

Jefferson Lab

# *Beamline Commissioning and Radiation*

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E12-19-003

Experiment Readiness Review

March 31, 2020

# Outline

- Beam Commissioning (charge 7)

Are the beam commissioning procedures and machine protection systems sufficiently defined for this stage?

- Radiation level (charge 4)

What is the impact of the expected neutron radiation on GlueX detector components such as the SiPMs? Is any local shielding required? Are the radiation levels expected to be generated in the hall acceptable?

# Photon Beam Requirements

Experiment	Energy Range (GeV)	Polarization	Flux in the energy range of interest $\gamma$ / sec	Flux on target (0.012 – 11.7 GeV) $\gamma$ / sec
GlueX Design	8.4 - 9.1	40 %	$10^8$	$1.8 \cdot 10^9$
GlueX II	8.4 - 9.1	40 %	$5 \cdot 10^7$	$9 \cdot 10^8$
<b>This experiment</b>	<b>8.4 - 9.1</b>	<b>40 %</b>	<b><math>2 \cdot 10^7</math></b>	<b><math>3.6 \cdot 10^8</math></b>

***This experiment***

*GlueX II*

Electron beam current:

**140 nA**

350 nA

Radiator thickness:

**$2 \cdot 10^{-4} X_0$**

$2 \cdot 10^{-4} X_0$

Collimator diameter:

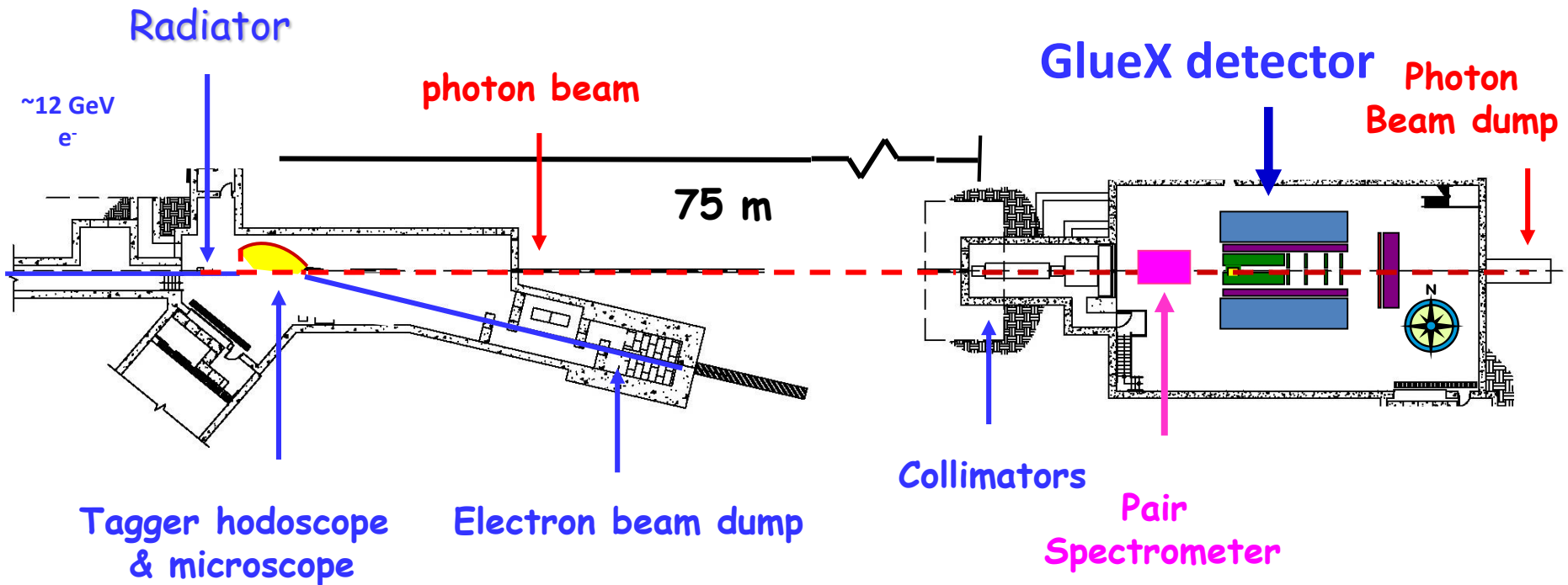
**5 mm**

5 mm

**Photon flux on target is about 2.5 smaller than GlueX II flux  
( 5 times smaller than GlueX designed flux)**

# Hall D Photon Beam Line

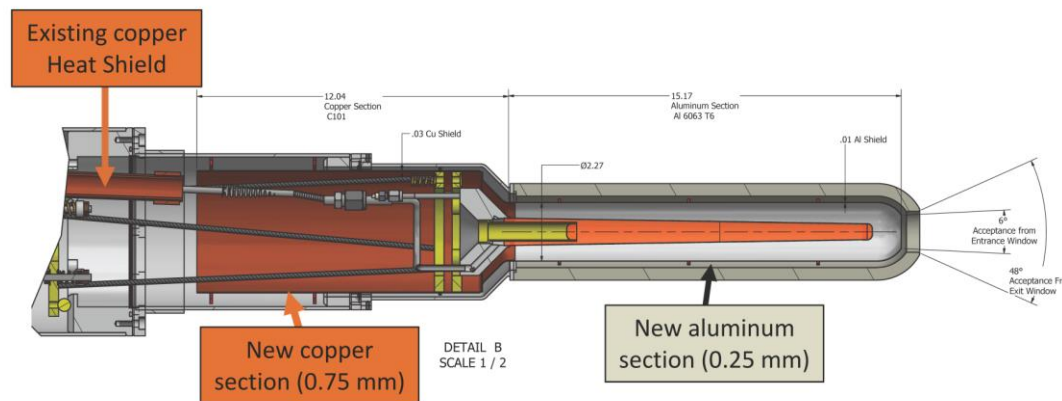
Use standard Hall D beam line equipment for SRC / CT !



# Targets

See C. Keith talk

- LD (LHe) target. Standard GlueX target cell and cryogenic system
  - LHe target was used by Hall D PrimEx experiment
- Carbon target
  - Similar to PrimEx Be target



# SRC/CT Beamline Summary

- 12 GeV polarized photon beam has been successfully used by the GlueX experiment in 2016 - 2019
- Typical GlueX beam configurations:
  - electron beam current 100 – 350 nA (data production)
  - < 5 nA (PS calibration)
- Beamline equipment installed in Hall D is ready to use by the SRC/CT experiment
- Photon beam conditions used for the GlueX data production satisfied specifications of the RC/CT experiment
- Beam delivery/monitoring procedures and machine protection systems are the same as for the GlueX experiment

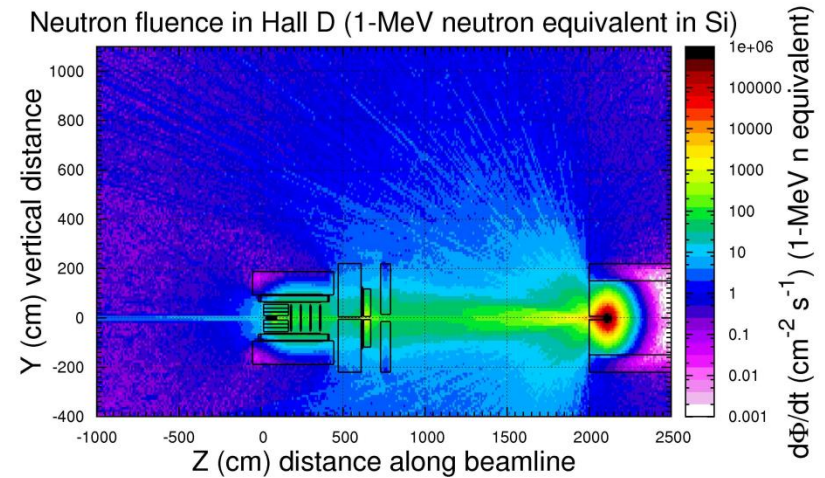
# Radiation Level in the Hall

Charge 4

JLAB-TN-11-005  
GlueX-doc-1660  
Version 0.3  
February 23, 2011

## Calculation of Radiation Damage to Silicon Photomultipliers in GlueX Experiment

P. Degtiarenko, A. Fassò, G. Kharashvili, A. Somov



- Estimated background for the LHe/LD target using Fluka and Geant simulations provided by the JLab Radiation Control group
- Neutron background is critical for SiPM operation

# Targets Run Conditions



# Radiation Level in the Hall

FLUKA, Liquid Hydrogen target

Position of control volume	n	p	$\pi$	$e^-$	$e^+$	Total
Start Counter	20.9	1.4	18.4	0.1	0.1	$40.9 \pm 3.1$
BCAL upstream SiPM	2.0	0.1	0.3	0.0	0.0	$2.4 \pm 0.2$
BCAL downstream SiPM	18.2	1.7	1.8	1.1	0.3	$23.2 \pm 0.6$
75 cm downstream from BCAL	16.7	2.2	2.3	18.2	5.6	$45.1 \pm 1.0$

GEANT, Liquid Hydrogen target

75 cm downstream from BCAL	30.5					
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FLUKA, Liquid Helium target

Start Counter	112.1	34.8	14.7	0.2	0.1	$162.9 \pm 5.9$
BCAL upstream SiPM	8.0	0.2	0.3	0.04	0.03	$8.6 \pm 2.2$
BCAL downstream SiPM	23.0	2.1	2.2	1.0	0.3	$28.7 \pm 0.3$
75 cm downstream from BCAL	21.1	2.7	2.5	20.1	6.8	$53.7 \pm 0.9$

Neutron background was evaluated for the GlueX proposed luminosity

Neutron background induced by the LHe target is about a factor of 4 – 5 larger than that for LH<sub>2</sub>

Table 1: 1-MeV neutron equivalent fluence in units of  $n_{eq} \cdot s^{-1} \cdot cm^{-2}$  estimated with FLUKA and GEANT simulations. The fluences were computed in the Start Counter and BCAL SiPM regions. See definitions of the regions in the text.

- SRC/CT beam flux on target is 5 times smaller than that for GlueX

**Background induced by the LHe target will not exceed the GlueX level**

(RSAD for SRC/CT will be similar to GlueX. It will be coordinated with the RadCon group)

# Comparison between LHe abn LD Targets

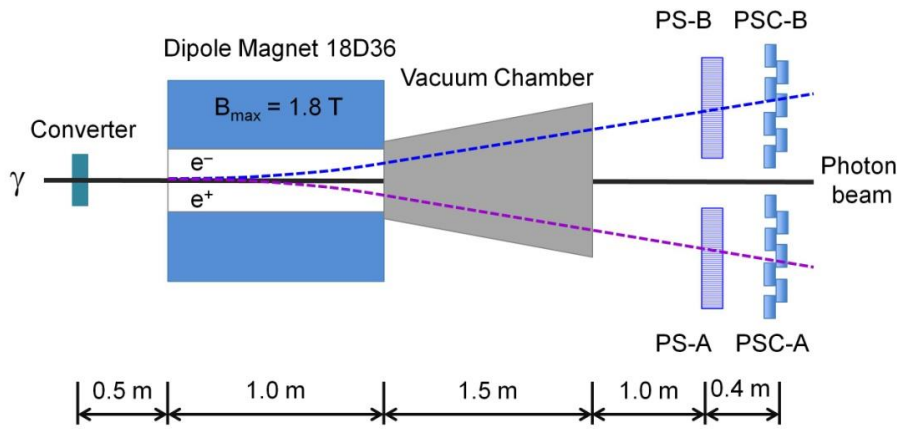
# Monitoring SiPM Dark Current

# Monitoring Radiation Level in Hall D

- Installed quick access ionization chambers (show locations)
- Install thermoluminescent dosimeters (**TLD**) close to the target
- Install **Bonner spheres** (determine the energy spectrum of neutrons) close to the target (coordinate with RadCon group)

# **Backup Slides**

# Photon Flux Measurements with Pair Spectrometer



Two layers of scintillator detectors:

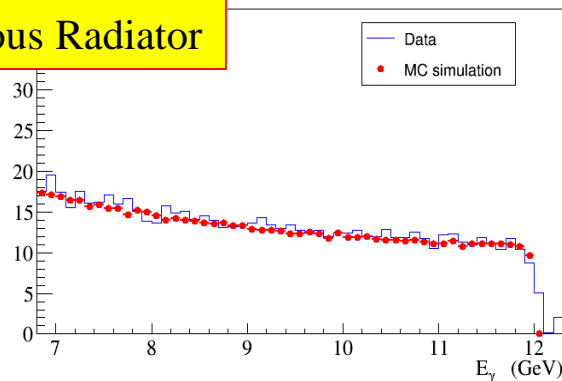
High-granularity hodoscope  
(measure photon energy in the  
range 6 – 12 GeV )

Low-granularity counters (use in trigger)

- Reconstruct the energy of a beam photon by detecting  $e^\pm$  pairs
  - measure the photon beam flux and spectrum of the collimated photon beam

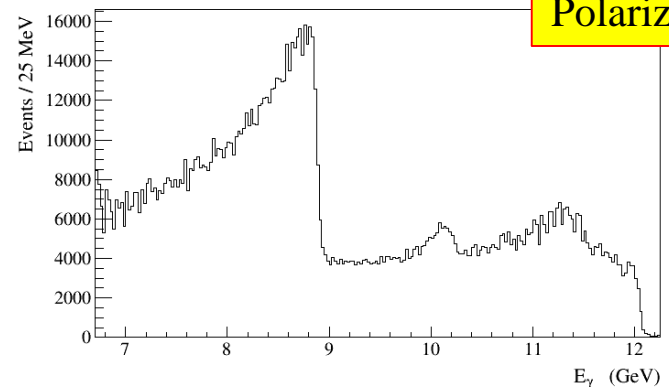
Run 4458

Amorphous Radiator



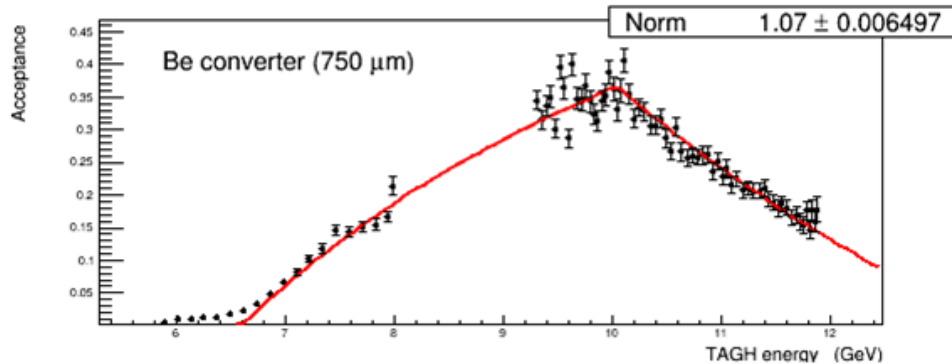
Run 10493

Polarized Beam



# Photon Flux Measurements with Pair Spectrometer

- PS acceptance and energy determination
  - Ray tracing (measure magnetic field map)
  - Calibrate using total-absorption-counters (TAC) at low luminosity



- 3.4 mm collimator ,  
2 · 10<sup>-5</sup> X<sub>0</sub> radiator,  
2 nA beam current

Calibration is performed regularly; takes 2-6 hours

- will be performed during PrimEx-D run

(Recommendation 1.5)

- Special trigger type – continuous flux monitor ( typical rate 1 – 3 kHz)
  - fadc / CTP scalers inserted to the data stream and EPICS

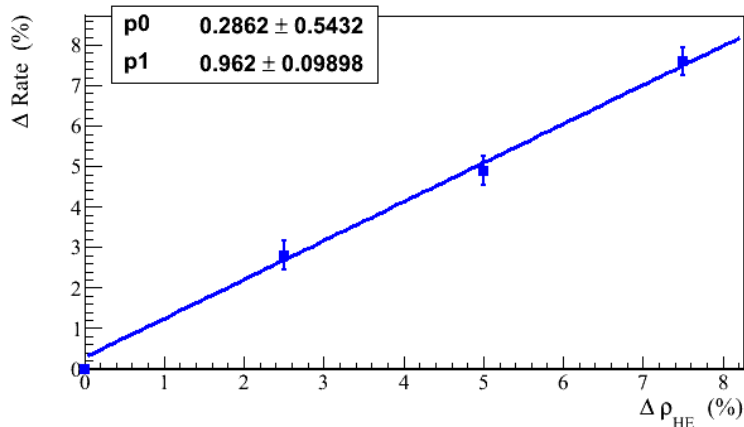
Monitor the photon flux with the precision < 1 %

# Target Density Monitor

- **Short term stability control:**

- photon beam flux provided by the PS
- rates in the Start Counter (ST) and Time-of-Fight (TOF) wall

ST rate dependence on the target density



ST consists of 30 paddles surrounding the target

ST rate for production runs: 250 kHz / paddle

Coincidence of hits between the ST and TOF  
(2 x 2 bars in TOF at R = 30 cm & one ST paddle)

1.5 kHz

- **Long term stability control:**

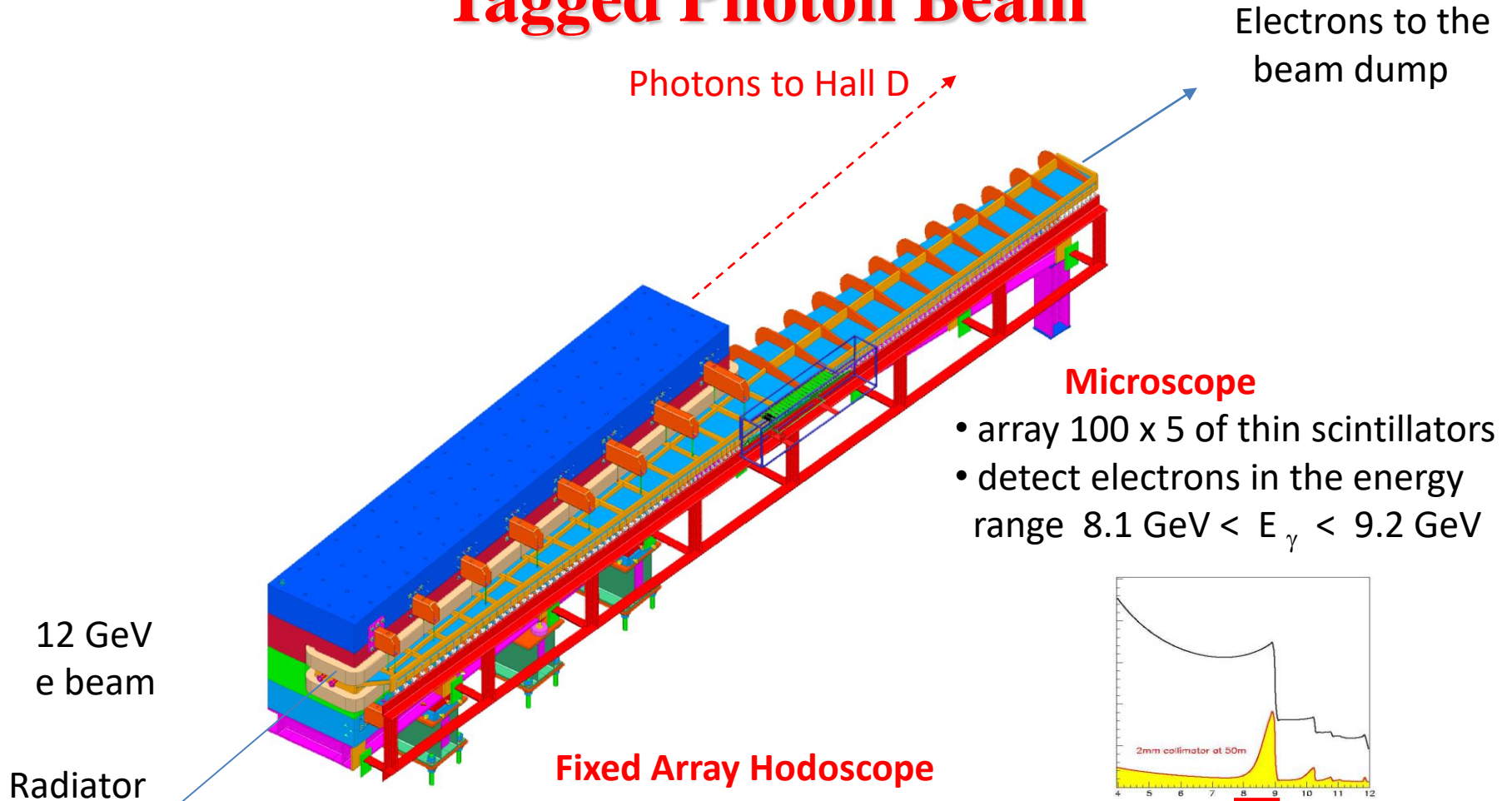
- monitor using Compton process; expected rate in the photon range of interest is about 30 Hz



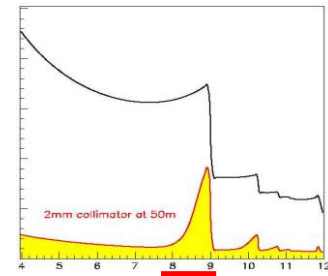
# Pair Spectrometer Acceptance Calibration

- Calibrate PS acceptance using total-absorption counter (TAC)
- Data samples were acquired for three converters
  - $5.7 \times 10^{-3}$  R.L. Al (508  $\mu\text{m}$  foil)
  - $2.1 \times 10^{-3}$  R.L. Be (750  $\mu\text{m}$  foil)
  - $0.21 \times 10^{-3}$  R.L. Be (75  $\mu\text{m}$  foil)
- Run conditions
  - 3.4 mm collimator ,  $2 \cdot 10^{-5}$  radiator, 2 nA beam current
- Trigger
  - run two triggers in parallel: PS and TAC (energy sum)
  - PS rate: 10 Hz 750  $\mu\text{m}$  Be
  - TAC rate: 200 – 300 kHz ( trigger prescaling factor 129 )

# Tagged Photon Beam



- array 100 x 5 of thin scintillators
- detect electrons in the energy range  $8.1 \text{ GeV} < E_\gamma < 9.2 \text{ GeV}$



- cover large energy range  $3 \text{ GeV} < E_\gamma < 11.7 \text{ GeV}$ ,  $\Delta E_\gamma / E_\gamma < 0.002$
- 233 counters installed
- detect tagged electrons with  $E_\gamma > 9.2 \text{ GeV}$  during data runs
- accidental background for PrimEx-D  $< 4 \%$