Supporting PSB commissioning with TbT BPM data

E.H.Maclean, E.Renner, F. Antoniou, F. Asvesta, J. H. Bartosik, C.Bracco, T. Prebibaj
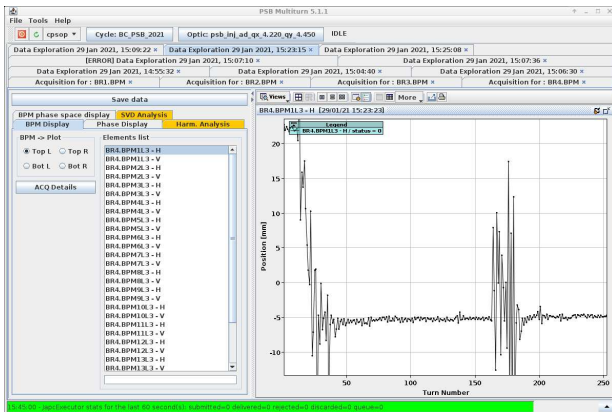
Main activities

- BPM issues
- KSW polarity
- BSW roll
- BSW optimization
- Optics during bump collapse

Since January benifitted significantly from deployment of new Multiturn application
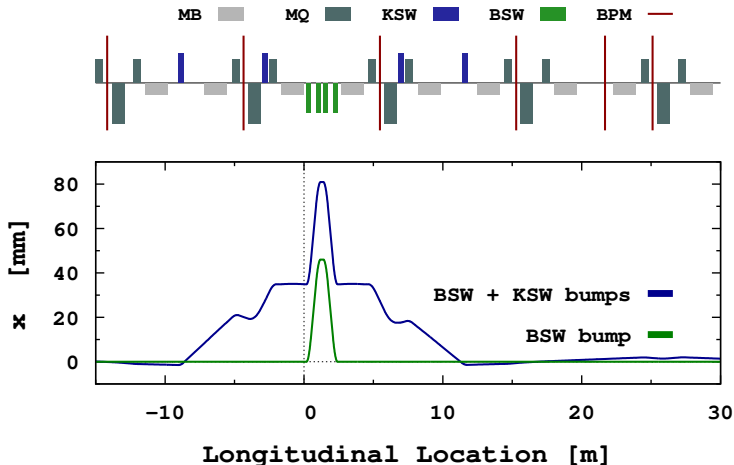
- Big improvement for taking TbT data compared to running / processing / viewing with matlab scripts

Massive thanks to Andrea Calia and collaborators for producing this tool for PSB!

Primary application of TbT data has been helping optimize injection bumps

- Injection Bump (**BSW**) and paining bump (**KSW**)

Primary application of TbT data has been helping optimize injection bumps

- TbT is effective complement to e.g. YASP, given rapid decay of injection bumps → (YASP takes average orbit over 1ms / 1000turns)

- KSW has initial rapid decay, then slow decay over $\sim 1000\,\text{turns}$

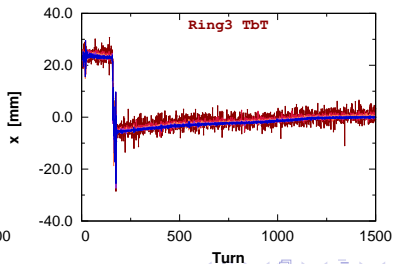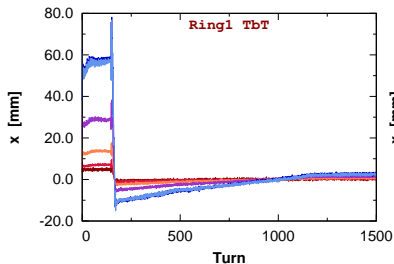- BSW decays over $\sim 5000\,\text{turns}$
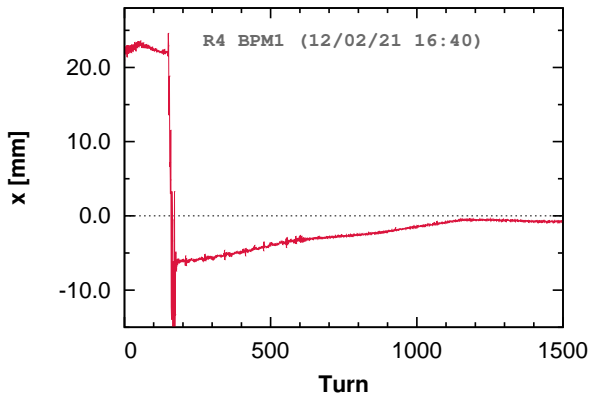
TbT data also been useful for identification of some BPM issues

- **Problem with BPM gain in Ring1 observed in both YASP and TbT early in commissioning period → issue vanished around 05/02, cause unknown**
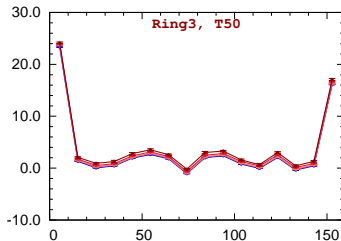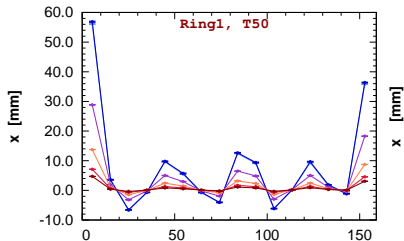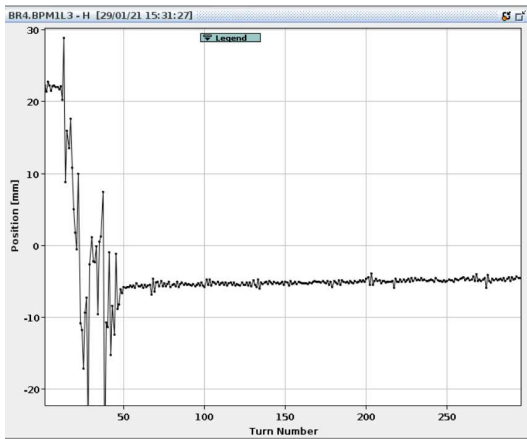
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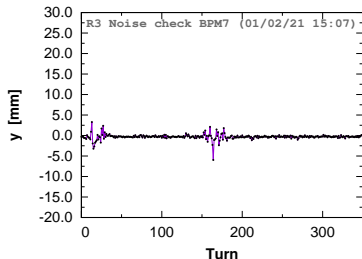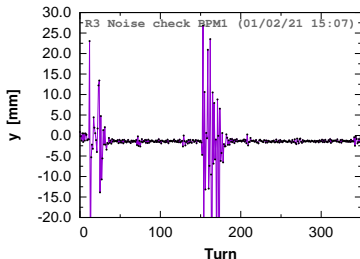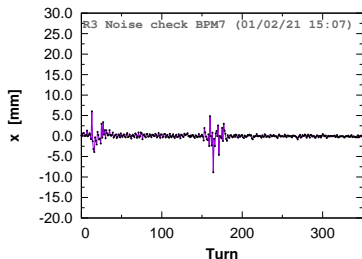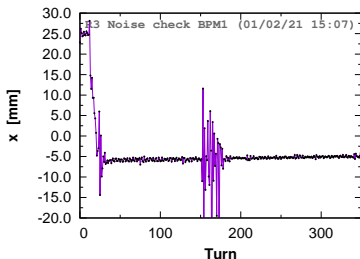- **See extremely noisy signal in TbT data during KSW ramp-down**

TbT data also been useful for identification of some BPM issues

- **Decay of KSW causing noise in the BPMs (also other rings), appears to some extent in all BPMs/Rings → options for shielding being explored**
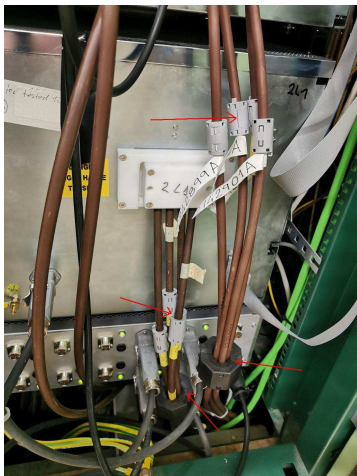
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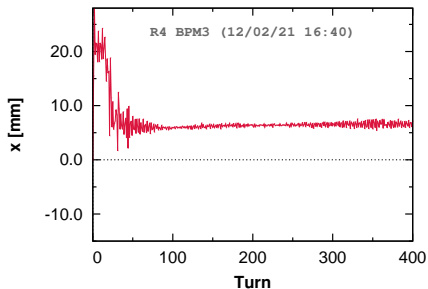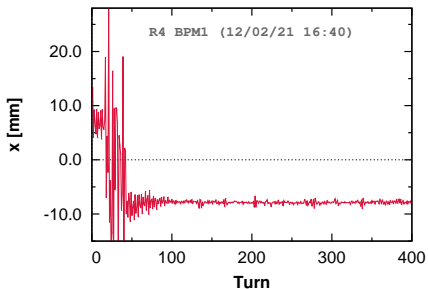

- **Noise on previous plot is after applying Ferrite beads to KSW cables in racks**

- could also consider further cable separation

- noise filtering inside generator
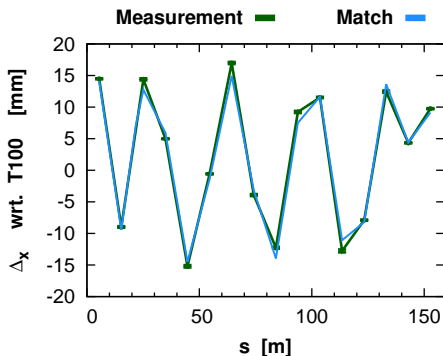
- Courtesy Gregor Grawer and Gian Piero Di Giovanni

TbT data particularly useful for study of KSW bump

- **Observe extremely large leakage of the KSW bump around the ring.**

TbT data particularly useful for study of KSW bump

- Observe extremely large leakage of the KSW bump around the ring.
- Taking difference orbit with respect to T100 see clear orbit wave around ring

Matched values:
KSW1L4 $= -0.0020$
KSW2L1 $= +0.0057$
KSW16L1 $= +0.0066$
KSW16L4 $= -0.0015$

**Nominal values:**
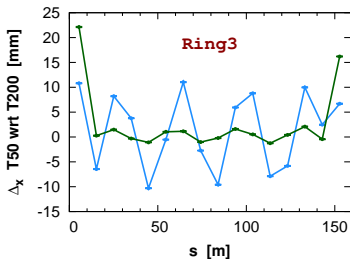KSW1L4 $= +0.0018$
KSW2L1 $= +0.0052$
KSW16L1 $= +0.0060$
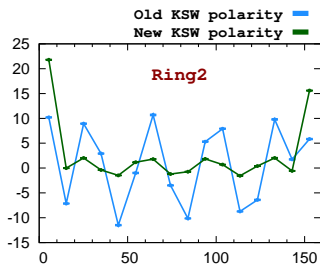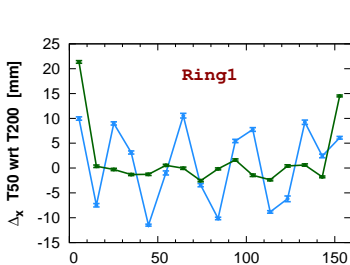KSW16L4 $= +0.0013$

- Matching of orbit wave implies an issue with polarity of 2 KSW

- **Not possible to swap polarity from control room**
- **but tried reducing strength of suspect circuits**
  - $\rightarrow$ showed reduced leakage
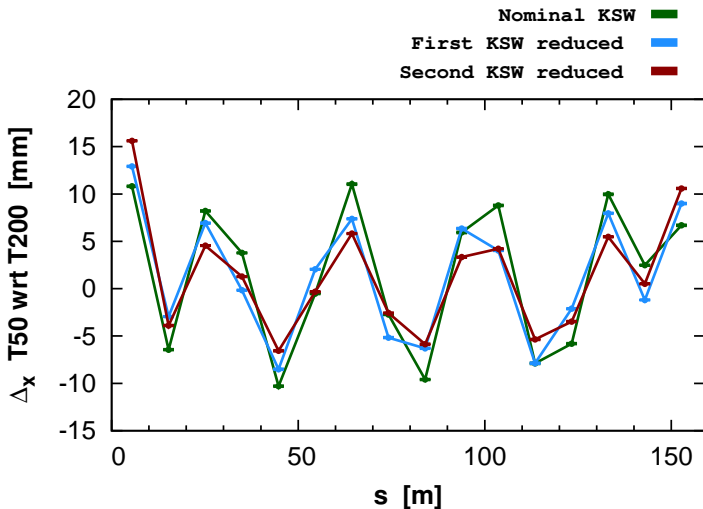
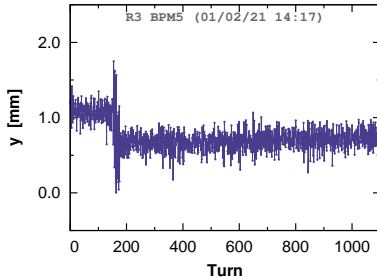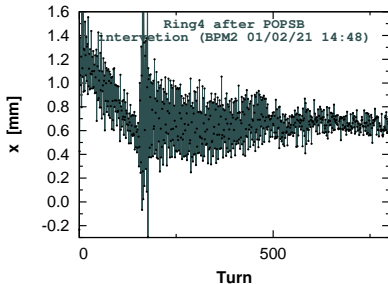- **Motivated intervention in tunnel to check cabling of KSW**
- **Confirmed opposite cabling of KSW1L4/KSW16L4 vs KSW2L1/KSW16L1.**
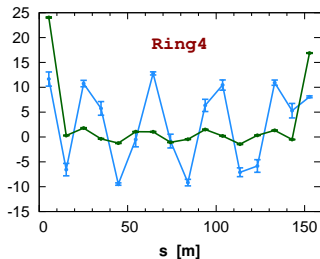
Still some issues to understand with KSW bump

- See decoherence post KSW-decay
- Some residual H-orbit leakage (WP dependent)
- Small V-orbit leakage

- **studies ongoing, but also complicated in first 1000 turns by need to disentangle from effect of BSW decay**

Using TbT data to examing collapse of BSW bump

- **BSW in bump in H plane, collapsing over first 5000 turns**
- **In practice also observe large V orbit change over 5000 turns in Ring2**
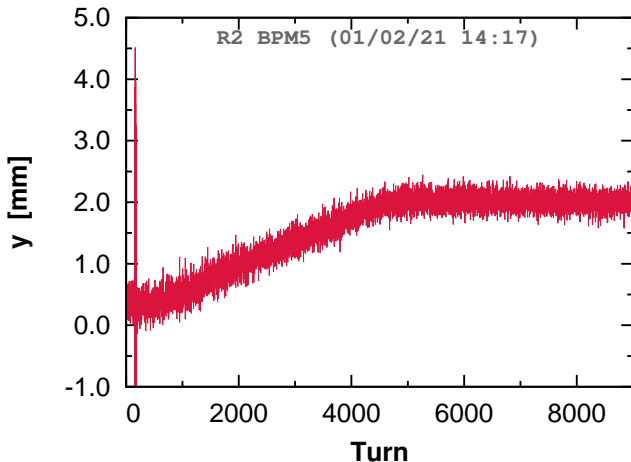
- **vertical leakage is notably worse in Ring2**
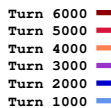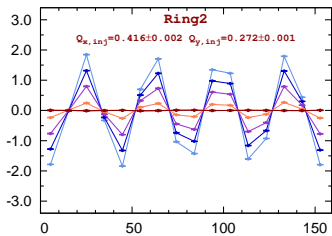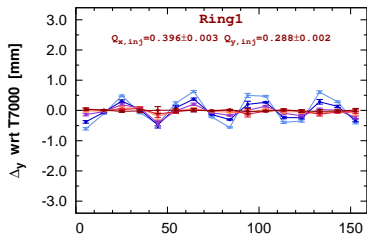
- **V leakage for Ring 2 was equivalent to the H leakage!**
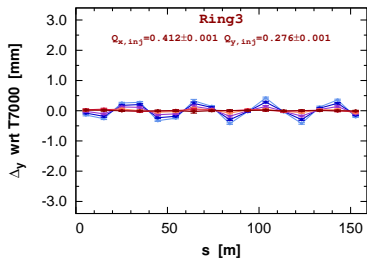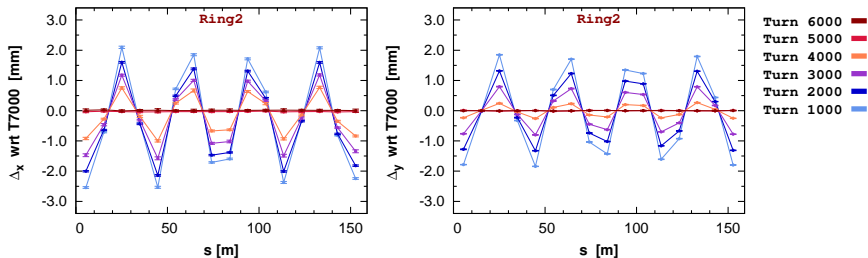

- **Initially considered issue with coupling or BPMs,
  but no visible coupling line in the spectrum from injection oscillations**

Absence of any coupling line suggests 2 likely sources

- **Large roll angle of BSW**
- **Large vertical offset in BSW, causing orbit shift from vertical edge focusing**

■ **Intervention confirmed existance of very large roll errors in BSW of ring2.**

Roll offsets [mrad]

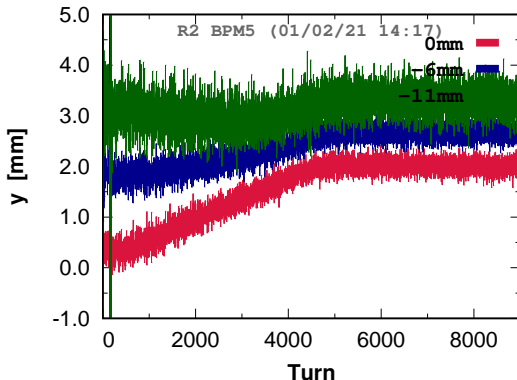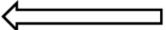| Column					
1L1.4	1L1.3	1L1.2	1L1.1	← BEAM direction	
0.58	0.67	0.52	3.16	BSW4	
-1.20	1.82	1.70	3.36	BSW3	Beam level
-0.68	5.42	5.23	5.35	BSW2	
1.06	3.92	4.83	4.04	BSW1	

Measurement campaign performed by P. Valentin & team (BE-GM-ASG)

Table presented at PSB MPC by G.P. Di Giovanni, B. Mikulecon behalf of the PSB BC Team

https://indico.cern.ch/event/1008209/

■ **Observed magnitude of 5mrad roll angles fits well with value expected from leakage of Ring2**

In practice, precise settings of BSW have gone through several optimizations by ABT → TbT measurements of orbit closure can provide nice cross check

- Settings of BSW 2,3,4 optimized via centering of beam at H0/H- monitor
  injection bump optimizations presented by E.Renner at IPP (21/01/21)
- After optimization of BSW2,3,4 best reproduction of remaining leakage
  obtained with only BSW1 (consistent with YASP anlalysis)
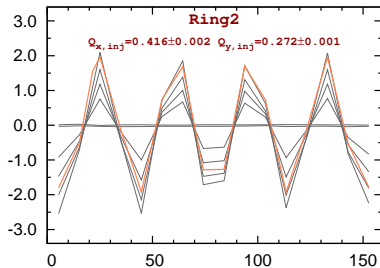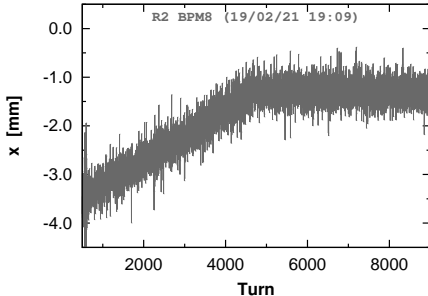
Optimization of BSW1 based upon refined calibration curve significantly improved remaining horizontal orbit leakage during BSW decay
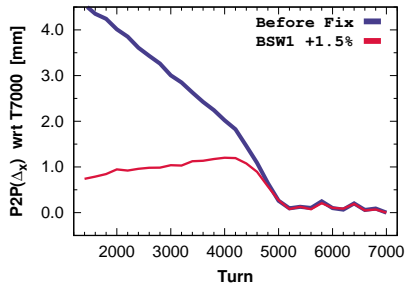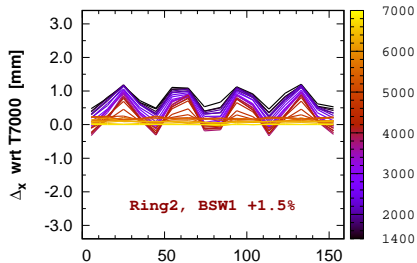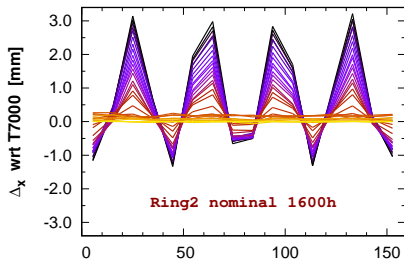
BSW decay slow enough that TbT studies above complementary to YASP

- **TbT also has good application to looking at timing of BSW decay**
- **examine changing injection oscillations vs start time of BSW decay**
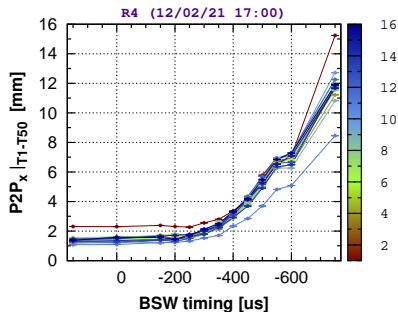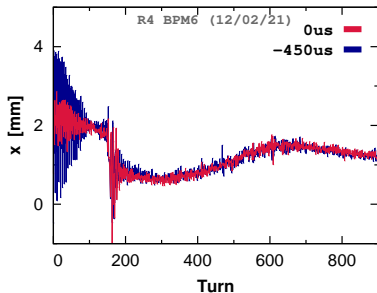
- Confirms with beam no significant global issue with timing of BSW decay due to settings or eddy currents

can also use TbT data look in detail at start/end of BSW decay
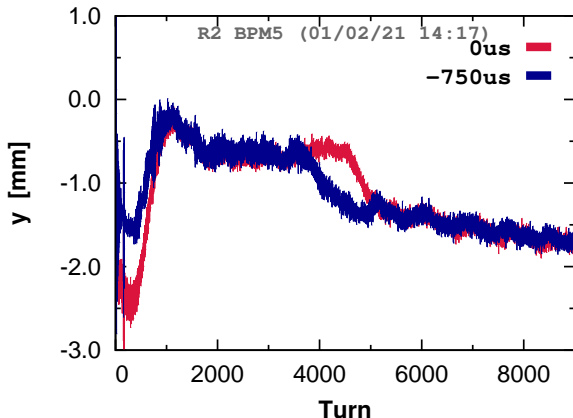
- **Orbit very stable all around ring during body of BSW decay, but see quite rapid changes in the leakage at start and end**
- **similar pattern accross the various rings**

can also use TbT data look in detail at start/end of BSW decay

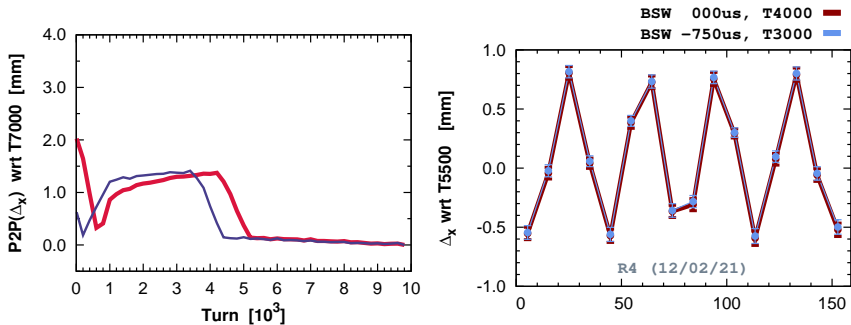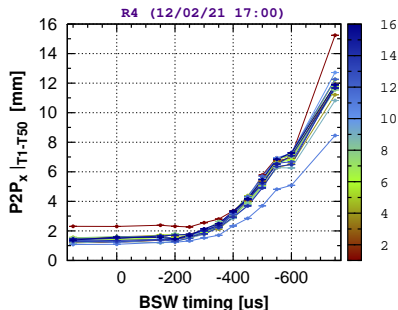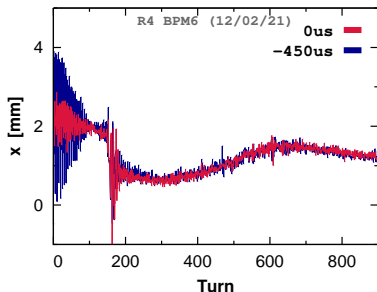- comparing different BSW timings the rapid change of leakage at T5000 can clearly be associated with the BSW decay
- best match to difference orbit obtained with BSW1 (1% of nominal)
- possibly delayed field in BSW1 due to eddy currents

Strategy for optics correction is based upon K-mod measurements

- **Measurements/analysis being performed by Tirsi Prebibaj**
  $\rightarrow$ nice presentation in OMC meeting (10/12/20)
- **TbT optics measurements very challenging due to poor signal/noise**
- Study from varying BSW timing presents interesting opportunity to try and measure optics via injection oscillations $\rightarrow$ although not OP configuration

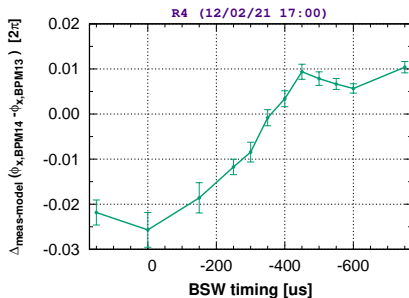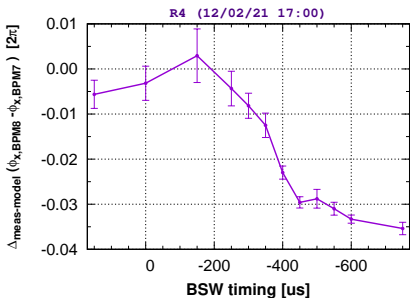**Strategy for optics correction is based upon K-mod measurements**

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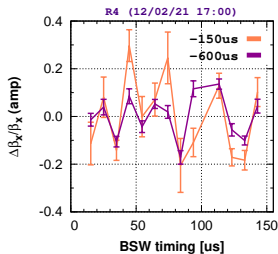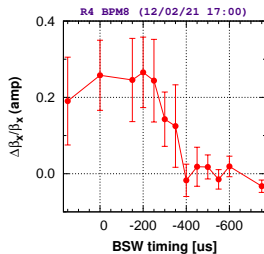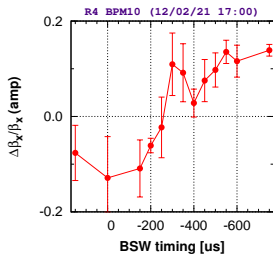
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Conclusions

- **TbT data been very useful for so far for PSB commissioning**
- **Particularly relevant for checks/optimization of KSW and BSW bumps**
  $\rightarrow$ identification of polarity swap in KSW magnets
  $\rightarrow$ roll errors in BSW
  $\rightarrow$ validation / complementary cross-checks to YASP based studies
  $\rightarrow$ BSW timings
- **Some first interesting observations of phase/beta-beating to be followed up with further measurements this week**