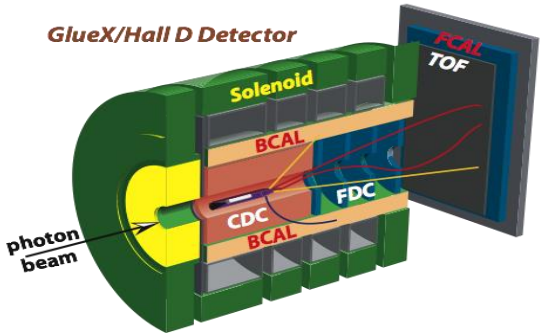


Jefferson Lab

Trigger Configuration

A. Somov, Jefferson Lab

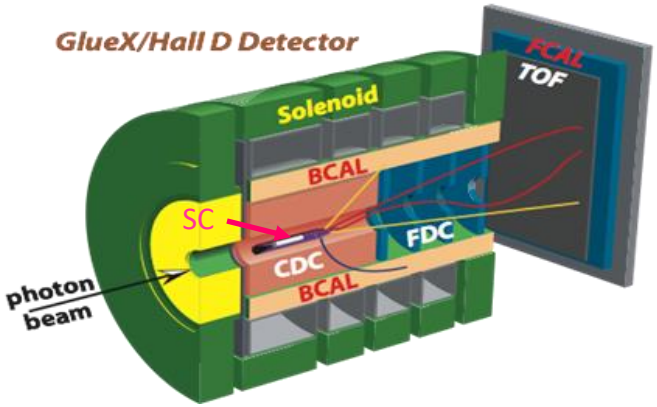
KLF Readiness Review

August 28, 2024

GlueX Level-1 Trigger

Detectors which can be used in the Level-1 trigger:

Forward Calorimeter	(FCAL)	(Energy deposition)
Barrel Calorimeter	(BCAL)	(Energy deposition)
Start Counter	(SC)	(Count hits)
Time of Flight	(TOF)	(Count hits)
Pair Spectrometer	(PS)	(Coincidence of hits)
Tagger	(TAGH)	(Count hits)

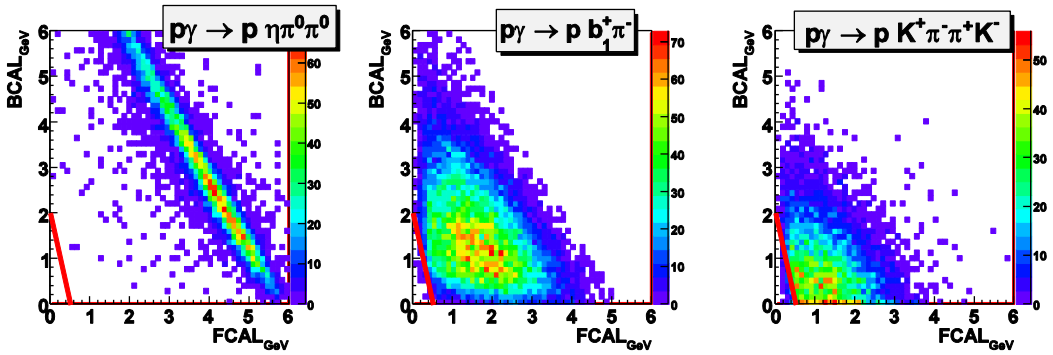


- Trigger algorithm based on measurement of energies in FCAL and BCAL

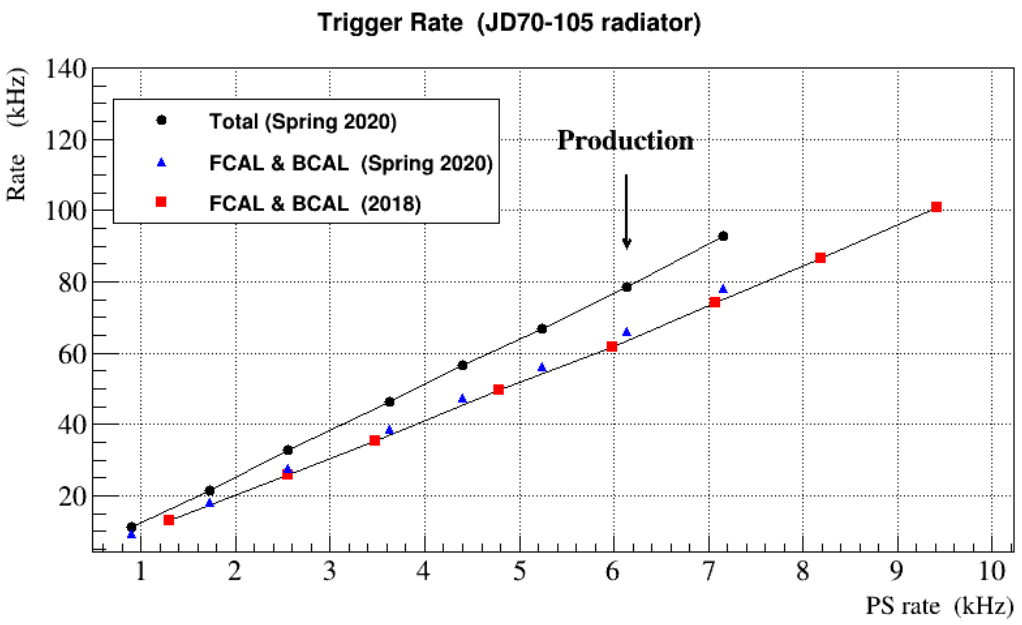
$$E_{BCAL} = A + B \cdot E_{FCAL}$$

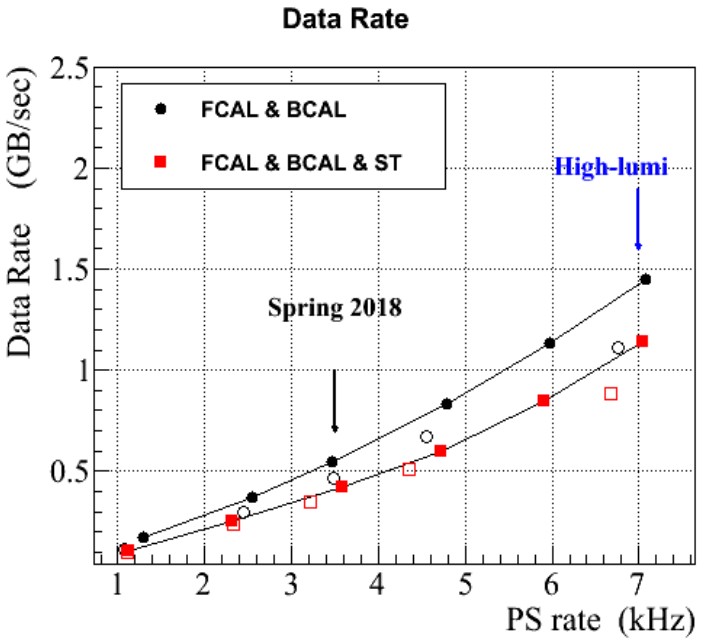
- Coincidence of calorimeters with Start Counter (SRC experiment)

- Trigger based on TOF and Calorimeters (CPP/NPP experiment)



Trigger Performance





- Trigger rate in production runs about 70 kHz
- Data rate about 1.4 GB/sec

KL Trigger Simulation

- Geant4 detector simulation

  - modify geometry of the LH2 target cell, add ECAL

- Study detector response for two types of beamline backgrounds:
  neutron and photons

  - use energy spectra and profiles at the target to generate background particles; input to Geant4 simulation

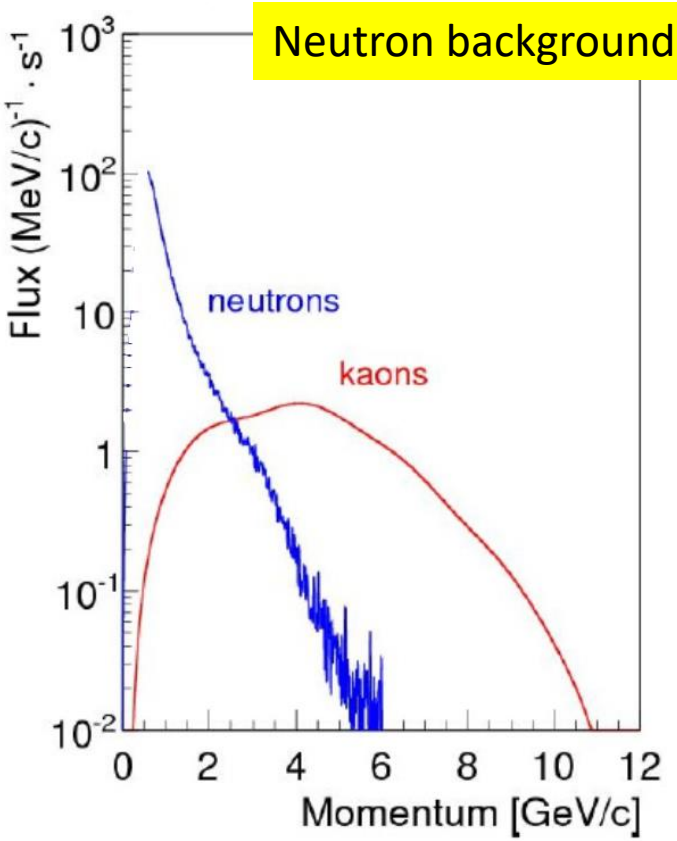
- Evaluate trigger efficiency for physics decay of interest

  - charged particles in the final state (produced at large polar angles, see talks..)
    (may add a table with decay channels)

Consider to use triggers based on the energy depositions in the calorimeters.
- lower energy thresholds below MIP energy (similar to the SRC experiment)

Main Sources of Background

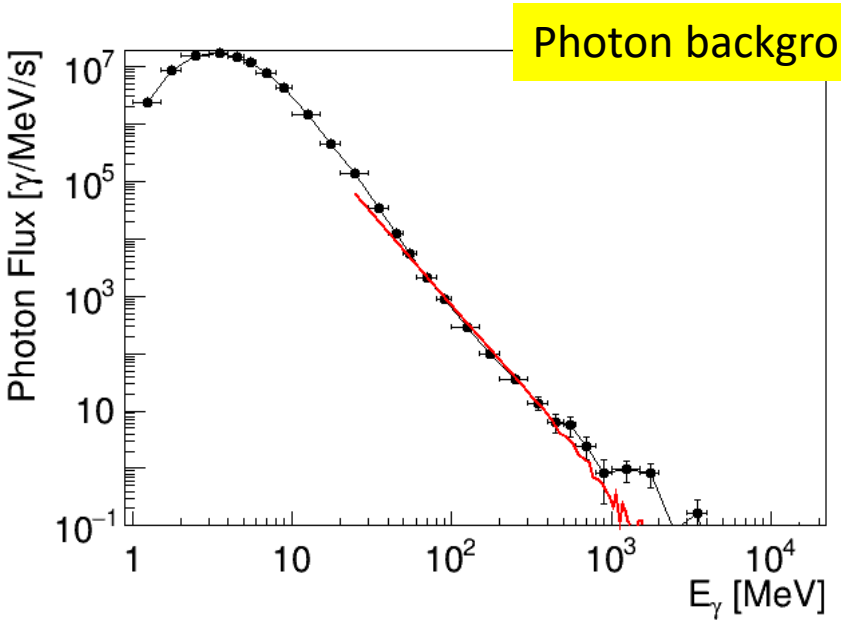
Neutron background



- Simulated using MCNP, Fluka, and Geant
- Integrated flux: 6.6 ·10^5 n/ s on the target

Energy spectrum of bremsstrahlung photons on the face of the Be target

Photon background

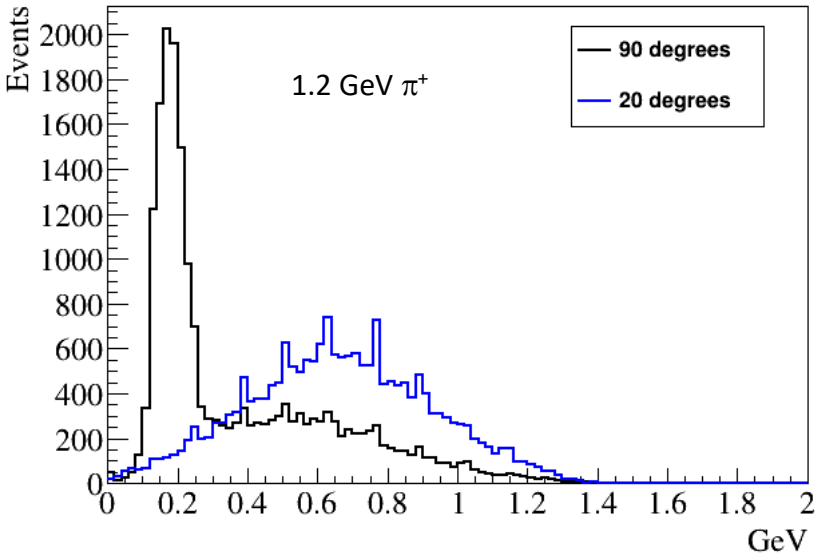


- Simulated using MCNP, Fluka, and Geant
- Integrated flux: 2 ·10^8 γ / s on the target

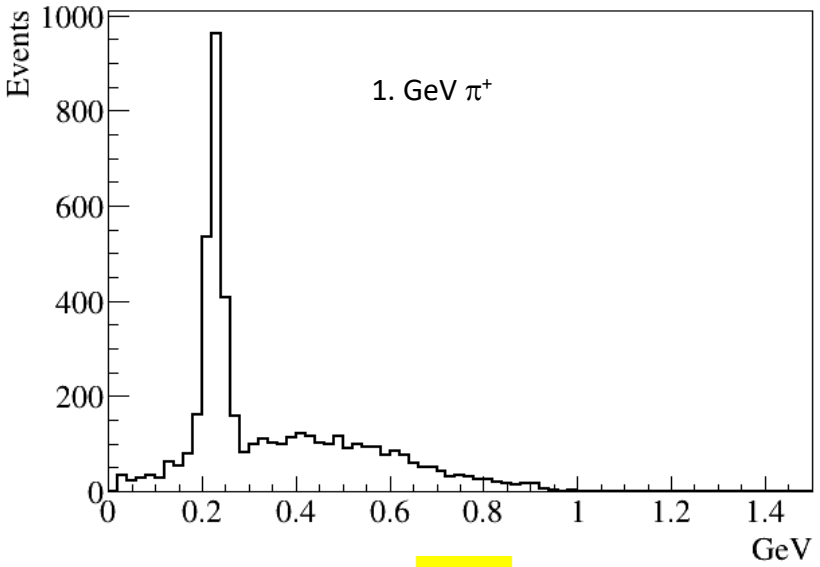
Uniform distribution of BG particles over the target face

Detector Response Induced by Charged Particles

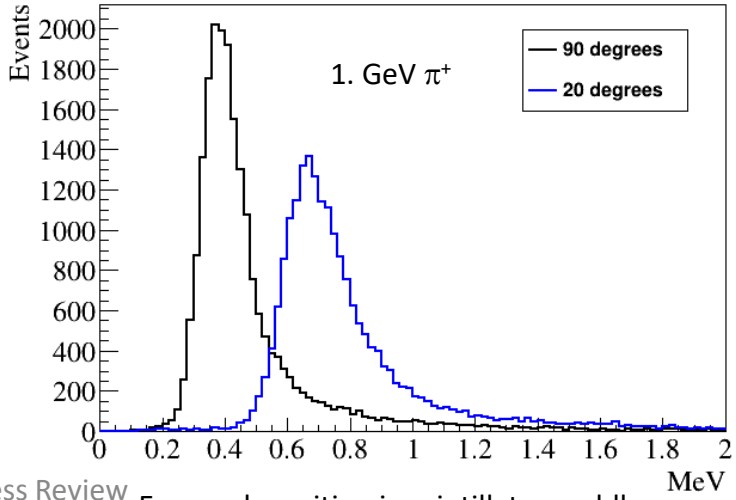
BCAL



ECAL



ST



Energy deposition in scintillator paddles

Geant4 simulation

charged pions generated at different angles

Background Rates

Background	Rates in the sub-detectors (kHz)			
	BCAL	ECAL/FCAL	BCAL + ECAL /FCAL	Start Counter
Neutrons	17.2	14.1	30.8	44.2
Photons	>> 1	>>1	>>1	5.8×10^3

- Trigger energy thresholds in the calorimeters:

  $E_{BCAL,\ ECAL} > 20$ MeV, $E_{FCAL} > 130$ MeV

  $E_{BCAL} + E_{BCAL} > 0.1$ GeV

- Exclude two ECAL inner rings from the reconstruction (12 x 12 cm)

Background Rates

Background	Rates in the sub-detectors (kHz)			
	BCAL	ECAL/FCAL	BCAL + ECAL /FCAL	Start Counter
Neutrons	17.2	14.1	30.8	44.2
Photons	>> 1	>>1	>>1	5.8×10^3

Neutron background

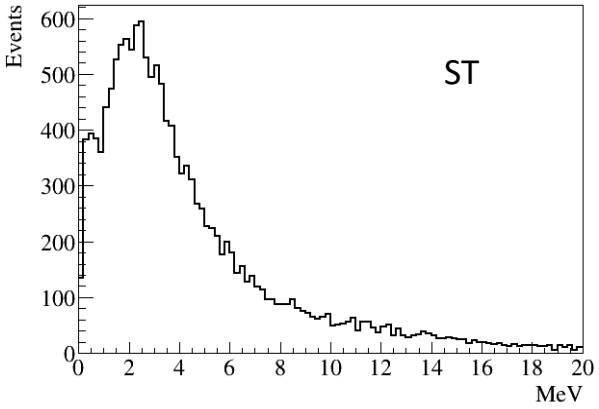
- large cross section of np scattering process

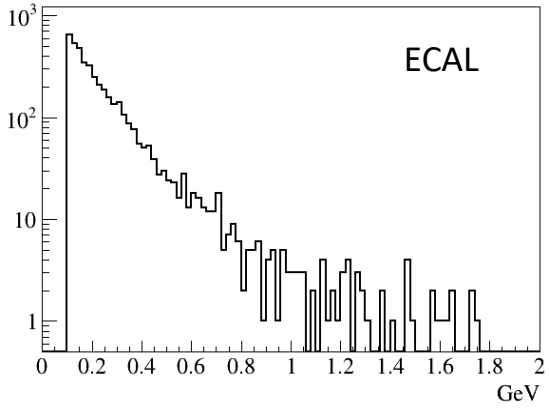
Photon background

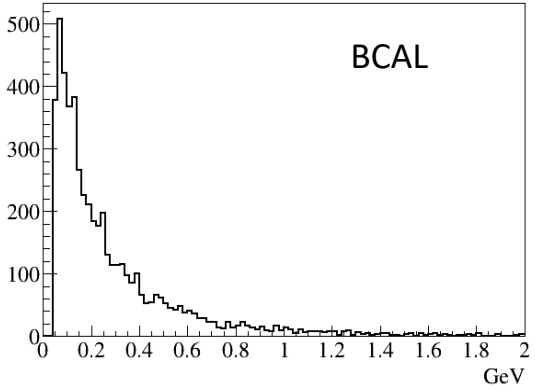
- low-energy photons
- large Compton cross section
- produce hits in the start counter
- almost no energy deposited in the calorimeters

Detector Response Induced by Background

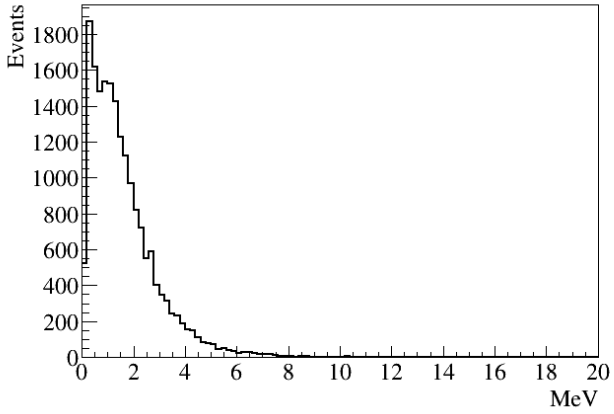
Neutron background







Photon background



Trigger Efficiencies

Channel	Efficiency (%)
KL + p -> K^+ + n	98.1
KL + p -> Ks + p (K_S -> π^+ π^-)	99.6
KL + p -> π^+ + Λ	99.4
KL + p -> K^+ + Ξ (Ξ -> Λ + π^0)	100
KL + p -> K*(892) + p (K* -> K^+ + π^-)	99.7

The trigger efficiency calculation:

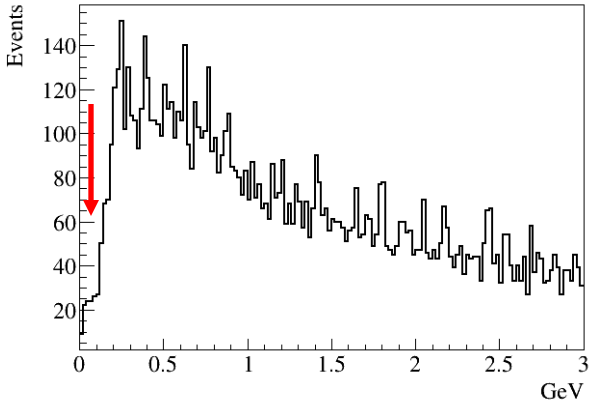
- all particles were required to be reconstructed in the detector

The trigger efficiency is almost 100 %

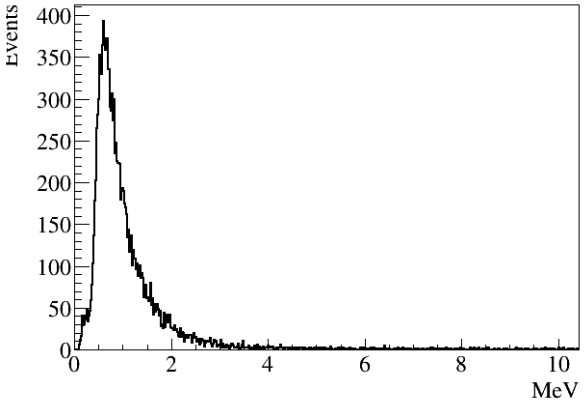
- allow for the optimization of trigger thresholds

Detector Response Induced by Physics Channels

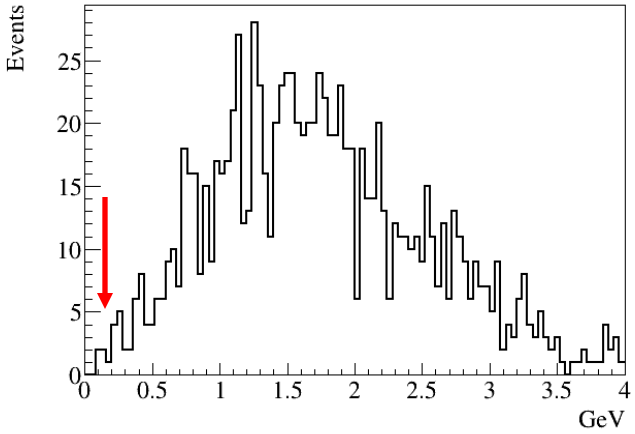
$E_{BCAL} + E_{ECAL/FCAL}$

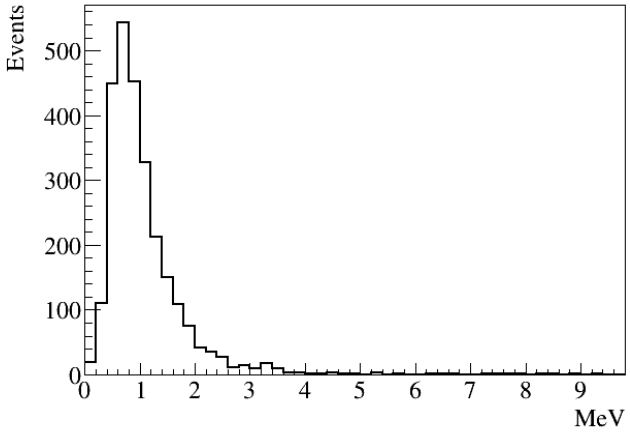


Energy deposition in SC



KL + p -> K^+ + n





KL + p -> Ks + p
(K_S -> π^+ π^-)

Total Trigger Rate & Data Rate

- The trigger rate is dominated by neutron background and constitutes about 30 kHz

- The contribution from KL p interactions:
  - total KL p cross section ~6 mb

  - the upper limit on the trigger rate (assume that accept all KL interactions)

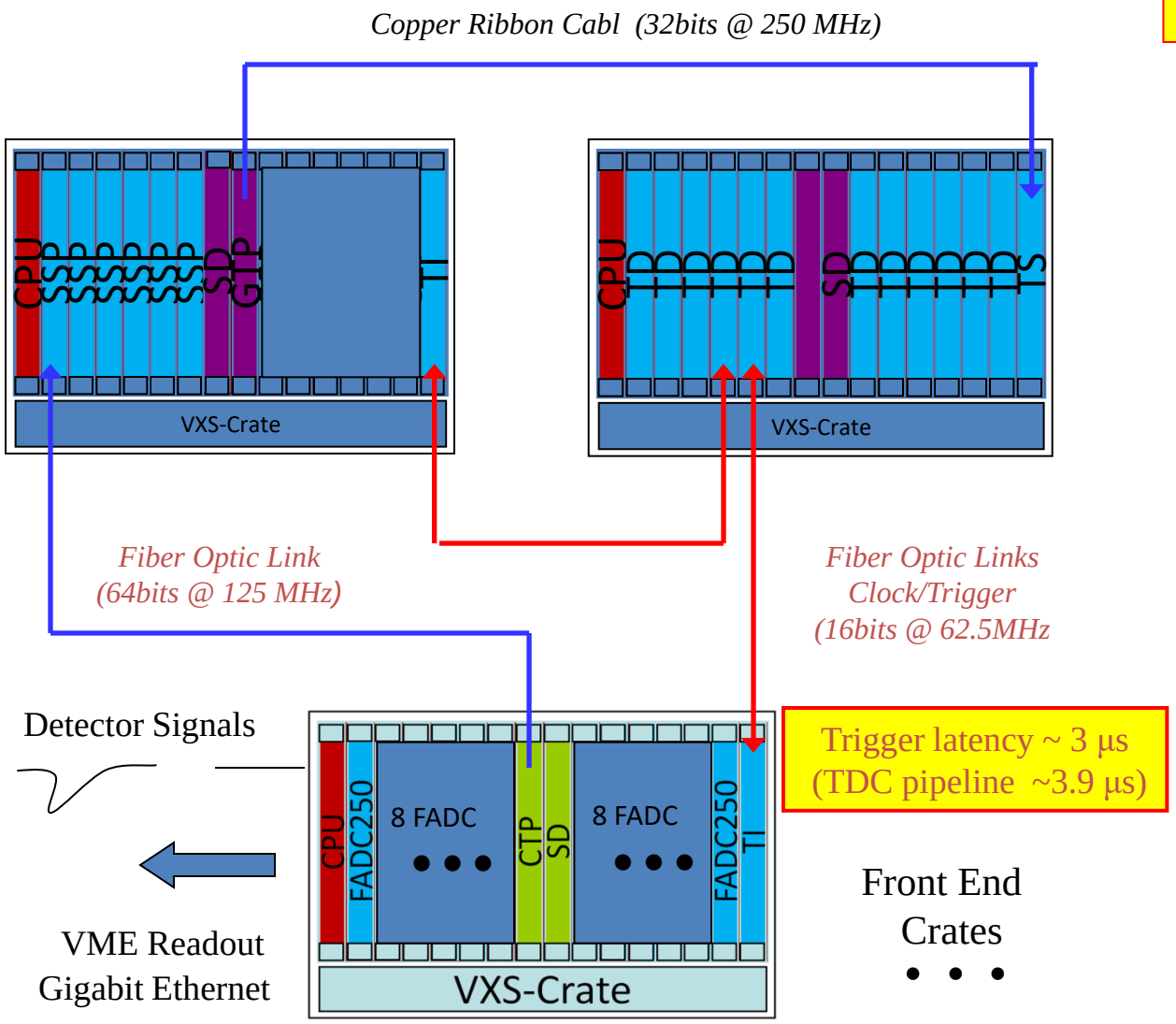
$$N_{Int} = N_{KL} \cdot N_{Prot} \cdot \sigma = 3 \cdot 10^{4} \cdot 1.7 \cdot 10^{24} \cdot 6 \cdot 10^{-27} = 300\ s^{-1}$$

- The GlueX detector can operate at a significantly higher rate of up to 70 kHz

- The upper limit on data rate (base on the GlueX data) is 700 Mbps
  (Note: the rate may be smaller due to the smaller event size)

Backup

Level-1 Trigger Electronics (operated at 250 MHz)



Custom Designed Boards at JLAB

Flash ADC , 250 Msps (FADC)
- 16 channel, 12 bits, digital pipeline
- sums amplitudes from 16 channel
- transfer energy sums or hit patterns to the CTP

Cate Trigger Processor (CTP)
- sums energies from fADC's
- transfers date over optical cables to SSP (10 Gbps capability)

SubSystem Processor (SSP)
-sums energies received from CTP's

Global Trigger Processor (GTP)
- collects data from 8 SSP's
- runs trigger equations

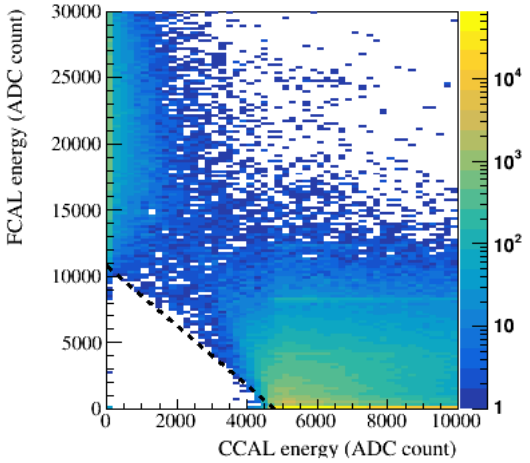
Trigger Supervisor (TS)
- manages triggers
- distributes clocks, triggers, sync to crates TI – TD

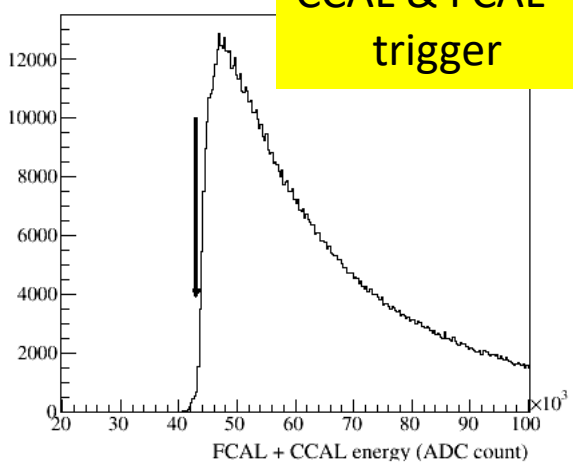
Trigger Interface (TI)

Trigger Distribution (TD)

Signal Distribution (SD)

PrimEx Production: Spring 2019





CCAL & FCAL trigger

Typical trigger rates for PrimEx production:

Total:	**23 kHz**	**Live time: 99 %**
CCAL & FCAL:	17.7 kHz	
FCAL:	1.2 kHz	
PS:	5.5 kHz	