UVa Progess Report

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1. Cell Inventory
2. Laser Beam Studies
3. Summary

G_E^n Cell Inventory

Cell	Geometry	Type
Panache	GEN-LARGE	K/Rb hybrid
Mama Mia	STANDARD	K/Rb hybrid
Sosa	GEN-LARGE	pure Rb
Anna	GEN-LARGE	K/Rb hybrid
Barbara*	GEN-LARGE	K/Rb hybrid

*Barbara is baking and pumping on gas system, pull-off scheduled for tomorrow.

- All hybrid cells have been filled with 1% mole fraction Rb in K.
- Total of four (4) GE180 Mike cells with geometry compatible with G_E^n target system.

Laser Beam Studies

Presumably Simple Question: How much laser power do we need for optimal cell performance?

Unilluminating and Possibly Boring Answer:

Well, it depends.

$$
\begin{aligned}
P_A^\infty &= P_{light}\cos(\theta)\frac{\gamma_{op}}{\gamma_{op}+\gamma} \\
\cos(\theta) &= \hat{B}_0 \cdot \left(\hat{E}(\vec{r}) \times \hat{B}(\vec{r})\right)_{light} \\
\gamma_{op} &= \int \Phi(\nu,\vec{r})\,\sigma(\nu)\;\;\mathrm{d}\nu \\
\frac{\partial\Phi(\nu,\vec{r})}{\partial z} &= -\left\{1 - P_A(\vec{r})\cos(\theta)\right\}\sigma(\nu)[A]\Phi(\nu,\vec{r})
\end{aligned}
$$

γ_{op} is the optical pumping rate per unit area

γ is the spin relaxation rate per unit area

σ is unpolarized absorption cross section

Φ is number of photons per unit time per unit area per unit frequency interval

$\vec{r}$ is the position in the cell

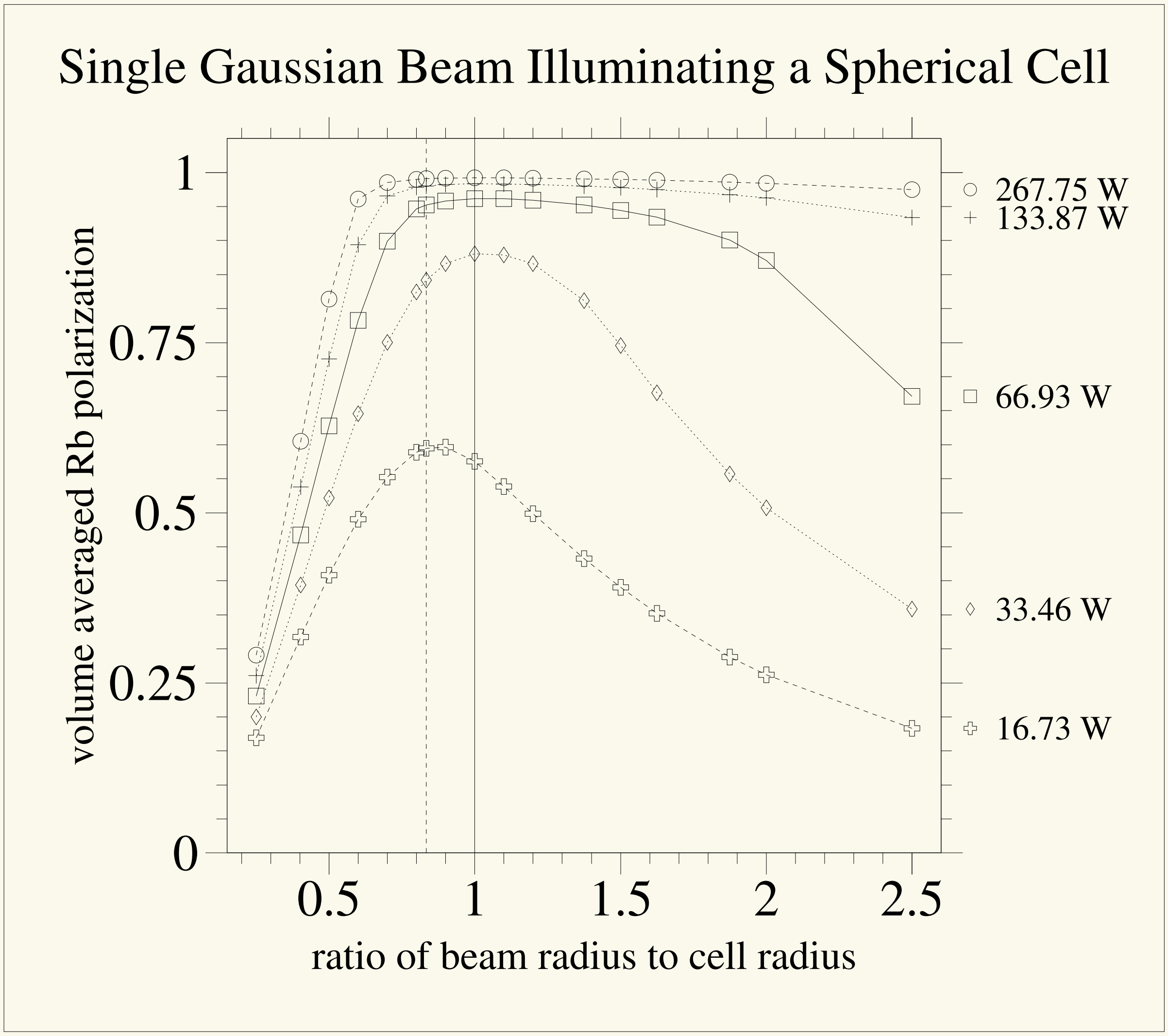
Model for Optical Pumping

1. "Cut" the pumping chamber into very thin slices perpendicular to the beam direction.
2. Choose some $\Phi(\nu, \vec{r})$ as input.
3. Calculate the equilibrium alkali polarization in the first slice, $P_A^\infty(z_0)$.
4. Figure out how many photons would be absorbed by this slice of alkali vapor.
5. Remove those photons from $\Phi(\nu, \vec{r})$.
6. Input the attenuated $\Phi(\nu, \vec{r})$ into the next slice.
7. Calculate the equilibrium alkali polarization for this slice, $P_A^\infty(z_1)$.
8. and so on...

General Comments

1. The photon flux is directly related to the intensity (power per unit area) of the light.
2. The photon flux needed for any one slice depends on γ, which is dominated by spin-loss collisions with ^{3}He.
3. Reducing the alkali number density, $[A]$, reduces the the number of photons lost per slice.
4. Skew pumping ($\theta \neq 0$) increases the number of photons lost per slice *at equilibrium.*
5. A spherical pumping chamber has different path lengths. A balance needs to be struck between the intensity of the light at the center of the pumping chamber with the edge of the pumping chamber.

Results from Version One

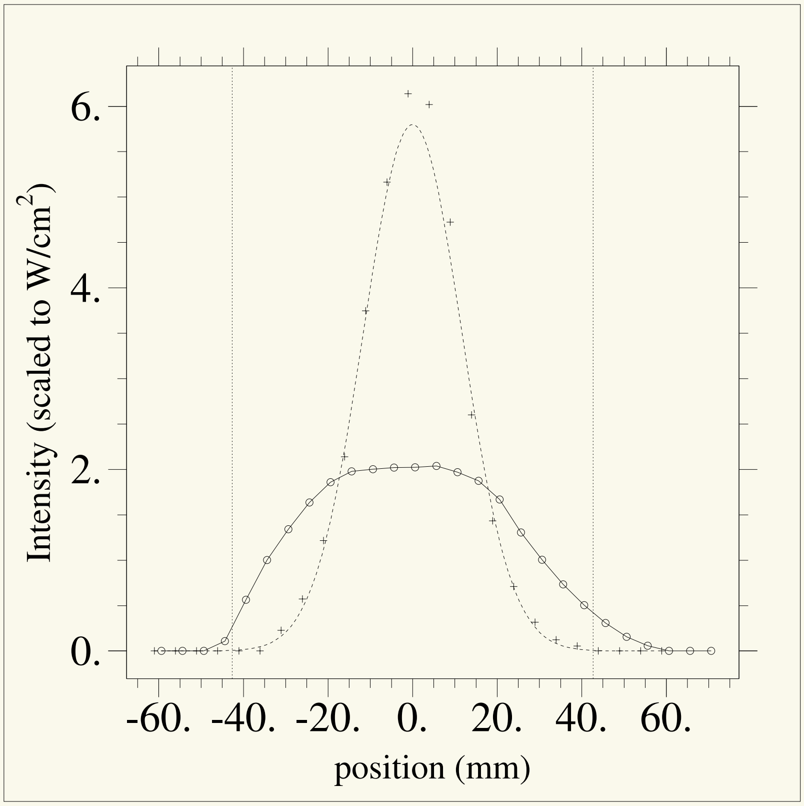


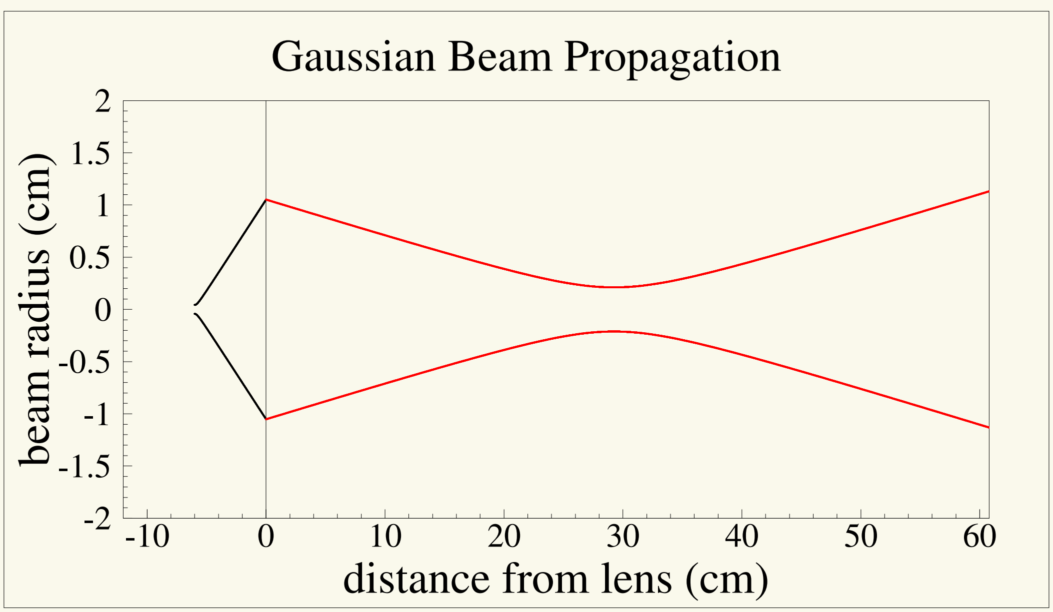
1. Pure Rb vapor
2. Large Pumping Chamber
3. No Diffusion Effects
4. Averaged over Frequency Dependance
5. No Skew Pumping

The Laser Beam

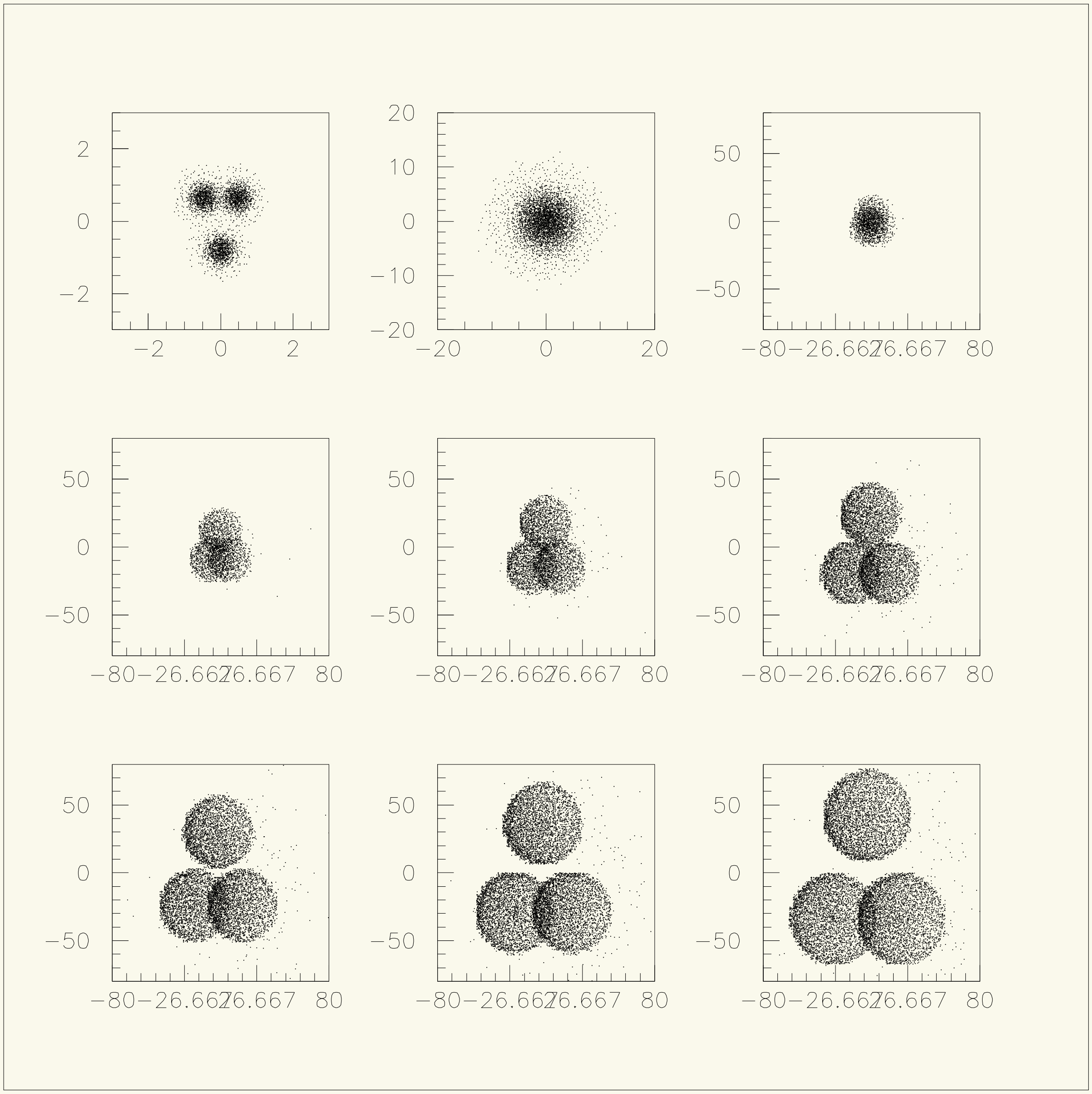
1. It is conveneient to describe the size of a single beam as the radius that encloses 86.5% of the total power.
2. Under our typical conditions, visual perception overestimates the size of the beam by 20%.
3. Simple geometric ray optics (by itself) does a poor job describing the propagation of a single beam.
4. Equations governing gaussian beam optics do an adequate job predicting the size of the beam as a function of distance.
5. We have measured the gaussian beam parameters for each laser with a combiner fiber.

Beam Profiling

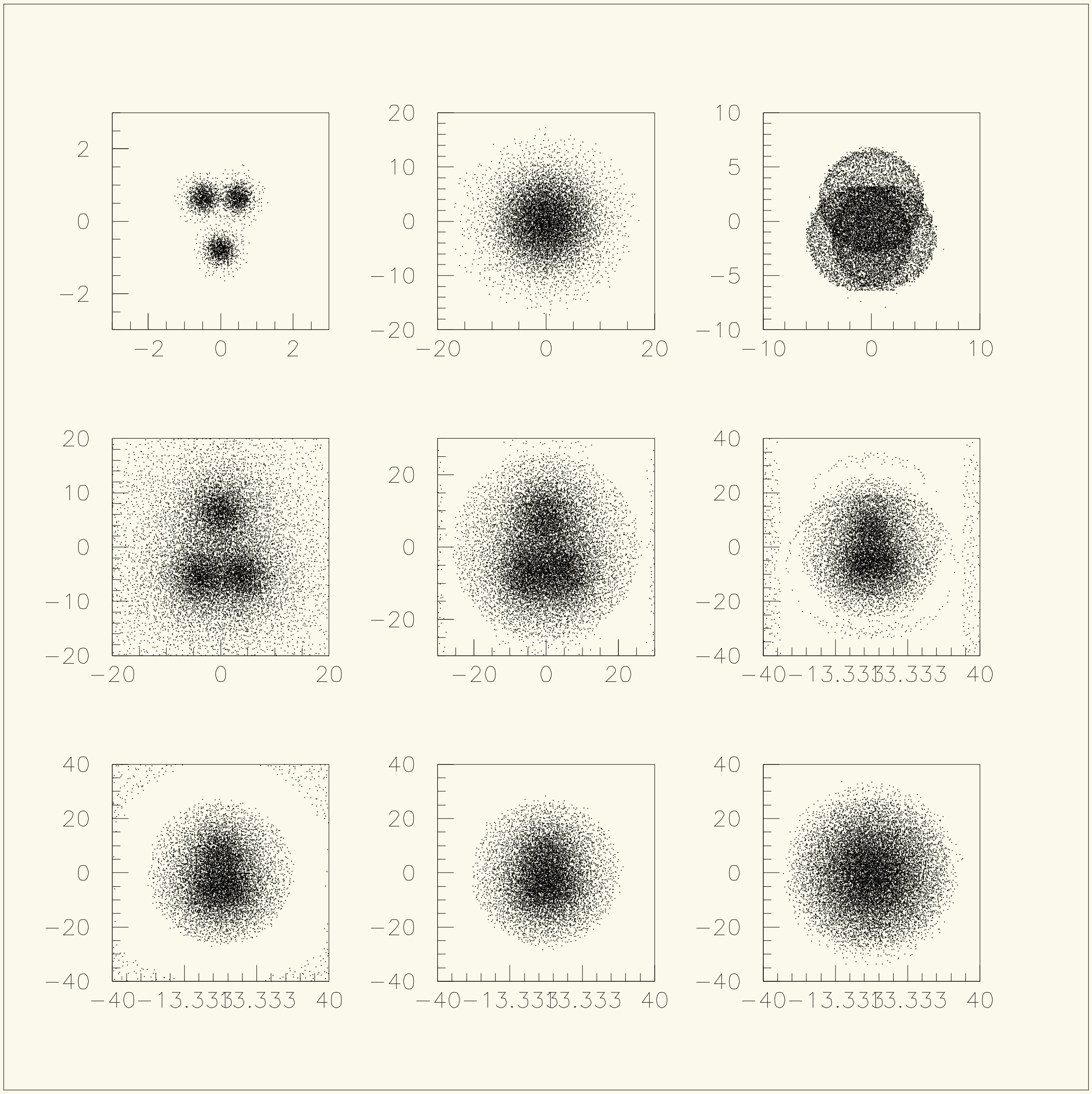




Bad Combiner



Good Combiner



Summary

1. By tomorrow we'll have five cells. Four have the proper geometry to fit in the new target.
2. Except for Panache, all cells are untested. Starting this weekend, it will take about 1.5 months solid to do spinups and spindowns.
3. The beam separation from the combiner was an unpleasant surprise, but we believe we have solved that problem. (Details at next G_E^n "biweekly" meeting.)
4. New optics design is basically ready. Before we start pumping, we need to make sure that we are not exceeding the damage threshold of our optics.
5. New optics design should allow coarse and fine tuning of laser beam size with little effort.
6. Faraday Rotation is next! (cross fingers...)
7. August 31, 2005 is a hard deadline!