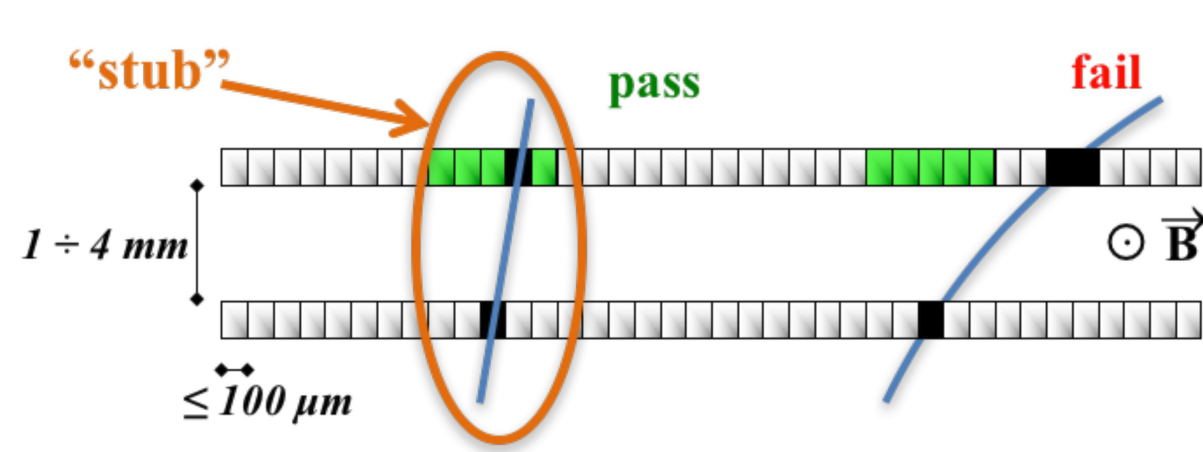


Level-1 track fining with an all-FPGA system at CMS for the HL-LHC

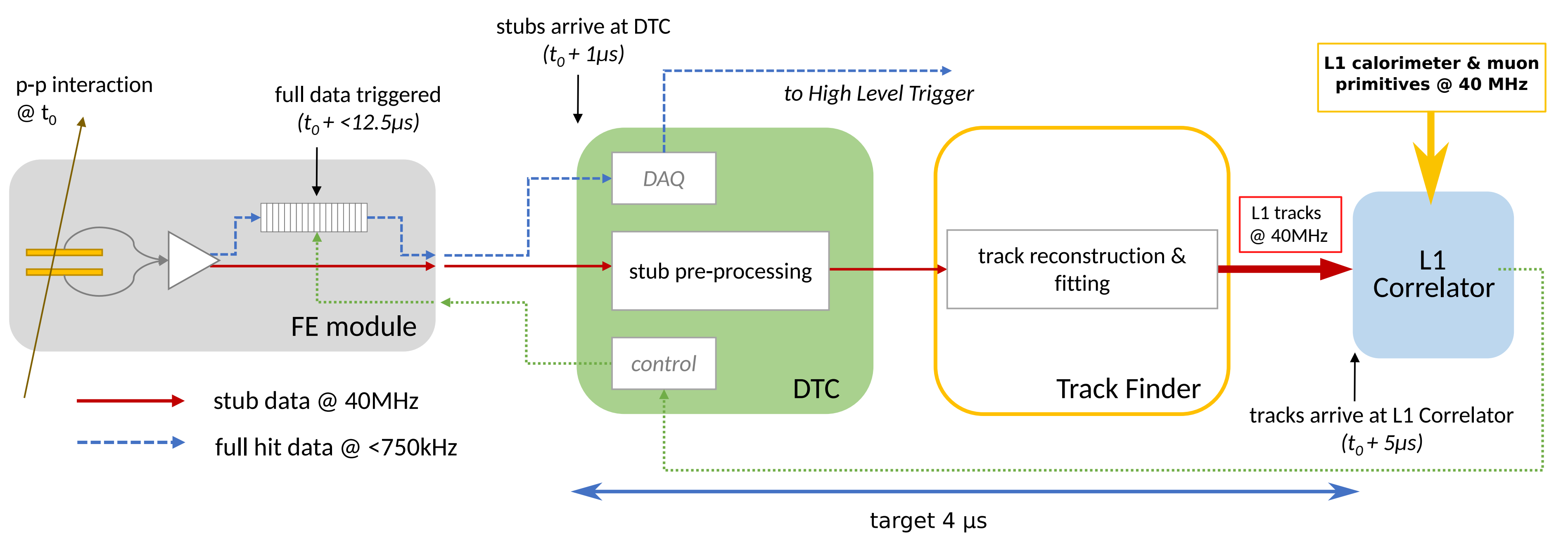
Luis E. Ardila-Perez on behalf of the CMS Collaboration
luis.ardila@kit.edu

CMS Tracker Upgrade

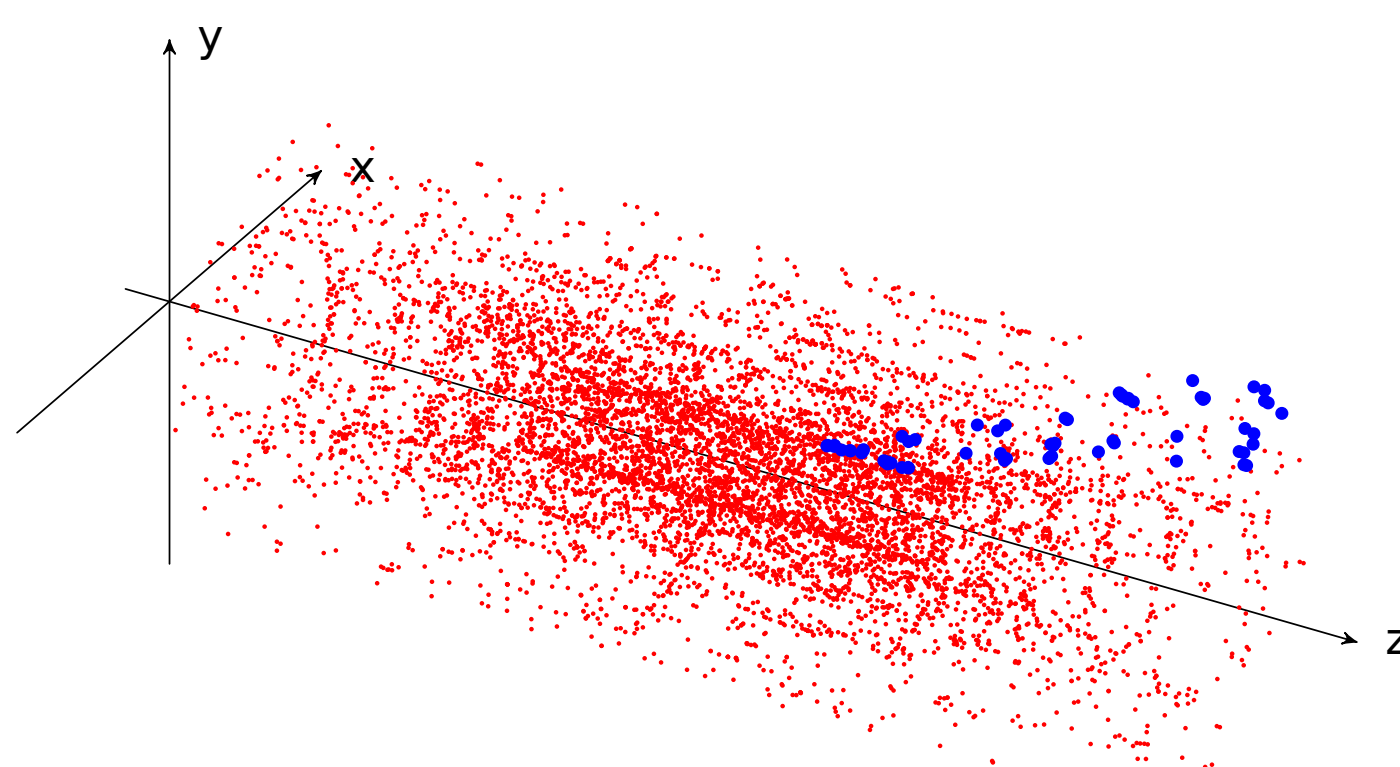
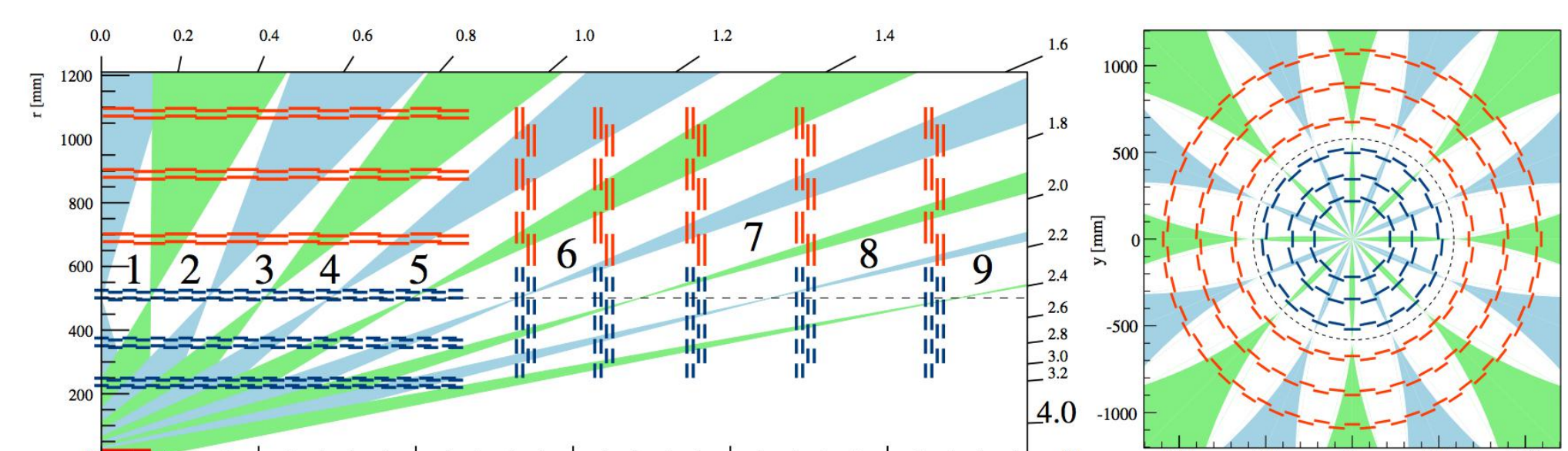
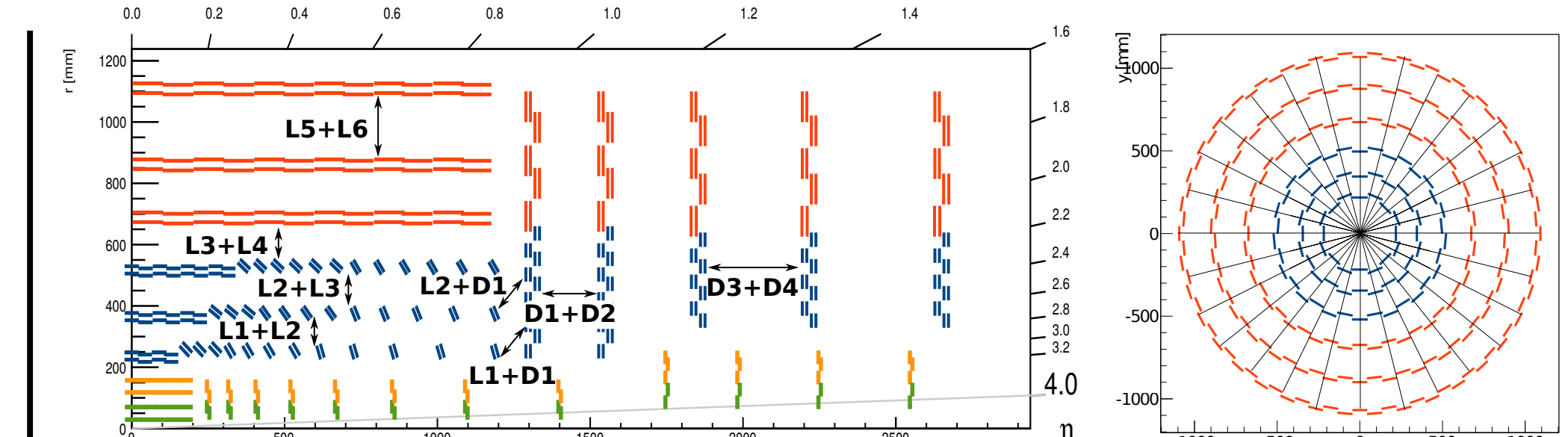
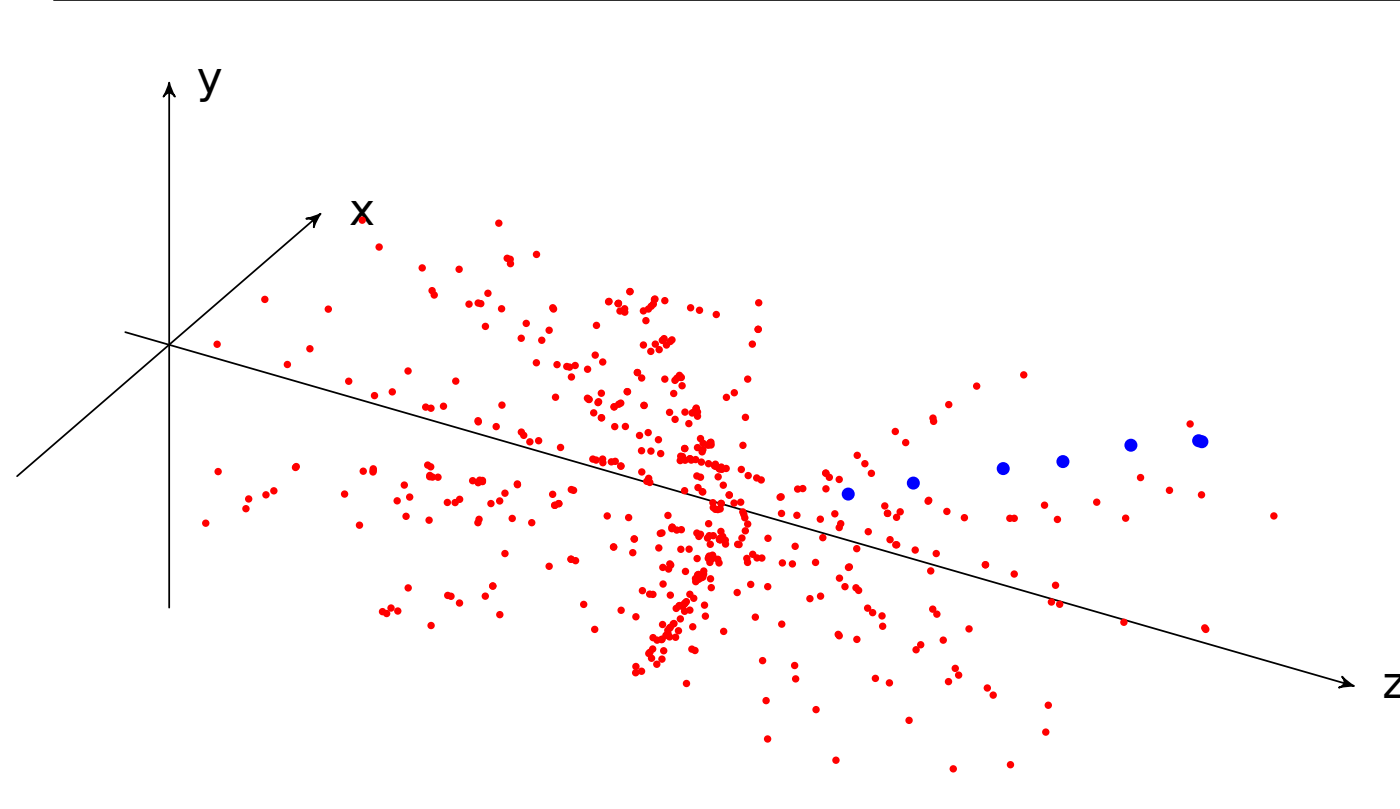
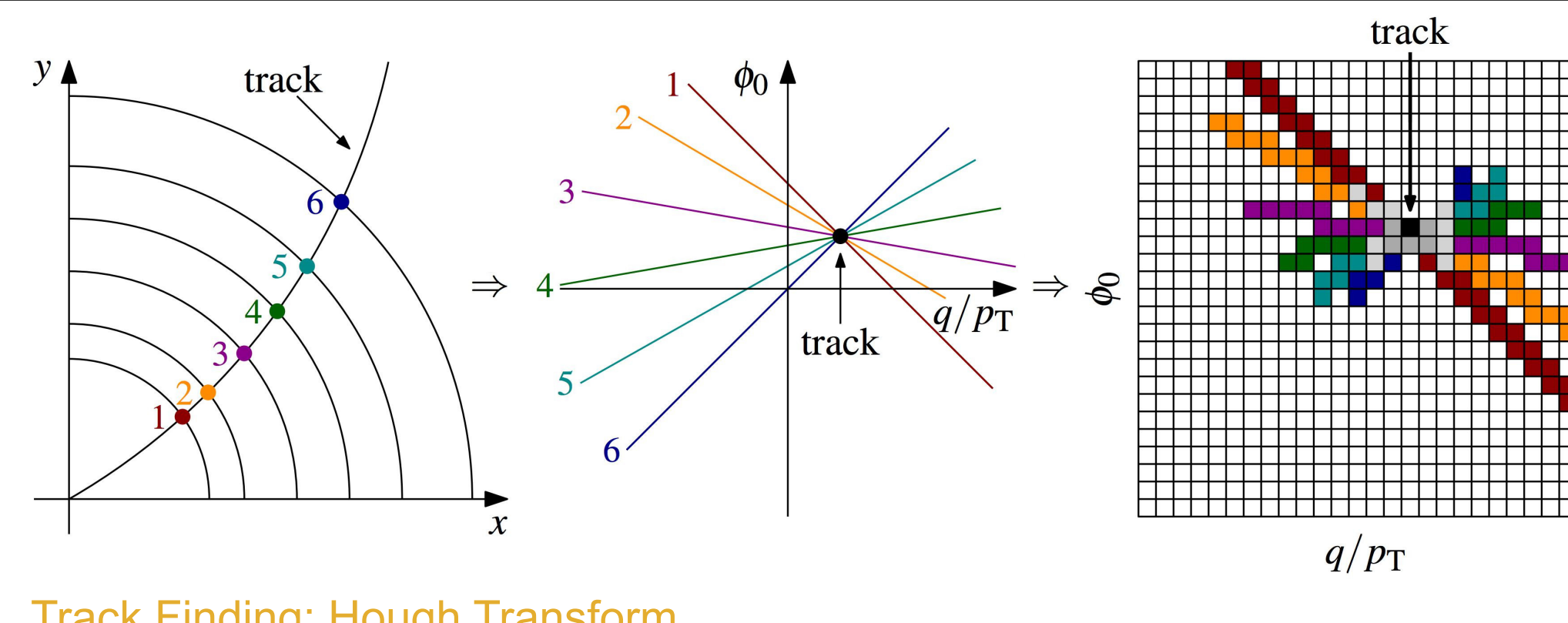
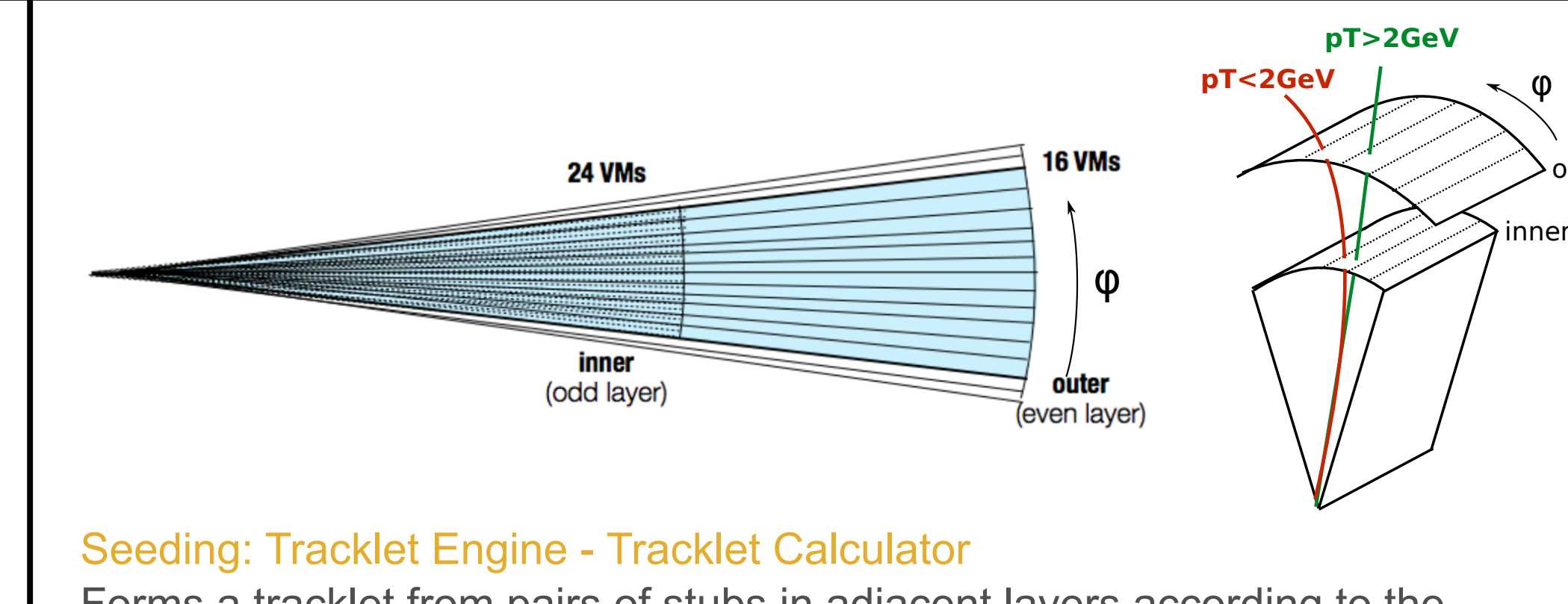
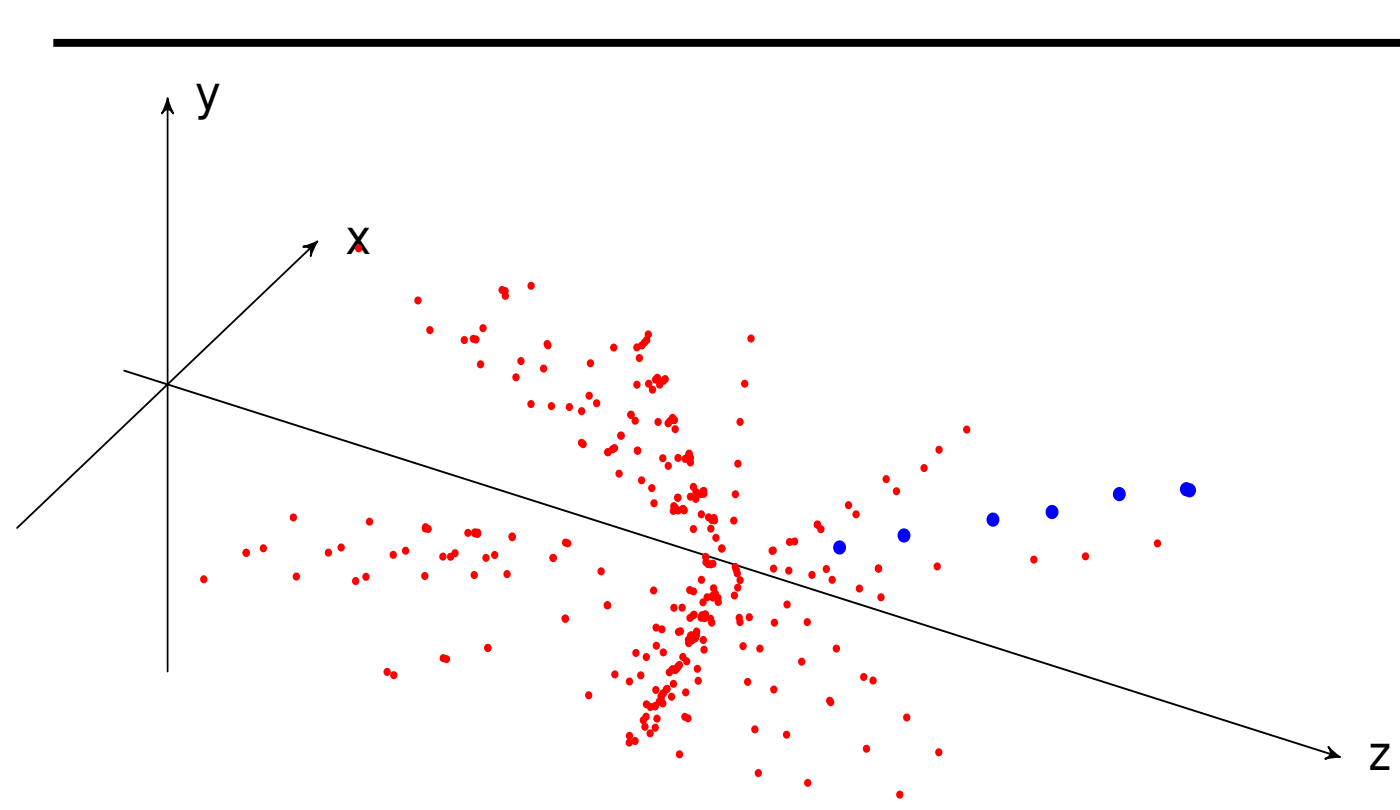
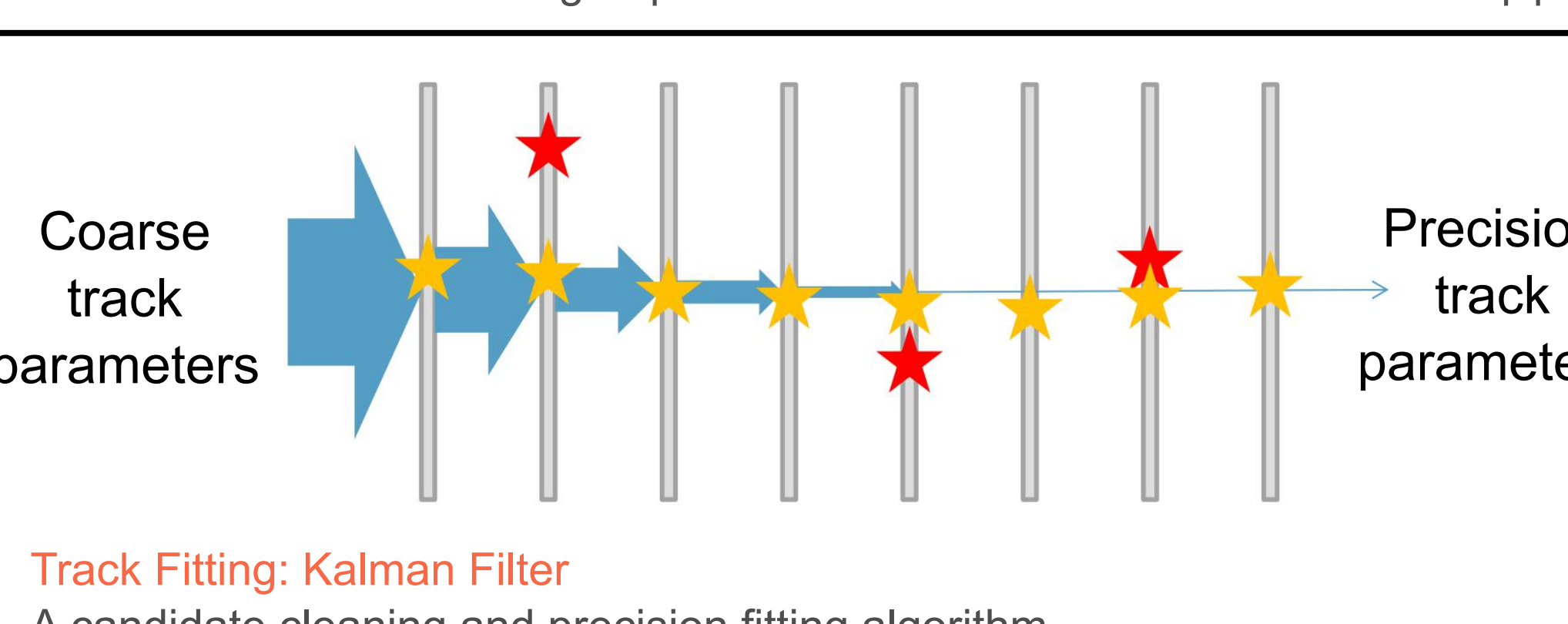
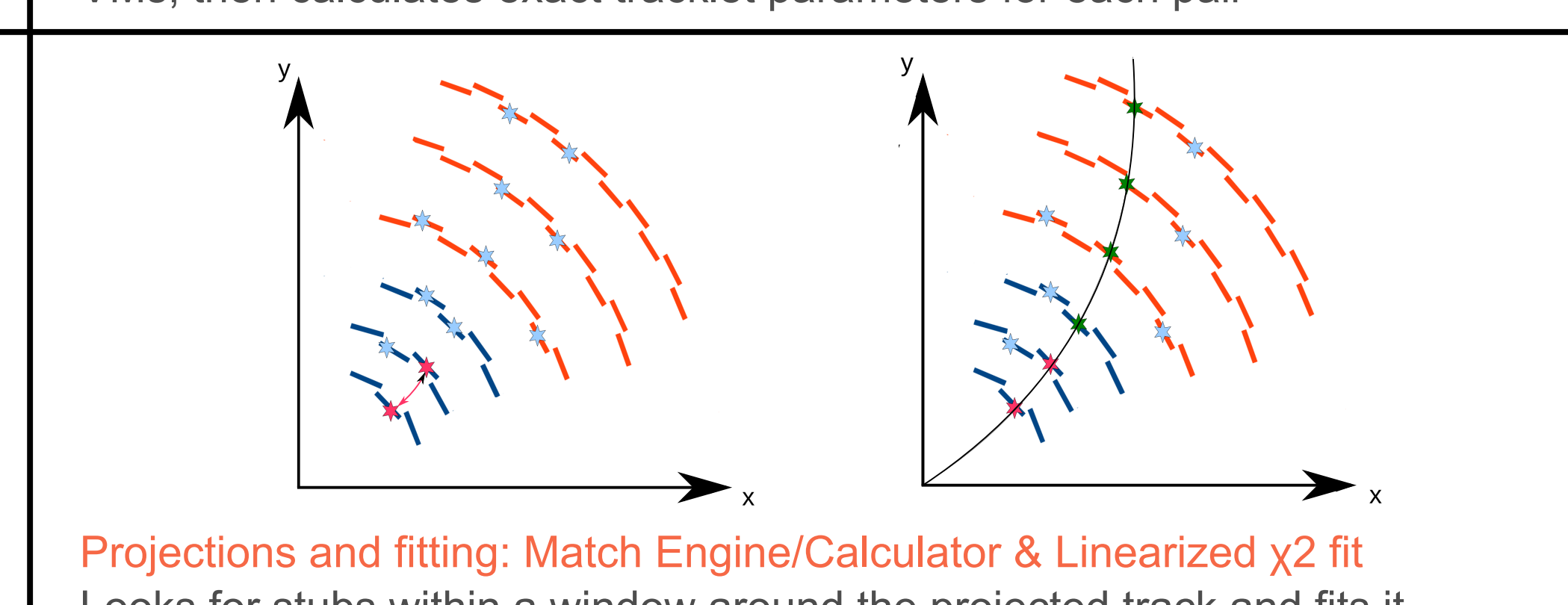
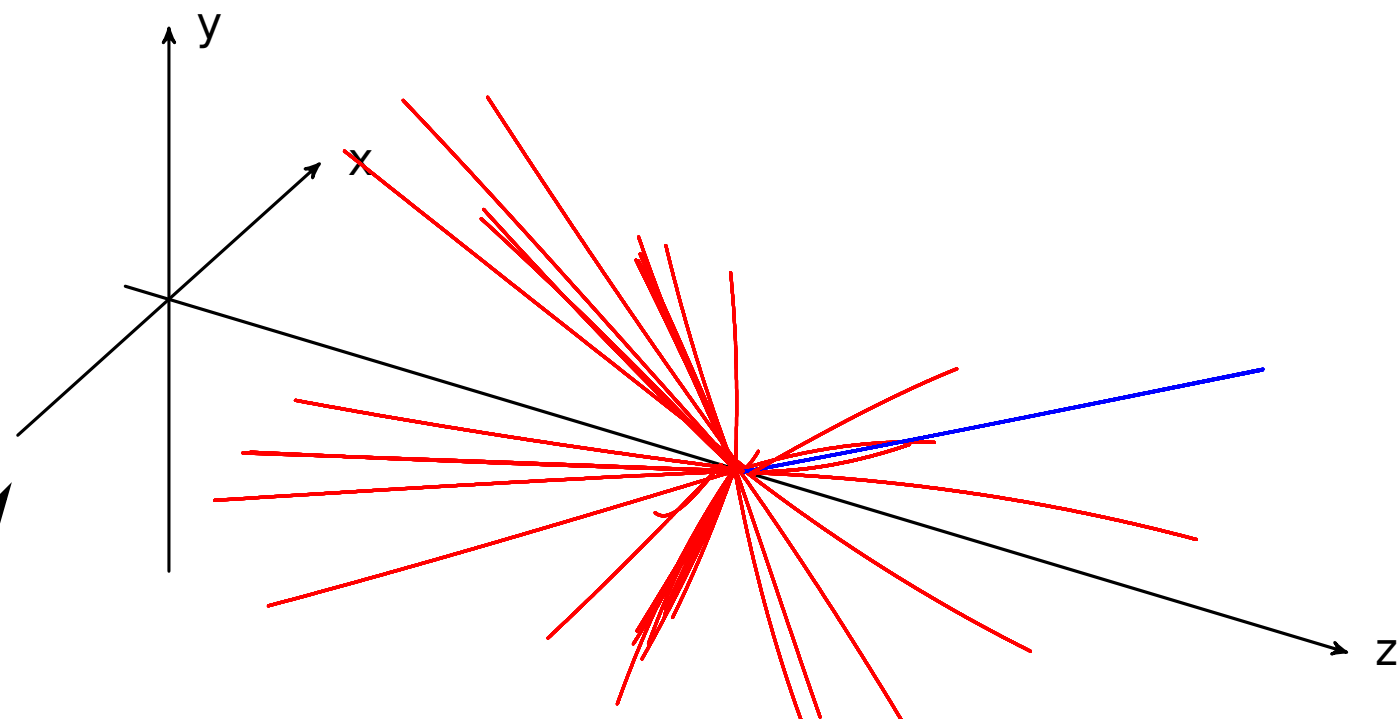
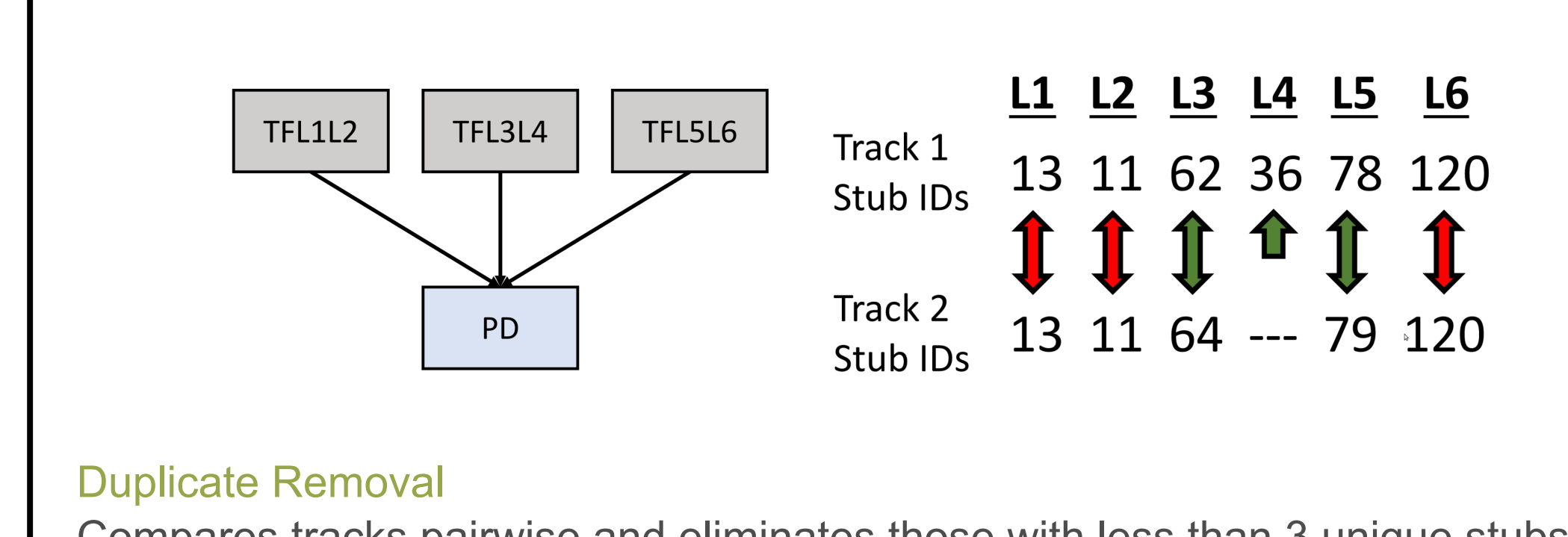
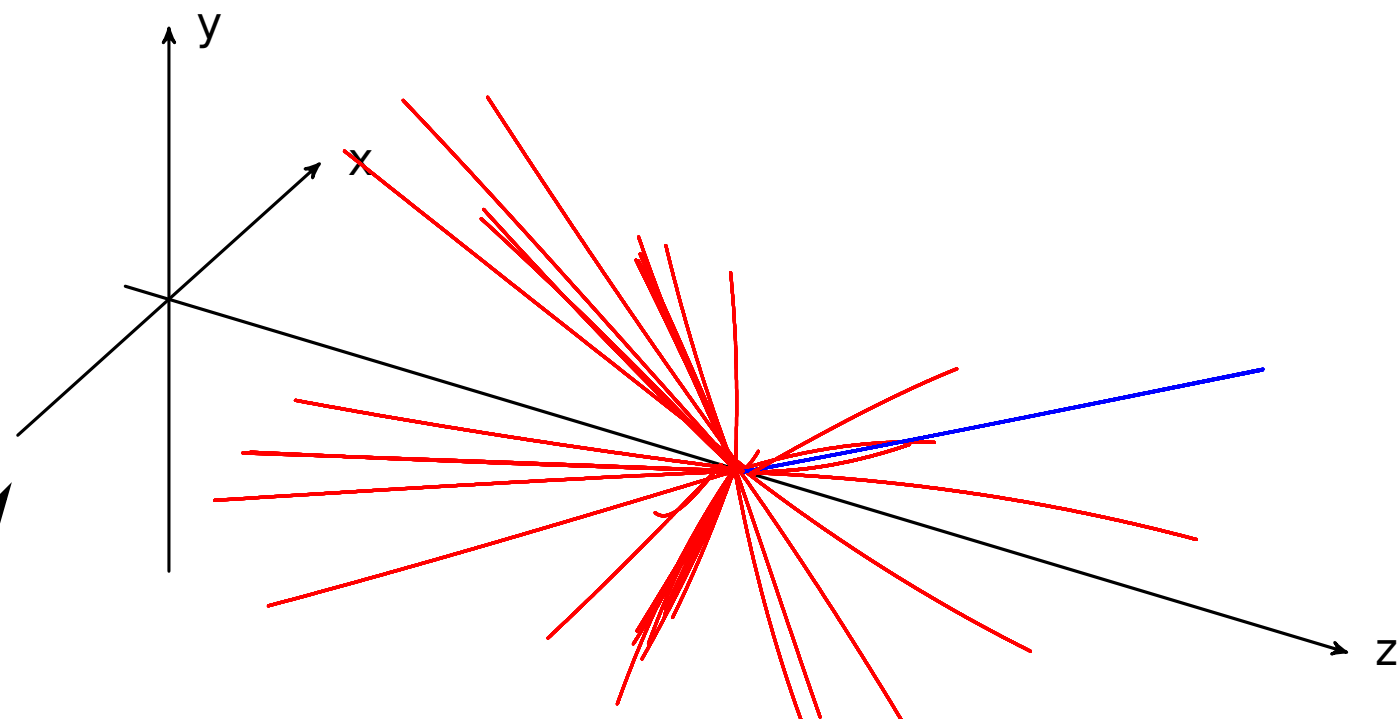
- High p_T tracks signs of interesting physics (decays of high mass particles)
- **Novel tracking modules** utilize two 1.6-4.0 mm spaced silicon sensors, to discriminate $p_T > 2-3$ GeV/c
- Forward these **stubs** to **off-detector trigger electronics** - rate reduction $O(100)$



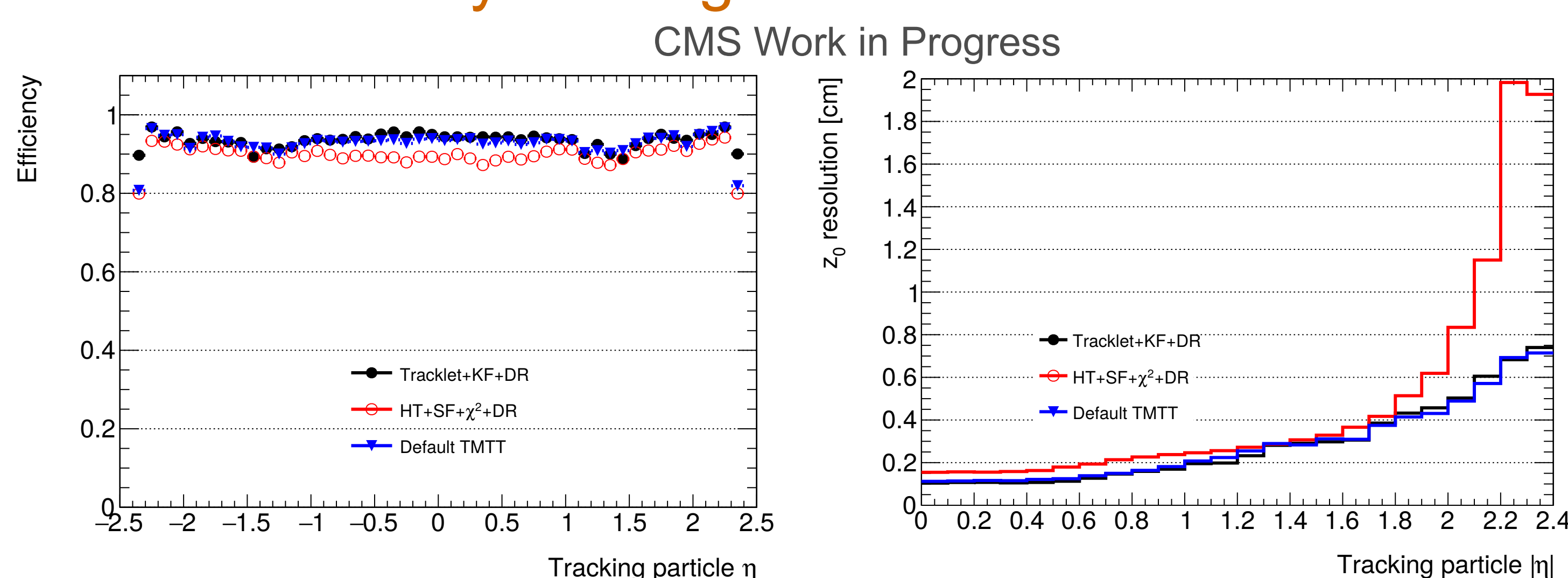
Track Finder Architecture



Track Finding Algorithms

Data Flow		<h3>TMTT</h3>  <p>Sector Assignment: Geometric Processor Processes stub data, and sub-divides the nonant into 36 finer sub-sectors</p>	<h3>Tracklet</h3>  <p>Stub Organization: Layer Router - VM Router Sorts input stubs into each layer/disk and splits processing module into virtual modules (VM)</p>
		 <p>Track Finding: Hough Transform Track finder that identifies groups of stubs consistent with a track in the r-ϕ plane</p>	 <p>Seeding: Tracklet Engine - Tracklet Calculator Forms a tracklet from pairs of stubs in adjacent layers according to the VMs, then calculates exact tracklet parameters for each pair</p>
		 <p>Track Fitting: Kalman Filter A candidate cleaning and precision fitting algorithm</p>	 <p>Projections and fitting: Match Engine/Calculator & Linearized χ^2 fit Looks for stubs within a window around the projected track and fits it</p>
		<p>Duplicate Removal Uses precise fit information to remove duplicate tracks generated by the HT</p>	 <p>Duplicate Removal Compares tracks pairwise and eliminates those with less than 3 unique stubs</p>
		<p>Duplicate Removal Compares tracks pairwise and eliminates those with less than 3 unique stubs</p>	<p>Duplicate Removal Compares tracks pairwise and eliminates those with less than 3 unique stubs</p>

Hybrid Algorithm Performance



► **Both all-FPGA approaches**, TMTT and Tracklet, proved feasibility and good performance by running samples from PU 0 to 200 using hardware demonstrators

► **Total latency** for TMTT (3.5 μs) and Tracklet (3.3 μs) **< 4 μs** target

► Efforts have started to **merge** the two approaches

- Common infrastructure R&D
- Hybrid algorithm analysis