ND-GAr Workshop – Jan 11-13, 2021
Additional Summary Items
(focusing on Mechanical Interface Discussions)

Jon Urheim, Indiana University

DUNE ND Meeting, 20 January 2021

Introduction

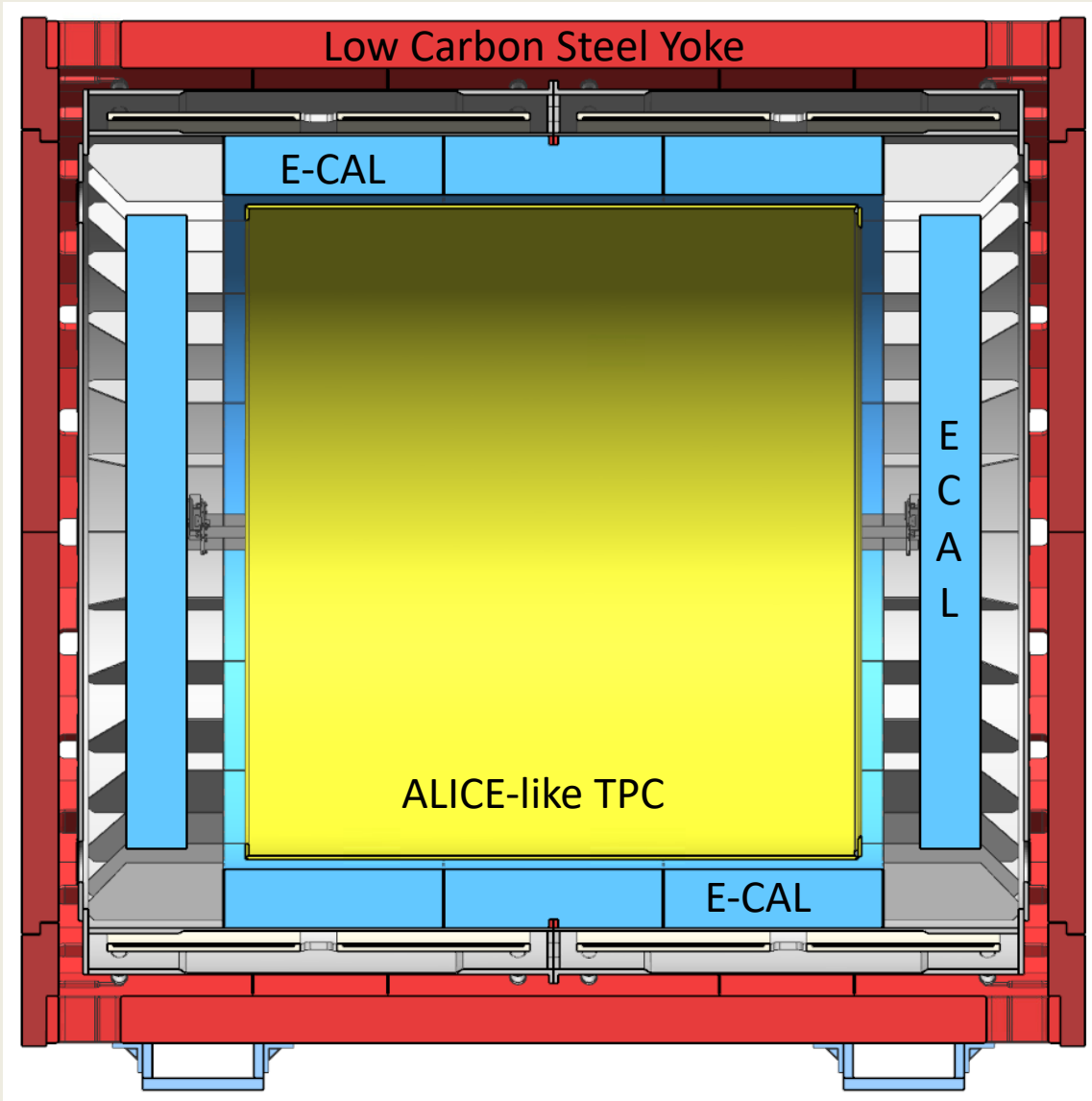
- **Alysia just covered many of the high-priority items discussed at the workshop**
  - See her slides!

- **Beyond this, the discussions were wide-ranging & responsive**
  - Recent evolution of magnet / pressure vessel concept opens interface questions
  - Many other cross-cutting mechanical (including gas & HV) system discussions
    - *Will try to give a flavor*
    - *Apologies to those discussions / presentations that get short shrift !!*
    - *Apologies to electronics & simulations/physics session participants – no coverage here.*

- **My general comments:**
  - Workshop was fun (despite being held via zoom)
  - Thanks to Alysia and Jen for workshop organization & leadership!
  - Thanks to all participants who navigated a highly discussion-oriented workshop!

Integrated Magnet + Pressure Vessel Concept

- **from Don Mitchell, Colin Narug,…**
- **Key features:**
  - 4 SC magnet coils housed in one or two cryostats
  - Cryostat inner wall forms barrel part of pressure vessel (PV)
  - ECal is now entirely within PV: truly 4pi coverage now.
  - PV endcaps consist of thin stainless steel planar membrane, 10-bar load supported by endcap flux return steel as strongback in stayed design
  - Assembly / Installation concept developed as well

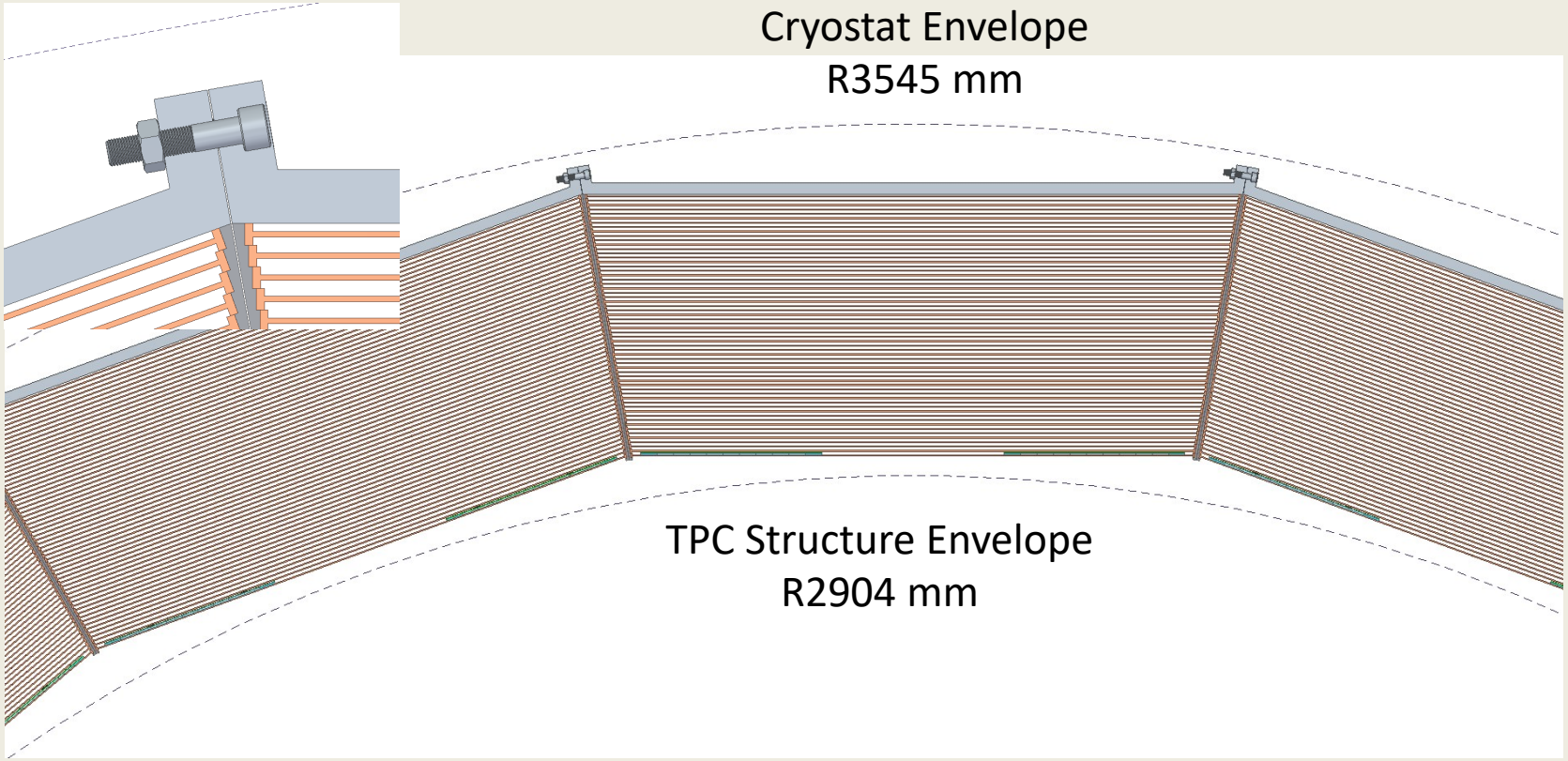


Mechanical Interface Discussions

- **Discussion of (barrel) ECAL geometry optimization/mounting – Marco Oriunno**
  - See next slide(s)
  - Two proposed schemes for ECAL mounting:
    1. complete barrel (constructed from ECAL modules (wedges) supported by two rails from cryostat, or…
    2. …Each wedge supported by its own rail – wedges are mechanically decoupled.
  - Nominal TPC support scheme: two rails mounted on opposing ECAL wedges
    - Alternate design uses S-shaped brackets to affix TPC ends directly to cryostat

Barrel ECal wedge modules

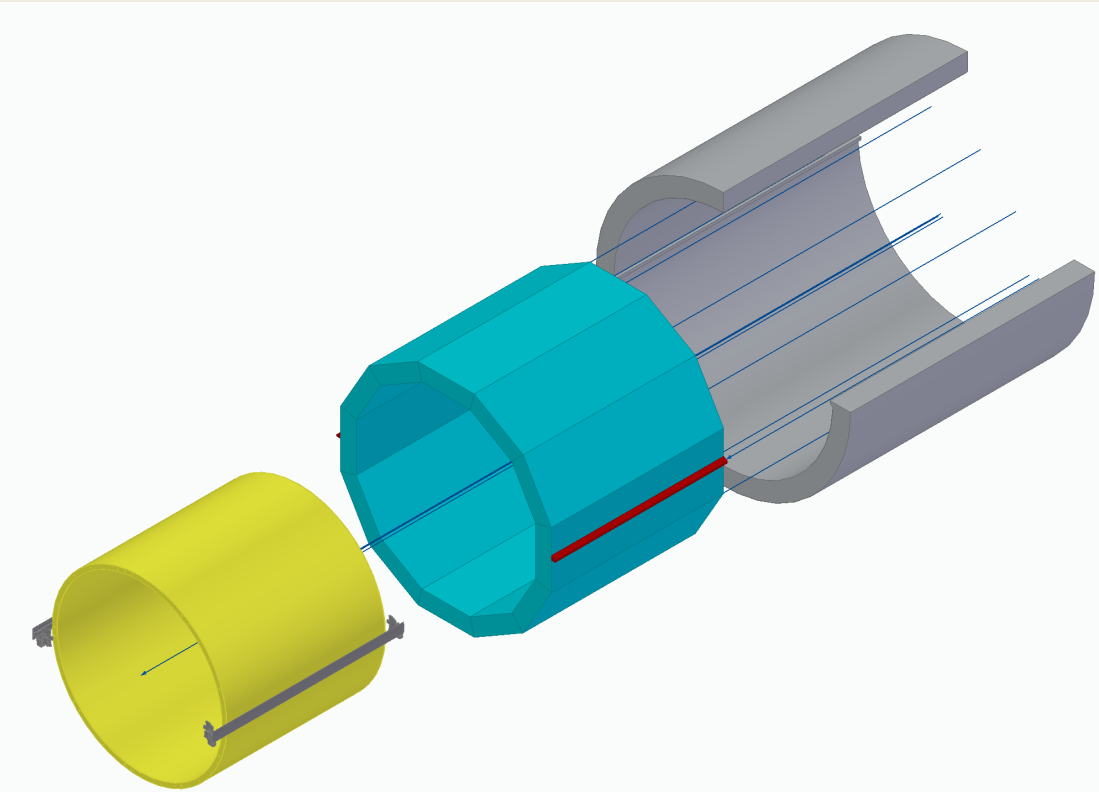
Marco Oriunno

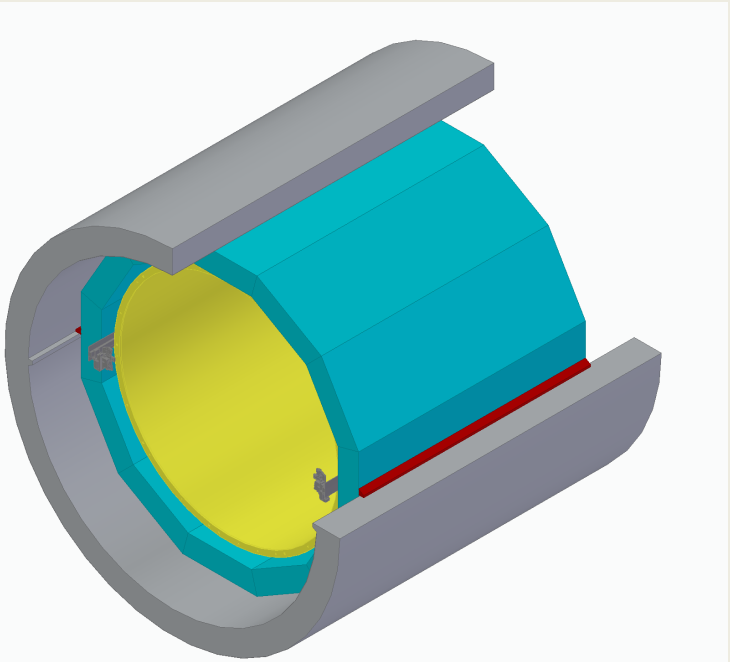


Self-supporting ECAL with two rails

SLAC

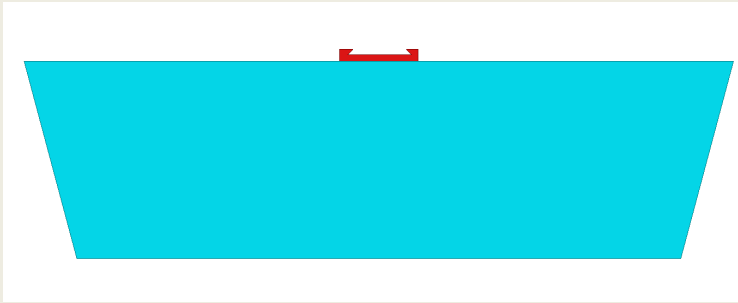
Marco Oriunno

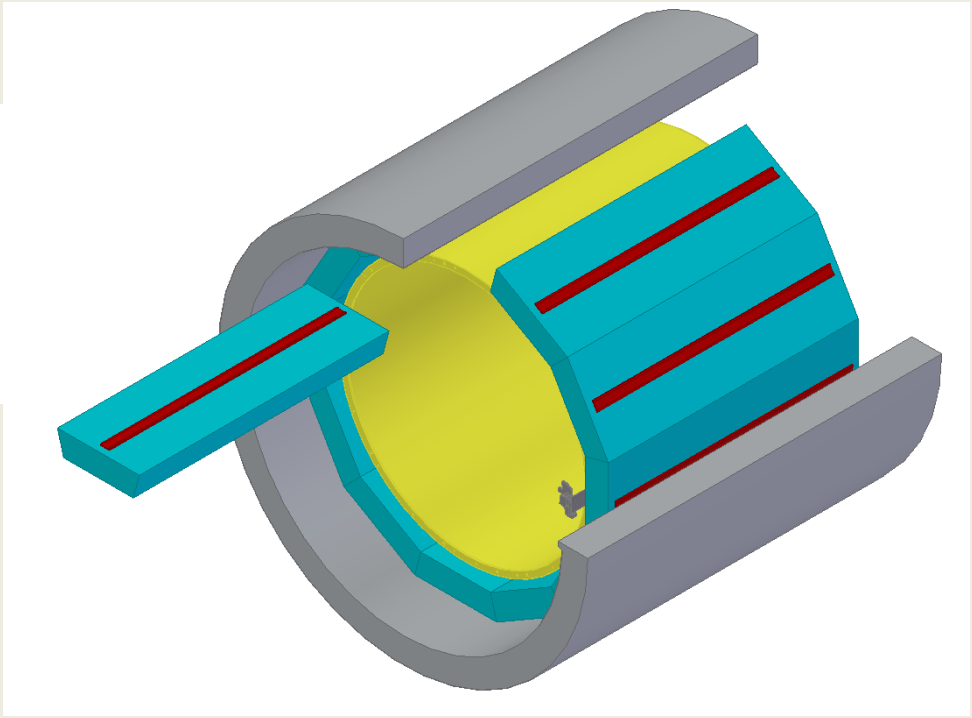




Modular design with individual rails

Marco Oriunno



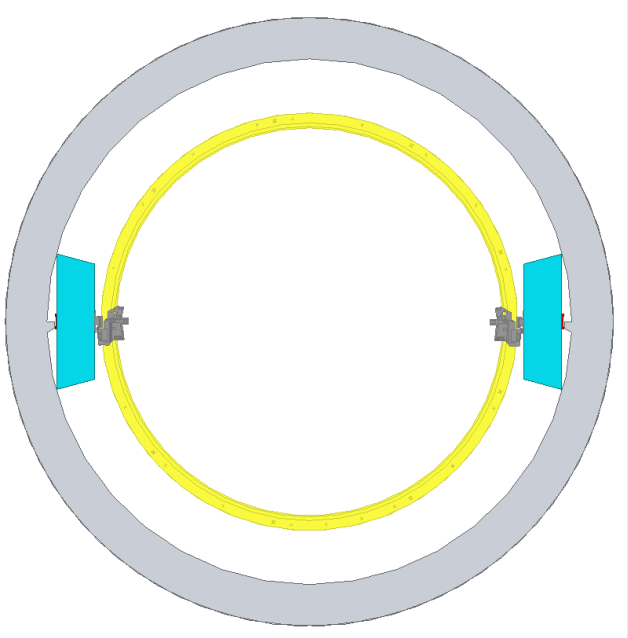


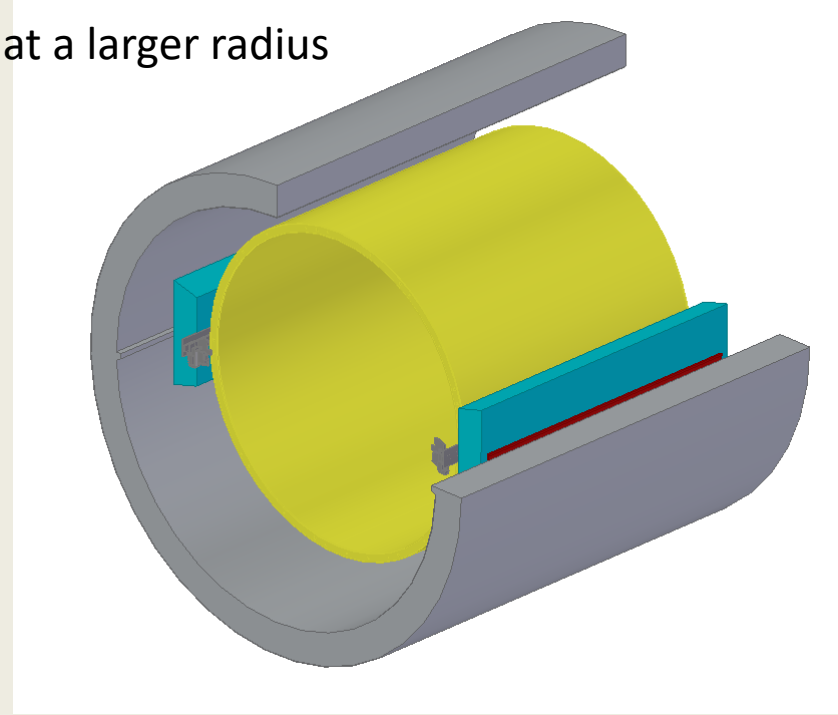
TPC Supported from ECAL

SLAC

Marco Oriunno

- ECAL requires a reinforcement plate at the inner radius
  - It adds material
  - It needs radial space that push ECAL at a larger radius



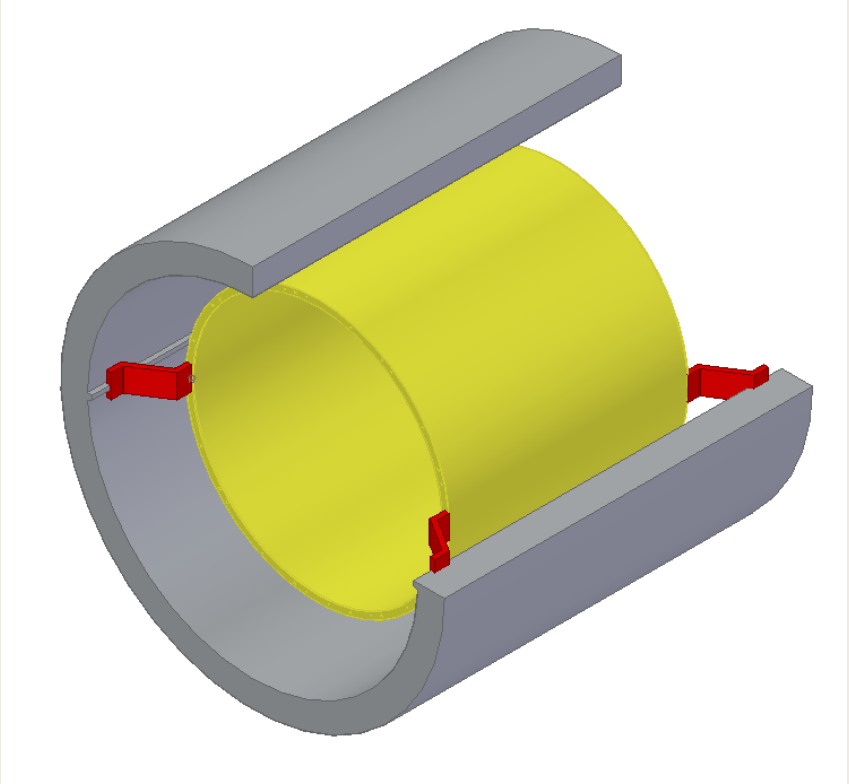


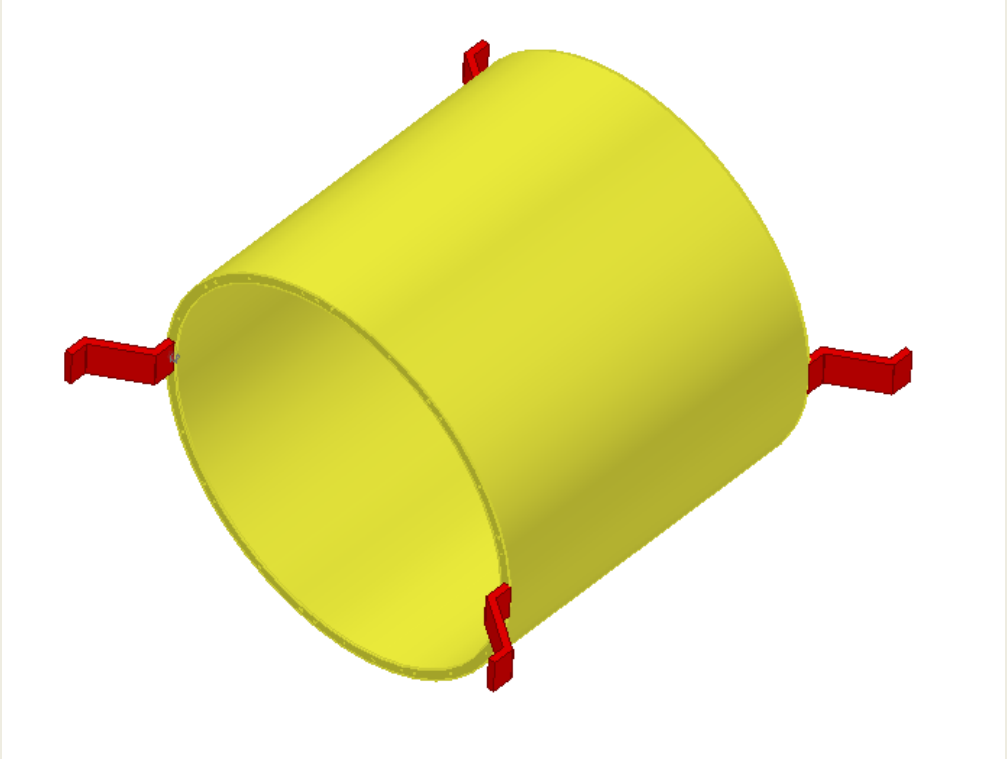
DUNE

TPC supported from cryostat

SLAC

Marco Oriunno

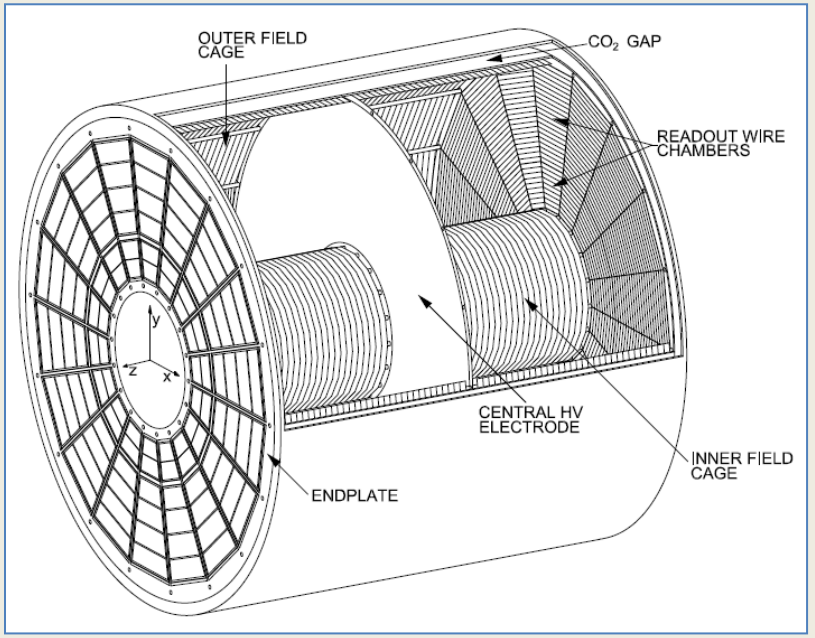


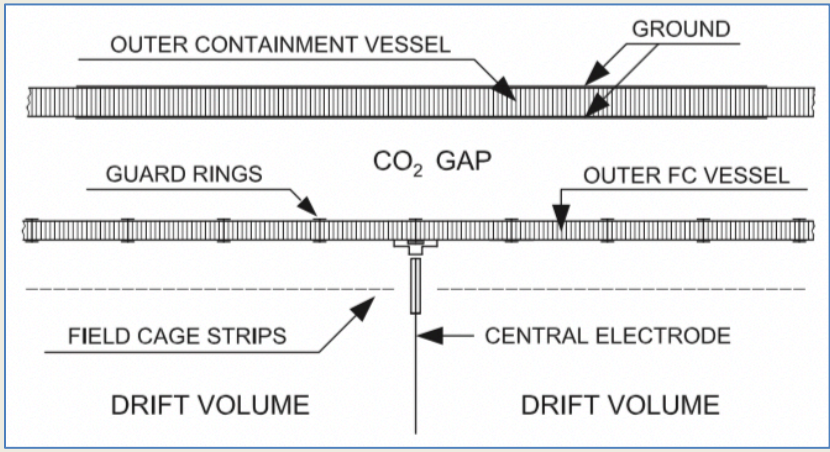


TPC Interface Discussions

- **Recall: TPC based on ALICE design**
  - Same dimensions, overlapping requirements
  - Elegant design, exquisitely engineered
  - DUNE requirements less stringent
    - Much room for value engineering

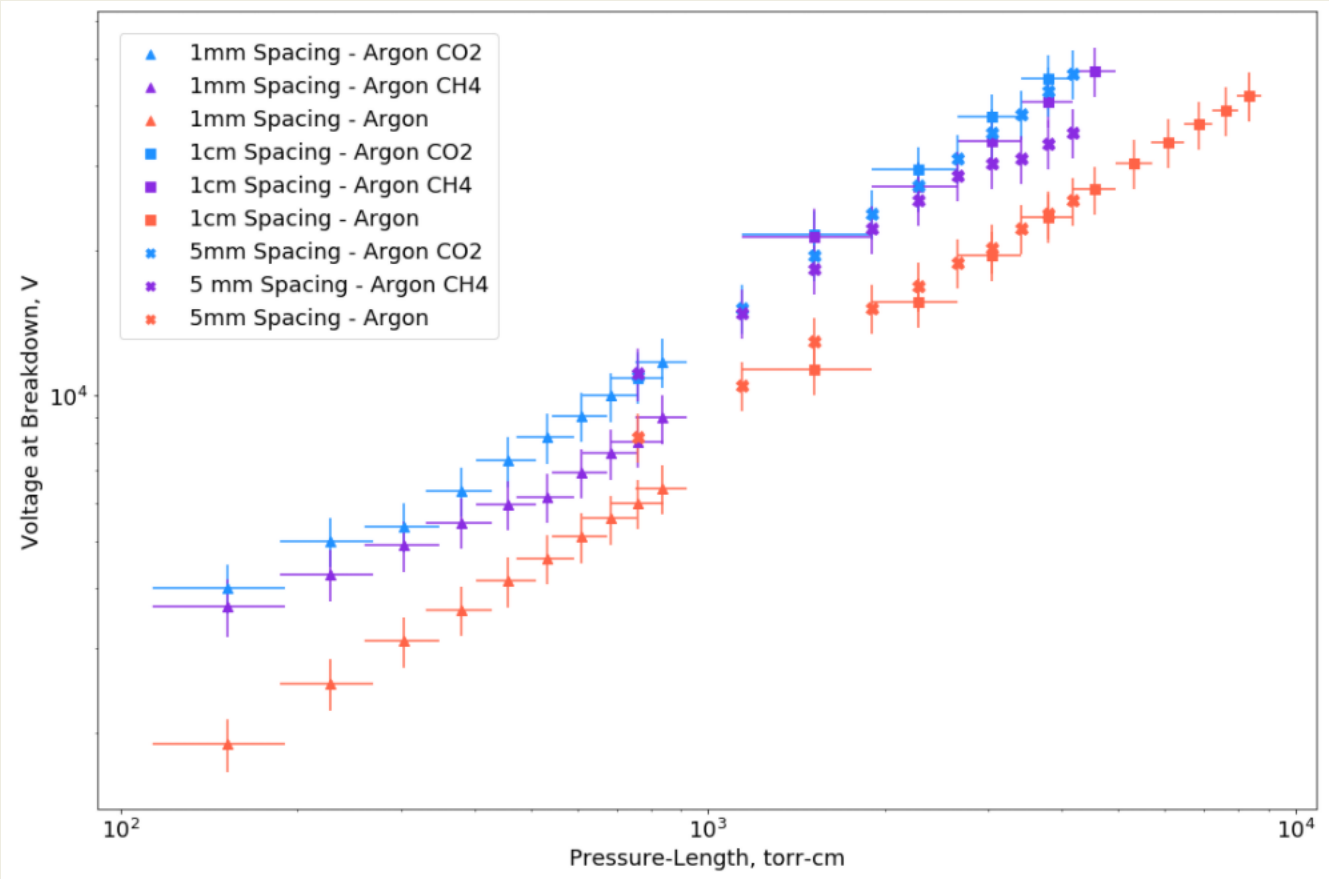
- **Gas volumes:**
  - ALICE TPC operated at atmospheric pressure
    - TPC had two gas volumes: chamber gas & HV degrader region (CO_2)
    - Environment exterior to outer containment vessel was ambient atmosphere
  - For DUNE, exterior environment at 10 bar:
    - Will need to manage gas in this volume
    - ECal will outgas in this environment, must be isolated from chamber gas volume
    - So, 3 gas volumes in total (unless HV degrader region is made solid)





HV Breakdown for different gases

- ***Results from measurements at UT Arlington***
  - *Ar+CH_4 Similar to Ar+CO_2, suggestion that chamber gas could work in degrader volume*

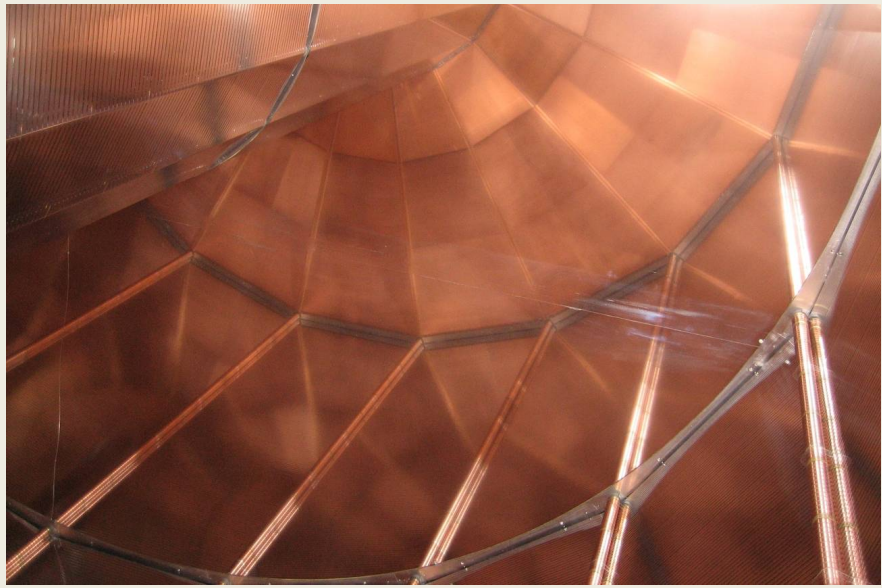


Ben Jones

Field Cage Discussions: ALICE design

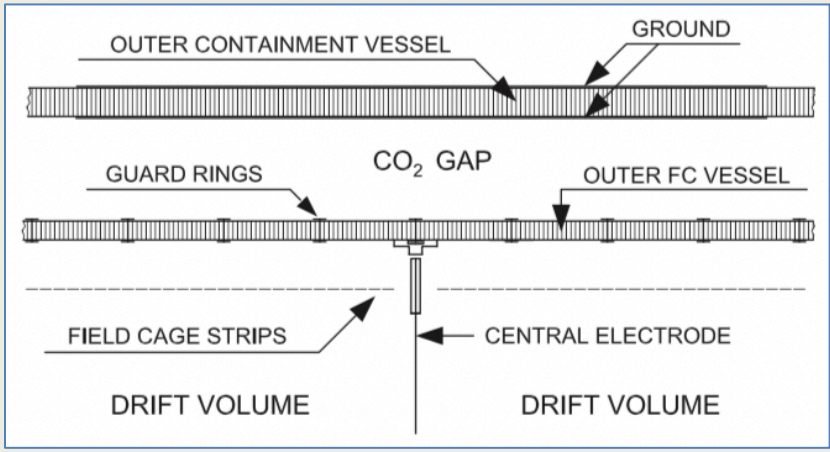
Field Cage Vessel: *thin (0.4% X_0), gas-tight, cylindrical structures*

- *Based on 20-mm Nomex honeycomb + epoxy fiberglass + PVF skins*



72 Polycarbonate Tubes: *44-mm OD, on interior walls at 18 azimuthal pts.*

- *Main function: standoff/support voltage strips; but some do more:*
- *4 Resistor Rods: Contain a chain of resistors for voltage gradient. water cooled*
- *6 Laser Rods per side: for laser calibration of the drift volume*
- *1 HV Cable Rod*
- *27 Gas Rods: 10 outer/17 inner. Used as gas circulation manifolds*



Voltage Strips:

- *Stretched aluminized mylar, 25-micron thick, 13-mm wide, hook-like CuBe foil ends held by CuBe hooks mounted on adjacent rods*
- *Strip separation of 2 mm connected with 7.5 M-Ohm resistor*
- *165 rows of strips on each side of the central electrode*

Central Electrode:

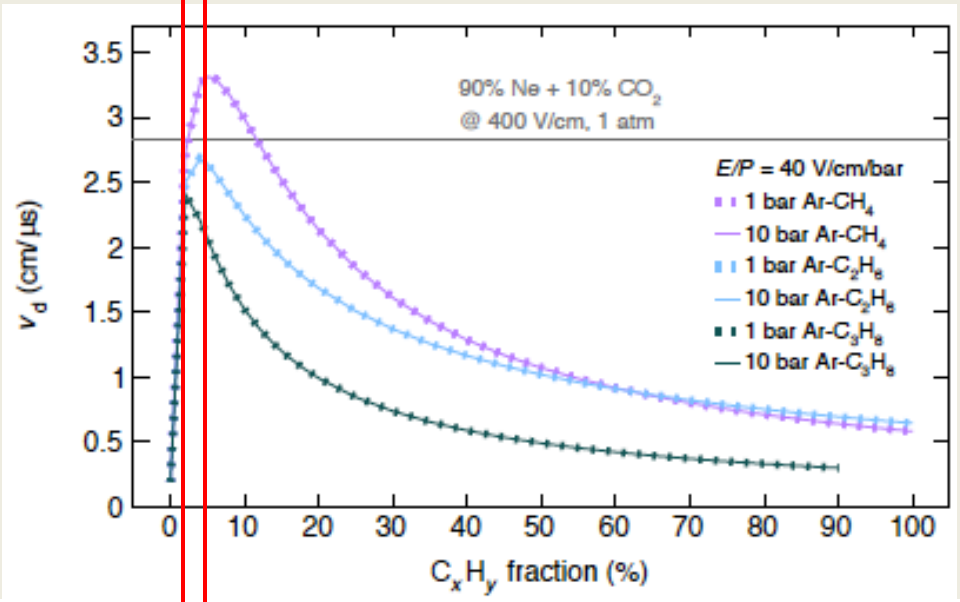
- *Stretched aluminized mylar foil, 23-micron thickness*

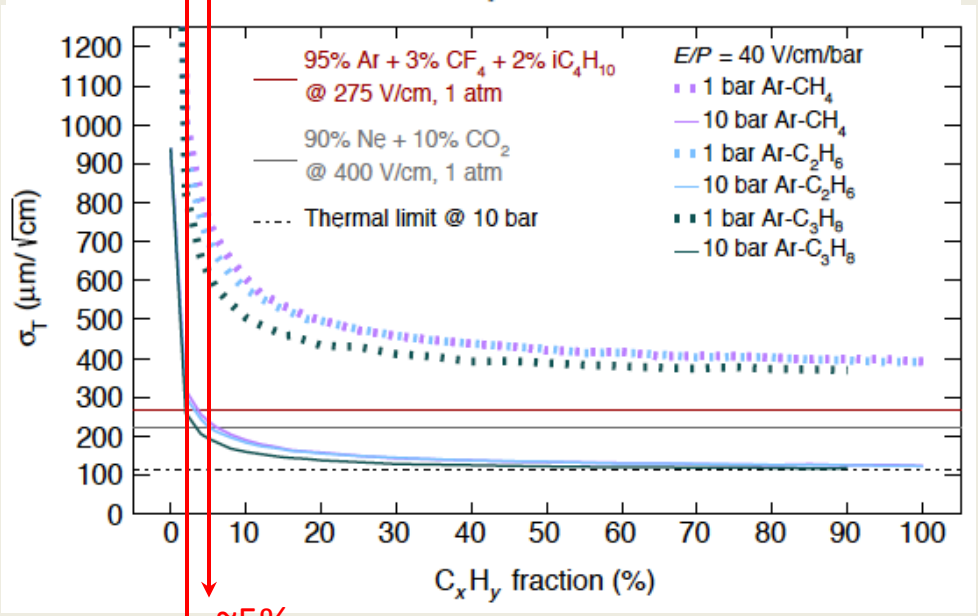
Field Cage Considerations for DUNE

- **Material budget *much* greater**
  - can go with less expensive field cage/containment vessel materials & designs
- **At high pressure, dielectric strength increases**
  - Can go with thinner HV (than ALICE 22 cm) degrader gas volume
- **Attractive alternatives to ALICE electrode strips**
  - Field cage elements (incl. resistor chain) integrated in flex circuit mounted to Field Cage Vessel wall.
  - Use of resistive material in place of discrete electrodes (à la ND-LAr)

Gas Discussions were Extensive

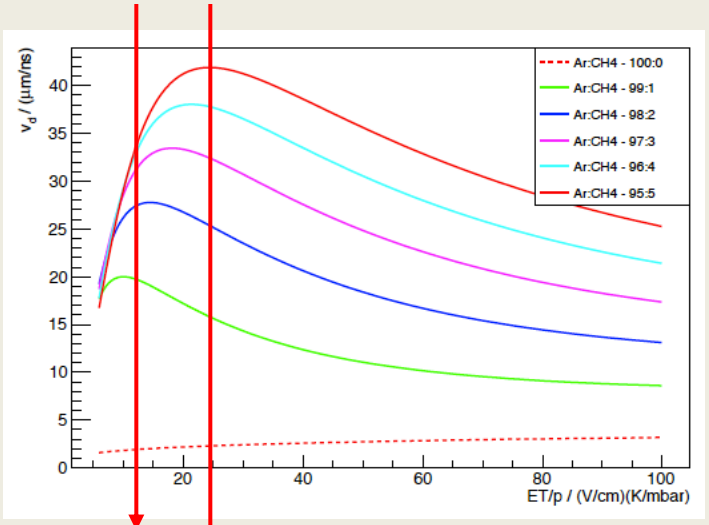
Diego González-Diaz





~5%

~2%



~400V/cm
@ 10bar

~800V/cm
@ 10bar

*2 from PXJ H-paper https://arxiv.org/pdf/2005.05252.pdf

Additional Material

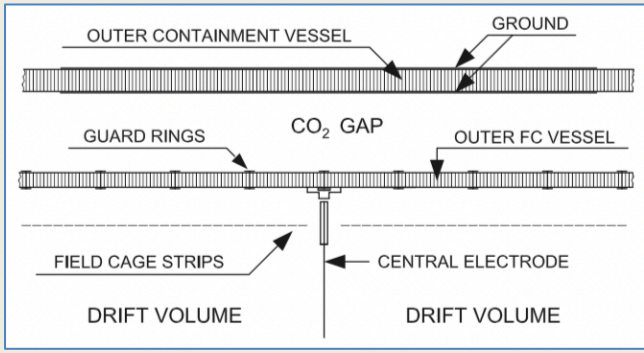
Notes from Monday Session

- **Cathode placement (for single or double drift volume configuration) identified as highest priority.**
  - See next slide(s)

- **Discussions on chamber gas selection, operational issues (slides)**
  - Methane concentration & safety; performance impacts of lower values
  - Implications of running at different pressures, or with different gases
    - *Chamber operation considerations*

- **Chamber operation discussions**
  - Reliability/ageing of existing ALICE ROC's. Testing plan.
  - Couples into single/double drift volume discussion

- **Configuration of field cage structures**
  - How many gas volumes, degrader gas
  - HV breakdown
  - Materials and alternatives to discrete FC electrodes (i.e., carbon-loaded Kapton?)



Notes from Tuesday Session

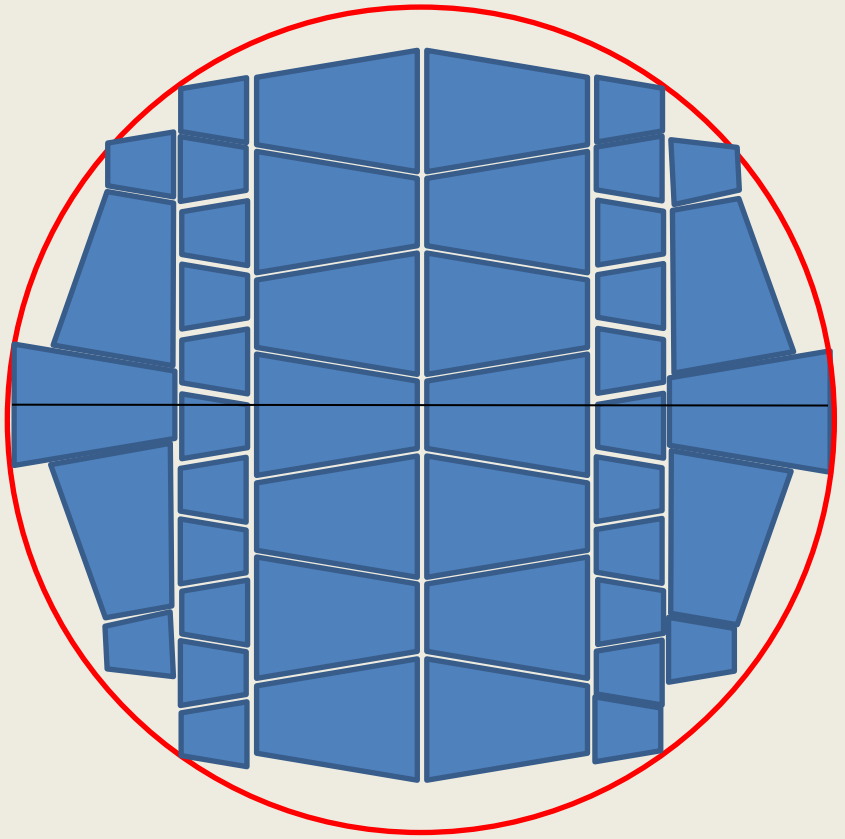
- **Discussion of (barrel) ECAL geometry optimization/mounting – Marco Oriunno**
  - See next slide(s)
  - Two schemes for mounting:
    - complete barrel supported by two rails from cryostat
    - Each wedge supported by its own rail – wedges are mechanically decoupled.
  - Nominal TPC support scheme: two rails mounted on opposing ECAL wedges
    - Alternate design uses S-shaped brackets to affix TPC ends directly to cryostat

- **More discussion of ROC arrangement in single-volume TPC**
  - Concerns about lost active area (also whether modules can go out to 5.3 m)

- **Return to discussion of field cage design issues including HV issues.**
  - How many gas volumes, gas species in each volume, circulation,
  - Dimensions and materials

Single vs. Dual Drift Volume

- ***Advantages of Dual Drift Option***
  - *Well understood from ALICE experience: 100kV ok, can extrapolate to 10-bar P10.*
  - *Some reconstruction challenges for cathode crossers offset by added value*
- ***Advantages of Single Drift Option:***
  - ***Reduction in electronics cost !***
  - *Now have spare chambers*
  - *Possibility of creative re-configuration, don't need to build specialized CROC's.*
  - *simplicity from having cathode plane at one end, at cost of symmetry wrt beam axis*
- ***Disadvantages of Single Drift Option:***
  - ***Double voltage for same drift properties***
  - ***Increased diffusion & attachment***



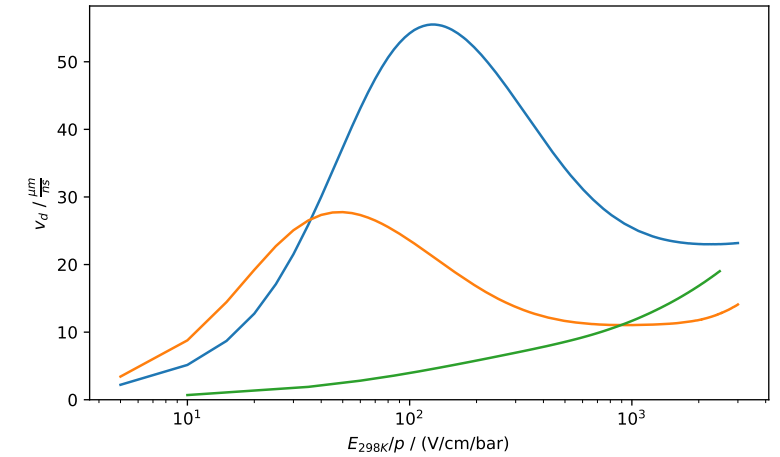
Diego González-Diaz

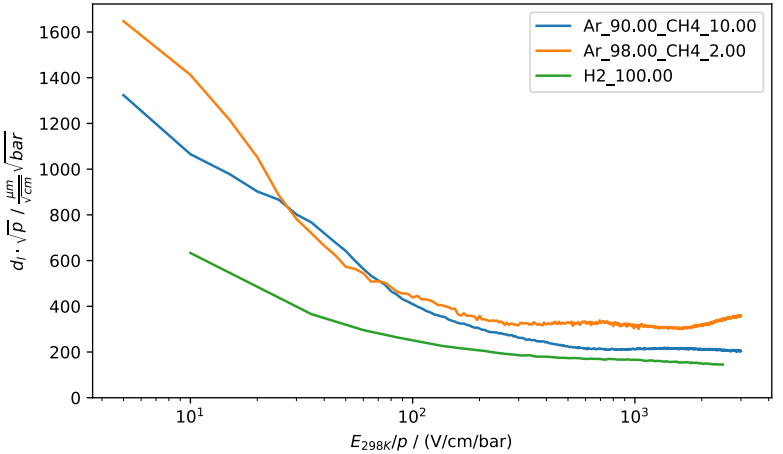
Drift Properties of different gas options

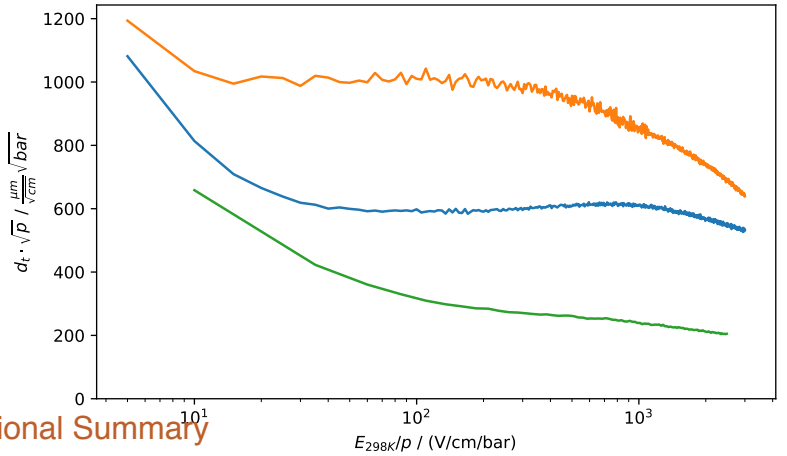
Comparing Ar+CH_4 mixtures (10% & 2% CH_4) with H_2

Note units on axes…

…and pressure rescaling for diffusion







Philip Hamacher-Baumann