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

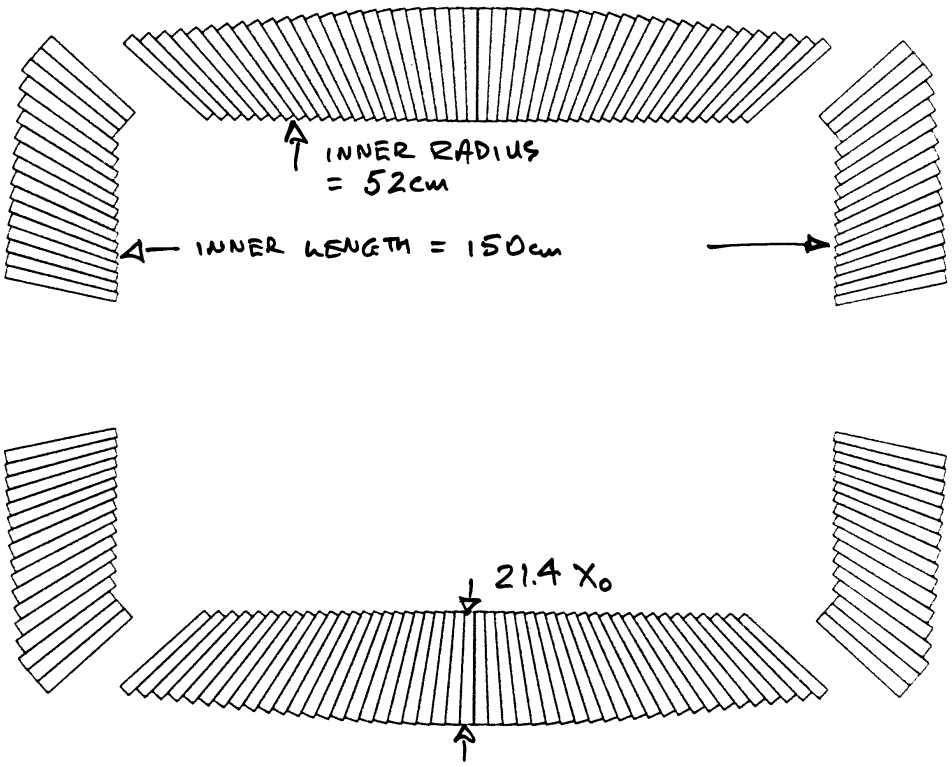
($1 ≈ 1.5 CHF)

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**

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

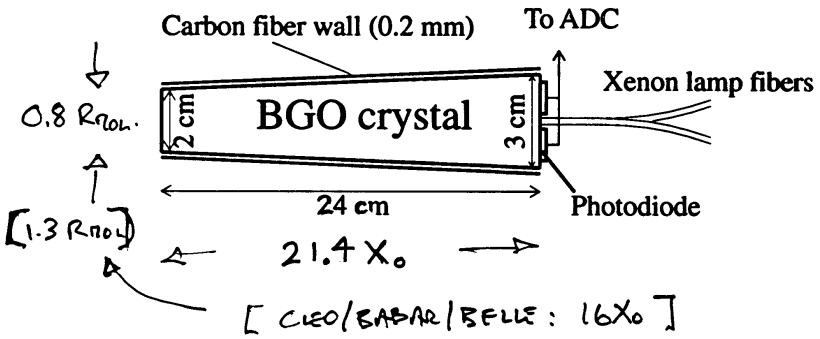
L3 BGO XSTAL EM CALORIMETER

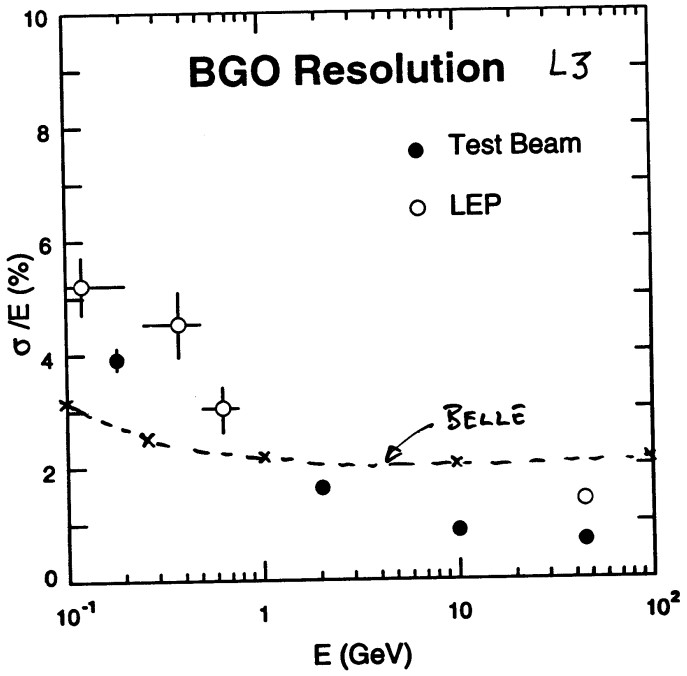


TOTAL XSTALS : 10.8 K

TOTAL COST ~ 50 MSF
(≡ $50M US ACCOUNTING)

L3 BGO XSTAL


Carbon fiber wall (0.2 mm)
To ADC
Xenon lamp fibers
0.8 $R_{MOL.}$
2 cm
BGO crystal
3 cm
24 cm
Photodiode
[1.3 R_{MOL}]
21.4 X_0
[CLEO/BABAR/BELLE : 16X_0]



(PIN DIODE READOUT)

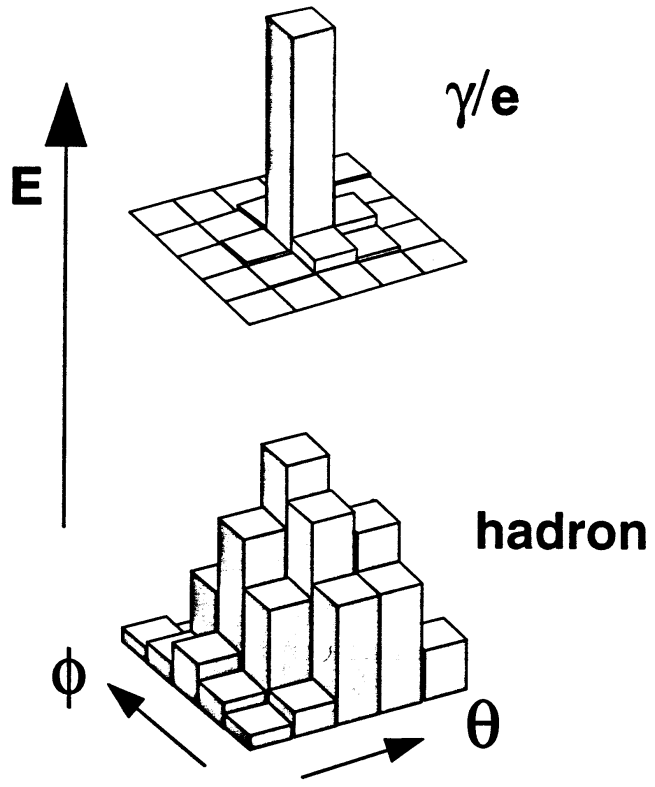
XSTAL EM CALORIMETER COMPARISON

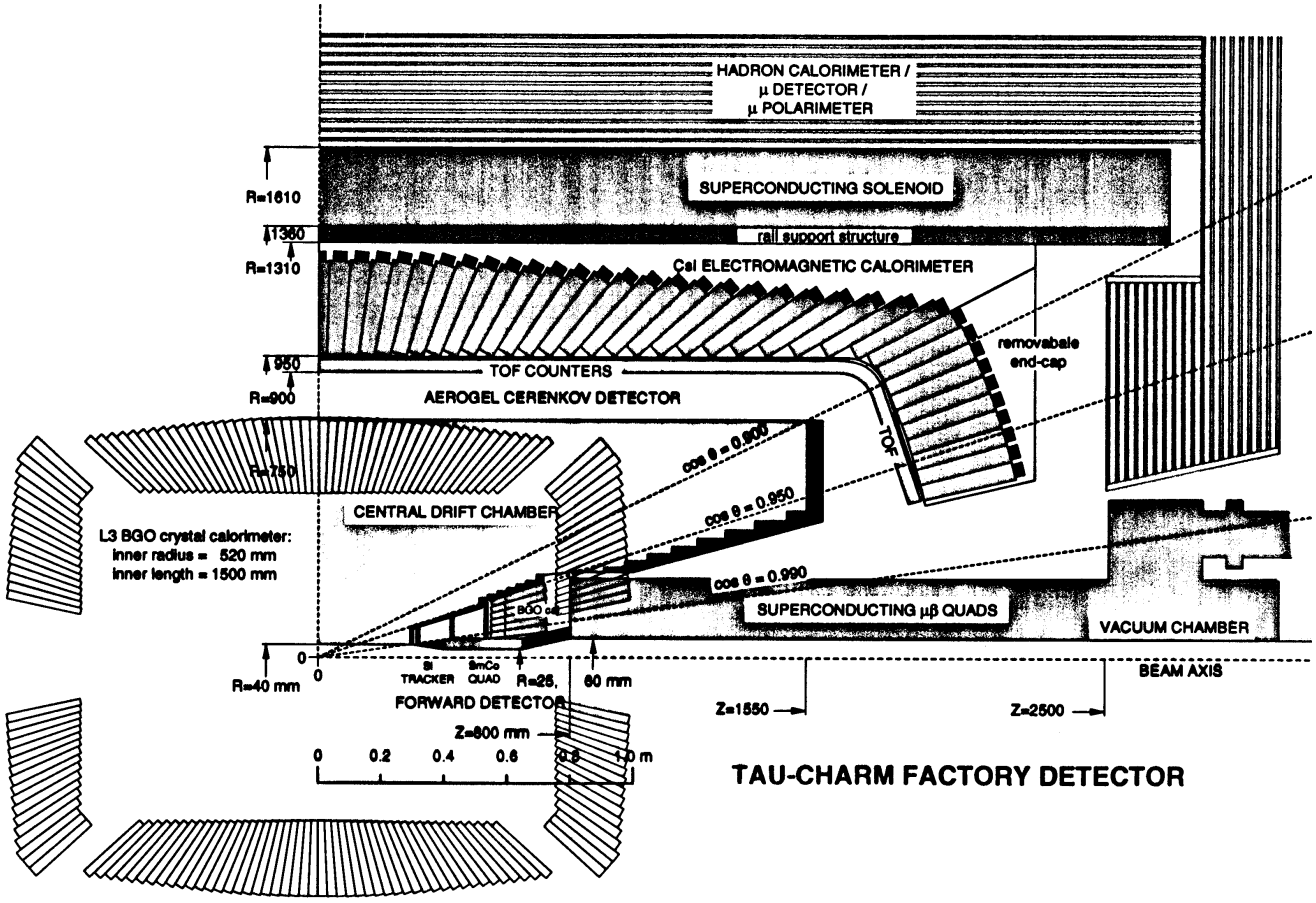
	MATERIAL	R_{INNER} (cm)	#XSTALS	RELATIVE RESOLUTION
BELLE	CsI(Tl)	125	8.8K	1
BABAR	CsI(Tl)	90	6.8K	1
L3TC	BGO	52	10.8K	0.6

$\Rightarrow$ 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	$0.2\% p \oplus 0.2\%$
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 $\propto \frac{1}{BL}$

$\Rightarrow$ L3TC WITH 3T SOLENOID HAS SAME MOMENTUM RESOLUTION AS BELLE / BABAR

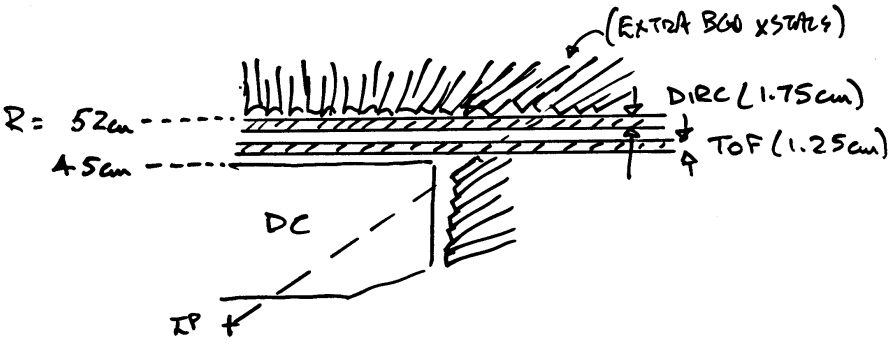
[NOTE THAT $P_{TRAP} \propto BL$ SO IT IS SAME FOR ALL DETECTORS]

* 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

  $\Rightarrow$ DIRC IS GOOD MATCH



- BABAR DIRC PERFORMANCE SUBSTANTIALLY EXCEEDS L3TC REQUIREMENTS

IMPROVEMENT OF BGO ENERGY RESOLUTION AND TIMING OF BGO CRYSTALS:

APD READOUT

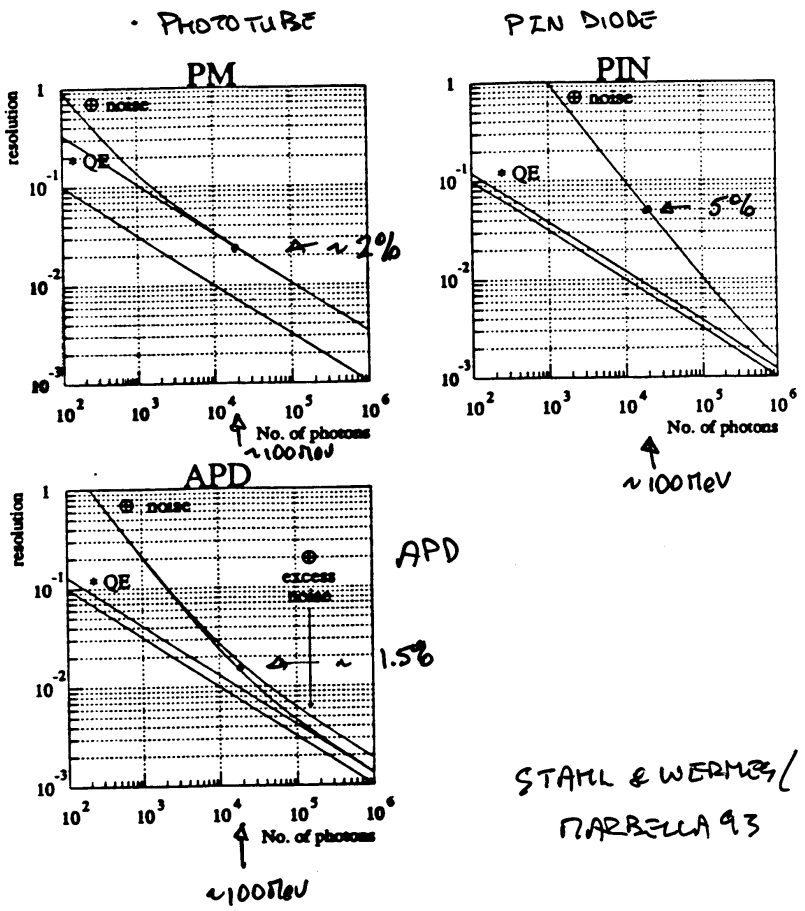


Figure 13: *Optimal resolutions for APD, PMT and PIN diode readouts of a BGO crystal as a function of the number of photons (see text).*

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

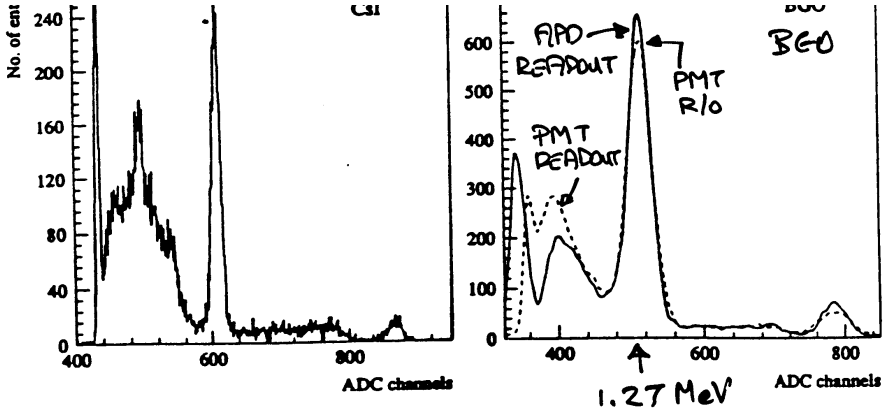


Figure 11: *Source spectra of* $1 \times 1 \times 1$ cm^3 *crystals with APD readout,* ^{22}Na *source. In (b) comparison to the readout by PMT is made.*

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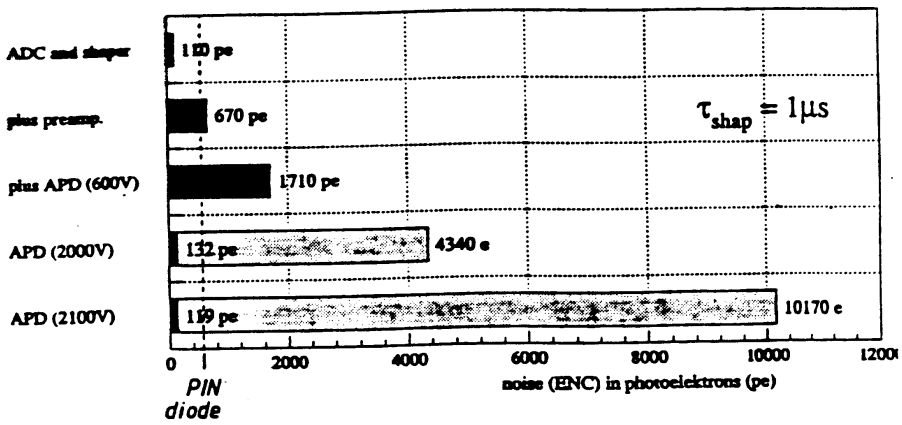

Figure 12: *Effective noise of the APD in comparison to PIN diode noise. From top to bottom the elements of the readout chain have been added successively.*

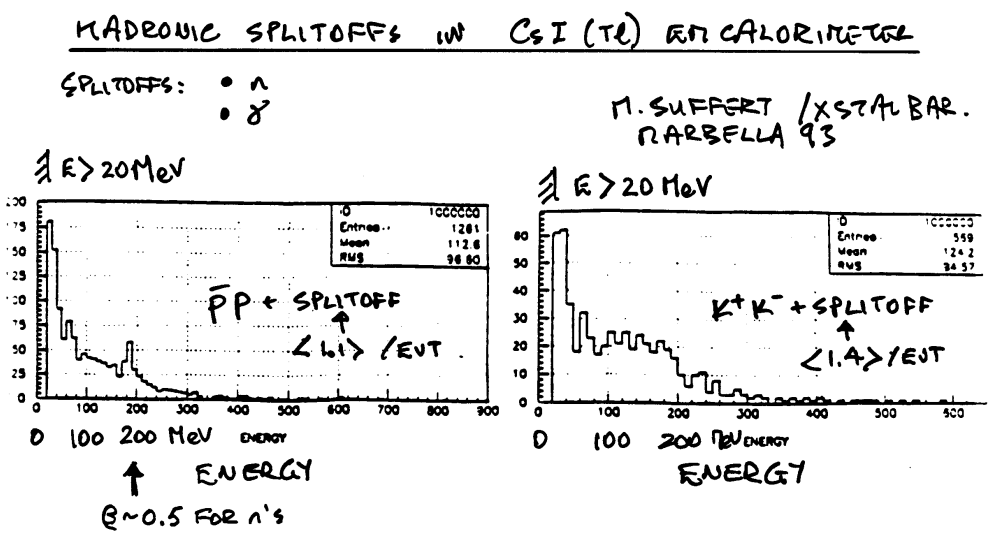

Figure 5: Distribution of energies (in MeV) of hadronic split-offs [4], at left: in $\bar{p}p \rightarrow p^+p$ events, at right: in $\bar{p}p \rightarrow K^+K^-$ events.

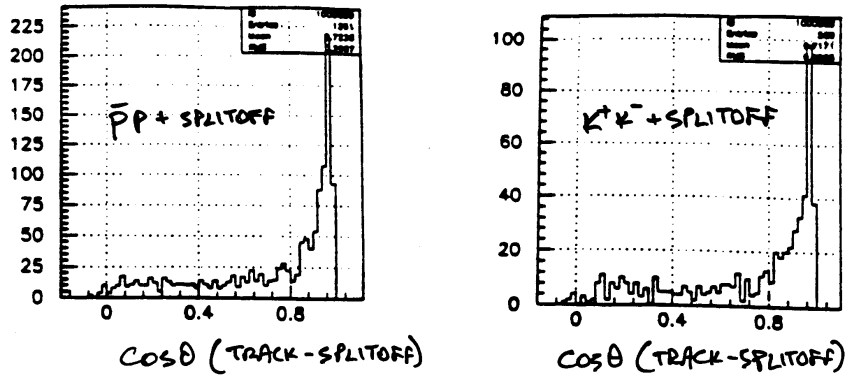

Figure 6: Angular separation (in cos θ) of hadronic split-offs from the nearest charged track, at left: for $\bar{p}p \rightarrow p^+p^-$ events; at right: for $\bar{p}p \rightarrow K^+K^-$ events.

TIMING OF EM CAL XSTALS:
BGO + APD READOUT

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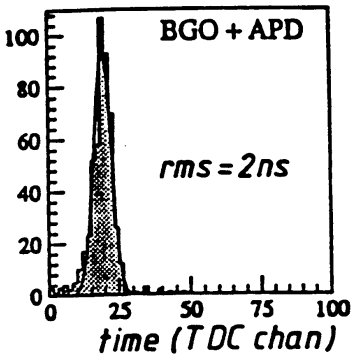

$\sigma = 2$ ns

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 $\pi \to \mu$ DECAYS BY ~ FACTOR 2
  - DETECTOR COST IS HALVED!