Tests of SM Physics at DAMSA

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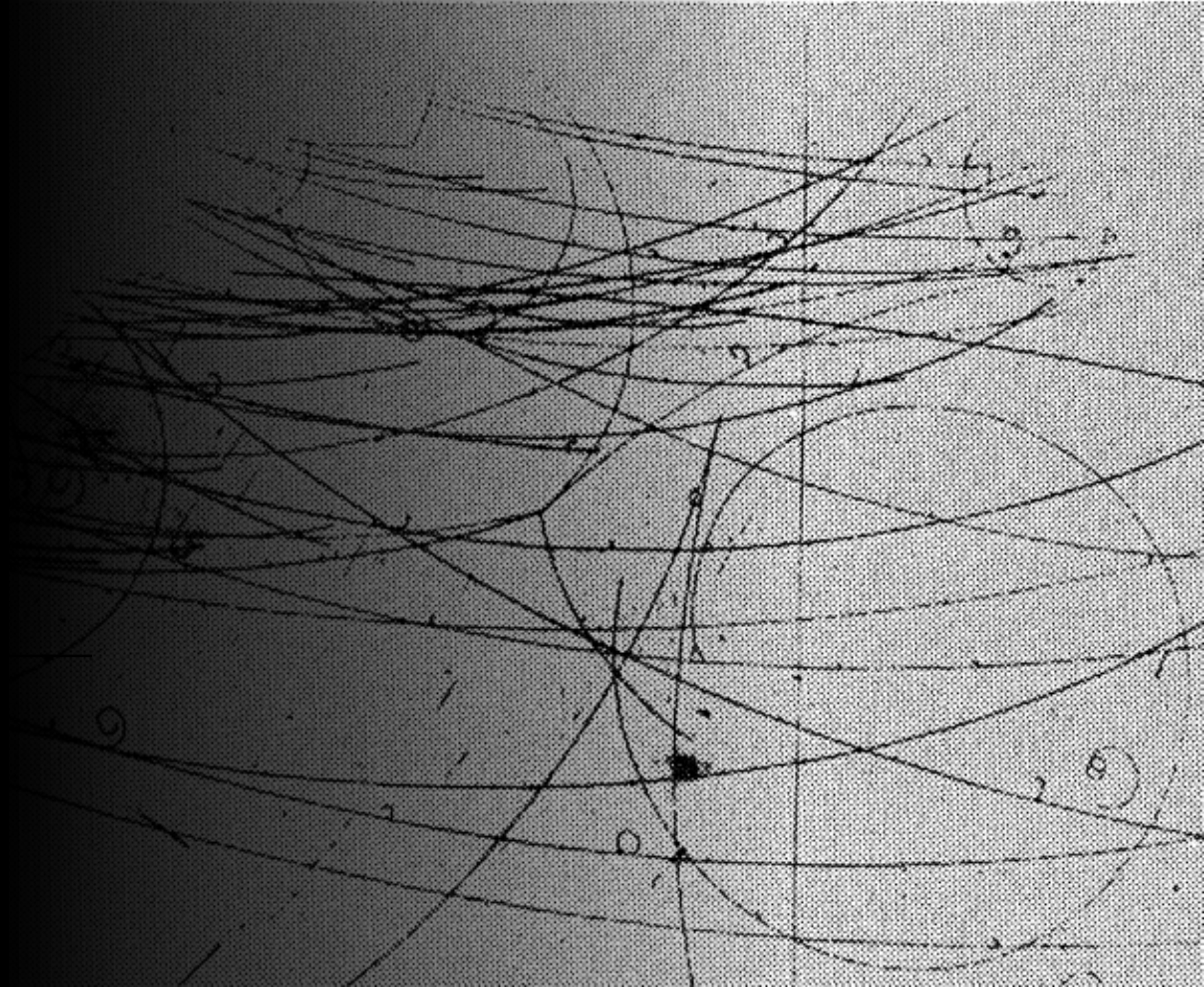
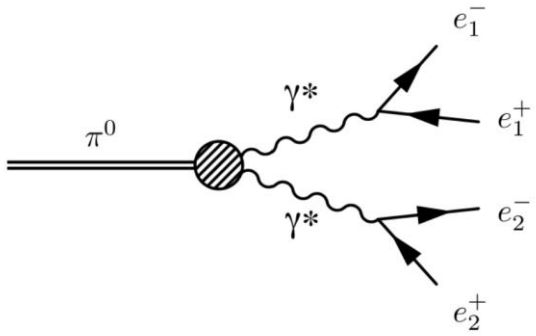


Test 1: Rare decays of neutral pions



	Mode	Fraction (Γ_i / Γ)	Scale Factor/ Conf. Level	P(MeV/c)
Γ_4	$\pi^0 \to e^+ e^+ e^- e^-$	$(3.34 \pm 0.16) \times 10^{-5}$	S=1.0	67

The following data is related to the above value:

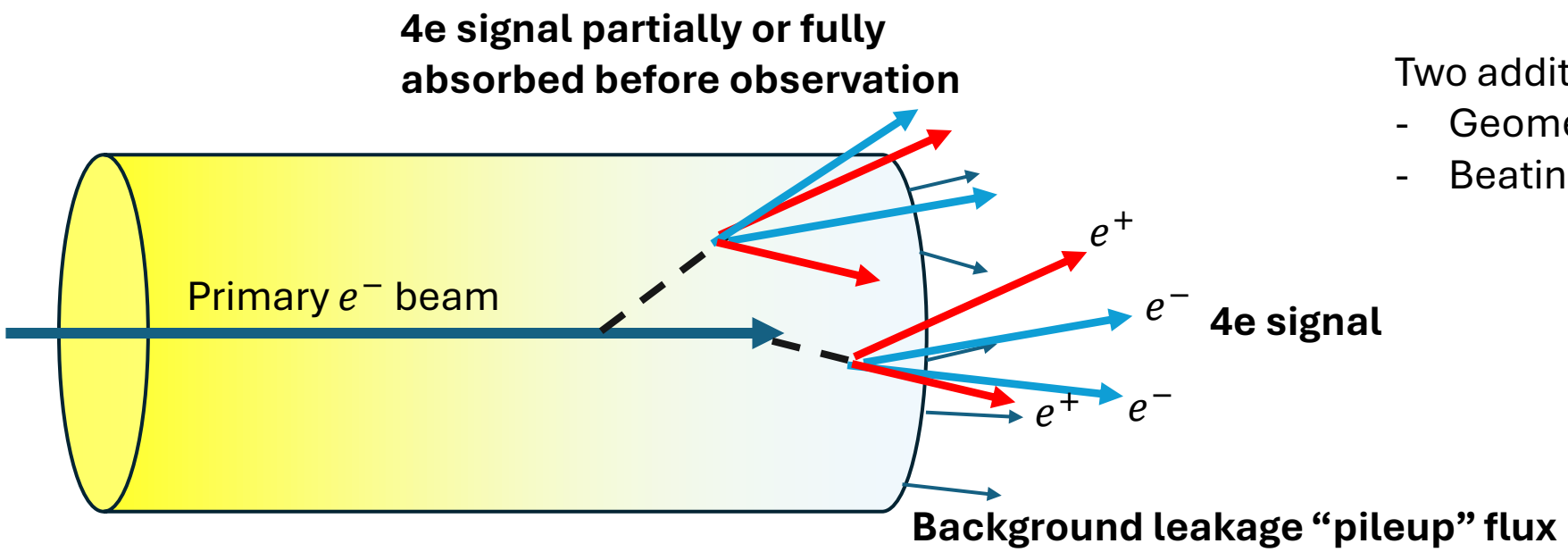
$\Gamma(\pi^0 \to e^+ e^+ e^- e^-)/\Gamma(\pi^0 \to 2\,\gamma)$ Γ_4/Γ_1

VALUE (10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
3.38 ± 0.16	OUR FIT				
3.38 ± 0.16	OUR AVERAGE				
3.46 ±0.19	30.5k	[1] ABOUZAID	2008D	KTEV	$K_L^0 \to \pi^0\pi^0\pi^0_{DD}$
3.18 ±0.30	146	[2] SAMIOS	1962B	HBC	

Have to beat KTeV's measurement:

Want >1e4 events

Concept



Pi0 decays **immediately** so the challenge is getting them to decay close enough to the end of the target

Two additional challenges:
- Geometric acceptance
- Beating leakage pileup

EM Showers: Particle Counting

- Review slides
- Ec is the critical energy where ionization/radiation cross

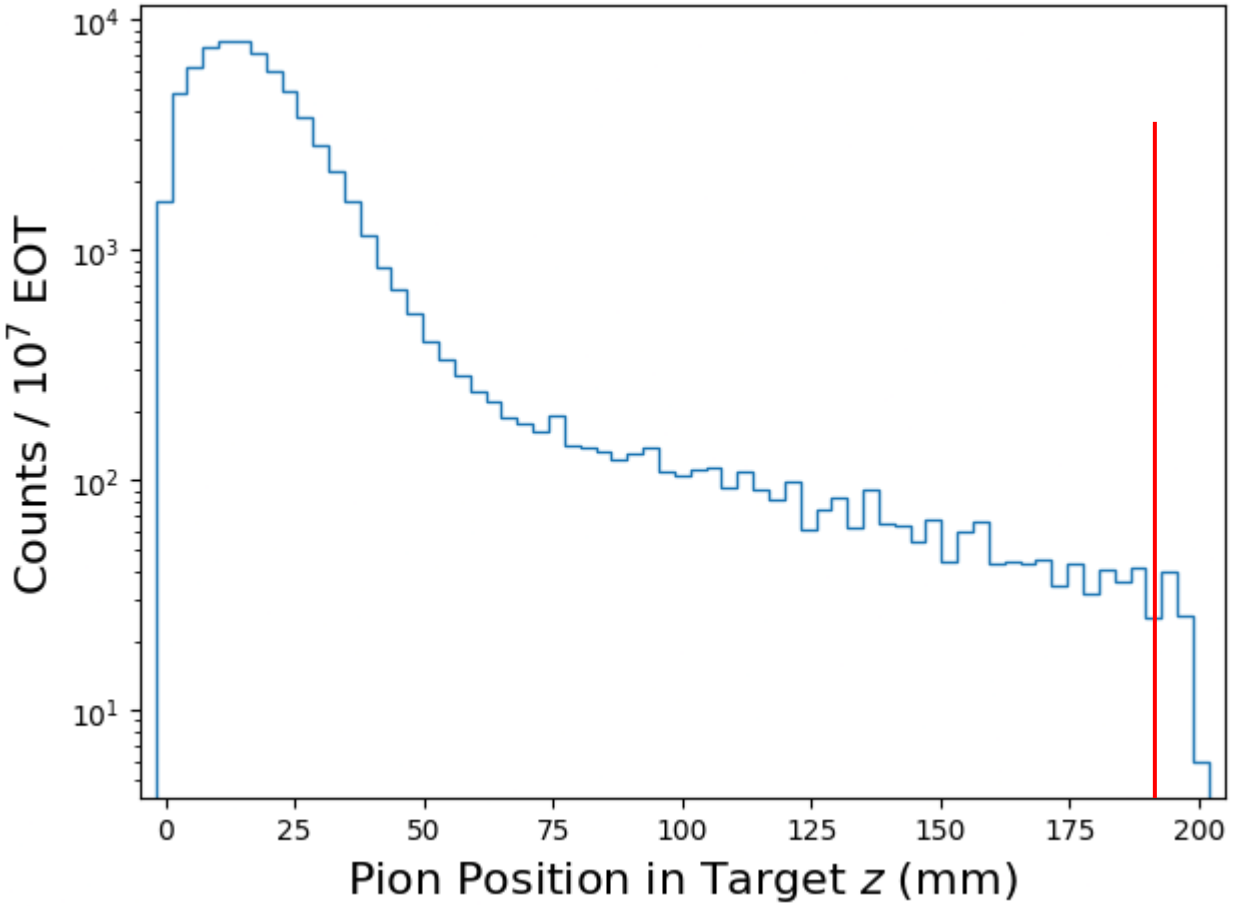
Shower maximum $t_{max} = \frac{\ln E_0 / E_C}{\ln 2}$

$N(t_{max}) \approx \frac{E_0}{E_C}$

Material	W	Pb	(liquid) Ar	Cu
Z	74	82	29	13
E_C(MeV)	8,4	7,1	37	20,2

- For E0 = 10 GeV, Ec=8.4 MeV,
  - t_max ~ 10 radiation lengths
  - N(t_max) ~ 1000 particles in the total shower
  - E ~ E0 / 2^t ~ 10 MeV is the typical energy at the end of the shower

Neutral Pion Production in the 20 cm target (11 GeV EOT)



Pions produced in the last 5-10 cm of the target can allow for 4e to escape?

Rate Estimation

$$Rate(4e) \approx N_{EOT} \times N_{\pi,\frac{end}{EOT}} \times BR(\pi \to 4e) \times Efficiency$$

$$Rate(4e) \approx N_{EOT} \times 10^{-5} \times 10^{-5} \times 10^{-1} = N_{EOT} \times 10^{-11}$$

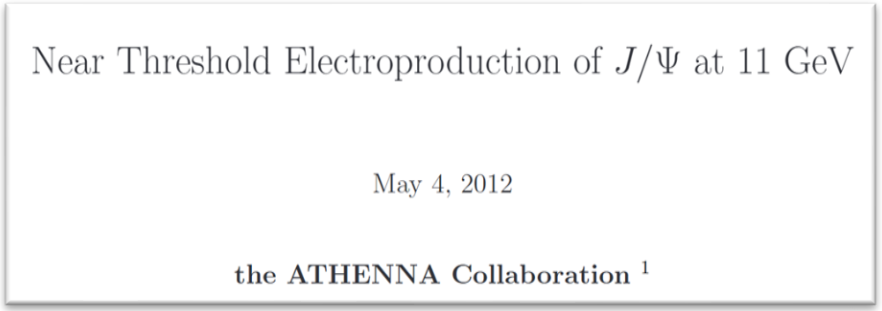
Therefore, we need

- >1e11 EOT to observe it
- >1e16 EOT to beat KTeV's precision
- EOT per pulse and target length optimization for signal/background

Other similar targets?

- J/Psi production from the e- beam?
- Exciting for QCD physics
- Also has 4mu final state

https://www.jlab.org/exp_prog/proposals/12/PR12-12-006.pdf



Near Threshold Electroproduction of J/Ψ at 11 GeV

May 4, 2012

the ATHENNA Collaboration [1]

Extracting the BR normalized to 2γ

Let the number of pions per electron on target (EOT) be denoted N_π, and let $\epsilon_{2\gamma}$ be the acceptance for capturing the 2γ decay inside the decay pipe and ϵ_{4e} be the acceptance for capturing all four leptons from the $\pi^0 \to 2e^+2e^-$ decay. Then suppose we mdoel the number of **measured** $\pi^0 \to 2\gamma$ decays as

$$N_{2\gamma} = N_{EOT} \times N_\pi \times \epsilon_{2\gamma} \tag{1}$$

while the number of **measured** $\pi^0 \to 2e^+2e^-$ decays are modeled as

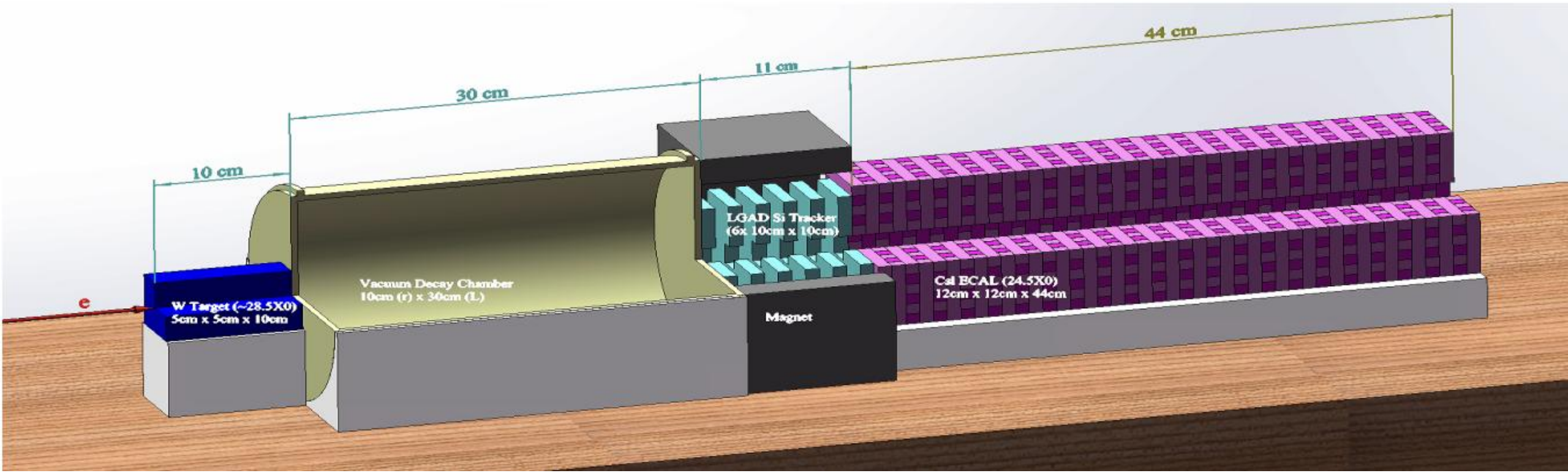
$$N_{4e} = N_{EOT} \times N_\pi \times \epsilon_{4e}\,. \tag{2}$$

The $\pi^0 \to 2e^+2e^-$ branching ratio is then related to the observed numbers via

$$\frac{N_{4e}}{N_{2\gamma}} = \frac{N_{EOT} \times N_\pi \times \epsilon_{4e} \times BR(\pi^0 \to 2e^+2e^-)}{N_{EOT} \times N_\pi \times \epsilon_{2\gamma}} \tag{3}$$

We can then extract $BR(\pi^0 \to 2e^+2e^-)$ with

$$BR(\pi^0 \to 2e^+2e^-) = \frac{\epsilon_{2\gamma}}{\epsilon_{4e}} \frac{N_{4e}}{N_{2\gamma}} \tag{4}$$


44 cm
11 cm
30 cm
10 cm
LGAD Si Tracker
(6x 10cm x 10cm)
Vacuum Decay Chamber
10cm (r) x 30cm (L)
W Target (~28.5X0)
5cm x 5cm x 10cm
e
Magnet
CsI ECAL (24.5X0)
12cm x 12cm x 44cm