Proposal # **C12-19-001** for **PAC48** **Hall: D**

Title: Strange Hadron Spectroscopy with Secondary KL Beam at GlueX

Contact person: Moskov Amaryan (ODU)

Beam time:

Beam days requested: 200
Detector commissioning time included in request: not specified

Beam parameters:

		Base Equipment
Energy:	~12 GeV	yes
Current:	5 μA	yes
Polarization:	N/A	yes
Emittance:	relaxed specs with respect to GlueX	yes
Bunch spacing	64 ns	no
Beam focusing	Defocused at the radiator	no
Radiator:	10%	no
Collimator:	Be target	no

Targets:

Nuclei:	Liquid ^{1}H, ^{2}D 6cm diameter	no

Spectrometers:

Hall D	standard	yes

Updates since the PAC47 proposal: *Significantly more details and calculation results have been added to the physics sections. More simulation of the expected radiation levels has been done and reported. On the technical side: new development of the design of the Compact Photon Source (CPS) and the electron beamline; a new design of the Be-target assembly.*
Noticed typos in the 2020 proposal*:* ***Table 4****: K°/K°_bar ratio is expected to be 2:1 at the Be target, rather than at the cryogenic target. At the cryogenic target it is expected to be close to 1:1.*
Fig.22 caption, and page 32*: Radiator thickness: instead of 0.005% should be 0.05%.*

New elements: injector elements, electron beamline elements, compact photon source, photon beamline, KL-production target and shielding, KL flux monitor, start counter (not yet decided, depending on collaborators).

Major modifications:

1. **Accelerator**: The bunch spacing of 64 ns (16 MHz repetition rate) will require new injector equipment, estimated at about $130k, as well as an R&D and installation labor performed by the injector group. It will also need a certain

commissioning time. The existing chopper/slit system can be used for this beam in the same way it is used for the regular Hall D beam. The bunch charge will be equivalent to 160 μA at the regular 500 MHz rate or 320 μA at 250 MHz, which is at the high end or even beyond of the regular CEBAF operations. This may cause interference with the beams for other halls and needs an R&D effort.

2. **Compact Photon Source** (CPS) **(***updated since 2019 due to the completion of the Hall A/C design)* will be permanently installed in the tagger hall right downstream of the tagger magnet. The CPS contains a radiator, an electromagnet and a beam dump. It will be followed by the existing 4 m long permanent magnet. During the regular photon beam operations the CPS magnet can be turned off, while the radiator will be removed. For the KL-beam operations the Tagger magnet will be turned off, while the CPS will be used. As with the existing system, the permanent magnet serves as an additional protection, sending the electron beam down, should the electromagnet trip and the FSD fail to stop the beam. The permanent magnet will be moved closer to the wall of the hall which would direct the electron beam to a different spot, which should be considered. A conceptual design of a 30 kW CPS has been developed by a CPS group at JLab, for use in Halls A/C. That design has to be modified in order to accommodate 60 kW, matching the existing Hall D beam dump. A possible issue is the requirement for a large beam spot of 15x15mm^2 on the radiator. It is proposed to use a defocused beam instead of a raster. It is not fully clear what does this number mean in such a case. One interpretation comes from a note by Todd Satogata that 96% of the beam is contained in that spot. A Gauss-shape beam with RMS=3mm would be contained in a spot of 15mm diameter. It is unclear where does the requirement for such a large spot come from. The Hall A/C design would use a 2x2mm ^{2} raster. Apart of problems for other equipment, the larger gap for the beam may cause a higher level of radiation leaking outside of CPS. Efforts should be taken to relax the beam spot requirement by changing the CPS length or other means. The floor load from CPS weight may be limited to 100 t. The CPS will be activated as the beam dumps are. The disassembling of the CPS will require a long "cool down". Once installed, it will not require significant efforts for switchover between the photon and kaon beams. It is expected that KLF operations at 5μA would produce about 10 times higher radiation rate in the upstream part of the tagger hall than the ongoing GlueX-II operations at about 0.5μA. The tagger hall detectors will not be used during KLF operation. The radiation-sensitive equipment can be removed from the tagger hall for KLF running.

3. **Electron beamline:** *(new development in 2020)* CPS operations may require a 15mm beam spot on the radiator (see the previous item in the list). The 2019 proposal considered a beam rastering. Now it is proposed to defocus the beam at the radiator area, keeping the convergence toward the Be target. According to Todd Satogata it is challenging but feasible. More studies are needed to determine if such a size will require a considerable modification of the electron beamline, as a replacement of several quadrupole magnets for larger ones. According to Jay Benesch the cost of such a scenario may be about $1.5M. Another potential problem with the large beam size is the level of radiation absorbed in the 1"

diameter channel in the tagger magnet steel upstream of CPS. This channel is used for the photon beam during the regular photon beam operations.

4. **Collimator Cave**: The cave was designed for high-intensity GlueX which would dump there about 5 W. The KL operations would dump about 6 kW. The proposal considers a local compact dump around the Be target, which absorbs ~99.9% of the photon beam energy. Detailed calculations of the radiation levels produced in Hall D and outside of the radiologically controlled area, including the "skyshine", found them acceptable. The switchover from photon to kaon beam and back would require major rearrangements of the collimator cave (on a scale of 6 months after the activation from the kaon operation drops to acceptable level). The additional elements needed (Be target, shielding) are a relatively "low-tech" equipment. No movable equipment or electromagnets are required in the cave for the KL beam operations. The shielding includes a tight labyrinth (70cm wide) which may require a special "confine space" procedure in order to get access to the area of the Be target. On the other hand, nearly nothing serviceable is planned for that area. *New development in 2020* : the Be-target and its beam dump have been optimized and redesigned, reducing the cost considerably without increasing the outside radiation.
5. New **liquid hydrogen/deuterium cryotarget**: 40cm long, 6cm diameter, will replace the existing, 30 cm long, 1.5cm diameter cryotarget. The new target system will have to withstand a higher pressure. The goals may be achievable with moderate modifications to the existing target system including the gas release system, requiring ~ 0.5Y*FTE from the Target Group. The changeover of the old and new targets may take 8 weeks.
6. **Kaon Flux Monitor:** will be a new device consisting of a superconducting solenoid and a detector system, all installed on the platform downstream of the Pair Spectrometer (PS) magnet. The plan is to keep the PS magnet off in order to extend the effective decay volume. A conceptual design has been presented. Achieving a few percent precision appears challenging. The detector should be able to separate well the 3 decays modes. The spectrum of the detected kaons will be different from the spectrum of the kaons reaching the target. On the technical side, the installation and operation of another superconducting magnet will require considerable efforts.
7. **Start counter:** The proposal puts a low priority on improving the timing resolution of the Start Counter, however indicating that such a project will be considered. On the other hand, the estimated level of neutron radiation is expected to damage the photo sensors (SiPM) of the existing Start Counter considerably by 70 days of operations. Potentially, the sensors can be replaced.

Summary:

Feasibility: The project appears to be technically feasible. The cost (without local labor) was estimated at about $4M , including about $1M for the Flux Monitor, which may become a foreign contribution. The beamline modifications described by T.Satogata may add $1.5M. More studies are needed for the CPS design and the requirements for the beam spot.

***Interference with the photon beam program*:** Switchover between the KL and photon beam regimes may take about 6 months, mostly for removing/installing the equipment in the collimator cave, the Flux Monitor, and the beamline elements upstream of the Hall D solenoid, by the efforts from the Hall D technical group, as well as from outside groups as the surveyors. The schedule would depend on the work load of the outside groups.
***Radiation safety**:* The CPS will be stationary, and thus not much different from other beam dumps. The collimator cave will contain an activated target enclosure, which will be pushed to the side wall for the regular photon beam operations. The radiation levels in the halls and outside of the radiologically controlled area will be acceptable according to the calculations presented.