Institute of High Energy Physics
Chinese Academy of Sciences

Circular Electron Positron Collider

CEPC requirements on the ground motion

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Many thanks to Fang Yan for providing HEPS experience on the study of ground motion

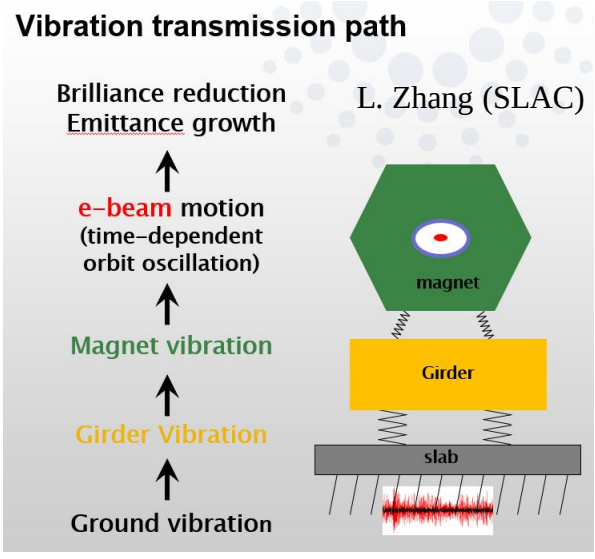
Outline

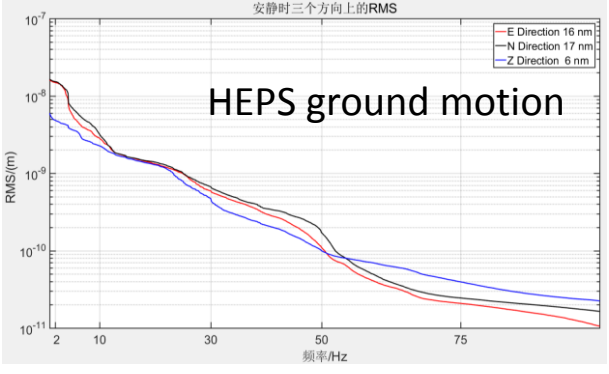
- Introduction to the ground motion study
- Requirements on the ground motion of the CEPC accelerator complex
  - Collider ring
  - Booster ring
  - Injector Linac

Introduction

- 地面振动传导到加速器的磁铁等元件上会导致束流中心轨道的抖动，进而引起束流等效发射度的增长、对撞亮度的下降等。
- 地面振动 (包括地脉动、周边环境中各种设备和人类活动包括轨道交通、行人等引起的振动)在一定频率范围内（典型值1-100Hz ）的RMS位移积分值应作出限制（HEPS为25nm），并进行如下参数分解：
  - 限制周边其他振动源引起的振动传导至隧道地面上的影响（HEPS为1nm）
  - 限制支架及基座 (包括磁铁) 对地面振动的放大倍数（HEPS为1）
- 按照不同的振动来源和频率，有不同的减振、隔振方法。

Ref: Fang Yan





CEPC requirements on ground motion (preliminary)

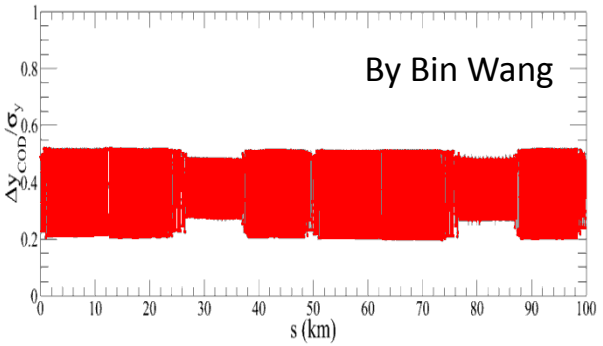
- Uniform distribution of the ground motion spectrum
- Amplification factor from ground to magnet is 1
- All magnets vibrate independently (worst case)

Collider ring

- The beam jitter shifts the beams centroids and thus the colliding beams do not fully overlap at the interaction point.
- The relative luminosity reduction with small jitter can be estimated with

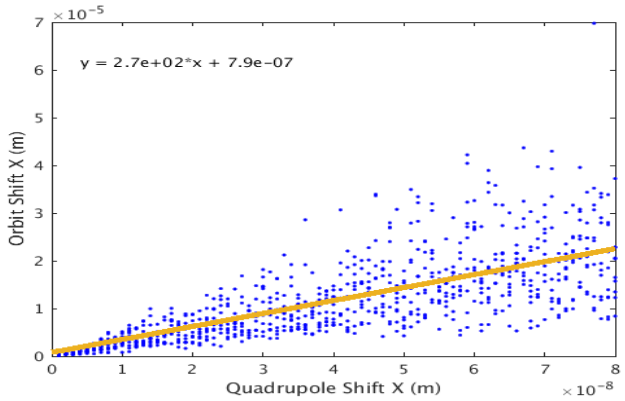
$$\frac{\Delta L}{L} \cong -\frac{(\Delta y/\sigma_y)^2}{4}$$

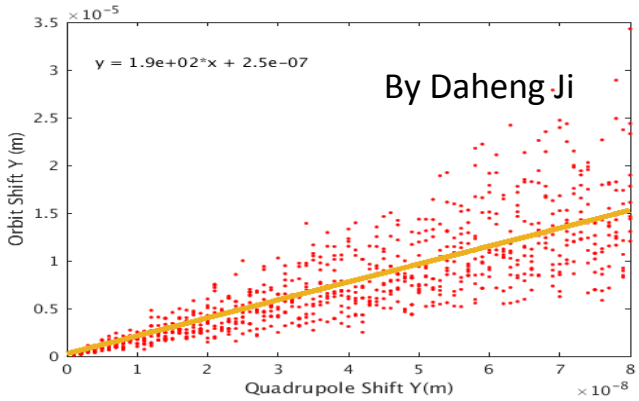
  - note the horizontal beam size is much larger than vertical one at the IP
- **If constraint luminosity reduction less than 1%**
  - **Vertical beam jitter at the IP $(\Delta y_{IPs}/\sigma_y)_{rms}$<0.2**
    - σ_y=60nm, amplification factor ~3,
    - Require the ground motion less than **4nm**



Booster ring

- Beam jitter will induce the emittanc growth and thus the reduction of injection efficiency
- **If constraint reduction of injection efficiency less than 1%**
  - **orbit stability of the whole ring less than 30um**
    - Amplification factor ~300(H)/200(V)
    - **Require the ground motion less than 100nm/150nm**





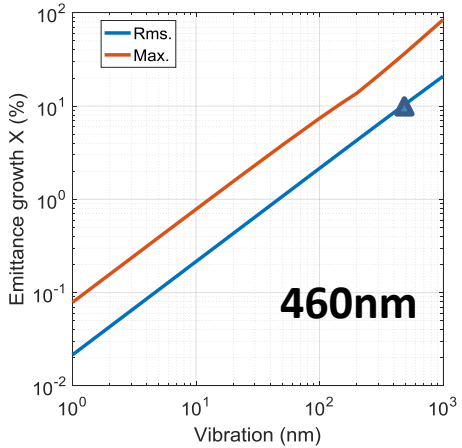
Injector linac

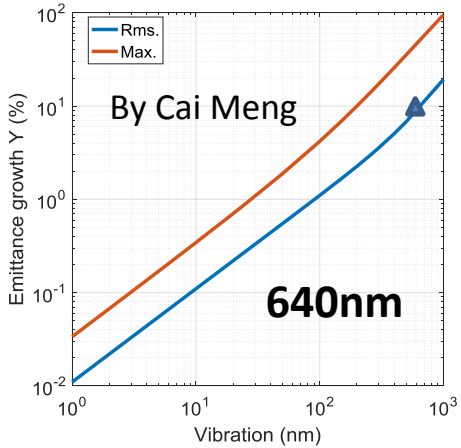
- Beam jitter will induce single-bunch and multi-bunch emittance growth (bunch repetition rate is higher than frequency of ground motion)
- **If constraint total emittance growth less than 30%** (DR to Booster: 30nm to 40nm)
  - **single-bunch emittance growth < 10%**
  - multi-bunch emittance growth < 20%
    - Require the **orbit stability less than** 10% of beam size, i.e. **0.1mm**

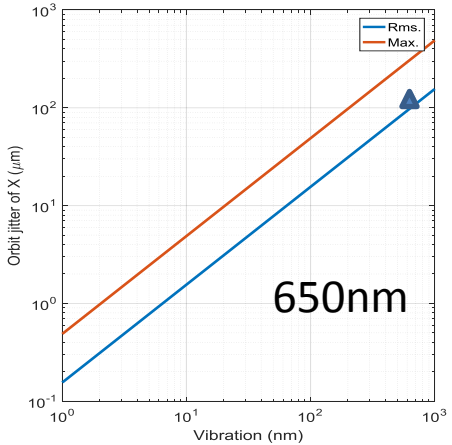
$$\varepsilon=\left(\frac{\sigma_x}{\sqrt{\beta_x}}+\frac{\Delta x}{\sqrt{\beta_x}}\right)^2=\varepsilon_0\left(1+2k+k^2\right),k=\frac{\Delta x}{\sigma_x}$$

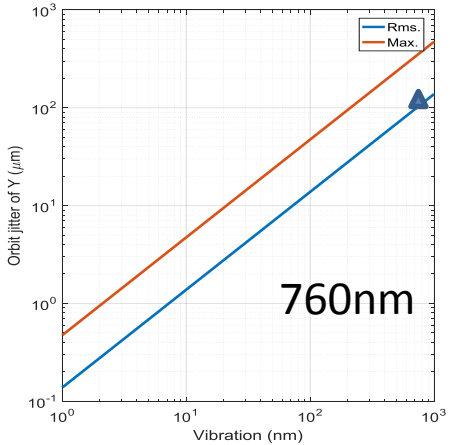
Single-bunch emittance growth and orbit stability

Assuming Independent magnet



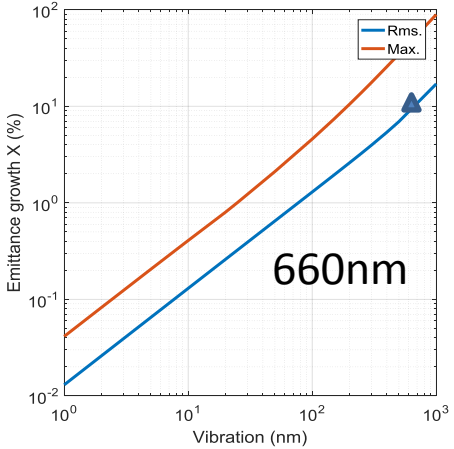


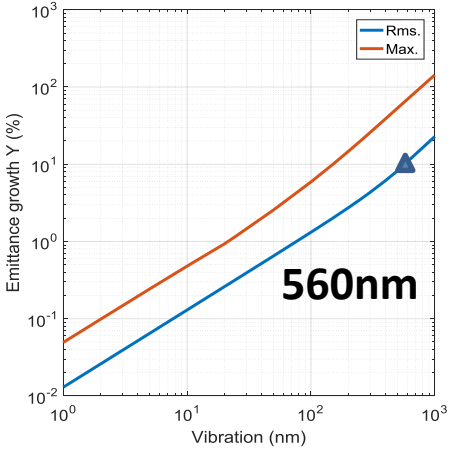


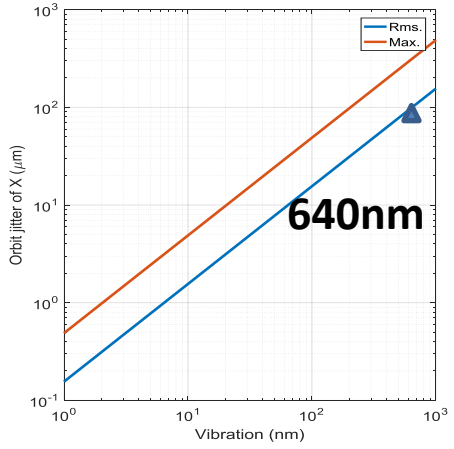


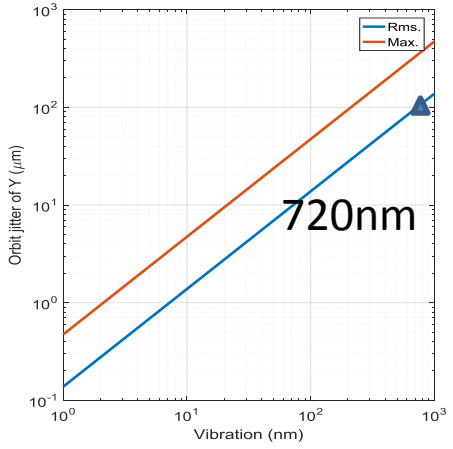
Single-bunch emittance growth and orbit stability

Assuming common girder for magnets of triplet cell



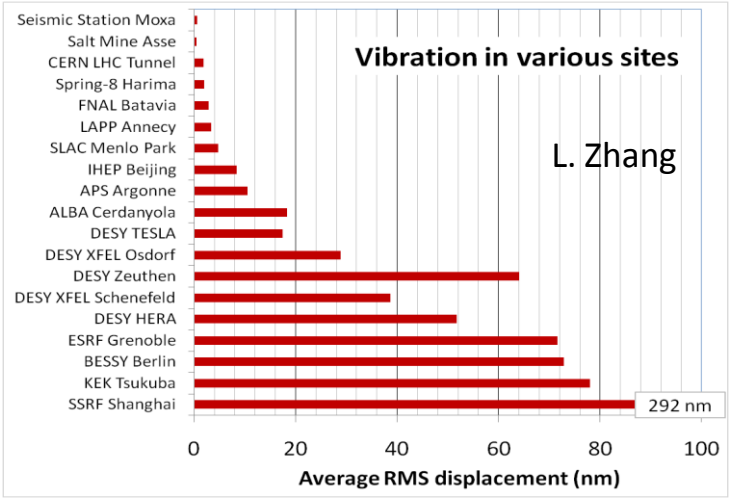






CEPC requirements on the ground motion (preliminary)

Machine	Constraint	Requirements on ground motion
Collider ring	luminosity reduction < 1%	< -/4nm
Booster ring	injection efficiency reduction < 1%	< 150/100nm
Injector linac	total emittance growth < 30%	< 460/560nm



Summary

- Preliminary requirements on the ground motion were got for the CEPC collider ring, booster ring and injector linac.
- More detailed simulation should be carried out to check the results.
  - The estimation of luminosity reduction should be checked with beam-beam simulation.
  - Simulation with realistic power spectrum of ground motion
  - Very low frequency of ground motion with large amplitude should be considered as CEPC is a large machine.

3. 减隔振思路

Fang Yan

振动源

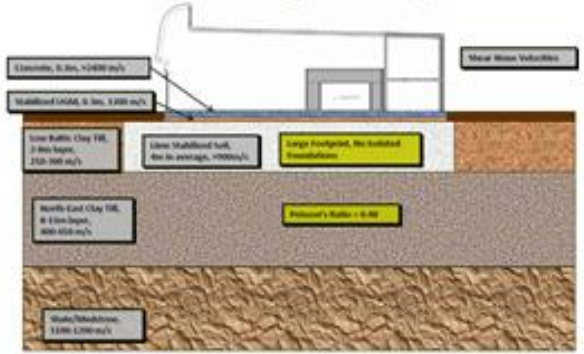
根据振动来源分：**凡知道来源的振动均做减隔振处理**

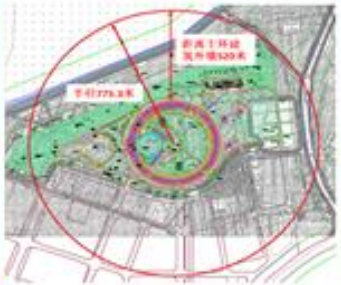
地脉动 → 隔振：与周边土的剪切波速差距2-3倍，使周边振动反射

交通载荷等外部振源 → 远离：控规：使振源远离关键设备，使振动通过经过长距离衰减达到限制要求

内部振源 → 减振：振源与减振弹簧的频率相差3-5倍达到减振的目的

Civil Engineering





怀柔规划新建城铁与项目安全距离

Courtesy of Max-IV

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