PR12-23-004

A Search for a Nonzero Strange Form Factor of the Proton at 2.5 $(GeV/c)^2$

R.Beminiwattha, S.P.Wells, N.Simicevic, D.Hamilton, O.Jevons, R.Montgomery, C. Palatchi, K.Paschke, S.Ali, X.Bai, G.Cates, R.Lindgren, N.Liyanage, V.Nelyubin, R. Richards, X.Zheng, **B.Wojtsekhowski**, A.Camsonne, S.Covrig Dusa, P.Degtiarenko, D.Gaskell, O.Hansen, W. Henry, D. Higinbotham, D.Jones, M.Jones, C.Keppel, D. Mack, S. Lassiter, D.Meekins, R.Michaels, B.Raydo, H.Szumila-Vance, A.S.Tadepalli, T.Horn, E.Cisbani, G. Urciuoli, E.King, J.Napolitano, P.M.King, P.A.Souder, P.Markowitz, E.Brash, P.Monaghan, T.Hobbs, G.Miller, J.Lichtenstadt, T.Kolar, E.Piasetzky, G.Ron, D.Armstrong, T.Averett, S.Mayilyan, H.Mkrtchyan, A.Mkrtchyan, A.Shahinyan, V.Tadevosyan, H.Voskanyan, W.Tireman, P.Datta, E.Fuchey, A.J.R.Puckett, S.Seeds, C.Munoz-Camacho

LaTech, Glascow, Indiana, UVa, JLab, CUA, INFN - Roma, Temple, Ohio, Syracuse, FIU, CNU, Fermilab, UWashington, Tel Aviv U, Hebrew U, W&M, AANL Yerevan, Northern Michigan, UConn, Orsay

Strongly motivated proposal

Highlights from PAC50 final report:

Motivation: The experiment aims at measuring the strange quark contribution to the proton electromagnetic form factors. This is crucial for their flavour decomposition. This compelling physics case is motivated by recent progress in lattice QCD calculations and by phenomenological models highlighting the potential of a measurement at large Q^2.

Summary: The presented physics case is timely and extremely compelling.

Measurement and Feasibility: Although the setup is very simple from the kinematic point of view and the measurement is largely limited by statistical uncertainty…

From the 2023 Theory TAC: In my opinion, the possibility to observe nontrivial SFF of the nucleon is very interesting and the experiment should be approved.

Updated technical details

"The PAC would like to see the results of a detailed Geant4 simulation of the experiment confirming the claim of low background in the experiment, as the independent TAC report recommended."

We developed detailed GEANT4 simulation to confirm our analytic estimates of rates and backgrounds

"In addition, a detailed design of the experimental setup (including electronics and DAQ) should be presented to assess the viability of the measurement."

We present a more complete description of the front-end electronics and DAQ

From the 2023 TAC The collaboration has done a good job of developing a GEANT4-based Monte Carlo simulation of the radiation and backgrounds and detector responses, thus addressing several of the concerns of the previous TAC. It would be advised to benchmark these simulations against measurements, perhaps using data from SBS or, when it runs, the NPS.

Charge symmetry and the nucleon form factors

Charge Symmetry

$$G_E^p = \frac{2}{3} G_E^{u,p} - \frac{1}{3} G_E^{d,p}$$
$$G_E^n = \frac{2}{3} G_E^{u,n} - \frac{1}{3} G_E^{d,n}$$

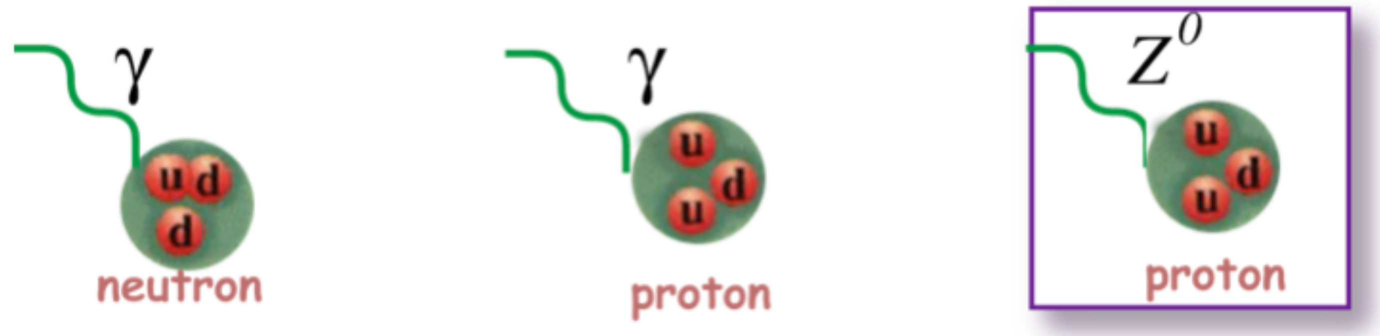
Charge symmetry is assumed for the form factors, $G_E^{u,p} = G_E^{d,n}$, *etc.*
and used to find the flavor separated form-factors,
measuring $G_{E,M}^{p,n}$ to find $G_{E,M}^{u,d}$

$$G_E^p = \frac{2}{3} G_E^{u,p} - \frac{1}{3} G_E^{d,p} - \frac{1}{3} G_E^s$$
$$G_E^n = \frac{2}{3} G_E^{u,n} - \frac{1}{3} G_E^{d,n} - \frac{1}{3} G_E^s$$

But this can broken! One way is to have a non-zero strange form-factor, which breaks the "2 equations and 2 unknowns" system

The weak form factor provides a third linear combination:

$$G_E^{p,Z} = \left(1 - \frac{8}{3}\sin^2\theta_W\right) G_E^{u,p} + \left(-1 + \frac{4}{3}\sin^2\theta_W\right) G_E^{d,p} + \left(-1 + \frac{4}{3}\sin^2\theta_W\right) G_E^s$$



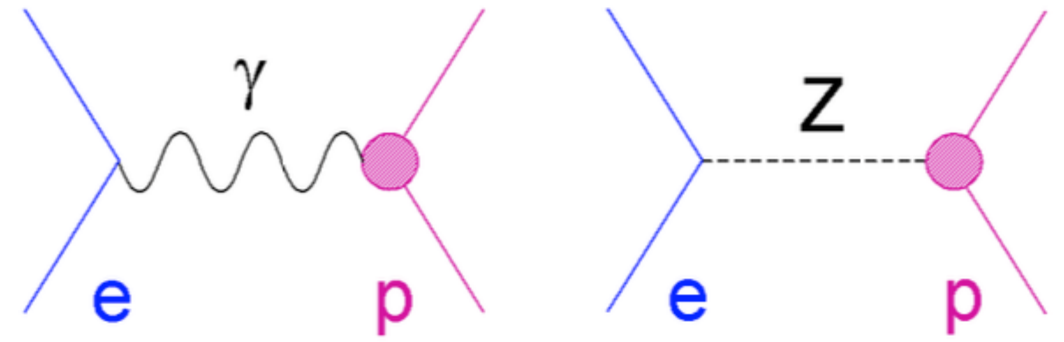
A strange quark form factor would be indistinguishable from a broken charge symmetry in u,d flavors

$$\delta G_E^u \equiv G_E^{u,p} - G_E^{d,n}$$
$$\delta G_E^d \equiv G_E^{d,p} - G_E^{u,n}$$

So, more generally: this experiment tests the assumption of charge symmetry which is crucial to the flavor decomposition of the form factors

Strangeness form factors

Polarized electron beam elastic e-p scattering



$$A_{PV} = -\frac{G_F Q^2}{4\pi\alpha\sqrt{2}} \cdot [(1-4\sin^2\theta_W) - \frac{\epsilon G_E^p G_E^n + \tau G_M^p G_M^n}{\epsilon (G_E^p)^2 + \tau (G_M^p)^2} - \frac{\epsilon G_E^p G_E^s + \tau G_M^p G_M^s}{\epsilon (G_E^p)^2 + \tau (G_M^p)^2}$$

$$+ \epsilon' (1-4\sin^2\theta_W) \frac{G_M^p G_A^{Zp}}{\epsilon (G_E^p)^2 + \tau (G_M^p)^2}]$$

A_{PV} = (-226 ppm) *[0.075 + 0.542 – 6.43*($G_M^s + 0.32\, G_E^s$) + 0.038]

Q_W EMFF strange form-factors axial

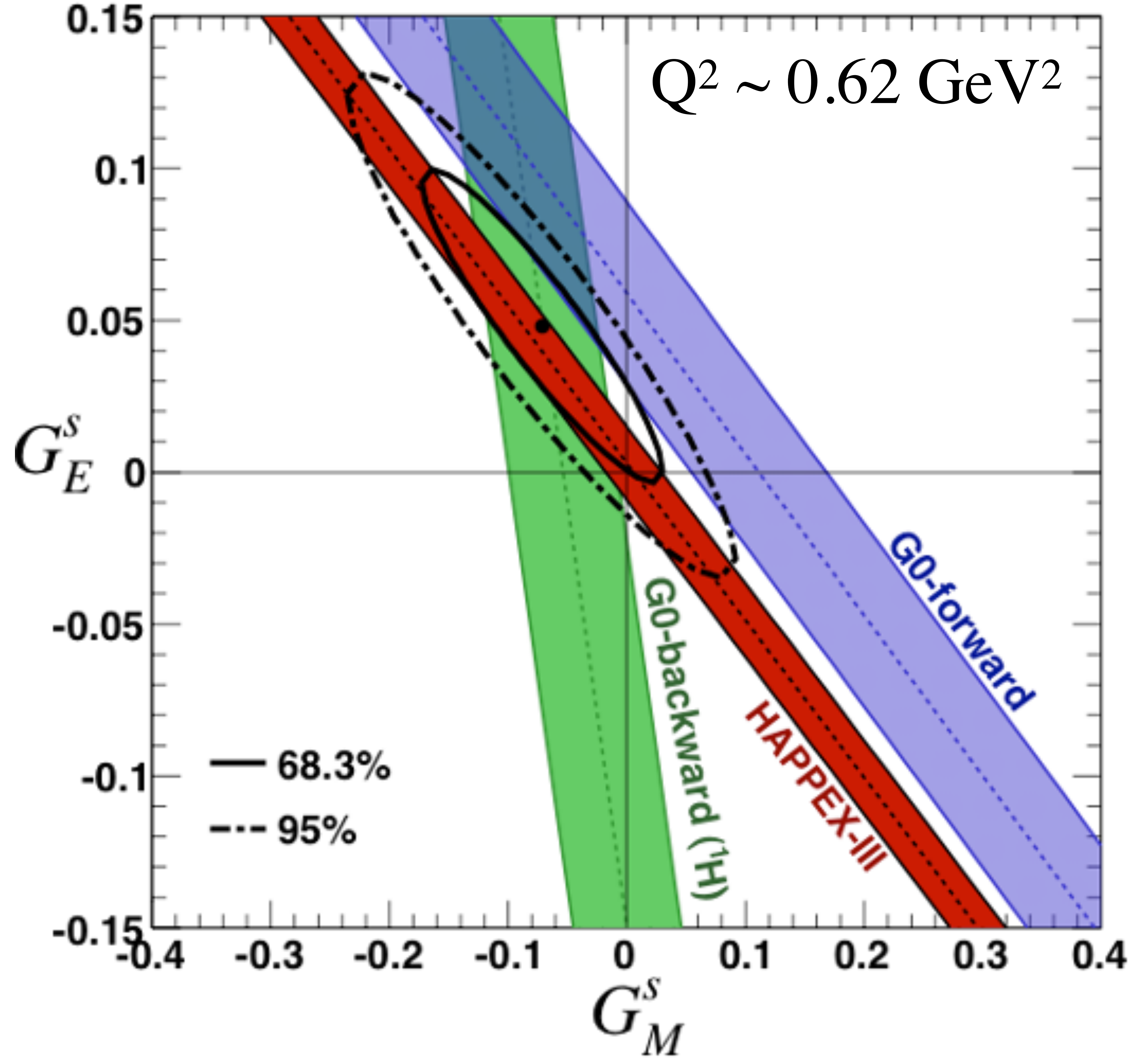
A_{PV} = 150 ppm at θ = 15.5°, Q^2 = 2.5 GeV^2 (if sFF = 0)

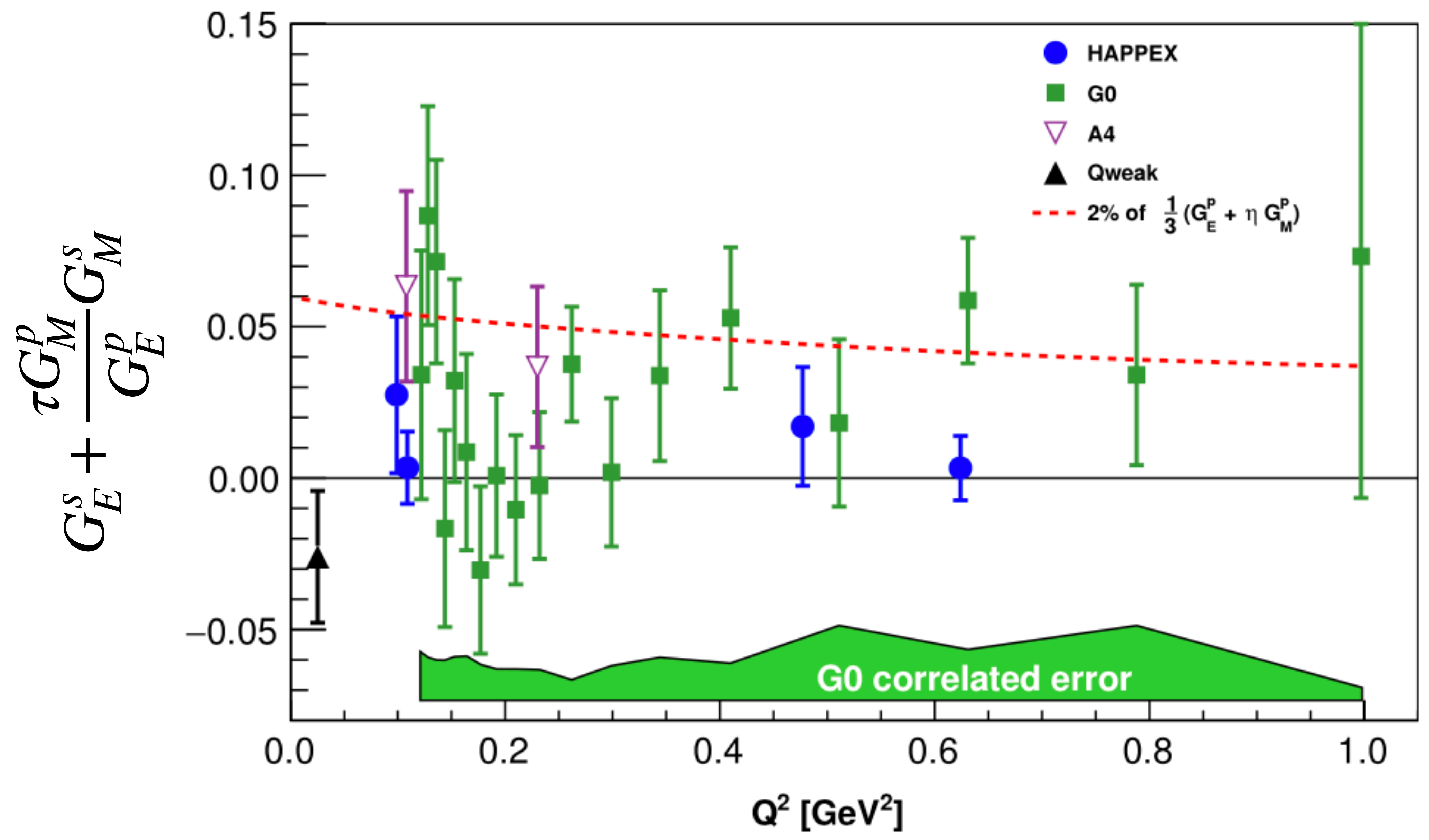
Proton strange form factors via parity violating elastic electron scattering

Strange form factors are measured to be consistent with zero at low Q^2,

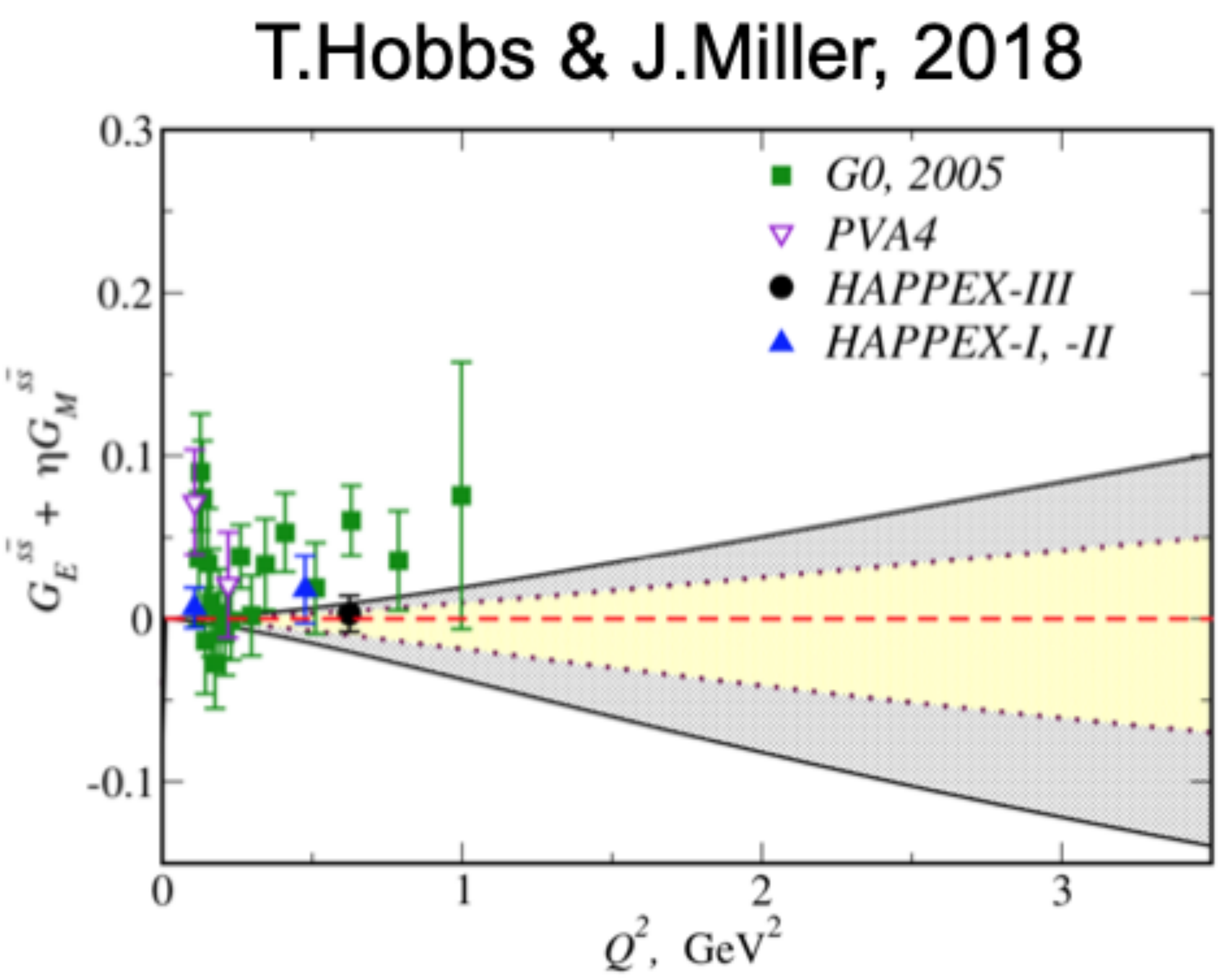
but do not rule out non-zero values at higher Q^2,

especially for magnetic form factor which is more accessible at higher Q^2





Strange form-factor predictions



Follows work from *Phys.Rev.C* 91 (2015) 3, 035205
(LFWF to tie DIS and elastic measurements in a simple model)

Conclusion: sFF small (but non-zero) at low Q^2, but quite reasonable to think they may grow relatively large at large Q^2

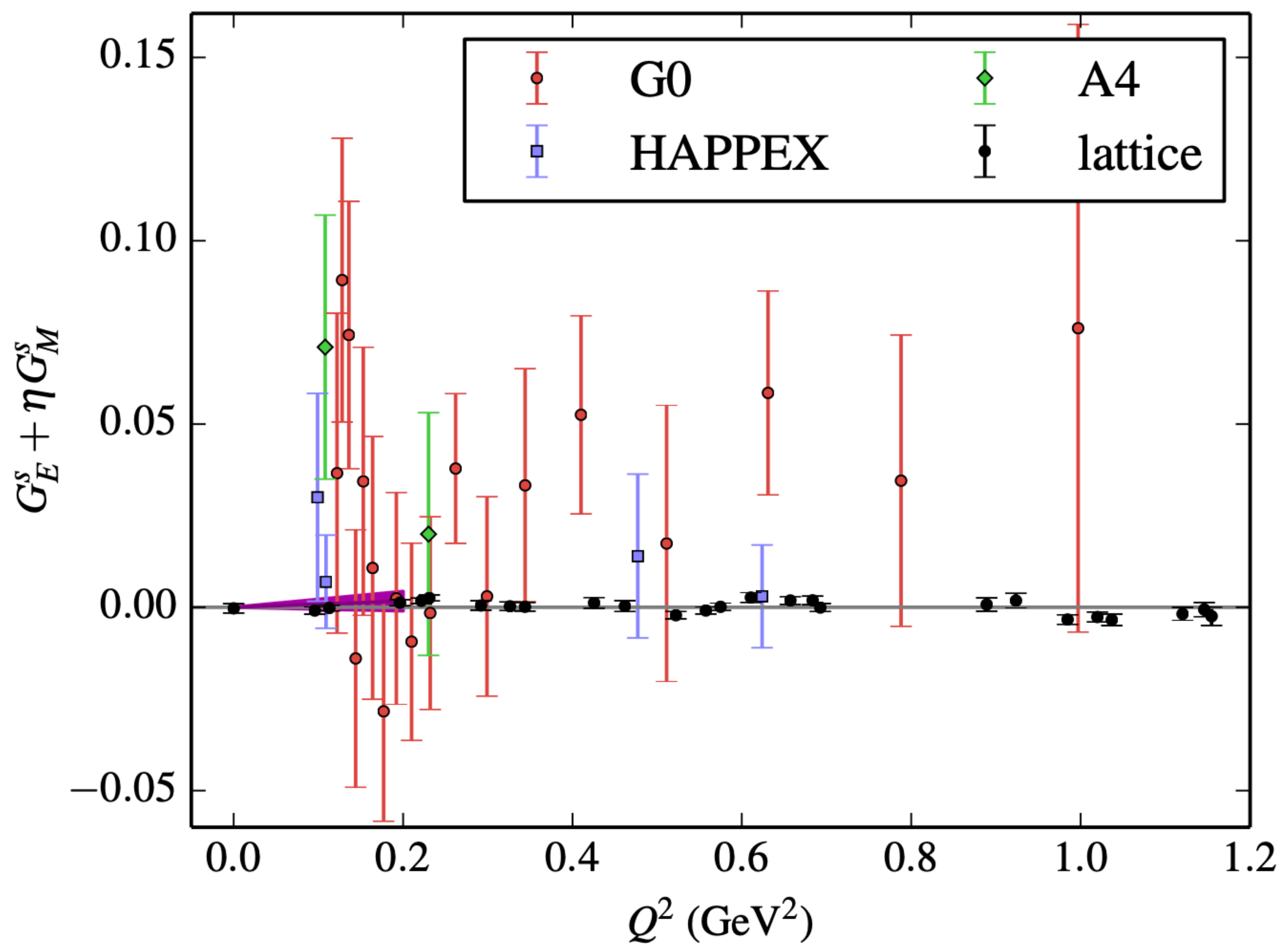
G_D = 0.0477 at 2.5 GeV^2
uncertainty here ranges from (0.036,-0.051)

G_s/G_D ~ 1 is not excluded

$\longrightarrow$ possible δA_{PV} ~ ±22 ppm, ~±15% of A_{PV}^{ns}

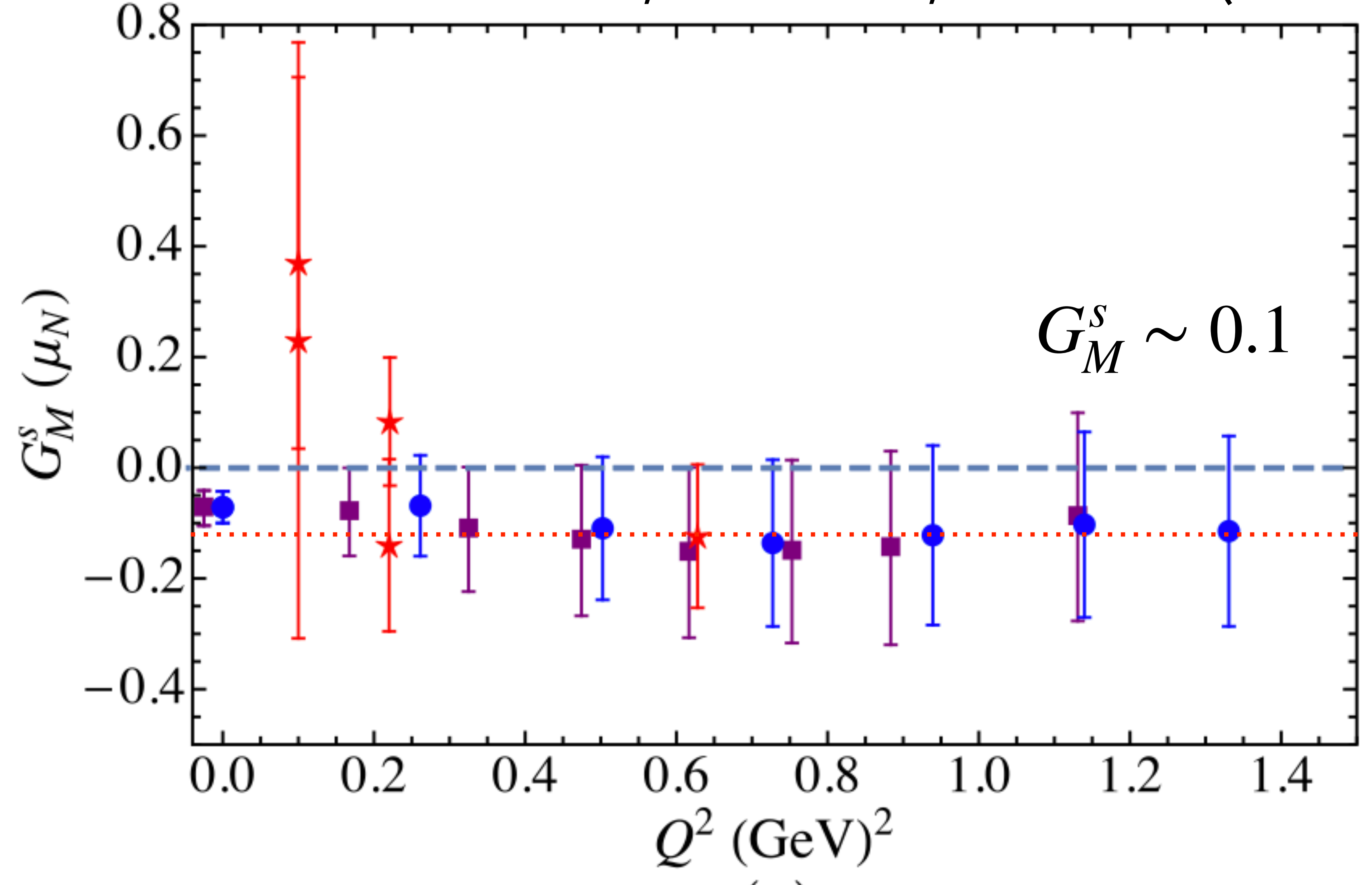
Tim Hobbs and Jerry Miller have both joined the collaboration

Strange form-factors on the lattice



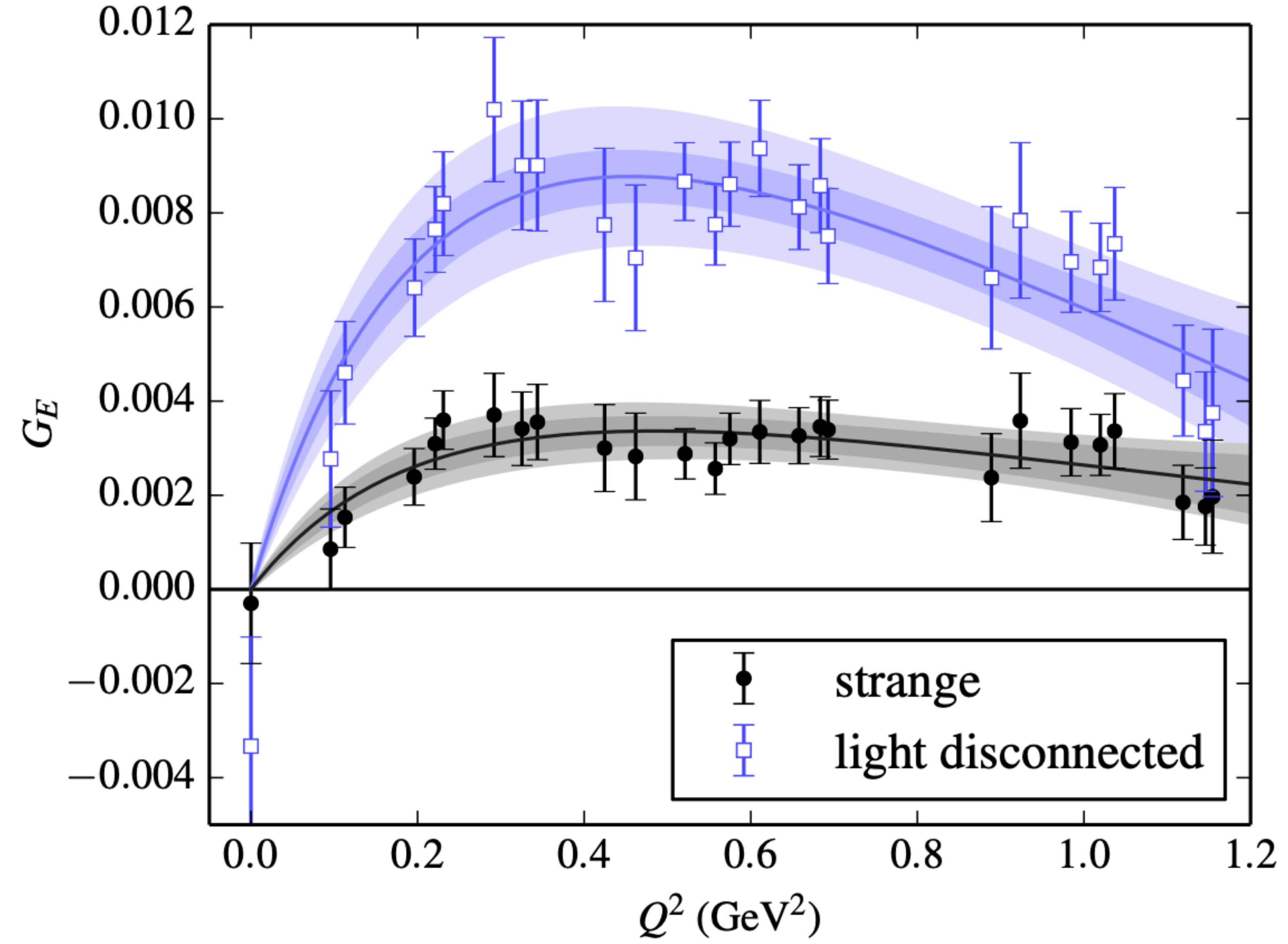
Some lattice calculations predict non-zero central values that would be visible with the proposed precision

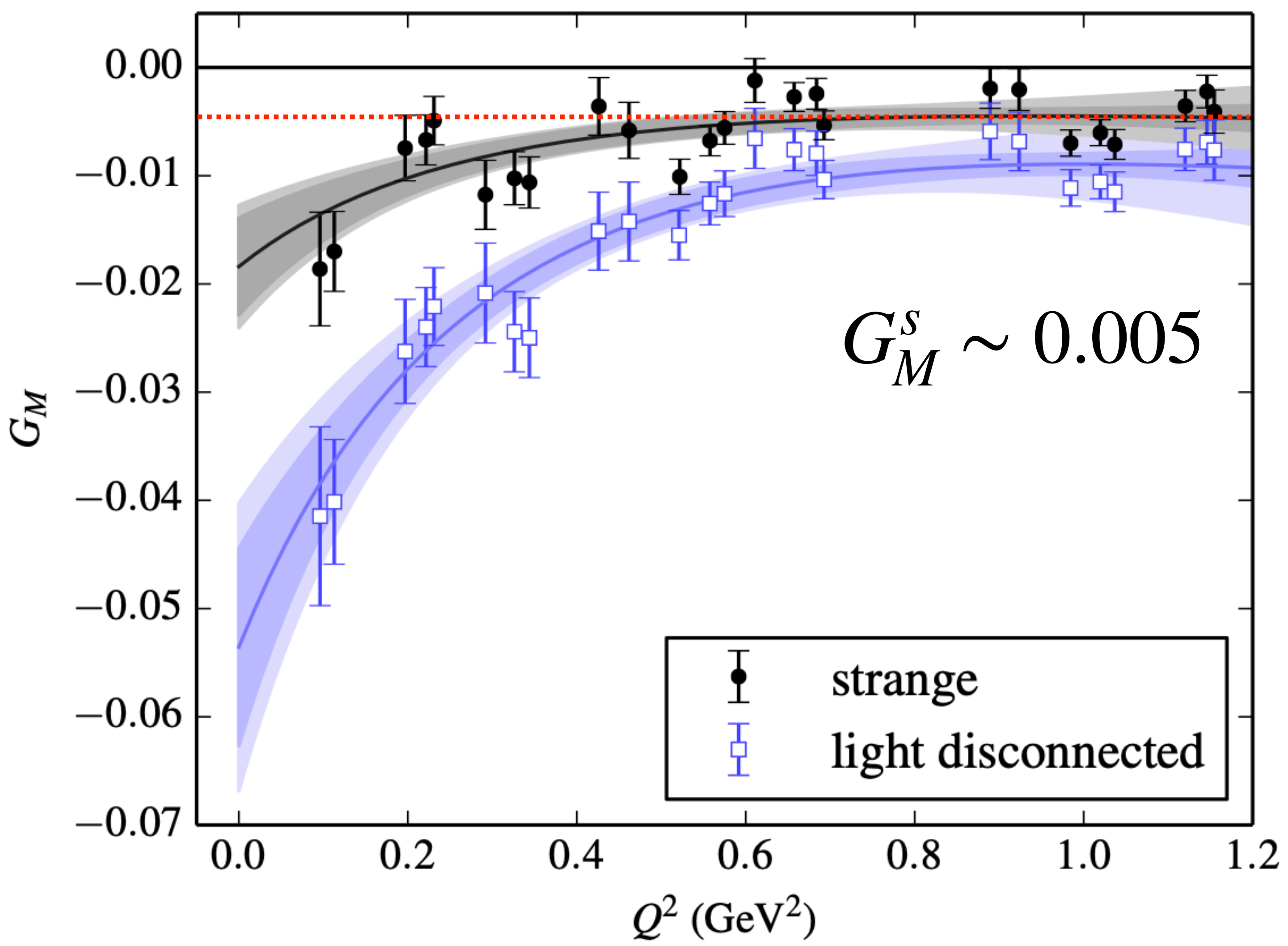
P. Shanahan *et al.*, PRL 114, 091802 (2015)

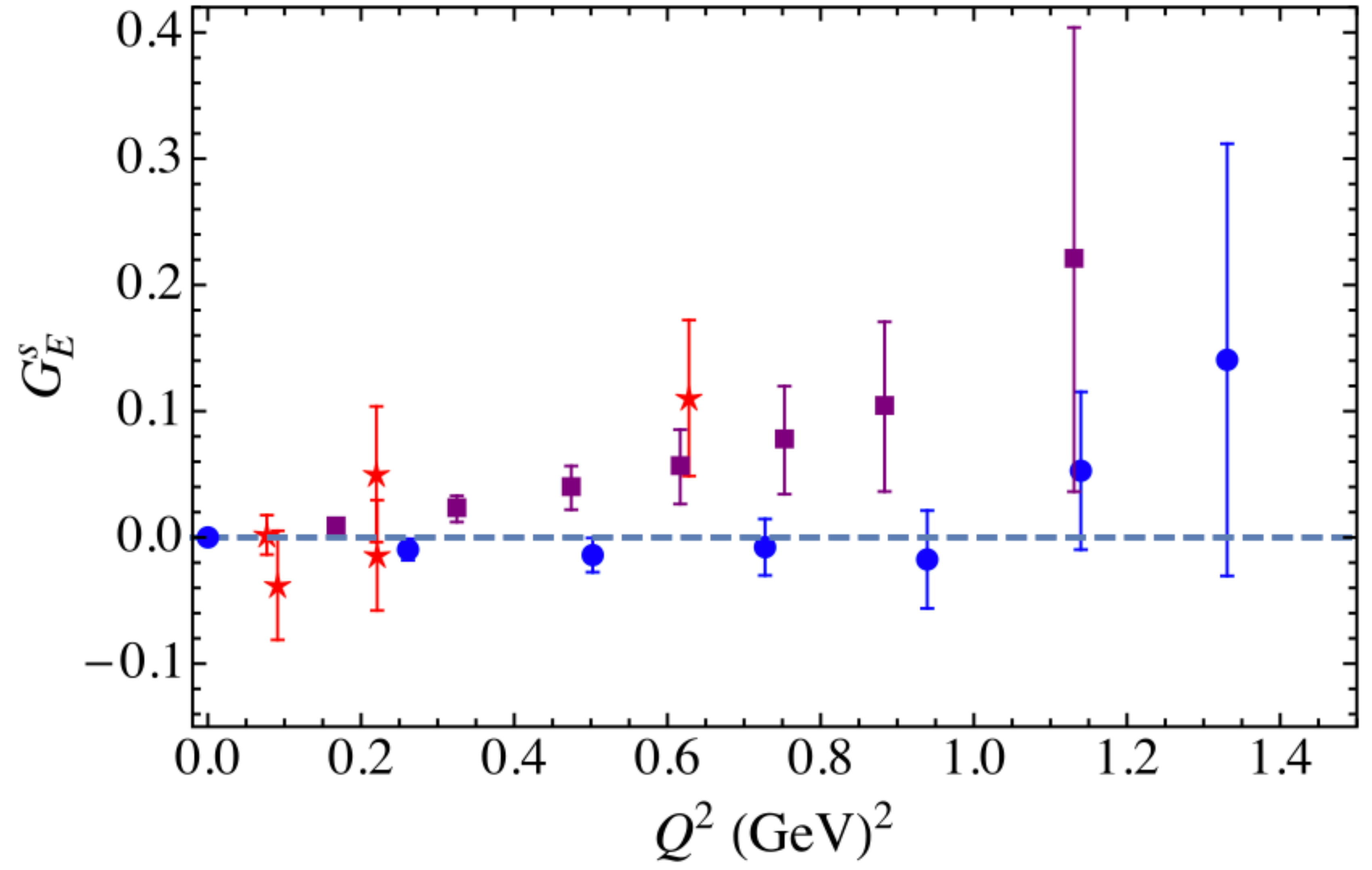


(a)

J. Green *et al.*, Phys. Rev. D 92, 031501 (2015)







(b)

Q^2 dependence of Q^4F_1

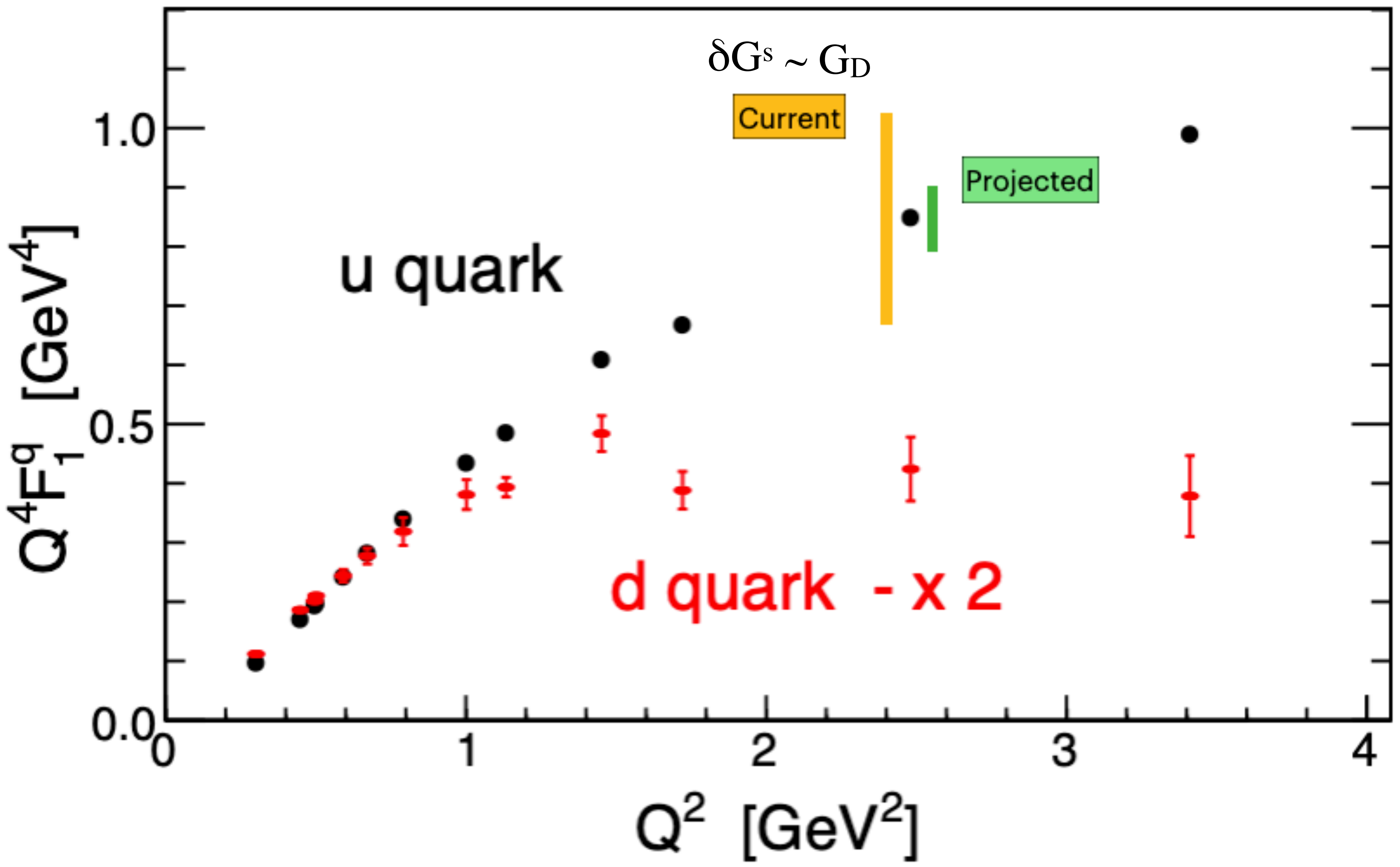
$$F_{1p} = e_u\, F_1^u \,+\, e_d\, F_1^d \,+\, e_s\, F_1^s$$

$$F_{1n} = e_u\, F_1^d \,+\, e_d\, F_1^u \,+\, e_s\, F_1^s$$

$$F_1^u = 2F_{1p} + F_{1n} - F_1^s \qquad F_1^d = 2F_{1n} + F_{1p} - F_1^s$$

Assuming $\delta G^s_{E,M} \sim G_D \sim 0.048 \longrightarrow \delta(Q^4 F_1^u) \sim \pm\, 0.17$

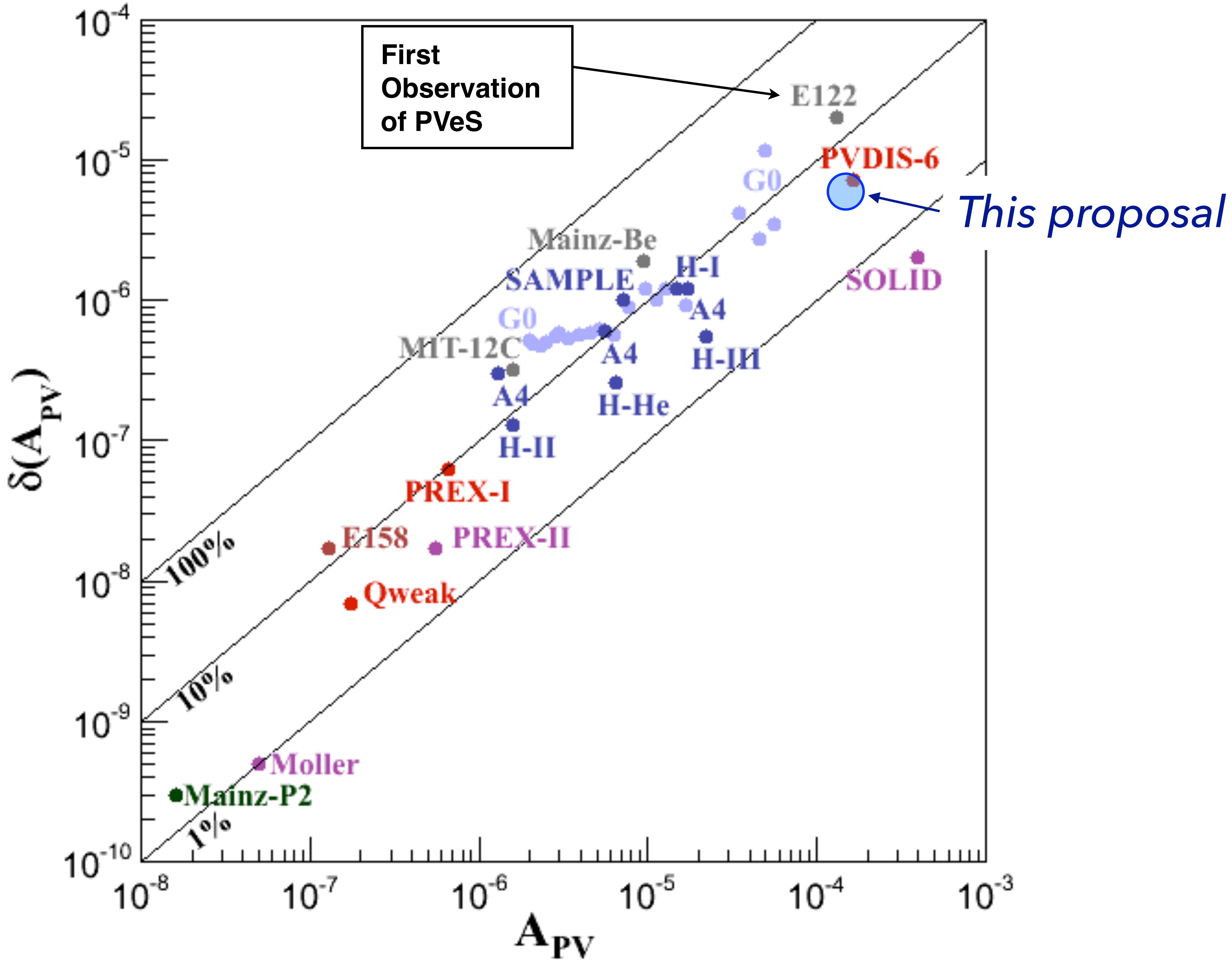
$$F_1 = \frac{G_E + \tau G_M}{1+\tau} = \frac{G_E + 0.7 G_M}{1.7} \sim \frac{G_D}{1.7}$$



- Flavor separated form factors are a crucial piece of information for GPDs / nuclear femtography.
- So far, these have relied on poorly tested assumptions of strange quark contributions.
- Experimentally not ruled out (at level of yellow band) and lattice calculations do not rule out significant contributions (at level of 1x-2x the green band)

This measurement is needed

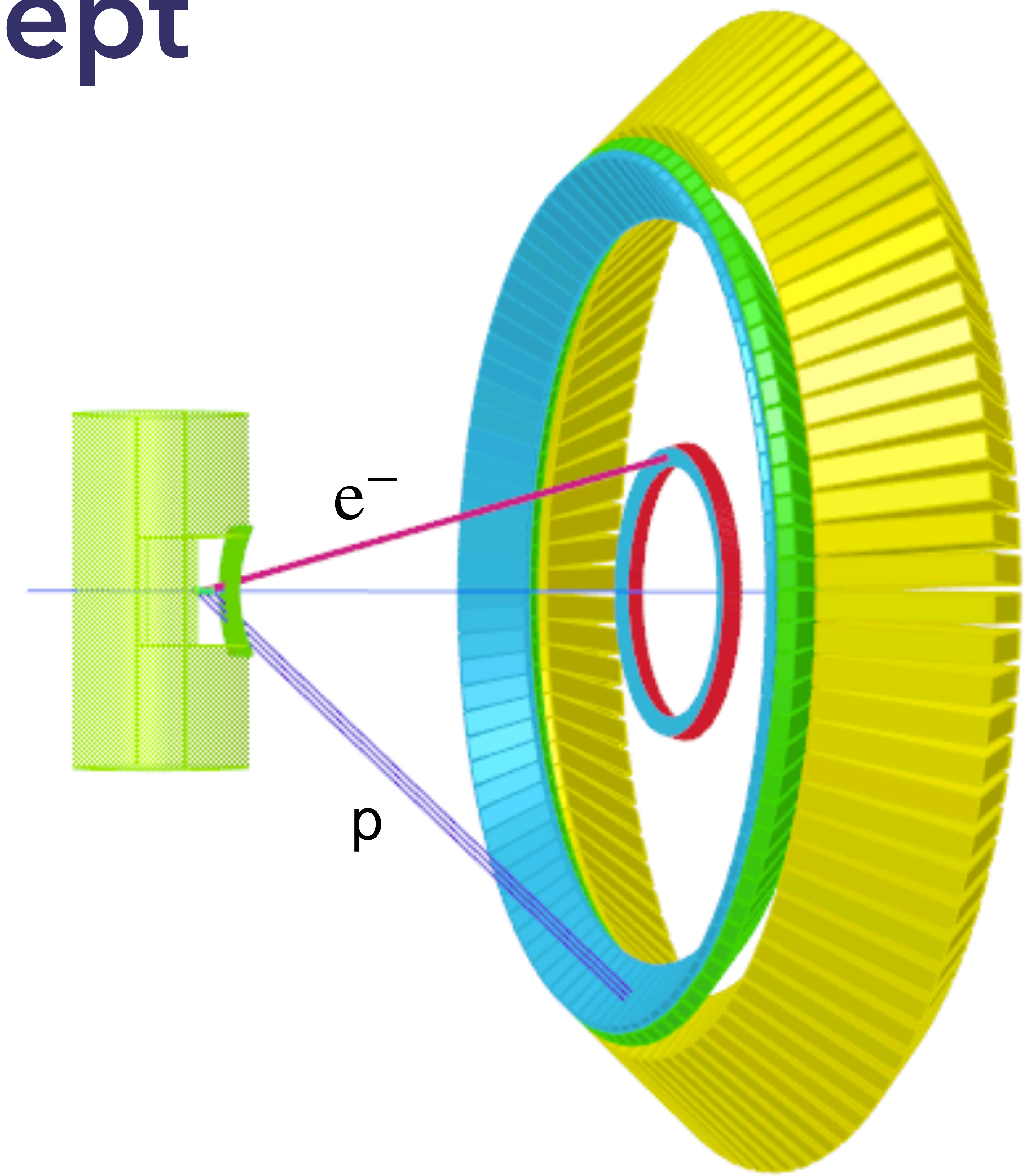
Experiment context



Experimental concept

- 6.6 GeV beam
- 10 cm LH_2 target, 65 μA, $\mathcal{L}$ =1.7 x 10^{38} cm^{-2}/s
- Full azimuthal coverage, ~42 msr

- Elastic kinematics between electron and proton
- Angular correlation e-p
  - Scattered electron at 15.5 degrees
  - Scattered proton at 42.4 degrees
- High resolution calorimeter for electron arm
- Calorimeter trigger for proton arm



Pipelined triggered readout, recording events with:
- E>threshold in calorimeter
- polar and azimuthal coincidence
- ECAL cluster center vs HCAL block matches ep elastic

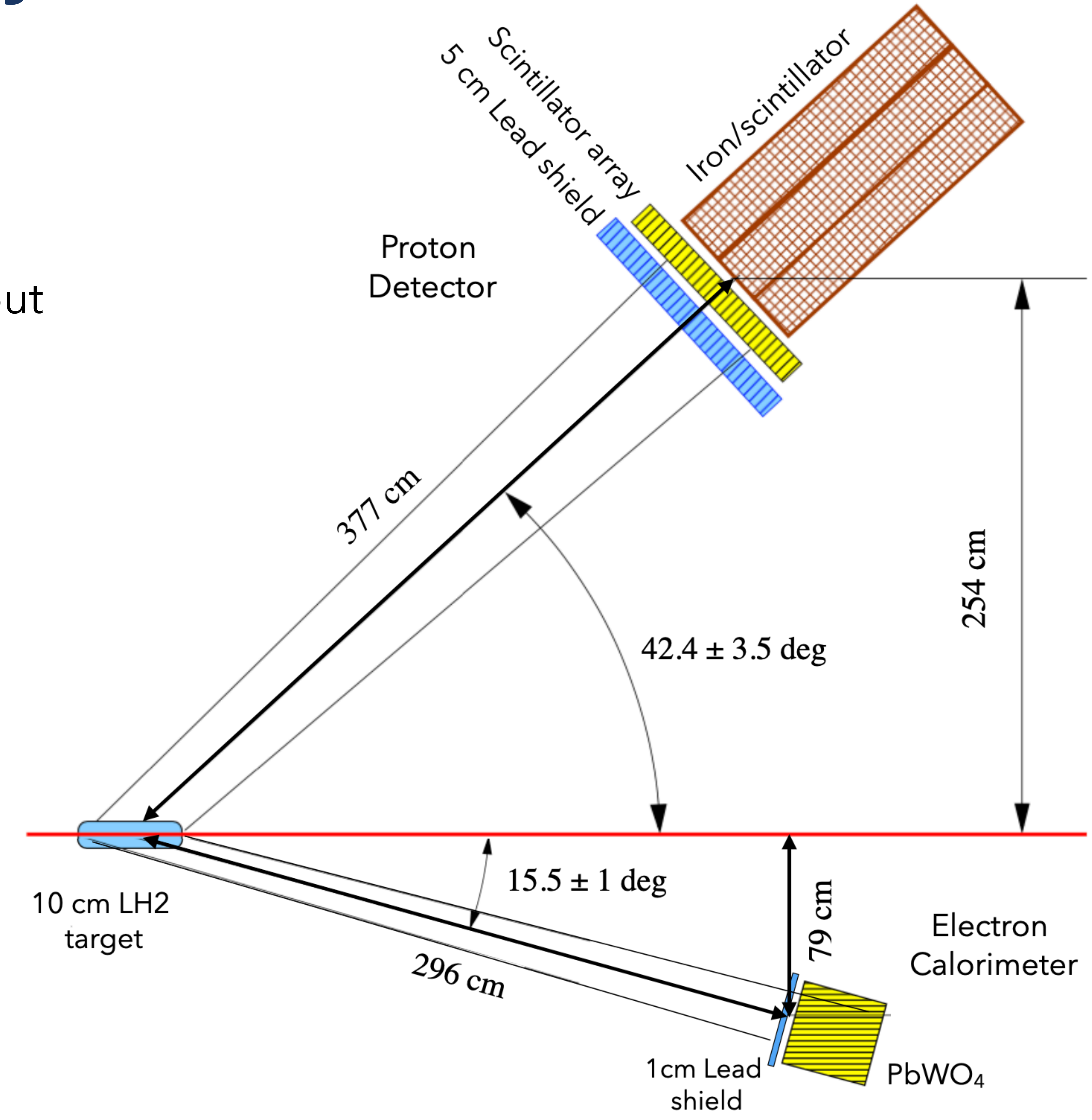
Off-line analysis
- pixel hodoscope adds more precise proton position
- Tighten cuts, especially polar angle

Detector System

HCAL - hadron calorimeter
- Detector elements from the SBS HCAL
- 288 blocks, each 15.5 x 15.5 x 100 cm^3
- iron/scintillator sandwich with wavelength shifting fiber readout

ECAL - electron calorimeter
- Detector elements from the NPS calorimeter
- 1200 blocks, each 2 x 2 x 20 cm^3
- $PbWO_4$ scintillator
- 1 cm lead shield

Scintillator array
- New detector, requires construction
- 7200 blocks, each 3 x 3 x 10 cm^3
- Used for position resolution in front of HCAL
- Not used to form trigger
- 5cm Lead shield in front to reduce photon load



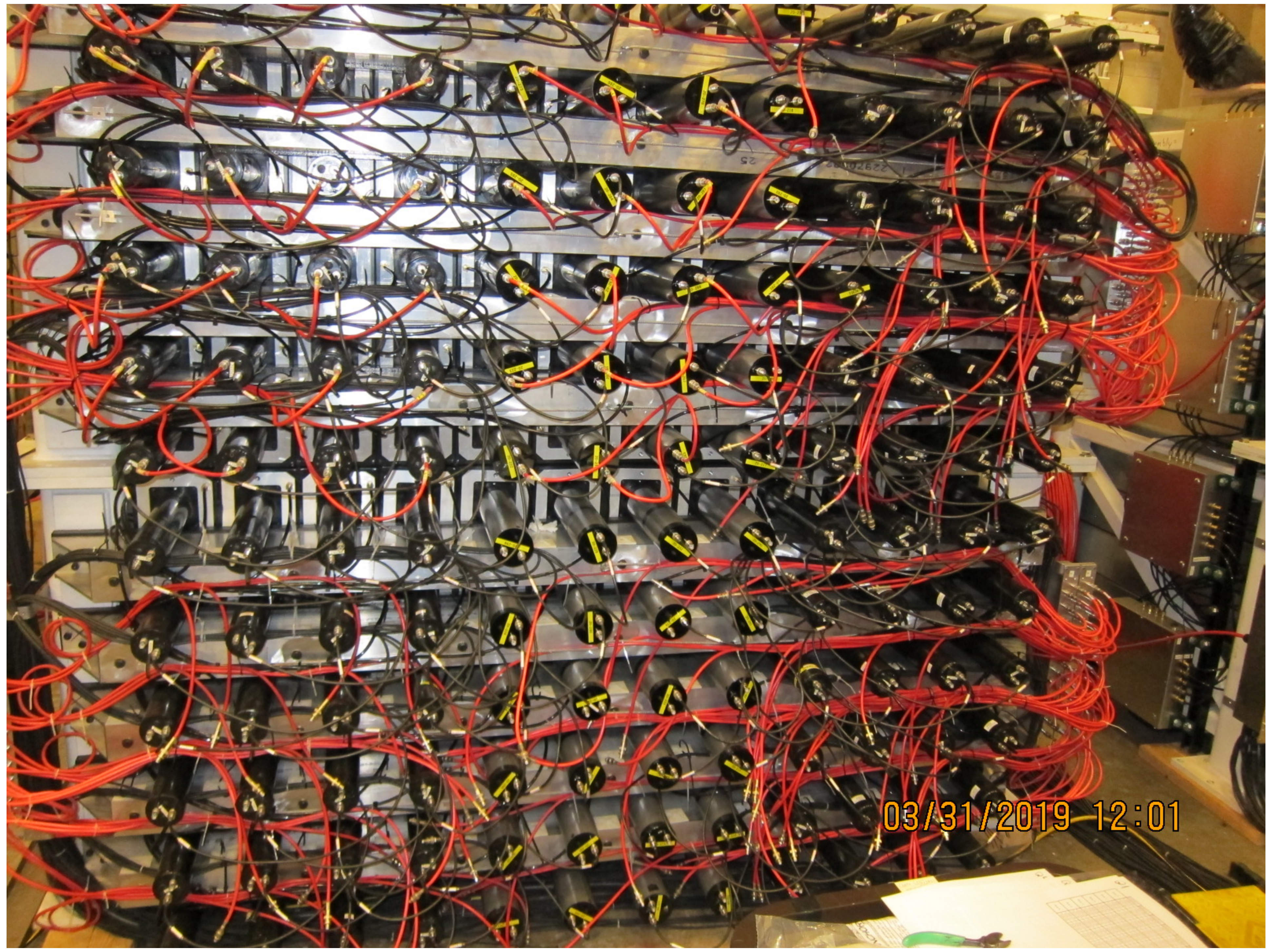
Calorimeters reusing components

NPS electromagnetic calorimeter

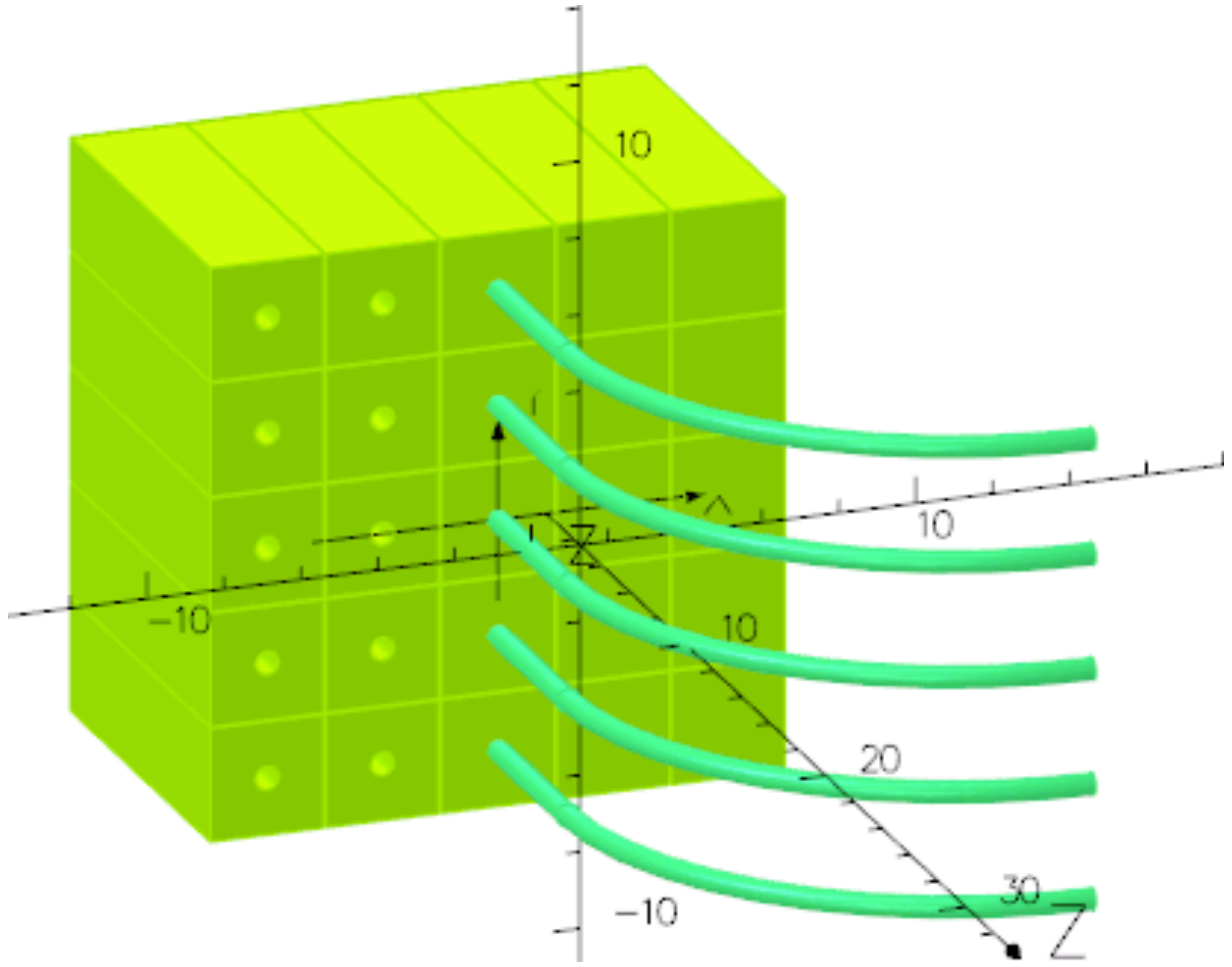
- 1200 $PBWO_4$ scintillators, PMTs + bases
- will run in future NPS experiment
- Only PMT base region needs cooling for required performance

SBS hadronic calorimeter

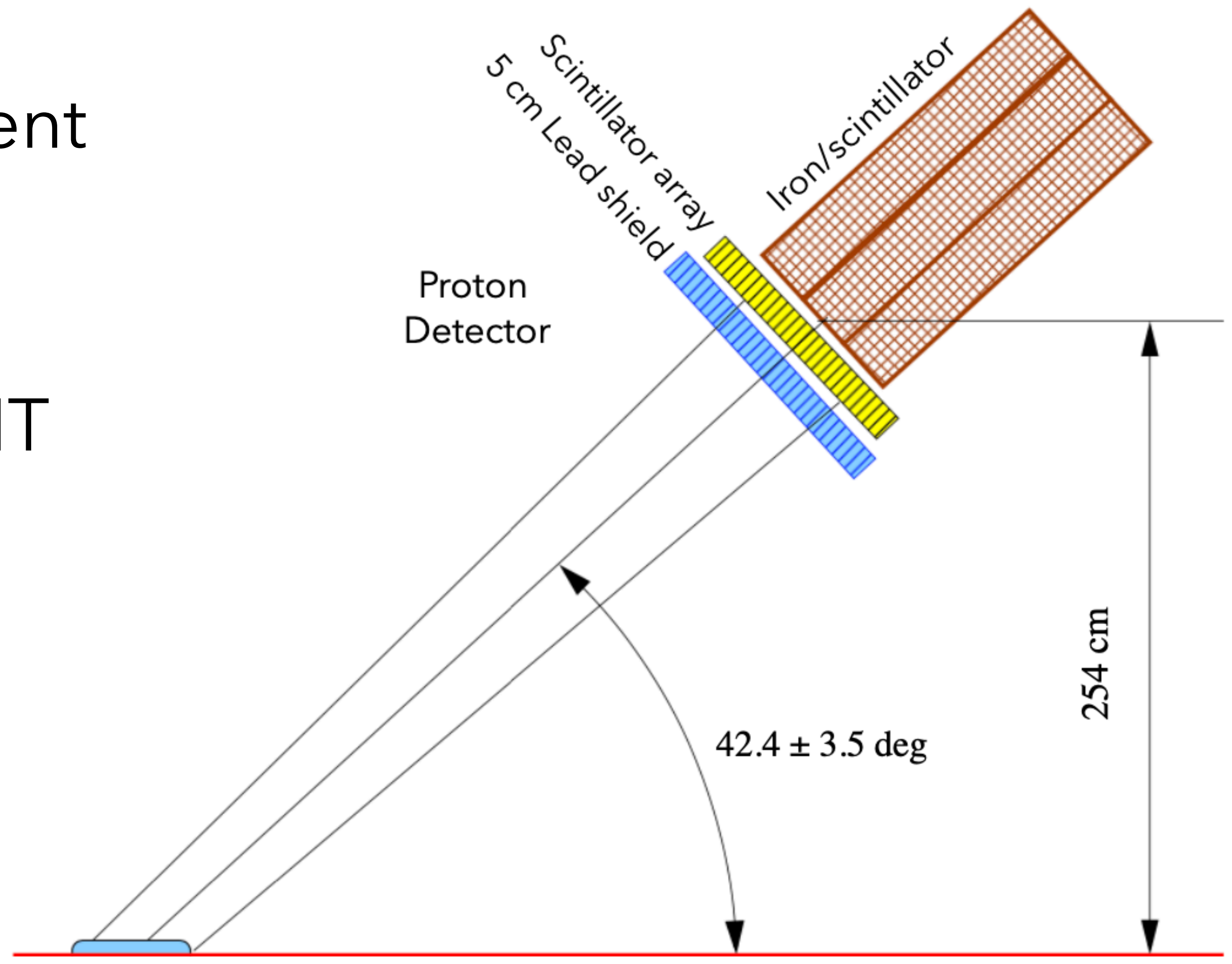
- 288 iron/scintillator detectors, PMTs + bases
- Already in use with SBS

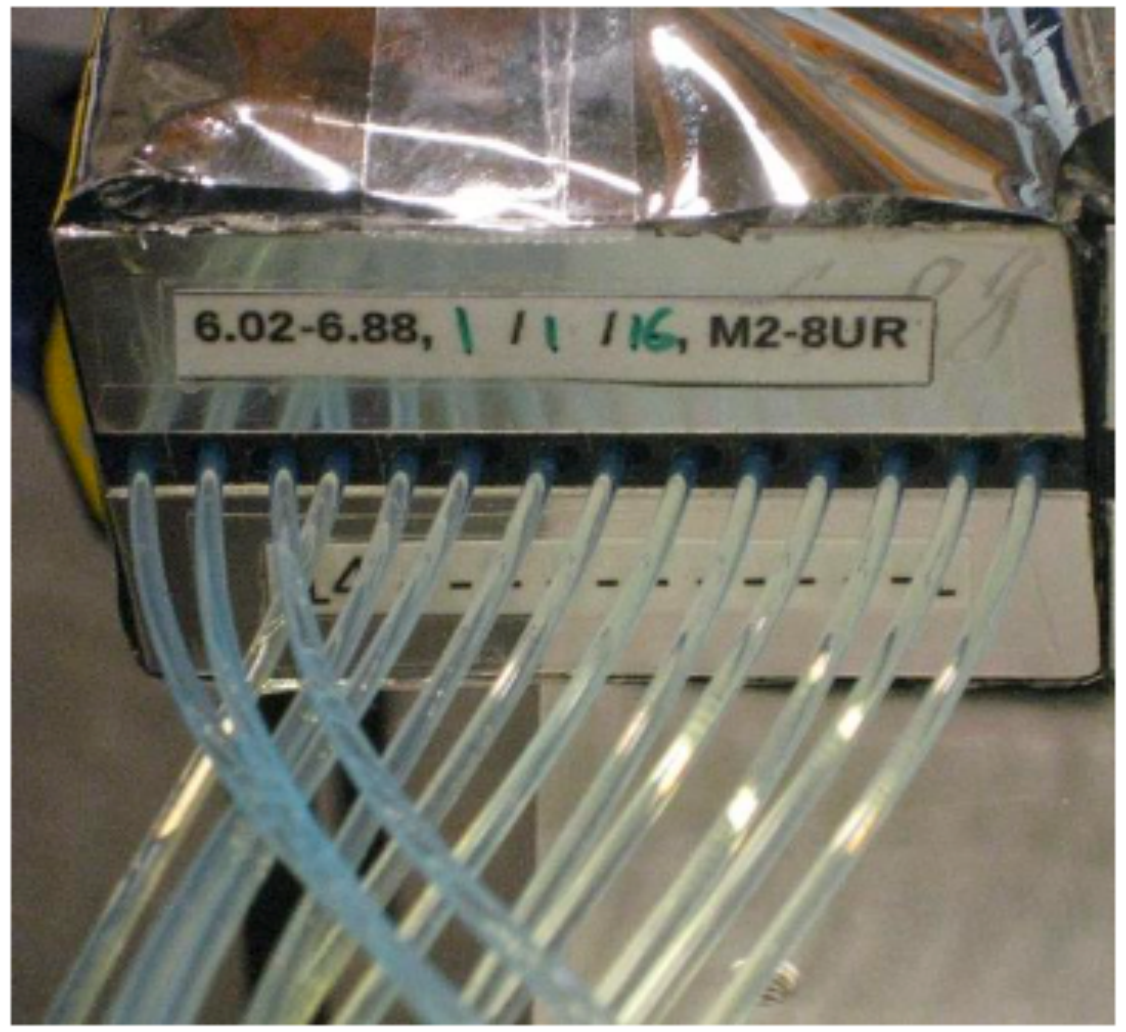
Scintillator Array

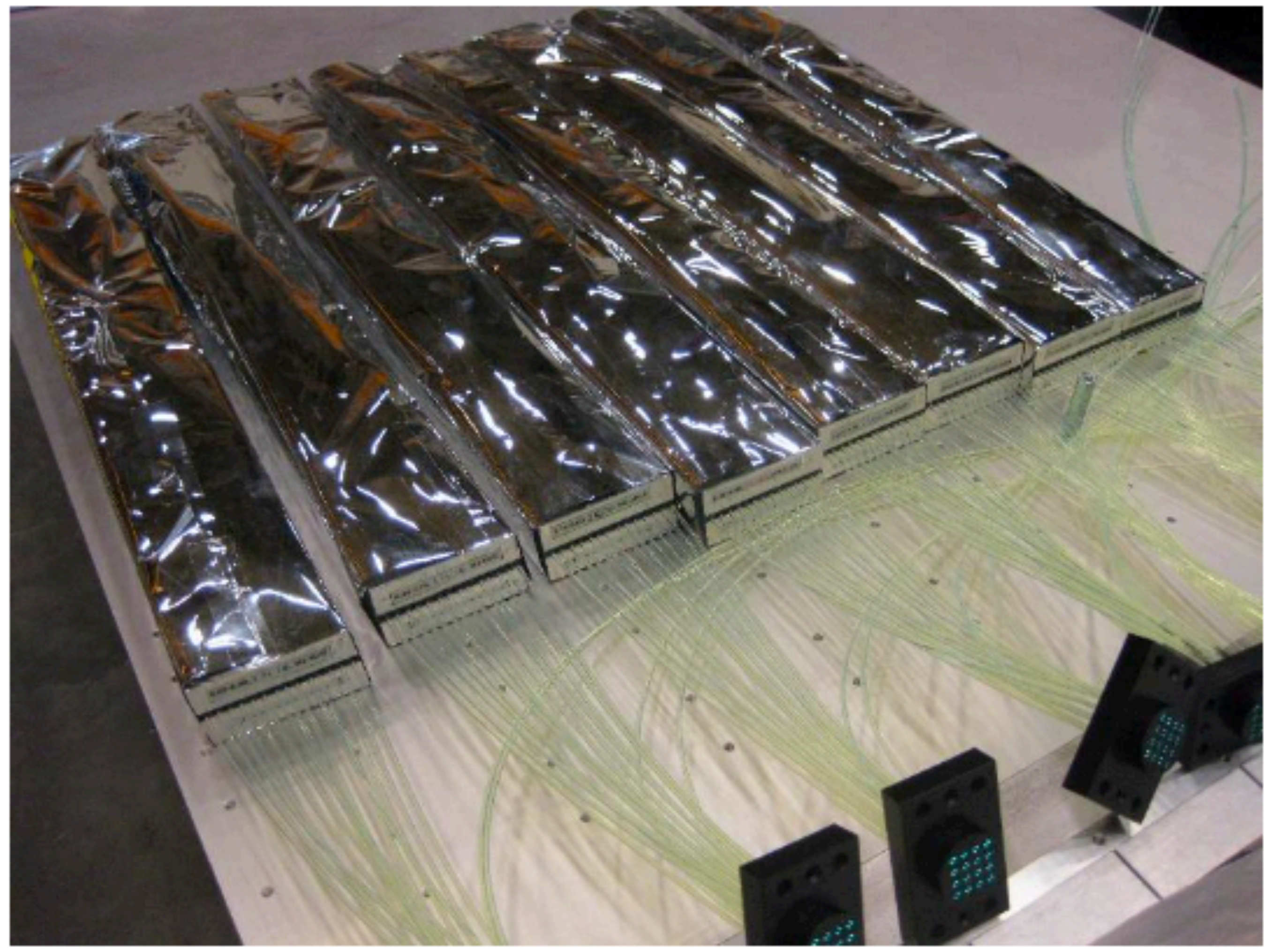


New detector, must be built for this experiment
- Extruded plastic scintillator block
- Readout with wavelength-shifting fiber
- Each fiber read by pixel on multi-anode PMT
- 7200 blocks, each 3 x 3 x 10 cm^3
- Pipeline TDC readout (VETROC)



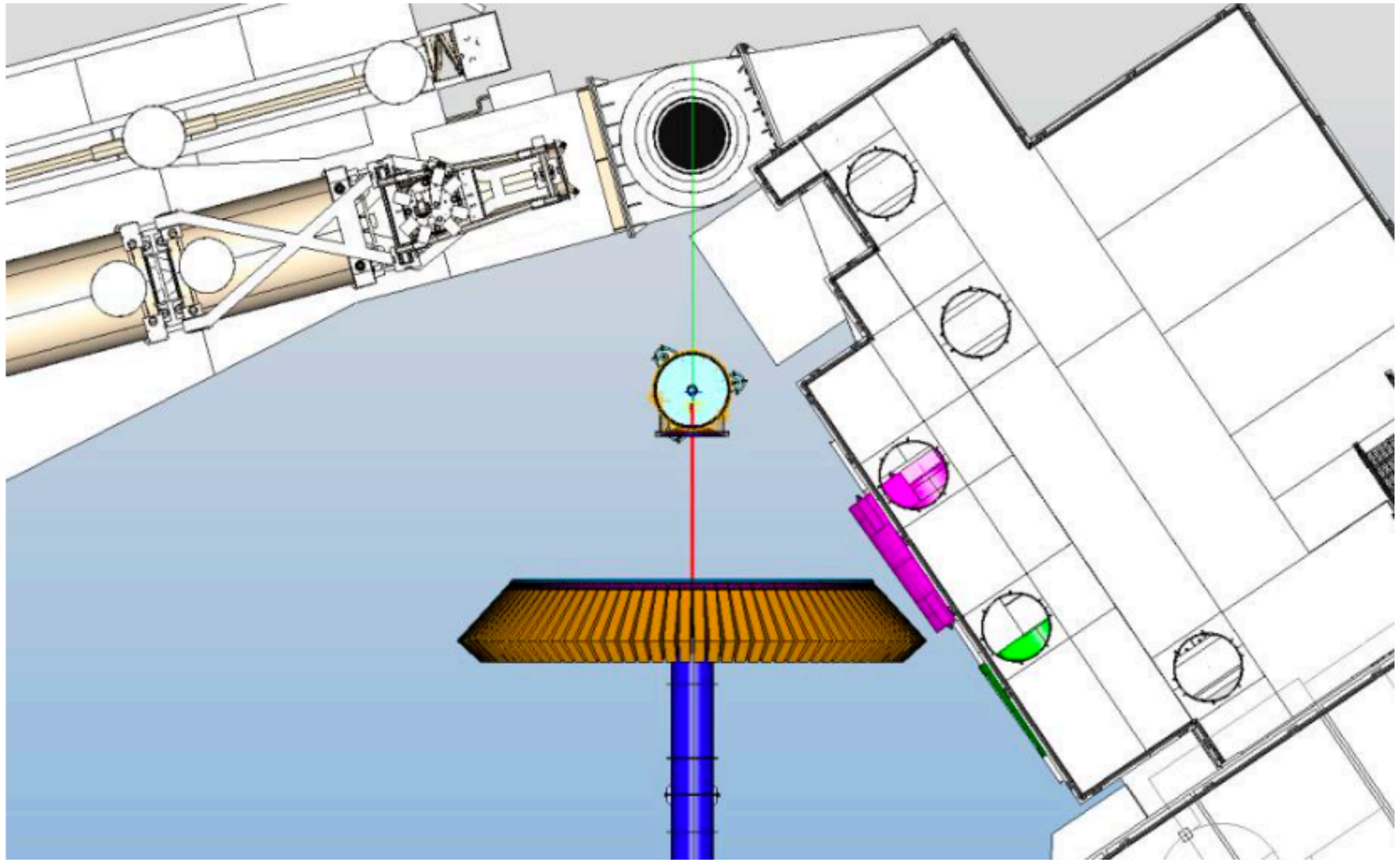
Design matches CDET scintillator array built for GEP
- 2400 elements, 0.5 x 4 x 50 cm^3
- Already built, will run next year

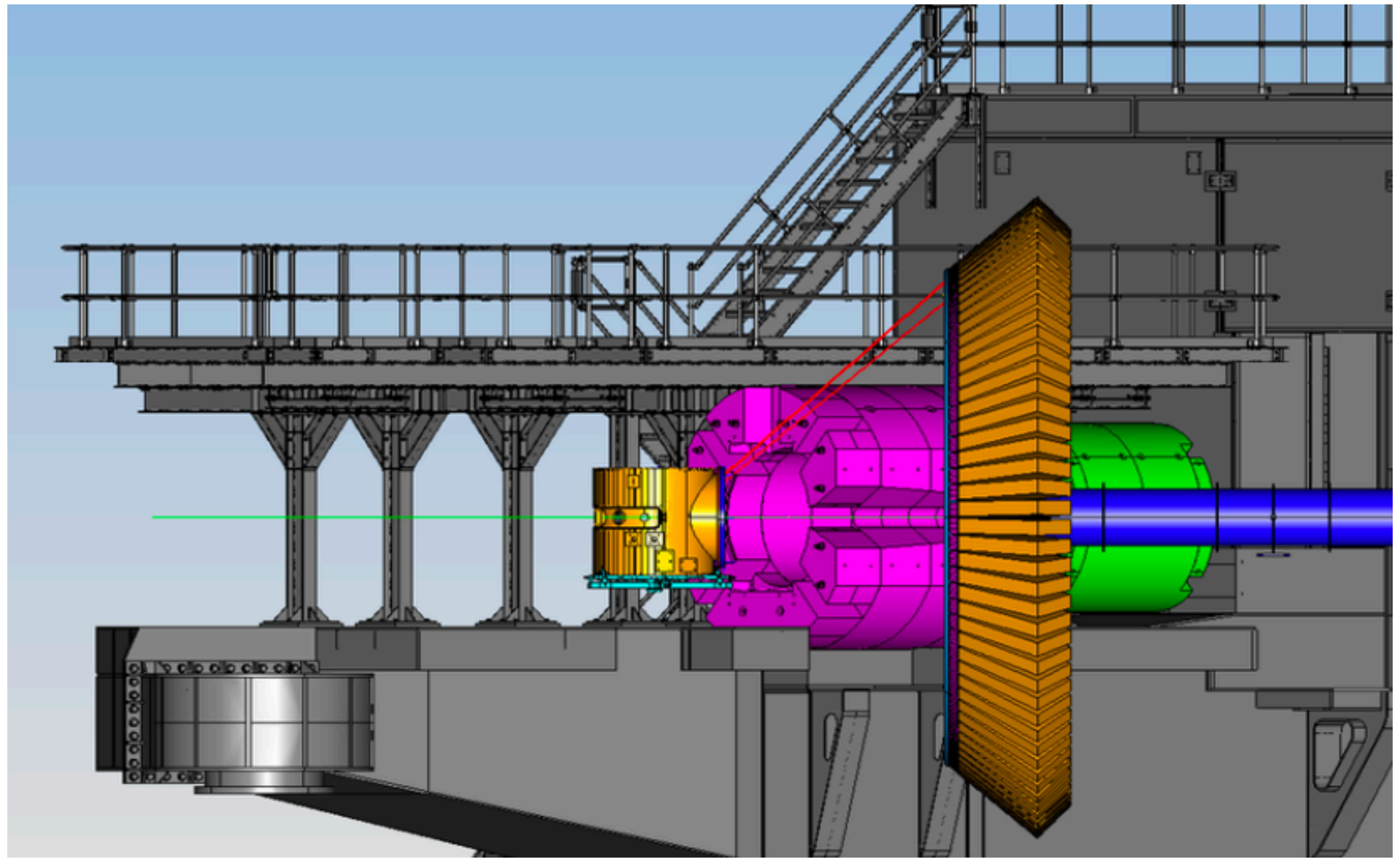




Installation in Hall C

3.5 m target shift downstream from pivot due to space limitation on the SHMS side
Will need a very substantial frame to support HCAL

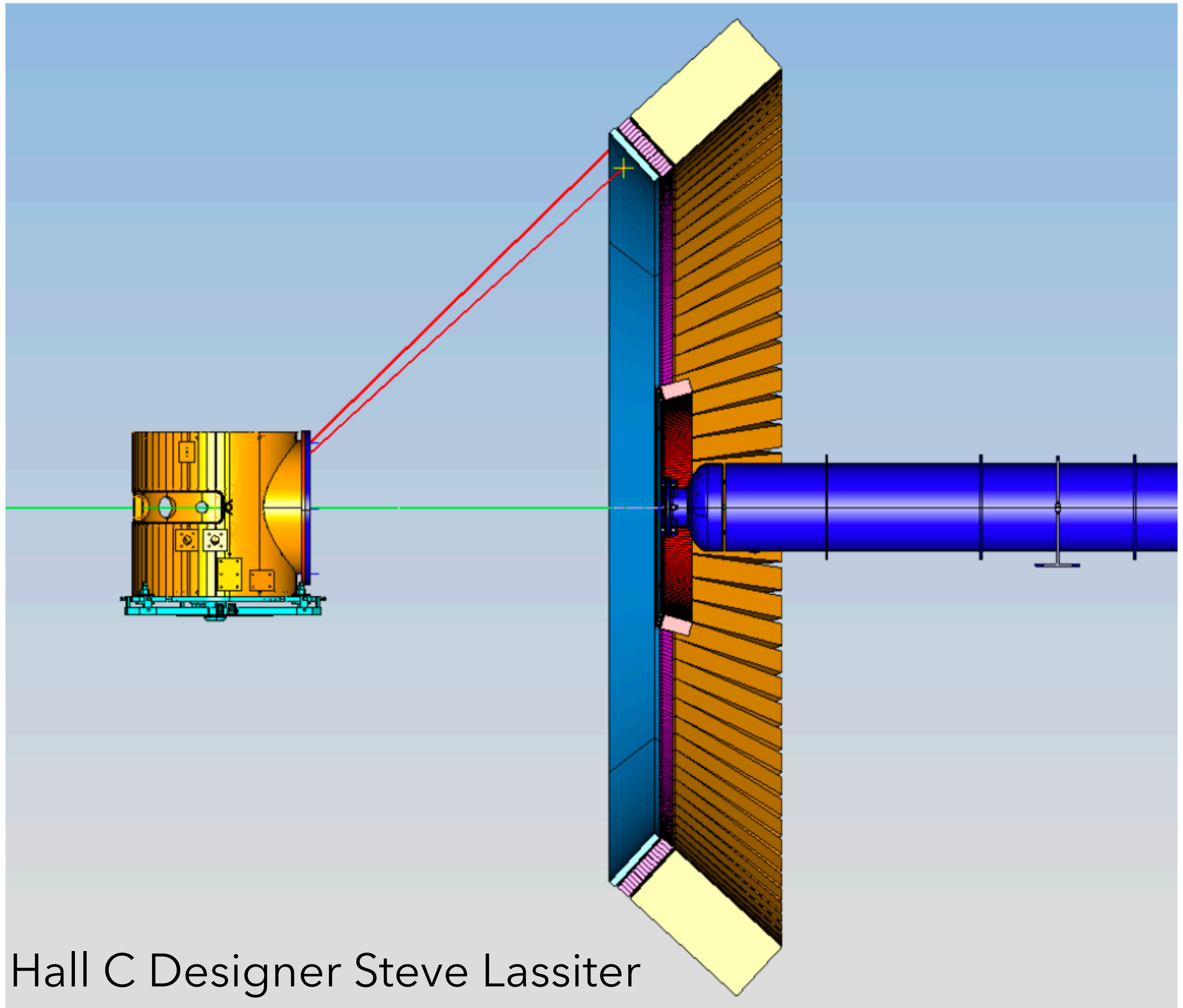


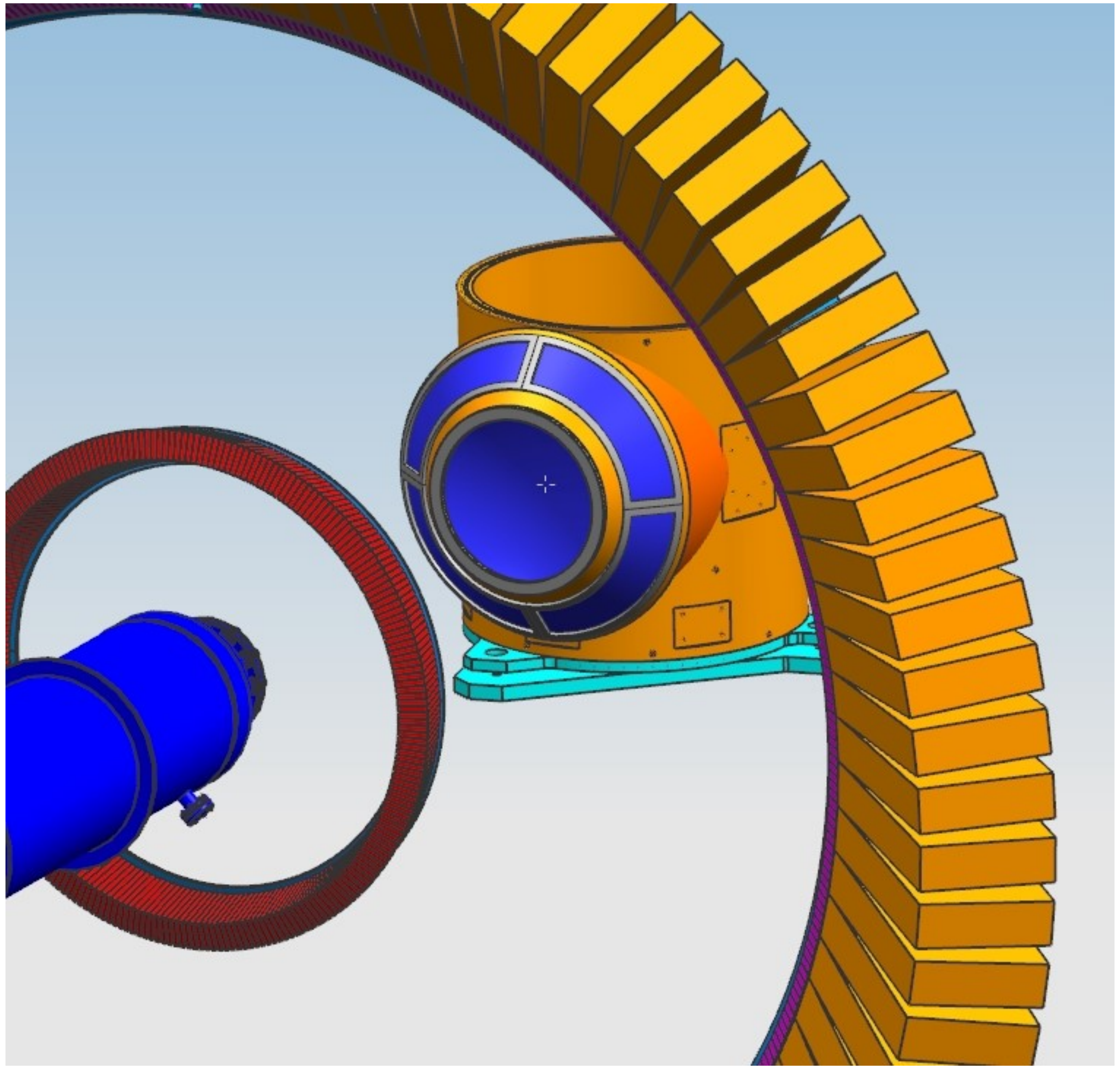


Scattering chamber

Cylindrical scattering chamber with large Al window to pass 15° electrons and 45° protons

Design uses a cone with "ribs", plus an inverted hemisphere center, windows could be as thin as 0.5mm





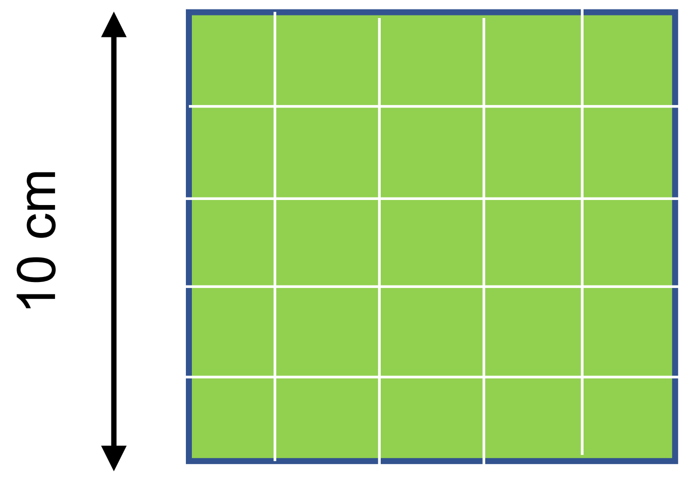
Requires air gap - will use He bag (not shown) to transport beam, so open air gap is only ~50cm

Triggering

Grouping calorimeter “subsystems” for energy threshold and coincidence triggering of event record

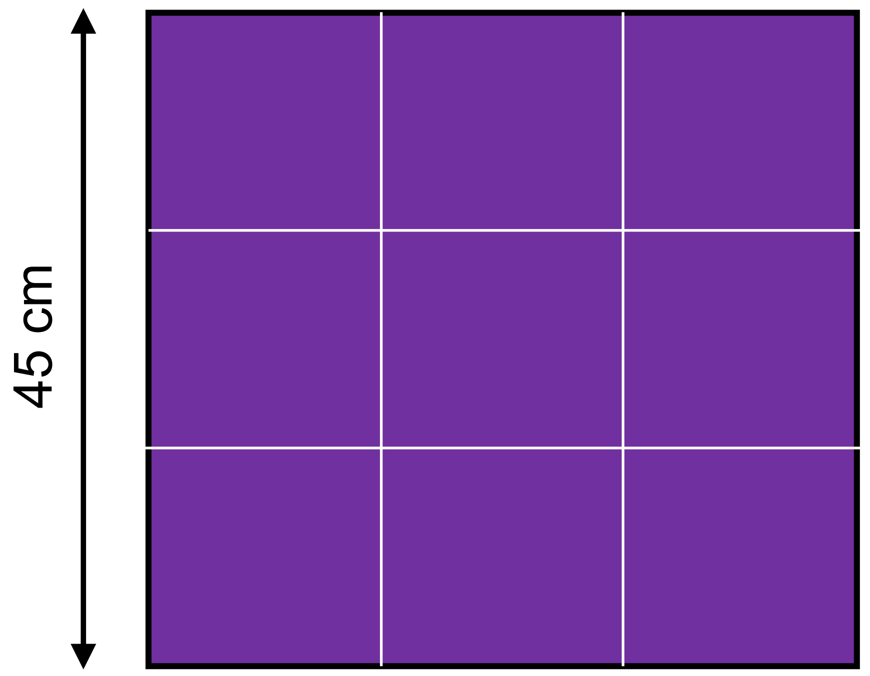
- each polar column of detectors, overlapping with neighbors
- sum amplitude with conservative coincidence timing window
- compare to conservative energy threshold
- trigger when complementary (ECAL and HCAL) subsystems are both above threshold ~ only about 35 kHz

Electron subsystems



- 1200 $PbWO_4$ crystals
- 2x2x20 cm^3
- 5x5 grouping for subsystem
- 240 overlapping subsystems

Proton subsystems



- 288 iron/scintillators
- 15.5x15.5x100 cm^3
- 3x3 grouping for subsystem
- 96 overlapping subsystems

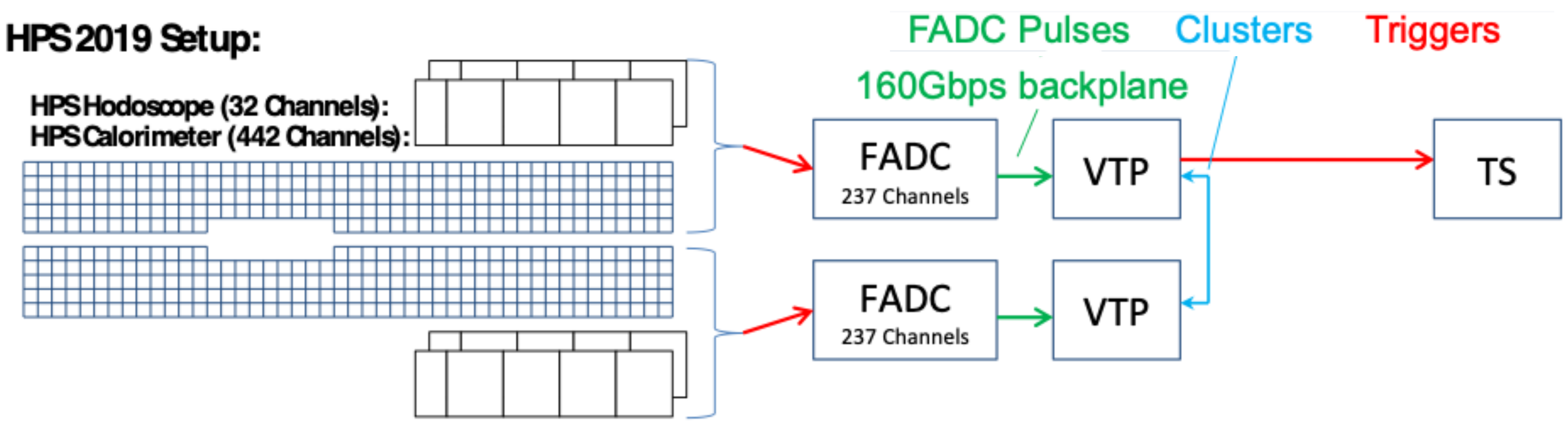
N.B. definitely triggered (not “streaming”) readout. I had to get educated about what people meant when they said that word…

Advantage: simplicity over dynamic clusterization, and fully sufficient for acceptance, resolution, and background

Buffered readout for fast counting

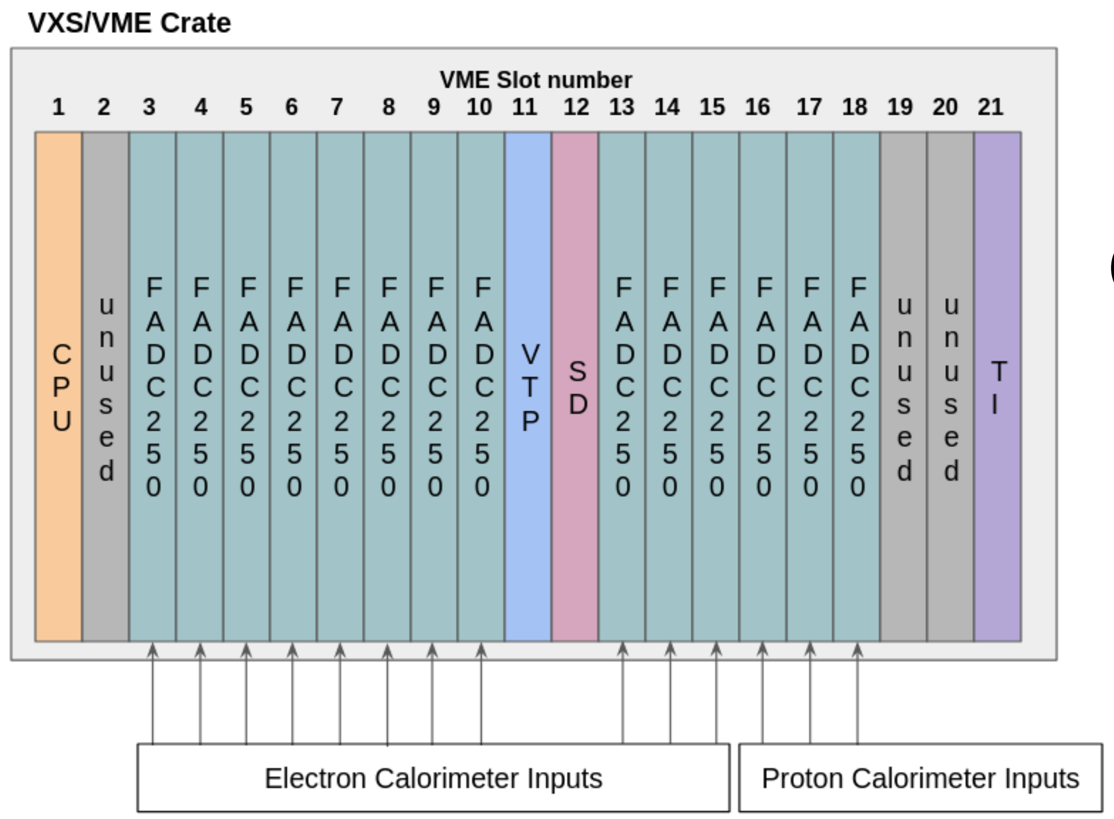
Readout for fast counting is now a very common challenge and enabled by new, and now common, technologies. In particular, SOLID will face this challenge in measurement of PV-DIS, and this experiment will be an important testing ground for precise asymmetry counting measurements.

Concept very similar to the HPS DAQ, used in 2019 or NPS DAQ:



JLab **FADC250** for HCAL and ECAL readout
Provides the pulse information for a fast, "deadtime-less" trigger

VTP (VXS Trigger Processor)
Running, updating sums over subsystems, finds ECAL+HCAL coincidence



One VXS crate will handle one sixth of ECAL + HCAL, also provide external trigger for ScintArray pipelineTDC readout

Expect ~35kHz total, ~450 Mb/s data rate, distributed over 6 separate crates

Scintillator TDC readout

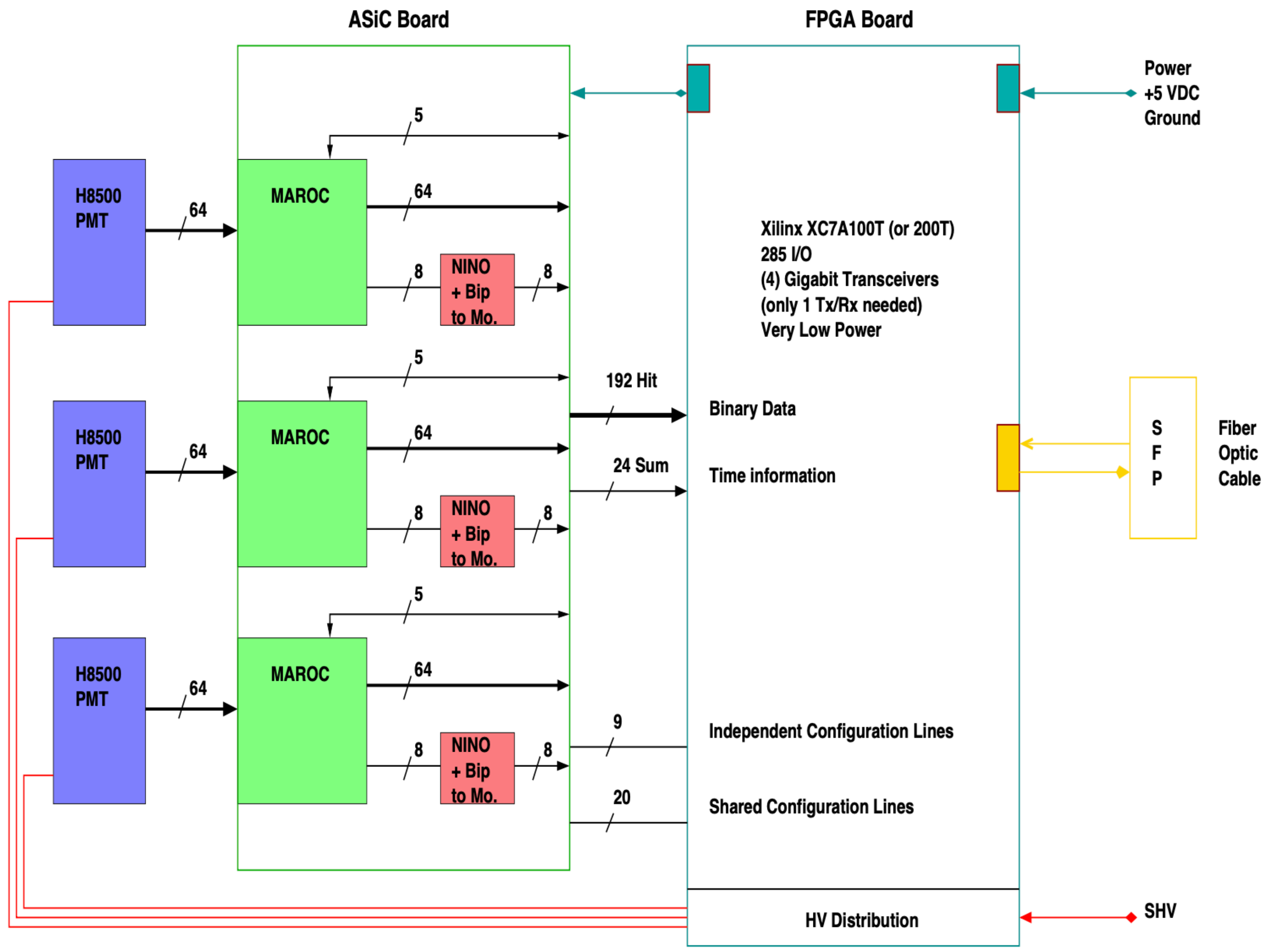
Two workable options, based on previously implements MAPMT pipeline readout

model based on CDET detector (GEP)

- NINO chip module, **VETROC** for scintillator readout.
- Need 38 boards, 3 crates.
- Pipeline event record triggered by calorimeter coincidence trigger.
- Use HCAL subsystem number to select scint elements for readout
- Record time, time-over-threshold for scint elements **(preferred)**
- 35 kHz trigger rate, 8 Bt/read, 225 elements = 65 MB/sec

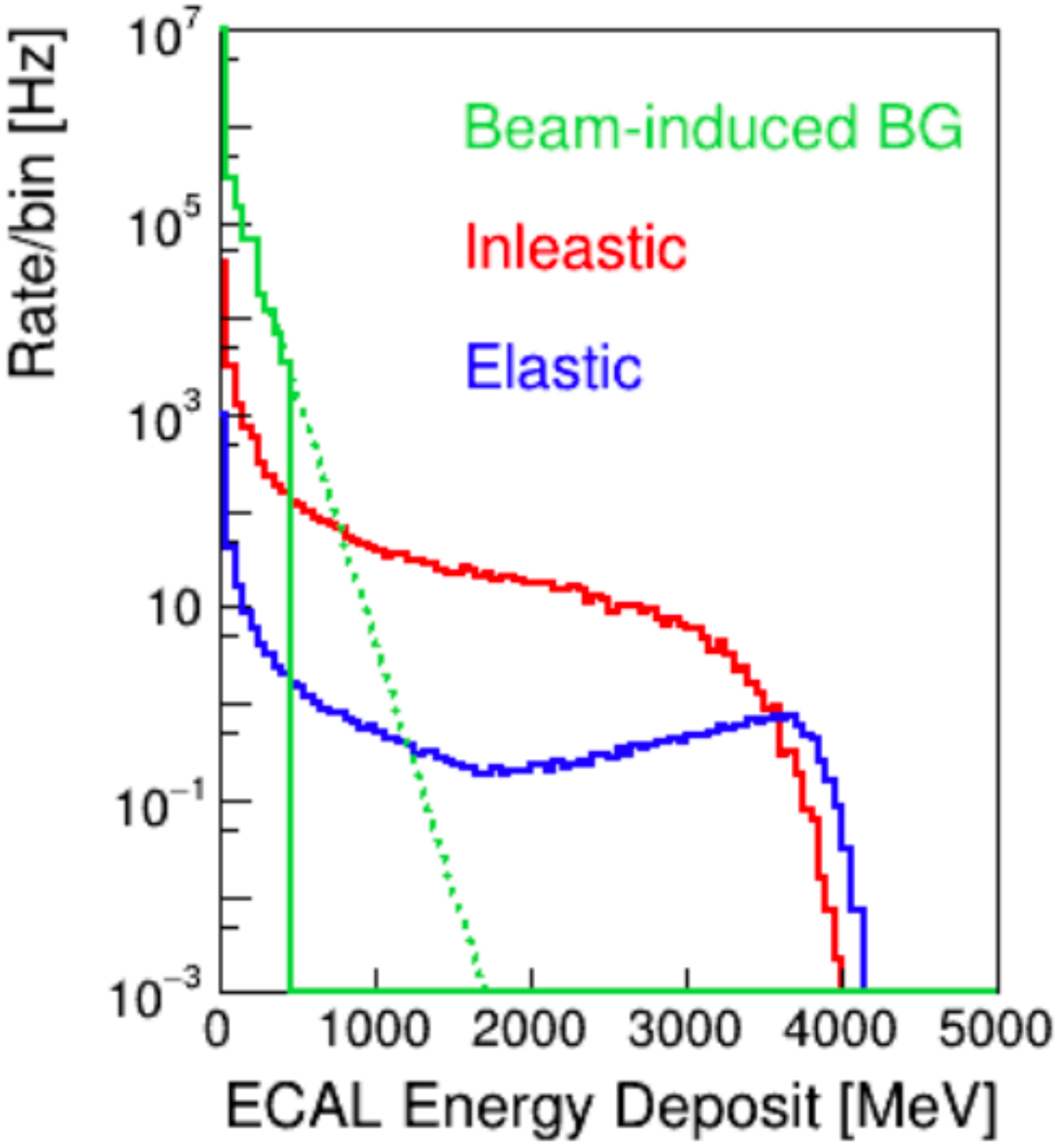
model based on CLAS12 RICH

- MAROC3a FPGA readout module
- discriminated signal
- SSP readout board for scintillator readout.
- Need 38 front-end boards, 2 SSP, 1 crate.
- Event record triggered by calorimeter coincidence trigger.
- All elements recorded hit or not, 35kHz*7200 bits = 32 MB/sec

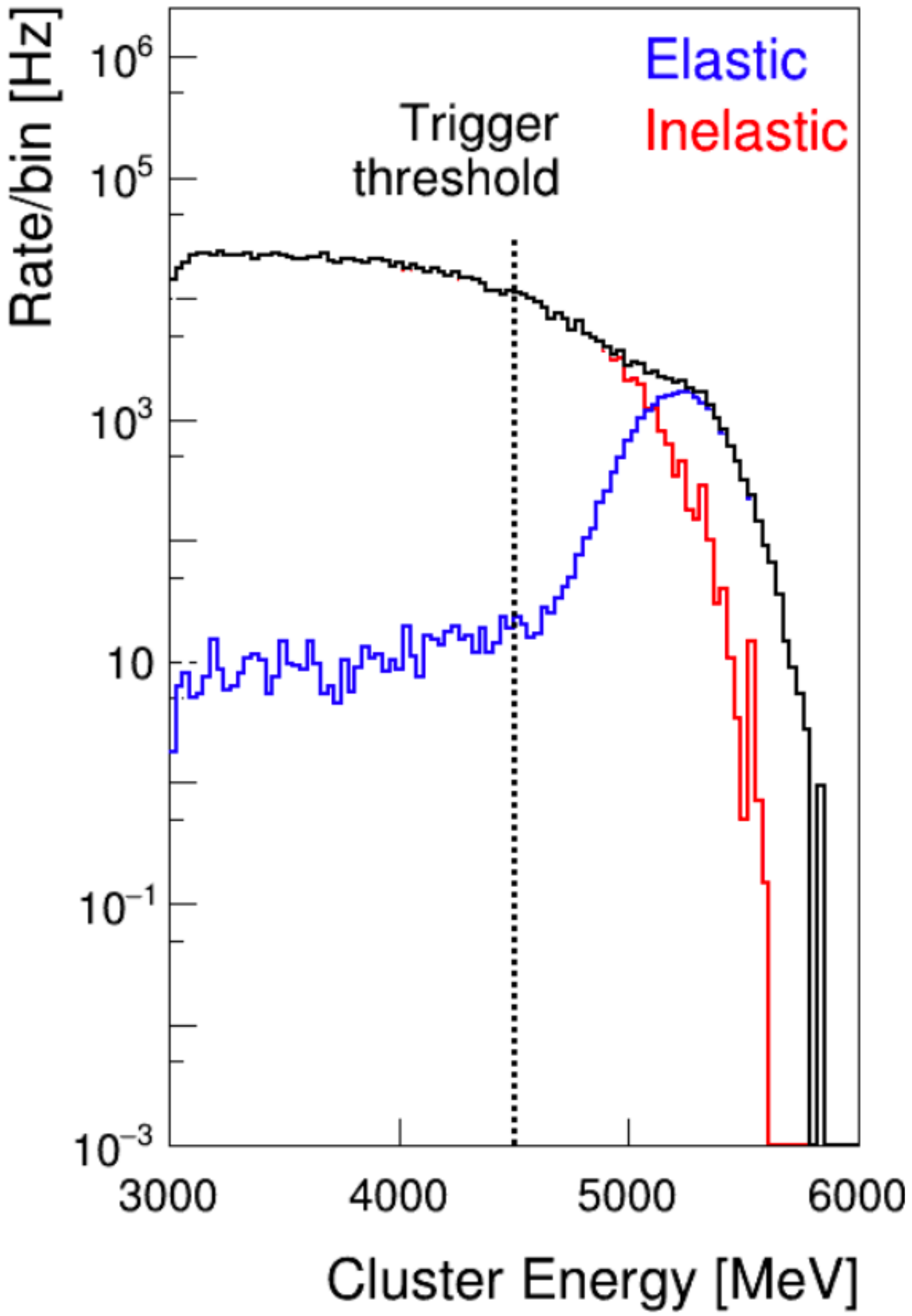


Other possible discriminator boards, if availability is limited (such as SAMPA…)

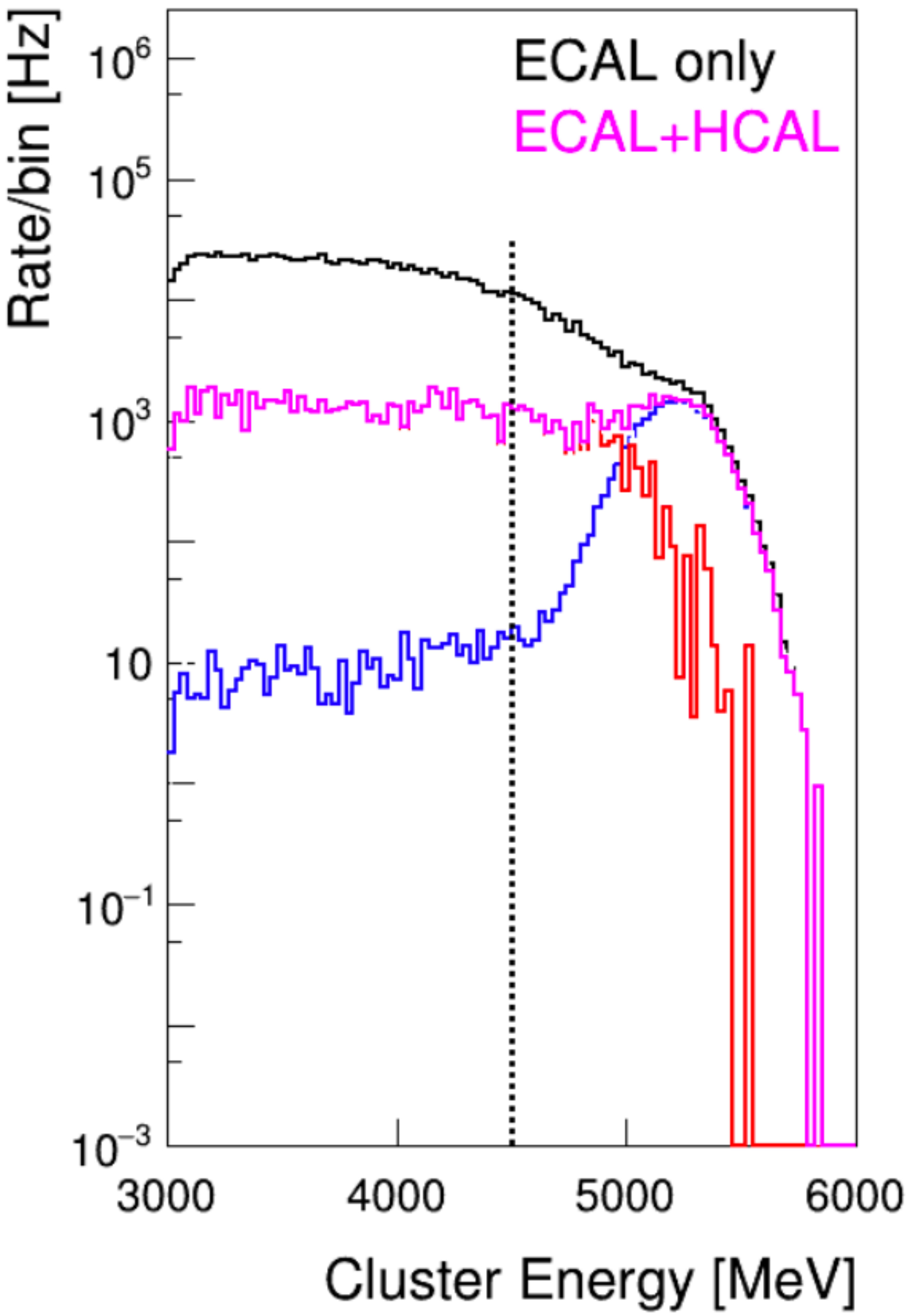
ECAL cluster rates



The relatively high ECAL cut (~66% of beam energy) greatly reduces the trigger rate



ECAL > 4.5 GeV	153 kHz



ECAL > 4.5 GeV & HCAL > 50 MeV	35 kHz

Rates and Precision

Beam and target: 60 uA on 10 cm LH_2 => luminosity is 1.6×10^{38} cm^{-2}/s

Trigger (online)

- Elastic coincidence 18 kHz signal in full detector
- Inelastic (pion production) coincidence trigger rate ~16 kHz
- Accidental coincidence rate < 2 kHz
    - ~150 kHz total singles rate in ECAL > 4.5 GeV energy threshold, 240/5 unique subsystems
    - ~19 MHz total singles rate in HCAL > 50 MeV energy threshold, 96/3 unique subsystems
    - Temporal coincidence cut 20ns
- ~35 kHz total coincidence trigger rate
- Live time (1- 35kHz*20ns) ~99.9%

Offline analysis

- ECAL cluster center, scintillator array to improve geometric cuts, cut edge hits, ECAL cut, 4 ns timing
- Accepted elastic signal reduced to 13 kHz - production statistics
- Inelastic (pion production) <0.4%, accidentals $<1\times10^{-5}$ due to angular precision and higher E cut

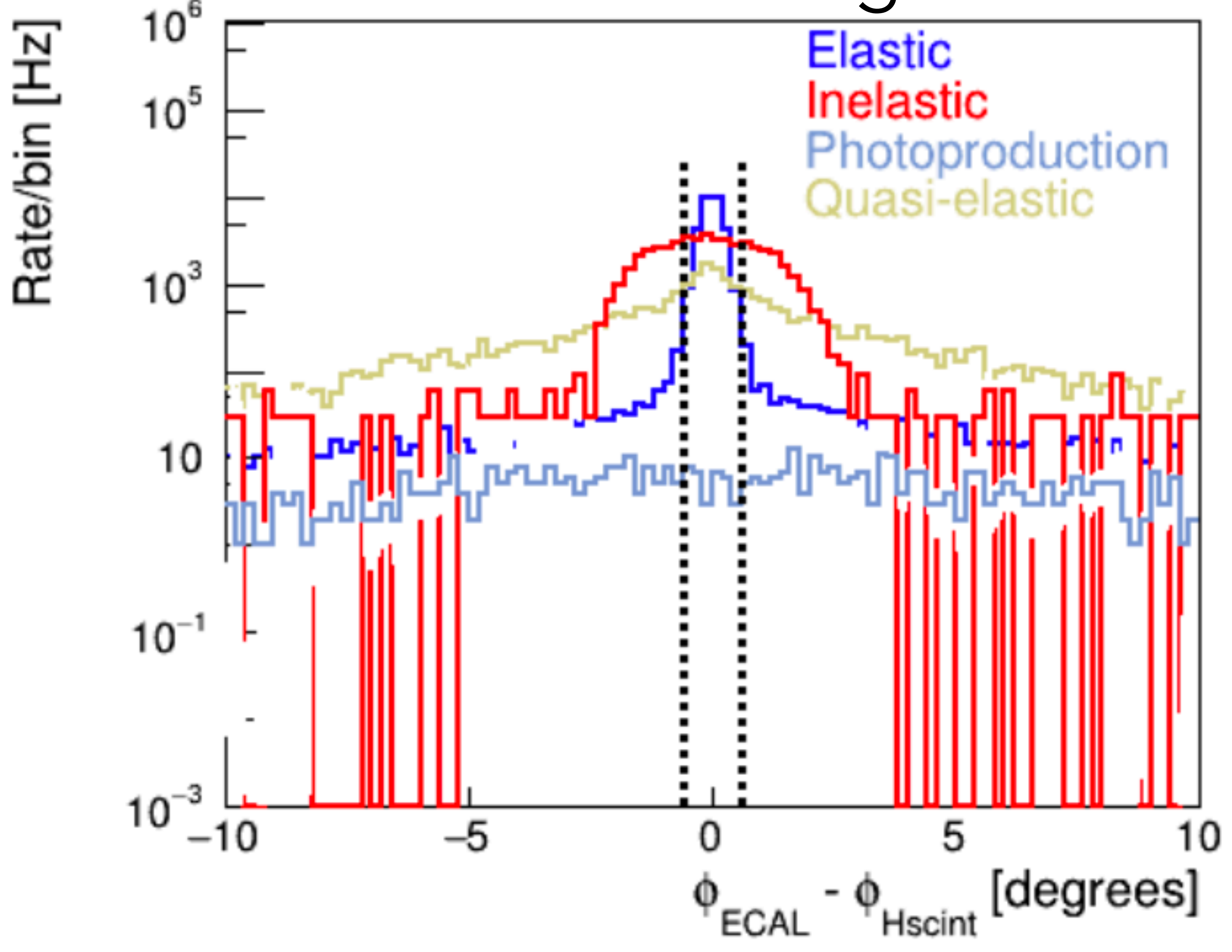
Beam polarization 85%

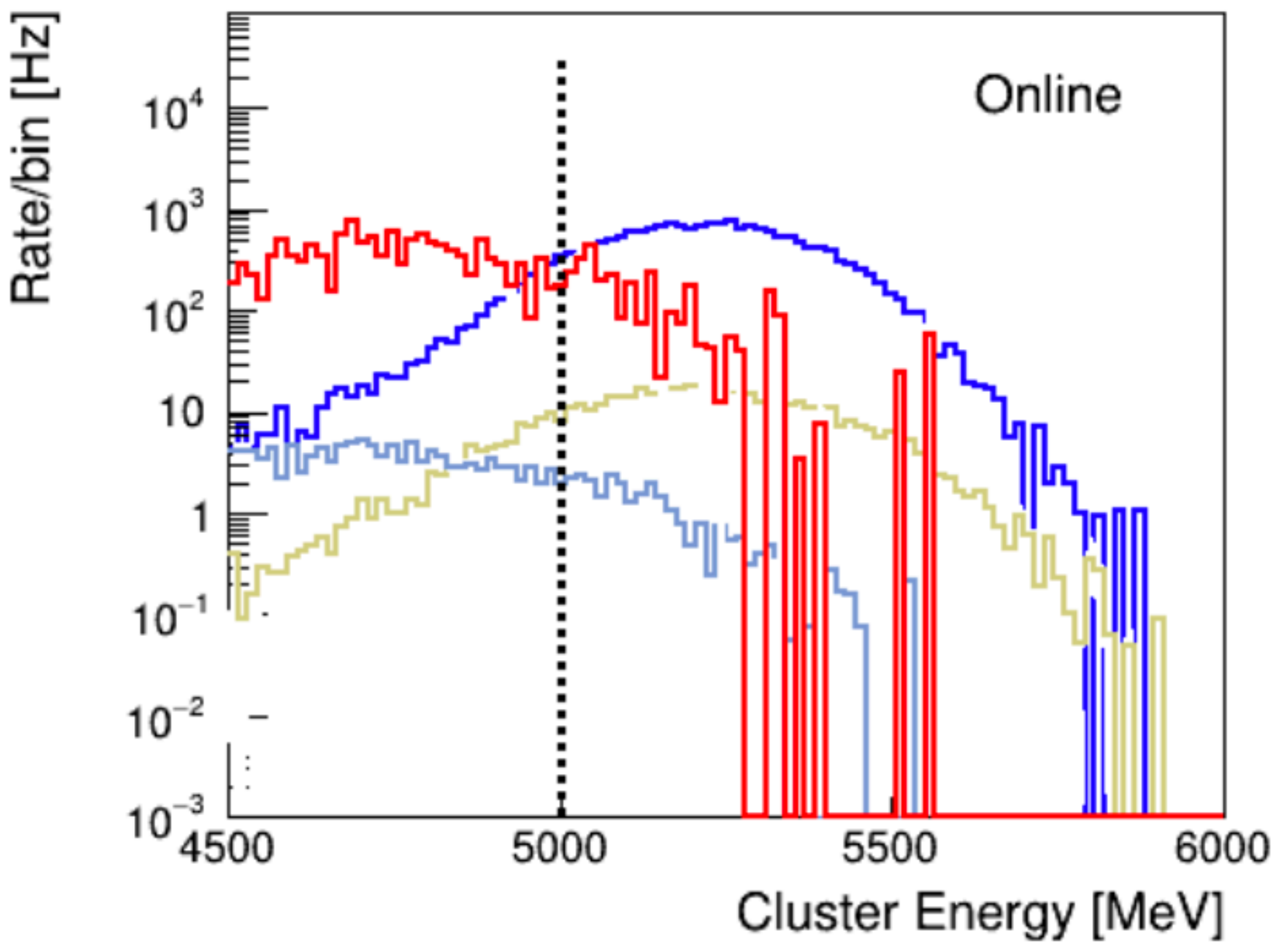
40 days production runtime $\longrightarrow$ Raw asymmetry statistical precision $\delta(A_{raw}) \sim 5$ ppm

$\longrightarrow$ $A_{PV} = -150 \pm 6.2$ ppm

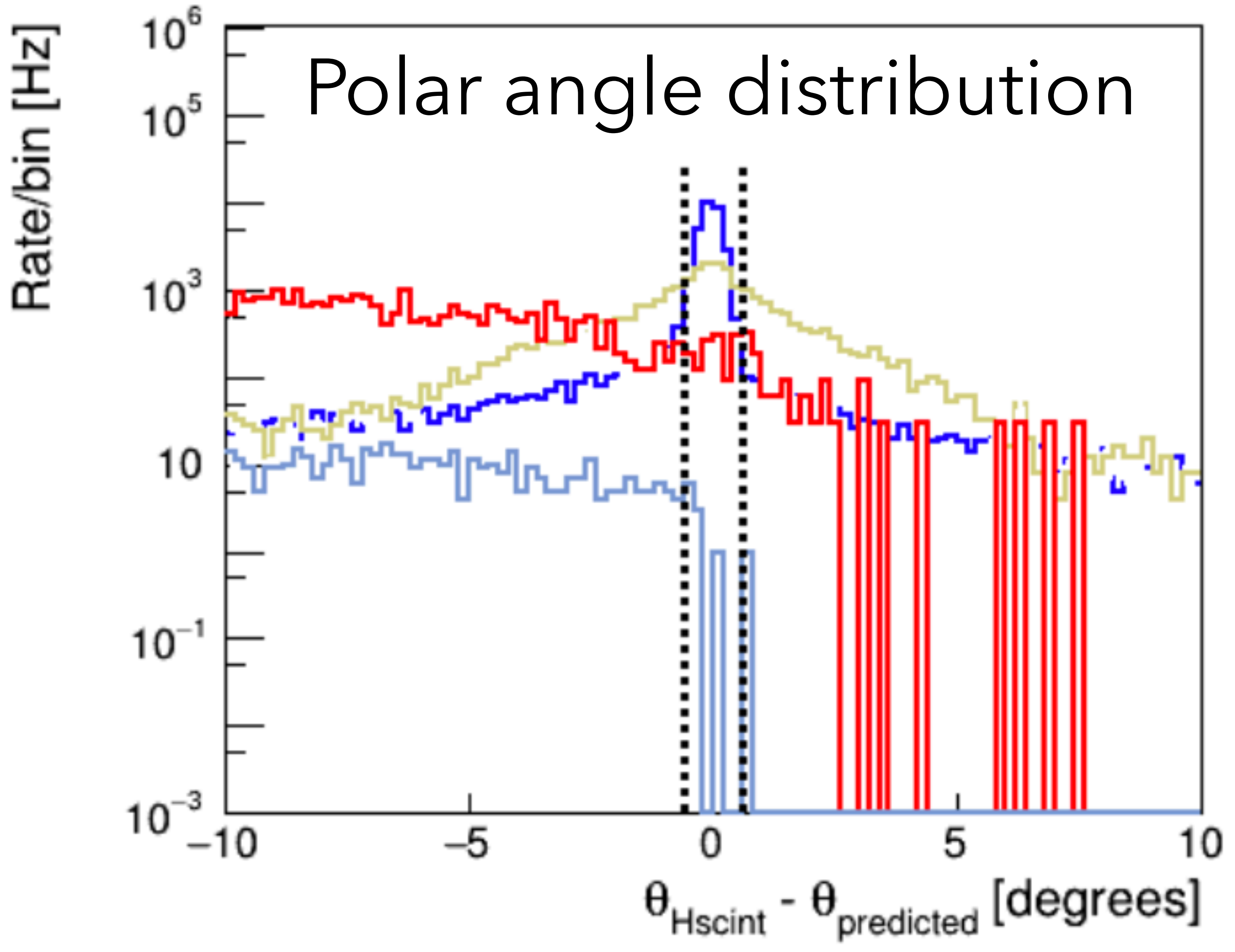
Elastic event discrimination

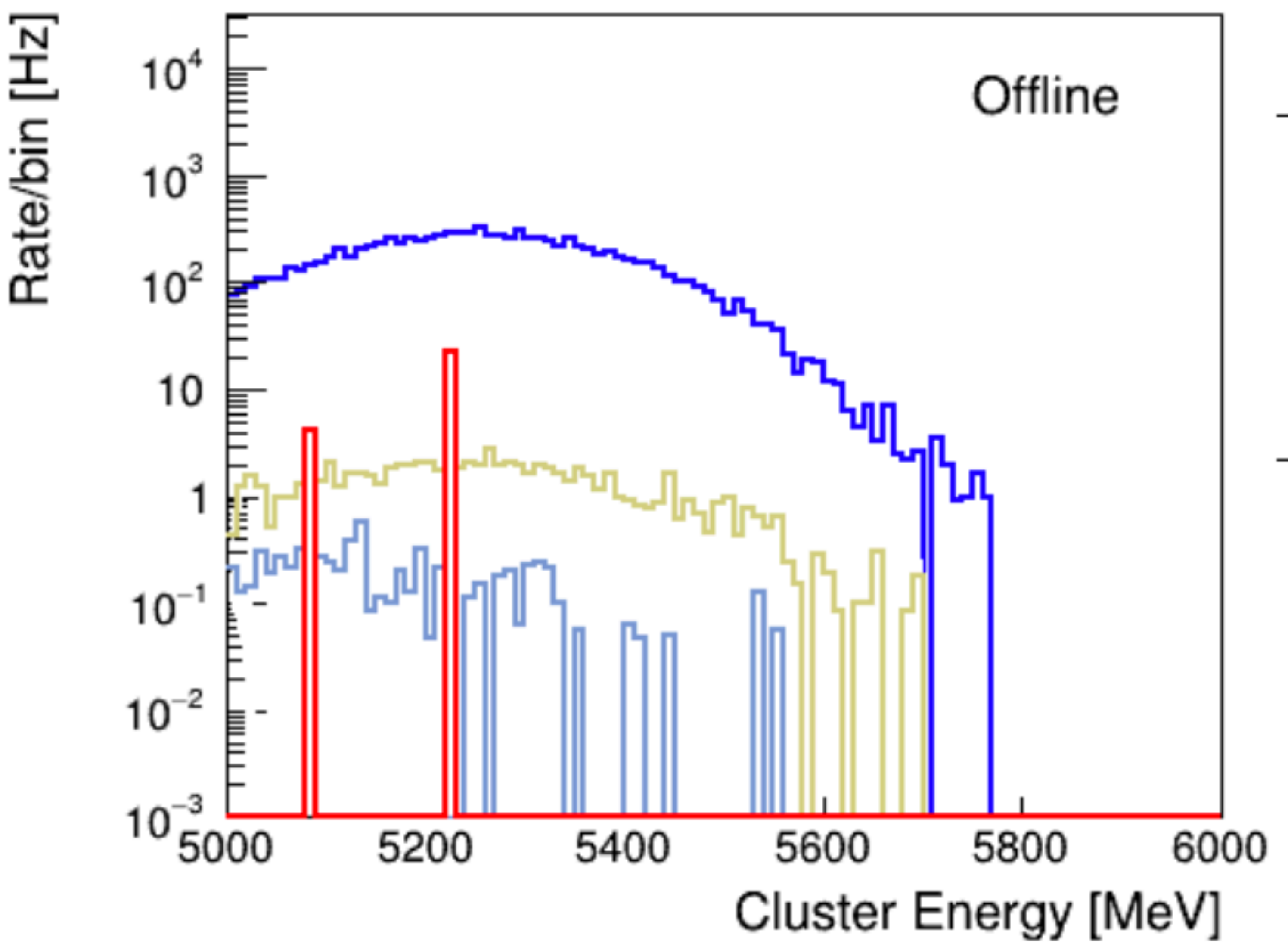
Azimuthal angle





dashed lines = offline cuts





Fraction of total by event type	Online	Offline
Elastic scattering	0.531	0.989
Inelastic (pion electro-production)	0.450	0.002
Quasi-elastic scattering (target windows)	0.015	0.008
π^0 photo-production	0.004	0.001

"sideband" analyses will help verify QE and inelastic asymmetries

Error budget

quantity	value	contributed uncertainty
Beam polarization	85% ± 1%	1.2%
Beam energy	6.6 + / − 0.003 GeV	0.1%
Scattering angle	$15.5^\circ \pm 0.03^\circ$	0.4%
Beam intensity	<100 nm,<10 ppm	0.2%
Backgrounds	< 0.2 ppm	0.2%
G_E^n/G_M^n	-0.2122 ± 0.017	0.9%
G_E^p/G_M^p	0.246 ± 0.0016	0.1%
σ_n/σ_p	0.402 ± 0.012	1.2%
$G_A^{Zp}/G_{\text{Dipole}}$	-0.15 ± 0.02	0.9%
Total systematic uncertainty:		2.2%

or 3.3 ppm

Statistical precision for A_{PV}: 6.2 ppm (4.1%)

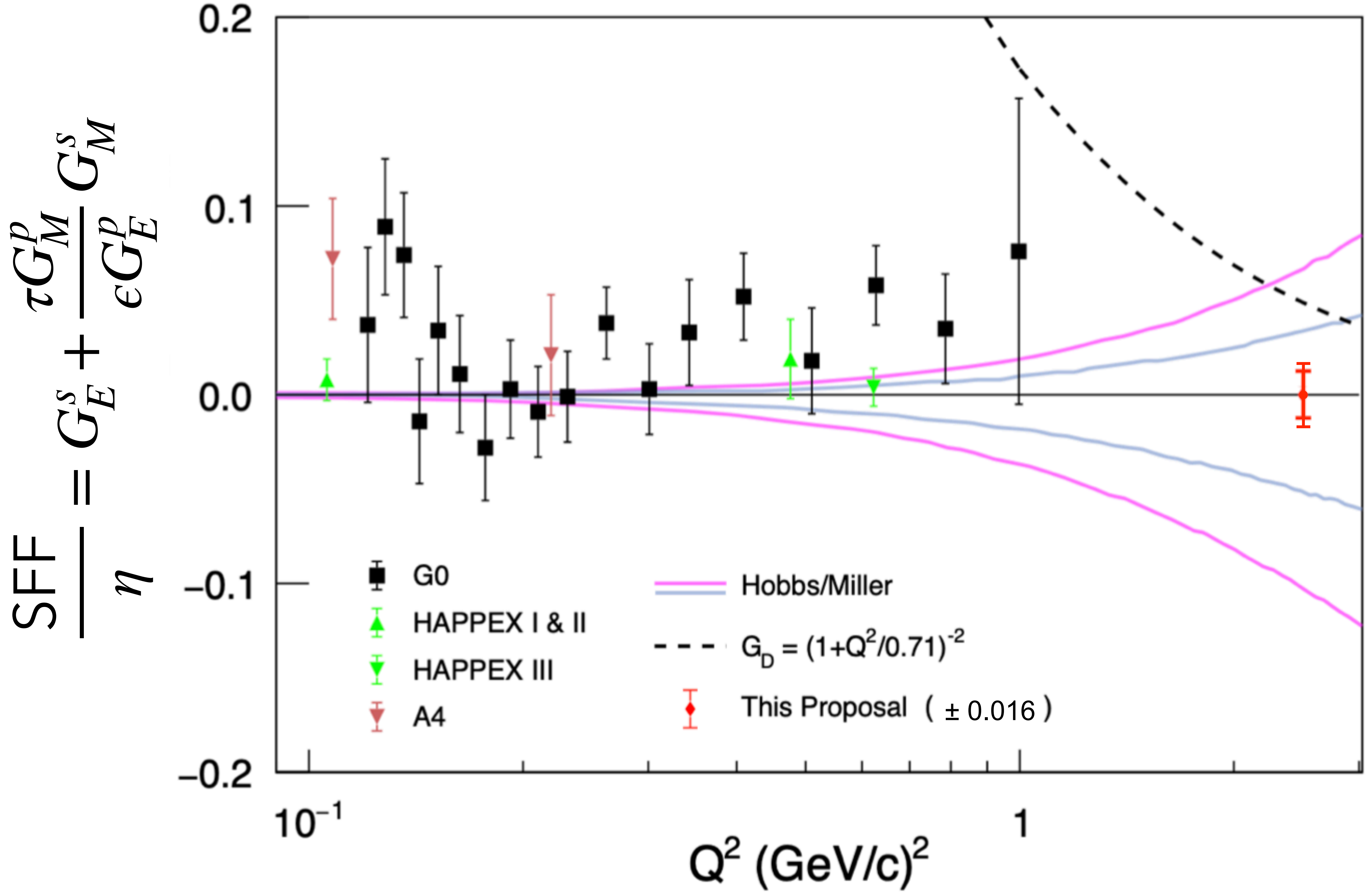
There is also an uncertainty from radiative correction, is small except for a dominant "anapole" piece.

If the anapole uncertainty is not improved, this would contribute at additional 4.1 ppm (2.7%) uncertainty

Projected result

δ A_{PV} = ± 6.2 (stat) ± 3.3 (syst)

$$\delta\left(G_E^s + 3.1 G_M^s\right) = \pm\ 0.013\ \text{(stat)}\ \pm\ 0.007\ \text{(syst)} = 0.015\ \text{(total)}$$



If $G_M^s = 0$, $\delta G_E^s \sim 0.015$, (about 34% of G_D)

If $G_E^s = 0$, $\delta G_M^s \sim 0.005$, (about 11% of G_D)

The proposed measurement is especially sensitive to G_M^s

The proposed error bar reaches the range of lattice predictions, and the empirically unknown range is much larger.

Summary

Configuration #	Procedure	Beam current, μA	time, days
C1	Beam parameters	1-70	1
C2	Detector calibration	10	2/3
C3	Dummy target data	20	1/3
C4	Moller polarimetery	1-5	3
C5	A_{PV} data taking	60	40
	Total requested time		45

- 10+ years after the last sFF searches were performed, a new experiment is proposed for much higher Q^2, motivated by interest in flavor decomposition of electromagnetic form factors
- Projected accuracy at 11% of the dipole value allows high sensitivity search for non-zero strange form factor.
- The proposed error bar is in the range possibly suggested by lattice predictions, and significantly inside the range from the simple extrapolation from previous data
- Technical case has been fleshed out, with a detailed MonteCarlo, significant CAD design work,
- We are requesting PAC approval of 45 days of beam time (65 uA on 10 cm long LH2 target).

Backup slides

Helicity-correlated Beam Asymmetries

Position differences (like angle, but angle ~10x smaller):
APV roughly proportional to Q^3 , so sensitivity $\delta A / \delta\theta \sim 3\, \delta\theta / \theta$

Assume very large (by today's standards) position difference of 200 nm, to be compared to 79cm radius of ECAL

200nm / 79 cm ~ 250 nrad $\longrightarrow \dfrac{\delta\theta}{\theta} \sim 1$ ppm, or $\dfrac{\delta A}{A} \sim 3$ ppm, ~2%.

Azimuthal symmetry leads to excellent cancellation, so the net effects will be very small.
Similarly, energy, assuming 200 nm in dispersive bpm (~1m dispersion)$\longrightarrow$ 0.2 ppm, or 0.15%
Can be corrected with regression

Charge asymmetry
Using feedback, <10ppm easily achievable. 1% calibration $\longrightarrow$ 0.1ppm systematic, 0.06%

A sense of scale in important here: Qweak ($\sigma \sim$ 10ppb), PREX-2 (16ppb) and CREX (100ppb) were between 60x - 600x more precise in terms of the absolute asymmetry error bar, they were all much more sensitive to beam asymmetries (by factors of 4x-100x), and they all successfully kept the total beam correction uncertainty to be small compared to their statistical error.

With regard to the challenges of HCBA, this proposal is far inside the envelope of the tools we have used many times here at JLab.

Strawman Budget

scattering chamber	Vacuum chamber – large pipe+window	*500k*
	Scattering chamber shift	will *exist*
ECAL/HCAL support	ECAL support	200k
	ECAL cooling	*tbd*
	Lead shield for ECAL	*tbd*
	HCAL support	300k
	FADCs (exist for HCAL/ECAL)	*exists*
	VTP, DAQ crates + CPUs + data links	*mostly exists*
Scintillator array construction ~7200 elements	Scint array maPMTs (125x64 channels)	450k
	Scint array extruded scint	50k
	Scint array support	100k
	Lead shield for scint array	*tbd*
Scintillator array readout	Scint Array TDC + front end	400k
	Total, a bit over	$2000k

Work packages

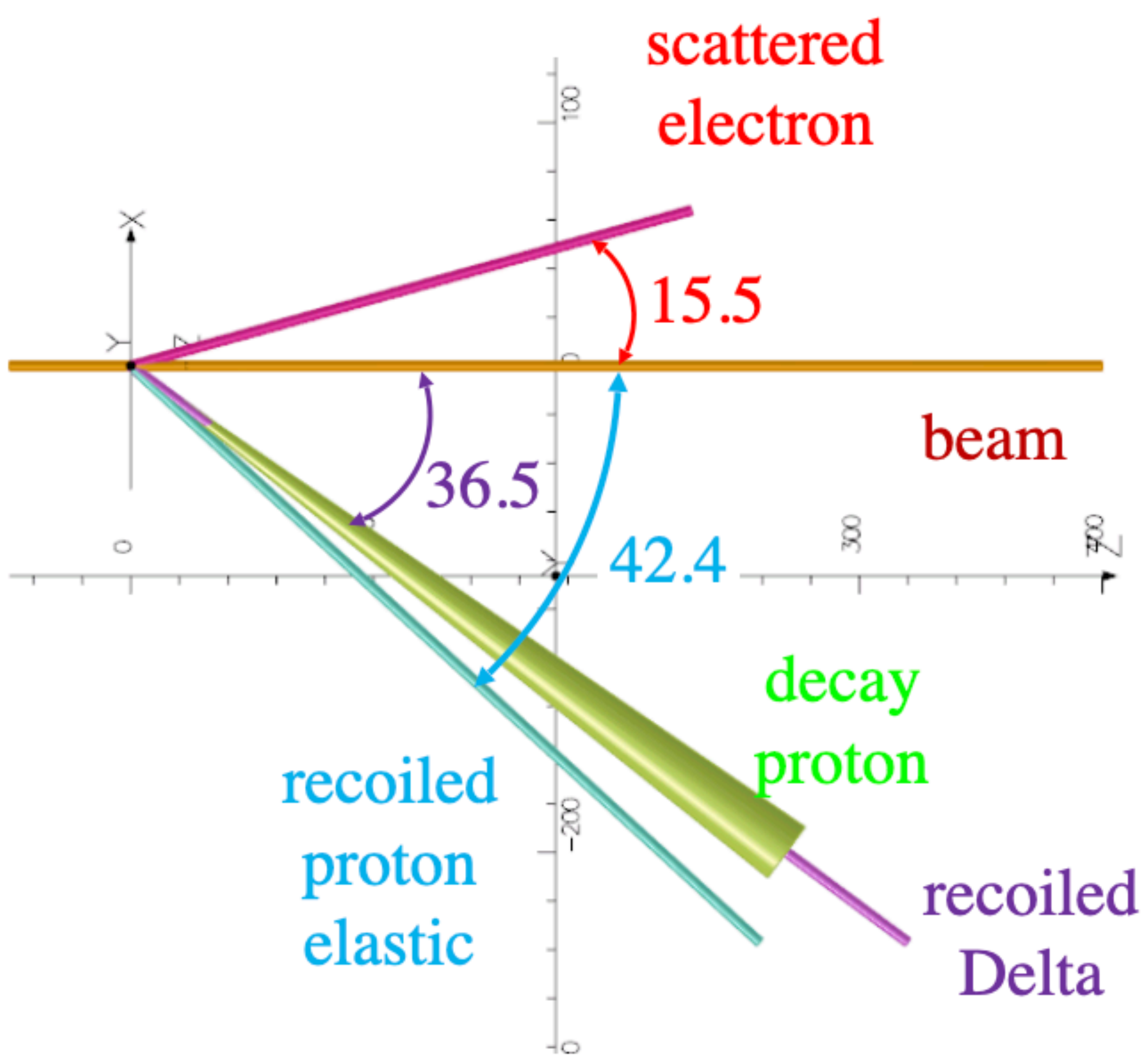
Collaboration institutions have expressed interest in various components

Component	Lead or interested groups
Target chamber and detector structure	JLAB target and design groups
HCAL design and assembly	JLab design, +….
ECAL design and assembly	AANL, with expert advice from Orsay
Scint array design and fabrication	LaTech, Indiana…
DAQ	JLab DAQ Group, UVa, Ohio…
Analysis software	Ohio, LaTech
Beam Polarimetry	UVa, Temple, JLab Hall A/C
Polarized beam and source	Indiana

Pion electro-production contribution

ep detection of inelastic scattering.

Largest contribution from Delta, with strong exclusion from coincidence geometery



Angular separation:

6° (at Δ peak)

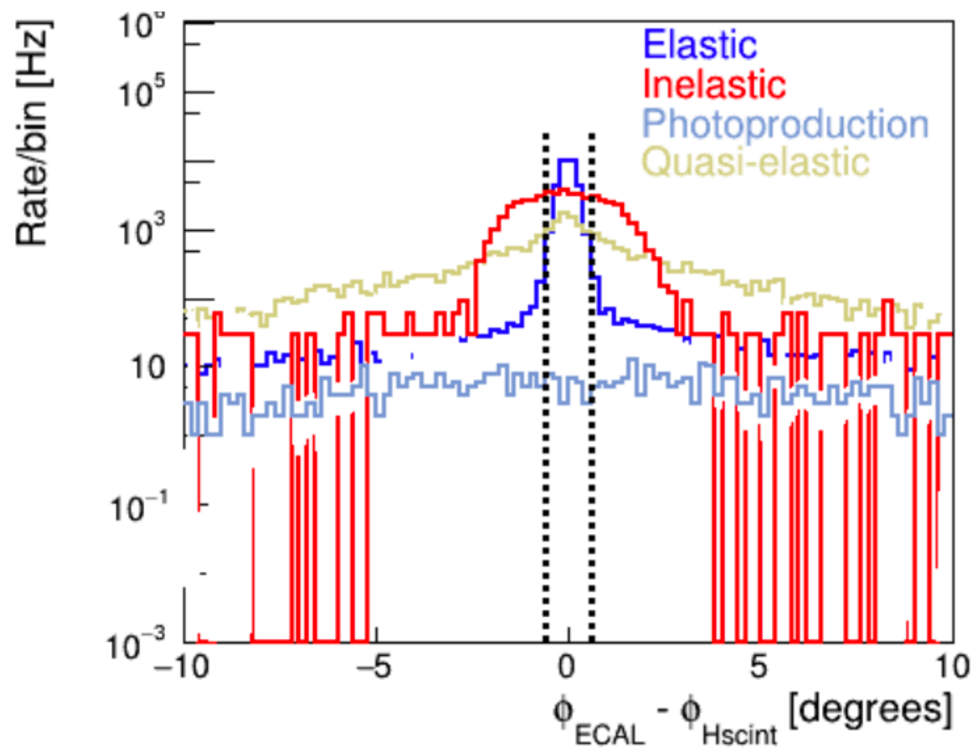
2.8° (at π threshold)

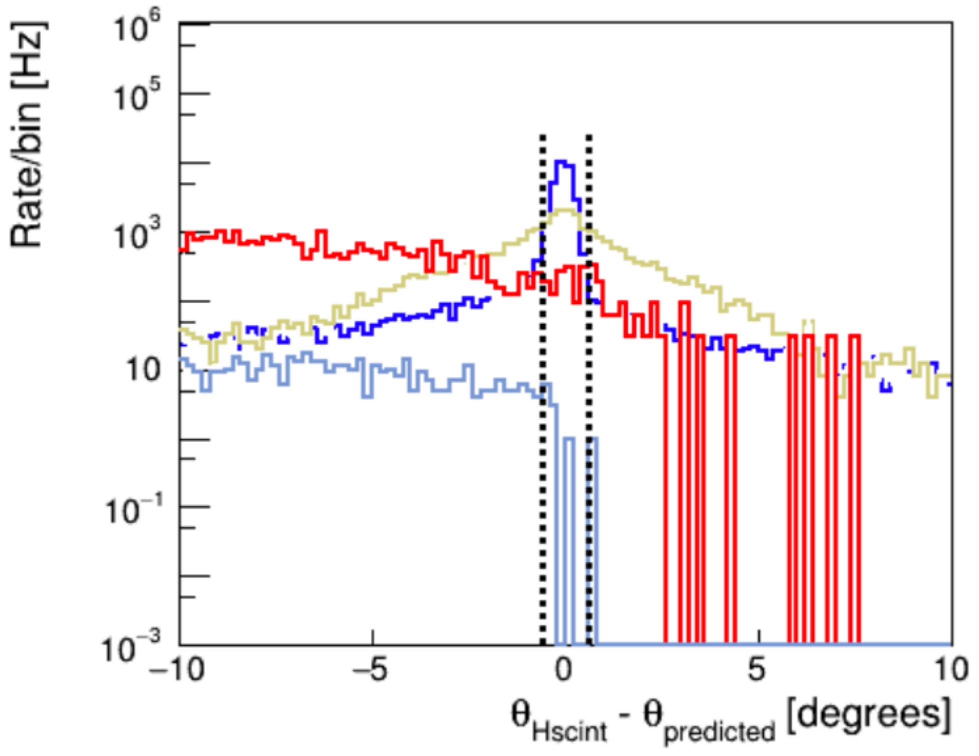
Angular resolution ~0.6° (polar)

Proton cone around Δ recoil, projected to polar angle:

RMS = 2° (so, 2.5σ separation for Δ)

Fraction to elastic rate < 0.3%

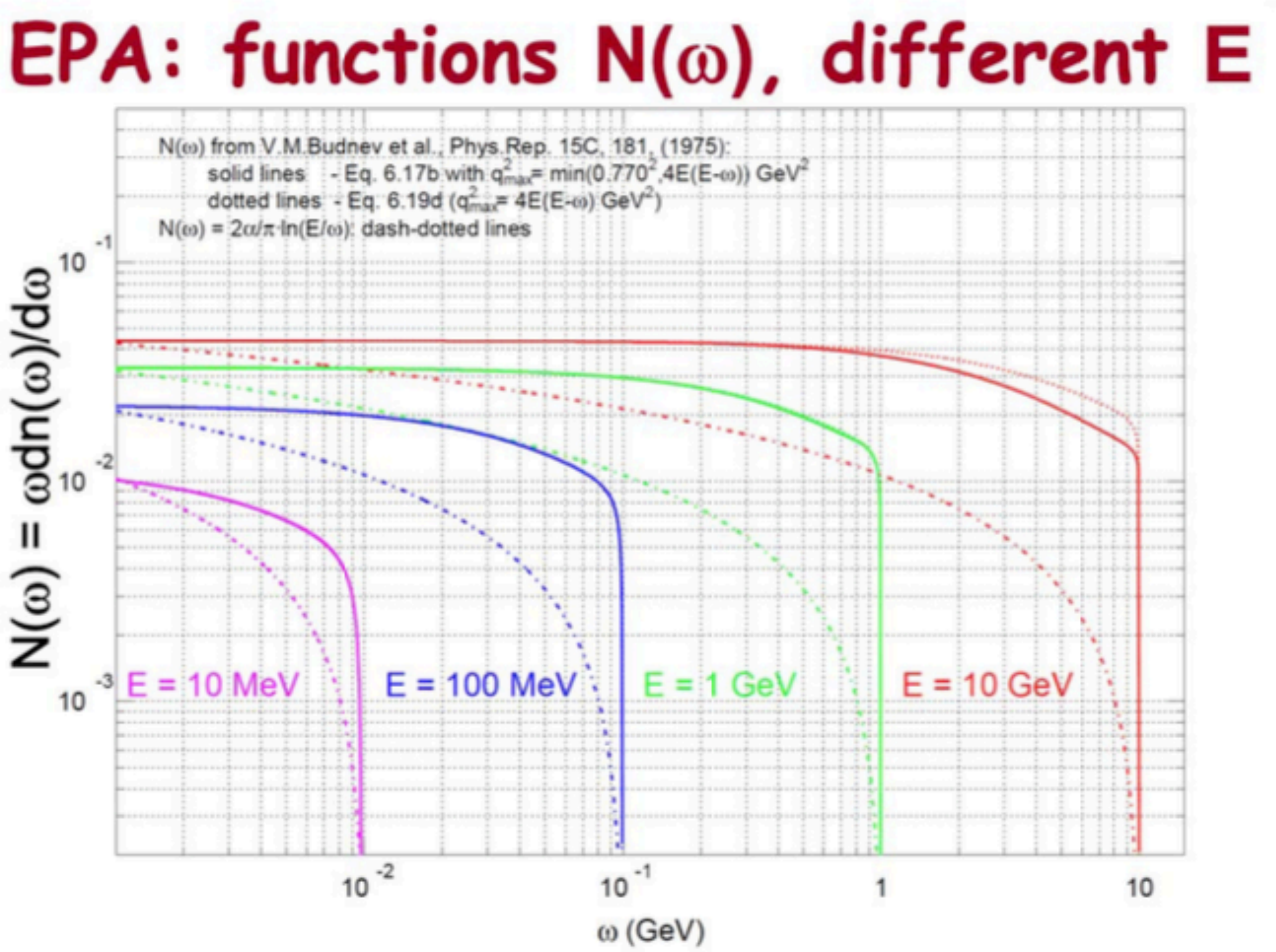




Fraction of total by event type	Online	Offline
Elastic scattering	0.531	0.989
Inelastic (pion electro-production)	0.450	0.002
Quasi-elastic scattering (target windows)	0.015	0.008
π^0 photo-production	0.004	0.001

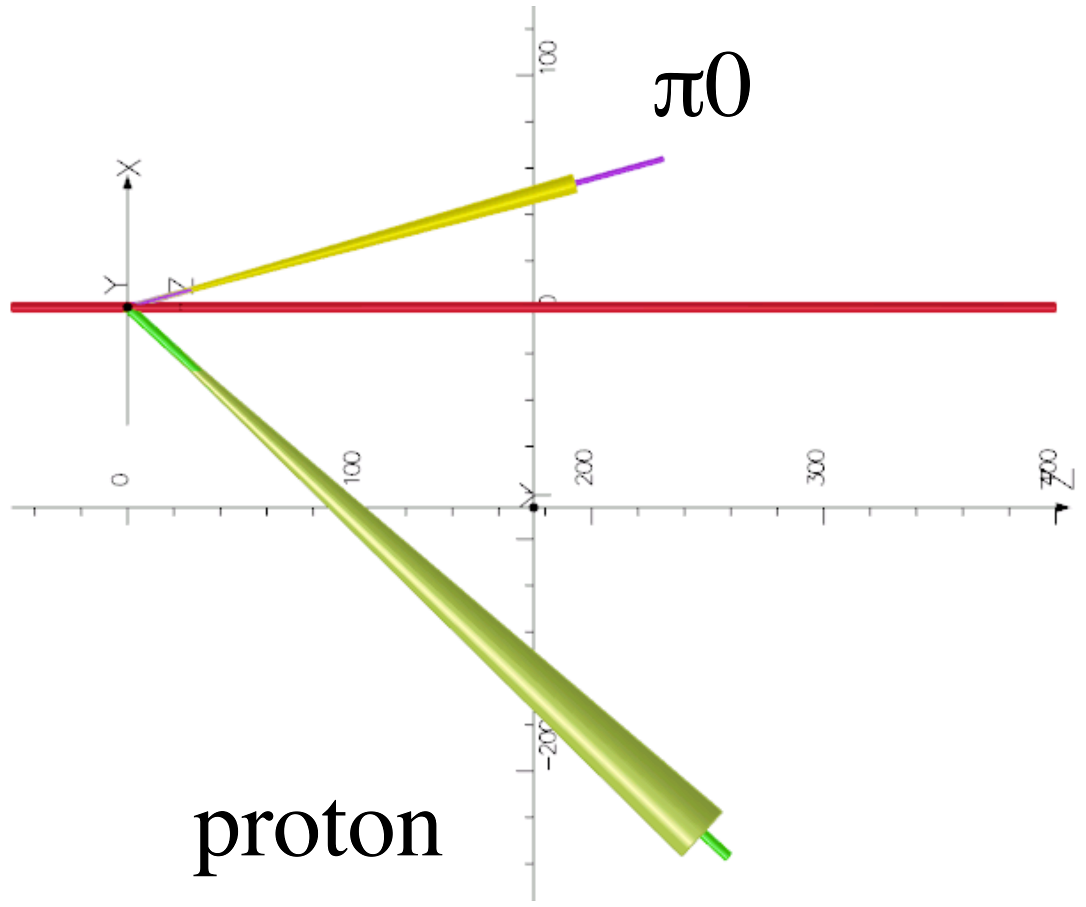
Single pion photo-production contribution

pion (ECAL) - proton (HCAL) coincidence



$$\frac{d\sigma}{dt}_{\gamma n\to\pi^- p} = 1.7\times 0.83\times\left(\frac{10}{s\,[\mathrm{GeV}^2]}\right)^7 (1-z)^{-5}(1+z)^{-4}\ \left(\mathrm{nb/GeV}^2\right),$$

$$N_{\pi^- p} = \frac{d\sigma}{dt}_{\pi^- p}\frac{p_{\pi^-}^2}{\pi}\Delta\Omega_{\pi^-} f_{\pi^- p}\left[\frac{\Delta E_\gamma}{E_\gamma}\frac{t_{rad}}{X_o}\mathcal{L}_{en}\right]$$



Near the end point the photon yield
is going down ⟶ reduction in factor t_{rad}/X_0

$f_{\pi-p}$ takes care of the cuts on angular correlation/resolution

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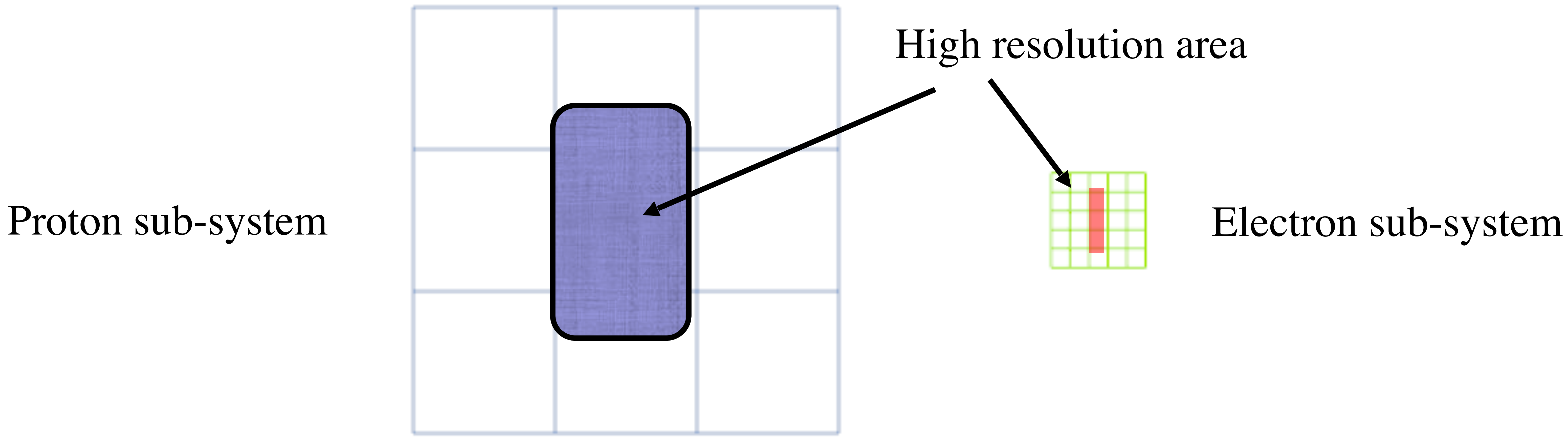
Remaining single pion events < 0.1% of elastic rate

Accidental background coincidence calculation

Online:
Electron arm single rate for $E_{e'}$ > 4.5 GeV is ~150 kHz : 3 kHz/subsystem
Proton arm single rate 19 MHz : 0.6 MHz/subsystem
Time window in the trigger 20 ns -> total accidental coincidence rate ~ 38 Hz x 48 subsystems: 2 kHz

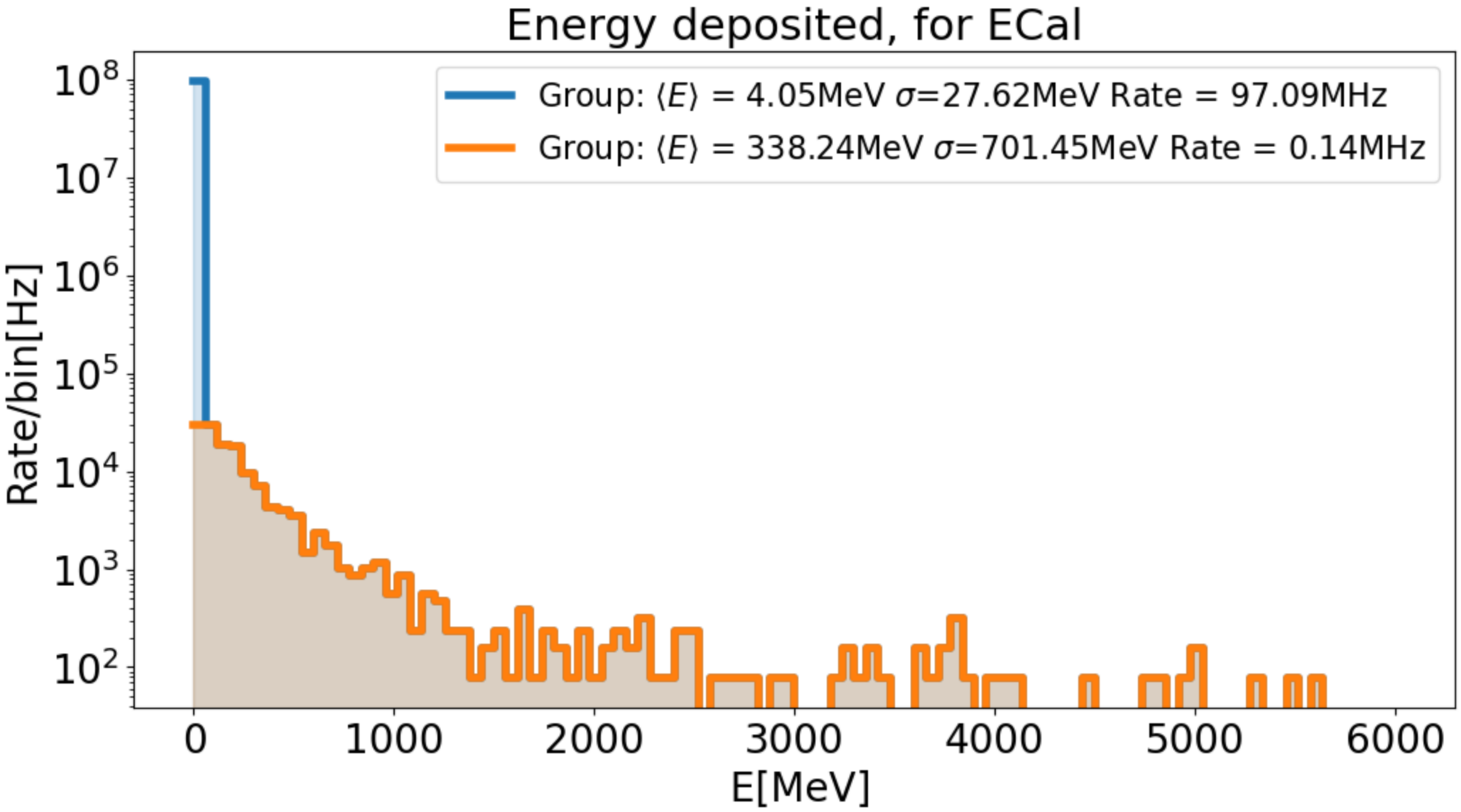
Offline:
Time window in analysis 4 ns, smaller area (high resolution part) and geometry cuts
⟶ Accidental rate is <10 Hz



Background events from Al

- assumed 5 mils target cell windows, ~5% nucleon
- Fermi energy smears quasi-elastic scattering distribution, about 80x suppression
- B/S < 0.1%
- a dummy target will be used to check accepted rate

Beam Background - per subsystem



Anapole Moment

In the context of a very large discrepancy from SAMPLE, the anapole radiative correction was investigated as a possible cause

$$\tilde{G}_A^e(Q^2) = \left[\tau_3 g_A(1 + R_A^{(T=1)}) + \frac{3F - D}{2} R_A^{(T=0)} + (1 + R_A^{(0)})\Delta s\right] G_A^D(Q^2)$$

The 1-quark and many-quark corrections to the axial charges in the $\overline{MS}$ renormalization scheme.

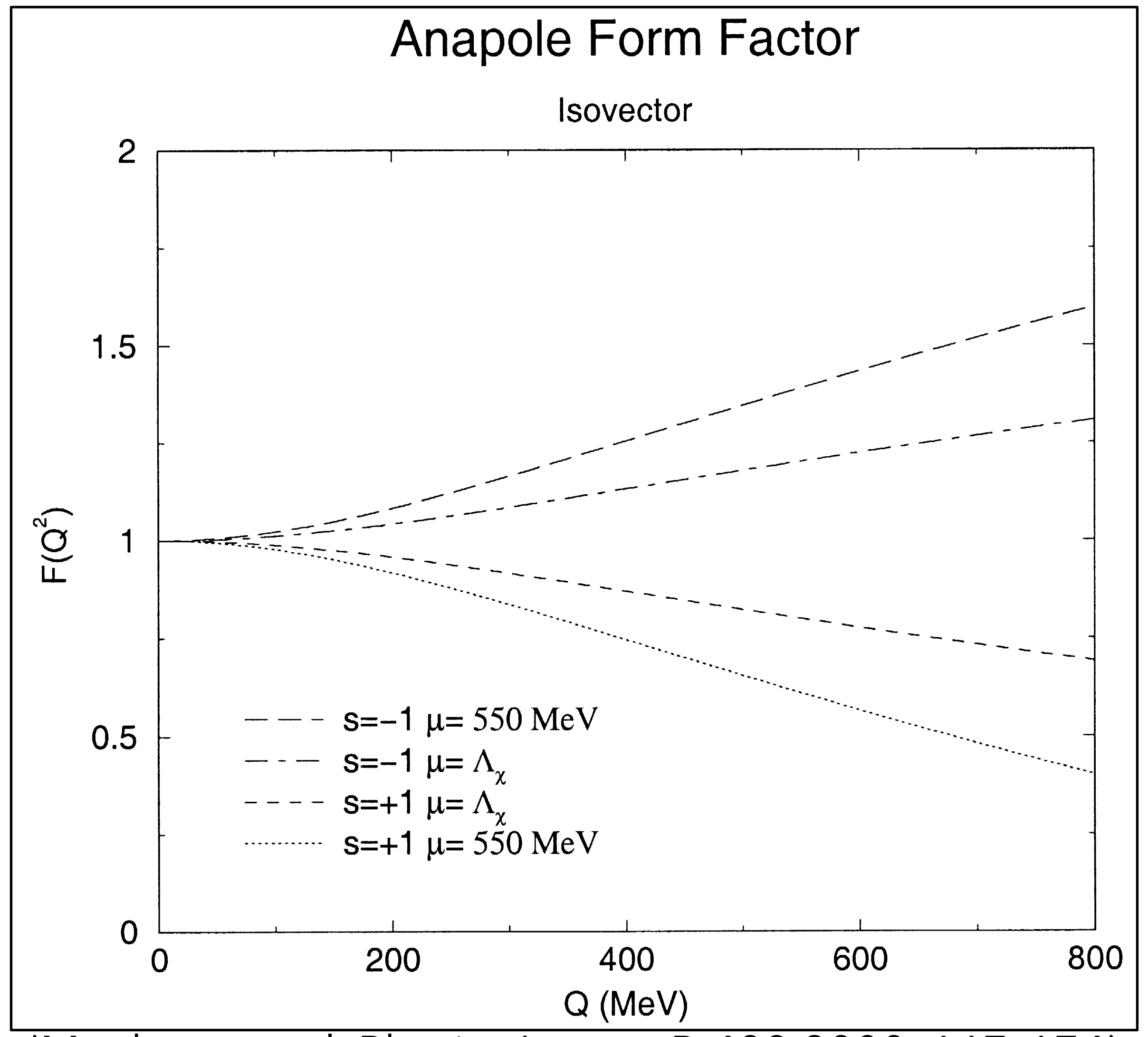
	$R_A^{(T=1)}$	$R_A^{(T=0)}$	$R_A^{(0)}$
1-quark	−0.172	−0.253	−0.551
Many-quark	$\boxed{-0.086(0.34)}$	0.014(0.19)	–
Total	−0.258(0.34)	−0.239(0.20)	−0.551

values from Shi-Lin Zhu, S.J. Puglia, Barry R. Holstein, M.J. Ramsey-Musolf, Phys. Rev. D 62 (2000) 033008.

Suggests a coefficient on the axial term at $Q^2 = 0$:

$$(1 + R_A^{(T=1)}) = 0.74 \pm 0.34$$

Without improvement, this would correspond to 4.1ppb, or 2.7% of A_{PV}



(Maekawa et al, Physics Letters B 488 2000. 167–174)

Q^2 dependence was explored at that time - suggested that it may be significant, but hasn't been evaluated since, or to high Q^2.

(Here, I believe this $F(Q^2)$ multiplies only the many-quark $R_A^{(T=1)}$= -0.086 contribution.)

Gamma-Z Box

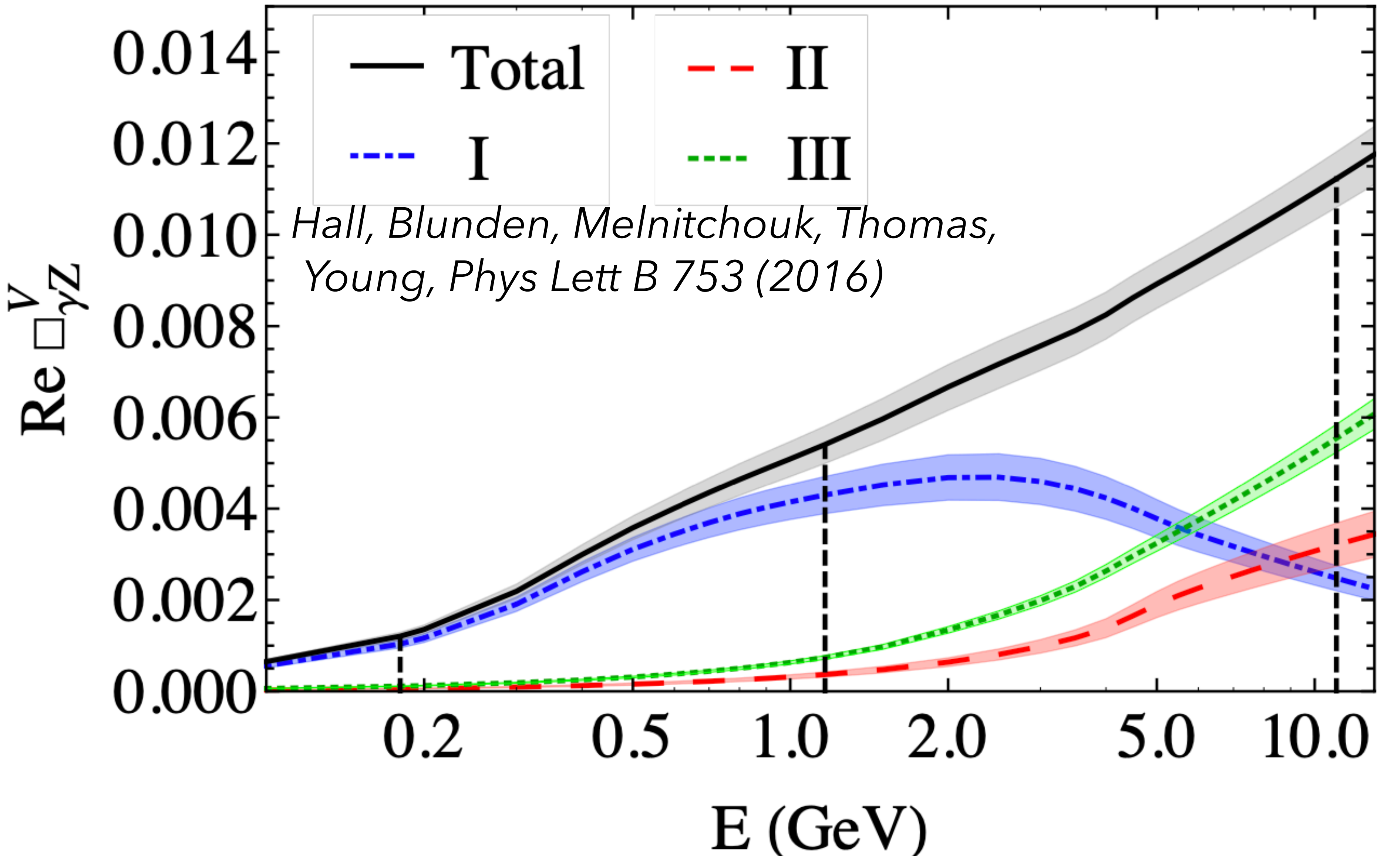
Additional radiative correction to Q_W

$$Q_W^p = (1+\Delta\rho+\Delta_e)\left(1-4\sin^2\theta_W(0)+\Delta_e'\right)+\Box_{WW}+\Box_{ZZ}+\underline{\Box_{\gamma Z}(0)}$$

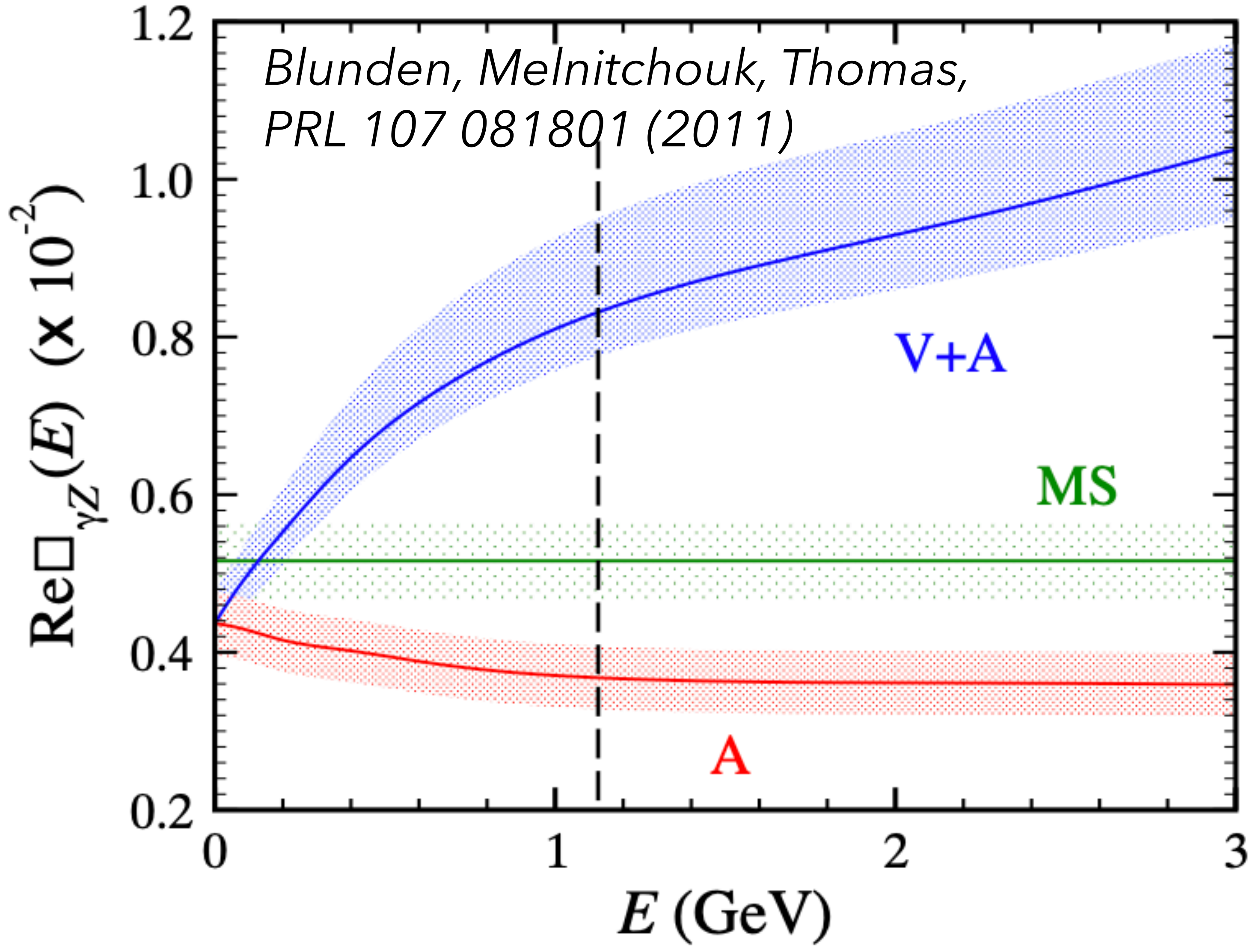
For Qweak, added ~0.5% uncertainty

Here, $\Box^{\mathrm{v}}_{\gamma Z}(0)$ = 0.0095 ± 0.0005 and $\Box^{\mathrm{a}}_{\gamma Z}(0)$ = -0.0036 ± 0.0004 which together is about 1.33±0.14 ppm (0.9±0.1%)

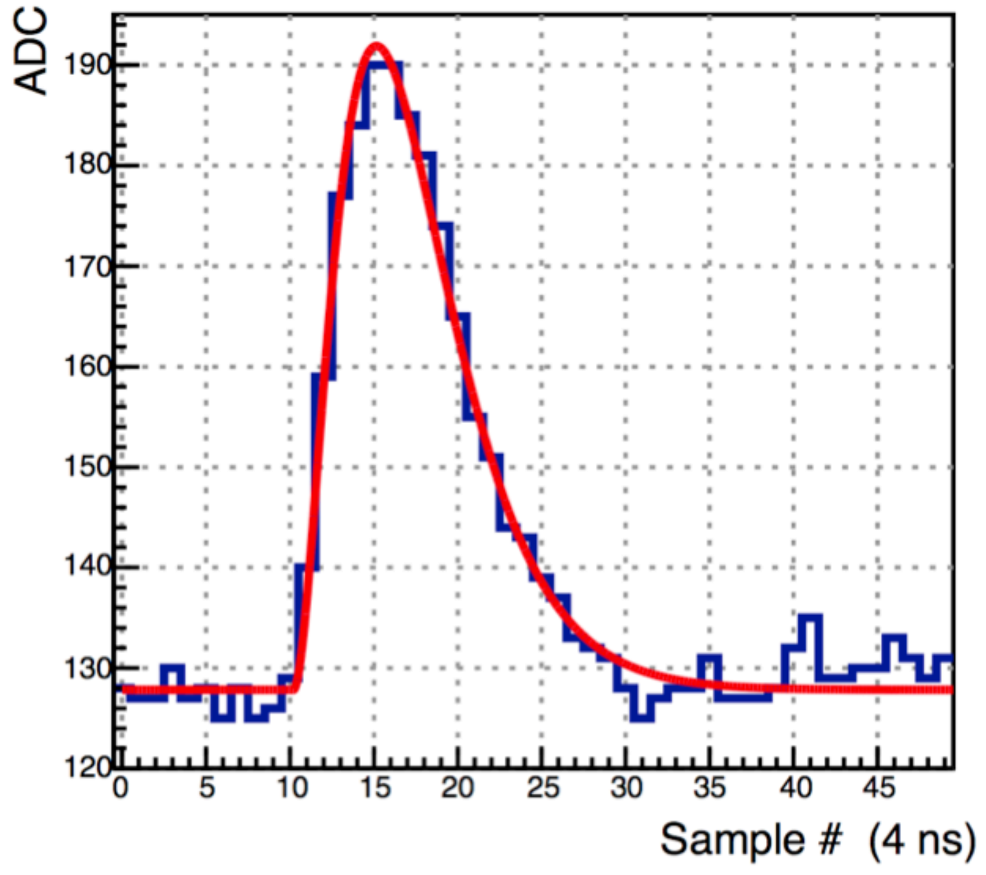
Caveat: this calculation is for forward direction. Off-forward expected to be greatly reduced (but this is also model dependent).



Axial piece smaller, didn't receive as much recent attention/update, seems stable with energy

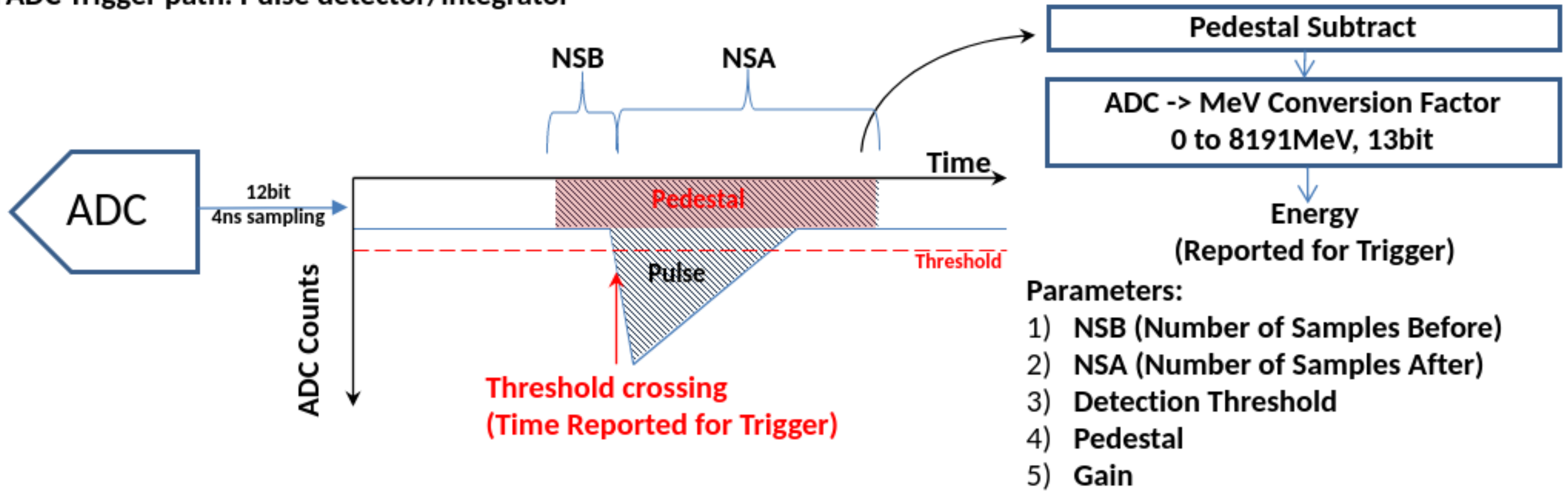


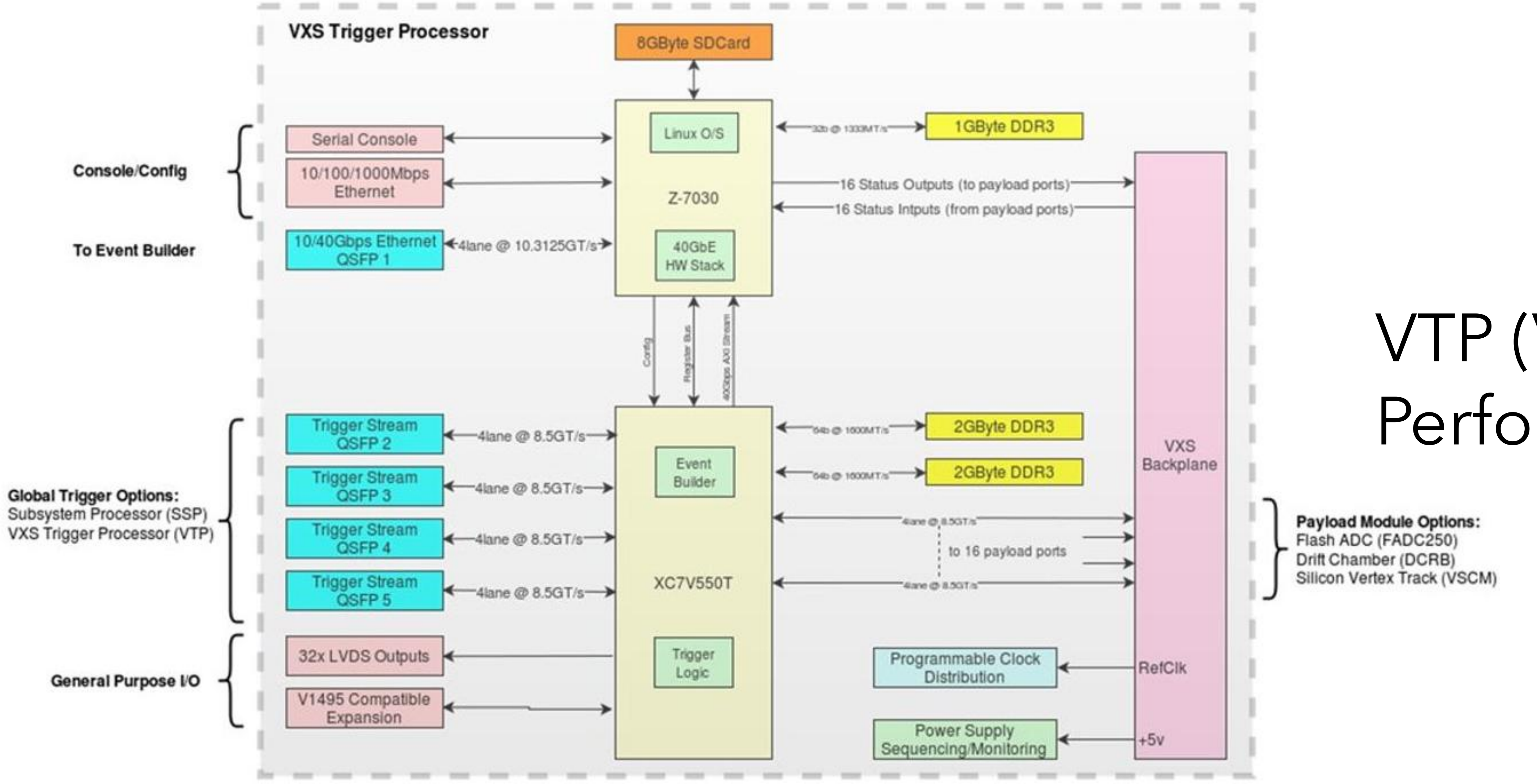
JLab Fast Electronics FADC250 / VTP



JLab FADC250 for HCAL and ECAL readout
Provides the input for a fast, "deadtime-less" trigger

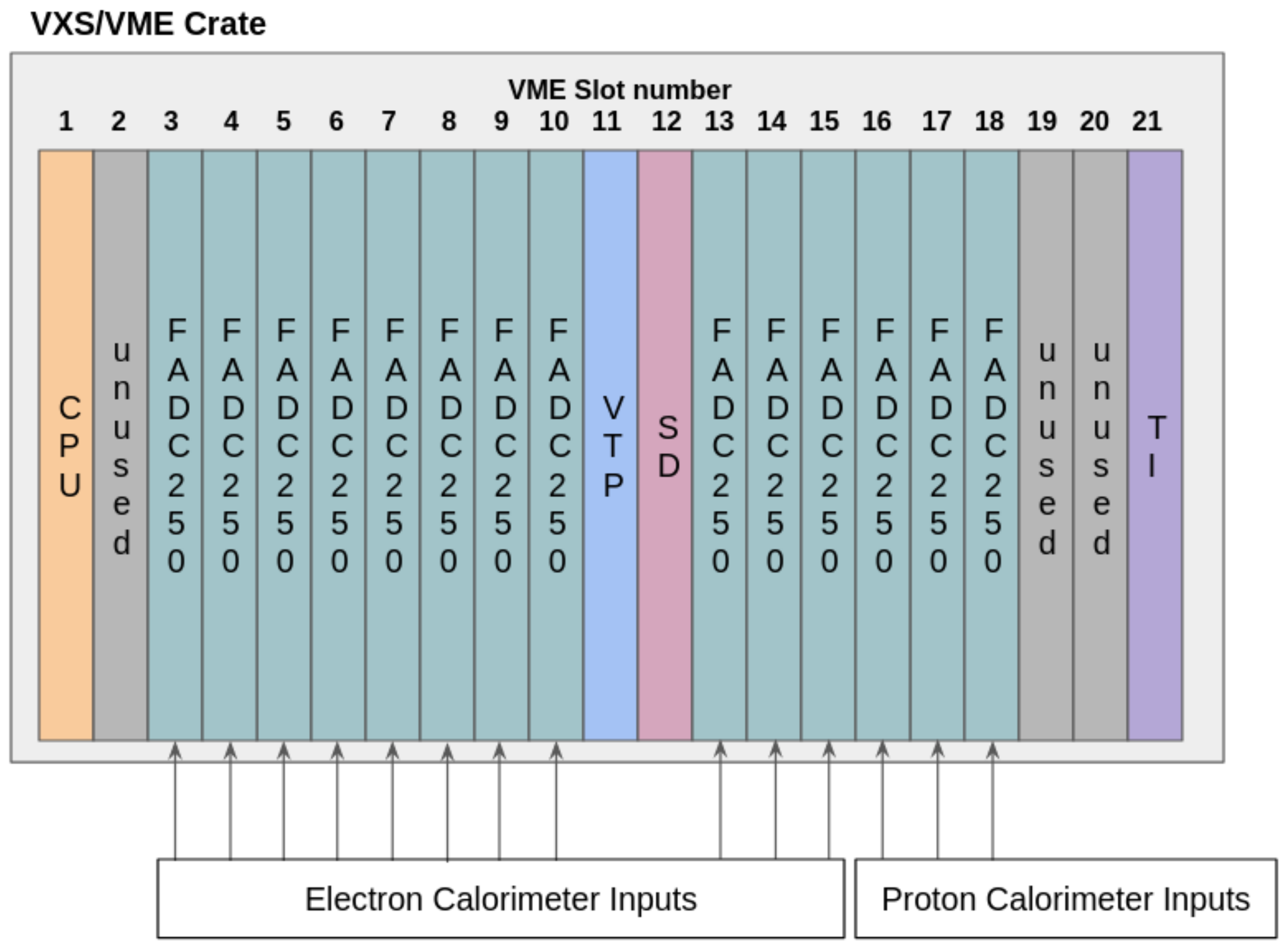
FADC Trigger path: Pulse detector/integrator



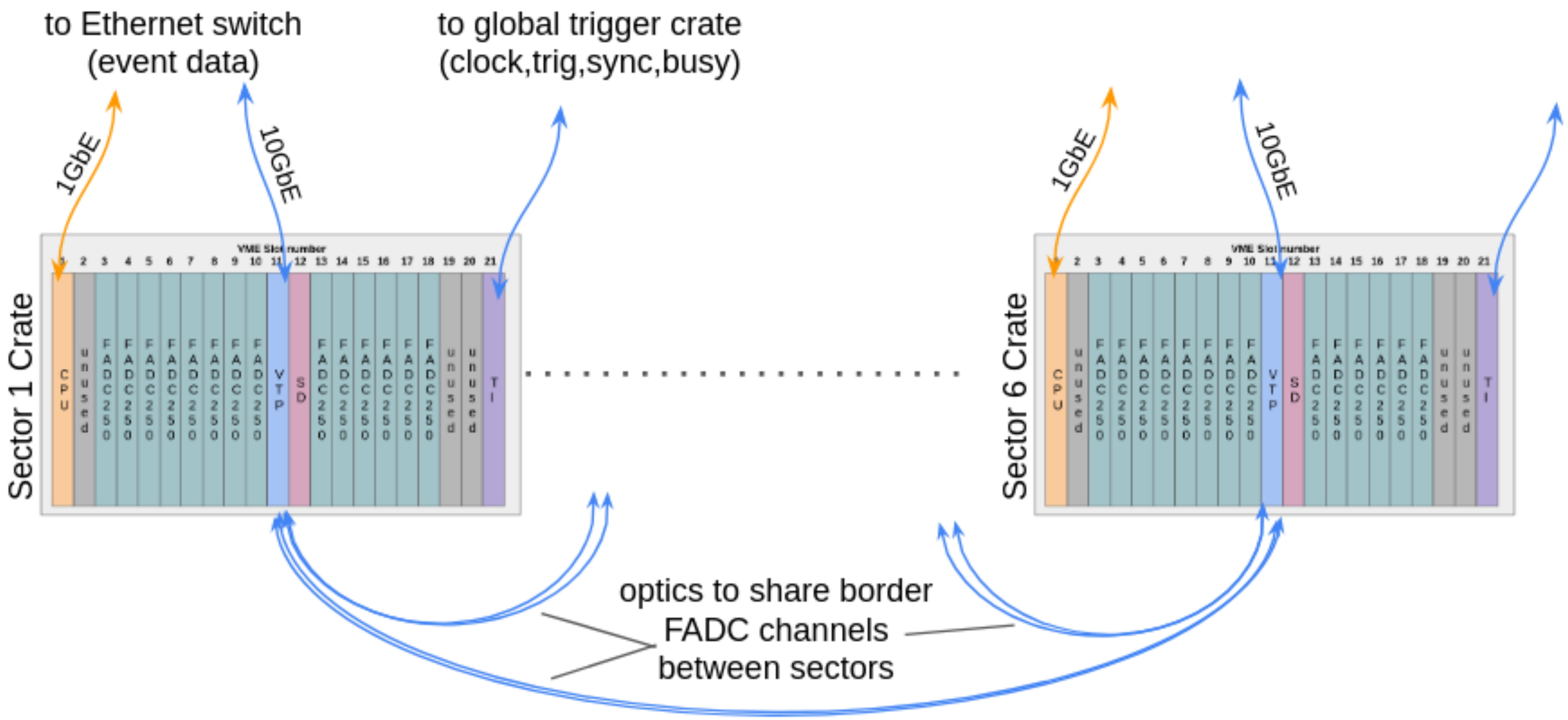


VTP (VXS Trigger Processor)
Performs the trigger logic computation

DAQ Diagram



One VXS crate will handle one sector of ECAL + HCAL, also provide external trigger for ScintArray TDC readout



This six synchronized but independent systems will form the full DAQ