



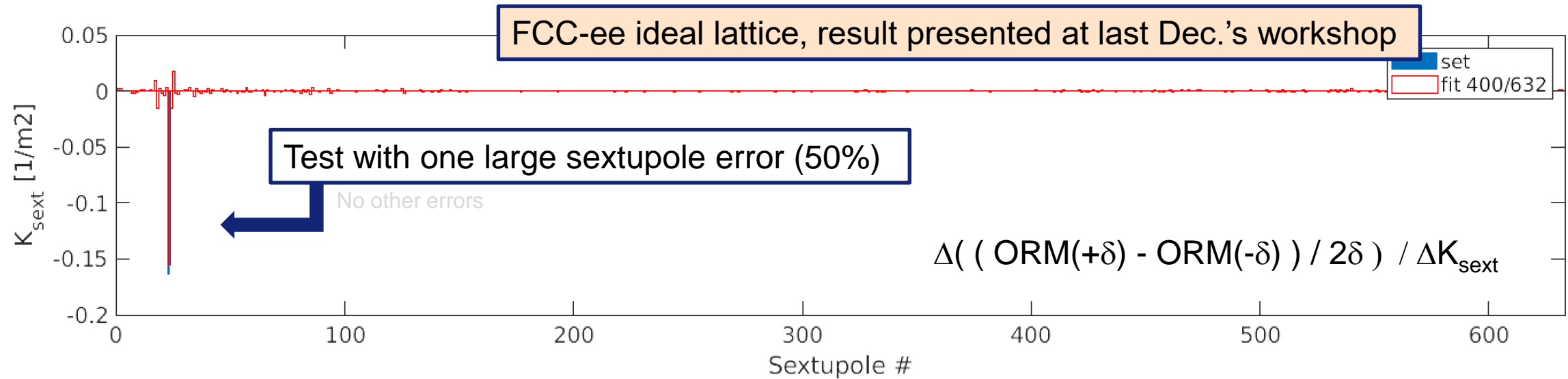
| The European Synchrotron

**Non-linear optics corrections at ESRF
&
status of FCC-ee simulations**

S.M.Liuzzo, A.Franchi, FCC-ee meeting, 10th February 2022

- From off-energy ORM to nonlinear optics correction (NOECO)
- Experimental results @ ESRF
- NOECO simulations of FCC-ee (Z)
 - ✓ detect & correct a sextupole error for an ideal lattice
 - ✓ detect & correct a sextupole error for a lattice with misalignments
 - ✓ detect & correct a sextupole error for a lattice with quad. errors
- Next steps

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PHYSICAL REVIEW ACCELERATORS AND BEAMS **23**, 102803 (2020)

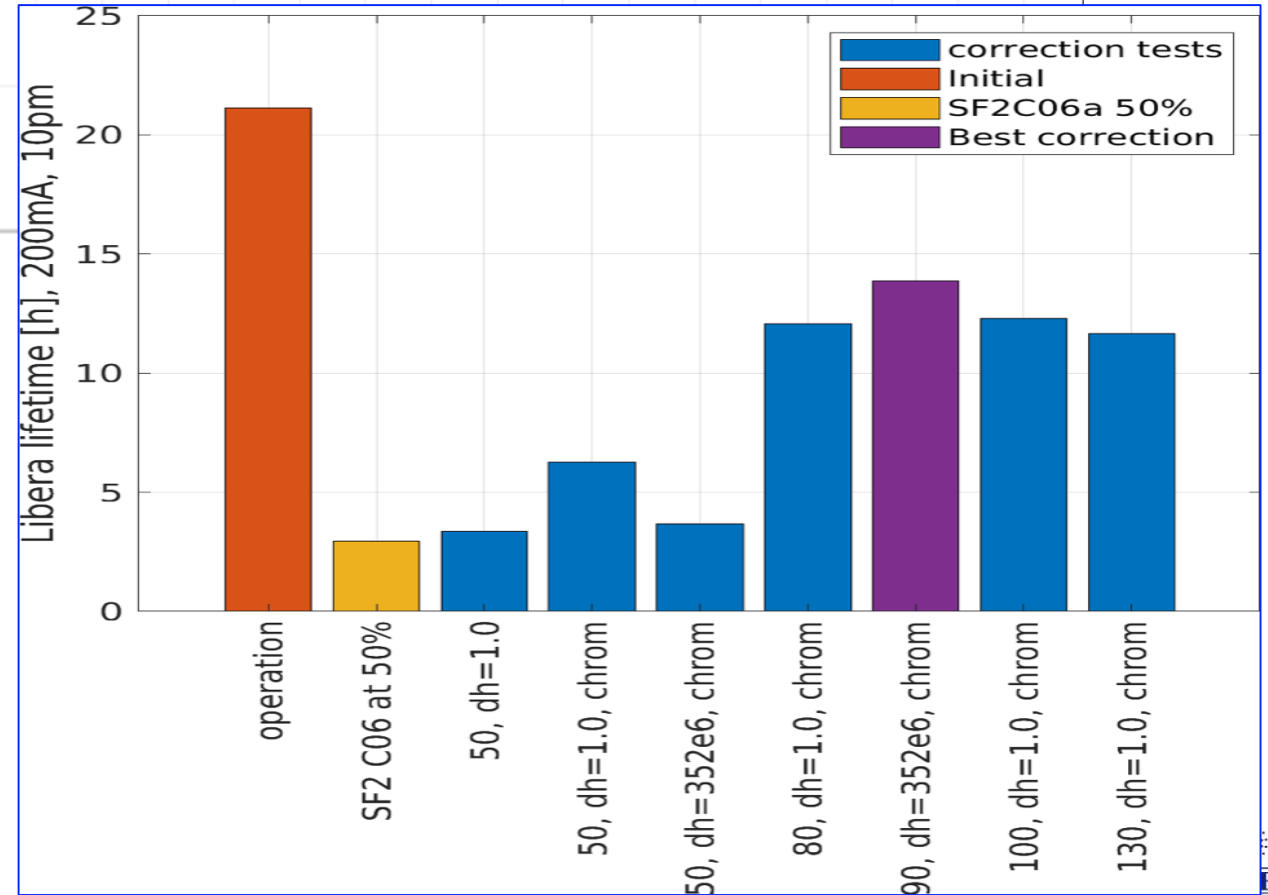
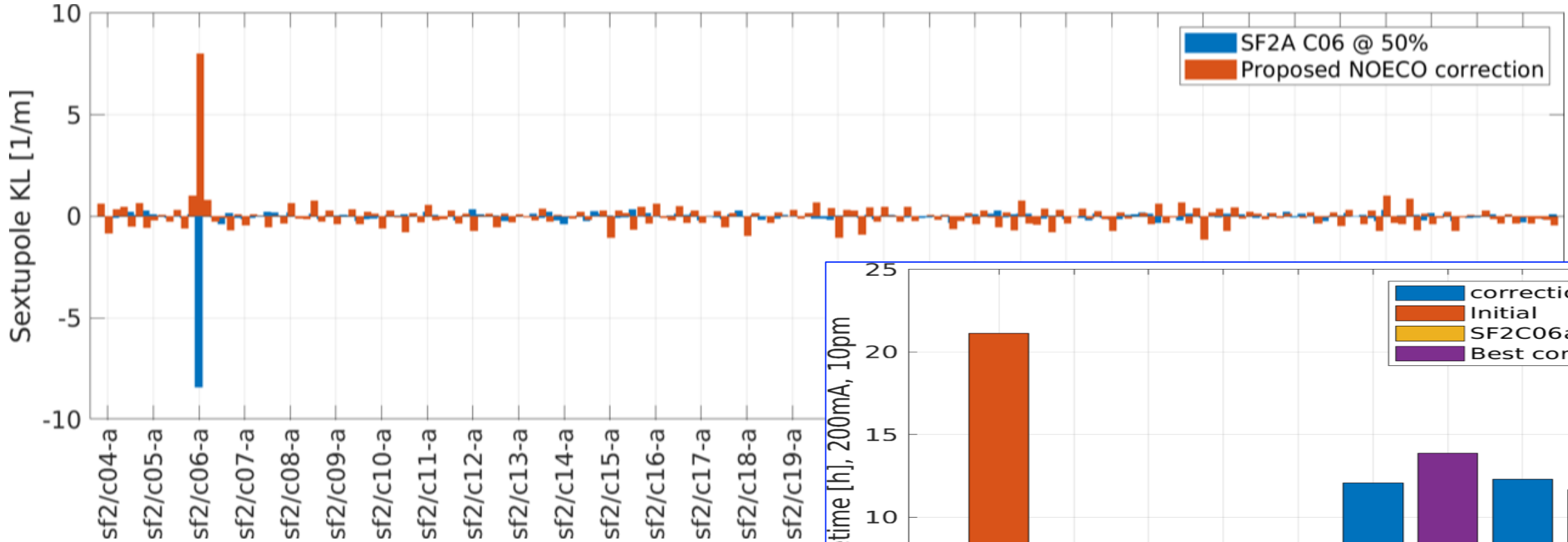
Nonlinear optics from off-energy closed orbits

David K. Olsson¹, Åke Andersson, and Magnus Sjöström
 MAX IV Laboratory, Lund University, SE-22100 Lund, Sweden

A. Franchi, N. Carmignani, Sextupole calibrations via measurements of off-energy orbit response matrix and high order dispersion, presented at the 25th European Synchrotron Light Source Workshop (ESLS'17), Dortmund, Germany, Nov. 2017, https://indico.cern.ch/event/657829/contributions/2782617/attachments/1569843/2475779/ESLS17_Carmignani_SextCalibration.pdf.

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FIRST MEASUREMENTS @ ESRF SR, 24TH JANUARY 2022

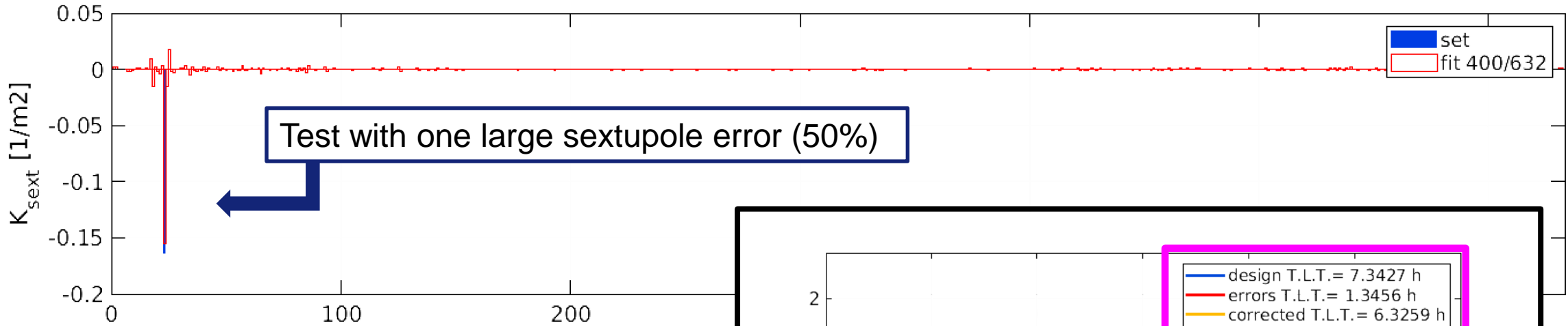


Top: Retrieve (large) sextupole error.

Right: measured lifetime for different scenarios & numerical parameters.

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SIMULATIONS (FIT & CORRECTION) FOR FCC-EE

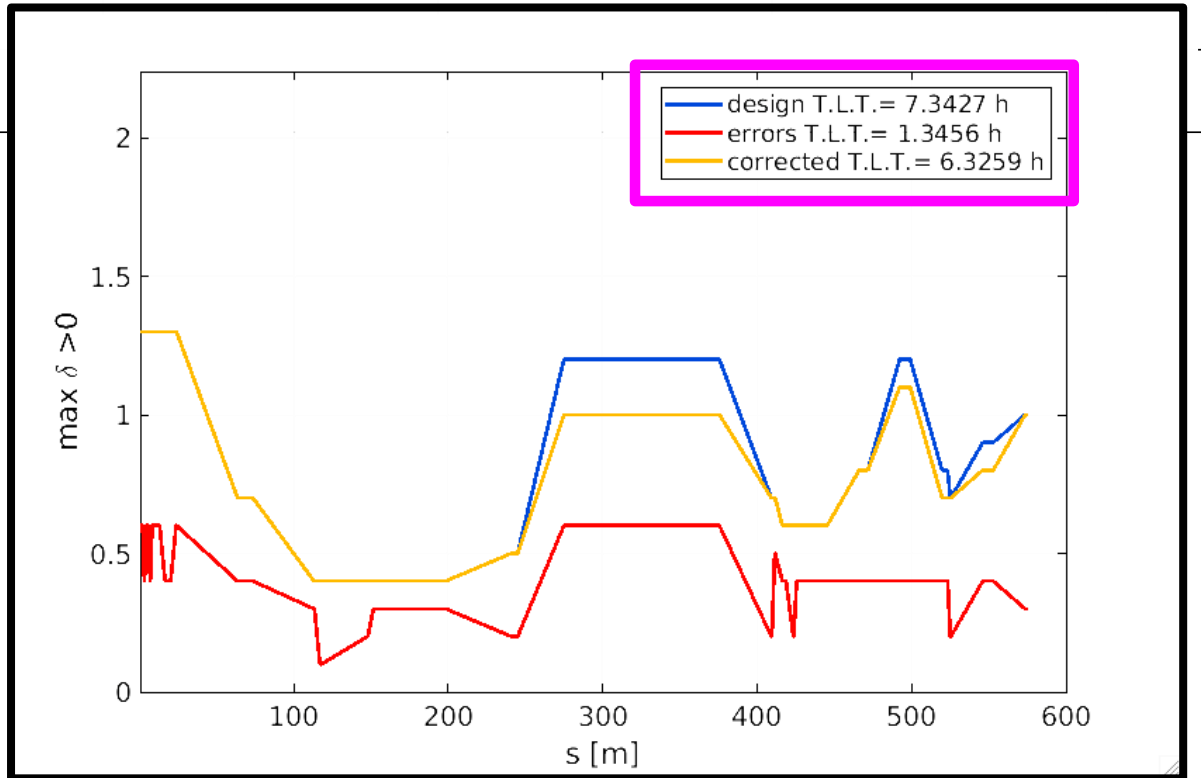


FCC-ee ideal lattice

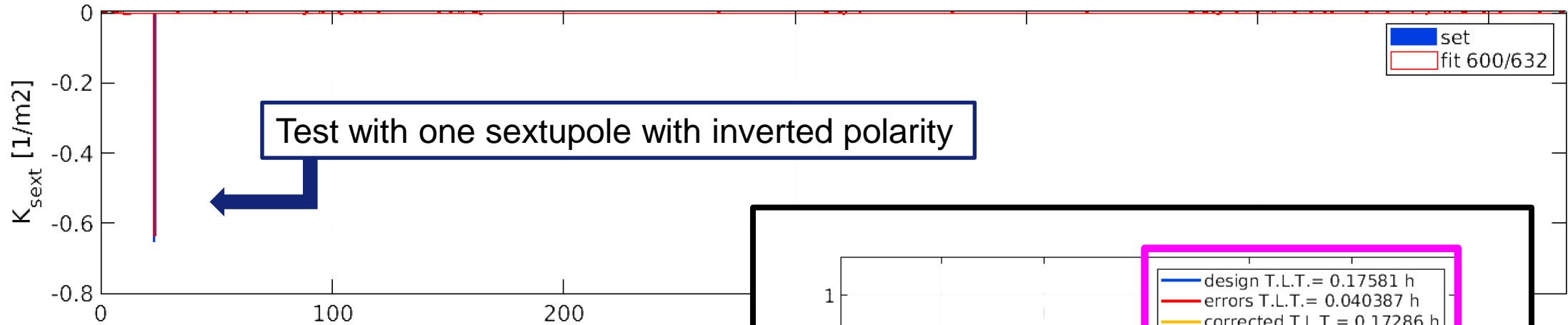
only ± 25 Hz RF
freq. shift possible
w/o making optics
unstable

Top: Retrieve (large) sextupole error.

Right: computed momentum acceptance
(over 600 m only) & Touschek lifetime



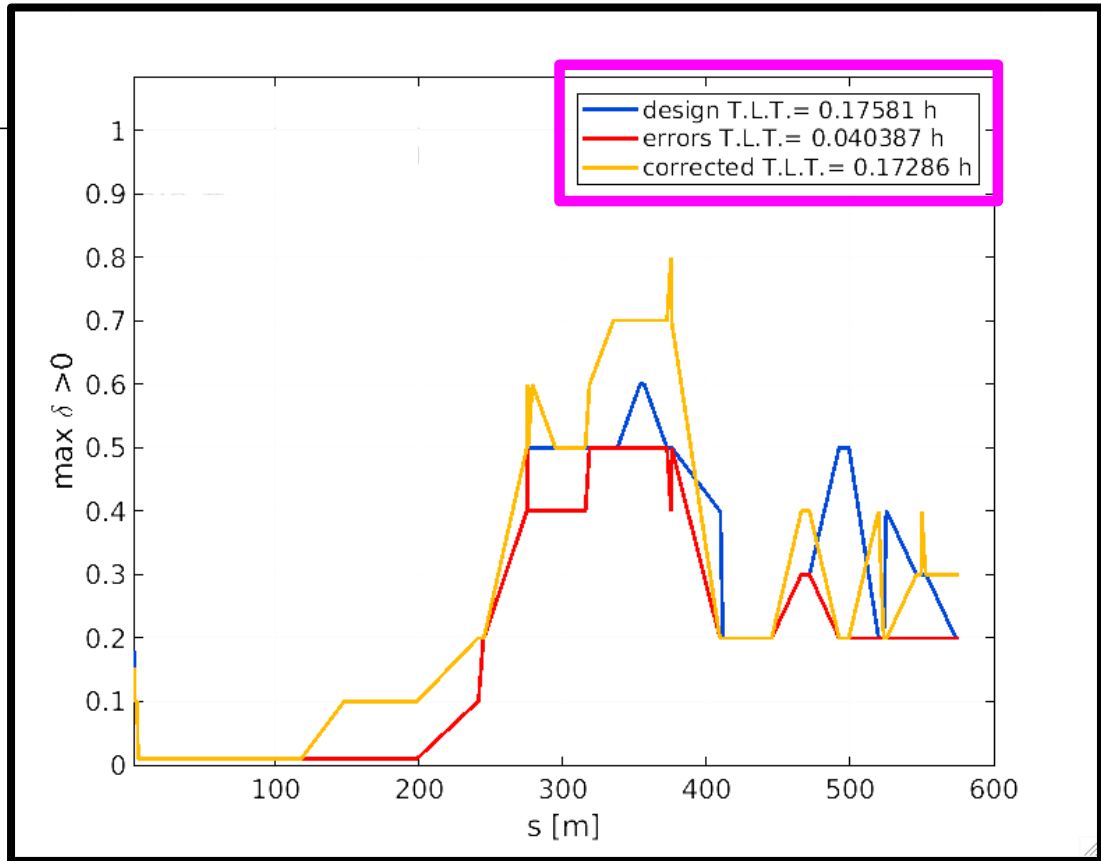
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FCC-ee uncorrected lattice with random quad. & sext. misalignments (RMS 0.1 μm)

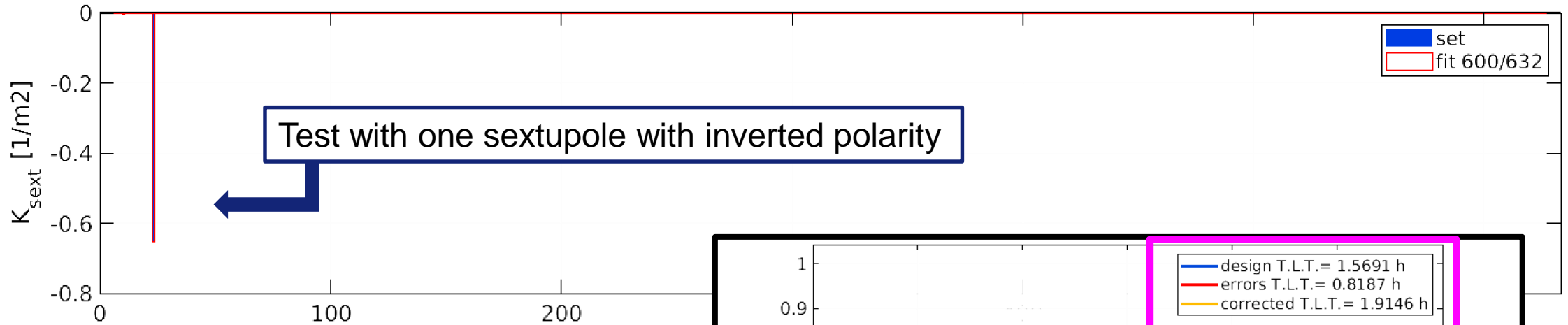
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Right: computed momentum acceptance (over 600 m only) & Touschek lifetime



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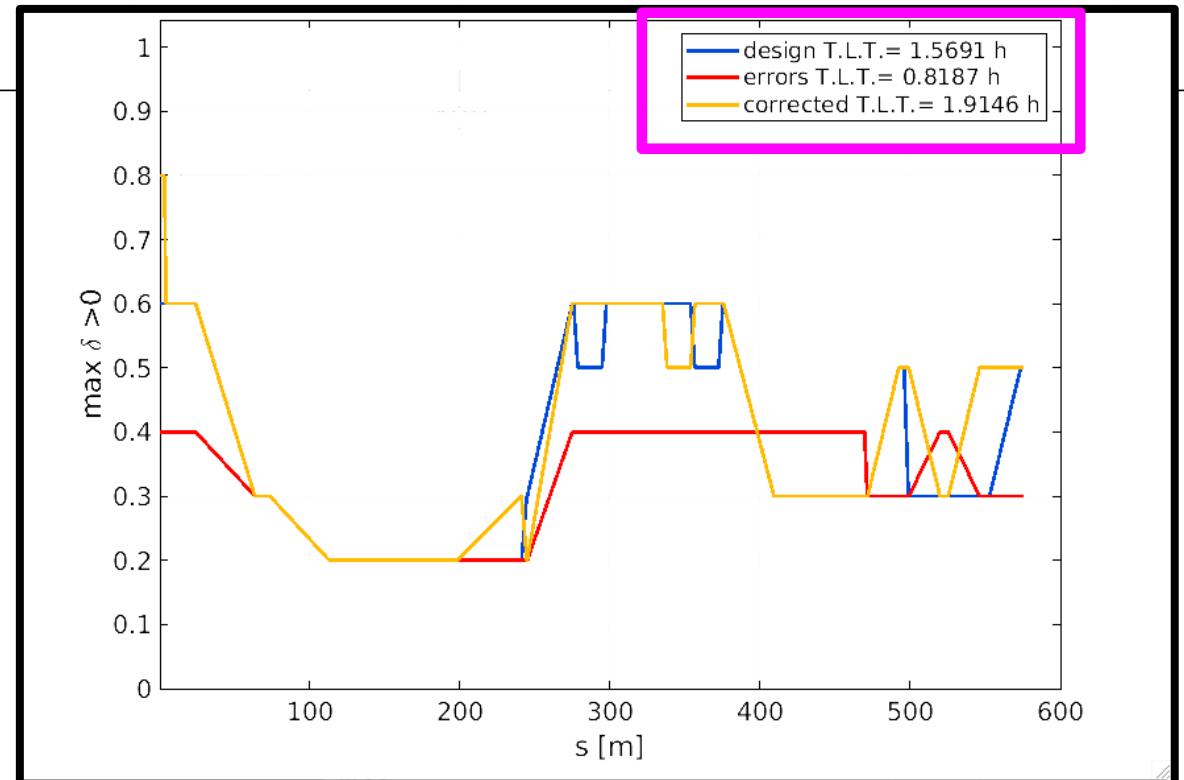
SIMULATIONS (FIT & CORRECTION) FOR FCC-EE



FCC-ee uncorrected lattice with random quad. gradient errors (RMS $3 \times 10^{-5} \text{ m}^{-2}$)

Top: Retrieve (large) sextupole error.

Right: computed momentum acceptance (over 600 m only) & Touschek lifetime



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- **Next steps**

- **Short-medium term: Implement & test linear lattice correction robust enough to work for FCC-ee lattice (still in Matlab)**
- **Long term: start migrating Matlab routines to Python (together with DESY colleagues).**

PROCEDURE FOR OPTICS CORRECTION

```
%% RDT+DISPERSION CORRECTION from lattice error model

% fit lattice errors model
[rfit]=FitResponseMatrixAndDispersionEBSsimple(...
    rerr,...
    r0,...
    inCOD,...
    indBPM,...
    indHCor(1:9*2:end),... % 4 correctors, 1 every 8 cells
    indHCor(1:9*2:end),... % 4 correctors, 1 every 8 cells
    [neigQuadFit,neigDipFit,neigSkewFit,neigDipFit],...
    4,...
    [speclab 'fitrm']);

% get change of strength of correctors
fq=atgetfieldvalues(rfit,indQuadCor,'PolynomB',{1,2});
fs=atgetfieldvalues(rfit,indSkewQuadCor,'PolynomA',{1,2});

% correct RDT and dispersion of fitted error model
[~,inCOD,fcq,fcs]=atRDTdispersioncorrection(...
    rfit,... <--- fitted error model! not lattice with errors!
    r0,...
    indBPM,...
    indQuadCor,...
    indSkewQuadCor,...
    inCOD,...
    [[floor(linspace(1,neigQuad,5)),neigQuad,neigQuad];...
    [floor(linspace(1,neigSkew,5)),neigSkew,neigSkew]],...
    [true],...
    1.0,...
    [0.8 0.1 0.8],...
    ModelRM);

%fcq=atgetfieldvalues(rfitcor,indQuadCor,'PolynomB',{1,2});
%fcs=atgetfieldvalues(rfitcor,indSkewQuadCor,'PolynomA',{1,2});

% store proposed correction
dcq(1,:)=(fcq-fq);
dcs(1,:)=(fcs-fs);
```

Fit of “measured” partial Orbit Response Matrix (slow)
→ **FITTED OPTICS MODEL**

Computation of normal and skew quadrupoles RDTs +
dispersion and correction
→ **Normal and skew quadrupole correction strengths**

This is LOCO equivalent (+ RDTs)

Linear problem + generalize potentially different fit
and correction locations

33. A. Franchi, L. Farvacque, J. Chavanne, F. Ewald, B. Nash, K. Scheidt, and R. Tomás, *Vertical emittance reduction and preservation in electron storage rings via resonance driving terms correction*, *Phys. Rev. ST Accel. Beams* **14**, 034002 (2011).