Micromegas for ATLAS

R&D for an upgrade of muon chambers for the SLHC

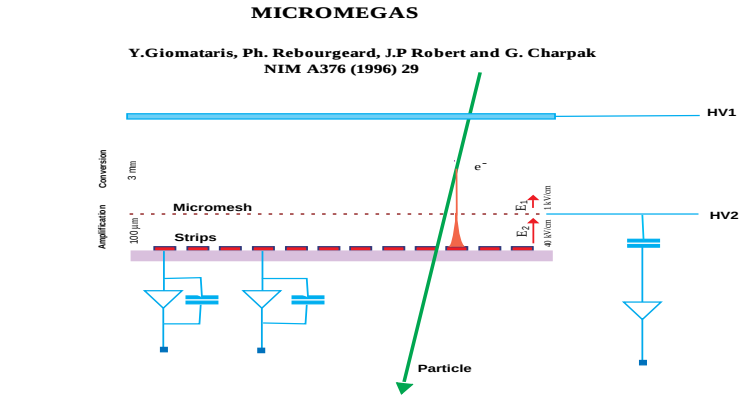
The scope

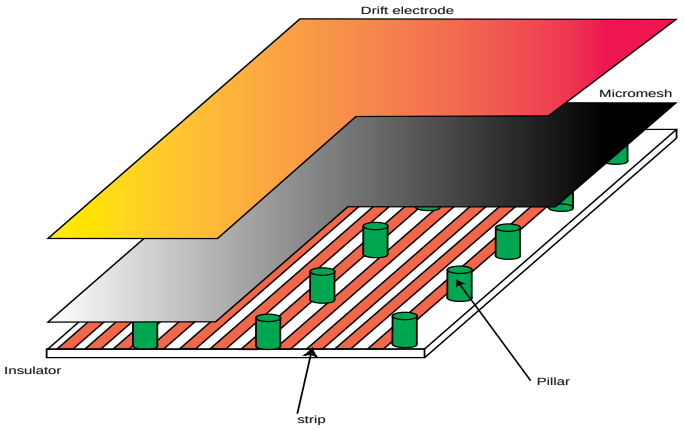
- L_{SLHC} = ~10 x L_{LHC}; Δt(bunch crossing) = 50 ns
- Replace muon chambers in regions with highest counting rates (few kHz/cm^2 @ L=10^{35}cm^{-2}s^{-1}, mostly from neutrons and γ's)
  - Inner and part of middle layer of end-cap chambers (100 – 200 m^2)
  - At present separate precision and trigger chambers (MDTs, CSCs, TGCs)
- Combine trigger & precision measurement function in single chamber

Micromegas as candidate technology

Attractive features

- Can combine triggering and tracking function
- Required performance
  - Efficiency > 98%
  - $\sigma_{sp} \approx 100\ \mu m$ ($\Theta_{track} < 45$ degr)
  - Good double track resolution
  - $\sigma_t < 5$ ns
- Potential for going to larger areas: 1 m x 2 m





ATLAS Micromegas R&D Collaboration

Evaluate possible use of micromegas for ATLAS muon chamber upgrade programme

- EoI submitted in February 2007 to ATLAS Upgrade Office
- Proposal submitted in June 2007
- 11 participating Institutes so far; with growing interest ...
- Regular weekly meetings at CERN since February.
- TWiki page with agenda, contributions and minutes of all meeting plus other useful information and links:

  https://twiki.cern.ch/twiki/bin/view/Atlas/MuonMicromegas

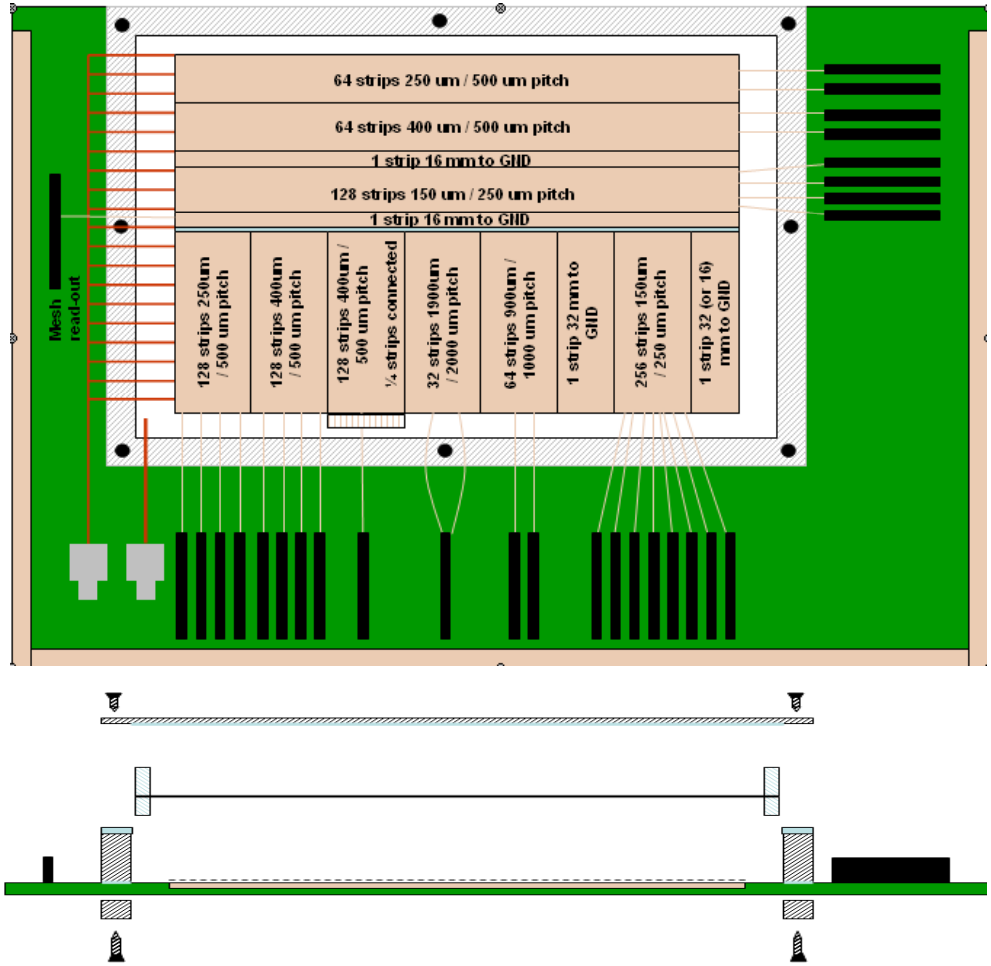
Goals

- Phase I: Build and evaluate small prototype(s) based on micromegas technology to
  - get familiar with technology
  - demonstrate required performance

  Decide on
  - Operating parameters (gas, gas gain, HV, etc...)
  - Readout pattern & electronics
- Phase II: Develop techniques for the construction of large-size detectors (1m x 2m)

Prototype layout

- Board Layout (not to scale)
  450mm x 350mm active area
  Several strip patterns (250, 500, 1000, 2000 µm pitch; long, short)
- Three variants with same board layout:
  1. Standard mesh (CERN)
  2. Segmented mesh (CERN) for trigger + 2nd coordinate Novel technology
  3. Standard mesh + resistive layer on the read-out strips → larger footprint (BNL)
- Drift gap: 2–5 mm

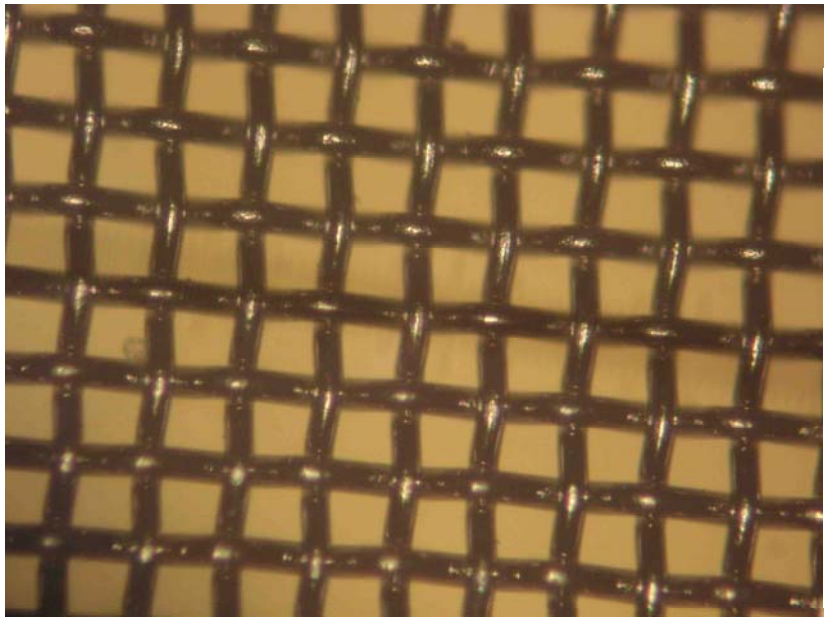


The mesh(es)

Mesh–readout electrode distance: 128 µm

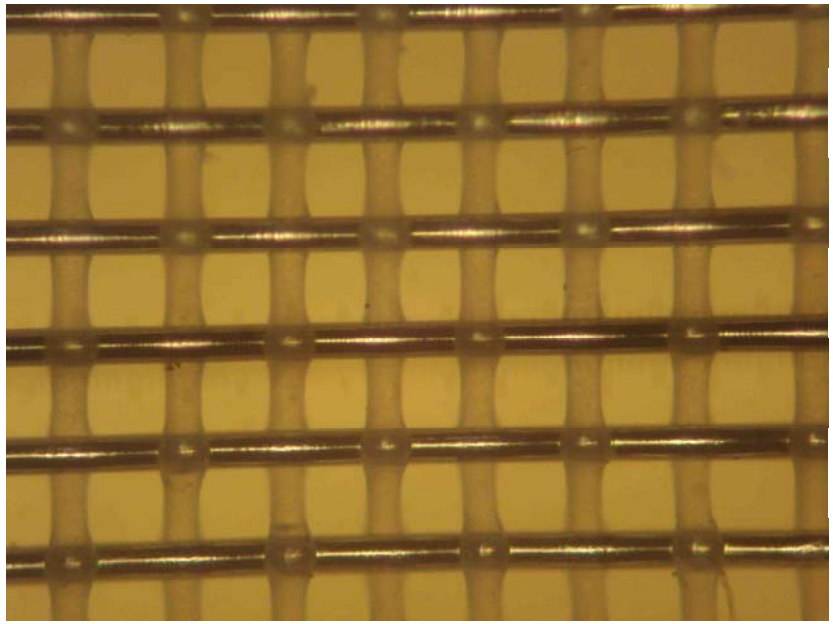
Prototype 1 (P1)

Homogeneous stainless steel mesh
450 lines/inch = 56 µm pitch



Prototype 2 (P2)

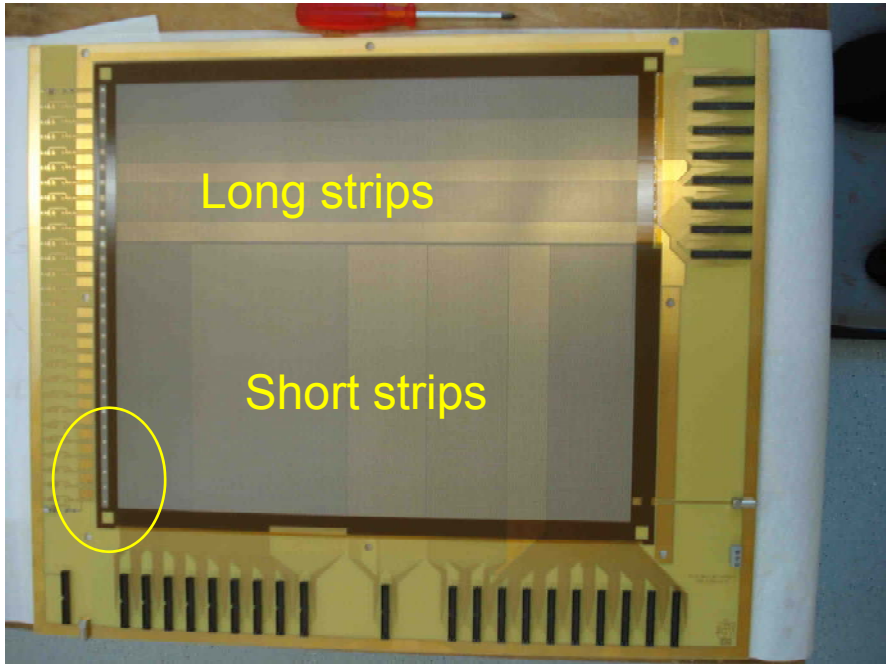
Unidirectional stainless steel/plastic mesh
200 lines/inch = 127 µm pitch



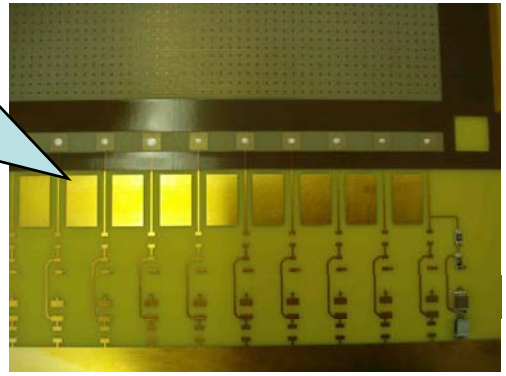
The first boards

P1 (homogeneous mesh): Done at CERN/TS-DEM; mechanical integration this/next week

P2 (segmented mesh): in production

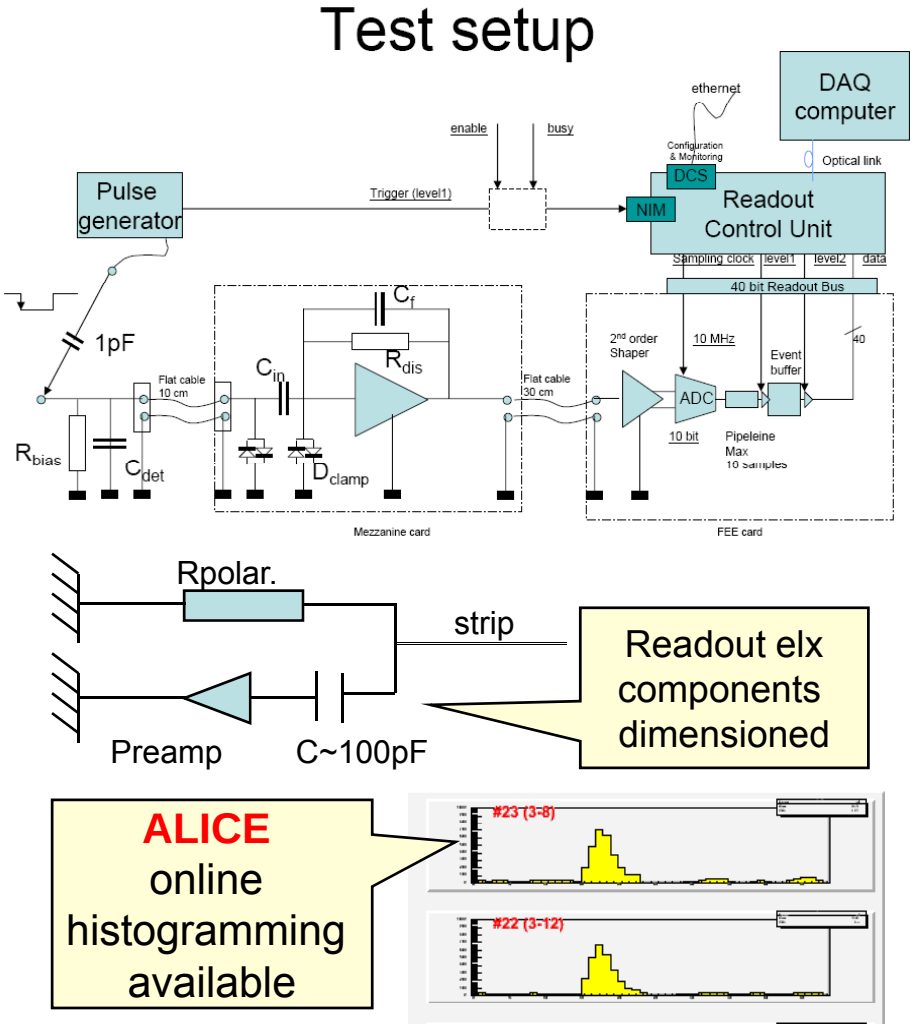


HV + signal connection for segmented mesh (groups of 100 wires)



Readout electronics 2007

- ALICE PHOS electr. + DAQ chain (H. Muller)
  - 128 channels (tested)
  - Spark protection with diodes tested
  - Strip signals only (neg.)
- BNL 32-chan. chip
  - 128 channels
  - Bi-polar (strips & mesh)
  - Standard readout



Plans 2007

- Oct/Nov 2007: test beam (H8)
  - Two prototypes (possibly more from BNL)
  - Three (non-flammable) gas mixtures:
    - Ar:CO_2 (80:20); Ar:CF_4 (85:15); Ar:Ne:CF_4 (45:45:10)
  - Learn how to work with micromegas
  - Evaluate different strip patterns
  - Study performance as function of track impact angle
  - Vary drift gap (2 – 5 mm)
- Target for end 2007/beg 2008:
  - Establish base-line readout strip pattern
  - Establish base-line gas and detector parameters

Plans for 2008+

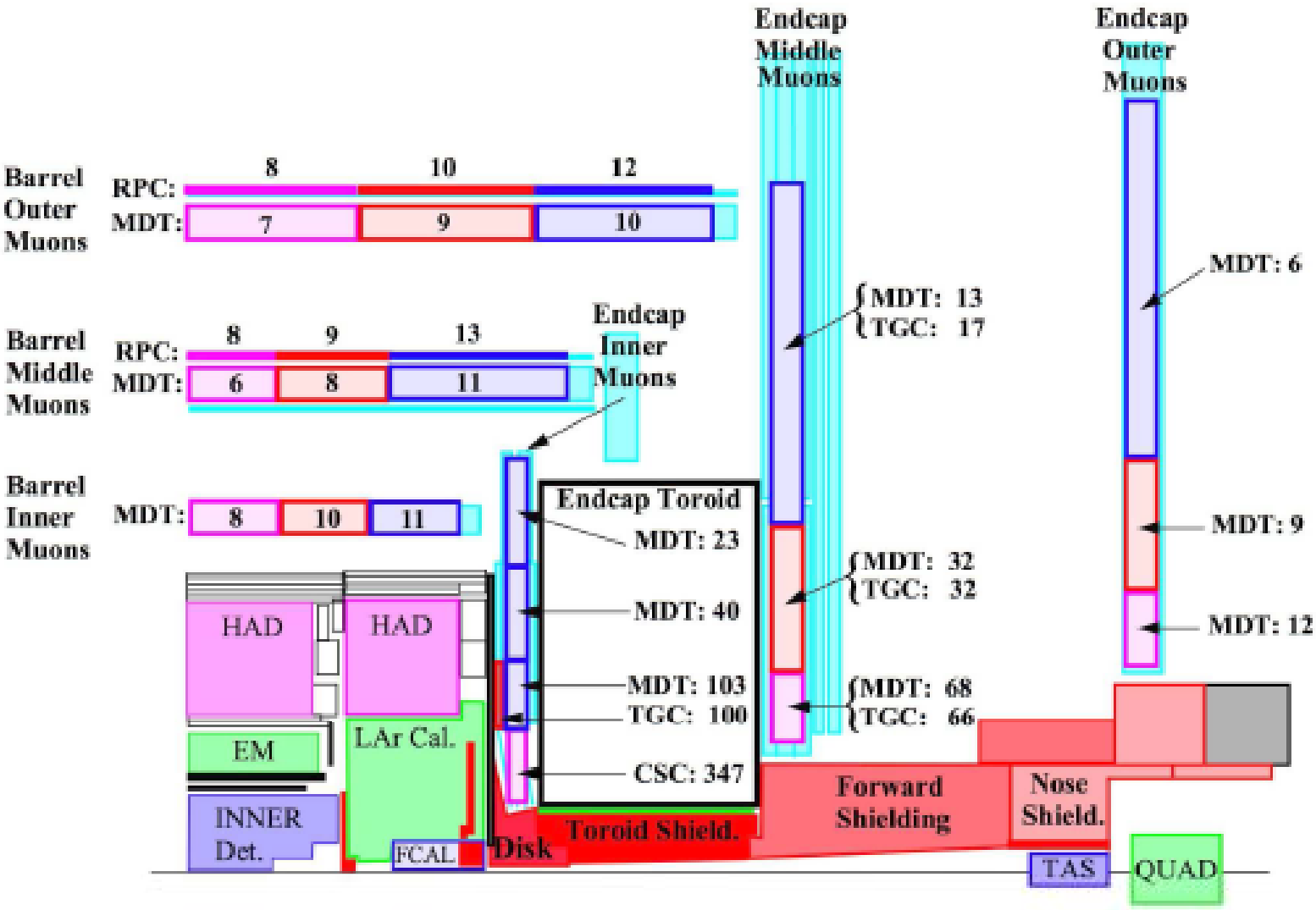
- Prototype construction
  - Possibly 2nd ‘small’ prototype, based on 2007 experience
  - Pursue segmented mesh option, optimise amplification gap size
  - Main emphasis on developing technology for building large-scale micromegas (1m x 2m)
- Read out electronics
  - Move to custom solution for micro pattern readout electronics, hope to profit from ongoing R&D activities in the field
  - Equip larger areas of prototype chambers
  - Evaluate triggering solutions, possibly adaptation to existing ATLAS trigger infrastructure
- Ageing tests under high photon irradiation (in GIF ?)
- ATLAS system integration + performance studies

Interest in common R&D

- Technology for large-area micromegas
- Production facilities for large-area board production
- Readout electronics
- Standardized test procedures (common lab)
- Simulation
- High rate/ageing studies
- Micromegas in large systems

Back-up slides

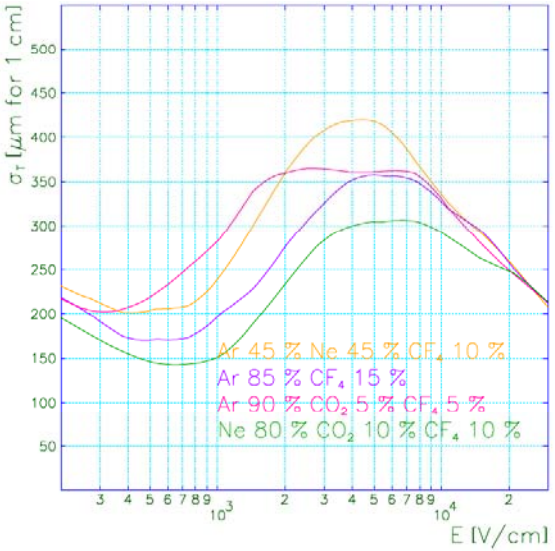
ATLAS: average single count rates for $L=10^{34}$ $cm^{-2}s^{-1}$



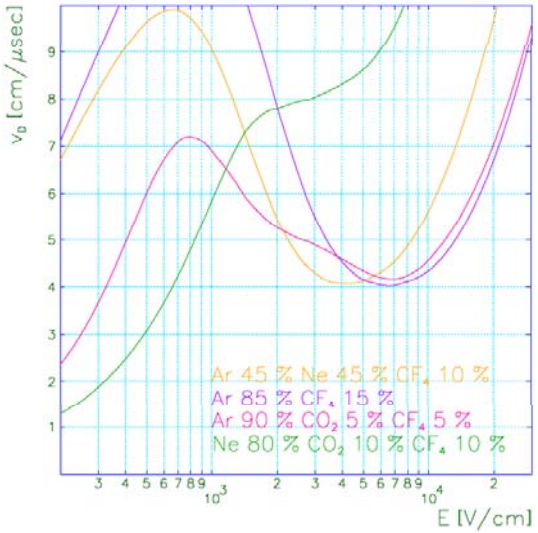
Gas simulation studies: K.Mermigka + R.Veenhof

GAS MIXTURES	**Drift Velocity** (cm/μs) for 1.5 kV/cm	**Transv. Diffusion** σ_T (μm) for 1.5 kV/cm	**Ionization** # e^-/cm for μ (20 GeV)	**Gain** (for 600V & 125 μm mesh dist)
Ar 45% Ne 45% CF_4 10%	7.0	320	50	**$7 \cdot 10^4$**
Ar 85% CF_4 15%	**10.0**	240	**73**	$8 \cdot 10^3$
Ar 90% CO_2 5% CF_4 5%	**5.9**	**350**	64	$7 \cdot 10^3$
Ne 80% CO_2 10% CF_4 10%	7.7	**200**	**40**	**$6 \cdot 10^3$**

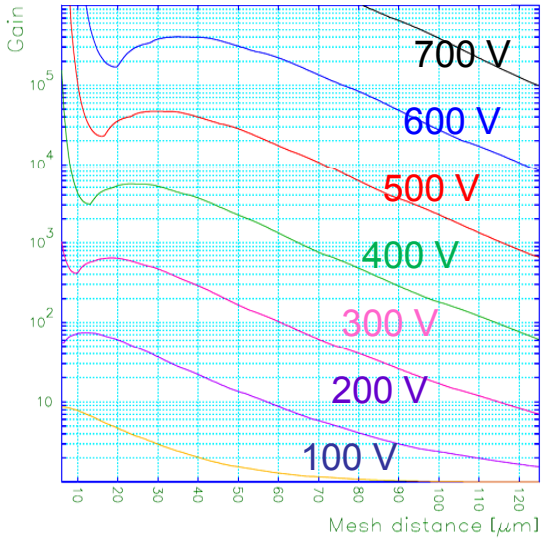
Transverse diffusion



Drift velocity



Ar 85% CF_4 15%



Gas gain

Ar 45% Ne 45% CF_4 10%