Actividades do grupo R&D em xénon líquido

Vitaly Chepel

Jornadas LIP, Braga, Feb.2020

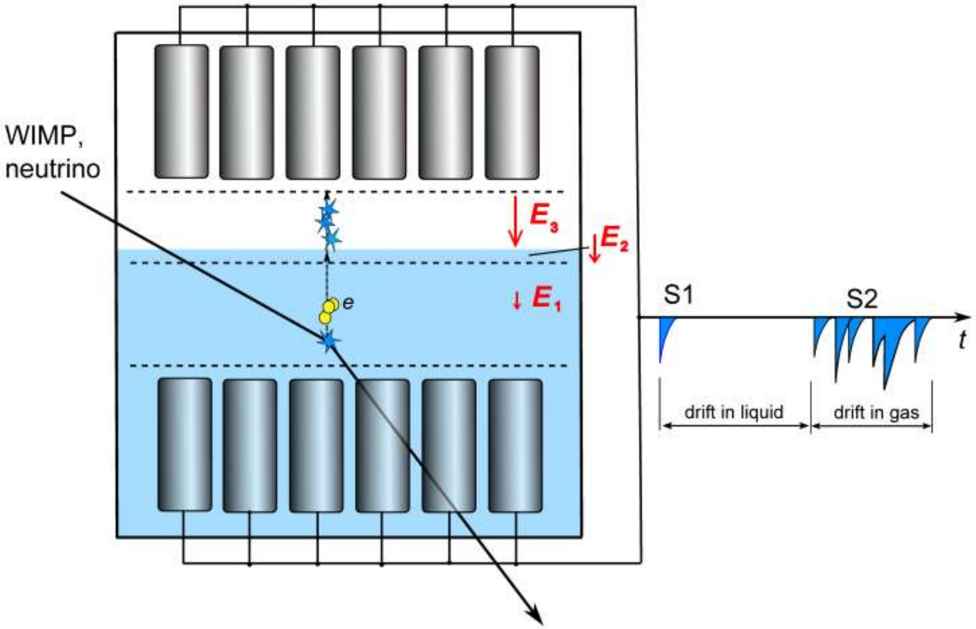
Base financeira:
Fundo CERN CERN/FIS-INS/0025/2017
"Participation in the RD51 Collaboration"
(Nov. 2018 – Oct. 2020):

Instituições participantes:
1. LIP (Coimbra) — 1/2
2. Universidade de Coimbra (GIAN) — 1/4
3. Universidade de Aveiro — 1/4

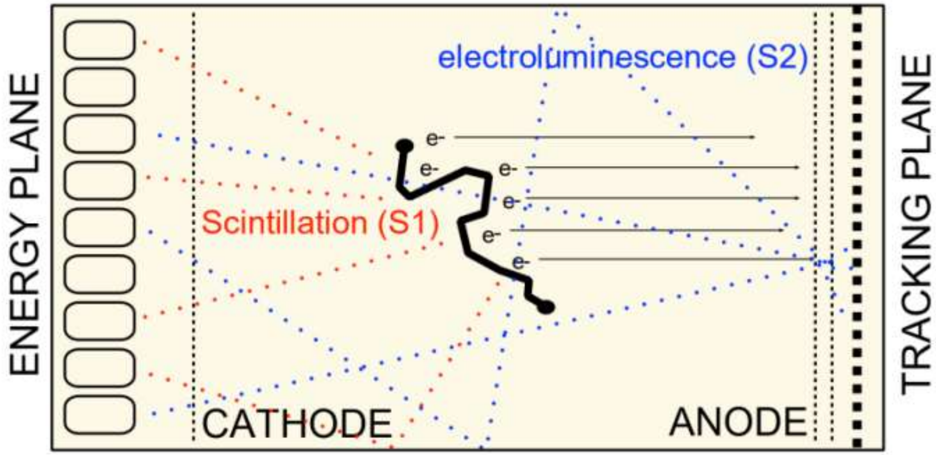
4 tarefas das quais 2 são da responsabilidade do LIP:
1. Estudo de mobilidade de iões (Grupo de Detectores Gasosos)
2. Estudo de sinais satélites em TPCs de xénon de alta densidade
(Grupo de R&D in LXe + Grupo de Detectores Gasosos)

So different and so similar…

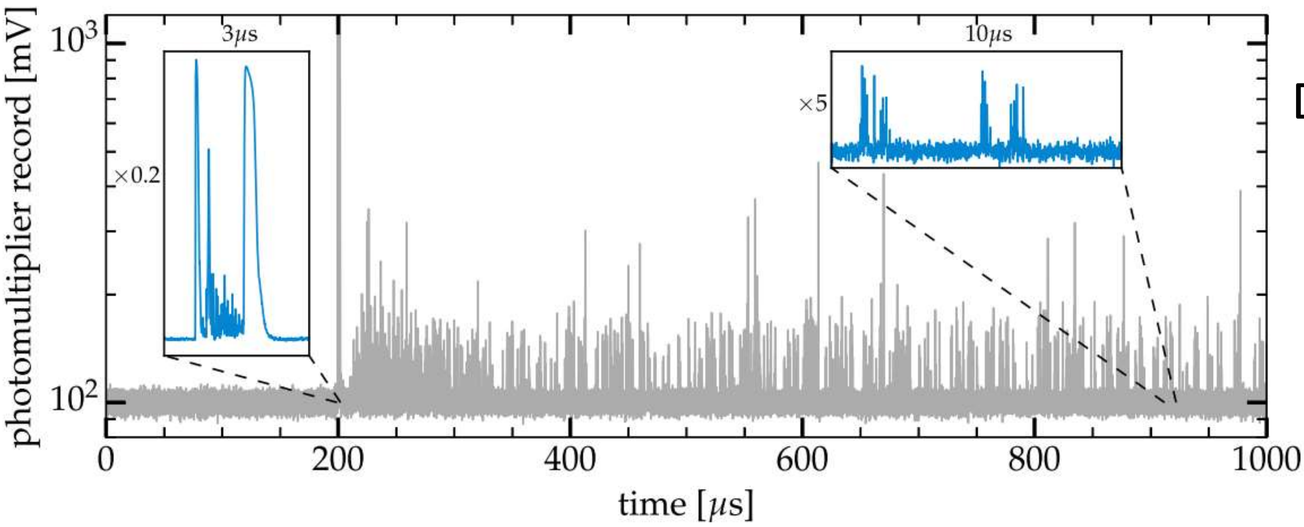
Double phase WIMP detectors



HP xenon TPC (NEXT)

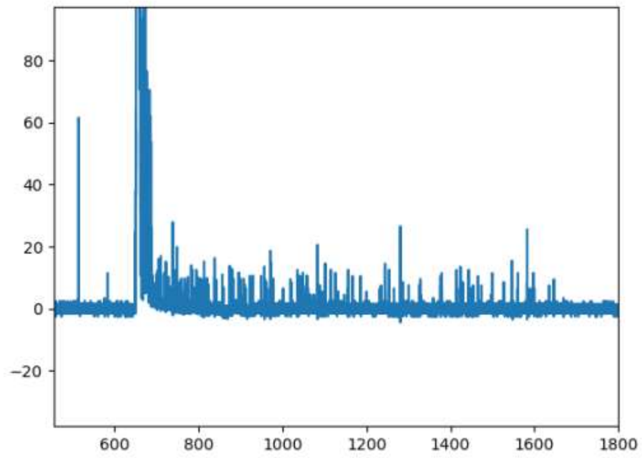


Satellite pulses in double phase xenon and high pressure gas



Double phase xenon

10 bar xenon TPC (NEXT)



Although the experiments, in general, learned to deal with the satellites, it still an embarrassing (and limiting) factor.

May be just instrumental but it is also possible that some interesting xenon physics lays behind.

Features

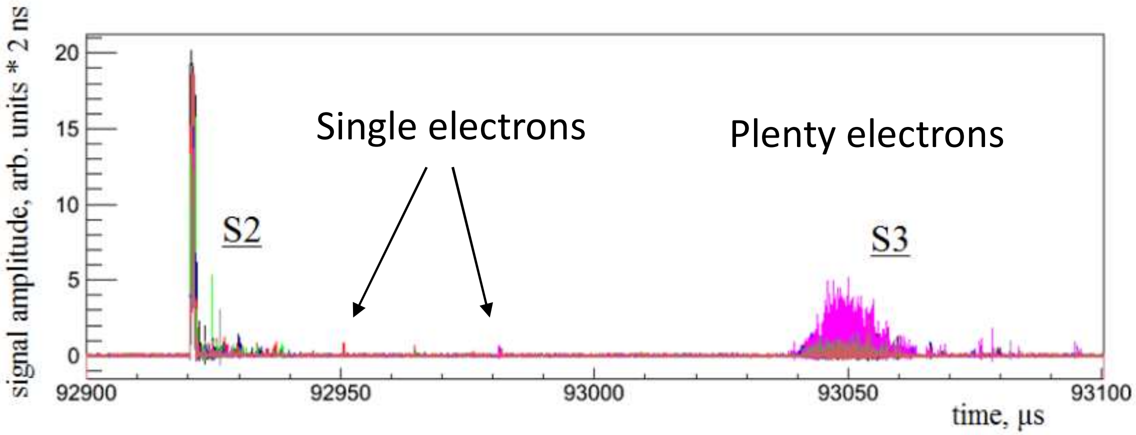
Some pulses seem to be correlated with the main signal
Others are not …

Some correspond to single electron emission
Others do not …

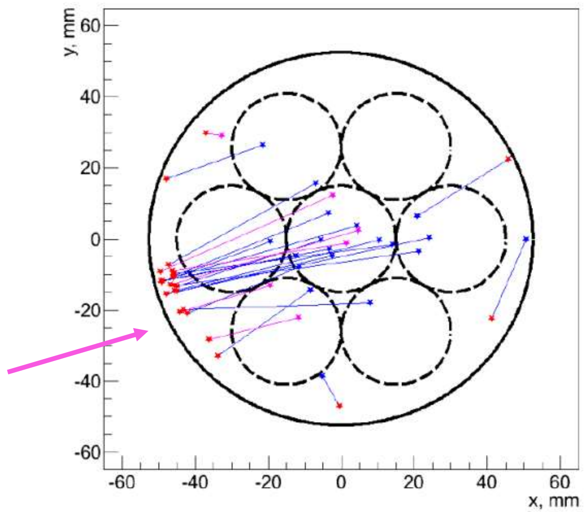
Some emerge in the μs scale
Others extend to many ms …

Some appear at the same site as the main signal
Others can appear far-far-away …

RED-1 (LXe double phase)



Spatial map



S1 or S2

S3

(Some) Working hypotheses

Related to the electron emission physics

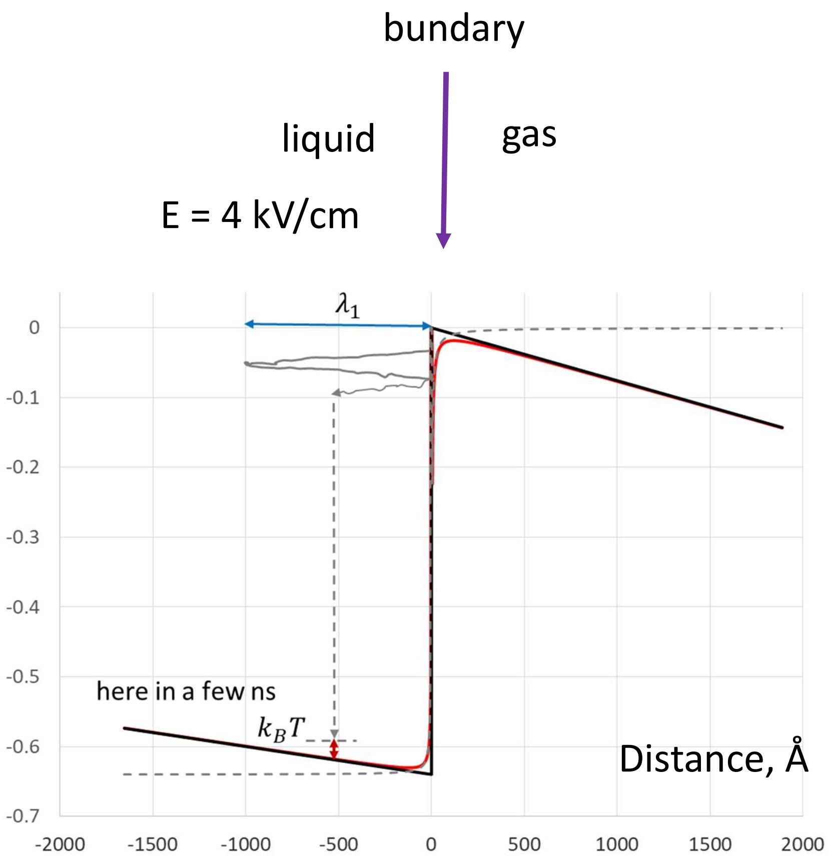
1. Those electrons that did not manage to cross the liquid surface at once are thermalized and captured in the potential well under the surface. Then they are “released” slowly and spontaneously (“released” – how?)
2. They may jump all together where the field is non-uniform (must suddenly become very hot for that)
3. Some electrons are attached to electronegative impurities forming negative ions that slowly drift in the same direction and stay retained under the surface → spontaneous detachment (?) and emission to gas (??)
4. Attached electrons are detached in the bulk → go to surface and jump to gas

All of them seem to challenge the currently accepted emission mechanism

and

None of them is applicable to xenon gas (obvious)

Electron energy and potential barrier at the LXe surface



$V_0 = -0.64$ eV

$\lambda_0 \approx 6$ nm – energy transfer

$\lambda_1 \approx 100$ nm –momentum transfer

$\tau_0 \sim 7 \times 10^{-14}$ s

$\tau_1 \sim 1 \times 10^{-12}$ s

$\sim 10^5$ collisions are needed to thermalize

(Some) Working hypotheses

Those of physical/instrumental nature

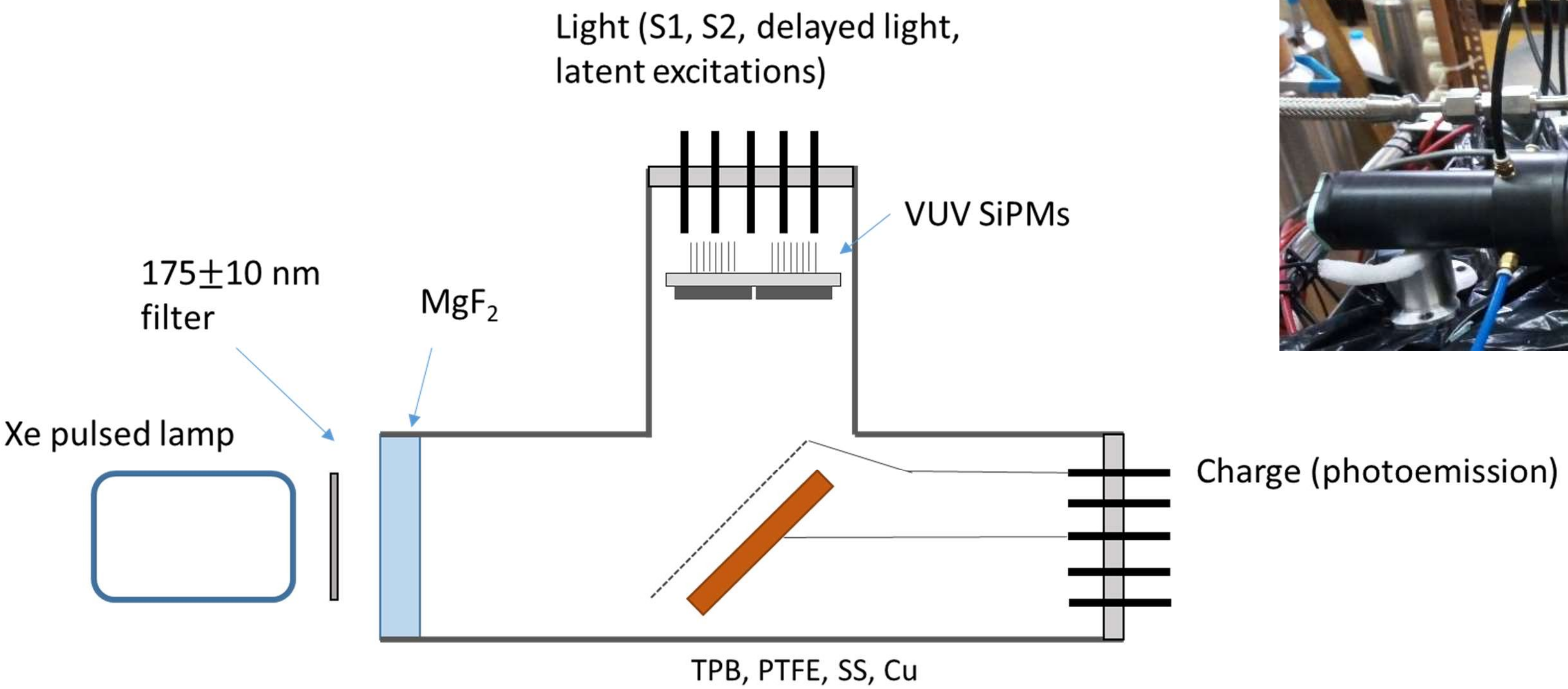
1. Photoelectric emission from the chamber components under VUV illumination
2. Photoionization of TPB (wavelength shifter) – it is everywhere in NEXT but LXe detectors do not have it
3. Photoionization of xenon by its own VUV (unimaginable on Xe, hard to believe on Xe_2, but Xe_n? or XeO??)
4. Photoionization of impurities

Other (unknown) physics?

1. Something to do with the surface hydrodynamics?
2. “Evaporation promoted” emission?
3. Unknown surface states?

The general idea is to reproduce the phenomena observed in large detectors with a simple and flexible benchtop setup so that the conditions can be easily controlled and changes.

Isolate the charge effects and those due to VUV light.

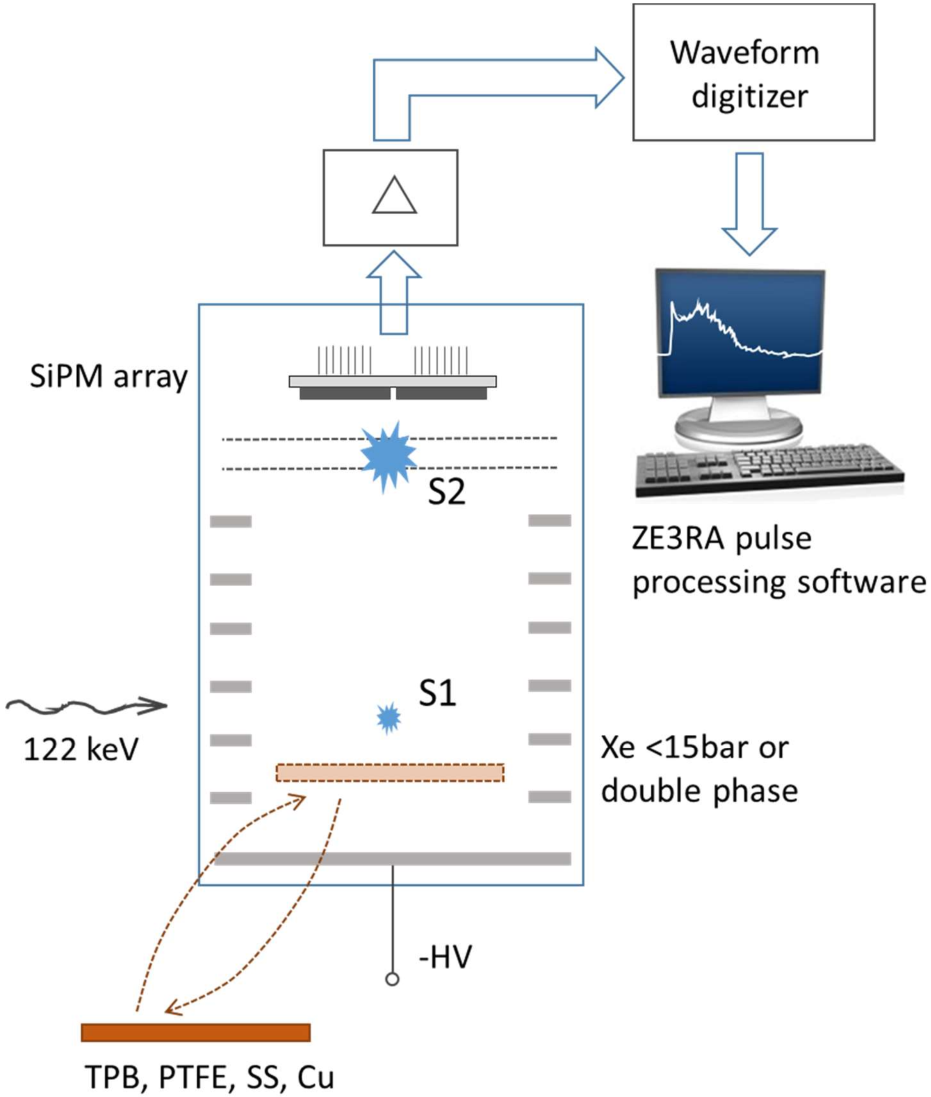


Vacuum, Xe <15bar or LXe

Status: Setup partially ready

Another possibility under consideration –
recover small TPC from 1993

~60 mm



Optimistic prospects:

1. Finish old CERN CERN/FIS-INS/0025/2017 — 31/10/2010
2. Start new CERN CERN/FIS-INS/0027/2019 — 01/11/2010