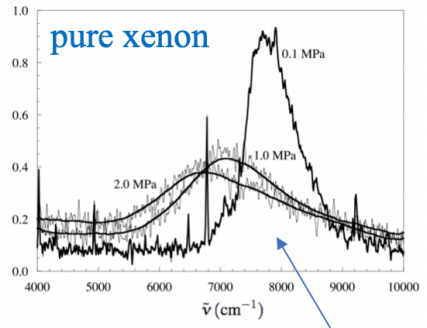


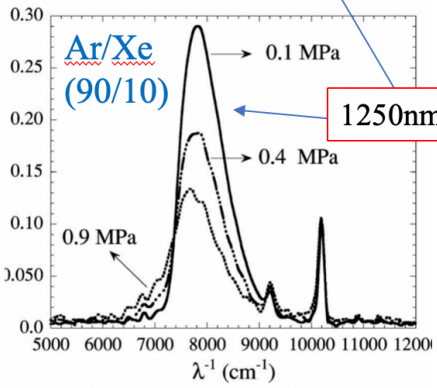
128nm->350nm (Ar/N_2)



T. Takahashi (1982) (secondary scint.)

128nm->1250nm





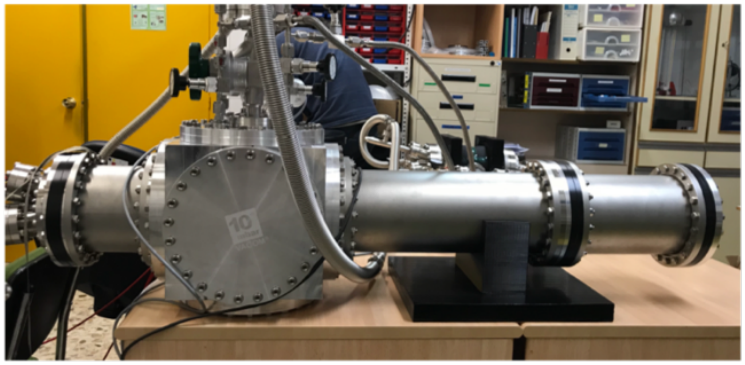
absent in pure Ar!

A. F. Borghesani (2001)
(electron gun)

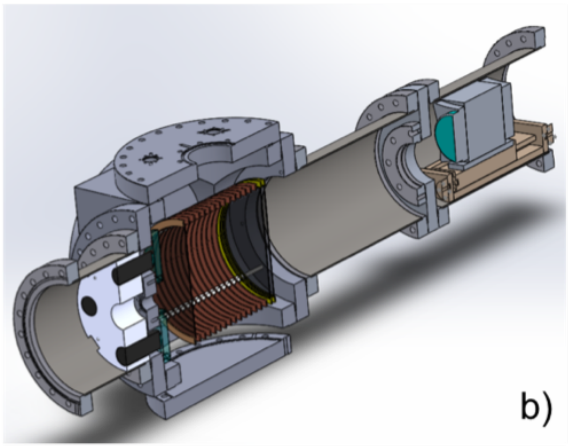
R&D Program

- Enabling a self-triggering capability with a t_0 obtained through primary scintillation, has the potential to be transformational in various important aspects
  - Can we find a gas mixture that can we maintain stable wire gain, appropriate v_d and acceptable D_L and D_T while adding this new functionality (t_0)?
    - Does argon IR emission survive at high pressure (700-900nm)?
  - Very large landscape of possible gas mixtures, pressures and fields.
  - Intersection of conventional charge readout and optical readout TPCs
- Groups
  - IGFAE, Coimbra, University of Aveiro, University of Texas Arlington, Harvard/IFIC, Fermilab
    - Connection with NEXT (Don't tell JJ)

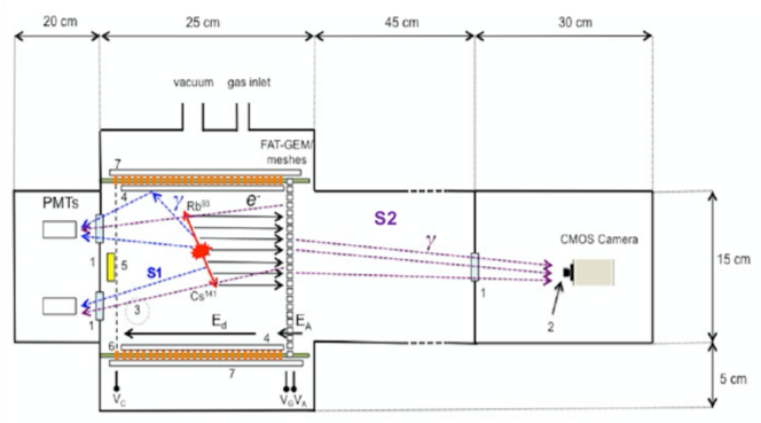
Technology-demonstrator at IGFAE-Santiago (Nausicaa)



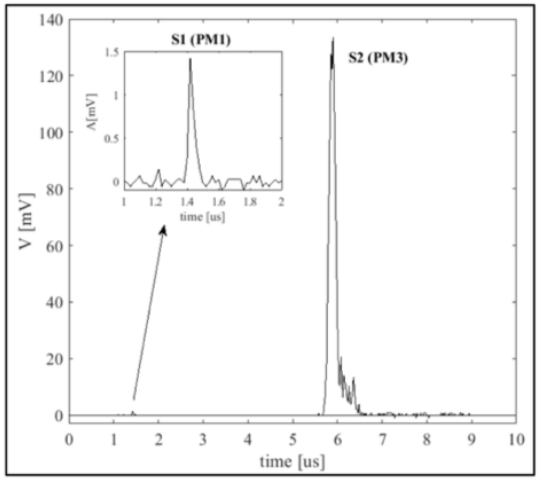
a)



b)



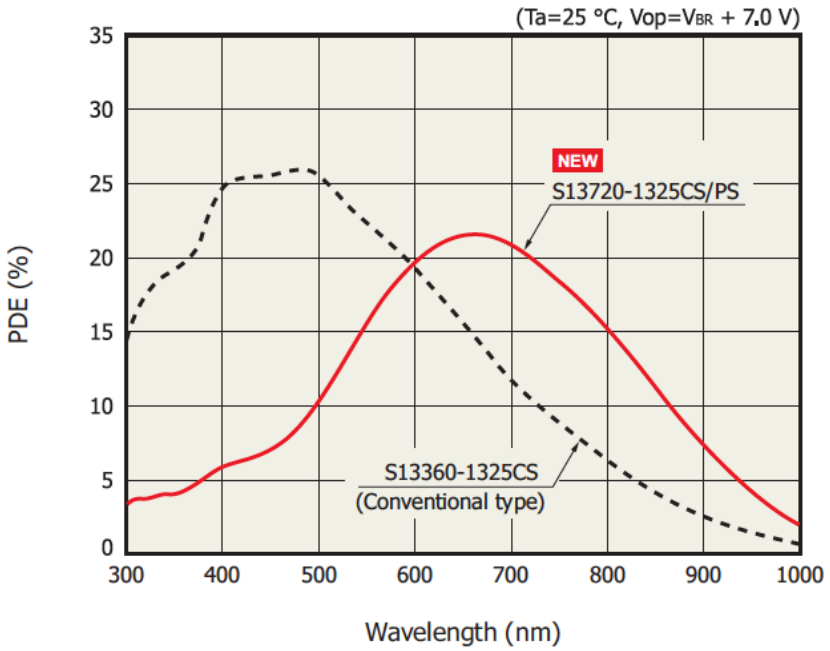
c)



d)

If we find a gas: Photon detection

- The 700-800nm emission is matched very well to a new SiPM
- Hamamatsu SiPM for LIDAR applications
  - TOF imager for automobiles: self-driving cars
    - Potentially big market



- Excellent match to the fluorescence in Lindbloom paper
- Fast
- Low noise: 1.5 kHz dark count rate
  - This is VERY low for SiPM!
- Price point very attractive
- FBK also producing near-IR sensitive devices

Conclusions

- Fluorescence timing/tagging within the HPgTPC active volume, while allowing for stable MWPC operation, appropriate v_d, D_L and D_t at the gains we need, 2-5k, looks possible.
- The NIR approach has many details to work out, but would be a game changer, if workable
- As usual: MUCH WORK TO BE DONE.
- A strong collaboration to work on this is forming and initial funding has been obtained

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INSTITUTO GALEGO DE FÍSICA DE ALTAS ENERXÍAS (IGFAE)

Facultade de Física
Campus Sur s/n
15782 Santiago de Compostela

Postdoc position for the development of next-generation high pressure TPCs with optical readout

IGFAE (Galician Institute for High Energy Physics)

The University of Santiago de Compostela, founded in 1495, is the oldest University in Galicia and one of the oldest, continuously running, universities in the world. It has over 40000 students and 2000 professors and researchers.

IGFAE, founded in 1999, is a Spanish Excellence Research Center, member of the SOMMa, the league of Severo Ochoa Centers and María de Maeztu Units to promote Spanish Excellence in research and to enhance its social impact at national and international levels. It is a joint research center of the University of Santiago de Compostela and the Autonomous Government of Galicia. The Institute performs frontier research in High Energy Particle Physics, Nuclear Physics, Astroparticle Physics and related areas, both theoretical and experimental.

One of the research programs of IGFAE relates to *Dark Matter and the Nature of the neutrinos*. The Institute is involved in the detector construction, operation and physics analysis of the NEXT experiment (conceived to determine the neutrino mass scale). In a broader context, it develops technology for next-generation optical time projections chambers, targeting nuclear and WIMP-based dark matter experiments, neutrino physics, as well as applied research. This position is supported by the IGNITE initiative of IGFAE, focused centrally on technological developments aimed at the introduction of a fluorescence-based T_o-scheme for the High Pressure Near Detector of DUNE.

Subject description

The Deep Underground Neutrino Experiment (DUNE) is a next-generation neutrino oscillation experiment at Fermi National Accelerator laboratory (Fermilab), in the US. Designed, as customary, with a suite of Near and Far Detectors. It is conceived as the ultimate neutrino oscillation experiment, with ability to extract the CP phase of the neutrino

If you know of a good candidate, please see full announcement uploaded under this talk.