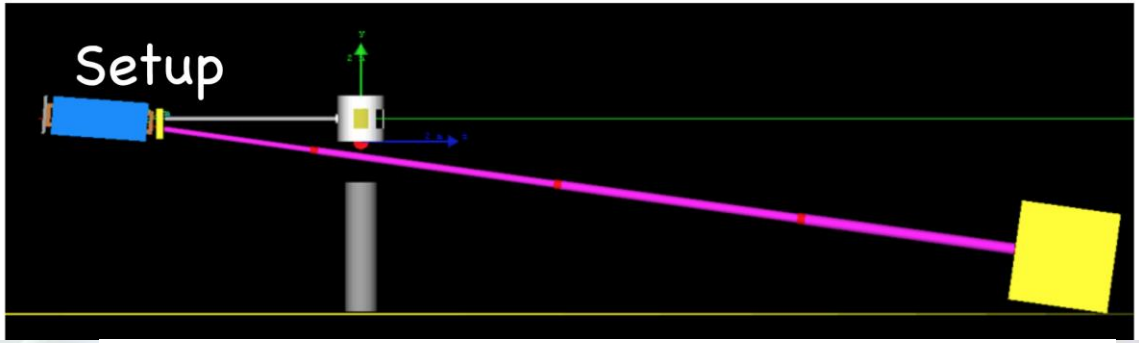
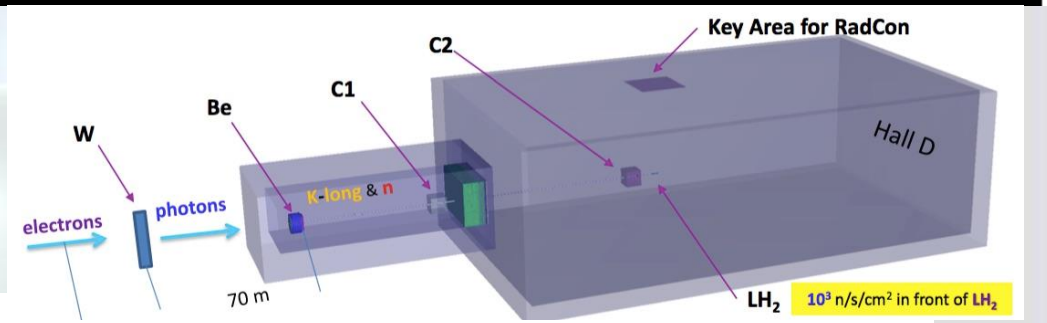
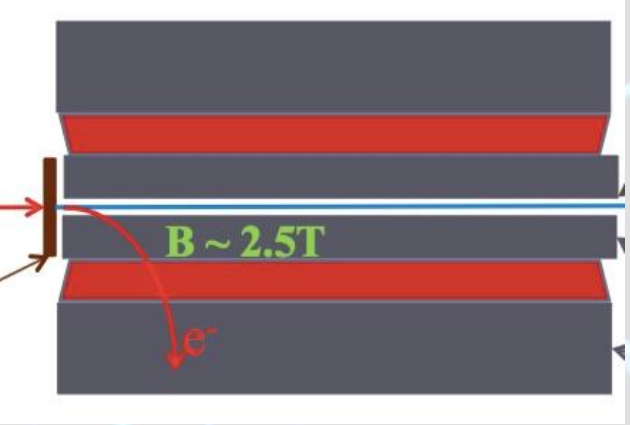
New Opportunities with High-Intensity Photon Sources

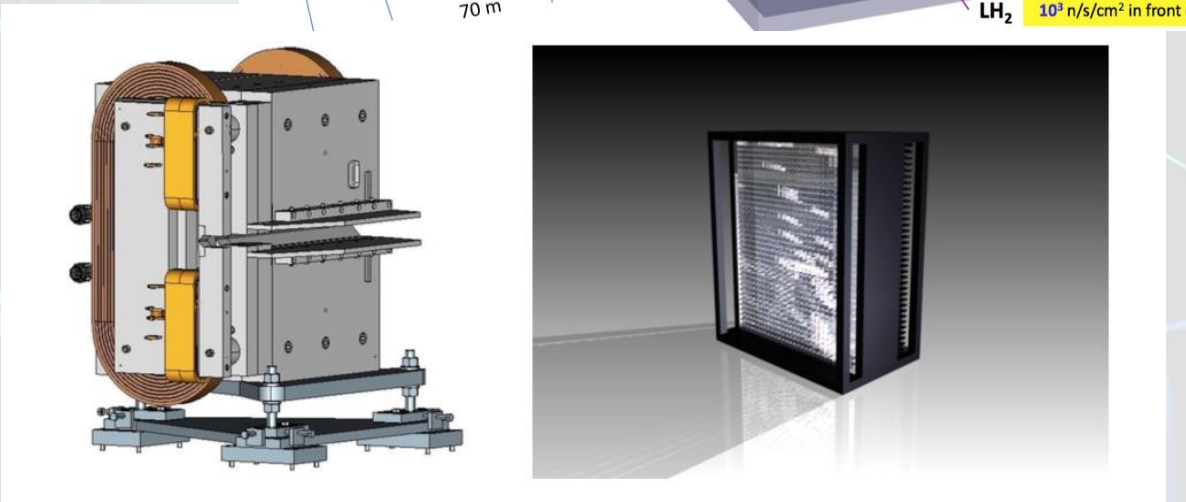
Summary of Optimized Photon Source and Science Opportunities

Thia Keppel

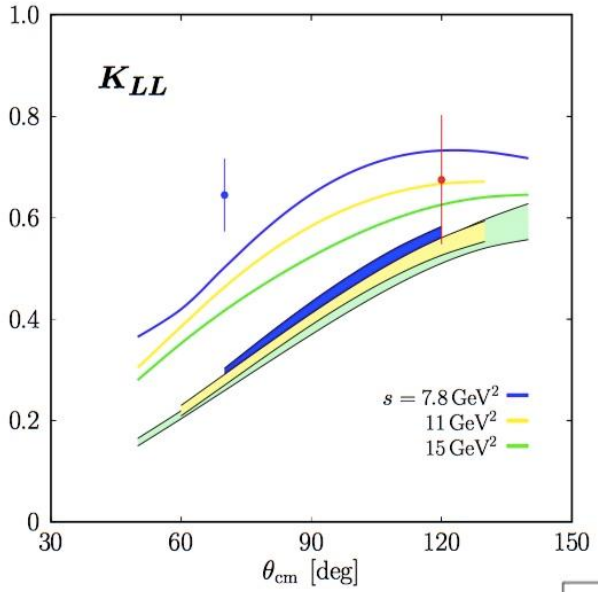








Multiple Science Opportunities….

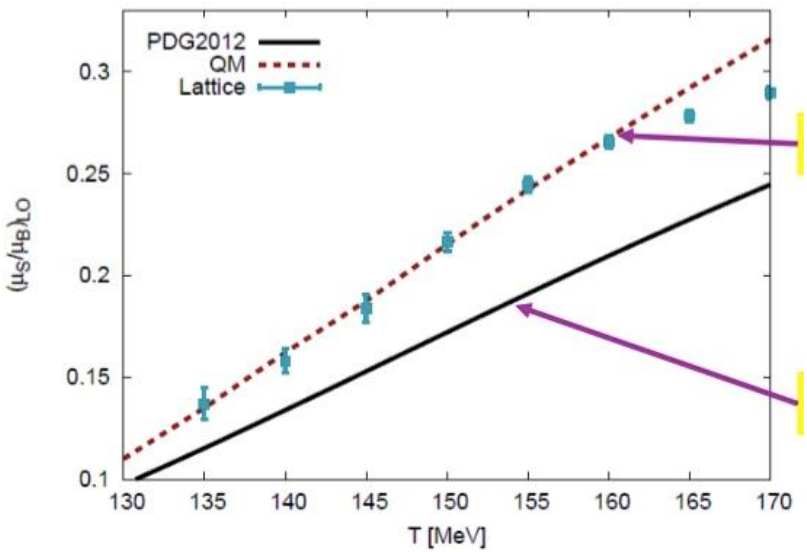


Wide Angle Compton Scattering
(K_{LL}, A_{LL}, K_{LS}, $A_{LS,..}$)

Kroll, Hamilton,..

Missing Hyperons
469!
Formation of baryons μseconds after big bang, QCD Thermodynamics of the Early Universe

Mai, Goity



measured yields of different hadron species in heavy ion collisions

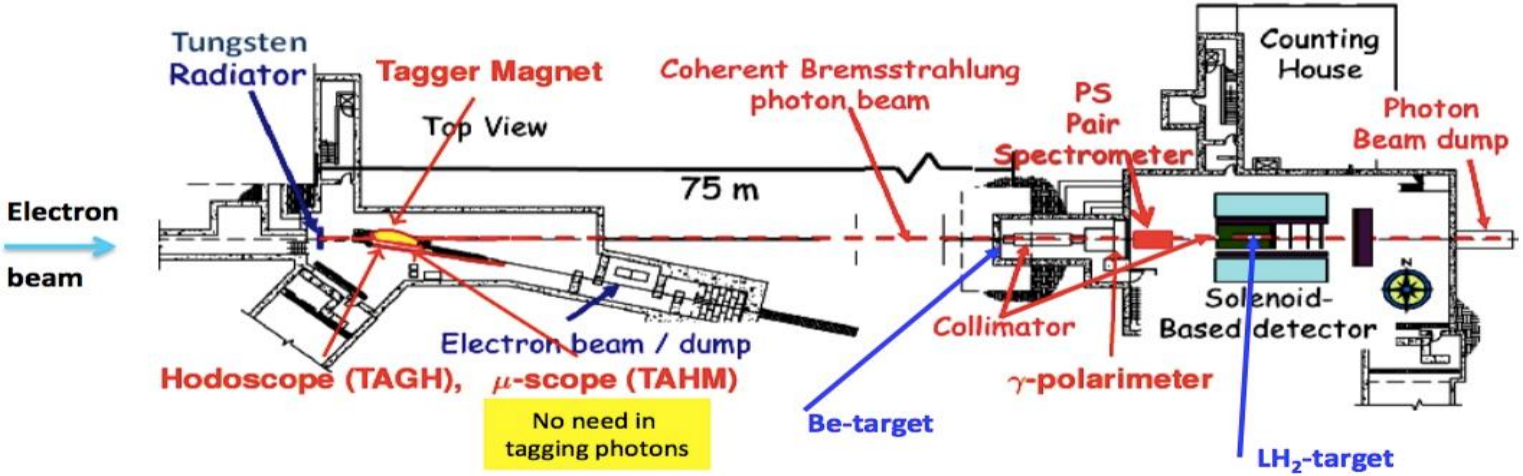
And more!

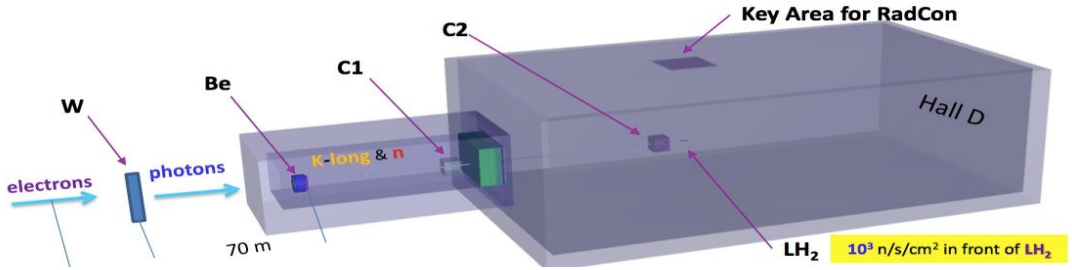
WACS exclusive photoproduction *(Sirca)*
Timelike Compton Scattering *(Tadevosyan, Mkrtchyan, Liuti)*
Short Range Correlations *(Sargsian, Patsyuk, Strikman)*
Photoproduction of Few Body Systems *(Sargsian)*

Also: Missing mesons, Phi production,…

Compact photon source is one component of K_L beam

(Strakovsky, Degtiarenko)

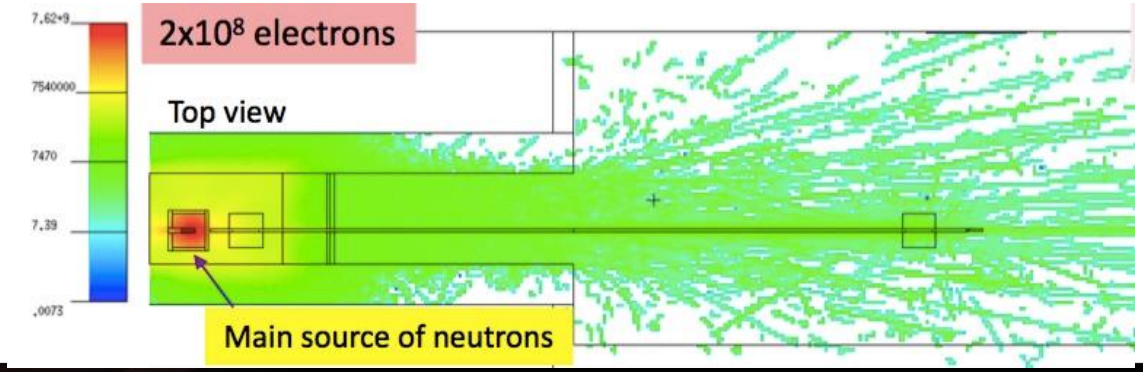




Approach:

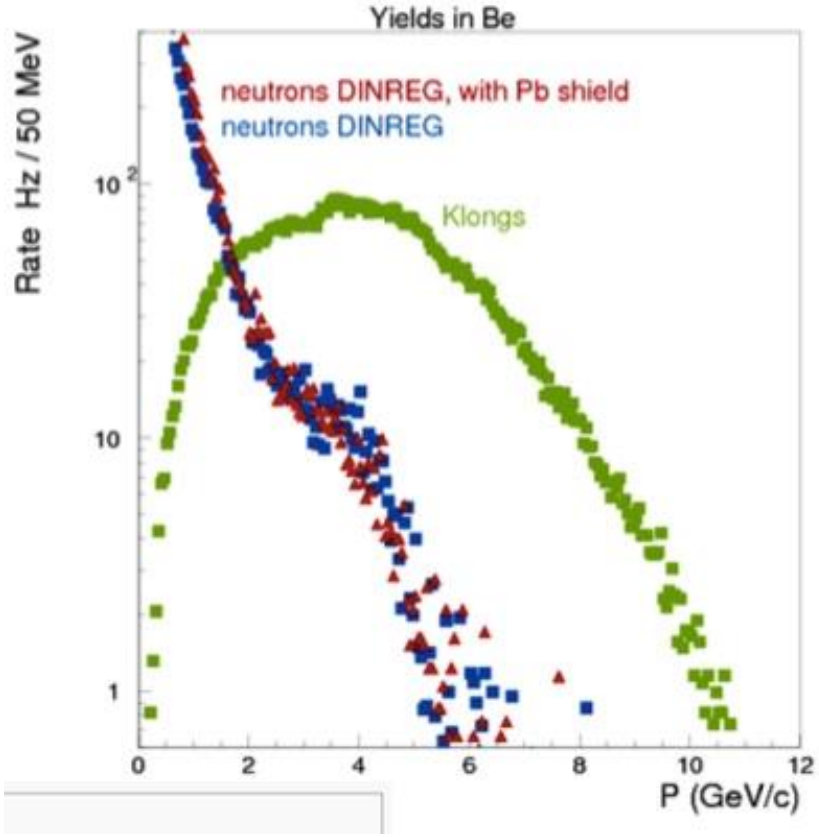
- Electrons hit W radiator
- Photons hit Be target
- K_Ls produced!

Tagger area facilitates shielding

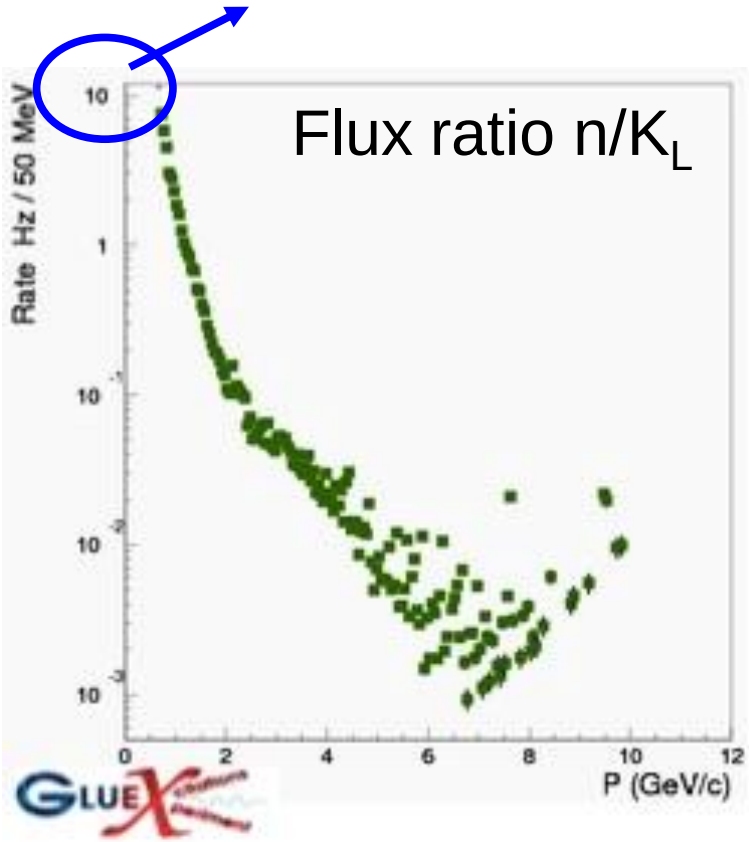


Refining the science case I…

- Hyperon spectroscopy, missing hyperons are strong motivation
- Large intensity and low neutron/K_L solid arguments



Compare to proton beam $n/K_L = 10^3$-10^4



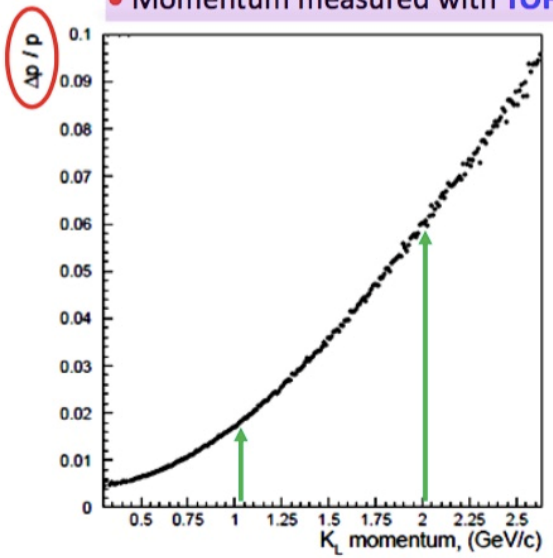
Could put SLAC data on same scale

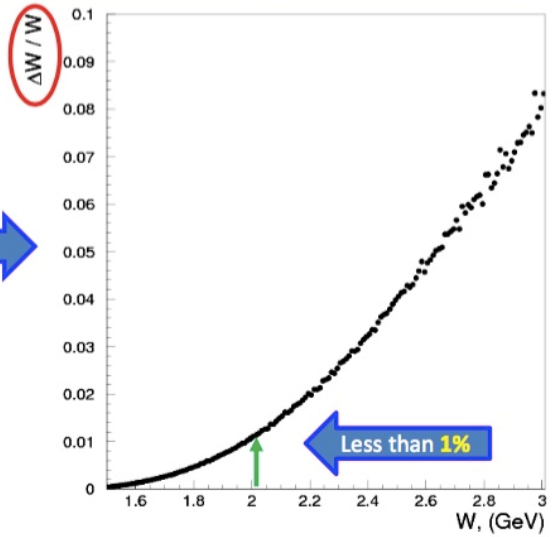
Refining the science case II…

Some suggestions:

1. Straightforward to improve resolution by using ~50 ps (?) timing rather than ~250 ps and get to W < 3 GeV!
2. Consider also unpolarized deuterium running (70/30% H/D split?)
3. Including expected data in Partial Wave Analysis to show potential impact of new measurements, *including p and n mix*

- Momentum measured with **TOF** between **SC** (surrounded **LH_2**) & **RF** from **CEBAF**.

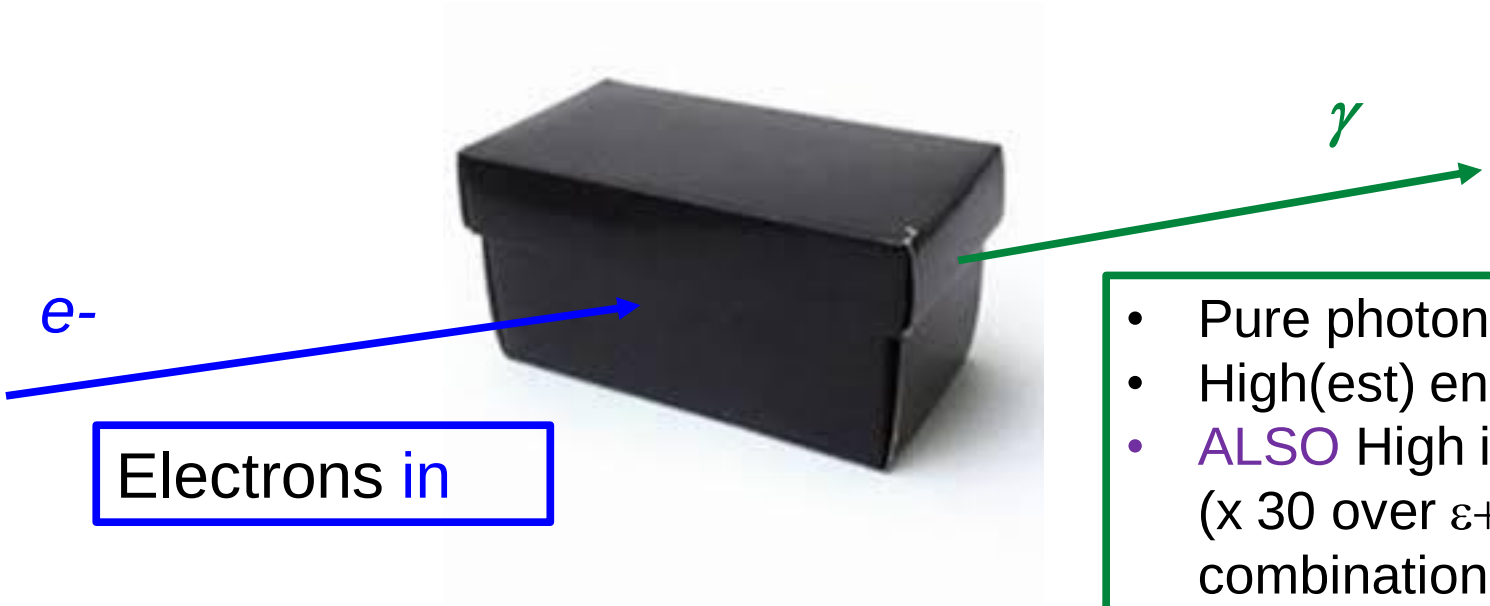




- Momentum resolution **Δp/p** is growing with momentum: for **1** GeV/c is **1.7%**, for **2** GeV/c is **6%**.

- For **W** < **2** GeV, **ΔW** < **20** MeV which is suitable to study **Hyperons** with **Γ** = **30** – **50** MeV.

A new, optimized photon source is required….

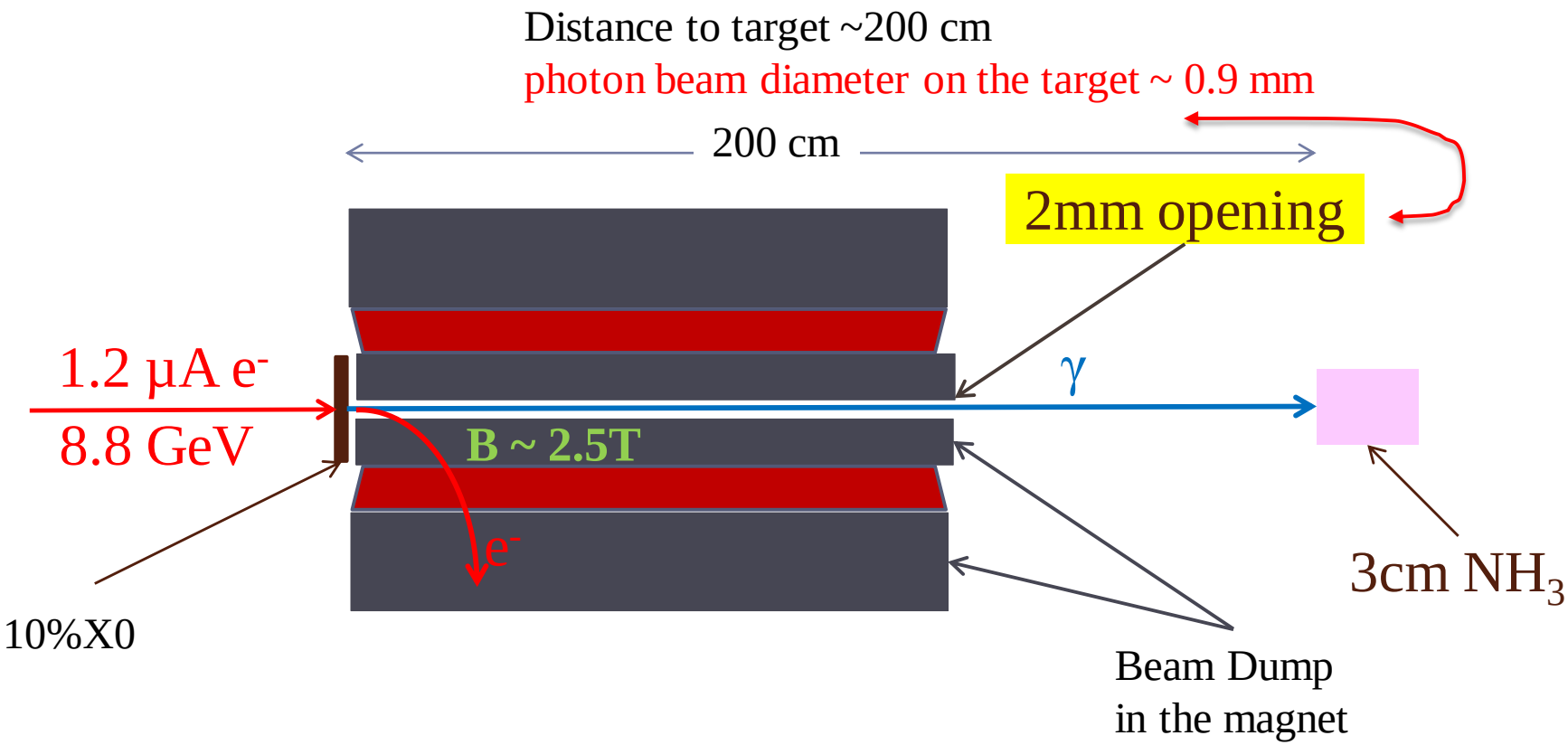


- Pure photons out
- High(est) energy
- ALSO High intensity (x 30 over ε+γ in combination with polarized target)
  - Reduced heat load
  - Higher polarization
  - Less depolarization

- But, what do we need in the box?
- Two main approaches (driven by Hall A/C WACS efforts)…

Hermetic Compact Photon Source (CPS)

(Wojtsekhowski, Niculescu)

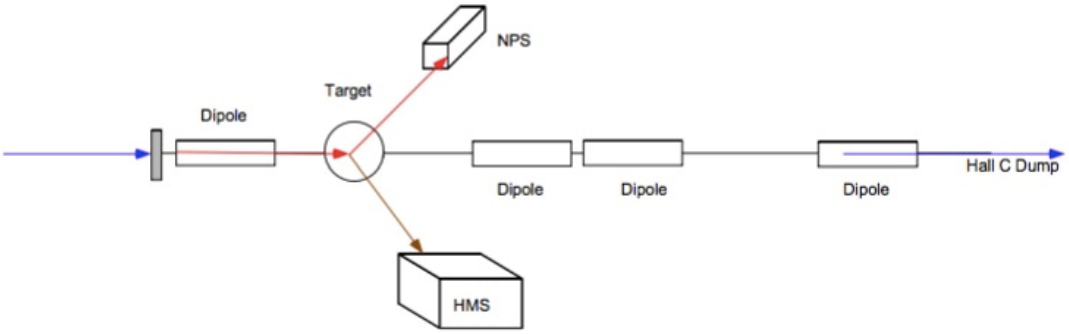


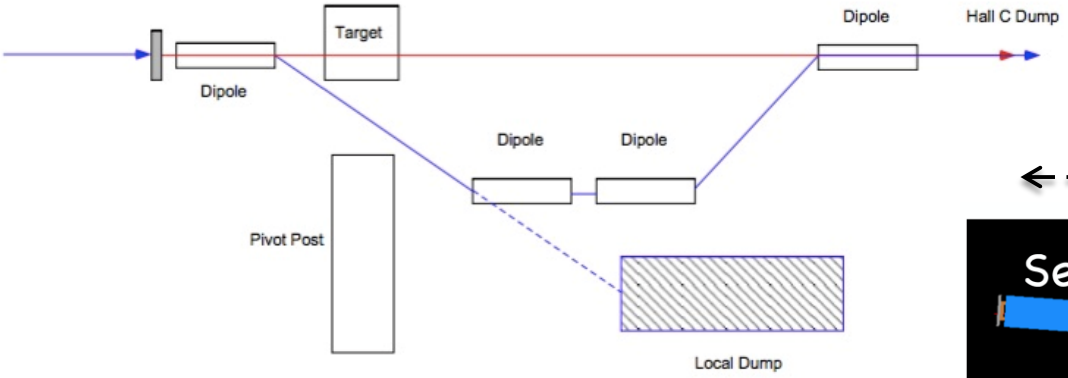
Approach:

- Bend magnet does double duty as beam dump
- Small bore allows high field (resistive)
- Compact, can place close to target

Separated Function Dipole and Dump (SDD)

(Day, Keller, Zhang)

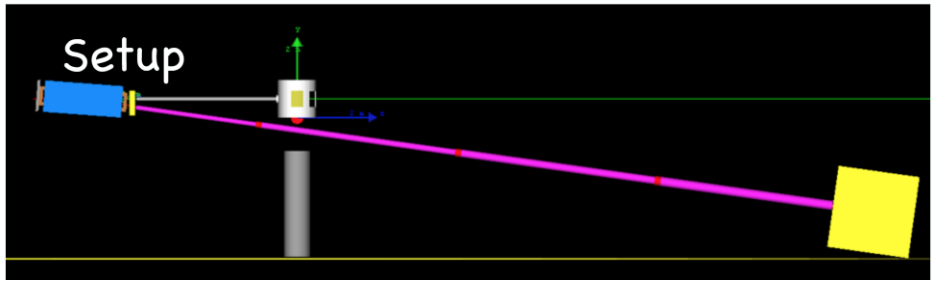




Approach:

- Beam dump separate and far away from target area
- Need to bend more to achieve this
- Reduces activation radiation to facilitate work on pivot

~ 20 m



How to compare? Some guiding parameters…

Physics considerations

- Pure photon
  - ✓ CPS
  - ✓ SDD
- High intensity (how high needed?) For 3 μAmp beam on 10% radiator…
  - ✓ CPS (6 x 10^{11} photons/sec)
  - ✓ SDD (4.2 x 10^{11} photons/sec)
- High energy (Multi-purpose source should design for 11 GeV)
  - ✓ CPS (8.8 GeV for WACS)
  - ✓ SDD (8.8 GeV for WACS)

How to compare? Some guiding parameters…

Practical considerations I

(Note: took out beam motion – assume rotating target *(Keller)*)

- < 2.5 T field
  - ✓ CPS
  - ✓ SDD (but higher field could bring closer to target, higher intensity)
- Hall integration (space)
  - ✓ CPS (shielding design/weight along beam line)
  - ✓ SDD (also beam dump fit at small spectrometer angles, could go red)
- Cooling needs (standalone magnet chiller? collimator?)
  - ? CPS
  - ? SDD
- Inter-Hall compatibility (note: both have associated NPS movement)
  - ✓ CPS (smaller, could be green)
  - ✓ SDD
- Cost
  - ? CPS
  - ? SDD

How to compare? Some guiding parameters…

Practical considerations II: Radiation *(Beminiwattha)*

- Minimize radiation for (~weekly?) work at pivot
  - ✓ CPS
  - ✓ SDD
- Minimize dose at de-installation – source magnet
  - ? CPS
  - ? SDD
- Minimize dose at de-installation – beam dump
  - ✓ CPS (no dump)
  - ? SDD
- Minimize dose to Hall equipment
  - ? CPS
  - ? SDD

A design path forward…

Need to compare apples to apples!

* Simulation benchmarking
  - Establish example, common (simple) setup for both groups to simulate and compare
  - Will likely also request JLab RadCon, others to do same
  - Beam on and beam off (radiation due to activation)
  - Neutron and photon
* Establish common numbers/locations for design goals
  - <2 mrem/hour at pivot right after beam off
  - For SDD, need dose rate at dump (done) - and along beam line?
  - Also goal number/location for Hall equipment (SHMS magnet?), dose and activation
- Consider experiments beyond WACS (even beyond Halls A/C)

** Lab will set up a meeting with CPS, SDD groups to fix goals and timeline*

A science/proposal path forward (for WACS)…

The PAC welcomes this physics, but recent proposals have lacked cohesive approach in both scientific focus and experiment design.

Suggestions:

- High s, t, u point(s) a clear priority
- Scan in s for ***both*** theta = 90 and ~120 degrees:

  ~2 more weeks PAC request won't matter!
- Combine efforts and collaboration, apples to apples comparison should make clear best photon source design choice – use ONE! (also a PAC suggestion)
- How important is large acceptance? Straightforward factor of ~3 from acceptance in beam time request? *Determine a strategy to determine Hall preference and also how to discuss in proposal.*
- Approach PAC willing to give up approved 15 days with combined beam if approved for pure photon.


Thank
you

Why are we here?

“This workshop aims at producing an optimized photon source concept with potential increase of scientific output at Jefferson Lab, and at refining the science for hadron physics experiments benefitting from such a high-intensity photon source. The workshop is dedicated to bringing together the communities directly using such sources for photo-production experiments, or for conversion into K_L beams. The combination of high precision calorimetry and high intensity photon sources can provide greatly enhances scientific benefit to (deep) exclusive processes like wide-angle and time-like Compton scattering. Potential prospects of such a high-intensity source with modern polarized targets will also be discussed. The availability of K_L beams would open new avenues for hadron spectroscopy, for example for the investigation of "missing" hyperon resonances, with potential impact on QCD thermodynamics and on freeze-out both in heavy ion collisions and in the early universe.”

Optimization of photon source concept – largely driven by Wide Angle Compton Scattering

Some clarification

- New “compact photon source” is optimized for use with polarized target
  - Designing for ~few x 10^{11} γ/s
  - If need high intensity and don’t mind electron-generated backgrounds, Bremsstrahlung source likely better
- Hall D already has a coherent photon source (10^8 γ/s)
  - The source being discussed here would be used in Hall D beam line to generate instead a K_L beam (use Be target)