Crystal Experiment Setup in H8

Outline

- Schedule
- Beam Setup
  - Beam interlock conditions – rate
  - Beam optics & performance - divergence
- Experimental Layout
  - Photos from various locations
  - Instrumentation
- Running conditions
  - Crystal Alignment
- Issues to look at in the coming months

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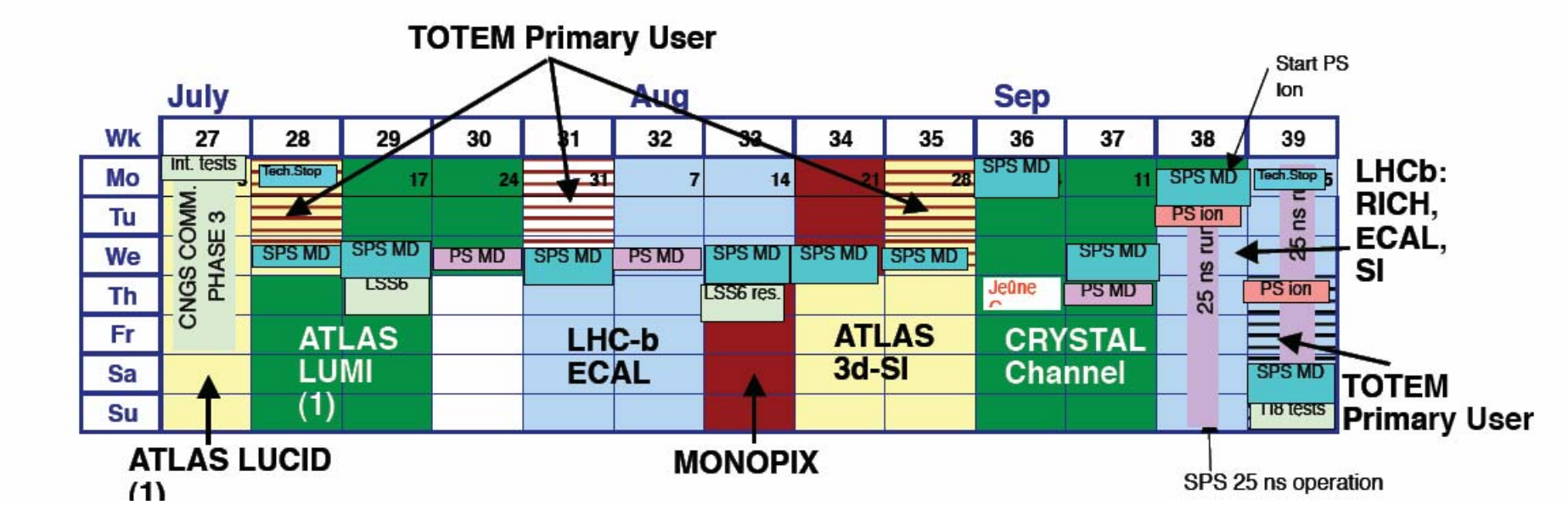
Crystal Exp. in H8
March 10, 2006

Schedule

- Crystal experiment scheduled for **weeks 36-38** [4-18 September] - **Note: still a DRAFT !!!**
  - Unfortunately during the “Jeune Genevois” week… (only relevant in case of problems!!)

- Monday September 4th will be the installation day – during the SPS MD
  - Experiment installation – should be possible !
  - Beam line modifications to switch to proton mode – typically few hours
- **Beam**: primary proton beam (400 GeV/c) through the BCT experiment
  - dumped ~100m downstream



Beam Intensity

- Typical beam intensity at T4 target: $\sim \mathbf{20 \times 10^{11}}$ **ppp**
- Due to radiation limits the beam intensity needs to be reduced to $\mathbf{< 10^{8}}$ **ppp**
- In any case, the experiment requires reduced rates $\mathbf{< 10^{4\text{-}5}}$ **ppp** (or even less!!!)

Available beam instrumentation to reduce intensity:

Element	Material	Interaction length (λ_I)	Att. factor
T4 target head	300 mm Beryllium	0.74	2.09
TAX1 absorber	800 mm Beryllium	1.96	7.16
TAX2 absorber	1200 mm Beryllium	2.94	19.08

- For TAX2 the material can be replaced with AIR but with a reduced 2mm Ø hole
- Further reduction is achieved by collimation
  - Collimators also serve to re-define the beam at specified locations thus reducing any beam blow up due to the TAX/TARGET material

Beam Intensity

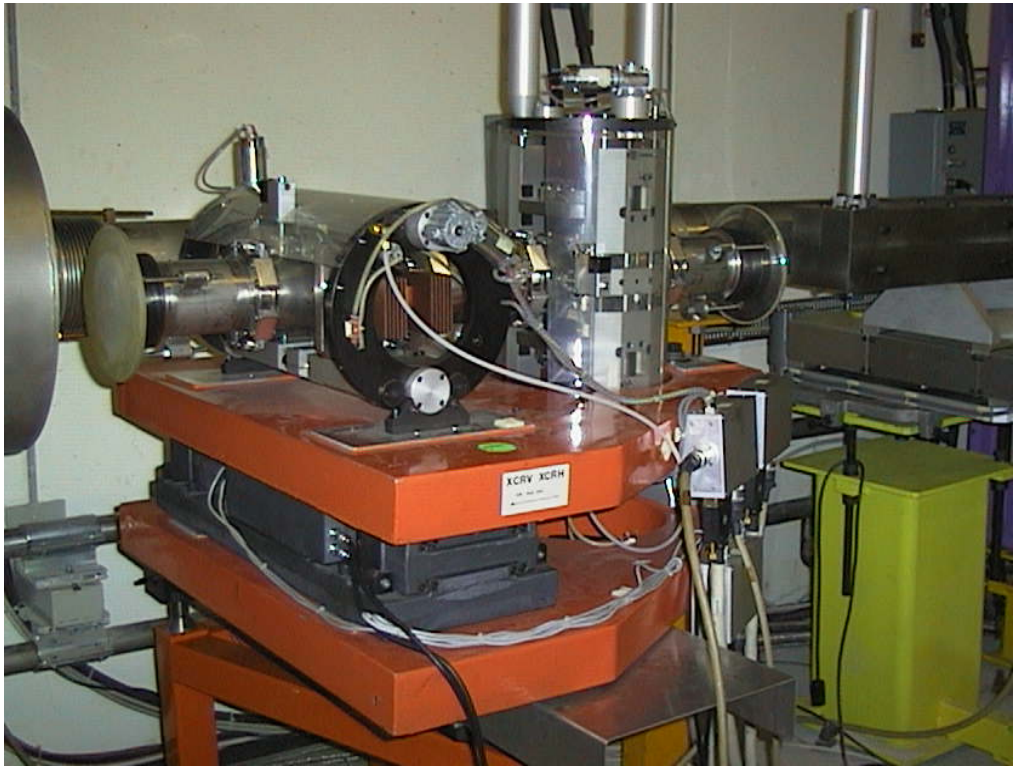
Micro collimator

- Allows reducing the intensity for the **proton beam (micro-beam)**
  - also a safety element in the beam interlock chain
- Jaws: $70 \times 70 \times 50$ mm air cooled steel blocks
- Range: ±12 mm opening ; ±5 mm overall adjustment {x,y}

Note:

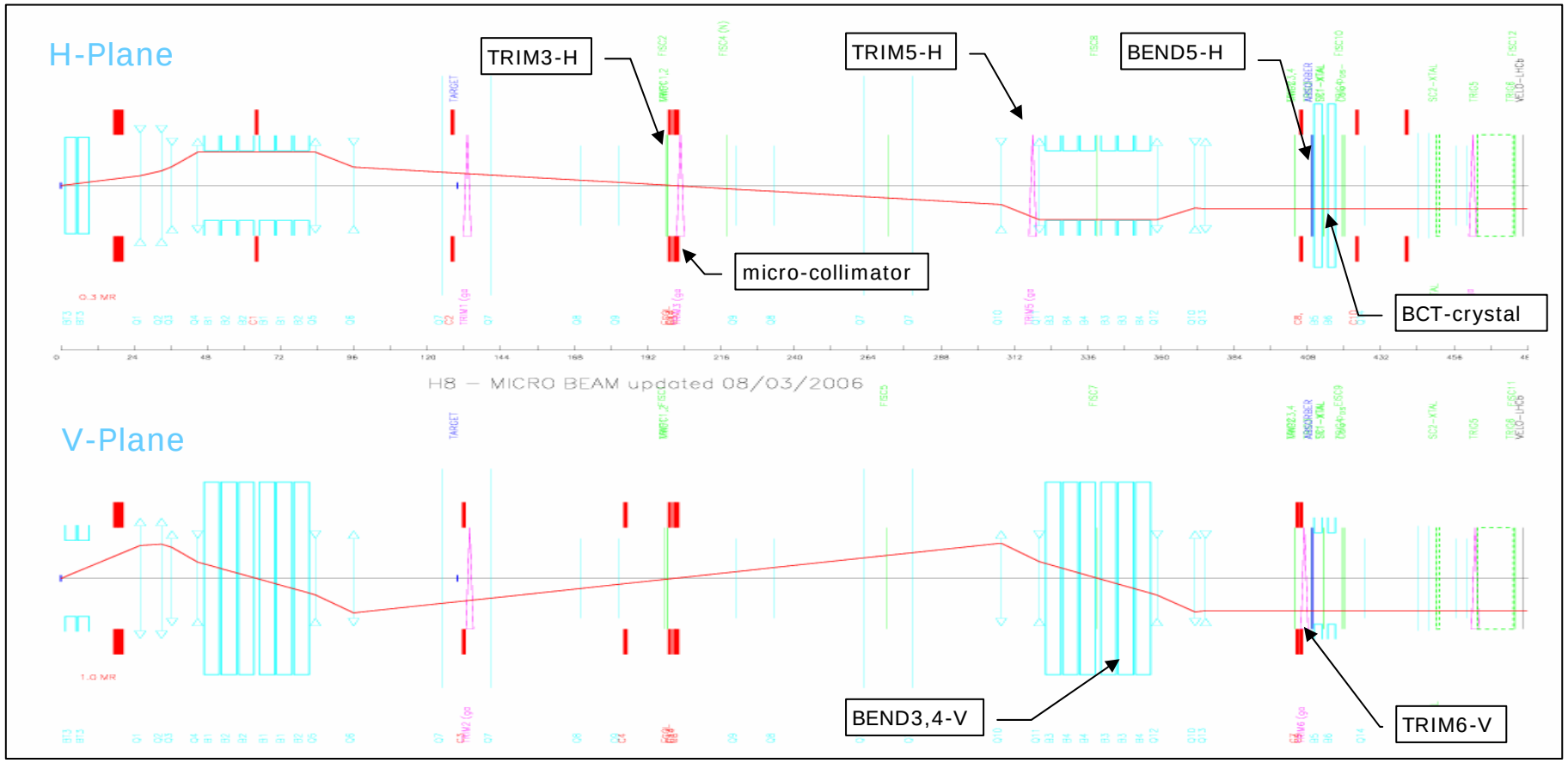
- the settings of the micro-collimator also affect the beam size and divergence

- Running values in previous experiment:



Beam Optics

- Provide parallel (**zero divergence**) beam at the experiment in both planes
- Larger beam in the H-plane where the bending plane of the crystal will be



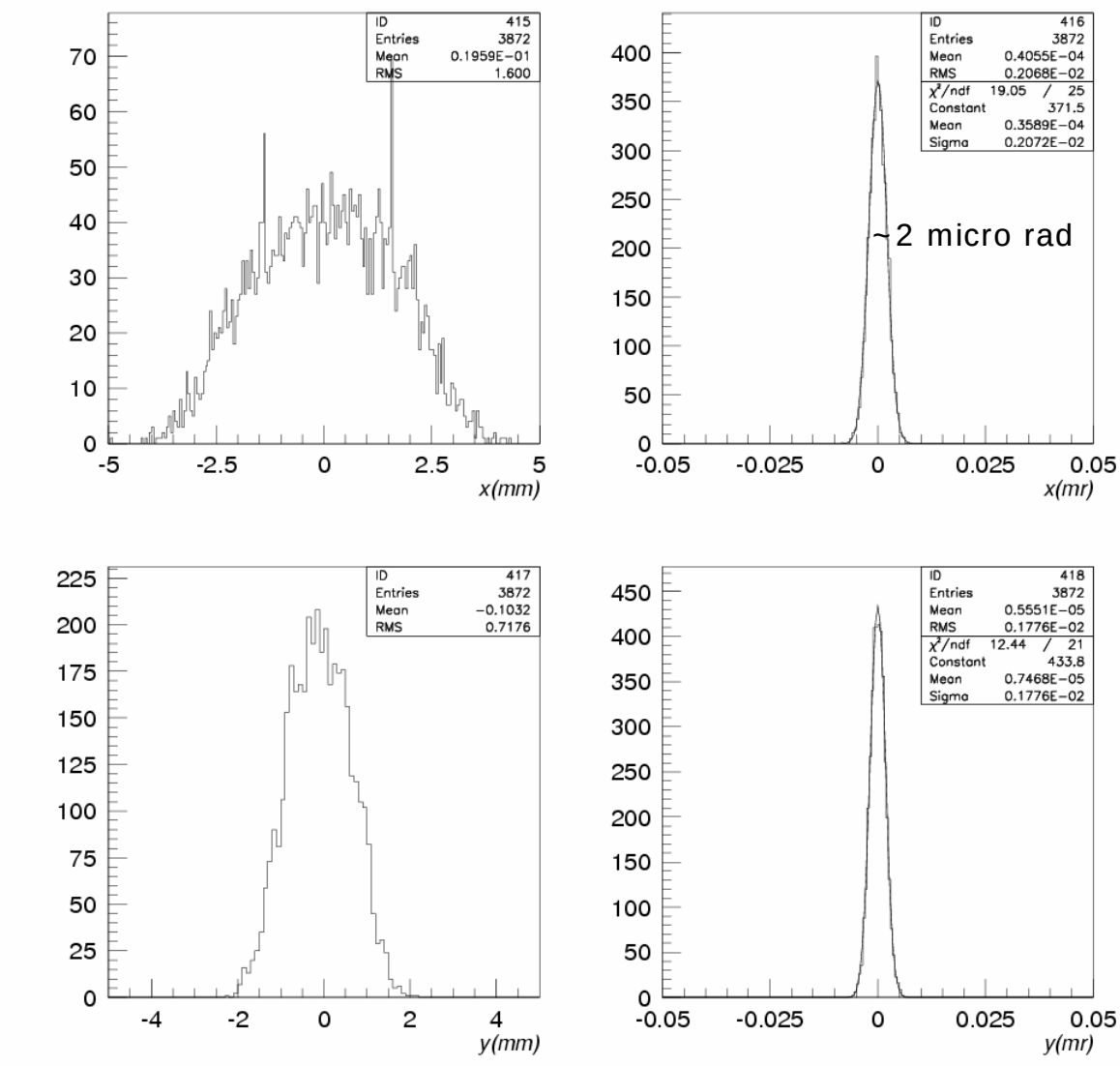
Beam Optics

Simulation results

- For typical settings of collimators as in previous crystal runs
- Achieved performance:
  - 2 micro-rad divergence
    - Was about 5 micro-rad for the full beam
  - 5mm (H) $\times$ 4 mm (V) beam profile at the crystal location

Available instrumentation

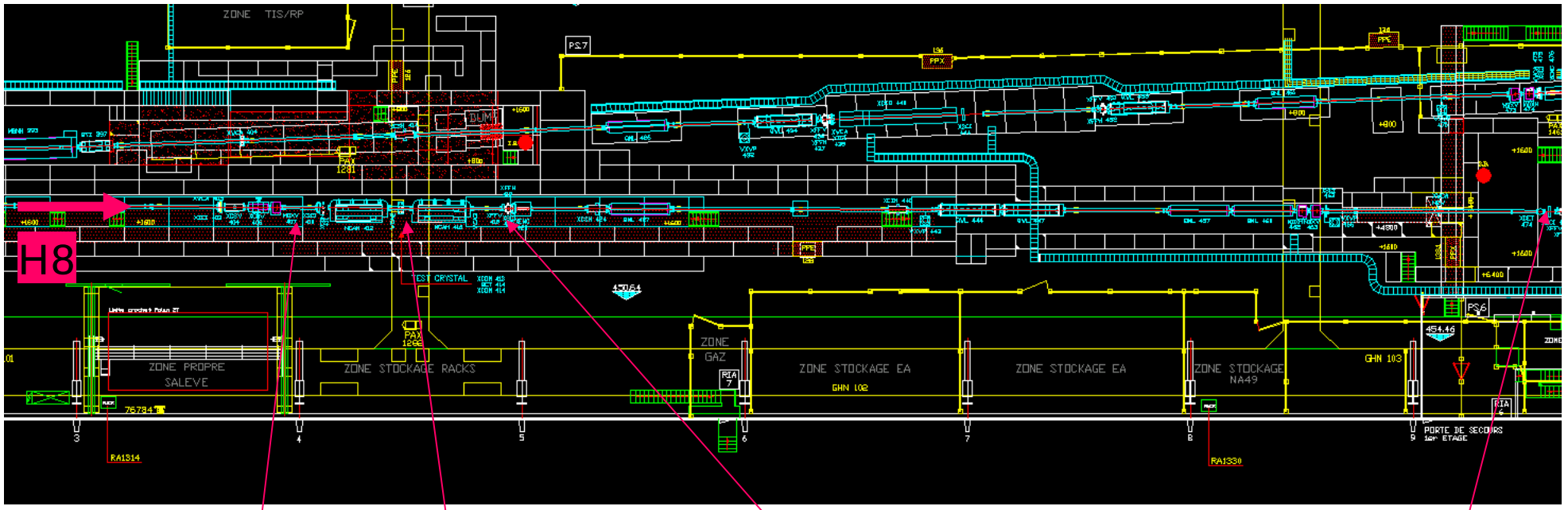
- Beam profile chambers (H, V) ~10m upstream
- Filament scanners-FISC (H, V): ~5m and 57m downstream
- Beam steering possibility in both planes
  - H-plane: TRIM3 & TRIM5
  - V-plane: TRIM6, BEND-4



Crystal Experiment Layout

H8 Beam Layout – PPE128

- Crystal (goniometer) installed between two dipoles
- Possibilities for one upstream and two downstream locations for detectors



Upstream instrumentation

- Wire chambers and scintillator counter
- -3.5 m from crystal

Crystal setup:

- Goniometer
- Upstream(downstream) counters
- 1m opening

Near FISC:

- 6.620m from crystal

Far FISC:

- ~57.0 m from near FISC
- ~63m from crystal

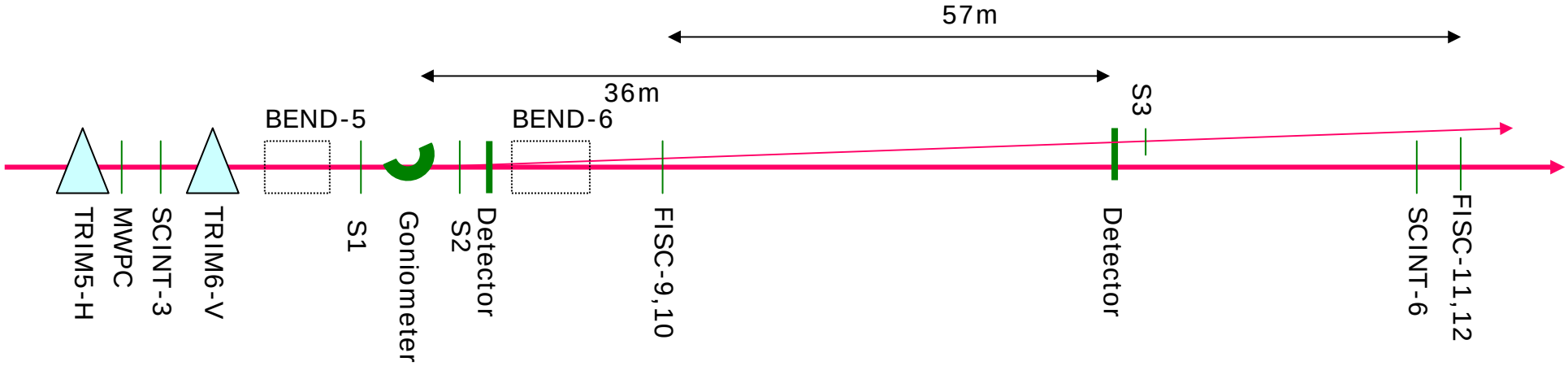
Beam tuning for Crystal Experiment

- Note that Bend-5 and Bend-6 have to deflect the beam by 1.8mrad each
  - If Bend-6 is switched OFF → the beam will hit the vacuum in less than 25m !

Tuning the beam parameters:

1. **Beam position wrt crystal**
   - Defined using a set of thin scintillators upstream / downstream of the goniometer
2. **Beam Parallelism**
   - Verified using a pair of Filament Scanners (FISCs) separated by ~57 m
3. **Angular scan**
   - Can be done at the H-plane using the available trim magnets
4. **Horizontal scan**
   - More complicated to do with the beam, use either:
     - The goniometer itself (displacement keeping the same angle)
     - Slice the beam using the pixel detector (?)

Experiment Layout & beam setup

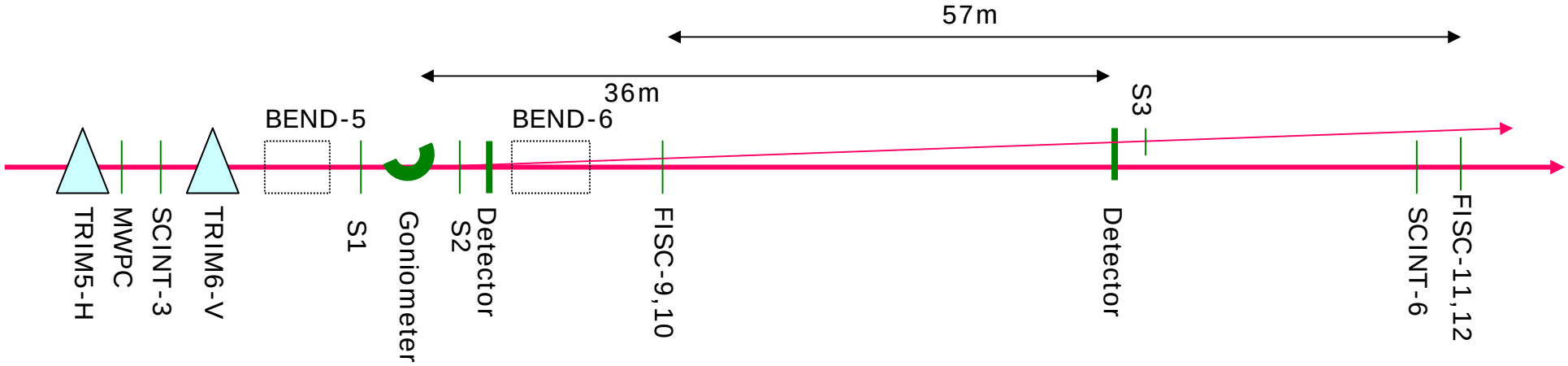


1. find the beam : count on SCINT-3 ⊕ SCINT-6 coincidence
   - Goniometer out of beam
   - Adjust collimators and rate (T4 target & TAX holes / material)
2. steer onto the S1, S2 counters

   H-plane:
   - Steer TRIM3(TRIM5) to maximize rate in S1 counter [~0.2mm/amp; ±30mm]
     - Alternatively, move the S1 counter to find the beam !
   - Use linear combination of BEND5 & TRIM5 to steer the angle around S1, i.e. keep the position the same, steer on S2 [~2μrad/A; ±100 μrad]
   - Use linear combination of TRIM3 & TRIM5 to displace the beam without changing the angle, [200μm/amp; ± 15mm]

   V-plane:
   - Steer BEND3,4 to maximize counts on S1 [~0.1mm/amp; ±15mm]
   - Use a linear combination of BEND4&TRIM6 to steer the angle arouns S1, i.e. keep the position unchanged, steer on S2 [~2μrad/A; ±100 μrad]

Experiment Layout & beam setup



Note:

- at this initial stage S1 could be replaced by a “wider” counter (5mm)
- it is assumed that S1 is an {x,y} counter
- after this operation is done, the position of the goniometer should be defined by the mechanics

1. Verify the parallelism of the beam
   - Use the FISC-FISC coincidence for FISC9,10 ⊕ FISC11,12 ; “angular scan”

   - Place FISC11 at x1 position and scan FISC9 across the beam → get profile-1
   - Place FISC11 at x2 position and scan FISC9 across the beam → get profile-2

   If the beam is parallel, the two mean and rms should be the same!

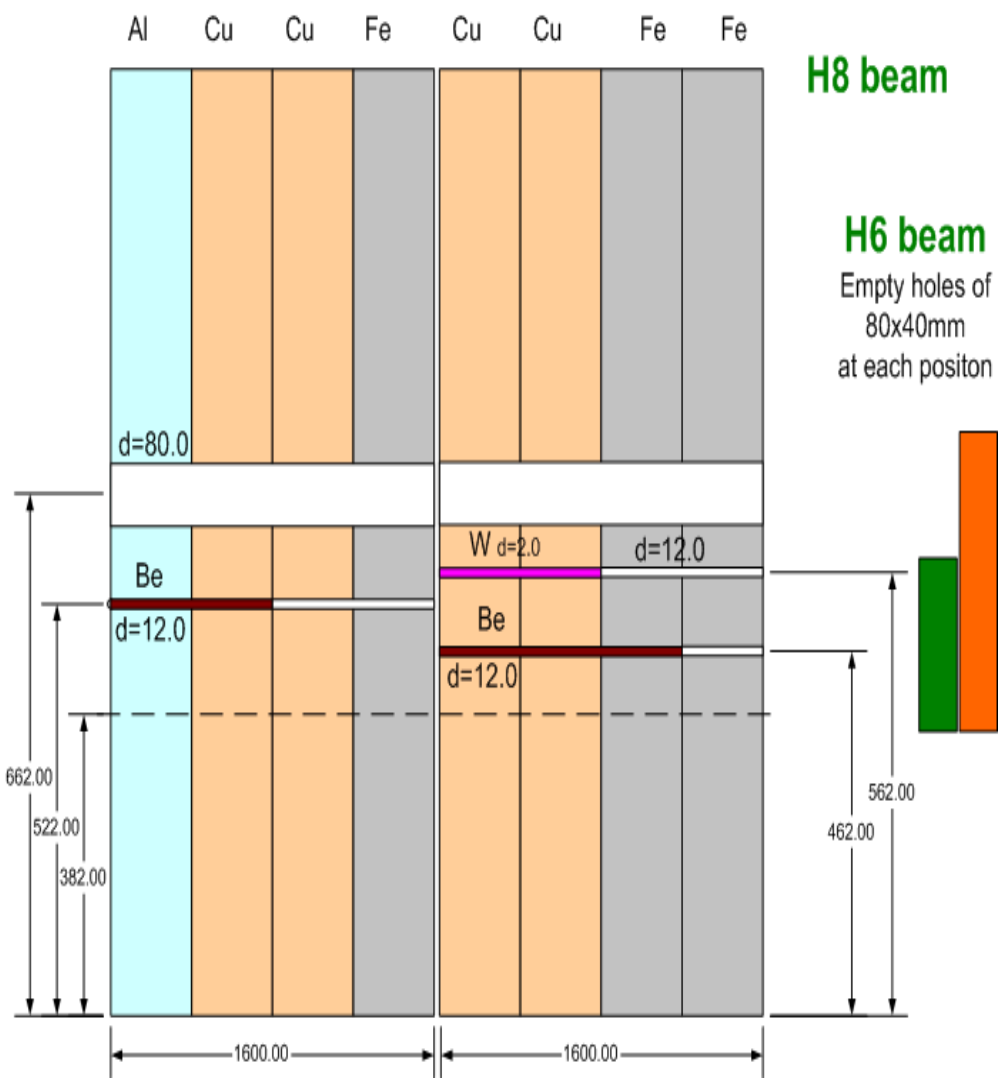
   - Repeat for the other plane
   - Use quadrupole settings to steer the beam and change parallelism

Numbers to remember

- Channeling angles : 100 μrad (channeled) ; 20 μrad (reflected) ?
  - Displacement of the beam at the far detector : 3.6mm
  - To be able to see the through and deflected beam we must have a separation of >6sigma between them
  - From previous experiments (references) the beam spot obtained was ~10μm (sigma) for intensities of 10^4-10^6
- DAQ: record data event-by-event basis:
  - 1kHz → 5k events per SPS extraction ; can it be 10 kHz? → silicon detectors?
- Trigger is provided by S1 ⊕ S2 ⊕ S3
  - S2 is sized to match completely the crystal face → intensity & acceptance defining counter
  - S4 could be used to count the deflected part of the beam
- Material budget:
  - S1, S2, S3, S4 : 1(5)x5 mm^2 scintillators → 0.2% X0 each → 1.3urad
  - Vacuum windows (180 μm thick) → 0.06% X0 each → 0.61urad
  - Detectors (300μm Silicon) → 0.3% X0 each → 1.5urad
  - Air: negligible
- Goniometer:
  - Allow crystal orientation with few microns – a) rotation movement b) alignment plane (horizontal)
  - S1, S2 should be included in the horizontal movement of the crystal

Backup slides

Target Attenuator (TAX)



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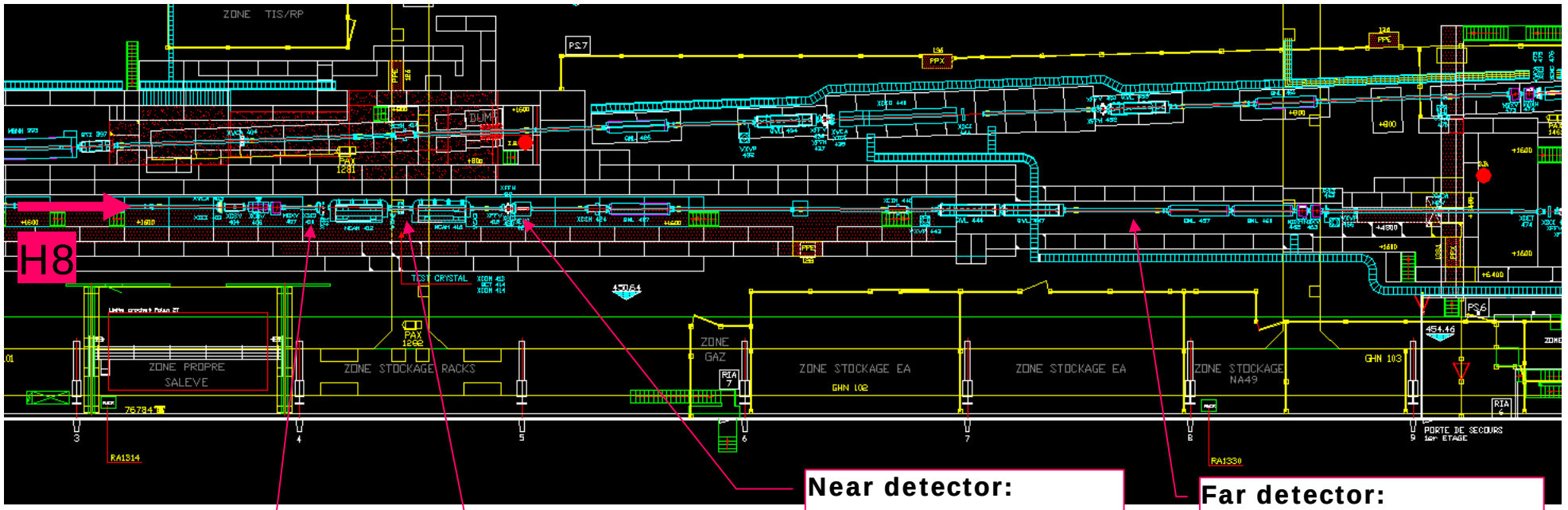


Upstream instrumentation

- ~0.5m opening
- -3.5 m from crystal

Crystal setup:

- Goniometer
- Upstream(downstream) counters
- 1m opening

Near detector:

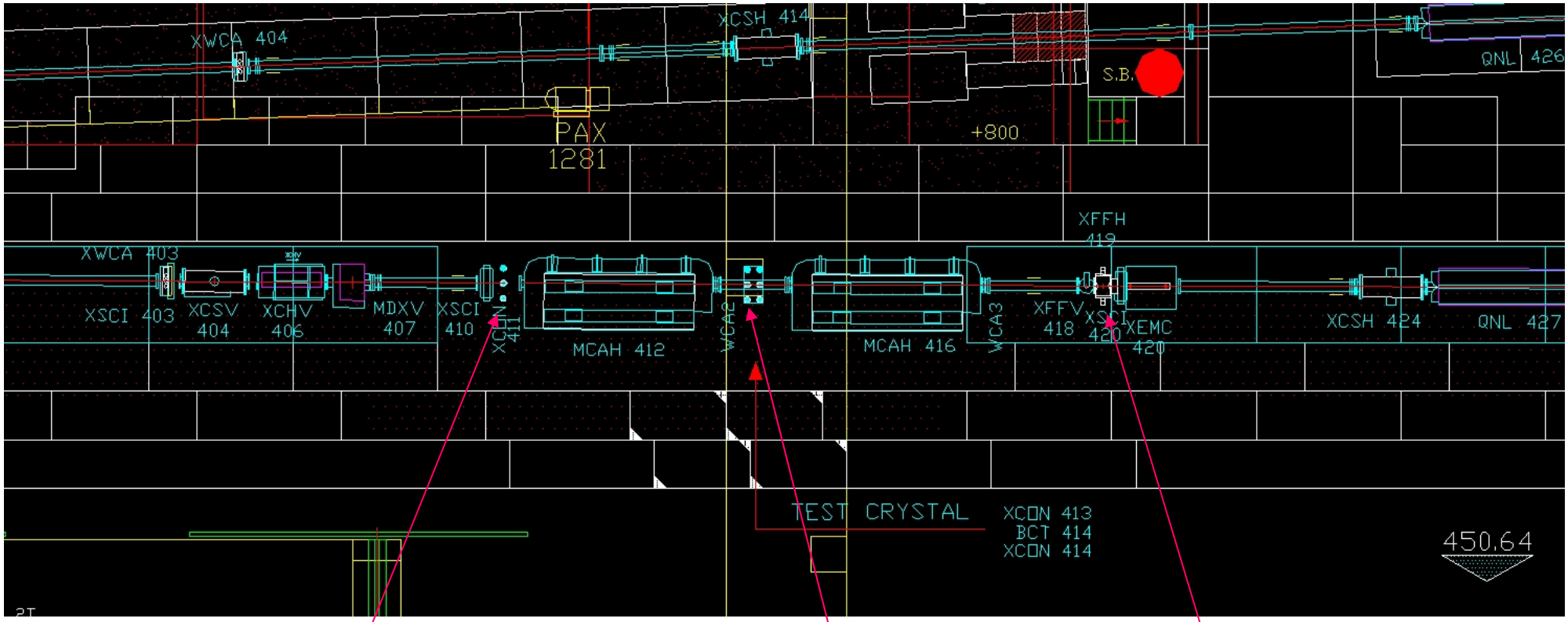
- hodoscope
- ~1m opening
- 6.620m from crystal

Far detector:

- Hodoscope
- ~6 m opening
- 35.5 to 41.0 m from crystal

Crystal Experiment Layout

BCT Crystal location



Upstream instrumentation

- ~0.5m opening
- -3.5 m from crystal

Crystal setup:

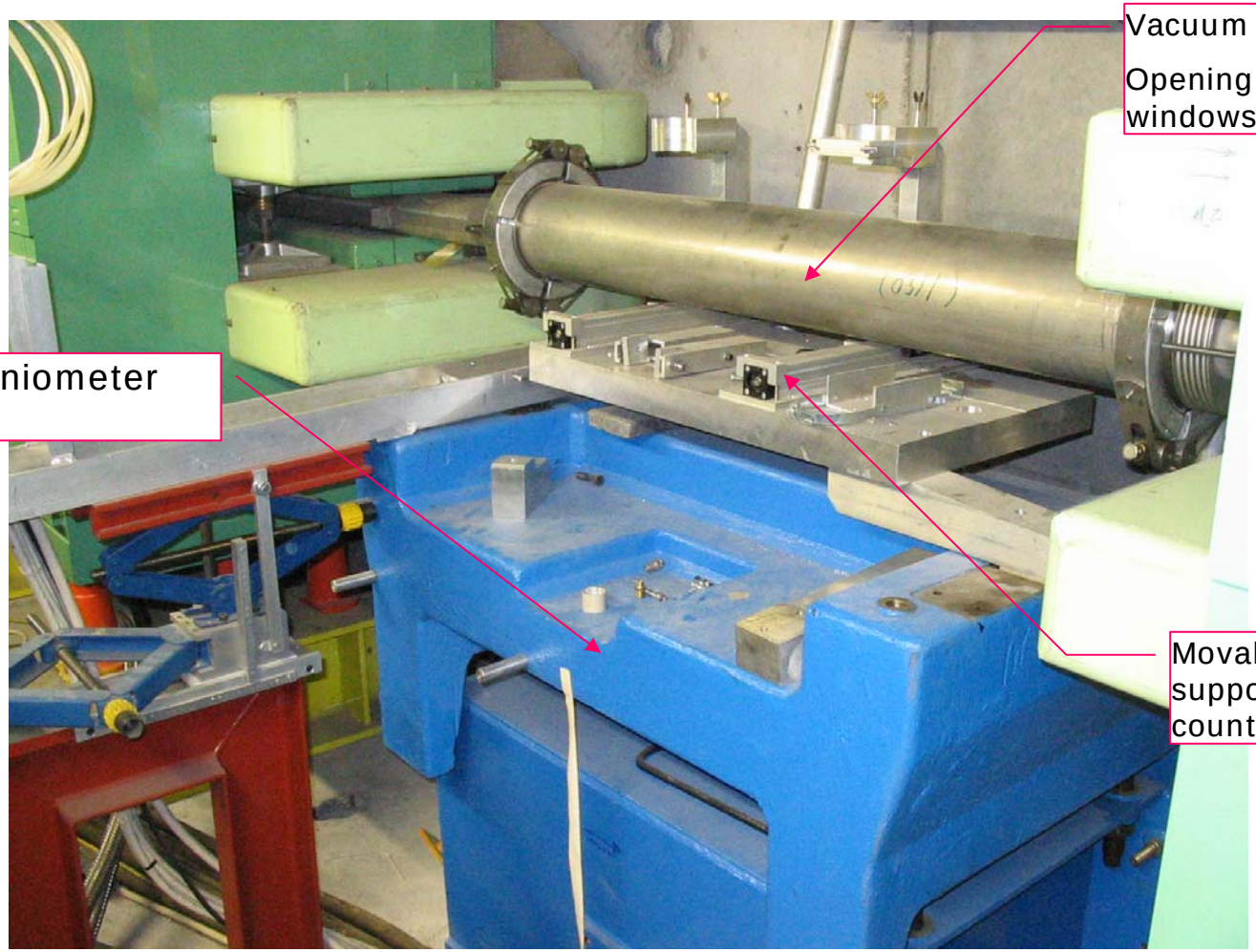
- Goniometer
- Upstream(downstream) counters
- 1m opening

Near detector:

- hodoscope
- ~1m opening
- 6.620m from crystal

Crystal Experiment Layout

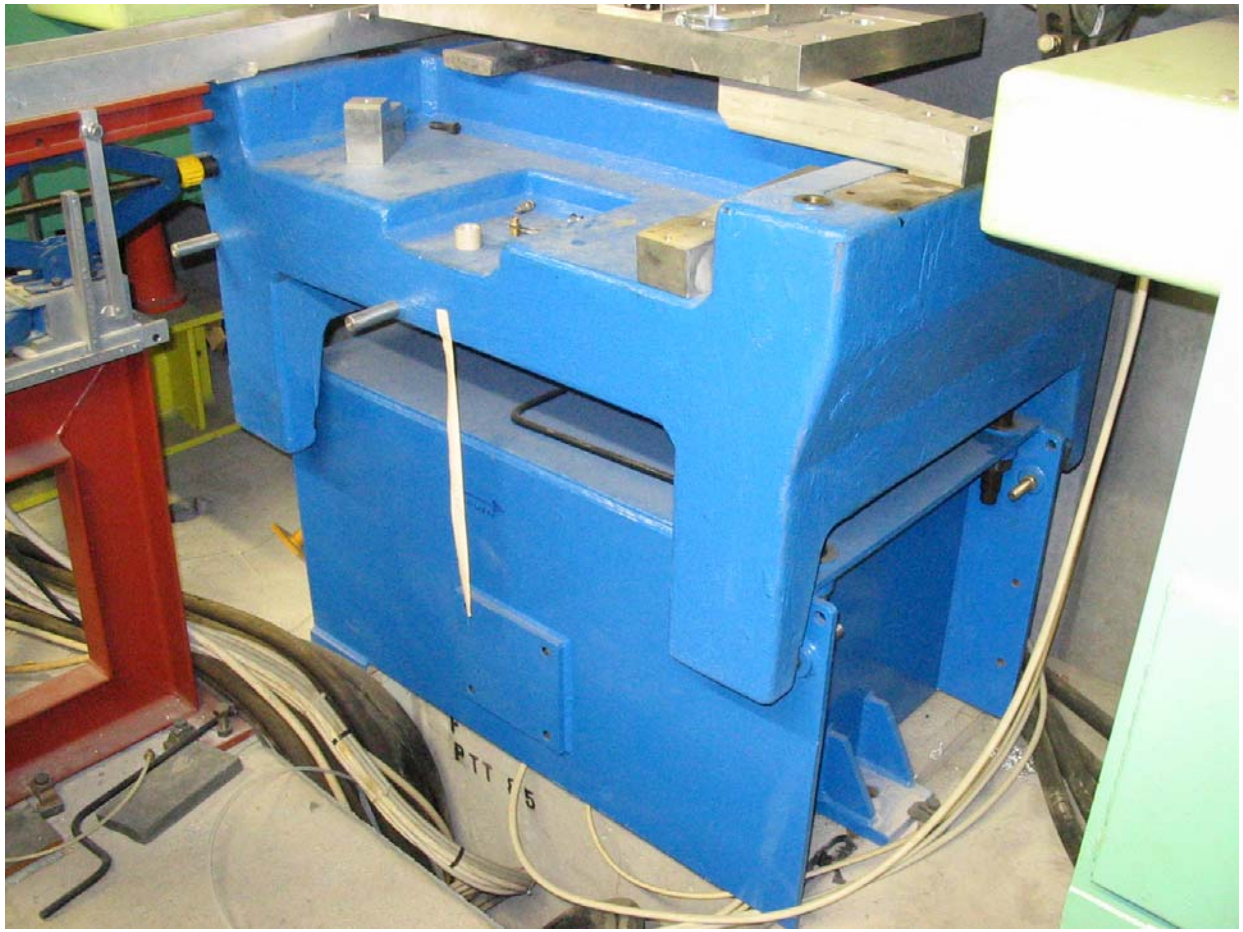
Location for the BCT crystal holder



Crystal Experiment Layout

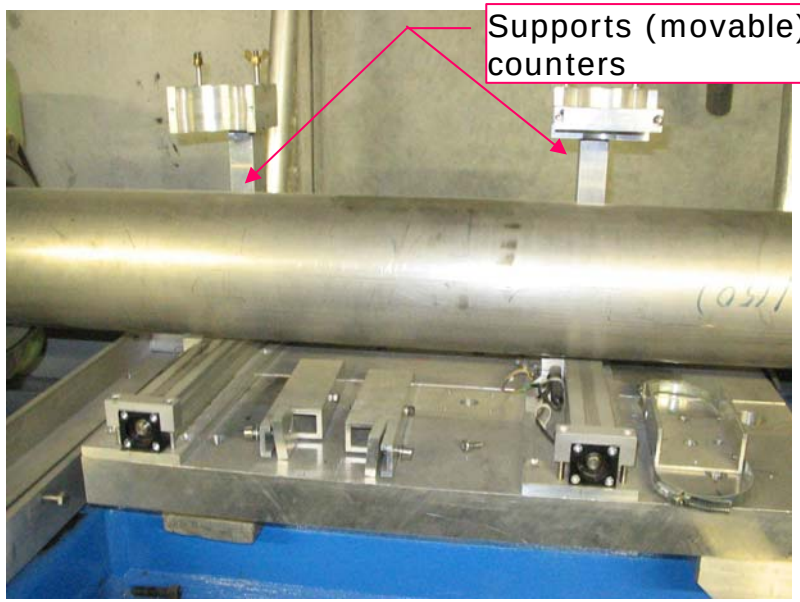
Base for BCT crystal holder

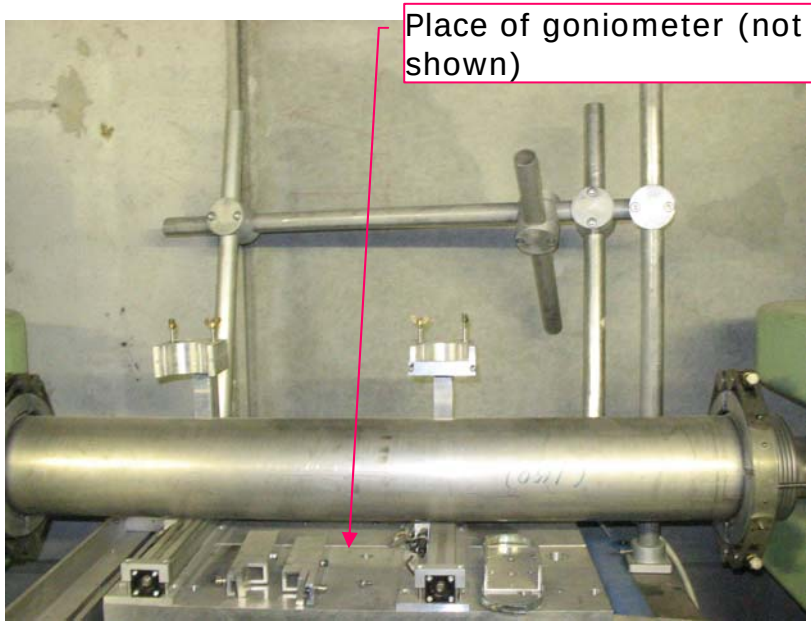
- Very solid base – good support for goniometer and avoid vibrations (overhead crane !!!)
- Very difficult to remove in any case



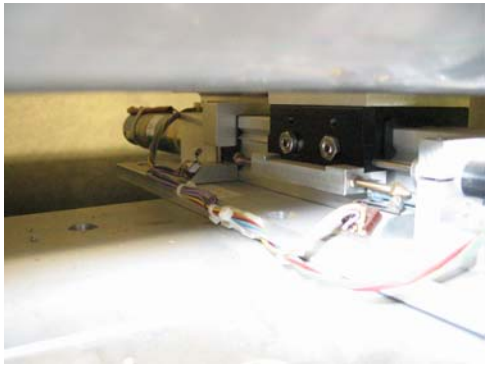
Crystal Experiment Layout

BCT crystal holder and nearby trigger setup





Motorization details



Crystal Experiment Layout

Location for upstream instrumentation

Crystal Experiment Layout

Location for near detector

- ~6m downstream – 1m longitudinal gap ; if not used will be replaced by vacuum

Pb-glass calorimeter to be removed

- either replaced by vacuum
- or possibility for a near detector

Crystal Experiment Layout

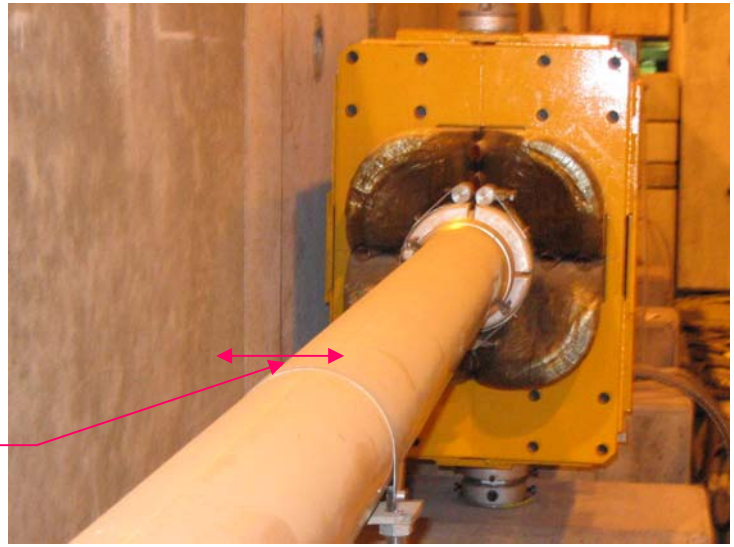
Location for far detector

- ~35.5÷41.0 m downstream

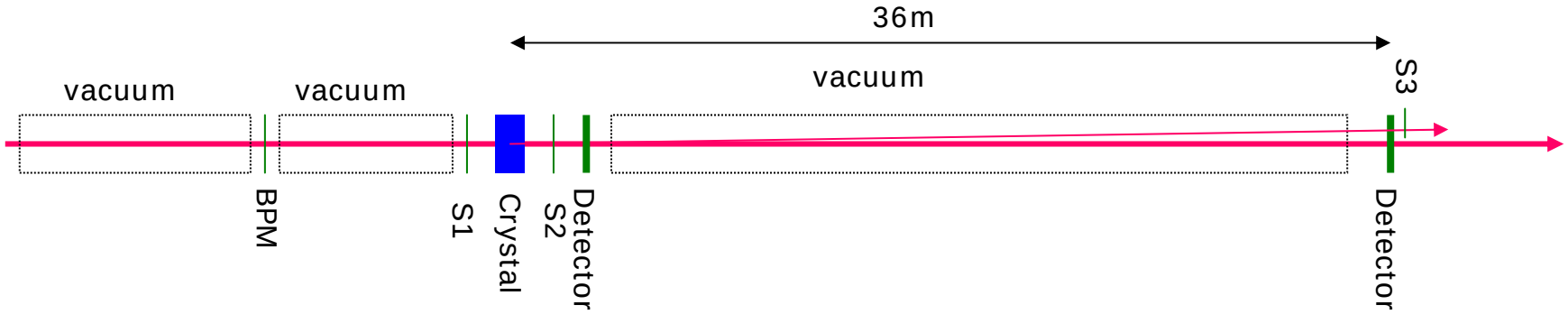
Vacuum pipe to remove

- ~6m opening
- new pipe to install to minimize air gap

Note: distance to wall <0.8m



Running conditions



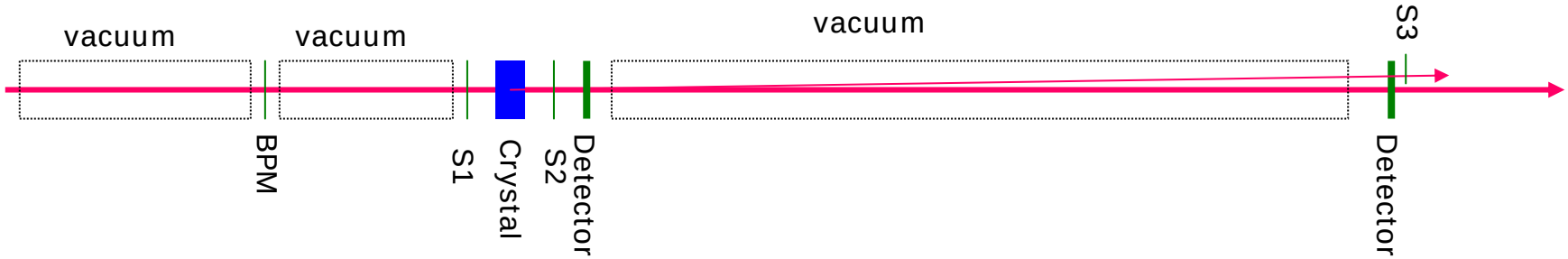
Important numbers:

- Deflection angle: 100 micro-rad ; Reflected beam : 200 micro-rad
- Separation at far detector: **3.6 mm (deflected beam)** , **7.2 mm (reflected beam)**

- To be able and observe the deflected beams:
  - Need to close the micro-collimator to have a small spot at the crystal
  - Must define the incoming beam AT LEAST of the mm level with a small trigger counter ; used also to position the beam wrt the crystal

  Note:
  - Beam divergence of <10 micro-rad not important, but must be considered and measured.

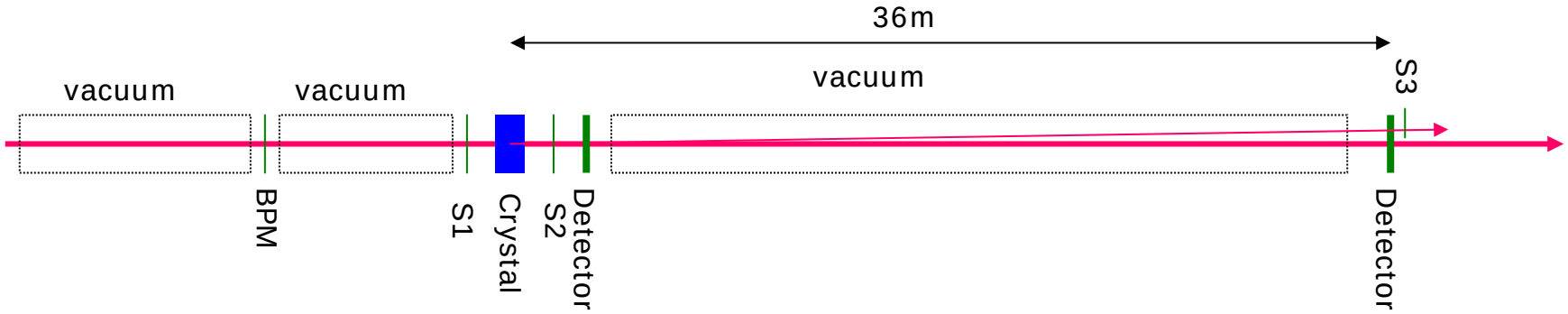
Running conditions



- **Material budget – correct?**
  - S1, S2, S3, S4 : 1mm scintillators → 0.2% X0 each → 1.3urad
  - Vacuum windows (180 um thick) → 0.06% X0 each → 0.61urad
  - Detectors (300um Silicon) → 0.3% X0 each → 1.5urad
  - Air: negligible

- **Crystal holder - goniometer:**
  - Minimize material around crystal – avoid large sprays of particles
  - Align S1, S2 with Crystal holder and move the beam to align them
  - How accurately can we re-position the goniometer and the crystal?

Running conditions



Trigger condition:

- S1⊕S2(or detector) ⊕S3 – and count particles !?
  - S1 – finger scintillator almost at the size of the crystal
  - S2 – larget scintillator , also needed to find the beam at the first place ; if the detector could provide such at trigger is not needed

Data analysis:

- Use near detector or BPM to slice the beam ?