EIC HRPPD aging studies at BNL: setup and procedure

Yifan Jin, Alexander Kiselev

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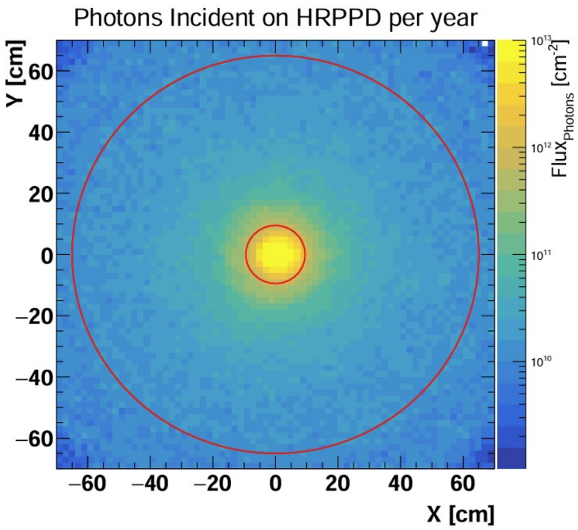
General comments

- Procedure: accelerated pixel-based aging in a pulsed laser setup
- Light source for both irradiation and single photon mode: 405 nm PiLas PIL-040-FC picosecond laser, coupled to the dark box via a SM fiber
  - Has sufficient power to produce a required integrated photon flux (see next slide)
- Main measured quantities characterizing photocathode and MCP aging: PDE (*rather than QE*) and gain degradation in a single photon mode
  - Also, secondary quantities like DCR, timing resolution, afterpulsing rate, etc
- Measure of accumulated "damage factor": integrated photon flux per mm^2 in a 1-3 mm diameter spot *for a nominal bias voltage of MCP#1* (*no C/cm² stuff*)
  - Requires a proof that ion backflow from MCP#2 is either small or absent

See the talk by Varghese

MC estimate of a max expected photon fluence

- Charged particle flux above Cherenkov threshold through aerogel and HRPPD windows was evaluated for primary interactions and proton beam gas background [what about electron beam gas background?]
- As our standalone pfRICH GEANT simulation shows, such tracks will produce O(10) *detected* photoelectrons in aerogel and O(100) in quartz
- Luminosity 10^{34} $cm^{-2}s^{-1}$, 26 full weeks a year, 10 years of running
- Extreme case of four pfRICH HRPPDs installed next to the beam pipe was taken as a reference
- A safety factor of 100 on top of this (hadronic showers have not been accounted, etc)



See the talk by Andrew

up to 10^{15} γ/cm^2

General comments, cont'd

- Will likely be using symmetric MCP bias mode (worst case scenario) *as a reference*, and assume an overall gain ~10^6 (160 fC single photon mode) as a working point for *pfRICH HRPPDs in ePIC*
  - Roughly speaking, 10^3 gain for both MCP#1 and #2

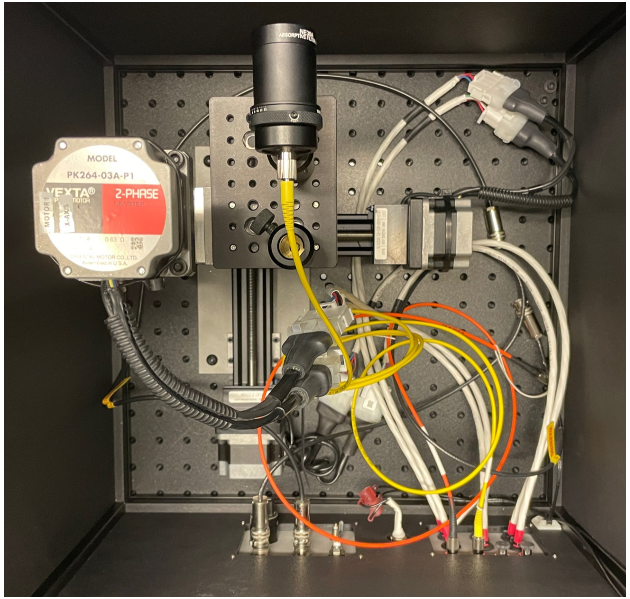
- Assuming MCP#2 plays no role *for the photocathode aging*, this gain times 10^{15} γ/cm^2 integrated flux defines a degree of damage an HRPPD should sustain in these studies *to prove it will work for ePIC pfRICH*

  -> Some of the groups should probably stop the measurements at this point

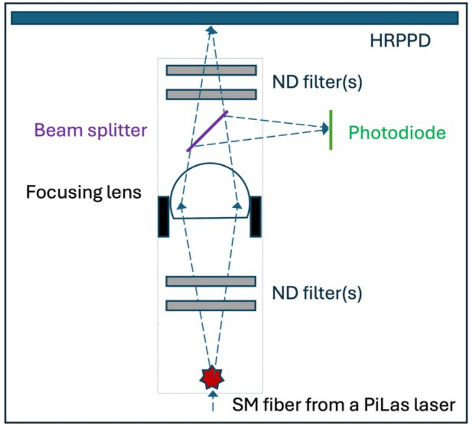
- Start with 100 V photocathode voltage
  - Damage may strongly depend on this setting -> foresee 2-3 runs at a (much) higher voltage?
  - B-field studies may suggest a higher PC voltage from the start

Dark box and optical head setup

- 3D motion control
- Single mode fiber port; focusing lens
- Beam splitter and a reference photodiode
  - Not present in the photo
- ND filter(s) as needed [perhaps a filter wheel]
  - Not present in the photo



- *Same configuration for both irradiation and control / aging evaluation modes (?)*
  - No photocathode current measurement involved
  - Change MCP bias voltages, ND filters and laser repetition rate and spot size to switch between the two modes



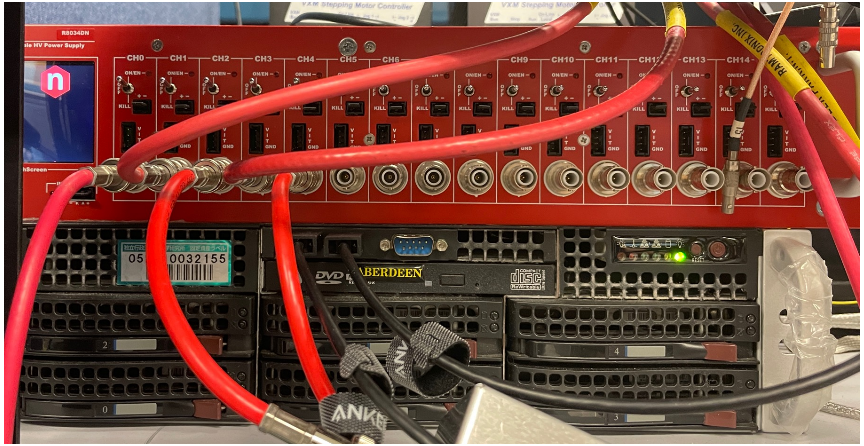
Other equipment

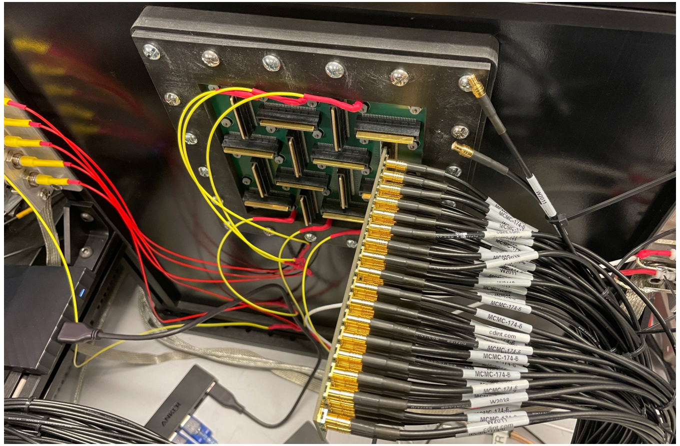
- Dark box
  - HRPPD mounted on its wall
- PiLas picosecond laser
- R8034DN HV power supply
- DRS4 electronics
- Keithley 6487 picoammeter
- NIM crate with fast logic
- DAQ PC

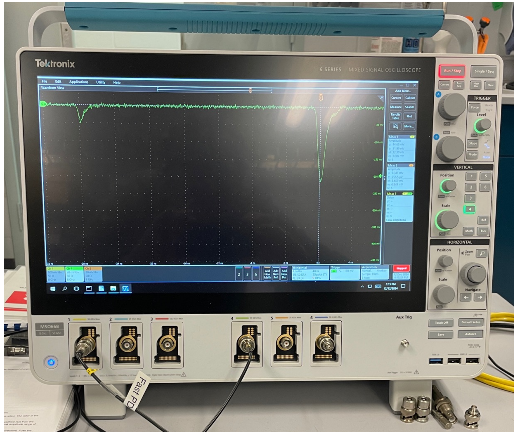
- Tektronix MSO 6 scope

Technically, can also use a second setup similar to this one

Other equipment







Flux accumulation mode

- A laser light spot up to ~3 mm diameter or so

- Assume HRPPD can sustain 10 kHz laser repetition rate in a single photon mode in a ~1 mm^2 spot at a 10^7 gain
  - Based on Incom's test report (we should have checked this, I know)
  - Roughly speaking, ~$3*10^3$ gain for both MCP#1 and #2

- Establish a non-saturated running mode with $<N_{pe}> \sim 1$ (by tuning laser repetition rate and observing average pulse height)
- Decrease MCP#2 bias voltage all the way down to ~1, at the same time increasing single laser pulse population all the way up to ~$3*10^3$
- Crank up the repetition rate up until MCP#1 shows signs of saturation (we should still see *anode* signals of a reasonable amplitude)

Running time estimates

- 10 kHz laser repetition rate
- ~3000 photoelectrons per pulse
- ~1 mm^2 laser spot size

→ ~$3*10^9$ γ/cm^2s

Looks like 3-4 days for a single series of measurements to reach ~10^{15} γ/cm^2 fluence

Performance evaluation mode

- A laser light spot few hundred μm diameter or so
- Laser intensity down to a single photon mode

- Scan area of ~5x5 pads around the irradiated spot

- Count signals above certain threshold (PDE)
- Measure single photon signal amplitudes (gain)
- Spot-like checks of timing resolution and afterpulsing
- Other quantities (DCR, …)?
    - Compare against reference measurements before irradiation

Timelines and organization of all this effort

- Measurement setups should likely be ready on a time scale of ~2 months at all three labs (perhaps earlier at BNL and JLab)
- A synchronized / coordinated campaign starting around March 1 or so?
- Arshak (JLab), Yifan (BNL) and TBD (INFN) as primary contact persons?
- Ideally, B-field measurements should happen at BNL before that
  - An option to consider: aging in a 1.3 T field with a selected set of HV settings?
- Obviously, a consolidated report for EIC Project at the end
- A joint publication?
  - Eliminates a need to torture all three HRPPDs to death