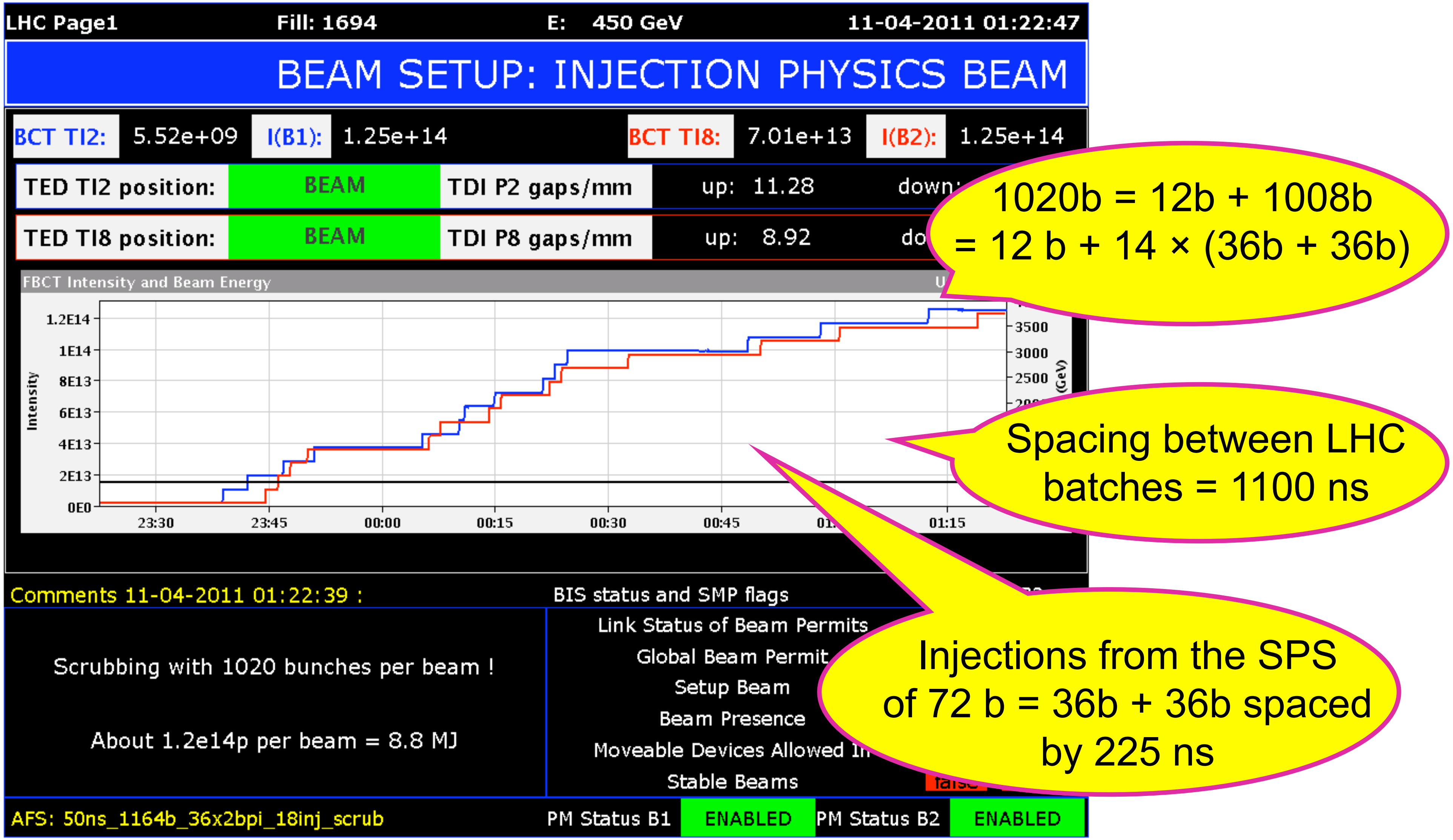
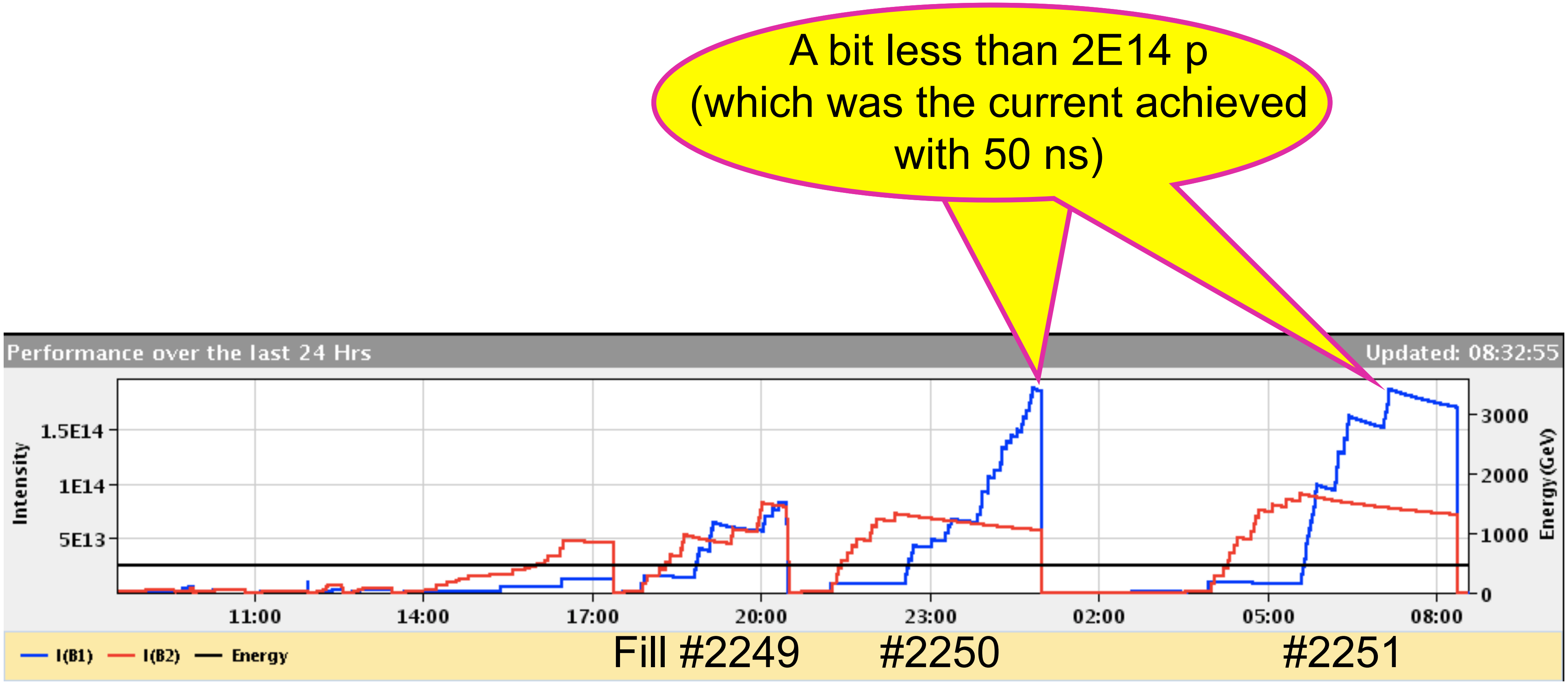
GOAL OF THE LHC SCRUBBING RUN => SCRUB and reach a "stable" situation with at least ~ 1000 bunches with 50 ns

=> ~ Done on Monday 11/04/11



GOAL OF THE LHC SCRUBBING RUN => SCRUB and reach a "stable" situation with at least ~ 1000 bunches with 50 ns

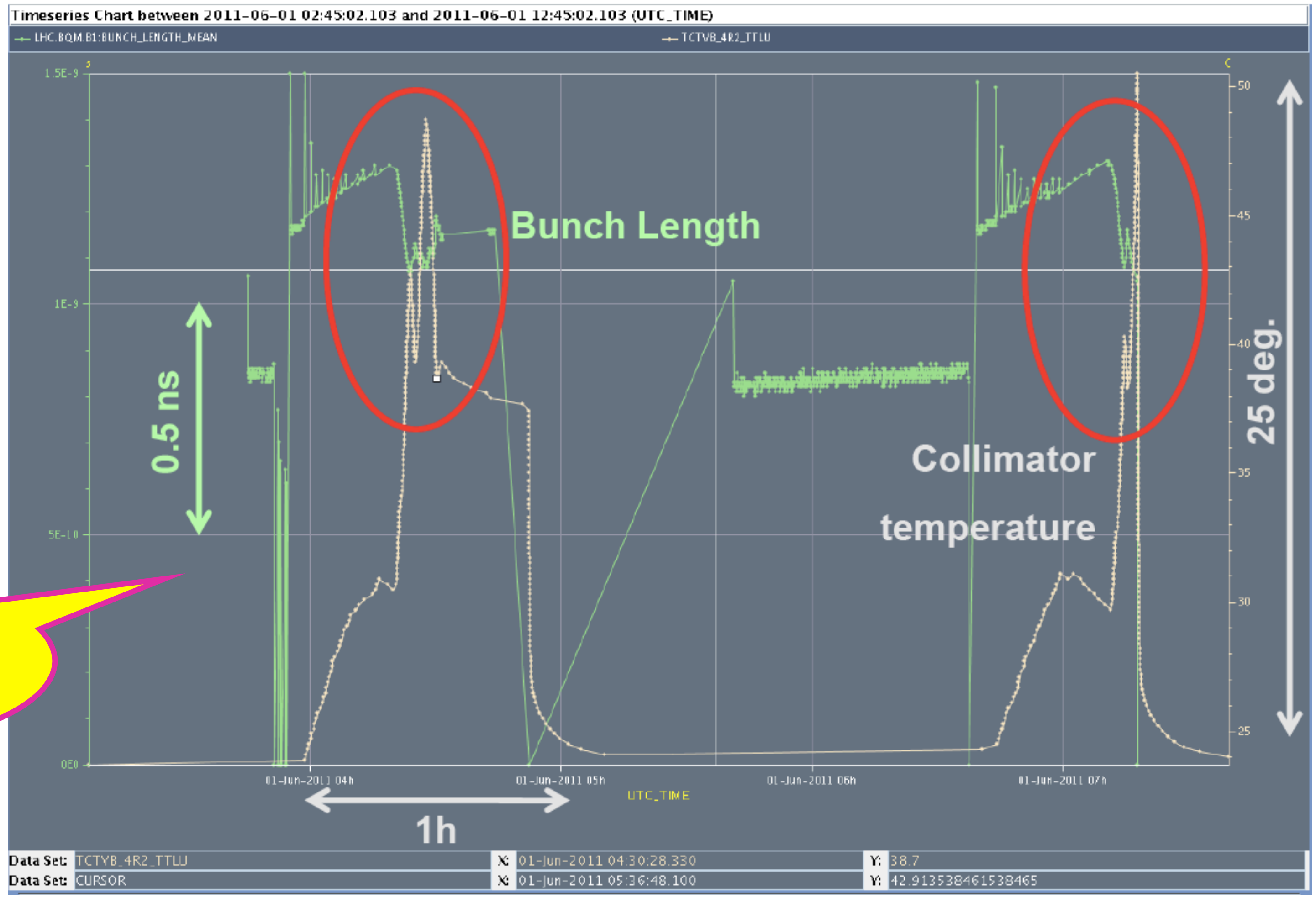
25 ns BEAM STUDIES IN THE LHC



25 ns BEAM STUDIES IN THE LHC

COLLECTIVE EFFECTS IN THE LHC

- **Beam stability provided by Landau damping (octupoles used from injection till end of the fill) + transverse feedback => No limit reached yet and good agreement with simulations/theory for TCBI**
- **HOWEVER, many heatings here and there => Still to be understood**



Example of the TCTVB_4R2

MANY BEAM-BEAM RESULTS

Observations: head-on beam-beam effects I

- Dedicated experiment with few bunches
- Test maximum beam-beam parameter (at injection energy) - head-on only
  - Intensity $1.9 \cdot 10^{11}$ p/bunch
  - Emittances 1.1 - 1.2 μm
  - Achieved:
    $\xi = 0.017$ for single collision ($\approx$ 5 times nominal !)
    $\xi = 0.034$ for two collision points (IP1 and IP5)
  - No obvious emittance increase or lifetime problems during collisions (maximum ξ not yet found)

⚠ No long range encounters present !

MANY BEAM-BEAM RESULTS

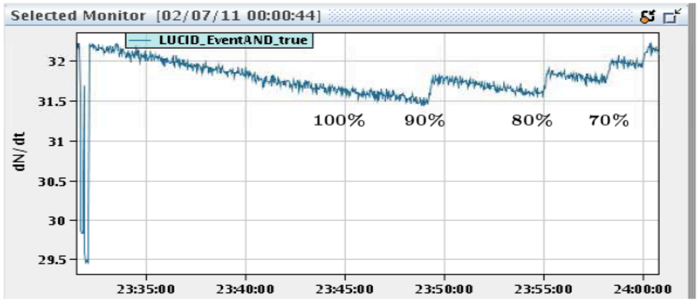
Observations: head-on beam-beam effects II

- Dedicated experiment with few bunches
- Test maximum luminosity per collision (pileup) (at 3.5 TeV, $\beta^* = 1$ m) - head-on, with crossing angle
  - Intensity $\approx 2.4 \cdot 10^{11}$ p/bunch
  - Emittances 2.5 - 3.0 μm (blown up during injection and ramp)
  - Achieved:
    $\xi = 0.018$ for two collision points (IP1 and IP5)
    "pileup" $\approx$ 35 per collision, lifetime above 30 hours

Allows very large head-on beam-beam tune shift ! Low noise ?

MANY BEAM-BEAM RESULTS

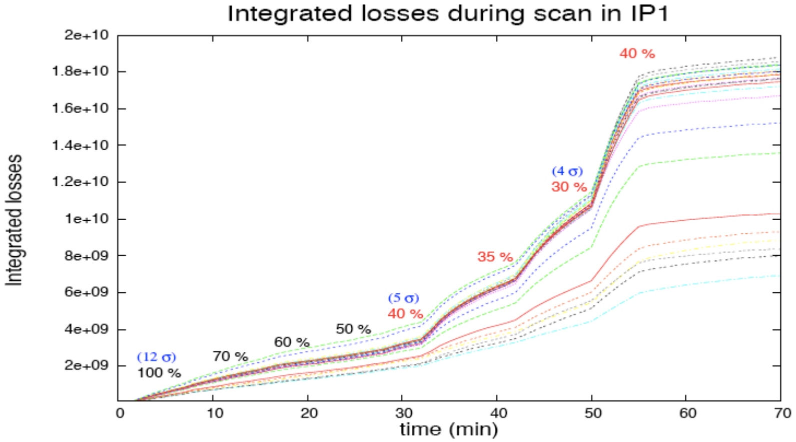
Scan of crossing angle: luminosity



- Luminosity in IP1 as function of crossing angle in IP1
- Reduction factor exactly as calculated !
- "Levelling" with crossing angle, no effect on 2nd IP

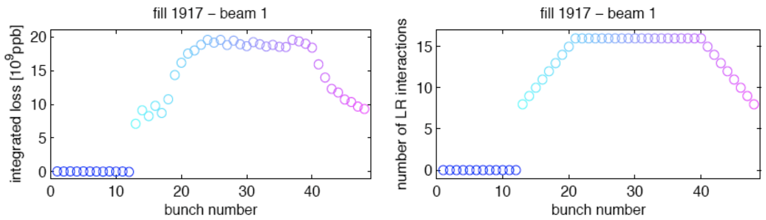
BUT: range very small !

Scan of crossing angle: losses



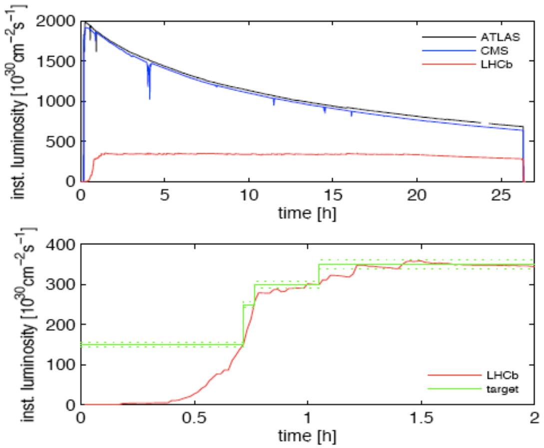
- Bunch by bunch loss as function of crossing angle in IP1

PACMAN effects



- Integrated losses and number of long range interactions
- Losses directly related to number of long range interactions
- So-called 'PACMAN' bunches have better life time !
- 'PACMAN' effects clearly visible

Luminosity levelling - standard operation



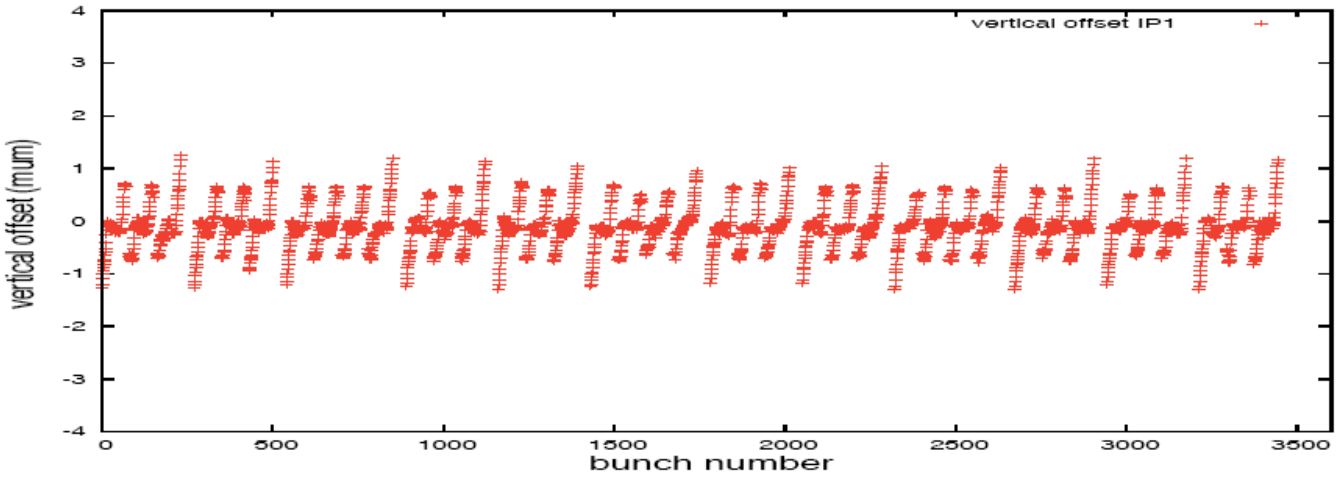
Luminosity levelling

- LHC has 4 experiments:
  2 require highest luminosity,
  2 require lower luminosity (up to factor 10^{-4})
- Luminosity levelling required already in 2011 (reduce luminosity and keep constant)
  - Achieved by transversely offset collisions (simple to do, very large range)
  - Separation $\approx 4\ \sigma$ (IP2) and ≈ 0.5 - $1.5\ \sigma$ (IP8)
  - Routinely done without detrimental effects

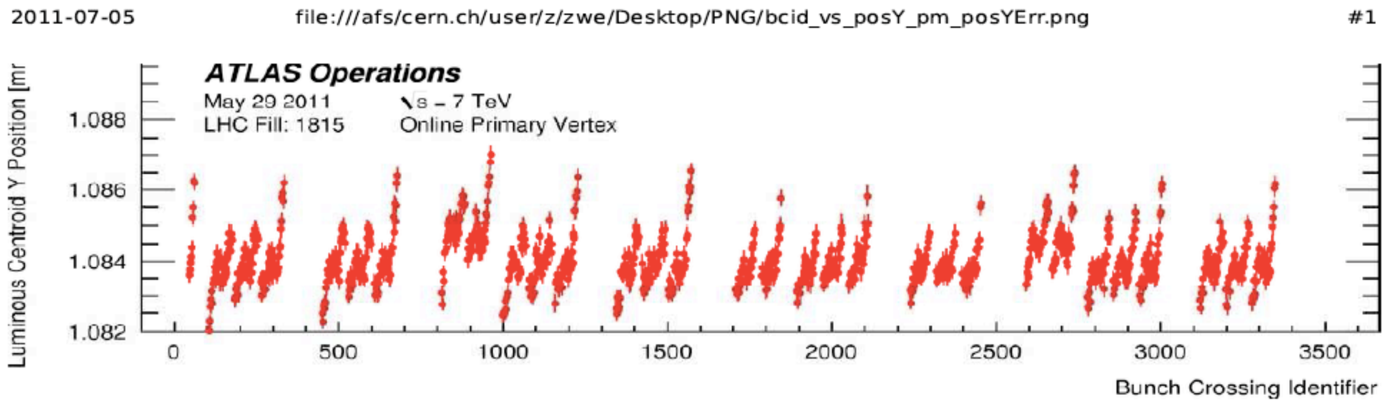
- Luminosity in LHC experiments during levelling
- Luminosity very constant in IP8, no effect on other IPs

MANY BEAM-BEAM RESULTS

PACMAN Orbit effects: calculation



PACMAN Orbit effects: observation



MANY BEAM-BEAM RESULTS

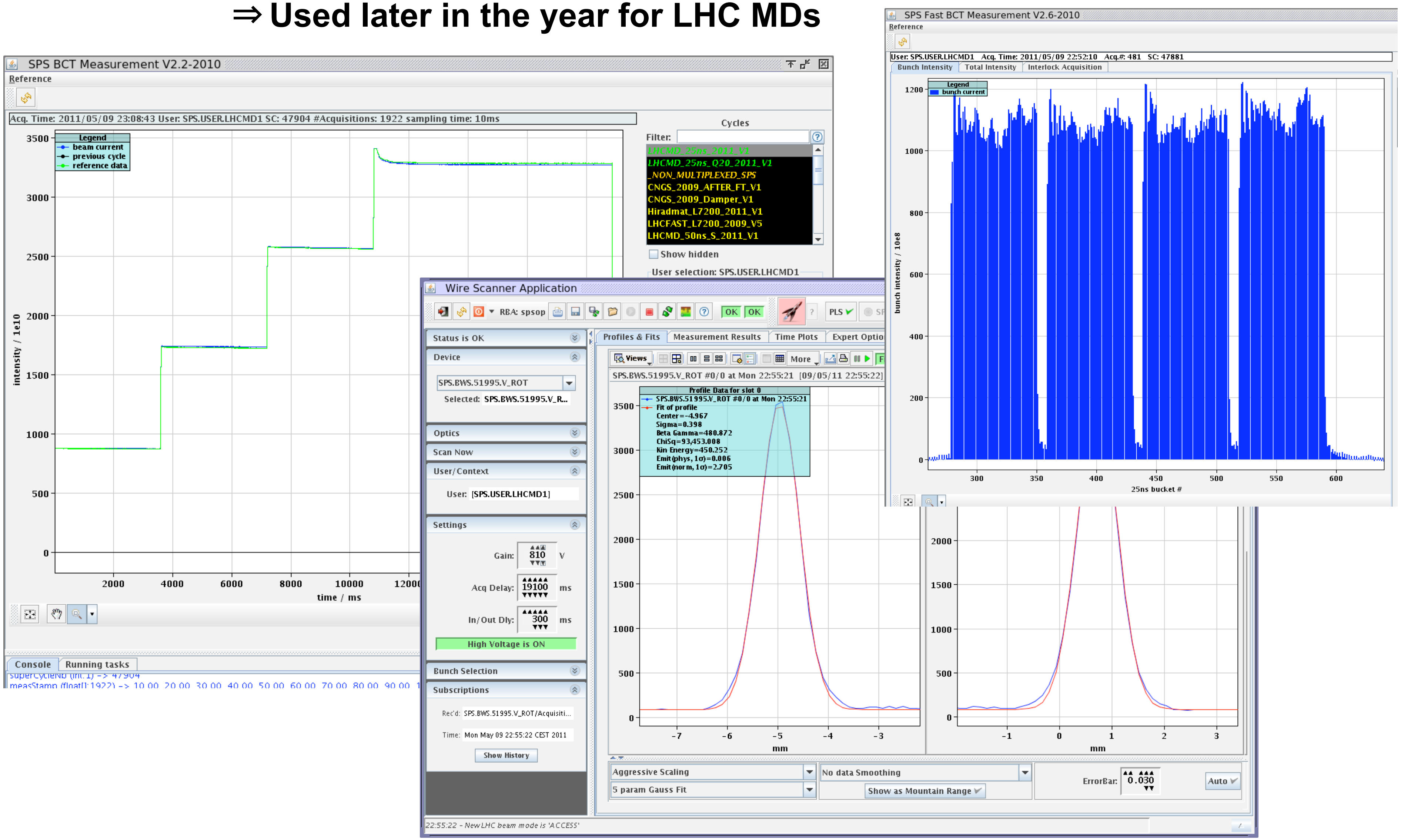
Summary of observations

- Obtained large head-on tune shifts above nominal

  In daily operation: twice "nominal" value is standard
- Effect of long range interactions clearly visible (losses, dynamic aperture), no data yet on 25 ns spacing ..
- Number of head-on and/or long range interactions important for losses
- All observations in excellent agreement with expectations and well understood (so far)
- Beam-beam effects should allow higher than nominal luminosity (with 2808 bunches, at 7 TeV)

MDs

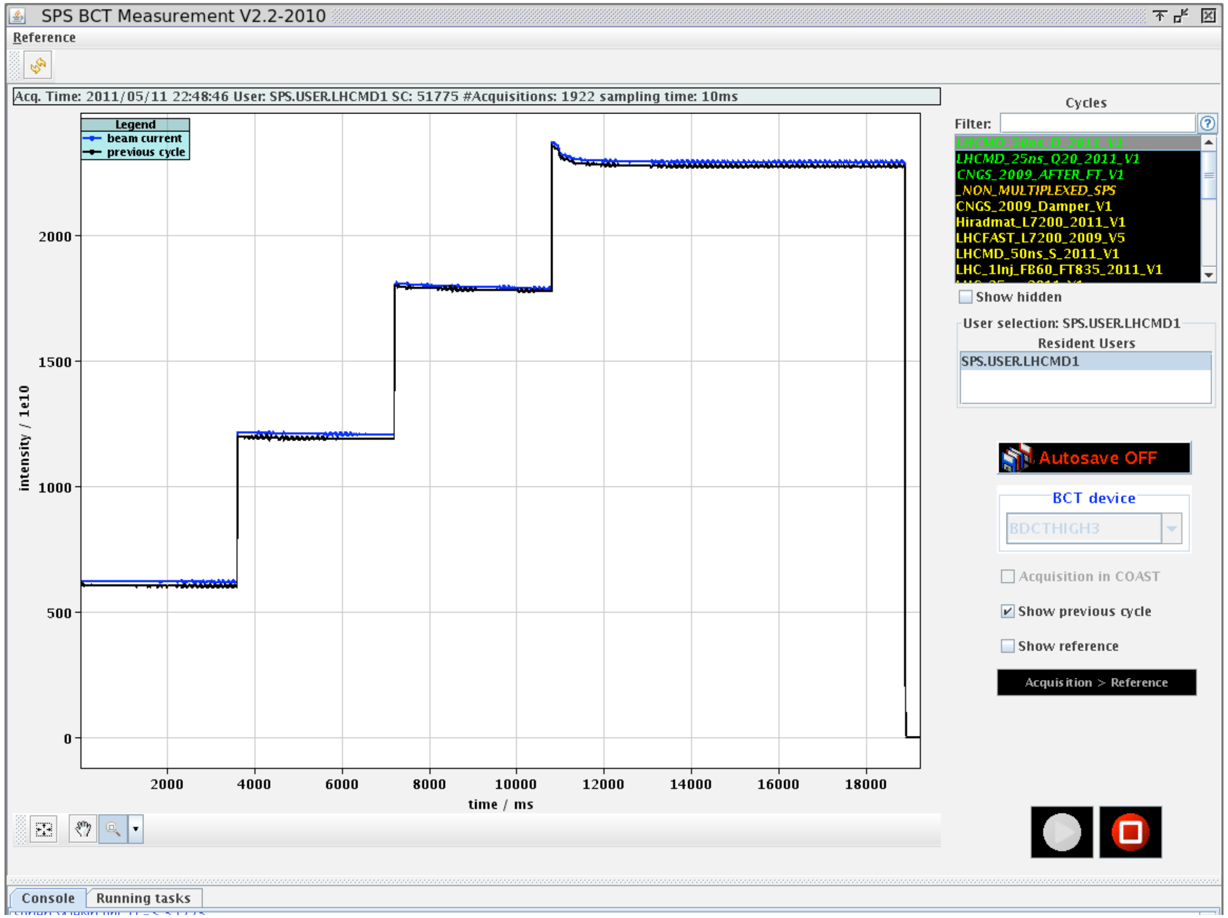
- Nominal intensity 25ns on Q26 optics (SPS)
  - 4 batches injected with **4% losses** along the cycle (reproducible 3-4%)
  - Transverse emittances of 2.4-2.7 μm
  - ⇒ **Used later in the year for LHC MDs**



MDs

– Up to 1.6 x 10^{11} ppb on 50ns beam at flat top on Q26 optics (SPS)
  - Only ~5% losses
  - Longitudinally unstable at flat top
  - Transverse emittances below 2 μm thanks to double batch

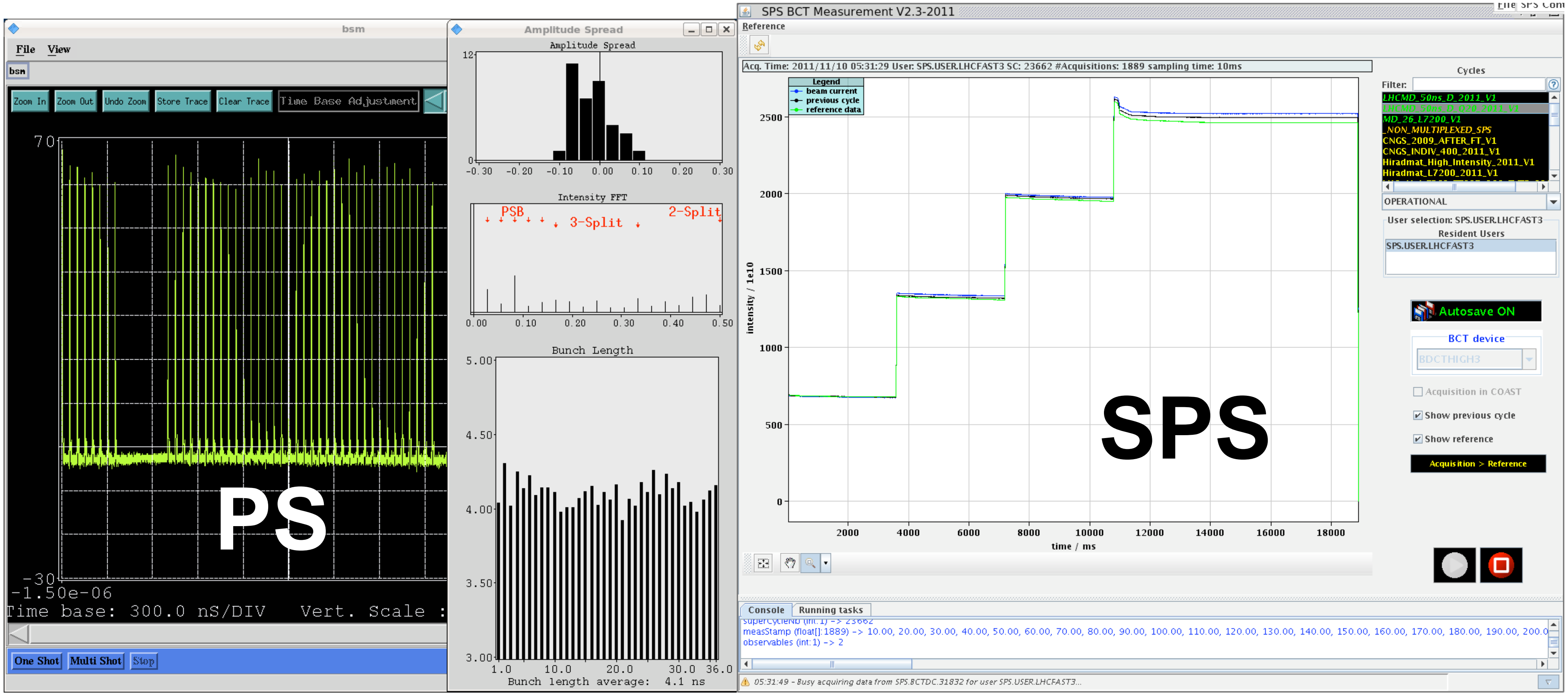
⇒ **This beam, first explored in MDs in early May, has been used operationally for filling the LHC after September 2011**



MDs

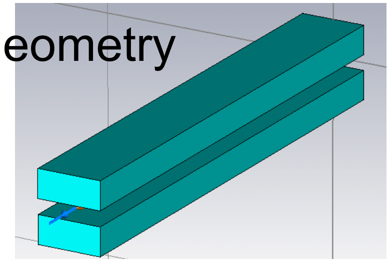
– Up to 1.75 x 10^{11} ppb on 50ns beam at flat top on Q20 optics (SPS)
  - Losses in the 5-7%
  - Longitudinally unstable at flat top
  - Transverse emittances of 1.8 μm measured in the PS (with 1.9 x 10^{11} ppb)
  - Though not optimized longitudinally, this beam appears to perform better than on Q26 optics due to better stability and lower losses at injection

⇒ **Maybe operational next year?**

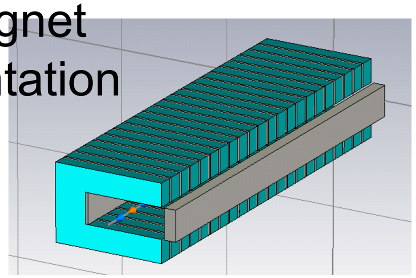


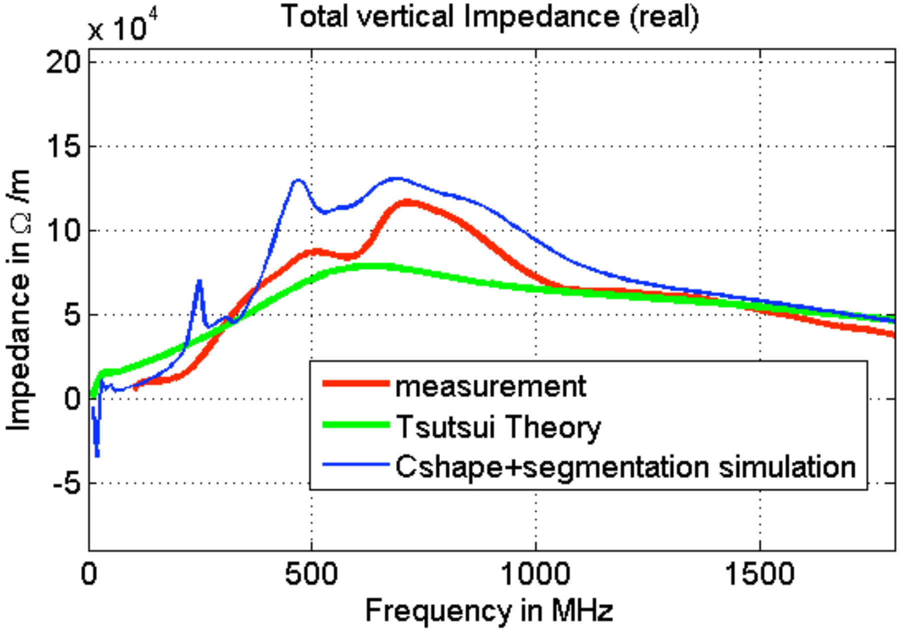
Refining the SPS kicker models: Comparison between single wire measurements and CST simulations on one MKP cell

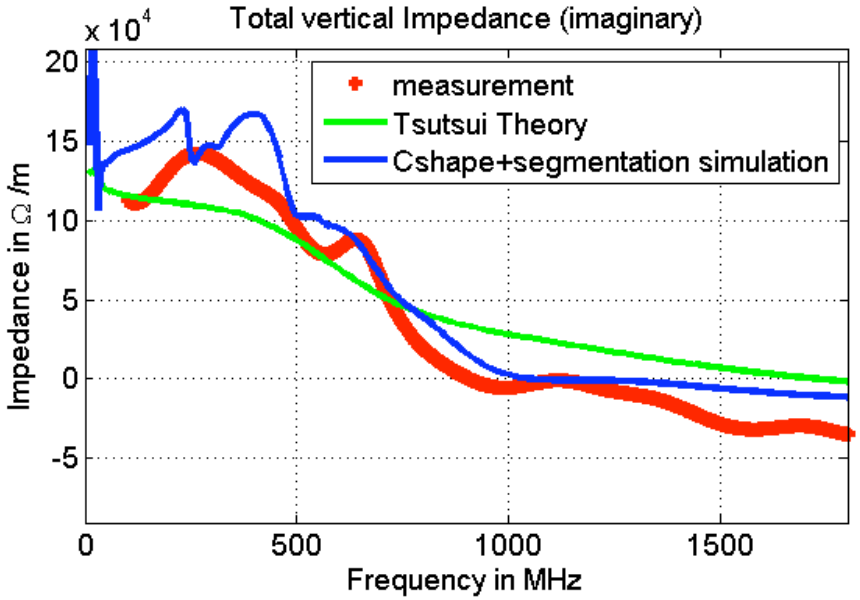
Tsutsui geometry



C shape magnet
with segmentation

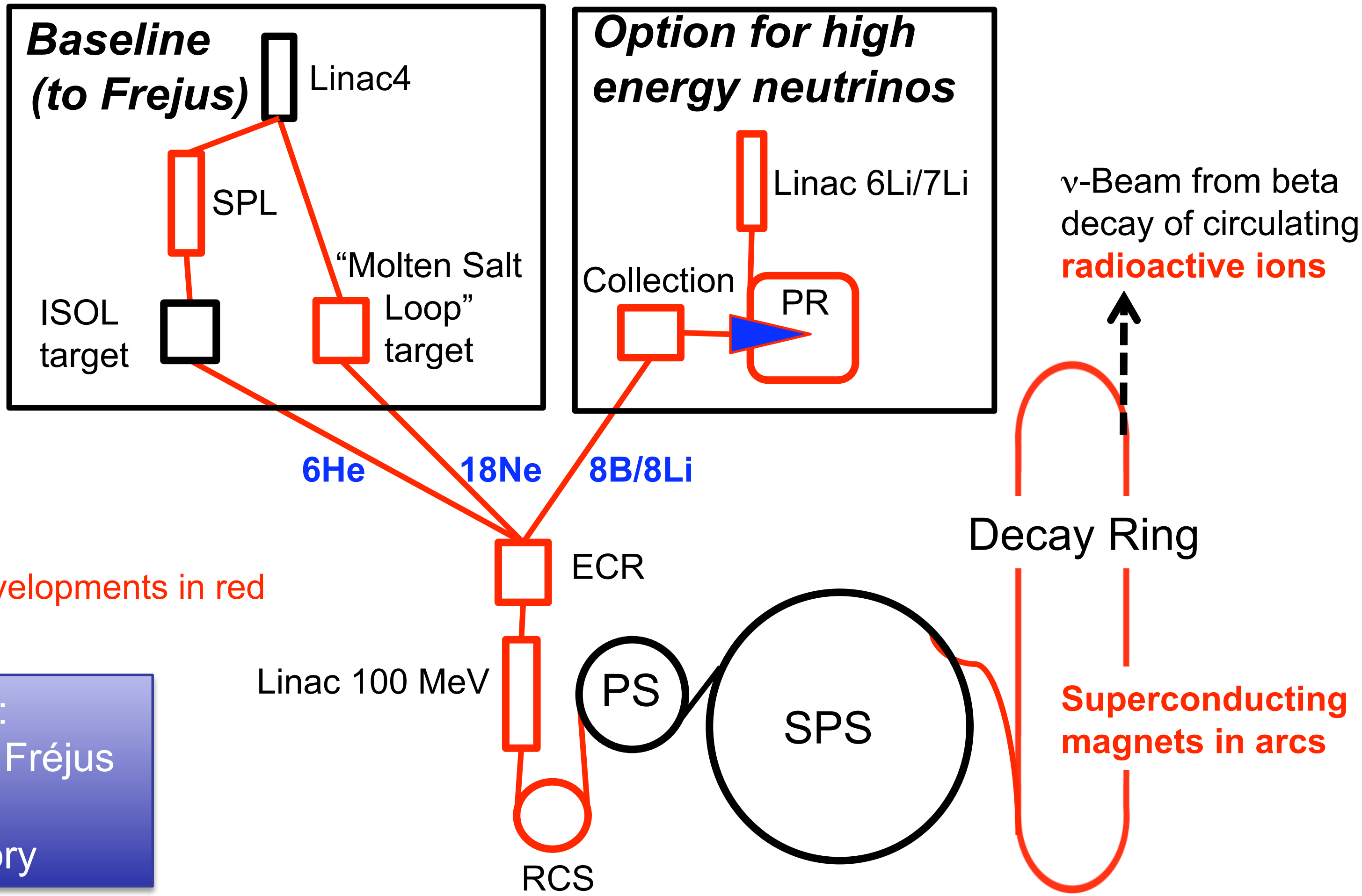






- Simulations are getting closer to the measurements!
- Transition pieces, internal and external circuits still need to be added to the model

The CERN Beta Beam (EUROnu, FP7)



Needed new developments in red

EUROnu covers:
1. Superbeam to Fréjus
2. **Beta Beam**
3. Neutrino Factory

Decay Ring: $B\rho \sim 500$ Tm, $B = \sim 6$ T, $C = \sim 6900$ m, $L_{ss} = \sim 2500$ m, $\gamma = 100$, all ions

The CERN Beta Beam

Beta Beams produce high intensity pure electron neutrino beams:

Excellent physics: high precision measurements of neutrino oscillation parameters

The Beta Beam is favored by hints from several neutrino experiments this year

Beta Beams use beta active isotopes to create the neutrino beam:

Production of 6He has been experimentally verified 2009
Experiments on 18Ne Isotope production has started this year at ISOLDE

Research (FP7 collaboration) on the production of high energy neutrino beams

Small Production Ring (proposed by C. Rubbia) for 8B and 8Li production (low priority option)

Optimization of overall beam performances (end to end simulations)

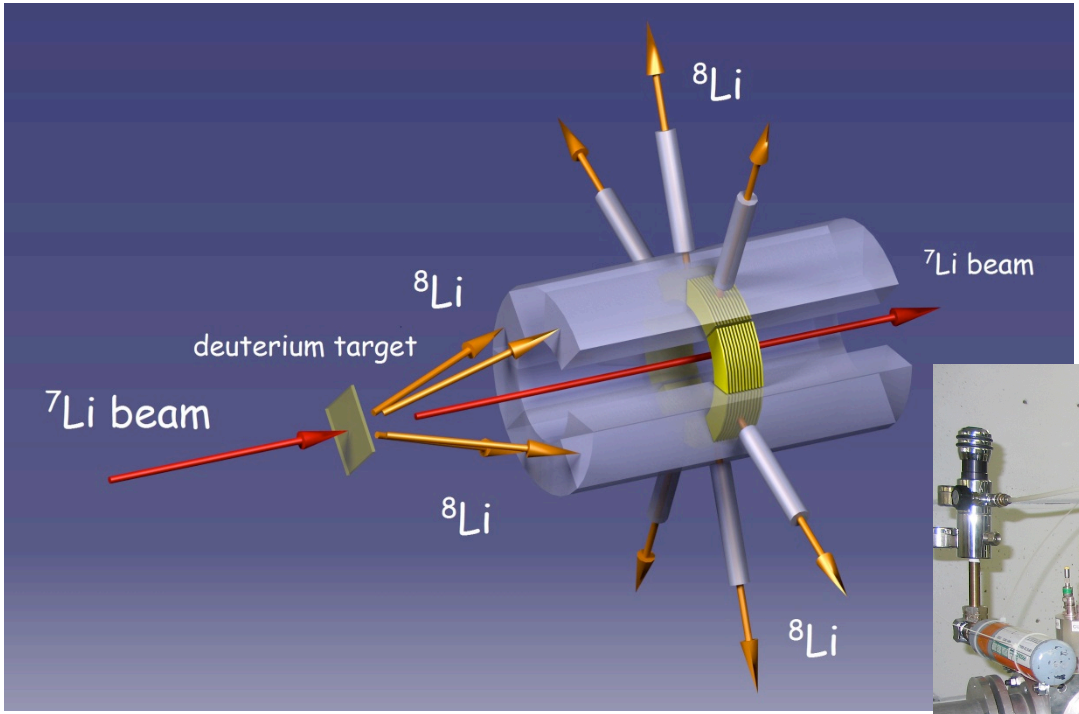
Take benefit of this year's results from neutrino experiments (T2K, Minos & DChooz)

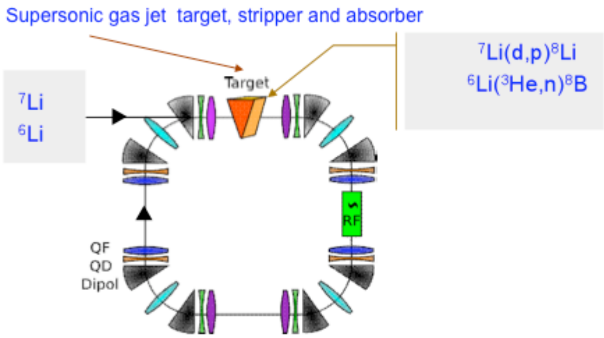
Costing of the complex for performance/cost comparison (EUROnu)

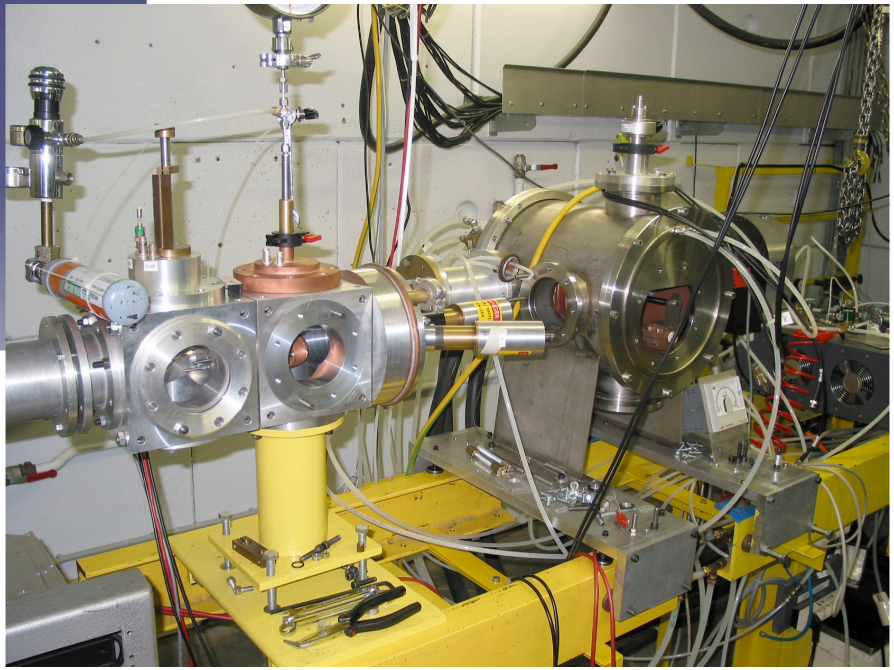
Reactivated this year, Civil Engineering (cost driver) with layouts has started

End of EUROnu August 2012: Cost/Performance evaluation of the 3 facilities Superbeams, Beta Beams and Neutrino Factories

The collection device for Prod. Ring







UCL, Louvain la Neuve