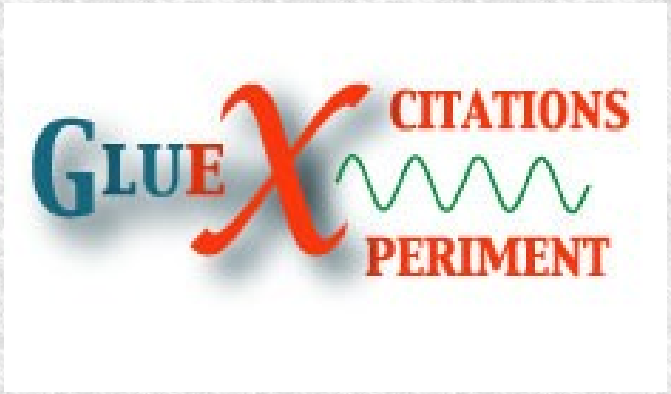


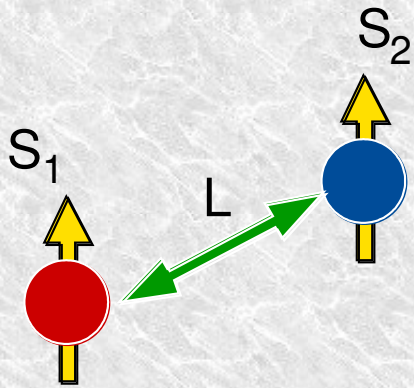
GlueX and the BCAL

Blake Leverington
(PhD student)
University of Regina

- What is GlueX? (what are we looking for?)
- How will we do it?
- BCAL: Regina's contribution to GlueX
- BCAL06: A beam test of the electromagnetic calorimeter in Hall B at Jlab
  - *analysis in progress (my contribution)*

The physics goal of GlueX is to map the spectrum of hybrid mesons (gluonic excitations) starting with those with the unique signature of exotic quantum numbers. Normal mesons in the quark model cannot have exotic J^{PC}.

Spin and angular momentum configurations as well as radial excitation give us our current meson spectrum.



$$S = S_1 + S_2$$

$$J = L + S$$

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

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

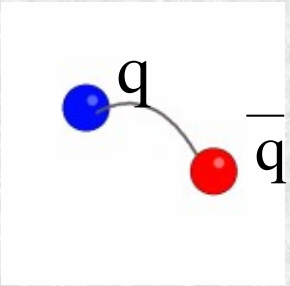
$J^{PC} = 0^{-+}\ 0^{++}\ 1^{--}\ 1^{+-}\ 2^{++}\ \ldots$

Allowed combinations

$J^{PC} = 0^{--}\ 0^{+-}\ 1^{-+}\ 2^{+-}\ \ldots$

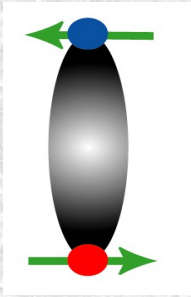
Not-allowed: exotic

The flux tube gives an extra degree of freedom with $J^{PC} = 1^{-+}$ or $J^{PC}=1^{+-}$ for the flux-tube in the first excited state.



Quarks $\oplus$ **Excited Flux Tube** → **Hybrid Meson**

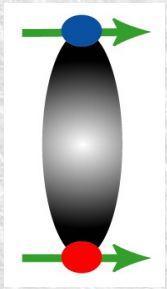
$S = 0$
$L = 0$
$J^{PC} = 0^{-+}$
like π, K



$$J^{PC} = \begin{cases} 1^{+-} \\ 1^{-+} \end{cases}$$

$$J^{PC} = \begin{cases} 1^{--} \\ 1^{++} \end{cases}$$

$S = 1$
$L = 0$
$J^{PC} = 1^{--}$
like γ, ρ



$$J^{PC} = \begin{cases} 1^{+-} \\ 1^{-+} \end{cases}$$

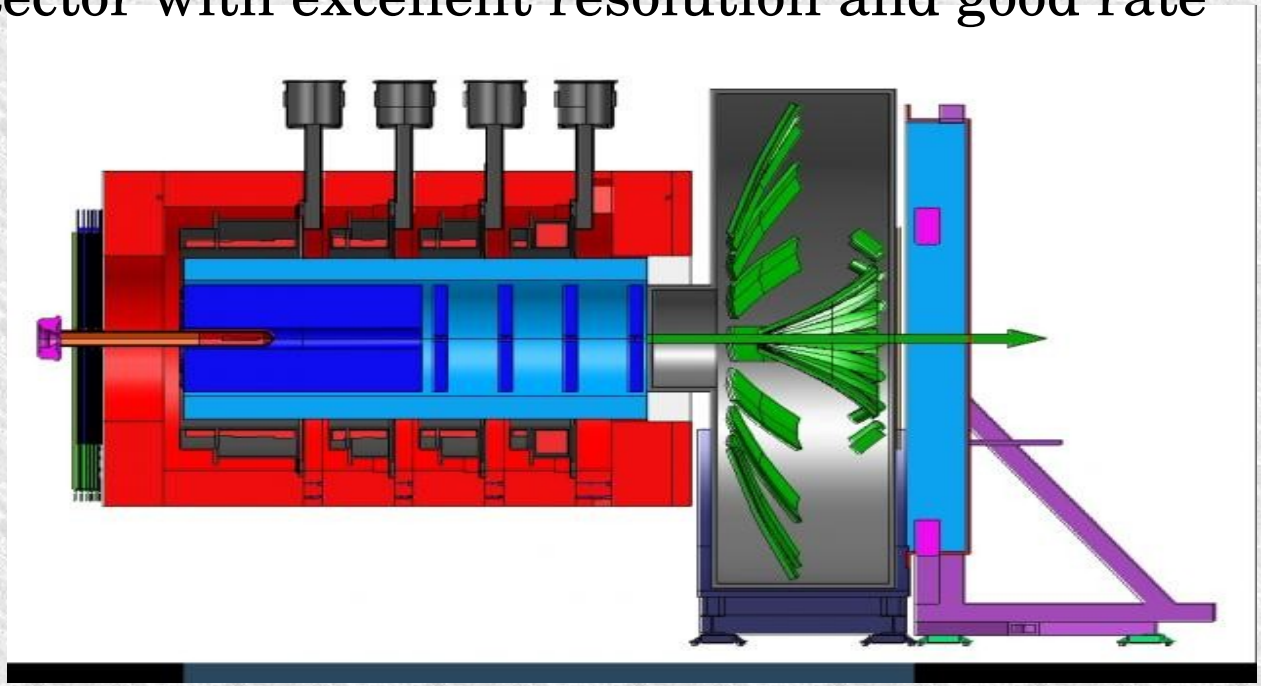
Exotic

$$J^{PC} = \begin{cases} 0^{-+} & 1^{-+} & 2^{-+} \\ 0^{++} & 1^{+-} & 2^{+-} \end{cases}$$

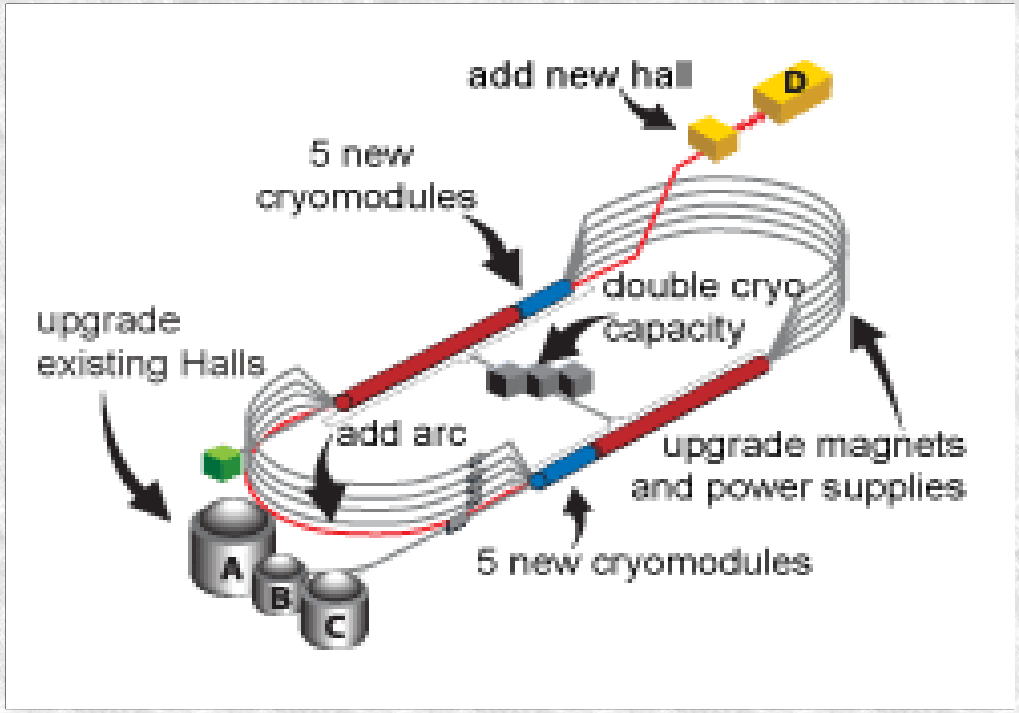
• The GlueX/Hall D collaboration was formed to design a photon beam and detector to map the exotic hybrid spectrum

•GlueX will collect statistics on mesons up to 2.5 GeV/c^2

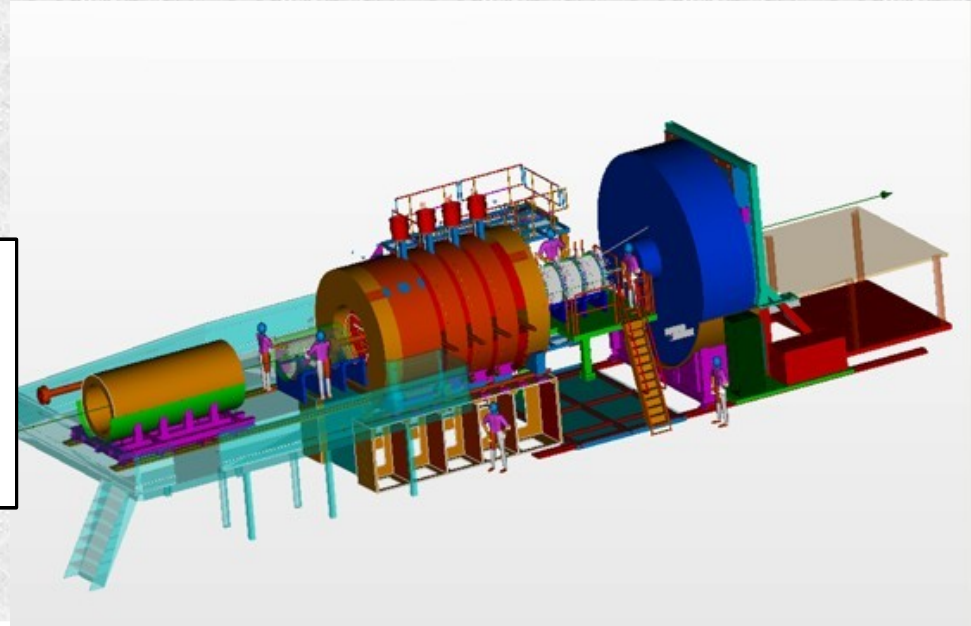
•Partial wave analysis (PWA) will be used to identify the quantum numbers of the mesons. This requires an hermetic detector with excellent resolution and good rate capabilities.

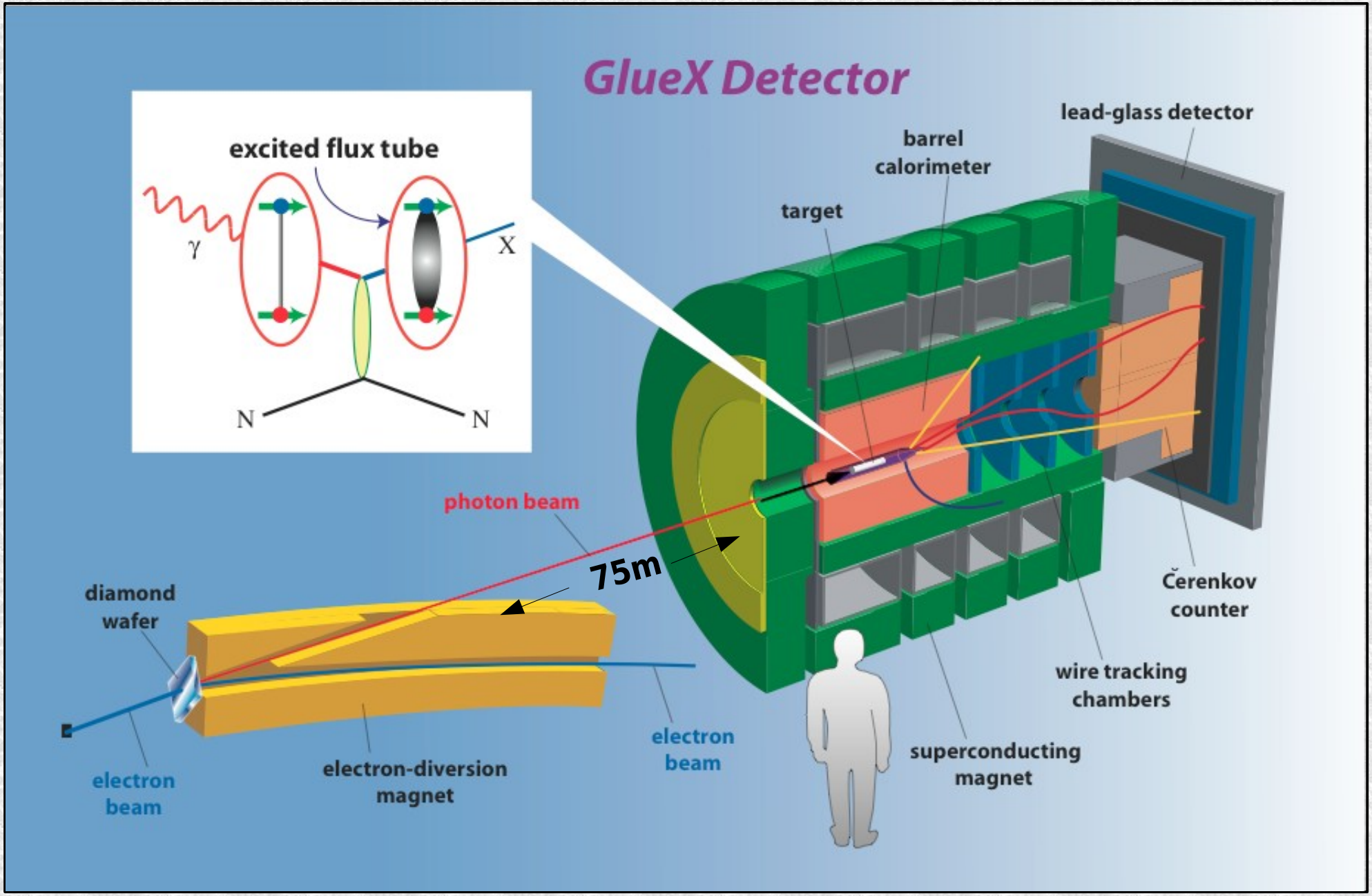


In addition, sensitivity to hybrid masses up to 2.5 GeV/c^2 requires 9 GeV photons which will be produced using coherent bremsstrahlung from 12 GeV electrons.



GLUEX CITATIONS PERIMENT




GlueX Detector
excited flux tube
γ
X
N
N
lead-glass detector
barrel calorimeter
target
photon beam
75m
diamond wafer
Čerenkov counter
wire tracking chambers
electron beam
electron-diversion magnet
electron beam
superconducting magnet

GlueX Electromagnetic Barrel Calorimeter (BCAL)

A key component of the GlueX detector

1. crucial for reconstructing all the photons from pi-0 and eta decays which can come from produced mesons
2. required for providing timing information for charged particles
3. in conjunction with the CDC will provide the PID for proton detection
4. will provide secondary dE/dx and timing info for other systems

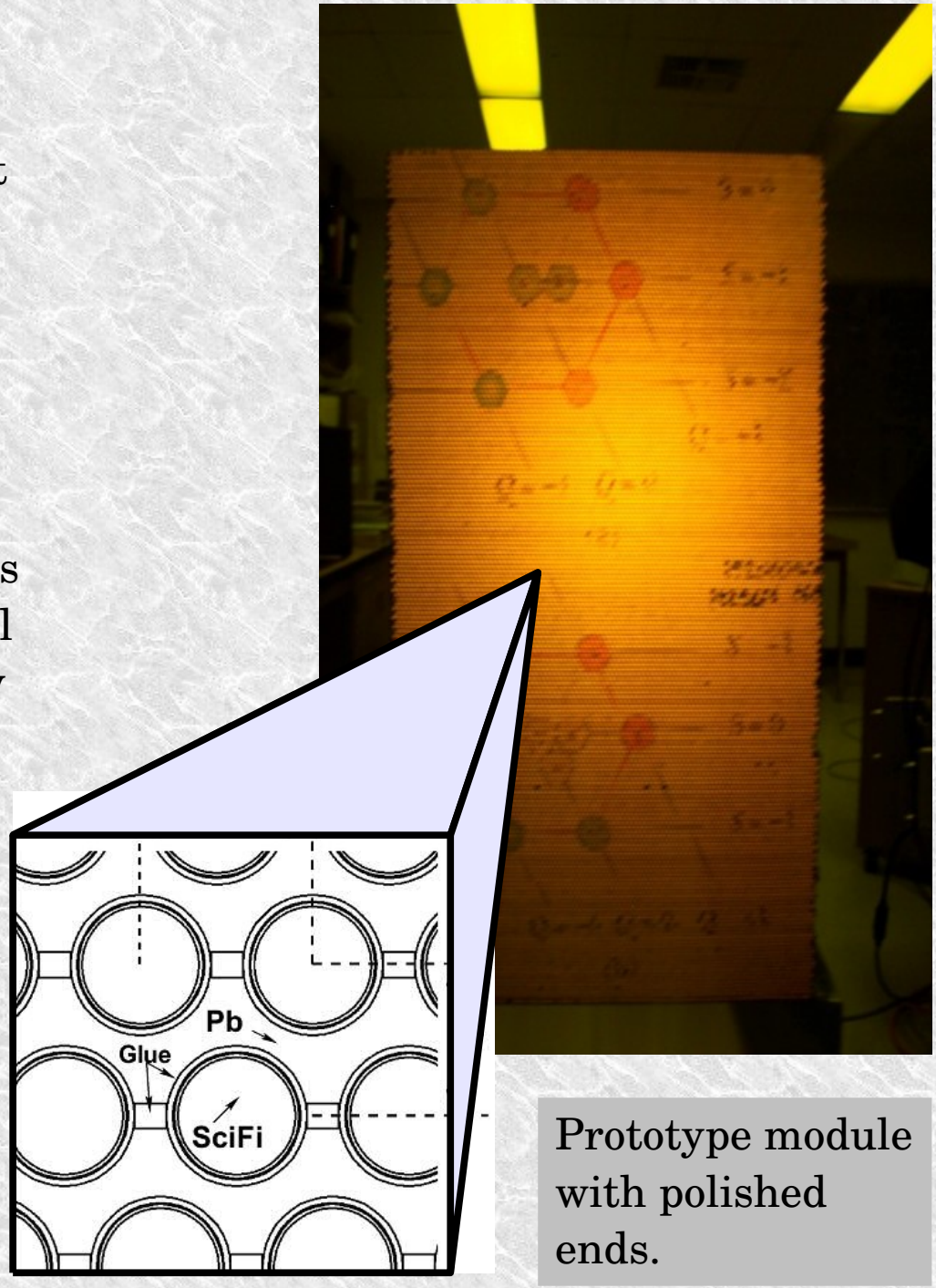
Students construct a prototype BCAL module in Edmonton, Alberta.

•Based on the KLOE design at DAΦNE but improved (better fibres, construction, etc.)

• The BCAL will consist of 48 modules 390cm long and 25cm thick in a barrel configuration (~40 tonnes)

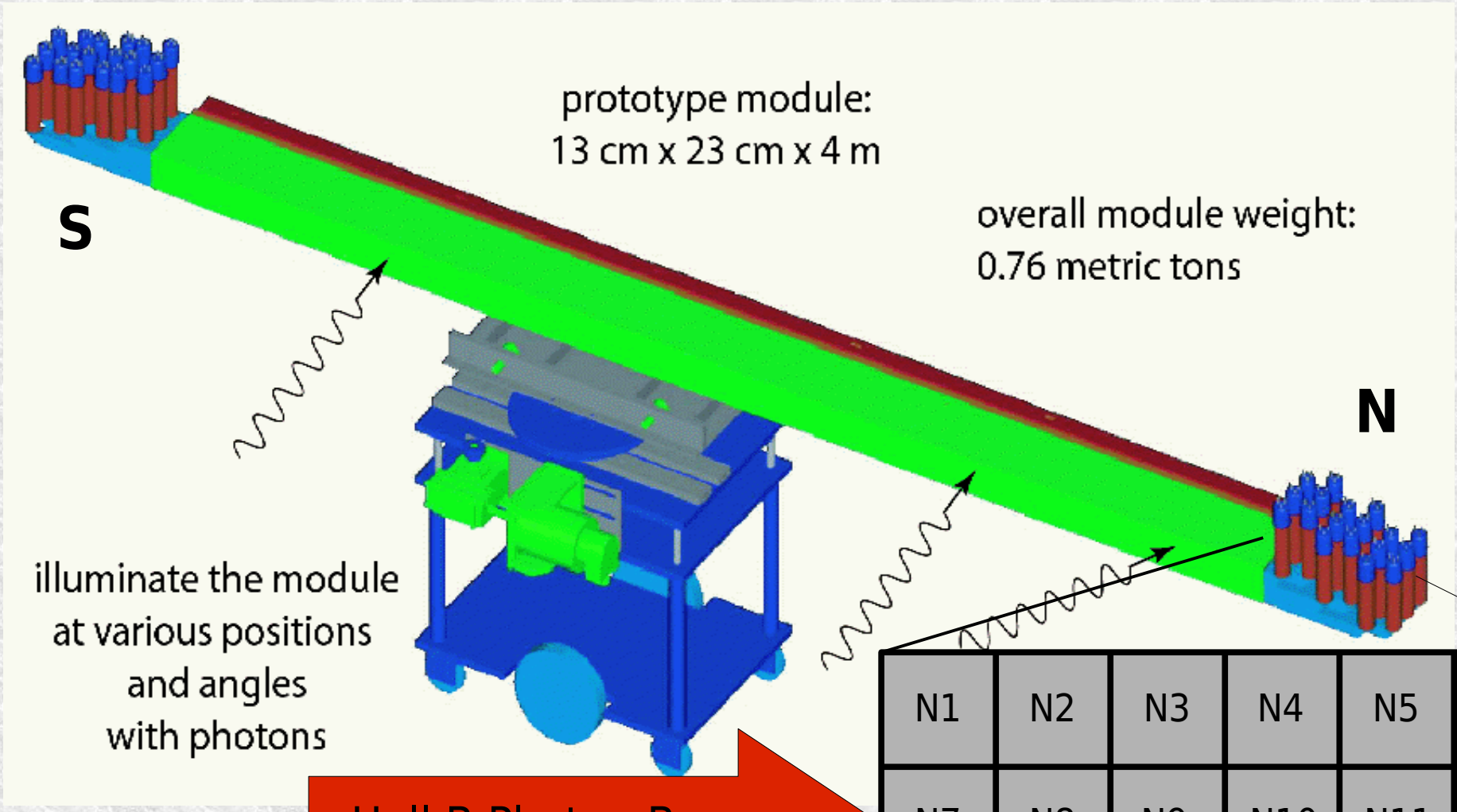
• Each module is made of alternating layers of lead, scintillating fibres and glue (optical epoxy) to bond them together (37:49:14 by vol.)

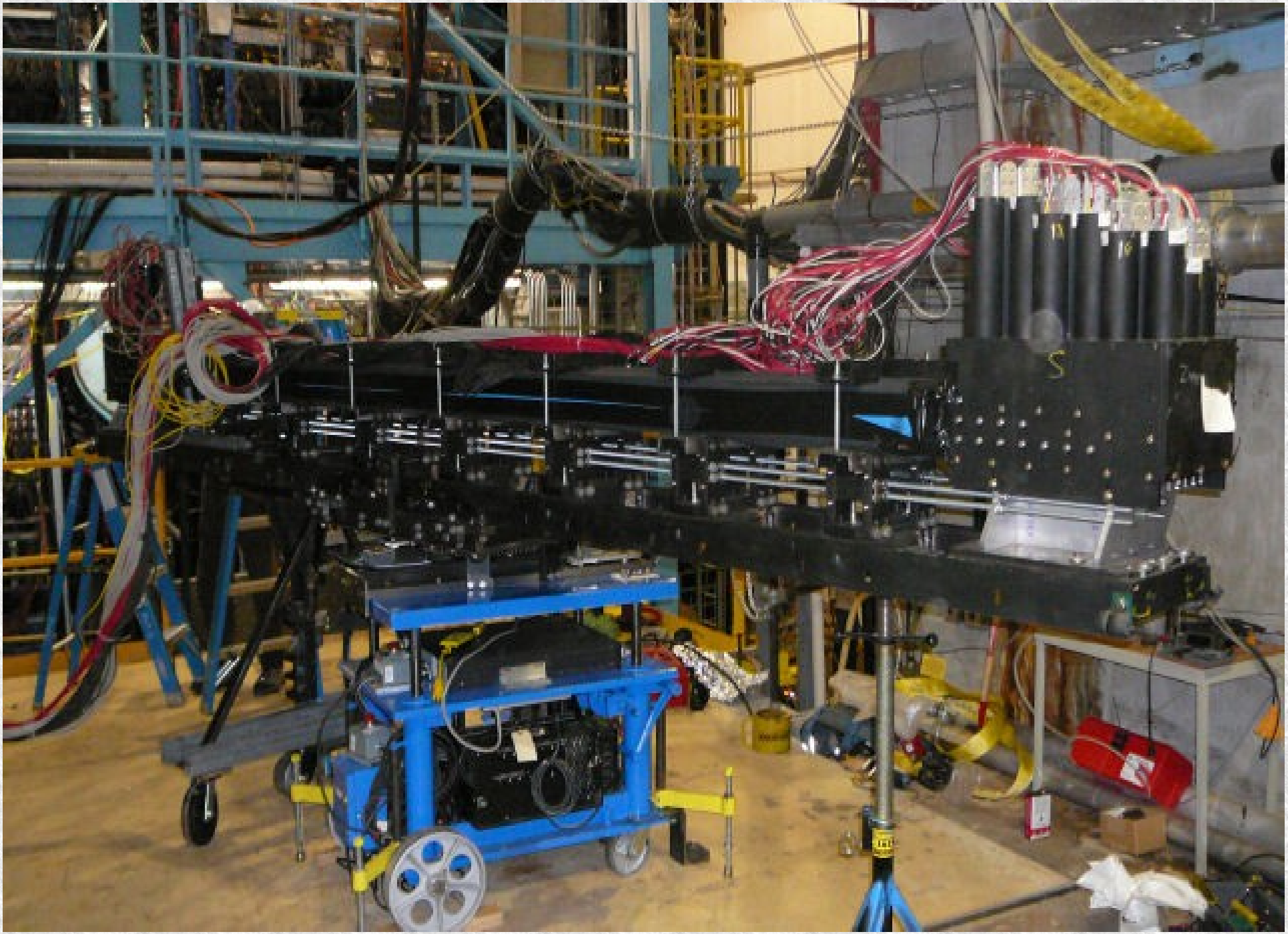
•The scintillating fibres (SciFi) have a polystyrene core which produces 8000 photons/MeV and are fast green or blue double clad (increases light captured by ~50%)



Prototype module with polished ends.

Hall B beam test of the BCAL in Fall 2006





Goals of the beam test: measure the energy, timing and position resolution of the calorimeter module.
Requirements of Gluex: ~5%/√E energy resolution and ~4cm/√E position resolution for photon reconstruction

KLOE final resolutions:

Energy

$$\frac{\sigma(E)}{E} = \frac{5.4\%}{\sqrt{(E(GeV))}} \oplus 0.7\%$$

"The resolution is dominated by sampling fluctuations with a contribution from photoelectron statistics of ~2.4%. [1]"

Timing

$$\sigma_t = \frac{56\,ps}{\sqrt{(E(GeV))}} \oplus 133\,ps$$

"The constant term is mostly due to the instrinsic time spread due to the finite length in the z direction of the luminous point. [1]"

[1] NIM A 494(2002)326-331

BCAL Beamtest Energy Resolution

Important step: Gain balance all 36 of the PMTs

Online: this was done to first order using cosmic ray runs prior to the photon beam runs (done during debugging and setup)

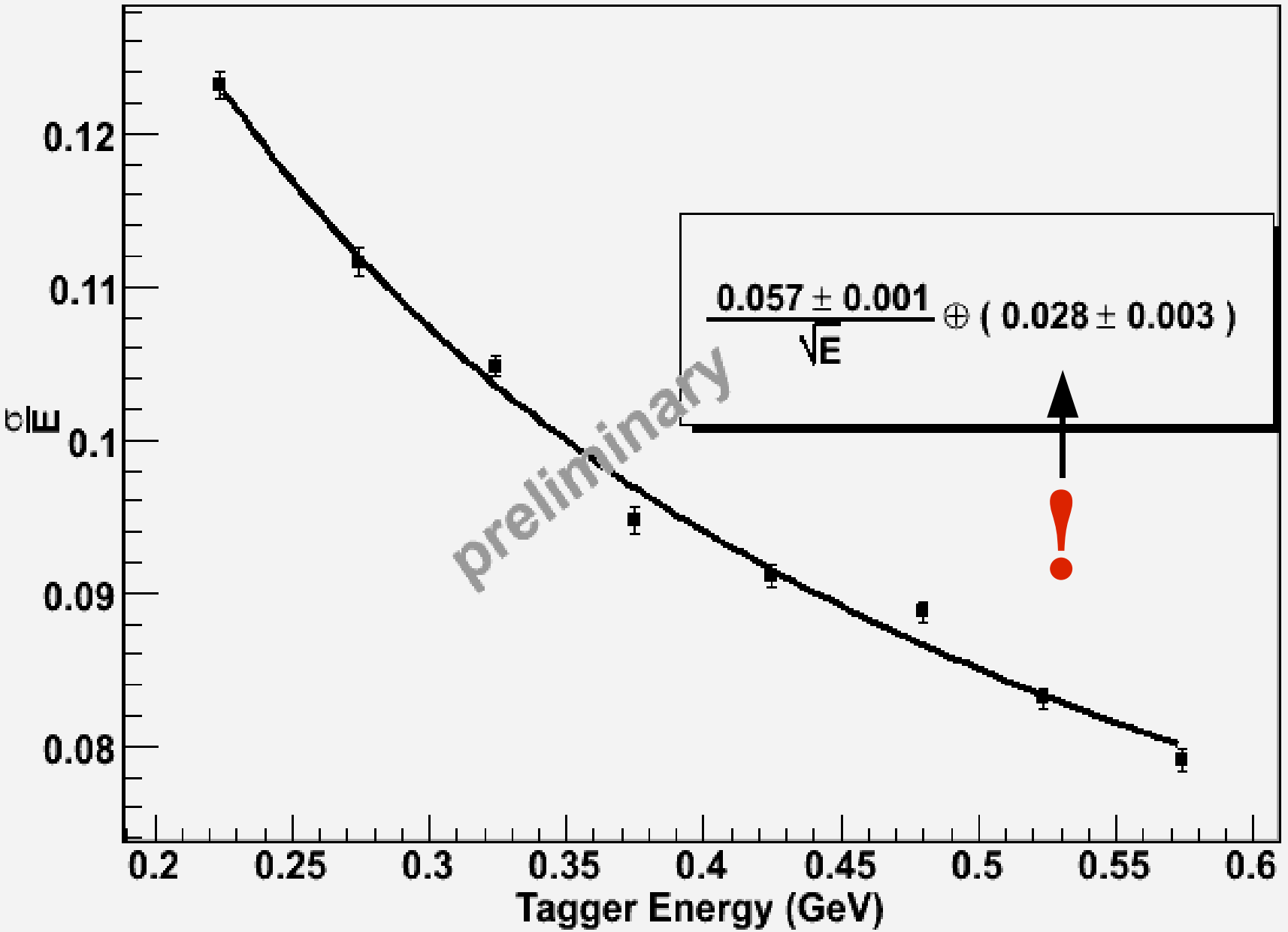
Offline: Method 1 – match ADC spectra to Monte Carlo energy data

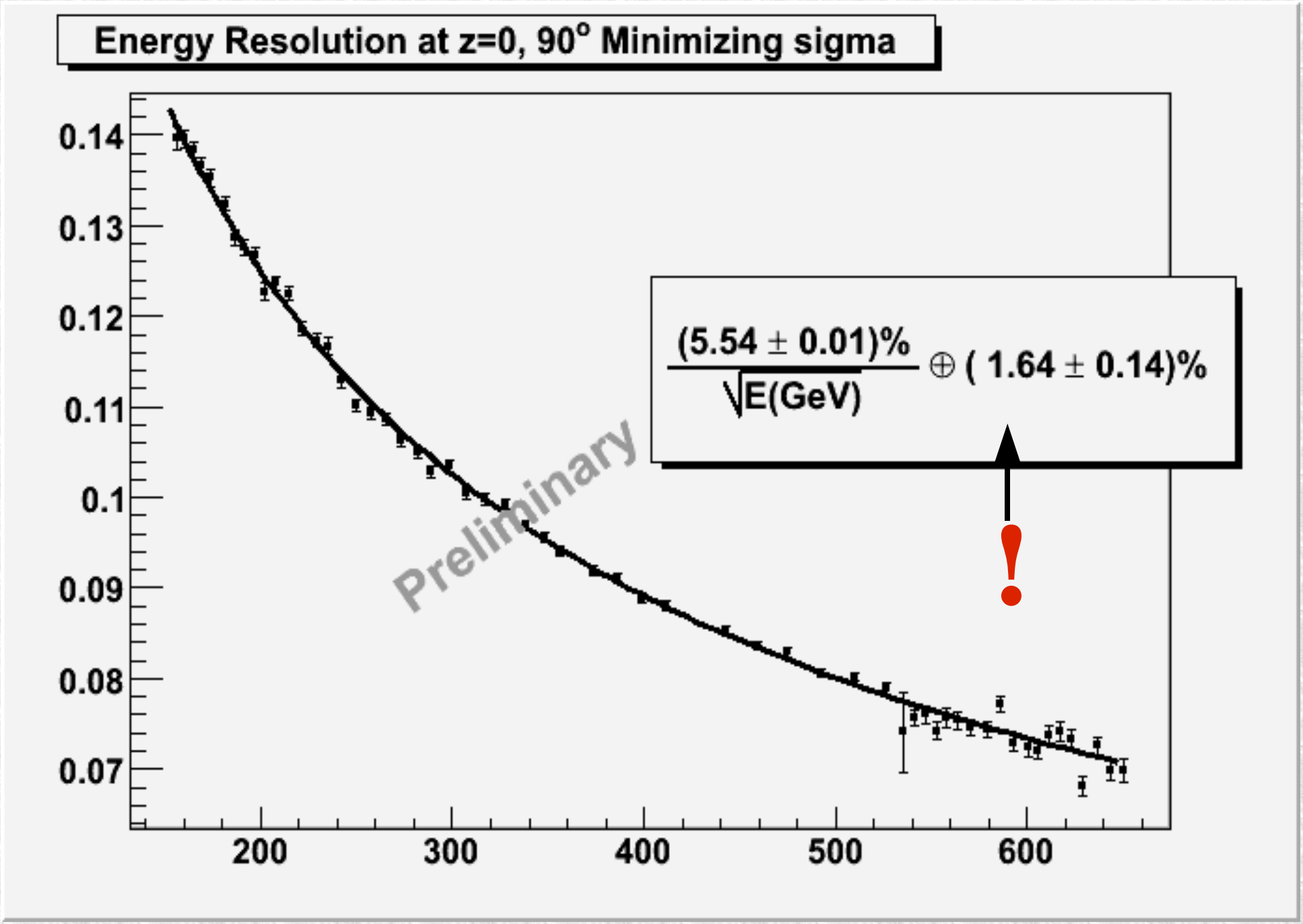
Method 2 – minimize the width of the difference between the tagged Beam energy and the Sum of the ADCs (like KLOE beam test)

$$z = \frac{E_{beam} - E_{bcal}}{E_{beam}}$$

Both work equally well to first order and nearly agree within error but floor term is slightly larger than expected.

Energy resolution at z=0cm Monte Carlo corrected




Energy Resolution at z=0, 90° Minimizing sigma
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
200
300
400
500
600
$\frac{(5.54 \pm 0.01)\%}{\sqrt{E(GeV)}} \oplus (1.64 \pm 0.14)\%$
Preliminary
!

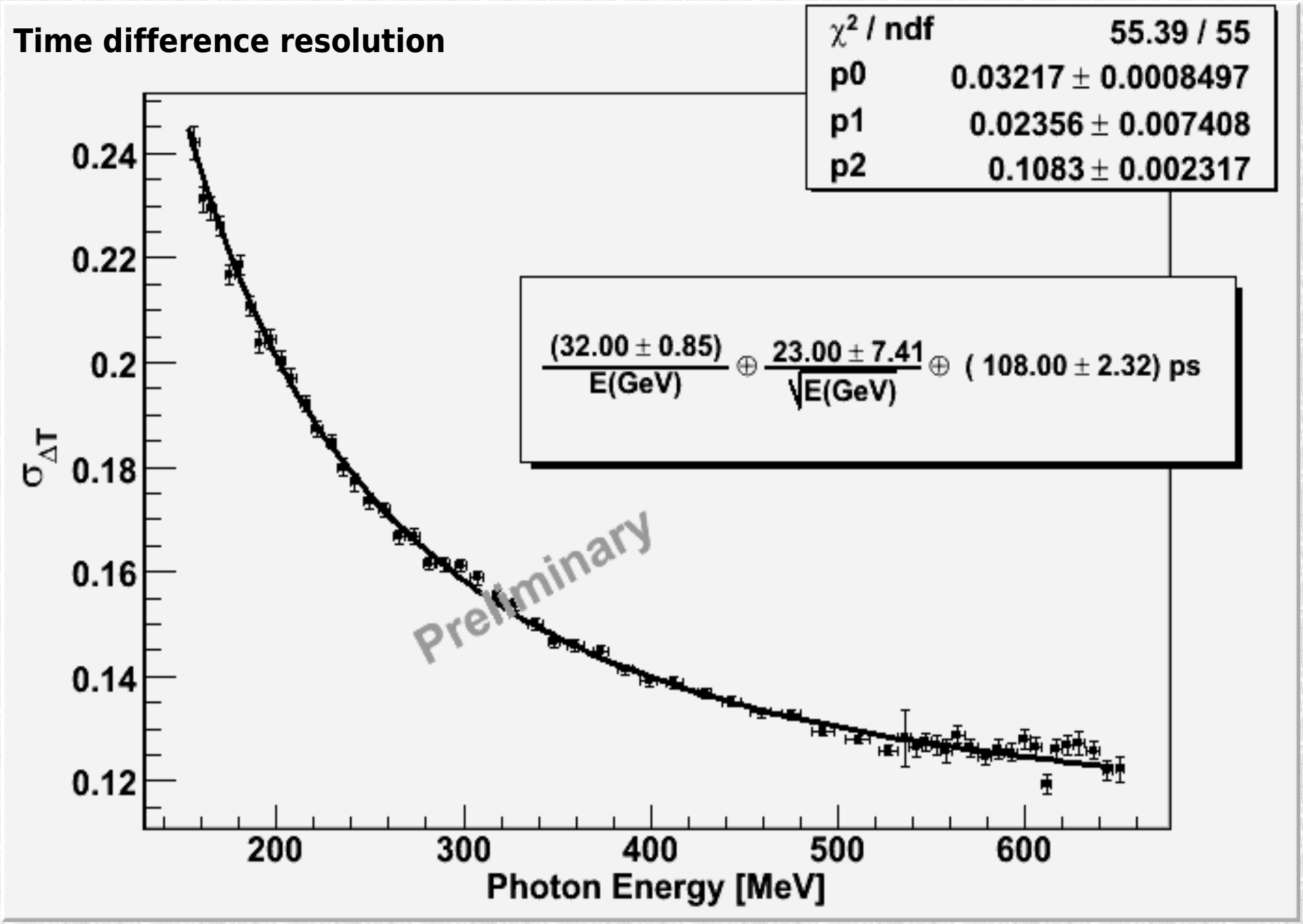
BCAL Beam test Timing Resolution

We want to find the **time difference** resolution, which gives the position resolution, as well as the **time average** resolution.

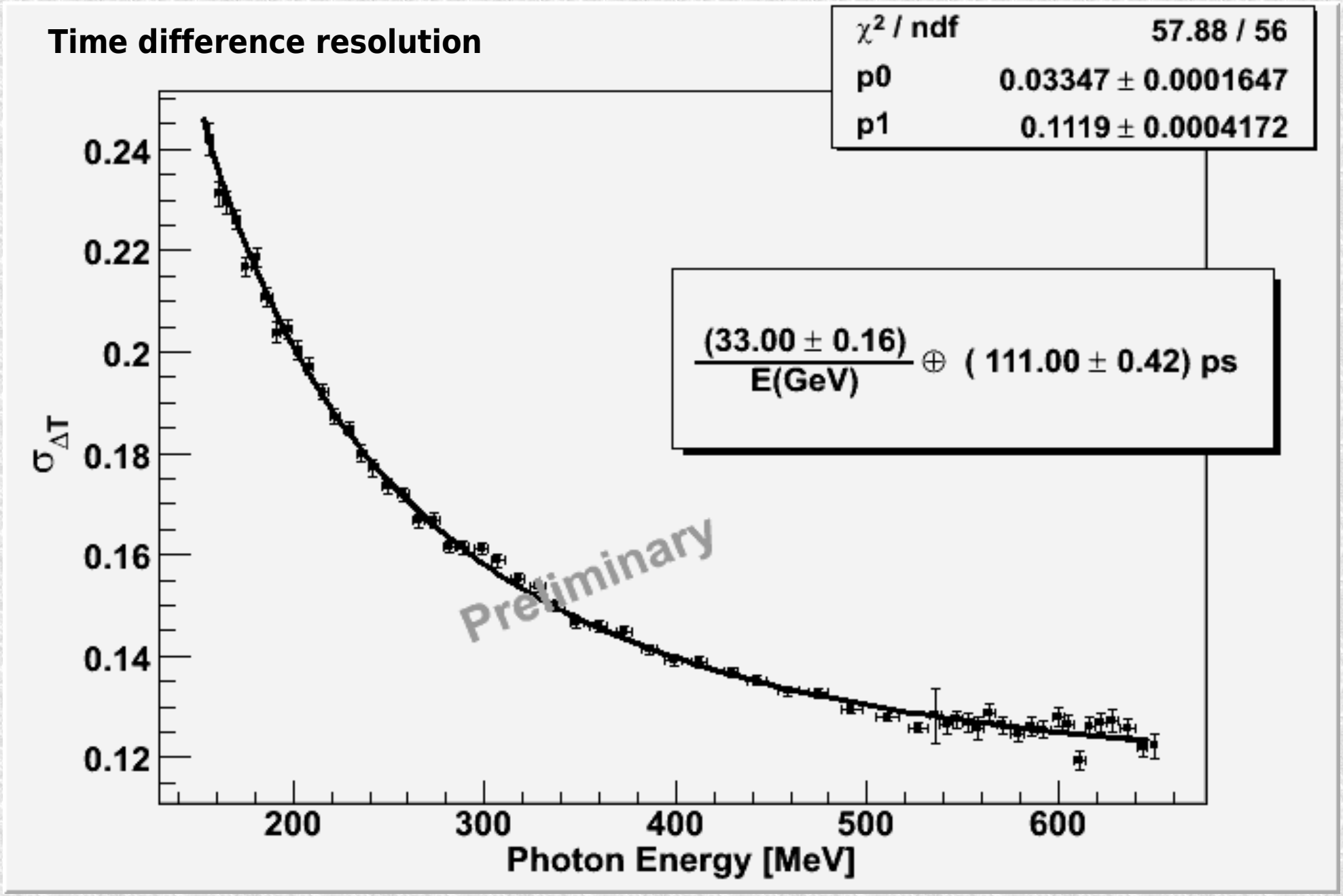
Time Average: The TDC data must be referenced with respect to another time signal (i.e. the Hall B tagger) which must then have its resolution unfolded from the overall resolution. The shower profile and fluctuations within the BCAL will reduce the apparent length of the BCAL. Important for **charged particle** tracking.

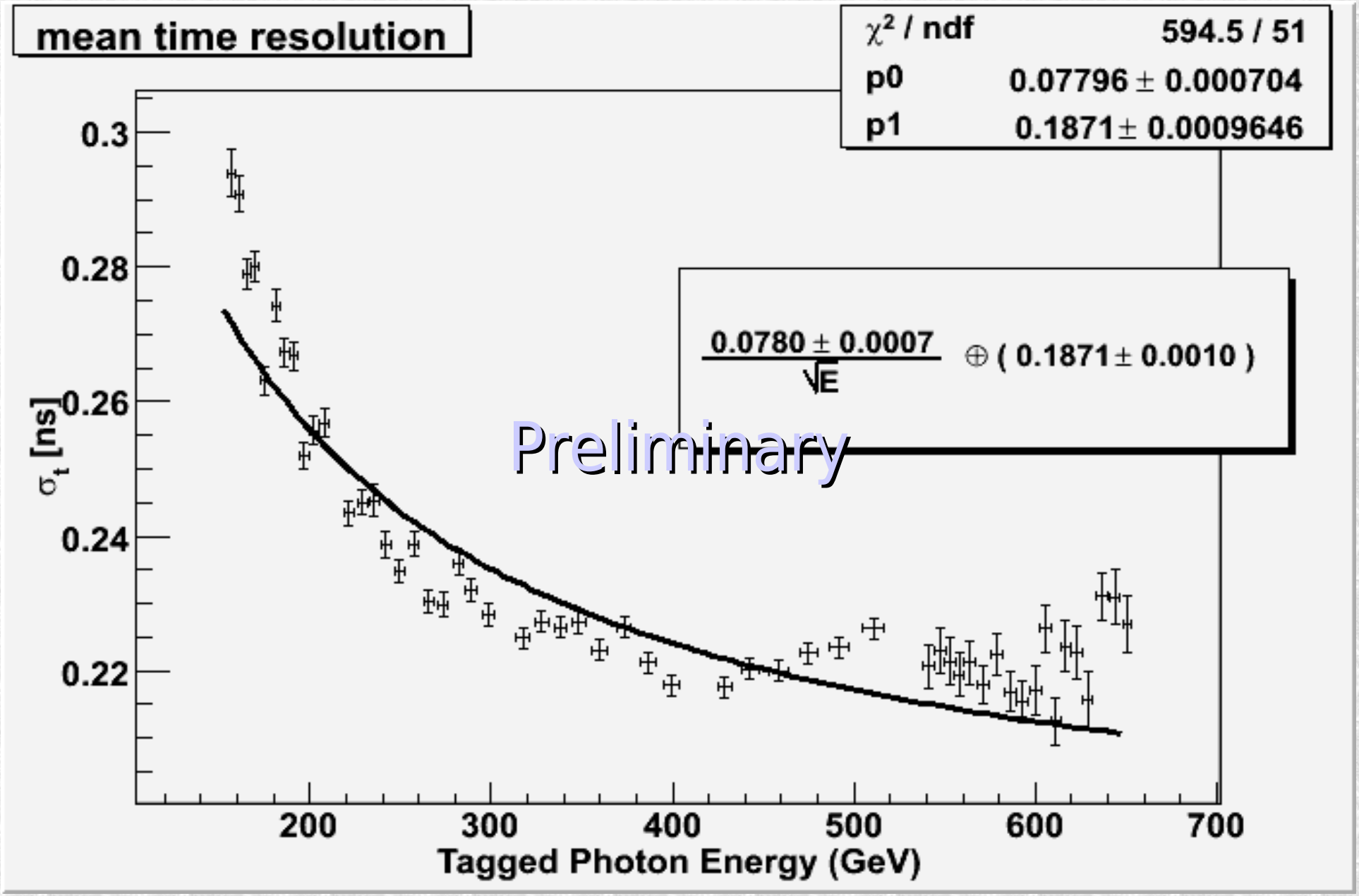
Time Difference: The width of the beam (1.8 cm at the BCAL) will contribute to the resolution (sigma/√12) and will have to be removed. This is needed for **photon** reconstruction.

Time difference resolution

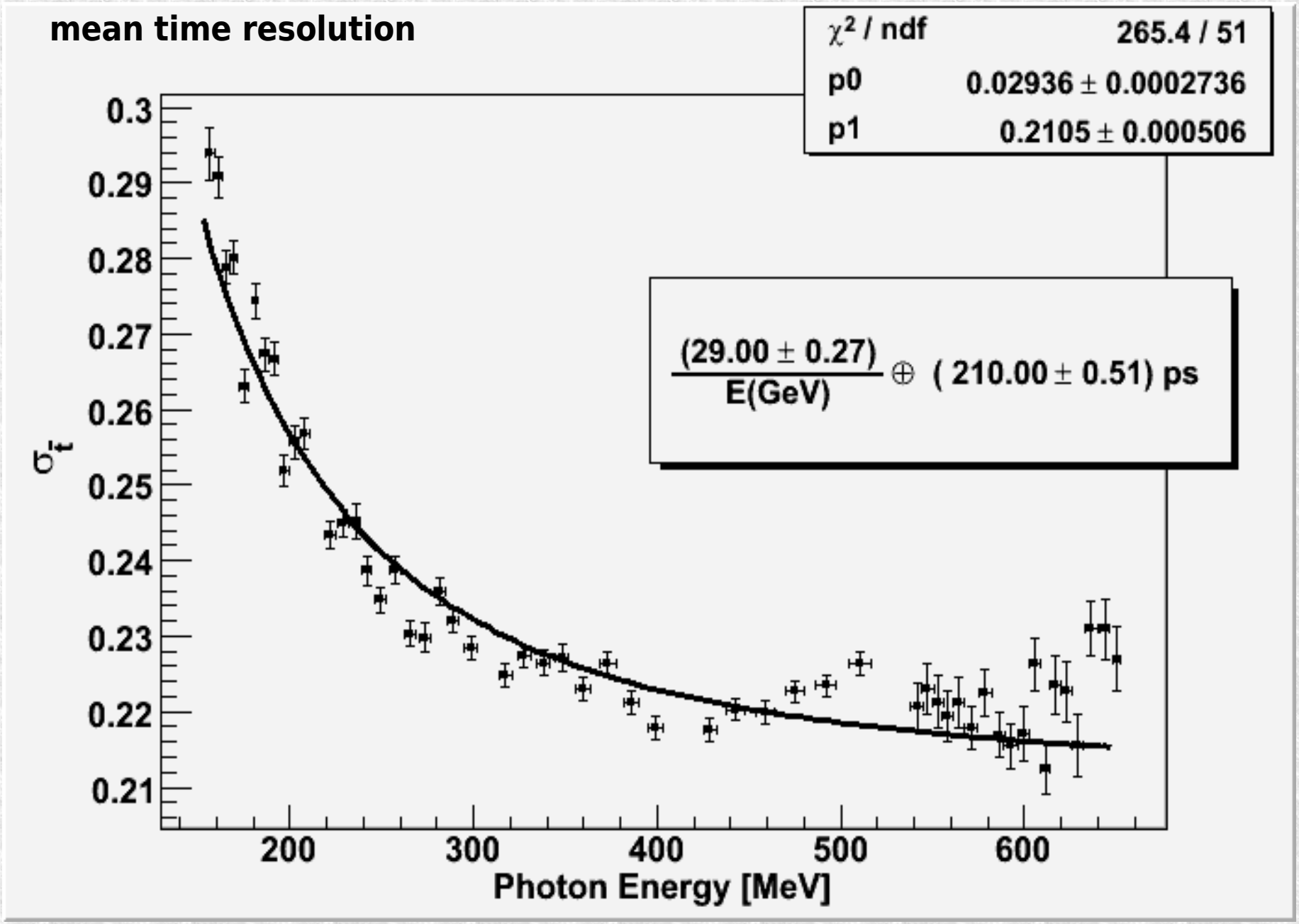


Time difference resolution




mean time resolution
χ^2 / ndf 594.5 / 51
p0 0.07796 ± 0.000704
p1 0.1871 ± 0.0009646
$\frac{0.0780 \pm 0.0007}{\sqrt{E}} \oplus (0.1871 \pm 0.0010)$
Preliminary
σ_t [ns]
0.3
0.28
0.26
0.24
0.22
200
300
400
500
600
700
Tagged Photon Energy (GeV)

mean time resolution



Summary

• More work needs to be done on the analysis but hopefully all should be completed before the end of the year!

•Preliminary results show nothing catastrophic and seem to indicate results similar to expectations.

•GlueX is an important experiment in understanding gluonic excitations in meson spectroscopy.

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(*) Institutions not yet committed but involved in workshops and planning

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Time difference resolution