

The GLUEX Experiment

Yves Van Haarlem
for the GLUEX collaboration

Carnegie Mellon

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OUTLINE



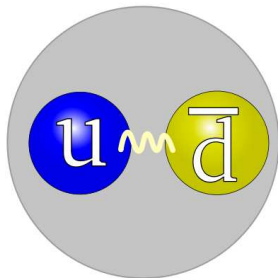
- 1 **Physics motivation**
 - Confinement
- 2 **Requirements**
 - Beam
 - Detector
 - Overview
- 3 **The GLUEX detector**
 - Hall-D
 - Spectrometer
- 4 **Status and Future**
- 5 **More physics**
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CONFINEMENT



- Strong QCD
 - Gluons have color-charge
→ are self interacting
 - Gives rise to flux tubes
(Y. Nambu - 1970)
 - $V(r) = -\kappa r$
 - Non-perturbative

CONFINEMENT



$0^{+-} : \pi^+$

$1^{--} : \rho^+$

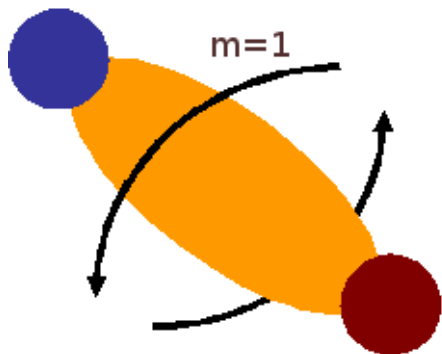
- Strong QCD

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- Mesons

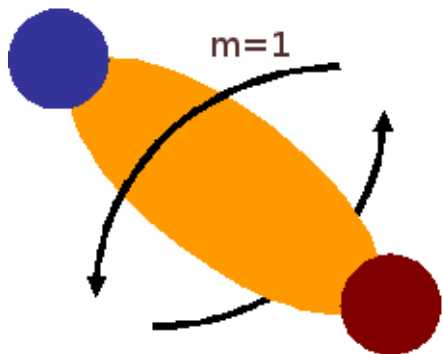
- 2 quarks + flux tube
- Studied/mapped in spectroscopy
- Characterized by J^{PC} quantum numbers
- Some combinations are forbidden (e.g. 0^{+-}):
→ Exotic mesons

CAN THE GLUE BE EXCITED?



- Mesons with excited flux tube
 - Hybrids: L in flux tube
 - $J^{PC} = 1^{+-}$ and 1^{-+}
 - About 1 GeV/c above ground state meson spectrum
 - Exotic quantum numbers possible

CAN THE GLUE BE EXCITED?



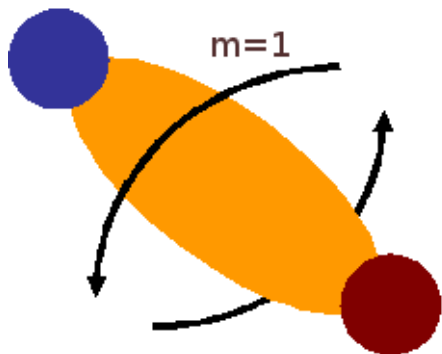
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- Lattice calculations predict:

(Phys. Rev. D56 (1997) 7039)

 - 1^{-+} : ~ 1.9 GeV/c² (lightest nonet)
 - 2^{+-} : ~ 2.1 GeV/c²
 - 0^{+-} : ~ 2.3 GeV/c²

→ **Exotic quantum numbers!**

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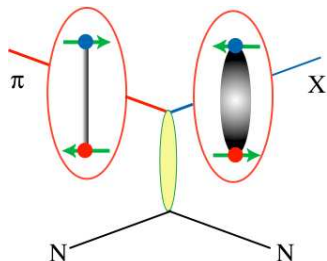
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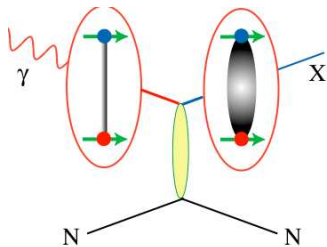
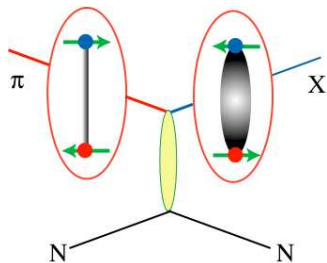
→ **Exotic quantum numbers!**

→ **GlueX wants to map out the hybrid mesons** ←
 Measurement of the excited QCD potential

π/γ BEAM? π beam

- π with excited flux tube:
 - $m=1, S=0, L=0, J=1 \rightarrow 1^{++} 1^{--}$
 - **No** exotic hybrids
- Quark spin flip \rightarrow exotic hybrids
BUT $\sigma_{exotic-meson}$ reduced ($\ll \sigma_{meson}$)
- A lot of data but little evidence for hybrids

π/γ BEAM?



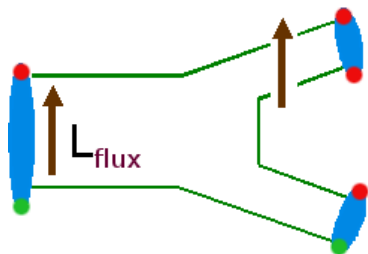
π beam

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γ beam

- $q\bar{q}$ with excited flux tube:
 - $m=1, S=1, L=0, J=0,1,2$
 $\rightarrow 0^{-+} 0^{+-} 1^{-+} 1^{+-} 2^{-+} 2^{+-}$
 - **Exotic hybrids!**
- $\sigma_{exotic-meson} \approx \sigma_{meson}$
- Almost no data available
- Linear polarized $\gamma \rightarrow$ parity measurement

HYBRID DECAYS



One decay meson gets L_{flux} :
 $\rightarrow L=0$ meson + $L=1$ meson

Examples of final states:

- $\eta_1 \rightarrow a_1^+ \pi^- \rightarrow \dots \rightarrow \pi^+ \pi^- \pi^+ \pi^-$
- $h_0 \rightarrow b_1^0 \pi^0 \rightarrow \dots \rightarrow \pi^+ \pi^- \gamma \gamma \gamma \gamma \gamma$
- $h_2' \rightarrow K_1^+ K^- \rightarrow \dots \rightarrow \pi^+ \pi^- K^+ K^-$

GlueX needs to detect:

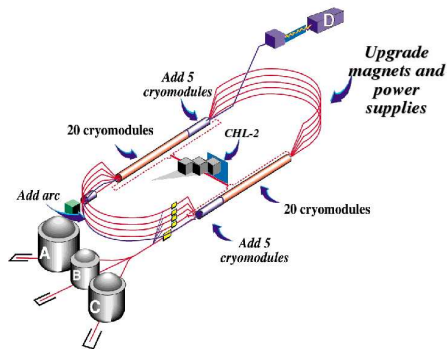
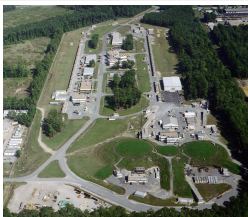
- Charged particles
- Multiple γ
 - 70% involved at least one π^0
 - 50% more than one π^0
- Strange particles

Exotic Meson	J^{PC}	I	G	Possible Modes
b_0	0^{+-}	1	+	
h_0	0^{+-}	0	-	$b_1 \pi$
π_1	1^{-+}	1	-	$\rho \pi, b_1 \pi$
η_1	1^{-+}	0	+	$a_2 \pi$
b_2	2^{+-}	1	+	$a_2 \pi$
h_2	2^{+-}	0	-	$\rho \pi, b_1 \pi$

REQUIREMENTS FOR HYBRID SPECTROSCOPY

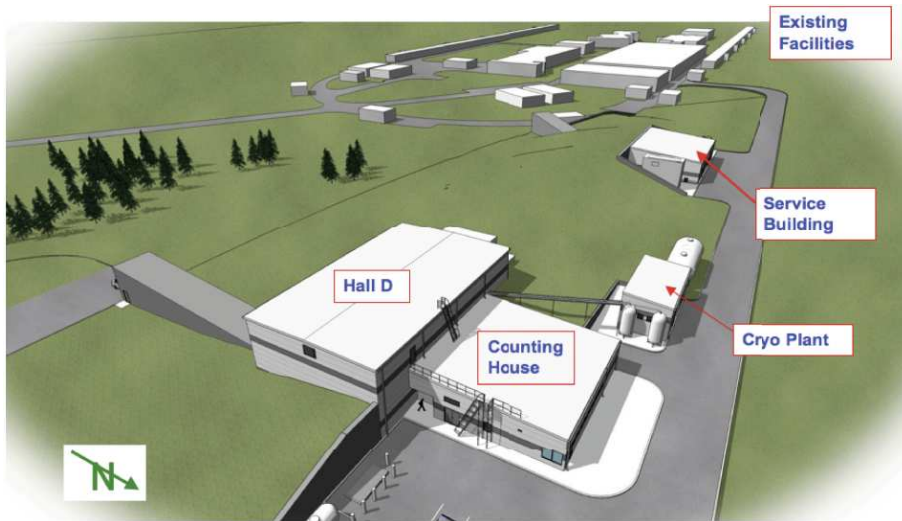
- γ - beam ($\sigma_{exotic-meson}$)
 - Linearly polarized (parity)
 - High enough in energy (to produce hybrids)
 - High luminosity
- Detector
 - Charged particle ID
 - Calorimetry (multiple γ s)
 - Good E/P resolution
 - High luminosity

REQUIREMENTS FOR HYBRID SPECTROSCOPY

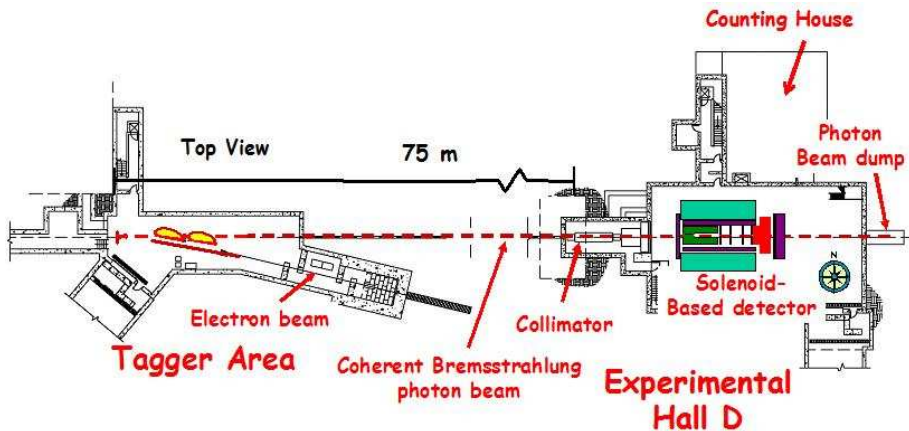


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Hall-D at JLab

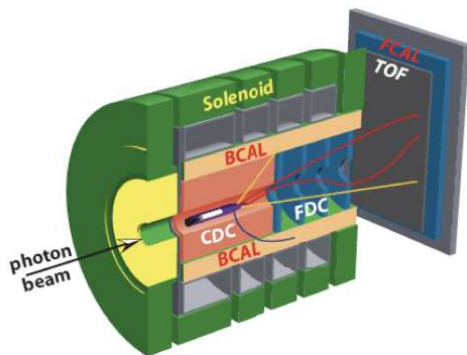


(Construction scheduled beginning 2009)



- e^- (12 GeV/c) on 20 μm diamond
- Coherent bremsstrahlung - γ -beam
- 9 GeV $\vec{\gamma}_s$ (tagged)
- 10^8 $\vec{\gamma}$ /s on p target
- Hybrid detection by solenoid based detector

SPECTROMETER



- Liquid H target
- Solenoid: 2.24 T
- Tracking (inside solenoid):
 - Start counter
 - Central Drift Chamber (CDC)
 - Forward Drift Chamber (FDC)
- Calorimetry
 - Barrel Calorimeter (BCAL)
 - Forward Calorimeter (FCAL)
- Time-of-flight wall (ToF)
- Cherenkov detector (future?)

STATUS

- Reviews:
 - (DOE) CD-3 achieved (signed in September)
 - Waiting for congress
- HALL-D construction start beginning 2009
- Detector procurement/construction starts end 2008
- Data taking: **2014**

MORE PHYSICS WITH GLUEX

Photon-hadron physics workshop (PHP) (March 2008)

- Primakoff effect
 - Good forward calorimetry
 - Primex might join GlueX
- Photo-production on nuclear targets
 - Medium effects on hadron production
- Charm photo-production (near threshold)
- Hadronic spectroscopy
 - $p\bar{p}$ photo-production on p target
- Inverse Virtual Compton Scattering (iVCS)
- ... (<http://conferences.jlab.org/php2008/index.html>)

SUMMARY

The GlueX collaboration

- Wants to map out the hybrid mesons
 - High intensity 9 GeV linear polarized photons
 - Large acceptance spectrometer
 - In the **new** experimental Hall-D at JLab
 - Charged particles
 - Neutral particles
- ⇒ **Session HH: GlueX instrumentation**
(Tomorrow 2:00pm: Jewett Ballroom F)
- CD-3 achieved
- More physics accessible as well