Preliminary LHC β*-reach in 2018

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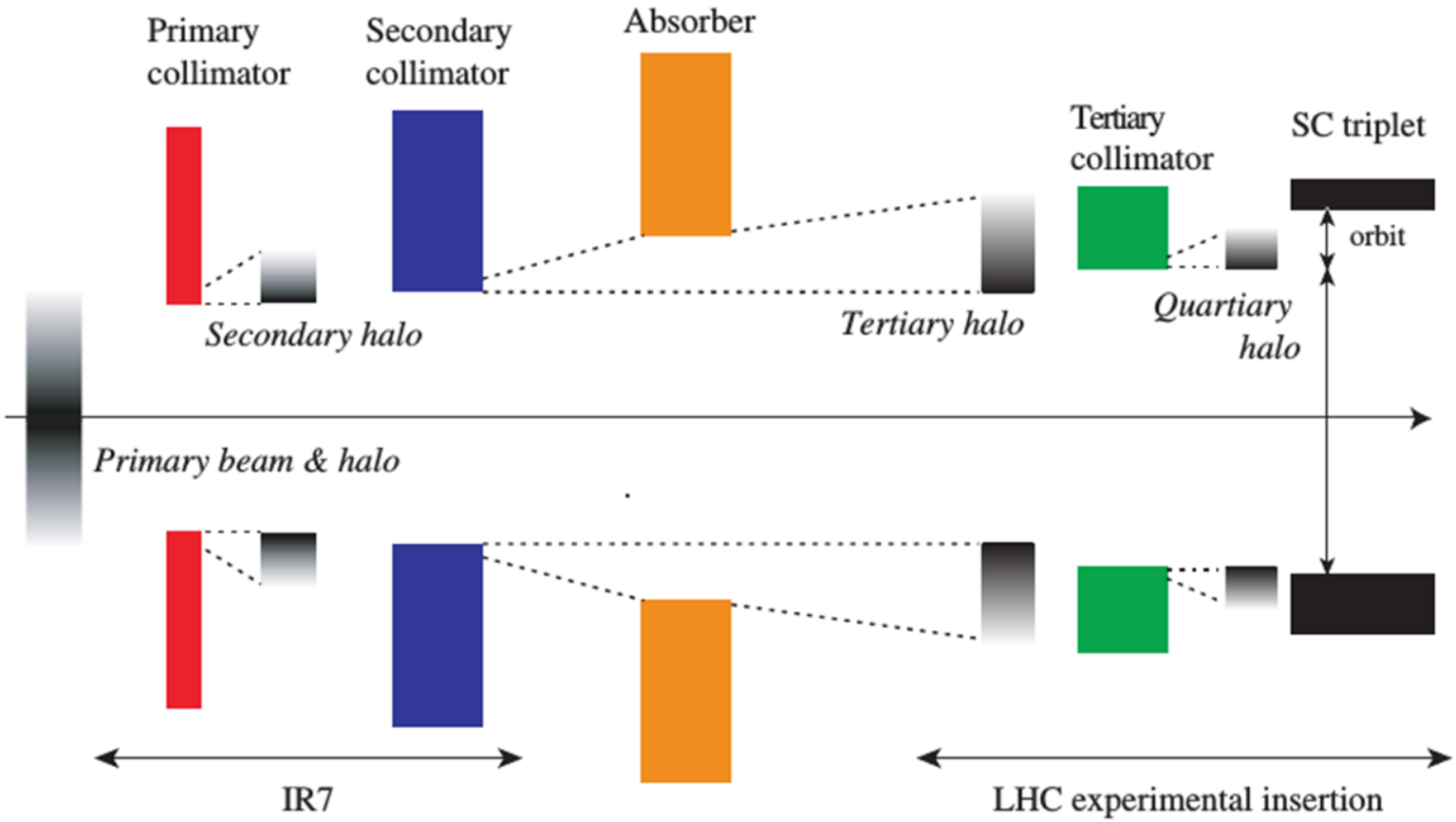
Acknowledgement: collimation and optics teams

Limit on aperture

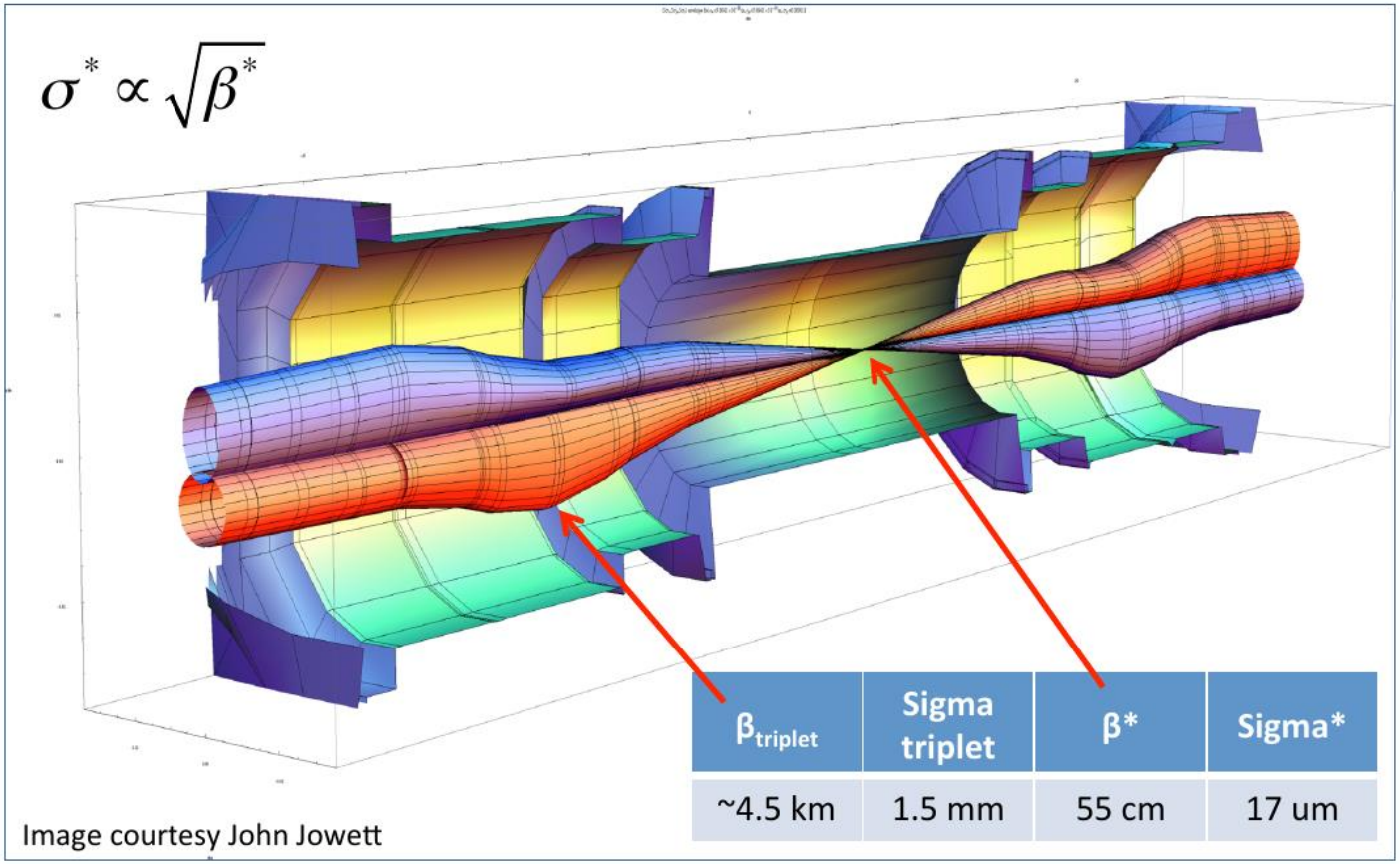
- Collimation hierarchy sets lower limit for protection of aperture
- All elements (e.g. triplet) must have larger apertures (in σ)



Triplet aperture and β*

- Beam size increases in triplet when β* is squeezed
- Smaller β* usually requires larger crossing angle

=> smaller normalized aperture in σ with smaller β*



$\beta_{triplet}$	Sigma triplet	β*	Sigma*
~4.5 km	1.5 mm	55 cm	17 um

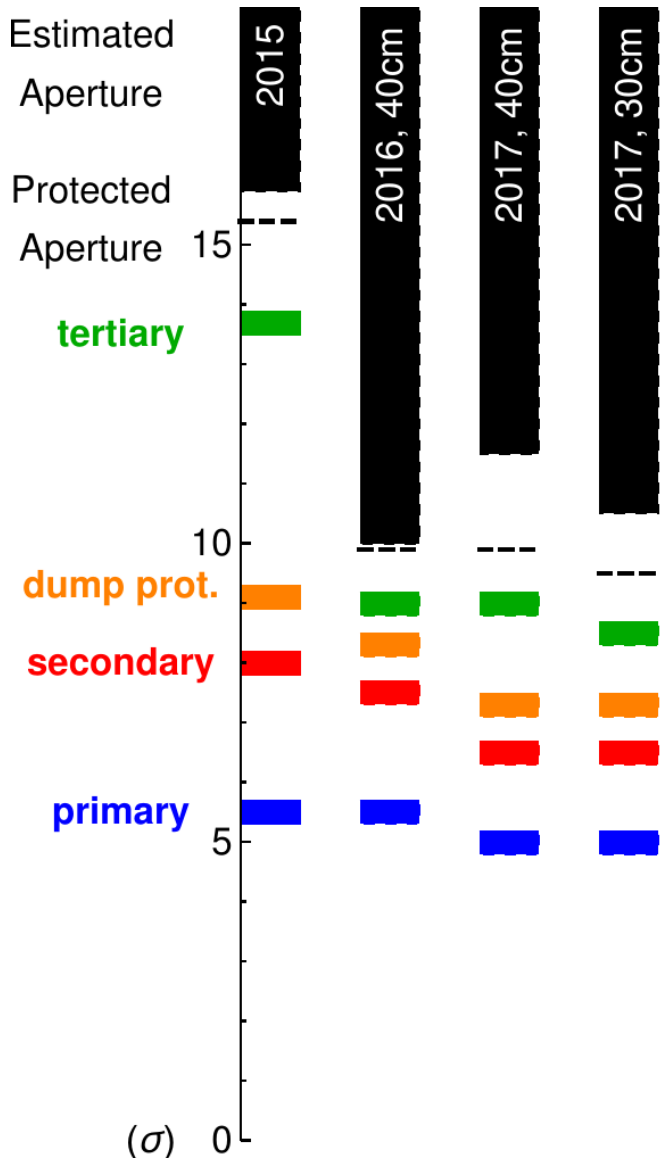
Ways to gain aperture

- Tighter collimators => protect smaller normalized aperture
  - Gain margin with MKD-TCT phase advance
- Smaller normalized beam-beam separation => smaller crossing angle and more aperture at any given β*
- Better knowledge of the aperture allows a smaller margin on the aperture
  - Used to squeeze in Run I

Strategy in 2016-2017

Recap: what did we do in 2017?

- Started with β*=40 cm, 150 µrad (10 σ beam-beam separation), ATS optics
  - Slight increase compared to end of 2016 (140 µrad)
  - Better aperture than in 2016 due to crossing angle reversal
- Tighter collimators than in 2016 to prepare for possible reduction of β*
  - Stayed at β*=40 cm to ease machine protection at startup
- After TS2, squeezed to β*=30 cm
  - Moved in slightly TCTs
  - Kept 150 µrad => decreased beam-beam separation to 8.6 σ.
    - Possible with 8b4e (see Yannis LMC 27/9)



Can we squeeze more in 2018?

- Beam-beam:
  - Studies ongoing in beam-beam team
  - For this study, assuming two options based on past operation
    - 10 σ separation with 25 ns => not much to gain in β*
    - 8.6 σ separation with 8b4e => more aperture => can squeeze β* further
- Collimation hierarchy and aperture:
  - Consider go to 1 σ retraction TCP-TCSG in IR7 => Gain 0.5 σ in hierarchy, but presently not clear if we risk hierarchy violations
    - Probably not a concern for impedance, but iteration is needed with impedance team
  - Not yet at the limit of using the MKD-TCT phase advance. Could still move in TCTs (2017b configuration in Evian 2016)

Proposed 2018 collimator settings

- Collimator settings for 2018 – two options
- Underlying assumption: MKD-TCT phase stays below 30 deg, so that we are not limited by asynch dumps

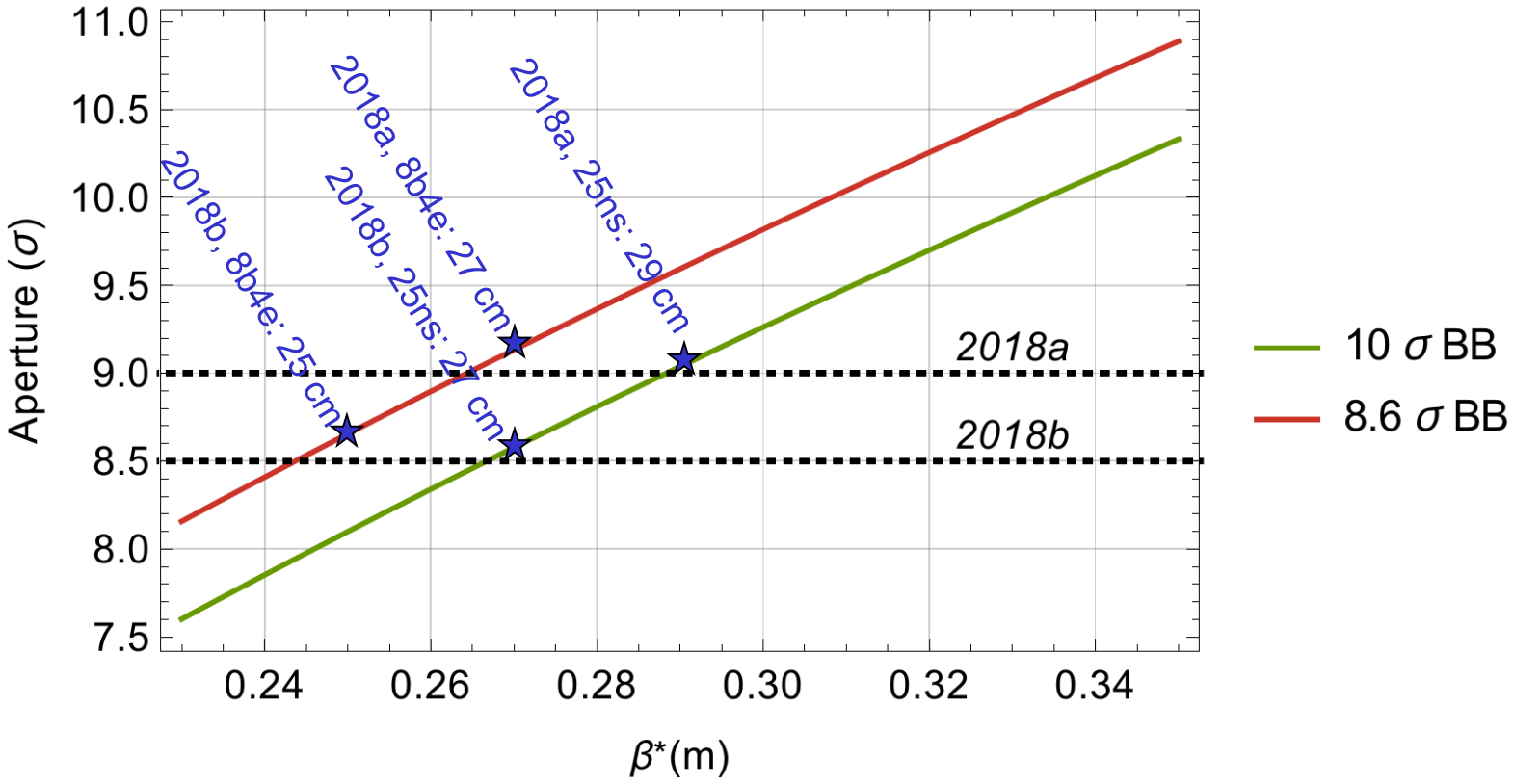
Collimator	2017	2018a	2018b
TCP IR7	5.0	5.0	5.0
TCSG IR7	6.5	6.5	6.0
TCLA IR7	10.0	10.0	9.5
TCP IR3	15.0	15.0	15.0
TCSG IR3	18.0	18.0	18.0
TCLA IR3	20.0	20.0	20.0
TCSG IR6	7.3	7.3	6.8
TCDQ IR6	7.3	7.3	6.8
TCT IR1/5	8.5	7.5	7.0
Aperture 1/5	*9.5+0.5*	*8.5+0.5*	*8.0+0.5*
TCT IR2	37.0	37.0	37.0
TCT IR8	15.0	15.0	15.0

Settings in σ with ε=3.5 μm

Aperture calculations

- Conservative approach for aperture calculations
  - Use most pessimistic measured 2017 aperture and scale it to new configuration – 11.5 σ measured at β*=40 cm with 150 µrad
  - Add 0.5 σ safety margin to account for drifts over the year
    - Assuming we keep present orientation of IR1 crossing - would otherwise lose
- Assuming that CMS vertical orbit shift does not decrease available aperture
  - In 2017 commissioning, bumps down to -2 mm checked without impact
- Separation plane not limiting in 2017 – assume this is the case also in 2018
- As always, crucial to re-measure aperture during commissioning

Aperture vs β*



- Depending on beam-beam separation and collimation scheme, reach in β* is between 25 cm and 29 cm
- If we do β*-levelling and allow smaller beam-beam separation at lower intensity, even smaller β* might be within reach at the end of the fills

Preliminary conclusions

- In 2017
  - Started at 40 cm and tighter collimators than in 2016
    - Additional margin to squeeze to 30 cm in the year
  - Decreased after TS2 to 30 cm
    - Using the tighter collimators
    - Smaller beam-beam for 8b4e => additional aperture margins
- Some options for 2018
  - **β*=30 cm :** staying with 2017 8b4e configuration, or switching to 25 ns BCMS beams and 10 σ beam-beam separation
    - Probably not worth to go to 29 cm
  - **β*=27 cm**
    - with 25 ns BCMS beams and tighter IR7 collimators
    - With 8b4e and 2017 IR7 collimators
  - **β*=25 cm** with 8b4e AND tighter IR7 collimators