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COULD THE L3 BGO XSTAL CALORIMETER BE THE BASIS FOR A HIGH-PERFORMANCE TCF DETECTOR ?

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SLAC TAU-CHARM W/S
8 MAR 99

- LEP WILL SHUTDOWN END 2000 AND L3 WILL BE DISMANTLED

- HALF THE COST OF THE TCF DETECTOR IS THE XSTAL EM CALORIMETER

  ⇒ NATURAL TO CONSIDER IF THE L3 BGO CALORIMETER COULD BE A GOOD MATCH FOR A TCF DETECTOR

PLEASE NOTE !

- THIS IS SIMPLY A PAPER EXERCISE AND DOESN'T CONSIDER OR IMPLY ANY OWNERSHIP ISSUES

Detector construction cost

($1 ≈ 1.5 CHF)

Item	Cost [MCHF]
Inner & central drift chamber	3.8
Superconducting solenoid	7.0
Cerenkov (DIRC)	2.3
Time-of-flight	1.2
Electromagnetic calorimeter [CsI(Tl)]	30.7
Forward BGO calorimeter	1.2
Forward Si tracker	1.6
Hadron calorimeter/μ detector	7.3
Trigger & data acquisition	7.9
Subtotal:	63.0
Contingency (10%):	6.3
Total:	**69.3**

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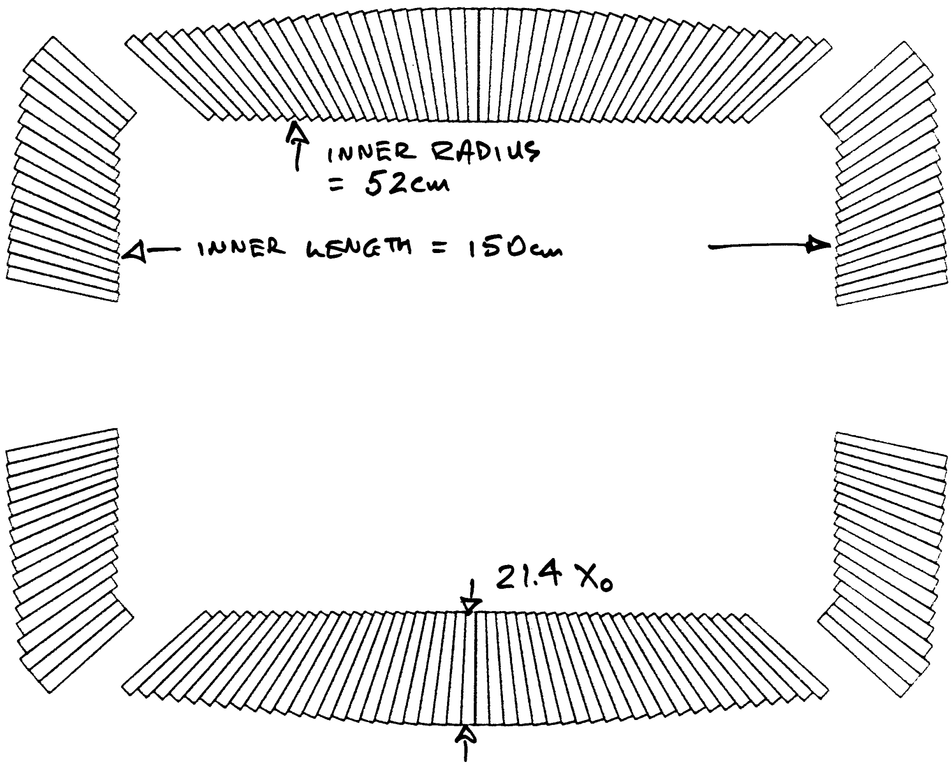
XSTAL SCINTILLATOR PROPERTIES

	CsI(Tl)	BGO
RADIATION LENGTH	1.9 cm	1.1 cm
[MOLIÈRE RADIUS	3.8 cm	2.4 cm]
DECAY TIME CONSTANT	1000 ns	300 ns
RELATIVE LIGHT OUTPUT	1.0	0.4

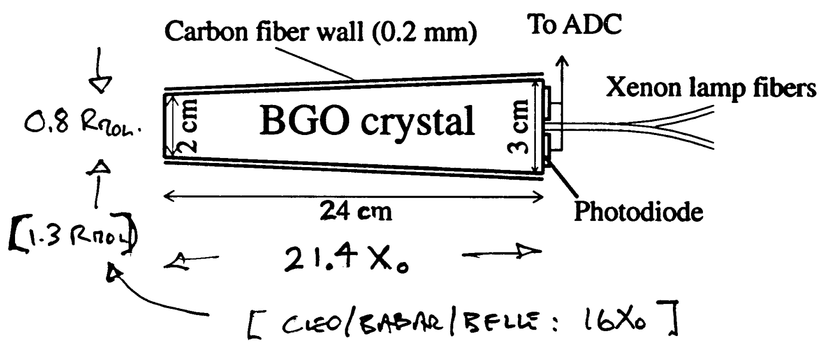
L3 BGO XSTAL EM CALORIMETER

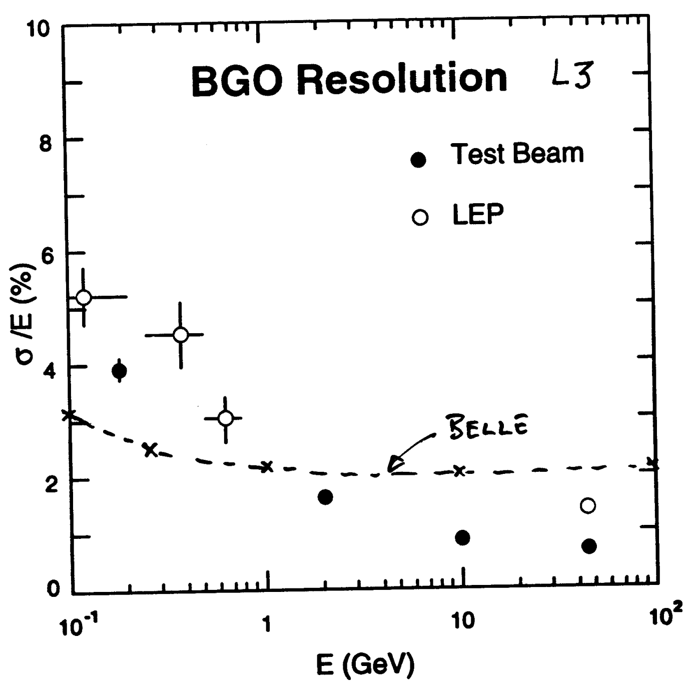


TOTAL XSTALS: 10.8 K

TOTAL COST ~ 50 M SF
(≅ $50M US ACCOUNTING)

L3 BGO XSTAL


Carbon fiber wall (0.2 mm)
To ADC
Xenon lamp fibers
BGO crystal
2 cm
3 cm
0.8 Rmol.
[1.3 Rmol]
24 cm
Photodiode
21.4 X0
[CLEO/BABAR/BELLE : 16X0]



(PIN DIODE READOUT)

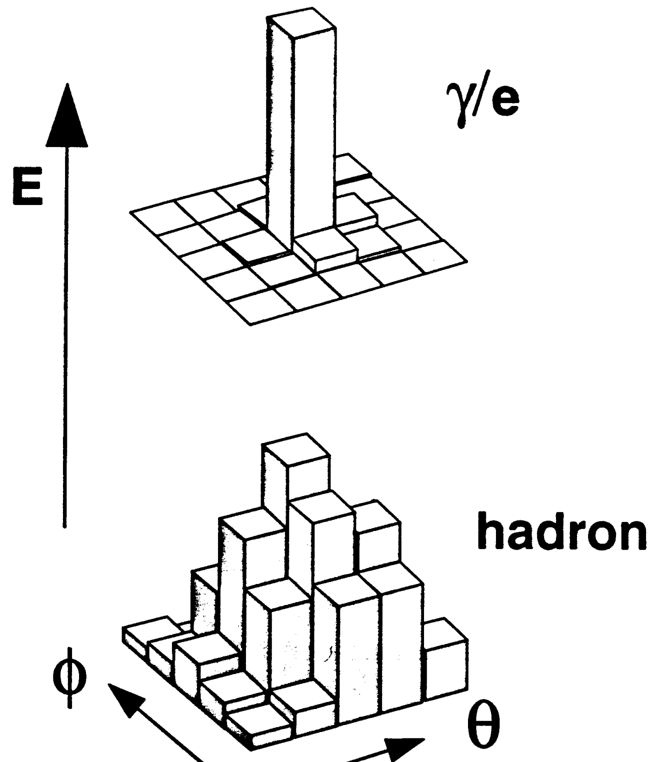
XSTAL EM CALORIMETER COMPARISON

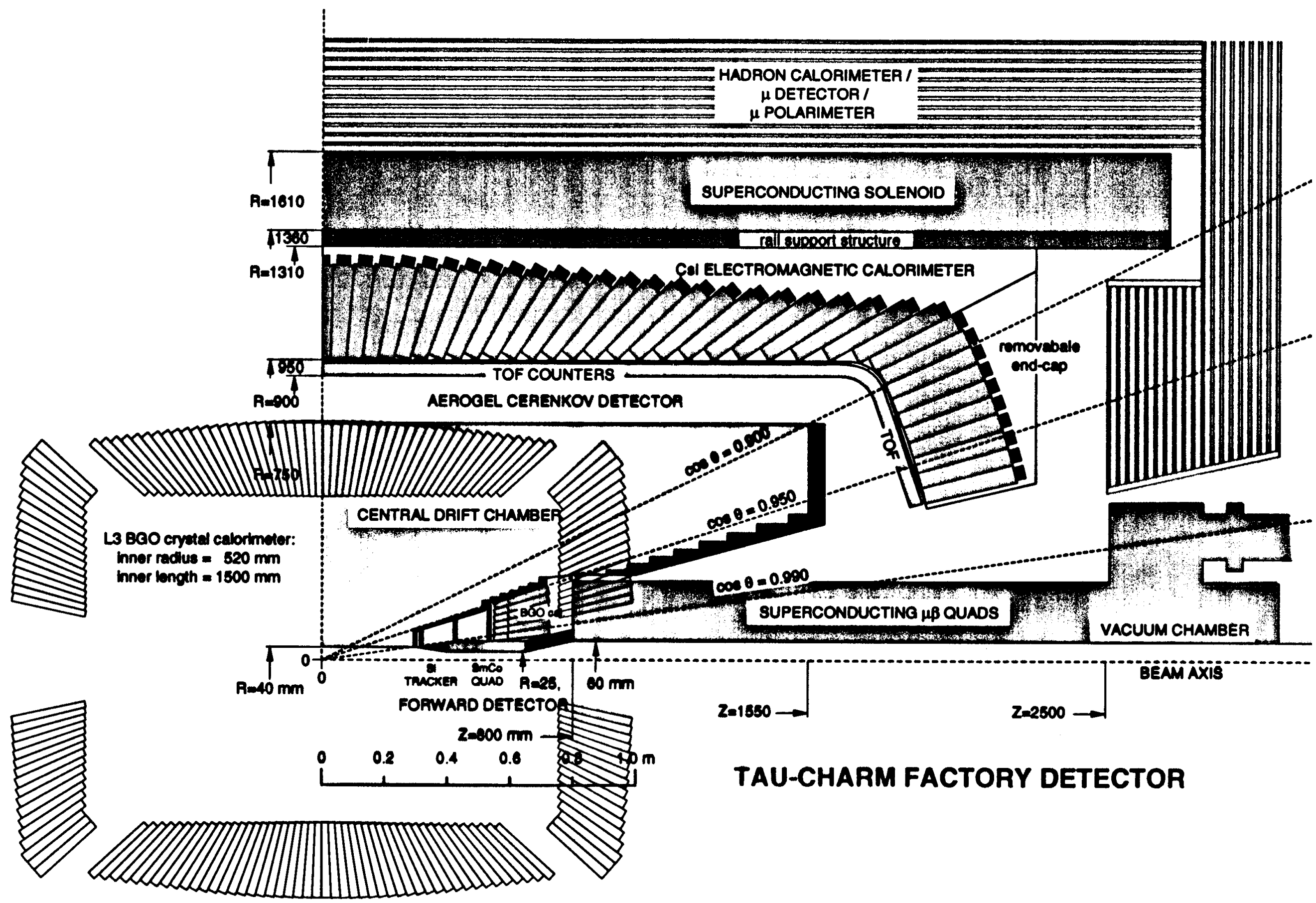
	MATERIAL	RINNER (cm)	#XSTALS	RELATIVE R MOLIÈRE
BELLE	CsI(Tl)	125	8.8K	1
BABAR	CsI(Tl)	90	6.8K	1
L3TC	BGO	52	10.8K	0.6

⇒ L3TC HAS ~SAME ANGULAR RESOLUTION
AS BELLE/BABAR
(AND HIGHER GRANULARITY)

Shower Shapes in the BGO

L3





TAU-CHARM FACTORY DETECTOR

MOMENTUM MEASUREMENT COMPARISON

	B (T)	L (m)	σ (μm)	MEAS. TERM $\frac{BL^2}{\sigma}$ (Tm^2/mm)	MCS TERM BL (Tm)	σ_p/p
BELLE	1.5	0.88	140	8	1.3	0.2% p ⊕ 0.2%
BABAR	1.5	0.80	140	7	1.2	
L3TC	3*	0.45	70+	8	1.3	

+ L3 TEC PERFORMANCE IS $\sigma = 50\mu m$

$$\frac{\sigma_p}{p} = a\% \, p \oplus \frac{b\%}{\beta}$$

MEAS. TERM $\propto \frac{\sigma}{BL^2}$ MCS TERM $\propto \frac{1}{BL}$

⇒ L3TC WITH 3 T SOLENOID HAS SAME MOMENTUM RESOLUTION AS BELLE / BABAR

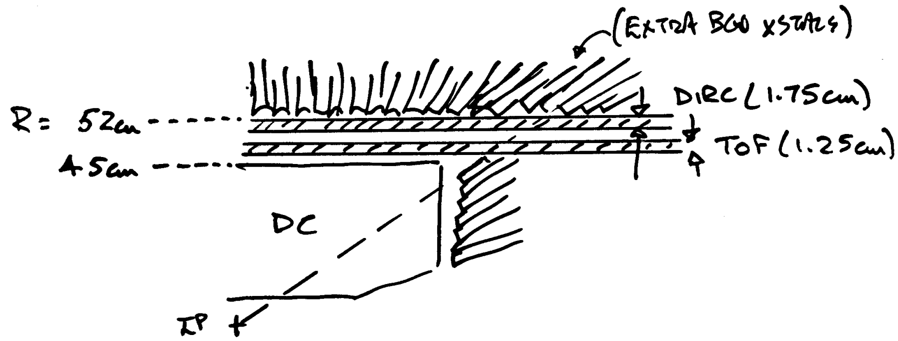
[NOTE THAT $P_{TRAP} \propto BL$ SO IT IS SAME FOR ALL DETECTORS]

* SORRY MAURY!

PARTICLE ID

- REQUIRED TO BE RADIALLY THIN AND LOCATED V. CLOSE TO ECAL ENTRANCE:
  - MAXIMIZE SPACE FOR TRACKING CHAMBER
  - MINIMIZE L.E γ INEFFICIENCY

  ⇒ DIRC IS GOOD MATCH



- BABAR DIRC PERFORMANCE SUBSTANTIALLY EXCEEDS L3TC REQUIREMENTS

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IMPROVEMENT OF BGO ENERGY RESOLUTION

AND TIMING OF BGO CRYSTALS:

APD READOUT

· PHOTOTUBE

PIN DIODE

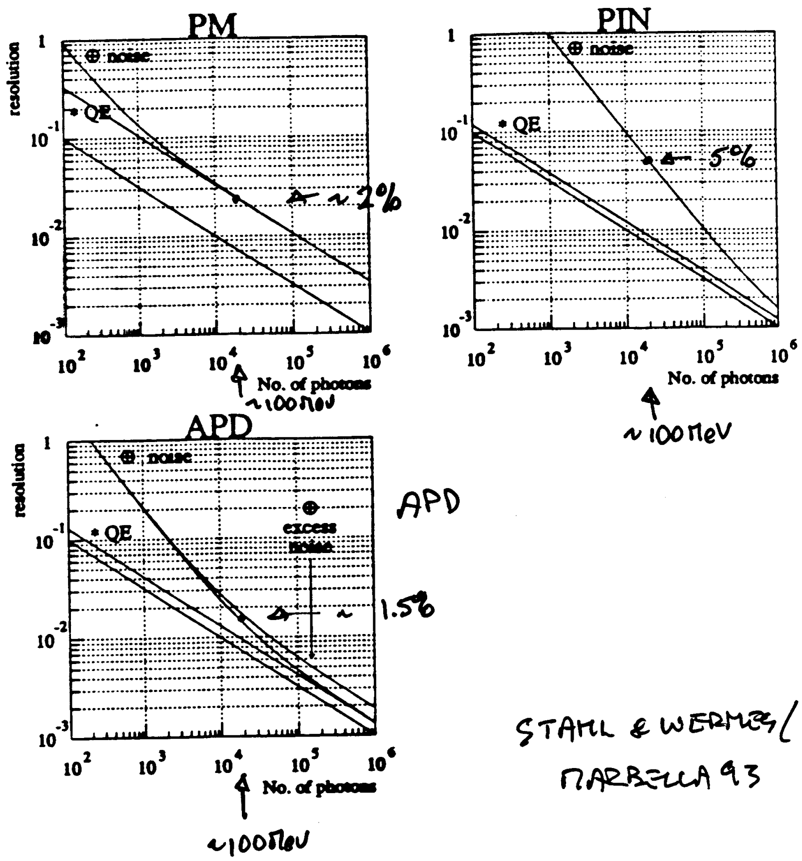

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Figure 13: *Optimal resolutions for APD, PMT and PIN diode readouts of a BGO crystal as a function of the number of photons (see text).*

⇒ MAY ACHIEVE ~FACTOR 3
IMPROVEMENT IN BGO ENERGY
RESOLUTION WITH APD READOUT

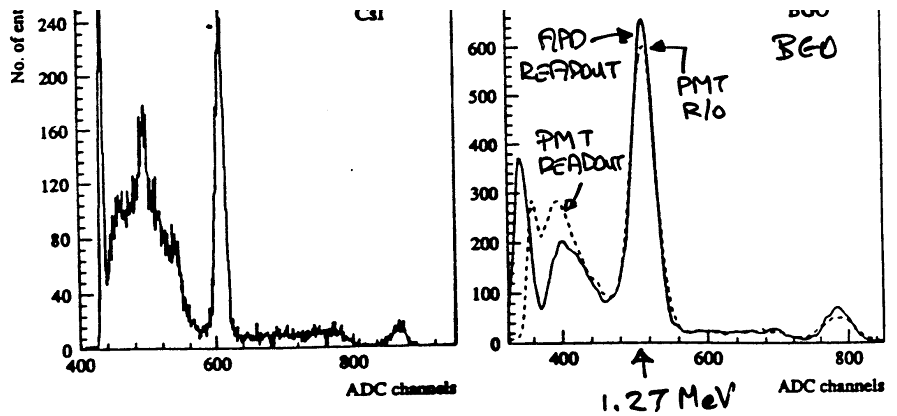

Figure 11: *Source spectra of* 1 × 1 × 1 *cm*^{3} *crystals with APD readout,* ^{22}Na *source. In (b) comparison to the readout by PMT is made.*

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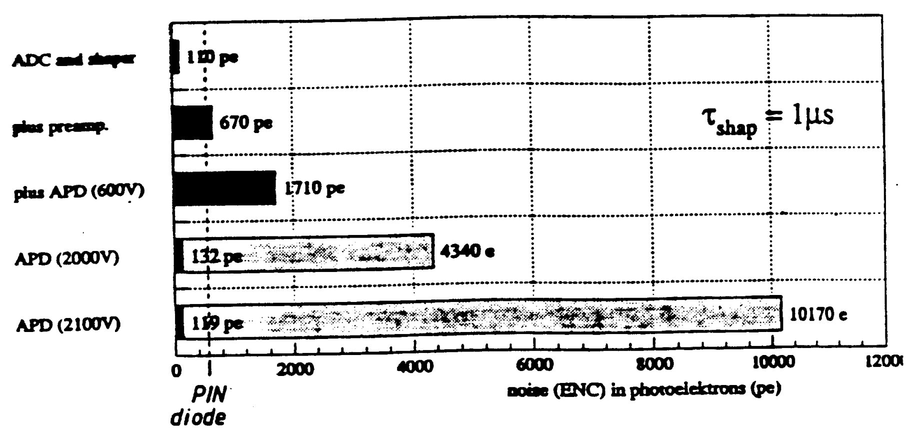

Figure 12: *Effective noise of the APD in comparison to PIN diode noise. From top to bottom the elements of the readout chain have been added successively.*

HADRONIC SPLITOFFS IN CsI (Tl) EM CALORIMETER

SPLITOFFS: • n
• γ

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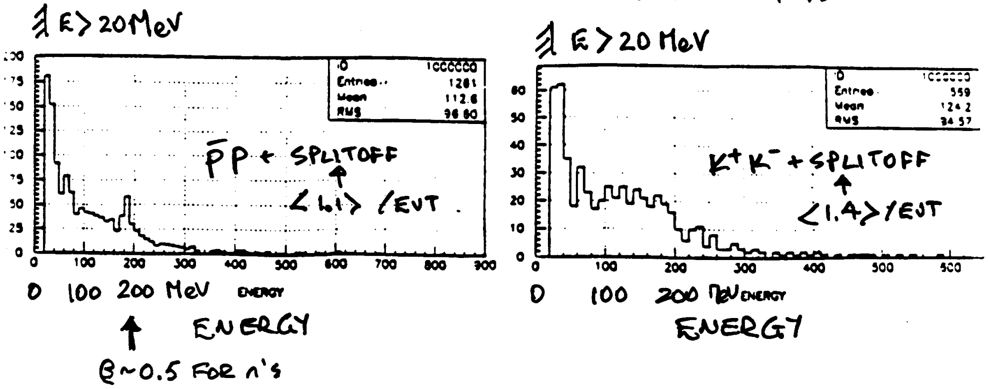

Figure 5: Distribution of energies (in MeV) of hadronic split-offs [4], at left: in $\bar{p}p \rightarrow p^+p$ events, at right: in $\bar{p}p \rightarrow K^+K^-$ events.

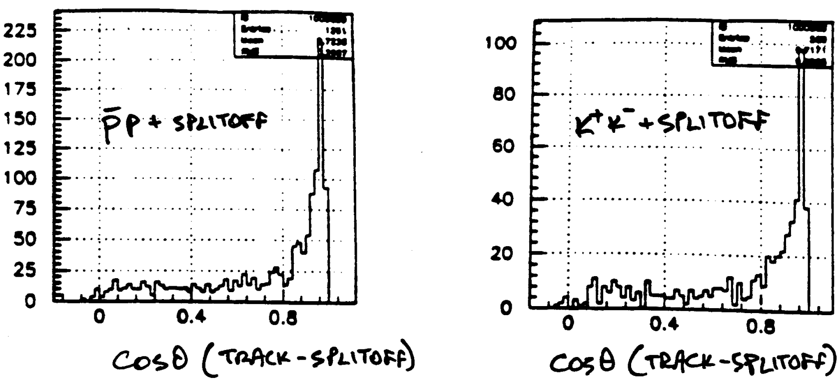

Figure 6: Angular separation (in cos θ) of hadronic split-offs from the nearest charged track, at left: for $\bar{p}p \rightarrow p^+p^-$ events; at right: for $\bar{p}p \rightarrow K^+K^-$ events.

TIMING OF EM CAL XSTALS:
BGO + APD READOUT

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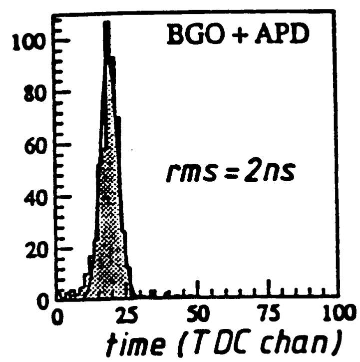

$\sigma = 2\,ns$

Figure 14: *Time resolution obtained with APD readout of a large BGO crystal at 1 GeV photon energy.*

CONCLUSIONS

- TOGETHER WITH A 3T SC SOLENOID, THE L3 BGO XSTAL CALORIMETER IS THE BASIS OF AN EXCELLENT TAU-CHARM DETECTOR
  - ⇒ PERFORMANCE FOR CHARGED PARTICLES AND PHOTONS EQUAL TO BELLE/BABAR

- AND, OF NOTE:
  - SUPPRESSION OF SPLITOFFS BY ECAL TIMING
  - REDUCTION OF OUTER DETECTOR AREA + MASS BY ~ FACTOR 2
  - REDUCTION OF $\pi \rightarrow \mu$ DECAYS BY ~ FACTOR 2
  - DETECTOR COST IS HALVED!