Status of High-Granularity ADRIANO2 R&D in T1604

(Very) Preliminary results of June 2021 test beam

Corrado Gatto

On behalf of T1604 Collaboration

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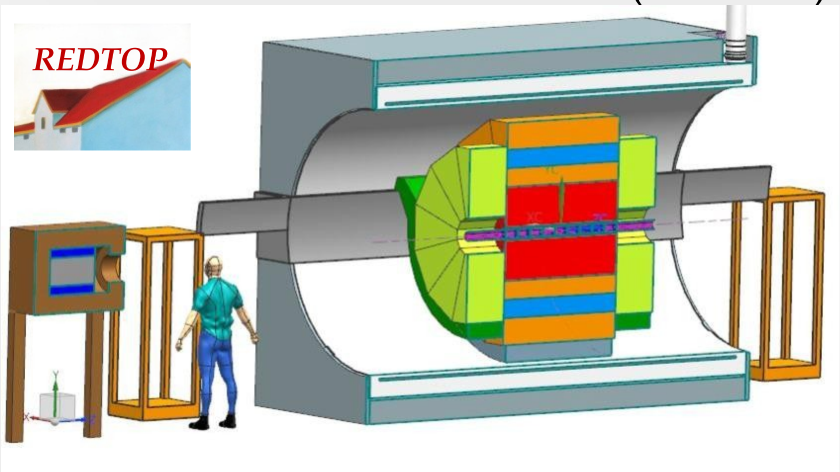
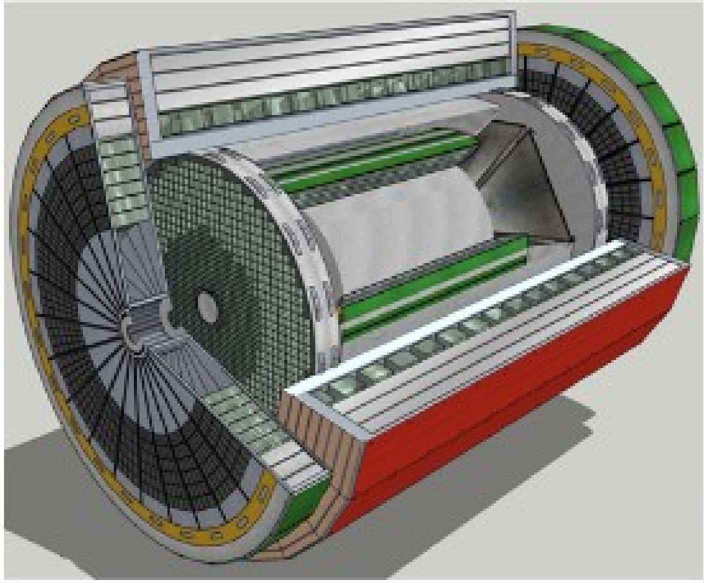
Rationale for ADRIANO2

- ADRIANO2 calorimeter
  - High-granularity tile calorimeter for PFA and dual-readout techniques
  - Sandwich of lead-glas and scintillating tiles optically independent
  - On-tile sipm readout
- Fast timing
  - Goal is 80 psec with ASIC readout (Petiroc2)
- Target experiments:
  - EIC and REDTOP (for now)





Tiles for Test Beam

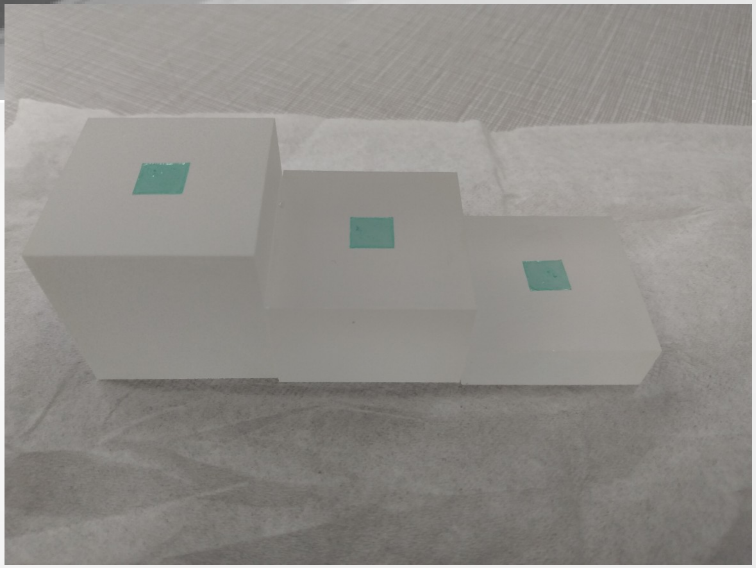
- Three sizes
  - $3x3x1\ cm^3$, $3x3x2\ cm^3$, $3x3x3\ cm^3$
- Three surface finish
  - Cut ground, sandblasted, polished
- Six coating
  - BaSO4, Teflon, Kevlar, Al sputtering, Al paint, ESR2000
- Two sensor interfaces
  - Dimple, no-dimple
- Two sensors
  - S13360, S14160 ($6x6\ mm^2$)
- One special tile
  - Two sensors – Al painted

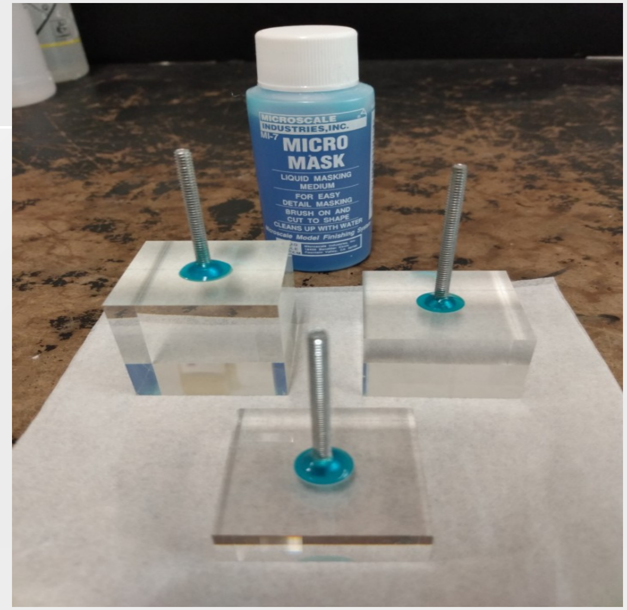
Total: 24 tiles tested

Tile preparation

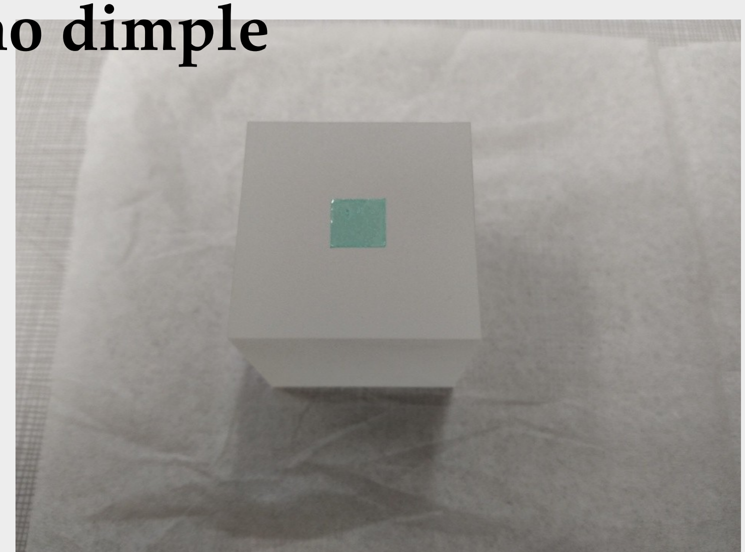
- Tiles manufactured at Cat-i-glass (US) from SF57 blocks.
- All coating at NIU (thanks to T. Fletcher and M. Figora).
- Sputtering at NIU Chem Dept. (thanks to E. Nesterov)
- Porka boards v2 for FEE (S. Los)
- Sampic and Wavecatcher for DAQ

Polished vs unpolished Tiles



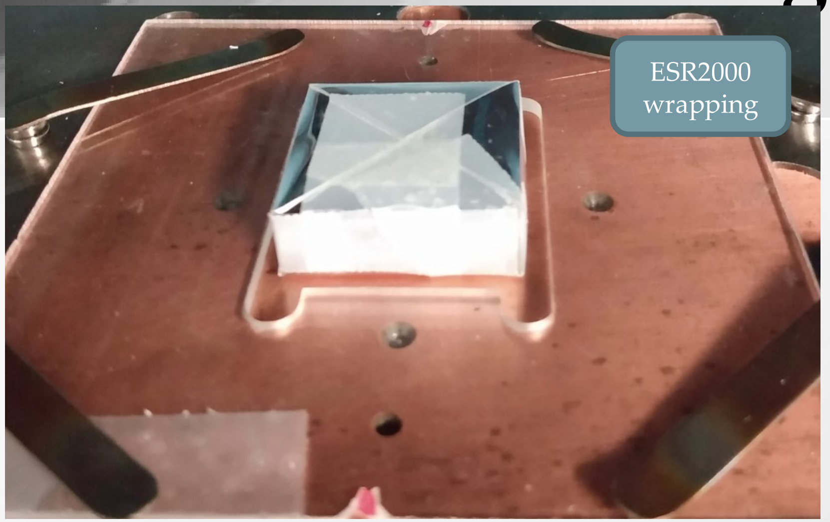


Dimple vs no dimple



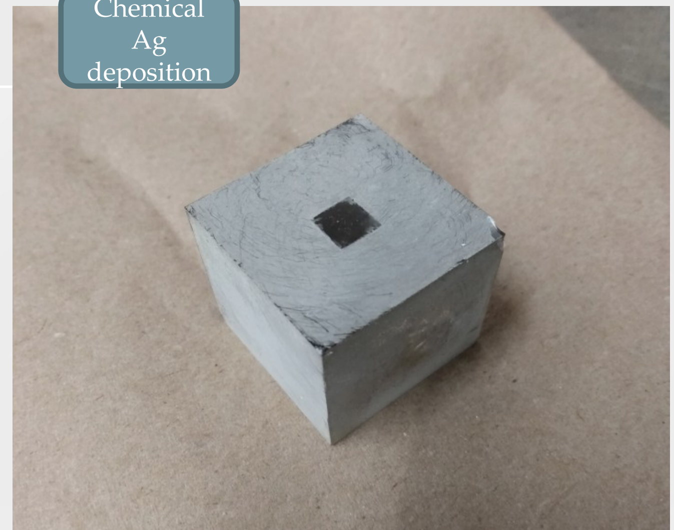
Cat-i-glass
(Elgin – US)

Coating vs wrapping



ESR2000 wrapping

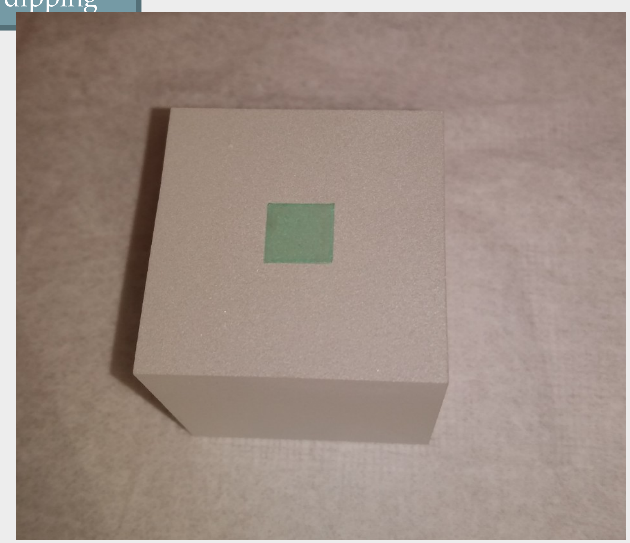
Chemical Ag deposition



Avian-B spray

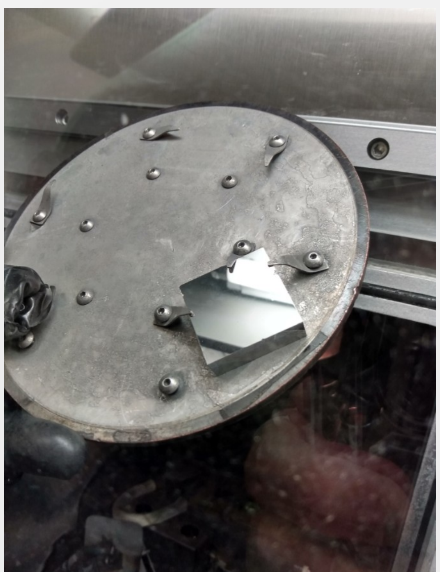
Avian-B dipping

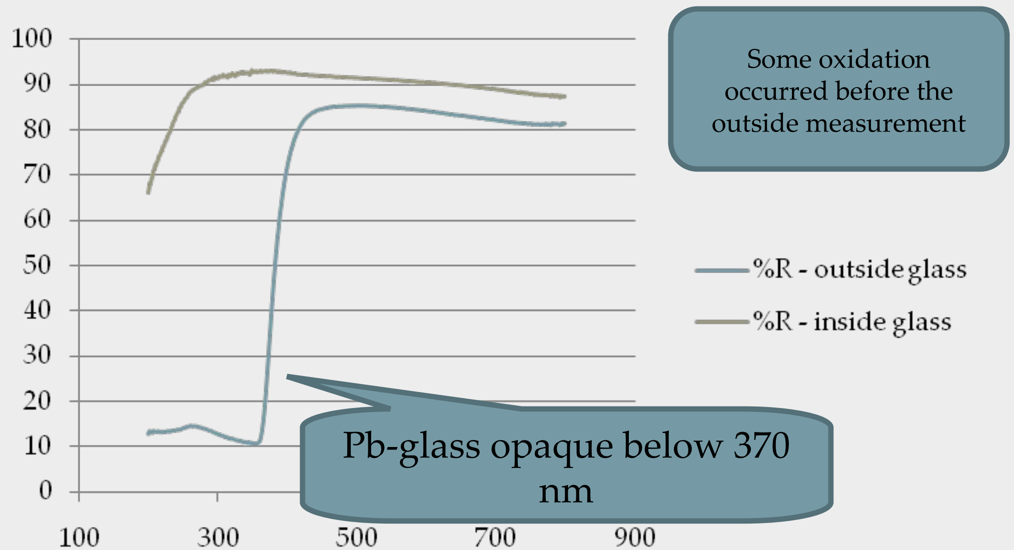
PTFE wrapping



Al/Ag sputtering (NIU Chem. Dept.)

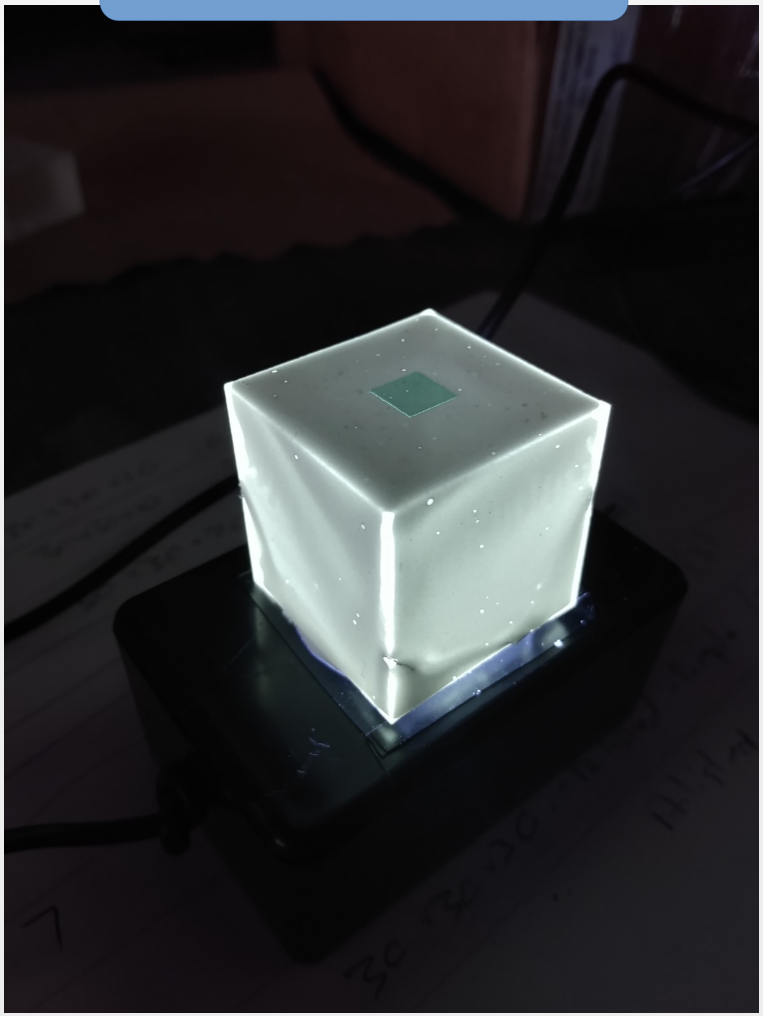
- Angstrom Engineering Nexdep series vacuum thermal deposition system mounted into an Innovative Technologies glove box (E. Nesterov lab. – NIU Chem. Dept.)
- 400 nm Aluminum on tile



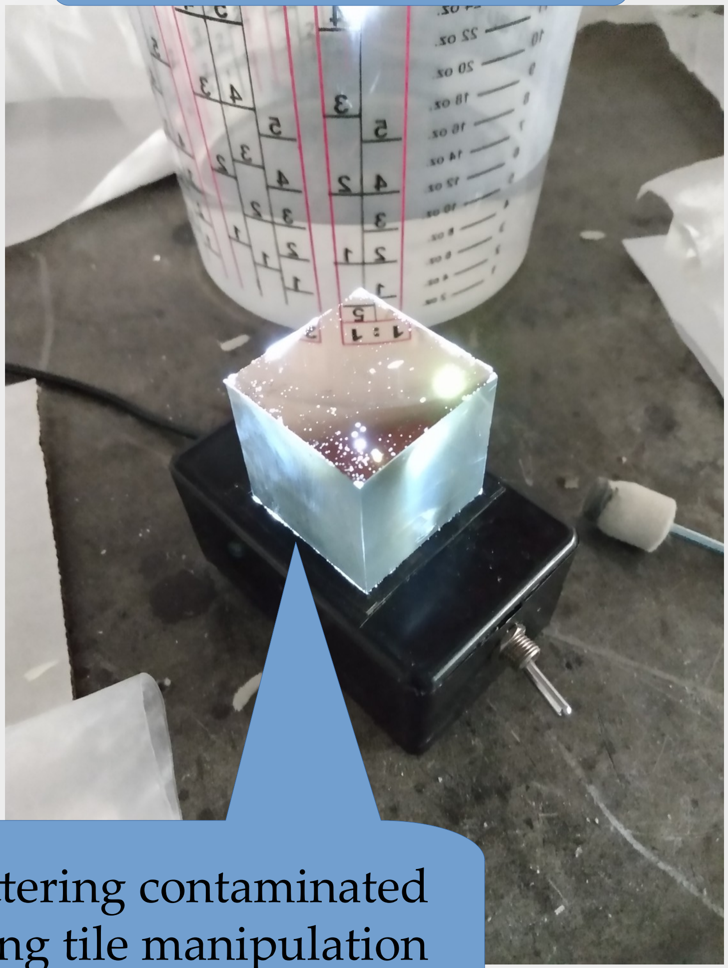


Coating coverage test

BaSO4 paint

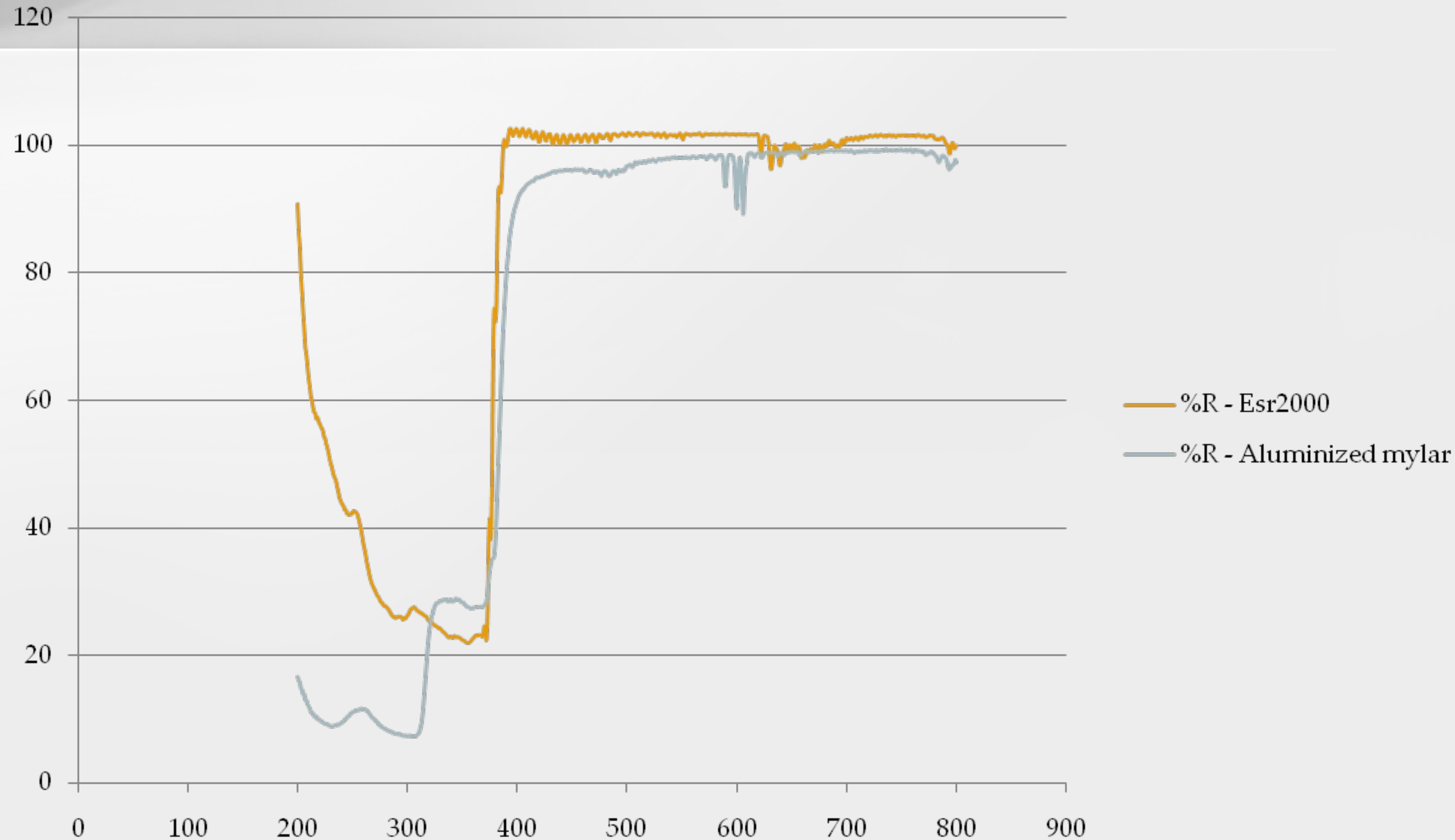


Al sputtering



Sputtering contaminated during tile manipulation in the glove box

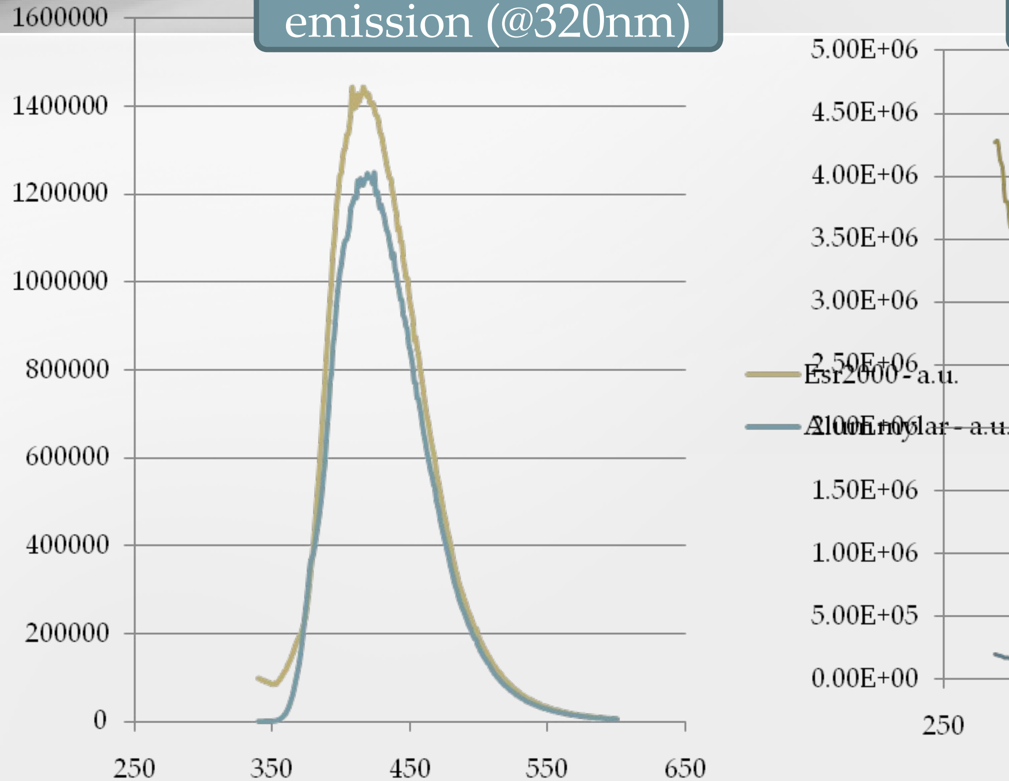
The saga of aluminized wrapping (latest measurements)



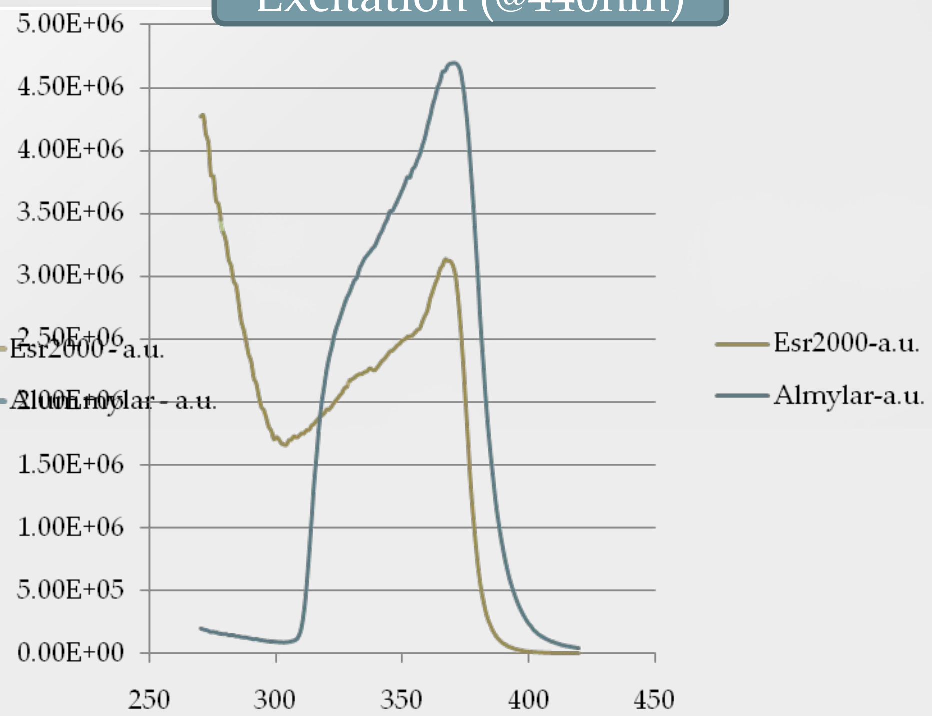
- Measurement performed with an Agilent Cary5000 uv-vis-nir spectrophotometer with DRA900 diffusive reflectance chamber (E. Nesterov lab. – NIU Chem. Dept.)
- **Esr2000 consistently shows above 100% reflectivity**

Fluorescence spectra

emission (@320nm)

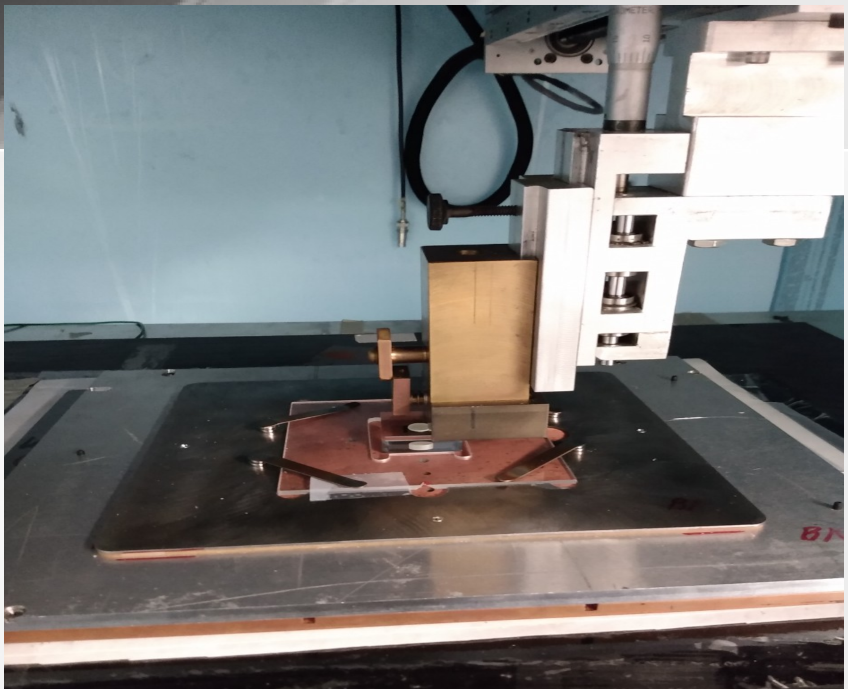


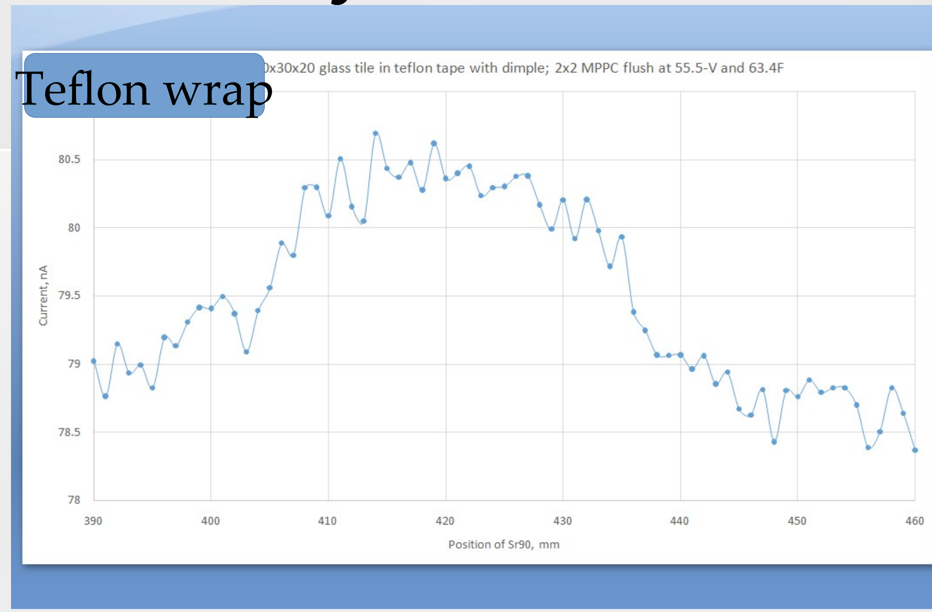
Excitation (@440nm)

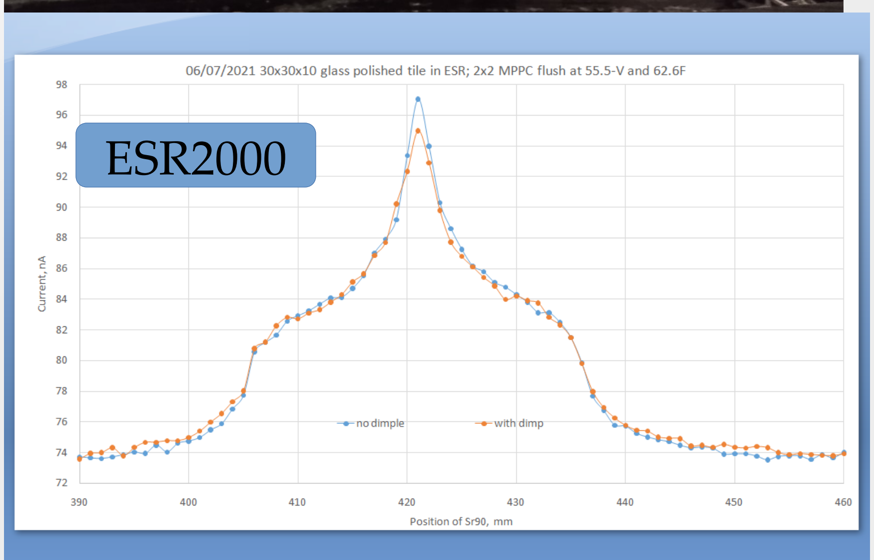


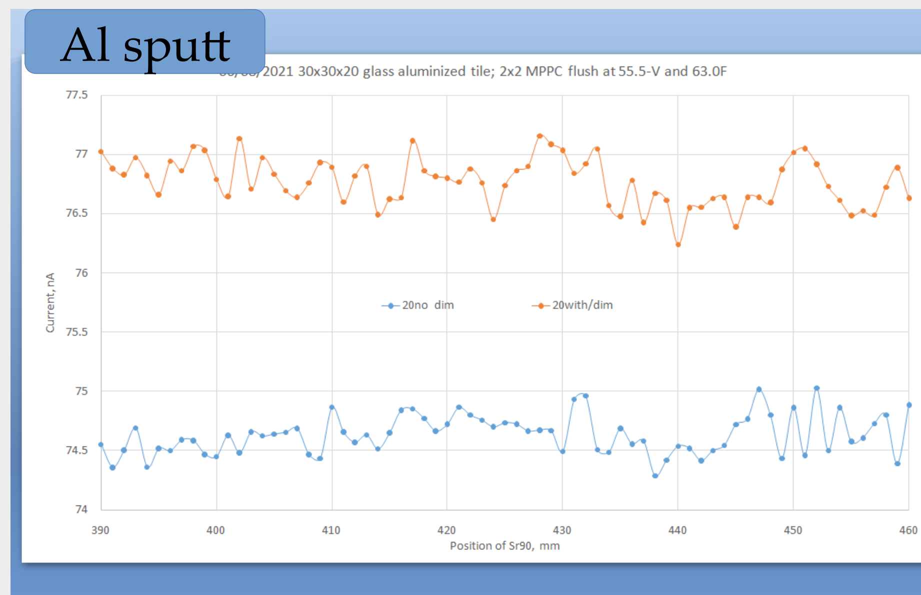
- Measurement performed with an PTI QuantaMaster4/2006SE spectrofluorimeter (E. Nesterov lab. – NIU Chem. Dept.)
- The excitation and emission spectra were acquired at the right-angle configuration
- **Results by M. Janecek are fully confirmed (brilliant fluorescence with τ=14nsec)**

^{90}Sr measurements (A. Dychkant)

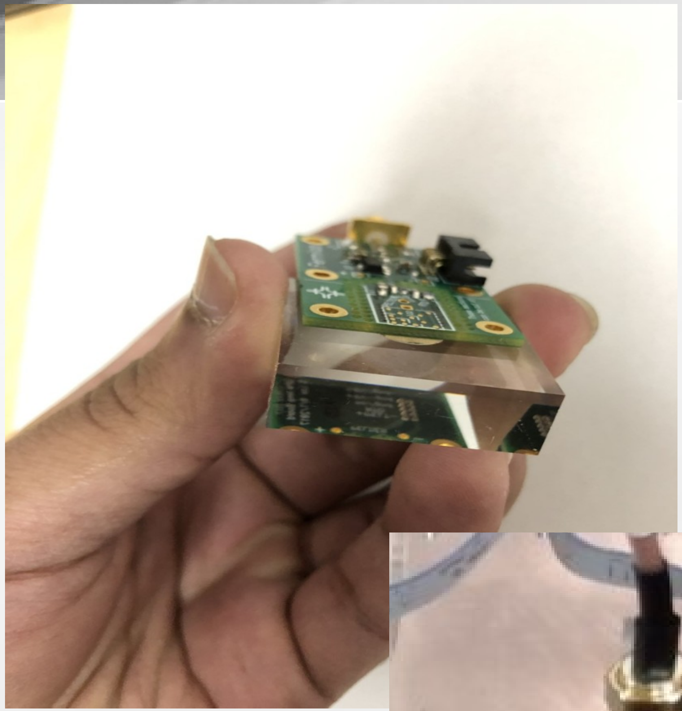


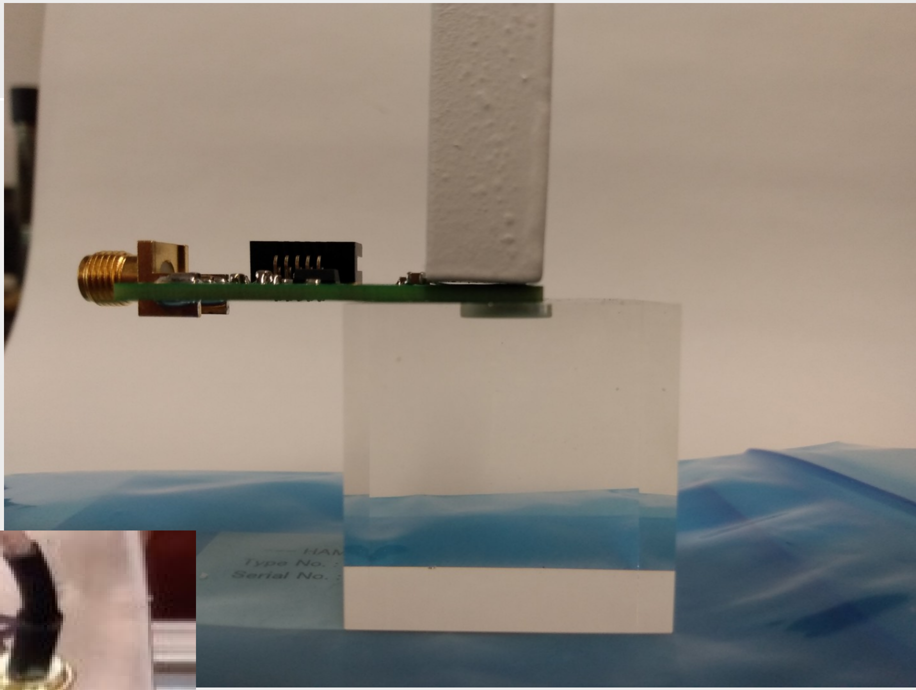


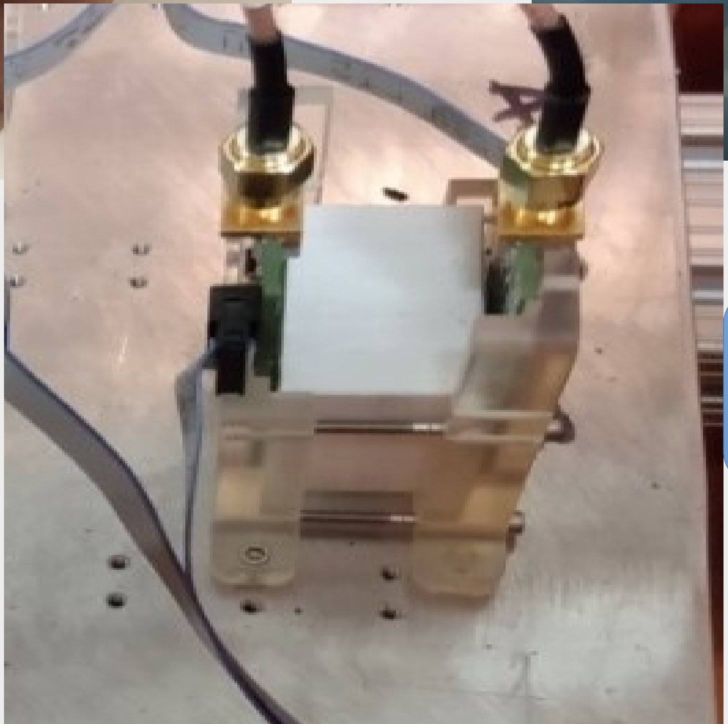




FEE + Tiles with dimple



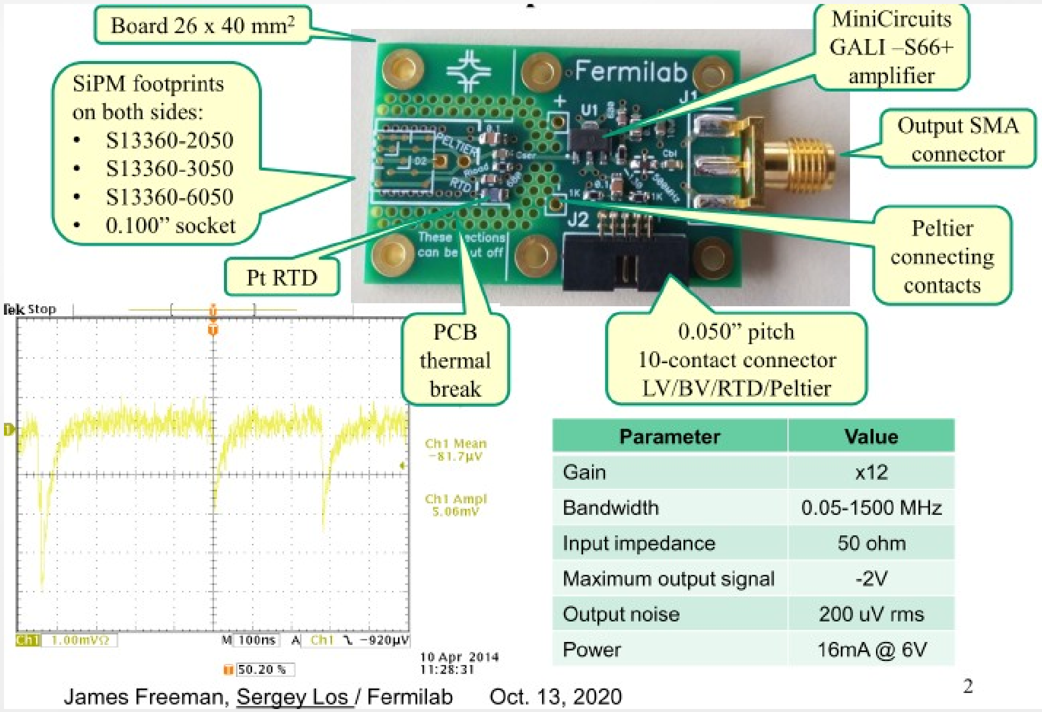




3D printed tile+FEE holder
(M. Figora)

FEE and DAQ: Test beam

Porka boards with Sampic (6.4 GSa/sec – 64 Sa) and wavecatcher digitizers (3.2 GSa/sec – 1024 Sa)

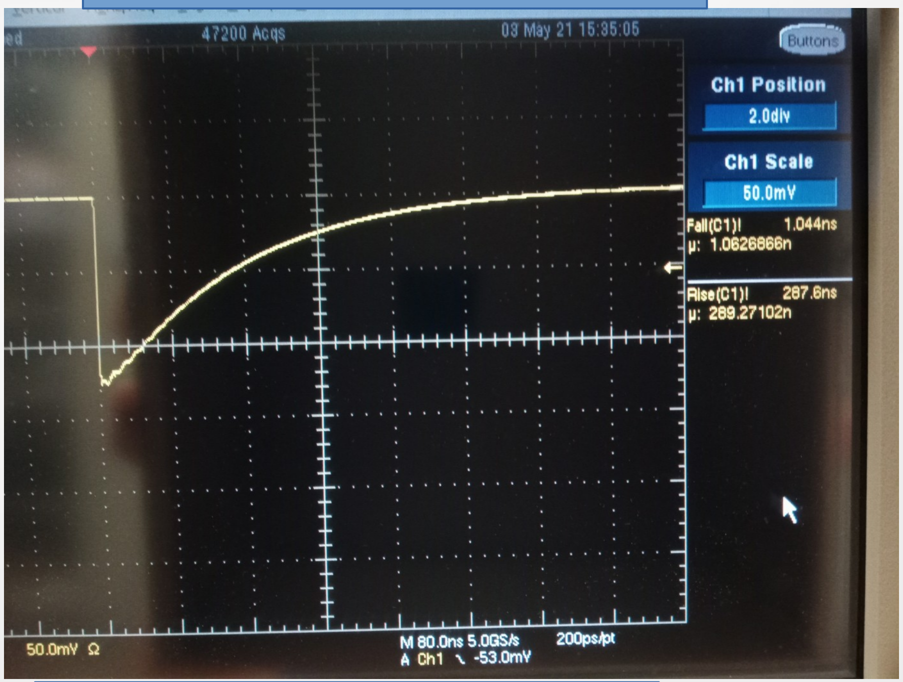


Parameter	Value
Gain	x12
Bandwidth	0.05-1500 MHz
Input impedance	50 ohm
Maximum output signal	-2V
Output noise	200 uV rms
Power	16mA @ 6V

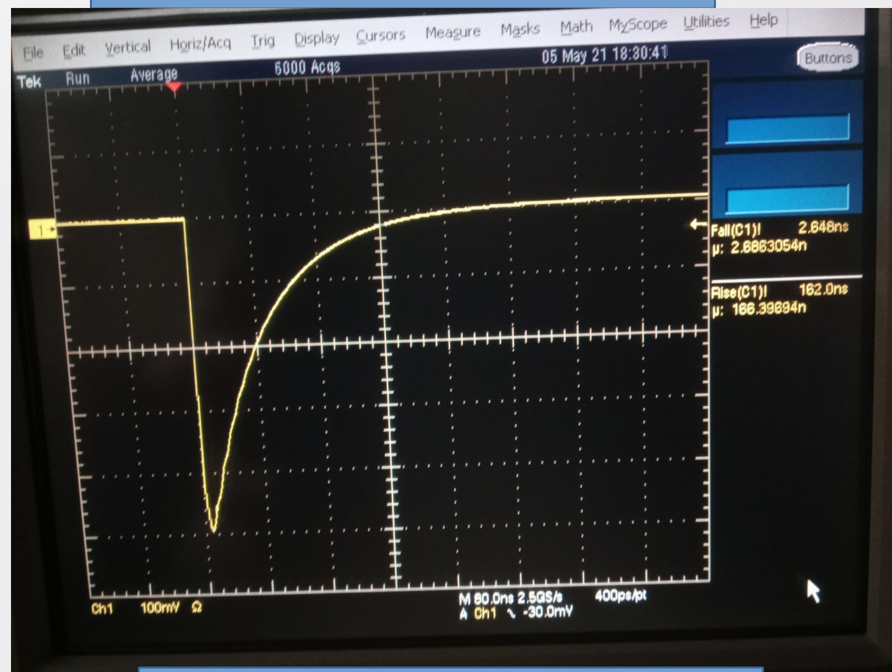
- FEE and slow control designed at Fermilab (S. Los).
- Integration with FTBF and slow control: K. Francis (NIU) J. Maalmi (ICJlab)

Sensors+FEE (S. Los)

S14160: 1 ns rise time



S13660: 2.7 ns rise time



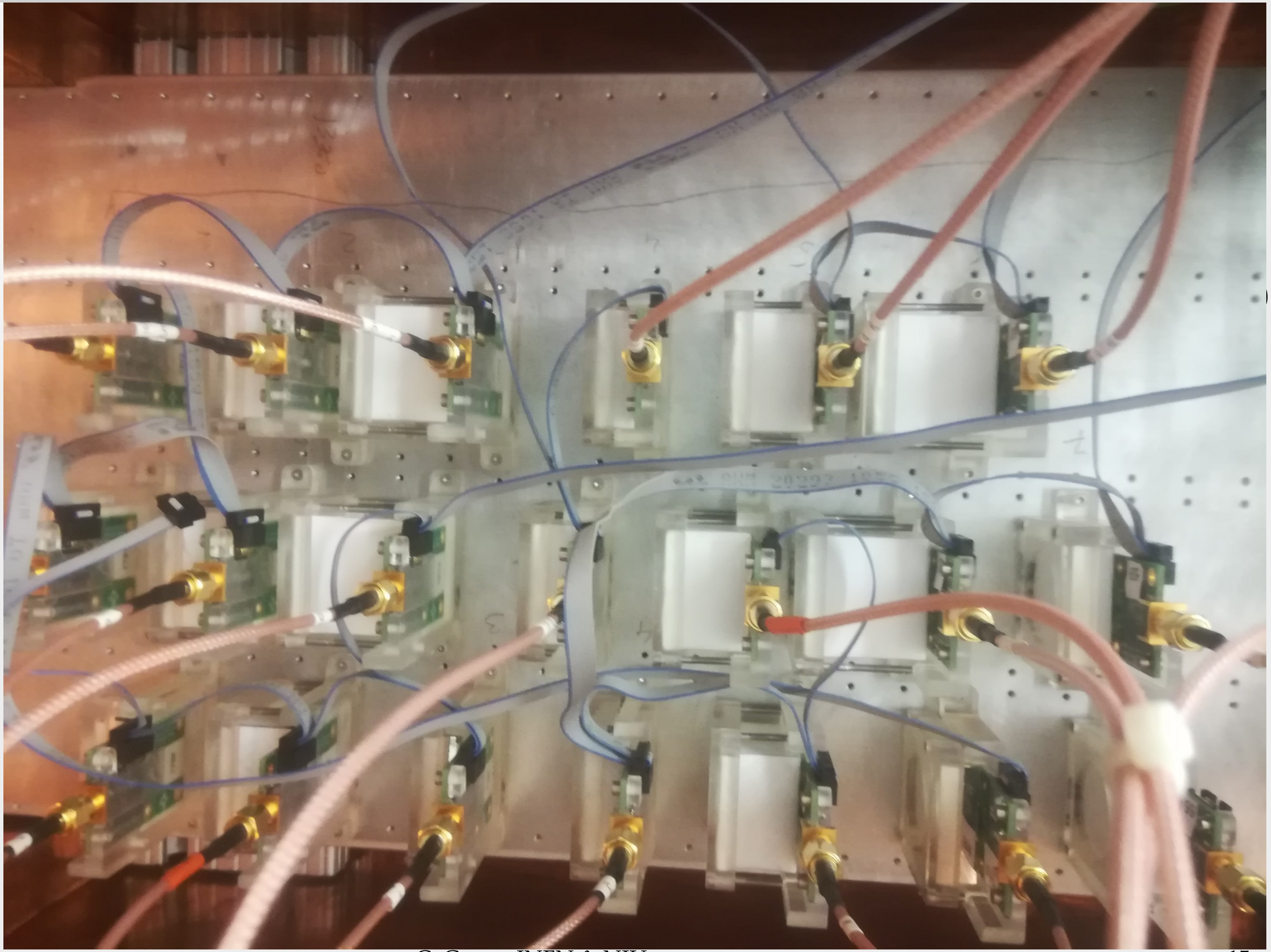
PDE = 50% at λp
Noise: ~10 MHz
Gain: 2.5×10^6

PDE = 40% at λp
Noise: ~2 MHz
Gain: 1.7×10^6

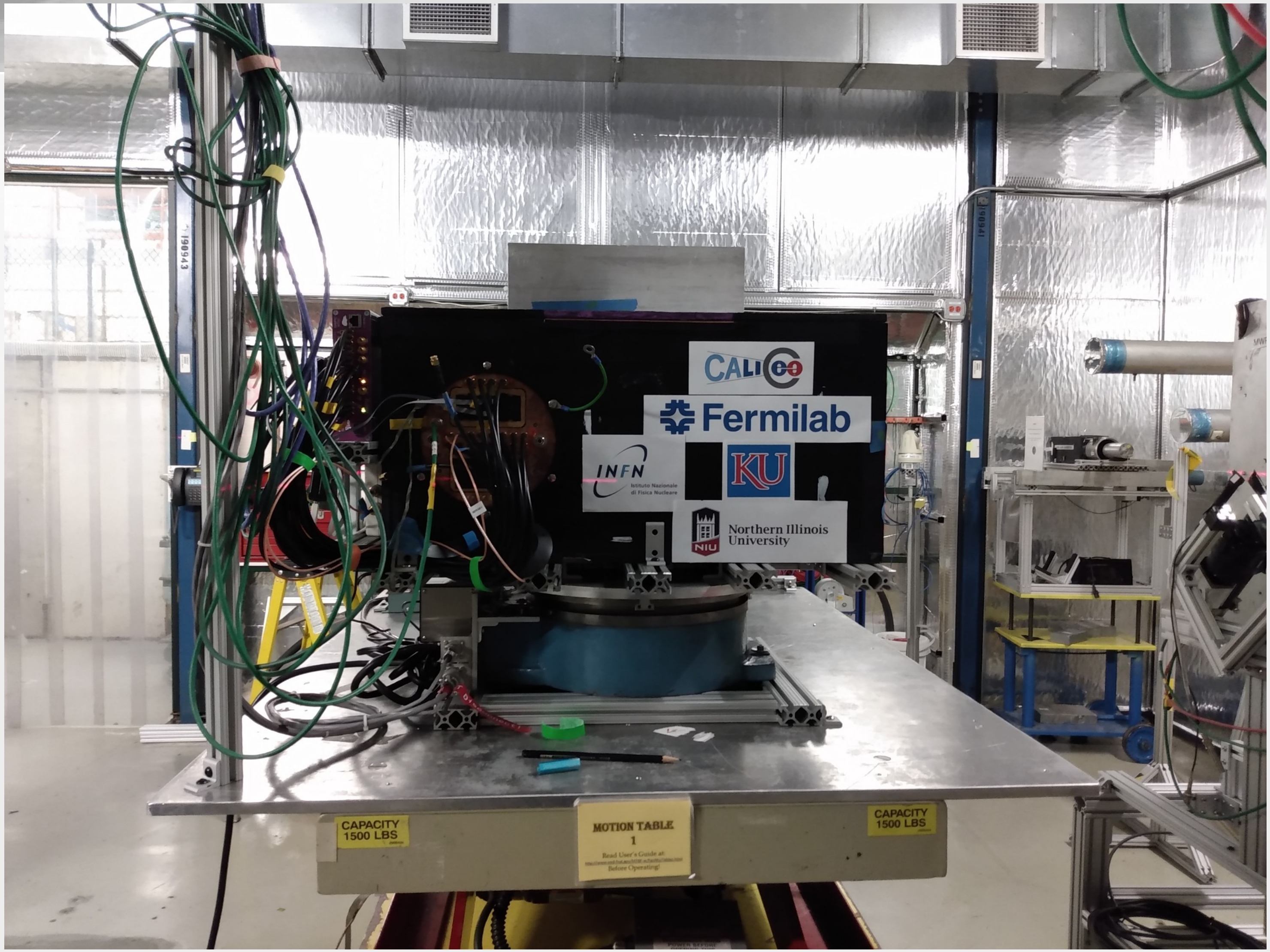
Overvoltages set to have similar signal for 1 pe

June 2021 Test beam Setup

New FEE boards: similar to the



ADRIANO2 at FTBF



Test beam results – June 2021

Very preliminary analysis

Amplitude analysis based on Wavecatcher only

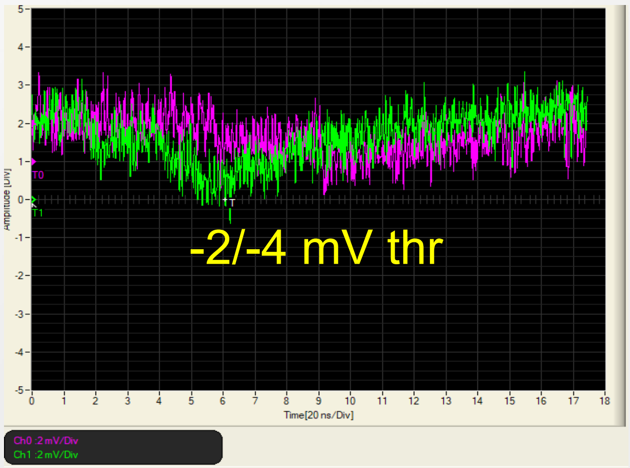
Time analysis based on Sampic and Wavecatcher

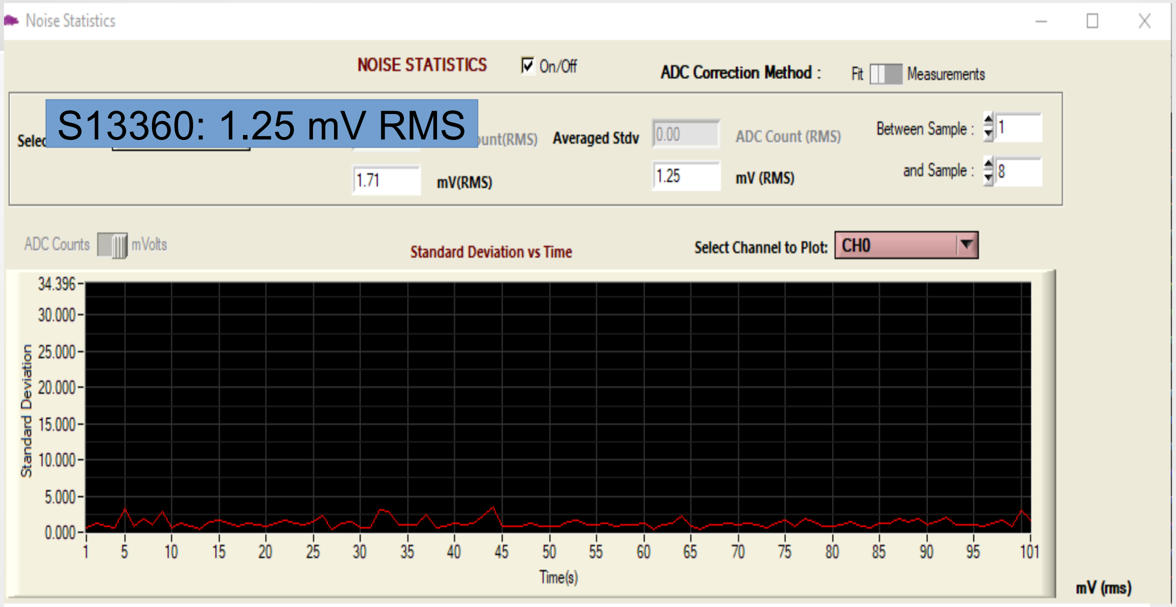
Calibration approximate for now; need a new led run

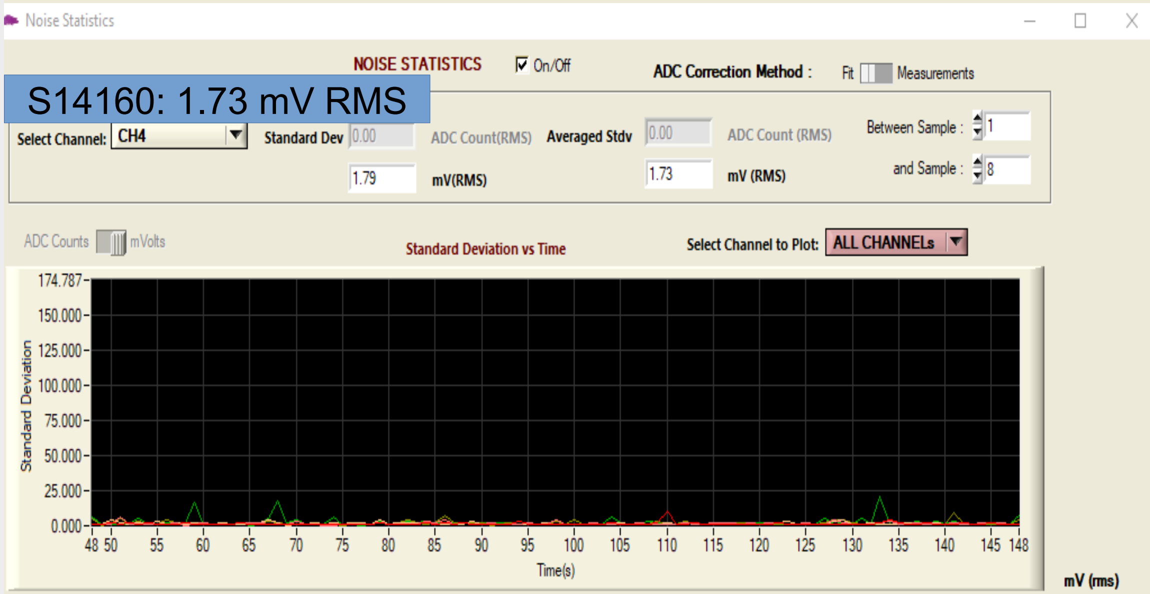
Light yield results finalized after calibration is complete

Noise analysis

Use Sampic at 6.2 GSa/s on baseline of waveform



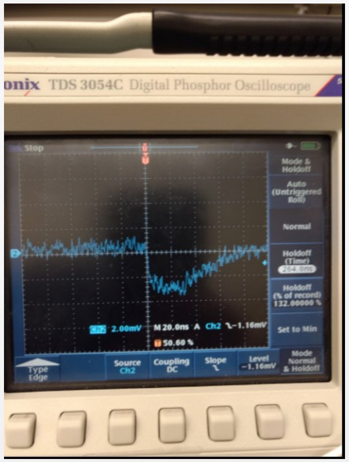


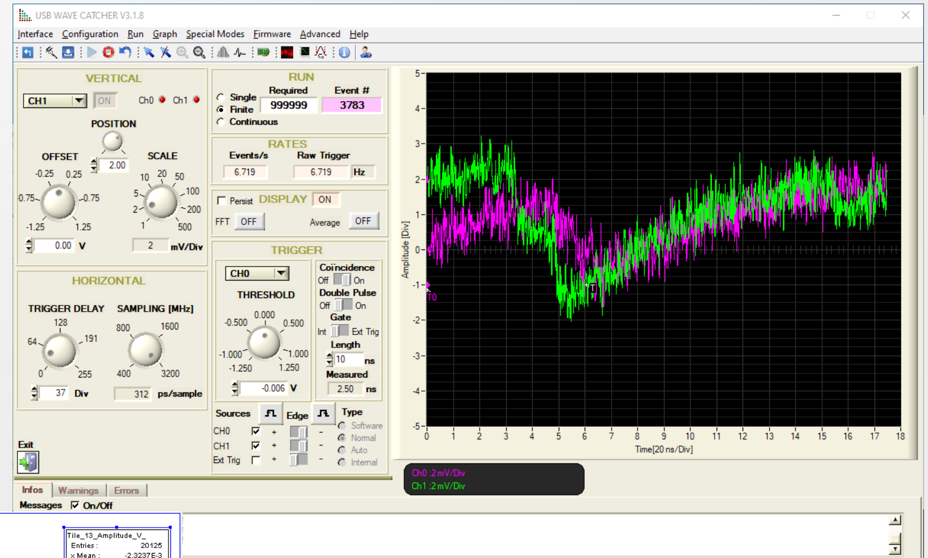


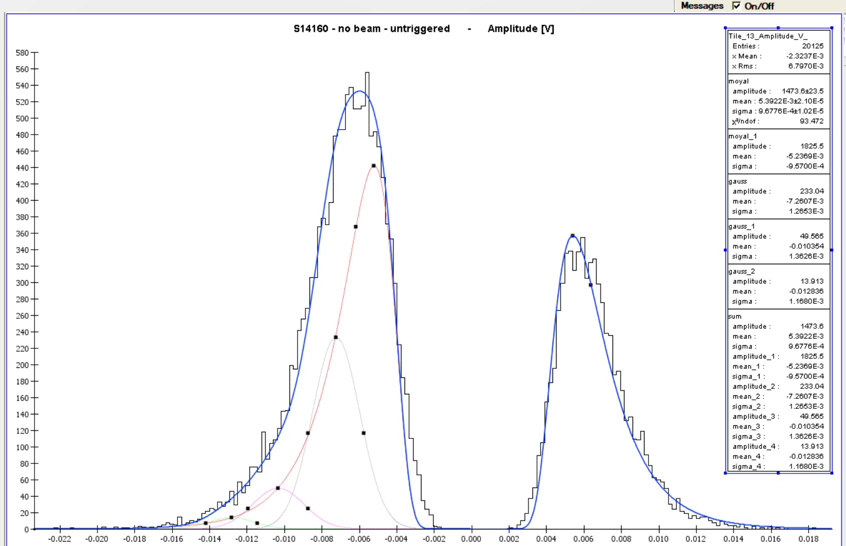
Calibration

Preliminary

- ❑Use WC/SAMPIC trigger in single on one channel and acquire the other channels arriving within +-200 nsec
- ❑Determine pedestal independently
- ❑Fit the amplitude plot with multiple equi-spaced gaussians + pedestal







Results

– S14160: 2.5 mV/pe

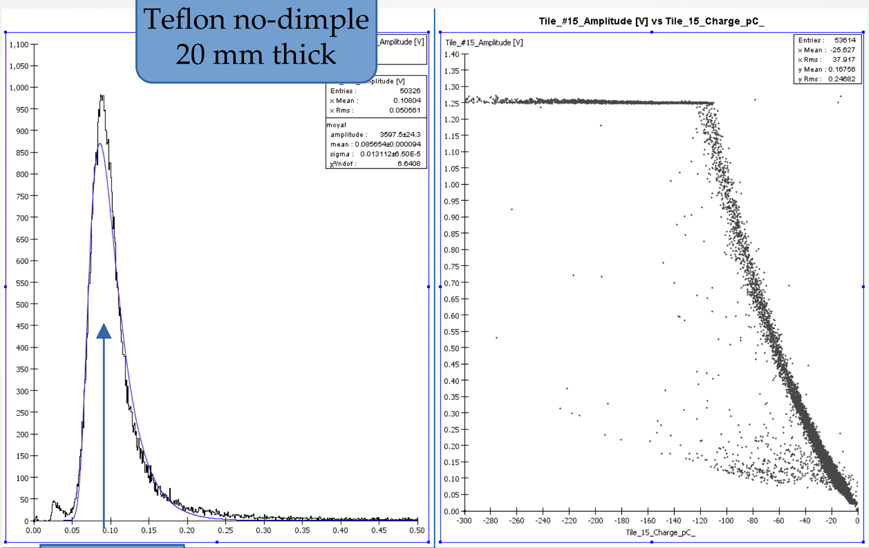
– S13360: 2.4 mV/pe

Very close to visual determination
With the Tektronix

MIP Amplitude Analysis (Wavecatcher)

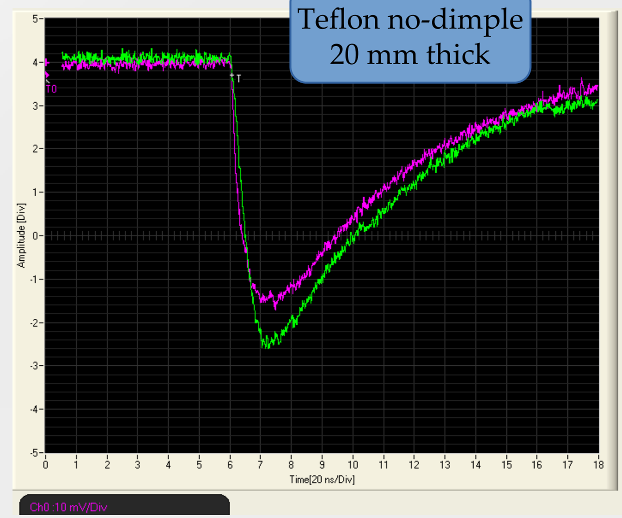
Diffuse coating

Teflon no-dimple
20 mm thick

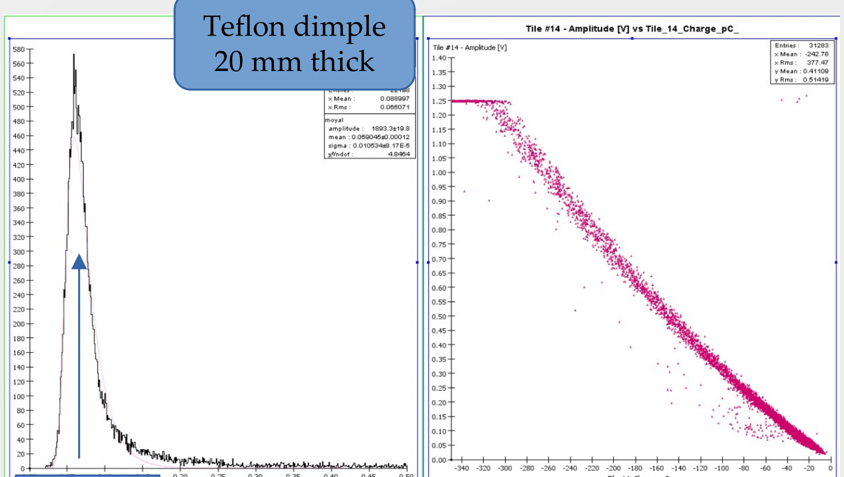


86 mV

Teflon no-dimple
20 mm thick

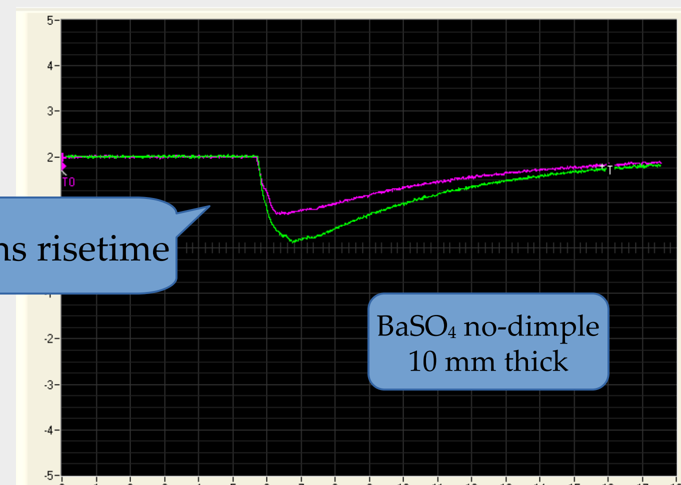


Teflon dimple
20 mm thick



89 mV

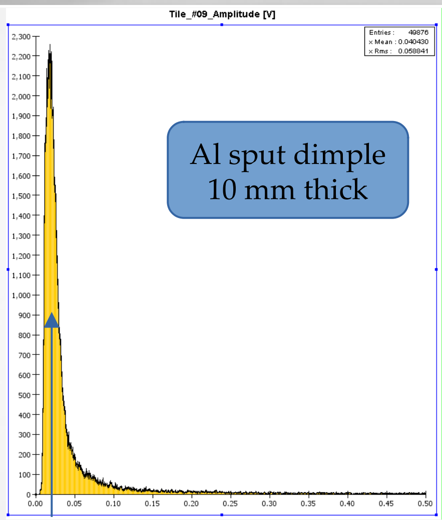
~8 ns risetime

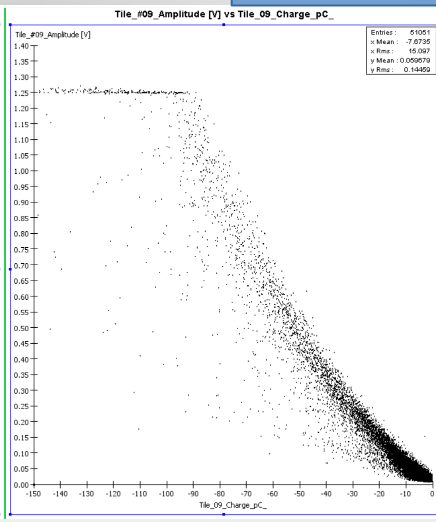


BaSO$_4$ no-dimple
10 mm thick

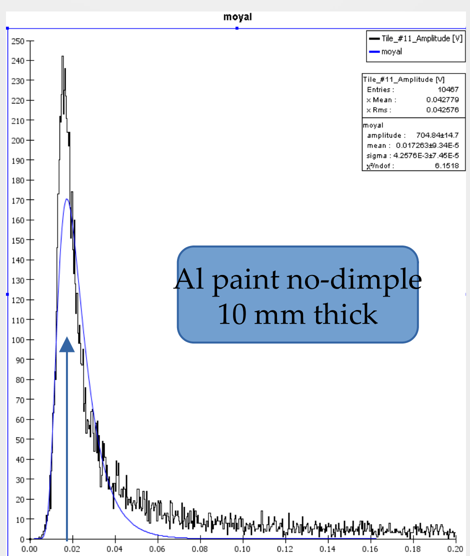
MIP Amplitude Analysis (Wavecatcher)

Mirror coating

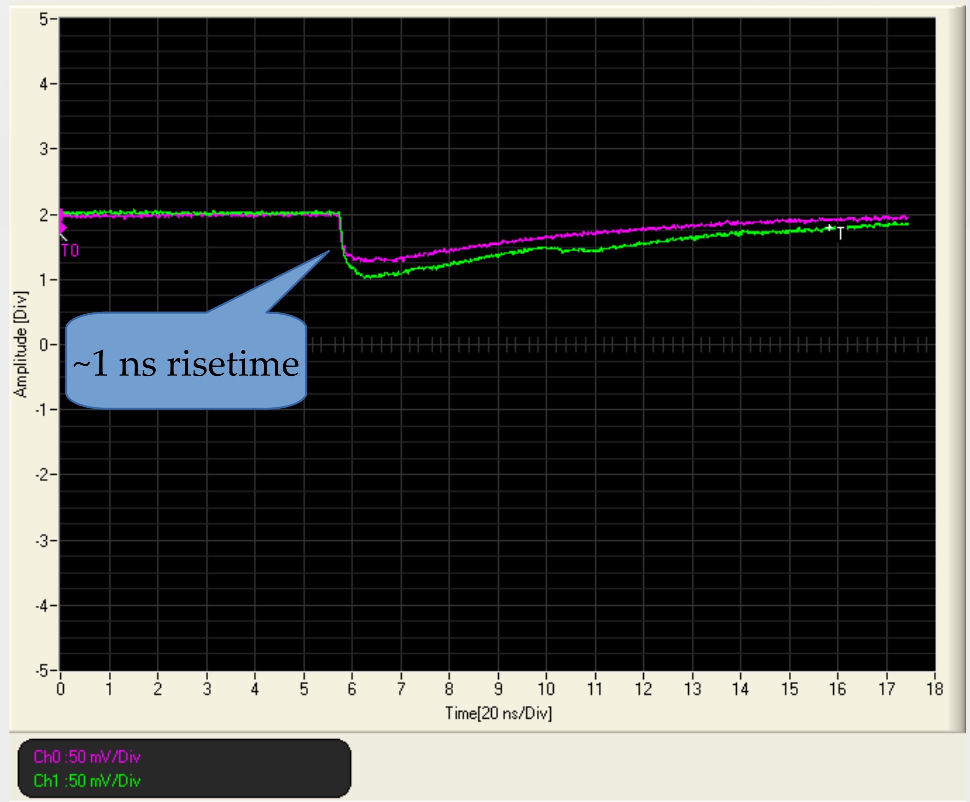




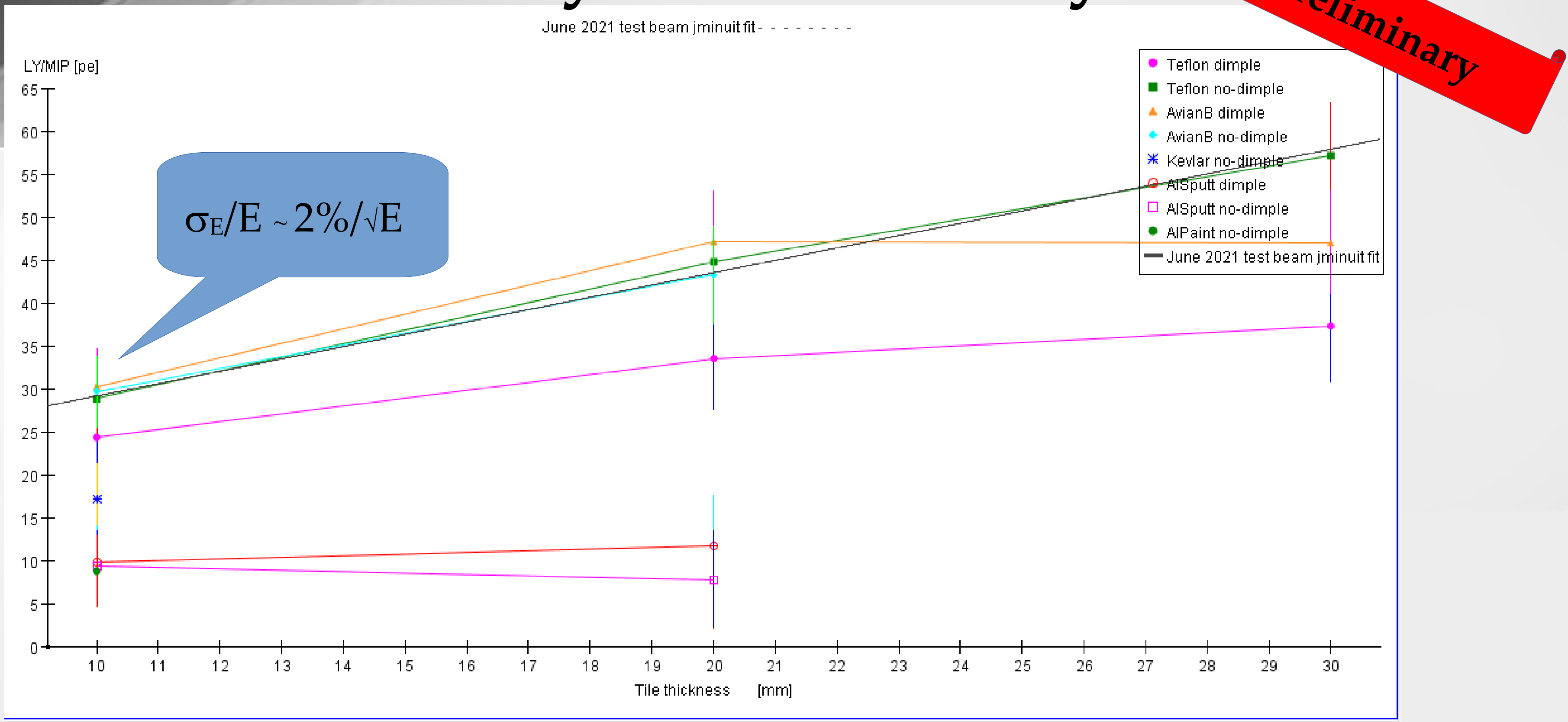
21 mV



17 mV

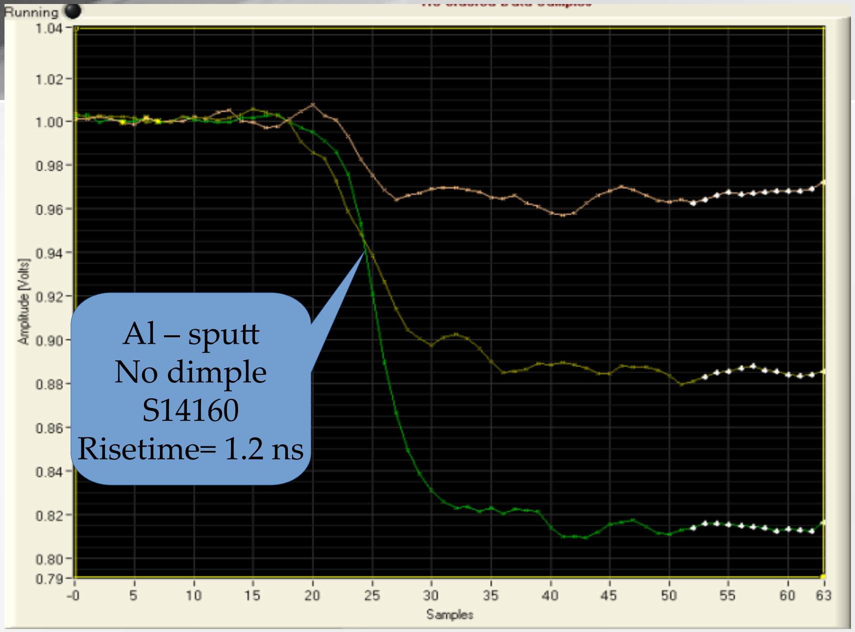


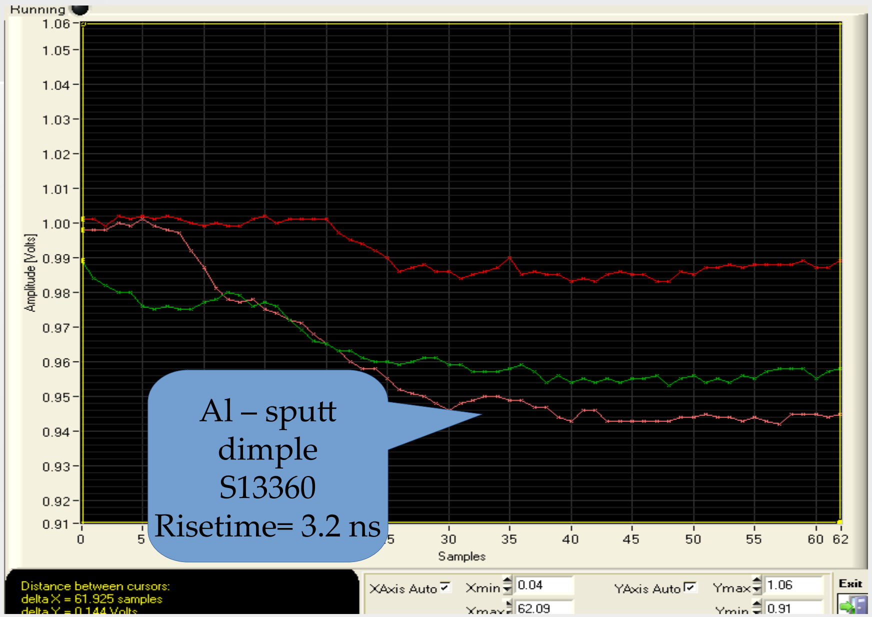
Summary LY/MIP Analysis

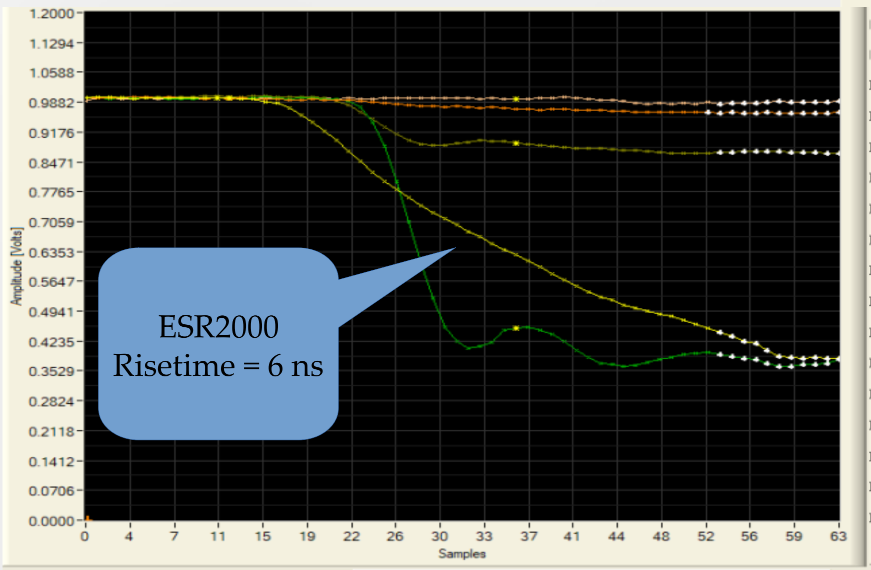


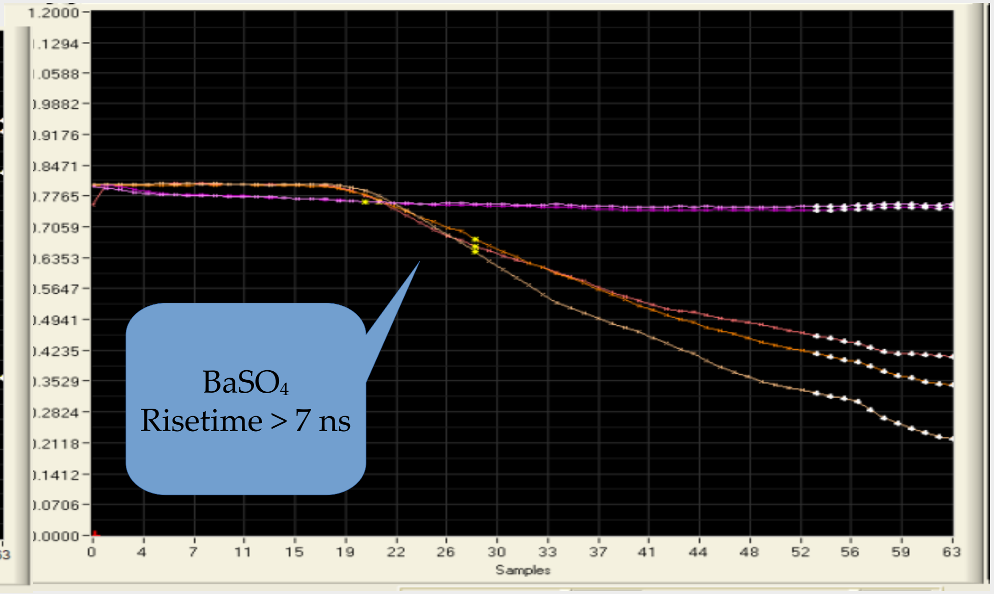
- 1 MIP in SF57 ~ 9 MeV/cm
- Teflon and $BaSO_4$ coating have very similar LY
- Kevlar has about 40% lower LY
- $BaSO_4$ tiles (ground) with dimple & S13360 have about the same LY as no-dimple & S14160 (surprising)
- Teflon tiles (polished) with dimple & S13360 have about 30% lower LY as no-dimple & S14160
- Al-sputtered and Al-paint have 1/3 the LY vs diffuse coating
- 3 cm thick sandblasted, $BaSO_4$ tile has 15% lower-than-expected LY (real or bad sipm coupling?)

Waveform with SAMPIC @ 6.4 GSa/s



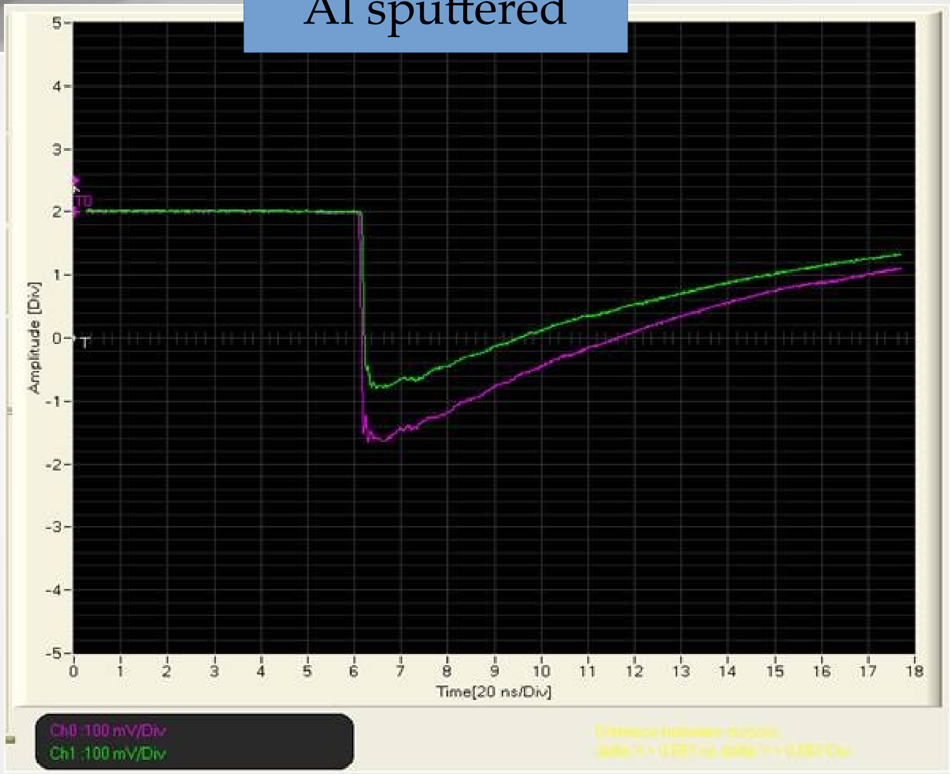




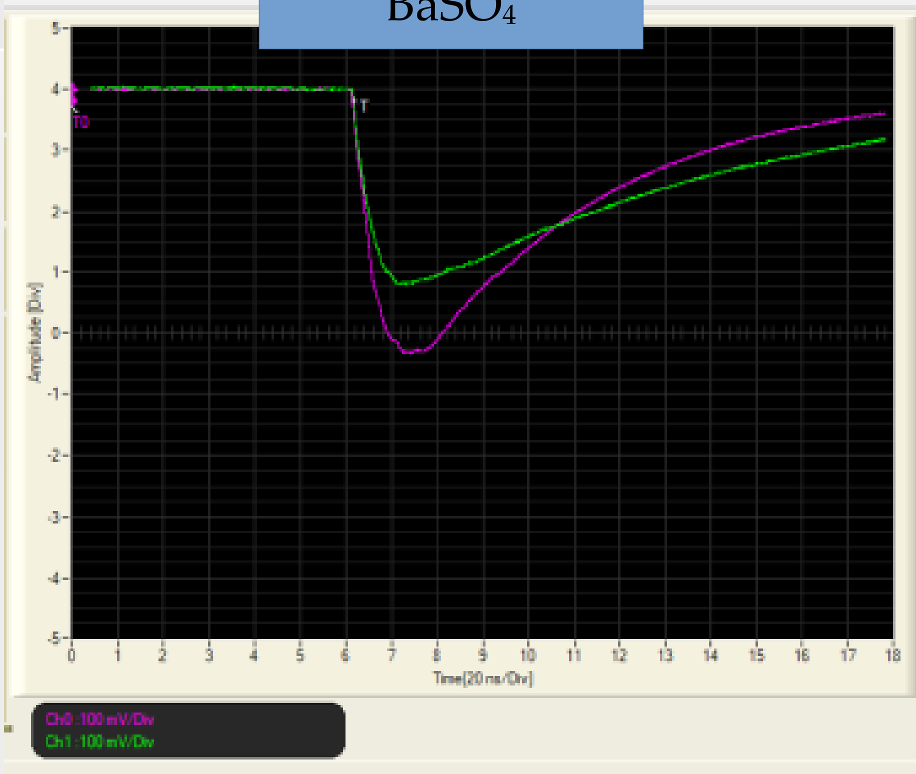


Waveform with WC @ 3.2 GSa/s

Al sputtered



$BaSO_4$



Similar risetime as measured with Sampic

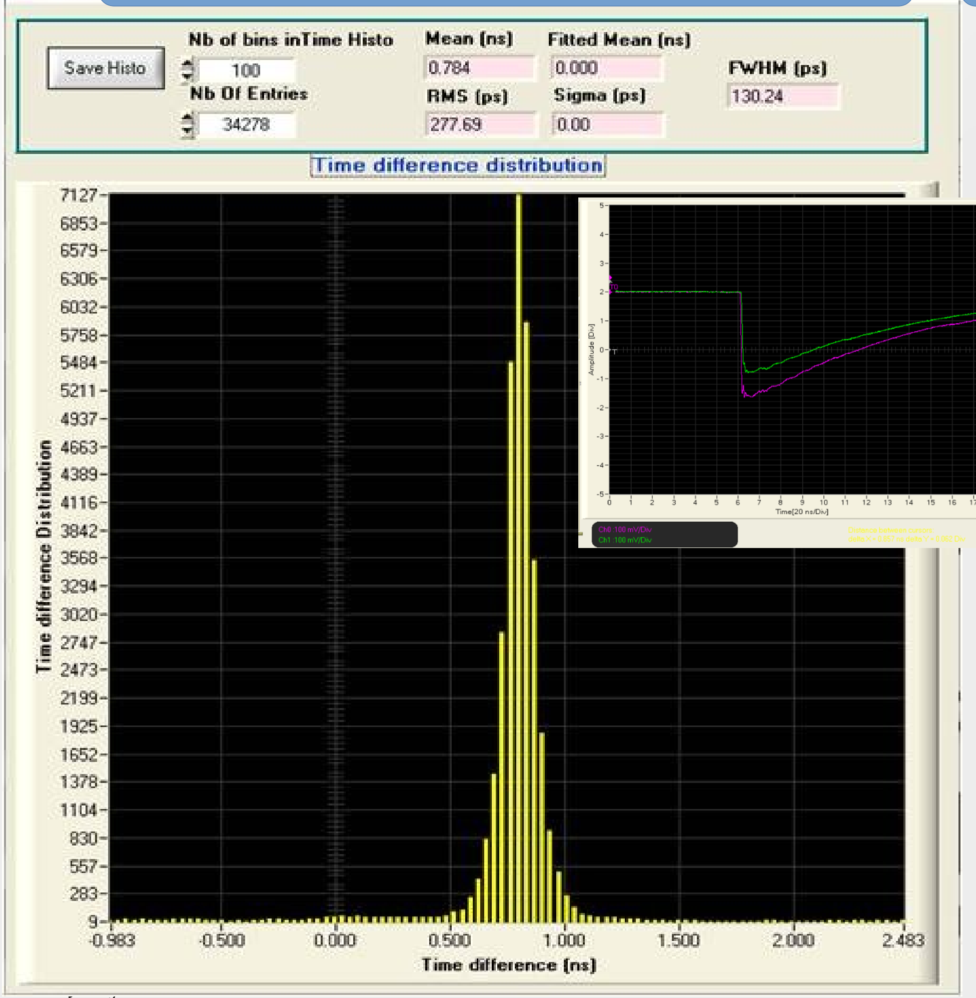
ΔT measurement

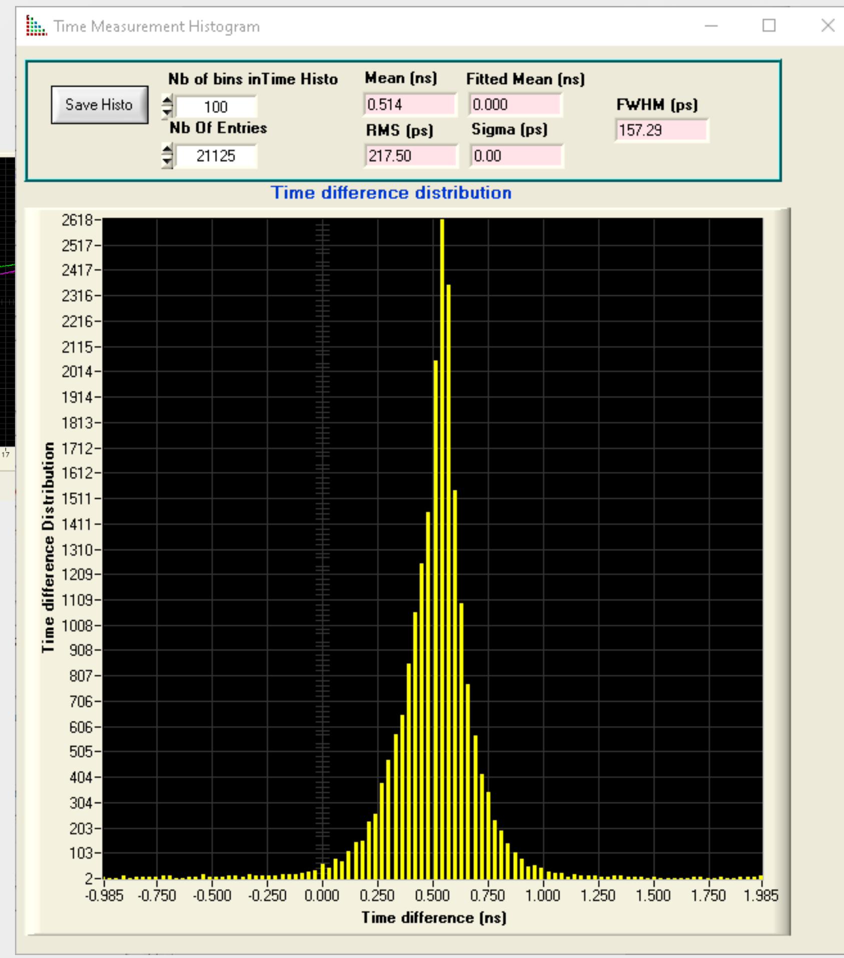
Preliminary

Time difference between two waveforms from 2 cells determined with a CF discriminator

Al-sputt with S14160: ΔT=55 ps

Al-sputt with S13360: ΔT=68 ps



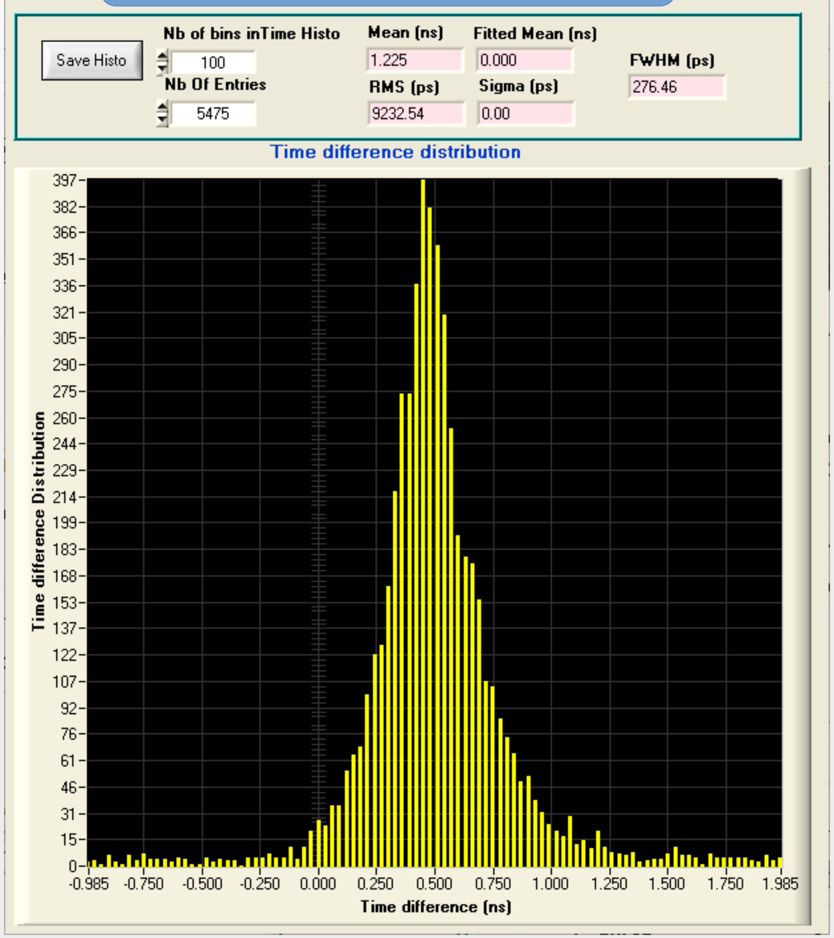


ΔT measurement

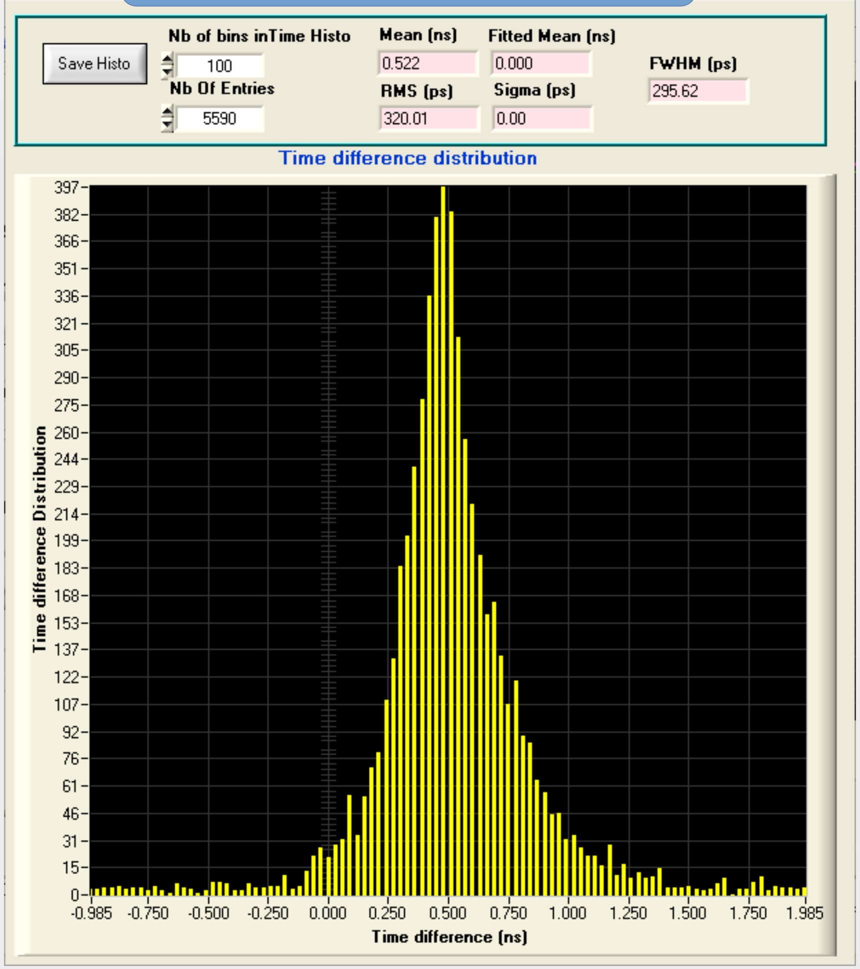
Preliminary

Time difference between two waveforms from 2 cells determined with a CF discriminator

BaSO$_4$ with S14160: ΔT=115 ps



BaSO$_4$ with S13360: ΔT=125 ps



Summary

- We had a good (but very intense) run in June. Thank you to all who participated to shifts (from KU and NIU) , S. L. for setting the electronics, M. F. and T. F. for (dis)installation
- All equipment worked flawlessly: Sampic and Wavecathers (ICJ Lab) are superb tools for this kind of R&D
- Data analysis is still very preliminary. However, the picure is quite clear:

1. Diffuse coating has excellent LY (exceeding the goal of 5%/√E) but poor timing resolution (~100 ps)
2. Mirror surface meet the goal defined in the DOE proposal (50 ps), but has a ~1/3 the LY of diffuse coatings. Poor sputtering, makes this measurement inconclusive
3. ESR2000 confirmed a large and very slow fluorescence component → drop it from future R&D

Future prospects

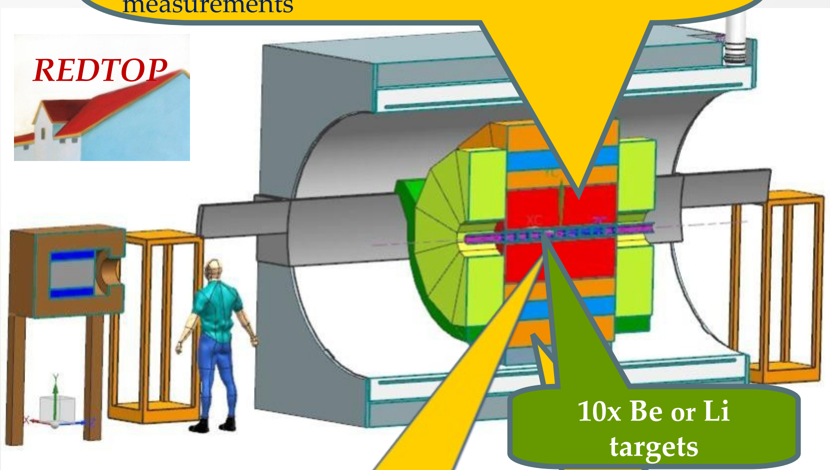
- Need to confirm the performance of mirroring surface with good sputtered tiles
- Reasons for mirror coating being faster than diffuse coating not understood yet. If it is related to the directional property of Cerenkov photons, need to test at different impinging angles
- FNAL has the expertise and the equipment for good quality sputtering. Very expensive process ($ 25K). Working with PPD to get support
- Plans are to run again in Fall 2021 with 12 new tiles with Al and Ag sputter
- Test beam with large prototype (32-64 ch) with Petiroc2 readout still on track for Winter 2022

Backup Slides

Foreseable Applications

REDTOP

Optical-TPC
For slow background rejection
or
LGAD Tracker surrounded by Quartz cells
For 4D track reconstruction and TOF measurements



10x Be or Li targets

Vertex Fiber tracker
for rejection of γ-conversion and identifying displaced vertices from long lived particles

5D- Calorimeter: ADRIANO2
(Dual-readout +PFA)
Sci and Cer light read by SiPM or SPAD
For excellent energy , position resolution and PID

EIC (Photon Project)