DRAFT 1
BigBite Trigger Specification and Costing

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0.1 The BigBite spectrometer

The BigBite spectrometer will provide a third arm which will greatly extend the experimental capabilities of Hall A. Its large momentum and angular acceptances, which allow a broad kinematic coverage in one setting, will offer completely complementary properties to the HRS and furthermore will permit the detection of two, final-state charged hadrons for the first time.

BigBite, originally designed for the low-luminosity NIKHEF internal target facility, has a 96 msr solid angle, 200–900 MeV/c momentum acceptance and a moderate momentum resolution of $\sigma_p/p \sim 0.8$ %. In Hall A luminosities can be factors $10^4 - 10^6$ higher than at NIKHEF and the counting rates in the focal place detection system will be correspondingly high. For the approved $\gamma^* + p \rightarrow p + \pi^0$ experiment E-01-014, protons will be ejected from the target at rates $> 10^6$ Hz, necessitating a new focal-plane detection system.

0.2 The trigger detector

A new array of trigger scintillators, displayed in Fig.1, will replace the original unsegmented layer of scintillator. This trigger detector must provide a precise hit time, to make clean coincidences with other spectrometers, and provide particle identification information by time of flight (TOF). Additionally it will generate the gate for the MWPC's used for high-precision tracking. Resolution of the 500 MHz RF microstructure of the JLab beam and TOF require ∼0.5 ns FWHM or better, which is well within the capabilities of plastic scintillator. The positioning of the two-plane trigger system with respect to the magnet is shown in Fig.2. A coincidence between two planes will provide a very positive hit and $\Delta E/E$ information for particle identification. Each plane will be segmented into 24 elements, with each element being read out via light guides

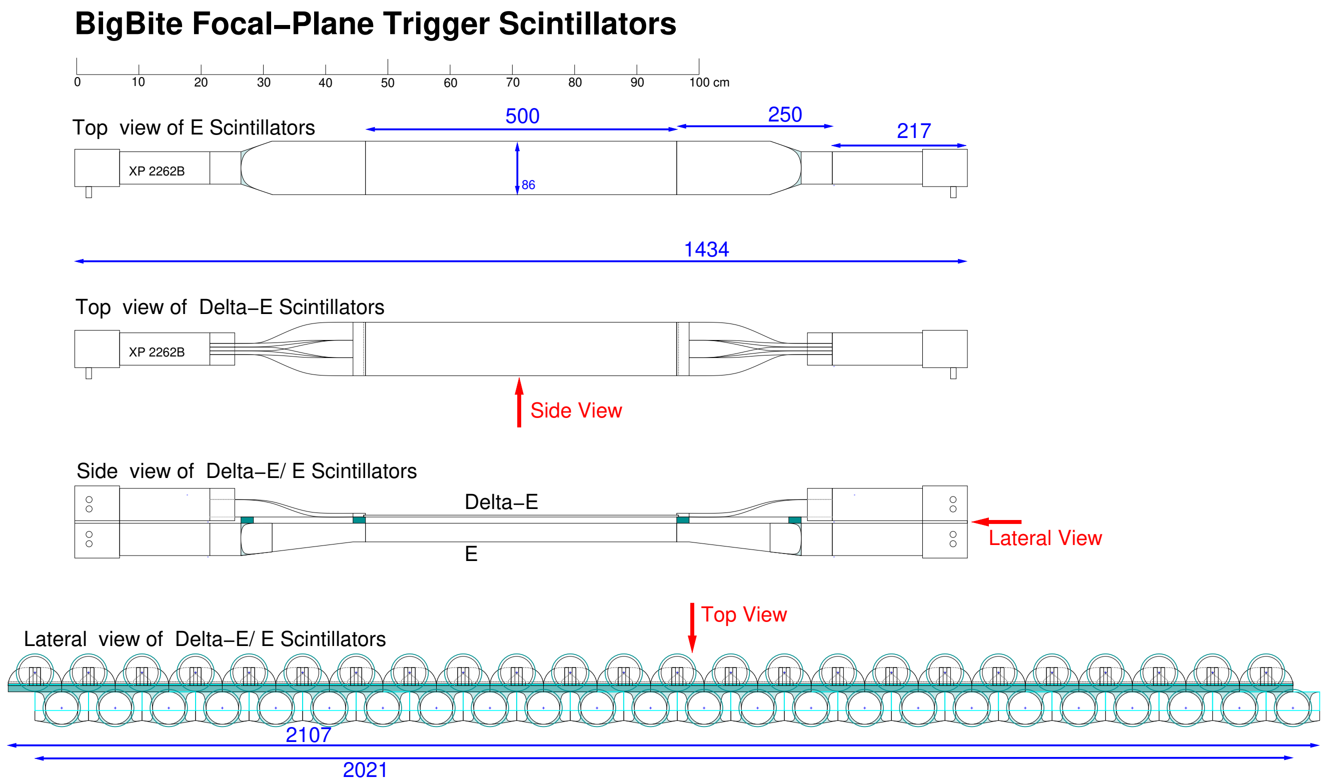

Figure 1: Scintillation counters used for the BigBite trigger detector

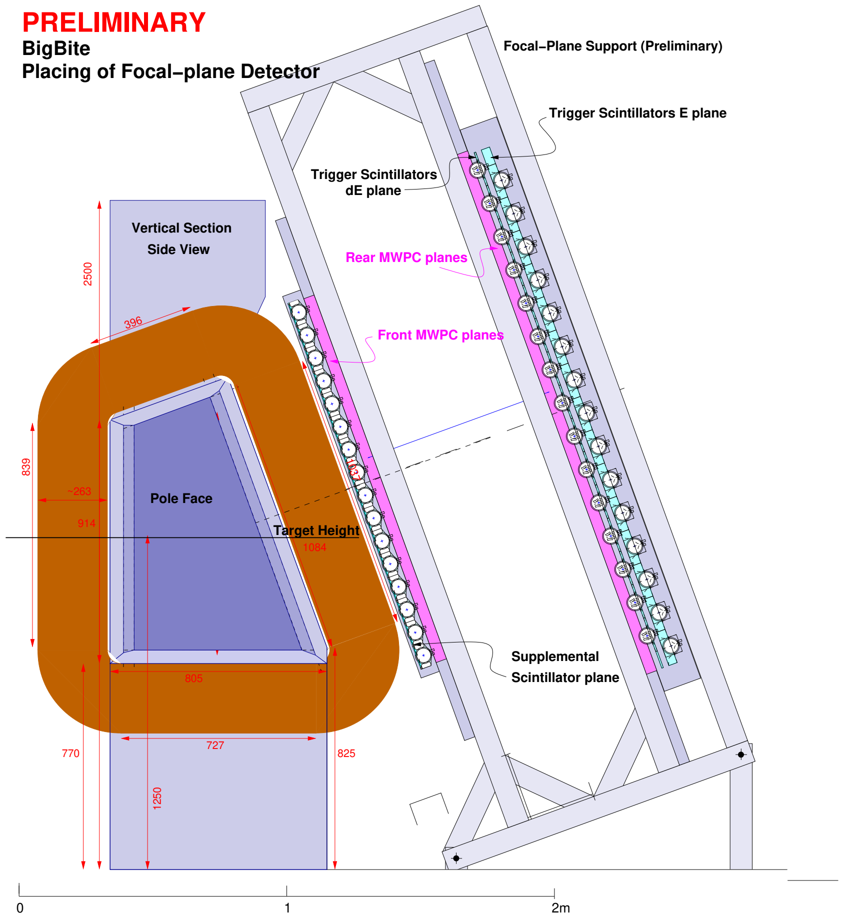

Figure 2: Side view of the BigBite magnet and focal-plane detector. The focal-plane support structure is a preliminary guess, but a quantitative design is in progress.

Table 1: Properties of EJ204 plastic. Equivalent to BC404.

Light Output (% anthracence)	68	10400 photons/MeVee
Peak emission wavelength (nm)	408	UV plexiglass guide desirable
Rise time (ns)	0.7	
Fall time (ns)	1.8	
Pulse width (ns)	2.2	
Attenuation length (mm)	1500	Adequate for a 500 mm long bar
Refractive index	1.58	Standard PVT-based plastic
Density	1.032	Standard PVT-based plastic

by two, fast 50 mm photomultipliers (PM). Two PM will provide a position-independent mean time, position information in the non-dispersive direction ($\delta y \sim 4$ cm FWHM) via time difference and optimum pulse-height resolution. Plastic scintillator EJ204 is specified as it combines good light output, fast response and reasonable transparency (Table 1), but since the peak emission wavelength is relatively low a UV transmitting plexiglas (BC800) light guide will provide significantly better transmission. Eljen are a relatively new company in the scintillator business, charge less than other makers of equivalent materials and is staffed by former "Nuclear Enterprises" employees, who have vast experience in plastic scintillator manufacture. Staggering the elements of each scintillator layer (Fig.1) will give a position resolution in the dispersive direction of ± 21.5 mm. The supplemental position information from the trigger detector may by useful to resolve ambiguities in the hit information given by fast-counting wire chambers, but will be absolutely necessary for experiments where the MWPC systems are not used. A preliminary costing of the trigger system is given in Table **??**.

Also shown in Fig.2 are the envisaged positions of the two superplanes of MWPC tracker (in magenta) and a supplemental plane of scintillators which will be used in experiments, such as $(e, e'pN)$ E-01-015, requiring high rate but only moderate momentum resolution. In this case the MWPC's would not be used. The intended detector would consist of 64 $22 \times 350 \times 2$ mm pieces of EJ204 plastic, each read by 1, 19 mm PM tube.

Circuitry for time pickoff and coincidence logic is displayed in Fig. 3. Cables from all PM's feed to passive, two-way pulse splitters with the branches feeding to:

1. LeCroy 200 MHz (max) 3412 leading edge discriminators, which in turn feed to:
   (a) subsequent logic circuitry
   (b) a TDC via delay. The $\sim$ 500 ns delay, necessary to accomodate the making of a coincidence with other Hall-A detctor arms, would

require active refreshing of the ECL pulse, as the bandwidth of twist-and-flat cable is unsufficiently high to allow ∼100 m lengths. If active delay circuitry is necessary then lumped delay lines, consisting of series capacitor-inductor elements may be more convenient than cable. These come packaged in DIL chips with optional ECL signal interfaces at the input and output and on paper their bandwidth and stability is as good as twist-and-flat cable. They would also provide the opportunity to tune the delay ot the particular experiment.

   (c) The TDC is a CAEN VME775, 32-channel, 6U single-width module. This is a 12-bit device with a resolution programmable from 35-300 ps/chan, 6μs convertion time, multi-event buffering, fast clear and MBLT64 (64-bit block data transfer) capability.

2. A switched 50Ω attenuator, for flexibility in setting the dynamic range, followed by $\sim$ 500 ns of delay into the QDC. Again lumped-delay-line chips are being considered for the delay elements.

   (a) The QDC is a CAEN VME792, 32-channel, 6U single-width module. This is a 12-bit device with a full scale of 400 pC (20 V.ns into 50 Ω), 6μs convertion time, multi-event buffering, fast clear and MBLT64 capability.

The 3412 discriminator is chosen as it has superior high-rate performance to any similar programmable CFD and walk correction may be performed offline as the pulse amplitude is recorded. The subsequent trigger logic circuit performs the following:

1. AND the discriminator outputs associated with the 2 PM attached to the scintillator element. When operating with low discriminator thresholds this will largely eliminate spurious hits produced by PM dark noise.

2. The AND output will drive a scaler to provide information on individual bar rates.

3. The AND output will daisy-chain to a subsequent AND where individual ΔE-E coincidences are made. Since the ΔE and E layers are overlapped 31 individual coincidences are necessary.

4. The outputs of these coincidences are ORed and fed to a main coincidence with the HRS e' (or whatever other detection arm is used) and the output of the coincidence drives QDC gates and TDC starts

Due to the expected rates **there will be no multiplexing**. Electronics costs are included in Table **??**. The most suitable module for performing the basic AND/OR logic would be the LeCroy 4516 which is a 16-channel device, each channel having 3 inputs for which any combination of AND/OR logic can be programmed, the combination being common to all 16 channels. This unit is not longer manufactured and a functional equivalent is not available. As this module is of very general utility, in-house manufacture of a functional equivalent is under consideration.

Also shown in Fig.3 is a preliminary view of the electronics to service the auxiliary plane of scintillators. Each element of the 64-element array is read by a single PM. It is proposed to feed the signals to a pulse-splitter and discriminator as in the main trigger planes, followed by an OR circuit (LeCroy 4564) which feeds into the main ΔE-E coincidence. The discriminator outputs are pregated by the main E OR output to avoid dead-time problems in the OR at high rate.

High rates will place a heavy demand on the data acquisition and provision is made for a dedicated high performance VMEbus based system to handle this task. A Motorola PPC running VXWORKS is in place in Glasgow ready for installation of CODA so that testing of the QDC/TDC readout can commence. Furthermore we plan also to develope BigBite momentum reconstruction software within the new C++/Root-based, Hall-A data analysis system.

0.3 Trigger system costs

Costs are listed in Table **??**. The BigBite trigger detector consists of 2 layers of plastic-scintillator with 24 elements per layer (**items a,c**). Each element has 2 light guides (**items b,d**) to couple the scintillator to the photomultipliers (PM) (**item f**). EJ204 plastic, read out by a 2 linear-focused, high gain XP2262B PM are specified to achieve a time resolution of < 0.5 ns FWHM. The trigger array is assembled on a sub-frame (**item e**) which attaches to the main focal plane mounts. PM high voltage supply and distribution are specified in **items g–i** and PM signal distribution in **items j,k**. It has been assumed that a suitable HV mainframe will be available at JLab, otherwise this must also be purchased. A CAMAC crate (**item l**) controlled via a parallel branch (**item m**) houses fast leading-edge discriminators (**item n**) and trigger logic (**item o,p,q)**, connected by twisted-pair and coaxial cable. A 6U CERN-spec VMEbus crate (**item r**) houses the data acquisition electronics which is controlled by a PPC-based single-board computer (**item s**). This runs the VXWORKS operating system, for which Jefferson Lab. provides the licence and the CODA data acquisition system which is standard in Hall A. Signals from the trigger detectors are digitised in VMEbus charge/time-to-digital convertors (**item t,u**) and VMEbus linkage to CAMAC is through **(item v)**.

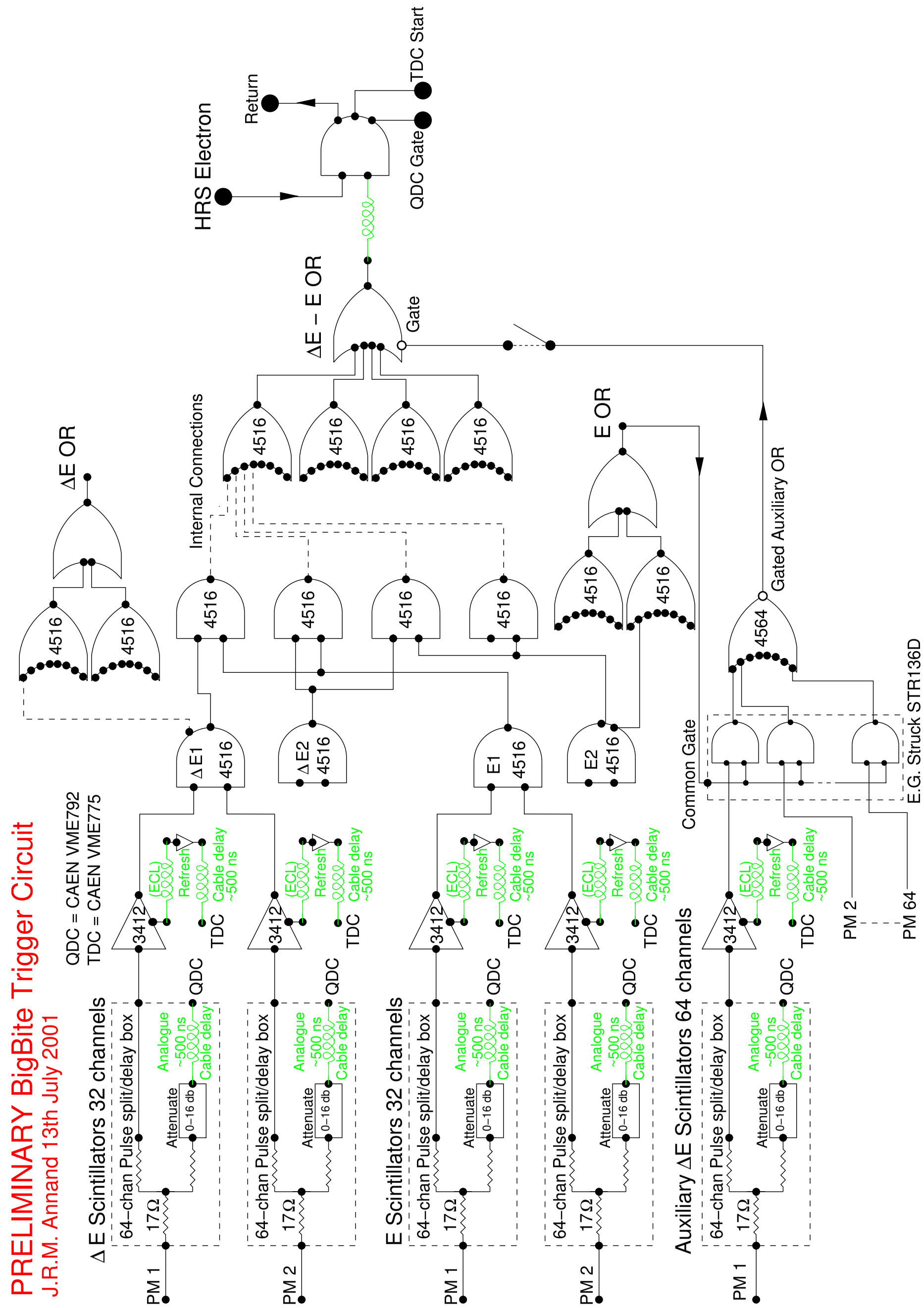

Figure 3: Trigger Electronics. AND/OR logic units LeCroy 4516 may be replaced by functional equivalents.

Table 2: BigBite Trigger Costs. Unit costs in UK pounds, totals in pounds and dollars assuming an exchange rate of \$1.43/£. Items purchased in the UK incur 17.5% tax.

	Item	Make	Unit (£)	Total (£)	Total (\$)
a	24 off 86×500×30 mm Scint	EJ204	400	9600	13728
b	48 off fish-tail light guides	BC800	250	12000	17160
c	24 off 86×500×3 mm Scint	EJ204	260	6240	8923
d	48 off adiabatic light guides	BC800	300	14400	20592
e	Mounting sub-frame	GU	3000	3000	4290
f	100 off 50 mm PM (4 spare)	XP2262B	235	23500	33605
g	8 off HV cards	LRS 1461	1360	10880	15558
h	96 off PM, HV dividers	GU	100	9600	13728
i	96 off HV cables	GU/JLab	25	*2400*	3432
j	96 off Signal cables	GU/JLab	15	1440	2059
k	Pulse-split & delay	GU	3600	3600	5148
l	CAMAC crate	Wiener UEC01	4324	4324	6183
m	CAMAC controller	CES CCA2	1480	1480	2116
n	6 off discriminators	LRS 3412	1836	11016	15752
o	6 off AND/OR PLU	LRS 4516/GU	1500	9000	12870
p	2 off Prog. gate gen.	CAEN V462	1280	2560	3661
q	Basic AND/OR logic	Phillips 758	1670	1670	2388
r	VMEbus crate	Wiener UEV 6021	3836	3836	5485
s	VMEbus CPU	MVME2700-3451	4239	4239	6062
t	4 off VME QDC	CAEN VME792	2204	8816	12607
u	4 off VME TDC	CAEN VME775	2970	11880	16988
v	CAMAC branch driver	CES CBD8210	3309	3309	4732
	TOTAL			158790	227070
	TOTAL including TAX			186578	266807
	(U.K. V.A.T @17.5%)				

Table 3: Preliminary BigBite auxiliary-plane costs in U.K. Pounds and US Dollars.

	Item	**Make**	**Unit (£)**	**Total (£)**	Total ($)
a	64, $22 \times 350 \times 2$ mm scint.	EJ 204	?	?	
b	64 light guides	Tel Aviv	?	?	
c	Mounting sub-frames	Tel Aviv	?	?	
d’	96 off 19 mm PM + base $+\mu$	R1450	300	28800	40320
e	6, 12-channel HV cards	LeCroy 1461	1904	11424	15994
f	**64 HV dividers**	Hamamatsu	?	?	
g	**64 HV cables**	?	?	?	
h	**64 Signal cables**	?	?	?	
i	Pulse split and delay box	?	3000	3000	4200
j	**4, 16-chan discriminators**	LeCroy 3412	1836	7344	10282
k	64-input, common gate	Struck STR136D	?	?	
l	64-input OR	LeCroy 4564	?	?	
m	Cabling	?	?	?	
n	2, 6U 32-chan VMEbus QDC	CAEN VME792	3086	6172	8641
o	2, 6U 32-chan VMEbus TDC	CAEN VME775	4158	8316	11642