Experimental Options for the Charm Studies at JLab

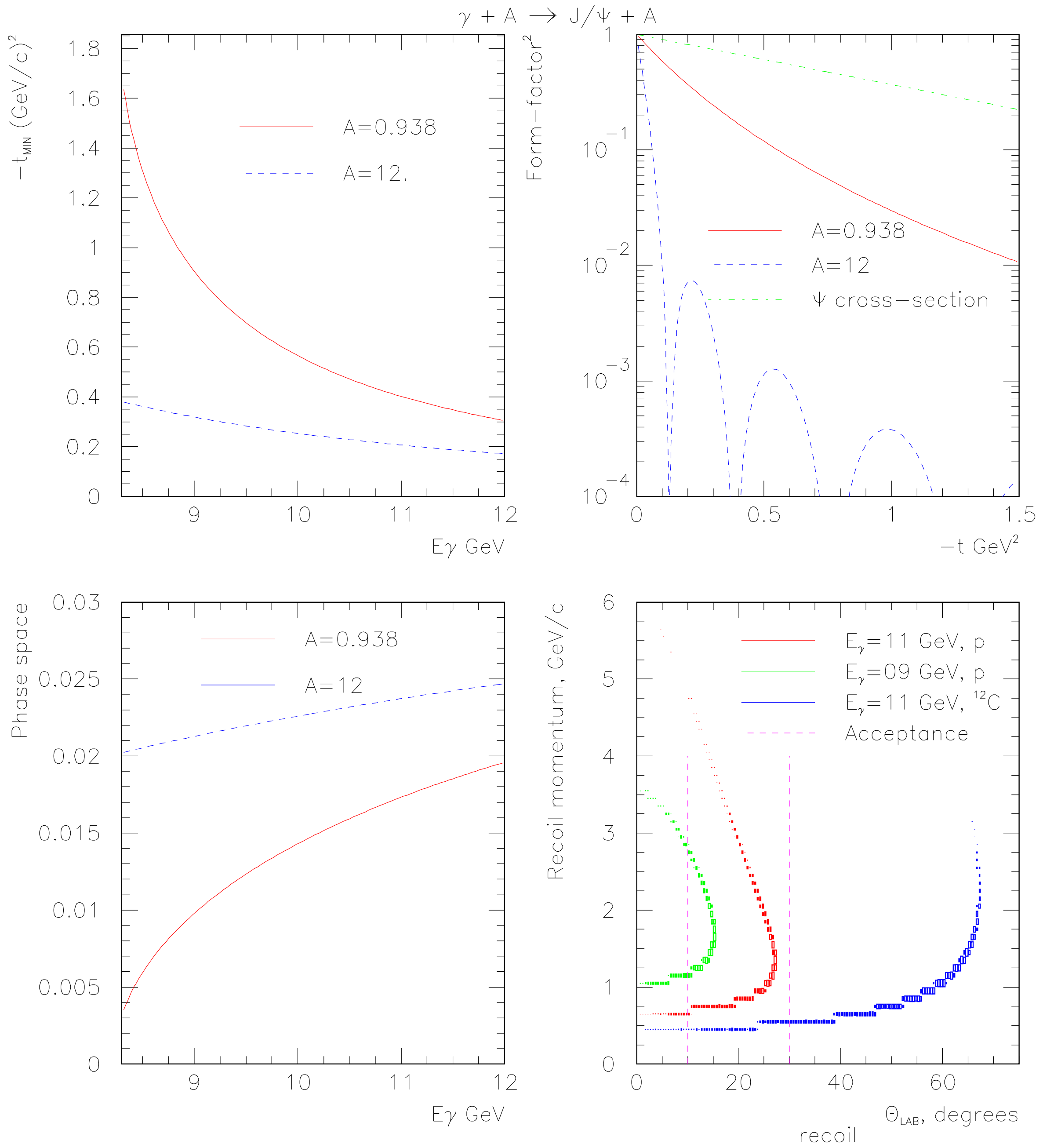
What can be done at JLab?

reaction	measured	impact
γp $\rightarrow J/\psi(1S)$p	$\frac{d\sigma}{dt}$ (E$_\gamma$)	Production mechanisms
$\psi \rightarrow$e$^+$e$^-$,$\mu^+\mu^-$		Models: gluon PDF
		Models: $\sigma_{\psi N}$
γA $\rightarrow J/\psi(1S)$X	$\frac{d\sigma}{dt}$ (A)	Models: $\sigma_{\psi N}$
$\psi \rightarrow$e$^+$e$^-$,$\mu^+\mu^-$		
γp $\rightarrow \Lambda_c^+ \overline{\mathrm{D}}^0$	$\frac{d\sigma}{dt}$ (E$_\gamma$)	Production mechanisms
$\overline{\mathrm{D}}^0 \rightarrow \mathrm{K}^+\pi^-$		
....		

$J/\psi(1S)$: improvements with respect to the old experiments:

- Higher statistics $\times 1000$ (energy bin $\approx$0.5GeV, cross-section down to 0.05nb).
- Detecting of the recoil (inelastic $\approx 30\%$!)
- Better systematics

γ+A$\rightarrow$ J/Ψ+A Kinematics



Elastic production on nuclei is strongly suppressed by the formfactor.

Experimental Options for the Charm Studies at JLab

How to detect, say $\gamma p \to J/\psi(1S)p$?

Recoil's momentum and angle ranges are similar to those of e^+e^-, but its direction is not correlated with e^+e^-.

- A large acceptance detector
- A relatively low luminocity

Let us consider an open detector consisting of:

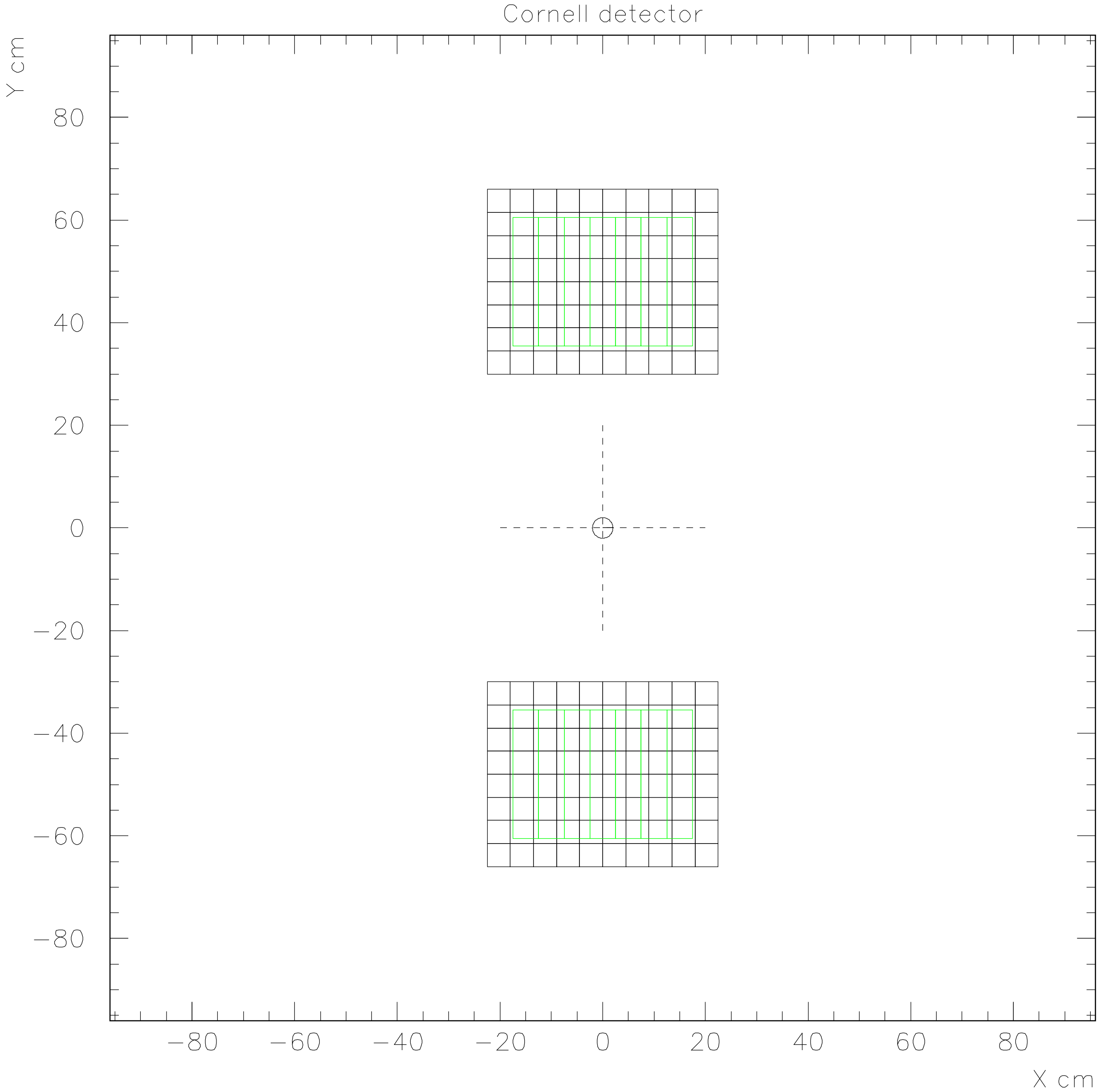
- Calorimeter for detecting e^+e^-: the energy and the coordinates are measured.
- A scintillator (lucite?) hodoscope in front of the calorimeter
- Protons are detected/identifies using the calorimeter and a scintillator detector behind
- Tracking would be of a big help in order to reduce the accidental rate (in a long target) and backgrounds

Limitations for "Open Detector" experiments

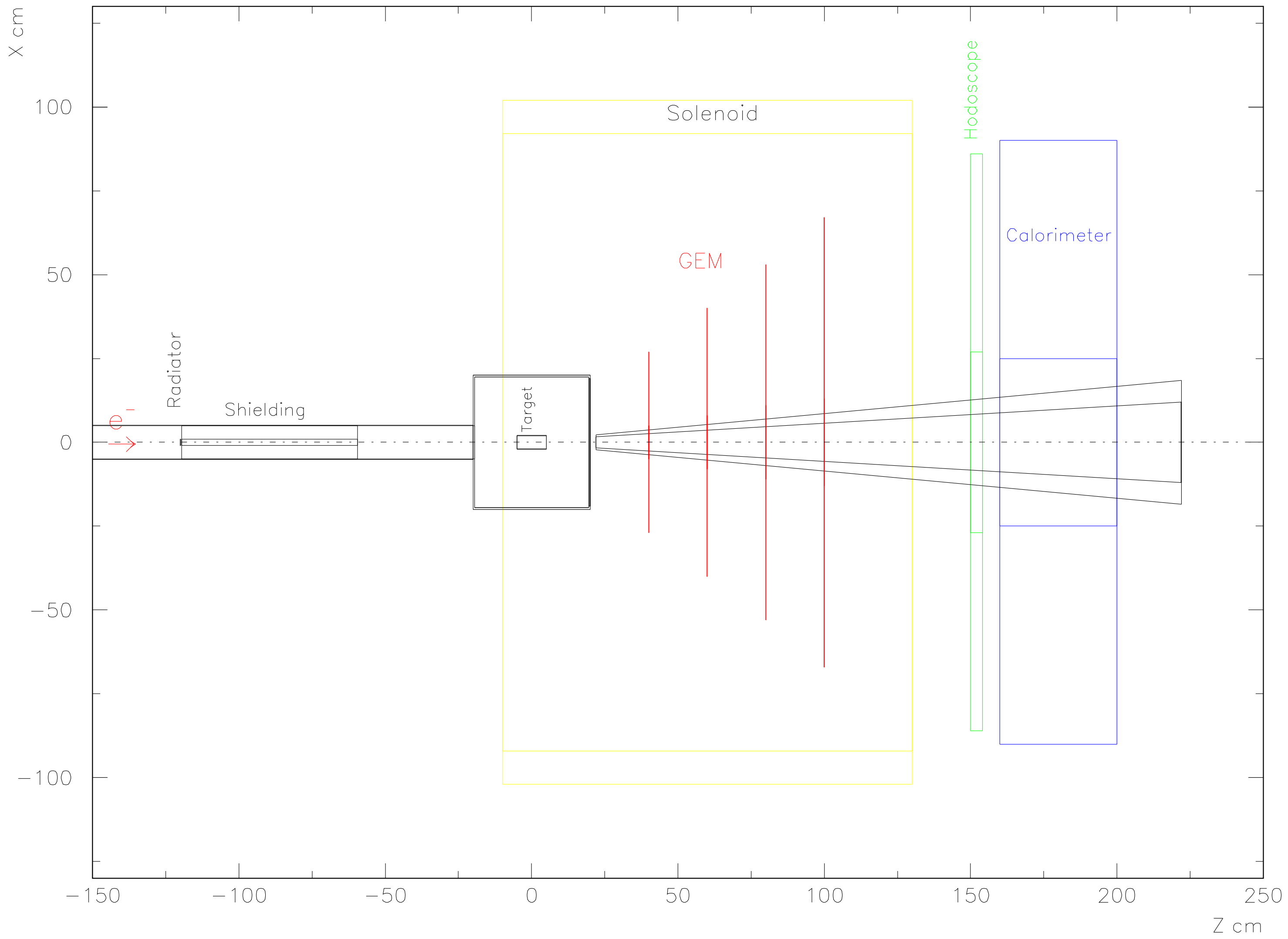
High rate of electromagnetic background in e^- and γ beams. The limitations on the possible luminocity are driven by:

- Detectors:
  - Calorimeters: energy flow/s/module ($< 2 \cdot 10^5$GeV - from RCS tests);
  - Track detectors: charged particle flow/s/cm^2 ($< 10^7$ for GEM, HERA-B: $< 0.25 \times 10^7$);
  - Scintillator: charged particle flow/s/module ($< 3 \times 10^6$);
- Trigger rate: ($< 2 \cdot 10^4$/s)
- Accidental coincidence
  - CEBAF: resolution time of 2ns;
  - Track reconstruction with an extended target: a factor of $>$10 improvement;

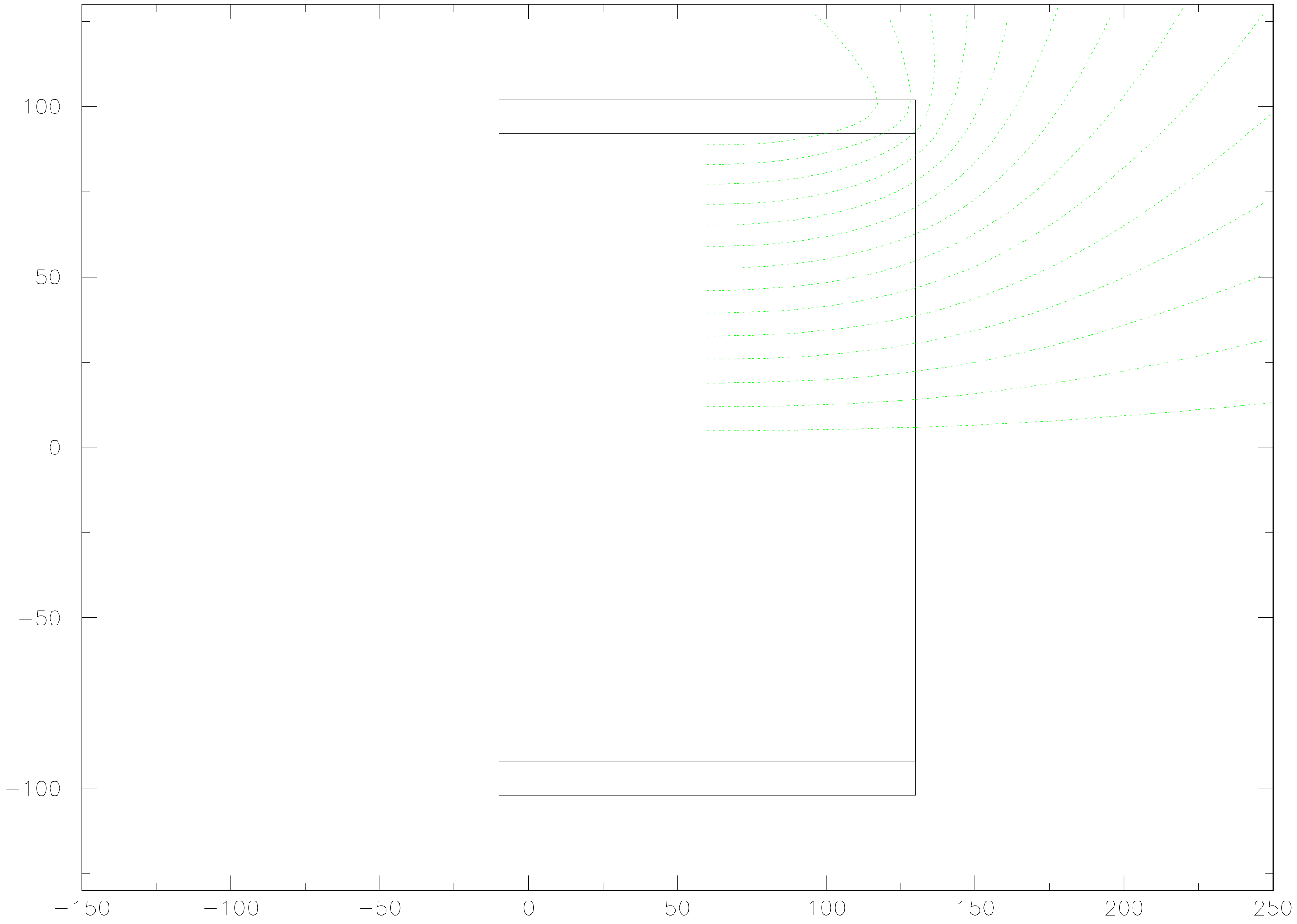
The Cornell Detector



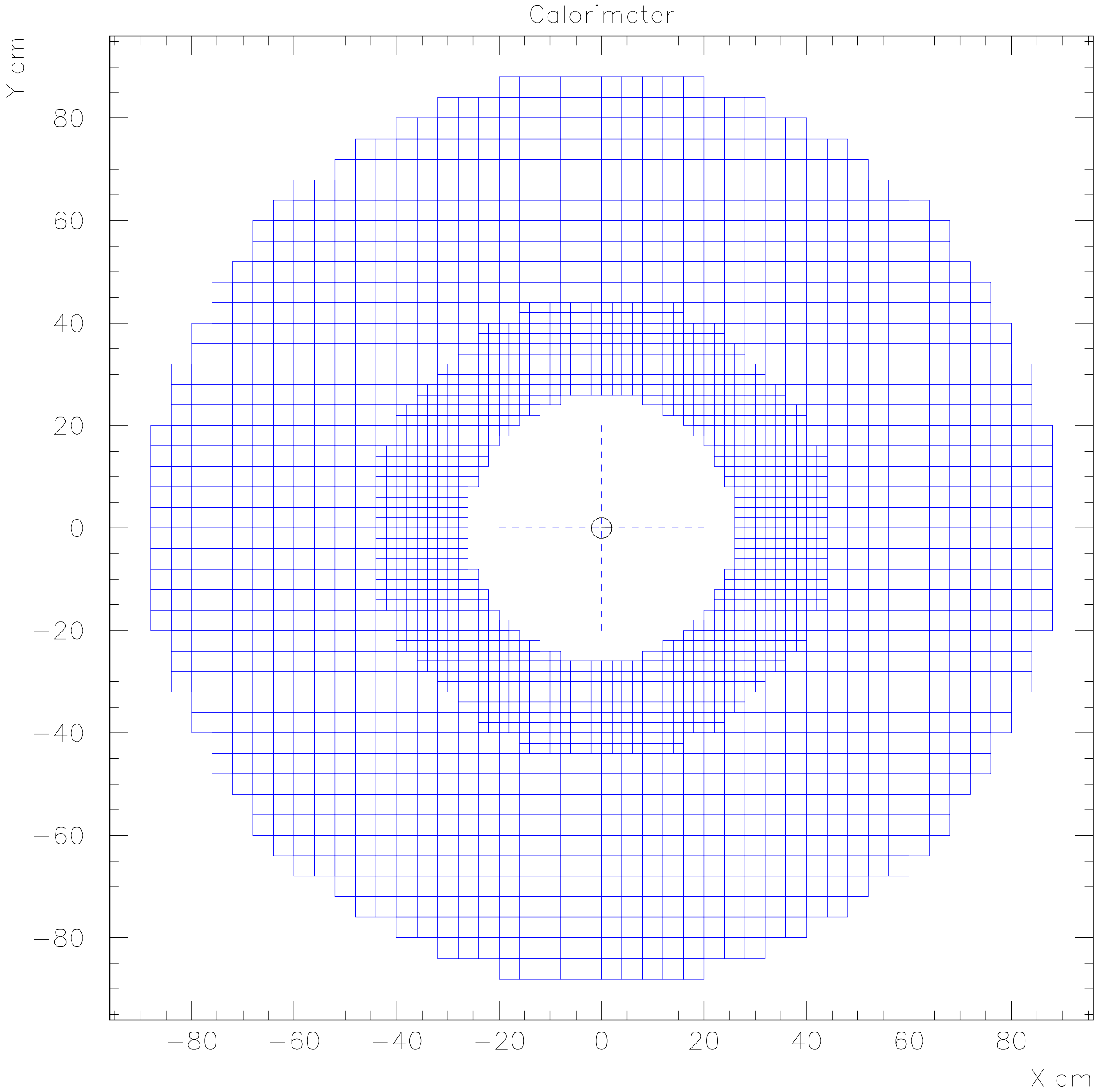
Proposed Calorimeter Setup



Solenoidal field

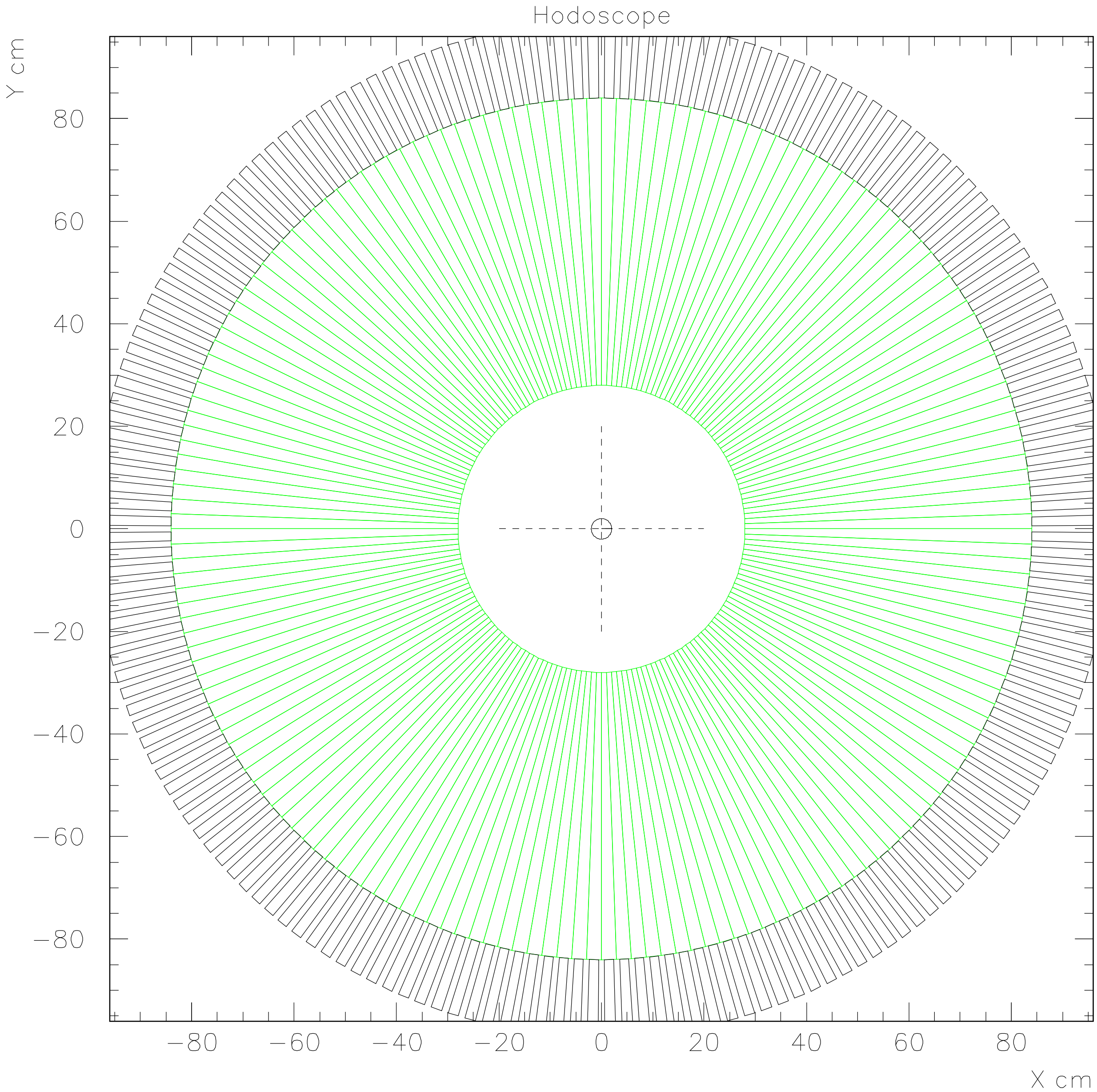


Proposed Detectors



Number of modules: 1136 of $4 \times 4\text{cm}^2$ lead-glass and 1028 of $2 \times 2\text{cm}^2$ PbW crystalls.

Proposed Detectors



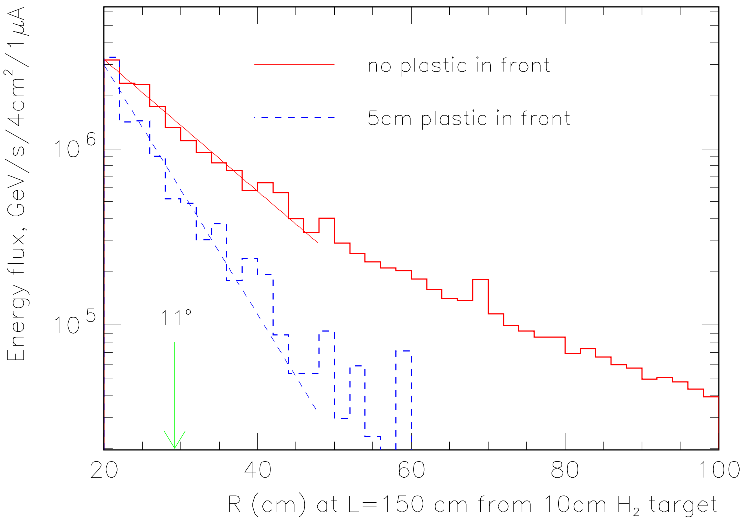
Number of modules: 180 of lucite.

Normalization of MC results

How well does GEANT simulate the background particle flux?

Tests in Hall A used LG modules 4×4cm^2 at 10m from the 15cm H_2 target. There ≈5cm of plastic in front of LG.

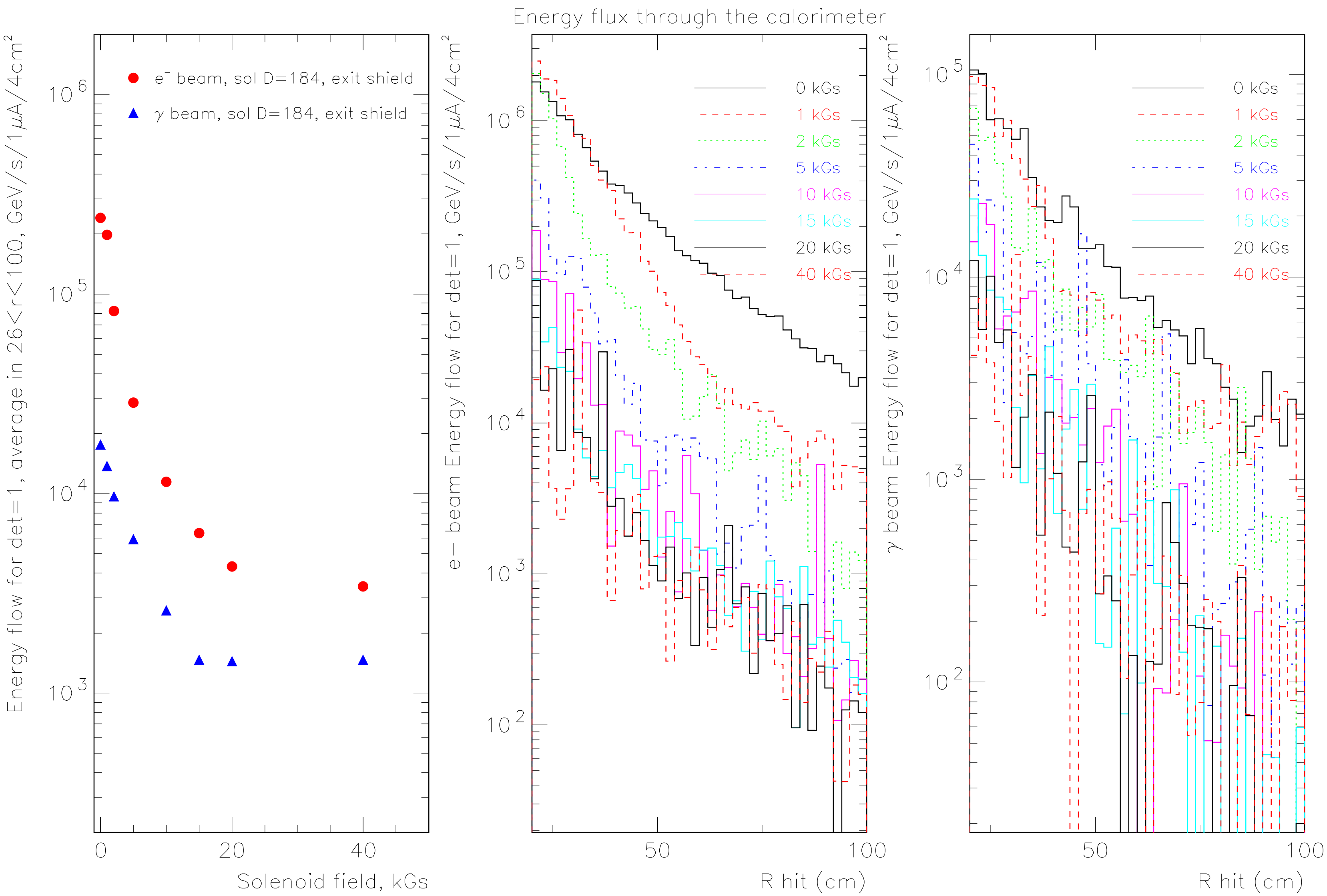
E_b GeV	μA	θ	pedestal shift	Energy flux GeV/s/block	MC flux GeV/s/block
1.833	23	11^o	14 cha	$1.1 \pm 0.2 \cdot 10^6$	$1.5 \cdot 10^6$
1.833	1	11^o	≈1 cha		



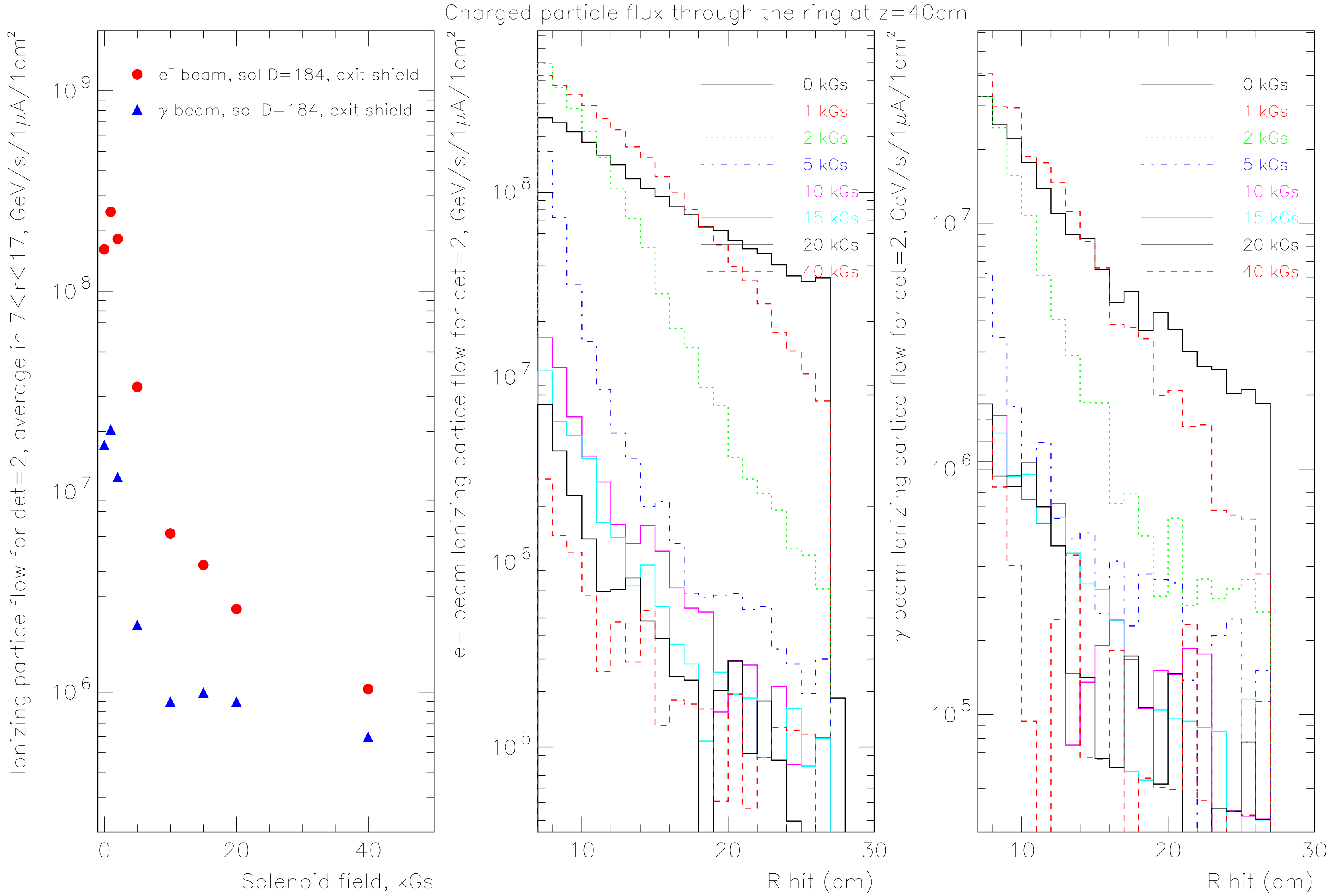
Mainly from e^- at low angles.

Result: GEANT provides a sufficiently good argeement with the measurements.

Background MC Simulation: Calorimeter



Background MC Simulation: Coordinate detectors



Comparison: Cornell - JLab proposal

meaning	Cornell, 1975	JLab proposal
Duty cycle	0.07	1.
End point, GeV	11.8	11.
E_γ range, GeV	9-11.8	8.5-11.
Beam	γ	e^-
e^- beam current	-	1μA
Radiator	-	0.05
N_γ, in spill, E range	$1.4 \cdot 10^{10}$/s	$6.2 \cdot 10^{11}$/s
Target	2.9 g/cm^2 Be	0.7 g/cm^2 LH
$\mathcal{L}$, in spill, cm^{-2}s^{-1}	2.5×10^{34}	2.6×10^{34}
Magnetic field	0.85kGs·m dipole	20kGs solenoid
Days of running	14	90*0.7=63
$\int \mathcal{L} \cdot$ dt, cm^{-2}	1.5×10^{39}	1.4×10^{41}
Acceptance	≈ 0.03	≈ 0.3
$J/\psi(1S)$ / BG	500/100	$\times 1000$
Recoil detected?	no	yes

Detecting γA $\rightarrow J/\psi(1S)$X

Options:

- Similar to γp $\rightarrow J/\psi(1S)$p, no nucleus recoil detected
- With the option of detecting a nucleus recoil
  - Thin target $\approx$ 20mg/cm^2
  - Beam $\approx 40\mu$A
  - Low pressure chamber for detecting nuclear recoils

Conclusion

Experiment for γA $\rightarrow$J/ψ(1S)X:

- Solenoid R>80cm, 2T
- Calorimeter: $\approx$1100 of 4×4cm^2 lead-glass and 1028 of 2×2cm^2 PbW crystalls.
- GEM $\approx$1.5m^2
- Hodoscope $\approx$200 modules

Would provide a precise measurement of $\frac{d\sigma}{dt}$ (E$_\gamma$) on protons, from 8.5 to 11 GeV (in 5 bins) in a 3 month run.

The same setup can be used for production on nuclei.