Summary of unblinded MuCap Results

October 11, 2006

1 Unblinding meeting

The meeting contributions are collected on the page
http://www.npl.uiuc.edu/exp/mucapture/coll/unblind/unblind.html

By studying them, you will get an overview on what was presented. The main presentations by Tom, Steve and Fred were projections of their updated analysis reports. Critical issues were extensively discussed. Alas, this discussion can only be partially reflected in the meeting webpage.

2 Final results before unblinding

Tom

E.5 Updated Berkeley systematics table

Below is my updated systematics table, as compiled on October 8, 2006, in immediate preparation for the unblinding of the DAQ clock frequency. I have conservatively enlarged some of the errors, but I have not changed any of the existing rates or corrections.

Stage	Source	|Correction| (ppm)	Error (ppm)
Pre-unblinding	Statistics	—	27.5
	Muon stop definition	—	2
	Muon scatter	9.9	2
	High-Z impurities	41.0	12
	Deuterium	19.5	2.5
	μp diffusion + scattering + impact cut	6.1	2
	Muon detector inefficiencies	—	2
	Electron detector inefficiencies	—	—
	Slop	—	2
Unblinding	Rescaling of error	—	< 1.1
Post-unblinding	DAQ clock stability (Agilent E4400)	—	1.4
	DAQ clock & beam structure beating	—	10
	Molecular formation ($\lambda_{pp\mu}$)	40	9
	Molecular transition ($\lambda_{\rm op}$)	10	5
	Total		...

Table 17: *Revised tabulation of corrections and errors, statistical and systematic, for the total μ^- disappearance rate in hydrogen, $\lambda_{\rm Run8}^{\rm unblinded}$. Note that I have not included the errors on λ_0 and $\Delta\lambda_{\rm bound}$, which will come into play when calculating Λ_S according to Equation 29. The numbers in the table are provided as ppm of $(\lambda_0 + \Lambda_S) \equiv (455,160\ {\rm s}^{-1} + 688\ {\rm s}^{-1}) = 455,848\ {\rm s}^{-1}$. Thus, to convert from ppm to Hertz one must multiply by the factor $(455,848\,{\rm s}^{-1}/(1\times 10^6)) \approx 1/2$.*

If we average my two results for cathode-AND and cathode-OR ,

$$\begin{aligned}\lambda_{\rm Run8}^{\rm UCB} &= (1/2){\rm cathode\text{-}AND} + (1/2){\rm cathode\text{-}OR}\\ &= (1/2)455,393.33\ {\rm s}^{-1} + (1/2)455,401.68\ {\rm s}^{-1}\\ &= 455,397.5\ {\rm s}^{-1}\end{aligned}$$

then we should also add in roughly 3.8 Hz error to cover the two values. Doing this, and and incorporating the new and/or revised errors in the systematics table gives

$$\lambda_{\rm Run8}^{\rm UCB} = 455,397.5 \pm 15.0\ {\rm s}^{-1}\ . \qquad (34)$$

Steve

1 UIUC Analysis Error Table, 11th Oct. 2006

	Prod50		NatH2	
	Value [s^{-1}]	Error [s^{-1}]	Value [s^{-1}]	Error [s^{-1}]
λ_{fit} from Lifetime Spectrum[a]	455433.98	±12.11	456471.71	±35.51
$Z > 1$ Impurities[b]	−13.90	±6.00	−88.00	±5.00
$\delta\lambda$ from D-Extrapolation[c]	−11.90	±1.08		
μp Diffusion[d]	−3.11	±0.20		
Seen $\mu + p$ Scatters	−1.10			
Unseen $\mu + p$ Scatters[e]	−2.00?	±2.00		
10 ns MuSC Deadtime	−0.06			
MuPCXorY Inefficiency[f]	1.10?			
Averaging with CathodeAND[g]	−3.07	±3		
Cut/No Cut Difference		±5		
Corrected λ	455400.84	±14.95		

[a] CathodeOR, 120 mm Impact Parameter Cut

[b] Using naive correction based on nitrogen impurities. The correction for Prod50 will be improved to include our knowledge of water in the gas. The NatH2 correction will be improved to include effects of deuterium on the capture yeild.

[c] Using $\tilde{c}^{-1} = 0.0122 \pm 0.0010$ from the λ vs. impact parameter studies.

[d] Using Model Diffusion Parameter $k = 0.4911 \pm 0.0070$ mm/$\sqrt{\mu s}$

[e] This is a very rough estimate at the moment. Improvements to the mu-stop definition will fix this value; in the meantime the correction is not applied to the net result.

[f] Not included in the net result.

[g] The statistically allowed difference between CathodeAND and CathodeOR is ≈ 3 Hz, and the observed difference is −6.14.

We still expect corrections at the few Hz level. In particular, the high Z corrections of Steve and Tom might not be consistent, as they get different decay rates for the CalibNat fill. Steve also plans to evaluate the μ+p scattering correction further, which will likely reduce his rate.

3 Unblinding procedure

The included spreadsheet was used for unblinding. Malte's envelope with the actual clock frequency stated that the blinding frequency was 100.1 MHz, a 1E-3 shift from the nominal frequency of 100 MHz. The unblinding gave an experimental capture rate 2 sigma higher than the theoretical prediction. Peter had been informed about a new calculation of radiative corrections by W. Marciano and collaborators, which shifted the theoretical prediction by 2.5%, but we did not know the sign of this shift. So we called Marciano and reached him at his home in New York on Sunday. He explained that the shift was positive.

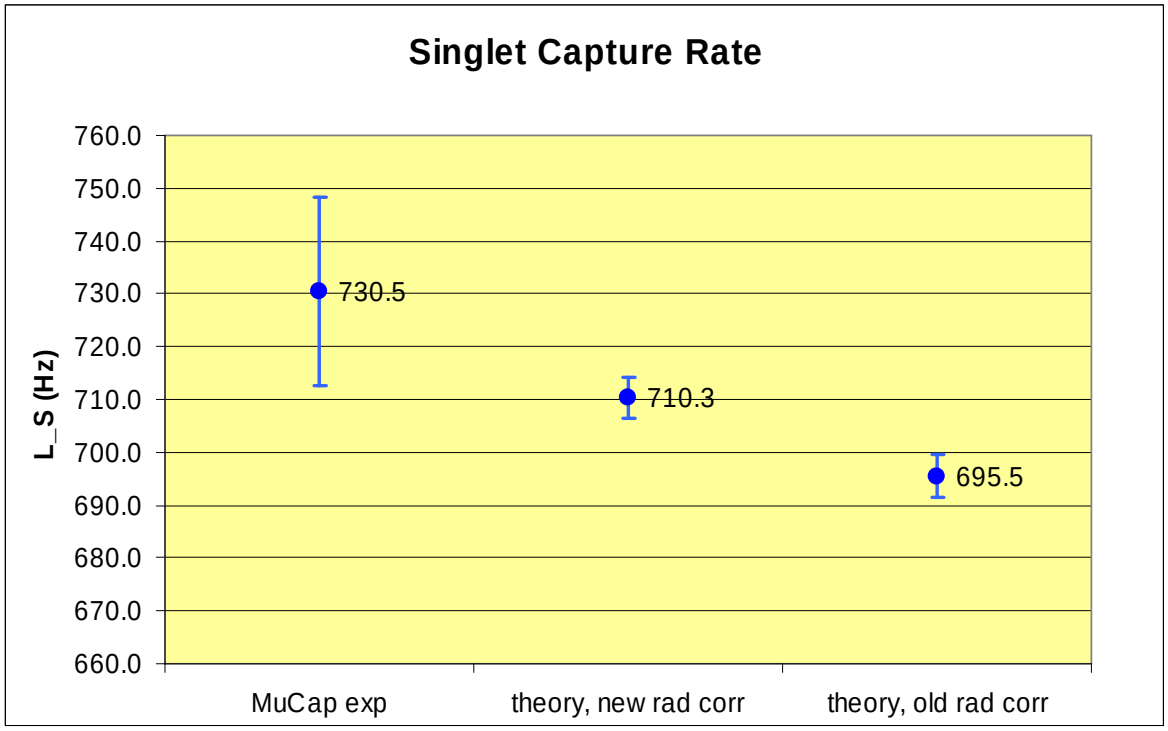
4 Results

Here is the unblinded spreadsheet with resulting graphs of Λ_S and g_P. Every collaboration member is asked to check this final calculation.

	mu-	sigma		mu+	sigma
best exp lambda	**455399**	15.000		454755	28.14
mu+ offset				1.0001	
frequency	100.1			100.1	
unblinded lambda	**455854.399**	15.000	**mu+ MuCap**	**455164**	**28.14**
ppm correction	19	4.095			
op correction	5	2.275			
corrected lambda	**455878.399**	15.714			
Uberall	12	0.000	decay		
corrected lambda	**455890.399**	15.714			
PDG mu+	455160	8.313		**455160**	**8.31**
Lambda_S MuCap	**730**	**18**	0.0243		
			MuCap-PDG	4	29.34
Lambda_S w/o rad	**691**				
Marciano	19.348	Goldman	4.5		
Lambda_S theory	**710**		695.5		

exp - theory	20				
δgP/gP / δLS/LS	-5.43	**error**			
dLs/Ls	0.0291	0.0243			
δgP/gP	**-0.16**	**-0.13**		theory	
δgP	**-1.31**	**-1.09**		8.26 ± 0.23	
gP	**6.95**	**1.09**			

Thus MuCap reports $\Lambda_S = 730 \pm 18$, which leads to $g_P = 6.95 \pm 1.09$ as a preliminary result.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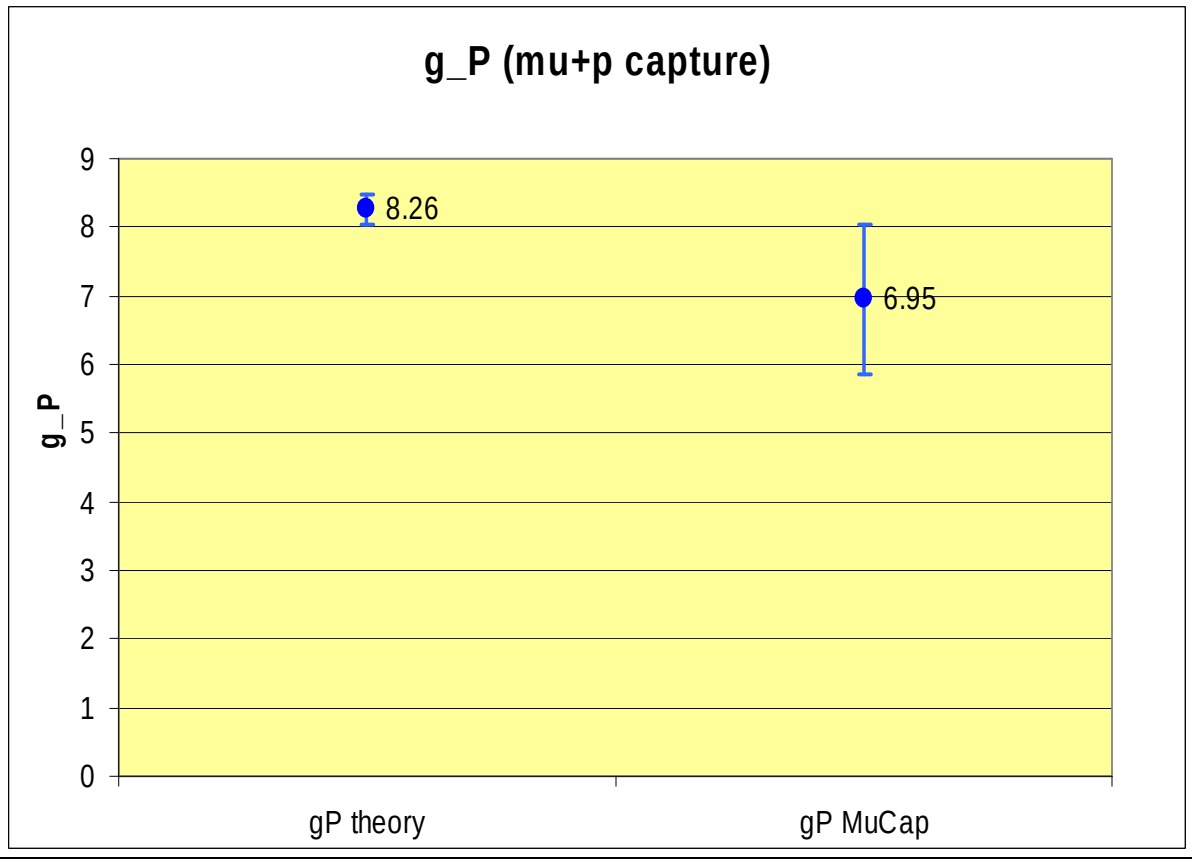
720.0
710.0
700.0
690.0
680.0
670.0
660.0
L_S (Hz)
730.5
710.3
695.5
MuCap exp
theory, new rad corr
theory, old rad corr


g_P (mu+p capture)
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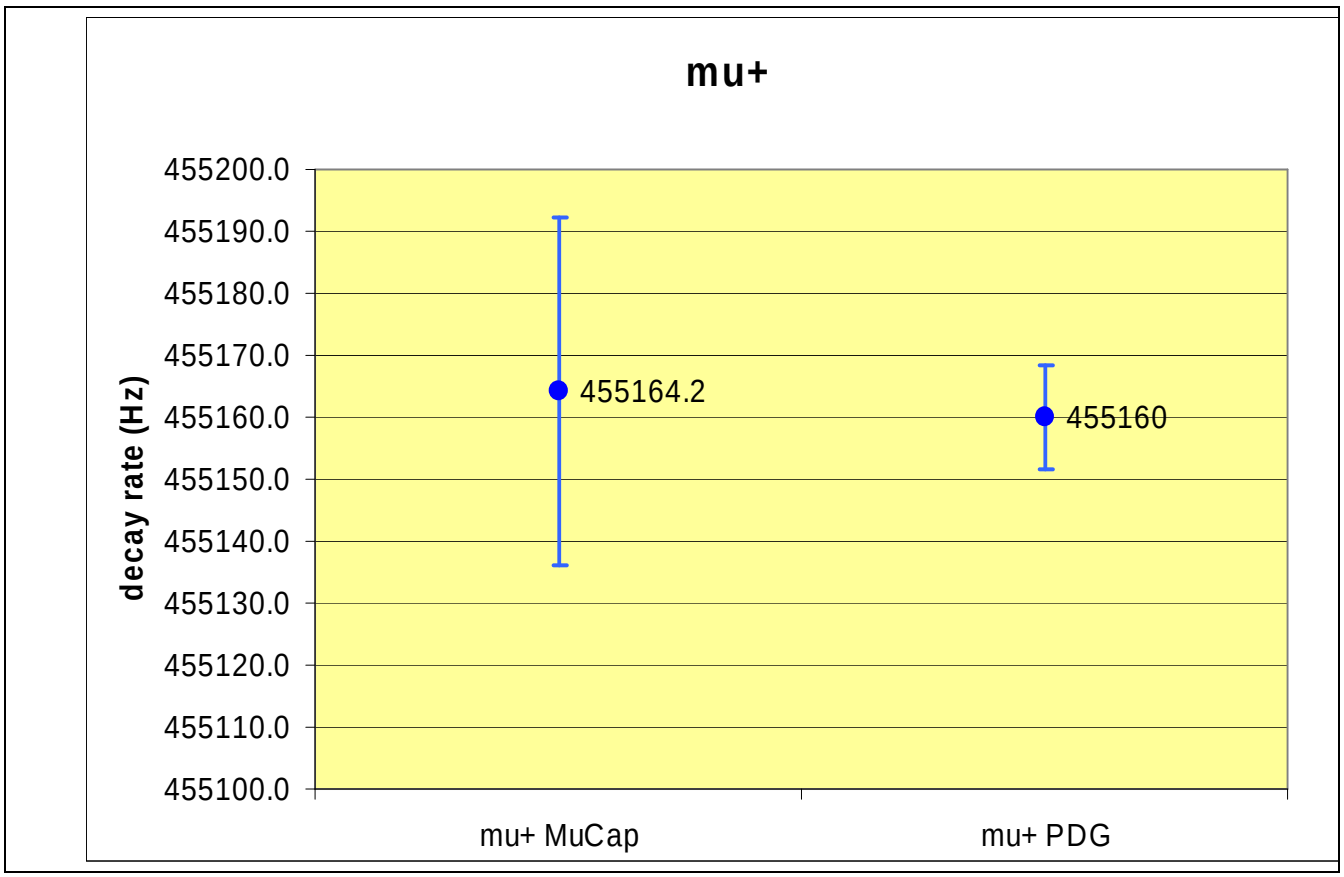
7
6
5
4
3
2
1
0
g_P
8.26
6.95
gP theory
gP MuCap



These results are preliminary. Please keep them private. The plan is to announce them at an invited talk on Saturday, October 28, 2006, 9:36 AM–10:12 AM

"First Physics Results from the MuCap Experiment at PSI"

at the annual American Physical Society meeting. I will post this talk internally, so that you can check it in advance.

5 Conclusions

We are excited and proud about this first physics result from this long and difficult journey. It confirms the chiral prediction within one sigma and for all practical purposes is independent of λ_{OP}. The one sigma disagreement leaves some excitement for our final results which should be 3x more accurate. The mu+ lifetime is in perfect agreement with expectations.

We will announce the results as preliminary. We will continue finalizing the analysis and systematic checks, as discussed in the tasklists and talks posted at the collaboration meeting page. The goal is to be ready with a letter publication before the end of the calendar year.