

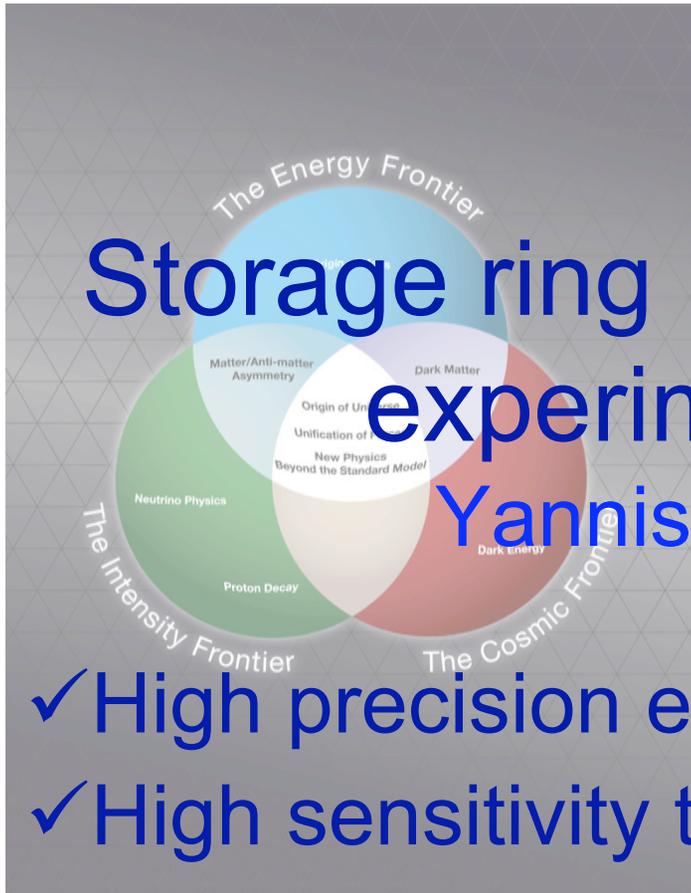
Storage ring Electric Dipole Moment experiment for the proton

Yannis K. Semertzidis, BNL

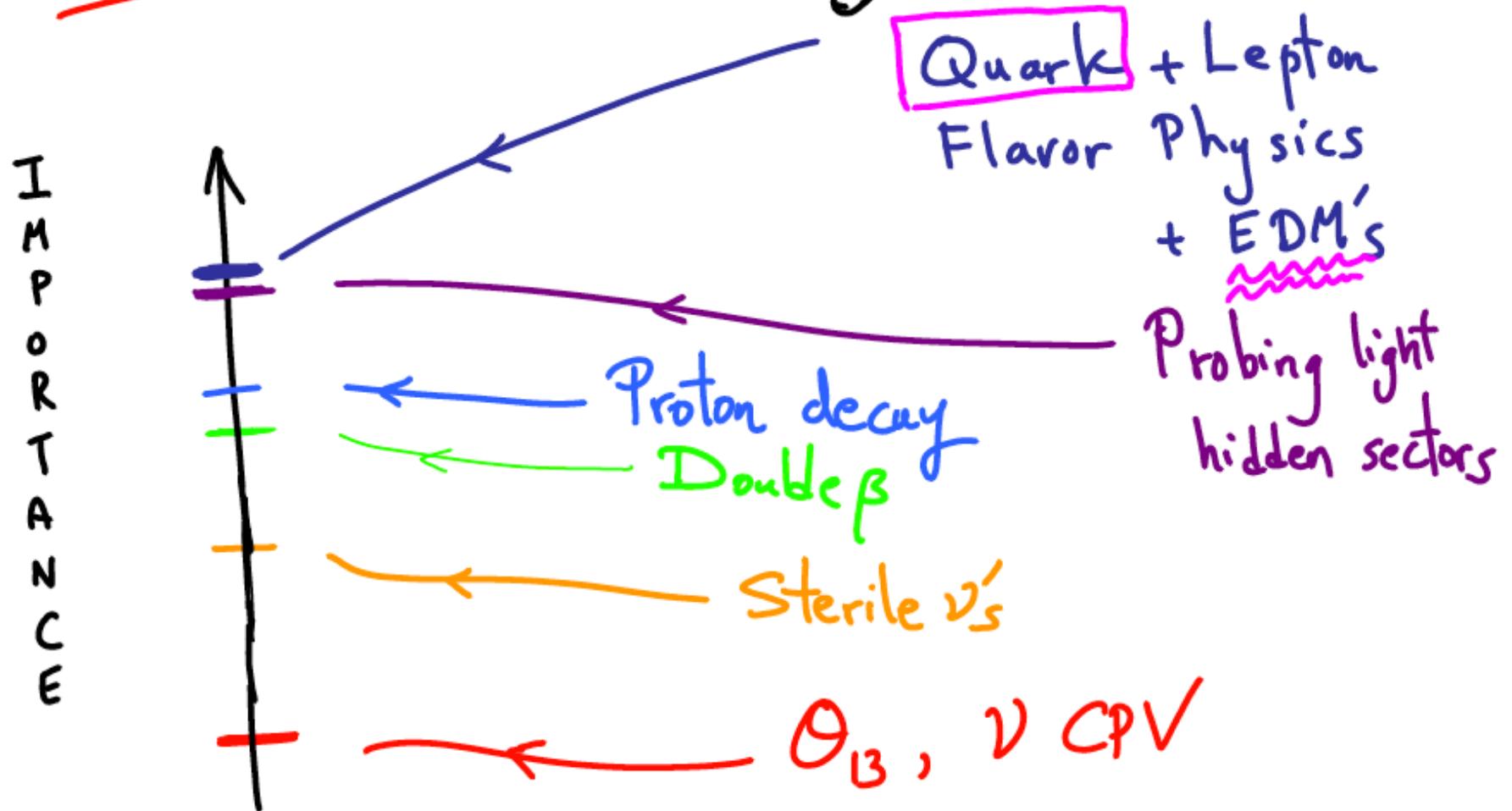
- ✓ High precision experiment: $10^{-29} \text{e}\cdot\text{cm}$
- ✓ High sensitivity to New Physics, $\sim 10^3 \text{ TeV}$

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

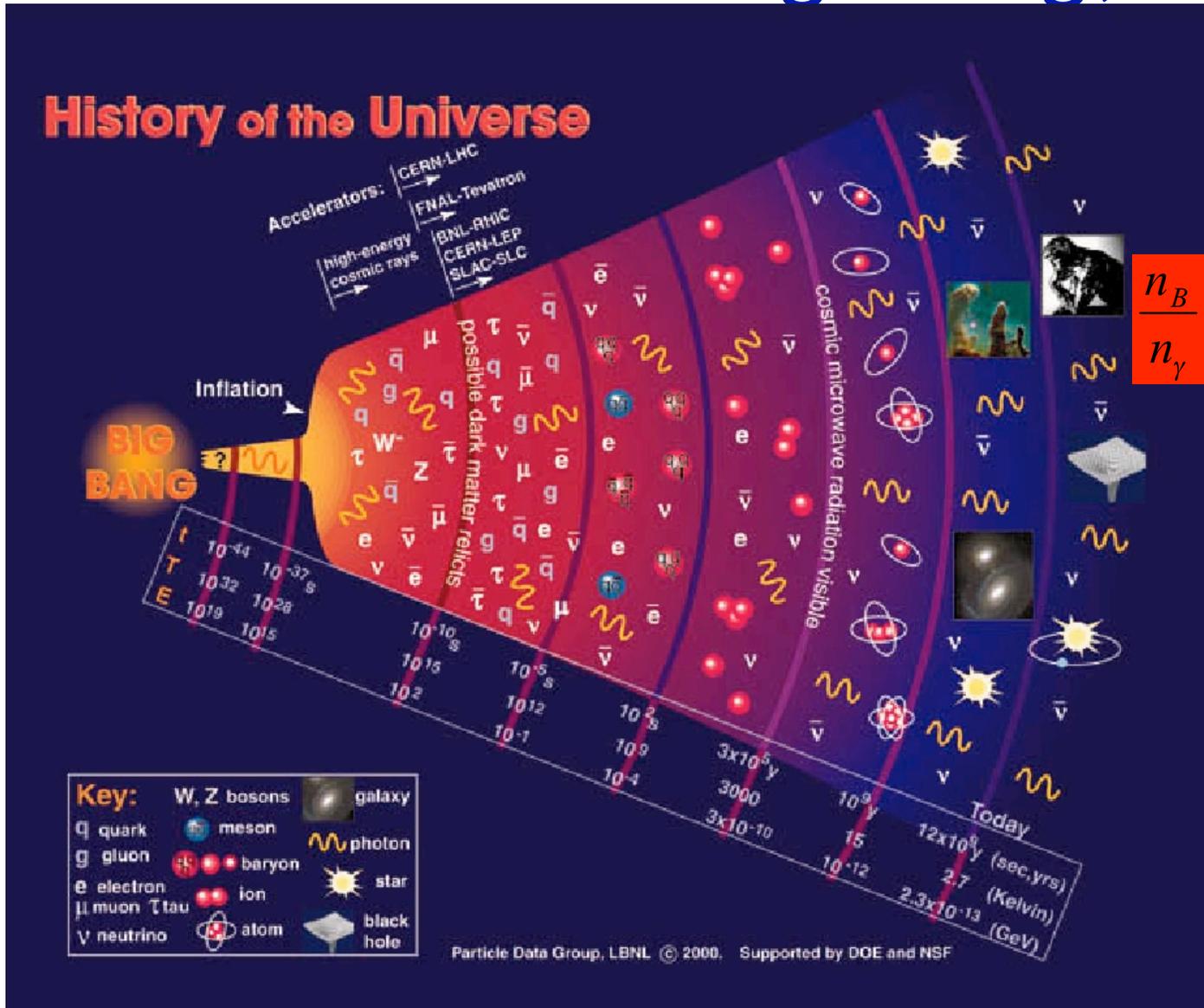
✓ Systematics best in an all-electric ring and counter-rotating (CR) stored beams.



My (Current!) Intensity Frontier Priorities



Why is there so much matter after the Big Bang;



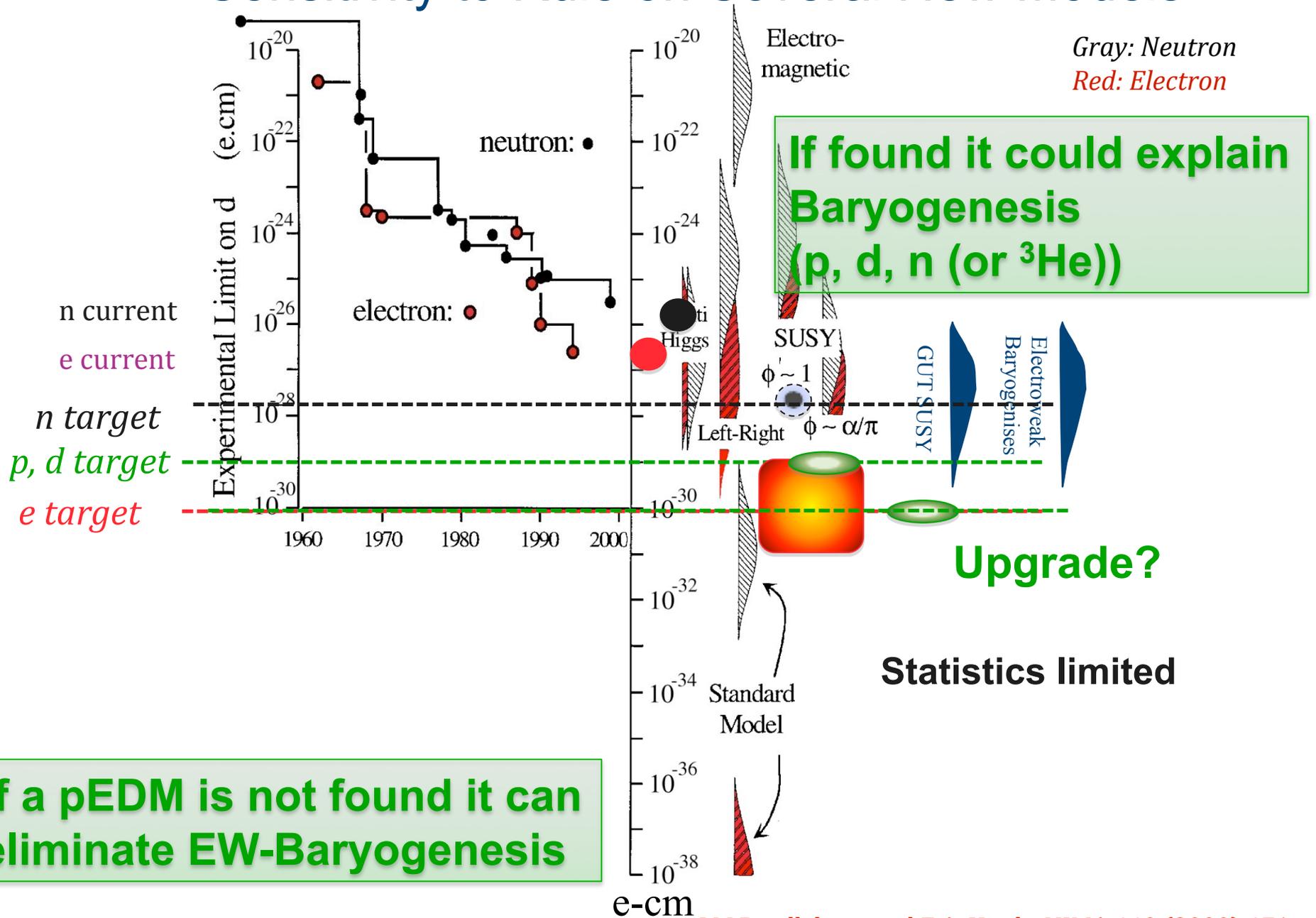
We see:

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

From the SM:

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

Sensitivity to Rule on Several New Models



If a pEDM is not found it can eliminate EW-Baryogenesis

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 detailed site plan of the North Area at Brookhaven National Laboratory. The map shows various buildings, roads, and utility lines in different colors. A red circle in the upper center is labeled '40 m' with a horizontal arrow, indicating the diameter of a proposed proton EDM ring. A blue arrow points from the text to this circle. A red line runs vertically through the right side of the map. At the bottom, two larger red circles are labeled 'Booster' and 'AGS', representing existing or planned facilities. The map also features several crosshair symbols.

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

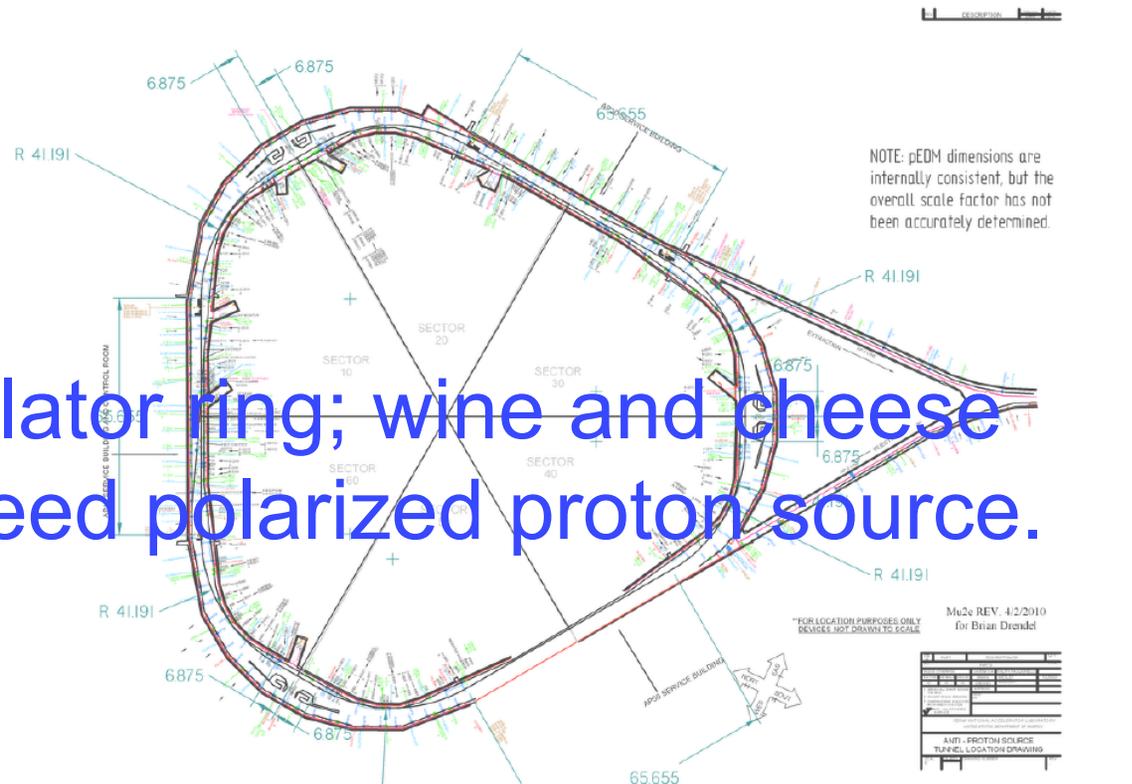
Figure 6 Storage Ring location in the North Area

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 $d_D = d_n + d_p + d(2 \text{ body}), d(^3\text{He}) \dots$