Alignment of Endcap Stations in CRUZET

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News

Completed alignment of endcap stations in CRUZET-2;
CRUZETs 1 and 3 are in the pipeline

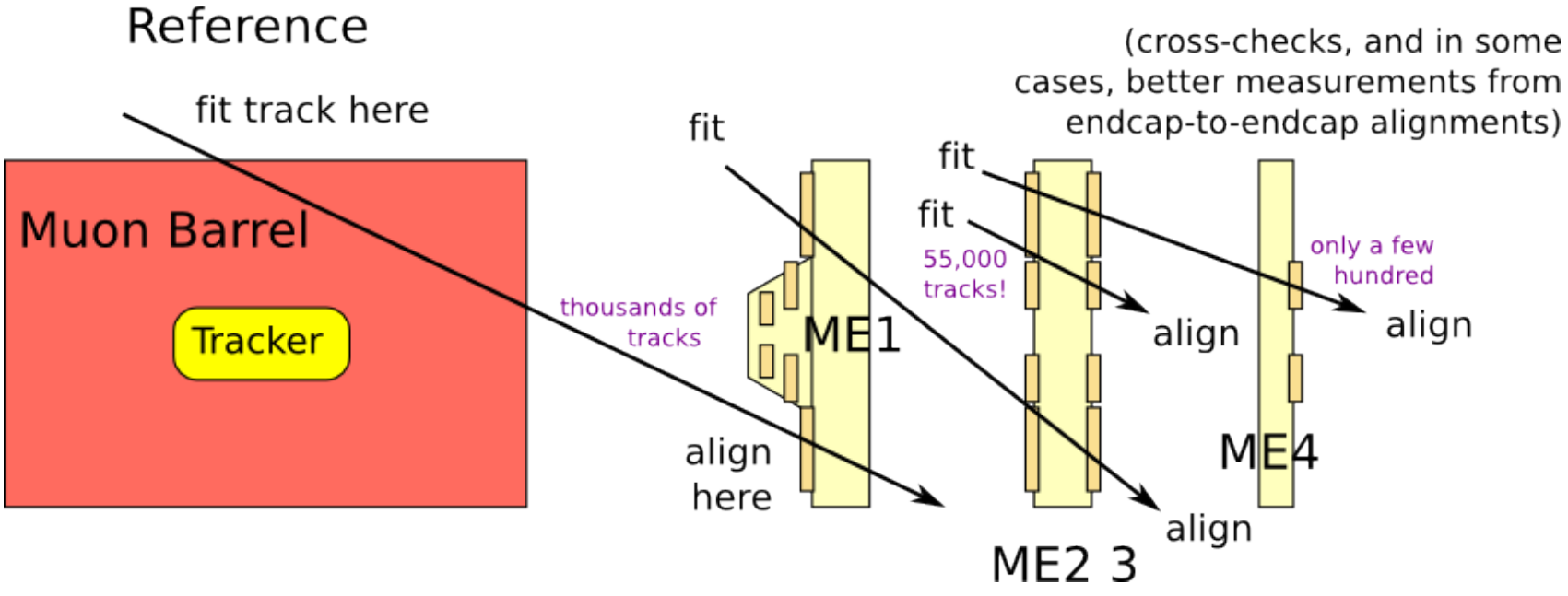
Outline

- How the alignment was done
- How to access the new constants
- Next steps

Station-by-station alignment

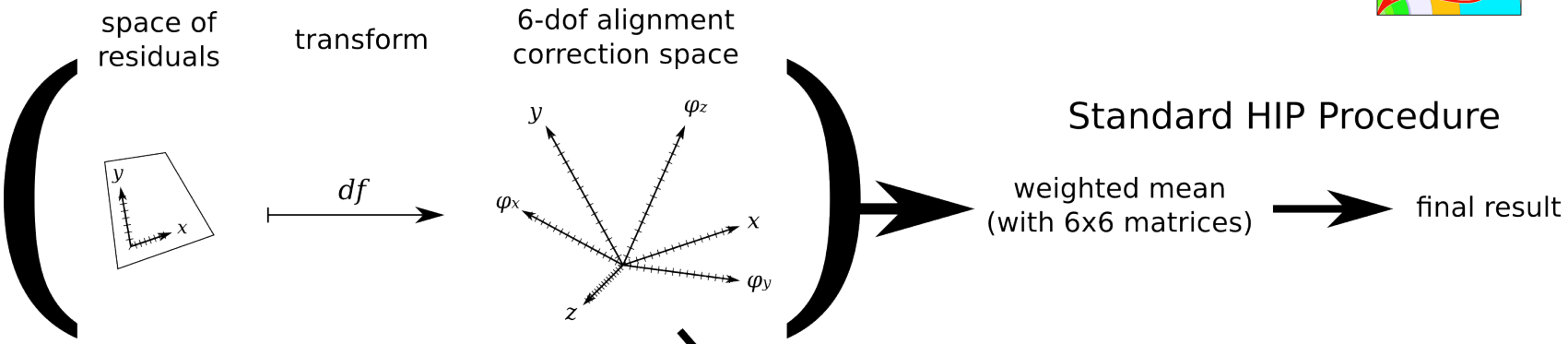
Treat each station (including rings) as a rigid body, find optimal position using tracks from barrel and other stations

- Largest and most important part of alignment, improves track residuals by many centimeters

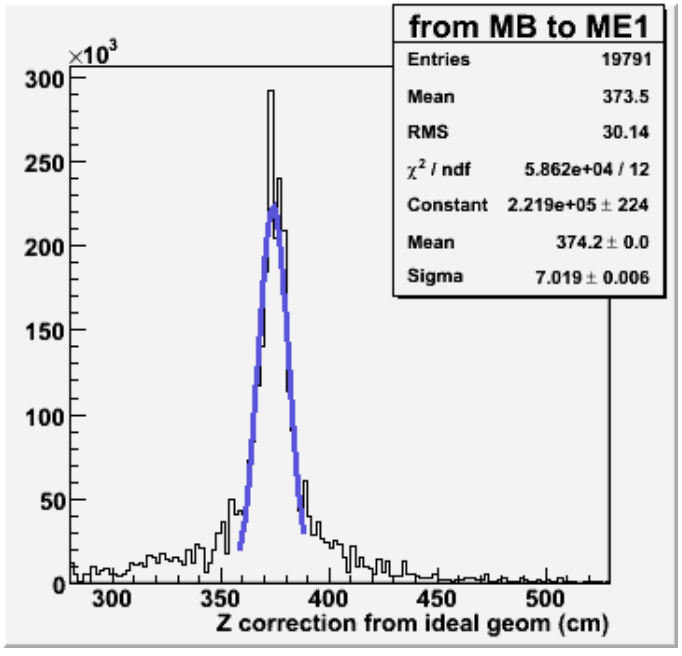


Similar to the "baseline" procedure for collisions data, except that the muon barrel is the reference, rather than the tracker

Use of HIP derivatives



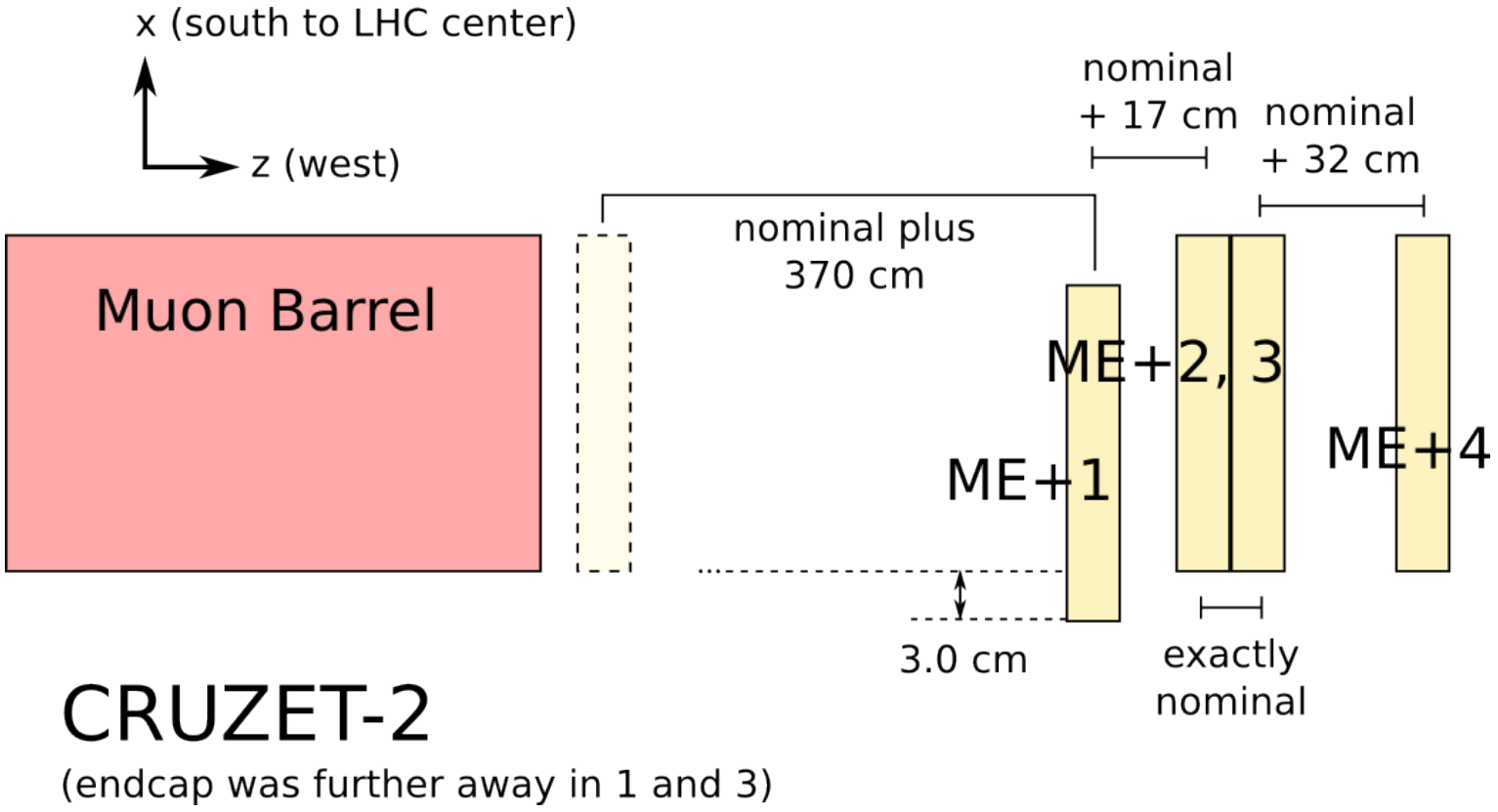
Every hit tells us where it thinks the station is



Histogram of z correction from every hit

- Without a magnetic field, can't cut on p_T
- Bad tracks/hits form a broad distribution
- Good tracks/hits agree on a z position
- Tape-measure agrees, too: 370 cm

Results at a glance: Where were our stations in CRUZET-2?



- Other parameters are all consistent with zero
- Verified 370 cm opening and possibility of $\mathcal{O}$(cm) transverse offset
- "Discovered" that ME+2 and ME+3 are mounted to the same yoke

Internal consistency check

"MB→1→2" means

- fit tracks in MB, use them to align ME1
- then fit a separate set of tracks in ME1, use them to align ME2
- should yield the same result as direct "MB→2"

Comparison	x (mm)	y (mm)	z (mm)	ϕ_z (mrad)
(MB→2) − (MB→1→2)	-12.8 ± 0.3	6.4 ± 0.4	39.9 ± 0.8	-4.75 ± 0.12
(MB→3) − (MB→2→3)	-3.4 ± 0.4	-8.7 ± 0.5	-15.3 ± 1.0	-1.06 ± 0.14
(MB→4) − (MB→3→4)	0.4 ± 0.8	6.0 ± 0.9	10.3 ± 2.4	2.8 ± 0.3

Statistics-only underestimates the error, but

$$\sqrt{\frac{1}{N-1}\sum(x_i - \bar{x})^2} = \begin{cases} 7.8 \text{ mm for } x \text{ and } y \\ 28 \text{ mm for } z \\ 3.8 \text{ mrad for } \phi_z \end{cases}$$

gives a rough (over-)estimate (double-counts MB→2 and MB→3)

Final values (relative to nominal)

	x (mm)	y (mm)	z (mm)	ϕ_z (mrad)
ME+1	-30.1038	-3.42741	3736.18	3.2184
ME+2	9.18771	-18.4147	3910.91	-0.466131
ME+3	10.4957	-15.9612	3911.03	-8.88953
ME+4	8.33082	0.576984	4227.06	-5.60561

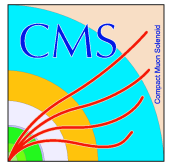
(ϕ_x and ϕ_y set to zero)

- Also includes 2.5 mm outward radial correction in ME2/2 and ME3/2 to fix error in DDD description

```
es_source = PoolDBESSource {
    string connect = "frontier://FrontierProd/CMS_COND_20X_ALIGNMENT"
    using CondDBSetup
    VPSet toGet = {
        {
            string record = "CSCAlignmentRcd"
            string tag = "CRUZET2-CSCStation-xyzphiz-2mmRadialFix"
        }
    }
}
```

- Track reconstruction must be performed in the same job for the alignment to take effect
- Do not use for CRUZET-1 and 3! (would be a 6 m error!)

Next steps (short-term)



- Work on CRUZET-1 alignment has started
- For CRUZET-3, we need a better sample of tracks (`/Cosmics/CRUZET3_CRUZET3_V2P_v3/RECO` was reconstructed with the 6 m error; many tracks must have failed pattern-recognition)
- A corrected CRUZET-3 re-reco begins this week, alignment will follow (finish sometime late next week?)
- Official re-reco with fully aligned constants will come later
- Very interesting to know how much CRUZET-2 alignment improves track-finding efficiency: 17 and 32 cm corrections between ME+1&2 and ME+3&4 are new (validation suite?)
- Work continues on CSC-Overlaps procedure, for chamber-by-chamber alignments relative to the stations