SNOWMASS 2001
M. ALBROW

CALORIMETRY AT VLHC

CAL AT 1 TeV + 1 TeV : CDF (Pb-SCINT + Fe SCINT WLS BARS → FIBRES)

D∅ LIQUID ARGON

AT 7 TeV + 7 TeV : CMS $PbWO_4$ em CRYSTALS

~~(Pb-scint 'shashlik')~~

Cu-SCINT-WLS FIBERS

ATLAS em: L.Argon ACCORDION

had: L.Argon FWD

SCINT-TILE BARREL

CMS VF & ALICE ZDC : QUARTZ FIBRES (> 1-2 GRAD)

(OR LIQ. SCINT IN TUBES)

CDF MINIPLUGS: LIQ SCINT + PLATES

LONGIT. WLS FIBRES – MAPMT's.

AT 20 TeV + 20 TeV ?

100 TeV + 100 TeV ?

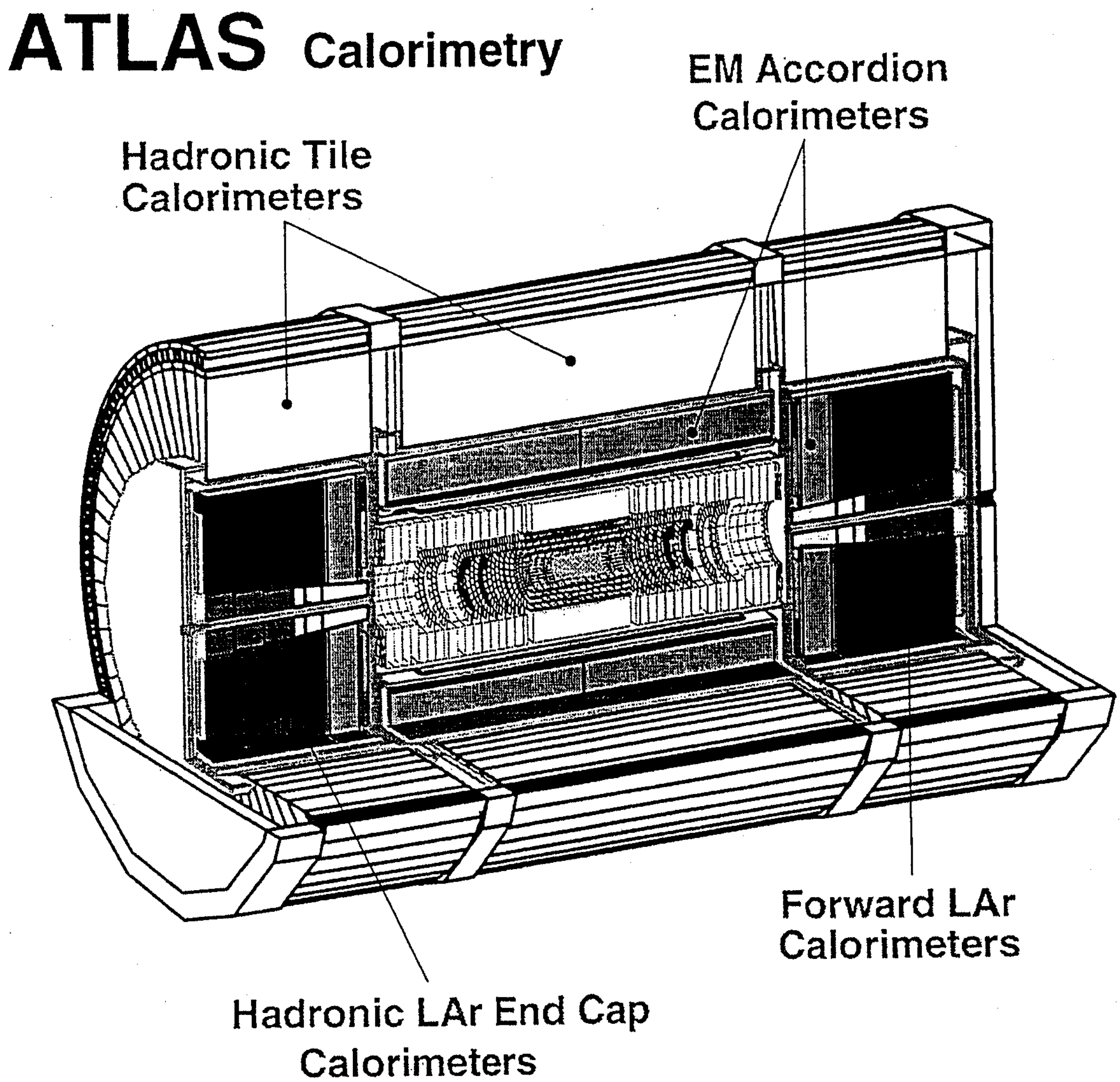


Figure 26: Three-dimensional view of the ATLAS detector emphasizing its calorimetry and inner tracker. The muon system completely surrounds the calorimetry.

(some) ISSUES

WHAT η COVERAGE (FULL ϕ COVERAGE & UNIFORM)

WHAT η-ϕ GRANULARITY
- em (+ shower max ?)
- had

ENERGY RESOLUTION
- e, γ
- jets

DYNAMIC RANGE (μ ?) – GeV → TeV ?
(e, h, j)

RADIATION HARDNESS (fn η)

SPEED OF RESPONSE / PILE-UP

LINEARITY

DEPTH SEGMENTATION

SCINTILLATOR CALS

V. WIDELY USED AND WELL-ESTABLISHED.

R/O FROM CONFINED SPACES "SOLVED" WITH WAVELENGTH-SHIFTING FIBRES (w/s) EMBEDDED IN PLATES OR PASSING THRO LIQUID.

HIGH GRANULARITIES ($\Delta\eta \cdot \Delta\phi$) & DEPTH SEGMENTATION

MAIN ISSUE IS RADIATION HARDNESS ?
- OF SCINT (LIQ. COULD BE REPLACED)
- WLS FIBERS
- PHOTODETECTORS (PMT, APD, HPD)

APD, HPD: CMS HAS THESE ∵ $\vec{H}$

& RESOLUTION INFERIOR TO eg. $PbWO_4$ (e.m.)

MiniPlug calorimeters proposed for CDF-II are 1.2λ and have no hadron tagging fibers.

The MiniPlug design combines a low cost construction with an efficient and high-resolution position determination. Monte Carlo predictions of the MiniPlug expected performance and results obtained from a test beam at the Brookhaven National Laboratory with 5 GeV electrons and 8 GeV pions are described elsewhere [1,2]. In this paper we review the prototype design and the MCPMT calibration, and present results obtained with high-energy positrons and pions in the 1997 test beam at Fermilab.

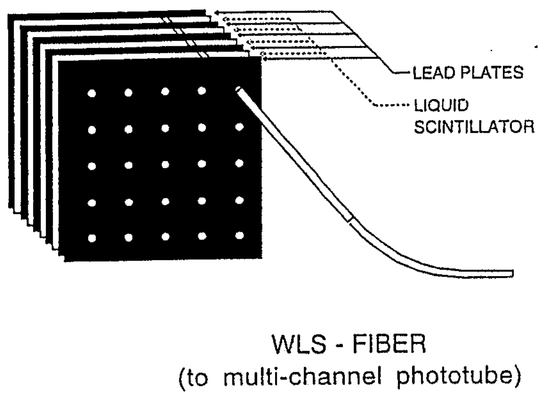


Fig. 1. Conceptual design of a "towerless" calorimeter: the fibers are arranged in a "towerless" geometry, i.e. with no discrete tower boundaries (see also Figs. 2 and 3).

2. The MiniPlug prototype

A schematic side view of the MiniPlug prototype is shown in Fig. 2. The prototype consists of 30 parallel lead plates, with dimensions 15 cm × 15 cm and 4.8 mm thick, spaced 6.4 mm apart. The plates were laminated with 0.5 mm thick aluminum sheets of 86% reflectivity glued on the lead with epoxy. Multiclad WLS Kuraray Y-11(350)M fibers of 0.83 mm diameter were inserted into an array of aligned

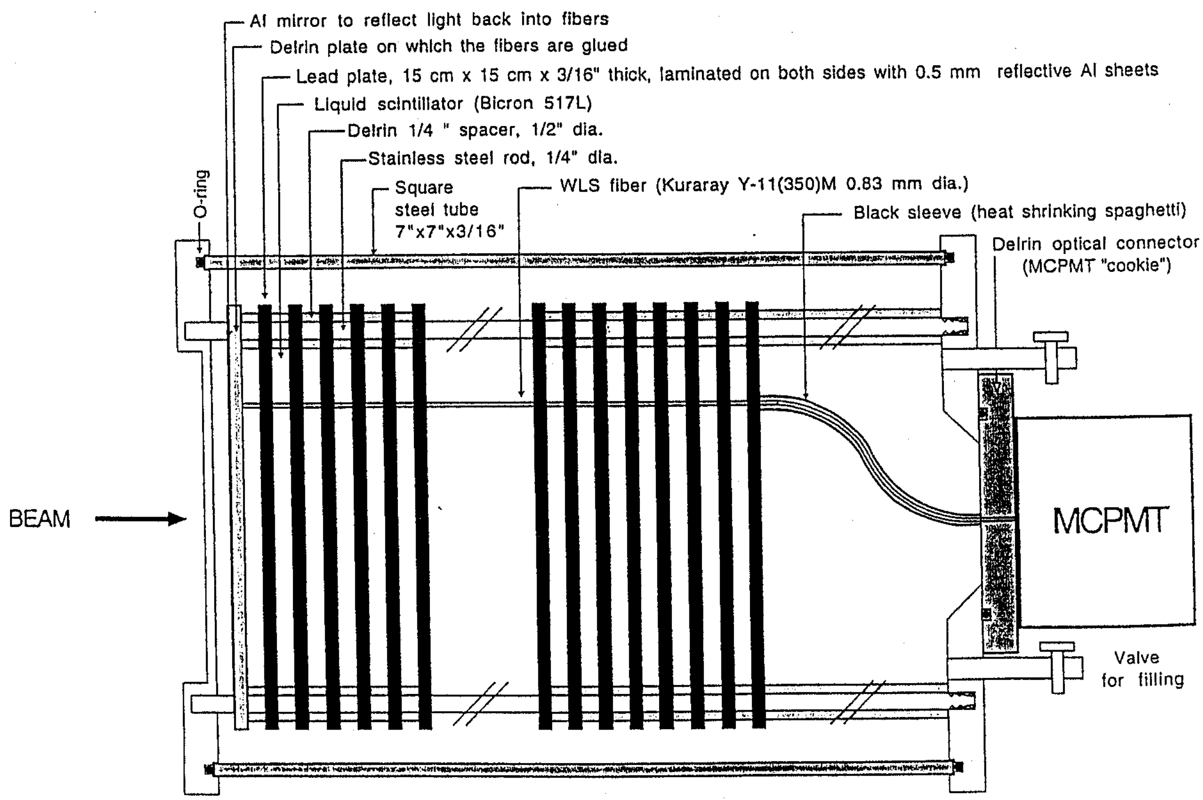


Fig. 2. Schematic side view of the MiniPlug prototype.

$PbWO_4$ LEAD TUNGSTATE CRYSTALS

RADN. LENGTH X_0 = 9 MM

MOLIERE RAD. = 2 cm.

GOOD ENERGY RESLN: $\frac{\sigma_E}{E} \sim \frac{2\%}{\sqrt{E}} \oplus 0.5\% \oplus \frac{0.15}{E}$ (GeV)

FAST

RADIATION HARDNESS 10 Mrad

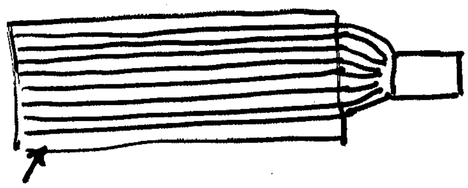
(" OF APD USED BY CMS)?

TEMPERATURE DEPENDENCE ?

LOOKS PROMISING FOR EM CAL.

WILL LEARN FROM EXPERIENCE CMS +

QUARTZ FIBER CALS



'SPAGHETTI'

CERENKOV LIGHT (<< SCINT. LIGHT)

VERY RADIATION HARD 30 Grad

VERY FAST (PROMPT LIGHT + P.D. RESPONSE) FEW ns

GOOD SPATIAL RESLN (ALSO FOR HADRONS, ∵ em CORE)

INSENSITIVE TO NEUTRONS & RADIOACTIVITY

HV~~E~~-QF FOR CMS

ENERGY RESOLUTION NOT GREAT (0.8 pe/GeV)

$\frac{\sigma_E}{E} \sim \frac{100\% - 140\%}{\sqrt{E}}$? NON-COMPENSATING ($e/h \sim 6$!)

SERIOUS OPTION ESP. VERY FORWARD?

DIAMOND CALORIMETERS

PLANES OF (ARTIFICIAL) CVD = CHEMICAL VAPOR DEPOSITION
DIAMOND MICRO-CRYSTALS BETWEEN ABSORBER PLATES.

PROPOSED IN 1990 FOR SSC, BUT REQUIRED
LOTS OF DEVELOPMENT / PROGRESS. THERE HAS BEEN BUT
IT STILL DOES!

RUTGERS MADE AN EM CAL PROTOTYPE

SIGNALS ↗ ×1000 IN 5 YEARS

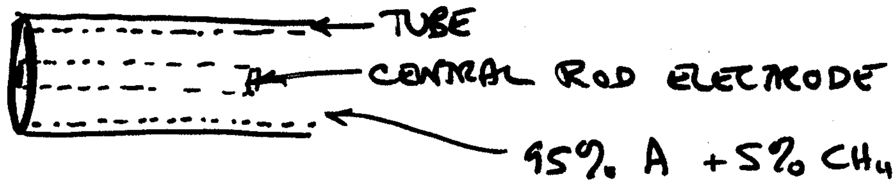
$$\frac{\sigma_E}{E} \sim \frac{20\%}{\sqrt{E}} \oplus 1.5\% \oplus \frac{8\%}{E} \quad (\text{GeV}).$$

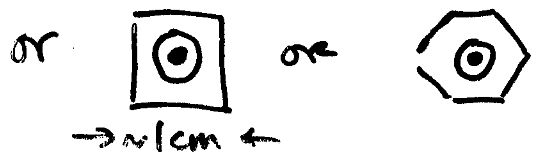
RADN HARDNESS > 100 × Si

BIGGEST ISSUE TODAY IS PRICE.

BUT BY 2015 ?

HIGH PRESSURE GAS TUBES





STACKING

LIKE A LIQUID ARGON CAL., BUT ~ 100 atm gas.

NO GAIN SO STABLE

TUBES CAN BE "WIGGLED"
WITH SPACERS AND ICE !
TO AVOID 'POINTING' PROBLEM.

VERY RADIATION HARD > Grad

RELATIVELY CHEAP

FAIRLY FAST (20ns FW)

TESTED HAD CAL $\frac{\sigma_E}{E} \sim \frac{70\%}{\sqrt{E}} \oplus 7.4\%$

< 3% WITH WEIGHTING?

V. INTERESTING OPTION, AT LEAST FOR HADCAL.

LIQUID ARGON CALORIMETERS

WELL ESTABLISHED TECHNIQUE
(SINCE ISR-R806 ~1975) --- DØ --- H1 --- ATLAS

INTRINSICALLY STABLE,
LINEAR,
RAD-HARD

GOOD ENERGY RESOLUTION:

H1 : $\frac{\sigma_E}{E} \sim \frac{51\%}{\sqrt{E}} \oplus 1.6\%$ (had) (PLATES)

ATLAS TESTS $\frac{\sigma_E}{E} \sim \frac{7.7\%}{\sqrt{E}} \oplus \sim 0$ (em) ACCORDION

HOWEVER MOBILITY of e & ions → COLLECTION TIME (500ns ?)

SLOW, PILE-UP AT HIGH $\mathcal{L}$

'SPACE CHARGE' EFFECTS. ⇝ IMPROVEMENTS ?