Summary

Conditional Review of E12-13-011 and E12-15-005 Experiments

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E12-13-011

Issues:
In order to obtain conclusive data with sufficient precision it is crucial to achieve a tensor polarization significantly higher than the value of 20% assumed in the proposal. While methods such as RF- “hole burning” are known to increase the tensor polarization above the thermal equilibrium value, these techniques including the polarization measurement have to be developed further to allow for a reliable operation under experimental conditions.

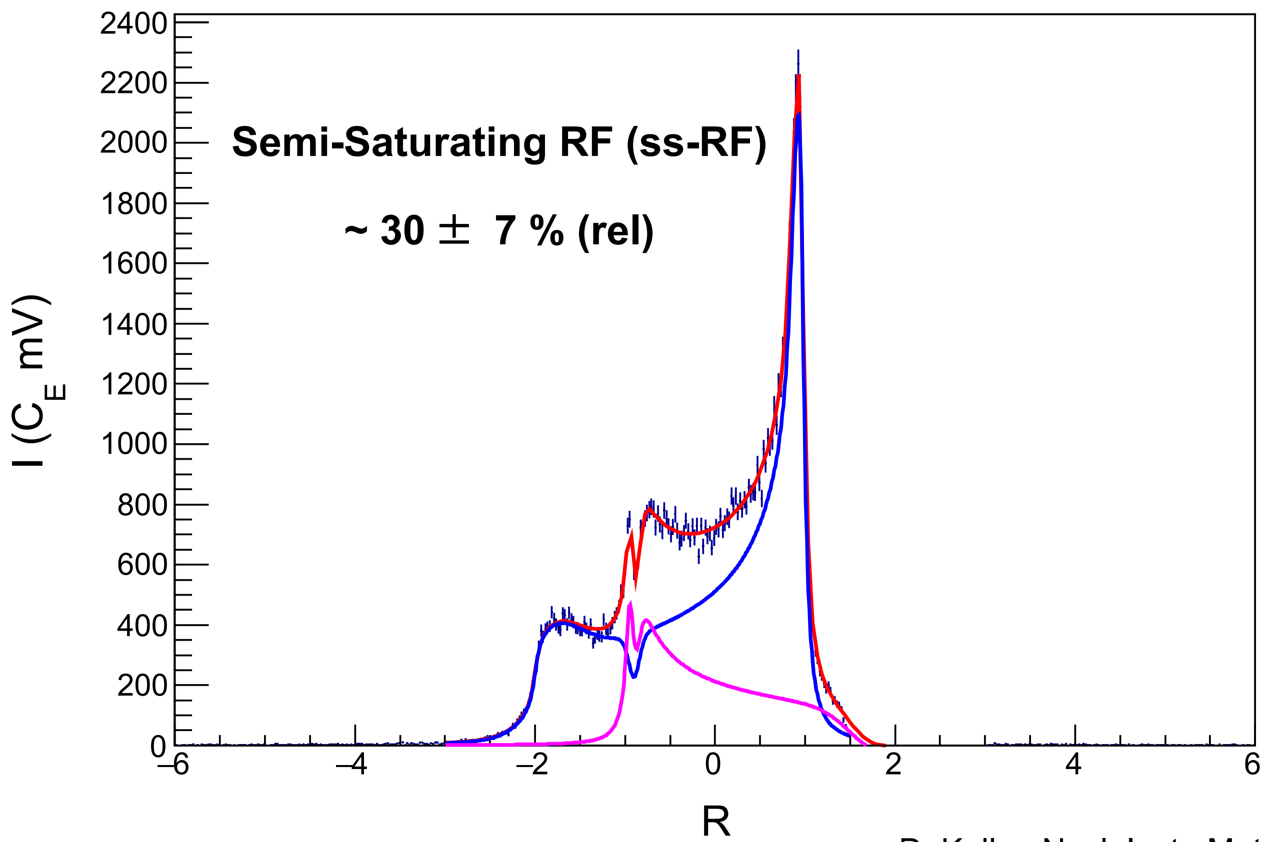
Conditions:
The experiment is conditionally approved with the condition that a tensor polarization of at least 30% be achieved and reliably demonstrated under experimental conditions.

E12-15-005

Issues: It is important to achieve the tensor polarization of 30% assumed in the proposal. While methods such as RF- “hole burning” are known to increase the tensor polarization above the thermal equilibrium value, these techniques including the polarization measurement have to be developed further to allow for a reliable operation under experimental conditions.

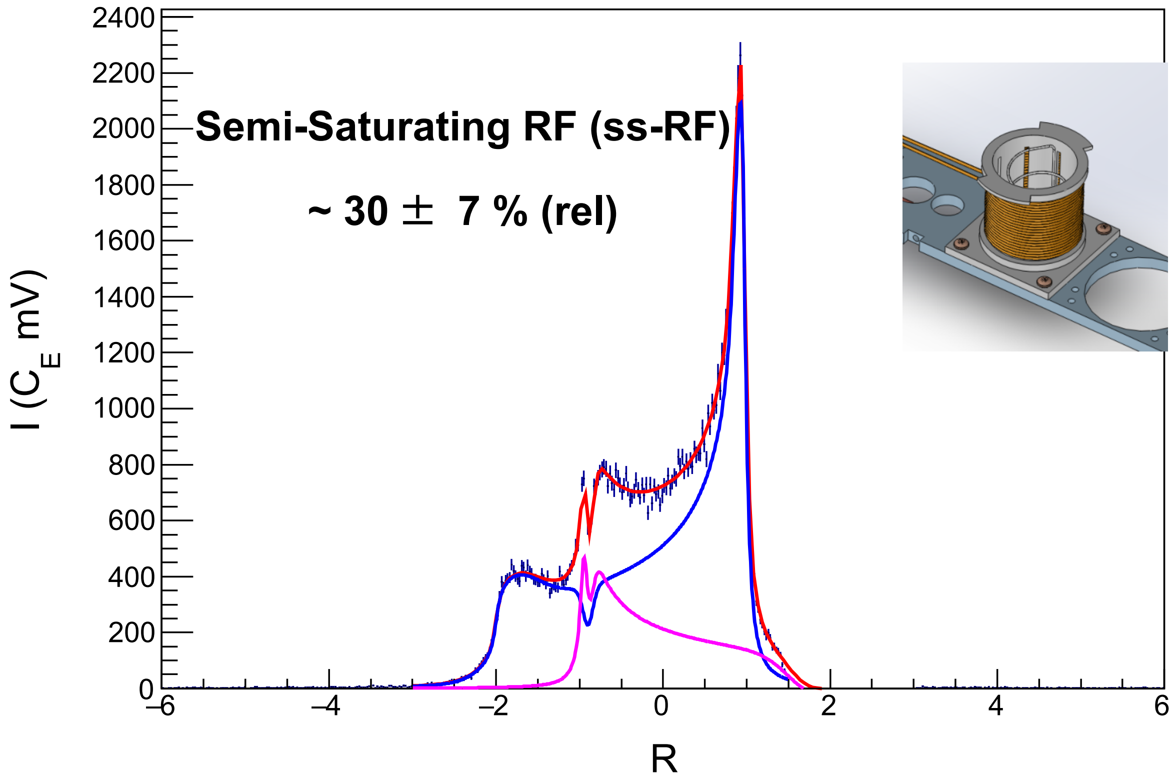
Summary:
The experiment is conditionally approved with the condition that a tensor polarization of close to 30% be achieved and reliably demonstrated under experimental conditions.

UVa solid polarized target group has achieved polarizations ≥ 30 %



D. Keller. Nucl. Instr. Meth.A 981 (2020)

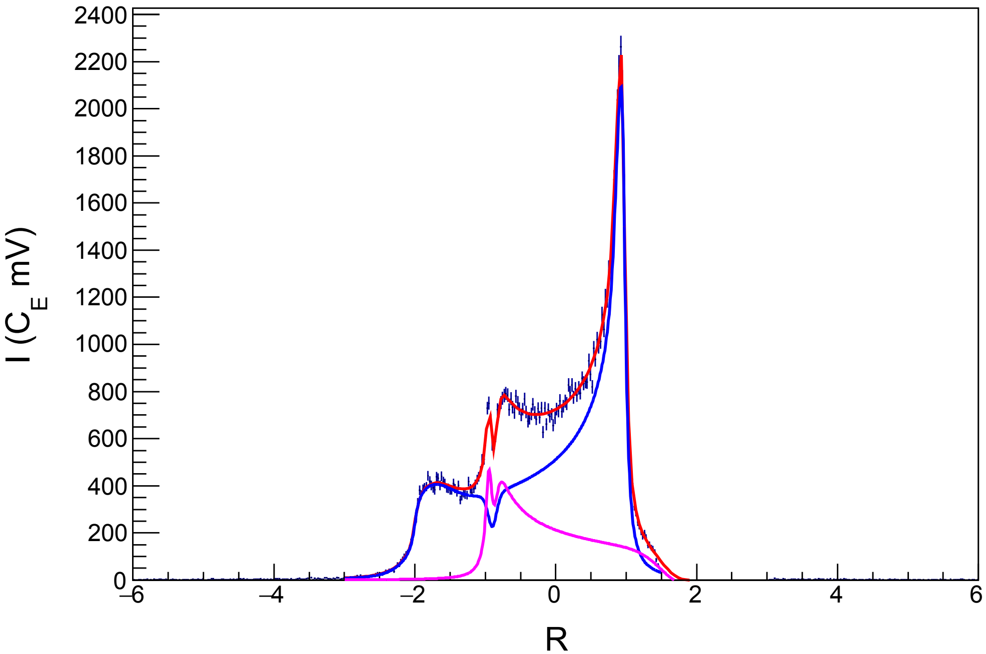
Charge 1: What technique(s) will be used to produce "a tensor polarization of 30% under standard experimental conditions".



ssRF + AFP: ~32 ± 8.5 % (rel)
rssRF: ~ 36 ± 9.5 % (rel)

D. Keller. Nucl. Instr. Meth.A 981 (2020)

Charge 2: How will the tensor polarization be measured and with what uncertainty? What crosschecks or auxiliary measurements can be made to validate the results? Will this uncertainty be sufficient to achieve meaningful physics results?



Measurement:

1. **Differential binning**
2. **Spin temperature consistency**

$$P = C(I_+ + I_-)$$
$$Q = C(I_+ - I_-)$$

3. **Rate response**

$$A_{lost} = \frac{1}{2} A_{gained}$$

J. Clement, D. Keller, Submitted to Nucl. Instr. Meth. A (2022)

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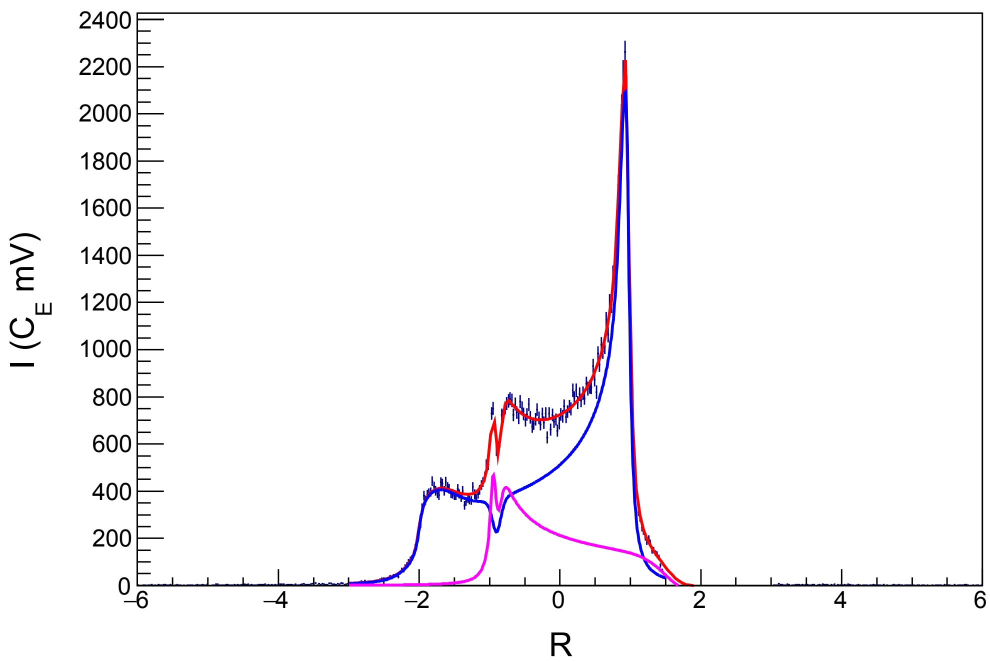

Sources of Uncertainty:

1. TE (area, temperature stability, among others)
2. Systematic variation in enhanced signal
3. NMR measurement limitations with respects to relaxation rate
4. Line-shape analysis

D. Keller. Nucl. Instr. Meth.A 981 (2020)

- **ss-RF (~7 % relative uncertainty)**
- **ss-RF + AFP (~8.5 % uncertainty measured)**
- **rss-SF (~9.5% relative uncertainty)**

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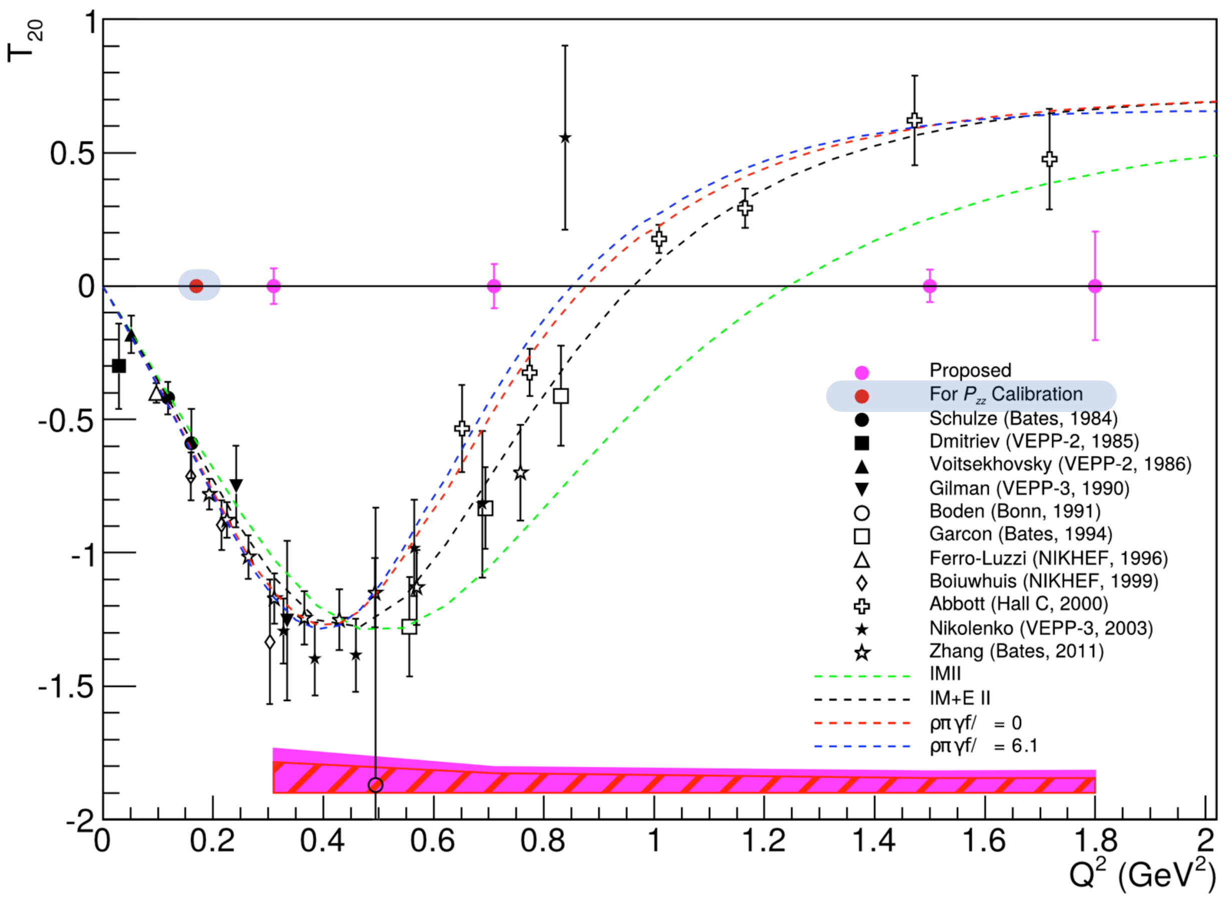

Crosschecks:

T_{20} Measurement

$$P_{zz} \sim \frac{1}{T_{20}}$$

The low Q^2 elastic measurement will validate the proposed enhancement and measurement techniques.

E. Long, et al. E12-15-005 proposal (2016).

P_{zz} Expected Uncertainty:
8.63% from T_{20} parametrization

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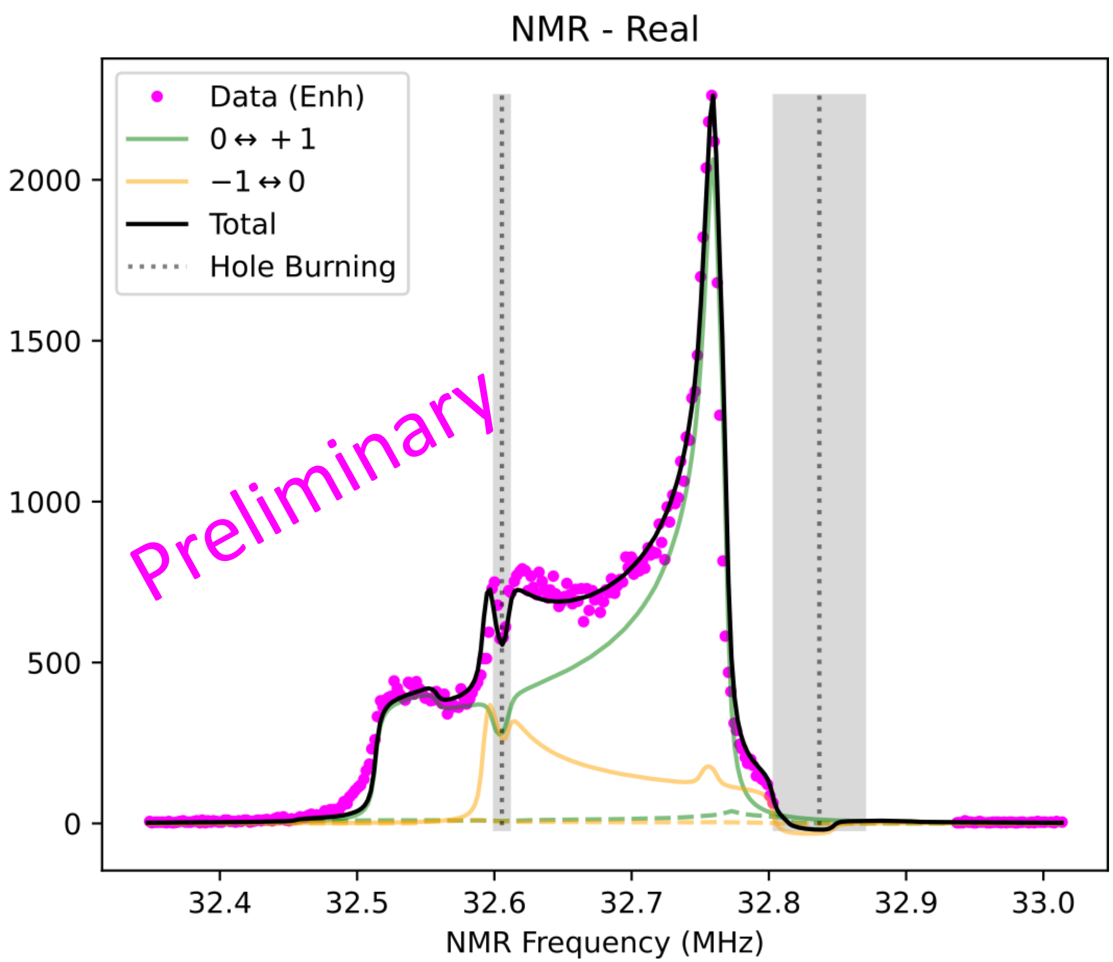
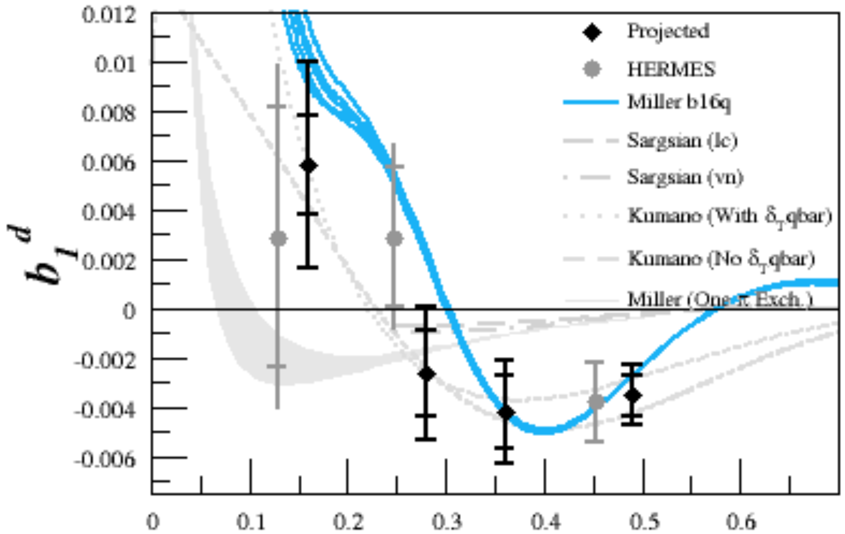


Simulation package in development at UNH

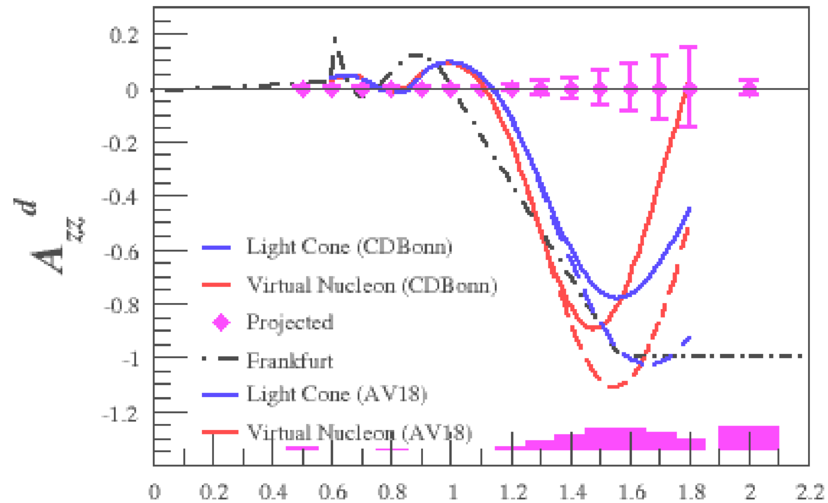
Courtesy of E. Long.

Charge 2: How will the tensor polarization be measured and with what uncertainty? What crosschecks or auxiliary measurements can be made to validate the results? **Will this uncertainty be sufficient to achieve meaningful physics results?**

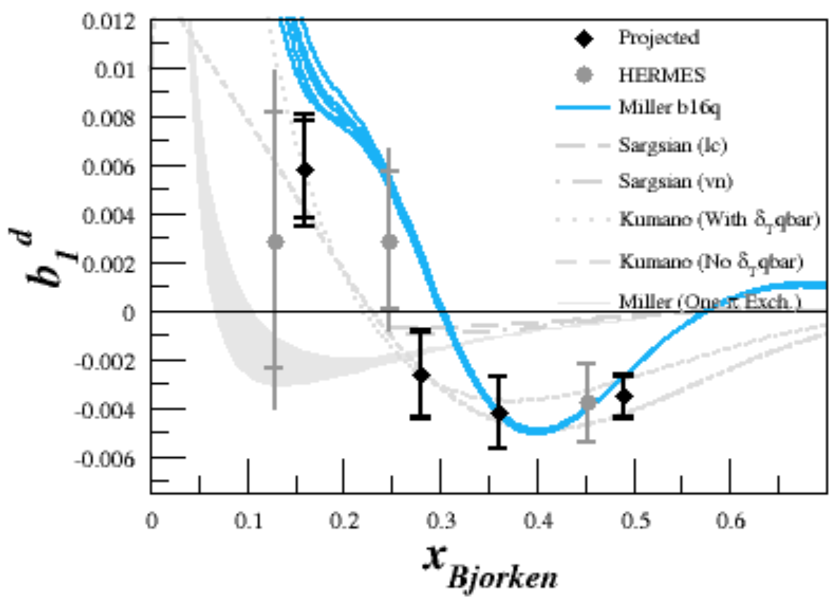
Proposal
P_{zz} = 30 ± 8 % (rel)



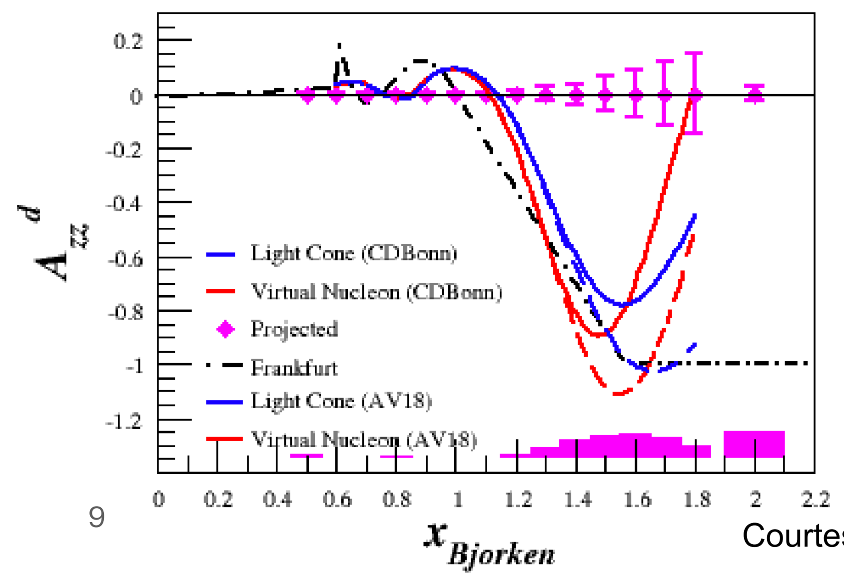
Proposal
P_{zz} = 30 ± 6 % (rel)



Update
P_{zz} = 30 ± 7 % (rel)

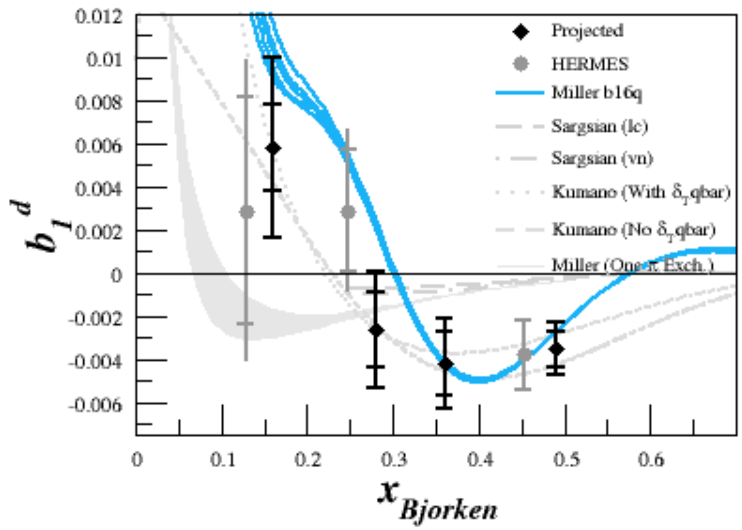


Update
P_{zz} = 30 ± 7 % (rel)



Courtesy of E. Long

Charge 2: How will the tensor polarization be measured and with what uncertainty? What crosschecks or auxiliary measurements can be made to validate the results? **Will this uncertainty be sufficient to achieve meaningful physics results?**



Proposal:

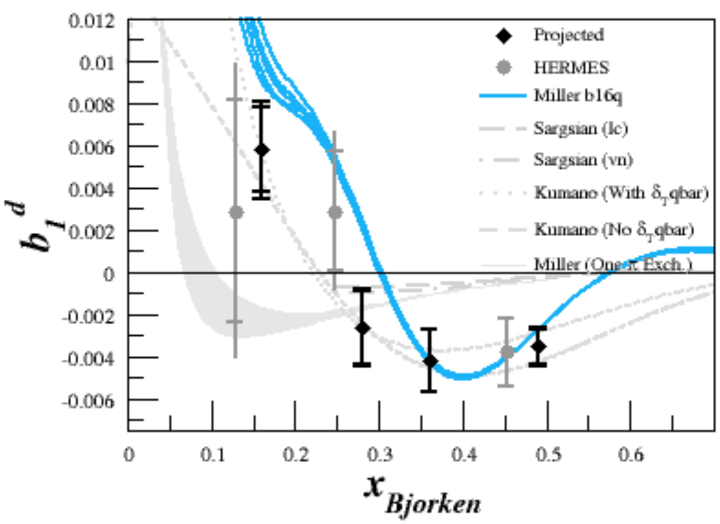
I = 115 nA (Current)

P_{zz} = 0.3 (Tensor polarization)

N = 30 (Helicity changes)

ϵ = 0.81 (Efficiency)

$IP_{zz}^2\sqrt{N} \sim$ **57**



Update:

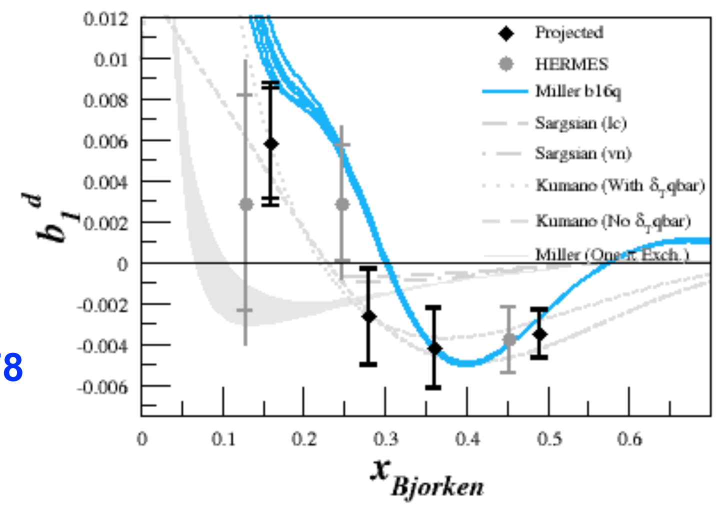
I = 115 nA

P_{zz} = 0.30

N = 720

ϵ = 0.72

$IP_{zz}^2\sqrt{N} \sim$**278**



Conservative Update:

I = 85 nA

P_{zz} = 0.26

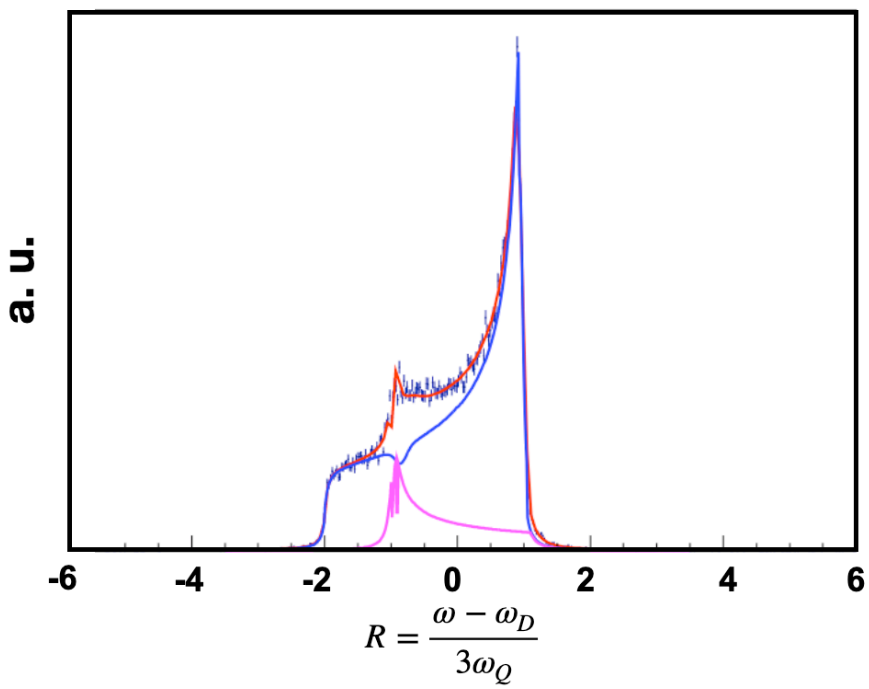
N = 720

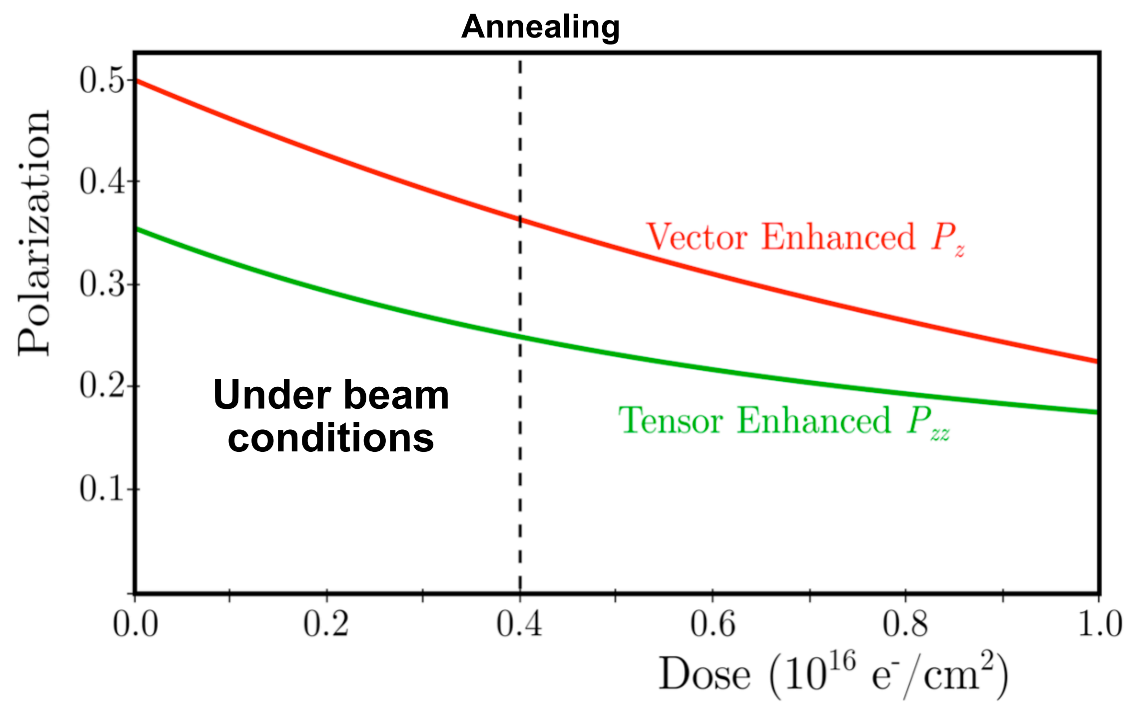
ϵ = 0.72

$IP_{zz}^2\sqrt{N} \sim$ **154**

Helicity states changes will be done in the order of minutes with RF which increases the FOM

Charge 3: What assumptions are made regarding the vector polarization of the target? How is the tensor polarization expected to respond as the vector polarization decays in beam?





Courtesy of D. Keller.

- 2 target cups
- One cup change per PAC day
- 1 anneal per PAC day
- Total of 6 material changes (After $2.1 \times 10^{16} e^-/cm^2$ accumulated dose per cup)

Charge 4: What is the current experimental situation? What is the maximum tensor polarization that has been achieved under the anticipated polarizing conditions of 5 T and 1 K?

Experimental setup:

DNP
5 T magnet
1 K with an evaporation refrigerator(1 W cooling power)
0.3 W microwave on material

Material
Irradiated Butanol (C_4D_9OH)
Note: Tensor enhancement can be treated similarly for materials with the same lineshape (ND_3).

D. Keller. Nucl. Instr. Meth.A 981 (2020)

ssRF: ~30 $\pm$ 7 % (rel)
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rssRF: ~ 36 $\pm$ 9.5 % (rel)

Also shown: Rapid spin state transitions (polarization flips *several per hour*)

Thank You

Special thanks to

E12-13-011 and E12-15-005 collaborations