ECFA/DESY 2000

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A LOOK AT TRACKING CALORIMETRY

MORE DETAILED SIMULATION OF DETECTOR RESPONSE SHOW US THE SEVERE LIMITATIONS DUE TO

- LACKING {LONGITUDINAL / LATERAL} SEGMENTATION
- VERY LIMITED P. ID.
  $\pi/\mu/e$?
  π^0/γ ?
- CONSEQUENCES OF RADIATION DAMAGE ON CALORIMETER PERFORMANCE
- LACK OF HERMETICITY / DEAD ANGLES, WALLS, ...

IS THERE A CHANCE WE CAN FIND
GEOMETRICALLY ADAPTABLE
LARGE TRACKING VOLUMES
THAT ALSO PROVIDE CALORIMETRIC INFORMATION?

WHAT WE WANT IS A "TRACKING CALORIMETER" THAT CAN "LIVE", RESOLVE SHOWERING & NON-SHOWERING TRACKS AND INTEGRATE ENERGIES ALONG THE TRACKS, MEASURE SOME MOMENTA,

INSIDE THE SOLENOIDAL FIELD

→ HERMETIC : NO WALLS, PARTITIONS

→ DOWN TO SMALL ANGLES

→ PROVIDE "GOOD GRANULARITY"

(AVOID THE DIFFICULTIES OF STACKED CRYSTALS)

→ PERMIT TRUE TARGET-POINTING GEOMETRY

GENERICALLY, THE IDEAL CALORIMETER WILL LOOK SOMEWHAT LIKE THE LIQUID IONIZATION CHAMBER WE SHOW HERE

→

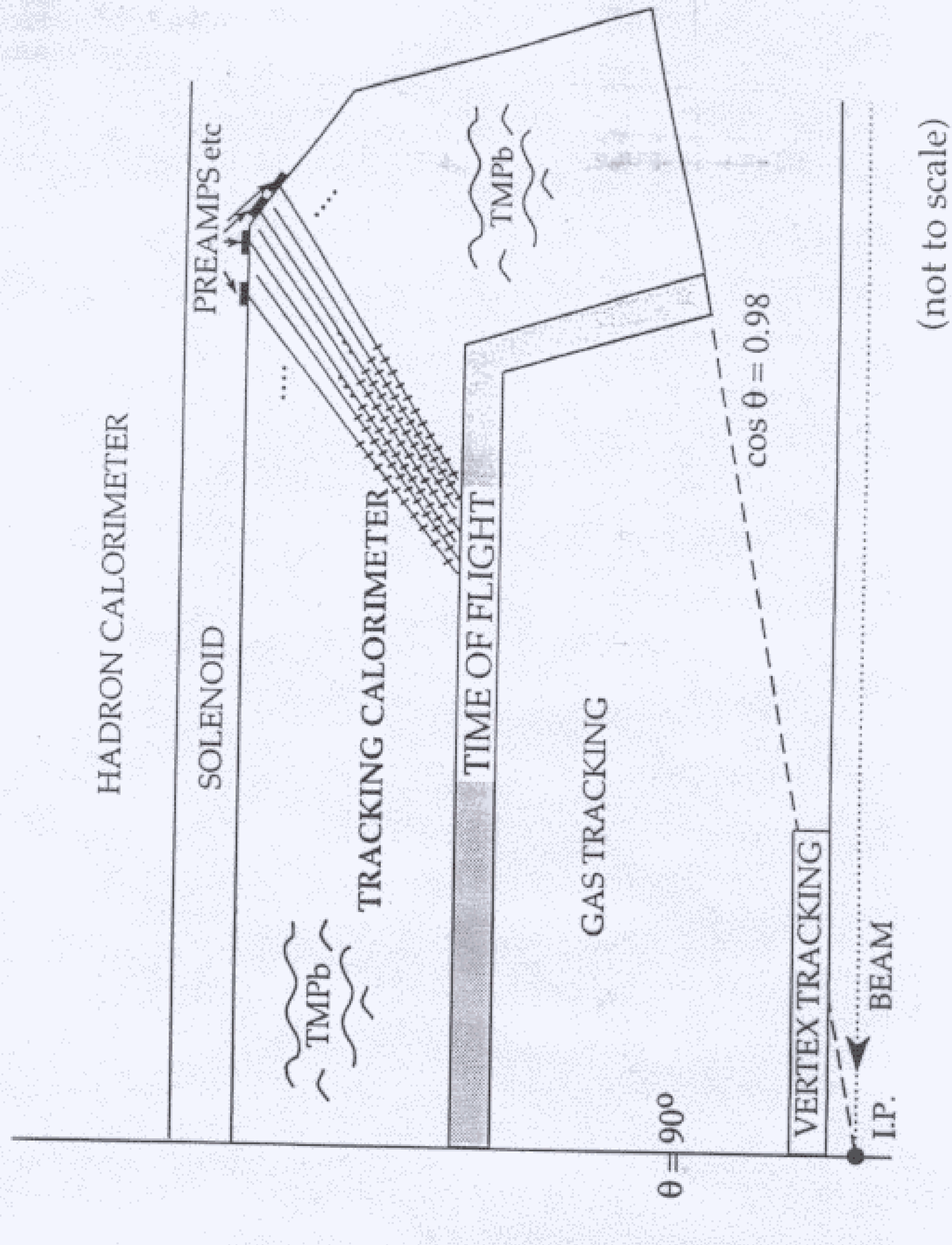
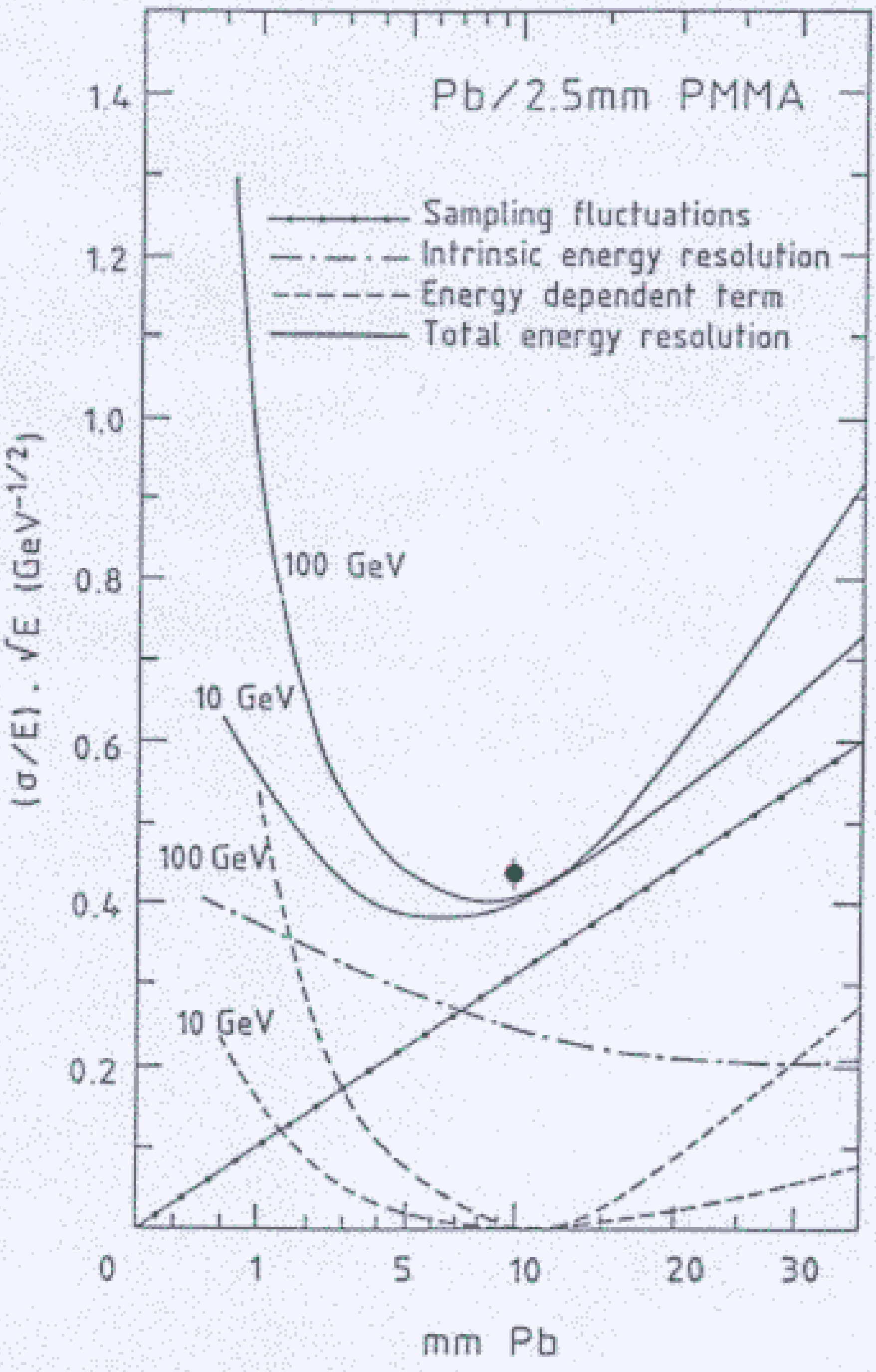


Fig. 2 Electromagnetic calorimeter section for generic [redacted] detector layout: Schematic quadrant of shell to be filled with heavy drifter fluid TMPb. "Massless" grids that establish drift fields and collect charges are deployed on target-pointing rods; readout electronics are arranged at outer shell. Uniform coverage $0 \leq \cos\theta \leq 0.98$ is assured. Segmentation is defined by position and size of grids.

TO ILLUSTRATE THE INFLUENCE OF SAMPLING VS. HOMOGENEOUS RADIATORS, LOOK AT RESOLUTION OF Pb/SCINT SANDWICH:



BUT MORE SERIOUS AT HIGH ENERGIES:

LITTLE GEOMETRIC ADAPTABILITY

SEGMENTATION LIMITATIONS

CONSIDERABLE MECHANICAL COMPLICATIONS...

WHAT EXACTLY DOES A 1 GeV SHOWER LOOK LIKE IN, SAY, THE x.y PERSPECTIVE OF A z-INTEGRATED VIEW OF A HOMOGENEOUS CALORIMETER?

→

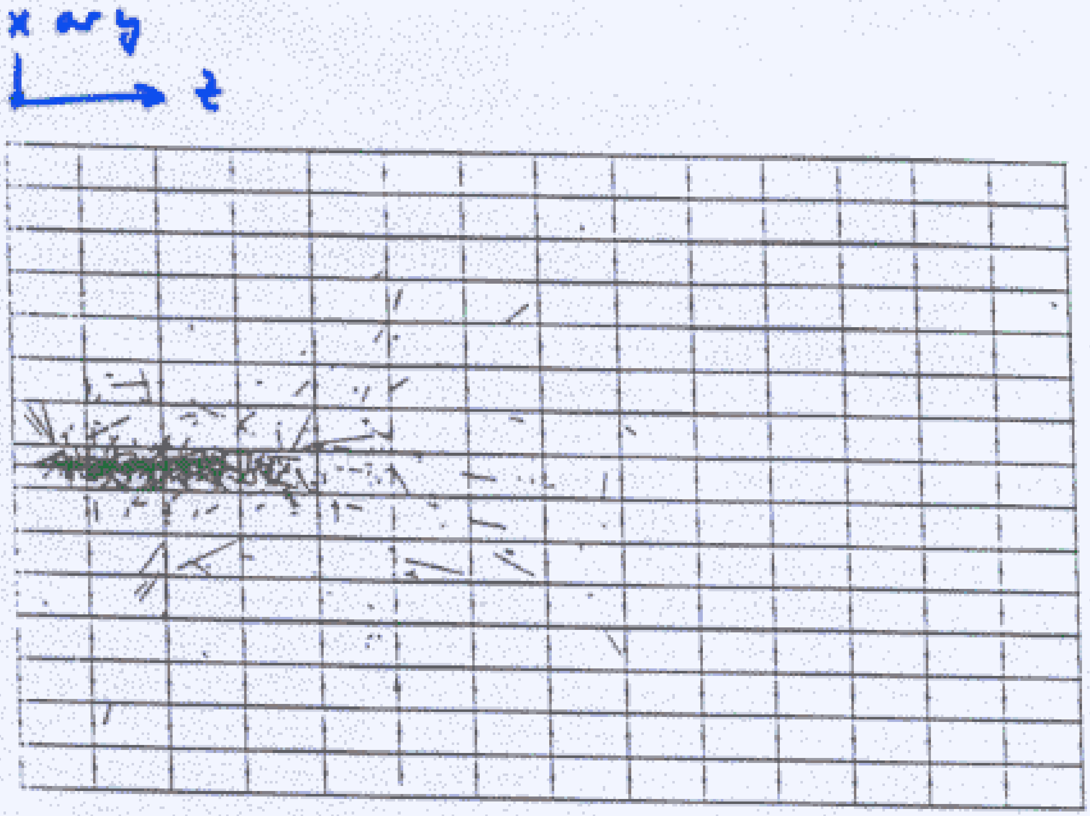
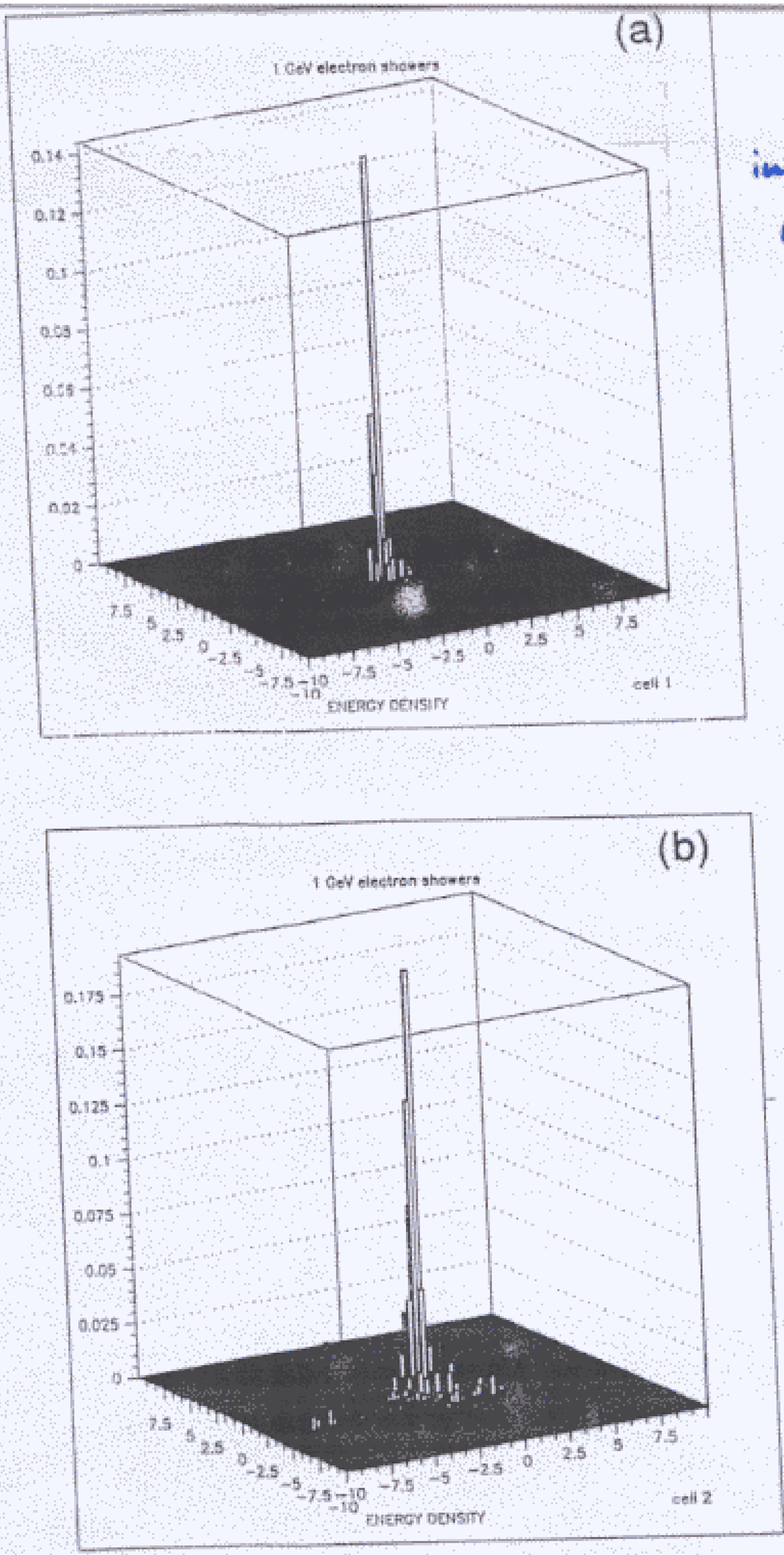


Fig. 2.5

Despite the "scattered" look in x,y, there is no trouble in doing pretty precise "tracking"

→



integrate $0 \le z \le 55$ mm

$55 \le z \le 112$ mm

Fig. 2.6

Longitudinal Segmentation by Readout Ganging

NOTE

A LARGE VESSEL PERMITS THE INTRODUCTION OF

- TARGET-POINTING PADS FOR PICK-UP OF ELECTRON DRIFT
- GANGING OF READOUT CHANNELS ACCORDING TO PHYSICS NEEDS
- PADS ARE ~ MASSLESS
- ACTIVE HEAVY LIQUID CAN EASILY BE RECYCLED
  - ⟹ UNIFORMITY
  - ⟹ REMOVAL OF POTENTIAL RADIATION DAMAGE

LIQUID KRYPTON VARIETY :

⊕ • NO RADIATION DAMAGE

⊕ • GREAT CHEMICAL STABILITY

⊖ • NEED FOR MASSIVE / BULKY CRYOSTAT, FEED THROUGHS

⊕ • LARGER SIGNALS

• SMALLER RADIATION LENGTH

I WILL ARGUE THAT

A LOOK AT THESE CRITERIA
LEAVES OPEN QUESTIONS
W.R.T. PRESENTLY PROPOSED /
TESTED SYSTEMS

CERTAIN DIFFICULT FEATURES <u>MAY</u>
BE SUCCESSFULLY OVERCOME BY

HOMOGENEOUS }
WARM } CALORIMETRY.
LIQUID }
(OR CRYOGENIC)

TO WIT →

THERE IS SOME EXPERIENCE WITH LIQUID KR

- NA 48 @ CERN

  (Fixed-target, does not make comparable demands)

- KEDR detector at VLEPP 4

  (no operation experience available)

  no true tracking capability projected

BUT:

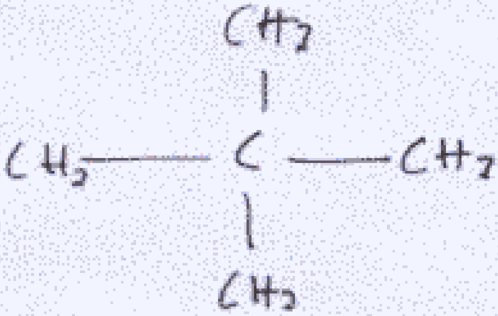
A CRYOGENIC DETECTOR BRINGS A NUMBER OF PROBLEMS:

- CRYOSTAT ADDS DEAD MATERIAL,
  WEIGHT
  BLIND RADIATOR
- EXPENSE
- MECHANICAL COMPLICATIONS

QUESTION: ARE THERE GOOD TOTALLY ABSORBING (LOW-X^0) NON-CRYOGENIC HEAVY ELECTRON DRIFTERS THAT WILL BE OPERABLE AS ENERGY METERS (THROUGH LIGHT OR CHARGE COLLECTION) AND AS TRACKING MEDIA (THROUGH IONIZATION-LIBERATED ELECTRONS DRIFTING TO COLLECTION PADS?

THE NON - CALORIMETRIC

TMP (Tetramethylpentane)



WAS SUCCESSFULLY USED IN THE UA-1 EXPERIMENT

TMPb IS THE MOST PROMISING:

ρ [g cm^{-3}] : 2.0

X^0 [cm] : 4.0

melting point [°C] : −27

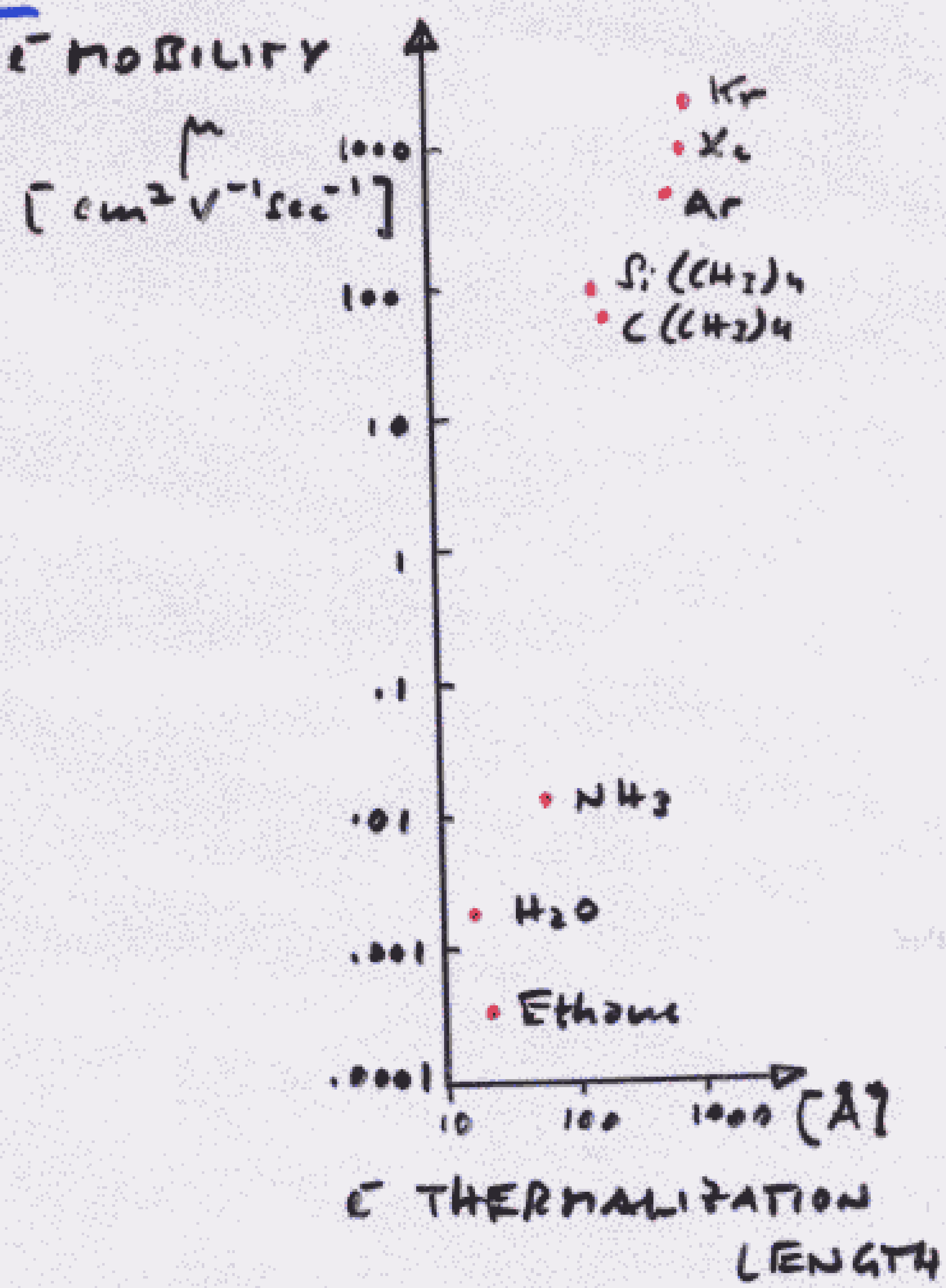
boiling point [°C] : 110

vapor pressure [g m^{-3}] at 20° : 30

UNFORTUNATELY, IT'S ALSO TOXIC,

HAS TO BE HANDLED WITH DUE CARE.

PARAMETERS



IT APPEARS THAT SYMMETRIC MOLECULES ARE BEST

HIGH MOBILITY – LOW RECOMBINATION

⇒ Try to identify substances that are technically realizable at reasonable cost, have "conduction electrons" for charge transport.

TMPb

is heavy enough to act as a homogeneous calorimeter substance

has an electron mobility (not yet measured) that is essentially certain to suffice

needs to be purified to a few ppb to be a good drifter substance

is plentifully available as anti-knock agent for leaded gasoline

is toxic but non-explosive — has to be handled with care.

Kr

is the most attractive heavy noble gas "plentifully" available from the atmosphere

⟹ A GOOD DEAL OF WORK IS NEEDED TO DEMONSTRATE THE {SUITABILITY / ADVISABILITY} OF GOING OVER TO

FULLY TRACKING CALORIMETER

IMPORTANT: **SAFETY ASPECTS**

Heavy metallo-organic substances are usually toxic, often unstable

BUT: there is a lot of information abo[ut] TMPb (anti-knock addition to gasoline)

⇒ a well-contained system at ambient temperature is entirely safe

BUT

→ THE POTENTIAL PAYOFF STANDS TO REVOLUTIONIZE FINAL-STATE RECOGNITION.

THE LINEAR COLLIDER MAY WELL BE THE MACHINE THE PHYSICS RESULTS OF WHICH ARE LIABLE TO DEMAND AND DESERVE A NEW QUANTUM JUMP IN THIS FIELD.

NOTE: RECYCLING OF LIQUID OBVIATES PROBLEMS OF RADIATION DAMAGE. STILL - NEEDS TO BE KEPT IN MIND.

CONCLUSION

THE LINEAR COLLIDER WILL HAVE UNUSUAL DEMANDS ON ITS DETECTOR:

THIS MAY WELL BE THE TIME TO GO BEYOND THE SLOW SEQUENCE OF CALORIMETER IMPROVEMENTS,

→ BLEND TRACKING AND CALORIMETRY

THERE IS ENOUGH TIME FOR DEVELOPMENT WORK !