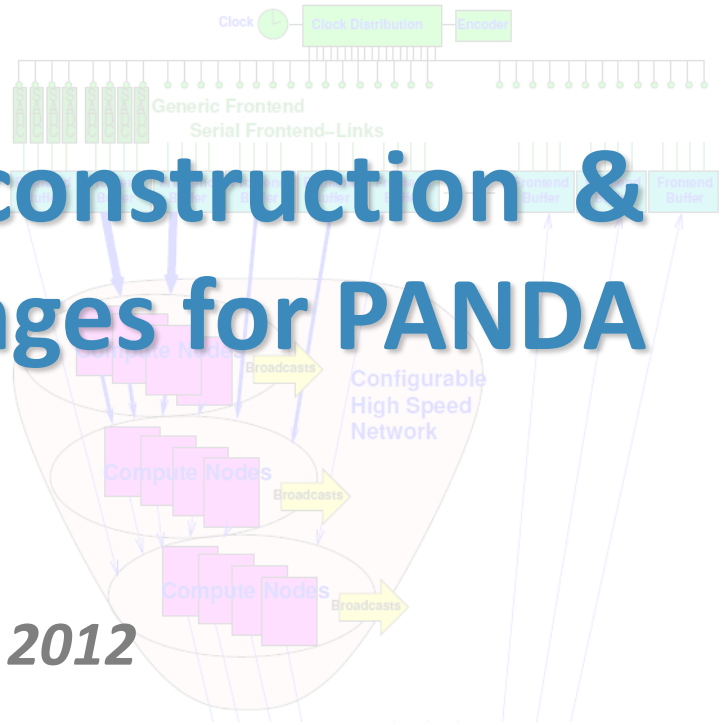
Event Timing, Reconstruction & Selection Challenges for PANDA



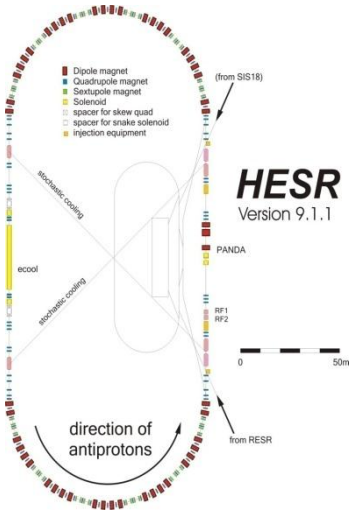
FAIR Event Reconstruction Workshop 2012

GSI, October 29, 2012

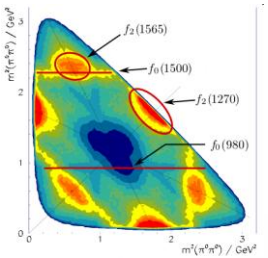
Klaus Götzen
GSI Darmstadt

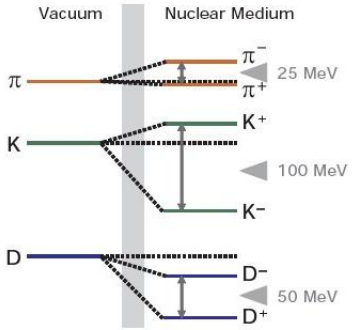
The PANDA Experiment

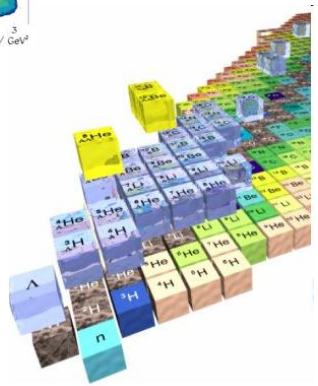
- Experiment characteristics
  - $\bar{p}p$ / $\bar{p}A$ Collisions
  - Momentum range p = 1.5 - 15 GeV/c
  - Luminosity up to $L = 2 \cdot 10^{32}\ cm^{-2}\ s^{-1}$



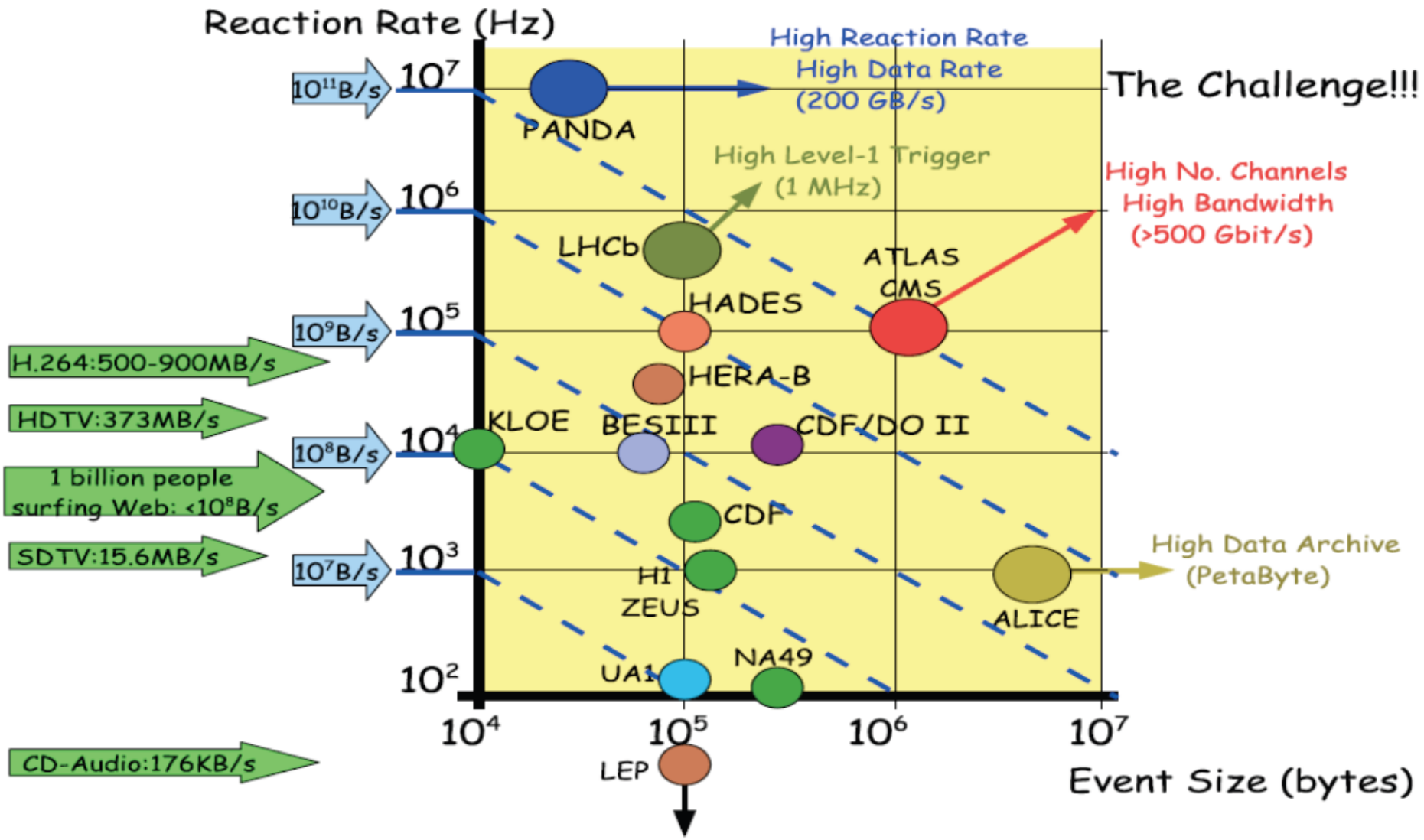
- Physics Program
  - Charmonium/Open Charm Physics
  - Exotic Matter
  - Hadrons in Media
  - Nucleon-Structur
  - Hypernuclear Physics



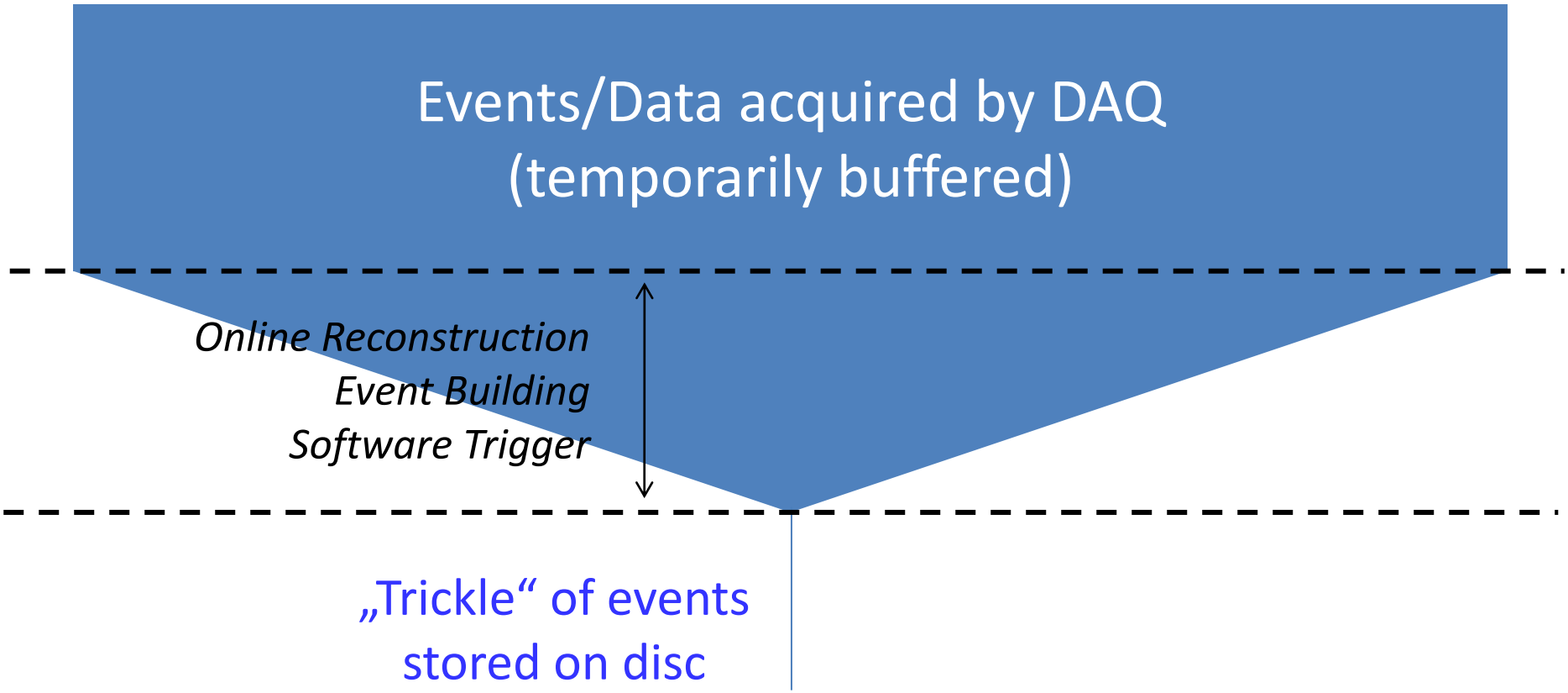




Data Rates & Event Sizes



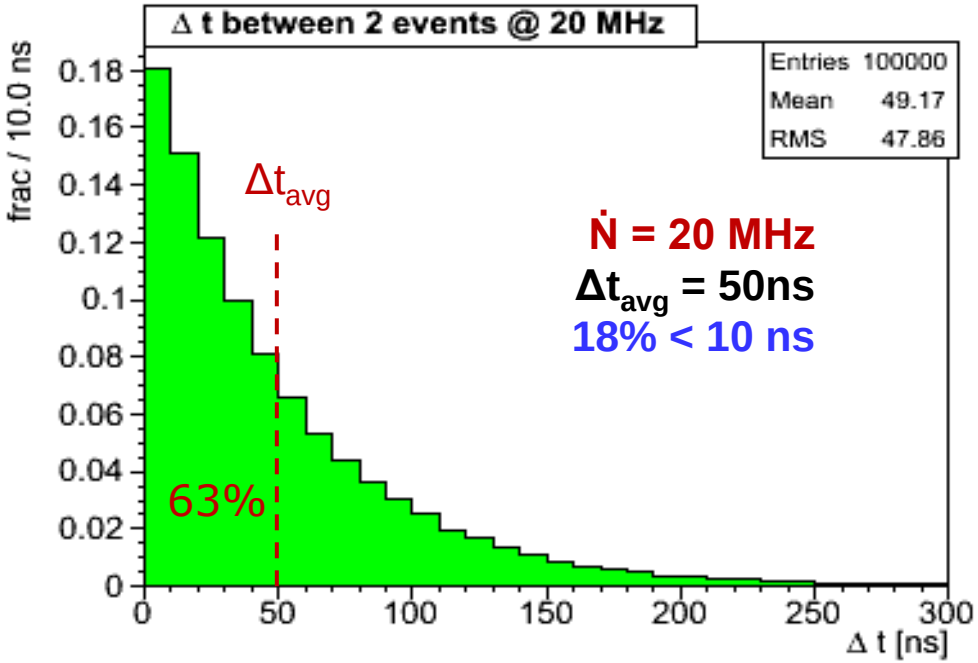
Data Reduction Requirement



- Required reduction factor: ≈1/1000
- A lot of physics channel triggers → even higher reduction factor required
- Difficulty: Interesting events look very similar to uninteresting ones!

Event Rates @ PANDA

- *How much time do we have for decision keep/reject?*
- PANDA high luminosity mode: $\dot{N}_{avg}$ = 20 MHz
- Time structure target and beam → $\dot{N}_{peak}$ = 30 ... 50 MHz

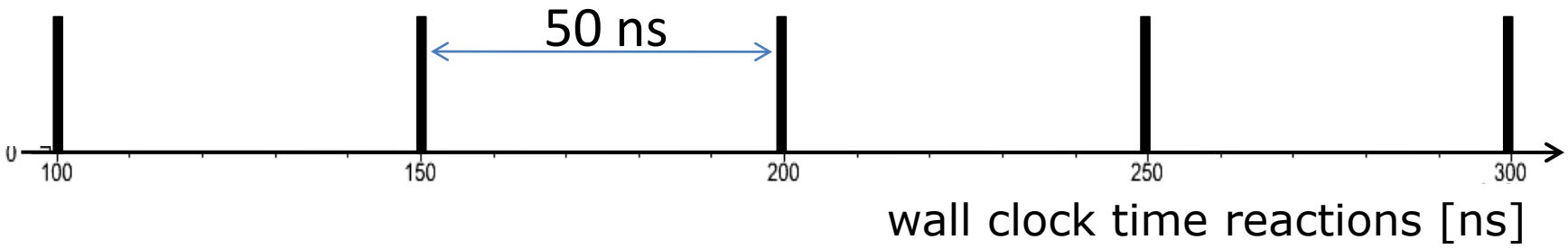


Rate [Mhz]	Δt_{avg} [ns]	frac. < 10 ns
10	100	9%
20	50	18%
50	20	39%

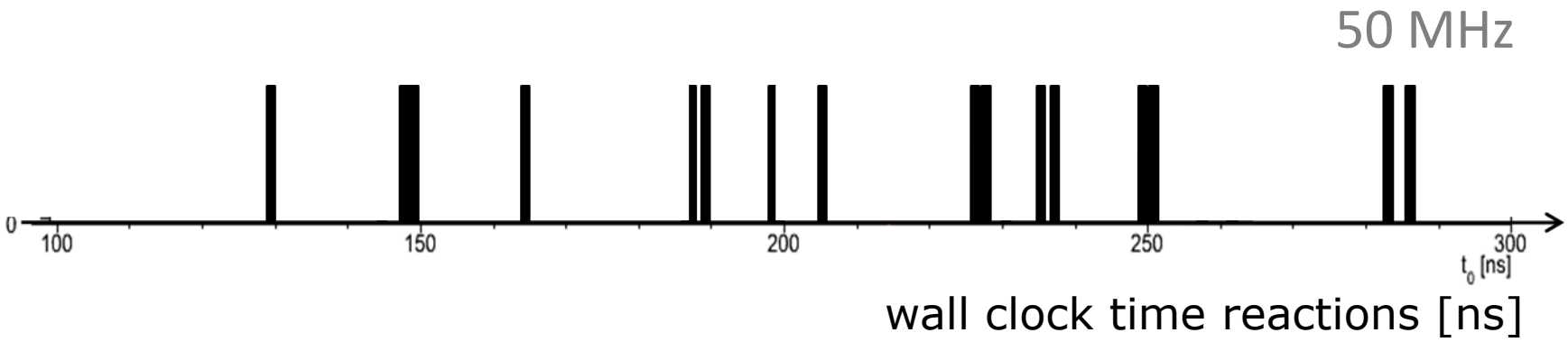
⇒ Most of events have **small time difference**!

What average rate of 20MHz means...

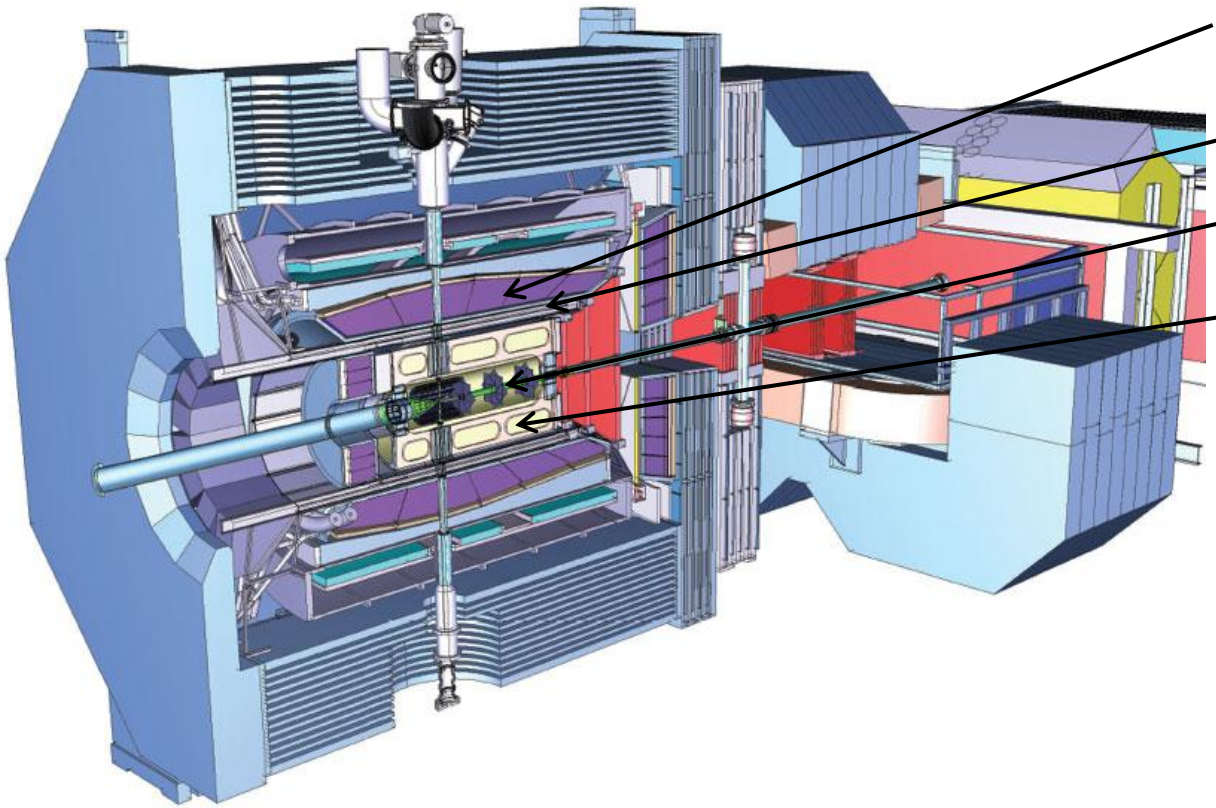
20 MHz average rate does NOT mean



but rather means sometimes



The PANDA Detector

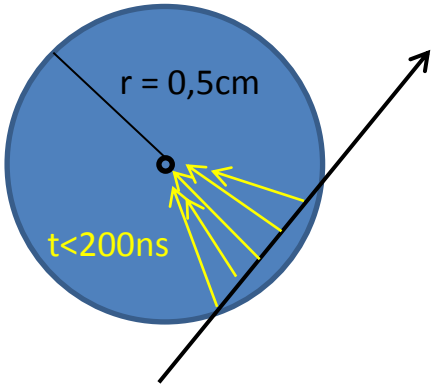


Electro-**M**agnetic **C**alorimeter

Scintilating **Til**es

Micro **V**ertex **D**etector

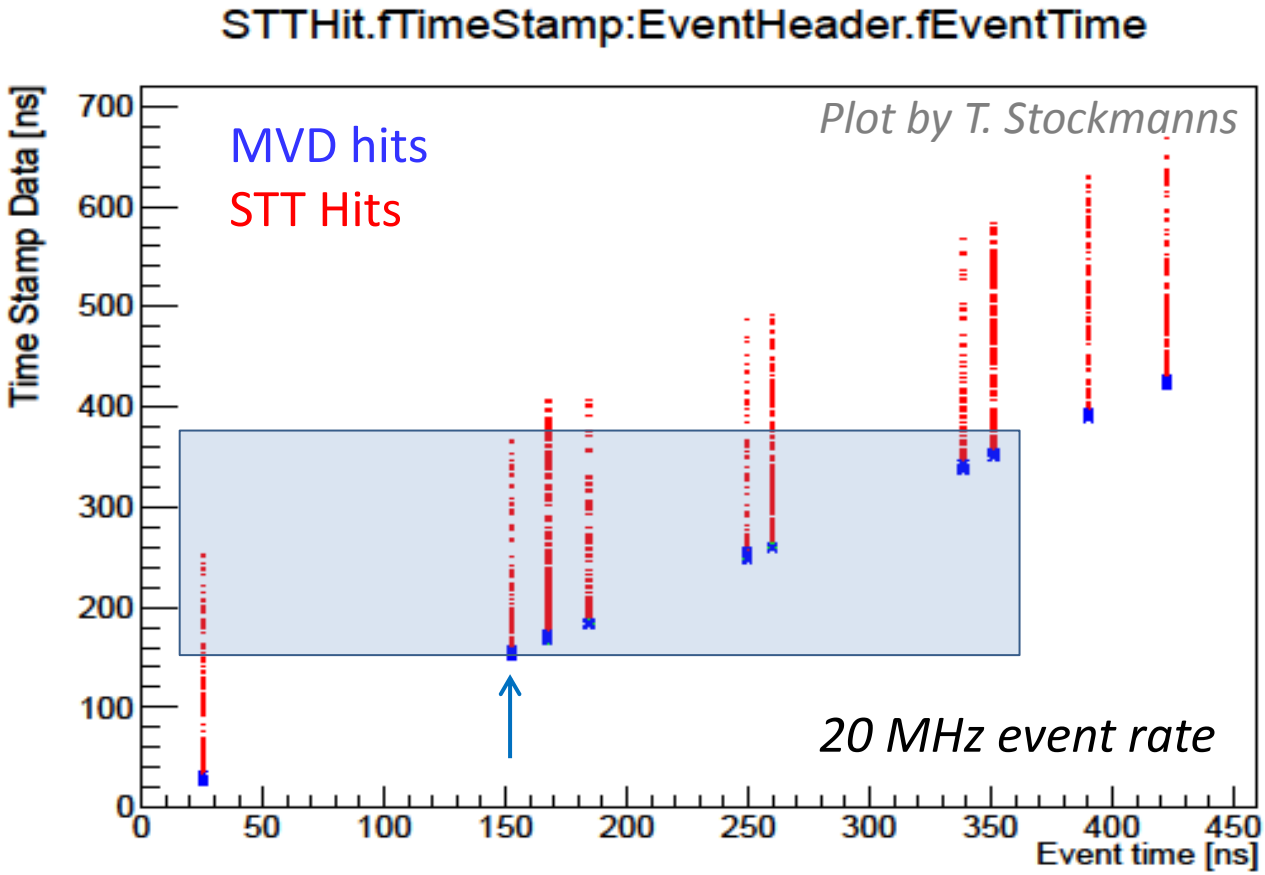
Straw **T**ube **T**racker



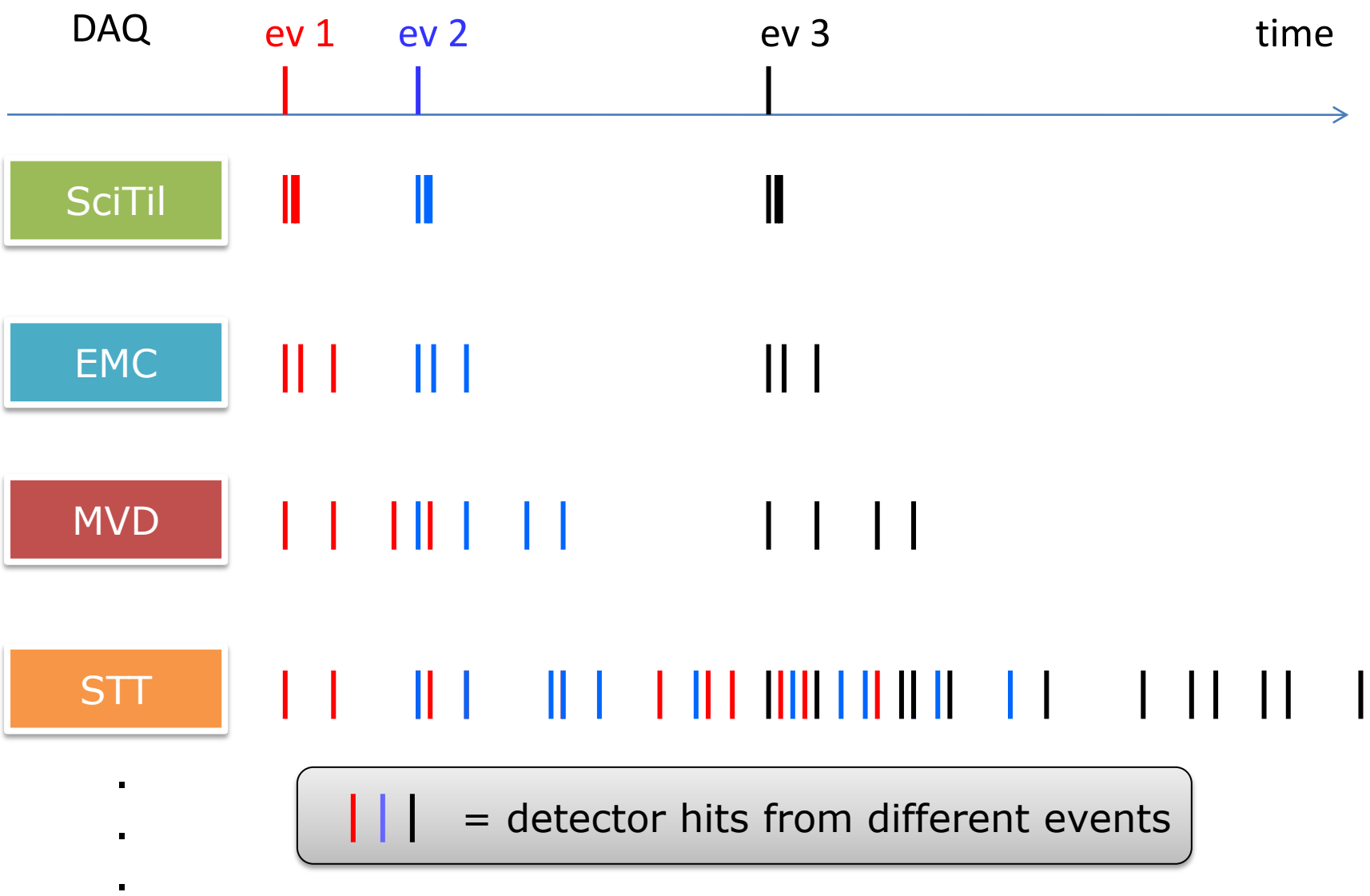
- Gas ionization based central tracker → drift times up to **200 ns**
- High rates → small time differences **(often <10-20ns)** between events
- High event overlap on hit level

Reco & Event Building Challenge

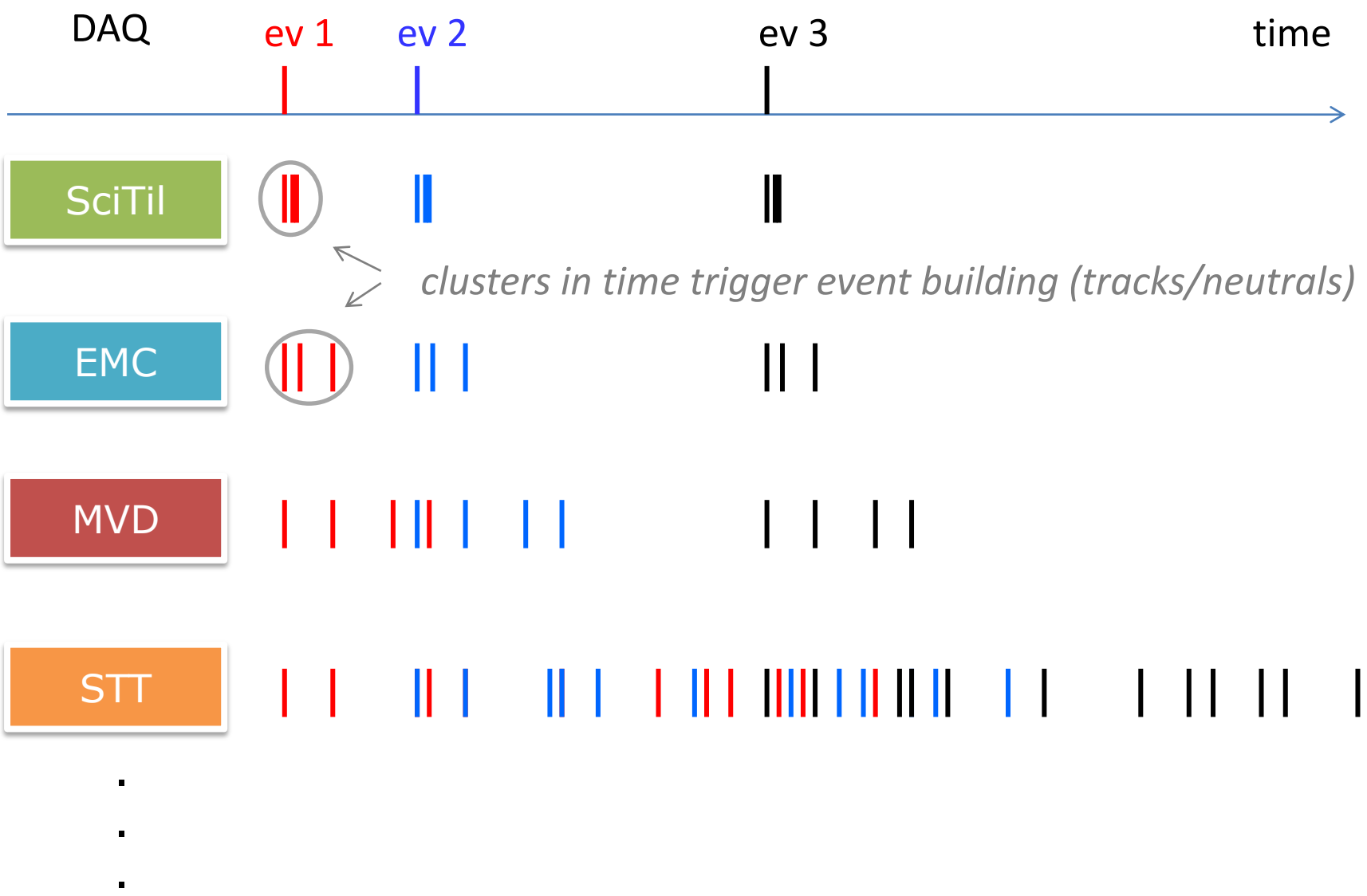
- Time ordered simulation (available within FairROOT)
- Strong overlap in time of hits from sequent events
- Need robust/fast reco to get disentangled by event building



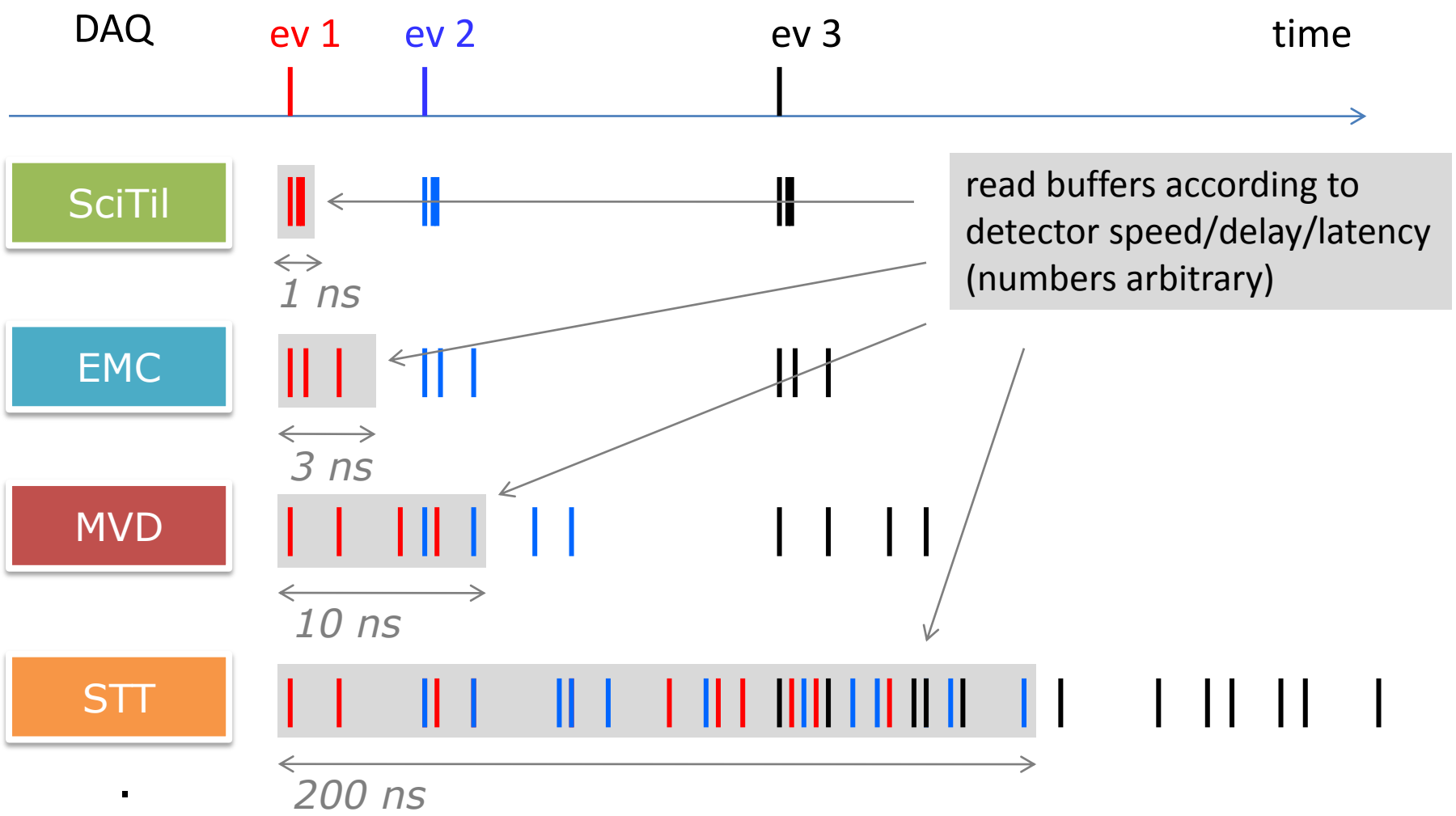
Online Reco + Event Building Schematic



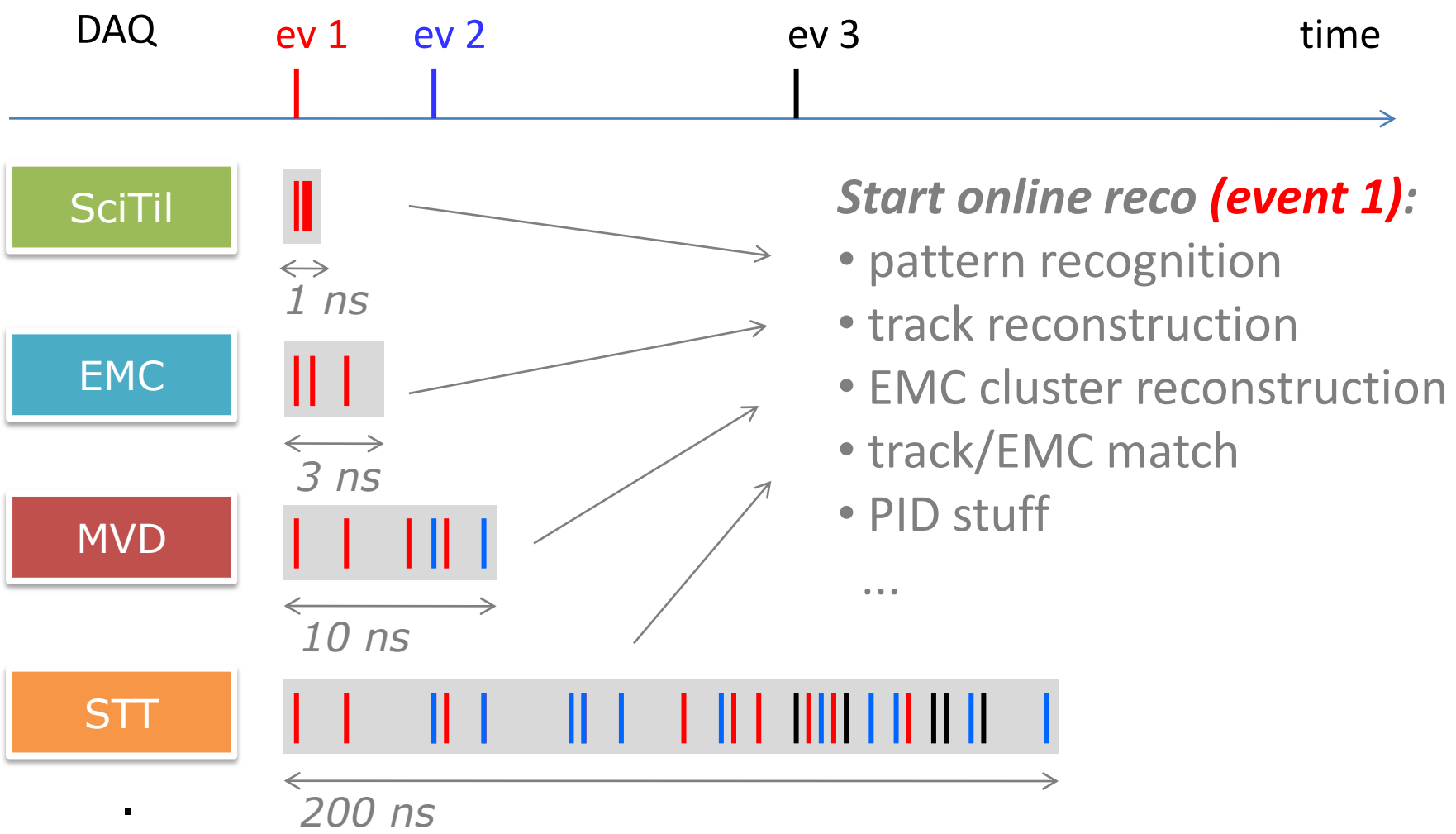
Online Reco + Event Building Schematic



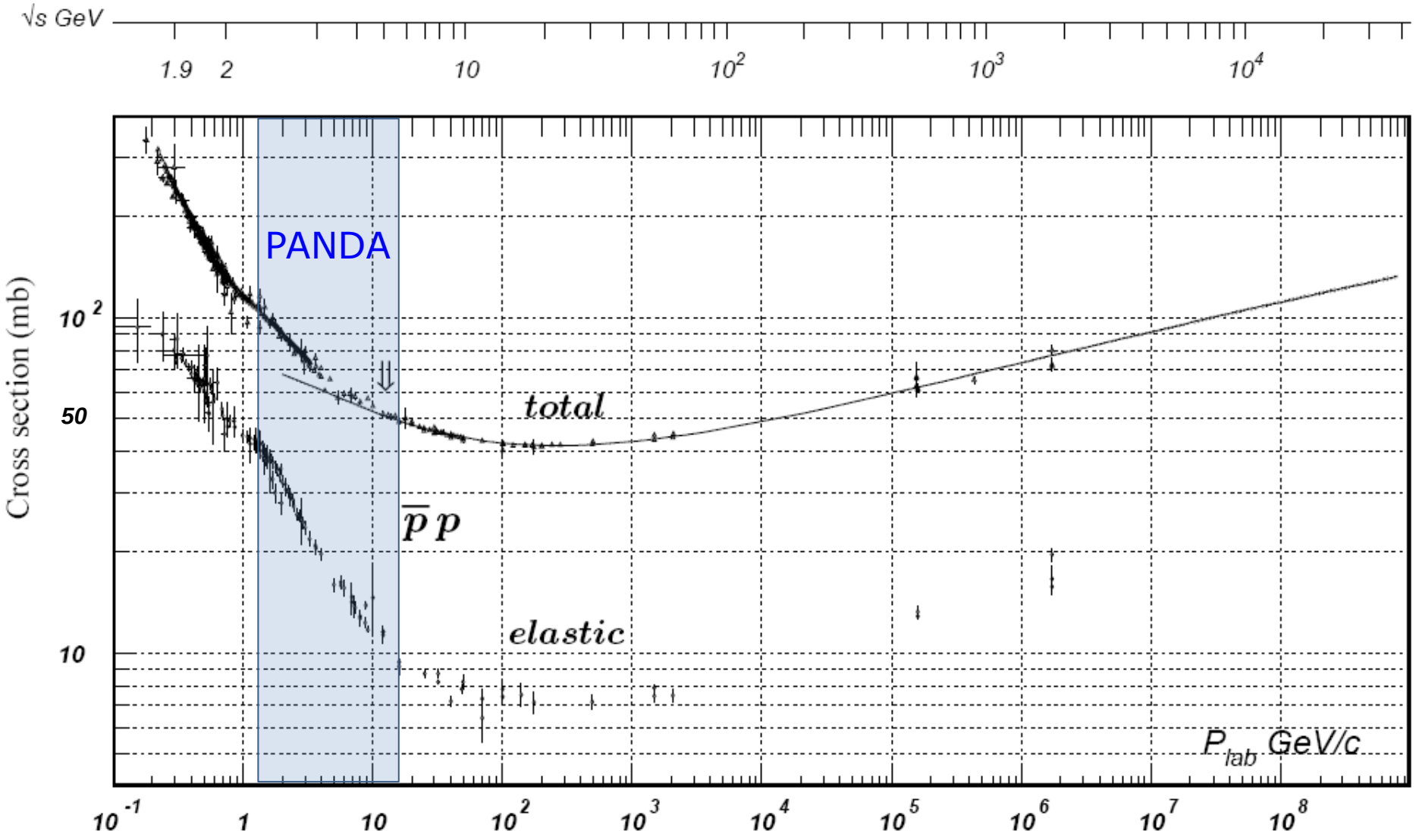
Online Reco + Event Building Schematic



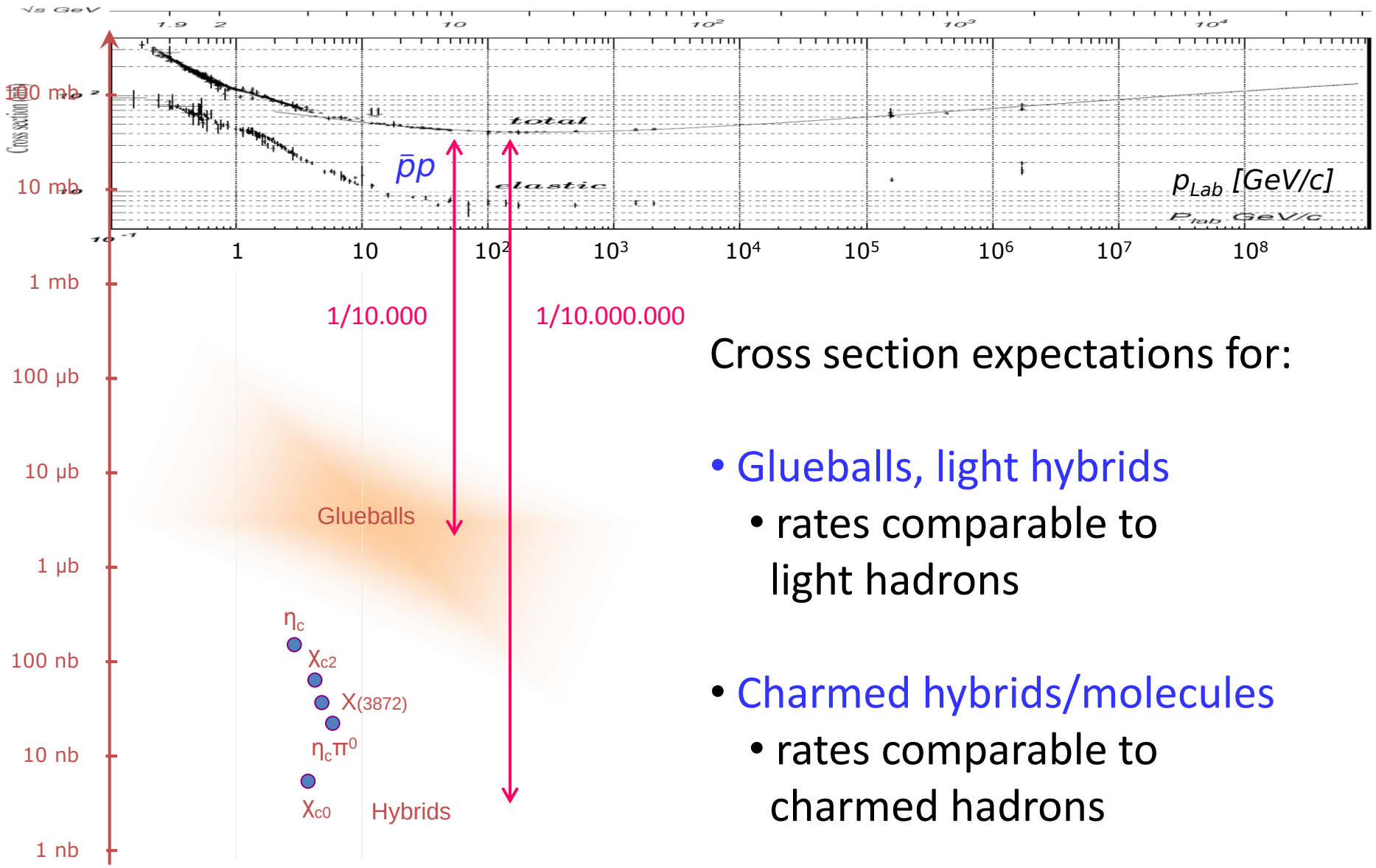
Online Reco + Event Building Schematic



$\bar{p}p$ Production Cross Sections



$\bar{p}p$ Production Cross Sections



Cross section expectations for:

- Glueballs, light hybrids
  - rates comparable to light hadrons
- Charmed hybrids/molecules
  - rates comparable to charmed hadrons

Physics Report Selection Strategies *(offline)*

- Rich physics program (more than 20 channels in report)
- Signal and background events look quite similar
- Selection criteria used
  - Exclusive reconstruction (4 constraint criterion!)
  - Particle Identification
  - Invariant masses & other kinematic requirements
  - Kinematic/Vertex fitting
- Signal/Background separation requires for online computing
  - Track reconstruction (good momentum resolution!)
  - EMC cluster reconstruction
  - Track – PID – matching
  - Event separation

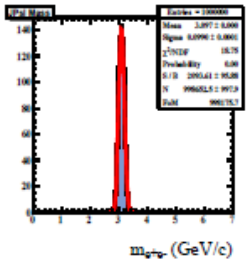
Example: $\bar{p}p \rightarrow J/\psi\ (e^+ e^-)\ \pi^+ \pi^-$ *(online scenario)*

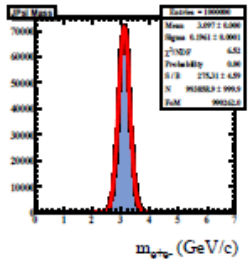
Dependence of J/ψ mass distribution on track momentum resolution

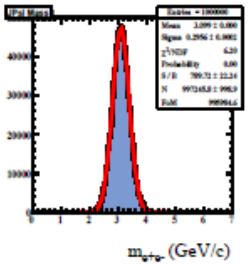
$\sqrt{s} = 3.526$ GeV

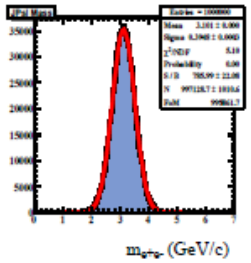
Signal (incl. *J/ψ*)

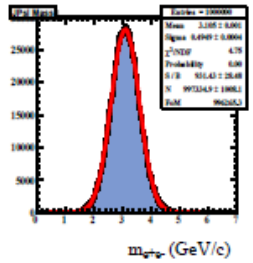
$\frac{\Delta p}{p} = 5\%$





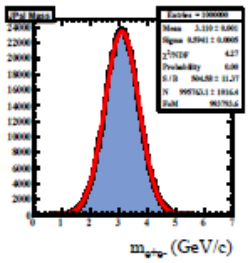


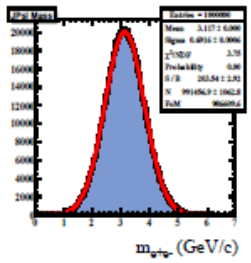


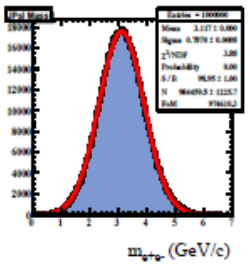


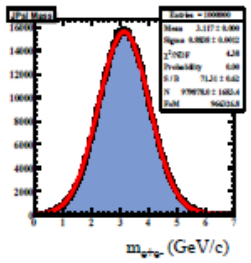
$\frac{\Delta p}{p} = 25\%$

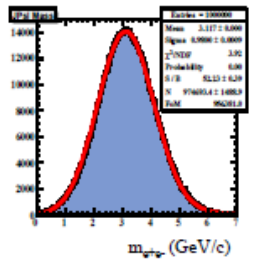
$\frac{\Delta p}{p} = 30\%$









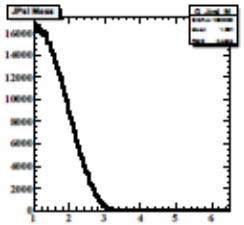


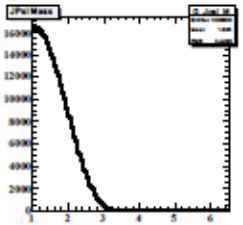
$\frac{\Delta p}{p} = 50\%$

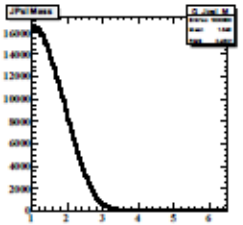
Background

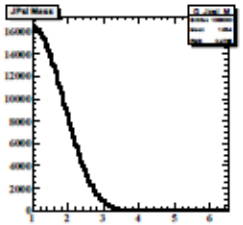
($\bar{p}p \rightarrow 4\pi^{\pm}$)

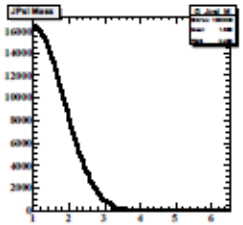
$\frac{\Delta p}{p} = 5\%$











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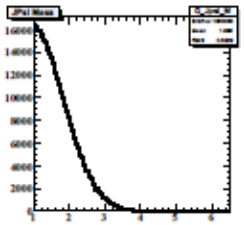
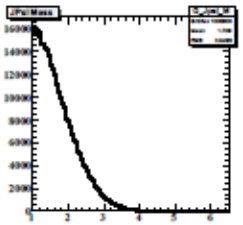
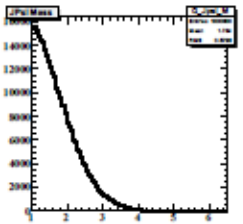
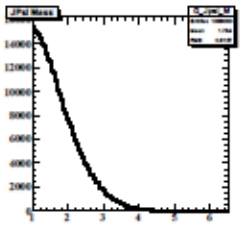
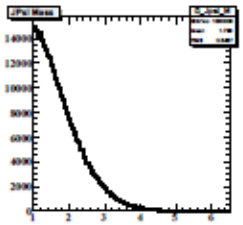
$\frac{\Delta p}{p} = 30\%$











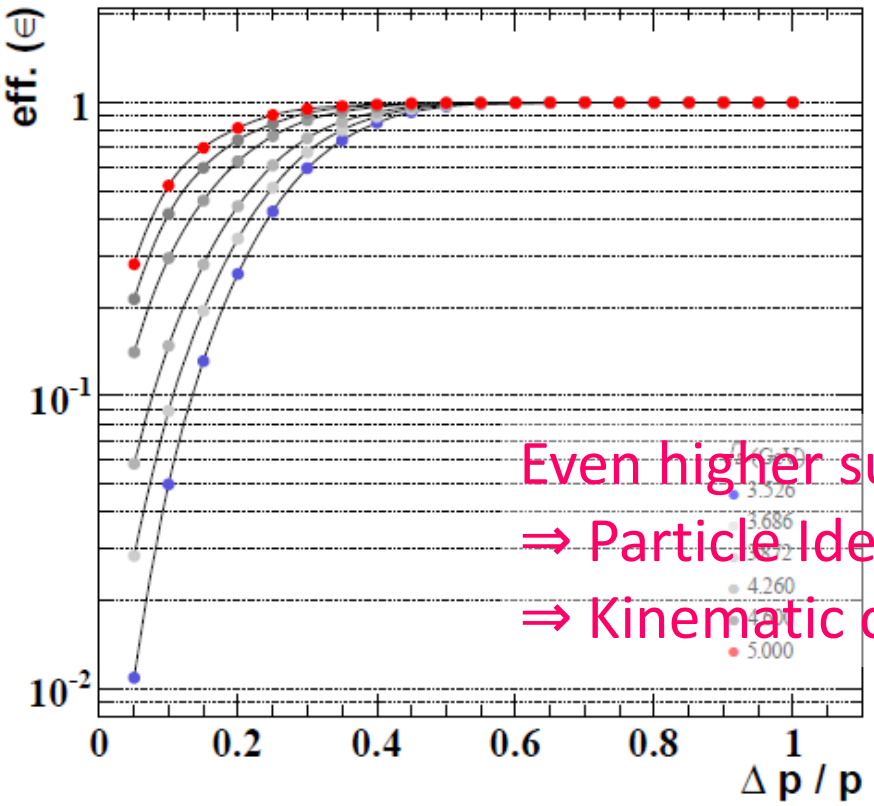
$\frac{\Delta p}{p} = 50\%$

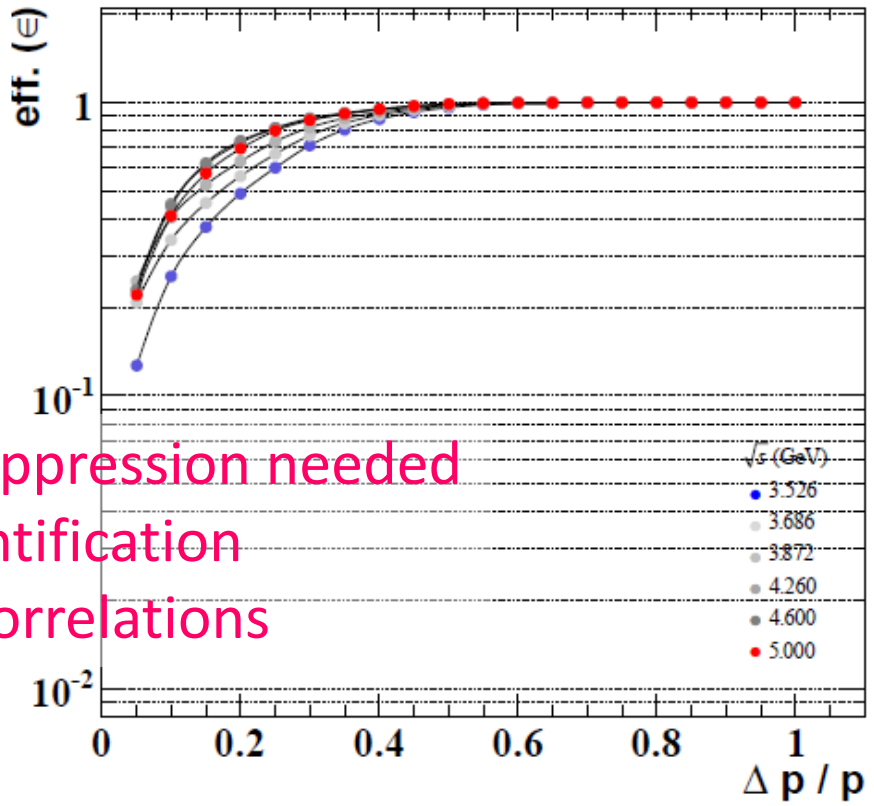
Background feedthrough vs. Δp/p

Cut on J/ψ mass: 2σ around mean value *(Sig. eff = 95%)*

EvtGen $\bar{p}p \to \pi^+\pi^-\pi^+\pi^-$

DPM $\bar{p}p \to \pi^+\pi^-\pi^+\pi^-$





Even higher suppression needed
⇒ Particle Identification
⇒ Kinematic correlations

Efficiency = accepted event / total generated event

Summary - Challenges for PANDA

- Many physics channels
- Signal and background events look very similar
- *Many, many* more background reactions ($\times 10^4 - 10^7$)
- Need to (at least sketchy) analyse all events; this requires
  - Track reconstruction
  - EMC cluster reconstruction
  - Track – PID – matching
  - Event separation
  - Combinatorics/Kinematic correlation analysis
- No ‚simple' hardware trigger can cope with that situation
- *Only possible with precise online reco + a lot computing power*

Current Technical/Organizational Status

- PANDA – GSI-SC-Cooperation
  - Close cooperation between PANDA and GSI Scientific Computing since several years
  - Common development: Time-based simulation, Track following, CAD2Root Converter, ...

- Algorithms and Methods used for (track/event) reconstruction
  - Kalman-Filter as universal track finding/fitting tool (GenFit, http://sourceforge.net/projects/genfit/)
  - Hough-Transformation, Conformal Mapping (online tracking)
  - Riemann-Fitting (offline track finding)
  - Cellular Automaton (Luminosity-Monitor)
  - Neural Network (alt. approach for central tracker)

BACKUP

Physics Report Selection Strategies *(offline!)*

Channel	TRK	NEUT	Excl.	mult	PID	p	E	ang.	inv M	dist cut	veto	4C	Vtx C	Mass C	Sig Eff[%]
J/psi pi+ pi-	4	0	x		e, pi				x				J/psi pi+ pi-		***30***
J/psi pi0 pi0	2	4	x		e		g		x		J/psi eta pi0	x	J/psi		***17***
chi_c1,2 gam	2	2	x		e		g		x			x	J/psi		***30***
J/psi gam	2	1	x		e				x			x	J/psi		***40***
J/psi eta	2	2	x		e				x			x	J/psi		***40***
h_c -> 3gam	0	3	x	3n			g	h_c	x			x			***8***
h_c -> 2phi gam	4	1	x		K		g		x		pi0	x			***8***
D+ D-	6	0	x		?	D			x	z(D)		x	D+-		***8***
D*+ D*-	6	0	x		?	D*			x	z(D*)		x	D0	D0	***14***
eta_c1 eta	2	7	x		e				x			x		chi, pi0, eta	***7***
eta_c1 eta	4	8	x		K, pi				x		>1 comb/ev	x	K pi	D0, D0*, eta, pi0	***5***
J/psi omega	4	2	x		e, pi				x			x	J/psi pi+pi-	J/psi, pi0	***15***
f2(2230) -> 2phi	4	0	x		K				x			x	phi		***20***
Ds Ds(2317)	3	0			K, pi			K	x				Ds, phi		***20***
Xi- Xi+ pi0	6	2	x		p, pi		g		x	d(IP-Xi)	>1 comb/ev	x	Lam,Xi+-	Xi Xi pi0	***16***
Lam Lam	6	0	x		p, pi				x	d(IP-Xi)			Lam		***11 … 23***
Xi- Xi+	6	0	x		p, pi				x				Lam, Lam pi		***19***

many exclusive analyses!

few multiplicity cuts

PID!

few kinematic cuts (except mass)

a lot of fitting!