RHIC Polarimetry: Run12 summary → Run13 plans

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of the polarimetry group

RHIC Retreat
25.07.2012

<u>Run12 problems → mitigating measures for Run13</u>

- RF pickup:
    - → stochastic cooling pickup
    - → electronics & detector: grounding & shielding; MUX
- Carbon target mortality:
    - → studies / developments standard C ribbons
    - → alternate technology: graphene
- EM modeling of scattering chamber: RF pickup & target stress

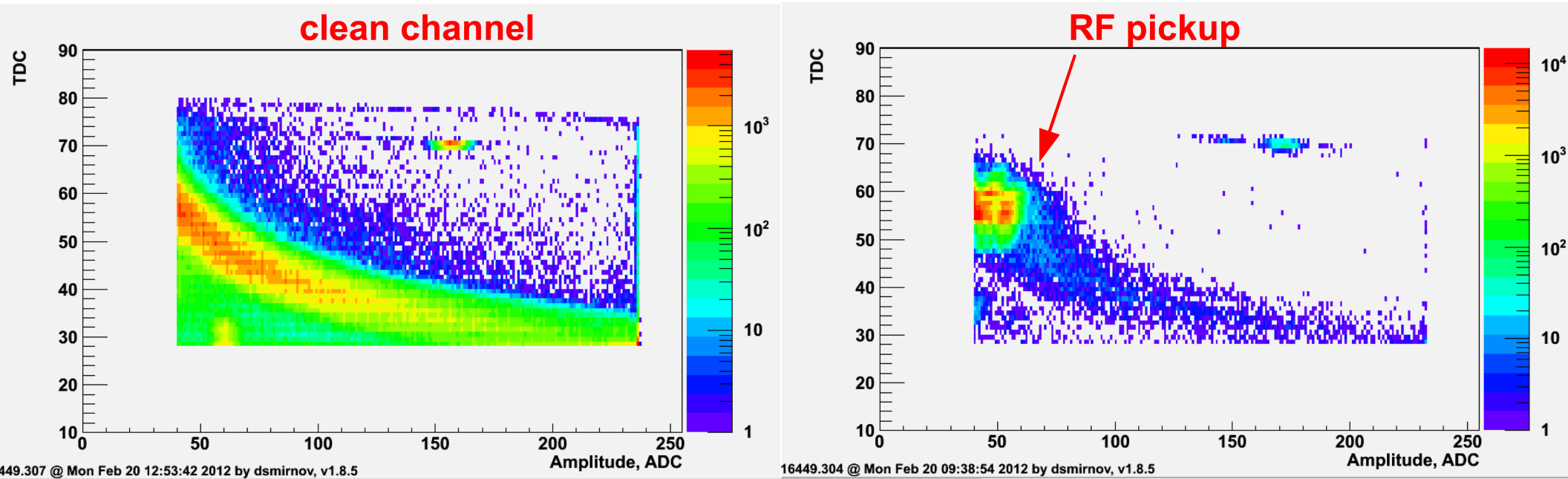<u>Plans: Run13 & beyond</u>
<u>Developments analysis & results:</u>

- P(t), R(t) etc.
- TOF based pC analysis
- measure C E-loss in target

<u>Note:</u>
Emphasis here on pC;
H-jet progress, plans
as noted

RF pickup: the problem

- TOF vs. Ekin. for scattered ^{12}C nuclei ('banana plot'):

- Associated with: proton bunches (i.e. RF from beam EM pulse),
      200 MHz voltage, stoch. cool. pickup pad position
- Severity varied from measurement to measurement;
      most problems in Yel polarim. (near stoch. cool. pickup)
- Varying amounts of noise seen on scope
- P measurement feasible w/ noisy channel exclusion
- 'Fixes' attempted, much improved after 14.3 maint. day (100→255GeV)
- Likely causes: RF 'leaking' from stoch. cool. pickup
      & inadequate grounding/shielding in polarim. electronics

Stochastic cooling pickup: cable
(maint. day 14.03.12)

- Yel stochastic cooling pickup signal cable (twisted pair) removed and feedthrough terminated (M. Brennan)

- After this sharp drop in # bad chan.:

#chan. excluded vs. fill

Y1D store
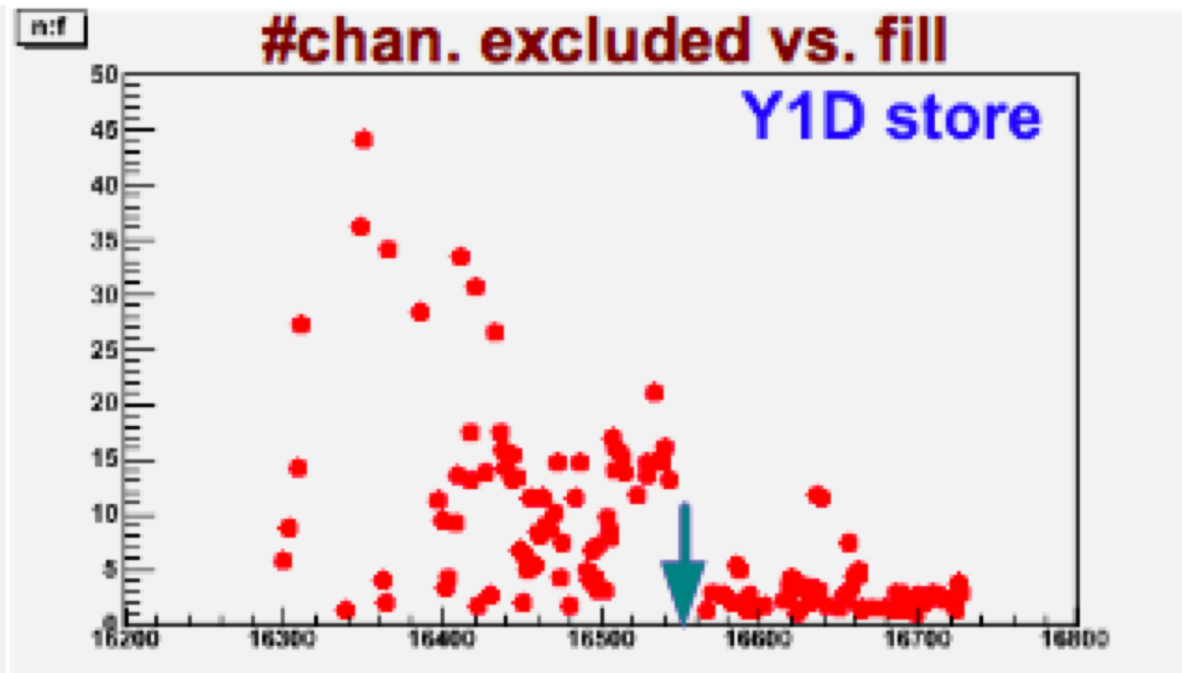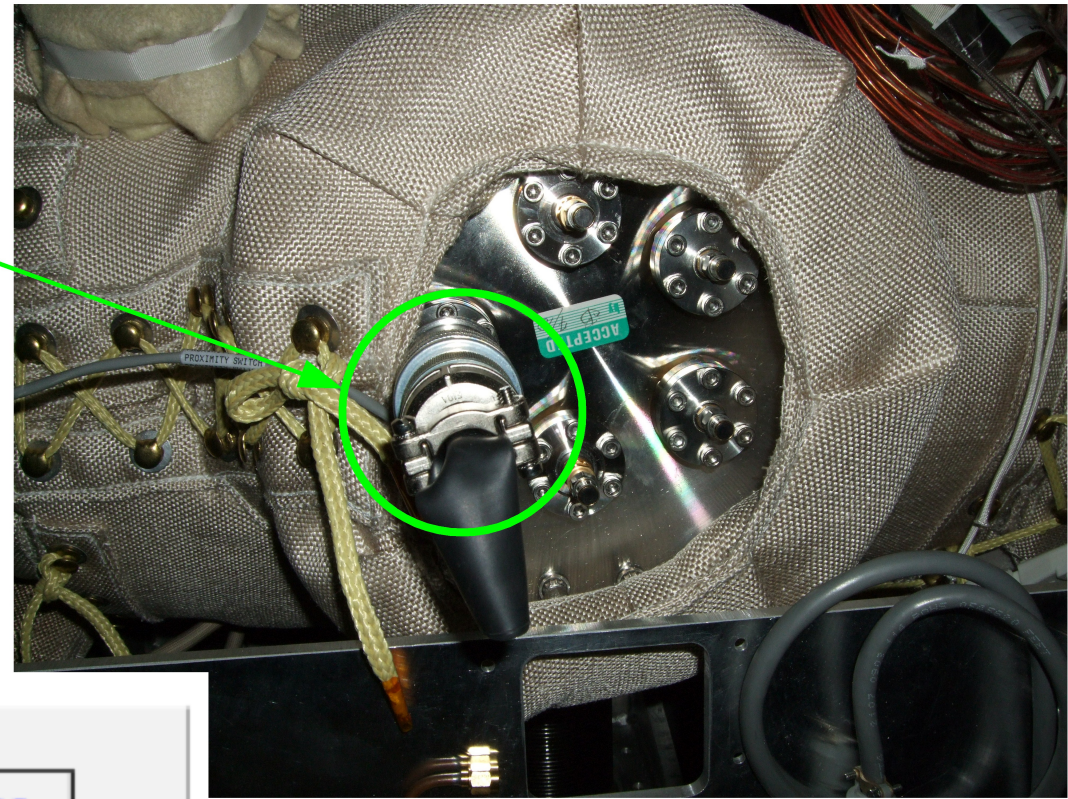
Stochastic cooling pickup: cable

- Subsequently: reattached / removed cable
- Checks on scope w/ beam: noise reappeared / disappeared

SEEMS THIS WAS THE MAJOR SOURCE OF OUR PROBLEMS

For shutdown / start Run13
- Close coordination with RF group on possible RF sources, remedies:
    ground/terminate/plug all 'holes' in Yel stoch. pickup
     as much as possible consistent w/ polarized-p operation
- Antenna to monitor external RF?

While diagnosing the problem:
- On our side found several weak points in polarim. shielding/grounding
- Steps to address main points for Run13 ↘

Electronics: preamp boxes

- Early attempt: back side of boxes (away from chamber) wrapped with Al foil
- No apparent help (still huge RF from stoch. pickup cable...)

- Later: front side of boxes (near chamber) wrapped with Al foil
- With applied RF clear reduction of RF seen on scope especially near connector hole, flange
- Confirmed in test bench setup

- Subsequently found: new power connectors on boxes (new Run12) were not properly grounded
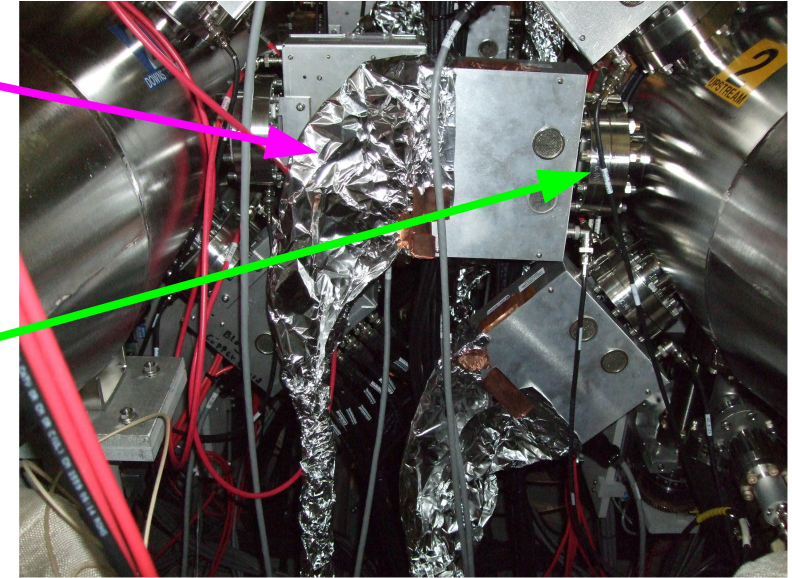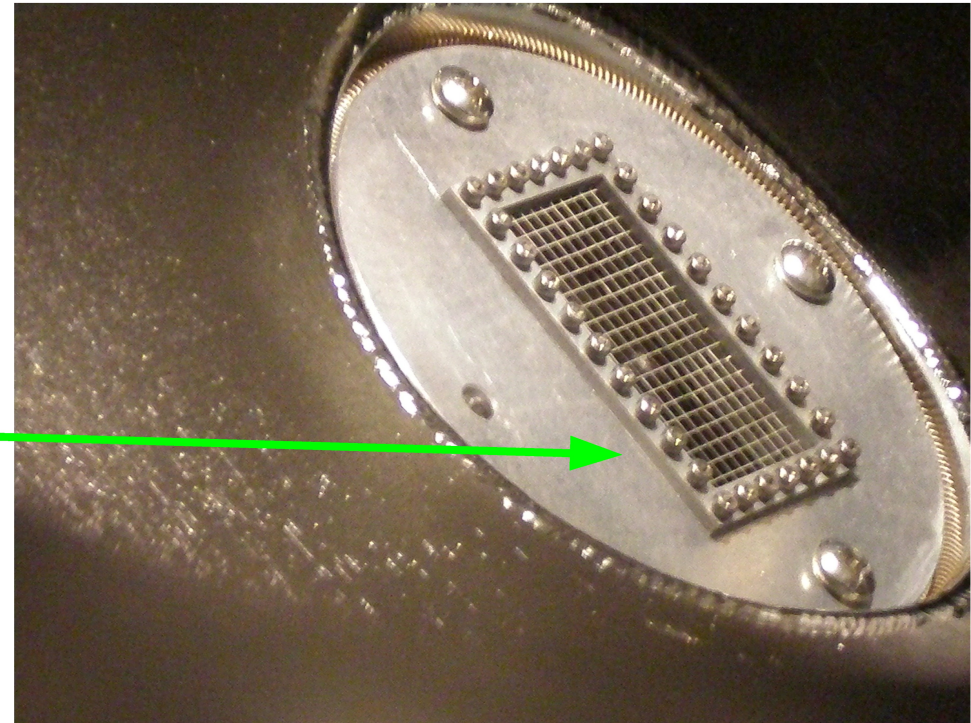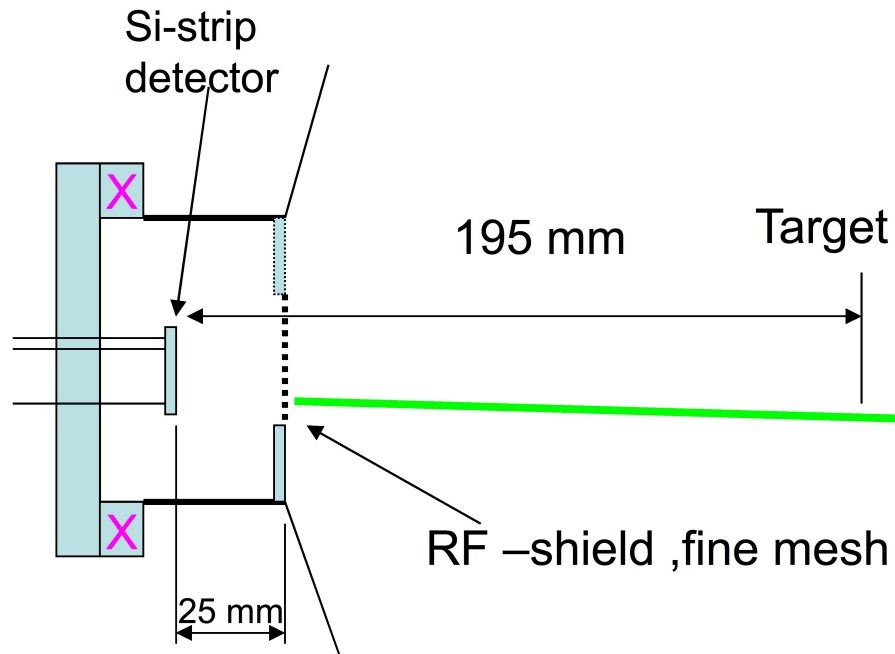
Work for shutdown:
- Complete mechanical redesign of box (not electronics)
- Proper attention to shielding & grounding, connector holes, …

Detector environment: RF screens

- RF screens cover hole scat. chamber → detector port:

Si-strip detector

X

X

195 mm

Target

RF –shield ,fine mesh

25 mm

- Attempts on maint. days (some det.):
  - screen→detector spacing maximized (port extenders X)
  - new tungsten screens installed
  - ⇒ checks on scope indicate reduced RF pickup
- Ongoing: test bench setup gives good comparison of relative merits of different screens: composition, wire size, spacing...
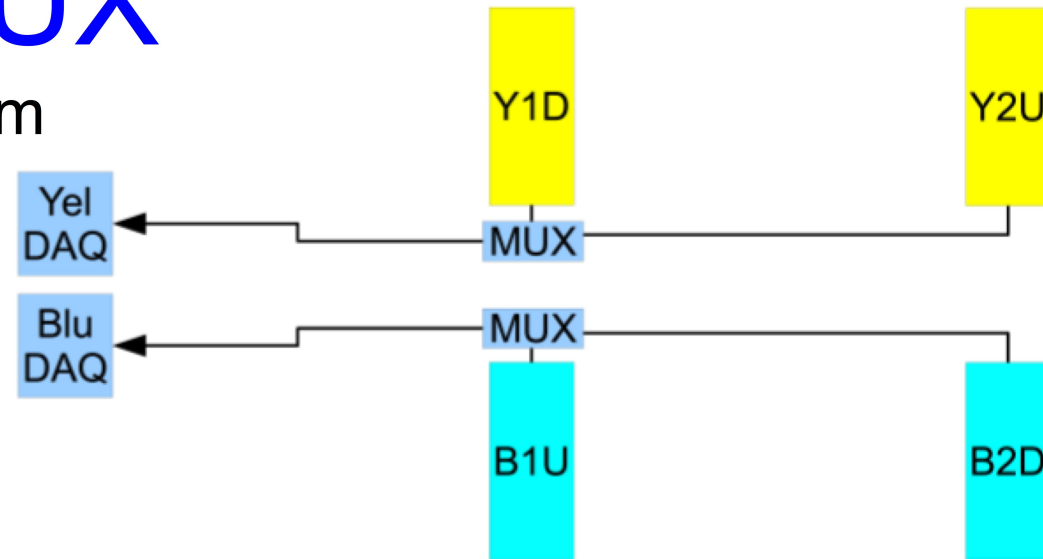
Work for shutdown:
- Apply best knowledge from bench tests; new screens
- Perhaps: space back all detectors?

MUX

- MUX switches DAQ up/downstream polarimeters each ring:
- MUX in tunnel next to polarim.

- MUX circuit diagram show inactive chan. are open circuit

- MUX housing found not grounded; grounded to polarim. frame 14.03.12

- No definitive evidence MUX is source of RF pickup, but suspicious...
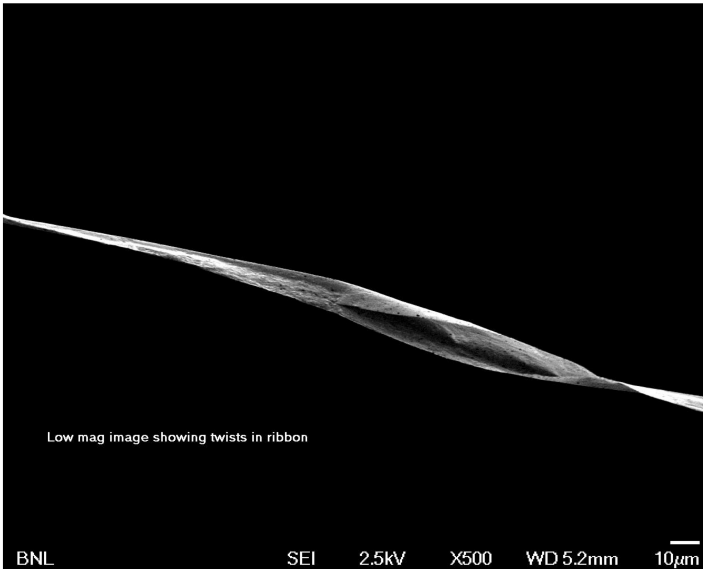
 Possibilities for shutdown work:
- Replace MUX circuit boards so inactive chan. are *not* open circuit
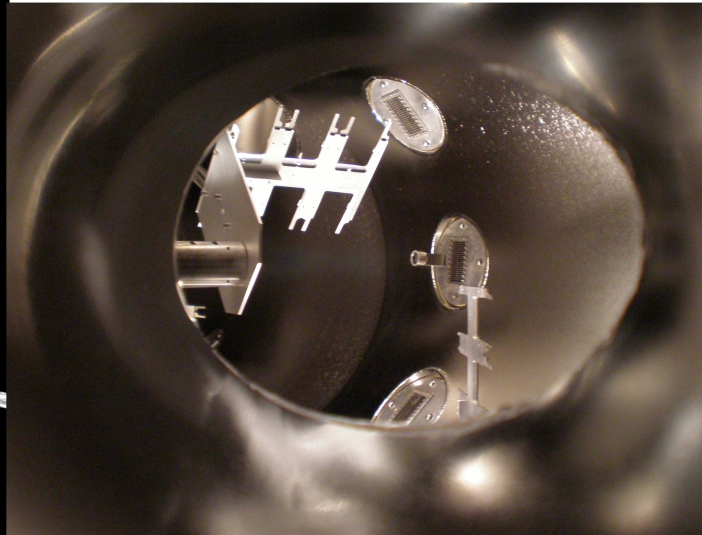 More ambitious:
- MUX electrics broke down twice, requiring tunnel access
- Move MUX tunnel→near counting room solves both problems: no RF near counting room, accessible for maintenance
- Requires ~150 signal cables from tunnel→near counting room

Carbon ribbon targets

in the lab: **in the chamber:**   **in the beam:**

Low mag image showing twists in ribbon

BNL   SEI   2.5kV   X500   WD 5.2mm   10μm

<u>Run12 unprecedented mortality rate:</u>
- Required 2 long accesses for replacement (~8 hr):
  - slow venting of scattering chamber
  - target ladder exchange (delicate)
  - slow pumpdown (slow to avoid 'breezes' breaking targets)
- Also: when target inventory low, reduced
  # P measurements to survive

<u>Efforts to improve:</u>
- Run12 history & observations
- Conventional target studies
- Alternative technologies

Run12 target history

- Dimensions 25mm x 10μ x 27nm
- Made by evaporating Carbon
- 48 targets (12 in each polarim., 6 H & 6 V)
- Initially installed Nov. 2011
- Targets dying...
- 42 of 48 targets replaced 03/14/2012
    during energy change 100$\rightarrow$255 GeV
- Targets dying...
- All 48 replaced 04/11/2012 during
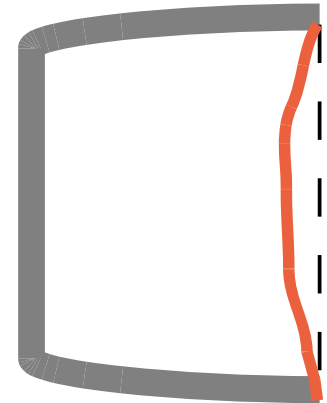   extended maintenance day.

Targets before/after beam

D. Steski

Before exposure to Beam

- Targets are mounted tight on frame
- Resistance between 200 MΩ and 800 MΩ*
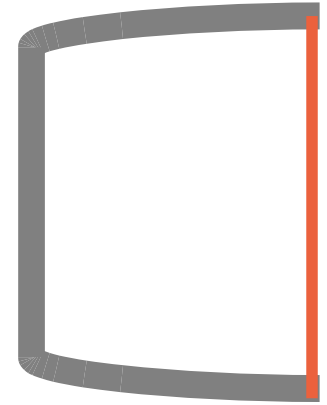
After exposure to Beam

- Survived targets become loose on frame**
- Resistance <1MΩ
- Broken targets usually not recovered
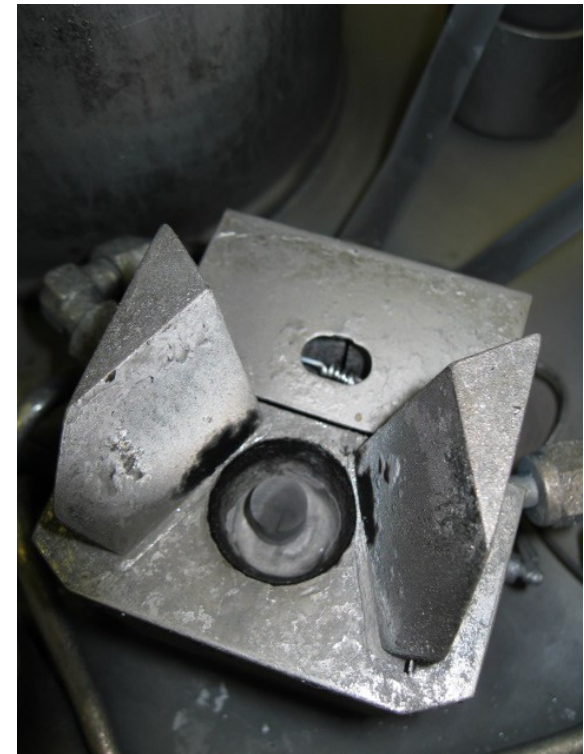
* Calculated for amorphous carbon: resistance ~3MΩ

**observe similar effect when tandem foils are conditioned with beam

Attempts to pre-condition targets (decrease R)

D. Steski

Electron Beam

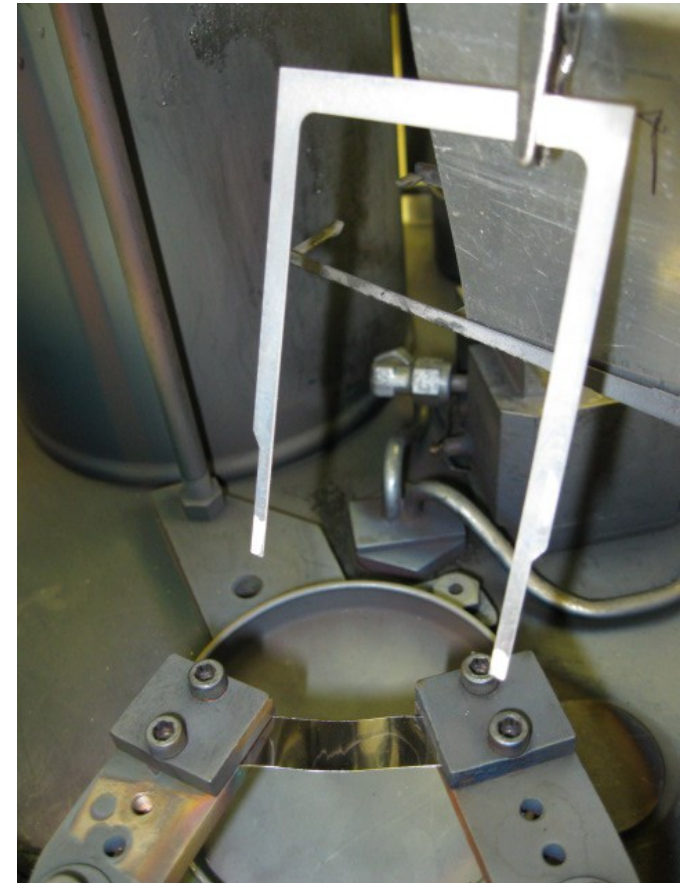- 10μA, 5kV electron beam
- Exposure 5 minutes
- Only 1 target out of 10 survived
- Surviving target had a resistance
  of ~4MΩ
- Too low survival rate...

Bake in Vacuum

D. Steski

- Tungsten strip heated by up to 150 Amps
- Targets become very brittle and broken during venting
- Inconclusive if lowered resistance
- Too low survival rate

Flashing Foils

D. Steski

- Ordinary camera flash
- Known conditioning method for tandem foils but replaced by conditioning in situ with beam
- For AGS targets (75-250μ wide) after flashing resistance <1MΩ
- Multiple flashes required
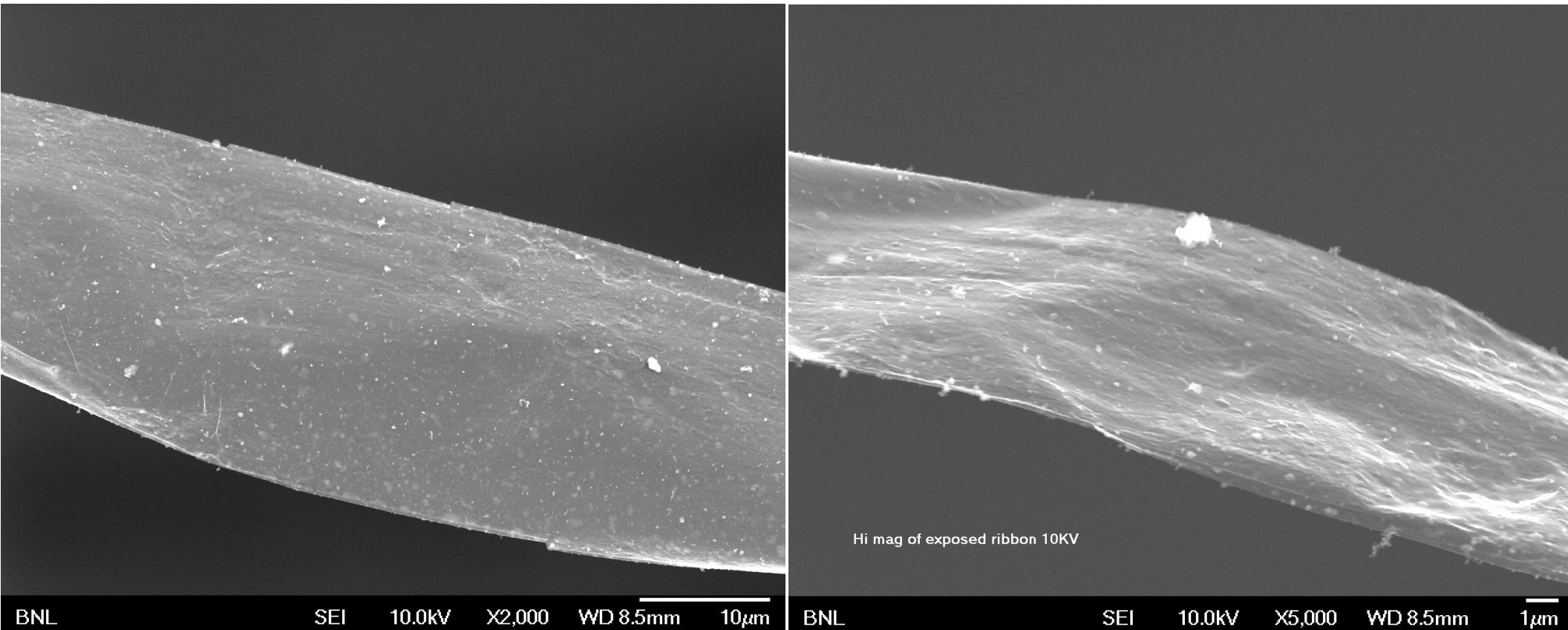- No effect on R for RHIC width (10μ) targets, not clear why...

Ongoing Tests, Developments

D. Steski

- More intense camera flash to condition RHIC targets
- Use of flash lamp to condition targets
- Direct use of laser to condition targets
- Test target strength electrostatically: Cu rod & applied V
- Can the target conditions in RHIC be
  simulated at the Tandem using Au beam? Checking #'s...
- Perhaps can condition targets w/ Tandem Au beam

Ongoing Developments

- Collaboration with Instrumentation group to understand the Carbon structure of targets
- SEM: exposed targets may be more wrinkled than unexposed:

Hi mag of exposed ribbon 10KV

BNL SEI 10.0kV X2,000 WD 8.5mm 10μm

BNL SEI 10.0kV X5,000 WD 8.5mm 1μm

- TEM: will investigate crystal structure: amorphous C, graphite, ...?

Alternative target technologies

- Collaboration with Instrumentation group for RHIC targets
    made of graphene (J. Warren)
- Contact with local nano-tech firm for RHIC targets
    made of graphene (V. Ranjbar → Graphene Laboratories)
- Graphene Labs has experience from solar cells development,
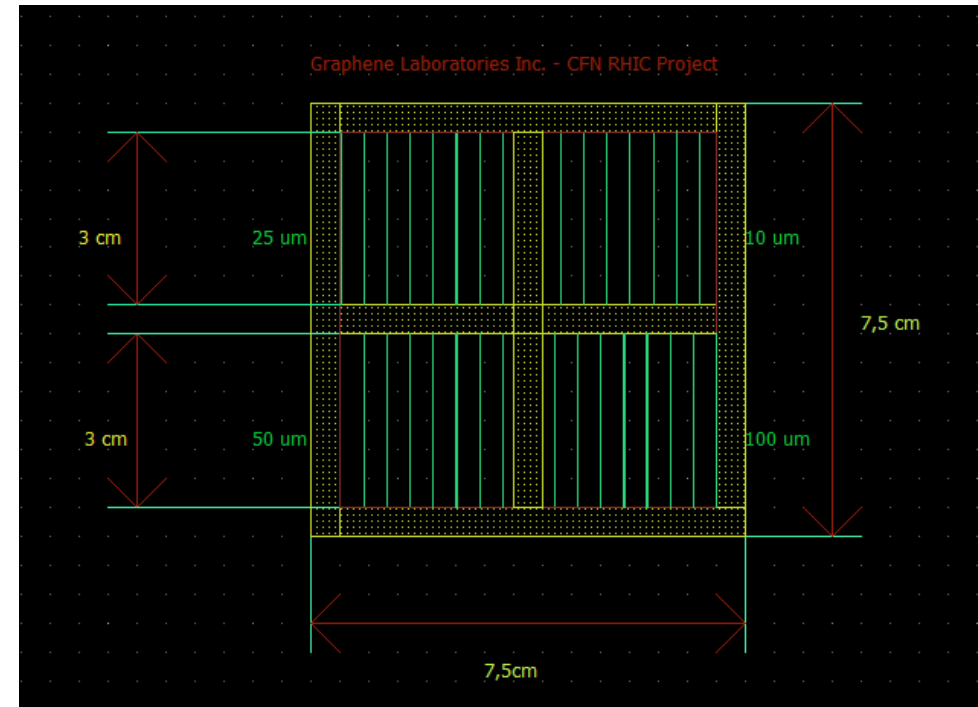 chemical vapor deposition (CVD) graphene layers on Ni film:

- Seems feasible to get
  desired thickness:

  25 nm ~ 70 graphene layers
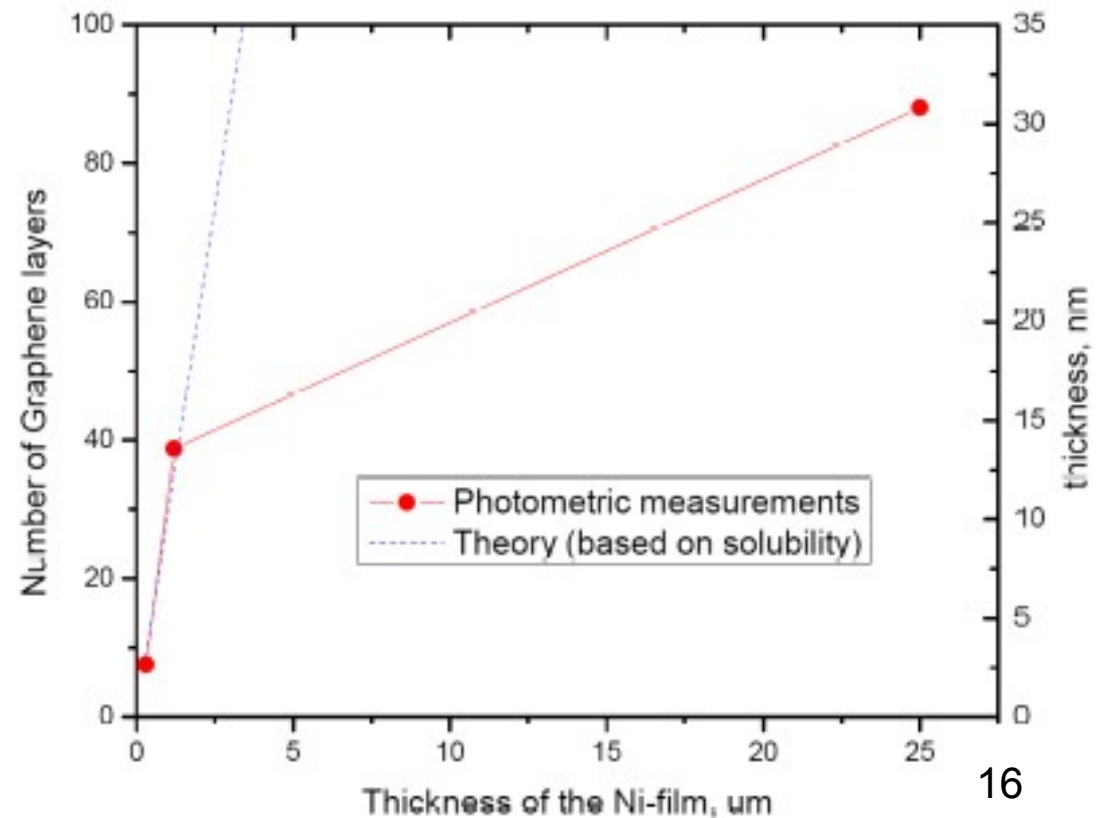
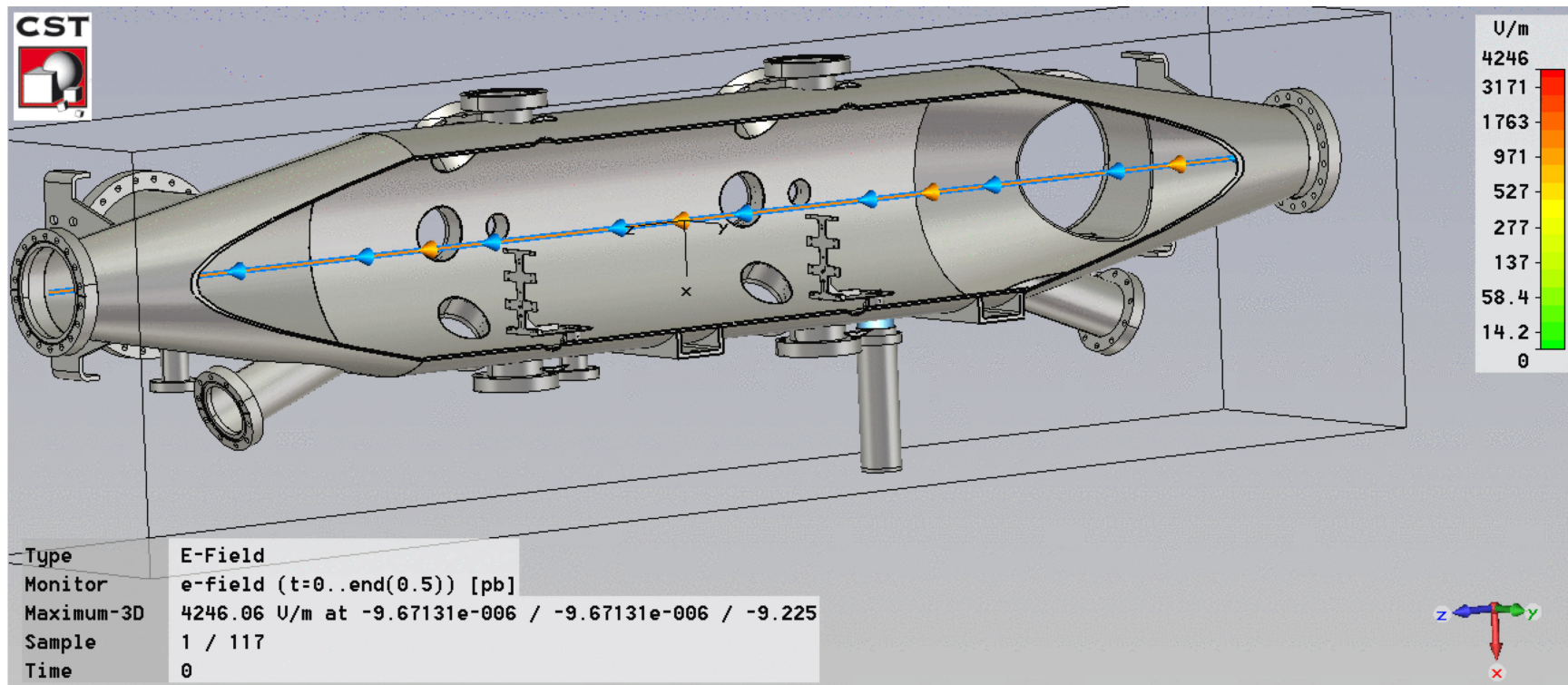# Alternative target technologies

- Graphene Labs using facilities @
  Center for Functional Nanomaterials
- E.g. for next tests, photomask
  for graphene patterning:
- Graphene Labs should provide
  some targets for Run13

- Two efforts toward graphene targets...
- Alternatives to carbon??? No ideas yet...

EM modeling of scat. chamber

- Started by M. Brennan:

Type	E-Field
Monitor	e-field (t=0..end(0.5)) [pb]
Maximum-3D	4246.06 U/m at -9.67131e-006 / -9.67131e-006 / -9.225
Sample	1 / 117
Time	0

- Continuing: 3D mech. model (G. Mahler)
  → micro-studio EM simulation (J. Kewisch)
- May lend insight:
  - sources of RF pickup
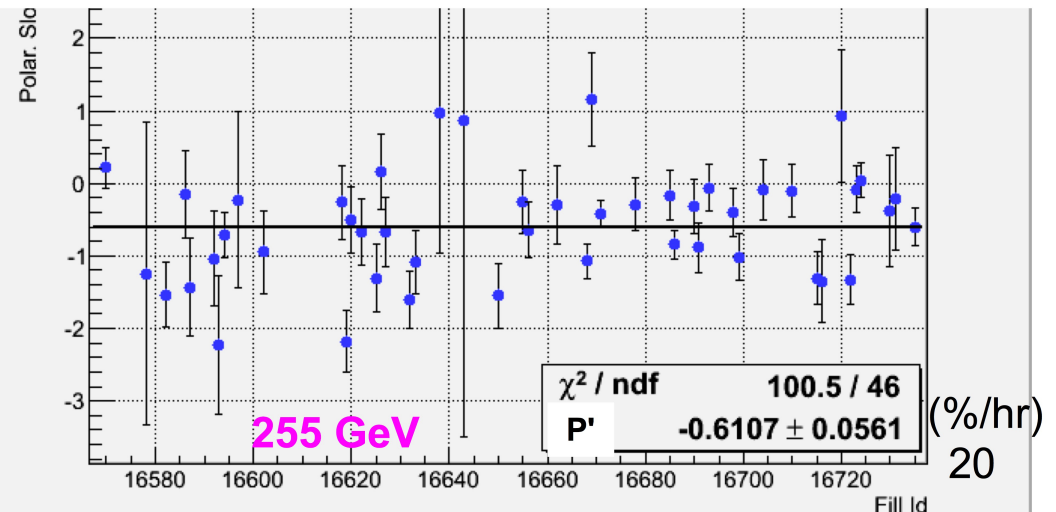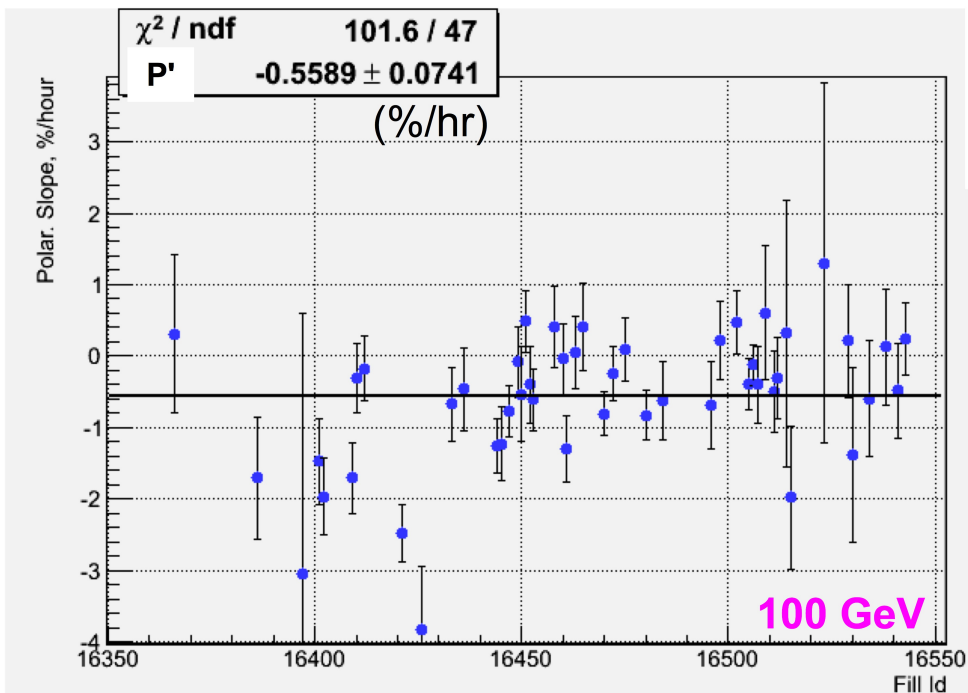 - EM stresses on targets
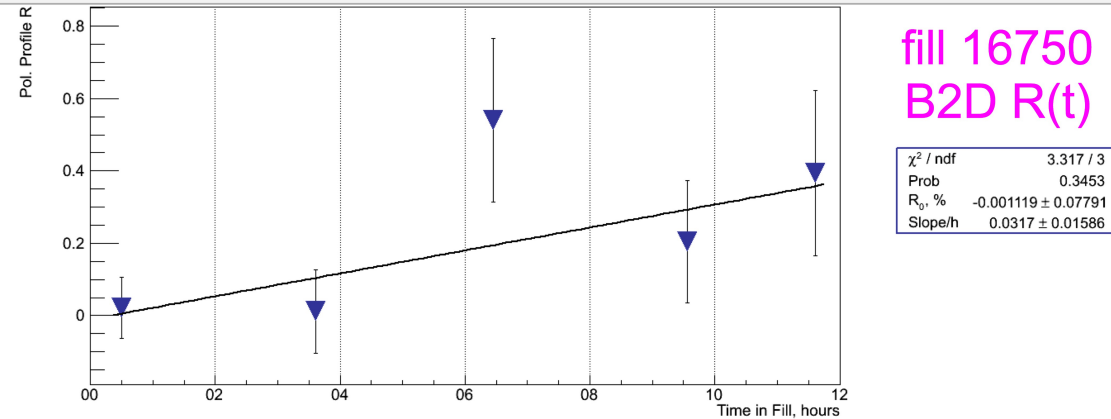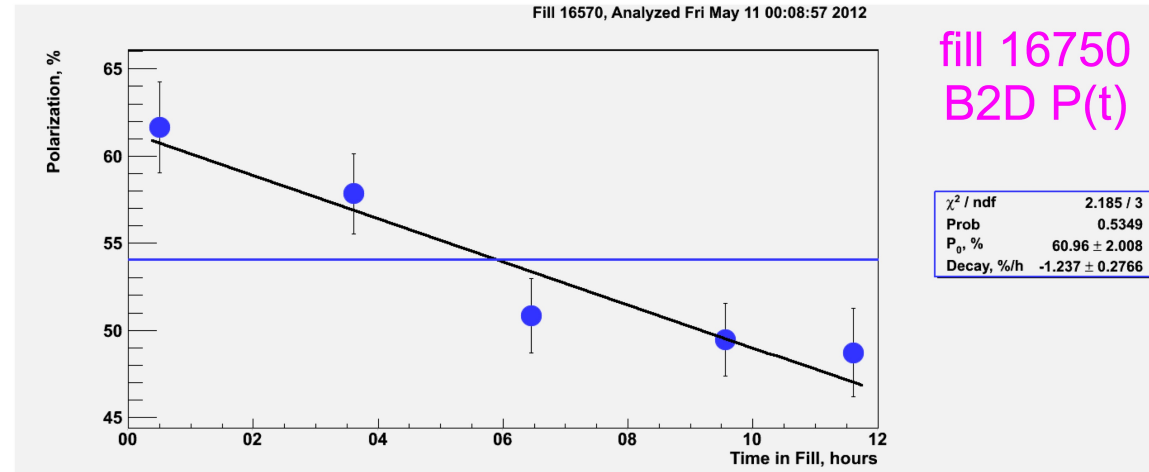
Run13 & beyond

Run13:
- No major changes beyond shielding & target efforts
- One change: will use BNL 1mm detectors all RHIC pC
  - one pair tested Run12, OK
  - may install long. segmented pairs again
    (motivation in later slides)

Possible future DAQ upgrade:
- Our DAQ is >10 yr. old Yale CAMAC WFDs (400 MHz, 8 bit)
- OK so far, but aging...
- Investigating: JLAB VME WFDs (250 MHz, 12 bit)
- Tested during Run12: in AGS & RHIC pC polarim.; RHIC H-jet
- Only waveforms read out, data looks useful
- T-reconstruction tested w/ waveforms;
  σ_T~1nS appears possible, adequate, slower sample rate not problem
- Would be good replacement for the longer term
- Latest cost estimate from JLAB: ~5k$ / 16-chan. module
  22 modules to replace H-jet/AGS/RHIC pC (w/ MUX; 32 w/o MUX)

New polar. results: P(t), R(t), ...

- Now for each fill param.:

$$P(t) \approx P_0 - P'\cdot t$$

$$R(t) \approx R_0 + R'\cdot t \quad \text{(profile param.)}$$

- And for experiments:

$$P_{SSA} \approx (1+ \tfrac{1}{2} R) P$$

- Important: not all physics data collected uniformly thru fills
- Nice data set, e.g. P` all fills:

Fill 16570, Analyzed Fri May 11 00:08:57 2012

fill 16750 B2D P(t)

χ^2 / ndf	2.185 / 3
Prob	0.5349
P_0, %	60.96 ± 2.008
Decay, %/h	-1.237 ± 0.2766

fill 16750 B2D R(t)

χ^2 / ndf	3.317 / 3
Prob	0.3453
R_0, %	-0.001119 ± 0.07791
Slope/h	0.0317 ± 0.01586

χ^2 / ndf	101.6 / 47
P'	-0.5589 ± 0.0741

(%/hr)

100 GeV

255 GeV

| χ^2 / ndf	100.5 / 46
P'	-0.6107 ± 0.0561

(%/hr)

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TOF based pC analysis

- To date all pC measurements based on carbon energy measured in Si detector
- Uncertainties e.g. dead layer $\Rightarrow$ uncertain E-scale, stability, ...
- <u>New:</u> pure TOF based measure, minimal dependence on Si E
- Diff. dist. $dN/dt \propto (1/t^3) \exp(-\beta/t^2)$ has a peak t_{max} & determines beam $\times$ing time t_0

- Shows stability to ~nS level, here e.g. t_{max} through Run12:

- Still in development; promising as check of or replacement for Si energy measurement...
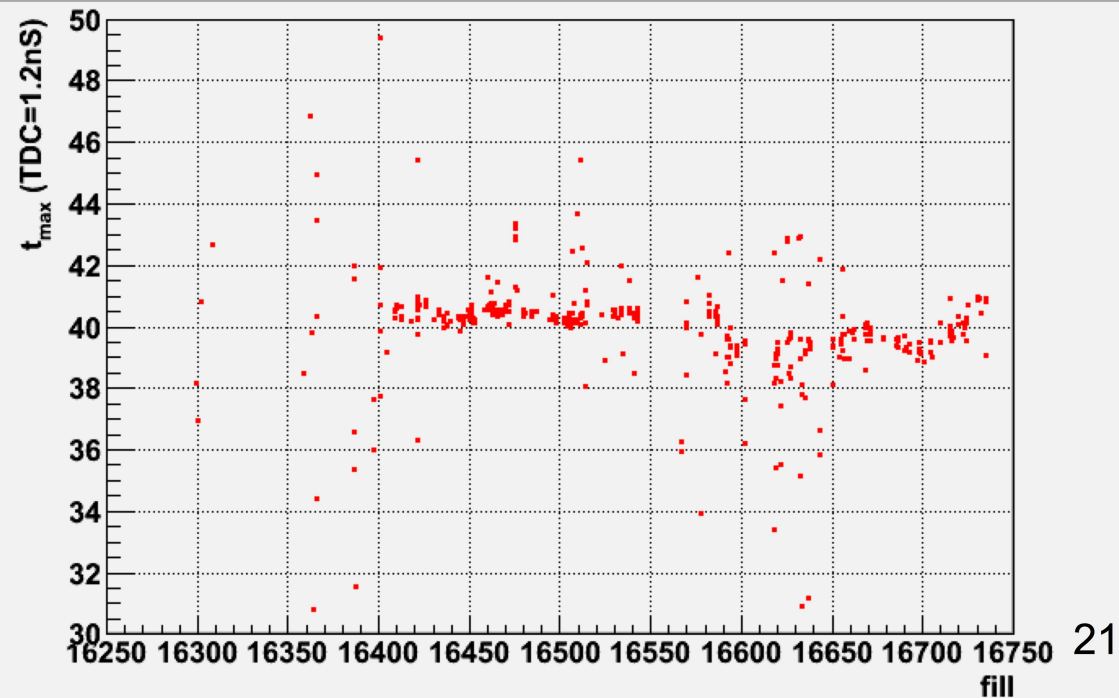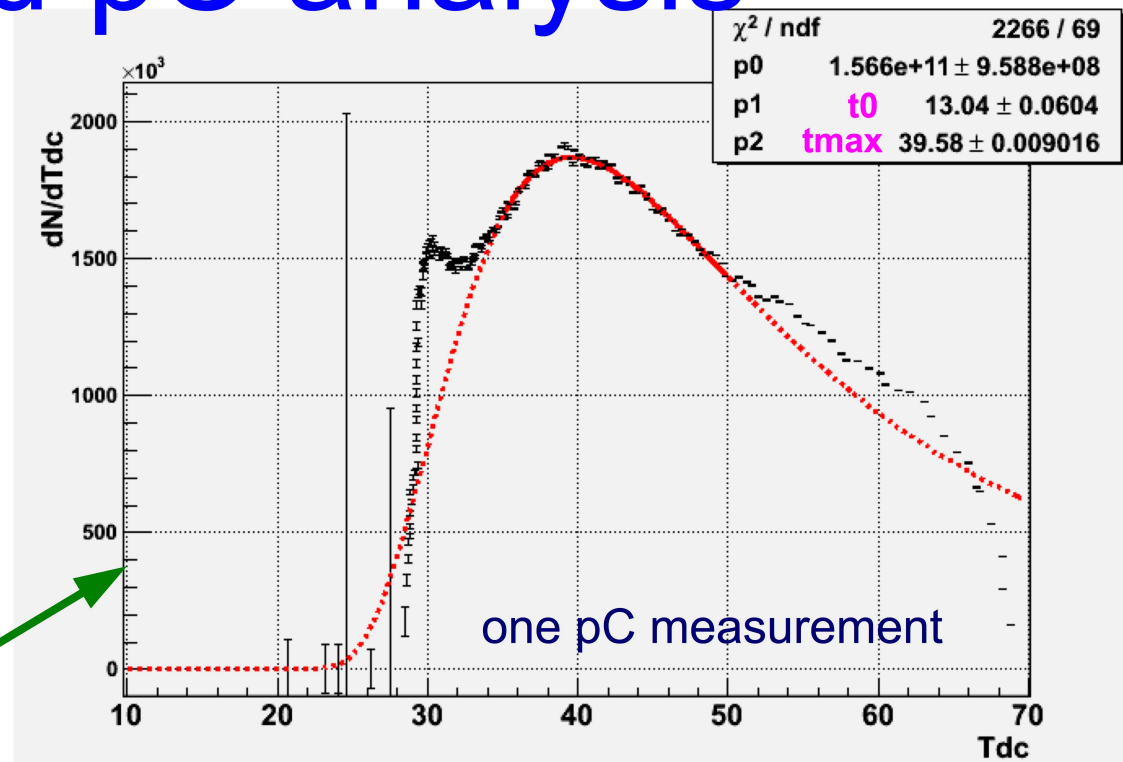
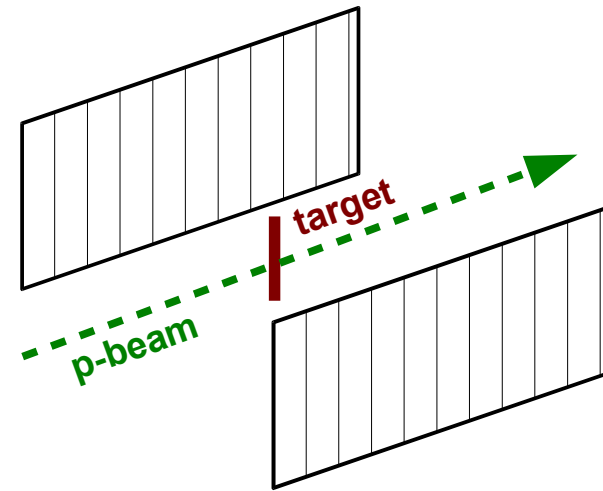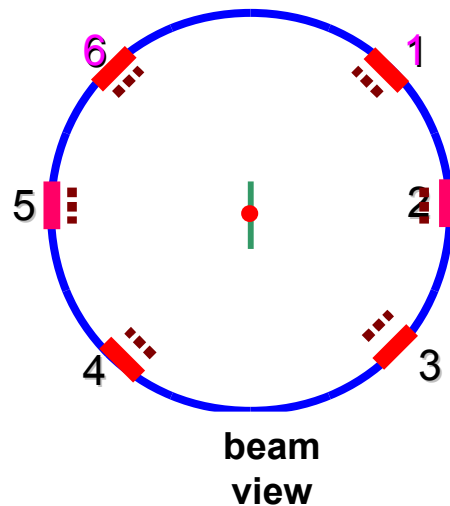one pC measurement

Target → A_N instability

- Longtime a concern: target mechanical instability ⇒ P measurement
  target instability clear from movies made end Run12: 'dancing targets'
- The problem:
  - as targets move, Carbon nuclei pass thru varying amounts
    of target material en route to detectors
  - they lose varying amounts through dE/dx: $E_{scat} \rightarrow E_{det}$
  - fixed meas. E_{det} range ⇒ varying E_{scat} range
  - A_N depends steeply on E_{scat}
    ⇒ instabilities in P measurement
- Sensitive to amount of material traversed:
  multiple coulomb scattering
- azimuthal distribution ~uniform,
  but longitudinal distribution peaked ~90°
- RMS of long. dist. $\propto \sqrt{L}$, L = material length
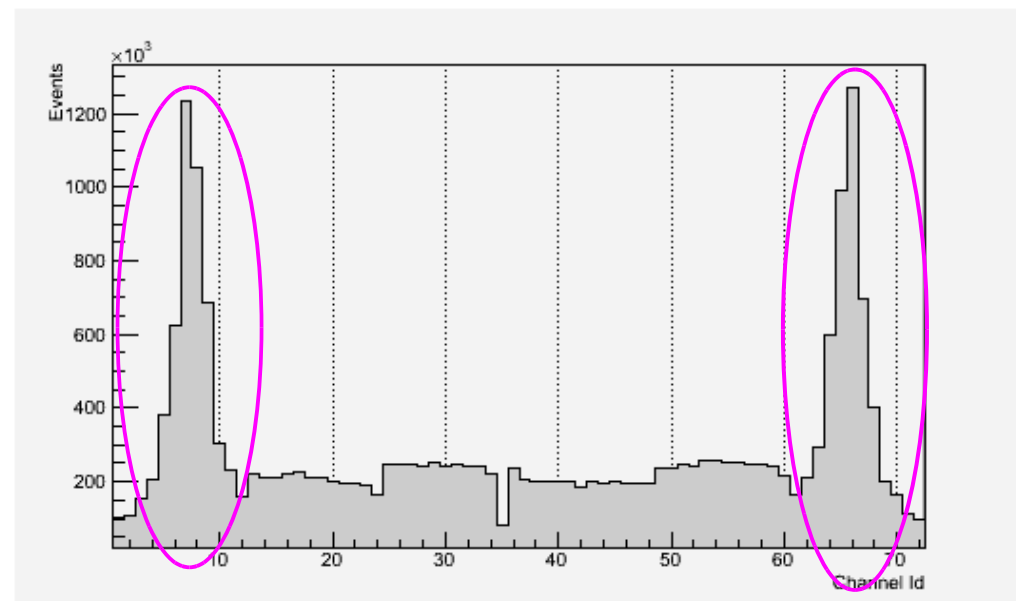 here L=(1-9)×25 nm
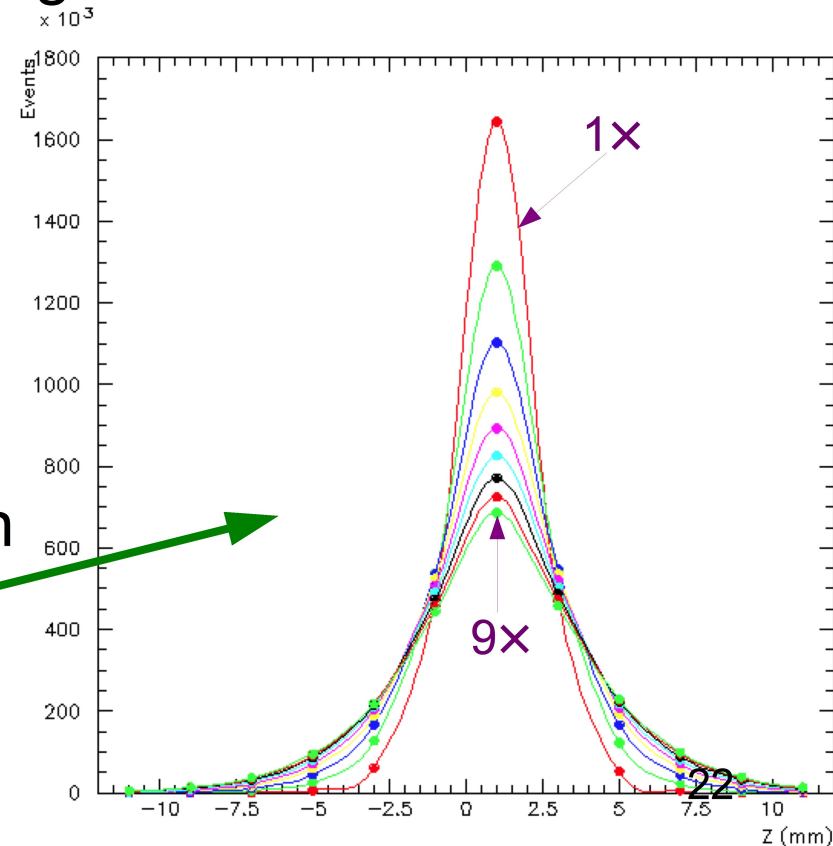
Long. segmented detectors

- Most RHIC pC detectors segmented azimuthally; for Run12: two detectors (B2D det. 1,6) rotated for longitudinal segmentation:
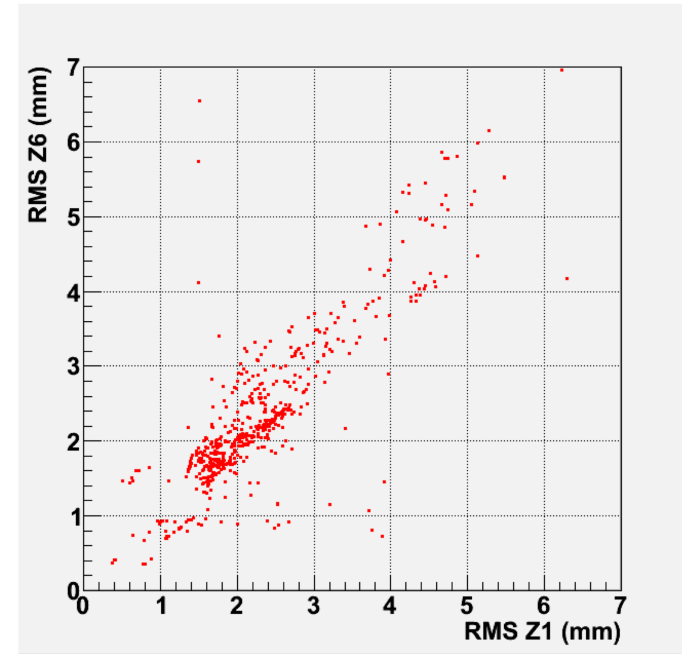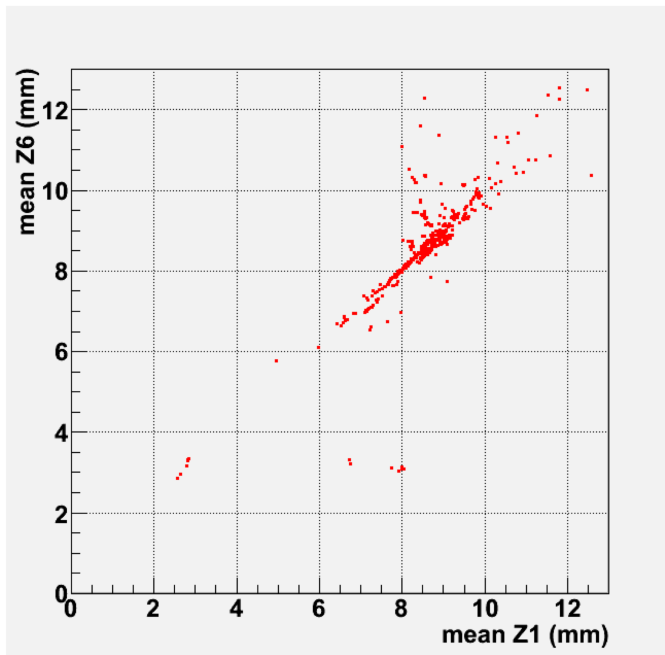

beam view

- Events/strip distribution from one measurement:
- Long. seg. det. are chan. 1-12, 61-72
- Mean → target Z
- RMS → √L

Long. segmented detectors

- All Run12 mean & RMS Z distributions, det. 6 vs. det. 1:

- Mean Z det. 1,6 vs. track
- measure same target Z ✓

- RMS Z det. 1,6 vs. ~track
- measure ~same target material L ✓

- Work in progress: need to check if A_N for these det. tracks RMS Z

- If so: correction to A_N (for P measurement) as function of RMS

- If correction proves helpful:
  - Run13 rotated detector pair all RHIC pC polarim.
  - **may allow use of thicker (stronger) targets w/ larger L...**

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