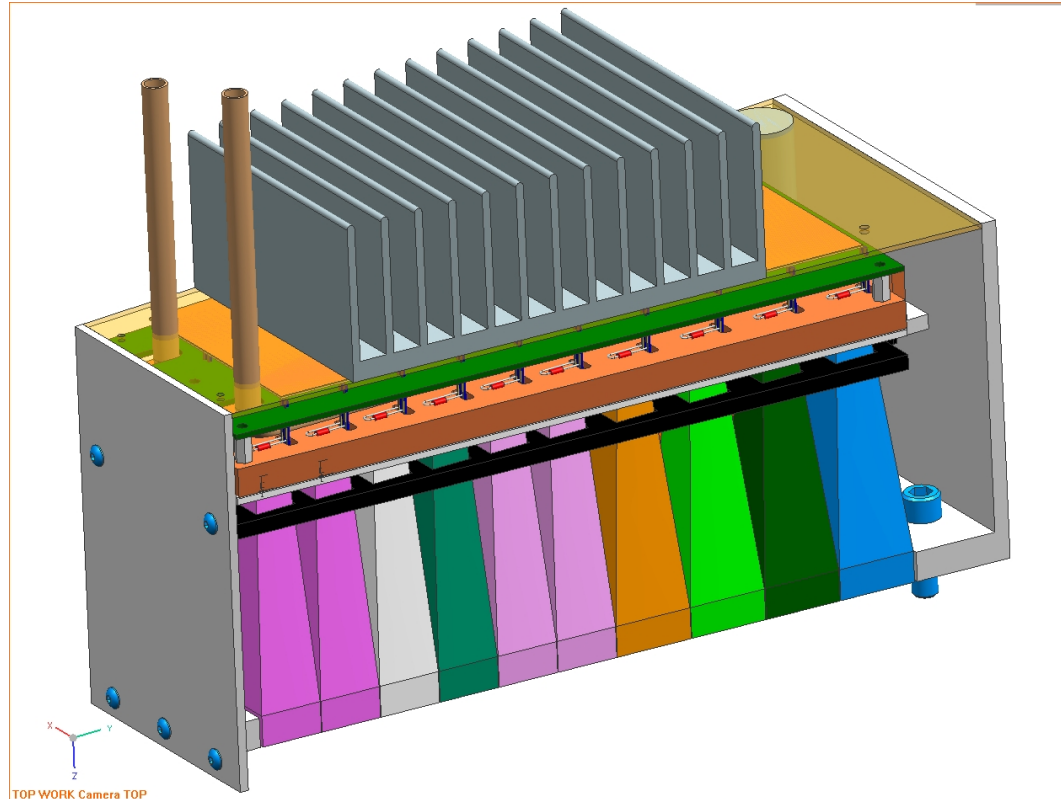


The GlueX Barrel Electromagnetic Calorimeter



University
of Regina



Z, Papandreou, U of Regina
APS 2011, Garden Grove, May 1, 2011

GlueX Scientific Goals and Means

- GlueX Physics
 - Elucidate the phenomenon of **confinement** in QCD
 - Definitive and detailed mapping of **hybrid meson spectrum**
 - Search for **smoking gun signature** of **exotic J^{PC} hybrid mesons**; no mixing with $q\bar{q}$
 - Test photo-couplings and phenomenology
 - $s\bar{s}$ and baryon spectroscopy, Primakoff effect, rare eta decays, etc...
- Tools for the GlueX Project at Jefferson Lab
 - 12 GeV electrons, 9 GeV tagged, **linearly polarized** photons with high flux
 - Detector: **hermiticity**, resolution, charged and neutrals
 - **Spin-Amplitude Analysis** of multi-particle final states
 - Computing power: Pb/year data collection, distributed computing, grid tools,...
- Key detector subsystem: **BCAL**
 - Pb-Scintillating Fibre sampling calorimeter
 - 70% of decay photons are captured by BCAL
 - 50% of BCAL ones have energies $< 300\text{MeV}$
 - 40 MeV – 3.5 GeV operating range; high magnetic field, tight space
 - **Under construction at Regina**
 - **Recent results: fibre testing and construction status quo**
- **Collaboration:** 75 physicists, 16 institutions, 6 countries, active theory group

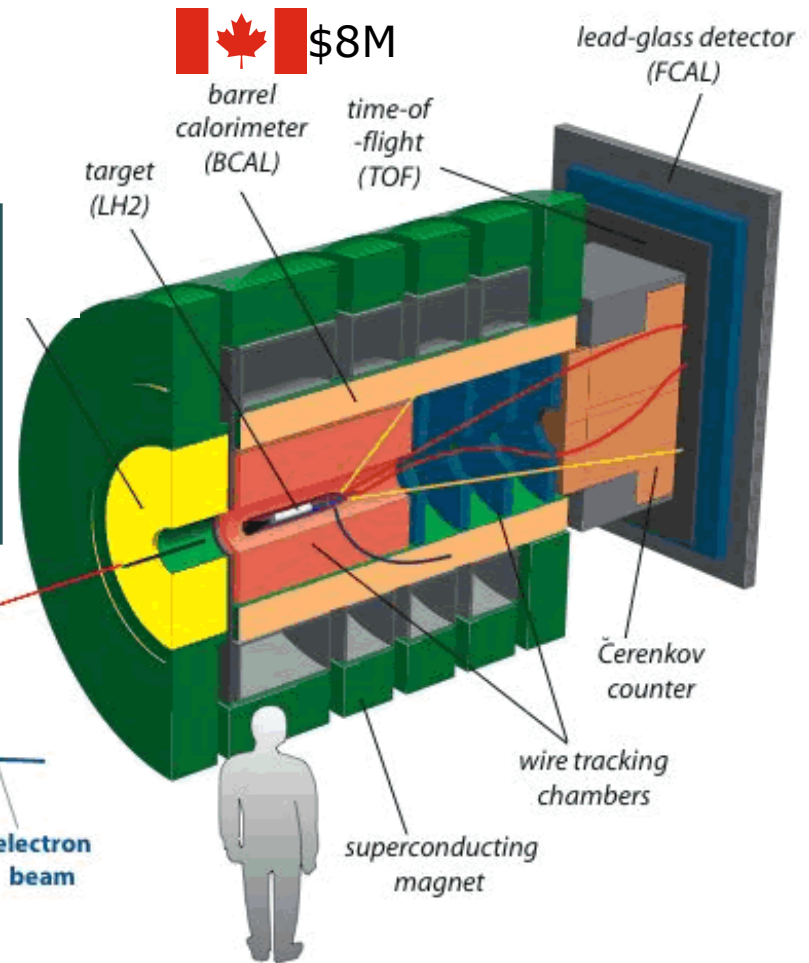
JLab
12 GeV



Magnet:

Experiment:

- large figure of merit for hybrids
- enormous statistics



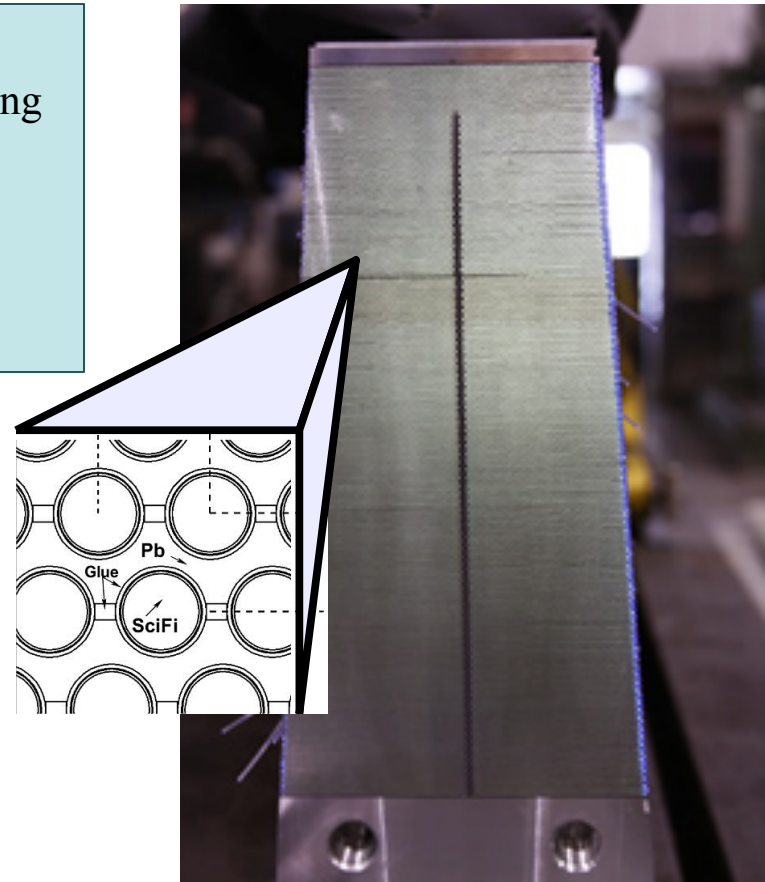
BCAL Highlights

Key component of the GlueX detector

- Crucial for reconstructing γ from π^0 and η resulting from decay mesons
- Provides timing information (neutrals/charged)
- With the CDC it provides charged particle PID
- It supplies secondary dE/dx

Geometry & Configuration

- Sampling calorimeter (11% sampling fraction)
- Based on KLOE Emcal design
- BCAL: ~25 tonnes
- The scintillating fibres have a polystyrene core which produces 8000 photons/MeV and are blue-green, double clad (increases light captured by ~50%).



**Machined module:
15,350 fibres**

GlueX Detector

photon beam

126.4°

118.1°

185 cm

30-cm target

48 cm

342 cm

560 cm

CDC
Central Drift Chamber

FDC
Forward Drift Chambers

Solenoid

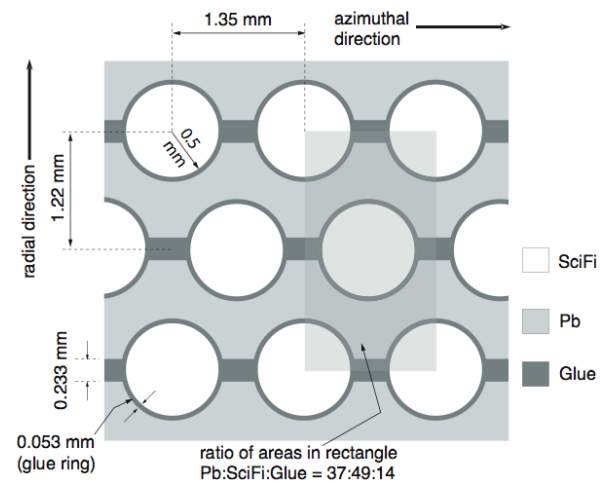
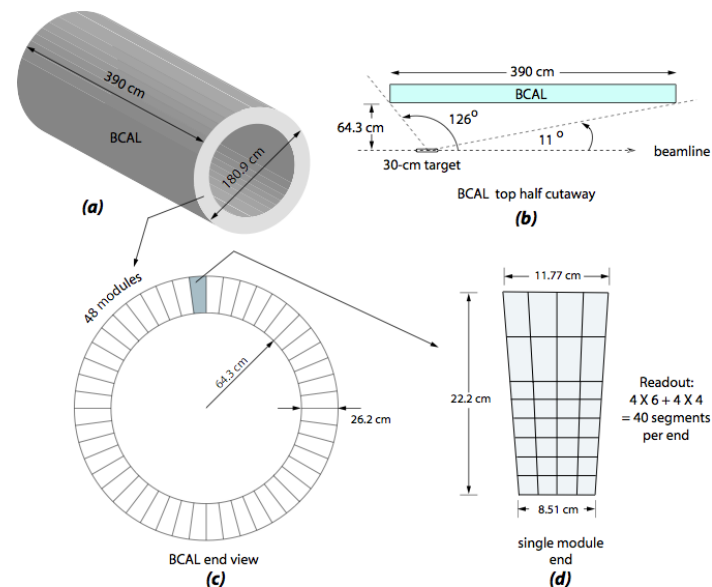
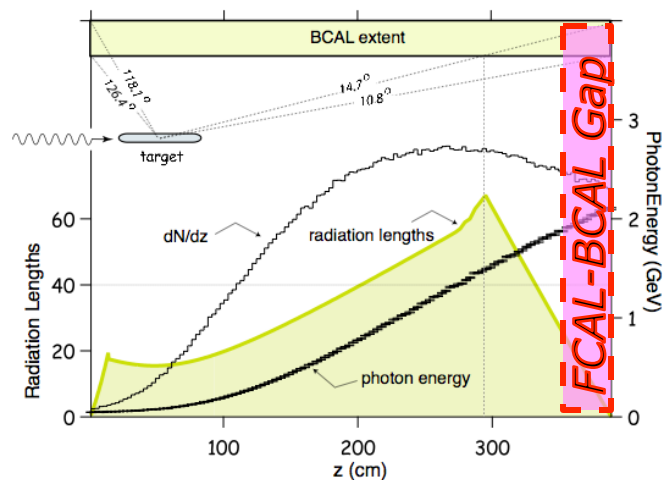
BCAL
Barrel Calorimeter
390 cm long
inner radius: 65 cm outer radius: 90 cm

FCAL
Forward Calorimeter
240 cm diameter
45 cm thick

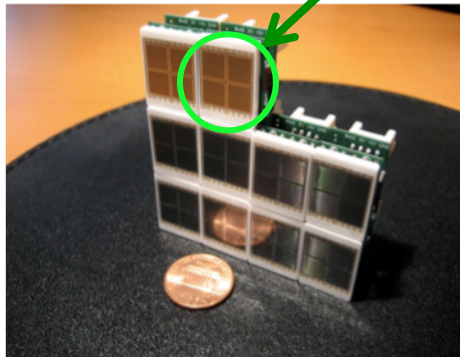
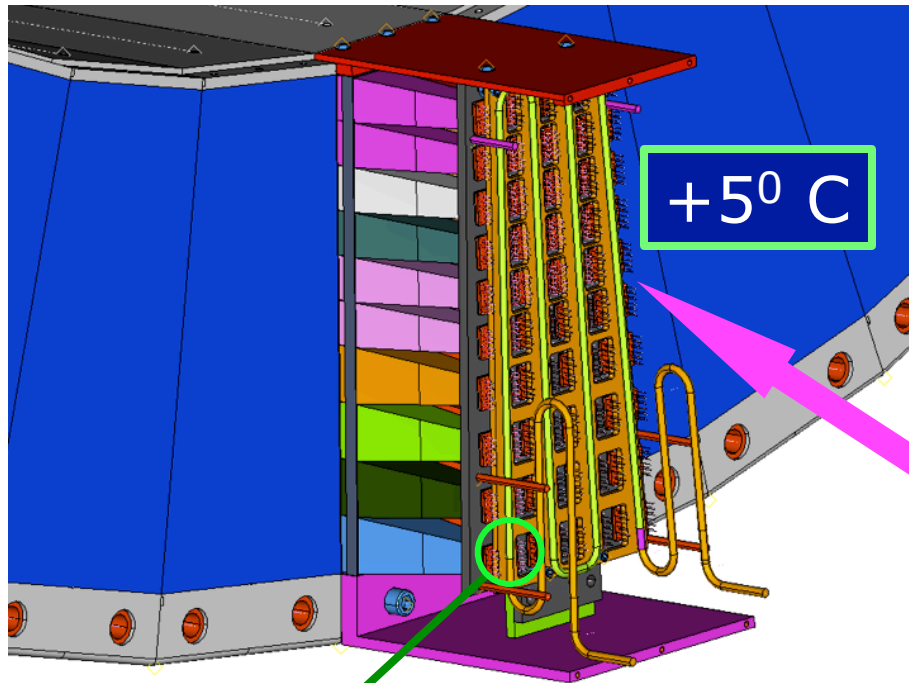
Future Particle ID

14.7°

10.8°

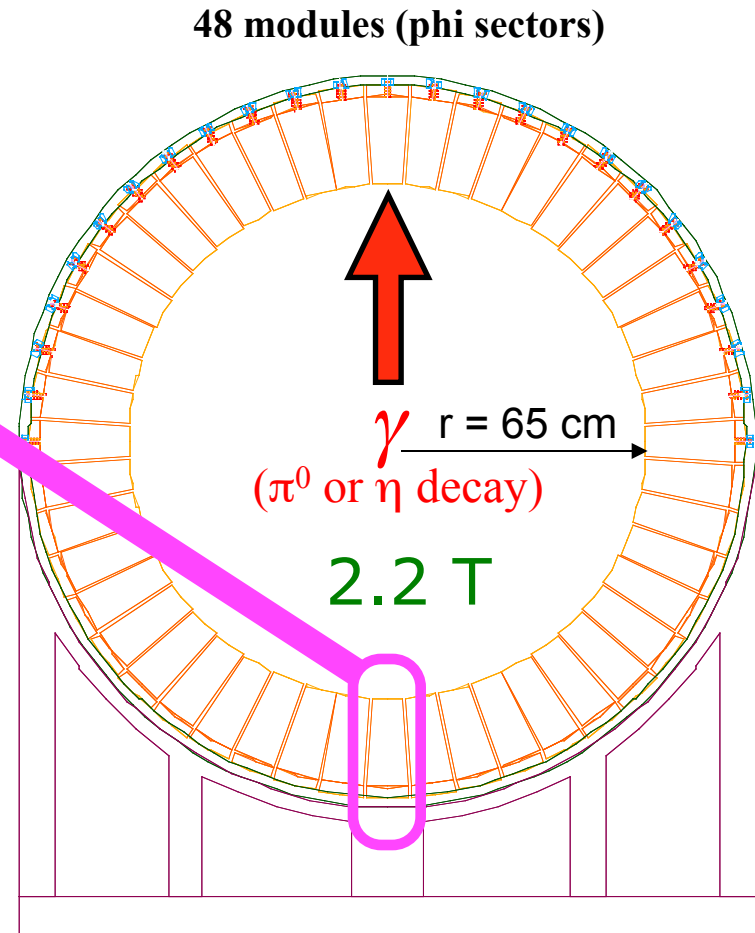


BCAL Readout: GlueX sets SiPM Array Standard!



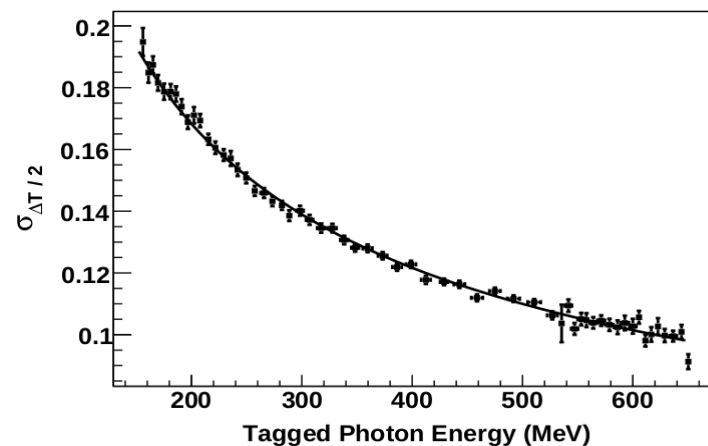
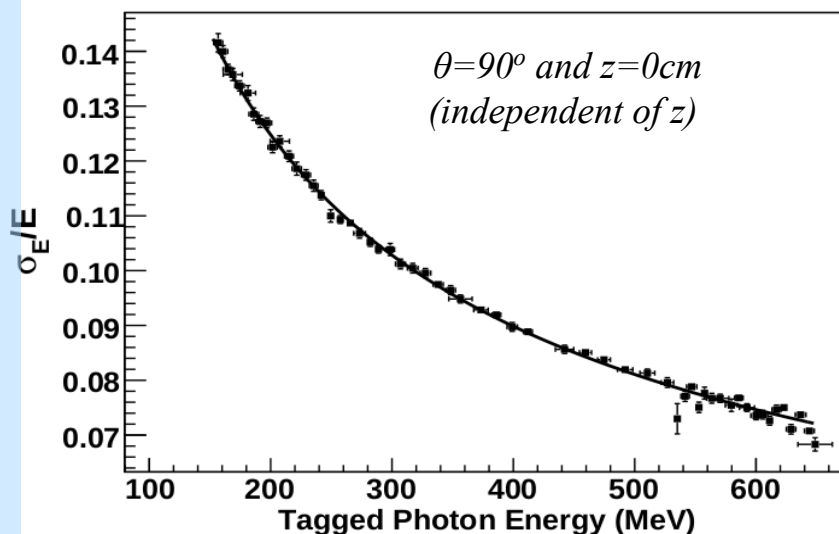
Hamamatsu MPPC

Array of 16
3x3 mm²
MPPC:
1.26 cm² area



BCAL beam view

BCAL Expected Performance



$$\frac{\sigma_E}{E} = \frac{5.5 \pm 0.1\%}{\sqrt{E}} \oplus 2.4 \pm 1\%$$

time difference resolution

$$\sigma_{\Delta T/2} = \frac{70\text{ps}}{\sqrt{E(\text{GeV})}}$$

$$KLOE \quad \left(\frac{\sigma_E}{E} = \frac{5.4\%}{\sqrt{E}} \oplus 0.7\% \right)$$

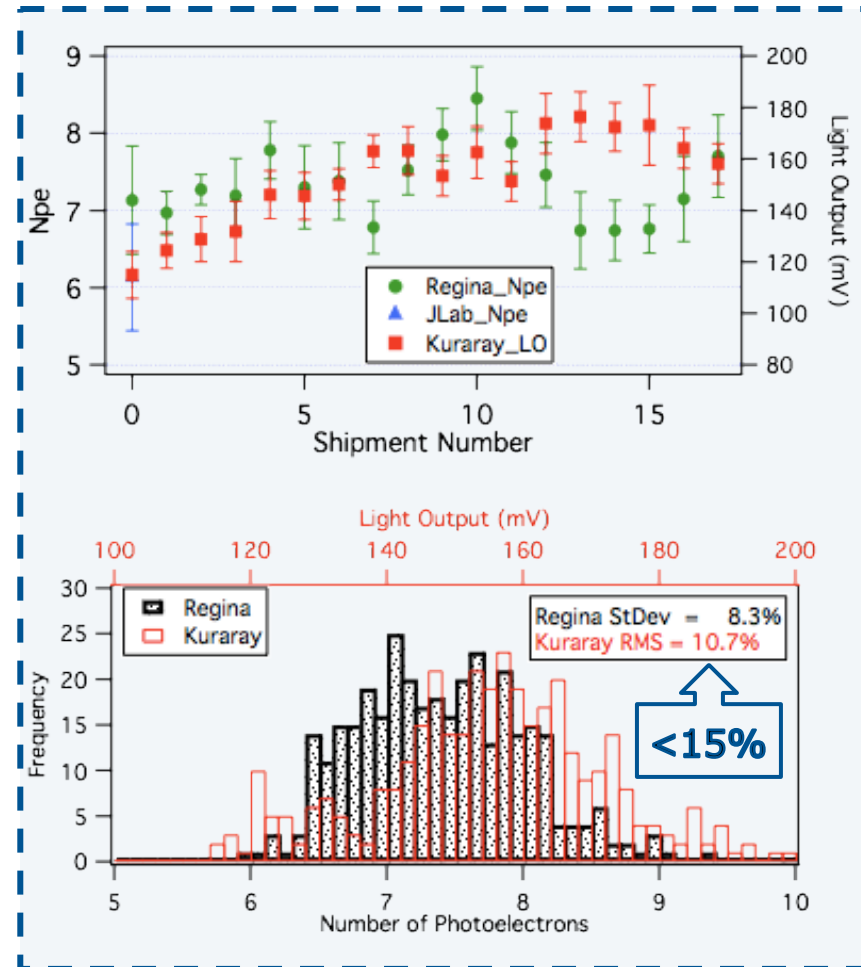
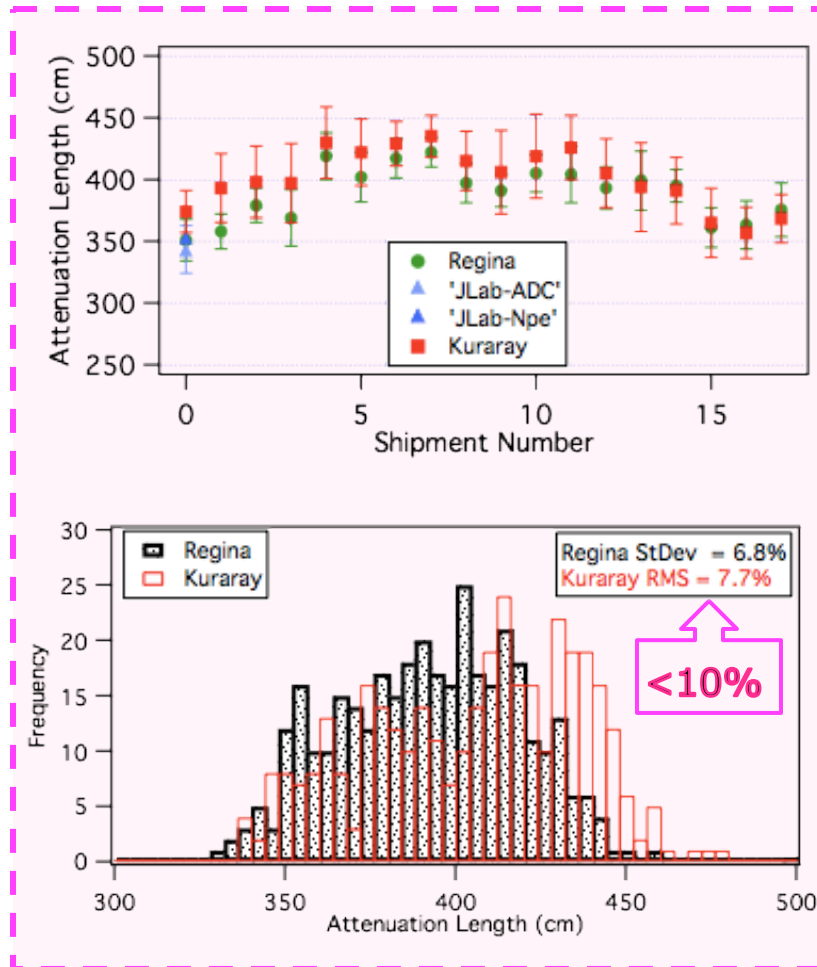
$$KLOE \quad \left(\sigma_t = \frac{72\text{ps}}{\sqrt{E}} \right)$$

BCAL: 660 pe/GeV vs KLOE: 700 pe/GeV
• single clad fibers, better light guides

NIMA 48874 (2008)

<http://dx.doi.org/10.1016/j.nima.2008.08.137>

Fibre Quality Assurance



SCSF-78MJ
780,000 fibres

Regina & Kuraray measurements track
Fibres meet specifications

Matrix Construction Facility @ Regina

ROLLING



GLUING



QUALITY CONTROL AT EVERY STEP

SWAGGING

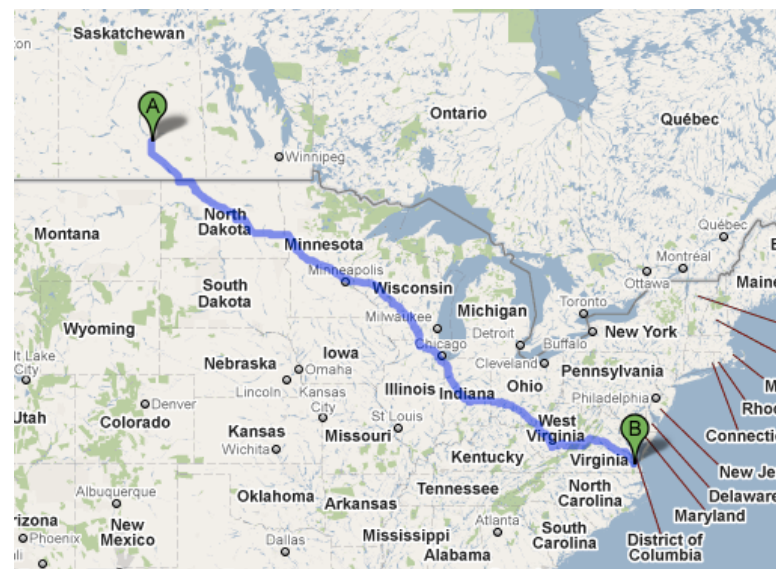


PRESSING



Machined Modules

Project duration: 36 months



1st detector delivery for 12 GeV program!

- Excellent finish of end faces & transmission uniformity
 - 36 modules have been built
 - 28 are at Jefferson Lab

Summary

- The nature of **confinement** is an outstanding and fundamental question of quarks and gluons in QCD.
- LQCD and phenomenology suggest **flux-tubes** as the explanation.
- The excitation of the gluonic field leads to an **entirely new spectrum** of mesons as predicted by LQCD. Data are needed.
- **PWA** and improved theoretical understanding is required.
- **The definitive experiment for this search will be GlueX at the energy-upgraded JLab. If exotic hybrids are there, we will find them!**

- Hall D ‘beneficial occupancy’ in fall 2011.
- BCAL construction is ahead of schedule; completion in spring 2012.
- Detector integration in 2013.
- Engineering data in 2014.
- Physics data in 2015.



GlueX-Regina Team

current team members:

Y. Cao, S. Katsaganis, D. Kolybaba, S. Krueger, T. Li,
M. Litzenberger, G. Lolos, E. Plummer, H. Qian,
M. Sauder, A. Semenov, I. Semenova, M. Tahani, L. Teigrob

past team members:

A. Baulin, J. Chan, B. Giesbrecht, A. Heinrichs,
 B. Leverington, K. Janzen, L. Sichello, Y. Sun,
K. Vuthitanachot, Y. Yongzhe, A. Watson

Z. Papandreou, U of Regina
 APS 2011, Garden Grove, May 1, 2011

*Thank you
 for your
 attention!*



Jefferson Lab



**NSERC
 CRSNG**



UNIVERSITY OF
 REGINA



Hall D at Jefferson Lab
www.gluex.org

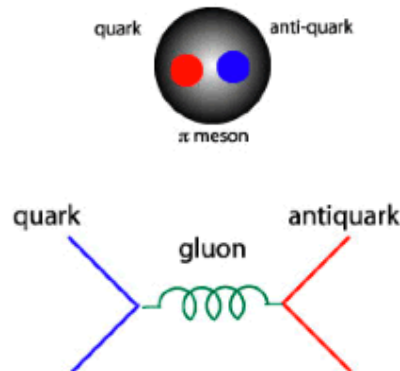
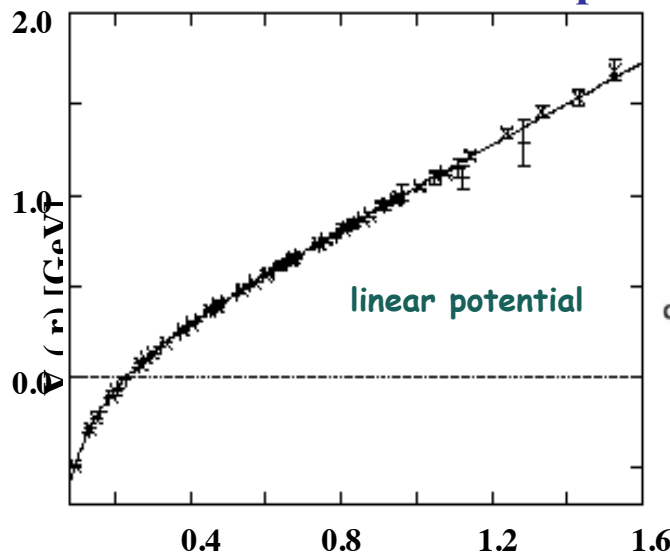
Backup Slides

Flux Tubes – Model & LQCD

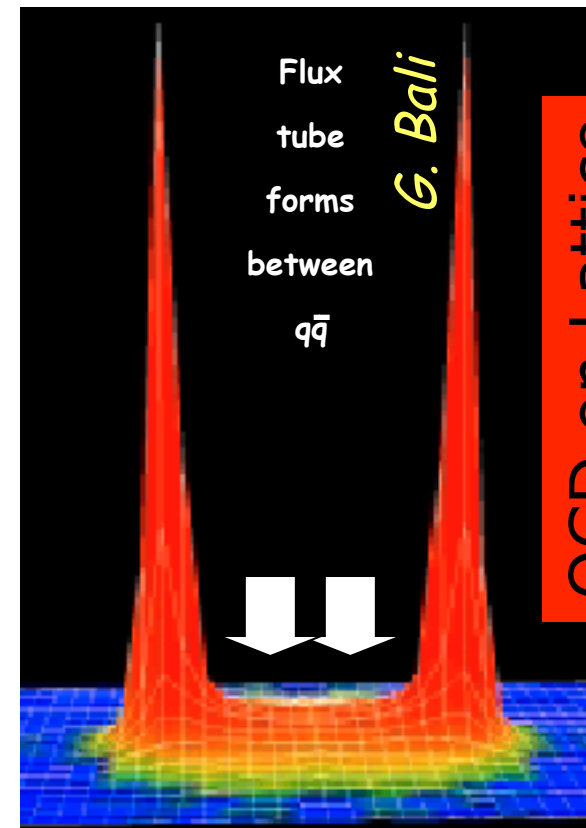
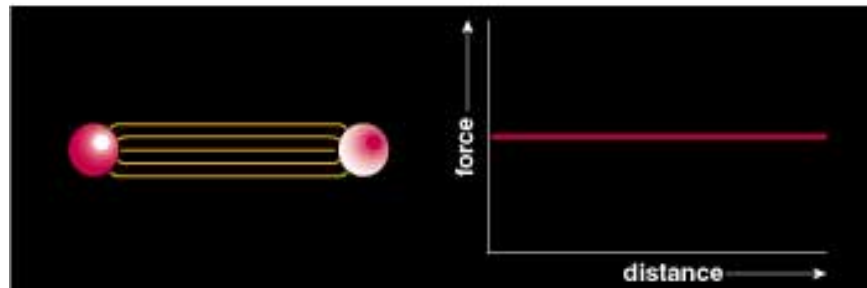
In the simple quark model, glue is not needed to describe hadrons.

But in QCD: Allowed systems: gg , ggg , $q\bar{q}g$, $q\bar{q}q\bar{q}$
 Glueballs Hybrids Molecules

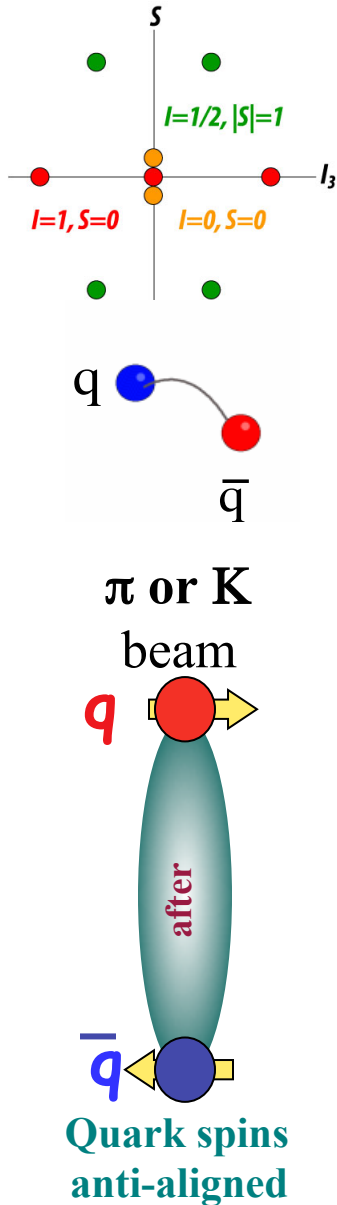
Color Field: Gluons possess color charge: they couple to each other!



**F
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X** **T
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B
E**



Evidence for Exotic Hybrids?



Data Candidates & Issues

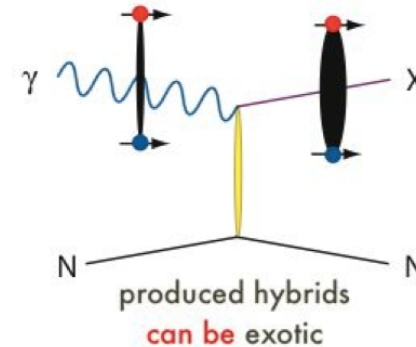
State	Mass (GeV)	Width (GeV)
$\pi_1(1400)$	1.351 ± 0.03	0.313 ± 0.040
$\pi_1(1600)$	1.662 ± 0.015	0.234 ± 0.050
$\pi_1(2015)$	2.01 ± 0.03	0.28 ± 0.05
State	Production	Decays
$\pi_1(1400)$	$\pi^- p, \bar{p} n$	$\pi^- \eta^\pm, \pi^0 \eta^\pm$
$\pi_1(1600)$	$\pi^- p, \bar{p} p$	$\eta' \pi, b_1 \pi, f_1 \pi, \rho \pi^\pm$
$\pi_1(2015)$	$\pi^- p$	$b_1 \pi, f_1 \pi$
State	Experiments	
$\pi_1(1400)$	E852, CBAR	
$\pi_1(1600)$	E852, VES, COMPASS, CBAR	
$\pi_1(2015)$	E852	

- Low statistics
- Possible leakage due to acceptance issues or insufficient no of wave sets
- Interpretation of line shapes and phases
- Inconsistencies in production
- Controversial decay channels

LQCD Hybrid Predictions

Name	J^{PC}	Total Width MeV	Large Decays	
		PSS	IKP	
π_1	1^{-+}	81 – 168	117	$b_1\pi, \rho\pi, f_1\pi, a_1\eta$
η_1	1^{-+}	59 – 158	107	$a_1\pi, f_1\eta, \pi(1300)\pi$
η_1'	1^{-+}	95 – 216	172	$K_1^m K, K_1^l K, K^* K$
b_0	0^{+-}	247 – 429	665	$\pi(1300)\pi, h_1\pi$
h_0	0^{+-}	59 – 262	94	$b_1\pi, h_1\eta, K(1460)K$
h_0'	0^{+-}	259 – 490	426	$K(1460)K, K_1^l K, h_1\eta$
b_2	2^{+-}	5 – 11	248	$a_2\pi, a_1\pi, h_1\pi$
h_2	2^{+-}	4 – 12	166	$b_1\pi, \rho\pi$
h_2'	2^{+-}	5 – 18	79	$K_1^m K, K_1^l K, K_2^* K$

- Different masses for hybrids
- Width ranges vary



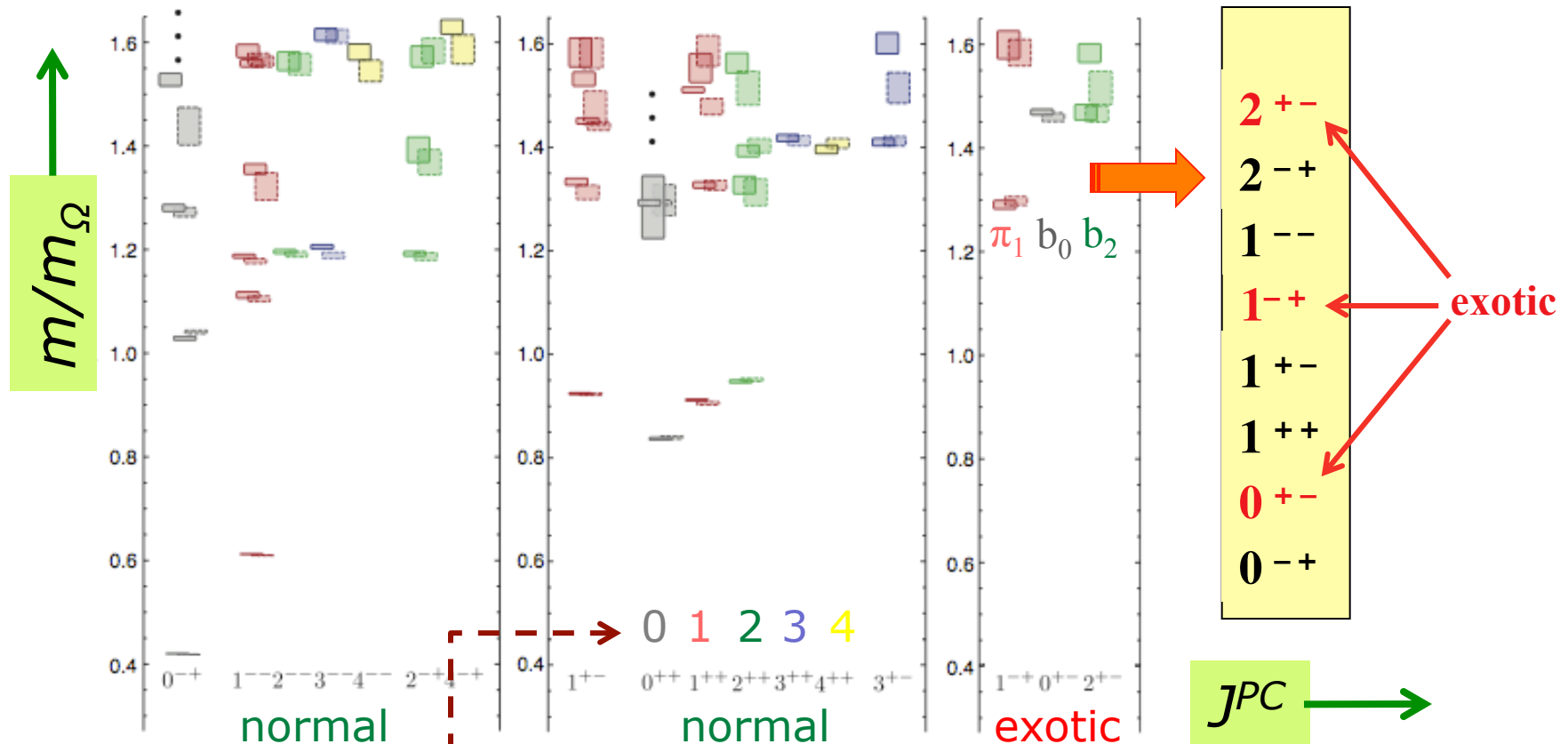
Exotics

$J^{PC} = 1^{+-}$ or
 $J^{PC} = 1^{-+}$

For excited
glue string

LQCD Isovector Meson Map

Two flavours of light quarks and one tuned to the strange quark mass



-390-700 MeV pion mass
-colour denotes spin
- no lattice volume effect

*J. Dudek et al. Phys. Rev. D **82**, 034508 (2010)
(unquenched, spectrum of light-quark mesons)*

BCAL Construction QC/QA: Fibres

- Kuraray SCSF-78MJ
(450nm peak)
- diameters: within specs →
- Spectra measured at Regina qualitatively agree with Kuraray's
- response is acceptable and scales by distance →

780,000 fibres

