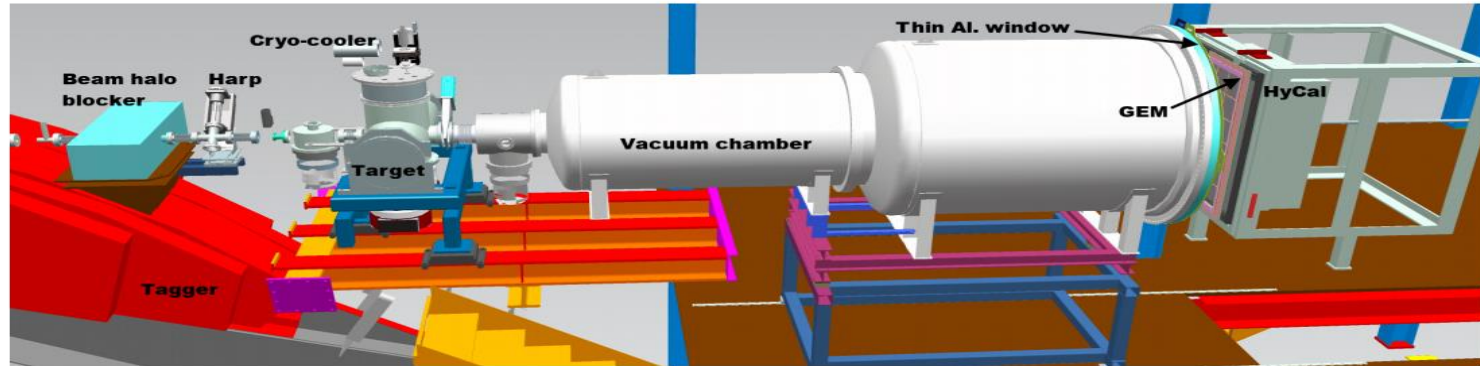


# A Blind Analysis for PRad-II Experiment



PRad Setup (Side View)

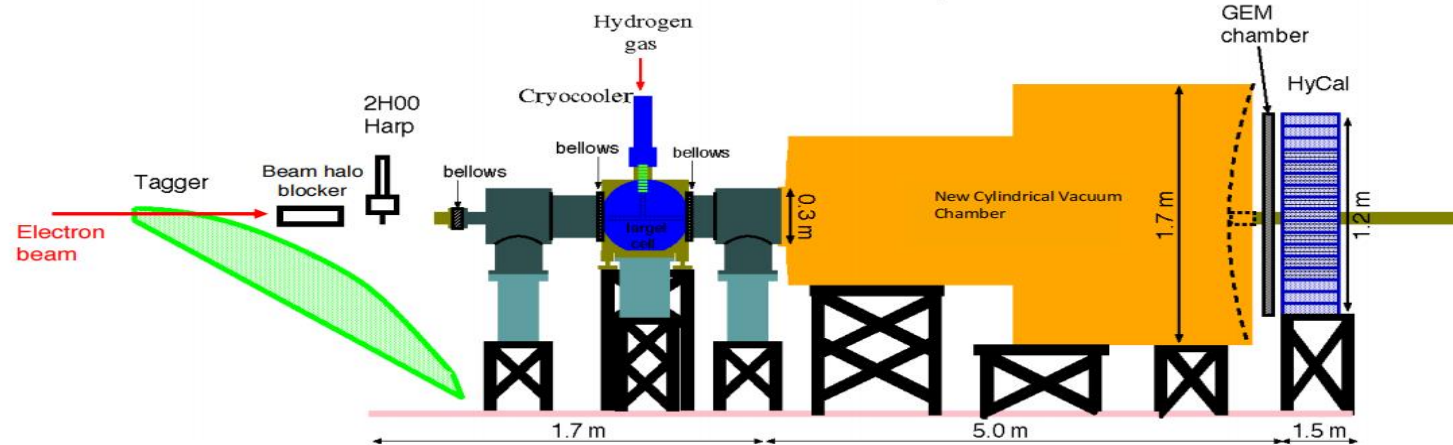
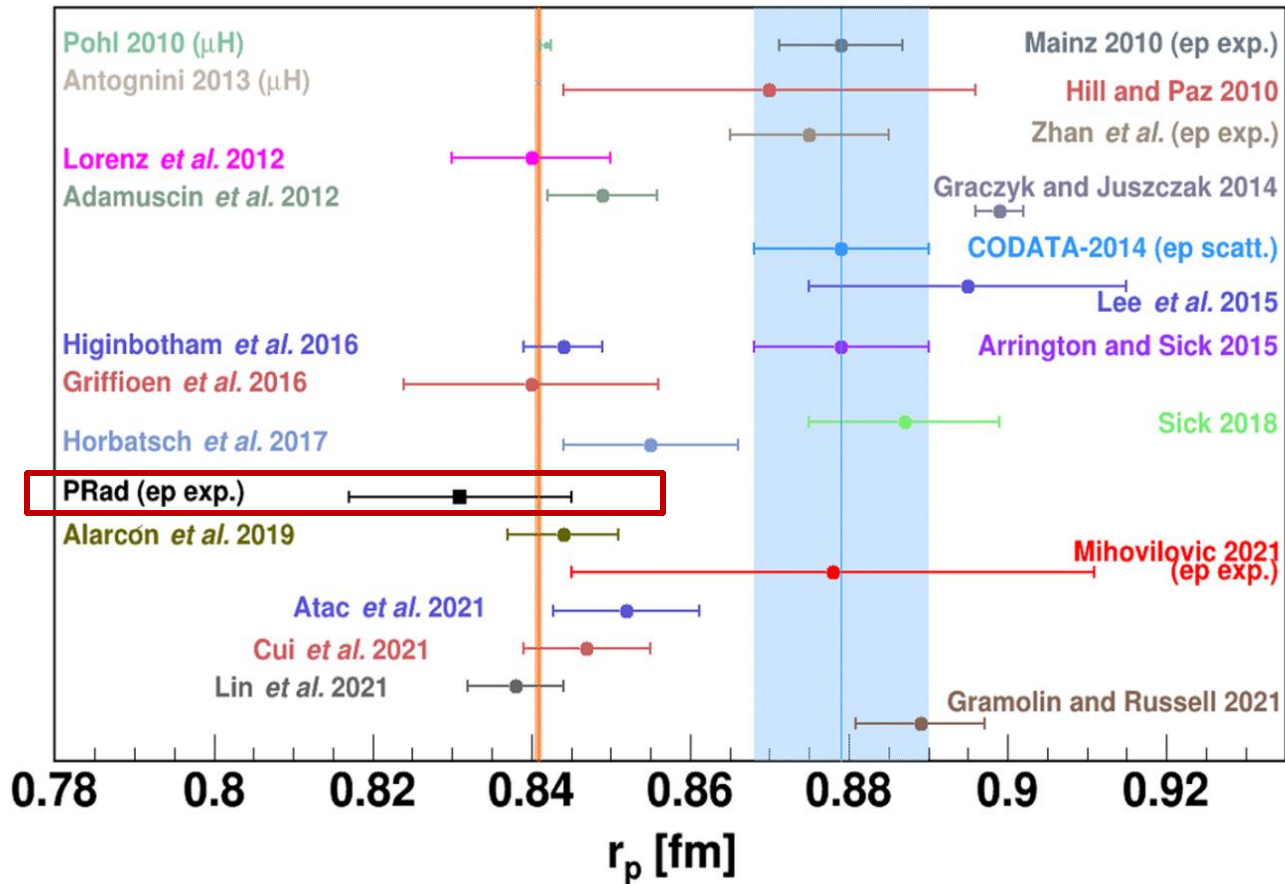


Figure 1: Schematic diagram of PRad Setup

# Result of the PRad Experiment



Xiong *et al.*, *Nature* 575, 147–150 (2019).

PRad:

- Two independent analyses
- No blind analysis

$$r_p = 0.831 \pm 0.007_{\text{stat.}} \pm 0.012_{\text{syst.}} \text{ fm}$$

# Why do we need a blind analysis?

We presented on how to carry out a blind analysis for PRad-II during the PRad-II C1 review

## Studies of Radiative Corrections for the PRad-II Experiment

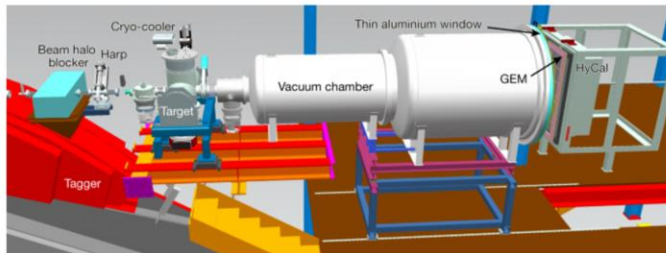


Haiyan Gao  
Duke University  
For the PRad Collaboration

**PR**oton  
**radius**

PRad-II C1  
Review

March 12, 2021



PRad-II C1 review, March 12, 2021

**PR**oton  
**radius**

1

- Goal of this study:

Test the proposed approaches and carry out blind analyses for PRad-II to enhance objectivity.

## Outline

Outline	Plan for blind analysis for PRad-II	RC studies for PRad	RC studies for PRad-II	Summary
---------	-------------------------------------	---------------------	------------------------	---------

- Plan for blind analysis to extract the proton radius ( $r_p$ ) for PRad-II
- Radiative correction (RC) studies for PRad
  - PRad's estimation of the RC systematic uncertainty of  $r_p$
  - Independent study of the RC systematic uncertainty of  $r_p$
- RC studies for PRad-II
  - Integrated Møller method
  - Plans for the next-to-next leading order (NNLO) calculations
  - Improvement from PRad to PRad-II
  - Partial testing of calculations of radiative effects
- Summary

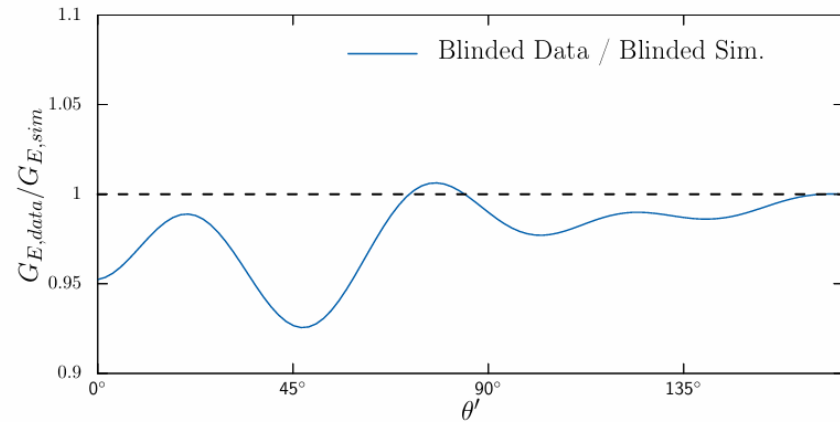
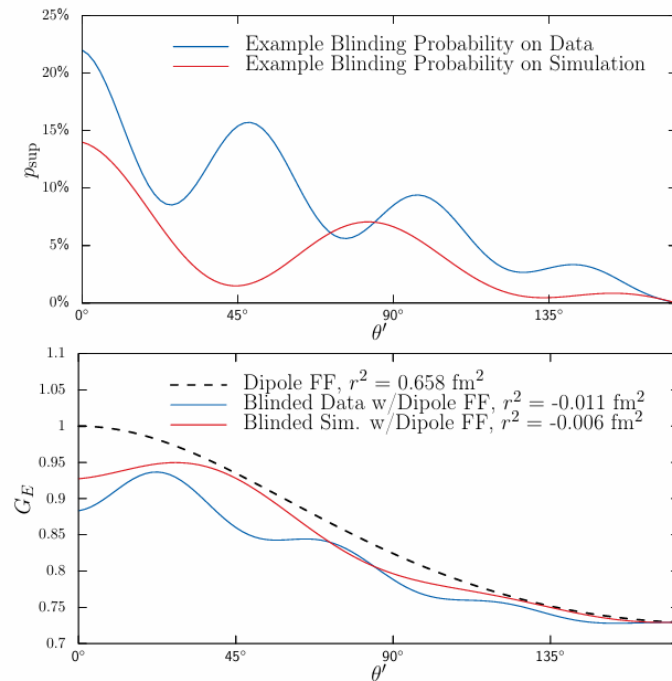
PRad-II C1 review, March 12, 2021

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**radius**

2

# Case Study and Example: MUSE Experiment

$$p_{\text{sup}} = \frac{0.2}{3} (A_i + 0.3 \cos B_i \theta') (3 - \theta') \quad A_i \in [0.25, 1] \quad B_i \in [3, 10]$$



**J.C. Bernauer et al.,**

***Blinding for precision scattering experiments: The MUSE approach as a case study, Phys. Rev. C, under review; arXiv:2310.11469v1 [physics.data-an]***

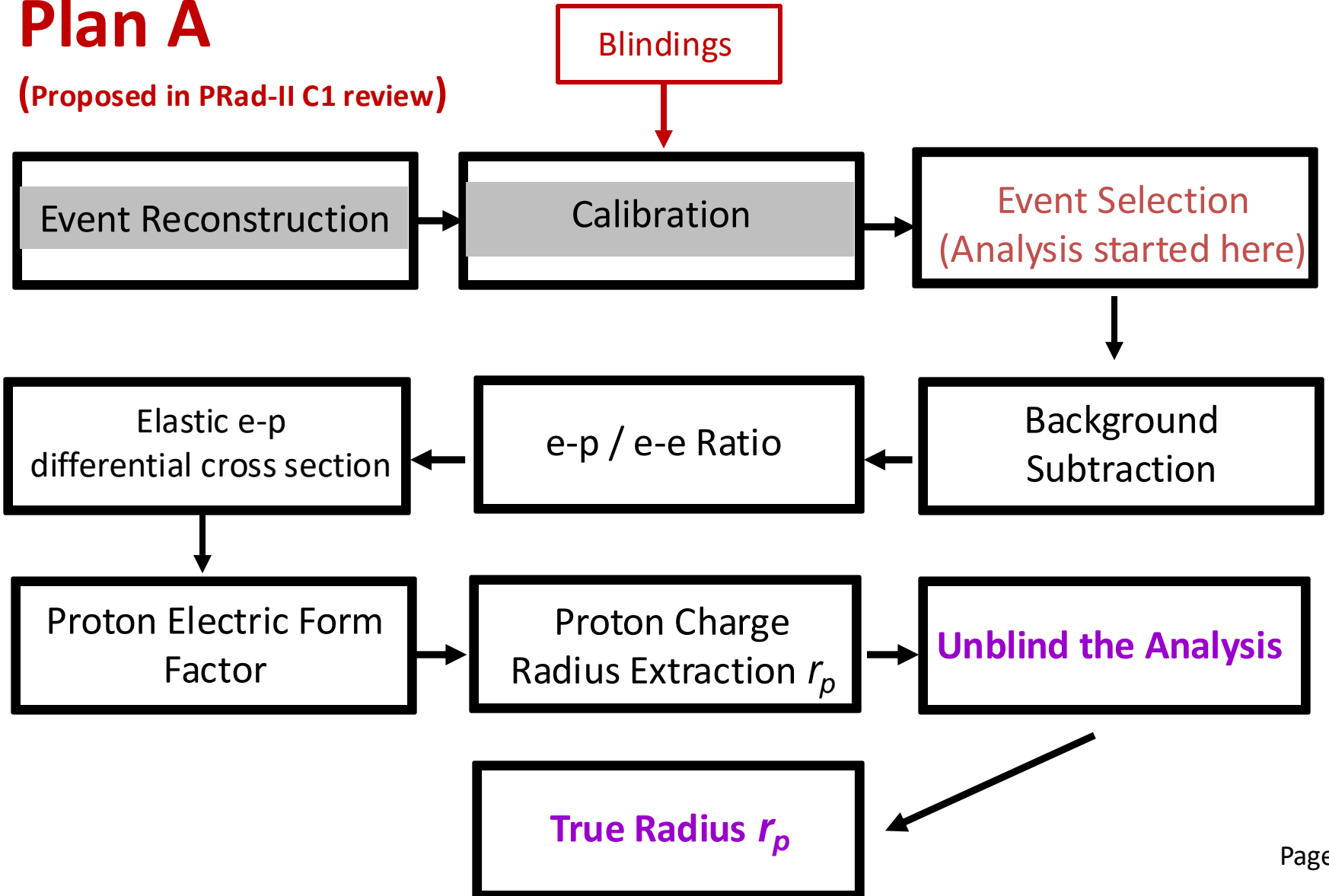
citation:

[https://indico.lns.tohoku.ac.jp/event/255/contributions/2094/attachments/788/1103/Talk\\_MUSE\\_LEES2024\\_MichaelKohl.pdf](https://indico.lns.tohoku.ac.jp/event/255/contributions/2094/attachments/788/1103/Talk_MUSE_LEES2024_MichaelKohl.pdf)

# Goal: Blind analysis for extraction of $r_p$ for PRad-II

## Plan A

(Proposed in PRad-II C1 review)



# Event Selections

$$E_{beam} = 2.143 \text{ GeV}$$

1. Matching hits between GEMs and HyCal.

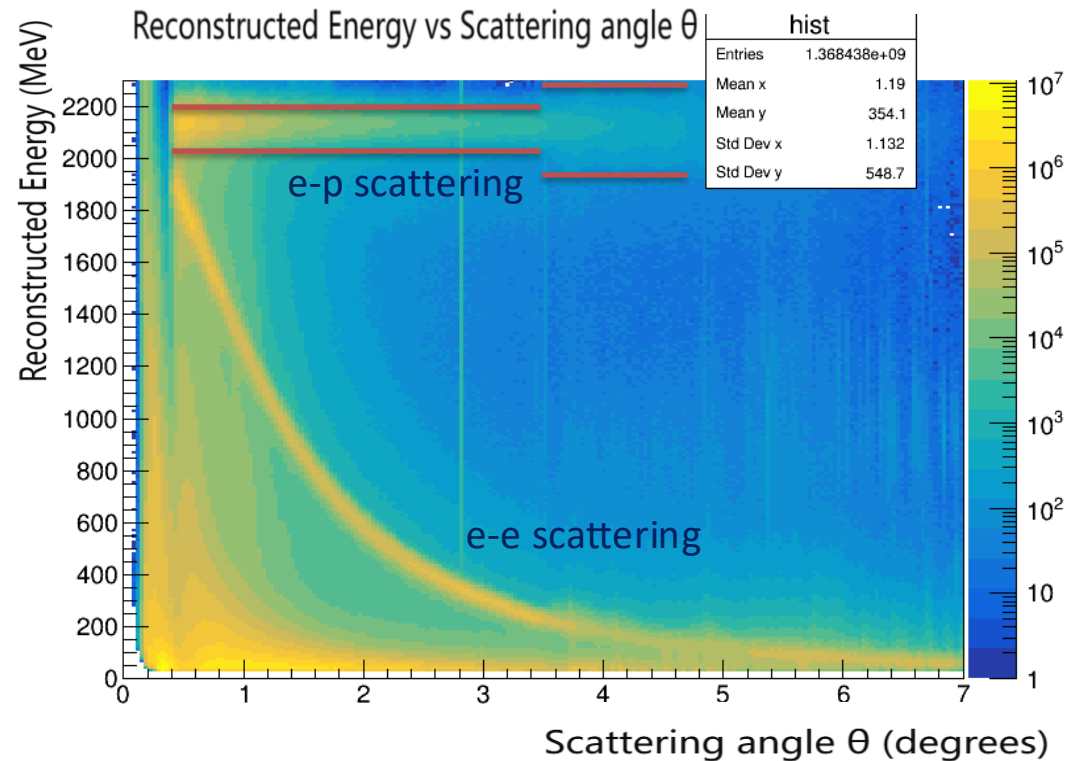
Remove Dead Modules on HyCal.

edges of HyCal modules cut.

2. For selecting both e-p and e-e events,  
Apply angle-dependent expected  
energy cuts based on kinematics.

$$|E_{rec} - E_{exp}| < N\sigma_{det}$$

(Cut sizes depend on detector's resolution)



# Event Selections

$$E_{beam} = 2.143 \text{ GeV}$$

3. In addition to 2, we apply additional cuts to find the double-arm e-e events:

- Co-planarity:  $|\phi_{e1} - \phi_{e2} - \pi| < 10^\circ$ ;

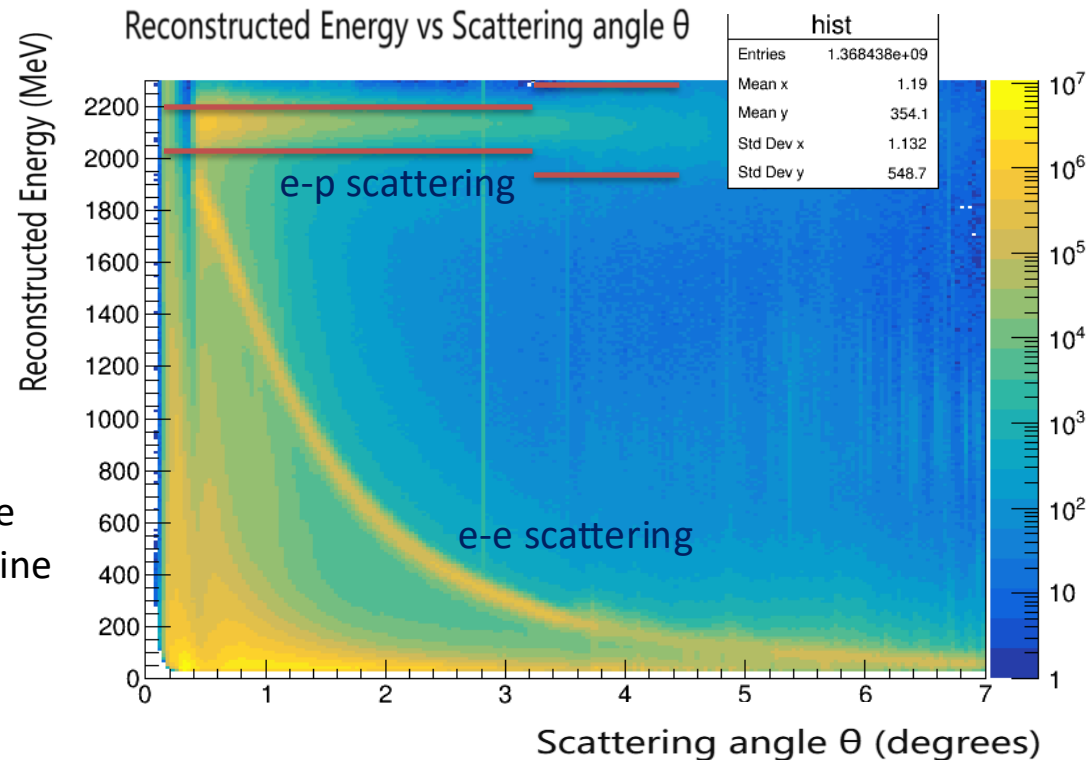
- Reconstructed Vertex z:

$$z = \sqrt{\frac{(m + E_\ell)R_1R_2}{2m}}$$

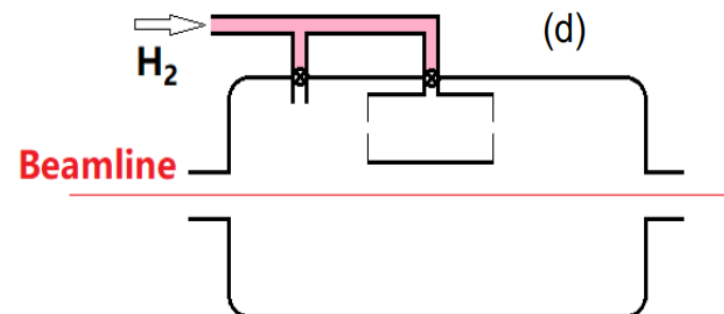
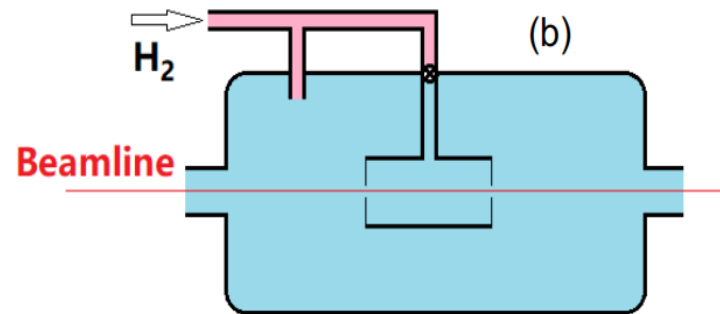
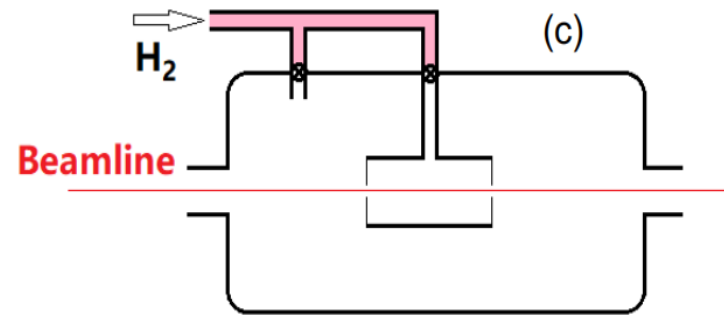
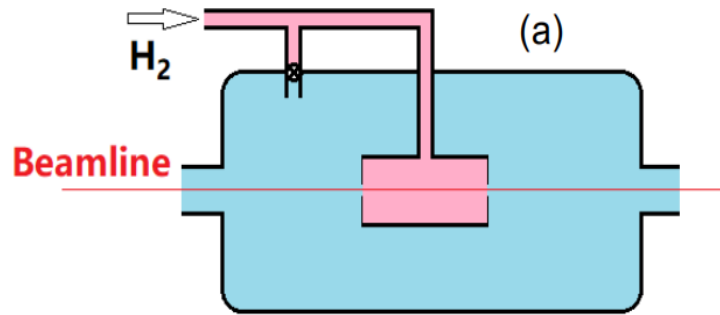
(  $R_{1,2}$  is the transverse distance between the hit position on the detector and the beam-line of the scattered electron.)

- Elasticity :

$$|E_{total} - E_b - m| = |E_{e1} + E_{e2} - E_b - m| < N\sigma_{det}$$



# Background Subtraction



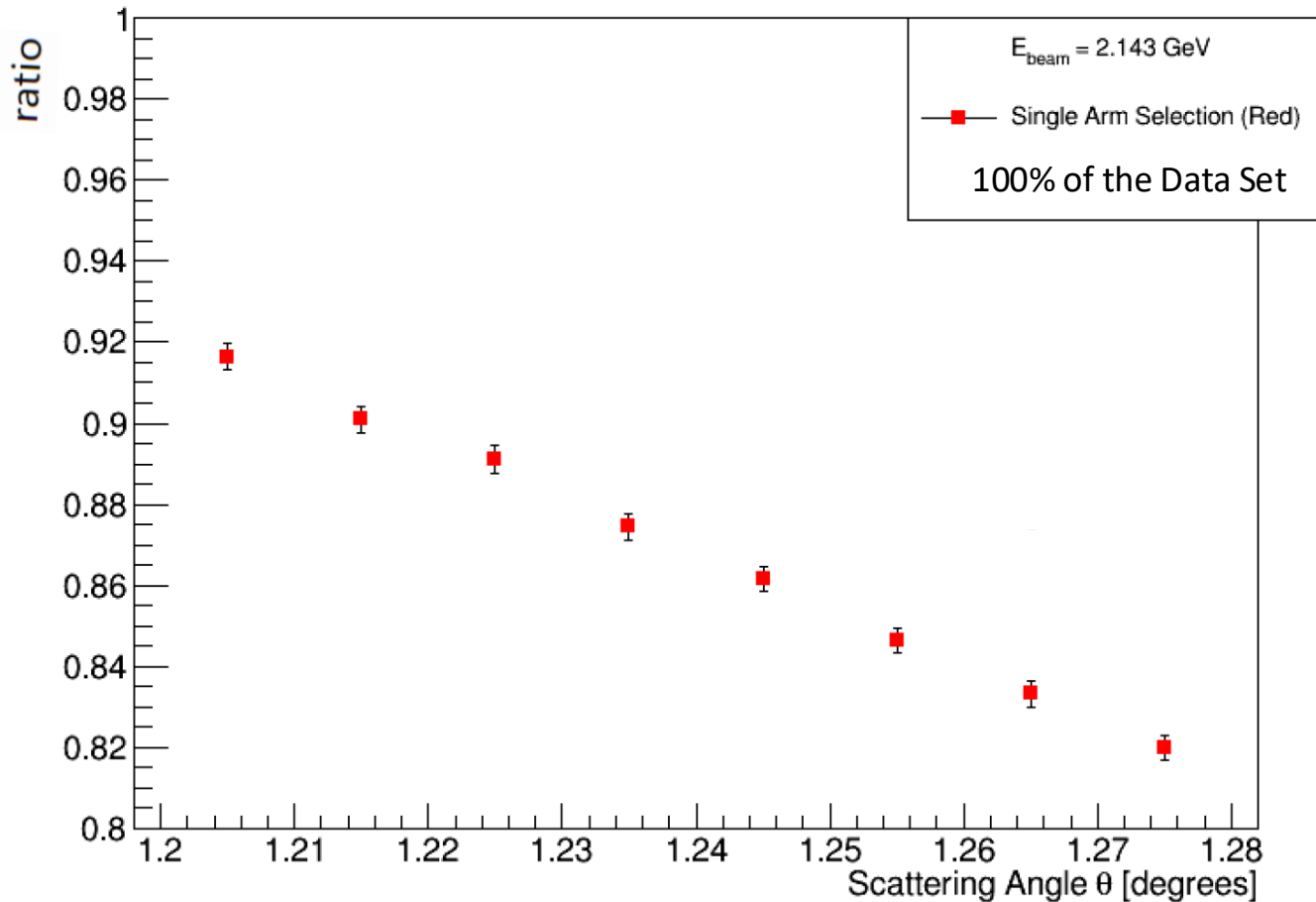
a) Full Target run:  $H_2$  gas was filled directly into the target cell

b) Empty Target run:  $H_2$  gas was filled directly into the chamber



# Forming the e-p/e-e ratio (In Progress)

Measured  $\frac{N_{ep}}{N_{ee}}$  ratio vs scattering angle  $\theta$



For e-e moller event:

Single arm selection:

- Expected energy cuts

Next:

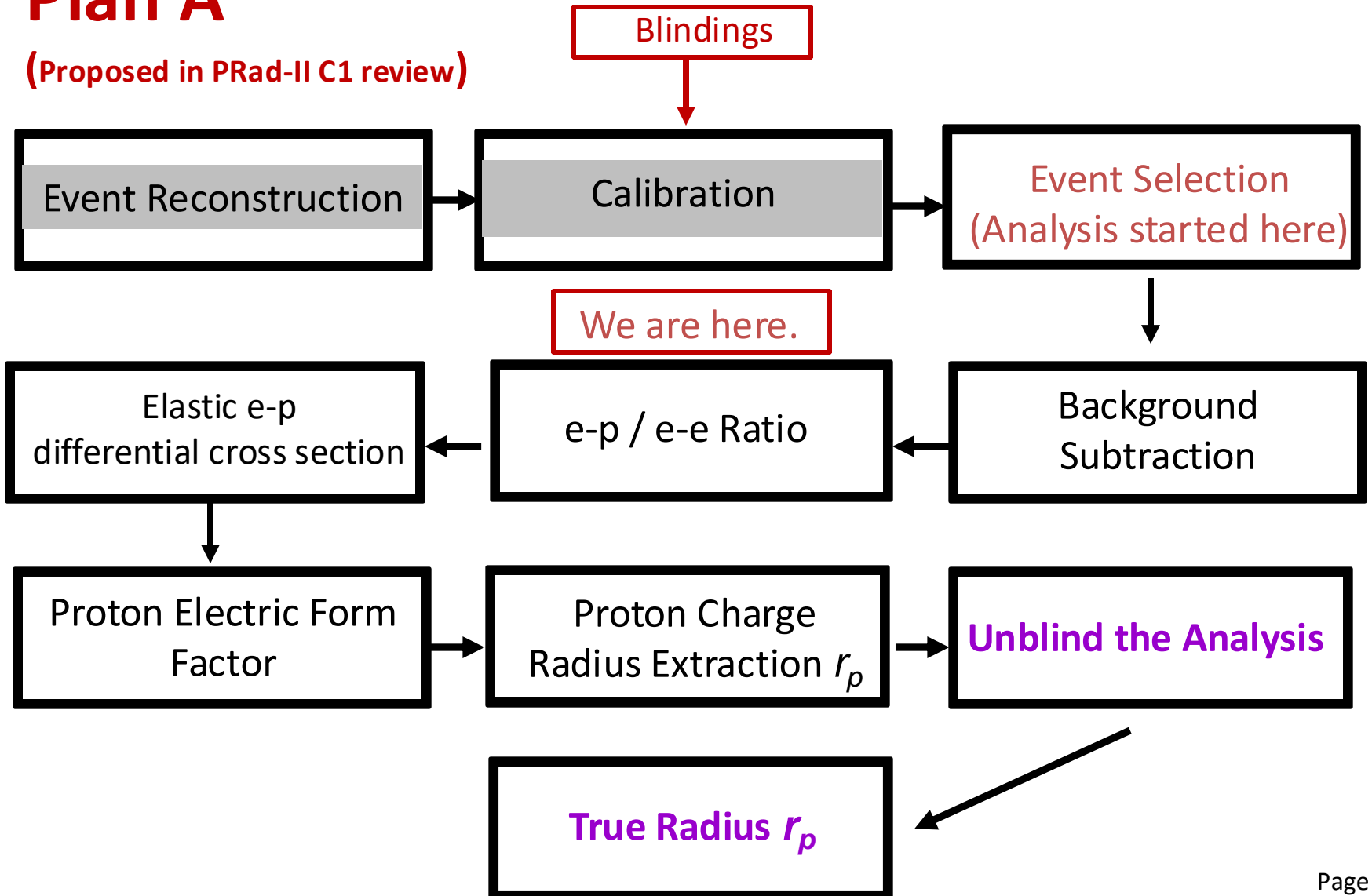
Double arm selection:

- Expected energy cuts
- Co-planarity cut
- Elasticity cut
- Vertex z cut

# Goal: Blind analysis for extraction of $r_p$ for PRad-II

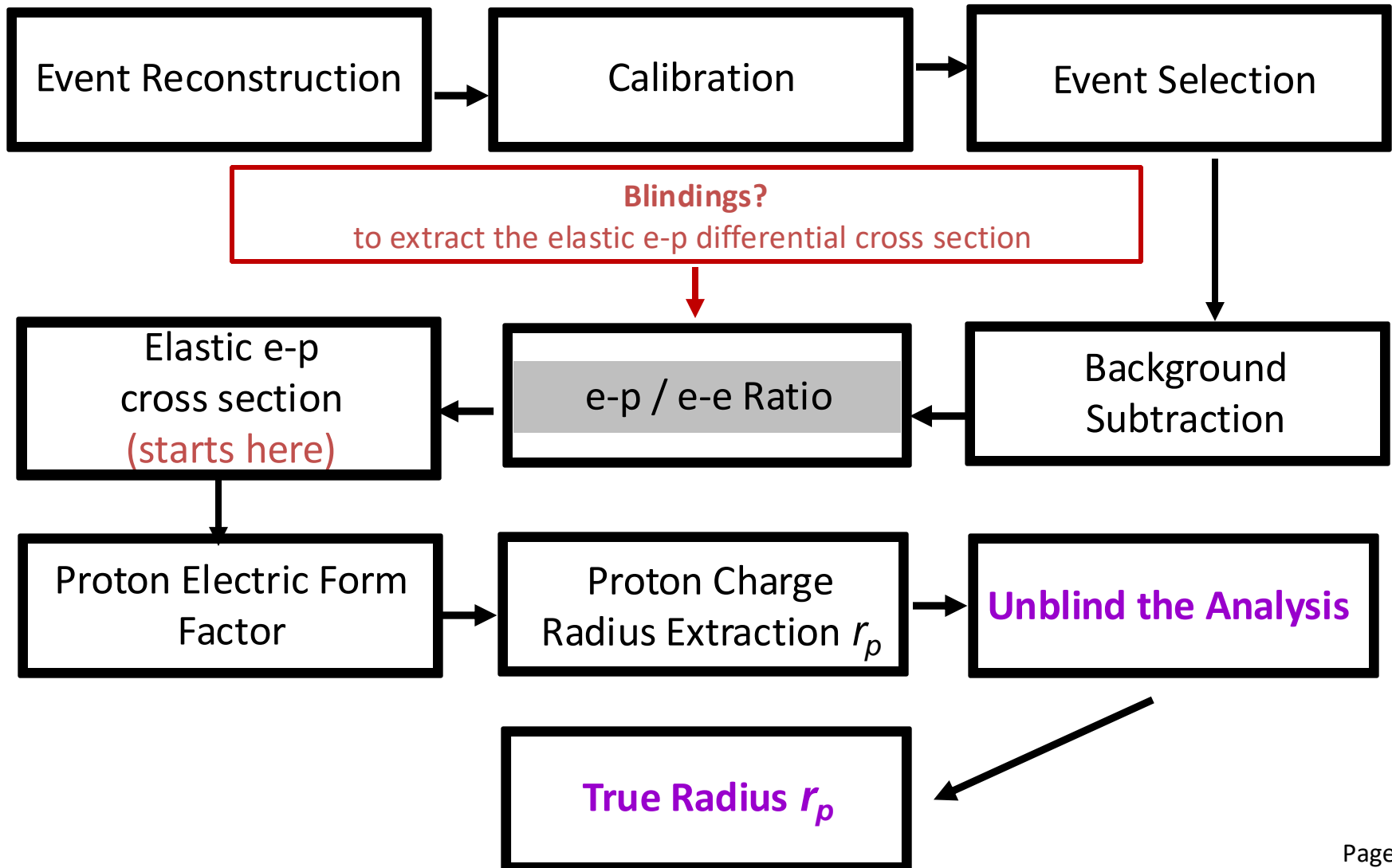
## Plan A

(Proposed in PRad-II C1 review)



# Goal: Blind analysis for extraction of $r_p$ for PRad-II

## Plan B (Proposed in PRad-II C1 review)



# Conclusion

- Blind analysis helps reduce bias when performing the analysis.
- Apply and test the blinding mechanism (Plan A and Plan B (or Plan C?) to PRad Data and then proceed such approaches to PRad-II.

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# Thank you!