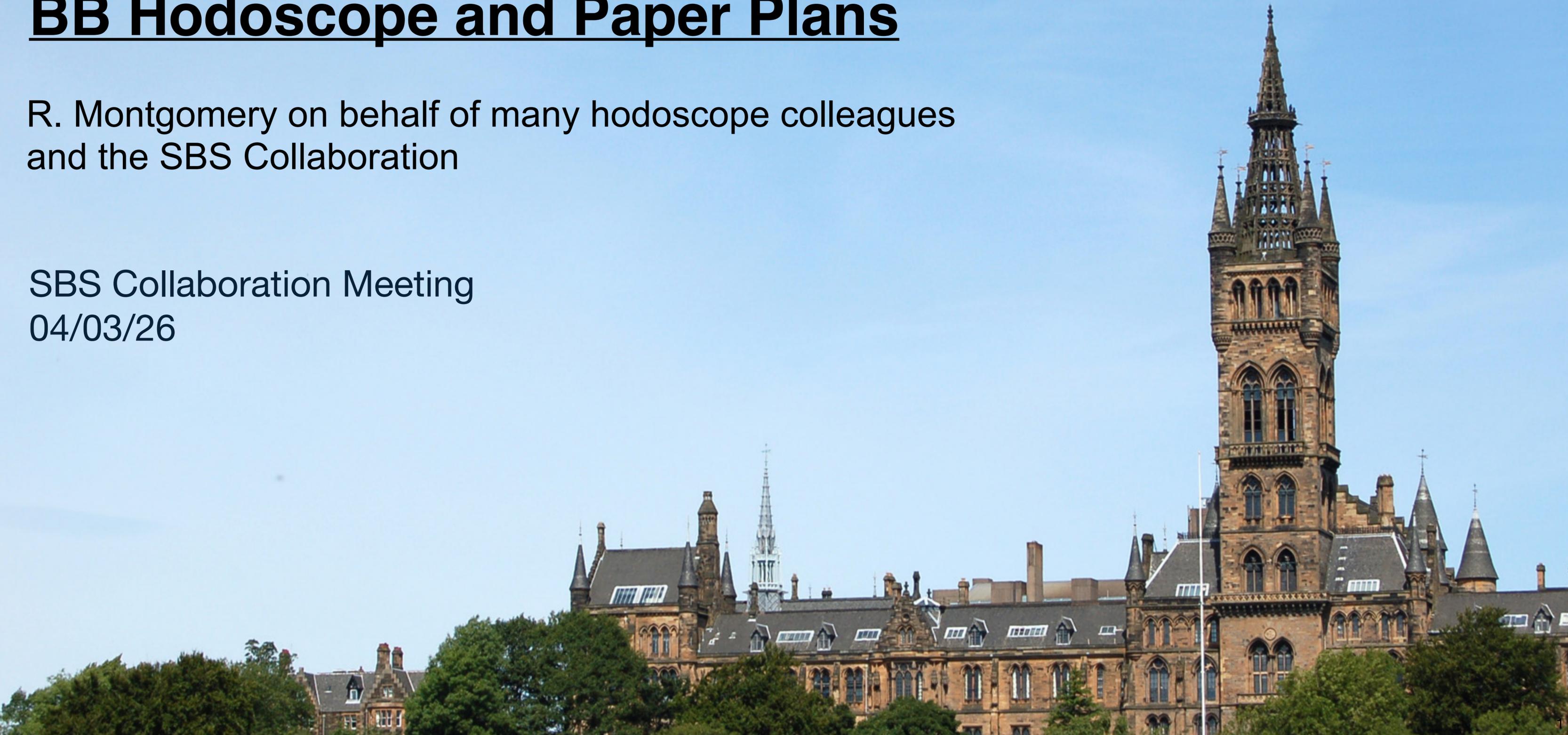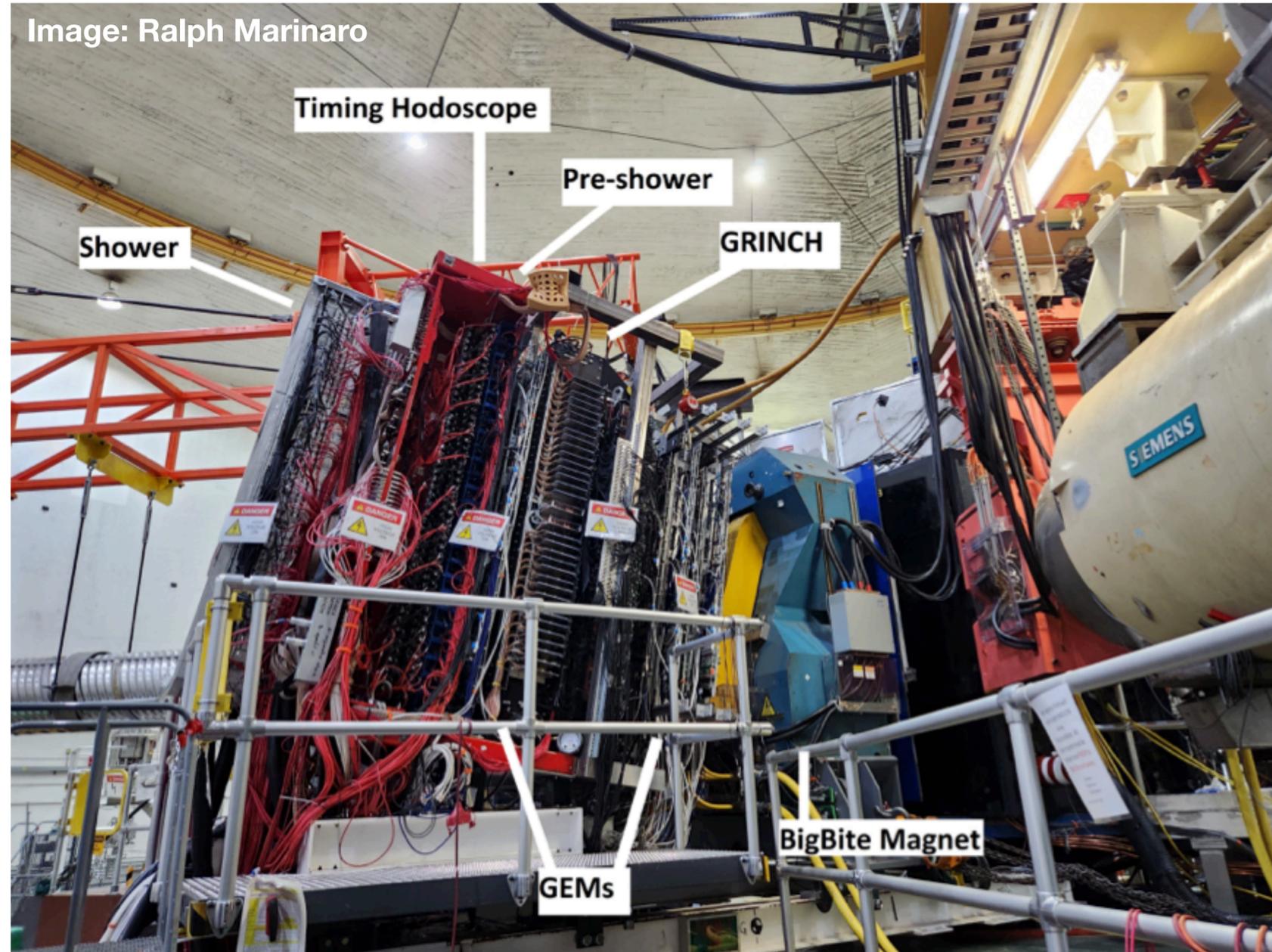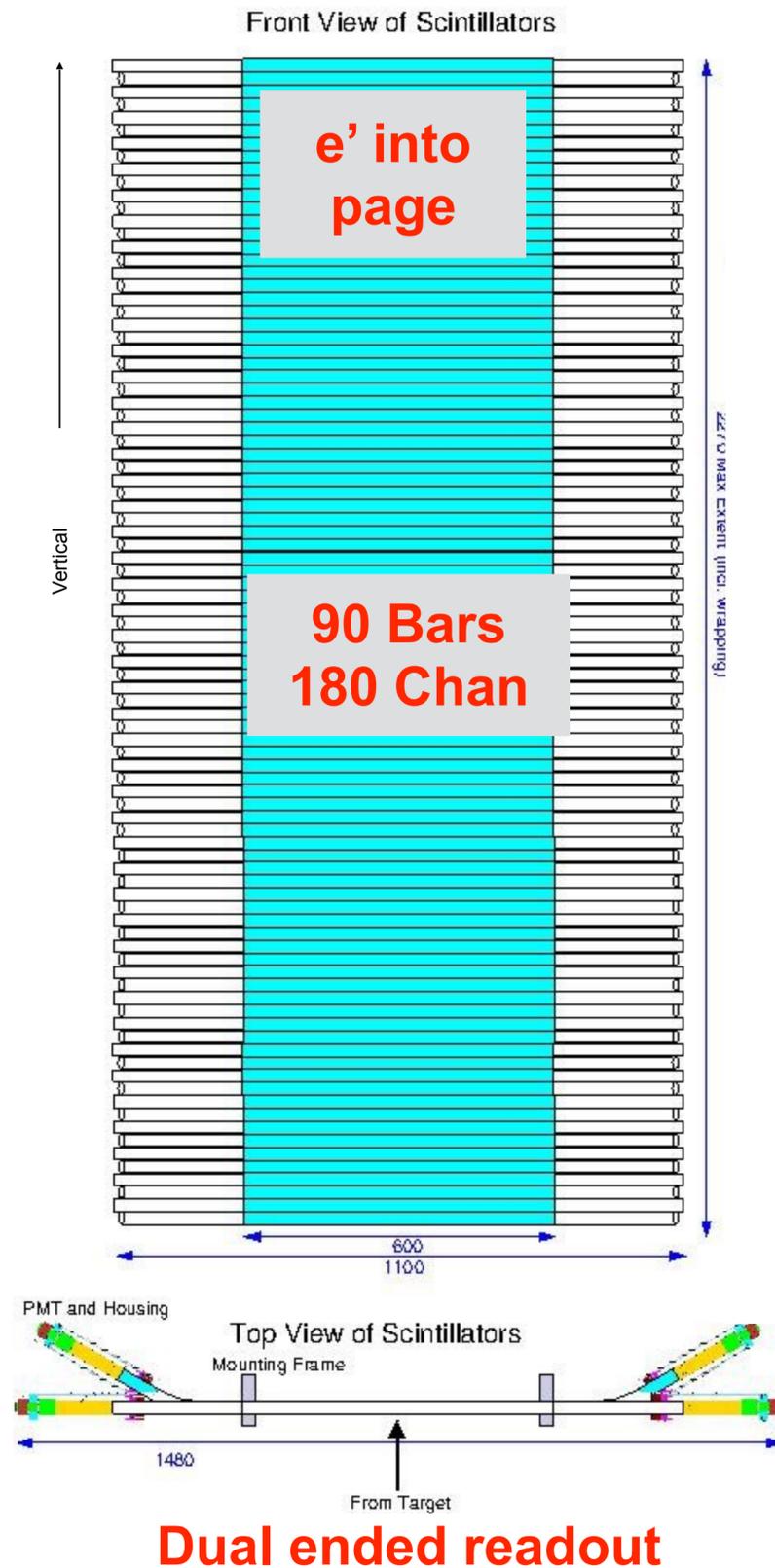# BB Hodoscope and Paper Plans

R. Montgomery on behalf of many hodoscope colleagues and the SBS Collaboration

SBS Collaboration Meeting
04/03/26

# BB Timing Hodoscope

Front View of Scintillators

e' into page

90 Bars 180 Chan

Vertical

600
1100

Top View of Scintillators

PMT and Housing

Mounting Frame

From Target

1480

Dual ended readout

Image: Ralph Marinaro

Timing Hodoscope

Pre-shower

Shower

GRINCH

GEMs

BigBite Magnet

- Subsystem of BigBite, used in all experiments except GEp
- Positioned between PS/SH in BB
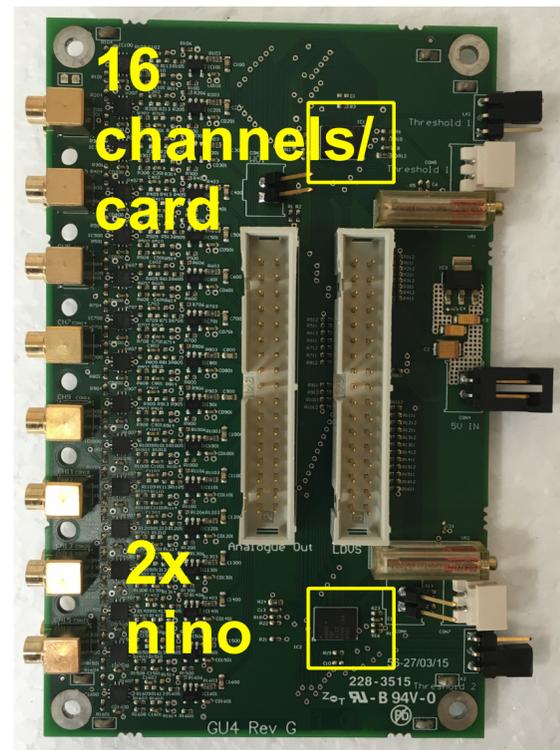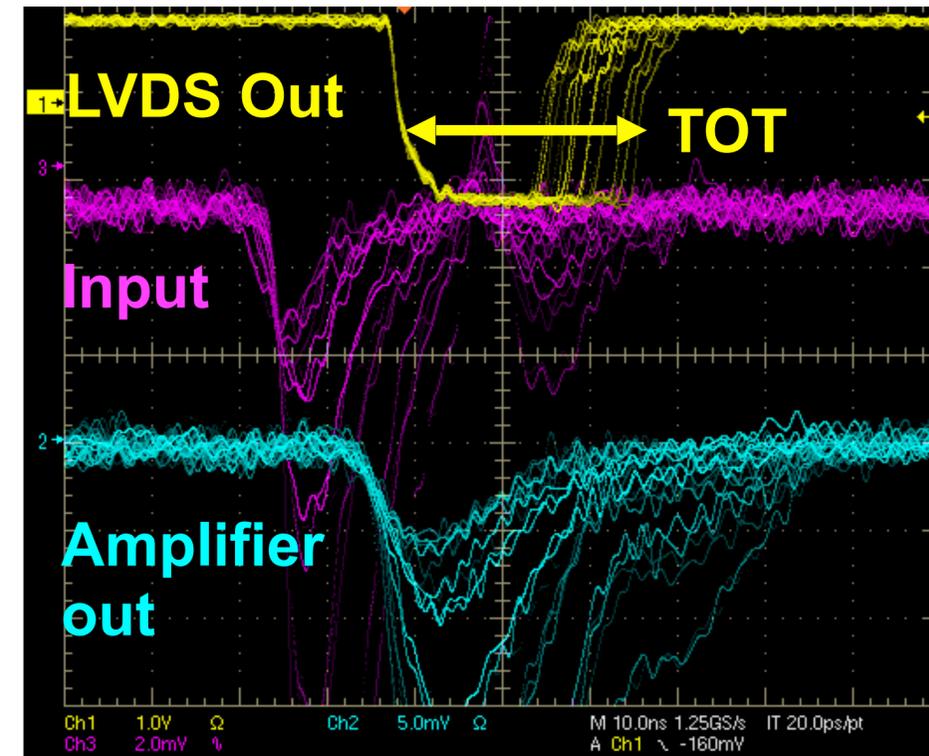- 90 vertically stacked scintillator bars
- (by design, in reality 89 were installed)
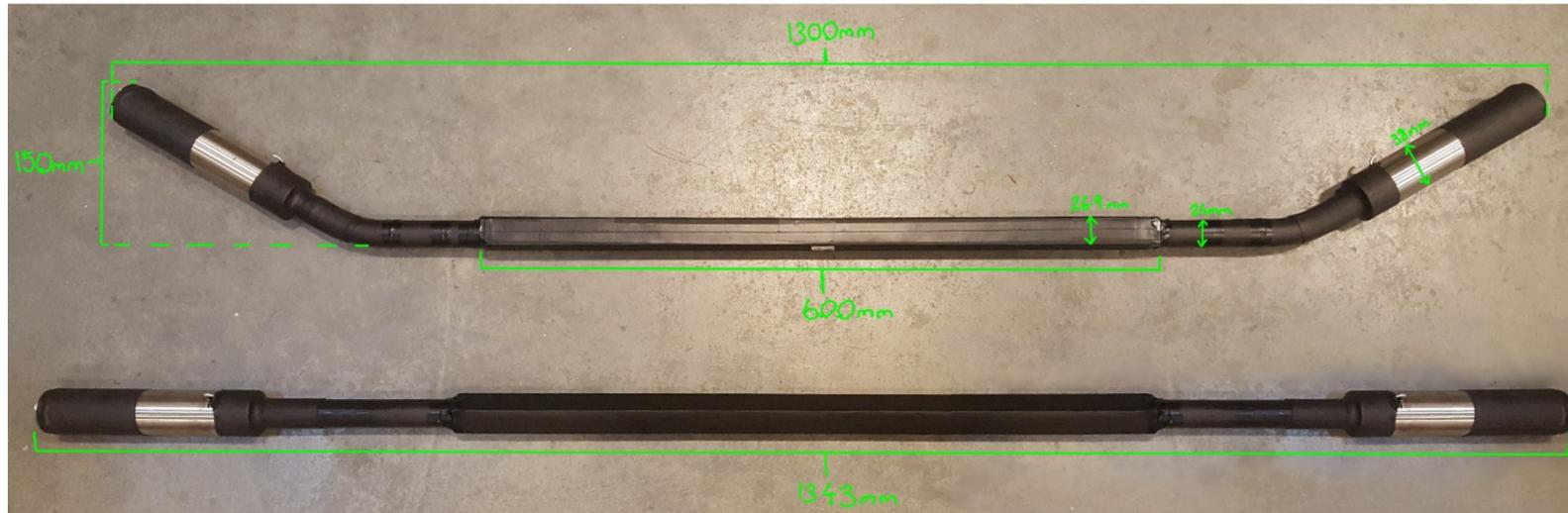
- 90 Scintillator bars: Eljen Technologies EJ200 plastic, 600 x 25 x 25mm, with support rods (not shown)
- 180 Light guides (LG): Eljen Technologies UVT acrylic
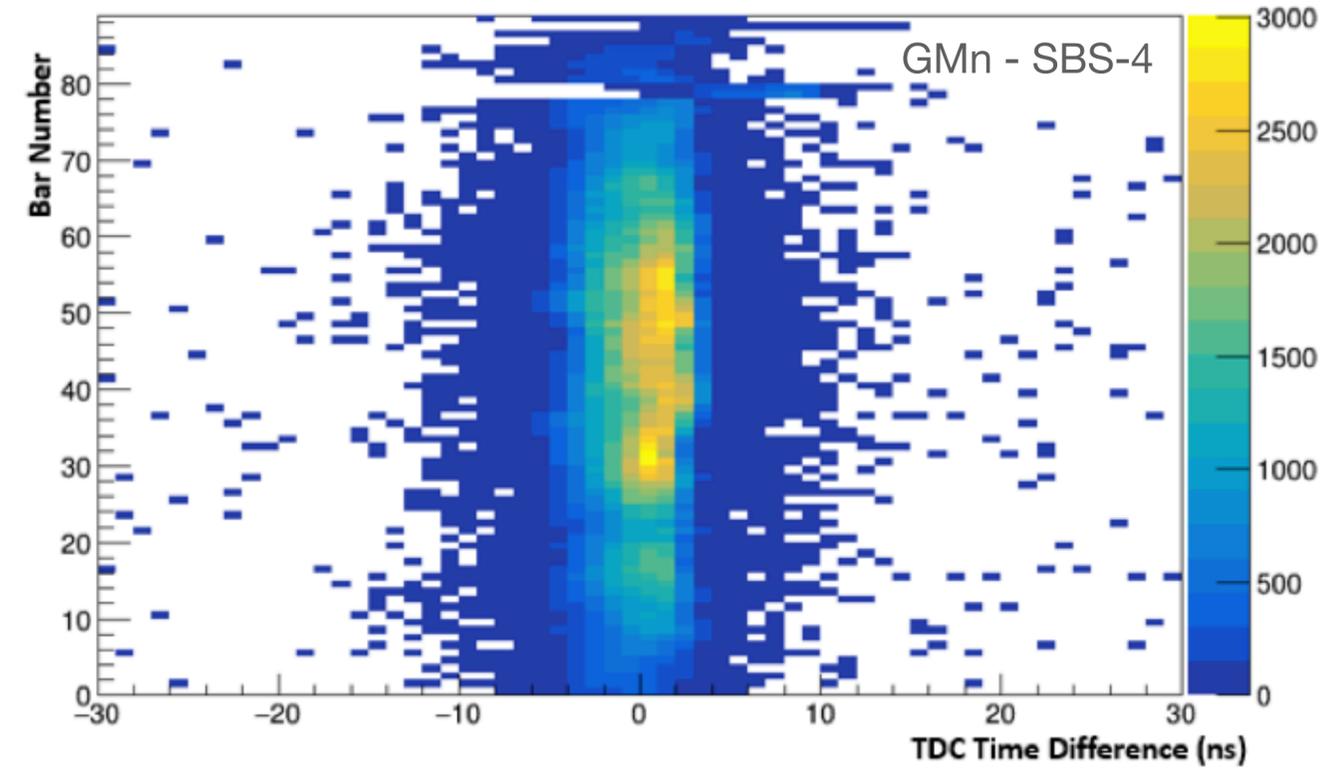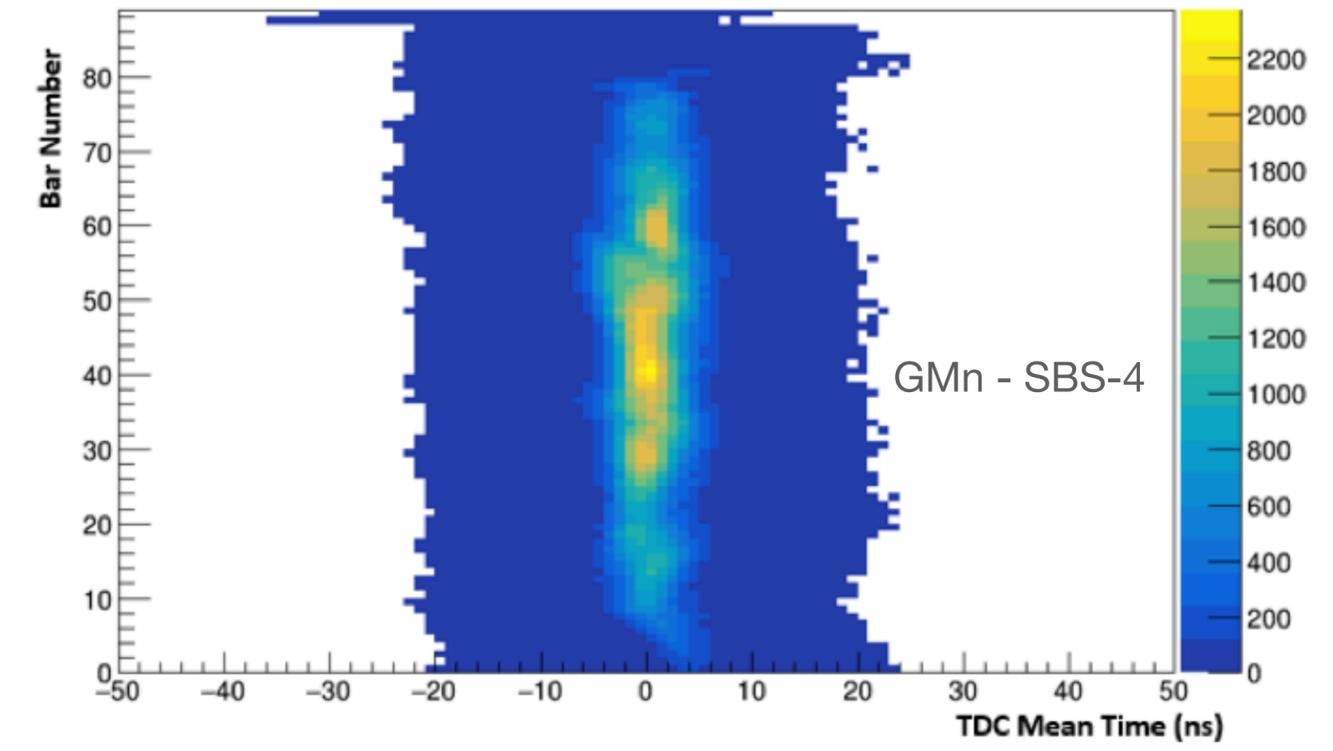- Dymax UV curable adhesive and ends roughened

Mu Metal

Light guide clamp

Al PMT housing

PMT and base

- 180 PMTs: Electron Tubes ET9124SB
- 180 custom bases
- 180 PMT assemblies: including mu metal

LVDS Out

TOT

Input

Amplifier out

16 channels/ card

2x nino

- 12 FE cards: custom amplifier/discriminator cards based on NINO ASIC
- NINO → time-over-threshold (TOT) available
- 2x CAEN V1190A TDCs
- 64 analogue chans (32 central bars) to CAEN V792 2x QDCs (for commissioning only)

Number of Hits vs. Bar Number

GMn - SBS-11

Bar
Left PMT
Right PMT

Cosmics

GMn - SBS-4

GMn - SBS-4
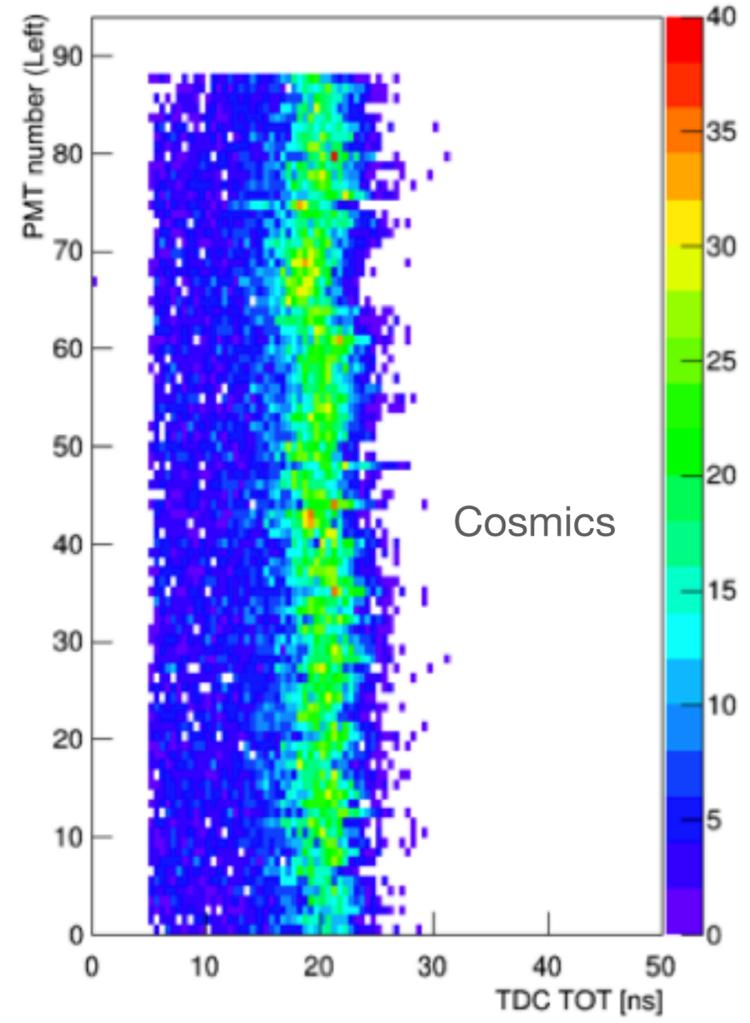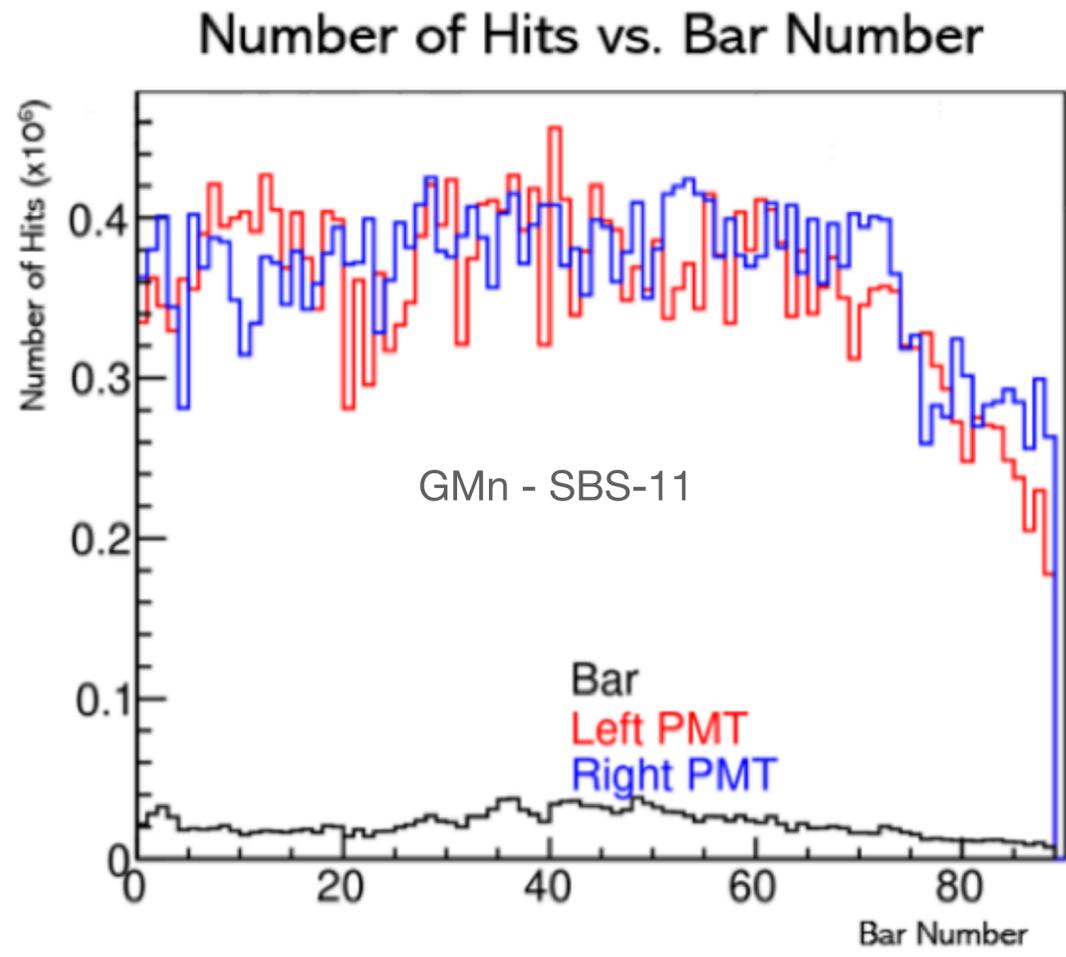
- Examples of typical plots observed online during data taking
- Plots from R. Marinaro

4

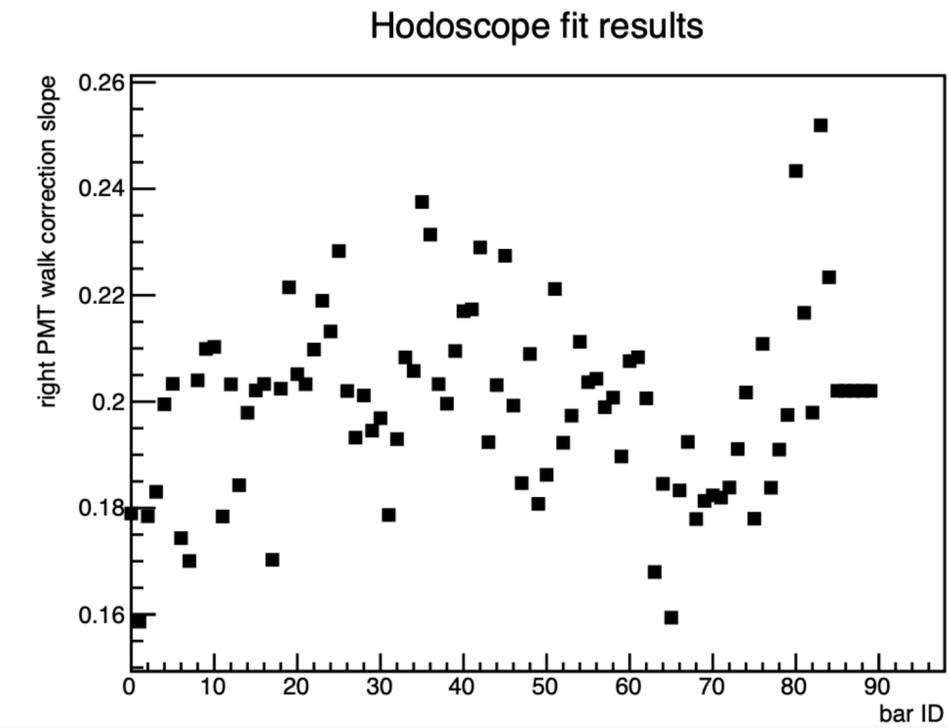- Andrew Puckett has developed TOFCal_consolidated procedure and script
- Currently being used by all experiments in their analyses

- Script to optimise TH timing, plus BBCAL and HCAL fADC timing

- 4 loops over data
- Includes alignment to RF bucket and trigger phase correction between TS and v1190
- Will not go into detail here since it is Andrew's code

- Loop 1 - internal alignment of hodoscope bars (minimizes squared differences between hodoscope cluster hits)

- Loop 2 - determination of RF offsets to apply to each bar to align corrected mean times with RF signal

- Loop 3 - RF alignment then updating all parameters for hodoscope, internal alignment of fadc times in BBCAL and HCAL

- Loop 4 - checking results, forming coincidences with other sub-systems (trigger phase correction important here)
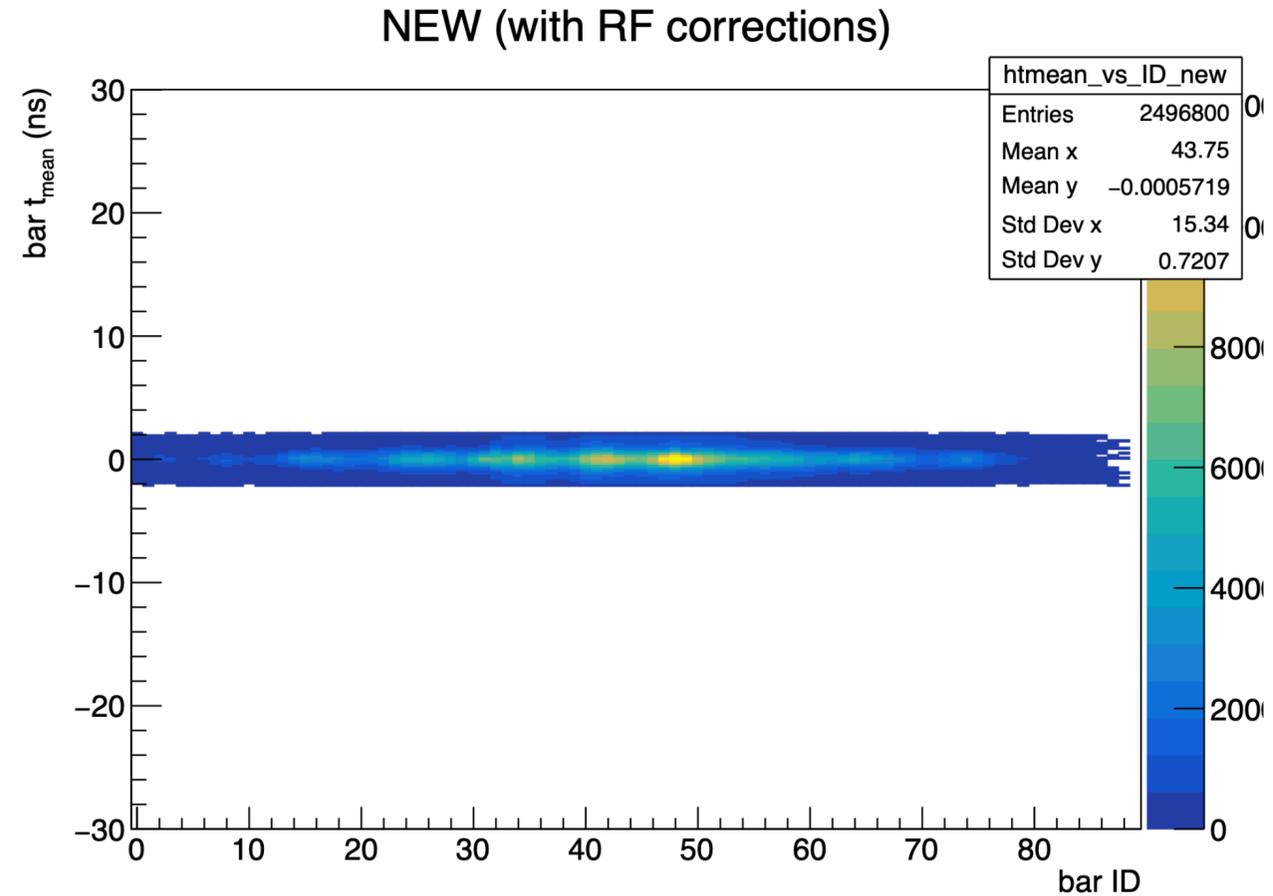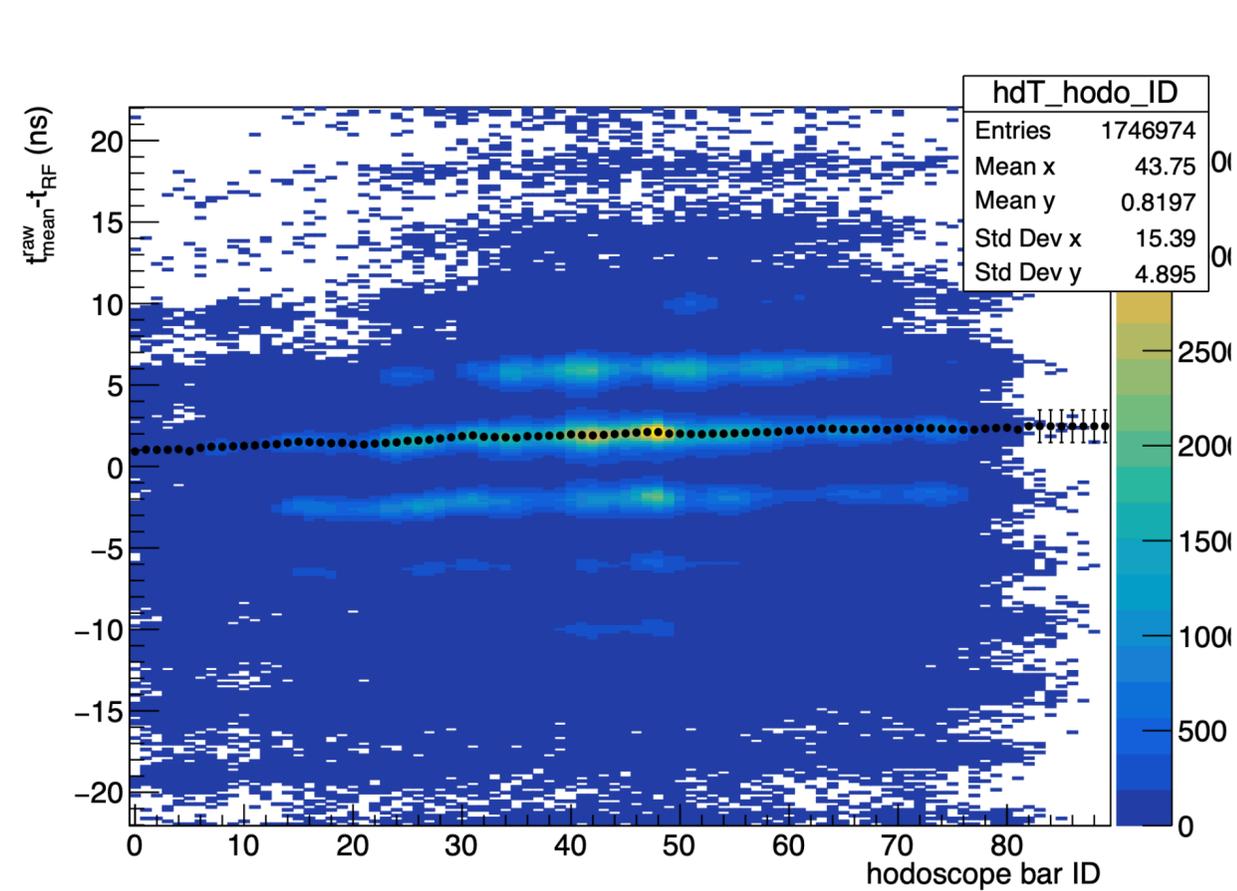
- Provakar Datta and Andrew Puckett: GMn Timing Calibration for Pass 3 Readiness SBS 11 (set 1)

Hodoscope fit results

Hodoscope fit results

Hodoscope fit results

Hodoscope fit results

- Provakar Datta and Andrew Puckett: GMn Timing Calibration for Pass 3 Readiness SBS 11 (set 1)

NEW (with RF corrections)

hdT_hodo_ID	
Entries	1746974
Mean x	43.75
Mean y	0.8197
Std Dev x	15.39
Std Dev y	4.895

htmean_vs_ID_new	
Entries	2496800
Mean x	43.75
Mean y	−0.0005719
Std Dev x	15.34
Std Dev y	0.7207

Bar 30, all corrections

htmean_corr_bar30	
Entries	34666
Mean	−0.0238
Std Dev	0.6756

Bar 31, all corrections

htmean_corr_bar31	
Entries	48580
Mean	0.002484
Std Dev	0.6442
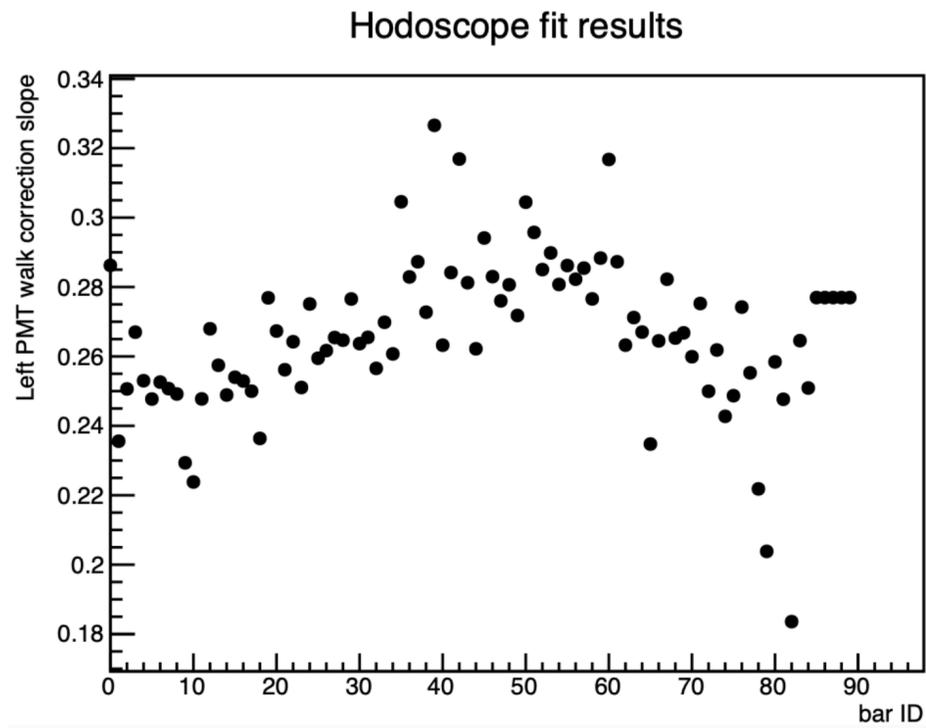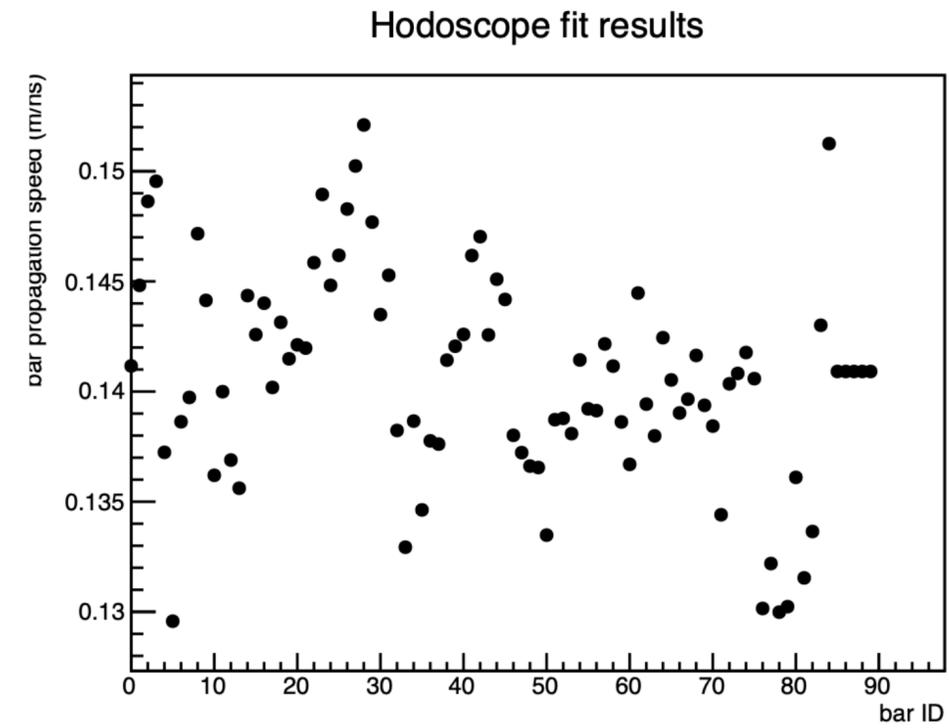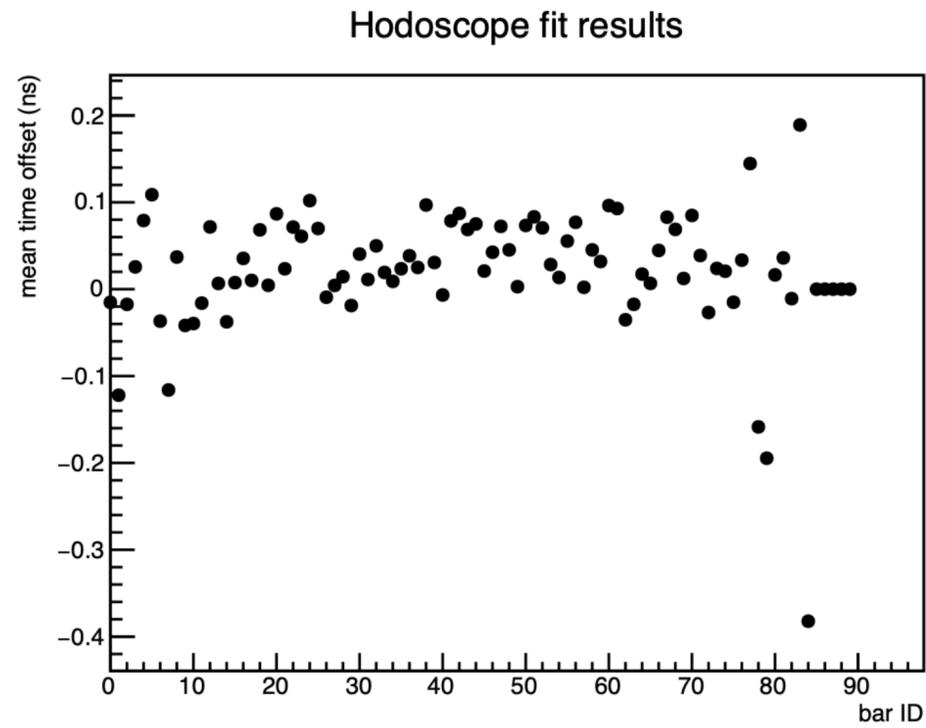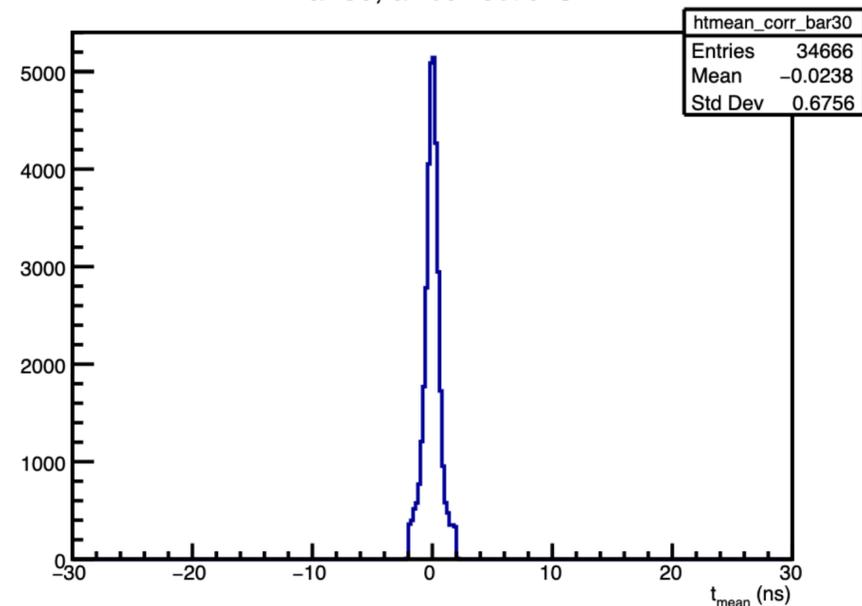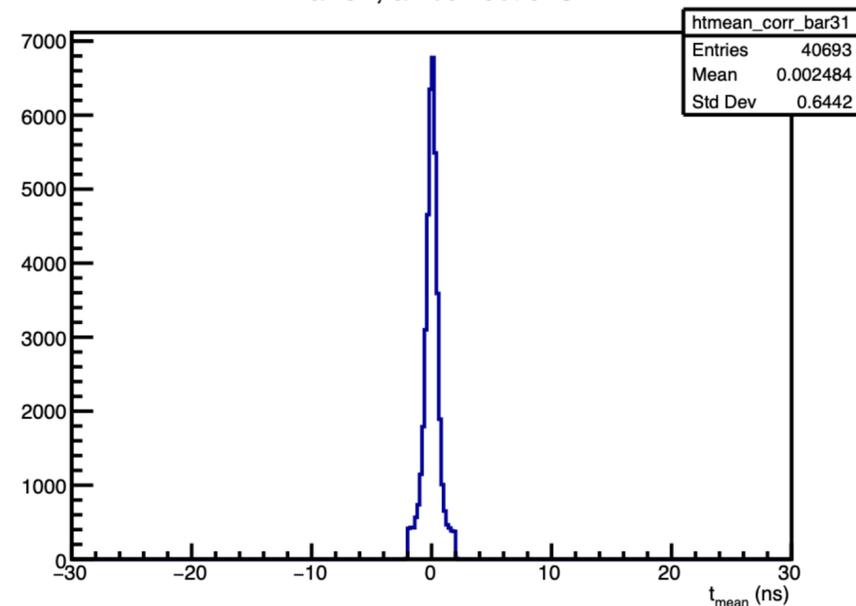
Bar 32, all corrections

htmean_corr_bar32	
Entries	48580
Mean	0.02223
Std Dev	0.7134
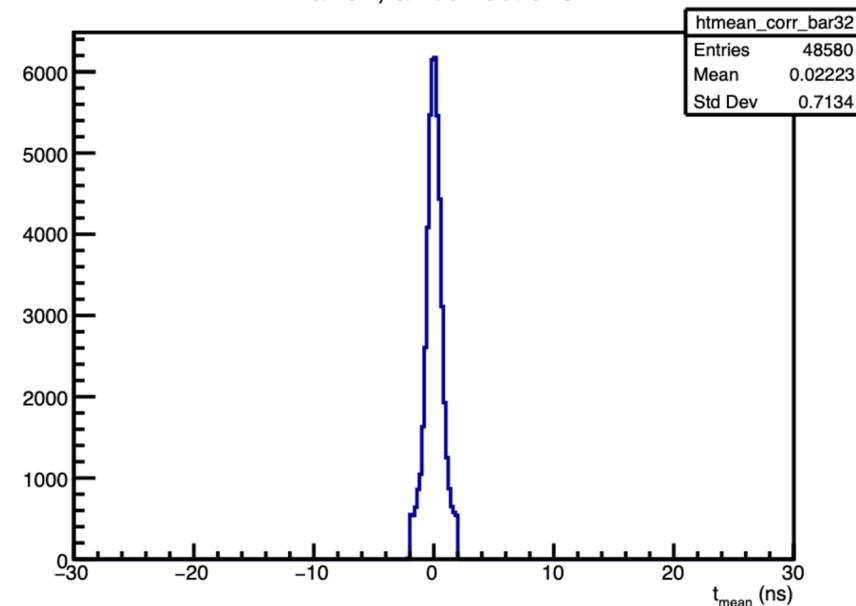
Some central bar mean time resolutions after all corrections ~644ps - 713ps for this kinematic (Resolution depends on e' energy)

• Provakar Datta and Andrew Puckett: GMn Timing Calibration for Pass 3 Readiness SBS 11 (set 1)
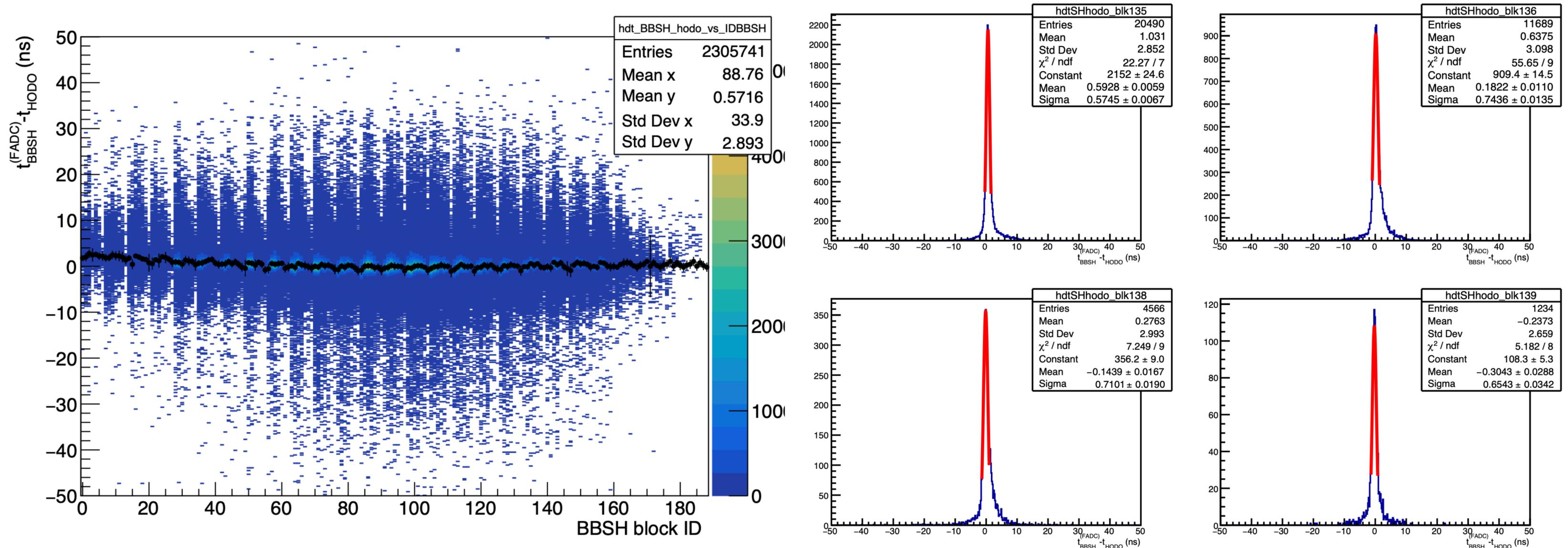
Possible due to trigger phase correction

Examples of some (selected at random) BB SH and TH coincident times <1ns (574ps - 743ps shown)

- Provakar Datta and Andrew Puckett: GMn Timing Calibration for Pass 3 Readiness SBS 11 (set 1)
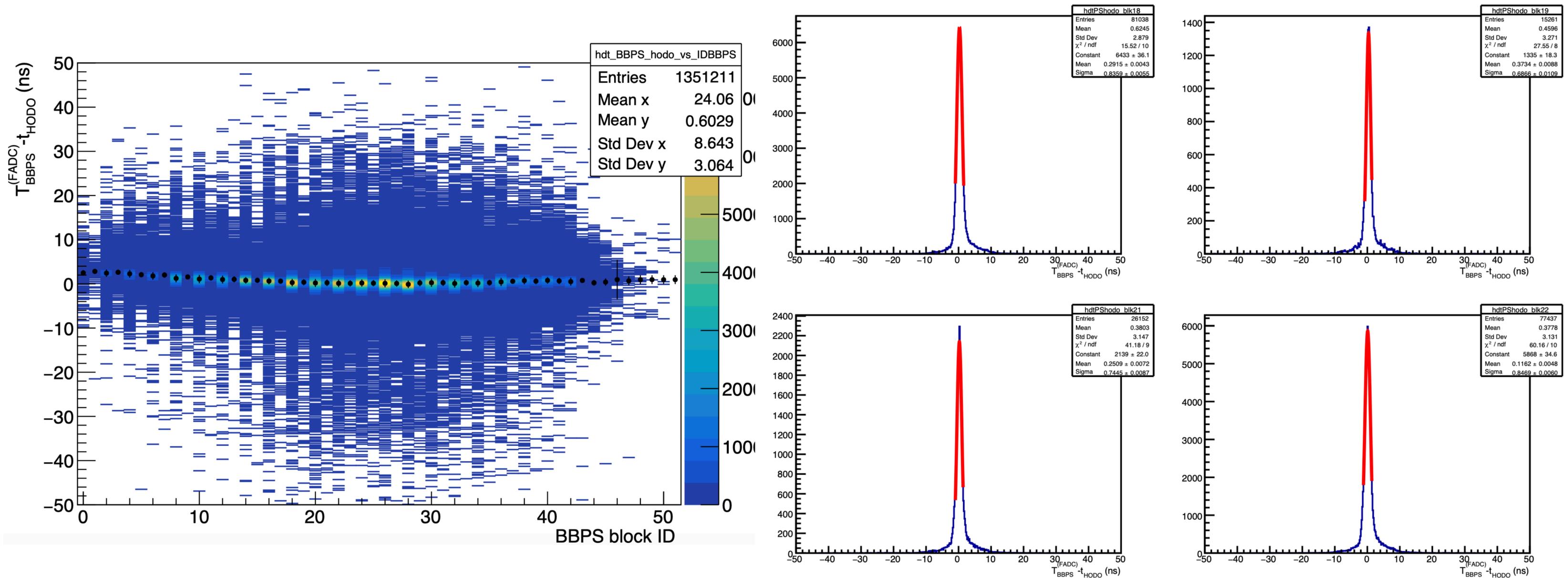
Examples of some (selected at random) BB PS and TH coincident times <1ns (687ps - 847ps shown)

• Provakar Datta and Andrew Puckett: GMn Timing Calibration for Pass 3 Readiness SBS 11 (set 1)

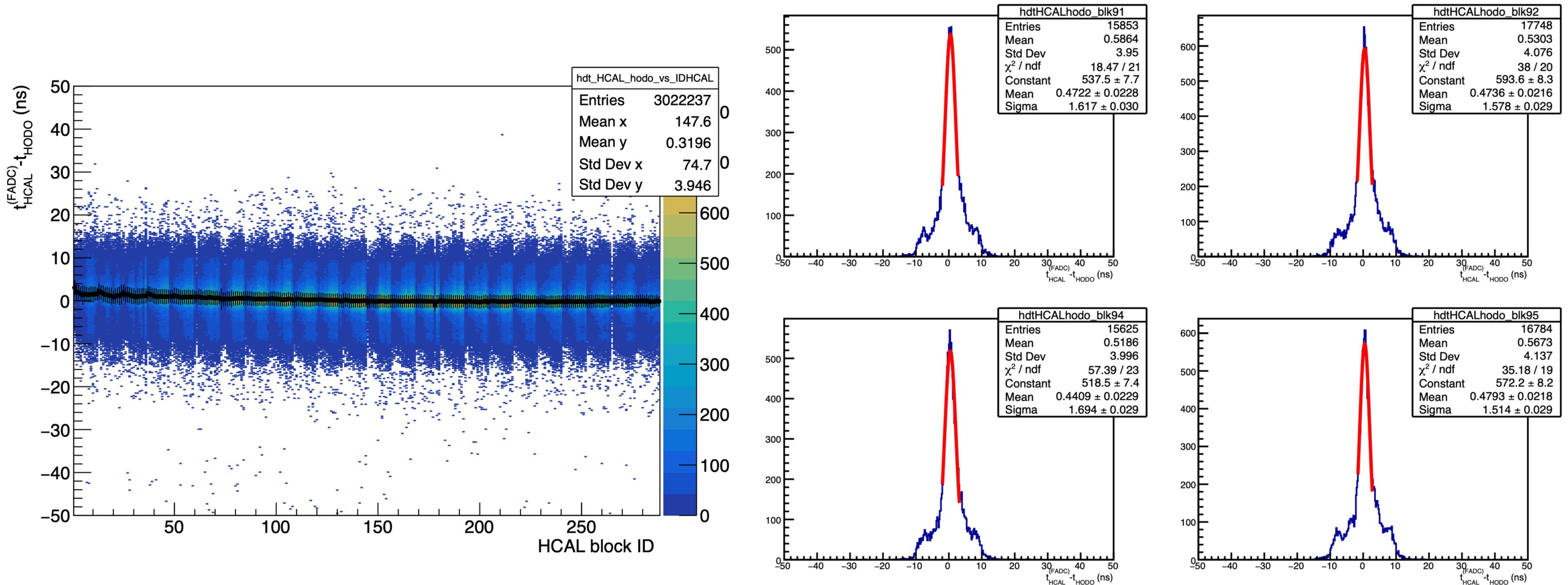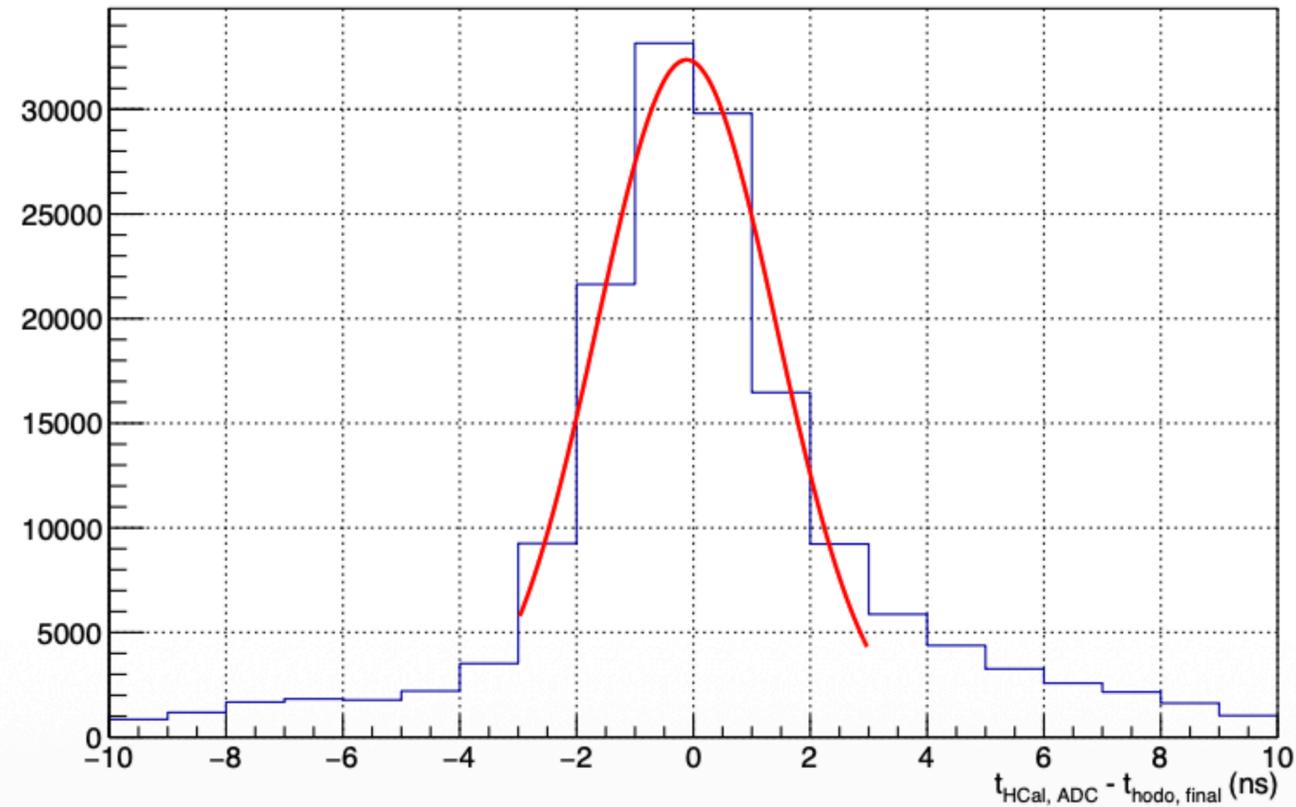Examples of some (selected at random) HCAL fADC and TH coincident times: 1.6ns - 1.7ns shown

Mean time (± σ): -0.116 (± 1.538)

Mean time (± σ): 0.002 (± 0.878)
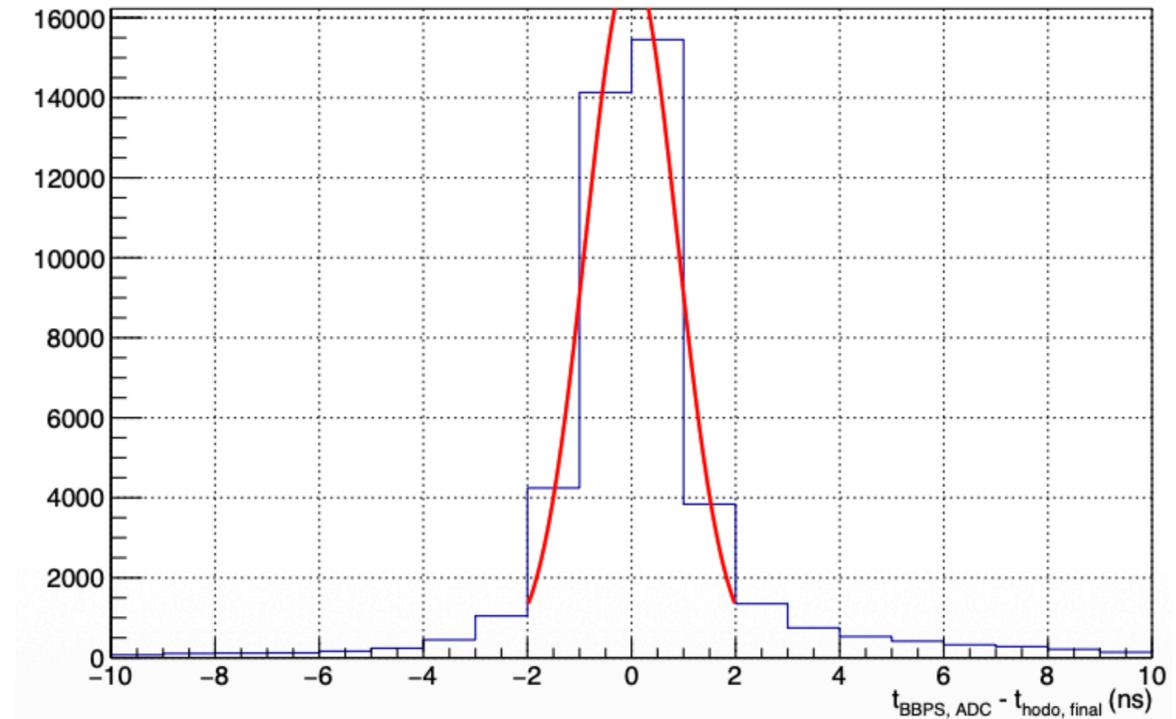
Mean time (± σ): 0.267 (± 1.182)
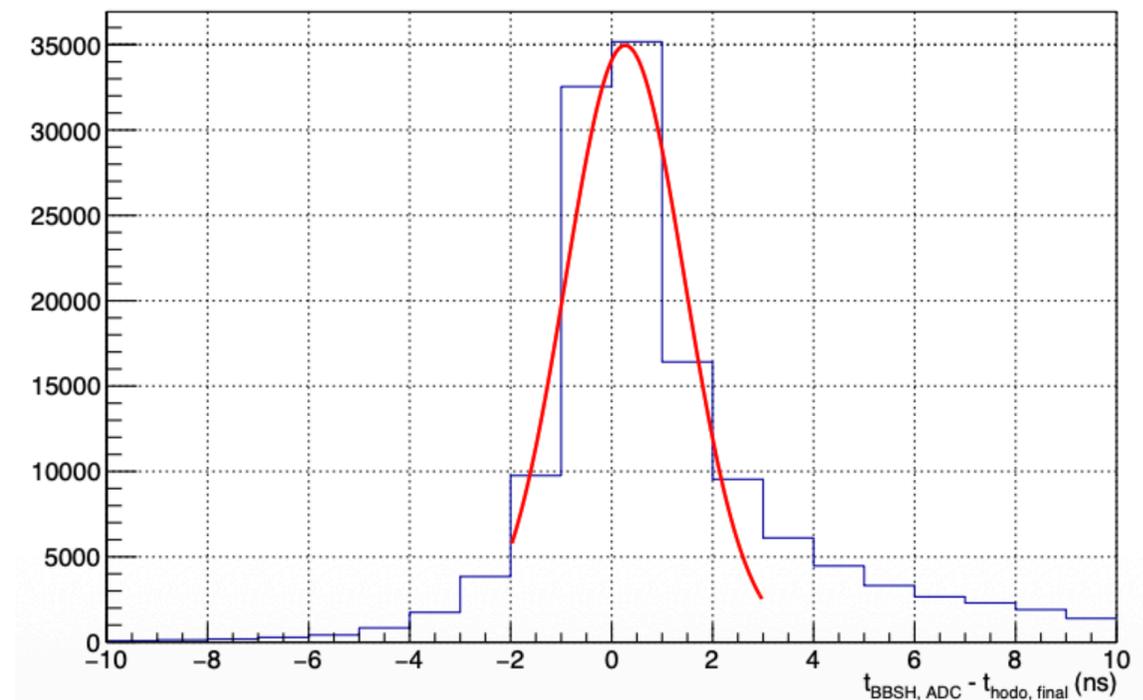
- From Eric Fuchey, Andrew Puckett and all working on GMn analysis

- Final QA plots for official pass 3 data

Other Examples

- Other examples from GMn are available on SBS docdb, e.g.:

- SBS 4: https://sbs.jlab.org/cgi-bin/DocDB/private/ShowDocument?docid=752
  (Anu Rathnayake and Andrew Pucket)

- SBS 7 and 14: https://sbs.jlab.org/cgi-bin/DocDB/private/ShowDocument?docid=750 (Eric Fuchey and Andrew Puckett)

- Here only have shown some GMn examples passed to us from analysis group

- Other experiments are also working with Andrew's script and will have latest plots

- Or see other analysis and student talks at this meeting (e.g. 1.3ns Hodo-HCAL fADC coincidence resolution for GEn Kin4b in gordon's talk)

- Currently we are getting to grips with TOFcal_consolidated

- Planning to look immediately at GEn-RP and GEn data whilst we get to grips with it

- Interested to check HCAL TDC and BB TH TDC coincident time? Should we look into that?
- Question to collaboration before looking into this - is there a reason in GEn and GEn-RP not to look at HCAL TDC?

- Planning to study g4sbs TH timing distributions to compare with experiment performance
- (Previously was done with stand alone G4 and resolutions compared well - would be good to expand to g4sbs)

- Working on developing paper and on getting above machinery working again locally to generate plots for paper

- All input to these activities for developing the paper are welcome and invited
- E.g. using tofcal_consolidated procedure and calibrated data from other subsystems - we recognize the work that has gone in to this and your advice is very welcome

The Bigbite Timing Hodoscope for the Super Bigbite Experimental Apparatus

Authors tbd

Snapshot from draft

Abstract

Keywords: SBS, Timing hodoscope, Plastic scintillator, Nucleon Form Factors

1. Introduction

Understanding the internal structure of the nucleon remains a central goal of contemporary nuclear and hadronic physics. Elastic electron–nucleon scattering provides direct access to the nucleon electromagnetic form factors, which encode information on the spatial distributions of charge and magnetization. Precision measurements of these observables at large four-momentum transfer require experimental apparatus capable of operating at high luminosity while maintaining excellent tracking, timing, and particle identification performance.

The experimental program at the Thomas Jefferson National Accelerator Facility (Jefferson Lab) is uniquely suited to ad-

program.

Measurements of the proton and neutron electromagnetic form factors using SBS place stringent requirements on detector stability, timing resolution, and rate capability. The BBTH, in conjunction with tracking detectors and calorimetry, enables efficient identification of elastic scattering events and accurate reconstruction of kinematic variables. Detailed characterization of its performance is therefore essential for ensuring the reliability of nucleon form factor measurements and for validating the SBS approach to high-Q^2 physics.

This paper presents a detailed description and performance evaluation of the BigBite Timing Hodoscope within the Super Bigbite experimental apparatus. Emphasis is placed on timing

bb.hodotdc.clus.bar.tdc.tmeanRFcorr

Entries	29939
Mean	24.91
Std Dev	14.45

Plot: G. Penman
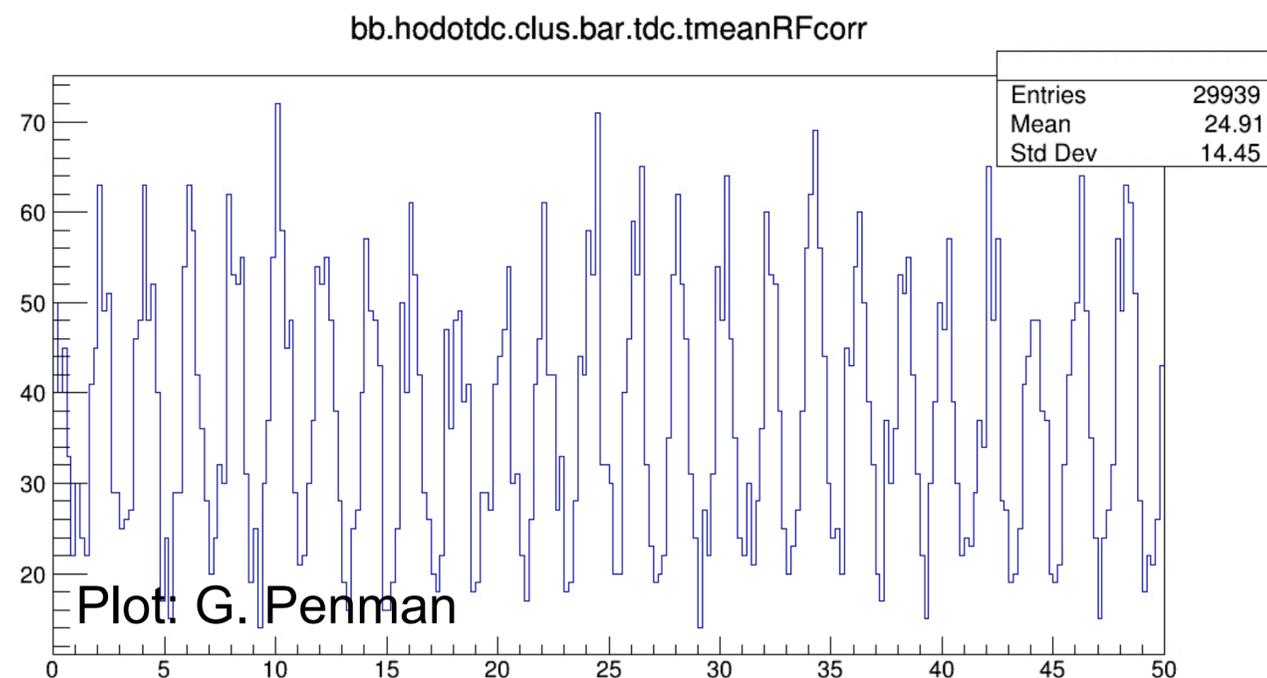
- We are currently working on draft of NIM paper

- Did not really want to advance on this too much before now, until RF pattern made more sense

- Would like to emphasise in the paper the high rate capability of the detector

- Currently working on structure plan and text

- Planning final list of plots, then need to generate plots

- Goal: by end of Summer to have a draft for circulation to collaboration

- Introduction to SBS suite of experiments and purpose of TH

- BB TH design, construction, installation
  - Including devoted section on NINO front end design for SBS suite of detectors *(or should this be its own paper?)*

- Running (e.g. online monitoring, general performance) and raw data observations
  - Including raw distributions to demonstrate how the level of high-rate device we are dealing with
  - Description of clustering and track matching with gems etc

- Detector calibrations
  - Method description
  - Plots… e.g. before and after of mean time alignment and resolution with RF after all corrections (and minimization)
  - Would be nice to show impact of each TH intrinsic contribution to resolution here too (eg time walk, v_scint ….), we can use our original calibration scripts for this

- G4 simulation of detector and comparison with experimental resolution

- Experimental performance
  - BB TH resolution, plus coincidence timing resolution examples from experiment
  - (Should we focus on those where we have BB TH TDC plus HCAL TDC)

- Some conclusions/discussion

- BB TH operated well and reliably in SBS experiments

- On-going analysis across all experiments to optimise TH timing and 2-arm coincident time resolutions

- We are actively working on paper draft

- Next steps will be creating the plots we want to show in the draft - working on that in Glasgow

- As mentioned earlier - please input to us

Back Up

- Provakar Datta and Andrew Puckett: [GMn Timing Calibration for Pass 3 Readiness SBS 11 (set 1)](#)
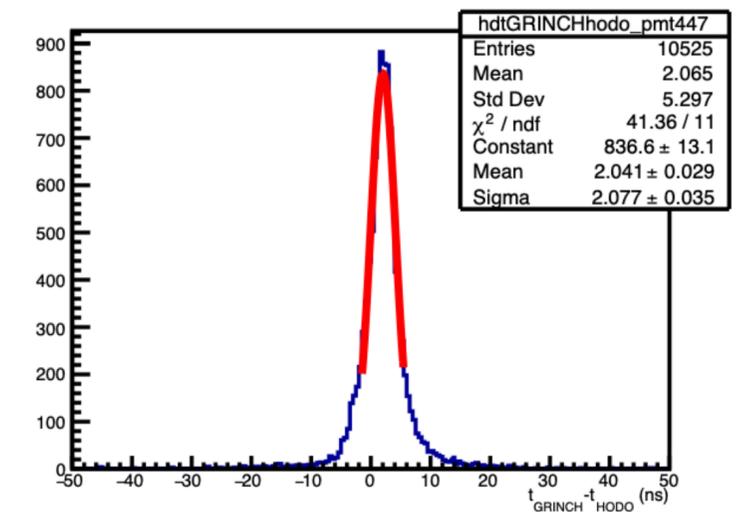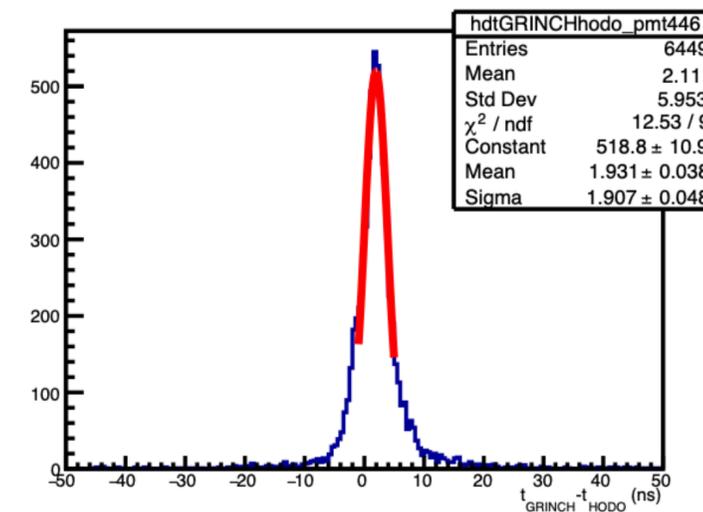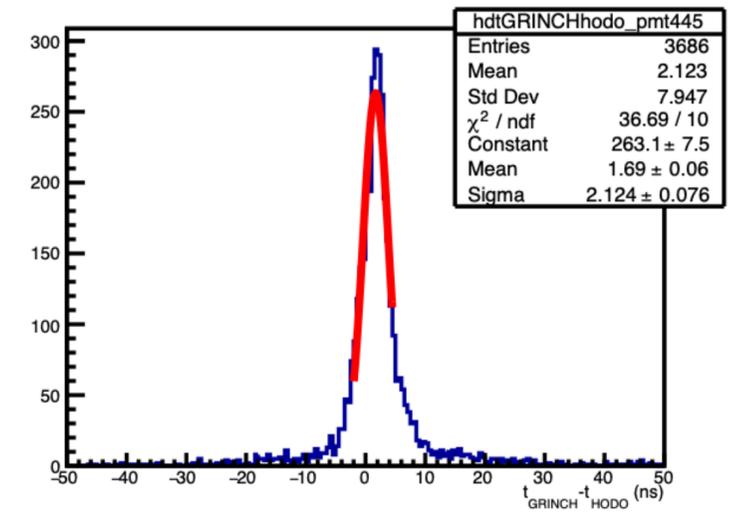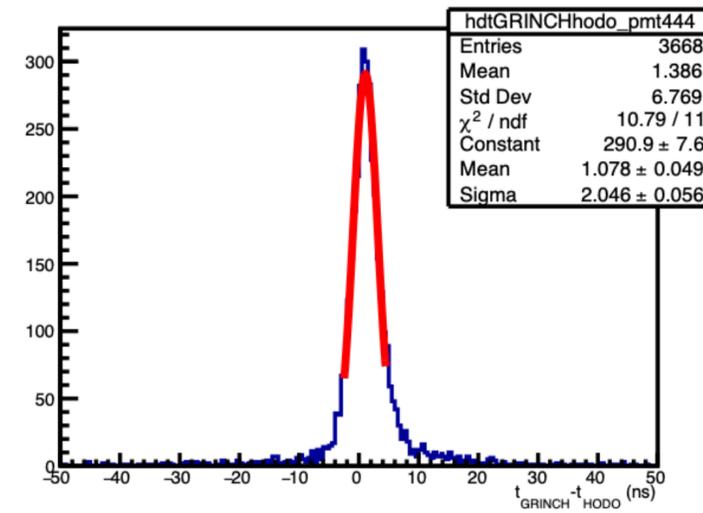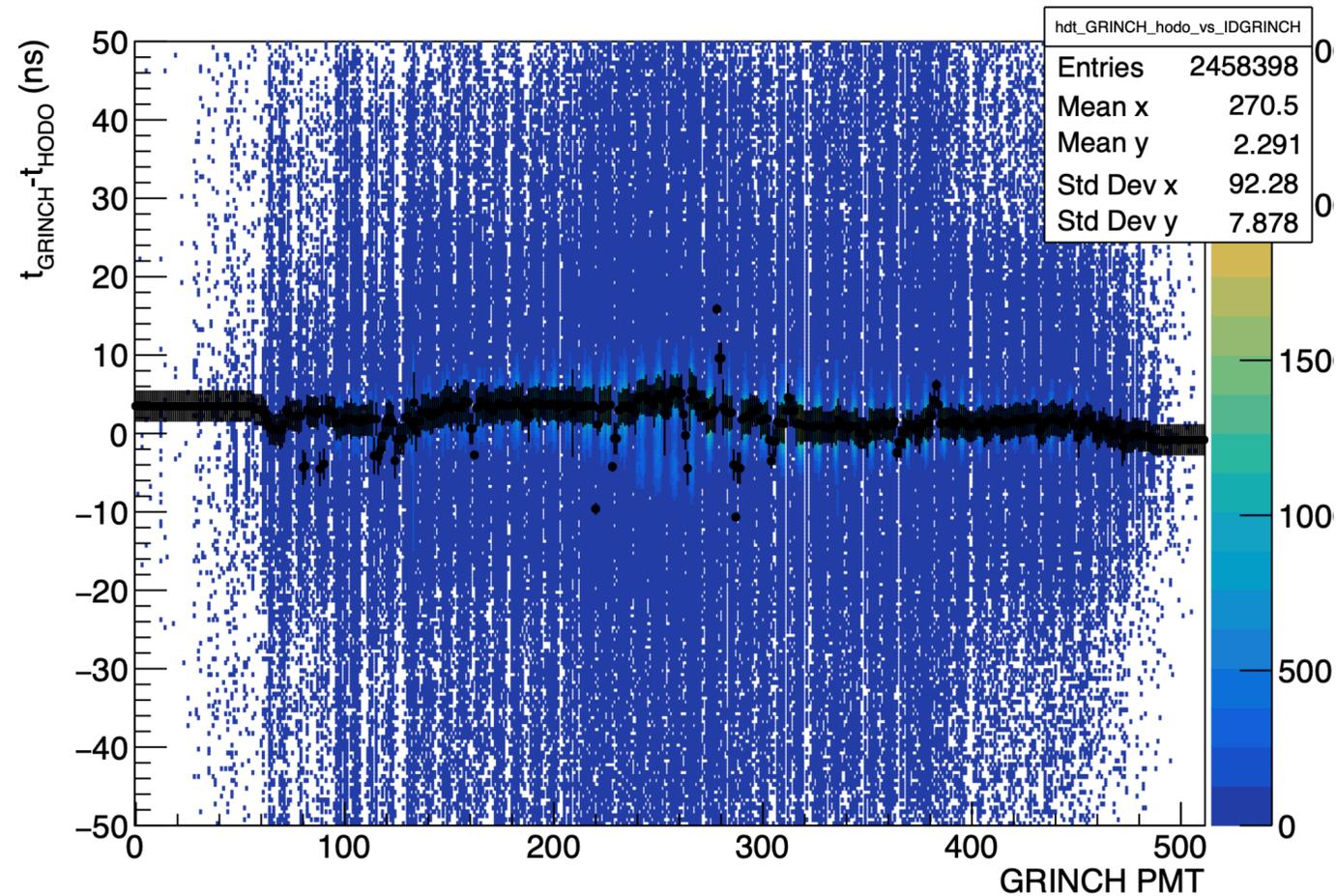
Examples of some (selected at random) GRINCH and TH coincident times, sitting at ~2ns