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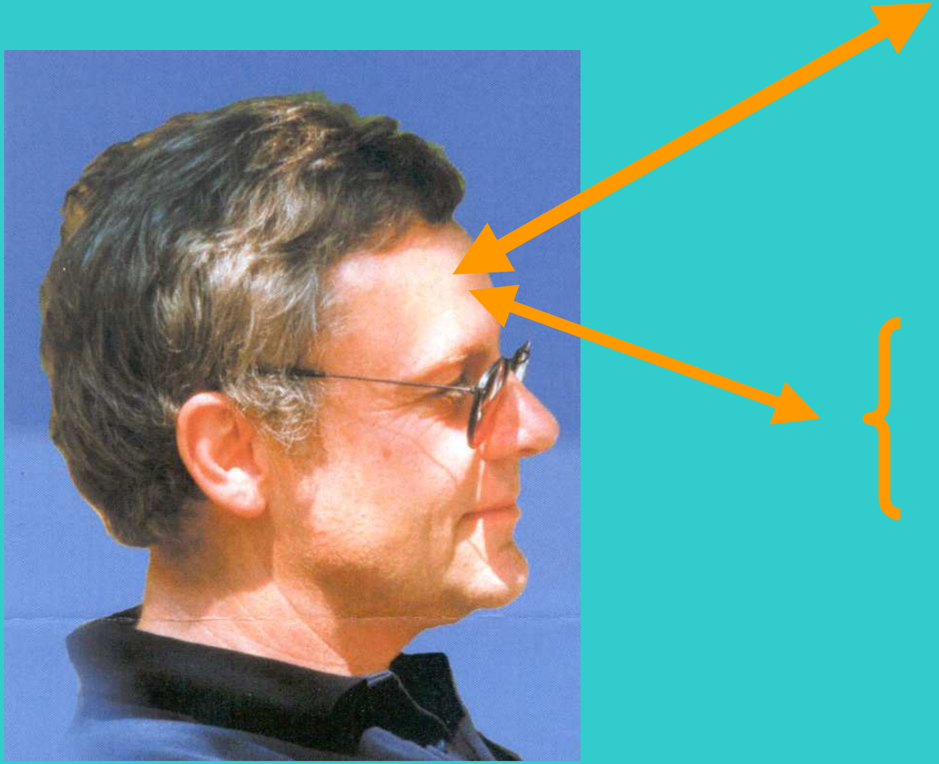
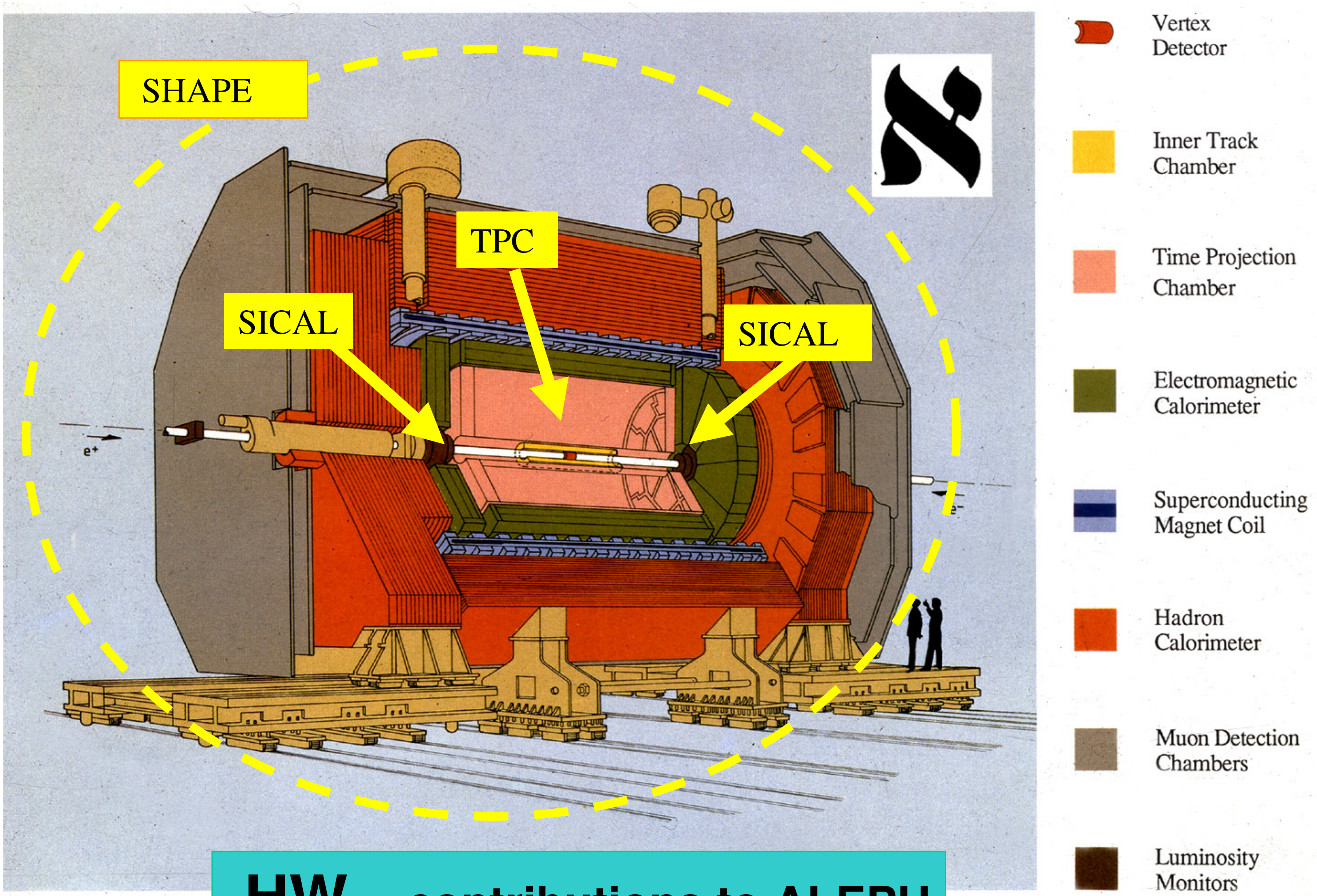
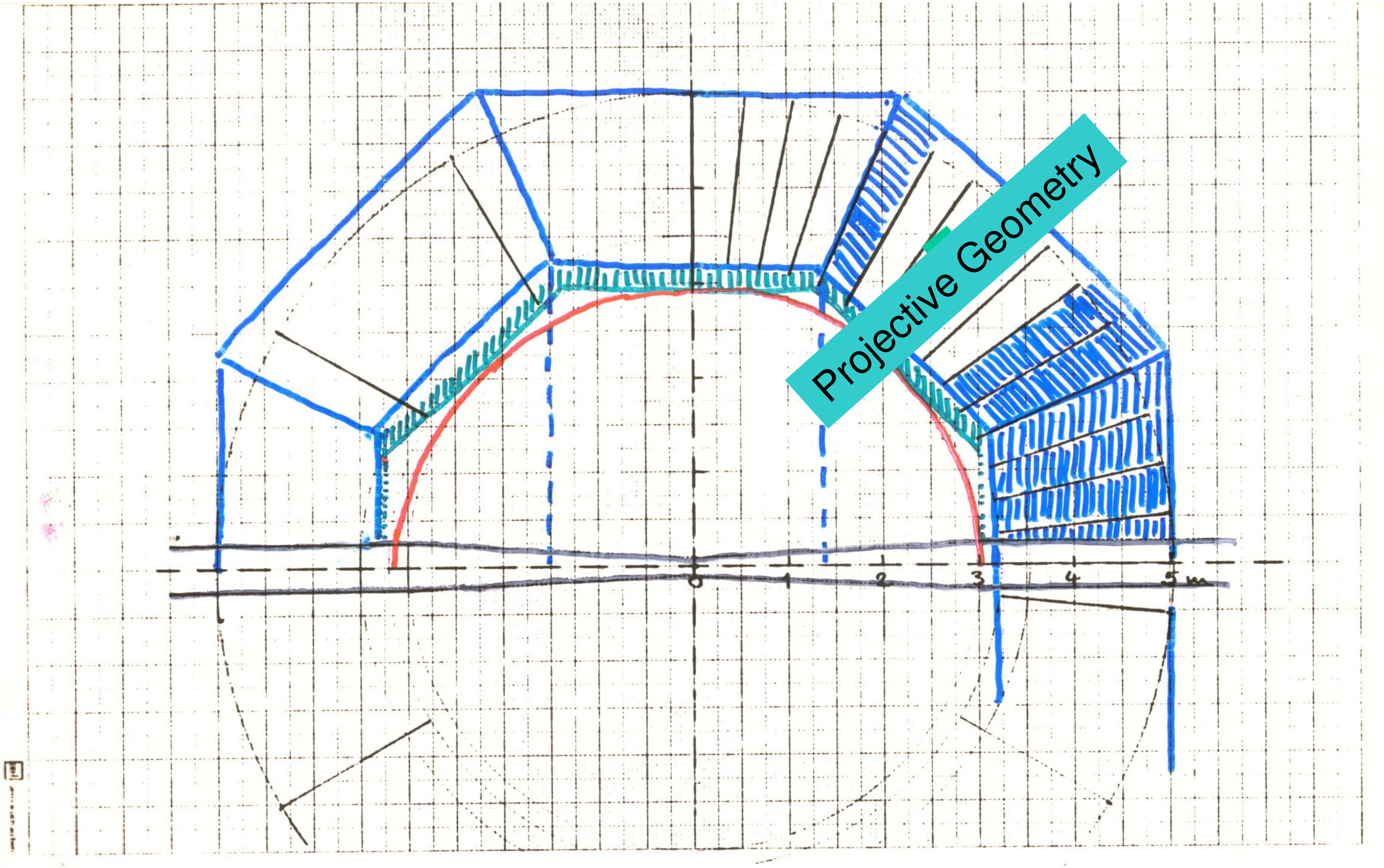


- Big Sphere
- TPC
- SICAL

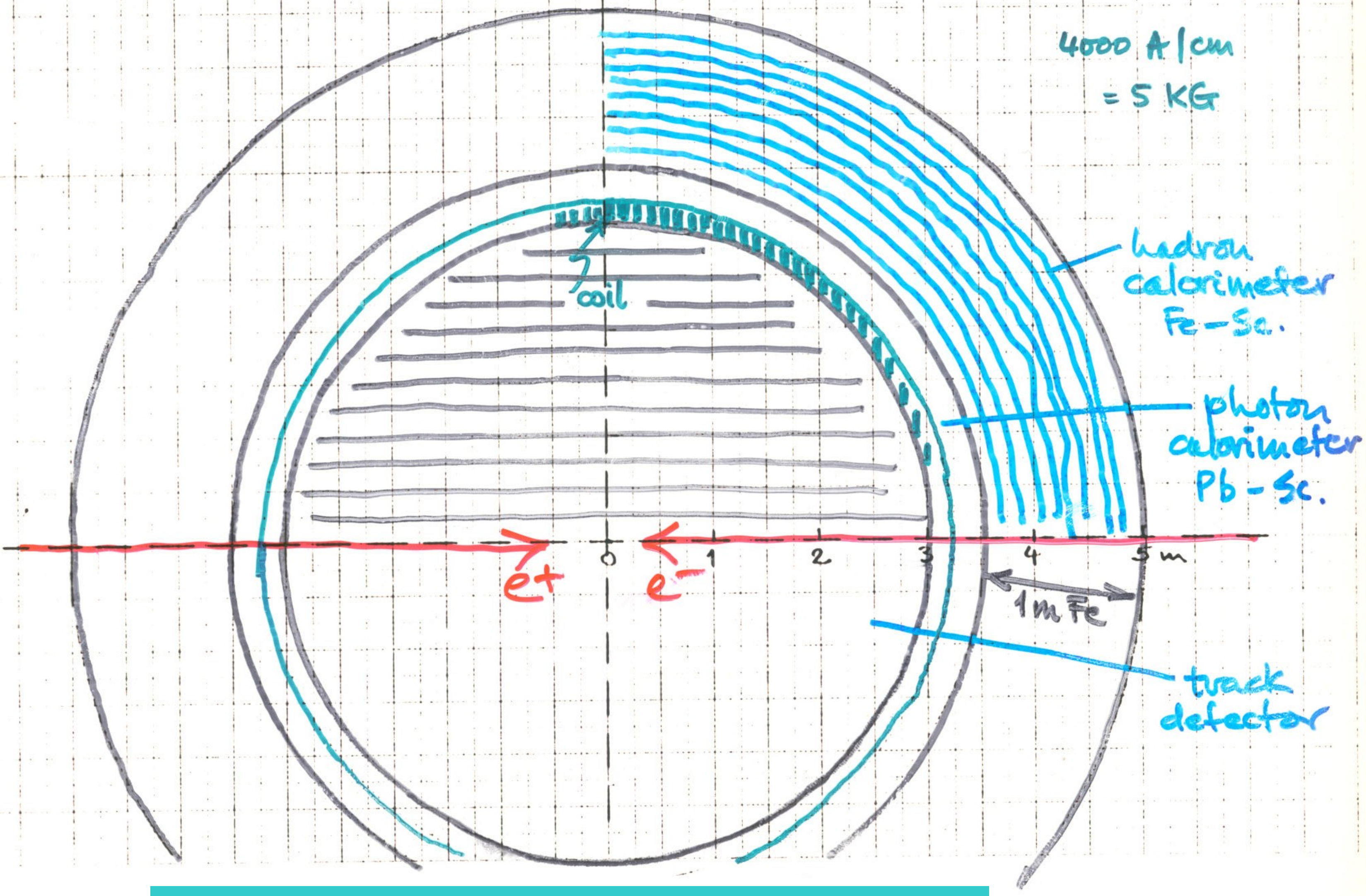

SHAPE
TPC
SICAL
SICAL
e+
e-
Vertex Detector
Inner Track Chamber
Time Projection Chamber
Electromagnetic Calorimeter
Superconducting Magnet Coil
Hadron Calorimeter
Muon Detection Chambers
Luminosity Monitors

HW: contributions to ALEPH



Projective Geometry

Physics: Spherical Symmetry


4000 A/cm
= 5 KG
hadron calorimeter Fe-Sc.
photon calorimeter Pb-Sc.
coil
track detector
1 m Fe
e+
e−
0
1
2
3
4
5 m

HW: sperical coil → homog. B-field

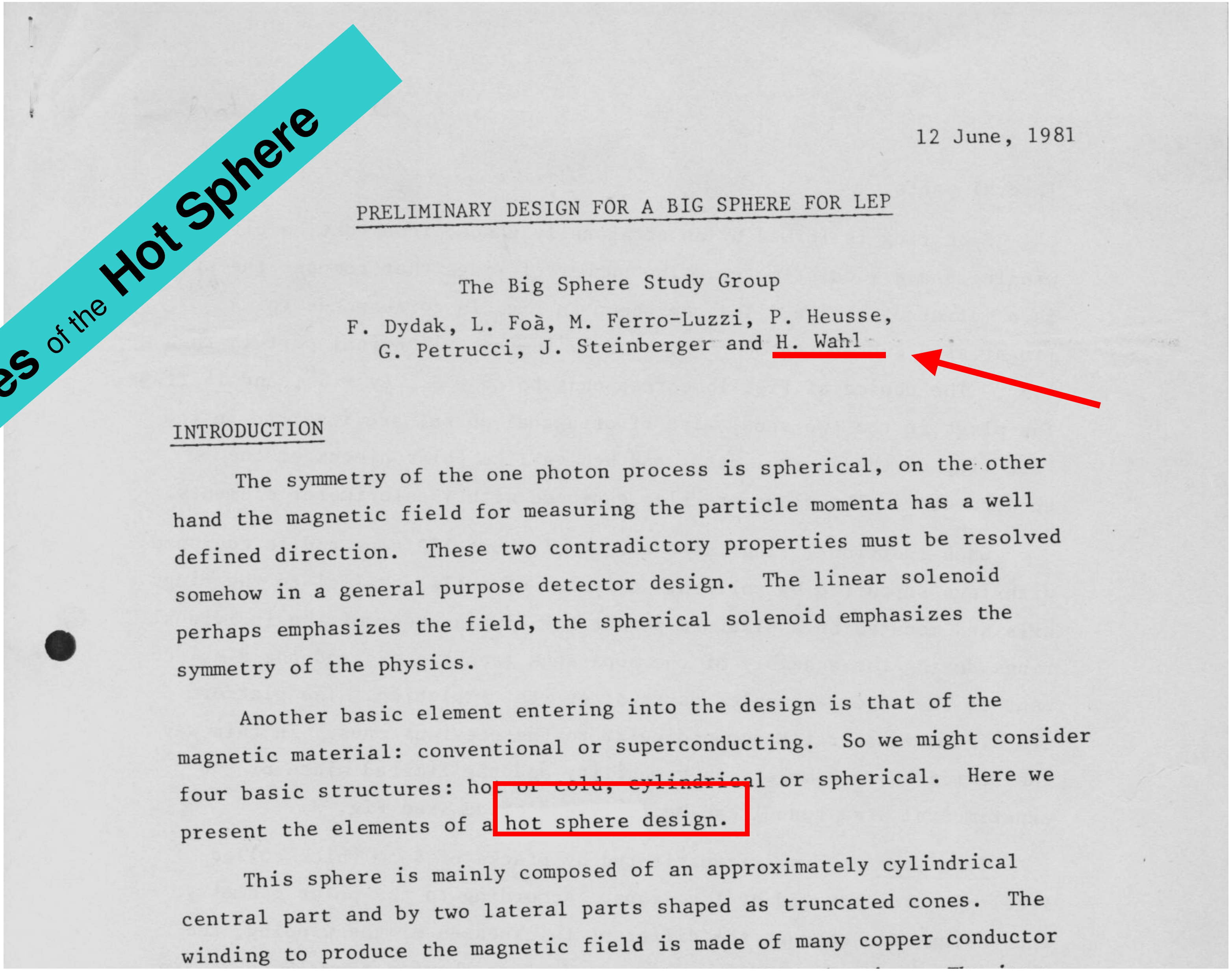
comparison of sphere and cylinder

10 MW power available

	sphere	cylinder	
magnetic radius	3.0	2.8	m
length		±3	m
field	0.57T	0.54	T
$\Delta p/p^2$ at 60°	2.1×10^{-3}	1.9×10^{-3}	
coil weight	20t	23	t
plastic surface (soft)	4240	5790	m^2
(hard)	8740	11800	m^2
weight lead	300	410	t
iron	1730	2330	t
scintillator	50	70	t
cost iron (5/Kg)	8.7	11.2	MSF
scintillator (500/m^2)	5.2	7.1	MSF
coil	0.4	0.5	MSF
fixed cost	15.0	15.0	MSF
total cost	~30	~33	MSF

fixed cost assumed for
wire construction & readout
pulse-heigt work: tubes, bases, cables, light-guides
drift-chambers for μ detection
on-line computer, power installation
assembly of calorimeter etc.

Heroes of the Hot Sphere



12 June, 1981

PRELIMINARY DESIGN FOR A BIG SPHERE FOR LEP

The Big Sphere Study Group

F. Dydak, L. Foà, M. Ferro-Luzzi, P. Heusse,
G. Petrucci, J. Steinberger and H. Wahl

INTRODUCTION

The symmetry of the one photon process is spherical, on the other hand the magnetic field for measuring the particle momenta has a well defined direction. These two contradictory properties must be resolved somehow in a general purpose detector design. The linear solenoid perhaps emphasizes the field, the spherical solenoid emphasizes the symmetry of the physics.

Another basic element entering into the design is that of the magnetic material: conventional or superconducting. So we might consider four basic structures: hot or cold, cylindrical or spherical. Here we present the elements of a hot sphere design.

This sphere is mainly composed of an approximately cylindrical central part and by two lateral parts shaped as truncated cones. The winding to produce the magnetic field is made of many copper conductor

Disadvantages

1. Complex construction of calorimeters and coil, in part due to projective geometry, in part due to conical ends.
2. Power cost [3 M.W. × 5 yrs × 2000 hrs/yr − 0.5 M.W. × 5 yrs × 4000 hrs/yr] × 0.07 F/KWH = 1.4 MSF. This is perhaps not a lot.
3. Power psychosis
4. Central chamber construction More difficult because of size.
5. Central chamber accuracy Will it be possible to achieve the same systematics as in a smaller chamber?
6. The shower calorimeter has some ugly features, linked to edge effects where the BBQ and mountings are located, and to the non-rectangular shape. Both can be largely overcome, but only with many calibration constants.
7. It is not yet known if the double light conversion will work (is the light output sufficient?)
8. The project uses no novel techniques.
9. No possibility to use TPC.

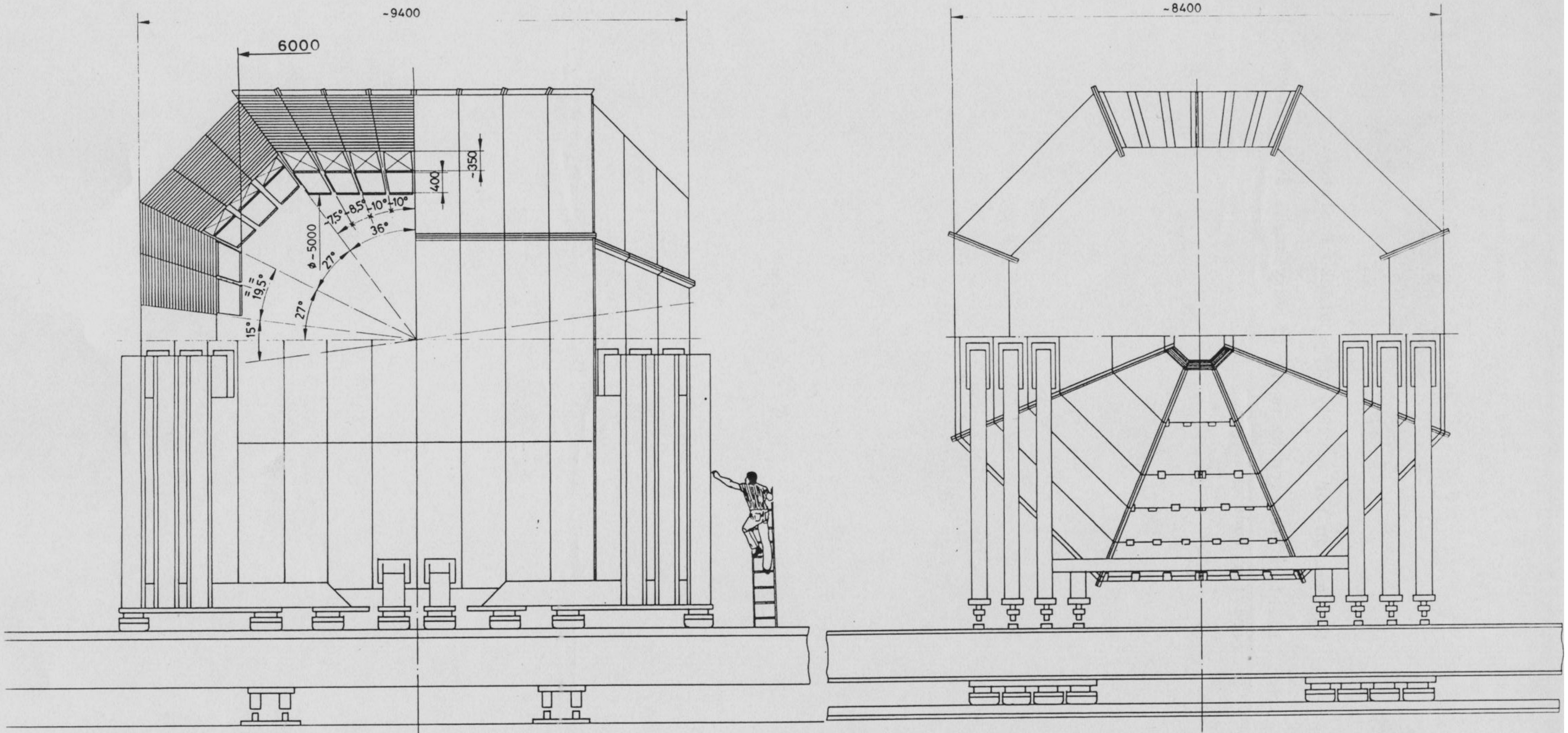

~9400
6000
~350
400
7,5°
8,5°
10°
10°
36°
ϕ~5000
27°
27°
= =
19,5°
15°
~8400

Fig 1a

Big Sphere Magnet

Solution:

SACLAY’s superconducting coil 1.5 T
TPC is possible !

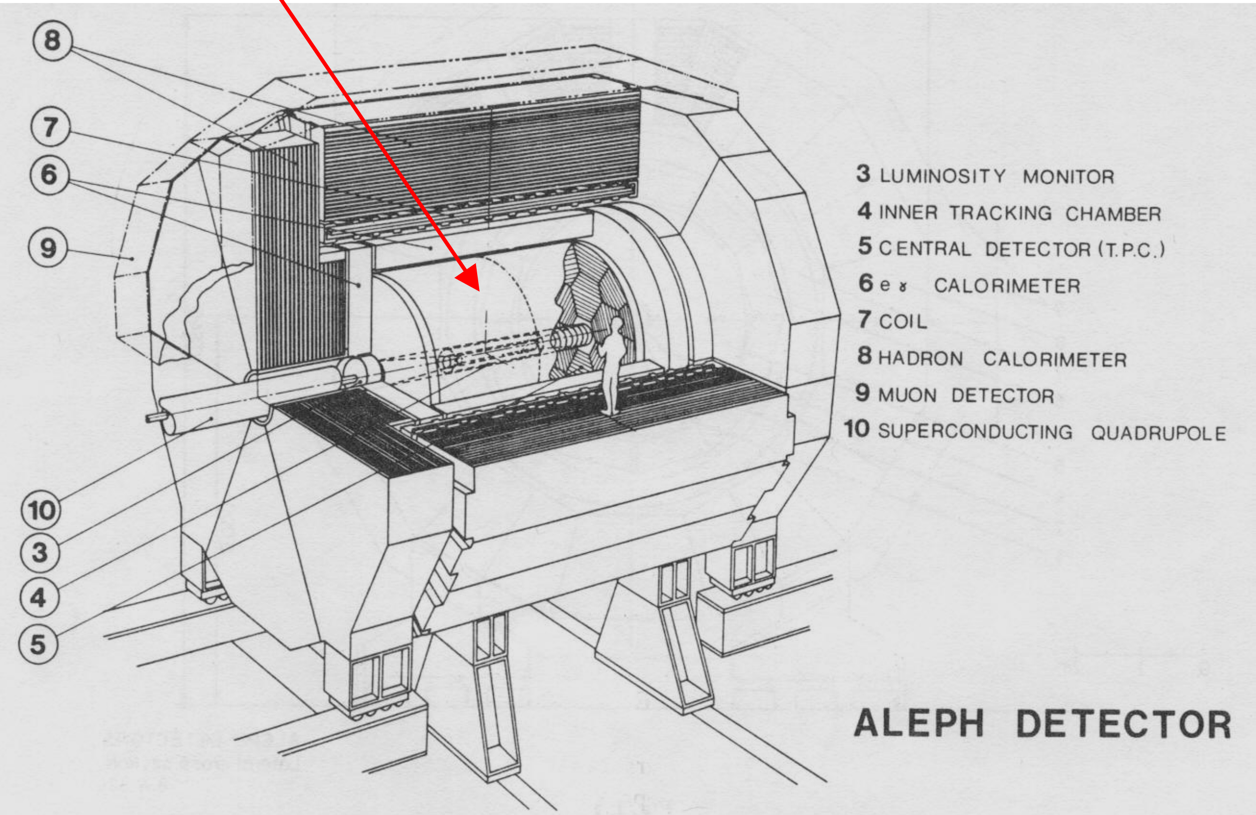
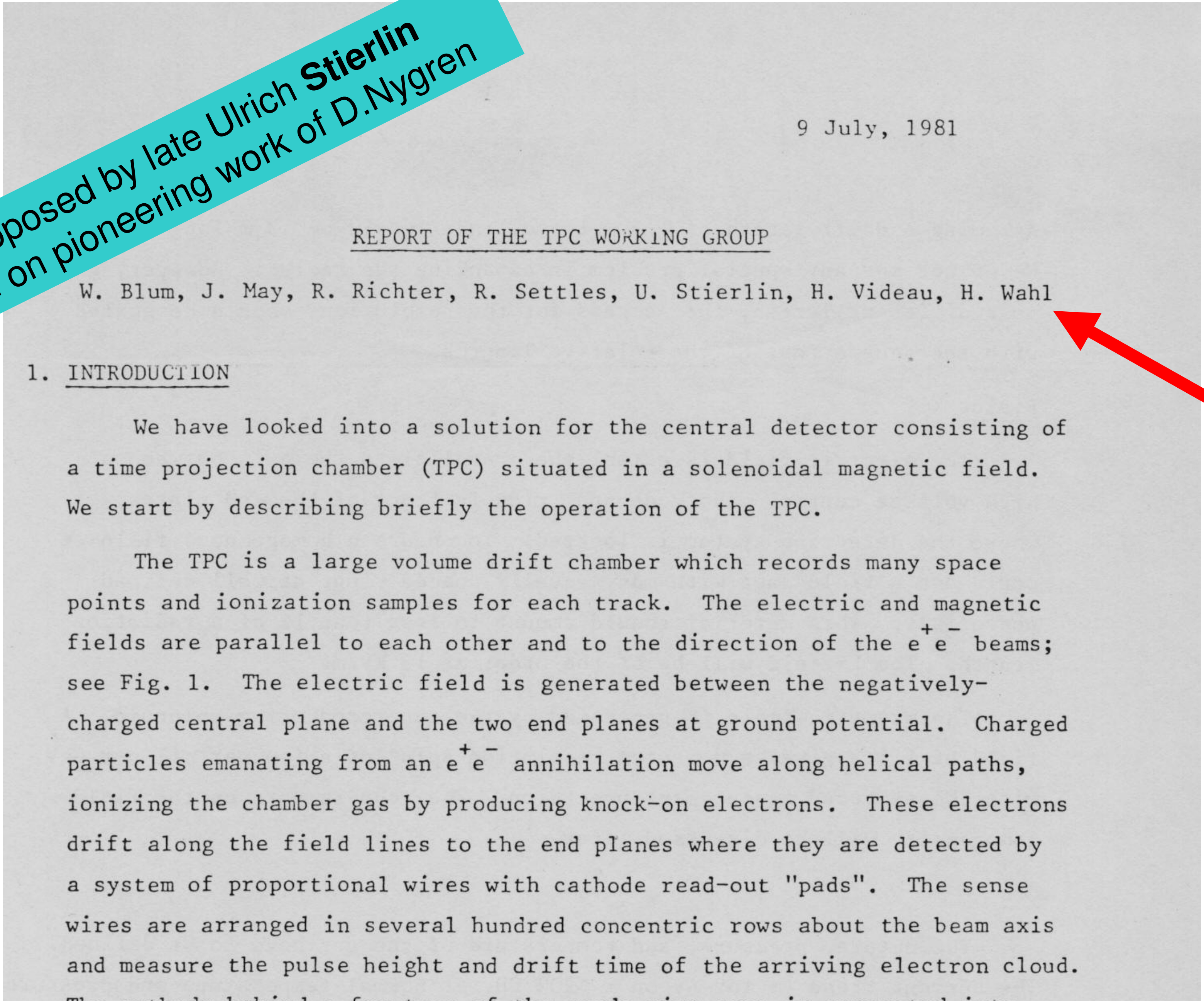

8
7
6
9
10
3
4
5
3 LUMINOSITY MONITOR
4 INNER TRACKING CHAMBER
5 CENTRAL DETECTOR (T.P.C.)
6 e γ CALORIMETER
7 COIL
8 HADRON CALORIMETER
9 MUON DETECTOR
10 SUPERCONDUCTING QUADRUPOLE
ALEPH DETECTOR

Fig. 1.1

TPC proposed by late Ulrich **Stierlin**
based on pioneering work of D.Nygren



9 July, 1981

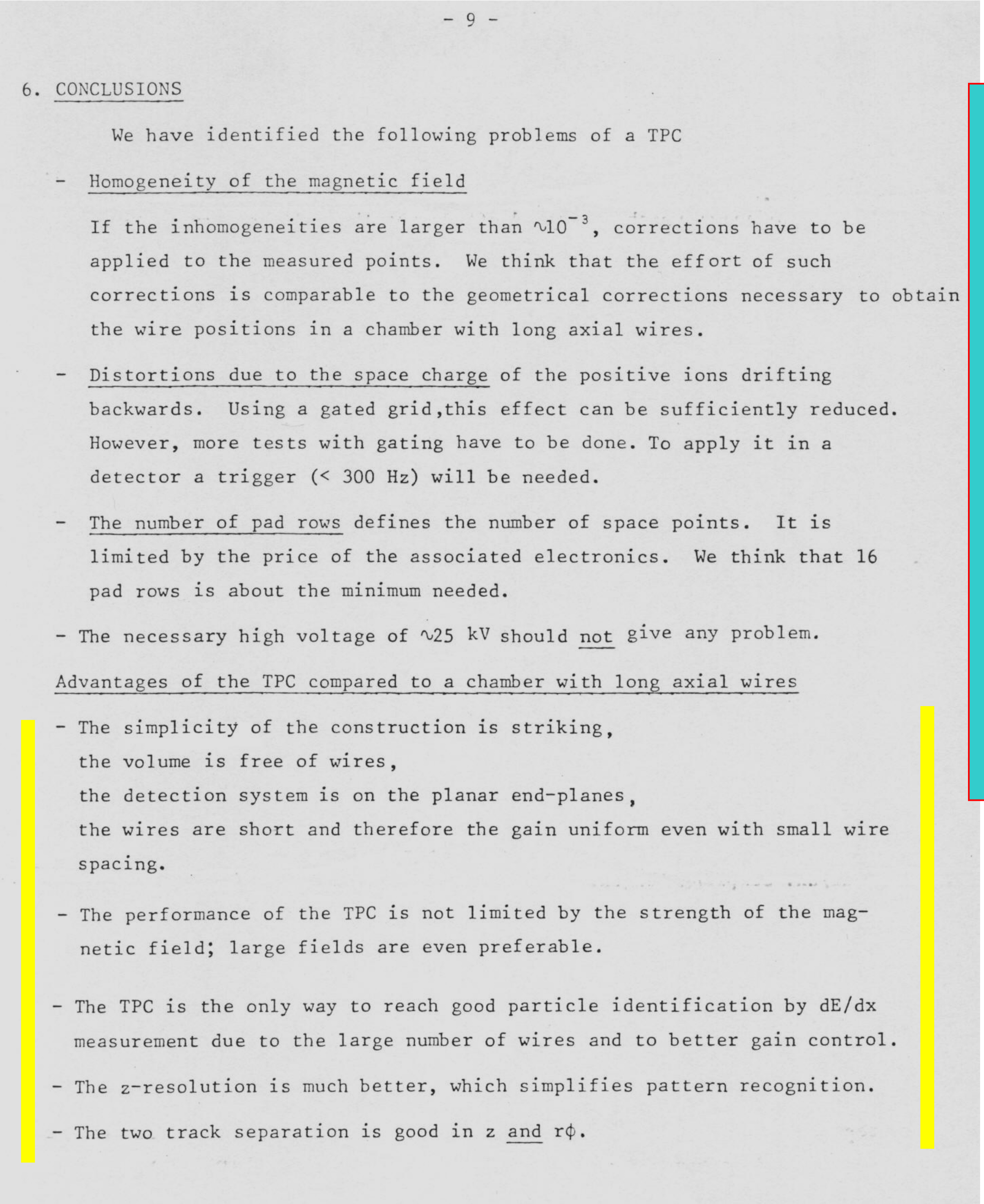
REPORT OF THE TPC WORKING GROUP

W. Blum, J. May, R. Richter, R. Settles, U. Stierlin, H. Videau, H. Wahl

1. INTRODUCTION

We have looked into a solution for the central detector consisting of a time projection chamber (TPC) situated in a solenoidal magnetic field. We start by describing briefly the operation of the TPC.

The TPC is a large volume drift chamber which records many space points and ionization samples for each track. The electric and magnetic fields are parallel to each other and to the direction of the e^+e^- beams; see Fig. 1. The electric field is generated between the negatively-charged central plane and the two end planes at ground potential. Charged particles emanating from an e^+e^- annihilation move along helical paths, ionizing the chamber gas by producing knock-on electrons. These electrons drift along the field lines to the end planes where they are detected by a system of proportional wires with cathode read-out "pads". The sense wires are arranged in several hundred concentric rows about the beam axis and measure the pulse height and drift time of the arriving electron cloud.



6. CONCLUSIONS

We have identified the following problems of a TPC

- Homogeneity of the magnetic field

  If the inhomogeneities are larger than $\sim 10^{-3}$, corrections have to be applied to the measured points. We think that the effort of such corrections is comparable to the geometrical corrections necessary to obtain the wire positions in a chamber with long axial wires.

- Distortions due to the space charge of the positive ions drifting backwards. Using a gated grid,this effect can be sufficiently reduced. However, more tests with gating have to be done. To apply it in a detector a trigger (< 300 Hz) will be needed.

- The number of pad rows defines the number of space points. It is limited by the price of the associated electronics. We think that 16 pad rows is about the minimum needed.

- The necessary high voltage of $\sim$25 kV should not give any problem.

Advantages of the TPC compared to a chamber with long axial wires

- The simplicity of the construction is striking,
  the volume is free of wires,
  the detection system is on the planar end-planes,
  the wires are short and therefore the gain uniform even with small wire spacing.

- The performance of the TPC is not limited by the strength of the magnetic field; large fields are even preferable.

- The TPC is the only way to reach good particle identification by dE/dx measurement due to the large number of wires and to better gain control.

- The z-resolution is much better, which simplifies pattern recognition.

- The two track separation is good in z and $r\phi$.

50 000 channels

Complicated electronics

Amount of data

Space charge

Distortions

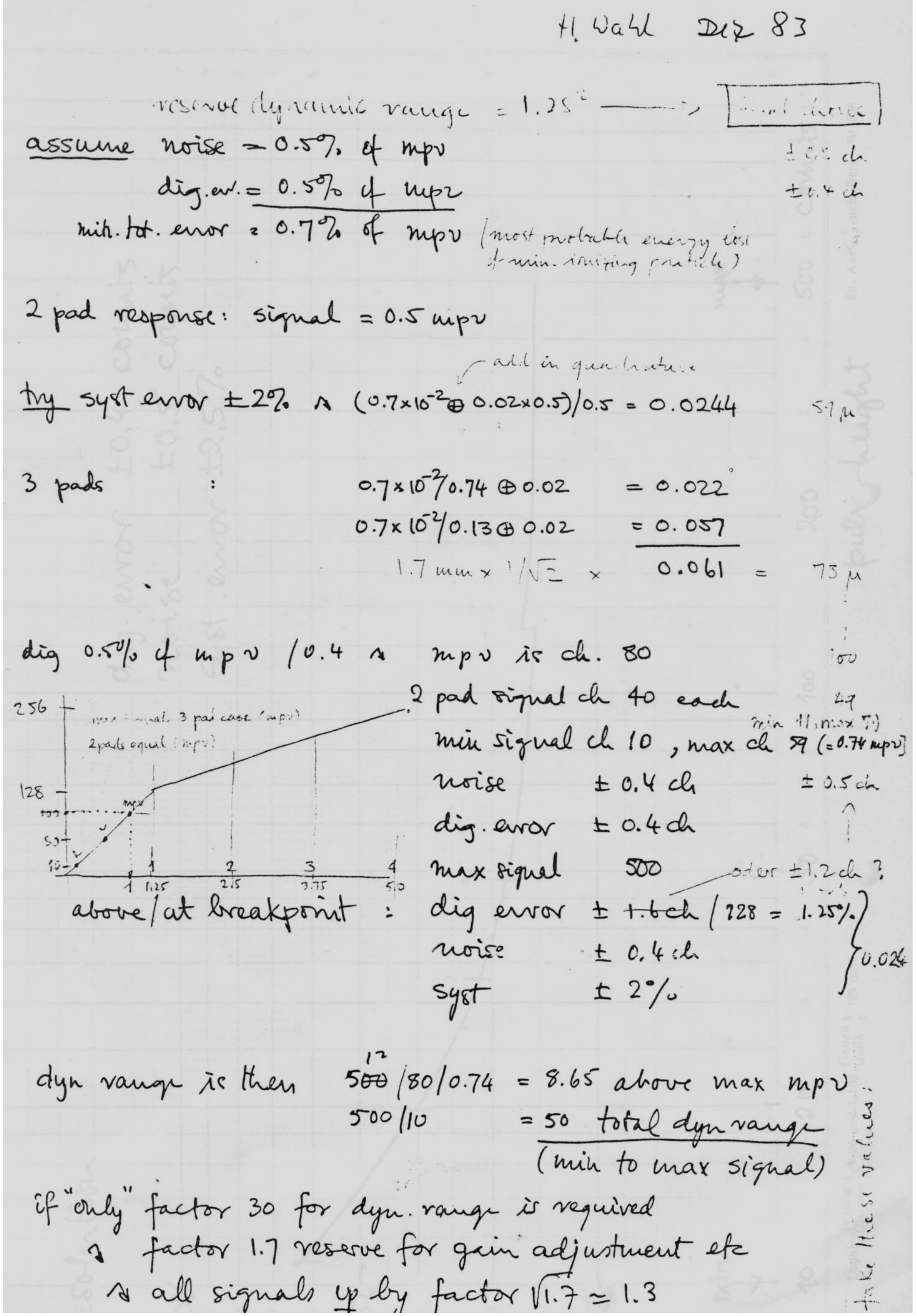
Angular effects

E x B

LEPC worried !

HW : electronics coordinator for TPC

dyn. range and resolution



H. Wahl Dez 83

reserve dynamic range = 1.25² ——> [illegible]

assume noise = 0.5% of mpv ±0.5 ch.

dig. err. = 0.5% of mpv ±0.4 ch

min. tot. error = 0.7% of mpv (most probable energy loss of min. ionizing particle)

2 pad response: signal = 0.5 mpv

add in quadrature

try syst error ±2% ⇝ $(0.7\times10^{-2} \oplus 0.02\times0.5)/0.5 = 0.0244$ 57 μ

3 pads : $0.7\times10^{-2}/0.74 \oplus 0.02 = 0.022$

$0.7\times10^{-2}/0.13 \oplus 0.02 = 0.057$

$1.7\text{ mm} \times 1/\sqrt{2} \times 0.061 = 73\ \mu$

dig 0.5% of mpv / 0.4 ⇝ mpv is ch. 80 100

2 pad signal ch 40 each 49

min signal ch 10, max ch 59 (= 0.74 mpv) (min 11, max 71)

noise ± 0.4 ch ± 0.5 ch

dig. error ± 0.4 ch

max signal 500

above/at breakpoint : dig error ± ~~1.6ch~~ / 128 = 1.25% oder ±1.2 ch ?

noise ± 0.4 ch

syst ± 2% } 0.024

dyn range is then $\overset{12}{\cancel{500}}/80/0.74$ = 8.65 above max mpv

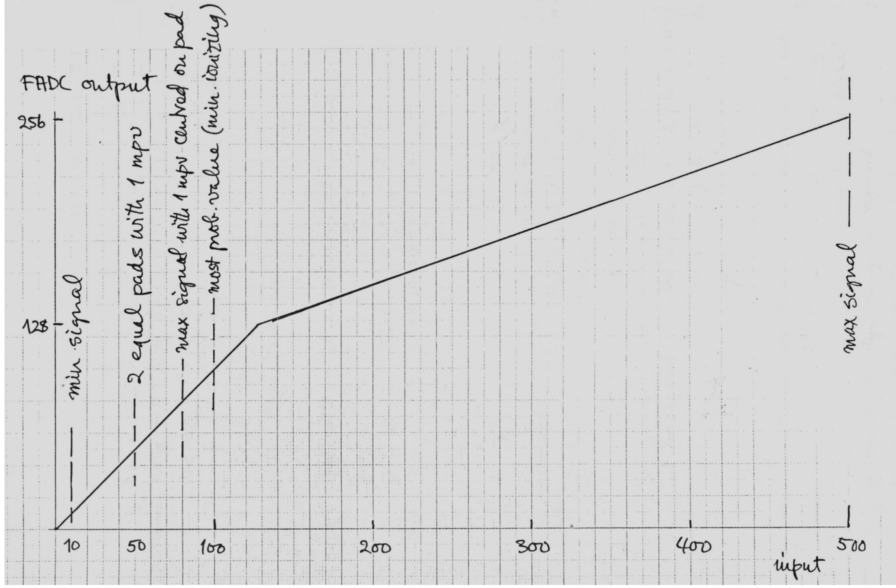
500/10 = 50 total dyn range (min to max signal)

take these values

if "only" factor 30 for dyn. range is required

⇝ factor 1.7 reserve for gain adjustment etc

⇝ all signals up by factor $\sqrt{1.7} \simeq 1.3$



500 time samples
calibrated data (4 DCs)/ch
zero suppression

8 bits

System:
120 FastBus crates

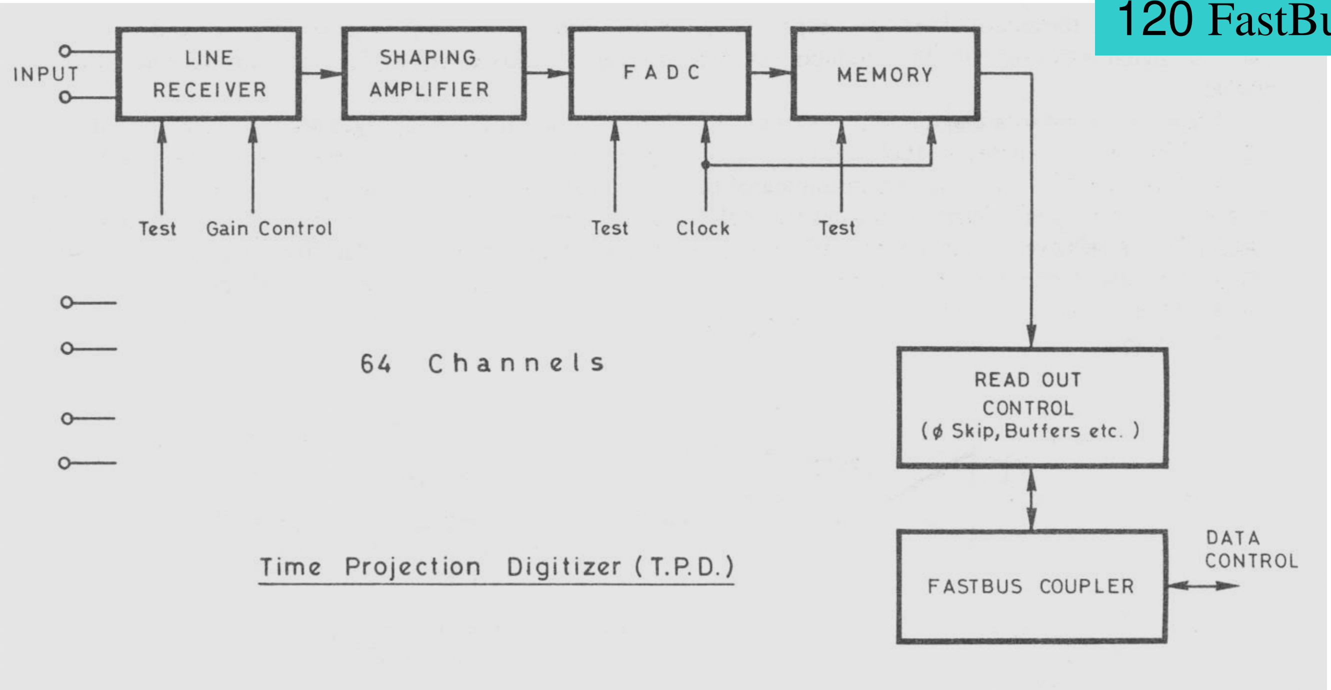
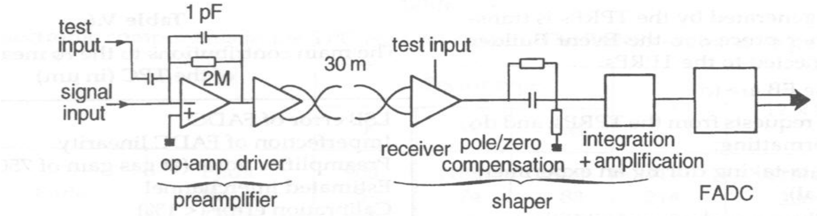

INPUT
LINE RECEIVER
SHAPING AMPLIFIER
FADC
MEMORY
Test
Gain Control
Test
Clock
Test
64 Channels
READ OUT CONTROL (ϕ Skip, Buffers etc.)
FASTBUS COUPLER
DATA CONTROL
Time Projection Digitizer (T.P.D.)

Fig. 4.3.5

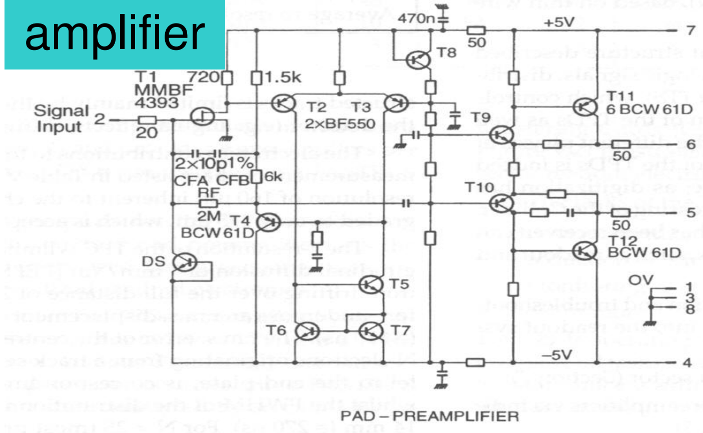
Analog chain: MPI Munich
TPD: Bo Lofstedt – H.Verweij
TPP: Pisa – Amendolia et al.

Pre-amplifier



test input
1 pF
signal input
2M
30 m
test input
receiver
op-amp driver
preamplifier
pole/zero compensation
integration + amplification
shaper
FADC

V.22 Functional diagram of the analog electronics chain.

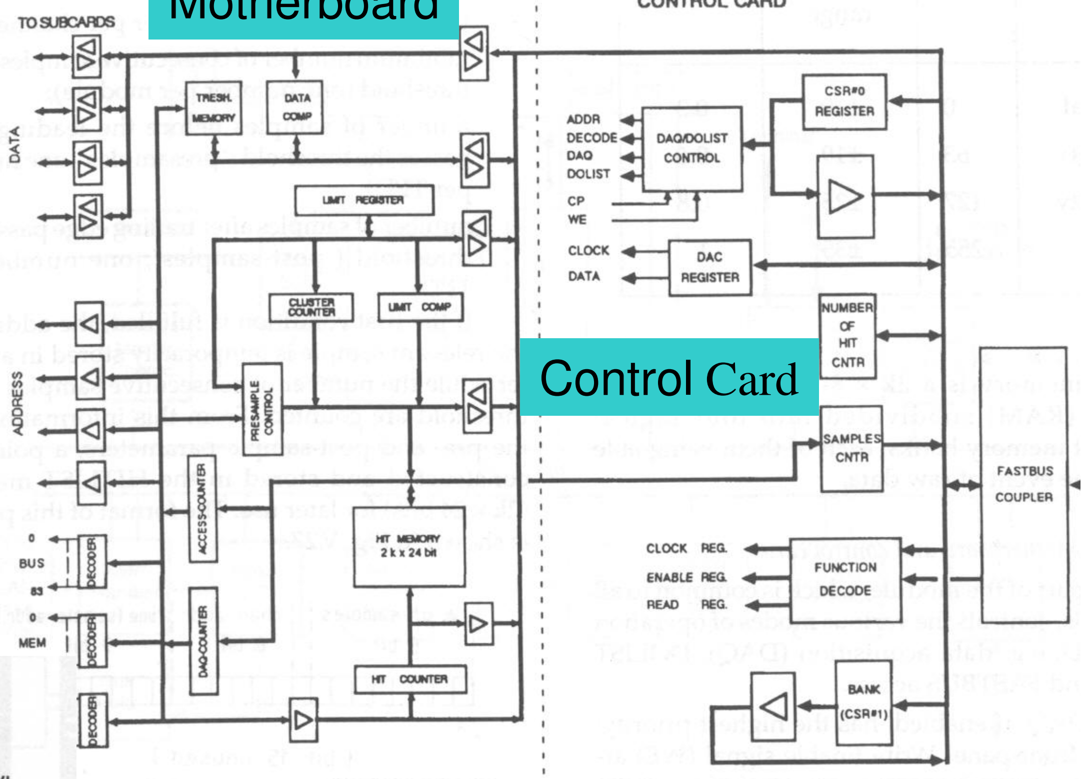


470n
+5V
7 +5V
T8
50
T1 MMBF 4393
720
1.5k
T2
T3
2×BF550
T11 6 BCW 61D
Signal Input 2
20
T9
6 Positive Output
50
2×10p1%
CFA CFB
6k
RF
2M
T4
BCW 61D
T10
5 Negative Output
50
T12 BCW 61D
DS
T5
OV
3 GND 8
T6
T7
−5V
4 −5V
PAD – PREAMPLIFIER

Fig. V.23 Circuit diagram of the pad amplifier.

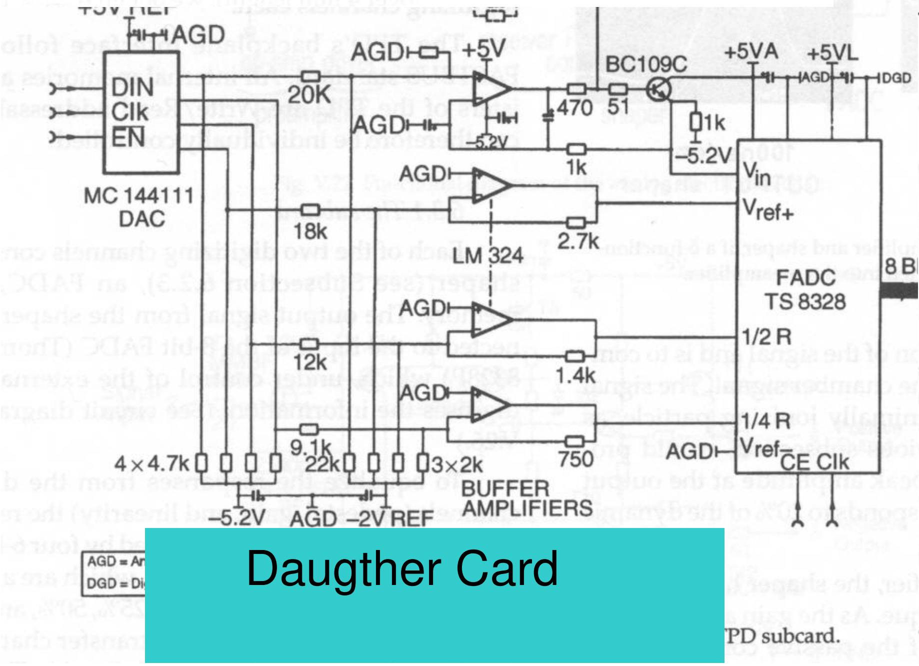
Motherboard

Control Card



TO SUBCARDS
DATA
TRESH MEMORY
DATA COMP
LIMIT REGISTER
CLUSTER COUNTER
LIMIT COMP
PRESAMPLE CONTROL
ADDRESS
ACCESS-COUNTER
HIT MEMORY 2 k x 24 bit
DAQ-COUNTER
HIT COUNTER
BUS
MEM
DECODER
CONTROL CARD
ADDR DECODE
DAQ DOLIST
CP
WE
CLOCK
DATA
DAQ/DOLIST CONTROL
CSR#0 REGISTER
DAC REGISTER
NUMBER OF HIT CNTR
SAMPLES CNTR
FASTBUS COUPLER
CLOCK REG.
ENABLE REG.
READ REG.
FUNCTION DECODE
BANK (CSR#1)

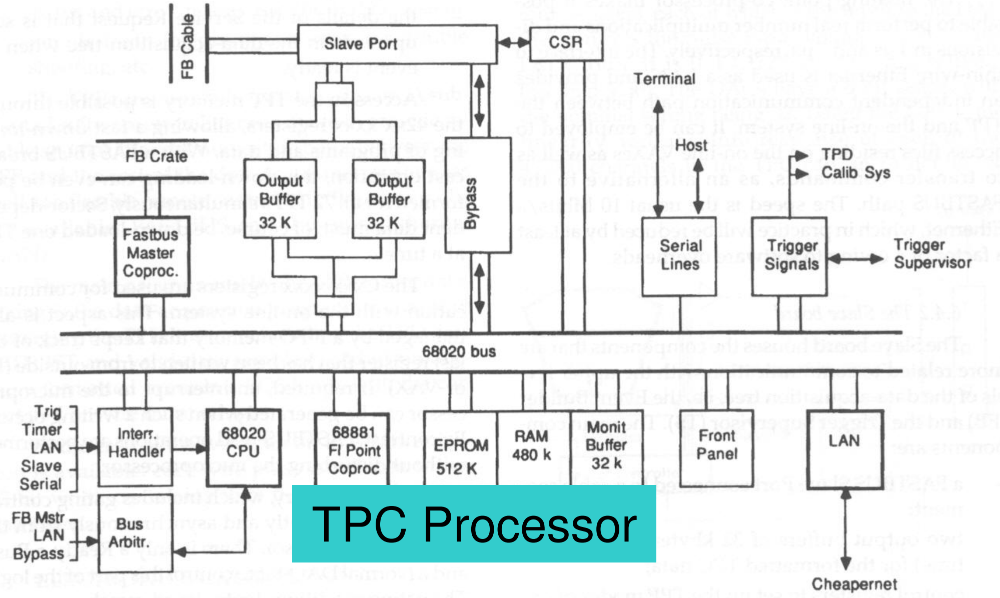
Daugther Card



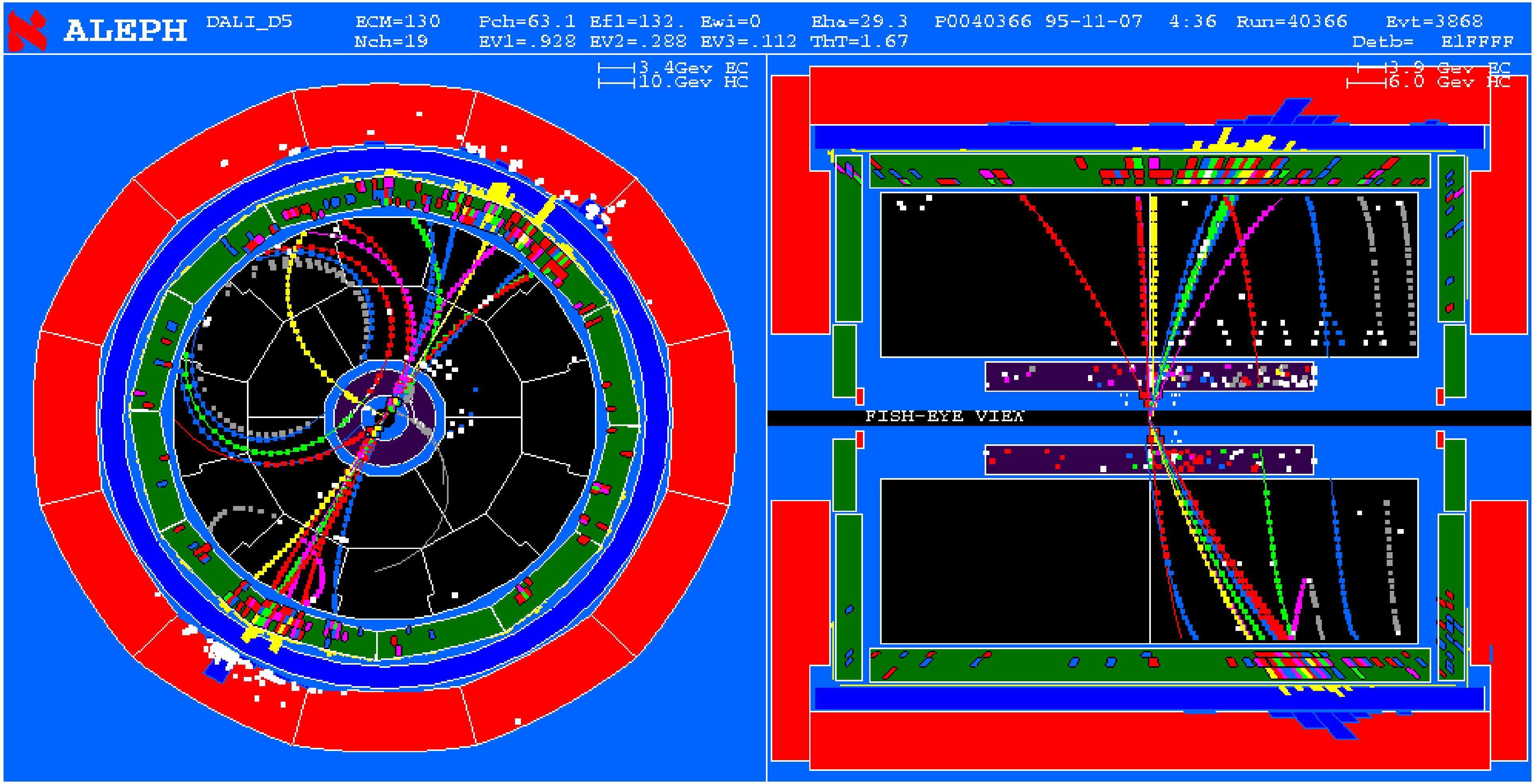
+5V REF
AGD
DIN
Clk
EN
MC 144111 DAC
20K
AGD
+5V
AGD
−5.2V
BC109C
+5VA
+5VL
AGD
DGD
470
51
1k
−5.2V
1k
Vin
Vref+
18k
2.7k
LM 324
FADC TS 8328
8 B
12k
1.4k
1/2 R
9.1k
1/4 R
4 × 4.7k
22k
3×2k
750
AGD
Vref−
CE Clk
BUFFER AMPLIFIERS
−5.2V
AGD
−2V REF
AGD = An
DGD = Di

TPD subcard.

TPC Processor

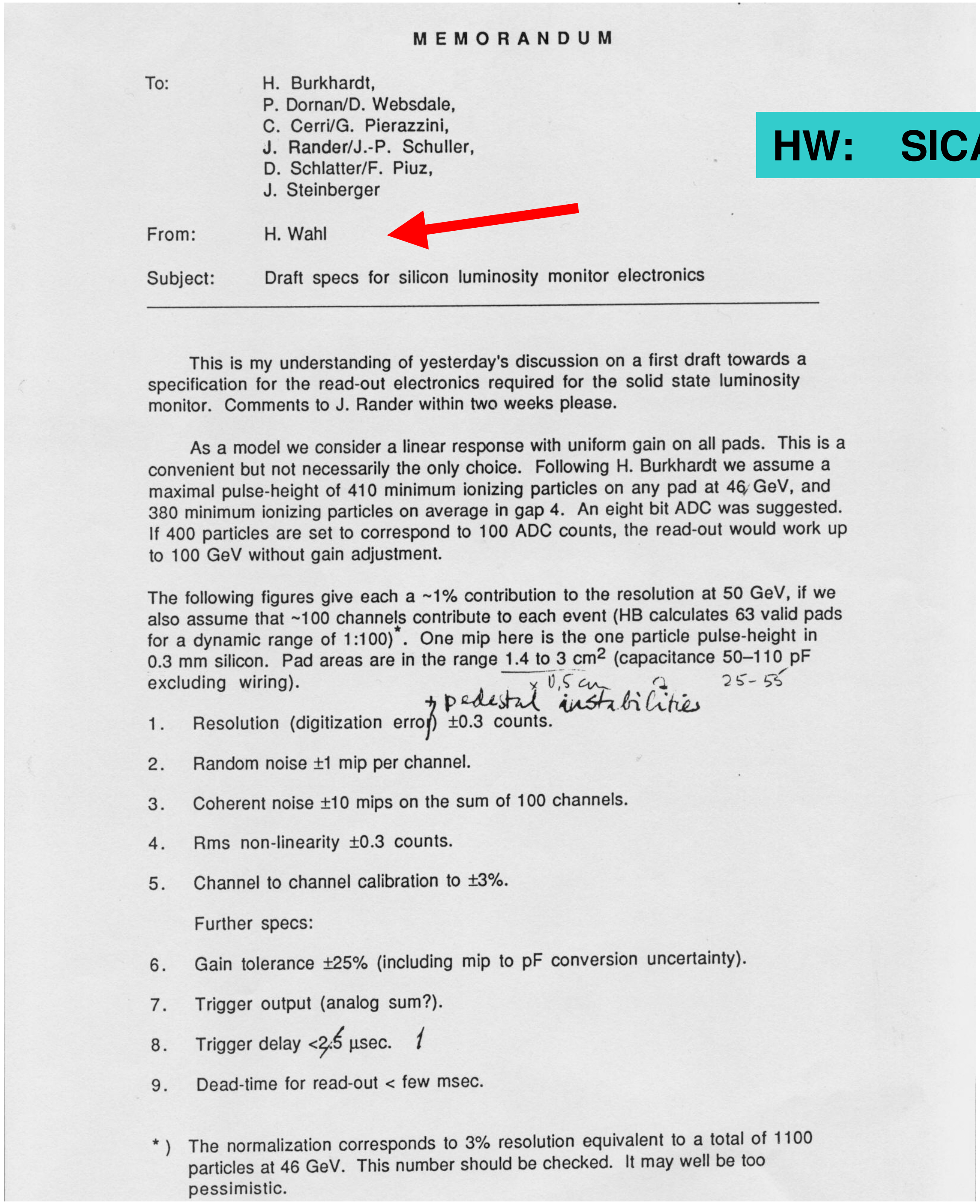


FB Cable
Slave Port
CSR
Terminal
FB Crate
Output Buffer 32 K
Output Buffer 32 K
Bypass
Host
TPD Calib Sys
Fastbus Master Coproc.
Serial Lines
Trigger Signals
Trigger Supervisor
68020 bus
Trig
Timer
LAN
Slave
Serial
FB Mstr
LAN
Bypass
Interr. Handler
68020 CPU
68881 Fl Point Coproc
EPROM 512 K
RAM 480 k
Monit Buffer 32 k
Front Panel
LAN
Bus Arbitr.
Cheapernet


ALEPH
DALI_D5
ECM=130
Nch=19
Pch=63.1 Efl=132. Ewi=0 Eha=29.3
EV1=.928 EV2=.288 EV3=.112 ThT=1.67
P0040366 95-11-07 4:36 Run=40366 Evt=3868
Detb= E1FFFF
3.4Gev EC
10.Gev HC
3.9 Gev EC
6.0 Gev HC
FISH-EYE VIEW

3-D track points

HW: SICAL electronics



MEMORANDUM

To: H. Burkhardt,
P. Dornan/D. Websdale,
C. Cerri/G. Pierazzini,
J. Rander/J.-P. Schuller,
D. Schlatter/F. Piuz,
J. Steinberger

From: H. Wahl

Subject: Draft specs for silicon luminosity monitor electronics

---

This is my understanding of yesterday's discussion on a first draft towards a specification for the read-out electronics required for the solid state luminosity monitor. Comments to J. Rander within two weeks please.

As a model we consider a linear response with uniform gain on all pads. This is a convenient but not necessarily the only choice. Following H. Burkhardt we assume a maximal pulse-height of 410 minimum ionizing particles on any pad at 46 GeV, and 380 minimum ionizing particles on average in gap 4. An eight bit ADC was suggested. If 400 particles are set to correspond to 100 ADC counts, the read-out would work up to 100 GeV without gain adjustment.

The following figures give each a ~1% contribution to the resolution at 50 GeV, if we also assume that ~100 channels contribute to each event (HB calculates 63 valid pads for a dynamic range of 1:100)*. One mip here is the one particle pulse-height in 0.3 mm silicon. Pad areas are in the range 1.4 to 3 cm^2 (capacitance 50–110 pF excluding wiring).

× 0,5 cm ? 25–55

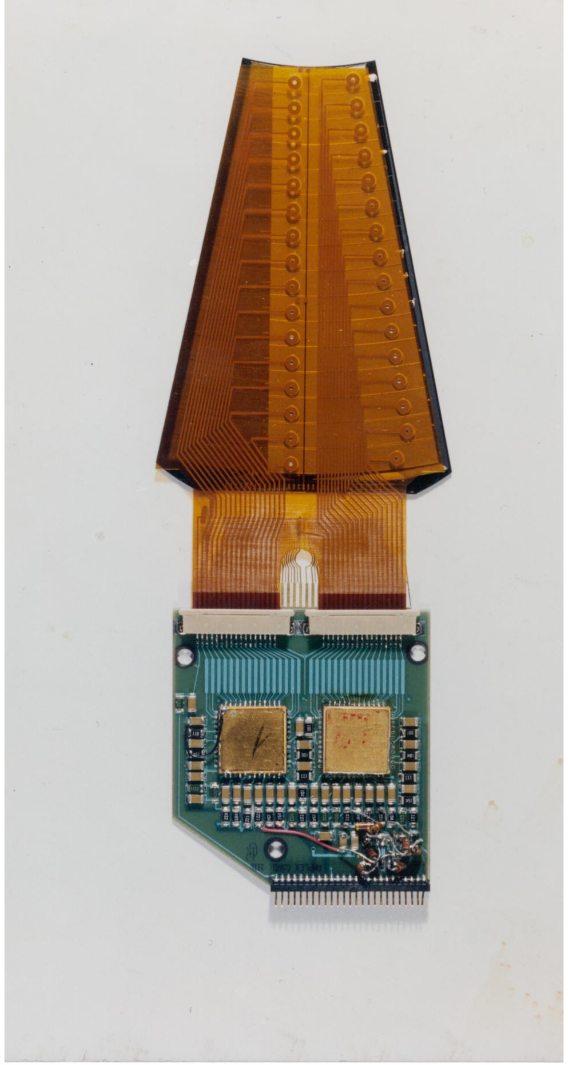
1. Resolution (digitization error) ±0.3 counts. + pedestal instabilities
2. Random noise ±1 mip per channel.
3. Coherent noise ±10 mips on the sum of 100 channels.
4. Rms non-linearity ±0.3 counts.
5. Channel to channel calibration to ±3%.

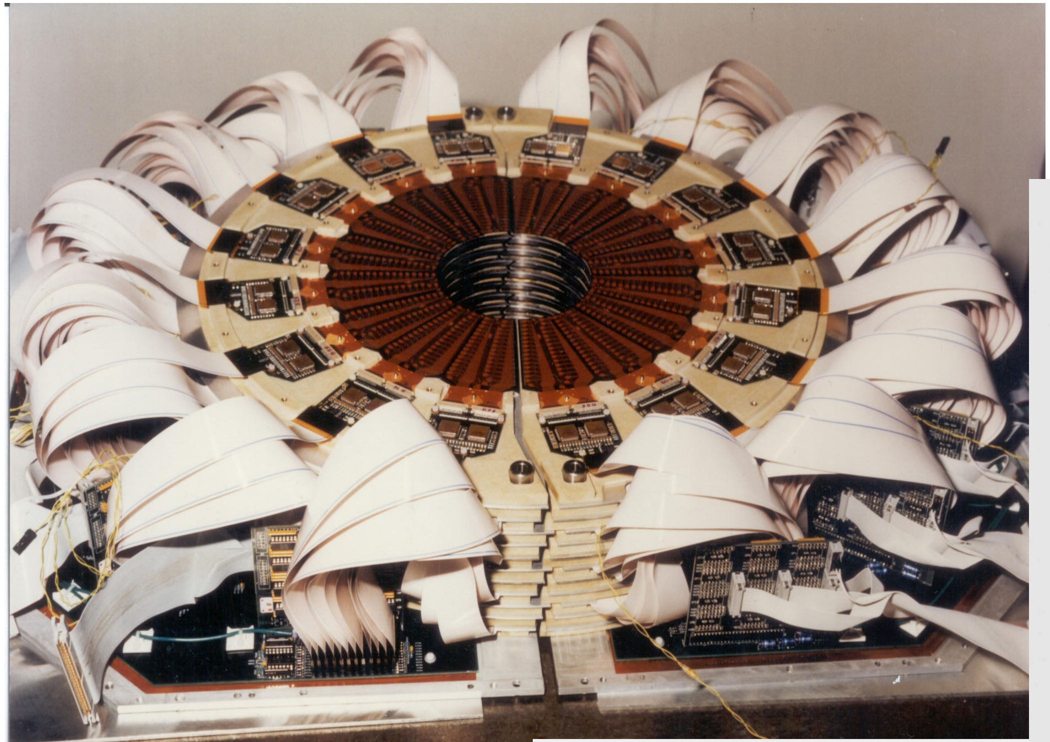
Further specs:

6. Gain tolerance ±25% (including mip to pF conversion uncertainty).
7. Trigger output (analog sum?).
8. Trigger delay <~~2~~.5 µsec. 1
9. Dead-time for read-out < few msec.

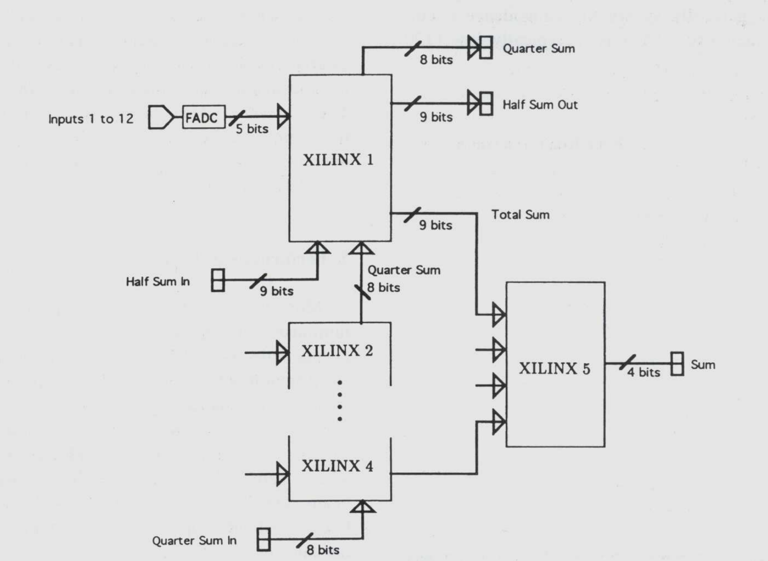
---

*) The normalization corresponds to 3% resolution equivalent to a total of 1100 particles at 46 GeV. This number should be checked. It may well be too pessimistic.





Trigger Mixer


Quarter Sum
8 bits
Half Sum Out
9 bits
Inputs 1 to 12
FADC
5 bits
XILINX 1
Total Sum
9 bits
Half Sum In
9 bits
Quarter Sum
8 bits
XILINX 2
XILINX 5
4 bits
Sum
XILINX 4
Quarter Sum In
8 bits

AMPLEX- SICAL

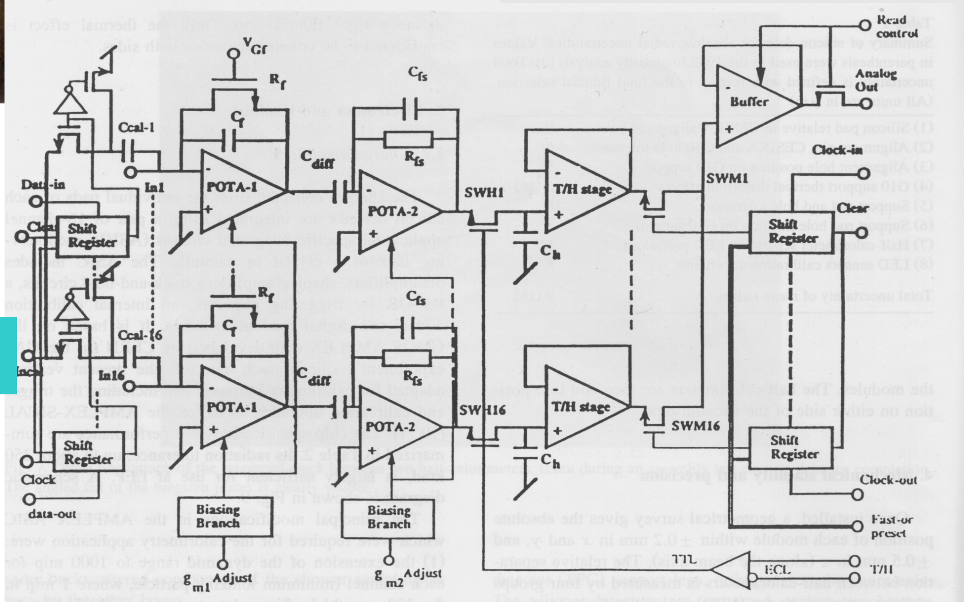
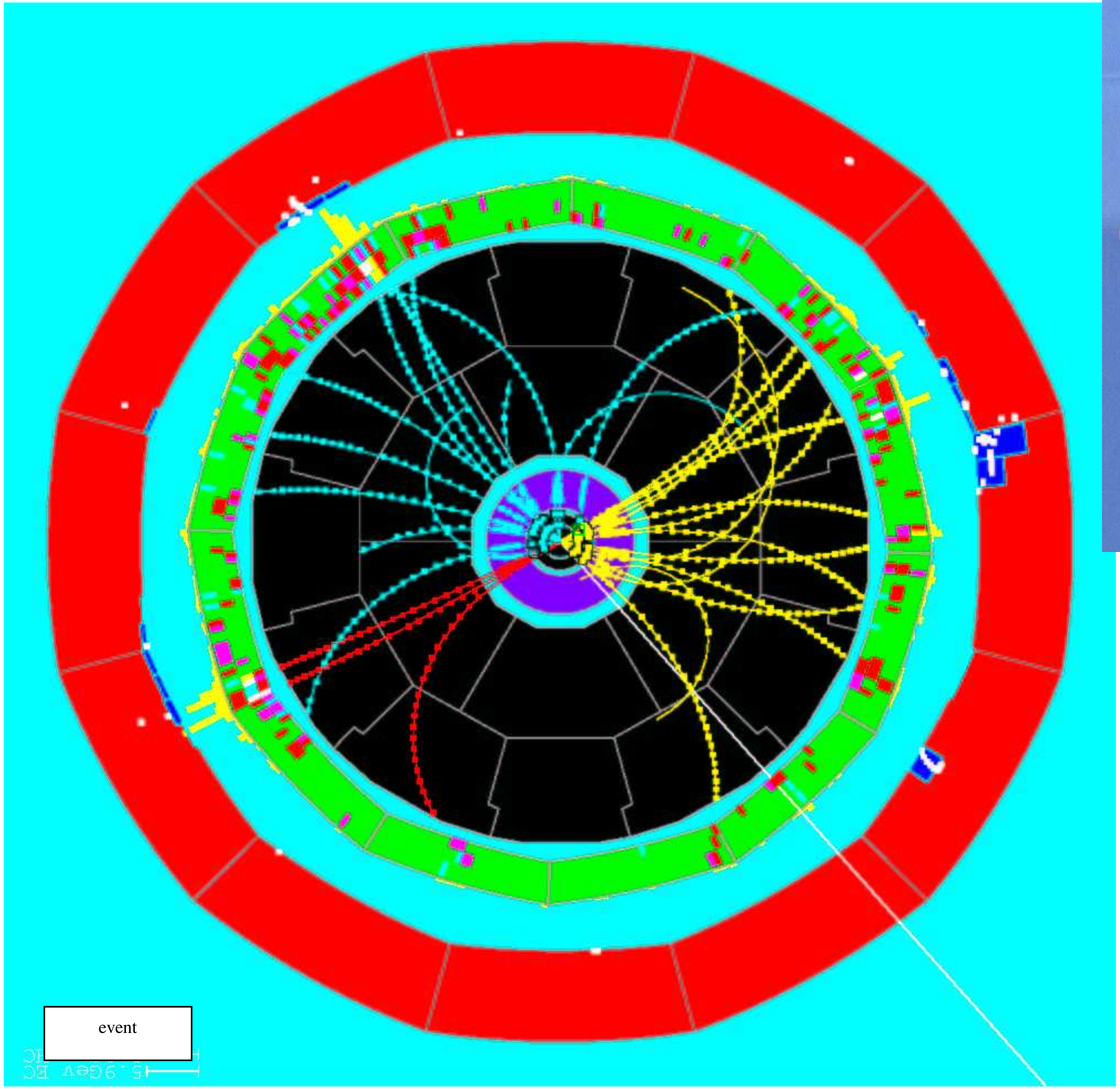
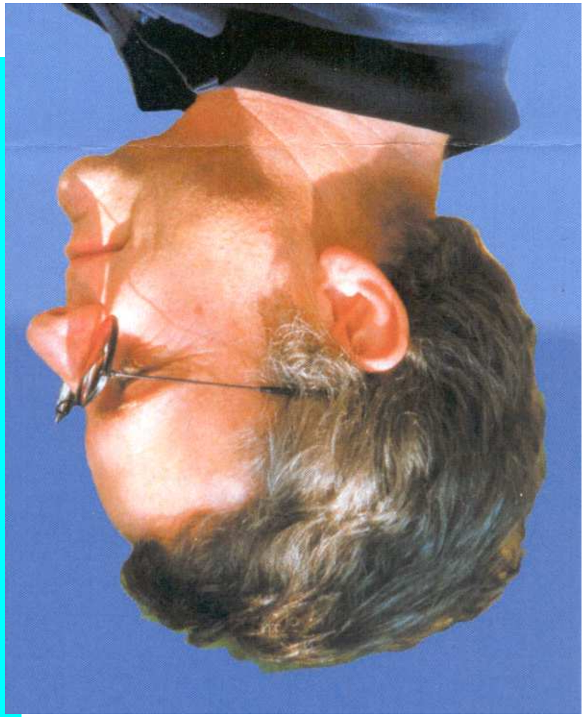

Read control
V_{Gf}
R_f
C_{fs}
Analog Out
Buffer
Ccal-1
C_f
C_{diff}
R_{fs}
Clock-in
Data-in
In1
POTA-1
POTA-2
SWH1
T/H stage
SWM1
Clear
Shift Register
Shift Register
C_h
R_f
C_{fs}
Ccal-16
C_f
R_{fs}
In16
C_{diff}
POTA-1
POTA-2
SWH16
T/H stage
SWM16
Shift Register
Shift Register
C_h
Clock
Clock-out
data-out
Biasing Branch
Biasing Branch
Fast-or preset
TTL
ECL
T/H
g_{m1} Adjust
g_{m2} Adjust

Fig. 9. AMPLEX-SICAL schematic diagram.


event
5.9Gev EC