# TCT - Locations

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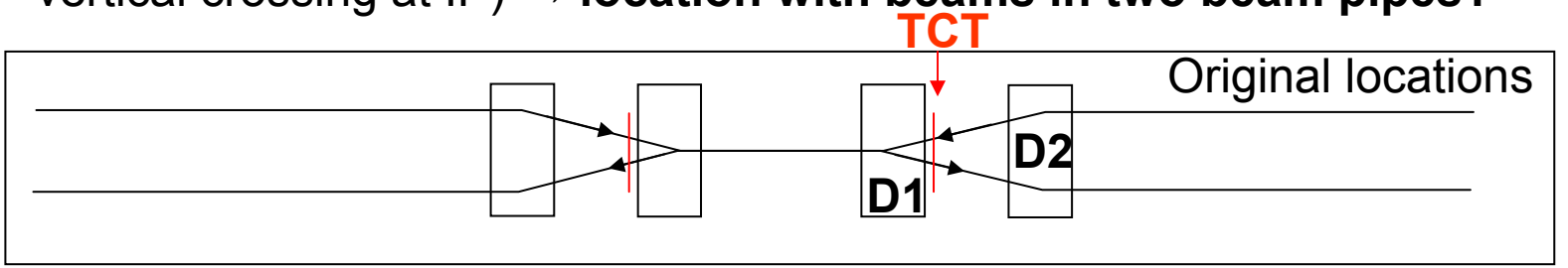
- Introduction:
  - Tertiary collimators (TCTs) for the LHC
    - Why alternative locations?
    - General proposal for IRs
- Proposed Locations for the different IRs
- Summary & Conclusion

Input from: **B. Goddard**, D. Macina, R. Veness, C. Rathjen, J.B. Jeanneret, O. Bruning, S. Fartoukh,…

# Why alternative locations?

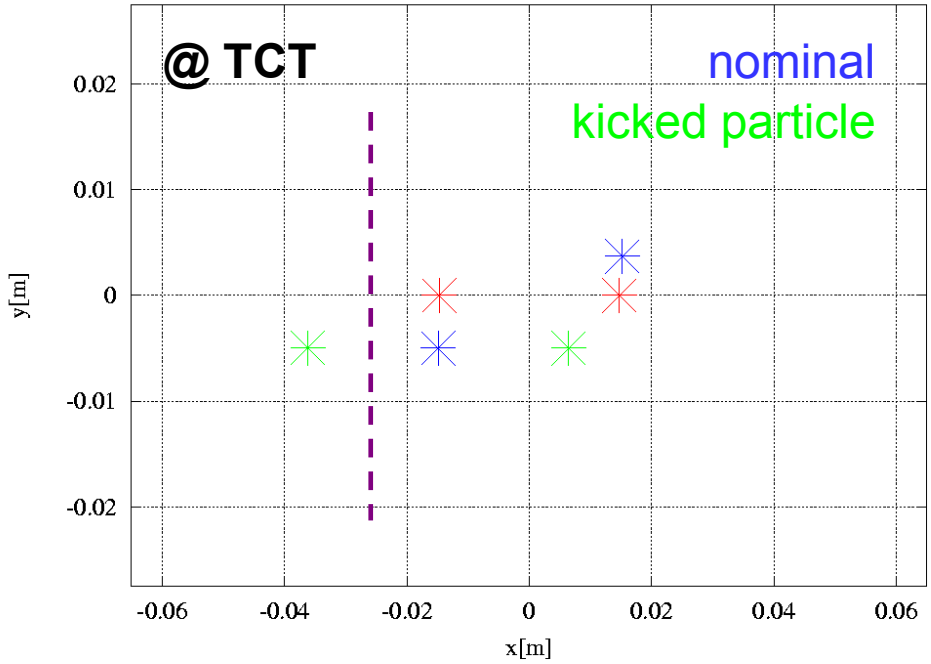
- Aperture bottleneck in the inner triplet: beta function ~4000m
- Purpose of TCT: protection of triplet and collimator (third stage)
- Space reservation in the 4 experiment insertions
  - **no space at the triplet** itself
  - at collision energy hardly any phase advance between D2 and triplet
  - upstream of D1 on both sides of the insertion
  - to act on the incoming beam
  - horizontal and vertical collimators
  - jaws: Cu (W), 1m
- D1 location: beams in common beam pipe, beams horizontally separated
  → single jaw protection/collimation horizontally
- Kick of D1 → only one side of triplet protected horizontally (specially if vertical crossing at IP) → **location with beams in two beam pipes?**



# Single jaw protection is not sufficient

Test @ IP1 (vert. crossing)

- Tracking 2 particles:
  at MCBCH.10L1:
  kicks: ±100μrad
- Both are lost at the triple
- Only one could have been captured by horizontal TCT at D1




**MAD output:**

```
particle #     1 lost turn      1  at pos. s =     337.47 element=mqxb.b2l1..1
     aperture =lhcscreen                 ▯    X= -0.0292372911  Y= -0.00474216231
T=  0.000210237718
particle #     2 lost turn      1  at pos. s =     337.47 element=mqxb.b2l1..1
     aperture =lhcscreen                 ▯    X=  0.0287974408  Y= -0.00474216234
T=-0.000225919112
```

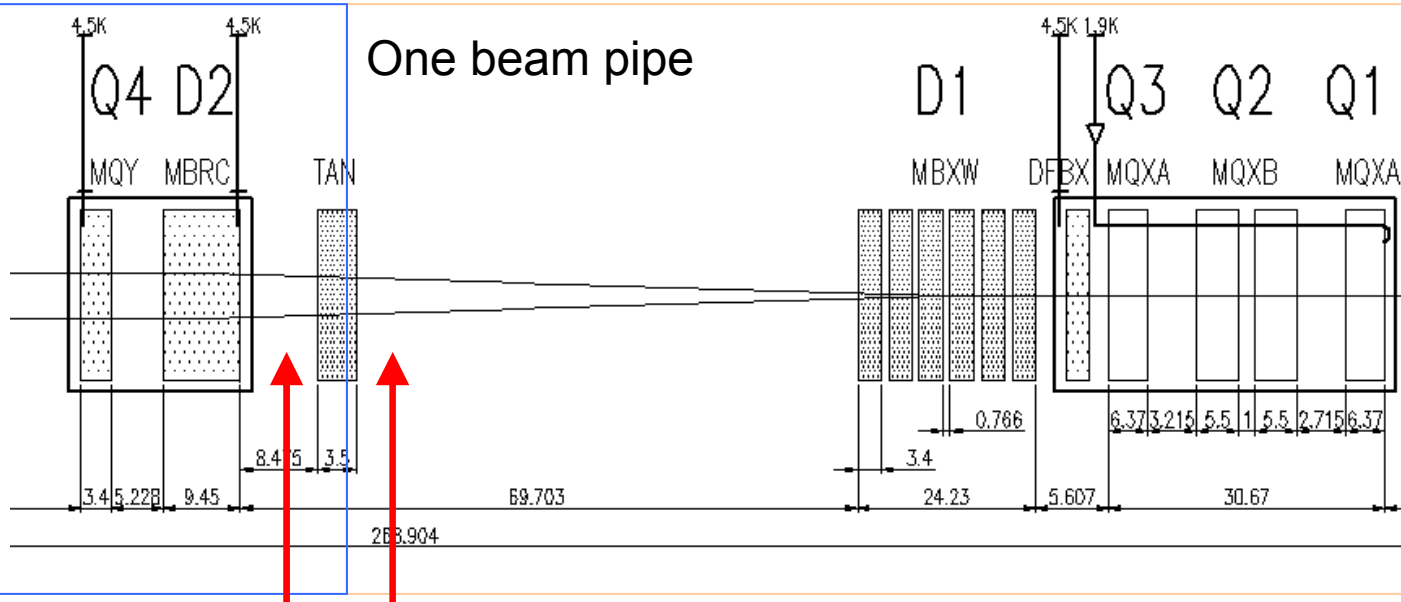
# Proposal for TCT locations optimised according to

- Triplet protection/collimation
- local space availability
- avoiding interference with already approved equipment

**Investigated possibilities:**

Two beam pipes

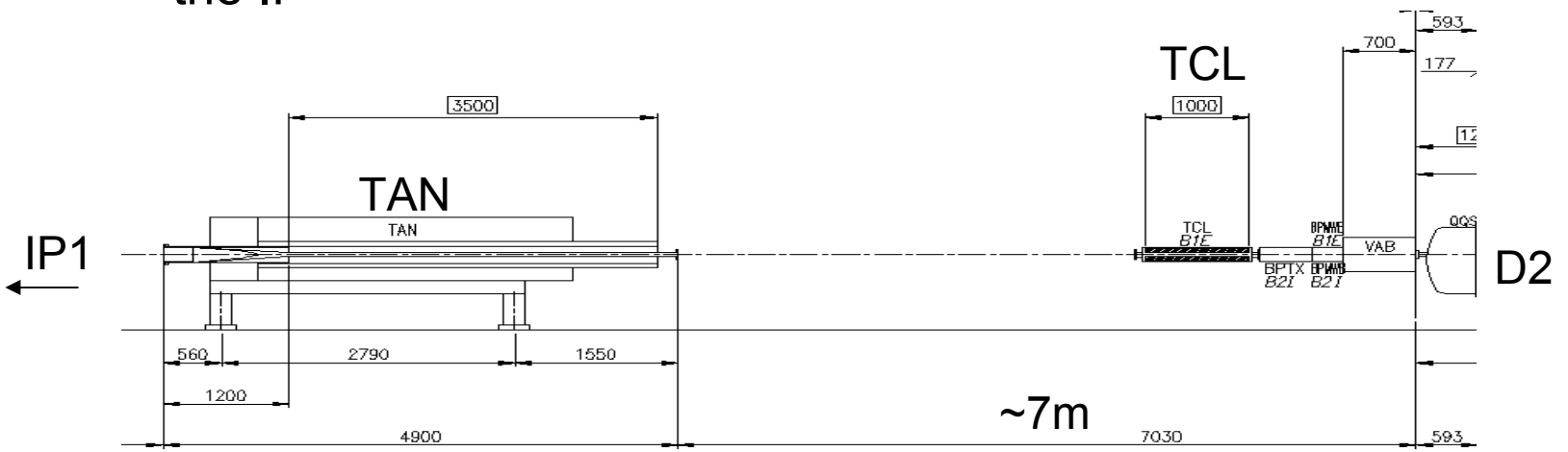
One beam pipe




**3, π upstream of triplet** **2** **1**

# Possibility 2 most promising…

- **1**: **downstream of TAN** (recombination chambers in IR2/IR8): common beam pipe, phase advance from triplet OK, sufficient beam separation for possible “finger” jaw between two beams. BUT: luminosity measurement at recombination chambers with the neutrals from the IP, totally new design
- **2**: During collision even **close to D2** phase advance to triplet OK (<5°): TCTs before recombination, separate beam pipes, maybe TCT design similar to TCS design
- **3**: **π upstream** of triplet not possible. TCTs should be functional during squeeze and not restrict the choice of β* at the IP



# Proposal for IRs: General

- 2 high-Z jaws (tungsten) per collimator
- Baseline location: **close to D2**
  - possibly **TCS-design**
  - highly recommended for insertions with vertical crossing for TCTh
- If interference with equipment:
  - TCTs at D1 location: already reserved (change to 4m)
  - Single jaw collimation and protection in horizontal plane
  - TCTv-design like **TCLI-design**

# Situation at the different IPs

- **IP1**: vertical crossing
  - 4m space close to D2 available: vertical and horizontal collimator possible there

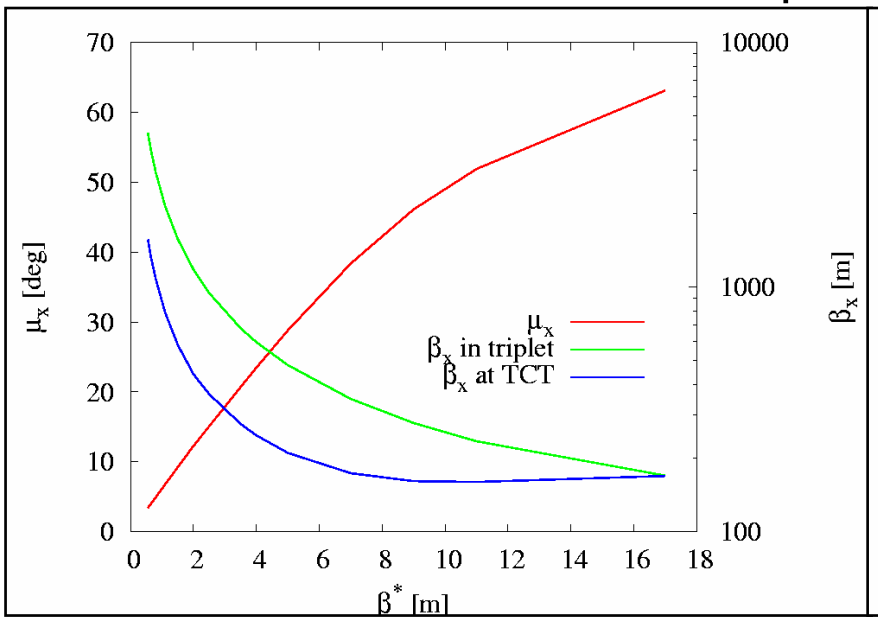
- **IP2**: vertical crossing ($\beta^*$=0.5m)
  - enough space at D1: only 50% protection in horizontal plane
  - close to D2 possibly space for horizontal TCT (implications for ZDC, luminometer, recombination chamber)
  - only needed for ion runs

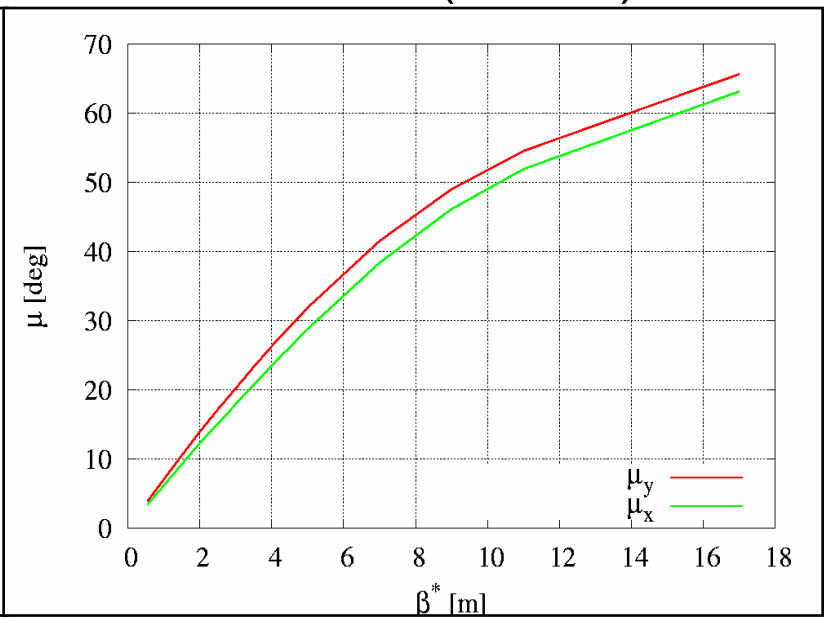
- **IP5**: horizontal crossing
  - no space at D2 (interference with TOTEM)
  - space at D1

- **IP8**: horizontal crossing ($\beta^*$=1m)
  - enough space at D1
  - Enough space close to D2 (possible ZDC?)
  - Only needed for early collision ($\mathcal{L}=10^{32}$ cm$^{-2}$s$^{-1}$)

# Proposal for IR1

- **TCTh close to D2, also enough space for TCTv (possible roman pots @Q6/Q7)**
  - Possibly using TCS-design
    - Smaller intra-beam distance 188mm to 165mm
  - Phase advance between triplet and TCT location (beam1):



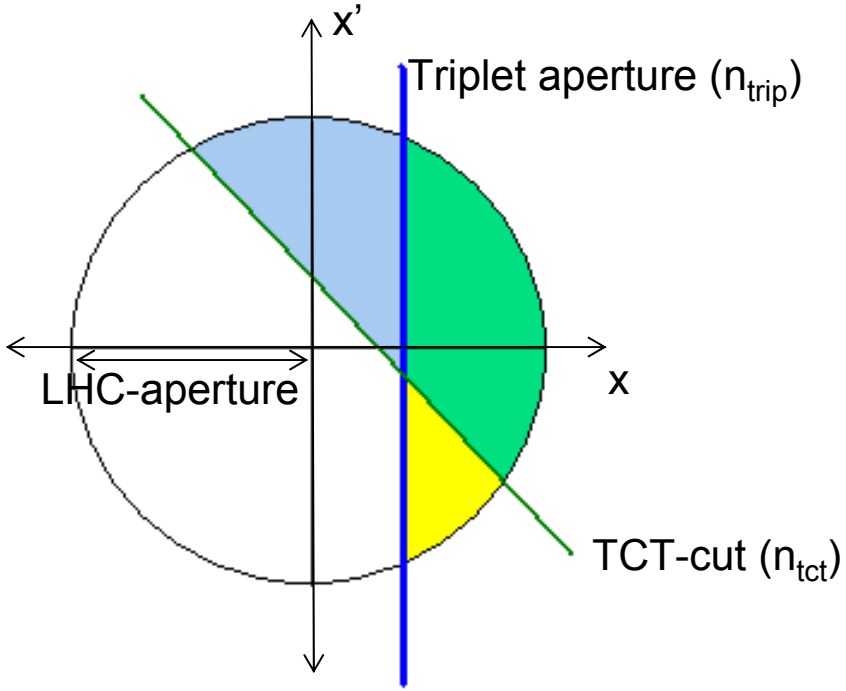

courtesy S. Fartoukh

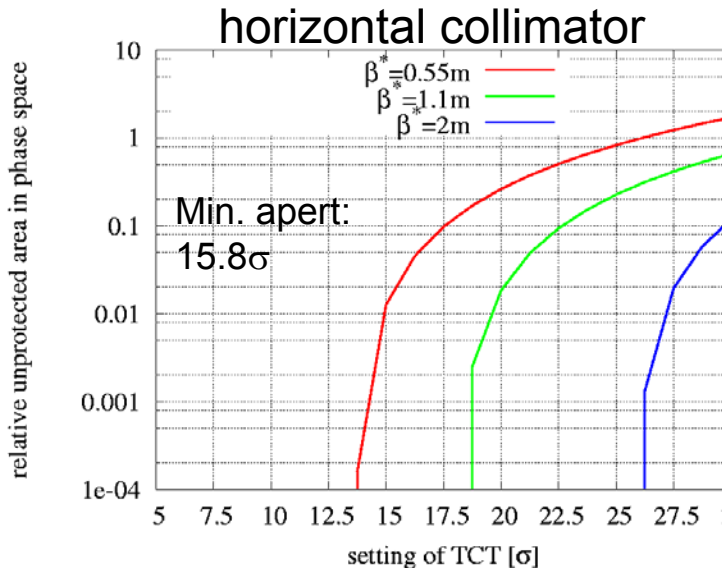
| β* [m] | 0.55 | 2 |
|---|---|---|
| $\mu_x$ [deg] | 3.4 | 12 |
| $\mu_y$ [deg] | 3.7 | 13 |
| min. apert. x [σ] | 15.8 | 31.6 |
| min. apert. y [σ] | 13 | 24.7 |

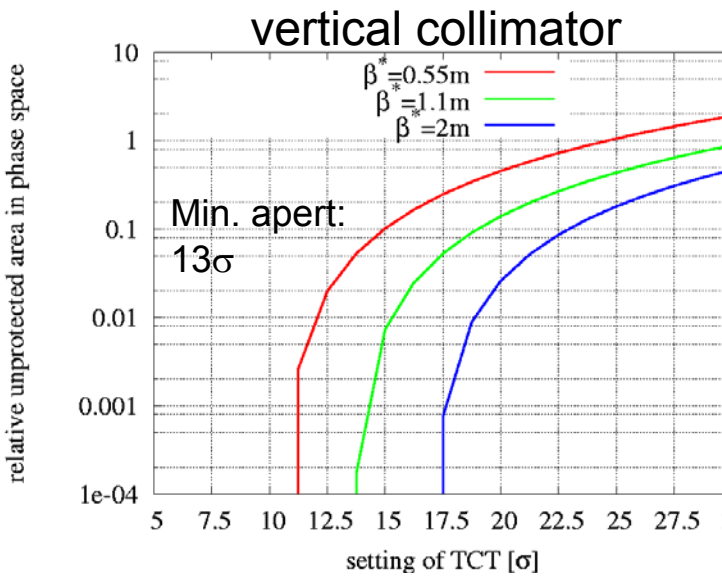
← Phase advance between TCT and triplet

← with betatron beamsize

# Proposal for IR1- protection setting

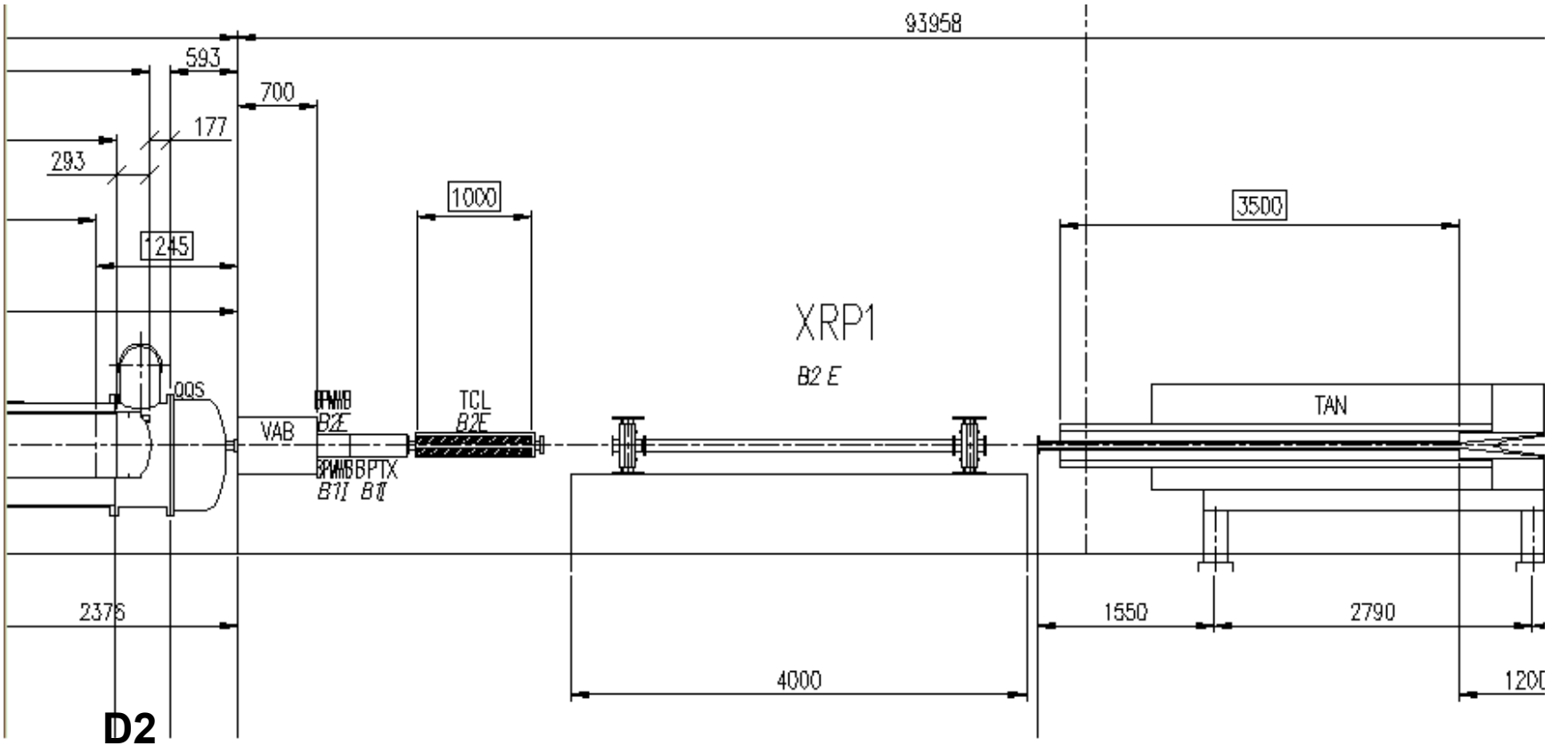


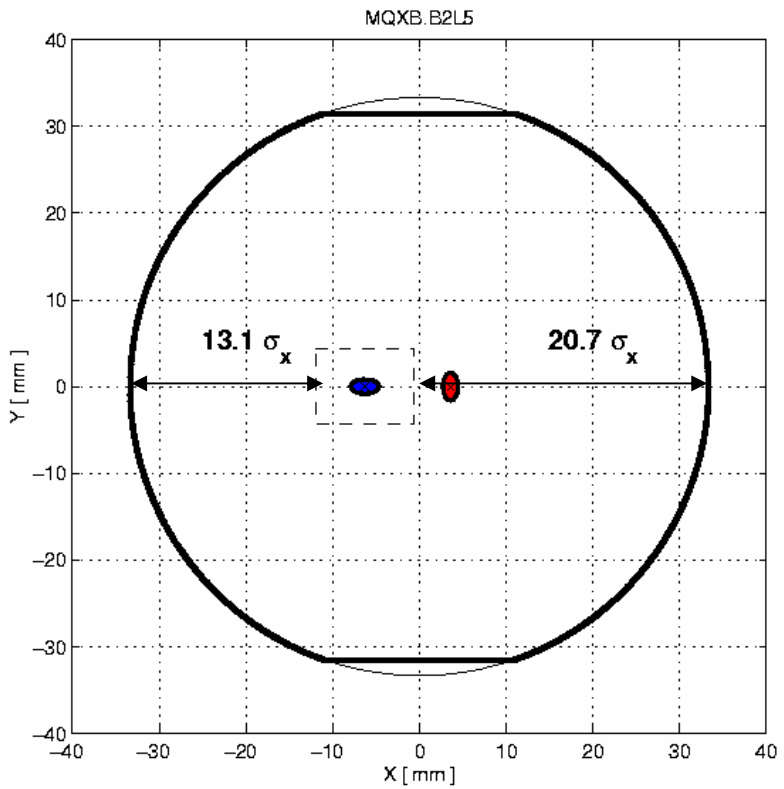

To **quantify the protection** for a certain setting ($n_{tct}$, $n_{trip}$, lhc-aperture, phase advance between TCT and triplet) the **area in yellow** is **compared with** the **dangerous region of phase-space** (green+yellow area).

# Proposal for IR5: Interference with TOTEM, no space for TCTs close to D2



# Proposal for IR5: so far …

- Both TCTs at D1
- Horizontal crossing at IP5: more margin to non-protected side in triplet
- only **ONE** horizontal collimator jaw
- collimation vertically with two jaws at D1
- **Less protection**, **less** efficiency for **cleaning**




Assuming an LHC-arc-aperture of 40σ: one horizontal jaw only ↔ no protection against 38% of dangerous horizontal phase-space

# IR5 – possible solutions

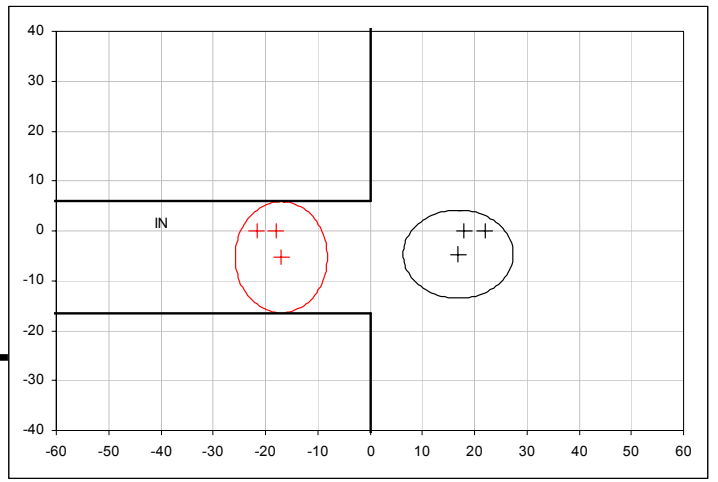
The present solution for IP5 is not optimal. Quenching the triplet might happen frequently.

1. If in trouble with triplet quenches: possibility of higher $\beta^*$ at IP5
2. Arrangement with TOTEM to have space for TCTh at D2
3. Combination of TCL and TCTh
    - TCL-collimator at D2 (for the time being not enough space reserved for it)
    - 2 collimators at the same longitudinal location
        - TCL on the outgoing beam
        - TCTh on the incoming beam
    - One more new design for the TCTs

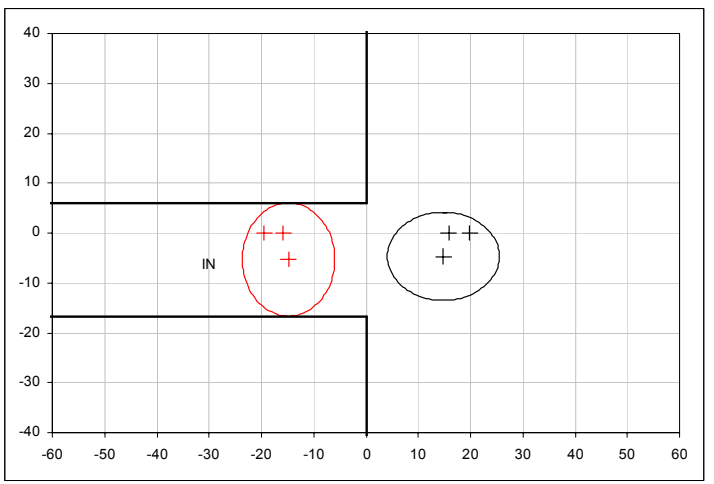
# IP5: TCTv at D1; horizont. crossing: OK

**Collimator for beam1**

**upstream end**

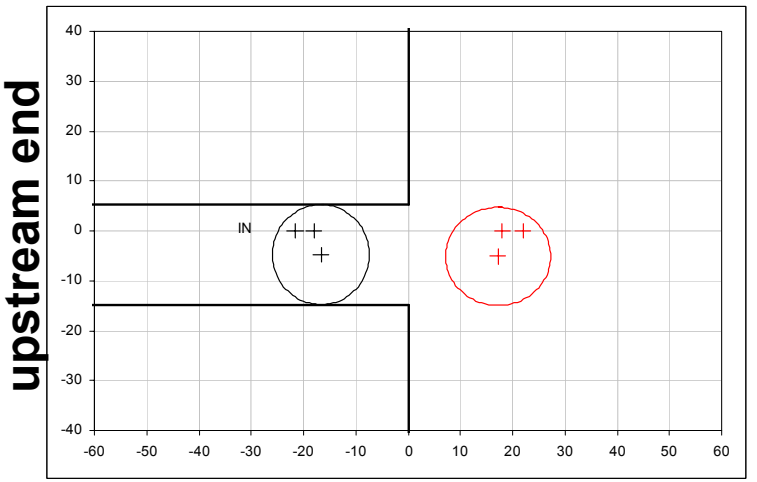



**downstream end**

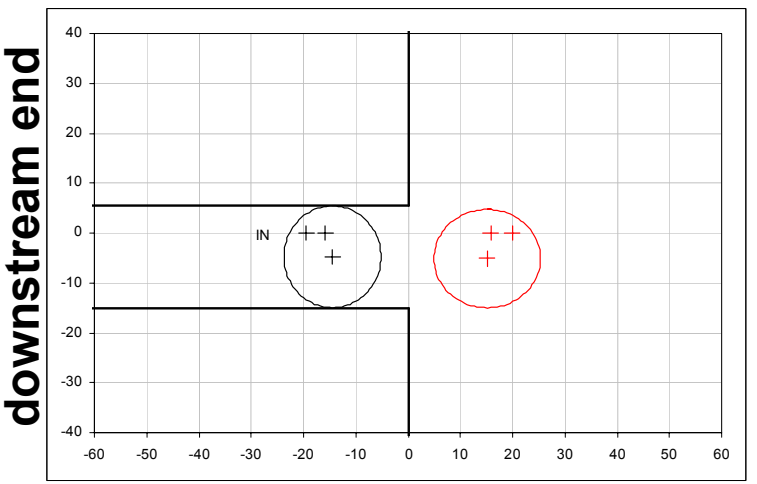



**Collimator for beam2**

**upstream end**




**downstream end**

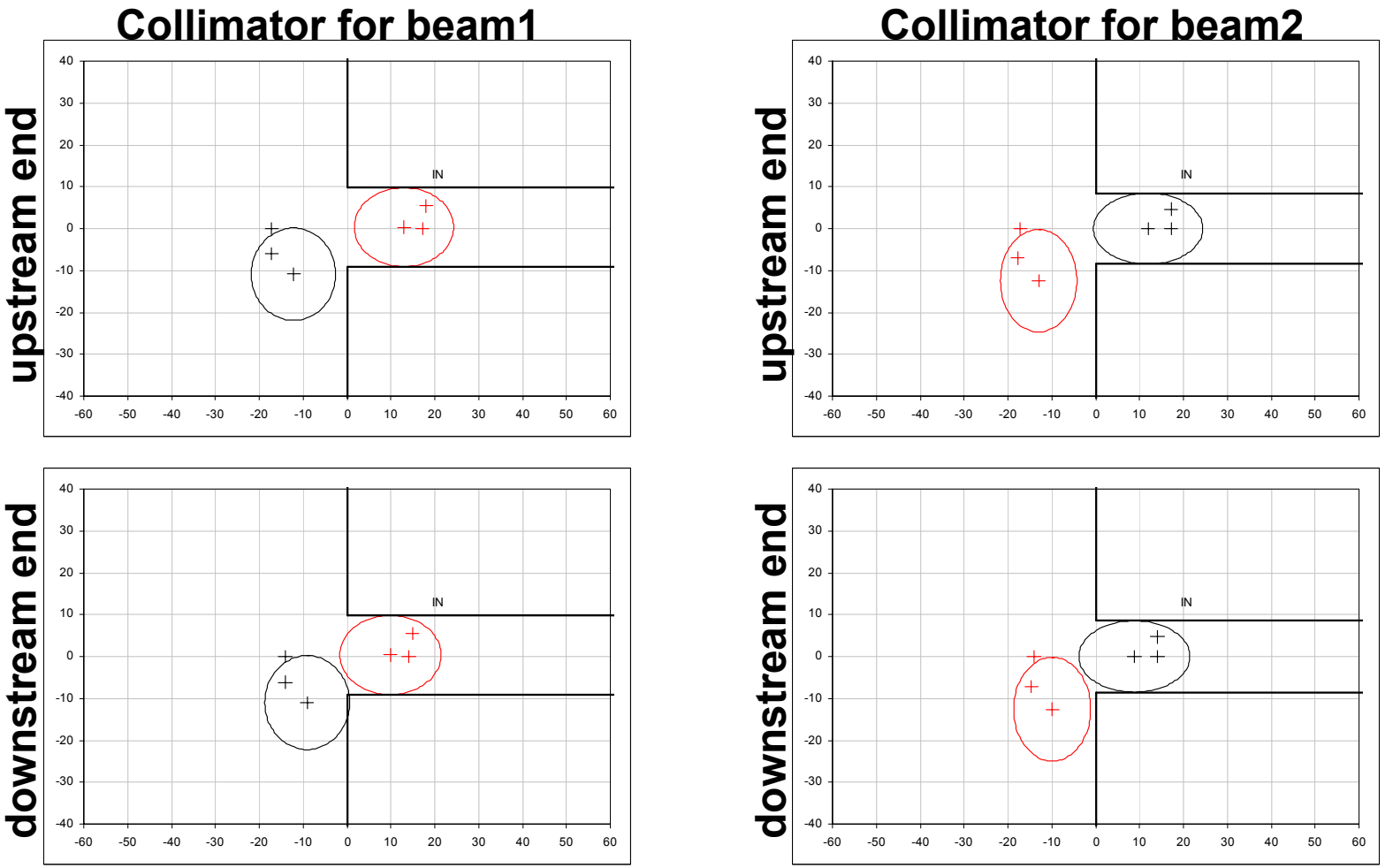


# Proposal for IR2: vertical crossing

- **TCTs for protection** (only): ion runs
- The ~4m space available between equipment downstream of D2 and recombination (RC) partly used up by:
  - Space reservation for ZDC: 2.5m
  - Luminometer (LM): either 40cm or 10cm space needed
- **With the present vacuum layout: no space for TCTh**.
- **TCTv at D1**
- **Phase advance between TCT-location at D2 and triplet: 1.8° (beam1)**

- Meeting for Vacuum-Layout of IR2 (R.Veness, April 1, 2004): people know about proposal for TCT at D2.
  - Moving ZDC closer to IP did not seem problematic (1-2m)
  - Concerns from ZDC group:
    - Background
    - Increased radioactivity limiting access to ZDC
- Proposed order of elements: IP-RC-LM-ZDC-TCTh-D2
- Possibly redesign of recombination chamber necessary

# IP2: TCTv at D1; vertical crossing → tight, but OK



# Proposal for IR8:

- TCTs might not be necessary
  - If decided to install TCTs:
    - for the time being space close to D2: but a ZDC detector might be installed there
    - horizontal crossing: both TCTs could be at D1
    - Enough space available: no interference with TCLI, TCDD, BPM, TDI
    - Halo cleaning at the D1 less efficient.

# Summary

## Proposed locations so far:

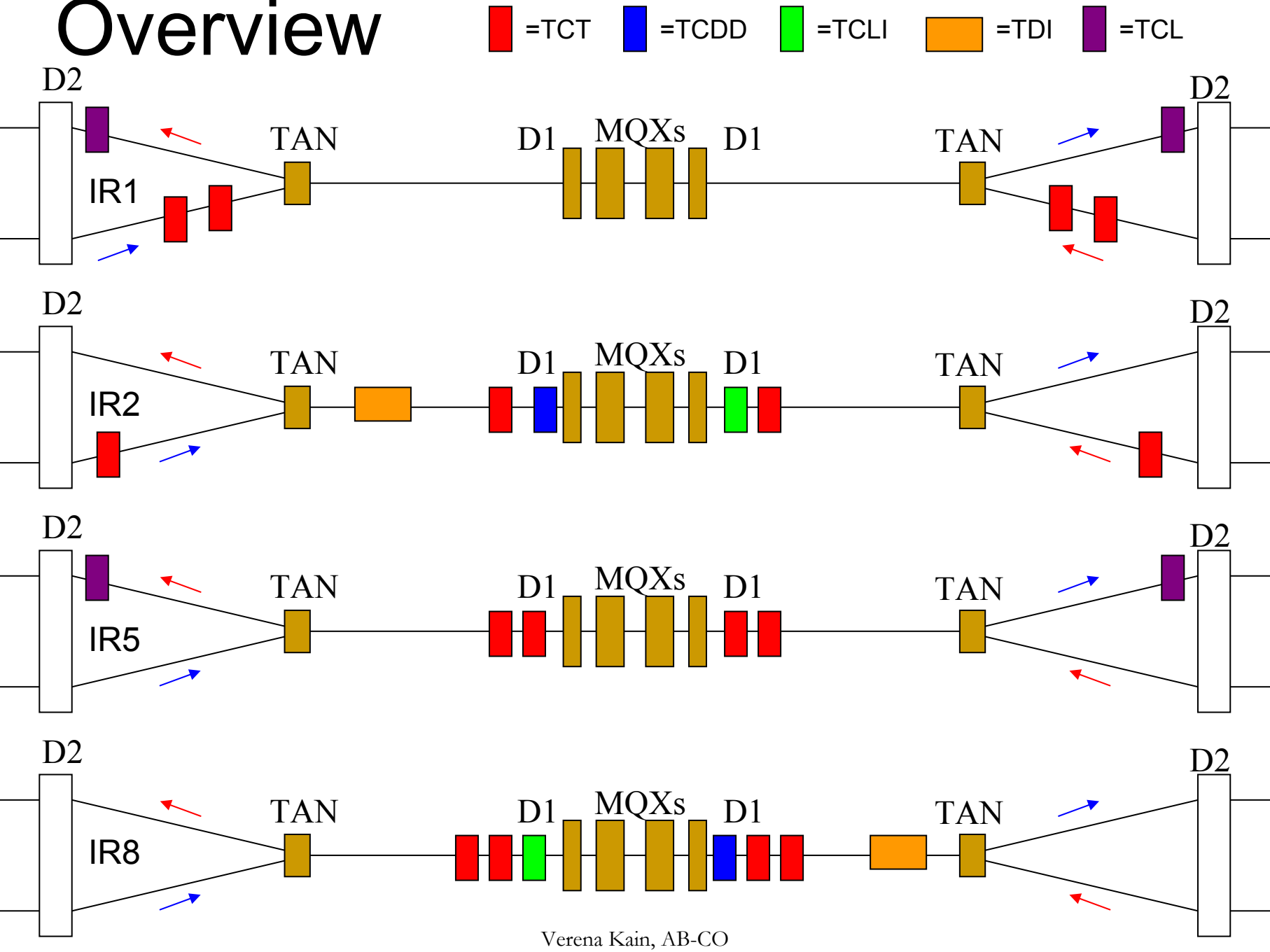
- IP1: TCTv+TCTh@D2
- IP5: TCTh+TCTv@D1
- IP2: TCTh@D2, TCTv@D1
- IP8 : (TCTh+TCTv@D1)

| @ | h-jaws | v-jaws | H: s from IP | V: s from IP | $\sigma_x$* | $\sigma_y$* |
|---|---|---|---|---|---|---|
| | | | [m] | [m] | [mm] | [mm] |
| **IP1** | 2 | 2 | 148 | 146 | 0.22-0.56 | 0.29-0.89 |
| **IP2** | 2 | 2 | 117 | 75 | 0.17-0.95 | 0.16-0.8 |
| **IP5** | 1 | 2 | 86 | 88 | 0.22-1.09 | 0.2-0.95 |
| **IP8** | (1) | (2) | 73 | 75 | 0.16-0.7 | 0.26-0.9 |
| TCLI@IP2 | - | 2 | - | 71 | | |
| TCLI@IP8 | - | 2 | - | -71 | | |
| TCL@IP1 | 2 | | 150 | | | |
| TCL@IP5 | 2 | | 150 | | | |

* betatron beamsize

TCLs are on both sides of the IP, TCLIs only on one side

# Overview



# Conclusion

- A successful solution for the TCTs could be found
- The locations were optimised according to
  - Triplet-protection/collimation
  - Space availability
  - Avoiding interference with already approved equipment
- There are still some issues for IR5. So far not fully satisfying. Minor issues for IR8, will have to be decided.
- There will be a meeting next week to discuss vacuum issues for TCTs and spoilers more in detail.

- Still to be done:
  - Space reservations, definition of required jaw thickness, … finally a design for the devices
  - Simulation of beam-background and of protection level of 1m W-jaw with FLUKA
    - If too much background during run caused by TCTs, they can always be opened.