Progress in design optimization of CBM

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- Introduction
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  - -Specific features and comparison to collider experiments
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  - - Track finding in ideal case
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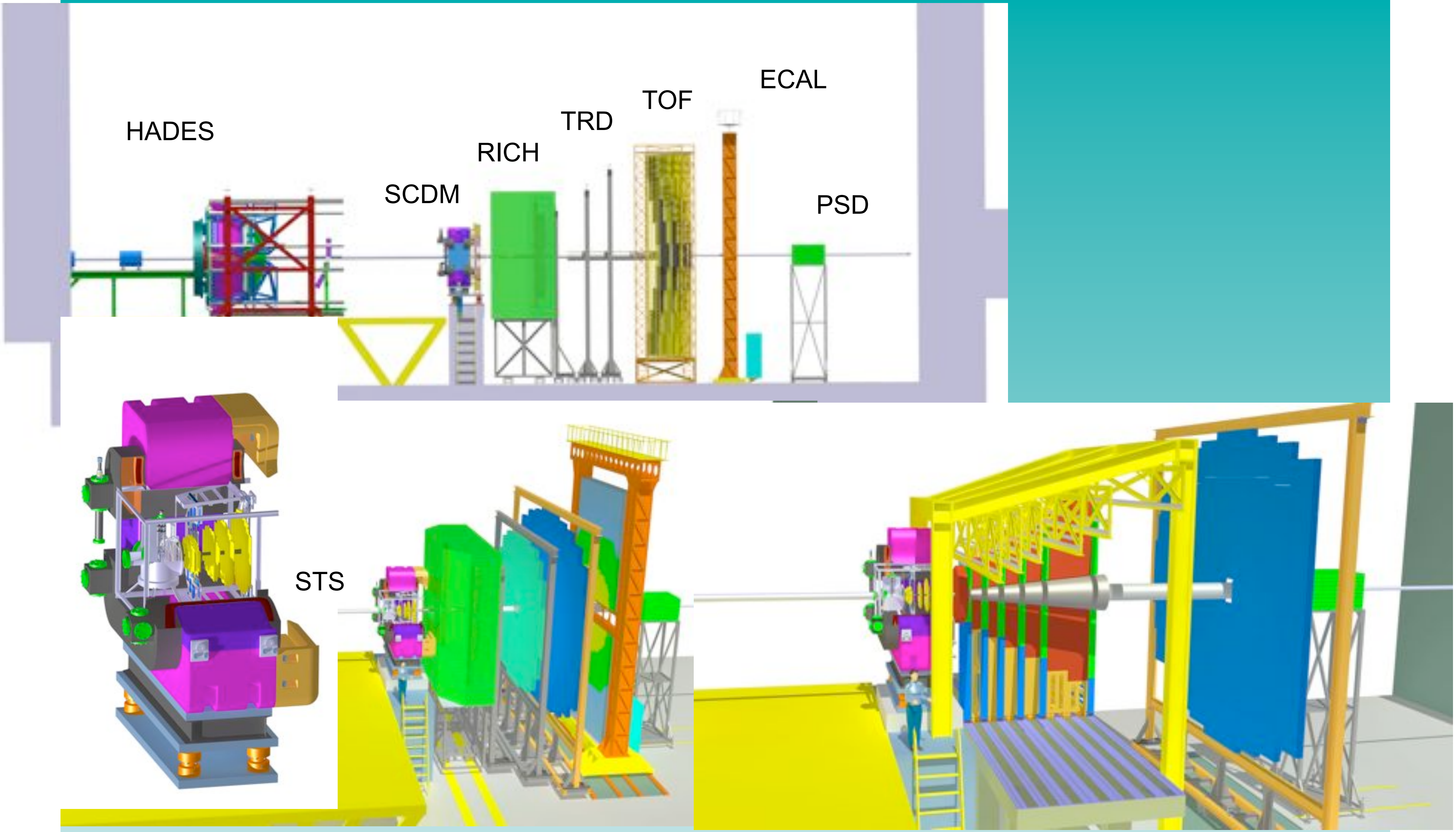
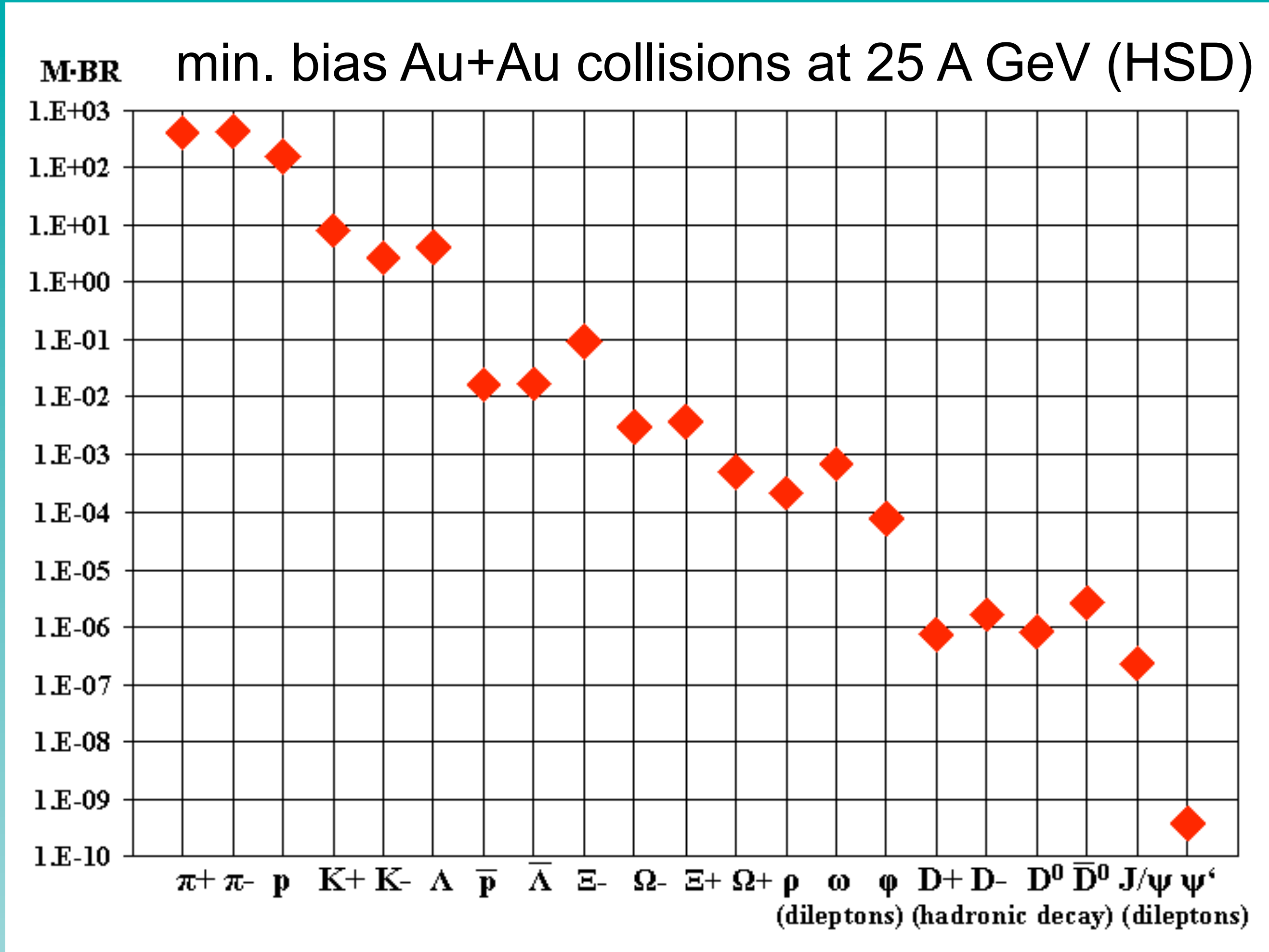
  - - What does layout optimization imply
  - - An amusing piece of system engineering
  - - Conceptual model of STS
- Conclusions

Layout of the experiment

Aperture: θ = 2.5° - 25°(PSD: 0.3° - 2.5°)



Specific features and comparison to collider experiments



The mission of CBM (one of) is to measure rare probes from dense matter. The methodology becomes close to one of low background physics (2 beta decay, dark matter): many improbable backgrounds able to mimic the signal should be studied and ruled out.

Specific features and comparison to collider experiments

	CBM (fixed Target)	Collider
Vacuum in the interaction zone	~10^{-3} torr – just to avoid discharges at MVD	~ $10^{-10...-11}$ torr - to avoid beam distortion by residual gas
Where high IR comes from	Dense target	Compact (in phase space) bunches
Energy	Can be lower	Should be high ($\varepsilon \sim 1/\beta\gamma$)
Beam spot	Not too wide (beam pipe), not too small – spot ~ 5-8 mm allows to find double primary vertices	The smaller the better

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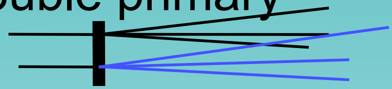

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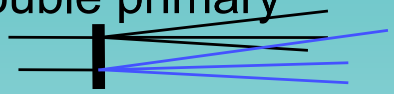
Beam spot	Not too wide (beam pipe), not too small – spot ~ 5-8 mm allows to find double primary vertices 	The smaller the better
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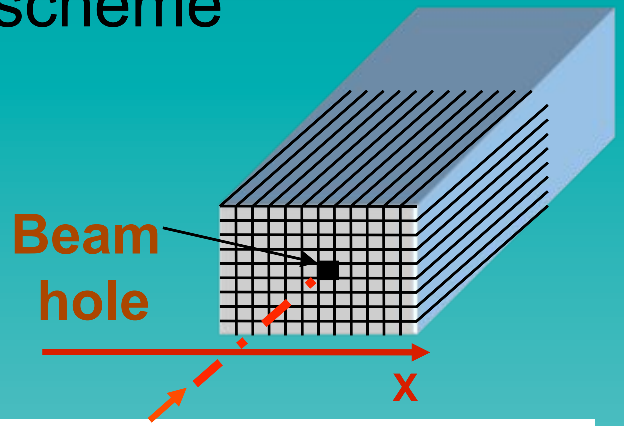
Beam after interactions	Scattered in the target – affects beampipe and PSD. Then goes to beamdump	Practically no change – kept circulating

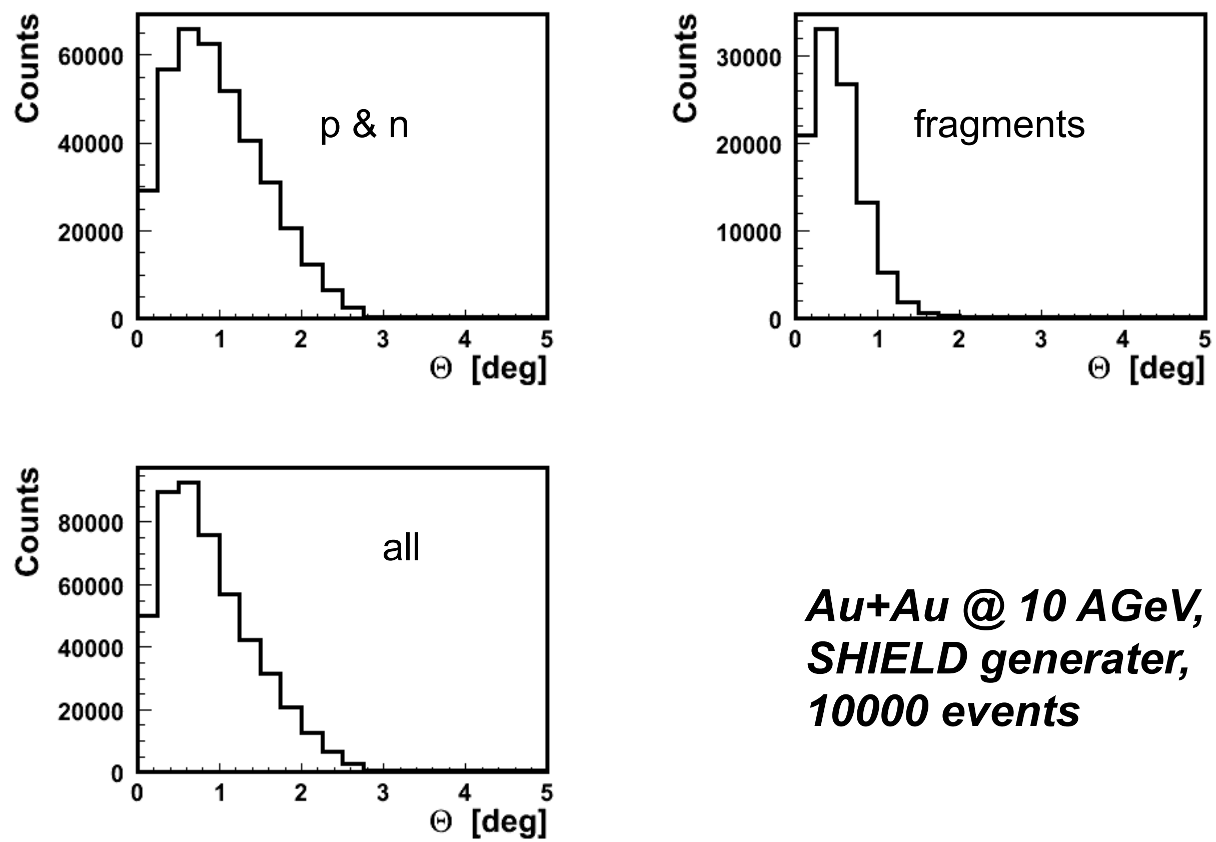
Consequences of the fixed target scheme



1. PSD: centrality, reaction plane

1% target: ~100 ions passed per event.
- Beam divergence due to emittance ~ 0.2°
- Beam hole at PSD ~ 0.3°
- Angular distribution for 10^6 gold ions scattered in the 0.25 mm thick gold target at 8 AGeV/c

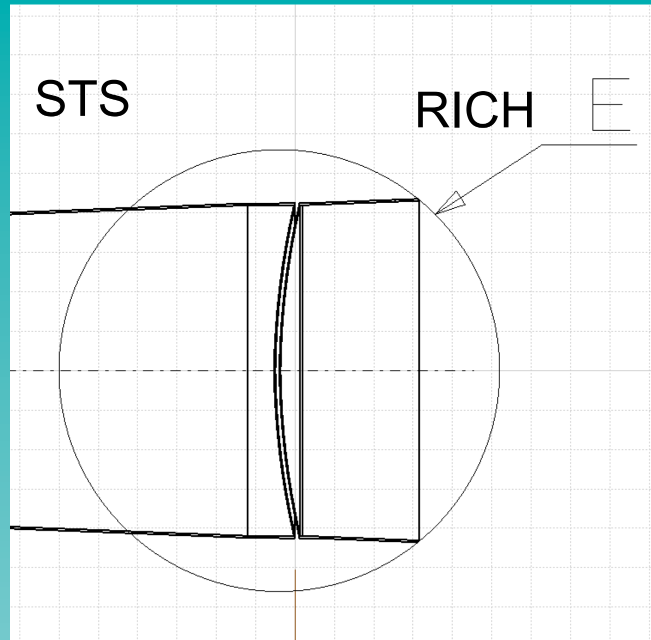
Theta > ,deg	Nevents
2,20	**10**
1,50	30
1,00	45
0,80	65
0,66	**100**
0,50	171
0,30	475
0,197	**1000**
0,10	3554

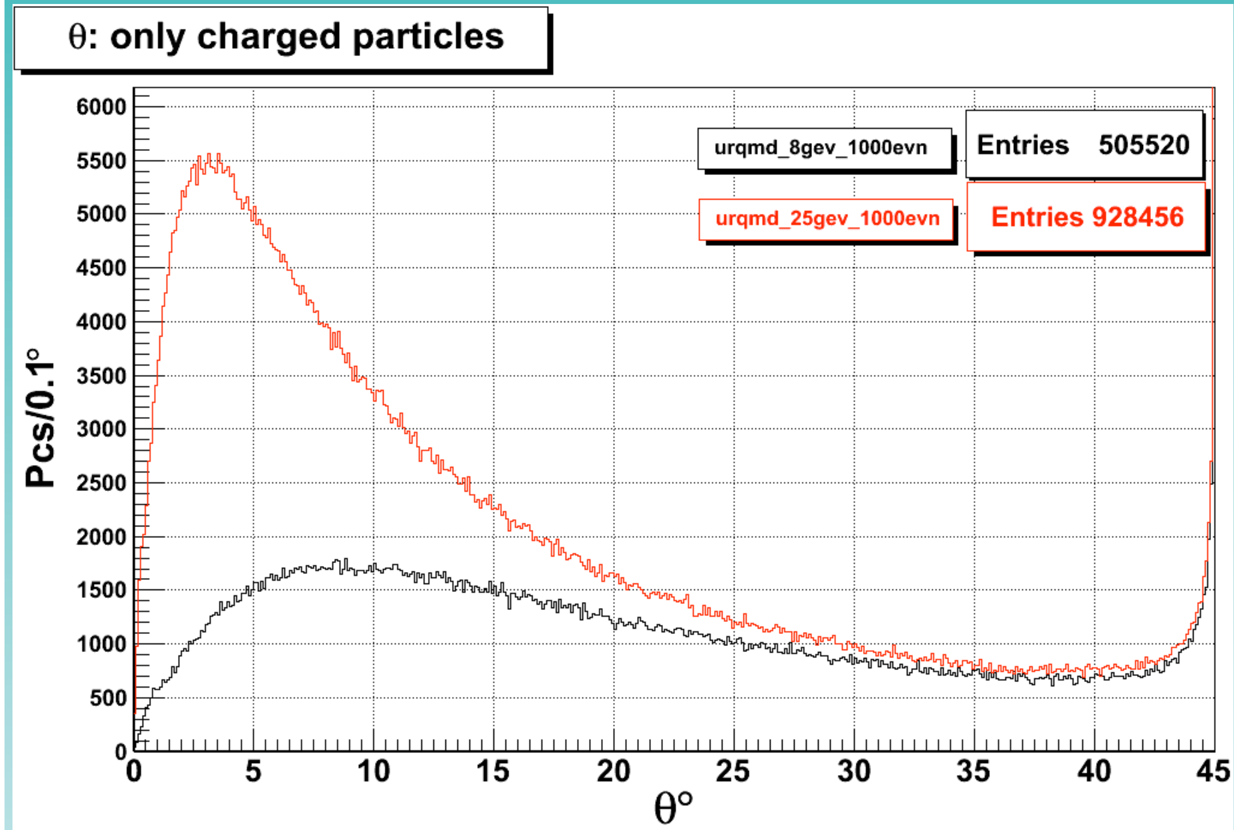


Au+Au @ 10 AGeV, SHIELD generator, 10000 events

Consequences of the fixed target scheme

2. Windows in vacuum channel can be used (much thinner than the target). It is convenient for assembling.

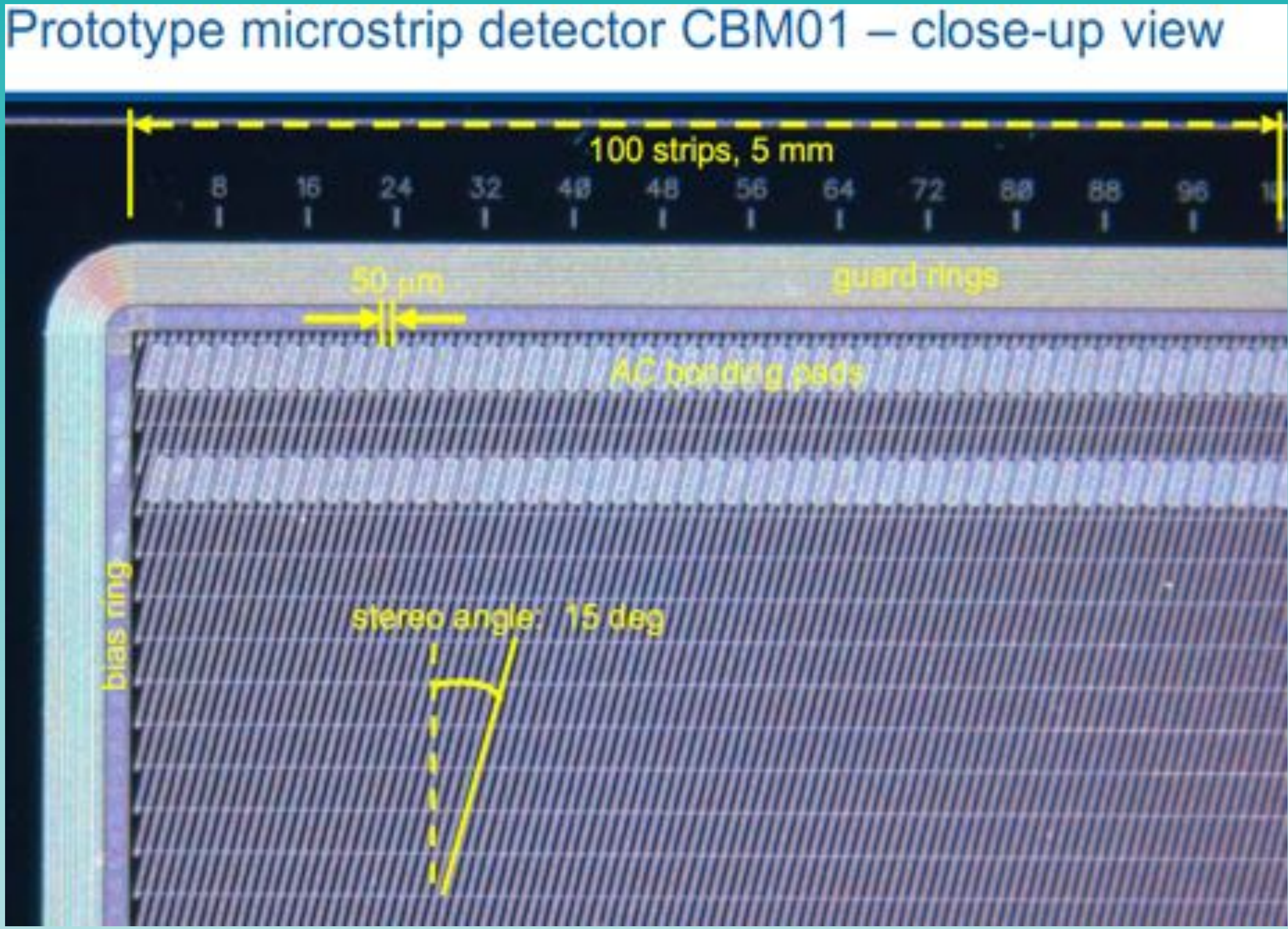




3. Angular distribution of the reaction products is narrowed by relativistic boost of CM reference frame

Closer look at Silicon Tracking System (STS)

Nature of data: hits and fakes



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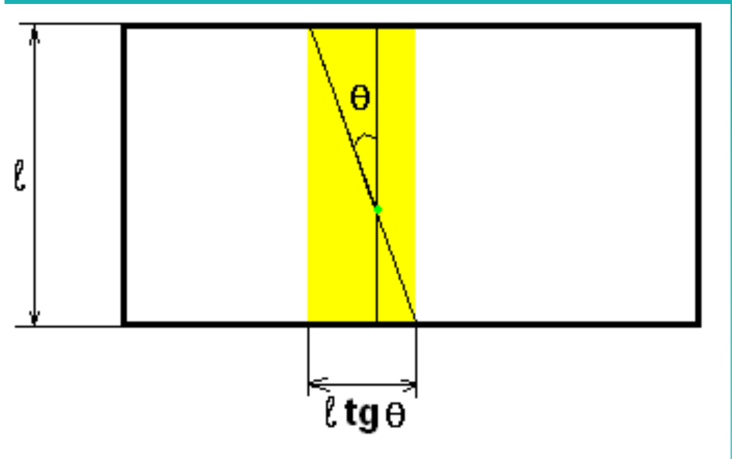
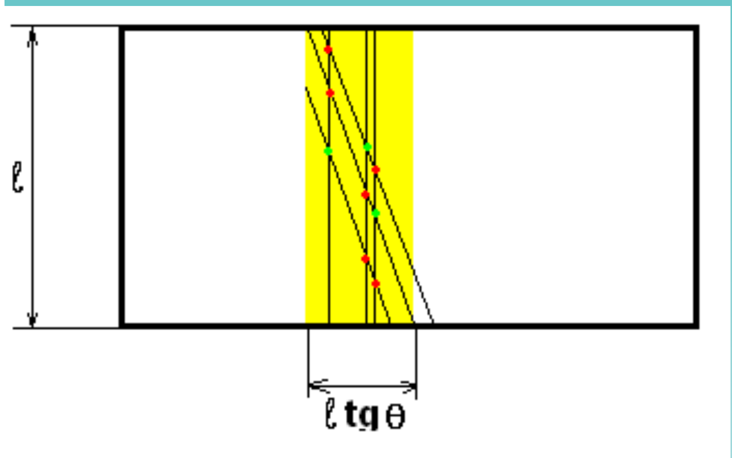




n_h, n_f – surface density of hits and fakes

$n_f \approx (n_h \cdot l^2 \cdot tg\theta)^2 / l^2 \cdot tg\theta = n_h^2 \cdot l^2 \cdot tg\theta)$

Decreasing θ one reduces fakes but spoils vertical resolution.

MF is mostly vertical → Δx converts into accuracy of momentum, Δy affects mostly attribution of the hits to the tracks and track merging.

Closer look at Silicon Tracking System (STS)

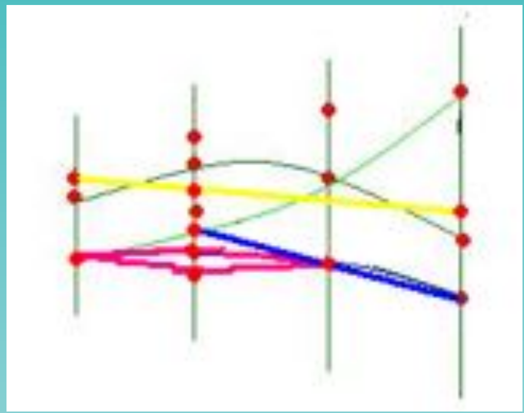
Track finding in an ideal case

TF procedure involves analysis of all possible (within reasonable margins) triplets of hits&fakes in successive 3 planes as seed candidates for tracks.

The bigger is combinatorics the longer and less efficient is procedure.

The shortest acceptable track has 4 hits in 4 successive planes.

In principle can be extended to missed hits – but number of combinations grows up.



Closer look at Silicon Tracking System (STS)

Track finding in an ideal case

cut=30keV; eLoss=70keV; MaxInvMom=0.5/0.1/0.1=Default; NO MVD;
Pipe configuration: **Be cone 2.3deg**
Au+Au, 25 AGeV/c, 1000 events central;

SIS-300

STS configuration	normal strips						short strips	
	15deg bstereo	10deg bstereo	8deg bstereo	6deg bstereo	4deg bstereo	2deg bstereo	15deg bstereo	8deg bstereo
Mean hits+fakes in stations 1,4,8	909+2524 1010+5471 837+2203	897+1668 1007+3739 839+1517	897+1354 1005+3037 838+1236	894+1032 1002+2335 836+952	885+703 998+1619 833+671	860+367 979+870 825+382	905+1382 998+3616 828+2099	892+759 990+2037 824+1162
RefPrim Eff.	0,952±0,001	0,961	0,964	0,966	0,934	0,913	0,965	0,975
RefSec Eff.	0,796±0,005	0,820	0,832	0,842	0,81	0,793	0,828	0,863
ExtraSec Eff.	0,496±0,009	0,540	0,56	0,581	0,57	0,565	0,497	0,573
Clone Prob.	0,019±0,001	0,019	0,021	0,02	0,065	0,028	0,017	0,019
Ghost Prob.	0,101±0,003	0,087	0,083	0,083	0,149	0,178	0,078	0,065
MC tr/ev found	634±1	643	647	649	628	605	631	647
TF time s/ev	2,931	1,496	1,122	0,792	0,698	0,481	2,605	1,016

cut Ref>1GeV/c, Extra<1GeV/c;
Pipe configuration: **Be cone 2.3deg**
Au+Au, 8 AGeV/c, 1000 events central;

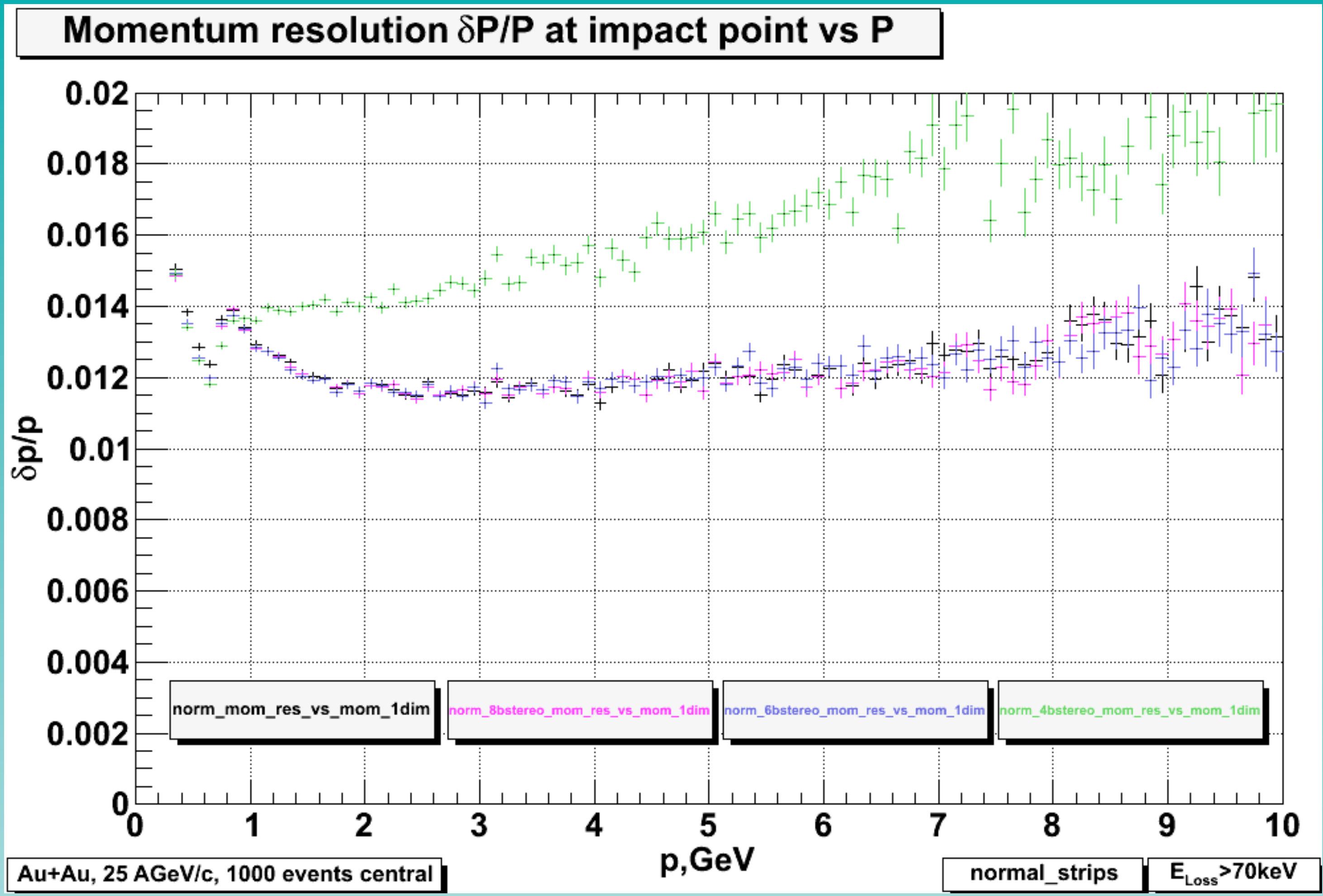
SIS-100

STS configuration	normal strips						short strips	
	15deg bstereo	10deg bstereo	8deg bstereo	6deg bstereo	4deg bstereo	2deg bstereo	15deg bstereo	8deg bstereo
Mean hits+fakes in stations 1,4,8	451+495 477+1420 381+542	449+348 474+976 379+375	449+289 473+804 378+312	447+230 472+629 377+249	444+168 470+451 376+184	433+102 463+262 373+117	449+332 467+1085 378+569	442+200 463+628 376+330
RefPrim Eff.	0,982	0,985	0,986	0,986	0,975	0,971	0,983	0,987
RefSec Eff.	0,928	0,936	0,936	0,939	0,929	0,921	0,934	0,938
ExtraSec Eff.	0,644	0,666	0,673	0,684	0,678	0,671	0,644	0,676
Clone Prob.	0,019	0,018	0,019	0,02	0,075	0,034	0,019	0,019
Ghost Prob.	0,035	0,031	0,031	0,029	0,044	0,042	0,034	0,03
MC tr/ev found	332	334	334	334	329	322	330	330
TF time s/ev	0,143	0,089	0,071	0,057	0,053	0,040	0,159	0,075

Ref>1GeV/c, Extra<1GeV/c;

Closer look at Silicon Tracking System (STS)

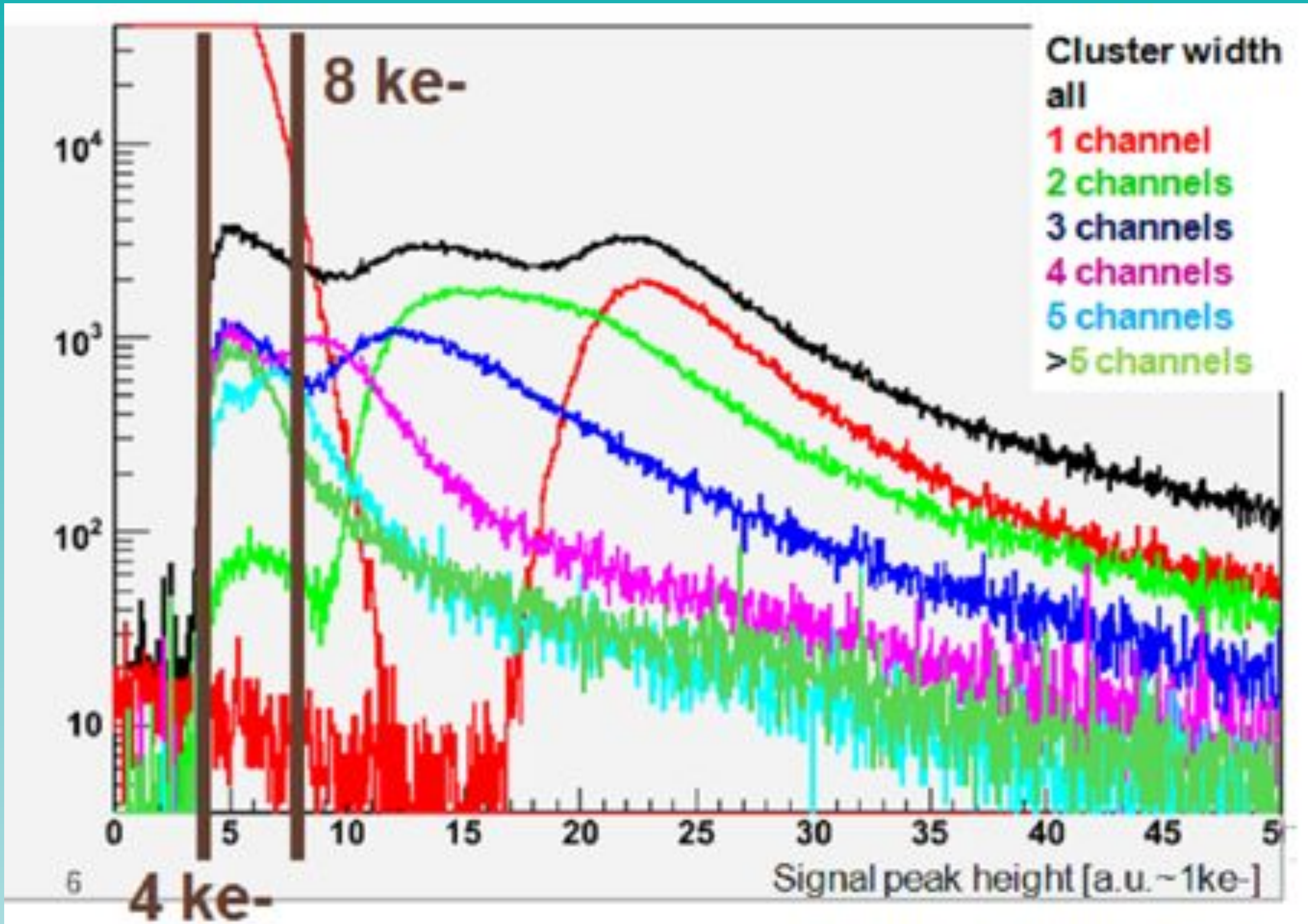
Track finding in an ideal case



Under certain conditions TF loses its ability to cope with data.

Closer look at Silicon Tracking System (STS)

Influence of realistic readout



Hit lost due to threshold and individual channel dead time forces us to keep fakes well under control for enabling "missed hit" operation

Closer look at Silicon Tracking System (STS)

What does layout optimization imply

What should be weighed for selection of the strip length.

Shorter strips:

Pro

- Processing time and efficiency

- Ability to deal with missed hits inevitable with noises and dead time

Contra

- Price
- Power consumption
- Material budget, especially at big angles (momentum resolution, deltas)

It is absolutely necessary to have prototype measurements of noises and pickups before finalizing the layout. Conditions at SIS100 and SIS300 are different, hence two different layouts are optimal.

Closer look at Silicon Tracking System (STS)

An amusing piece of system engineering

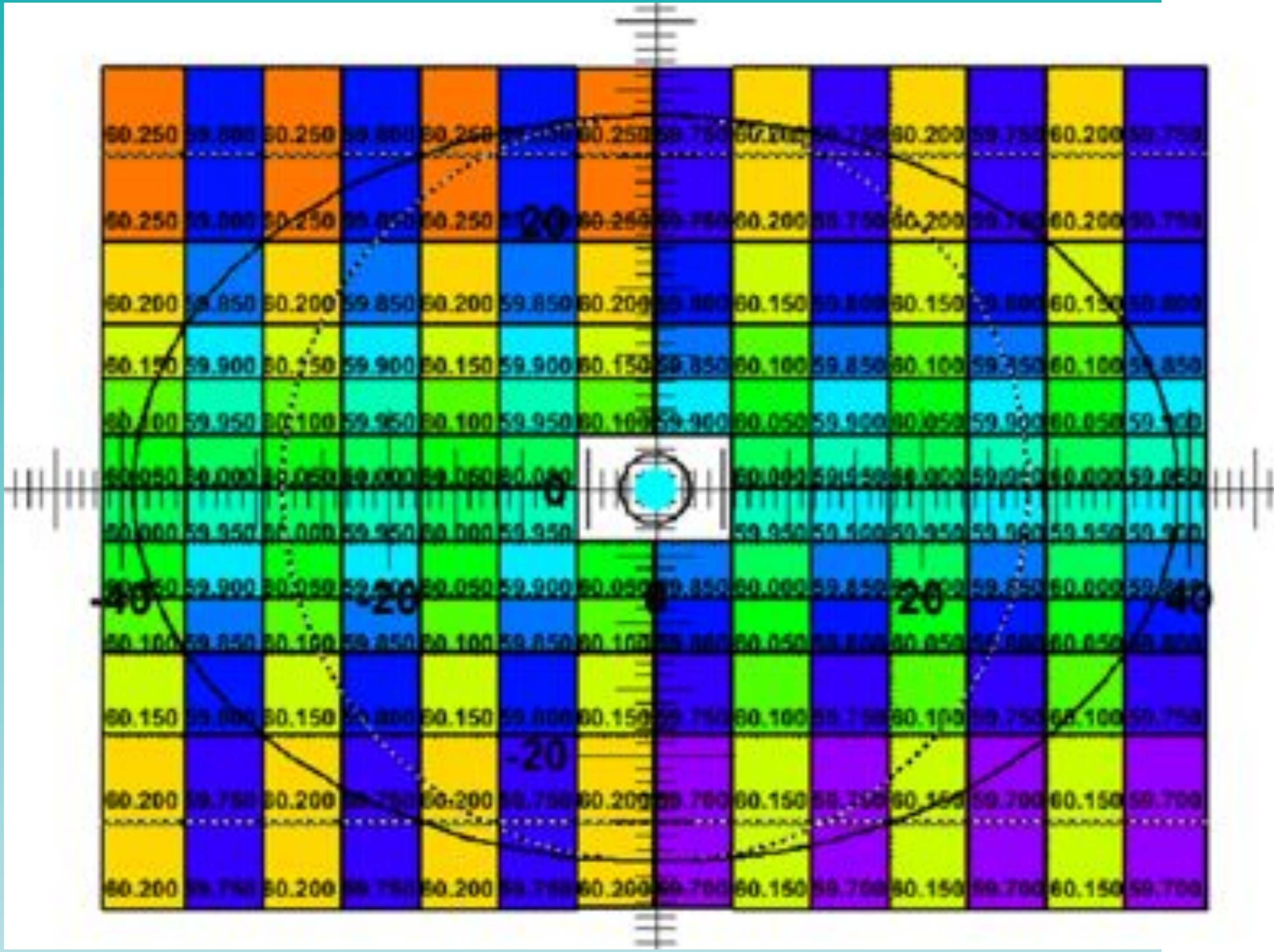
What is a spare module to keep in stock?

We should not have too many types of spare part.

Spare module is a ladder.

This way of thinking leads to such stations:→

But, Another thinking of a “module” leads to another result…



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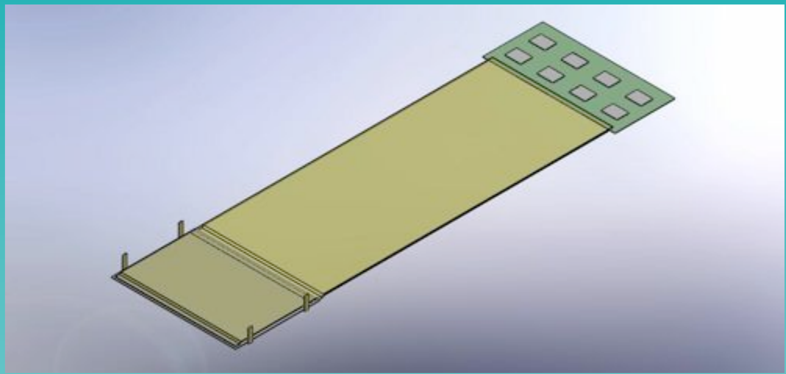
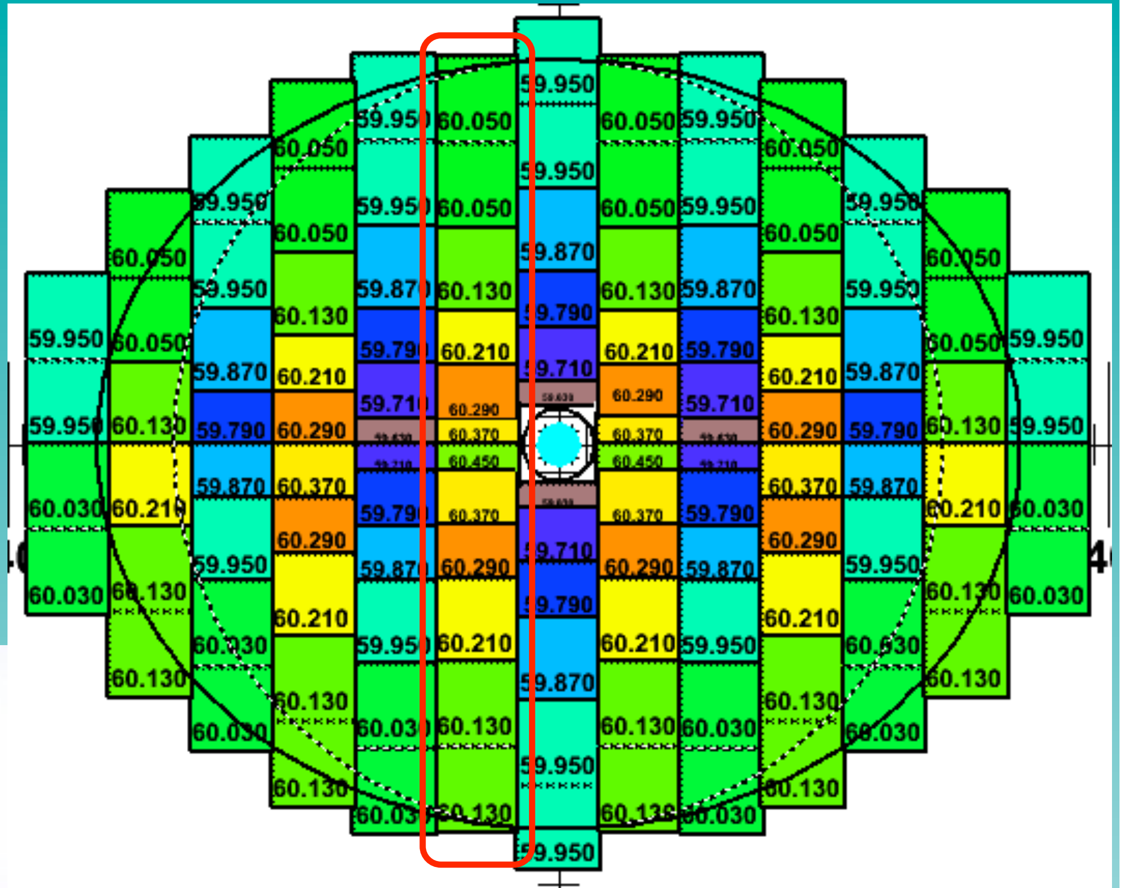


A module is (sector + cable + FEB)

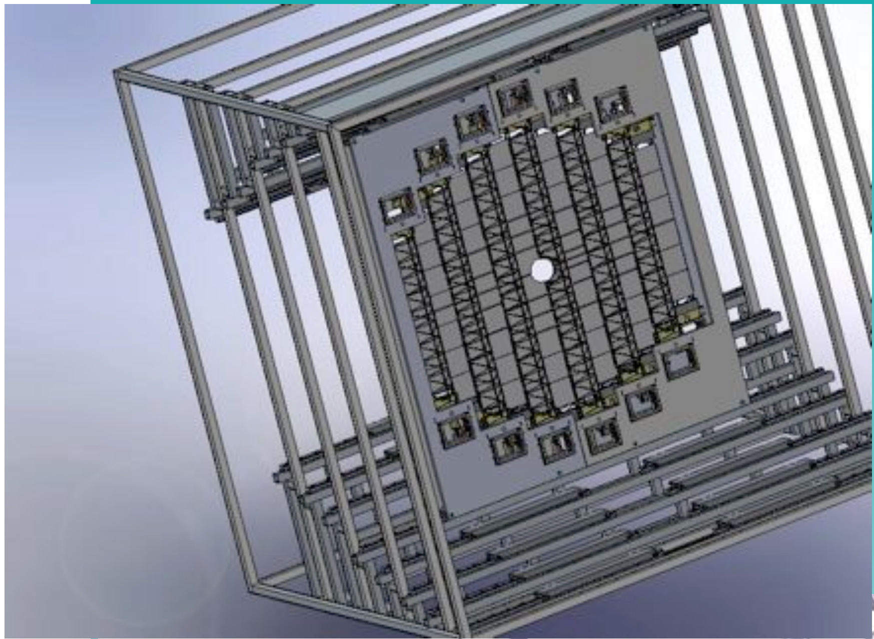


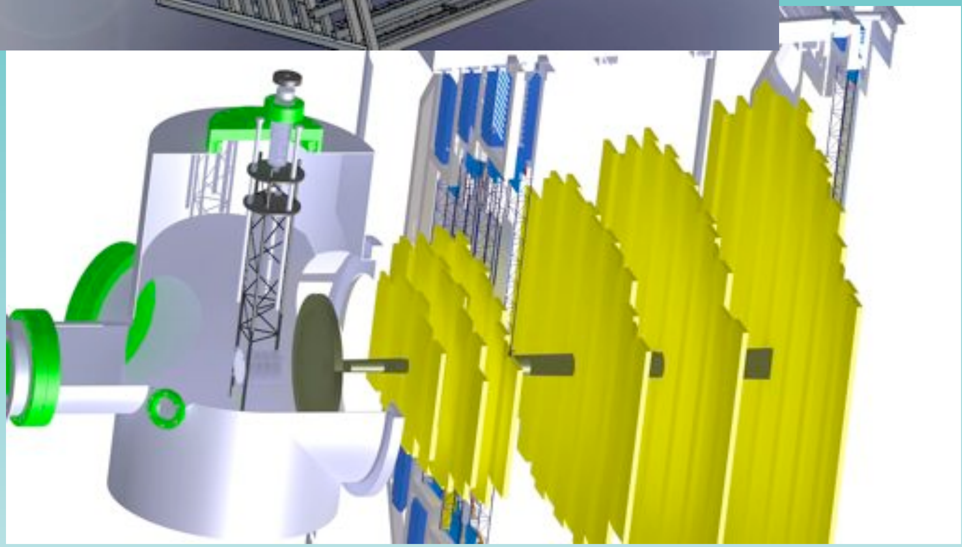
A concept of "Basic Ladder" – maximum set of modules for a ladder of given station.

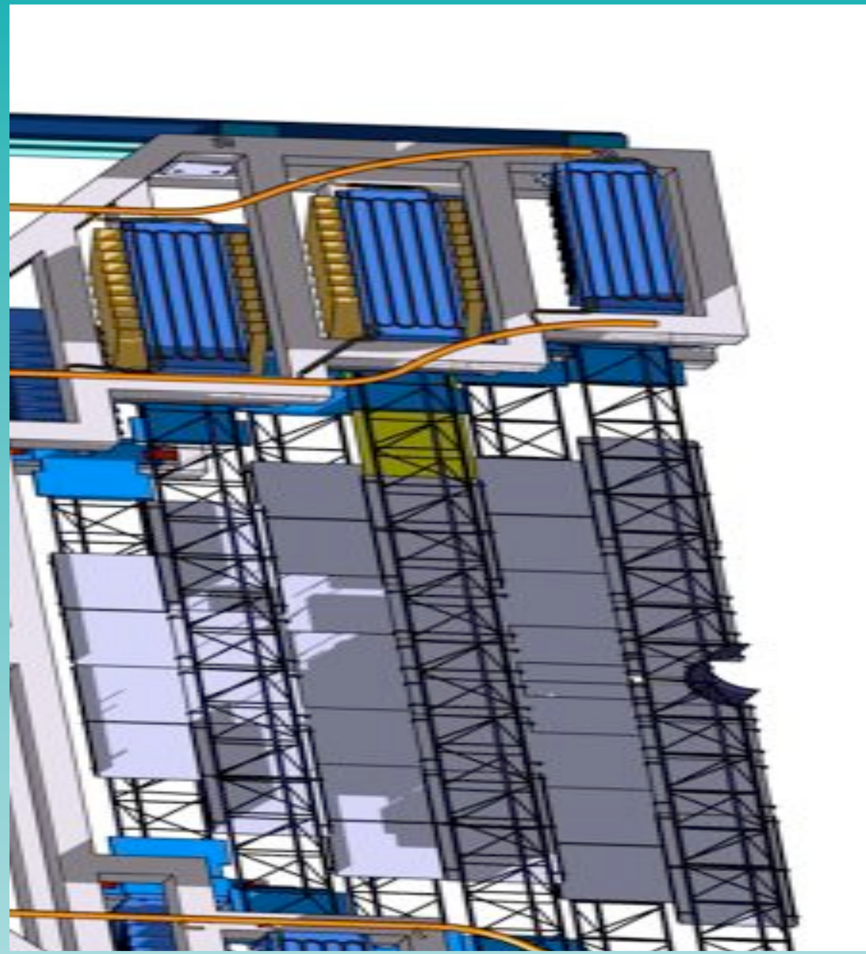
Assembling jigs allow to compose a ladder in a time comparable to the STS opening

Closer look at Silicon Tracking System (STS)

Conceptual model of STS





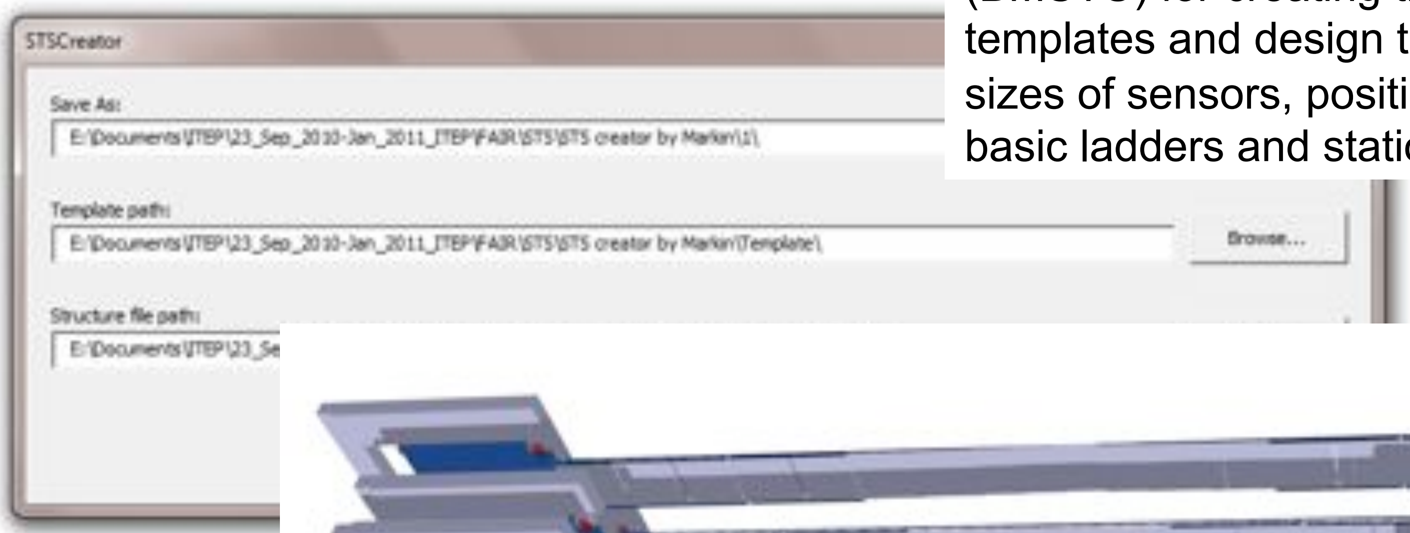


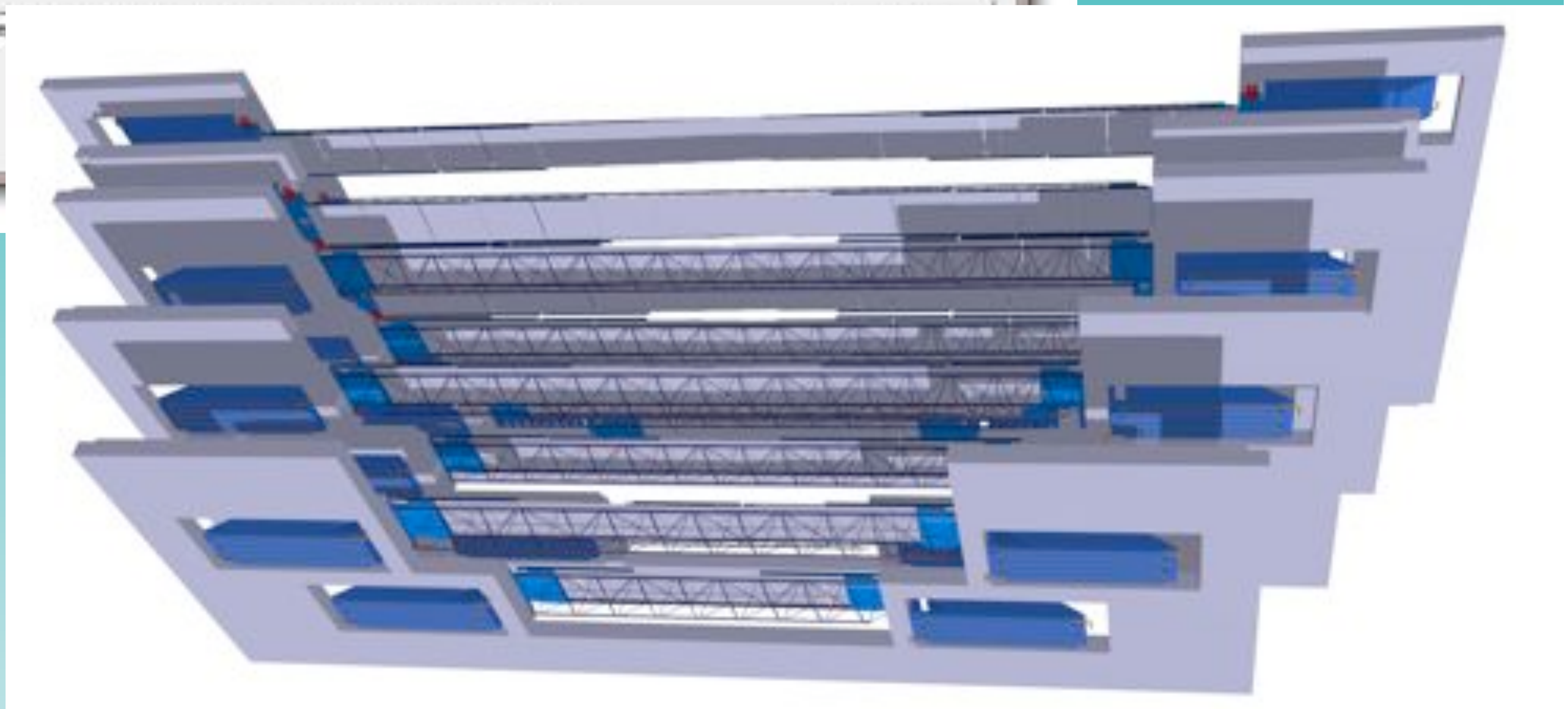
Conceptual model of spring 2009 and more technical of Nov. 2010 – both only 4-th station detailed.

Closer look at Silicon Tracking System (STS)

Conceptual model of STS

A CATIA macro was written by A. Markin, (BMSTU) for creating the STS model from templates and design table containing detailed sizes of sensors, position and composition of basic ladders and stations





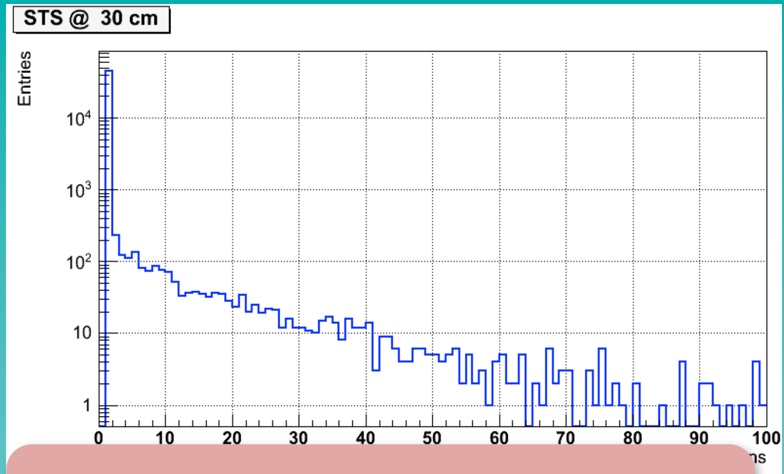
Conclusions

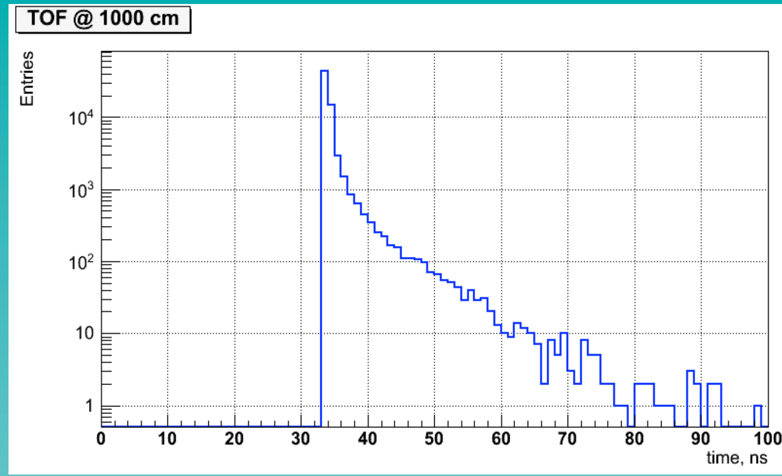
-CBM is planned at the edge, where design solutions are highly perceived by physical performance

-Well thought out staged upgrade strategy may help to get a good result with realistic funds

Data from presentations of CBM colleagues: A. Chernogorov, F. Guber, J. Heuser, S. Igolkin, A. Kotynia, P. Senger are used here.

The Problem (V. Friese at CHEP10)

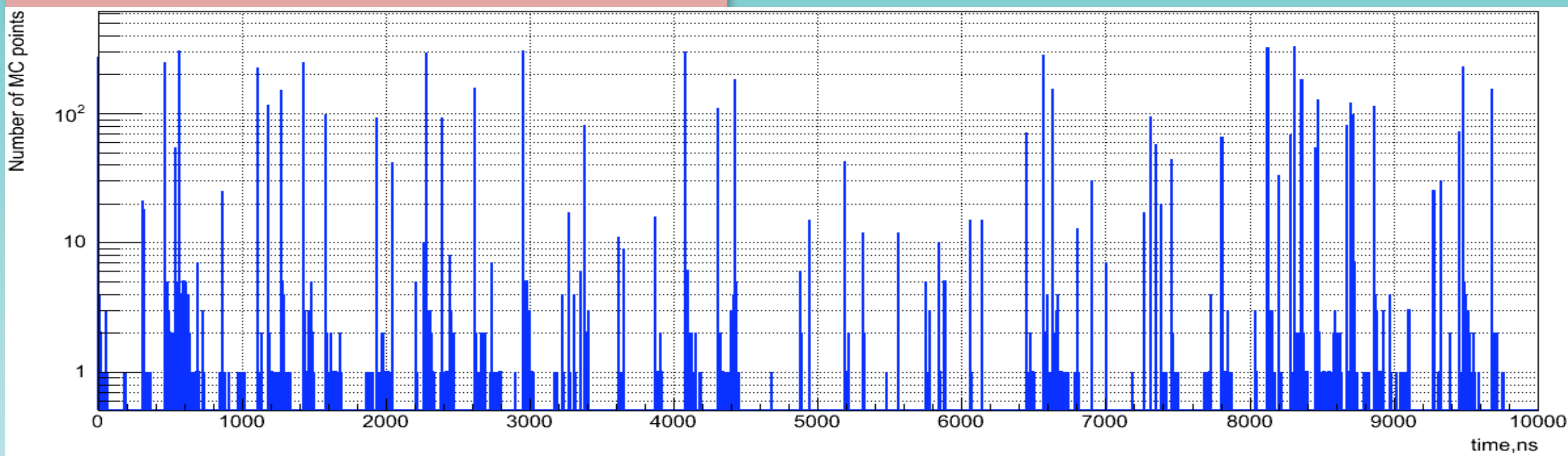


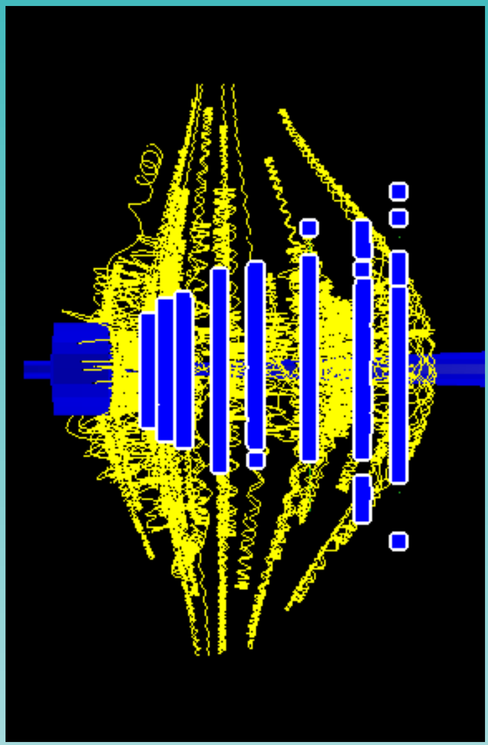


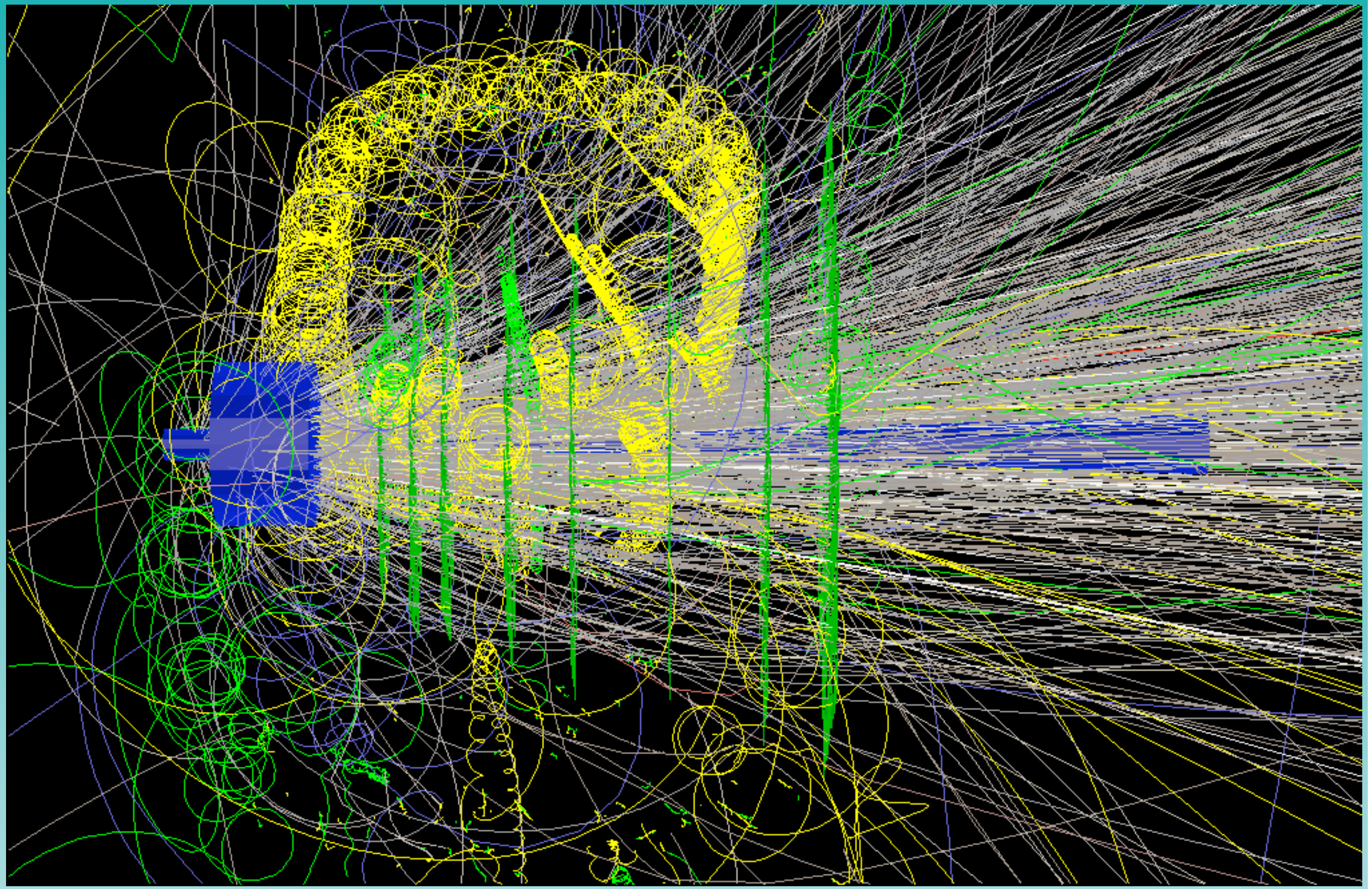
MC hit time, relative to event start

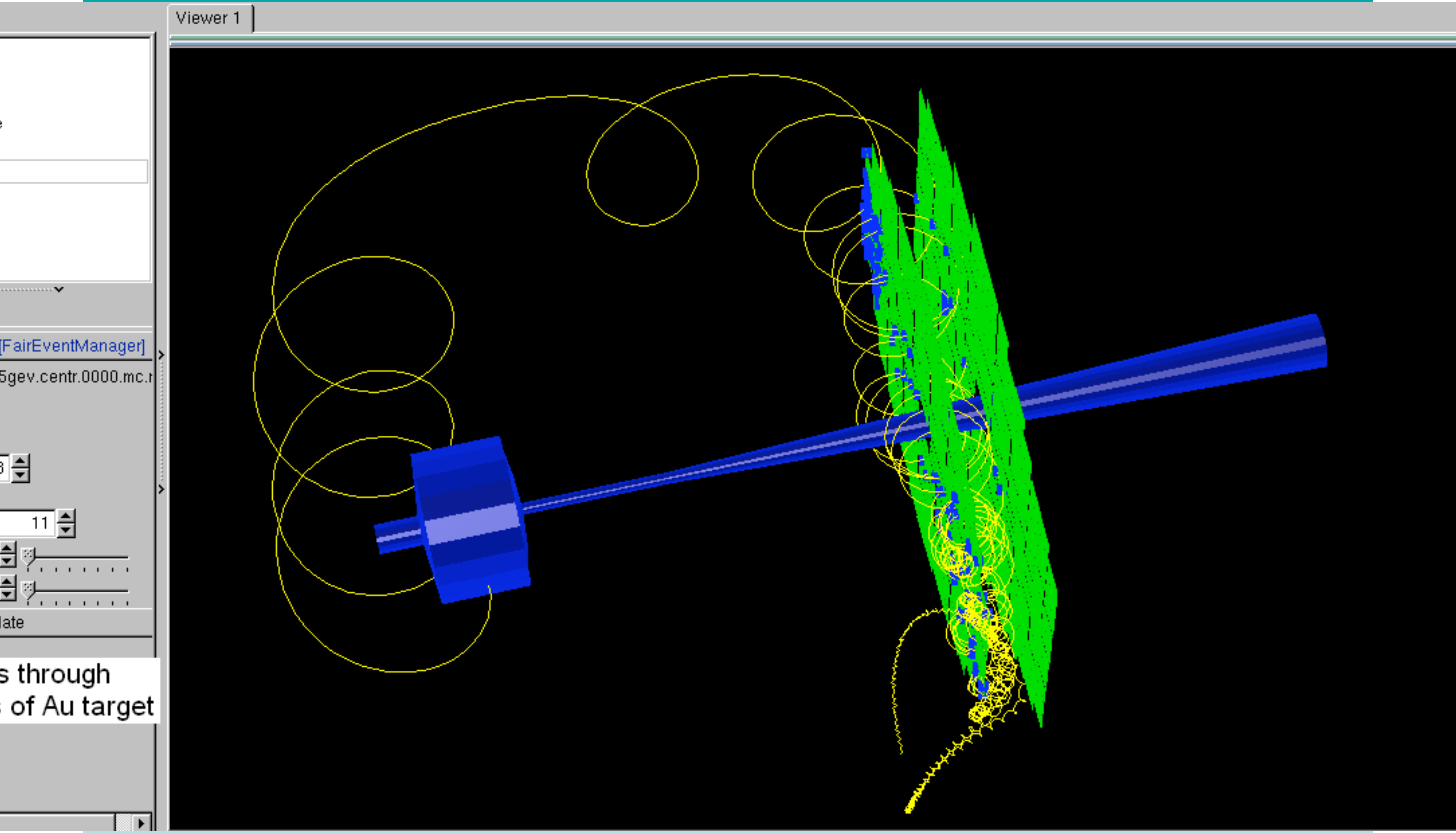
white beam, 10^7 events/s

MC hit absolute time (STS only)





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