Status of the ASTRID2 RF

Jørgen S. Nielsen
Center for Storage Ring Facilities (ISA)
Aarhus University
Denmark

ASTRID2

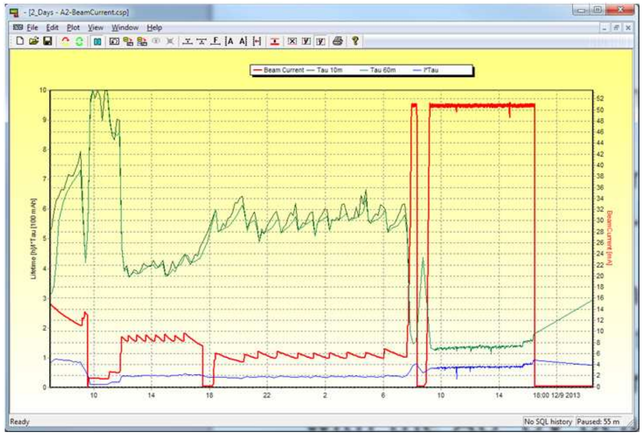
- ASTRID2 is the new synchrotron light source being built in Aarhus, Denmark
- ASTRID2 main parameters
  - Electron energy: 580 MeV
  - Emittance: 12 nm
  - Beam Current: 200 mA
  - Circumference: 45.7 m
  - 6-fold symmetry
    - lattice: DBA with 12 combined function dipole magnets
      - Integrated quadrupole gradient
  - 4 straight sections for insertion devices
  - Will use ASTRID as booster (full energy injection)
    - Allows top-up operation

ASTRID2 Layout

ASTRID2 Status

- 90 mA continuous TopUp
  - Problem with bumpers limits continuous TopUp operation to 90 mA
- Friday 13/9 2013: Accumulated 200 mA
  - TopUp for ~20 min

- May 2013: First light in a beam line
- 11-12/9 2013: First experiments performed with the AU-UV beam line
  - UV absorption and Circular Dichroism



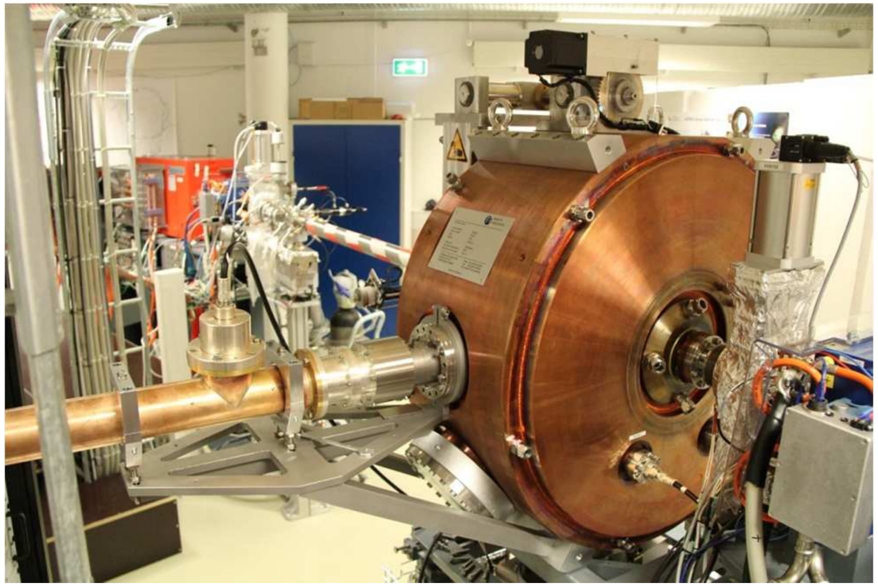
- 5 beam lines are being installed

ASTRID2 RF

- 105 MHz (like ASTRID)
- Main RF parameters
  - Harmonic: 16
  - RF voltage: 50–150 kV
  - Synchrotron frequency: 10–20 kHz
  - Synchrotron radiation power: ~1.4 kW
  - Cavity power: 0.5–7 kW
- 8 kW solid state amplifier from Tomco Technologies (Australia)
  - Has been running exceptional well, except for two humidity sensor boards which failed in a way so an internal 5V supply was overloaded, preventing operation

ASTRID2 Cavity

- Basically the same as MAX IV cavities
  - Built by RI (RF design by MaxLab)
- Conditioned to ~80 kV (~900 W)
  - No problems seen
  - Will condition to higher voltages when time permit
- Have ordered a 315 MHz Landau cavity (also from RI and based on MaxLab design).
  - Delivery next year



ASTRIDx LLRF

- Since January 2011: New LLRF in operation at ASTRID
  - Same system for ASTRID and ASTRID2
    (except for different tuning control)
- Digital control of baseband signals
  - A computer (PC) running LabVIEW Real-Time with FPGA equipped multifunction card to measure and control the baseband signals
    - NI PCIe-7852R:
      - Virtex 5 FPGA, 8 AI, 750 kS/s/ch, 8 AO, 1 MS/s/ch, 16 bit
  - Detection: IQ demodulators with low pass filter
    - ±180° phase detection
  - Control: Amplitude and Phase (voltage controlled)
- FPGA (Amplitude Loop): No problems at all
- Real-time (Tuning Loop and Phase Loop): A few restarts have been necessary (data acquisition loop stops)
- Very happy with the systems

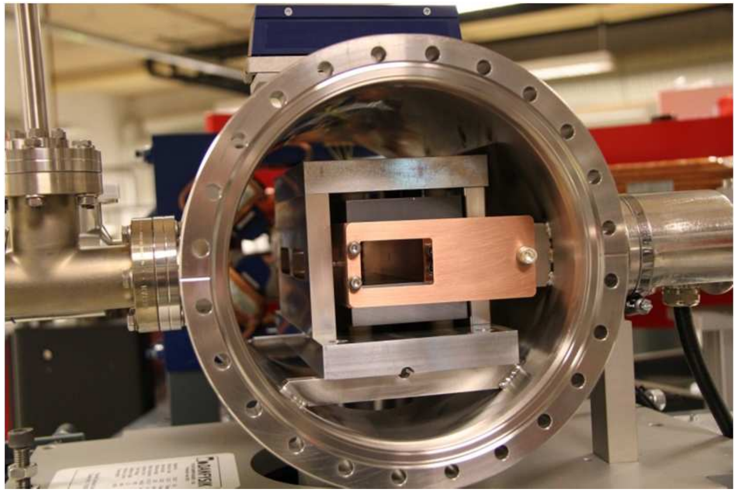
Problems

- Injection bumpers are getting warm at high beam currents
  - Expect RF heating of ferrites
- Observing a fast horizontal instability
  - Visible on a SR camera with short exposure time
  - Threshold of only a few mA

Injection bumpers

- Simple design (in-vacuum ferrite)
- First version: Beam current limited to 60 mA
- We believe the problem is due to absorption of beam induced RF fields in the ferrites, causing them to heat above the Curie temperature of 130°C

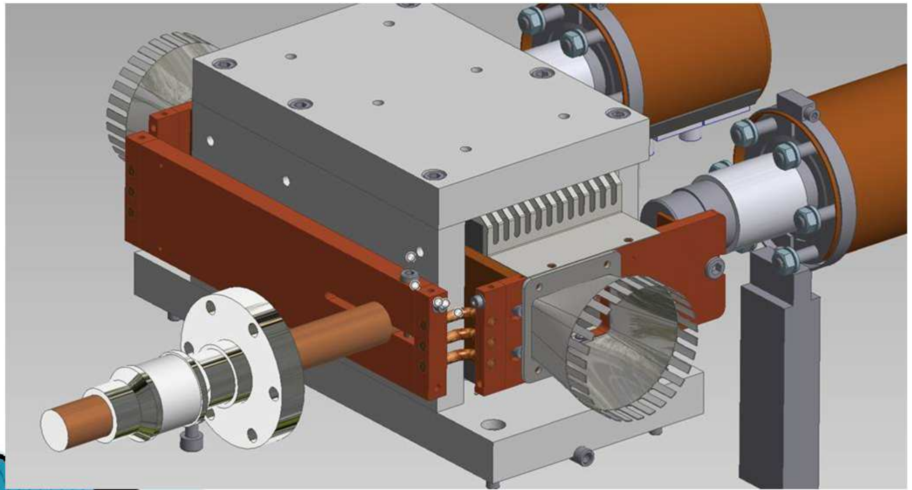
First version

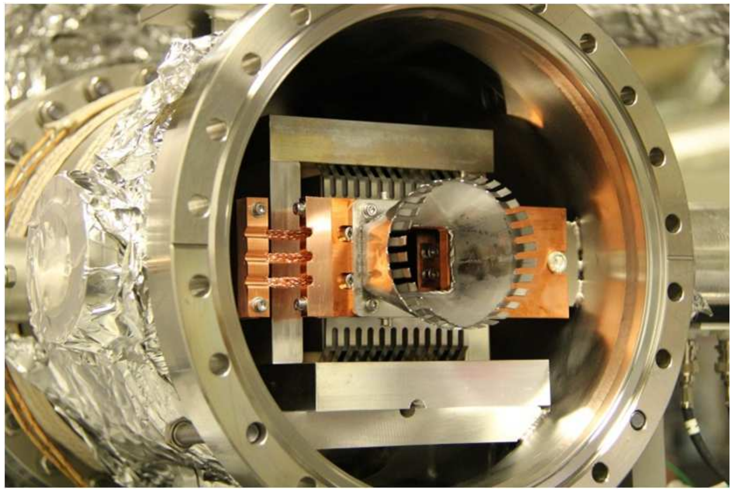


Injection bumpers 2

- Second version:
  - Added shields at the ends and cooling of ground conductor
- Beam current limited to 90 mA !
  - With no cooling water we can achieve 85 mA ??

Second version

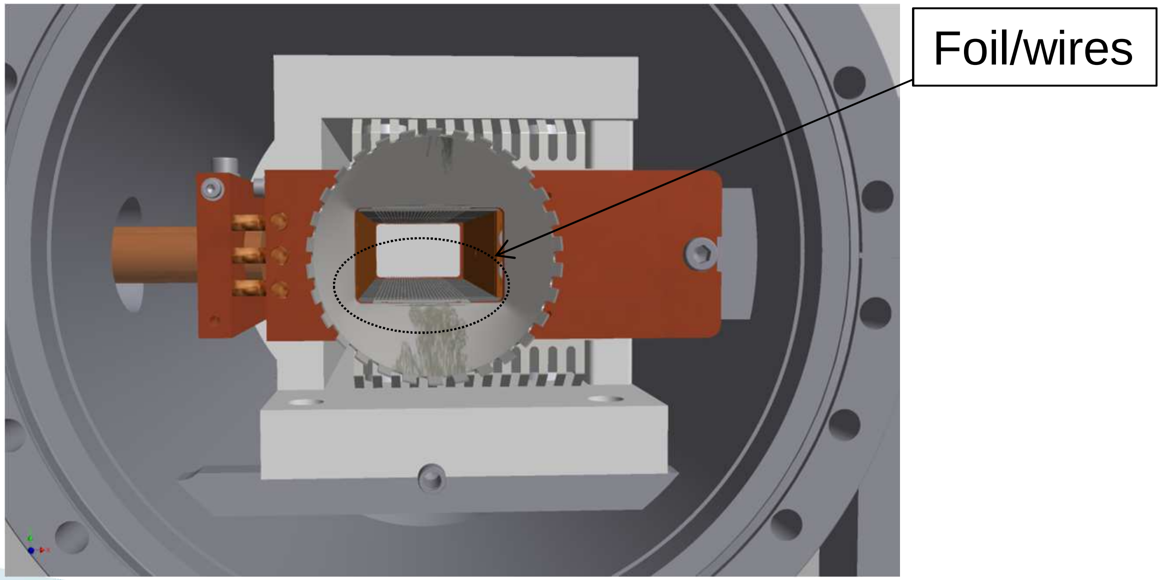




Injection bumpers 3

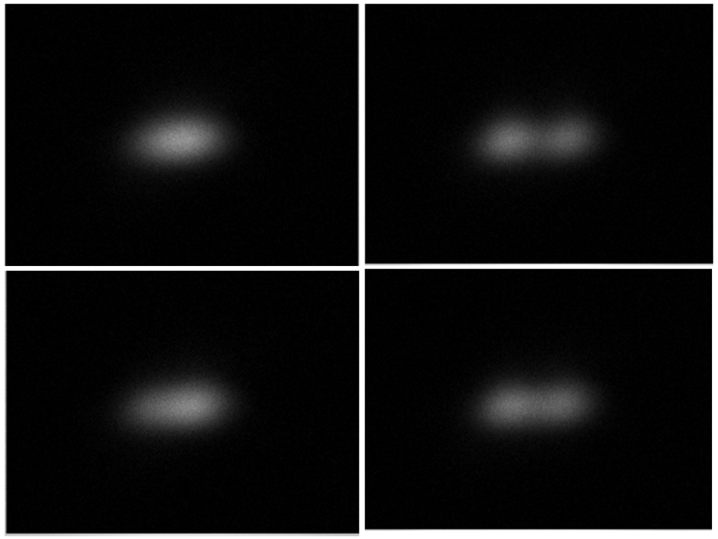
- Third version(?):
  - Need to figure out why cooling is ineffective
  - Add foils along the ferrites
    - How thick?
    - Can we cut foils so we get wires?

Third version?

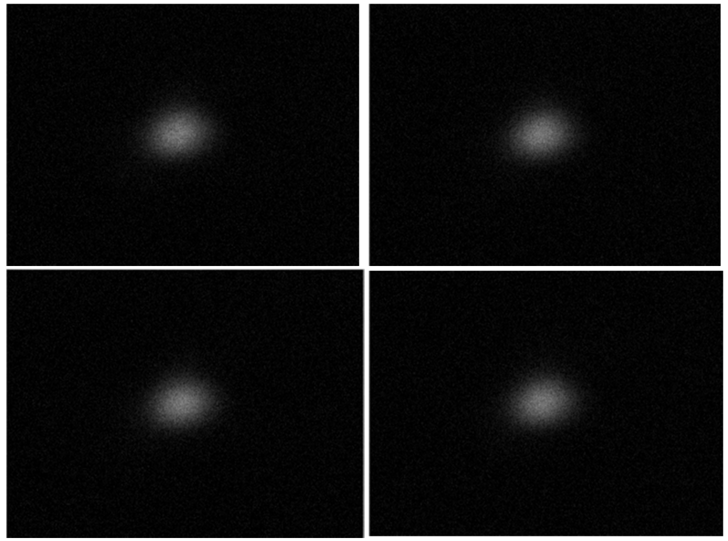


Fast horizontal instability ?

20 mA, ~60 kV cavity voltage



1.6 mA, ~70 kV cavity voltage

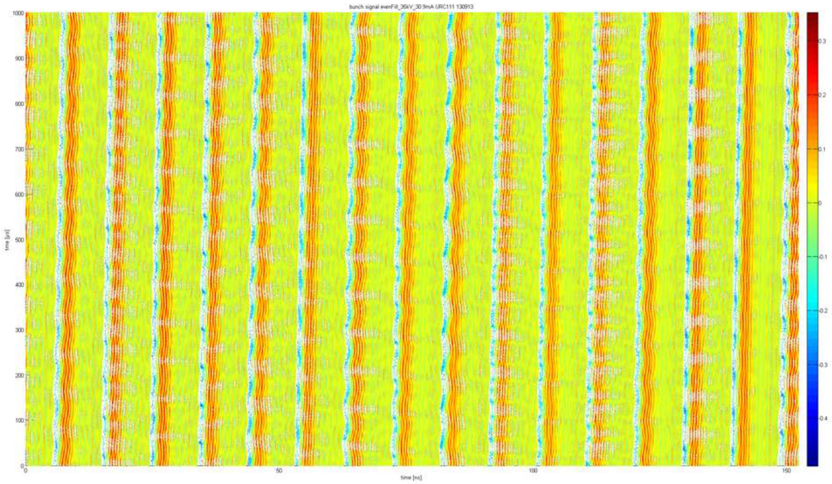


The split in the two spots is ~0.4 mm. With D ~ 0.18 m, this gives $\Delta E/E \sim \pm 1 \cdot 10^{-3}$. Natural energy spread is $4 \cdot 10^{-4}$.

Longitudinal coupled bunch instability ?

- Measurement of longitudinal bunch oscillations
  - Measured with fast scope and aligning the different turns in software

30 mA, ~70 kV cavity voltage

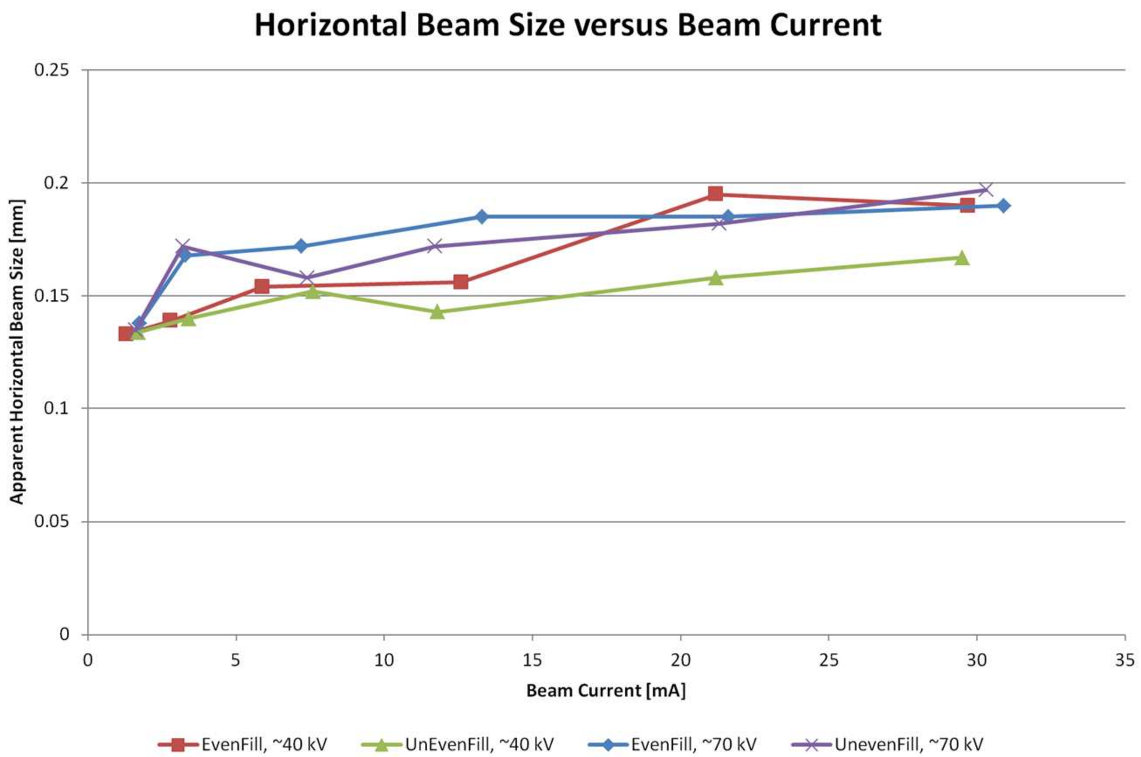


2.8 mA, ~40 kV cavity voltage

- Amplitude of longitudinal oscillations => energy oscillations amplitude of $0.5 \cdot 10^{-3}$
  - Fits within a factor 2 of value from horizontal split using dispersion

Fast horizontal instability ? / Longitudinal coupled bunch instability ?

- The threshold current is low (3-5 mA)
  - Depends on cavity voltage



Fast horizontal instability ? / Longitudinal coupled bunch instability ?

- More measurements
  - Using a 4 channel scope and a BPM in a dispersive position, we can measure the beam position bunch-by-bunch
  - This allows quantitative measurements

- Questions
  - Will this instability be cured by the Landau cavity?
  - How do we fight the instability?
    - RF cavity:
      - HOM dampers?
      - Temperature control?
    - Longitudinal bunch-by-bunch feedback?