



# Liquid xenon purification using high-voltage electric discharge technology

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# Xenon purification problem

The main goal to have a reasonable electron drift length in RED100  $> 1$  m

For RED-100 detector we have  $\approx 270$  kg of depleted xenon (without Xe-136)  
It was found out in a test chamber that this gas is very dirty (zero electron lifetime)

Moreover, during this test SAES PS4-MT15-R2 and SAES PS3-MT3-R2 hot getters were burnt out

Probably xenon was contaminated with centrifuge oil which cannot be effectively removed with commercial getters

Modified getters working at temperatures up to  $650$  °C and xenon flow rate  $< 1$  slpm gave no result

We have to find an alternative way to purify our xenon using **spark discharge technology**

# Spark discharge technology

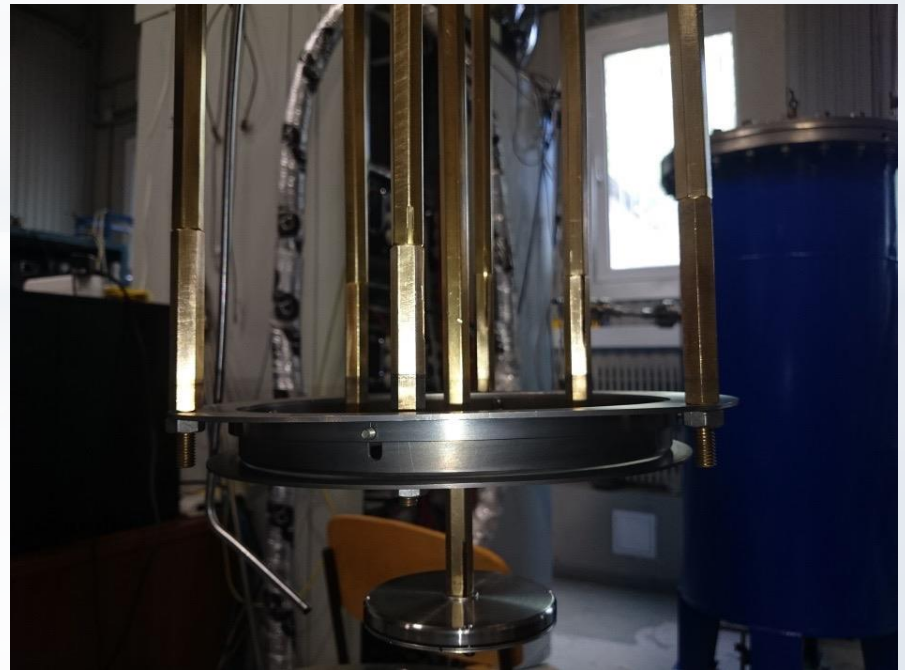
This method of noble gas purification was invented 40 years ago in MEPHI by Obodovski *et al*

It is used for purification of noble gases or liquids

A pair “knife-to-plate” titanium electrodes are placed in liquid and electrical spark discharge is produced between them by applying high voltage.

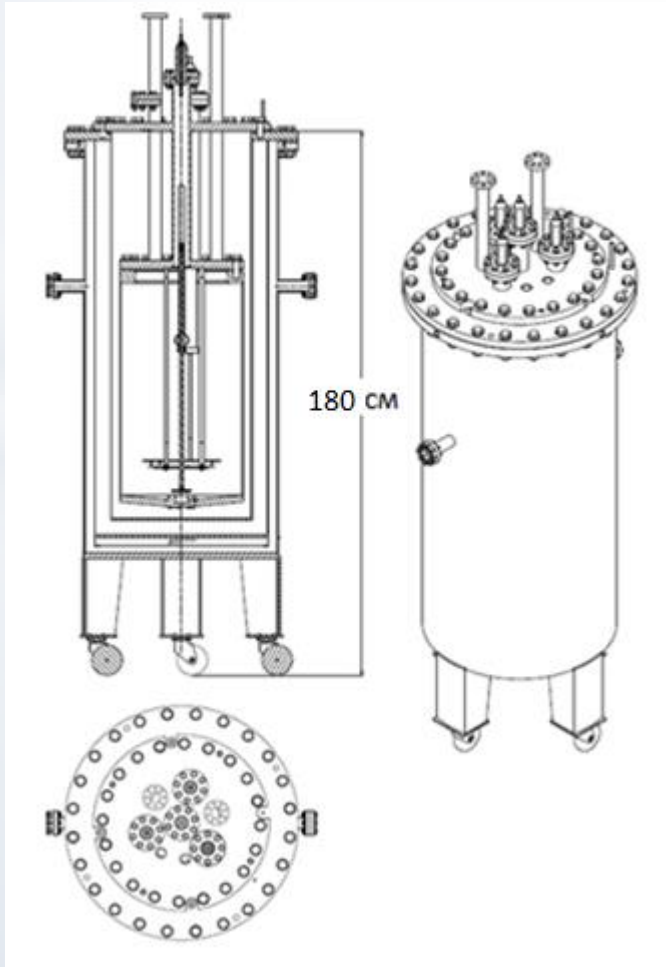
This discharge generates UV light and titanium dust.

- 1) UV disintegrates heavy molecules
- 2) Dispersed titanium particles work as a getter

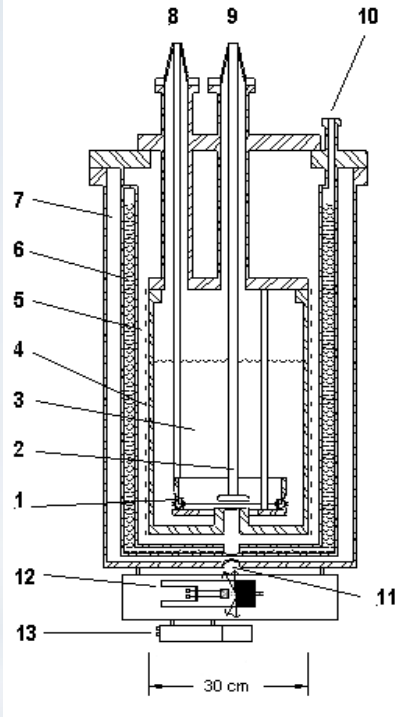


# Mojdodyr setup

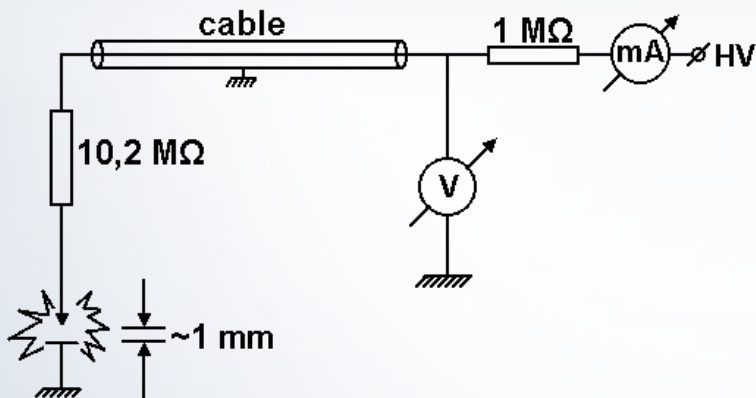
«Mojdodyr» was built in ITEP in the 80's to purify LKr (electron drift length  $L > 1$  m) ПТЭ №2 (1991) 73-82



# Modified Mojodyr experimental setup

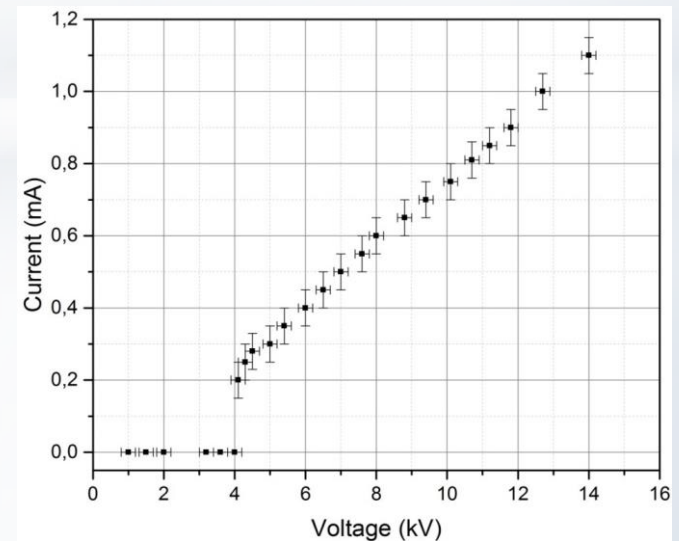


- 1 - electric discharge in liquid noble gas between titanium electrodes of "knife-to-plate" type;
- 2 - anode of the ionization chamber for purity measurements;
- 3 - liquid xenon;
- 4 - cold chamber surrounded by copper screen with electrical heaters installed on it;
- 5 - nitrogen gas vessel;
- 6 - liquid nitrogen vessel;
- 7 - vacuum vessel;
- 8 - high-voltage feedthrough to provide the electric discharge;
- 9 - ionization signal output;
- 10 - inlet for liquid nitrogen;
- 11 - aluminum windows for X-ray input into the ionization chamber between electrode gap;
- 12 - X-ray tube of BSV-7 type;
- 13 - scintillation detector

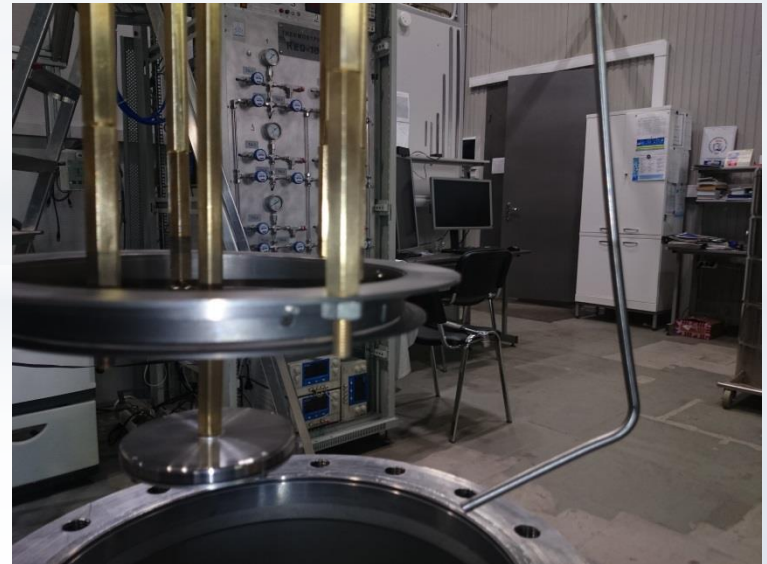


Discharge circuit

## Voltage-current characteristic



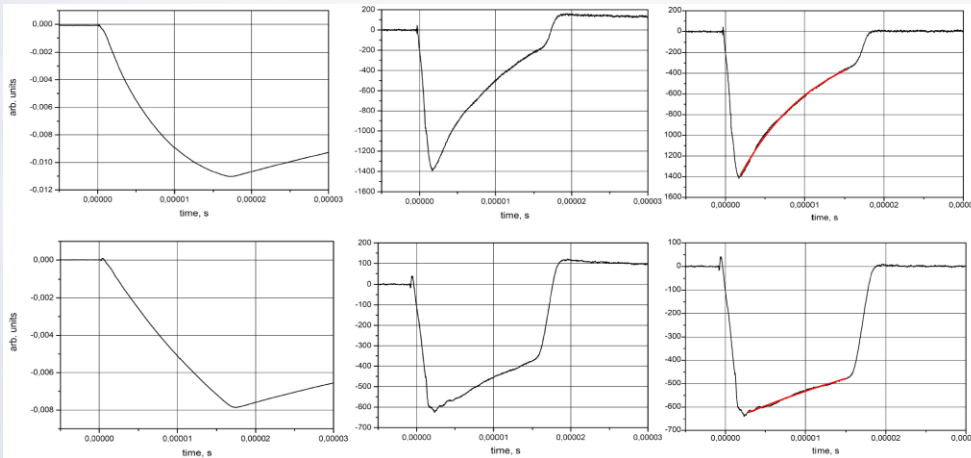
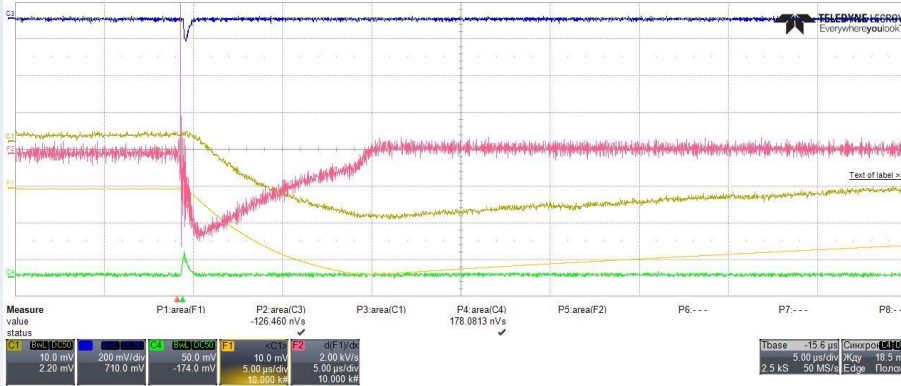
# Mojdodyr internal structure



# Xenon purification

Purification of 55 kg was done in two stages :

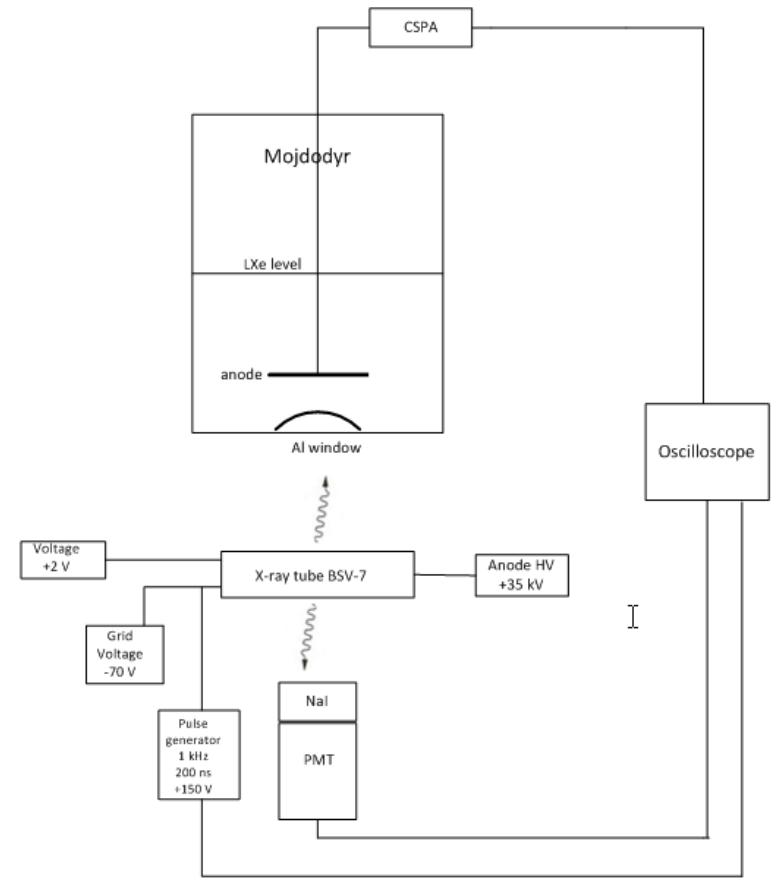
- 1) burn out high molecular weight impurities
- 2) fine purification with Ti dust



Voltage waveforms averaged over 10000 signals taken from CSPA

Average current (after differentiation and smoothing)

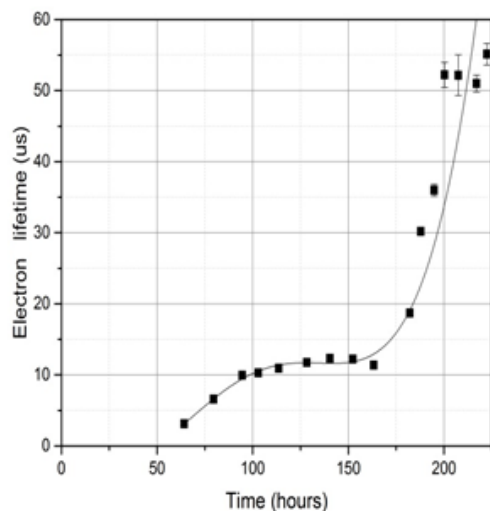
Average current (after CSPA discharge correction)



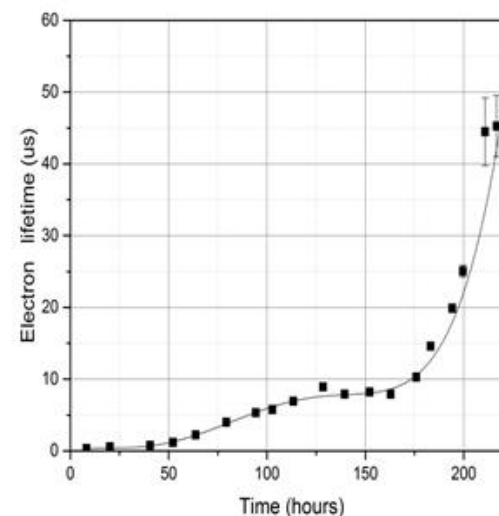
$$I = A \cdot e^{-t/\tau}$$

# Electron lifetime measurement

Full process of purification 55 kg took about 10 days



100 V at ionization chamber anode

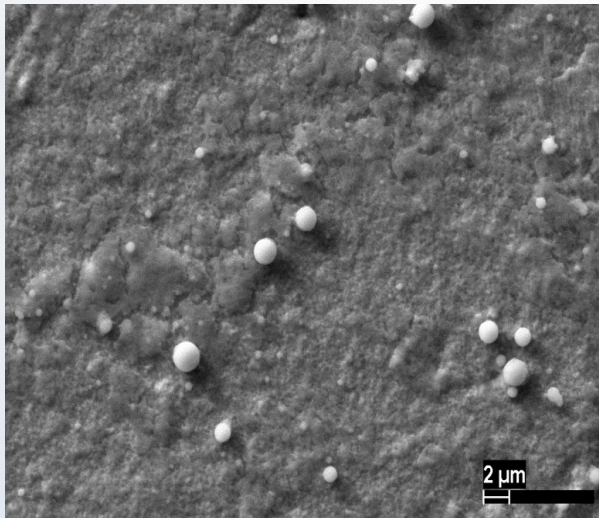
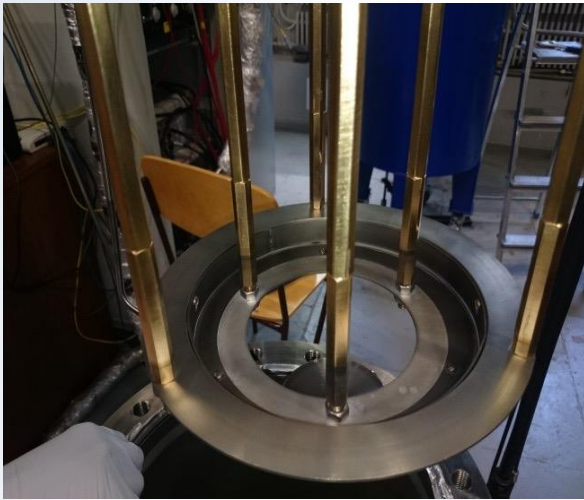


1000 V at ionization chamber anode

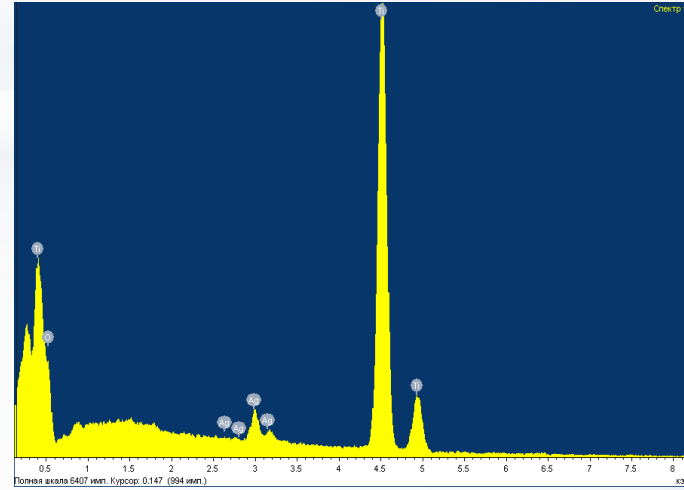
50  $\mu$ s electron lifetime was achieved at electric field strength of between 50 and 500 V/cm

These results to be published in JINST





Titanium black dust image from electron scanning microscope



X-ray analyses of an element composition of Ti particles on scanning electron microscope

# Summary

It was found out that to purify centrifuged xenon is very difficult with conventional getters

Usage of spark discharge technology with Mojdodyr experimental setup allowed to purify 55 kg of Xe to electron lifetime of 50  $\mu$ s

This technology will be used to purify all xenon for RED-100

**Thank you for your attention!**