

Next Steps for PRad Analysis

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for PRad Collaboration



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PRoton Radius







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The Proton Charge Radius Puzzle



4 different methods to measure the proton charge radius



 $\blacktriangleright \sim 8\sigma$ discrepancy between muonic hydrogen spectroscopy and atomic hydrogen measurements



Model dependent fitting of G_E to extract r_p



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ep Scattering

ENERGY

- Previous measurements have large systematic uncertainties and a limited coverage at small Q^2
- Requirements for PRad Experiment:
 - ▶ large Q² range
 - extend to very low Q²
 - controlled systematics at sub-percent precision
- Extraction of $\langle r^2 \rangle = -6 \cdot \frac{dG_E^p}{dQ^2} \Big|_{Q^2=0}$ through:

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{Mott} \frac{E'}{E} \frac{1}{1+\tau} \left(G_E^{p2}(Q^2) + \frac{\tau}{\epsilon} G_M^{p2}(Q^2)\right)$$









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PRad Timeline



- 2011 2012 Initial proposal
- 2012 Approved by JLab PAC39
- 2012 Funding proposal for windowless H_2 gas flow target
- 2012 2015 Development, construction of the target
- 2013 Funding proposals for the GEM detectors
- 2013 2015 Development, construction of the GEM detectors
- 2015, 2016 Experiment readiness reviews
- January/April 2016 Beam line installation
- May 2016 Beam commissioning
- May 24 May 31 Detectors calibration
- June 4 June 15 1.1 GeV data taking
- June 15 June 22 2.2 GeV data taking

ALS



PRad Setup





- \blacktriangleright Electron beam or tagged photon beam at $\sim 1 \mbox{ GeV}$ and $\sim 2 \mbox{ GeV}$
- Windowless H_2 gas flow target
- Vacuum box

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- GEM detectors
- Primex HyCal







▶ Same analysis chain for *e*− data and Monte-Carlo



 Progress of analysis around background substraction and event separation

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 Total yields are subtracted from residual interaction upstream and downstream the target



Weizhi Xiong





Møller and ep Separation

 Møller and *ep* events can be separated down to 0.7 ° for the 1.1 GeV data set and for any angle for the 2.2 GeV data set





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- Møller and *ep* yields are taken in the same conditions and will be corrected with the same acceptance
- $\rightarrow\,$ Normalization of cross-section possible

$$N_{ep,normalized} = N_{ep,data} \cdot rac{N_{M ilde{ extsf{w}}ller,MC}}{N_{M ilde{ extsf{w}}ller,data}}$$

- After acceptance correction, two different cross-sections can be calculated:
 - σ_{ep,normalized}
 - $\sigma_{ep,MC}$ depending on the G_E theoretical distribution and on the radiative correction model















- The PRad experiment was uniquely designed to address the Proton Radius Puzzle
- ▶ The experiment was successfully performed in May-June 2016
- Detector studies finalized (still working on improvements)
- The planned physics analysis is on progress

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