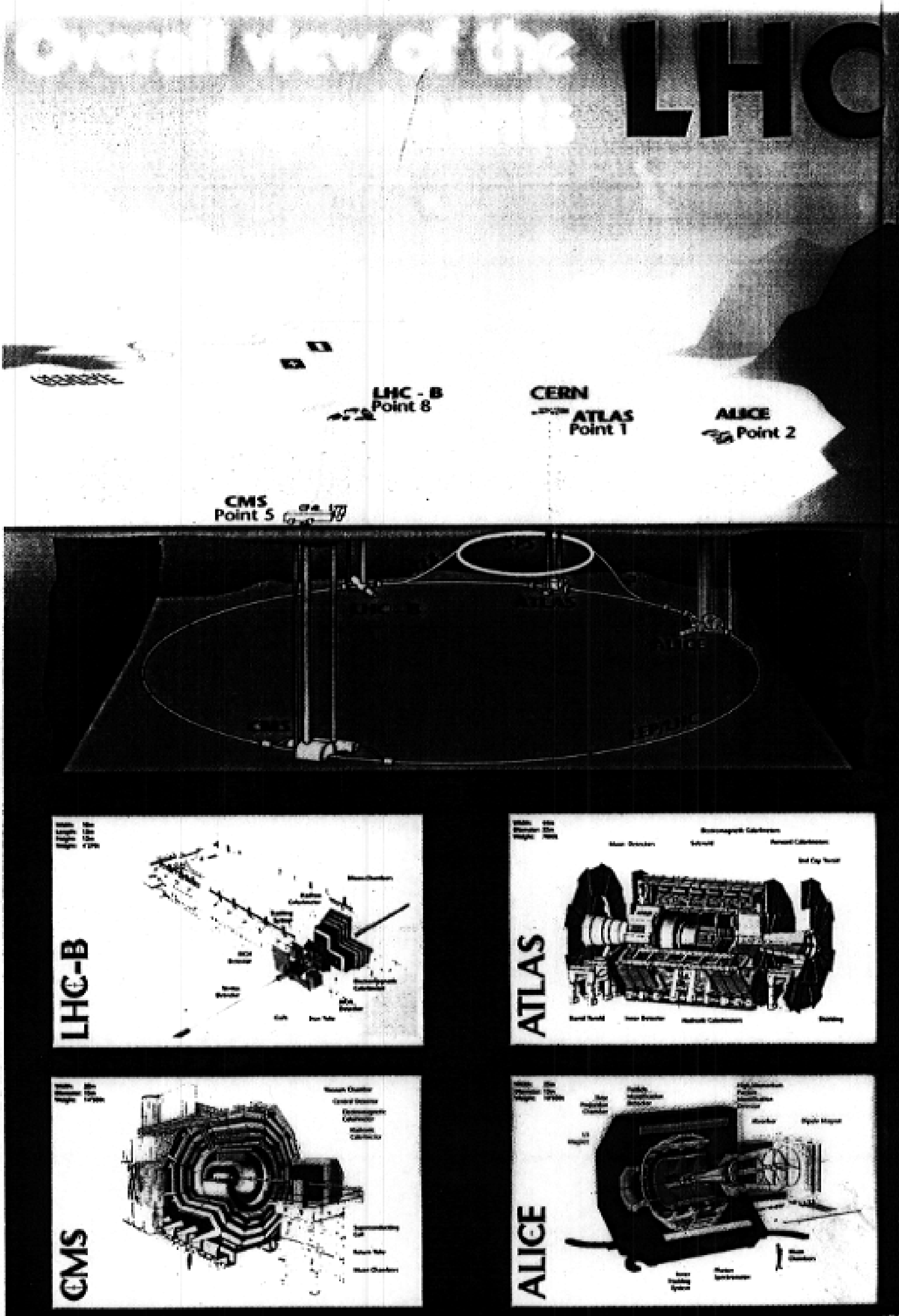
STATUS OF THE LHC EXPERIMENTS

R. J Cashmore

ICFA 5.10.99

- ATLAS, CMS, ALICE, LHCb
  TOTEM, MOEDAL
- PHYSICS + COMPUTING


LHC
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
LHC-B
ATLAS
CMS
ALICE

APPROVAL + MONITORING PROCESS

LHCC

- Letter of Intent
- Technical Proposal } Approval by LHCC + RB
- Technical Design Reports

  → Approval by LHCC → RB

- ATLAS : Production Readiness Review
  CMS : Engineering Design Review

- Regular review by the LHCC

RRB

- Monitor & Approve Resources
  (year-by-year)
- Receive technical progress reports

Status of ATLAS TDRs

	Submitted	*Approval Research Board*
Calorimetry TDRs	December 1996	June 1997
Inner Detector TDRs	April 1997	September 1997
Pixel TDR	May 1998	September 1998
Muon Spectrometer	May 1997	September 1997
Magnet System TDRs	April 1997	September 1997
Trigger and DAQ TDRs		
Level-1	June 1998	September 1998
High levels, DAQ	2001	
Technical Co-ord. TDR	January 1999	[redacted] June 1999
Computing TP	December 1996	June 1997

⇒ In construction

Status of CMS TDRs

	Submitted	*Approval Research Board*
Magnet TDR	May 1997	September 1997
HCAL TDR	June 1997	September 1997
ECAL TDR	December 1997	April 1998
Muon TDR	December 1997	April 1998
Tracker TDR	April 1998	September 1998
Trigger TDR	2000	
DAQ TDR	2001	
Computing TP	December 1996	June 1997

⇒ In construction

Status of ALICE TDRs

	Submitted	Approval Research Board
RICH HMPID TDR	August 1998	November 1998
Photon Spectrometer TDR	March 1999	June 1999
Zero Degree Cal. TDR	March 1999	June 1999
Inner Tracker TDR	June 1999	Sept 1999
Muon Arm TDR	August 1999	
Time Projection Ch. TDR	~~September 1999~~ → Jan 2000	
TOF TDR	~~September 1999~~ → Jan 2000	
Computing TP	2000	

→ ALICE beginning construction

Status of the experiment:

- Detector parameters optimisation; cost vs. physics performance
- R&D, prototype construction and beam tests
- Decision on technologies

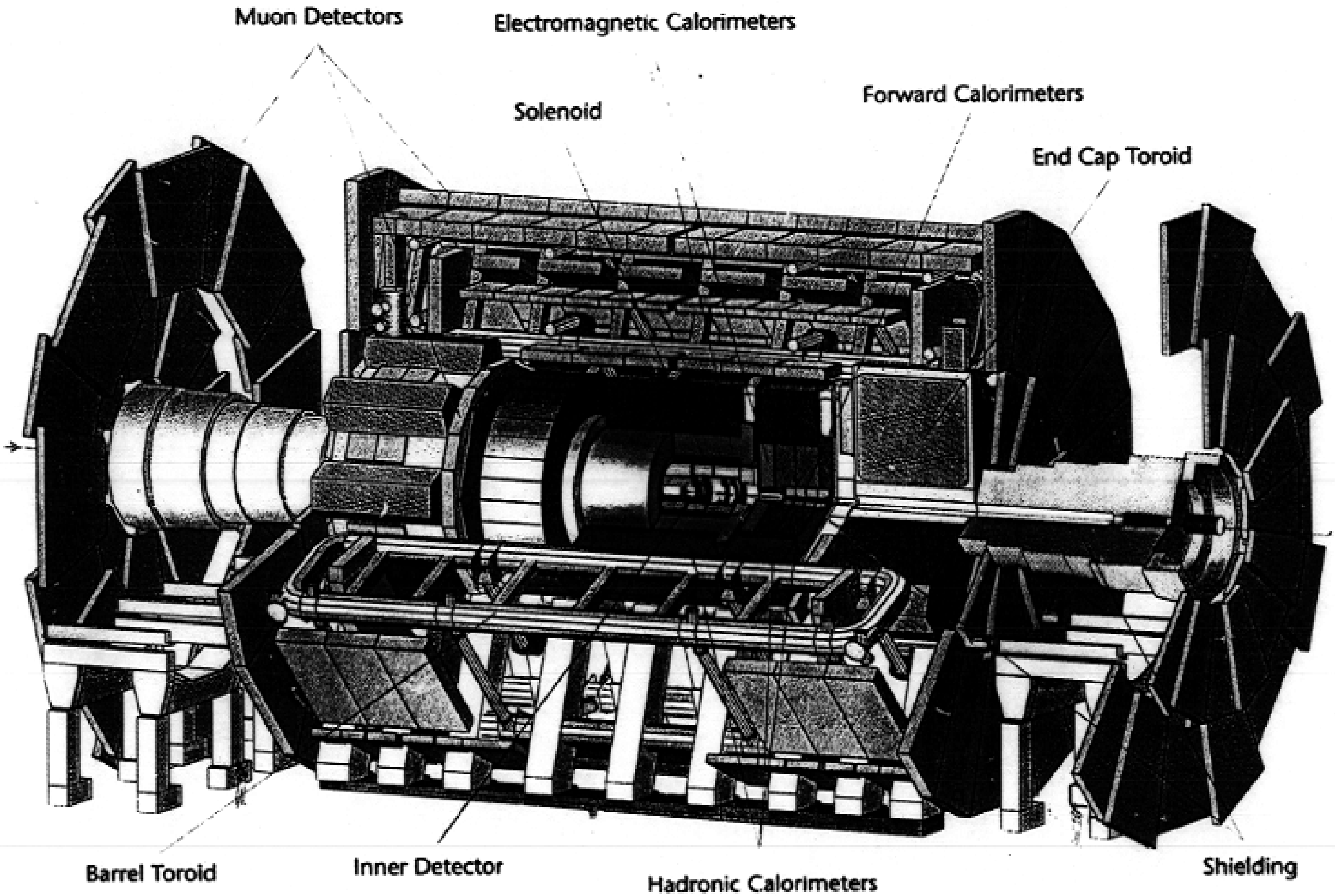
Goal → Technical Design Reports

Note: No final responsibilities are assigned to the institutes yet.

Plan for the TDR submissions

Magnet	Dec 1999 (call for tender)
Vertex	April 2001
Inner Tracker	September 2001
Outer Tracker	September 2000
RICH	June 2000
Muon	January 2001
Calorimeter	July 2000
Trigger	January 2002
DAQ	January 2002
Computing	July 2002

Technical
Proposal
Approved 1998



Muon Detectors
Electromagnetic Calorimeters
Solenoid
Forward Calorimeters
End Cap Toroid
Barrel Toroid
Inner Detector
Hadronic Calorimeters
Shielding

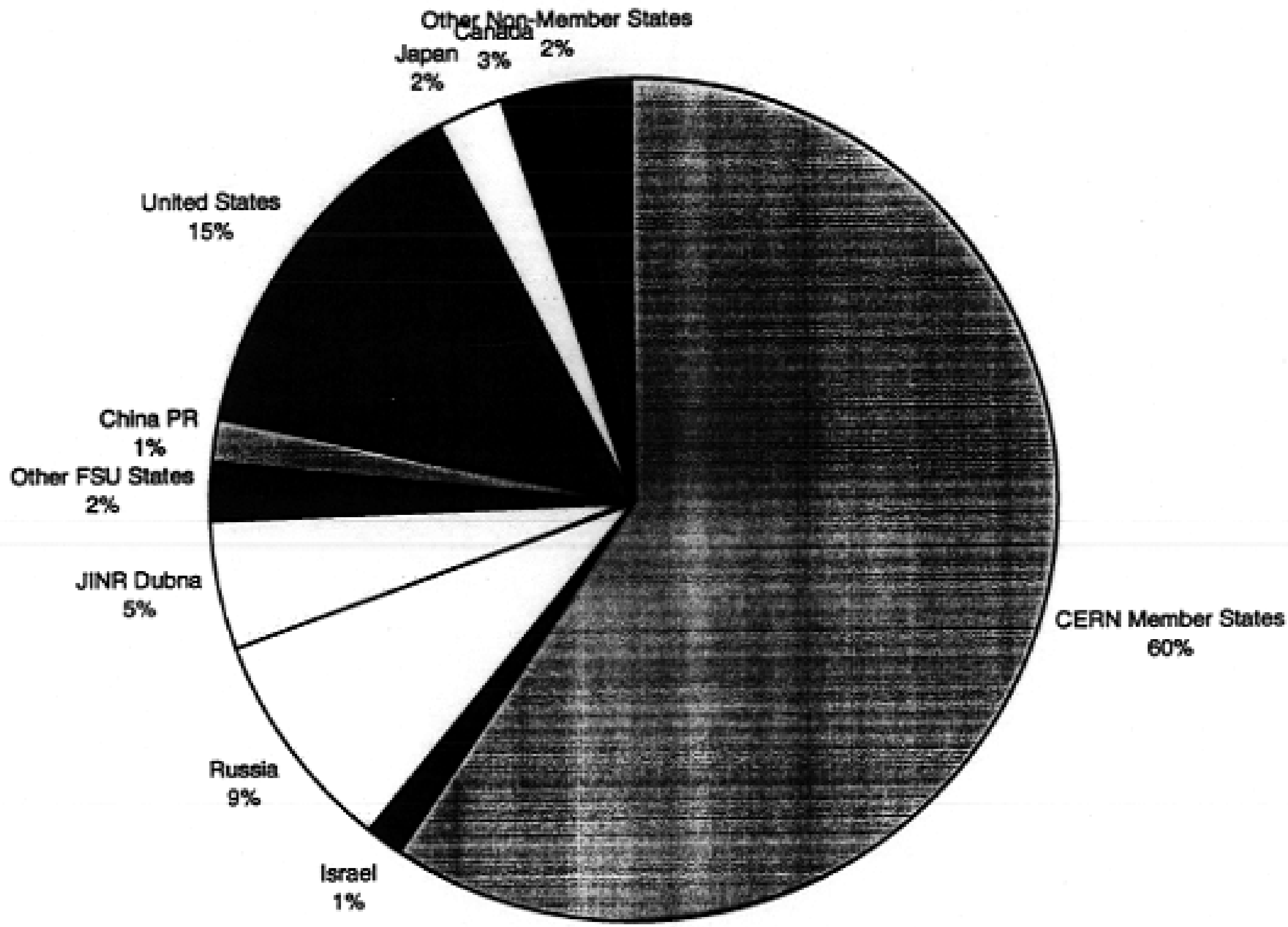
ATLAS Collaboration

(Status April 1999)

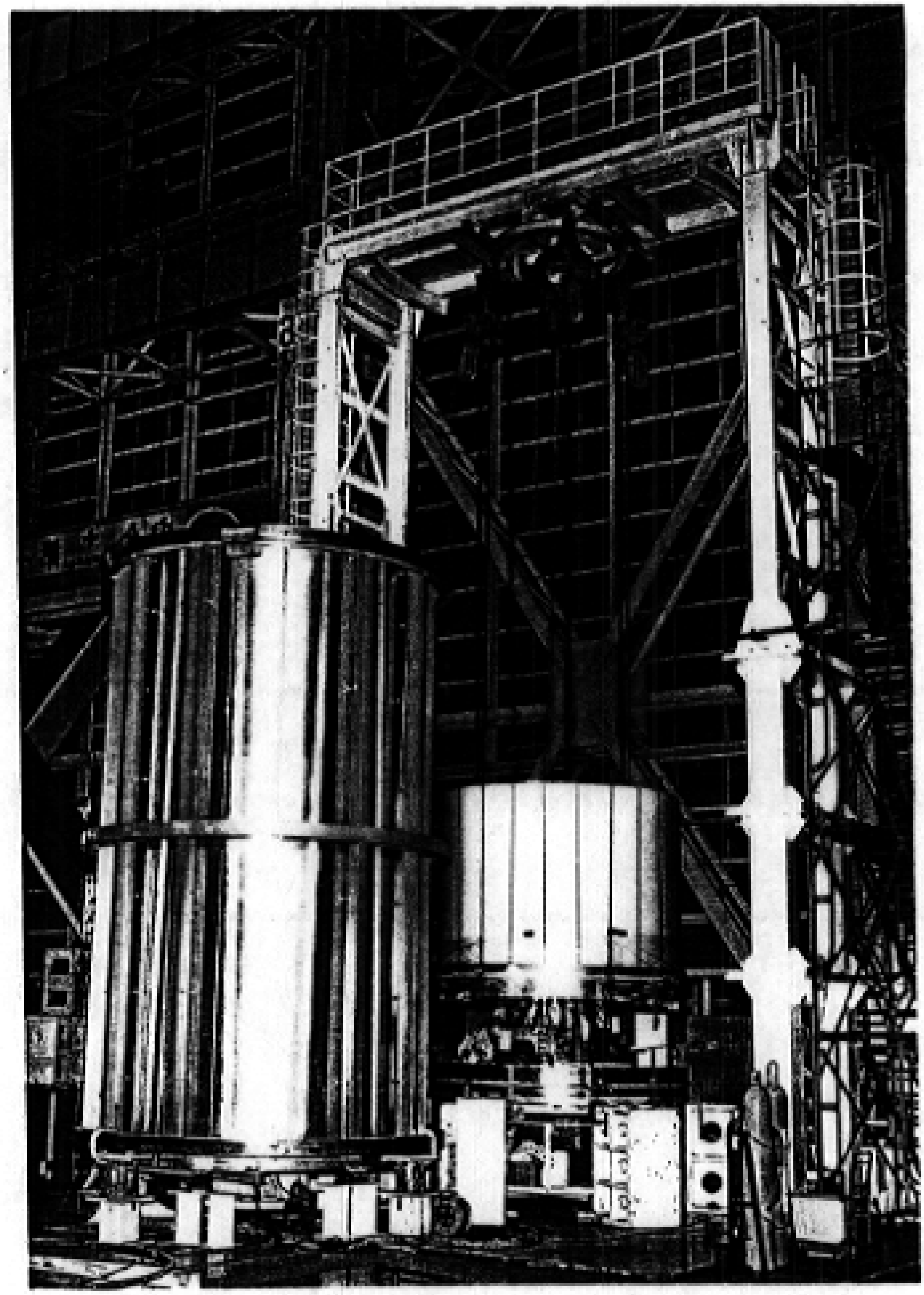
Albany, Alberta, NIKHEF Amsterdam, Ankara, Ann Arbor, LAPP Annecy, Argonne NL, Arizona, Arlington UT, Athens, NTU Athens, Baku, IFAE Barcelona, Bergen, Berkeley LBL and UC, Bern, Birmingham, Bonn, Boston, Brandeis, Bratislava/SAS Kosice, Brookhaven NL, Bucharest, Cambridge, Carleton/CRPP, Casablanca/Rabat, CERN, Chinese Cluster, Chicago, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, INP Cracow, FPNT Cracow, Dortmund, JINR Dubna, Duke, Edinburgh, Frascati, Freiburg, Fukui, Geneva, Genoa, Glasgow, ISN Grenoble, Technion Haifa, Hampton, Harvard, Heidelberg, Helsinki, Hiroshima, Hiroshima IT, Indiana, Innsbruck, Irvine UC, Istanbul Bogazici, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, Lecce, Lisbon LIP, Liverpool, Ljubljana, QMW London, RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, Mannheim, CPPM Marseille, MIT, Melbourne, Michigan SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, FIAN Moscow, ITEP Moscow, MEPhI Moscow, MSU Moscow, Munich LMU, MPI Munich, Nagasaki IAS, Naples, Naruto UE, New Mexico, Nijmegen, Northern Illinois, BINP Novosibirsk, Ohio SU, Oklahoma, LAL Orsay, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, UFRJ Rio de Janeiro, Rochester, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Southern Methodist, NPI Petersburg, Stockholm, KTH Stockholm, Stony Brook, Sydney, Tbilisi, Tel-Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Tokyo UAT, Toronto, TRIUMF, Tufts, Udine, Uppsala, Urbana UI, Valencia, UBC Vancouver, Victoria, Washington, Weizmann Rehovot, Wisconsin, Wuppertal, Yerevan

(146 Institutions with about 1800 authors)

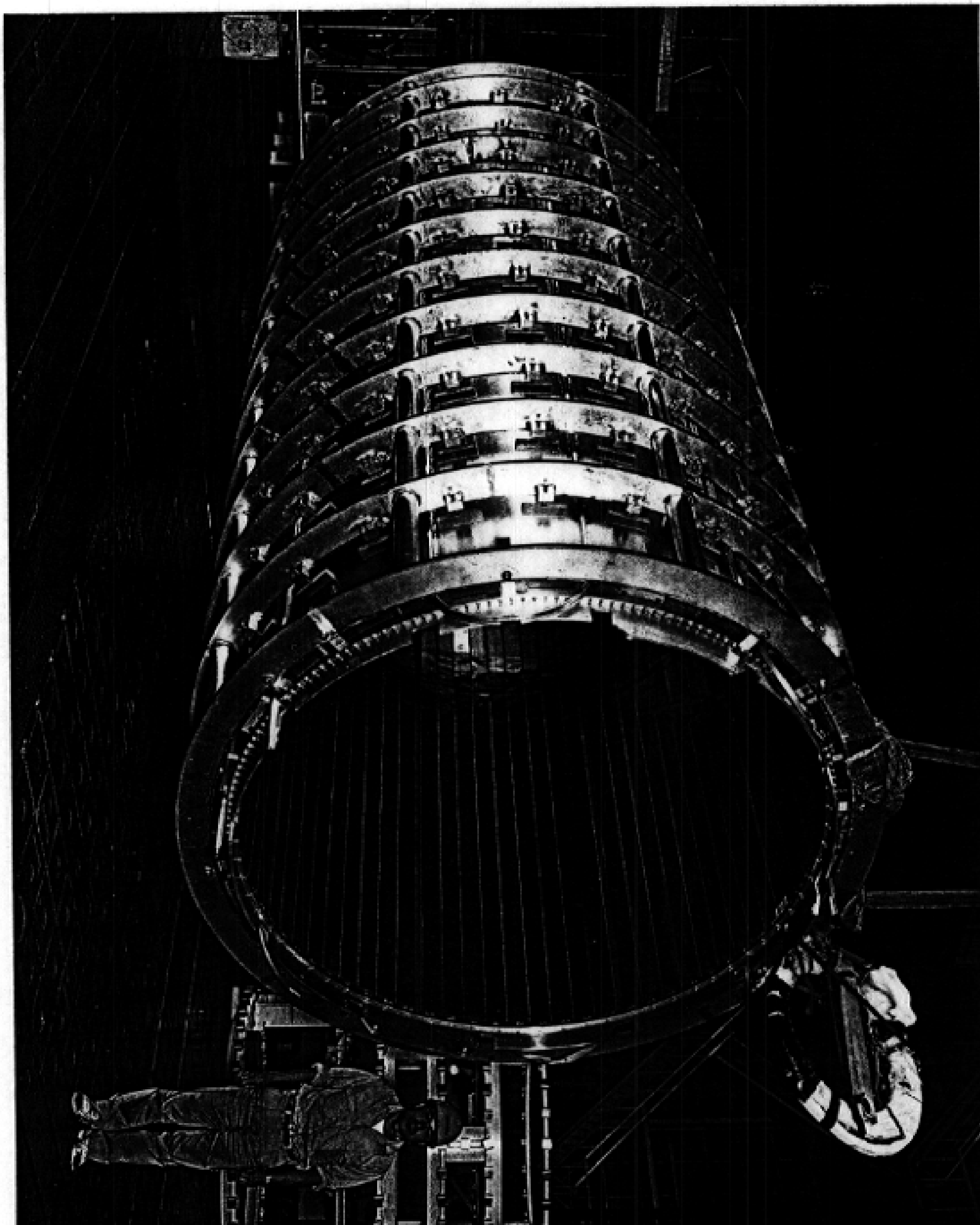
ATLAS Collaboration

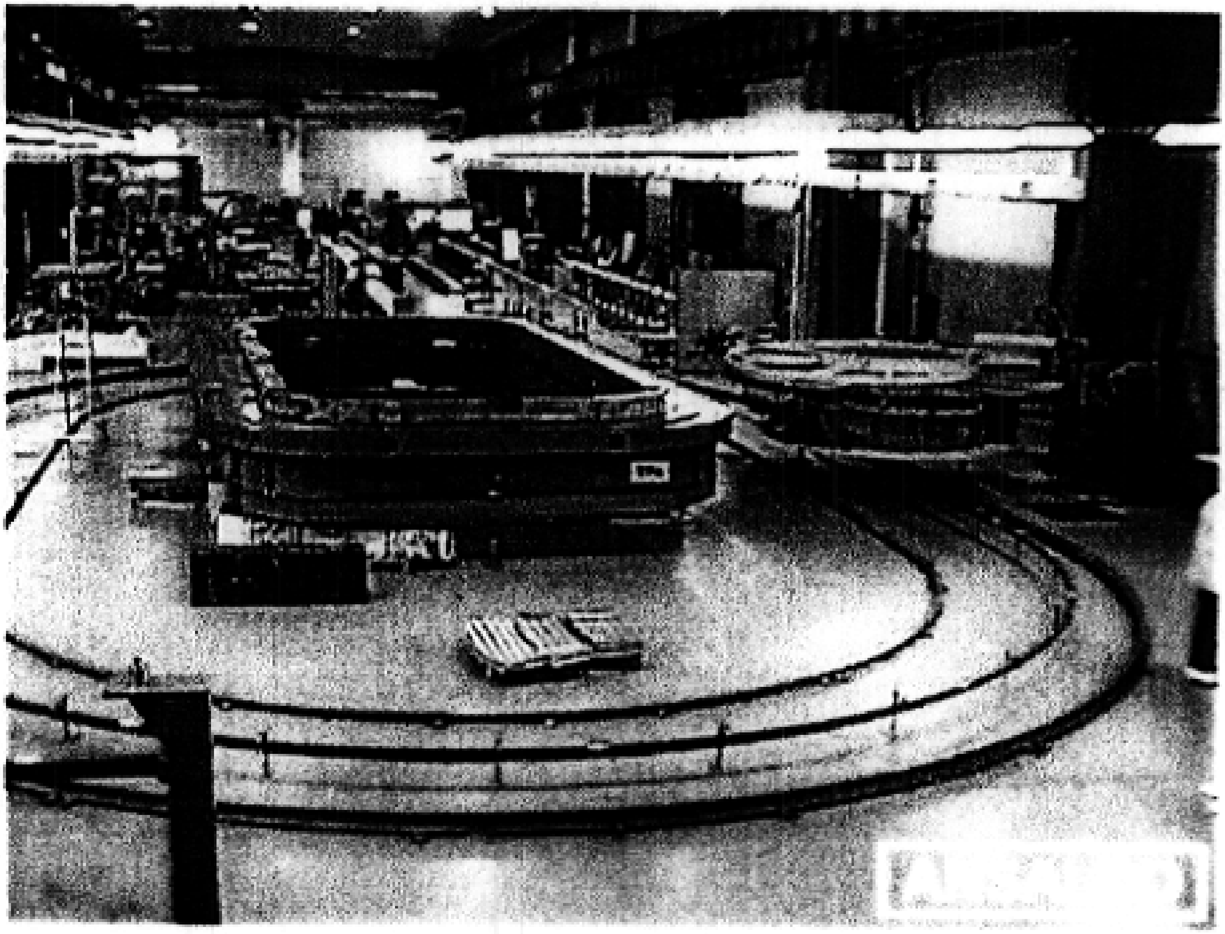


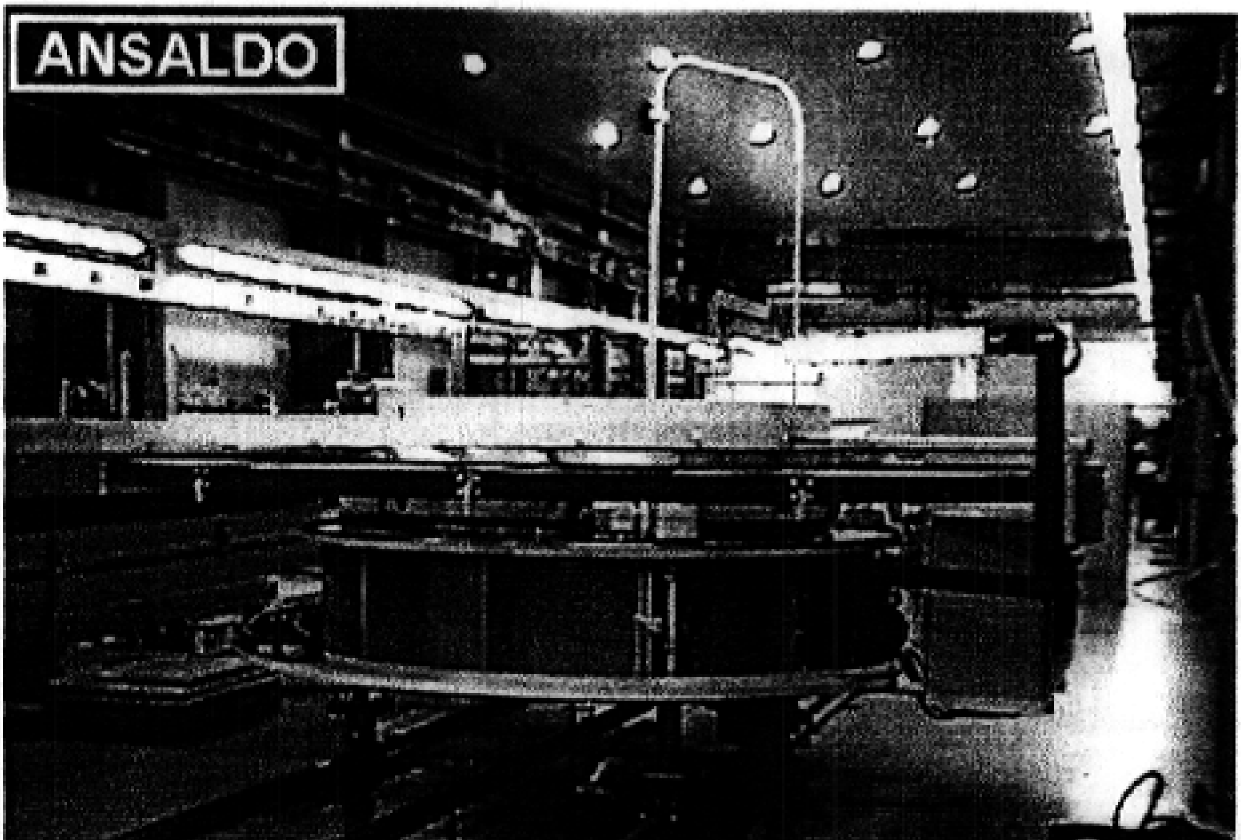
FUSO

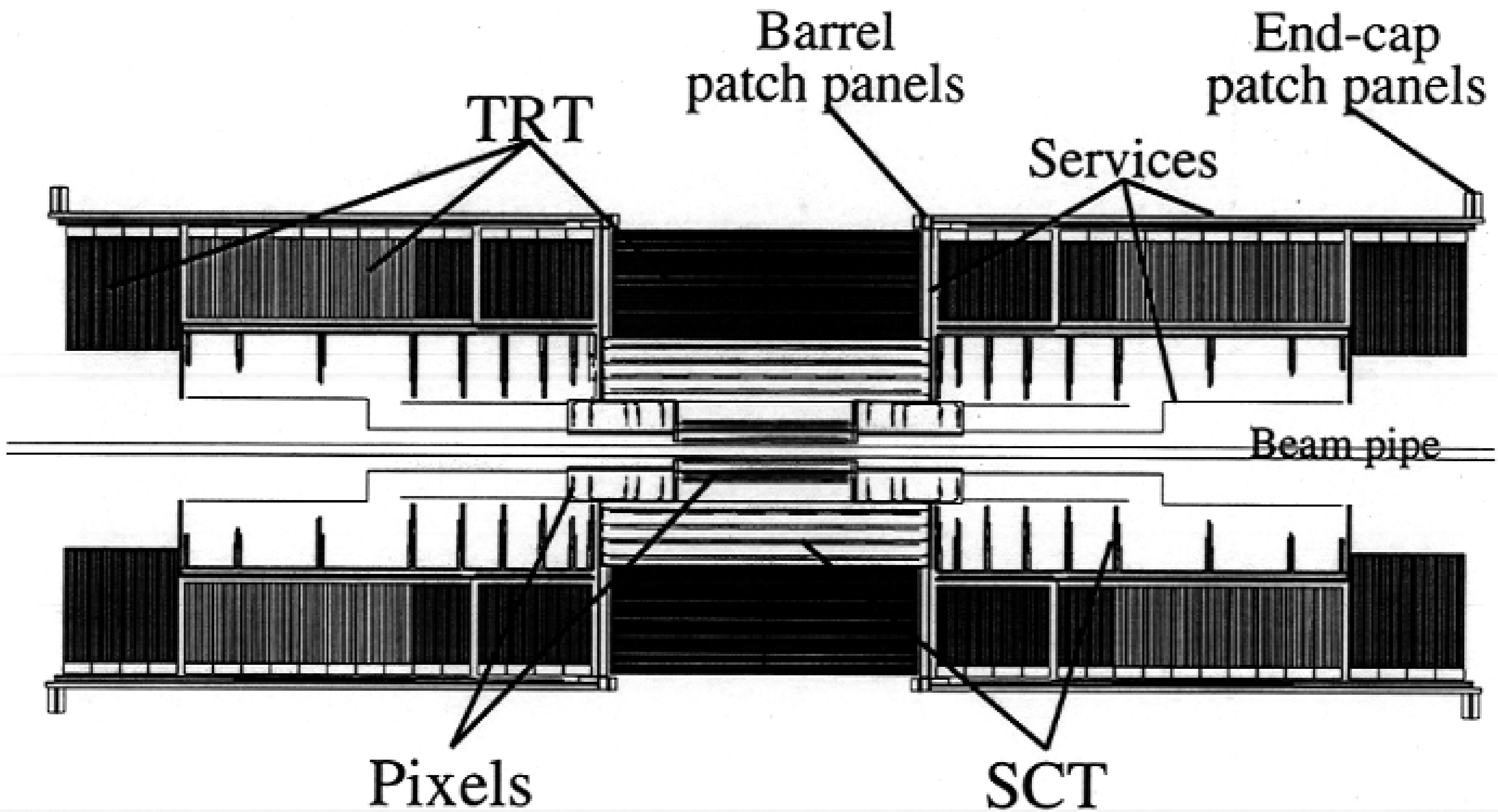


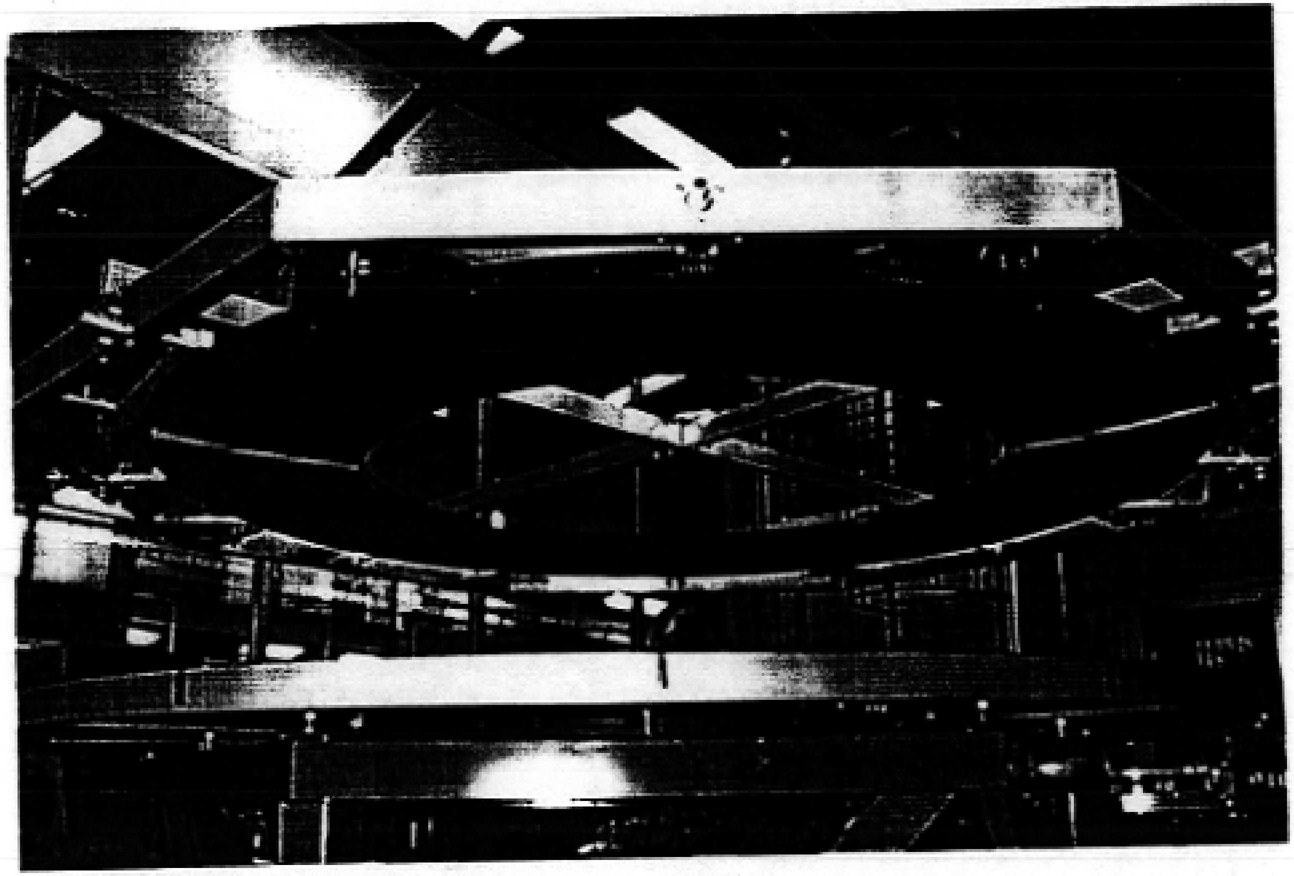
ATLAS Solenoid





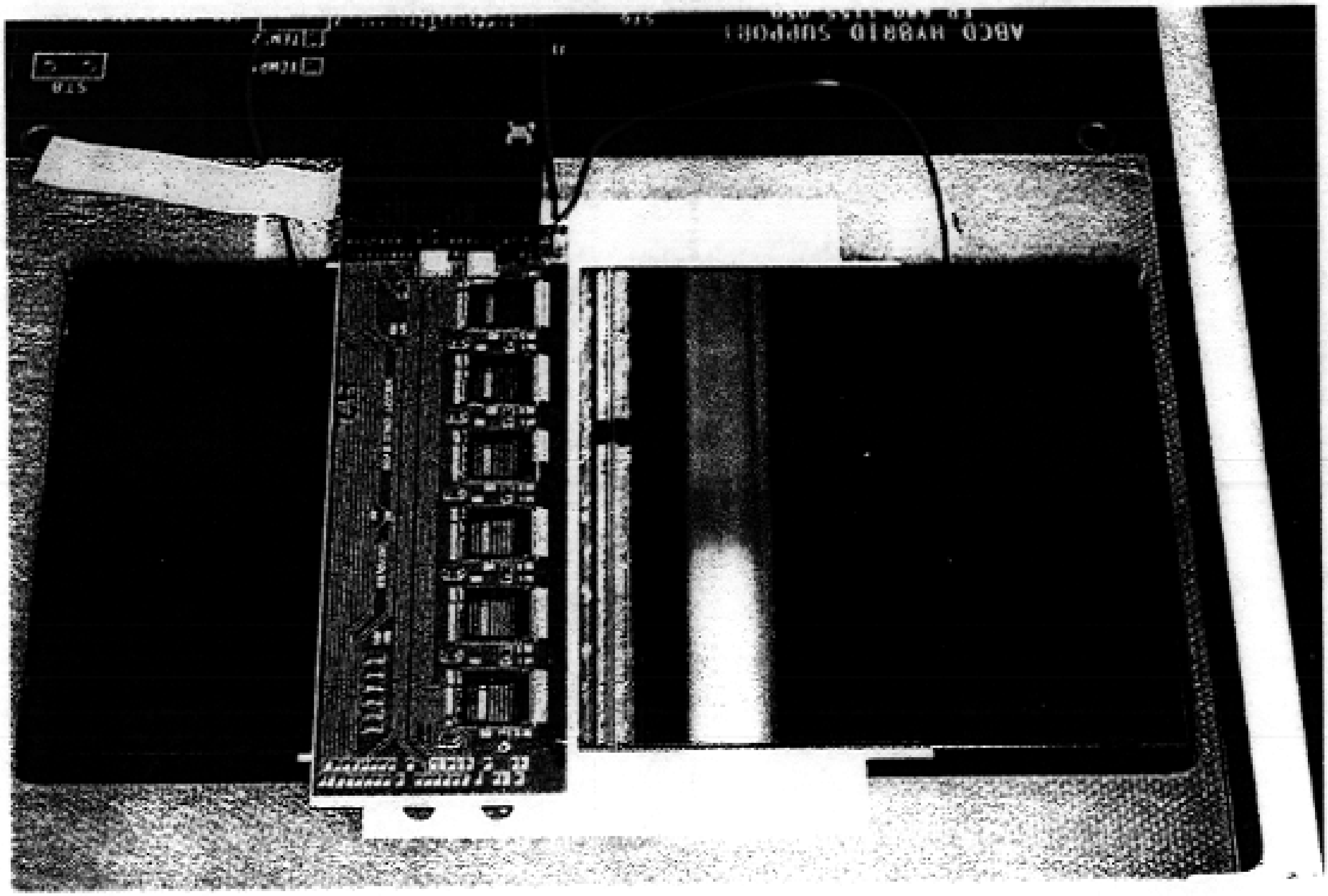

ANSALDO

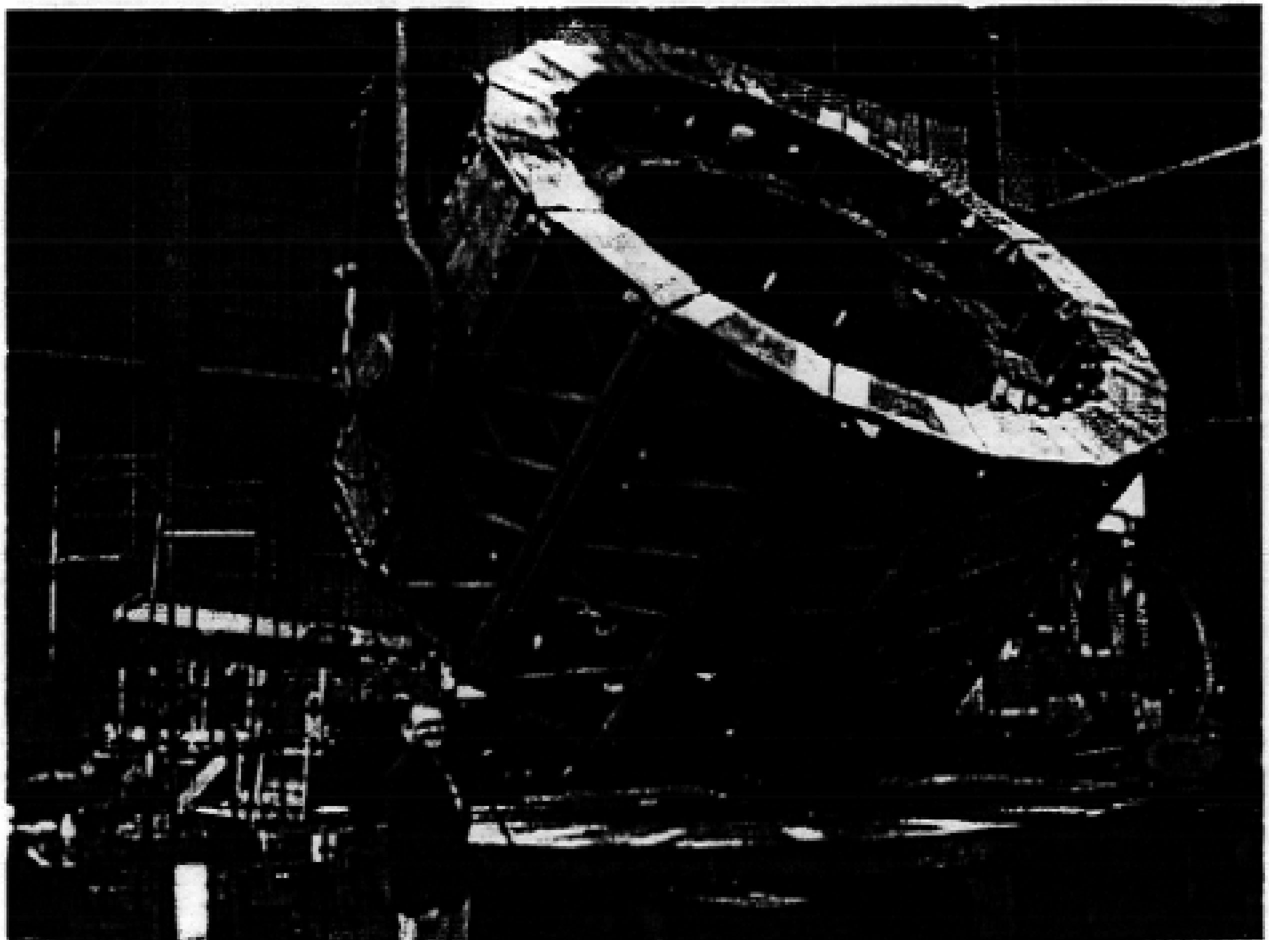

TRT
Barrel
patch panels
End-cap
patch panels
Services
Beam pipe
Pixels
SCT



End-cap TRT 4-plane module-0 in transport frame

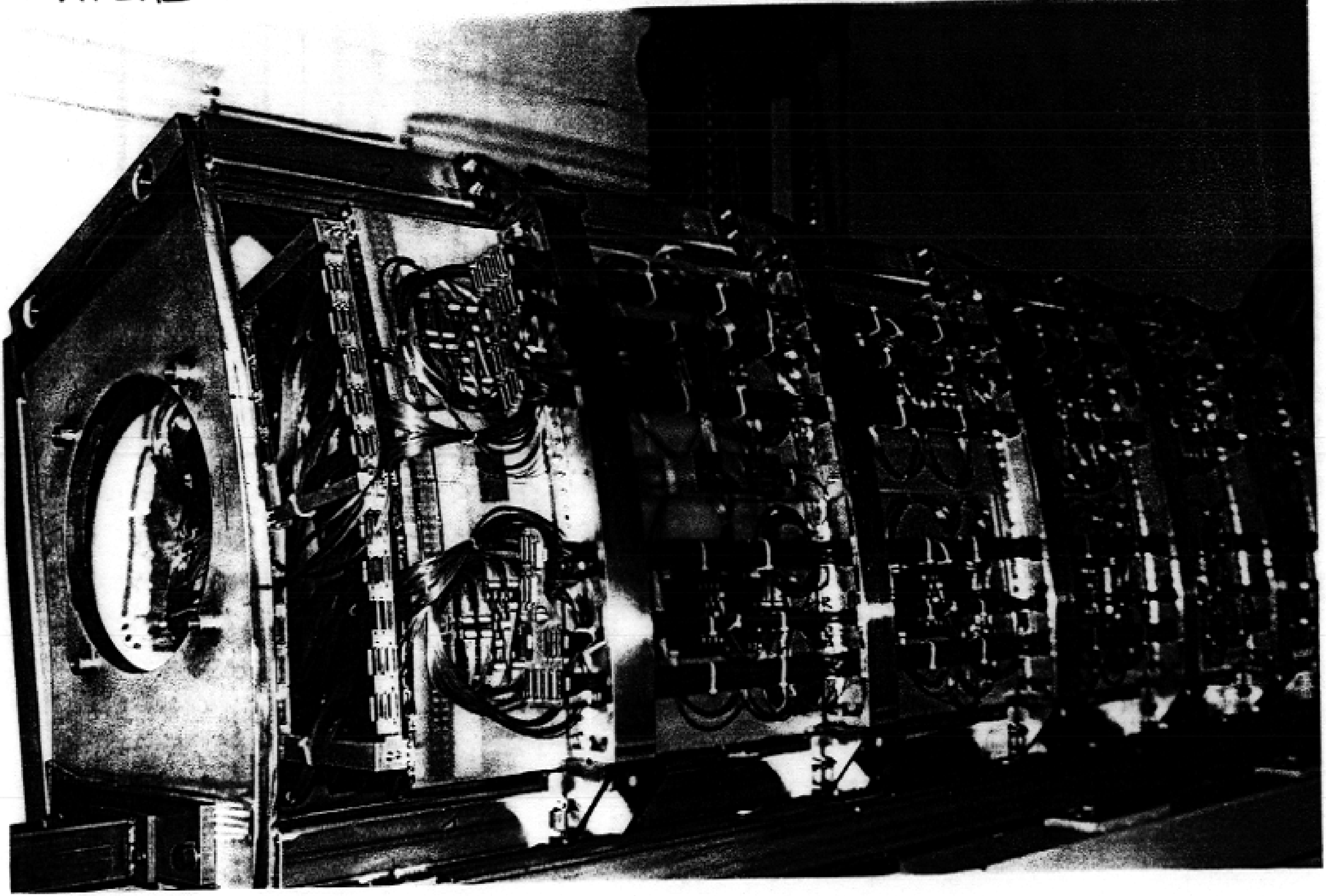
Single-Sided Detector Module with ABCD ICs

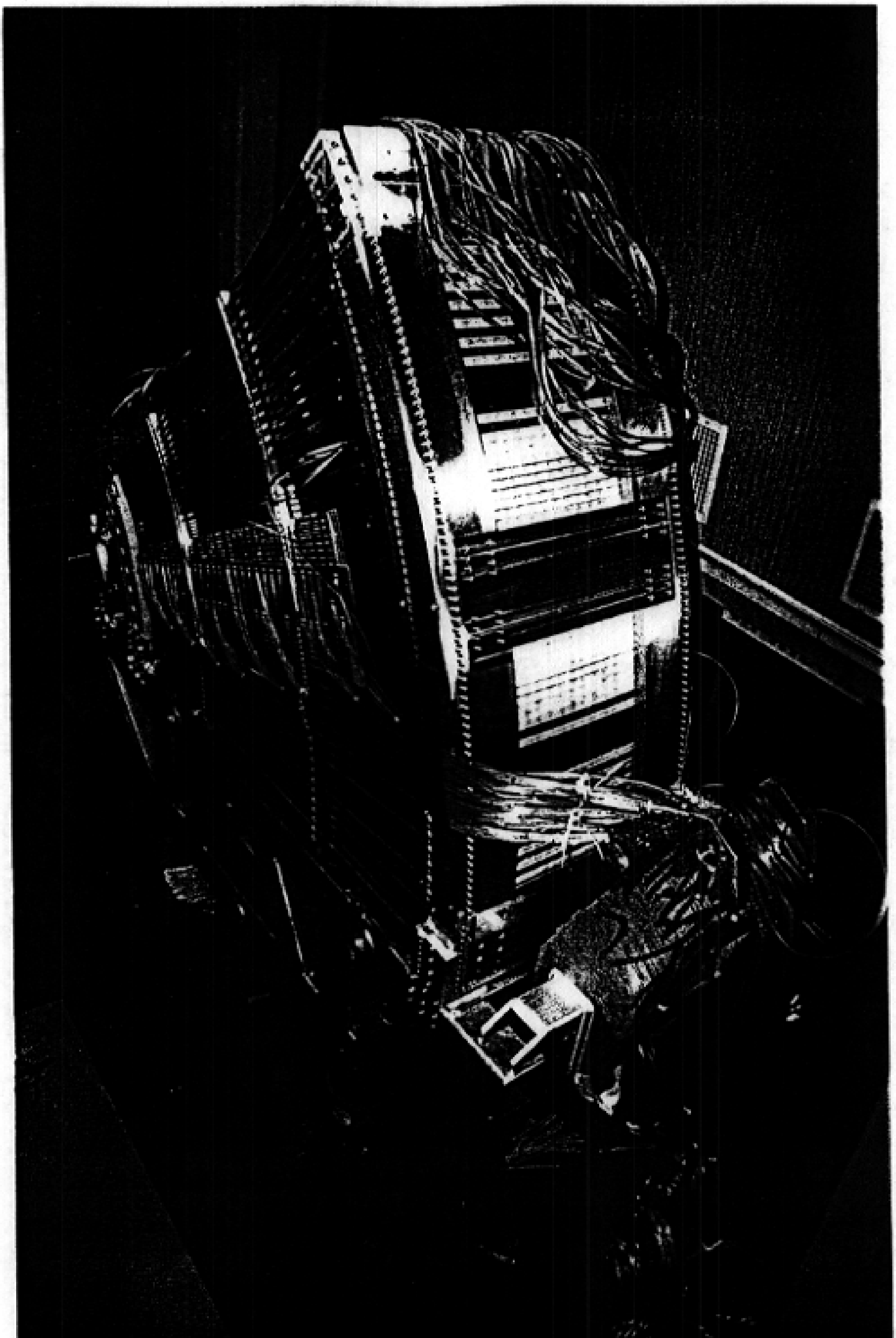




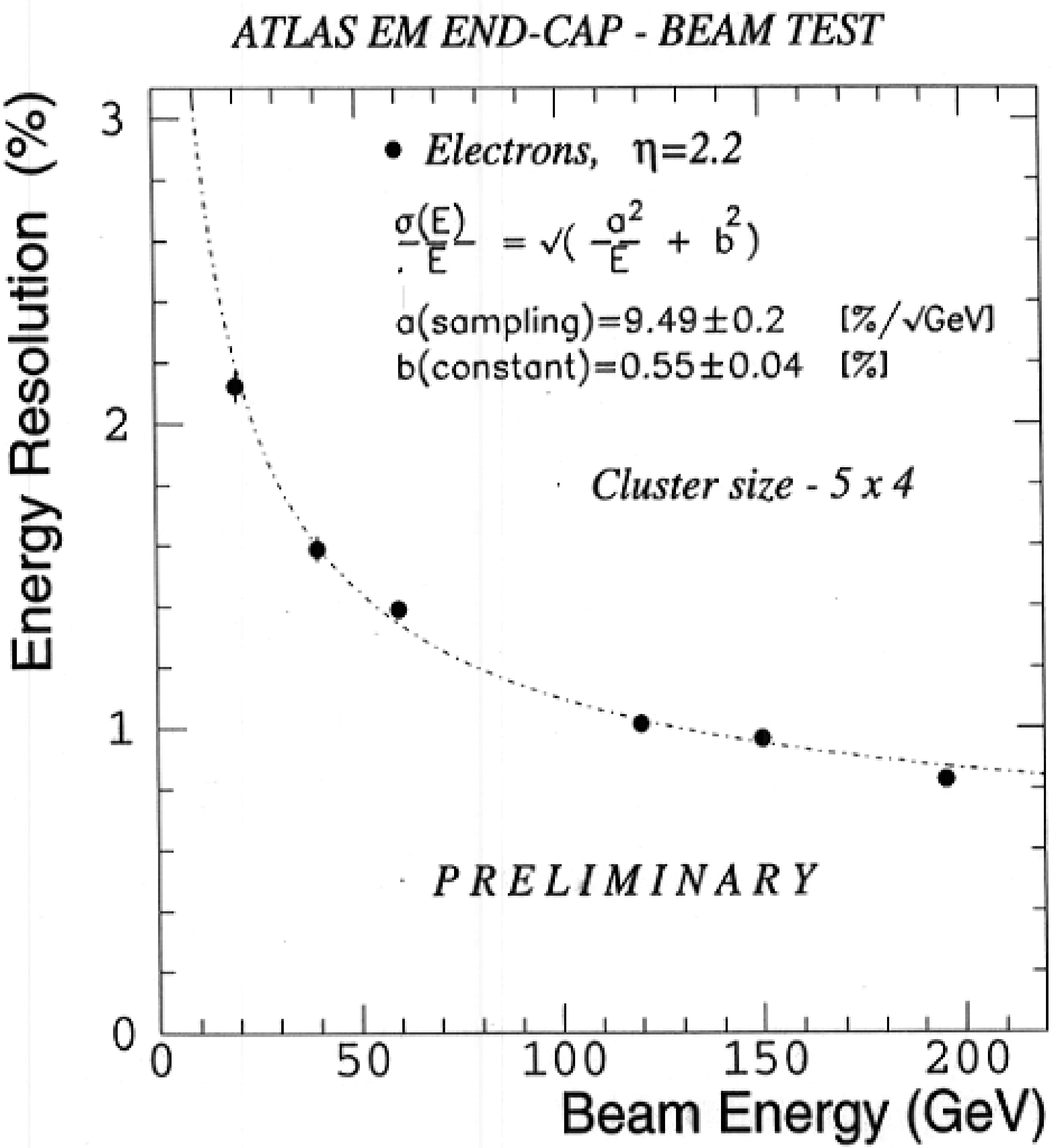
LAr EM Calorimeter: mechanical load test of the backbone support structure (half barrel)

ATLAS LAr EM Calorimeter Barrel Module-0





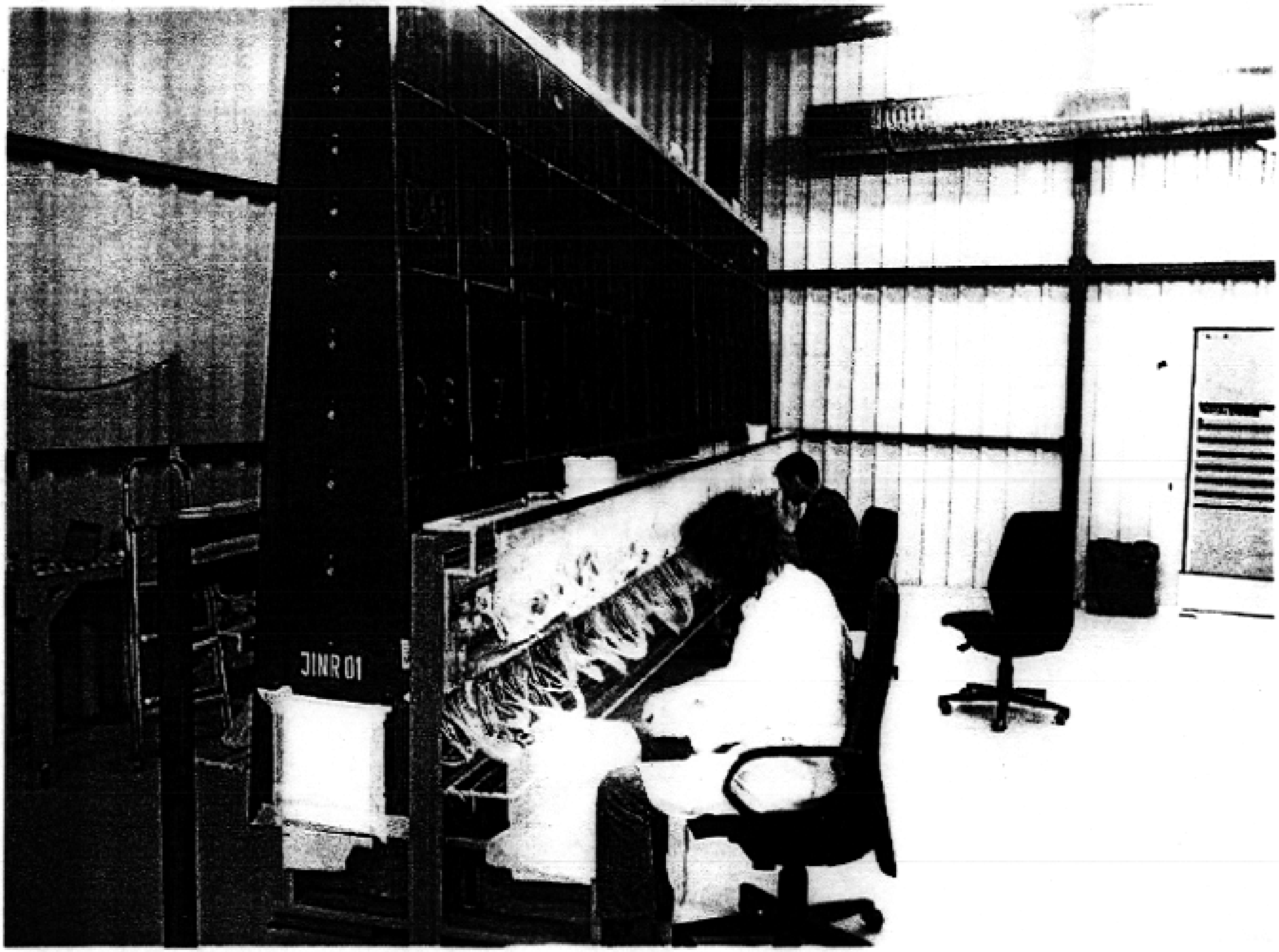
LAr EM end-cap



ATLAS EM END-CAP - BEAM TEST
Electrons, η=2.2
σ(E)/E = √(a²/E + b²)
a(sampling)=9.49±0.2 [%/√GeV]
b(constant)=0.55±0.04 [%]
Cluster size - 5 x 4
PRELIMINARY
Energy Resolution (%)
Beam Energy (GeV)
0
1
2
3
0
50
100
150
200

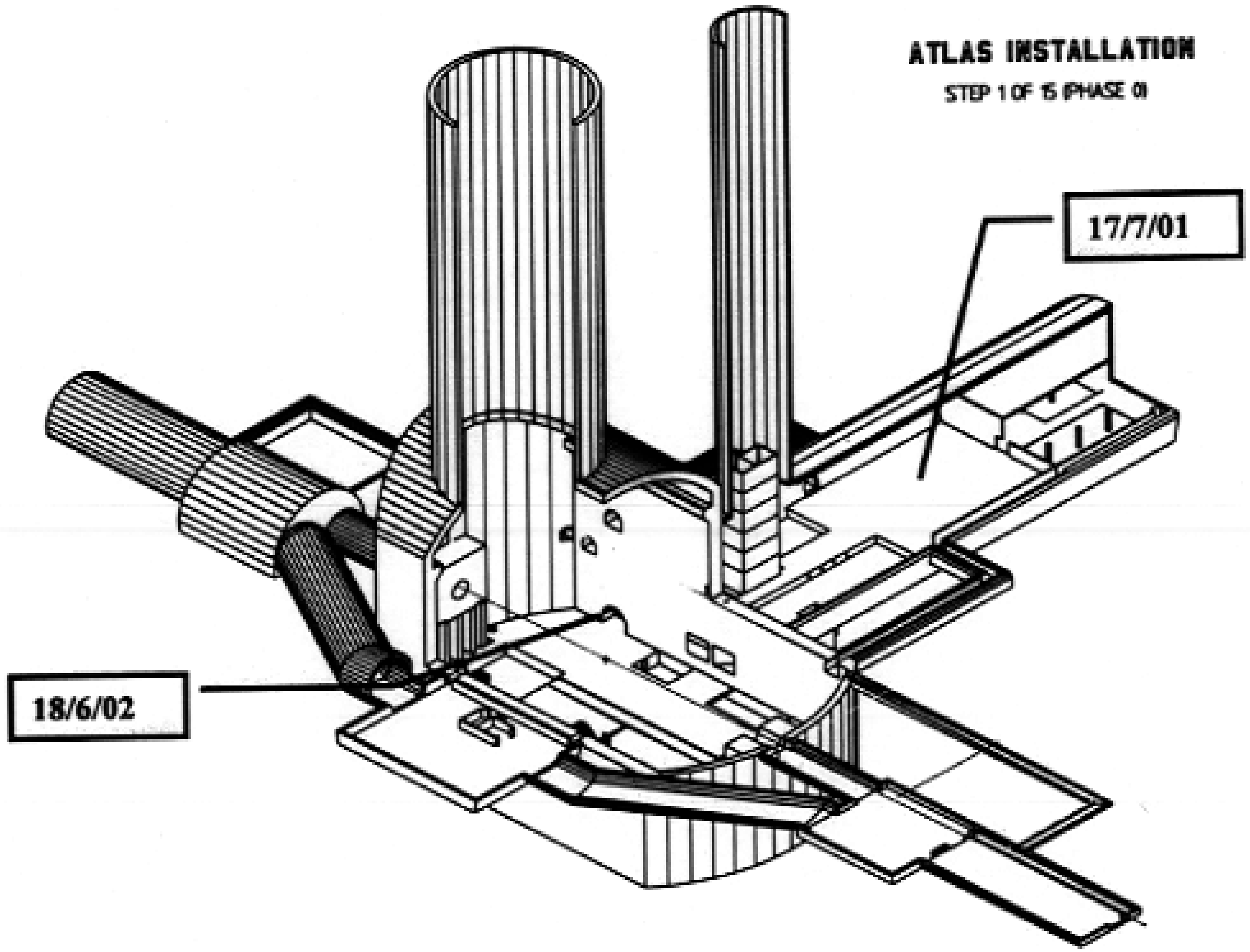
Tile Calorimeter absorber serial production

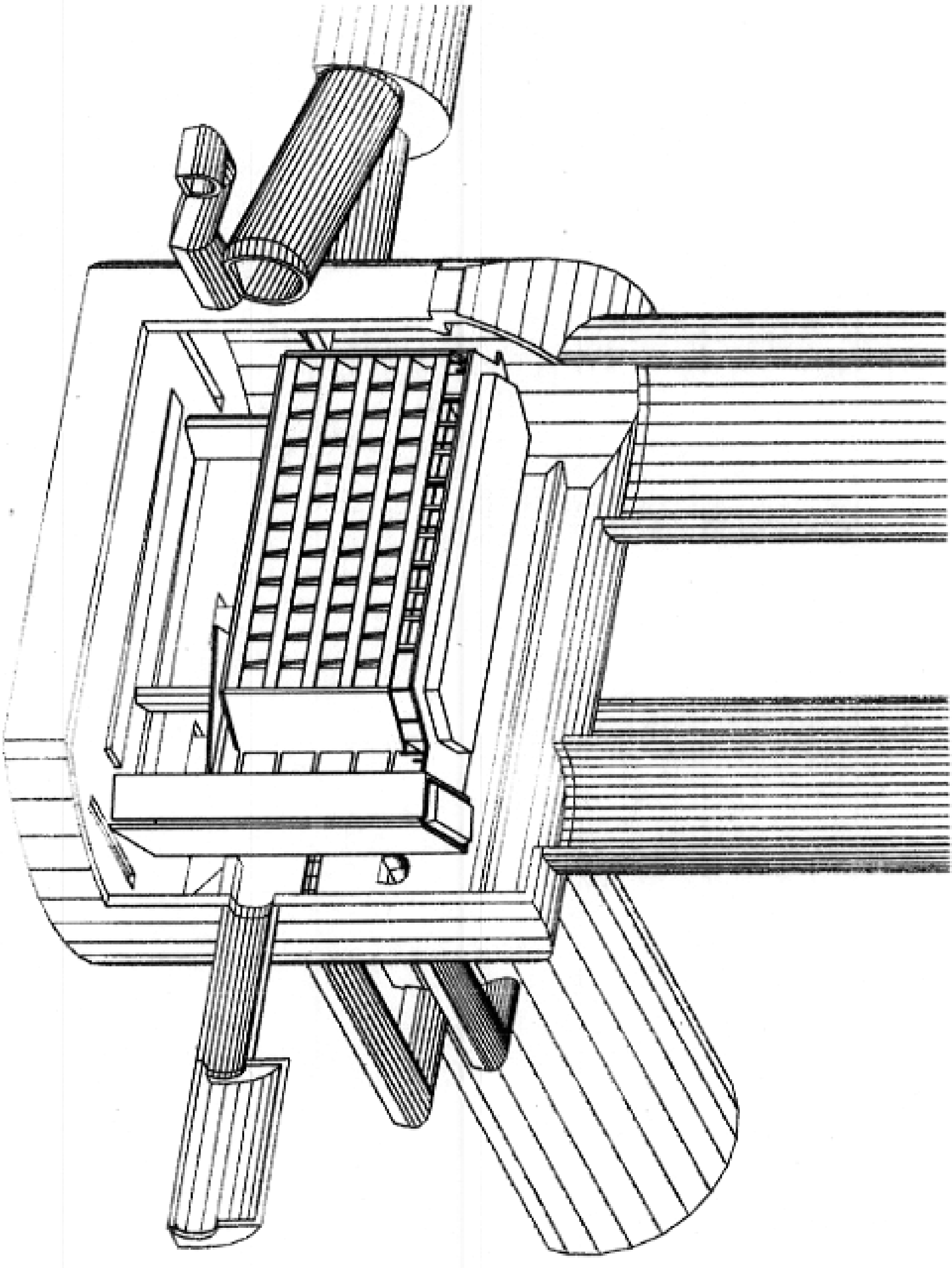
ATLAS Tile Calorimeter   Barrel Module No 1



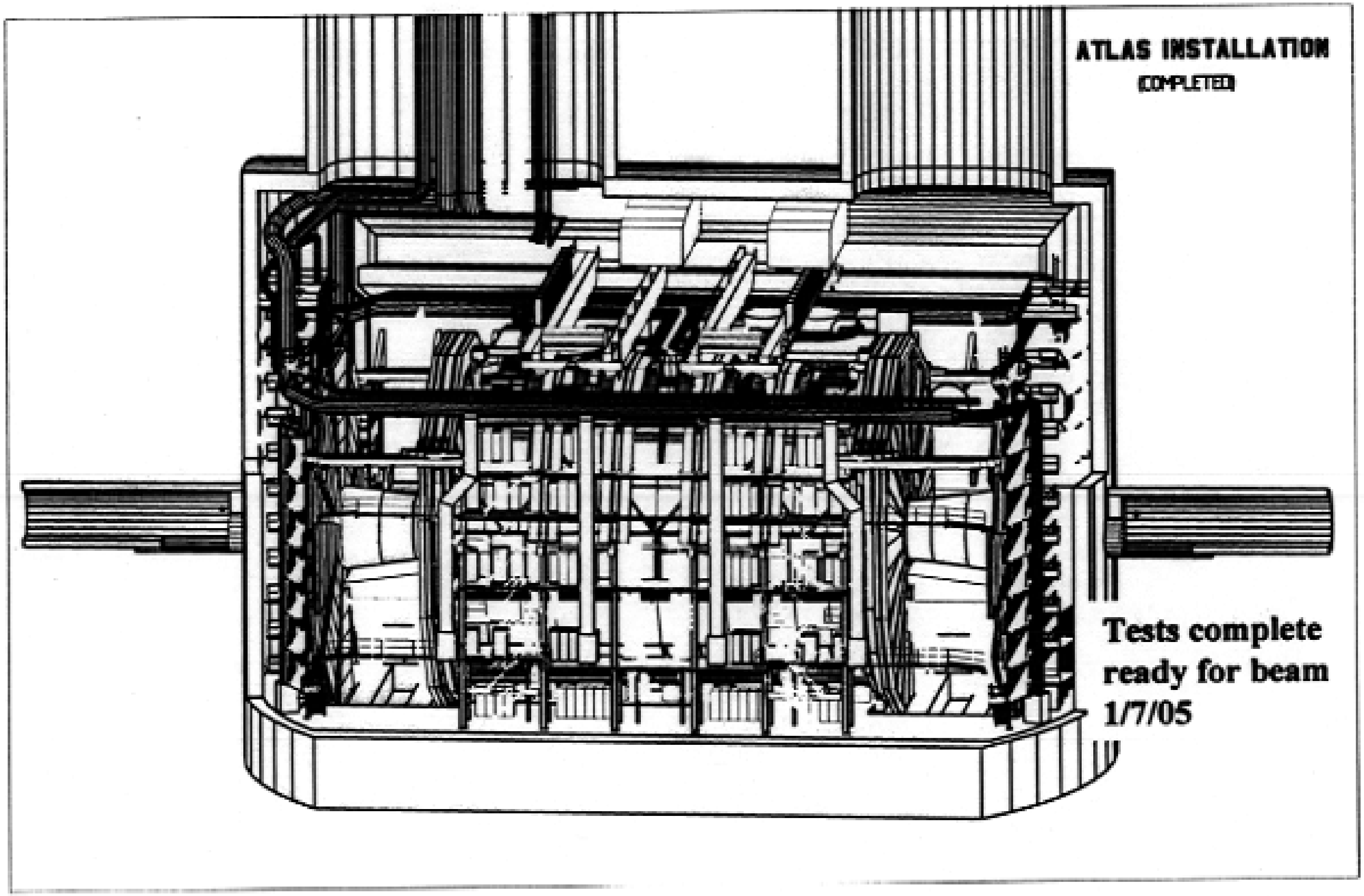
ATLAS

Prototype of a complete BML muon station (MDT + RPC + support)


ATLAS INSTALLATION
STEP 1 OF 15 (PHASE 0)
17/7/01
18/6/02

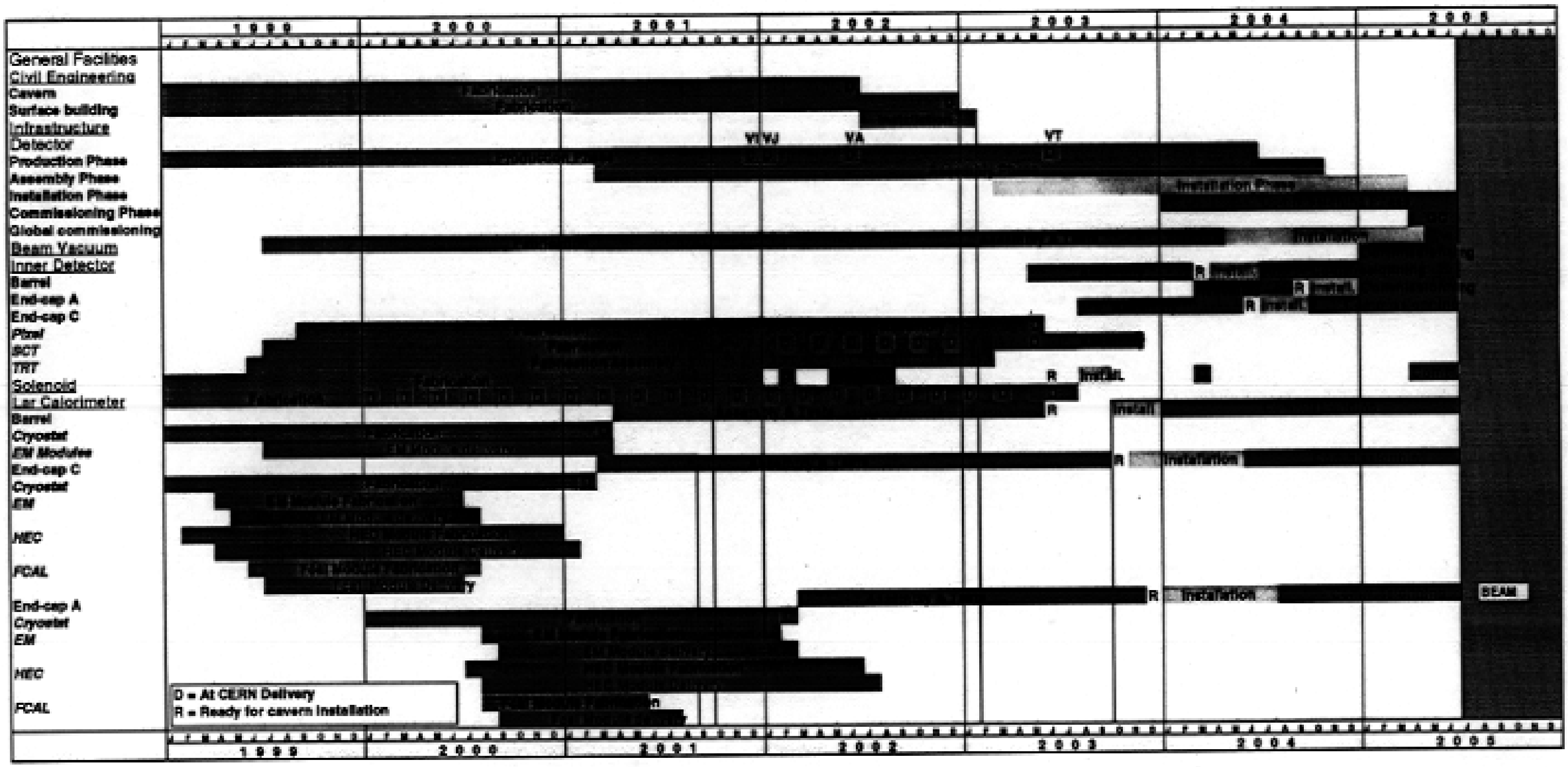


ATLAS
C



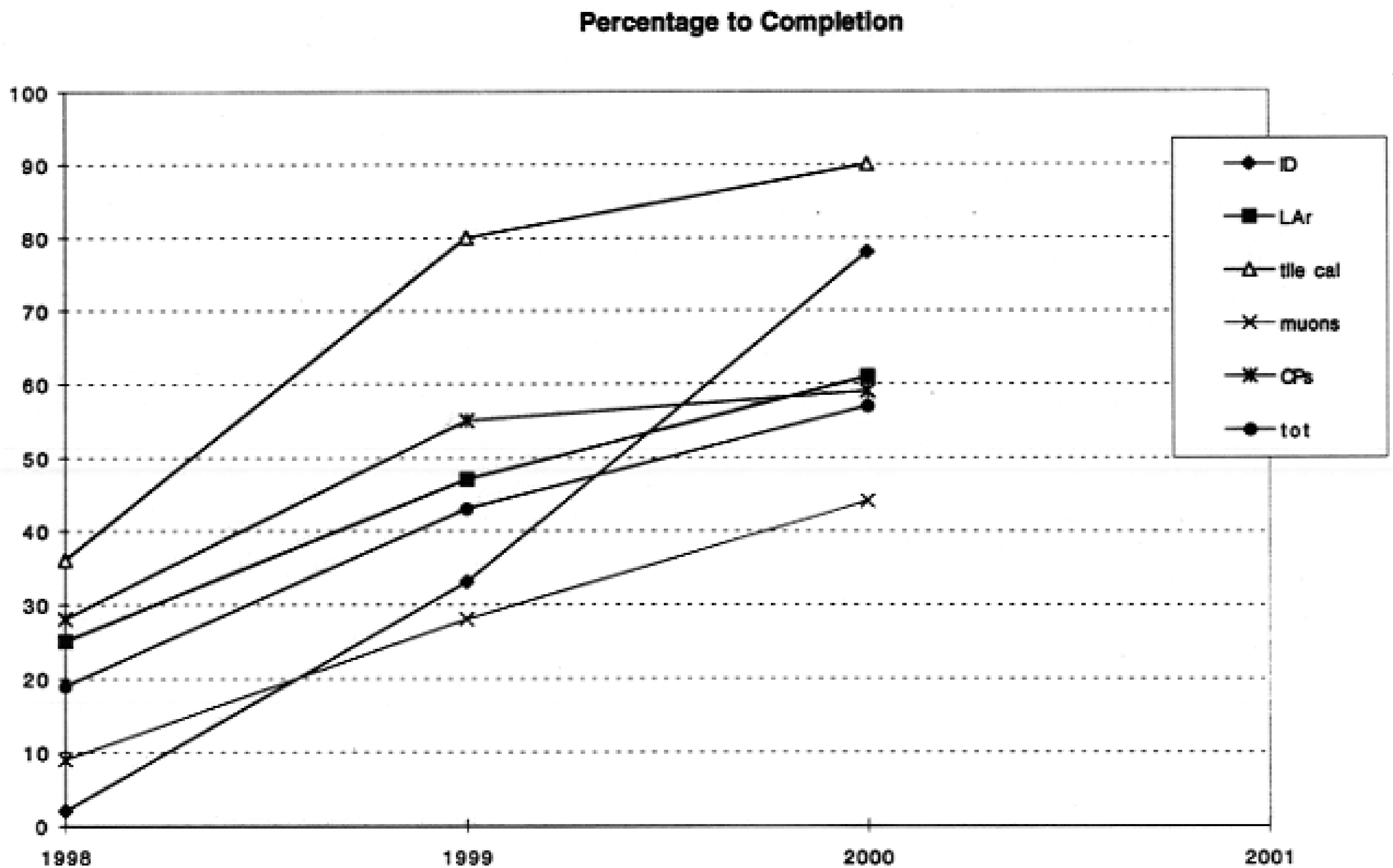
LMCC
23-25/3/99
MH 18

ATLAS Summary Schedule

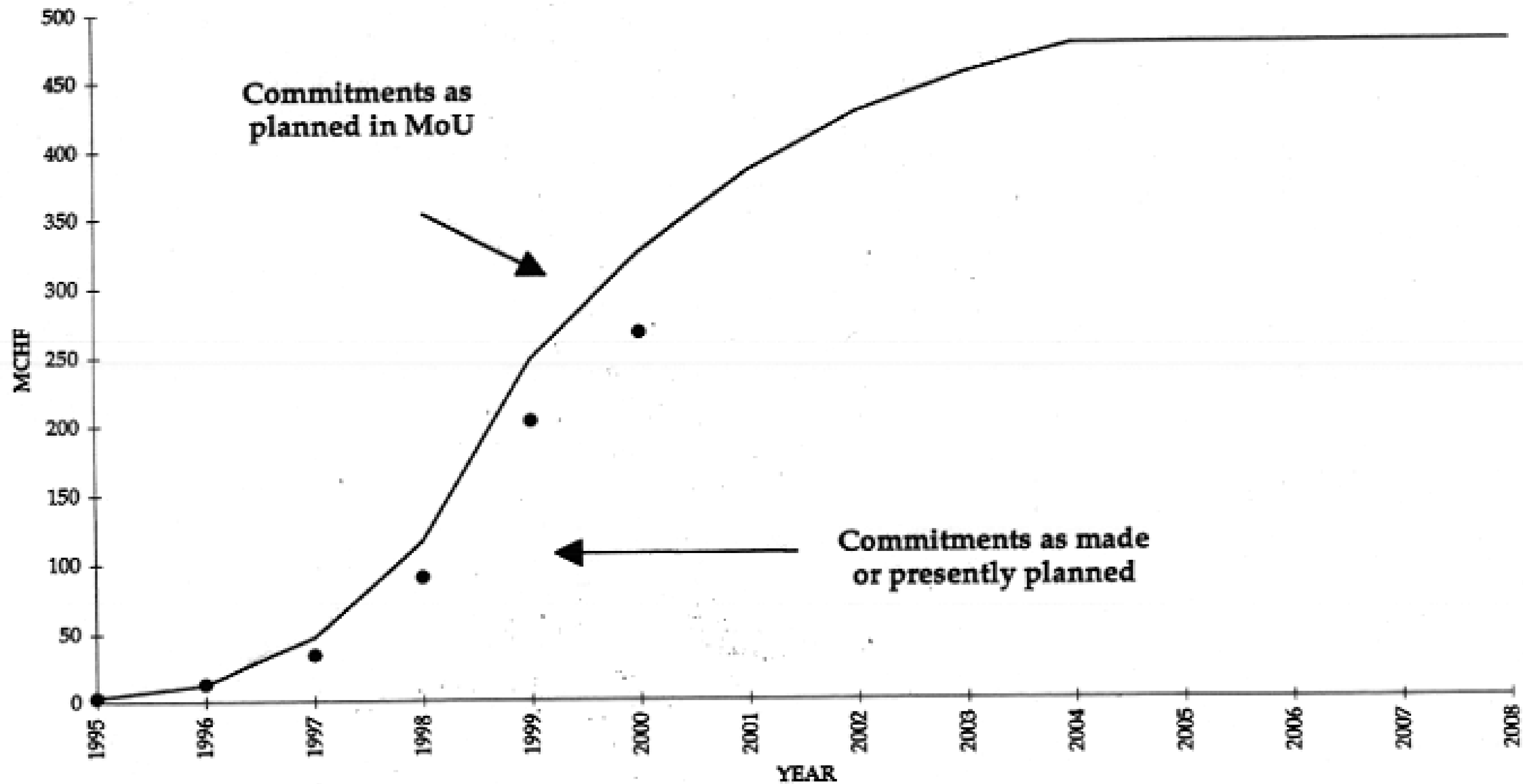


1999
2000
2001
2002
2003
2004
2005
Tile Calorimeter
Barrel
End-cap C
End-cap A
Toroid Magnet
Barrel
End-caps
End-cap C
End-cap A
Muon System
Barrel A&C
Big Wheel A& C
Shield disc A & C
End wall A&C
MDT
CSC
RPC
TGC
Shielding
JD
JF
JT
JM
Structures
Installation
Install.
R
D = At CERN Delivery
R = Ready for cavern installation

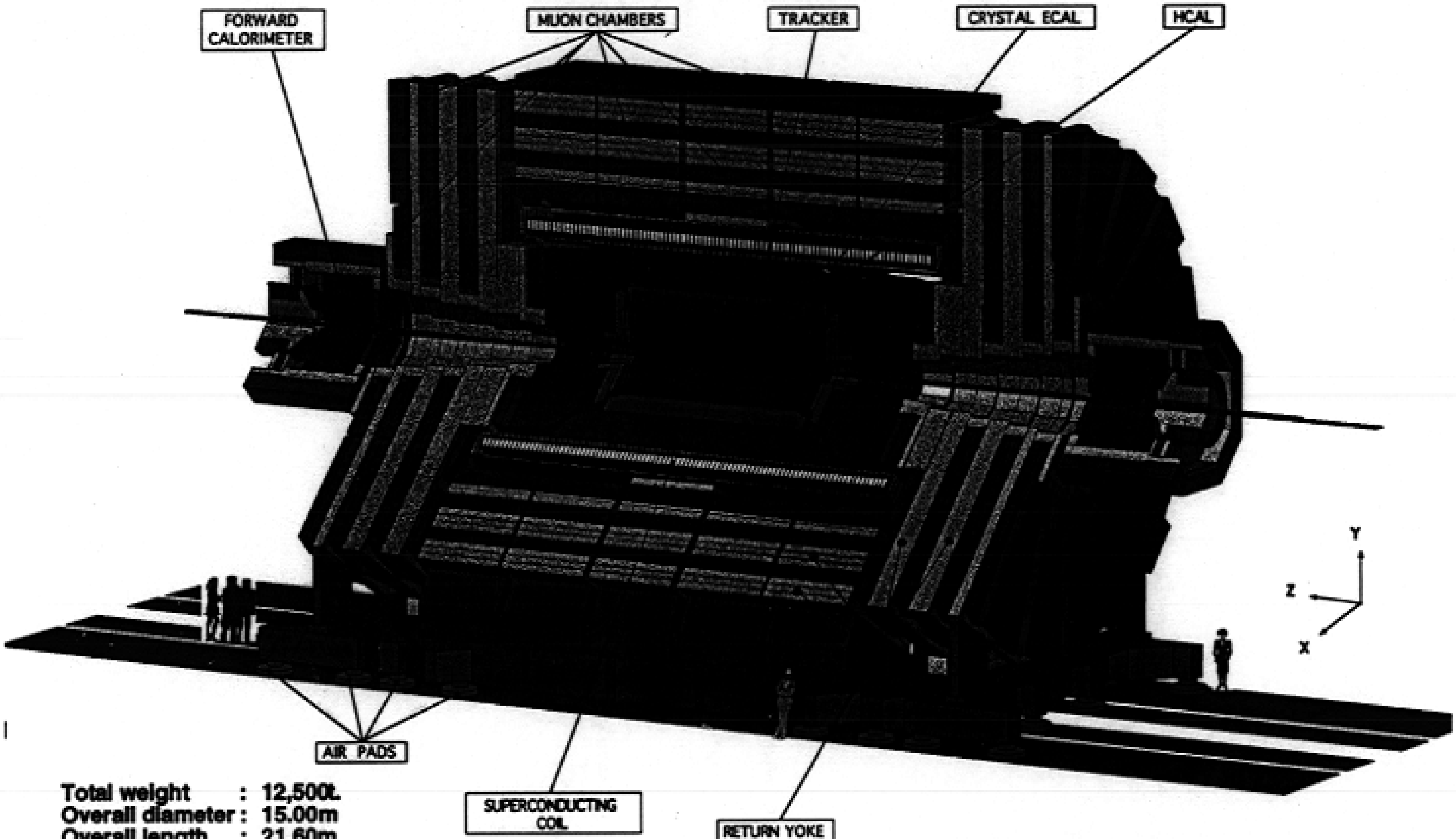
Commitments for ATLAS Systems



ATLAS Detector Construction
Evolution of Commitments



CMS
A Compact Solenoidal Detector for LHC



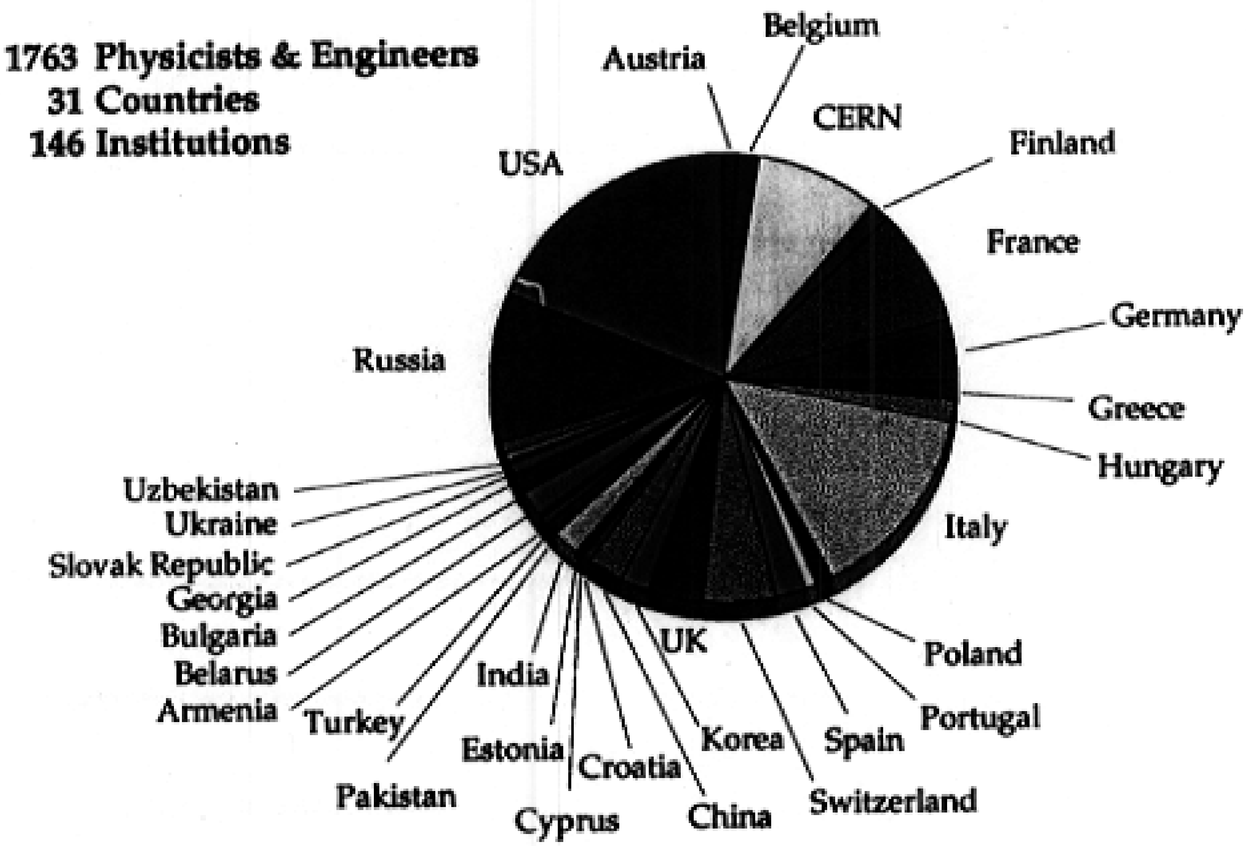
Total weight : 12,500t.
Overall diameter : 15.00m
Overall length : 21.60m
Magnetic field : 4 Tesla

CMS-PARA-001-06/11/97 JLB.PP

The CMS Collaboration

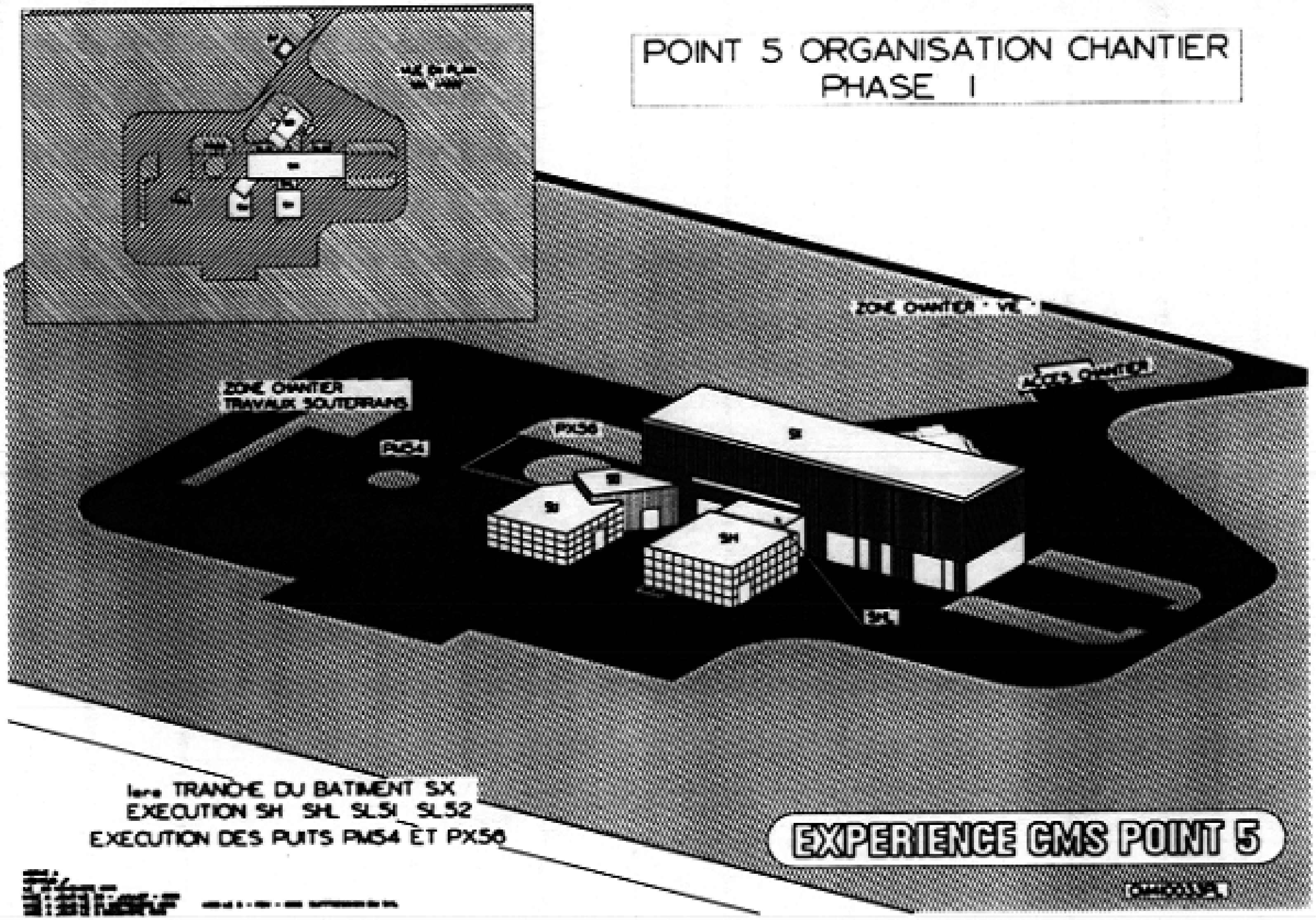
	Number of Laboratories
Member States	57
Non-Member States	51
USA	38
Total	146

	Number of scientists
Member States	988
Non-Member States	445
USA	330
Total	1763



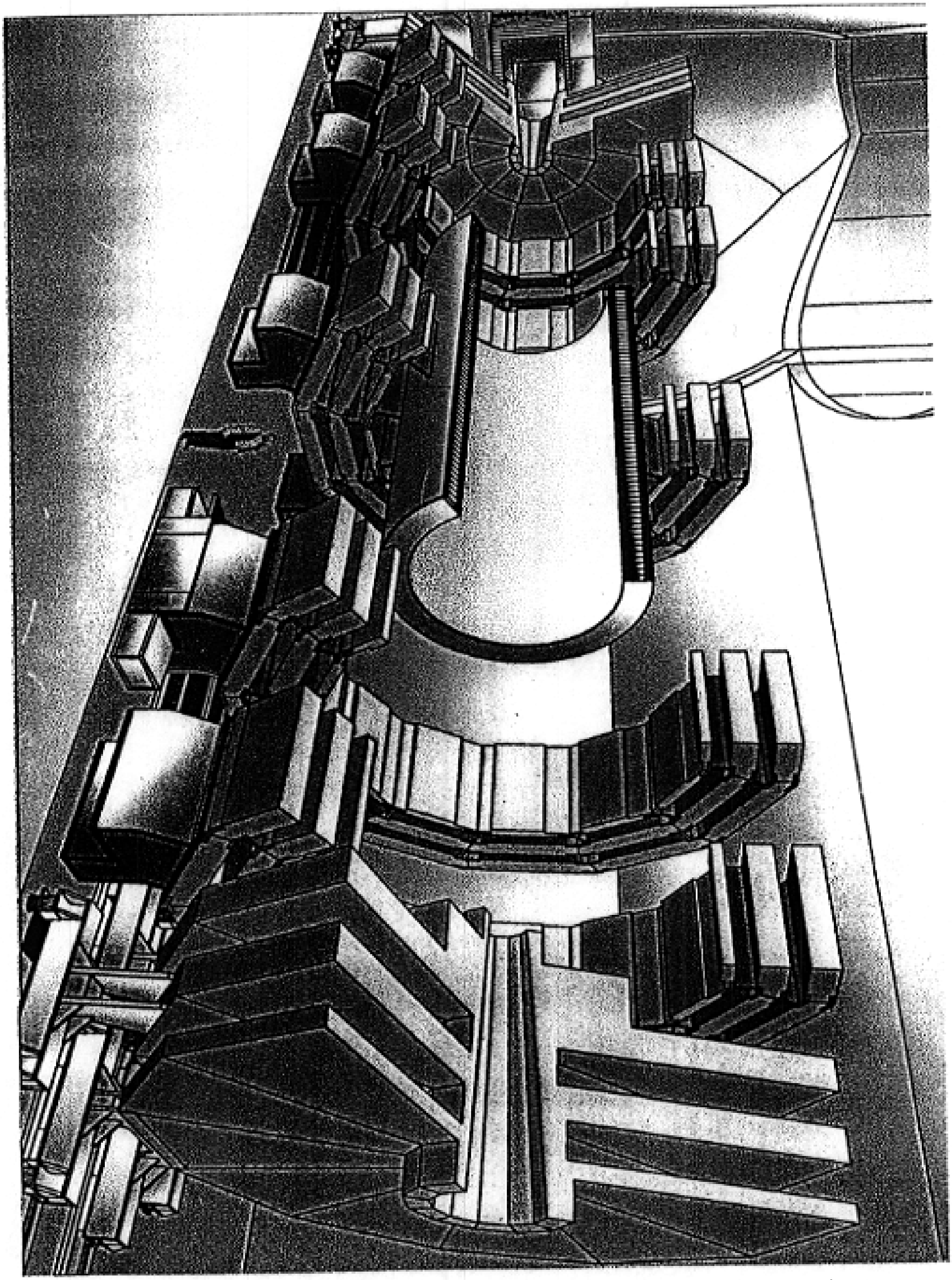
May, 31st, 1999/av
http://cmsdoc.cern.ch/pictures/cmsorg/overview.html

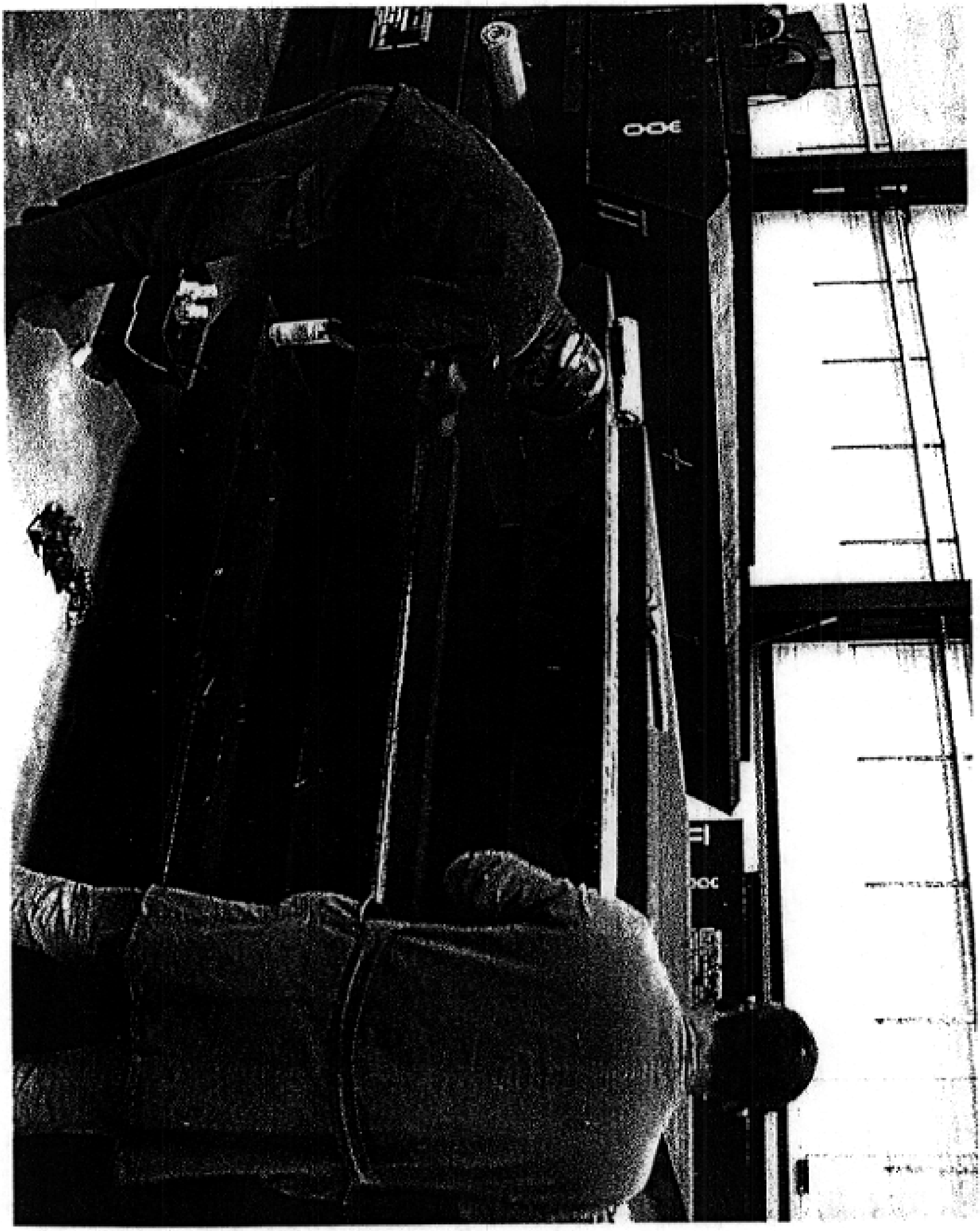
Point 5 Design

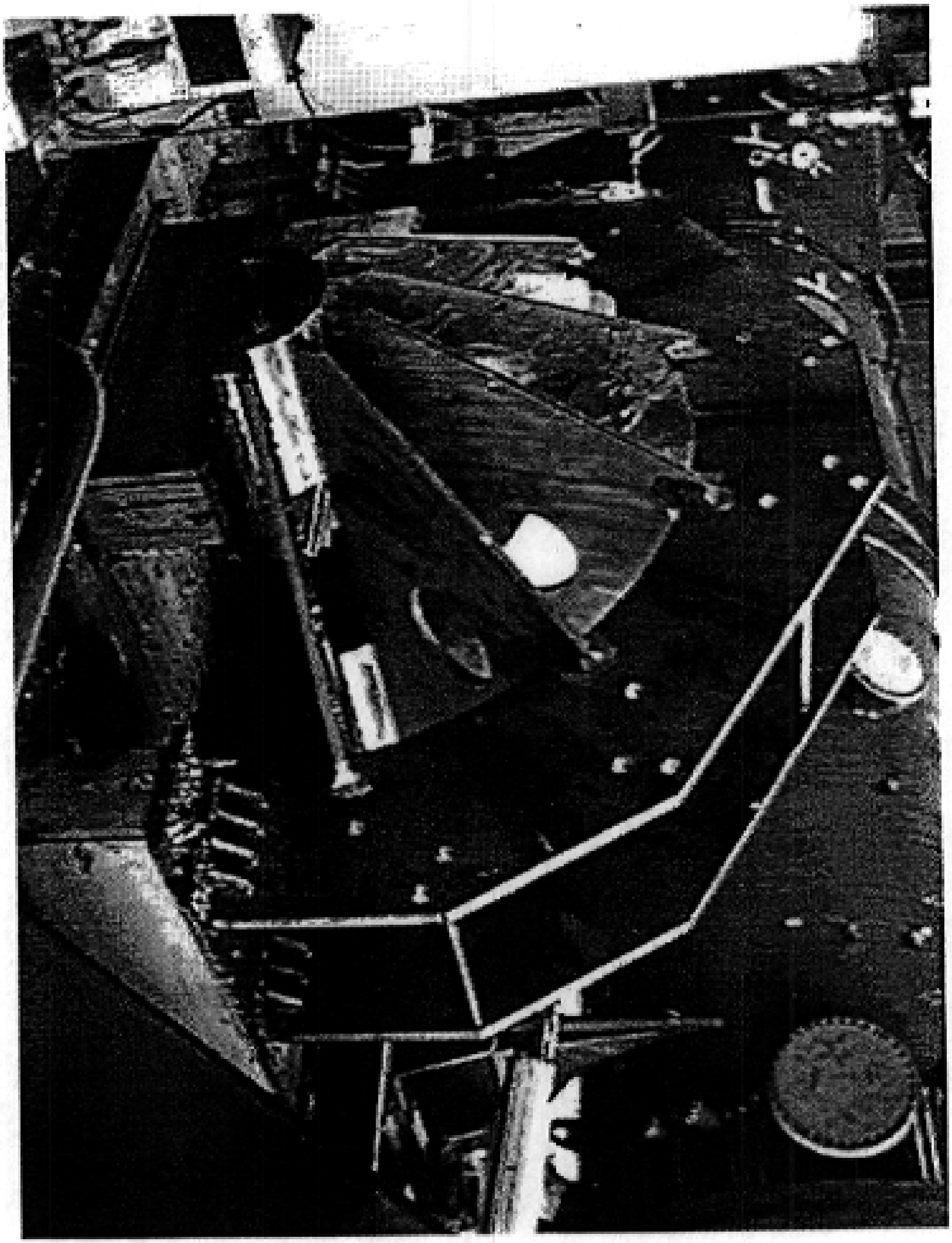


Point 5

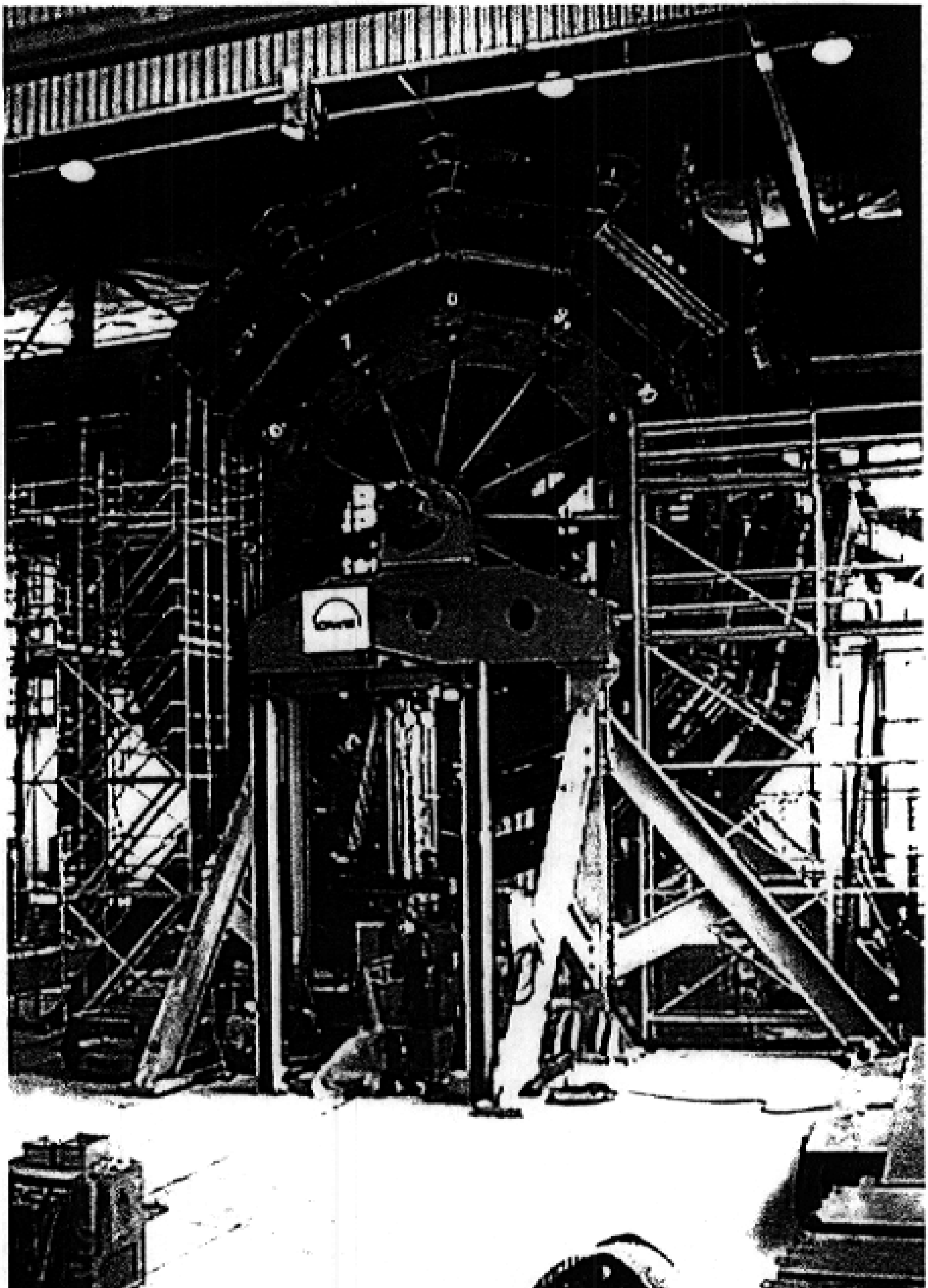
Point 5 - SX5 gantry crane installation - September 17, 1999 - CERN ST-CE





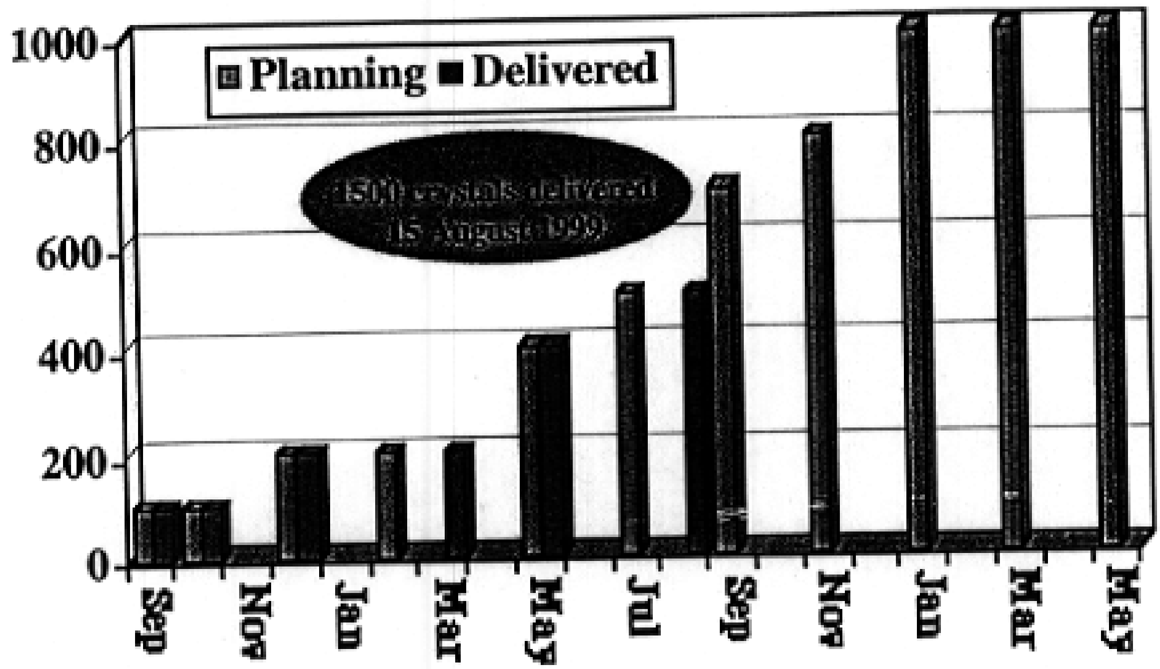


CMS Barrel Yoke

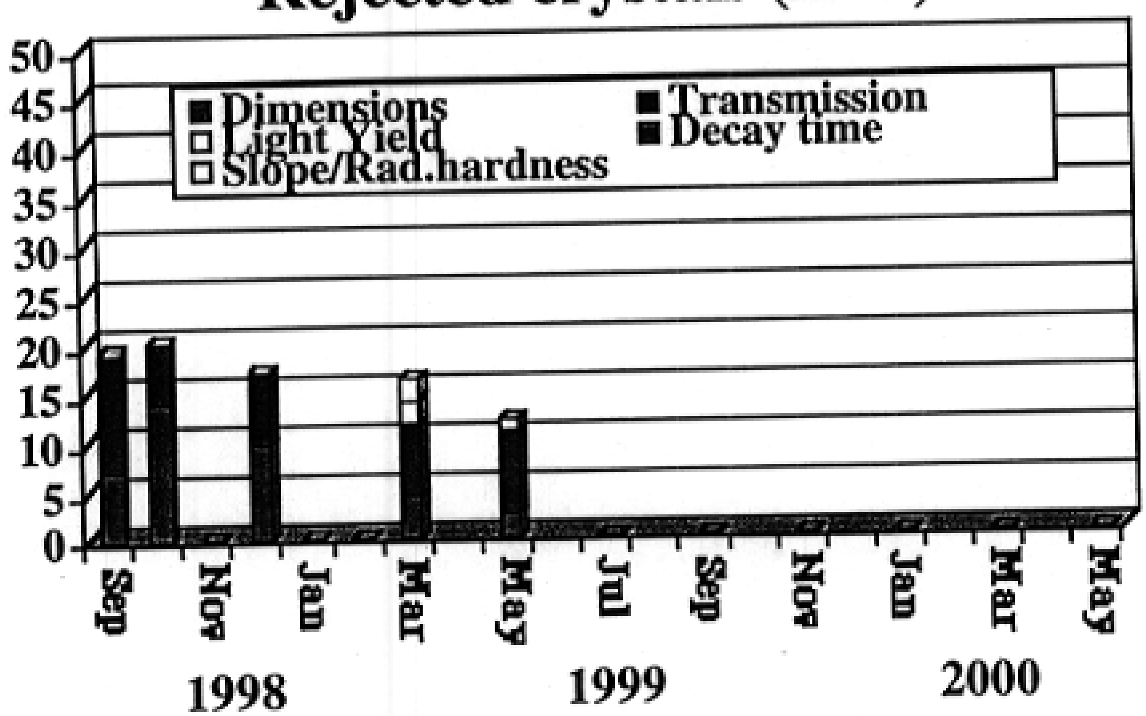


Status of crystal delivery from Bogoroditsk (Russia)

Delivered crystals

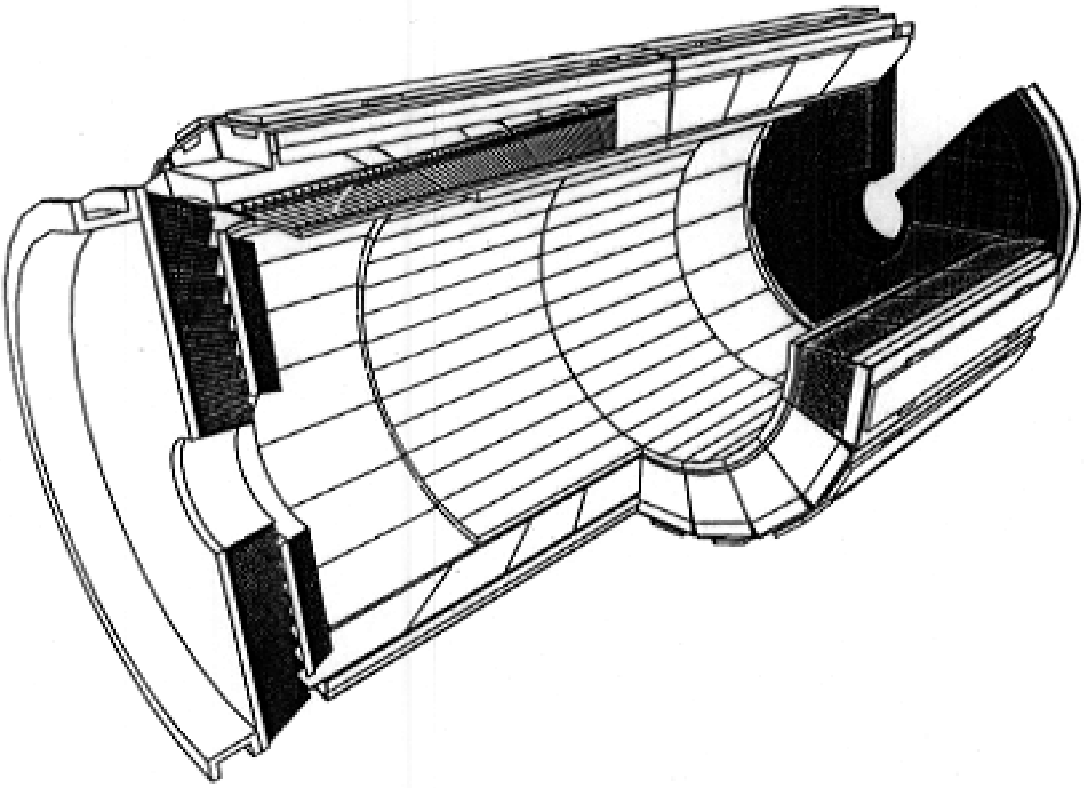


Rejected crystals (in %)



P. Lecoq CMS/ECAL

Electromagnetic Calorimeter



Parameter	Barrel	Endcap
η coverage	$\lvert\eta\rvert < 1.48$	$1.48 < \lvert\eta\rvert < 3.0$
Granularity ($\Delta\eta\times\Delta\phi$)	0.0175×0.0175	varies in η
Crystal Dims. (cm^3)	$2.18\times2.18\times23$	$2.85\times2.85\times22$
Depth in X_0	25.8	24.7 ($+3X_0$)
No. of crystals	61,200	14,950
Crystal Volume (m^3)	8.14	3.04
Photodetector	APDs	VPTs
Modularity	36 supermodules	4 Dees

Specification of Optical Parameters

For good radiation hardness

Longitudinal Transmission

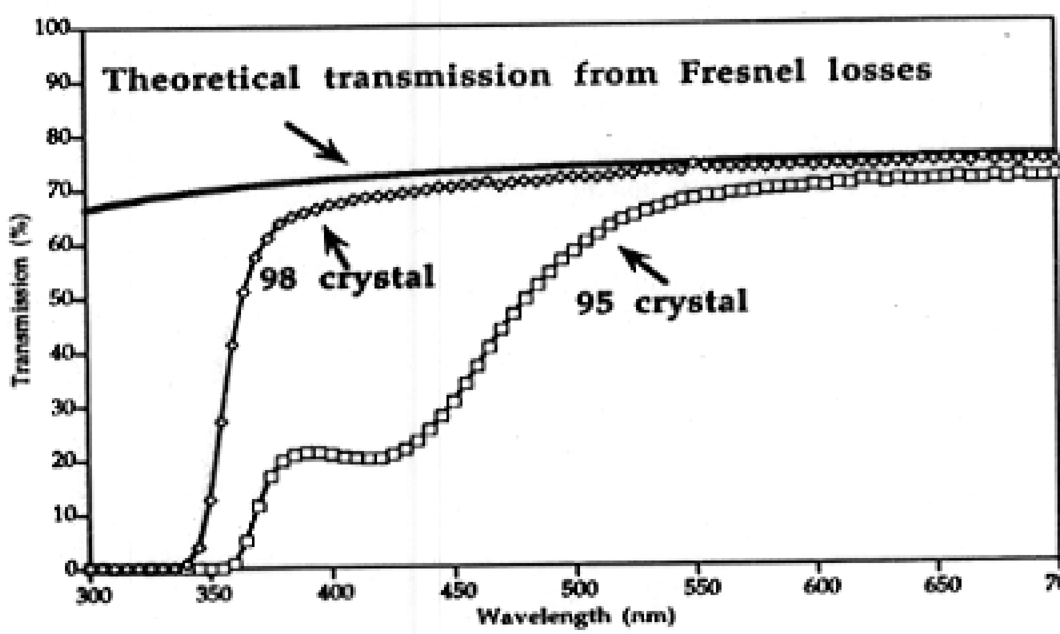
≥ 10% at 350 nm
≥ 55% at 420 nm
≥ 65% at 600 nm

Transverse Transmission

For T=50% $\delta\lambda \leq 6$ nm

Slope of Transmission Edge

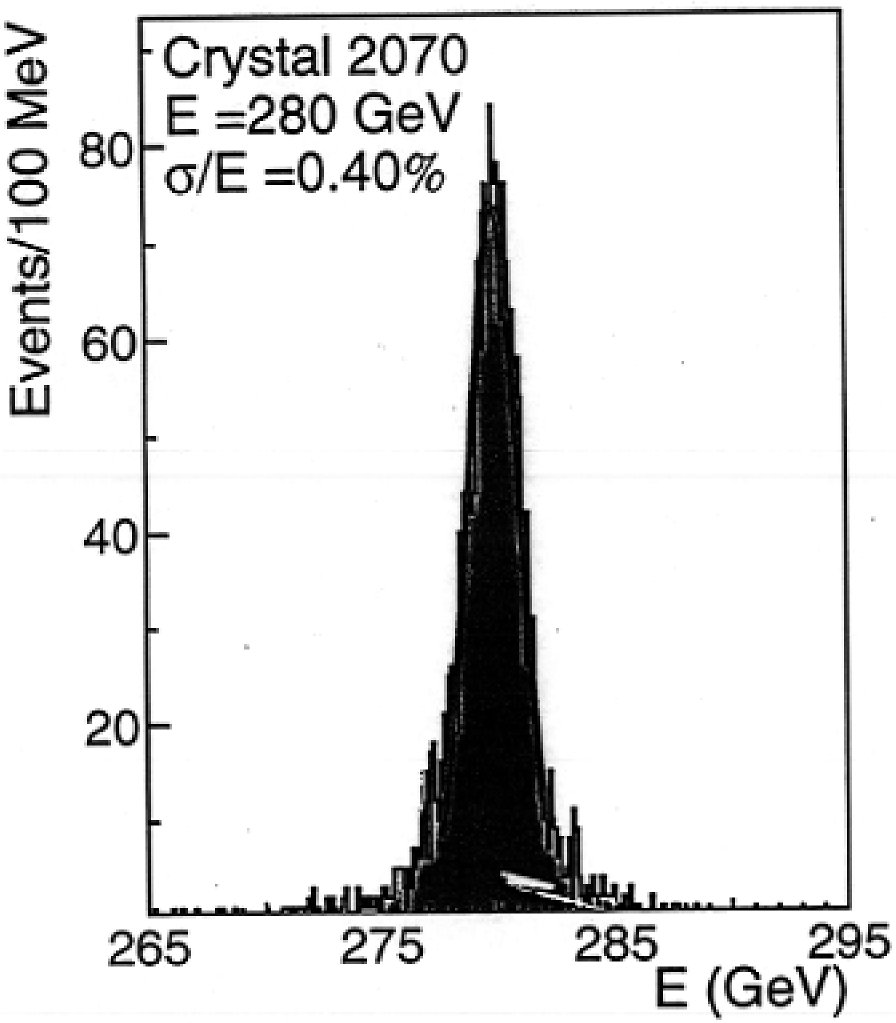
S > 1.5%/nm between 340 nm and 370 nm



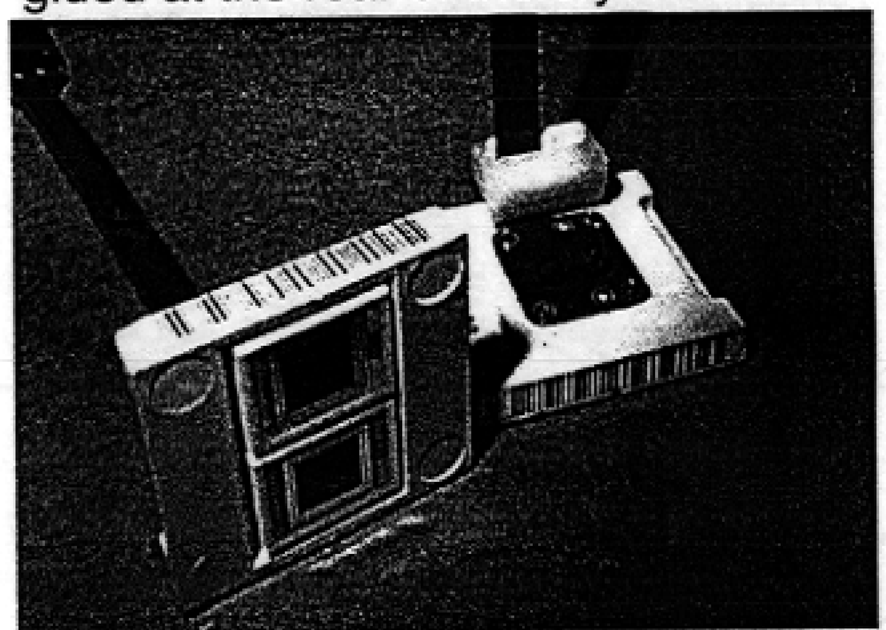
Acceptance ≥ 85% for the 1st Preproduction Batch

Electromagnetic Calorimeter

Test Beam Results 1999



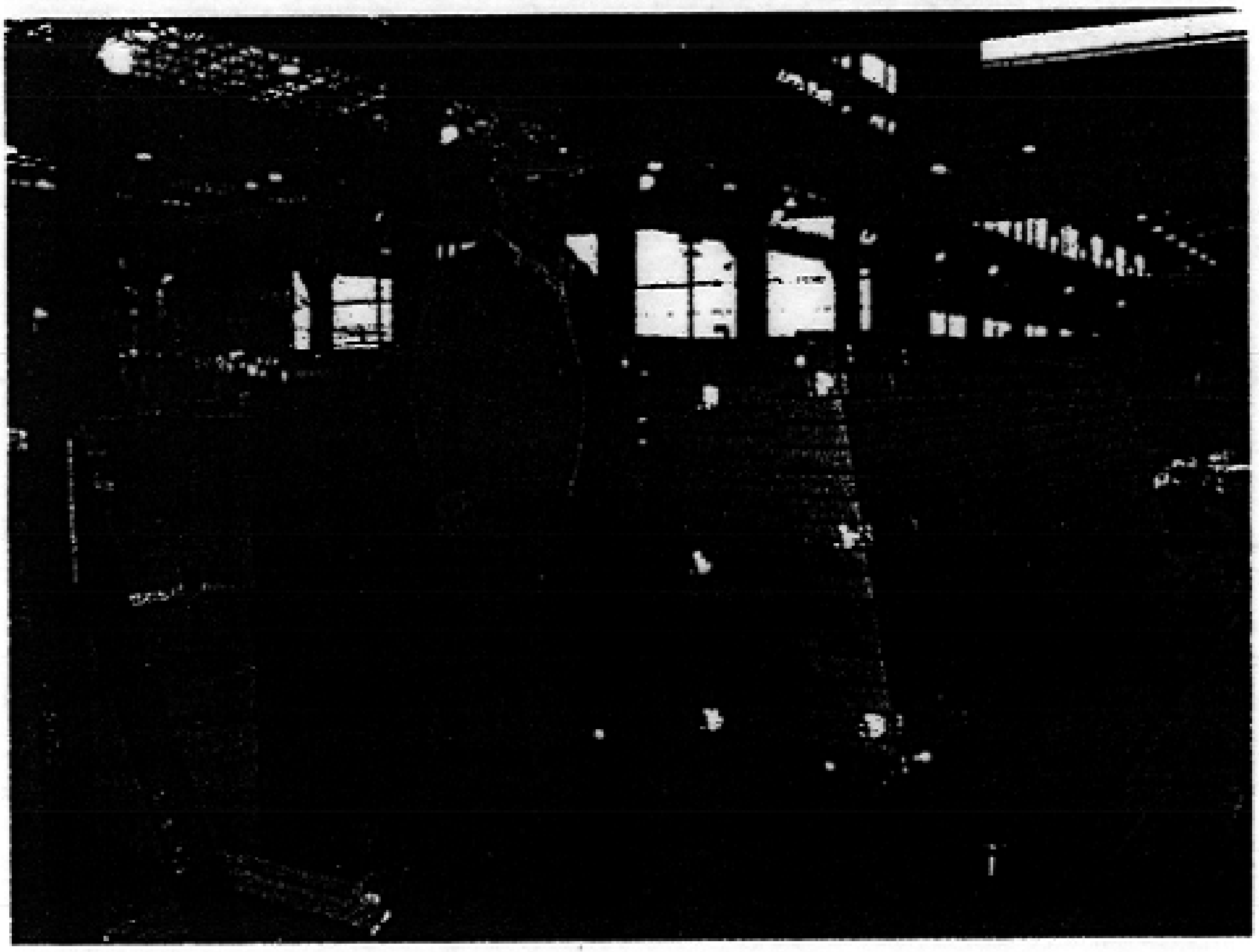
Two APDs 5 x 5 mm surface mounted in a supporting structure (capsule) glued at the rear of the crystal

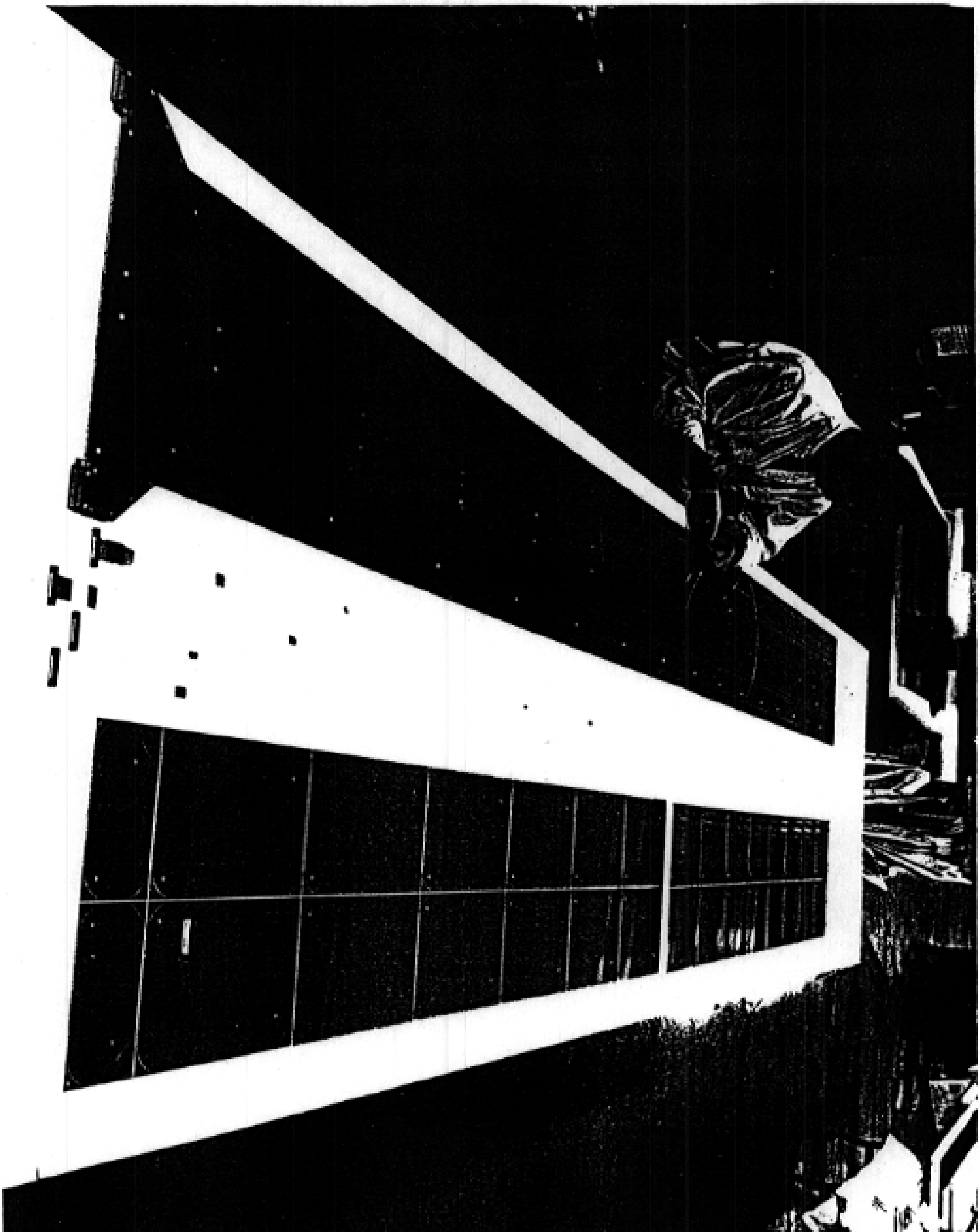


ECAL construction

ECAL : 83.000 $PbWO_4$ crystals
Two production facilities of 1700 unit/month
Start of production : 1999
ECAL assembled : 2004
Start of LHC : 2005

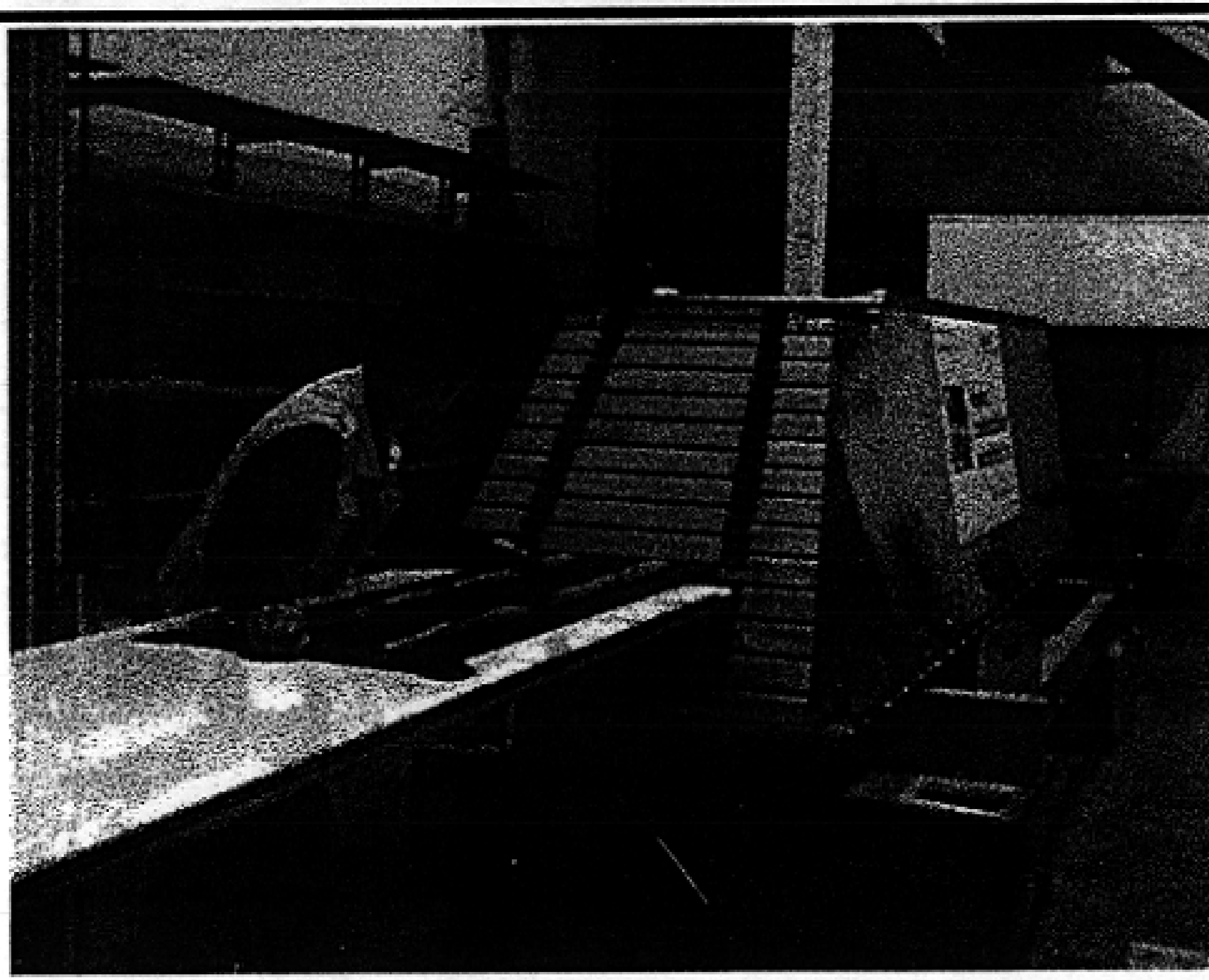
HB : PPP2 assembled (Felguera, Spain)



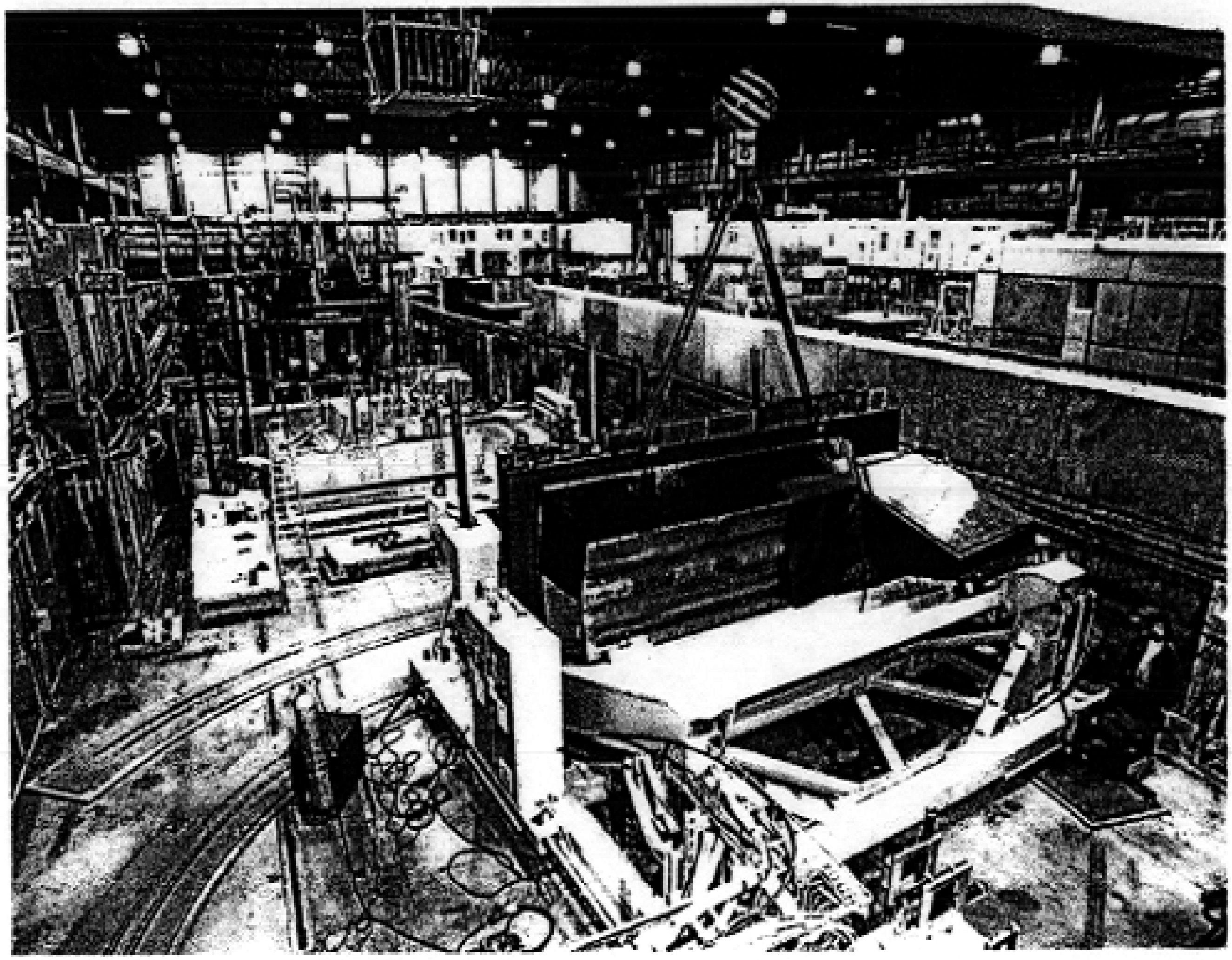


8-1120

HB : scintillator megatile insertion in PPP

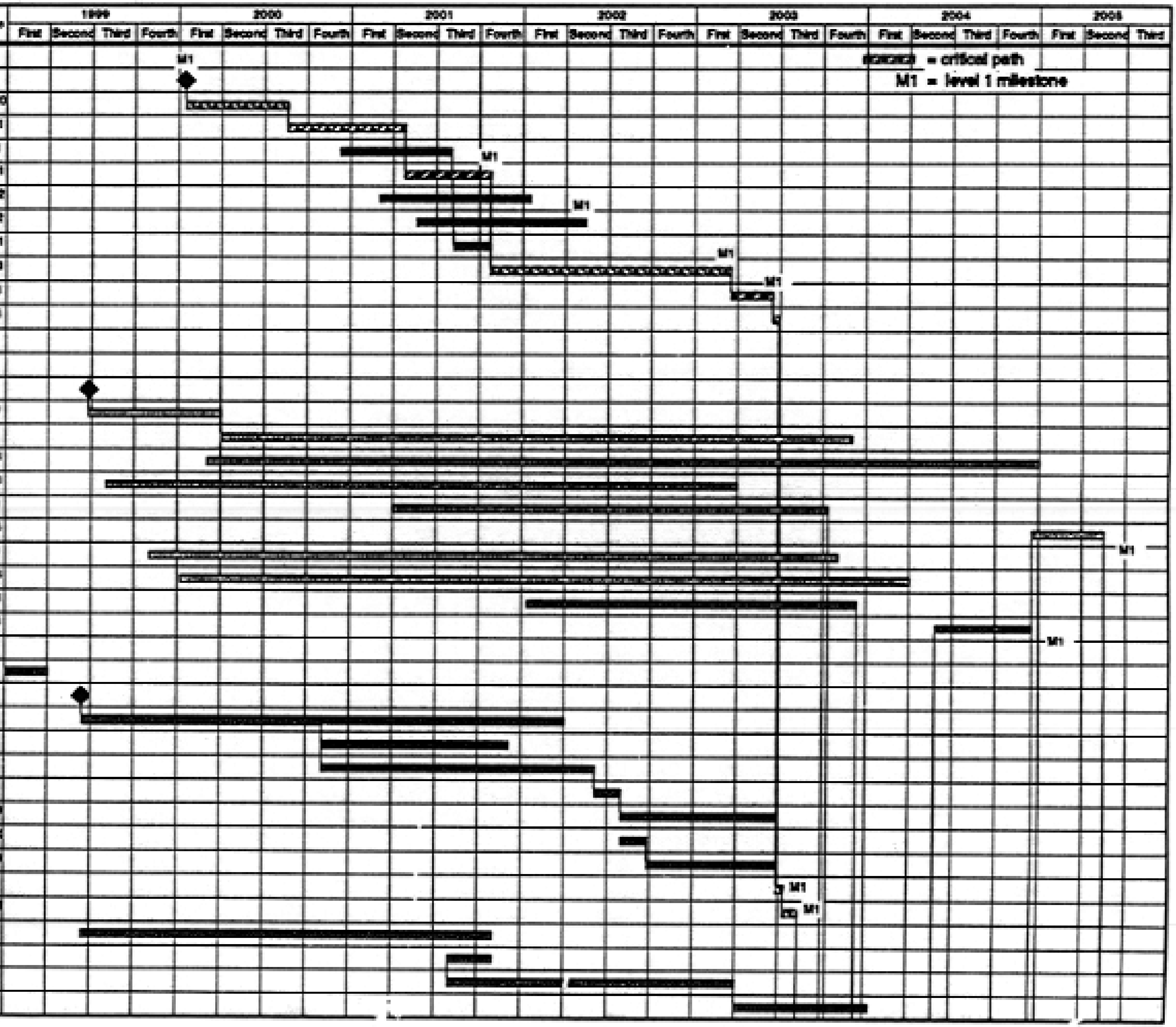


HCAL Beam Test Layout



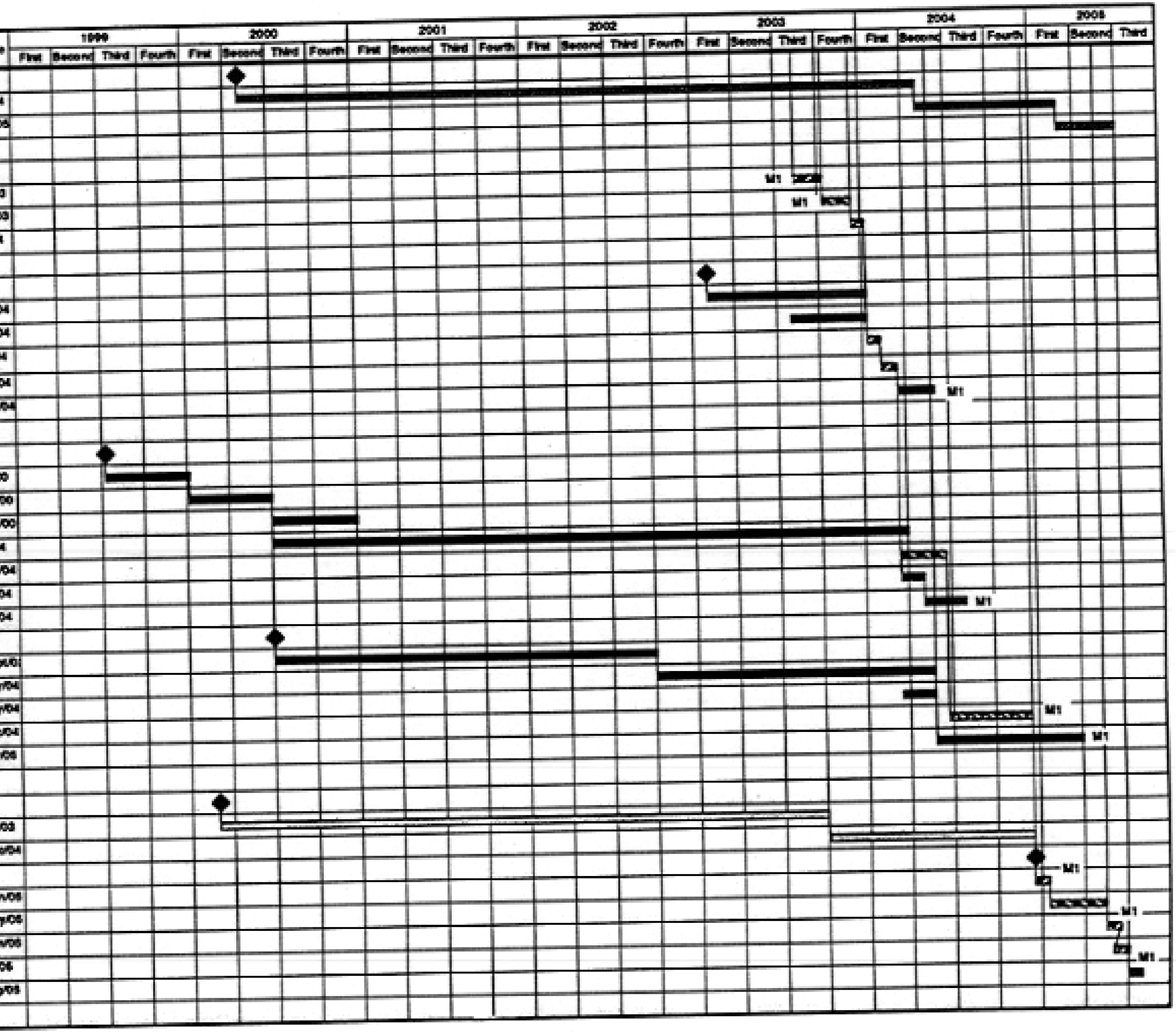
CMS Summary Schedule v 1.0 9'th June 1999 (preliminary)

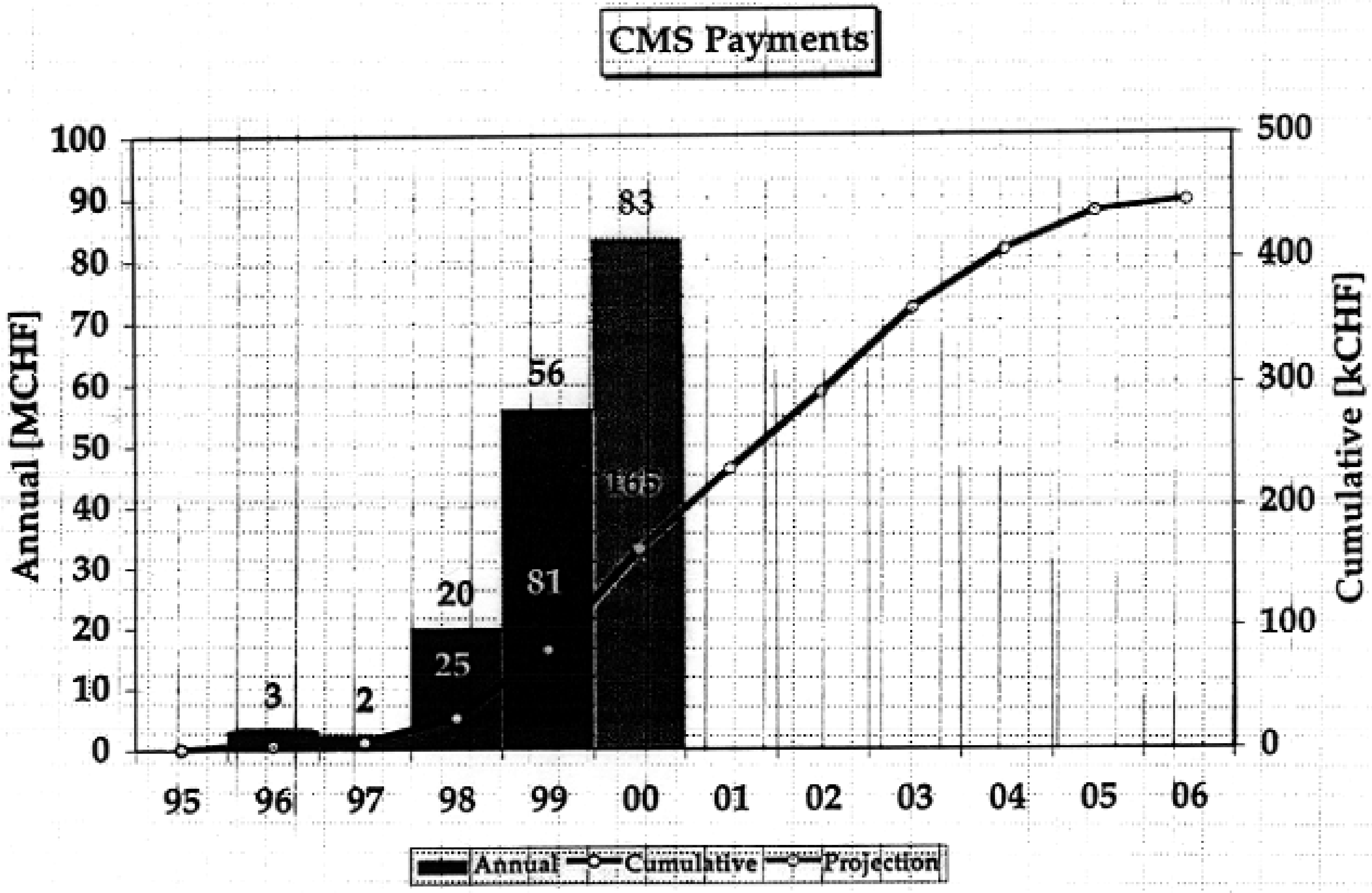
Activity Name	Start Date	Finish Date
Surface assembly/testing	S21/Dec/03	M5/Apr/04
SX building ready	F14/Jan/00	
equip SX	S19/Jan/00	S19/Aug/00
Barrel yoke YB -1 & -2 assy.	S19/Aug/00	M23/Apr/01
YB0 + vac tank assembly	F8/Dec/00	W1/Aug/01
YB +1 & +2 assembly	M23/Apr/01	W24/Oct/01
Endcap yoke YE -1 assembly	T1/Mar/01	W16/Jan/02
YE +1 assembly	F18/May/01	F10/May/02
assemble coil swivel device	S4/Aug/01	W24/Oct/01
coil modules -2 --> +2 assy.	W24/Oct/01	M17/Mar/03
coil into vac tank	M17/Mar/03	T12/Jun/03
close vac tank & swivel coil	T12/Jun/03	T24/Jun/03
Muon system MB/ME/RPC		
EDR(follow-up)	W23/Jun/99	
MB pre-production 3 DT's/site	W23/Jun/99	F31/Mar/00
DT manufacture/test	F31/Mar/00	M1/Dec/03
DT delivery to CERN	W1/Mar/00	F31/Dec/04
RPC (bar) manufacture	S1/Aug/99	M31/Mar/03
MB SX install	W28/Mar/01	F10/Oct/03
MB UX install	F17/Dec/04	T17/May/05
CSC assembly	S31/Oct/99	F31/Oct/03
RPC (ec) prod	W5/Jan/00	W31/Mar/04
ME SX install	S12/Jan/02	T11/Dec/03
ME UX install	S23/May/04	F17/Dec/04
Hadron Calorimeter HB/HE/HE		
Setup factories , make PPP's	T1/Sept/98	T1/Apr/99
HE/HOB (HB) EDR	F11/Jun/99	
HB Abs +optics manufacture	S12/Jun/99	M1/Apr/02
HB Absorber delivery to CERN	F3/Nov/00	M3/Dec/01
36 HB module assembly	F3/Nov/00	M3/Jun/02
Barrel HB - assy	M3/Jun/02	M29/Jul/02
HB- test	M29/Jul/02	W25/Jun/03
HB + assy	M29/Jul/02	M23/Sept/02
HB + test	T24/Sept/02	W25/Jun/03
Insert in coil	T24/Jun/03	S12/Jul/03
Test EB supermod. insertion	S12/Jul/03	M11/Aug/03
HE Abs + optics manufacture	S12/Jun/99	W31/Oct/01
HE absorber delivery to CERN	T31/Jul/01	W31/Oct/01
Assemble HE to YE & test	W1/Aug/01	M31/Mar/03
HE testing	M31/Mar/03	S10/Jan/04



CMS Summary Schedule v 1.0 9'th June 1999 (preliminary)

Activity Name	Start Date	Finish Date
HF EDR	S30/Apr/00	
HF manufacture & assembly	S30/Apr/00	F30/Apr/04
HF assembly	F30/Apr/04	M28/Feb/05
HF testing	M28/Feb/05	F1/Jul/05
Magnet tests		
cool coil	M11/Aug/03	F10/Oct/03
close yoke, test	F10/Oct/03	T11/Dec/03
final mag test	T11/Dec/03	W7/Jan/04
Underground Installation		
UX ready	F31/Jan/03	
UX infrastructure & rot shield	S1/Feb/03	S10/Jan/04
install gantry crane	T31/Jul/03	S10/Jan/04
lower YE + & coil/YB	S10/Jan/04	M9/Feb/04
lower HB + & HB -	T10/Feb/04	S14/Mar/04
HB testing	S14/Mar/04	M31/May/04
ECAL EB/EE		
EDR barrel (EB)	T8/Jul/99	
crystal optimisation, protmod	T8/Jul/99	W5/Jan/00
Supermod 1 assembly	W5/Jan/00	F30/Jun/00
Supermod 1 calib	F30/Jun/00	S31/Dec/00
36 Supermods assy/cal	F30/Jun/00	T1/Apr/04
EB install	S14/Mar/04	S20/Jun/04
YE - lower	M15/Mar/04	M3/May/04
HE testing	M3/May/04	S31/Jul/04
EDR endcap (EE)	F30/Jun/00	
EE : Dee 1 assembly/cal	F30/Jun/00	M30/Sept/02
EE: 4 Dees assembly/cal	M30/Sept/02	S23/May/04
EE+ and EE- install	S13/Mar/04	S23/May/04
EB test	S20/Jun/04	F17/Dec/04
EE test	S23/May/04	T31/Mar/05
TRACKER, TK		
EDR	M28/Feb/00	
TK manufacture	M28/Feb/00	W1/Oct/03
TK assembly & burn-in	T2/Oct/03	F17/Dec/04
Tracker to SX	F17/Dec/04	
TK install	F17/Dec/04	M17/Jan/05
TK test	M17/Jan/05	T17/May/05
beampipe install	T17/May/05	T16/Jun/05
close detector, OK for beam	W1/Jun/05	M4/Jul/05
install HF, close shielding	F1/Jul/05	M1/Aug/05



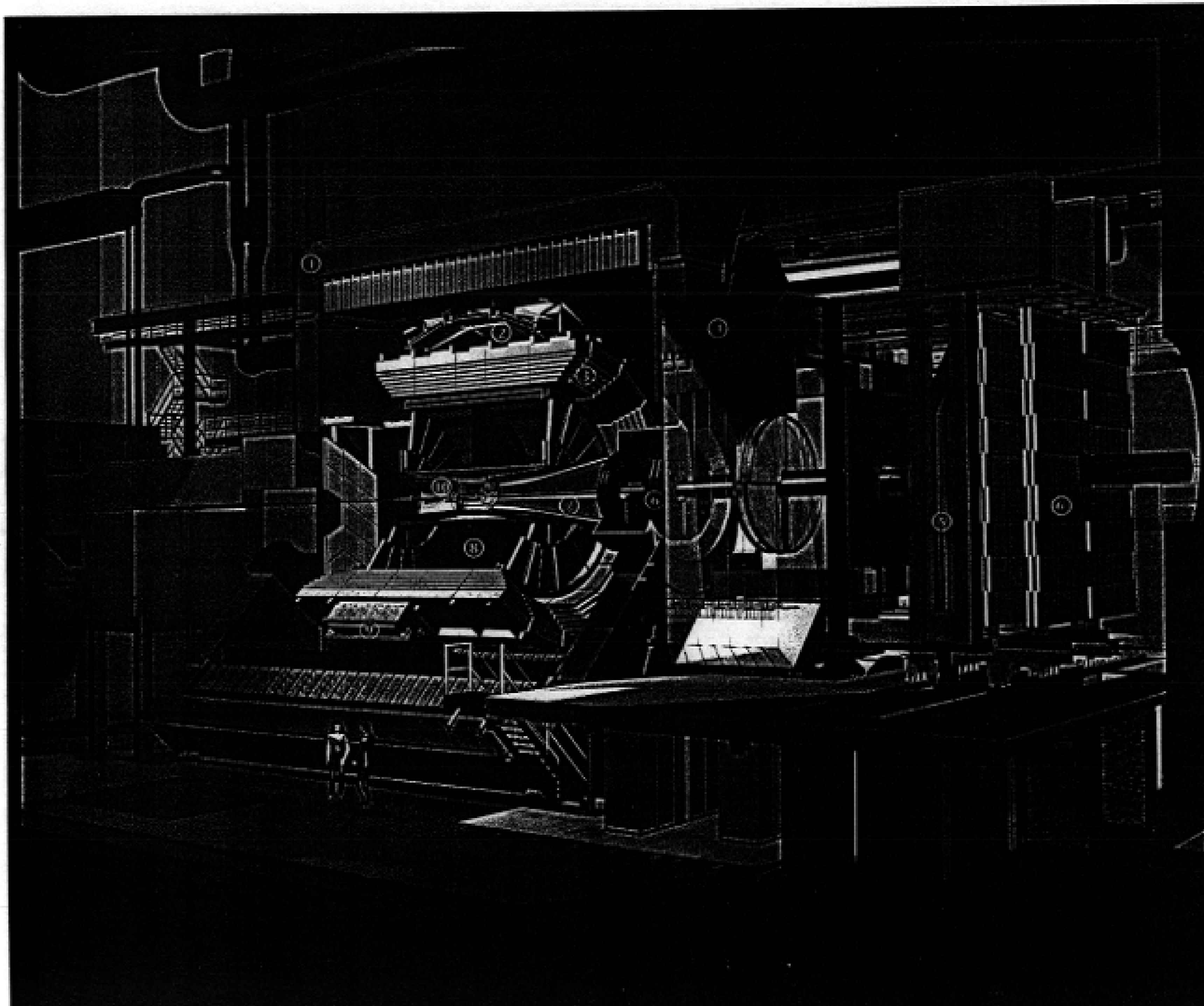

CMS Payments
Annual [MCHF]
Cumulative [kCHF]
100
90
80
70
60
50
40
30
20
10
0
500
400
300
200
100
0
95
96
97
98
99
00
01
02
03
04
05
06
3
2
20
25
56
81
83
Annual
Cumulative
Projection

ATLAS & CMS

- Well into construction
- Some choices still need to be made

Inevitable problems will have to be overcome

↳ Working Experiments JULY 2005



ALICE

1- L3 MAGNET
2- HMPID
3- TOF
4- DIPOLE MAGNET
5- MUON FILTER
6- TRACKING CHAMBERS
6'- TRIGGER CHAMBERS
7- ABSORBER
8- TPC
9- PHOS
10- ITS

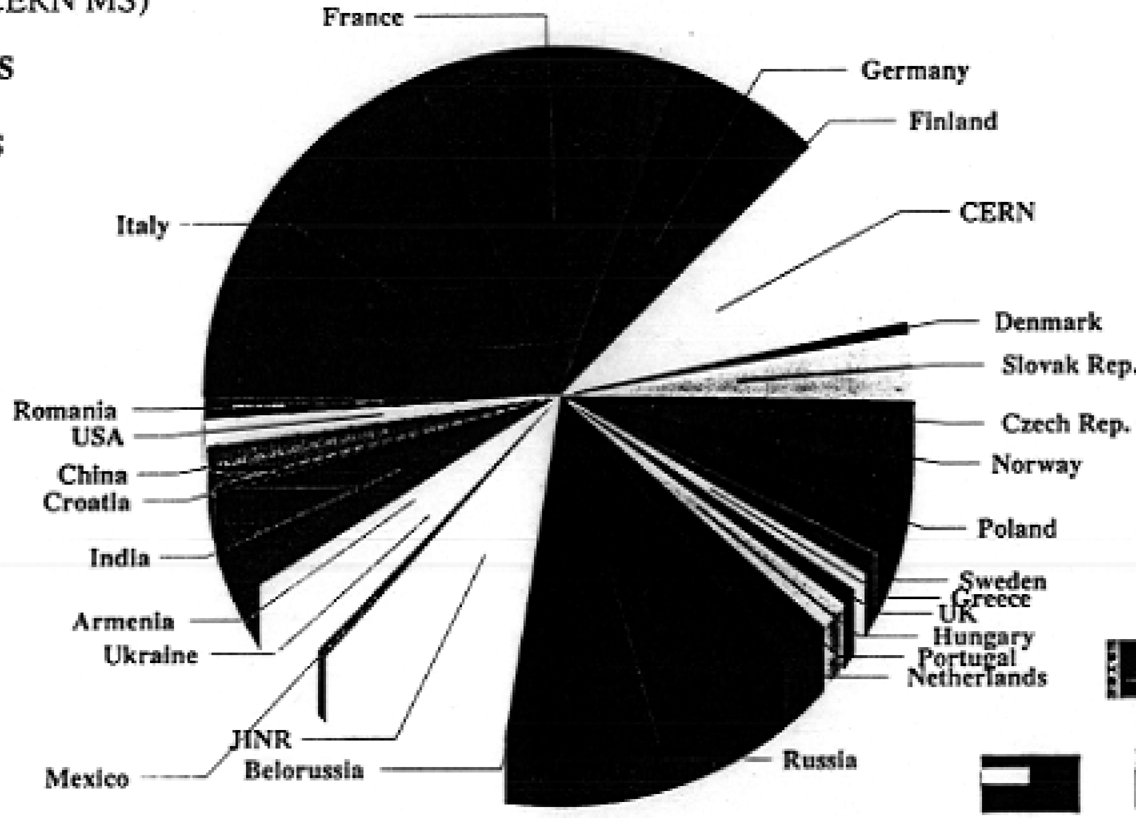
CERN

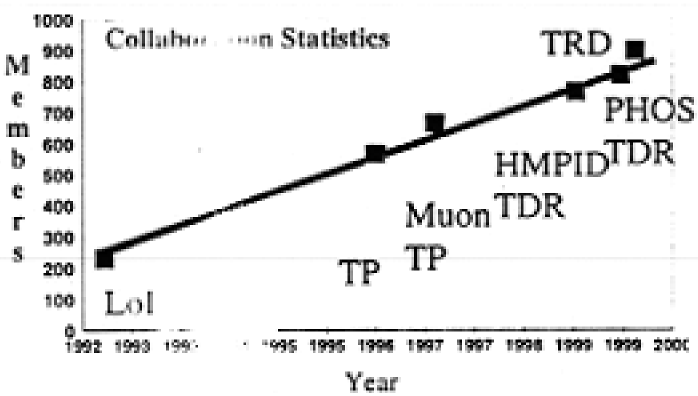
ALICE Collaboration

897 M bers
(64 m CERN MS)

28 C tries

74 In utes





Studying the quark/gluon plasma

1. Look for fluctuations — phase transitions
(within single events)

→ Identify hadrons

2. Look for direct probes of plasma

→ $\left\{ \begin{array}{l} e, \mu, \gamma \\ J/\psi, \Upsilon \text{ melting} \\ \text{charm} \end{array} \right.$

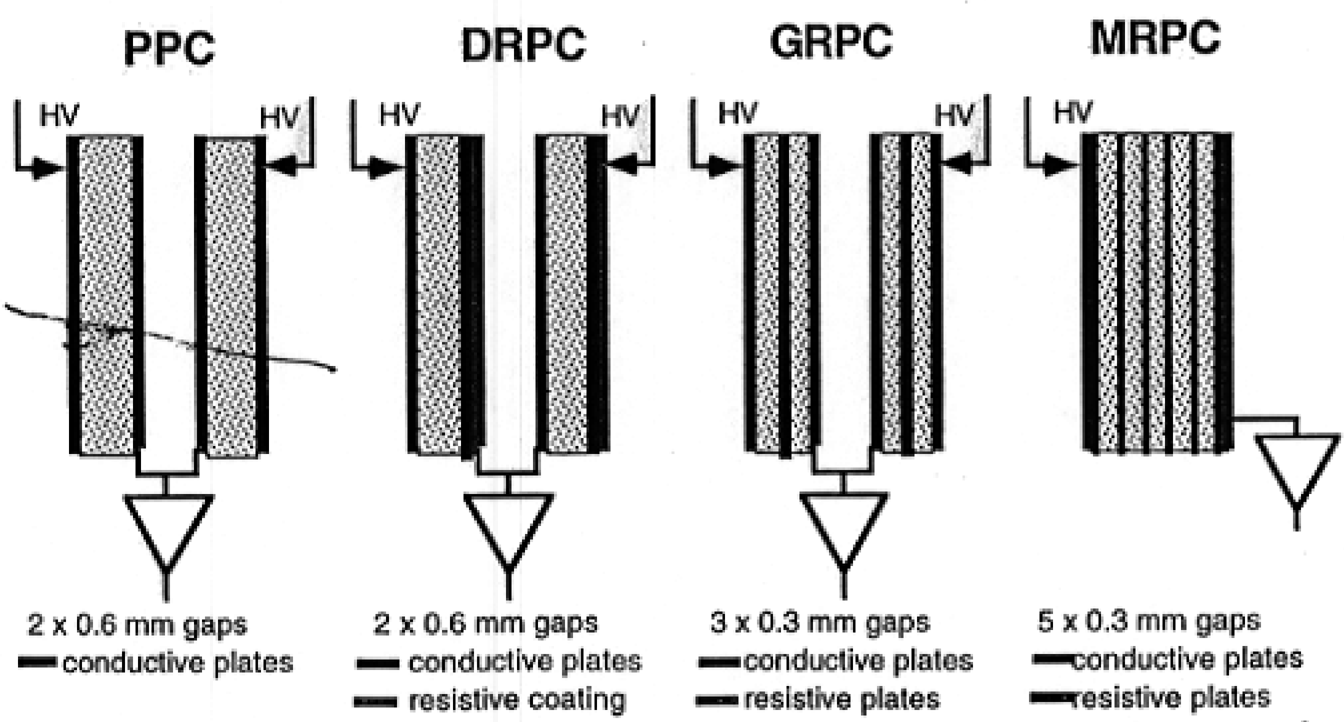
→ **ALICE**

- utilizes L3 magnet and infrastructure
- low momentum/energy particles

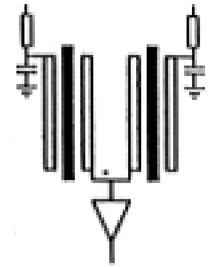
R&D Status

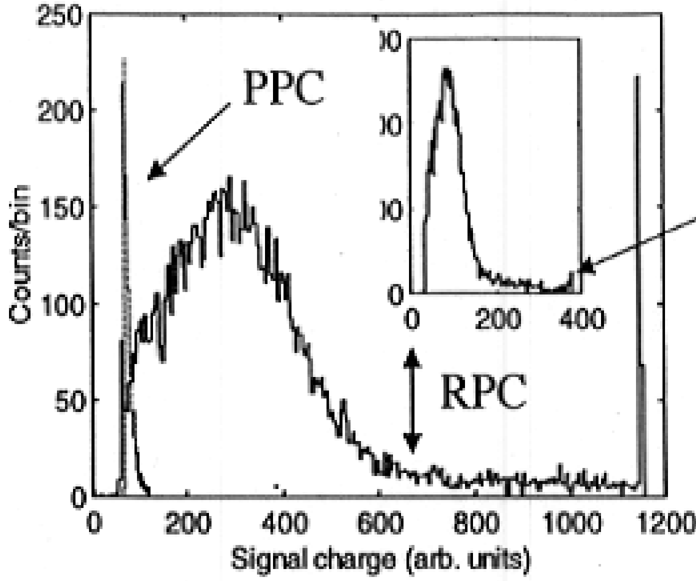
- **TOF: aim of R&D**
  - ➪ **affordable & high performance & large area** TOF array
    - ☆ **scint. + PM:** $\sigma \approx$ 100 ps, cost > 160 MCHF !!
    - ☆ **aim: same performance at 1/20 of cost**
  - ➪ **Pestov: better resolution** (x2), but only (!) **1/10 cost**
  - ➪ **PPC: 1/20 cost, but worse resolution** (x 2)

- **R&D: major progress !**
  - ➪ PPC -> **RPC**
  - ➪ sparks -> **streamers** ('mini sparks)
  - ➪ simple & safe gas
  - ➪ pulse height X 20 !!
  - ➪ **time resolution** $\sigma \approx$ 250-300 ps -> **110 - 150** ps !!!



4×0.3mm Glass RPC





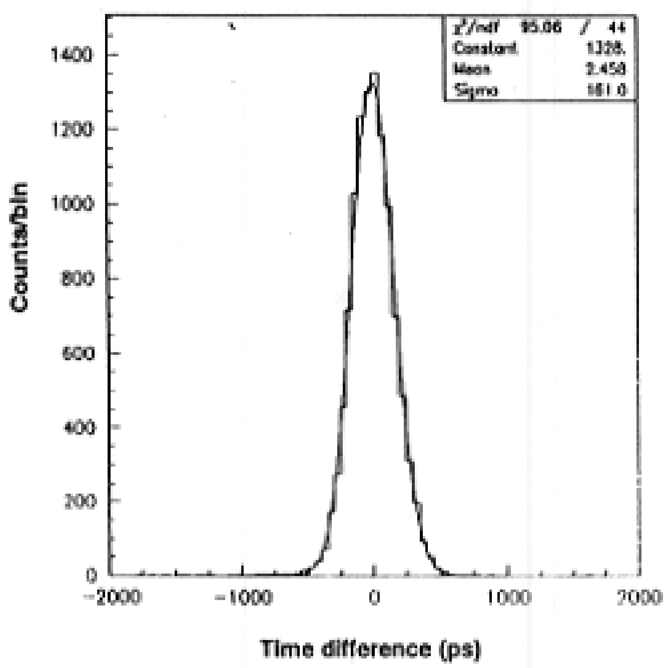
Small amount of streamers tolerated (2% in this case)

Resistive plate limits the maximum current available to the discharge

↓

Signal is 10 to 20 times larger than for PPCs because:

- Larger gas gain possible
- External capacitor allowed
- 4 gaps instead of 2



Effective time resolution

$$\sqrt{161^2-120^2} = 107 \text{ ps } (\sigma)$$

(After subtraction of start counter jitter)

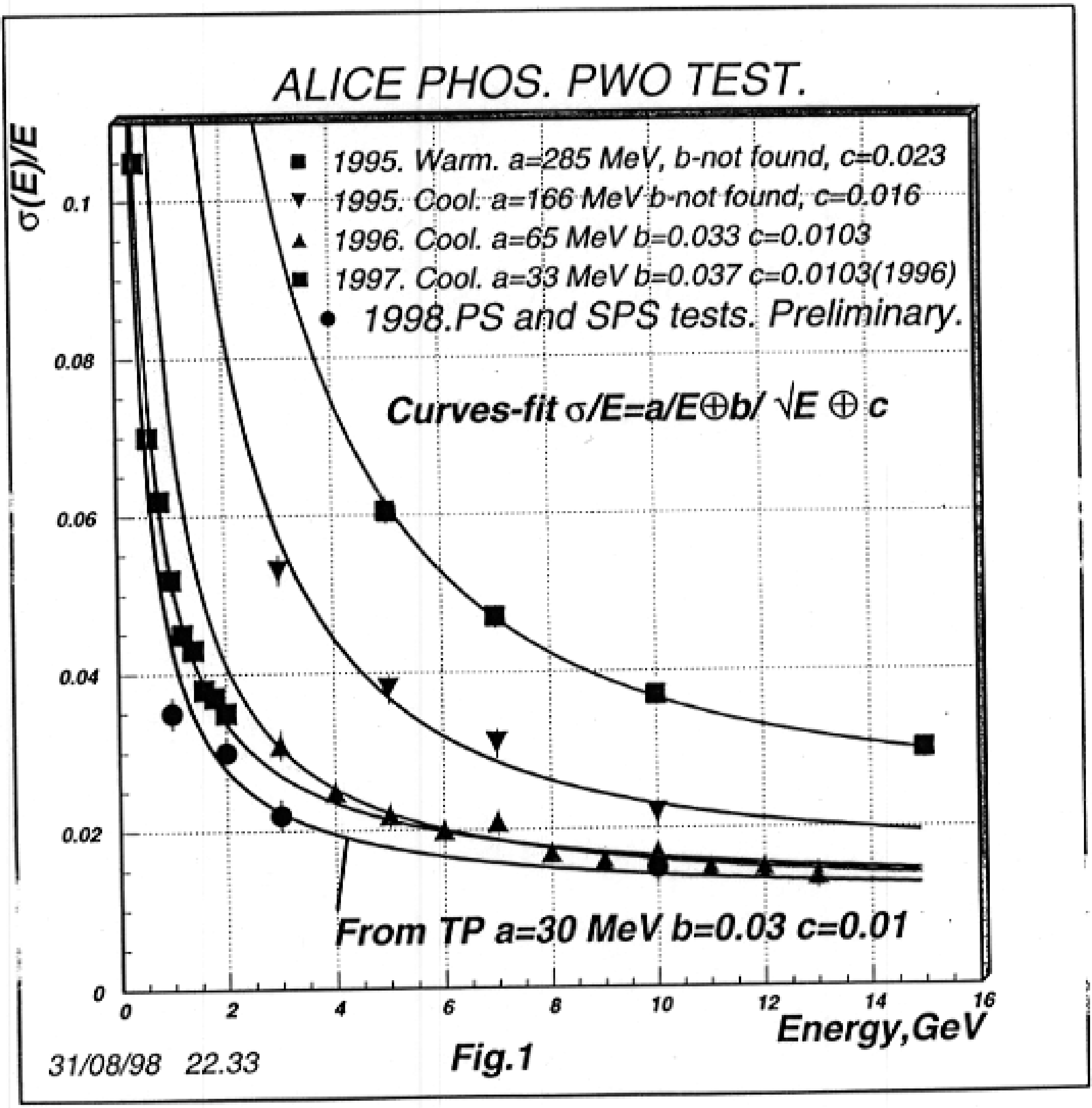
- Thinner gas gap.
- More gaps⇒better statistics
- Larger signal⇒less contribution from noise

Gas: $C_2H_2F_4$ + 5% iso-butane + 10% SF_6 (also no DME)

R&D Status

- **PHOS:** **TDR 5.3.99**
  - ➩ main aim: **direct photons** (**'Temperature'** of QGP)
  - ➩ **crystals & PIN diode: ≈ final,** within specs
  - ➩ **mech & cooling: prototypes** tested, within specs
  - ➩ **ready** for crystal pre-production
  - ➩ **size reduced** to fit resources to ≈ **1/2** ($8m^2$)
    - ☆ inclusive physics: **statistics** ≈ **1/6**
      partially recuperated with stand-alone trigger
    - ☆ E-by-E physics: **accuracy** ≈ **1/√2**
  - ➩ **price: 14MSF -> 8.6 MSF**

- **Collaboration**
  - ➩ **Russia:** Kurchatov, IHEP Protvino, VNIIEF Sarov
  - ➩ **Norway:** Oslo, Bergen
  - ➩ **China:** CIAE Bejing, Wuhan, SIC Shanghai **(tbc)**
  - ➩ **Czech Rep** (IoP Prag), **France** (Nantes), **Poland** (SINS Warsaw), **Germany** (Munster), **CERN**
    - ☆ under discussion: **US-DOE** (Oak Ridge)



ALICE PHOS. PWO TEST.
σ(E)/E
1995. Warm. a=285 MeV, b-not found, c=0.023
1995. Cool. a=166 MeV b-not found, c=0.016
1996. Cool. a=65 MeV b=0.033 c=0.0103
1997. Cool. a=33 MeV b=0.037 c=0.0103(1996)
1998.PS and SPS tests. Preliminary.
Curves-fit σ/E=a/E⊕b/ √E ⊕ c
From TP a=30 MeV b=0.03 c=0.01
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
12
14
16
Energy,GeV
31/08/98 22.33

Fig.1

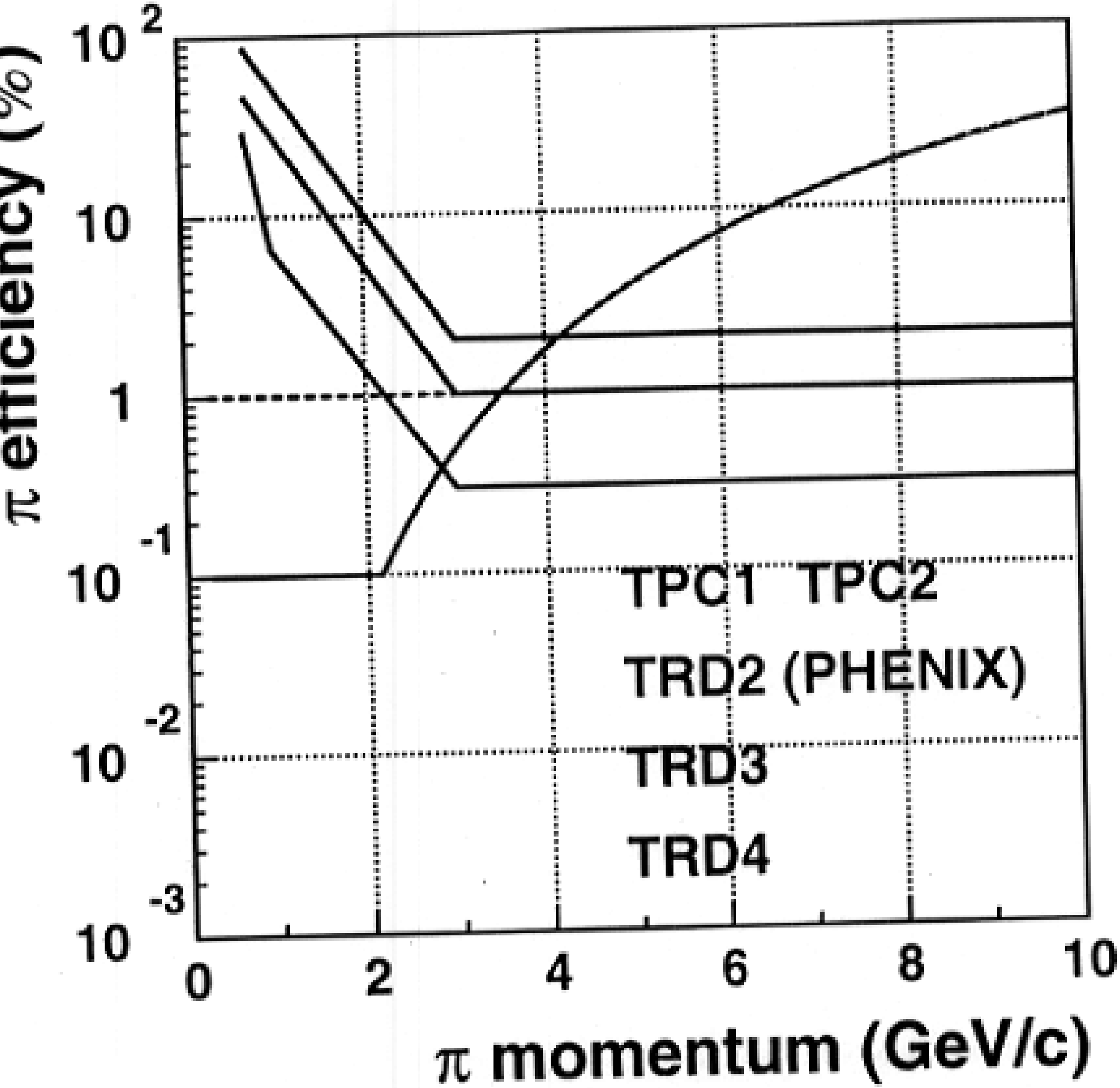
TRD upgrade

- **increased importance of em & hard probes**
  - ⇨ **TH progress** in preparing for RHIC/LHC
  - ⇨ **NA50 results** on J/Ψ suppression
    - ☆ μ-arm included in ALICE
  - ⇨ **NA45/NA50** results on low/interm. mass l^+l^-

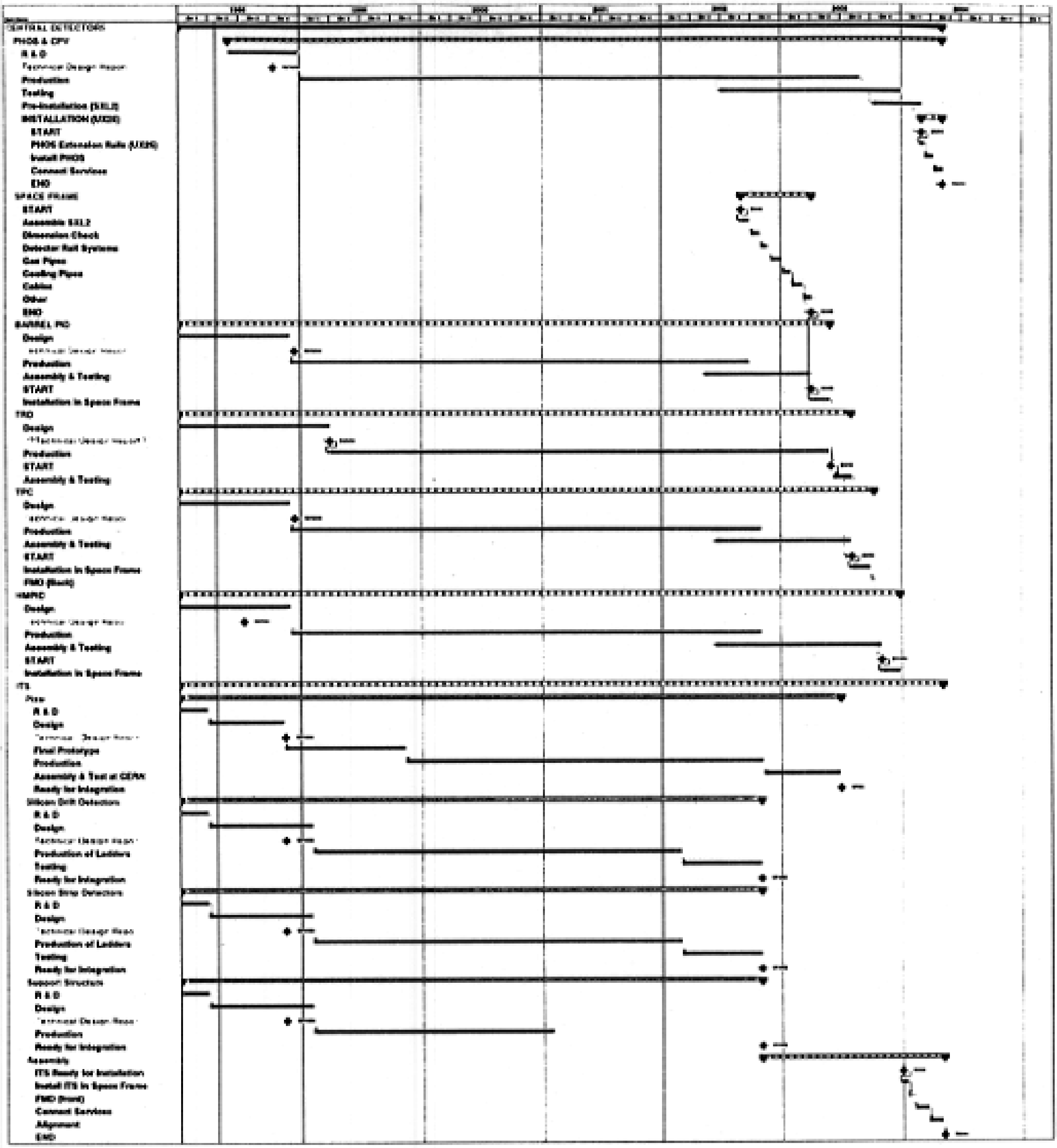
- **ALICE had no dedicated e-ID**
  - ⇨ **ALICE** modelled starting 1990 **similar to NA49/STAR**
  - ⇨ **challenging topic** (physics & hardware)
  - ⇨ **no** dedicated **group** in ALICE

- **<u>proposal:</u> large area TRD ($-1<\eta<1$)**
  - ⇨ **dedicated group** (GSI/HD, ≈ NA45)
  - ⇨ **feasible hardware** (TRD developed for PHENIX)
  - ⇨ **prepared & discussed since > 2 years**

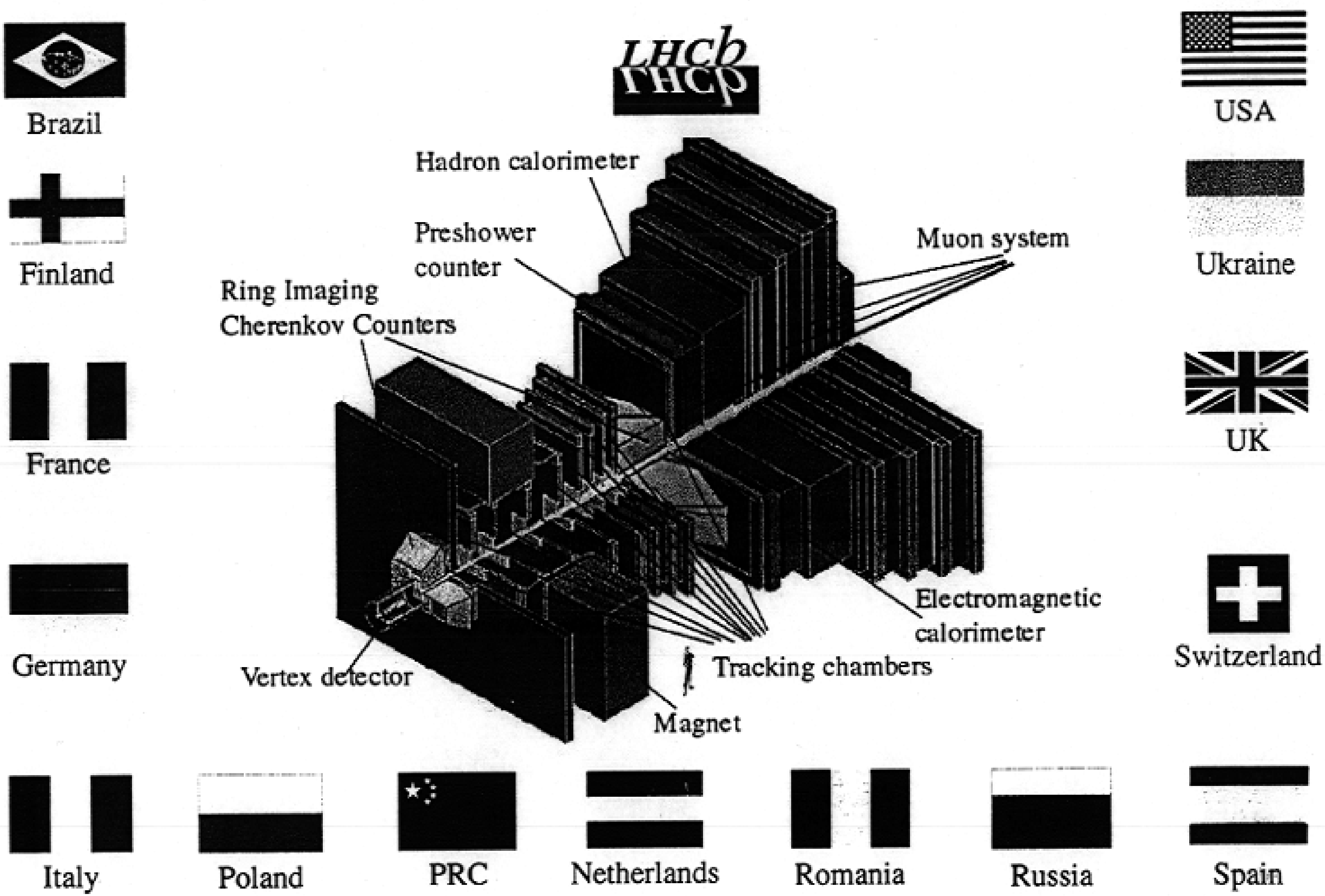
- **<u>physics:</u> single electrons & e^+e^- pairs**
  - ⇨ **J/Ψ & Y** suppression at y=0
    - ☆ complementary to μ-arm
  - ⇨ open **charm & beauty** production
  - ⇨ **light mesons** (ω/ϕ)
  - ⇨ **continuum** lepton pairs


π efficiency (%)
10 2
10
1
10 -1
10 -2
10 -3
0
2
4
6
8
10
π momentum (GeV/c)
TPC1 TPC2
TRD2 (PHENIX)
TRD3
TRD4

ALICE CENTRAL DETECTOR PLANNING



C. R. Gregory/Fri 24/4/98

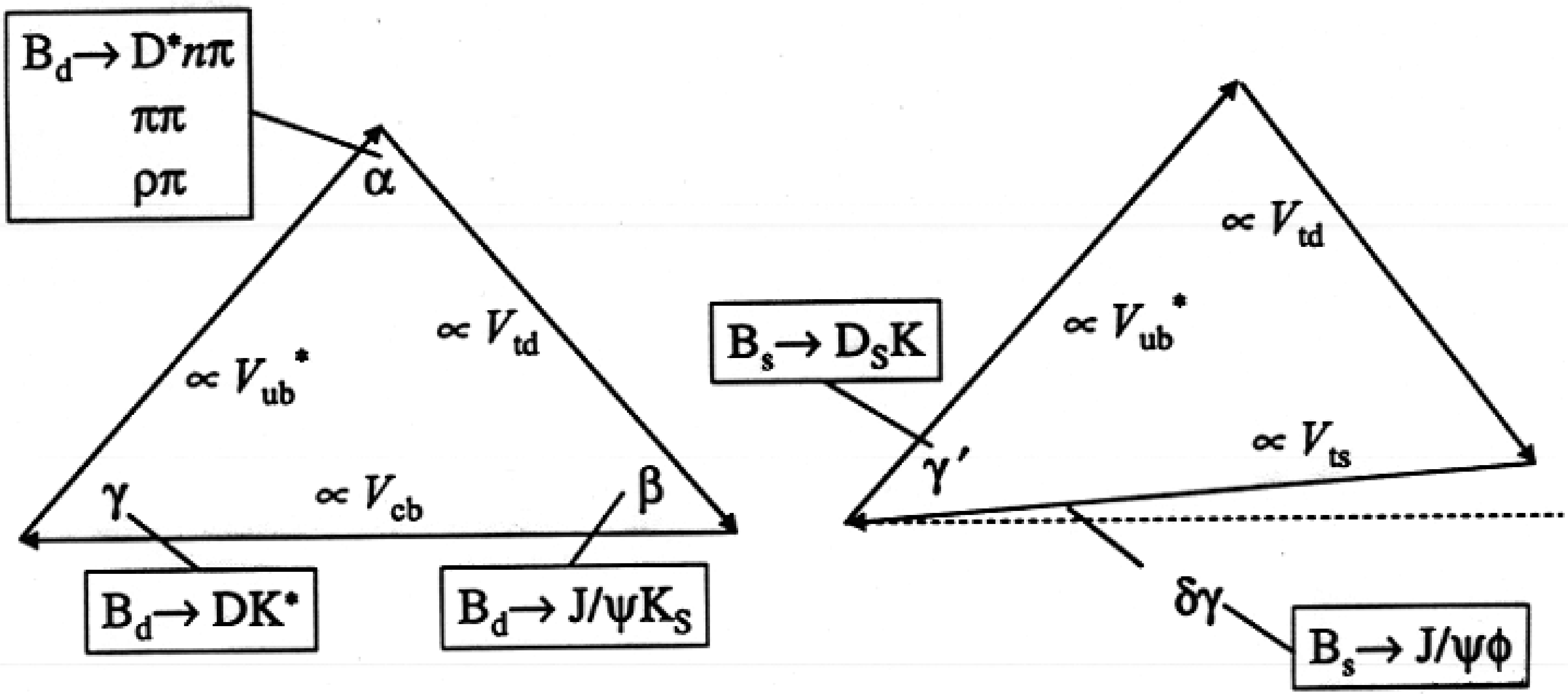


LHCb
Hadron calorimeter
Preshower
counter
Ring Imaging
Cherenkov Counters
Muon system
Electromagnetic
calorimeter
Tracking chambers
Vertex detector
Magnet
Brazil
Finland
France
Germany
Italy
Poland
PRC
Netherlands
Romania
Russia
Spain
USA
Ukraine
UK
Switzerland

Angles of CKM Unitarity Triangles

(and decay modes to measure them)

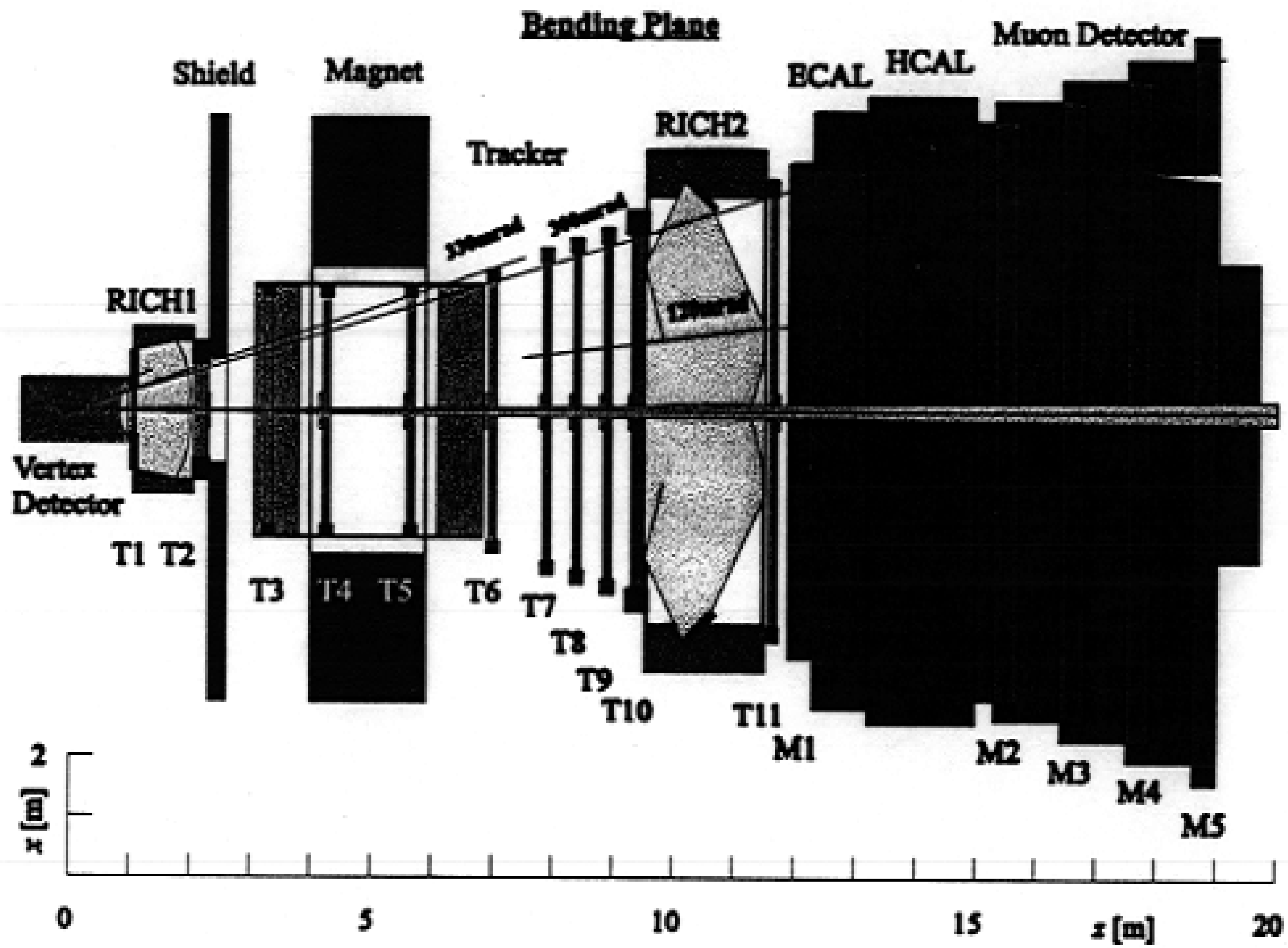
$V_{td} V_{tb}^* + V_{cd} V_{cb}^* + V_{ud} V_{ub}^* = 0 \quad V_{td} V_{ud}^* + V_{ts} V_{us}^* + V_{tb} V_{ub}^* = 0$



The *LHCb* Collaboration (24.3.99)

Finland:	Espoo-Vantaa Inst. Tech.
France:	Clermont-Ferrand, CPPM Marseille, LAL Orsay
Germany:	Humboldt Univ. Berlin, Univ. Freiburg, Tech. Univ. Dresden, Phys. Inst. Univ. Heidelberg, IHEP Univ. Heidelberg, MPI Heidelberg.
Italy:	Bologna, Cagliari , Genoa, Milan, Univ. Rome I (La Sapienza) . Univ. Rome II(Tor Vergata)
Netherlands:	Univ. Amsterdam, Free Univ. Amsterdam, Univ. Utrecht, FOM
Poland:	Cracow Inst. Nucl. Phys., Soltan Inst. Nucl. Study Warsaw
Spain:	Univ. Barcelona, Univ. Santiago de Compostela
Switzerland:	Univ. Lausanne
UK:	Univ. Cambridge, Univ. Edinburgh, Univ. Glasgow, IC London, Univ. Liverpool, Univ. Oxford
CERN	
Brazil:	UFRJ
China:	IHEP(Beijing), Univ. Sci. and Tech.(Hefei), Nanjing Univ., Shandong Uni.
Russia:	INR, ITEP, Lebedev Inst., IHEP, PNPI(Gatchina)
Romania:	Inst. of Atomic Phys. Bucharest
Ukraine:	Inst. Phys. Tech. (Kharkov), Inst. Nucl. Research (Kiev)
U.S.A.:	Univ. Virginia, Northwestern Univ., Rice Univ.

The LHCb Detector



Level	Characteristics	Sub-detector		
Level-0	high p_T :e :h :μ pile-up	ECAL E+HCAL Muon Pile-up	(60k channels)	in-put 40 MHz latency 3.2 μs
	on-detector → off-detector electronics (1 TB/s)			
Level-1	sec. vertices high p_T	Vertex Trackers+L0-Seed	(220k)	1 MHz <256 μs
	off-detector → event buffer (2-4 GB/s)			
Level-2	refined sec. vertices	Vertex + Trackers		40 kHz 10 ms
Level-3	partial and full reconstruction of final states	All		5 kHz 200 ms To tape = 200 Hz

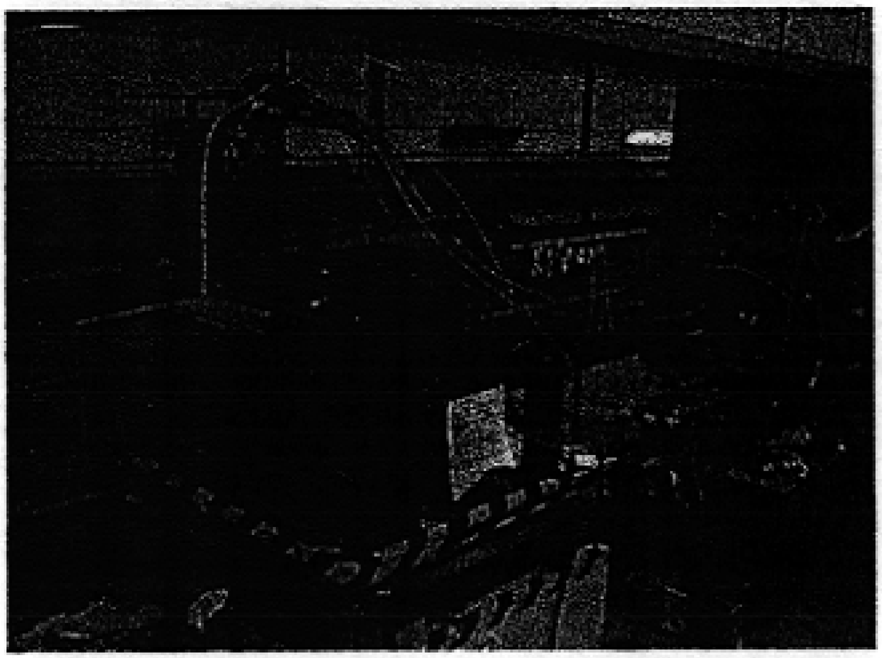
LHCb Trigger Efficiency

for reconstructed and correctly tagged events

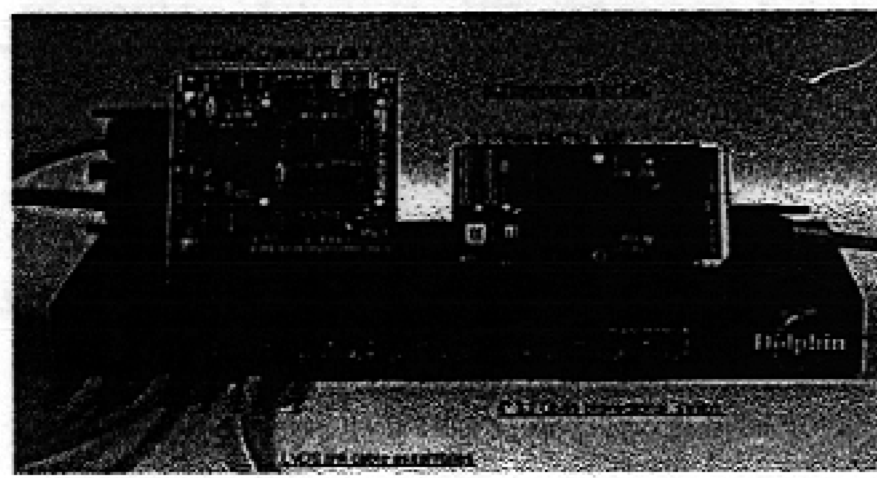
	L0(%)				L1(%)	L2(%)	Total(%)
	μ	e	h	all			
$B_d \rightarrow J/\psi(ee)K_S$ + tag	17	**63**	17	72	42	81	**24**
$B_d \rightarrow J/\psi(\mu\mu)K_S$ + tag	**87**	6	16	88	50	81	**36**
$B_s \rightarrow D_s K$ + tag	15	9	**45**	54	56	92	**28**
$B_d \rightarrow DK^*$	8	3	31	37	59	95	21
$B_d \rightarrow \pi^+\pi^-$ + tag	14	8	**70**	76	48	83	**30**

- trigger efficiencies are ~ 30%
- hadron trigger is important for hadronic final states
- lepton trigger is important for final states with leptons

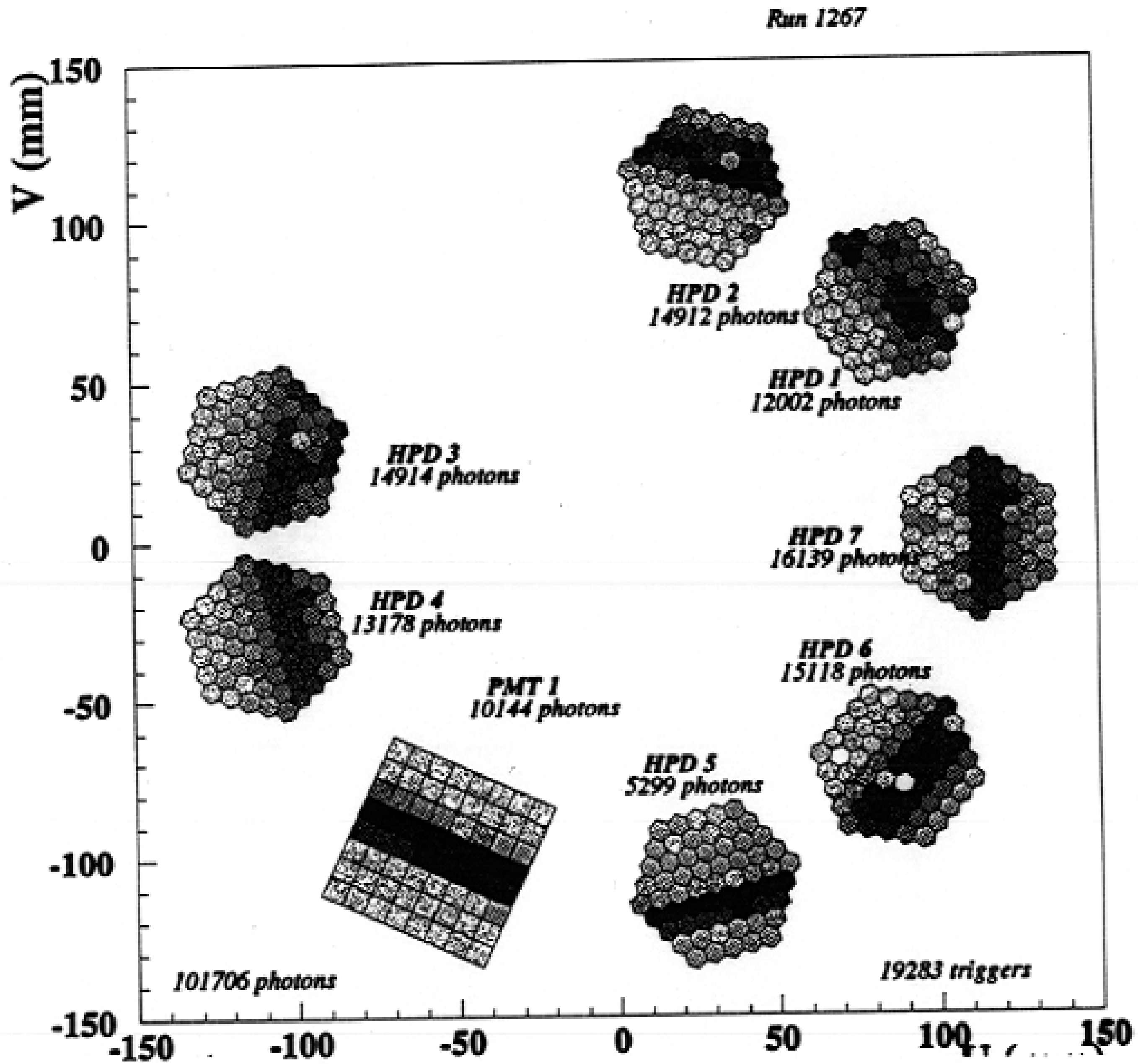
RICH-2
full scale prototype



SCI link test card



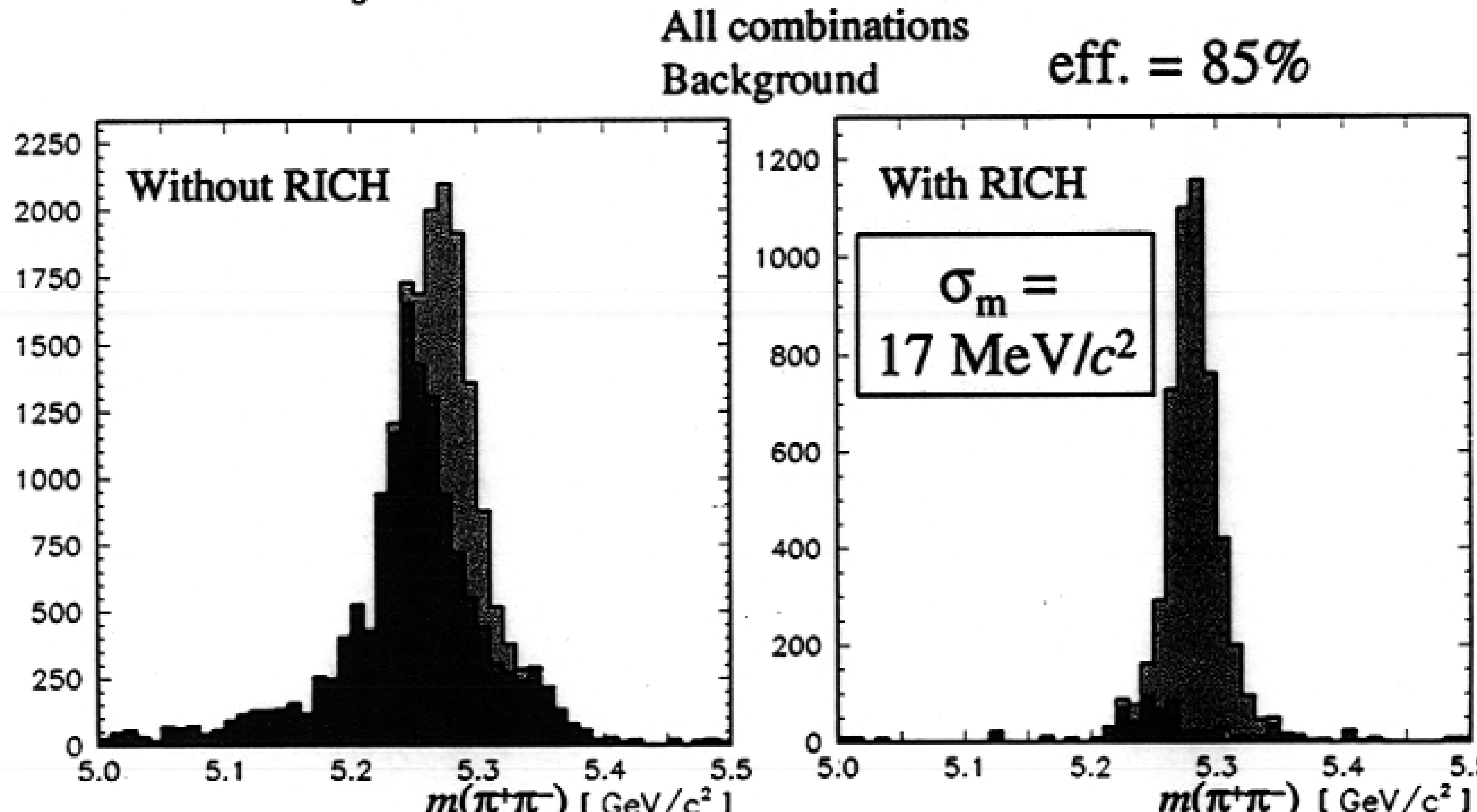
Observed
Cherenkov ring



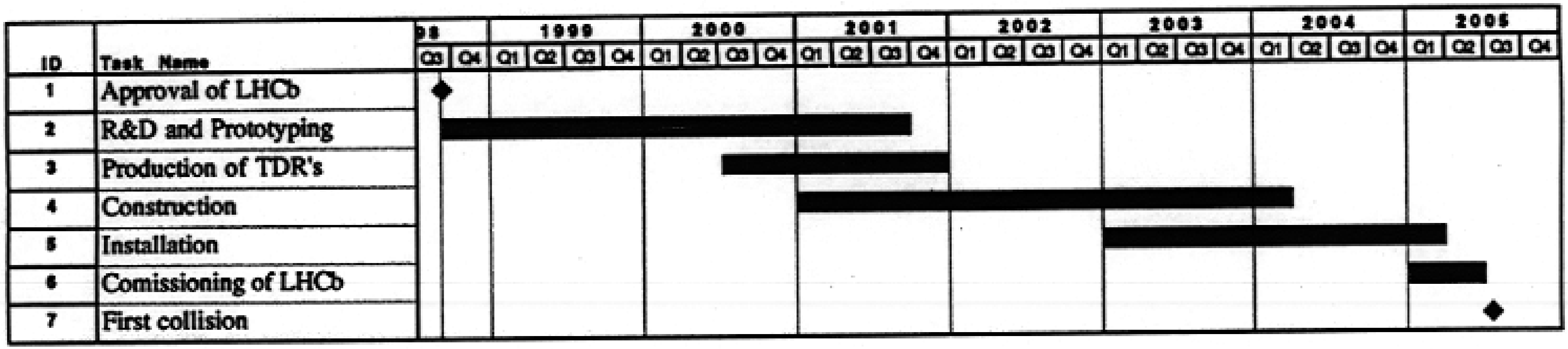
Importance of particle identification

Br: $B_d \to \pi^+\pi^- = 0.7\times10^{-5}$, $\to K^\pm\pi^\mp = 1.5\times10^{-5}$

$B_s \to K^+K^- = 1.5\times10^{-5}$, $\to K^\pm\pi^\mp = 0.7\times10^{-5}$



LHCb Master Plan



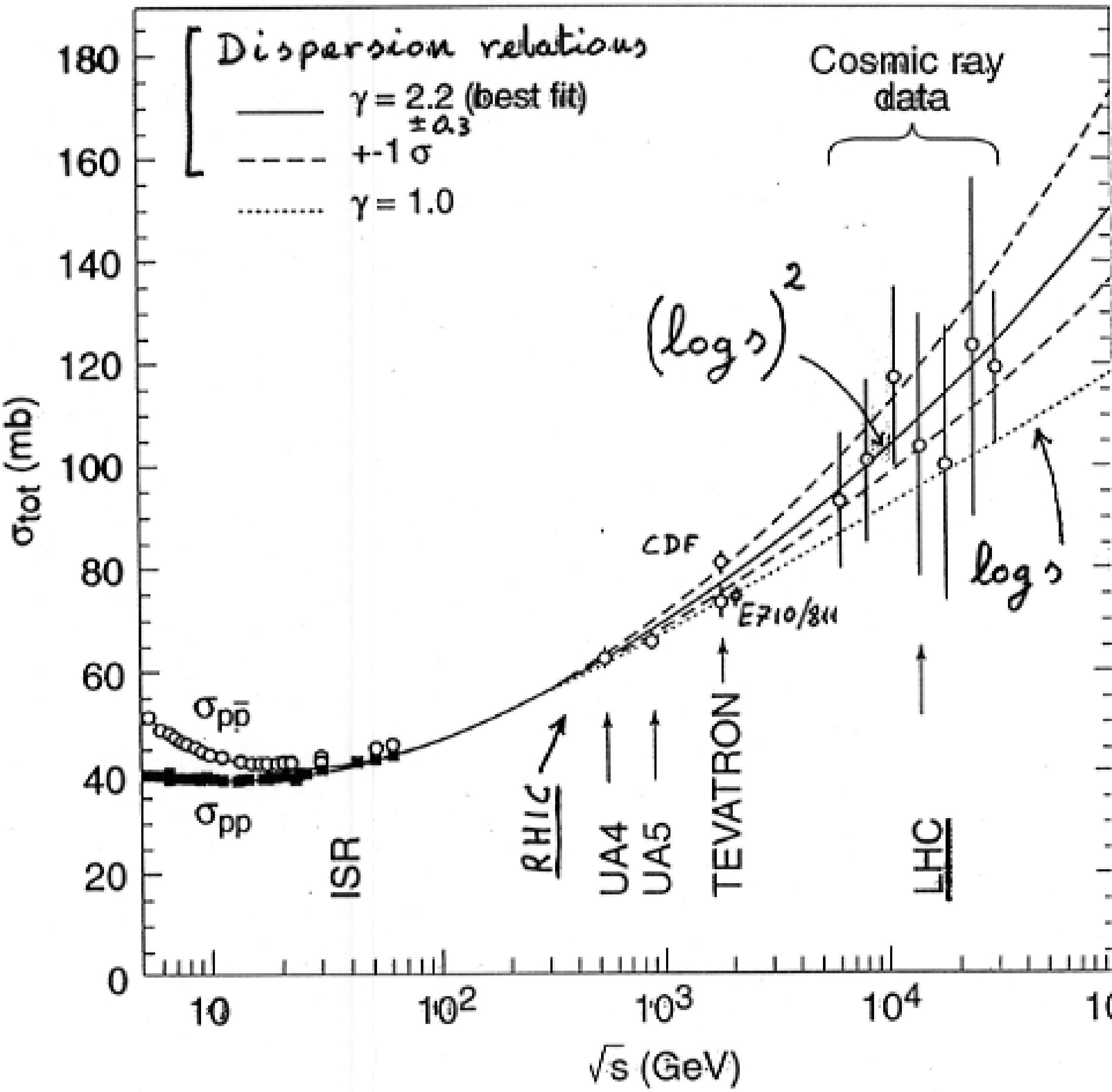
R&D and Prototyping
Production of TDR's
Construction of Sub-systems
Installation of the LHCb detector
Commissioning of the experiment

NEWER PROPOSALS

- TOTEM – total cross-sections
  - ↳ extrapolation to optical poi
  - $\sigma_{el} + \sigma_{inel}$
- MOEDAL – search for monopoles
  ......
  - ↳ $M_M \sim 3\text{–}4$ TeV

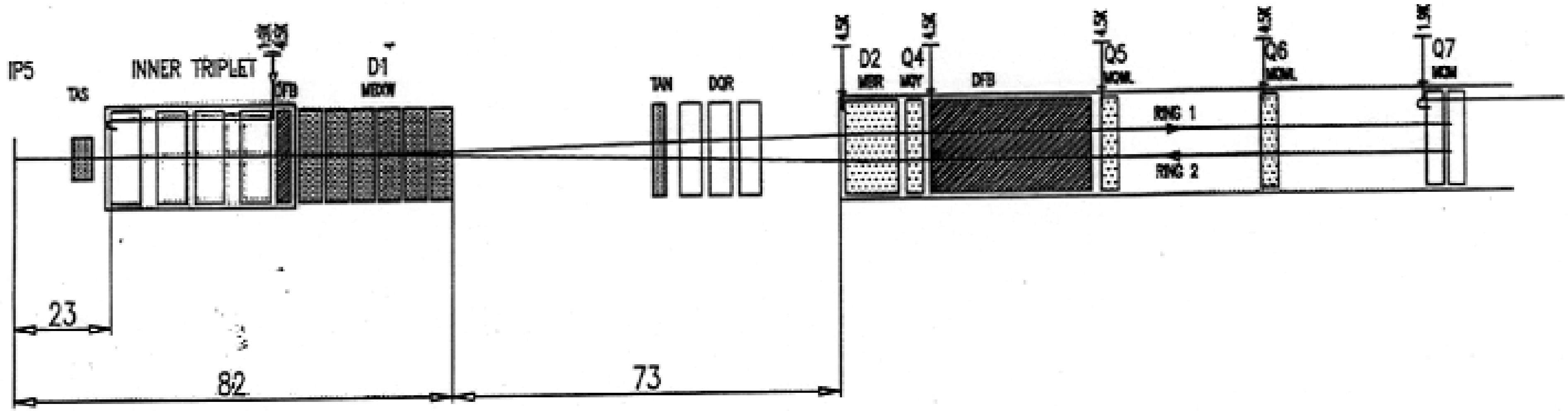
TOTEM

- Associated with CMS
- Uses $\left\{ \begin{array}{l} \text{Roman Pots + detectors} \\ \text{chambers } \eta \gtrsim 4 \end{array} \right\}$

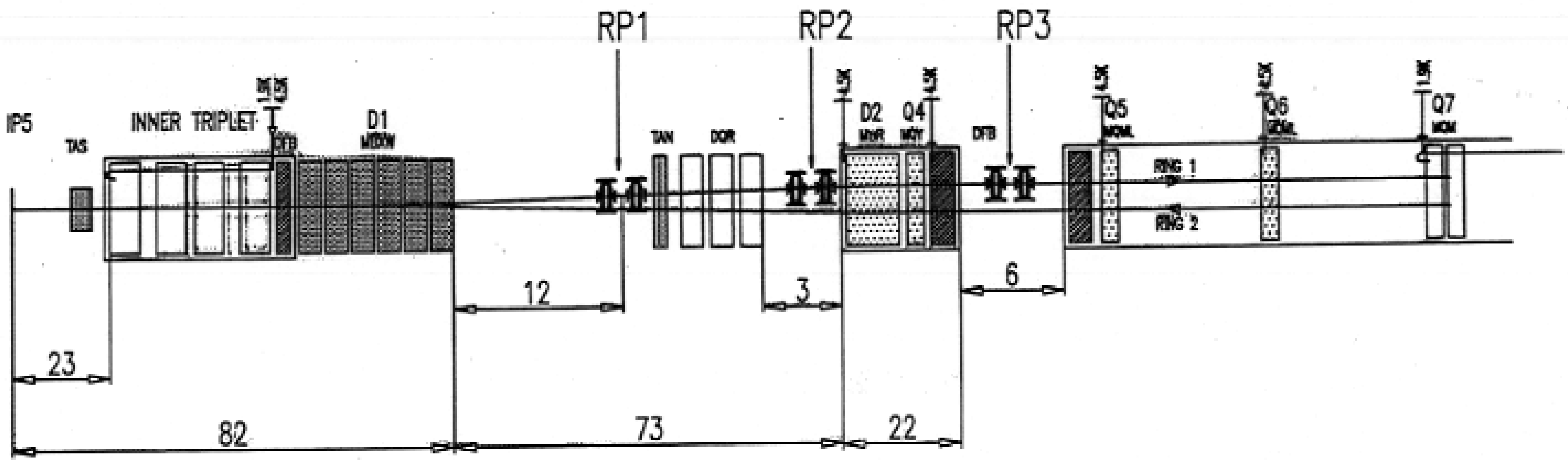


AIM OF TOTEM : $\Delta\sigma_{tot} \approx 1$ mb

GML
LHCC
25.3.03



IP5
TAS
INNER TRIPLET
DFB
D1
MBXW
TAN
DQR
D2
MBR
Q4
MQY
DFB
Q5
MQML
Q6
MQML
Q7
MQM
RING 1
RING 2
4.5K
1.9K
23
82
73

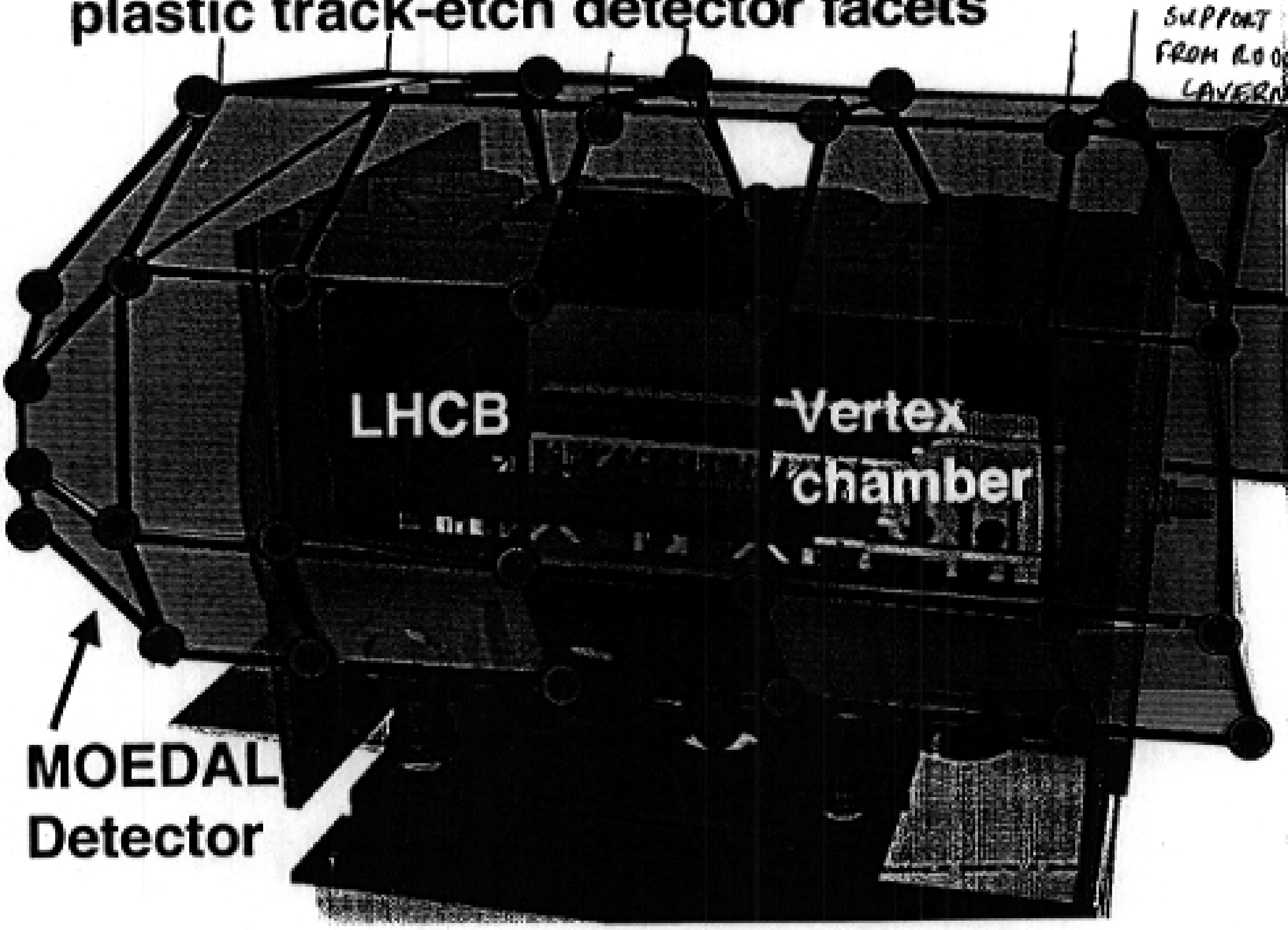


RP1
RP2
RP3
IP5
TAS
INNER TRIPLET
DFB
D1
MBXW
TAN
DQR
D2
MBR
Q4
MQY
DFB
Q5
MQML
Q6
MQML
Q7
MQM
RING 1
RING 2
4.5K
1.9K
12
3
6
23
82
73
22

CMS

The MOEDAL Detector in the LHCB Vertex Region

- MOEDAL highly ionizing particle detector comprised of a fast assembly/dissembly frame with multi-layer (4->5) lexan/CR39 plastic track-etch detector facets



- Track-etch detectors are light, inert and easy to machine/cut
- Final design of MOEDAL detector depends on final design of LHCB vertex region -- hence, flexible "framework" approach

COMPUTING FOR THE LHC ERA

- Preliminary Estimates

  → Substantial Increase in Capacity

  (Spec95 ≅ 40 M

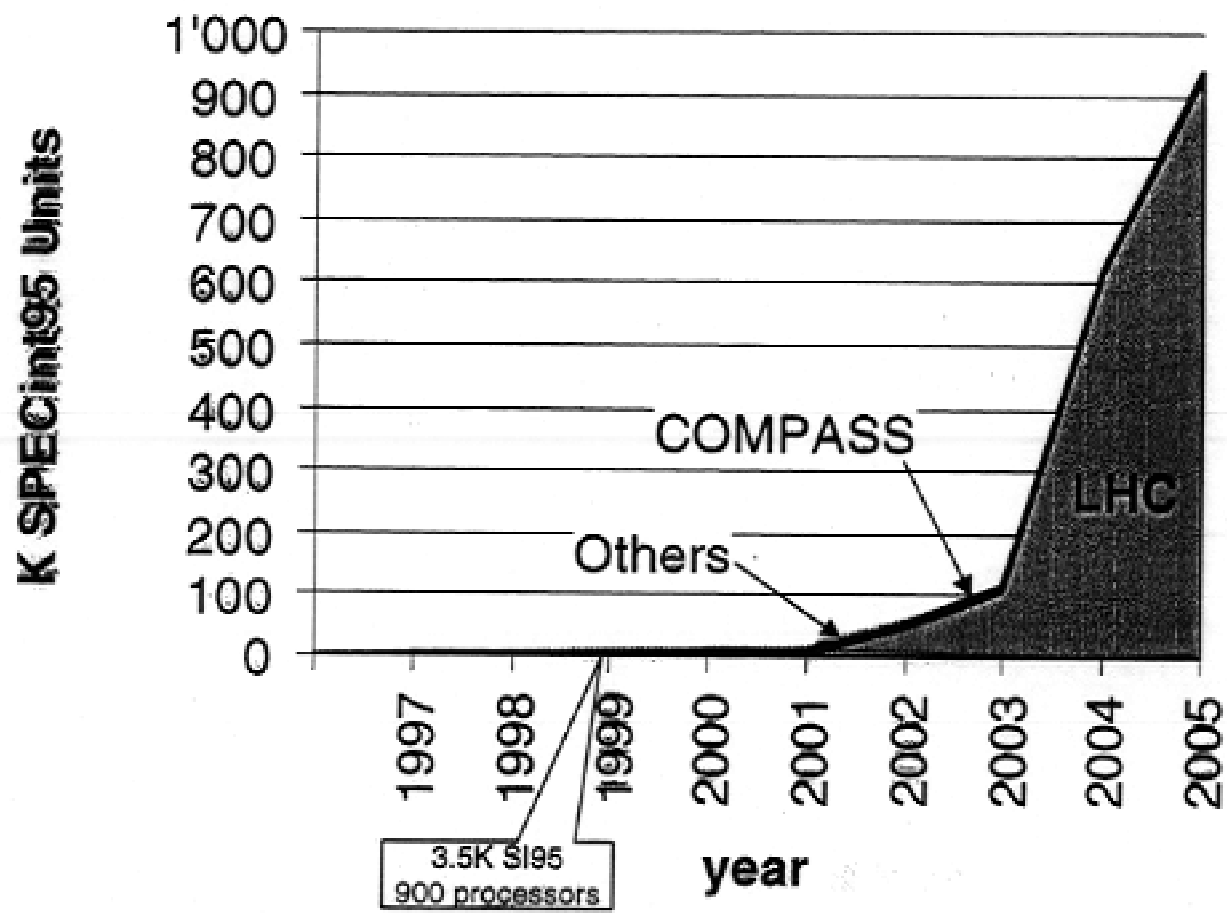
- Software methodology ...

  → New ways of working

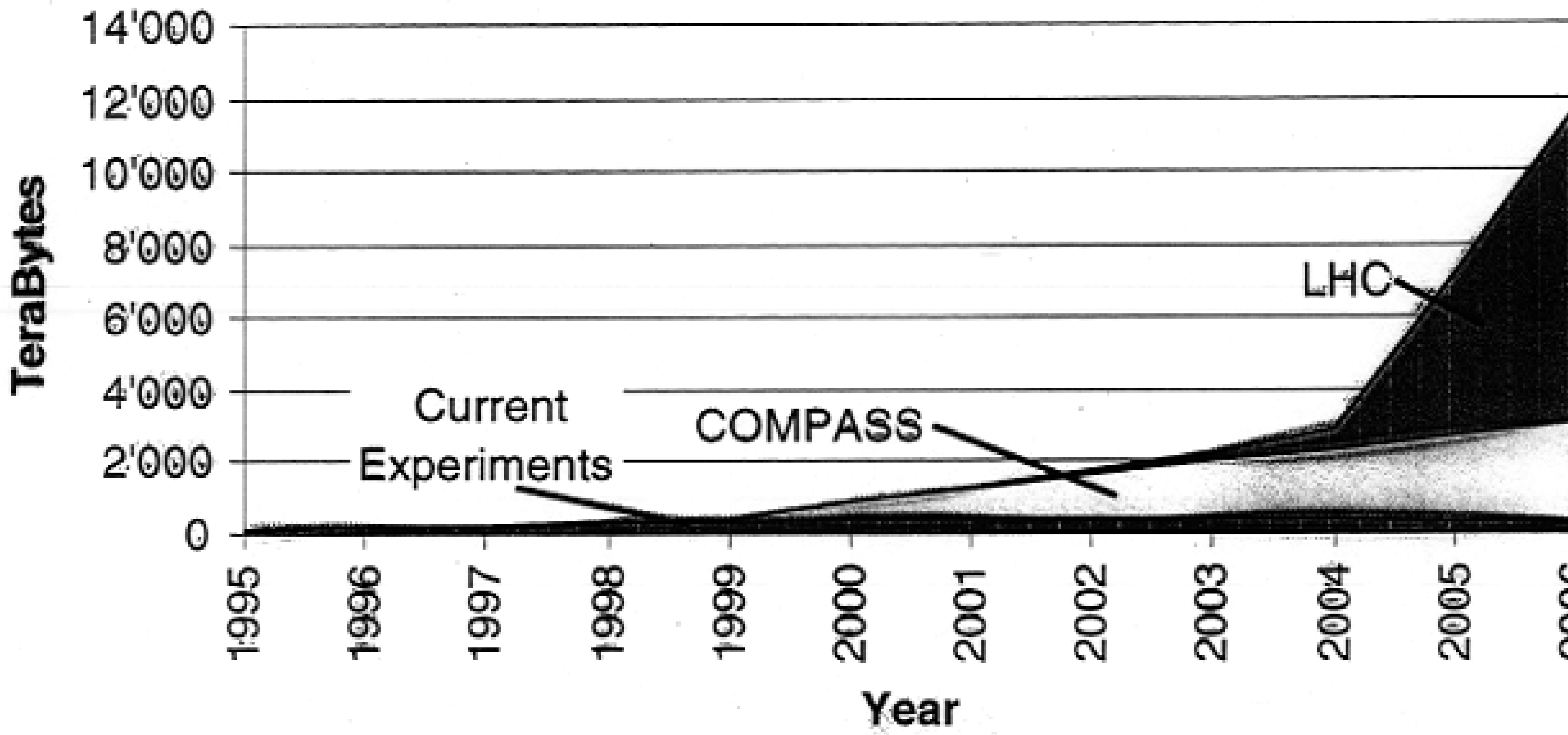
⇒ Major effort by the whole Community – Coordinated Effort

→ Review by/at/with CERN in 1999 / 2000

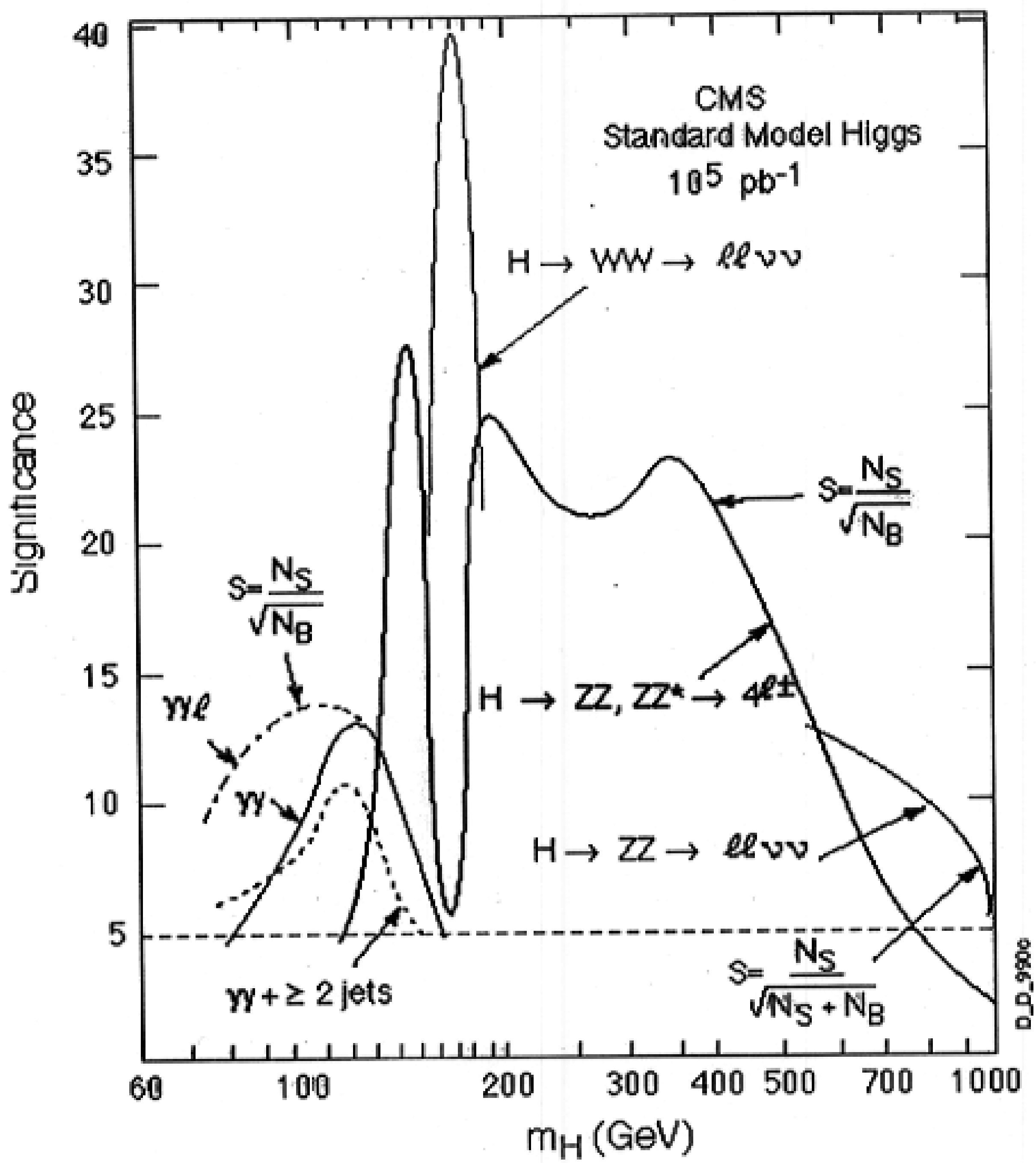
Evolution of Computing Capacity - SPECint95



Long Term Tape Storage Estimates



Observability of SM Higgs

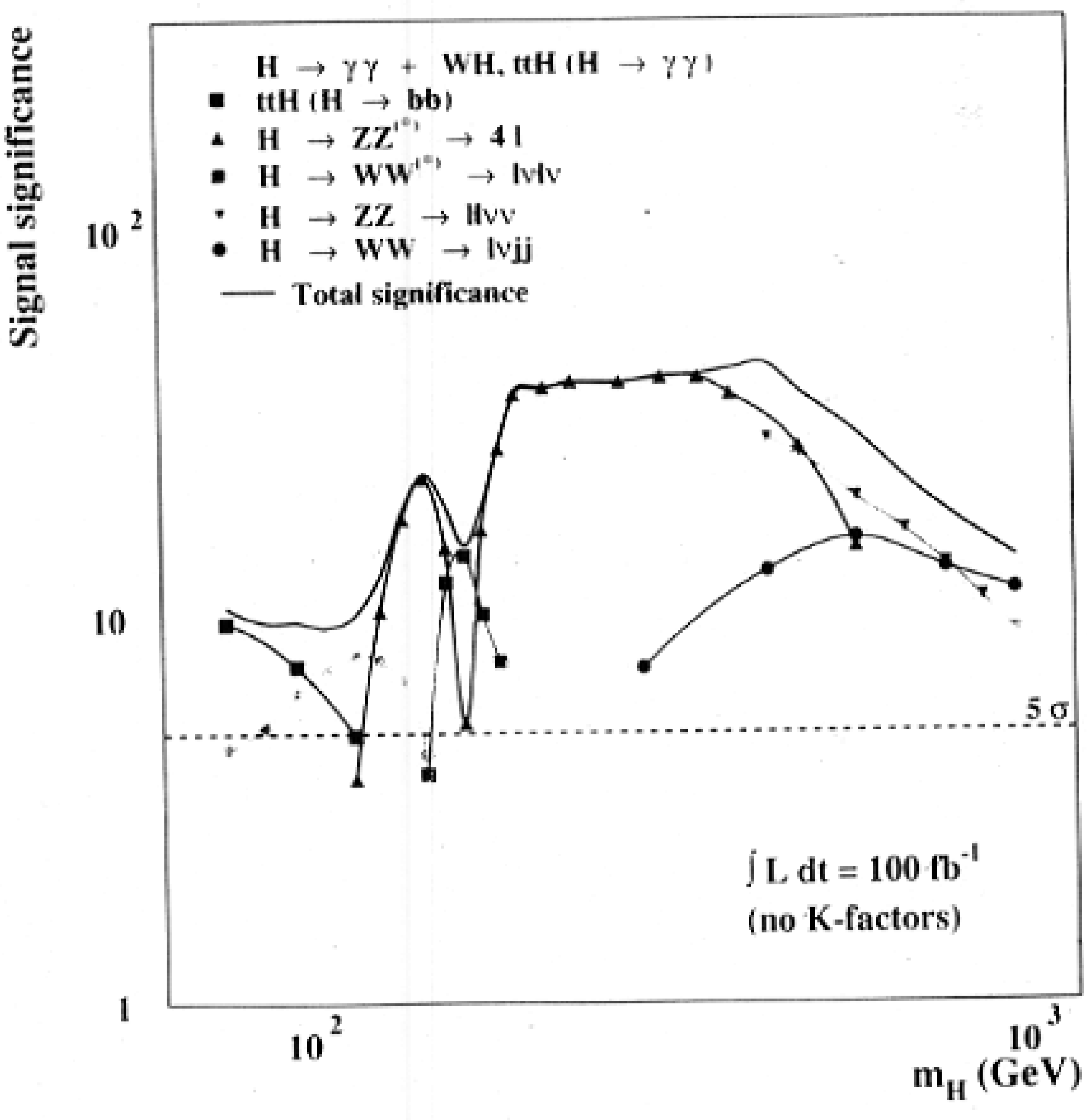


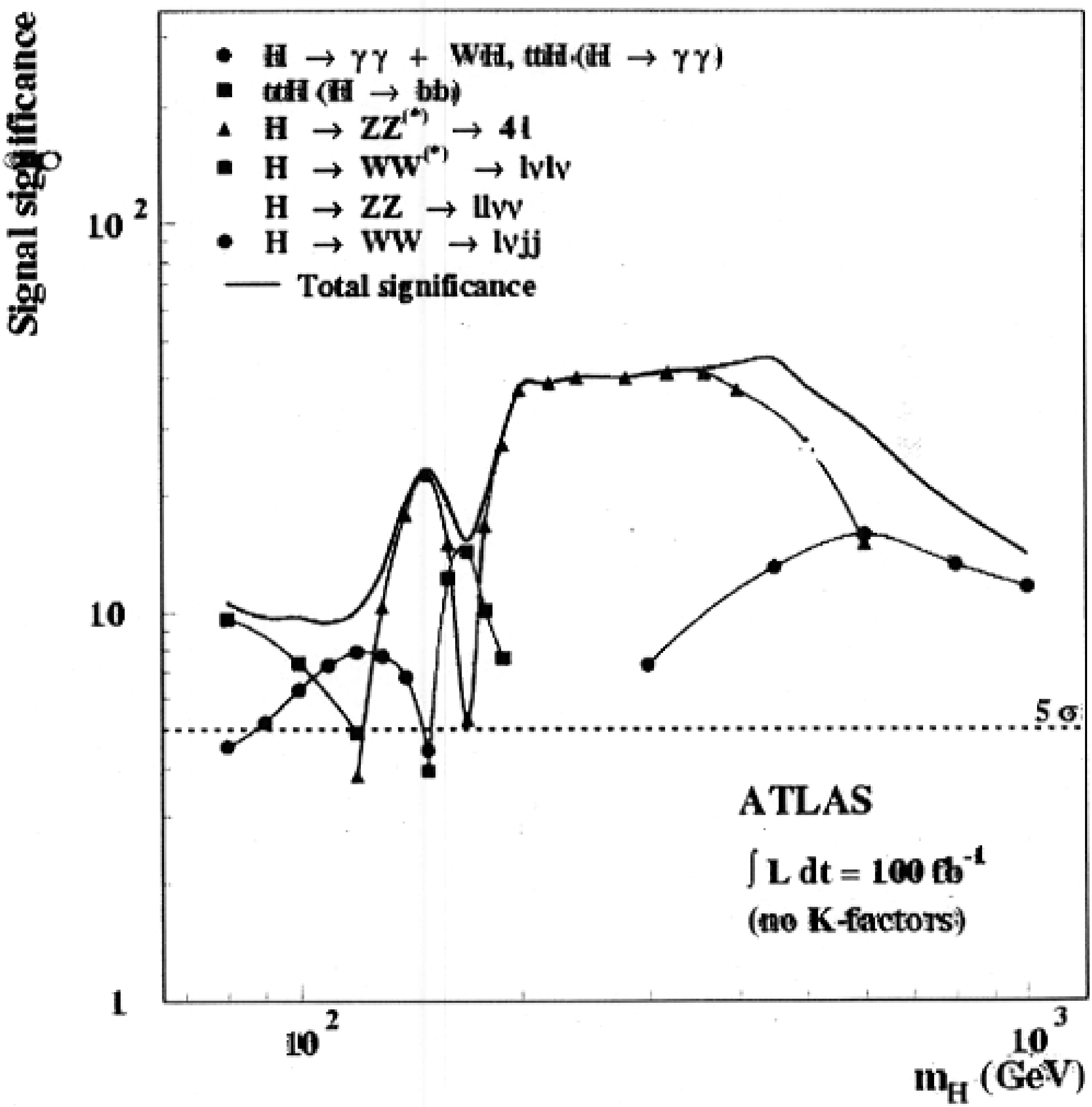
CERN/LHCC/99-15
ATLAS TDR-15
25 MAY 1999

ATLAS

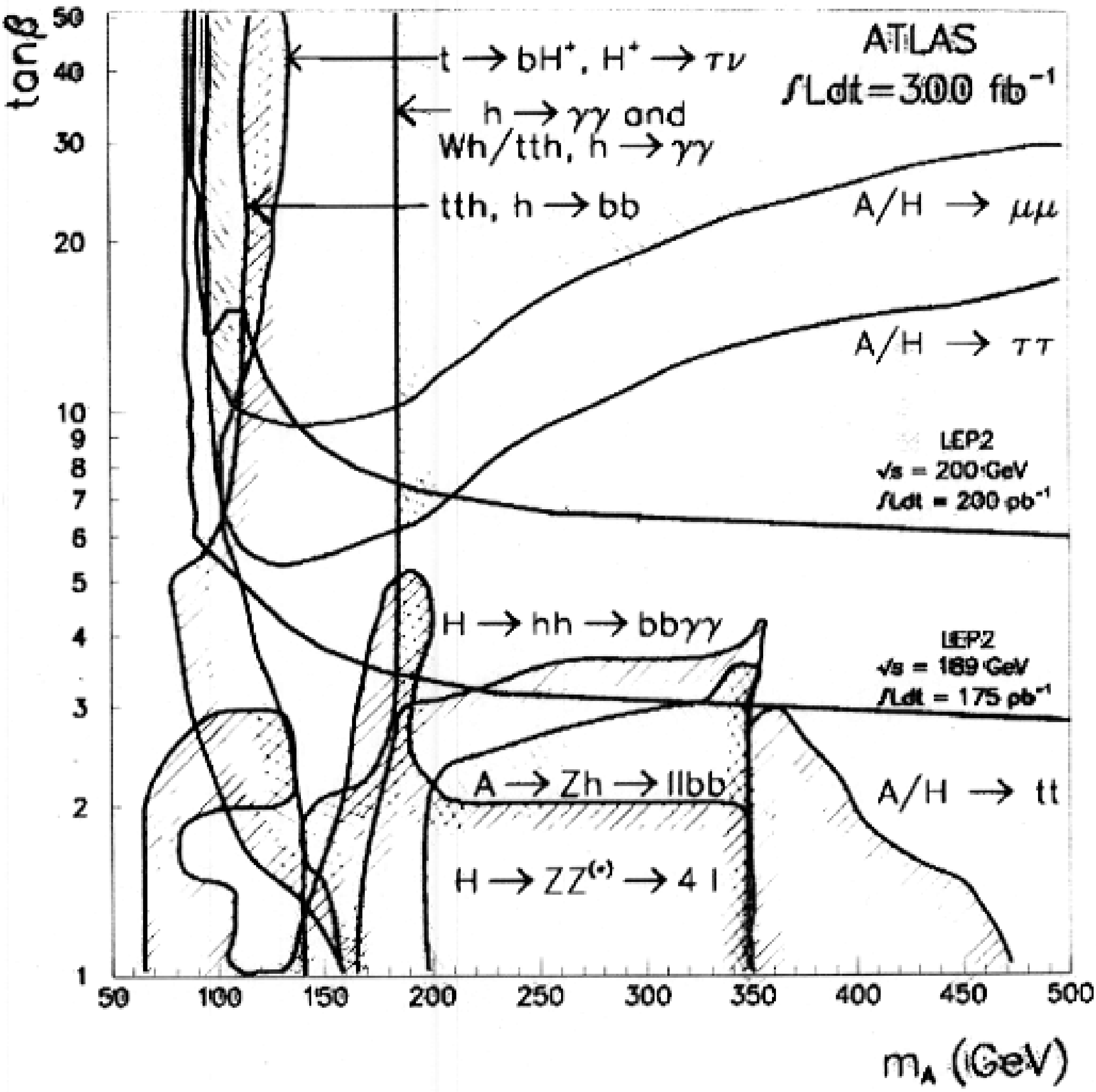
DETECTOR AND PHYSICS PERFORMANCE

TECHNICAL DESIGN REPORT

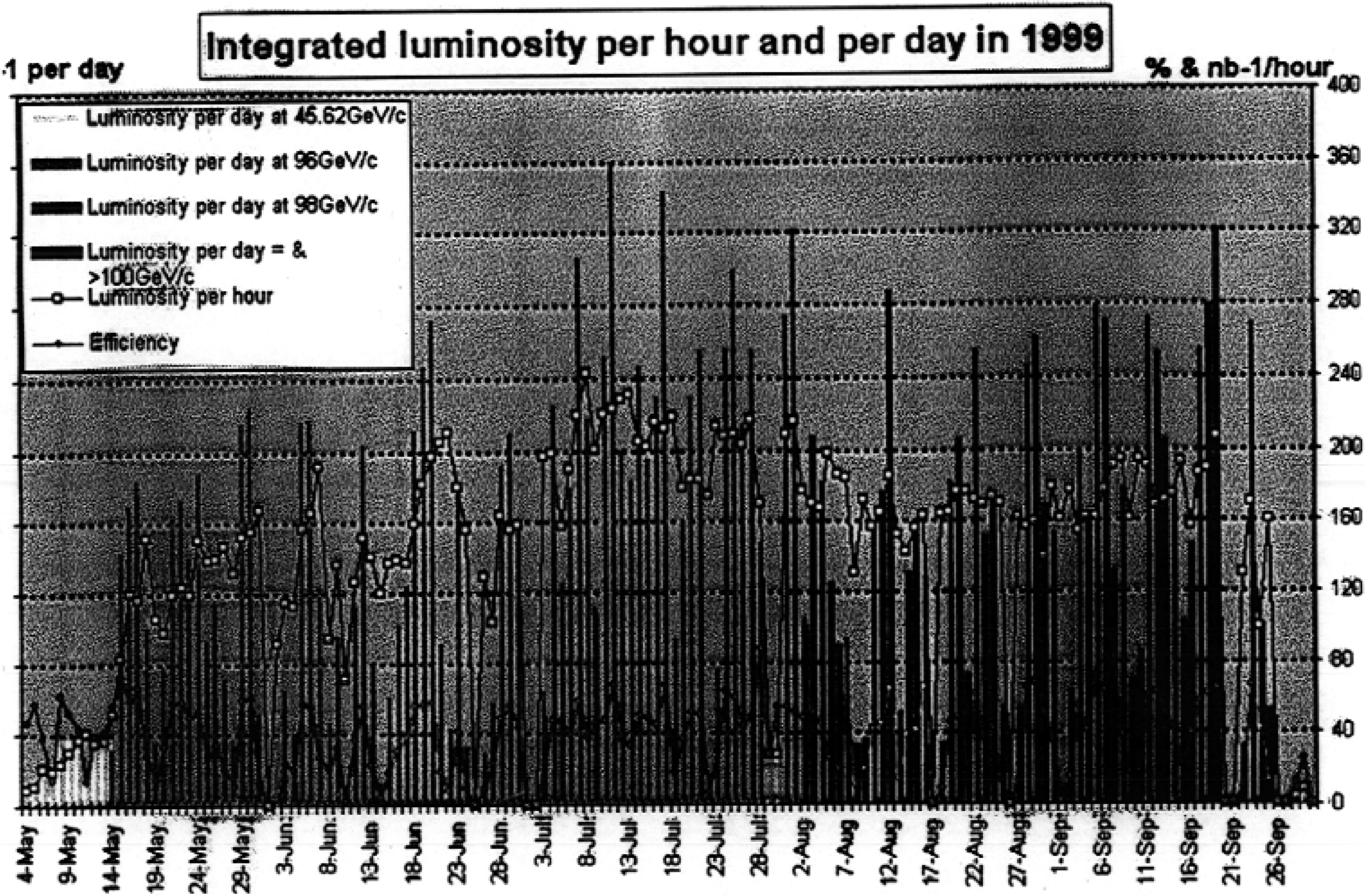




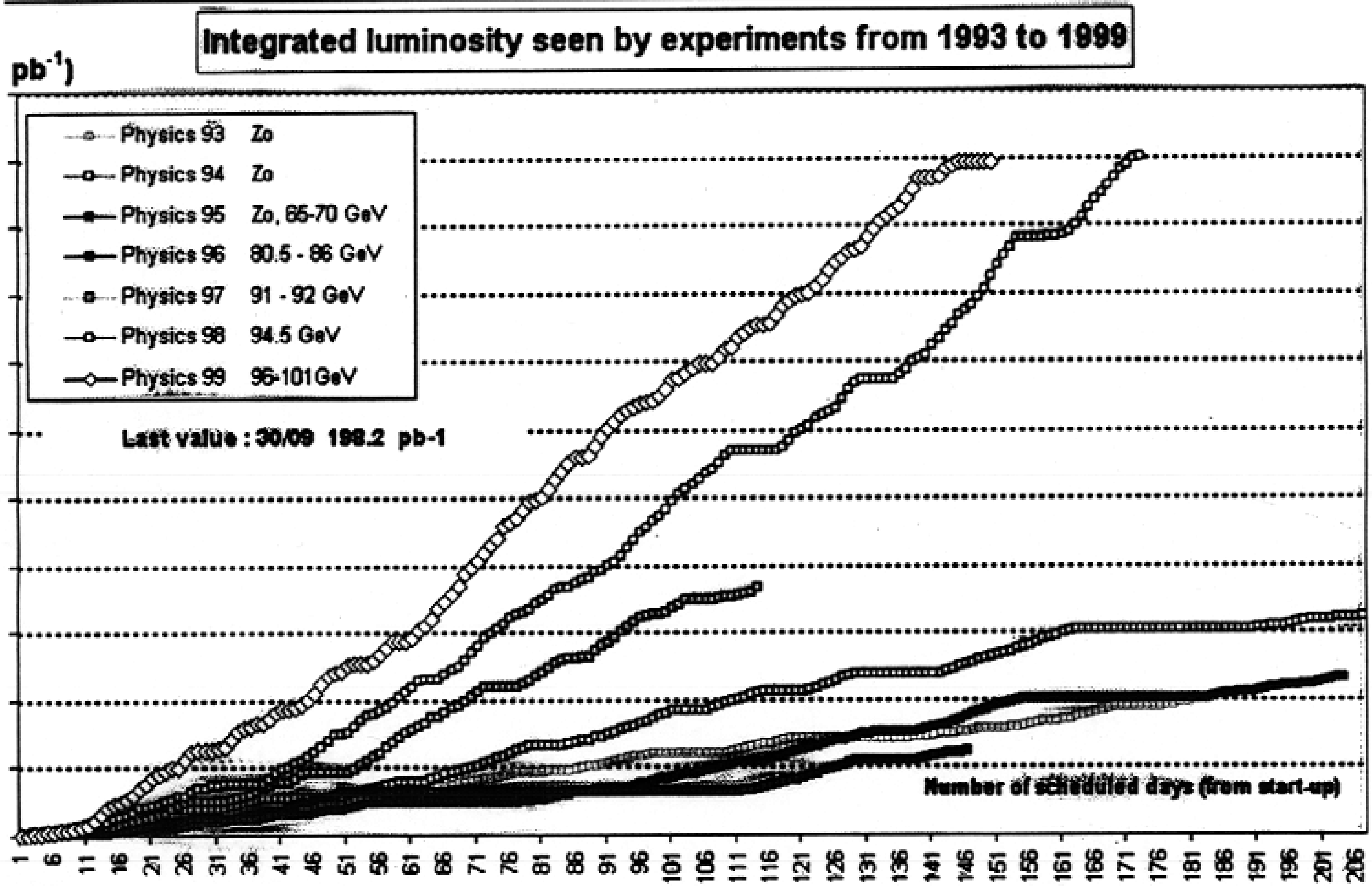
Signal significance
$H \rightarrow \gamma\gamma$ + WH, ttH ($H \rightarrow \gamma\gamma$)
ttH ($H \rightarrow bb$)
$H \rightarrow ZZ^{(*)} \rightarrow 4l$
$H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$
$H \rightarrow ZZ \rightarrow ll\nu\nu$
$H \rightarrow WW \rightarrow l\nu jj$
Total significance
10^2
10
1
5 σ
ATLAS
$\int L\,dt = 100\ fb^{-1}$
(no K-factors)
10^2
10^3
m_H (GeV)



ATLAS
∫Ldt=300 fb⁻¹
t → bH⁺, H⁺ → τν
h → γγ and
Wh/tth, h → γγ
tth, h → bb
A/H → μμ
A/H → ττ
LEP2
√s = 200 GeV
∫Ldt = 200 pb⁻¹
H → hh → bbγγ
LEP2
√s = 189 GeV
∫Ldt = 175 pb⁻¹
A → Zh → llbb
A/H → tt
H → ZZ(*) → 4 l
tanβ
m_A (GeV)



Integrated luminosity per hour and per day in 1999
-1 per day
% & nb-1/hour
Luminosity per day at 45.62GeV/c
Luminosity per day at 96GeV/c
Luminosity per day at 98GeV/c
Luminosity per day = & >100GeV/c
Luminosity per hour
Efficiency
0
40
80
120
160
200
240
280
320
360
400
4-May
9-May
14-May
19-May
24-May
29-May
3-Jun
8-Jun
13-Jun
18-Jun
23-Jun
28-Jun
3-Jul
8-Jul
13-Jul
18-Jul
23-Jul
28-Jul
2-Aug
7-Aug
12-Aug
17-Aug
22-Aug
27-Aug
1-Sep
6-Sep
11-Sep
16-Sep
21-Sep
26-Sep


Integrated luminosity seen by experiments from 1993 to 1999
pb-1)
Physics 93 Zo
Physics 94 Zo
Physics 95 Zo, 65-70 GeV
Physics 96 80.5 - 86 GeV
Physics 97 91 - 92 GeV
Physics 98 94.5 GeV
Physics 99 96-101GeV
Last value : 30/09 198.2 pb-1
Number of scheduled days (from start-up)
1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96 101 106 111 116 121 126 131 136 141 146 151 156 161 166 171 176 181 186 191 196 201 206

SUMMARY

- Experiments are progressing
  - Construction Phase
    - Ready to operate mid 2005
- Enormous task
- Computing Environment will be a challenge
  - Review report in 2000
    - Ready in 2005