

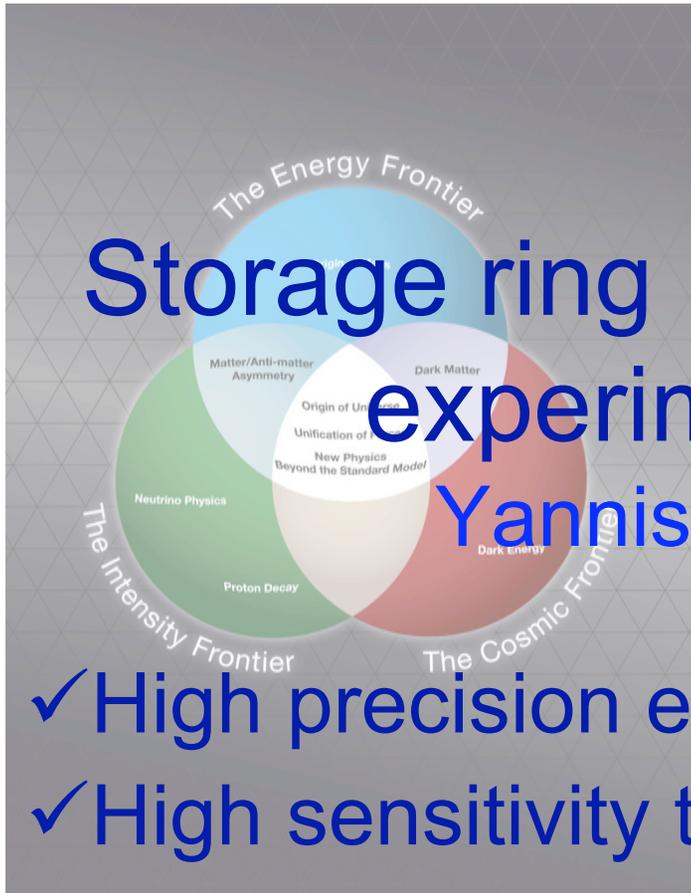
Storage ring Electric Dipole Moment experiment for the proton

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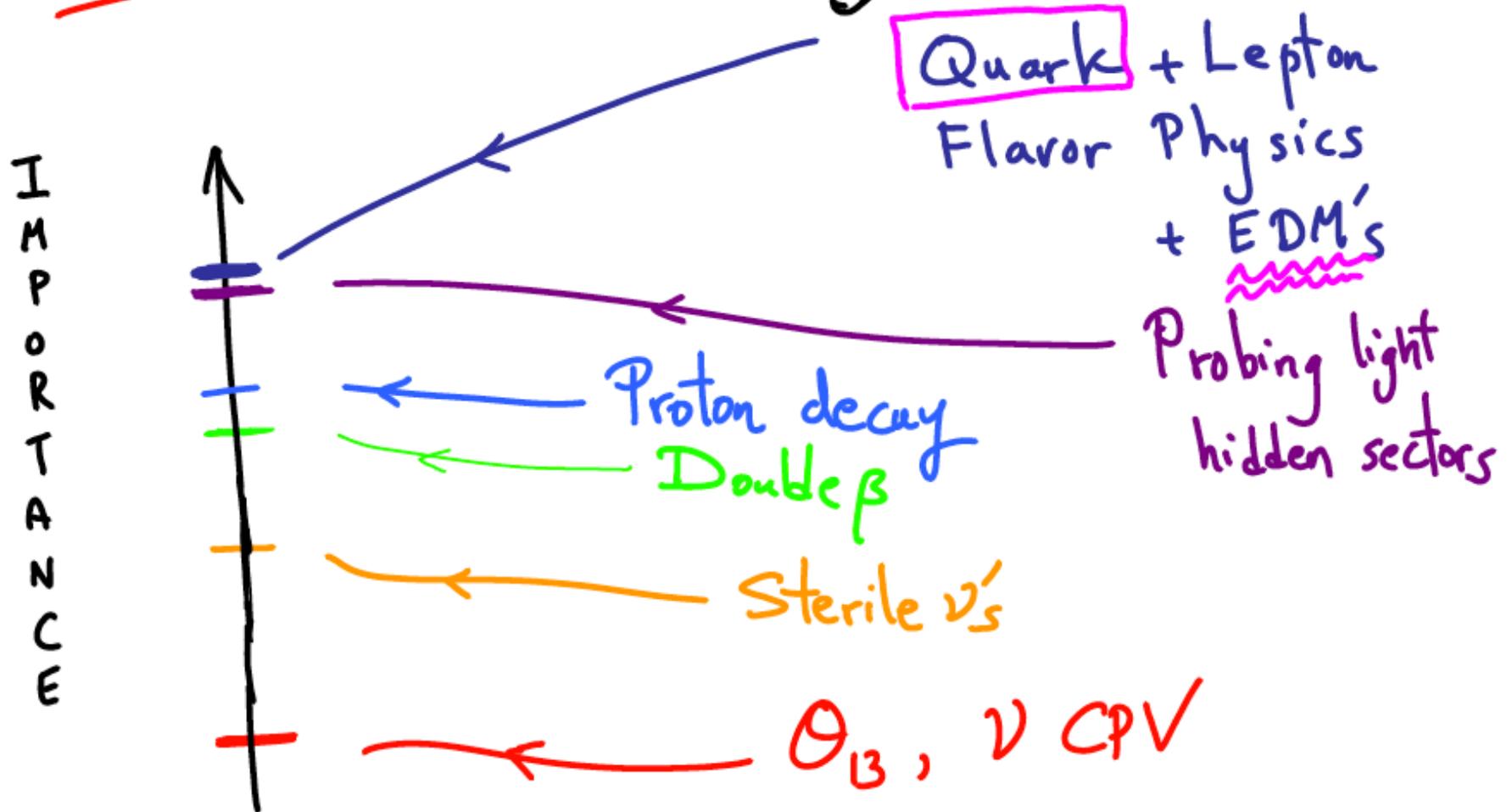
- ✓ High precision experiment: $10^{-29} \text{e}\cdot\text{cm}$
- ✓ High sensitivity to New Physics, $\sim 10^3 \text{ TeV}$

✓ 4×10^{10} Polarized protons in a storage ring every 20 min can provide the statistics.

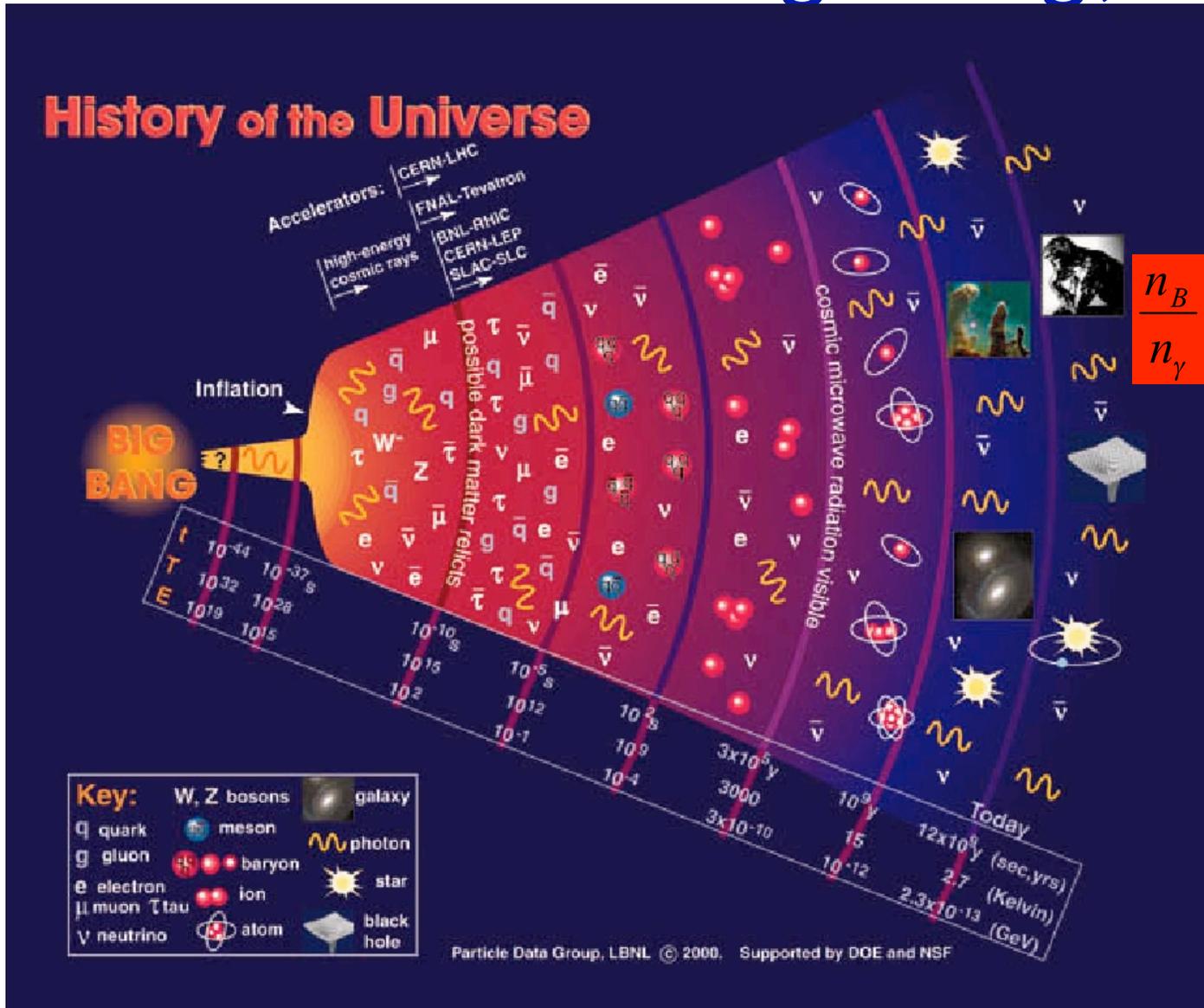
✓ Systematics best in an all-electric ring and counter-rotating (CR) stored beams.



My (Current!) Intensity Frontier Priorities



Why is there so much matter after the Big Bang;



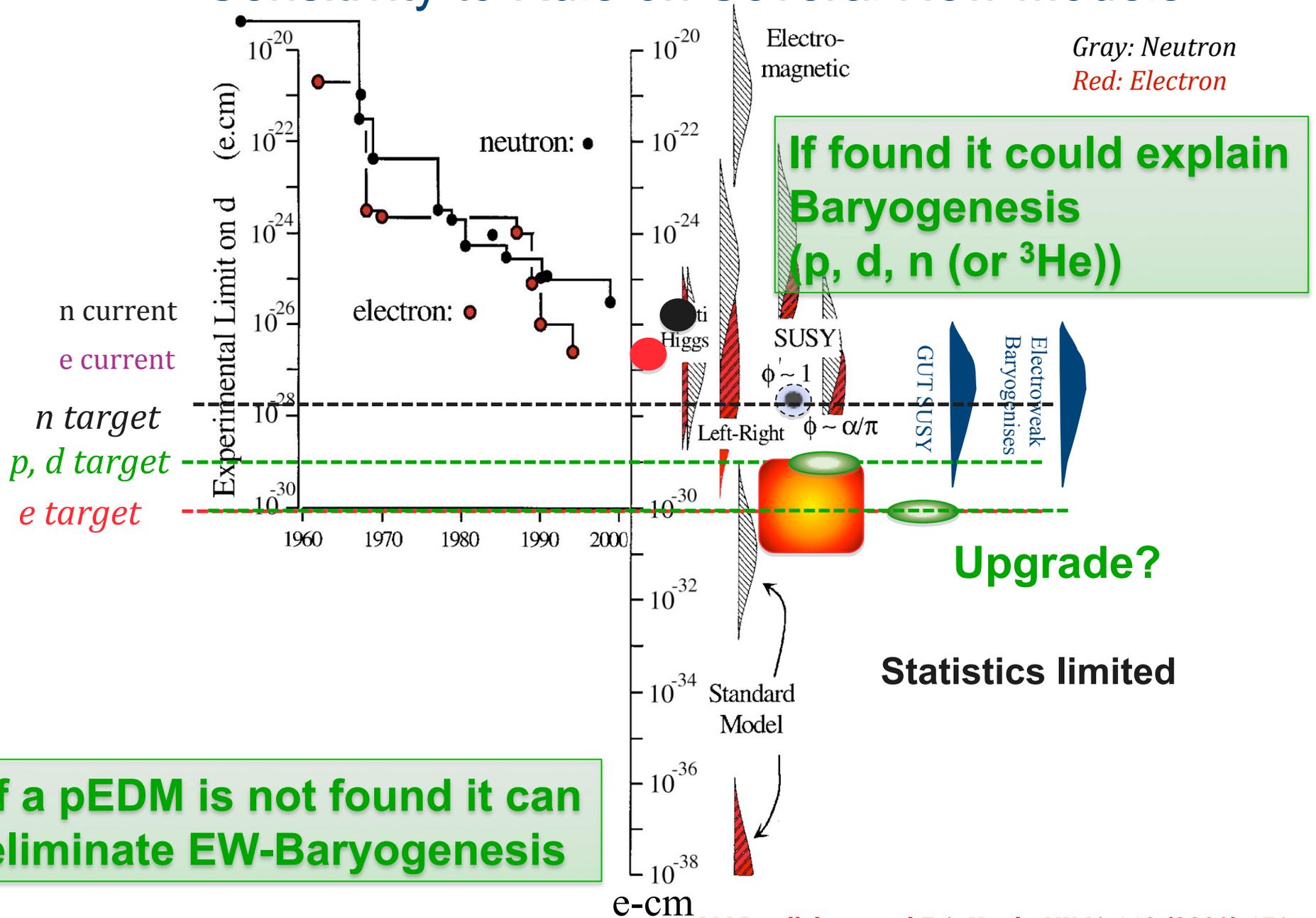
We see:

$$\frac{n_B}{n_\gamma} \approx (6.08 \pm 0.14) \times 10^{-10}$$

From the SM:

$$\frac{n_B}{n_\gamma} = \frac{n_{\bar{B}}}{n_\gamma} \approx 10^{-18}$$

Sensitivity to Rule on Several New Models



Physics reach of magic pEDM (Marciano)

• Currently: $\bar{\theta} \leq 10^{-10}$, Sensitivity with pEDM: $\bar{\theta} < 0.3 \times 10^{-13}$

• Sensitivity to new contact interaction: **3000 TeV**

• Sensitivity to SUSY-type new Physics:

$$pEDM \approx 10^{-24} \text{ e} \cdot \text{cm} \times \sin \delta \times \left(\frac{1 \text{ TeV}}{M_{\text{SUSY}}} \right)^2$$

The proton EDM at $10^{-29} \text{ e} \cdot \text{cm}$ has a reach of **>300 TeV** or, if new physics exists at the LHC scale, **$\delta < 10^{-7} - 10^{-6}$ rad** CP-violating phase; an unprecedented sensitivity level. Fine tuned SUSY: OK

The deuteron EDM sensitivity is similar.

Current status

- ✓ E-field: reproduced state of the art. Cornell (experts) joined.
- ✓ Working EDM lattice with long SCT and large enough acceptance ($1.3 \times 10^{-29} \text{e}\cdot\text{cm}/\text{year}$)
- ✓ Polarimeter work on systematic errors (COSY), just published (N. Brantjes et al., NIM A664, 49 (2012))
- Planning BPM-prototype demonstration including tests at RHIC (submitted summary LDRD for nano-meter resolution BPM).

The current status

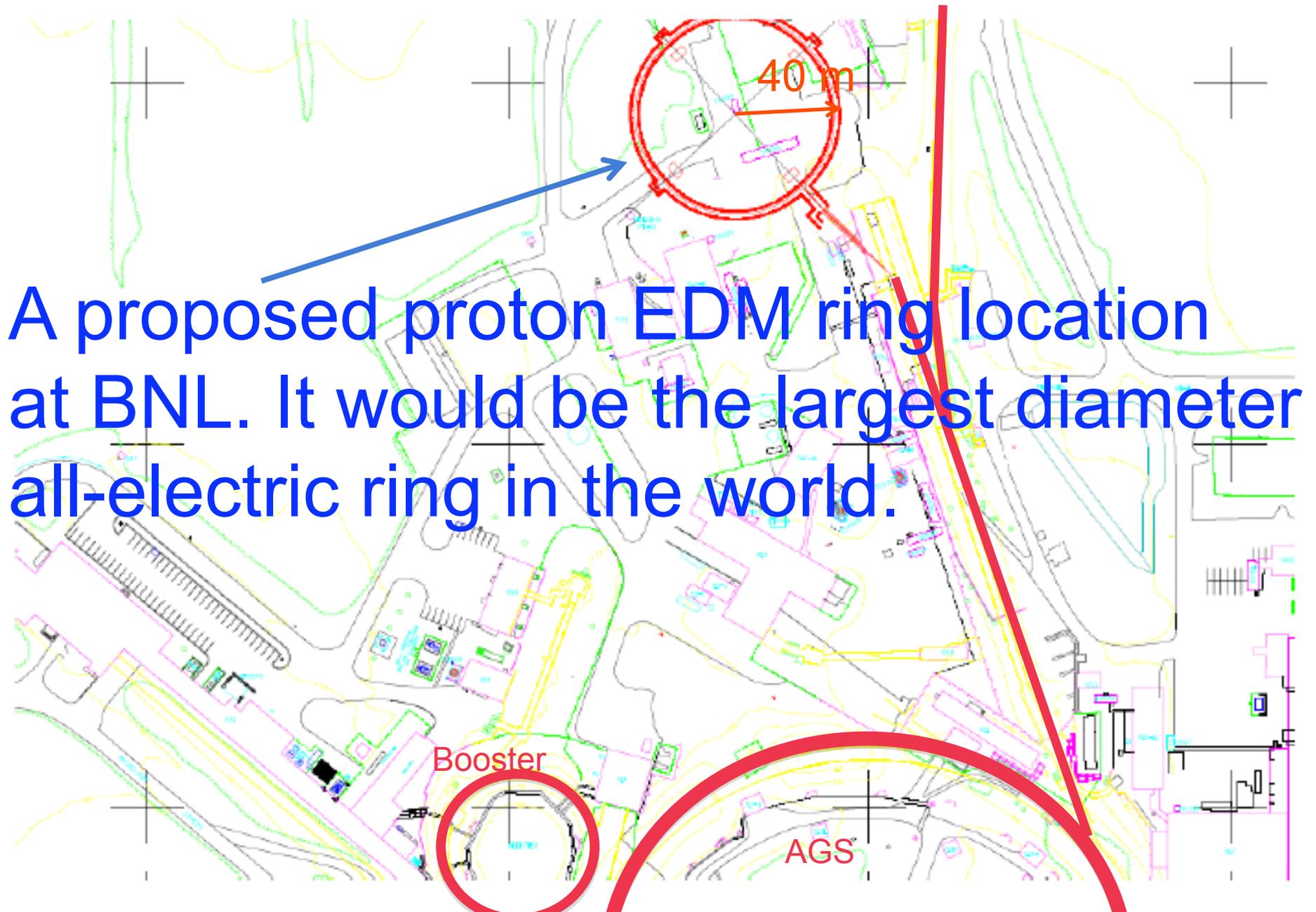
- Have developed R&D plans (need \$1M/year for two years) for
 - 1) BPM magnetometers, 2) SCT tests at COSY, 3) E-field development, and 4) Polarimeter prototype
- We had two successful technical reviews: Dec 2009, and March 2011.
- Sent a proposal to DOE NP for a proton EDM experiment at BNL: November 2011

Physics/effort comparison

- Physics reach $\sim 10^3$ TeV, similar to mu2e (MECO) experiment at FNAL; moreover, it can explain BAU (EW-Baryogenesis)
- SUSY-like new physics at LHC scale, it probes CP-violating phases to sub micro-radian level, complementary to LHC (plus fine-tuned SUSY)
- At 10^{-29} e·cm it's > an order of magnitude better than the best neutron EDM plans anywhere. Statistically superior to neutron EDM exps.
- Method can be applied to proton, deuteron, and ^3He to unravel the underlying physics. More than other methods can do.

Why srEDM at BNL?

- First rate physics, establishing leadership in the precision frontier (from the people who brought to you the Muon g-2 experiment...)
- Spin expertise: one of the best in the world;
Polarized sources: highest intensity in the world
- BNL can readily provide required proton beam parameters
- Possibility of S.C. with bunched beams to increase spin coherence time (SCT) $\rightarrow 10^{-30} \text{e}\cdot\text{cm}$
- Proton logistics (4×10^{10} pol. Protons/20mins) does not prevent other programs in parallel



A proposed proton EDM ring location at BNL. It would be the largest diameter all-electric ring in the world.

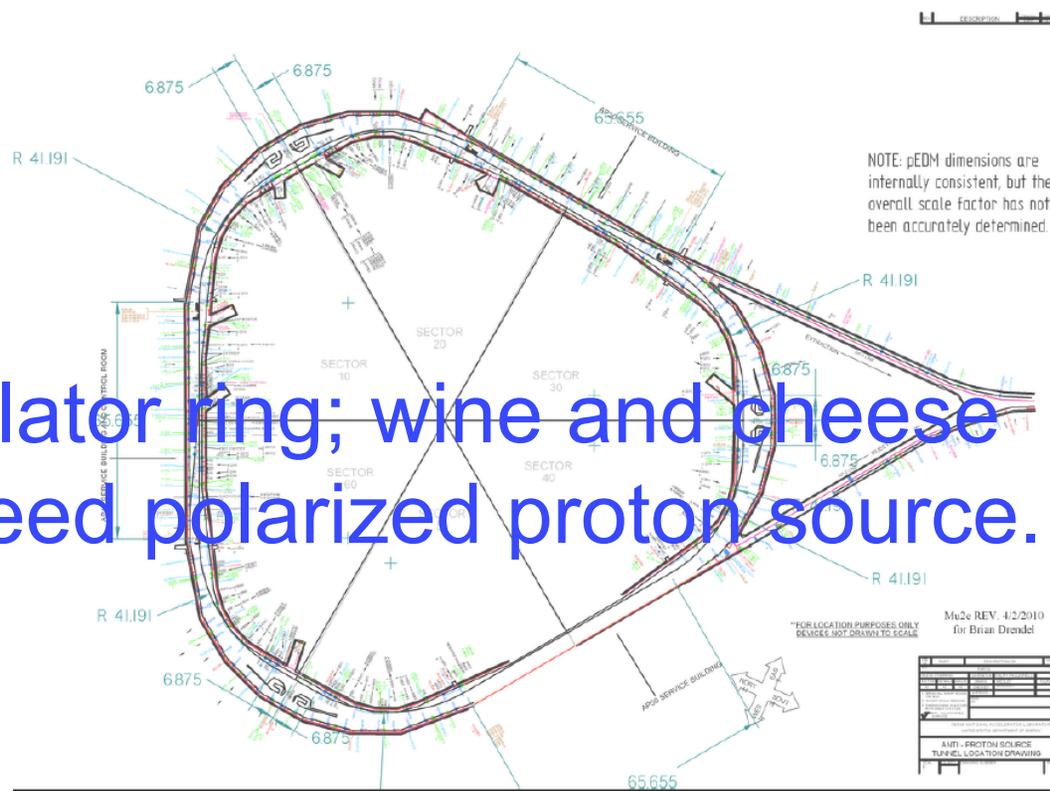
Figure 6 Storage Ring location in the North Area

Other possible places?

- COSY (Jülich/Germany) competes with FAIR (1B Euro) at GSI for funding; proposal for a precursor experiment; we have a common R&D collaboration.



- Fermilab, accumulator ring; wine and cheese talk on April 20; need polarized proton source.



From **Marciano's** presentation at the March 2011 review

Conclusion

1. Measurements of d_n & d_p with similar sensitivity essential to unfold underlying physics. Explain Baryogenesis
2. d_p has potential to do (10x) better than d_n
3. d_p at 10^{-29} e-cm **must do** experiment
**Explores physics up to scales
 $O(3000\text{TeV})$ for $\phi^{NP} \sim O(1)$ i.e. beyond LHC
or $\phi^{NP} \sim 10^{-7}$ at LHC discovery scales!**
4. Sets stage for $d_D = d_n + d_p + d(2 \text{ body}), d(^3\text{He}) \dots$