# OPTIONS FOR GAIN ELEMENTS AND GAS MIXTURES IN A HIGH RATE EIC TIME PROJECTION CHAMBER.

B.Azmoun[2], C.Beattie[1], J.W. Harris[1], R. Majka[3], N. Smirnov[1]*, C. Woody[2].

## Demands on a Future EIC Detector

- High rate (high luminosity collider)
- Limited space available inside of SC magnet (~1.5T)
- Best possible precision for momentum reconstruction, electron energy measurement, hadron and electron PID.
- High quality primary and secondary vertices reconstruction

- TPC is on the EIC list for barrel tracking and PID (good track-finding, momentum reconstruction, dE/dX, and low $X_0$). Next step is to use a TPC as a high rate detector with high electron drift velocity and low number of pad rows. The solution is a TPC with the best precision of ionization clusters reconstruction by optimizing the gas mixture, transverse diffusion, and readout structure.
- The challenge is to guarantee that all known TPC distortions are under control and corrected with the same (or better) precision.
- The main distortions in a high rate TPC is due to Space Charge. These distortions are a function of primary ionization (interaction rate and background), gas gain, ion back flow (IBF), and ion mobility (drift velocity).
- Contrary for dE/dX measurements, it is reasonable to increase the primary ionization and gain for the best possible energy resolution and Signal to Noise ratio.

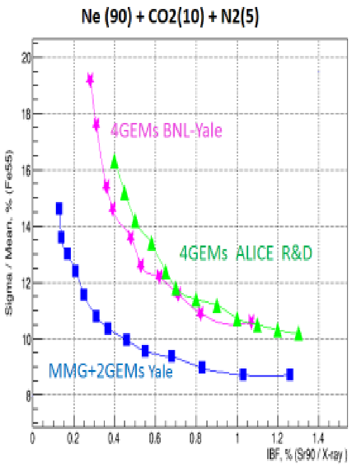
Therefor: IBF – Energy resolution – Stability are the main goals of R&D

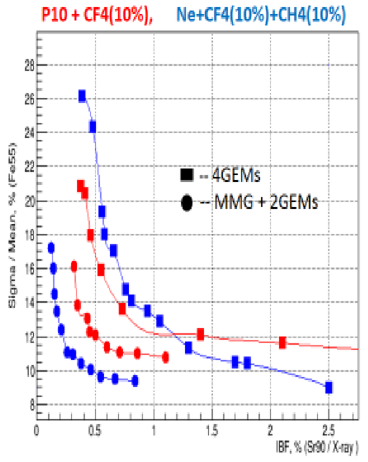
Gas mixture option: Ne + CF4. However, this combination has two issues: a strong e- absorption resonance and $Ne^+ + CF_4 \rightarrow Ne + CF_3^+ + F$.**)

**Third component : CH4.** **) D.J.G. Marque et al 2019 JINST 14 P04015

## Some examples to compare 4GEMs and MMG+2GEMs setups performance.

E resolution (%) vs IBF (%) Gain ~ 2000



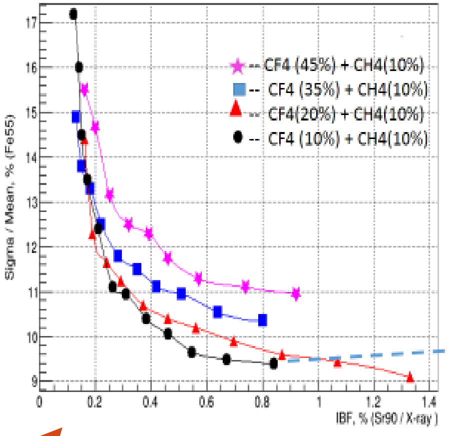



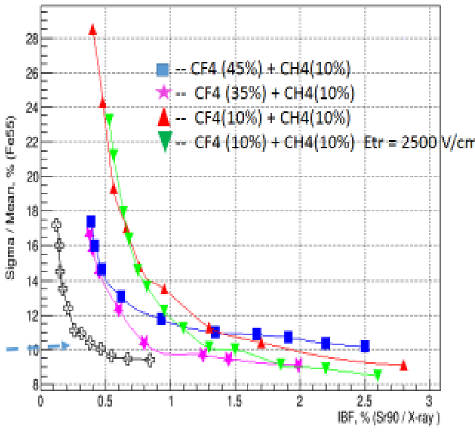

More results can be found: NIM A 834 (2016) 149

## Ne + ... Gas mixture. Edrift = 0.4 kV/cm, Gain ~ 2000

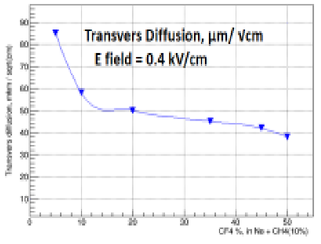
MMG+2 GEMS, E transf. = 2000 V/cm, E ind. = 75 V/cm

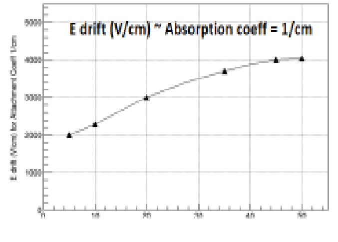
4 GEMs ALICE style, low IBF mode




## GARFIRLD: Ne + CF4(5 – 50%) + CH4(10%), B field = 1.5T ***)

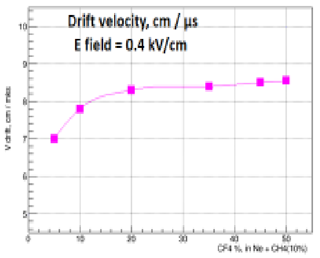


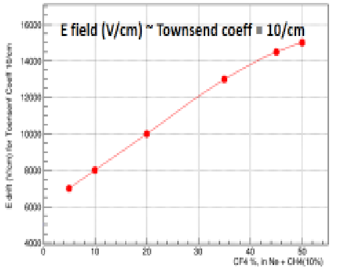




Absorption probability

For same E

Gas gain



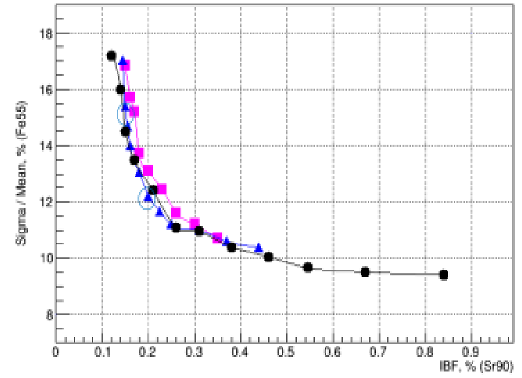




% CF4 in a gas mixture  % CF4 in a gas mixture

## TPC R&D, MMG+2GEMs. Ne+CH4(10%)+CF4(10%) More details.

E drift – 0.4 kV/cm, E transfer – 2.0 kV/cm, E induction – 0.075 kV/cm, Gain ~ 2000.

GARFIELD: E-field: 0.4 kV/cm, B-field: 1.5T. Electron drift speed: 7.8 cm/µs , Tr. Diffusion: 58 µm/Vcm.




Black: new data with different setup (no R-protection )

For two selected voltages (V MMG: 450 and 480 V) "stability" test was done : Anode current : 10 nA/cm², 7 hours, no sparks

Using setup with R-protection the MMG mesh HV PS reaction on MMG sparks were tested ($Am^{241}$ source, V mesh ~ 670 V, C10 gas mixture).

In a case of spark ( rate ~1/20s) HV drops ~ 0.4 V , recovery time ~ 600 µs (including oscilloscope capacitance )

## Summary

TPC gain structure MMG+2 GEMs appears to be an optimal option for EIC TPC in a combination with a gas mixture Ne+CF4(10%)+CH4(10%).

- very low IBF, and good Energy resolution.
- fast electron drift velocity, and high ion mobility.
- extremely robust, low HV values on all elements.
- passed "standard" stability test with X-ray gun (~10 nA/cm2 Anode current). This conforms very low probability but possible MMG sparks occur largely due to interaction high momentum particles with a mesh material.
- with Resistor protection on a pad structure there is no HV recovery "dead" time in a event of a spark.
- both MMG and GEM are well tested technologies: R&D, mass production, and utilization in experiments.

***) Prakhar Garg web page

1) Yale University 2) BNL 3) Yale University (deceased), *) contact person {Nikolai.Smirnov@yale.edu}