OROC test stand and testing at RHUL & Imperial College London

Alexander Deisting (Royal Holloway) on behalf of the groups at Royal Holloway, University of London and Imperial College London

22^{th} of October, 2019

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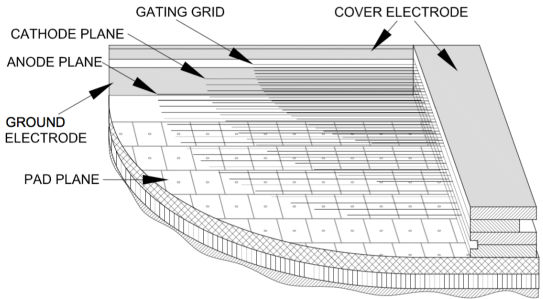
Use case:

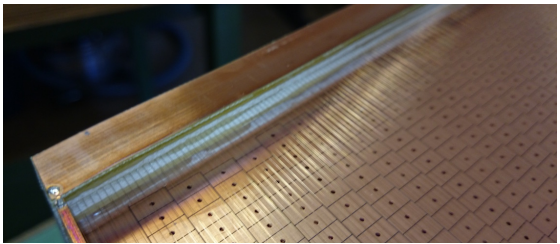
- Answer the question: **Will an OROC work at the pressure required for the DUNE High Pressure gaseous TPC (HPgTPC)?**

This talk:

- Short introduction to ALICE multi wire proportional chambers
- The Royal Holloway high pressure platform
- Current status of the tests and steps planned from now on

ALICE TPC multi wire proportional chambers





- 18 Inner and Outer ReadOut Chambers (IROCs/OROCs) per side
- Each has three wire planes: Anode wires, cathode wires and gating grid wires
- Pad sizes: $4 \times 7.5\,\mathrm{mm}^2$, $6 \times 10\,\mathrm{mm}^2$ and $6 \times 15\,\mathrm{mm}^2$, in total 160 pad rows

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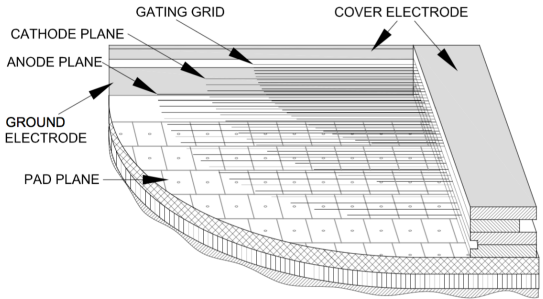

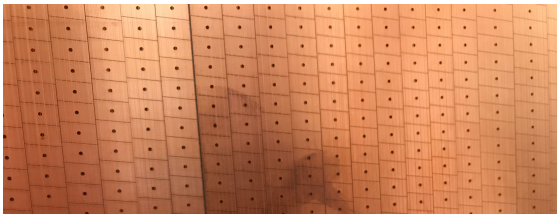

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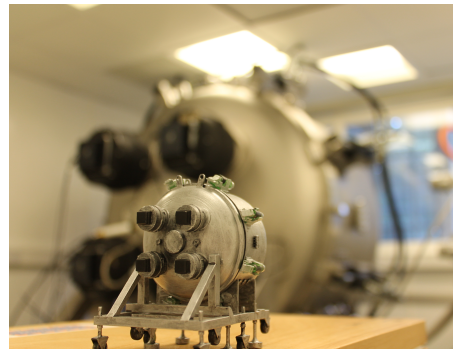
The Royal Holloway high pressure gas platform:
Large enough to fit an OROC



Royal Holloway high pressure platform

- Rated to 5 bar absolute pressure, cylindrical volume > 1000 l, inner diameter 140 cm, length 73 cm

$\Rightarrow$ It fits an ALICE outer readout chamber

- Equipped with the necessary feed-throughs for services as gas lines, signal lines and HV
- In addition there are five mounts for DN200 optical flanges
- Currently houses a high pressure gas TPC prototype with hybrid optical and charge readout

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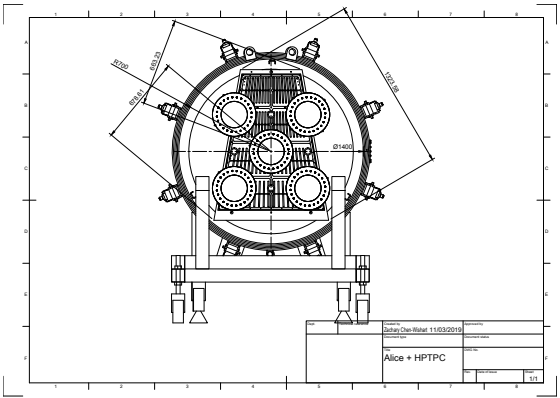
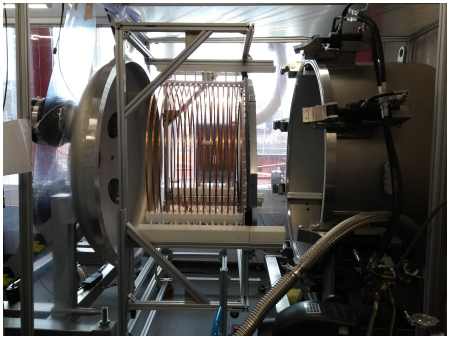


Gas system, slow control and high voltage

- Gas fills are done by evacuating the vessel down to $\sim 1 \times 10^{-6}$ bar absolute pressure and filling afterwards
- To create gas mixtures, gas lines for four bottles are available. Mixes are done by filling from each gas line at a time to the desired partial pressures
- The custom made slow control as well as the DAQ can be accessed through a web-page
- One Spellman Power Supply (PS) with 30 kV output voltage is available
- In addition we have standard several lab PSs with up to 8 kV output voltage
- Tow CAEN N6730 8-channel digitisers can be used (2 V dynamic range / 500 MHz)

High pressure gas TPC prototype



- Cylindrical gas TPC with 44.7 cm drift length and 111 cm diameter.
- Its active volume is enclosed by a field cage with 12 field shaping strips, $E_{\mathrm{drift}} \leq 500\,\mathrm{V\,cm^{-1}}$
- The amplification region consists out of three unsegmented meshes, each equipped with charge signal readout
- Four FLI Proline PL09000 CCDs with 3056×3056 active pixels are coupled to the vessel on custom camera mounts.
- Each camera images a 71×71 cm field of view with a vixel size of 230 µm.

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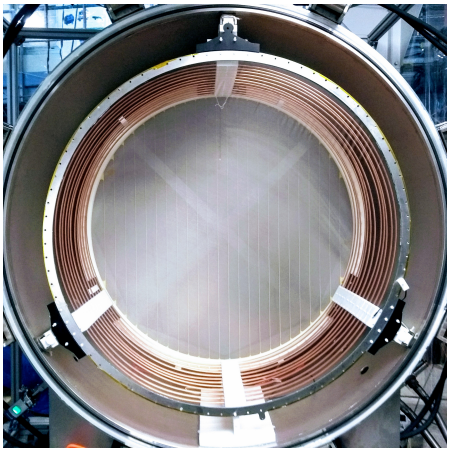

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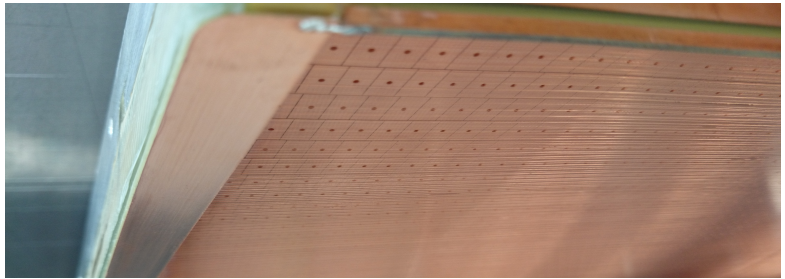
OROC tests at RHUL and ICL



OROC arrival and first steps

- We received a ALICE TPC test (MWPC) OROC in its original test box.
- As first step we got tools produced, which allow to access the OROC in the test box.
- To ensure that the chamber is in theory functional, we did an optical inspection, resistance and capacitance measurements as well as HV tests in air
- During these tests the OROC was mounted again into the test box, in preparation for tests in gas
- The test box is equipped with Mylar windows on the cathode side as well as a field cage, allowing for a uniform drift field over 12 cm

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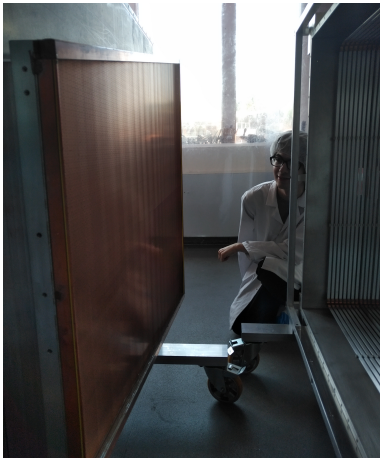

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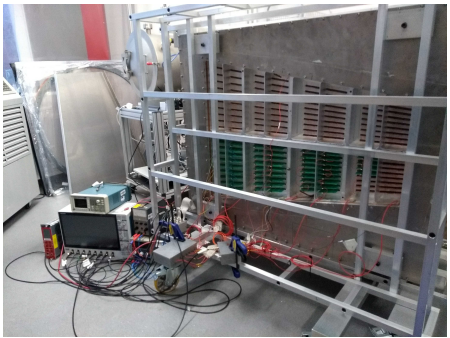
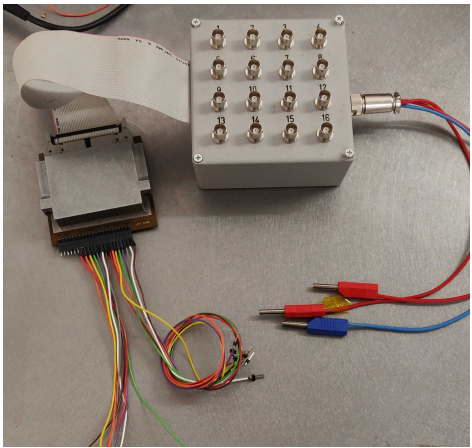


Readout electronics

- To amplify signals we use a 16 channel ALEPH pre-amplifier module
- For the first tests we hook up 15 channels to single shortening cards and one channel to 9 daisy-chained cards
- An oscilloscope is used to look at/digitise eight channels at the same time
- As a first test we coupled test pulses into the cathode wire grid and examined with response on the pads



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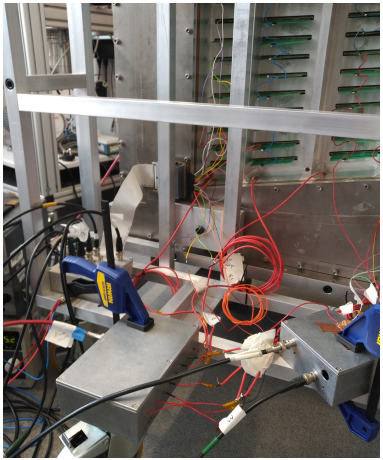

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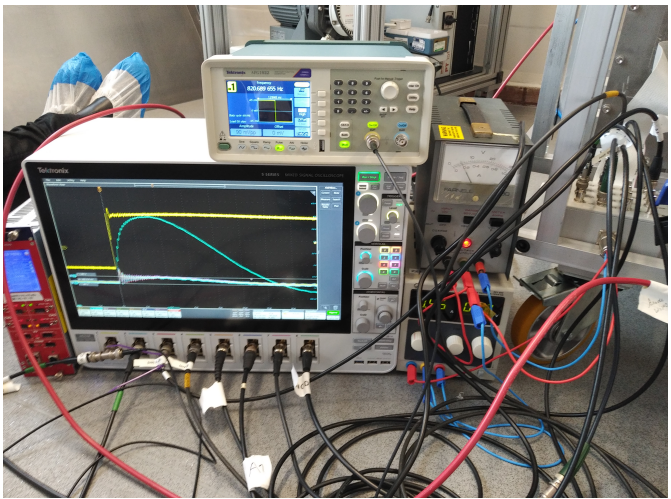

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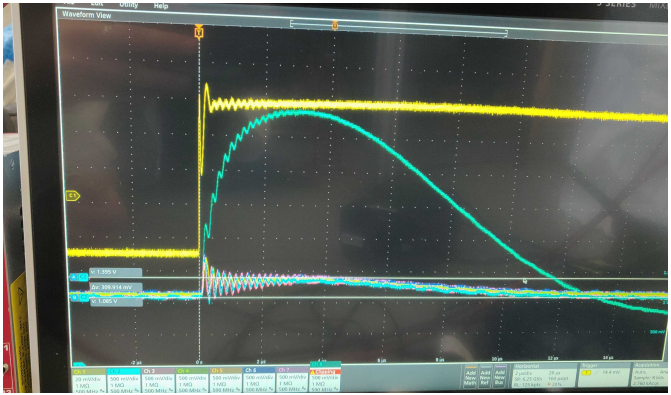
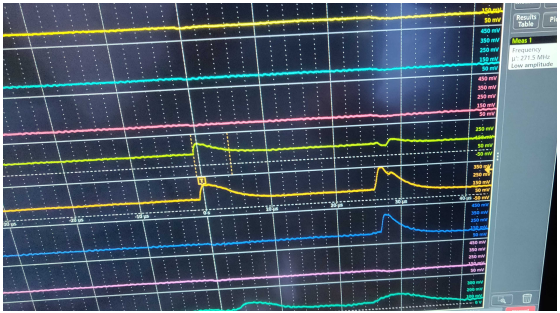


OROC tests in a counting gas

- After flushing the test-box for a day with $\mathrm{Ar\text{-}CO_2}$ (85-15) at high flow ($> 50\,\mathrm{l/h}$) we eventually switched on
- We used a drift field of $400\,\mathrm{V\,cm^{-1}}$ and set the gating grid wires to the appropriate voltage ($V_{\mathrm{GG}} = -120\,\mathrm{V}$)
- Fist signals were observed from cosmic μs as well as β radiation from a $^{137}\mathrm{Cs}$ source
- Signals are visible for anode voltages starting from $V_{\mathrm{AG}} \sim 1000\,\mathrm{V}$, we ramped until $V_{\mathrm{AG}} \sim 1850\,\mathrm{V}$



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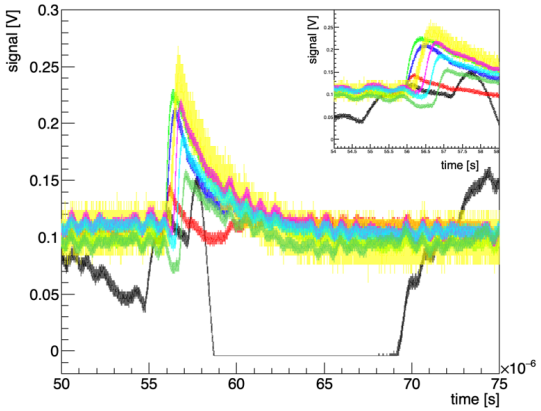
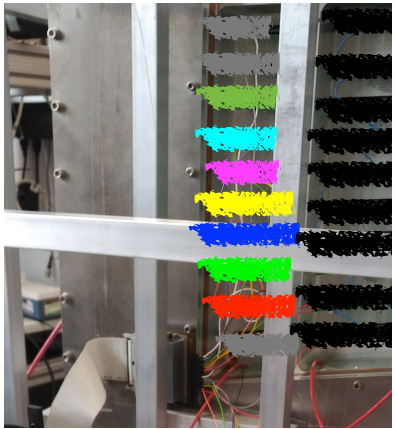
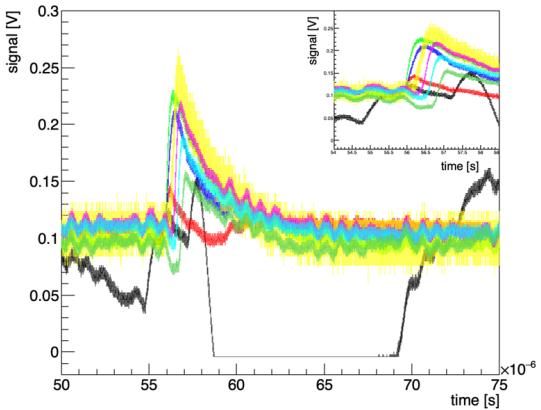


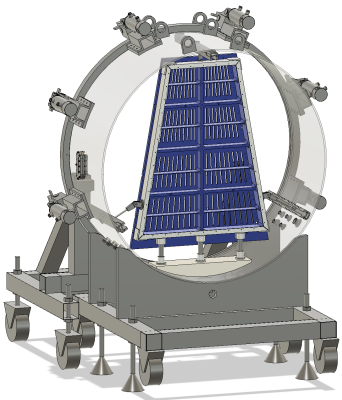
Coarse tracking





⇒ The relative difference of the onset of each shortening-cards signal allows to establish the track inclination angle

Towards high pressure tests



- The OROC holder for the high pressure vessel is ready, preliminary fitting tests went well and final tests are pending
- A field line termination plane is under construction
- The OROC will be hardly accessible in the high pressure vessel. Explore before hand (at 1 atm):
  - Possible problems with HV supply lines & signal lines
  - The best configuration for measuring signals from calibration sources
- After: OROC insertion into the pressure vessel:
- The final configuration for the charge readout in the pressure vessel will depend on the current tests

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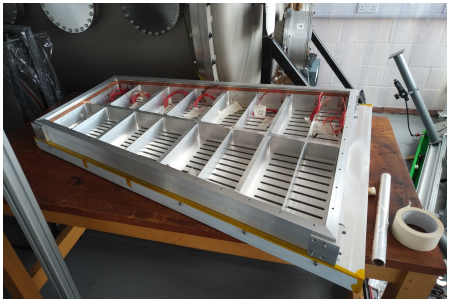

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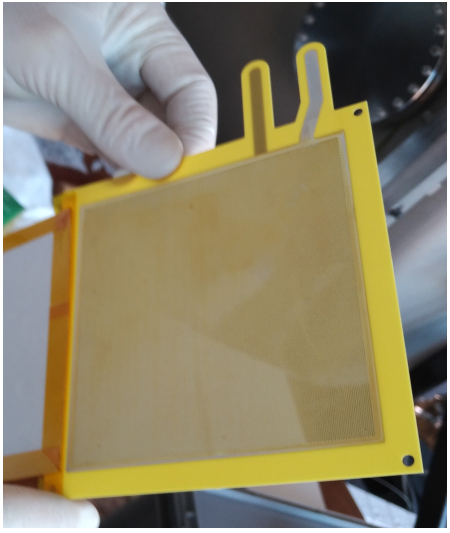
Tests at 1 atm

- Gain measurements for different gas mixes and voltage settings will be done in the test box (using $^{55}\mathrm{Fe}$). Planed are:
  - Ar-$\mathrm{CO_2}$ (90-10) $\leftrightarrow$ Same mixture as used at FNAL
  - Pure Ar
  - Ar-$\mathrm{CO_2}$ (85-15) $\rightarrow$ gas mixture which was fastest available and is tested now
- The gain measurements based on a $^{55}\mathrm{Fe}$ source yields as well the energy resolution for the particular settings
- Same is true for signal-to-noise estimate

All these measurements will be compared to the efforts ongoing (and already done) at FNAL and to the ALICE performance figures of these ROCs.

Other developments

- At RHUL we are developing a Micro Pattern Gaseous Detector (MPGD) based gas amplification stage, using GEMs or THGEMs
- This MPGD amplification region will be commissioned for high pressure operations
- We have a pad plane with 120 pads of about $1\,\mathrm{cm}^2$ size
- Dedicated front end electronics has been developed at ICL based on the APV chip and a custom made digitiser board
- The digitiser board will interface with FELIX to ship the data from the detector
- Currently we are looking into the possibility to read 120 pads of the OROC



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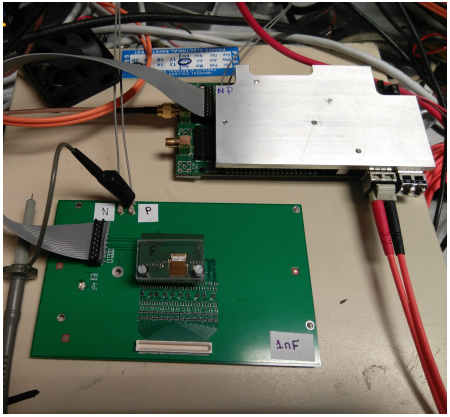


Conclusions

- The OROC we received is working fine at atmospheric pressure
- Test measurements in preparation for the high pressure testing a well under-way
- We are in good shape to answer the question: **Will an OROC work for the MPD of DUNE's near detector?**

Future measurements

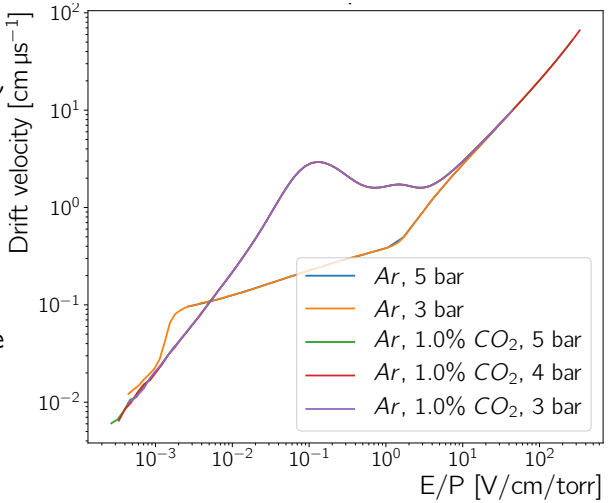
- Qualitative exploration of voltages at gas pressures up to 5 bar absolute pressure
- Quantitative measurements of gas gain for different pressures and gases with Ar predominance
- Readout electronics tests with the Imperial APV board

Backup

Operating at higher than atmospheric pressure – Implications:

- **ALICE TPC @** 1 atm ⇒ **DUNE HPgTPC @** 10 atm
- Higher interaction probability *i.e.* more ν interactions in the detector volume
- Larger primary ionisation density
- Need for a high pressure vessel
- A **high** voltage power supply is needed to compensate for the E/P scaling
- Readout chambers which can provide the necessary gas amplification at high pressure

⇒ **Rigorous testing and optimisation needed to find** 10 atm **settings**



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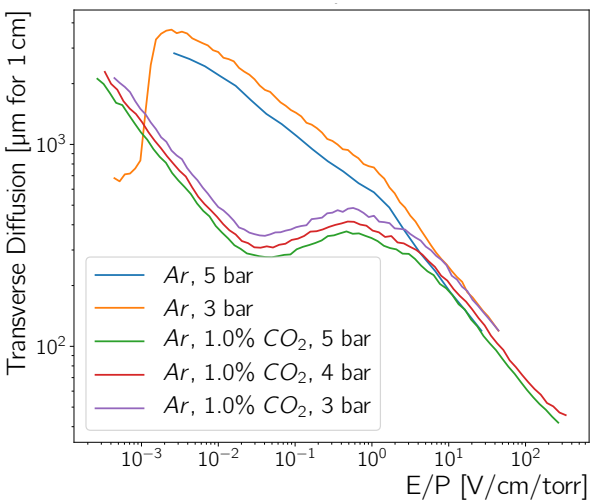

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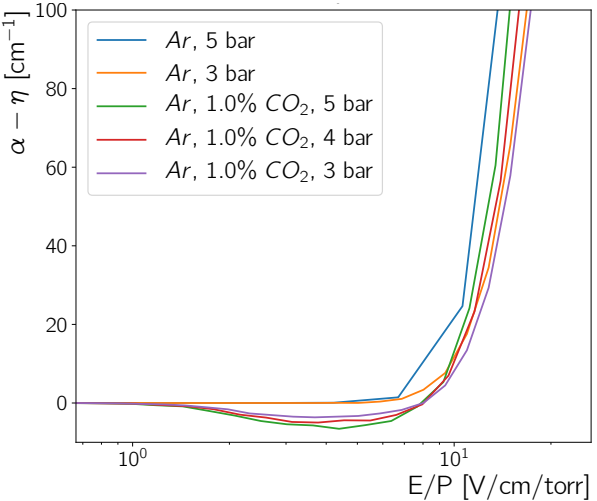

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Gas amplification

$$N_e = N_0 \exp\left(\int_{x_0}^{x_1} (\alpha - \eta)\left(\frac{E(x)}{N}\right) \mathrm{d}x\right)$$