PS flux update

Justin Stevens
Beamline Meeting: 9.11.17
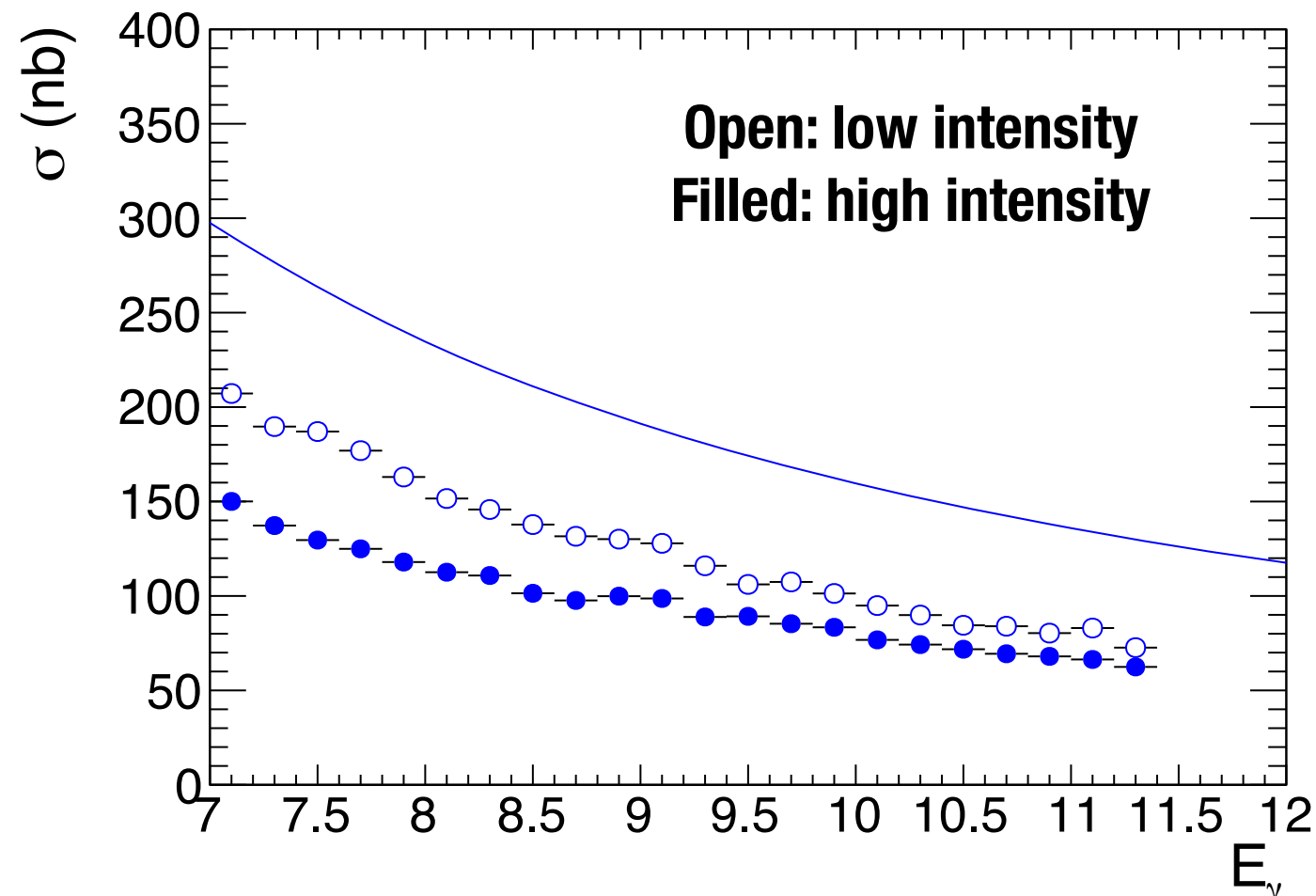
WILLIAM & MARY

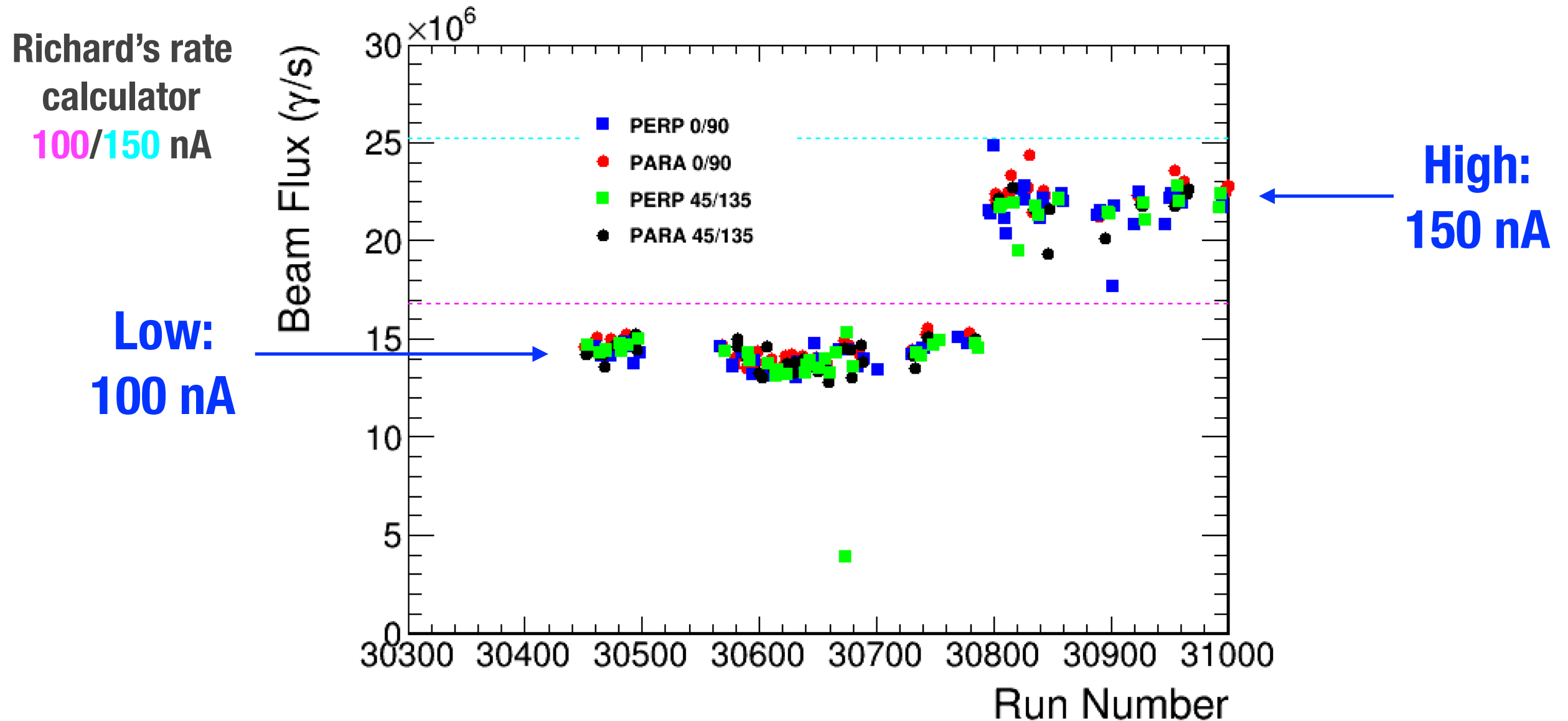CHARTERED 1693

Initial goal: understand 2017 difference

Spring 2017: $\gamma p \rightarrow p\pi^0$

Open: low intensity
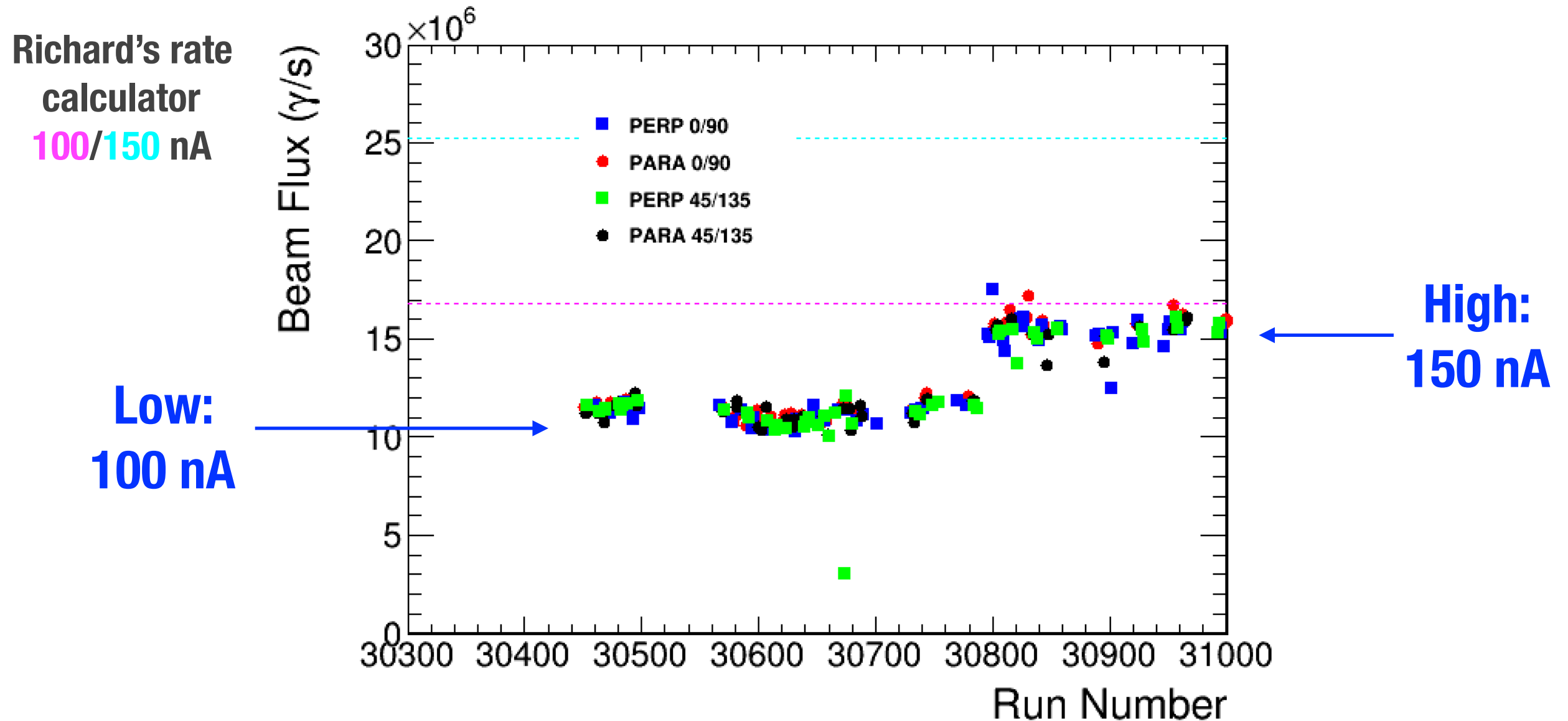**Filled: high intensity**

- ✳ ~25% reduction in π^0 cross section for higher intensity

  - ✳ Used the same MC (with no background) for efficiency

- ✳ Something wrong with flux, or changing efficiency?

Scaling with beam current: un-tagged

Richard's rate calculator
100/150 nA

Low: 100 nA

High: 150 nA

Legend:
- PERP 0/90 (blue square)
- PARA 0/90 (red circle)
- PERP 45/135 (green square)
- PARA 45/135 (black circle)

* Determine **un-tagged** coherent peak flux in units γ/s for every run and compare low/high (100/150 nA) current

* PS flux scales with beam current as expected

Scaling with beam current: tagged

Richard's rate calculator **100**/**150 nA**

Low: 100 nA

High: 150 nA

Legend:
- PERP 0/90
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- PARA 45/135

Beam Flux (γ/s) ×10⁶ vs Run Number

* Determine **tagged** coherent peak flux in units ɣ/s for every run and compare low/high (100/150 nA) current
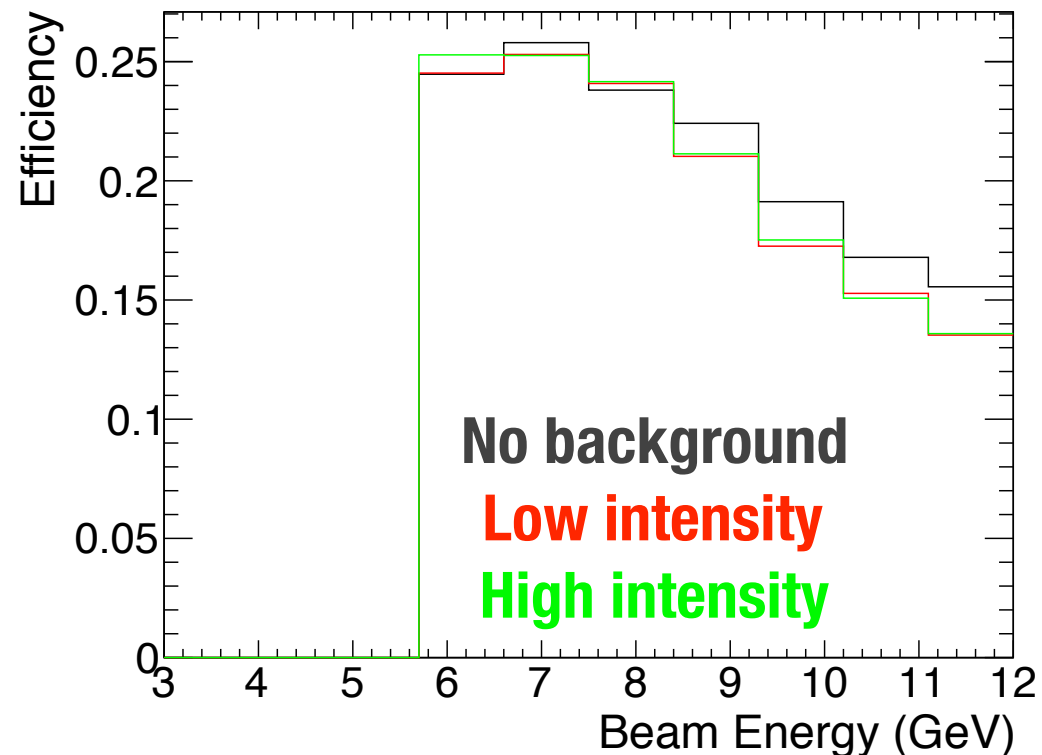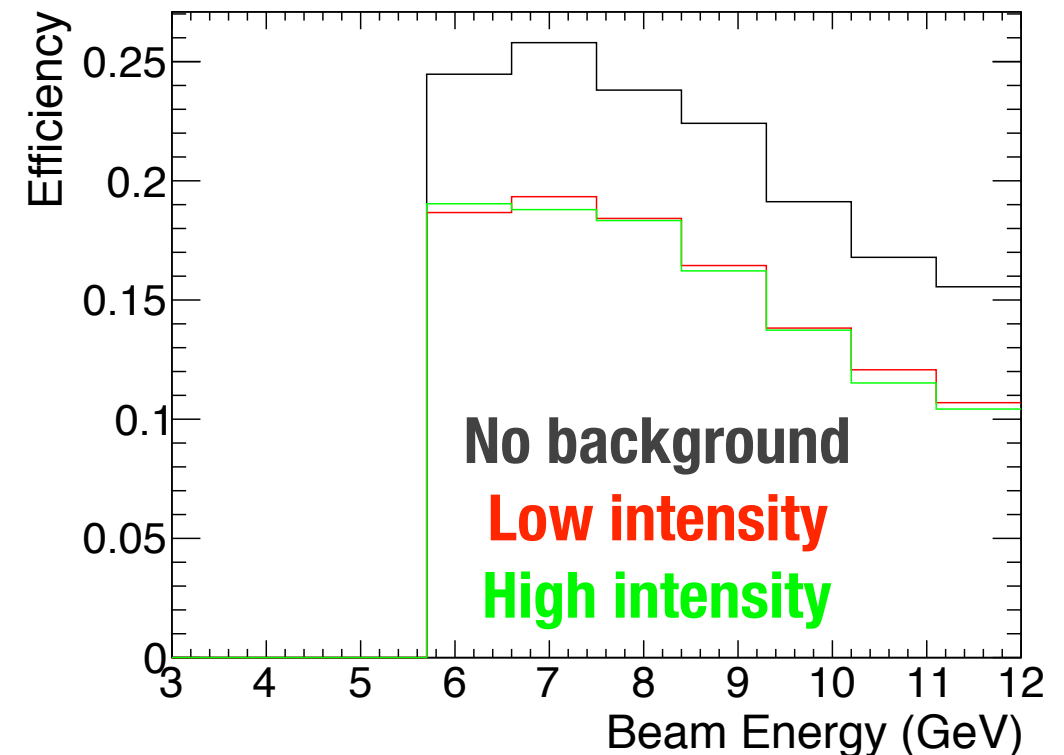
* PS flux scales with beam current as expected

π^0 efficiencies: different beam currents

hdgeant EM background

random triggers background

- Generate 1M π^0 events and measure efficiency for:

  - No EM background

  - hdgeant EM background

  - Mix random triggers with simulation for background

Summary

* Scaling of un-tagged and tagged flux between 100 and 150 nA electron beam currents validates relative flux for spring 2017

* Introducing backgrounds to π^0 MC does give a reduced efficiency, but does not depend as strongly on intensity as the difference observed in the data

* Beni started looking at PS code, needs to be studied with Sasha's improved reconstruction also

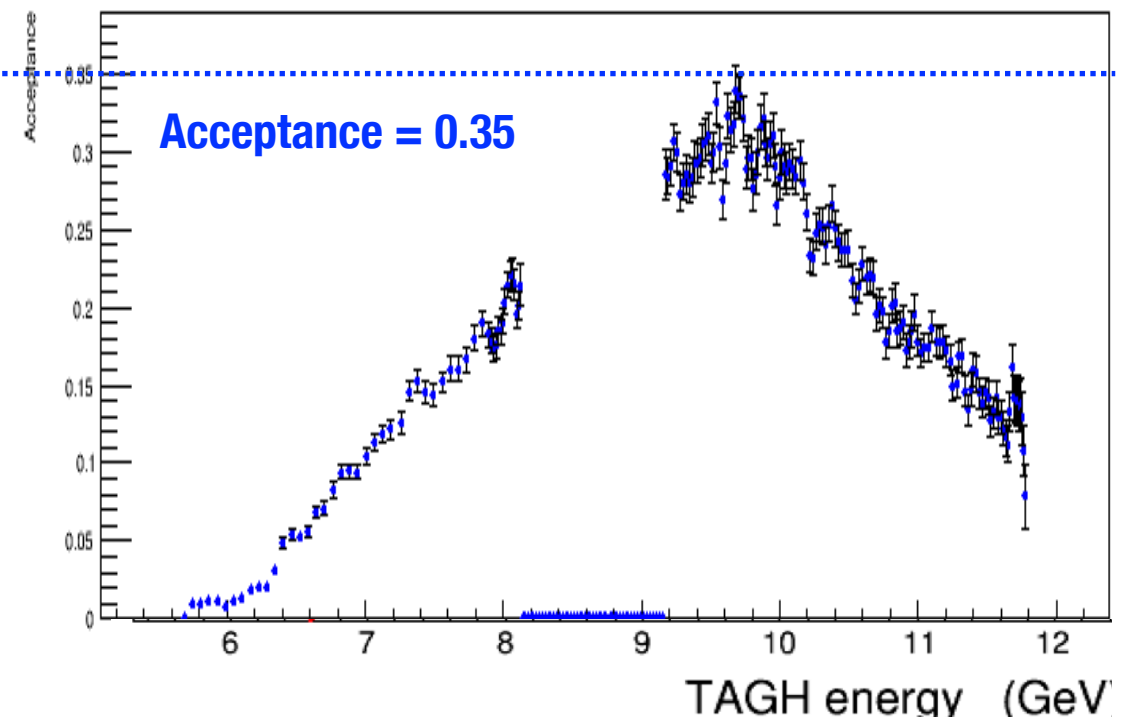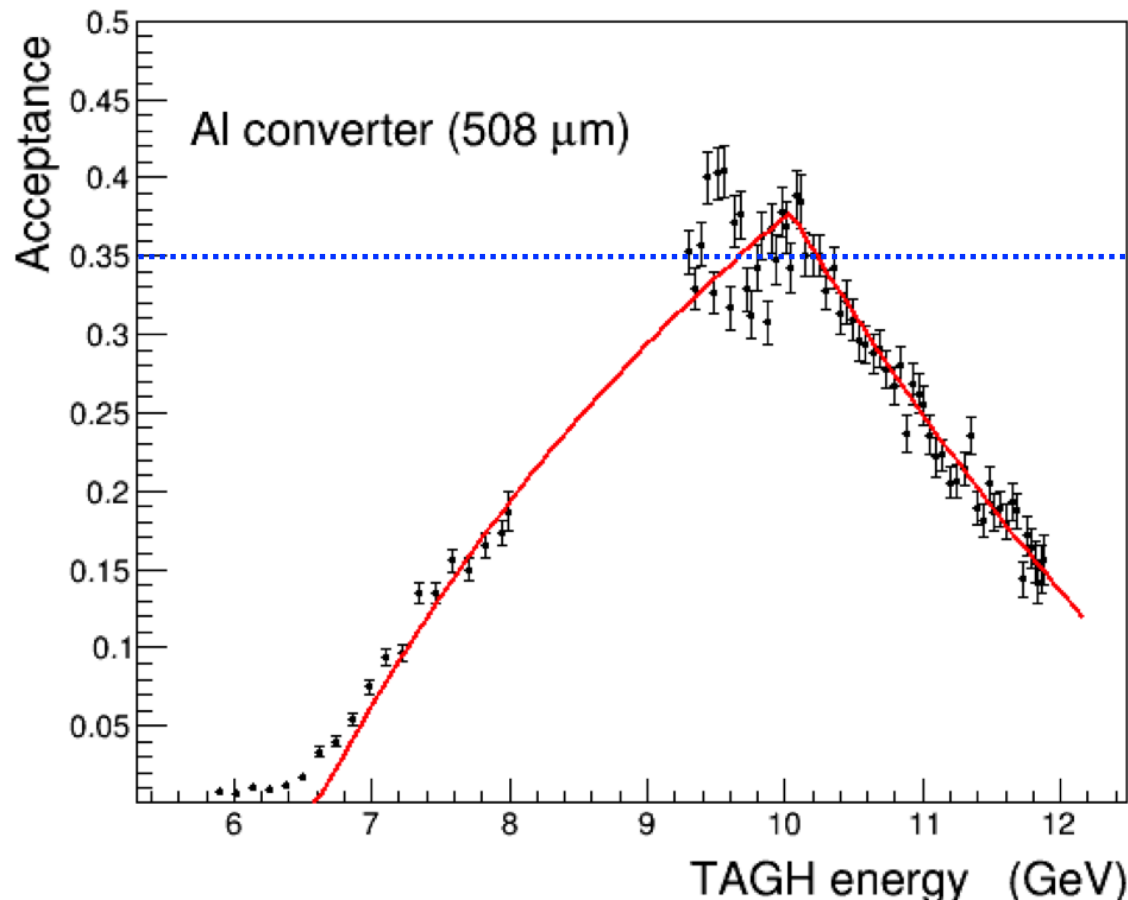   * The PS-Tagger energy match cut is currently a little tight, meaning flux will increase slightly

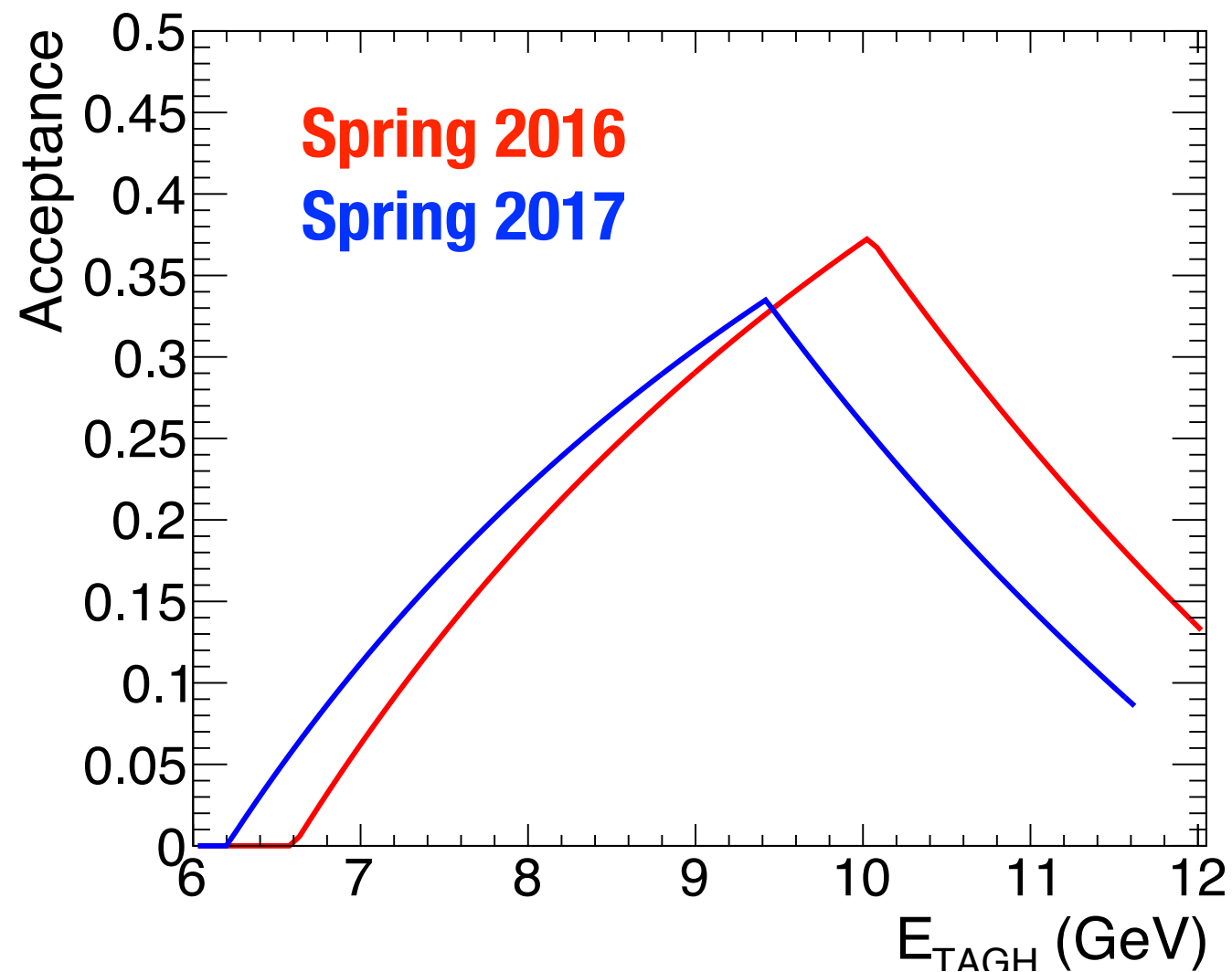# Backup

PS acceptance: 2016 vs 2017

Spring 2016

Preliminary Spring 2017

https://logbooks.jlab.org/entry/3466753

* Lower acceptance in Spring 2017 and peak shifted to lower energy as expected for lower field setting

* Appears 2017 TAGH energy scale is incorrect (old e⁻ beam endpoint?)

* For flux estimates rescale x-axis by ratio of endpoints (11.65/12.05)
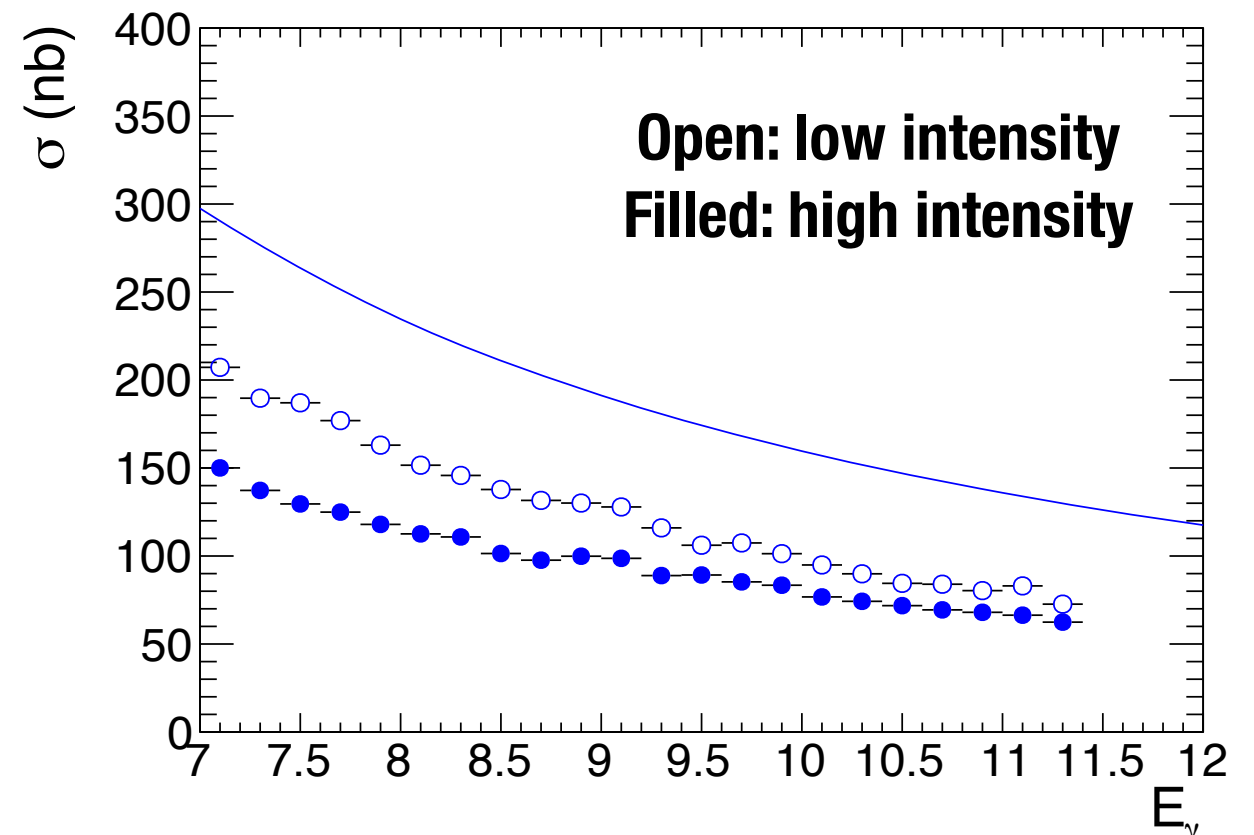
PS acceptance: 2016 vs 2017

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* Appears 2017 TAGH energy scale is incorrect (old e^- beam endpoint?)

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Normalize $\gamma p \rightarrow \pi^0 p$ yields: 2016 vs 2017

Spring 2016
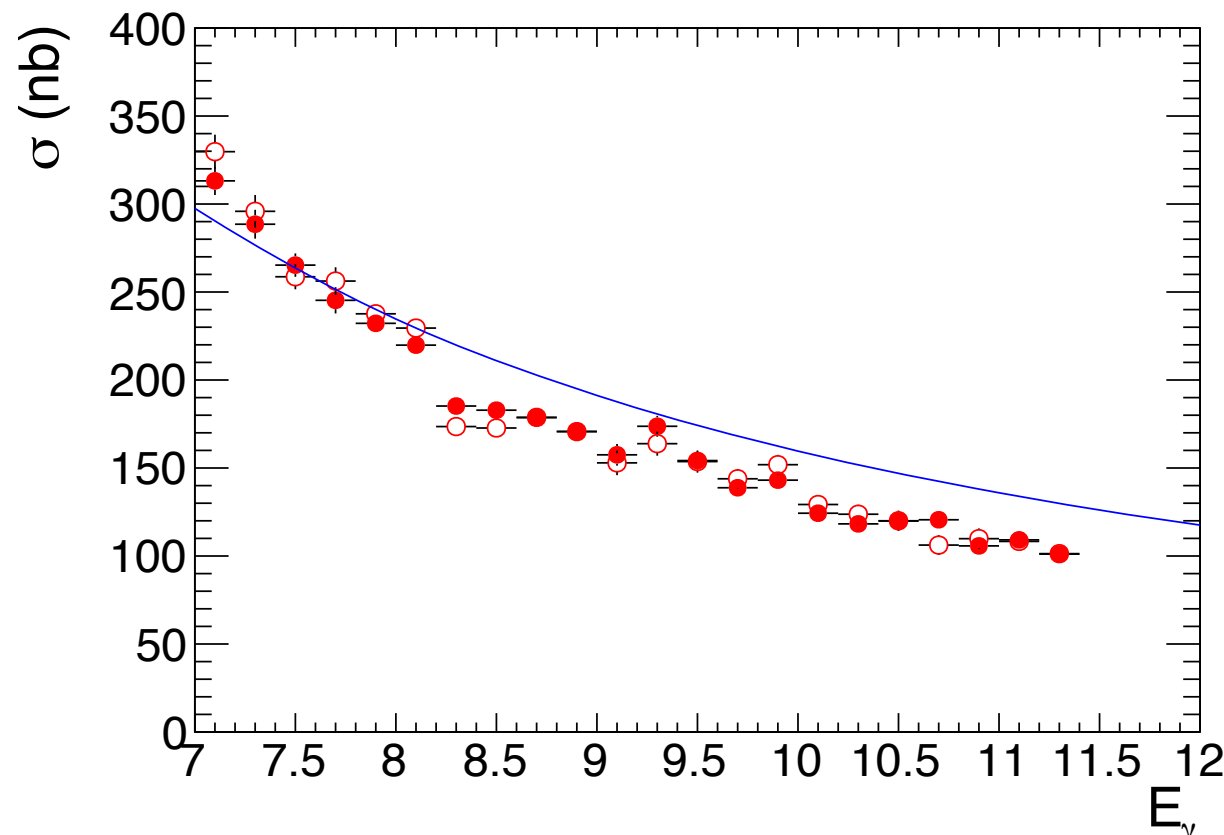
Spring 2017

* Reasonable agreement between low and high beam current runs for Spring 2016

* For Spring 2017 find smaller $\gamma p \rightarrow \pi^0 p$ yields relative to tagged flux, decreases for higher intensity

CCDB implementation

* Tagged PS photon flux determined for runs 11366-11663 with RCDB: @is_prodution and @status_approved

* Loaded to private ccdb.sqlite file and tool written to produce flux histograms with arbitrary energy binning

* **Location:** /group/halld/Users/jrsteven/psflux/plot_flux_ccdb.py

* **Command:**

```
python plot_flux_ccdb.py -b 11366 -e 11555
```

* **Output:** Photon flux vs beam energy integrated over the run boundaries provide by the user

* **Still needed:** other parameters in CCDB (eg. PS accept. func., etc.)

Beam photon flux: definitions

* **Un-tagged flux:**

  * Flux of photons through the collimator, incident on the target

  * Useful for comparison to predictions for collimated rate from coherent bremsstrahlung generators

$$Flux(E_\gamma) = \frac{N_{PS}(E_\gamma)}{Acceptance_{PS}(E_\gamma) \cdot Livetime_{PS}} \cdot \frac{1}{\frac{7}{9}RL_{conv}}$$

* **Tagged Flux:**

  * Flux of photons through the collimator, incident on the target, **with a coincident TAGM/TAGH hit**

  * The relevant quantity for cross section measurements

$$Flux(E_\gamma) = \frac{N_{PS+TAG}(E_\gamma)}{Acceptance_{PS}(E_\gamma) \cdot Livetime_{PS}} \cdot \frac{1}{\frac{7}{9}RL_{conv}}$$

Cross sections and Normalization

$$\sigma = \frac{N}{\epsilon \cdot \mathcal{L}} = \frac{N}{\epsilon \cdot \text{Un-tagged flux} \cdot \text{Target thickness}}$$

$$\frac{\text{Tagged Flux}}{\text{Un-tagged Flux}} = \frac{N_{PS+TAG}(E_\gamma)}{N_{PS}(E_\gamma)} = \epsilon_{TAG}$$

✳ Tagger efficiency cancels when normalizing event yield (N) by tagged flux

$$\sigma = \frac{N}{\epsilon_{non-TAG} \cdot \epsilon_{TAG} \cdot \frac{\text{Tagged Flux}}{\epsilon_{TAG}} \cdot \text{Target thickness}}$$

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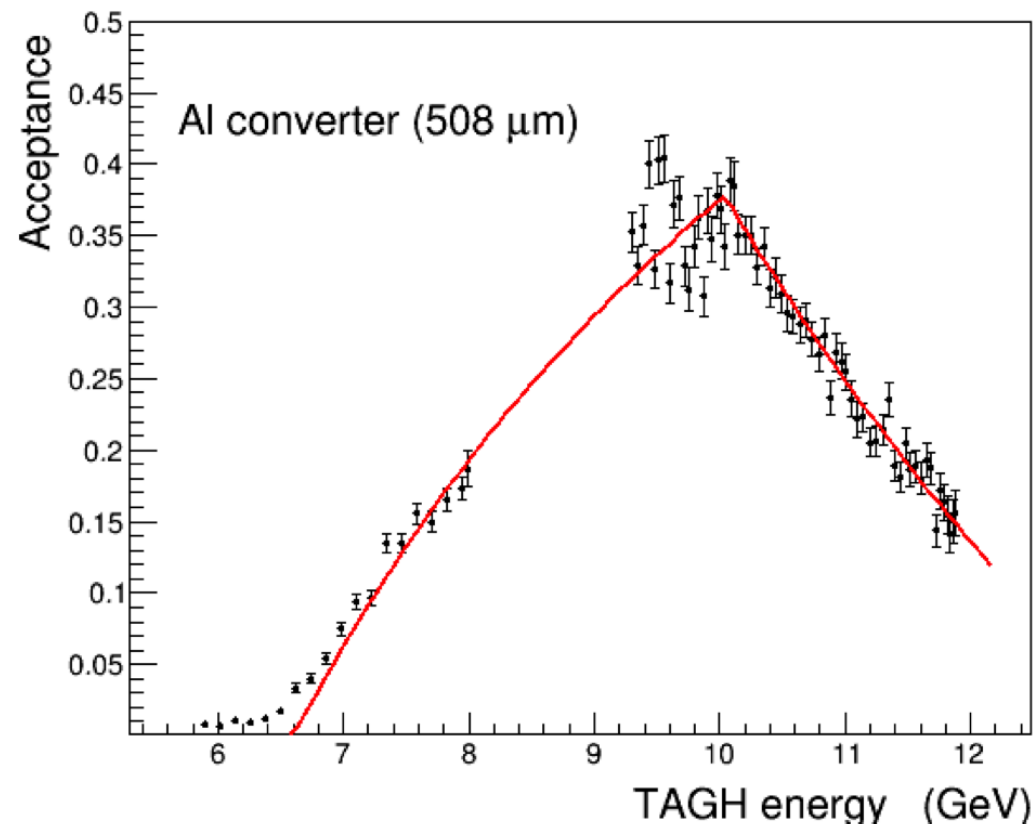
* Tagger efficiency cancels when normalizing event yield (N) by tagged flux

$$\sigma = \frac{N}{\epsilon_{non-TAG} \cdot \cancel{\epsilon_{TAG}} \cdot \frac{\text{Tagged Flux}}{\cancel{\epsilon_{TAG}}} \cdot \text{Target thickness}}$$

* Provide Tagged Flux (or luminosity) in bins of E_γ for each run, and analyzers determine **yield** and **non-tag efficiency**

* Target thickness ~1.22 b^{-1} for a 29.2 cm LH$_2$ target

PS acceptance correction

$$Flux(E_\gamma) = \frac{N_{PS}(E_\gamma)}{Acceptance_{PS}(E_\gamma) \cdot Livetime_{PS}} \cdot \frac{1}{\frac{7}{9} RL_{conv}}$$


* Acceptance function from Sasha's TAC analysis, presented at PrimeX review (slide 10 of link below)

* Radiator thickness not explicitly measured, so ratio of 508 um Al and 75 um Be converters is an uncertainty in the flux determination (2016 only)

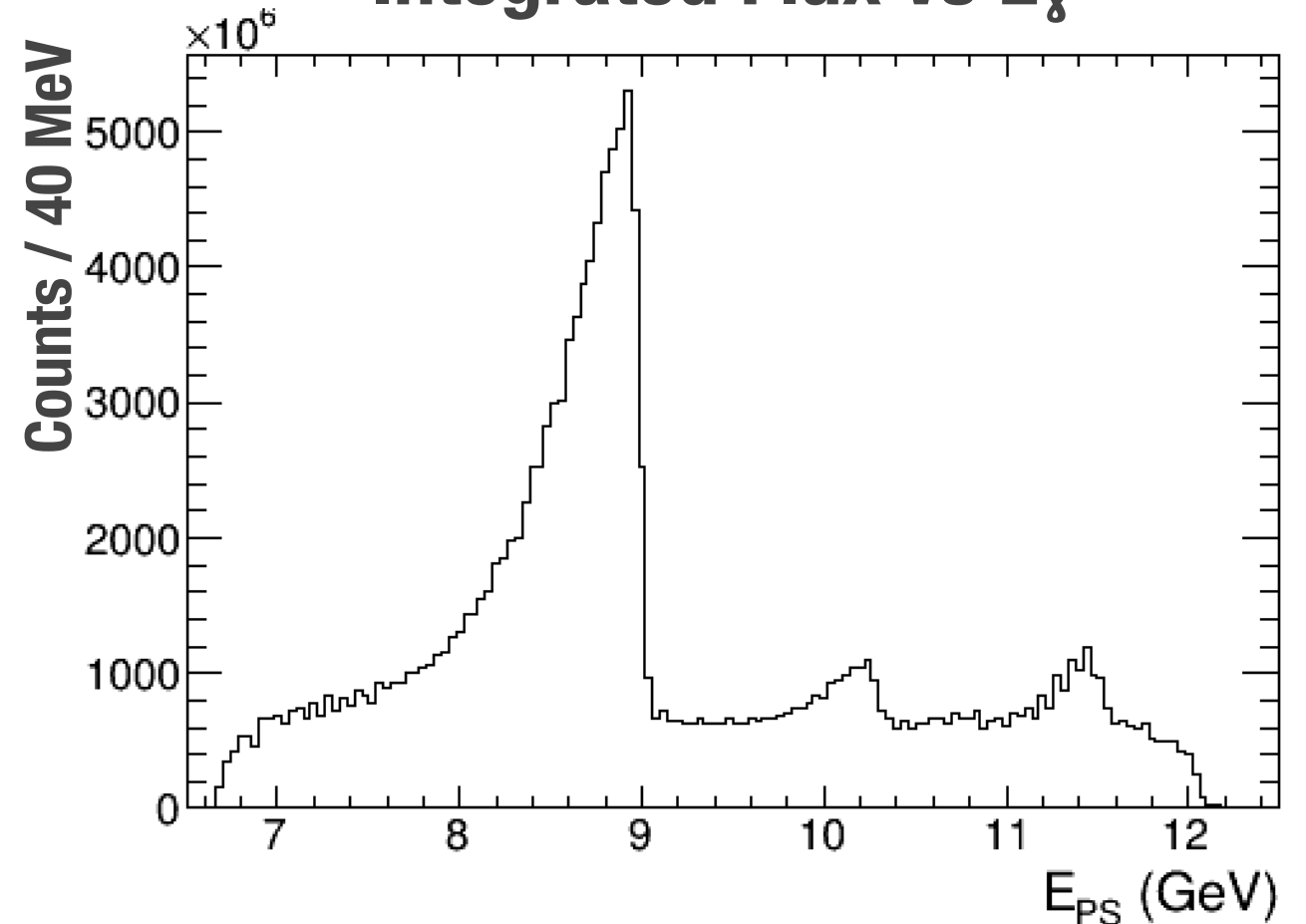**https://cnidlamp.jlab.org/RareEtaDecay/JDocDB/system/files/biblio/2016/07/beamline_trigger.pdf**

PS acceptance correction

$$Flux(E_\gamma) = \frac{N_{PS}(E_\gamma)}{Acceptance_{PS}(E_\gamma) \cdot Livetime_{PS}} \cdot \frac{1}{\frac{7}{9}RL_{conv}}$$

Untagged PS Yield vs E$_\gamma$
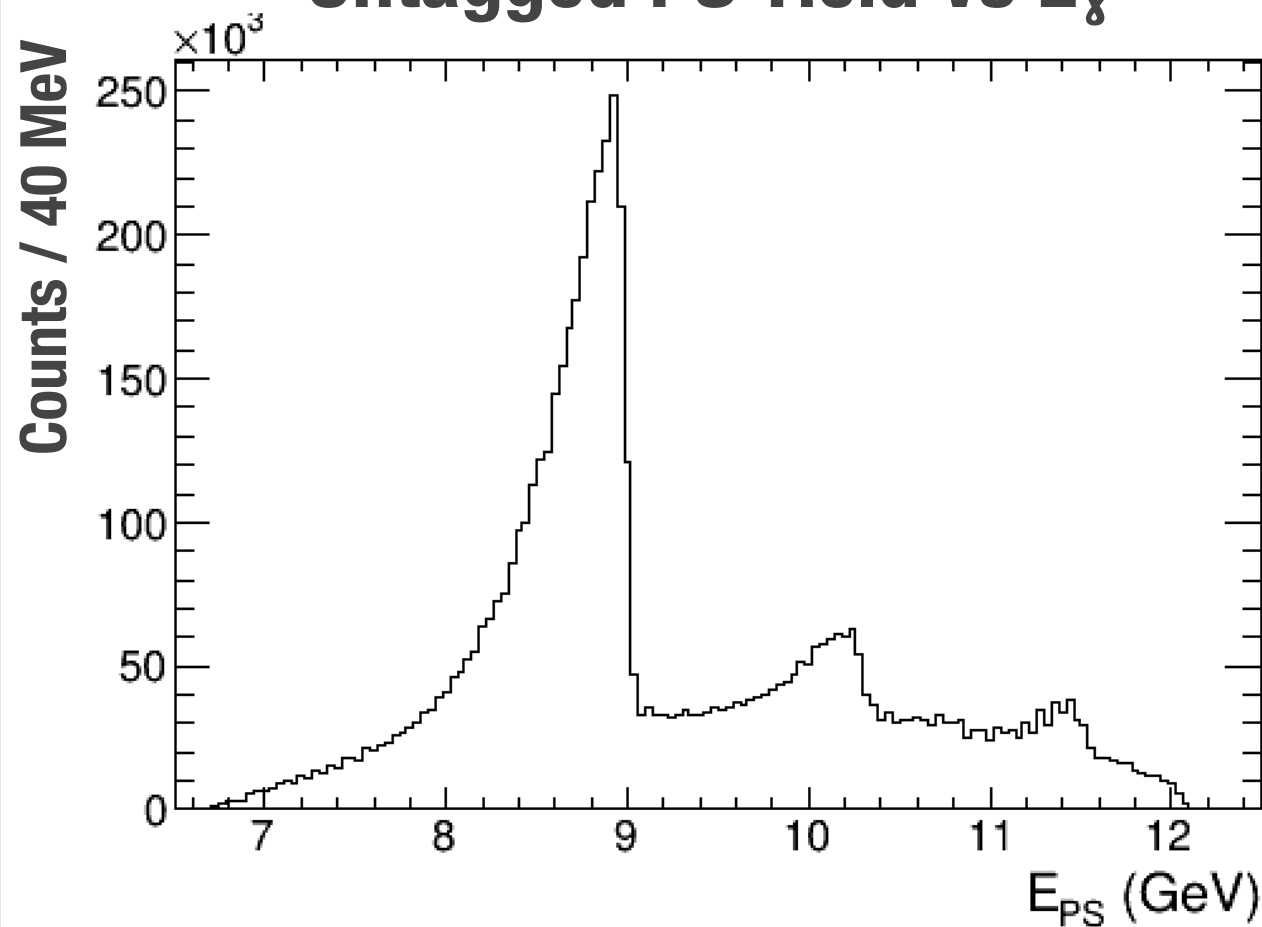
Intergrated Flux vs E$_\gamma$

Livetime and RL correction

$$Flux(E_\gamma) = \frac{N_{PS}(E_\gamma)}{Acceptance_{PS}(E_\gamma) \cdot Livetime_{PS}} \cdot \frac{1}{\frac{7}{9}RL_{conv}}$$
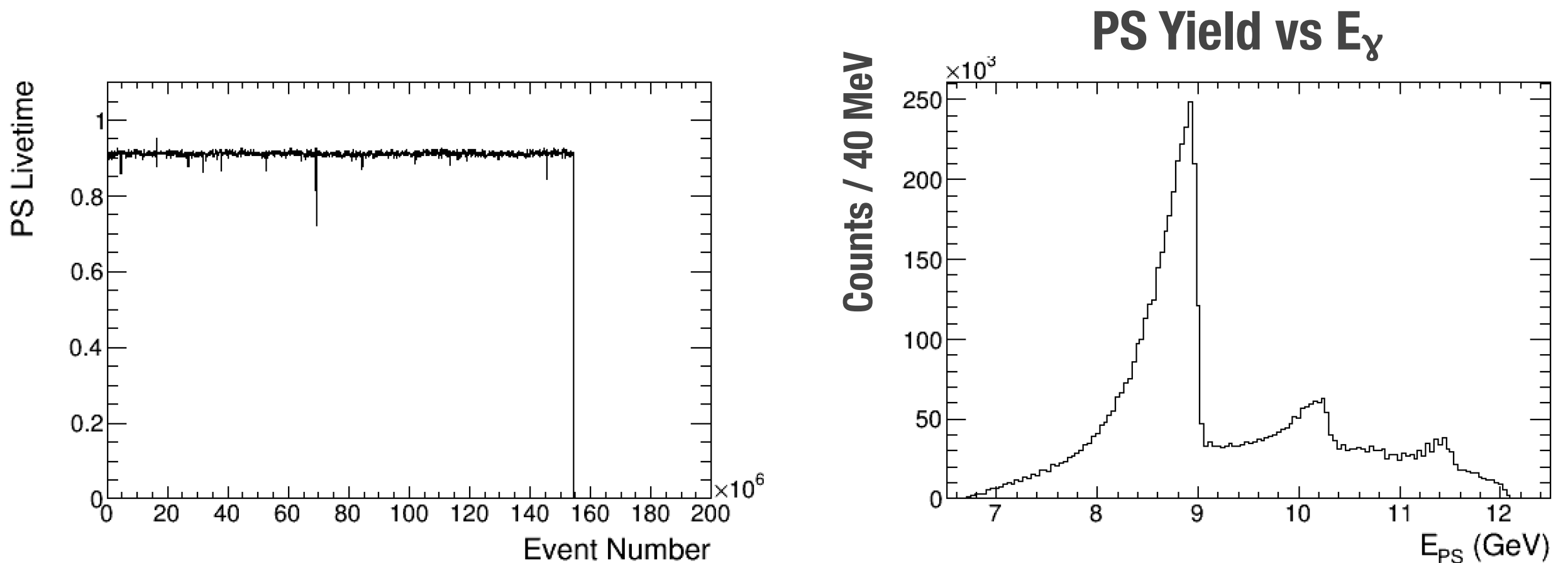

PS Yield vs E_γ

* Correct raw PS yield for Livetime, which is uniform vs Event number within a run (this is an example for run 11529)

* 75 μm Beryllium converter has radiation length of 2.1×10^{-3}