Summary of MDI/CFS Sessions

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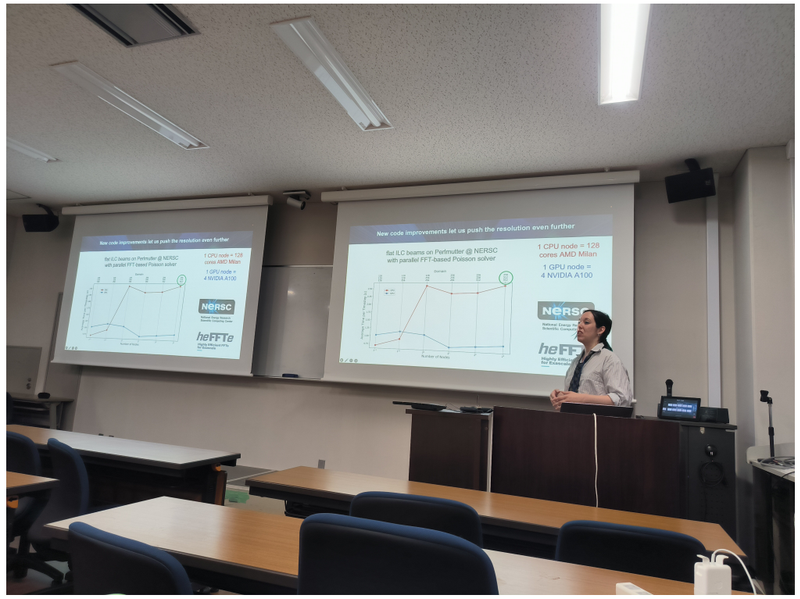
Nobuhiro Tenamura, Tomoyuki Sanuki, John Osborne

LCWS 2024 – Tokyo (JP) – July 2024

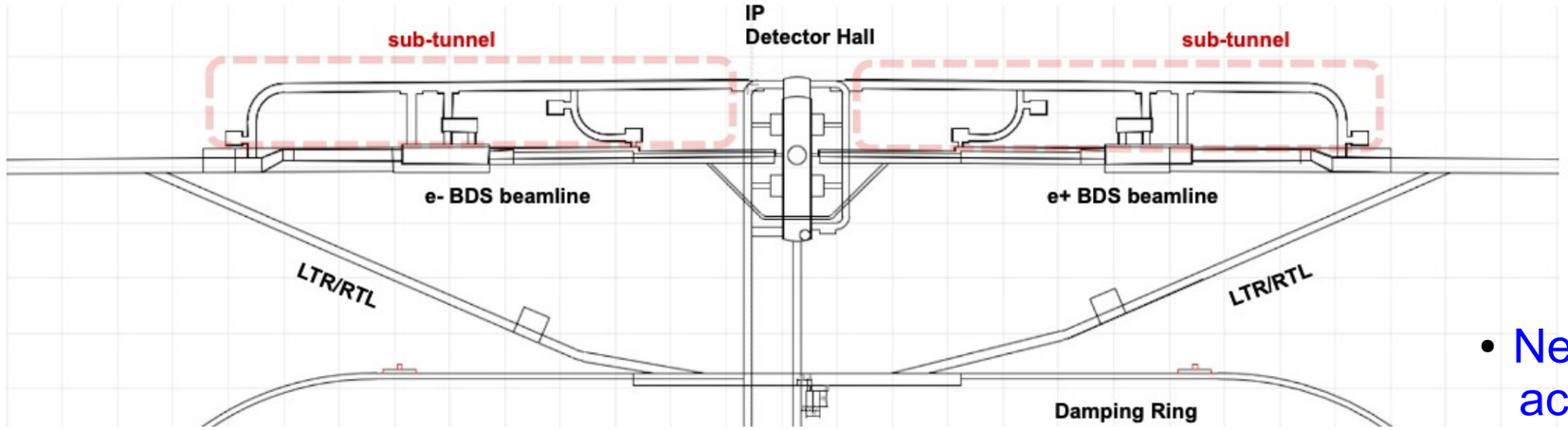
CFS/MDI Sessions@LCWS 2024

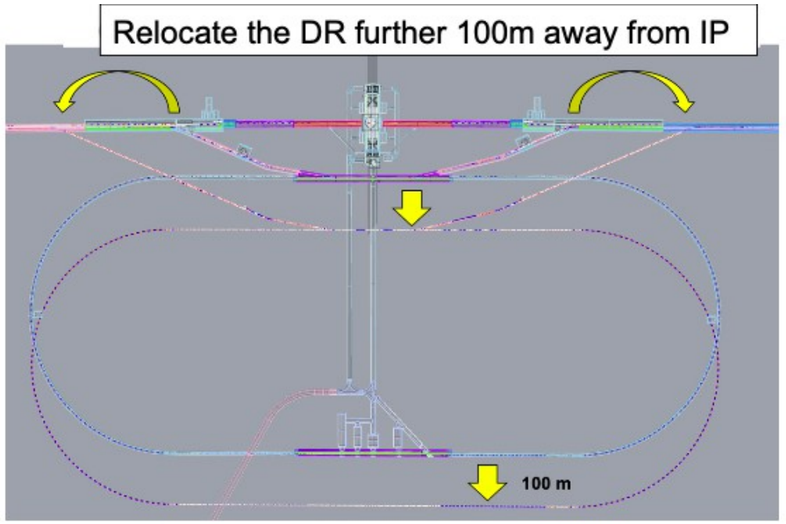
- Three sessions, 12 talks grouped around four topics:
  - Site issues, planning and “Heavy Metal”
  - Tools for beam background and impact on detectors
  - Design of MDI regions
  - Real life experience
- Excellent talks
  - … partially with illustrative animations
- Lively discussions
- All faults in this summary are mine



Plan of sub-tunnel from IP to dump section

- **Extended from the access tunnel surrounding the DH.**
- **Parallel to the BDS tunnel with several connections to it.**
  - Serves as a delivery route other than PM 8s.
  - Equipment rooms can be located in the middle of connecting tunnels.





- New sub tunnel to render more convenient access to BDS system

=> Displace DR 100m from IP

- New system already implemented in CAD model
- N.B. has also consequences for arcs at the beginning of the main linac

N. Terunuma

July 9th, 2024, LCWS2024, CF/MDI session 7

“Big Magnet Crisis”

K. Büßer

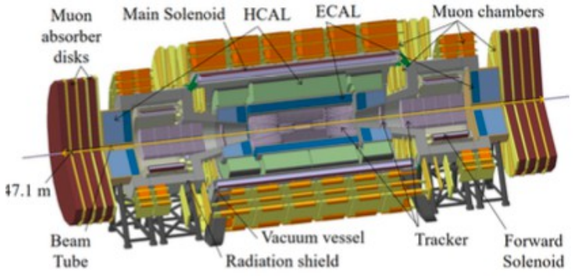
Future Detector Magnets

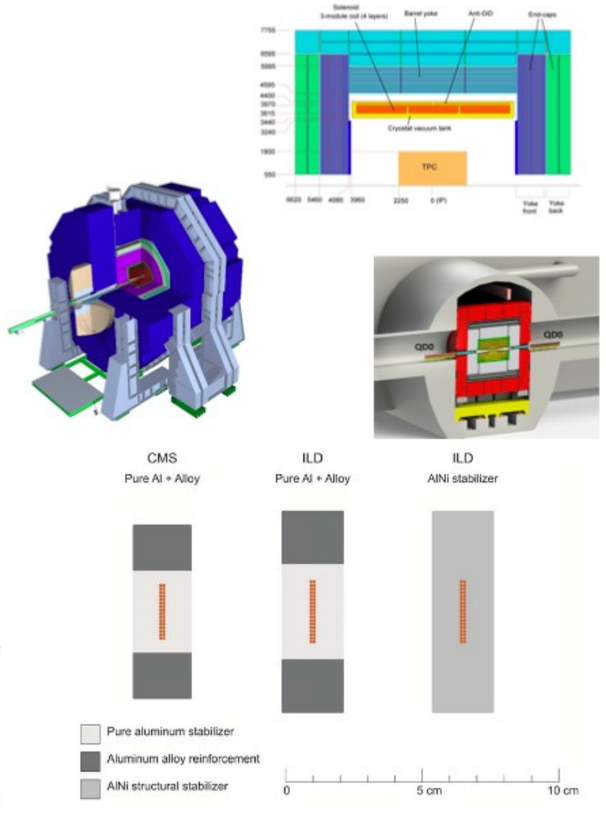
Follow basically CMS-Example
- Al-stabilised conductor
- Co-extrusion process

Industry has dropped the ball
- No facilities available with a proven track record
  - Not an interesting market for industry

R&D is slowly taking up again
- CEPC is working together with Toly Electric
- First results look promising

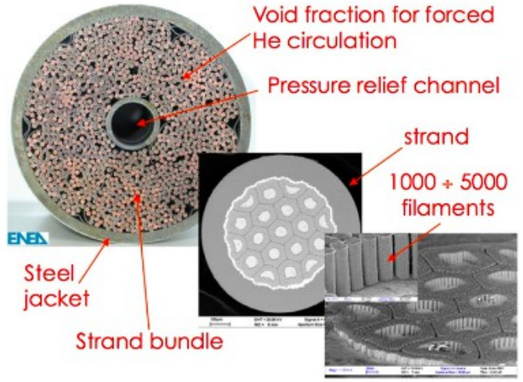
Need to pick up the ball
- Cooperation between Labs and industry is crucial!



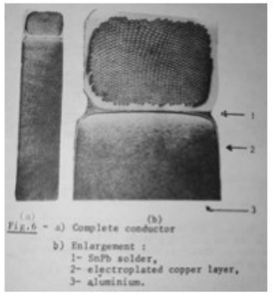


New/other technologies?

CICC



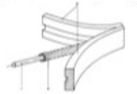
Soldiering/beam welding



Cello Conductor

One of the first aluminum soldered conductor 1979 for a solenoid of 1.5 T (Øi= 1.6 m, length 4 m).

One year after Morpurgo magnet



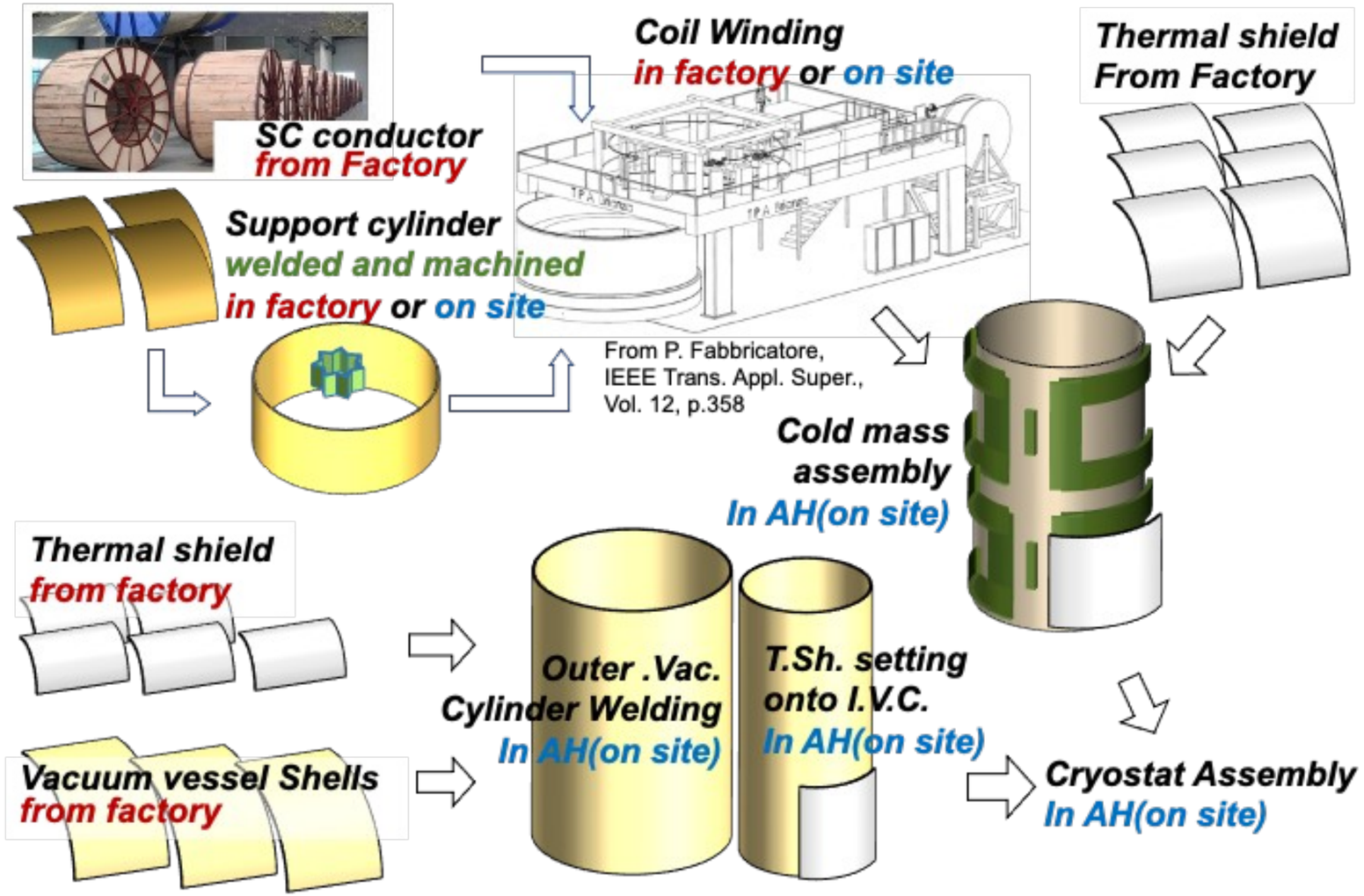
CERN workshop– 12-14/09/2022

- No Magnet, no detector
- Serious problem, regular meetings since 2022
- Can HEP (CERN) provide the production?

… and HTS

On or off-site? That's the question – Magnet Manufacturing

Y. Makida



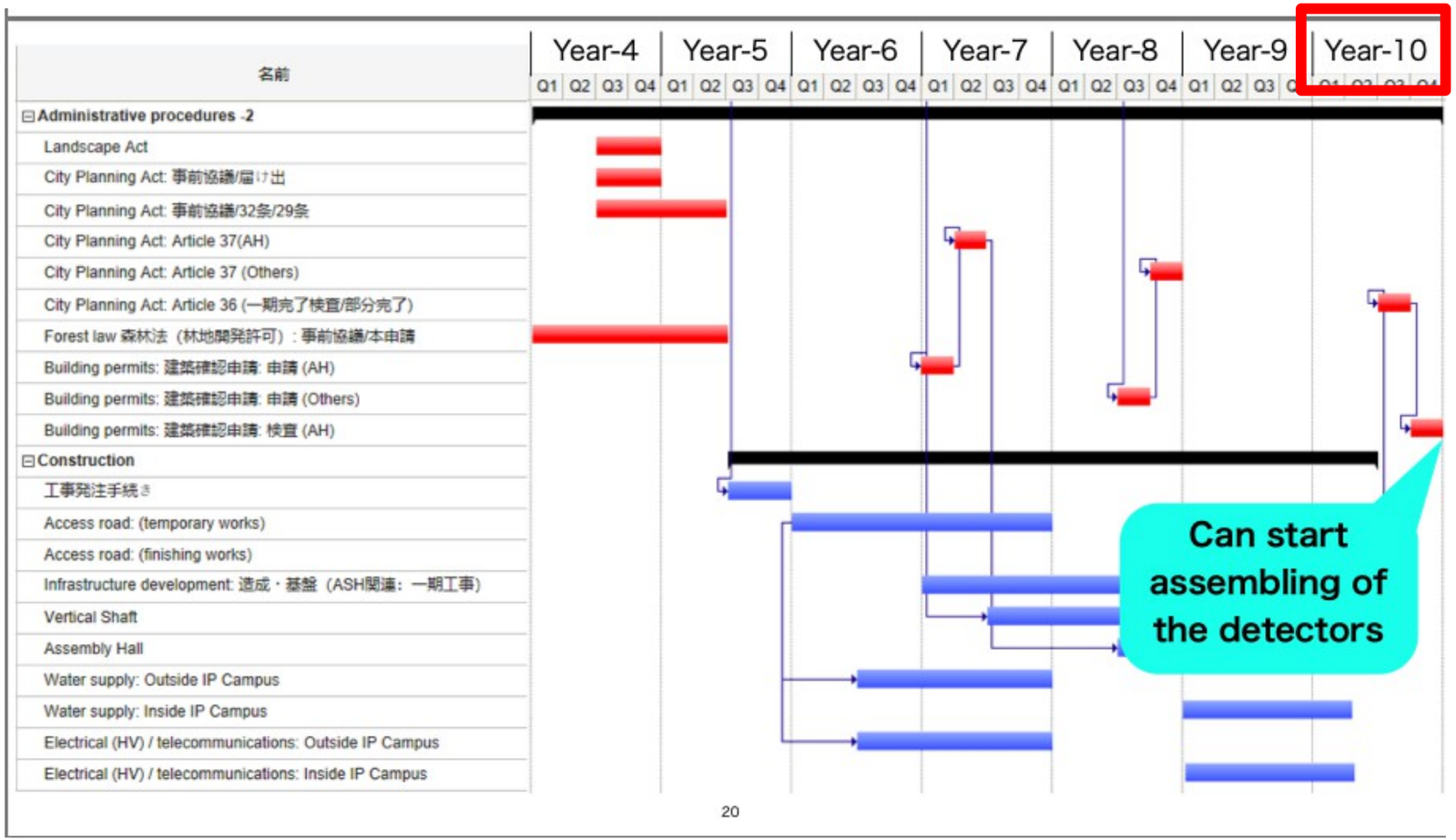
This would be a major infrastructure needed at the earliest occasion next to the IP

ILC Site Development of Kitakami IP Campus - “Reference Site Schedule”

General Procedure

Project Approval by Politics

Timeline



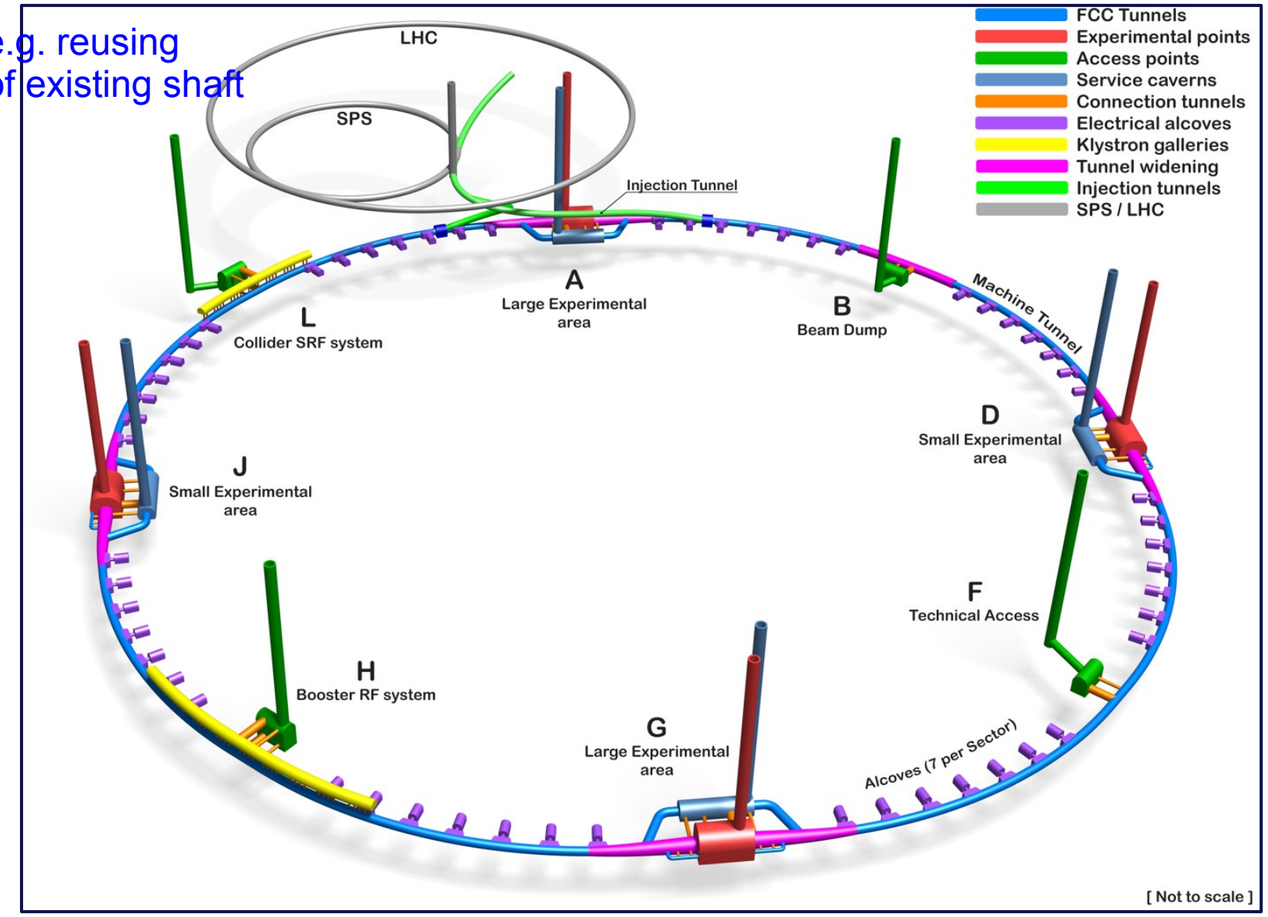
- Detector assembly can only start 10 Years after project approval
- Note that it takes (according to our best estimate) seven years to assemble the detector
- What can be parallelised to be not paralysed?

T. Sanuki

FCC Civil Engineering

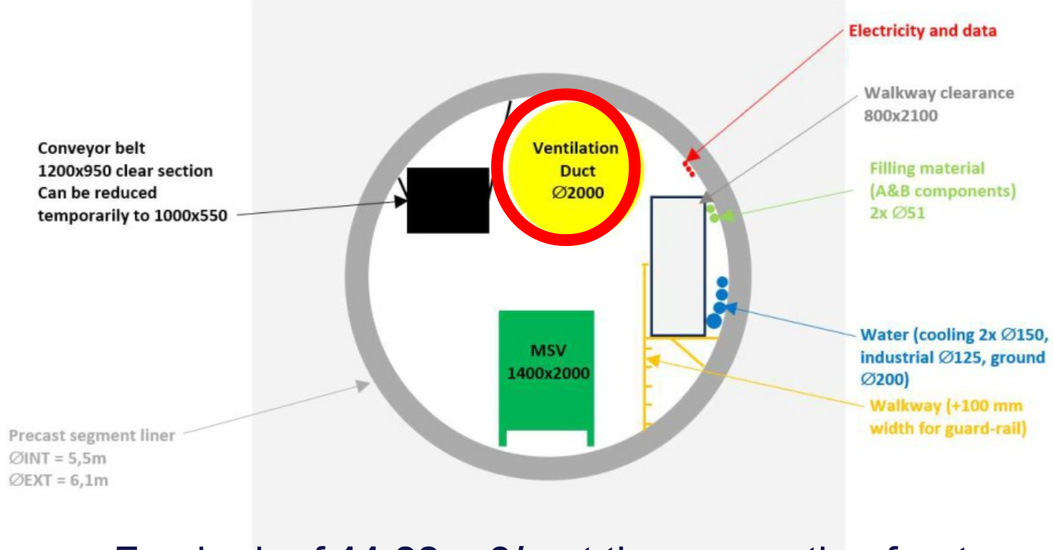
L. Bromiley “Post Midterm Review” Layout (WiP)

e.g. reusing of existing shaft



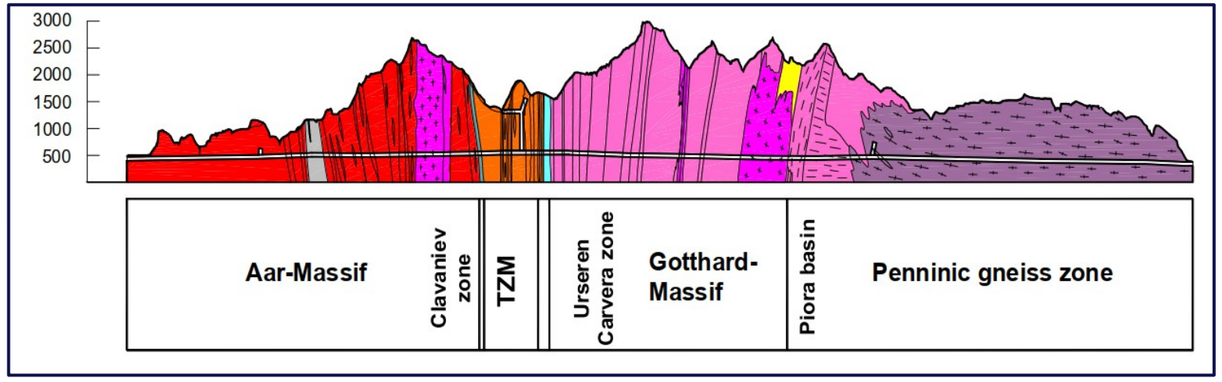
Shafts 200 – 550 m deep
Tunnel: At least 80m below Lake Geneva surface

Ventilation is important for working in tunnel

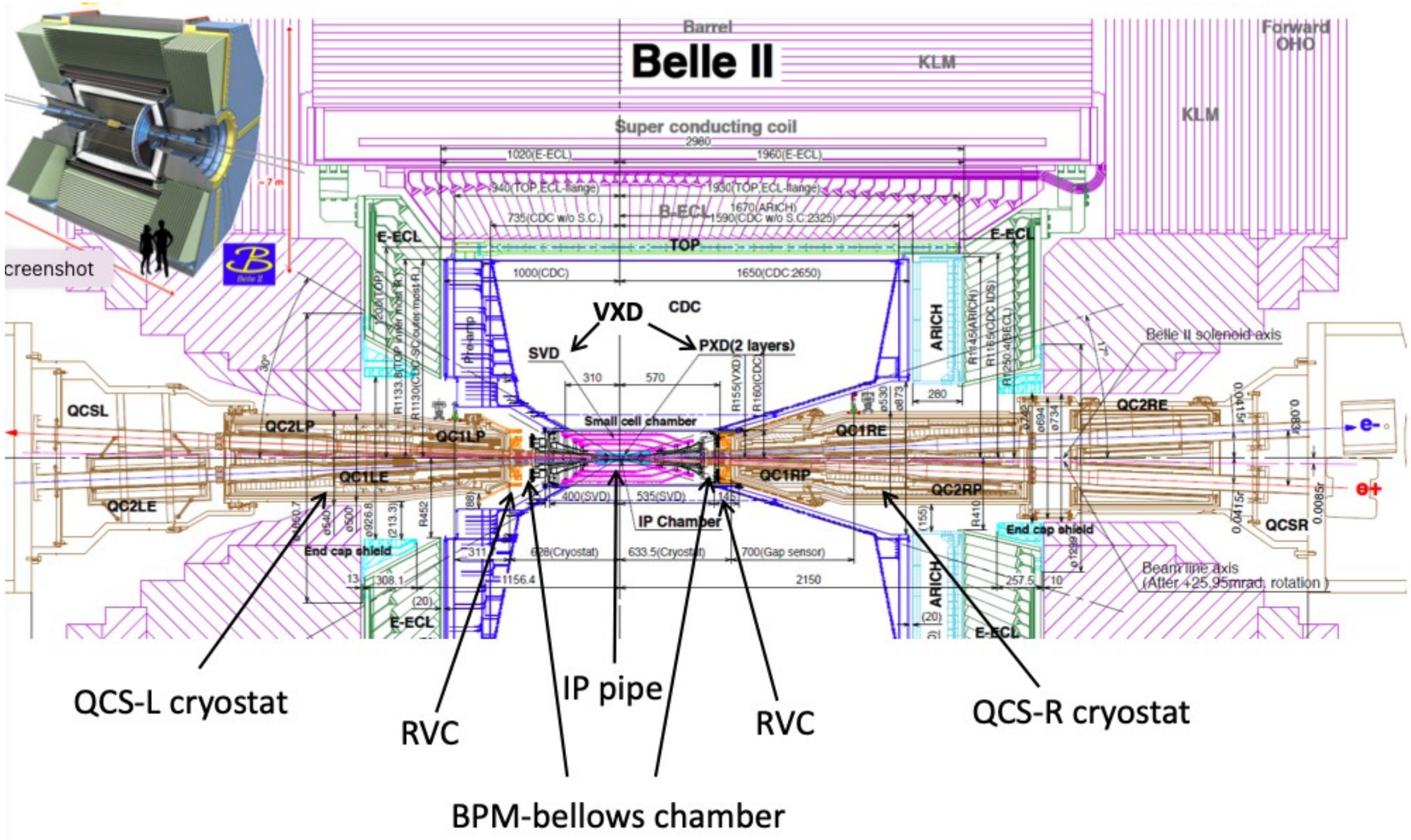


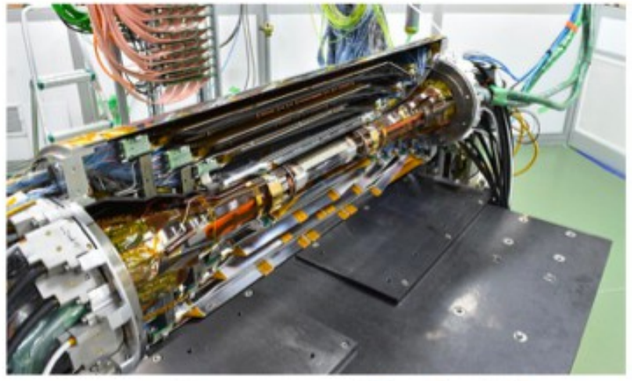
e.g.: Fresh air of **11.88 m3/s** at the excavation front required.

Tunnel Drilling: Case study Gotthard Tunnel



SuperKEKB – IA Region Vacuum System

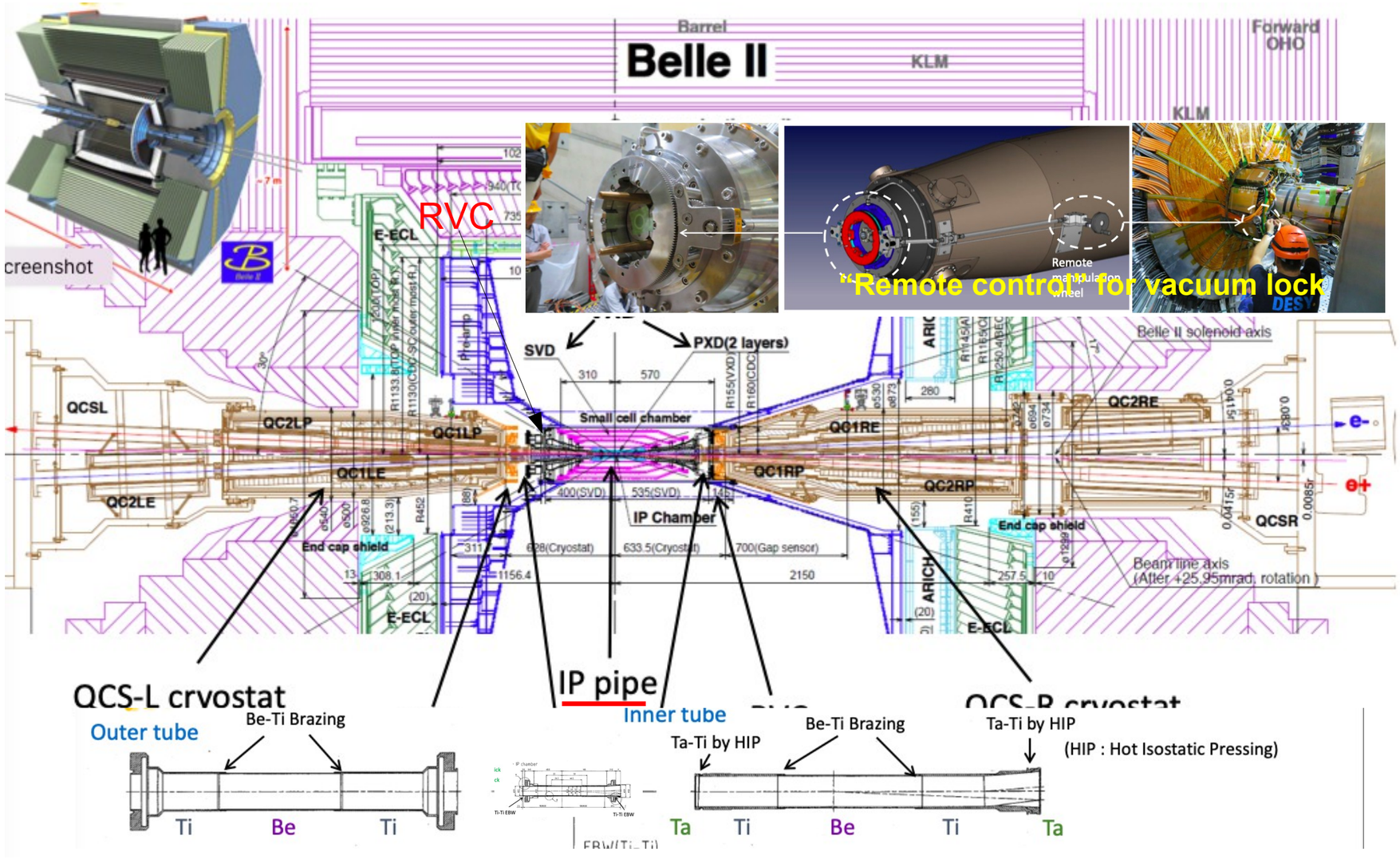


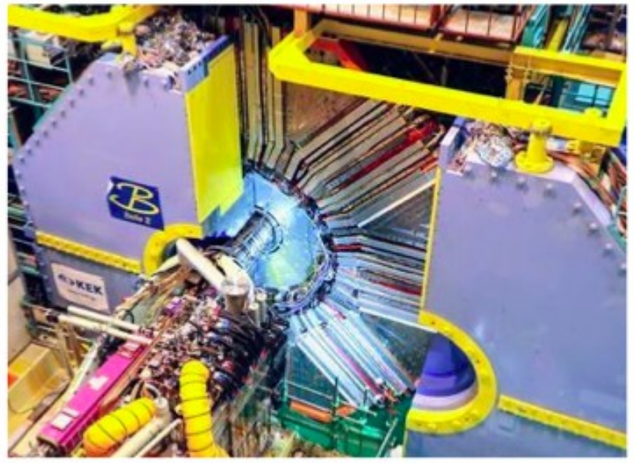


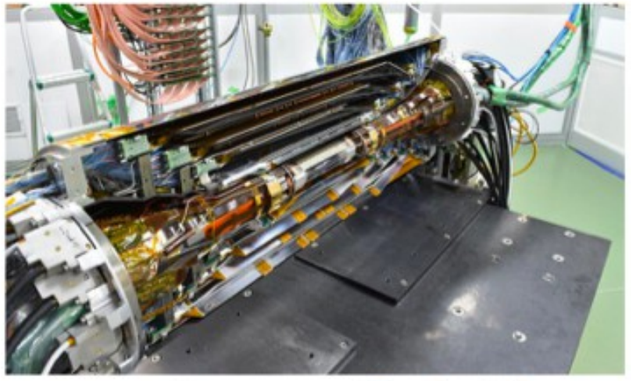
IP pipe assembled with VerteX Detector (VXD)

K. Shibata

SuperKEKB – IA Region Vacuum System





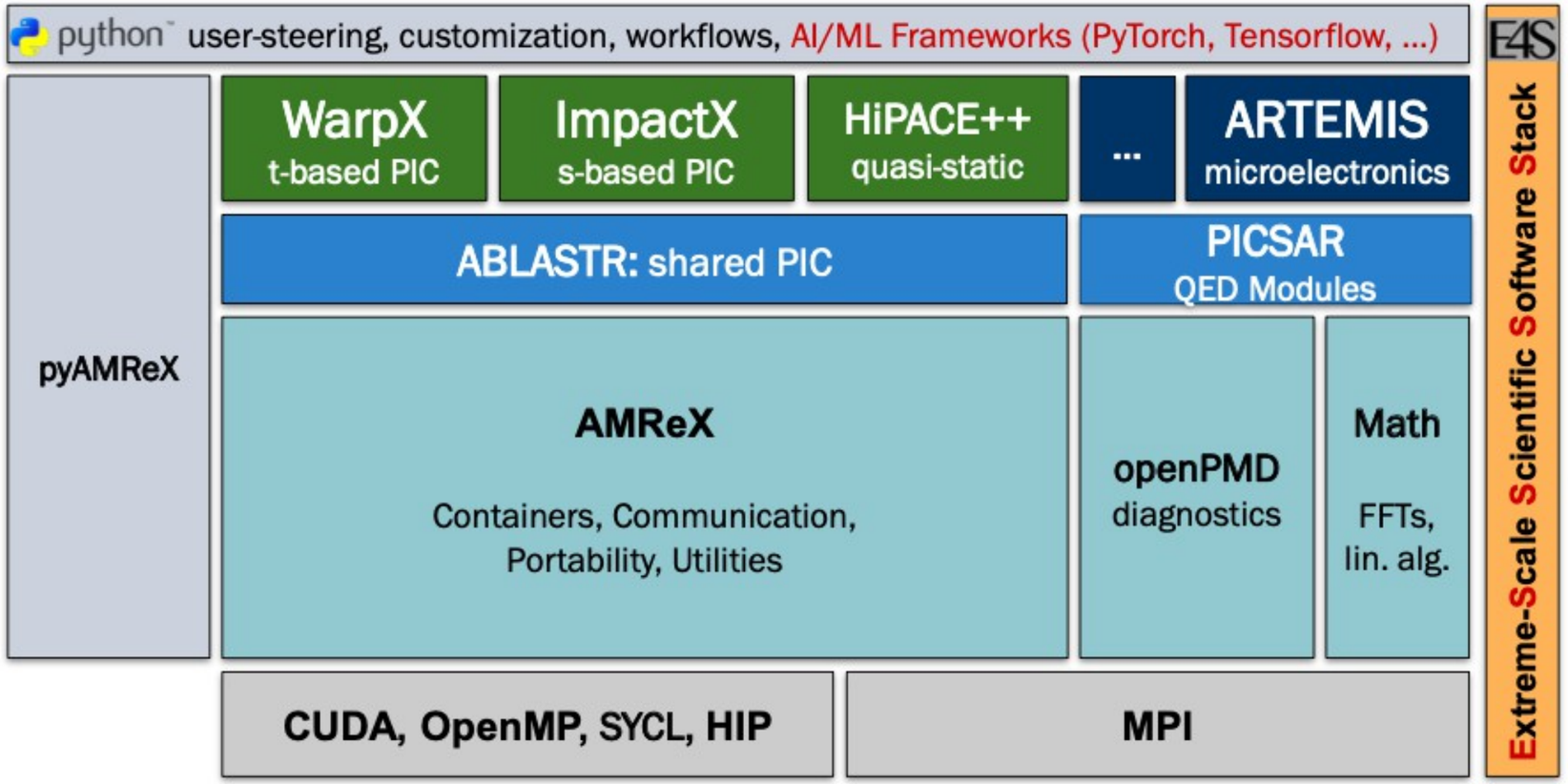


IP pipe assembled with VerteX Detector (VXD)

Welding of different materials: Ti, Be, Ta ...

Beam Plasma and Acceleration Simulation Toolkit - BLAST

High-performance, integrated suite for particle accelerator modeling (& more)



E4S is **unique in the world:**
➔ advantage of **unparallel performance & portability.**

Python interface:
- **Modular approach pioneered by Warp 20+ years ago**
  ➔Coupling to other codes (e.g., Posinst, ICOOL, …)
- **Access to powerful AI/ML tools**

ECP EXASCALE COMPUTING PROJECT

Laboratory Directed Research & Development
BERKELEY LAB

SciDAC
Scientific Discovery through Advanced Computing

➔ Propose to leverage for faster & larger scale modeling for colliders (all types) R&D

- Impressive project for end-to-end accelerator modeling
- Beam-Beam Interaction by WarpX component

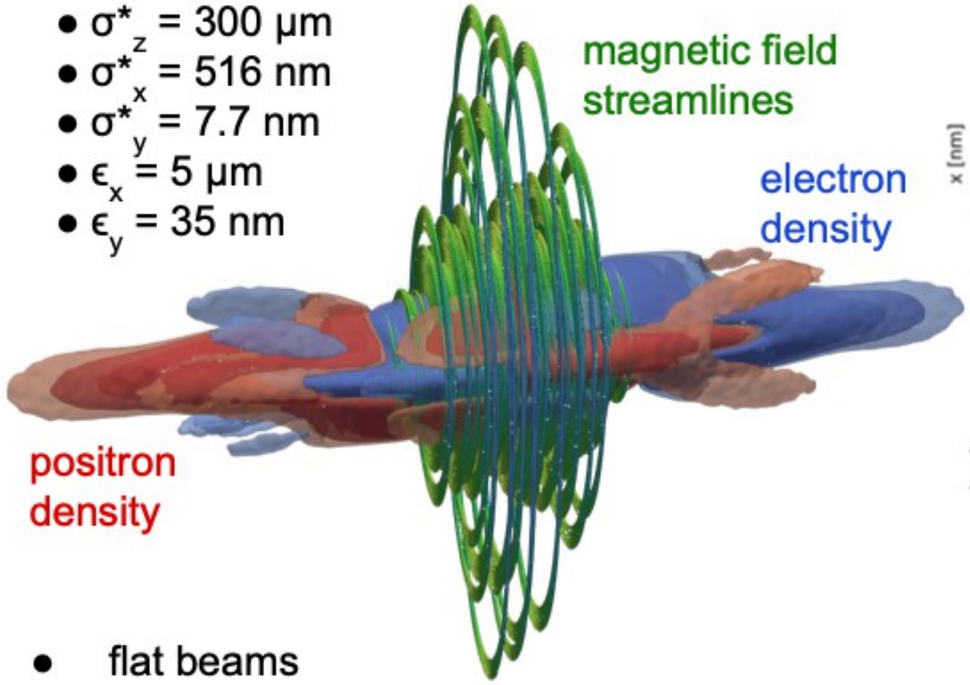
J. L. Vay

WarpX – Benchmarking for ILC beams

A. Formenti

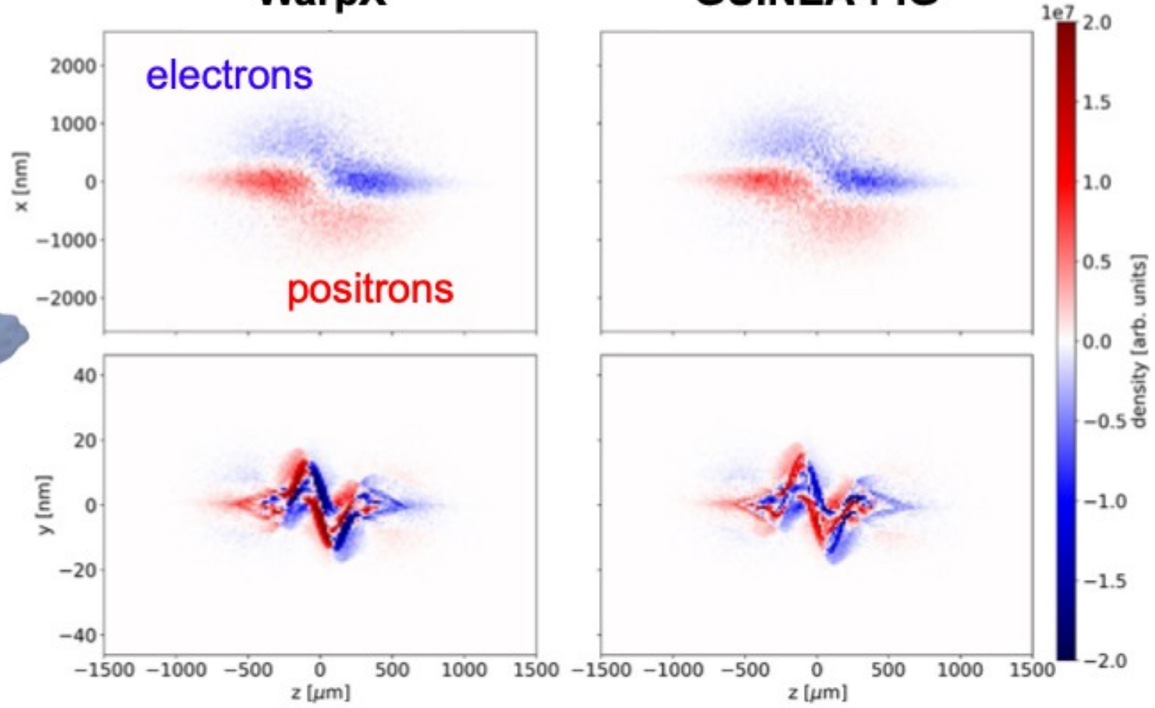
main parameters
- E_{COM} = 250 GeV
- N = 2 10^{10}
- σ^*_z = 300 µm
- σ^*_x = 516 nm
- σ^*_y = 7.7 nm
- ϵ_x = 5 µm
- ϵ_y = 35 nm

The International Linear Collider: Report to Snowmass 2021



- flat beams
- significant disruption D_x = 0.30, D_y = 24.39
- negligible coherent pairs

snapshot of the beams' ***density integrated along the missing coordinate*** during collision



offsets along x and y ~$\sigma_{x,y}$/10 to induce the kink instability and mitigate stochastic discrepancies

- … results identical to GuineaPig for ILC flat beams

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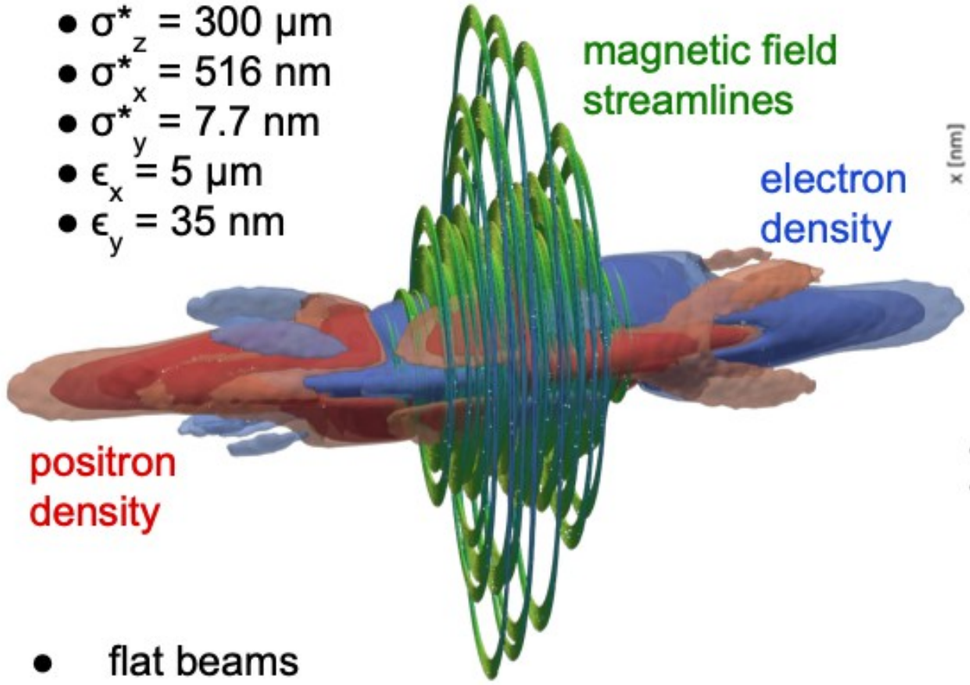

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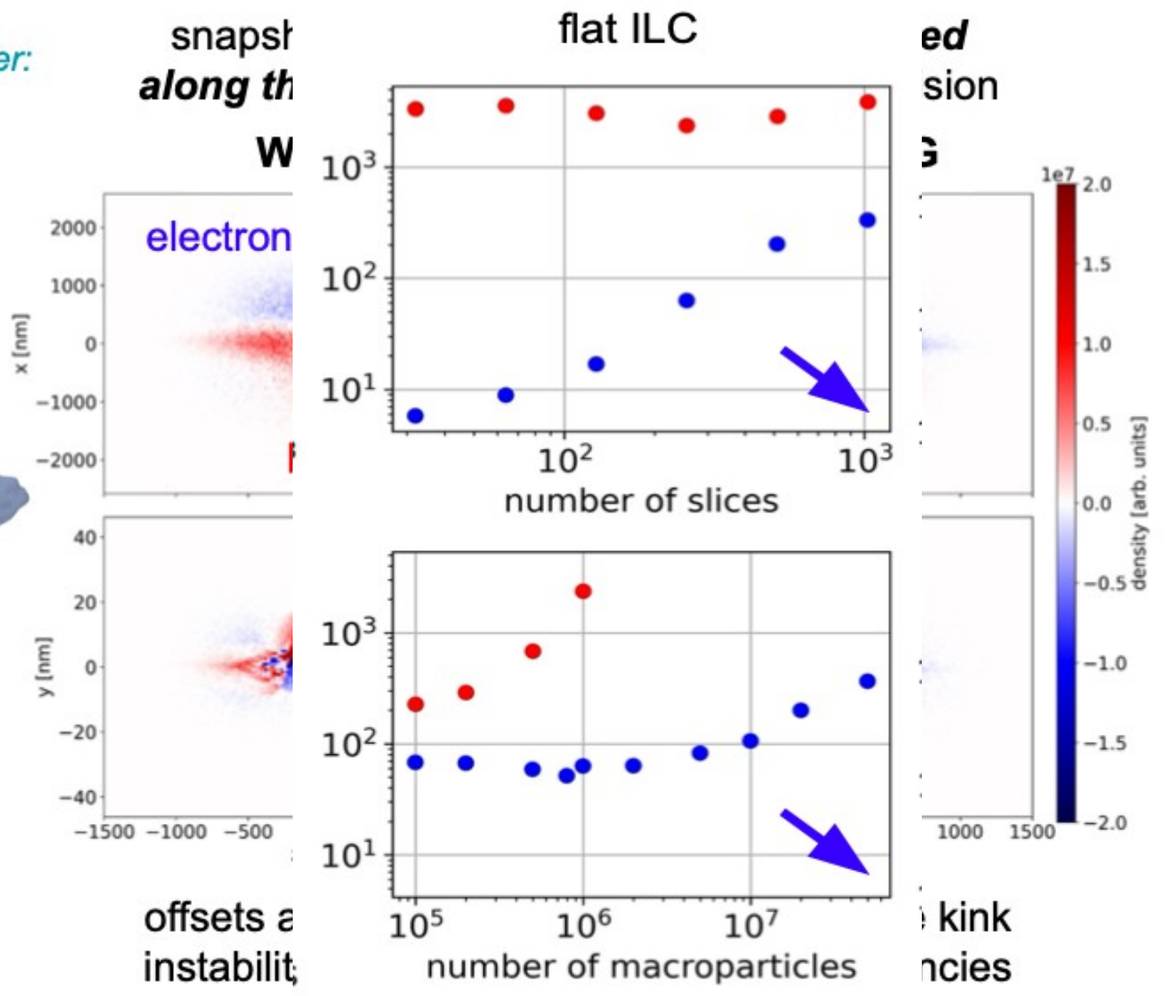
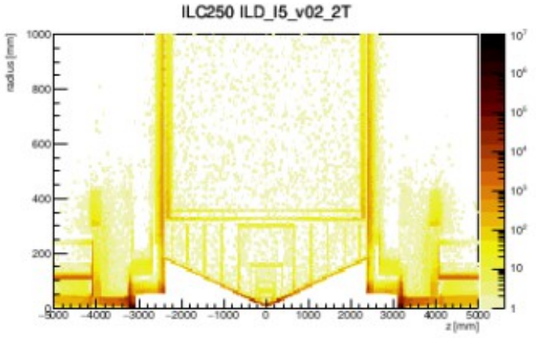


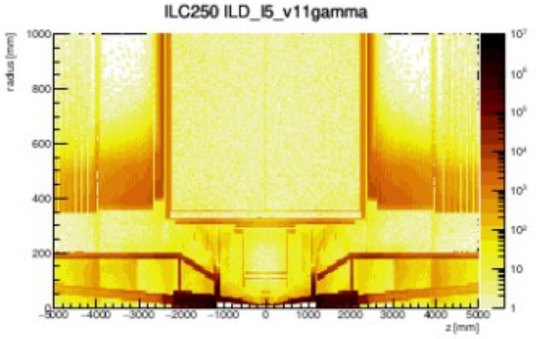
- … at much higher computing speed
- Note in passing the capability to go to highest energies (10 TeV) and the spherical beam spots

Beam Induced Background – ILC vs. FCCee

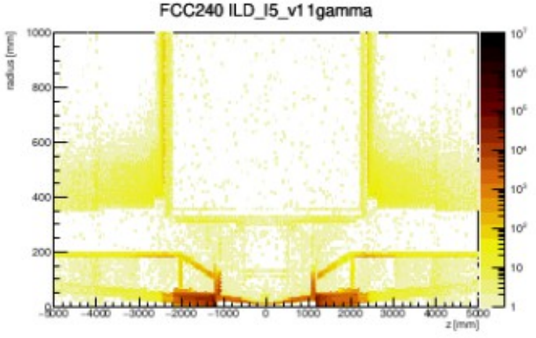
Hits from backscattered particles - MC Particle endpoints in 100 BX



ILC250 beamstrahlung
ILC-like detector



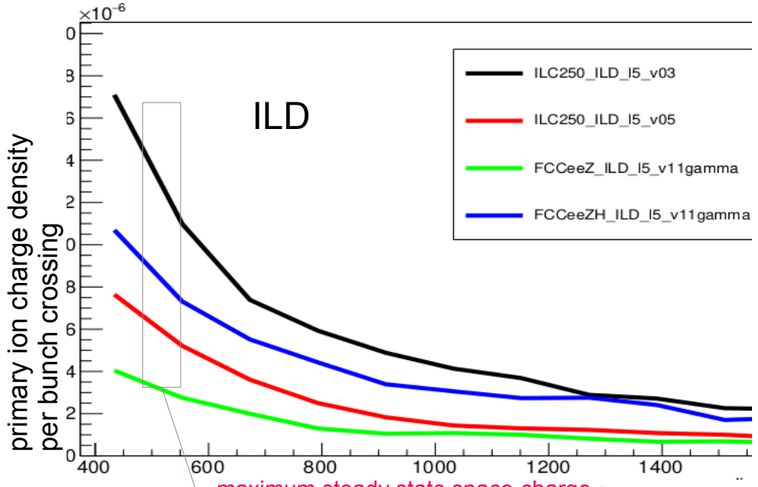
ILC250 beamstrahlung
FCC-like detector



FCC-240 beamstrahlung
FCC-like detector

ILC250 w/ “ILC layout” = FCCee240 w/ FCCee layout

Charge density from ion production



D. Jeans

	max (single BX)	BX freq	max (steady state)
FCCee91	4e-6 nC/m^3	30M	26 nC/m^3
FCC240	1e-5 nC/m^3	800k	2 nC/m^3
ILC250 (v5)	8e-6 nC/m^3	6.6k	0.01 nC/m^3
ALICE		50k	120 nC/m^3 with IBF=20

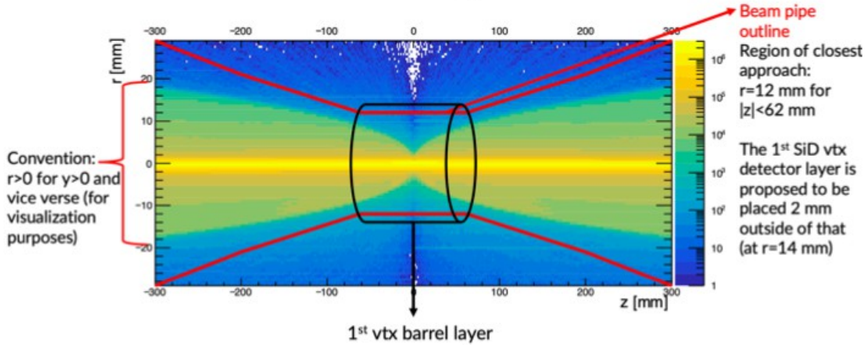
primary ions only: IBF=0

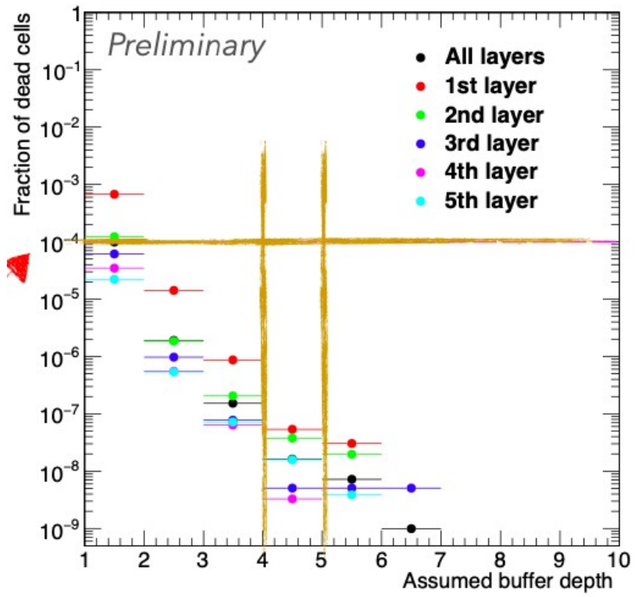
TPC at FCCee91 with IBF of 3~5
→ similar space-charge as at ALICE
O(1~10) cm max distortions
consistent with our “first-principles” estimate

C^3 Background in SiD

Pair Background

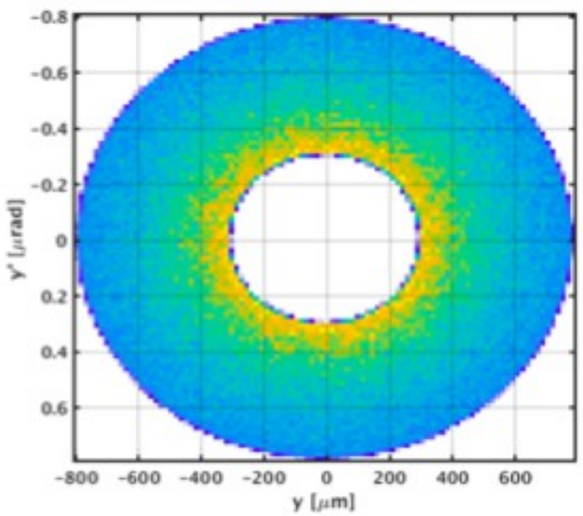
Hit density for 133 bunch crossings for C^3-250 simulated with GUINEA-PIG and tracked through a 5T solenoid field

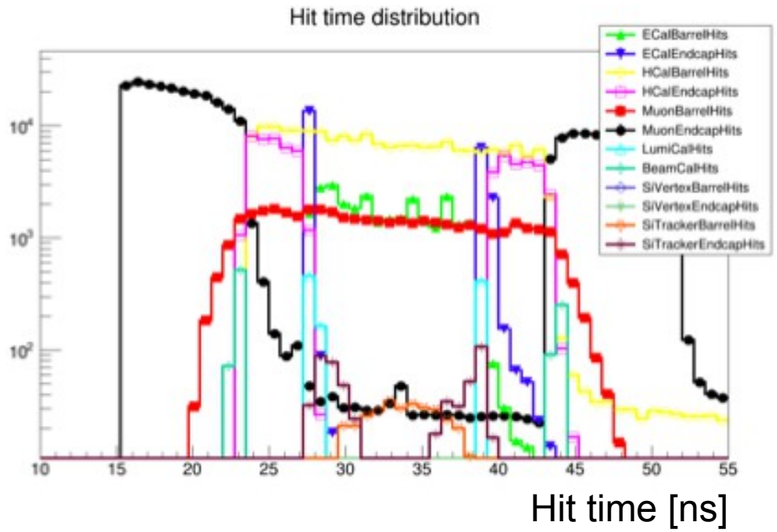




- ***Occupancy in the SiD vertex barrel for the C^3 beam structure is well within the limits set for ILC.***

Muon Background



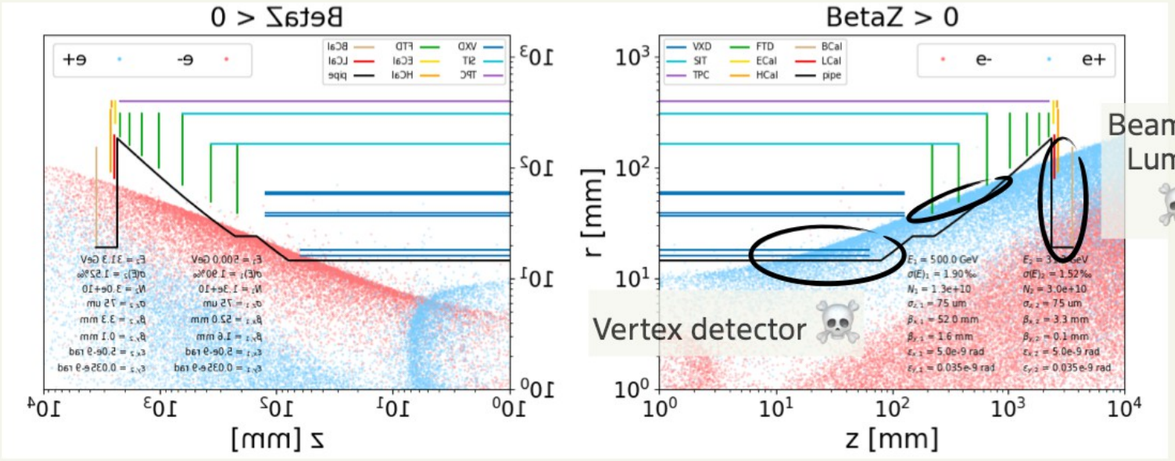


- Good to see that these studies are picked up
- Used “old” muon background files by Daniel
- MUCARLO not maintained anymore

D. Ntounis

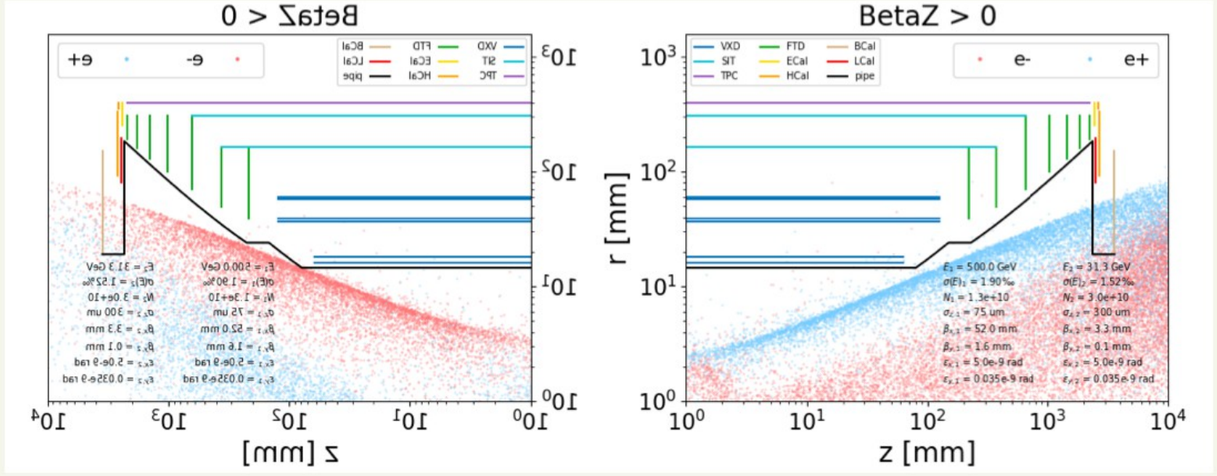
Pair Induced Background at HAHLF

- Energy = 500 : 31.3 GeV
- charge = **1.33 : 3** x 10^{10} particles **=> imbalance left/right: is it really helpful?**
- σ_z = 75 : 75 µm HALHF:



- Energy = 500 : 31.3 GeV
- charge = 1.33 : 3 x 10^{10} particles
- σ_z = 75 : 300 µm

Detector model: ILC...
with **5 T magnetic field** => **looks OK** !



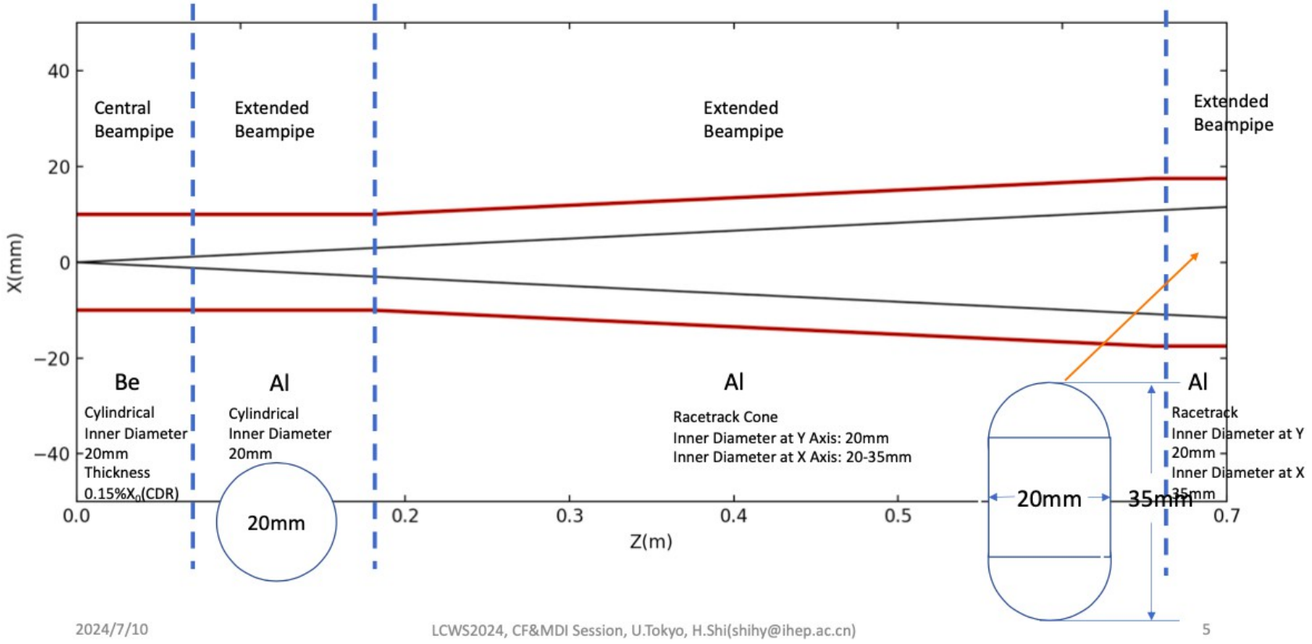
Adaptation of beam sizes and
Magnetic field to reduce background

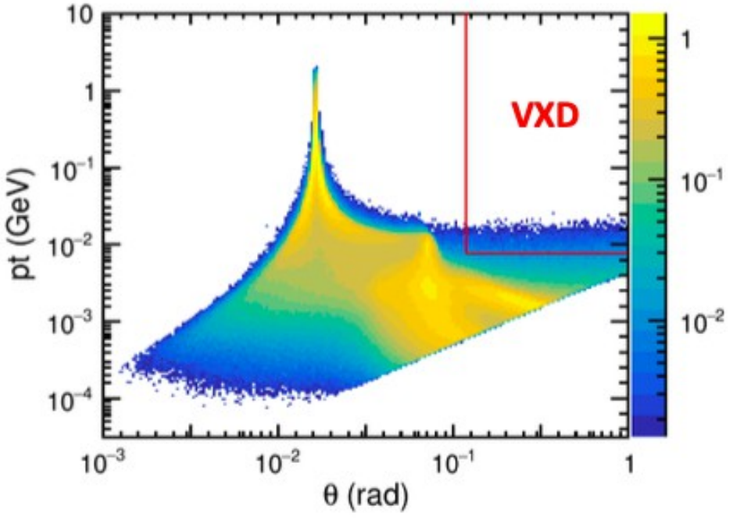
A. Laudrain

CEPC Reference Detector – New Beampipe Design

H. Shi

- "Extended" Beampipe with 20mm radius
- Compare with 16mm for "typical" FCCee Detector



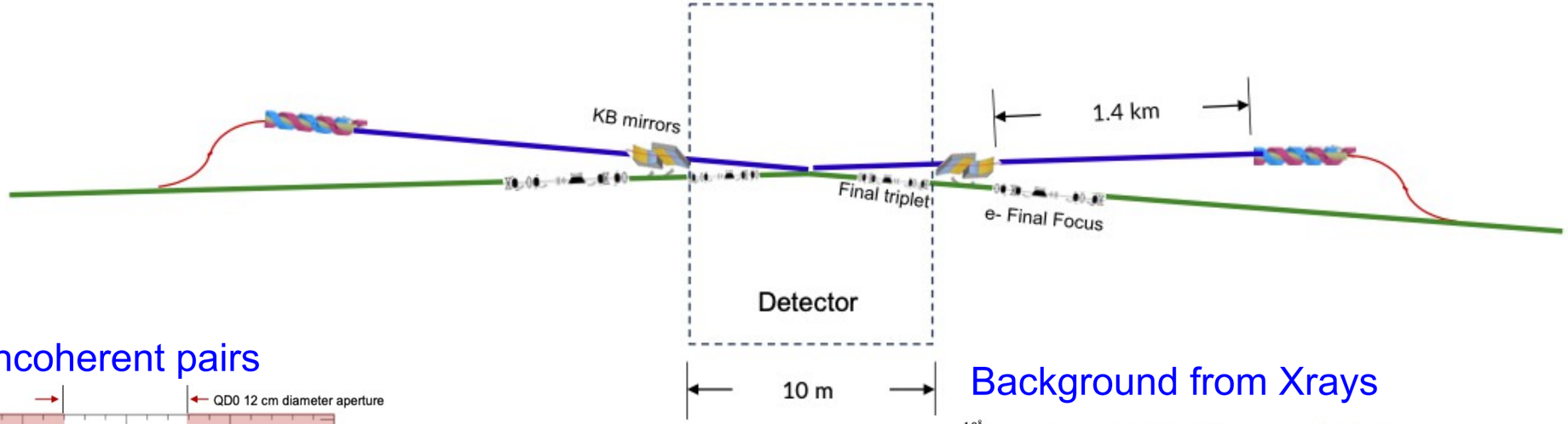


- Luminosity related backgrounds
- One of the dominant backgrounds at the CEPC, may lead to two different impacts:
  - The impacts on detector, caused by the electrons/positrons produced by photons
  - The impacts on accelerator components outside of the IR, caused by the photons directly.
- Hard to mitigate

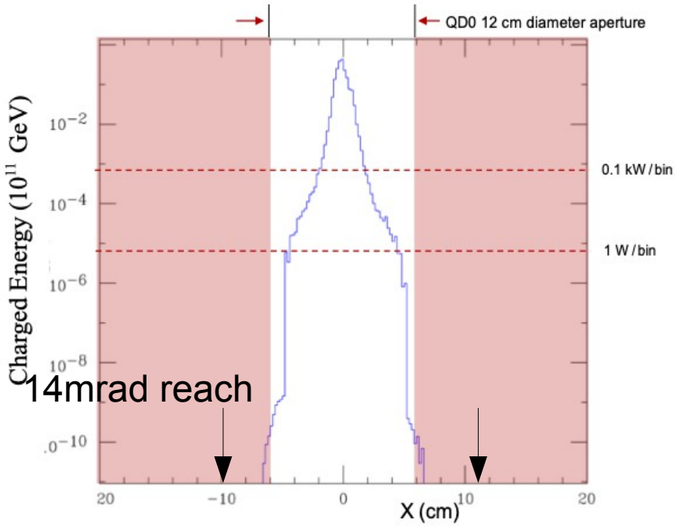
MDI at XCC

T. Barklow

- Challenges: Host four beampipes and Kirkpatrick-Baez (KB) Mirrors
- Design with 2mrad crossing angle instead of 14mrad
  - 2mrad crossing angle increase Higgs production rate by a factor of 6

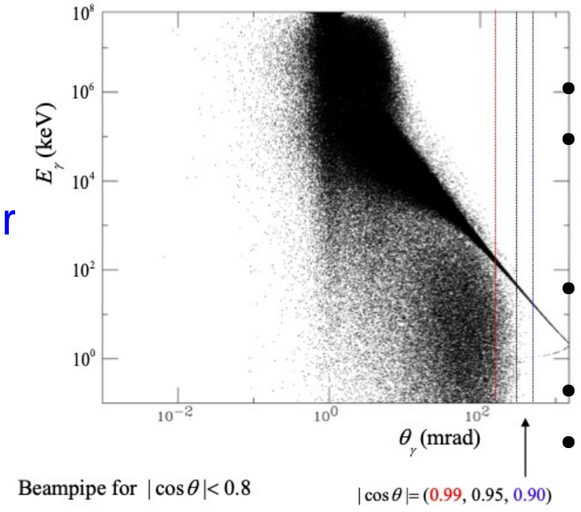


Incoherent pairs



- CAIN simulation
- Cone for 2mrad narrower than for 14mrad

Background from Xrays



- CAIN simulation
- May need
  - 0.1%-1% X0 for |cosθ| < 0.8
  - 1% X0 for |cosθ| < 0.93
- 0.95< |cosθ| < 0.99 complicated
- May not be able
- to instrument |cosθ| > 0.99

5

Summary

- Infrastructure
  - Damping ring moved 100m away in current ILC IP region design
  - ILC site development may slow down the project realisation (not only) at Kitakami
  - FCC civil engineering advancing impressively, studies are also useful for LC (Gotthard Tunnel study)

- Magnets are a serious concern
  - No manufacturer of Al stabilised Rutherford cables. Alternatives?
  - Magnet winding on or off-site (a striking example for conflict with site development)?

- “Real life” experience
  - Competences developed for SuperKEKB will be valuable for LC
    - e.g. Beam pipe welding

- MDI regions
  - Each collider option yields a different MDI region
  - Most striking difference between Circular and Linear Colliders (different L*)
  - XCC has to host four beam pipes (and short L*)

- Tools
  - CAIN and GuineaPig are still our working horses to study beam-beam interactions
  - MUCARLO not maintained
  - Vibrant project BLAST for accelerator modeling including MDI region
    - LC community should have very strong interest to get (more) involved

Backup