Pen and Paper Efficiencies (again)

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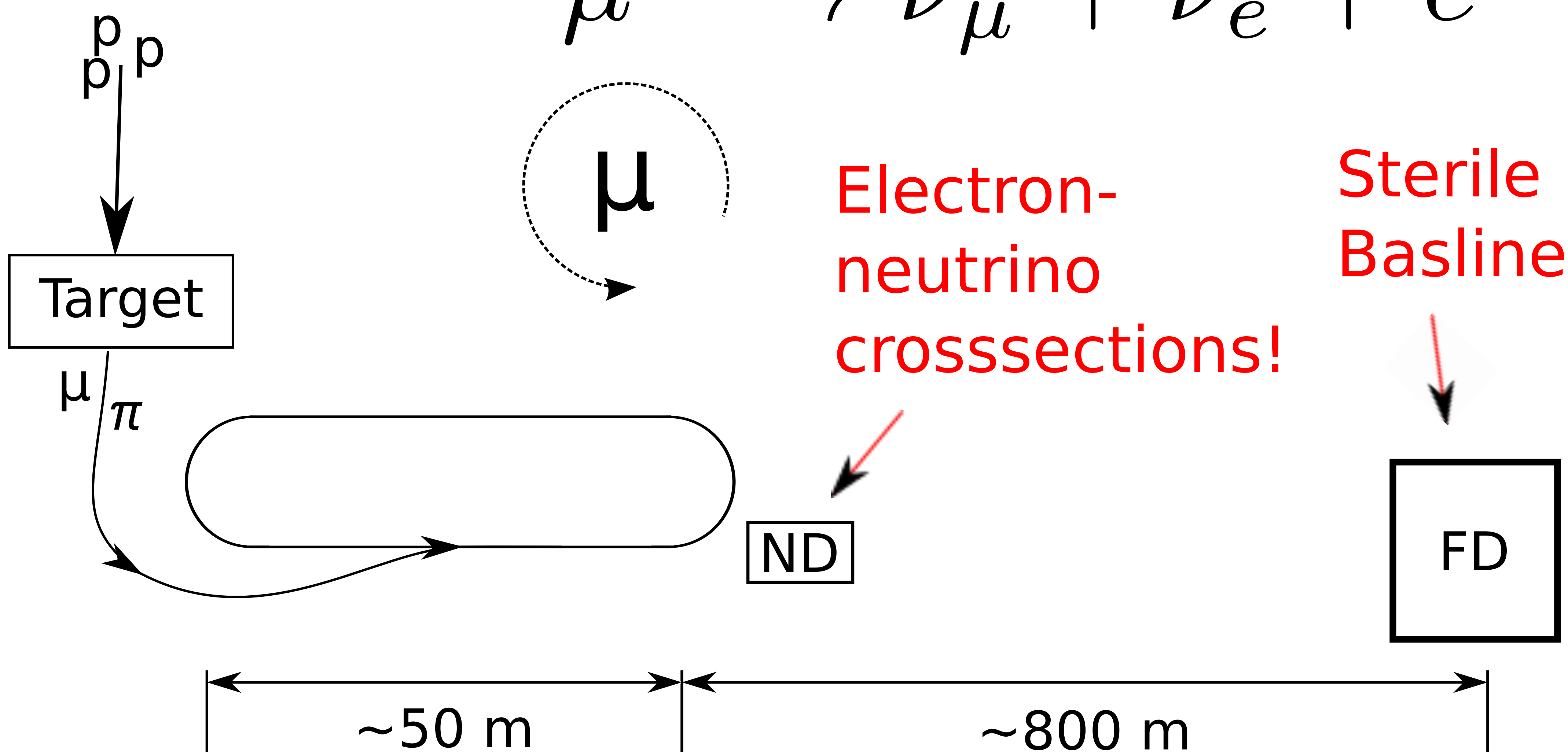
Thanks to Alain Blondel for
sharing work that was adapted for VLENF

Review

$$\mu^+ \rightarrow \bar{\nu}_\mu + \nu_e + e^+$$



Appearance-only (though disappearance good too!)

$$Pr[e \rightarrow \mu] = 4|U_{e4}|^2|U_{\mu4}|^2 \sin^2(\frac{\Delta m_{41}^2 L}{4E})$$

Review

The VLENF Parameterization

Target Mass:	1 kt
Muon Energy:	2 GeV
Number of Muons:	2.00E+17
Baseline:	800 m
Detector efficiency	(90 +/- 2)%
NC Background Probability	1e-4 +/- 20%
Charge Mis-ID	1e-5 +/- 20%
Length of accelerator straight:	30 m
Twiss parameters in straight	α=0, β=25m
Energy spread	20%
Gaussian emittance	15 mm

can we do this?

Methodology

- MCs are the oracles of our time, but take longer to get results from
- What's the physics behind the numbers?
- What can we learn quickly to guide what we simulate?
- (There is a rough write-up of the work)

Momentum kicks

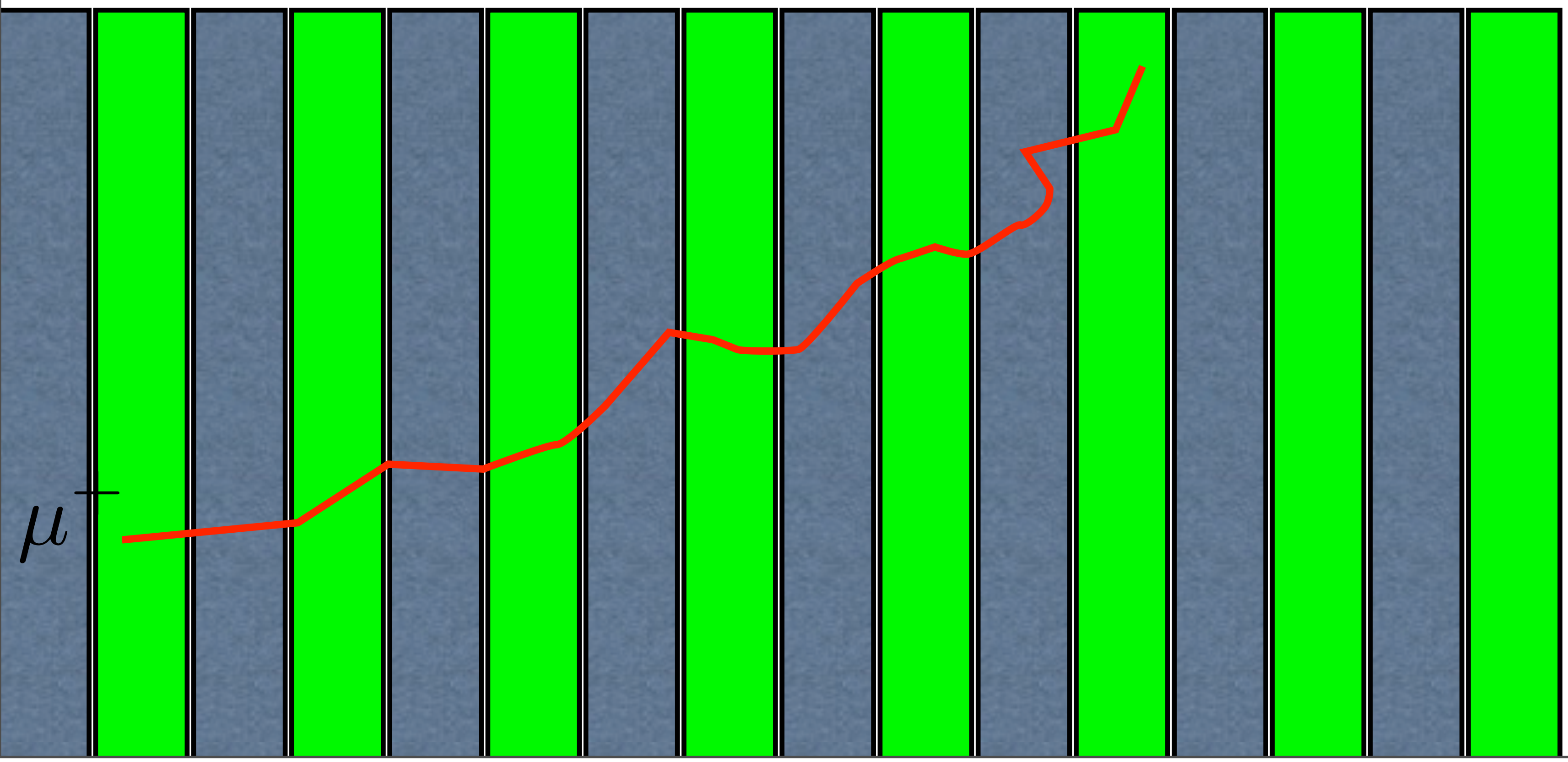
$$p_\perp^{\rm MS} = \frac{13.6\ {\rm MeV}}{\beta c}\sqrt{x/X_0}$$

$$p_\perp^B\ [{\rm MeV/c}] = 300Bx\ [\text{Tesla-meters}]$$

$$\frac{p_\perp^B}{p_\perp^{\rm MS}} = \frac{300Bx \times \beta c}{13.6\sqrt{x/X_0}}$$

$$\simeq 22B\sqrt{x}\sqrt{X_0}\beta c$$

1 cm Fe, 1 cm scint., ...



Want ratio
> 4.26

Ranges and Values

Region	Parameter	Value
Pure Iron	X_0	1.76 cm
	Thickness	1 cm
	Density	7.874 g cm^{-3}
	Magnetic Field	2 Tesla
	Range	576 g cm^{-2}
Polystyrene ($[C_6H_5CHCH_2]_n$)	X_0	43 cm
	Thickness	1 cm
	Density	1.06 g cm^{-3}
	Magnetic Field	0 Tesla
Effective	X_0	3.52 cm
	Thickness	2 cm
	Density	4.437 g cm^{-3}
	Magnetic Field	1 Tesla

optimist

Momentum [MeV/c]	Range [cm]	$p_\perp^B$	$p_\perp^{MS}$	$p_\perp^B/p_\perp^{MS}$
500.0	55.0	165.0	54.9	3.0
1000.0	126.0	378.0	81.8	4.6
2000.0	258.0	774.0	116.6	6.6
5000.0	623.0	1869.0	181.0	10.3

pessimist, beta > 0.9

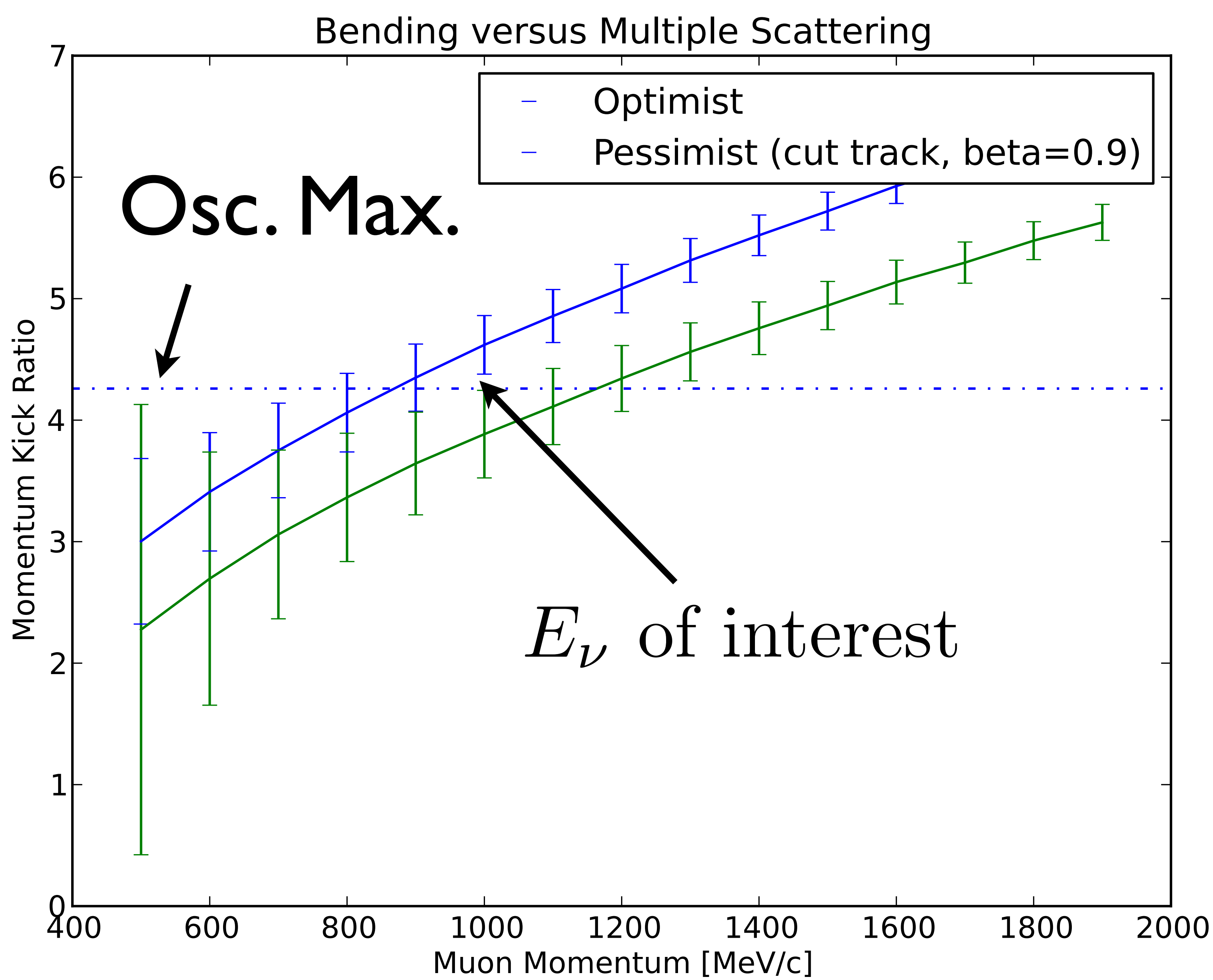
Momentum [MeV/c]	Range [cm]	$p_\perp^B$	$p_\perp^{MS}$	$p_\perp^B/p_\perp^{MS}$
500.0	39.0	117.0	46.3	2.5
1000.0	110.0	330.0	76.4	4.3
2000.0	242.0	726.0	112.9	6.4
5000.0	607.0	1821.0	178.6	10.2

CID Result

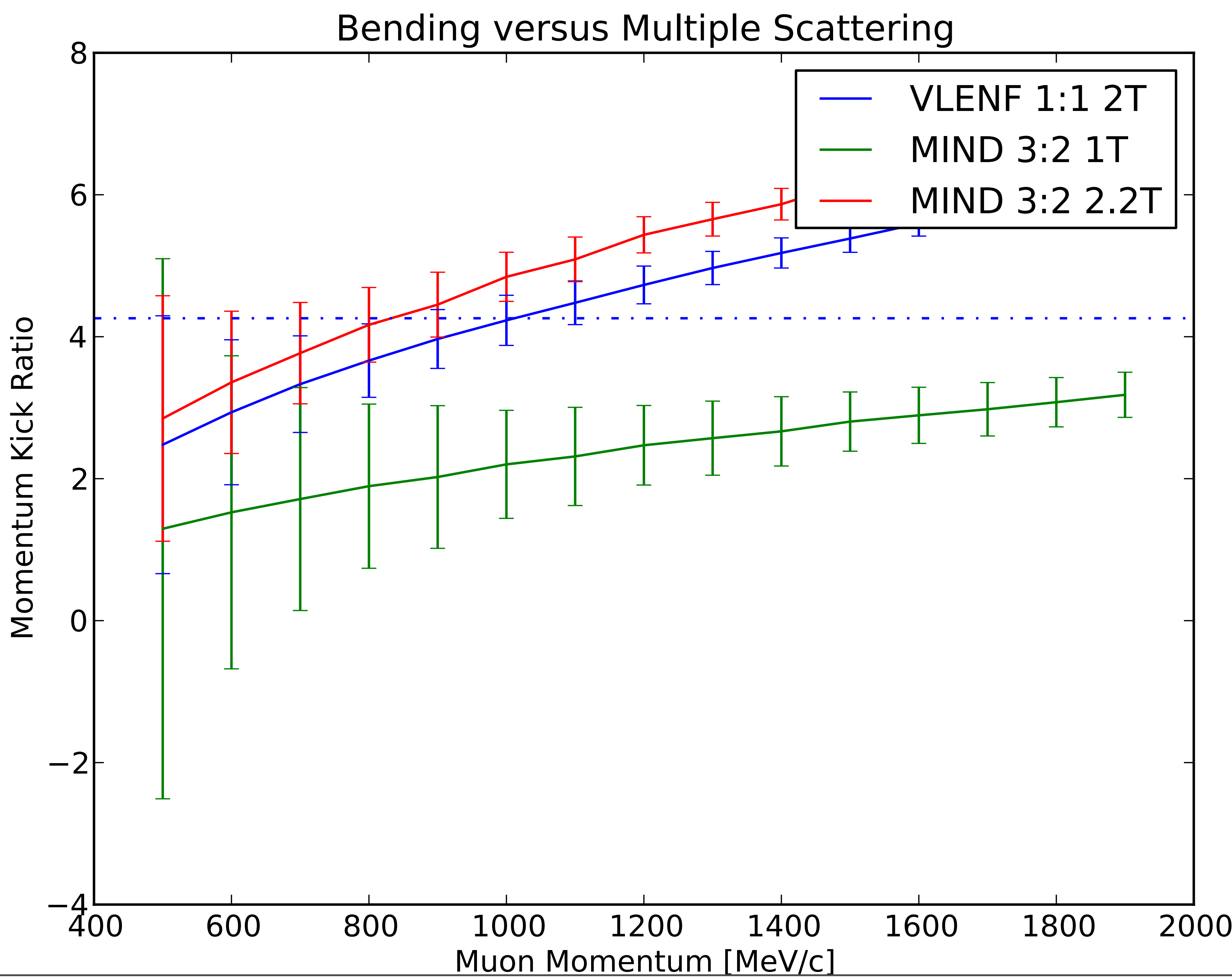
Before you say the errors are too large!!!...

Errors are Gluckstern uncertainties for 1 cm bars

$$\delta p = \frac{p^2}{300B} \frac{\epsilon}{L^2} \sqrt{\frac{720}{N+5}}$$



New plot:
MIND comparison



From IDR, the MIND material ratio is 3 cm Iron to 2 cm Scint

CID Summary

- I think this says: we get roughly the CID we want by just seeing where the muon lands
- Using information from the saggita helps a little
- Certainly can be improved, but certainly is optimistic
- Waiting for real fieldmap

Comment on NC

- If it was just iron, 4 x 10^-3 of charged-pions decay before interacting, faking a wrong-sign muon.
- Scint. has longer pion interaction length
- Alan: "Need kinematic cuts, kink detection, etc."
- Need to MC to do better.

The future

- Non-MC exercises like this are running out of steam
- Genie work in progress
- Got a handle on what is easy v.s. hard, now the real work begins...

Idea

- For LBNE, if WC then can we shoot at uBooNe? CD3, right?
- For LBNE, if LAr, can we shoot at their 1 kT prototype? Then 'upgrade' and build our detector?
- Golden channel is good and all...
- but we're better than a conventional beam even if magnetization is hard.