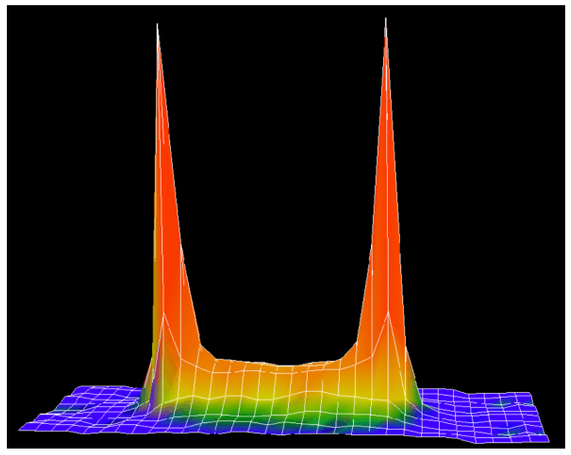
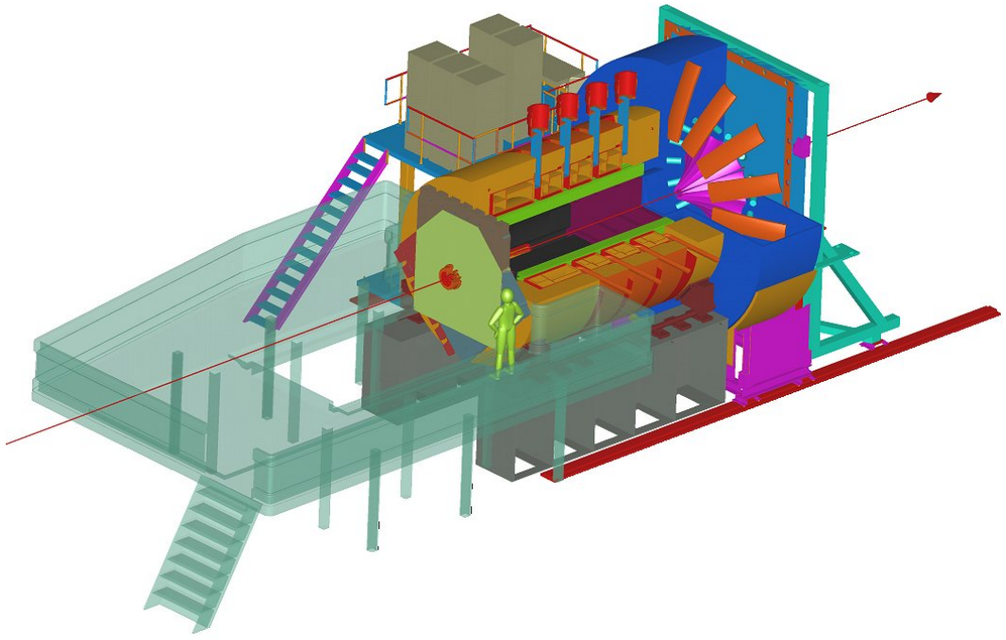
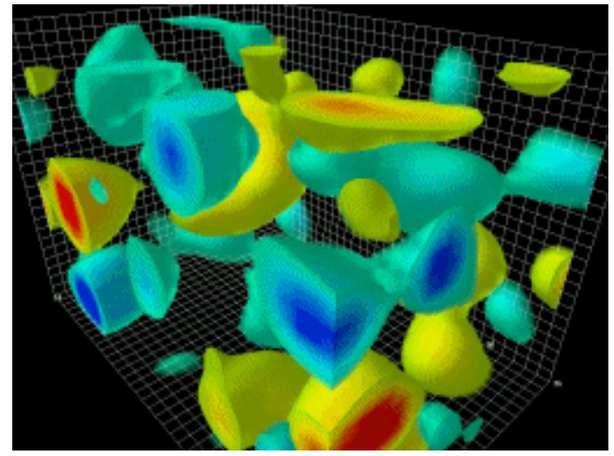






The GlueX Experiment:
Commissioning is underway

Zisis Papandreou

University of Regina

CAP Congress
Sudbury
June 19, 2014

In a nutshell

- The Physics: *flagship experiment at JLab*
  - How do $\mathcal{L}_{QCD}$ quark and gluon d.o.f. manifest themselves in the hadron spectrum?
  - Elucidate the phenomenon of confinement in QCD
  - Discover exotic J^{PC} hybrid mesons
- The Tools
  - 12 GeV electrons, 9 GeV tagged, linearly polarized photons with high flux
  - Detector: hermiticity, resolution, charged and neutrals, strange and non-strange
  - Spin-amplitude analysis and Boosted Decision Trees
  - Computing power: petabytes/yr data, distributed computing, grid tools
- Barrel Calorimeter: description and commissioning

The Collaboration

Collaboration governance:

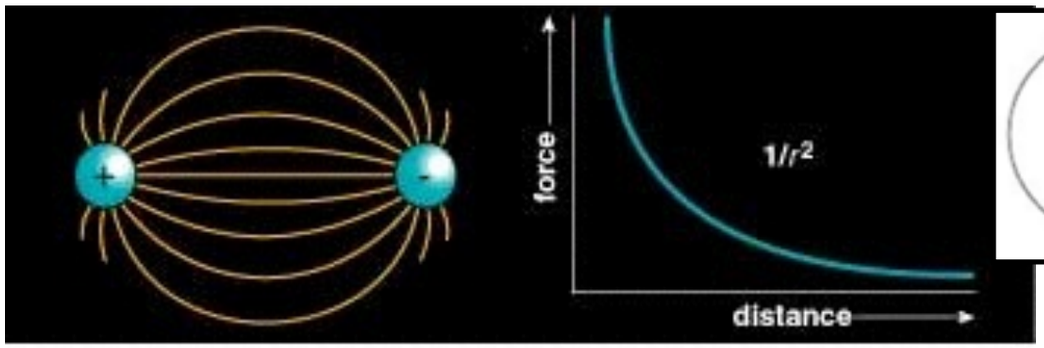
- Board, Spokesman, Deputy, Executive
- Working Groups, Technical Committees
- Membership

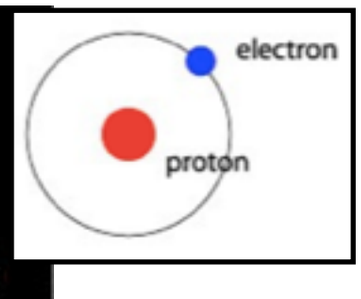
Flux Tubes in QCD

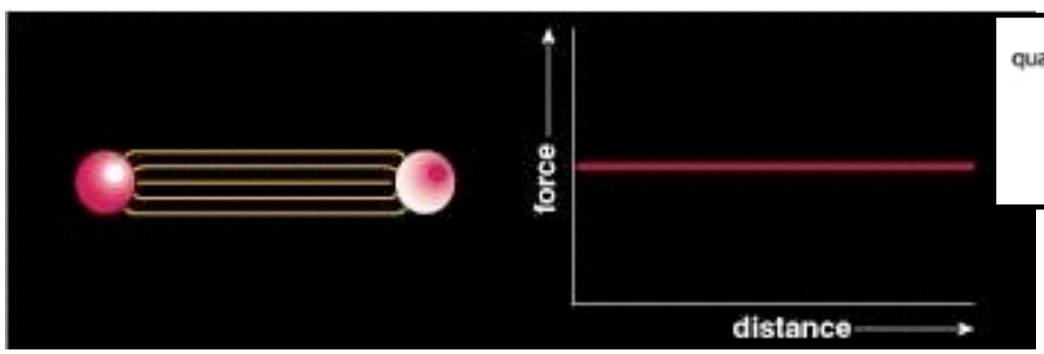
In the simple quark model, glue is not needed to describe hadrons.

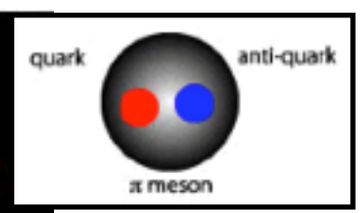
But in QCD: Allowed systems: gg, ggg, **Glueballs**; $q\bar{q}g$, **Hybrids**; $q\bar{q}q\bar{q}$ **Molecules**

COLOR FIELD: GLUONS POSSESS COLOR CHARGE: THEY COUPLE TO EACH OTHER!



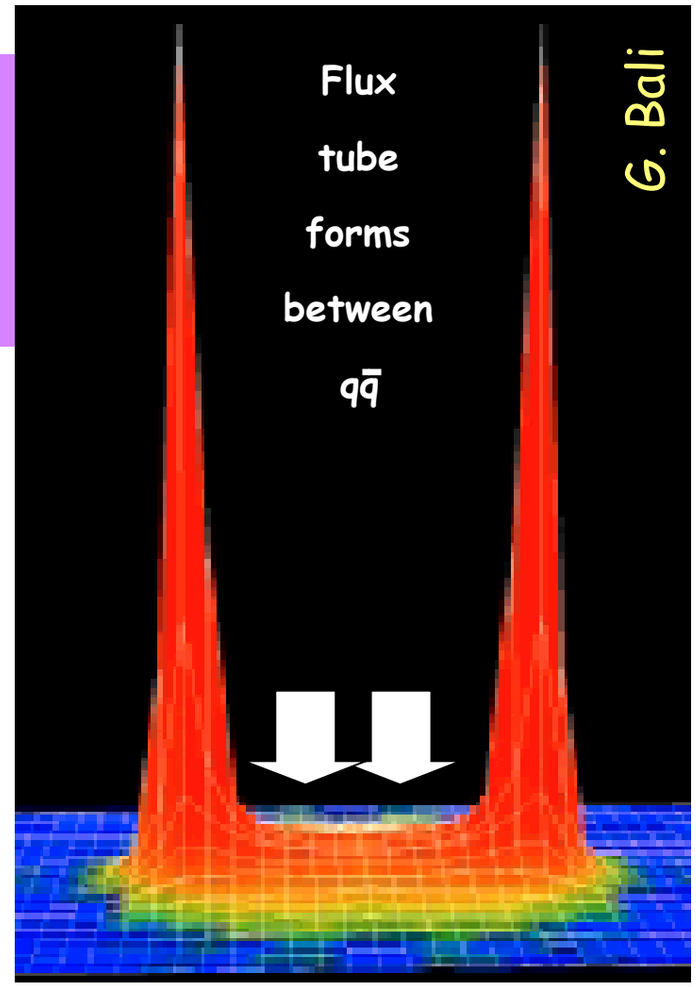






Flux Tube

Lattice

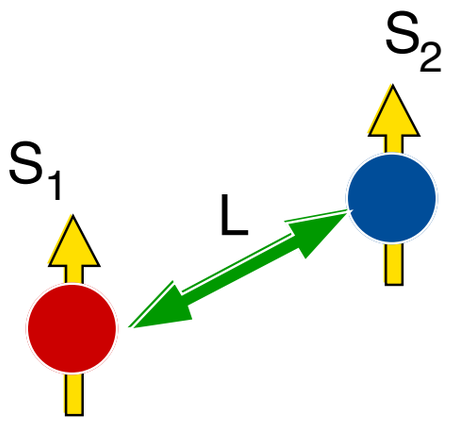


Quantum Numbers

Q: How do we look for gluonic degrees of freedom in spectroscopy?

A: By isolating objects with unique JPC quantum numbers.

Nonets characterized by given J^{PC}

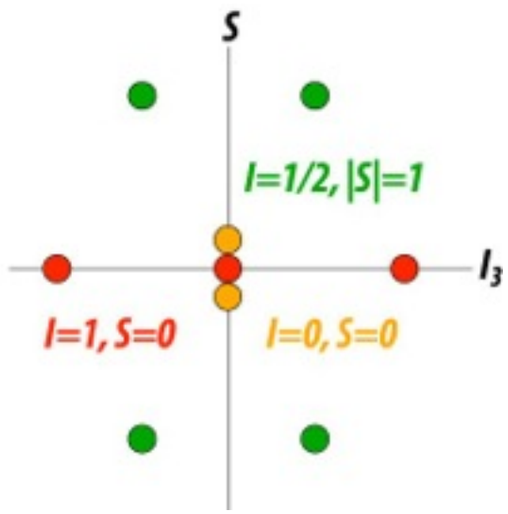


$S = S_1 + S_2$

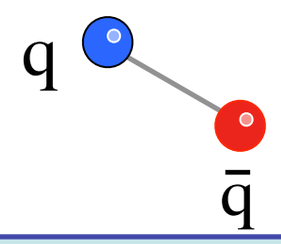
$J = L + S$

$P = (-1)^{L+1}$

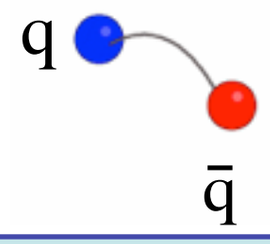
$C = (-1)^{L+S}$



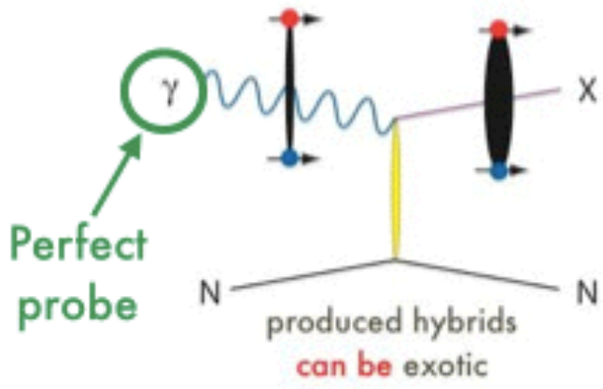
Normal meson:
flux tube in ground state
m=0
$PC=(-1)^{S+1}$



Hybrid meson:
flux tube in excited state
m=1
$PC=(-1)^{S}$



In the first-excited state the linear combinations lead to $J^{PC} = 1^{-+}$ or $J^{PC}=1^{+-}$ for the excited glue string.



Where are the Hybrids?

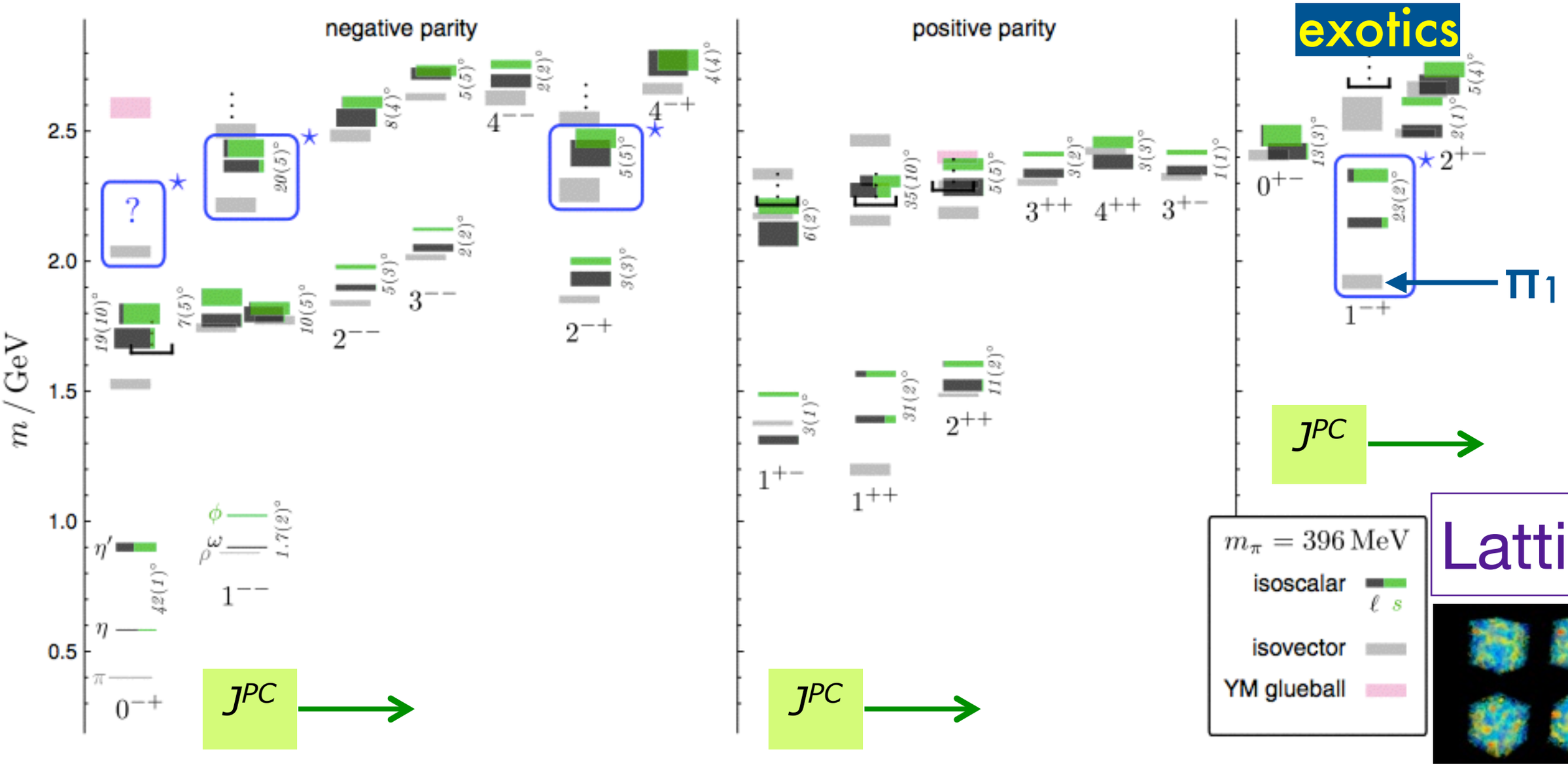
Exotic QN compilation: masses, widths and decay channels

	Approximate Mass (MeV)	J^{PC}	Total Width (MeV) PSS	IKP	Relevant Decays	Final States
π_1	1900	1^{-+}	$80-170$	120	$b_1\pi^\dagger$, $\rho\pi^\dagger$, $f_1\pi^\dagger$, $a_1\eta$, $\eta'\pi^\dagger$	$\omega\pi\pi^\dagger$, $3\pi^\dagger$, 5π, $\eta 3\pi^\dagger$, $\eta'\pi^\dagger$
η_1	2100	1^{-+}	$60-160$	110	$a_1\pi$, $f_1\eta^\dagger$, $\pi(1300)\pi$	4π, $\eta 4\pi$, $\eta\eta\pi\pi^\dagger$
η_1'	2300	1^{-+}	$100-220$	170	$K_1(1400)K^\dagger$, $K_1(1270)K^\dagger$, $K^*K^\dagger$	$KK\pi\pi^\dagger$, $KK\pi^\dagger$, $KK\omega^\dagger$
b_0	2400	0^{+-}	$250-430$	670	$\pi(1300)\pi$, $h_1\pi$	4π
h_0	2400	0^{+-}	$60-260$	90	$b_1\pi^\dagger$, $h_1\eta$, $K(1460)K$	$\omega\pi\pi^\dagger$, $\eta 3\pi$, $KK\pi\pi$
h_0'	2500	0^{+-}	$260-490$	430	$K(1460)K$, $K_1(1270)K^\dagger$, $h_1\eta$	$KK\pi\pi^\dagger$, $\eta 3\pi$
b_2	2500	2^{+-}	10	250	$a_2\pi^\dagger$, $a_1\pi$, $h_1\pi$	4π, $\eta\pi\pi^\dagger$
h_2	2500	2^{+-}	10	170	$b_1\pi^\dagger$, $\rho\pi^\dagger$	$\omega\pi\pi^\dagger$, $3\pi^\dagger$
h_2'	2600	2^{+-}	$10-20$	80	$K_1(1400)K^\dagger$, $K_1(1270)K^\dagger$, $K_2^*K^\dagger$	$KK\pi\pi^\dagger$, $KK\pi^\dagger$

Experimental Candidates

- Low statistics
- Possible acceptance leakage
- Insufficient number of wave sets
- Interpretation of line shapes and phases
- Controversial decay channels

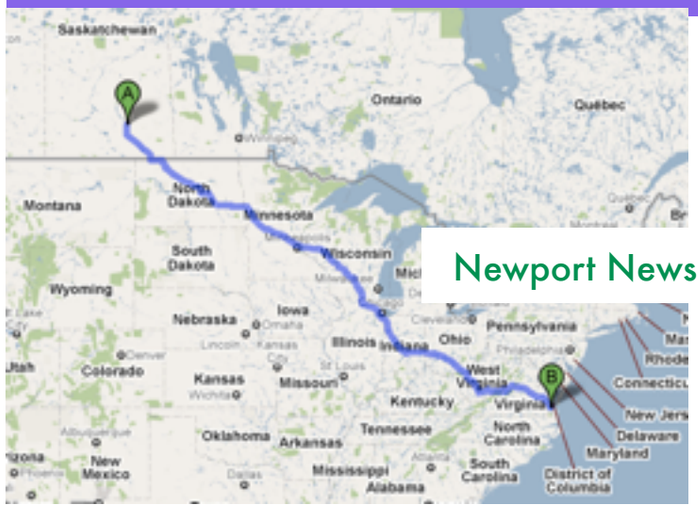
LQCD Periodic Table



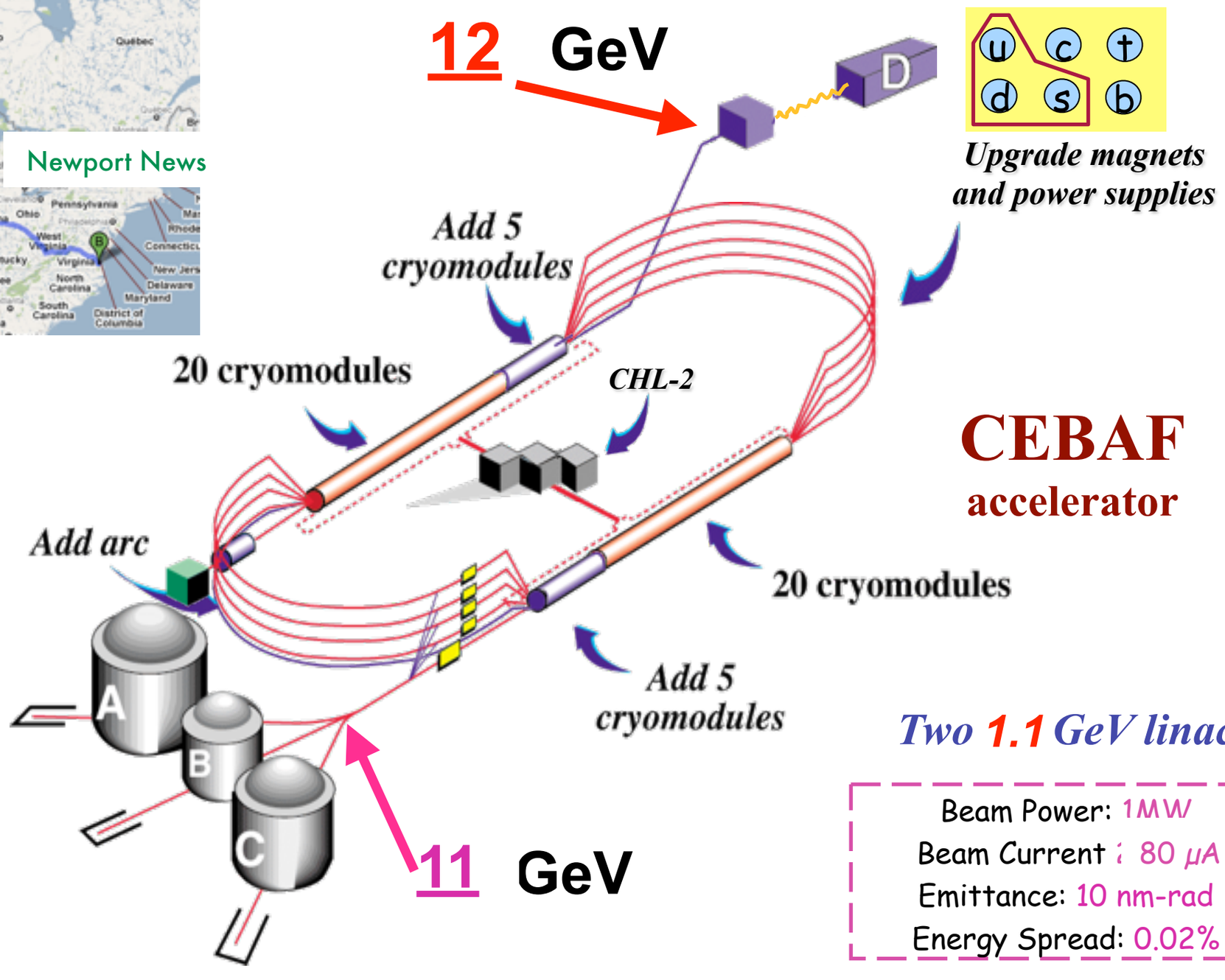
•candidate states for lightest **hybrid** supermultiplet

J.J. Dudek,
PRD 84 074023 (20121)

Jefferson Lab



Newport News



CEBAF
accelerator

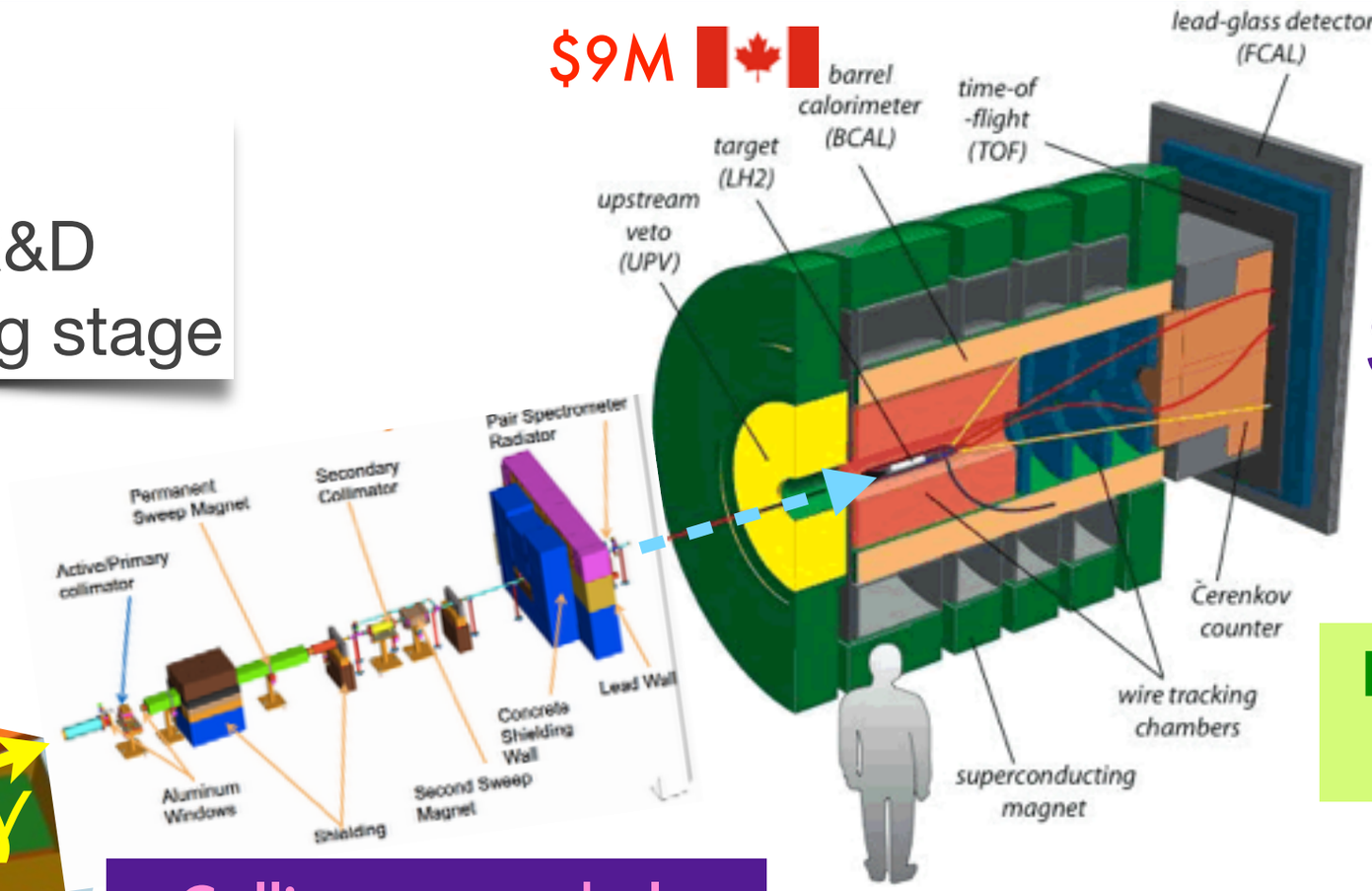
Two 1.1 GeV linacs

Beam Power: 1MW
Beam Current : 80 μA
Emittance: 10 nm-rad
Energy Spread: 0.02%

The GlueX Detector

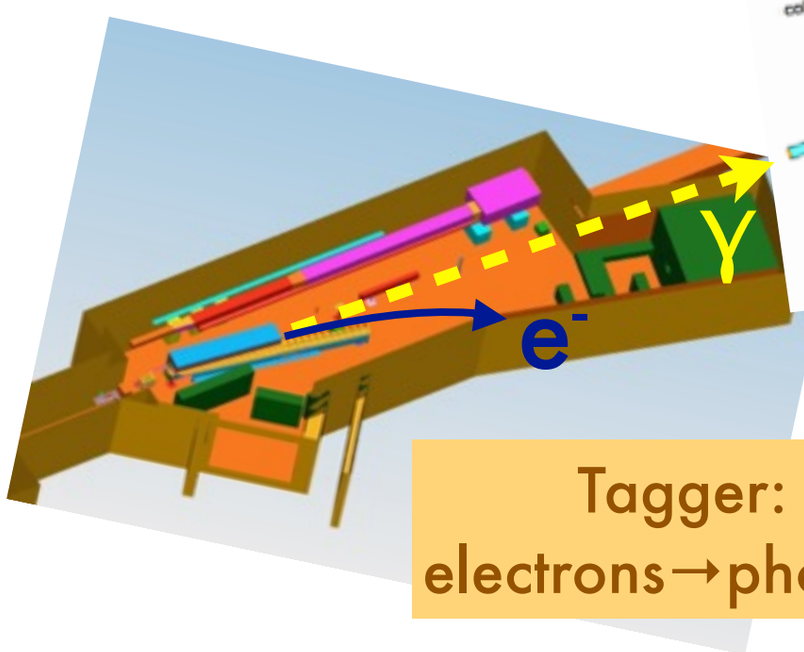
- 2.2 T solenoid
- ~10 years of R&D
- Commissioning stage

$9M



$40M

Detector: hermetic

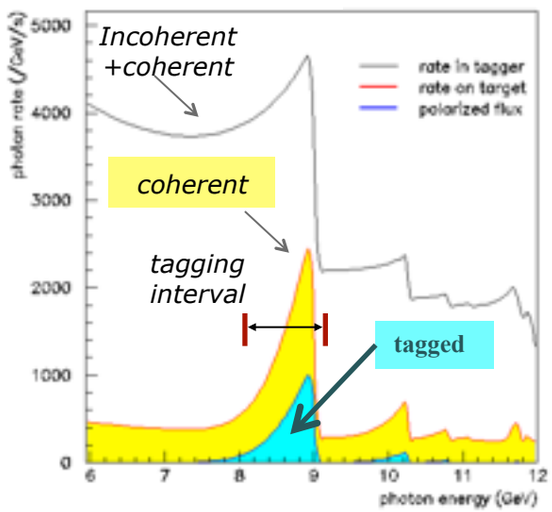


Collimator: no halo

Tagger: electrons→photons

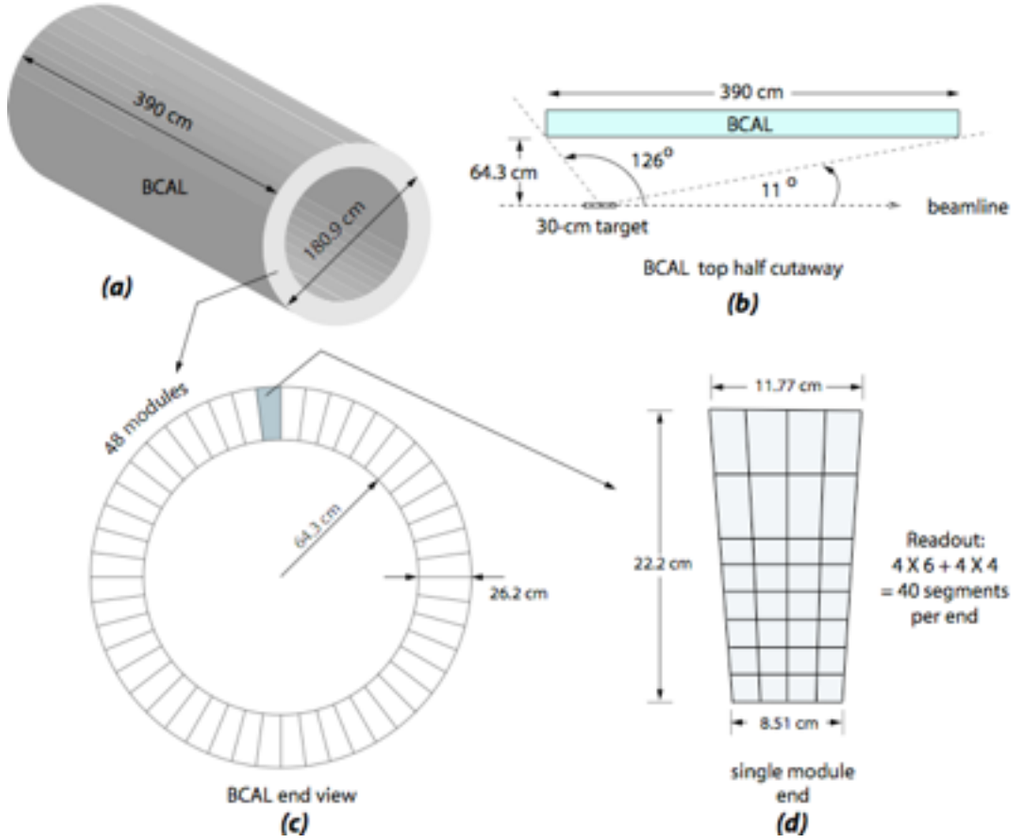
12 GeV endpoint, 9 GeV γ's
- 20 μm diamond crystal
- 300 nA electron beam
- diamond – collimator: 76 m
- collimator diameter: 3.5 mm
- dE/E = 0.1%, Pol = 40%

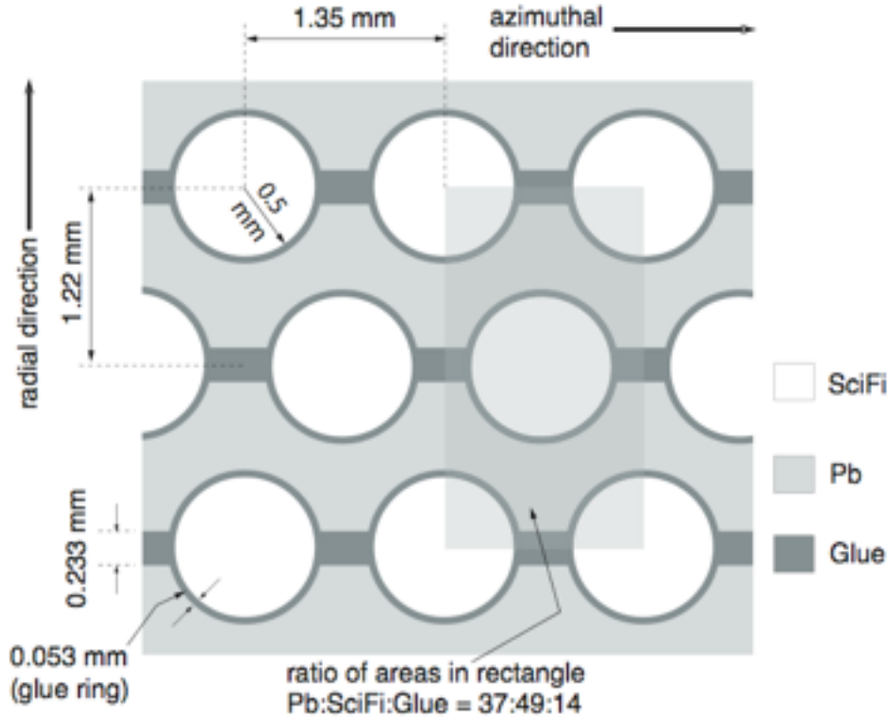
10^7 γ/s on target → 10^8 γ/s



The Barrel Calorimeter

Built at the University of Regina





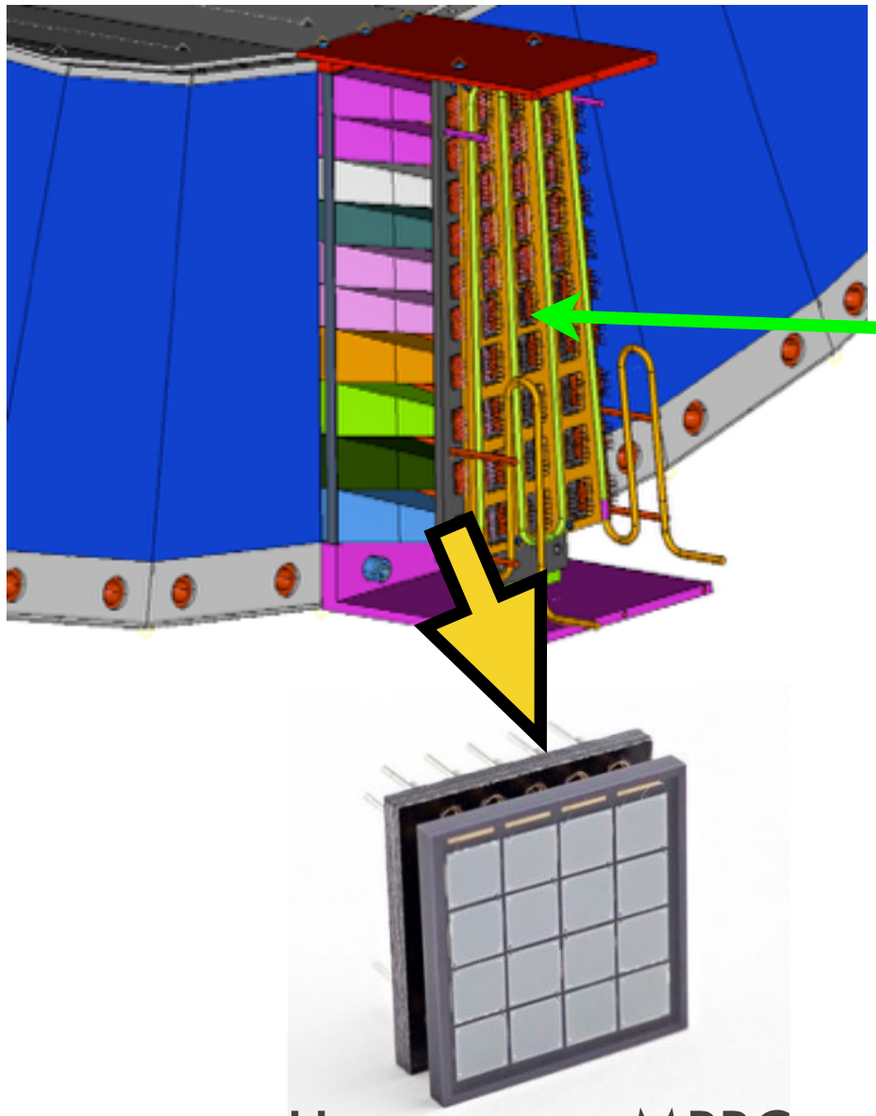
Key component of the GlueX detector

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

Geometry & Configuration

- 48 azimuthal sections (modules)
- Sampling calorimeter (9.5% sampling fraction)
- BCAL: 28 tonnes

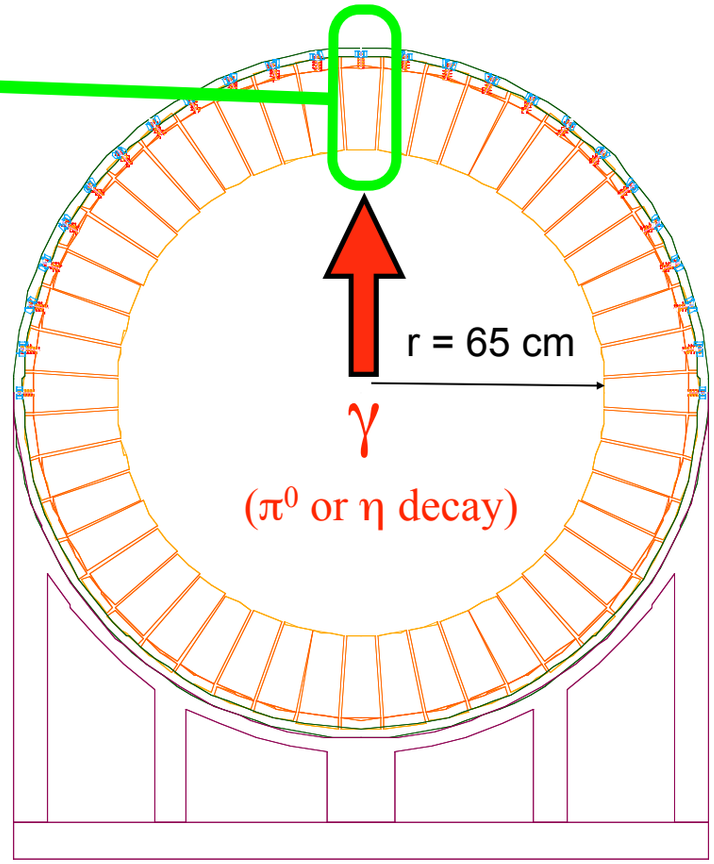
BCAL Readout

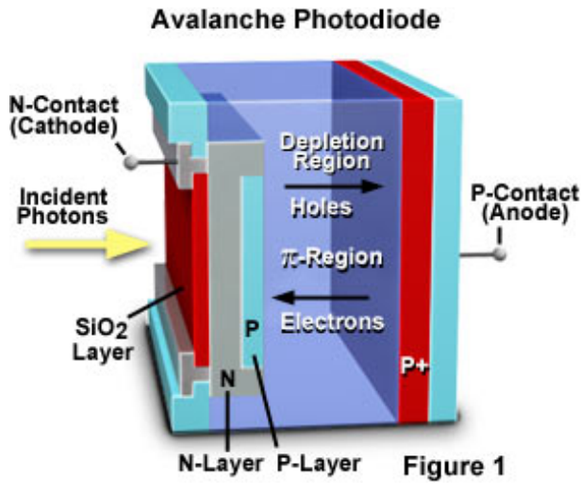


Hamamatsu MPPC

3840 units

Front view

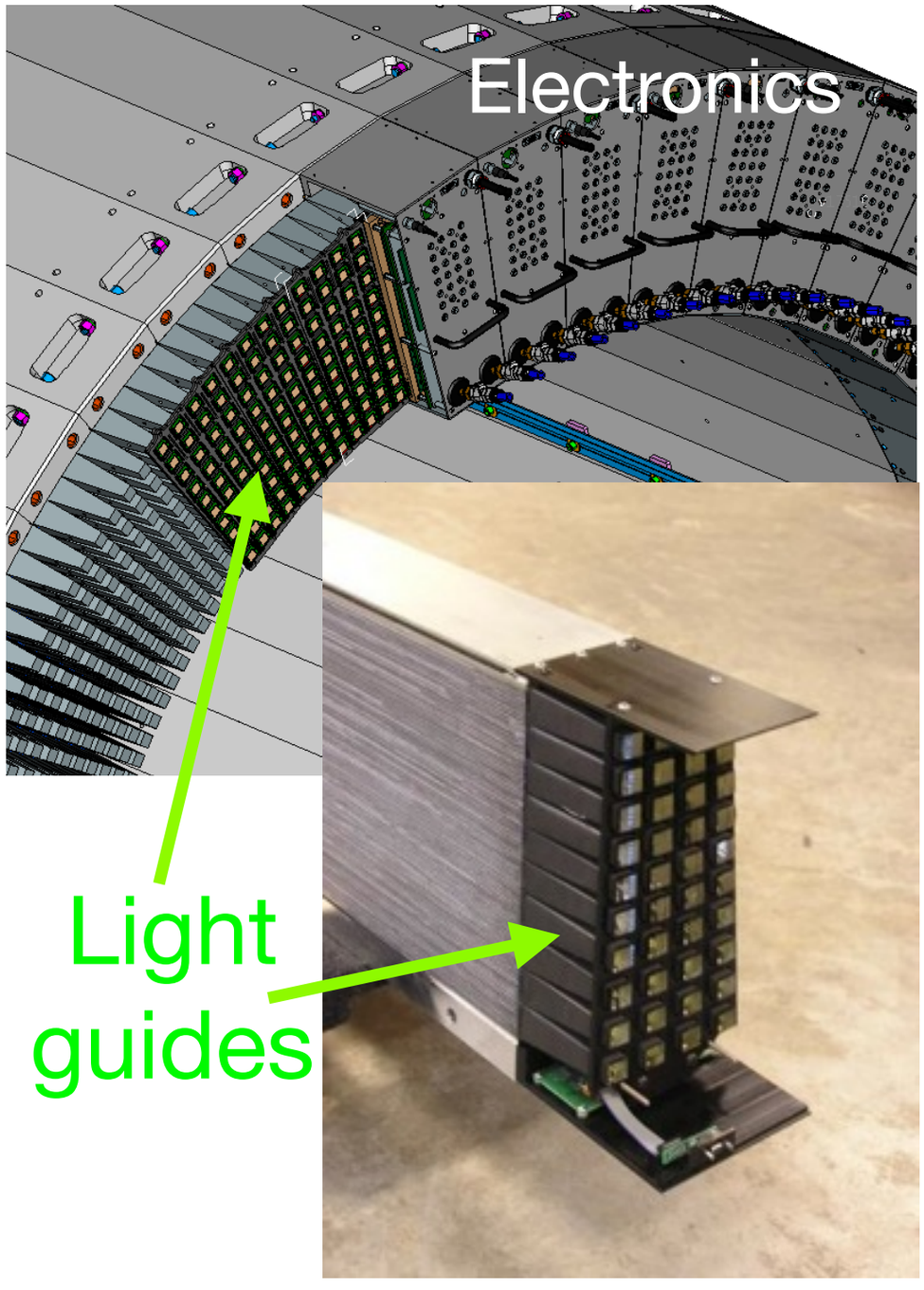


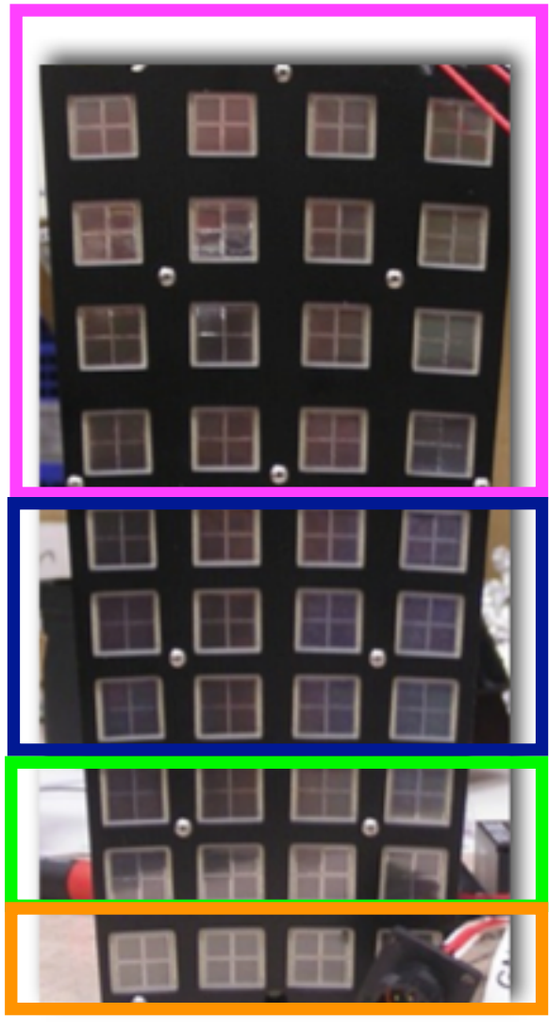


Features of SiPMs:

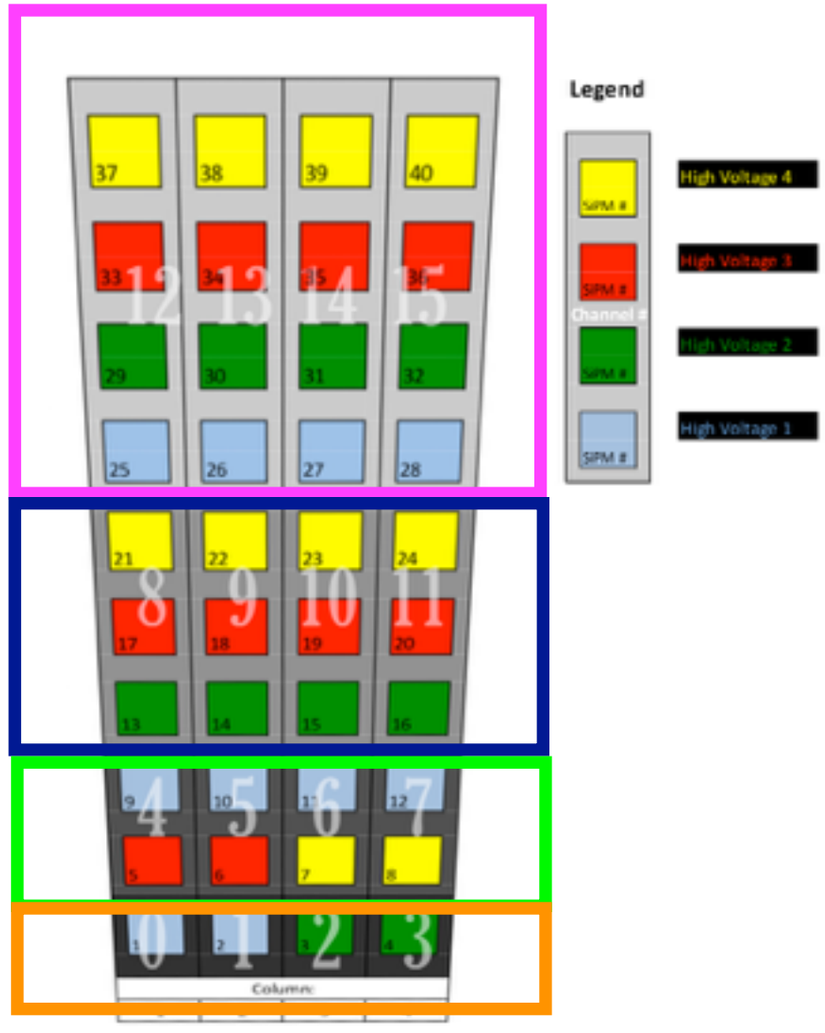
- High gain (10^6)
- Low bias voltage (~71V)
- Compact and stable
- Insensitive to magnetic fields
- Tolerant to excess light

MPPC Assemblies





Full Assembly



Sensor Summing

BCAL Installation

Sep ’13: installed

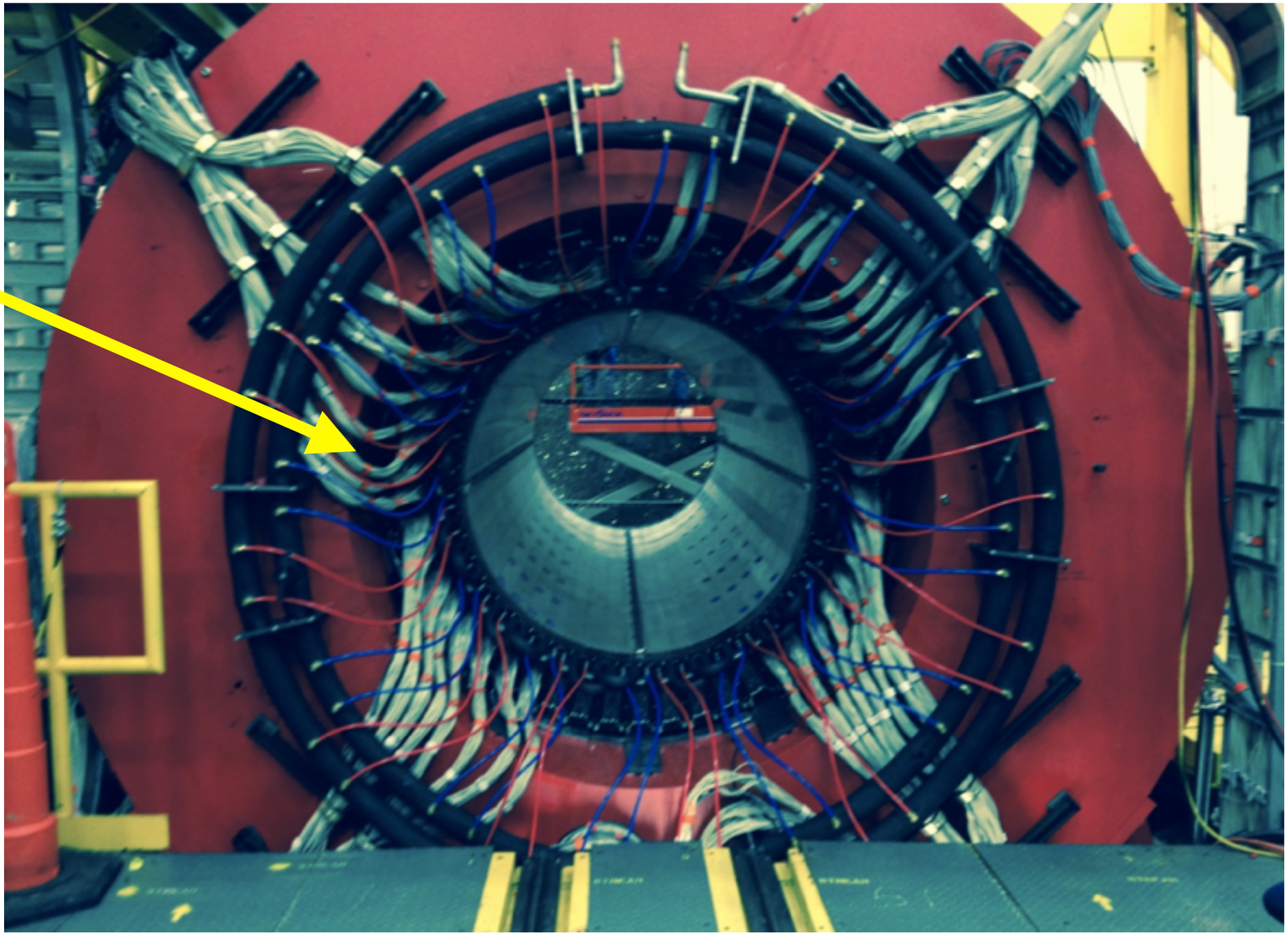
Dec ’13: cabled

Jan ’14: power

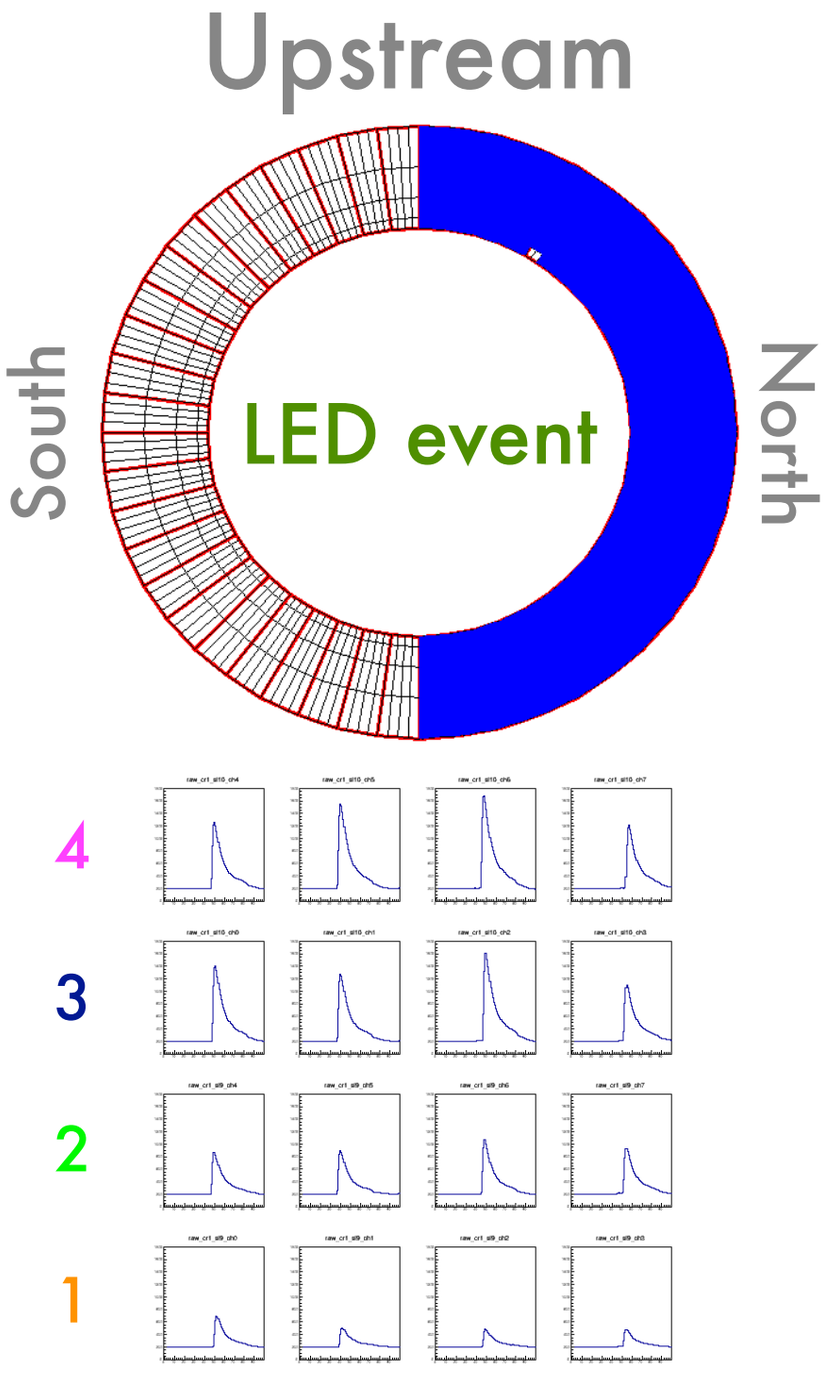
Feb ’14: N2 & cooling

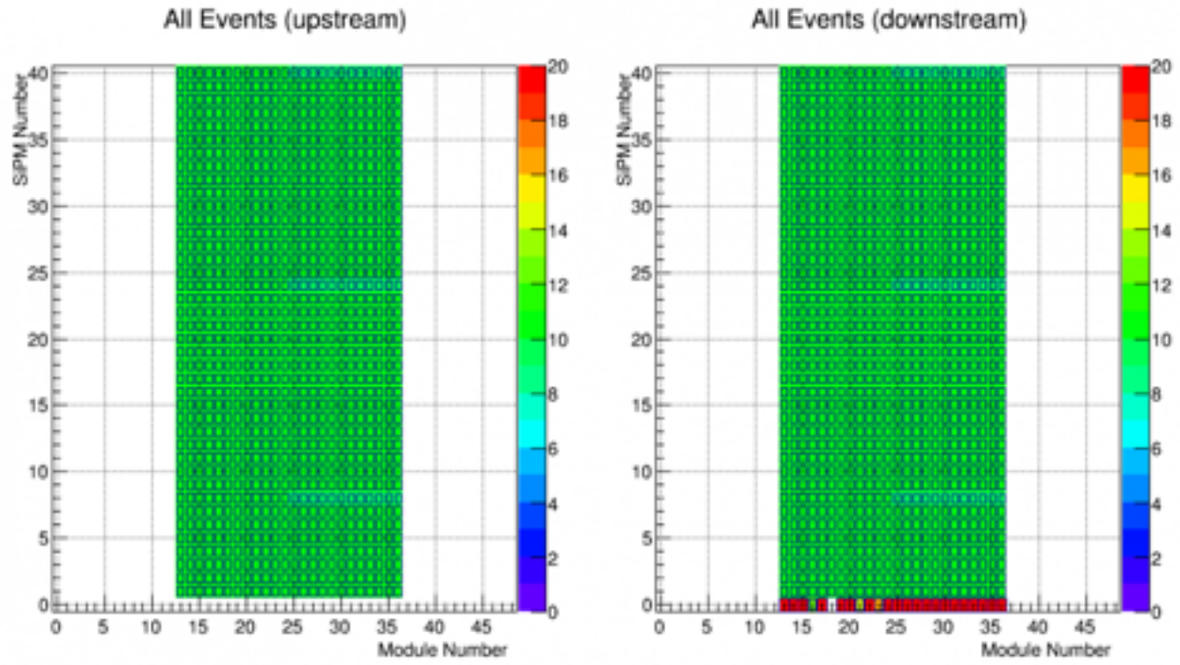
Mar ’14: turn on

Summer ’14: LED and cosmics



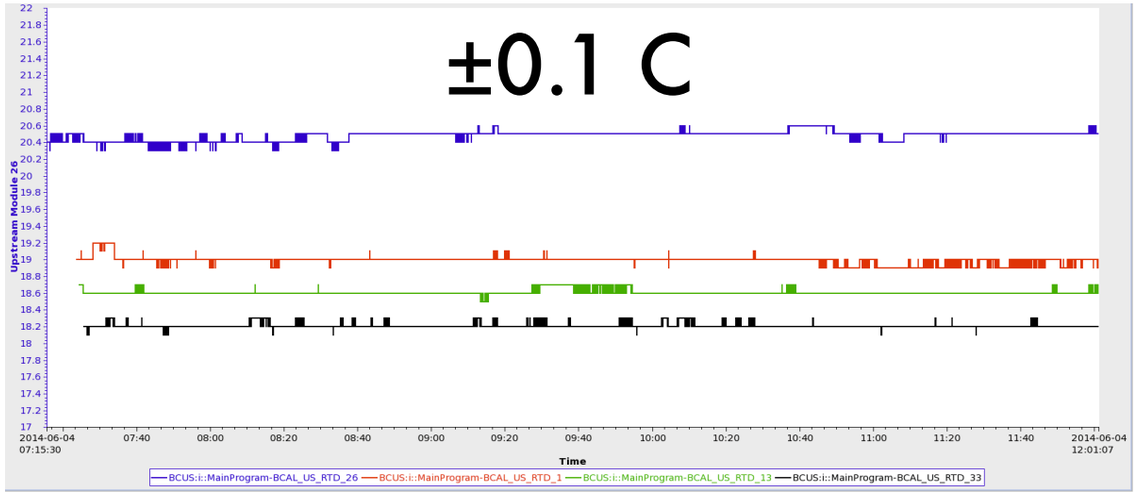
BCAL Commissioning



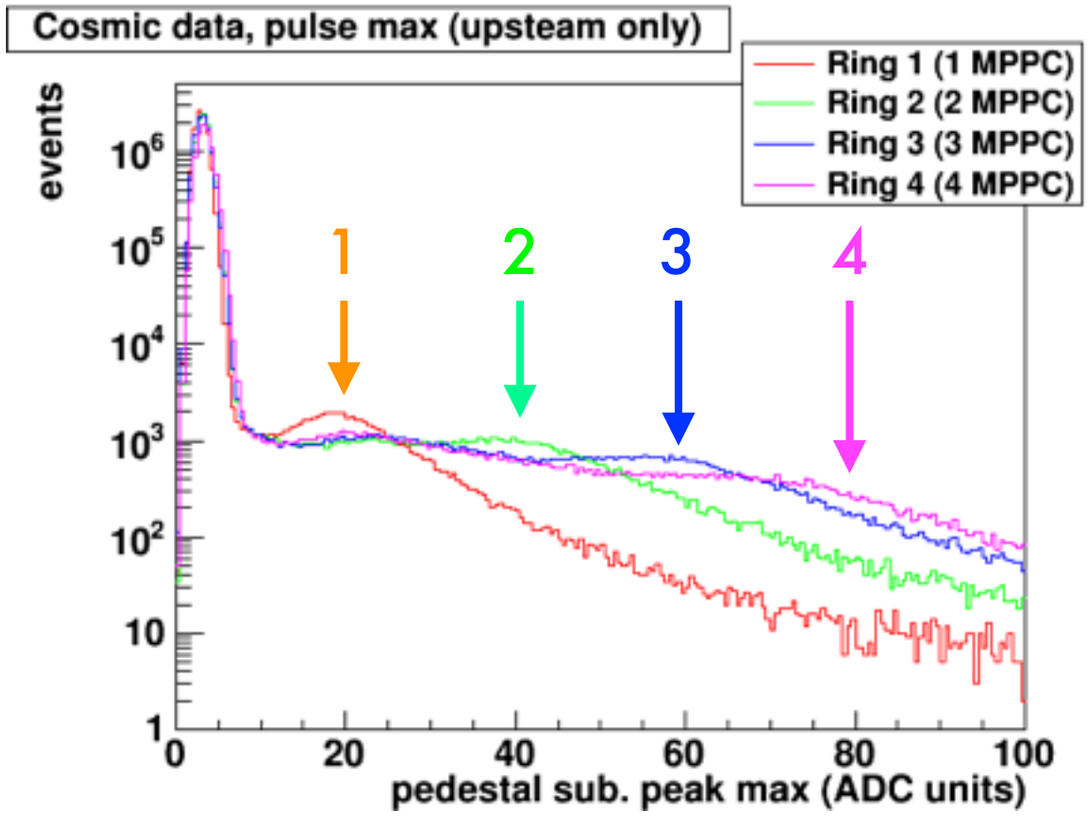


Temperature Stability

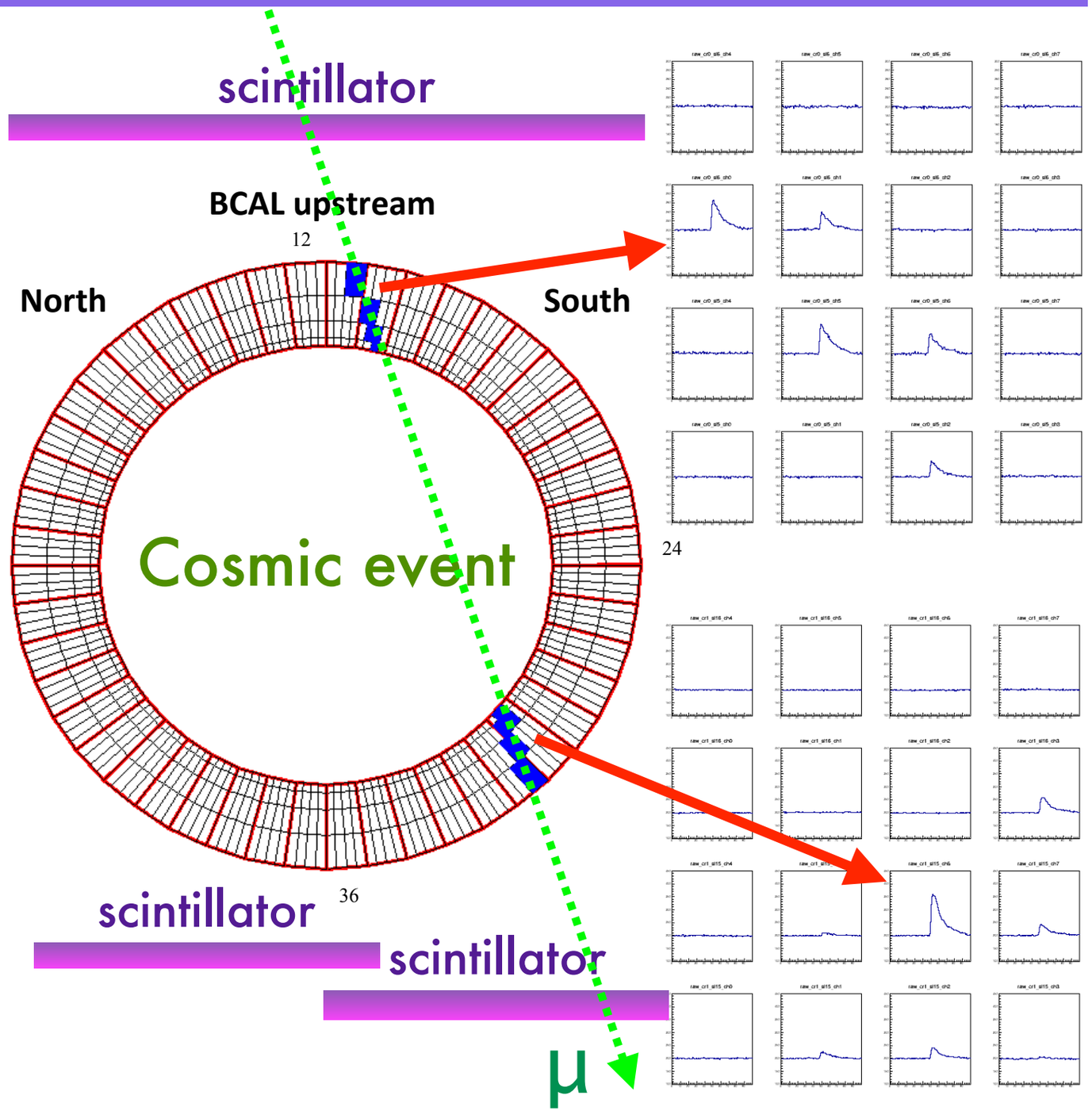
±0.1 C



BCAL Commissioning



Trigger:
- scintillators
- self-trigger



Bottom Line

- Understand quark and gluon d.o.f. in hadron spectrum; advance knowledge on quark confinement.
- Study a new spectrum of mesons as predicted by Lattice QCD and flux-tube model.
- The definitive experiment is GlueX at the 12GeV JLab.

Ongoing “Data Challenges” on the Grid
“Engineering data” in Oct-Dec 2014
“Physics data” in 2015
“Flat-out” running for at least 5 years

Acknowledgements

- A. Dzierba, Indiana University
- C. Meyer, Carnegie Mellon University
- J. Dudek, Jefferson Lab/ODU
- G. Bali, Universität Regensburg
- D. Leinweber, CSSM / U. Adelaide
- Particle Adventure
- **portal.gluex.org**
- **www.halld.org**
- **www.gluex.org**

Thank you!